SIEMENS

SIMATIC

S7-200
Programmable Controller System Manual

This manual has the order number:
6ES7298-8FA24-8BH0

Edition 08/2008
A5E00307987-04

Safety Guidelines

This manual contains notices which you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows according to the level of danger:

Danger

Danger indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Warning

Warning indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution

Caution used with the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Caution

Caution used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

Notice

Notice indicates a potential situation which, if not avoided, may result in an undesirable result or state.

Qualified Personnel

Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical descriptions, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

Trademarks

SIMATIC®, SIMATIC HMI® and SIMATIC NET® are registered trademarks of SIEMENS AG.

Some of other designations used in these documents are also registered trademarks; the owner’s rights may be violated if they are used by third parties for their own purposes.

Disclaimer of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

Siemens AG
Bereich Automation and Drives
Geschaeftsgebiet Industrial Automation Systems
Postfach 4848, D- 90327 Nuernberg

Technical data subject to change.

Preface

Purpose of the manual

The S7-200 series is a line of micro-programmable logic controllers (Micro PLCs) that can control a variety of automation applications. Compact design, low cost, and a powerful instruction set make the S7-200 a perfect solution for controlling small applications. The wide variety of S7-200 models and the Windows-based programming tool give you the flexibility you need to solve your automation problems.

This manual provides information about installing and programming the S7-200 Micro PLCs and is designed for engineers, programmers, installers, and electricians who have a general knowledge of programmable logic controllers.

Required Basic Knowledge

To understand this manual, it is necessary to have a general knowledge of automation and programmable logic controllers.

Scope of the Manual

This manual is valid for STEP 7–Micro/WIN, version 4.0 and the S7-200 CPU product family. For a complete list of the S7-200 products and order numbers described in this manual, see Appendix A.

Changes compared to the previous version

This manual has been revised to include two new analog expansion modules and one additional appendix.

- EM 231 Analog Input RTD, 4 Inputs
- EM 231 Analog Input Thermocouple 8 Inputs
- Appendix H, S7-200CN Products

Certification

The SIMATIC S7-200 products have the following certification:

- Underwriters Laboratories, Inc. UL 508 Listed (Industrial Control Equipment), Registration number E75310
- Canadian Standards Association: CSA C22.2 Number 142 (Process Control Equipment)
- Factory Mutual Research: Class Number 3600, Class Number 3611, FM Class I, Division 2, Groups A, B, C, & D Hazardous Locations, T4A and Class I, Zone 2, IIC, T4

Tip

The SIMATIC S7-200 series meets the CSA standard.

The cULus logo indicates that the S7-200 has been examined and certified by Underwriters Laboratories (UL) to standards UL 508 and CSA 22.2 No. 142.

CE Labeling

Refer to the General Technical Specifications in Appendix A for more information.

C-Tick

The SIMATIC S7-200 products are compliant with requirements of the AS/NZS 2064 (Australian) standard.

Standards:

The SIMATIC S7-200 products fulfill the requirement and criteria of IEC 61131–2, Programmable controllers – Equipment requirements.

Refer to Appendix A for additional compliance information.

Place of this Documentation in the Information Environment

Product Family	Documentation	Order Number
S7-200	S7-200 Point-to-Point Interface Communication Manual (English/German)	6ES7 298–8GA00–8XH0
	SIMATIC Text Display User Manual (included on the STEP 7–Micro/WIN documentation CD)	none
	HMI device OP 73micro, TP 177micro (WinCC Flexible) Operating Instructions (English)	6AV6 691–1DF01–0AB0
	SIMATIC HMI WinCC flexible 2005 Micro User's Manual (English)	6AV6 691–1AA01–0AB0
	SIMATIC NET CP 243–2 AS-Interface Master Manual (English)	6GK7 243–2AX00–8BA0
	SIMATIC NET CP 243–1 Communications processor of Industrial Ethernet Technical Manual (English)	J31069–D0428–U001–A2–7618
	SIMATIC NET CP 243–1 IT Communications Processor of Industrial Ethernet and Information Technology Technical Manual (English)	J31069–D0429–U001–A2–7618
	SIMATIC NET S7Beans / Applets for IT–CPs Programming Tips (English)	C79000–G8976–C180–02
	SIMATIC NET GPRS/GSM–Modem SINAUT MD720–3 System manual (English)	C79000–G8976–C211
	SIMATIC NET SINAUT MICRO SC System manual (English)	C79000–G8900–C210
	SIWAREX MS Device Manual (English) (included with device)	none
	S7-200 Programmable Controller System Manual (English)	6ES7 298–8FA24–8BH0

Finding Your Way

If you are a first-time user of S7-200 Micro PLCs, you should read the entire *S7-200 Programmable Controller System Manual*. If you are an experienced user, refer to the table of contents or index to find specific information.

The *S7-200 Programmable Controller System Manual* is organized according to the following topics:

- ❑ Chapter 1 (Product Overview) provides an overview of some of the features of the S7-200 family of Micro PLC products.
- ❑ Chapter 2 (Getting Started) provides a tutorial for creating and downloading a sample control program to an S7-200.
- ❑ Chapter 3 (Installing the S7-200) provides the dimensions and basic guidelines for installing the S7-200 CPU modules and expansion I/O modules.
- ❑ Chapter 4 (PLC Concepts) provides information about the operation of the S7-200.
- ❑ Chapter 5 (Programming Concepts, Conventions, and Features) provides information about the features of STEP 7-Micro/WIN, the program editors and types of instructions (IEC 1131-3 or SIMATIC), S7-200 data types, and guidelines for creating programs.
- ❑ Chapter 6 (S7-200 Instruction Set) provides descriptions and examples of programming instructions supported by the S7-200.
- ❑ Chapter 7 (Communicating over a Network) provides information for setting up the different network configurations supported by the S7-200.
- ❑ Chapter 8 (Hardware Troubleshooting Guide and Software Debugging Tools) provides information for troubleshooting problems with the S7-200 hardware and about the STEP 7-Micro/WIN features that help you debug your program.
- ❑ Chapter 9 (Open Loop Motion Control with the S7-200) provides information about three methods of open loop motion control: Pulse Width Modulation, Pulse Train Output, and the EM 253 Position Control Module.
- ❑ Chapter 10 (Creating a Program for the Modem Module) provides information about the instructions and wizard used to create a program for the EM 241 Modem module.
- ❑ Chapter 11 (Using the USS Protocol Library to Control a MicroMaster Drive) provides information about the instructions used to create a control program for a MicroMaster drive. It also provides information about how to configure the MicroMaster 3 and MicroMaster 4 drives.
- ❑ Chapter 12 (Using the Modbus Protocol Library) provides information about the instructions used to create a program that uses the Modbus protocol for communications.
- ❑ Chapter 13 (Using Recipes) provides information about organizing and loading automation program recipes in the memory cartridge.
- ❑ Chapter 14 (Using Data Logs) provides information about storing process measurement data in the memory cartridge.
- ❑ Chapter 15 (PID Auto-Tune and the PID Tuning Control Panel) provides information about using these features to greatly enhance the utility and ease of use of the PID function provided by the S7-200.
- ❑ Appendix A (Technical Specifications) provides the technical information and data sheets about the S7-200 hardware.

The other appendices provide additional reference information, such as descriptions of the error codes, descriptions of the Special Memory (SM) area, part numbers for ordering S7-200 equipment, STL instruction execution times, and S7-200CN product information.

In addition to this manual, STEP 7-Micro/WIN provides extensive online help for getting started with programming the S7-200. Included with the purchase of the STEP 7-Micro/WIN software is a free documentation CD. On this CD you can find application tips, an electronic version of this manual and other information.

Online Help

Help is only a keystroke away! Pressing F1 accesses the extensive online help for STEP 7-Micro/WIN. The online help includes useful information about getting started with programming the S7-200, as well as many other topics.

Electronic Manual

An electronic version of this S7-200 System Manual is available on the documentation CD. You can install the electronic manual onto your computer so that you can easily access the information in the manual while you are working with the STEP 7-Micro/WIN software.

Programming Tips

The documentation CD includes Programming Tips, a set of application examples with sample programs. Reviewing or modifying these examples can help you find efficient or innovative solutions for your own application. You can also find the most current version of Programming Tips on the S7-200 Internet site.

Recycling and Disposal

Please contact a company certified in the disposal of electronic scrap for environmentally safe recycling and disposal of your device.

Additional Support

Local Siemens Sales Office or Distributor

For assistance in answering any technical questions, for training on the S7-200 products, or for ordering S7-200 products, contact your Siemens distributor or sales office. Because your sales representatives are technically trained and have the most specific knowledge about your operations, process and industry, as well as about the individual Siemens products that you are using, they can provide the fastest and most efficient answers to any problems that you might encounter.

Service & Support on the Internet

In addition to our documentation, we offer our Know-how online on the Internet at:

http://www.siemens.com/automation/service&support

where you will find the following:

❑ www.siemens.com/S7-200 *for S7-200 product information*

  The S7-200 Internet site includes frequently asked questions (FAQs), Programming Tips (application examples and sample programs), information about newly released products, and product updates or downloads.

❑ The newsletter, which constantly provides you with up-to-date information on your products.

❑ The right documents via our Search function in Service & Support.

❑ A forum, where users and experts from all over the world exchange their experiences.

❑ Your local representative for Automation & Drives.

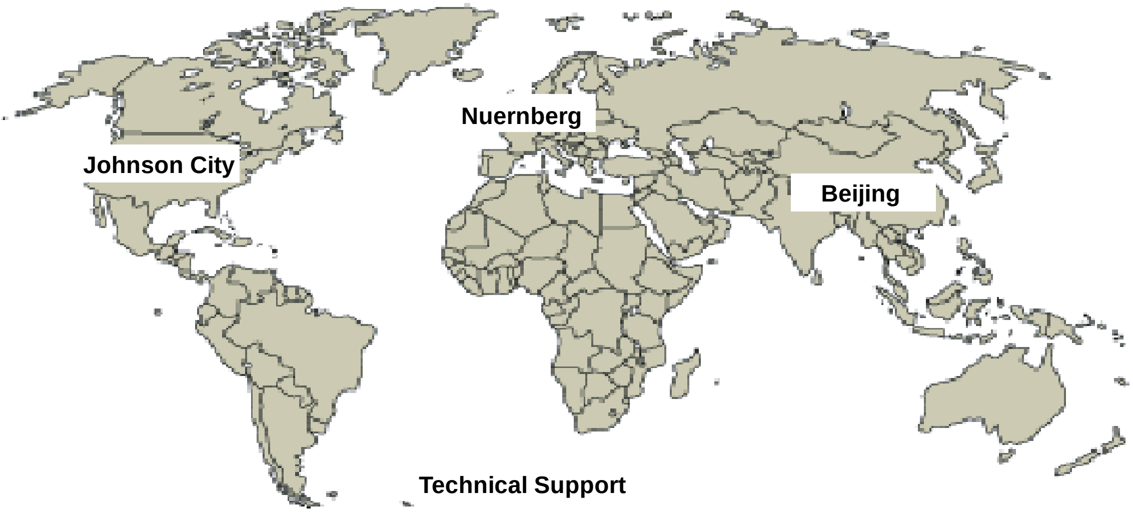
❑ Information on field service, repairs, spare parts and more under “Services”.

Technical Services

The highly trained staff of the S7-200 Technical Services center is also available to help you solve any problems that you might encounter. You can call on them 24 hours a day, 7 days a week.

A&D Technical Support

Worldwide, available 24 hours a day:



Worldwide (Nuernberg) **Technical Support** 24 hours a day, 365 days a year Phone: +49 (180) 5050-222 Fax: +49 (180) 5050-223 mailto:adsupport@siemens.com GMT: +1:00	**United States** (Johnson City) **Technical Support and Authorization** Local time: Mon.-Fri. 8:00 AM to 5:00 PM Phone: +1 (423) 262 2522 +1 (800) 333–7421 (USA only) Fax: +1 (423) 262 2289 mailto:simatic.hotline@sea.siemens.com GMT: –5:00	**Asia / Australia** (Beijing) **Technical Support and Authorization** Local time: Mon.-Fri. 8:00 AM to 5:00 PM Phone: +86 10 64 75 75 75 Fax: +86 10 64 74 74 74 mailto:adsupport.asia@siemens.com GMT: +8:00
Europe / Africa (Nuernberg) **Authorization** Local time: Mon.-Fri. 8:00 AM to 5:00 PM Phone: +49 (180) 5050–222 Fax: +49 (180) 5050-223 mailto:adsupport@siemens.com GMT: +1:00		
The languages of the SIMATIC Hotlines and the authorization hotline are generally German and English.		

Contents

1

Product Overview

The S7-200 series of micro-programmable logic controllers (Micro PLCs) can control a wide variety of devices to support your automation needs.

The S7-200 monitors inputs and changes outputs as controlled by the user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices. The compact design, flexible configuration, and powerful instruction set combine to make the S7-200 a perfect solution for controlling a wide variety of applications.

In This Chapter

What’s New?

The new features of the SIMATIC S7-200 include two new analog expansion modules:

- ❑ EM 231 Analog Input RTD, 4 Inputs
- ❑ EM 231 Analog Input Thermocouple 8 Inputs
- ❑ Appendix H, S7-200CN Products

S7-200 CPU

The S7-200 CPU combines a microprocessor, an integrated power supply, input circuits, and output circuits in a compact housing to create a powerful Micro PLC. See Figure 1-1. After you have downloaded your program, the S7-200 contains the logic required to monitor and control the input and output devices in your application.

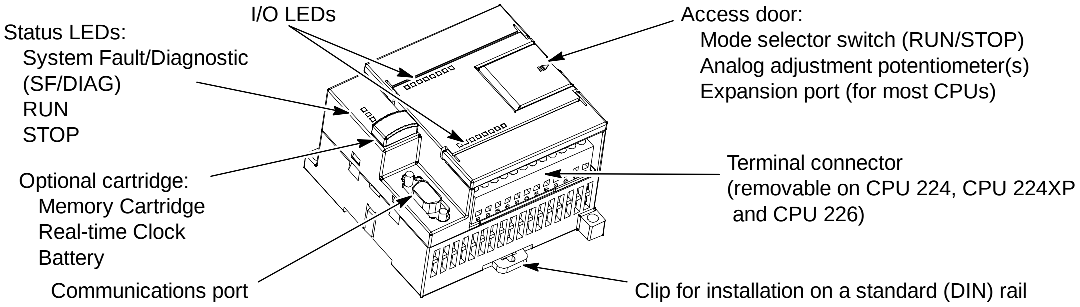


Figure 1-1 S7-200 Micro PLC

Siemens provides different S7-200 CPU models with a diversity of features and capabilities that help you create effective solutions for your varied applications. Table 1-1 briefly compares some of the features of the CPU. For detailed information about a specific CPU, see Appendix A.

Table 1-1 Comparison of the S7-200 CPU Models

Feature	CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
Physical size (mm)	90 x 80 x 62	90 x 80 x 62	120.5 x 80 x 62	140 x 80 x 62	190 x 80 x 62
Program memory:					
with run mode edit	4096 bytes	4096 bytes	8192 bytes	12288 bytes	16384 bytes
without run mode edit	4096 bytes	4096 bytes	12288 bytes	16384 bytes	24576 bytes
Data memory	2048 bytes	2048 bytes	8192 bytes	10240 bytes	10240 bytes
Memory backup	50 hours typical	50 hours typical	100 hours typical	100 hours typical	100 hours typical
Local on-board I/O					
Digital	6 In/4 Out	8 In/6 Out	14 In/10 Out	14 In/10 Out	24 In/16 Out
Analog	–	–	–	2 In/1 Out	–
Expansion modules	0 modules	2 modules[1]	7 modules[1]	7 modules[1]	7 modules[1]
High-speed counters					
Single phase	4 at 30 kHz	4 at 30 kHz	6 at 30 kHz	4 at 30 kHz 2 at 200 kHz	6 at 30 kHz
Two phase	2 at 20 kHz	2 at 20 kHz	4 at 20 kHz	3 at 20 kHz 1 at 100 kHz	4 at 20 kHz
Pulse outputs (DC)	2 at 20 kHz	2 at 20 kHz	2 at 20 kHz	2 at 100 kHz	2 at 20 kHz
Analog adjustments	1	1	2	2	2
Real-time clock	Cartridge	Cartridge	Built-in	Built-in	Built-in
Communications ports	1 RS–485	1 RS–485	1 RS–485	2 RS–485	2 RS–485
Floating-point math	Yes				
Digital I/O image size	256 (128 in, 128 out)				
Boolean execution speed	0.22 microseconds/instruction				

[1] You must calculate your power budget to determine how much power (or current) the S7-200 CPU can provide for your configuration. If the CPU power budget is exceeded, you may not be able to connect the maximum number of modules. See Appendix A for CPU and expansion module power requirements, and Appendix B to calculate your power budget.

S7-200 Expansion Modules

To better solve your application requirements, the S7-200 family includes a wide variety of expansion modules. You can use these expansion modules to add additional functionality to the S7-200 CPU. Table 1-2 provides a list of the expansion modules that are currently available. For detailed information about a specific module, see Appendix A.

Table 1-2 S7-200 Expansion Modules

Expansion Modules	Type			
Discrete modules				
Input	8 x DC In	8 x AC In	16 x DC In	
Output	4 x DC Out	4 x Relays	8 x Relay	
	8 x DC Out	8 x AC Out		
Combination	4 x DC In/ 4 x DC Out	8 x DC In/ 8 x DC Out	16 x DC In/ 16 x DC Out	32 x DC In/ 32 x DC Out
	4 x DC In / 4 x Relay	8 x DC In / 8 x Relay	16 x DC In/ 16 x Relay	32 x DC In/ 32 x Relay
Analog modules				
Input	4 x Analog In	8 x Analog In	4 x Thermocouple In	8 x Thermocouple In
	2 x RTD In	4 x RTD In		
Output	2 x Analog Out	4 x Analog Out		
Combination	4 x Analog In 4 x Analog Out			
Intelligent modules				
	Position	Modem	PROFIBUS-DP	
	Ethernet	Ethernet IT		
Other modules				
	AS-Interface	SIWAREX MS[1]		

[1] Detailed information not included in Appendix A. Please refer to your module documentation.

STEP 7-Micro/WIN Programming Package

The STEP 7-Micro/WIN programming package provides a user-friendly environment to develop, edit, and monitor the logic needed to control your application. STEP 7-Micro/WIN provides three program editors for convenience and efficiency in developing the control program for your application. To help you find the information you need, STEP 7-Micro/WIN provides an extensive online help system and a documentation CD that contains an electronic version of this manual, application tips, and other useful information.

Computer Requirements

STEP 7-Micro/WIN runs on either a personal computer or a Siemens programming device, such as a PG 760. Your computer or programming device should meet the following minimum requirements:

- Operating system:
  Windows 2000, Windows XP, Vista
- At least 350M bytes of free hard disk space
- Mouse (recommended)

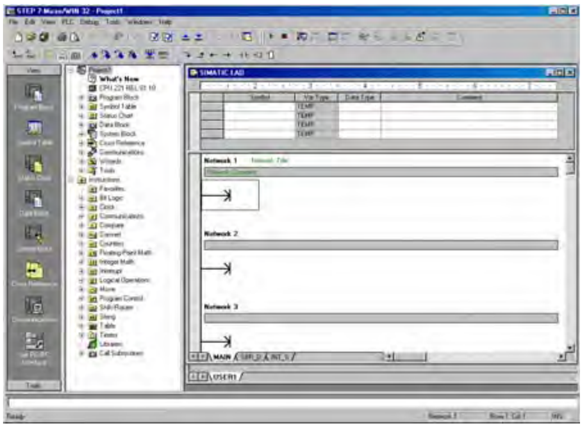

STEP 7-Micro/WIN 32 - Project1
File Edit View PLC Debug Tools Windows Help
SIMATIC LAD
Network 1
Network 2
Network 3
MAIN
SBR_0
INT_0
USER1

Figure 1-2 STEP 7-Micro/WIN

Installing STEP 7-Micro/WIN

Insert the STEP 7-Micro/WIN CD into the CD-ROM drive of your computer. The installation wizard starts automatically and prompts you through the installation process. Refer to the Readme file for more information about installing STEP 7-Micro/WIN.

Tip

To install STEP 7-Micro/WIN on a Windows 2000, Windows XP, or Windows Vista operating system, you must log in with Administrator privileges.

Communications Options

Siemens provides two programming options for connecting your computer to your S7-200: a direct connection with a PPI Multi-Master cable, or a Communications Processor (CP) card with an MPI cable.

The PPI Multi-Master programming cable is the most common and economical method of connecting your computer to the S7-200. This cable connects the communications port of the S7-200 to the serial communications of your computer. The PPI Multi-Master programming cable can also be used to connect other communications devices to the S7-200.

Display Panels

Text Display Units

The Text Display (TD) is a display device that can be connected to the S7-200. Using the Text Display wizard, you can easily program your S7-200 to display text messages and other data pertaining to your application.

The TD device provides a low cost interface to your application by allowing you to view, monitor, and change the process variables pertaining to your application.

The S7-200 product family provides four TD devices:

- The TD100C has a 4-line text display with 2 font choices.
- The TD 200C has a 2-line text display with 20 characters per line for a total of 40 characters.
- The TD 200 has a faceplate which provides four keys with predefined, set-bit functions and allows up to eight set-bit functions.
- The TD400C can have a 2- or 4-line text display depending on your font and character choice.

Text Display

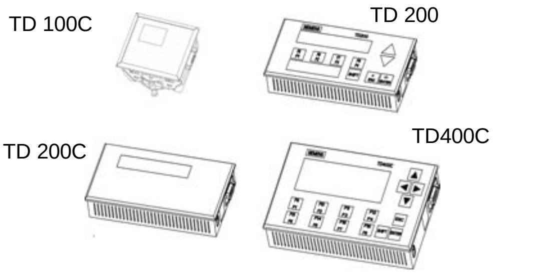


Figure 1-3 Text Display Units

For more information about the Text Display Units, refer to the *SIMATIC Text Display (TD) User Manual* on the STEP 7-Micro/WIN docuCD.

The Text Display wizard in STEP 7-Micro/WIN helps you configure Text Display messages quickly and easily. To start the Text Display wizard, select the **Tools > Text Display Wizard** menu command.

Operator and Touch Panel Displays

The OP 73micro and TP 177micro panels are tailored to applications with SIMATIC S7-200 Micro PLC and provide operating and monitoring functions for small-scale machines and plants. Short configuration and commissioning times, and their configuration in WinCC flexible form the highlights of these panels. In addition, these panels support up to 32 configuration languages and five online languages, including the Asian and Cyrillic character sets.

The mounting dimensions of the Operator Panel OP 73micro with its graphical 3” display unit are compatible with OP3 and TD 200.

Touch Panel TP 177micro replaces the Touch Panel TP 070/TP 170micro. It can be mounted vertically to accommodate additional applications. This feature enables its use even when space is restricted.

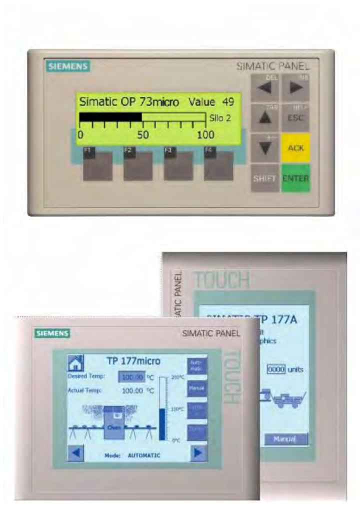


Figure 1-4 Operator and Touch Panel Displays

2 Getting Started

STEP 7–Micro/WIN makes it easy for you to program your S7-200. In just a few short steps using a simple example, you can learn how to connect, program, and run your S7-200.

All you need for this example is a PPI Multi-Master cable, an S7-200 CPU, and a programming device running the STEP 7–Micro/WIN programming software.

In This Chapter

Connecting the S7-200 CPU

Connecting your S7-200 is easy. For this example, you only need to connect power to your S7-200 CPU and then connect the communications cable between your programming device and the S7-200 CPU.

Connecting Power to the S7-200 CPU

The first step is to connect the S7-200 to a power source. Figure 2-1 shows the wiring connections for either a DC or an AC model of the S7-200 CPU.

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Always follow appropriate safety precautions and ensure that power to the S7-200 is disabled before attempting to install or remove the S7-200.

Warning

Attempts to install or wire the S7-200 or related equipment with power applied could cause electric shock or faulty operation of equipment. Failure to disable all power to the S7-200 and related equipment during installation or removal procedures could result in death or serious injury to personnel, and/or damage to equipment.

Always follow appropriate safety precautions and ensure that power to the S7-200 is disabled before attempting to install or remove the S7-200 or related equipment.

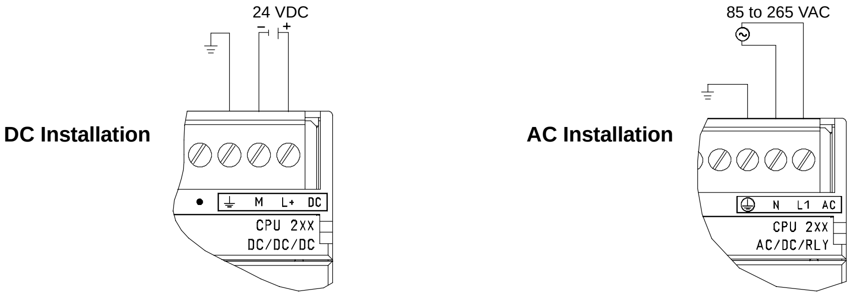


Figure 2-1 Connecting Power to the S7-200 CPU

Connecting the RS-232/PPI Multi-Master Cable

Figure 2-2 shows an RS-232/PPI Multi-Master cable connecting the S7-200 to the programming device. To connect the cable:

1. Connect the RS-232 connector (marked “PC”) of the RS-232/PPI Multi-Master cable to the communications port of the programming device. (For this example, connect to COM 1.)
2. Connect the RS-485 connector (marked “PPI”) of the RS-232/PPI Multi-Master cable to Port 0 or Port 1 of the S7-200.
3. Ensure that the DIP switches of the RS-232/PPI Multi-Master cable are set as shown in Figure 2-2.

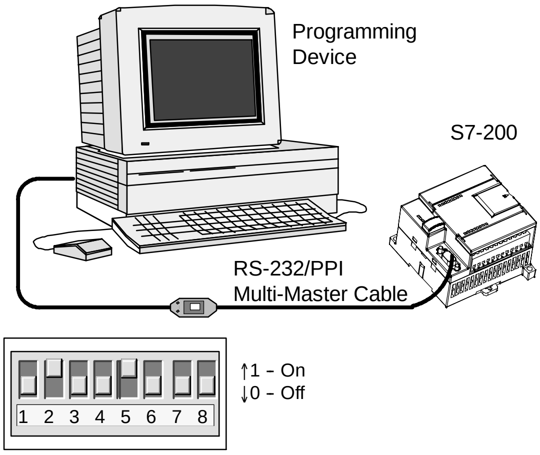


Figure 2-2 Connecting the RS-232/PPI Multi-Master Cable

Tip

Examples in this manual use the RS-232/PPI Multi-Master cable. The RS-232/PPI Multi-Master cable replaces the previous PC/PPI cable. A USB/PPI Multi-Master cable is also available. Refer to Appendix E for order numbers.

Starting STEP 7-Micro/WIN

Click on the STEP 7-Micro/WIN icon to open a new project. Figure 2-3 shows a new project.

Notice the navigation bar. You can use the icons on the navigation bar to open elements of the STEP 7-Micro/WIN project.

Click on the Communications icon in the navigation bar to display the Communications dialog box. You use this dialog box to set up the communications for STEP 7-Micro/WIN.

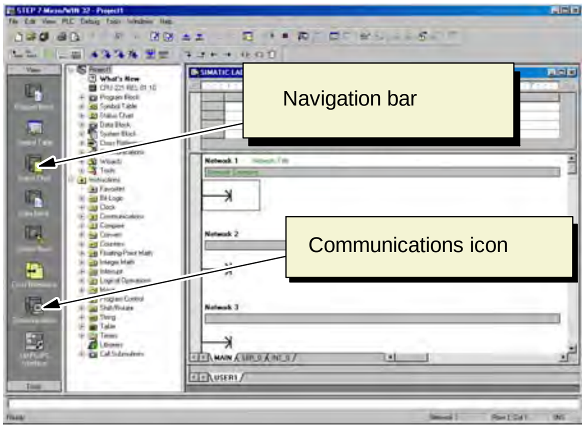


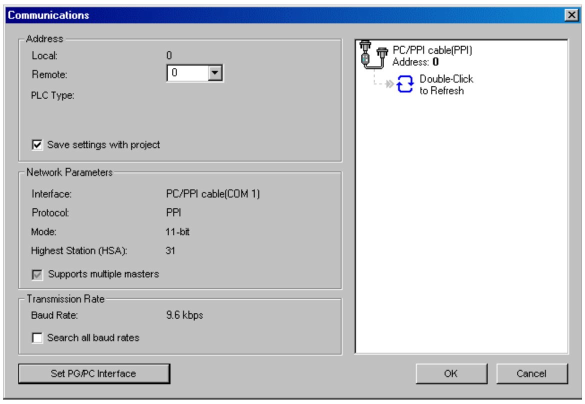
Figure 2-3 New STEP 7-Micro/WIN Project

Verifying the Communications Parameters for STEP 7-Micro/WIN

The example project uses the default settings for STEP 7-Micro/WIN and the RS-232/PPI Multi-Master cable. To verify these settings:

1. Verify that the address of the PC/PPI cable in the Communications dialog box is set to 0.
2. Verify that the interface for the network parameter is set for PC/PPI cable(COM1).
3. Verify that the transmission rate is set to 9.6 kbps.

If you need to change your communications parameter settings, see Chapter 7.



Communications

Address
Local: 0
Remote: 0
PLC Type:
☑ Save settings with project

Network Parameters
Interface: PC/PPI cable(COM 1)
Protocol: PPI
Mode: 11-bit
Highest Station (HSA): 31
☑ Supports multiple masters

Transmission Rate
Baud Rate: 9.6 kbps
□ Search all baud rates

Figure 2-4   Verifying the Communications Parameters

Establishing Communications with the S7-200

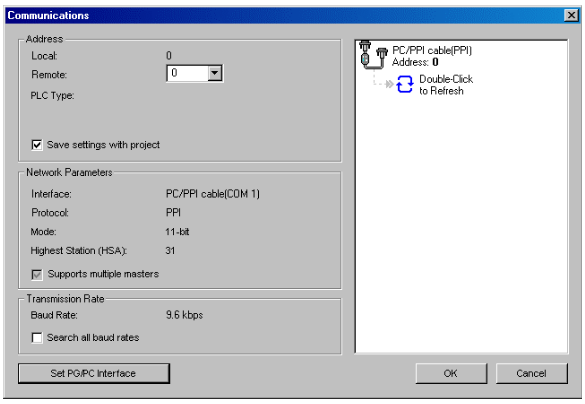
Use the Communications dialog box to connect with your S7-200 CPU:

1. Double-click the refresh icon in the Communications dialog box.

   STEP 7-Micro/WIN searches for the S7-200 station and displays a CPU icon for the connected S7-200 station.
2. Select the S7-200 and click OK.

If STEP 7-Micro/WIN does not find your S7-200 CPU, check the settings for the communications parameters and repeat these steps.

After you have established communications with the S7-200, you are ready to create and download the example program.



Communications

Address
Local: 0
Remote: 0
PLC Type:
☑ Save settings with project

Network Parameters
Interface: PC/PPI cable(COM 1)
Protocol: PPI
Mode: 11-bit
Highest Station (HSA): 31
☑ Supports multiple masters

Transmission Rate
Baud Rate: 9.6 kbps
□ Search all baud rates

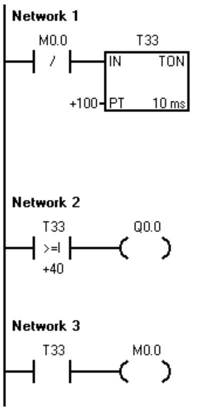
Figure 2-5   Establishing Communications to the S7-200

Creating a Sample Program

Entering this example of a control program will help you understand how easy it is to use STEP 7-Micro/WIN. This program uses six instructions in three networks to create a very simple, self-starting timer that resets itself.

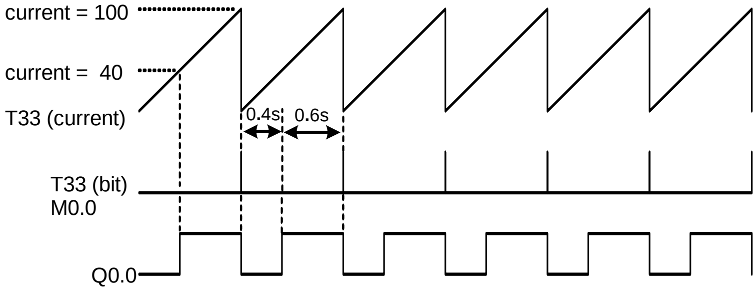
For this example, you use the Ladder (LAD) editor to enter the instructions for the program. The following example shows the complete program in both LAD and Statement List (STL). The network comments in the STL program explain the logic for each network. The timing diagram shows the operation of the program.

Example: Sample Program for getting started with STEP 7-Micro/WIN



```
Network 1       //10 ms timer T33 times out after
                //(100 x 10 ms = 1 s) M0.0 pulse is
                // too fast to monitor with Status view.
LDN     M0.0
TON     T33, +100
Network 2       //Comparison becomes true at a
                //rate that is visible with
                //Status view. Turn on Q0.0 after
                //(40 x 10 ms = 0.4 s), for a
                // 40% OFF/60% ON waveform.
LDW>=   T33, +40
=       Q0.0
Network 3       //T33 (bit) pulse too fast to monitor with
                //Status view.  Reset the timer through
                //M0.0 after the (100 x 10 ms  = 1 s) period.
LD      T33
=       M0.0
```

Timing Diagram



Opening the Program Editor

Click on the Program Block icon to open the program editor. See Figure 2-6.

Notice the instruction tree and the program editor. You use the instruction tree to insert the LAD instructions into the networks of the program editor by dragging and dropping the instructions from the instruction tree to the networks.

The toolbar icons provide shortcuts to the menu commands.

After you enter and save the program, you can download the program to the S7-200.

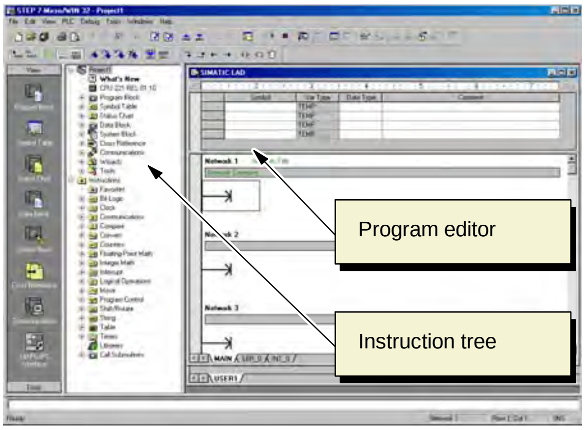


Figure 2-6 STEP 7-Micro/WIN Window

Entering Network 1: Starting the Timer

When M0.0 is off (0), this contact turns on and provides power flow to start the timer. To enter the contact for M0.0:

1. Either double-click the Bit Logic icon or click on the plus sign (+) to display the bit logic instructions.
2. Select the Normally Closed contact.
3. Hold down the left mouse button and drag the contact onto the first network.
4. Click on the “???” above the contact and enter the following address: M0.0
5. Press the Return key to enter the address for the contact.

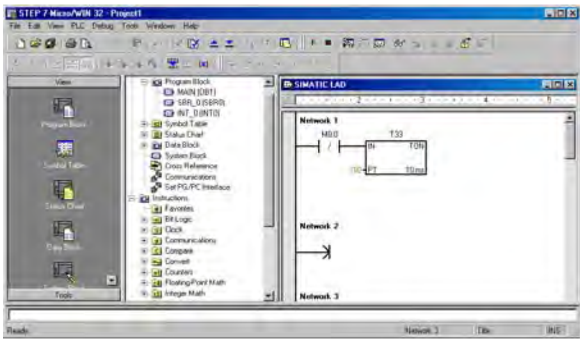


Figure 2-7 Network 1

To enter the timer instruction for T33:

1. Double-click the Timers icon to display the timer instructions.
2. Select the TON (On-Delay Timer).
3. Hold down the left mouse button and drag the timer onto the first network.
4. Click on the “???” above the timer box and enter the following timer number: T33
5. Press the Return key to enter the timer number and to move the focus to the preset time (PT) parameter.
6. Enter the following value for the preset time: 100
7. Press the Return key to enter the value.

Entering Network 2: Turning the Output On

When the timer value for T33 is greater than or equal to 40 (40 times 10 milliseconds, or 0.4 seconds), the contact provides power flow to turn on output Q0.0 of the S7-200. To enter the Compare instruction:

1. Double-click the Compare icon to display the compare instructions. Select the >=I instruction (Greater-Than-Or-Equal-To-Integer).
2. Hold down the left mouse button and drag the compare instruction onto the second network.
3. Click on the “???” above the contact and enter the address for the timer value: T33
4. Press the Return key to enter the timer number and to move the focus to the other value to be compared with the timer value.
5. Enter the following value to be compared with the timer value: 40
6. Press the Return key to enter the value.

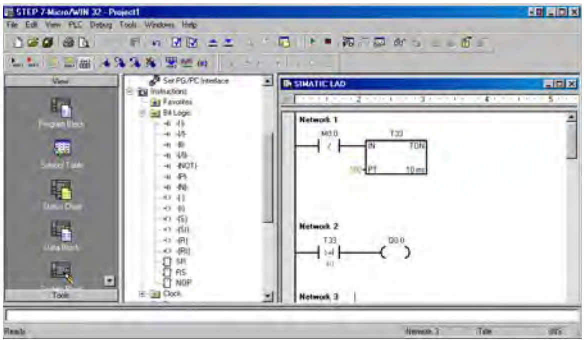


Figure 2-8 Network 2

To enter the instruction for turning on output Q0.0:

1. Double-click the Bit Logic icon to display the bit logic instructions and select the output coil.
2. Hold down the left mouse button and drag the coil onto the second network.
3. Click on the “???” above the coil and enter the following address: Q0.0
4. Press the Return key to enter the address for the coil.

Entering Network 3: Resetting the Timer

When the timer reaches the preset value (100) and turns the timer bit on, the contact for T33 turns on. Power flow from this contact turns on the M0.0 memory location. Because the timer is enabled by a Normally Closed contact for M0.0, changing the state of M0.0 from off (0) to on (1) resets the timer.

To enter the contact for the timer bit of T33:

1. Select the Normally Open contact from the bit logic instructions.
2. Hold down the left mouse button and drag the contact onto the third network.
3. Click on the “???” above the contact and enter the address of the timer bit: T33
4. Press the Return key to enter the address for the contact.

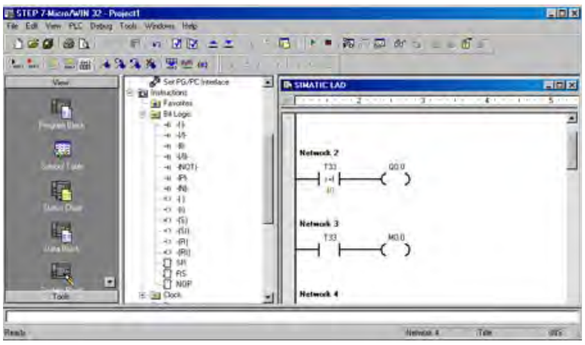


Figure 2-9 Network 3

To enter the coil for turning on M0.0:

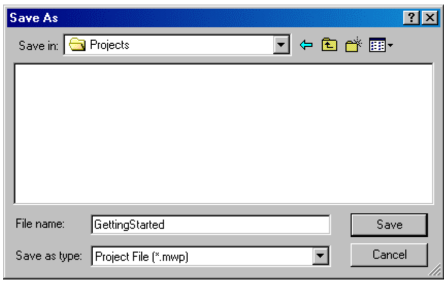
1. Select the output coil from the bit logic instructions.
2. Hold down the left mouse button and drag the output coil onto the third network.
3. Double-click the “???” above the coil and enter the following address: M0.0
4. Press the Return key to enter the address for the coil.

Saving the Sample Project

After entering the three networks of instructions, you have finished entering the program. When you save the program, you create a project that includes the S7-200 CPU type and other parameters. To save the project:

1. Select the **File > Save As** menu command from the menu bar.
2. Enter a name for the project in the Save As dialog box.
3. Click OK to save the project.

After saving the project, you can download the program to the S7-200.


Save As

Save in: Projects

File name: GettingStarted

Save as type: Project File (*.mwp)

Figure 2-10 Saving the Example Program

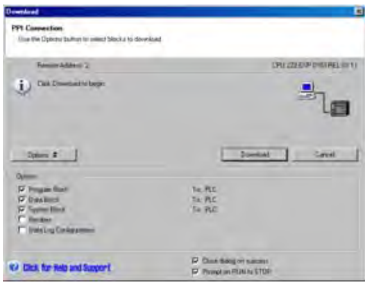
Downloading the Sample Program

Tip

Each STEP 7-Micro/WIN project is associated with a CPU type (CPU 221, CPU 222, CPU 224, CPU 224XP, or CPU 226). If the project type does not match the CPU to which you are connected, STEP 7-Micro/WIN indicates a mismatch and prompts you to take an action. If this occurs, choose “Continue Download” for this example.

1. Click the Download icon on the toolbar or select the **File > Download** menu command to download the program. See Figure 2-11.
2. Click OK to download the elements of the program to the S7-200.

If your S7-200 is in RUN mode, a dialog box prompts you to place the S7-200 in STOP mode. Click Yes to place the S7-200 into STOP mode.



Download

PPI Connection

Use the Options button to select blocks to download

Remote Address: 2

CPU [illegible]

Click Download to begin.

Options

☑ Program Block To: PLC
☑ Data Block To: PLC
☑ System Block To: PLC
☐ Recipes
☐ Data Log Configurations

☑ Close dialog on success
☑ Prompt on RUN to STOP

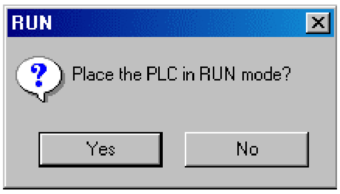
Figure 2-11 Downloading the Program

Placing the S7-200 in RUN Mode

For STEP 7-Micro/WIN to place the S7-200 CPU in RUN mode, the mode switch of the S7-200 must be set to TERM or RUN. When you place the S7-200 in RUN mode, the S7-200 executes the program:

1. Click the RUN icon on the toolbar or select the **PLC > RUN** menu command.
2. Click OK to change the operating mode of the S7-200.

When the S7-200 goes to RUN mode, the output LED for Q0.0 turns on and off as the S7-200 executes the program.



RUN

Place the PLC in RUN mode?

Figure 2-12 Placing the S7-200 in RUN Mode

Congratulations! You have just completed your first S7-200 program.

You can monitor the program by selecting the **Debug > Program Status** menu command. STEP 7-Micro/WIN displays the values for the instructions. To stop the program, place the S7-200 in STOP mode by clicking the STOP icon or by selecting the **PLC > STOP** menu command.

Installing the S7-200

3

The S7-200 equipment is designed to be easy to install. You can use the mounting holes to attach the modules to a panel, or you can use the built-in clips to mount the modules onto a standard (DIN) rail. The small size of the S7-200 allows you to make efficient use of space.

This chapter provides guidelines for installing and wiring your S7-200 system.

In This Chapter

Guidelines for Installing S7-200 Devices

You can install an S7-200 either on a panel or on a standard rail, and you can orient the S7-200 either horizontally or vertically.

Warning

The SIMATIC S7-200 PLCs are Open Type Controllers. It is required that you install the S7-200 in a housing, cabinet, or electric control room. Entry to the housing, cabinet, or electric control room should be limited to authorized personnel.

Failure to follow these installation requirements could result in death or serious injury to personnel, and/or damage to equipment.

Always follow these requirements when installing S7-200 PLCs.

Separate the S7-200 Devices from Heat, High Voltage, and Electrical Noise

As a general rule for laying out the devices of your system, always separate the devices that generate high voltage and high electrical noise from the low-voltage, logic-type devices such as the S7-200.

When configuring the layout of the S7-200 inside your panel, consider the heat-generating devices and locate the electronic-type devices in the cooler areas of your cabinet. Operating any electronic device in a high-temperature environment will reduce the time to failure.

Consider also the routing of the wiring for the devices in the panel. Avoid placing low voltage signal wires and communications cables in the same tray with AC power wiring and high-energy, rapidly-switched DC wiring.

Provide Adequate Clearance for Cooling and Wiring

S7-200 devices are designed for natural convection cooling. For proper cooling, you must provide a clearance of at least 25 mm above and below the devices. Also, allow at least 75 mm of depth.

Caution

For vertical mounting, the maximum allowable ambient temperature is reduced by 10 degrees C. Mount the S7-200 CPU below any expansion modules.

When planning your layout for the S7-200 system, allow enough clearance for the wiring and communications cable connections. For additional flexibility in configuring the layout of the S7-200 system, use the I/O expansion cable.

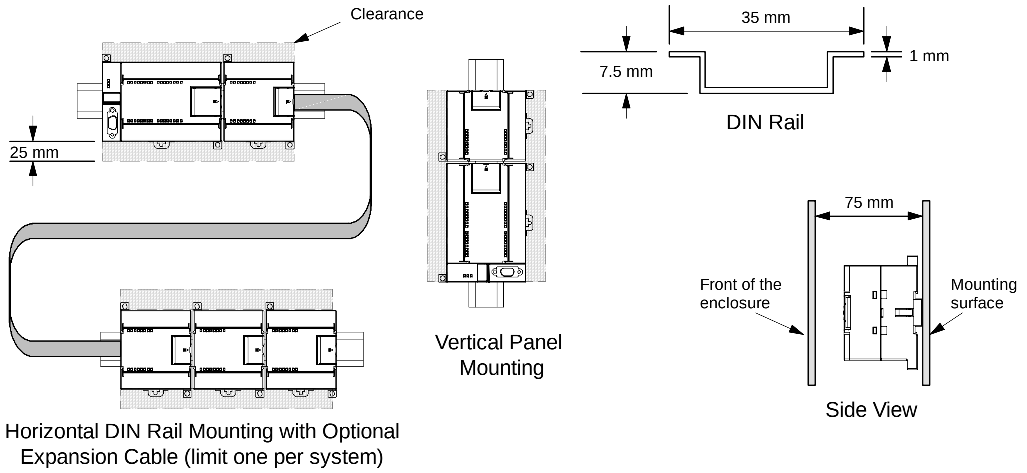


Figure 3-1 Mounting Methods, Orientation, and Clearance

Power Budget

All S7-200 CPUs have an internal power supply that provides power for the CPU, the expansion modules, and other 24 VDC user power requirements.

The S7-200 CPU provides the 5 VDC logic power needed for any expansion in your system. Pay careful attention to your system configuration to ensure that your CPU can supply the 5V power required by your selected expansion modules. If your configuration requires more power than the CPU can supply, you must remove a module or select a CPU with more power capability. Refer to Appendix A for information about the 5 VDC logic budget supplied by your S7-200 CPU and the 5 VDC power requirements of the expansion modules. Use Appendix B as a guide for determining how much power (or current) the CPU can provide for your configuration.

All S7-200 CPUs also provide a 24 VDC sensor supply that can supply 24 VDC for input points, for relay coil power on the expansion modules, or for other requirements. If your power requirements exceed the budget of the sensor supply, then you must add an external 24 VDC power supply to your system. Refer to Appendix A for the 24 VDC sensor supply power budget for your particular S7-200 CPU.

If you require an external 24 VDC power supply, ensure that the power supply is not connected in parallel with the sensor supply of the S7-200 CPU. For improved electrical noise protection, it is recommended that the commons (M) of the different power supplies be connected.

> **Warning**
> Connecting an external 24 VDC power supply in parallel with the S7-200 24 VDC sensor supply can result in a conflict between the two supplies as each seeks to establish its own preferred output voltage level.
>
> The result of this conflict can be shortened lifetime or immediate failure of one or both power supplies, with consequent unpredictable operation of the PLC system. Unpredictable operation could result in death or serious injury to personnel, and/or damage to equipment.
>
> The S7-200 DC sensor supply and any external power supply should provide power to different points.

Installing and Removing the S7-200 Modules

The S7-200 can be easily installed on a standard DIN rail or on a panel.

Prerequisites

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

> **Warning**
> Attempts to install or remove S7-200 or related equipment with the power applied could cause electric shock or faulty operation of equipment.
>
> Failure to disable all power to the S7-200 and related equipment during installation or removal procedures could result in death or serious injury to personnel, and/or damage to equipment.
>
> Always follow appropriate safety precautions and ensure that power to the S7-200 is disabled before attempting to install or remove S7-200 CPUs or related equipment.

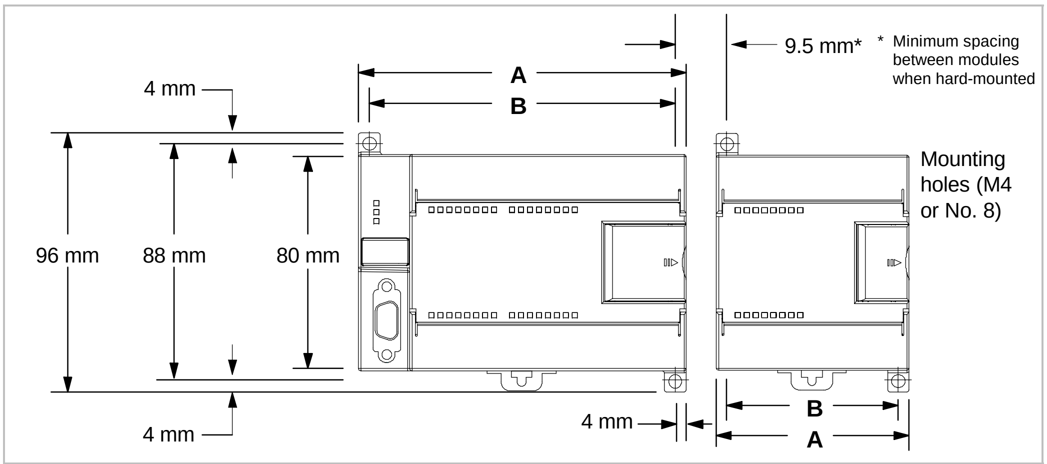
Always ensure that whenever you replace or install an S7-200 device you use the correct module or equivalent device.

> **Warning**
> If you install an incorrect module, the program in the S7-200 could function unpredictably.
>
> Failure to replace an S7-200 device with the same model, orientation, or order could result in death or serious injury to personnel, and/or damage to equipment.
>
> Replace an S7-200 device with the same model, and be sure to orient and position it correctly.

Mounting Dimensions

The S7-200 CPUs and expansion modules include mounting holes to facilitate installation on panels. Refer to Table 3-1 for the mounting dimensions.

Table 3-1 Mounting Dimensions


9.5 mm*
* Minimum spacing between modules when hard-mounted
A
B
4 mm
96 mm
88 mm
80 mm
Mounting holes (M4 or No. 8)
4 mm
4 mm
B
A

S7-200 Module		Width A	Width B
CPU 221 and CPU 222		90 mm	82 mm
CPU 224		120.5 mm	112.5 mm
CPU 224XP, CPU 224XPsi		140 mm	132 mm
CPU 226		196 mm	188 mm
Expansion modules:	4- and 8-point DC and Relay I/O (8I, 4Q, 8Q, 4I/4Q) and Analog Out (2 AQ)	46 mm	38 mm
Expansion modules:	16-point digital I/O (16I, 8I/8Q), Analog I/O (4AI, 8AI, 4AQ, 4AI/1AQ), RTD, Thermocouple, PROFIBUS, Ethernet, Internet, AS-Interface, 8-point AC (8I and 8Q), Position, and Modem	71.2 mm	63.2 mm
Expansion modules:	32-point digital I/O (16I/16Q)	137.3 mm	129.3 mm
Expansion modules:	64-point digital I/O (32I/32Q)	196 mm	188 mm

Installing a CPU or Expansion Module

Installing the S7-200 is easy! Just follow these steps.

Panel Mounting

1. Locate, drill, and tap the mounting holes (M4 or American Standard number 8), using the dimensions in Table 3-1.
2. Secure the module(s) to the panel, using the appropriate screws.
3. If you are using an expansion module, connect the expansion module ribbon cable into the expansion port connector under the access door.

DIN Rail Mounting

1. Secure the rail to the mounting panel every 75 mm.
2. Snap open the DIN clip (located on the bottom of the module) and hook the back of the module onto the DIN rail.
3. If you are using an expansion module, connect the expansion module ribbon cable into the expansion port connector under the access door.
4. Rotate the module down to the DIN rail and snap the clip closed. Carefully check that the clip has fastened the module securely onto the rail. To avoid damage to the module, press on the tab of the mounting hole instead of pressing directly on the front of the module.

Tip

Using DIN rail stops could be helpful if your S7-200 is in an environment with high vibration potential or if the S7-200 has been installed vertically.

If your system is in a high-vibration environment, then panel-mounting the S7-200 will provide a greater level of vibration protection.

Removing a CPU or Expansion Module

To remove an S7-200 CPU or expansion module, follow these steps:

1. Remove power from the S7-200.
2. Disconnect all the wiring and cabling that is attached to the module. Most S7-200 CPU and expansion modules have removable connectors to make this job easier.
3. If you have expansion modules connected to the unit that you are removing, open the access cover door and disconnect the expansion module ribbon cable from the adjacent modules.
4. Unscrew the mounting screws or snap open the DIN clip.
5. Remove the module.

Removing and Reinstalling the Terminal Block Connector

Most S7-200 modules have removable connectors to make installing and replacing the module easy. Refer to Appendix A to determine whether your S7-200 module has removable connectors. You can order an optional fan-out connector for modules that do not have removable connectors. See Appendix E for order numbers.

To Remove the Connector

1. Open the connector door to gain access to the connector.
2. Insert a small screwdriver in the notch in the middle of the connector.
3. Remove the terminal connector by prying the screwdriver away from the S7-200 housing. See Figure 3-2.

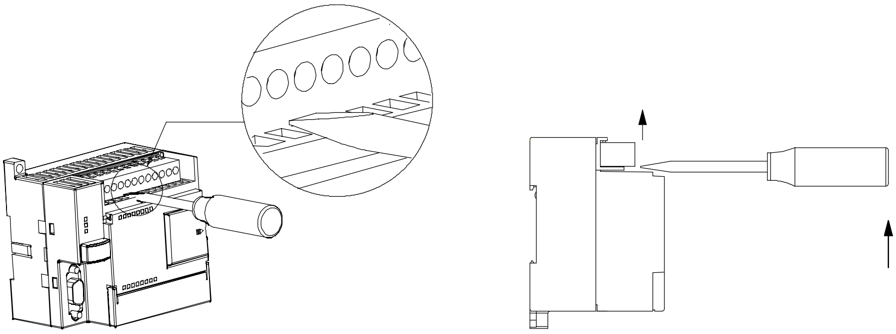


Figure 3-2 Removing the Connector

To Reinstall the Connector

1. Open the connector door.
2. Align the connector with the pins on the unit and align the wiring edge of the connector inside the rim of the connector base.
3. Press down firmly to rotate the connector until it snaps into place. Check carefully to ensure that the connector is properly aligned and fully engaged.

Guidelines for Grounding and Wiring

Proper grounding and wiring of all electrical equipment is important to help ensure the optimum operation of your system and to provide additional electrical noise protection for your application and the S7-200.

Prerequisites

Before you ground or install wiring to any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

Ensure that you follow all applicable electrical codes when wiring the S7-200 and related equipment. Install and operate all equipment according to all applicable national and local standards. Contact your local authorities to determine which codes and standards apply to your specific case.

Warning

Attempts to install or wire the S7-200 or related equipment with power applied could cause electric shock or faulty operation of equipment. Failure to disable all power to the S7-200 and related equipment during installation or removal procedures could result in death or serious injury to personnel, and/or damage to equipment.

Always follow appropriate safety precautions and ensure that power to the S7-200 is disabled before attempting to install or remove the S7-200 or related equipment.

Always take safety into consideration as you design the grounding and wiring of your S7-200 system. Electronic control devices, such as the S7-200, can fail and can cause unexpected operation of the equipment that is being controlled or monitored. For this reason, you should implement safeguards that are independent of the S7-200 to protect against possible personal injury or equipment damage.

Warning

Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment. Such unexpected operations could result in death or serious injury to personnel, and/or damage to equipment.

Use an emergency stop function, electromechanical overrides, or other redundant safeguards that are independent of the S7-200.

Guidelines for Isolation

S7-200 AC power supply boundaries and I/O boundaries to AC circuits have been designed and approved to provide safe separation between AC line voltages and low voltage circuits. These boundaries include double or reinforced insulation, or basic plus supplementary insulation, according to various standards. Components which cross these boundaries such as optical couplers, capacitors, transformers, and relays have been approved as providing safe separation. Isolation boundaries which meet these requirements have been identified in S7-200 product data sheets as having 1500VAC or greater isolation. This designation is based on a routine factory test of (2Ue + 1000VAC) or equivalent according to approved methods. S7-200 safe separation boundaries have been type tested to 4242 VDC.

The sensor supply output, communications circuits, and internal logic circuits of an S7-200 with included AC power supply are sourced as SELV (safety extra-low voltage) according to EN 61131-2. These circuits become PELV (protective extra-low voltage) if the sensor supply M, or any other non-isolated M connection to the S7-200 is connected to ground. Other S7-200 M connections which may ground reference the low voltage are designated as not isolated to logic on specific product data sheets. Examples are RS485 communications port M, analog I/O M, and relay coil power M.

To maintain the SELV / PELV character of the S7-200 low voltage circuits, external connections to communications ports, analog circuits, and all 24V nominal power supply and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards.

Warning

Use of non-isolated or single insulation supplies to supply low voltage circuits from an AC line can result in hazardous voltages appearing on circuits that are expected to be touch safe, such as communications circuits and low voltage sensor wiring.

Such unexpected high voltages could result in death or serious injury to personnel, and/or damage to equipment.

Only use high voltage to low voltage power converters that are approved as sources of touch safe, limited voltage circuits.

Guidelines for Grounding the S7-200

The best way to ground your application is to ensure that all the common and ground connections of your S7-200 and related equipment are grounded to a single point. This single point should be connected directly to the earth ground for your system.

For improved electrical noise protection, it is recommended that all DC common returns be connected to the same single-point earth ground. Connect the 24 VDC sensor supply common (M) to earth ground.

All ground wires should be as short as possible and should use a large wire size, such as 2 mm^2 (14 AWG).

When locating grounds, remember to consider safety grounding requirements and the proper operation of protective interrupting devices.

Guidelines for Wiring the S7-200

When designing the wiring for your S7-200, provide a single disconnect switch that simultaneously removes power from the S7-200 CPU power supply, from all input circuits, and from all output circuits. Provide overcurrent protection, such as a fuse or circuit breaker, to limit fault currents on supply wiring. You might want to provide additional protection by placing a fuse or other current limit in each output circuit.

Install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Avoid placing low-voltage signal wires and communications cables in the same wire tray with AC wires and high-energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

Use the shortest wire possible and ensure that the wire is sized properly to carry the required current. The connector accepts wire sizes from 2 mm^2 to 0.3 mm^2 (14 AWG to 22 AWG). Use shielded wires for optimum protection against electrical noise. Typically, grounding the shield at the S7-200 gives the best results.

When wiring input circuits that are powered by an external power supply, include an overcurrent protection device in that circuit. External protection is not necessary for circuits that are powered by the 24 VDC sensor supply from the S7-200 because the sensor supply is already current-limited.

Most S7-200 modules have removable connectors for user wiring. (Refer to Appendix A to determine if your module has removable connectors.) To prevent loose connections, ensure that the connector is seated securely and that the wire is installed securely into the connector. To avoid damaging the connector, be careful that you do not over-tighten the screws. The maximum torque for the connector screw is 0.56 N-m (5 inch-pounds).

To help prevent unwanted current flows in your installation, the S7-200 provides isolation boundaries at certain points. When you plan the wiring for your system, you should consider these isolation boundaries. Refer to Appendix A for the amount of isolation provided and the location of the isolation boundaries. Isolation boundaries rated less than 1500 VAC must not be depended on as safety boundaries.

Tip

For a communications network, the maximum length of the communications cable is 50 m without using a repeater. The communications port on the S7-200 is non-isolated. Refer to Chapter 7 for more information.

Guidelines for Inductive Loads

You should equip inductive loads with suppression circuits to limit voltage rise when the control output turns off. Suppression circuits protect your outputs from premature failure due to high inductive switching currents. In addition, suppression circuits limit the electrical noise generated when switching inductive loads.

Tip

The effectiveness of a given suppression circuit depends on the application, and you must verify it for your particular use. Always ensure that all components used in your suppression circuit are rated for use in the application.

DC Outputs and Relays That Control DC Loads

The DC outputs have internal protection that is adequate for most applications. Since the relays can be used for either a DC or an AC load, internal protection is not provided.

Figure 3-3 shows a sample suppression circuit for a DC load. In most applications, the addition of a diode (A) across the inductive load is suitable, but if your application requires faster turn-off times, then the addition of a Zener diode (B) is recommended. Be sure to size your Zener diode properly for the amount of current in your output circuit.

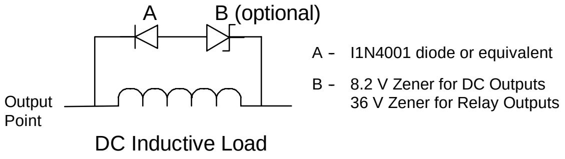

A
B (optional)
A - I1N4001 diode or equivalent
B - 8.2 V Zener for DC Outputs
36 V Zener for Relay Outputs
Output Point
DC Inductive Load

Figure 3-3 Suppression Circuit for a DC Load

AC Outputs and Relays That Control AC Loads

The AC outputs have internal protection that is adequate for most applications. Since the relays can be used for either a DC or an AC load, internal protection is not provided.

Figure 3-4 shows a sample suppression circuit for an AC load. When you use a relay or AC output to switch 115 V/230 VAC loads, place resistor/capacitor networks across the AC load as shown in this figure. You can also use a metal oxide varistor (MOV) to limit peak voltage. Ensure that the working voltage of the MOV is at least 20% greater than the nominal line voltage.

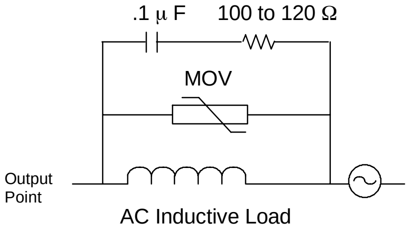


Figure 3-4 Suppression Circuit for an AC Load

Warning

When relay expansion modules are used to switch AC inductive loads, the external resistor/capacitor noise suppression circuit must be placed across the AC load to prevent unexpected machine or process operation. See Figure 3-4.

Guidelines for Lamp Loads

Lamp loads are damaging to relay contacts because of the high turn-on surge current. This surge current will nominally be 10 to 15 times the steady state current for a Tungsten lamp. A replaceable interposing relay or surge limiter is recommended for lamp loads that will be switched a large number of times during the lifetime of the application.

PLC Concepts

4

The basic function of the S7-200 is to monitor field inputs and, based on your control logic, turn on or off field output devices. This chapter explains the concepts used to execute your program, the various types of memory used, and how that memory is retained.

In This Chapter

Understanding How the S7-200 Executes Your Control Logic

The S7-200 continuously cycles through the control logic in your program, reading and writing data.

The S7-200 Relates Your Program to the Physical Inputs and Outputs

The basic operation of the S7-200 is very simple:

❑ The S7-200 reads the status of the inputs.

❑ The program that is stored in the S7-200 uses these inputs to evaluate the control logic. As the program runs, the S7-200 updates the data.

❑ The S7-200 writes the data to the outputs.

Figure 4-1 shows a simple diagram of how an electrical relay diagram relates to the S7-200. In this example, the state of the switch for starting the motor is combined with the states of other inputs. The calculations of these states then determine the state for the output that goes to the actuator which starts the motor.

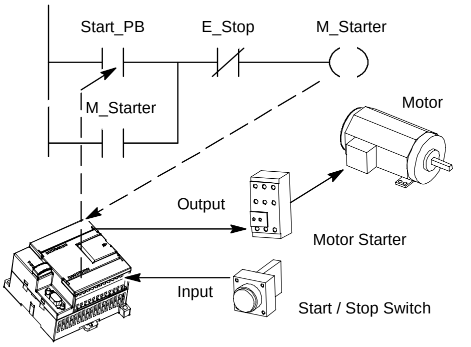


Figure 4-1 Controlling Inputs and Outputs

The S7-200 Executes Its Tasks in a Scan Cycle

The S7-200 executes a series of tasks repetitively. This cyclical execution of tasks is called the scan cycle. As shown in Figure 4-2, the S7-200 performs most or all of the following tasks during a scan cycle:

❑ Reading the inputs: The S7-200 copies the state of the physical inputs to the process-image input register.

❑ Executing the control logic in the program: The S7-200 executes the instructions of the program and stores the values in the various memory areas.

❑ Processing any communications requests: The S7-200 performs any tasks required for communications.

❑ Executing the CPU self-test diagnostics: The S7-200 ensures that the firmware, the program memory, and any expansion modules are working properly.

❑ Writing to the outputs: The values stored in the process-image output register are written to the physical outputs.

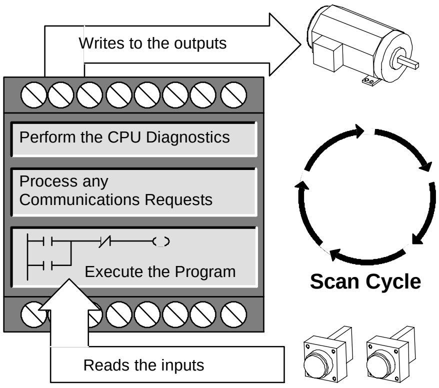


Figure 4-2 S7-200 Scan Cycle

The execution of the user program is dependent upon whether the S7-200 is in STOP mode or in RUN mode. In RUN mode, your program is executed; in STOP mode, your program is not executed.

Reading the Inputs

Digital inputs: Each scan cycle begins by reading the current value of the digital inputs and then writing these values to the process-image input register.

Analog inputs: The S7-200 does not update analog inputs from expansion modules as part of the normal scan cycle unless filtering of analog inputs is enabled. An analog filter is provided to allow you to have a more stable signal. You can enable the analog filter for each analog input point.

When analog input filtering is enabled for an analog input, the S7-200 updates that analog input once per scan cycle, performs the filtering function, and stores the filtered value internally. The filtered value is then supplied each time your program accesses the analog input.

When analog filtering is not enabled, the S7-200 reads the value of the analog input from expansion modules each time your program accesses the analog input.

Analog inputs AIW0 and AIW2 included on the CPU 224XP are updated every scan with the most recent result from the analog-to-digital converter. This converter is an averaging type (sigma-delta) and those values will usually not need software filtering.

Tip

Analog input filtering is provided to allow you to have a more stable analog value. Use the analog input filter for applications where the input signal varies slowly with time. If the signal is a high-speed signal, then you should not enable the analog filter.

Do not use the analog filter with modules that pass digital information or alarm indications in the analog words. Always disable analog filtering for RTD, Thermocouple, and AS-Interface Master modules.

Executing the Program

During the execution phase of the scan cycle, the S7-200 executes your program, starting with the first instruction and proceeding to the end instruction. The immediate I/O instructions give you immediate access to inputs and outputs during the execution of either the program or an interrupt routine.

If you use subroutines in your program, the subroutines are stored as part of the program. The subroutines are executed when they are called by the main program, by another subroutine, or by an interrupt routine. Subroutine nesting depth is 8 from the main and 1 from an interrupt routine.

If you use interrupts in your program, the interrupt routines that are associated with the interrupt events are stored as part of the program. The interrupt routines are not executed as part of the normal scan cycle, but are executed when the interrupt event occurs (which could be at any point in the scan cycle).

Local memory is reserved for each of eleven entities: one main, eight subroutine nesting levels when initiated from the main, one interrupt, and one subroutine nesting level when initiated from an interrupt routine. Local memory has a local scope in that it is available only within its associated program entity, and cannot be accessed by the other program entities. For more information about Local memory, refer to Local Memory Area: L in this chapter.

Figure 4-3 depicts the flow of a typical scan including the Local memory usage and two interrupt events, one during the program–execution phase and another during the communications phase of the scan cycle. Subroutines are called by the next higher level, and are executed when called. Interrupt routines are not called; they are a result of an occurrence of the associated interrupt event.

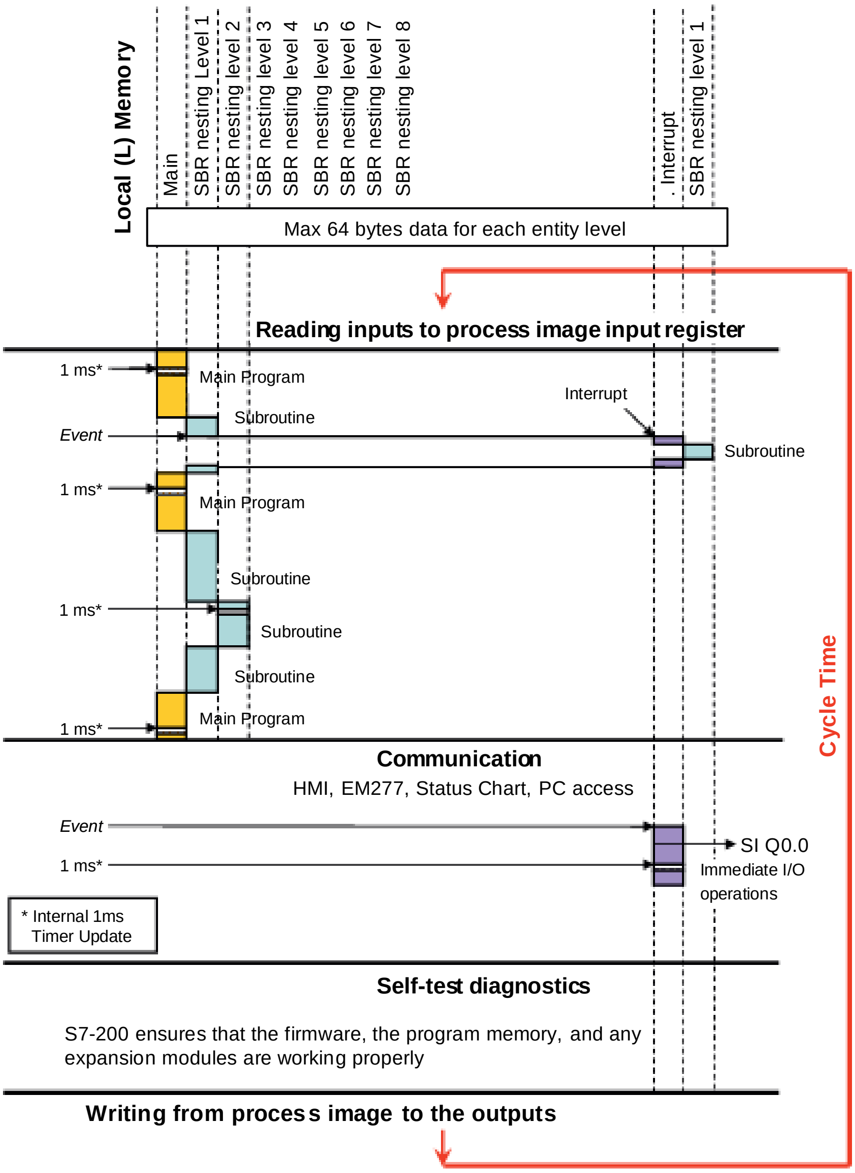


Figure 4-3 Typical Scan Flow

Processing Any Communications Requests

During the message-processing phase of the scan cycle, the S7-200 processes any messages that were received from the communications port or intelligent I/O modules.

Executing the CPU Self-test Diagnostics

During this phase of the scan cycle, the S7-200 checks for proper operation of the CPU and for the status of any expansion modules.

Writing to the Digital Outputs

At the end of every scan cycle, the S7-200 writes the values stored in the process-image output register to the digital outputs. (Analog outputs are updated immediately, independently from the scan cycle.)

Accessing the Data of the S7-200

The S7-200 stores information in different memory locations that have unique addresses. You can explicitly identify the memory address that you want to access. This allows your program to have direct access to the information. Table 4-1 shows the range of integer values that can be represented by the different sizes of data.

Table 4-1 Decimal and Hexadecimal Ranges for the Different Sizes of Data

Representation	Byte (B)	Word (W)	Double Word (D)
Unsigned Integer	0 to 255 0 to FF	0 to 65,535 0 to FFFF	0 to 4,294,967,295 0 to FFFF FFFF
Signed Integer	–128 to +127 80 to 7F	–32,768 to +32,767 8000 to 7FFF	–2,147,483,648 to +2,147,483,647 8000 0000 to 7FFF FFFF
Real IEEE 32-bit Floating Point	*Not applicable*	*Not applicable*	+1.175495E–38 to +3.402823E+38 (positive) –1.175495E–38 to –3.402823E+38 (negative)

To access a bit in a memory area, you specify the address, which includes the memory area identifier, the byte address, and the bit number. Figure 4-4 shows an example of accessing a bit (which is also called “byte.bit” addressing). In this example, the memory area and byte address (I = input, and 3 = byte 3) are followed by a period (“.”) to separate the bit address (bit 4).

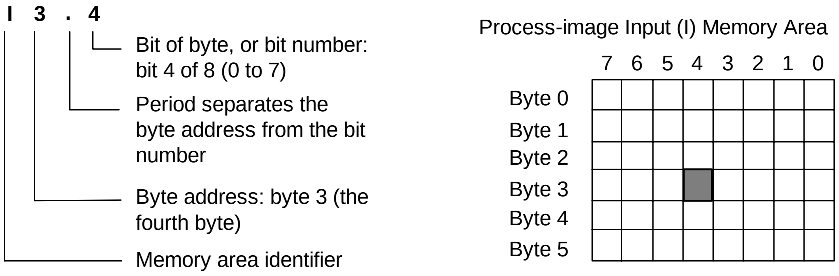

I 3 . 4
Bit of byte, or bit number: bit 4 of 8 (0 to 7)
Period separates the byte address from the bit number
Byte address: byte 3 (the fourth byte)
Memory area identifier
Process-image Input (I) Memory Area
7 6 5 4 3 2 1 0
Byte 0
Byte 1
Byte 2
Byte 3
Byte 4
Byte 5

Figure 4-4 Byte.Bit Addressing

You can access data in most memory areas (V, I, Q, M, S, L, and SM) as bytes, words, or double words by using the byte-address format. To access a byte, word, or double word of data in the memory, you must specify the address in a way similar to specifying the address for a bit. This includes an area identifier, data size designation, and the starting byte address of the byte, word, or double-word value, as shown in Figure 4-5.

Data in other memory areas (such as T, C, HC, and the accumulators) are accessed by using an address format that includes an area identifier and a device number.

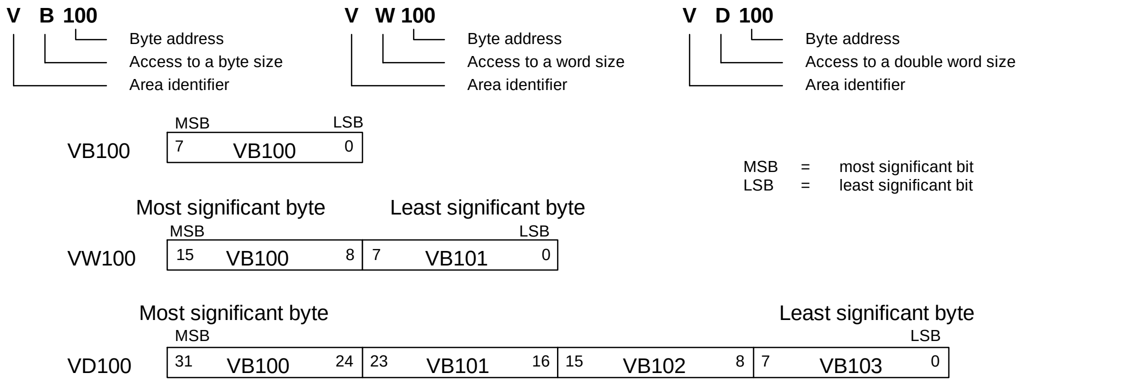


Figure 4-5 Comparing Byte, Word, and Double-Word Access to the Same Address

Accessing Data in the Memory Areas

Process-Image Input Register: I

The S7-200 samples the physical input points at the beginning of each scan cycle and writes these values to the process-image input register. You can access the process-image input register in bits, bytes, words, or double words:

Bit:	I*[byte address].[bit address]*	I0.1
Byte, Word, or Double Word:	I*[size][starting byte address]*	IB4

Process-Image Output Register: Q

At the end of the scan cycle, the S7-200 copies the values stored in the process-image output register to the physical output points. You can access the process-image output register in bits, bytes, words, or double words:

Bit:	Q*[byte address].[bit address]*	Q1.1
Byte, Word, or Double Word:	Q*[size][starting byte address]*	QB5

Variable Memory Area: V

You can use V memory to store intermediate results of operations being performed by the control logic in your program. You can also use V memory to store other data pertaining to your process or task. You can access the V memory area in bits, bytes, words, or double words:

Bit:	V*[byte address].[bit address]*	V10.2
Byte, Word, or Double Word:	V*[size][starting byte address]*	VW100

Bit Memory Area: M

You can use the bit memory area (M memory) as control relays to store the intermediate status of an operation or other control information. You can access the bit memory area in bits, bytes, words, or double words:

Bit:	M*[byte address].[bit address]*	M26.7
Byte, Word, or Double Word:	M*[size][starting byte address]*	MD20

Timer Memory Area: T

The S7-200 provides timers that count increments of time in resolutions (time-base increments) of 1 ms, 10 ms, or 100 ms. Two variables are associated with a timer:

- ❑ Current value: this 16-bit signed integer stores the amount of time counted by the timer.
- ❑ Timer bit: this bit is set or cleared as a result of comparing the current and the preset value. The preset value is entered as part of the timer instruction.

You access both of these variables by using the timer address (T + timer number). Access to either the timer bit or the current value is dependent on the instruction used: instructions with bit operands access the timer bit, while instructions with word operands access the current value. As shown in Figure 4-6, the Normally Open Contact instruction accesses the timer bit, while the Move Word instruction accesses the current value of the timer.

Format: T*[timer number]* T24

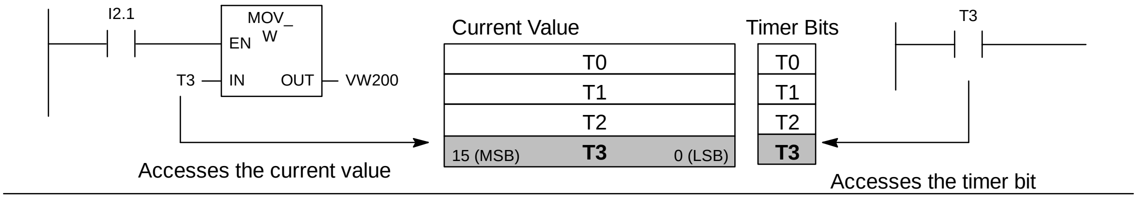


Figure 4-6 Accessing the Timer Bit or the Current Value of a Timer

Counter Memory Area: C

The S7-200 provides three types of counters that count each low-to-high transition event on the counter input(s): one type counts up only, one type counts down only, and one type counts both up and down. Two variables are associated with a counter:

- ❑ Current value: this 16-bit signed integer stores the accumulated count.
- ❑ Counter bit: this bit is set or cleared as a result of comparing the current and the preset value. The preset value is entered as part of the counter instruction.

You access both of these variables by using the counter address (C + counter number). Access to either the counter bit or the current value is dependent on the instruction used: instructions with bit operands access the counter bit, while instructions with word operands access the current value. As shown in Figure 4-7, the Normally Open Contact instruction accesses the counter bit, while the Move Word instruction accesses the current value of the counter.

Format: C*[counter number]* C24

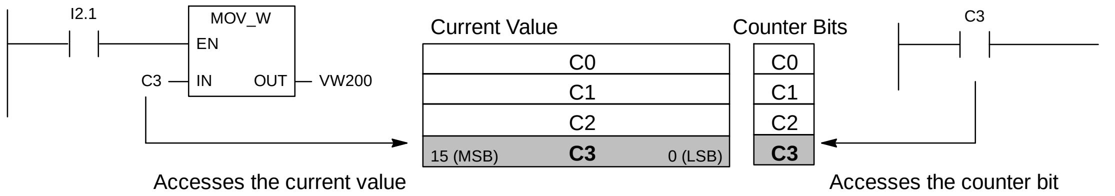


Figure 4-7 Accessing the Counter Bit or the Current Value of a Counter

High-Speed Counters: HC

The high-speed counters count high-speed events independent of the CPU scan. High-speed counters have a signed, 32-bit integer counting value (or current value). To access the count value for the high-speed counter, you specify the address of the high-speed counter, using the memory type (HC) and the counter number (such as HC0). The current value of the high-speed counter is a read-only value and can be addressed only as a double word (32 bits).

Format: HC*[high-speed counter number]* HC1

Accumulators: AC

The accumulators are read/write devices that can be used like memory. For example, you can use accumulators to pass parameters to and from subroutines and to store intermediate values used in a calculation. The S7-200 provides four 32-bit accumulators (AC0, AC1, AC2, and AC3). You can access the data in the accumulators as bytes, words, or double words.

The size of the data being accessed is determined by the instruction that is used to access the accumulator. As shown in Figure 4-8, you use the least significant 8 or 16 bits of the value that is stored in the accumulator to access the accumulator as bytes or words. To access the accumulator as a double word, you use all 32 bits.

For information about how to use the accumulators within interrupt subroutines, refer to the Interrupt Instructions in Chapter 6.

Format: AC*[accumulator number]* AC0

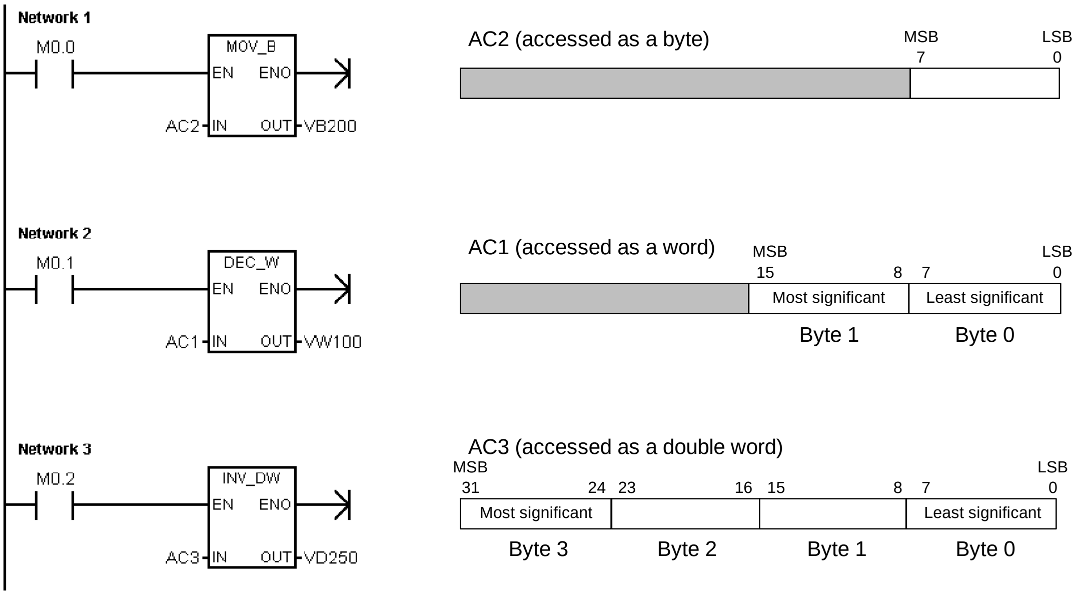


Figure 4-8 Accessing the Accumulators

Special Memory: SM

The SM bits provide a means for communicating information between the CPU and your program. You can use these bits to select and control some of the special functions of the S7-200 CPU, such as: a bit that turns on for the first scan cycle, a bit that toggles at a fixed rate, or a bit that shows the status of math or operational instructions. (For more information about the SM bits, see Appendix D.) You can access the SM bits as bits, bytes, words, or double words:

Bit:	SM*[byte address].[bit address]*	SM0.1
Byte, Word, or Double Word:	SM*[size][starting byte address]*	SMB86

Local Memory Area: L

The S7-200 provides 64 bytes of local memory of which 60 can be used as scratchpad memory or for passing formal parameters to subroutines.

Tip

If you are programming in either LAD or FBD, STEP 7‑Micro/WIN reserves the last four bytes of local memory for its own use.

Local memory is similar to V memory with one major exception. V memory has a global scope while L memory has a local scope. The term global scope means that the same memory location can be accessed from any program entity (main program, subroutines, or interrupt routines). The term local scope means that the memory allocation is associated with a particular program entity. The S7-200 allocates 64 bytes of L memory for the main program, 64 bytes for each subroutine nesting level, and 64 bytes for interrupt routines.

The allocation of L memory for the main program cannot be accessed from subroutines or from interrupt routines. A subroutine cannot access the L memory allocation of the main program, an interrupt routine, or another subroutine. Likewise, an interrupt routine cannot access the L memory allocation of the main program or of a subroutine.

The allocation of L memory is made by the S7-200 on an as-needed basis. This means that while the main portion of the program is being executed, the L memory allocations for subroutines and interrupt routines do not exist. At the time that an interrupt occurs or a subroutine is called, local memory is allocated as required. The new allocation of L memory might reuse the same L memory locations of a different subroutine or interrupt routine.

The L memory is not initialized by the S7-200 at the time of allocation and might contain any value. When you pass formal parameters in a subroutine call, the values of the parameters being passed are placed by the S7-200 in the appropriate L memory locations of the called subroutine. L memory locations, which do not receive a value as a result of the formal parameter passing step, will not be initialized and might contain any value at the time of allocation.

Bit:	L*[byte address].[bit address]*	L0.0
Byte, Word, or Double Word:	L*[size] [starting byte address]*	LB33

Analog Inputs: AI

The S7-200 converts an analog value (such as temperature or voltage) into a word-length (16-bit) digital value. You access these values by the area identifier (AI), size of the data (W), and the starting byte address. Since analog inputs are words and always start on even-number bytes (such as 0, 2, or 4), you access them with even-number byte addresses (such as AIW0, AIW2, or AIW4). Analog input values are read-only values.

Format:	AIW*[starting byte address]*	AIW4

Analog Outputs: AQ

The S7-200 converts a word-length (16-bit) digital value into a current or voltage, proportional to the digital value (such as for a current or voltage). You write these values by the area identifier (AQ), size of the data (W), and the starting byte address. Since analog outputs are words and always start on even-number bytes (such as 0, 2, or 4), you write them with even-number byte addresses (such as AQW0, AQW2, or AQW4). Analog output values are write-only values.

Format:	AQW*[starting byte address]*	AQW4

Sequence Control Relay (SCR) Memory Area: S

SCRs or S bits are used to organize machine operations or steps into equivalent program segments. SCRs allow logical segmentation of the control program. You can access the S bits as bits, bytes, words, or double words.

Bit:	S*[byte address].[bit address]*	S3.1
Byte, Word, or Double Word:	S*[size][starting byte address]*	SB4

Format for Real Numbers

Real (or floating-point) numbers are represented as 32-bit, single-precision numbers, whose format is described in the ANSI/IEEE 754–1985 standard. See Figure 4-9. Real numbers are accessed in double-word lengths.

For the S7-200, floating point numbers are accurate up to 6 decimal places. Therefore, you can specify a maximum of 6 decimal places when entering a floating-point constant.

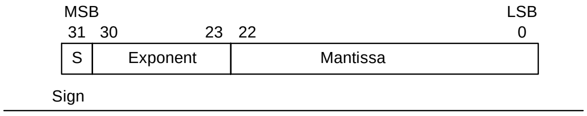


Figure 4-9 Format of a Real Number

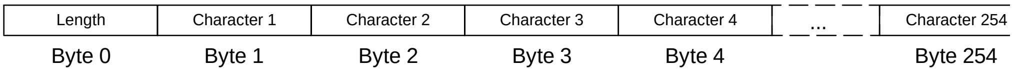
Accuracy when Calculating Real Numbers

Calculations that involve a long series of values including very large and very small numbers can produce inaccurate results. This can occur if the numbers differ by 10 to the power of *x*, where *x* > 6.

For example: 100 000 000 + 1 = 100 000 000

Format for Strings

A string is a sequence of characters, with each character being stored as a byte. The first byte of the string defines the length of the string, which is the number of characters. Figure 4-10 shows the format for a string. A string can have a length of 0 to 254 characters, plus the length byte, so the maximum length for a string is 255 bytes. A string constant is limited to 126 bytes.



Length	Character 1	Character 2	Character 3	Character 4	...	Character 254
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4		Byte 254

Figure 4-10 Format for Strings

Specifying a Constant Value for S7-200 Instructions

You can use a constant value in many of the S7-200 instructions. Constants can be bytes, words, or double words. The S7-200 stores all constants as binary numbers, which can then be represented in decimal, hexadecimal, ASCII, or real number (floating point) formats. See Table 4-2.

Table 4-2 Representation of Constant Values

Representation	Format	Sample
Decimal	[decimal value]	20047
Hexadecimal	16#[hexadecimal value]	16#4E4F
Binary	2#[binary number]	2#1010_0101_1010_0101
ASCII	’[ASCII text]’	’ABCD’
Real	ANSI/IEEE 754–1985	+1.175495E–38 (positive) –1.175495E–38 (negative)
String	“[stringtext]”	“ABCDE”

Tip

The S7-200 CPU does not support “data typing” or data checking (such as specifying that the constant is stored as an integer, a signed integer, or a double integer). For example, an Add instruction can use the value in VW100 as a signed integer value, while an Exclusive Or instruction can use the same value in VW100 as an unsigned binary value.

Addressing the Local and Expansion I/O

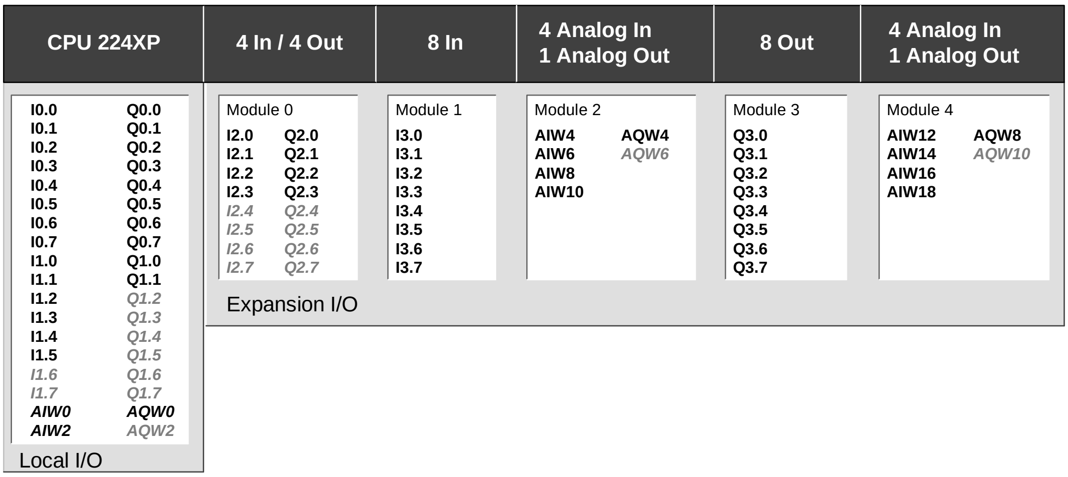
The local I/O provided by the CPU provides a fixed set of I/O addresses. You can add I/O points to the S7-200 CPU by connecting expansion I/O modules to the right side of the CPU, forming an I/O chain. The addresses of the points of the module are determined by the type of I/O and the position of the module in the chain, with respect to the preceding input or output module of the same type. For example, an output module does not affect the addresses of the points on an input module, and vice versa. Likewise, analog modules do not affect the addressing of digital modules, and vice versa.

Tip

Process-image register space for digital I/O is always reserved in increments of eight bits (one byte). If a module does not provide a physical point for each bit of each reserved byte, these unused bits cannot be assigned to subsequent modules in the I/O chain. For input modules, the unused bits are set to zero with each input update cycle.

Analog I/O points are always allocated in increments of two points. If a module does not provide physical I/O for each of these points, these I/O points are lost and are not available for assignment to subsequent modules in the I/O chain.

Figure 4-11 provides an example of the I/O numbering for a particular hardware configuration. The gaps in the addressing (shown as gray italic text) cannot be used by your program.



CPU 224XP	4 In / 4 Out	8 In	4 Analog In 1 Analog Out	8 Out	4 Analog In 1 Analog Out
Local I/O	Module 0	Module 1	Module 2	Module 3	Module 4
I0.0 Q0.0 I0.1 Q0.1 I0.2 Q0.2 I0.3 Q0.3 I0.4 Q0.4 I0.5 Q0.5 I0.6 Q0.6 I0.7 Q0.7 I1.0 Q1.0 I1.1 Q1.1 I1.2 *Q1.2* I1.3 *Q1.3* I1.4 *Q1.4* I1.5 *Q1.5* *I1.6* *Q1.6* *I1.7* *Q1.7* *AIW0* *AQW0* *AIW2* *AQW2*	I2.0 Q2.0 I2.1 Q2.1 I2.2 Q2.2 I2.3 Q2.3 *I2.4* *Q2.4* *I2.5* *Q2.5* *I2.6* *Q2.6* *I2.7* *Q2.7*	I3.0 I3.1 I3.2 I3.3 I3.4 I3.5 I3.6 I3.7	AIW4 AQW4 AIW6 *AQW6* AIW8 AIW10	Q3.0 Q3.1 Q3.2 Q3.3 Q3.4 Q3.5 Q3.6 Q3.7	AIW12 AQW8 AIW14 *AQW10* AIW16 AIW18

Figure 4-11 Sample I/O Addresses for Local and Expansion I/O (CPU 224XP)

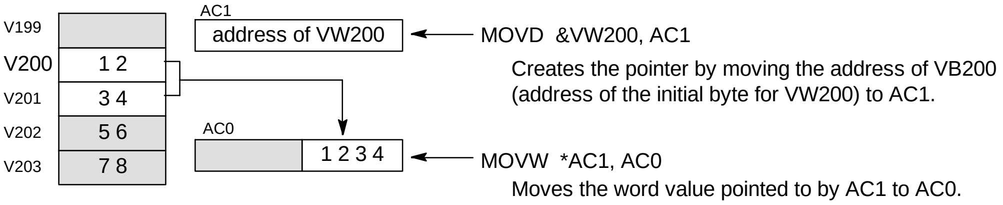
Using Pointers for Indirect Addressing of the S7-200 Memory Areas

Indirect addressing uses a pointer to access the data in memory. Pointers are double word memory locations that contain the address of another memory location. You can only use V memory locations, L memory locations, or accumulator registers (AC1, AC2, AC3) as pointers. To create a pointer, you must use the Move Double Word instruction to move the address of the indirectly addressed memory location to the pointer location. Pointers can also be passed to a subroutine as a parameter.

The S7-200 allows pointers to access the following memory areas: I, Q, V, M, S, AI, AQ, SM, T (current value only), and C (current value only). You cannot use indirect addressing to access an individual bit or to access HC or L memory areas.

To indirectly access the data in a memory address, you create a pointer to that location by entering an ampersand (&) and the memory location to be addressed. The input operand of the instruction must be preceded with an ampersand (&) to signify that the address of a memory location, instead of its contents, is to be moved into the location identified in the output operand of the instruction (the pointer).

Entering an asterisk (*) in front of an operand for an instruction specifies that the operand is a pointer. As shown in Figure 4-12, entering *AC1 specifies that AC1 is a pointer to the word-length value being referenced by the Move Word (MOVW) instruction. In this example, the values stored in both VB200 and VB201 are moved to accumulator AC0.

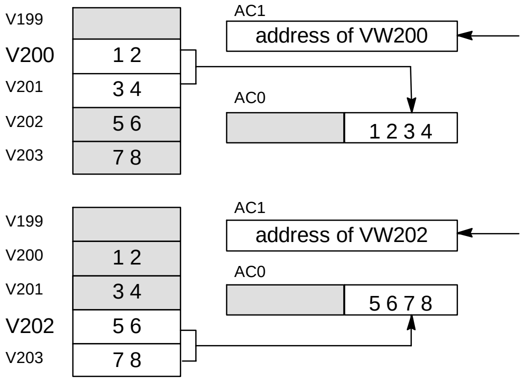


Creates the pointer by moving the address of VB200 (address of the initial byte for VW200) to AC1.

Moves the word value pointed to by AC1 to AC0.

Figure 4-12 Creating and Using a Pointer

As shown in Figure 4-13, you can change the value of a pointer. Since pointers are 32-bit values, use double-word instructions to modify pointer values. Simple mathematical operations, such as adding or incrementing, can be used to modify pointer values.



MOVD &VW200, AC1
Creates the pointer by moving the address of VB200 (address of VW200's initial byte) to AC1.

MOVW *AC1, AC0
Moves the word value pointed to by AC1 (VW200) to AC0.

+D +2, AC1
Adds 2 to the accumulator to point to the next word location.

MOVW *AC1, AC0
Moves the word value pointed to by AC1 (VW202) to AC0.

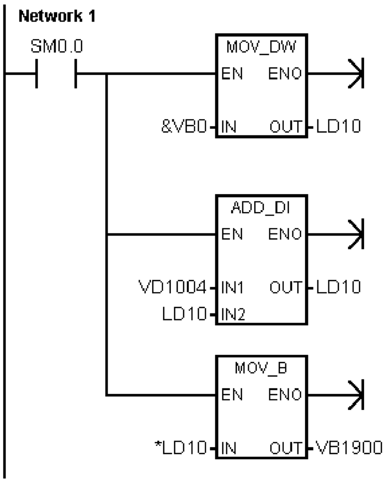
Figure 4-13 Modifying a Pointer

Tip

Remember to adjust for the size of the data that you are accessing: to access a byte, increment the pointer value by 1; to access a word or a current value for a timer or counter, add or increment the pointer value by 2; and to access a double word, add or increment the pointer value by 4.

Sample Program for Using an Offset to Access Data in V Memory

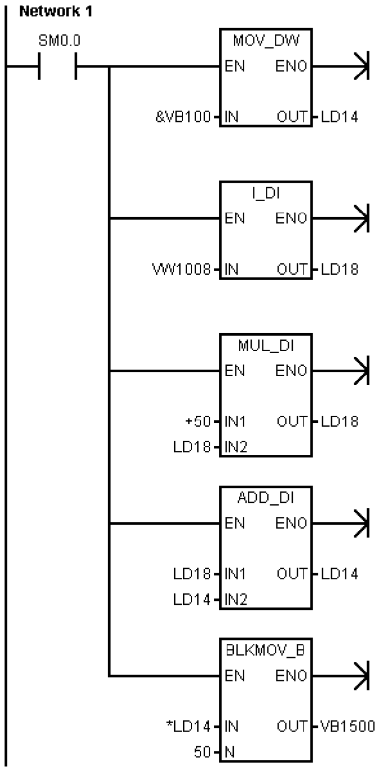
This example uses LD10 as a pointer to the address VB0. You then increment the pointer by an offset stored in VD1004. LD10 then points to another address in V memory (VB0 + offset). The value stored in the V memory address pointed to by LD10 is then copied to VB1900. By changing the value in VD1004, you can access any V memory location.



```
Network 1   //How to use an offset to read the value
            //of any VB location:
            //
            //1.  Load the starting address of the
            //V memory to a pointer.
            //2.  Add the offset value to the pointer.
            //3.  Copy the value from the V memory
            //location (offset) to VB1900.
            //
LD      SM0.0
MOVD    &VB0, LD10
+D      VD1004, LD10
MOVB    *LD10, VB1900
```

Sample Program for Using a Pointer to Access Data in a Table

This example uses LD14 as a pointer to a recipe stored in a table of recipes that begins at VB100. In this example, VW1008 stores the index to a specific recipe in the table. If each recipe in the table is 50 bytes long, you multiply the index by 50 to obtain the offset for the starting address of a specific recipe. By adding the offset to the pointer, you can access the individual recipe from the table. In this example, the recipe is copied to the 50 bytes that start at VB1500.



```
Network 1   //How to transfer a recipe from a table of recipes:
            // –  Each recipe is 50 bytes long.
            // –  The index parameter (VW1008) identifies
            //    the recipe to be loaded.
            //
            //1.  Create a pointer to the starting address
            //     of the recipe table.
            //2.  Convert the index of the recipe to a
            //    double-word value.
            //3.  Multiply the offset to accommodate
            //    the size of each recipe.
            //4.  Add the adjusted offset to the pointer.
            //5.  Transfer the selected recipe to
            //    VB1500 through VB1549.

LD      SM0.0
MOVD    &VB100, LD14
ITD     VW1008, LD18
*D      +50, LD18
+D      LD18, LD14
BMB     *LD14, VB1500, 50
```

Understanding How the S7-200 Saves and Restores Data

The S7-200 provides a variety of features to ensure that your user program and data are properly retained in the S7-200.

❑ Retentive Data Memory – Areas of data memory the user selects to remain unchanged over a power cycle, as long as the super capacitor and the optional battery cartridge have not been discharged. V, M, Timer Currents, and Counter Currents are the only data memory areas that are configurable to be retentive.

❑ Permanent Memory – Non-volatile memory used to store the program block, data block, system block, forced values, M memory configured to be saved on loss of power, and selected values written under user program control

❑ Memory Cartridge – Removable non-volatile memory used to store the program block, data block, system block, recipes, data logs, and forced values

You can use the S7-200 Explorer to store documentation files (doc, text, pdf, etc.) into the cartridge. You can also use the S7-200 Explorer to perform general file maintenance on the memory cartridge (copy, delete, directory and launch).

To install a memory cartridge, remove the plastic slot cover from the S7-200 CPU and insert the memory cartridge in the slot. The memory cartridge is keyed for proper installation.

Caution

Electrostatic discharge can damage the memory cartridge or the receptacle on the S7-200 CPU.

Make contact with a grounded conductive pad and/or wear a grounded wrist strap when you handle the cartridge. Store the cartridge in a conductive container.

Downloading and Uploading the Elements of Your Project

Your project consists of different elements:

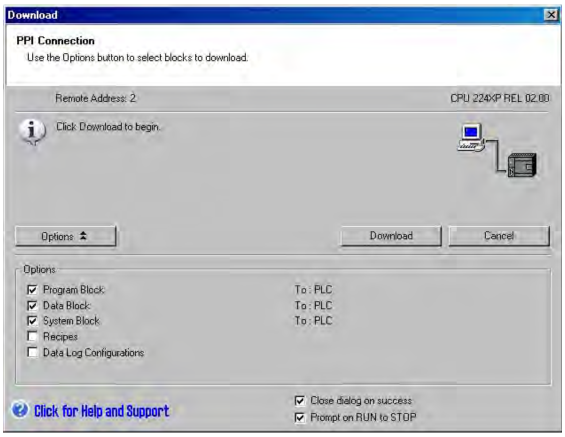
- ❑ Program block
- ❑ Data block (optional)
- ❑ System block (optional)
- ❑ Recipes (optional)
- ❑ Data log configurations (optional)

When you download a project, the program block, data block and system block are stored in permanent memory for safekeeping. Recipes and data log configurations are stored in the memory cartridge, and replace any existing recipes and data logs. Any program elements not included in the download operation are left unchanged in permanent memory and the memory cartridge.

If a project download includes recipes or data log configurations, the memory cartridge must remain installed for proper program operation.

To download your project to an S7-200 CPU:

1. Select the **File > Download** menu command.
2. Click each project element you wish to download.
3. Click the Download Button.



Use the Options button to select blocks to download.

Remote Address: 2

CPU 224XP REL 02.00

Click Download to begin.

Options

☑ Program Block To : PLC
☑ Data Block To : PLC
☑ System Block To : PLC
☐ Recipes
☐ Data Log Configurations

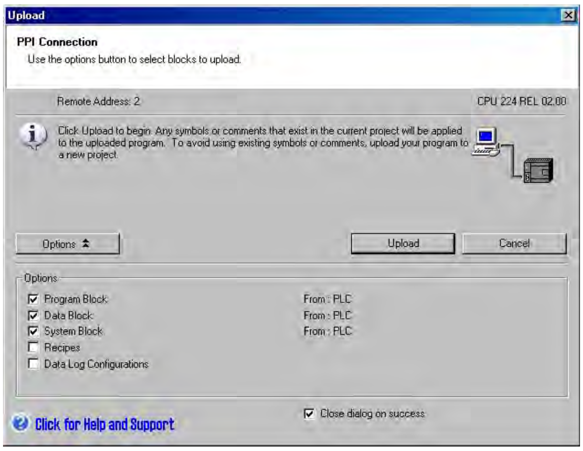
☑ Close dialog on success
☑ Prompt on RUN to STOP

Figure 4-14 Download a Project to S7-200 CPU

When you upload a project to your computer using STEP 7–Micro/WIN, the S7-200 uploads the program block, data block and system block from permanent memory. The recipes and data log configurations are uploaded from the memory cartridge. The data from the data logs is not uploaded to your computer using STEP7–Micro/WIN. The S7-200 Explorer is used to upload the data from the data logs (see Chapter 14).

To upload your project from an S7-200 CPU:

1. Select the **File > Upload** menu command.
2. Click each project element that you wish to upload.
3. Click the Upload Button.



Use the options button to select blocks to upload.

Remote Address: 2

CPU 224 REL 02.00

Click Upload to begin. Any symbols or comments that exist in the current project will be applied to the uploaded program. To avoid using existing symbols or comments, upload your program to a new project.

Options

☑ Program Block From : PLC
☑ Data Block From : PLC
☑ System Block From : PLC
☐ Recipes
☐ Data Log Configurations

☑ Close dialog on success

Figure 4-15 Upload a Project to the S7-200

Storing your Program on a Memory Cartridge

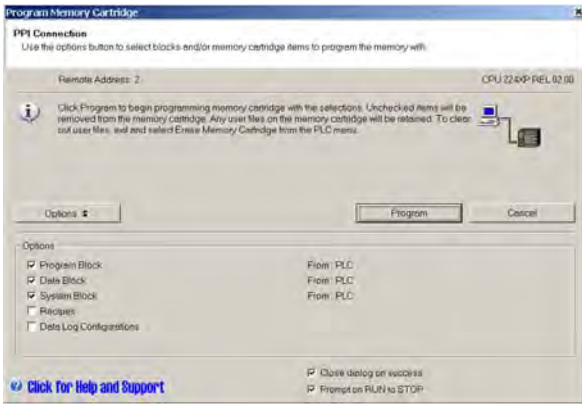
The S7-200 allows you to copy your user program from one CPU to another using a memory cartridge. You can also distribute updates for any of the following blocks in your S7-200: the program block, system block or data block.

Before copying any program elements to the memory cartridge, STEP 7–Micro/WIN deletes all program elements (including recipes and data logs) except for user files on the memory cartridge. If your program will not fit because of the size of your files, you can do one of two things to create enough storage space for your program. You can either erase the memory cartridge using the **PLC > Erase Memory Cartridge** menu command. Or, you can open the S7-200 Explorer and remove user files that are no longer needed.

The PLC must be in STOP mode to program the memory cartridge.

To store your program in the memory cartridge:

1. Select the **PLC > Program Memory Cartridge** menu command.
2. Click each project element you wish to copy to the memory cartridge (all program elements that exist in your project are selected by default). If the system block is selected the force values will be copied as well.
3. Click the Program Button



Program Memory Cartridge

PPI Connection

Use the options button to select blocks and/or memory cartridge items to program the memory with

Remote Address: 2

CPU 224XP REL 02.00

Click Program to begin programming memory cartridge with the selections. Unchecked items will be removed from the memory cartridge. Any user files on the memory cartridge will be retained. To clear out user files, exit and select Erase Memory Cartridge from the PLC menu.

Options

☑ Program Block From: PLC

☑ Data Block From: PLC

☑ System Block From: PLC

☐ Recipes

☐ Data Log Configurations

☑ Close dialog on success

☑ Prompt on RUN to STOP

Figure 4-16 Store a Program on a Memory Cartridge

The program block, system block, data block, and any forced values are copied from permanent memory in the S7-200 to the memory cartridge. The recipes and data log configurations are copied from STEP 7–Micro/WIN to the memory cartridge.

Restoring a Program from a Memory Cartridge

To transfer the program from a memory cartridge to the S7-200, you must apply power to the S7-200 with the memory cartridge installed. If any of the blocks or force values present in the memory cartridge are different from the blocks or force values in the S7-200, then all blocks present in the memory cartridge are copied to the S7-200.

- If a program block was transferred from the memory cartridge, the program block in permanent memory is replaced.
- If a data block was transferred from the memory cartridge, the data block in permanent memory is replaced, all of V memory is cleared, and V memory is initialized with the contents of the data block.
- If a system block was transferred from the memory cartridge, the system block and force values in the permanent memory are replaced and all retentive memory is cleared.

Once the transferred program has been stored to permanent memory you can remove the memory cartridge. However, if recipes or data logs are present in the cartridge, you must leave the memory cartridge installed. Leaving the memory cartridge installed will delay entry to RUN mode on subsequent power cycles.

Notice

Powering on an S7-200 CPU with an installed memory cartridge that was programmed by a different model of S7-200 CPU can cause an error. Memory cartridges that are programmed by a lower model number CPU can be read by a higher model number CPU. However, the opposite is not true. For example, memory cartridges that are programmed by a CPU 221 or CPU 222 can be read by a CPU 224, but memory cartridges that are programmed by a CPU 224 are rejected by a CPU 221 or CPU 222.

For a complete list of memory cartridge usage restrictions, see Optional Cartridges (Memory Cartridge) in Appendix A.

Saving the Retentive M Memory Area on Power Loss

If you configured any of the first 14 bytes of bit memory (MB0 to MB13) to be retentive, these bytes are saved to permanent memory when the S7-200 loses power. By default, the first 14 bytes of M memory are selected to be non-retentive.

Restoring Data after Power On

When power is applied, the S7-200 restores the program block and the system block from permanent memory. The S7-200 then verifies that the super capacitor and optional battery cartridge, if installed, has successfully maintained the data stored in RAM memory. If the data was successfully maintained, the retentive areas of user data memory are left unchanged. The non-retentive portions of V memory are restored from the contents of the data block in permanent memory. The non-retentive portions of other memory areas are cleared.

If the contents of RAM were not maintained (such as after an extended power failure), the S7-200 clears all user data areas, sets the Retentive Data Lost memory bit (SM0.2), restores V memory from the contents of the data block in permanent memory, and restores the first 14 bytes of M memory from permanent memory if these bytes were previously configured as retentive.

Using Your Program to Save V Memory to Permanent Memory

You can save a value (byte, word, or double word) stored in any location of the V memory area to permanent memory. A save to permanent memory operation typically increases the scan time by 10 to 15 ms. The value written by the Save operation overwrites any previous value stored in the V memory area of permanent memory.

The save to permanent memory operation does not update the data in the memory cartridge.

Tip

Since the number of save operations to the permanent memory (EEPROM) is limited (100,000 minimum, and 1,000,000 typical), you should ensure that only necessary values are saved. Otherwise, the EEPROM can wear out and the CPU can fail. Typically, you should perform save operations at the occurrence of specific events that occur rather infrequently.

For example, if the scan time of the S7-200 is 50 ms and a value was saved once per scan, the EEPROM would last a minimum of 5,000 seconds, which is less than an hour and a half. On the other hand, if a value were saved once an hour, the EEPROM would last a minimum of 11 years.

Copying V Memory to Permanent Memory

Special Memory Byte 31 (SMB31) commands the S7-200 to copy a value in V memory to the V memory area of permanent memory. Special Memory Word 32 (SMW32) stores the address location of the value that is to be copied. Figure 4-17 shows the format of SMB31 and SMW32.

Use the following steps to program the S7-200 to save or write a specific value in V memory:

1. Load the V memory address of the value to be saved in SMW32.
2. Load the size of the data in SM31.0 and SM31.1, as shown in Figure 4-17.
3. Set SM31.7 to 1.

At the end of every scan cycle, the S7-200 checks SM31.7; if SM31.7 equals 1, the specified value is saved to permanent memory. The operation is complete when the S7-200 resets SM31.7 to 0.

Do not change the value in V memory until the save operation is complete.

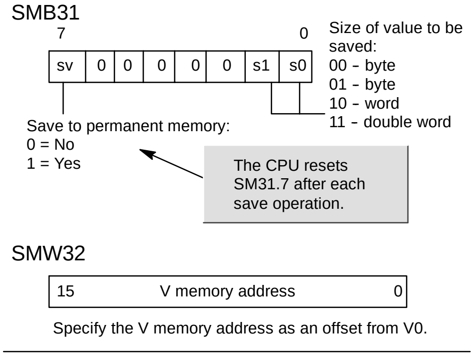

SMB31
7
0
sv
0
0
0
0
0
s1
s0
Size of value to be saved:
00 – byte
01 – byte
10 – word
11 – double word
Save to permanent memory:
0 = No
1 = Yes
The CPU resets SM31.7 after each save operation.
SMW32
15
V memory address
0
Specify the V memory address as an offset from V0.

Figure 4-17 SMB31 and SMW32

Tip

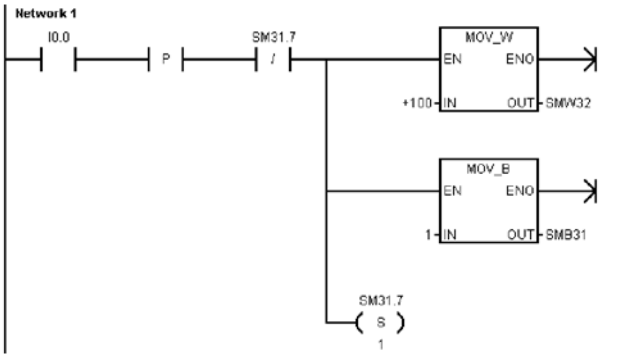
Copying V Memory to permanent memory can be used to save values that are created from an HMI and stored from the program to the internal EEPROM.

To include the values saved to the internal EEPROM in your STEP 7–Micro/WIN project, you must upload the DB. However, this upload is only possible if the DB (which included a variable that was at an equal or higher address than the V Memory address saved in SMW32) was previously downloaded from STEP 7–Micro/WIN.

Sample Program: Copying V Memory to the Permanent Memory

This example transfers VB100 to permanent memory. On a rising edge of I0.0, if another transfer is not in progress, it loads the address of the V memory location to be transferred to SMW32. It selects the amount of V memory to transfer (1=Byte; 2=Word; 3=Double Word or Real). It then sets SM31.7 to have the S7-200 transfer the data at the end of the scan.

The S7-200 automatically resets SM31.7 when the transfer is complete.



```
Network 1        //Transfer a V memory
                 //location (VB100) to
                 //permanent memory
LD       I0.0
EU
AN       SM31.7
MOVW     +100, SMW32
MOVB     1, SMB31
S        SM31.7, 1
```

Selecting the Operating Mode for the S7-200 CPU

The S7-200 has two modes of operation: STOP mode and RUN mode. The status LEDs on the front of the CPU indicates the current mode of operation. In STOP mode, the S7-200 is not executing the program, and you can download a program or the CPU configuration. In RUN mode, the S7-200 is running the program.

- The S7-200 provides a mode switch for changing the mode of operation. You can use the mode switch (located under the front access door of the S7-200) to manually select the operating mode: setting the mode switch to STOP mode stops the execution of the program; setting the mode switch to RUN mode starts the execution of the program; and setting the mode switch to TERM (terminal) mode does not change the operating mode.

  If a power cycle occurs when the mode switch is set to either STOP or TERM, the S7-200 goes automatically to STOP mode when power is restored. If a power cycle occurs when the mode switch is set to RUN, the S7-200 goes to RUN mode when power is restored.

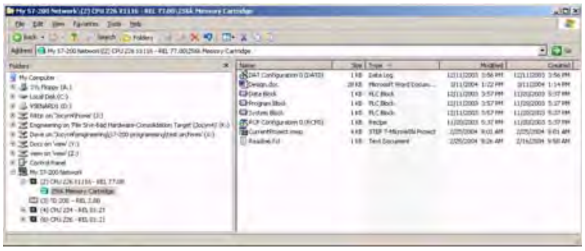
- STEP 7–Micro/WIN allows you to change the operating mode of the online S7-200. To enable the software to change the operating mode, you must manually set the mode switch on the S7-200 to either TERM or RUN. You can use the **PLC > STOP** or **PLC > RUN** menu commands or the associated buttons on the toolbar to change the operating mode.

- You can insert the STOP instruction in your program to change the S7-200 to STOP mode. This allows you to halt the execution of your program based on the program logic. For more information about the STOP instruction, see Chapter 6.

Using the S7-200 Explorer

The S7-200 Explorer is an extension to the Windows Explorer application that provides access to S7-200 PLCs and allows the contents of each connected PLC to be explored. The different blocks that may reside in either the PLC or the memory cartridge can be determined. Properties are available for each block.

Since the S7-200 Explorer is an extension to the Windows Explorer application, standard Windows navigation and behaviors are supported.



Name	Size	Type	Modified	Created
DAT Configuration 0 (DAT0)	1 KB	Data Log	12/11/2003 3:56 PM	12/11/2003 3:56 PM
Design.doc	28 KB	Microsoft Word Docum...	3/11/2004 1:22 PM	3/11/2004 1:14 PM
Data Block	1 KB	PLC Block	12/11/2003 3:57 PM	11/20/2003 5:37 PM
Program Block	1 KB	PLC Block	12/11/2003 3:57 PM	11/20/2003 5:37 PM
System Block	1 KB	PLC Block	12/11/2003 5:57 PM	11/20/2003 5:37 PM
RCP Configuration 0 (RCP0)	1 KB	Recipe	11/20/2003 5:37 PM	11/20/2003 5:37 PM
CurrentProject.mwp	4 KB	STEP 7-Micro/WIN Project	2/25/2004 9:01 AM	2/25/2004 9:01 AM
Readme.txt	1 KB	Text Document	2/25/2004 9:26 AM	2/16/2004 9:58 AM

Figure 4-18 S7-200 Explorer

The S7-200 Explorer is the mechanism used to read data log data stored within the memory cartridge. Refer to Chapter 14 for more information about data logs.

The S7-200 Explorer can also be used to read or write user files to the memory cartridge. These can be any type of files, Word documents, bitmap files, jpeg files, or STEP 7-Micro/WIN projects.

Features of the S7-200

The S7-200 provides several special features that allow you to customize how the S7-200 functions to better fit your application.

The S7-200 Allows Your Program to Immediately Read or Write the I/O

The S7-200 instruction set provides instructions that immediately read from or write to the physical I/O. These immediate I/O instructions allow direct access to the actual input or output point, even though the image registers are normally used as either the source or the destination for I/O accesses.

The corresponding process-image input register location is not modified when you use an immediate instruction to access an input point. The corresponding process-image output register location is updated simultaneously when you use an immediate instruction to access an output point.

Tip

The S7-200 handles reads of analog inputs as immediate data, unless you enable analog input filtering. When you write a value to an analog output, the output is updated immediately.

It is usually advantageous to use the process-image register rather than to directly access inputs or outputs during the execution of your program. There are three reasons for using the image registers:

❑ The sampling of all inputs at the start of the scan synchronizes and freezes the values of the inputs for the program execution phase of the scan cycle. The outputs are updated from the image register after the execution of the program is complete. This provides a stabilizing effect on the system.

❑ Your program can access the image register much more quickly than it can access I/O points, allowing faster execution of the program.

❑ I/O points are bit entities and must be accessed as bits or bytes, but you can access the image register as bits, bytes, words, or double words. Thus, the image registers provide additional flexibility.

The S7-200 Allows Your Program to Interrupt the Scan Cycle

If you use interrupts, the routines associated with each interrupt event are stored as part of the program. The interrupt routines are not executed as part of the normal scan cycle, but are executed when the interrupt event occurs (which could be at any point in the scan cycle).

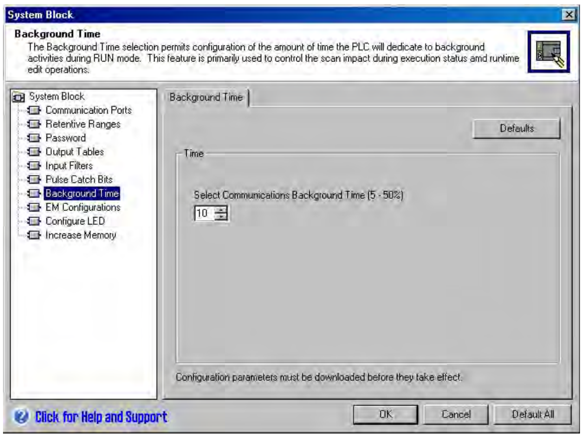
Interrupts are serviced by the S7-200 on a first-come-first-served basis within their respective priority assignments. See the Interrupt instructions in Chapter 6 for more information.

The S7-200 Allows You to Allocate Processing Time for Run Mode Edit and Execution Status

You can configure a percentage of the scan cycle to be dedicated for processing a run mode edit compilation or execution status. (Run mode edit and execution status are options provided by STEP 7–Micro/WIN to make debugging your program easier.) As you increase the percentage of time that is dedicated to these two tasks, you increase the scan time, which makes your control process run more slowly.

The default percentage of the scan dedicated to processing run mode edits and execution status is set to 10%. This setting was chosen to provide a reasonable compromise for processing the compilation and status operations while minimizing the impact to your control process. You can adjust this value by 5% increments up to a maximum of 50%. To set the scan cycle time-slice for background communications:

1. Select the **View > Component > System Block** menu command and select Background Time.
2. In the Background tab, use the drop down box to select the communications background time.
3. Click OK to save your selection.
4. Download the modified system block to the S7-200.



Background Time
The Background Time selection permits configuration of the amount of time the PLC will dedicate to background activities during RUN mode. This feature is primarily used to control the scan impact during execution status amd runtime edit operations.

Select Communications Background Time (5 - 50%) 10

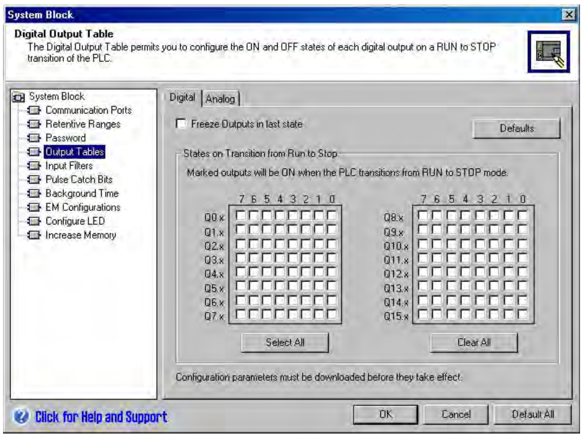
Configuration parameters must be downloaded before they take effect.

Figure 4-19 Communications Background Time

The S7-200 Allows You to Set the States of Digital Outputs for Stop Mode

The output table of the S7-200 allows you to determine whether to set the state of the digital output points to known values upon a transition to the STOP mode, or to leave the outputs in the state they were in before the transition to the STOP mode. The output table is part of the system block that is downloaded and stored in the S7-200.

1. Select the **View > Component > System Block** menu command and select Output Table. Click on the Digital tab.
2. To freeze the outputs in their last state, select the Freeze Outputs checkbox.
3. To copy the table values to the outputs, enter the output table values by clicking the checkbox for each output bit you want to set to On (1) after a run-to-stop transition. The default values of the table are all zeroes.
4. Click OK to save your selections.
5. Download the modified system block to the S7-200.



System Block

Digital Output Table

The Digital Output Table permits you to configure the ON and OFF states of each digital output on a RUN to STOP transition of the PLC.

☐ Freeze Outputs in last state

States on Transition from Run to Stop

Marked outputs will be ON when the PLC transitions from RUN to STOP mode.

	7	6	5	4	3	2	1	0		7	6	5	4	3	2	1	0
Q0.x	☐	☐	☐	☐	☐	☐	☐	☐	Q8.x	☐	☐	☐	☐	☐	☐	☐	☐
Q1.x	☐	☐	☐	☐	☐	☐	☐	☐	Q9.x	☐	☐	☐	☐	☐	☐	☐	☐
Q2.x	☐	☐	☐	☐	☐	☐	☐	☐	Q10.x	☐	☐	☐	☐	☐	☐	☐	☐
Q3.x	☐	☐	☐	☐	☐	☐	☐	☐	Q11.x	☐	☐	☐	☐	☐	☐	☐	☐
Q4.x	☐	☐	☐	☐	☐	☐	☐	☐	Q12.x	☐	☐	☐	☐	☐	☐	☐	☐
Q5.x	☐	☐	☐	☐	☐	☐	☐	☐	Q13.x	☐	☐	☐	☐	☐	☐	☐	☐
Q6.x	☐	☐	☐	☐	☐	☐	☐	☐	Q14.x	☐	☐	☐	☐	☐	☐	☐	☐
Q7.x	☐	☐	☐	☐	☐	☐	☐	☐	Q15.x	☐	☐	☐	☐	☐	☐	☐	☐

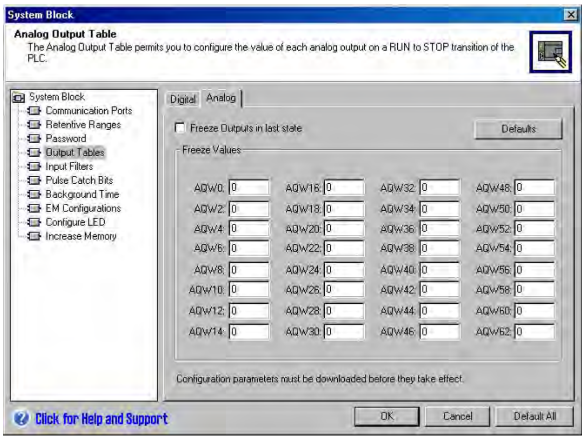
Configuration parameters must be downloaded before they take effect.

Figure 4-20 Digital Output Table

The S7-200 Allows You to Configure the Value of Analog Outputs

The Analog Output Table allows you to set analog output points to known values after a RUN-to-STOP transition, or to preserve the output values that existed before the transition to STOP mode. The Analog Output table is part of the system block that is downloaded and stored in the S7-200 CPU.

1. Select the **View > Component > System Block** menu command and select Output Table. Click on the Analog tab.
2. To freeze the outputs in their last state, select the Freeze Outputs check box.
3. The Freeze Values table allows you to set the analog outputs to a known value (–32768 to 37262), on a RUN-to-STOP transition.
4. Click OK to save your selections.
5. Download the modified system block to the S7-200.



System Block

Analog Output Table

The Analog Output Table permits you to configure the value of each analog output on a RUN to STOP transition of the PLC.

☐ Freeze Outputs in last state

Freeze Values

AQW0:	0	AQW16:	0	AQW32:	0	AQW48:	0
AQW2:	0	AQW18:	0	AQW34:	0	AQW50:	0
AQW4:	0	AQW20:	0	AQW36:	0	AQW52:	0
AQW6:	0	AQW22:	0	AQW38:	0	AQW54:	0
AQW8:	0	AQW24:	0	AQW40:	0	AQW56:	0
AQW10:	0	AQW26:	0	AQW42:	0	AQW58:	0
AQW12:	0	AQW28:	0	AQW44:	0	AQW60:	0
AQW14:	0	AQW30:	0	AQW46:	0	AQW62:	0

Configuration parameters must be downloaded before they take effect.

Figure 4-21 Analog Output Table

The S7-200 Allows You to Define Memory to Be Retained on Loss of Power

You can define up to six retentive ranges to select the areas of memory you want to retain through power cycles. You can define ranges of addresses in the following memory areas to be retentive: V, M, C, and T. For timers, only the retentive timers (TONR) can be retained. The default setting for the first 14 bytes of M Memory is to be non-retentive.

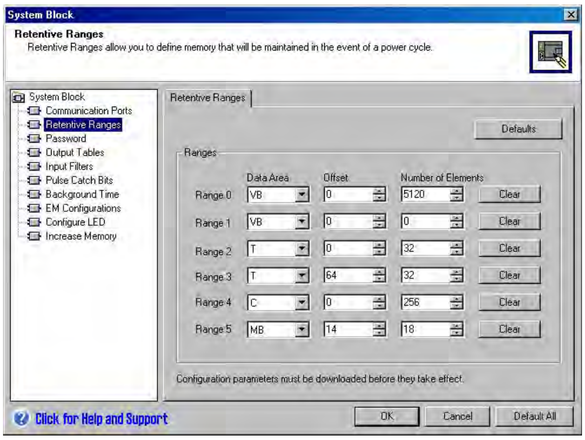
Only the current values for timers and counters can be retained: the timer and counter bits are not retentive.

Tip

Changing the range MB0 to MB13 to be retentive enables a special feature that automatically saves these locations to the permanent memory on power down.

To define the retentive memory:

1. Select the **View > Component > System Block** menu command and select Retentive Ranges.
2. Select the ranges of memory to be retained following loss of power and click OK.
3. Download the modified system block to the S7-200.



Retentive Ranges

Retentive Ranges allow you to define memory that will be maintained in the event of a power cycle.

	Data Area	Offset	Number of Elements
Range 0	VB	0	5120
Range 1	VB	0	0
Range 2	T	0	32
Range 3	T	64	32
Range 4	C	0	256
Range 5	MB	14	18

Configuration parameters must be downloaded before they take effect.

Figure 4-22 Retentive Memory

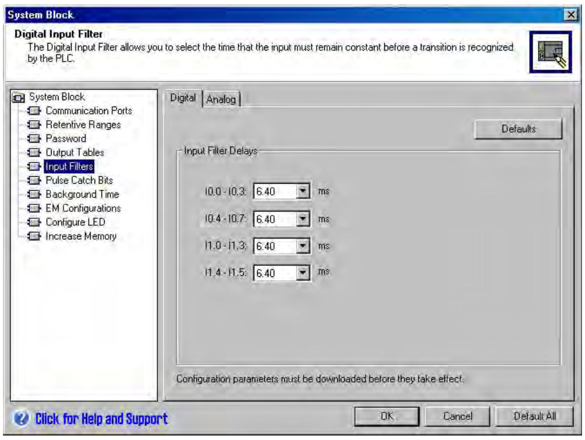
The S7-200 Allows You to Filter the Digital Inputs

The S7-200 allows you to select an input filter that defines a delay time (selectable from 0.2 ms to 12.8 ms) for some or all of the local digital input points. This delay helps to filter noise on the input wiring that could cause inadvertent changes to the states of the inputs.

The input filter is part of the system block that is downloaded and stored in the S7-200. The default filter time is 6.4 ms. As shown in Figure 4-23, each delay specification applies to groups of input points.

To configure the delay times for the input filter:

1. Select the **View > Component > System Block** menu command and select Input Filters. Click on the Digital tab.
2. Enter the amount of delay for each group of inputs and click OK.
3. Download the modified system block to the S7-200.



Digital Input Filter

The Digital Input Filter allows you to select the time that the input must remain constant before a transition is recognized by the PLC.

I0.0 - I0.3: 6.40 ms
I0.4 - I0.7: 6.40 ms
I1.0 - I1.3: 6.40 ms
I1.4 - I1.5: 6.40 ms

Configuration parameters must be downloaded before they take effect.

Figure 4-23 Digital Input Filter

Tip

The digital input filter affects the input value as seen by instruction reads, input interrupts, and pulse catches. Depending on your filter selection, your program could miss an interrupt event or pulse catch. The high speed counters count the events on the unfiltered inputs.

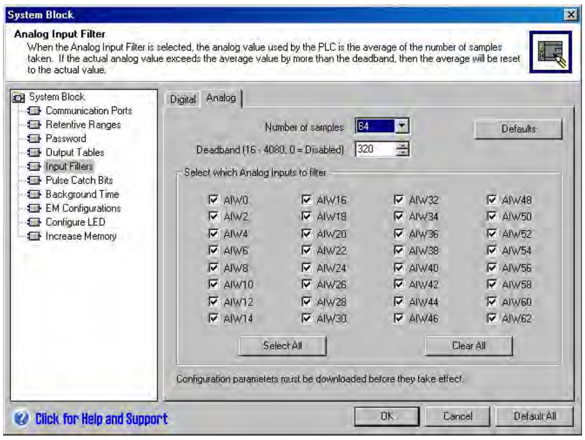
The S7-200 Allows You to Filter the Analog Inputs

The S7-200 allows you to select software filtering on individual analog inputs. The filtered value is the average value of a preselected number of samples of the analog input. The filter specification (number of samples and deadband) is the same for all analog inputs for which filtering is enabled.

The filter has a fast response feature to allow large changes to be quickly reflected in the filter value. The filter makes a step function change to the latest analog input value when the input exceeds a specified change from the current value. This change, called the deadband, is specified in counts of the digital value of the analog input.

The default configuration is to enable filtering for all analog inputs except AIW0 and AIW2 on CPU 224XP.

1. Select the **View > Component > System Block** menu command and select Input Filters. Click on the Analog tab.
2. Select the analog inputs that you want to filter, the number of samples, and the deadband.
3. Click OK.
4. Download the modified system block to the S7-200.



System Block

Analog Input Filter

When the Analog Input Filter is selected, the analog value used by the PLC is the average of the number of samples taken. If the actual analog value exceeds the average value by more than the deadband, then the average will be reset to the actual value.

Number of samples: 64

Deadband (16 - 4080, 0 = Disabled): 320

Select which Analog Inputs to filter

☑ AIW0	☑ AIW16	☑ AIW32	☑ AIW48
☑ AIW2	☑ AIW18	☑ AIW34	☑ AIW50
☑ AIW4	☑ AIW20	☑ AIW36	☑ AIW52
☑ AIW6	☑ AIW22	☑ AIW38	☑ AIW54
☑ AIW8	☑ AIW24	☑ AIW40	☑ AIW56
☑ AIW10	☑ AIW26	☑ AIW42	☑ AIW58
☑ AIW12	☑ AIW28	☑ AIW44	☑ AIW60
☑ AIW14	☑ AIW30	☑ AIW46	☑ AIW62

Configuration parameters must be downloaded before they take effect.

Figure 4-24 Analog Input Filter

Tip

Do not use the analog filter with modules that pass digital information or alarm indications in the analog words. Always disable analog filtering for RTD, Thermocouple, and AS-Interface Master modules.

Tip

AIW0 and AIW2 on the CPU 224XP are filtered by the analog to digital converter, and usually will not need the additional software filter.

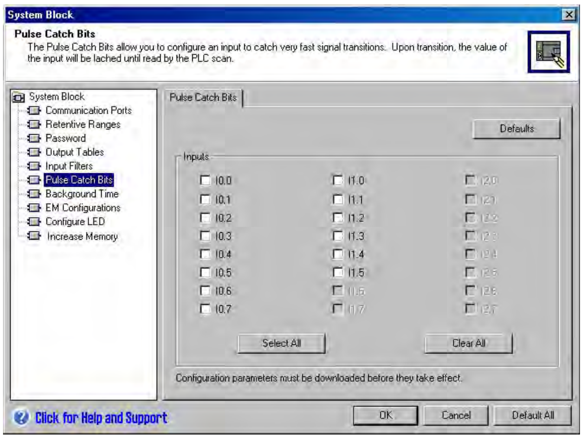
The S7-200 Allows You to Catch Pulses of Short Duration

The S7-200 provides a pulse catch feature which can be used for some or all of the local digital input points. The pulse catch feature allows you to capture high-going pulses or low-going pulses that are of such a short duration that they would not always be seen when the S7-200 reads the digital inputs at the beginning of the scan cycle. When pulse catch is enabled for an input, a change in state of the input is latched and held until the next input cycle update. This ensures that a pulse which lasts for a short period of time is caught and held until the S7-200 reads the inputs.

You can individually enable the pulse catch operation for each of the local digital inputs.

To access the pulse catch configuration screen:

1. Select the **View > Component > System Block** menu command and select Pulse Catch Bits.
2. Click the corresponding check box and click OK.
3. Download the modified system block to the S7-200.



System Block

Pulse Catch Bits

The Pulse Catch Bits allow you to configure an input to catch very fast signal transitions. Upon transition, the value of the input will be lached until read by the PLC scan.

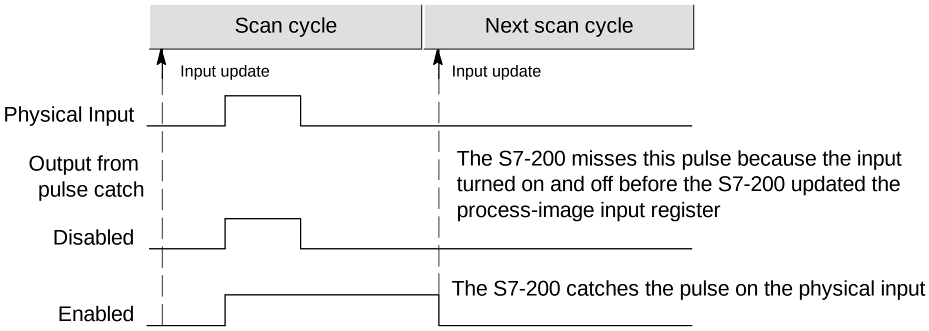
Inputs

□ I0.0	□ I1.0	□ I2.0
□ I0.1	□ I1.1	□ I2.1
□ I0.2	□ I1.2	□ I2.2
□ I0.3	□ I1.3	□ I2.3
□ I0.4	□ I1.4	□ I2.4
□ I0.5	□ I1.5	□ I2.5
□ I0.6	□ I1.6	□ I2.6
□ I0.7	□ I1.7	□ I2.7

Configuration parameters must be downloaded before they take effect.

Figure 4-25 Pulse Catch

Figure 4-26 shows the basic operation of the S7-200 with and without pulse catch enabled.



The S7-200 misses this pulse because the input turned on and off before the S7-200 updated the process-image input register

The S7-200 catches the pulse on the physical input

Figure 4-26 Operation of the S7-200 with the Pulse Catch Feature Enabled and Disabled

Because the pulse catch function operates on the input after it passes through the input filter, you must adjust the input filter time so that the pulse is not removed by the filter. Figure 4-27 shows a block diagram of the digital input circuit.

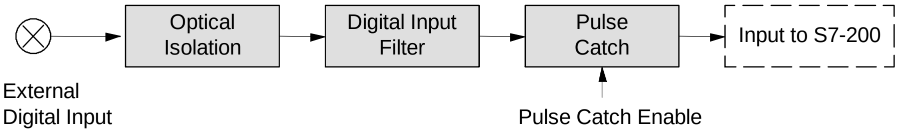


Figure 4-27 Digital Input Circuit

Figure 4-28 shows the response of an enabled pulse catch function to various input conditions. If you have more than one pulse in a given scan, only the first pulse is read. If you have multiple pulses in a given scan, you should use the rising/falling edge interrupt events. (For a listing of interrupt events, see Table 6-46.)

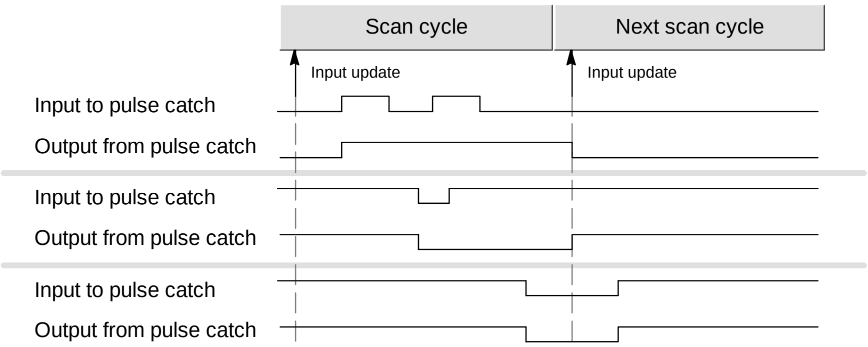


Figure 4-28 Responses of the Pulse Catch Function to Various Input Conditions

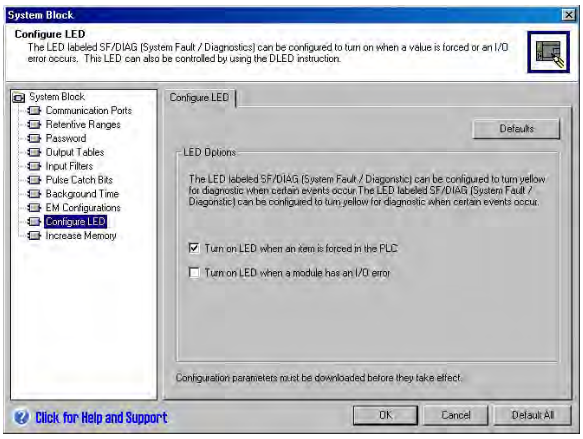
The S7-200 Provides a User-Controlled LED

The S7-200 provides an LED (SF/DIAG) that can indicate red (system fault LED) or yellow (diagnostic LED). The diagnostic LED can be illuminated under user program control, or can automatically illuminate under certain conditions: when an I/O point or data value is forced, or when a module has an I/O error.

To configure the automatic selections for the diagnostic LED:

1. Select the **View > Component > System Block** menu command and select Configure LED.
2. Click each item to either enable or disable turning on the LED when an I/O point or data value is forced, or when a module has an I/O error.
3. Download the modified system block to the S7-200.

To control the state of the diagnostic LED with your user program, use the Diagnostic LED instruction in Chapter 6.



Configure LED
The LED labeled SF/DIAG (System Fault / Diagnostics) can be configured to turn on when a value is forced or an I/O error occurs. This LED can also be controlled by using the DLED instruction.

The LED labeled SF/DIAG (System Fault / Diagonstic) can be configured to turn yellow for diagnostic when certain events occur.The LED labeled SF/DIAG (System Fault / Diagonstic) can be configured to turn yellow for diagnostic when certain events occur.

☑ Turn on LED when an item is forced in the PLC

□ Turn on LED when a module has an I/O error

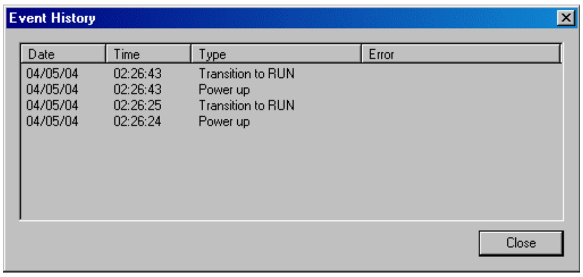
Configuration parameters must be downloaded before they take effect.

Figure 4-29 Diagnostic LED

The S7-200 Maintains a History Log of Major CPU Events

The S7-200 maintains a log that contains a time-stamped history of major CPU events, such as when power is applied, when the CPU enters RUN mode, and when fatal errors occur. Your time-of-day clock must be configured in order to get valid time and date stamps on the log entries.

To view the Event History log, select the **PLC > Information** menu command and select Event History.



Date	Time	Type	Error
04/05/04	02:26:43	Transition to RUN	
04/05/04	02:26:43	Power up	
04/05/04	02:26:25	Transition to RUN	
04/05/04	02:26:24	Power up	

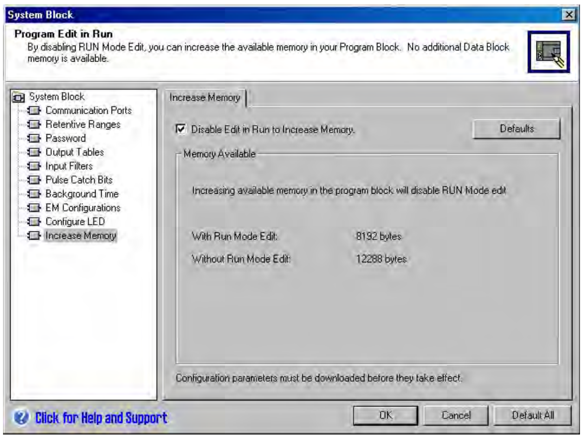
Figure 4-30 Viewing the Event History Log

The S7-200 Allows You to Increase Your Available User Program Memory

The S7-200 allows you to disable the run mode edit feature in the CPU 224, CPU 224XP, and CPU 226 in order to increase the amount of program memory available for your use. Refer to Table 1-1 to see the amount of program memory for each CPU model.

To disable the run mode edit feature, follow these steps

1. Select the **View > System Block** menu command and select Increase Program Memory.
2. Click the Increase Memory item to disable the run mode edit feature.
3. Download the modified system block to the S7-200.



Program Edit in Run
By disabling RUN Mode Edit, you can increase the available memory in your Program Block. No additional Data Block memory is available.

☑ Disable Edit in Run to Increase Memory.

Increasing available memory in the program block will disable RUN Mode edit

With Run Mode Edit: 8192 bytes
Without Run Mode Edit: 12288 bytes

Configuration parameters must be downloaded before they take effect.

Figure 4-31 Disable Run Mode Edit

The S7-200 Provides Password Protection

All models of the S7-200 provide password protection for restricting access to specific functions.

A password authorizes access to the functions and memory: without a password, the S7-200 provides unrestricted access. When it is password protected, the S7-200 limits all restricted operations according to the configuration provided when the password was installed

The password is not case-sensitive.

As shown in Table 4-3, the S7-200 provides four levels of access restriction. Each level allows certain functions to be accessible without a password. For the four levels of access, entering the correct password provides access to the functions as noted below. The default condition for the S7-200 is level 1 (no restriction).

Entering the password over a network does not compromise the password protection for the S7-200.

You can in effect, disable the password by changing the password level 4, 3, or 2 to Level 1, since Level 1 allows all unrestricted CPU access.

Table 4-3 Restricting Access to the S7-200

CPU Function	Level 1	Level 2	Level 3	Level 4
Read and write user data	Access allowed	Access allowed	Access allowed	Access allowed
Start, Stop, and Power-Up Reset of the CPU				
Read and write the time-of-day Clock				
Upload the user program, data, and the CPU configuration			Password required	Never allowed
Download of Program Block, Data Block or System Block		Password required		Password required (Never allowed for System Block)
Runtime Edits				Never allowed
Delete of Program Block, Data Block, or System Data Block				Password required (Never allowed for System Block)
Copy of Program Block, Data Block, or System Data Block to the memory cartridge				Password required
Force data in status chart				
Execute the single or multiple scan				
Writing of output in STOP mode				
Reset of scan rates in PLC information				
Execution status				Never allowed
Project compare				

Having one user authorized to access restricted functions Reset of Scan Rates in PLC information does not authorize other users to access those functions. Only one user is allowed unrestricted access to the S7-200 at a time.

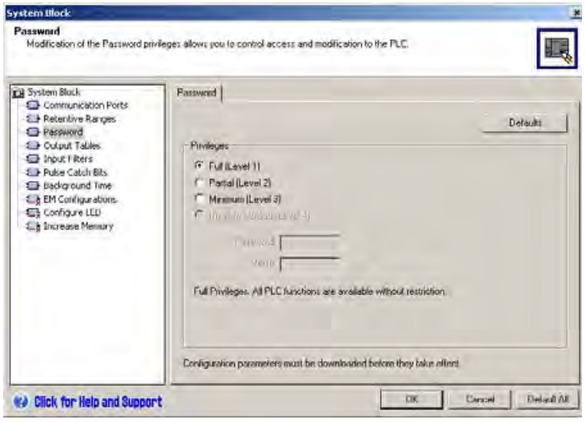
Tip

After you enter the password, the authorization level for that password remains effective for up to one minute after the programming device has been disconnected from the S7-200. Always exit STEP 7-Micro/WIN before disconnecting the cable to prevent another user from accessing the privileges of the programming device.

Configuring a Password for the S7-200

The System Block dialog box (Figure 4-32) allows you to configure a password for the S7-200. The default condition for the S7-200 is set at Full (Level 1), no restriction.

1. Select the **View > Component > System Block** menu command to display the System Block dialog box and select Password.
2. Select the appropriate level of access for the S7-200.
3. Enter and verify the password for Partial (Level 2) or Minimum (Level 3).
4. Click OK.
5. Download the modified system block to the S7-200.



System Block

Password

Modification of the Password privileges allows you to control access and modification to the PLC.

Privileges

● Full (Level 1)

○ Partial (Level 2)

○ Minimum (Level 3)

○ [illegible]

Password

Verify

Full Privileges. All PLC functions are available without restriction.

Configuration parameters must be downloaded before they take effect.

Figure 4-32 Creating a Password

Recovering from a Lost Password

If you forget the password, you must clear the memory of the S7-200 and reload your program. Clearing the memory puts the S7-200 in STOP mode and resets the S7-200 to the factory-set defaults, except for the network address, baud rate, and the time-of-day clock. To clear your program in the S7-200:

1. Select the **PLC > Clear** menu command to display the Clear dialog box.
2. Select all three blocks and confirm your action by clicking OK.
3. If a password had been configured, STEP 7–Micro/WIN displays a password-authorization dialog box. To clear the password, enter CLEARPLC in the password-authorization dialog box to continue the Clear All operation. (The CLEARPLC password is not case sensitive.)

The Clear All operation does not remove the program from a memory cartridge. Since the memory cartridge stores the password along with the program, you must also reprogram the memory cartridge to remove the lost password.

Warning

Clearing the S7-200 memory causes the outputs to turn off (or in the case of an analog output, to be frozen at a specific value).

If the S7-200 is connected to equipment when you clear the memory, changes in the state of the outputs can be transmitted to the equipment. If you had configured the “safe state” for the outputs to be different from the factory settings, changes in the outputs could cause unpredictable operation of your equipment, which in turn could cause death or serious injury to personnel, and/or damage to equipment.

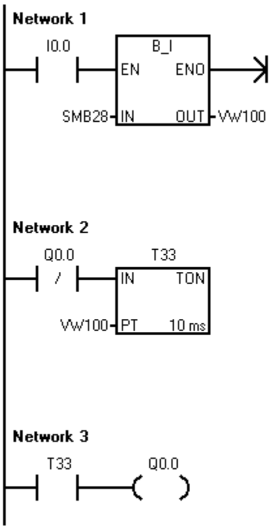
Always follow appropriate safety precautions and ensure that your process is in a safe state before clearing the S7-200 memory.

The S7-200 Provides Analog Adjustment Potentiometers

The analog adjustment potentiometers are located under the front access cover of the module. You can adjust these potentiometers to increase or decrease values that are stored in bytes of Special Memory (SMB). These read-only values can be used by the program for a variety of functions, such as updating the current value for a timer or a counter, entering or changing the preset values, or setting limits. Use a small screwdriver to make the adjustments: turn the potentiometer clockwise (to the right) to increase the value, and counterclockwise (to the left) to decrease the value.

SMB28 holds the digital value that represents the position of analog adjustment 0. SMB29 holds the digital value that represents the position of analog adjustment 1. The analog adjustment has a nominal range of 0 to 255 and a repeatability of ±2 counts.

Sample Program for Referencing the Value Entered with the Analog Adjustment Potentiometers



```
Network 1   //Read analog adjustment 0 (SMB28).
            //Save the value as an integer in VW100.
LD      I0.0
BTI     SMB28, VW100

Network 2   //Use the integer value (VW100) as
            //a preset for a timer.
LDN     Q0.0
TON     T33, VW100

Network 3   //Turn on Q0.0 when T33 reaches
            //the preset value.
LD      T33
=       Q0.0
```

The S7-200 Provides High-speed I/O

High-Speed Counters

The S7-200 provides integrated high-speed counter functions that count high speed external events without degrading the performance of the S7-200. See Appendix A for the rates supported by your CPU model. Each counter has dedicated inputs for clocks, direction control, reset, and start, where these functions are supported. You can select different quadrature modes for varying the counting rate. For more information on high-speed counters, see Chapter 6.

High-Speed Pulse Output

The S7-200 supports high-speed pulse outputs, with outputs Q0.0 and Q0.1 generating either a high-speed pulse train output (PTO) or pulse width modulation (PWM).

The PTO function provides a square wave (50% duty cycle) output for a specified number of pulses (from 1 to 4,294,967,295 pulses) and a specified cycle time (in either microsecond or millisecond increments. You can program the PTO function to produce either one train of pulses or a pulse profile consisting of multiple trains of pulses. For example, you can use a pulse profile to control a stepper motor through a simple ramp up, run, and ramp down sequence or more complicated sequences.

The PWM function provides a fixed cycle time with a variable duty cycle output, with the cycle time and the pulse width specified in either microsecond or millisecond increments. When the pulse width is equal to the cycle time, the duty cycle is 100 percent and the output is turned on continuously. When the pulse width is zero, the duty cycle is 0 percent and the output is turned off.

For more information on the high-speed pulse output instruction, see Chapter 6. For more information about using PTO in open loop motion control, see Chapter 9.

5 Programming Concepts, Conventions, and Features

The S7-200 continuously executes your program to control a task or process. You use STEP 7-Micro/WIN to create this program and download it to the S7-200. STEP 7-Micro/WIN provides a variety of tools and features for designing, implementing, and debugging your program.

In This Chapter

Guidelines for Designing a Micro PLC System

There are many methods for designing a Micro PLC system. The following general guidelines can apply to many design projects. Of course, you must follow the directives of your own company's procedures and the accepted practices of your own training and location.

Partition Your Process or Machine

Divide your process or machine into sections that have a level of independence from each other. These partitions determine the boundaries between controllers and influence the functional description specifications and the assignment of resources.

Create the Functional Specifications

Write the descriptions of operation for each section of the process or machine. Include the following topics: I/O points, functional description of the operation, states that must be achieved before allowing action for each actuator (such as solenoids, motors, and drives), description of the operator interface, and any interfaces with other sections of the process or machine.

Design the Safety Circuits

Identify equipment requiring hard-wired logic for safety. Control devices can fail in an unsafe manner, producing unexpected startup or change in the operation of machinery. Where unexpected or incorrect operation of the machinery could result in physical injury to people or significant property damage, consideration should be given to the use of electro-mechanical overrides which operate independently of the S7-200 to prevent unsafe operations. The following tasks should be included in the design of safety circuits:

- ❑ Identify improper or unexpected operation of actuators that could be hazardous.
- ❑ Identify the conditions that would assure the operation is not hazardous, and determine how to detect these conditions independently of the S7-200.
- ❑ Identify how the S7-200 CPU and I/O affect the process when power is applied and removed, and when errors are detected. This information should only be used for designing for the normal and expected abnormal operation, and should not be relied on for safety purposes.
- ❑ Design manual or electro-mechanical safety overrides that block the hazardous operation independent of the S7-200.
- ❑ Provide appropriate status information from the independent circuits to the S7-200 so that the program and any operator interfaces have necessary information.
- ❑ Identify any other safety-related requirements for safe operation of the process.

Specify the Operator Stations

Based on the requirements of the functional specifications, create drawings of the operator stations. Include the following items:

- ❑ Overview showing the location of each operator station in relation to the process or machine
- ❑ Mechanical layout of the devices, such as display, switches, and lights, for the operator station
- ❑ Electrical drawings with the associated I/O of the S7-200 CPU or expansion module

Create the Configuration Drawings

Based on the requirements of the functional specification, create configuration drawings of the control equipment. Include the following items:

- ❑ Overview showing the location of each S7-200 in relation to the process or machine
- ❑ Mechanical layout of the S7-200 and expansion I/O modules (including cabinets and other equipment)
- ❑ Electrical drawings for each S7-200 and expansion I/O module (including the device model numbers, communications addresses, and I/O addresses)

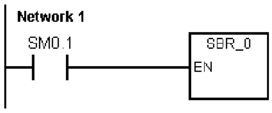
Create a List of Symbolic Names (optional)

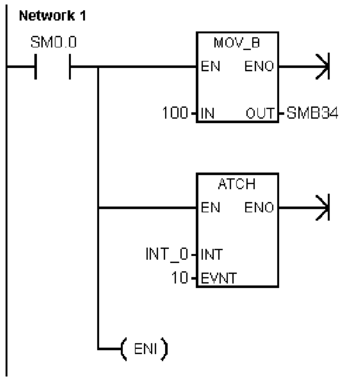
If you choose to use symbolic names for addressing, create a list of symbolic names for the absolute addresses. Include not only the physical I/O signals, but also the other elements to be used in your program.

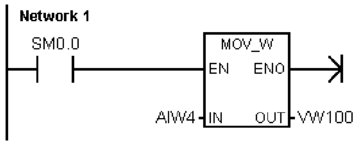
Basic Elements of a Program

A program block is composed of executable code and comments. The executable code consists of a main program and any subroutines or interrupt routines. The code is compiled and downloaded to the S7-200; the program comments are not. You can use the organizational elements (main program, subroutines, and interrupt routines) to structure your control program.

The following example shows a program that includes a subroutine and an interrupt routine. This sample program uses a timed interrupt for reading the value of an analog input every 100 ms.

Example:Basic Elements of a Program		
M A I N		Network 1 //On first scan, call subroutine 0. LD SM0.1 CALL SBR_0

S
B
R
0
	 Network 1
	SM0.0
	MOV_B
	EN
	ENO
	100
	IN
	OUT
	SMB34
	ATCH
	EN
	ENO
	INT_0
	INT
	10
	EVNT
	ENI
		Network 1 //Set the interval to 100 ms
		//for the timed interrupt.
		//Enable interrupt 0.
		LD SM0.0
		MOVB 100, SMB34
		ATCH INT_0, 10
		ENI

I N T 0	 Network 1 SM0.0 MOV_W EN ENO AIW4 IN OUT VW100	Network 1 //Sample the Analog Input 4. LD SM0.0 MOVW AIW4,VW100

Main Program

The main body of the program contains the instructions that control your application. The S7-200 executes these instructions sequentially, once per scan cycle. The main program is also referred to as OB1.

Subroutines

These optional elements of your program are executed only when called: by the main program, by an interrupt routine, or by another subroutine. Subroutines are useful in cases where you want to execute a function repeatedly. Rather than rewriting the logic for each place in the main program where you want the function to occur, you can write the logic once in a subroutine and call the subroutine as many times as needed during the main program. Subroutines provide several benefits:

- Using subroutines reduces the overall size of your program.
- Using subroutines decreases your scan time because you have moved the code out of the main program. The S7-200 evaluates the code in the main program every scan cycle, whether the code is executed or not, but the S7-200 evaluates the code in the subroutine only when you call the subroutine, and does not evaluate the code during the scans in which the subroutine is not called.
- Using subroutines creates code that is portable. You can isolate the code for a function in a subroutine, and then copy that subroutine into other programs with little or no rework.

Tip

Using V memory addresses can limit the portability of your subroutine, because it is possible for V memory address assignment from one program to conflict with an assignment in another program. Subroutines that use the local variable table (L memory) for all address assignments, by contrast, are highly portable because there is no concern about address conflicts between the subroutine and another part of the program when using local variables.

Interrupt Routines

These optional elements of your program react to specific interrupt events. You design an interrupt routine to handle a pre-defined interrupt event. Whenever the specified event occurs, the S7-200 executes the interrupt routine.

The interrupt routines are not called by your main program. You associate an interrupt routine with an interrupt event, and the S7-200 executes the instructions in the interrupt routine only on each occurrence of the interrupt event.

Tip

Because it is not possible to predict when the S7-200 might generate an interrupt, it is desirable to limit the number of variables that are used both by the interrupt routine and elsewhere in the program.

Use the local variable table of the interrupt routine to ensure that your interrupt routine uses only the temporary memory and does not overwrite data used somewhere else in your program.

There are a number of programming techniques you can use to ensure that data is correctly shared between your main program and the interrupt routines. These techniques are described in Chapter 6 with the Interrupt instructions.

Other Elements of the Program

Other blocks contain information for the S7-200. You can choose to download these blocks when you download your program.

System Block

System Block

The system block allows you to configure different hardware options for the S7-200.

Data Block

Data Block

The data block stores the values for different variables (V memory) used by your program. You can use the data block to enter initial values for the data.

Using STEP 7-Micro/WIN to Create Your Programs

To open STEP 7-Micro/WIN, double-click on the STEP 7-Micro/WIN icon, or select the **Start > SIMATIC > STEP 7 MicroWIN V4.0** menu command. As shown in Figure 5-1, the STEP 7-Micro/WIN project window provides a convenient working space for creating your control program.

The toolbars provide buttons for shortcuts to frequently used menu commands. You can view or hide any of the toolbars.

The navigation bar presents groups of icons for accessing different programming features of STEP 7-Micro/WIN.

The instruction tree displays all of the project objects and the instructions for creating your control program. You can drag and drop individual instructions from the tree into your program, or you can double-click an instruction to insert it at the current location of the cursor in the program editor.

The program editor contains the program logic and a local variable table where you can assign symbolic names for temporary local variables. Subroutines and interrupt routines appear as tabs at the bottom of the program editor window. Click on the tabs to move between the subroutines, interrupts, and the main program.

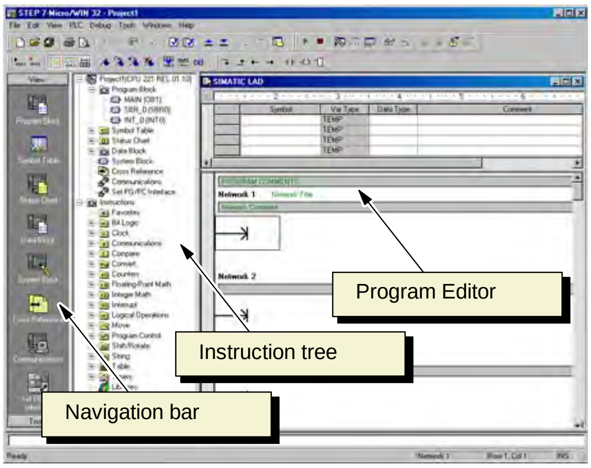


Figure 5-1 STEP 7-Micro/WIN

Program Editor

STEP 7-Micro/WIN provides three editors for creating your program: Ladder Logic (LAD), Statement List (STL), and Function Block Diagram (FBD). With some restrictions, programs written in any of these program editors can be viewed and edited with the other program editors.

Features of the STL Editor

The STL editor displays the program as a text-based language. The STL editor allows you to create control programs by entering the instruction mnemonics. The STL editor also allows you to create programs that you could not otherwise create with the LAD or FBD editors. This is because you are programming in the native language of the S7-200, rather than in a graphical editor where some restrictions must be applied in order to draw the diagrams correctly. As shown in Figure 5-2, this text-based concept is very similar to assembly language programming.

The S7-200 executes each instruction in the order dictated by the program, from top to bottom, and then restarts at the top.

STL uses a logic stack to resolve the control logic. You insert the STL instructions for handling the stack operations.

```
LD      I0.0        //Read one input
A       I0.1        //AND with another input
=       Q1.0        //Write value to output 1
```

Figure 5-2 Sample STL Program

Consider these main points when you select the STL editor:

□ STL is most appropriate for experienced programmers.

□ STL sometimes allows you to solve problems that you cannot solve very easily with the LAD or FBD editor.

□ You can only use the STL editor with the SIMATIC instruction set.

□ While you can always use the STL editor to view or edit a program that was created with the LAD or FBD editors, the reverse is not always true. You cannot always use the LAD or FBD editors to display a program that was written with the STL editor.

Features of the LAD Editor

The LAD editor displays the program as a graphical representation similar to electrical wiring diagrams. Ladder programs allow the program to emulate the flow of electric current from a power source through a series of logical input conditions that in turn enable logical output conditions. A LAD program includes a left power rail that is energized. Contacts that are closed allow energy to flow through them to the next element, and contacts that are open block that energy flow.

The logic is separated into networks. The program is executed one network at a time, from left to right and then top to bottom as dictated by the program. Figure 5-3 shows an example of a LAD program. The various instructions are represented by graphic symbols and include three basic forms.

Contacts represent logic input conditions such as switches, buttons, or internal conditions.

Coils usually represent logic output results such as lamps, motor starters, interposing relays, or internal output conditions.

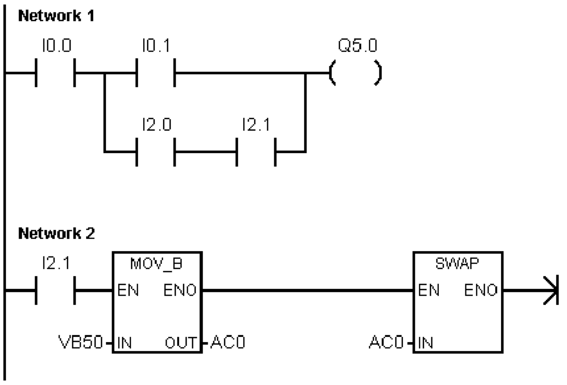


Figure 5-3 Sample LAD Program

Boxes represent additional instructions, such as timers, counters, or math instructions.

Consider these main points when you select the LAD editor:

- ❑ Ladder logic is easy for beginning programmers to use.
- ❑ Graphical representation is easy to understand and is popular around the world.
- ❑ The LAD editor can be used with both the SIMATIC and IEC 1131–3 instruction sets.
- ❑ You can always use the STL editor to display a program created with the SIMATIC LAD editor.

Features of the FBD Editor

The FBD editor displays the program as a graphical representation that resembles common logic gate diagrams. There are no contacts and coils as found in the LAD editor, but there are equivalent instructions that appear as box instructions.

Figure 5-4 shows an example of an FBD program.

FBD does not use the concept of left and right power rails; therefore, the term “power flow” is used to express the analogous concept of control flow through the FBD logic blocks.

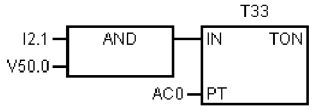


Figure 5-4 Sample FBD Program

The logic “1” path through FBD elements is called power flow. The origin of a power flow input and the destination of a power flow output can be assigned directly to an operand.

The program logic is derived from the connections between these box instructions. That is, the output from one instruction (such as an AND box) can be used to enable another instruction (such as a timer) to create the necessary control logic. This connection concept allows you to solve a wide variety of logic problems.

Consider these main points when you select the FBD editor:

- ❑ The graphical logic gate style of representation is good for following program flow.
- ❑ The FBD editor can be used with both the SIMATIC and IEC 1131–3 instruction sets.
- ❑ You can always use the STL editor to display a program created with the SIMATIC FBD editor.

Choosing Between the SIMATIC and IEC 1131–3 Instruction Sets

Most PLCs offer similar basic instructions, but there are usually small differences from vendor to vendor in appearance, operation, and so forth. Over the last several years, the International Electrotechnical Commission (IEC) has developed an emerging global standard that specifically relates to many aspects of PLC programming. This standard encourages different PLC manufacturers to offer instructions that are the same in both appearance and operation.

Your S7-200 offers two instruction sets that allow you to solve a wide variety of automation tasks. The IEC instruction set complies with the IEC 1131–3 standard for PLC programming, and the SIMATIC instruction set is designed specifically for the S7-200.

Tip

When STEP 7–Micro/WIN is set to the IEC mode, it displays a red diamond (♦) in the Instruction Tree beside the instructions that are not defined by the IEC 1131–3 standard.

There are a few key differences between the SIMATIC instruction set and the IEC instruction set:

- ❑ The IEC instruction set is restricted to those instructions that are standard among PLC vendors. Some instructions that are normally included in the SIMATIC set are not standard instructions in the IEC 1131–3 specification. These are still available for use as non-standard instructions, but if you use them, the program is no longer strictly IEC 1131–3 compatible.
- ❑ Some IEC box instructions accept multiple data formats. This practice is often referred to as overloading. For example, rather than have separate ADD_I (Add Integer) and ADD_R (Add Real), math boxes, the IEC ADD instruction examines the format of the data being added and automatically chooses the correct instruction in the S7-200. This can save valuable program design time.
- ❑ When you use the IEC instructions, the instruction parameters are automatically checked for the proper data format, such as a signed integer versus an unsigned integer. For example, an error results if you try to enter an integer value for an instruction that expected a bit value (on/off). This feature helps to minimize programming syntax errors.

Consider these points when you select either the SIMATIC or the IEC instruction set:

- ❑ SIMATIC instructions usually have the shortest execution times. Some IEC instructions might have longer execution times.
- ❑ Some IEC instructions, such as timers, counters, multiply, and divide, operate differently than their SIMATIC counterparts.
- ❑ You can use all three program editors (LAD, STL, FBD) with the SIMATIC instruction set. You can use only the LAD and FBD program editors for IEC instructions.
- ❑ The operation of the IEC instructions is standard for different brands of PLCs, and the knowledge about creating an IEC-compliant program can be leveraged across PLC platforms.
- ❑ While the IEC standard defines fewer instructions than are available in the SIMATIC instruction set, you can always include SIMATIC instructions in your IEC program.
- ❑ IEC 1131–3 specifies that variables must be declared with a type, and supports system checking of data type.

Understanding the Conventions Used by the Program Editors

STEP 7-Micro/WIN uses the following conventions in all of the program editors:

- A # in front of a symbol name (#var1) indicates that the symbol is of local scope.
- For IEC instructions, the % symbol indicates a direct address.
- The operand symbol “?.?” or “????” indicates that an operand configuration is required.

LAD programs are divided into segments called networks. A network is an ordered arrangement of contacts, coils, and boxes that are all connected to form a complete circuit: no short circuits, no open circuits, and no reverse power flow conditions exist. STEP 7-Micro/WIN allows you to create comments for your LAD program on a network-by-network basis. FBD programming uses the network concept for segmenting and commenting your program.

STL programs do not use networks; however, you can use the NETWORK keyword to segment your program.

Conventions Specific to the LAD Editor

In the LAD editor, you can use the F4, F6, and F9 keys on your keyboard to access contact, box, and coil instructions. The LAD editor uses the following conventions:

- The symbol “--->>” is an open circuit or a required power flow connection.
- The symbol “⇥” indicates that the output is an optional power flow for an instruction that can be cascaded or connected in series.
- The symbol “>>” indicates that you can use power flow.

Conventions Specific to the FBD Editor

In the FBD editor, you can use the F4, F6, and F9 keys on your keyboard to access AND, OR, and box instructions. The FBD editor uses the following conventions:

- The symbol “--->>” on an EN operand is a power flow or operand indicator. It can also depict an open circuit or a required power flow connection.
- The symbol “⇥” indicates that the output is an optional power flow for an instruction that can be cascaded or connected in series.
- The symbols “<<” and “>>” indicate that you can use either a value or power flow.
- Negation bubbles: The logical NOT condition or inverted condition of the operand or power flow is shown by the small circle on the input. In Figure 5-5, Q0.0 is equal to the NOT of I0.0 AND I0.1. Negation bubbles are only valid for Boolean signals, which can be specified as parameters or power flow.

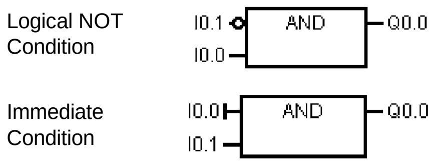


Figure 5-5 FBD Conventions

- Immediate indicators: As shown in Figure 5-5, the FBD editor displays an immediate condition of a Boolean operand with a vertical line on the input to an FBD instruction. The immediate indicator causes an immediate read from the specified physical input. Immediate operators are only valid for physical inputs.
- Box with no input or output: A box with no input indicates an instruction that is independent of power flow.

Tip

The number of operands can be expanded up to 32 inputs for AND and OR instructions. To add or subtract operand tics, use the “+” and “-” keys on your keyboard.

General Conventions of Programming for an S7-200

EN/ENO Definition

EN (Enable IN) is a Boolean input for boxes in LAD and FBD. Power flow must be present at this input for the box instruction to be executed. In STL, the instructions do not have an EN input, but the top of stack value must be a logic “1” for the corresponding STL instruction to be executed.

ENO (Enable Out) is a Boolean output for boxes in LAD and FBD. If the box has power flow at the EN input and the box executes its function without error, then the ENO output passes power flow to the next element. If an error is detected in the execution of the box, then power flow is terminated at the box that generated the error.

In STL, there is no ENO output, but the STL instructions that correspond to the LAD and FBD instructions with ENO outputs do set a special ENO bit. This bit is accessible with the AND ENO (AENO) instruction and can be used to generate the same effect as the ENO bit of a box.

Tip

The EN/ENO operands and data types are not shown in the valid operands table for each instruction because the operands are the same for all LAD and FBD instructions. Table 5-1 lists these operands and data types for LAD and FBD. These operands apply to all LAD and FBD instructions shown in this manual.

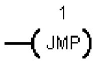
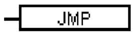
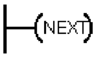
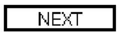
Table 5-1 EN/ENO Operands and Data Types for LAD and FBD

Program Editor	Inputs/Outputs	Operands	Data Types
LAD	EN, ENO	Power Flow	BOOL
FBD	EN, ENO	I, Q, V, M, SM, S, T, C, L	BOOL

Conditional/Unconditional Inputs

In LAD and FBD, a box or a coil that is dependent upon power flow is shown with a connection to any element on the left side. A coil or box that is independent of power flow is shown with a connection directly to the left power rail. Table 5-2 shows an example of both a conditional and an unconditional input.

Table 5-2 Representation of Conditional and Unconditional Inputs

Power Flow	LAD	FBD
Instruction that is dependent on power flow (conditional)		
Instruction that is independent of power flow (unconditional)		

Instructions without Outputs

Boxes that cannot cascade are drawn with no Boolean outputs. These include the Subroutine Call, Jump, and Conditional Return instructions. There are also ladder coils that can only be placed on the left power rail. These include the Label, Next, Load SCR, Conditional SCR End, and SCR End instructions. These are shown in FBD as boxes and are distinguished with unlabeled power inputs and no outputs.

Compare Instructions

The compare instruction is executed regardless of the state of power flow. If power flow is false, the output is false. If power flow is true, the output is set depending upon the result of the compare. SIMATIC FBD, IEC Ladder, and IEC FBD compare instructions are shown as boxes, although the operation is performed as a contact.

Using Wizards To Help You Create Your Control Program

STEP 7-Micro/WIN provides wizards to make aspects of your programming easier and more automatic. In Chapter 6, instructions that have an associated wizard are identified by the following Instruction Wizard icon:

Instruction
Wizard

Handling Errors in the S7-200

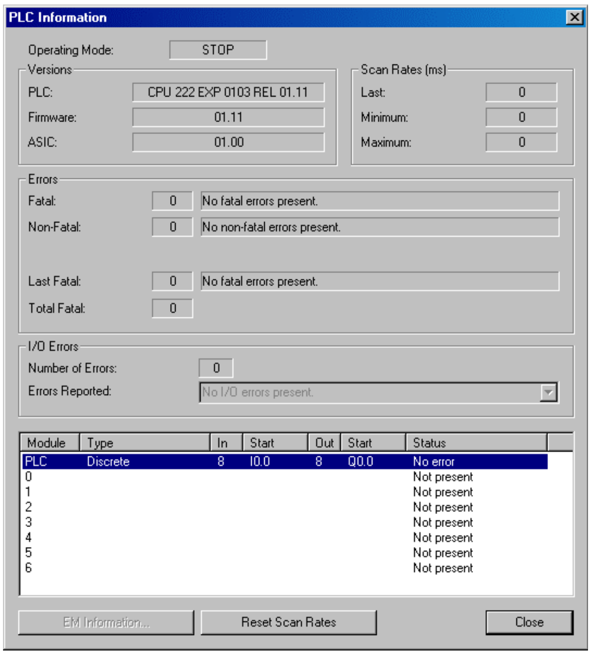
The S7-200 classifies errors as either fatal errors or non-fatal errors. You can view the error codes that were generated by an error by selecting the **PLC > Information** menu command.

Figure 5-6 shows the PLC Information dialog box that displays the error code and the description of the error.

The Last Fatal field shows the previous fatal error code generated by the S7-200. This value is retained over power cycles if the RAM is retained. This location is cleared either whenever all memory of the S7-200 is cleared or if the RAM is not retained after a prolonged power outage.

The Total Fatal field is the count of fatal errors generated by the S7-200 since the last time the S7-200 had all memory areas cleared. This value is retained over power cycles if the RAM is retained. This location is cleared whenever all memory of the S7-200 is cleared, or when the RAM is not retained after a prolonged power outage.

Appendix C lists the S7-200 error codes, and Appendix D describes the special memory (SM) bits, which can be used for monitoring errors.



PLC Information

Operating Mode: STOP

Versions
PLC: CPU 222 EXP 0103 REL 01.11
Firmware: 01.11
ASIC: 01.00

Scan Rates (ms)
Last: 0
Minimum: 0
Maximum: 0

Errors
Fatal: 0 No fatal errors present.
Non-Fatal: 0 No non-fatal errors present.
Last Fatal: 0 No fatal errors present.
Total Fatal: 0

I/O Errors
Number of Errors: 0
Errors Reported: No I/O errors present.

Module	Type	In	Start	Out	Start	Status
PLC	Discrete	8	I0.0	8	Q0.0	No error
0						Not present
1						Not present
2						Not present
3						Not present
4						Not present
5						Not present
6						Not present

Figure 5-6 PLC Information Dialog Box

Non-Fatal Errors

Non-fatal errors are those indicating problems with the construction of the user program, with the execution of an instruction in the user program, and with expansion I/O modules. You can use STEP 7-Micro/WIN to view the error codes that were generated by the non-fatal error. There are three basic categories of non-fatal errors.

Program-compile errors

The S7-200 compiles the program as it downloads. If the S7-200 detects that the program violates a compilation rule, the download is aborted and an error code is generated. (A program that was already downloaded to the S7-200 would still exist in the permanent memory and would not be lost.) After you correct your program, you can download it again. Refer to Appendix C for a list of compile rule violations.

I/O errors

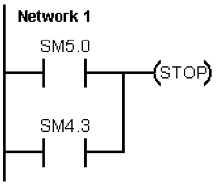
At startup, the S7-200 reads the I/O configuration from each module. During normal operation, the S7-200 periodically checks the status of each module and compares it against the configuration obtained during startup. If the S7-200 detects a difference, the S7-200 sets the configuration error bit in the module error register. The S7-200 does not read input data from or write output data to that module until the module configuration again matches the one obtained at startup.

The module status information is stored in special memory (SM) bits. Your program can monitor and evaluate these bits. Refer to Appendix D for more information about the SM bits used for reporting I/O errors. SM5.0 is the global I/O error bit and remains set while an error condition exists on an expansion module.

Program execution errors

Your program can create error conditions while being executed. These errors can result from improper use of an instruction or from the processing of invalid data by an instruction. For example, an indirect-address pointer that was valid when the program compiled could be modified during the execution of the program to point to an out-of-range address. This is an example of a run-time programming problem. SM4.3 is set upon the occurrence of a run-time programming problem and remains set while the S7-200 is in RUN mode. (Refer to Appendix C for the list of run-time programming problems). Program execution error information is stored in special memory (SM) bits. Your program can monitor and evaluate these bits. Refer to Appendix D for more information about the SM bits used for reporting program execution errors.

The S7-200 does not change to STOP mode when it detects a non-fatal error. It only logs the event in SM memory and continues with the execution of your program. However, you can design your program to force the S7-200 to STOP mode when a non-fatal error is detected. The following sample program shows a network of a program that is monitoring two of the global non-fatal error bits and changes the S7-200 to STOP whenever either of these bits turns on.

Sample Program: Logic for Detecting a Non-Fatal Error Condition	
	Network 1 //When an I/O error or a run-time error occurs, //go to STOP mode LD SM5.0 O SM4.3 STOP

Fatal Errors

Fatal errors cause the S7-200 to stop the execution of your program. Depending upon the severity of the fatal error, it can render the S7-200 incapable of performing any or all functions. The objective for handling fatal errors is to bring the S7-200 to a safe state from which the S7-200 can respond to interrogations about the existing error conditions. When a fatal error is detected, the S7-200 changes to STOP mode, turns on the SF/DIAG (Red) and the STOP LED, overrides the output table, and turns off the outputs. The S7-200 remains in this condition until the fatal error condition is corrected.

Once you have made the changes to correct the fatal error condition, use one of the following methods to restart the S7-200:

- Turn the power off and then on.
- Change the mode switch from RUN or TERM to STOP.
- Select the **PLC > Power-Up Reset** menu command from STEP 7–Micro/WIN to restart the S7-200. This forces the S7-200 to restart and clear any fatal errors.

Restarting the S7-200 clears the fatal error condition and performs power-up diagnostic testing to verify that the fatal error has been corrected. If another fatal error condition is found, the S7-200 again sets the fault LED, indicating that an error still exists. Otherwise, the S7-200 begins normal operation.

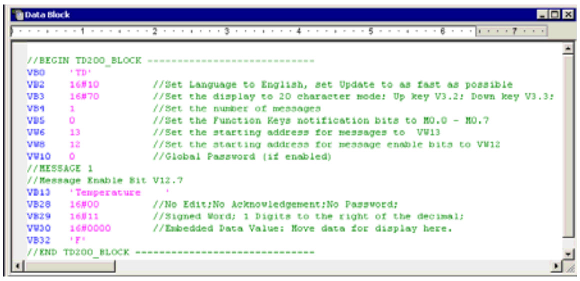
Some error conditions can render the S7-200 incapable of communication. In these cases, you cannot view the error code from the S7-200. These types of errors indicate hardware failures that require the S7-200 to be repaired; they cannot be fixed by changes to the program or clearing the memory of the S7-200.

Assigning Addresses and Initial Values in the Data Block Editor

Data Block

The data block editor allows you to make initial data assignments to V memory (variable memory) only. You can make assignments to bytes, words, or double words of V memory. Comments are optional.

The data block editor is a free-form text editor; that is, no specific fields are defined for particular types of information. After you finish typing a line and press the Enter key, the data block editor formats the line (aligns columns of addresses, data, comments; capitalizes V memory addresses) and redisplays it. Pressing CTRL–ENTER, after completing an assignment line, auto-increments the address to the next available address.



```
//BEGIN TD200_BLOCK ----------------------------
VB0    'TD'
VB2    16#10         //Set Language to English, set Update to as fast as possible
VB3    16#70         //Set the display to 20 character mode: Up key V3.2: Down key V3.3:
VB4    1             //Set the number of messages
VB5    0             //Set the Function Keys notification bits to M0.0 - M0.7
VW6    13            //Set the starting address for messages to  VW13
VW8    12            //Set the starting address for message enable bits to VW12
VW10   0             //Global Password (if enabled)
//MESSAGE 1
//Message Enable Bit V12.7
VB13   'Temperature     '
VB28   16#00         //No Edit;No Acknowledgement;No Password;
VB29   16#11         //Signed Word; 1 Digits to the right of the decimal;
VW30   16#0000       //Embedded Data Value: Move data for display here.
VB32   'F'
//END TD200_BLOCK ------------------------------
```

Figure 5-7   Data Block Editor

The data block editor assigns an appropriate amount of V memory based on your previous address allocations and the size (byte, word, or double word) of the data value(s).

The first line of the data block must have an explicit address assignment. Subsequent lines can have explicit or implicit address assignments. An implicit address assignment is made by the editor when you type multiple data values after a single address assignment, or type a line that contains only data values.

The data block editor accepts uppercase or lowercase letters and allows commas, tabs, or spaces to serve as separators between addresses and data values.

Using the Symbol Table for Symbolic Addressing of Variables

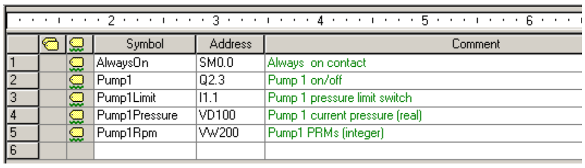
Symbol Table

The symbol table allows you to define and edit the symbols that can be accessed by the symbolic name anywhere in your program. You can create multiple symbol tables. There is also a tab in the symbol table for system-defined symbols that you can use in your program. The symbol table is also referred to as the global variable table.

You can identify the operands of the instructions in your program absolutely or symbolically. An absolute reference uses the memory area and bit or byte location to identify the address. A symbolic reference uses a combination of alphanumeric characters to identify the address.

For SIMATIC programs, you make global symbol assignments by using the symbol table. For IEC programs, you make global symbol assignments by using the global variable table.

To assign a symbol to an address:



			Symbol	Address	Comment
1			AlwaysOn	SM0.0	Always on contact
2			Pump1	Q2.3	Pump 1 on/off
3			Pump1Limit	I1.1	Pump 1 pressure limit switch
4			Pump1Pressure	VD100	Pump 1 current pressure (real)
5			Pump1Rpm	VW200	Pump1 PRMs (integer)
6					

Figure 5-8   Symbol Table

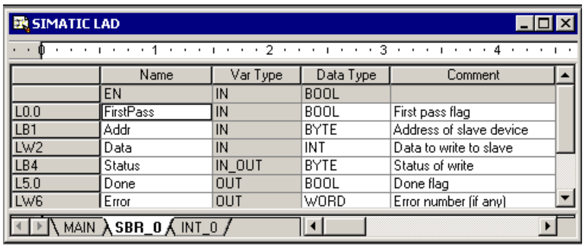
1. Click on the Symbol Table icon in the navigation bar to open the symbol table.
2. Enter the symbol name (for example, Input1) in the Symbol Name column. The maximum symbol length is 23 characters.
3. Enter the address (for example, I0.0) in the Address column.
4. For an IEC global variable table, enter a value in the Data Type column or select one from the list box.

You can create multiple symbol tables; however, you cannot use the same string more than once as a global symbol assignment, neither within a single table nor among several tables.

Using Local Variables

You can use the local variable table of the program editor to assign variables that are unique to an individual subroutine or interrupt routine. See Figure 5-9.

Local variables can be used as parameters that are passed in to a subroutine and they increase the portability or reuse of a subroutine.



	Name	Var Type	Data Type	Comment
	EN	IN	BOOL	
L0.0	FirstPass	IN	BOOL	First pass flag
LB1	Addr	IN	BYTE	Address of slave device
LW2	Data	IN	INT	Data to write to slave
LB4	Status	IN_OUT	BYTE	Status of write
L5.0	Done	OUT	BOOL	Done flag
LW6	Error	OUT	WORD	Error number (if any)

Figure 5-9 Local Variable Table

Using the Status Chart to Monitor Your Program

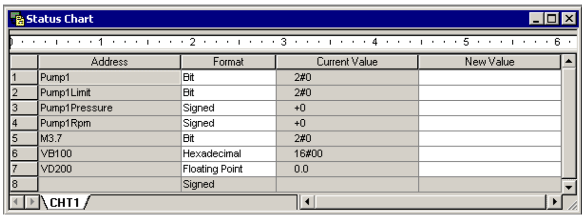
Status Chart

A status chart allows you to monitor or modify the values of the process variables as your S7-200 runs the control program. You can track the status of program inputs, outputs, or variables by displaying the current values. The status chart also allows you to force or change the values of the process variables.

You can create multiple status charts in order to view elements from different portions of your program.

To access the status chart, select the **View > Component > Status Chart** menu command or click the Status Chart icon in the navigation bar.

When you create a status chart, you enter addresses of process variables for monitoring. You cannot view the status of constants, accumulators, or local variables. You can display a timer or counter value either as a bit or as a word. Displaying the value as a bit shows the status of the timer or counter bit; displaying the value as a word shows the timer or counter value.



	Address	Format	Current Value	New Value
1	Pump1	Bit	2#0	
2	Pump1Limit	Bit	2#0	
3	Pump1Pressure	Signed	+0	
4	Pump1Rpm	Signed	+0	
5	M3.7	Bit	2#0	
6	VB100	Hexadecimal	16#00	
7	VD200	Floating Point	0.0	
8		Signed		

Figure 5-10 Status Chart

To build a status chart and monitor the variables:

1. Enter the address for each desired value in the Address field.
2. Select the data type in the Format column.
3. To view the status of the process variables in your S7-200, select the **Debug > Chart Status** menu command.
4. To continuously sample the values, or to perform a single read of the status, click the button on the toolbar. The Status Chart also allows you to modify or force values for the different process variables.

You can insert additional rows in your Status Chart by selecting the **Edit > Insert > Row** menu command.

Tip

You can create multiple status charts to divide the variables into logical groups so that each group can be viewed in a shorter and separate status chart.

Creating an Instruction Library

STEP 7-Micro/WIN allows you either to create a custom library of instructions, or to use a library created by someone else. See Figure 5-11.

To create a library of instructions, you create standard STEP 7-Micro/WIN subroutine and interrupt routines and group them together. You can hide the code in these routines to prevent accidental changes or to protect the technology (know-how) of the author.

To create an instruction library, perform the following tasks:

1. Write the program as a standard STEP 7-Micro/WIN project and put the function to be included in the library into subroutines or interrupt routines.
2. Ensure that all V memory locations in the subroutines or interrupt routines have been assigned a symbolic name. To minimize the amount of V memory that the library requires, use sequential V memory locations.
3. Rename the subroutines or interrupt routines to the names that you want to appear in the instruction library.
4. Select the **File > Create Library** menu command to compile the new instruction library.

For more information about creating libraries, refer to the online help for STEP 7-Micro/WIN.

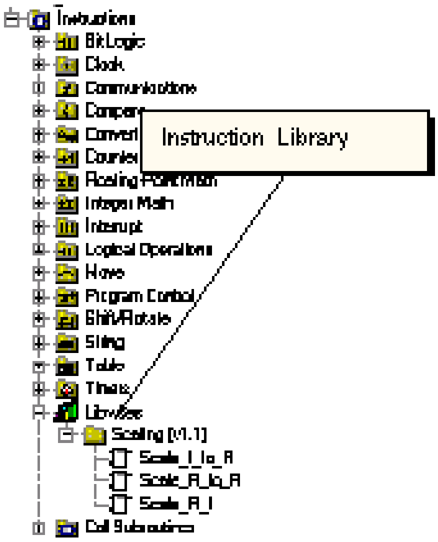


Figure 5-11 Instruction Tree with Libraries

Use the following procedure to access an instruction in an instruction library:

1. Add the Libraries directory to the instruction tree by selecting the **File > Add Libraries** menu command.
2. Select the specific instruction and insert it into your program (as you would any standard instruction).

   If the library routine requires any V memory, STEP 7-Micro/WIN prompts you when the project is compiled to assign a block of memory. Use the Library Memory Allocation dialog box to assign blocks of memory.

Features for Debugging Your Program

STEP 7-Micro/WIN provides the following features to help you debug your program:

- ❑ Bookmarks in your program to make it easy to move back and forth between lines of a long program.
- ❑ Cross Reference table allow you to check the references used in your program.
- ❑ RUN-mode editing allows you to make small changes to your program with minimal disturbance to the process controlled by the program. You can also download the program block when you are editing in RUN mode.

For more information about debugging your program, refer to Chapter 8.

S7-200 Instruction Set

6

This chapter describes the SIMATIC and IEC 1131 instruction set for the S7-200 Micro PLCs.

In This Chapter

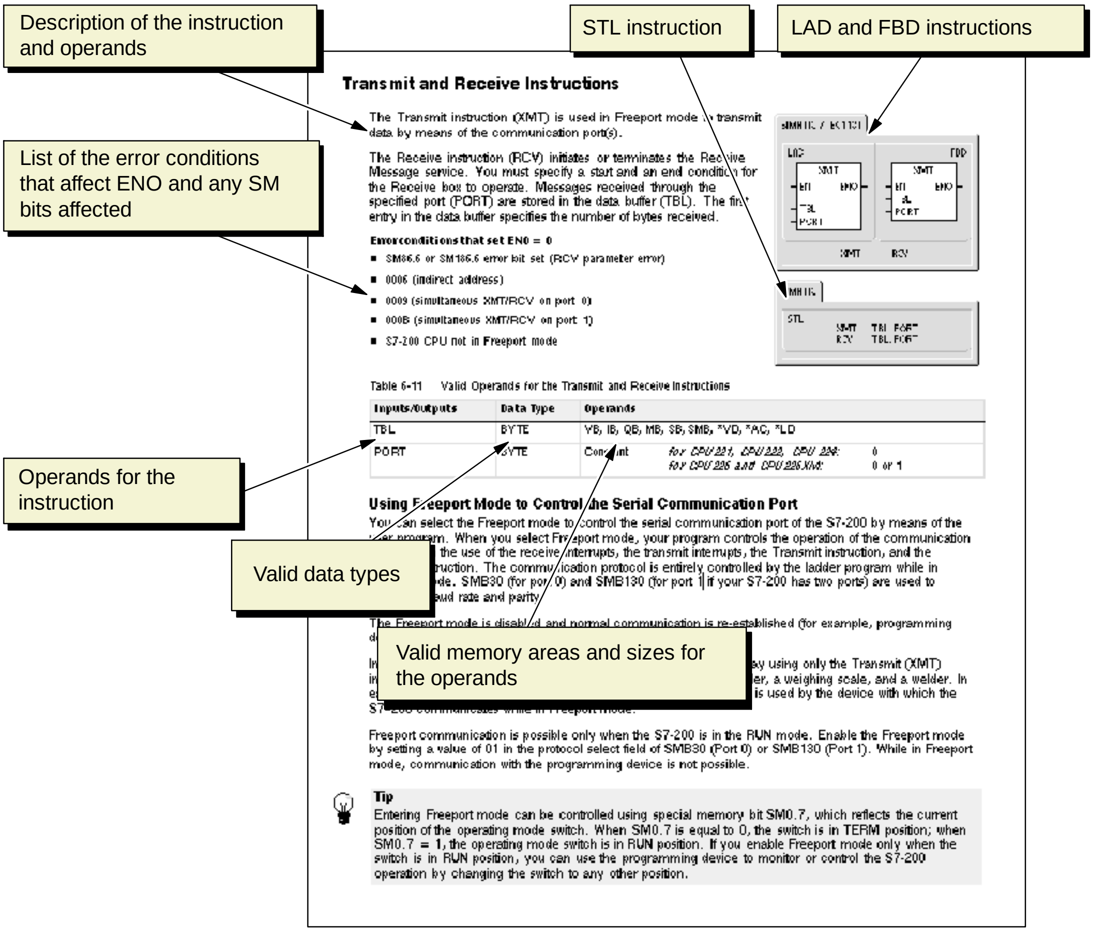
Conventions Used to Describe the Instructions

Figure 6-1 shows a typical description for an instruction and points to the different areas used to describe the instruction and its operation. The illustration of the instruction shows the format in LAD, FBD, and STL. The operand table lists the operands for the instruction and shows the valid data types, memory areas and sizes for each operand.

EN/ENO operands and data types are not shown in the instruction operand table because the operands are the same for all LAD and FBD instructions.

❑ *For LAD:* EN and ENO are power flow and are BOOL data types.

❑ *For FBD:* EN and ENO are I, Q, V, M, SM, S, T, C, L, or power flow and are BOOL data types.


Description of the instruction and operands
STL instruction
LAD and FBD instructions
List of the error conditions that affect ENO and any SM bits affected
Operands for the instruction
Valid data types
Valid memory areas and sizes for the operands
LAD
FBD
XMT
EN
ENO
TBL
PORT
XMT
RCV
STL
XMT TBL, PORT
RCV TBL, PORT

Transmit and Receive Instructions

The Transmit instruction (XMT) is used in Freeport mode to transmit data by means of the communication port(s).

The Receive instruction (RCV) initiates or terminates the Receive Message service. You must specify a start and an end condition for the Receive box to operate. Messages received through the specified port (PORT) are stored in the data buffer (TBL). The first entry in the data buffer specifies the number of bytes received.

Error conditions that set ENO = 0

- SM86.6 or SM186.6 error bit set (RCV parameter error)
- 0006 (indirect address)
- 0009 (simultaneous XMT/RCV on port 0)
- 000B (simultaneous XMT/RCV on port 1)
- S7-200 CPU not in Freeport mode

Table 6-11 Valid Operands for the Transmit and Receive Instructions

Inputs/Outputs	Data Type	Operands		
TBL	BYTE	VB, IB, QB, MB, SB, SMB, *VD, *AC, *LD		

PORT	BYTE	Constant	*for CPU 221, CPU 222, CPU 224:*
			for CPU 226 and CPU 226XM:
				0
				0 or 1

Using Freeport Mode to Control the Serial Communication Port

You can select the Freeport mode to control the serial communication port of the S7-200 by means of the user program. When you select Freeport mode, your program controls the operation of the communication ... the use of the receive interrupts, the transmit interrupts, the Transmit instruction, and the ...truction. The communication protocol is entirely controlled by the ladder program while in ...de. SMB30 (for port 0) and SMB130 (for port 1 if your S7-200 has two ports) are used to ...aud rate and parity.

The Freeport mode is disabled and normal communication is re-established (for example, programming d...

In... ...ay using only the Transmit (XMT) in... ...er, a weighing scale, and a welder. In e... ...is used by the device with which the S7-200 communicates while in Freeport mode.

Freeport communication is possible only when the S7-200 is in the RUN mode. Enable the Freeport mode by setting a value of 01 in the protocol select field of SMB30 (Port 0) or SMB130 (Port 1). While in Freeport mode, communication with the programming device is not possible.

Tip

Entering Freeport mode can be controlled using special memory bit SM0.7, which reflects the current position of the operating mode switch. When SM0.7 is equal to 0, the switch is in TERM position; when SM0.7 = 1, the operating mode switch is in RUN position. If you enable Freeport mode only when the switch is in RUN position, you can use the programming device to monitor or control the S7-200 operation by changing the switch to any other position.

Figure 6-1 Instruction Descriptions

S7-200 Memory Ranges and Features

Table 6-1 Memory Ranges and Features for the S7-200 CPUs

Description	CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
User program size with run mode edit without run mode edit	 4096 bytes 4096 bytes	 4096 bytes 4096 bytes	 8192 bytes 12288 bytes	 12288 bytes 16384 bytes	 16384 bytes 24576 bytes
User data size	2048 bytes	2048 bytes	8192 bytes	10240 bytes	10240 bytes
Process-image input register	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7
Process-image output register	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7
Analog inputs (read only)	AIW0 to AIW30	AIW0 to AIW30	AIW0 to AIW62	AIW0 to AIW62	AIW0 to AIW62
Analog outputs (write only)	AQW0 to AQW30	AQW0 to AQW30	AQW0 to AQW62	AQW0 to AQW62	AQW0 to AQW62
Variable memory (V)	VB0 to VB2047	VB0 to VB2047	VB0 to VB8191	VB0 to VB10239	VB0 to VB10239
Local memory (L)[1]	LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63
Bit memory (M)	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7
Special Memory (SM) Read only	SM0.0 to SM179.7 SM0.0 to SM29.7	SM0.0 to SM299.7 SM0.0 to SM29.7	SM0.0 to SM549.7 SM0.0 to SM29.7	SM0.0 to SM549.7 SM0.0 to SM29.7	SM0.0 to SM549.7 SM0.0 to SM29.7
Timers	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)
Retentive on-delay 1 ms	T0, T64	T0, T64	T0, T64	T0, T64	T0, T64
10 ms	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68
100 ms	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95
On/Off delay 1 ms	T32, T96	T32, T96	T32, T96	T32, T96	T32, T96
10 ms	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100
100 ms	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255
Counters	C0 to C255	C0 to C255	C0 to C255	C0 to C255	C0 to C255
High-speed counters	HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5
Sequential control relays (S)	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7
Accumulator registers	AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3
Jumps/Labels	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
Call/Subroutine	0 to 63	0 to 63	0 to 63	0 to 63	0 to 127
Interrupt routines	0 to 127	0 to 127	0 to 127	0 to 127	0 to 127
Positive/negative transitions	256	256	256	256	256
PID loops	0 to 7	0 to 7	0 to 7	0 to 7	0 to 7
Ports	Port 0	Port 0	Port 0	Port 0, Port 1	Port 0, Port 1

[1] LB60 to LB63 are reserved by STEP 7-Micro/WIN, version 3.0 or later.

Table 6-2 Operand Ranges for the S7-200 CPUs

Access Method		CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
Bit access (byte.bit)	I	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7
	Q	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7	0.0 to 15.7
	V	0.0 to 2047.7	0.0 to 2047.7	0.0 to 8191.7	0.0 to 10239.7	0.0 to 10239.7
	M	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7
	SM	0.0 to 165.7	0.0 to 299.7	0.0 to 549.7	0.0 to 549.7	0.0 to 549.7
	S	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7	0.0 to 31.7
	T	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
	C	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
	L	0.0 to 63.7	0.0 to 63.7	0.0 to 63.7	0.0 to 63.7	0.0 to 63.7
Byte access	IB	0 to 15	0 to 15	0 to 15	0 to 15	0 to 15
	QB	0 to 15	0 to 15	0 to 15	0 to 15	0 to 15
	VB	0 to 2047	0 to 2047	0 to 8191	0 to 10239	0 to 10239
	MB	0 to 31	0 to 31	0 to 31	0 to 31	0 to 31
	SMB	0 to 165	0 to 299	0 to 549	0 to 549	0 to 549
	SB	0 to 31	0 to 31	0 to 31	0 to 31	0 to 31
	LB	0 to 63	0 to 63	0 to 63	0 to 63	0 to 63
	AC	0 to 3	0 to 3	0 to 3	0 to 255	0 to 255
	KB (Constant)	KB (Constant)	KB (Constant)	KB (Constant)	KB (Constant)	KB (Constant)
Word access	IW	0 to 14	0 to 14	0 to 14	0 to 14	0 to 14
	QW	0 to 14	0 to 14	0 to 14	0 to 14	0 to 14
	VW	0 to 2046	0 to 2046	0 to 8190	0 to 10238	0 to 10238
	MW	0 to 30	0 to 30	0 to 30	0 to 30	0 to 30
	SMW	0 to 164	0 to 298	0 to 548	0 to 548	0 to 548
	SW	0 to 30	0 to 30	0 to 30	0 to 30	0 to 30
	T	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
	C	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
	LW	0 to 62	0 to 62	0 to 62	0 to 62	0 to 62
	AC	0 to 3	0 to 3	0 to 3	0 to 3	0 to 3
	AIW	0 to 30	0 to 30	0 to 62	0 to 62	0 to 62
	AQW	0 to 30	0 to 30	0 to 62	0 to 62	0 to 62
	KW (Constant)	KW (Constant)	KW (Constant)	KW (Constant)	KW (Constant)	KW (Constant)
Double word access	ID	0 to 12	0 to 12	0 to 12	0 to 12	0 to 12
	QD	0 to 12	0 to 12	0 to 12	0 to 12	0 to 12
	VD	0 to 2044	0 to 2044	0 to 8188	0 to 10236	0 to 10236
	MD	0 to 28	0 to 28	0 to 28	0 to 28	0 to 28
	SMD	0 to 162	0 to 296	0 to 546	0 to 546	0 to 546
	SD	0 to 28	0 to 28	0 to 28	0 to 28	0 to 28
	LD	0 to 60	0 to 60	0 to 60	0 to 60	0 to 60
	AC	0 to 3	0 to 3	0 to 3	0 to 3	0 to 3
	HC	0 to 5	0 to 5	0 to 5	0 to 5	0 to 5
	KD (Constant)	KD (Constant)	KD (Constant)	KD (Constant)	KD (Constant)	KD (Constant)

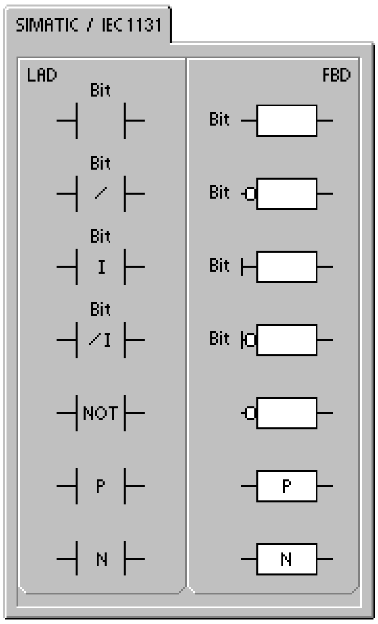
Bit Logic Instructions

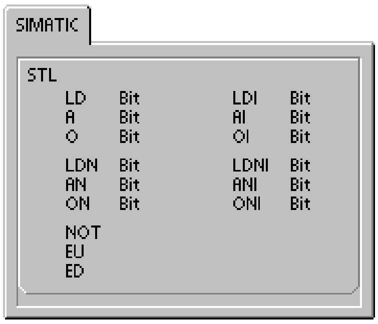
Contacts

Standard Contacts

The Normally Open contact instructions (LD, A, and O) and Normally Closed contact instructions (LDN, AN, ON) obtain the referenced value from the memory or from the process-image register. The standard contact instructions obtain the referenced value from the memory (or process-image register if the data type is I or Q).

The Normally Open contact is closed (on) when the bit is equal to 1, and the Normally Closed contact is closed (on) when the bit is equal to 0. In FBD, inputs to both the And and Or boxes can be expanded to a maximum of 32 inputs. In STL, the Normally Open instructions Load, AND, or OR the bit value of the address bit to the top of the stack, and the Normally Closed instructions Load, AND, or OR the logical NOT of the bit value to the top of the stack.




SIMATIC

```
STL
     LD    Bit           LDI    Bit
     A     Bit           AI     Bit
     O     Bit           OI     Bit
     LDN   Bit           LDNI   Bit
     AN    Bit           ANI    Bit
     ON    Bit           ONI    Bit
     NOT
     EU
     ED
```

Immediate Contacts

An immediate contact does not rely on the S7-200 scan cycle to update; it updates immediately. The Normally Open Immediate contact instructions (LDI, AI, and OI) and Normally Closed Immediate contact instructions (LDNI, ANI, and ONI) obtain the physical input value when the instruction is executed, but the process-image register is not updated.

The Normally Open Immediate contact is closed (on) when the physical input point (bit) is 1, and the Normally Closed Immediate contact is closed (on) when the physical input point (bit) is 0. The Normally Open instructions immediately Load, AND, or OR the physical input value to the top of the stack, and the Normally Closed instructions immediately Load, AND, or OR the logical NOT of the value of the physical input point to the top of the stack.

NOT Instruction

The Not instruction (NOT) changes the state of power flow input (that is, it changes the value on the top of the stack from 0 to 1 or from 1 to 0).

Positive and Negative Transition Instructions

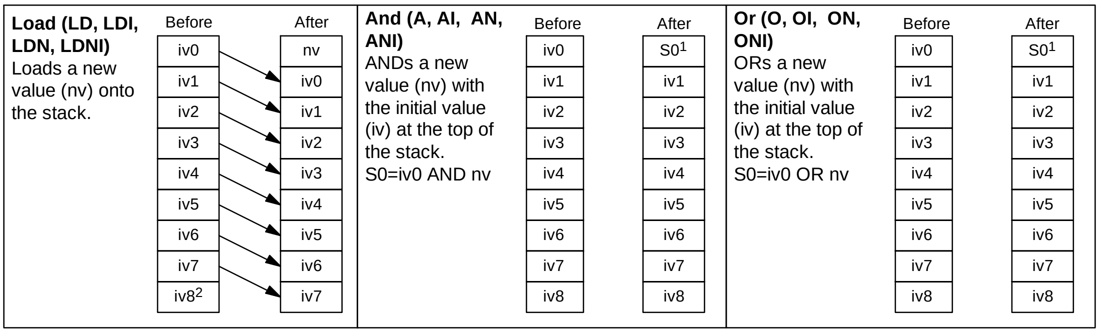
The Positive Transition contact instruction (EU) allows power to flow for one scan for each off-to-on transition. The Negative Transition contact instruction (ED) allows power to flow for one scan for each on-to-off transition. For the Positive Transition instruction, detection of a 0-to-1 transition in the value on the top of the stack sets the top of the stack value to 1; otherwise, it is set to 0. For a Negative Transition instruction, detection of a 1-to-0 transition in the value on the top of the stack sets the top of the stack value to 1; otherwise, it is set to 0.

For run mode editing (when you edit your program in RUN mode), you must enter a parameter for the Positive Transition and Negative Transition instructions. Refer to Chapter 5 for more information about editing in RUN mode.

Table 6-3 Valid Operands for the Bit Logic Input Instructions

Inputs/Outputs	Data Type	Operands
Bit	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Bit (immediate)	BOOL	I

As shown in Figure 6-2, the S7-200 uses a logic stack to resolve the control logic. In these examples, “iv0” to “iv7” identify the initial values of the logic stack, “nv” identifies a new value provided by the instruction, and “S0” identifies the calculated value that is stored in the logic stack.



Load (LD, LDI, LDN, LDNI)
Loads a new value (nv) onto the stack.

Before	After
iv0	nv
iv1	iv0
iv2	iv1
iv3	iv2
iv4	iv3
iv5	iv4
iv6	iv5
iv7	iv6
iv8[2]	iv7

And (A, AI, AN, ANI)
ANDs a new value (nv) with the initial value (iv) at the top of the stack.
S0=iv0 AND nv

Before	After
iv0	S0[1]
iv1	iv1
iv2	iv2
iv3	iv3
iv4	iv4
iv5	iv5
iv6	iv6
iv7	iv7
iv8	iv8

Or (O, OI, ON, ONI)
ORs a new value (nv) with the initial value (iv) at the top of the stack.
S0=iv0 OR nv

Before	After
iv0	S0[1]
iv1	iv1
iv2	iv2
iv3	iv3
iv4	iv4
iv5	iv5
iv6	iv6
iv7	iv7
iv8	iv8

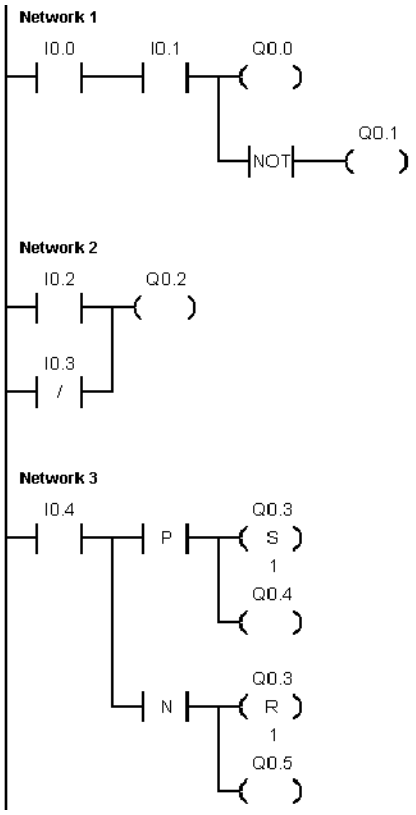
[1] S0 identifies the calculated value that is stored in the logic stack.
[2] After the execution of a Load, the value iv8 is lost.

Figure 6-2 Operations of the Contact Instructions.

Tip

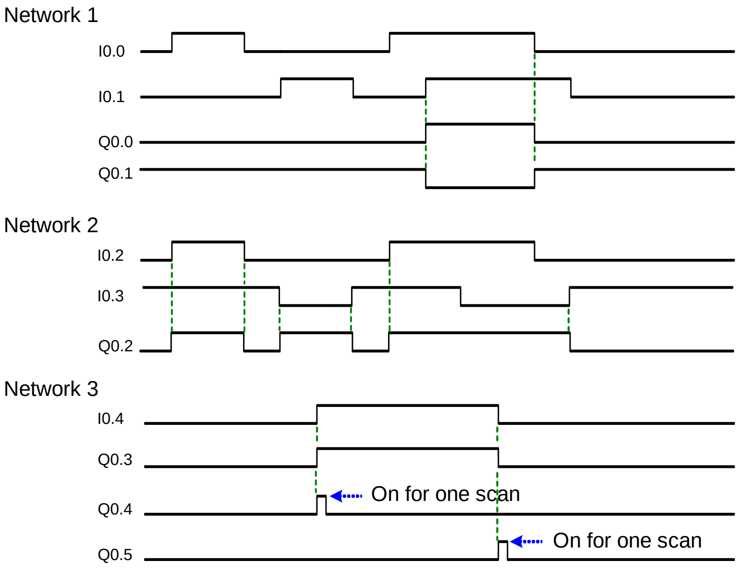
Because the Positive Transition and Negative Transition instructions require an on-to-off or an off-to-on transition, you cannot detect an edge-up or edge-down transition on the first scan. During the first scan, the S7-200 sets the state of the bit specified by these instructions. On subsequent scans, these instructions can then detect transitions for the specified bit.

Example: Contact Instructions

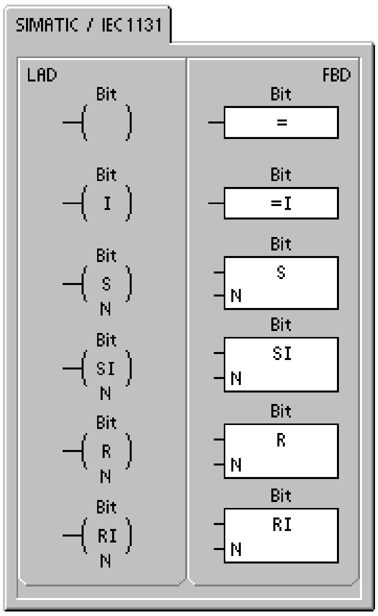


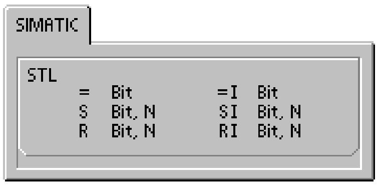
```
Network 1    //N.O. contacts I0.0 AND I0.1 must be on
             //(closed) to activate Q0.0. The NOT
             //instruction acts as an inverter. In RUN
             // mode, Q0.0 and Q0.1 have opposite logic states.
LD      I0.0
A       I0.1
=       Q0.0
NOT
=       Q0.1
Network 2    //N.O. contact I0.2 must be on or N.C.
             //contact I0.3 must be off to activate Q0.2.
             // One or more parallel LAD branches
             //(OR logic inputs) must be true to make
             //the output active.
LD      I0.2
ON      I0.3
=       Q0.2
Network 3    //A positive Edge Up input on a P contact
             //or a negative Edge Down input on a N contact
             //outputs a pulse with a 1 scan cycle
             //duration. In RUN mode, the pulsed state
             //changes of Q0.4 and Q0.5 are too fast to
             // be visible in program status view.
             //The Set and Reset outputs latch the
             // pulse in Q0.3 and make the state
             //change visible in program status view.
LD      I0.4
LPS
EU
S       Q0.3, 1
=       Q0.4
LPP
ED
R       Q0.3, 1
=       Q0.5
```

Timing Diagram



Coils





```
STL
     =  Bit          =I  Bit
     S  Bit, N       SI  Bit, N
     R  Bit, N       RI  Bit, N
```

Output

The Output instruction (=) writes the new value for the output bit to the process-image register. When the Output instruction is executed, the S7-200 turns the output bit in the process-image register on or off. For LAD and FBD, the specified bit is set equal to power flow. For STL, the value on the top of the stack is copied to the specified bit.

Output Immediate

The Output Immediate instruction (=I) writes the new value to both the physical output and the corresponding process-image register location when the instruction is executed.

When the Output Immediate instruction is executed, the physical output point (Bit) is immediately set equal to power flow. For STL, the instruction immediately copies the value on the top of the stack to the specified physical output bit (STL). The “I” indicates an immediate reference; the new value is written to both the physical output and the corresponding process-image register location when the instruction is executed. This differs from the non-immediate references, which write the new value to the process-image register only.

Set and Reset

The Set (S) and Reset (R) instructions set (turn on) or reset (turn off) the specified number of points (N), starting at the specified address (Bit). You can set or reset from 1 to 255 points.

If the Reset instruction specifies either a timer bit (T) or counter bit (C), the instruction resets the timer or counter bit and clears the current value of the timer or counter.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)

Set Immediate and Reset Immediate

The Set Immediate and Reset Immediate instructions immediately set (turn on) or immediately reset (turn off) the number of points (N), starting at specified address (Bit). You can set or reset from 1 to 128 points immediately.

The “I” indicates an immediate reference; when the instruction is executed, the new value is written to both the physical output point and the corresponding process-image register location. This differs from the non-immediate references, which write the new value to the process-image register only.

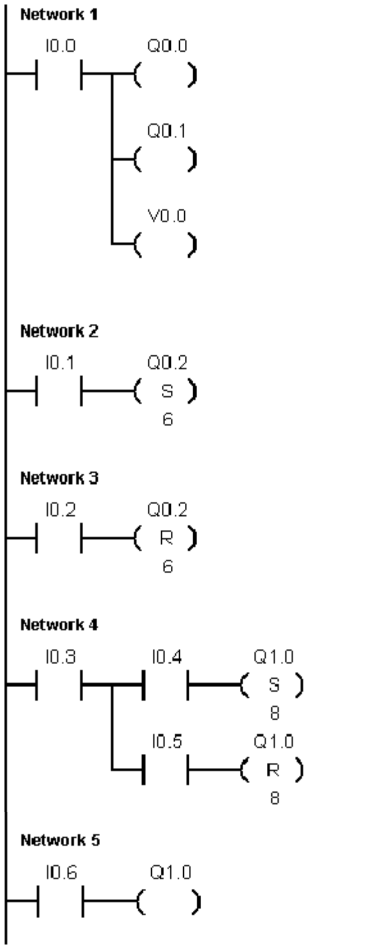
Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)

Table 6-4 Valid Operands for the Bit Logic Output Instructions

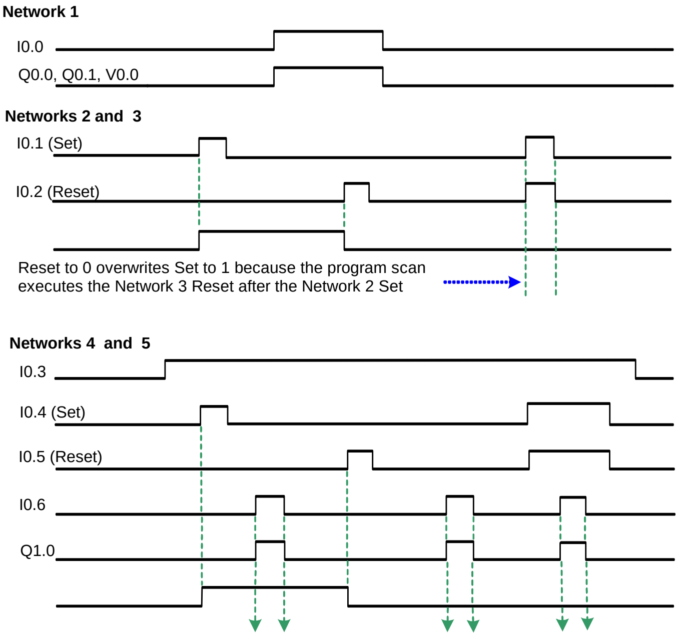
Inputs/Outputs	Data Type	Operands
Bit	BOOL	I, Q, V, M, SM, S, T, C, L
Bit (immediate)	BOOL	Q
N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant

Example: Coil Instructions



```
Network 1   //Output instructions assign bit values to external I/O (I, Q)
            //and internal memory (M, SM, T, C, V, S, L).
LD     I0.0
=      Q0.0
=      Q0.1
=      V0.0
Network 2   //Set a sequential group of 6 bits to a value of 1. Specify a
            //starting bit address and how many bits to set. The program
            //status indicator for Set is ON when the value of the first bit
            //(Q0.2) is 1.
LD     I0.1
S      Q0.2, 6
Network 3   //Reset a sequential group of 6 bits to a value of 0.
            //Specify a starting bit address and how many bits to reset.
            //The program status indicator for Reset is ON when the value
            //of the first bit (Q0.2) is 0.
LD     I0.2
R      Q0.2, 6
Network 4   //Sets and resets 8 output bits (Q1.0 to Q1.7) as a group.
LD     I0.3
LPS
A      I0.4
S      Q1.0, 8
LPP
A      I0.5
R      Q1.0, 8
Network 5   //The Set and Reset instructions perform the function of a latched
            //relay. To isolate the Set/Reset bits, make sure they are not
            //overwritten by another assignment instruction. In this example,
            //Network 4 sets and resets eight output bits (Q1.0 to Q1.7)
            //as a group. In RUN mode, Network 5 can overwrite
            //the Q1.0 bit value and control the Set/Reset program
            //status indicators in Network 4.
LD     I0.6
=      Q1.0
```

Timing Diagram



Reset to 0 overwrites Set to 1 because the program scan executes the Network 3 Reset after the Network 2 Set

Network 5 Output bit (=) instruction overwrites the first bit (Q1.0) Set/Reset in Network 4 because the program scan executes the Network 5 assignment last

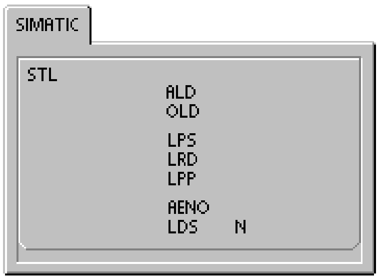
Logic Stack Instructions

AND Load

The AND Load instruction (ALD) combines the values in the first and second levels of the stack using a logical AND operation. The result is loaded in the top of stack. After the ALD is executed, the stack depth is decreased by one.

OR Load

The OR Load instruction (OLD) combines the values in the first and second levels of the stack, using a logical OR operation. The result is loaded in the top of the stack. After the OLD is executed, the stack depth is decreased by one.



```
STL
            ALD
            OLD

            LPS
            LRD
            LPP

            AENO
            LDS    N
```

Logic Push

The Logic Push instruction (LPS) duplicates the top value on the stack and pushes this value onto the stack. The bottom of the stack is pushed off and lost.

Logic Read

The Logic Read instruction (LRD) copies the second stack value to the top of stack. The stack is not pushed or popped, but the old top-of-stack value is destroyed by the copy.

Logic Pop

The Logic Pop instruction (LPP) pops one value off of the stack. The second stack value becomes the new top of stack value.

AND ENO

The AND ENO instruction (AENO) performs a logical AND of the ENO bit with the top of the stack to generate the same effect as the ENO bit of a box in LAD or FBD. The result of the AND operation is the new top of stack.

ENO is a Boolean output for boxes in LAD and FBD. If a box has power flow at the EN input and is executed without error, the ENO output passes power flow to the next element. You can use the ENO as an enable bit that indicates the successful completion of an instruction. The ENO bit is used with the top of stack to affect power flow for execution of subsequent instructions. STL instructions do not have an EN input. The top of the stack must be a logic 1 for conditional instructions to be executed. In STL there is also no ENO output. However, the STL instructions that correspond to LAD and FBD instructions with ENO outputs set a special ENO bit. This bit is accessible with the AENO instruction.

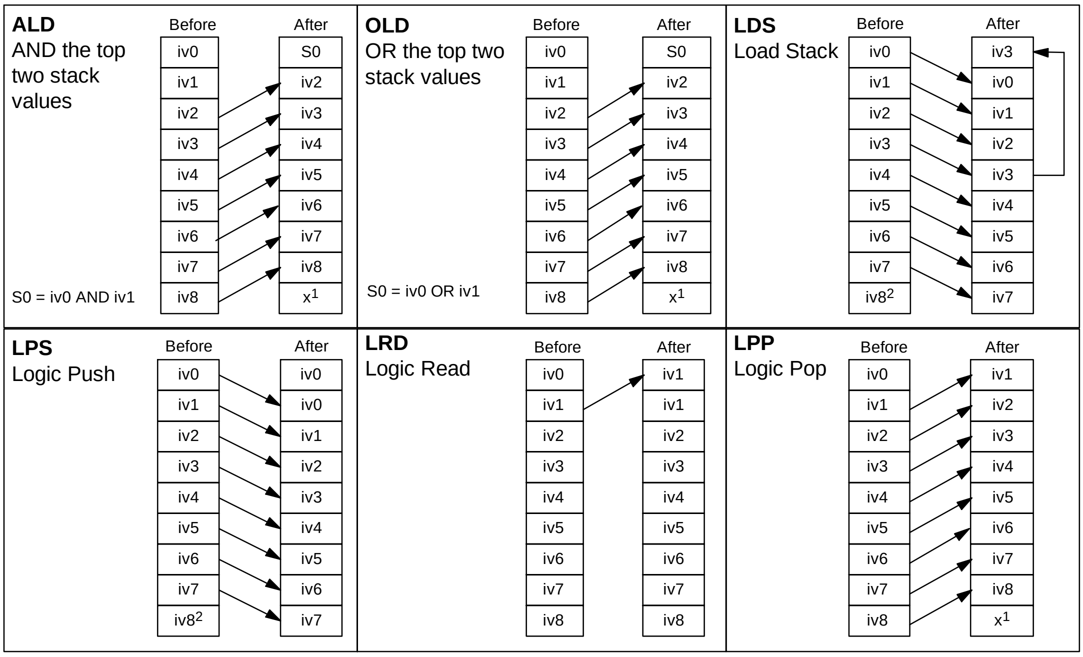
Load Stack

The Load Stack instruction (LDS) duplicates the stack bit (N) on the stack and places this value on top of the stack. The bottom of the stack is pushed off and lost.

Table 6-5 Valid Operands for the Load Stack Instruction

Inputs/Outputs	Data Type	Operands
N	BYTE	Constant (0 to 8)

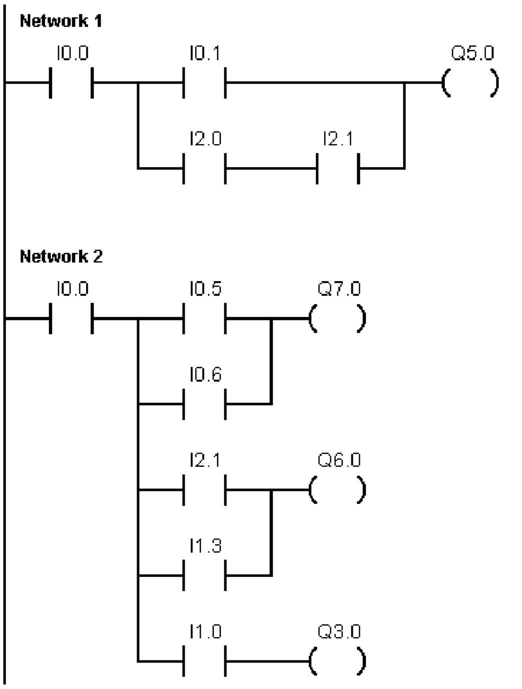
As shown in Figure 6-3, the S7-200 uses a logic stack to resolve the control logic. In these examples, “iv0” to “iv7” identify the initial values of the logic stack, “nv” identifies a new value provided by the instruction, and “S0” identifies the calculated value that is stored in the logic stack.


ALD
AND the top two stack values
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8
S0 iv2 iv3 iv4 iv5 iv6 iv7 iv8 x1
S0 = iv0 AND iv1
OLD
OR the top two stack values
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8
S0 iv2 iv3 iv4 iv5 iv6 iv7 iv8 x1
S0 = iv0 OR iv1
LDS
Load Stack
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv82
iv3 iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7
LPS
Logic Push
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv82
iv0 iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7
LRD
Logic Read
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8
iv1 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8
LPP
Logic Pop
Before
After
iv0 iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8
iv1 iv2 iv3 iv4 iv5 iv6 iv7 iv8 x1

[1] The value is unknown (it could be either a 0 or a 1).
[2] After the execution of a Logic Push or a Load Stack instruction, value iv8 is lost.

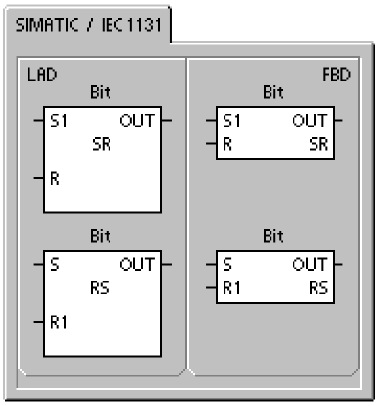
Figure 6-3 Operations of the Logic Stack Instructions

Example: Logic Stack Instructions



```
Network 1
LD      I0.0
LD      I0.1
LD      I2.0
A       I2.1
OLD
ALD
=       Q5.0
Network 2
LD      I0.0
LPS
LD      I0.5
O       I0.6
ALD
=       Q7.0
LRD
LD      I2.1
O       I1.3
ALD
=       Q6.0
LPP
A       I1.0
=       Q3.0
```

Set and Reset Dominant Bistable Instructions



The Set Dominant Bistable is a latch where the set dominates. If the set (S1) and reset (R) signals are both true, the output (OUT) is true.

The Reset Dominant Bistable is a latch where the reset dominates. If the set (S) and reset (R1) signals are both true, the output (OUT) is false.

The Bit parameter specifies the Boolean parameter that is set or reset. The optional output reflects the signal state of the Bit parameter.

Table 6-7 shows the truth tables for the sample program.

Table 6-6 Valid Operands for the Set Dominant Bistable and Reset Dominant Bistable Instructions

Inputs/Outputs	Data Types	Operands
S1, R	BOOL	I, Q, V, M, SM, S, T, C, Power Flow
S, R1, OUT	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Bit	BOOL	I, Q, V, M, S

Example: Set and Reset Dominant Bistable Instructions

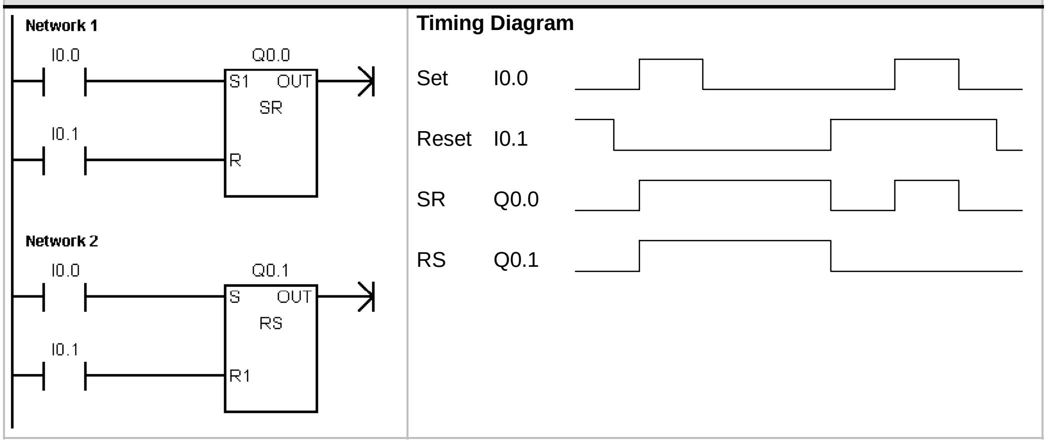
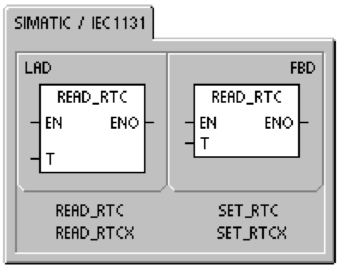


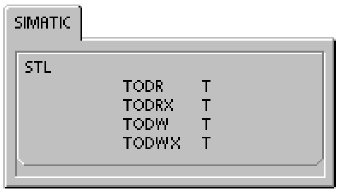
Table 6-7 Truth Table for the Set and Reset Dominant Bistable Instructions

Instruction	S1	R	Out (Bit)
Set Dominant Bistable instruction (SR)	0	0	Previous state
	0	1	0
	1	0	1
	1	1	1
Instruction	**S**	**R1**	**Out (Bit)**
Reset Dominant Bistable instruction (RS)	0	0	Previous state
	0	1	0
	1	0	1
	1	1	0

Clock Instructions

Read Real-Time Clock and Set Real-Time Clock





```
STL
          TODR    T
          TODRX   T
          TODW    T
          TODWX   T
```

The Read Real-Time Clock (TODR) instruction reads the current time and date from the hardware clock and loads it in an 8-byte Time buffer starting at address T. The Set Real-Time Clock (TODW) instruction writes the current time and date to the hardware clock, beginning at the 8-byte Time buffer address specified by T.

You must code all date and time values in BCD format (for example, 16#97 for the year 1997). Figure 6-4 shows the format of the 8-Byte Time buffer (T).

The time-of-day (TOD) clock initializes the following date and time after extended power outages or when memory has been lost:

Date:	01–Jan–90
Time:	00:00:00
Day of Week:	Sunday

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0007 (TOD data error) *Set Real-Time Clock only*
- 000C (clock not present)

Table 6-8 Valid Operands for the Clock Instructions

Inputs/Outputs	Data Types	Operands
T	BYTE	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC

T	T+1	T+2	T+3	T+4	T+5	T+6	T+7
Year: 00 to 99	Month: 01 to 12	Day: 01 to 31	Hours: 00 to 23	Minutes: 00 to 59	Seconds: 00 to 59	0	Day of Week: 0 to 7*

*T+7 1=Sunday, 7=Saturday
0 disables the day of week.

Figure 6-4 Format of the 8-Byte Time Buffer (T)

Tip

The S7-200 CPU does not perform a check to verify that the day of week is correct based upon the date. Invalid dates, such as February 30, could be accepted. You should ensure that the date you enter is correct.

Do not use the TODR/TODW instruction in both the main program and in an interrupt routine. A TODR/TODW instruction in an interrupt routine that attempts to execute while another TODR/TODW instruction is in process cannot be executed. SM4.3 is set indicating that two simultaneous accesses to the clock were attempted (non-fatal error 0007).

The time-of-day clock in the S7-200 uses only the least significant two digits for the year, so for the year 2000, the year is represented as 00. The S7-200 PLC does not use the year information in any way. However, user programs that use arithmetic or compares with the year's value must take into account the two-digit representation and the change in century.

Leap year is correctly handled through year 2096.

Read Real Time Clock Extended

The Read Real Time Clock Extended (TODRX) instruction reads the current time, date, and daylight savings configuration from the PLC and loads it in a 19-byte buffer beginning at the address specified by T.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 000C (clock cartridge not present)
- 0091 (range error)

Set Real Time Clock Extended

The Set Real Time Clock (TODWX) instruction writes the current time, date, and daylight savings configuration to the PLC beginning at the 19-byte buffer address specified by T.

You must code all date and time values in BCD format (for example, 16#02 for the year 2002). Table 6-9 shows the format of the 19-Byte Time Buffer (T).

The time-of-day clock initializes the following date and time after extended power outages or memory has been lost:

Date:	01–Jan–90
Time	00:00:00
Day of Week:	Sunday

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0007 (TOD data error)
- 000C (clock cartridge not present)
- 0091 (range error)

Tip

The only time the S7-200 CPU uses bytes 9 to18 is when the "User Specified" mode is selected in byte 8. Otherwise, the last value written to these bytes by STEP 7–Micro/WIN or the SET_RTCX instruction is returned.

Table 6-9 Format of the 19-Byte Time Buffer (TI)

T Byte	Description	Byte Data
0	year (0–99)	current year (BCD value)
1	month (1–12)	current month (BCD value)
2	day (1–31)	current day (BCD value
3	hour (0–23)	current hour (BCD value)
4	minute (0–59)	current minute (BCD value)
5	second (0–59)	current second (BCD value)
6	00	reserved – always set to 00
7	day of week (1–7)	current day of the week, 1=Sunday (BCD value)
8	mode (00H–03H, 08H, 10H–13H, FFH)	correction mode: 00H = correction disabled 01H = EU (time zone offset from UTC = 0 hrs) [1] 02H = EU (time zone offset from UTC = +1 hrs) [1] 03H = EU (time zone offset from UTC = +2 hrs) [1] 04H–07H = reserved 08H = EU (time zone offset from UTC = –1 hrs) [1] 09H–0FH = reserved 10H = US [2] 11H = Australia [3] 12H = Australia (Tasmania) [4] 13H = New Zealand [5] 14H–FEH = reserved FFH = user specified (using values in bytes 9–18)
9	correction hours (0–23)	correction amount, hours (BCD value)
10	correction minutes (0–59)	correction amount, minutes (BCD value)
11	beginning month (1–12)	beginning month of daylight saving time (BCD value)
12	beginning day (1–31)	beginning day of daylight saving time (BCD value)
13	beginning hour (0–23)	beginning hour of daylight saving time (BCD value)
14	beginning minute (0–59)	beginning minute of daylight saving time (BCD value)
15	ending month (1–12)	ending month of daylight saving time (BCD value)
16	ending day (1–31)	ending day of daylight saving time (BCD value)
17	ending hour (0–23)	ending hour of daylight saving time (BCD value
18	ending minute (0–59)	ending minute of daylight saving time (BCD value)

[1] EU convention: Adjust time ahead one hour on last Sunday in March at 1:00 a.m. UTC. Adjust time back one hour on last Sunday in October at 2:00 a.m UTC. (The local time when the correction is made depends upon the time zone offset from UTC).

[2] US convention: Adjust time ahead one hour on first Sunday in April at 2:00 a.m local time. Adjust time back one hour on last Sunday in October at 2:00 a.m local time.

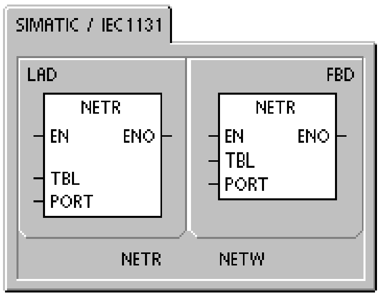
[3] Australia convention: Adjust time ahead one hour on last Sunday in October at 2:00 a.m. local time. Adjust time back one hour on last Sunday in March at 3:00 a.m. local time.

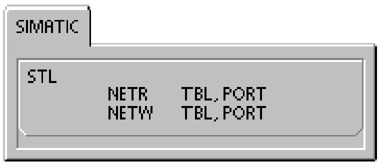
[4] Australia (Tasmania) convention: Adjust time ahead one hour on first Sunday in October at 2:00 a.m. local time. Adjust time back one hour on last Sunday in March at 3:00 a.m. local time

[5] New Zealand convention: Adjust time ahead one hour on first Sunday in October at 2:00 a.m. local time. Adjust time back one hour on first Sunday on or after March 15 at 3:00 a.m. local time

Communications Instructions

Network Read and Network Write Instructions





```
NETR    TBL, PORT
NETW    TBL, PORT
```

The Network Read instruction (NETR) initiates a communications operation to gather data from a remote device through the specified port (PORT), as defined by the table (TBL). The Network Write instruction (NETW) initiates a communications operation to write data to a remote device through the specified port (PORT), as defined by the table (TBL).

Error conditions that set ENO = 0:

- 0006 (indirect address)
- If the function returns an error and sets the E bit of table status byte (see Figure 6-5)

The Network Read instruction can read up to 16 bytes of information from a remote station, and the Network Write instruction can write up to 16 bytes of information to a remote station.

You can have any number of Network Read and Network Write instructions in the program, but only a maximum of eight Network Read and Network Write instructions can be activated at any one time. For example, you can have 4 Network Read and 4 Network Write instructions, or 2 Network Read and 6 Network Write instructions, active at the same time in a given S7-200.

Instruction Wizard

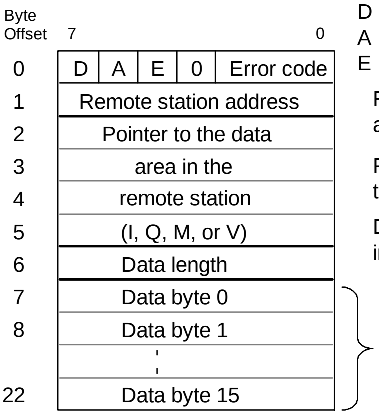
You can use the Network Read/Network Write Instruction Wizard to configure the counter. To start the Network Read/Network Write Instruction Wizard, select the **Tools > Instruction Wizard** menu command and then select Network Read/Network Write from the Instruction Wizard window.

Table 6-10 Valid Operands for the Network Read and Network Write Instructions

Inputs/Outputs	Data Type	Operands		
TBL	BYTE	VB, MB, *VD, *LD, *AC		

PORT	BYTE	Constant	*for CPU 221, CPU 222, CPU 224:*
			for CPU 224XP, CPU 226:
				0
				0 or 1

Figure 6-5 describes the table that is referenced by the TBL parameter, and Table 6-11 lists the error codes.



Byte Offset	7				0
0	D	A	E	0	Error code
1	Remote station address				
2	Pointer to the data				
3	area in the				
4	remote station				
5	(I, Q, M, or V)				
6	Data length				
7	Data byte 0				
8	Data byte 1				
	⋮				
22	Data byte 15				

D	Done (function has been completed):	0 = not done	1 = done
A	Active (function has been queued):	0 = not active	1 = active
E	Error (function returned an error):	0 = no error	1 = error

Remote station address: the address of the PLC whose data is to be accessed.

Pointer to the data area in the remote station: an indirect pointer to the data that is to be accessed.

Data length: the number of bytes of data that are to be accessed in the remote station (1 to 16 bytes).

Receive or transmit data area. 1 to 16 bytes reserved for the data.

For a Network Read instruction, stores the values that were read from the remote station when the instruction was executed.

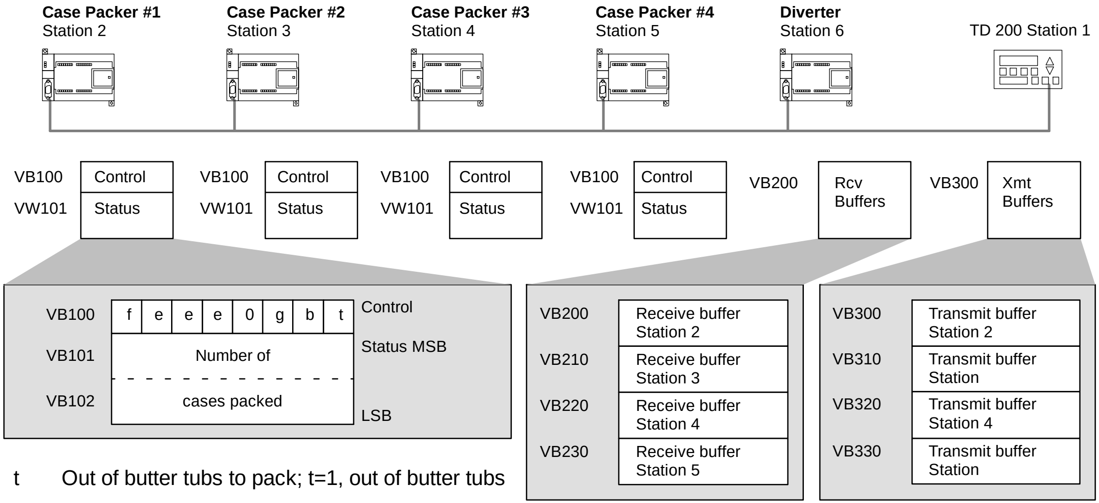
For a Network Write instruction, stores the values to be sent to the remote station when the instruction is executed.

Figure 6-5 TBL Parameter for the Network Read and Network Write Instructions

Table 6-11 Error Codes for the TBL Parameter

Code	Definition
0	No error.
1	Time-out error: Remote station not responding.
2	Receive error: Parity, framing, or checksum error in the response.
3	Offline error: Collisions caused by duplicate station addresses or failed hardware.
4	Queue overflow error: More than 8 Network Read or Network Write instructions have been activated.
5	Protocol violation: Attempt to execute a Network Read or Network Write instruction without enabling the PPI Master Mode in SMB30 or SMB130.
6	Illegal parameter: TBL parameter contains an illegal or invalid value.
7	No resource: Remote station is busy. (An upload or a download sequence is in process.)
8	Layer 7 error: Application protocol violation
9	Message error: Wrong data address or incorrect data length
A to F	Not used. (Reserved)

Figure 6-6 shows an example to illustrate the utility of the Network Read and Network Write instructions. For this example, consider a production line where tubs of butter are being filled and sent to one of four boxing machines (case packers). The case packer packs eight tubs of butter into a single cardboard box. A diverter machine controls the flow of butter tubs to each of the case packers. Four S7-200s control the case packers, and an S7-200 with a TD 200 operator interface controls the diverter.



t Out of butter tubs to pack; t=1, out of butter tubs

b Box supply is low; b=1, must add boxes in the next 30 minutes

g Glue supply is low; g=1, must add glue in the next 30 minutes

eee error code identifying the type of fault experienced

f Fault indicator; f=1, the case packer has detected an error

Figure 6-6 Example of the Network Read and Network Write Instructions

Figure 6-7 shows the receive buffer (VB200) and transmit buffer (VB300) for accessing the data in station 2. The S7-200 uses a Network Read instruction to read the control and status information on a continuous basis from each of the case packers. Each time a case packer has packed 100 cases, the diverter notes this and sends a message to clear the status word using a Network Write instruction.

Receive Buffer *for reading from Case Packer #1*

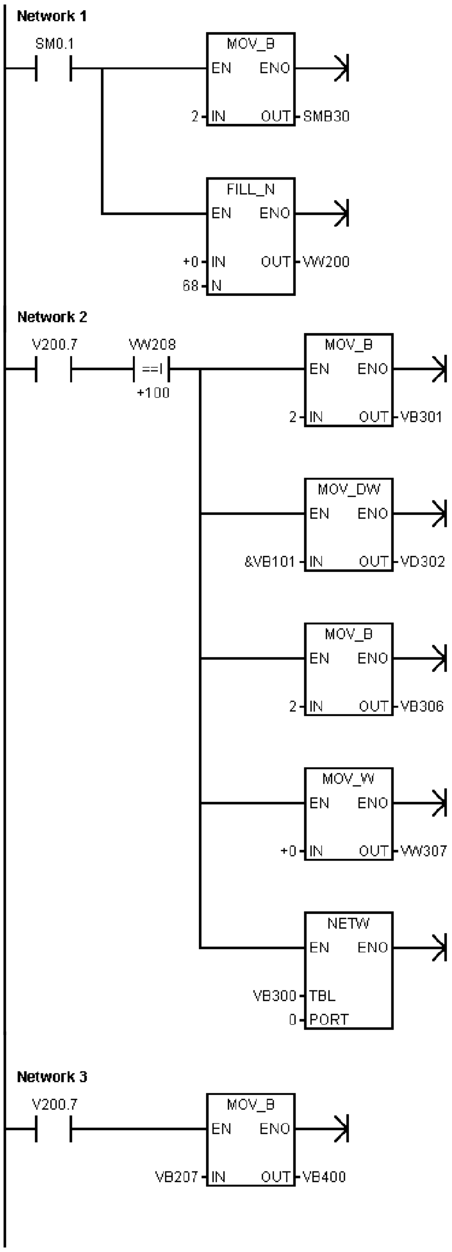
	7				0
VB200	D	A	E	0	Error Code
VB201	Remote station address = 2				
VB202	Pointer to the				
VB203	data area				
VB204	in the				
VB205	Remote station = (&VB100)				
VB206	Data length = 3 bytes				
VB207	Control				
VB208	Status (MSB)				
VB209	Status (LSB)				

Transmit Buffer *for clearing the count of Case Packer #1*

	7				0
VB300	D	A	E	0	Error Code
VB301	Remote station address = 2				
VB302	Pointer to the				
VB303	data area				
VB304	in the				
VB305	Remote station = (&VB101)				
VB306	Data length = 2 bytes				
VB307	0				
VB308	0				

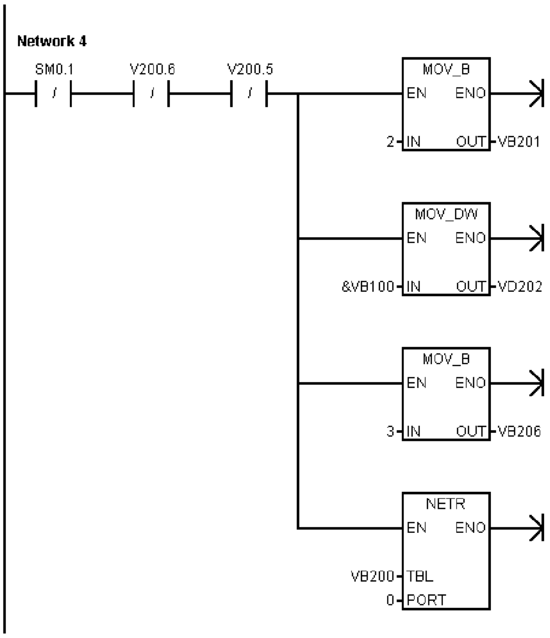
Figure 6-7 Sample TBL Data for the Network Read/Write Example

Example: Network Read and Network Write Instructions



```
Network 1   //On the first scan, enable the
            //PPI master mode
            //and clear all receive and transmit buffers.
LD          SM0.1
MOVB        2, SMB30
FILL        +0, VW200, 68

Network 2   //When the NETR Done bit (V200.7)
            //is set and 100 cases have been
            //packed:
            //1.   Load the station address of
            //     case packer #1.
            //2.   Load a pointer to the data in
            //     the remote station.
            //3.   Load the length of data to be
            //      transmitted.
            //4.   Load the data to transmit.
            //5.   Reset the number of cases packed
            //     by case packer #1
LD          V200.7
AW=         VW208, +100
MOVB        2, VB301
MOVD        &VB101, VD302
MOVB        2, VB306
MOVW        +0, VW307
NETW        VB300, 0

Network 3   //When the NETR Done bit is set,
            //save the control data from
            //case packer #1.
LD          V200.7
MOVB        VB207, VB400
```

Example: Network Read and Network Write Instructions , continued



```
Network 4    //If not the first scan and there are
             //no errors:
             //1.   Load the station address of
             //     case packer #1.
             //2.   Load a pointer to the data in
             //     the remote station.
             //3.   Load the length of data to
             //     be received.
             //4.   Read the control and status data
             //     in case packer #1.
LDN          SM0.1
AN           V200.6
AN           V200.5
MOVB         2, VB201
MOVD         &VB100, VD202
MOVB         3, VB206
NETR         VB200, 0
```

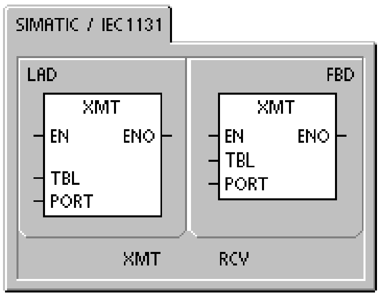
Transmit and Receive Instructions (Freeport)

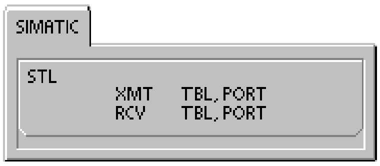
The Transmit instruction (XMT) is used in Freeport mode to transmit data by means of the communications port(s).

The Receive instruction (RCV) initiates or terminates the receive message function. You must specify a start and an end condition for the Receive box to operate. Messages received through the specified port (PORT) are stored in the data buffer (TBL). The first entry in the data buffer specifies the number of bytes received.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0009 (simultaneous Transmit/Receive on port 0)
- 000B (simultaneous Transmit/Receive on port 1)
- Receive parameter error sets SM86.6 or SM186.6
- S7-200 CPU is not in Freeport mode





```
XMT   TBL, PORT
RCV   TBL, PORT
```

Table 6-12 Valid Operands for the Transmit and Receive Instructions

Inputs/Outputs	Data Type	Operands
TBL	BYTE	IB, QB, VB, MB, SMB, SB, *VD, *LD, *AC
PORT	BYTE	Constant *for CPU 221, CPU 222, CPU 224:* 0 *for CPU 224XP, CPU 226:* 0 or 1

For more information about using Freeport mode, see the section Creating User-Defined Protocols with Freeport Mode on page 226 in Chapter 7.

Using Freeport Mode to Control the Serial Communications Port

You can select the Freeport mode to control the serial communications port of the S7-200 by means of the user program. When you select Freeport mode, your program controls the operation of the communications port through the use of the receive interrupts, the transmit interrupts, the Transmit instruction, and the Receive instruction. The communications protocol is entirely controlled by the ladder program while in Freeport mode. SMB30 (for port 0) and SMB130 (for port 1 if your S7-200 has two ports) are used to select the baud rate and parity.

The Freeport mode is disabled and normal communications are re-established (for example, programming device access) when the S7-200 is in STOP mode.

In the simplest case, you can send a message to a printer or a display using only the Transmit (XMT) instruction. Other examples include a connection to a bar code reader, a weighing scale, and a welder. In each case, you must write your program to support the protocol that is used by the device with which the S7-200 communicates while in Freeport mode.

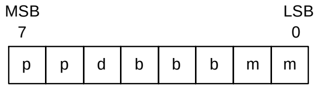
Freeport communications are possible only when the S7-200 is in RUN mode. Enable the Freeport mode by setting a value of 01 in the protocol select field of SMB30 (Port 0) or SMB130 (Port 1). While in Freeport mode, communications with the programming device are not possible.

Tip

Freeport mode can be controlled using special memory bit SM0.7, which reflects the current position of the operating mode switch. When SM0.7 is equal to 0, the switch is in TERM position; when SM0.7 = 1, the operating mode switch is in RUN position. If you enable Freeport mode only when the switch is in RUN position, you can use the programming device to monitor or control the S7-200 operation by changing the switch to any other position.

Changing PPI Communications to Freeport Mode

SMB30 and SMB130 configure the communications ports, 0 and 1 respectively, for Freeport operation and provide selection of baud rate, parity, and number of data bits. Figure 6-8 describes the Freeport control byte. One stop bit is generated for all configurations.



SMB30 = Port 0
SMB130 = Port 1

pp: Parity select

00 =	no parity
01 =	even parity
10 =	no parity
11 =	odd parity

d: Data bits per character

0 =	8 bits per character
1 =	7 bits per character

bbb: Freeport baud rate

000 =	38,400 baud
001 =	19,200 baud
010 =	9,600 baud
011 =	4,800 baud
100 =	2,400 baud
101 =	1,200 baud
110 =	115.2 kbaud[1]
111 =	57.6 kbaud[1]

mm: Protocol selection

00 =	PPI/slave mode
01 =	Freeport protocol
10 =	PPI/master mode
11 =	Reserved (defaults to PPI/slave mode)

[1] Requires S7-200 CPUs version 1.2 or later

Figure 6-8 SM Control Byte for Freeport Mode (SMB30 or SMB130)

Transmitting Data

The Transmit instruction lets you send a buffer of one or more characters, up to a maximum of 255.

Figure 6-9 shows the format of the Transmit buffer.

If an interrupt routine is attached to the transmit complete event, the S7-200 generates an interrupt (interrupt event 9 for port 0 and interrupt event 26 for port 1) after the last character of the buffer is sent.

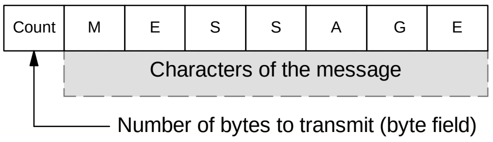

Count
M
E
S
S
A
G
E
Characters of the message
Number of bytes to transmit (byte field)

Figure 6-9 Format for the Transmit Buffer

You can make transmissions without using interrupts (for example, sending a message to a printer) by monitoring SM4.5 or SM4.6 to signal when transmission is complete.

You can use the Transmit instruction to generate a BREAK condition by setting the number of characters to zero and then executing the Transmit instruction. This generates a BREAK condition on the line for 16-bit times at the current baud rate. Transmitting a BREAK is handled in the same manner as transmitting any other message, in that a Transmit interrupt is generated when the BREAK is complete and SM4.5 or SM4.6 signals the current status of the Transmit operation.

Receiving Data

The Receive instruction lets you receive a buffer of one or more characters, up to a maximum of 255.

Figure 6-10 shows the format of the Receive buffer.

If an interrupt routine is attached to the receive message complete event, the S7-200 generates an interrupt (interrupt event 23 for port 0 and interrupt event 24 for port 1) after the last character of the buffer is received.

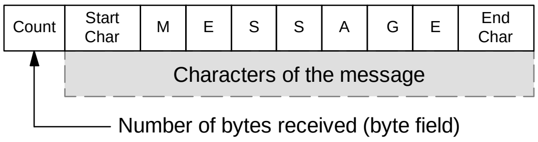

Count
Start Char
M
E
S
S
A
G
E
End Char
Characters of the message
Number of bytes received (byte field)

Figure 6-10 Format for the Receive Buffer

You can receive messages without using interrupts by monitoring SMB86 (port 0) or SMB186 (port 1). This byte is non-zero when the Receive instruction is inactive or has been terminated. It is zero when a receive is in progress.

As shown in Table 6-13, the Receive instruction allows you to select the message start and message end conditions, using SMB86 through SMB94 for port 0 and SMB186 through SMB194 for port 1.

Tip

The receive message function is automatically terminated in case of an overrun or a parity error. You must define a start condition and an end condition (maximum character count) for the receive message function to operate.

Table 6-13 Bytes of the Receive Buffer (SMB86 to SMB94, and SM1B86 to SMB194)

Port 0	Port 1	Description
SMB86	SMB186	Receive message status byte MSB 7 LSB 0 n r e 0 0 t c p n: 1 = Receive message function terminated: user issued disable command. r: 1 = Receive message function terminated: error in input parameters or missing start or end condition. e: 1 = End character received. t: 1 = Receive message function terminated: timer expired. c: 1 = Receive message function terminated: maximum character count achieved. p 1 = Receive message function terminated: a parity error.
SMB87	SMB187	Receive message control byte MSB 7 LSB 0 en sc ec il c/m tmr bk 0 en: 0 =Receive message function is disabled. 1 =Receive message function is enabled. The enable/disable receive message bit is checked each time the RCV instruction is executed. sc: 0 =Ignore SMB88 or SMB188. 1 =Use the value of SMB88 or SMB188 to detect start of message. ec: 0 =Ignore SMB89 or SMB189. 1 =Use the value of SMB89 or SMB189 to detect end of message. il: 0 =Ignore SMW90 or SMW190. 1 =Use the value of SMW90 or SMW190 to detect an idle line condition. c/m: 0 =Timer is an inter-character timer. 1 =Timer is a message timer. tmr: 0 =Ignore SMW92 or SMW192. 1 =Terminate receive if the time period in SMW92 or SMW192 is exceeded. bk: 0 =Ignore break conditions. 1 =Use break condition as start of message detection.
SMB88	SMB188	Start of message character.
SMB89	SMB189	End of message character.
SMW90	SMW190	Idle line time period given in milliseconds. The first character received after idle line time has expired is the start of a new message.
SMW92	SMW192	Inter-character/message timer time-out value given in milliseconds. If the time period is exceeded, the receive message function is terminated.
SMB94	SMB194	Maximum number of characters to be received (1 to 255 bytes). This range must be set to the expected maximum buffer size, even if the character count message termination is not used.

Start and End Conditions for the Receive Instruction

The Receive instruction uses the bits of the receive message control byte (SMB87 or SMB187) to define the message start and end conditions.

> **Tip**
>
> If there is traffic present on the communications port from other devices when the Receive instruction is executed, the receive message function could begin receiving a character in the middle of that character, resulting in a possible parity error and termination of the receive message function. If parity is not enabled the received message could contain incorrect characters. This situation can occur when the start condition is specified to be a specific start character or any character, as described in item 2. and item 6. below.
>
> The Receive instruction supports several message start conditions. Specifying a start condition involving a break or an idle line detection avoids this problem by forcing the receive message function to synchronize the start of the message with the start of a character before placing characters into the message buffer.

The Receive instruction supports several start conditions:

1. *Idle line detection:* The idle line condition is defined as a quiet or idle time on the transmission line. A receive is started when the communications line has been quiet or idle for the number of milliseconds specified in SMW90 or SMW190. When the Receive instruction in your program is executed, the receive message function initiates a search for an idle line condition. If any characters are received before the idle line time expires, the receive message function ignores those characters and restarts the idle line timer with the time from SMW90 or SMW190. See Figure 6-11. After the idle line time expires, the receive message function stores all subsequent characters received in the message buffer.

   The idle line time should always be greater than the time to transmit one character (start bit, data bits, parity and stop bits) at the specified baud rate. A typical value for the idle line time is three character times at the specified baud rate.

   You use idle line detection as a start condition for binary protocols, protocols where there is not a particular start character, or when the protocol specifies a minimum time between messages.

   Setup: il = 1, sc = 0, bk = 0, SMW90/SMW190 = idle line timeout in milliseconds

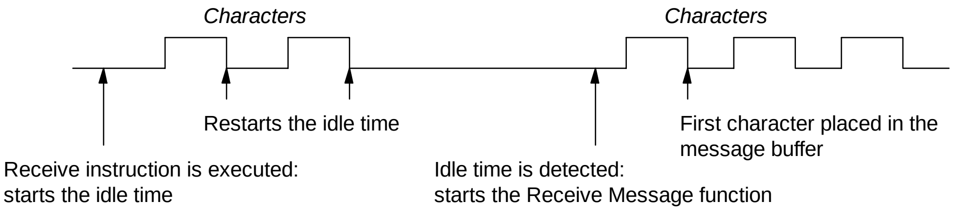

Characters
Characters
Restarts the idle time
First character placed in the message buffer
Receive instruction is executed: starts the idle time
Idle time is detected: starts the Receive Message function

Figure 6-11 Using Idle Time Detection to Start the Receive Instruction

2. *Start character detection:* The start character is any character which is used as the first character of a message. A message is started when the start character specified in SMB88 or SMB188 is received. The receive message function stores the start character in the receive buffer as the first character of the message. The receive message function ignores any characters that are received before the start character. The start character and all characters received after the start character are stored in the message buffer.

   Typically, you use start character detection for ASCII protocols in which all messages start with the same character.

   Setup: il = 0, sc = 1, bk = 0, SMW90/SMW190 = don’t care, SMB88/SMB188 = start character

3. *Idle line and start character:* The Receive instruction can start a message with the combination of an idle line and a start character. When the Receive instruction is executed, the receive message function searches for an idle line condition. After finding the idle line condition, the receive message function looks for the specified start character. If any character but the start character is received, the receive message function restarts the search for an idle line condition. All characters received before the idle line condition has been satisfied and before the start character has been received are ignored. The start character is placed in the message buffer along with all subsequent characters.

   The idle line time should always be greater than the time to transmit one character (start bit, data bits, parity and stop bits) at the specified baud rate. A typical value for the idle line time is three character times at the specified baud rate.

   Typically, you use this type of start condition when there is a protocol that specifies a minimum time between messages, and the first character of the message is an address or something which specifies a particular device. This is most useful when implementing a protocol where there are multiple devices on the communications link. In this case the Receive instruction triggers an interrupt only when a message is received for the specific address or devices specified by the start character.

   Setup: il = 1, sc = 1, bk = 0, SMW90/SMW190 > 0, SMB88/SMB188 = start character

4. *Break detection:* A break is indicated when the received data is held to a zero value for a time greater than a full character transmission time. A full character transmission time is defined as the total time of the start, data, parity and stop bits. If the Receive instruction is configured to start a message on receiving a break condition, any characters received after the break condition are placed in the message buffer. Any characters received before the break condition are ignored.

   Typically, you use break detection as a start condition only when a protocol requires it.

   Setup: il = 0, sc = 0, bk = 1, SMW90/SMW190 = don’t care, SMB88/SMB188 = don’t care

5. *Break and a start character:* The Receive instruction can be configured to start receiving characters after receiving a break condition, and then a specific start character, in that sequence. After the break condition, the receive message function looks for the specified start character. If any character but the start character is received, the receive message function restarts the search for an break condition. All characters received before the break condition has been satisfied and before the start character has been received are ignored. The start character is placed in the message buffer along with all subsequent characters.

   Setup: il = 0, sc = 1, bk = 1, SMW90/SMW190 = don’t care,
   SMB88/SMB188 = start character

6. *Any character:* The Receive instruction can be configured to immediately start receiving any and all characters and placing them in the message buffer. This is a special case of the idle line detection. In this case the idle line time (SMW90 or SMW190) is set to zero. This forces the Receive instruction to begin receiving characters immediately upon execution.

   Setup: il = 1, sc = 0, bk = 0, SMW90/SMW190 = 0, SMB88/SMB188 = don’t care

   Starting a message on any character allows the message timer to be used to time out the receiving of a message. This is useful in cases where Freeport is used to implement the master or host portion of a protocol and there is a need to time out if no response is received from a slave device within a specified amount of time. The message timer starts when the Receive instruction executes because the idle line time was set to zero. The message timer times out and terminates the receive message function if no other end condition is satisfied.

   Setup: il = 1, sc = 0, bk = 0, SMW90/SMW190 = 0, SMB88/SMB188 = don’t care
   c/m = 1, tmr = 1, SMW92 = message timeout in milliseconds

The Receive instruction supports several ways to terminate a message. The message can be terminated on one or a combination of the following:

1. *End character detection:* The end character is any character which is used to denote the end of the message. After finding the start condition, the Receive instruction checks each character received to see if it matches the end character. When the end character is received, it is placed in the message buffer and the receive is terminated.

   Typically, you use end character detection with ASCII protocols where every message ends with a specific character. You can use end character detection in combination with the intercharacter timer, the message timer or the maximum character count to terminate a message.

   Setup: ec = 1, SMB89/SMB189 = end character

2. *Intercharacter timer:* The intercharacter time is the time measured from the end of one character (the stop bit) to the end of the next character (the stop bit). If the time between characters (including the second character) exceeds the number of milliseconds specified in SMW92 or SMW192, the receive message function is terminated. The intercharacter timer is restarted on each character received. See Figure 6-12.

   You can use the intercharacter timer to terminate a message for protocols which do not have a specific end-of-message character. This timer must be set to a value greater than one character time at the selected baud rate since this timer always includes the time to receive one entire character (start bit, data bits, parity and stop bits).

   You can use the intercharacter timer in combination with the end character detection and the maximum character count to terminate a message.

   Setup: c/m = 0, tmr = 1, SMW92/SMW192 = timeout in milliseconds

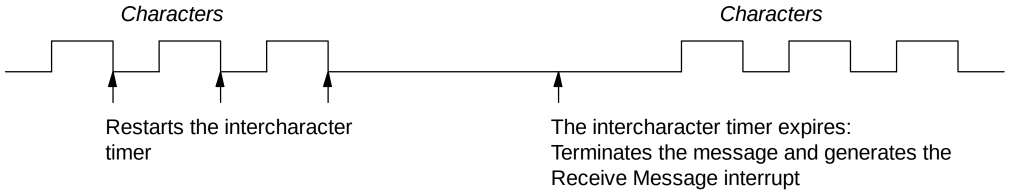

Characters
Characters
Restarts the intercharacter timer
The intercharacter timer expires: Terminates the message and generates the Receive Message interrupt

Figure 6-12 Using the Intercharacter Timer to Terminate the Receive Instruction

3. *Message timer:* The message timer terminates a message at a specified time after the start of the message. The message timer starts as soon as the start condition(s) for the receive message function have been met. The message timer expires when the number of milliseconds specified in SMW92 or SMW192 have passed. See Figure 6-13.

   Typically, you use a message timer when the communications devices cannot guarantee that there will not be time gaps between characters or when operating over modems. For modems, you can use a message timer to specify a maximum time allowed to receive the message after the message has started. A typical value for a message timer would be about 1.5 times the time required to receive the longest possible message at the selected baud rate.

   You can use the message timer in combination with the end character detection and the maximum character count to terminate a message.

   Setup: c/m = 1, tmr = 1, SMW92/SMW192 = timeout in milliseconds

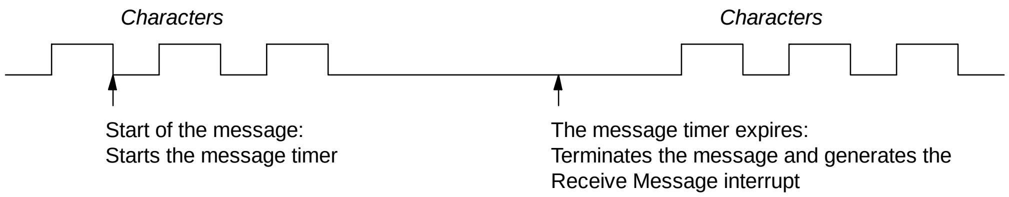

Characters
Characters
Start of the message:
Starts the message timer
The message timer expires:
Terminates the message and generates the Receive Message interrupt

Figure 6-13 Using the Message Timer to Terminate the Receive Instruction

4. *Maximum character count:* The Receive instruction must be told the maximum number of characters to receive (SMB94 or SMB194). When this value is met or exceeded, the receive message function is terminated. The Receive instruction requires that the user specify a maximum character count even if this is not specifically used as a terminating condition. This is because the Receive instruction needs to know the maximum size of the receive message so that user data placed after the message buffer is not overwritten.

   The maximum character count can be used to terminate messages for protocols where the message length is known and always the same. The maximum character count is always used in combination with the end character detection, intercharacter timer, or message timer.

5. *Parity errors:* The Receive instruction is automatically terminated when the hardware signals a parity error on a received character. Parity errors are only possible if parity is enabled in SMB30 or SMB130. There is no way to disable this function.

6. *User termination:* The user program can terminate a receive message function by executing another Receive instruction with the enable bit (EN) in SMB87 or SMB187 set to zero. This immediately terminates the receive message function.

Using Character Interrupt Control to Receive Data

To allow complete flexibility in protocol support, you can also receive data using character interrupt control. Each character received generates an interrupt. The received character is placed in SMB2, and the parity status (if enabled) is placed in SM3.0 just prior to execution of the interrupt routine attached to the receive character event. SMB2 is the Freeport receive character buffer. Each character received while in Freeport mode is placed in this location for easy access from the user program. SMB3 is used for Freeport mode and contains a parity error bit that is turned on when a parity error is detected on a received character. All other bits of the byte are reserved. Use the parity bit either to discard the message or to generate a negative acknowledgement to the message.

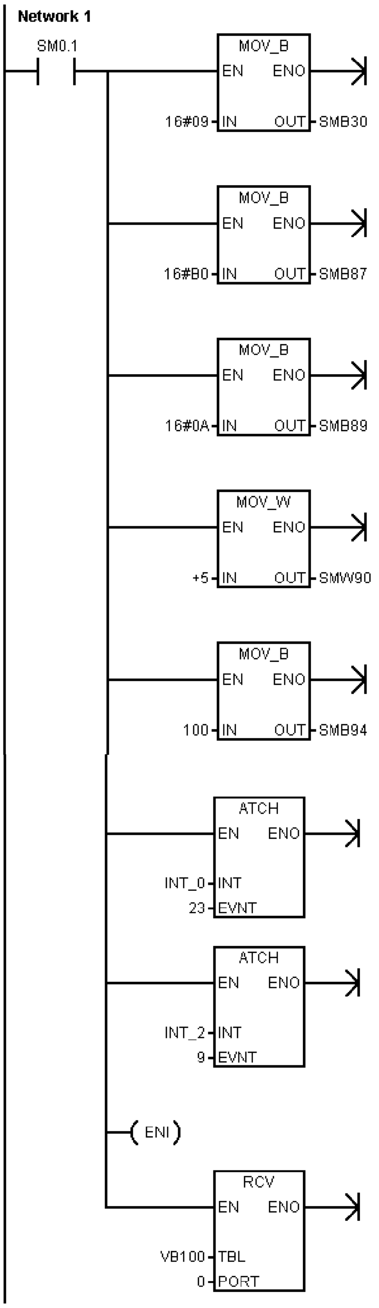
When the character interrupt is used at high baud rates (38.4 kbaud to 115.2 kbaud), the time between interrupts is very short. For example, the character interrupt for 38.4 kbaud is 260 microseconds, for 57.6 kbaud is 173 microseconds, and for 115.2 kbaud is 86 microseconds. Ensure that you keep the interrupt routines very short to avoid missing characters, or else use the Receive instruction.

Tip

SMB2 and SMB3 are shared between Port 0 and Port 1. When the reception of a character on Port 0 results in the execution of the interrupt routine attached to that event (interrupt event 8), SMB2 contains the character received on Port 0, and SMB3 contains the parity status of that character. When the reception of a character on Port 1 results in the execution of the interrupt routine attached to that event (interrupt event 25), SMB2 contains the character received on Port 1 and SMB3 contains the parity status of that character.

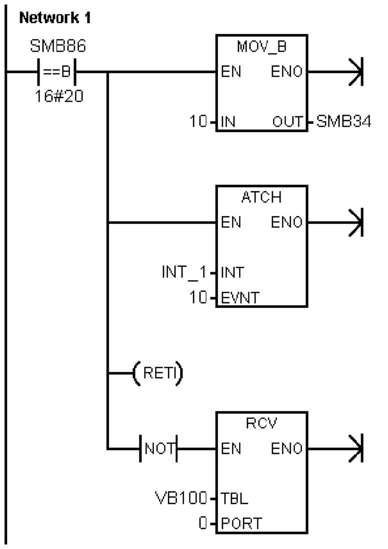
Example: Transmit and Receive Instructions

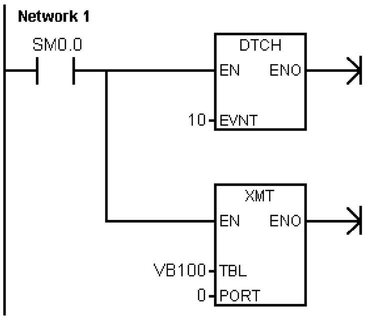
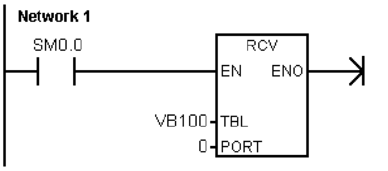
M
A
I
N



```
Network 1      //This program receives a string of characters
               //until a line feed character is received.
               //The message is then transmitted back
               //to the sender.

LD     SM0.1          //On the first scan:
MOVB   16#09, SMB30   //1.  Initialize Freeport:
                      //    - Select 9600 baud.
                      //    - Select 8 data bits.
                      //    - Select no parity.

MOVB   16#B0, SMB87   //2.  Initialize RCV message control byte:
                      //    - RCV enabled.
                      //    - Detect end of message character.
                      //    - Detect idle line condition
                      //      as the message start condition.

MOVB   16#0A, SMB89   //3.  Set end of message character
                      //    to hex OA (line feed).

MOVW   +5, SMW90      //4.  Set idle line timeout
                      //    to 5 ms.

MOVB   100, SMB94     //5.  Set maximum number of characters
                      //    to 100.

ATCH   INT_0, 23      //6.  Attach interrupt 0
                      //    to the Receive Complete event.

ATCH   INT_2, 9       //7.  Attach interrupt 2
                      //    to the Transmit Complete event.

ENI                   //8.  Enable user interrupts.

RCV    VB100, 0       //9.  Enable receive box with
                      //    buffer at VB100.
```

Example: Transmit and Receive Instructions, continued		

I
N
T
0
	 Network 1
	SMB86
	==B
	16#20
	MOV_B
	EN
	ENO
	10
	IN
	OUT
	SMB34
	ATCH
	EN
	ENO
	INT_1
	INT
	10
	EVNT
	RETI
	NOT
	RCV
	EN
	ENO
	VB100
	TBL
	0
	PORT
		Network 1 //Receive complete interrupt routine:
		//1. If receive status shows receive of
		// end character, then attach a
		// 10 ms timer to trigger a transmit and return.
		//2. If the receive completed for any other reason,
		// then start a new receive.
		LDB= SMB86, 16#20
		MOVB 10, SMB34
		ATCH INT_1, 10
		CRETI
		NOT
		RCV VB100, 0

I N T 1	 Network 1 SM0.0 DTCH EN ENO 10 EVNT XMT EN ENO VB100 TBL 0 PORT	Network 1 //10-ms Timer interrupt: //1. Detach timer interrupt. //2. Transmit message back to user on port. LD SM0.0 DTCH 10 XMT VB100, 0
I N T 2	 Network 1 SM0.0 RCV EN ENO VB100 TBL 0 PORT	Network 1 //Transmit Complete interrupt: //Enable another receive. LD SM0.0 RCV VB100, 0

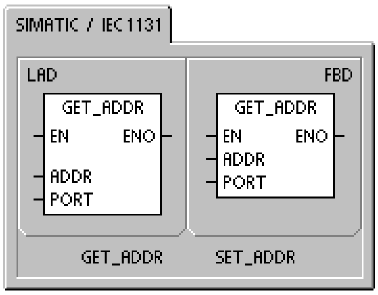
Get Port Address and Set Port Address Instructions

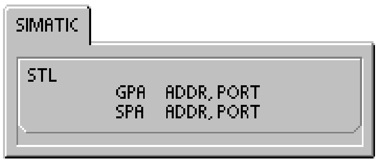
The Get Port Address instruction (GPA) reads the station address of the S7-200 CPU port specified in PORT and places the value in the address specified in ADDR.

The Set Port Address instruction (SPA) sets the port station address (PORT) to the value specified in ADDR. The new address is not saved permanently. After a power cycle, the affected port returns to the last address (the one that was downloaded with the system block).

Error conditions that set ENO = 0:

- 0006 (indirect address)
- 0004 (attempted to perform a Set Port Address instruction in an interrupt routine)





```
GPA  ADDR, PORT
SPA  ADDR, PORT
```

Table 6-14 Valid Operands for the Get Port Address and Set Port Address Instructions

Inputs/Outputs	Data Type	Operands
ADDR	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant *(A constant value is valid only for the Set Port Address instruction.)*
PORT	BYTE	Constant *for CPU 221, CPU 222, CPU 224:* 0 *for CPU 224XP, CPU 226:* 0 or 1

Compare Instructions

Comparing Numerical Values

The compare instructions are used to compare two values:

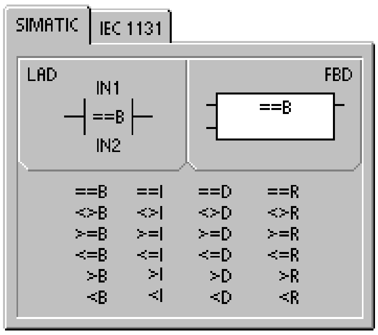
IN1 = IN2	IN1 >= IN2	IN1 <= IN2
IN1 > IN2	IN1 < IN2	IN1 <> IN2

Compare Byte operations are unsigned.
Compare Integer operations are signed.
Compare Double Word operations are signed.
Compare Real operations are signed.

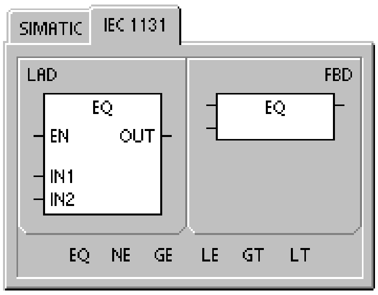
For LAD and FBD: When the comparison is true, the Compare instruction turns on the contact (LAD) or output (FBD).

For STL: When the comparison is true, the Compare instruction Loads, ANDs, or ORs a 1 with the value on the top of the stack (STL).

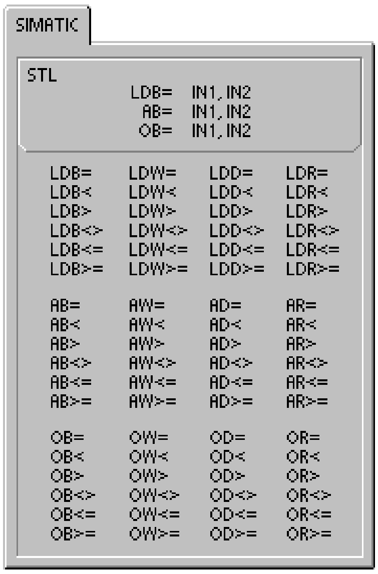
When you use the IEC compare instructions, you can use various data types for the inputs. However, both input values must be of the same data type.



```
==B   ==I   ==D   ==R
<>B   <>I   <>D   <>R
>=B   >=I   >=D   >=R
<=B   <=I   <=D   <=R
 >B    >I    >D    >R
 <B    <I    <D    <R
```



```
EQ   NE   GE   LE   GT   LT
```



```
STL
              LDB=   IN1, IN2
               AB=   IN1, IN2
               OB=   IN1, IN2

LDB=    LDW=    LDD=    LDR=
LDB<    LDW<    LDD<    LDR<
LDB>    LDW>    LDD>    LDR>
LDB<>   LDW<>   LDD<>   LDR<>
LDB<=   LDW<=   LDD<=   LDR<=
LDB>=   LDW>=   LDD>=   LDR>=

AB=     AW=     AD=     AR=
AB<     AW<     AD<     AR<
AB>     AW>     AD>     AR>
AB<>    AW<>    AD<>    AR<>
AB<=    AW<=    AD<=    AR<=
AB>=    AW>=    AD>=    AR>=

OB=     OW=     OD=     OR=
OB<     OW<     OD<     OR<
OB>     OW>     OD>     OR>
OB<>    OW<>    OD<>    OR<>
OB<=    OW<=    OD<=    OR<=
OB>=    OW>=    OD>=    OR>=
```

Notice

The following conditions are fatal errors and cause your S7-200 to immediately stop the execution of your program:

- Illegal indirect address is encountered (any Compare instruction)
- Illegal real number (for example, NAN) is encountered (Compare Real instruction)

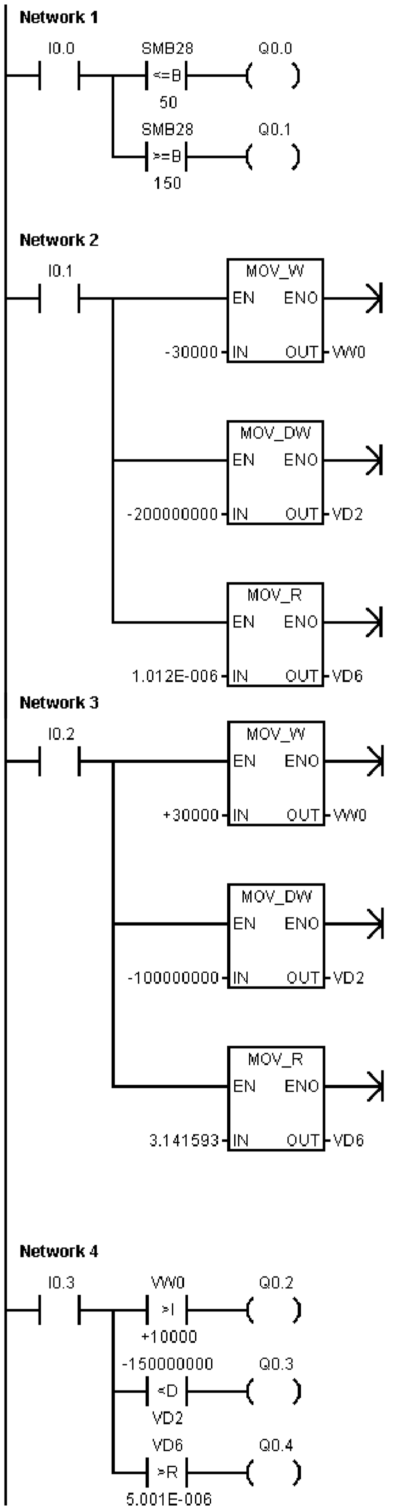
To prevent these conditions from occurring, ensure that you properly initialize pointers and values that contain real numbers before executing compare instructions that use these values.

Compare instructions are executed regardless of the state of power flow.

Table 6-15 Valid Operands for the Compare Instructions

Inputs/Outputs	Type	Operands
IN1, IN2	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
Output (or OUT)	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow

Example: Compare Instructions



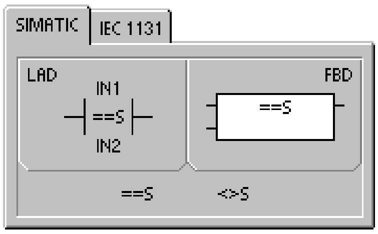
```
Network 1     //Turn analog adjustment potentiometer 0
              //to vary the SMB28 byte value.
              //Q0.0 is active when the SMB28 value
              //is less than or equal to 50.
              //Q0.1 is active when the SMB28 value
              //is greater than or equal to 150.
              //The status indicator is on when
              //the comparison is true.
LD      I0.0
LPS
AB<=    SMB28, 50
=       Q0.0
LPP
AB>=    SMB28, 150
=       Q0.1

Network 2     //Load V memory addresses with
              //low values that make the comparisons
              //false and that turn
              //the status indicators off.
LD      I0.1
MOVW    -30000, VW0
MOVD    -200000000, VD2
MOVR    1.012E-006, VD6

Network 3     //Load V memory addresses with
              //high values that make the
              //comparisons true and that turn
              //the status indicators on.
LD      I0.2
MOVW    +30000, VW0
MOVD    -100000000, VD2
MOVR    3.141593, VD6

Network 4     //The Integer Word comparison tests
              //to find if VW0 > +10000 is true.
              //Uses program constants to show the
              // different data types. You can also
              //compare two values
              //stored in programmable memory
              //like:  VW0 > VW100
LD      I0.3
LPS
AW>     VW0, +10000
=       Q0.2
LRD
AD<     -150000000, VD2
=       Q0.3
LPP
AR>     VD6, 5.001E-006
=       Q0.4
```

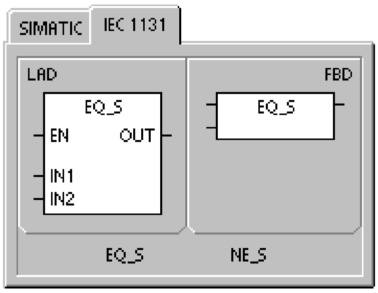
Compare String

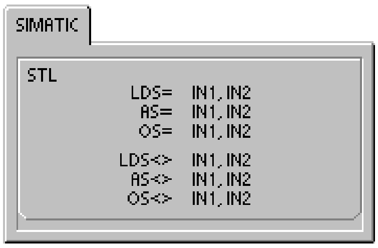
The Compare String instruction compares two strings of ASCII characters:

IN1 = IN2   IN1 <> IN2

When the comparison is true, the Compare instruction turns the contact (LAD) or output (FBD) on, or the compare instruction Loads, ANDs or ORs a 1 with the value on the top of the stack (STL).







```
LDS=   IN1, IN2
 AS=   IN1, IN2
 OS=   IN1, IN2
LDS<>  IN1, IN2
 AS<>  IN1, IN2
 OS<>  IN1, IN2
```

Notice

The following conditions are fatal errors and cause your S7-200 to immediately stop the execution of your program:

- Illegal indirect address is encountered (any compare instruction)
- A string with a length greater than 254 characters is encountered (Compare String instruction)
- A string whose starting address and length are such that it will not fit in the specified memory area (Compare String instruction)

To prevent these conditions from occurring, ensure that you properly initialize pointers and memory locations that are intended to hold ASCII strings prior to executing compare instructions that use these values. Ensure that the buffer reserved for an ASCII string can reside completely within the specified memory area.

Compare instructions are executed regardless of the state of power flow.

Table 6-16 Valid Operands for the Compare String Instructions

Inputs/Outputs	Type	Operands
IN1	STRING	VB, LB, *VD, *LD, *AC, constant
IN2	STRING	VB, LB, *VD, *LD, *AC
Output (OUT)	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow

Conversion Instructions

Standard Conversion Instructions

Numerical Conversions

The Byte to Integer (BTI), Integer to Byte (ITB), Integer to Double Integer (ITD), Double Integer to Integer (DTI), Double Integer to Real (DTR), BCD to Integer (BCDI) and Integer to BCD (IBCD) instructions convert an input value IN to the specified format and stores the output value in the memory location specified by OUT. For example, you can convert a double integer value to a real number. You can also convert between integer and BCD formats.

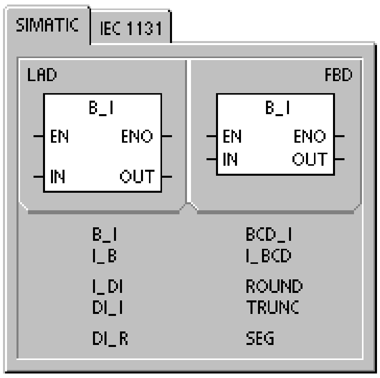
Round and Truncate

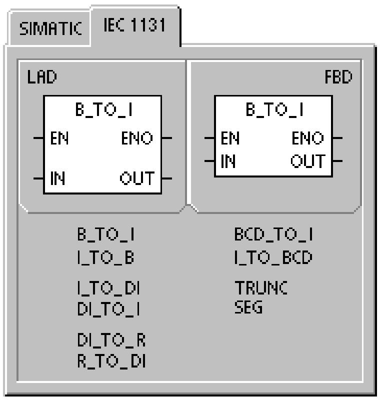
The Round instruction (ROUND) converts a real value IN to a double integer value and places the rounded result into the variable specified by OUT.

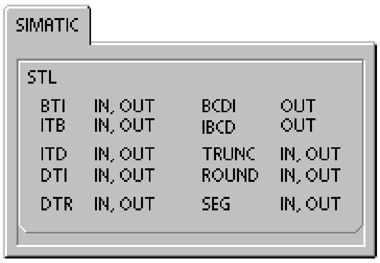
The Truncate instruction (TRUNC) converts a real number IN into a double integer and places the whole-number portion of the result into the variable specified by OUT.

Segment

The Segment instruction (SEG) allows you to generate a bit pattern that illuminates the segments of a seven-segment display.







```
BTI   IN, OUT     BCDI    OUT
ITB   IN, OUT     IBCD    OUT

ITD   IN, OUT     TRUNC   IN, OUT
DTI   IN, OUT     ROUND   IN, OUT

DTR   IN, OUT     SEG     IN, OUT
```

Table 6-17 Valid Operands for the Standard Conversion Instructions

Inputs/Outputs	Data Type	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	WORD, INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AIW, AC, *VD, *LD, *AC, Constant
	DINT	ID, QD, VD, MD, SMD, SD, LD, HC, AC, *VD, *LD, *AC, Constant
	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC
	WORD, INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *LD, *AC
	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Operation of the BCD to Integer and Integer to BCD Instructions

The BCD to Integer instruction (BCDI) converts the binary-coded decimal value IN to an integer value and loads the result into the variable specified by OUT. The valid range for IN is 0 to 9999 BCD.

The Integer to BCD instruction (IBCD) converts the input integer value IN to a binary-coded decimal and loads the result into the variable specified by OUT. The valid range for IN is 0 to 9999 integer.

Error conditions that set ENO = 0

- SM1.6 (invalid BCD)
- 0006 (indirect address)

SM bits affected:

- SM1.6 (invalid BCD)

Operation of the Double Integer to Real Instruction

The Double Integer to Real instruction (DTR) converts a 32-bit, signed integer IN into a 32-bit real number and places the result into the variable specified by OUT.

Error conditions that set ENO = 0

- 0006 (indirect address)

Operation of the Double Integer to Integer Instruction

The Double Integer to Integer instruction (DTI) converts the double integer value IN to an integer value and places the result into the variable specified by OUT.

If the value that you are converting is too large to be represented in the output, then the overflow bit is set and the output is not affected.

Error conditions that set ENO = 0

- SM1.1 (overflow)
- 0006 (indirect address)

SM bits affected:

- SM1.1 (overflow)

Operation of the Integer to Double Integer Instruction

The Integer to Double Integer instruction (ITD) converts the integer value IN to a double integer value and places the result into the variable specified by OUT. The sign is extended.

Error conditions that set ENO = 0

- 0006 (indirect address)

Operation of the Byte to Integer Instruction

The Byte to Integer instruction (BTI) converts the byte value IN to an integer value and places the result into the variable specified by OUT. The byte is unsigned, therefore there is no sign extension.

Error conditions that set ENO = 0

- 0006 (indirect address)

Operation of the Integer to Byte Instruction

The Integer to Byte instruction (ITB) converts the word value IN to a byte value and places the result into the variable specified by OUT. Values 0 to 255 are converted. All other values result in overflow and the output is not affected.

Error conditions that set ENO = 0

- SM1.1 (overflow)
- 0006 (indirect address)

SM bits affected:

- SM1.1 (overflow)

Tip

To change an integer to a real number, use the Integer to Double Integer instruction and then use the Double Integer to Real instruction.

Operation of the Round and Truncate Instructions

The Round instruction (ROUND) converts the real-number value IN to a double integer value and places the result into the variable specified by OUT. If the fraction portion is 0.5 or greater, the number is rounded up.

The Truncate instruction (TRUNC) converts a real-number value IN into a double integer and places the result into the variable specified by OUT. Only the whole number portion of the real number is converted, and the fraction is discarded.

Error conditions that set ENO = 0

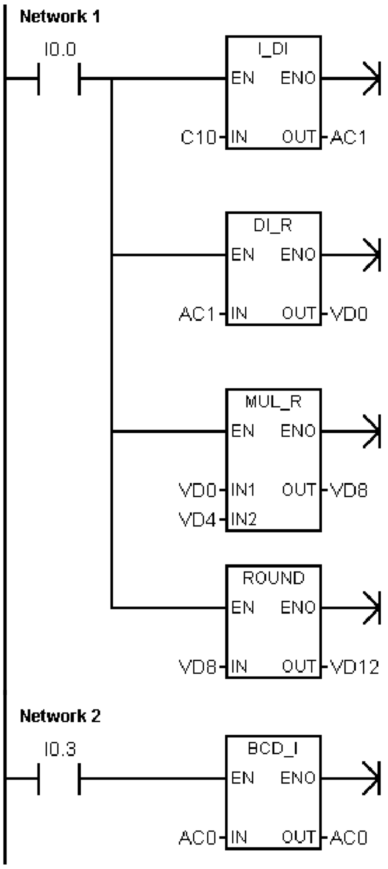
- SM1.1 (overflow)
- 0006 (indirect address)

SM bits affected:

- SM1.1 (overflow)

If the value that you are converting is not a valid real number or is too large to be represented in the output, then the overflow bit is set and the output is not affected.

Example: Standard Conversion Instructions



```
Network 1       //Convert inches to centimeters:
                //1.  Load a counter value (inches) into AC1.
                //2.  Convert the value to a real number.
                //3.  Multiply by 2.54 (convert to centimeters).
                //4.  Convert the value back to an integer.
LD          I0.0
ITD         C10, AC1
DTR         AC1, VD0
MOVR        VD0, VD8
*R          VD4, VD8
ROUND       VD8, VD12

Network 2       //Convert a BCD value to an integer
LD          I0.3
BCDI        AC0
```

Double Word Integer to Real and Round

C10	101	Count = 101 inches
VD0	101.0	Count (as a real number)
VD4	2.54	2.54 constant (inches to centimeters)
VD8	256.54	256.54 centimeters as real number
VD12	257	257 centimeters as double integer

BCD to Integer

AC0	1234
	BCDI
AC0	04D2

Operation of the Segment Instruction

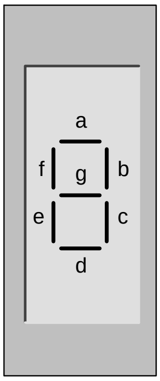
To illuminate the segments of a seven-segment display, the Segment instruction (SEG) converts the character (byte) specified by IN to generate a bit pattern (byte) at the location specified by OUT.

The illuminated segments represent the character in the least significant digit of the input byte. Figure 6-14 shows the seven-segment display coding used by the Segment instruction.

Error conditions that set ENO = 0

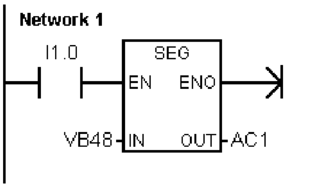
- ■ 0006 (indirect address)

(IN) LSD	Segment Display	(OUT) – g f e d c b a
0		0 0 1 1 1 1 1 1
1		0 0 0 0 0 1 1 0
2		0 1 0 1 1 0 1 1
3		0 1 0 0 1 1 1 1
4		0 1 1 0 0 1 1 0
5		0 1 1 0 1 1 0 1
6		0 1 1 1 1 1 0 1
7		0 0 0 0 0 1 1 1



(IN) LSD	Segment Display	(OUT) – g f e d c b a
8		0 1 1 1 1 1 1 1
9		0 1 1 0 0 1 1 1
A		0 1 1 1 0 1 1 1
B		0 1 1 1 1 1 0 0
C		0 0 1 1 1 0 0 1
D		0 1 0 1 1 1 1 0
E		0 1 1 1 1 0 0 1
F		0 1 1 1 0 0 0 1

Figure 6-14 Coding for a Seven-Segment Display

Example: Segment Instruction		
 Network 1 I1.0 SEG EN ENO VB48 IN OUT AC1	Network 1 LD I1.0 SEG VB48, AC1	05 SEG 6D VB48 AC1 (display character)

ASCII Conversion Instructions

Valid ASCII characters are the hexadecimal values 30 to 39, and 41 to 46.

Converting between ASCII and Hexadecimal Values

The ASCII to Hexadecimal instruction (ATH) converts a number LEN of ASCII characters, starting at IN, to hexadecimal digits starting at OUT. The Hexadecimal to ASCII instruction (HTA) converts the hexadecimal digits, starting with the input byte IN, to ASCII characters starting at OUT. The number of hexadecimal digits to be converted is specified by length LEN.

The maximum number of ASCII characters or hexadecimal digits that can be converted is 255. Valid ASCII input

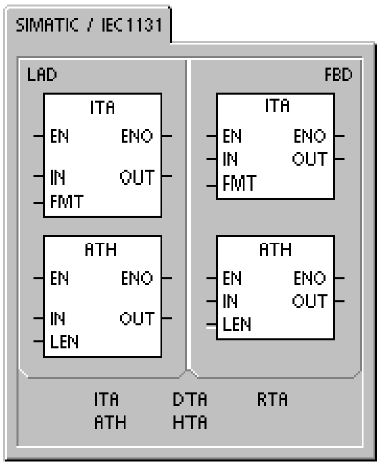
Valid ASCII input characters are alphanumeric characters 0 to 9 with a hex code value of 30 to 39, and uppercase characters A to F with a hex code value of 41 to 46.

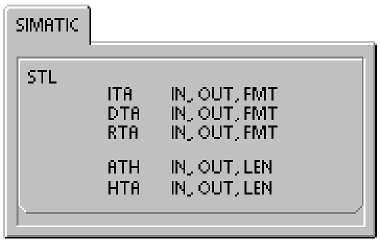
Error conditions that set ENO = 0

- SM1.7 (illegal ASCII) *ASCII to Hexadecimal only*
- 0006 (indirect address)
- 0091 (operand out of range)

SM bits affected:

- SM1.7 (illegal ASCII)





```
SIMATIC
STL
        ITA    IN, OUT, FMT
        DTA    IN, OUT, FMT
        RTA    IN, OUT, FMT

        ATH    IN, OUT, LEN
        HTA    IN, OUT, LEN
```

Converting Numerical Values to ASCII

The Integer to ASCII (ITA), Double Integer to ASCII (DTA), and Real to ASCII (RTA) instructions convert integer, double integer, or real number values to ASCII characters.

Table 6-18 Valid Operands for the ASCII Conversion Instructions

Inputs/Outputs	Data Type	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC
	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
LEN, FMT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC

Operation of the Integer to ASCII Instruction

The Integer to ASCII instruction (ITA) converts an integer word IN to an array of ASCII characters. The format FMT specifies the conversion precision to the right of the decimal, and whether the decimal point is to be shown as a comma or a period. The resulting conversion is placed in 8 consecutive bytes beginning with OUT.

Error conditions that set ENO = 0

- 0006 (indirect address)
- Illegal format
- *nnn* > 5

The array of ASCII characters is always 8 characters.

Figure 6-15 describes the format operand for the Integer to ASCII instruction. The size of the output buffer is always 8 bytes. The number of digits to the right of the decimal point in the output buffer is specified by the *nnn* field. The valid range of the *nnn* field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. For values of *nnn* bigger than 5, the output buffer is filled with ASCII spaces. The *c* bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction. The upper 4 bits must be zero.

Figure 6-15 shows examples of values that are formatted using a decimal point (c=0) with three digits to the right of the decimal point (nnn=011). The output buffer is formatted according to the following rules:

- ❑ Positive values are written to the output buffer without a sign.
- ❑ Negative values are written to the output buffer with a leading minus sign (–).
- ❑ Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- ❑ Values are right-justified in the output buffer.

FMT

MSB 7	6	5	4	3	2	1	LSB 0
0	0	0	0	c	n	n	n

c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

	Out	Out +1	Out +2	Out +3	Out +4	Out +5	Out +6	Out +7
in=12				0	.	0	1	2
in=–123			–	0	.	1	2	3
in=1234				1	.	2	3	4
in = –12345		–	1	2	.	3	4	5

Figure 6-15 FMT Operand for the Integer to ASCII (ITA) Instruction

Operation of the Double Integer to ASCII Instruction

The Double Integer to ASCII (DTA) instruction converts a double word IN to an array of ASCII characters. The format operand FMT specifies the conversion precision to the right of the decimal. The resulting conversion is placed in 12 consecutive bytes beginning with OUT.

Error conditions that set ENO = 0

- ■ 0006 (indirect address)
- ■ Illegal format
- ■ *nnn* > 5

The size of the output buffer is always 12 bytes.

Figure 6-16 describes the format operand for the Double Integer to ASCII instruction. The number of digits to the right of the decimal point in the output buffer is specified by the *nnn* field. The valid range of the *nnn* field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. For values of *nnn* bigger than 5, the output buffer is filled with ASCII spaces. The *c* bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction. The upper 4 bits must be zero.

Figure 6-16 shows examples of values that are formatted using a decimal point (c=0) with four digits to the right of the decimal point (nnn=100). The output buffer is formatted according to the following rules:

- ❑ Positive values are written to the output buffer without a sign.
- ❑ Negative values are written to the output buffer with a leading minus sign (–).
- ❑ Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- ❑ Values are right-justified in the output buffer.

FMT

MSB							LSB
7	6	5	4	3	2	1	0
0	0	0	0	c	n	n	n

c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

	Out	Out +1	Out +2	Out +3	Out +4	Out +5	Out +6	Out +7	Out +8	Out +9	Out +10	Out +11
in=-12						-	0	.	0	0	1	2
in=1234567					1	2	3	.	4	5	6	7

Figure 6-16 FMT Operand for the Double Integer to ASCII (DTA) Instruction

Operation of the Real to ASCII Instruction

The Real to ASCII instruction (RTA) converts a real-number value IN to ASCII characters. The format FMT specifies the conversion precision to the right of the decimal, whether the decimal point is shown as a comma or a period, and the output buffer size.

The resulting conversion is placed in an output buffer beginning with OUT.

Error conditions that set ENO = 0

- 0006 (indirect address)
- nnn > 5
- ssss < 3
- ssss< number of characters in OUT

The number (or length) of the resulting ASCII characters is the size of the output buffer and can be specified to a size ranging from 3 to 15 bytes or characters.

The real-number format used by the S7-200 supports a maximum of 7 significant digits. Attempting to display more than 7 significant digits produces a rounding error.

Figure 6-17 describes the format operand (FMT) for the RTA instruction. The size of the output buffer is specified by the ssss field. A size of 0, 1, or 2 bytes is not valid. The number of digits to the right of the decimal point in the output buffer is specified by the nnn field. The valid range of the nnn field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. The output buffer is filled with ASCII spaces for values of nnn bigger than 5 or when the specified output buffer is too small to store the converted value. The c bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction.

Figure 6-17 also shows examples of values that are formatted using a decimal point (c=0) with one digit to the right of the decimal point (nnn=001) and a buffer size of six bytes (ssss=0110). The output buffer is formatted according to the following rules:

- ❏ Positive values are written to the output buffer without a sign.
- ❏ Negative values are written to the output buffer with a leading minus sign (-).
- ❏ Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- ❏ Values to the right of the decimal point are rounded to fit in the specified number of digits to the right of the decimal point.
- ❏ The size of the output buffer must be a minimum of three bytes more than the number of digits to the right of the decimal point.
- ❏ Values are right-justified in the output buffer.

FMT

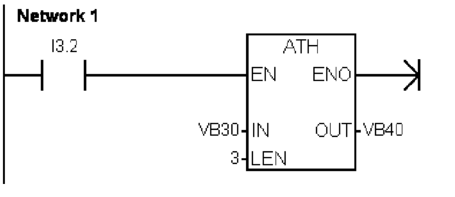
MSB							LSB
7	6	5	4	3	2	1	0
s	s	s	s	c	n	n	n

ssss = size of output buffer
c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

	Out	Out +1	Out +2	Out +3	Out +4	Out +5
in = 1234.5	1	2	3	4	.	5
in = -0.0004				0	.	0
in = -3.67526			-	3	.	7
in = 1.95				2	.	0

Figure 6-17 FMT Operand for the Real to ASCII (RTA) Instruction

Example: ASCII to Hexadecimal Instruction

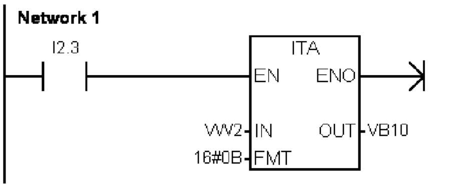


```
Network 1
LD      I3.2
ATH     VB30, VB40, 3
```

‘3’	‘E’	‘A’			
33	45	41	ATH	3E	Ax
VB30				VB40	

Note: The X indicates that the “nibble” (half of a byte) is unchanged.

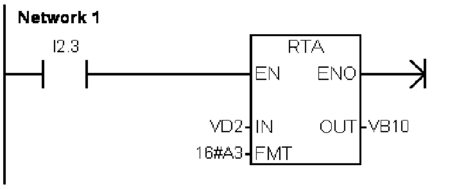
Example: Integer to ASCII Instruction



```
Network 1     //Convert the integer value at VW2
              //to 8 ASCII characters starting at VB10,
              //using a format of 16#0B
              //(a comma for the decimal point,
              //followed by 3 digits).
LD      I2.3
ITA     VW2, VB10, 16#0B
```

		‘ ’	‘ ’	‘1’	‘2’	‘,’	‘3’	‘4’	‘5’
12345	ITA	20	20	31	32	2C	33	34	35
VW2		VB10	VB11	...					

Example: Real to ASCII Instruction



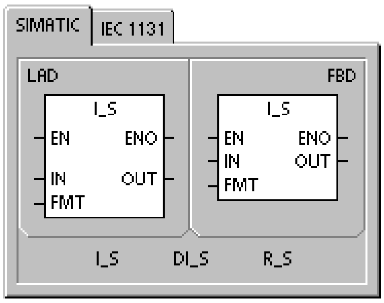
```
Network 1     //Convert the real value at VD2
              //to 10 ASCII characters starting at VB10,
              //using a format of 16#A3
              //(a period for the decimal point,
              //followed by 3 digits).
LD      I2.3
RTA     VD2, VB10, 16#A3
```

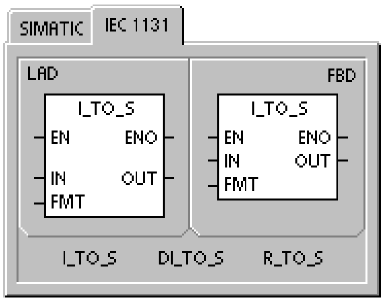
		‘ ’	‘ ’	‘ ’	‘1’	‘2’	‘3’	‘.’	‘4’	‘5’	‘0’
123.45	RTA	20	20	20	31	32	33	2E	34	35	30
VD2		VB10	VB11	...							

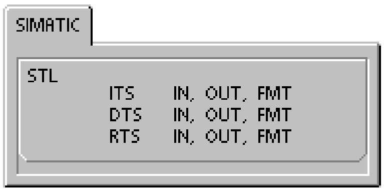
String Conversion Instructions

Converting Numerical Values to String

The Integer to String (ITS), Double Integer to String (DTS), and Real to String (RTS) instructions convert integers, double integers, or real number values (IN) to an ASCII string (OUT).







```
ITS   IN, OUT, FMT
DTS   IN, OUT, FMT
RTS   IN, OUT, FMT
```

Operation of the Integer to String

The Integer to String instruction (ITS) converts an integer word IN to an ASCII string with a length of 8 characters. The format (FMT) specifies the conversion precision to the right of the decimal, and whether the decimal point is to be shown as a comma or a period. The resulting string is written to 9 consecutive bytes starting at OUT. See the section, format for strings in Chapter 4 for more information.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)
- Illegal format (nnn > 5)

Figure 6-18 describes the format operand for the Integer to String instruction. The length of the output string is always 8 characters. The number of digits to the right of the decimal point in the output buffer is specified by the nnn field. The valid range of the nnn field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. For values of nnn greater than 5, the output is a string of 8 ASCII space characters. The c bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction. The upper 4 bits of the format must be zero.

Figure 6-18 also shows examples of values that are formatted using a decimal point (c= 0) with three digits to the right of the decimal point (nnn = 011).The value at OUT is the length of the string.

The output string is formatted according to the following rules:

- ❑ Positive values are written to the output buffer without a sign.
- ❑ Negative values are written to the output buffer with a leading minus sign (–).
- ❑ Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- ❑ Values are right-justified in the output string.

Table 6-19 Valid Operands for the Instructions That Convert Numerical Values to Strings

Inputs/Outputs	Data Type	Operands
IN	INT DINT REAL	IW, QW, VW, MW, SMW, SW, T, C, LW, AIW, *VD, *LD, *AC, Constant ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
FMT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
OUT	STRING	VB, LB, *VD, *LD, *AC

FMT

MSB LSB

7	6	5	4	3	2	1	0
0	0	0	0	c	n	n	n

c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

	Out	Out +1	Out +2	Out +3	Out +4	Out +5	Out +6	Out +7	Out +8
in=12	8				0	.	0	1	2
in=–123	8				0	.	1	2	3
in=1234	8				1	.	2	3	4
in = –12345	8		–	1	2	.	3	4	5

Figure 6-18 FMT Operand for the Integer to String Instruction

Operation of the Double Integer to String

The Double Integer to String instruction (DTS) converts a double integer IN to an ASCII string with a length of 12 characters. The format (FMT) specifies the conversion precision to the right of the decimal, and whether the decimal point is to be shown as a comma or a period. The resulting string is written to 13 consecutive bytes starting at OUT. For more information, see the section that describes the format for strings in Chapter 4.

Error conditions that set ENO = 0

- ■ 0006 (indirect address)
- ■ 0091 (operand out of range)
- ■ Illegal format (nnn > 5)

Figure 6-19 describes the format operand for the Integer to String instruction. The length of the output string is always 8 characters. The number of digits to the right of the decimal point in the output buffer is specified by the nnn field. The valid range of the nnn field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. For values of nnn greater than 5, the output is a string of 12 ASCII space characters. The c bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction. The upper 4 bits of the format must be zero.

Figure 6-19 also shows examples of values that are formatted using a decimal point (c= 0) with four digits to the right of the decimal point (nnn = 100). The value at OUT is the length of the string. The output string is formatted according to the following rules:

- ❑ Positive values are written to the output buffer without a sign.
- ❑ Negative values are written to the output buffer with a leading minus sign (–).
- ❑ Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- ❑ Values are right-justified in the output string.

FMT

MSB LSB

7	6	5	4	3	2	1	0
0	0	0	0	c	n	n	n

c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

	Out	Out +1	Out +2	Out +3	Out +4	Out +5	Out +6	Out +7	Out +8	Out +9	Out +10	Out +11	Out +12
in=12	12					.	–	0	.	0	0	1	2
in=–1234567	12					1	2	3	.	4	5	6	7

Figure 6-19 FMT Operand for the Double Integer to String Instruction

Operation of the Real to String

The Real to String instruction (RTS) converts a real value IN to an ASCII string. The format (FMT) specifies the conversion precision to the right of the decimal, whether the decimal point is to be shown as a comma or a period and the length of the output string.

The resulting conversion is placed in a string beginning with OUT. The length of the resulting string is specified in the format and can be 3 to 15 characters. For more information, see the section that describes the format for strings in Chapter 4.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)
- Illegal format:
  nnn > 5
  ssss < 3
  ssss < number of characters required

The real-number format used by the S7-200 supports a maximum of 7 significant digits. Attempting to display more than the 7 significant digits produces a rounding error.

Figure 6-20 describes the format operand for the Real to String instruction. The length of the output string is specified by the ssss field. A size of 0, 1, or 2 bytes is not valid. The number of digits to the right of the decimal point in the output buffer is specified by the nnn field. The valid range of the nnn field is 0 to 5. Specifying 0 digits to the right of the decimal point causes the value to be displayed without a decimal point. The output string is filled with ASCII space characters when nnn is greater than 5 or when the specified length of the output string is too small to store the converted value. The c bit specifies the use of either a comma (c=1) or a decimal point (c=0) as the separator between the whole number and the fraction.

Figure 6-20 also shows examples of values that are formatted using a decimal point (c= 0) with one digit to the right of the decimal point (nnn = 001) and a output string length of 6 characters (ssss = 0110). The value at OUT is the length of the string. The output string is formatted according to the following rules:

- Positive values are written to the output buffer without a sign.
- Negative values are written to the output buffer with a leading minus sign (–).
- Leading zeros to the left of the decimal point (except the digit adjacent to the decimal point) are suppressed.
- Values to the right of the decimal point are rounded to fit in the specified number of digits to the right of the decimal point.
- The size of the output string must be a minimum of three bytes more than the number of digits to the right of the decimal point.
- Values are right-justified in the output string.

FMT

MSB							LSB
7	6	5	4	3	2	1	0
s	s	s	s	c	n	n	n

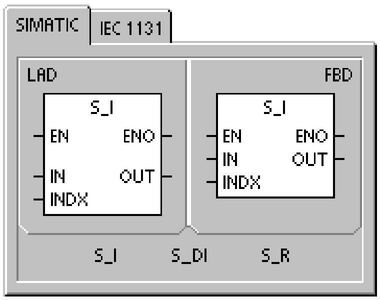
ssss = length of output string
c = comma (1) or decimal point (0)
nnn = digits to right of decimal point

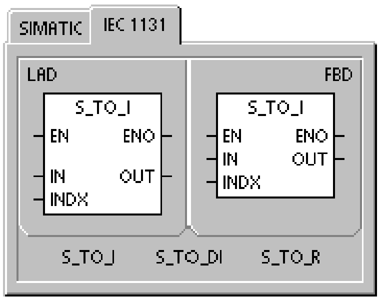
	Out	Out +1	Out +2	Out +3	Out +4	Out +5	Out +6
in=1234.5	6	1	2	3	4	.	5
in= –0.0004	6				0	.	0
in= –3.67526	6			–	3	.	7
in = 1.95	6				2	.	0

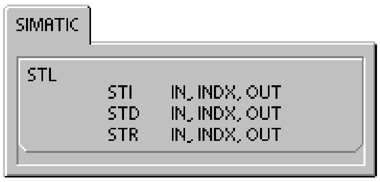
Figure 6-20 FMT Operand for the Real to String Instruction

Converting Substrings to Numerical Values

The Substring to Integer (STI), Substring to Double Integer (STD), and Substring to Real (STR) instructions convert a string value IN, starting at the offset INDX, to an integer, double integer or real number value OUT .







```
STI    IN, INDX, OUT
STD    IN, INDX, OUT
STR    IN, INDX, OUT
```

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)
- 009B (index = 0)
- SM1.1 (overflow)

The Substring to Integer and Substring to Double Integer convert strings with the following form:
[spaces] [+ or –] [digits 0 – 9]

The Substring to Real instruction converts strings with the following form: [spaces] [+ or –] [digits 0 – 9] [. or ,] [digits 0 – 9]

The INDX value is normally set to 1, which starts the conversion with the first character of the string. The INDX value can be set to other values to start the conversion at different points within the string. This can be used when the input string contains text that is not part of the number to be converted. For example, if the input string is “Temperature: 77.8”, you set INDX to a value of 13 to skip over the word “Temperature: ” at the start of the string.

The Substring to Real instruction does not convert strings using scientific notation or exponential forms of real numbers. The instruction does not produce an overflow error (SM1.1) but converts the string to a real number up to the exponential and then terminates the conversion. For example, the string ‘1.234E6’ converts without errors to a real value of 1.234.

The conversion is terminated when the end of the string is reached or when the first invalid character is found. An invalid character is any character which is not a digit (0 – 9).

The overflow error (SM1.1) is set whenever the conversion produces an integer value that is too large for the output value. For example, the Substring to Integer instruction sets the overflow error if the input string produces a value greater than 32767 or less than –32768.

The overflow error (SM1.1) is also set if no conversion is possible when the input string does not contain a valid value. For example, if the input string contains ‘A123’, the conversion instruction sets SM1.1 (overflow) and the output value remains unchanged.

Table 6-20 Valid Operands for the Instructions That Convert Substrings to Numerical Values

Inputs/Outputs	Data Type	Operands
IN	STRING	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC, Constant
INDX	BYTE	VB, IB, QB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
OUT	INT DINT, REAL	VW, IW, QW, MW, SMW, SW, T, C, LW, AC, AQW, *VD, *LD, *AC VD, ID, QD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Valid Input Strings
for Integer and Double Integer

Input String	Output Integer
‘123’	123
‘–00456’	–456
‘123.45’	123
‘+2345’	2345
‘000000123ABCD’	123

Valid Input Strings
for Real Numbers

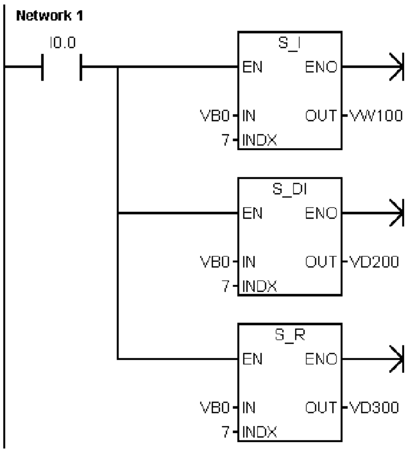
Input String	Output Real
‘123’	123.0
‘–00456’	–456.0
‘123.45’	123.45
‘+2345’	2345.0
‘00.000000123’	0.000000123

Invalid Input Strings

Input String
‘A123’
‘ ’
‘++123’
‘+–123
‘+ 123’

Figure 6-21 Examples of Valid and Invalid Input Strings

Example: String Conversion: Substring to Integer, Double Integer and Real



```
Network 1     //Converts the numeric string to an integer.
              //Converts the numeric string to a double integer.
              //Converts the numeric string to a real.
LD      I0.0
STI     VB0,7,VW100
STD     VB0,7,VD200
STR     VB0,7,VD300
```

VB0											VB11
11	’T’	’e’	’m’	’p’	’ ’	’ ’	’9’	’8’	’.’	’6’	’F’

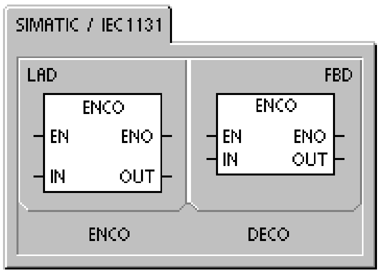
After executing the network:

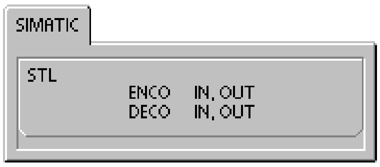
VW100 (integer) = 98

VD200 (double integer) = 98

VD300 (real) = 98.6

Encode and Decode Instructions





```
ENCO    IN, OUT
DECO    IN, OUT
```

Encode

The Encode instruction (ENCO) writes the bit number of the least significant bit set of the input word IN into the least significant “nibble” (4 bits) of the output byte OUT.

Decode

The Decode instruction (DECO) sets the bit in the output word OUT that corresponds to the bit number represented by the least significant “nibble” (4 bits) of the input byte IN. All other bits of the output word are set to 0.

SM Bits and ENO

For both the Encode and Decode instructions, the following conditions affect ENO.

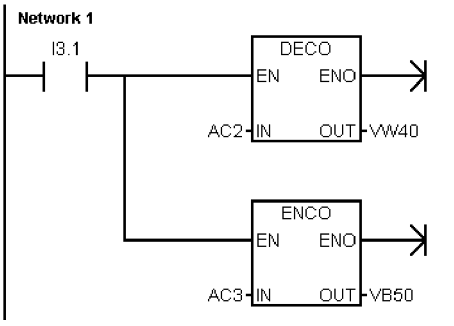
Error conditions that set ENO = 0

- 0006 (indirect address)

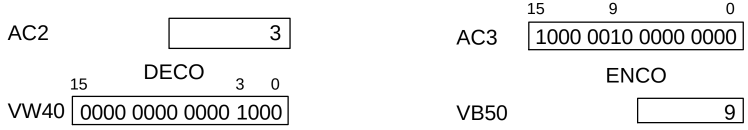
Table 6-21 Valid Operands for the Encode and Decode Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE WORD	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
OUT	BYTE WORD	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AQW, *VD, *LD, *AC

Example: Decode and Encode Instructions



```
Network 1     //AC2 contains error bits.
              //1.  The DECO instruction sets
                    the bit in VW40
              //    that corresponds to this error
              //    code.
              //2.  The ENCO instruction converts
              //    the least significant bit set to an
              //    error code
              //    that is stored in VB50.
LD       I3.1
DECO     AC2, VW40
ENCO     AC3, VB50
```



Counter Instructions

SIMATIC Counter Instructions

Count Up Counter

The Count Up instruction (CTU) counts up from the current value each time the count up (CU) input makes the transition from off to on. When the current value Cxx is greater than or equal to the preset value PV, the counter bit Cxx turns on. The counter is reset when the Reset (R) input turns on, or when the Reset instruction is executed. The counter stops counting when it reaches the maximum value (32,767).

STL operation :

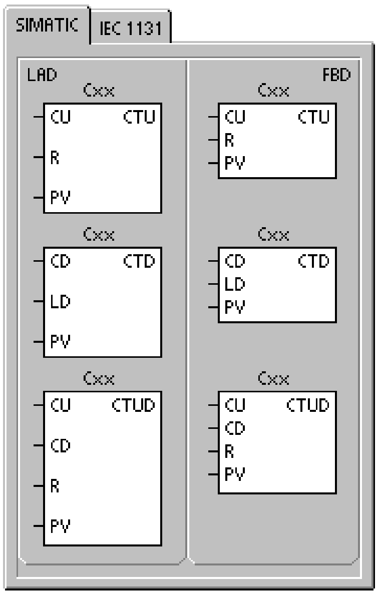
- Reset input: Top of stack
- Count Up input: Value loaded in the second stack location

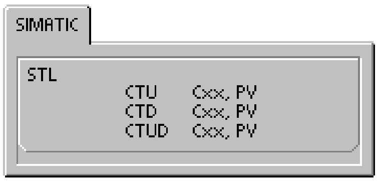
Count Down Counter

The Count Down instruction (CTD) counts down from the current value of that counter each time the count down (CD) input makes the transition from off to on. When the current value Cxx is equal to 0, the counter bit Cxx turns on. The counter resets the counter bit Cxx and loads the current value with the preset value PV when the load input LD turns on. The counter stops upon reaching zero, and the counter bit Cxx turns on.

STL operation:

- Load input: Top of stack
- Count Down input: Value loaded in the second stack location.





```
STL
            CTU     Cxx, PV
            CTD     Cxx, PV
            CTUD    Cxx, PV
```

Count Up/Down Counter

The Count Up/Down instruction (CTUD) counts up each time the count up (CU) input makes the transition from off to on, and counts down each time the count down (CD) input makes the transition from off to on. The current value Cxx of the counter maintains the current count. The preset value PV is compared to the current value each time the counter instruction is executed.

Upon reaching maximum value (32,767), the next rising edge at the count up input causes the current count to wrap around to the minimum value (–32,768). On reaching the minimum value (–32,768), the next rising edge at the count down input causes the current count to wrap around to the maximum value (32,767).

When the current value Cxx is greater than or equal to the preset value PV, the counter bit Cxx turns on. Otherwise, the counter bit turns off. The counter is reset when the Reset (R) input turns on, or when the Reset instruction is executed.

STL operation:

- Reset input: Top of stack
- Count Down input: Value loaded in the second stack location
- Count Up input: Value loaded in the third stack location

Table 6-22 Valid Operands for the SIMATIC Counter Instructions

Inputs/Outputs	Data Types	Operands
Cxx	WORD	Constant (C0 to C255)
CU, CD, LD, R	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
PV	INT	IW, QW, VW, MW, SMW, SW, LW, T, C, AC, AIW, *VD, *LD, *AC, Constant

Tip

Since there is one current value for each counter, do not assign the same number to more than one counter. (Up Counters, Up/Down Counters, and Down counters with the same number access the same current value.)

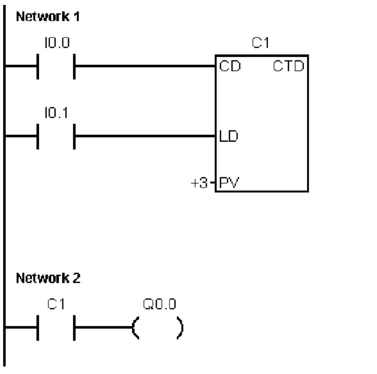
When you reset a counter using the Reset instruction, the counter bit is reset and the counter current value is set to zero. Use the counter number to reference both the current value and the counter bit of that counter.

Table 6-23 Operations of the Counter Instructions

Type	Operation	Counter Bit	Power Cycle/First Scan
CTU	CU increments the current value. Current value continues to increment until it reaches 32,767.	The counter bit turns on when: Current value >= Preset	Counter bit is off. Current value can be retained.[1]
CTUD	CU increments the current value. CD decrements the current value. Current value continues to increment or decrement until the counter is reset.	The counter bit turns on when: Current value >= Preset	Counter bit is off. Current value can be retained.[1]
CTD	CD decrements the current value until the current value reaches 0.	The counter bit turns on when: Current value = 0	Counter bit is off. Current value can be retained.[1]

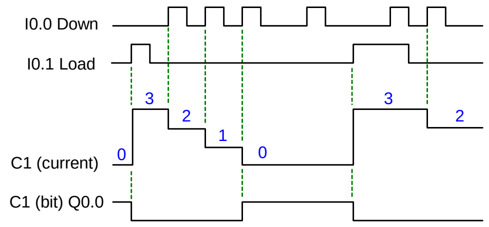
[1] You can select that the current value for the counter be retentive. See Chapter 4 for information about memory retention for the S7-200 CPU.

Example: SIMATIC Count Down Counter Instruction

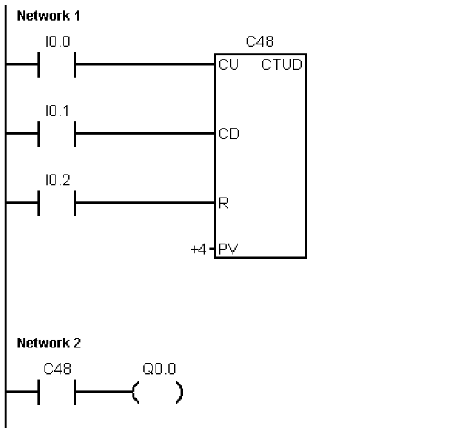


```
Network 1      //Count down counter C1 current value
               //counts from 3 to 0
               //with I0.1 off,
               //I0.0 Off-on decrements C1 current value
               //I0.1 On loads countdown preset value 3
LD        I0.0
LD        I0.1
CTD       C1, +3

Network 2      //C1 bit is on when counter C1 current value = 0
LD        C1
=         Q0.0
```

Timing Diagram

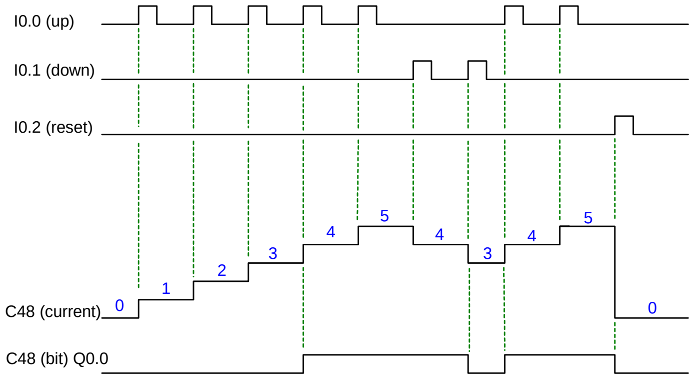


Example: SIMATIC Count Up/Down Counter Instruction

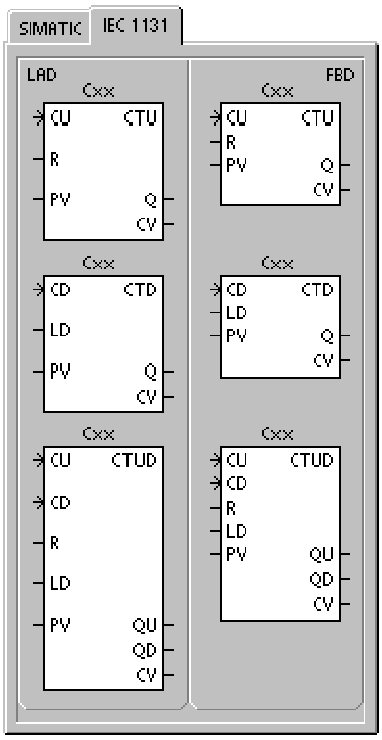


```
Network 1      //I0.0 counts up
               //I0.1 counts down
               //I0.2 resets current value to 0
LD        I0.0
LD         I0.1
LD        I0.2
CTUD      C48, +4

Network 2      //Count Up/Down counter C48
               //turns on C48 bit  when
               //current value >= 4
LD        C48
=         Q0.0
```

Timing Diagram



IEC Counter Instructions



Up Counter

The Count Up instruction (CTU) counts up from the current value to the preset value (PV) on the rising edges of the Count Up (CU) input. When the current value (CV) is greater than or equal to the preset value, the counter output bit (Q) turns on. The counter resets when the reset input (R) is enabled. The Up Counter stops counting when it reaches the preset value.

Down Counter

The Count Down instruction (CTD) counts down from the preset value (PV) on the rising edges of the Count Down (CD) input. When the current value (CV) is equal to zero, the counter output bit (Q) turns on. The counter resets and loads the current value with the preset value when the load input (LD) is enabled. The Down Counter stops counting when it reaches zero.

Up/Down Counter

The Count Up/Down instruction (CTUD) counts up or down from the current value (CV) on the rising edges of the Count Up (CU) or Count Down (CD) input. When the current value is equal to preset, the up output (QU) turns on. When the current value is equal to zero, the down output (QD) turns on. The counter loads the current value with the preset value (PV) when the load (LD) input is enabled. Similarly, the counter resets and loads the current value with 0 when the reset (R) is enabled. The counter stops counting when it reaches preset or 0.

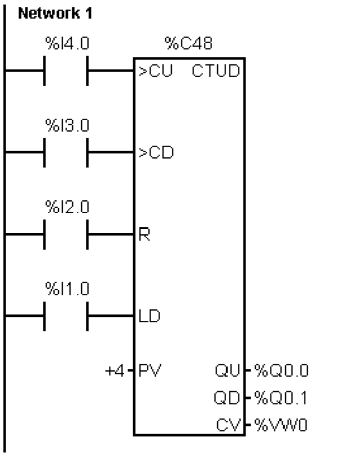
Table 6-24 Valid Operands for the IEC Counter Instructions

Inputs/Outputs	Data Types	Operands
Cxx	CTU, CTD, CTUD	Constant (C0 to C255)
CU, CD, LD, R	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
PV	INT	IW, QW, VW, MW, SMW, SW, LW, AC, AIW, *VD, *LD, *AC, Constant
Q, QU, QD	BOOL	I, Q, V, M, SM, S, L
CV	INT	IW, QW, VW, MW, SW, LW, AC, *VD, *LD, *AC

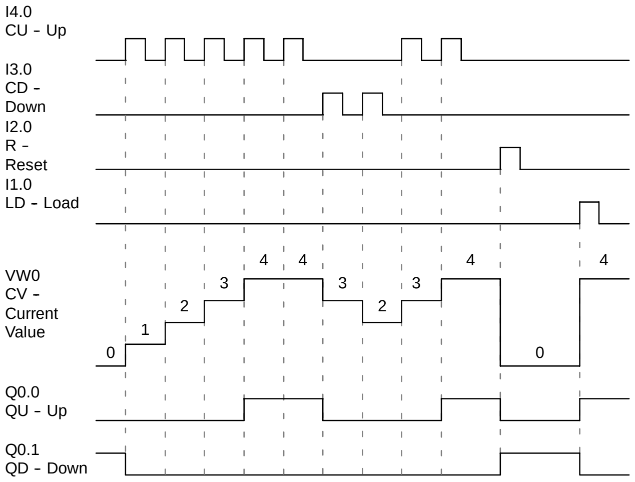
Tip

Since there is one current value for each counter, do not assign the same number to more than one counter. (Up Counters, Down Counters, and Up/Down Counters access the same current value.)

Example: IEC Counter Instructions

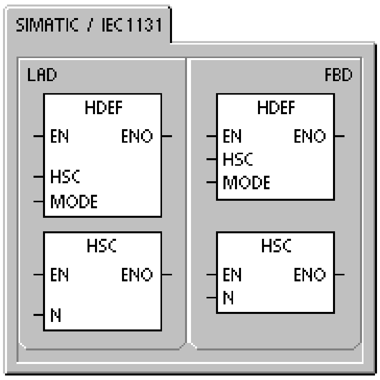


Timing Diagram



High-Speed Counter Instructions

High-Speed Counter Definition

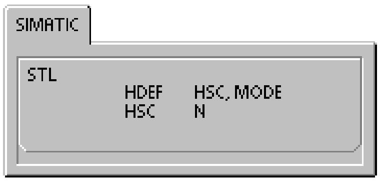


The High-Speed Counter Definition instruction (HDEF) selects the operating mode of a specific high-speed counter (HSCx). The mode selection defines the clock, direction, start, and reset functions of the high-speed counter.

You use one High-Speed Counter Definition instruction for each high-speed counter.

Error conditions that set ENO = 0

- 0003 (input point conflict)
- 0004 (illegal instruction in interrupt)
- 000A (HSC redefinition)



```
HDEF     HSC, MODE
HSC      N
```

High-Speed Counter

The High-Speed Counter (HSC) instruction configures and controls the high-speed counter, based on the state of the HSC special memory bits. The parameter N specifies the high-speed counter number.

The high-speed counters can be configured for up to twelve different modes of operation. See Table 6-26.

Each counter has dedicated inputs for clocks, direction control, reset, and start, where these functions are supported. For the two-phase counters, both clocks can run at their maximum rates. In quadrature modes, you can select one times (1x) or four times (4x) the maximum counting rates. All counters run at maximum rates without interfering with one another.

Error conditions that set ENO = 0

- 0001 (HSC before HDEF)
- 0005 (simultaneous HSC/PLS)

Table 6-25 Valid Operands for the High-Speed Counter Instructions

Inputs/Outputs	Data Types	Operands
HSC, MODE	BYTE	Constant
N	WORD	Constant

Programming Tips

Refer to the Programming Tips on the documentation CD for programs that use high-speed counters. See Tip 4 and Tip 29.

High-speed counters count high-speed events that cannot be controlled at S7-200 scan rates. The maximum counting frequency of a high-speed counter depends upon your S7-200 CPU model. Refer to Appendix A for more information.

Tip

CPU 221 and CPU 222 support four high-speed counters: HSC0, HSC3, HSC4, and HSC5. These CPUs do not support HSC1 and HSC2.

CPU 224, CPU 224XP, and CPU 226 support six high-speed counters: HSC0 to HSC5.

Typically, a high-speed counter is used as the drive for a drum timer, where a shaft rotating at a constant speed is fitted with an incremental shaft encoder. The shaft encoder provides a specified number of counts per revolution and a reset pulse that occurs once per revolution. The clock(s) and the reset pulse from the shaft encoder provide the inputs to the high-speed counter.

The high-speed counter is loaded with the first of several presets, and the desired outputs are activated for the time period where the current count is less than the current preset. The counter is set up to provide an interrupt when the current count is equal to preset and also when reset occurs.

As each current-count-value-equals-preset-value interrupt event occurs, a new preset is loaded and the next state for the outputs is set. When the reset interrupt event occurs, the first preset and the first output states are set, and the cycle is repeated.

Since the interrupts occur at a much lower rate than the counting rates of the high-speed counters, precise control of high-speed operations can be implemented with relatively minor impact to the overall PLC scan cycle. The method of interrupt attachment allows each load of a new preset to be performed in a separate interrupt routine for easy state control. (Alternatively, all interrupt events can be processed in a single interrupt routine.)

Understanding the Different High-Speed Counters

All counters function the same way for the same counter mode of operation. There are four basic types of counters: single-phase counter with internal direction control, single-phase counter with external direction control, two-phase counter with 2 clock inputs, and A/B phase quadrature counter. Note that every mode is not supported by every counter. You can use each type: without reset or start inputs, with reset and without start, or with both start and reset inputs.

- When you activate the reset input, it clears the current value and holds it clear until you deactivate reset.
- When you activate the start input, it allows the counter to count. While start is deactivated, the current value of the counter is held constant and clocking events are ignored.
- If reset is activated while start is inactive, the reset is ignored and the current value is not changed. If the start input becomes active while the reset input is active, the current value is cleared.

Before you use a high-speed counter, you use the HDEF instruction (High-Speed Counter Definition) to select a counter mode. Use the first scan memory bit, SM0.1 (this bit is turned on for the first scan and is then turned off), to call a subroutine that contains the HDEF instruction.

Programming a High-Speed Counter

Instruction Wizard

You can use the HSC Instruction Wizard to configure the counter. The wizard uses the following information: type and mode of counter, counter preset value, counter current value, and initial counting direction. To start the HSC Instruction Wizard, select the **Tools > Instruction Wizard** menu command and then select HSC from the Instruction Wizard window.

To program a high-speed counter, you must perform the following basic tasks:

- Define the counter and mode.
- Set the control byte.
- Set the current value (starting value).
- Set the preset value (target value).
- Assign and enable the interrupt routine.
- Activate the high-speed counter.

Defining Counter Modes and Inputs

Use the High-Speed Counter Definition instruction to define the counter modes and inputs.

Table 6-26 shows the inputs used for the clock, direction control, reset, and start functions associated with the high-speed counters. The same input cannot be used for two different functions, but any input not being used by the present mode of its high-speed counter can be used for another purpose. For example, if HSC0 is being used in mode 1, which uses I0.0 and I0.2, I0.1 can be used for edge interrupts or for HSC3.

Tip

Note that all modes of HSC0 (except mode 12) always use I0.0 and all modes of HSC4 always use I0.3, so these points are never available for other uses when these counters are in use.

Table 6-26 Inputs for the High-Speed Counters

Mode	Description	Inputs			
	HSC0	I0.0	I0.1	I0.2	
	HSC1	I0.6	I0.7	I1.0	I1.1
	HSC2	I1.2	I1.3	I1.4	I1.5
	HSC3	I0.1			
	HSC4	I0.3	I0.4	I0.5	
	HSC5	I0.4			
0	Single-phase counter with internal direction control	Clock			
1		Clock		Reset	
2		Clock		Reset	Start
3	Single-phase counter with external direction control	Clock	Direction		
4		Clock	Direction	Reset	
5		Clock	Direction	Reset	Start
6	Two-phase counter with 2 clock inputs	Clock Up	Clock Down		
7		Clock Up	Clock Down	Reset	
8		Clock Up	Clock Down	Reset	Start
9	A/B phase quadrature counter	Clock A	Clock B		
10		Clock A	Clock B	Reset	
11		Clock A	Clock B	Reset	Start
12	Only HSC0 and HSC3 support mode12. HSC0 counts the number of pulses going out of Q0.0. HSC3 counts the number of pulses going out of Q0.1.				

Examples of HSC Modes

The timing diagrams in Figure 6-22 through Figure 6-26 show how each counter functions according to mode.

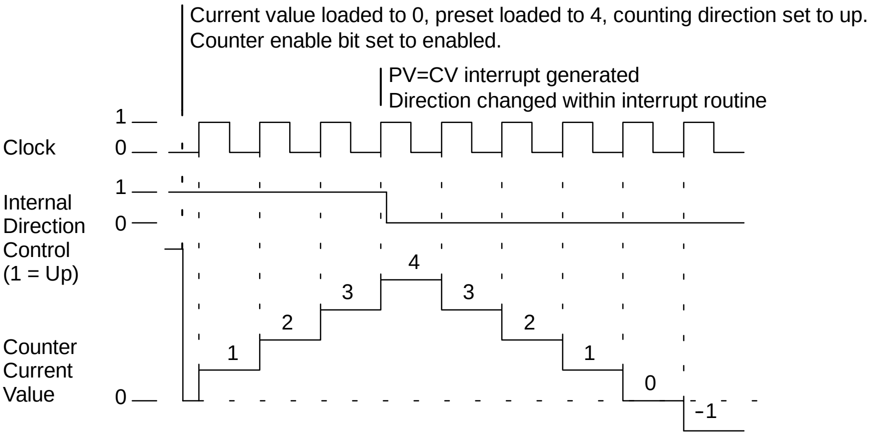

Current value loaded to 0, preset loaded to 4, counting direction set to up.
Counter enable bit set to enabled.
PV=CV interrupt generated
Direction changed within interrupt routine
Clock
1
0
Internal Direction Control (1 = Up)
1
0
Counter Current Value
0
1
2
3
4
3
2
1
0
-1

Figure 6-22 Operation Example of Modes 0, 1, or 2

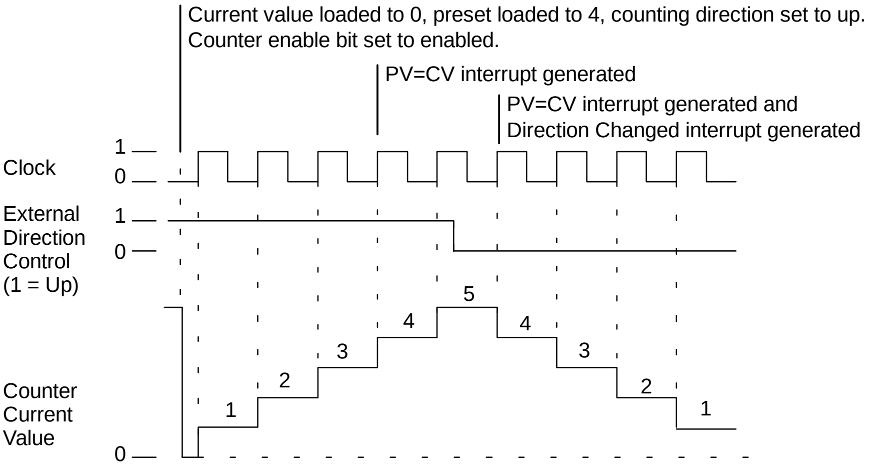

Current value loaded to 0, preset loaded to 4, counting direction set to up.
Counter enable bit set to enabled.
PV=CV interrupt generated
PV=CV interrupt generated and
Direction Changed interrupt generated
Clock
1
0
External Direction Control (1 = Up)
1
0
Counter Current Value
0
1
2
3
4
5
4
3
2
1

Figure 6-23 Operation Example of Modes 3, 4, or 5

When you use counting modes 6, 7, or 8, and rising edges on both the up clock and down clock inputs occur within 0.3 microseconds of each other, the high-speed counter could see these events as happening simultaneously. If this happens, the current value is unchanged and no change in counting direction is indicated. As long as the separation between rising edges of the up and down clock inputs is greater than this time period, the high-speed counter captures each event separately. In either case, no error is generated and the counter maintains the correct count value.

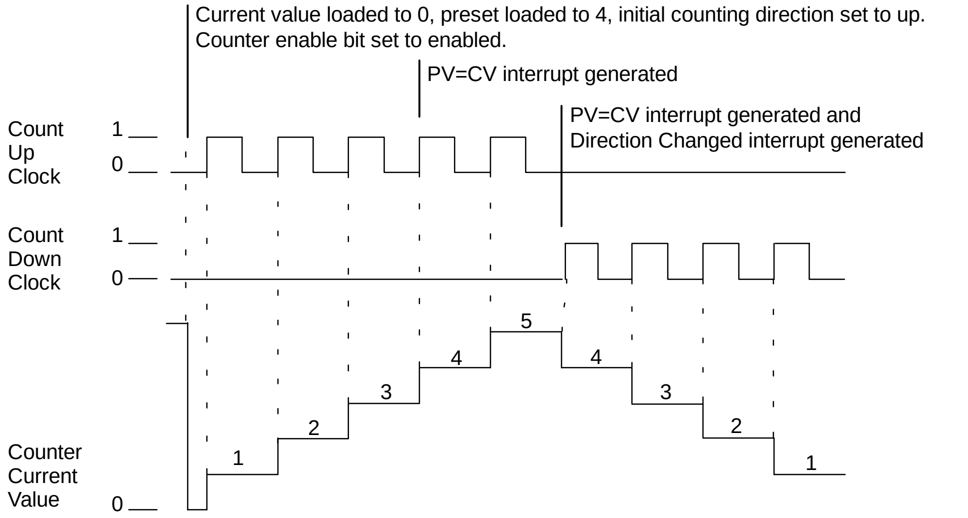

Current value loaded to 0, preset loaded to 4, initial counting direction set to up.
Counter enable bit set to enabled.
PV=CV interrupt generated
PV=CV interrupt generated and
Direction Changed interrupt generated
Count
Up
Clock
1
0
Count
Down
Clock
1
0
Counter
Current
Value
0
1
2
3
4
5
4
3
2
1

Figure 6-24 Operation Example of Modes 6, 7, or 8

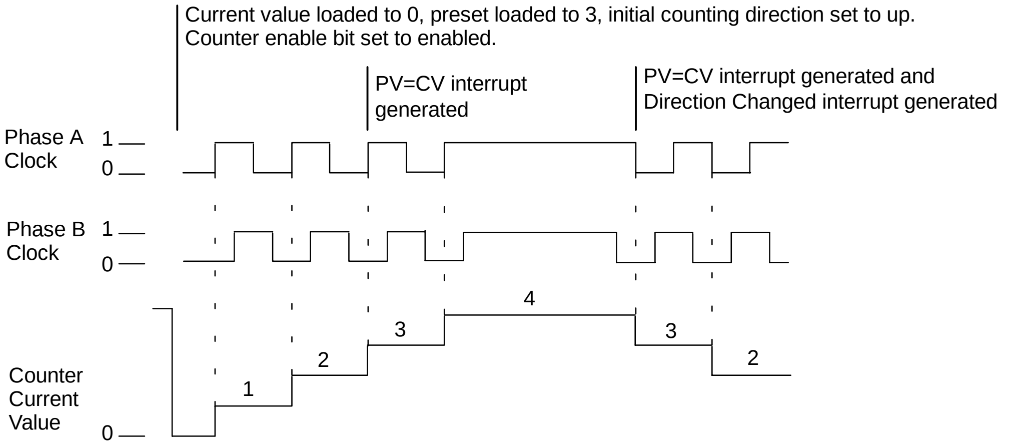

Current value loaded to 0, preset loaded to 3, initial counting direction set to up.
Counter enable bit set to enabled.
PV=CV interrupt
generated
PV=CV interrupt generated and
Direction Changed interrupt generated
Phase A
Clock
1
0
Phase B
Clock
1
0
Counter
Current
Value
0
1
2
3
4
3
2

Figure 6-25 Operation Example of Modes 9, 10, or 11 (Quadrature 1x Mode)

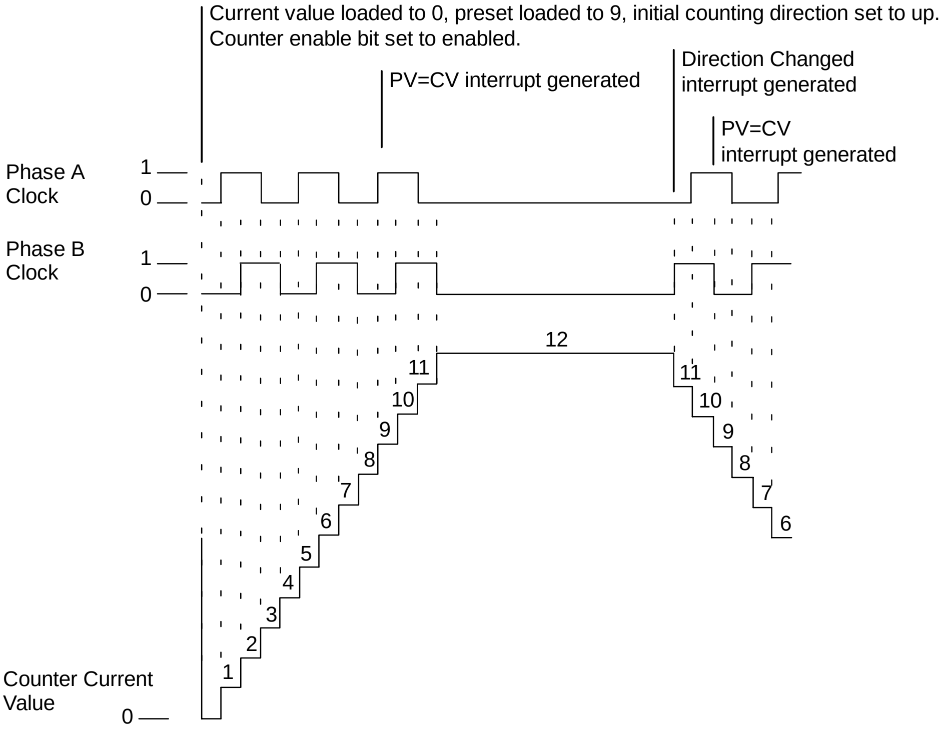

Current value loaded to 0, preset loaded to 9, initial counting direction set to up. Counter enable bit set to enabled.
PV=CV interrupt generated
Direction Changed interrupt generated
PV=CV interrupt generated
Phase A Clock
1
0
Phase B Clock
1
0
Counter Current Value
0
1
2
3
4
5
6
7
8
9
10
11
12
11
10
9
8
7
6

Figure 6-26 Operation Example of Modes 9, 10, or 11 (Quadrature 4x Mode)

Reset and Start Operation

The operation of the reset and start inputs shown in Figure 6-27 applies to all modes that use reset and start inputs. In the diagrams for the reset and start inputs, both reset and start are shown with the active state programmed to a high level.

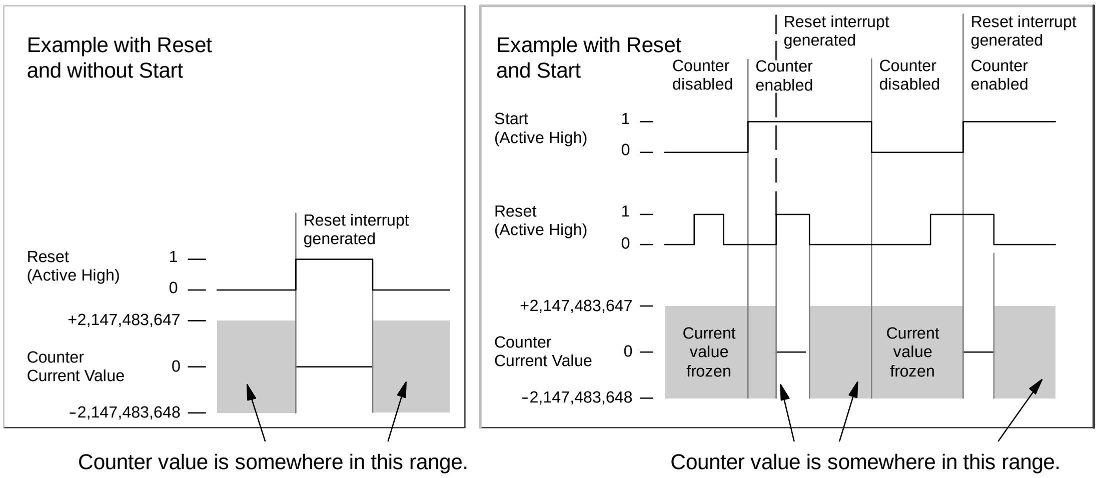


Figure 6-27 Operation Examples Using Reset with and without Start

Four counters have three control bits that are used to configure the active state of the reset and start inputs and to select 1x or 4x counting modes (quadrature counters only). These bits are located in the control byte for the respective counter and are only used when the HDEF instruction is executed. These bits are defined in Table 6-27.

Tip

You must set these three control bits to the desired state before the HDEF instruction is executed. Otherwise, the counter takes on the default configuration for the counter mode selected.

Once the HDEF instruction has been executed, you cannot change the counter setup unless you first place the S7-200 in STOP mode.

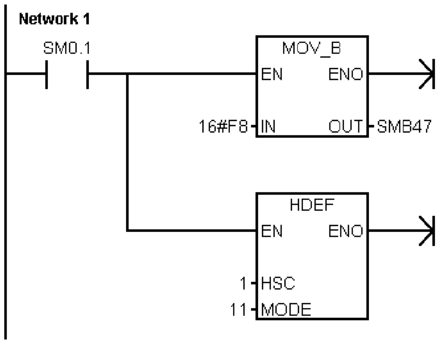
Table 6-27 Active Level for Reset, Start, and 1x/4x Control Bits

HSC0	HSC1	HSC2	HSC4	Description (used only when HDEF is executed)
SM37.0	SM47.0	SM57.0	SM147.0	Active level control bit for Reset[1]: 0 = Reset is active high 1 = Reset is active low
---	SM47.1	SM57.1	---	Active level control bit for Start[1]: 0 = Start is active high 1 = Start is active low
SM37.2	SM47.2	SM57.2	SM147.2	Counting rate selection for quadrature counters: 0 = 4X counting rate 1 = 1X counting rate

[1] The default setting of the reset input and the start input are active high, and the quadrature counting rate is 4x (or four times the input clock frequency).

Example: High-Speed Counter Definition Instruction

MAIN



```
Network 1    //On the first scan:
             //1.  Select the start and reset
             //     inputs to be active high
             //    and select 4x mode.
             //2.  Configure HSC1 for
             //    quadrature mode with reset
             //     and start inputs
LD       SM0.1
MOVB     16#F8, SMB47
HDEF     1, 11
```

Setting the Control Byte

After you define the counter and the counter mode, you can program the dynamic parameters of the counter. Each high-speed counter has a control byte that allows the following actions:

- ❑ Enabling or disabling the counter
- ❑ Controlling the direction (modes 0, 1, and 2 only), or the initial counting direction for all other modes
- ❑ Loading the current value
- ❑ Loading the preset value

Examination of the control byte and associated current and preset values is invoked by the execution of the HSC instruction. Table 6-28 describes each of these control bits.

Table 6-28 Control Bits for HSC0, HSC1, HSC2, HSC3, HSC4, and HSC5

HSC0	HSC1	HSC2	HSC3	HSC4	HSC5	Description
SM37.3	SM47.3	SM57.3	SM137.3	SM147.3	SM157.3	Counting direction control bit: 0 = Count down 1 = Count up
SM37.4	SM47.4	SM57.4	SM137.4	SM147.4	SM157.4	Write the counting direction to the HSC: 0 = No update 1 = Update direction
SM37.5	SM47.5	SM57.5	SM137.5	SM147.5	SM157.5	Write the new preset value to the HSC: 0 = No update 1 = Update preset
SM37.6	SM47.6	SM57.6	SM137.6	SM147.6	SM157.6	Write the new current value to the HSC: 0 = No update 1 = Update current value
SM37.7	SM47.7	SM57.7	SM137.7	SM147.7	SM157.7	Enable the HSC: 0 = Disable the HSC 1 = Enable the HSC

Reading the Current Value

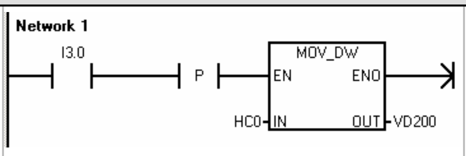
The current value of each high-speed counter can only be read using the data type HC (High-Speed-Counter Current) followed by the counter number (0, 1, 2, 3, 4, or 5) as shown in Table 6-29. Use the HC data type whenever you wish to read the current count, either in a status chart or in the user program. The HC data type is read–only; you cannot write a new current count to the high speed counter using the HC data type.

Table 6-29 Current Values of HSC0, HSC1, HSC2, HSC3, HSC4, and HSC5

Value to be Read	HSC0	HSC1	HSC2	HSC3	HSC4	HSC5
Current value (CV)	HC0	HC1	HC2	HC3	HC4	HC5

Example: Reading and Saving the Current Count

M
A
I
N



```
Network 1     //Save the value of
              //High Speed Counter 0
              //into VD200 when I3.0
              //transitions from OFF to ON.

LD       I3.0
EU
MOVD     HC0, VD200
```

Setting Current Values and Preset Values

Each high-speed counter has a 32–bit current value (CV) and a 32–bit preset value (PV) stored internally. The current value is the actual count value of the counter, while the preset value is a comparison value optionally used to trigger an interrupt when the current value reaches the preset value. You can read the current value using the HC data type as described in the previous section. You cannot read the preset value directly. To load a new current or preset value into the high-speed counter, you must set up the control byte and the special memory double-word(s) that hold the desired new current and/or new preset values, and also execute the HSC instruction to cause the new values to the transferred to the high-speed counter. Table 6-30 lists the special memory double words used to hold the desired new current and preset values.

Use the following steps to write a new current value and/or new preset value to the high-speed counter (steps 1 and 2 can be done in either order):

1. Load the value to be written into the appropriate SM new–current value and/or new preset value (Table 6-30). Loading these new values does not affect the high-speed counter yet.
2. Set or clear the appropriate bits in the appropriate control byte (Table 6-28) to indicate whether to update the current and/or preset values (bit x.5 for preset and x.6 for current). Manipulating these bits does not affect the high-speed counter yet.
3. Execute the HSC instruction referencing the appropriate high-speed counter number. Executing this instruction causes the control byte to be examined. If the control byte specifies an update for the current, the preset, or both, then the appropriate values are copied from the SM new current value and/or new preset value locations into the high–speed counter internal registers.

Table 6-30 New Current and New Preset Values of HSC0, HSC1, HSC2, HSC3, HSC4, and HSC5

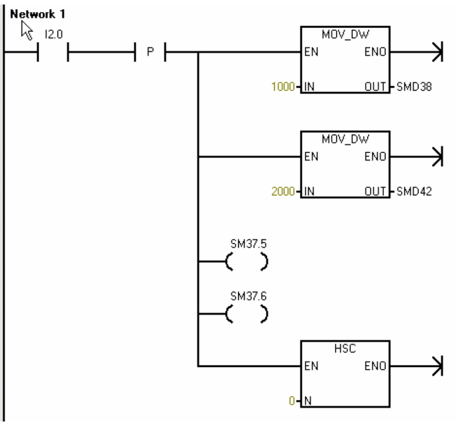
Value to be Loaded	HSC0	HSC1	HSC2	HSC3	HSC4	HSC5
New current value (new CV)	SMD38	SMD48	SMD58	SMD138	SMD148	SMD158
New preset value (new PV)	SMD42	SMD52	SMD62	SMD142	SMD152	SMD162

Tip

Changes to the control byte and the SM locations for new current value and new preset value will not affect the high-speed counter until the corresponding HSC instruction is executed.

Example: Updating the Current and Preset Values

MAIN



```
Network 1    //Update the current count to 1000
             //and the preset value to 2000
             //for High-Speed counter 0 when I2.0
             //transitions from OFF to ON

LD           I2.0
EU
MOVD         1000, SMD38
MOVD         2000, SMD42
=            SM37.5
=            SM37.6
HSC          0
```

Assigning Interrupts

All counter modes support an interrupt event when the current value of the HSC is equal to the loaded preset value. Counter modes that use an external reset input support an interrupt on activation of the external reset. All counter modes except modes 0, 1, and 2 support an interrupt on a change in counting direction. Each of these interrupt conditions can be enabled or disabled separately. For a complete discussion on the use of interrupts, see the section on Communications and Interrupt instructions.

Notice

A fatal error can occur if you attempt either to load a new current value or to disable and then re-enable the high-speed counter from within the external reset interrupt routine.

Status Byte

A status byte for each high-speed counter provides status memory bits that indicate the current counting direction and whether the current value is greater or equal to the preset value. Table 6-31 defines these status bits for each high-speed counter.

Tip

Status bits are valid only while the high-speed counter interrupt routine is being executed. The purpose of monitoring the state of the high-speed counter is to enable interrupts for the events that are of consequence to the operation being performed.

Table 6-31 Status Bits for HSC0, HSC1, HSC2, HSC3, HSC4, and HSC5

HSC0	HSC1	HSC2	HSC3	HSC4	HSC5	Description
SM36.0	SM46.0	SM56.0	SM136.0	SM146.0	SM156.0	Not used
SM36.1	SM46.1	SM56.1	SM136.1	SM146.1	SM156.1	Not used
SM36.2	SM46.2	SM56.2	SM136.2	SM146.2	SM156.2	Not used
SM36.3	SM46.3	SM56.3	SM136.3	SM146.3	SM156.3	Not used
SM36.4	SM46.4	SM56.4	SM136.4	SM146.4	SM156.4	Not used
SM36.5	SM46.5	SM56.5	SM136.5	SM146.5	SM156.5	Current counting direction status bit: 0 = Counting down 1 = Counting up
SM36.6	SM46.6	SM56.6	SM136.6	SM146.6	SM156.6	Current value equals preset value status bit: 0 = Not equal 1 = Equal
SM36.7	SM46.7	SM56.7	SM136.7	SM146.7	SM156.7	Current value greater than preset value status bit: 0 = Less than or equal 1 = Greater than

Sample Initialization Sequences for the High-Speed Counters

HSC1 is used as the model counter in the following descriptions of the initialization and operation sequences. The initialization descriptions assume that the S7-200 has just been placed in RUN mode, and for that reason, the first scan memory bit is true. If this is not the case, remember that the HDEF instruction can be executed only one time for each high-speed counter after entering RUN mode. Executing HDEF for a high-speed counter a second time generates a run-time error and does not change the counter setup from the way it was set up on the first execution of HDEF for that counter.

Tip

Although the following sequences show how to change direction, current value, and preset value individually, you can change all or any combination of them in the same sequence by setting the value of SMB47 appropriately and then executing the HSC instruction.

Initialization Modes 0, 1, or 2

The following steps describe how to initialize HSC1 for Single Phase Up/Down Counter with Internal Direction (Modes 0, 1, or 2).

1. Use the first scan memory bit to call a subroutine in which the initialization operation is performed. Since you use a subroutine call, subsequent scans do not make the call to the subroutine, which reduces scan time execution and provides a more structured program.
2. In the initialization subroutine, load SMB47 according to the desired control operation. For example:

SMB47 = 16#F8	*Produces the following results:* Enables the counter Writes a new current value Writes a new preset value Sets the direction to count up Sets the start and reset inputs to be active high

3. Execute the HDEF instruction with the HSC input set to 1 and the MODE input set to one of the following: 0 for no external reset or start, 1 for external reset and no start, or 2 for both external reset and start.
4. Load SMD48 (double-word-sized value) with the desired current value (load with 0 to clear it).
5. Load SMD52 (double-word-sized value) with the desired preset value.
6. In order to capture the current value equal to preset event, program an interrupt by attaching the CV = PV interrupt event (event 13) to an interrupt routine. See the section that discusses the Interrupt Instructions for complete details on interrupt processing.
7. In order to capture an external reset event, program an interrupt by attaching the external reset interrupt event (event 15) to an interrupt routine.
8. Execute the global interrupt enable instruction (ENI) to enable interrupts.
9. Execute the HSC instruction to cause the S7-200 to program HSC1.
10. Exit the subroutine.

Initialization Modes 3, 4, or 5

The following steps describe how to initialize HSC1 for Single Phase Up/Down Counter with External Direction (Modes 3, 4, or 5):

1. Use the first scan memory bit to call a subroutine in which the initialization operation is performed. Since you use a subroutine call, subsequent scans do not make the call to the subroutine, which reduces scan time execution and provides a more structured program.
2. In the initialization subroutine, load SMB47 according to the desired control operation. For example:

   SMB47 = 16#F8 *Produces the following results:*
   Enables the counter
   Writes a new current value
   Writes a new preset value
   Sets the initial direction of the HSC to count up
   Sets the start and reset inputs to be active high

3. Execute the HDEF instruction with the HSC input set to 1 and the MODE input set to one of the following: 3 for no external reset or start, 4 for external reset and no start, or 5 for both external reset and start.
4. Load SMD48 (double-word-sized value) with the desired current value (load with 0 to clear it).
5. Load SMD52 (double-word-sized value) with the desired preset value.
6. In order to capture the current-value-equal-to-preset event, program an interrupt by attaching the CV = PV interrupt event (event 13) to an interrupt routine. See the section that discusses the Interrupt Instructions for complete details on interrupt processing.
7. In order to capture direction changes, program an interrupt by attaching the direction changed interrupt event (event 14) to an interrupt routine.
8. In order to capture an external reset event, program an interrupt by attaching the external reset interrupt event (event 15) to an interrupt routine.
9. Execute the global interrupt enable instruction (ENI) to enable interrupts.
10. Execute the HSC instruction to cause the S7-200 to program HSC1.
11. Exit the subroutine.

Initialization Modes 6, 7, or 8

The following steps describe how to initialize HSC1 for Two Phase Up/Down Counter with Up/Down Clocks (Modes 6, 7, or 8):

1. Use the first scan memory bit to call a subroutine in which the initialization operations are performed. Since you use a subroutine call, subsequent scans do not make the call to the subroutine, which reduces scan time execution and provides a more structured program.
2. In the initialization subroutine, load SMB47 according to the desired control operation. For example:

SMB47 = 16#F8	*Produces the following results:* Enables the counter Writes a new current value Writes a new preset value Sets the initial direction of the HSC to count up Sets the start and reset inputs to be active high

3. Execute the HDEF instruction with the HSC input set to 1 and the MODE set to one of the following: 6 for no external reset or start, 7 for external reset and no start, or 8 for both external reset and start.
4. Load SMD48 (double-word-sized value) with the desired current value (load with 0 to clear it).
5. Load SMD52 (double-word-sized value) with the desired preset value.
6. In order to capture the current-value-equal-to-preset event, program an interrupt by attaching the CV = PV interrupt event (event 13) to an interrupt routine. See the section on interrupts.
7. In order to capture direction changes, program an interrupt by attaching the direction changed interrupt event (event 14) to an interrupt routine.
8. In order to capture an external reset event, program an interrupt by attaching the external reset interrupt event (event 15) to an interrupt routine.
9. Execute the global interrupt enable instruction (ENI) to enable interrupts.
10. Execute the HSC instruction to cause the S7-200 to program HSC1.
11. Exit the subroutine.

Initialization Modes 9, 10, or 11

The following steps describe how to initialize HSC1 for A/B Phase Quadrature Counter (for modes 9, 10, or 11):

1. Use the first scan memory bit to call a subroutine in which the initialization operations are performed. Since you use a subroutine call, subsequent scans do not make the call to the subroutine, which reduces scan time execution and provides a more structured program.
2. In the initialization subroutine, load SMB47 according to the desired control operation.

   Example (1x counting mode):

SMB47 = 16#FC	*Produces the following results:* Enables the counter Writes a new current value Writes a new preset value Sets the initial direction of the HSC to count up Sets the start and reset inputs to be active high

   Example (4x counting mode):

SMB47 = 16#F8	*Produces the following results:* Enables the counter Writes a new current value Writes a new preset value Sets the initial direction of the HSC to count up Sets the start and reset inputs to be active high

3. Execute the HDEF instruction with the HSC input set to 1 and the MODE input set to one of the following: 9 for no external reset or start, 10 for external reset and no start, or 11 for both external reset and start.
4. Load SMD48 (double-word-sized value) with the desired current value (load with 0 to clear it).
5. Load SMD52 (double-word-sized value) with the desired preset value.
6. In order to capture the current-value-equal-to-preset event, program an interrupt by attaching the CV = PV interrupt event (event 13) to an interrupt routine. See the section on enabling interrupts (ENI) for complete details on interrupt processing.
7. In order to capture direction changes, program an interrupt by attaching the direction changed interrupt event (event 14) to an interrupt routine.
8. In order to capture an external reset event, program an interrupt by attaching the external reset interrupt event (event 15) to an interrupt routine.
9. Execute the global interrupt enable instruction (ENI) to enable interrupts.
10. Execute the HSC instruction to cause the S7-200 to program HSC1.
11. Exit the subroutine.

Initialization Mode 12

The following steps describe how to initialize HSC0 for counting pulses generated by PTO0 (Mode 12).

1. Use the first scan memory bit to call a subroutine in which the initialization operation is performed. Since you use a subroutine call, subsequent scans do not make the call to the subroutine, which reduces scan time execution and provides a more structured program.
2. In the initialization subroutine, load SMB37 according to the desired control operation. For example:

SMB37 = 16#F8	*Produces the following results:* Enables the counter Writes a new current value Writes a new preset value Sets the direction to count up Sets the start and reset inputs to be active high

3. Execute the HDEF instruction with the HSC input set to 0 and the MODE input set to 12.
4. Load SMD38 (double-word-sized value) with the desired current value (load with 0 to clear it).
5. Load SMD42 (double-word-sized value) with the desired preset value.
6. In order to capture the current value equal to preset event, program an interrupt by attaching the CV = PV interrupt event (event 12) to an interrupt routine. See the section that discusses the Interrupt Instructions for complete details on interrupt processing.
7. Execute the global interrupt enable instruction (ENI) to enable interrupts.
8. Execute the HSC instruction to cause the S7-200 to program HSC0.
9. Exit the subroutine.

Change Direction in Modes 0, 1, 2, or 12

The following steps describe how to configure HSC1 for Change Direction for Single Phase Counter with Internal Direction (Modes 0, 1, 2, or 12):

1. Load SMB47 to write the desired direction:

SMB47 = 16#90	Enables the counter Sets the direction of the HSC to count down
SMB47 = 16#98	Enables the counter Sets the direction of the HSC to count up

2. Execute the HSC instruction to cause the S7-200 to program HSC1.

Loading a New Current Value (Any Mode)

Changing the current value forces the counter to be disabled while the change is made. While the counter is disabled, it does not count or generate interrupts.

The following steps describe how to change the counter current value of HSC1 (any mode):

1. Load SMB47 to write the desired current value:

   SMB47 = 16#C0 Enables the counter
   Writes the new current value

2. Load SMD48 (double-word-sized value) with the desired current value (load with 0 to clear it).
3. Execute the HSC instruction to cause the S7-200 to program HSC1.

Loading a New Preset Value (Any Mode)

The following steps describe how to change the preset value of HSC1 (any mode):

1. Load SMB47 to write the desired preset value:

   SMB47 = 16#A0 Enables the counter
   Writes the new preset value

2. Load SMD52 (double-word-sized value) with the desired preset value.
3. Execute the HSC instruction to cause the S7-200 to program HSC1.

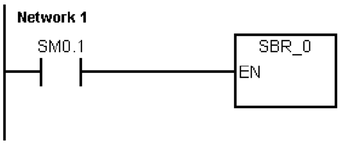
Disabling a High-Speed Counter (Any Mode)

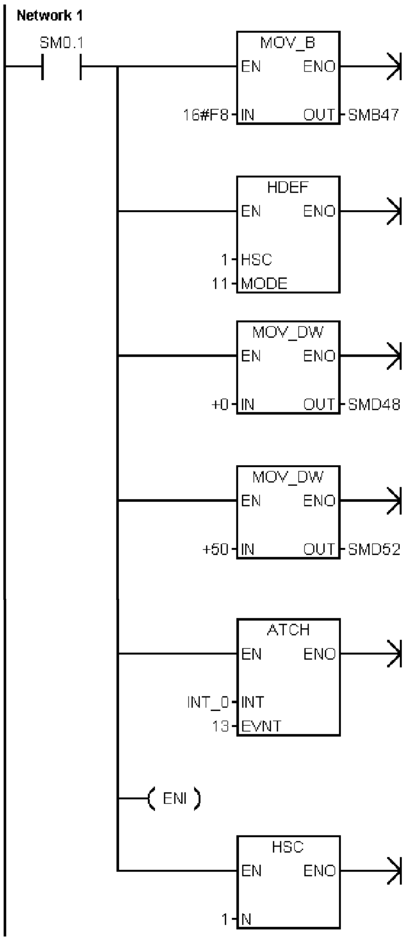
The following steps describe how to disable the HSC1 high-speed counter (any mode):

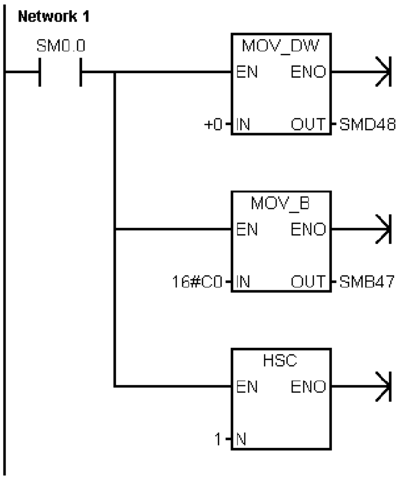
1. Load SMB47 to disable the counter:

   SMB47 = 16#00 Disables the counter

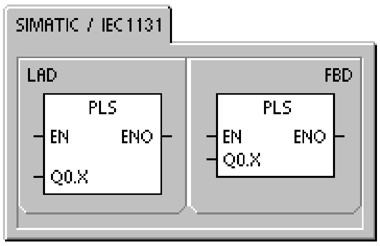
2. Execute the HSC instruction to disable the counter.

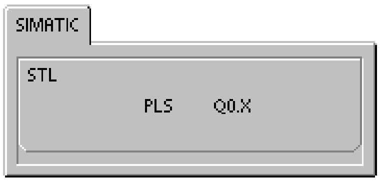
Example: High-Speed Counter Instruction		
M A I N		Network 1 //On the first scan, call SBR_0. LD SM0.1 CALL SBR_0

S
B
R
0
	 Network 1
	SM0.1
	MOV_B
	EN ENO
	16#F8 IN OUT SMB47
	HDEF
	EN ENO
	1 HSC
	11 MODE
	MOV_DW
	EN ENO
	+0 IN OUT SMD48
	MOV_DW
	EN ENO
	+50 IN OUT SMD52
	ATCH
	EN ENO
	INT_0 INT
	13 EVNT
	ENI
	HSC
	EN ENO
	1 N
		Network 1 //On the first scan, configure HSC1:
		//1. Enable the counter.
		// - Write a new current value.
		// - Write a new preset value.
		// - Set the initial direction to count up.
		// - Select the start and reset inputs
		// to be active high.
		// - Select 4x mode.
		//2. Configure HSC1 for quadrature mode
		// with reset and start inputs.
		//3. Clear the current value of HSC1.
		//4. Set the HSC1 preset value to 50.
		//5. When HSC1 current value = preset value,
		// attach event 13 to interrupt routine INT_0.
		//6. Global interrupt enable.
		//7. Program HSC1.
		LD SM0.1
		MOVB 16#F8, SMB47
		HDEF 1, 11
		MOVD +0, SMD48
		MOVD +50, SMD52
		ATCH INT_0, 13
		ENI
		HSC 1

I N T 0	 Network 1 SM0.0 MOV_DW EN ENO +0 IN OUT SMD48 MOV_B EN ENO 16#C0 IN OUT SMB47 HSC EN ENO 1 N	Network 1 //Program HSC1: //1. Clear the current value of HSC1. //2. Select to write only a new current // and leave HSC1 enabled. LD SM0.0 MOVD +0, SMD48 MOVB 16#C0, SMB47 HSC 1

Pulse Output Instruction





```
PLS     Q0.X
```

Position Control

The Pulse Output instruction (PLS) is used to control the Pulse Train Output (PTO) and Pulse Width Modulation (PWM) functions available on the high-speed outputs (Q0.0 and Q0.1).

The improved Position Control Wizard creates instructions customized to your application that simplify your programming tasks and take advantage of the extra features of the S7-200 CPUs. Refer to Chapter 9 for more information about the Position Control Wizard.

You can continue to use the old PLS instruction to create your own motion application, but the linear ramp on the PTO is only supported by instructions created by the improved Position Control Wizard.

PTO provides a square wave (50% duty cycle) output with user control of the cycle time and the number of pulses.

PWM provides a continuous, variable duty cycle output with user control of the cycle time and the pulse width.

The S7-200 has two PTO/PWM generators that create either a high-speed pulse train or a pulse width modulated waveform. One generator is assigned to digital output point Q0.0, and the other generator is assigned to digital output point Q0.1. A designated special memory (SM) location stores the following data for each generator: a control byte (8-bit value), a pulse count value (an unsigned 32-bit value), and a cycle time and pulse width value (an unsigned 16-bit value).

The PTO/PWM generators and the process-image register share the use of Q0.0 and Q0.1. When a PTO or PWM function is active on Q0.0 or Q0.1, the PTO/PWM generator has control of the output, and normal use of the output point is inhibited. The output waveform is not affected by the state of the process-image register, the forced value of the point, or the execution of immediate output instructions. When the PTO/PWM generator is inactive, control of the output reverts to the process-image register. The process-image register determines the initial and final state of the output waveform, causing the waveform to start and end at a high or low level.

Table 6-32   Valid Operands for Pulse Output Instruction

Inputs/Outputs	Data Types	Operands
Q0.X	WORD	Constant: 0 (= Q0.0) *or* 1 (= Q0.1)

Tip

Before enabling PTO or PWM operation, set the value of the process-image register for Q0.0 and Q0.1 to 0.

Default values for all control bits, cycle time, pulse width, and pulse count values are 0.

The PTO/PWM outputs must have a minimum load of at least 10% of rated load to provide crisp transitions from off to on, and from on to off.

Programming Tips

Refer to the Programming Tips on the documentation CD for programs that use the PLS instruction for PTO/PWM operation. See Tip 7, Tip 22, Tip 23, Tip 30, and Tip 50.

Pulse Train Operation (PTO)

PTO provides a square wave (50% duty cycle) output for a specified number of pulses and a specified cycle time. (See Figure 6-28.) PTO can produce either a single train of pulses or multiple trains of pulses (using a pulse profile). You specify the number of pulses and the cycle time (in either microsecond or millisecond increments):

❑	Number of pulses:	1 to 4,294,967,295
❑	Cycle time:	10 μs to 65,535 μs or 2 ms to 65,535 ms.

Specifying an odd number of microseconds or milliseconds for the cycle time (such as 75 ms), causes some distortion in the duty cycle.

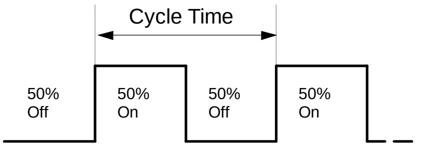


Figure 6-28 Pulse Train Output (PTO)

See Table 6-33 for pulse count and cycle time limitations.

Table 6-33 Pulse Count and Cycle Time in the PTO function

Pulse Count/Cycle TIme	Reaction
Cycle time < 2 time units	Cycle time defaults to 2 time units.
Pulse count = 0	Pulse count defaults to 1 pulse.

The PTO function allows the “chaining” or “pipelining” of pulse trains. When the active pulse train is complete, the output of a new pulse train begins immediately. This allows continuity between subsequent output pulse trains.

Using the Position Control Wizard

The Position Control Wizard automatically handles single and multiple segment pipelining of PTO pulses, pulse width modulation, SM Location configuration, and creating a profile table. The information is here for your reference. It is recommended that you use the Position Control Wizard. For more information about the Position Control Wizard, see Chapter 9.

Single-Segment Pipelining of PTO Pulses

In single-segment pipelining, you are responsible for updating the SM locations for the next pulse train. After the initial PTO segment has been started, you must modify immediately the SM locations as required for the second waveform and execute the PLS instruction again. The attributes of the second pulse train are held in a pipeline until the first pulse train is completed. Only one entry at a time can be stored in the pipeline. When the first pulse train completes, the output of the second waveform begins, and the pipeline is made available for a new pulse train specification. You can then repeat this process to set up the characteristics of the next pulse train.

Smooth transitions between pulse trains occur unless there is a change in the time base or the active pulse train completes before a new pulse train setup is captured by the execution of the PLS instruction.

Multiple-Segment Pipelining of PTO Pulses

In multiple-segment pipelining, the S7-200 automatically reads the characteristics of each pulse train segment from a profile table located in V memory. The SM locations used in this mode are the control byte, the status byte, and the starting V memory offset of the profile table (SMW168 or SMW178). The time base can be either microseconds or milliseconds, but the selection applies to all cycle time values in the profile table, and cannot be changed while the profile is running. Execution on the PLS instruction starts multiple segment operation.

Each segment entry is 8 bytes in length, and is composed of a 16-bit cycle time value, a 16-bit cycle time delta value, and a 32-bit pulse count value. Table 6-34 shows the format of the profile table. You can increase or decrease the cycle time automatically by programming a specified amount for each pulse. A positive value in the cycle time delta field increases cycle time, a negative value in the cycle time delta field decreases cycle time, and 0 results in an unchanging cycle time.

While the PTO profile is operating, the number of the currently active segment is available in SMB166 (or SMB176).

Table 6-34 Profile Table Format for Multiple-Segment PTO Operation

Byte Offset	Segment	Description of Table Entries
0		Number of segments: 1 to 255[1]
1	#1	Initial cycle time (2 to 65,535 units of the time base)
3		Cycle time delta per pulse (signed value) (–32,768 to 32,767 units of the time base)
5		Pulse count (1 to 4,294,967,295)
9	#2	Initial cycle time (2 to 65,535 units of the time base)
11		Cycle time delta per pulse (signed value) (–32,768 to 32,767 units of the time base)
13		Pulse count (1 to 4,294,967,295)
(Continues)	#3	(Continues)

[1] Entering a value of 0 for the number of segments generates a non-fatal error. No PTO output is generated.

Pulse Width Modulation (PWM)

PWM provides a fixed cycle time output with a variable duty cycle. (See Figure 6-29.) You can specify the cycle time and the pulse width in either microsecond or millisecond increments:

❑ Cycle time:	10 μs to 65,535 μs or 2 ms to 65,535 ms
❑ Pulse width time:	0 μs to 65,535 μs or 0 ms to 65,535 ms

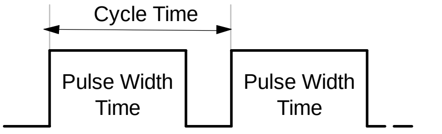


Figure 6-29 Pulse Width Modulation (PWM)

As shown in Table 6-35, setting the pulse width equal to the cycle time (which makes the duty cycle 100 percent) turns the output on continuously. Setting the pulse width to 0 (which makes the duty cycle 0 percent) turns the output off.

Table 6-35 Pulse Width Time and Cycle Time and Reactions in the PWM Function

Pulse Width Time/ Cycle Time	Reaction
Pulse width time >= Cycle time value	The duty cycle is 100%: the output is turned on continuously.
Pulse width time = 0	The duty cycle is 0%: the output is turned off.
Cycle time < 2 time units	The cycle time defaults to two time units.

There are two different ways to change the characteristics of a PWM waveform:

- ❑ Synchronous Update: If no time base changes are required, you can use a synchronous update. With a synchronous update, the change in the waveform characteristics occurs on a cycle boundary, providing a smooth transition.
- ❑ Asynchronous Update: Typically with PWM operation, the pulse width is varied while the cycle time remains constant so time base changes are not required. However, if a change in the time base of the PTO/PWM generator is required, an asynchronous update is used. An asynchronous update causes the PTO/PWM generator to be disabled momentarily, asynchronous to the PWM waveform. This can cause undesirable jitter in the controlled device. For that reason, synchronous PWM updates are recommended. Choose a time base that you expect to work for all of your anticipated cycle time values.

Tip

The PWM Update Method bit (SM67.4 or SM77.4) in the control byte specifies the update type used when the PLS instruction is executed to invoke changes.

If the time base is changed, an asynchronous update occurs regardless of the state of the PWM Update Method bit.

Using SM Locations to Configure and Control the PTO/PWM Operation

The PLS instruction reads the data stored in the specified SM memory locations and programs the PTO/PWM generator accordingly. SMB67 controls PTO 0 or PWM 0, and SMB77 controls PTO 1 or PWM 1. Table 6-36 describes the registers used to control the PTO/PWM operation. You can use Table 6-37 as a quick reference to determine the value to place in the PTO/PWM control register to invoke the desired operation.

You can change the characteristics of a PTO or PWM waveform by modifying the locations in the SM area (including the control byte) and then executing the PLS instruction. You can disable the generation of a PTO or PWM waveform at any time by writing 0 to the PTO/PWM enable bit of the control byte (SM67.7 or SM77.7) and then executing the PLS instruction.

The PTO Idle bit in the status byte (SM66.7 or SM76.7) is provided to indicate the completion of the programmed pulse train. In addition, an interrupt routine can be invoked upon the completion of a pulse train. (Refer to the descriptions of the Interrupt instructions and the Communications instructions.) If you are using the multiple segment operation, the interrupt routine is invoked upon completion of the profile table.

The following conditions set SM66.4 (or SM76.4) and SM66.5 (or SM76.5):

- ❑ Specifying a cycle time delta value that results in an illegal cycle time after a number of pulses generates a mathematical overflow condition that terminates the PTO function and sets the Delta Calculation Error bit (SM66.4 or SM76.4) to 1. The output reverts to image register control.
- ❑ Manually aborting (disabling) a PTO profile in progress sets the User Abort bit (SM66.5 or SM76.5) to 1.
- ❑ Attempting to load the pipeline while it is full sets the PTO/PWM overflow bit (SM66.6 or SM76.6) to 1. You must clear this bit manually after an overflow is detected if you want to detect subsequent overflows. The transition to RUN mode initializes this bit to 0.

Tip

When you load a new pulse count (SMD72 or SMD82), pulse width (SMW70 or SMW80), or cycle time (SMW68 or SMW78), also set the appropriate update bits in the control register before you execute the PLS instruction. For a multiple segment pulse train operation, you must also load the starting offset (SMW168 or SMW178) of the profile table and the profile table values before you execute the PLS instruction.

Table 6-36 SM Locations of the PTO / PWM Control Registers

Q0.0	Q0.1	Status Bits		
SM66.4	SM76.4	PTO profile aborted (delta calculation error):	0 = no error	1 = aborted
SM66.5	SM76.5	PTO profile aborted due to user command:	0 = no abort	1 = aborted
SM66.6	SM76.6	PTO/PWM pipeline overflow/underflow:	0 = no overflow	1 = overflow/underflow
SM66.7	SM76.7	PTO idle:	0 = in progress	1 = PTO idle
Q0.0	**Q0.1**	**Control Bits**		
SM67.0	SM77.0	PTO/PWM update the cycle time:	0 = no update	1 = update cycle time
SM67.1	SM77.1	PWM update the pulse width time:	0 = no update	1 = update pulse width
SM67.2	SM77.2	PTO update the pulse count value:	0 = no update	1 = update pulse count
SM67.3	SM77.3	PTO/PWM time base:	0 = 1 µs/tick	1 = 1 ms/tick
SM67.4	SM77.4	PWM update method:	0 =asynchronous	1 = synchronous
SM67.5	SM77.5	PTO single/multiple segment operation:	0 = single	1 = multiple
SM67.6	SM77.6	PTO/PWM mode select:	0 = PTO	1 = PWM
SM67.7	SM77.7	PTO/PWM enable:	0 = disable	1 = enable
Q0.0	**Q0.1**	**Other PTO/PWM Registers**		
SMW68	SMW78	PTO/PWM cycle time value	range: 2 to 65,535	
SMW70	SMW80	PWM pulse width value	range: 0 to 65,535	
SMD72	SMD82	PTO pulse count value	range: 1 to 4,294,967,295	
SMB166	SMB176	Number of the segment in progress	Multiple-segment PTO operation only	
SMW168	SMW178	Starting location of the profile table (byte offset from V0)	Multiple-segment PTO operation only	
SMB170	SMB180	Linear profile status byte		
SMB171	SMB181	Linear profile result register		
SMD172	SMD182	Manual mode frequency register		

Table 6-37 PTO/PWM Control Byte Reference

Control Register (Hex Value)		Result of Executing the PLS Instruction						
	Enable	**Select Mode**	**PTO Segment Operation**	**PWM Update Method**	**Time Base**	**Pulse Count**	**Pulse Width**	**Cycle Time**
16#81	Yes	PTO	Single		1 µs/cycle			Load
16#84	Yes	PTO	Single		1 µs/cycle	Load		
16#85	Yes	PTO	Single		1 µs/cycle	Load		Load
16#89	Yes	PTO	Single		1 ms/cycle			Load
16#8C	Yes	PTO	Single		1 ms/cycle	Load		
16#8D	Yes	PTO	Single		1 ms/cycle	Load		Load
16#A0	Yes	PTO	Multiple		1 µs/cycle			
16#A8	Yes	PTO	Multiple		1 ms/cycle			
16#D1	Yes	PWM		Synchronous	1 µs/cycle			Load
16#D2	Yes	PWM		Synchronous	1 µs/cycle		Load	
16#D3	Yes	PWM		Synchronous	1 µs/cycle		Load	Load
16#D9	Yes	PWM		Synchronous	1 ms/cycle			Load
16#DA	Yes	PWM		Synchronous	1 ms/cycle		Load	
16#DB	Yes	PWM		Synchronous	1 ms/cycle		Load	Load

Calculating Profile Table Values

The multiple-segment pipelining capability of the PTO/PWM generators can be useful in many applications, particularly in stepper motor control.

For example, you can use PTO with a pulse profile to control a stepper motor through a simple ramp up, run, and ramp down sequence or more complicated sequences by defining a pulse profile that consists of up to 255 segments, with each segment corresponding to a ramp up, run, or ramp down operation.

Figure 6-30 illustrates sample profile table values required to generate an output waveform that accelerates a stepper motor (segment 1), operates the motor at a constant speed (segment 2), and then decelerates the motor (segment 3).

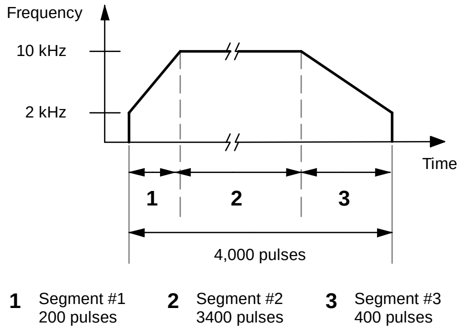


Figure 6-30 Frequency/Time Diagram

For this example: The starting and final pulse frequency is 2 kHz, the maximum pulse frequency is 10 kHz, and 4000 pulses are required to achieve the desired number of motor revolutions. Since the values for the profile table are expressed in terms of period (cycle time) instead of frequency, you must convert the given frequency values into cycle time values. Therefore, the starting (initial) and final (ending) cycle time is 500 μs, and the cycle time corresponding to the maximum frequency is 100 μs. During the acceleration portion of the output profile, the maximum pulse frequency should be reached in approximately 200 pulses. The deceleration portion of the profile should be completed in approximately 400 pulses.

You can use the following formula to determine the delta cycle time value for a given segment that the PTO/PWM generator uses to adjust the cycle time of each pulse:

Delta cycle time for a segment = $| End\_CT_{seg} - Init\_CT_{seg} | / Quantity_{seg}$

where: End_CT_{seg} = Ending cycle time for this segment
$Init\_CT_{seg}$ = Initial cycle time for this segment
$Quantity_{seg}$ = Quantity of pulses in this segment

Using this formula to calculate the delta cycle time values for the sample application:

Segment 1 (acceleration):
Delta cycle time = –2

Segment 2 (constant speed):
Delta cycle time = 0

Segment 3 (deceleration):
Delta cycle time = 1

Table 6-38 lists the values for generating the example waveform (assumes that the profile table is located in V memory, starting at V500). You can include instructions in your program to load these values into V memory, or you can define the values of the profile in the data block.

Table 6-38 Profile Table Values

Address	Value	Description	
VB500	3	Total number of segments	
VW501	500	Initial cycle time	Segment 1
VW503	–2	Initial delta cycle time	
VD505	200	Number of pulses	
VW509	100	Initial cycle time	Segment 2
VW511	0	Delta cycle time	
VD513	3400	Number of pulses	
VW517	100	Initial cycle time	Segment 3
VW519	1	Delta cycle time	
VD521	400	Number of pulses	

In order to determine if the transitions between waveform segments are acceptable, you need to determine the cycle time of the last pulse in a segment. Unless the delta cycle time is 0, you must calculate the cycle time of the last pulse of a segment, because this value is not specified in the profile. Use the following formula to calculate the cycle time of the last pulse:

Cycle time of the last pulse for a segment = $\text{Init\_CT}_{seg} + (\text{Delta}_{seg} * (\text{Quantity}_{seg} - 1))$

where: Init_CT_{seg} = Initial cycle time for this segment

Delta_{seg} = Delta cycle time for this segment

Quantity_{seg} = Quantity of pulses in this segment

While the simplified example above is useful as an introduction, real applications can require more complicated waveform profiles. Remember that the delta cycle time can be specified only as an integer number of microseconds or milliseconds, and the cycle time modification is performed on each pulse.

The effect of these two items is that calculation of the delta cycle time value for a given segment could require an iterative approach. Some flexibility in the value of the ending cycle time or the number of pulses for a given segment might be required.

The duration of a given profile segment can be useful in the process of determining correct profile table values. Use the following formula to calculate the length of time for completing a given profile segment:

Duration of segment = $\text{Quantity}_{seg} * (\text{Init\_CT} + ((\text{Delta}_{seg}/2) * (\text{Quantity}_{seg} - 1)))$

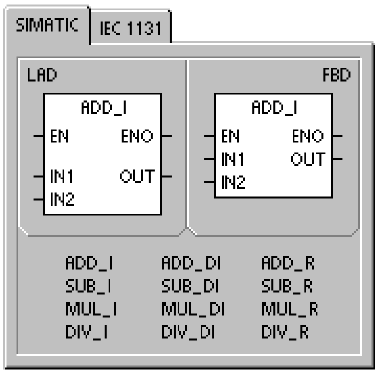
where: Quantity_{seg} = Quantity of pulses in this segment

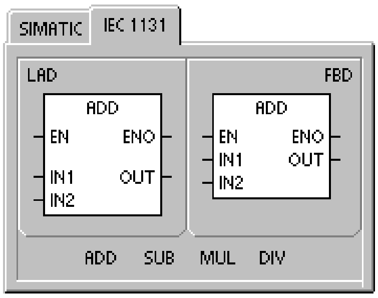
Init_CT_{seg} = Initial cycle time for this segment

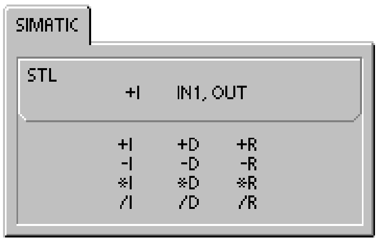
Delta_{seg} = Delta cycle time for this segment

Math Instructions

Add, Subtract, Multiply, and Divide Instructions







```
+I    IN1, OUT

+I   +D   +R
-I   -D   -R
*I   *D   *R
/I   /D   /R
```

Add	Subtract	
IN1 + IN2 = OUT	IN1 – IN2 = OUT	*LAD and FBD*
IN1 + OUT = OUT	OUT – IN1 = OUT	*STL*

The Add Integer (+I) or Subtract Integer (–I) instructions add or subtract two 16-bit integers to produce a 16-bit result. The Add Double Integer (+D) or Subtract Double Integer (–D) instructions add or subtract two 32-bit integers to produce a 32-bit result. The Add Real (+R) and Subtract Real (–R) instructions add or subtract two 32-bit real numbers to produce a 32-bit real number result.

Multiply	Divide	
IN1 * IN2 = OUT	IN1 / IN2 = OUT	*LAD and FBD*
IN1 * OUT = OUT	OUT / IN1 = OUT	*STL*

The Multiply Integer (*I) or Divide Integer (/I) instructions multiply or divide two 16-bit integers to produce a 16-bit result. (For division, no remainder is kept.) The Multiply Double Integer (*D) or Divide Double Integer (/D) instructions multiply or divide two 32-bit integers to produce a 32-bit result. (For division, no remainder is kept.) The Multiply Real (*R) or Divide Real (/R) instructions multiply or divide two 32-bit real numbers to produce a 32-bit real number result.

SM Bits and ENO

SM1.1 indicates overflow errors and illegal values. If SM1.1 is set, then the status of SM1.0 and SM1.2 is not valid and the original input operands are not altered. If SM1.1 and SM1.3 are not set, then the math operation has completed with a valid result and SM1.0 and SM1.2 contain valid status. If SM1.3 is set during a divide operation, then the other math status bits are left unchanged.

Error conditions that set ENO = 0

- SM1.1 (overflow)
- SM1.3 (divide by zero)
- 0006 (indirect address)

Special Memory bits affected

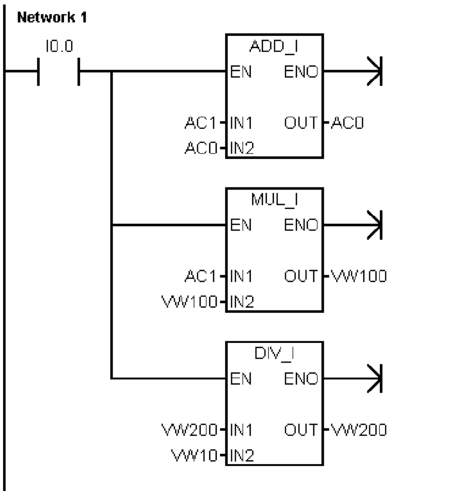
- SM1.0 (zero)
- SM1.1 (overflow, illegal value generated during the operation, or illegal input parameter found)
- SM1.2 (negative)
- SM1.3 (divide by zero)

Table 6-39 Valid Operands for Add, Subtract, Multiply, and Divide Instructions

Inputs/Outputs	Data Types	Operands
IN1, IN2	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *AC, *LD, Constant
	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
OUT	INT	IW, QW, VW, MW, SMW, SW, LW, T, C, AC, *VD, *AC, *LD
	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Real (or floating-point) numbers are represented in the format described in the ANSI/IEEE 754–1985 standard (single-precision). Refer to that standard for more information.

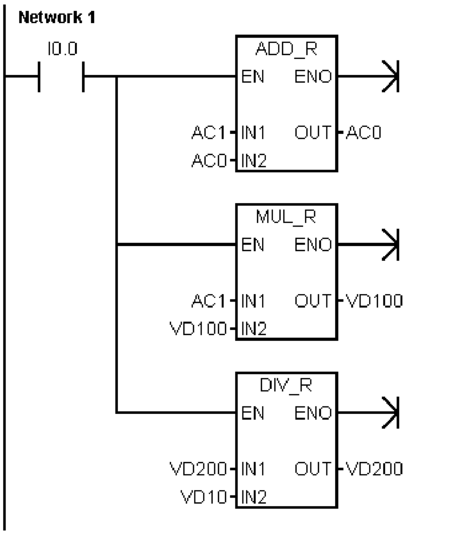
Example: Integer Math Instructions



```
Network 1
LD      I0.0
+I      AC1, AC0
*I      AC1, VW100
/I      VW10, VW200
```

Add					Multiply					Divide				
40	+	60	=	100	40	*	20	=	800	4000	/	40	=	100
AC1		AC0		AC0	AC1		VW100		VW100	VW200		VW10		VW200

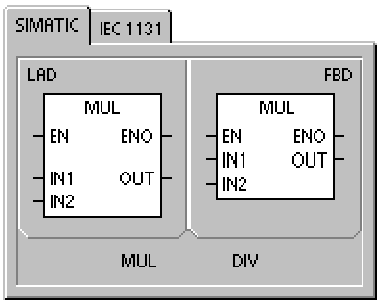
Example: Real Math Instructions

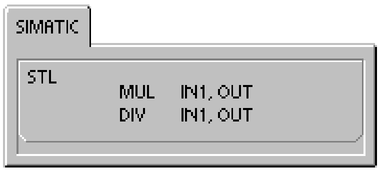


```
Network 1
LD      I0.0
+R      AC1, AC0
*R      AC1, VD100
/R      VD10, VD200
```

Add					Multiply					Divide				
4000.0	+	6000.0	=	10000.0	400.0	*	200.0	=	80000.0	4000.0	/	41.0	=	97.5609
AC1		AC0		AC0	AC1		VD100		VD100	VD200		VD10		VD200

Multiply Integer to Double Integer and Divide Integer with Remainder





```
MUL    IN1, OUT
DIV    IN1, OUT
```

Multiply Integer to Double Integer

IN1 * IN2 = OUT   LAD and FBD
IN1 * OUT = OUT   STL

The Multiply Integer to Double Integer instruction (MUL) multiplies two 16-bit integers and produces a 32-bit product. In the STL MUL instruction, the least-significant word (16 bits) of the 32-bit OUT is used as one of the factors.

Divide Integer with Remainder

IN1 / IN2 = OUT   LAD and FBD
OUT / IN1 = OUT   STL

The Divide Integer with Remainder instruction (DIV) divides two 16-bit integers and produces a 32-bit result consisting of a 16-bit remainder (the most-significant word) and a 16-bit quotient (the least-significant word).

In STL, the least-significant word (16 bits) of the 32-bit OUT is used as the dividend.

SM Bits and ENO

For both of the instructions on this page, Special Memory (SM) bits indicate errors and illegal values. If SM1.3 (divide by zero) is set during a divide operation, then the other math status bits are left unchanged. Otherwise, all supported math status bits contain valid status upon completion of the math operation.

Error conditions that set ENO = 0

- SM1.1 (overflow)
- SM1.3 (divide by zero)
- 0006 (indirect address)

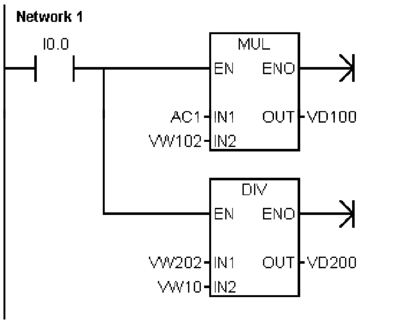
Special Memory bits affected

- SM1.0 (zero)
- SM1.1 (overflow)
- SM1.2 (negative)
- SM1.3 (divide by zero)

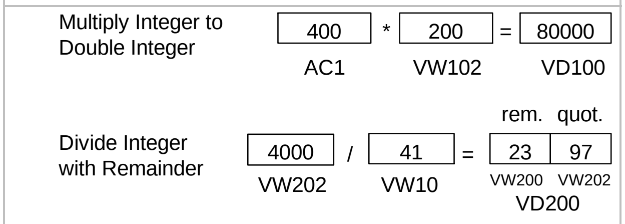
Table 6-40 Valid Operands for Multiply Integer to Double Integer and Divide Integer with Remainder

Inputs/Outputs	Data Types	Operands
IN1, IN2	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
OUT	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Example: Multiply Integer to Double Integer Instruction and Divide Integer with Remainder Instruction



```
Network 1
LD      I0.0
MUL     AC1, VD100
DIV     VW10, VD200
```



Note: VD100 contains: VW100 and VW102, and VD200 contains: VW200 and VW202.

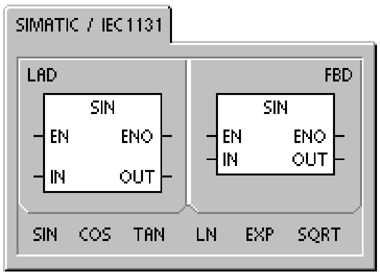
Numeric Functions Instructions

Sine, Cosine, and Tangent

The Sine (SIN), Cosine (COS), and Tangent (TAN) instructions evaluate the trigonometric function of the angle value IN and place the result in OUT. The input angle value is in radians.

SIN (IN) = OUT COS (IN) = OUT TAN (IN) = OUT

To convert an angle from degrees to radians: Use the MUL_R (*R) instruction to multiply the angle in degrees by 1.745329E-2 (approximately by π/180).

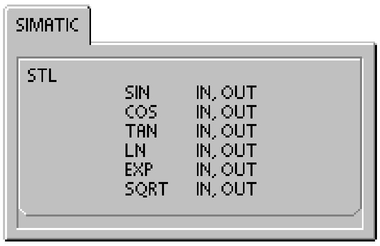


Natural Logarithm and Natural Exponential

The Natural Logarithm instruction (LN) performs the natural logarithm of the value in IN and places the result in OUT.

The Natural Exponential instruction (EXP) performs the exponential operation of e raised to the power of the value in IN and places the result in OUT.

LN (IN) = OUT EXP (IN)= OUT



```
STL
          SIN     IN, OUT
          COS     IN, OUT
          TAN     IN, OUT
          LN      IN, OUT
          EXP     IN, OUT
          SQRT    IN, OUT
```

To obtain the base 10 logarithm from the natural logarithm: Divide the natural logarithm by 2.302585 (approximately the natural logarithm of 10).

To raise any real number to the power of another real number, including fractional exponents: Combine the Natural Exponential instruction with the Natural Logarithm instruction. For example, to raise X to the Y power, enter the following instruction: EXP (Y * LN (X)).

Square Root

The Square Root instruction (SQRT) takes the square root of a real number (IN) and produces a real number result OUT.

SQRT (IN)= OUT

To obtain other roots: 5 cubed = 5^3 = EXP(3*LN(5)) = 125
The cube root of 125 = 125^(1/3) = EXP((1/3)*LN(125))= 5
The square root of 5 cubed = 5^(3/2) = EXP(3/2*LN(5)) = 11.18034

SM Bits and ENO for the Numeric Functions Instructions

For all of the instructions that are described on this page, SM1.1 is used to indicate overflow errors and illegal values. If SM1.1 is set, then the status of SM1.0 and SM1.2 is not valid and the original input operands are not altered. If SM1.1 is not set, then the math operation has completed with a valid result and SM1.0 and SM1.2 contain valid status.

Error conditions that set ENO = 0

- SM1.1 (overflow)
- 0006 (indirect address)

Special Memory bits affected

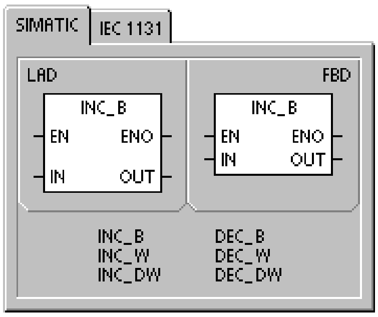
- SM1.0 (zero)
- SM1.1 (overflow)
- SM1.2 (negative)

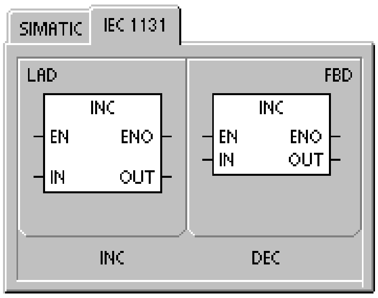
Table 6-41 Valid Operands for Numeric Functions

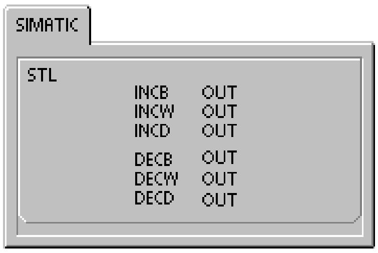
Inputs/Outputs	Data Types	Operands
IN	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
OUT	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Real (or floating-point) numbers are represented in the format described in the ANSI/IEEE 754-1985 standard (single-precision). Refer to that standard for more information.

Increment and Decrement Instructions







```
INCB  OUT
INCW  OUT
INCD  OUT

DECB  OUT
DECW  OUT
DECD  OUT
```

Increment

IN + 1 = OUT	*LAD and FBD*
OUT + 1 = OUT	*STL*

Decrement

IN – 1 = OUT	*LAD and FBD*
OUT – 1 = OUT	*STL*

The Increment and Decrement instructions add or subtract 1 to or from the input IN and place the result into the variable OUT.

Increment Byte (INCB) and Decrement Byte (DECB) operations are unsigned.

Increment Word (INCW) and Decrement Word (DECW) operations are signed.

Increment Double Word (INCD) and Decrement Double Word (DECD) operations are signed.

Error conditions that set ENO = 0:

- SM1.1 (overflow)
- 0006 (indirect address)

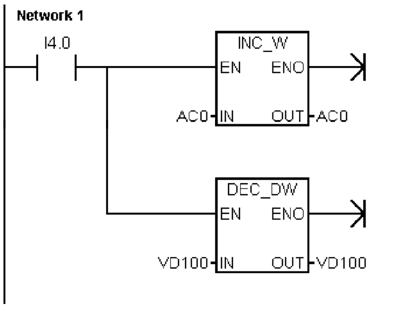
Special Memory bits affected:

- SM1.0 (zero)
- SM1.1 (overflow)
- SM1.2 (negative) for Word and Double Word operations

Table 6-42 Valid Operands for the Increment and Decrement Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC,*VD, *LD, *AC
	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Example: Increment and Decrement Instructions

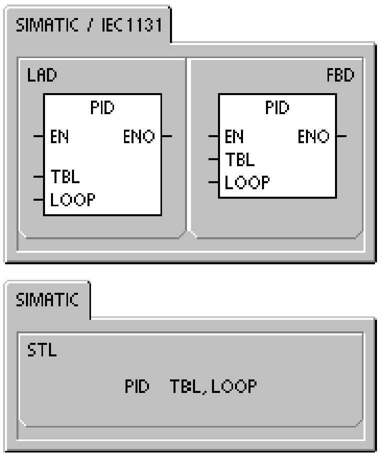


```
Network 1
LD      I4.0
INCW    AC0
DECD    VD100
```

Increment Word 125 + 1 = 126
AC0 AC0

Decrement Double Word 128000 - 1 = 127999
VD100 VD100

Proportional/Integral/Derivative (PID) Loop Instruction



```
PID   TBL, LOOP
```

The PID Loop instruction (PID) executes a PID loop calculation on the referenced LOOP based on the input and configuration information in Table (TBL).

Error conditions that set ENO = 0:

- SM1.1 (overflow)
- 0006 (indirect address)

Special Memory bits affected:

- SM1.1 (overflow)

The PID loop instruction (Proportional, Integral, Derivative Loop) is provided to perform the PID calculation. The top of the logic stack (TOS) must be ON (power flow) to enable the PID calculation. The instruction has two operands: a TABLE address which is the starting address of the loop table and a LOOP number which is a constant from 0 to 7.

Eight PID instructions can be used in a program. If two or more PID instructions are used with the same loop number (even if they have different table addresses), the PID calculations will interfere with one another and the output will be unpredictable.

The loop table stores nine parameters used for controlling and monitoring the loop operation and includes the current and previous value of the process variable, the setpoint, output, gain, sample time, integral time (reset), derivative time (rate), and the integral sum (bias).

To perform the PID calculation at the desired sample rate, the PID instruction must be executed either from within a timed interrupt routine or from within the main program at a rate controlled by a timer. The sample time must be supplied as an input to the PID instruction via the loop table.

Auto-Tune capability has been incorporated into the PID instruction. Refer to Chapter 15 for a detailed description of auto-tuning. The PID Tuning Control Panel only works with PID loops created by the PID wizard..

Table 6-43 Valid Operands for the PID Loop Instruction

Inputs/Outputs	Data Types	Operands
TBL	BYTE	VB
LOOP	BYTE	Constant (0 to 7)

Instruction Wizard

STEP 7-Micro/WIN offers the PID Wizard to guide you in defining a PID algorithm for a closed-loop control process. Select the **Tools > Instruction Wizard** menu command and then select **PID** from the Instruction Wizard window.

Tip

The setpoint of the low range and the setpoint of the high range should correspond to the process variable low range and high range.

Understanding the PID Algorithm

In steady state operation, a PID controller regulates the value of the output so as to drive the error (e) to zero. A measure of the error is given by the difference between the setpoint (SP) (the desired operating point) and the process variable (PV) (the actual operating point). The principle of PID control is based upon the following equation that expresses the output, M(t), as a function of a proportional term, an integral term, and a differential term:

Output = Proportional term + Integral term + Differential term

$$\mathbf{M(t)} = \mathbf{K_C * e} + \mathbf{K_C \int_0^t e\,dt + M_{initial}} + \mathbf{K_C * de/dt}$$

where:
$M_{(t)}$ is the loop output as a function of time
K_C is the loop gain
e is the loop error (the difference between setpoint and process variable)
$M_{initial}$ is the initial value of the loop output

In order to implement this control function in a digital computer, the continuous function must be quantized into periodic samples of the error value with subsequent calculation of the output. The corresponding equation that is the basis for the digital computer solution is:

$$\mathbf{M_n} = \mathbf{K_c * e_n} + \mathbf{K_I * \sum_1^n e_x + M_{initial}} + \mathbf{K_D * (e_n - e_{n-1})}$$

output = proportional term + integral term + differential term

where:
M_n is the calculated value of the loop output at sample time n
K_C is the loop gain
e_n is the value of the loop error at sample time n
e_{n-1} is the previous value of the loop error (at sample time n – 1)
e_x is the value of the loop error at sample time x
K_I is the proportional constant of the integral term
$M_{initial}$ is the initial value of the loop output
K_D is the proportional constant of the differential term

From this equation, the integral term is shown to be a function of all the error terms from the first sample to the current sample. The differential term is a function of the current sample and the previous sample, while the proportional term is only a function of the current sample. In a digital computer, it is not practical to store all samples of the error term, nor is it necessary.

Since the digital computer must calculate the output value each time the error is sampled beginning with the first sample, it is only necessary to store the previous value of the error and the previous value of the integral term. As a result of the repetitive nature of the digital computer solution, a simplification in the equation that must be solved at any sample time can be made. The simplified equation is:

$$\mathbf{M_n} = \mathbf{K_c * e_n} + \mathbf{K_I * e_n + MX} + \mathbf{K_D * (e_n - e_{n-1})}$$

output = proportional term + integral term + differential term

where:
M_n is the calculated value of the loop output at sample time n
K_C is the loop gain
e_n is the value of the loop error at sample time n
e_{n-1} is the previous value of the loop error (at sample time n – 1)
K_I is the proportional constant of the integral term
MX is the previous value of the integral term (at sample time n – 1)
K_D is the proportional constant of the differential term

The S7-200 uses a modified form of the above simplified equation when calculating the loop output value. This modified equation is:

M_n	=	MP_n	+	MI_n	+	MD_n
output	=	proportional term	+	integral term	+	differential term

where: Mn is the calculated value of the loop output at sample time n
MP_n is the value of the proportional term of the loop output at sample time n
MI_n is the value of the integral term of the loop output at sample time n
MDn is the value of the differential term of the loop output at sample time n

Understanding the Proportional Term of the PID Equation

The proportional term MP is the product of the gain (K_C), which controls the sensitivity of the output calculation, and the error (e), which is the difference between the setpoint (SP) and the process variable (PV) at a given sample time. The equation for the proportional term as solved by the S7-200 is:

$$MP_n = K_C * (SP_n - PV_n)$$

where: MPn is the value of the proportional term of the loop output at sample time n
K_C is the loop gain
SP_n is the value of the setpoint at sample time n
PV_n is the value of the process variable at sample time n

Understanding the Integral Term of the PID Equation

The integral term MI is proportional to the sum of the error over time. The equation for the integral term as solved by the S7-200 is:

$$MI_n = K_C * T_S / T_I * (SP_n - PV_n) + MX$$

where: MI_n is the value of the integral term of the loop output at sample time n
K_C is the loop gain
T_S is the loop sample time
T_I is the integration period of the loop (also called the integral time or reset)
SP_n is the value of the setpoint at sample time n
PV_n is the value of the process variable at sample time n
MX is the value of the integral term at sample time n – 1 (also called the integral sum or the bias)

The integral sum or bias (MX) is the running sum of all previous values of the integral term. After each calculation of MI_n, the bias is updated with the value of MI_n which might be adjusted or clamped (see the section “Variables and Ranges” for details). The initial value of the bias is typically set to the output value ($M_{initial}$) just prior to the first loop output calculation. Several constants are also part of the integral term, the gain (K_C), the sample time (T_S), which is the cycle time at which the PID loop recalculates the output value, and the integral time or reset (T_I), which is a time used to control the influence of the integral term in the output calculation.

Understanding the Differential Term of the PID Equation

The differential term MD is proportional to the change in the error. The S7-200 uses the following equation for the differential term:

$$\mathbf{MD_n = K_C * T_D / T_S * ((SP_n - PV_n) - (SP_{n-1} - PV_{n-1}))}$$

To avoid step changes or bumps in the output due to derivative action on setpoint changes, this equation is modified to assume that the setpoint is a constant ($SP_n = SP_{n-1}$). This results in the calculation of the change in the process variable instead of the change in the error as shown:

$$\mathbf{MD_n = K_C * T_D / T_S * (SP_n - PV_n - SP_n + PV_{n-1})}$$

or just:

$$\mathbf{MD_n = K_C * T_D / T_S * (PV_{n-1} - PV_n)}$$

where: MD_n is the value of the differential term of the loop output at sample time n
K_C is the loop gain
T_S is the loop sample time
T_D is the differentiation period of the loop (also called the derivative time or rate)
SP_n is the value of the setpoint at sample time n
SP_{n-1} is the value of the setpoint at sample time n-1
PV_n is the value of the process variable at sample time n
PV_{n-1} is the value of the process variable at sample time n-1

The process variable rather than the error must be saved for use in the next calculation of the differential term. At the time of the first sample, the value of PV_{n-1} is initialized to be equal to PV_n.

Selecting the Type of Loop Control

In many control systems, it might be necessary to employ only one or two methods of loop control. For example, only proportional control or proportional and integral control might be required. The selection of the type of loop control desired is made by setting the value of the constant parameters.

If you do not want integral action (no “I” in the PID calculation), then a value of infinity “INF”, should be specified for the integral time (reset). Even with no integral action, the value of the integral term might not be zero, due to the initial value of the integral sum MX.

If you do not want derivative action (no “D” in the PID calculation), then a value of 0.0 should be specified for the derivative time (rate).

If you do not want proportional action (no “P” in the PID calculation) and you want I or ID control, then a value of 0.0 should be specified for the gain. Since the loop gain is a factor in the equations for calculating the integral and differential terms, setting a value of 0.0 for the loop gain will result in a value of 1.0 being used for the loop gain in the calculation of the integral and differential terms.

Converting and Normalizing the Loop Inputs

A loop has two input variables, the setpoint and the process variable. The setpoint is generally a fixed value such as the speed setting on the cruise control in your automobile. The process variable is a value that is related to loop output and therefore measures the effect that the loop output has on the controlled system. In the example of the cruise control, the process variable would be a tachometer input that measures the rotational speed of the tires.

Both the setpoint and the process variable are real world values whose magnitude, range, and engineering units could be different. Before these real world values can be operated upon by the PID instruction, the values must be converted to normalized, floating-point representations.

The first step is to convert the real world value from a 16-bit integer value to a floating-point or real number value. The following instruction sequence is provided to show how to convert from an integer value to a real number.

```
ITD      AIW0, AC0           //Convert an input value to a double word
DTR      AC0,  AC0           //Convert the 32-bit integer to a real number
```

The next step is to convert the real number value representation of the real world value to a normalized value between 0.0 and 1.0. The following equation is used to normalize either the setpoint or process variable value:

$$\mathbf{R_{Norm} = ((R_{Raw} / Span) + Offset)}$$

where: R_{Norm} is the normalized, real number value representation of the real world value
R_{Raw} is the un-normalized or raw, real number value representation of the real world value

Offset is 0.0 for unipolar values
is 0.5 for bipolar values

Span is the maximum possible value minus the minimum possible value:
= 32,000 for unipolar values (typical)
= 64,000 for bipolar values (typical)

The following instruction sequence shows how to normalize the bipolar value in AC0 (whose span is 64,000) as a continuation of the previous instruction sequence:

```
/R       64000.0,  AC0       //Normalize the value in the accumulator
+R       0.5,  AC0           //Offset the value to the range from 0.0 to 1.0
MOVR     AC0,  VD100         //Store the normalized value in the loop TABLE
```

Converting the Loop Output to a Scaled Integer Value

The loop output is the control variable, such as the throttle setting of the cruise control on an automobile. The loop output is a normalized, real number value between 0.0 and 1.0. Before the loop output can be used to drive an analog output, the loop output must be converted to a 16-bit, scaled integer value. This process is the reverse of converting the PV and SP to a normalized value. The first step is to convert the loop output to a scaled, real number value using the formula given below:

$$\mathbf{R_{Scal} = (M_n - Offset) * Span}$$

where: R_{Scal} is the scaled, real number value of the loop output
M_n is the normalized, real number value of the loop output

Offset is 0.0 for unipolar values
is 0.5 for bipolar values

Span is the maximum possible value minus the minimum possible value
= 32,000 for unipolar values (typical)
= 64,000 for bipolar values (typical)

The following instruction sequence shows how to scale the loop output:

```
MOVR    VD108,  AC0          //Moves the loop output to the accumulator
–R      0.5,  AC0            //Include this statement only if the value is bipolar
*R      64000.0,  AC0        //Scales the value in the accumulator
```

Next, the scaled, real number value representing the loop output must be converted to a 16-bit integer. The following instruction sequence shows how to do this conversion:

```
ROUND   AC0, AC0             //Converts the real number to a 32-bit integer
DTI     AC0,  LW0            //Converts the value to a 16-bit integer
MOVW    LW0, AQW0            //Writes the value to the analog output
```

Forward- or Reverse-Acting Loops

The loop is forward-acting if the gain is positive and reverse-acting if the gain is negative. (For I or ID control, where the gain value is 0.0, specifying positive values for integral and derivative time will result in a forward-acting loop, and specifying negative values will result in a reverse-acting loop.)

Variables and Ranges

The process variable and setpoint are inputs to the PID calculation. Therefore the loop table fields for these variables are read but not altered by the PID instruction.

The output value is generated by the PID calculation, so the output value field in the loop table is updated at the completion of each PID calculation. The output value is clamped between 0.0 and 1.0. The output value field can be used as an input by the user to specify an initial output value when making the transition from manual control to PID instruction (auto) control of the output. (See the discussion in the “Modes” section below).

If integral control is being used, then the bias value is updated by the PID calculation and the updated value is used as an input in the next PID calculation. When the calculated output value goes out of range (output would be less than 0.0 or greater than 1.0), the bias is adjusted according to the following formulas:

$$\mathbf{MX = 1.0 - (MP_n + MD_n)} \qquad \textit{when the calculated output } M_n > 1.0$$

or

$$\mathbf{MX = - (MP_n + MD_n)} \qquad \textit{when the calculated output } M_n < 0.0$$

*w*here: MX is the value of the adjusted bias
MP_n is the value of the proportional term of the loop output at sample time n
MD_n is the value of the differential term of the loop output at sample time n
M_n is the value of the loop output at sample time n

By adjusting the bias as described, an improvement in system responsiveness is achieved once the calculated output comes back into the proper range. The calculated bias is also clamped between 0.0 and 1.0 and then is written to the bias field of the loop table at the completion of each PID calculation. The value stored in the loop table is used in the next PID calculation.

The bias value in the loop table can be modified by the user prior to execution of the PID instruction in order to address bias value problems in certain application situations. Care must be taken when manually adjusting the bias, and any bias value written into the loop table must be a real number between 0.0 and 1.0.

A comparison value of the process variable is maintained in the loop table for use in the derivative action part of the PID calculation. You should not modify this value.

Modes

There is no built-in mode control for S7-200 PID loops. The PID calculation is performed only when power flows to the PID box. Therefore, “automatic” or “auto” mode exists when the PID calculation is performed cyclically. “Manual” mode exists when the PID calculation is not performed.

The PID instruction has a power-flow history bit, similar to a counter instruction. The instruction uses this history bit to detect a 0-to-1 power-flow transition. When the power-flow transition is detected, it will cause the instruction to perform a series of actions to provide a bumpless change from manual control to auto control. In order for change to auto mode control to be bumpless, the value of the output as set by the manual control must be supplied as an input to the PID instruction (written to the loop table entry for M_n) before switching to auto control. The PID instruction performs the following actions to values in the loop table to ensure a bumpless change from manual to auto control when a 0-to-1 power-flow transition is detected:

❑ Sets setpoint (SP_n) = process variable (PV_n)

❑ Sets old process variable (PV_{n-1}) = process variable (PV_n)

❑ Sets bias (MX) = output value (M_n)

The default state of the PID history bits is “set” and that state is established at startup and on every STOP-to-RUN mode transition of the controller. If power flows to the PID box the first time that it is executed after entering RUN mode, then no power-flow transition is detected and the bumpless mode change actions are not performed.

Alarm Checking and Special Operations

The PID instruction is a simple but powerful instruction that performs the PID calculation. If other processing is required such as alarm checking or special calculations on loop variables, these must be implemented using the basic instructions supported by the S7-200.

Error Conditions

When it is time to compile, the CPU will generate a compile error (range error) and the compilation will fail if the loop table start address or PID loop number operands specified in the instruction are out of range.

Certain loop table input values are not range checked by the PID instruction. You must take care to ensure that the process variable and setpoint (as well as the bias and previous process variable if used as inputs) are real numbers between 0.0 and 1.0.

If any error is encountered while performing the mathematical operations of the PID calculation, then SM1.1 (overflow or illegal value) is set and execution of the PID instruction is terminated. (Update of the output values in the loop table could be incomplete, so you should disregard these values and correct the input value causing the mathematical error before the next execution of the loop’s PID instruction.)

Loop Table

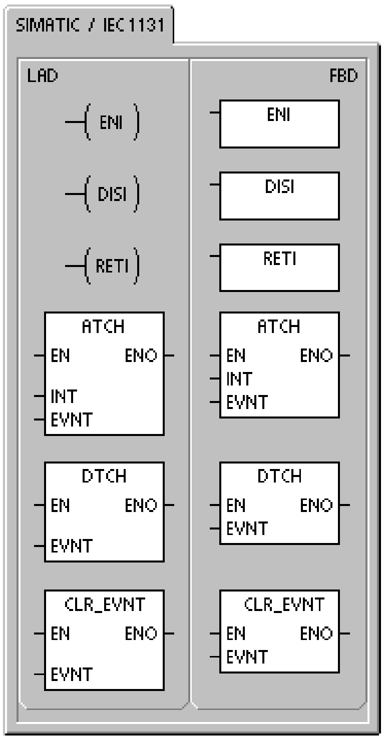
The loop table is 80 bytes long and has the format shown in Table 6-44.

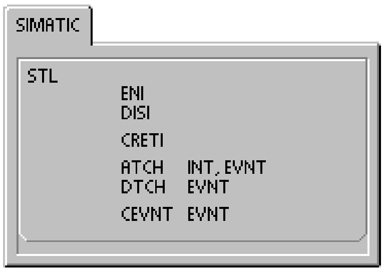
Table 6-44 Loop Table

Offset	Field	Format	Type	Description
0	Process variable (PV_n)	REAL	In	Contains the process variable, which must be scaled between 0.0 and 1.0.
4	Setpoint (SP_n)	REAL	In	Contains the setpoint, which must be scaled between 0.0 and 1.0.
8	Output (M_n)	REAL	In/Out	Contains the calculated output, scaled between 0.0 and 1.0.
12	Gain (K_C)	REAL	In	Contains the gain, which is a proportional constant. Can be a positive or negative number.
16	Sample time (T_S)	REAL	In	Contains the sample time, in seconds. Must be a positive number.
20	Integral time or reset (T_I)	REAL	In	Contains the integral time or reset, in minutes. Must be a positive number.
24	Derivative time or rate (T_D)	REAL	In	Contains the derivative time or rate, in minutes. Must be a positive number.
28	Bias (MX)	REAL	In/Out	Contains the bias or integral sum value between 0.0 and 1.0.
32	Previous process variable (PV_{n-1})	REAL	In/Out	Contains the value of the process variable stored from the last execution of the PID instruction.
36 to 79	Reserved for auto-tuning variables. Refer to Table 15-1 for details.			

Interrupt Instructions

Enable Interrupt and Disable Interrupt





```
STL      ENI
         DISI
         CRETI
         ATCH   INT, EVNT
         DTCH   EVNT
         CEVNT  EVNT
```

The Enable Interrupt instruction (ENI) globally enables processing of all attached interrupt events. The Disable Interrupt instruction (DISI) globally disables processing of all interrupt events.

When you make the transition to RUN mode, interrupts are initially disabled. In RUN mode, you can enable interrupt processing by executing the Enable Interrupt instruction. Executing the Disable Interrupt instruction inhibits the processing of interrupts; however, active interrupt events will continue to be queued.

Error conditions that set ENO = 0:

- 0004 (attempted execution of ENI, DISI, or HDEF instructions in an interrupt routine)

Conditional Return from Interrupt

The Conditional Return from Interrupt instruction (CRETI) can be used to return from an interrupt, based upon the condition of the preceding logic.

Attach Interrupt

The Attach Interrupt instruction (ATCH) associates an interrupt event EVNT with an interrupt routine number INT and enables the interrupt event.

Error conditions that set ENO = 0:

- 0002 (conflicting assignment of inputs to an HSC)

Detach Interrupt

The Detach Interrupt instruction (DTCH) disassociates an interrupt event EVNT from all interrupt routines and disables the interrupt event.

Clear Interrupt Event

The Clear Interrupt Event instruction removes all interrupt events of type EVNT from the interrupt queue. Use this instruction to clear the interrupt queue of unwanted interrupt events. If this instruction is being used to clear out spurious interrupt events, you should detach the event before clearing the events from the queue. Otherwise new events will be added to the queue after the clear event instruction has been executed.

The example shows a high-speed counter in quadrature mode using the CLR_EVNT instruction to remove interrupts. If a light chopper stepper sensor was stopped in a position that is on the edge of a light to dark transition, then small machine vibrations could generate unwanted interrupts before the new PV can be loaded.

Table 6-45 Valid Operands for the Interrupt Instructions

Inputs/Outputs	Data Types	Operands		
INT	BYTE	Constant (0 to 127)		
EVNT	BYTE	Constant	*CPU 221 and CPU 222:* *CPU 224:* *CPU 224XP and CPU 226:*	0 to 12, 19 to 23, and 27 to 33 0 to 23 and 27 to 33 0 to 33

Operation of the Attach Interrupt and Detach Interrupt Instructions

Before an interrupt routine can be invoked, an association must be established between the interrupt event and the program segment that you want to execute when the event occurs. Use the Attach Interrupt instruction to associate an interrupt event (specified by the interrupt event number) and the program segment (specified by an interrupt routine number). You can attach multiple interrupt events to one interrupt routine, but one event cannot be concurrently attached to multiple interrupt routines.

When you attach an interrupt event to an interrupt routine, that interrupt is automatically enabled. If you disable all interrupts using the global disable interrupt instruction, each occurrence of the interrupt event is queued until interrupts are re-enabled, using the global enable interrupt instruction, or the interrupt queue overflows.

You can disable individual interrupt events by breaking the association between the interrupt event and the interrupt routine with the Detach Interrupt instruction. The Detach Interrupt instruction returns the interrupt to an inactive or ignored state. Table 6-46 lists the different types of interrupt events.

Table 6-46 Interrupt Events

Event	Description		CPU 221 CPU 222	CPU 224	CPU 224XP CPU 226
0	I0.0	Rising edge	Y	Y	Y
1	I0.0	Falling edge	Y	Y	Y
2	I0.1	Rising edge	Y	Y	Y
3	I0.1	Falling edge	Y	Y	Y
4	I0.2	Rising edge	Y	Y	Y
5	I0.2	Falling edge	Y	Y	Y
6	I0.3	Rising edge	Y	Y	Y
7	I0.3	Falling edge	Y	Y	Y
8	Port 0	Receive character	Y	Y	Y
9	Port 0	Transmit complete	Y	Y	Y
10	Timed interrupt 0	SMB34	Y	Y	Y
11	Timed interrupt 1	SMB35	Y	Y	Y
12	HSC0	CV=PV (current value = preset value)	Y	Y	Y
13	HSC1	CV=PV (current value = preset value)		Y	Y
14	HSC1	Direction changed		Y	Y
15	HSC1	External reset		Y	Y
16	HSC2	CV=PV (current value = preset value)		Y	Y
17	HSC2	Direction changed		Y	Y
18	HSC2	External reset		Y	Y
19	PLS0	PTO pulse count complete interrupt	Y	Y	Y
20	PLS1	PTO pulse count complete interrupt	Y	Y	Y
21	Timer T32	CT=PT interrupt	Y	Y	Y

Table 6-46 Interrupt Events, continued

Event	Description		CPU 221 CPU 222	CPU 224	CPU 224XP CPU 226
22	Timer T96	CT=PT interrupt	Y	Y	Y
23	Port 0	Receive message complete	Y	Y	Y
24	Port 1	Receive message complete			Y
25	Port 1	Receive character			Y
26	Port 1	Transmit complete			Y
27	HSC0	Direction changed	Y	Y	Y
28	HSC0	External reset	Y	Y	Y
29	HSC4	CV=PV (current value = preset value)	Y	Y	Y
30	HSC4	Direction changed	Y	Y	Y
31	HSC4	External reset	Y	Y	Y
32	HSC3	CV=PV (current value = preset value)	Y	Y	Y
33	HSC5	CV=PV (current value = preset value)	Y	Y	Y

Understanding How the S7-200 Processes Interrupt Routines

The interrupt routine is executed in response to an associated internal or external event. Once the last instruction of the interrupt routine has been executed, control is returned to the main program. You can exit the routine by executing a Conditional Return from Interrupt instruction (CRETI). Table 6-47 emphasizes some guidelines and restrictions for using interrupt routines in your program.

Table 6-47 Guidelines and Restrictions for Using Interrupt Routines

Guidelines
Interrupt processing provides quick reaction to special internal or external events. You should optimize interrupt routines to perform a specific task, and then return control to the main routine. By keeping the interrupt routines short and to the point, execution is quick and other processes are not deferred for long periods of time. If this is not done, unexpected conditions can cause abnormal operation of equipment controlled by the main program. For interrupts, the axiom, “the shorter, the better,” is definitely true.
Restrictions
You cannot use the Disable Interrupt (DISI), Enable Interrupt (ENI), High-Speed Counter Definition (HDEF), and End (END) instructions in an interrupt routine.

System Support for Interrupts

Because contact, coil, and accumulator logic can be affected by interrupts, the system saves and reloads the logic stack, accumulator registers, and the special memory bits (SM) that indicate the status of accumulator and instruction operations. This avoids disruption to the main user program caused by branching to and from an interrupt routine.

Sharing Data Between the Main Program and Interrupt Routines

You can share data between the main program and one or more interrupt routines. Because it is not possible to predict when the S7-200 might generate an interrupt, it is desirable to limit the number of variables that are used by both the interrupt routine and elsewhere in the program. Problems with the consistency of shared data can result due to the actions of interrupt routines when the execution of instructions in your main program is interrupted by interrupt events. Use the local variable table of the interrupt routine to ensure that your interrupt routine uses only the temporary memory and does not overwrite data used somewhere else in your program.

There are a number of programming techniques you can use to ensure that data is correctly shared between your main program and interrupt routines. These techniques either restrict the way access is made to shared memory locations or prevent interruption of instruction sequences using shared memory locations.

- ❑ For an STL program that is sharing a single variable: If the shared data is a single byte, word, or double word variable and your program is written in STL, then correct shared access can be ensured by storing the intermediate values from operations on shared data only in non-shared memory locations or accumulators.
- ❑ For a LAD program that is sharing a single variable: If the shared data is a single byte, word, or double word variable and your program is written in LAD, then correct shared access can be ensured by establishing the convention that access to shared memory locations be made using only Move instructions (MOVB, MOVW, MOVD, MOVR). While many LAD instructions are composed of interruptible sequences of STL instructions, these Move instructions are composed of a single STL instruction whose execution cannot be affected by interrupt events.
- ❑ For an STL or LAD program that is sharing multiple variables: If the shared data is composed of a number of related bytes, words, or double words, then the interrupt disable/enable instructions (DISI and ENI) can be used to control interrupt routine execution. At the point in your main program where operations on shared memory locations are to begin, disable the interrupts. Once all actions affecting the shared locations are complete, re-enable the interrupts. During the time that interrupts are disabled, interrupt routines cannot be executed and therefore cannot access shared memory locations; however, this approach can result in delayed response to interrupt events.

Calling Subroutines from Interrupt Routines

You can call one nesting level of subroutines from an interrupt routine. The accumulators and the logic stack are shared between an interrupt routine and a subroutine that is called.

Types of Interrupts Supported by the S7-200

The S7-200 supports the following types of interrupt routines:

- ❑ Communications port interrupts: The S7-200 generates events that allow your program to control the communications port.
- ❑ I/O interrupts: The S7-200 generates events for different changes of state for various I/O. These events allow your program to respond to the high-speed counters, the pulse outputs, or to rising or falling states of the inputs.
- ❑ Time-based interrupts: The S7-200 generates events that allow your program to react at specific intervals.

Communications Port Interrupts

The serial communications port of the S7-200 can be controlled by your program. This mode of operating the communications port is called Freeport mode. In Freeport mode, your program defines the baud rate, bits per character, parity, and protocol. The Receive and Transmit interrupts are available to facilitate your program-controlled communications. Refer to the Transmit and Receive instructions for more information.

I/O Interrupts

I/O interrupts include rising/falling edge interrupts, high-speed counter interrupts, and pulse train output interrupts. The S7-200 can generate an interrupt on rising and/or falling edges of an input (either I0.0, I0.1, I0.2, or I0.3). The rising edge and the falling edge events can be captured for each of these input points. These rising/falling edge events can be used to signify a condition that must receive immediate attention when the event happens.

The high-speed counter interrupts allow you to respond to conditions such as the current value reaching the preset value, a change in counting direction that might correspond to a reversal in the direction in which a shaft is turning, or an external reset of the counter. Each of these high-speed counter events allows action to be taken in real time in response to high-speed events that cannot be controlled at programmable logic controller scan speeds.

The pulse train output interrupts provide immediate notification of completion of outputting the prescribed number of pulses. A typical use of pulse train outputs is stepper motor control.

You can enable each of the above interrupts by attaching an interrupt routine to the related I/O event.

Time-Based Interrupts

Time-based interrupts include timed interrupts and the timer T32/T96 interrupts. You can specify actions to be taken on a cyclic basis using a timed interrupt. The cycle time is set in 1-ms increments from 1 ms to 255 ms. You must write the cycle time in SMB34 for timed interrupt 0, and in SMB35 for timed interrupt 1.

The timed interrupt event transfers control to the appropriate interrupt routine each time the timer expires. Typically, you use timed interrupts to control the sampling of analog inputs or to execute a PID loop at regular intervals.

A timed interrupt is enabled and timing begins when you attach an interrupt routine to a timed interrupt event. During the attachment, the system captures the cycle time value, so subsequent changes to SMB34 and SMB35 do not affect the cycle time. To change the cycle time, you must modify the cycle time value, and then re-attach the interrupt routine to the timed interrupt event. When the re-attachment occurs, the timed interrupt function clears any accumulated time from the previous attachment and begins timing with the new value.

After being enabled, the timed interrupt runs continuously, executing the attached interrupt routine on each expiration of the specified time interval. If you exit RUN mode or detach the timed interrupt, the timed interrupt is disabled. If the global disable interrupt instruction is executed, timed interrupts continue to occur. Each occurrence of the timed interrupt is queued (until either interrupts are enabled or the queue is full).

The timer T32/T96 interrupts allow timely response to the completion of a specified time interval. These interrupts are only supported for the 1-ms resolution on-delay (TON) and off-delay (TOF) timers T32 and T96. The T32 and T96 timers otherwise behave normally. Once the interrupt is enabled, the attached interrupt routine is executed when the active timer’s current value becomes equal to the preset time value during the normal 1-ms timer update performed in the S7-200. You enable these interrupts by attaching an interrupt routine to the T32/T96 interrupt events.

Interrupt Priority and Queuing

Interrupts are serviced by the S7-200 on a first-come-first-served basis within their respective priority group. Only one user-interrupt routine is ever being executed at any point in time. Once the execution of an interrupt routine begins, the routine is executed to completion. It cannot be pre-empted by another interrupt routine, even by a higher priority routine. Interrupts that occur while another interrupt is being processed are queued for later processing.

Table 6-48 shows the three interrupt queues and the maximum number of interrupts they can store.

Table 6-48 Maximum Number of Entries per Interrupt Queue

Queue	CPU 221, CPU 222, CPU 224	CPU 224XP and CPU 226
Communications queue	4	8
I/O Interrupt queue	16	16
Timed Interrupt queue	8	8

Potentially, more interrupts can occur than the queue can hold. Therefore, queue overflow memory bits (identifying the type of interrupt events that have been lost) are maintained by the system. Table 6-49 shows the interrupt queue overflow bits. You should use these bits only in an interrupt routine because they are reset when the queue is emptied, and control is returned to the main program.

Table 6-50 shows all interrupt events, with their priority and assigned event number.

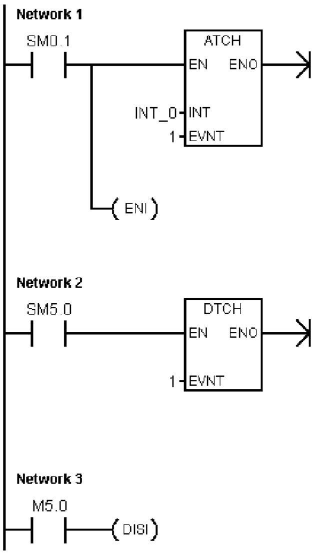
Table 6-49 Interrupt Queue Overflow Bits

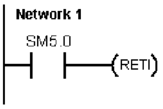
Description (0 = No Overflow, 1 = Overflow)	SM Bit
Communications queue	SM4.0
I/O Interrupt queue	SM4.1
Timed Interrupt queue	SM4.2

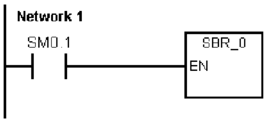
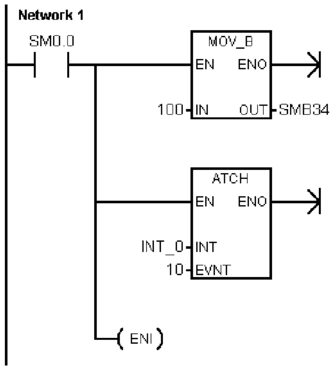
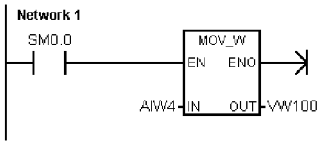
Table 6-50 Priority Order for Interrupt Events

Event	Description		Priority Group	Priority in Group
8	Port 0	Receive character	Communications *Highest Priority*	0
9	Port 0	Transmit complete		0
23	Port 0	Receive message complete		0
24	Port 1	Receive message complete		1
25	Port 1	Receive character		1
26	Port 1	Transmit complete		1
19	PLS0	PTO pulse count complete interrupt	Discrete *Medium Priority*	0
20	PLS1	PTO pulse count complete interrupt		1
0	I0.0	Rising edge		2
2	I0.1	Rising edge		3
4	I0.2	Rising edge		4
6	I0.3	Rising edge		5
1	I0.0	Falling edge		6
3	I0.1	Falling edge		7
5	I0.2	Falling edge		8
7	I0.3	Falling edge		9
12	HSC0	CV=PV (current value = preset value)		10
27	HSC0	Direction changed		11
28	HSC0	External reset		12
13	HSC1	CV=PV (current value = preset value)		13
14	HSC1	Direction changed		14
15	HSC1	External reset		15
16	HSC2	CV=PV (current value = preset value)		16
17	HSC2	Direction changed		17
18	HSC2	External reset		18
32	HSC3	CV=PV (current value = preset value)		19
29	HSC4	CV=PV (current value = preset value)		20
30	HSC4	Direction changed		21
31	HSC4	External reset		22
33	HSC5	CV=PV (current value = preset value)		23
10	Timed interrupt 0	SMB34	Timed *Lowest Priority*	0
11	Timed interrupt 1	SMB35		1
21	Timer T32	CT=PT interrupt		2
22	Timer T96	CT=PT interrupt		3

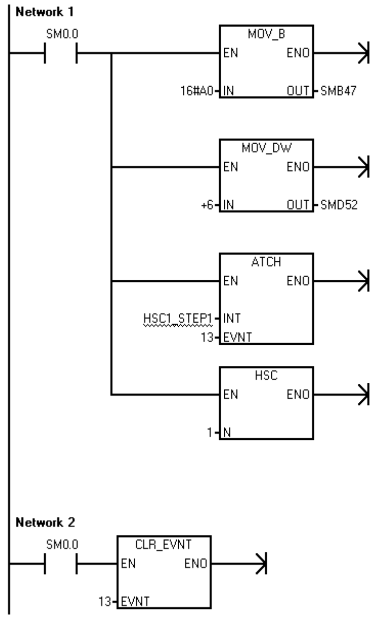
Example: Interrupt Instructions		

M
A
I
N
	 Network 1
	SM0.1
	ATCH
	EN
	ENO
	INT_0
	INT
	1
	EVNT
	ENI
	Network 2
	SM5.0
	DTCH
	EN
	ENO
	1
	EVNT
	Network 3
	M5.0
	DISI
		Network 1 //On the first scan:
		//1. Define interrupt routine INT_0 to
		// be a falling-edge interrupt for I0.0
		//2. Globally enable interrupts.
		LD SM0.1
		ATCH INT_0, 1
		ENI
		Network 2 //If an I/O error is detected,
		//disable the falling-edge interrupt for I0.0.
		//This network is optional.
		LD SM5.0
		DTCH 1
		Network 3 //When M5.0 is on,
		//disable all interrupts.
		LD M5.0
		DISI

I N T 0		Network 1 //I0.0 falling-edge interrupt routine: //Conditional return based on an I/O error. LD SM5.0 CRETI

Example: Timed Interrupt for Reading the Value of an Analog Input		
M A I N		Network 1 //On the first scan, call subroutine 0. LD SM0.1 CALL SBR_0
S B R 0	 Network 1 SM0.0 MOV_B EN ENO 100 IN OUT SMB34 ATCH EN ENO INT_0 INT 10 EVNT ENI	Network 1 //1. Set the interval for the timed interrupt 0 to 100 ms. //2. Attach timed interrupt 0 (Event 10) to INT_0. //3. Global interrupt enable. LD SM0.0 MOVB 100, SMB34 ATCH INT_0, 10 ENI
I N T 0	 Network 1 SM0.0 MOV_W EN ENO AIW4 IN OUT VW100	Network 1 //Read the value of AIW4 every 100 ms LD SM0.0 MOVW AIW4, VW100

Example: Clear Interrupt Event Instruction



```
Network 1       // Instruction Wizard HSC

LD       SM0.0
MOVB     16#A0, SMB47
                 //Set control bits:
                //write preset;

MOVD     +6, SMD52
                //PV = 6;

ATCH     HSC1_STEP1, 13
                //Interrupt HSC1_STEP1: CV = PV for HC1

Network 2       //Clear unwanted interrupts caused
                //by machine vibration

LD              SM0.0
CEVNT           13
```

Logical Operations Instructions

Invert Instructions

Invert Byte, Word, and Double Word

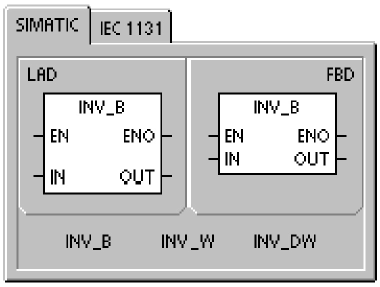
The Invert Byte (INVB), Invert Word (INVW), and Invert Double Word (INVD) instructions form the one's complement of the input IN and load the result into the memory location OUT.

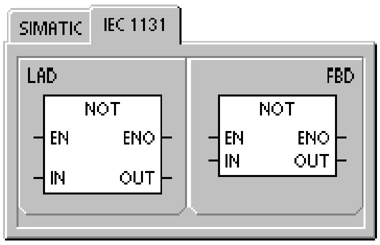
Error conditions that set ENO = 0

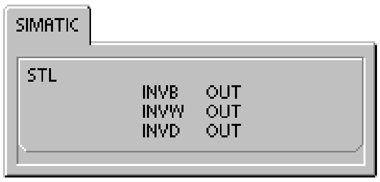
- 0006 (indirect address)

SM bits affected:

- SM1.0 (zero)



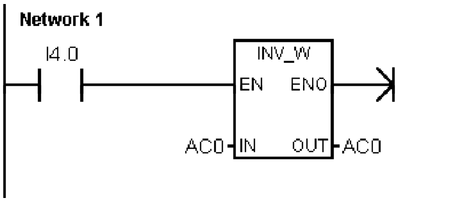




```
INVB   OUT
INVW   OUT
INVD   OUT
```

Table 6-51 Valid Operands for the Invert Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC,*VD, *LD, *AC
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *LD, *AC
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Example: Invert Instruction	
 Network 1 I4.0 INV_W EN ENO AC0 IN OUT AC0	Network 1 LD I4.0 INVW AC0 Invert Word AC0 1101 0111 1001 0101 complement AC0 0010 1000 0110 1010

AND, OR, and Exclusive OR Instructions

AND Byte, AND Word, and AND Double Word

The AND Byte (ANDB), AND Word (ANDW), and AND Double Word (ANDD) instructions AND the corresponding bits of two input values IN1 and IN2 and load the result in a memory location OUT.

OR Byte, OR Word and OR Double Word

The OR Byte (ORB), OR Word instruction (ORW), and OR Double Word (ORD) instructions OR the corresponding bits of two input values IN1 and IN2 and load the result in a memory location OUT.

Exclusive OR Byte, Exclusive OR Word, and Exclusive OR Double Word

The Exclusive OR Byte (XROB), Exclusive OR Word (XORW), and Exclusive OR Double Word (XORD) instruction XOR the corresponding bits of two input values IN1 and IN2 and load the result in a memory location OUT.

SM Bits and ENO

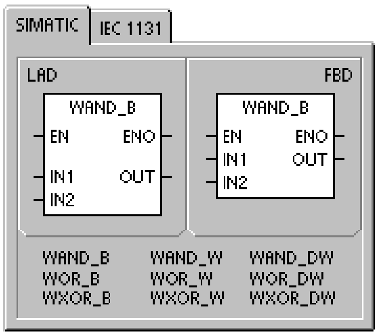
For all of the instructions described on this page, the following conditions affect SM bits and ENO.

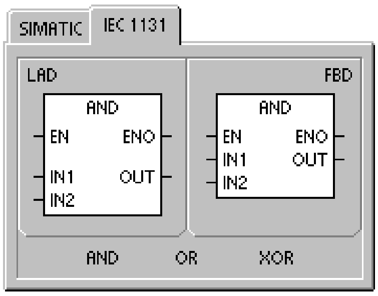
Error conditions that set ENO = 0

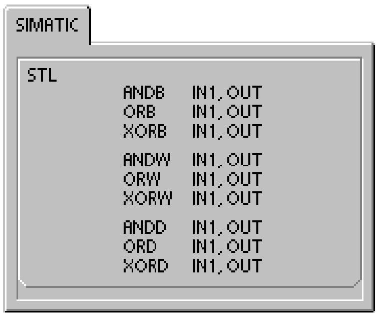
- 0006 (indirect address)

SM bits affected:

- SM1.0 (zero)





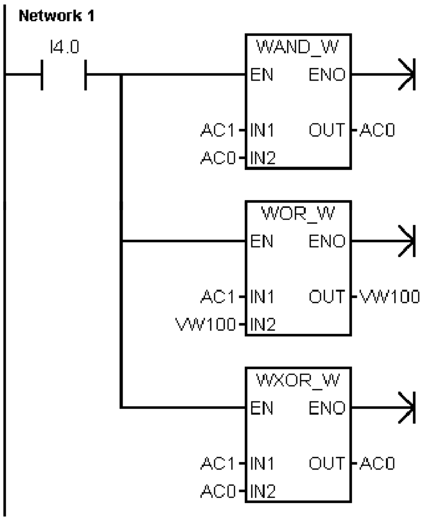


```
ANDB   IN1, OUT
ORB    IN1, OUT
XORB   IN1, OUT

ANDW   IN1, OUT
ORW    IN1, OUT
XORW   IN1, OUT

ANDD   IN1, OUT
ORD    IN1, OUT
XORD   IN1, OUT
```

Table 6-52 Valid Operands for the AND, OR, and Exclusive OR Instructions

Inputs/Outputs	Data Types	Operands
IN1, IN2	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *AC, *LD
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

Example: AND, OR, and Exclusive OR Instructions



Network 1

```
LD      I4.0
ANDW    AC1, AC0
ORW     AC1, VW100
XORW    AC1, AC0
```

AND Word

AC1 0001 1111 0110 1101
AND
AC0 1101 0011 1110 0110
equals
AC0 0001 0011 0110 0100

OR Word

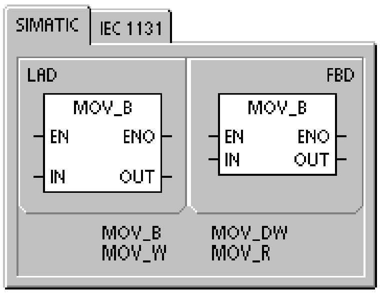
AC1 0001 1111 0110 1101
OR
VW100 1101 0011 1010 0000
equals
VW100 1101 1111 1110 1101

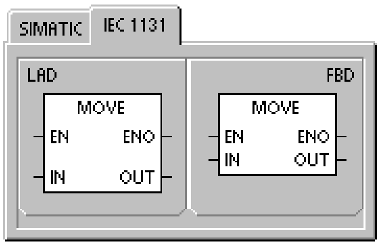
Exclusive OR Word

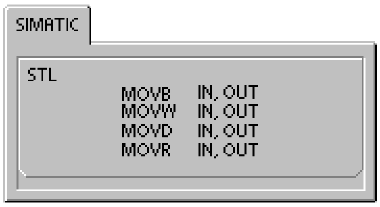
AC1 0001 1111 0110 1101
XOR
AC0 0001 0011 0110 0100
equals
AC0 0000 1100 0000 1001

Move Instructions

Move Byte, Word, Double Word, or Real







```
STL
        MOVB  IN, OUT
        MOVW  IN, OUT
        MOVD  IN, OUT
        MOVR  IN, OUT
```

The Move Byte (MOVB), Move Word (MOVW), Move Double Word (MOVD), and Move Real (MOVR) instructions move a value from a memory location IN to a new memory location OUT without changing the original value.

Use the Move Double Word instruction to create a pointer. For more information, refer to the section on pointers and indirect addressing in Chapter 4.

For the IEC Move instruction, the input and output data types can vary, but must be of the same size.

Error conditions that set ENO = 0

- 0006 (indirect address)

Table 6-53 Valid Operands for the Move Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	WORD, INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *AC, *LD, Constant
	DWORD, DINT	ID, QD, VD, MD, SMD, SD, LD, HC, &VB, &IB, &QB, &MB, &SB, &T, &C, &SMB, &AIW, &AQW, AC, *VD, *LD, *AC, Constant,
	REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC
	WORD, INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AQW, *VD, *LD, *AC
	DWORD, DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Move Byte Immediate (Read and Write)

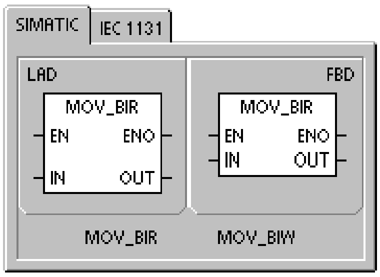
The Move Byte Immediate instructions allow you to immediately move a byte between the physical I/O and a memory location.

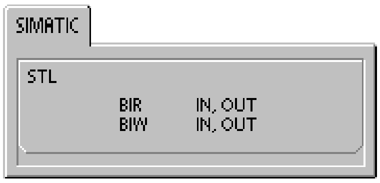
The Move Byte Immediate Read (BIR) instruction reads physical input (IN) and writes the result to the memory address (OUT), but the process-image register is not updated.

The Move Byte Immediate Write instruction (BIW) reads the data from the memory address (IN) and writes to physical output (OUT), and the corresponding process image location.

Error conditions that set ENO = 0

- 0006 (indirect address)
- Unable to access expansion module





```
BIR     IN, OUT
BIW     IN, OUT
```

Table 6-54 Valid Operands for the Move Byte Immediate Read Instruction

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, *VD, *LD, *AC
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC

Table 6-55 Valid Operands for the Move Byte Immediate Write Instruction

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
OUT	BYTE	QB, *VD, *LD, *AC

Block Move Instructions

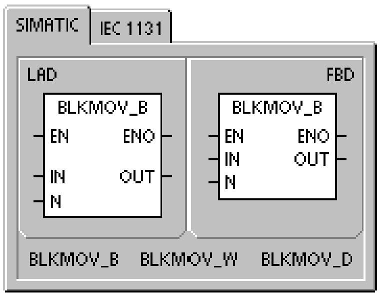
Block Move Byte, Word, or Double Word

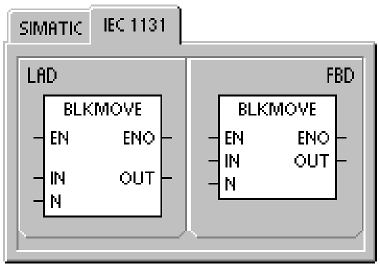
The Block Move Byte (BMB), Block Move Word (BMW), and Block Move Double Word (BMD) instructions move a specified amount of data to a new memory location by moving the number of bytes, words, or double words N starting at the input address IN to a new block starting at the output address OUT.

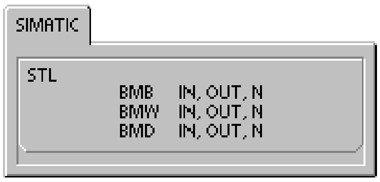
N has a range of 1 to 255.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)





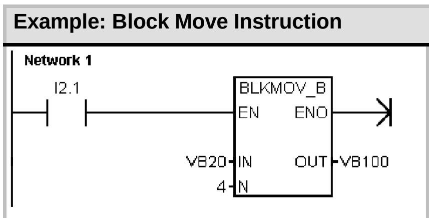


```
STL
          BMB   IN, OUT, N
          BMW   IN, OUT, N
          BMD   IN, OUT, N
```

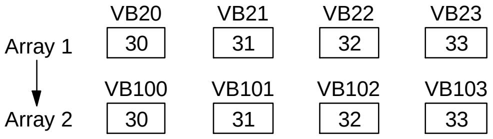
Table 6-56 Valid Operands for the Block Move Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE WORD, INT DWORD, DINT	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC IW, QW, VW, MW, SMW, SW, T, C, LW, AIW, *VD, *LD, *AC ID, QD, VD, MD, SMD, SD, LD, *VD, *LD, *AC
OUT	BYTE WORD, INT DWORD, DINT	IB, QB, VB, MB, SMB, SB, LB, *VD, *LD, *AC IW, QW, VW, MW, SMW, SW, T, C, LW, AQW, *VD, *LD, *AC ID, QD, VD, MD, SMD, SD, LD, *VD, *LD, *AC
N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, Constant, *VD, *LD, *AC

Example: Block Move Instruction



```
Network 1      //Move array 1 (VB20 to VB23)
               //to array 2 (VB100 to VB103)
LD        I2.1
BMB       VB20, VB100, 4
```

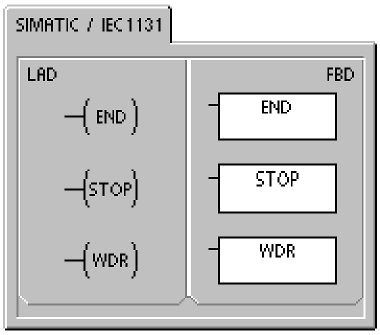


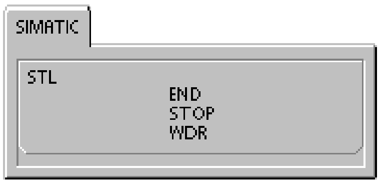
	VB20	VB21	VB22	VB23
Array 1	30	31	32	33
	VB100	VB101	VB102	VB103
Array 2	30	31	32	33

Program Control Instructions

Conditional End

The Conditional End instruction (END) terminates the current scan based upon the condition of the preceding logic. You can use the Conditional End instruction in the main program, but you cannot use it in either subroutines or interrupt routines.





```
END
STOP
WDR
```

Stop

The Stop instruction (STOP) terminates the execution of your program by causing a transition of the S7-200 CPU from RUN to STOP mode.

If the Stop instruction is executed in an interrupt routine, the interrupt routine is terminated immediately, and all pending interrupts are ignored. Remaining actions in the current scan cycle are completed, including execution of the main user program, and the transition from RUN to STOP mode is made at the end of the current scan.

Watchdog Reset

The Watchdog Reset instruction (WDR) retriggers the system watchdog timer of the S7-200 CPU to extend the time that the scan is allowed to take without getting a watchdog error.

You should use the Watchdog Reset instruction carefully. If you use looping instructions either to prevent scan completion or to delay excessively the completion of the scan, the following processes are inhibited until the scan cycle is completed:

- Communications (except Freeport Mode)
- I/O updating (except Immediate I/O)
- Force updating
- SM bit updating (SM0, SM5 to SM29 are not updated)
- Run-time diagnostics
- 10-ms and 100-ms timers will not properly accumulate time for scans exceeding 25 seconds
- STOP instruction, when used in an interrupt routine
- Expansion modules with discrete outputs also include a watchdog timer that turns off outputs if the module is not written by the S7-200. Use an immediate write to each expansion module with discrete outputs to keep the correct outputs on during extended scan times. Refer to the example that follows this description.

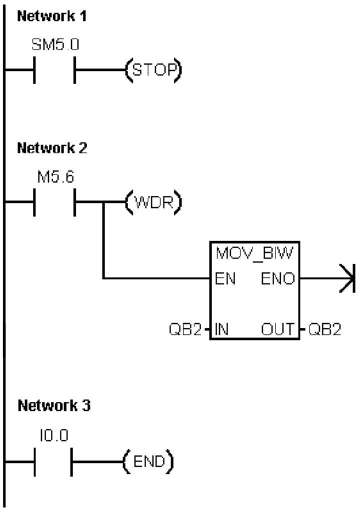
Tip

If you expect your scan time to exceed 500 ms, or if you expect a burst of interrupt activity that could prevent returning to the main scan for more than 500 ms, you should use the Watchdog Reset instruction to retrigger the watchdog timer.

Each time you use the Watchdog Reset instruction, you should also use an immediate write to one output byte (QB) in each discrete expansion module to reset each expansion module watchdog.

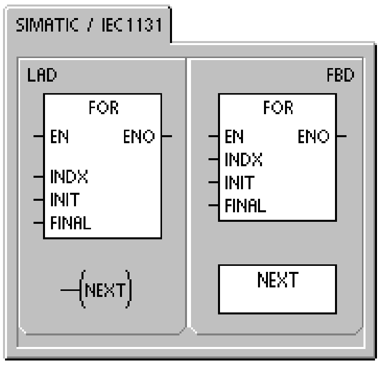
If you use the Watchdog Reset instruction to allow the execution of a program that requires a long scan time, changing the mode switch to the STOP position causes the S7-200 to transition to STOP mode within 1.4 seconds.

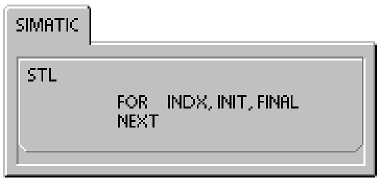
Example: Stop, End, and Watchdog Reset Instructions



```
Network 1     //When an I/O error is detected:
              //Force the transition to STOP mode.
LD       SM5.0
STOP

Network 2     //When M5.6 is on, allow the scan to
              //be extended:
              //1. Retrigger the Watchdog Reset for the S7-200.
              //2. Retrigger the watchdog for the
                    first output module.
LD       M5.6
WDR
BIW      QB2, QB2

Network 3     //When I0.0 is on, terminate the current scan.
LD       I0.0
END
```

For-Next Loop Instructions





```
FOR   INDX, INIT, FINAL
NEXT
```

Use the For (FOR) and Next (NEXT) instructions to delineate a loop that is repeated for the specified count. Each For instruction requires a Next instruction. You can nest For-Next loops (place a For-Next loop within a For-Next loop) to a depth of eight.

The For instruction executes the instructions between the For and the Next instructions. You specify the index value or current loop count INDX, the starting value INIT, and the ending value FINAL.

The Next instruction marks the end of the FOR loop.

Error conditions that set ENO = 0

- 0006 (indirect address)

If you enable the For-Next loop, it continues the looping process until it finishes the iterations, unless you change the final value from within the loop itself. You can change the values while the For-Next loop is in the looping process. When the loop is enabled again, it copies the initial value into the index value (current loop number).

The For-Next instruction resets itself the next time it is enabled.

For example, given an INIT value of 1 and a FINAL value of 10, the instructions between the For instruction and the Next instruction are executed 10 times with the INDX value being incremented:

1, 2, 3, ...10.

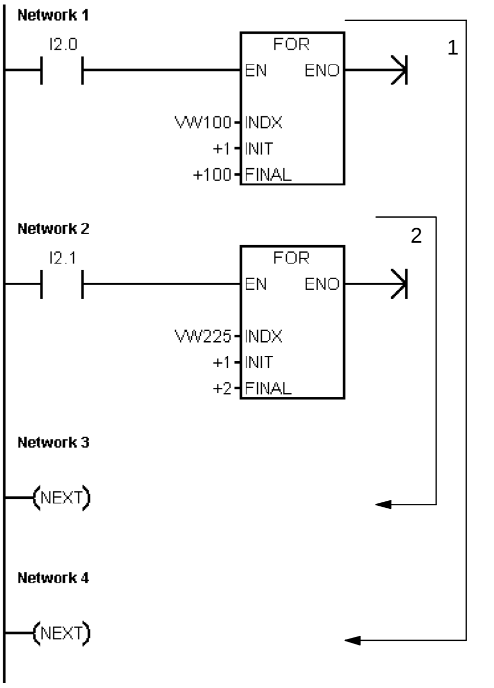
If the starting value is greater than the final value, the loop is not executed. After each execution of the instructions between the For instruction and the Next instruction, the INDX value is incremented and the result is compared to the final value. If the INDX is greater than the final value, the loop is terminated.

If the top of stack is 1 when your program enters the For-Next loop, then the top of stack will be 1 when your program exits the For-Next loop.

Table 6-57 Valid Operands for the For and Next Instructions

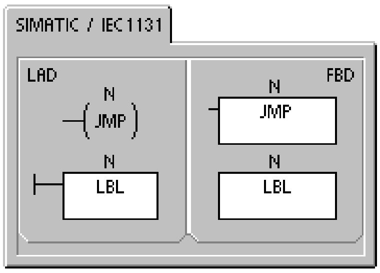
Inputs/Outputs	Data Types	Operands
INDX	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *LD, *AC
INIT, FINAL	INT	VW, IW, QW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant

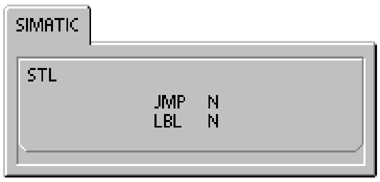
Example: For-Next Loop Instructions



```
Network 1       //When I2.0 comes on, the outside loop
                //(arrow 1) is executed 100 times
LD      I2.0
FOR     VW100, +1, +100

Network 2       //The inside loop (arrow 2)
                //is executed twice for each
                //execution of the outside loop
                //when I2.1 is on.
LD      I2.1
FOR     VW225, +1, +2

Network 3       //End of Loop 2.
NEXT

Network 4       //End of Loop 1 .
NEXT
```

Jump Instructions





```
JMP   N
LBL   N
```

The Jump to Label instruction (JMP) performs a branch to the specified label N within the program.

The Label instruction (LBL) marks the location of the jump destination N.

You can use the Jump instruction in the main program, in subroutines, or in interrupt routines. The Jump and its corresponding Label instruction must always be located within the same segment of code (either the main program, a subroutine, or an interrupt routine).

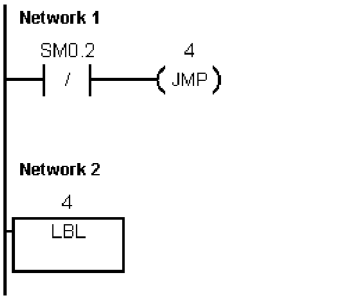
You cannot jump from the main program to a label in either a subroutine or an interrupt routine. Likewise, you cannot jump from a subroutine or interrupt routine to a label outside that subroutine or interrupt routine.

You can use a Jump instruction within an SCR segment, but the corresponding Label instruction must be located within the same SCR segment.

Table 6-58 Valid Operands for the Jump Instructions

Inputs/Outputs	Data Types	Operands
N	WORD	Constant (0 to 255)

Example: Jump to Label Instruction

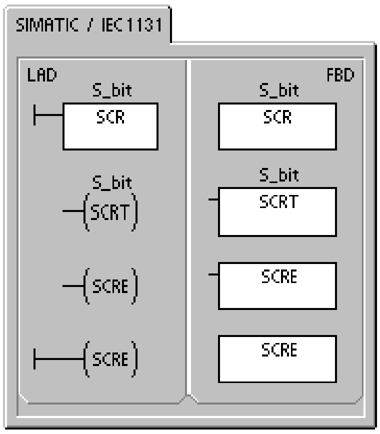


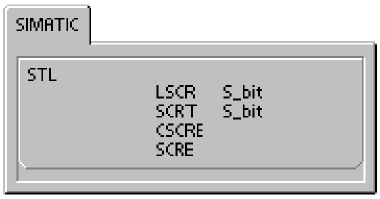
```
Network 1       //If the retentive data has not been lost,
                //Jump to LBL4
LDN     SM0.2
JMP     4
Network 2
LBL     4
```

Sequence Control Relay (SCR) Instructions

SCR instructions provide you with a simple yet powerful state control programming technique that fits naturally into a LAD, FBD, or STL program.

Whenever your application consists of a sequence of operations that must be performed repetitively, SCRs can be used to structure your program so that it corresponds directly to your application. As a result, you can program and debug your application more quickly and easily.





```
LSCR   S_bit
SCRT   S_bit
CSCRE
SCRE
```

The Load SCR instruction (LSCR) loads the SCR and logic stacks with the value of the S bit referenced by the instruction N.

The SCR segment is energized or de-energized by the resulting value of the SCR stack. The value of the SCR stack is copied to the top of the logic stack so that boxes or output coils can be tied directly to the left power rail without an intervening contact.

Restrictions

When using SCRs, be aware of the following restrictions:

- You cannot use the same S bit in more than one routine. For example, if you use S0.1 in the main program, do not use it in a subroutine.
- You cannot jump into or out of an SCR segment; however, you can use Jump and Label instructions to jump around SCR segments or to jump within an SCR segment.
- You cannot use the END instruction in an SCR segment.

Table 6-59 Valid Operands for the Sequence Control Relay Instructions

Inputs/Outputs	Data Types	Operands
S_bit	BOOL	S

Figure 6-31 shows the S stack and the logic stack and the effect of executing the Load SCR instruction. The following is true of Sequence Control Relay instructions:

- The Load SCR instruction (LSCR) marks the beginning of an SCR segment, and the SCR End instruction (SCRE) marks the end of an SCR segment. All logic between the Load SCR and the SCR End instructions are dependent upon the value of the S stack for its execution. Logic between the SCR End and the next Load SCR instruction is not dependent on the value of the S stack.
- The SCR Transition instruction (SCRT) provides the means to transfer control from an active SCR segment to another SCR segment.

  Execution of the SCR Transition instruction when it has power flow will reset the S bit of the currently active segment and will set the S bit of the referenced segment. Resetting the S bit of the active segment does not affect the S stack at the time the SCR Transition instruction executes. Consequently, the SCR segment remains energized until it is exited.

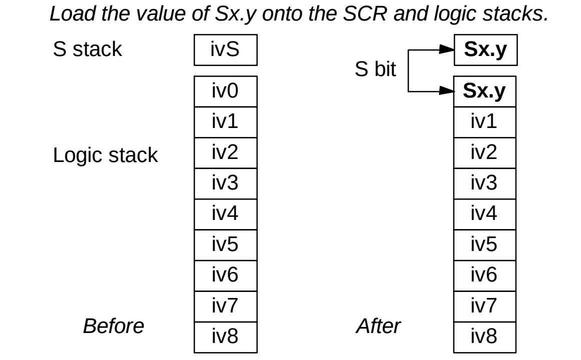
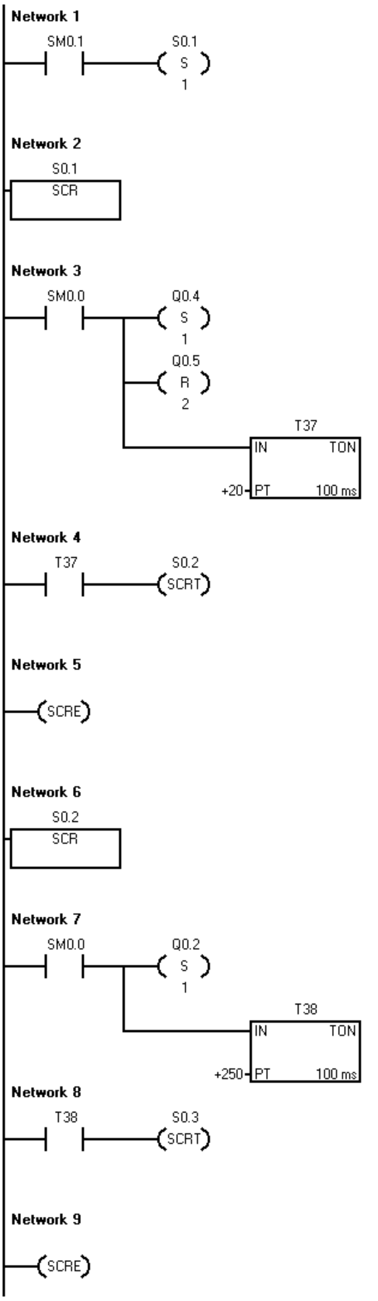


Figure 6-31 Effect of LSCR on the Logic Stack

- The Conditional SCR End instruction (CSCRE) provides a means to exit an active SCR segment without executing the instructions between the Conditional SCR End and the SCR End instructions. The Conditional SCR End instruction does not affect any S bit nor does it affect the S stack.

In the following example, the first scan bit SM0.1 sets S0.1, which will be the active State 1 on the first scan. After a 2-second delay, T37 causes a transition to State 2. This transition deactivates the State 1 SCR (S0.1) segment and activates the State 2 SCR (S0.2) segment.

Example: Sequence Control Relay Instruction



```
Network 1      //On the first scan enable State 1.
LD        SM0.1
S         S0.1, 1

Network 2      //Beginning of State 1 control region.
LSCR      S0.1

Network 3      //Control the signals for Street 1:
               //1. Set: Turn on the red light.
               //2. Reset: Turn off the yellow and green lights.
               //3. Start a 2-second timer.
LD        SM0.0
S         Q0.4, 1
R         Q0.5, 2
TON       T37, +20

Network 4      //After a 2 second delay, transition to State 2.
LD         T37
SCRT      S0.2

Network 5      //End of SCR region for State 1.
SCRE

Network 6      //Beginning of State 2 control region.
LSCR      S0.2

Network 7      //Control the signals for Street 2:
               //1. Set: Turn on the green light.
               //2. Start a 25-second timer.
LD        SM0.0
S         Q0.2, 1
TON       T38, +250

Network 8      //After a 25 second delay, transition to State 3.
LD         T38
SCRT      S0.3

Network 9      //End of SCR region for State 2.
SCRE
```

Divergence Control

In many applications, a single stream of sequential states must be split into two or more different streams. When a control stream diverges into multiple streams, all outgoing streams must be activated simultaneously. This is shown in Figure 6-32.

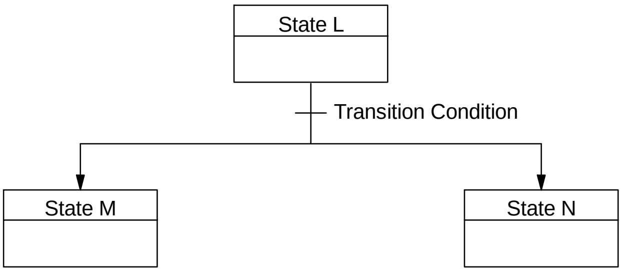
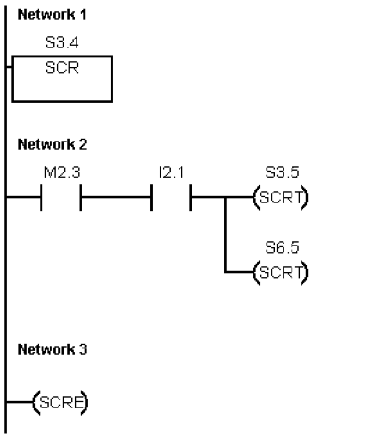


Figure 6-32 Divergence of a Control Stream

The divergence of control streams can be implemented in an SCR program by using multiple SCRT instructions enabled by the same transition condition, as shown in the following example.

Example: Divergence of Control Streams



```
Network 1        //Beginning of State L control region.
LSCR     S3.4

Network 2
LD       M2.3
A        I2.1
SCRT     S3.5              //Transition to State M
SCRT     S6.5              //Transition to State N

Network 3        //End of the State region for State L.
SCRE
```

Convergence Control

A situation similar to divergence control arises when two or more streams of sequential states must be merged into a single stream. When multiple streams merge into a single stream, they are said to converge. When streams converge, all incoming streams must be complete before the next state is executed. Figure 6-33 depicts the convergence of two control streams.

The convergence of control streams can be implemented in an SCR program by making the transition from state L to state L’ and by making the transition from state M to state M’. When both SCR bits representing L’ and M’ are true, state N can the enabled as shown in the following example.

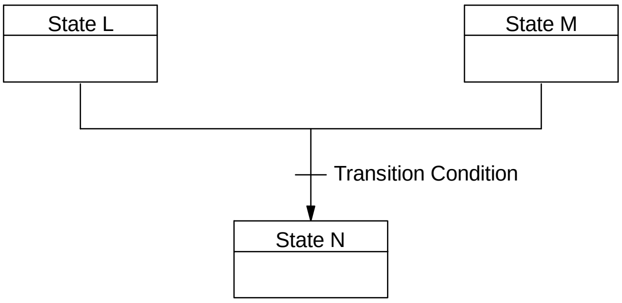
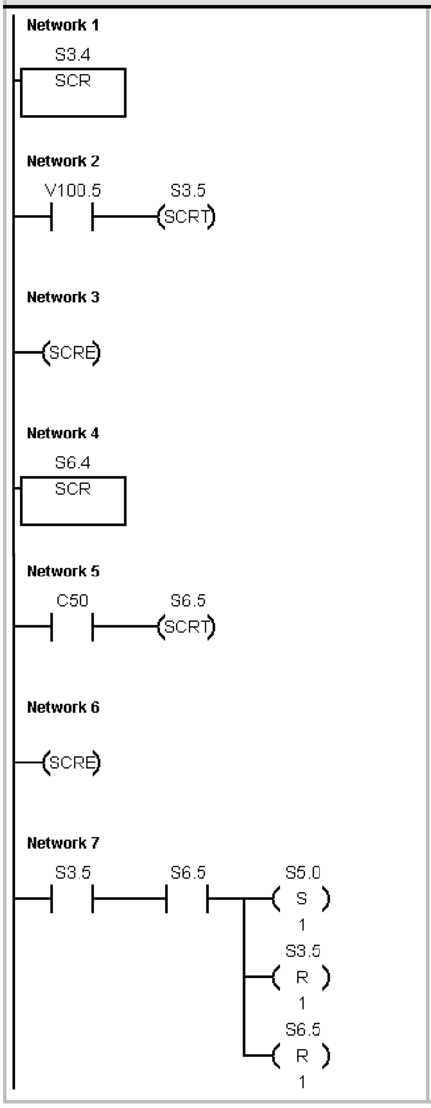


Figure 6-33 Convergence of a Control Stream

Example: Convergence of Control Streams



```
Network 1       //Beginning of State L control region
LSCR    S3.4

Network 2       //Transition to State L'
LD      V100.5
SCRT    S3.5

Network 3       //End of SCR region for State L
SCRE

Network 4       //Beginning of State M control region
LSCR    S6.4

Network 5       //Transition to State M'
LD      C50
SCRT    S6.5

Network 6       //End of SCR region for State M
SCRE

Network 7       //When both State L' and State M'
                //are activated:
                //1. Enable State N (S5.0)
                //2. Reset State L' (S3.5)
                //3. Reset State M' (S6.5)
LD      S3.5
A       S6.5
S       S5.0, 1
R       S3.5, 1
R       S6.5, 1
```

In other situations, a control stream might be directed into one of several possible control streams, depending upon which transition condition comes true first. Such a situation is depicted in Figure 6-34, which shows an equivalent SCR program.

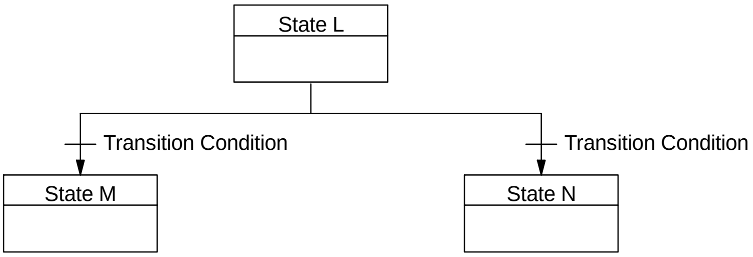
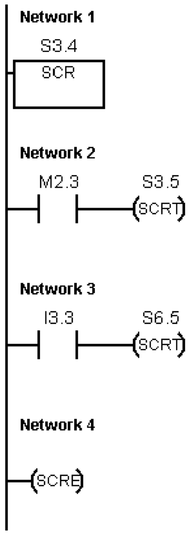


Figure 6-34 Divergence of a Control Stream, Depending on the Transition Condition

Example: Conditional Transitions



```
Network 1      //Beginning of State L control region
LSCR     S3.4

Network 2      //Transition to State M
LD       M2.3
SCRT     S3.5

Network 3      //Transition to State N
LD       I3.3
SCRT     S6.5

Network 4      //End of SCR region for State L
SCRE
```

Diagnostic LED Instruction

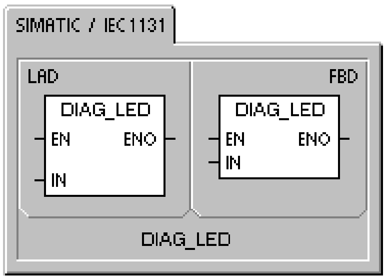
If the input parameter IN has a value of zero, then set the diagnostic LED OFF. If the input parameter IN has a value greater than zero, then set the diagnostic LED ON (yellow).

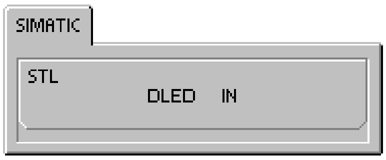
The CPU light emitting diode (LED) labeled SF/ DIAG can be configured to indicate yellow when either the conditions specified in the System Block are true or when the DIAG_LED instruction is executed with a non-zero IN parameter.

System Block (Configure LED) check box options:

- ❑ SF/ DIAG LED is ON (yellow) when an item is forced in the CPU
- ❑ SF/ DIAG LED is ON (yellow) when a module has an I/O error

Uncheck both Configure LED options to give the DIAG_LED instruction sole control over SF/ DIAG yellow illumination. A CPU System Fault (SF) is indicated with red illumination.





```
DLED    IN
```

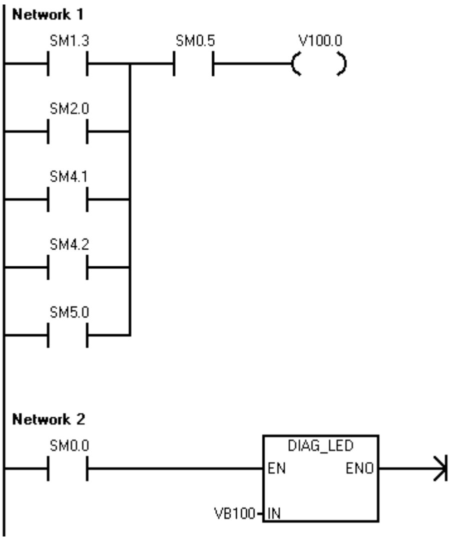
Table 6-60 Valid Operands for the Diagnostic LED Instruction

Inputs/Outputs	Data Types	Operands
IN	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *LD, *AC

Example 1 Diagnostic LED Instruction

Blink the diagnostic LED when an error is detected.

Blink the diagnostic LED any time one of the 5 error conditions is detected.

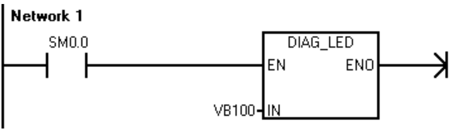


```
Network 1
LD      SM1.3
O       SM 2.0
O       SM4.1
O       SM4.2
O       SM5.0
A       SM0.5
=       V100.0

Network 2
LD      SM0.0
DLED    VB100
```

Example 2 Diagnostic LED Instruction

Turn the diagnostic LED ON when an error is returned.

When an error code is reported in VB100, turn on the diagnostic LED



```
Network 1
LD      SM0.0
DLED    VB100
```

Shift and Rotate Instructions

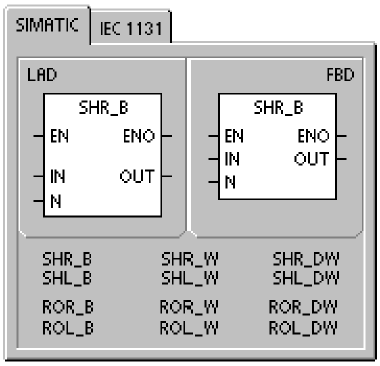
Shift Right and Shift Left Instructions

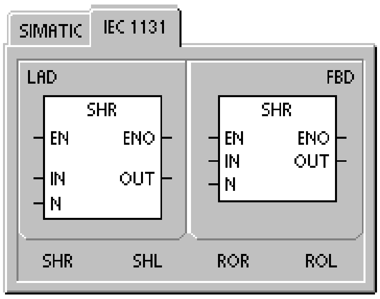
The Shift instructions shift the input value IN right or left by the shift count N and load the result in the output OUT.

The Shift instructions fill with zeros as each bit is shifted out. If the shift count (N) is greater than or equal to the maximum allowed (8 for byte operations, 16 for word operations, and 32 for double word operations), the value is shifted the maximum number of times for the operation. If the shift count is greater than 0, the overflow memory bit (SM1.1) takes on the value of the last bit shifted out. The zero memory bit (SM1.0) is set if the result of the shift operation is zero.

Byte operations are unsigned. For word and double word operations, the sign bit is shifted when you use signed data types.

Error conditions that set ENO = 0	SM bits affected:
■ 0006 (indirect address)	■ SM1.0 (zero) ■ SM1.1 (overflow)

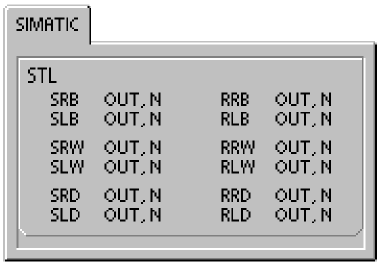




Rotate Right and Rotate Left Instructions

The Rotate instructions rotate the input value (IN) right or left by the shift count (N) and load the result in the memory location (OUT). The rotate is circular.

If the shift count is greater than or equal to the maximum for the operation (8 for a byte operation, 16 for a word operation, or 32 for a double-word operation), the S7-200 performs a modulo operation on the shift count to obtain a valid shift count before the rotation is executed. This result is a shift count of 0 to 7 for byte operations, 0 to 15 for word operations, and 0 to 31 for double-word operations.



```
STL
  SRB  OUT, N      RRB  OUT, N
  SLB  OUT, N      RLB  OUT, N
  SRW  OUT, N      RRW  OUT, N
  SLW  OUT, N      RLW  OUT, N
  SRD  OUT, N      RRD  OUT, N
  SLD  OUT, N      RLD  OUT, N
```

If the shift count is 0, a rotate operation is not performed. If the rotate operation is performed, the value of the last bit rotated is copied to the overflow bit (SM1.1).

If the shift count is not an integer multiple of 8 (for byte operations), 16 (for word operations), or 32 (for double-word operations), the last bit rotated out is copied to the overflow memory bit (SM1.1). The zero memory bit (SM1.0) is set when the value to be rotated is zero.

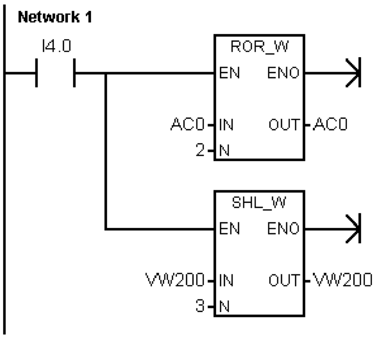
Byte operations are unsigned. For word and double word operations, the sign bit is shifted when you use signed data types.

Error conditions that set ENO = 0	SM bits affected:
■ 0006 (indirect address)	■ SM1.0 (zero) ■ SM1.1 (overflow)

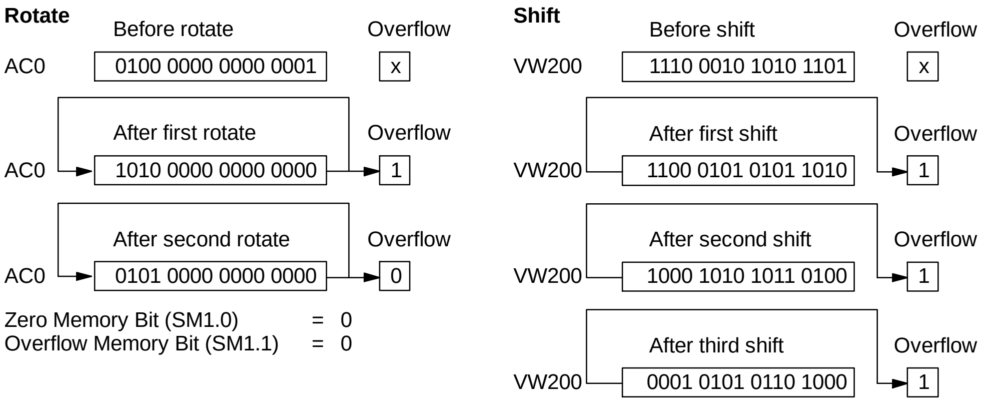
Table 6-61 Valid Operands for the Shift and Rotate Instructions

Inputs/Outputs	Data Types	Operands
IN	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC, Constant
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC
	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *LD, *AC
	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *LD, *AC
N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant

Example: Shift and Rotate Instructions



```
Network 1
LD      I4.0
RRW     AC0, 2
SLW     VW200, 3
```



Rotate

		Overflow
AC0	Before rotate: 0100 0000 0000 0001	x
AC0	After first rotate: 1010 0000 0000 0000	1
AC0	After second rotate: 0101 0000 0000 0000	0

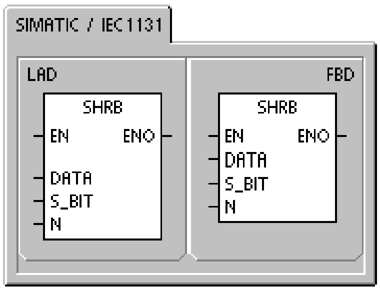
Zero Memory Bit (SM1.0) = 0
Overflow Memory Bit (SM1.1) = 0

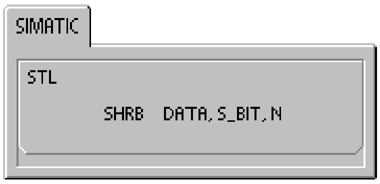
Shift

		Overflow
VW200	Before shift: 1110 0010 1010 1101	x
VW200	After first shift: 1100 0101 0101 1010	1
VW200	After second shift: 1000 1010 1011 0100	1
VW200	After third shift: 0001 0101 0110 1000	1

Zero Memory Bit (SM1.0) = 0
Overflow Memory Bit (SM1.1) = 1

Shift Register Bit Instruction





```
SHRB   DATA, S_BIT, N
```

The Shift Register Bit instruction shifts a value into the Shift Register. This instruction provides an easy method for sequencing and controlling product flow or data. Use this instruction to shift the entire register one bit, once per scan.

The Shift Register Bit instruction shifts the value of DATA into the Shift Register. S_BIT specifies the least significant bit of the Shift Register. N specifies the length of the Shift Register and the direction of the shift (Shift Plus = N, Shift Minus = –N).

Each bit shifted out by the SHRB instruction is placed in the overflow memory bit (SM1.1).

This instruction is defined by both the least significant bit (S_BIT) and the number of bits specified by the length (N).

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)
- 0092 (error in count field)

SM bits affected:

- SM1.1 (overflow)

Table 6-62 Valid Operands for the Shift Register Bit Instruction

Inputs/Outputs	Data Types	Operands
DATA, S_Bit	BOOL	I, Q, V, M, SM, S, T, C, L
N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant

Use the following equation to compute the address of the most significant bit of the Shift Register (MSB.b):

MSB.b = *[(Byte of S_BIT) + ([N] – 1 + (bit of S_BIT)) / 8].[remainder of the division by 8]*

For example: if S_BIT is V33.4 and N is 14, the following calculation shows that the MSB.b is V35.1.

```
MSB.b        = V33 + ([14] – 1 +4)/8
             = V33 + 17/8
             = V33 + 2 with a remainder of 1
             = V35.1
```

On a Shift Minus, indicated by a negative value of length (N), the input data shifts into the most significant bit of the Shift Register, and shifts out of the least significant bit (S_BIT). The data shifted out is then placed in the overflow memory bit (SM1.1).

On a Shift Plus, indicated by a positive value of length (N), the input data (DATA) shifts into the least significant bit of the Shift Register, specified by the S_BIT, and out of the most significant bit of the Shift Register. The data shifted out is then placed in the overflow memory bit (SM1.1).

The maximum length of the shift register is 64 bits, positive or negative. Figure 6-35 shows bit shifting for negative and positive values of N.

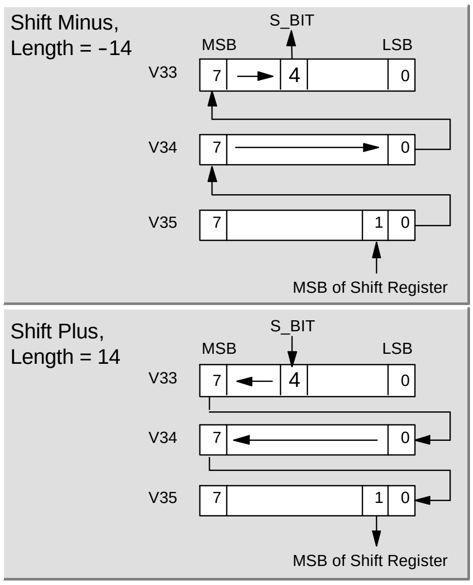
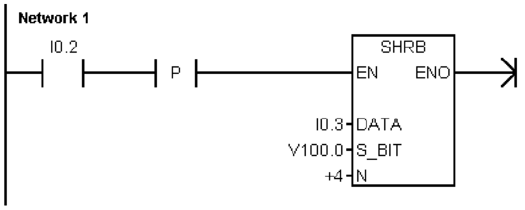


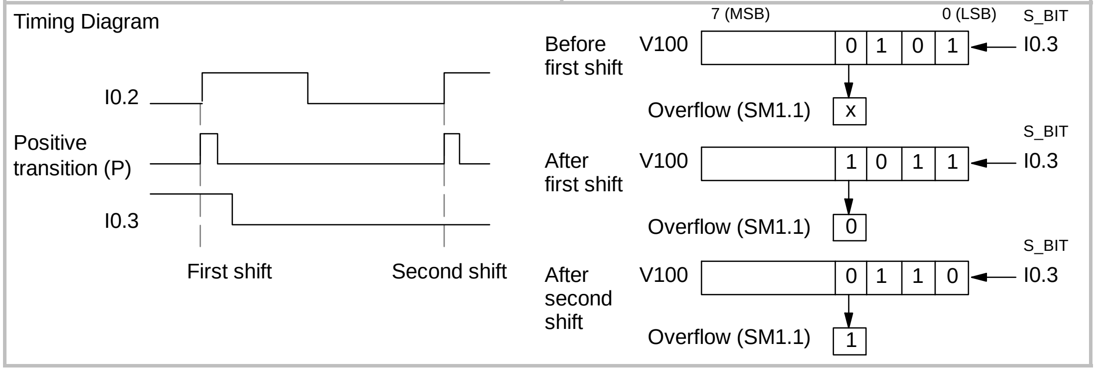
Figure 6-35 Shift Register Entry and Exit

Example: Shift Register Bit Instruction



```
Network 1
LD      I0.2
EU
SHRB    I0.3, V100.0, +4
```

Timing Diagram

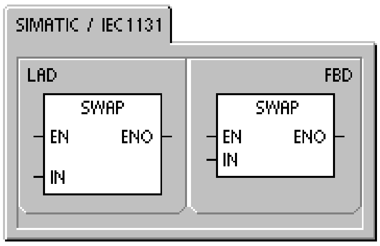


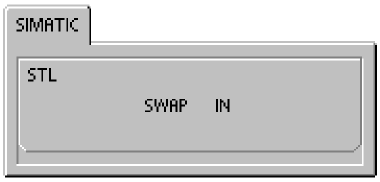
Swap Bytes Instruction

The Swap Bytes instruction exchanges the most significant byte with the least significant byte of the word IN.

Error conditions that set ENO = 0

- 0006 (indirect address)

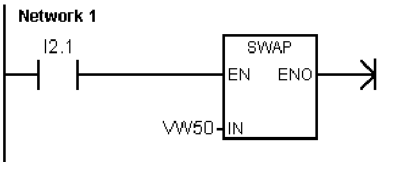




```
SWAP    IN
```

Table 6-63 Valid Operands for the Swap Bytes Instruction

Inputs/Outputs	Data Types	Operands
IN	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW,AC, *VD, *LD, *AC

Example: Swap Instructions	
	Network 1 LD I2.1 SWAP VW50
Swap VW50 D6 C3 → VW50 C3 D6	

String Instructions

String Length

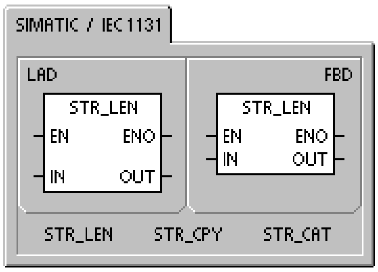
The String Length instruction (SLEN) returns the length of the string specified by IN.

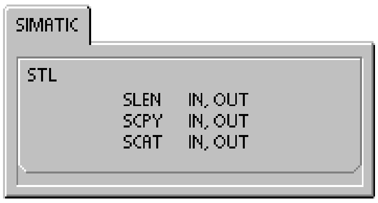
Copy String

The Copy String instruction (SCPY) copies the string specified by IN to the string specified by OUT.

Concatenate String

The Concatenate String instruction (SCAT) appends the string specified by IN to the end of the string specified by OUT.





```
SLEN   IN, OUT
SCPY   IN, OUT
SCAT   IN, OUT
```

SM Bits and ENO

For the String Length, Copy String, and Concatenate String instructions, the following conditions affect ENO.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (range error)

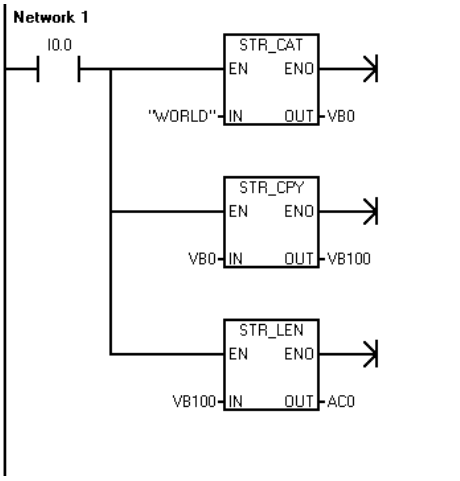
Table 6-64 Valid Operands for the String Length Instruction

Inputs/Outputs	Data Types	Operands
IN	STRING	VB, LB, *VD, *LD, *AC, Constant String
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC

Table 6-65 Valid Operands for the Copy String and Concatenate String Instructions

Inputs/Outputs	Data Types	Operands
IN	STRING	VB, LB, *VD, *LD, *AC , Constant String
OUT	STRING	VB, LB, *VD, *AC, *LD

Example: Concatenate String, Copy String, and String Length Instructions



```
Network 1       //1.  Append the string at "WORLD"
                //    to the string at VB0
                //2.  Copy the string at VB0
                //    to a new string at VB100
                //3.  Get the length of the string
                //    that starts at VB100

LD          I0.0
SCAT        "WORLD", VB0
STRCPY  VB0, VB100
STRLEN  VB100, AC0
```

Before executing the program

VB0						VB6
6	’H’	’E’	’L’	’L’	’O’	’ ’

After executing the program

VB0											VB11
11	’H’	’E’	’L’	’L’	’O’	’ ’	’W’	’O’	’R’	’L’	’D’

VB100											VB111
11	’H’	’E’	’L’	’L’	’O’	’ ’	’W’	’O’	’R’	’L’	’D’

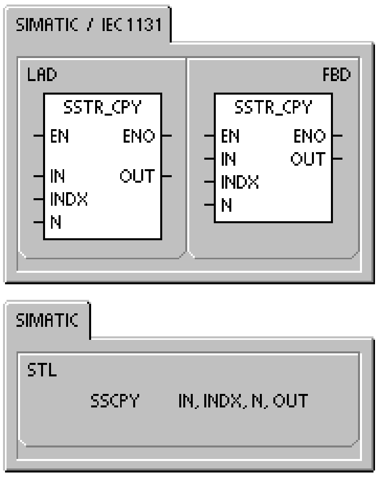
AC0
11

Copy Substring from String

The Copy Substring from String instruction (SSCPY) copies the specified number of characters N from the string specified by IN, starting at the index INDX, to a new string specified by OUT.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (range error)
- 009B (index=0)

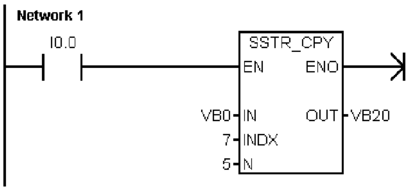


```
SSCPY     IN, INDX, N, OUT
```

Table 6-66 Valid Operands for the Copy Substring from String Instructions

Inputs/Outputs	Data Types	Operands
IN	STRING	VB, LB, *VD, *LD, *AC, Constant String
OUT	STRING	VB, LB, *VD, *LD, *AC
INDX, N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant

Example: Copy Substring Instruction

 Network 1
I0.0
SSTR_CPY
EN
ENO
VB0
IN
OUT
VB20
7
INDX
5
N
	Network 1 //Starting at the seventh character in
	//the string at VB0, copy 5 characters
	//to a new string at VB20
	LD I0.0
	SSCPY VB0, 7, 5, VB20

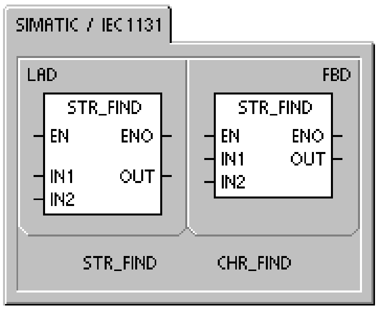
Before executing the program

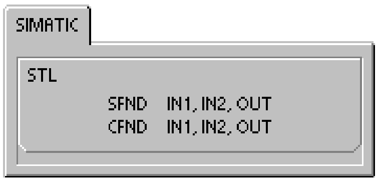
VB0											VB11
11	'H'	'E'	'L'	'L'	'O'	' '	'W'	'O'	'R'	'L'	'D'

After executing the program

VB20					VB25
5	'W'	'O'	'R'	'L'	'D'

Find String Within String





```
SFND   IN1, IN2, OUT
CFND   IN1, IN2, OUT
```

The Find String Within String instruction (SFND) searches for the first occurrence of the string IN2 within the string IN1. The search begins at the starting position specified by OUT (which must be in range 1 through the string length). If a sequence of characters is found that matches exactly the string IN2, the position of the first character in the sequence for the string is written to OUT. If the string IN2 was not found in the string IN1, the instruction OUT is set to 0.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (range error)
- 009B (index=0)

Find First Character Within String

The Find First Character Within String instruction (CFND) searches the string IN1 for the first occurrence of any character from the character set described in the string IN2. The search begins at starting position OUT (which must be in range 1 through the string length). If a matching character is found, the position of the character is written to OUT. If no matching character is found, OUT is set to 0.

Error conditions that set ENO = 0

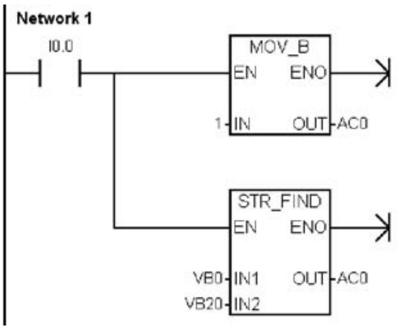
- 0006 (indirect address)
- 0091 (range error)
- 009B (index=0)

Table 6-67 Valid Operands for Find String Within String and Find First Character Within String Instructions

Inputs/Outputs	Data Types	Operands
IN1, IN2	STRING	VB, LB, *VD, *LD, *AC, Constant String
OUT	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC

Example: Find String Within String Instruction

The following example uses a string stored at VB0 as a command for turning a pump on or off. A string ’On’ is stored at VB20, and a string ’Off’ is stored at VB30. The result of the Find String Within String instruction is stored in AC0 (the OUT parameter). If the result is not 0, then the string ’On’ was found in the command string (VB12).



```
Network 1       //1.  Set AC0 to 1.
                //    (AC0 is used as the OUT parameter.)
                //2.  Search the string at VB0 for the string
                //    at VB20 (’On’), starting at the first
                //    position (AC0=1).
LD        I0.0
MOVB     1, AC0
SFND     VB0, VB20, AC0
```

VB0												VB12
12	’T’	’u’	’r’	’n’	’ ’	’P’	’u’	’m’	’p’	’ ’	’O’	’n’

VB20		VB22
2	’O’	’n’

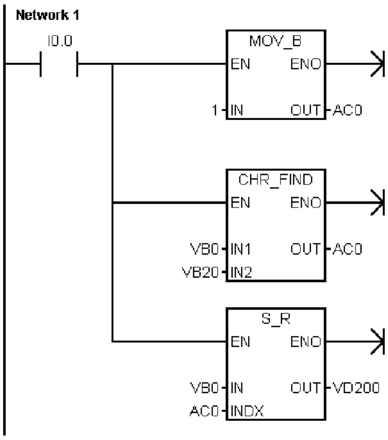
VB30			VB33
3	’O’	’f’	’f’

If the string in VB20 is found: AC0 11

If the string in VB20 is not found: AC0 0

Example: Find Character Within String Instruction

In the following example, a string stored at VB0 contains the temperature. The string at VB20 stores all the numeric characters (and the + and -) that can identify a temperature in a string. The sample program finds the starting position for a number in that string and then converts the numeric characters into a real number. VD200 stores the real-number value of the temperature.



```
Network 1       //1.  Set AC0 to 1.
                //    (AC0 is used as the OUT parameter
                //    and points to the first position of the string.)
                //2.  Find the numeric character
                //    in the string at VB0.
                //3.  Convert the string to a real number.
LD        I0.0
MOVB     1, AC0
CFND     VB0, VB20, AC0
STR      VB0, AC0, VD200
```

VB0											VB11
11	’T’	’e’	’m’	’p’	’ ’	’ ’	’9’	’8’	’.’	’6’	’F’

VB20												VB32
12	’1’	’2’	’3’	’4’	’5’	’6’	’7’	’8’	’9’	’0’	’+’	’-’

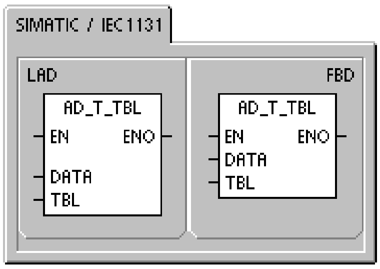
Starting position of the temperature stored in VB0: AC0

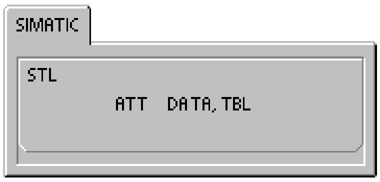
7

Real-number value of the temperature: VD200 98.6

Table Instructions

Add To Table





```
STL
        ATT  DATA, TBL
```

The Add To Table instruction adds word values (DATA) to a table (TBL). The first value of the table is the maximum table length (TL). The second value is the entry count (EC), which specifies the number of entries in the table. New data are added to the table after the last entry. Each time new data are added to the table, the entry count is incremented.

A table can have up to 100 data entries.

Error conditions that set ENO = 0

- SM1.4 (table overflow)
- 0006 (indirect address)
- 0091 (operand out of range)

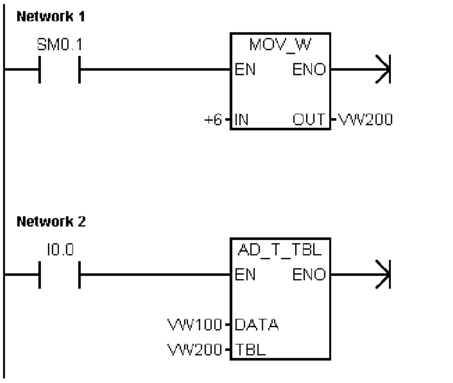
SM bits affected:

- SM1.4 is set to 1 if you try to overfill the table

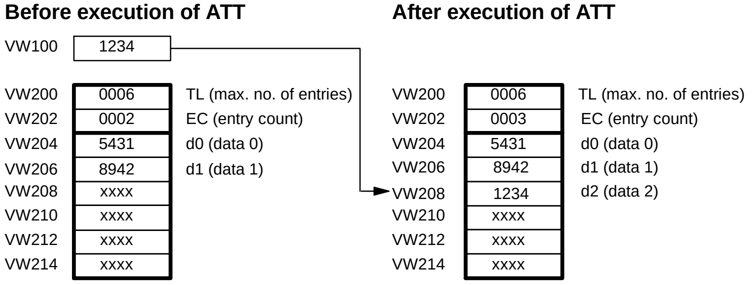
Table 6-68 Valid Operands for the Table Instructions

Inputs/Outputs	Data Types	Operands
DATA	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
TBL	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, *VD, *LD, *AC

Example: Add to Table Instruction



```
Network 1     //Load maximum table length
LD        SM0.1
MOVW      +6, VW200

Network 2
LD        I0.0
ATT       VW100, VW200
```



Before execution of ATT

VW100	1234	
VW200	0006	TL (max. no. of entries)
VW202	0002	EC (entry count)
VW204	5431	d0 (data 0)
VW206	8942	d1 (data 1)
VW208	xxxx	
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

After execution of ATT

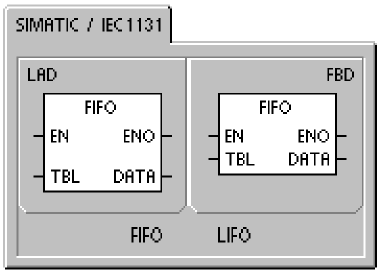
VW200	0006	TL (max. no. of entries)
VW202	0003	EC (entry count)
VW204	5431	d0 (data 0)
VW206	8942	d1 (data 1)
VW208	1234	d2 (data 2)
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

First-In-First-Out and Last-In-First-Out

A table can have up to 100 data entries.

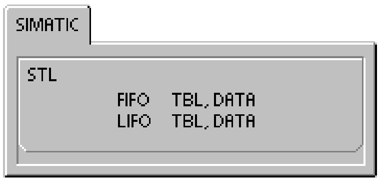
First-In-First-Out

The First-In-First-Out instruction (FIFO) moves the oldest (or first) entry in a table to the output memory address by removing the first entry in the table (TBL) and moving the value to the location specified by DATA. All other entries of the table are shifted up one location. The entry count in the table is decremented for each instruction execution.



Last-In-First-Out

The Last-In-First-Out instruction (LIFO) moves the newest (or last) entry in the table to the output memory address by removing the last entry in the table (TBL) and moving the value to the location specified by DATA. The entry count in the table is decremented for each instruction execution.


SIMATIC

STL

```
FIFO   TBL, DATA
LIFO   TBL, DATA
```

Error conditions that set ENO = 0

- SM1.5 (empty table)
- 0006 (indirect address)
- 0091 (operand out of range)

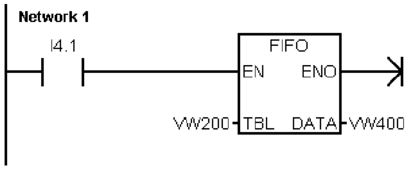
SM bits affected:

- SM1.5 is set to 1 if you try to remove an entry from an empty table

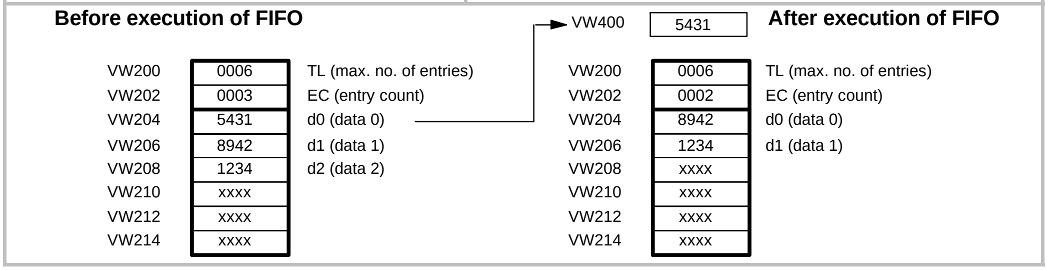
Table 6-69 Valid Operands for the First-In-First-Out and Last-In-First-Out Instructions

Inputs/Outputs	Data Types	Operands
TBL	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, *VD, *LD, *AC
DATA	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AQW, *VD, *LD, *AC

Example: First-In-First-Out Instruction



```
Network 1
LD       I4.1
FIFO     VW200, VW400
```



Before execution of FIFO

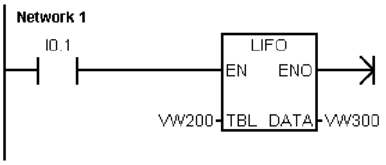
VW200	0006	TL (max. no. of entries)
VW202	0003	EC (entry count)
VW204	5431	d0 (data 0)
VW206	8942	d1 (data 1)
VW208	1234	d2 (data 2)
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

VW400	5431

After execution of FIFO

VW200	0006	TL (max. no. of entries)
VW202	0002	EC (entry count)
VW204	8942	d0 (data 0)
VW206	1234	d1 (data 1)
VW208	xxxx	
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

Example: Last-In-First-Out Instruction



```
Network 1
LD      I0.1
LIFO    VW200, VW300
```

Before execution of LIFO

VW200	0006	TL (max. no. of entries)
VW202	0003	EC (entry count)
VW204	5431	d0 (data 0)
VW206	8942	d1 (data 1)
VW208	1234	d2 (data 2)
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

VW300 1234

After execution of LIFO

VW200	0006	TL (max. no. of entries)
VW202	0002	EC (entry count)
VW204	5431	d0 (data 0)
VW206	8942	d1 (data 1)
VW208	xxxx	
VW210	xxxx	
VW212	xxxx	
VW214	xxxx	

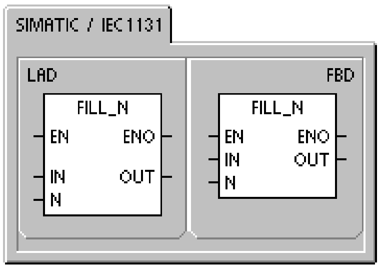
Memory Fill

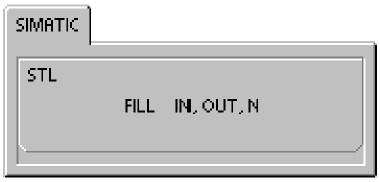
The Memory Fill instruction (FILL) writes N consecutive words, beginning at address OUT, with the word value contained in address IN.

N has a range of 1 to 255.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)



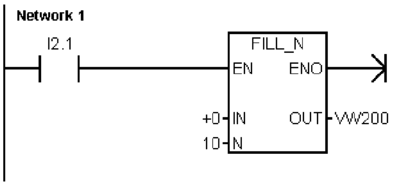


```
FILL   IN, OUT, N
```

Table 6-70 Valid Operands for the Memory Fill Instruction

Inputs/Outputs	Data Types	Operands
IN	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
N	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *LD, *AC, Constant
OUT	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AQW, *VD, *LD, *AC

Example: Memory Fill Instruction



```
Network 1
LD      I2.1
FILL    +0, VW200, 10
```

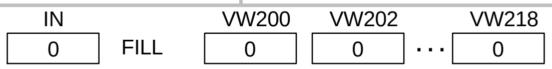
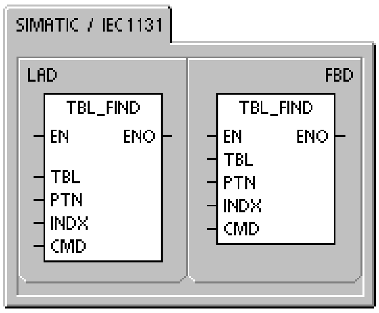
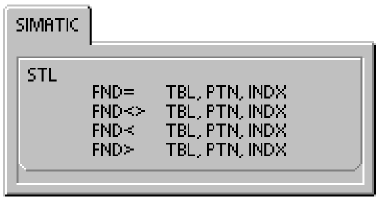


Table Find





```
FND=    TBL, PTN, INDX
FND<>   TBL, PTN, INDX
FND<    TBL, PTN, INDX
FND>    TBL, PTN, INDX
```

The Table Find instruction (FND) searches a table for data that matches certain criteria. The Table Find instruction searches the table TBL, starting with the table entry INDX, for the data value or pattern PTN that matches the search criteria defined by CMD. The command parameter CMD is given a numeric value of 1 to 4 that corresponds to =, <>, <, and >, respectively.

If a match is found, the INDX points to the matching entry in the table. To find the next matching entry, the INDX must be incremented before invoking the Table Find instruction again. If a match is not found, the INDX has a value equal to the entry count.

A table can have up to 100 data entries. The data entries (area to be searched) are numbered from 0 to a maximum value of 99.

Error conditions that set ENO = 0

- 0006 (indirect address)
- 0091 (operand out of range)

Table 6-71 Valid Operands for the Table Find Instruction

Inputs/Outputs	Data Types	Operands
TBL	WORD	IW, QW, VW, MW, SMW, T, C, LW, *VD, *LD, *AC
PTN	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant
INDX	WORD	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, *VD, *LD, *AC
CMD	BYTE	(Constant) 1: Equal (=), 2: Not Equal (<>), 3: Less Than (<), 4: Greater Than (>)

Tip

When you use the Table Find instruction with tables generated with the Add to Table, Last-In-First-Out, and First-In-First-Out instructions, the entry count and the data entries correspond directly. The maximum-number-of-entries word required for the Add to Table, Last-In-First-Out, or First-In-First-Out instructions is not required by the Table Find instruction. See Figure 6-36.

Consequently, you should set the TBL operand of a Find instruction to one-word address (two bytes) higher than the TBL operand of a corresponding the Add to Table, Last-In-First-Out, or First-In-First-Out instruction.

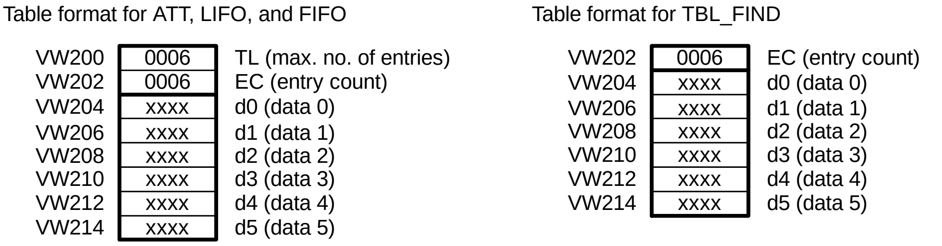


Table format for ATT, LIFO, and FIFO

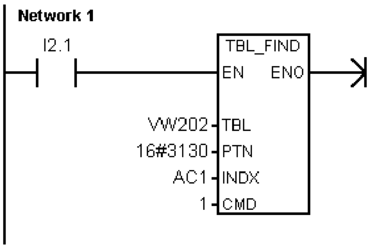
VW200	0006	TL (max. no. of entries)
VW202	0006	EC (entry count)
VW204	xxxx	d0 (data 0)
VW206	xxxx	d1 (data 1)
VW208	xxxx	d2 (data 2)
VW210	xxxx	d3 (data 3)
VW212	xxxx	d4 (data 4)
VW214	xxxx	d5 (data 5)

Table format for TBL_FIND

VW202	0006	EC (entry count)
VW204	xxxx	d0 (data 0)
VW206	xxxx	d1 (data 1)
VW208	xxxx	d2 (data 2)
VW210	xxxx	d3 (data 3)
VW212	xxxx	d4 (data 4)
VW214	xxxx	d5 (data 5)

Figure 6-36 Different Table Formats between the Table Find Instruction and the ATT, LIFO, and FIFO Instructions

Example: Table Find Instruction



```
Network 1
LD          I2.1
FND=        VW202, 16#3130, AC1
```

When I2.1 is on, search the table for a value equal to 3130 HEX.

VW202	0006	EC (entry count)
VW204	3133	d0 (data 0)
VW206	4142	d1 (data 1)
VW208	3130	d2 (data 2)
VW210	3030	d3 (data 3)
VW212	3130	d4 (data 4)
VW214	4541	d5 (data 5)

If the table was created using ATT, LIFO, and FIFO instructions, VW200 contains the maximum number of allowed entries and is not required by the Find instructions.

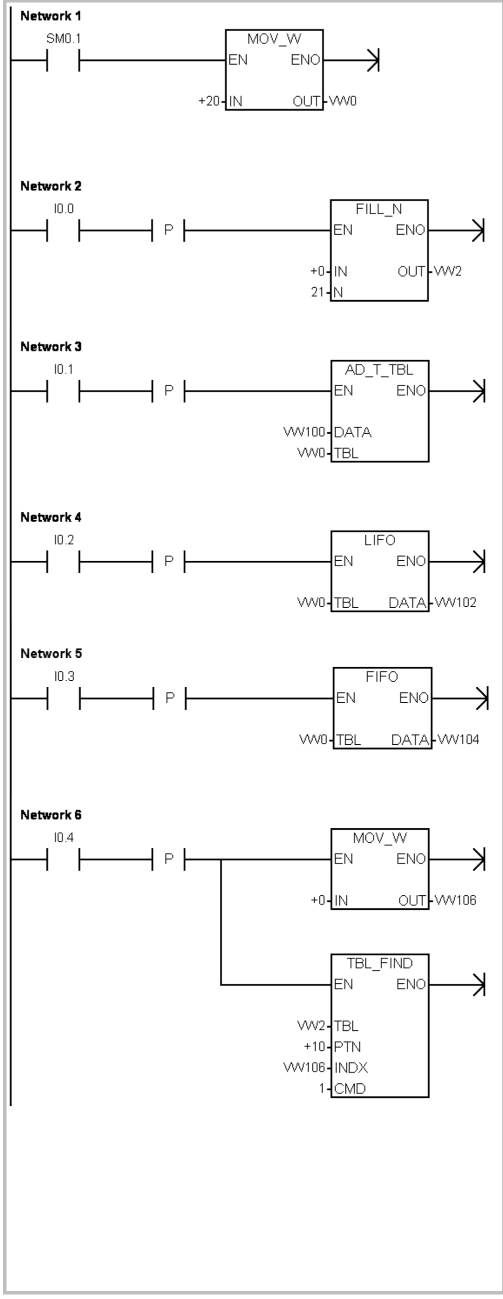
AC1	0	AC1 must be set to 0 to search from the top of table.
Execute table search		
AC1	2	AC1 contains the data entry number corresponding to the first match found in the table (d2).
AC1	3	Increment the INDX by one, before searching the remaining entries of the table.
Execute table search		
AC1	4	AC1 contains the data entry number corresponding to the second match found in the table (d4).
AC1	5	Increment the INDX by one, before searching the remaining entries of the table.
Execute table search		
AC1	6	AC1 contains a value equal to the entry count. The entire table has been searched without finding another match.
AC1	0	Before the table can be searched again, the INDX value must be reset to 0.

Example: Creating a Table

The following program creates a table with 20 entries. The first memory location of the table contains the length of the table (in this case 20 entries). The second memory location shows the current number of table entries. The other locations contain the entries. A table can have up to 100 entries. It does not include the parameters defining the maximum length of the table or the actual number of entries (here VW0 and VW2). The actual number of entries in the table (here VW2) is automatically incremented or decremented by the CPU with every command.

Before you work with a table, assign the maximum number of table entries. Otherwise, you cannot make entries in the table. Also, be sure that all read and write commands are activated with edges.

To search the table, the index (VW106) must set to 0 before doing the find. If a match is found, the index will have the table entry number, but if no match is found, the index will match the current entry count for the table (VW2).



```
Network 1      //Create table with 20 entries starting
               //with memory location 4.
               //1.  On the first scan, define the
               //maximum length of the table.
LD             SM0.1
MOVW           +20, VW0
Network 2      //Reset table with input I0.0
               //On the rising edge of I0.0, fill
               //memory locations from VW2 with ”+0” .
LD       I0.0
EU
FILL     +0, VW2, 21
Network 3      //Write value to table with input I0.1
               //On the rising edge of I0.1, copy
               //value of memory location
               //VW100 to table.
LD       I0.1
EU
ATT      VW100, VW0
Network 4      //Read first table value with
               //input I0.2.  Move the last table
               //value to location VW102.
               //This reduces the number of entries.
               //On the rising edge of I0.2,
               //Move last table value to VW102
LD       I0.2
EU
LIFO     VW0, VW102
Network 5      //Read last table value with
               //input I0.3.  Move the first table
               //value to location VW102.
               //This reduces the number of entries.
               //On the rising edge of I0.0,
               //Move first table value to VW104
LD       I0.3
EU
FIFO     VW0, VW104
Network 6      //Search table for the first location
               //that has a value of 10.
               //1.  On the rising edge of I0.4,
               //    reset index pointer.
               //2.  Find a table entry that equals 10.
LD       I0.4
EU
MOVW     +0, VW106
FND=     VW2, +10, VW106
```

Timer Instructions

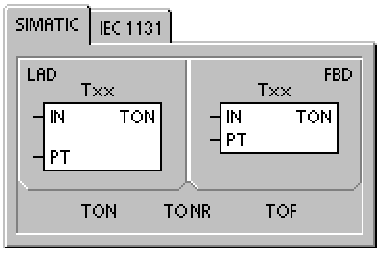
SIMATIC Timer Instructions

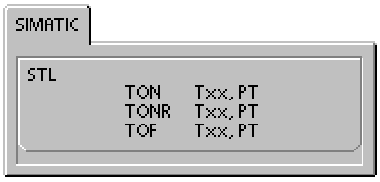
On-Delay Timer
Retentive On-Delay Timer

The On-Delay Timer (TON) and Retentive On-Delay Timer (TONR) instructions count time when the enabling input is on. The timer number (Txx) determines the resolution of the timer, and the resolution is now shown in the instruction box.

Off-Delay Timer

The Off-Delay Timer (TOF) is used to delay turning an output off for a fixed period of time after the input turns off. The timer number (Txx) determines the resolution of the timer, and the resolution is now shown in the instruction box.





```
STL
        TON    Txx, PT
        TONR   Txx, PT
        TOF    Txx, PT
```

Table 6-72 Valid Operands for the SIMATIC Timer Instructions

Inputs/Outputs	Data Types	Operands
Txx	WORD	Constant (T0 to T255)
IN	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
PT	INT	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *LD, *AC, Constant

Tip

You cannot share the same timer number (Txx) for an off-delay timer (TOF) and an on-delay timer (TON). For example, you cannot have both a TON T32 and a TOF T32.

As shown in Table 6-73, the three types of timers perform different types of timing tasks:

- You can use a TON for timing a single interval.
- You can use a TONR for accumulating a number of timed intervals.
- You can use a TOF for extending time past an off (or false) condition, such as for cooling a motor after it is turned off.

Table 6-73 Operations of the Timer Instructions

Type	Current >= Preset	State of the Enabling Input (IN)	Power Cycle/First Scan
TON	Timer bit on Current continues counting to 32,767	ON: Current value counts time OFF: Timer bit off, current value = 0	Timer bit off Current value = 0
TONR	Timer bit on Current continues counting to 32,767	ON: Current value counts time OFF: Timer bit and current value maintain last state	Timer bit off Current value can be maintained[1]
TOF	Timer bit off Current = Preset, stops counting	ON: Timer bit on, current value = 0 OFF: Timer counts after on-to-off transition	Timer bit off Current value = 0

[1] The retentive timer current value can be selected for retention through a power cycle. See Chapter 4 for information about memory retention for the S7-200 CPU.

Programming Tips

Refer to the Programming Tips on the documentation CD for a sample program that uses the on-delay timer (TON). See Tip 31

The TON and TONR instructions count time when the enabling input is on. When the current value is equal to or greater than the preset time, the timer bit is on.

❑ The current value of a TON timer is cleared when the enabling input is off, whereas the current value of the TONR timer is maintained when the input is off.

❑ You can use the TONR timer to accumulate time when the input turns on and off. Use the Reset instruction (R) to clear the current value of the TONR.

❑ Both the TON and the TONR timers continue counting after the preset is reached, and they stop counting at the maximum value of 32,767.

The TOF instruction is used to delay turning an output off for a fixed period of time after the input turns off. When the enabling input turns on, the timer bit turns on immediately, and the current value is set to 0. When the input turns off, the timer counts until the elapsed time reaches the preset time.

❑ When the preset is reached, the timer bit turns off and the current value stops incrementing; however, if the input turns on again before the TOF reaches the preset value, the timer bit remains on.

❑ The enabling input must make an on-to-off transition for the TOF to begin counting time intervals.

❑ If the TOF timer is inside an SCR region and the SCR region is inactive, then the current value is set to 0, the timer bit is turned off, and the current value does not increment.

Tip

You can reset a TONR only by using the Reset (R) instruction. You can also use the Reset instruction to reset any TON or TOF. The Reset instruction performs the following operations:

■ Timer Bit = off

■ Timer Current = 0

After a reset, TOF timers require the enabling input to make the transition from on to off in order for the timer to restart.

Determining the Resolution of the Timer

Timers count time intervals. The resolution (or time base) of the timer determines the amount of time in each interval. For example, a TON with a resolution of 10 ms counts the number of 10-ms intervals that elapse after the TON is enabled: a count of 50 on a 10-ms timer represents 500 ms. The SIMATIC timers are available in three resolutions: 1 ms, 10 ms, and 100 ms. As shown in Table 6-74, the timer number determines the resolution of the timer.

Tip

To guarantee a minimum time interval, increase the preset value (PV) by 1. For example: To ensure a minimum timed interval of at least 2100 ms for a 100-ms timer, set the PV to 22.

Table 6-74 Timer Numbers and Resolutions

Timer Type	Resolution	Maximum Value	Timer Number
TONR (retentive)	1 ms	32.767 s (0.546 min.)	T0, T64
	10 ms	327.67 s (5.46 min.)	T1 to T4, T65 to T68
	100 ms	3276.7 s (54.6 min.)	T5 to T31, T69 to T95
TON, TOF (non-retentive)	1 ms	32.767 s (0.546 min.)	T32, T96
	10 ms	327.67 s (5.46 min.)	T33 to T36, T97 to T100
	100 ms	3276.7 s (54.6 min.)	T37 to T63, T101 to T255

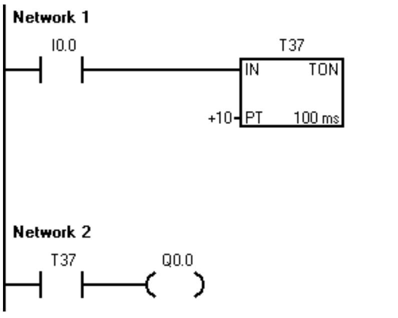
Understanding How Resolution Affects the Timer Action

For a timer with a resolution of 1 ms, the timer bit and the current value are updated asynchronous to the scan cycle. For scans greater than 1 ms, the timer bit and the current value are updated multiple times throughout the scan.

For a timer with a resolution of 10 ms, the timer bit and the current value are updated at the beginning of each scan cycle. The timer bit and current value remain constant throughout the scan, and the time intervals that accumulate during the scan are added to the current value at the start of each scan.

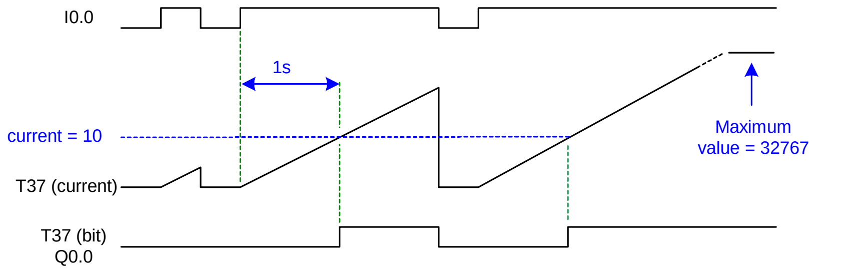
For a timer with a resolution of 100 ms, the timer bit and current value are updated when the instruction is executed; therefore, ensure that your program executes the instruction for a 100-ms timer only once per scan cycle in order for the timer to maintain the correct timing.

Example: SIMATIC On-Delay Timer



```
Network 1     //100 ms timer T37 times out after
              //(10 x 100 ms = 1s)
              //I0.0 ON=T37 enabled,
              //I0.0 OFF=disable and reset T37
LD       I0.0
TON      T37, +10

Network 2     //T37 bit is controlled by timer T37
LD       T37
=        Q0.0
```

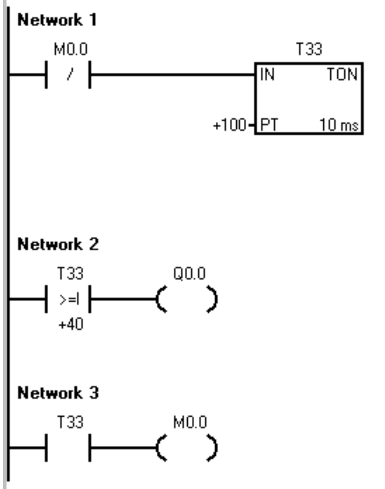
Timing Diagram



Tip

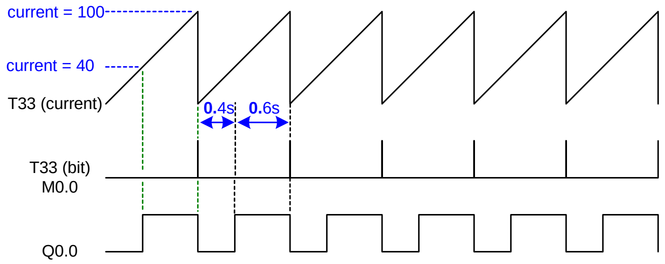
To guarantee that the output of a self-resetting timer is turned on for one scan each time the timer reaches the preset value, use a normally closed contact instead of the timer bit as the enabling input to the timer.

Example: SIMATIC Self-Resetting On-Delay Timer

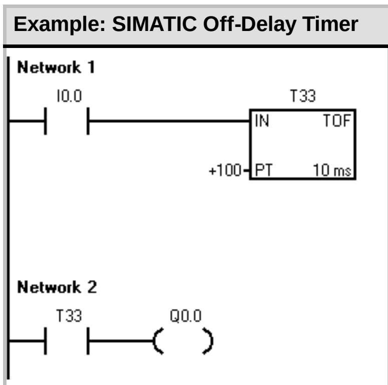


```
Network 1     //10 ms timer T33 times out after
              //(100 x 10 ms = 1s)
              //M0.0 pulse is too fast to monitor
              //with Status view
LDN     M0.0
TON     T33, +100
Network 2     //Comparison becomes true at a
              //rate that is visible with Status view.
              //Turn on Q0.0 after (40 x 10 ms)
              //for a 40% OFF/60% ON waveform
LDW>=   T33, +40
=       Q0.0
Network 3     //T33 (bit) pulse too fast to monitor
              //with Status view
              //Reset the timer through M0.0 after
              //the (100 x 10 ms)  period
LD      T33
=       M0.0
```

Timing Diagram

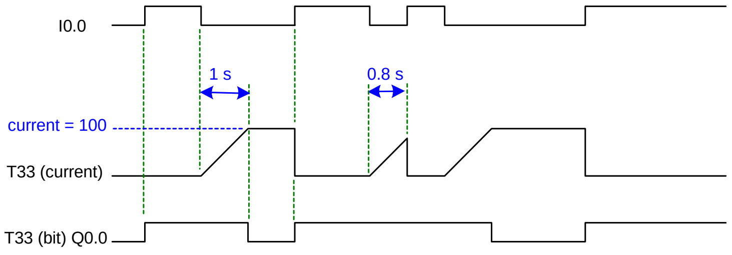


Example: SIMATIC Off-Delay Timer

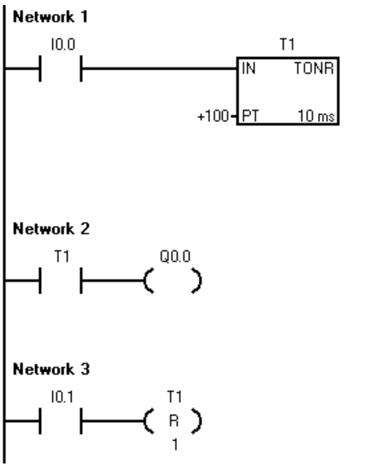


```
Network 1     //10-ms timer T33 times out after (100 x 10 ms = 1s)
              //I0.0 ON-to-OFF=T33 enabled
              //I0.0 OFF-to-ON=disable and reset T33
LD      I0.0
TOF     T33, +100

Network 2      //Timer T33 controls Q0.0 through timer contact T33
LD       T33
=       Q0.0
```

Timing Diagram

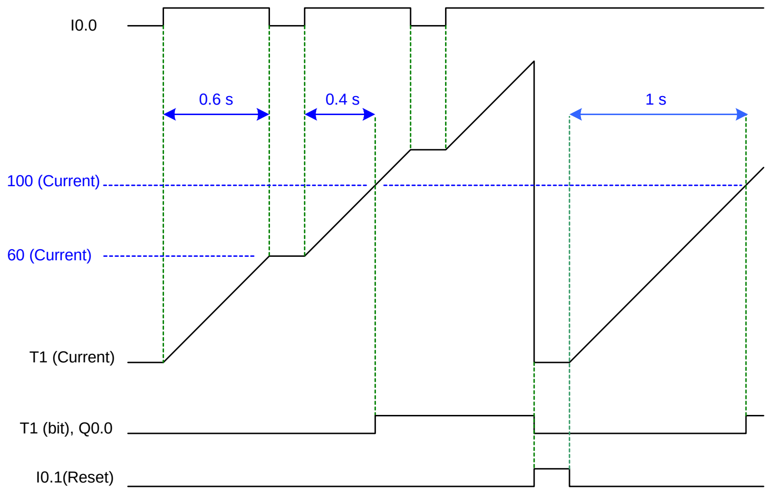


Example: SIMATIC Retentive On-Delay Timer

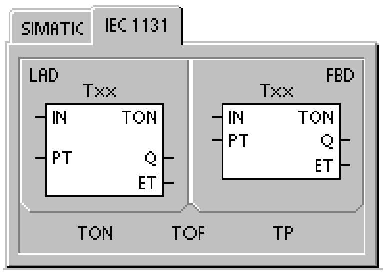


```
Network 1        //10 ms TONR timer T1 times out at
                 //PT=(100 x 10 ms=1s)
LD      I0.0
TONR    T1, +100

Network 2        //T1 bit is controlled by timer T1.
                 //Turns Q0.0 on after the timer accumulates a total
                 //of 1 second
LD      T1
=       Q0.0

Network 3        //TONR timers must be reset by a Reset instruction
                 //with a T address.
                 //Resets timer T1 (current and bit) when I0.1 is on.
LD      I0.1
R       T1, 1
```

Timing Diagram



IEC Timer Instructions



On-Delay Timer

The On-Delay Timer (TON) instruction counts time when the enabling input is on.

Off-Delay Timer

The Off-Delay Timer (TOF) delays turning an output off for a fixed period of time after the input turns off.

Pulse Timer

The Pulse Timer (TP) generates pulses for a specific duration.

Table 6-75 Valid Operands for the IEC Timer Instructions

Inputs/Outputs	Data Types	Operands
Txx	TON, TOF, TP	Constant (T32 to T63, T96 to T255)
IN	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
PT	INT	IW, QW, VW, MW, SMW, SW, LW, AC, AIW, *VD, *LD, *AC, Constant
Q	BOOL	I, Q, V, M, SM, S, L
ET	INT	IW, QW, VW, MW, SMW, SW, LW, AC, AQW, *VD, *LD, *AC

Tip
You cannot share the same timer numbers for TOF, TON, and TP. For example, you cannot have both a TON T32 and a TOF T32.

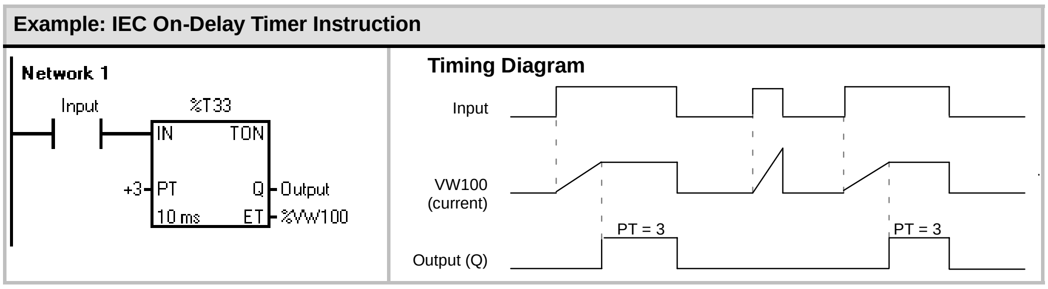
- ❑ The TON instruction counts time intervals up to the preset value when the enabling input (IN) becomes true. When the elapsed time (ET) is equal to the Preset Time (PT), the timer output bit (Q) turns on. The output bit resets when the enabling input turns off. When the preset is reached, timing stops and the timer is disabled.
- ❑ The TOF instruction delays setting an output to off for a fixed period of time after the input turns off. It times up to the preset value when the enabling input (IN) turns off. When the elapsed time (ET) is equal to the preset time (PT), the timer output bit (Q) turns off. When the preset is reached, the timer output bit turns off and the elapsed time is maintained until the enabling input makes the transition to on. If the enabling input sets the transition to off for a period of time shorter than the preset time, the output bit remains on.
- ❑ The TP instruction generates pulses for a specific duration. As the enabling input (IN) turns on, the output bit (Q) turns on. The output bit remains on for the pulse specified within the preset time (PT). When the elapsed time (ET) reaches preset (PT), the output bit turns off. The elapsed time is maintained until the enabling input turns off. When the output bit turns on, it remains on until the pulse time has elapsed.

Each count of the current value is a multiple of the time base. For example, a count of 50 on a 10-ms timer represents 500 ms. The IEC timers (TON, TOF, and TP) are available in three resolutions. The resolution is determined by the timer number, as shown in Table 6-76.

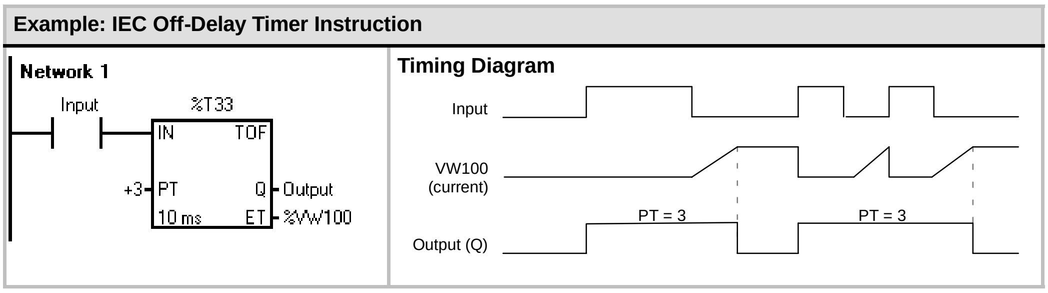
Table 6-76 Resolution of the IEC Timers

Resolution	Maximum Value	Timer Number
1 ms	32.767 s (0.546 minutes)	T32, T96
10 ms	327.67 s (5.46 minutes)	T33 to T36, T97 to T100
100 ms	3276.7 s (54.6 minutes)	T37 to T63, T101 to T255

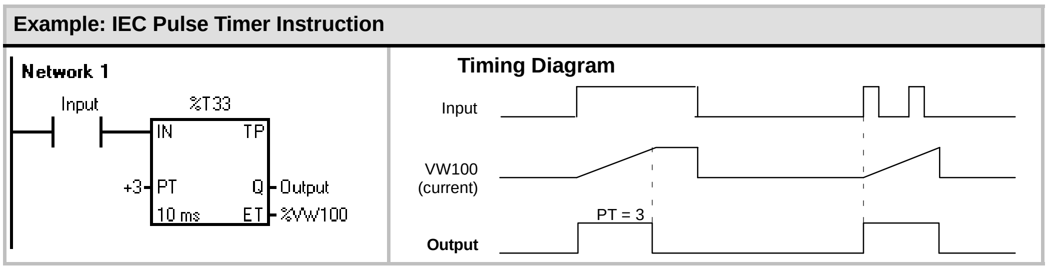
Example: IEC On-Delay Timer Instruction



Example: IEC Off-Delay Timer Instruction



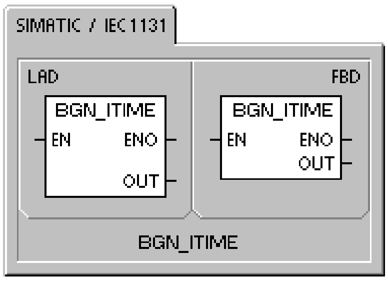
Example: IEC Pulse Timer Instruction

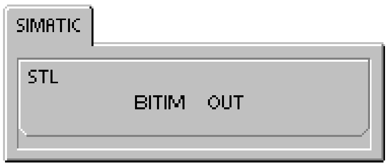


Interval Timers

Beginning Interval Time

The Beginning Interval Time (BITIM) instruction reads the current value of the built-in 1 millisecond counter and stores the value in OUT. The maximum timed interval for a DWORD millisecond value is 2 raised to the 32 power or 49.7 days.

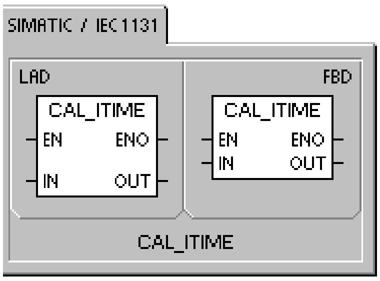


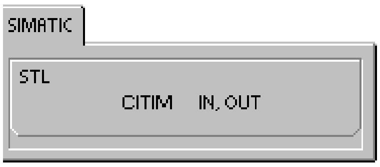


```
BITIM    OUT
```

Calculate Interval Time

The Calculate Interval Time (CITIM) instruction calculates the time difference between the current time and the time provided in IN. The difference is stored in OUT. The maximum timed interval for a DWORD millisecond value is 2 raised to the 32 power or 49.7 days. CITIM automatically handles the one millisecond timer rollover that occurs within the maximum interval, depending on when the BITIM instruction was executed.

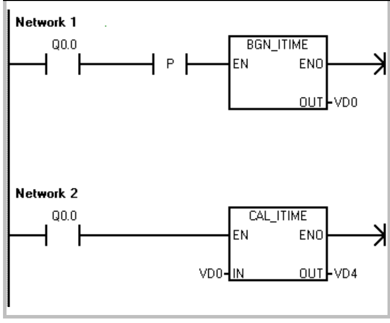




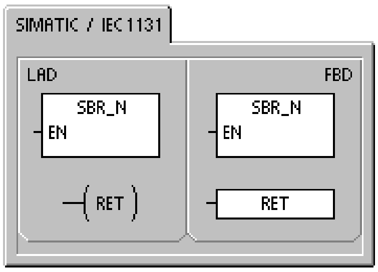
```
CITIM    IN, OUT
```

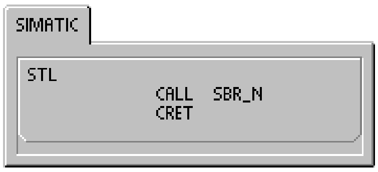
Table 6-77 Valid Operands for the Interval Timer Instructions

Inputs/Outputs	Data Types	Operands
IN	DWORD	VD, ID, QD, MD, SMD, SD, LD, HC, AC, *VD, *LD, *AC
OUT	DWORD	VD, ID, QD, MD, SMD, SD, LD, AC, *VD, *LD, *AC

Example: SIMATIC Beginning Interval Time and Calculate Interval Time	
 Network 1 Q0.0 P BGN_ITIME EN ENO OUT VD0 Network 2 Q0.0 CAL_ITIME EN ENO VD0 IN OUT VD4	Network 1 //Capture the time that Q0.0 turned on. LD Q0.0 EU BITIM VD0 Network 2 // Calculate time Q0.0 has been on. LD Q0.0 CITIM VD0, VD4

Subroutine Instructions





```
CALL  SBR_N
CRET
```

The Call Subroutine instruction (CALL) transfers control to the subroutine SBR_N. You can use a Call Subroutine instruction with or without parameters. After the subroutine completes its execution, control returns to the instruction that follows the Call Subroutine.

The Conditional Return from Subroutine instruction (CRET) terminates the subroutine based upon the preceding logic.

To add a subroutine, select the **Edit > Insert > Subroutine** menu command.

Error conditions that set ENO = 0

- 0008 (maximum subroutine nesting exceeded)
- 0006 (indirect address)

From the main program, you can nest subroutines (place a subroutine call within a subroutine) to a depth of eight. From an interrupt routine, you cannot nest subroutines.

A subroutine call cannot be placed in any subroutine called from an interrupt routine. Recursion (a subroutine that calls itself) is not prohibited, but you should use caution when using recursion with subroutines.

Table 6-78 Valid Operands for the Subroutine Instruction

Inputs/Outputs	Data Types	Operands
SBR_N	WORD	Constant *for CPU 221, CPU 222, CPU 224*: 0 to 63 *for CPU 224XP and CPU 226* 0 to 127
IN	BOOL	V, I, Q, M, SM, S, T, C, L, Power Flow
	BYTE	VB, IB, QB, MB, SMB, SB, LB, AC, *VD, *LD, *AC[1], constant
	WORD, INT	VW, T, C, IW, QW, MW, SMW, SW, LW, AC, AIW, *VD, *LD, *AC[1], constant
	DWORD, DINT	VD, ID, QD, MD, SMD, SD, LD, AC, HC, *VD, *LD, *AC[1], &VB, &IB, &QB, &MB, &T, &C, &SB, &AI, &AQ, &SMB, constant
	STRING	*VD, *LD, *AC, constant
IN/OUT	BOOL	V, I, Q, M, SM[2], S, T, C, L
	BYTE	VB, IB, QB, MB, SMB[2], SB, LB, AC, *VD, *LD, *AC[1]
	WORD, INT	VW, T, C, IW, QW, MW, SMW[2], SW, LW, AC, *VD, *LD, *AC[1]
	DWORD, DINT	VD, ID, QD, MD, SMD[2], SD, LD, AC, *VD, *LD, *AC[1]
OUT	BOOL	V, I, Q, M, SM[2], S, T, C, L
	BYTE	VB, IB, QB, MB, SMB[2], SB, LB, AC, *VD, *LD, *AC[1]
	WORD, INT	VW, T, C, IW, QW, MW, SMW[2], SW, LW, AC, AQW, *VD, *LD, *AC[1]
	DWORD, DINT	VD, ID, QD, MD, SMD[2], SD, LD, AC, *VD, *LD, *AC[1]

[1] Must be offset 1 or above
[2] Must be offset 30 or above

Tip

STEP 7-Micro/WIN automatically adds an unconditional return from each subroutine.

When a subroutine is called, the entire logic stack is saved, the top of stack is set to one, all other stack locations are set to zero, and control is transferred to the called subroutine. When this subroutine is completed, the stack is restored with the values saved at the point of call, and control is returned to the calling routine.

Accumulators are common to subroutines and the calling routine. No save or restore operation is performed on accumulators due to subroutine use.

When a subroutine is called more than once in the same cycle, the edge/up, edge/down, timer and counter instructions should not be used.

Calling a Subroutine With Parameters

Subroutines can contain passed parameters. The parameters are defined in the local variable table of the subroutine. The parameters must have a symbol name (maximum of 23 characters), a variable type, and a data type. Sixteen parameters can be passed to or from a subroutine.

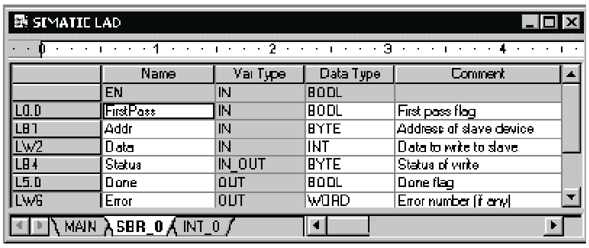
The variable type field in the local variable table defines whether the variable is passed into the subroutine (IN), passed into and out of the subroutine (IN_OUT), or passed out of the subroutine (OUT). Table 6-79 describes the parameter types for a subroutine. To add a parameter entry, place the cursor on the variable type field of the type (IN, IN_OUT, or OUT) that you want to add. Click the right mouse button to get a menu of options. Select the Insert option and then the Row Below option. Another parameter entry of the selected type appears below the current entry.

Table 6-79 Parameter Types for a Subroutine

Parameter	Description
IN	Parameters are passed into the subroutine. If the parameter is a direct address (such as VB10), the value at the specified location is passed into the subroutine. If the parameter is an indirect address (such as *AC1), the value at the location pointed to is passed into the subroutine. If the parameter is a data constant (16#1234) or an address (&VB100), the constant or address value is passed into the subroutine.
IN_OUT	The value at the specified parameter location is passed into the subroutine, and the result value from the subroutine is returned to the same location. Constants (such as 16#1234) and addresses (such as &VB100) are not allowed for input/output parameters.
OUT	The result value from the subroutine is returned to the specified parameter location. Constants (such as 16#1234) and addresses (such as &VB100) are not allowed as output parameters. Since output parameters do not retain the value assigned by the last execution of the subroutine, you must assign values to outputs each time the subroutine is called. Note that the SET and RESET instructions only affect the value of the Boolean operand(s) when power flow is ON.
TEMP	Any local memory that is not used for passed parameters can be used for temporary storage within the subroutine.

As shown in Figure 6-37, the data type field in the local variable table defines the size and format of the parameter. The parameter types are listed below:

- ❑ BOOL: This data type is used for single bit inputs and outputs. IN3 in the following example is a Boolean input.
- ❑ BYTE, WORD, DWORD: These data types identify an unsigned input or output parameter of 1, 2, or 4 bytes, respectively.
- ❑ INT, DINT: These data types identify signed input or output parameters of 2 or 4 bytes, respectively.



	Name	Var Type	Data Type	Comment
	EN	IN	BOOL	
L0.0	FirstPass	IN	BOOL	First pass flag
LB1	Addr	IN	BYTE	Address of slave device
LW2	Data	IN	INT	Data to write to slave
LB4	Status	IN_OUT	BYTE	Status of write
L5.0	Done	OUT	BOOL	Done flag
LW6	Error	OUT	WORD	Error number (if any)

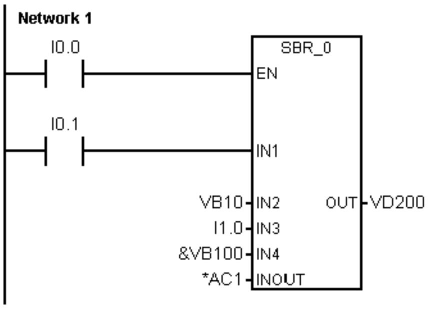
Figure 6-37 Local Variable Table

- ❑ REAL: This data type identifies a single precision (4 byte) IEEE floating-point value.
- ❑ STRING: This data type is used as a four-byte pointer to a string.
- ❑ Power Flow: Boolean power flow is allowed only for bit (Boolean) inputs. This declaration tells STEP 7-Micro/WIN that this input parameter is the result of power flow based on a combination of bit logic instructions. Boolean power flow inputs must appear first in the local variable table before any other type input. Only input parameters are allowed to be used this way. The enable input (EN) and the IN1 inputs in the following example use Boolean logic.

Example: Subroutine Call

There are two STL examples provided. The first set of STL instructions can be displayed only in the STL editor since the BOOL parameters used as power flow inputs are not saved to L memory.

The second set of STL instructions can be displayed also in the LAD and FBD editors because L memory is used to save the state of the BOOL inputs parameters that are shown as power flow inputs in LAD and FBD.



STL only:

Network 1

```
LD      I0.0
CALL    SBR_0, I0.1, VB10, I1.0, &VB100, *AC1, VD200
```

To display correctly in LAD and FBD:

Network 1

```
LD      I0.0
=       L60.0
LD      I0.1
=       L63.7
LD      L60.0
CALL    SBR_0, L63.7, VB10, I1.0, &VB100, *AC1,
VD200
```

Address parameters such as IN4 (&VB100) are passed into a subroutine as a DWORD (unsigned double word) value. The type of a constant parameter must be specified for the parameter in the calling routine with a constant descriptor in front of the constant value. For example, to pass an unsigned double word constant with a value of 12,345 as a parameter, the constant parameter must be specified as DW#12345. If the constant describer is omitted from the parameter, the constant can be assumed to be a different type.

There are no automatic data type conversions performed on the input or output parameters. For example, if the local variable table specifies that a parameter has the data type REAL, and in the calling routine a double word (DWORD) is specified for that parameter, the value in the subroutine will be a double word.

When values are passed to a subroutine, they are placed into the local memory of the subroutine. The left-most column of the local variable table shows the local memory address for each passed parameter. Input parameter values are copied to the subroutine's local memory when the subroutine is called. Output parameter values are copied from the subroutine's local memory to the specified output parameter addresses when the subroutine execution is complete.

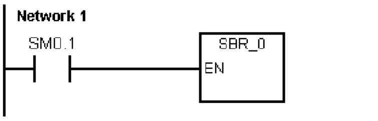
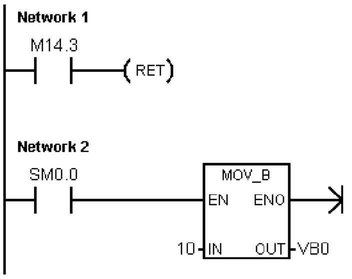
The data element size and type are represented in the coding of the parameters. Assignment of parameter values to local memory in the subroutine is as follows:

- ❑ Parameter values are assigned to local memory in the order specified by the call subroutine instruction with parameters starting at L.0.
- ❑ One to eight consecutive bit parameter values are assigned to a single byte starting with Lx.0 and continuing to Lx.7.
- ❑ Byte, word, and double word values are assigned to local memory on byte boundaries (LBx, LWx, or LDx).

In the Call Subroutine instruction with parameters, parameters must be arranged in order with input parameters first, followed by input/output parameters, and then followed by output parameters.

If you are programming in STL, the format of the CALL instruction is:

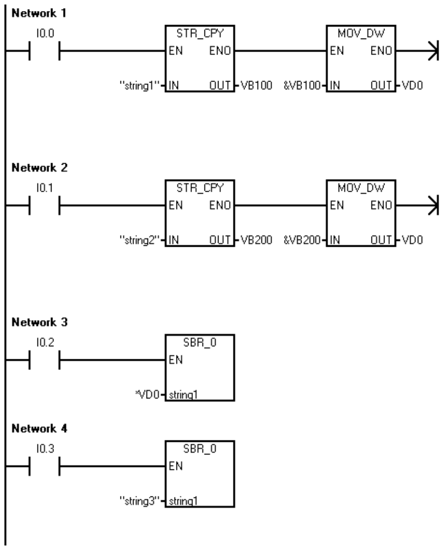
```
CALL    subroutine number, parameter 1, parameter 2, ... , parameter
```

<table>
<tr><th colspan="3">Example: Subroutine and Return from Subroutine Instructions</th></tr>
<tr><td>M
A
I
N</td><td> </td><td>Network 1 //On the first scan, call subroutine 0
//for initialization.
LD SM0.1
CALL SBR_0</td></tr>
<tr><td>S
B
R
0</td><td>

Network 1
M14.3
RET
Network 2
SM0.0
MOV_B
EN
ENO
10
IN
OUT
VB0

</td><td>Network 1 //You can use a conditional return to leave
//the subroutine before the last network.
LD M14.3
CRET

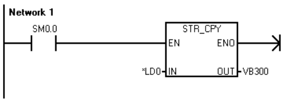
Network 2 //This network will be skipped if M14.3 is on.
LD SM0.0
MOVB 10, VB0</td></tr>
</table>

<table>
<tr><th colspan="3">Example: Subroutine Call with strings</th></tr>
<tr><td colspan="3">This example copies a different string literal to a unique address depending upon the given input. The unique address of this string is saved. The string address is then passed to the subroutine by using an indirect address. The data type of the subroutine input parameter is string. The subroutine then moves the string to a different location.
A string literal can also be passed to the subroutine. The string reference inside the subroutine is always the same.</td></tr>
<tr><td>M
A
I
N</td><td>

Network 1
I0.0
STR_CPY
EN
ENO
"string1"
IN
OUT
VB100
MOV_DW
EN
ENO
&VB100
IN
OUT
VD0
Network 2
I0.1
STR_CPY
EN
ENO
"string2"
IN
OUT
VB200
MOV_DW
EN
ENO
&VB200
IN
OUT
VD0
Network 3
I0.2
SBR_0
EN
*VD0
string1
Network 4
I0.3
SBR_0
EN
"string3"
string1

</td><td>Network 1 //
LD I0.0
SSCPY "string1", VB100
AENO
MOVD &VB100, VD0

Network2 //
LD I0.1
SSCPY "string2", VB200
AENO
MOVD &VB200, VD0

Network3 //
LD I0.2
CALL SBR_0, *VD0</td></tr>
<tr><td>S
B
R
0</td><td>

Network 1
SM0.0
STR_CPY
EN
ENO
*LD0
IN
OUT
VB300

</td><td>Network 1 //
LD SM0.0
SSCPY *LD0, VB300</td></tr>
</table>

7 Communicating over a Network

The S7-200 is designed to solve your communications and networking needs by supporting not only the simplest of networks but also supporting more complex networks. The S7-200 also provides tools that allow you to communicate with other devices, such as printers and weigh scales which use their own communications protocols.

STEP 7-Micro/WIN makes setting up and configuring your network simple and straightforward.

In This Chapter

Understanding the Basics of S7-200 Network Communications

Selecting the Communication Interface for Your Network

The S7-200 supports many different types of communication networks. The selection of a network is performed within the Set PG/PC Interface property dialog. A selected network is referred to as an Interface. The different types of interfaces available to access these communication networks are:

- ❑ PPI Multi-Master cables
- ❑ CP communication cards
- ❑ Ethernet communication cards

To select the communication interface for STEP 7‑Micro/WIN, you perform the following steps. See Figure 7-1.

1. Double-click the icon in the Communications Setup window.
2. Select the interface parameter for STEP 7‑Micro/WIN.

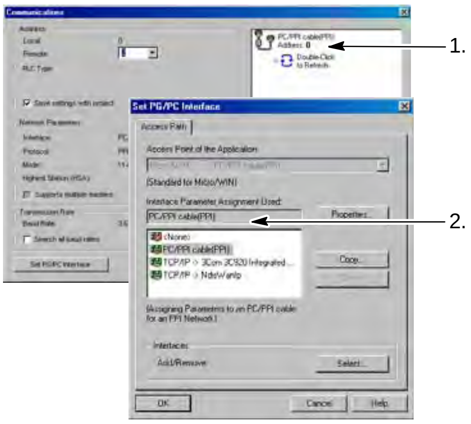


Figure 7-1 STEP 7‑Micro/WIN Communications Interface

PPI Multi-Master Cables

The S7-200 supports communication through two different types of PPI Multi-Master cables. These cable types permit communication through either an RS-232 or a USB interface.

As shown in Figure 7-2, selecting the PPI Multi-Master cable type is simple. You perform the following steps:

1. Click the Properties button on the Set PG/PC Interface property page.
2. Click the Local Connection tab on the Properties page.
3. Select the USB or the desired COM port .

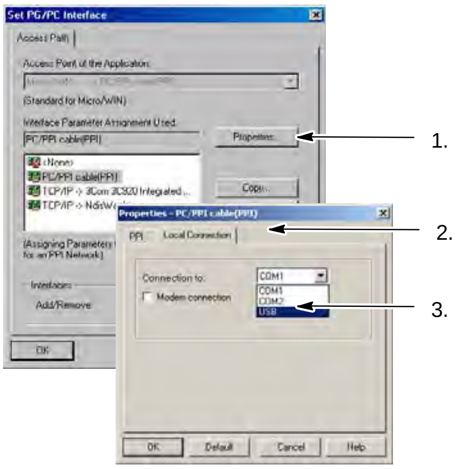


Figure 7-2 PPI Multi-Master Cable Selection

Tip
Please note that only one USB cable can be used at a time.

Tip
Examples in this manual use the RS-232/PPI Multi-Master cable. The RS-232/PPI Multi-Master cable replaces the previous PC/PPI cable. A USB/PPI Multi-Master cable is also available. Refer to Appendix E for order numbers.

Using Master and Slave Devices on a PROFIBUS Network

The S7-200 supports a master-slave network and can function as either a master or a slave in a PROFIBUS network, while STEP 7-Micro/WIN is always a master.

Masters

A device that is a master on a network can initiate a request to another device on the network. A master can also respond to requests from other masters on the network. Typical master devices include STEP 7-Micro/WIN, human-machine interface devices such as a TD 200, and S7-300 or S7-400 PLCs. The S7-200 functions as a master when it is requesting information from another S7-200 (peer-to-peer communications).

Slaves

A device that is configured as a slave can only respond to requests from a master device; a slave never initiates a request. For most networks, the S7-200 functions as a slave. As a slave device, the S7-200 responds to requests from a network master device, such as an operator panel or STEP 7-Micro/WIN.

Setting the Baud Rate and Network Address

The speed that data is transmitted across the network is the baud rate, which is typically measured in units of kilobaud (kbaud) or megabaud (Mbaud). The baud rate measures how much data can be transmitted within a given amount of time. For example, a baud rate of 19.2 kbaud describes a transmission rate of 19,200 bits per second.

Every device that communicates over a given network must be configured to transmit data at the same baud rate. Therefore, the fastest baud rate for the network is determined by the slowest device connected to the network.

Table 7-1 lists the baud rates supported by the S7-200.

Table 7-1 Baud Rates Supported by the S7-200

Network	Baud Rate
Standard Network	9.6 kbaud to 187.5 kbaud
Using an EM 277	9.6 kbaud to 12 Mbaud
Freeport Mode	1200 baud to 115.2 kbaud

The network address is a unique number that you assign to each device on the network. The unique network address ensures that the data is transferred to or retrieved from the correct device. The S7-200 supports network addresses from 0 to 126. For an S7-200 with two ports, each port has a network address. Table 7-2 lists the default (factory) settings for the S7-200 devices.

Table 7-2 Default Addresses for S7-200 Devices

S7-200 Device	Default Address
STEP 7-Micro/WIN	0
HMI (TD 200, TP, or OP)	1
S7-200 CPU	2

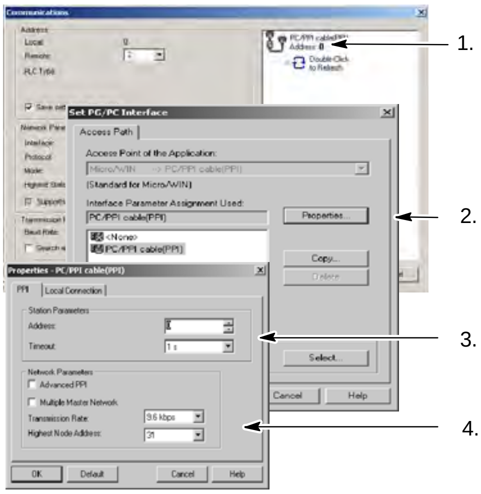
Setting the Baud Rate and Network Address for STEP 7-Micro/WIN

You must configure the baud rate and network address for STEP 7-Micro/WIN. The baud rate must be the same as the other devices on the network, and the network address must be unique.

Typically, you do not change the network address (0) for STEP 7-Micro/WIN. If your network includes another programming package, you might need to change the network address for STEP 7-Micro/WIN.

As shown in Figure 7-3, configuring the baud rate and network address for STEP 7-Micro/WIN is simple. After you click the Communications icon in the Navigation bar, you perform the following steps:

1. Double-click the icon in the Communications Setup window.
2. Click the Properties button on the Set PG/PC Interface dialog box.
3. Select the network address for STEP 7-Micro/WIN.
4. Select the baud rate for STEP 7-Micro/WIN.



Access Point of the Application: Micro/WIN --> PC/PPI cable(PPI)
(Standard for Micro/WIN)
Interface Parameter Assignment Used: PC/PPI cable(PPI)

Station Parameters
Address:
Timeout: 1 s

Network Parameters
□ Advanced PPI
□ Multiple Master Network
Transmission Rate: 9.6 kbps
Highest Node Address: 31

Figure 7-3 Configuring STEP 7-Micro/WIN

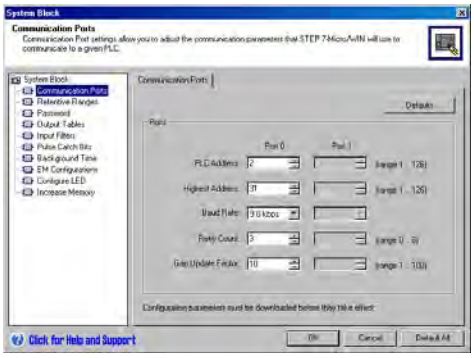
Setting the Baud Rate and Network Address for the S7-200

You must also configure the baud rate and network address for the S7-200. The system block of the S7-200 stores the baud rate and network address. After you select the parameters for the S7-200, you must download the system block to the S7-200.

The default baud rate for each S7-200 port is 9.6 kbaud, and the default network address is 2.

As shown in Figure 7-4, use STEP 7-Micro/WIN to set the baud rate and network address for the S7-200. After you select the System Block icon in the Navigation bar or select the **View > Component > System Block** menu command, you perform the following steps:

1. Select the network address for the S7-200.
2. Select the baud rate for the S7-200.
3. Download the system block to the S7-200.



Communication Ports
Communication Port settings allow you to adjust the communication parameters that STEP 7-Micro/WIN will use to communicate to a given PLC.

	Port 0	Port 1	
PLC Address:	2		(range 1 ... 126)
Highest Address:	31		(range 1 ... 126)
Baud Rate:	9.6 kbps		
Retry Count:	3		(range 0 ... 8)
Gap Update Factor:	10		(range 1 ... 100)

Configuration parameters must be downloaded before they take effect.

Figure 7-4 Configuring the S7-200 CPU

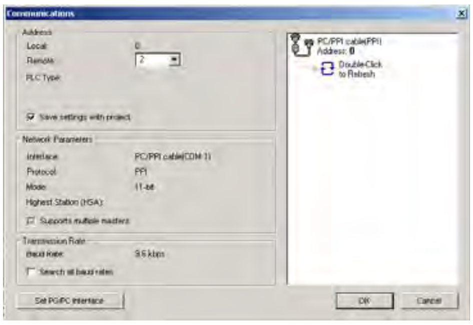
Tip

Selection of all baud rate options is permitted. STEP 7-Micro/WIN validates this selection during the download of the System Block. Baud rate selections that would prevent STEP 7-Micro/WIN from communicating with the S7-200 are prevented from being downloaded.

Setting the Remote Address

Before you can download the updated settings to the S7-200, you must set both the communications (COM) port of STEP 7–Micro/WIN (local) and the address of the S7-200 (remote) to match the current setting of the remote S7-200. See Figure 7-5.

After you download the updated settings, you may need to reconfigure the PG/PC Interface baud rate setting (if different from the setting used when downloading to the remote S7-200). Refer to Figure 7-3 to configure the baud rate.



Communications

Address
Local: 0
Remote: 2
PLC Type:
☑ Save settings with project

Network Parameters
Interface: PC/PPI cable(COM 1)
Protocol: PPI
Mode: 11-bit
Highest Station (HSA):
☑ Supports multiple masters

Transmission Rate
Baud Rate: 9.6 kbps
☐ Search all baud rates

PC/PPI cable(PPI)
Address: 0

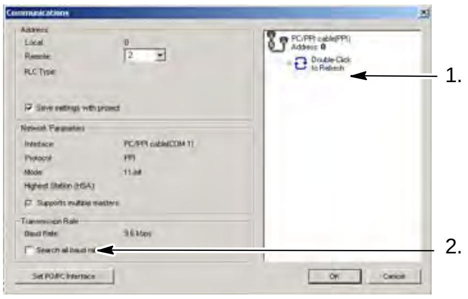
Figure 7-5 Configuring STEP 7–Micro/WIN

Searching for the S7-200 CPUs on a Network

You can search for and identify the S7-200 CPUs that are attached to your network. You can also search the network at a specific baud rate or at all baud rates when looking for S7-200s.

Only PPI Multi-Master cables permit searching of all baud rates. This feature is not available if communicating through a CP card. The search starts at the baud rate that is currently selected.

1. Open the Communications dialog box and double-click the Refresh icon to start the search.
2. To search all baud rates, select the Search All Baud Rates check box.



Communications

Address
Local: 0
Remote: 2
PLC Type:
☑ Save settings with project

Network Parameters
Interface: PC/PPI cable(COM 1)
Protocol: PPI
Mode: 11-bit
Highest Station (HSA):
☑ Supports multiple masters

Transmission Rate
Baud Rate: 9.6 kbps
☐ Search all baud rates

PC/PPI cable(PPI)
Address: 0

Figure 7-6 Searching for CPUs on a Network

Selecting the Communications Protocol for Your Network

The following information is an overview of the protocols supported by the S7-200 CPUs.

❑ Point-to-Point Interface (PPI)

❑ Multi-Point Interface (MPI)

❑ PROFIBUS

Based on the Open System Interconnection (OSI) seven-layer model of communications architecture, these protocols are implemented on a token ring network which conforms to the PROFIBUS standard as defined in the European Standard EN 50170. These protocols are asynchronous, character-based protocols with one start bit, eight data bits, even parity, and one stop bit. Communications frames depend upon special start and stop characters, source and destination station addresses, frame length, and a checksum for data integrity. The protocols can run on a network simultaneously without interfering with each other, as long as the baud rate is the same for each protocol.

Ethernet is also available for the S7-200 CPU with expansion modules CP243–1 and CP243–1 IT.

PPI Protocol

PPI is a master-slave protocol: the master devices send requests to the slave devices, and the slave devices respond. See Figure 7-7. Slave devices do not initiate messages, but wait until a master sends them a request or polls them for a response.

Masters communicate to slaves by means of a shared connection which is managed by the PPI protocol. PPI does not limit the number of masters that can communicate with any one slave; however, you cannot install more than 32 masters on the network.

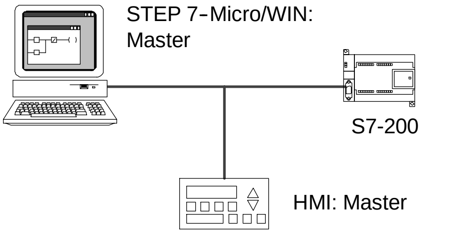


Figure 7-7 PPI Network

S7-200 CPUs can act as master devices while they are in RUN mode, if you enable PPI master mode in the user program. (See the description of SMB30 in Appendix D.) After enabling PPI master mode, you can use the Network Read or the Network Write instructions to read from or write to other S7-200s. While the S7-200 is acting as a PPI master, it still responds as a slave to requests from other masters.

PPI Advanced allows network devices to establish a logical connection between the devices. With PPI Advanced, there are a limited number of connections supplied by each device. See Table 7-3 for the number of connections supported by the S7-200.

All S7-200 CPUs support both PPI and PPI Advanced protocols, while PPI Advanced is the only PPI protocol supported by the EM 277 module.

Table 7-3 Number of Connections for the S7-200 CPU and EM 277 Modules

Module		Baud Rate	Connections
S7-200 CPU	Port 0	9.6 kbaud, 19.2 kbaud, or 187.5 kbaud	4
	Port 1	9.6 kbaud, 19.2 kbaud, or 187.5 kbaud	4
EM 277 Module		9.6 kbaud to 12 Mbaud	6 per module

MPI Protocol

MPI allows both master-master and master-slave communications. See Figure 7-8. To communicate with an S7-200 CPU, STEP 7–Micro/WIN establishes a master–slave connection. MPI protocol does not communicate with an S7-200 CPU operating as a master.

Network devices communicate by means of separate connections (managed by the MPI protocol) between any two devices. Communication between devices is limited to the number of connections supported by the S7-200 CPU or EM 277 modules. See Table 7-3 for the number of connections supported by the S7-200.

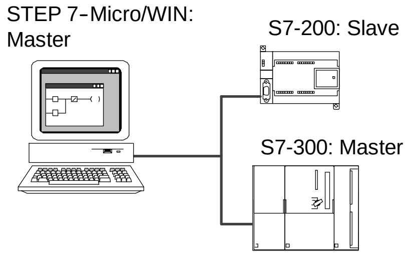


Figure 7-8 MPI Network

For MPI protocol, the S7-300 and S7-400 PLCs use the XGET and XPUT instructions to read and write data to the S7-200 CPU. For information about these instructions, refer to your S7-300 or S7-400 programming manual.

PROFIBUS Protocol

The PROFIBUS protocol is designed for high-speed communications with distributed I/O devices (remote I/O). There are many PROFIBUS devices available from a variety of manufacturers. These devices range from simple input or output modules to motor controllers and PLCs.

PROFIBUS networks typically have one master and several slave I/O devices. See Figure 7-9. The master device is configured to know what types of I/O slaves are connected and at what addresses. The master initializes the network and verifies that the slave devices on the network match the configuration. The master continuously writes output data to the slaves and reads input data from them.

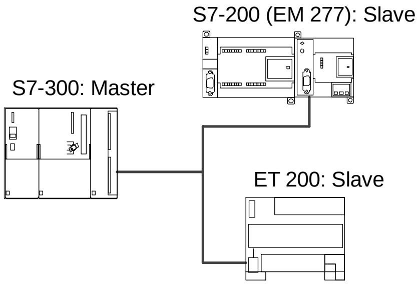


Figure 7-9 PROFIBUS Network

When a DP master configures a slave device successfully, it then owns that slave device. If there is a second master device on the network, it has very limited access to the slaves owned by the first master.

TCP/IP Protocol

The S7-200 can support TCP/IP Ethernet communication through the use of an Ethernet (CP 243–1) or Internet (CP 243–1 IT) expansion module. Table 7-4 shows the baud rate and number of connections supported by these modules.

Table 7-4 Number of Connections for the Ethernet (CP 243–1) and the Internet (CP 243–1 IT) Modules

Module	Baud Rate	Connections
Ethernet (CP 243–1) Module Internet (CP 243–1 IT) Module	10 to 100 Mbaud	8 general purpose connections
		1 STEP 7–Micro/WIN connection

Refer to the *SIMATIC NET CP 243–1 Communications Processor for Industrial Ethernet Manua*l or the *SIMATIC NET CP 243–1 IT Communications Processor for Industrial Ethernet and Information Technology Manua*l for additional information.

Sample Network Configurations Using Only S7-200 Devices

Single-Master PPI Networks

For a simple single-master network, the programming station and the S7-200 CPU are connected by either a PPI Multi-Master cable or by a communications processor (CP) card installed in the programming station.

In the sample network at the top of Figure 7-10, the programming station (STEP 7-Micro/WIN) is the network master. In the sample network at the bottom of Figure 7-10, a human-machine interface (HMI) device (such as a TD 200, TP, or OP) is the network master.

In both sample networks, the S7-200 CPU is a slave that responds to requests from the master.

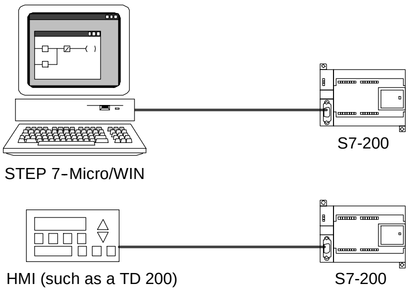


Figure 7-10 Single-Master PPI Network

For a single-master PPI network, configure STEP 7-Micro/WIN to use PPI protocol. Uncheck the Multiple Master Network and the PPI Advanced check boxes, if available.

Multi-Master PPI Networks

Figure 7-11 shows a sample network of multiple masters with one slave. The programming station (STEP 7-Micro/WIN) uses either a CP card or a PPI Multi-Master cable. STEP 7-Micro/WIN and the HMI device share the network.

Both STEP 7-Micro/WIN and the HMI device are masters and must have separate network addresses. When the PPI Multi-Master cable is being used, the cable is a master and uses the network address supplied by STEP 7-Micro/WIN. The S7-200 CPU is a slave.

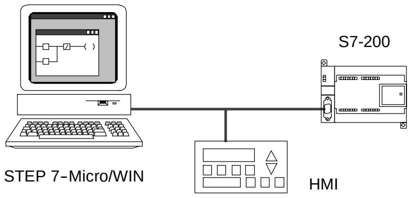


Figure 7-11 Multiple Masters with One Slave

Figure 7-12 shows a PPI network with multiple masters communicating with multiple slaves. In this example, both STEP 7-Micro/WIN and the HMI can request data from any S7-200 CPU slave. STEP 7-Micro/WIN and the HMI device share the network.

All devices (masters and slaves) have different network addresses. When the PPI Multi-Master cable is being used, the cable is a master and uses the network address supplied by STEP 7-Micro/WIN. The S7-200 CPUs are slaves.

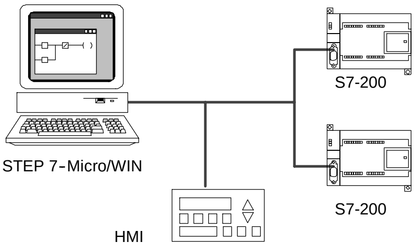


Figure 7-12 Multiple Masters and Slaves

For a network with multiple masters and one or more slaves, configure STEP 7-Micro/WIN to use PPI protocol and check the Multiple Master Network and the PPI Advanced check boxes if they are available. If you are using a PPI Multi-Master cable, the Multiple Master Network and PPI Advanced check boxes are ignored.

Complex PPI Networks

Figure 7-13 shows a sample network that uses multiple masters with peer-to-peer communications.

STEP 7-Micro/WIN and the HMI device read and write over the network to the S7-200 CPUs, and the S7-200 CPUs use the Network Read and Network Write instructions to read and write to each other (peer-to-peer communications).

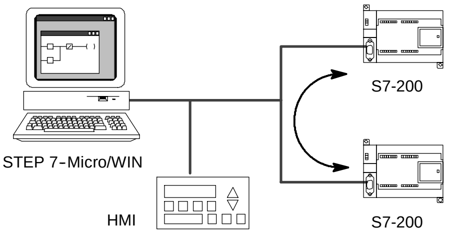


Figure 7-13 Peer-to-Peer Communications

Figure 7-14 shows another, example of a complex PPI network that uses multiple masters with peer-to-peer communications. In this example, each HMI monitors one S7-200 CPU.

The S7-200 CPUs use the NETR and NETW instructions to read and write to each other (peer-to-peer communications).

For complex PPI networks configure STEP 7-Micro/WIN to use PPI protocol and check the Multiple Master Network and the PPI Advanced check boxes if available. If you are using a PPI Multi-Master cable, the Multiple Master Network and PPI Advanced check boxes are ignored.

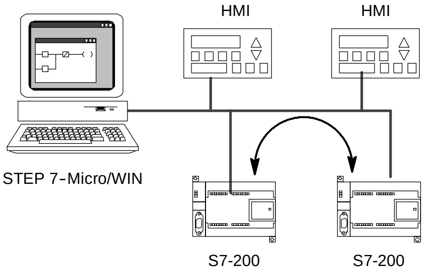


Figure 7-14 HMI Devices and Peer-to-Peer

Sample Network Configurations Using S7-200, S7-300, and S7-400 Devices

Networks with Baud Rates Up to 187.5 kbaud

In the sample network shown in Figure 7-15, the S7-300 uses the XPUT and XGET instructions to communicate with an S7-200 CPU. The S7-300 cannot communicate with an S7-200 CPU in master mode.

To communicate with the S7 CPUs, configure STEP 7-Micro/WIN to use PPI protocol and check the Multiple Master Network and the PPI Advanced check boxes if available. If you are using a PPI Multi-Master cable, the Multiple Master Network and PPI Advanced check boxes are ignored.

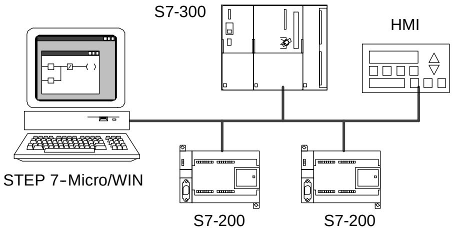


Figure 7-15 Baud Rates Up to 187.5 Kbaud

Networks with Baud Rates Above 187.5 kbaud

For baud rates above 187.5 kbaud, the S7-200 CPU must use an EM 277 module for connecting to the network. See Figure 7-16. STEP 7-Micro/WIN must be connected by a communications processor (CP) card.

In this configuration, the S7-300 can communicate with the S7-200s, using the XPUT and XGET instructions, and the HMI can monitor either the S7-200s or the S7-300.

The EM 277 is always a slave device.

STEP 7-Micro/WIN can program or monitor either S7-200 CPU through the attached EM 277. To communicate with an EM 277 above 187.5 kbaud, configure STEP 7-Micro/WIN to use MPI protocol with a CP card. The maximum baud rate for the PPI Multi-Master cables is 187.5 kbaud.

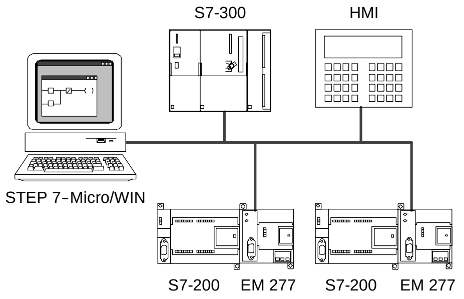


Figure 7-16 Baud Rates Above 187.5 Kbaud

Sample PROFIBUS-DP Network Configurations

Networks with S7-315-2 DP as PROFIBUS Master and EM 277 as PROFIBUS Slave

Figure 7-17 shows a sample PROFIBUS network that uses an S7-315-2 DP as the PROFIBUS master. An EM 277 module is a PROFIBUS slave.

The S7-315-2 DP can read data from or write data to the EM 277, from 1 byte up to 128 bytes. The S7-315-2 DP reads or writes V memory locations in the S7-200.

This network supports baud rates from 9600 baud to 12 Mbaud.

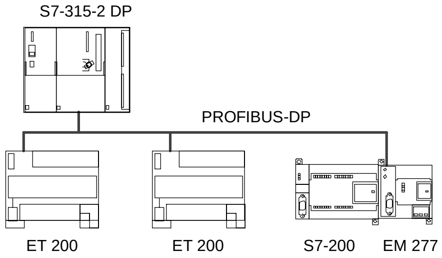


Figure 7-17 Network with S7-315-2 DP

Networks with STEP 7-Micro/WIN and HMI

Figure 7-18 shows a sample network with an S7-315-2 DP as the PROFIBUS master and EM 277 as a PROFIBUS slave. In this configuration, the HMI monitors the S7-200 through the EM 277. STEP 7-Micro/WIN programs the S7-200 through the EM 277.

This network supports baud rates from 9600 baud to 12 Mbaud. STEP 7-Micro/WIN requires a CP card for baud rates above 187.5 kbaud.

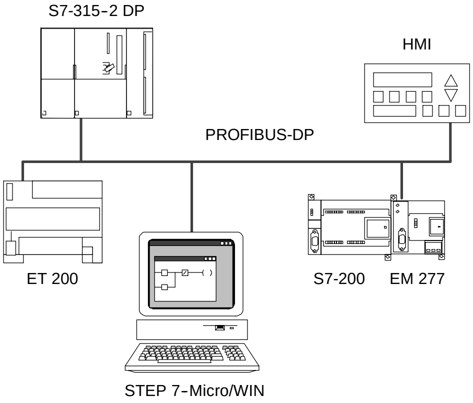


Figure 7-18 PROFIBUS Network

Configure STEP 7–Micro/WIN to use PROFIBUS protocol for a CP card. Select the DP or Standard profile if there are only DP devices present on the network. Select the Universal (DP/FMS) profile for all master devices if there are any non–DP devices on the network, such as TD 200s. All masters on the network must be set up to use the same PROFIBUS profile (DP, Standard or Universal) for the network to operate.

The PPI Multi-master cables will function on networks up to 187.5 kbaud only if all master devices are using the Universal (DP/FMS) profile.

Sample Network Configurations Using Ethernet and/or Internet Devices

In the configuration shown in Figure 7-19, an Ethernet connection is used to allow STEP 7–Micro/WIN to communicate with either of the S7-200 CPUs which are using an Ethernet (CP 243–1) module or an Internet (CP 243–1 IT) module. The S7-200 CPUs can exchange data through the Ethernet connection. A standard browser program running on the PC with STEP 7–Micro/WIN can be used to access the home page of the Internet (CP 243–1 IT) module.

For Ethernet networks, you configure STEP 7–Micro/WIN to use TCP/IP protocol.

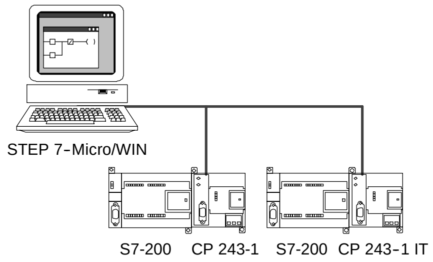


Figure 7-19 10/100 Mbaud Ethernet Network

Tip

In the Set PG/PC Interface dialog, there are at least two TCP/IP choices. The selection TCP/IP –> NdisWanlp is not supported by the S7-200.

❑ In the Set PG/PC Interface dialog box, the option(s) depend upon the type of Ethernet interface provided in your PC. Choose the one that connects your computer to the Ethernet network where the CP 243–1 or CP 243–1 IT module is connected.

❑ On the Communications dialog, you must enter the Remote IP address(es) of each of the Ethernet/Internet modules with which you wish to communicate.

Installing and Removing Communications Interfaces

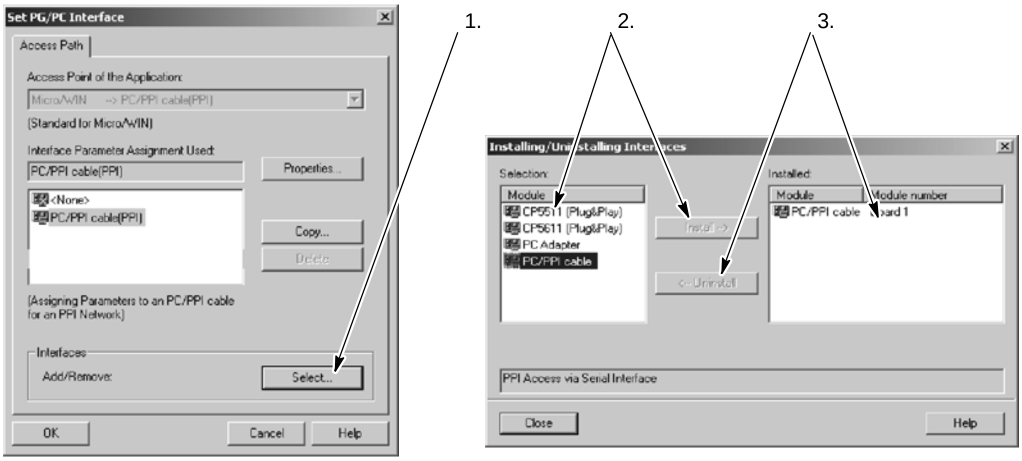
From the Set PG/PC Interface dialog box, you use the Installing/Uninstalling Interfaces dialog box to install or remove communications interfaces for your computer

1. In the Set PG/PC Interface dialog box, click Select to access the Installing/Uninstalling Interfaces dialog box.

   The Selection box lists the interfaces that are available, and the Installed box displays the interfaces that have already been installed on your computer.

2. *To add a communications interface:* Select the communications hardware installed on your computer and click Install. When you close the Installing/Uninstallling Interfaces dialog box, the Set PG/PC Interface dialog box displays the interface in the Interface Parameter Assignment Used box.

3. *To remove a communications interface:* Select the interface to be removed and click Uninstall. When you close the Installing/Uninstallling Interfaces dialog box, the Set PG/PC Interface dialog box removes the interface from the Interface Parameter Assignment Used box.



Set PG/PC Interface

Access Point of the Application: Micro/WIN --> PC/PPI cable(PPI)
(Standard for Micro/WIN)

Interface Parameter Assignment Used: PC/PPI cable(PPI)

<None>
PC/PPI cable(PPI)

(Assigning Parameters to an PC/PPI cable for an PPI Network)

Interfaces
Add/Remove:

Installing/Uninstalling Interfaces

Selection:

Module
CP5511 (Plug&Play)
CP5611 (Plug&Play)
PC Adapter
PC/PPI cable

Installed:

Module	Module number
PC/PPI cable	board 1

PPI Access via Serial Interface

Figure 7-20   Set PG/PC Interface and Installing/Uninstalling Interfaces Dialog Boxes

Adjusting the Port Settings of Your Computer for PPI Multi-Master

If you are using the USB/PPI Multi-Master cable or the RS-232/PPI Multi-Master cable in PPI mode, adjustment of your computer’s port settings is not necessary and operation in multi-master networks is possible with the Windows NT operating system.

If you are using the RS-232/PPI Multi-Master cable in PPI/Freeport mode for communication between an S7-200 CPU and STEP 7--Micro/WIN on an operating system that supports the PPI Multi-Master configuration (Windows NT does not support the PPI Multi-Master), you might need to adjust the port settings on your computer:

1. Right-click the My Computer icon on the desktop and select the Properties menu command.
2. Select the Device Manager tab. For Windows 2000, select first the Hardware tab and then Device Manager button.
3. Double-click the Ports (COM & LPT).
4. Select the communications port that you are currently using (for example, COM1).
5. On the Port Settings tab, click the Advanced button.
6. Set the Receive Buffer and the Transmit Buffer controls to the lowest value (1).
7. Click OK to apply the change, close all the windows, and reboot the computer to make the new settings active.

Building Your Network

General Guidelines

Always install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Avoid placing low-voltage signal wires and communications cables in the same wire tray with AC wires and high-energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

The communications port of the S7-200 CPU is not isolated. Consider using an RS-485 repeater or an EM 277 module to provide isolation for your network.

Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable.

These unwanted currents can cause communications errors or can damage equipment.

Be sure all equipment that you are about to connect with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows. See the information about grounding and circuit reference points for using isolated circuits in Chapter 3.

Determining the Distances, Transmission Rate, and Cable for Your Network

As shown in Table 7-5, the maximum length of a network segment is determined by two factors: isolation (using an RS-485 repeater) and baud rate.

Isolation is required when you connect devices at different ground potentials. Different ground potentials can exist when grounds are physically separated by a long distance. Even over short distances, load currents of heavy machinery can cause a difference in ground potential.

Table 7-5 Maximum Length for a Network Cable

Baud Rate	Non-Isolated CPU Port[1]	CPU Port with Repeater or EM 277
9.6 kbaud to 187.5 kbaud	50 m	1,000 m
500 kbaud	Not supported	400 m
1 Mbaud to 1.5 Mbaud	Not supported	200 m
3 Mbaud to 12 Mbaud	Not supported	100 m

[1] The maximum distance allowed without using an isolator or repeater is 50 m. You measure this distance from the first node to the last node in the segment.

Using Repeaters on the Network

An RS-485 repeater provides bias and termination for the network segment. You can use a repeater for the following purposes:

- ❑ *To increase the length of a network:* Adding a repeater to your network allows you to extend the network another 50 m. If you connect two repeaters with no other nodes in between (as shown in Figure 7-21), you can extend the network to the maximum cable length for the baud rate. You can use up to 9 repeaters in series on a network, but the total length of the network must not exceed 9600 m.
- ❑ *To add devices to a network:* Each segment can have a maximum of 32 devices connected up to 50 m at 9600 baud. Using a repeater allows you to add another segment (32 devices) to the network.
- ❑ *To electrically isolate different network segments:* Isolating the network improves the quality of the transmission by separating the network segments which might be at different ground potentials.

A repeater on your network counts as one of the nodes on a segment, even though it is not assigned a network address.

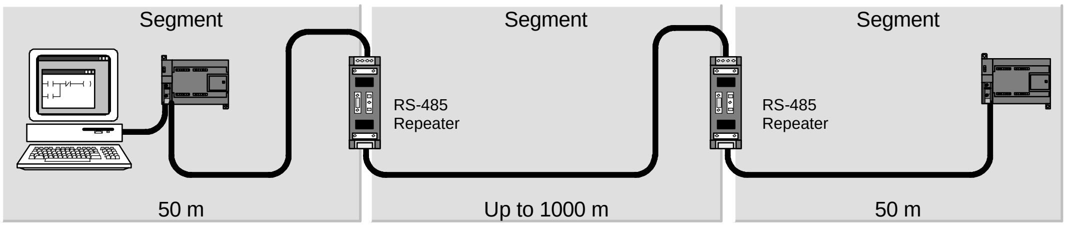


Figure 7-21 Sample Network with Repeaters

Selecting the Network Cable

S7-200 networks use the RS-485 standard on twisted pair cables. Table 7-6 lists the specifications for the network cable. You can connect up to 32 devices on a network segment.

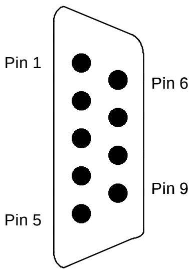
Table 7-6 General Specifications for Network Cable

Specifications	Description
Cable type	Shielded, twisted pair
Loop resistance	≤115 Ω/km
Effective capacitance	30 pF/m
Nominal impedance	Approximately 135 Ω to 160 Ω *(frequency =3 MHz to 20 MHz)*
Attenuation	0.9 dB/100 m *(frequency=200 kHz)*
Cross-sectional core area	0.3 mm^2 to 0.5 mm^2
Cable diameter	8 mm ±0.5 mm

Connector Pin Assignments

The communications ports on the S7-200 CPU are RS-485 compatible on a nine-pin subminiature D connector in accordance with the PROFIBUS standard as defined in the European Standard EN 50170. Table 7-7 shows the connector that provides the physical connection for the communications port and describes the communications port pin assignments.

Table 7-7 Pin Assignments for the S7-200 Communications Port

Connector	Pin Number	PROFIBUS Signal	Port 0/Port 1
	1	Shield	Chassis ground
	2	24 V Return	Logic common
	3	RS-485 Signal B	RS-485 Signal B
	4	Request-to-Send	RTS (TTL)
	5	5 V Return	Logic common
	6	+5 V	+5 V, 100 Ω series resistor
	7	+24 V	+24 V
	8	RS-485 Signal A	RS-485 Signal A
	9	Not applicable	10-bit protocol select (input)
	Connector shell	Shield	Chassis ground

Biasing and Terminating the Network Cable

Siemens provides two types of network connectors that you can use to easily connect multiple devices to a network: a standard network connector (see Table 7-7 for the pin assignments), and a connector that includes a programming port, which allows you to connect a programming station or an HMI device to the network without disturbing any existing network connections. The programming port connector passes all signals (including the power pins) from the S7-200 through to the programming port, which is especially useful for connecting devices that draw power from the S7-200 (such as a TD 200).

Both connectors have two sets of terminal screws to allow you to attach the incoming and outgoing network cables. Both connectors also have switches to bias and terminate the network selectively. Figure 7-22 shows typical biasing and termination for the cable connectors.

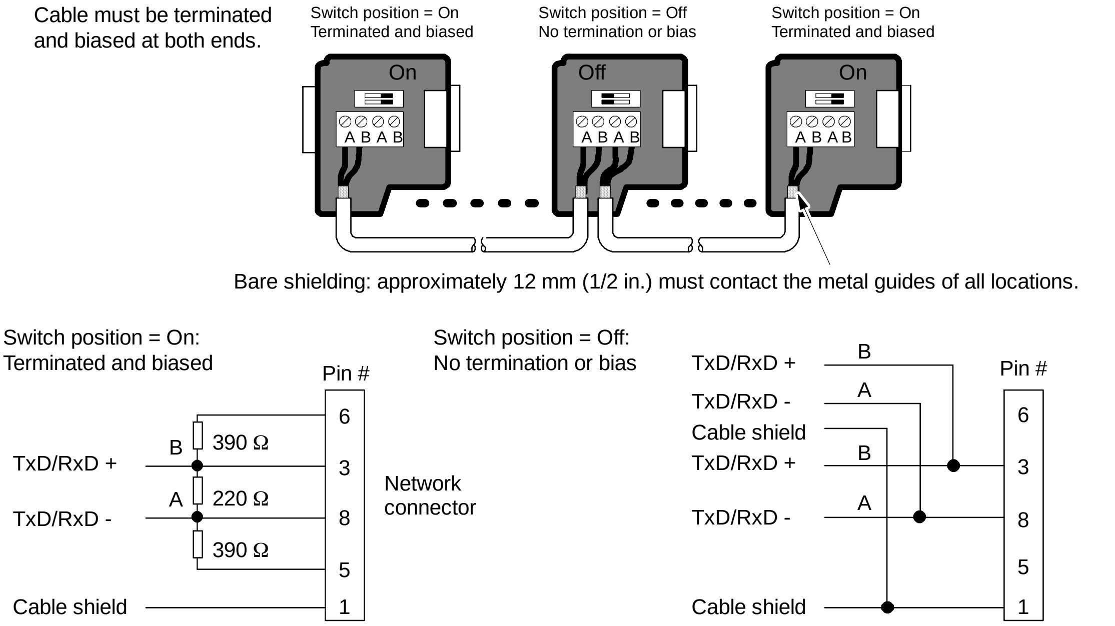


Figure 7-22 Bias and Termination of the Network Cable

Choosing a PPI Multi-Master Cable or a CP Card for Your Network

As shown in Table 7-8, STEP 7–Micro/WIN supports the RS-232/PPI Multi-Master cable and the USB/PPI Multi-Master cable as well as several CP cards that allow the programming station (your computer or SIMATIC programming device) to act as a network master.

For baud rates up to 187.5 kbaud the PPI Multi-Master cables provide the simplest and most cost-effective connection between STEP 7–Micro/WIN and one S7-200 CPU or an S7-200 network. Two types of PPI Multi-Master cables are available and both can be used for local connection between STEP 7–Micro/WIN and an S7-200 network.

The USB/PPI Multi-Master cable is a plug and play device that can be used with PCs that support the USB Version 1.1. It provides isolation between your PC and the S7-200 network while supporting PPI communication at baud rates up to 187.5 kbaud. There are no switches to set; just connect the cable, choose the PC/PPI cable as the interface, select PPI protocol, and set the port to USB in the PC Connection tab. Only one USB/PPI Multi-Master cable can be connected to the PC at a time for use by STEP 7–Micro/WIN.

The RS-232/PPI Multi-Master cable has eight DIP switches: two of these switches are used to configure the cable for operation with STEP 7–Micro/WIN.

- ❑ If you are connecting the cable to the PC, select PPI mode (switch 5 = 1) and Local operation (switch 6 = 0).
- ❑ If you are connecting the cable to a modem, select PPI mode (switch 5 = 1) and Remote operation (switch 6 = 1).

The cable provides isolation between your PC and the S7-200 network. Choose the PC/PPI cable as the interface and select the RS-232 port that you want to use under the PC Connection tab. Under the PPI tab, select the station address and the network baud rate. You do not need to make any other selections because protocol selection is automatic with the RS-232/PPI Multi-Master cable.

Both the USB/PPI and the RS-232/PPI Multi-Master cables have LEDs that provide an indication of the communication activity with the PC as well as network communication activity.

- ❑ The Tx LED indicates that the cable is transmitting information to the PC.
- ❑ The Rx LED indicates that the cable is receiving information from the PC.
- ❑ The PPI LED indicates that the cable is transmitting data on the network. Since the Multi-Master cables are token holders, the PPI LED is on continuously once communication has been initialized by STEP 7–Micro/WIN. The PPI LED is turned off when the connection with STEP 7–Micro/WIN is closed. The PPI LED will also flash at 1 Hz rate while waiting to join the network.

The CP cards contain dedicated hardware to assist the programming station in managing a multi-master network and can support different protocols at several baud rates.

Each CP card provides a single RS-485 port for connection to the network. The CP 5511 PCMCIA card has an adapter that provides the 9-pin D port. You connect one end of the cable to the RS-485 port of the card and connect the other end to a programming port connector on your network.

If you are using a CP card with PPI communications, STEP 7–Micro/WIN will not support two different applications running on the same CP card at the same time. You must close the other application before connecting STEP 7–Micro/WIN to the network through the CP card. If you are using MPI or PROFIBUS communication, multiple STEP 7–Micro/WIN applications are permitted to communicate over the network at the same time.

Caution

Using a non-isolated RS-485-to-RS-232 converter can damage the RS-232 port of your computer.

The Siemens RS-232/PPI and USB/PPI Multi-Master cables (order number 6ES7 901–3CB30–0XA0 or 6ES7 901–3DB30–0XA0, respectively) provide electrical isolation between the RS-485 port on the S7-200 CPU and the RS-232 or USB port that connects to your computer. If you do not use the Siemens Multi-Master cable, you must provide isolation for the RS-232 port of your computer.

Table 7-8 CP Cards and Protocols Supported by STEP 7–Micro/WIN

Configuration	Baud Rate	Protocol
RS-232/PPI Multi-Master or USB/PPI Multi-Master cable[1] Connected to a port on the programming station	9.6 kbaud to 187.5 kbaud	PPI
PC Adapter USB, V1.1 or later	9.6 kbaud to 187.5 baud	PPI, MPI, and PROFIBUS
CP 5512 Type II, PCMCIA card (for a notebook computer)	9.6 kbaud to 12 Mbaud	PPI, MPI, and PROFIBUS
CP 5611 (version 3 or greater) PCI card	9.6 kbaud to 12 Mbaud	PPI, MPI, and PROFIBUS
CP 1613, S7-1613 PCI card	10 Mbaud or 100 Mbaud	TCP/IP
CP 1612, SoftNet-S7 PCI card	10 Mbaud or 100 Mbaud	TCP/IP
CP 1512, SoftNet-S7 PCMCIA card (for a notebook computer)	10 Mbaud or 100 Mbaud	TCP/IP

[1] The Multi-Master cables provide electrical isolation between the RS-485 port (on the S7-200 CPU) and the port that connects to your computer. Using a non-isolated RS-485-to-RS-232 converter could damage the RS-232 port of your computer.

Using HMI Devices on Your Network

The S7-200 CPU supports many types of HMI devices from Siemens and also from other manufacturers. While some of these HMI devices (such as the TD 200) do not allow you to select the communications protocol used by the device, other devices (such as the OP and TP product lines) allow you to select the communications protocol for that device.

If your HMI device allows you to select the communications protocol, consider the following guidelines:

- For an HMI device connected to the communications port of the S7-200 CPU, with no other devices on the network, select either the PPI or the MPI protocol for the HMI device.
- For an HMI device connected to an EM 277 PROFIBUS module, select either the MPI or the PROFIBUS protocol.
  - If the network with the HMI device includes S7-300 or S7-400 PLCs, select the MPI protocol for the HMI device.
  - If the network with the HMI device is a PROFIBUS network, select the PROFIBUS protocol for the HMI device and select a profile consistent with the other masters on the PROFIBUS network.
- For an HMI device connected to the communications port of the S7-200 CPU which has been configured as a master, select the PPI protocol for the HMI device. Advanced PPI is optimal. The MPI and PROFIBUS protocols do not support the S7-200 CPU as a master.

For more information about how to configure the HMI device, refer to the specific manual for your device (see Table 7-9). These manuals are included in the STEP 7–Micro/WIN documentation CD.

Table 7-9 HMI Devices Supported by the S7-200 CPU

HMI	Configuration Software	Configuration Cable	Communications Cable
TD 100C	Text Display Wizard Keypad Designer (part of STEP 7–Micro/WIN)	no	6ES7 901–3EB10–0XA0
TD 200			Part of TD 200
TD 200C			Part of TD 200C
TD400C			Part of TD400C
TP177micro	WinCC flexible micro WinCC flexible Compact WinCC flexible Standard WinCC flexible Advanced	S7–200 RS–232 PC–PPI cable, (6ES7 901–3CB30–0XA0)	See SIMATIC HMI catalog ST80 (http://www.siemens.com search on ST80)
OP73micro			

Creating User-Defined Protocols with Freeport Mode

Freeport mode allows your program to control the communications port of the S7-200 CPU. You can use Freeport mode to implement user-defined communications protocols to communicate with many types of intelligent devices. Freeport mode supports both ASCII and binary protocols.

To enable Freeport mode, you use special memory bytes SMB30 (for Port 0) and SMB130 (for Port 1). Your program uses the following to control the operation of the communications port:

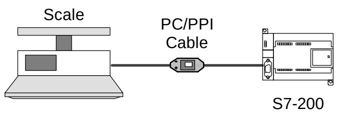
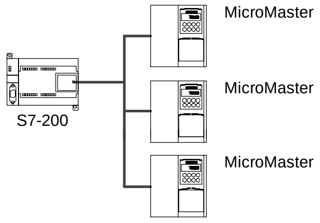
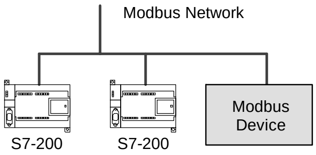
❑ Transmit instruction (XMT) and the transmit interrupt: The Transmit instruction allows the S7-200 to transmit up to 255 characters from the COM port. The transmit interrupt notifies your program in the S7-200 when the transmission has been completed.

❑ Receive character interrupt: The receive character interrupt notifies the user program that a character has been received on the COM port. Your program can then act on that character, based on the protocol being implemented.

❑ Receive instruction (RCV): The Receive instruction receives the entire message from the COM port and then generates an interrupt for your program when the message has been completely received. You use the SM memory of the S7-200 to configure the Receive instruction for starting and stopping the receiving of messages, based on defined conditions. The Receive instruction allows your program to start or stop a message based on specific characters or time intervals. Most protocols can be implemented with the Receive instruction.

Freeport mode is active only when the S7-200 is in RUN mode. Setting the S7-200 to STOP mode halts all Freeport communications, and the communications port then reverts to the PPI protocol with the settings which were configured in the system block of the S7-200.

Table 7-10 Using Freeport Mode

Network Configuration		Description
Using Freeport over an RS-232 connection		Example: Using an S7-200 with an electronic scale that has an RS-232 port. • RS-232/PPI Multi-Master cable connects the RS-232 port on the scale to the RS-485 port on the S7-200 CPU. (Set the cable to PPI/Freeport mode, switch 5=0.) • S7-200 CPU uses Freeport to communicate with the scale. • Baud rate can be from 1200 baud to 115.2 kbaud. • User program defines the protocol.
Using USS protocol		Example: Using an S7-200 with SIMODRIVE MicroMaster drives. • STEP 7-Micro/WIN provides a USS library. • S7-200 CPU is a master, and the drives are slaves. Programming Tips *Refer to the Programming Tips on the documentation CD for a sample USS program. See Tip 28.*
Creating a user program that emulates a slave device on another network		Example: Connecting S7-200 CPUs to a Modbus network. • User program in the S7-200 emulates a Modbus slave. • STEP 7-Micro/WIN provides a Modbus library. Programming Tips *Refer to the Programming Tips on the documentation CD for a sample Modbus program. See Tip 41.*

Using the RS-232/PPI Multi-Master Cable and Freeport Mode with RS-232 Devices

You can use the RS-232/PPI Multi-Master cable and the Freeport communications functions to connect the S7-200 CPUs to many devices that are compatible with the RS-232 standard. The cable must be set to PPI/Freeport mode (switch 5 = 0) for Freeport operation. Switch 6 selects either Local mode (DCE) (switch 6 = 0), or Remote mode (DTE) (switch 6 = 1).

The RS-232/PPI Multi-Master cable is in Transmit mode when data is transmitted from the RS-232 port to the RS-485 port. The cable is in Receive mode when it is idle or is transmitting data from the RS-485 port to the RS-232 port. The cable changes from Receive to Transmit mode immediately when it detects characters on the RS-232 transmit line.

The RS-232/PPI Multi-Master cable supports baud rates between 1200 baud and 115.2 kbaud. Use the DIP switches on the housing of the RS-232/PPI Multi-Master cable to configure the cable for the correct baud rate. Table 7-11 shows the baud rates and switch positions.

The cable switches back to Receive mode when the RS-232 transmit line is in the idle state for a period of time defined as the turnaround time of the cable. The baud rate selection of the cable determines the turnaround time, as shown in Table 7-11.

If you are using the RS-232/PPI Multi-Master cable in a system where Freeport communications is used, the program in the S7-200 must comprehend the turnaround time for the following situations:

Table 7-11 Turnaround Time and Settings

Baud Rate	Turnaround Time	Settings (1 = Up)
115200	0.15 ms	110
57600	0.3 ms	111
38400	0.5 ms	000
19200	1.0 ms	001
9600	2.0 ms	010
4800	4.0 ms	011
2400	7.0 ms	100
1200	14.0 ms	101

❑ The S7-200 responds to messages transmitted by the RS-232 device.

After the S7-200 receives a request message from the RS-232 device, the S7-200 must delay the transmission of a response message for a period of time greater than or equal to the turnaround time of the cable.

❑ The RS-232 device responds to messages transmitted from the S7-200.

After the S7-200 receives a response message from the RS-232 device, the S7-200 must delay the transmission of the next request message for a period of time greater than or equal to the turnaround time of the cable.

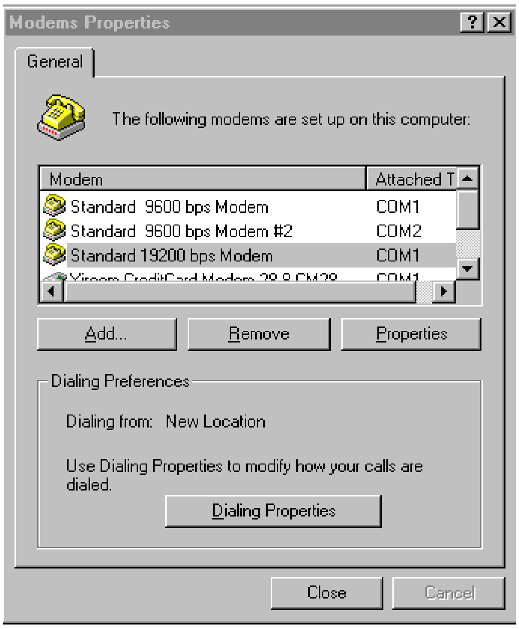
In both situations, the delay allows the RS-232/PPI Multi-Master cable sufficient time to switch from Transmit mode to Receive mode so that data can be transmitted from the RS-485 port to the RS-232 port.

Using Modems and STEP 7-Micro/WIN with Your Network

STEP 7-Micro/WIN version 3.2 or later uses the standard Windows Phone and Modem Options for selecting and configuring telephone modems. The Phone and Modem Options are under the Windows Control Panel. Using the Windows setup options for modems allows you to:

- ❑ Use most internal and external modems supported by Windows.
- ❑ Use the standard configurations for most modems supported by Windows.
- ❑ Use the standard Windows dialing rules for selection of locations, country and area code support, pulse or tone dialing, and calling card support.
- ❑ Use higher baud rates when communicating to the EM 241 Modem module.

Use the Windows control panel to display the Modem Properties dialog box. This dialog box allows you to configure the local modem. You select your modem from the list of modems supported by Windows. If your modem type is not listed in the Windows modem dialog box, select a type that is the closest match for your modem, or contact your modem vendor to acquire the modem configuration files for Windows.



The following modems are set up on this computer:

Modem	Attached T
Standard 9600 bps Modem	COM1
Standard 9600 bps Modem #2	COM2
Standard 19200 bps Modem	COM1
Xircom CreditCard Modem 28.8 CM28	COM1

Dialing Preferences

Dialing from: New Location

Use Dialing Properties to modify how your calls are dialed.

Figure 7-23 Configuring the Local Modem

STEP 7-Micro/WIN also lets you use radio and cellular modems. These modem types do not appear in the Windows Modem Properties dialog box, but are available when configuring a connection for STEP 7-Micro/WIN.

Configuring a Modem Connection

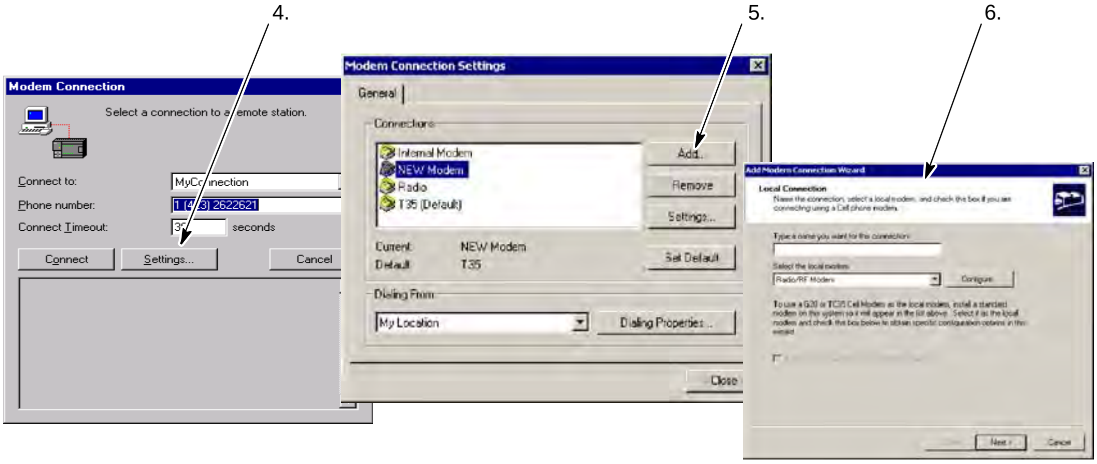
A connection associates an identifying name with the physical properties of the connection. For a telephone modem these properties include the type of modem, 10 or 11 bit protocol selections, and timeouts. For cellular modems the connection allows setting of a PIN and other parameters. Radio modem properties include selections for baud rate, parity, flow control and other parameters.

Adding a Connection

Connection Wizard

Use the Connection wizard to add a new connection, remove, or edit a connection as shown in Figure 7-24.

1. Double-click the icon in the Communications Setup window.
2. Double-click the PC/PPI cable to open the PG/PC interface. Select the PPI cable and click the Properties button. On the Local Connection tab, check the Modem Connection box.
3. Double-click the modem Connect icon in the Communications dialog.
4. Click the Settings button to display the Modem Connections Settings dialog box.
5. Click the Add button to start the Add Modem Connection wizard.
6. Configure the connection as prompted by the wizard.



Select a connection to a remote station.

Connect to: MyConnection

Phone number: 1 (423) 2622621

Connect Timeout: 30 seconds

Internal Modem

NEW Modem

Radio

T35 (Default)

Current: NEW Modem

Default: T35

My Location

Local Connection

Name the connection, select a local modem, and check the box if you are connecting using a Cell phone modem.

Type a name you want for the connection:

Select the local modem:

Radio/RF Modem

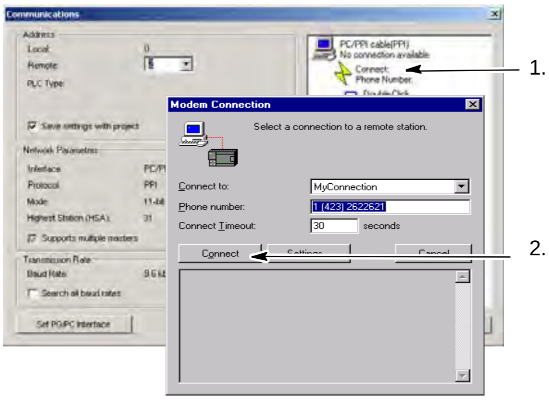
To use a G20 or TC35 Cell Modem as the local modem, install a standard modem on the system so it will appear in the list above. Select it as the local modem and check the box below to obtain specific configuration options in the wizard.

Figure 7-24   Adding a Modem Connection

Connecting to the S7-200 with a Modem

After you have added a modem connection, you can connect to an S7-200 CPU.

1. Open the Communications dialog box and double-click on the Connect icon to display the Modem Connection dialog box.
2. In the Modem Connection dialog box, click Connect to dial the modem.



Address

Local: 0

Remote: 2

PLC Type:

☑ Save settings with project

Network Parameters

Interface: PC/PPI

Protocol: PPI

Mode: 11-bit

Highest Station (HSA): 31

☑ Supports multiple masters

Transmission Rate

Baud Rate: 9.6 kbps

☐ Search all baud rates

PC/PPI cable(PPI)

No connection available

Connect:

Phone Number:

Double-Click

Select a connection to a remote station.

Connect to: MyConnection

Phone number: 1 (423) 2622621

Connect Timeout: 30 seconds

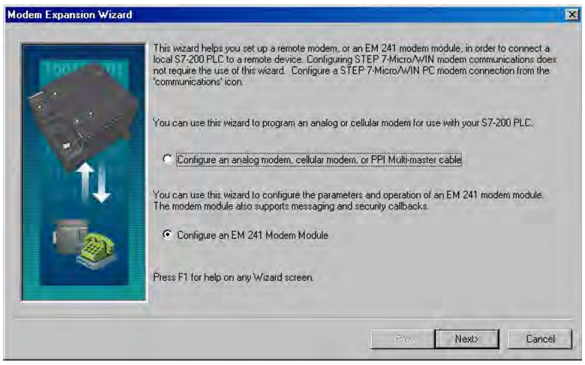
Figure 7-25   Connecting to the S7-200

Configuring a Remote Modem

Modem Expansion Wizard

The remote modem is the modem that is connected to the S7-200. If the remote modem is an EM 241 Modem module, no configuration is required. If you are connecting to a stand-alone modem or cell modem, you must configure the connection.

The Modem Expansion wizard configures the remote modem which is connected to the S7-200 CPU. Special modem configurations are required in order to properly communicate with the RS-485 half duplex port of the S7-200 CPU. Simply select the type of modem, and enter the information as prompted by the wizard. For more information, refer to the online help.



This wizard helps you set up a remote modem, or an EM 241 modem module, in order to connect a local S7-200 PLC to a remote device. Configuring STEP 7-Micro/WIN modem communications does not require the use of this wizard. Configure a STEP 7-Micro/WIN PC modem connection from the 'communications' icon.

You can use this wizard to program an analog or cellular modem for use with your S7-200 PLC.

○ Configure an analog modem, cellular modem, or PPI Multi-master cable

You can use this wizard to configure the parameters and operation of an EM 241 modem module. The modem module also supports messaging and security callbacks.

● Configure an EM 241 Modem Module

Press F1 for help on any Wizard screen.

Figure 7-26 Modem Expansion Wizard

Configuring a PPI Multi-Master Cable to Work with a Remote Modem

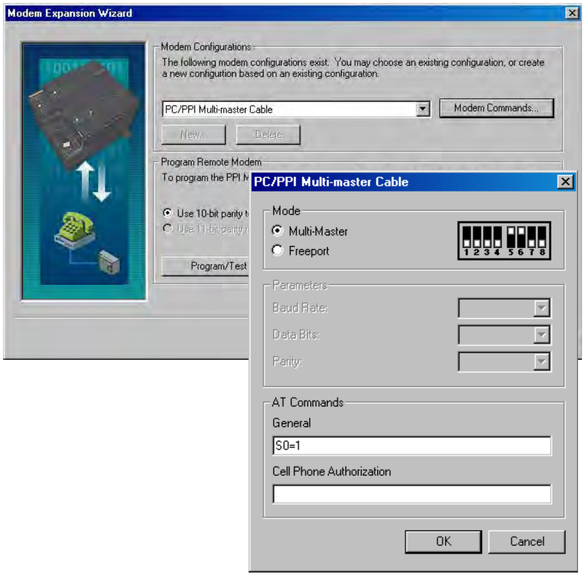
The RS-232 PPI Multi-Master cable provides the ability to send modem AT command strings upon power-up of the cable. Please note that this configuration is only required if the default modem settings must be changed. See Figure 7-27.

Modem commands can be specified in the General commands. The auto answer command will be the only default setting.

Cell phone authorization commands and PIN numbers can be specified in the Cell Phone Authorization field, for example +CPIN=1234.

Each command string will be sent separately to the modem. Each string will be preceded with the AT modem attention command.

These commands will be initialized within the cable by selecting the Program/Test button.



The following modem configurations exist. You may choose an existing configuration, or create a new configurtion based on an existing configuration.

PC/PPI Multi-master Cable

● Multi-Master
○ Freeport

General: S0=1

Cell Phone Authorization:

Figure 7-27 Modem Expansion Wizard – Sending Modem Commands

Please note that the bitmap will depict the recommended switch settings depending upon the selected parameters.

While configuring the RS-232/PPI Multi-Master cable with STEP 7–Micro/WIN, you must connect the RS-485 connector to an S7-200 CPU. This is the source of the 24V power required for the cable to operate. Be sure to supply power to the S7-200 CPU.

After exiting the STEP 7–Micro/WIN configuration of the RS-232/PPI Multi-Master cable, disconnect the cable from the PC and connect it to the modem. Power cycle both the modem and the cable. You are now ready to use the cable for remote operation in a PPI multi-master network.

Tip

Your modem must be at the factory default settings for use with a PPI Multi-Master cable.

Configuring a PPI Multi-Master Cable to Work with Freeport

The RS-232 PPI Multi-Master cable provides the same ability to send modem AT command strings with the cable configured for Freeport mode. Please note that this configuration is only required if the default modem settings must be changed.

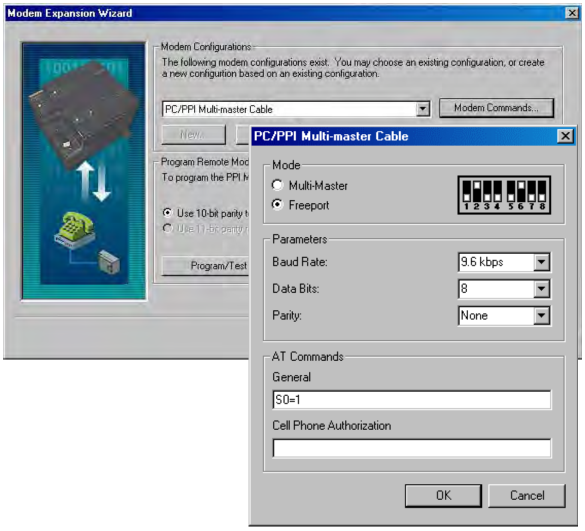
However, the cable must also be configured to match the S7-200 port's baud rate, parity, and number of data bits. This is required since the S7-200 application program will control configuration of these parameters.

Baud rates can be selected between 1.2 kbaud and 115.2 kbaud.

Seven or eight data bits can be selected.

Even, odd, or no parity can be selected.

Please note that the bitmap will depict the recommended switch settings depending upon the selected parameters.


Modem Expansion Wizard

Modem Configurations

The following modem configurations exist. You may choose an existing configuration, or create a new configurtion based on an existing configuration.

PC/PPI Multi-master Cable

PC/PPI Multi-master Cable

Mode

○ Multi-Master

◉ Freeport

Parameters

Baud Rate: 9.6 kbps

Data Bits: 8

Parity: None

AT Commands

General

S0=1

Cell Phone Authorization

Figure 7-28 Modem Expansion Wizard – Sending Modem Command in Freeport Mode

While configuring the RS-232/PPI Multi-Master cable with STEP 7–Micro/WIN, you must connect the RS-485 connector to an S7-200 CPU. This is the source of the 24V power required for the cable to operate. Be sure to supply power to the S7-200 CPU.

After exiting the STEP 7–Micro/WIN configuration of the RS-232/PPI Multi-Master cable, disconnect the cable from the PC and connect it to the modem. Power cycle both the modem and the cable. You are now ready to use the cable for remote operation in a PPI multi-master network.

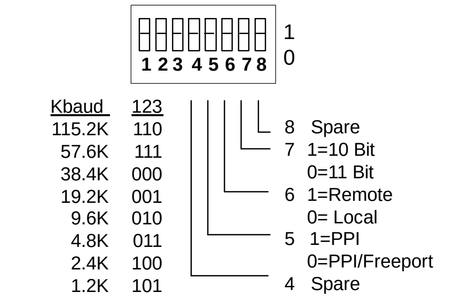
Tip

Your modem must be at the factory default settings for use with a PPI Multi-Master cable.

Using a Telephone Modem with the RS-232/PPI Multi-Master Cable

You can use an RS-232/PPI Multi-Master cable to connect the RS-232 communications port of a modem to an S7-200 CPU. See Figure 7-29.

- ❑ Switches 1, 2, and 3 set the baud rate.
- ❑ Switch 5 selects PPI or PPI/Freeport mode.
- ❑ Switch 6 select either Local (equivalent to the Data Communications Equipment – DCE) or remote (equivalent to Data Terminal Equipment – DTE) mode.
- ❑ Switch 7 selects either 10-bit or 11-bit PPI protocol.



Kbaud	123
115.2K	110
57.6K	111
38.4K	000
19.2K	001
9.6K	010
4.8K	011
2.4K	100
1.2K	101

Figure 7-29 Settings for the RS-232/PPI Multi-Master Cable

Switch 5 selects operation in PPI mode or in PPI/Freeport mode. If you are using STEP 7–Micro/WIN to communicate with the S7-200 through modems, select PPI mode (switch 5 = 1). Otherwise, select PPI/Freeport mode (switch 5 = 0).

Switch 7 of the RS-232/PPI Multi-Master cable selects either a 10–bit or 11–bit mode for PPI/Freeport mode. Use switch 7 only when the S7-200 is connected to STEP 7–Micro/WIN with a modem in PPI/Freeport mode. Otherwise, set switch 7 for 11–bit mode to ensure proper operation with other devices.

Switch 6 of the RS-232/PPI Multi-Master cable allows you to set the RS-232 port of the cable to either Local (DCE) or Remote (DTE) mode.

- ❑ If you are using the RS-232/PPI Multi-Master cable with STEP 7–Micro/WIN or if the RS-232/PPI Multi-Master cable is connected to a computer, set the RS-232/PPI Multi-Master cable to Local (DCE) mode.
- ❑ If you are using the RS-232/PPI Multi-Master cable with a modem (which is a DCE device), set the RS-232/PPI Multi-Master cable to Remote (DTE) mode.

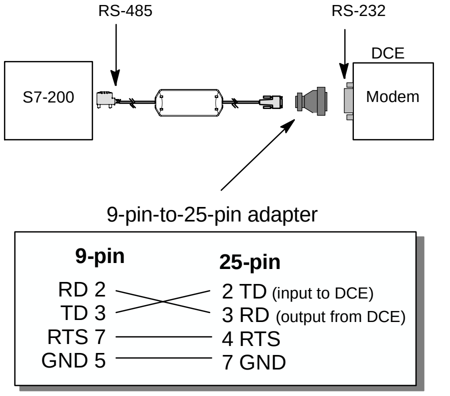


Figure 7-30 Pin Assignments for Adapters

This eliminates the need to install a null modem adapter between the RS-232/PPI Multi-Master cable and the modem. Depending on the connector on the modem, you might still need to use a 9-pin-to-25-pin adapter.

Figure 7-30 shows the pin assignment for a common modem adapter.

See Appendix A for more information about the RS-232/PPI Multi-Master cable. The pin numbers and functions for the RS-485 and RS-232 ports of the RS-232/PPI Multi-Master cable in Local (DCE) mode are shown in Table A-69. Table A-70 shows the pin numbers and functions for the RS-485 and RS-232 ports of the RS-232/PPI Multi-Master cable in Remote (DTE) mode. The RS-232/PPI Multi-Master cable supplies RTS only when it is in Remote (DTE) mode.

Using a Radio Modem with the RS-232/PPI Multi-Master Cable

You can use an RS-232/PPI Multi-Master cable to connect the RS-232 communications port of a radio modem to an S7-200 CPU. However, operation with radio modems is not the same as it is with telephone modems.

PPI Mode

With the RS-232/PPI Multi-Master cable set for PPI mode (switch 5 = 1), you would normally select remote mode (switch 6 = 1) for operation with a modem. However, selecting the remote mode causes the cable to send the character string ’AT’ and wait for the modem to reply with ’OK’ on each power up. While telephone modems use this sequence to establish the baud rate, radio modems do not generally accept AT commands.

Therefore, for operation with radio modems you must select local mode (switch 6 = 0) and use a null modem adapter between the RS-232 connector of the cable and the RS-232 port on your radio modem. Null modem adapters are available in either 9-pin-to-9 pin or 9-pin-to-25 pin configurations.

Configure the radio modem to operate at 9.6, 19.2, 38.4, 57.6 or 115.2 kbaud. The RS-232/PPI Multi-Master cable will automatically adjust to any one of these baud rates on the first character transmitted by the radio modem.

PPI/Freeport Mode

With the RS-232/PPI Multi-Master cable set for PPI/Freeport mode (switch 5 = 0), select remote mode (switch 6 = 1) for operation with a radio modem. Configure the cable so that it will not send any AT commands to setup the modem.

Switches 1, 2, and 3 on the RS-232/PPI Multi-Master cable set the baud rate. See Figure 7–29. Select the baud rate setting that corresponds to the baud rate of the PLC and the radio modem.

Advanced Topics

Optimizing the Network Performance

The following factors affect network performance (with baud rate and number of masters having the greatest effect):

- ❑ Baud rate: Operating the network at the highest baud rate supported by all devices has the greatest effect on the network.
- ❑ Number of masters on the network: Minimizing the number of masters on a network also increases the performance of the network. Each master on the network increases the overhead requirements of the network; having fewer masters lessens the overhead.
- ❑ Selection of master and slave addresses: The addresses of the master devices should be set so that all of the masters are at sequential addresses with no gaps between addresses. Whenever there is an address gap between masters, the masters continually check the addresses in the gap to see if there is another master wanting to come online. This checking requires time and increases the overhead of the network. If there is no address gap between masters, no checking is done and so the overhead is minimized. You can set the slave addresses to any value without affecting network performance, as long as the slaves are not between masters. Slaves between masters increase the network overhead in the same way as having address gaps between masters.
- ❑ Gap update factor (GUF): Used only when an S7-200 CPU is operating as a PPI master, the GUF tells the S7-200 how often to check the address gap for other masters. You use STEP 7-Micro/WIN to set the GUF in the CPU configuration for a CPU port. This configures the S7-200 to check address gaps only on a periodic basis. For GUF=1, the S7-200 checks the address gap every time it holds the token; for GUF=2, the S7-200 checks the address gap once every two times it holds the token. If there are address gaps between masters, a higher GUF reduces the network overhead. If there are no address gaps between masters, the GUF has no effect on performance. Setting a large number for the GUF causes long delays in bringing masters online, because the addresses are checked less frequently. The default GUF setting is 10.
- ❑ Highest station address (HSA): Used only when an S7-200 CPU is operating as a PPI master, the HSA defines the highest address at which a master should look for another master. You use STEP 7-Micro/WIN to set the HSA in the CPU configuration for a CPU port. Setting an HSA limits the address gap which must be checked by the last master (highest address) in the network. Limiting the size of the address gap minimizes the time required to find and bring online another master. The highest station address has no effect on slave addresses: masters can still communicate with slaves which have addresses greater than the HSA. As a general rule, set the highest station address on all masters to the same value. This address should be greater than or equal to the highest master address. The default value for the HSA is 31.

Calculating the Token Rotation Time for a Network

In a token-passing network, the only station that can initiate communications is the station that holds the token. The token rotation time (the time required for the token to be circulated to each of the masters in the logical ring) measures the performance of your network.

Figure 7-31 provides a sample network as an example for calculating the token rotation time for a multiple-master network. In this example, the TD 200 (station 3) communicates with the CPU 222 (station 2), the TD 200 (station 5) communicates with the CPU 222 (station 4), and so on. The two CPU 224 modules use the Network Read and Network Write instructions to gather data from the other S7-200s: CPU 224 (station 6) sends messages to stations 2, 4, and 8, and the CPU 224 (station 8) sends messages to stations 2, 4, and 6. In this network, there are six master stations (the four TD 200 units and the two CPU 224 modules) and two slave stations (the two CPU 222 modules).

Programming Tips

Refer to the Programming Tips on the documentation CD for a discussion about token rotation. See Tip 42.

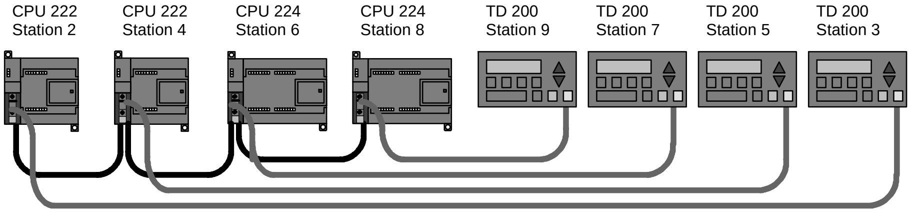


Figure 7-31 Example of a Token-Passing Network

In order for a master to send a message, it must hold the token. For example: When station 3 has the token, it initiates a request message to station 2 and then it passes the token to station 5. Station 5 then initiates a request message to station 4 and then passes the token to station 6. Station 6 then initiates a message to station 2, 4, or 8, and passes the token to station 7. This process of initiating a message and passing the token continues around the logical ring from station 3 to station 5, station 6, station 7, station 8, station 9, and finally back to station 3. The token must rotate completely around the logical ring in order for a master to be able to send a request for information. For a logical ring of six stations, sending one request message per token hold to read or write one double-word value (four bytes of data), the token rotation time is approximately 900 ms at 9600 baud. Increasing the number of bytes of data accessed per message or increasing the number of stations increases the token rotation time.

The token rotation time is determined by how long each station holds the token. You can determine the token rotation time for your multiple-master network by adding the times that each master holds the token. If the PPI master mode has been enabled (under the PPI protocol on your network), you can send messages to other S7-200s by using the Network Read and Network Write instructions with the S7-200. If you send messages using these instructions, you can use the following formula to calculate the approximate token rotation time, based on the following assumptions: each station sends one request per token hold, the request is either a read or write request for consecutive data locations, there is no conflict for use of the one communications buffer in the S7-200, and there is no S7-200 that has a scan time longer than about 10 ms.

Token hold time (T_{hold}) = (128 overhead + *n* data char) x 11 bits/char x 1/baud rate	
Token rotation time (T_{rot}) = T_{hold} of master 1 + T_{hold} of master 2 + . . . + T_{hold} of master *m*	
where	*n* is the number of data characters (bytes) *m* is the number of masters

The following equations calculate the rotation times (one “bit time” equals the duration of one signaling period) for the example shown in Figure 7-31:

T (token hold time) = (128 + 4 char) x 11 bits/char x 1/9600 bit times/s
= 151.25 ms per master
T (token rotation time) = 151.25 ms per master ≦ 6 masters
= 907.5 ms

Tip

SIMATIC NET COM PROFIBUS software provides an analyzer to determine network performance.

Comparing Token Rotation Times

Table 7-12 shows comparisons of the token rotation time versus the number of stations, amount of data, and the baud rate. The times are figured for a case where you use the Network Read and Network Write instructions with the S7-200 CPU or other master devices.

Table 7-12 Token Rotation Time (in Seconds)

Baud Rate	Bytes Transferred	Number of Masters								
		2	3	4	5	6	7	8	9	10
9.6 kbaud	1	0.30	0.44	0.59	0.74	0.89	1.03	1.18	1.33	1.48
	16	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.65
19.2 kbaud	1	0.15	0.22	0.30	0.37	0.44	0.52	0.59	0.67	0.74
	16	0.17	0.25	0.33	0.41	0.50	0.58	0.66	0.74	0.83
187.5 kbaud	1	0.009	0.013	0.017	0.022	0.026	0.030	0.035	0.039	0.043
	16	0.011	0.016	0.021	0.026	0.031	0.037	0.042	0.047	0.052

Understanding the Connections That Link the Network Devices

Network devices communicate through individual connections, which are private links between the master and slave devices. As shown in Figure 7-32, the communications protocols differ in how the connections are handled:

- The PPI protocol utilizes one shared connection among all of the network devices.
- The PPI Advanced, MPI, and PROFIBUS protocols utilize separate connections between any two devices communicating with each other.

When using PPI Advanced, MPI, or PROFIBUS, a second master cannot interfere with a connection that has been established between a master and a slave. S7-200 CPUs and EM 277s always reserve one connection for STEP 7-Micro/WIN and one connection for HMI devices. Other master devices cannot use these reserved connections. This ensures that you can always connect at least one programming station and at least one HMI device to the S7-200 CPU or EM 277 when the master is using a protocol that supports connections, such as PPI Advanced.

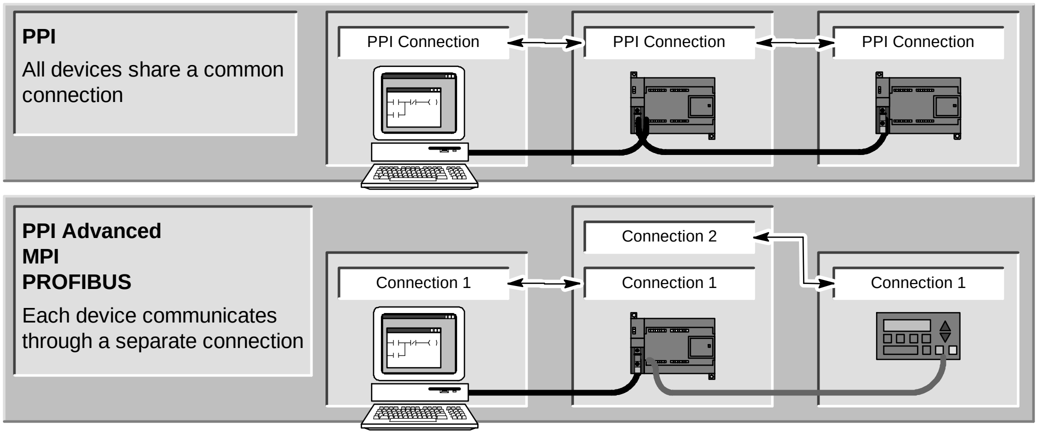


Figure 7-32 Managing the Communications Connections

As shown in Table 7-13, the S7-200 CPU or EM 277 provide a specific number of connections. Each port (Port 0 and Port 1) of an S7-200 CPU supports up to four separate connections. (This allows a maximum of eight connections for the S7-200 CPU.) This is in addition to the shared PPI connection. An EM 277 supports six connections. Each port reserves one connection for a programmer and one connection for an operator panel (OP or TP). The remaining connections are available for general use.

Table 7-13 Capabilities of the S7-200 CPU and EM 277 Modules

Connection Point		Baud Rate	Connections	STEP 7-Micro/WIN Protocol Profile Selections
S7-200 CPU	Port 0	9.6 kbaud, 19.2 kbaud, or 187.5 kbaud	4	PPI, PPI Advanced, MPI, and PROFIBUS[1]
	Port 1	9.6 kbaud, 19.2 kbaud, or 187.5 kbaud	4	PPI, PPI Advanced, MPI, and PROFIBUS[1]
EM 277 Module		9.6 kbaud to 12 Mbaud	6 per module[2]	PPI Advanced, MPI, and PROFIBUS

[1] If a CP card is used to connect STEP 7-Micro/WIN to the S7-200 CPU through Port 0 or Port 1, you can select either MPI or DP PROFIBUS profiles only when the S7-200 device is configured as a slave.

[2] In addition to the PROFIBUS connection.

Working with Complex Networks

For the S7-200, complex networks typically have multiple S7-200 masters that use the Network Read (NETR) and Network Write (NETW) instructions to communicate with other devices on a PPI network. Complex networks typically present special problems that can block a master from communicating with a slave.

If the network is running at a lower baud rate (such as 9.6 kbaud or 19.2 kbaud), then each master completes the transaction (read or write) before passing the token. At 187.5 kbaud, however, the master issues a request to a slave and then passes the token, which leaves an outstanding request at the slave.

Figure 7-33 shows a network with potential communications conflicts. In this network, Station 1, Station 2, and Station 3 are masters, using the Network Read or Network Write instructions to communicate with Station 4. The Network Read and Network Write instructions use PPI protocol so all of the S7-200s share the single PPI connection in Station 4.

In this example, Station 1 issues a request to Station 4. For baud rates above 19.2 kbaud, Station 1 then passes the token to Station 2. If Station 2 attempts to issue a request to Station 4, the request from Station 2 is rejected because the request from Station 1 is still present. All requests to Station 4 will be rejected until Station 4 completes the response to Station 1. Only after the response has been completed can another master issue a request to Station 4.

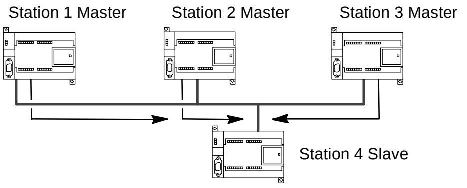


Figure 7-33 Communications Conflict

To avoid this conflict for the communications port on Station 4, consider making Station 4 the only master on the network, as shown in Figure 7-34. Station 4 then issues the read/write requests to the other S7-200s.

Not only does this configuration ensure that there is no conflict in communications, but it also reduces the overhead caused by having multiple masters and allows the network to operate more efficiently.

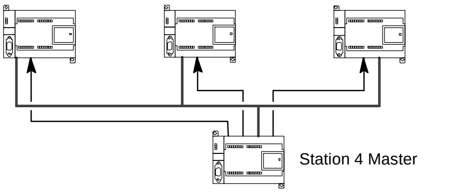


Figure 7-34 Avoiding Conflict

For some applications, however, reducing the number of masters on the network is not an option. When there are several masters, you must manage the token rotation time and ensure that the network does not exceed the target token rotation time. (The token rotation time is the amount of time that elapses from when a master passes the token until that master receives the token again.)

Table 7-14 HSA and Target Token Rotation Time

HSA	9.6 kbaud	19.2 kbaud	187.5 kbaud
HSA=15	0.613 s	0.307 s	31 ms
HSA=31	1.040 s	0.520 s	53 ms
HSA=63	1.890 s	0.950 s	97 ms
HSA=126	3.570 s	1.790 s	183 ms

If the time required for the token to return to the master is greater than a target token rotation time, then the master is not allowed to issue a request. The master can issue a request only when the actual token rotation time is less than the target token rotation time.

The highest station address (HSA) and the baud rate settings for the S7-200 determine the target token rotation time. Table 7-14 lists target rotation times.

For the slower baud rates, such as 9.6 kbaud and 19.2 kbaud, the master waits for the response to its request before passing the token. Because processing the request/response cycle can take a relatively long time in terms of the scan time, there is a high probability that every master on the network can have a request ready to transmit every time it holds the token. The actual token rotation time would then increase, and some masters might not be able to process any requests. In some situations, a master might only rarely be allowed to process requests.

For example: Consider a network of 10 masters that transmit 1 byte at 9.6 kbaud that is configured with an HSA of 15. For this example, each of the masters always has a message ready to send. As shown in Table 7-14, the target rotation time for this network is 0.613 s. However, based on the performance data listed in Table 7-12, the actual token rotation time required for this network is 1.48 s. Because the actual token rotation time is greater than the target token rotation time, some of the masters will not be allowed to transmit a message until some later rotation of the token.

You have two basic options for improving a situation where the actual token rotation time is greater than the target token rotation time:

- ❑ You can reduce actual token rotation time by reducing the number of masters on your network. Depending on your application, this might not be a feasible solution.
- ❑ You can increase the target token rotation time by increasing the HSA for all of the master devices on the network.

Increasing the HSA can cause a different problem for your network by affecting the amount of time that it takes for a S7-200 to switch to master mode and enter the network. If you use a timer to ensure that the Network Read or Network Write instruction completes its execution within a specified time, the delay in initializing master mode and adding the S7-200 as a master on the network can cause the instruction to time out. You can minimize the delay in adding masters by reducing the Gap Update Factor (GUF) for all masters on the network.

Because of the manner in which requests are posted to and left at the slave for 187.5 kbaud, you should allow extra time when selecting the target token rotation time. For 187.5 kbaud, the actual token rotation time should be approximately half of the target token rotation time.

To determine the token rotation time, use the performance data in Table 7-12 to determine the time required for completing the Network Read and Network Write operations. To calculate the time required for HMI devices (such as the TD 200), use the performance data for transferring 16 bytes. Calculate the token rotation time by adding the time for each device on the network. Adding all of the times together describes a worst-case scenario where all devices want to process a request during the same token rotation. This defines the maximum token rotation time required for the network.

For example: Consider a network running at 9.6 kbaud with four TD 200s and four S7-200s, with each S7-200 writing 10 bytes of data to another S7-200 every second. Use Table 7-12 to calculate the specific transfer times for the network:

4 TD 200 devices transferring 16 bytes of data =	0.66 s
4 S7-200s transferring 10 bytes of data =	0.63 s
Total token rotation time =	1.29 s

To allow enough time for this network to process all requests during one token rotation, set the HSA to 63. (See Table 7-14.) Selecting a target token rotation (1.89 s) that is greater than the maximum token rotation time (1.29 s) ensures that every device can transfer data on every rotation of the token.

To help improve the reliability of a multi-master network, you should also consider the following actions:

- Change the update rate for the HMI devices to allow more time between updates. For example, change the update rate for a TD 200 from “As fast as possible” to “Once per second.”
- Reduce the number of requests (and the network overhead for processing the requests) by combining the operations of Network Read or Network Write operations. For example, instead of using two Network Read operations that read 4 bytes each, use one Network Read operation that reads 8 bytes. The time to process the two requests of 4 bytes is much greater than the time to process one request for 8 bytes.
- Change the update rate of the S7-200 masters so that they do not attempt to update faster than the token rotation time.

Configuring the RS-232/PPI Multi-Master Cable for Remote Operation

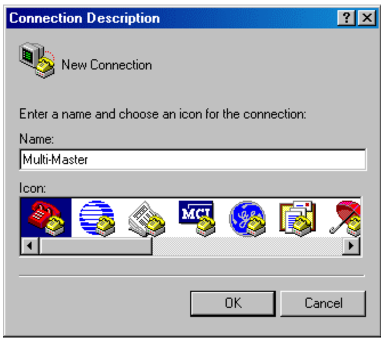
HyperTerminal as a Configuration Tool

If STEP 7–Micro/WIN is not available for you to use to configure the RS-232/PPI Multi-Master cable for remote operation, you can use HyperTerminal or any other dumb terminal package. The RS-232/PPI Multi-Master cable provides built-in menus to guide you as you configure the cable for remote operation.

While configuring the RS-232/PPI Multi-Master cable with HyperTerminal, you must connect the RS-485 connector to an S7-200 CPU. This is the source of the 24V power required for the cable to operate. Be sure to supply power to the S7-200 CPU.

To invoke HyperTerminal on your PC, click on **Start > Programs > Accessories > Communications > HyperTerminal**.

HyperTerminal application launches and prompts for a Connection Description. You must supply a name for the connection (for example, Multi-Master). Click OK. You can select an icon or accept the default icon provided with the new connection. See Figure 7-35.


Connection Description

New Connection

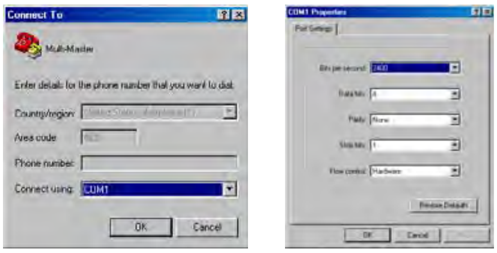
Enter a name and choose an icon for the connection:

Name: Multi-Master

Icon:

Figure 7-35 HyperTerminal Connection Description

The Connect To screen is displayed. Select the communications port that you will be using and click OK. The next screen displayed is COMx Properties. Accept the default and click OK. See Figure 7-36.


Connect To

Multi-Master

Enter details for the phone number that you want to dial:

Country/region:

Area code:

Phone number:

Connect using: COM1

COM1 Properties

Port Settings

Bits per second: 2400

Data bits: 8

Parity: None

Stop bits: 1

Flow control: Hardware

Figure 7-36 HyperTerminal Connect To Screen and COMx Properties Screen

After clicking OK, your cursor is placed in the edit window of the HyperTerminal screen as shown in Figure 7-37. Notice that the status bar at the bottom of the HyperTerminal window indicates that you are connected and a timer is running to indicate the duration of the connection.

From the menu, select **Call > Disconnect**. The status bar now indicates you are disconnected.

Select **View > Font**. Select Courier New and click OK.

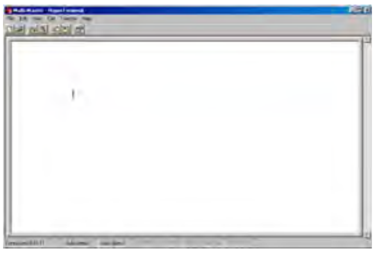
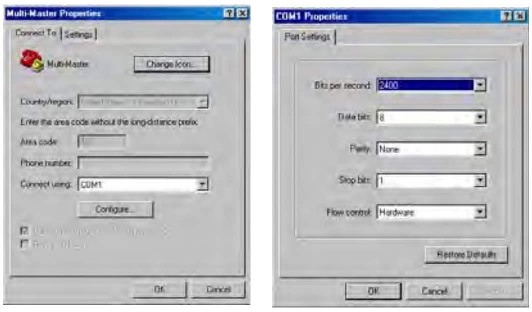


Figure 7-37 Multi-Master HyperTerminal Edit Window

Select **File > Properties**. On the Connect To tab, click the **Configure ...** button to display the communication port properties. See Figure 7-38.

In the COMx Properties dialog, select the baud rate from the drop down menu for Bits per second. You must choose a baud rate from 9600 to115200 bits per second (typically, 9600). Select 8 data bits, no parity, one stop bit and no flow control by using the appropriate drop down menus.

Click OK to return to the Connect To tab.



Multi-Master Properties

Connect To | Settings

Multi-Master

Country/region:

Enter the area code without the long-distance prefix.

Area code:

Phone number:

Connect using: COM1

COM1 Properties

Port Settings

Bits per second: 2400

Data bits: 8

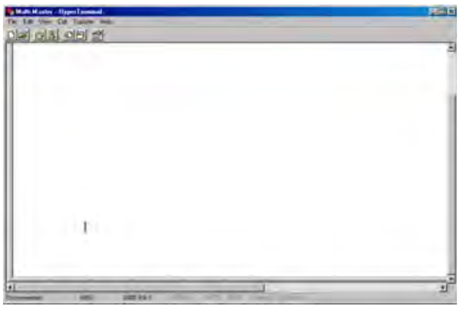
Parity: None

Stop bits: 1

Flow control: Hardware

Figure 7-38 Multi-Master Properties and COMx Properties

Select the Settings tab. In the Emulation drop down menu, select ANSI and click OK. This will return you to the edit window of the HyperTerminal screen. The status bar at the bottom of the screen should indicate: “Disconnected ANSI 9600 8–N–1” as shown in Figure 7-39.



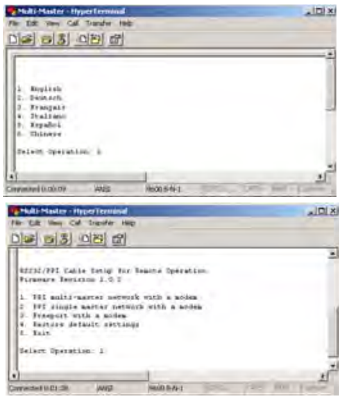
Multi-Master - HyperTerminal
File Edit View Call Transfer Help

Figure 7-39 HyperTerminal Edit – Disconnect ANSI

To initiate communication with the RS-232/PPI Multi-Master cable, type “hhh”. The Rx LED on the cable should blink on for about a second as you type “hhh”. The TX LED turns on briefly as the cable responds with a choice of languages.

Enter the number that corresponds to your choice of language (use the backspace key to eliminate the default selection) and depress the ENTER key. Figure 7-40 shows the language selection display and the RS232/PPI Cable Setup for Remote Operation selection display.

This display also shows the firmware revision of the cable.



Multi-Master - HyperTerminal
File Edit View Call Transfer Help

```
1. English
2. Deutsch
3. Français
4. Italiano
5. Español
6. Chinese

Select Operation: 1
```

Connected 0:00:09 ANSI 9600 8-N-1

```
RS232/PPI Cable Setup for Remote Operation
Firmware Revision 1.0.2

1. PPI multi-master network with a modem
2. PPI single master network with a modem
3. Freeport with a modem
4. Restore default settings
5. Exit

Select Operation: 1
```

Connected 0:01:28 ANSI 9600 8-N-1

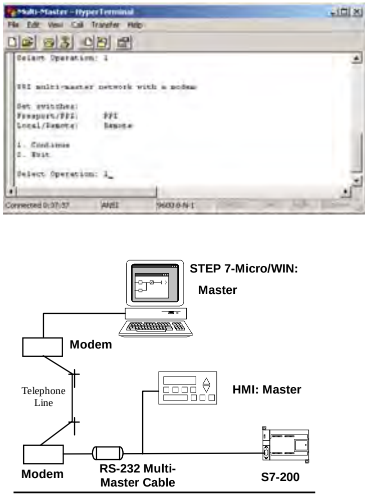
Figure 7-40 HyperTerminal Language Selection and RS-232/PPI Cable Setup

The RS232/PPI Cable Setup for Remote Operation display guides you through the steps required to configure the cable for the type of remote operation you desire.

- ❑ If you have an earlier version of STEP 7–Micro/WIN, select option 2 “PPI single master network with a modem”.
- ❑ If you are using Freeport communication with a modem, select option 3.

For example, select option 1 for PPI multi-master network with a modem using STEP 7–Micro/WIN 3.2 Service Pack 4 or later.

The HyperTerminal display shown in Figure 7-41 indicates the switch settings you need to set on the cable. The switch settings allow STEP 7–Micro/WIN to participate in a remote network via modems with one or more masters and one or more S7-200 PLCs. Such a network is shown in Figure 7-41.

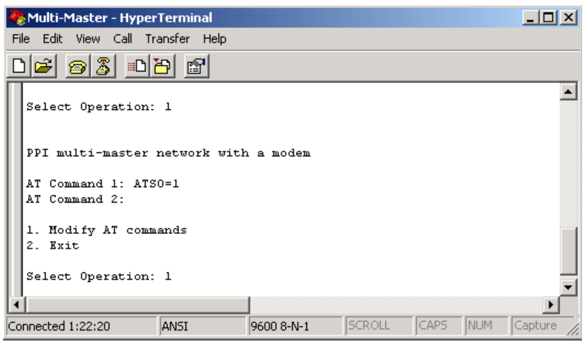


```
Select Operation: 1


PPI multi-master network with a modem

Set switches:
Freeport/PPI:       PPI
Local/Remote:       Remote

1. Continue
2. Exit

Select Operation: 1_
```

Figure 7-41 HyperTerminal – RS-232/PPI Cable Setup

After setting the switches as indicated, select continue. The resulting HyperTerminal display is shown in Figure 7-42.

The remote modem (the one connected to the RS-232/PPI Multi-Master cable) should be set to factory defaults. With the remote modem set to factory defaults, enter the AT strings required to program the modem for operation with the RS-232/PPI Multi-Master cable. Typically, the only string that needs to be sent is ATS0=1, which configures the modem to auto–answer incoming calls on the first ring.



```
Select Operation: 1


PPI multi-master network with a modem

AT Command 1: ATS0=1
AT Command 2:

1. Modify AT commands
2. Exit

Select Operation: 1
```

Multi-Master - HyperTerminal
File Edit View Call Transfer Help
Connected 1:22:20
ANSI
9600 8-N-1
SCROLL
CAPS
NUM
Capture

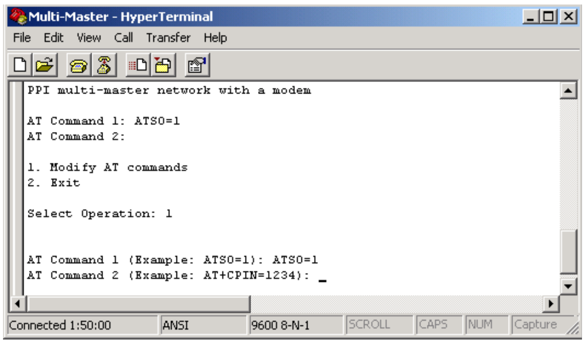
Figure 7-42 HyperTerminal – Remote Modem

If you are using a cell modem that requires a PIN, use the second AT command to supply the PIN (refer to your modem manual for the AT commands supported by your modem). If you need to modify the AT commands, make the selection and enter the commands required as you are prompted for them. The prompts include example AT command strings to help you with the formatting of the commands.

The RS-232/PPI Multi-Master cable will send these AT strings to the modem each time the cable powers up. Make sure that the modem is powered up before or very close to the same time the cable is powered up. Also, if you power cycle the modem, be sure to power cycle the cable. This allows the cable to properly configure the modem and operate at the highest available baud rate.

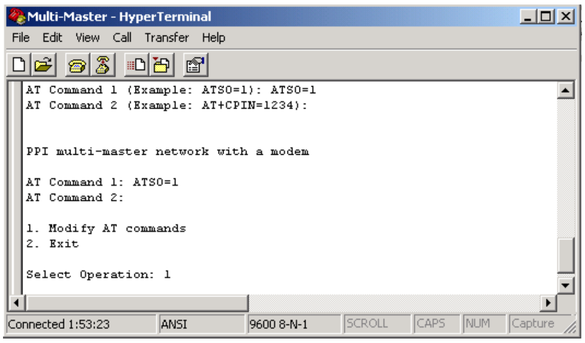
The HyperTerminal displays in Figure 7-43 show how to enter the AT commands. If you do not need to supply a second AT command at the prompt, press the ENTER key. This returns you to the selection for modifying the AT commands or exiting. If you finished entering the AT commands select Exit.

After exiting the HyperTerminal configuration of the RS-232/PPI Multi-Master cable, disconnect the cable from the PC and connect it to the modem. Power cycle both the modem and the cable. You are now ready to use the cable for remote operation in a PPI multi-master network.



Multi-Master - HyperTerminal
File Edit View Call Transfer Help
Connected 1:50:00
ANSI
9600 8-N-1
SCROLL
CAPS
NUM
Capture

```
PPI multi-master network with a modem

AT Command 1: ATS0=1
AT Command 2:

1. Modify AT commands
2. Exit

Select Operation: 1


AT Command 1 (Example: ATS0=1): ATS0=1
AT Command 2 (Example: AT+CPIN=1234): _
```



Multi-Master - HyperTerminal
File Edit View Call Transfer Help
Connected 1:53:23
ANSI
9600 8-N-1
SCROLL
CAPS
NUM
Capture

```
AT Command 1 (Example: ATS0=1): ATS0=1
AT Command 2 (Example: AT+CPIN=1234):


PPI multi-master network with a modem

AT Command 1: ATS0=1
AT Command 2:

1. Modify AT commands
2. Exit

Select Operation: 1
```

Figure 7-43   HyperTerminal – AT Commands

Freeport Operation with HyperTerminal

Configuring the RS-232/PPI Multi-Master cable for Freeport operation using HyperTerminal is very similar to the example configuration described above. Follow the prompts to configure the cable according to your needs.

8 Hardware Troubleshooting Guide and Software Debugging Tools

STEP 7-Micro/WIN provides software tools to help you debug and test your program. These features include viewing the status of the program as it is executed by the S7-200, selecting to run the S7-200 for a specified number of scans, and forcing values.

Use Table 8-1 as a guide for determining the cause and possible solution when troubleshooting problems with the S7-200 hardware.

In This Chapter

Features for Debugging Your Program

STEP 7–Micro/WIN provides several features to help you debug your program: bookmarks, cross reference tables, and run mode edits.

Using Bookmarks for Easy Program Access

You can set bookmarks in your program to make it easy to move back and forth between designated (bookmarked) lines of a long program. You can move to the next or the previous bookmarked line of your program.

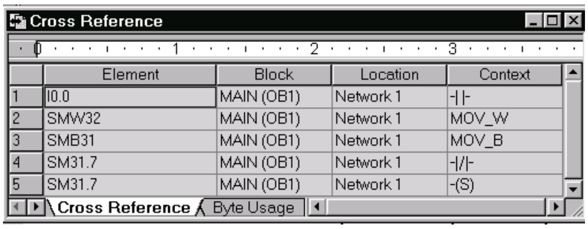
Using the Cross Reference Table to Check Your Program References

Cross Reference

The cross reference table allows you to display the cross references and element usage information for your program.

The cross reference table identifies all operands used in the program, and identifies the program block, network or line location, and instruction context of the operand each time it is used.

You can toggle between symbolic and absolute view to change the representation of all operands.



	Element	Block	Location	Context
1	I0.0	MAIN (OB1)	Network 1	-| |-
2	SMW32	MAIN (OB1)	Network 1	MOV_W
3	SMB31	MAIN (OB1)	Network 1	MOV_B
4	SM31.7	MAIN (OB1)	Network 1	-|/|-
5	SM31.7	MAIN (OB1)	Network 1	-(S)

Figure 8-1 Cross Reference Table

Tip

Double-clicking on an element in the cross reference table takes you to that part of your program or block.

Editing Your Program in RUN Mode

The S7-200 CPUs Rel. 2.0 (and higher) models support RUN mode edits. The RUN mode edit capability is intended to allow you to make small changes to a user program with minimal disturbance to the process being controlled by the program. However, implementing this capability also allows massive program changes that could be disruptive or even dangerous.

Warning

When you download changes to an S7-200 in RUN mode, the changes immediately affect process operation. Changing the program in RUN mode can result in unexpected system operation, which could cause death or serious injury to personnel, and/or damage to equipment.

Only authorized personnel who understand the effects of RUN mode edits on system operation should perform a RUN mode edit.

To perform a program edit in RUN mode, the online S7-200 CPU must support RUN mode edits and must be in RUN mode.

1. Select the **Debug > Program Edit in RUN** menu command.
2. If the project is different than the program in the S7-200, you are prompted to save it. The RUN mode edit can be performed only on the program in the S7-200.
3. STEP 7–Micro/WIN alerts you about editing your program in RUN mode and prompts you to either continue or to cancel the operation. If you click Continue, STEP 7–Micro/WIN uploads the program from the S7-200. You can now edit your program in RUN mode. No restrictions on edits are enforced.

Tip

Positive (EU) and Negative (ED) transition instructions are shown with an operand. To view information about edge instructions, select the Cross Reference icon in the View. The Edge Usage tab lists numbers for the edge instructions in your program. Be careful not to assign duplicate edge numbers as you edit your program.

Downloading the Program in RUN Mode

RUN-mode editing allows you to download only your program block while the S7-200 is in RUN mode. Before downloading the program block in RUN mode, consider the effect of a RUN-mode modification on the operation of the S7-200 for the following situations:

❑ If you deleted the control logic for an output, the S7-200 maintains the last state of the output until the next power cycle or transition to STOP mode.

❑ If you deleted a high-speed counter or pulse output functions which were running, the high-speed counter or pulse output continues to run until the next power cycle or transition to STOP mode.

❑ If you deleted an Attach Interrupt instruction but did not delete the interrupt routine, the S7-200 continues to execute the interrupt routine until a power cycle or a transition to STOP mode. Likewise, if you deleted a Detach Interrupt instruction, the interrupts are not shut down until the next power cycle or transition to STOP mode.

❑ If you added an Attach Interrupt instruction that is conditional on the first scan bit, the event is not activated until the next power cycle or STOP-to-RUN mode transition.

❑ If you deleted an Enable Interrupt instruction, the interrupts continue to operate until the next power cycle or transition from RUN to STOP mode.

❑ If you modified the table address of a receive box and the receive box is active at the time that the S7-200 switches from the old program to the modified program, the S7-200 continues to write the data received to the old table address. Network Read and Network Write instructions function in the same manner.

❑ Any logic that is conditional on the state of the first scan bit will not be executed until the next power cycle or transition from STOP to RUN mode. The first scan bit is set only by the transition to RUN mode and is not affected by a RUN-mode edit.

Tip

Before you can download your program in RUN mode, the S7-200 must support RUN mode edits, the program must compile with no errors, and the communications between STEP 7–Micro/WIN and the S7-200 must be error-free.

You can download only the program block.

To download your program in RUN mode, click on the Download button or select the **File > Download** menu command. If the program compiles successfully, STEP 7–Micro/WIN downloads the program block to the S7-200.

Exiting RUN-Mode Edit

To exit RUN-mode editing, select the **Debug > Program Edit in RUN** menu command and deselect the checkmark. If you have changes that have not been saved, STEP 7–Micro/WIN prompts you either to continue editing, to download changes and exit RUN-mode editing, or to exit without downloading.

Displaying the Program Status

STEP 7–Micro/WIN allows you to monitor the status of the user program as it is being executed. When you monitor the program status, the program editor displays the status of instruction operand values.

To display the status, click the Program Status button or select the **Debug > Program Status** menu command.

Displaying the Status of the Program in LAD and FBD

STEP 7–Micro/WIN provides two options for displaying the status of LAD and FBD programs:

- ❑ End of scan status: STEP 7–Micro/WIN acquires the values for the status display across multiple scan cycles and then updates the status screen display. The status display does not reflect the actual status of each element at the time of execution. The end-of-scan status does not show status for L memory or for the accumulators.

  For end of scan status, the status values are updated in all of the CPU operating modes.

- ❑ Execution status: STEP 7–Micro/WIN displays the values of the networks as the elements are executed in the S7-200. For displaying the execution status, select the **Debug > Use Execution Status** menu command.

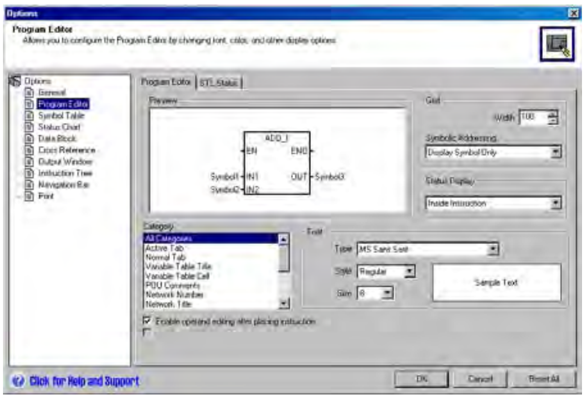
  For execution status, the status values are updated only when the CPU is in RUN mode.

> **Tip**
>
> STEP 7–Micro/WIN provides a simple method for changing the state of a variable. Simply select the variable and right-click to display a menu of options.

Configuring How the Status is Displayed in the LAD and FBD Program

STEP 7–Micro/WIN provides a variety of options for displaying the status in the program.

To configure the display option for the status screen, select the **Tools > Options** menu command, select Program Editor and click on the Program Editor tab, as shown in Figure 8-2.



Options

Program Editor

Allows you to configure the Program Editor by changing font, color, and other display options

Width: 100

Symbolic Addressing: Display Symbol Only

Status Display: Inside Instruction

Category: All Categories

Type: MS Sans Serif

Style: Regular

Size: 8

☑ Enable operand editing after placing instruction

☐

Figure 8-2   Options for the Status Display

Displaying the Status of the Program in STL

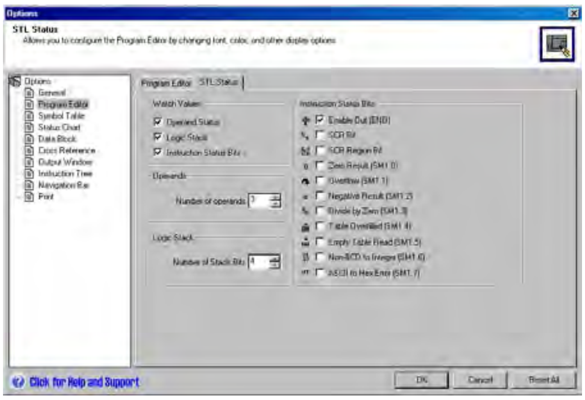
You can monitor the execution status of your STL program on an instruction-by-instruction basis. For an STL program, STEP 7–Micro/WIN displays the status of the instructions that are displayed on the screen.

STEP 7–Micro/WIN gathers status information from the S7-200, beginning from the first STL statement at the top of the editor window. As you scroll down the editor window, new information is gathered from the S7-200.

STEP 7–Micro/WIN continuously updates values on the screen. To halt the screen updates, select the Triggered Pause button. The current data remains on the screen until you deselect the Triggered Pause button.

Configuring Which Parameters Are Displayed in the STL Program

STEP 7–Micro/WIN allows you to display the status of a variety of parameters for the STL instructions. Select the **Tools > Options** menu command, select Program Editor, and click on the STL Status tab. See Figure 8-3.



STL Status

Allows you to configure the Program Editor by changing font, color, and other display options

Watch Values

☑ Operand Status

☑ Logic Stack

☑ Instruction Status Bits

Operands

Number of operands: 3

Logic Stack

Number of Stack Bits: 4

Instruction Status Bits

☑ Enable Out (ENO)

□ SCR Bit

□ SCR Region Bit

□ Zero Result (SM1.0)

□ Overflow (SM1.1)

□ Negative Result (SM1.2)

□ Divide by Zero (SM1.3)

□ Table Overfilled (SM1.4)

□ Empty Table Read (SM1.5)

□ Non-BCD to Integer (SM1.6)

□ ASCII to Hex Error (SM1.7)

Figure 8-3 Options for Displaying STL Status

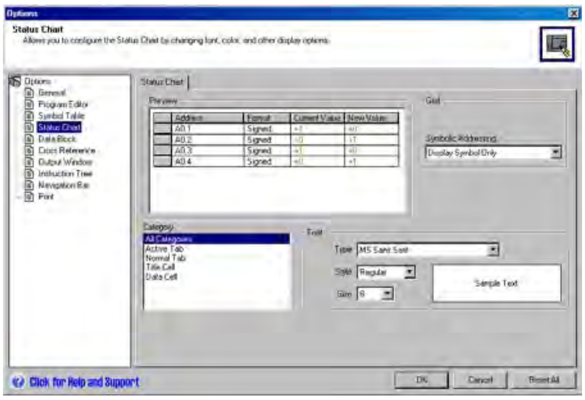
Using a Status Chart to Monitor and Modify the Data in the S7-200

The Status Chart allows you to read, write, force, and monitor variables while the S7-200 is executing your program. Select the **View > Component > Status Chart** menu command to create a status chart. Figure 8-4 shows a sample status chart.

You can create multiple status charts.

STEP 7–Micro/WIN provides toolbar icons for manipulating the status chart: Sort Ascending, Sort Descending, Single Read, Write All, Force, Unforce, Unforce All, and Read All Forced.

To select a format for a cell, select the cell and click the right mouse button to display the context menu.



Status Chart

Allows you to configure the Status Chart by changing font, color, and other display options

Preview

	Address	Format	Current Value	New Value
	A0.1	Signed	+1	+0
	A0.2	Signed	+0	+1
	A0.3	Signed	+1	+0
	A0.4	Signed	+0	+1

Grid

Symbolic Addressing: Display Symbol Only

Category: All Categories, Active Tab, Normal Tab, Title Cell, Data Cell

Font

Type: MS Sans Serif

Style: Regular

Size: 8

Figure 8-4 Status Chart

Forcing Specific Values

The S7-200 allows you to force any or all of the I/O points (I and Q bits). In addition, you can also force up to 16 memory values (V or M) or analog I/O values (AI or AQ). V memory or M memory values can be forced in bytes, words, or double words. Analog values are forced as words only, on even-numbered byte boundaries, such as AIW6 or AQW14. All forced values are stored in the permanent memory of the S7-200.

Because the forced data might be changed during the scan cycle (either by the program, by the I/O update cycle, or by the communications- processing cycle), the S7-200 reapplies the forced values at various times in the scan cycle.

❑ *Reading the inputs:* The S7-200 applies the forced values to the inputs as they are read.

❑ *Executing the control logic in the program:* The S7-200 applies the forced values to all immediate I/O accesses. Forced values are applied for up to 16 memory values after the program has been executed.

❑ *Processing any communications requests:* The S7-200 applies the forced values to all read/write communications accesses.

❑ *Writing to the outputs:* The S7-200 applies the forced values to the outputs as they are written.

You can use the Status Chart to force values. To force a new value, enter the value in the New Value column of the Status Chart, then press the Force button on the toolbar. To force an existing value, highlight the value in the Current Value column, then press the Force button.

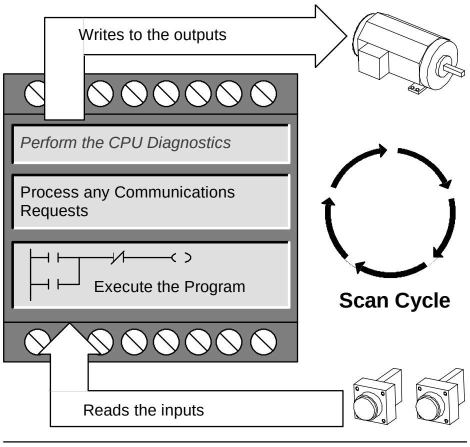


Figure 8-5 S7-200 Scan Cycle

Tip
The Force function overrides a Read Immediate or Write Immediate instruction. The Force function also overrides the output table that was configured for transition to STOP mode. If the S7-200 goes to STOP mode, the output reflects the forced value and not the value that was configured in the output table.

Running Your Program for a Specified Number of Scans

To help you debug your program, STEP 7–Micro/WIN allows you to run the program for a specific number of scans.

You can have the S7-200 execute only the first scan. This allows you to monitor the data in the S7-200 after the first scan. Select the **Debug > First Scan** menu command to run the first scan.

You can have the S7-200 execute your program for a limited number of scans (from 1 scan to 65,535 scans). This allows you to monitor the program as it changes variables. Select the **Debug > Multiple Scans** menu command to specify the number of scans to be executed.

Hardware Troubleshooting Guide

Table 8-1 Troubleshooting Guide for the S7-200 Hardware

Symptom	Possible Causes	Possible Solution
Outputs stop working	• The device being controlled has caused an electrical surge that damaged the output • User program error • Wiring loose or incorrect • Excessive load • Output point is forced	• When connecting to an inductive load (such as a motor or relay), a proper suppression circuit should be used. Refer to Chapter 3. • Correct user program • Check wiring and correct • Check load against point ratings • Check the S7-200 for forced I/O
SF (System Fault) light on the S7-200 turns on (Red)	The following list describes the most common error codes and causes: • User programming error – 0003 Watchdog error – 0011 Indirect addressing – 0012 Illegal floating-point value – 0014 Range error • Electrical noise (0001 through 0009) • Component damage (0001 through 0010)	Read the fatal error code number and refer to Appendix C for information about the type of error: • For a programming error, check the usage of the FOR, NEXT, JMP, LBL, and Compare instructions. • For electrical noise: – Refer to the wiring guidelines in Chapter 3. It is very important that the control panel is connected to a good ground and that high voltage wiring is not run in parallel with low voltage wiring. – Connect the M terminal on the 24 VDC Sensor Power Supply to ground.
None of the LEDs turn on	• Blown fuse • Reversed 24 V power wires • Incorrect voltage	Connect a line analyzer to the system to check the magnitude and duration of the over-voltage spikes. Based on this information, add the proper type arrestor device to your system. Refer to the wiring guidelines in Chapter 3 for information about installing the field wiring.
Intermittent operation associated with high energy devices	• Improper grounding • Routing of wiring within the control cabinet • Too short of a delay time for the input filters	Refer to the wiring guidelines in Chapter 3. It is very important that the control panel is connected to a good ground and that high voltage wiring is not run in parallel with low voltage wiring. Connect the M terminal on the 24 VDC Sensor Power Supply to ground. Increase the input filter delay in the system data block.
Communications network is damaged when connecting to an external device Either the port on the computer, the port on the S7-200, or the PC/PPI cable is damaged	The communications cable can provide a path for unwanted currents if all non-isolated devices, such as PLCs, computers, or other devices that are connected to the network do not share the same circuit common reference. The unwanted currents can cause communications errors or damage to the circuits.	• Refer to the wiring guidelines in Chapter 3 and to the network guidelines in Chapter 7. • Purchase the isolated PC/PPI cable. • Purchase the isolated RS-485-to-RS-485 repeater when you connect machines that do not have a common electrical reference. Refer to Appendix E for information about order numbers for S7-200 equipment.
Other communications problems (STEP 7–Micro/WIN)	Refer to Chapter 7 for information about network communications.	
Error handling	Refer to Appendix C for information about error codes.	

9 Open Loop Motion Control with the S7-200

The S7-200 provides three methods of open loop motion control:

- ❑ Pulse Width Modulation (PWM) – built into the S7-200 for speed, position or duty cycle control
- ❑ Pulse Train Output (PTO) – built into the S7-200 for speed and position control
- ❑ EM 253 Position Module – an add on module for speed and position control

To simplify the use of position control in your application, STEP 7–Micro/WIN provides a Position Control wizard that allows you to completely configure the PWM, PTO or Position module in minutes. The wizard generates position instructions that you can use to provide dynamic control of speed and position in your application. For the Position module STEP 7–Micro/WIN also provides a control panel that allows you to control, monitor and test your motion operations.

In This Chapter

Overview

The S7-200 provides three methods of open loop motion control:

- Pulse Width Modulation (PWM) – built into the S7-200 for speed, position or duty cycle control
- Pulse Train Output (PTO) – built into the S7-200 for speed and position control
- EM 253 Position Module – an add on module for speed and position control

Position Control

The S7-200 provides two digital outputs (Q0.0 and Q0.1) that can be configured using the Position Control Wizard for use as either PWM or a PTO outputs. The Position Control Wizard can also be used to configure the EM 253 Position Module.

When an output is configured for PWM operation, the cycle time of the output is fixed and the pulse width or duty cycle of the pulse is controlled by your program. The variations in pulse width can be used to control the speed or position in your application.

When an output is configured for PTO operation, a 50% duty cycle pulse train is generated for open loop control of the speed and position for either stepper motors or servo motors. The built in PTO function only provides the pulse train output. Direction and limit controls must be supplied by your application program using I/O built into the PLC or provided by expansion modules.

The EM 253 Position Module provides a single pulse train output with integrated direction control, disable and clear outputs. It also includes dedicated inputs which allow the module to be configured for several modes of operation including automatic reference point seek. The module provides a unified solution for open loop control of the speed and position for either stepper motors or servo motors.

To simplify the use of position control in your application, STEP 7–Micro/WIN provides a Position Control wizard that allows you to completely configure the PWM, PTO or Position module in minutes. The wizard generates position instructions that you can use to provide dynamic control of speed and position in your application. For the Position module STEP 7–Micro/WIN also provides a control panel that allows you to control, monitor and test your motion operations.

Using the PWM (Pulse Width Modulation) Output

PWM provides a fixed cycle time output with a variable duty cycle. The PWM output runs continuously after being started at the specified frequence (cycle time). The pulse width is varied as required to effect the desired control. Duty cycle can be expressed as a percentage of the cycle time or as a time value corresponding to pulse width. The pulse width can vary from 0% (no pulse, always off) to 100% (no pulse, always on). See Figure 9-1.

Since the PWM output can be varied from 0% to 100%, it provides a digital output that in many ways is analogous to an analog output. For example the PWM output can be used to control the speed of a motor from stop to full speed or it can be used to control position of a valve from closed to full open.

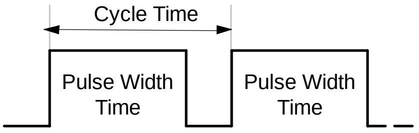
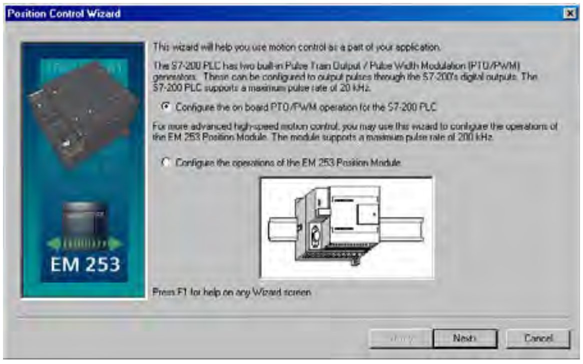


Figure 9-1 Pulse Width Modulation (PWM)

Configuring the PWM Output

To configure one of the built-in outputs for PWM control, use the Position Control wizard. To start the Position Control wizard, either click the Tools icon in the navigation bar and then double-click the Position Control Wizard icon, or select the **Tools> Position Control Wizard** menu command. See Figure 9-2

1. Select the option to configure the onboard PTO/PWM operation for the S7-200 PLC.
2. Choose the output Q0.0 or Q0.1 that you wish to configure as a PWM output.
3. Next select Pulse Width Modulation (PWM) from the drop down dialog box, select the time base of microseconds or milliseconds and specify the cycle time.
4. Select Finish to complete the wizard.



This wizard will help you use motion control as a part of your application.

The S7-200 PLC has two built-in Pulse Train Output / Pulse Width Modulation (PTO/PWM) generators. These can be configured to output pulses through the S7-200's digital outputs. The S7-200 PLC supports a maximum pulse rate of 20 kHz.

● Configure the on board PTO/PWM operation for the S7-200 PLC

For more advanced high-speed motion control, you may use this wizard to configure the operations of the EM 253 Position Module. The module supports a maximum pulse rate of 200 kHz.

○ Configure the operations of the EM 253 Position Module

Press F1 for help on any Wizard screen.

Figure 9-2 Configuring the PWM Output

The wizard will generate one instruction for you to use to control the duty cycle of the the PWM output.

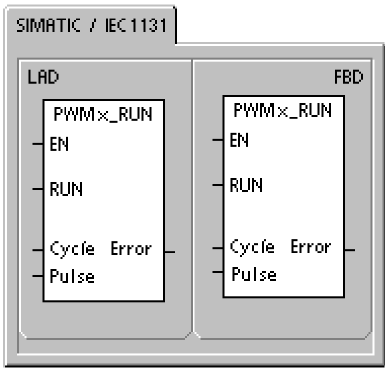
PWMx_RUN Instruction

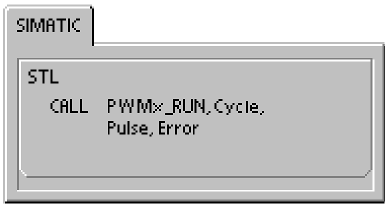
The PWMx_RUN instruction allows you to control the duty cycle of the output by varying the pulse width from 0 to the pulse width of the cycle time.

The Cycle input is a word value that defines the cycle time for the PWM output. The allowed range is from 2 to 65535 units of the time base (microseconds or milliseconds) that was specified within the wizard.

The Duty_Cycle input is a word value that defines the pulse width for the PWM output. The allowed range of values is from 0.0 to 65535 units of the time base (microseconds or milliseconds) that was specified within the wizard.

The Error is a byte value returned by the PWMx_RUN instruction that indicates the result of execution. See Table for a description of the possible error codes.





```
STL
   CALL   PWMx_RUN, Cycle,
          Pulse, Error
```

Table 9-1 Parameters for the PWMx_RUN Instruction

Inputs/Outputs	Data Types	Operands
Cycle, Duty_Cycle	Word	IW, QW, VW, MW, SMW, SW, T, C, LW, AC, AIW, *VD, *AC, *LD, Constant
Error	Byte	IB, QB, VB, MBV, SMB, LB, AC, *VD, *AC, *LD, Constant

Table 9-2 PWMx_RUN Instruction Error Codes

Error Code	Description
0	No error, normal completion
1	Immediate STOP issued during move. STOP command completed successfully

Basic Information for Open Loop Position Control Using Steppers or Servos

Both the PTO built-in to the S7-200 PLC and the EM 253 Position Module use a pulse train output to control both the speed and position of a stepper motor or a servo motor.

Using the PTO or the module for open loop position control requires expertise in the field of motion control. This chapter is not meant to educate the novice in this subject. However, it provides fundamental information that will help as you use the Position Control wizard to configure the PTO or module for your application.

Maximum and Start/Stop Speeds

The wizard will prompt you for the maximum speed (MAX_SPEED) and Start/Stop Speed (SS_SPEED) for your application. See Figure 9-3.

❑ MAX_SPEED: Enter the value for the optimum operating speed of your application within the torque capability of your motor. The torque required to drive the load is determined by friction, inertia, and the acceleration/deceleration times.

❑ The Position Control wizard calculates and displays the minimum speed that can be controlled by the Position module based on the MAX_SPEED you specify.

❑ For the PTO output you must specify the desired start/stop speed. Since at least one cycle at the start/stop speed is generated each time a move is executed, use a start/stop speed whose period is less than the acceleration/deceleration time.

❑ SS_SPEED: Enter a value within the capability of your motor to drive your load at low speeds. If the SS_SPEED value is too low, the motor and load could vibrate or move in short jumps at the beginning and end of travel. If the SS_SPEED value is too high, the motor could lose pulses on start up, and the load could overdrive the motor when attempting to stop.

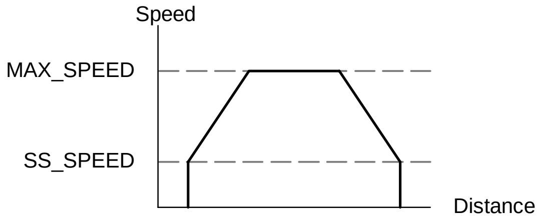


Figure 9-3 Maximum Speed and Start/Stop Speed

Motor data sheets have different ways of specifying the start/stop (or pull-in/pull-out) speed for a motor and given load. Typically, a useful SS_SPEED value is 5% to 15% of the MAX_SPEED value. To help you select the correct speeds for your application, refer to the data sheet for your motor. Figure 9-4 shows a typical motor torque/speed curve.

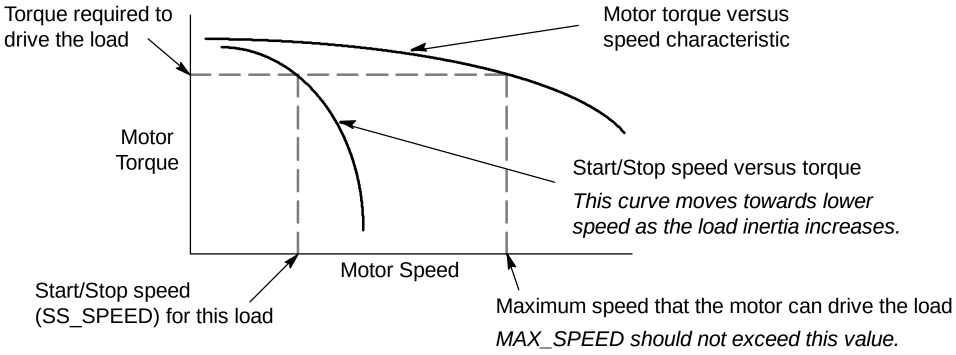


Figure 9-4 Typical Torque-Speed Curve for a Motor

Entering the Acceleration and Deceleration Times

As part of the configuration, you set the acceleration and deceleration times. The default setting for both the acceleration time and the deceleration time is 1 second. Typically, motors can work with less than 1 second. See Figure 9-5. You specify the following times in milliseconds:

- ❑ ACCEL_TIME: Time required for the motor to accelerate from SS_SPEED to MAX_SPEED. Default = 1000 ms
- ❑ DECEL_TIME: Time required for the motor to decelerate from MAX_SPEED to SS_SPEED. Default = 1000 ms

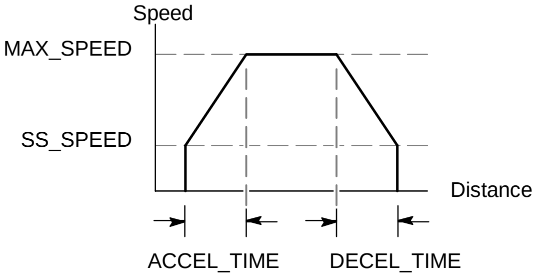


Figure 9-5 Acceleration and Deceleration Times

Tip

Motor acceleration and deceleration times are determined by trial and error. You should start by entering a large value. Optimize these settings for the application by gradually reducing the times until the motor starts to stall.

Configuring the Motion Profiles

A profile is a pre-defined motion description consisting of one or more speeds of movement that effect a change in position from a starting point to an ending point. You do not have to define a profile in order to use the PTO or the module. The Position Control wizard provides instructions for you to use to control moves without running a profile.

A profile is programmed in steps consisting of an acceleration/deceleration to a target speed followed by a fixed number of pulses at the target speed. In the case of single step moves or the last step in a move there is also a deceleration from the target speed (last target speed) to stop.

The PTO and module support a maximum of 25 profiles.

Defining the Motion Profile

The Position Control wizard guides you through a Motion Profile Definition where you define each motion profile for your application. For each profile, you select the operating mode and define the specifics of each individual step for the profile. The Position Control wizard also allows you to define a symbolic name for each profile by simply entering the symbol name as you define the profile.

Selecting the Mode of Operation for the Profile

You configure the profile according the the mode of operation desired. The PTO supports relative position and single speed continuous rotation. The Position module supports absolute position, relative position, single-speed continuous rotation, and two-speed continuous rotation. Figure 9-6 shows the different modes of operation.

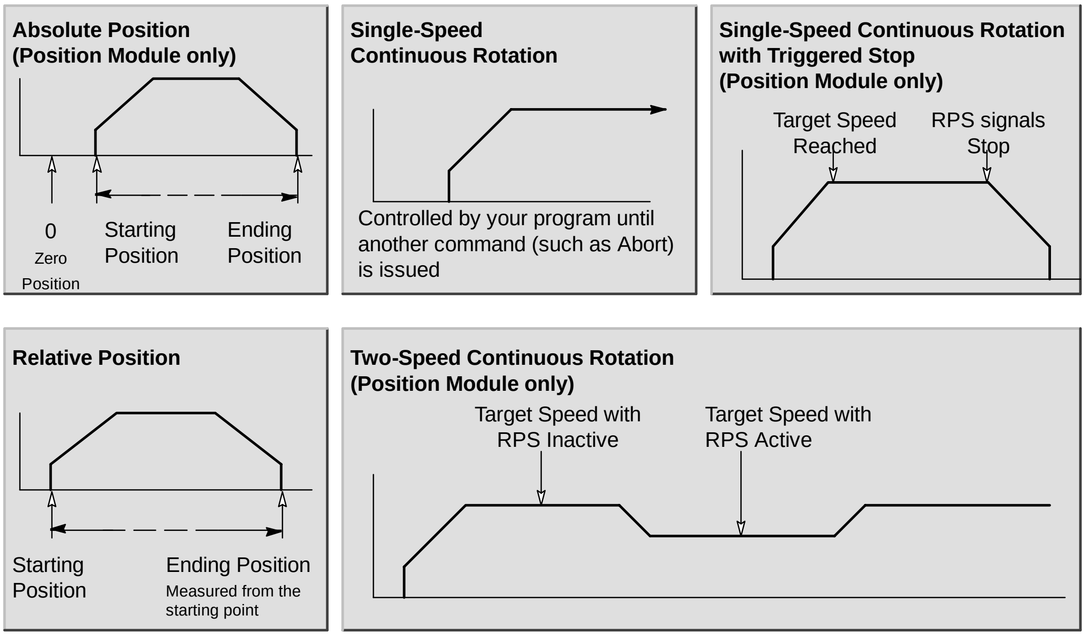


Figure 9-6 Mode Selections for the Position Module

Creating the Steps for the Profile

A step is a fixed distance that a tool moves, including the distance covered during acceleration and deceleration times. In the case of the PTO a maximum of 29 steps are allowed in each profile. The module supports a maximum of 4 steps in each profile.

You specify the target speed and ending position or number of pulses for each step. Additional steps are entered one at a time. Figure 9-7 illustrates a one-step, two-step, three-step and a four-step profile.

Notice that a one-step profile has one constant speed segment, a two-step profile has two constant speed segments, and so on. The number of steps in the profile matches the number of constant speed segments of the profile.

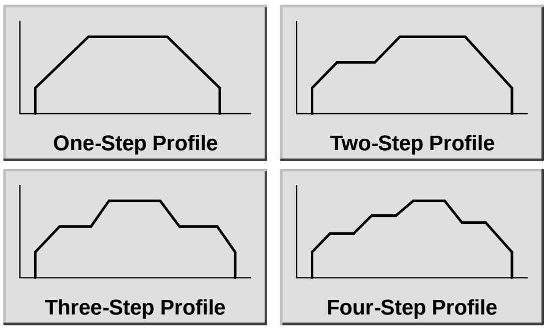


Figure 9-7 Sample Motion Profiles

Using the PTO Output

PTO provides a square wave output (50% duty cycle) for a specified number of pulses. The frequency or cycle time of each pulse changes linearly with frequency during acceleration and deceleration and remains fixed during the constant frequency portions of a movement. Once the specified number of pulses have been generated, the PTO output turns off and no further pulses are generated until a new specification is loaded. See Figure 9-8.

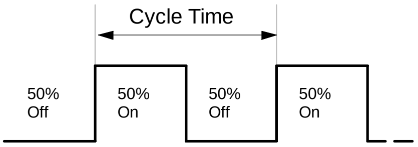


Figure 9-8 Pulse Train Output (PTO)

Configuring the PTO Output

To configure one of the built in outputs for PTO operation use the Position Control wizard. To start the Position Control wizard, either click the Tools icon in the navigation bar and then double-click the Position Control Wizard icon, or select the **Tools> Position Control Wizard** menu command.

1. Select the option to configure the onboard PTO/PWM operation for the S7-200 PLC.
2. Choose the output Q0.0 or Q0.1 that you wish to configure as a PTO output.
3. Select Linear Pulse Train Output (PTO) from the drop down dialog box.
4. If you wish to monitor the number of pulses generated by the PTO, select the use High Speed Counter by clicking the check box.
5. Enter the MAX_SPEED and the SS_SPEED in the designated edit boxes.
6. Enter the acceleration and deceleration times in the designated edit boxes.
7. In the motion profile definition screen, click the new profile button to enable defining the profile. Choose the desired mode of operation.

   For a relative position profile:

   > Fill in the target speed and the number of pulses. You may then click the plot step button to see a graphical representation of the move.
   >
   > If more than one step is needed, click the new step button and fill in the step information as required.

   For a single speed, continuous rotation:

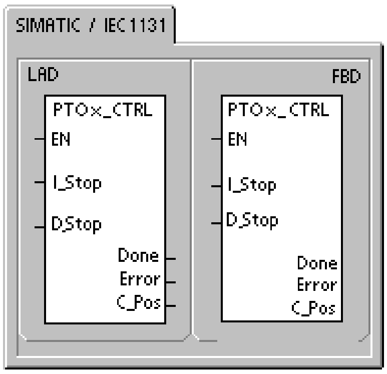
   > Enter the single speed value in the edit box.
   >
   > If you wish to terminate the single speed, continuous rotation move, click the Program a Subroutine check box and and enter the number of pulses to move after the Stop event.

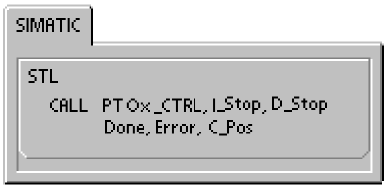
8. Define as many profiles and steps as you need to perform the desired movement
9. Then select Finish to complete the wizard.

Instructions Created by the Position Control Wizard

The Position Control wizard makes controlling your built-in PTO easier by creating five unique instruction subroutines. Each position instruction is prefixed with a “PTO*x*_” where *x* is the channel number (x=0 for Q0.0, x=1 for Q0.1).

PTOx_CTRL Subroutine





```
CALL  PTOx_CTRL, I_Stop, D_Stop
      Done, Error, C_Pos
```

The PTOx_CTRL subroutine (Control) enables and initializes the PTO output for use with a stepper or servo motor. Use this subroutine only once in your program and ensure that it is executed every scan. Always use SM0.0 as the input for the EN input.

The I_STOP (Immediate STOP) input is a Boolean input. When this input is low, the PTO function operates normally. When this input goes high, the PTO terminates the issuance of pulses immediately.

The D_STOP (Decelerated STOP) input is a Boolean input. When this input is low, the PTO function operates normally. When this input goes high, the PTO generates a pulse train that decelerates the motor to a stop.

The Done output is a Boolean output. When the Done bit is set high, it indicates the subroutine has been executed by the CPU.

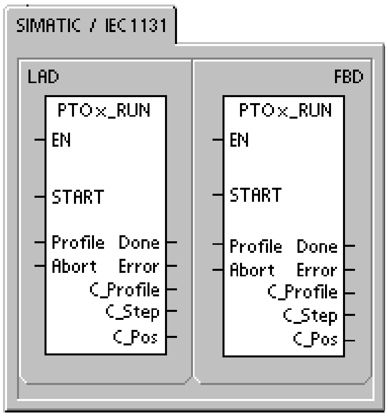
When the Done bit is high, the Error byte reports normal completion with no error or with an error code. See Table 9-7 for definitions of the error codes.

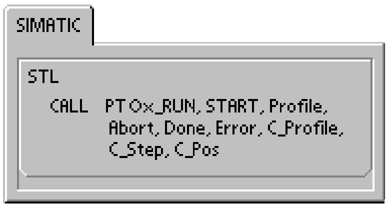
The C_Pos parameter contains the current position of the module as the number of pulses if the HSC was enabled in the wizard. Otherwise the current position is always 0.

Table 9-3 Parameters for the PTOx_CTRL Instruction

Inputs/Outputs	Data Types	Operands
I_STOP	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
D_STOP	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos	DWORD	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

PTOx_RUN Subroutine





```
STL
  CALL  PTOx_RUN, START, Profile,
        Abort, Done, Error, C_Profile,
        C_Step, C_Pos
```

The PTOx_RUN subroutine (Run Profile) commands the PLC to execute the motion operation in a specific profile stored in the configuration/profile table.

Turning on the EN bit enables the subroutine. Ensure that the EN bit stays on until the Done bit signals that the execution of the subroutine has completed.

Turning on the START parameter initiates execution of the profile. For each scan when the START parameter is on and the PTO is not currently active, the instruction activates the PTO. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The Profile parameter contains the number or the symbolic name for the motion profile.

Turning on the Abort parameter commands the Position module to stop the current profile and decelerate until the motor comes to a stop.

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-7 for definitions of the error codes.

The C_Profile parameter contains the profile currently being executed by the Position module.

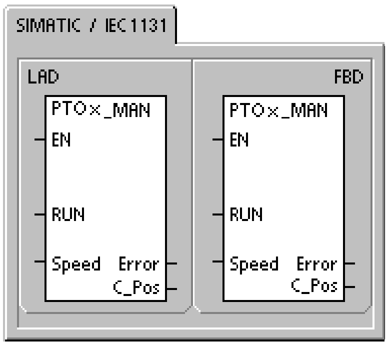
The C_Step parameter contains the step of the profile currently being executed.

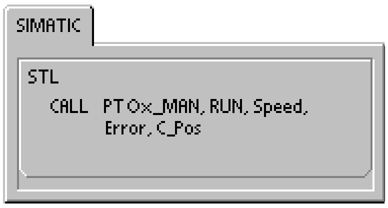
The C_Pos parameter contains the current position of the module as the number of pulses if the HSC was enabled in the wizard. Otherwise the current position is always 0.

Table 9-4 Parameters for the PTOx_RUN Instruction

Inputs/Outputs	Data Types	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Profile	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD, Constant
Abort, Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error, C_Profile, C_Step	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

PTOx_MAN Subroutine





```
STL
  CALL  PTOx_MAN, RUN, Speed,
        Error, C_Pos
```

The PTOx_MAN subroutine (Manual Mode) puts the PTO output in manual mode. This allows the motor to be started, stopped and run at different speeds within the range from Start/Stop speed through Maximum speed as specified in the wizard. While the PTOx_MAN subroutine is enabled, no other PTOx_RUN or PTOx_ADV instructions should be executed.

Enabling the RUN (Run/Stop) parameter commands the PTO to accelerate to the specified speed (Speed parameter). You can change the value for the Speed parameter while the motor is running. Disabling the RUN parameter commands the PTO to decelerate until the motor comes to a stop.

The Speed parameter determines the speed when RUN is enabled. The speed will be clamped to Start/Stop or Maximum for values of the Speed parameter outside this range. The speed is a DINT value for pulses/second. You can change this parameter while the motor is running.

The Error parameter contains the result of this instruction. See Table 9-7 for definitions of the error codes.

The C_Pos parameter contains the current position of the module as the number of pulses if the HSC was enabled in the wizard. Otherwise the current position is always 0.

Table 9-5 Parameters for the PTOx_MAN Instruction

Inputs/Outputs	Data Types	Operands
RUN	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
SPEED	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD, Constant
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

Tip

The PTO may not react to small changes in the Speed parameter, especially if the configured acceleration or deceleration time is short and the difference between the configured maximum speed and start/stop speed is large.

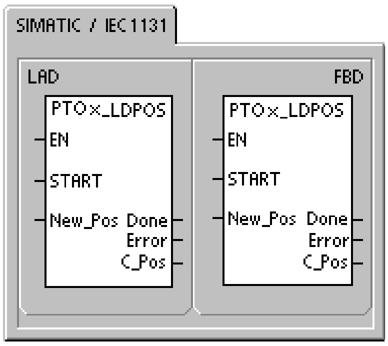
PTOx_LDPOS Instruction

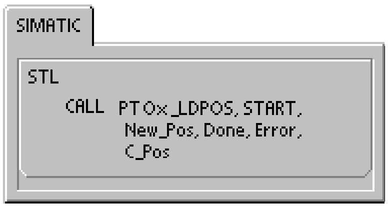
The PTOx_LDPOS instruction (Load Position) changes the current position value of the PTO pulse counter to a new value. You can also use this instruction to establish a new zero position for any move command.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter loads a new position into the PTO pulse counter. For each scan when the START parameter is on and the PTO is not currently busy, the instruction loads a new position into the PTO pulse counter. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The New_Pos parameter provides the new value to replace the current position value that is reported. The position value is expressed as a number of pulses.





```
CALL  PTOx_LDPOS, START,
       New_Pos, Done, Error,
       C_Pos
```

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-7 for definitions of the error codes.

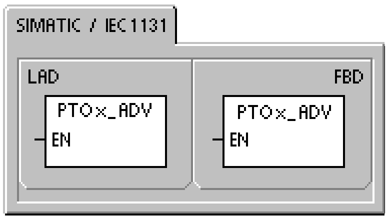
The C_Pos parameter contains the current position of the module as the number of pulses if the HSC was enabled in the wizard. Otherwise the current position is always 0.

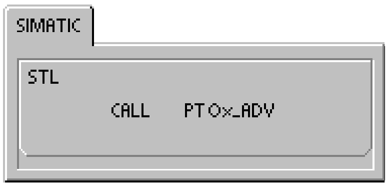
Table 9-6 Parameters for the PTOx_LDPOS Instruction

Inputs/Outputs	Data Types	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
New_Pos, C_Pos	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

PTOx_ADV Subroutine

The PTOx_ADV subroutine stops the current continuous motion profile and advances the number of pulses specified in the wizard profile definition. This subroutine is created if you have specified at least one single speed continuous rotation with the PTOx_ADV option enabled in the Position Control Wizard.





```
CALL    PTOx_ADV
```

Error Codes for the PTO Instructions

Table 9-7   PTO Instruction Error Codes

Error Code	Description
0	No error, normal completion
1	Immediate STOP issued during move. STOP command completed successfully
2	Decelerated STOP issued during move. STOP command completed successfully
3	Execution error detected in the pulse generator or in format of the PTO table
127	An ENO error was encountered. Check PLC information for description on non-fatal error
128	Busy. Another PTO operation is already in process
129	Both the Immediate STOP and Decelerated STOP commands were enabled at the same time, resulting in an immediate STOP
130	The PTO instruction is currently being commanded to STOP
132	Requested profile number is out of range

Features of the Position Module

The Position module provides the functionality and performance that you need for single-axis, open-loop position control:

- ❑ Provides high-speed control, with a range from 20 pulses per second up to 200,000 pulses per second
- ❑ Supports both jerk (S curve) or linear acceleration and deceleration
- ❑ Provides a configurable measuring system that allows you to enter data either as engineering units (such as inches or centimeters) or as a number of pulses
- ❑ Provides configurable backlash compensation
- ❑ Supports absolute, relative, and manual methods of position control
- ❑ Provides continuous operation
- ❑ Provides up to 25 motion profiles, with up to 4 speed changes per profile
- ❑ Provides four different reference-point seek modes, with a choice of the starting seek direction and the final approach direction for each sequence
- ❑ Provides removable field wiring connectors for easy installation and removal

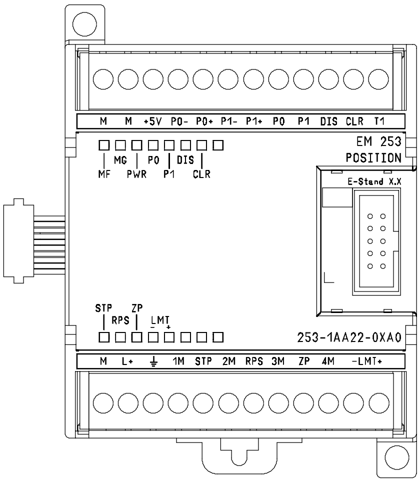


Figure 9-9 EM 253 Position Module

You use STEP 7–Micro/WIN to create all of the configuration and profile information used by the Position module. This information is downloaded to the S7-200 with your program blocks. Because all the information required for position control is stored in the S7-200, you can replace a Position module without having to reprogram or reconfigure the module.

The S7-200 reserves 8 bits of the process image output register (Q memory) for the interface to the Position module. Your application program in the S7-200 uses these bits to control the operation of the Position module. These 8 output bits are not connected to any of the physical field outputs of the Position module.

The Position module provides five digital inputs and four digital outputs that provide the interface to your motion application. See Table 9-8. These inputs and outputs are local to the Position module. Appendix A provides the detailed specifications for the Position module and also includes wiring diagrams for connecting the Position module to some of the more common motor driver/amplifier units.

Table 9-8 Inputs and Outputs of the Position Module

Signal	Description
STP	The STP input causes the module to stop the motion in progress. You can select the desired operation of STP within the Position Control wizard.
RPS	The RPS (Reference Point Switch) input establishes the reference point or home position for absolute move operations.
ZP	The ZP (Zero Pulse) input helps establish the reference point or home position. Typically, the motor driver/amplifier pulses ZP once per motor revolution.
LMT+ LMT–	LMT+ and LMT– inputs establish the maximum limits for motion travel. The Position Control wizard allows you to configure the operation of LMT+ and LMT– inputs.
P0 P1 P0+, P0– P1+, P1–	P0 and P1 are open drain transistor pulse outputs that control the movement and direction of movement of the motor. P0+, P0– and P1+, P1– are differential pulse outputs that provide the identical functions of P0 and P1, respectively, while providing superior signal quality. The open drain outputs and the differential outputs are all active simultaneously. Based upon the interface requirements of motor driver/amplifier, you choose which set of pulse outputs to use.
DIS	DIS is an open drain transistor output used to disable or enable the motor driver/amplifier.
CLR	CLR is an open drain transistor output used to clear the servo pulse count register.

Programming the Position Module

STEP 7–Micro/WIN provides easy-to-use tools for configuring and programming the Position module. Simply follow these steps:

1. Configure the Position module. STEP 7–Micro/WIN provides a Position Control wizard for creating the configuration/profile table and the position instructions. See Configuring the Position Module on page 270 for information about configuring the Position module.

2. Test the operation of the Position Module. STEP 7–Micro/WIN provides an EM 253 control panel for testing the wiring of the inputs and outputs, the configuration of the Position module, and the operation of the motion profiles. See page 290 for information about the EM 253 control panel.

3. Create the program to be executed by the S7-200. The Position Control wizard automatically creates the position instructions that you insert into your program. See page 273 for information about the position instructions. Insert the following instructions into your program:

    - To enable the Position module, insert a POSx_CTRL instruction. Use SM0.0 (Always On) to ensure that this instruction is executed every scan.
    - To move the motor to a specific location, use a POSx_GOTO or a POSx_RUN instruction. The POSx_GOTO instruction move to a location specified by the inputs from your program. The POSx_RUN instruction executes the motion profiles you configured with the Position Control wizard.
    - To use absolute coordinates for your motion, you must establish the zero position for your application. Use the a POSx_RSEEK or a POSx_LDPOS instruction to establish the zero position.
    - The other instructions that are created by the Position Control wizard provide functionality for typical applications and are optional for your specific application.

4. Compile your program and download the system block, data block, and program block to the S7-200.

Tip

Refer to Appendix A for information about connecting the Position module to several common stepper motor controllers.

Tip

To match the default settings in the Position Control wizard, set the DIP switches on the stepper motor controller to 10,000 pulses per revolution.

Configuring the Position Module

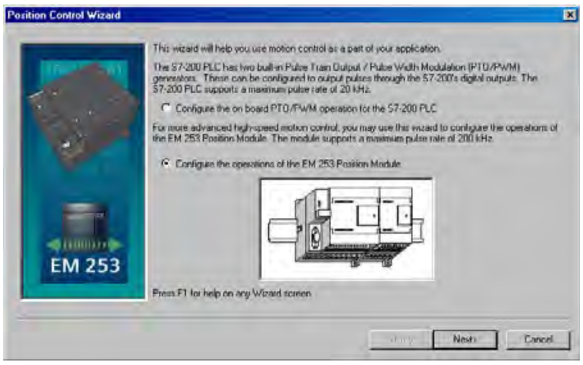
Position Control

You must create a configuration/profile table for the Position module in order for the module to control your motion application. The Position Control wizard makes the configuration process quick and easy by leading you step-by-step through the configuration process. Refer to the Advanced Topics on page 294 for detailed information about the configuration/profile table.

The Position Control wizard also allows you to create the configuration/profile table offline. You can create the configuration without being connected to an S7-200 CPU with a Position module installed.

To run the Position Control wizard, your project must have been compiled and set to symbolic addressing mode.

To start the Position Control wizard, either click the Tools icon in the navigation bar and then double-click the Position Control Wizard icon, or select the **Tools> Position Control Wizard** menu command.



This wizard will help you use motion control as a part of your application.

The S7-200 PLC has two built-in Pulse Train Output / Pulse Width Modulation (PTO/PWM) generators. These can be configured to output pulses through the S7-200's digital outputs. The S7-200 PLC supports a maximum pulse rate of 20 kHz.

○ Configure the on board PTO/PWM operation for the S7-200 PLC

For more advanced high-speed motion control, you may use this wizard to configure the operations of the EM 253 Position Module. The module supports a maximum pulse rate of 200 kHz.

● Configure the operations of the EM 253 Position Module

Press F1 for help on any Wizard screen

Figure 9-10 Position Control Wizard

To configure the Position Control Module use the Position Control wizard. Select the option to configure the EM 253 Position Control Module.

Enter location of module

Specify the module slot position (module 0 to module 6). If STEP 7-Micro/WIN is connected to the PLC, you only have to click the Read Modules button. For an S7-200 CPU with firmware prior to version 1.2, the module must be installed next to the CPU.

Select type of measurement

Select the measurement system. You can select either engineering units or pulses. If you select pulses, no other information is required. If you select engineering units, the number of pulses required to produce one revolution of the motor (refer to the data sheet for your motor or drive), the base unit of measurement (such as inch, foot, millimeter, or centimeter), and the distance traveled in one revolution of the motor.

❑ STEP 7-Micro/WIN provides an EM253 Control Panel that allows you to modify the number of units per revolution after the Position module has been configured.

❑ If you change the measurement system later, you must delete the entire configuration including any instructions generated by the Position Control wizard. You must then enter your selections consistent with the new measurement system.

Edit default input and output configuration

To change or view the default configuration of the integrated inputs/outputs select the Advanced Options button.

❑ Use the Input Active Levels tab to select the active level (High or Low). When the level is set to High, a logic 1 is read when current is flowing in the input. When the level is set to Low, a logic 1 is read when there is no current flow in the input. A logic 1 level is always interpreted as meaning the condition is active. The LEDs are illuminated when current flows in the input, regardless of activation level. (Default = active high)

❑ Use the Input Filter Times tab to select the filter time constant (0.20 ms to 12.80 ms) for the STP, RPS, LMT+, and LMT– inputs. Increasing the filter time constant eliminates more noise, but it also slows down the response time to a signal state change. (Default = 6.4 ms)

❑ Use the Pulse and Directional Outputs tab to select the polarity of the outputs and to select the direction control method. See Figures 9-11 and 9-12 to see the effects of polarity and direction control method selections.

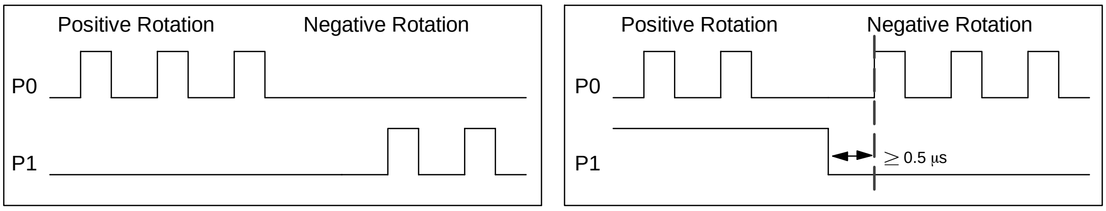


Figure 9-11 Rotation Options for Positive Polarity

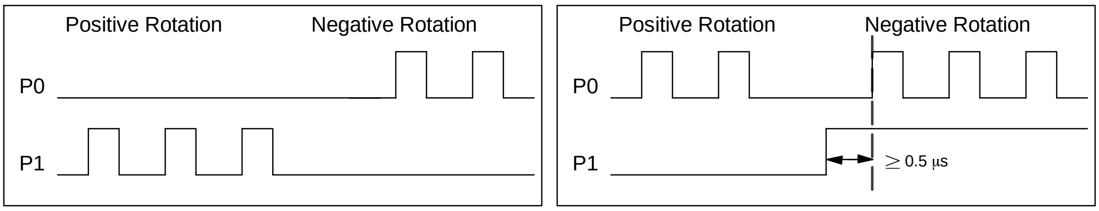


Figure 9-12 Rotation Options for Negative Polarity

Warning

Control devices can fail in unsafe conditions, and can result in unpredictable operation of controlled equipment. Such unpredictable operations could result in death or serious personal injury, and/or equipment failure.

The limit and stop functions in the Position Module are electronic logic implementations that do not provide the level of protection provided by electromechanical controls. Consider using an emergency stop function, electromechanical overrides, or redundant safeguards that are independent of the Position module and the S7-200 CPU.

Configure response of module to physical inputs

Next, select the module response to the LMT+, the LMT–, and the STP inputs. Use the drop down box to select: no action (ignore the input condition), decelerate to a stop (default), or immediate stop.

Enter maximum start and stop speed

Enter the maximum speed (MAX_SPEED) and Start/Stop Speed (SS_SPEED) for your application

Enter jog parameters

Next, enter the JOG_SPEED and the JOG_INCREMENT values.

- ❑ JOG_SPEED: The JOG_SPEED (Jog speed for the motor) is the maximum speed that can be obtained while the JOG command remains active.
- ❑ JOG_INCREMENT: Distance that the tool is moved by a momentary JOG command.

Figure 9-13 shows the operation of the Jog command. When the Position module receives a Jog command, it starts a timer. If the Jog command is terminated before 0.5 seconds has elapsed, the Position module moves the tool the amount specified in the JOG_INCREMENT at the speed defined by SS_SPEED. If the Jog command is still active when the 0.5 seconds have elapsed, the Position module accelerates to the JOG_SPEED. Motion continues until the Jog command is terminated. The Position module then performs a decelerated stop. You can enable the Jog command either from the EM 253 control panel or with a position instruction.

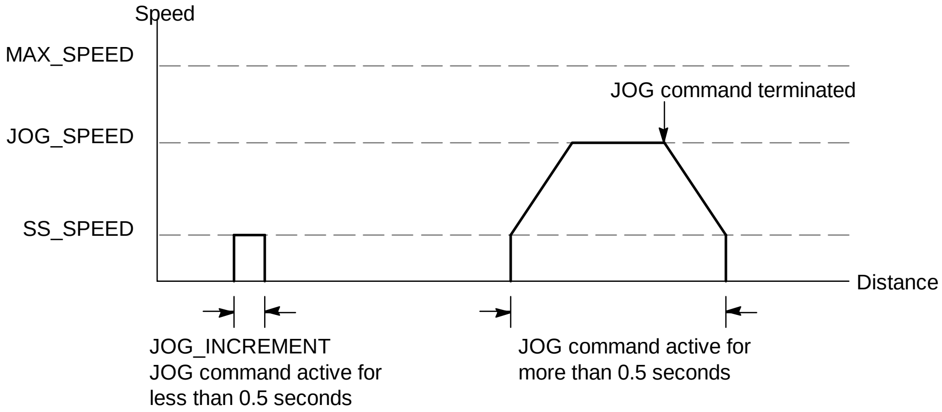


Figure 9-13 Representation of a JOG Operation

Enter acceleration time

Enter the acceleration and deceleration times in the edit boxes

Enter jerk time

For single step moves enter the jerk time compensation. This provides smoother position control by reducing the jerk (rate of change) in acceleration and deceleration parts of the motion profile. See Figure 9-14.

Jerk time compensation is also known as ”S curve profiling.” This compensation is applied equally to the beginning and ending portions of both the acceleration and deceleration curve. Jerk compensation is not applied to the initial and final step between zero speed and SS_SPEED.

You specify the jerk compensation by entering a time value (JERK_TIME). This is the time required for acceleration to change from zero to the maximum acceleration rate. A longer jerk time yields smoother operation with a smaller increase in total cycle time than would be obtained by decreasing the ACCEL_TIME and DECEL_TIME. A value of zero indicates that no compensation is to be applied.

(Default = 0 ms)

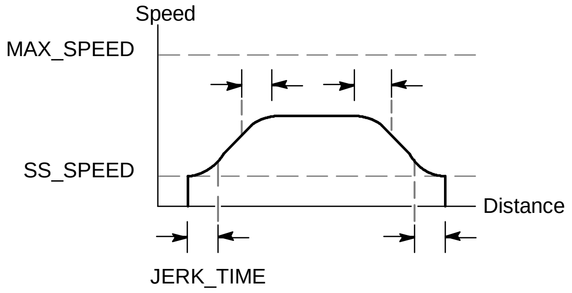


Figure 9-14 Jerk Compensation

Tip
A good first value for JERK_TIME is 40% of ACCEL_TIME.

Configure reference point and seek parameters

Select using a reference point or not using a reference point for your application.

❑ If your application requires that movements start from or be referenced to an absolute position, you must establish a reference point (RP) or zero position that fixes the position measurements to a known point on the physical system.

❑ If a reference point is used, you will want to define a way to automatically relocate the reference point. The process of automatically locating the reference point is called Reference Point Seek. Defining the Reference Point Seek process requires two steps in the wizard.

Enter the Reference Point seek speeds (a fast seek speed and a slow seek speed). Define the initial seek direction and the final reference point approach direction. Use the advanced RP Options button to enter Reference Point Offset and backlash compensation values.

RP_FAST is the initial speed the module uses when performing an RP seek command. Typically, the RP_FAST value is approximately 2/3 of the MAX_SPEED value.

RP_SLOW is the speed of the final approach to the RP. A slower speed is used on approach to the RP, so as not to miss it. Typically, the RP_SLOW value is the SS_SPEED value.

RP_SEEK_DIR is the initial direction for the RP seek operation. Typically, this is the direction from the work zone to the vicinity of the RP. Limit switches play an important role in defining the region that is searched for the RP. When performing a RP seek operation, encountering a limit switch can result in a reversal of the direction, which allows the search to continue. (Default = Negative)

RP_APPR_DIR is the direction of the final approach to the RP. To reduce backlash and provide more accuracy, the reference point should be approached in the same direction used to move from the RP to the work zone. (Default = Positive)

❑ The Position Control wizard provides advanced reference point options that allow you to specify an RP offset (RP_OFFSET), which is the distance from the RP to the zero position. See Figure 9-15.

RP_OFFSET: Distance from the RP to the zero position of the physical measuring system. Default = 0

Backlash compensation: Distance that the motor must move to eliminate the slack (backlash) in the system on a direction change. Backlash compensation is always a positive value. Default = 0

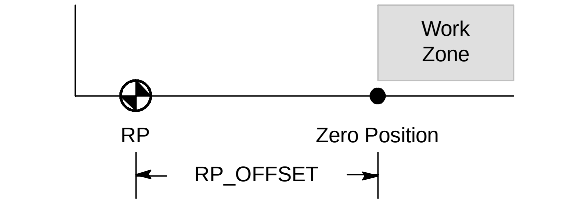


Figure 9-15 Relationship Between RP and Zero Position

Choose a Reference Point search sequence.

❑ The Position module provides a reference point switch (RPS) input that is used when seeking the RP. The RP is identified by a method of locating an exact position with respect to the RPS. The RP can be centered in the RPS Active zone, the RP can be located on the edge of the RPS Active zone, or the RP can be located a specified number of zero pulse (ZP) input transitions from the edge of the RPS Active zone.

You can configure the sequence that the Position module uses to search for the reference point. Figure 9-16 shows a simplified diagram of the default RP search sequence. You can select the following options for the RP search sequence:

RP Seek mode 0: Does not perform a RP seek sequence

RP Seek mode 1: The RP is where the RPS input goes active on the approach from the work zone side. (Default)

RP Seek mode 2: The RP is centered within the active region of the RPS input.

RP Seek mode 3: The RP is located outside the active region of the RPS input. RP_Z_CNT specifies how many ZP (Zero Pulse) input counts should be received after the RPS becomes inactive.

RP Seek mode 4: The RP is generally within the active region of the RPS input. RP_Z_CNT specifies how many ZP (Zero Pulse) input counts should be received after the RPS becomes active.

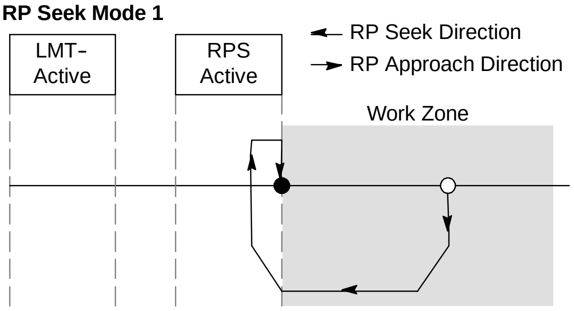


Figure 9-16 Default RP Search Sequence (Simplified)

Tip

The RPS Active region (which is the distance that the RPS input remains active) must be greater than the distance required to decelerate from the RP_FAST speed to the RP_SLOW speed. If the distance is too short, the Position module generates an error.

Command byte

Next enter the Q byte address for the command byte. The command byte is the address of the 8 digital outputs reserved in the process image register for the interface to the Position Module. See Figure 4-11 in Chapter 4 for a description of the I/O numbering.

Defining the motion profile

In the motion profile definition screen, click the new profile button to enable defining the profile. Choose the desired mode of operation.

- For an absolute position profile:

  Fill in the target speed and the ending position. You may then click the plot step button to see a graphical representation of the move.

  If more than one step is needed, click the new step button and fill in the step information as required.

- For a relative position profile:

  Fill in the target speed and the ending position. You may then click the plot step button to see a graphical representation of the move.

  If more than one step is needed, click the new step button and fill in the step information as required.

- For a single-speed, continuous rotation:

  Enter the single speed value in the edit box.

  Select the direction of rotation

  If you wish to terminate the single speed, continuous rotation move using the RPS input, click the check box.

- For a two-speed, continuous rotation:

  Enter the target speed value when RPS is high in the edit box.

  Enter the target speed value when RPS is low in the edit box.

  Select the direction of rotation

Define as many profiles and steps as you need to perform the desired movement.

Finish the configuration

After you have configured the operation of the Position module, you simply click Finish, and the Position Control wizard performs the following tasks:

- Inserts the module configuration and profile table into the data block for your S7-200 program
- Creates a global symbol table for the motion parameters
- Adds the motion instruction subroutines into the project program block for you to use in your application

You can run the Position Control wizard again in order to modify any configuration or profile information.

Tip

Because the Position Control wizard makes changes to the program block, the data block and the system block, be sure to download all three blocks to the S7-200 CPU. Otherwise, the Position module might not have all the program components that it needs for proper operation.

Instructions Created by the Position Control Wizard for the Position Module

The Position Control wizard makes controlling the Position module easier by creating unique instruction subroutines based on the position of the module and configuration options you selected. Each position instruction is prefixed with a ”POS*x*_” where *x* is the module location. Because each position instruction is a subroutine, the 11 position instructions use 11 subroutines.

Tip

The position instructions increase the amount of memory required for your program by up to 1700 bytes. You can delete unused position instructions to reduce the amount of memory required. To restore a deleted position instruction, simply run the Position Control wizard again.

Guidelines for Using the Position Instructions

You must ensure that only one position instruction is active at a time.

You can execute the POSx_RUN and POSx_GOTO from an interrupt routine. However, it is very important that you do not attempt to start an instruction in an interrupt routine if the module is busy processing another command. If you start an instruction in an interrupt routine, then you can use the outputs of the POSx_CTRL instruction to monitor when the Position module has completed the movement.

The Position Control wizard automatically configures the values for the speed parameters (Speed and C_Speed) and the position parameters (Pos or C_Pos) according to the measurement system that you selected. For pulses, these parameters are DINT values. For engineering units, the parameters are REAL values for the type of unit that you selected. For example: selecting centimeters (cm) stores the position parameters as REAL values in centimeters and stores the speed parameters as REAL values in centimeters per second (cm/sec).

The following position instructions are required for specific position control tasks:

❑ Insert the POSx_CTRL instruction in your program and use the SM0.0 contact to execute it every scan.

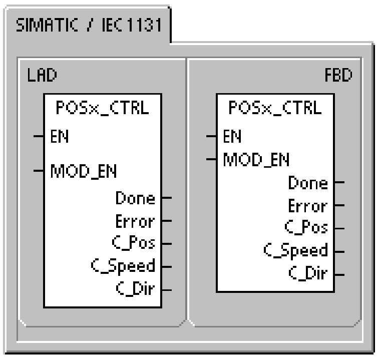
❑ To specify motion to an absolute position, you must first use either an POSx_RSEEK or a POSx_LDPOS instruction to establish the zero position.

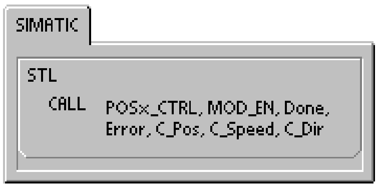
❑ To move to a specific location, based on inputs from your program, use the POSx_GOTO instruction.

❑ To run the motion profiles you configured with the Position Control wizard, use the POSx_RUN instruction.

The other position instructions are optional.

POSx_CTRL Instruction





```
CALL   POSx_CTRL, MOD_EN, Done,
       Error, C_Pos, C_Speed, C_Dir
```

The POSx_CTRL instruction (Control) enables and initializes the Position module by automatically commanding the Position module to load the configuration/profile table each time the S7-200 changes to RUN mode.

Use this instruction only once in your project, and ensure that your program calls this instruction every scan. Use SM0.0 (Always On) as the input for the EN parameter.

The MOD_EN parameter must be on to enable the other position instructions to send commands to the Position module. If the MOD_EN parameter turns off, then the Position module aborts any command that is in progress.

The output parameters of the POSx_CTRL instruction provide the current status of the Position module.

The Done parameter turns on when the Position module completes any instruction.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

The C_Pos parameter is the current position of the module. Based of the units of measurement, the value is either a number of pulses (DINT) or the number of engineering units (REAL).

The C_Speed parameter provides the current speed of the module. If you configured the measurement system for the Position module for pulses, C_Speed is a DINT value containing the number of pulses/second. If you configured the measurement system for engineering units, C_Speed is a REAL value containing the selected engineering units/second (REAL).

The C_Dir parameter indicates the current direction of the motor.

Table 9-9 Parameters for the POSx_CTRL Instruction

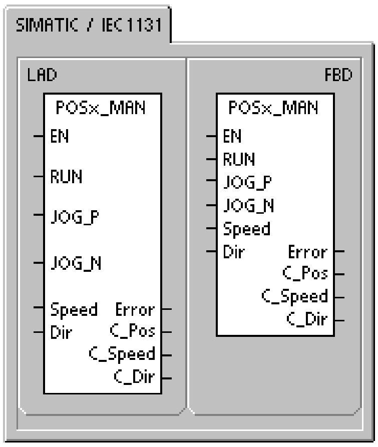
Inputs/Outputs	Data Type	Operands
MOD_EN	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done, C_Dir	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos, C_Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

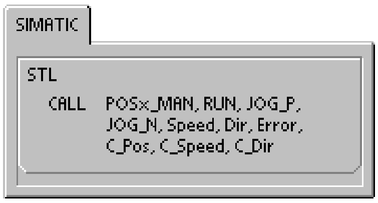
Tip

The Position module reads the configuration/profile table only at power-up or when commanded to load the configuration.

- If you use the Position Control wizard to modify the configuration, then the POSx_CTRL instruction automatically commands the Position module to load the configuration/profile table every time the S7-200 CPU changes to RUN mode.
- If you use the EM 253 Control Panel to modify the configuration, clicking the Update Configuration button commands the Position module to load the new configuration/profile table.
- If you use another method to modify the configuration, then you must also issue a Reload the Configuration command to the Position module to load the configuration/profile table. Otherwise, the Position module continues to use the old configuration/profile table.

POSx_MAN Instruction





```
STL
  CALL   POSx_MAN, RUN, JOG_P,
         JOG_N, Speed, Dir, Error,
         C_Pos, C_Speed, C_Dir
```

The POSx_MAN instruction (Manual Mode) puts the Position module into manual mode. This allows the motor to be run at different speeds or to be jogged in a positive or negative direction. While the POSx_MAN instruction is enabled, only the POSx_CTRL and POSx_DIS instructions are allowed.

You can enable only one of the RUN, JOG_P, or JOG_N inputs at a time.

Enabling the RUN (Run/Stop) parameter commands to the Position module to accelerate to the specified speed (Speed parameter) and direction (Dir parameter). You can change the value for the Speed parameter while the motor is running, but the Dir parameter must remain constant. Disabling the RUN parameter commands the Position module to decelerate until the motor comes to a stop.

Enabling the JOG_P (Jog Positive Rotation) or the JOG_N (Jog Negative Rotation) parameter commands the Position module to jog in either a positive or negative direction. If the JOG_P or JOG_N parameter remains enabled for less than 0.5 seconds, the Position module issues pulses to travel the distance specified in JOG_INCREMENT. If the JOG_P or JOG_N parameter remains enabled for 0.5 seconds or longer, the motion module begins to accelerate to the specified JOG_SPEED.

The Speed parameter determines the speed when RUN is enabled. If you configured the measuring system of the Position module for pulses, the speed is a DINT value for pulses/second. If you configured the measuring system of the Position module for engineering units, the speed is a REAL value for units/second. You can change this parameter while the motor is running.

Tip

The Position module may not react to small changes in the Speed parameter, especially if the configured acceleration or deceleration time is short and the difference between the configured maximum speed and start/stop speed is large.

For more information refer to FAQ 22632118 on the Siemens Internet site at www.siemens.com/S7-200.

The Dir parameter determines the direction to move when RUN is enabled. You cannot change this value when the RUN parameter is enabled.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

The C_Pos parameter contains the current position of the module. Based of the units of measurement selected, the value is either a number of pulses (DINT) or the number of engineering units (REAL).

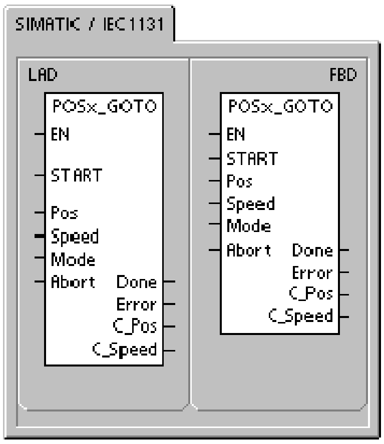
The C_Speed parameter contains the current speed of the module. Based of the units of measurement selected, the value is either the number of pulses/second (DINT) or the engineering units/second (REAL).

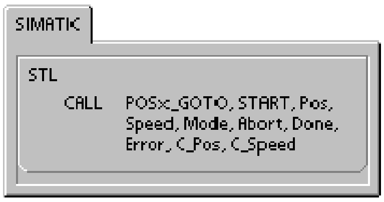
The C_Dir parameter indicates the current direction of the motor.

Table 9-10 Parameters for the POSx_MAN Instruction

Inputs/Outputs	Data Type	Operands
RUN, JOG_P, JOG_N	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD, Constant
Dir, C_Dir	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos, C_Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

POSx_GOTO Instruction





```
CALL    POSx_GOTO, START, Pos,
        Speed, Mode, Abort, Done,
        Error, C_Pos, C_Speed
```

The POSx_GOTO instruction commands the Position Module to go to a desired location.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the DONE bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a GOTO command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a GOTO command to the Position module. To ensure that only one GOTO command is sent, use an edge detection element to pulse the START parameter on.

The Pos parameter contains a value that signifies either the location to move (for an absolute move) or the distance to move (for a relative move). Based of the units of measurement selected, the value is either a number of pulses (DINT) or the engineering units (REAL).

The Speed parameter determines the maximum speed for this movement. Based of the units of measurement, the value is either a number of pulses/second (DINT) or the engineering units/second (REAL).

The Mode parameter selects the type of move:
0 – Absolute position
1 – Relative position
2 – Single–speed, continuous positive rotation
3 – Single–speed, continuous negative rotation

The Done parameter turns on when the Position module completes this instruction.

Turning on the Abort parameter commands the Position module to stop the current profile and decelerate until the motor comes to a stop.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

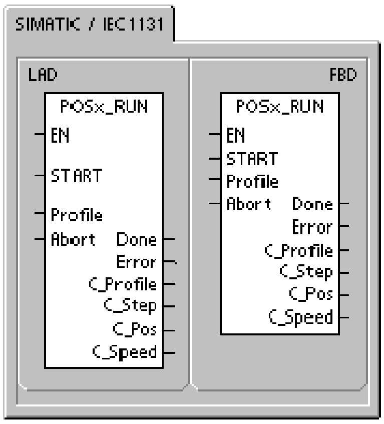
The C_Pos parameter contains current position of the module. Based of the units of measurement, the value is either a number of pulses (DINT) or the number of engineering units (REAL).

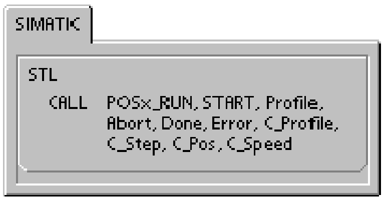
The C_Speed parameter contains the current speed of the module. Based of the units of measurement, the value is either a number of pulses/second (DINT) or the engineering units/second (REAL).

Table 9-11 Parameters for the POSx_GOTO Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Pos, Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD, Constant
Mode	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD, Constant
Abort, Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos, C_Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

POSx_RUN Instruction





```
CALL   POSx_RUN, START, Profile,
       Abort, Done, Error, C_Profile,
       C_Step, C_Pos, C_Speed
```

The POSx_RUN instruction (Run Profile) commands the Position module to execute the motion operation in a specific profile stored in the configuration/profile table.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a RUN command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a RUN command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The Profile parameter contains the number or the symbolic name for the motion profile. You can also select the advanced motion commands (118 to 127). For information about the motion commands, see Table 9-26.

Turning on the Abort parameter commands the Position module to stop the current profile and decelerate until the motor comes to a stop.

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

The C_Profile parameter contains the profile currently being executed by the Position module.

The C_Step parameter contains the step of the profile currently being executed.

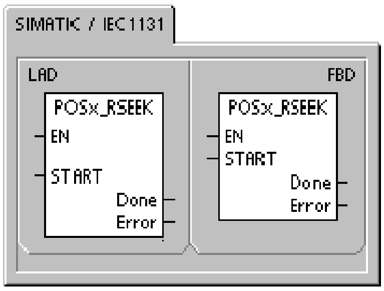
The C_Pos parameter contains the current position of the module. Based of the units of measurement, the value is either a number of pulses (DINT) or the number of engineering units (REAL).

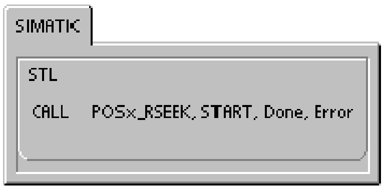
The C_Speed parameter contains the current speed of the module. Based of the units of measurement, the value is either a number of pulses/second (DINT) or the engineering units/second (REAL).

Table 9-12 Parameters for the POSx_RUN Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Profile	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD, Constant
Abort, Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error, C_Profile, C_Step	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD
C_Pos, C_Speed	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD

POSx_RSEEK Instruction





```
CALL    POSx_RSEEK, START, Done, Error
```

The POSx_RSEEK instruction (Seek Reference Point Position) initiates a reference point seek operation, using the search method in the configuration/profile table. When the Position module locates the reference point and motion has stopped, the Position module loads the RP_OFFSET parameter value into the current position and generates a 50-millisecond pulse on the CLR output.

The default value for RP_OFFSET is 0. You can use the Position Control wizard, the EM253 Control Panel, or the POSx_LDOFF (Load Offset) instruction to change the RP_OFFSET value.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a RSEEK command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a RSEEK command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

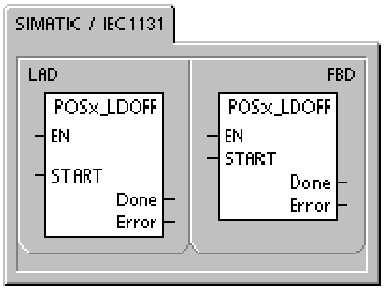
The Done parameter turns on when the module completes this instruction.

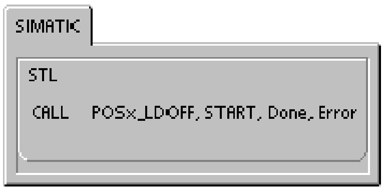
The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

Table 9-13 Parameters for the POSx_RSEEK Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

POSx_LDOFF Instruction




SIMATIC

STL

```
CALL   POSx_LDOFF, START, Done, Error
```

The POSx_LDOFF instruction (Load Reference Point Offset) establishes a new zero position that is at a different location from the reference point position.

Before executing this instruction, you must first determine the position of the reference point. You must also move the machine to the starting position. When the instruction sends the LDOFF command, the Position module computes the offset between the starting position (the current position) and the reference point position. The Position module then stores the computed offset to the RP_OFFSET parameter and sets the current position to 0. This establishes the starting position as the zero position.

In the event that the motor loses track of its position (such as on loss of power or if the motor is repositioned manually), you can use the POSx_RSEEK instruction to re-establish the zero position automatically.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a LDOFF command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a LDOFF command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-20 on for definitions of the error codes.

Table 9-14 Parameters for the POSx_LDOFF Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

POSx_LDPOS Instruction

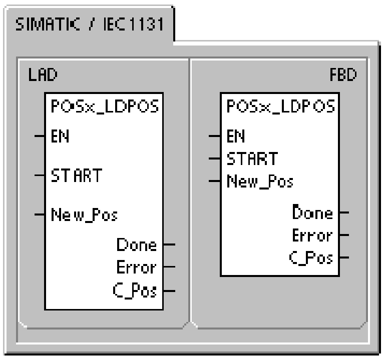
The POSx_LDPOS instruction (Load Position) changes the current position value in the Position module to a new value. You can also use this instruction to establish a new zero position for any absolute move command.

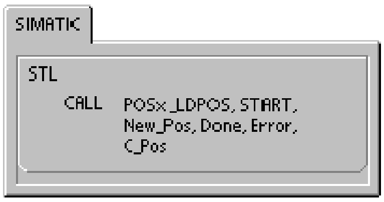
Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a LDPOS command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a LDPOS command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The New_Pos parameter provides the new value to replace the current position value that the Position module reports and uses for absolute moves. Based of the units of measurement, the value is either a number of pulses (DINT) or the engineering units (REAL).

The Done parameter turns on when the module completes this instruction.





```
CALL   POSx_LDPOS, START,
       New_Pos, Done, Error,
       C_Pos
```

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

The C_Pos parameter contains the current position of the module. Based of the units of measurement, the value is either a number of pulses (DINT) or the number of engineering units (REAL).

Table 9-15 Parameters for the POSx_LDPOS Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
New_Pos, C_Pos	DINT, REAL	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

POSx_SRATE Instruction

The POSx_SRATE instruction (Set Rate) commands the Position module to change the acceleration, deceleration, and jerk times.

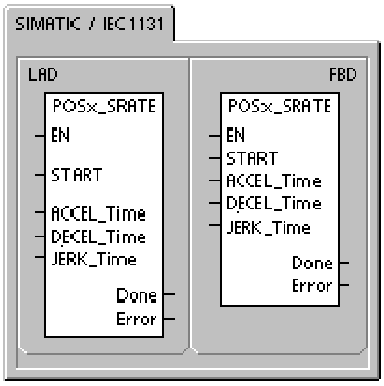
Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

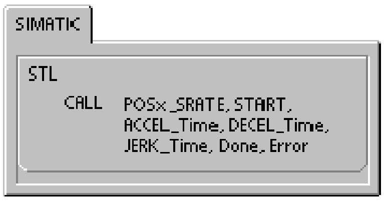
Turning on the START parameter copies the new time values to the configuration/profile table and sends a SRATE command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a SRATE command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The ACCEL_Time, DECEL_Time, and JERK_Time parameters determine the new acceleration time, deceleration time, and jerk time in milliseconds (ms).

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.





```
CALL    POSx_SRATE, START,
        ACCEL_Time, DECEL_Time,
        JERK_Time, Done, Error
```

Table 9-16 Parameters for the POSx_SRATE Instruction

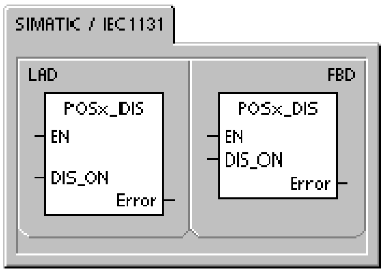
Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L
ACCEL_Time, DECEL_Time, JERK_Time	DINT	ID, QD, VD, MD, SMD, SD, LD, AC, *VD, *AC, *LD, Constant
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

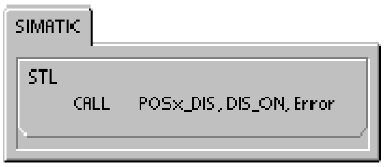
POSx_DIS Instruction

The POSx_DIS instruction turns the DIS output of the Position module on or off. This allows you to use the DIS output for disabling or enabling a motor controller. If you use the DIS output on the Position module, then this instruction can be called every scan or only when you need to change the value of the DIS output.

When the EN bit turns on to enable the instruction, the DIS_ON parameter controls the DIS output of the Position module. For more information about the DIS output, see Table 9-8 or refer to the specifications for the Position module in Appendix A.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.



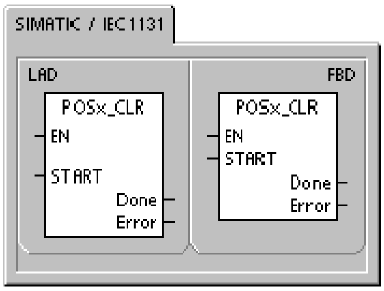


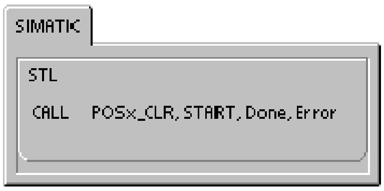
```
CALL    POSx_DIS, DIS_ON, Error
```

Table 9-17 Parameters for the POSx_DIS Instruction

Inputs/Outputs	Data Type	Operands
DIS_ON	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD, Constant
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

POSx_CLR Instruction





```
CALL   POSx_CLR, START, Done, Error
```

The POSx_CLR instruction (Pulse the CLR Output) commands the Position module to generate a 50-ms pulse on the CLR output.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a CLR command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a CLR command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

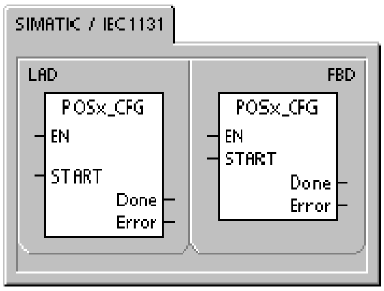
The Done parameter turns on when the module completes this instruction.

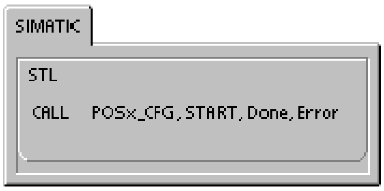
The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

Table 9-18 Parameters for the POSx_CLR Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

POSx_CFG Instruction





```
CALL    POSx_CFG, START, Done, Error
```

The POSx_CFG instruction (Reload Configuration) commands the Position module to read the configuration block from the location specified by the configuration/profile table pointer. The Position module then compares the new configuration with the existing configuration and performs any required setup changes or recalculations.

Turning on the EN bit enables the instruction. Ensure that the EN bit stays on until the Done bit signals that the execution of the instruction has completed.

Turning on the START parameter sends a CFG command to the Position module. For each scan when the START parameter is on and the Position module is not currently busy, the instruction sends a CFG command to the Position module. To ensure that only one command is sent, use an edge detection element to pulse the START parameter on.

The Done parameter turns on when the module completes this instruction.

The Error parameter contains the result of this instruction. See Table 9-20 for definitions of the error codes.

Table 9-19 Parameters for the POSx_CFG Instruction

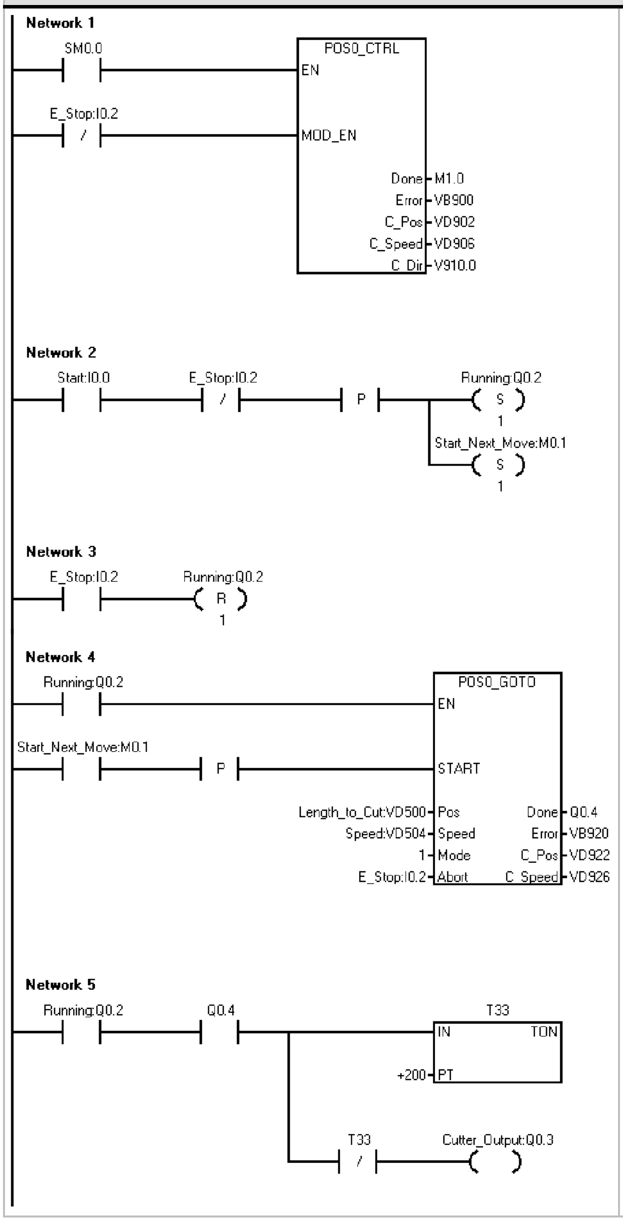
Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, V, M, SM, S, T, C, L, Power Flow
Done	BOOL	I, Q, V, M, SM, S, T, C, L
Error	BYTE	IB, QB, VB, MB, SMB, SB, LB, AC, *VD, *AC, *LD

Sample Programs for the Position Module

The first sample program shows a simple relative move that uses the POSx_CTRL and POSx_GOTO instructions to perform a cut-to-length operation. This program does not require an RP seek mode or a motion profile, and the length can be measured in either pulses or engineering units. Enter the length (VD500) and target speed (VD504). When I0.0 (Start) turns on, the machine starts. When I0.1 (Stop) turns on, the machine finishes the current operation and stops. When I0.2 (E_Stop) turns on, the machine aborts any motion and immediately stops.

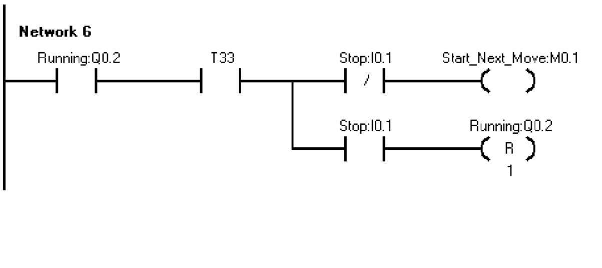
The second sample program provides an example of the POSx_CTRL, POSx_RUN, POSx_RSEEK, and POSx_MAN instructions. You must configure the RP seek mode and a motion profile.

Sample Program 1: Simple Relative Move (Cut to Length application)



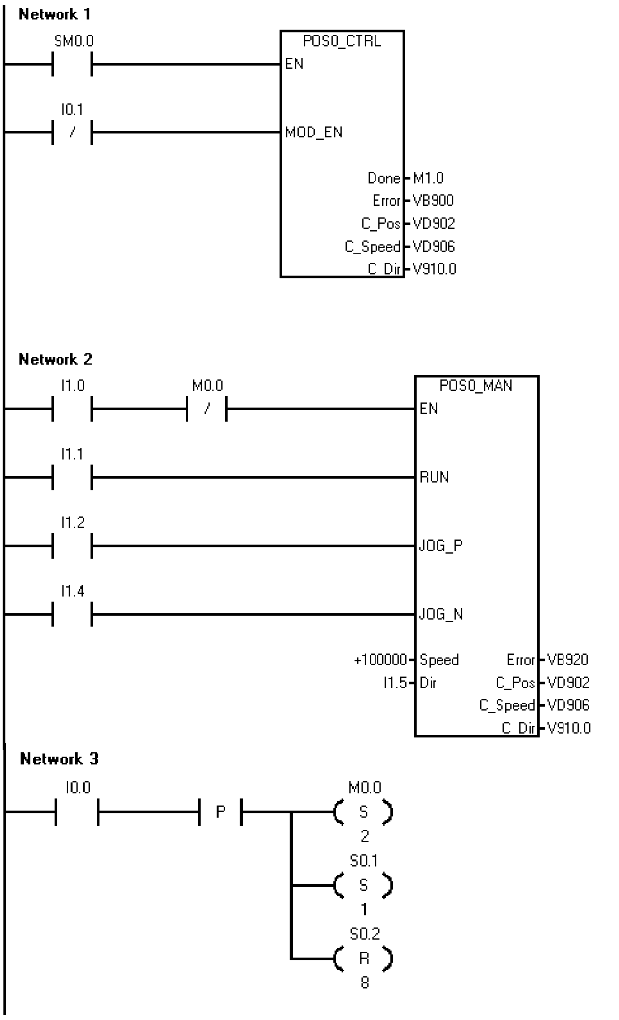
```
Network 1       //Control instruction (module in slot 0).
LD      SM0.0
=       L60.0
LDN     I0.2
=       L63.7
LD      L60.0
CALL    POS0_CTRL, L63.7, M1.0, VB900,
        VD902, VD906, V910.0

Network 2       //Start puts machine into
                //automatic mode
LD      I0.0
AN      I0.2
EU
S       Q0.2, 1
S       M0.1, 1

Network 3       //E_Stop: stops immediately and
                //turns off automatic mode.
LD      I0.2
R       Q0.2, 1

Network 4       //Move to a certain point:
                //Enter the length to cut.
                //Enter the target speed into Speed.
                //Set the mode to 1 (Relative mode).
LD      Q0.2
=       L60.0
LD      M0.1
EU
=       L63.7
LD      L60.0
CALL    POS0_GOTO, L63.7, VD500, VD504,
        1, I0.2, Q0.4, VB920, VD922, VD926

Network 5       //When in position, turn on the cutter
                //for 2 seconds to finish the cut.
LD      Q0.2
A       Q0.4
TON     T33, +200
AN      T33
=       Q0.3
```

Sample Program 1: Simple Relative Move (Cut to Length application) , continued



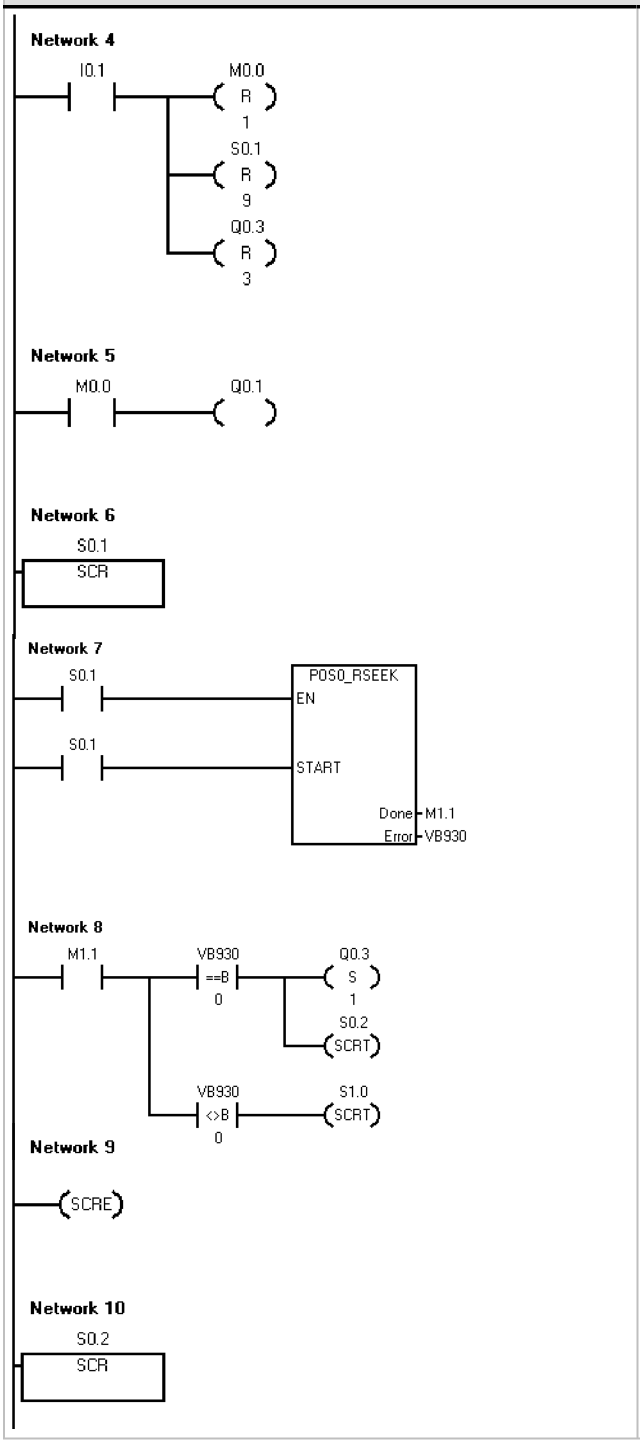
```
Network 6      //When the cut is finished then restart
               //unless the Stop is active.
LD      Q0.2
A       T33
LPS
AN      I0.1
=       M0.1
LPP
A       I0.1
R       Q0.2, 1
```

Sample Program 2: Program with POSx_CTRL, POSx_RUN, POSx_SEEK, and POSx_MAN



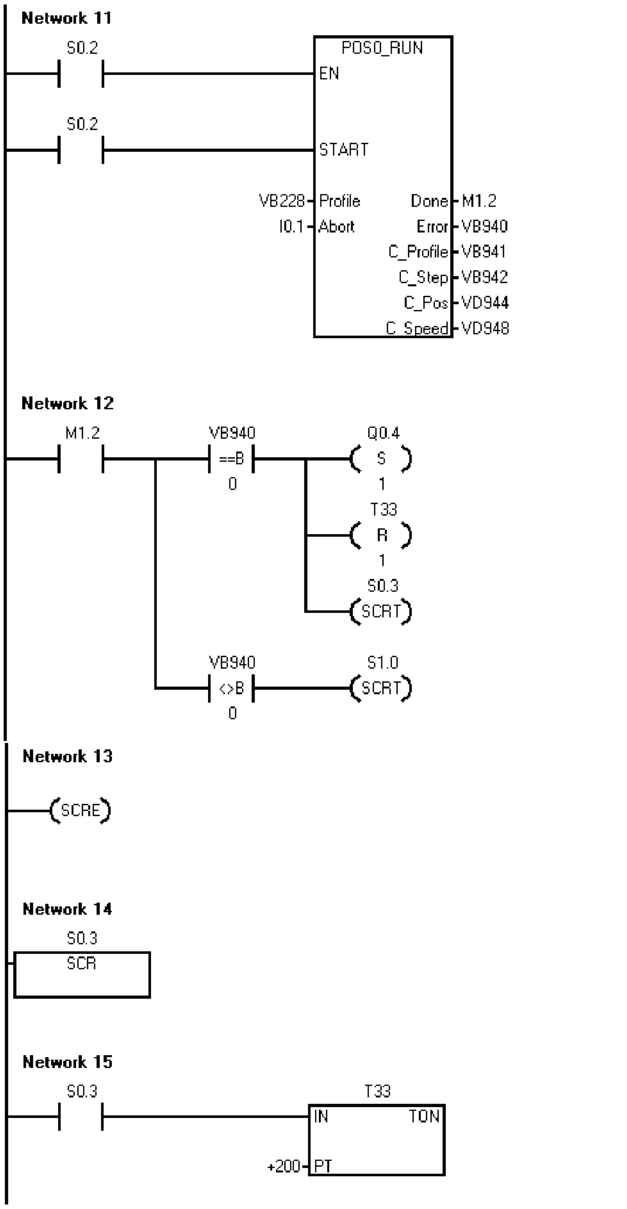
```
Network 1      //Enable the Position module
LD      SM0.0
=       L60.0
LDN     I0.1
=       L63.7
LD      L60.0
CALL    POS0_CTRL, L63.7, M1.0, VB900,
        VD902, VD906, V910.0

Network 2      //Manual mode if not in auto mode
LD      I1.0
AN      M0.0
=       L60.0
LD      I1.1
=       L63.7
LD      I1.2
=       L63.6
LD      I1.4
=       L63.5
LD      L60.0
CALL    POS0_MAN, L63.7, L63.6,
        L63.5, +100000, 1.5, VB920,
        VD902, VD906, V910.0

Network 3      //Enable auto mode
LD      I0.0
EU
S       M0.0, 2
S       S0.1, 1
R       S0.2, 8
```

Sample Program 2: Program with POSx_CTRL, POSx_RUN, POSx_SEEK, and POSx_MAN, continued



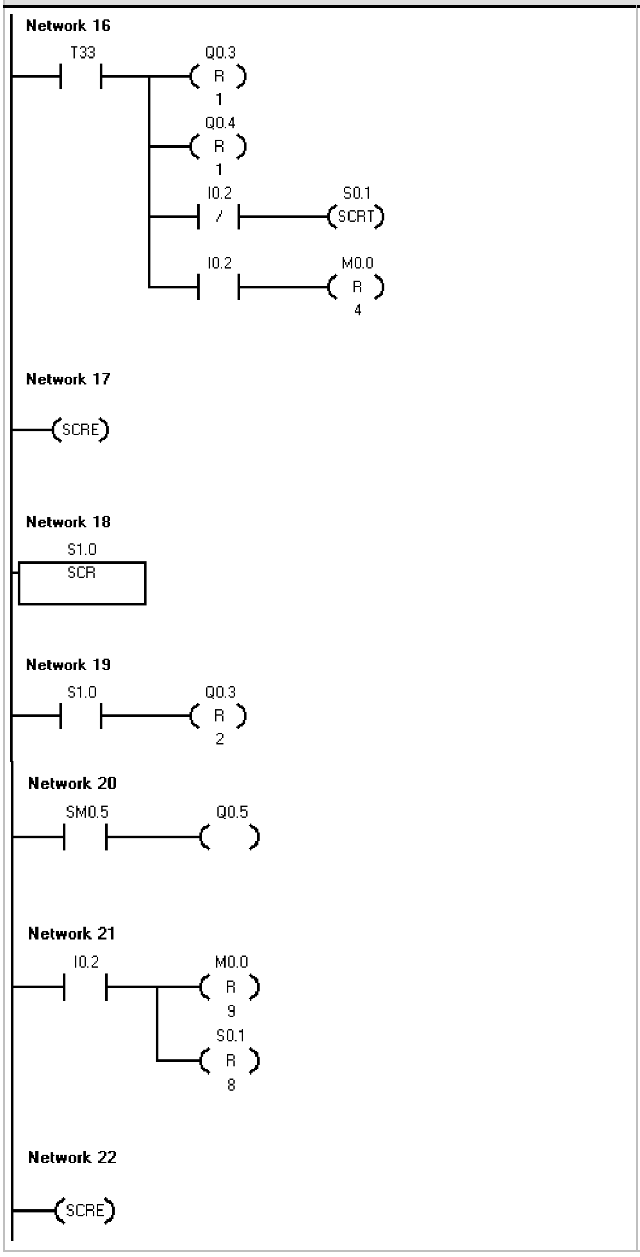
```
Network 4       //Emergency Stop
                //Disable the module and auto mode
LD      I0.1
R       M0.0, 1
R       S0.1, 9
R       Q0.3, 3

Network 5       //When in auto mode:
                //Turn on the Running light
LD      M0.0
=       Q0.1

Network 6
LSCR    S0.1

Network 7       //Find the reference point (RP)
LD      S0.1
=       L60.0
LD      S0.1
=       L63.7
LD      L60.0
CALL    POS0_RSEEK, L63.7, M1.1, VB930

Network 8       //When at reference point (RP):
                //Clamp the material and
                //Go to the next step.
LD      M1.1
LPS
AB=     VB930, 0
S       Q0.3, 1
SCRT    S0.2
LPP
AB<>    VB930, 0
SCRT    S1.0

Network 9
SCRE

Network 10
LSCR    S0.2
```

Sample Program 2: Program with POSx_CTRL, POSx_RUN, POSx_SEEK, and POSx_MAN, continued



```
Network 11      //Use profile 1 to move into position.
LD      S0.2
=       L60.0
LD      S0.2
=       L63.7
LD      L60.0
CALL    POS0_RUN, L63.7, VB228, I0.1,
        M1.2, VB940, VB941, VB942,
        VD944, VD948

Network 12      //When positioned, turn
                //on the cutter and go to
                //the next step.
LD      M1.2
LPS
AB=     VB940, 0
S       Q0.4, 1
R       T33, 1
SCRT    S0.3
LPP
AB<>    VB940, 0
SCRT    S1.0

Network 13
SCRE

Network 14      //Wait for the cut to finish
LSCR    S0.3

Network 15
LD      S0.3
TON     T33, +200
```

Sample Program 2: Program with POSx_CTRL, POSx_RUN, POSx_SEEK, and POSx_MAN, continued



```
Network 16      //Unless STOP is on, restart
                //when the cut is finished.
LD      T33
LPS
R       Q0.3, 1
R       Q0.4, 1
AN      I0.2
SCRT    S0.1
LPP
A       I0.2
R       M0.0, 4
Network 17
SCRE

Network 18
LSCR    S1.0

Network 19      //Reset the outputs.
LD      S1.0
R       Q0.3, 2

Network 20      //Flash the error light.
LD      SM0.5
=       Q0.5

Network 21      //Exit the error routine if STOP is on.
LD      I0.2
R       M0.0, 9
R       S0.1, 8

Network 22
SCRE
```

Monitoring the Position Module with the EM 253 Control Panel

To aid you in the development of your Position Control solution, STEP 7–Micro/WIN provides the EM 253 Control Panel. The Operation, Configuration and Diagnostics tabs make it easy for you to monitor and control the operation of the Position module during the startup and test phases of your development process.

Use the EM 253 Control Panel to verify that the Position module is wired correctly, to adjust the configuration data, and to test each movement profile.

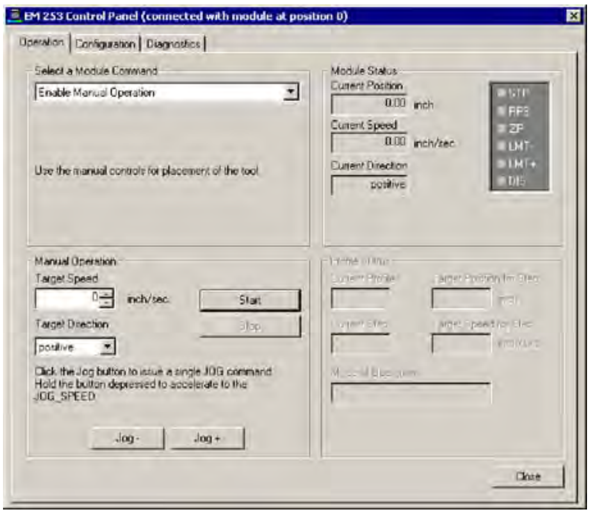
Displaying and Controlling the Operation of the Position Module

The Operation tab of the control panel allows you to interact with the operations of the Position Module. The control panel displays the current speed, the current position and the current direction of the Position module. You can also see the status of the input and output LEDs (excluding the Pulse LEDs).

The control panel allows you to interact with the Position module by changing the speed and direction, by stopping and starting the motion, and by jogging the tool (if the motion is stopped).

You can also generate the following motion commands:

- ❑ Enable Manual Operation. This command allows you to use the manual controls for positioning the tool.
- ❑ Run a Motion Profile. This command allows you to select a profile to be executed. The control panel displays the status of the profile which is being executed by the Position module.



Select a Module Command: Enable Manual Operation

Use the manual controls for placement of the tool.

Module Status
Current Position: 0.00 inch
Current Speed: 0.00 inch/sec
Current Direction: positive

Manual Operation
Target Speed: 0 inch/sec.
Target Direction: positive

Click the Jog button to issue a single JOG command. Hold the button depressed to accelerate to the JOG_SPEED

Figure 9-17 Operation Tab of the EM 253 Control Panel

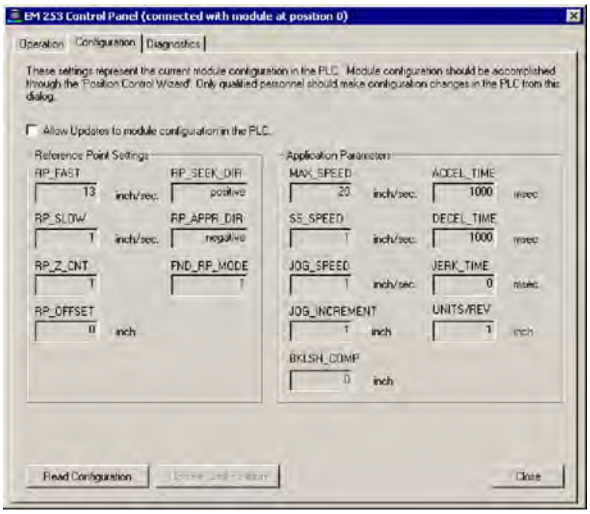
- ❑ Seek to a Reference Point. This command finds the reference point by using the configured search mode.
- ❑ Load Reference Point Offset. After you use the manual controls to jog the tool to the new zero position, you then load the Reference Point Offset.
- ❑ Reload Current Position. This command updates the current position value and establishes a new zero position.
- ❑ Activate the DIS output and Deactivate the DIS output. These commands turn the DIS output of the Position module on and off.
- ❑ Pulse the CLR output. This command generates a 50 ms pulse on the CLR output of the Position module.
- ❑ Teach a Motion Profile. This command allows you to save the target position and speed for a motion profile and step as you manually position the tool. The control panel displays the status of the profile which is being executed by the Position module.
- ❑ Load Module Configuration. This command loads a new configuration by commanding the Position module to read the configuration block from the V memory of the S7-200.

- ❑ Move to an Absolute Position. This command allows you to move to a specified position at a target speed. Before using this command, you must have already established the zero position.
- ❑ Move by a Relative Amount. This command allows you to move a specified distance from the current position at a target speed. You can enter a positive or negative distance.
- ❑ Reset the Command Interface. This command clears the command byte for the Position module and sets the Done bit. Use this command if the Position module appears to not be responding to commands.

Displaying and Modifying the Configuration of the Position Module

The Configuration tab of the control panel allows you to view and modify the configuration settings for the Position module that are stored in the data block of the S7-200.

After you modify the configuration settings, you simple click a button to update the settings in both the STEP 7‑Micro/Win project and the data block of the S7-200.



EM 253 Control Panel (connected with module at position 0)

These settings represent the current module configuration in the PLC. Module configuration should be accomplished through the 'Position Control Wizard'. Only qualified personnel should make configuration changes in the PLC from this dialog.

□ Allow Updates to module configuration in the PLC.

Reference Point Settings

RP_FAST: 13 inch/sec.
RP_SEEK_DIR: positive
RP_SLOW: 1 inch/sec.
RP_APPR_DIR: negative
RP_Z_CNT: 1
FND_RP_MODE: 1
RP_OFFSET: 0 inch

Application Parameters

MAX_SPEED: 20 inch/sec.
ACCEL_TIME: 1000 msec
SS_SPEED: 1 inch/sec.
DECEL_TIME: 1000 msec
JOG_SPEED: 1 inch/sec.
JERK_TIME: 0 msec
JOG_INCREMENT: 1 inch
UNITS/REV: 1 inch
BKLSH_COMP: 0 inch

Figure 9-18 Configuration Tab of the EM 253 Control Panel

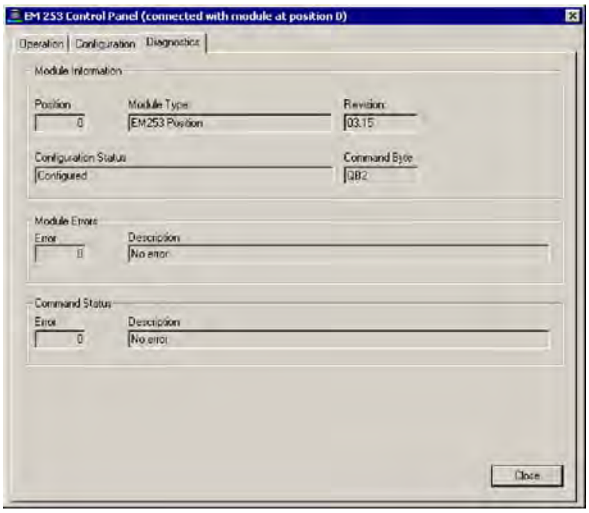
Displaying the Diagnostics Information for the Position Module

The Diagnostics tab of the control panel allows you to view the diagnostic information about the Position module.

You can view specific information about the Position module, such as the position of the module in the I/O chain, the module type and firmware version number, and the output byte used as the command byte for the module.

The control panel displays any error condition that resulted from a commanded operation. Refer to Table 9-20 for the instruction error conditions.

You can also view any error condition reported by the Position module. Refer to Table 9-21 for the module error conditions.



EM 253 Control Panel (connected with module at position 0)

Module Information

Position: 0
Module Type: EM253 Position
Revision: 03.15
Configuration Status: Configured
Command Byte: QB2

Module Errors

Error: 0
Description: No error

Command Status

Error: 0
Description: No error

Figure 9-19 Diagnostics Tab of the EM 253 Control Panel

Error Codes for the Position Module and the Position Instructions

Table 9-20 Instruction Error Codes

Error Code	Description
0	No error
1	Aborted by user
2	Configuration error Use the EM 253 Control Panel Diagnostics tab to view error codes
3	Illegal command
4	Aborted due to no valid configuration Use the EM 253 Control Panel Diagnostics tab to view error codes
5	Aborted due to no user power
6	Aborted due to no defined reference point
7	Aborted due to STP input active
8	Aborted due to LMT– input active
9	Aborted due to LMT+ input active
10	Aborted due to problem executing motion
11	No profile block configured for specified profile
12	Illegal operation mode
13	Operation mode not supported for this command
14	Illegal number of steps in profile block
15	Illegal direction change
16	Illegal distance
17	RPS trigger occurred before target speed reached
18	Insufficient RPS active region width
19	Speed out of range
20	Insufficient distance to perform desired speed change
21	Illegal position
22	Zero position unknown
23 to 127	Reserved
128	Position module cannot process this instruction: either the Position module is busy with another instruction, or there was no Start pulse on this instruction
129	Position module error: Module ID incorrect or module logged out. Refer to SMB8 to SMB21 (I/O Module ID and Error Register) for other error conditions.
130	Position module is not enabled
131	Position module is not available due to a module error or module not enabled (See the POSx_CTRL status)
132	The Q memory address that was configured with the Position Control wizard does not match the memory address for the module at this location.

Table 9-21 Module Error Codes

Error Code	Description
0	No error
1	No user power
2	Configuration block not present
3	Configuration block pointer error
4	Size of configuration block exceeds available V memory
5	Illegal configuration block format
6	Too many profiles specified
7	Illegal STP_RSP specification
8	Illegal LMT-_RPS specification
9	Illegal LMT+_RPS specification
10	Illegal FILTER_TIME specification
11	Illegal MEAS_SYS specification
12	Illegal RP_CFG specification
13	Illegal PLS/REV value
14	Illegal UNITS/REV value
15	Illegal RP_ZP_CNT value
16	Illegal JOG_INCREMENT value
17	Illegal MAX_SPEED value
18	Illegal SS_SPD value
19	Illegal RP_FAST value
20	Illegal RP_SLOW value
21	Illegal JOG_SPEED value
22	Illegal ACCEL_TIME value
23	Illegal DECEL_TIME value
24	Illegal JERK_TIME value
25	Illegal BKLSH_COMP value

Advanced Topics

Understanding the Configuration/Profile Table

The Position Control wizard has been developed to make motion applications easy by automatically generating the configuration and profile information based upon the answers you give about your position control system. Configuration/profile table information is provided for advanced users who want to create their own position control routines.

The configuration/profile table is located in the V memory area of the S7-200. As shown in Table 9-22, the configuration settings are stored in the following types of information:

- The configuration block contains information used to set up the module in preparation for executing motion commands.
- The interactive block supports direct setup of motion parameters by the user program.
- Each profile block describes a predefined move operation to be performed by the Position module. You can configure up 25 profile blocks.

Tip

To create more than 25 motion profiles, you can exchange configuration/profile tables by changing the value stored in the configuration/profile table pointer.

Table 9-22 Configuration/Profile Table

Offset	Name	Function Description	Type
Configuration Block			
0	MOD_ID	Module identification field	– –
5	CB_LEN	The length of the configuration block in bytes (1 byte)	– –
6	IB_LEN	The length of the interactive block in bytes (1 byte)	– –
7	PF_LEN	The length of a single profile in bytes (1 byte)	– –
8	STP_LEN	The length of a single step in bytes (1 byte)	– –
9	STEPS	The number of steps allowed per profile (1 byte)	– –
10	PROFILES	Number of profiles from 0 to 25 (1 byte)	– –
11	Reserved	Set to 0x0000	– –
13	IN_OUT_CFG	Specifies the use of the module inputs and outputs (1 byte) MSB 7 6 5 4 3 2 1 0 LSB P/D POL 0 0 STP RPS LMT– LMT+ P/D This bit specifies the use of P0 and P1. Positive Polarity (POL=0): 0 – P0 pulses for positive rotation P1 pulses for negative rotation 1 – P0 pulses for rotation P1 controls rotation direction (0 – positive, 1 – negative) Negative Polarity (POL=1): 0 – P0 pulses for positive rotation P1 pulses for negative rotation 1 – P0 pulses for rotation P1 controls rotation direction (0 – positive, 1 – negative) POL This bit selects the polarity convention for P0 and P1. (0 – positive polarity, 1 – negative polarity) STP This bit controls the active level for the stop input. RPS This bit controls the active level for the RPS input. LMT– This bit controls the active level for the negative travel limit input. LMT+ This bit controls the active level for the positive travel limit input 0 – Active high 1 – Active low	– –

Table 9-22 Configuration/Profile Table, continued

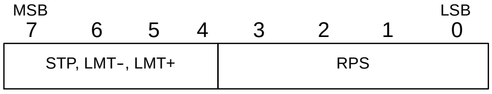
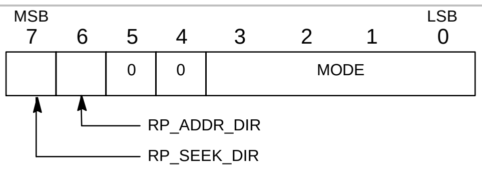
Offset	Name	Function Description	Type
14	STP_RSP	Specifies the response of the drive to the STP input (1 byte) 0 No action. Ignore the input condition. 1 Decelerate to a stop and indicate that the STP input is active. 2 Terminate the pulses and indicate STP input 3 to 255 Reserved (error if specified)	--
15	LMT-_RSP	Specifies the response of the drive to the negative limit input (1 byte) 0 No action. Ignore the input condition. 1 Decelerate to a stop and indicate that the limit has been reached. 2 Terminate the pulses and indicate that the limit has been reached. 3 to 255 Reserved (error if specified)	--
16	LMT+_RSP	Specifies the response of the drive to the positive limit input (1 byte) 0 No action. Ignore the input condition. 1 Decelerate to a stop and indicate that the limit has been reached. 2 Terminate pulses and indicate that the limit has been reached. 3 to 255 Reserved (error if specified)	--
17	FILTER_TIME	Specifies the filter time for the STP, LMT-, LMT+, and RPS inputs (1 byte)  '0000' 200 μsec '0101' 3200 μsec '0001' 400 μsec '0110' 6400 μsec '0010' 800 μsec '0111' 12800 μsec '0011' 1600 μsec '1000' No filter '0100' 1600 μsec '1001 ' to '1111' Reserved (error if specified)	--
18	MEAS_SYS	Specifies the measurement system (1 byte) 0 Pulses (speed is measured in pulses/second, and the position values are measured in pulses). Values are stored as DINT. 1 Engineering units (speed is measured in units/second, and the position values are measured in units). Values are stored as single-precision REAL. 2 to 255 Reserved (error if specified)	--
19	--	Reserved (Set to 0)	--
20	PLS/REV	Specifies the number of pulses per revolution of the motor (4 bytes) Only applicable when MEAS_SYS is set to 1.	DINT
24	UNITS/REV	Specifies the engineering units per revolution of the motor (4 bytes) Only applicable when MEAS_SYS is set to 1.	REAL
28	UNITS	Reserved for STEP 7-Micro/WIN to store a custom units string (4 bytes)	--
32	RP_CFG	Specifies the reference point search configuration (1 byte)  MSB LSB 7 6 5 4 3 2 1 0 0 0 MODE RP_ADDR_DIR RP_SEEK_DIR RP_SEEK_DIR This bit specifies the starting direction for a reference point search. (0 - positive direction, 1 - negative direction) RP_APPR_DIR This bit specifies the approach direction for terminating the reference point search. (0 - positive direction, 1 - negative direction) MODE Specifies the reference point search method. '0000' Reference point search disabled. '0001' The reference point is where the RPS input goes active. '0010' The reference point is centered within the active region of the RPS input. '0011' The reference point is outside the active region of the RPS input. '0100' The reference point is within the active region of the RPS input. '0101' to '1111' Reserved (error if selected)	--
33	--	Reserved (Set to 0)	--
34	RP_Z_CNT	Number of pulses of the ZP input used to define the reference point (4 bytes)	DINT
38	RP_FAST	Fast speed for the RP seek operation: MAX_SPD or less (4 bytes)	DINT REAL

Table 9-22 Configuration/Profile Table, continued

Offset	Name	Function Description	Type
42	RP_SLOW	Slow speed for the RP seek operation: maximum speed from which the motor can instantly go to a stop or less (4 bytes)	DINT REAL
46	SS_SPEED	Start/Stop Speed. (4 bytes) The starting speed is the max. speed to which the motor can instantly go from a stop and the maximum speed from which the motor can instantly go to a stop. Operation below this speed is allowed, but the acceleration and deceleration times do not apply.	DINT REAL
50	MAX_SPEED	Maximum operating speed of the motor (4 bytes)	DINT REAL
54	JOG_SPEED	Jog speed. MAX_SPEED or less (4 bytes)	
58	JOG_INCREMENT	The jog increment value is the distance (or number of pulses) to move in response to a single jog pulse. (4 bytes)	DINT REAL
62	ACCEL_TIME	Time required to accelerate from minimum to maximum speed in milliseconds (4 bytes)	DINT
66	DECEL_TIME	Time required to decelerate from maximum to minimum speed in milliseconds (4 bytes)	DINT
70	BKLSH_COMP	Backlash compensation: the distance used to compensate for the system backlash on a direction change (4 bytes)	DINT REAL
74	JERK_TIME	Time during which jerk compensation is applied to the beginning and ending portions of an acceleration/deceleration curve (S curve). Specifying a value of 0 disables jerk compensation. The jerk time is given in milliseconds. (4 bytes)	DINT
Interactive Block			
78	MOVE_CMD	Selects the mode of operation (1 byte) 0 Absolute position 1 Relative position 2 Single-speed, continuous operation, positive rotation 3 Single-speed, continuous operation, negative rotation 4 Manual speed control, positive rotation 5 Manual speed control, negative rotation 6 Single-speed, continuous operation, positive rotation with triggered stop (RPS input signals stop) 7 Single-speed, continuous operation, negative rotation with triggered stop (RPS input signals stop) 8 to 255 – Reserved (error if specified)	--
79	--	Reserved. Set to 0	--
80	TARGET_POS	Target position to go to in this move (4 bytes)	DINT REAL
84	TARGET_SPEED	Target speed for this move (4 bytes)	DINT REAL
88	RP_OFFSET	Absolute position of the reference point (4 bytes)	DINT REAL
Profile Block 0			
92 (+0)	STEPS	Number of steps in this move sequence (1 byte)	--
93 (+1)	MODE	Selects the mode of operation for this profile block (1 byte) 0 Absolute position 1 Relative position 2 Single-speed, continuous operation, positive rotation 3 Single-speed, continuous operation, negative rotation 4 Reserved (error if specified) 5 Reserved (error if specified) 6 Single-speed, continuous operation, positive rotation with triggered stop (RPS selects speed) 7 Single-speed, continuous operation, negative rotation with triggered stop (RPS input signals stop) 8 Two-speed, continuous operation, positive rotation (RPS selects speed) 9 Two-speed, continuous operation, negative rotation (RPS selects speed) 10 to 255 – Reserved (error if specified)	--

Table 9-22 Configuration/Profile Table, continued

Offset	Name		Function Description	Type
94 (+2)	0	POS	Position to go to in move step 0 (4 bytes)	DINT REAL
98 (+6)		SPEED	Target speed for move step 0 (4 bytes)	DINT REAL
102 (+10)	1	POS	Position to go to in move step 1 (4 bytes)	DINT REAL
106 (+14)		SPEED	Target speed for move step 1 (4 bytes)	DINT REAL
110 (+18)	2	POS	Position to go to in move step 2 (4 bytes)	DINT REAL
114 (+22)		SPEED	Target speed for move step 2 (4 bytes)	DINT REAL
118 (+26)	3	POS	Position to go to in move step 3 (4 bytes)	DINT REAL
122 (+30)		SPEED	Target speed for move step 3 (4 bytes)	DINT REAL
Profile Block 1				
126 (+34)	STEPS		Number of steps in this move sequence (1 byte)	--
127 (+35)	MODE		Selects the mode of operation for this profile block (1 byte)	--
128 (+36)	0	POS	Position to go to in move step 0 (4 bytes)	DINT REAL
132 (+40)		SPEED	Target speed for move step 0 (4 bytes)	DINT REAL
...	...	...	...	...

Special Memory Locations for the Position Module

The S7-200 allocates 50 bytes of special memory (SM) to each intelligent module, based on the physical position of the module in the I/O system. See Table 9-23. When the module detects an error condition or a change in status of the data, the module updates these SM locations. The first module updates SMB200 through SMB249 as required to report the error condition, the second module updates SMB250 through SMB299, and so on.

Table 9-23 Special Memory Bytes SMB200 to SMB549

SM Bytes for an intelligent module in:						
Slot 0	**Slot 1**	**Slot 2**	**Slot 3**	**Slot 4**	**Slot 5**	**Slot 6**
SMB200 to SMB249	SMB250 to SMB299	SMB300 to SMB349	SMB350 to SMB399	SMB400 to SMB449	SMB450 to SMB499	SMB500 to SMB549

Table 9-24 shows the structure of the SM data area allocated for an intelligent module. The definition is given as if this were the intelligent module is located in slot 0 of the I/O system.

Table 9-24 Special Memory Area Definition for the EM 253 Position Module

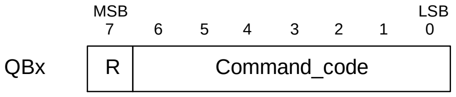
<table>
<tr><th>SM Address</th><th>Description</th></tr>
<tr><td>SMB200 to SMB215</td><td>Module name (16 ASCII characters). SMB200 is the first character: “EM253 Position”</td></tr>
<tr><td>SMB216 to SMB219</td><td>Software revision number (4 ASCII characters). SMB216 is the first character.</td></tr>
<tr><td>SMW220</td><td>Error code for the module. See Table 9-21 for a description of the error codes.</td></tr>
<tr><td>SMB222</td><td>Input/output status. Reflects the status of the inputs and outputs of the module.
<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>DIS</td><td>0</td><td>0</td><td>STP</td><td>LMT-</td><td>LMT+</td><td>RPS</td><td>ZP</td></tr>
</table>
<table>
<tr><td>DIS</td><td>Disable outputs</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
<tr><td>STP</td><td>Stop input</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
<tr><td>LMT-</td><td>Negative travel limit input</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
<tr><td>LMT+</td><td>Positive travel limit input</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
<tr><td>RPS</td><td>Reference point switch input</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
<tr><td>ZP</td><td>Zero pulse input</td><td>0 = No current flow</td><td>1 = Current flow</td></tr>
</table></td></tr>
<tr><td>SMB223</td><td>Instantaneous module status. Reflects the status of the module configuration and rotation direction status.
<table>
<tr><td>MSB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>OR</td><td>R</td><td>CFG</td></tr>
</table>
<table>
<tr><td>OR</td><td>Target speed out of range</td><td>0 = In range</td><td>1 = Out of range</td></tr>
<tr><td>R</td><td>Direction of rotation</td><td>0 = Positive rotation</td><td>1 = Negative rotation</td></tr>
<tr><td>CFG</td><td>Module configured</td><td>0 = Not configured</td><td>1 = Configured</td></tr>
</table></td></tr>
<tr><td>SMB224</td><td>CUR_PF is a byte that indicates the profile currently being executed.</td></tr>
<tr><td>SMB225</td><td>CUR_STP is a byte that indicates the step currently being executed in the profile.</td></tr>
<tr><td>SMD226</td><td>CUR_POS is a double-word value that indicates the current position of the module.</td></tr>
<tr><td>SMD230</td><td>CUR_SPD is a double-word value that indicates the current speed of the module.</td></tr>
<tr><td>SMB234</td><td>Result of the instruction. See Table 9-20 for descriptions of the error codes. Error conditions above 127 are generated by the instruction subroutines created by the wizard.
<table>
<tr><td>MSB</td><td></td><td>LSB</td></tr>
<tr><td>7</td><td>6</td><td>0</td></tr>
<tr><td>D</td><td colspan="2">ERROR</td></tr>
</table>
<table>
<tr><td>D</td><td>Done bit</td><td>0= Operation in progress
1= Operation complete (set by the module during initialization)</td></tr>
</table></td></tr>
<tr><td>SMB235 to SMB244</td><td>Reserved</td></tr>
<tr><td>SMB245</td><td>Offset to the first Q byte used as the command interface to this module. The offset is supplied by the S7-200 automatically for the convenience of the user and is not needed by the module.</td></tr>
<tr><td>SMD246</td><td>Pointer to the V memory location of the configuration/profile table. A pointer value to an area other than V memory is not valid. The Position module monitors this location until it receives a non-zero pointer value.</td></tr>
</table>

Understanding the Command Byte for the Position Module

The Position module provides one byte of discrete outputs which is used as the command byte. Figure 9-20 shows the command byte definition. Table 9-20 shows the Command_code definitions.

A write to the command byte where the R bit changes from 0 to 1 is interpreted by the module as a new command.

If the module detects a transition to idle (R bit changes state to 0) while a command is active, then the operation in progress is aborted and, if a motion is in progress, then a decelerated stop is performed.



R 0 = Idle
1 = Execute the command specified in Command_code (See Table 9-25)

Figure 9-20 Definition of the Command Byte

After an operation has completed, the module must see a transition to idle before a new command is accepted. If an operation is aborted, then the module must complete any deceleration before a new command is accepted. Any change in the Command_code value while a command is active is ignored.

Table 9-25 Command_code Definitions

Command_code	Command	
000 0000 to 000 1111	0 to 24	Execute motion specified in Profile Blocks 0 to 24
100 0000 to 111 0101	25 to 117	Reserved (Error if specified)
111 0110	118	Activate the DIS output
111 0111	119	Deactivate the DIS output
111 1000	120	Pulse the CLR output
111 1001	121	Reload current position
111 1010	122	Execute motion specified in the Interactive Block
111 1011	123	Capture reference point offset
111 1100	124	Jog positive rotation
111 1101	125	Jog negative rotation
111 1110	126	Seek to reference point position
111 1111	127	Reload configuration

The response of the Position module to a change in the operating mode of the S7-200 or to a fault condition is governed by the effect that the S7-200 exerts over the discrete outputs according to the existing definition of the S7-200 function:

- *If the S7-200 changes from STOP to RUN:* The program in the S7-200 controls the operation of the Position module.
- *If the S7-200 changes from RUN to STOP:* You can select the state that the discrete outputs are to go to on a transition to STOP or that the outputs are to retain their last state.
  - *If the R bit is turned off when going to STOP:* The Position module decelerates any motion in progress to a stop
  - *If the R bit is turned on when going to STOP:* The Position module completes any command that is in progress. If no command is in progress, the Position module executes the command which is specified by the Command_code bits.
  - *If the R bit is held in its last state:* The Position module completes any motion in progress.
- *If the S7-200 detects a fatal error and turns off all discrete outputs:* The Position module decelerates any motion in progress to a stop.

The Position module implements a watchdog timer that turns the outputs off if communications with the S7-200 are lost. If the output watchdog timer expires, the Position module decelerates any motion in progress to a stop.

If a fatal error in the hardware or firmware of the module is detected, the Position module sets the P0, P1, DIS and CLR outputs to the inactive state.

Table 9-26 Motion Commands

Command	Description
Commands 0 to 24: *Executes the motion specified in profile blocks 0 to 24*	When this command is executed, the Position module performs the motion operation specified in the MODE field of the profile block indicated by the Command_code portion of the command. • In Mode 0 (absolute position), the motion profile block defines from one to four steps with each step containing both the position (POS) and speed (SPEED) that describes the move segment. The POS specification represents an absolute location, which is based on the location designated as reference point. The direction of movement is determined by the relationship between the current position and the position of the first step in the profile. In a multi-step move a reversal of direction of travel is prohibited and results in an error condition being reported. • In Mode 1 (relative position), the motion profile block defines from one to four steps with each step containing both the position (POS) and the speed (SPEED) that describes the move segment. The sign of the position value (POS) determines the direction of the movement. In a multi-step move, a reversal of direction of travel is prohibited and results in the reporting of an error condition. • In Modes 2 and 3 (single-speed, continuous operation modes), the position (POS) specification is ignored and the module accelerates to the speed specified in the SPEED field of the first step. Mode 2 is used for positive rotation, and Mode 3 is used for negative rotation. Movement stops when the command byte transitions to Idle. • In Modes 6 and 7 (single-speed, continuous operation modes with triggered stop), the module accelerates to the speed specified in the SPEED field of the first step. If and when the RPS input becomes active, movement stops after completing the distance specified in the POS field of the first step. (The distance specified in the POS field must include the deceleration distance.) If the POS field is zero when the RPS input becomes active, the Position module decelerates to a stop. Mode 6 is used for positive rotation, and Mode 7 is used for negative rotation. • In Modes 8 and 9, the binary value of the RPS input selects one of two speed values as specified by the first two steps in the profile block. – If the RPS is inactive: Step 0 controls the speed of the drive. – If the RPS is active: Step 1 controls the speed of the drive. Mode 8 is used for positive rotation, and Mode 9 is used for negative rotation. The SPEED value controls the speed of movement. The POS values are ignored in this mode.
Command 118 *Activates the DIS output*	When this command is executed, the Position module activates the DIS output.
Command 119 *Deactivates the DIS output*	When this command is executed, the Position module deactivates the DIS output.
Command 120 *Pulses the CLR output*	When this command is executed, the Position module generates a 50-millisecond pulse on the CLR output.
Command 121 *Reloads the Current Position*	When this command is executed, the Position module sets the current position to the value found in the TARGET_POS field of the interactive block.

Table 9-26 Motion Commands, continued

Command	Description
Command 122 *Execute the motion specified in the interactive block*	When this command is executed, the Position module performs the motion operation specified in the MOVE_CMD field of the interactive block. • In Modes 0 and 1 (absolute and relative motion modes), a single step motion is performed based upon the target speed and position information provided in the TARGET_SPEED and TARGET_POS fields of the interactive block. • In Modes 2 and 3 (single-speed, continuous operation modes), the position specification is ignored, and the Position module accelerates to the speed specified in the TARGET_SPEED field of the interactive block. Movement stops when the command byte transitions to Idle. • In Modes 4 and 5 (manual speed control modes), the position specification is ignored and your program loads the value of speed changes into the TARGET_SPEED field of the interactive block. The Position module continuously monitors this location and responds appropriately when the speed value changes.
Command 123 *Capture the Reference Point offset*	When this command is executed, the Position module establishes a zero position that is at a different location from the reference point position. Before issuing this command, you must have determined the position of the reference point and must also have jogged the machine to the work starting position. After receiving this command, the Position module computes the offset between the work starting position (the current position) and the reference point position and writes the computed offset to the RP_OFFSET field of the Interactive Block. The current position is then set to 0 to establish the work starting position as the zero position. In the event that the stepper motor loses track of its position (for example, if power is lost or the stepper motor is repositioned manually) the Seek to Reference Point Position command can be issued to re-establish the zero position automatically.
Command 124 *Jog positive rotation*	This command allows you to manually issue pulses for moving the stepper motor in the positive direction. If the command remains active for less than 0.5 seconds, the Position module issues pulses to travel the distance specified in JOG_INCREMENT. If the command remains active for 0.5 seconds or longer, the motion module begins to accelerate to the specified JOG_SPEED. When a transition to idle is detected, the Position module decelerates to a stop.
Command 125 *Jog negative rotation*	This command allows you to manually issue pulses for moving the stepper motor in the negative direction. If the command remains active for less than 0.5 seconds, the Position module issues pulses to travel the distance specified in JOG_INCREMENT. If the command remains active for 0.5 seconds or longer, the Position module begins to accelerate to the specified JOG_SPEED. When a transition to idle is detected, the Position module decelerates to a stop.
Command 126 *Seek to Reference Point position*	When this command is executed, the Position module initiates a reference point seek operation using the specified search method. When the reference point has been located and motion has stopped, the Position module loads the value read from the RP_OFFSET field of the interactive block into the current position and pulses the CLR output on for 50 milliseconds.
Command 127 *Reload the configuration*	When this command is executed, the Position module reads the configuration/profile table pointer from the appropriate location in SM memory and then reads the configuration block from the location specified by the configuration/profile table pointer. The Position module compares the configuration data just obtained against the existing module configuration and performs any required setup changes or recalculations. Any cached profiles are discarded.

Understanding the Profile Cache of the Position Module

The Position module stores the execution data for up to 4 profiles in cache memory. When the Position module receives a command to execute a profile, it checks to see if the requested profile is stored in the cache memory. If the execution data for the profile is resident in the cache, the Position module immediately executes the profile. If the the execution data for the profile is not resident in the cache, the Position module reads the profile block information from the configuration/profile table in the S7-200 and calculates the execution data for the profile before executing the profile.

Command 122 (Execute the motion specified in the interactive block) does not use cache memory to store the execution data, but always reads the interactive block from the configuration/profile table in the S7-200 and calculates the execution data for the motion.

Reconfiguring the Position module deletes all of the execution data stored in the cache memory.

Creating Your Own Position Control Instructions

The Position Control wizard creates the position instructions for controlling the operation of the Position module; however, you can also create your own instructions. The following STL code segment provides an example of how you might create your own control instructions for the Position module.

This example uses an S7-200 CPU 224 with a Position module located in slot 0. The Position module is configured on power-up. CMD_STAT is a symbol for SMB234, CMD is a symbol for QB2, and NEW_CMD is a symbol for the profile.

Sample Program: Controlling the Position Module

```
Network 1     //New move command state
LSCR     State_0

Network 2     //CMD_STAT is a symbol for SMB234
              //CMD is a symbol for QB2
              //NEW_CMD is a symbol for the profile.
              //
              //1. Clear the Done bit of the Position module.
              //2. Clear the command byte of the Position module.
              //3. Issue the new command.
              //4. Wait for the command to be executed.
LD       SM0.0
MOVB     0, CMD_STAT
BIW      0, CMD
BIW      NEW_CMD, CMD
SCRT     State_1

Network 3
SCRE

Network 4     //Wait for the command to be completed.
LSCR     State_1

Network 5     //If the command is complete without error, go to the idle state.
LDB=     CMD_STAT, 16#80
SCRT     Idle_State

Network 6     //If the command is complete with an error, go to the error handling state.
LDB>     CMD_STAT, 16#80
SCRT     Error_State

Network 7
SCRE
```

Understanding the RP Seek Modes Supported by the Position Module

The following figures provide diagrams of the different options for each RP seek mode.

❑ Figure 9-21 shows two of the options for RP seek mode 1. This mode locates the RP where the RPS input goes active on the approach from the work zone side.

❑ Figure 9-22 shows two of the options for RP seek mode 2. This mode locates the RP in the center within the active region of the RPS input.

❑ Figure 9-23 shows two of the options for RP seek mode 3. This mode locates the RP a specified number of zero pulses (ZP) outside the active region of the RPS input.

❑ Figure 9-24 shows two of the options for RP seek mode 4. This mode locates the RP a specified number of zero pulses (ZP) within the active region of the RPS input.

For each mode, there are four combinations of RP Seek direction and RP Approach direction. (Only two of the combinations are shown.) These combinations determine the pattern for the RP seek operation. For each of the combinations, there are also four different starting points:

The work zones for each diagram have been located so that moving from the reference point to the work zone requires movement in the same direction as the RP Approach Direction. By selecting the location of the work zone in this way, all the backlash of the mechanical gearing system is removed for the first move to the work zone after a reference point seek.

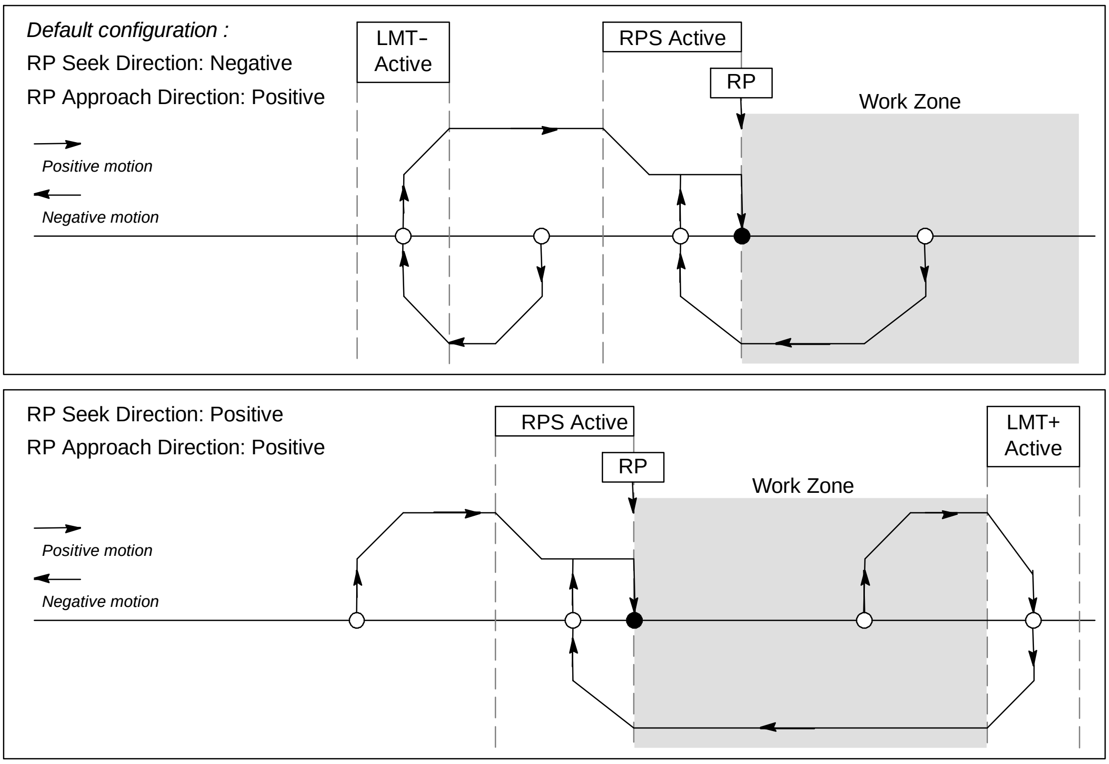

Default configuration :
RP Seek Direction: Negative
RP Approach Direction: Positive
Positive motion
Negative motion
LMT– Active
RPS Active
RP
Work Zone
RP Seek Direction: Positive
RP Approach Direction: Positive
Positive motion
Negative motion
RPS Active
RP
Work Zone
LMT+ Active

Figure 9-21 RP Seek Mode 1

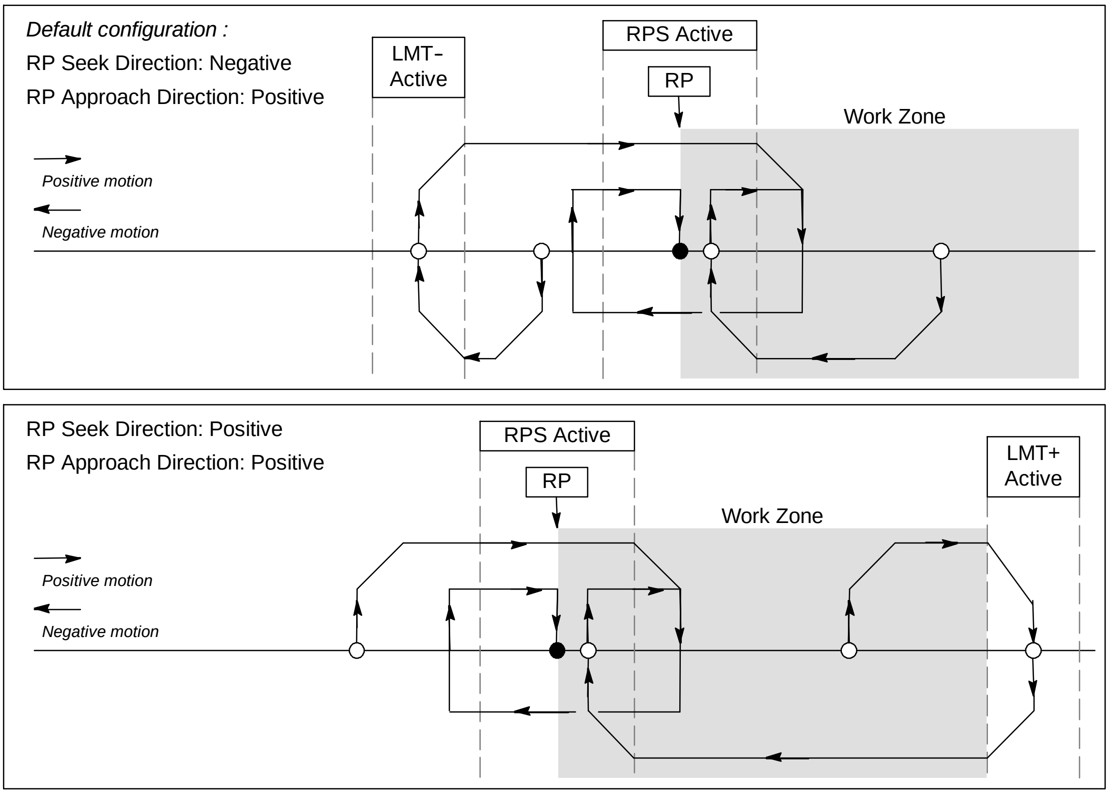


Figure 9-22 RP Seek: Mode 2

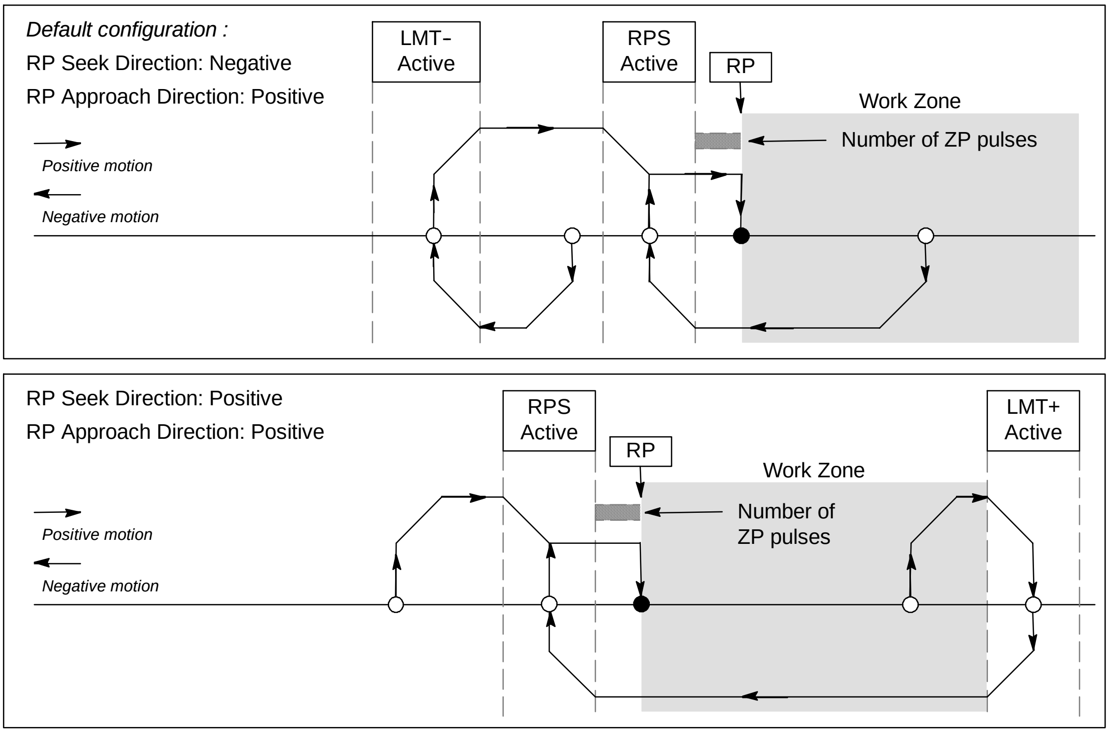


Figure 9-23 RP Seek: Mode 3

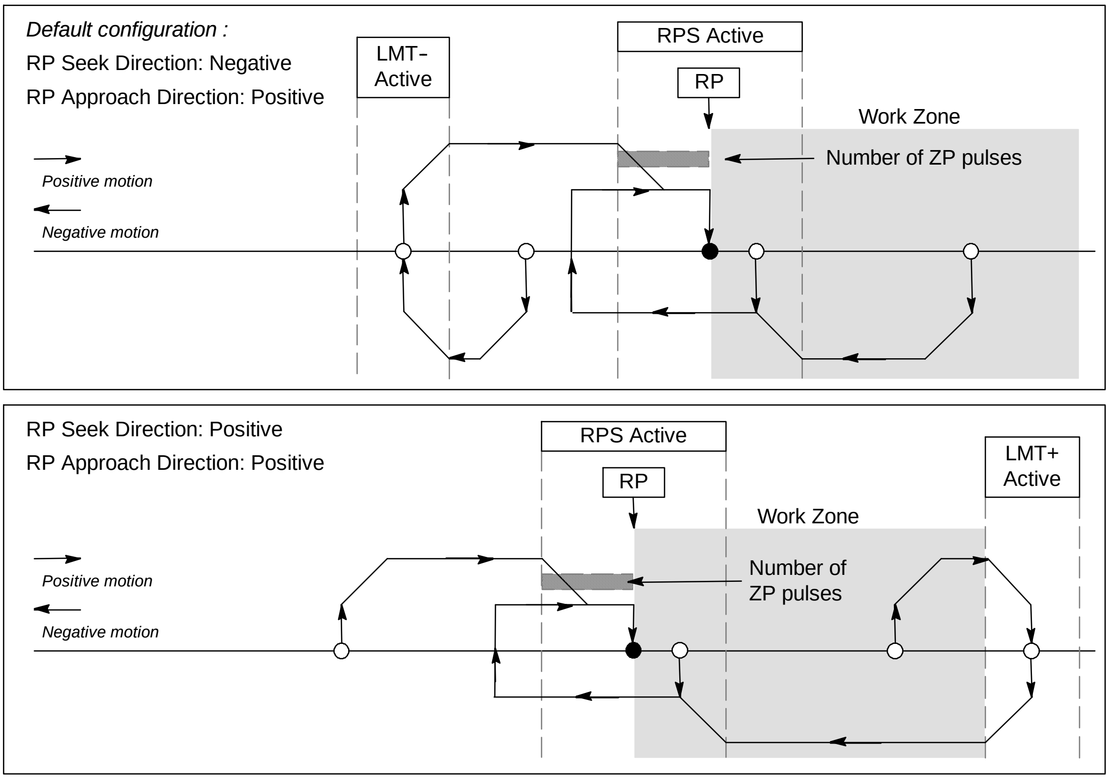


Figure 9-24 RP Seek: Mode 4

Selecting the Location of the Work Zone to Eliminate Backlash

Figure 9-25 shows the work zone in relationship to the reference point (RP), the RPS Active zone, and the limit switches (LMT+ and LMT–) for an approach direction that eliminates the backlash. The second part of the illustration places the work zone so that the backlash is not eliminated. Figure 9-25 shows RP seek mode 3. A similar placement of the work zone is possible, although not recommended, for each of the search sequences for each of the other RP seek modes.

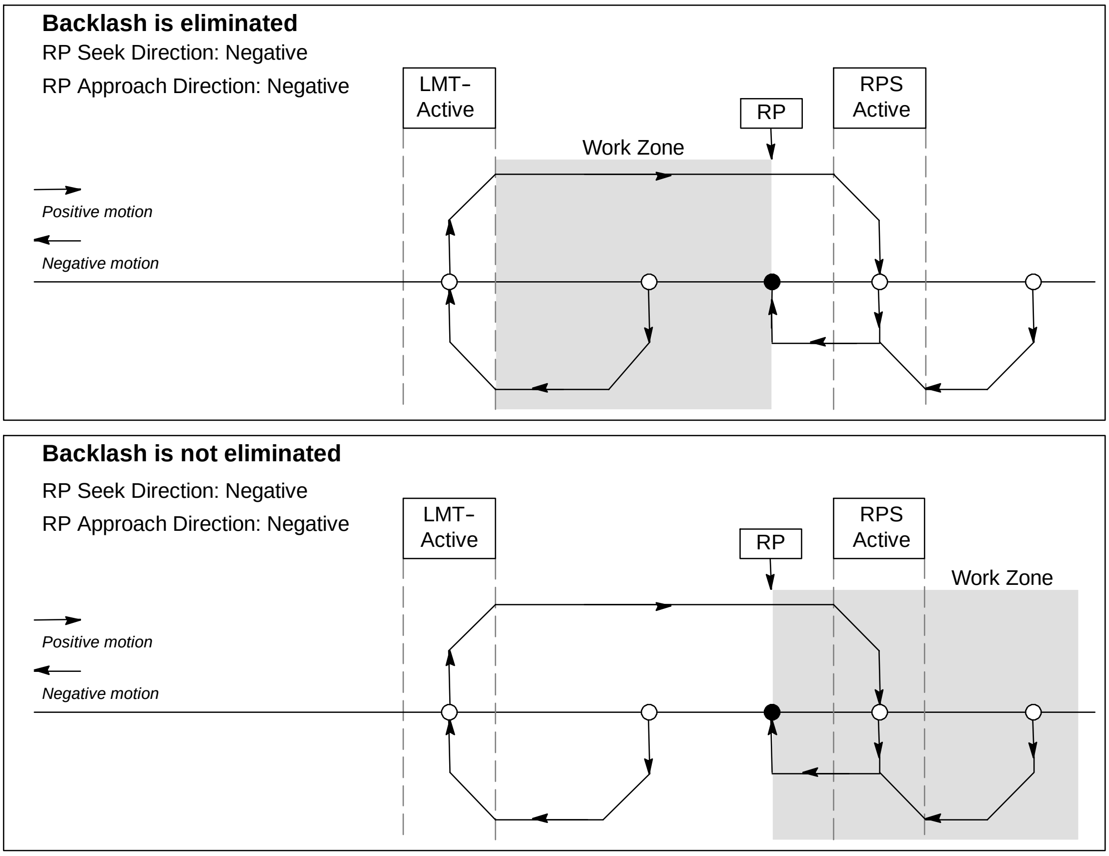

Backlash is eliminated
RP Seek Direction: Negative
RP Approach Direction: Negative
LMT–
Active
RP
RPS
Active
Work Zone
Positive motion
Negative motion
Backlash is not eliminated
RP Seek Direction: Negative
RP Approach Direction: Negative
LMT–
Active
RP
RPS
Active
Work Zone
Positive motion
Negative motion

Figure 9-25 Placement of the Work Zone with and without the Elimination of Backlash

Creating a Program for the Modem Module

10

The EM 241 Modem module allows you to connect your S7-200 directly to an analog telephone line, and supports communications between your S7-200 and STEP 7-Micro/WIN. The Modem module also supports the Modbus slave RTU protocol. Communications between the Modem module and the S7-200 are made over the Expansion I/O bus.

STEP 7-Micro/WIN provides a Modem Expansion wizard to help set up a remote modem or a Modem module for connecting a local S7-200 to a remote device.

In This Chapter

Features of the Modem Module

The Modem module allows you to connect your S7-200 directly to an analog telephone line and provides the following features:

- ❑ Provides international telephone line interface
- ❑ Provides a modem interface to STEP 7-Micro/WIN for programming and troubleshooting (teleservice)
- ❑ Supports the Modbus RTU protocol
- ❑ Supports numeric and text paging
- ❑ Supports SMS messaging
- ❑ Allows CPU-to-CPU or CPU-to Modbus data transfers
- ❑ Provides password protection
- ❑ Provides security callback
- ❑ The Modem module configuration is stored in the CPU

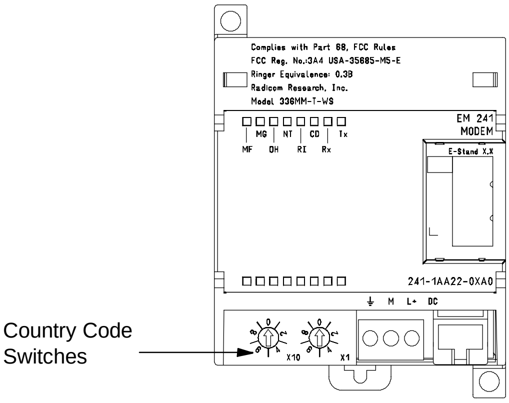
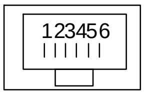


Figure 10-1 EM 241 Modem Module

You can use the STEP 7-Micro/WIN Modem Expansion wizard to configure the Modem module. Refer to Appendix A for the specifications of the Modem module.

International Telephone Line Interface

The Modem module is a standard V.34 (33.6 kBaud), 10-bit modem, and is compatible with most internal and external PC modems. The Modem module does not communicate with 11-bit modems.



Pin	Description
3	Ring
4	Tip

Reverse connection is allowed.

Figure 10-2 View of RJ11 Jack

You connect the Modem module to the telephone line with the six-position four-wire RJ11 connector mounted on the front of the module. See Figure 10-2.

An adapter may be required to convert the RJ11 connector for connection to the standard telephone line termination in the various countries. Refer to the documentation for your adapter connector for more information.

The modem and telephone line interface is powered from an external 24 VDC supply. This can be connected to the CPU sensor supply or to an external source. Connect the ground terminal on the Modem module to the system earth ground.

The Modem module automatically configures the telephone interface for country-specific operation when power is applied to the module. The two rotary switches on the front of the module select the country code. You must set the switches to the desired country selection before the Modem module is powered up. Refer to Table 10-1 for switch settings for the countries supported.

Table 10-1 Countries Supported by the EM 241

Switch Setting	Country
00	Australia
01	Austria
02	Belgium
05	Canada
06	China
08	Denmark
09	Finland
10	France
11	Germany
12	Greece
16	Ireland
18	Italy
22	Luxembourg
25	Netherlands
26	New Zealand
27	Norway
30	Portugal
34	Spain
35	Sweden
36	Switzerland
38	U.K.
39	U.S.A.

STEP 7-Micro/WIN Interface

The Modem module allows you to communicate with STEP 7-Micro/WIN over a telephone line (teleservice). You do not need to configure or program the S7-200 CPU to use the Modem module as the remote modem when used with STEP 7-Micro/WIN.

Follow these steps to use the Modem module with STEP 7-Micro/WIN:

1. Remove the power from the S7-200 CPU and attach the Modem module to the I/O expansion bus. Do not attach any I/O modules while the S7-200 CPU is powered up.
2. Connect the telephone line to the Modem module. Use an adapter if necessary.
3. Connect 24 volts DC to the Modem module terminal blocks.
4. Connect the Modem module terminal block ground connection to the system ground.
5. Set the country code switches.
6. Power up the S7-200 CPU and the Modem module.
7. Configure STEP 7-Micro/WIN to communicate to a 10-bit modem.

Modbus RTU Protocol

You can configure the Modem module to respond as a Modbus RTU slave. The Modem module receives Modbus requests over the modem interface, interprets those requests and transfers data to or from the CPU. The Modem module then generates a Modbus response and transmits it out over the modem interface.

Tip

If the Modem module is configured to respond as a Modbus RTU slave, STEP 7-Micro/WIN is not able to communicate to the Modem module over the telephone line.

The Modem module supports the Modbus functions shown in Table 10-2.

Modbus functions 4 and 16 allow reading or writing a maximum of 125 holding registers (250 bytes of V memory) in one request. Functions 5 and 15 write to the output image register of the CPU. These values can be overwritten by user program.

Modbus addresses are normally written as 5 or 6 character values containing the data type and the offset. The first one or two characters determine the data type, and the last four characters select the proper value within the data type. The Modbus master device maps the addresses to the correct Modbus functions.

Table 10-2 Modbus Functions Supported by Modem Module

Function	Description
Function 01	Read coil (output) status
Function 02	Read input status
Function 03	Read holding registers
Function 04	Read input (analog input) registers
Function 05	Write single coil (output)
Function 06	Preset single register
Function 15	Write multiple coils (outputs)
Function 16	Preset multiple registers

Table 10-3 shows the Modbus addresses supported by the Modem module, and the mapping of Modbus addresses to the S7-200 CPU addresses.

Use the Modem Expansion wizard to create a configuration block in for the Modem module to support Modbus RTU protocol. The Modem module configuration block must be downloaded to the CPU data block before you can use the Modbus protocol.

Table 10-3 Mapping Modbus Addresses to the S7-200 CPU

Modbus Address	S7-200 CPU Address
000001	Q0.0
000002	Q0.1
000003	Q0.2
...	...
000127	Q15.6
000128	Q15.7
010001	I0.0
010002	I0.1
010003	I0.2
...	...
010127	I15.6
010128	I15.7
030001	AIW0
030002	AIW2
030003	AIW4
...	...
030032	AIW62
040001	VW0
040002	VW2
040003	VW4
...	...
04xxxx	VW 2*(xxxx–1)

Paging and SMS Messaging

The Modem module supports sending numeric and text paging messages, and SMS (Short Message Service) messages to cellular phones (where supported by the cellular provider). The messages and telephone numbers are stored in the Modem module configuration block which must be downloaded to the data block in the S7-200 CPU. You can use the Modem Expansion wizard to create the messages and telephone numbers for the Modem module configuration block. The Modem Expansion wizard also creates the program code to allow your program to initiate the sending of the messages.

Numeric Paging

Numeric paging uses the tones of a touch tone telephone to send numeric values to a pager. The Modem module dials the requested paging service, waits for the voice message to complete, and then sends the tones corresponding to the digits in the paging message. The digits 0 through 9, asterisk (*), A, B, C and D are allowed in the paging message. The actual characters displayed by a pager for the asterisk and A, B, C, and D characters are not standardized, and are determined by the pager and the paging service provider.

Text Paging

Text paging allows alphanumeric messages to be transmitted to a paging service provider, and from there to a pager. Text paging providers normally have a modem line that accepts text pages. The Modem module uses Telelocator Alphanumeric Protocol (TAP) to transmit the text messages to the service provider. Many providers of text paging use this protocol to accept messages.

Short Message Service (SMS)

Short Message Service (SMS) messaging is supported by some cellular telephone services, generally those that are GSM compatible. SMS allows the Modem module to send a message over an analog telephone line to an SMS provider. The SMS provider then transmits the message to the cellular telephone, and the message appears on the text display of the telephone. The Modem module uses the Telelocator Alphanumeric Protocol (TAP) and the Universal Computer Protocol (UCP) to send messages to the SMS provider. You can send SMS messages only to SMS providers that support these protocols on a modem line.

Embedded Variables in Text and SMS Messages

The Modem module can embed data values from the CPU in the text messages and format the data values based on a specification in the message. You can specify the number of digits to the left and right of the decimal point, and whether the decimal point is a period or a comma. When the user program commands the Modem module to transmit a text message, the Modem module retrieves the message from the CPU, determines what CPU values are needed within the message, retrieves those values from the CPU, and then formats and place the values within the text message before transmitting the message to the service provider.

The telephone number of the messaging provider, the message, and the variables embedded within the message are read from the CPU over multiple CPU scan cycles. Your program should not modify telephone numbers or messages while a message is being sent. The variables embedded within a message can continue to be updated during the sending of a message. If a message contains multiple variables, those variables are read over multiple scan cycles of the CPU. If you want all of the embedded variables within a message to be consistent, the you must not change any of the embedded variables after you send a message.

Data Transfers

The Modem module allows your program to transfer data to another CPU or to a Modbus device over the telephone line. The data transfers and telephone numbers are configured with the Modem Expansion wizard, and are stored in the Modem module configuration block. The configuration block is then downloaded to the data block in the S7-200 CPU. The Modem Expansion wizard also creates program code to allow your program to initiate the data transfers.

A data transfer can be either a request to read data from a remote device, or a request to write data to a remote device. A data transfer can read or write between 1 and 100 words of data. Data transfers move data to or from the V memory of the attached CPU.

The Modem Expansion wizard allows you to create a data transfer consisting of a single read from the remote device, a single write to the remote device, or both a read from and a write to the remote device.

Data transfers use the configured protocol of the Modem module. If the Modem module is configured to support PPI protocol (where it responds to STEP 7-Micro/WIN), the Modem module uses the PPI protocol to transfer data. If the Modem module is configured to support the Modbus RTU protocol, data transfers are transmitted using the Modbus protocol.

The telephone number of the remote device, the data transfer request and the data being transferred are read from the CPU over multiple CPU scan cycles. Your program should not modify telephone numbers or messages while a message is being sent. Also, you should not modify the data being transferred while a message is being sent.

If the remote device is another Modem module, the password function can be used by the data transfers by entering the password of the remote Modem module in the telephone number configuration. The callback function cannot be used with data transfers.

Password Protection

The password security of the Modem module is optional and is enabled with the Modem Expansion wizard. The password used by the Modem module is not the same as the CPU password. The Modem module password is a separate 8-character password that the caller must supply to the Modem module before being allowed access to the attached CPU. The password is stored in the V memory of the CPU as part of the Modem module configuration block. The Modem module configuration block must be downloaded to the data block of the attached CPU.

If the CPU has the password security enabled in the System Data Block, the caller must supply the CPU password to gain access to any password protected functions.

Security Callback

The callback function of the Modem module is optional and is configured with the Modem Expansion wizard. The callback function provides additional security for the attached CPU by allowing access to the CPU only from predefined telephone numbers. When the callback function is enabled, the Modem module answers any incoming calls, verifies the caller, and then disconnects the line. If the caller is authorized, the Modem module then dials a predefined telephone number for the caller, and allows access to the CPU.

The Modem module supports three callback modes:

- ❑ Callback to a single predefined telephone number
- ❑ Callback to multiple predefined telephone numbers
- ❑ Callback to any telephone number

The callback mode is selected by checking the appropriate option in the Modem Expansion wizard and then defining the callback telephone numbers. The callback telephone numbers are stored in the Modem module configuration block stored in the data block of the attached CPU.

The simplest form of callback is to a single predefined telephone number. If only one callback number is stored in the Modem module configuration block, whenever the Modem module answers an incoming call, it notifies the caller that callback is enabled, disconnects the caller, and then dials the callback number specified in the configuration block.

The Modem module also supports callback for multiple predefined telephone numbers. In this mode the caller is asked for a telephone number. If the supplied number matches one of the predefined telephone numbers in the Modem module configuration block, the Modem module disconnects the caller, and then calls back using the matching telephone number from the configuration block. The user can configure up to 250 callback numbers.

Where there are multiple predefined callback numbers, the callback number supplied when connecting to the Modem module must be an exact match of the number in the configuration block of the Modem module except for the first two digits. For example, if the configured callback is 91(123)4569999 because of a need to dial an outside line (9) and long distance (1), the number supplied for the callback could be any of the following:

- ❑ 91(123)4569999
- ❑ 1(123)4569999
- ❑ (123)4569999

All of the above telephone number are considered to be a callback match. The Modem module uses the callback telephone number from its configuration block when performing the callback, in this example 91(123)4569999. When configuring multiple callback numbers, make sure that all telephone numbers are unique excluding the first two digits. Only the numeric characters in a telephone number are used when comparing callback numbers. Characters such as commas or parenthesis are ignored when comparing callback numbers.

The callback to any telephone number is set up in the Modem Expansion wizard by selecting the “Enable callbacks to any phone number” option during the callback configuration. If this option is selected, the Modem module answers an incoming call and requests a callback telephone number. After the telephone number is supplied by the caller, the Modem module disconnects and dials that telephone number. This callback mode only provides a means to allow telephone charges to be billed to the Modem module’s telephone connection and does not provide any security for the S7-200 CPU. The Modem module password should be used for security if this callback mode is used.

The Modem module password and callback functions can be enabled at the same time. The Modem module requires a caller to supply the correct password before handling the callback.

Configuration Table for the Modem Module

All of the text messages, telephone numbers, data transfer information, callback numbers and other options are stored in a Modem module configuration table which must loaded into the V memory of the S7-200 CPU. The Modem Expansion wizard guides you through the creation of a Modem module configuration table. STEP 7-Micro/WIN then places the Modem module configuration table in the Data Block which is downloaded to the S7-200 CPU.

The Modem module reads this configuration table from the CPU on startup and within five seconds of any STOP-to-RUN transition of the CPU. The Modem module does not read a new configuration table from the CPU as long the Modem module is online with STEP 7-Micro/WIN. If a new configuration table is downloaded while the Modem module is online, the Modem module reads the new configuration table when the online session is ended.

If the Modem module detects an error in the configuration table, the Module Good (MG) LED on the front of the module flashes on and off. Check the PLC Information screen in STEP 7-Micro/WIN, or read the value in SMW220 (for module slot 0) for information about the configuration error. The Modem module configuration errors are listed in Table 10-4. If you use the Modem Expansion wizard to create the Modem module configuration table, STEP 7-Micro/WIN checks the data before creating the configuration table.

Table 10-4 EM 241 Configuration Errors (Hexadecimal)

Error	Description
0000	No error
0001	No 24 VDC external power
0002	Modem failure
0003	No configuration block ID - The EM 241 identification at the start of the configuration table is not valid for this module.
0004	Configuration block out of range - The configuration table pointer does not point to V memory, or some part of the table is outside the range of V memory for the attached CPU.
0005	Configuration error - Callback is enabled and the number of callback telephone numbers equals 0 or it is greater than 250. The number of messages is greater than 250. The number of messaging telephone numbers is greater than 250, or if length of the messaging telephone numbers is greater than 120 bytes.
0006	Country selection error - The country selection on the two rotary switches is not a supported value.
0007	Phone number too large - Callback is enabled and the callback number length is greater than the maximum.
0008 to 00FF	Reserved
01xx	Error in callback number xx - There are illegal characters in callback telephone number xx. The value xx is 1 for the first callback number, 2 for the second, etc.
02xx	Error in telephone number xx - One of the fields in a message telephone number xx or a data transfer telephone number xx contains an illegal value. The value xx is 1 for the first telephone number, 2 for the second, etc.
03xx	Error in message xx - Message or data transfer number xx exceeds the maximum length. The value xx is 1 for the first message, 2 for the second, etc.
0400 to FFFF	Reserved

Status LEDs of the Modem Module

The Modem module has 8 status LEDs on the front panel. Table 10-5 describes the status LEDs.

Table 10-5 EM 241 Status LEDs

LED	Description
MF	Module Fail – This LED is on when the module detects a fault condition such as: • No 24 VDC external power • Timeout of the I/O watchdog • Modem failure • Communications error with the local CPU
MG	Module Good – This LED is on when there is no module fault condition. The Module Good LED flashes if there is a error in the configuration table, or the user has selected an illegal country setting for the telephone line interface. Check the PLC Information screen in STEP 7–Micro/WIN or read the value in SMW220 (for module slot 0) for information about the configuration error.
OH	Off Hook – This LED is on when the EM 241 is actively using the telephone line.
NT	No Dial Tone – This LED indicates an error condition and turns on when the EM 241 has been commanded to send a message and there is no dial tone on the telephone line. This is only an error condition if the EM 241 has been configured to check for a dial tone before dialing. The LED remains on for approximately 5 seconds after a failed dial attempt.
RI	Ring Indicator –This LED indicates that the EM 241 is receiving an incoming call.
CD	Carrier Detect – This LED indicates that a connection has been established with a remote modem.
Rx	Receive Data – This LED flashes on when the modem is receiving data.
Tx	Transmit Data – This LED flashes on when the modem is transmitting data.

Using the Modem Expansion Wizard to Configure the Modem Module

Modem Expansion

Start the Modem Expansion wizard from the STEP 7–Micro/WIN Tools menu or from the Tools portion of the Navigation Bar.

To use this wizard, the project must be compiled and set to Symbolic Addressing Mode. If you have not already compiled your program, compile it now.

1. On first screen of the Modem Expansion wizard, select Configure an EM 241 Modem module and click Next>.
2. The Modem Expansion wizard requires the Modem module's position relative to the S7-200 CPU in order to generate the correct program code. Click the Read Modules button to automatically read the positions of the intelligent modules attached to the CPU. Expansion modules are numbered sequentially starting at zero. Double-click the Modem module that you want to configure, or set the Module Position field to the position of the Modem module. Click Next>.

   For an S7-200 CPU with firmware prior to version 1.2, you must install the intelligent module next to the CPU in order for the Modem Expansion wizard to configure the module.
3. The password protection screen allows you to enable password protection for the Modem module and assign a 1 to 8 character password for the module. This password is independent of the S7-200 CPU password. When the module is password-protected, anyone who attempts to connect with the S7-200 CPU through the Modem module is required to supply the correct password. Select password protection if desired, and enter a password. Click Next>.

4. The Modem module supports two communications protocols: PPI protocol (to communicate with STEP 7–Micro/WIN), and Modbus RTU protocol. Protocol selection is dependent on the type of device that is being used as the remote communications partner. This setting controls the communications protocol used when the Modem module answers a call and also when the Modem module initiates a CPU data transfer. Select the appropriate protocol and click Next>.
5. You can configure the module to send numeric and text messages to pagers, or Short Message Service (SMS) messages to cellular telephones. Check the Enable messaging checkbox and click the Configure Messaging... button to define messages and the recipient's telephone numbers.
6. When setting up a message to be sent to a pager or cellular phone, you must define the message and the telephone number. Select the Messages tab on the Configure Messaging screen and click the New Message button. Enter the text for the message and specify any CPU data values to insert into the message. To insert a CPU data value into the message, move the cursor to the position for the data and click the Insert Data... button. Specify the address of the CPU data value (i.e. VW100), the display format (i.e. Signed Integer) and the digits left and right of the decimal point. You can also specify if the decimal point should be a comma or a period.
   - Numeric paging messages are limited to the digits 0 to 9, the letters A, B, C and D, and the asterisk (*). The maximum allowed length of a numeric paging message varies by service provider.
   - Text messages can be up to 119 characters in length and contain any alphanumeric character.
   - Text messages can contain any number of embedded variables.
   - Embedded variables can be from V, M, SM, I, Q, S, T, C or AI memory in the attached CPU.
   - Hexadecimal data is displayed with a leading '16#'. The number of characters in the value is based on the size of the variable. For example, VW100 displays as 16#0123.
   - The number of digits left of the decimal must be large enough to display the expected range of values, including the negative sign, if the data value is a signed integer or floating point value.
   - If the data format is integer and the number of digits right of the decimal point is not zero, the integer value is displayed as a scaled integer. For example, if VW100 = 1234 and there are 2 digits right of the decimal point, the data is displayed as '12.34'.
   - If the data value is greater than can be displayed in the specified field size, the Modem module places the # character in all character positions of data value.
7. Telephone numbers are configured by selecting the Phone Numbers tab on the Configure Messaging screen. Click the New Phone Number... button to add a new telephone number. Once a telephone number has been configured it must be added to the project. Highlight the telephone number in the Available Phone Numbers column and click the right arrow box to add the telephone number to the current project. Once you have added the telephone number to the current project, you can select the telephone number and add a symbolic name for this number to use in your program.

   The telephone number consists of several fields which vary based on the type of messaging selected by the user.
   - The Messaging Protocol selection tells the Modem module which protocol to use when sending the message to the message service provider. Numeric pagers support only numeric protocol. Text paging services usually require TAP (Telelocator Alphanumeric Protocol). SMS messaging providers are supported with either TAP or UCP (Universal Computer Protocol). There are three different UCP services normally used for SMS messaging. Most providers support command 1 or 51. Check with the SMS provider to determine the protocol and commands required by that provider.
   - The Description field allows you to add a text description for the telephone number.

- The Phone Number field is the telephone number of the messaging service provider. For text messages this is the telephone number of the modem line the service provider uses to accept text messages. For numeric paging this is the telephone number of the pager itself. The Modem module allows the telephone number field to be a maximum of 40 characters. The following characters are allowed in telephone numbers that the Modem module uses to dial out:

0 to 9	allowed from a telephone keypad
A B C D * #	DTMF digits (tone dialing only)
,	pause dialing for 2 seconds
!	commands the modem to generate a hook flash
@	wait for 5 seconds of silence
W	wait for a dial tone before continuing
( )–	ignored (can be used to format the telephone number)

  The dash character (–) is only supported in Version 1.1 of the EM 241 Modem module.

- The Specific Pager ID or Cell Phone Number field is where you enter the pager number or cellular telephone number of the message recipient. This number should not contain any characters except the digits 0 through 9. A maximum of 20 characters is allowed.

- The Password field is optional for TAP message. Some providers require a password but normally this field should be left blank. The Modem module allows the password to be up to 15 characters.

- The Originating Phone Number field allows the Modem module to be identified in the SMS message. This field is required by some service providers which use UCP commands. Some service providers might require a minimum number of characters in this field. The Modem module allows up to 15 characters.

- The Modem Standard field is provided for use in cases where the Modem module and the service provider modem cannot negotiate the modem standard. The default is V.34 (33.6 kBaud).

- The Data Format fields allow you to adjust the data bits and parity used by the modem when transmitting a message to a service provider. TAP normally used 7 data bits and even parity, but some service providers use 8 data bits and no parity. UCP always uses 8 data bits with no parity. Check with the service provider to determine which settings to use.

8. You can configure the Modem module to transfer data to another S7-200 CPU (if PPI protocol was selected) or to transfer data to a Modbus device (if Modbus protocol was selected). Check the Enable CPU data transfers checkbox and click the Configure CPU-to... button to define the data transfers and the telephone numbers of the remote devices.

9. When setting up a CPU-to-CPU or a CPU-to-Modbus data transfer you must define the data to transfer and the telephone number of the remote device. Select the Data Transfers tab on the Configure Data Transfers screen and click the New Transfer button. A data transfer consists of a data read from the remote device, a data write to the remote device, or both a read from and a write to the remote device. If both a read and a write are selected, the read is performed first and then the write.

   Up to 100 words can be transferred in each read or write. Data transfers must be to or from the V Memory in the local CPU. The wizard always describes the memory locations in the remote device as if the remote device is an S7-200 CPU. If the remote device is a Modbus device, the transfer is to or from holding registers in the Modbus device (address 04xxxx). The equivalent Modbus address (xxxx) is determined as follows:

   Modbus address = 1 + (V memory address / 2)
   V memory address = (Modbus address – 1) * 2

10. The Phone Numbers tab on the Configure CPU Data Transfers screen allows you to define the telephone numbers for CPU-to-CPU or a CPU-to-Modbus data transfers. Click the New Phone Number... button to add a new telephone number. Once a telephone number has been configured it must be added to the project. Highlight the telephone number in the Available Phone Numbers column and click the right arrow box to add the telephone number to the current project. Once you have added the telephone number to the current project, you can select the telephone number and add a symbolic name for this telephone number to use in your program.

    The Description and Phone Number fields are the same as described earlier for messaging. The Password field is required if the remote device is a Modem module and password protection has been enabled. The Password field in the local Modem module must be set to the password of the remote Modem module. The local Modem module supplies this password when it is requested by the remote Modem module.

11. Callback causes the Modem module to automatically disconnect and dial a predefined telephone number after receiving an incoming call from a remote STEP 7–Micro/WIN. Select the Enable callback checkbox and click the Configure Callback... button to configure callback telephone numbers. Click Next>.

12. The Configure Callback... screen allows you enter the telephone numbers the Modem module uses when it answers an incoming call. Check the ‘Enable callbacks to only specified phone numbers’ if the callback numbers are to be predefined. If the Modem module is to accept any callback number supplied by the incoming caller (to reverse the connection charges), check the ‘Enable callbacks to any phone number’ selection.

    If only specified callback telephone numbers are allowed, click the New Phone Number button to add callback telephone numbers. The Callback Properties screen allows you to enter the predefined callback telephone numbers and a description for the callback number. The callback number entered here is the telephone number that the Modem module uses to dial when performing the callback. This telephone number should include all digits required to connect to an outside line, pause while waiting for an outside line, connect to long distance, etc.

    After entering a new callback telephone number, it must be added to the project. Highlight the telephone number in the Available Callback Phone Numbers column and click the right arrow box to add the telephone number to the current project.

13. You can set the number of dialing attempts that the Modem module makes when sending a message or during a data transfer. The Modem module reports an error to the user program only when all attempts to dial and send the message are unsuccessful.

    Some telephone lines do not have a dial tone present when the telephone receiver is lifted. Normally, the Modem module returns an error to the user program if a dial tone is not present when the Modem module is commanded to send a message or perform a callback. To allow dialing out on a line with no dial tone, check the box, Enable Dialing Without Dial Tone Selection.

14. Version 1.1 of the EM 241 Module can be programmed to answer after a specific number of rings. The module will answer on the first ring unless another value is specified. You can select the answering ring number between 0 and 20. Values of 0 and 1 will answer on the first ring. The value of zero provides compatibility with the previous version of the EM 241.

    When using Modbus RTU protocol, Version 1.1 of the EM 241 Module allows the user to configure the module to answer only a specific Modbus address. You can specify Modbus addresses between 0 and 247. An address of zero provides compatibility with the previous version of the EM 241 and causes the EM 241 to answer any address.

15. The Modem Expansion wizard creates a configuration block for the Modem module and requires the user to enter the starting memory address where the Modem module configuration data is stored. The Modem module configuration block is stored in V Memory in the CPU. STEP 7–Micro/WIN writes the configuration block to the project Data Block. The size of the configuration block varies based on the number of messages and telephone numbers configured. You can select the V Memory address where you want the configuration block stored, or click the Suggest Address button if you want the wizard to suggest the address of an unused V Memory block of the correct size. Click Next>.

16. The final step in configuring the Modem module is to specify the Q memory address of the command byte for the Modem module. You can determine the Q memory address by counting the output bytes used by any modules with discrete outputs installed on the

S7-200 before the Modem module. Click Next>.

17. The Modem Expansion wizard now generates the project components for your selected configuration (program block and data block) and makes that code available for use by your program. The final wizard screen displays your requested configuration project components. You must download the Modem module configuration block (Data Block) and the Program Block to the S7-200 CPU.

Overview of Modem Instructions and Restrictions

The Modem Expansion wizard makes controlling the Modem module easier by creating unique instruction subroutines based on the position of the module and configuration options you selected. Each instruction is prefixed with a “MODx_” where x is the module location.

Requirements for Using the EM 241 Modem Module Instructions

Consider these requirements when you use Modem module instructions:

- ❑ The Modem module instructions use three subroutines.
- ❑ The Modem module instructions increase the amount of memory required for your program by up to 370 bytes. If you delete an unused instruction subroutine, you can rerun the Modem Expansion wizard to recreate the instruction if needed.
- ❑ You must make sure that only one instruction is active at a time.
- ❑ The instructions cannot be used in an interrupt routine.
- ❑ The Modem module reads the configuration table information when it first powers up and after a STOP-to-RUN transition. Any change that your program makes to the configuration table is not seen by the module until a mode change or the next power cycle.

Using the EM 241 Modem Module Instructions

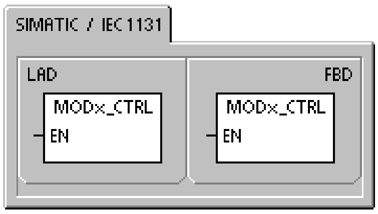
To use the Modem module instructions in your S7-200 program, follow these steps:

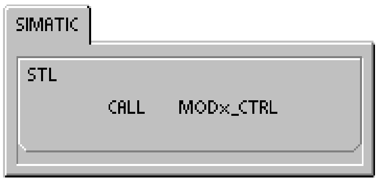
1. Use the Modem Expansion wizard to create the Modem module configuration table.
2. Insert the MODx_CTRL instruction in your program and use the SM0.0 contact to execute it every scan.
3. Insert a MODx_MSG instruction for each message you need to send.
4. Insert a MODx_XFR instruction for each data transfer.

Instructions for the Modem Module

MODx_CTRL Instruction

The MODx_CTRL (Control) instruction is used to enable and initialize the Modem module. This instruction should be called every scan and should only be used once in the project.





```
CALL     MODx_CTRL
```

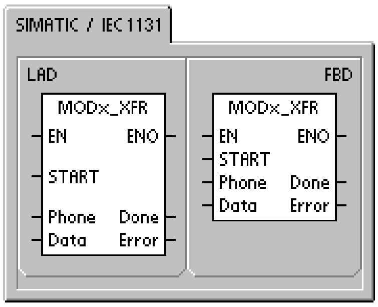
MODx_XFR Instruction

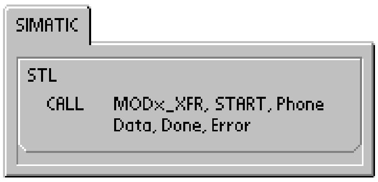
The MODx_XFR (Data Transfer) instruction is used to command the Modem module to read and write data to another S7-200 CPU or a Modbus device. This instruction requires 20 to 30 seconds from the time the START input is triggered until the Done bit is set.

The EN bit must be on to enable a command to the module, and should remain on until the Done bit is set, signaling completion of the process. An XFR command is sent to the Modem module on each scan when START input is on and the module is not currently busy. The START input can be pulsed on through an edge detection element, which only allows one command to be sent.

Phone is the number of one of the data transfer telephone numbers. You can use the symbolic name you assigned to each data transfer telephone number when the number was defined with the Modem Expansion wizard.

Data is the number of one of the defined data transfers. You can use the symbolic name you assigned to the data transfer when the request was defined using the Modem Expansion wizard.





```
CALL     MODx_XFR, START, Phone
         Data, Done, Error
```

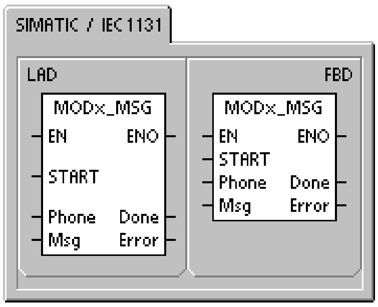
Done is a bit that comes on when the Modem module completes the data transfer.

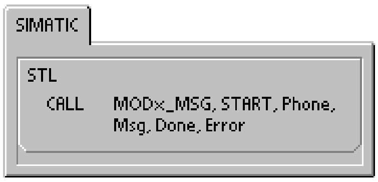
Error is a byte that contains the result of the data transfer. Table 10-4 defines the possible error conditions that could result from executing this instruction.

Table 10-6 Parameters for the MODx_XFR Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, M, S, SM, T, C, V, L, Power Flow
Phone, Data	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

MODx_MSG Instruction





```
CALL    MODx_MSG, START, Phone,
        Msg, Done, Error
```

The MODx_MSG (Send Message) instruction is used to send a paging or SMS message from Modem module. This instruction requires 20 to 30 seconds from the time the START input is triggered until the Done bit is set.

The EN bit must be on to enable a command to the module, and should remain on until the Done bit is set, signaling completion of the process. A MSG command is sent to the Modem module on each scan when START input is on and the module is not currently busy. The START input can be pulsed on through an edge detection element, which only allows one command to be sent.

Phone is the number of one of the message telephone numbers. You can use the symbolic name you assigned to each message telephone number the when the number was defined with the Modem Expansion wizard.

Msg is the number of one of the defined messages. You can use the symbolic name you assigned to the message when the message was defined using the Modem Expansion wizard.

Done is a bit that comes on when the Modem module completes the sending of the message to the service provider.

Error is a byte that contains the result of this request to the module. Table 10-8 defines the possible error conditions that could result from executing this instruction.

Table 10-7 Parameters for the MODx_MSG Instruction

Inputs/Outputs	Data Type	Operands
START	BOOL	I, Q, M, S, SM, T, C, V, L, Power Flow
Phone, Msg	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Table 10-8 Error Values Returned by MODx_MSG and MODx_XFR Instructions

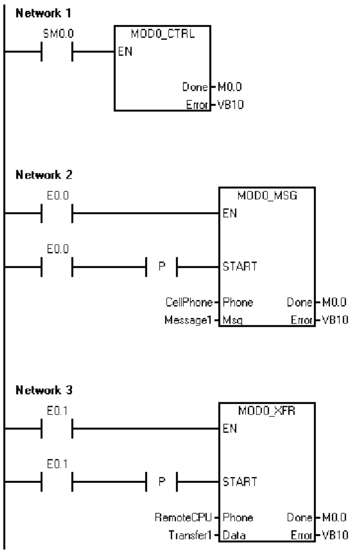
Error	Description
0	No error
Telephone line errors	
1	No dial tone present
2	Busy line
3	Dialing error
4	No answer
5	Connect timeout (no connection within 1 minute)
6	Connection aborted or an unknown response
Errors in the command	
7	Numeric paging message contains illegal digits
8	Telephone number (Phone input) out of range
9	Message or data transfer (Msg or Data input) out of range
10	Error in text message or data transfer message
11	Error in messaging or data transfer telephone number
12	Operation not allowed (i.e. attempts set to zero)
Service provider errors	
13	No response (timeout) from messaging service
14	Message service disconnected for unknown reason
15	User aborted message (disabled command bit)
TAP – Text paging and SMS message errors returned by service provider	
16	Remote disconnect received (service provider aborted session)
17	Login not accepted by message service (incorrect password)
18	Block not accepted by message service (checksum or transmission error)
19	Block not accepted by message service (unknown reason)
UCP – SMS message errors returned by service provider	
20	Unknown error
21	Checksum error
22	Syntax error
23	Operation not supported by system (illegal command)
24	Operation not allowed at this time
25	Call barring active (blacklist)
26	Caller address invalid
27	Authentication failure
28	Legitimization code failure
29	GA not valid
30	Repetition not allowed
31	Legitimization code for repetition, failure
32	Priority call not allowed
33	Legitimization code for priority call, failure
34	Urgent message not allowed
35	Legitimization code for urgent message, failure
36	Reverse charging not allowed
37	Legitimization code for reverse charging, failure

Table 10-8 Error Values Returned by MODx_MSG and MODx_XFR Instructions, continued

Error	Description
UCP – SMS message errors returned by service provider (continued)	
38	Deferred delivery not allowed
39	New AC not valid
40	New legitimization code not allowed
41	Standard text not valid
42	Time period not valid
43	Message type not supported by system
44	Message too long
45	Requested standard text not valid
46	Message type not valid for pager type
47	Message not found in SMSC
48	Reserved
49	Reserved
50	Subscriber hang up
51	Fax group not supported
52	Fax message type not supported
Data transfer errors	
53	Message timeout (no response from remote device)
54	Remote CPU busy with upload or download
55	Access error (memory out of range, illegal data type)
56	Communications error (unknown response)
57	Checksum or CRC error in response
58	Remote EM 241 set for callback (not allowed)
59	Remote EM 241 rejected the provided password
60 to 127	Reserved
Instruction use errors	
128	Cannot process this request. Either the Modem module is busy with another request, or there was no START pulse on this request.
129	Modem module error: • The location of the Modem module or the Q memory address that was configured with the Modem Expansion wizard does not match the actual location or memory address • Refer to SMB8 to SMB21 (I/O Module ID and Error Register)

Sample Program for the Modem Module

Example: Modem Module



```
Network 1       // Call the MOD0_CTRL
                // subroutine  on every scan.
LD          SM0.0
CALL        MOD0_CTRL

Network 2       // Send a text message
                //to a cell phone.
LD          I0.0
EU
=           L63.7
LD          I0.0
CALL        MOD0_MSG, L63.7, Cell Phone,
             Message1, M0.0, VB10

Network 3       // Transfer data to
                a remote CPU.
LD          I0.1
EU
=           L63.7
LD          I0.1
CALL        MOD0_XFR, L63.7, Remote CPU,
            Transfer1, M0.0, VB10
```

S7-200 CPUs that Support Intelligent Modules

The Modem module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table 10-9.

Table 10-9 EM 214 Module Compatibility with S7-200 CPUs

CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel. 2.00 or greater	CPU 224XP DC/DC/DC and CPU 224XP AC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

Special Memory Location for the Modem Module

Fifty bytes of special memory (SM) are allocated to each intelligent module based on its physical position in the I/O expansion bus. When an error condition or a change in status is detected, the module indicates this by updating the SM locations corresponding to the module’s position. If it is the first module, it updates SMB200 through SMB249 as needed to report status and error information. If it is the second module, it updates SMB250 through SMB299, and so on. See Table 10-10.

Table 10-10 Special Memory Bytes SMB200 to SMB549

Special Memory Bytes SMB200 to SMB549						
Intelligent Module in Slot 0	Intelligent Module in Slot 1	Intelligent Module in Slot 2	Intelligent Module in Slot 3	Intelligent Module in Slot 4	Intelligent Module in Slot 5	Intelligent Module in Slot 6
SMB200 to SMB249	SMB250 to SMB299	SMB300 to SMB349	SMB350 to SMB399	SMB400 to SMB449	SMB450 to SMB499	SMB500 to SMB549

Table10-11 shows the Special Memory data area allocated for the Modem module. This area is defined as if this were the intelligent module located in Slot 0 of the I/O system.

Table 10-11 SM Locations for the EM 241 Modem Module

SM Address	Description
SMB200 to SMB215	Module name (16 ASCII characters) SMB200 is the first character. “EM241 Modem”
SMB216 to SMB219	S/W revision number (4 ASCII characters) SMB216 is the first character.
SMW220	Error code 0000 – No error 0001 – No user power 0002 – Modem failure 0003 – No configuration block ID 0004 – Configuration block out of range 0005 – Configuration error 0006 – Country code selection error 0007 – Phone number too large 0008 – Message too large 0009 to 00FF – Reserved 01xx – Error in callback number xx 02xx – Error in pager number xx 03xx – Error in message number xx 0400 to FFFF – Reserved
SMB222	Module status – reflects the LED status MSB LSB 7 6 5 4 3 2 1 0 F G H T R C 0 0 F – EM_FAULT 0 – no fault 1 – fault G – EM_GOOD 0 – not good 1 – good H – OFF_HOOK 0 – on hook, 1 – off hook T – NO DIALTONE 0 – dial tone 1 – no dial tone R – RING 0 – not ringing 1 – phone ringing C – CONNECT 0 – not connected 1 – connected
SMB223	Country code as set by switches (decimal value)
SMW224	Baud rate at which the connection was established (unsigned decimal value).
SMB226	Result of the user command MSB LSB 7 6 5 0 D 0 ERROR D – Done bit; 0 – operation in progress 1 – operation complete ERROR : Error Code Description, see Table 10-8
SMB227	Telephone number selector – This byte specifies which messaging telephone number to use when sending a message. Valid values are 1 through 250.
SMB228	Message selector – This byte specifies which message to send. Valid values are 1 through 250.
SMB229 to SMB244	Reserved
SMB245	Offset to the first Q byte used as the command interface to this module. The offset is supplied by the CPU for the convenience of the user and is not needed by the module.
SMD246	Pointer to the configuration table for the Modem module in V memory. A pointer value to an area other than V memory is not accepted and the module continues to examine this location, waiting for a non-zero pointer value.

Advanced Topics

Understanding the Configuration Table

The Modem Expansion wizard has been developed to make modem applications easy by automatically generating the configuration table based upon the answers you give about your system. Configuration table information is provided for advanced users who want to create their own Modem module control routines and format their own messages.

The configuration table is located in the V memory area of the S7-200. In Table 10-12, the Byte Offset column of the table is the byte offset from the location pointed to by the configuration area pointer in SM memory. The configuration table information is divided into four sections.

- ❑ The Configuration Block contains information to configure the module.
- ❑ The Callback Telephone Number Block contains the predefined telephone numbers allowed for callback security.
- ❑ The Message Telephone Number Block contains the telephone numbers used when dialing messaging services or CPU data transfers.
- ❑ The Message Block contains the predefined messages to send to the messaging services.

Table 10-12 Configuration Table for the Modem Module

Configuration Block	
Byte Offset	**Description**
0 to 4	Module Identification – Five ASCII characters used for association of the configuration table to an intelligent module. Release 1.00 of the EM 241 Modem module expects “M241A”.
5	The length of the Configuration Block – Currently 24.
6	Callback telephone number length – Valid values are 0 through 40.
7	Messaging telephone number length – Valid values are 0 through 120.
8	Number of callback telephone numbers – Valid values are 0 through 250.
9	Number of messaging telephone numbers – Valid values are 0 through 250.
10	Number of messages – Valid values are 0 through 250.
11	Answer ring number – Valid values are 0 through 20.
12	Modbus RTU address – Valid values are 0 through 247.
13	This byte contains the enable bits for the features supported. MSB LSB 7 6 5 4 3 2 1 0 PD CB PW MB BD 0 0 0 PD – 0 = tone dialing 1 = pulse dialing CB – 0 = callback disabled 1 = callback enabled PW – 0 = password disabled 1 = password enabled MB – 0 = PPI protocol enabled 1 = Modbus protocol enabled BD – 0 = blind dialing disabled 1 = blind dialing enabled Bits 2, 1 and 0 are ignored by the module
14	Reserved
15	Attempts – This value specifies the number of times the modem is to attempt to dial and send a message before returning an error. A value of 0 prevents the modem from dialing out.
16 to 23	Password – Eight ASCII characters

Table 10-12 Configuration Table for the Modem Module, continued

Callback Telephone Number Block (optional)	
Byte Offset	**Description**
24	Callback Telephone Number 1 – A string representing the first telephone number that is authorized for callback access from the EM 241 Modem module. Each callback telephone number must be allocated the same amount of space as specified in the callback telephone number length field (offset 6 in the Configuration Block).
24+ callback number	Callback Telephone Number 2
:	:
:	Callback Telephone Number n
Messaging Telephone Number Block (optional)	
Byte Offset	**Description**
M	Messaging Telephone Number 1 – A string representing a messaging telephone number which includes protocol and dialing options. Each telephone number must be allocated the same amount of space as specified in the messaging telephone number length field (offset 7 in the Configuration Block). The messaging telephone number format is described below
M + messaging number length	Messaging Telephone Number 2
:	:
:	Messaging Telephone Number n
Message Block (optional)	
Byte Offset	**Description**
N	V memory offset (relative to VB0) for the first message (2 bytes)
N+2	Length of message 1
N+3	Length of message 2
:	
:	Length of message n
P	Message 1 – A string (120 bytes max.) representing the first message. This string includes text and embedded variable specifications or it could specify a CPU data transfer. See the Text Message Format and the CPU Data Transfer Format described below.
P + length of message 1	Message 2
:	:
:	Message n

The Modem module re-reads the configuration table when these events occur:

❑ Within five seconds of each STOP-to-RUN transition of the S7-200 CPU (unless the modem is currently online)

❑ Every five seconds until a valid configuration is found (unless the modem is currently online)

❑ Every time the modem transitions from an online to an offline condition

Messaging Telephone Number Format

The Messaging Telephone Number is a structure which contains the information needed by the Modem module to send a message. The Messaging Telephone Number is an ASCII string with a leading length byte followed by ASCII characters. The maximum length of a Messaging Telephone Number is 120 bytes (which includes the length byte).

The Messaging Telephone Number contains up to 6 fields separated by a forward slash (/) character. Back-to-back slashes indicate an empty (null) field. Null fields are set to default values in the Modem module.

Format: <Telephone Number>/<ID>/<Password/<Protocol>/<Standard>/<Format>

The Telephone Number field is the telephone number that the Modem module dials when sending a message. If the message being sent is a text or SMS message, this is the telephone number of the service provider. If the message is a numeric page, this field is the pager telephone number. If the message is a CPU data transfer, this is the telephone number of the remote device. The maximum number of characters in this field is 40.

The ID is the pager number or cellular telephone number. This field should consist of the digits 0 to 9 only. If the protocol is a CPU data transfer, this field is used to supply the address of the remote device. Up to 20 characters are allowed in this field.

The Password field is used to supply the a password for messages sent via TAP if a password is required by the service provider. For messages sent via UCP this field is used as the originating address or telephone number. If the message is a CPU data transfer to another Modem module, this field can be used to supply the password of the remote Modem module. The password can be up to 15 characters in length.

The Protocol field consists of one ASCII character which tells the Modem module how it should format and transmit the message. The following values are allowed:

1 – Numeric paging protocol (default)
2 – TAP
3 – UCP command 1
4 – UCP command 30
5 – UCP command 51
6 – CPU data transfer

The Standard field forces the Modem module to use a specific modem standard. The standard field is one ASCII character. The following values are allowed:

1 – Bell 103
2 – Bell 212
3 – V.21
4 – V.22
5 – V.22 bit
6 – V.23c
7 – V.32
8 – V.32 bit
9 – V.34 (default)

The Format field is three ASCII characters which specify the number of data bits and parity to be used when transmitting the message. This field does not apply if the protocol is set to numeric paging. Only the following two settings are allowed:

8N1 – 8 data bits, no parity, one stop bit (default)
7E1 – 7 data bits, even parity, one stop bit

Text Message Format

The Text Message Format defines the format of text paging or SMS messages. These types of messages can contain text and embedded variables. The text message is an ASCII string with a leading length byte followed by ASCII characters. The maximum length of a text message is 120 bytes (which includes the length byte).

Format: <Text><Variable><Text><Variable>...

The Text field consists of ASCII characters.

The Variable field defines an embedded data value which the Modem module reads from the local CPU, formats, and places in the message. The percent (%) character is used to mark the start and the end of a variable field. The address and the left fields are separated with a colon. The delimiter between the Left and Right fields can be either a period or a comma and is used as the decimal point in the formatted variable. The syntax for the variable field is:

%Address:Left.Right Format%

The Address field specifies the address, data type and size of the embedded data value (i.e. VD100, VW50, MB20 or T10). The following data types are allowed: I, Q, M, SM, V, T (word only), C (word only), and AI (word only). Byte, word and double word sizes are allowed.

The Left field defines the number of digits to display left of the decimal point. This value should be large enough to handle the expected range of the embedded variable including a minus sign if needed. If Left is zero the value is displayed with a leading zero. The valid range for Left is 0 to 10.

The Right field defines the number of digits to display right of the decimal point. Zeros to the right of the decimal point are always displayed. If Right is zero the number is displayed without a decimal point. The valid range for Right is 0 to 10.

The Format field specifies the display format of the embedded value. The following characters are allowed for the format field:

i – signed integer
u – unsigned integer
h – hexadecimal
f – floating point/real

Example: “Temperature = %VW100:3.1i% Pressure = %VD200:4.3f%”

CPU Data Transfer Message Format

A CPU data transfer, either a CPU-to-CPU or a CPU-to-Modbus data transfer, is specified using the CPU Data Transfer Message Format. A CPU Data Transfer Message is an ASCII string which can specify any number of data transfers between devices, up to the number of specifications that fit in the maximum message length of 120 bytes (119 characters plus a length byte). An ASCII space can be used to separate the data transfer specifications, but is not required. All data transfer specifications are executed within one connection. Data transfers are executed in the order defined in the message. If an error is detected in a data transfer, the connection to the remote device is terminated and subsequent transactions are not processed.

If the operation is specified as a read, Count number of words are read from the remote device starting at the Remote_address, and then written to V Memory in the local CPU starting at the Local_address.

If the operation is specified as a write, Count number of words are read from the local CPU starting at the Local_address, and then written to the remote device starting at Remote_address.

Format: <Operation>=<Count>,<Local_address>,<Remote_address>

The Operation field consists of one ASCII character and defines the type of transfer.

R – Read data from the remote device
W – Write data to the remote device

The Count field specifies the number of words to be transferred. The valid range for the count field is 1 to 100 words.

The Local_address field specifies the V Memory address in the local CPU for the data transfer (i.e. VW100).

The Remote_address field specifies the address in the remote device for the data transfer (i.e. VW500). This address is always specified as a V Memory address even if the data transfer is to a Modbus device. If the remote device is a Modbus device, the conversion between V Memory address and Modbus address is as follows:

Modbus address = 1 + (V Memory address / 2)
V Memory address = (Modbus address – 1) * 2

Example: R=20,VW100, VW200 W=50,VW500,VW1000 R=100,VW1000,VW2000

11

Using the USS Protocol Library to Control a MicroMaster Drive

STEP 7-Micro/WIN Instruction Libraries makes controlling MicroMaster drives easier by including preconfigured subroutines and interrupt routines that are specifically designed for using the USS protocol to communicate with a motor drive. You can control the physical drive and the read/write drive parameters with the USS instructions.

You find these instructions in the Libraries folder of the STEP 7-Micro/WIN instruction tree. When you select a USS instruction, one or more associated subroutines (USS1 through USS7) are added automatically.

Siemens Libraries are sold on a separate CD, STEP 7-Micro/WIN Add-On: Instruction Library, with the order number 6ES7 830-2BC00-0YX0. After version 1.1 of the Siemens Library is purchased and installed, any subsequent STEP 7-Micro/WIN V3.2x and V4.0 upgrade that you install will also upgrade your libraries automatically at no additional cost (when library additions or modifications are made).

In This Chapter

Requirements for Using the USS Protocol

The STEP 7–Micro/WIN Instruction Libraries provide subroutines, interrupt routines, and instructions to support the USS protocol. The USS instructions use the following resources in the S7-200:

- USS Protocol is an interrupt driven application. In the worst case the receive message interrupt routine requires up to 2.5ms to execute. During this time all other interrupt events are queued for service after the receive message interrupt routine has been executed. If your application cannot tolerate this worst case delay, then you may want to consider other solutions for controlling drives.
- Initializing the USS protocol dedicates an S7-200 port for USS communications.

  You use the USS_INIT instruction to select either USS or PPI for port 0. (USS refers to the USS protocol for SIMOTION MicroMaster drives.) You can also use USS_INIT_P1 to assign port 1 for USS communication. When a port is set to use the USS protocol for communicating with drives, you cannot use the port for any other purpose, including communicating with STEP 7–Micro/WIN.

  During the development of the program for an application using the USS protocol, you should use a two port model, CPU 226, CPU 226XM, or EM 277 PROFIBUS_DP module connected to a PROFIBUS CP card in your computer. The second communications port allows STEP 7–Micro/WIN to monitor the control program while USS protocol is running.
- The USS instructions affect all of the SM locations that are associated with Freeport communications on the assigned port.
- The USS subroutines and interrupt routines are stored in your program.
- The USS instructions increase the amount of memory required for your program by up to 3050 bytes. Depending on the specific USS instructions used, the support routines for these instructions can increase the overhead for the control program by at least 2150 bytes, up to 3500 bytes.
- The variables for the USS instructions require a 400-byte block of V memory. The starting address for this block is assigned by the user and is reserved for USS variables.
- Some of the USS instructions also require a 16-byte communications buffer. As a parameter for the instruction, you provide a starting address in V memory for this buffer. It is recommended that a unique buffer be assigned for each instance of USS instructions.
- When performing calculations, the USS instructions use accumulators AC0 to AC3. You can also use the accumulators in your program; however, the values in the accumulators will be changed by the USS instructions.
- The USS instructions cannot be used in an interrupt routine.

Tip

To change the operation of a port back to PPI so that you can communicate with STEP 7–Micro/WIN, use another USS_INIT instruction to reassign the port to PPI operation..

You can also set the mode switch on the S7-200 to STOP mode. This resets the parameters for the port. Be aware that stopping the communications to the drives also stops the drives.

Calculating the Time Required for Communicating with the Drive

Communications with the drive are asynchronous to the S7-200 scan. The S7-200 typically completes several scans before one drive communications transaction is completed. The following factors help determine the amount of time required: the number of drives present, the baud rate, and the scan time of the S7-200.

Some drives require longer delays when using the parameter access instructions. The amount of time required for a parameter access is dependent on the drive type and the parameter being accessed.

After a USS_INIT instruction assigns Port 0 to use the USS Protocol (or USS_INIT_P1 for port 1), the S7-200 regularly polls all active drives at the intervals shown in Table 11-1. You must set the time-out parameter of each drive to allow for this task.

Table 11-1   Communications Times

Baud Rate	Time Between Polls of Active Drives (with No Parameter Access Instructions Active)
1200	240 ms (maximum) times the number of drives
2400	130 ms (maximum) times the number of drives
4800	75 ms (maximum) times the number of drives
9600	50 ms (maximum) times the number of drives
19200	35 ms (maximum) times the number of drives
38400	30 ms (maximum) times the number of drives
57600	25 ms (maximum) times the number of drives
115200	25 ms (maximum) times the number of drives

Tip

Only one USS_RPM_x or USS_WPM_x instruction can be active at a time. The Done output of each instruction should signal completion before user logic initiates a new instruction.

Use only one USS_CTRL instruction for each drive.

Using the USS Instructions

To use the USS protocol instructions in your S7-200 controller program, follow these steps:

1. Insert the USS_INIT instruction in your program and execute the USS_INIT instruction for one scan only. You can use the USS_INIT instruction either to initiate or to change the USS communications parameters.

   When you insert the USS_INIT instruction, several hidden subroutines and interrupt routines are automatically added to your program.

2. Place only one USS_CTRL instruction in your program for each active drive.

   You can add as many USS_RPM_x and USS_WPM_x instructions as required, but only one of these can be active at a time.

3. Allocate the V memory for the library instructions by right-clicking (to get the menu) on the Program Block node in the instruction tree.

   Select the Library Memory option to display the Library Memory Allocation dialog box.

4. Configure the drive parameters to match the baud rate and address used in the program.

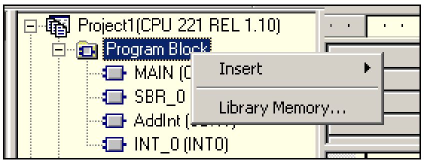


Figure 11-1   Allocating V Memory for the Instruction Library

5. Connect the communications cable between the S7-200 and the drives.

   Ensure that all of the control equipment, such as the S7-200, that is connected to the drive be connected by a short, thick cable to the same ground or star point as the drive.

Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable. These unwanted currents can cause communications errors or damage equipment.

Ensure that all equipment that is connected with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows.

The shield must be tied to chassis ground or pin 1 on the 9-pin connector. It is recommended that you tie wiring terminal 2–0V on the MicroMaster drive to chassis ground.

Instructions for the USS Protocol

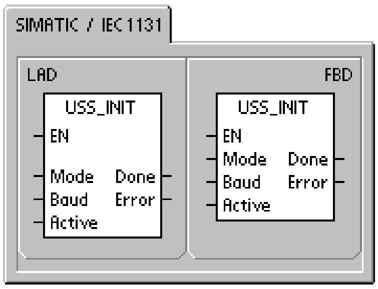
USS_INIT Instruction

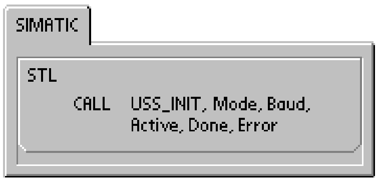
The USS_INIT instruction (port 0) or USS_INIT_P1 (port 1) is used to enable and initialize, or to disable MicroMaster Drive communications. Before any other USS instruction can be used, the USS_INIT instruction must be executed without errors. The instruction completes and the Done bit is set immediately, before continuing to the next instruction.

The instruction is executed on each scan when the EN input is on.

Execute the USS_INIT instruction only once for each change in communications state. Use an edge detection instruction to pulse the EN input on. To change the initialization parameters, execute a new USS_INIT instruction.

The value for Mode selects the communications protocol: an input value of 1 assigns a port to USS protocol and enables the protocol, and an input value of 0 assigns port 0 to PPI and disables the USS protocol.




SIMATIC

STL

```
CALL    USS_INIT, Mode, Baud,
        Active, Done, Error
```

Baud sets the baud rate at 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200. Baud rates 57600 and 115200 are supported by S7-200 CPUs version 1.2 or later.

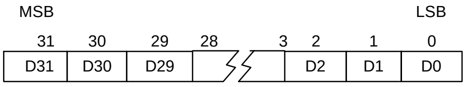
Table 11-2 Parameters for the USS_INIT Instruction

Inputs/Outputs	Data Type	Operands
Mode	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Baud, Active	DWORD	VD, ID, QD, MD, SD, SMD, LD, Constant, AC *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Active indicates which drives are active. Some drives only support addresses 0 through 30.

Figure 11-2 shows the description and format of the active drive input. Any drive that is marked as Active is automatically polled in the background to control the drive, collect status, and prevent serial link time-outs in the drive.

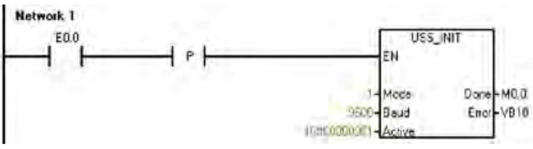
Refer to Table 11-1 to compute the time between status polls.



D0 Drive 0 active bit; 0 – drive not active, 1 – drive active
D1 Drive 1 active bit; 0 – drive not active, 1 – drive active
...

Figure 11-2 Format for the Active Drive Parameter

When the USS_INIT instruction completes, the Done output is turned on. The Error output byte contains the result of executing the instruction. Table 11-6 defines the error conditions that could result from executing the instruction.

Example: USS_INIT Subroutine	
	Network 1 LD I0.0 EU CALL USS_INIT, 1, 9600, 16#00000001, M0.0, VB10

USS_CTRL Instruction

The USS_CTRL (port 0) or USS_CTRL_P1 (port 1) instruction is used to control an active MicroMaster drive. The USS_CTRL instruction places the selected commands in a communications buffer, which is then sent to the addressed drive (Drive parameter), if that drive has been selected in the Active parameter of the USS_INIT instruction.

Only one USS_CTRL instruction should be assigned to each drive.

Some drives report speed only as a positive value. If the speed is negative, the drive reports the speed as positive but reverses the D_Dir (direction) bit.

The EN bit must be on to enable the USS_CTRL instruction. This instruction should always be enabled.

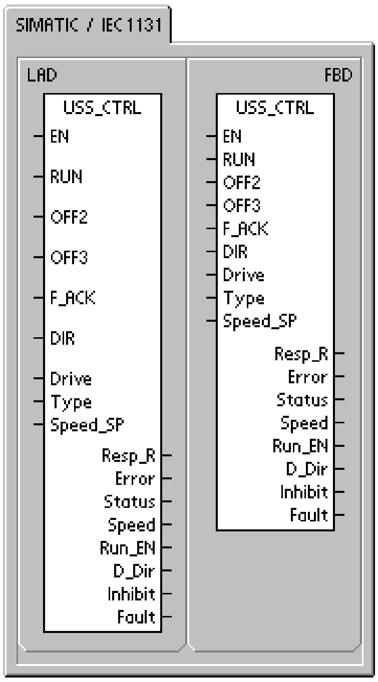
RUN (RUN/STOP) indicates whether the drive is on (1) or off (0). When the RUN bit is on, the MicroMaster drive receives a command to start running at the specified speed and direction. In order for the drive to run, the following must be true:

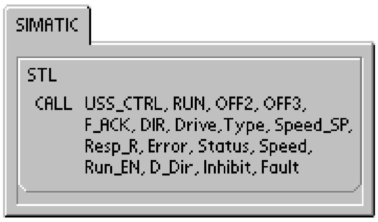
❑ Drive must be selected as Active in USS_INIT.

❑ OFF2 and OFF3 must be set to 0.

❑ Fault and Inhibit must be 0.

When RUN is off, a command is sent to the MicroMaster drive to ramp the speed down until the motor comes to a stop. The OFF2 bit is used to allow the MicroMaster drive to coast to a stop. The OFF3 bit is used to command the MicroMaster drive to stop quickly.





```
CALL  USS_CTRL, RUN, OFF2, OFF3,
      F_ACK, DIR, Drive,Type, Speed_SP,
      Resp_R, Error, Status, Speed,
      Run_EN, D_Dir, Inhibit, Fault
```

The Resp_R (response received) bit acknowledges a response from the drive. All the Active drives are polled for the latest drive status information. Each time the S7-200 receives a response from the drive, the Resp_R bit is turned on for one scan and all the following values are updated.

The F_ACK (fault acknowledge) bit is used to acknowledge a fault in the drive. The drive clears the fault (Fault) when F_ACK goes from 0 to 1.

The DIR (direction) bit indicates in which direction the drive should move.

Table 11-3 Parameters of the USS_CTRL Instruction

Inputs/Outputs	Data Types	Operands
RUN, OFF 2, OFF 3, F_ACK, DIR	BOOL	I, Q, M, S, SM, T, C, V, L, Power Flow
Resp_R, Run_EN, D_Dir, Inhibit, Fault	BOOL	I, Q, M, S, SM, T, C, V, L
Drive, Type	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD, Constant
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD
Status	WORD	VW, T, C, IW, QW, SW, MW, SMW, LW, AC, AQW, *VD, *AC, *LD
Speed_SP	REAL	VD, ID, QD, MD, SD, SMD, LD, AC, *VD, *AC, *LD, Constant
Speed	REAL	VD, ID, QD, MD, SD, SMD, LD, AC, *VD, *AC, *LD

The Drive (drive address) input is the address of the MicroMaster drive to which the USS_CTRL command is to be sent. Valid addresses: 0 to 31

The Type (drive type) input selects the type of drive. For a MicroMaster 3 (or earlier) drive, set Type to 0. For a MicroMaster 4 drive, set Type to 1.

Speed_SP (speed setpoint) is drive speed as a percentage of full speed. Negative values of Speed_SP cause the drive to reverse its direction of rotation. Range: –200.0% to 200.0%

Error is an error byte that contains the result of the latest communications request to the drive. Table 11-6 defines the error conditions that could result from executing the instruction.

Status is the raw value of the status word returned by the drive. Figure 11-3 shows the status bits for Standard Status Word and Main Feedback.

Speed is drive speed as a percentage of full speed. Range: –200.0% to 200.0%

Run_EN (RUN enable) indicates whether the drive is running (1) or stopped (0).

D_Dir indicates the drive’s direction of rotation.

Inhibit indicates the state of the inhibit bit on the drive (0 – not inhibited, 1 – inhibited). To clear the inhibit bit, the Fault bit must be off, and the RUN, OFF2, and OFF3 inputs must also be off.

Fault indicates the state of the fault bit (0 – no fault, 1 – fault). The drive displays the fault code. (Refer to the manual for your drive). To clear the Fault bit, correct the cause of the fault and turn on the F_ACK bit.

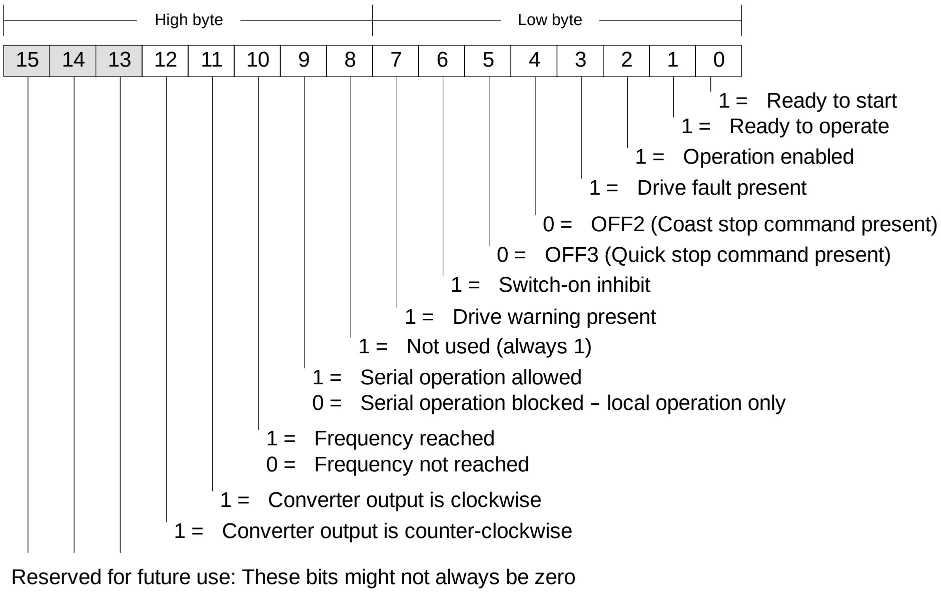

High byte
Low byte
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1 = Ready to start
1 = Ready to operate
1 = Operation enabled
1 = Drive fault present
0 = OFF2 (Coast stop command present)
0 = OFF3 (Quick stop command present)
1 = Switch-on inhibit
1 = Drive warning present
1 = Not used (always 1)
1 = Serial operation allowed
0 = Serial operation blocked – local operation only
1 = Frequency reached
0 = Frequency not reached
1 = Converter output is clockwise
1 = Converter output is counter-clockwise
Reserved for future use: These bits might not always be zero

Figure 11-3 Status Bits for Standard Status Word for MicroMaster 3 and Main Feedback

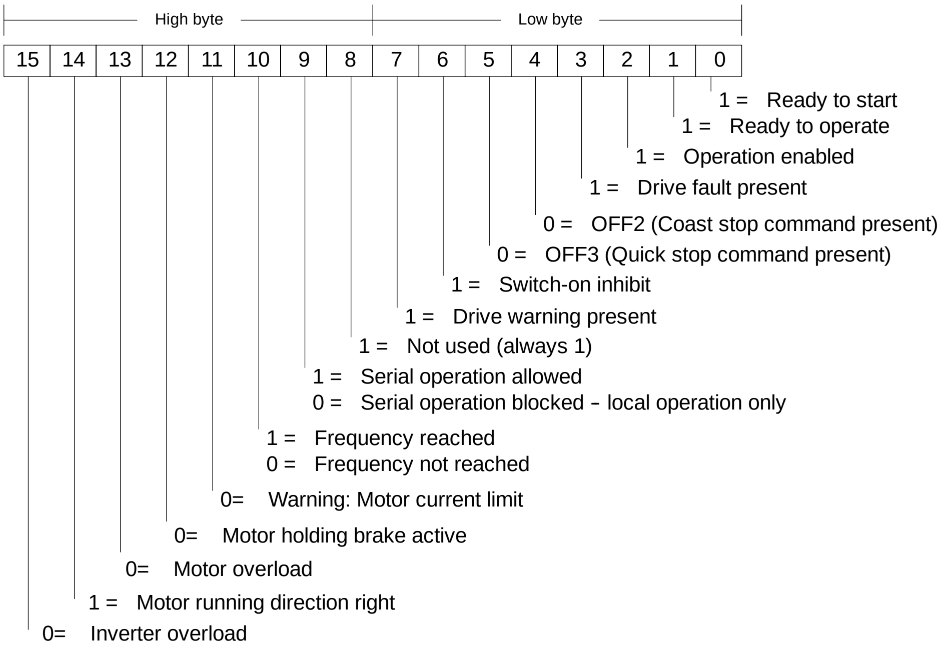
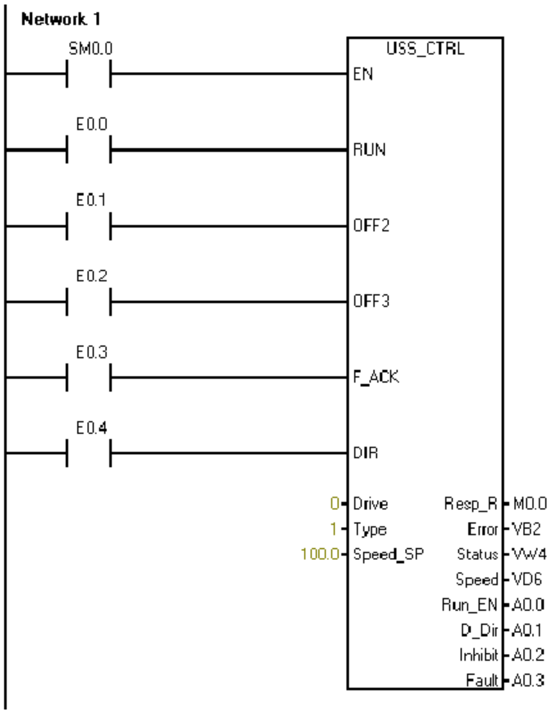

High byte
Low byte
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1 = Ready to start
1 = Ready to operate
1 = Operation enabled
1 = Drive fault present
0 = OFF2 (Coast stop command present)
0 = OFF3 (Quick stop command present)
1 = Switch-on inhibit
1 = Drive warning present
1 = Not used (always 1)
1 = Serial operation allowed
0 = Serial operation blocked – local operation only
1 = Frequency reached
0 = Frequency not reached
0= Warning: Motor current limit
0= Motor holding brake active
0= Motor overload
1 = Motor running direction right
0= Inverter overload

Figure 11-4 Status Bits for Standard Status Word for MicroMaster 4 and Main Feedback

Example: USS_CTRL Subroutine



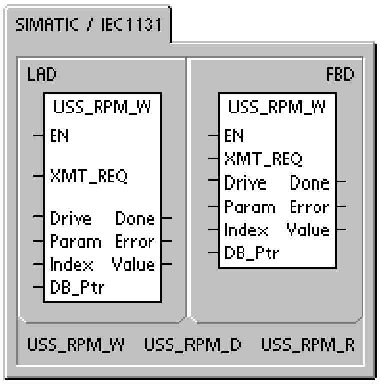
To display in STL only:

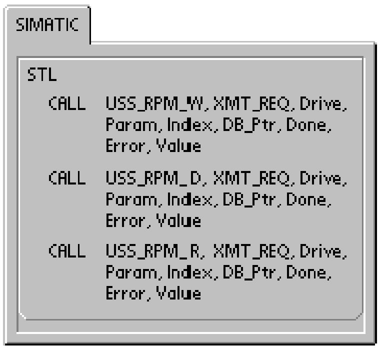
```
Network 1     //Control box for drive 0
LD        SM0.0
CALL      USS_CTRL, I0.0, I0.1, I0.2, I0.3,
          I0.4, 0, 1, 100.0, M0.0, VB2, VW4,
          VD6, Q0.0, Q0.1, Q0.2, Q0.3
```

To display in LAD or FBD:

```
Network 1     //Control box for drive 0
LD        SM0.0
=         L60.0
LD         I0.0
=         L63.7
LD        I0.1
=         L63.6
LD        I0.2
=          L63.5
LD        I0.3
=         L63.4
LD        I0.4
=         L63.3
LD        L60.0
CALL      USS_CTRL, L63.7, L63.6, L63.5,
          L63.4, L63.3, 0, 1, 100.0, M0.0,
          VB2, VW4, VD6, Q0.0, Q0.1, Q0.2,
          Q0.3
```

USS_RPM_x Instruction





```
CALL    USS_RPM_W, XMT_REQ, Drive,
        Param, Index, DB_Ptr, Done,
        Error, Value
CALL    USS_RPM_D, XMT_REQ, Drive,
        Param, Index, DB_Ptr, Done,
        Error, Value
CALL    USS_RPM_R, XMT_REQ, Drive,
        Param, Index, DB_Ptr, Done,
        Error, Value
```

There are three read instructions for the USS protocol:

- ❑ USS_RPM_W (port 0) or USS_RPM_W_P1 (port 1) instruction reads an unsigned word parameter.
- ❑ USS_RPM_D (port 0) or USS_RPM_D_P1 (port 1) instruction reads an unsigned double word parameter.
- ❑ USS_RPM_R (port 0) or USS_RPM_R_P1 (port 1) instruction reads a floating-point parameter.

Only one read (USS_RPM_x) or write (USS_WPM_x) instruction can be active at a time.

The USS_RPM_x transactions complete when the MicroMaster drive acknowledges receipt of the command, or when an error condition is posted. The logic scan continues to execute while this process awaits a response.

The EN bit must be on to enable transmission of a request, and should remain on until the Done bit is set, signaling completion of the process. For example, a USS_RPM_x request is transmitted to the MicroMaster drive on each scan when XMT_REQ input is on. Therefore, the XMT_REQ input should be pulsed on through an edge detection element which causes one request to be transmitted for each positive transition of the EN input.

The Drive input is the address of the MicroMaster drive to which the USS_RPM_x command is to be sent. Valid addresses of individual drives are 0 to 31.

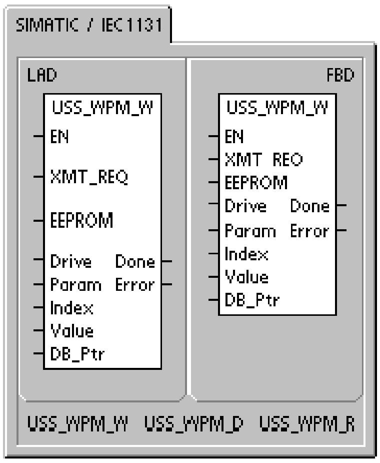
Param is the parameter number. Index is the index value of the parameter that is to be read. Value is the parameter value returned. The address of a 16-byte buffer must be supplied to the DB_Ptr input. This buffer is used by the USS_RPM_x instruction to store the results of the command issued to the MicroMaster drive.

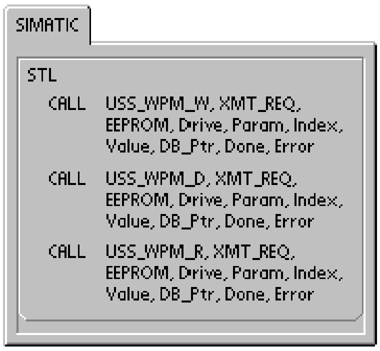
When the USS_RPM_x instruction completes, the Done output is turned on and the Error output byte and the Value output contain the results of executing the instruction. Table 11-6 defines the error conditions that could result from executing the instruction. The Error and Value outputs are not valid until the Done output turns on.

Table 11-4 Valid Operands for the USS_RPM_x

Inputs/Outputs	Data Type	Operands
XMT_REQ	BOOL	I, Q, M, S, SM, T, C, V, L, Power Flow conditioned by a rising edge detection element
Drive	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD, Constant
Param, Index	WORD	VW, IW, QW, MW, SW, SMW, LW, T, C, AC, AIW, *VD, *AC, *LD, Constant
DB_Ptr	DWORD	&VB
Value	WORD DWORD, REAL	VW, IW, QW, MW, SW, SMW, LW, T, C, AC, AQW, *VD, *AC, *LD VD, ID, QD, MD, SD, SMD, LD, *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC. *VD, *AC, *LD

USS_WPM_x Instruction





```
CALL   USS_WPM_W, XMT_REQ,
       EEPROM, Drive, Param, Index,
       Value, DB_Ptr, Done, Error
CALL   USS_WPM_D, XMT_REQ,
       EEPROM, Drive, Param, Index,
       Value, DB_Ptr, Done, Error
CALL   USS_WPM_R, XMT_REQ,
       EEPROM, Drive, Param, Index,
       Value, DB_Ptr, Done, Error
```

There are three write instructions for the USS protocol:

- ❑ USS_WPM_W (port 0) or USS_WPM_W_P1 (port 1) instruction writes an unsigned word parameter.
- ❑ USS_WPM_D (port 0) or USS_WPM_D_P1 (port 1) instruction writes an unsigned double word parameter.
- ❑ USS_WPM_R (port 0) or USS_WPM_R_P1 (port 1) instruction writes a floating-point parameter.

Only one read (USS_RPM_x) or write (USS_WPM_x) instruction can be active at a time.

The USS_WPM_x transactions complete when the MicroMaster drive acknowledges receipt of the command, or when an error condition is posted. The logic scan continues to execute while this process awaits a response.

The EN bit must be on to enable transmission of a request, and should remain on until the Done bit is set, signaling completion of the process. For example, a USS_WPM_x request is transmitted to the MicroMaster drive on each scan when XMT_REQ input is on. Therefore, the XMT_REQ input should be pulsed on through an edge detection element which causes one request to be transmitted for each positive transition of the EN input.

The EEPROM input enables writing to both RAM and EEPROM of the drive when it is on and only to the RAM when it is off. Note that this function is not supported by MM3 drives, so this input must be off.

The Drive input is the address of the MicroMaster drive to which the USS_WPM_x command is to be sent. Valid addresses of individual drives are 0 to 31.

Param is the parameter number. Index is the index value of the parameter that is to be written. Value is the parameter value to be written to the RAM in the drive. For MicroMaster 3 drives, you can also write this value to the EEPROM of the drive, based on how you have configured P971 (EEPROM Storage Control).

The address of a 16-byte buffer must be supplied to the DB_Ptr input. This buffer is used by the USS_WPM_x instruction to store the results of the command issued to the MicroMaster drive.

When the USS_WPM_x instruction completes, the Done output is turned on and the Error output byte contains the result of executing the instruction. Table 11-6 defines the error conditions that could result from executing the instruction.

When the EEPROM input is turned on, the instruction writes to both the RAM and the EEPROM of the drive. When the the input is turned off, the instruction writes only to the RAM of the drive. Because the MicroMaster 3 drive does not support this function, you must ensure that this input is off in order to use this instruction with a MicroMaster 3 drive.

Table 11-5 Valid Operands for the USS_WPM_x Instructions

Inputs/Outputs	Data Type	Operands
XMT_REQ	BOOL	I, Q, M, S,SM,T,C,V,L, Power Flow conditioned by a rising edge detection element
EEPROM	BOOL	I, Q, M, S, SM, T, C, V, L, Power Flow
Drive	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD, Constant
Param, Index	WORD	VW, IW, QW, MW, SW, SMW, LW, T, C, AC, AIW, *VD, *AC, *LD, Constant
DB_Ptr	DWORD	&VB
Value	WORD DWORD, REAL	VW, IW, QW, MW, SW, SMW, LW, T, C, AC, AQW, *VD, *AC, *LD VD, ID, QD, MD, SD, SMD, LD, *VD, *AC, *LD

Table 11-5 Valid Operands for the USS_WPM_x Instructions, continued

Inputs/Outputs	Data Type	Operands
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC. *VD, *AC, *LD

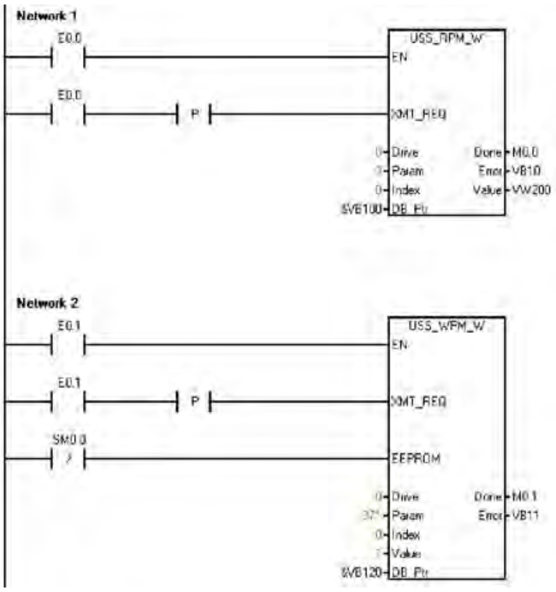
Caution

When you use an USS_WPM_x instruction to update the parameter set stored in drive EEPROM, you must ensure that the maximum number of write cycles (approximately 50,000) to the EEPROM is not exceeded.

Exceeding the maximum number of write cycles will result in corruption of the stored data and subsequent data loss. The number of read cycles is unlimited.

If frequent writes to the drive parameters are required, then you should first set the EEPROM storage control parameter in the drive to zero (for MicroMaster 3 drives) and turn off the EEPROM input for MicroMaster 4 drives.

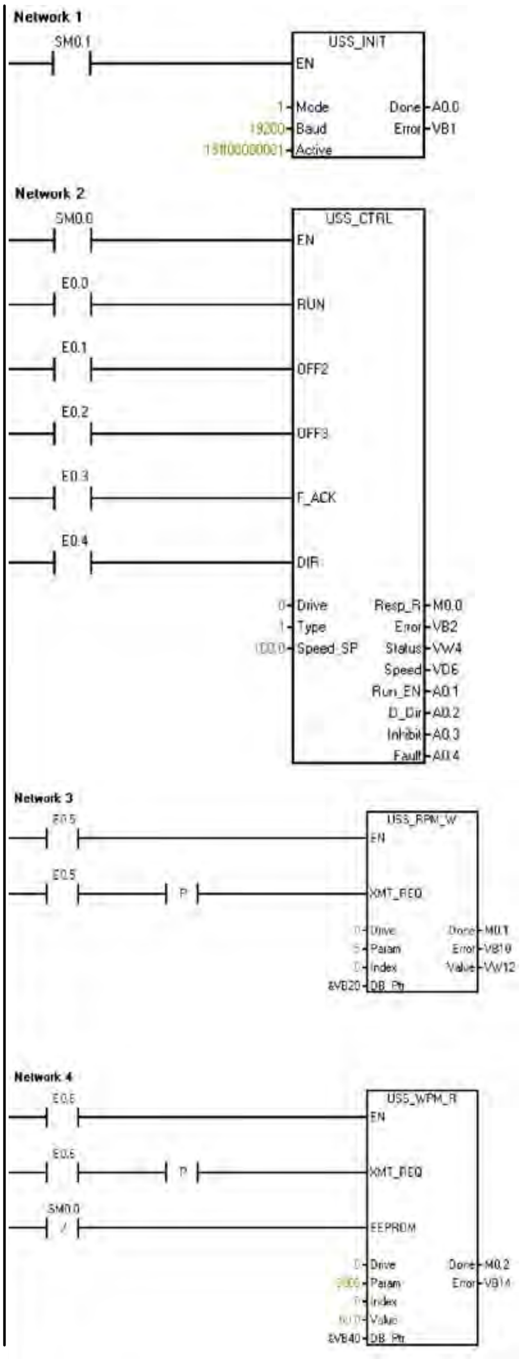
Example: USS_RPM_x and USS_WPM_x



```
Network 1      //The two contacts must have the
               //same address.
LD       I0.0
=        L60.0
LD       I0.0
EU
=        L63.7
LD       L60.0
CALL     USS_RPM_W, L63.7, 0, 3, 0, &VB100,
         M0.0, VB10, VW200

Network 2      //The two contacts must have the
               same address
LD       I0.1
=        L60.0
LD       I0.1
EU
=        L63.7
LDN      SM0.0
=        L63.6
LD       L60.0
CALL     USS_WPM_W, L63.7, L63.6, 0, 971, 0, 1,
         &VB120, M0.1, VB11
```

Sample Programs for the USS Protocol

Example: USS Instructions Sample Program that Correctly Displays in STL



```
Network 1       //Initialize USS Protocol:
                //On the first scan, enable USS
                //protocol for port 0 at 19200
                //with drive address
                //"0" active.
LD      SM0.1
CALL    USS_INIT, 1, 19200, 16#00000001, Q0.0,
        VB1

Network 2       //Control parameters for Drive 0
LD      SM0.0
CALL    USS_CTRL, I0.0, I0.1, I0.2, I0.3, I0.4, 0, 1,
        100.0, M0.0, VB2, VW4, VD6, Q0.1, Q0.2,
        Q0.3, Q0.4

Network 3       //Read a Word parameter from Drive 0.
                //Read parameter 5 index 0.
                //1.  Save the state of I0.5 to a
                //    temporary location so that this
                //    network displays in LAD.
                //2.  Save the rising edge pulse of I0.5
                //    to a temporary L location so that
                //    it can be passed to the subroutine.
LD      I0.5
=        L60.0
LD       I0.5
EU
=       L63.7
LD      L60.0
CALL    USS_RPM_W, L63.7, 0, 5, 0, &VB20, M0.1,
        VB10, VW12
Network 4       //Write a Word parameter to Drive 0.
                //Write parameter 2000 index 0.
LD      I0.6
=       L60.0
LD      I0.6
EU
=        L63.7
LDN     SM0.0
=       L63.6
LD      L60.0
CALL    USS_WPM_R, L63.7, L63.6, 0, 2000, 0, 50.0,
        &VB40, M0.2, VB14
```

Note: This STL code does not compile to LAD or FBD.

USS Execution Error Codes

Table 11-6 Execution Error Codes for the USS Instructions

Error Codes	Description
0	No error
1	Drive did not respond
2	A checksum error in the response from the drive was detected
3	A parity error in the response from the drive was detected
4	An error was caused by interference from the user program
5	An illegal command was attempted
6	An illegal drive address was supplied
7	The communications port was not set up for USS protocol
8	The communications port is busy processing an instruction
9	The drive speed input is out of range
10	The length of the drive response is incorrect
11	The first character of the drive response is incorrect
12	The length character in the drive response is not supported by USS instructions
13	The wrong drive responded
14	The DB_Ptr address supplied is incorrect
15	The parameter number supplied is incorrect
16	An invalid protocol was selected
17	USS is active; change is not allowed
18	An illegal baud rate was specified
19	No communications: the drive is not ACTIVE
20	The parameter or value in the drive response is incorrect or contains an error code
21	A double word value was returned instead of the word value requested
22	A word value was returned instead of the double word value requested

Connecting and Setting Up the MicroMaster Series 3 Drive

Connecting the MicroMaster 3 Drive

You can use the standard PROFIBUS cable and connectors to connect the S7-200 to the MicroMaster Series 3 (MM3) drive. See Figure 11-5 for the proper cable bias and termination of the interconnecting cable.

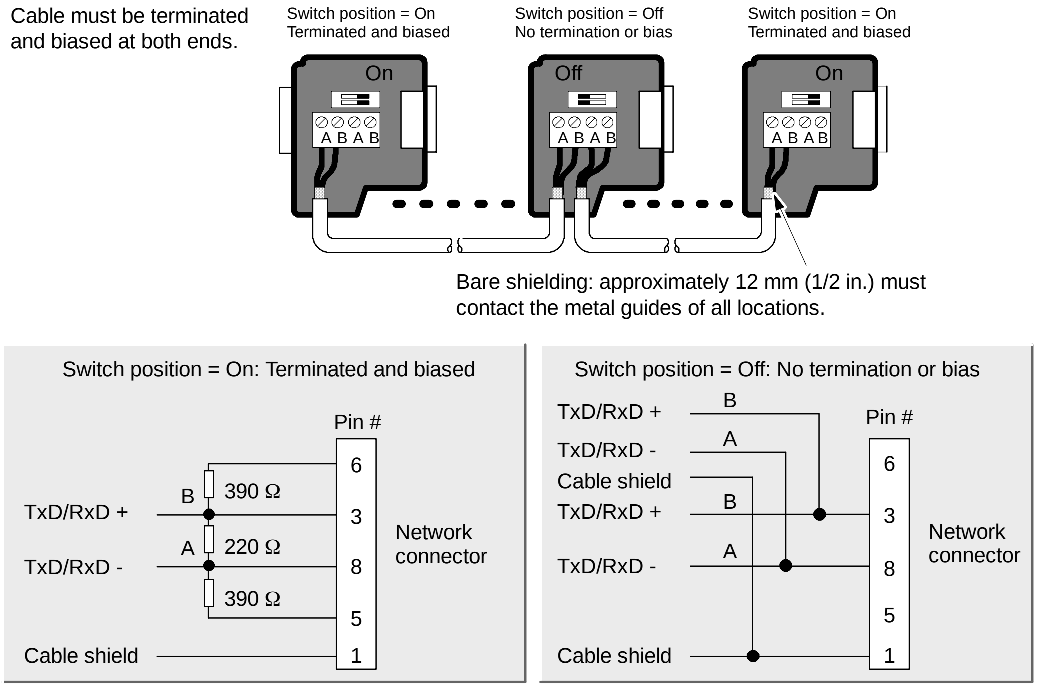
Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable.

These unwanted currents can cause communications errors or damage equipment.

Be sure all equipment that you are about to connect with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows.

The shield must be tied to chassis ground or pin 1 on the 9-pin connector. It is recommended that you tie wiring terminal 2–0V on the MicroMaster drive to chassis ground.


Cable must be terminated and biased at both ends.

Bare shielding: approximately 12 mm (1/2 in.) must contact the metal guides of all locations.

Figure 11-5 Bias and Termination of the Network Cable

Setting Up the MicroMaster 3 Drive

Before you connect a drive to the S7-200, you must ensure that the drive has the following system parameters. Use the keypad on the drive to set the parameters:

1. Reset the drive to factory settings (optional). Press the P key: P000 is displayed. Press the up or down arrow key until the display shows the P944. Press P to enter the parameter.

   P944=1

2. Enable the read/write access to all parameters. Press the P key. Press the up or down arrow key until the display shows P009. Press P to enter the parameter.

   P009=3

3. Check motor settings for your drive. The settings will vary according to the motor(s) being used. Press the P key. Press the up or down arrow key until the display shows the motor setting for your drive. Press P to enter the parameter.

   P081=Nominal frequency of motor (Hz)
   P082=Nominal speed of motor (RPM)
   P083=Nominal current of motor (A)
   P084=Nominal voltage of motor (V)
   P085=Nominal power of motor (kW/HP)

4. Set the Local/Remote control mode. Press the P key. Press the up or down arrow key until the display shows P910. Press P to enter the parameter.

   P910=1 Remote control mode

5. Set the Baud Rate of the RS–485 serial interface. Press the P key. Press the up or down arrow key until P092 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the number that corresponds to the baud rate of your RS–485 serial interface. Press P to enter.

P092	3	(1200 baud)
	4	(2400 baud)
	5	(4800 baud)
	6	(9600 baud – default)
	7	(19200 baud)

6. Enter the Slave address. Each drive (a maximum of 31) can be operated over the bus. Press the P key. Press the up or down arrow key until P091 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the slave address you want. Press P to enter.
P091=0 through 31.

7. Ramp up time (optional). This is the time in seconds that it takes the motor to accelerate to maximum frequency. Press the P key. Press the up or down arrow key until P002 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the ramp up time you want. Press P to enter.
P002=0–650.00

8. Ramp down time (optional). This is the time in seconds that it takes the motor to decelerate to a complete stop. Press the P key. Press the up or down arrow key until P003 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the ramp down time you want. Press P to enter.
P003=0–650.00

9. Serial Link Time-out. This is the maximum permissible period between two incoming data telegrams. This feature is used to turn off the inverter in the event of a communications failure.

   Timing starts after a valid data telegram has been received. If a further data telegram is not received within the specified time period, the inverter will trip and display fault code F008. Setting the value to zero switches off the control. Use Table 11-1 to calculate the time between the status polls to the drive.

   Press the P key. Press the up or down arrow key until P093 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the serial link time-out you want. Press P to enter.
P093=0–240 (0 is default; time is in seconds)

10. Serial Link Nominal System Setpoint. This value can vary, but will typically correspond to 50 Hz or 60 Hz, which defines the corresponding 100% value for PVs or SPs. Press the P key. Press the up or down arrow key until P094 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the serial link nominal system setpoint you want. Press P to enter.

    P094=0–400.00

11. USS Compatibility (optional). Press the P key. Press the up or down arrow key until P095 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the number that corresponds to the USS compatibility you want. Press P to enter.

P095 =	0	0.1 Hz resolution (default)
	1	0.01 Hz resolution

12. EEPROM storage control (optional). Press the P key. Press the up or down arrow key until P971 appears. Press P to enter the parameter. Press the up or down arrow key until the display shows the number that corresponds to the EEPROM storage control you want. Press P to enter.

    P971 = 0 Changes to parameter settings (including P971) are lost when power is removed.
    1 (default) Changes to parameter settings are retained during periods when power is removed.

13. Operating display. Press P to exit out of parameter mode.

Connecting and Setting Up the MicroMaster Series 4 Drive

Connecting the MicroMaster 4 Drive

To make the connection to the MicroMaster Series 4 (MM4) drive, insert the ends of the RS-485 cable into the two caged clamp, screwless terminals provided for USS operation. The standard PROFIBUS cable and connectors can be used to connect the S7-200.

Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable.

These unwanted currents can cause communications errors or damage equipment.

Be sure all equipment that you are about to connect with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows.

The shield must be tied to chassis ground or pin 1 on the 9-pin connector. It is recommended that you tie wiring terminal 2–0V on the MicroMaster drive to chassis ground.

As shown in Figure 11-6, the two wires at the opposite end of the RS-485 cable must be inserted into the MM4 drive terminal blocks. To make the cable connection on a MM4 drive, remove the drive cover(s) to access the terminal blocks. See the MM4 user manual for details about how to remove the covers(s) of your specific drive.

The terminal block connections are labeled numerically. Using a PROFIBUS connector on the S7-200 side, connect the A terminal of the cable to the drive terminal 15 (for an MM420) or terminal 30 (MM440). Connect the B terminal of the cable connector to terminal 14 (MM420) or terminal 29 (MM440).

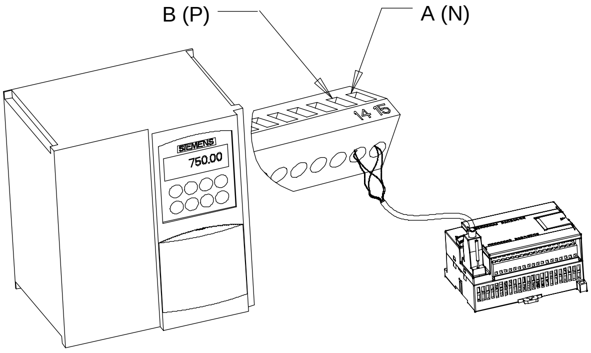


Figure 11-6 Connecting to the MM420 Terminal Block

If the S7-200 is a terminating node in the network, or if the connection is point-to-point, it is necessary to use terminals A1 and B1 (not A2 and B2) of the connector since they allow the termination settings to be set (for example, with DP connector type 6ES7 972–0BA40–0X40).

Caution

Make sure the drive covers are replaced properly before supplying power to the unit.

If the drive is configured as the terminating node in the network, then termination and bias resistors must also be wired to the appropriate terminal connections. For example, Figure 11-7 shows an example of the connections necessary for termination and bias for the MM4 drive.

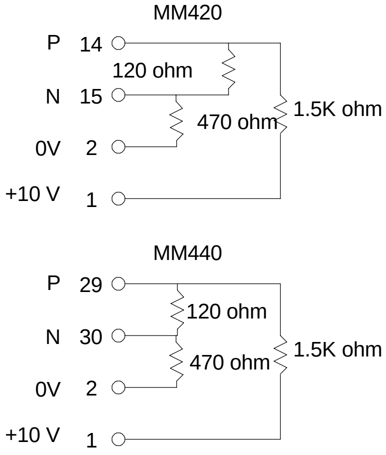


Figure 11-7 Sample Termination and Bias

Setting Up the MM4 Drive

Before you connect a drive to the S7-200, you must ensure that the drive has the following system parameters. Use the keypad on the drive to set the parameters:

1. Reset the drive to factory settings (optional): P0010=30
   P0970=1

   If you skip this step, ensure that the following parameters are set to these values:

USS PZD length:	P2012 Index 0=2
USS PKW length:	P2013 Index 0=127

2. Enable the read/write access to all parameters (Expert mode): P0003=3
3. Check motor settings for your drive: P0304=Rated motor voltage (V)
   P0305=Rated motor current (A)
   P0307=Rated motor power (W)
   P0310=Rated motor frequency (Hz)
   P0311=Rated motor speed (RPM)

   The settings will vary according to the motor(s) being used.

   In order to set the parameters P304, P305, P307, P310, and P311, you must first set parameter P010 to 1 (quick commissioning mode). When you are finished setting the parameters, set parameter P010 to 0. Parameters P304, P305, P307, P310, and P311 can only be changed in the quick commissioning mode.
4. Set the local/remote control mode: P0700 Index 0=5
5. Set selection of frequency setpoint to USS on COM Link: P1000 Index 0=5
6. Ramp up time (optional): P1120=0 to 650.00

   This is the time in seconds that it takes the motor to accelerate to maximum frequency.
7. Ramp down time (optional): P1121=0 to 650.00

   This is the time in seconds that it takes the motor to decelerate to a complete stop.
8. Set the serial link reference frequency: P2000=1 to 650 Hz
9. Set the USS normalization: P2009 Index 0=0
10. Set the baud rate of the RS–485 serial interface: P2010 Index 0=

4	(2400 baud)
5	(4800 baud)
6	(9600 baud)
7	(19200 baud
8	(38400 baud)
9	(57600 baud)
12	(115200 baud)

11. Enter the Slave address: P2011 Index 0=0 to 31

    Each drive (a maximum of 31) can be operated over the bus.
12. Set the serial link timeout: P2014 Index 0=0 to 65,535 ms
    (0=timeout disabled)

    This is the maximum permissible period between two incoming data telegrams. This feature is used to turn off the inverter in the event of a communications failure. Timing starts after a valid data telegram has been received. If a further data telegram is not received within the specified time period, the inverter will trip and display fault code F0070. Setting the value to zero switches off the control. Use Table 11-1 to calculate the time between the status polls to the drive.
13. Transfer the data from RAM to EEPROM:

    P0971=1 (Start transfer) Save the changes to the parameter settings to EEPROM

Using the Modbus Protocol Library 12

The STEP 7–Micro/WIN Instruction Libraries make communicating to Modbus devices easier by including pre-configured subroutines and interrupt routines that are specifically designed for Modbus communications. With the Modbus Protocol Instructions, you can configure the S7-200 to act as a Modbus master or slave device.

You find these instructions in the Libraries folder of the STEP 7–Micro/WIN instruction tree. When you put a Modbus instruction in your program, one or more associated subroutines are automatically added to your project.

Siemens Libraries are sold on a separate CD, STEP 7–Micro/WIN Add-On: Instruction Library, with the order number 6ES7 830–2BC00–0YX0. After version 1.1 of the Siemens Library is purchased and installed, any subsequent STEP 7–Micro/WIN V3.2x and V4.0 upgrade that you install will also upgrade your libraries automatically at no additional cost (when library additions or modifications are made).

In This Chapter

Overview

STEP 7–Micro/WIN Instruction Libraries make communicating to Modbus master and slave devices easier by including pre-configured subroutines and interrupt routines that are specifically designed for Modbus communications.

Modbus slave instructions can configure the S7-200 to act as a Modbus RTU slave device and communicate to Modbus master devices.

Modbus master instructions can configure the S7-200 to act as a Modbus RTU master device and communicate to one or more Modbus slave devices.

The Modbus instructions are installed into the libraries folder in the STEP 7–Micro/WIN instruction tree. These instructions enable the S7-200 to act as a Modbus device. When you place a Modbus instruction in your program, one or more associated subroutines are automatically added to your project.

There are two versions of the Modbus master protocol library. One version uses port 0 of the CPU and the other uses port 1 of the CPU. The port 1 library has a _P1 appended to the POU names (for example, MBUS_CTRL_P1) to denote that the POU utilizes port 1 on the CPU. The two Modbus master libraries are identical in all other respects.

The Modbus slave library only supports port 0 communication.

Requirements for Using Modbus Protocol

The **Modbus Master Protocol** instructions use the following resources from the S7-200:

- Initializing the Modbus Slave Protocol dedicates the specific CPU port for Modbus Master Protocol communications.

  When the CPU port is being used for Modbus Master Protocol communications, it cannot be used for any other purpose, including communications with STEP 7–Micro/WIN. The MBUS_CTRL instruction controls assignment of Port 0 to Modbus Master Protocol or PPI. The MBUS_CTRL_P1 instruction (from the port 1 library) controls assignment of Port 1 to Modbus Master Protocol or PPI
- The Modbus Master Protocol instructions affect all of the SM locations associated with Freeport communications port in use
- The Modbus Master Protocol instructions use 3 subroutines and 1 interrupt routine.
- The Modbus Master Protocol instructions require about 1620 bytes of program space for the two Modbus Master instructions and the support routines.
- The variables for the Modbus Master Protocol instructions require a 284 byte block of V memory. The starting address for this block is assigned by the user and is reserved for Modbus variables.
- The S7-200 CPU must be firmware revision 2.00 or greater to support the Modbus Master Protocol Library (CPU MLFB 21x–2xx23–0XB0)
- The Modbus Master Library uses the user interrupts for some functions. The user interrupts must not be disabled by the user program.

Tip

To change the operation of the CPU communications port back to PPI so that you can communicate with STEP 7-Micro/WIN, you can do one of the following:

– Set the Mode parameter of the MBUS_CTRL instruction to a zero (0).

– Set the mode switch on the S7-200 to STOP mode position.

Either of these methods will set the CPU communications port to communicate with STEP 7–Micro/WIN.

The **Modbus Slave Protocol** instructions use the following resources from the S7-200:

- ❑ Initializing the Modbus Slave Protocol dedicates Port 0 for Modbus Slave Protocol communications.

  When Port 0 is being used for Modbus Slave Protocol communications, it cannot be used for any other purpose, including communications with STEP 7-Micro/WIN. The MBUS_INIT instruction controls assignment of Port 0 to Modbus Slave Protocol or PPI.
- ❑ The Modbus Slave Protocol instructions affect all of the SM locations associated with Freeport communications on Port 0.
- ❑ The Modbus Slave Protocol instructions use 3 subroutines and 2 interrupts.
- ❑ The Modbus Slave Protocol instructions require 1857 bytes of program space for the two Modbus Slave instructions and the support routines.
- ❑ The variables for the Modbus Slave Protocol instructions require a 779-byte block of V memory. The starting address for this block is assigned by the user and is reserved for Modbus variables.

Tip

To change the operation of Port 0 back to PPI so that you can communicate with STEP 7-Micro/WIN, you can do one of the following:

- Use another MBUS_INIT instruction to reassign Port 0.

- Set the mode switch on the S7-200 to STOP mode.

Either of these methods will set the parameters for Port 0 so that you can communicate with STEP 7-Micro/WIN.

Initialization and Execution Time for Modbus Protocol

Modbus Master Protocol - The Modbus Master Protocol requires a small amount of time every scan to execute the MBUS_CTRL instruction. The time will be about 1.11 milliseconds when the MBUS_CTRL is initializing the Modbus Master (first scan), and about 0.41 milliseconds on subsequent scans.

The scan time is extended when the MBUS_MSB subroutine executes a request. Most of the time is spent calculating the Modbus CRC for the request and the response. The CRC (Cyclic Redundancy Check) insures the integrity of the communications message. The scan time is extended by about 1.85 milliseconds for each word in request and in the response. A maximum request/response (read or write of 120 words) extends the scan time to approximately 222 milliseconds. A read request extends the scan mainly when the response is received from the slave, and to a lesser extent when the request is sent. A write request extends the scan mainly when the data is sent to the slave, and to a lesser extent when the response is received.

Modbus Slave Protocol - Modbus communications utilize a CRC (cyclic redundancy check) to insure the integrity of the communications messages. The Modbus Slave Protocol uses a table of precalculated values to decrease the time required to process a message. The initialization of this CRC table requires about 240 milliseconds. This initialization is done inside the MBUS_INIT subroutine and is normally done in the first scan of the user program after entering RUN mode. You are responsible for resetting the watchdog timer and keeping the outputs enabled (if required for expansion modules) if the time required by the MBUS_INIT subroutine and any other user initialization exceeds the 500 millisecond scan watchdog. The output module watchdog timer is reset by writing to the outputs of the module. See the Watchdog Reset Instruction in Chapter 6.

The scan time is extended when the MBUS_SLAVE subroutine services a request. Since most of the time is spent calculating the Modbus CRC, the scan time is extended by about 420 microseconds for every byte in the request and in the response. A maximum request/response (read or write of 120 words) extends the scan time by approximately 100 milliseconds.

Modbus Addressing

Modbus addresses are normally written as 5 character values containing the data type and the offset. The first character determines the data type, and the last four characters select the proper value within the data type.

Modbus Master Addressing – The Modbus Master instructions then map the address to the correct functions to send to the slave device. The following Modbus addresses are supported by the Modbus Master instructions:

- ❑ 00001 to 09999 are discrete outputs (coils)
- ❑ 10001 to 19999 are discrete inputs (contacts)
- ❑ 30001 to 39999 are input registers (generally analog inputs)
- ❑ 40001 to 49999 are holding registers

All Modbus addresses are one-based, meaning that the first data value starts at address one. The range of valid addresses will depend on the slave device. Different slave devices will support different data types and address ranges.

Modbus Slave Addressing –The Modbus Master device then maps the addresses to the correct functions. The following addresses are supported by the Modbus Slave instructions:

- ❑ 00001 to 00128 are discrete outputs mapped to Q0.0 - Q15.7
- ❑ 10001 to 10128 are discrete inputs mapped to I0.0 - I15.7
- ❑ 30001 to 30032 are analog input registers mapped to AIW0 to AIW62
- ❑ 40001 to 04xxxx are holding registers mapped to V memory.

All Modbus addresses are one-based. Table 12-1 shows the mapping of Modbus addresses to the S7-200 addresses.

The Modbus Slave Protocol allows you to limit the amount of inputs, outputs, analog inputs, and holding registers (V memory) accessible to a Modbus master.

The MaxIQ parameter of the MBUS_INIT instruction specifies the maximum number of discrete inputs or outputs (Is or Qs) the Modbus master is allowed to access.

The MaxAI parameter of the MBUS_INIT instruction specifies the maximum number of input registers (AIWs) the Modbus master is allowed to access.

The MaxHold parameter of the MBUS_INIT instruction specifies the maximum number of holding registers (V memory words) the Modbus master is allowed to access.

See the description of the MBUS_INIT instruction for more information on setting up the memory restrictions for the Modbus slave.

Table 12-1 Mapping Modbus Addresses to the S7-200

Modbus Address	S7-200 Address
00001	Q0.0
00002	Q0.1
00003	Q0.2
...	...
00127	Q15.6
00128	Q15.7
10001	I0.0
10002	I0.1
10003	I0.2
...	...
10127	I15.6
10128	I15.7
30001	AIW0
30002	AIW2
30003	AIW4
...	...
30032	AIW62
40001	HoldStart
40002	HoldStart+2
40003	HoldStart+4
...	...
4xxxx	HoldStart+2 x (xxxx–1)

Configuring the Symbol Table

After you enter an address for the first symbol, the table automatically calculates and assigns the remainder of the symbols in the table.

You should assign a starting V location for the table which occupies 779 bytes. Be sure that the assignment of the Modbus Slave symbols do not overlap with the V memory assigned to the Modbus holding registers with the HoldStart and MaxHold parameters on the MBUS_INIT instruction. If there is any overlap of the memory areas, the MBUS_INIT instruction returns an error.

Using the Modbus Master Instructions

To use the Modbus Master instructions in your S7-200 program, follow these steps:

1. Insert the MBUS_CTRL instruction in your program and execute the MBUS_CTRL on every scan. You can use the MBUS_CTRL instruction either to initiate or to change the Modbus communications parameters.

   When you insert the MBUS_CTRL instruction, several hidden subroutines and interrupt routines are automatically added to your program.
2. Use the Library Memory command to assign a starting address for the V memory required for Modbus Master Protocol instructions.
3. Place one or more MBUS_MSG instructions in your program. You can add as many MBUS_MSG instructions to your program as you require, but only one of these instructions can be active at a time.
4. Connect the communications cable between Port 0 on the S7-200 CPU (or Port 1 for the Port 1 library), and the Modbus slave devices.

Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable. These unwanted currents can cause communications errors or damage equipment.

Ensure that all equipment that is connected with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows.

The Modbus Master instructions use the Modbus functions shown below to read or write a specific Modbus address. The Modbus slave device must support the Modbus function(s) required to read or write a particular Modbus address.

Table 12-2 Required Modbus Slave Function Support

Modbus Address	Read or Write	Modbus Slave Function Required
00001 to 09999 discrete outputs	Read	Function 1
	Write	Function 5 for a single output point
		Function 15 for multiple output points
10001 to 19999 discrete inputs	Read	Function 2
	Write	Not possible
30001 to 39999 input registers	Read	Function 4
	Write	Not possible
40001 to 49999 holding registers	Read	Function 3
	Write	Function 6 for a single register
		Function 16 for multiple registers

Using the Modbus Slave Instructions

To use the Modbus Slave instructions in your S7-200 program, follow these steps:

1. Insert the MBUS_INIT instruction in your program and execute the MBUS_INIT instruction for one scan only. You can use the MBUS_INIT instruction either to initiate or to change the Modbus communications parameters.

   When you insert the MBUS_INIT instruction, several hidden subroutines and interrupt routines are automatically added to your program.

2. Use the Library Memory command to assign a starting address for the V memory required for Modbus Slave Protocol instructions.
3. Place only one MBUS_SLAVE instruction in your program. This instruction is called every scan to service any requests that have been received.
4. Connect the communications cable between Port 0 on the S7-200 and the Modbus master device.

Caution

Interconnecting equipment with different reference potentials can cause unwanted currents to flow through the interconnecting cable. These unwanted currents can cause communications errors or damage equipment.

Ensure that all equipment that is connected with a communications cable either shares a common circuit reference or is isolated to prevent unwanted current flows.

The accumulators (AC0, AC1, AC2, AC3) are utilized by the Modbus slave instructions and appear in the Cross Reference listing. Prior to execution, the values in the accumulators of a Modbus Slave instruction are saved and restored to the accumulators before the Modbus Slave instruction is complete, ensuring that all user data in the accumulators is preserved while executing a Modbus Slave instruction.

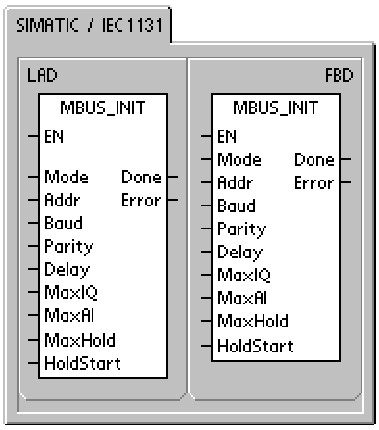
The Modbus Slave Protocol instructions support the Modbus RTU protocol. These instructions utilize the Freeport utilities of the S7-200 to support the most common Modbus functions. The following Modbus functions are supported:

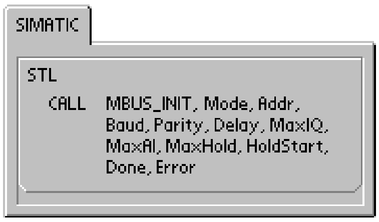
Table 12-3 Modbus Slave Protocol Functions Supported

Function	Description
1	Read single/multiple coil (discrete output) status. Function 1 returns the on/off status of any number of output points (Qs).
2	Read single/multiple contact (discrete input) status. Function 2 returns the on/off status of any number of input points (Is).
3	Read single/multiple holding registers. Function 3 returns the contents of V memory. Holding registers are word values under Modbus and allow you to read up to 120 words in one request.
4	Read single/multiple input registers. Function 4 returns Analog Input values.
5	Write single coil (discrete output). Function 5 sets a discrete output point to the specified value. The point is not forced and the program can overwrite the value written by the Modbus request.
6	Write single holding register. Function 6 writes a single holding register value to the V memory of the S7-200.
15	Write multiple coils (discrete outputs). Function 15 writes the multiple discrete output values to the Q image register of the S7-200. The starting output point must begin on a byte boundary (for example, Q0.0 or Q2.0) and the number of outputs written must be a multiple of eight. This is a restriction for the Modbus Slave Protocol instructions. The points are not forced and the program can overwrite the values written by the Modbus request.
16	Write multiple holding registers. Function 16 writes multiple holding registers to the V memory of the S7-200. There can be up to 120 words written in one request.

Instructions for the Modbus Protocol

MBUS_INIT Instruction (Initialize Slave)





```
CALL   MBUS_INIT, Mode, Addr,
       Baud, Parity, Delay, MaxIQ,
       MaxAI, MaxHold, HoldStart,
       Done, Error
```

The MBUS_INIT instruction is used to enable and initialize, or to disable Modbus communications. Before the MBUS_SLAVE instruction can be used, the MBUS_INIT instruction must be executed without errors. The instruction completes and the Done bit is set immediately, before continuing to the next instruction.

The instruction is executed on each scan when the EN input is on.

The MBUS_INIT instruction should be executed exactly once for each change in communications state. Therefore, the EN input should be pulsed on through an edge detection element, or executed only on the first scan.

The value for the Mode input selects the communications protocol: an input value of 1 assigns port 0 to Modbus protocol and enables the protocol, and an input value of 0 assigns port 0 to PPI and disables Modbus protocol.

The parameter Baud sets the baud rate at 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200. Baud rates 57600 and 115200 are supported by S7-200 CPUs version 1.2 or later.

The parameter Addr sets the address at inclusive values between 1 and 247.

Table 12-4 Parameters for the MBUS_INIT Instruction

Inputs/Outputs	Data Type	Operands
Mode, Addr, Parity	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Baud, HoldStart	DWORD	VD, ID, QD, MD, SD, SMD, LD, AC, Constant, *VD, *AC, *LD
Delay, MaxIQ, MaxAI, MaxHold	WORD	VW, IW, QW, MW, SW, SMW, LW, AC, Constant, *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

The parameter Parity is set to match the parity of the Modbus master. All settings use one stop bit. The accepted values are:

❑ 0-no parity

❑ 1-odd parity

❑ 2-even parity

The parameter Delay extends the standard Modbus end-of-message timeout condition by adding the specified number of milliseconds to the standard Modbus message timeout. The typical value for this parameter should be 0 when operating on a wired network. If you are using modems with error correction, set the delay to a value of 50 to 100 milliseconds. If you are using spread spectrum radios, set the delay to a value of 10 to 100 milliseconds. The Delay value can be 0 to 32767 milliseconds.

The parameter MaxIQ sets the number of I and Q points available to Modbus addresses 0xxxx and 1xxxx at values of 0 to 128. A value of 0 disables all reads and writes to the inputs and outputs. The suggested value for MaxIQ is 128, which allows access to all I and Q points in the S7-200.

The parameter MaxAI sets the number of word input (AI) registers available to Modbus address 3xxxx at values of 0 to 32. A value of 0 disables reads of the analog inputs. The suggested value for MaxAI to allow access to all of the S7-200 analog inputs, is as follows:

❑ 0 for CPU 221

❑ 16 for CPU 222

❑ 32 for CPU 224, CPU 224XP, and CPU 226

The parameter MaxHold sets the number of word holding registers in V memory available to Modbus address 4xxxx. For example, to allow the master to access 2000 bytes of V memory, set MaxHold to a value of 1000 words (holding registers).

The parameter HoldStart is the address of the start of the holding registers in V memory. This value is generally set to VB0, so the parameter HoldStart is set to &VB0 (address of VB0). Other V memory addresses can be specified as the starting address for the holding registers to allow VB0 to be used elsewhere in the project. The Modbus master has access to MaxHold number of words of V memory starting at HoldStart.

When the MBUS_INIT instruction completes, the Done output is turned on. The Error output byte contains the result of executing the instruction. Table 12-6 defines the error conditions that could result from executing the instruction.

MBUS_SLAVE Instruction

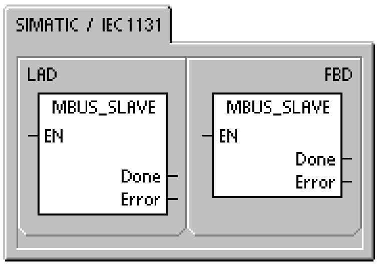
The MBUS_SLAVE instruction is used to service a request from the Modbus master and must be executed every scan to allow it to check for and respond to Modbus requests.

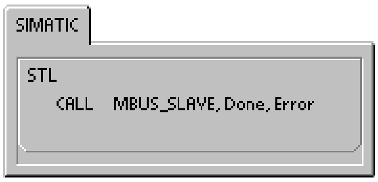
The instruction is executed on each scan when the EN input is on.

The MBUS_SLAVE instruction has no input parameters.

The Done output is on when the MBUS_SLAVE instruction responds to a Modbus request. The Done output is turned off if there was no request serviced.

The Error output contains the result of executing the instruction. This output is only valid if Done is on. If Done is off, the error parameter is not changed. Table 12-6 defines the error conditions that could result from executing the instruction.





```
CALL   MBUS_SLAVE, Done, Error
```

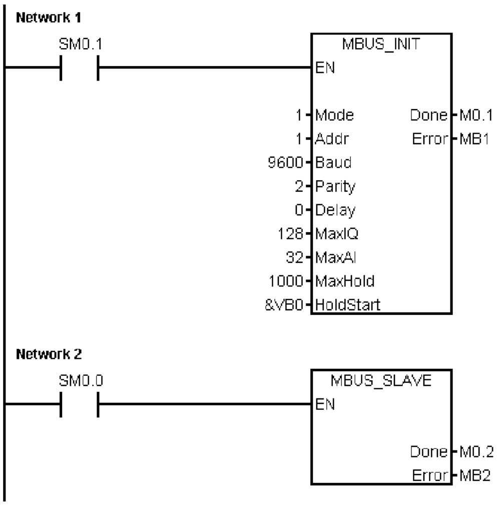
Table 12-5 Parameters for the MBUS_SLAVE Instruction

Parameter	Data Type	Operands
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Table 12-6 Modbus Slave Protocol Execution Error Codes

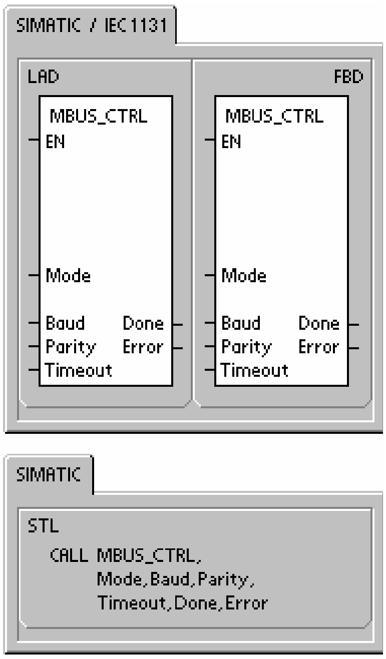
Error Codes	Description
0	No Error
1	Memory range error
2	Illegal baud rate or parity
3	Illegal slave address
4	Illegal value for Modbus parameter
5	Holding registers overlap Modbus Slave symbols
6	Receive parity error
7	Receive CRC error
8	Illegal function request/function not supported
9	Illegal memory address in request
10	Slave function not enabled

Example of Programming the Modbus Slave Protocol



```
Network 1
            //Initialize the Modbus Slave Protocol on the
            //first scan. Set the slave address to 1, set
            // port 0 to 9600 baud with even parity, all
            //access to all I, Q and AI values, allow
            //access to 1000 holding registers (2000
            // bytes) starting at VB0.
LD          SM0.1
CALL        MBUS_INIT,1,1,9600,2,0,128,32,1000,
            &VB0,M0.1,MB1
Network 2
            //Execute the Modbus Slave Protocol on
            //every scan.
LD          SM0.0
CALL        MBUS_SLAVE,M0.2,MB2
```

MBUS_CTRL Instruction (Initialize Master)



```
CALL MBUS_CTRL,
     Mode,Baud,Parity,
     Timeout,Done,Error
```

The MBUS_CTRL instruction for S7-200 port 0 (or MBUS_CTRL_P1 for port 1) is used to initialize, monitor, or to disable Modbus communications. Before the MBUS_MSG instruction can be used, the MBUS_CTRL instruction must be executed without errors. The instruction completes and the Done bit is set immediately before continuing to the next instruction. This instruction is executed on each scan when the EN input is on.

The MBUS_CTRL instruction must be called every scan (including the first scan) to allow it to monitor the progress of any outstanding messages initiated with the MBUS_MSG instruction. The Modbus Master Protocol will not operate correctly unless MBUS_CTRL is called every scan.

The value for the Mode input selects the communications protocol. An input value of 1 assigns the CPU port to Modbus protocol and enables the protocol. An input value of 0 assigns the CPU port to PPI system protocol and disables Modbus protocol.

The parameter Parity is set to match the parity of the Modbus slave device. All settings use one start bit and one stop bit. The allowed values are:

- ❑ 0 – no parity
- ❑ 1 – odd parity
- ❑ 2 – even parity

The parameter Timeout is set to the number of milliseconds to wait for the response from the slave. The Timeout value can be set anywhere in the range of 1 millisecond through 32767 milliseconds. A typical value would be 1000 milliseconds (1 second). The Timeout parameter should be set to a value large enough so that the slave device has time to respond at the selected baud rate.

The Timeout parameter is used to determine if the Modbus slave device is responding to a request. The Timeout value determines how long the Modbus Master will wait for the first character of the response after the last character of the request has been sent. The Modbus Master will receive the entire response from the Modbus slave device if at least one character of the response is received within the Timeout time.

When the MBUS_CTRL instruction completes, the Done output is turned on.

The Error output contains the result of executing the instruction. Table 12-8 defines the error conditions that could result from executing the MBUS_CTRL instruction.

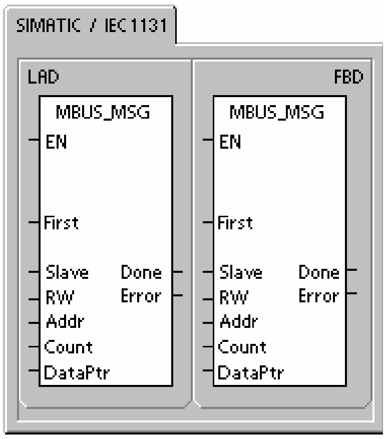
Table 12-7 Parameters for the MBUS_CTRL Instruction

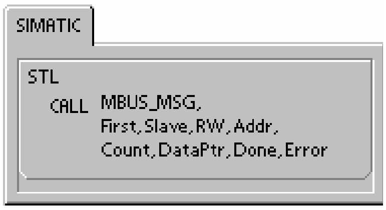
Parameter	Data Type	Operands
Mode	BOOL	I, Q, M, S, SM, T, C, V, L
Baud	DWORD	VD, ID, QD, MD, SD, SMD, LD, AC, Constant, *VD, *AC, *LD
Parity	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Timeout	WORD	VW, IW, QW, MW, SW, SMW, LW, AC, Constant, *VD, *AC, *LD
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Table 12-8   Modbus Slave Protocol Execution Error Codes

Error Codes	Description
0	No Error
1	Parity selection is not valid
2	Baud rate selection is not valid
3	Timeout selection is not valid
4	Mode selection is not valid

MBUS_MSG Instruction




SIMATIC

```
STL
  CALL  MBUS_MSG,
        First,Slave,RW,Addr,
        Count,DataPtr,Done,Error
```

The MBUS_MSG instruction (or MBUS_MSG_P1 for port 1) is used to initiate a request to a Modbus slave and process the response.

The MBUS_MSG instruction initiates a request to a Modbus slave when both the EN input and the First inputs are on. Sending the request, waiting for the response, and processing the response usually requires several scans. The EN input must be on to enable the sending of the request, and should remain on until the Done bit is set.

Note: Only one MBUS_MSG instruction can be active at a time. If there is more than one MBUS_MSG instruction enabled, the first MBUS_MSG instruction executed will be processed and all subsequent MBUS_MSG instructions will abort with an error code 6.

The parameter First should be on for only one scan when there is a new request to send. The First input should be pulsed on through an edge detection element (i.e. Positive Edge) which will cause the request to be transmitted one time. See the example program.

The parameter Slave is the address of the Modbus slave device. The allowed range is 0 through 247. Address 0 is the broadcast address and can only be used for write requests. There is no response to a broadcast request to address 0. Not all slave devices will support the broadcast address. The S7-200 Modbus Slave Library does not support the broadcast address.

The parameter RW specifies if this message is to be a read or a write. The following two values are allowed for RW.

- 0 – Read
- 1 – Write

Discrete outputs (coils) and holding registers support both read and write requests. Discrete inputs (contacts) and input registers only support read requests. The parameter Addr is the starting Modbus address. The following ranges of values are allowed:

- 00001 to 09999 for discrete outputs (coils)
- 10001 to 19999 for discrete inputs (contacts)
- 30001 to 39999 for input registers
- 40001 to 49999 for holding registers

The specific range of values for Addr are based on the addresses that the Modbus slave device supports.

The parameter Count specifies the number of data elements to read or write in this request. The Count will be the number of bits for the bit data types, and the number of words for the word data types.

- ❑ Address 0xxxx Count is the number of bits to read or write
- ❑ Address 1xxxx Count is the number of bits to read
- ❑ Address 3xxxx Count is the number of input register words to read
- ❑ Address 4xxxx Count is the number of holding register words to read or write

The MBUS_MSG instruction will read or write a maximum of 120 words or 1920 bits (240 bytes of data). The actual limit on the value of Count will depend upon the limits in the Modbus slave device.

The parameter DataPtr is an indirect address pointer which points to the V memory in the S7-200 CPU for the data associated with the read or write request. For a read request, DataPtr should point to the first CPU memory location used to store the data read from the Modbus slave. For a write request, DataPtr should point to the first CPU memory location of the data to be sent to the Modbus slave.

The DataPtr value is passed into MBUS_MSG as an indirect address pointer. For example, if the data to be written to a Modbus slave device starts at address VW200 in the S7-200 CPU, the value for the DataPtr would be &VB200 (address of VB200). Pointers must always be a type VB even if they point to word data.

Table 12-9 Parameters for the MBUS_MSG Instruction

Parameter	Data Type	Operands
First	BOOL	I, Q, M, S, SM, T, C, V, L (Power flow conditioned by a positive edge detection element)
Slave	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
RW	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, Constant, *VD, *AC, *LD
Addr	DWORD	VD, ID, QD, MD, SD, SMD, LD, AC, Constant, *VD, *AC, *LD
Count	INT	VW, IW, QW, MW, SW, SMW, LW, AC, Constant, *VD, *AC, *LD
DataPtr	DWORD	&VB
Done	BOOL	I, Q, M, S, SM, T, C, V, L
Error	BYTE	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Holding registers (address 4xxxx) and input registers (address 3xxxx) are word values (2 bytes or 16 bits). S7-200 CPU words are formatted the same as Modbus registers. The lower numbered V-memory address is the most significant byte of the register. The higher numbered V–memory address is the least significant byte of the register. The table below shows how the S7-200 byte and word addressing corresponds to the Modbus register format.

Table 12-10 Modbus Holding Register

S7-200 CPU Memory Byte Address		S7-200 CPU Memory Word Address		Modbus Holding Register Address	
Address	Hex Data	Address	Hex Data	Address	Hex Data
VB200	12	VW200	12 34	4001	12 34
VB201	34				
VB202	56	VW202	56 78	4002	56 78
VB203	78				
VB204	9A	VW204	9A BC	4003	9A BC
VB205	BC				

The bit data (addresses 0xxxx and 1xxxx) areas are read and written as packed bytes, that is, 8 bits are packed into each byte of data. The least significant bit of the first data byte is the addressed bit number (the parameter Addr). If only a single bit is written then the bit must be in the least significant bit of the byte pointed to by DataPtr.

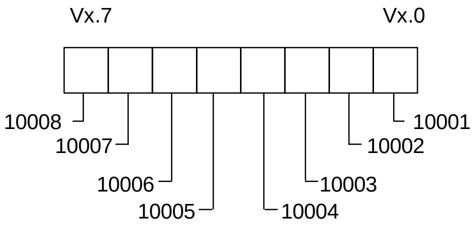


Figure 12-1 Format for Packed Bytes (Discrete Input Addresses)

For bit data addresses that do not start on even byte boundaries, the bit corresponding to the starting address must be in the least significant bit of the byte. See below for an example of the packed byte format for 3 bits starting at Modbus address 10004.

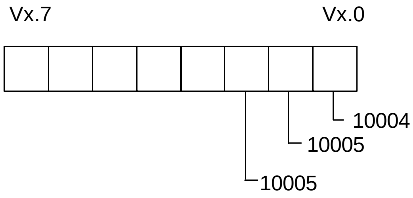


Figure 12-2 Format for Packed Bytes (Discrete input starting at address 10004)

When writing to the discrete output data type (coils), the user is responsible for placing the bits in the correct bit positions within the packed byte before the data is passed to the MBUS_MSG instruction via DataPtr.

The Done output is off while a request is being sent and the response is being received. The Done output is on when the response is complete or when the MBUS_MSG instruction was aborted because of an error.

The Error output is valid only when the Done output is on. See the Modbus Master MBUS_MSG Execution Errors returned by the MBUS_MSG instruction.

The low numbered error codes (1 through 8) are errors that are detected by the MBUS_MSG instruction. These error codes generally indicate a problem with the input parameters of the MBUS_MSG instruction, or a problem receiving the response from the slave. Parity and CRC errors indicate that there was a response but that the data was not received correctly. This is usually caused by an electrical problem such as a bad connection or electrical noise.

The high numbered error codes (starting with 101) are errors that are returned by the Modbus slave device. These errors indicate that the slave does not support the requested function or that the requested address (either data type or range of addresses) is not supported by the Modbus slave device.

Table 12-11 Modbus Master MBUS_MSG Execution Error Codes

Error Codes	Description
0	No Error
1	Parity error in response: This is only possible if even or odd parity is used. The transmission was disturbed and possibly incorrect data was received. This error is usually caused by an electrical problem such as incorrect wiring or electrical noise affecting the communication.
2	Not used
3	Receive timeout: There was no response from the slave within the Timeout time. Some possible causes are bad electrical connection to the slave device, master and slave are set to a different baud rate / parity setting, and incorrect slave address.
4	Error in request parameter: One or more of the input parameters (Slave, RW, Addr, or Count) is set to an illegal value. Check the documentation for allowed values for the input parameters.
5	Modbus master not enabled: Call MBUS_CTRL on every scan prior to calling MBUS_MSG.

Table 12-11   Modbus Master MBUS_MSG Execution Error Codes, continued

Error Codes	Description
6	Modbus is busy with another request: Only one MBUS_MSG instruction can be active at a time.
7	Error in response: The response received does not correspond to the request. This indicates some problem in the slave device or that the wrong slave device answered the request.
8	CRC error in response: The transmission was disturbed and possibly incorrect data was received. This error is usually caused by an electrical problem such as incorrect wiring or electrical noise affecting the communication.
101	Slave does not support the requested function at this address: See the required Modbus slave function support table in the ”Using the Modbus master Instructions” help topic.
102	Slave does not support the data address: The requested address range of Addr plus Count is outside the allowed address range of the slave.
103	Slave does not support the data type: The Addr type is not supported by the slave device.
105	Slave accepted the message but the response is delayed:: This is an error for MBUS_MSG and the user program should resend the request at a later time.
106	Slave accepted the message but the response is delayed:: This is an error for MBUS_MSG and the user program should resend the request at a later time. Slave is busy and rejected the message: You can try the same request again to get a response.
107	Slave rejected the message for an unknown reason
108	Slave memory parity error: There is an error in the slave device.

Program Example

This example program shows how to use the Modbus Master instructions to write and then read 4 holding registers to and from a Modbus slave each time input I0.0 is turned on.

The S7-200 CPU will write 4 words starting at VW100 to the Modbus slave. The data will be written to 4 holding registers in the slave starting at address 40001.

The S7-200 CPU will then read 4 holding registers from the Modbus slave. The data will come from holding registers 40010 – 40013 and be placed into the V–memory of the S7-200 CPU starting at VW200.

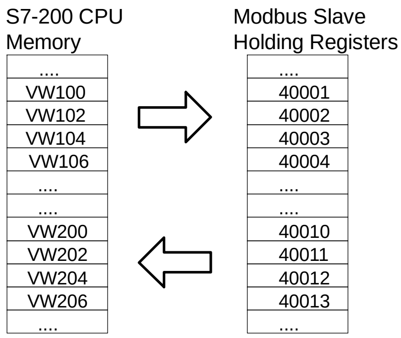
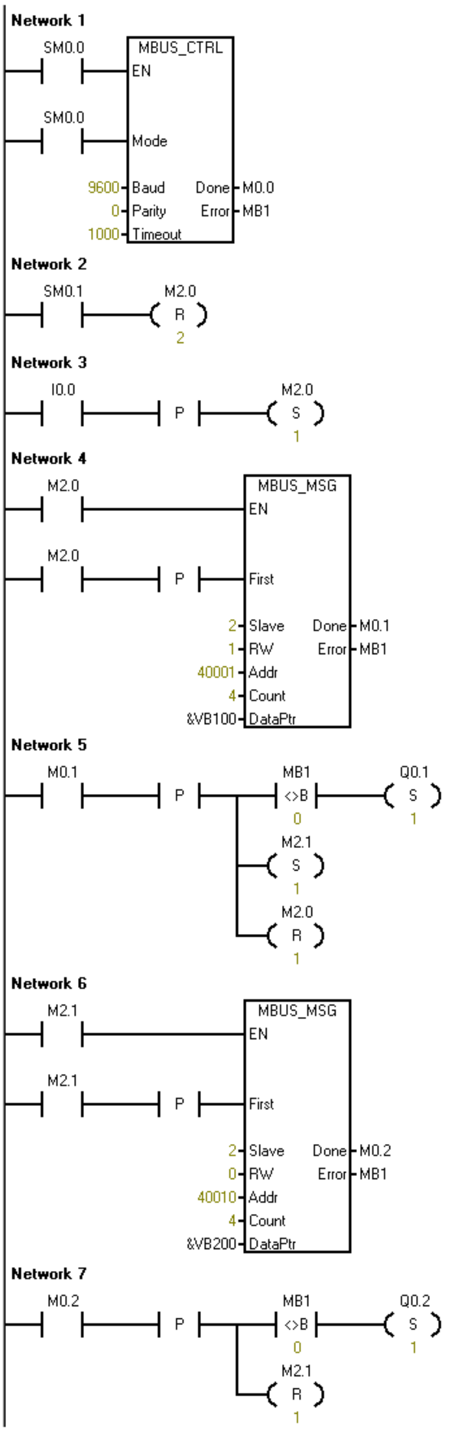


Figure 12-3   Example Program Data Transfers

Example of Programming the Modbus Master Protocol

The program will turn on outputs Q0.1 and Q0.2 if there is an error returned from the MBUS_MSG instruction.



Network 1

// Initialize and monitor the Modbus
// Master by calling MBUS_CTRL on
// every scan.

// The Modbus Master is set for 9600 baud
// and no parity. The slave is allowed 1000
// milliseconds (1 second) to respond.

Network 2

// On the first scan, reset the enable flags
// (M2.0 and M2.1) used for the two
// MBUS_MSG instructions.

Network 3

// When I0.0 changes from OFF to ON, set
// the enable flag for the first MBUS_MSG
// instruction (M2.0).

Network 4

// Call the MBUS_MSG instruction when the
// first enable flag (M2.0) is ON. The First
// parameter must be set for only the first
// scan that the instruction is enabled.

//This instruction writes (RW = 1) 4 holding
// registers to slave 2. The write data is taken
// from VB100 VB107 (4 words) in the CPU
// and written to address 40001 – 40004 in
// the Modbus slave.

Network 5

//When the first MBUS_MSG instruction is
// complete (Done goes from 0 to 1), clear
// the enable for the first MBUS_MSG and set
// the enable for the second MBUS_MSG
// instruction.

//If Error (MB1) is not zero then set Q0.1 to
// show the error.

Network 6

// Call the second MBUS_MSG instruction
// when the second enable flag (M2.1) is ON.
// The First parameter must be set for only
// the first scan that the instruction is
// enabled.

//This instruction reads (RW = 0) 4 holding
// registers from slave 2. The data is read
// from address 40010 – 40013 in the Modbus
// slave and copied to VB200 – VB207
(4 words) in the CPU.

Network 7

//When the second MBUS_MSG instruction
// is complete (Done goes from 0 to 1), clear
// the enable for the second MBUS_MSG
// instruction.

//If Error (MB1) is not zero then set Q0.2 to
// show the error.

Advanced Topics

This topic contains information for advanced users of the Modbus Master Protocol Library. Most users of the Modbus Master Protocol Library should not need this information and should not modify the default operation of the Modbus Master Protocol Library.

Retries

The Modbus Master instructions will automatically resend the request to the slave device if one of the following errors is detected:

- ❑ There is no response within the response timeout time (parameter Timeout on the MBUS_CTRL) instruction (Error code 3).
- ❑ The time between characters of the response exceeded the allowed value (Error code 3).
- ❑ There is a parity error in the response from the slave (Error code 1).
- ❑ There is a CRC error in the response from the slave (Error code 8).
- ❑ The returned function did not match the request (Error code 7).

The Modbus Master will resend the request two additional times before setting the Done and Error output parameters.

The number of retries can be changed by finding the symbol mModbusRetries in the Modbus Master symbol table and changing this value after MBUS_CTRL has been executed. The mModbusRetries value is a BYTE with a range of 0 to 255 retries.

Inter-character timeout

The Modbus Master will abort a response from a slave device if the time between characters in the response exceeds a specified time limit. The default time is set to 100 milliseconds which should allow the Modbus Master Protocol to work with most slave devices over wire or telephone modems. If this error is detected, the MBUS CTRL Error parameter will be set to error code 3.

There may be cases where a longer time between characters is required, either because of the transmission medium (i.e. telephone modem) or because the slave device itself requires more time. This timeout can be lengthened by finding the symbol mModbusCharTimeout in the Modbus Master symbol table and changing this value after MBUS_CTRL has been executed. The mModbusCharTimeout value is an INT with a range of 1 to 30000 milliseconds.

Single vs. Multiple Bit/Word Write Functions

Some Modbus slave devices do not support the Modbus functions to write a single discrete output bit (Modbus function 5) or to write a single holding register (Modbus function 6). These devices only support the multiple bit write (Modbus function 15) or multiple register write (Modbus function 16) instead. The MBUS_MSG instruction will return an error code 101 if the slave device does not support the single bit/word Modbus functions.

The Modbus Master Protocol allows you to force the MBUS_MSG instruction to use the multiple bit/word Modbus functions instead of the single bit/word Modbus functions. You can force the multiple bit/word instructions by finding the symbol mModbusForceMulti in the Modbus Master symbol table and changing this value after MBUS_CTRL has been executed. The mModbusForceMulti value is a data type BOOL value and should be set to a 1 to force the use of the multiple bit/word functions when a single bit/register is written.

Accumulator Usage

The accumulators (AC0, AC1, AC2, AC3) are utilized by the Modbus Master instructions and appear in the Cross Reference listing. The values in the accumulators are saved and restored by the Modbus Master instructions. All user data in the accumulators is preserved while executing the Modbus Master instructions.

Holding Registers Addresses Greater Than 9999

Modbus holding addresses are generally within the range of 40001 through 49999. This range is adequate for most applications but there are some Modbus slave devices with data mapped into holding registers with addresses greater than 9999. These devices do not fit the normal Modbus addressing scheme.

The Modbus Master instructions support addressing holding registers greater than 9999 via an alternate addressing method. The MBUS_MSG instruction allows an additional range for the parameter Addr to support an extended range of holding register addresses.

400001 to 465536 for holding registers

For example: to access holding register 16768, the Addr parameter of MBUS_MSG should be set to 416768.

The extended addressing allows access to the full range of 65536 possible addresses supported by the Modbus protocol. This extended addressing is only supported for holding registers.

13

Using Recipes

STEP 7–Micro/Win provides the Recipe Wizard to help you organize recipes and recipe definitions. Recipes are stored in the memory cartridge instead of the PLC.

In This Chapter

Overview

Support for recipes has been incorporated into STEP 7–Micro/WIN and the S7-200 PLC. STEP 7–Micro/Win provides the Recipe Wizard to help you organize recipes and recipe definitions.

Recipe

All recipes are stored in the memory cartridge. Therefore, to use the recipe feature, an optional 64kB or 256kB memory cartridge must be installed in the PLC. See Appendix A for more information about the memory cartridges.

All recipes are stored in the memory cartridge. However, a single recipe is read into PLC memory when the user program is processing this individual recipe. For example, if you are making cookies, there may be recipes for chocolate chip, sugar, and oatmeal cookies. Only one type of cookie can be made at a time, so the proper recipe must be selected and read into PLC memory.

Figure 13-1 illustrates a process for making multiple types of cookies using recipes. The recipe for each type of cookie is stored in the memory cartridge. Using a TD 200C text display, the operator selects the type of cookie to be made, and the user program loads that recipe into memory.

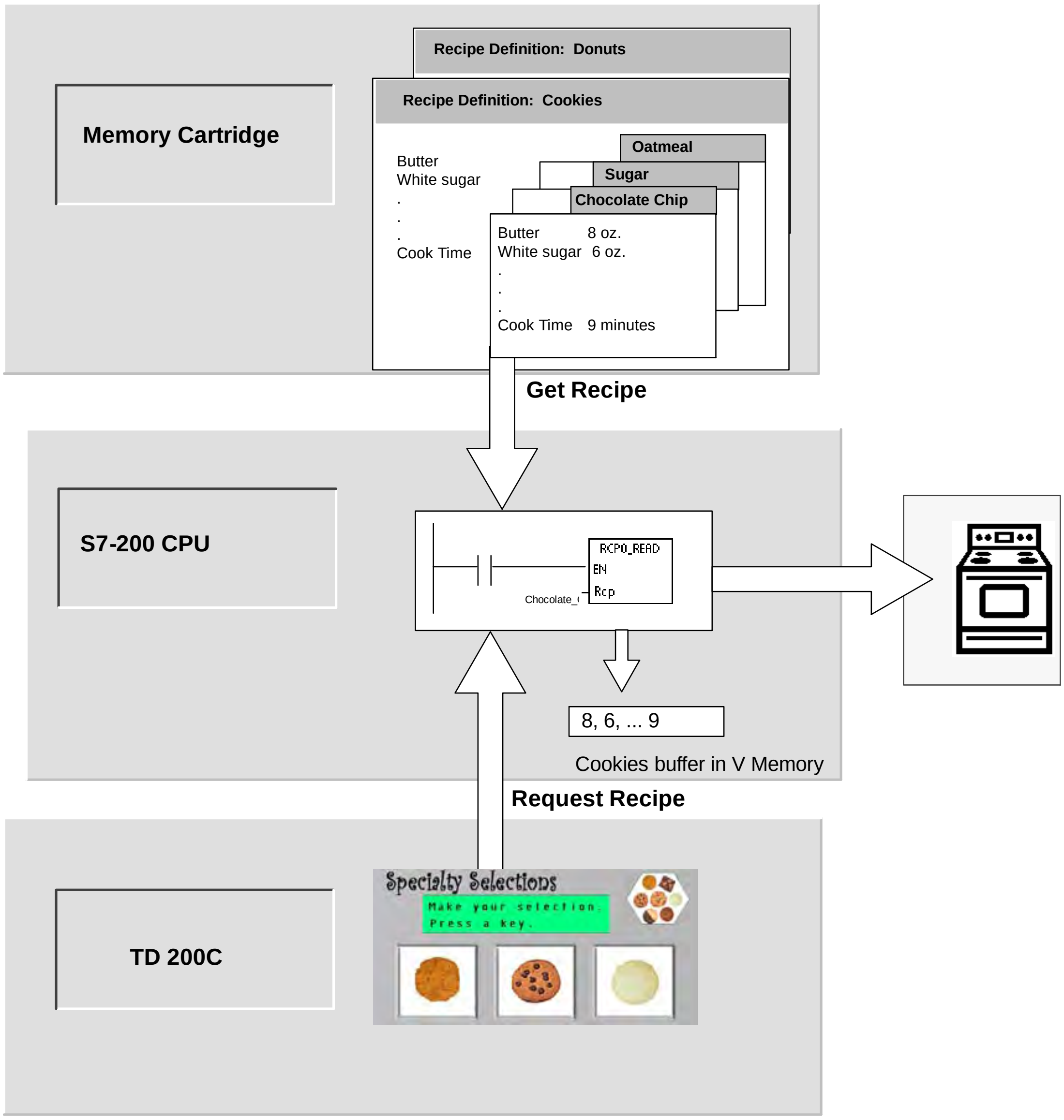


Figure 13-1 Example of Recipe Application

Recipe Definition and Terminology

To help you understand the Recipe Wizard, the following definitions and terms are explained.

❑ A recipe configuration is the set of project components generated by the Recipe Wizard. These components include instruction subroutines, data block tabs, and symbol tables.

❑ A recipe definition is a collection of recipes that have the same set of parameters. However, the values for the parameters can vary depending upon the recipe.

❑ A recipe is the set of parameters and parameter values that provides the information needed to produce a product or control a process.

For example, different recipe definitions can be created, such as donuts and cookies. The cookie recipe definition may contain many different recipes, such as chocolate chip and sugar cookies. Example fields and values are shown in Table 13-1.

Table 13-1 Example of Recipe Definition – Cookies

Field Name	Data Type	Chocolate_Chip (Recipe 0)	Sugar (Recipe 1)	Comment
Butter	Byte	8	8	Ounces
White_Sugar	Byte	6	12	Ounces
Brown_Sugar	Byte	6	0	Ounces
Eggs	Byte	2	1	each
Vanilla	Byte	1	1	Teaspoon
Flour	Byte	18	32	Ounces
Baking_Soda	Real	1.0	0.5	Teaspoon
Baking_Powder	Real	0	1.0	Teaspoon
Salt	Real	1.0	0.5	Teaspoon
Chocolate_Chips	Real	16	0.0	Ounces
Lemon_Peel	Real	0.0	1.0	Tablespoon
Cook_Time	Real	9.0	10.0	Minutes

Using the Recipe Wizard

Use the Recipe Wizard to create recipes and recipe definitions. Recipes are stored in the memory cartridge. Recipes and recipe definitions can be entered directly in the Recipe Wizard. Later changes to individual recipes can be made by running the Recipe Wizard again or by programming with the RCPx_WRITE instruction subroutine.

The Recipe Wizard creates a recipe configuration that includes the following:

❑ A symbol table for each recipe definition. Each table includes symbol names that are the same as the recipe field names. These symbols define the V memory addresses needed to access the recipe values currently loaded in memory. Each table also includes a symbolic constant to reference each recipe.

❑ A data block tab for each recipe definition. This tab defines the initial values for each V memory address represented within the symbol table.

❑ A RCPx_READ instruction subroutine. This instruction is used to read the specified recipe from the memory cartridge to V memory.

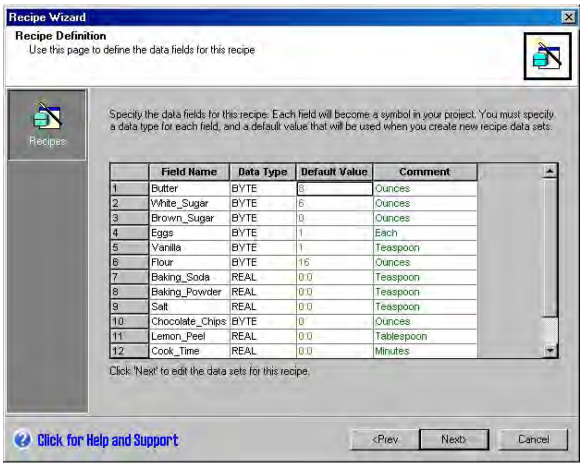
❑ A RCPx_WRITE instruction subroutine. This instruction is used to write recipe values from V memory to the memory cartridge.

Defining Recipes

To create a recipe using the Recipe Wizard, select the **Tools > Recipe Wizard** menu command. The first screen is an introductory screen defining the basic operations of the recipe wizard. Click on the Next button to begin configuring your recipes.

To create a recipe definition, follow the steps below. See Figure 13-2.

1. Specify the field names for the recipe definition. Each name will become a symbol in your project as previously defined.
2. Select a data type from the drop down list.
3. Enter a default value and comment for each name. All new recipes specified within this definition will begin with these default values.
4. Click Next to create and edit recipes for this recipe definition



Recipe Wizard

Recipe Definition

Use this page to define the data fields for this recipe

Specify the data fields for this recipe. Each field will become a symbol in your project. You must specify a data type for each field, and a default value that will be used when you create new recipe data sets.

	Field Name	Data Type	Default Value	Comment
1	Butter	BYTE	8	Ounces
2	White_Sugar	BYTE	6	Ounces
3	Brown_Sugar	BYTE	0	Ounces
4	Eggs	BYTE	1	Each
5	Vanilla	BYTE	1	Teaspoon
6	Flour	BYTE	16	Ounces
7	Baking_Soda	REAL	0.0	Teaspoon
8	Baking_Powder	REAL	0.0	Teaspoon
9	Salt	REAL	0.0	Teaspoon
10	Chocolate_Chips	BYTE	0	Ounces
11	Lemon_Peel	REAL	0.0	Tablespoon
12	Cook_Time	REAL	0.0	Minutes

Click 'Next' to edit the data sets for this recipe.

Figure 13-2 Defining Recipes

Use as many rows as necessary to define all data fields in the recipe. You can have up to four different recipe definitions. The number of recipes for each definition is limited only by the available space within the memory cartridge.

Creating and Editing Recipes

The Create and Edit Recipes screen allows you to create individual recipes and specify values for these recipes. Each editable column represents a unique recipe.

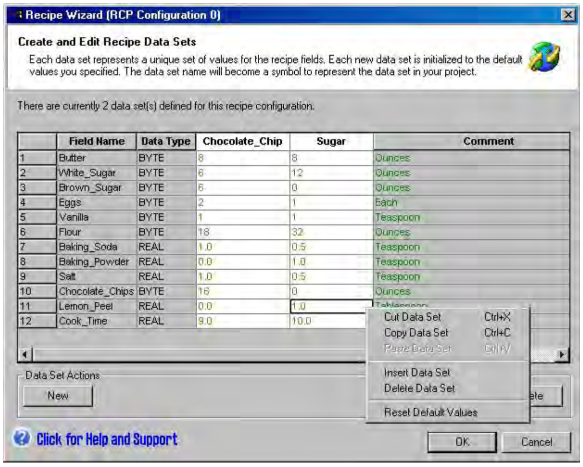
Recipes can be created by pressing the New button. Each recipe is initialized with the default values specified during the creation of the recipe definition.

Recipes can also be created from the right mouse context menu by copying and pasting existing recipes. New columns will be inserted to the left of the current cursor position including the comment field.

Each new recipe will be given a default name that includes a reference to the recipe definition and recipe number. This name will be in the form of DEFx_RCPy.

To create and edit recipes, follow the steps below. See Figure 13-3.

1. Click on the Next button to get to the Create and Edit Recipe window.
2. Select the New button to insert a new recipe as needed.
3. Rename the recipe name to an appropriate non-default name.
4. Change the values in each recipe data set as needed.
5. Click OK.



Recipe Wizard (RCP Configuration 0)

Create and Edit Recipe Data Sets

Each data set represents a unique set of values for the recipe fields. Each new data set is initialized to the default values you specified. The data set name will become a symbol to represent the data set in your project.

There are currently 2 data set(s) defined for this recipe configuration.

	Field Name	Data Type	Chocolate_Chip	Sugar	Comment
1	Butter	BYTE	8	8	Ounces
2	White_Sugar	BYTE	6	12	Ounces
3	Brown_Sugar	BYTE	6	0	Ounces
4	Eggs	BYTE	2	1	Each
5	Vanilla	BYTE	1	1	Teaspoon
6	Flour	BYTE	18	32	Ounces
7	Baking_Soda	REAL	1.0	0.5	Teaspoon
8	Baking_Powder	REAL	0.0	1.0	Teaspoon
9	Salt	REAL	1.0	0.5	Teaspoon
10	Chocolate_Chips	BYTE	16	0	Ounces
11	Lemon_Peel	REAL	0.0	1.0	Tablespoon
12	Cook_Time	REAL	9.0	10.0	

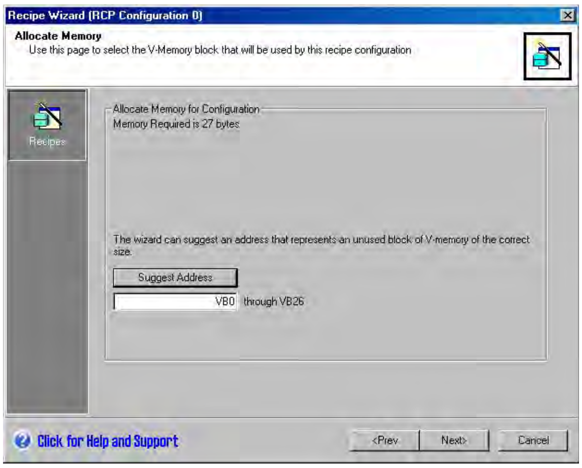
Figure 13-3 Creating and Editing Recipes

Allocating Memory

The Allocate Memory screen specifies the starting address of the V memory area that will store the recipe loaded from the memory cartridge. You can either select the V memory address or let the Recipe wizard to suggest the address of an unused V memory block of the correct size.

To allocate memory, follow the steps below. See Figure 13-4.

1. To select the V memory address where you want the recipe to be stored, click in the window and enter the address.
2. To let the Recipe Wizard select an unused V memory block of the correct size, click the Suggest Address button.
3. Click the Next button.



Recipe Wizard (RCP Configuration 0)

Allocate Memory

Use this page to select the V-Memory block that will be used by this recipe configuration

Allocate Memory for Configuration

Memory Required is 27 bytes

The wizard can suggest an address that represents an unused block of V-memory of the correct size.

VB0 through VB26

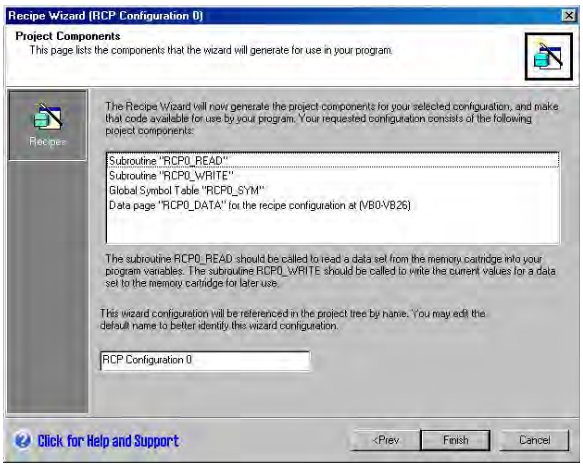
Figure 13-4 Allocating Memory

Project Components

The project components screen lists the different components that will be added to your project. See Figure 13-5.

Click Finish to complete the Recipe Wizard and add these components.

Each recipe configuration can be given a unique name. This name will be shown in the project tree with each wizard configuration. The recipe definition (RCPx) will be appended to the end of this name.



Recipe Wizard (RCP Configuration 0)

Project Components

This page lists the components that the wizard will generate for use in your program.

The Recipe Wizard will now generate the project components for your selected configuration, and make that code available for use by your program. Your requested configuration consists of the following project components:

Subroutine "RCP0_READ"
Subroutine "RCP0_WRITE"
Global Symbol Table "RCP0_SYM"
Data page "RCP0_DATA" for the recipe configuration at (VB0-VB26)

The subroutine RCP0_READ should be called to read a data set from the memory cartridge into your program variables. The subroutine RCP0_WRITE should be called to write the current values for a data set to the memory cartridge for later use.

This wizard configuration will be referenced in the project tree by name. You may edit the default name to better identify this wizard configuration.

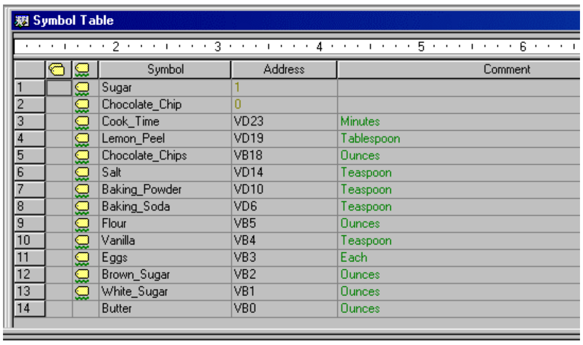
RCP Configuration 0

Figure 13-5 Project Components

Using the Symbol Table

A symbol table is created for each recipe definition. Each table defines constant values that represent each recipe. These symbols can be used as parameters for the RCPx_READ and RCPx_WRITE instructions to indicate the desired recipe See Figure 13-6.

Each table also creates symbol names for each field of the recipe. You can use these symbols to access the values of the recipe in V memory.



Symbol Table

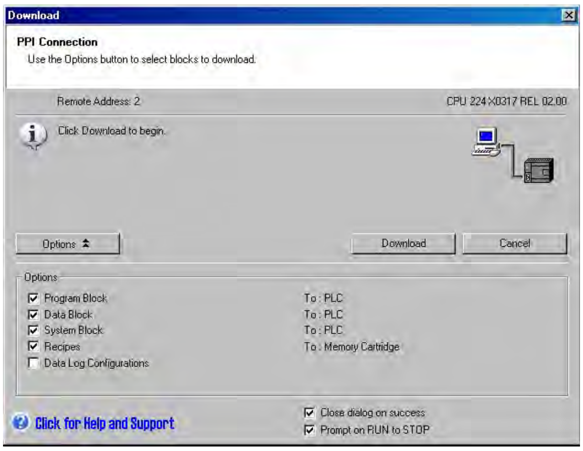
	Symbol	Address	Comment
1	Sugar	1	
2	Chocolate_Chip	0	
3	Cook_Time	VD23	Minutes
4	Lemon_Peel	VD19	Tablespoon
5	Chocolate_Chips	VB18	Ounces
6	Salt	VD14	Teaspoon
7	Baking_Powder	VD10	Teaspoon
8	Baking_Soda	VD6	Teaspoon
9	Flour	VB5	Ounces
10	Vanilla	VB4	Teaspoon
11	Eggs	VB3	Each
12	Brown_Sugar	VB2	Ounces
13	White_Sugar	VB1	Ounces
14	Butter	VB0	Ounces

Figure 13-6 Symbol Table

Downloading the Project with a Recipe Configuration

To download a project that contains a recipe configuration, follow the steps below. See Figure 13-7.

1. Select **File > Download**.
2. In the dialog, under Options, ensure that the Program Block, Data Block, and Recipes boxes are checked.
3. Click the Download button.



Download

PPI Connection

Use the Options button to select blocks to download.

Remote Address: 2

CPU 224 X0317 REL 02.00

Click Download to begin.

Options

☑ Program Block To : PLC
☑ Data Block To : PLC
☑ System Block To : PLC
☑ Recipes To : Memory Cartridge
☐ Data Log Configurations

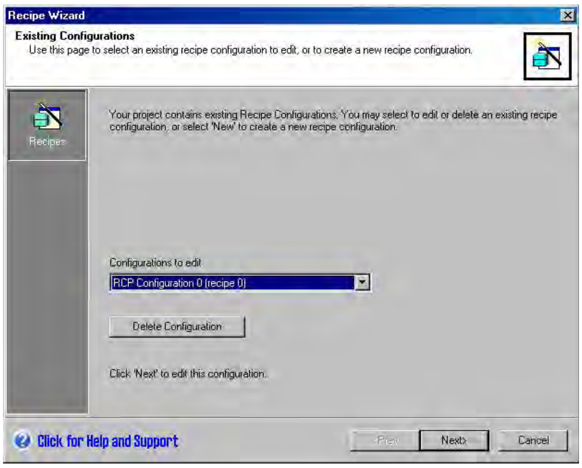
☑ Close dialog on success
☑ Prompt on RUN to STOP

Figure 13-7 Downloading a Project with Recipe Configuration

Edit Existing Recipe Configurations

To edit existing recipe configurations follow the steps below. See Figure 13-8.

1. Click on the configuration drop down list and select an existing recipe configuration.
2. To delete an existing recipe configuration, click on the Delete Configuration button.



Recipe Wizard

Existing Configurations

Use this page to select an existing recipe configuration to edit, or to create a new recipe configuration.

Your project contains existing Recipe Configurations. You may select to edit or delete an existing recipe configuration, or select 'New' to create a new recipe configuration.

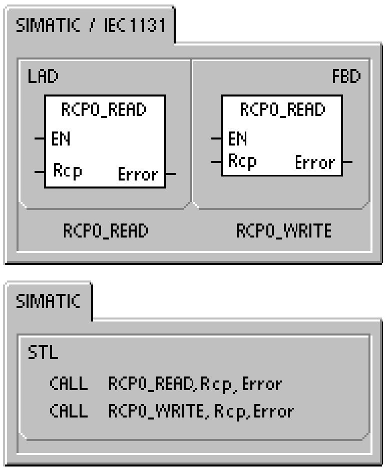
Configurations to edit: RCP Configuration 0 (recipe 0)

Click 'Next' to edit this configuration.

Figure 13-8 Editing Existing Recipe Configurations

Instructions Created by the Recipe Wizard

RCPx_Read Subroutine



```
CALL   RCP0_READ,Rcp,Error
CALL   RCP0_WRITE,Rcp,Error
```

The Subroutine RCPx_READ is created by the Recipe Wizard and is used to read an individual recipe from the memory cartridge to the specified area in V memory.

The x in the RCPx_READ instruction corresponds to the recipe definition that contains the recipe that you wish to read.

The EN input enables the execution of the instruction when this input is high.

The Rcp input identifies the recipe that will be loaded from the memory cartridge

The Error output returns the result of the execution of this instruction. See Table 13-3 for definitions of the error codes.

RCPx_Write Subroutine

The Subroutine RCPx_WRITE is created by the Recipe Wizard and is used to replace a recipe in the memory cartridge with the contents of the recipe contained in V memory.

The x in the RCPx_WRITE instruction corresponds to the recipe definition that contains the recipe that you wish to replace.

The EN input enables the execution of the instruction when this input is high.

The Rcp input identifies the recipe that will be replaced in the memory cartridge.

The Error output returns the result of the execution of this instruction. See Table 13-3 for definitions of the error codes.

Table 13-2 Valid Operands for the Recipe Subroutine

Inputs/Outputs	Data Type	Operands
Rcp	Word	VW, IW, QW, MW, SW, SMW, LW, AC, *VD, *AC, *LD, Constant
Error	Byte	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Table 13-3 Error Codes for the Recipe Instructions

Error Code	Description
0	No error
132	Access to the memory cartridge failed

Tip

The EEPROM used in the memory cartridge will support a limited number of write operations. Typically, this is one million write cycles. Once this limit has been reached, the EEPROM will not operate properly.

Make sure that you do not enable the RCPx_WRITE instruction on every scan. Enabling this instruction on every scan will wear out the memory cartridge in a relatively short period of time.

14 Using Data Logs

STEP 7-Micro/Win provides the Data Log Wizard to store process measurement data in the memory cartridge. Moving process data to the memory cartridge frees V memory addresses that would otherwise be required to store this data.

In This Chapter

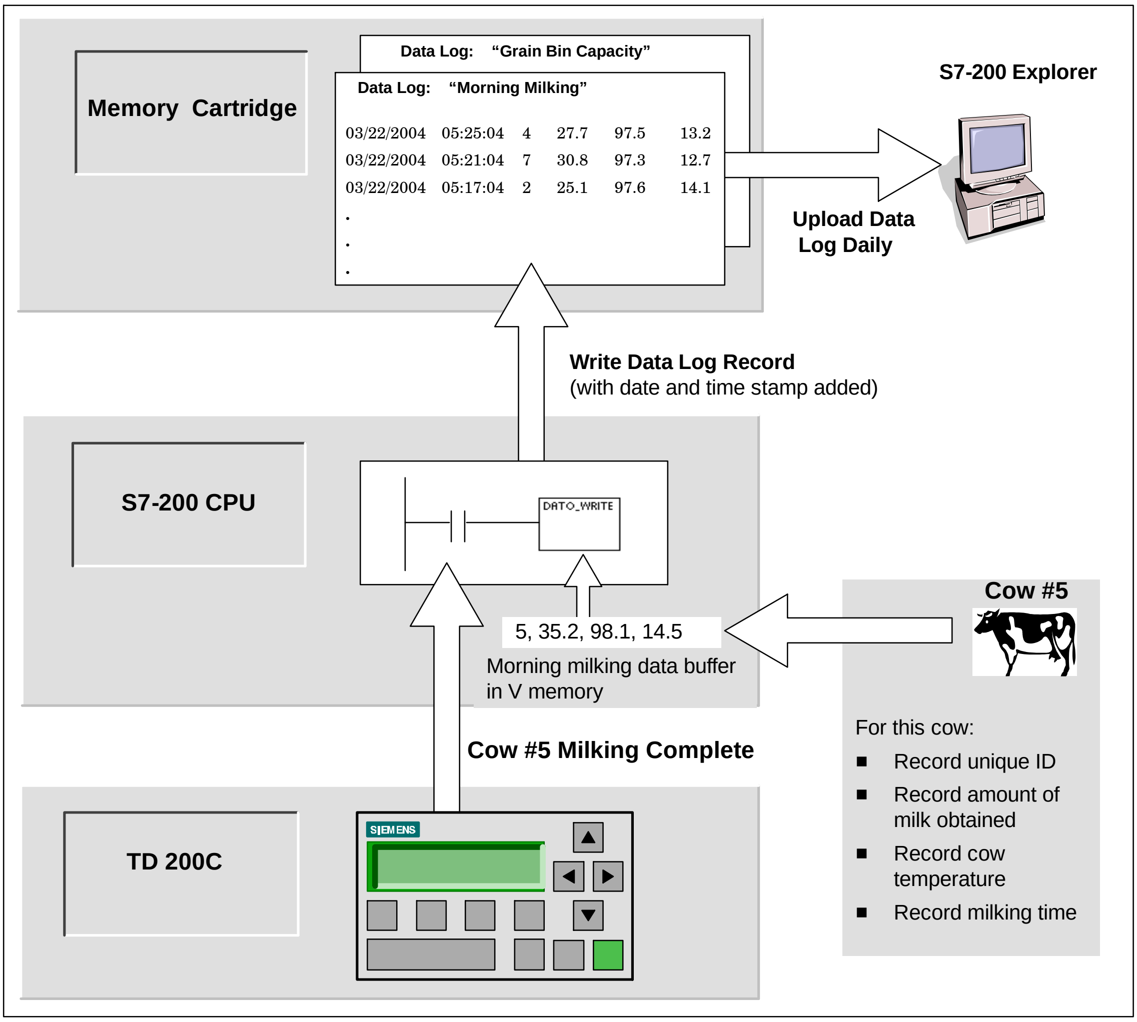
Overview

Support for data logs have been incorporated into STEP 7–Micro/WIN and the S7-200 PLC. With this feature, you can permanently store records containing process data under program control. These records can optionally contain a time and date stamp. You can configure up to four independent data logs. The data log record format is defined using the new Data Log Wizard

All data logs are stored in the memory cartridge. To use the data log feature, you must have installed an optional 64K or 256K memory cartridge in your PLC. See Appendix A for information about the memory cartridges.

You must use the S7-200 Explorer to upload the contents of your data logs to your computer.

An example of a Data Log application is shown in Figure 14-1.



03/22/2004	05:25:04	4	27.7	97.5	13.2
03/22/2004	05:21:04	7	30.8	97.3	12.7
03/22/2004	05:17:04	2	25.1	97.6	14.1
.					
.					
.					

For this cow:

- Record unique ID
- Record amount of milk obtained
- Record cow temperature
- Record milking time

Figure 14-1 Example of Data Log Application

Data Log Definition and Terminology

To help you understand the Data Log Wizard, the following definitions and terms are explained.

❑ A data log is a set of records usually ordered by date and time. Each record represents some process event that records a set of process data. The organization of this data is defined with the data log wizard.

❑ A data log record is a single row of data written to the data log.

Using the Data Log Wizard

Use the Data Log Wizard to configure up to four data logs. The Data Log Wizard is used to:

Data Log

- ❑ Define the format of the data log record
- ❑ Select data log options such as time stamp, date stamp, and clear data log on upload
- ❑ Specify the maximum number of records that can be stored in the data log
- ❑ Create project code used to store records in the data log.

The Data Log Wizard creates a data log configuration that includes the following:

- ❑ A symbol table for each data log configuration. Each table includes symbol names that are the same as the data log field names. Each symbol defines the V memory addresses needed to store the current data log. Each table also includes a symbolic constant to reference each data log.
- ❑ A data block tab for each data log record that assigns V memory addresses for each data log field. Your program uses these V memory addresses to accumulate the current log data set.
- ❑ A DATx_WRITE subroutine. This instruction copies the specified data log record from V memory to the memory cartridge. Each execution of DATx_WRITE adds a new data record to the log data stored in the memory cartridge.

Data Log Options

You can configure the following optional behaviors for the data log. See Figure 14-2.

Time Stamp

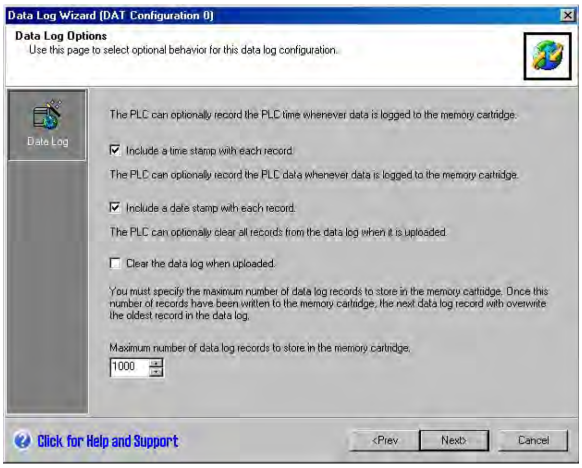
You can include a Time Stamp with each data log record. When selected, the CPU automatically includes a time stamp with each record when the user program commands a data log write.

Date Stamp

You can add a Date Stamp to each data log record. When selected, the CPU automatically includes a date stamp with each record when the user program commands a data log write.

Clear Data Log

Clear Data Log – You can clear all records from the data log whenever it is uploaded. If you set the Clear Data Log option, the data log will be cleared each time it is uploaded.



Data Log Wizard (DAT Configuration 0)

Data Log Options
Use this page to select optional behavior for this data log configuration.

The PLC can optionally record the PLC time whenever data is logged to the memory cartridge.

☑ Include a time stamp with each record.

The PLC can optionally record the PLC data whenever data is logged to the memory cartridge.

☑ Include a date stamp with each record.

The PLC can optionally clear all records from the data log when it is uploaded.

☐ Clear the data log when uploaded.

You must specify the maximum number of data log records to store in the memory cartridge. Once this number of records have been written to the memory cartridge, the next data log record with overwrite the oldest record in the data log.

Maximum number of data log records to store in the memory cartridge.
1000

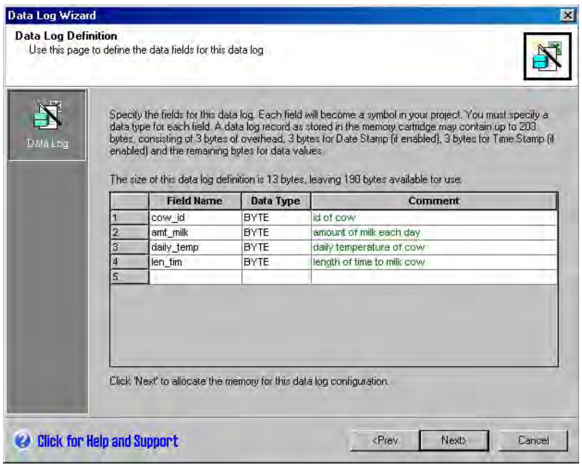
Figure 14-2 Data Log Options

Data logs are implemented as a circular queue (when the log is full, a new record replaces the oldest record). You must specify the maximum number of records to store in the data log. The maximum number of records allowed in a data log is 65,535. The default value for the number of records is 1000.

Defining the Data Log

You specify the fields for the data log and each field becomes a symbol in your project. You must specify a data type for each field. A data log record can contain between 4 and 203 bytes of data. To define the data fields in the data log, follow the steps below. See Figure 14-3.

1. Click on the Field Name cell to enter the name. The name becomes the symbol referenced by the user program.
2. Click on the Data Type cell and select a data type from the drop down list.
3. To enter a comment, click on the Comment cell.
4. Use as many rows as necessary to define a record.
5. Click OK .



Data Log Definition
Use this page to define the data fields for this data log

Specify the fields for this data log. Each field will become a symbol in your project. You must specify a data type for each field. A data log record as stored in the memory cartridge may contain up to 203 bytes, consisting of 3 bytes of overhead, 3 bytes for Date Stamp (if enabled), 3 bytes for Time Stamp (if enabled) and the remaining bytes for data values.

The size of this data log definition is 13 bytes, leaving 190 bytes available for use.

	Field Name	Data Type	Comment
1	cow_id	BYTE	id of cow
2	amt_milk	BYTE	amount of milk each day
3	daily_temp	BYTE	daily temperature of cow
4	len_tim	BYTE	length of time to milk cow
5			

Click 'Next' to allocate the memory for this data log configuration.

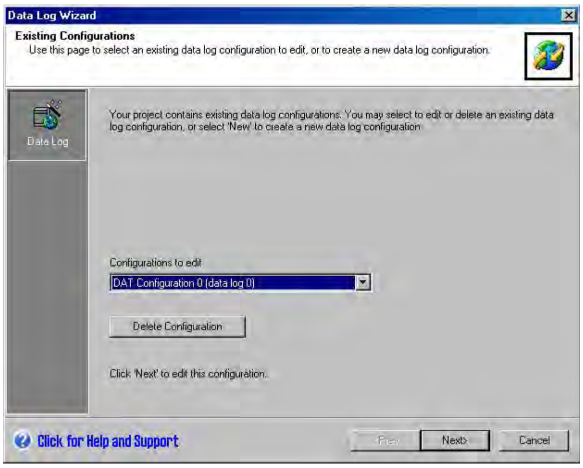
Figure 14-3 Defining the Data Log Record

Edit Existing Data Log Configuration

To edit an existing data log configuration, follow the steps below:

1. Click on the configuration dropdown list and select an existing data log configuration as shown in Figure 14-4.
2. To delete an existing data log configuration, click on the Delete Configuration button.

You can have up to four different data logs.



Existing Configurations
Use this page to select an existing data log configuration to edit, or to create a new data log configuration.

Your project contains existing data log configurations. You may select to edit or delete an existing data log configuration, or select 'New' to create a new data log configuration

Configurations to edit: DAT Configuration 0 (data log 0)

Click 'Next' to edit this configuration.

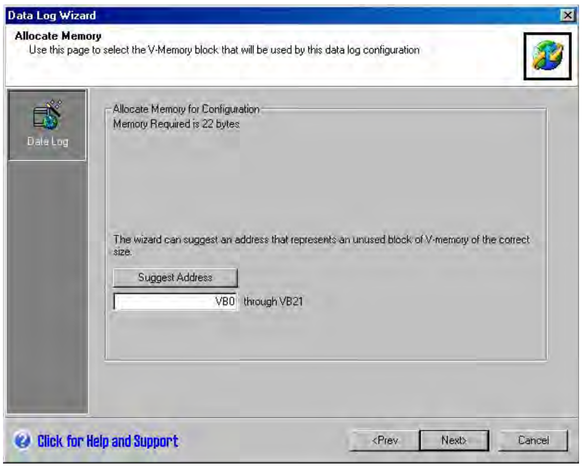
Figure 14-4 Edit Existing Data Log Configurations

Allocating Memory

The Data Log Wizard creates a block in the V memory area of the PLC. This block is the memory address where a data log record will be constructed before it is written to the memory cartridge. You specify a starting V memory address where you want the configuration to be placed. You can either select the V memory address or let the Data Log wizard suggest the address of an unused V memory block of the correct size. The size of the block varies based on the specific choices you have made in the Data Log wizard. See Figure 14-5.

To allocate memory, follow the steps below:

1. To select the V memory address where the data log record will be constructed, click in the Suggested Address area and enter the address.
2. To let the Data Log Wizard select an unused V memory block of the correct size, click the Suggest Address button.
3. Click the Next button.


Data Log Wizard

Allocate Memory
Use this page to select the V-Memory block that will be used by this data log configuration

Allocate Memory for Configuration
Memory Required is 22 bytes

The wizard can suggest an address that represents an unused block of V-memory of the correct size.

VB0 through VB21

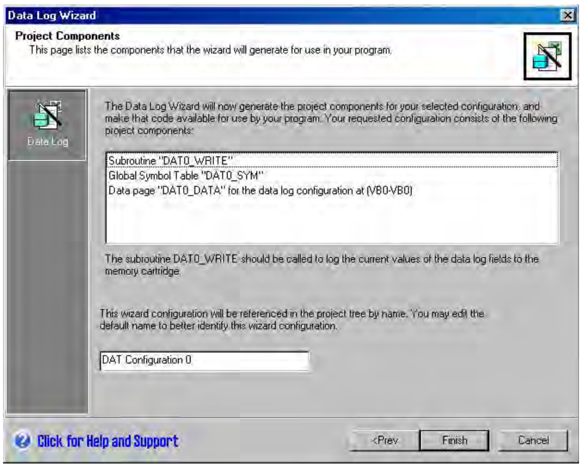
Figure 14-5 Allocating Memory

Project Components

The project components screen lists the different components that will be added to your project. See Figure 14-6.

Click Finish to complete the Data Log Wizard and add these components.

Each data log configuration can be given a unique name. This name will be shown in the project tree with each wizard configuration. The data log definition (DATx) will be appended to the end of this name.


Data Log Wizard

Project Components
This page lists the components that the wizard will generate for use in your program.

The Data Log Wizard will now generate the project components for your selected configuration, and make that code available for use by your program. Your requested configuration consists of the following project components:

Subroutine "DAT0_WRITE"
Global Symbol Table "DAT0_SYM"
Data page "DAT0_DATA" for the data log configuration at (VB0-VB0)

The subroutine DAT0_WRITE should be called to log the current values of the data log fields to the memory cartridge.

This wizard configuration will be referenced in the project tree by name. You may edit the default name to better identify this wizard configuration.

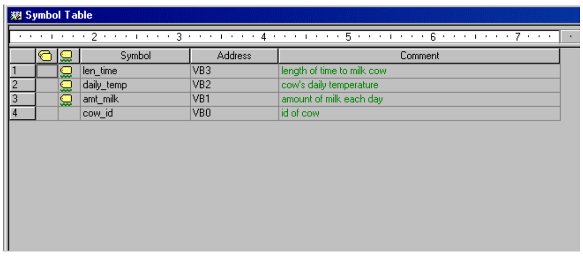
DAT Configuration 0

Figure 14-6 Project Components

Using the Symbol Table

A symbol table is created for each data log configuration. Each table defines constant values that represent each data log. These symbols can be used as parameters for the DATx_WRITE instructions.

Each table also creates symbol names for each field of the data log. You can use these symbols to access the values of the data log in V memory.


Symbol Table

	●	●	Symbol	Address	Comment
1		●	len_time	VB3	length of time to milk cow
2		●	daily_temp	VB2	cow's daily temperature
3		●	amt_milk	VB1	amount of milk each day
4			cow_id	VB0	id of cow

Figure 14-7 Symbol Table

Downloading a Project that contains a Data Log Configuration

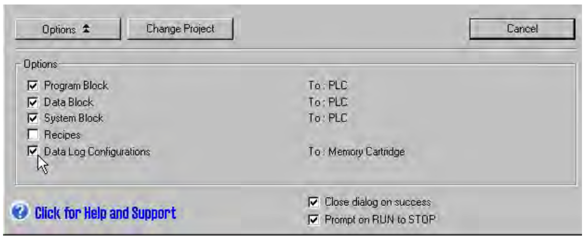
You must download a project that contains a data log configuration to an S7-200 CPU before the data log can be used. If a project has a data log configuration, then the download window has the Data Log Configurations option checked by default.

Tip

When you download a project that contains data log configurations, any data log records currently stored on the memory cartridge will be lost.

To download a project that contains data log configurations, follow the steps below. See Figure 14-8.

1. Select **File > Download**.
2. In the dialog, under Options, ensure that the Data Log Configuration box is checked.
3. Click the Download button.



Options

☑ Program Block	To : PLC
☑ Data Block	To : PLC
☑ System Block	To : PLC
□ Recipes	
☑ Data Log Configurations	To : Memory Cartridge

☑ Close dialog on success
☑ Prompt on RUN to STOP

Figure 14-8 Downloading a Project with a Data Log Configuration

Using the S7-200 Explorer

The S7-200 Explorer is the application used to read a data log from the memory cartridge, and then store the data log in a Comma separated Values (CSV) file.

Each time a data log is read, a new file is created. This file is saved in the Data Log directory. The file name is formatted as follows: PLC Address, data log name, date, and time.

You can choose whether the application associated with the CSV extension is automatically launched when the data log has successfully been read. This selection is available from the right mouse menu of the data log file.

The Data Log directory will be below the directory specified during installation. The default installation directory is c:\program files\siemens\Microsystems (if STEP 7 is not installed). The default installation is c:\siemens\Microsystems (if STEP 7 is installed).

To read a data log, follow the steps below:

1. Open Windows Explorer. The My S7-200 Network folder should automatically become visible.
2. Select the My S7-200 Network folder.
3. Select the correct S7-200 PLC folder.

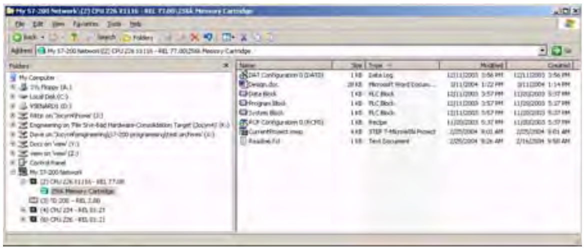


Figure 14-9 Using the S7-200 Explorer

4. Select the memory cartridge folder
5. Find the correct data log configuration file. These files will be named DAT Configuration x (DATx).
6. Select the right mouse context menu, and then select Upload.

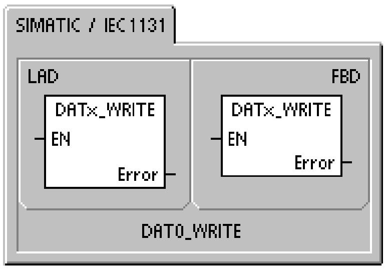
Instruction Created by the Data Log Wizard

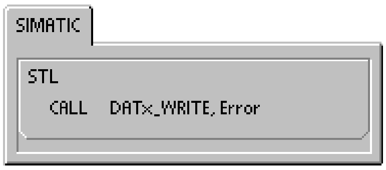
The Data Log Wizard adds one instruction subroutine to your project.

DATx_WRITE Subroutine

The Subroutine DATx_WRITE is used to log the current values of the data log fields to the memory cartridge. DATxWRITE adds one record to the logged data in the memory cartridge. A call to this subroutine appears as follows.

Error 132 is returned when this instruction fails to correctly access the memory cartridge.





```
STL
  CALL   DATx_WRITE, Error
```

Table 14-1 Parameters for the DATAx_WRITE Subroutine

Inputs/Outputs	Data Type	Operands
Error	Byte	VB, IB, QB, MB, SB, SMB, LB, AC, *VD, *AC, *LD

Tip

The EEPROM used in the memory cartridge will support a limited number of write operations. Typically, this is one million write cycles. Once this limit has been reached, the EEPROM will not operate properly.

Make sure that you do not enable the DATx_WRITE instruction on every scan. Enabling this instruction on every scan will wear out the memory cartridge in a relatively short period of time.

15

PID Auto-Tune and the PID Tuning Control Panel

PID Auto-Tune capability has been incorporated into the S7-200 PLCs and STEP 7-Micro/WIN has added a PID Tuning Control Panel. Together, these two features greatly enhance the utility and ease of use of the PID function provided in the S7-200 Micro PLC line.

Auto-tune can be initiated by the user program from an operator panel or by the PID Tuning Control Panel. PID loops can be auto-tuned one at a time or all eight loops can be auto-tuned at the same time if necessary. The PID Auto-Tune computes suggested (near optimum) values for the gain, integral time (reset) and derivative time (rate) tuning values. It also allows you to select tuning for fast, medium, slow or very slow response of your loop.

With the PID Tuning Control Panel you can initiate the auto-tuning process, abort the auto-tuning process and monitor the results in a graphical form. The control panel displays any error conditions or warnings that might be generated. It also allows you to apply the gain, reset and rate values computed by auto-tune.

In This Chapter

Understanding the PID Auto-Tune

Introduction

The auto-tuning algorithm used in the S7-200 is based upon a technique called relay feedback suggested by K. J. Åström and T. Hägglund in 1984. Over the past twenty years relay feedback has been used across a wide variety of industries.

The concept of relay feedback is to produce a small, but sustained oscillation in an otherwise stable process. Based upon the period of the oscillations and the amplitude changes observed in the process variable, the ultimate frequency and the ultimate gain of the process are determined. Then, using the ultimate gain and ultimate frequency values, the PID Auto-tuner suggests a value for the gain, reset and rate tuning values.

The values suggested depend upon your selection for speed of response of the loop for your process. You can select fast, medium, slow or very slow response. Depending upon your process a fast response may have overshoot and would correspond to an underdamped tuning condition. A medium speed response may be on the verge of having overshoot and would correspond to a critically damped tuning condition. A slow response may not have any overshoot and would correspond to an overdamped tuning condition. A very slow response may not have overshoot and would correspond to a heavily overdamped tuning condition.

In addition to suggesting tuning values the PID Auto-tuner can automatically determine the values for hysteresis and peak PV deviation. These parameters are used to reduce the effect of the process noise while limiting the amplitude of the sustained oscillations set up by the PID Auto-Tuner.

The PID Auto-Tuner is capable of determining suggested tuning values for both direct-acting and reverse-acting P, PI, PD, and PID loops.

The purpose of the PID Auto-Tuner is to determine a set of tuning parameters that provide a reasonable approximation to the optimum values for your loop. Starting with the suggested tuning values will allow you to make fine tuning adjustments and truly optimize your process.

Expanded Loop Table

The PID instruction for the S7-200 references a loop table that contains the loop parameters. This table was originally 36 bytes long. With the addition of PID Auto-Tuning the loop table has been expanded and is now 80 bytes long. The expanded loop table is shown in Table 15-1 and Table 15-2.

If you use the PID Tuning Control Panel, all interaction with the PID loop table is handled for you by the control panel. If you need to provide auto-tuning capability from an operator panel, your program must provide the interaction between the operator and the PID loop table to initiate, and monitor the auto-tuning process, and then apply the suggested tuning values.

Table 15-1 Loop Table

Offset	Field	Format	Type	Description
0	Process variable (PV_n)	REAL	In	Contains the process variable, which must be scaled between 0.0 and 1.0.
4	Setpoint (SP_n)	REAL	In	Contains the setpoint, which must be scaled between 0.0 and 1.0.
8	Output (M_n)	REAL	In/Out	Contains the calculated output, scaled between 0.0 and 1.0.
12	Gain (K_C)	REAL	In	Contains the gain, which is a proportional constant. Can be a positive or negative number.
16	Sample time (T_S)	REAL	In	Contains the sample time, in seconds. Must be a positive number.
20	Integral time or reset (T_I)	REAL	In	Contains the integral time or reset, in minutes.
24	Derivative time or rate (T_D)	REAL	In	Contains the derivative time or rate, in minutes.
28	Bias (MX)	REAL	In/Out	Contains the bias or integral sum value between 0.0 and 1.0.
32	Previous process variable (PV_{n-1})	REAL	In/Out	Contains the value of the process variable stored from the last execution of the PID instruction.
36	PID Extended Table ID	ASCII	Constant	'PIDA' (PID Extended Table, Version A): ASCII constant
40	AT Control (ACNTL)	BYTE	In	See Table 15-2
41	AT Status (ASTAT)	BYTE	Out	See Table 15-2
42	AT Result (ARES)	BYTE	In/Out	See Table 15-2
43	AT Config (ACNFG)	BYTE	In	See Table 15-2
44	Deviation (DEV)	REAL	In	Normalized value of the maximum PV oscillation amplitude (range: 0.025 to 0.25).
48	Hysteresis (HYS)	REAL	In	Normalized value of the PV hysteresis used to determine zero crossings (range: 0.005 to 0.1). If the ratio of DEV to HYS is less than 4, a warning will be indicated during auto-tune.
52	Initial Output Step (STEP)	REAL	In	Normalized size of the step change in the output value used to induce oscillations in the PV (range: 0.05 to 0.4)
56	Watchdog Time (WDOG)	REAL	In	Maximum time allowed between zero crossings in seconds (range: 60 to 7200)
60	Suggested Gain (AT_K_C)	REAL	Out	Suggested loop gain as determined by the auto-tune process.
64	Suggested Integral Time (AT_T_I)	REAL	Out	Suggested integral time as determined by the auto-tune process.
68	Suggested Derivative Time (AT_T_D)	REAL	Out	Suggested derivative time as determined by the auto-tune process.
72	Actual Step size (ASTEP)	REAL	Out	Normalized output step size value as determined by the auto-tune process.
76	Actual Hysteresis (AHYS)	REAL	Out	Normalized PV hysteresis value as determined by the auto-tune process.

Table 15-2 Expanded Description of Control and Status Fields

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>AT Control (ACNTL)
Input – Byte</td><td>
<table>
<tr><td>MSB
7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB
0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>EN</td></tr>
</table>
EN – Set to 1 to start auto-tune; set to 0 to abort auto-tune
</td></tr>
<tr><td>AT Status (ASTAT)
Output – Byte</td><td>
<table>
<tr><td>MSB
7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB
0</td></tr>
<tr><td>W0</td><td>W1</td><td>W2</td><td>0</td><td>AH</td><td>0</td><td>0</td><td>IP</td></tr>
</table>
W0 – Warning: The deviation setting is not four times greater than the hysteresis setting.
W1 – Warning: Inconsistent process deviations may result in incorrect adjustment of the output step value.
W2 – Warning: Actual average deviation is not four times greater than the hysteresis setting.
AH – Auto-hysteresis calculation in progress:
0 – not in progress
1 – in progress
IP – Auto-tune in progress:
0 – not in progress
1 – in progress
Each time an auto-tune sequence is started the PLC clears the warning bits and sets the in progress bit. Upon completion of auto-tune, the PLC clears the in progress bit.
</td></tr>
<tr><td>AT Result (ARES)
Input/Output – Byte</td><td>
<table>
<tr><td>MSB
7</td><td>LSB
0</td></tr>
<tr><td>D</td><td>Result Code</td></tr>
</table>
D – Done bit:
0 – auto-tune not complete
1 – auto-tune complete
Must be set to 0 before auto-tune can start
Result Code:
00 – completed normally (suggested tuning values available)
01 – aborted by the user
02 – aborted, watchdog timed out waiting for a zero crossing
03 – aborted, process (PV) out-of-range
04 – aborted, maximum hysteresis value exceeded
05 – aborted, illegal configuration value detected
06 – aborted, numeric error detected
07 – aborted, PID instruction executed without having power flow (loop in manual mode)
08 – aborted, auto-tuning allowed only for P, PI, PD, or PID loops
09 to 7F – reserved
</td></tr>
<tr><td>AT Config (ACNFG)
Input – Byte</td><td>
<table>
<tr><td>MSB
7</td><td></td><td></td><td></td><td></td><td></td><td></td><td>LSB
0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>R1</td><td>R0</td><td>DS</td><td>HS</td></tr>
</table>
<table>
<tr><td>R1</td><td>R0</td><td>Dynamic response</td></tr>
<tr><td>0</td><td>0</td><td>Fast response</td></tr>
<tr><td>0</td><td>1</td><td>Medium response</td></tr>
<tr><td>1</td><td>0</td><td>Slow response</td></tr>
<tr><td>1</td><td>1</td><td>Very slow response</td></tr>
</table>
DS – Deviation setting:
0 – use deviation value from loop table
1 – determine deviation value automatically
HS – Hysteresis setting:
0 – use hysteresis value from loop table
1 – determine hysteresis value automatically
</td></tr>
</table>

Prerequisites

The loop that you want to auto-tune must be in automatic mode. The loop output must be controlled by the execution of the PID instruction. Auto-tune will fail if the loop is in manual mode.

Before initiating an auto-tune operation your process must be brought to a stable state which means that the PV has reached setpoint (or for a P type loop, a constant difference between PV and setpoint) and the output is not changing erratically.

Ideally, the loop output value needs to be near the center of the control range when auto-tuning is started. The auto-tune procedure sets up an oscillation in the process by making small step changes in the loop output. If the loop output is close to either extreme of its control range, the step changes introduced in the auto-tune procedure may cause the output value to attempt to exceed the minimum or the maximum range limit.

If this were to happen, it may result in the generation of an auto-tune error condition, and it will certainly result in the determination of less than near optimal suggested values.

Auto-Hysteresis and Auto-Deviation

The hysteresis parameter specifies the excursion (plus or minus) from setpoint that the PV (process variable) is allowed to make without causing the relay controller to change the output. This value is used to minimize the effect of noise in the PV signal to more accurately determine the natural oscillation frequency of the process.

If you select to automatically determine the hysteresis value, the PID Auto-Tuner will enter a hysteresis determination sequence. This sequence involves sampling the process variable for a period of time and then performing a standard deviation calculation on the sample results.

In order to have a statistically meaningful sample, a set of at least 100 samples must be acquired. For a loop with a sample time of 200 msec, acquiring 100 samples takes 20 seconds. For loops with a longer sample time it will take longer. Even though 100 samples can be acquired in less than 20 seconds for loops with sample times less than 200 msec, the hysteresis determination sequence always acquires samples for at least 20 seconds.

Once all the samples have been acquired, the standard deviation for the sample set is calculated. The hysteresis value is defined to be two times the standard deviation. The calculated hysteresis value is written into the actual hysteresis field (AHYS) of the loop table.

Tip

While the auto-hysteresis sequence is in progress, the normal PID calculation is not performed. Therefore, it is imperative that the process be in a stable state prior to initiating an auto-tune sequence. This will yield a better result for the hysteresis value and it will ensure that the process does not go out of control during the auto-hysteresis determination sequence.

The deviation parameter specifies the desired peak-to-peak swing of the PV around the setpoint. If you select to automatically determine this value, the desired deviation of the PV is computed by multiplying the hysteresis value by 4.5. The output will be driven proportionally to induce this magnitude of oscillation in the process during auto-tuning.

Auto-Tune Sequence

The auto-tuning sequence begins after the hysteresis and deviation values have been determined. The tuning process begins when the initial output step is applied to the loop output.

This change in output value should cause a corresponding change in the value of the process variable. When the output change drives the PV away from setpoint far enough to exceed the hysteresis boundary a zero-crossing event is detected by the auto-tuner. Upon each zero crossing event the auto-tuner drives the output in the opposite direction.

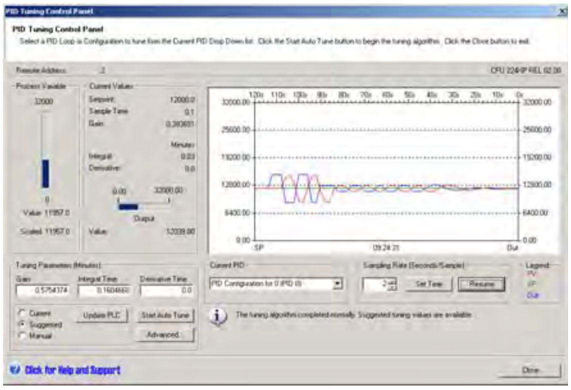
The tuner continues to sample the PV and waits for the next zero crossing event. A total of twelve zero-crossings are required to complete the sequence. The magnitude of the observed peak-to-peak PV values (peak error) and the rate at which zero-crossings occur are directly related to the dynamics of the process.

Early in the auto-tuning process, the output step value is proportionally adjusted once to induce subsequent peak-to-peak swings of the PV to more closely match the desired deviation amount. Once the adjustment is made, the new output step amount is written into the Actual Step Size field (ASTEP) of the loop table.

The auto-tuning sequence will be terminated with an error, if the time between zero crossings exceeds the zero crossing watchdog interval time. The default value for the zero crossing watchdog interval time is two hours.

Figure 15-1 shows the output and process variable behaviors during an auto-tuning sequence on a direct acting loop. The PID Tuning Control Panel was used to initiate and monitor the tuning sequence.

Notice how the auto-tuner switches the output to cause the process (as evidenced by the PV value) to undergo small oscillations. The frequency and the amplitude of the PV oscillations are indicative of the process gain and natural frequency.



PID Tuning Control Panel

Select a PID Loop in Configuration to tune from the Current PID Drop Down list. Click the Start Auto Tune button to begin the tuning algorithm. Click the Close button to exit.

Remote Address: 2

CPU 224XP REL 02.00

Process Variable: 32000, 0, Value: 11957.0, Scaled: 11957.0

Current Values: Setpoint: 12000.0, Sample Time: 0.1, Gain: 0.383691, Minutes, Integral: 0.03, Derivative: 0.0

Output: 0.00 – 32000.00, Value: 12039.00

Tuning Parameters (Minutes): Gain: 0.5754374, Integral Time: 0.1604660, Derivative Time: 0.0

○ Current ● Suggested ○ Manual

Current PID: PID Configuration for 0 (PID 0)

Sampling Rate (Seconds/Sample): 2

The tuning algorithm completed normally. Suggested tuning values are available.

Figure 15-1 Auto-Tuning Sequence on a Direct Acting Loop

Based upon the information collected about the frequency and gain of the process during the auto-tune process, the ultimate gain and ultimate frequency values are calculated. From these values the suggested values for gain (loop gain), reset (integral time) and rate (derivative time) are calculated.

Tip

Your loop type determines which tuning values are calculated by the auto-tuner. For example, for a PI loop, the auto-tuner will calculate gain and integral time values, but the suggested derivative time will be 0.0 (no derivative action).

Once the auto-tune sequence has completed, the output of the loop is returned to its initial value. The next time the loop is executed, the normal PID calculation will be performed.

Exception Conditions

Three warning conditions can be generated during tuning execution. These warnings are reported in three bits of the ASTAT field of the loop table and, once set, these bits remain set until the next auto-tune sequence is initiated.

- ❑ Warning 0 is generated if the deviation value is not at least 4X greater than the hysteresis value. This check is performed when the hysteresis value is actually known, which depends upon the auto-hysteresis setting.
- ❑ Warning 1 is generated if there is more than an 8X difference between the two peak error values gathered during the first 2.5 cycles of the auto-tune procedure.
- ❑ Warning 2 is generated if the measured average peak error is not at least 4X greater than the hysteresis value.

In addition to the warning conditions several error conditions are possible. Table 15-3 lists the error conditions along with a description of the cause of each error.

Table 15-3 Error Conditions during Tuning Execution

Result Code (in ARES)	Condition
01 aborted by user	EN bit cleared while tuning is in progress
02 aborted due to a zero-crossing watchdog timeout	Half-cycle elapsed time exceeds zero-crossing watchdog interval
03 aborted due to the process out-of-range	PV goes out-of-range: • during the auto-hysteresis sequence, or • twice before the fourth zero-crossing, or • after the fourth zero crossing
04 aborted due to hysteresis value exceeding maximum	User-specified hysteresis value, or automatically determined hysteresis value > maximum
05 aborted due to illegal configuration value	The following range checking errors: • Initial loop output value is < 0.0 or > 1.0 • User-specified deviation value is <= hysteresis value , or is > maximum • Initial output step is <= 0.0 or is > maximum • Zero-crossing watchdog interval time is < minimum • Sample time value in loop table is negative
06 aborted due to a numeric error	Illegal floating point number or divide by zero encountered
07 PID instruction was executed with no power flow (manual mode)	PID instruction executed with no power flow while auto-tuning is in progress or is requested
08 auto-tuning allowed only for P, PI, PD, or PID loops	Loop type is not P, PI, PD, or PID

Notes Concerning PV Out-of-Range (Result Code 3)

The process variable is considered to be in-range by the auto-tuner if its value is greater than 0.0 and less than 1.0.

If the PV is detected to be out-of-range during the auto-hysteresis sequence, then the tuning is immediately aborted with a process out-of-range error result.

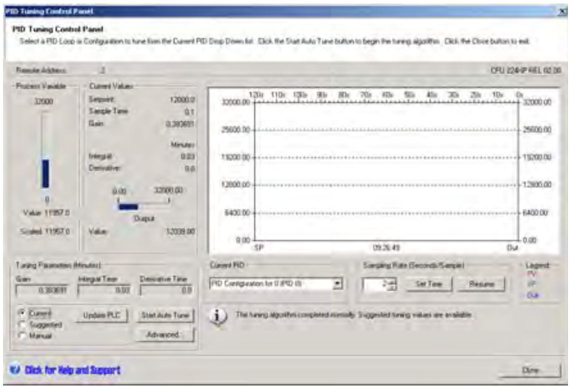
If the PV is detected to be out-of-range between the starting point of the tuning sequence and the fourth zero-crossing, then the output step value is cut in half and the tuning sequence is restarted from the beginning. If a second PV out-of-range event is detected after the first zero-crossing following the restart, then the tuning is aborted with a process out-of-range error result.

Any PV out-of-range event occurring after the fourth zero-crossing results in an immediate abort of the tuning and a generation of a process out-of-range error result.

PID Tuning Control Panel

STEP 7–Micro/WIN includes a PID Tuning Control Panel that allows you to graphically monitor the behavior of your PID loops. In addition, the control panel allows you to initiate the auto-tune sequence, abort the sequence, and apply the suggested tuning values or your own tuning values.

To use the control panel, you must be communicating with an S7-200 PLC and a wizard-generated configuration for a PID loop must exist in the PLC. The PLC must be in RUN mode for the control panel to display the operation of a PID loop. Figure 15-2 shows the default screen for the control panel.



PID Tuning Control Panel

Select a PID Loop in Configuration to tune from the Current PID Drop Down list. Click the Start Auto Tune button to begin the tuning algorithm. Click the Close button to exit.

Remote Address: 2

CPU 224XP REL 02.00

Process Variable: Value: 11957.0, Scaled: 11957.0

Current Values: Setpoint: 12000.0, Sample Time: 0.1, Gain: 0.383691, Integral: 0.03, Derivative: 0.0 (Minutes)

Output: Value: 12039.00

Tuning Parameters (Minutes): Gain: 0.383691, Integral Time: 0.03, Derivative Time: 0.0

● Current ○ Suggested ○ Manual

Current PID: PID Configuration for 0 (PID 0)

Sampling Rate (Seconds/Sample): 2

The tuning algorithm completed normally. Suggested tuning values are available.

Figure 15-2   PID Tuning Control Panel

The control panel displays the station address (Remote Address) of the target PLC at the top left-hand side of the screen. At the top right-hand side of the screen, the PLC type and version number are displayed. Underneath the Remote Address field is a bar chart representation of the process variable value along with both it's scaled and unscaled values. Just to the right of the PV bar chart is a Current Values region.

In the Current Values region, the values of the Setpoint, Sample Time, Gain, Integral time, and Derivative time are displayed. The value of the Output is displayed in a horizontal bar chart along with its numerical value. To the right of the Current Values region is a graphical display.

The graphical display shows color coded plots of the PV, SP, and Output as a function of time. The PV and SP share the same vertical scale which is located at the left hand side of the graph while the vertical scale for the output is located on the right hand side of the graph.

At the bottom left hand side of the screen is the Tuning Parameters (Minutes) region. Inside this region, the Gain, Integral Time and Derivative Time values are displayed. Radio buttons indicate whether the Current, Suggested or Manual values for Gain, Integral Time and Derivative Time are being displayed. You may click on the radio button to display any one of the three sources for these values. To modify the tuning parameters, click the manual radio button.

You can use the Update PLC button to transfer the displayed Gain, Integral Time and Derivative Time values to the PLC for the PID loop that is being monitored. You can use the Start Auto Tune button to initiate an auto-tuning sequence. Once an auto-tuning sequence has started, the Start Auto Tune button becomes a Stop Auto Tune button.

Directly underneath the graphical display is a Current PID selection region with a pull down menu that allows you to select the PID loop that you wish to monitor with the control panel.

In the Sampling Rate region you can select the graphical display sampling rate from 1 to 480 seconds per sample. You can edit the sampling rate, then use the Set Time button to apply the change. The time scale of the graph is automatically adjusted to best display the data at the new rate.

You can freeze the graph by pressing the Pause button. Press the Resume button to resume sampling data at the selected rate. To clear the graph, select Clear from the right-mouse button within the graph.

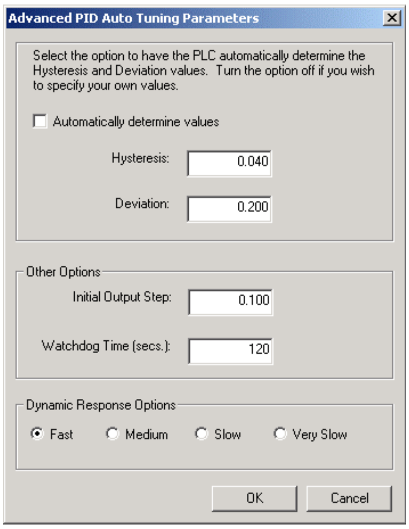
To the right of the Chart Options region is a Legend that identifies the colors used to plot the PV, SP, and Output values.

Directly beneath the Current PID selection region is an area that is used to display information pertinent to the operation being performed.

The Advanced ... button in the Tuning Parameters region allows you to further configure parameters for the auto-tuning process. The advanced screen is shown below in Figure 15-3.

From the advanced screen you can check the box that will cause the auto-tuner to automatically determine the values for the Hysteresis and Deviation (default setting) or you can enter the values for these fields that minimize the disturbance to your process during the auto-tune procedure.

In the Other Options region you can specify the initial output step size and enter the zero crossing watchdog timeout period.



Advanced PID Auto Tuning Parameters

Select the option to have the PLC automatically determine the Hysteresis and Deviation values. Turn the option off if you wish to specify your own values.

□ Automatically determine values

Hysteresis: 0.040

Deviation: 0.200

Other Options

Initial Output Step: 0.100

Watchdog Time (secs.): 120

Dynamic Response Options

● Fast ○ Medium ○ Slow ○ Very Slow

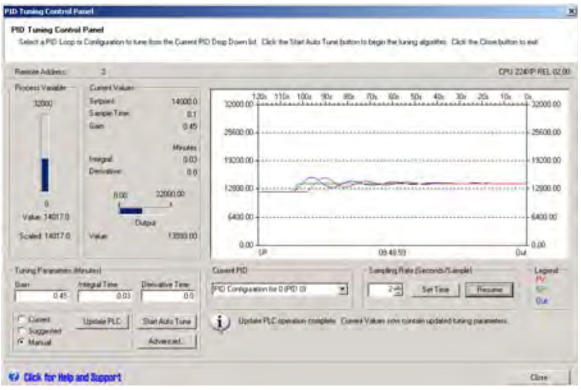
Figure 15-3 Advanced Parameters

In the Dynamic Response Options region click the radio button that corresponds to the type of loop response that you wish to have for your process. Depending upon your process a fast response may have overshoot and would correspond to an underdamped tuning condition. A medium speed response may be on the verge of having overshoot and would correspond to a critically damped tuning condition. A slow response may not have any overshoot and would correspond to an overdamped tuning condition. A very slow response may not have overshoot and would correspond to a heavily overdamped tuning condition.

Once you have made the desired selections, click OK to return to the main screen of the PID Tuning Control Panel.

Once you have completed the auto-tune sequence and have transferred the suggested tuning parameters to the PLC, you can use the control panel to monitor your loop's response to a step change in the setpoint. Figure 15-4 shows the loop's response to a setpoint change (12000 to 14000) with the original tuning parameters (before running auto-tune).

Notice the overshoot and the long, damped ringing behavior of the process using the original tuning parameters.



PID Tuning Control Panel

PID Tuning Control Panel

Select a PID Loop or Configuration to tune from the Current PID Drop Down list. Click the Start Auto Tune button to begin the tuning algorithm. Click the Close button to exit.

Remote Address: 2

CPU 224XP REL 02.00

Process Variable: 32000, 0, Value: 14017.0, Scaled: 14017.0

Current Values

Setpoint: 14000.0

Sample Time: 0.1

Gain: 0.45

Minutes

Integral: 0.03

Derivative: 0.0

Output: 0.00, 32000.00

Value: 13550.00

Tuning Parameters (Minutes)

Gain: 0.45

Integral Time: 0.03

Derivative Time: 0.0

○ Current ○ Suggested ● Manual

Current PID: PID Configuration for 0 (PID 0)

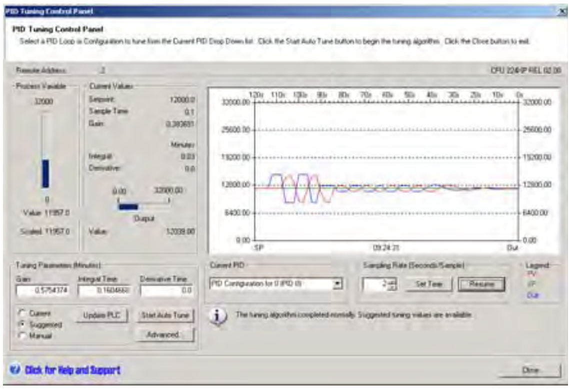
Sampling Rate (Seconds/Sample): 2

Update PLC operation complete. Current Values now contain updated tuning parameters.

Figure 15-4 Response to a Setpoint Change

Figure 15-5 shows the loop’s response to the same setpoint change (12000 to 14000) after applying the values determined by the auto-tune process using the selection for a fast response. Notice that for this process there is no overshoot, but there is just a little bit of ringing. If you wish to eliminate the ringing at the expense of the speed of response, you need to select a medium or a slow response and re-run the auto-tuning process.

Once you have a good starting point for the tuning parameters for your loop, you can use the control panel to tweak the parameters. Then you can monitor the loop’s response to a setpoint change. In this way you can fine tune your process for an optimum response in your application.



PID Tuning Control Panel

Select a PID Loop in Configuration to tune from the Current PID Drop Down list. Click the Start Auto Tune button to begin the tuning algorithm. Click the Close button to exit.

Remote Address: 2

CPU 224XP REL 02.00

Process Variable: 32000, 0, Value: 11957.0, Scaled: 11957.0

Current Values: Setpoint: 12000.0, Sample Time: 0.1, Gain: 0.380681, Integral: 0.03 Minutes, Derivative: 0.0 Minutes, Output: 0.00 – 32000.00, Value: 12039.00

Tuning Parameters (Minutes): Gain: 0.5754374, Integral Time: 0.1604660, Derivative Time: 0.0

○ Current
● Suggested
○ Manual

Current PID: PID Configuration for 0 (PID 0)

Sampling Rate (Seconds/Sample): 2

The tuning algorithm completed normally. Suggested tuning values are available.

Figure 15-5 Response after Auto-Tune Process

Technical Specifications

A

In This Chapter

General Technical Specifications

Standards Compliance

The national and international standards listed below were used to determine appropriate performance specifications and testing for the S7-200 family of products. Table A-1 defines the specific adherence to these standards.

- European Community (CE) Low Voltage Directive 73/23/EEC
  EN 61131–2:2003 Programmable controllers – Equipment requirements
- European Community (CE) EMC Directive 89/336/EEC

  Electromagnetic emission standard
  EN 61000–6–3:2001 residential, commercial, and light industry
  EN 61000–6–4:2001 industrial environment

  Electromagnetic immunity standards
  EN 61000–6–2:2001 industrial environment
- European Community ATEX Directive 94/9/EC
  EN 60079–15 Type of protection ‘n’

  ATEX Directive applies to CPUs and expansion modules with a rated voltage of 24 VDC. It does not apply to modules with AC power systems or Relay outputs.

After July 2009, the following applies:

- EC Directive 2006/95EC (Low Voltage Directive) “Electrical Equipment Designed for Use within Certain Voltage Limits”

  EN 61131–2:2007 Programmable controllers – Equipment requirements and tests
- EC Directive 2004/108/EC (EMC Directive) “Electromagnetic Compatibility”

  EN 61000–6–4:2007: Industrial Environment

  EN 61131–2:2007: Programmable controllers – Equipment requirements and tests
- EC Directive 94/9/EC (ATEX) “Equipment and Protective Systems Intending for Use in Potential Explosive Atmospheres”

  EN 60079–15:2005 Type of protection ‘n’

The CE Declaration of Conformity is held on file available to competent authorities at:

Siemens AG
IA AS RD ST PLC Amberg
Werner–von–Siemens–Str. 50
D92224 Amberg
Germany

- Underwriters Laboratories, Inc.: UL 508 Listed (Industrial Control Equipment), Registration number E75310
- Canadian Standards Association: CSA C22.2 Number 142 (Process Control Equipment)
- Factory Mutual Research: Class Number 3600, Class Number 3611, FM Class I, Division 2, Groups A, B, C, & D Hazardous Locations, T4A and Class I, Zone 2, IIC, T4.

> **Tip**
>
> The SIMATIC S7-200 series meets the CSA standard.
>
> The cULus logo indicates that the S7-200 has been examined and certified by Underwriters Laboratories (UL) to standards UL 508 and CSA 22.2 No. 142.

Maritime Approvals

The S7-200 products are periodically submitted for special agency approvals related to specific markets and applications. This table identifies the agency and certificate number that the S7-200 products have been approved for. Most S7-200 products in this manual have been approved for these special agency approvals. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

Agency	Certificate Number
Lloyds Register of Shipping (LRS)	99 / 20018(E1)
American Bureau of Shipping (ABS)	01–HG20020–PDA
Germanischer Lloyd (GL)	12 045 – 98 HH
Det Norske Veritas (DNV)	A–8862
Bureau Veritas (BV)	09051 / B0BV
Nippon Kaiji Kyokai (NK)	A–534
Polski Rejestr	TE/1246/883241/99

Relay Electrical Service Life

The typical performance data supplied by relay vendors is shown in Figure A-1. Actual performance may vary depending upon your specific application.

An external protection circuit that is adapted to the load will enhance the service life of the contacts.

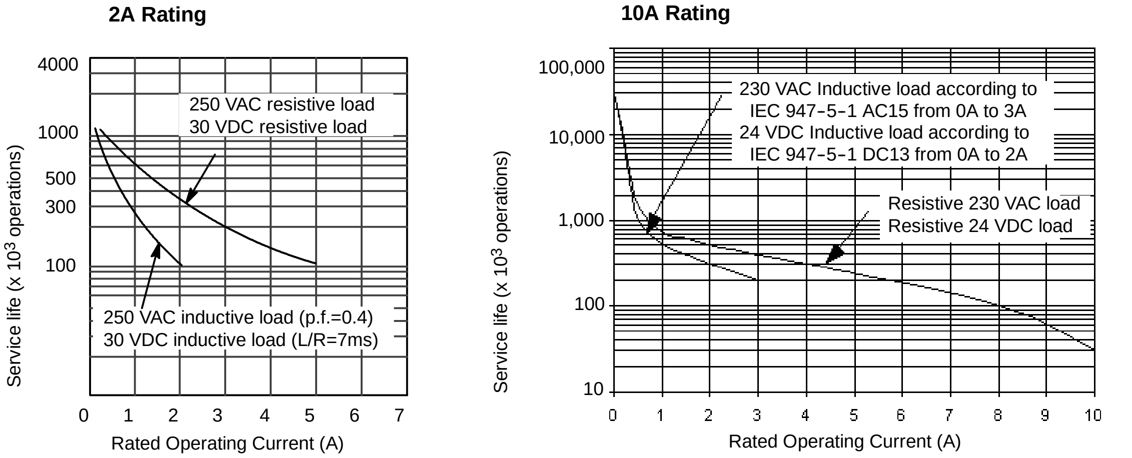


Figure A-1 Relay Electrical Service Life

Technical Specifications

All S7-200 CPUs and expansion modules conform to the technical specifications listed in Table A-1.

Notice

When a mechanical contact turns on output power to the S7-200 CPU, or any digital expansion module, it sends a “1” signal to the digital outputs for approximately 50 microseconds. You must plan for this, especially if you are using devices which respond to short duration pulses.

Table A-1 Technical Specifications

Environmental Conditions — Transport and Storage	
EN 60068–2–2, Test Bb, Dry heat and EN 60068–2–1, Test Ab, Cold	–40° C to +70° C
EN 60068–2–30, Test Db, Damp heat	25° C to 55° C, 95% humidity
EN 60068–2–14, Test Na, Temperature Shock	–40° C to +70° C dwell time 3 hours, 2 cycles
EN 60068–2–32, Free fall	0.3 m, 5 times, product packaging
Environmental Conditions — Operating	
Ambient Temperature Range (Inlet Air 25 mm below unit)	0° C to 55° C horizontal mounting, 0° C to 45° C vertical mounting 95% non-condensing humidity
Atmospheric pressure	1080 to 795 hPa (Corresponding to an altitude of –1000 to 2000 m)
Concentration of contaminants	S0$_2$: < 0.5 ppm; H$_2$S: < 0.1 ppm; RH < 60% non-condensing
EN 60068–2–14, Test Nb, Temperature change	5° C to 55° C, 3° C/minute
EN 60068–2–27 Mechanical shock	15 G, 11 ms pulse, 6 shocks in each of 3 axis
EN 60068–2–6 Sinusoidal vibration	Panel mount: 7.0 mm from 5 to 9 Hz; 2 G from 9 to 150 Hz DIN rail mount: 3.5 mm from 5 to 9 Hz; 1 G from 9 to 150 Hz 10 sweeps each axis, 1 octave/minute
EN 60529, IP20 Mechanical protection	Protects against finger contact with high voltage as tested by standard probes. External protection is required for dust, dirt, water, and foreign objects of < 12.5 mm in diameter.
Electromagnetic Compatibility — Immunity per EN61000–6–2[1]	
EN 61000–4–2 Electrostatic discharge	8 kV air discharge to all surfaces and communications port, 4 kV contact discharge to exposed conductive surfaces
EN 61000–4–3 Radiated electromagnetic field	10 V/m from 80–1000 MHz, 80% AM at 1kHz 3 V/m from 1.4–2.0 GHz, 80% AM at 1kHz[3] 1 V/m from 2.0–2.7 GHz, 80% AM at 1kHz[3]
EN 61000–4–4 Fast transient bursts	2 kV, 5 kHz with coupling network to AC and DC system power 2 kV, 5 kHz with coupling clamp to I/O 1 kV, 5 kHz with coupling clamp to communications
EN 61000–4–5 Surge immunity	Power supply: 2 kV asymmetrical, 1 kV symmetrical I/O 1 kV symmetrical (24 VDC circuits require external surge protection)
EN 61000–4–6 Conducted disturbances	0.15 to 80 MHz, 10 V RMS, 80% AM at 1kHz
EN 61000–4–11 Voltage dips, short interruptions and voltage variations	Residual voltage: 0% for 1 cycle, 40% for 12 cycles and 70% for 30 cycles @ 60Hz voltage jump at zero crossing
VDE 0160 Non-periodic overvoltage	At 85 VAC line, 90° phase angle, apply 390 V peak, 1.3 ms pulse At 180 VAC line, 90° phase angle, apply 750 V peak, 1.3 ms pulse

Table A-1 Technical Specifications, continued

Electromagnetic Compatibility — Conducted and Radiated Emissions per EN 61000-6-3[2] and EN 61000-6-4	
EN 55011, Class A, Group 1, conducted[1]	
0.15 MHz to 0.5 MHz	< 79 dB (μV) Quasi-peak; < 66 dB (μV) Average
0.5 MHz to 5 MHz	< 73 dB (μV) Quasi-peak; < 60 dB (μV) Average
5 MHz to 30 MHz	< 73 dB (μV) Quasi-peak; < 60 dB (μV) Average
EN 55011, Class A, Group 1, radiated[1]	
30 MHz to 230 MHz	40 dB (μV/m) Quasi-peak; measured at 10 m
230 MHz to 1 GHz	47 dB (μV/m) Quasi-peak; measured at 10 m
EN 55011, Class B, Group 1, conducted[2]	
0.15 to 0.5 MHz	< 66 dB (μV) Quasi-peak decreasing with log frequency to 56 dB (μV);
	< 56 dB (μV) Average decreasing with log frequency to 46 dB (μV)
0.5 MHz to 5 MHz	< 56 dB (μV) Quasi-peak; < 46 dB (μV) Average
5 MHz to 30 MHz	< 60 dB (μV) Quasi-peak; < 50 dB (μV) Average
EN 55011, Class B, Group 1, radiated[2]	
30 MHz to 230 kHz	30 dB (μV/m) Quasi-peak; measured at 10 m
230 MHz to 1 GHz	37 dB (μV/m) Quasi-peak; measured at 10 m
High Potential Isolation Test	
24 V/5 V nominal circuits	500 VAC (type test of optical isolation boundaries)
115/230 V circuits to ground	1500 VAC routine test / 2500 VDC type test
115/230 V circuits to 115/230 V circuits	1500 VAC routine test / 2500 VDC type test
115/230 V circuits to 24 V/5 V circuits	1500 VAC routine test / 4242 VDC type test

[1] Unit must be mounted on a grounded metallic frame with the S7-200 ground connection made directly to the mounting metal. Cables are routed along metallic supports.

[2] Unit must be mounted in a grounded metal enclosure. AC input power line must be equipped with a EPCOS B84115-E-A30 filter or equivalent, 25 cm max. wire length from filters to the S7-200. The 24 VDC supply and sensor supply wiring must be shielded.

[3] Requirements apply after July 2009

CPU Specifications

Table A-2 CPU Order Numbers

Order Number	CPU Model	Power Supply (Nominal)	Digital Inputs	Digital Outputs	Comm Ports	Analog Inputs	Analog Outputs	Removable Connector
6ES7 211-0AA23-0XB0	CPU 221	24 VDC	6 x 24 VDC	4 x 24 VDC	1	No	No	No
6ES7 211-0BA23-0XB0	CPU 221	120 to 240 VAC	6 x 24 VDC	4 x Relay	1	No	No	No
6ES7 212-1AB23-0XB0	CPU 222	24 VDC	8 x 24 VDC	6 x 24 VDC	1	No	No	No
6ES7 212-1BB23-0XB0	CPU 222	120 to 240 VAC	8 x 24 VDC	6 x Relay	1	No	No	No
6ES7 214-1AD23-0XB0	CPU 224	24 VDC	14 x 24 VDC	10 x 24 VDC	1	No	No	Yes
6ES7 214-1BD23-0XB0	CPU 224	120 to 240 VAC	14 x 24 VDC	10 x Relay	1	No	No	Yes
6ES7 214-2AD23-0XB0	CPU 224XP	24 VDC	14 x 24 VDC	10 x 24 VDC	2	2	1	Yes
6ES7 214-2AS23-0XB0	CPU 224XPsi	24 VDC	14 x 24 VDC	10 x 24 VDC	2	2	1	Yes
6ES7 214-2BD23-0XB0	CPU 224XP	120 to 240 VAC	14 x 24 VDC	10 x Relay	2	2	1	Yes
6ES7 216-2AD23-0XB0	CPU 226	24 VDC	24 x 24 VDC	16 x 24 VDC	2	No	No	Yes
6ES7 216-2BD23-0XB0	CPU 226	120 to 240 VAC	24 x 24 VDC	16 x Relay	2	No	No	Yes

Table A-3 CPU General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Available	
					+5 VDC	+24 VDC[1]
6ES7 211-0AA23-0XB0	CPU 221 DC/DC/DC 6 Inputs/ 4 Outputs	90 x 80 x 62	270 g	3 W	0 mA	180 mA
6ES7 211-0BA23-0XB0	CPU 221 AC/DC/Relay 6 Inputs/ 4 Relays	90 x 80 x 62	310 g	6 W	0 mA	180 mA
6ES7 212-1AB23-0XB0	CPU 222 DC/DC/DC 8 Inputs/ 6 Outputs	90 x 80 x 62	270 g	5 W	340 mA	180 mA
6ES7 212-1BB23-0XB0	CPU 222 AC/DC/Relay 8 Inputs/ 6 Relays	90 x 80 x 62	310 g	7 W	340 mA	180 mA
6ES7 214-1AD23-0XB0	CPU 224 DC/DC/DC 14 Inputs/ 10 Outputs	120.5 x 80 x 62	360 g	7 W	660 mA	280 mA
6ES7 214-1BD23-0XB0	CPU 224 AC/DC/Relay14 Inputs/ 10 Relays	120.5 x 80 x 62	410 g	10 W	660 mA	280 mA
6ES7 214-2AD23-0XB0	CPU 224XP DC/DC/DC 14 Inputs/10 Outputs	140 x 80 x 62	390 g	8 W	660 mA	280 mA
6ES7 214-2AS23-0XB0	CPU 224XPsi DC/DC/DC 14 Inputs/10 Outputs	140 x 80 x 62	390 g	8 W	660 mA	280 mA
6ES7 214-2BD23-0XB0	CPU 224XP AC/DC/Relay 14 Inputs/10 Relays	140 x 80 x 62	440 g	11 W	660 mA	280 mA
6ES7 216-2AD23-0XB0	CPU 226 DC/DC/DC 24 Inputs/16 Outputs	196 x 80 x 62	550 g	11 W	1000 mA	400 mA
6ES7 216-2BD23-0XB0	CPU 226 AC/DC/Relay 24 Inputs/16 Relays	196 x 80 x 62	660 g	17 W	1000 mA	400 mA

[1] This is the 24 VDC sensor power that is available after the internal relay coil power and 24 VDC comm port power requirements have been accounted for.

Table A-4 CPU Specifications

	CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
Memory					
User program size with run mode edit without run mode edit	4096 bytes 4096 bytes		8192 bytes 12288 bytes	12288 bytes 16384 bytes	16384 bytes 24576 bytes
User data	2048 bytes		8192 bytes	10240 bytes	10240 bytes
Backup (super cap) (optional battery)	50 hours typical (8 hours min. at 40°C) 200 days typical		100 hours typical (70 hours min. at 40°C) 200 days typical	100 hours typical (70 hours min. at 40°C) 200 days typical	
I/O					
Digital I/O	6 inputs/4outputs	8 inputs/6 outputs	14 inputs/10 outputs	14 inputs/10 outputs	24 inputs/16 outputs
Analog I/O	none			2 inputs/1 output	none
Digital I/O image size	256 (128 In/128 Out)				
Analog I/O image size	None	32 (16 In/16 Out)	64 (32 In/32 Out)		
Max. expansion modules allowed	None	2 modules[1]	7 modules[1]		
Max. intelligent modules allowed	None	2 modules[1]	7 modules[1]		
Pulse Catch inputs	6	8	14		24
High-Speed Counters Single phase Two phase	4 counters total 4 at 30 kHz 2 at 20 kHz		6 counters total 6 at 30 kHz 4 at 20 kHz	6 counters total 4 at 30 kHz 2 at 200 kHz 3 at 20 kHz 1 at 100 kHz	6 counters total 6 at 30 kHz 4 at 20 kHz
Pulse outputs	2 at 20 kHz (DC outputs only)			2 at 100 kHz (DC outputs only)	2 at 20 kHz (DC outputs only)
General					
Timers	256 total timers; 4 timers (1 ms); 16 timers (10 ms); 236 timers (100 ms)				
Counters	256 (backed by super capacitor or battery)				
Internal memory bits Stored on power down	256 (backed by super capacitor or battery) 112 (stored to EEPROM)				
Timed interrupts	2 with 1 ms resolution				
Edge interrupts	4 up and/or 4 down				
Analog adjustment	1 with 8 bit resolution		2 with 8 bit resolution		
Boolean execution speed	0.22 μs per instruction				
Real Time Clock	Optional cartridge		Built-in		
Cartridge options	Memory, Battery, and Real Time Clock		Memory and battery		
Communications Built-in					
Ports (Limited Power)	1 RS-485 port			2 RS-485 ports	
PPI, MPI (slave) baud rates	9.6, 19.2, 187.5 kbaud				
Freeport baud rates	1.2 kbaud to 115.2 kbaud				
Max. cable length per segment	With isolated repeater: 1000 m up to 187.5 kbaud, 1200 m up to 38.4 kbaud Without isolated repeater: 50 m				
Max. number of stations	32 per segment, 126 per network				
Max. number of masters	32				
Peer to Peer (PPI Master Mode)	Yes (NETR/NETW)				
MPI connections	4 total, 2 reserved (1 for a PG and 1 for an OP)				

[1] You must calculate your power budget to determine how much power (or current) the S7-200 CPU can provide for your configuration. If the CPU power budget is exceeded, you may not be able to connect the maximum number of modules. See Appendix A for CPU and expansion module power requirements, and Appendix B to calculate your power budget.

Table A-5 CPU Power Specifications

	DC		AC	
Input Power				
Input voltage	20.4 to 28.8 VDC		85 to 264 VAC (47 to 63 Hz)	
Input current	CPU only at 24 VDC	Max. load at 24 VDC	CPU only	Max. load
CPU 221	80 mA	450 mA	30/15 mA at 120/240 VAC	120/60 mA at120/240 VAC
CPU 222	85 mA	500 mA	40/20 mA at 120/240 VAC	140/70 mA at 120/240 VAC
CPU 224	110 mA	700 mA	60/30 mA at 120/240 VAC	200/100 mA at 120/240VAC
CPU 224XP	120 mA	900 mA	70/35 mA at 120/240 VAC	220/100 mA at 120/240 VAC
CPU 224XPsi	120 mA	900 mA	–	–
CPU 226	150 mA	1050 mA	80/40 mA at 120/240 VAC	320/160 mA at 120/240VAC
Inrush current	12 A at 28.8 VDC		20 A at 264 VAC	
Isolation (field to logic)	Not isolated		1500 VAC	
Hold up time (loss of power)	10 ms at 24 VDC		20/80 ms at 120/240 VAC	
Fuse (non-replaceable)	3 A, 250 V Slow Blow		2 A, 250 V Slow Blow	
24 VDC Sensor Power				
Sensor voltage (Limited Power)	L+ minus 5 V		20.4 to 28.8 VDC	
Current limit	1.5 A peak, thermal limit non-destructive (See Table A-3 for rated load.)			
Ripple noise	Derived from input power		Less than 1 V peak-to-peak	
Isolation (sensor to logic)	Not isolated			

Table A-6 CPU Digital Input Specifications

General	24 VDC Input (CPU 221, CPU 222, CPU 224, CPU 226)		24 VDC Input (CPU 224XP, CPU 224XPsi)
Type	Sink/Source (IEC Type 1 Sink)		Sink/Source (IEC Type 1 Sink, except I0.3 to I0.5)
Rated voltage	24 VDC at 4 mA typical		24 VDC at 4 mA typical
Max. continuous permissible voltage	30 VDC		
Surge voltage	35 VDC for 0.5 s		
Logic 1 (min.)	15 VDC at 2.5 mA		15 VDC at 2.5 mA (I0.0 to I0.2 and I0.6 to I1.5) 4 VDC at 8 mA (I0.3 to I0.5)
Logic 0 (max.)	5 VDC at 1 mA		5 VDC at 1 mA (I0.0 to I0.2 and I0.6 to I1.5) 1 VDC at 1 mA (I0.3 to I0.5)
Input delay	Selectable (0.2 to 12.8 ms)		
Connection of 2 wire proximity sensor (Bero)			
Permissible leakage current (max.)	1 mA		
Isolation (field to logic)	Yes		
Optical (galvanic)	500 VAC for 1 minute		
Isolation groups	See wiring diagram		
High Speed Counter (HSC) input rate			
HSC Inputs	Logic 1 Level	Single phase	Two phase
All HSC	15 to 30 VDC	20 kHz	10 kHz
All HSC	15 to 26 VDC	30 kHz	20 kHz
HC4, HC5 on CPU 224XP and CPU 224XPsi only	> 4 VDC	200 kHz	100 kHz
Inputs on simultaneously	All		All CPU 224XP AC/DC/RELAY only: All at 55° C with DC inputs at 26 VDC max. All at 50° C with DC inputs at 30 VDC max.
Cable length (max.)			
Shielded	500 m normal inputs, 50 m HSC inputs[1]		
Unshielded	300 m normal inputs		

[1] Shielded twisted pair is recommended for HSC inputs.

Table A-7 CPU Digital Output Specifications

General	24 VDC Output (CPU 221, CPU 222, CPU 224, CPU 226)	24 VDC Output (CPU 224XP)	24 VDC Output (CPU 224XPsi)	Relay Output
Type	Solid State-MOSFET (Sourcing)		Solid State-MOSFET (Sinking)	Dry contact
Rated voltage	24 VDC	24 VDC	24 VDC	24 VDC or 250 VAC
Voltage range	20.4 to 28.8 VDC	5 to 28.8 VDC (Q0.0 to Q0.4) 20.4 to 28.8 VDC (Q0.5 to Q1.1)	5 to 28.8 VDC	5 to 30 VDC or 5 to 250 VAC
Surge current (max.)	8 A for 100 ms			5 A for 4 s @ 10% duty cycle
Logic 1 (min.)	20 VDC at maximum current	L+ minus 0.4 V at max. current	External Voltage Rail minus 0.4V with 10K pullup to External Voltage Rail	–
Logic 0 (max.)	0.1 VDC with 10 K Ω Load		1M + 0.4V at max. load	–
Rated current per point (max.)	0.75 A			2.0 A
Rated current per common (max.)	6 A	3.75 A	7.5 A	10 A
Leakage current (max.)	10 μ A			–
Lamp load (max.)	5 W			30 W DC; 200 W AC[2, 3]
Inductive clamp voltage	L+ minus 48 VDC, 1 W dissipation		1M +48 VDC, 1 W dissipation	–
On State resistance (contact)	0.3 Ω typical (0.6 Ω max.)			0.2 Ω (max. when new)
Isolation Optical (galvanic, field to logic) Logic to contact Resistance (logic to contact) Isolation groups	 500 VAC for 1 minute – – See wiring diagram			 – 1500 VAC for 1 minute 100 M Ω See wiring diagram
Delay (max.) Off to on (μs) On to off (μs) Switching	 2μs (Q0.0, Q0.1), 15μs (all other) 10μs (Q0.0, Q0.1), 130μs (all other) –	 0.5μs (Q0.0, Q0.1), 15μs (all other) 1.5μs (Q0.0, Q0.1), 130μs (all other) –		 – – 10 ms
Pulse frequency (max.)	20 kHz[1] (Q0.0 and Q0.1)	100 kHz[1] (Q0.0 and Q0.1)	100 kHz[1] (Q0.0 and Q0.1)	1 Hz
Lifetime mechanical cycles	–	–	–	10,000,000 (no load)
Lifetime contacts	–	–	–	100,000 (rated load)
Outputs on simultaneously	All at 55° C (horizontal), All at 45° C (vertical)			
Connecting two outputs in parallel	Yes, only outputs in same group			No
Cable length (max.) Shielded Unshielded	 500 m 150 m			

[1] Depending on your pulse receiver and cable, an additional external load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

[2] Relay lifetime with a lamp load will be reduced by 75% unless steps are taken to reduce the turn-on surge below the surge current rating of the output.

[3] Lamp load wattage rating is for rated voltage. Reduce the wattage rating proportionally for voltage being switched (for example 120 VAC – 100 W).

Warning

When a mechanical contact turns on output power to the S7-200 CPU, or any digital expansion module, it sends a “1” signal to the digital outputs for approximately 50 microseconds.

This could cause unexpected machine or process operation which could result in death or serious injury to personnel, and/or damage to equipment.

You must plan for this, especially if you are using devices which respond to short duration pulses.

Table A-8 CPU 224XP and CPU 224XPsi Analog Input Specifications

General	Analog Input (CPU 224XP, CPU 224XPsi)
Number of inputs	2 points
Analog input type	Single-ended
Voltage range	±10 V
Data word format, full scale range	-32,000 to +32,000
DC Input impedance	> 100 KΩ
Maximum input voltage	30 VDC
Resolution	11 bits plus 1 sign bit
LSB value	4.88 mV
Isolation	None
Accuracy[1] Worst case 0° to 55° C Typical 25° C	 ±2.5% of full scale ±1.0% of full scale
Repeatability	±0.05% of full scale
Analog to digital conversion time	125 msec
Conversion type	Sigma Delta
Step response	250 ms max.
Noise rejection	-20 dB @ 50 Hz typical

[1] Analog input accuracy may deviate up to +/-10% of full scale when subjected to severe RF interferences such as specified in the product standard EN 61131-2:2007.

Table A-9 CPU 224XP and CPU 224XPsi Analog Output Specifications

General	Analog Output (CPU 224XP, CPU 224XPsi)
Number of outputs	1 point
Signal range Voltage Current	 0 to 10 V (Limited Power) 0 to 20 mA (Limited Power)
Data word format, full range	0 to +32767
Date word format, full scale	0 to +32000
Resolution, full range	12 bits
LSB value Voltage Current	 2.44 mV 4.88 μA
Isolation	none
Accuracy Worst case, 0° to 55° C Voltage output Current output Typical 25° C Voltage output Current output	 ± 2% of full-scale ± 3% of full-scale ± 1% of full-scale ± 1% of full-scale
Settling time Voltage output Current output	 < 50 μS < 100 μS
Maximum output drive Voltage output Current output	 ≥ 5000 Ω minimum ≤ 500 Ω maximum

Wiring Diagrams

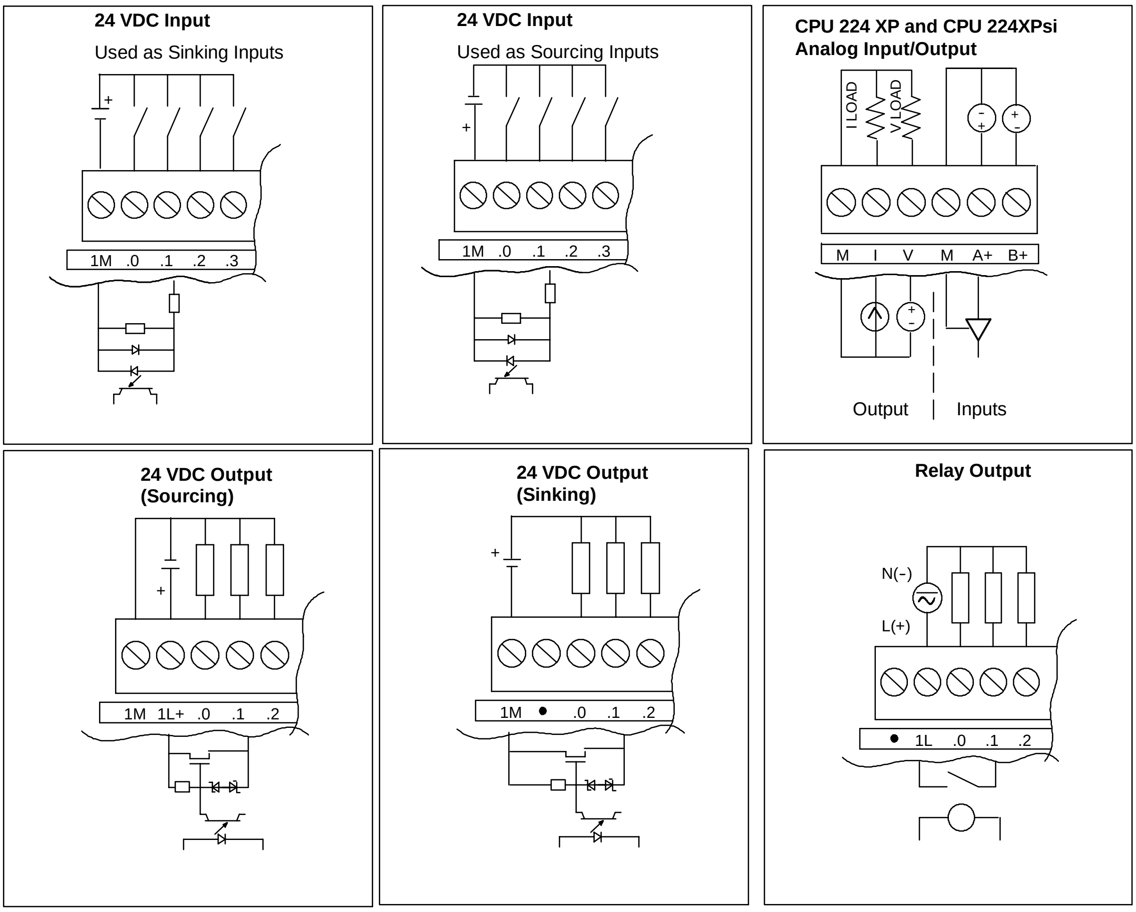


Figure A-2 CPU Inputs and Outputs

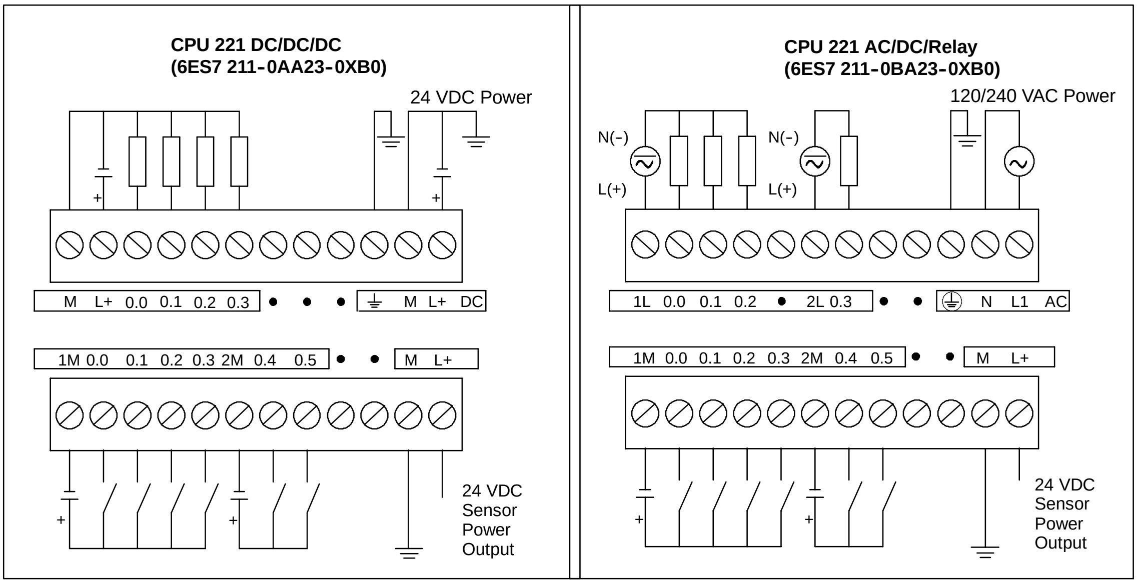


Figure A-3 CPU 221 Wiring Diagrams

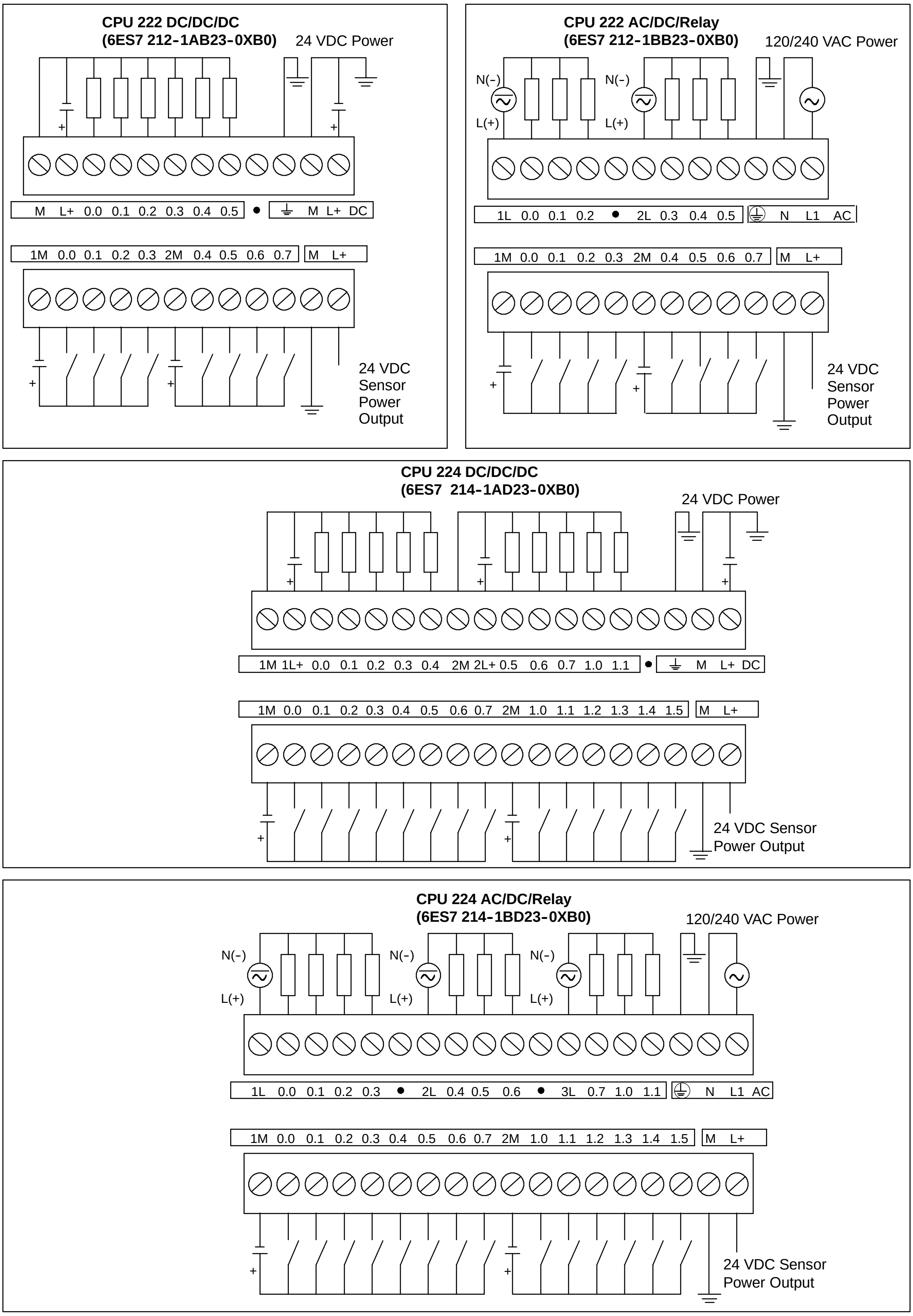

CPU 222 DC/DC/DC
(6ES7 212-1AB23-0XB0)
24 VDC Power
M L+ 0.0 0.1 0.2 0.3 0.4 0.5 ● ⏚ M L+ DC
1M 0.0 0.1 0.2 0.3 2M 0.4 0.5 0.6 0.7 M L+
24 VDC
Sensor
Power
Output
CPU 222 AC/DC/Relay
(6ES7 212-1BB23-0XB0)
120/240 VAC Power
N(-)
L(+)
1L 0.0 0.1 0.2 ● 2L 0.3 0.4 0.5 ⏚ N L1 AC
1M 0.0 0.1 0.2 0.3 2M 0.4 0.5 0.6 0.7 M L+
24 VDC
Sensor
Power
Output
CPU 224 DC/DC/DC
(6ES7 214-1AD23-0XB0)
24 VDC Power
1M 1L+ 0.0 0.1 0.2 0.3 0.4 2M 2L+ 0.5 0.6 0.7 1.0 1.1 ● ⏚ M L+ DC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 1.0 1.1 1.2 1.3 1.4 1.5 M L+
24 VDC Sensor
Power Output
CPU 224 AC/DC/Relay
(6ES7 214-1BD23-0XB0)
120/240 VAC Power
N(-)
L(+)
1L 0.0 0.1 0.2 0.3 ● 2L 0.4 0.5 0.6 ● 3L 0.7 1.0 1.1 ⏚ N L1 AC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 1.0 1.1 1.2 1.3 1.4 1.5 M L+
24 VDC Sensor
Power Output

Figure A-4 CPU 222 and CPU 224 Wiring Diagrams

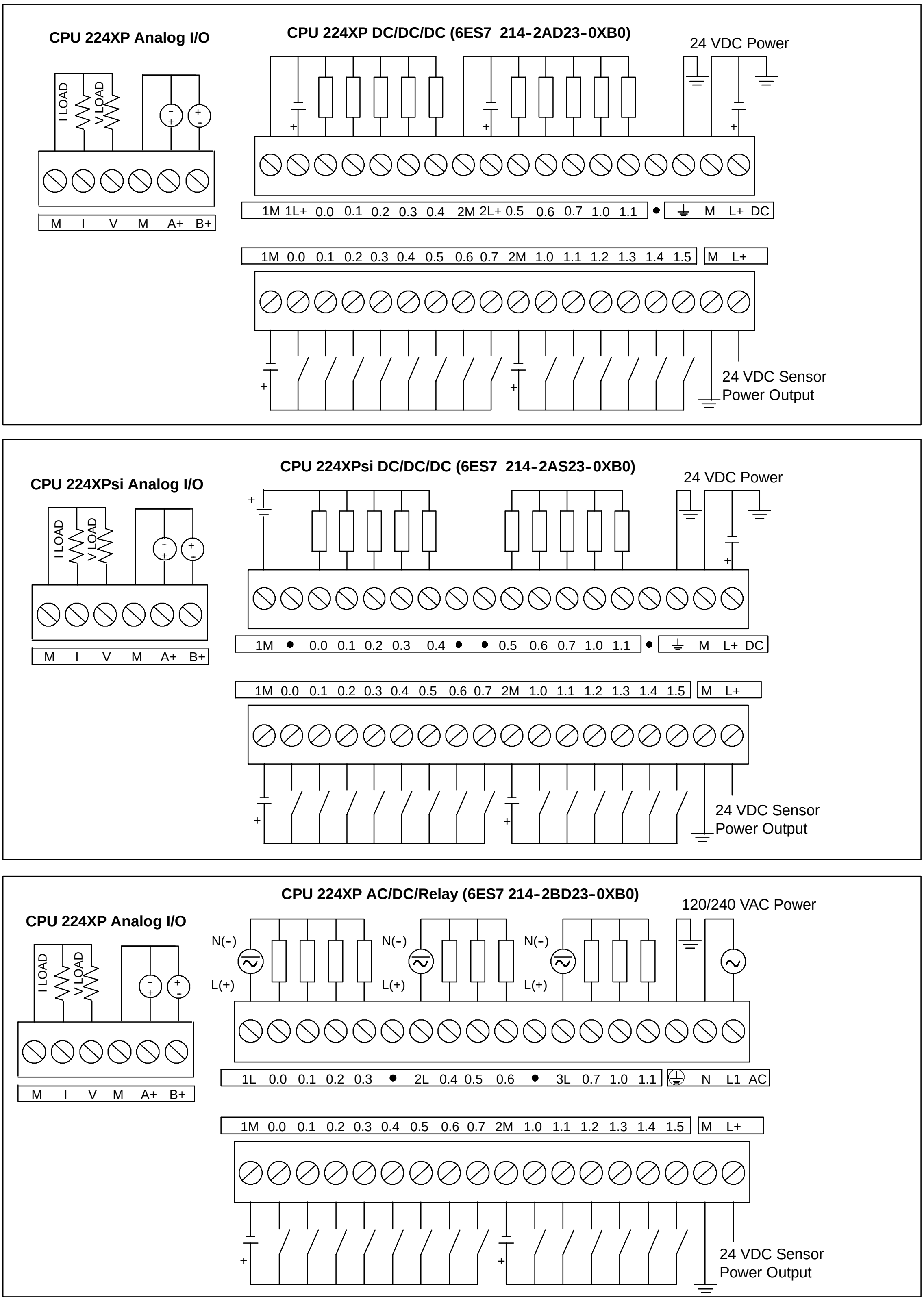

CPU 224XP Analog I/O
CPU 224XP DC/DC/DC (6ES7 214-2AD23-0XB0)
24 VDC Power
I LOAD
V LOAD
M I V M A+ B+
1M 1L+ 0.0 0.1 0.2 0.3 0.4 2M 2L+ 0.5 0.6 0.7 1.0 1.1 ● M L+ DC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 1.0 1.1 1.2 1.3 1.4 1.5 M L+
24 VDC Sensor Power Output
CPU 224XPsi Analog I/O
CPU 224XPsi DC/DC/DC (6ES7 214-2AS23-0XB0)
24 VDC Power
I LOAD
V LOAD
M I V M A+ B+
1M ● 0.0 0.1 0.2 0.3 0.4 ● ● 0.5 0.6 0.7 1.0 1.1 ● M L+ DC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 1.0 1.1 1.2 1.3 1.4 1.5 M L+
24 VDC Sensor Power Output
CPU 224XP Analog I/O
CPU 224XP AC/DC/Relay (6ES7 214-2BD23-0XB0)
120/240 VAC Power
N(-)
L(+)
N(-)
L(+)
N(-)
L(+)
I LOAD
V LOAD
M I V M A+ B+
1L 0.0 0.1 0.2 0.3 ● 2L 0.4 0.5 0.6 ● 3L 0.7 1.0 1.1 N L1 AC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 1.0 1.1 1.2 1.3 1.4 1.5 M L+
24 VDC Sensor Power Output

Figure A-5 CPU 224XP Wiring Diagrams

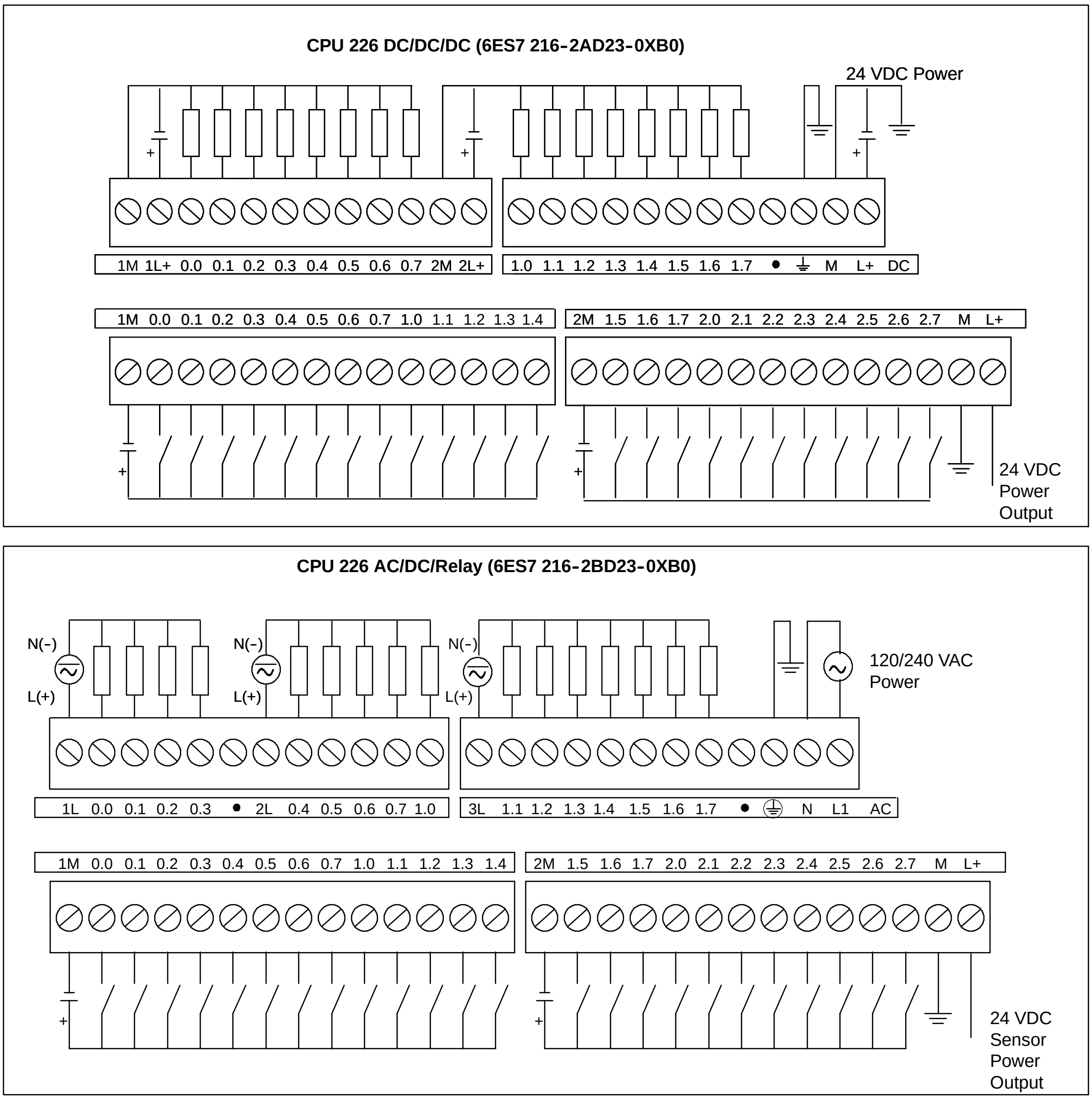
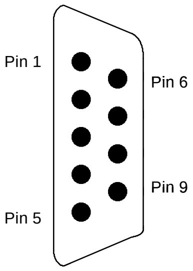

CPU 226 DC/DC/DC (6ES7 216-2AD23-0XB0)
24 VDC Power
1M 1L+ 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 2M 2L+
1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 • ⏚ M L+ DC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 1.3 1.4
2M 1.5 1.6 1.7 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 M L+
24 VDC Power Output
CPU 226 AC/DC/Relay (6ES7 216-2BD23-0XB0)
N(-)
L(+)
N(-)
L(+)
N(-)
L(+)
120/240 VAC Power
1L 0.0 0.1 0.2 0.3 • 2L 0.4 0.5 0.6 0.7 1.0
3L 1.1 1.2 1.3 1.4 1.5 1.6 1.7 • ⏚ N L1 AC
1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 1.3 1.4
2M 1.5 1.6 1.7 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 M L+
24 VDC Sensor Power Output

Figure A-6 CPU 226 Wiring Diagrams

Table A-10 Pin Assignments for the S7-200 Communications Port (Limited Power)

Connector	Pin Number	PROFIBUS Signal	Port 0/Port 1
	1	Shield	Chassis ground
	2	24 V Return	Logic common
	3	RS-485 Signal B	RS-485 Signal B
	4	Request-to-Send	RTS (TTL)
	5	5 V Return	Logic common
	6	+5 V	+5 V, 100 Ω series resistor
	7	+24 V	+24 V
	8	RS-485 Signal A	RS-485 Signal A
	9	Not applicable	10-bit protocol select (input)
	Connector shell	Shield	Chassis ground

Digital Expansion Modules Specifications

Table A-11 Digital Expansion Modules Order Numbers

Order Number	Expansion Model	Digital Inputs	Digital Outputs	Removable Connector
6ES7 221-1BF22-0XA0	EM 221 Digital Input 8 x 24 VDC	8 x 24 VDC	-	Yes
6ES7 221-1EF22-0XA0	EM 221 Digital Input 8 x 120/230 VAC	8 x 120/230 VAC	-	Yes
6ES7 221-1BH22-0XA0	EM 221 Digital Input 16 x 24 VDC	16 x 24 VDC	-	Yes
6ES7 222-1BD22-0XA0	EM 222 Digital Output 4 x 24 VDC-5A	-	4 x 24 VDC-5A	Yes
6ES7 222-1HD22-0XA0	EM 222 Digital Output 4 x Relays-10A	-	4 x Relay-10A	Yes
6ES7 222-1BF22-0XA0	EM 222 Digital Output 8 x 24 VDC	-	8 x 24 VDC-0.75A	Yes
6ES7 222-1HF22-0XA0	EM 222 Digital Output 8 x Relays	-	8 x Relay-2A	Yes
6ES7 222-1EF22-0XA0	EM 222 Digital Output 8 x 120/230 VAC	-	8 x 120/230 VAC	Yes
6ES7 223-1BF22-0XA0	EM 223 24 VDC Digital Comb 4 Inputs/4 Outputs	4 x 24 VDC	4 x 24 VDC-0.75A	Yes
6ES7 223-1HF22-0XA0	EM 223 24 VDC Digital Comb 4 Inputs/4 Relay Outputs	4 x 24 VDC	4 x Relay-2A	Yes
6ES7 223-1BH22-0XA0	EM 223 24 VDC Digital Comb 8 Inputs/8 Outputs	8 x 24 VDC	8 x 24 VDC-0.75A	Yes
6ES7 223-1PH22-0XA0	EM 223 24 VDC Digital Comb 8 Inputs/8 Relay Outputs	8 x 24 VDC	8 x Relay-2A	Yes
6ES7 223-1BL22-0XA0	EM 223 24 VDC Digital Comb 16 Inputs/16 Outputs	16 x 24 VDC	16 x 24 VDC-0.75A	Yes
6ES7 223-1PL22-0XA0	EM 223 24 VDC Digital Comb 16 Inputs/16 Relay Outputs	16 x 24 VDC	16 x Relay-2A	Yes
6ES7 223-1BM22-0XA0	EM 223 24 VDC Digital Comb 32 Inputs/32 Outputs	32 x 24 VDC	32 x 24 VDC-0.75 A	Yes
6ES7 223-1PM22-0XA0	EM 223 24 VDC Digital Comb 32 Inputs/32 Relay Outputs	32 x 24 VDC	32 x Relay-2 A	Yes

Table A-12 Digital Expansion Modules General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 221-1BF22-0XA0	EM 221 DI 8 x 24 VDC	46 x 80 x 62	150 g	2 W	30 mA	ON: 4 mA/input
6ES7 221-1EF22-0XA0	EM 221 DI 8 x 120/230 VAC	71.2 x 80 x 62	160 g	3 W	30 mA	-
6ES7 221-1BH22-0XA0	EM 221 DI 16 x 24 VDC	71.2 x 80 x 62	160 g	3 W	70 mA	ON: 4 mA/input
6ES7 222-1BD22-0XA0	EM 222 DO 4 x 24 VDC-5A	46 x 80 x 62	120 g	3 W	40 mA	-
6ES7 222-1HD22-0XA0	EM 222 DO 4 x Relays-10A	46 x 80 x 62	150 g	4 W	30 mA	ON: 20 mA/output
6ES7 222-1BF22-0XA0	EM 222 DO 8 x 24 VDC	46 x 80 x 62	150 g	2 W	50 mA	-
6ES7 222-1HF22-0XA0	EM 222 DO 8 x Relays	46 x 80 x 62	170 g	2 W	40 mA	ON: 9 mA/output
6ES7 222-1EF22-0XA0	EM 222 DO 8 x 120/230 VAC	71.2 x 80 x 62	165 g	4 W	110 mA	-
6ES7 223-1BF22-0XA0	EM 223 24 VDC 4 In/4 Out	46 x 80 x 62	160 g	2 W	40 mA	ON: 4 mA/input
6ES7 223-1HF22-0XA0	EM 223 24 VDC 4 In/4 Relays	46 x 80 x 62	170 g	2 W	40 mA	ON: 9 mA/output, 4 mA/input
6ES7 223-1BH22-0AX0	EM 223 24 VDC 8 In/8 Out	71.2 x 80 x 62	200 g	3 W	80 mA	ON: 4 mA/input
6ES7 223-1PH22-0XA0	EM 223 24 VDC 8 In/8 Relays	71.2 x 80 x 62	300 g	3 W	80 mA	ON: 9 mA/output, 4 mA/input
6ES7 223-1BL22-0XA0	EM 223 24 VDC 16 In/16 Out	137.3 x 80 x 62	360 g	6 W	160 mA	ON: 4 mA/input
6ES7 223-1PL22-0XA0	EM 223 24 VDC 16 In/16 Relays	137.3 x 80 x 62	400 g	6 W	150 mA	ON: 9 mA/output, 4 mA/input
6ES7 223-1BM22-0XA0	EM 223 24 VDC 32 In/32 Out	196 x 80 x 62	500 g	9 W	240 mA	ON: 4 mA/input
6ES7 223-1PM22-0XA0	EM 223 24 VDC 32 In/32 Relay	196 x 80 x 62	580 g	13 W	205 mA	ON: 9 mA/output 4 mA/input

Table A-13 Digital Expansion Modules Input Specifications

General	24 VDC Input	120/230 VAC Input (47 to 63 HZ)
Type	Sink/Source (IEC Type 1 sink)	IEC Type I
Rated voltage	24 VDC at 4 mA	120 VAC at 6 mA or 230 VAC at 9 mA nominal
Maximum continuous permissible voltage	30 VDC	264 VAC
Surge voltage (max.)	35 VDC for 0.5 s	–
Logic 1 (min.)	15 VDC at 2.5 mA	79 VAC at 2.5 mA
Logic 0 (max.)	5 VDC at 1 mA	20 VAC or 1 mA AC
Input delay (max.)	4.5 ms	15 ms
Connection of 2 wire proximity sensor (Bero) Permissible leakage current (max.)	1 mA	1 mA AC
Isolation Optical (galvanic, field to logic) Isolation groups	500 VAC for 1 minute See wiring diagram	1500 VAC for 1 minute 1 point
Inputs on simultaneously	All at 55° C (horizontal), All on at 45° C (vertical)	
Cable length (max.) Shielded Unshielded	500 m 300 m	500 m 300 m

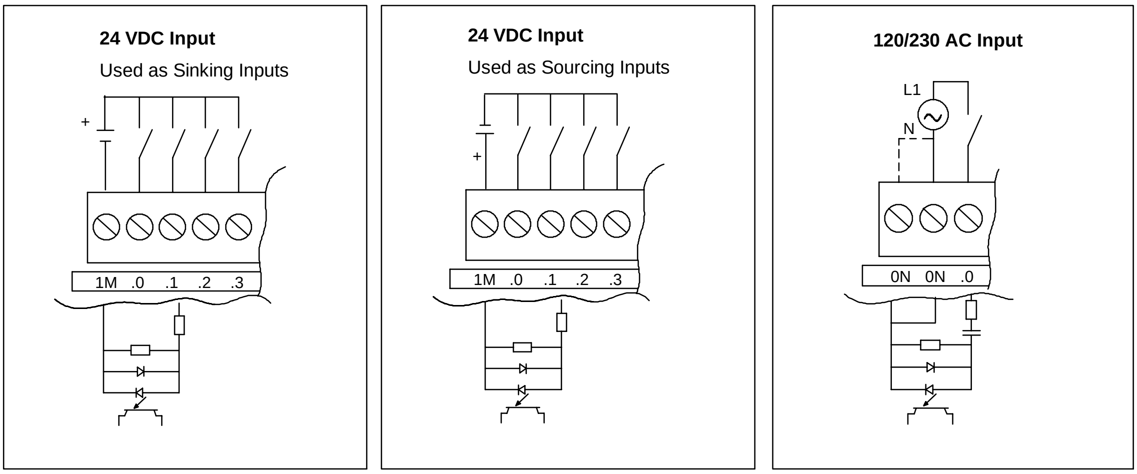


Figure A-7 S7-200 Digital Expansion Modules Inputs

Table A-14 Digital Expansion Modules Output Specifications

General	24 VDC Output		Relay Output		120/230 VAC Output
	0.75 A	**5 A**	**2 A**	**10 A**	
Type	Solid state-MOSFET (Sourcing)		Dry contact		Triac, zero-cross turn-on
Rated voltage	24 VDC		24 VDC or 250 VAC		120/230 VAC
Voltage range	20.4 to 28.8 VDC		5 to 30 VDC or 5 to 250 VAC	12 to 30 VDC or 12 to 250 VAC	40 to 264 VAC (47 to 63 Hz)
24 VDC coil power voltage range	–		20.4 to 28.8 VDC		–
Surge current (max.)	8 A for 100 ms	30 A	5 A for 4 s @ 10% duty cycle	15 A for 4 s @ 10% duty cycle	5 A rms for 2 AC cycles
Logic 1 (min.)	20 VDC		–		L1 (–0.9 V rms)
Logic 0 (max.)	0.1 VDC with 10 K Ω Load	0.2 VDC with 5 K Ω Load	–		–

Rated current per point (max.)	0.75 A	5 A	2.00 A	10 A resistive;
				2 A DC inductive;
				3 A AC inductive
					0.5 A AC[1]

Rated current per common (max.)	10 A	5 A	10 A	10 A	0.5 A AC
Leakage current (max.)	10 μA	30 μA	–		1.1 mA rms at 132 VAC and 1.8 mA rrms at 264 VAC
Lamp load (max.)	5 W	50 W	30 W DC/ 200 W AC[4,5]	100 W DC/ 1000 W AC	60 W
Inductive clamp voltage	L+ minus 48 V	L+ minus 47 V[2]	–		–
On state resistance (contact)	0.3 Ω typical (0.6 Ω max.)	0.05 Ω max.	0.2 Ω max. when new	0.1 Ω max. when new	410 Ω max. when load current is less than 0.05A
Isolation					
Optical (galvanic, field to logic)	500 VAC for 1 minute		–		1500 VAC for 1minute
Coil to logic	–		None		–
Coil to contact	–		1500 VAC for 1 minute		–
Resistance (coil to contact)	–		100 M Ω min. when new		–
Isolation groups	See wiring diagram		See wiring diagram		1 point
Delay Off to On/On to Off (max.)	50 μs / 200 μs	500 μs	–	–	0.2 ms + 1/2 AC cycle
Switching (max.)	–	–	10 ms	15 ms	–
Switching frequency (max.)	–		1 Hz		10 Hz
Lifetime mechanical cycles	–		10,000,000 (no load)	30,000,000 (no load)	–
Lifetime contacts	–		100,000 (rated load)	30,000 (rated load)	–
Output on simultaneously	All at 55° C (horizontal), All at 45° C (vertical)			All at 55 °C (horizontal) with 20A max. module current. All at 45°C (vertical) with 20A max. module current[5]. All at 40 °C (horizontal) with 10A per point	All at 55° C (horizontal), All at 45° C (vertical)
Connecting two outputs in parallel	Yes, only outputs in same group		No		No
Cable length (max.)					
Shielded	500 m		500 m		500 m
Unshielded	150 m		150 m		150 m

[1] Load current must be full wave AC and must not be half-wave because of the zero-cross circuitry. Minimum load current is 0.05 A AC. With a load current between 5 mA and 50 mA AC, the current can be controlled, but there is an additional voltage drop due to series resistance of 410 Ohms.

[2] If the output overheats due to excessive inductive switching or abnormal conditions, the output point may turn off or be damaged. The output could overheat or be damaged if the output is subjected to more than 0.7 J of energy switching an inductive load off. To eliminate the need for this limitation, a suppression circuit as described in Chapter 3 can be added in parallel with the load. These components need to be sized properly for the given application.

[3] The EM 222 DO 4 x Relay has a different FM rating than the rest of the S7-200. This module has a T4 rating, instead of T4A for FM Class I, Division Groups A, B, C, and D Hazardous Locations.

[4] Relay lifetime with a lamp load will be reduced by 75% unless steps are taken to reduce the turn-on surge below the surge current rating of the output.

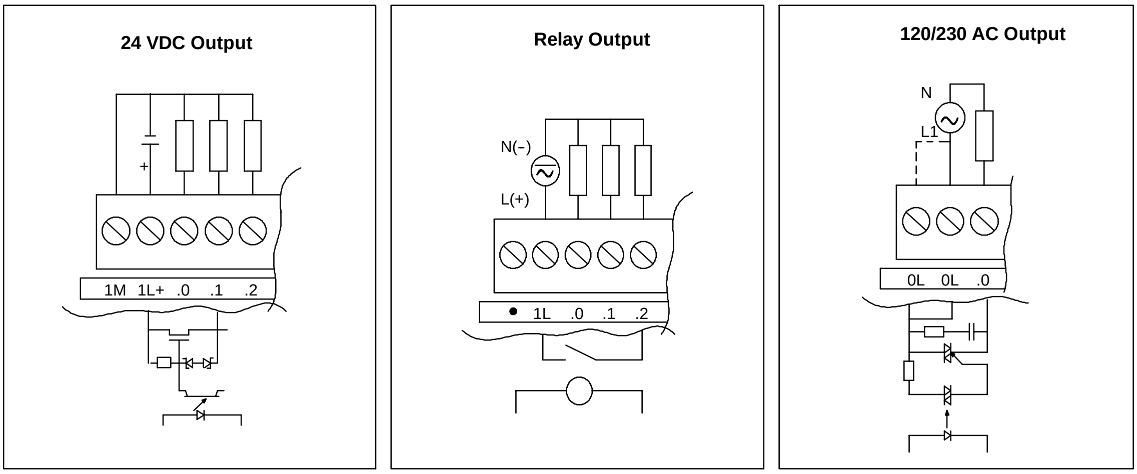
[5] Lamp load wattage rating is for rated voltage. Reduce the wattage rating proportionally for voltage being switched (for example 120 VAC – 100 W).

Warning

When a mechanical contact turns on output power to the S7-200 CPU, or any digital expansion module, it sends a "1" signal to the digital outputs for approximately 50 microseconds.

This could cause unexpected machine or process operation which could result in death or serious injury to personnel, and/or damage to equipment.

You must plan for this, especially if you are using devices which respond to short duration pulses.



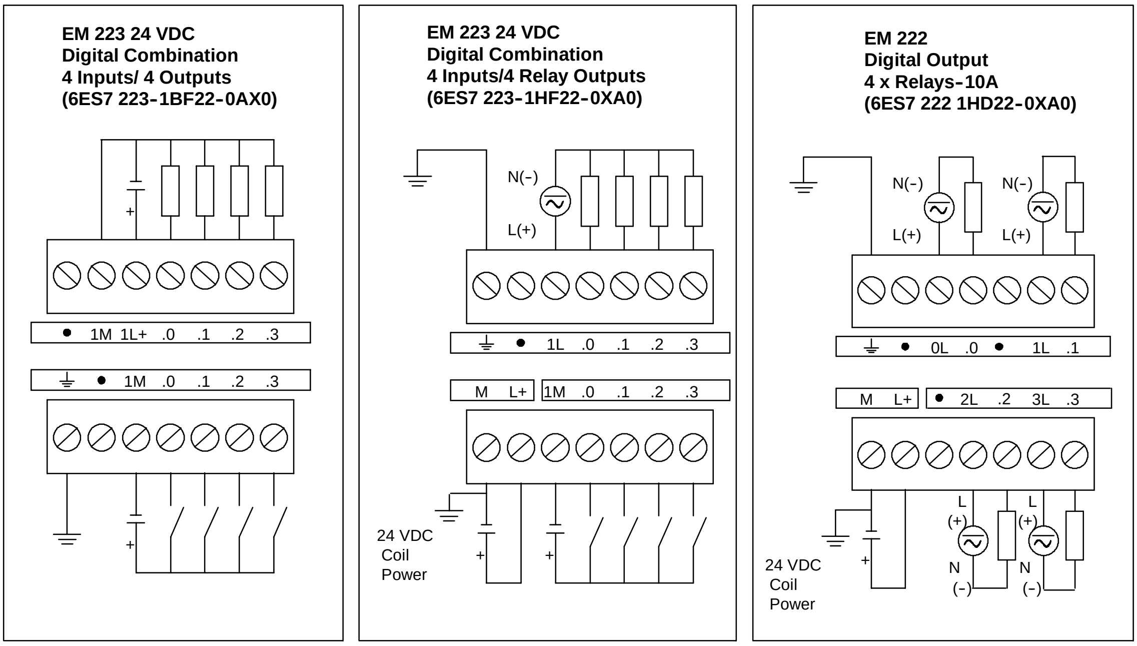
24 VDC Output

Relay Output

120/230 AC Output

Figure A-8 S7-200 Digital Expansion Modules Outputs

Wiring Diagrams



EM 223 24 VDC
Digital Combination
4 Inputs/ 4 Outputs
(6ES7 223-1BF22-0AX0)

EM 223 24 VDC
Digital Combination
4 Inputs/4 Relay Outputs
(6ES7 223-1HF22-0XA0)

EM 222
Digital Output
4 x Relays-10A
(6ES7 222 1HD22-0XA0)

Figure A-9 Wiring Diagrams for EM 222 and EM 223 Expansion Modules

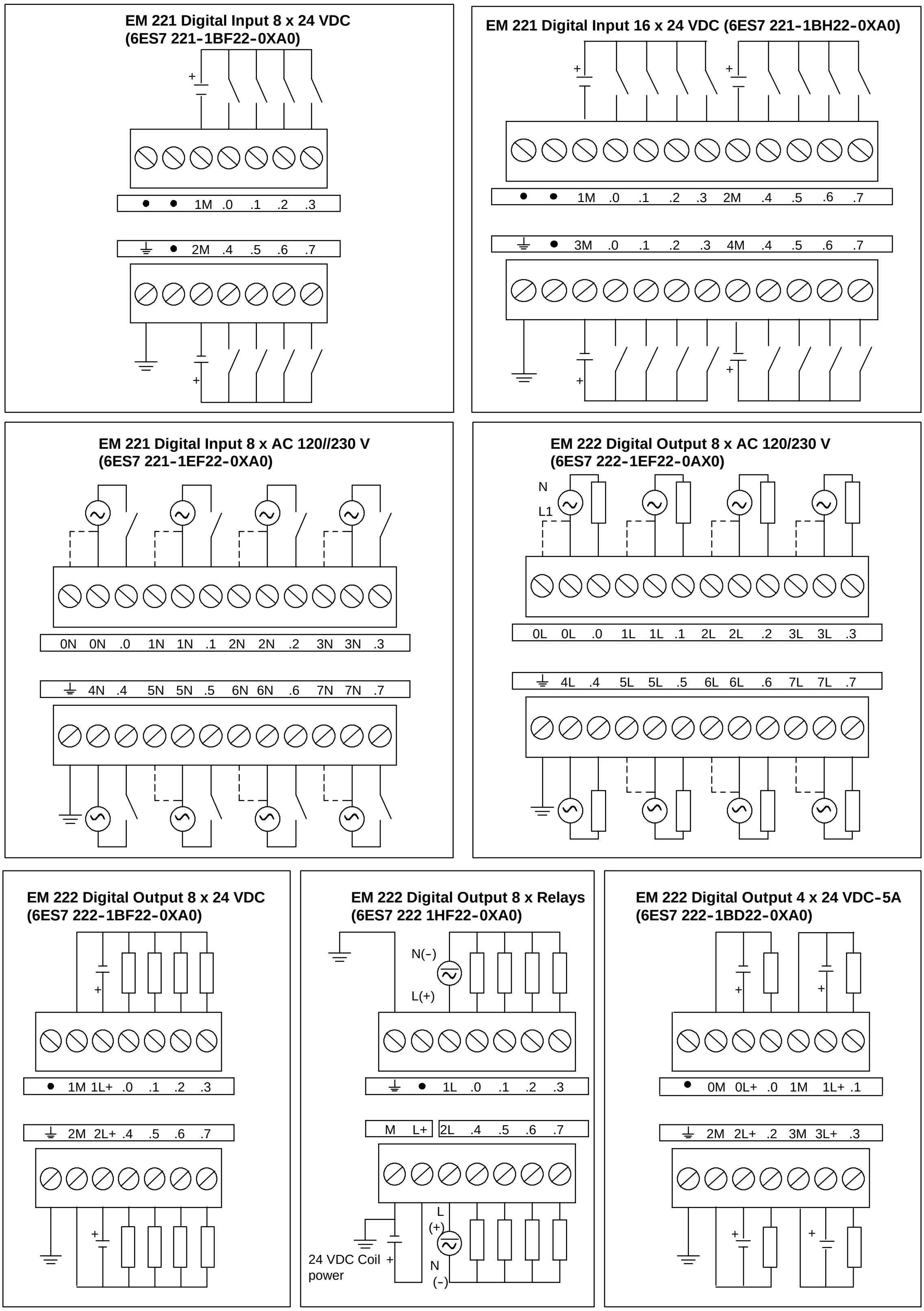
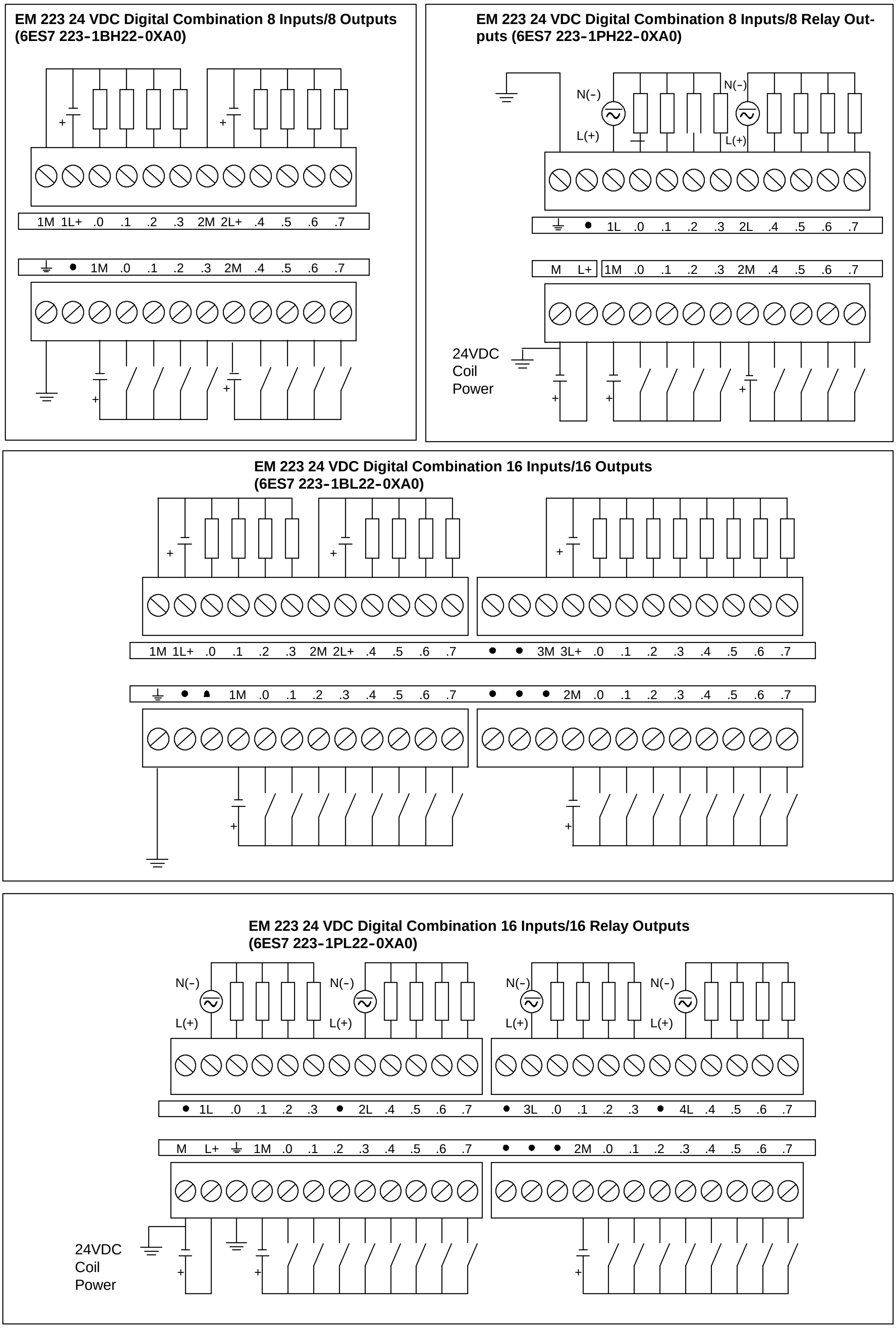

EM 221 Digital Input 8 x 24 VDC
(6ES7 221-1BF22-0XA0)
+
● ● 1M .0 .1 .2 .3
⏚ ● 2M .4 .5 .6 .7
+
EM 221 Digital Input 16 x 24 VDC (6ES7 221-1BH22-0XA0)
+
+
● ● 1M .0 .1 .2 .3 2M .4 .5 .6 .7
⏚ ● 3M .0 .1 .2 .3 4M .4 .5 .6 .7
+
+
EM 221 Digital Input 8 x AC 120//230 V
(6ES7 221-1EF22-0XA0)
0N 0N .0 1N 1N .1 2N 2N .2 3N 3N .3
⏚ 4N .4 5N 5N .5 6N 6N .6 7N 7N .7
EM 222 Digital Output 8 x AC 120/230 V
(6ES7 222-1EF22-0AX0)
N
L1
0L 0L .0 1L 1L .1 2L 2L .2 3L 3L .3
⏚ 4L .4 5L 5L .5 6L 6L .6 7L 7L .7
EM 222 Digital Output 8 x 24 VDC
(6ES7 222-1BF22-0XA0)
+
● 1M 1L+ .0 .1 .2 .3
⏚ 2M 2L+ .4 .5 .6 .7
+
EM 222 Digital Output 8 x Relays
(6ES7 222 1HF22-0XA0)
N(-)
L(+)
⏚ ● 1L .0 .1 .2 .3
M L+ 2L .4 .5 .6 .7
L
(+)
N
(-)
24 VDC Coil
power
+
EM 222 Digital Output 4 x 24 VDC-5A
(6ES7 222-1BD22-0XA0)
+
+
● 0M 0L+ .0 1M 1L+ .1
⏚ 2M 2L+ .2 3M 3L+ .3
+
+

Figure A-10 Wiring Diagrams for EM 221 and EM 222 Expansion Modules



EM 223 24 VDC Digital Combination 8 Inputs/8 Outputs (6ES7 223-1BH22-0XA0)

EM 223 24 VDC Digital Combination 8 Inputs/8 Relay Outputs (6ES7 223-1PH22-0XA0)

EM 223 24 VDC Digital Combination 16 Inputs/16 Outputs (6ES7 223-1BL22-0XA0)

EM 223 24 VDC Digital Combination 16 Inputs/16 Relay Outputs (6ES7 223-1PL22-0XA0)

1M 1L+ .0 .1 .2 .3 2M 2L+ .4 .5 .6 .7
1M .0 .1 .2 .3 2M .4 .5 .6 .7
N(-)
L(+)
1L .0 .1 .2 .3 2L .4 .5 .6 .7
M L+ 1M .0 .1 .2 .3 2M .4 .5 .6 .7
24VDC Coil Power
1M 1L+ .0 .1 .2 .3 2M 2L+ .4 .5 .6 .7 3M 3L+ .0 .1 .2 .3 .4 .5 .6 .7
1M .0 .1 .2 .3 .4 .5 .6 .7 2M .0 .1 .2 .3 .4 .5 .6 .7
1L .0 .1 .2 .3 2L .4 .5 .6 .7 3L .0 .1 .2 .3 4L .4 .5 .6 .7
M L+ 1M .0 .1 .2 .3 .4 .5 .6 .7 2M .0 .1 .2 .3 .4 .5 .6 .7
24VDC Coil Power
+

Figure A-11 Wiring Diagrams for EM 223 Expansion Modules

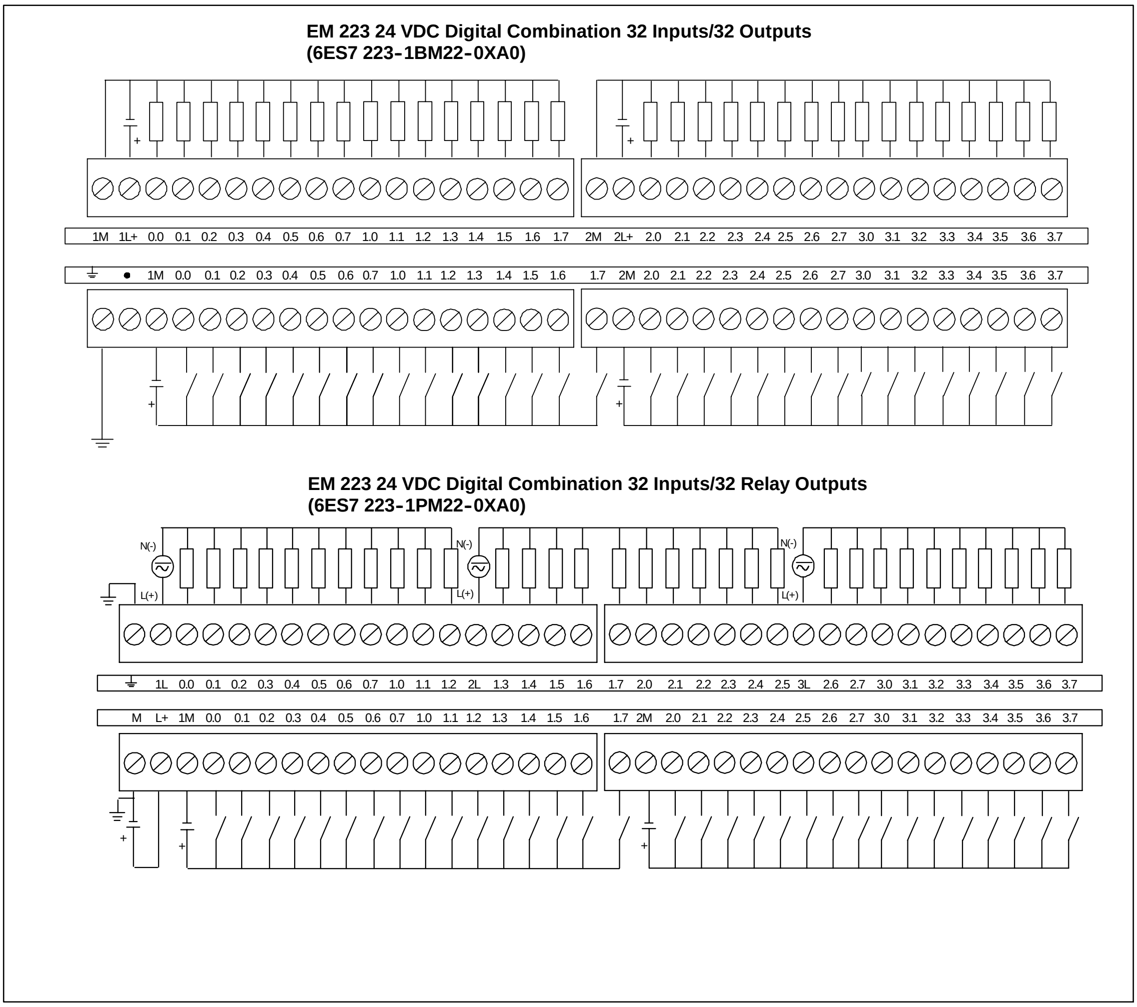

EM 223 24 VDC Digital Combination 32 Inputs/32 Outputs
(6ES7 223-1BM22-0XA0)
+
+
1M 1L+ 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 2M 2L+ 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7
● 1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 2M 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7
+
+
EM 223 24 VDC Digital Combination 32 Inputs/32 Relay Outputs
(6ES7 223-1PM22-0XA0)
N(-)
L(+)
N(-)
L(+)
N(-)
L(+)
1L 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 2L 1.3 1.4 1.5 1.6 1.7 2.0 2.1 2.2 2.3 2.4 2.5 3L 2.6 2.7 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7
M L+ 1M 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 2M 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7
+
+
+

Figure A-12 Wiring Diagrams for EM 223 Expansion Modules

Analog Expansion Modules Specifications

Table A-15 Analog Expansion Modules Order Numbers

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 231-0HC22-0XA0	EM 231 Analog Input, 4 Inputs	4	-	No
6ES7 231-0HF22-0XA0	EM 231 Analog Input, 8 Inputs	8	-	No
6ES7 232-0HB22-0XA0	EM 232 Analog Output, 2 Outputs	-	2	No
6ES7 232-0HD22-0XA0	EM 232 Analog Output, 4 Outputs	-	4	No
6ES7 235-0KD22-0XA0	EM 235 Analog Combination 4 Inputs/1 Output	4	1[1]	No

[1] The CPU reserves 2 analog output points for this module.

Table A-16 Analog Expansion Modules General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 231-0HC22-0XA0	EM 231 Analog Input, 4 Inputs	71.2 x 80 x 62	183 g	2 W	20 mA	60 mA
6ES7 231-0HF22-0XA0	EM 231 Analog Input, 8 Inputs	71.2 x 80 x 62	190 g	2 W	20 mA	60 mA
6ES7 232-0HB22-0XA0	EM 232 Analog Output, 2 Outputs	46 x 80 x 62	148 g	2 W	20 mA	70 mA (with both outputs at 20 mA)
6327 232-0HD22-0XA0	EM 232 Analog Output, 4 Outputs	71.2 x 80 x 62	190 g	2 W	20 mA	100 MA (with all outputs at 20 mA)
6ES7 235-0KD22-0XA0	EM 235 Analog Combination 4 Inputs/1 Output	71.2 x 80 x 62	186 g	2 W	30 mA	60 mA (with output at 20 mA)

Table A-17 Analog Expansion Modules Input Specifications

General	6ES7 231-0HC22-0XA0 6ES7 235-0KD22-0XA0	6ES7 231-0HF22-0XA0
Data word format	(See Figure A-16)	
Bipolar, full-scale range	-32000 to +32000	
Unipolar, full-scale range	0 to 32000	
DC Input impedance	≥2 MΩ voltage input 250 Ω current input	> 2 MΩ voltage input 250 Ω current input
Input filter attenuation	-3 db at 3.1 Khz	
Maximum input voltage	30 VDC	
Maximum input current	32 mA	
Resolution Bipolar Unipolar	11 bits plus 1 sign bit 12 bits	
Isolation (field to logic)	None	
Input type	Differential	Differential voltage, two channels selectable for current
Input ranges	Voltage: Selectable, see Table A-20 for available ranges Current: 0 to 20 mA	Voltage: Channels 0 to 7 0 to +10V, 0 to +5V and +/-2.5 Current: Channels 6 and 7 0 to 20mA
Input resolution	See Table A-20	See Table A-22
Analog to digital conversion time	< 250 μs	< 250 μs
Analog input step response	1.5 ms to 95%	1.5 ms to 95%
Common mode rejection	40 dB, DC to 60 Hz	40 dB, DC to 60 Hz
Common mode voltage	Signal voltage plus common mode voltage must be ≤ ±12 V	Signal voltage plus common mode voltage must be ≤ ±12 V
24 VDC supply voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)	

Table A-18 Analog Expansion Modules Output Specifications

General	6ES7 232-0HB22-0XA0 6ES7 232-0HD22-0XA0 6ES7 235-0KD22-0XA0
Isolation (field to logic)	None
Signal range	
Voltage output	± 10 V
Current output	0 to 20 mA
Resolution, full-scale	
Voltage	11 bits
Current	11 bits
Data word format	
Voltage	-32000 to +32000
Current	0 to +32000
Accuracy	
Worst case, 0° to 55° C	
Voltage output	± 2% of full-scale
Current output	± 2% of full-scale
Typical, 25° C	
Voltage output	± 0.5% of full-scale
Current output	± 0.5% of full-scale
Setting time	
Voltage output	100 μS
Current output	2 mS
Maximum drive	
Voltage output	5000 Ω minimum
Current output	500 Ω maximum
24 VDC supply voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)

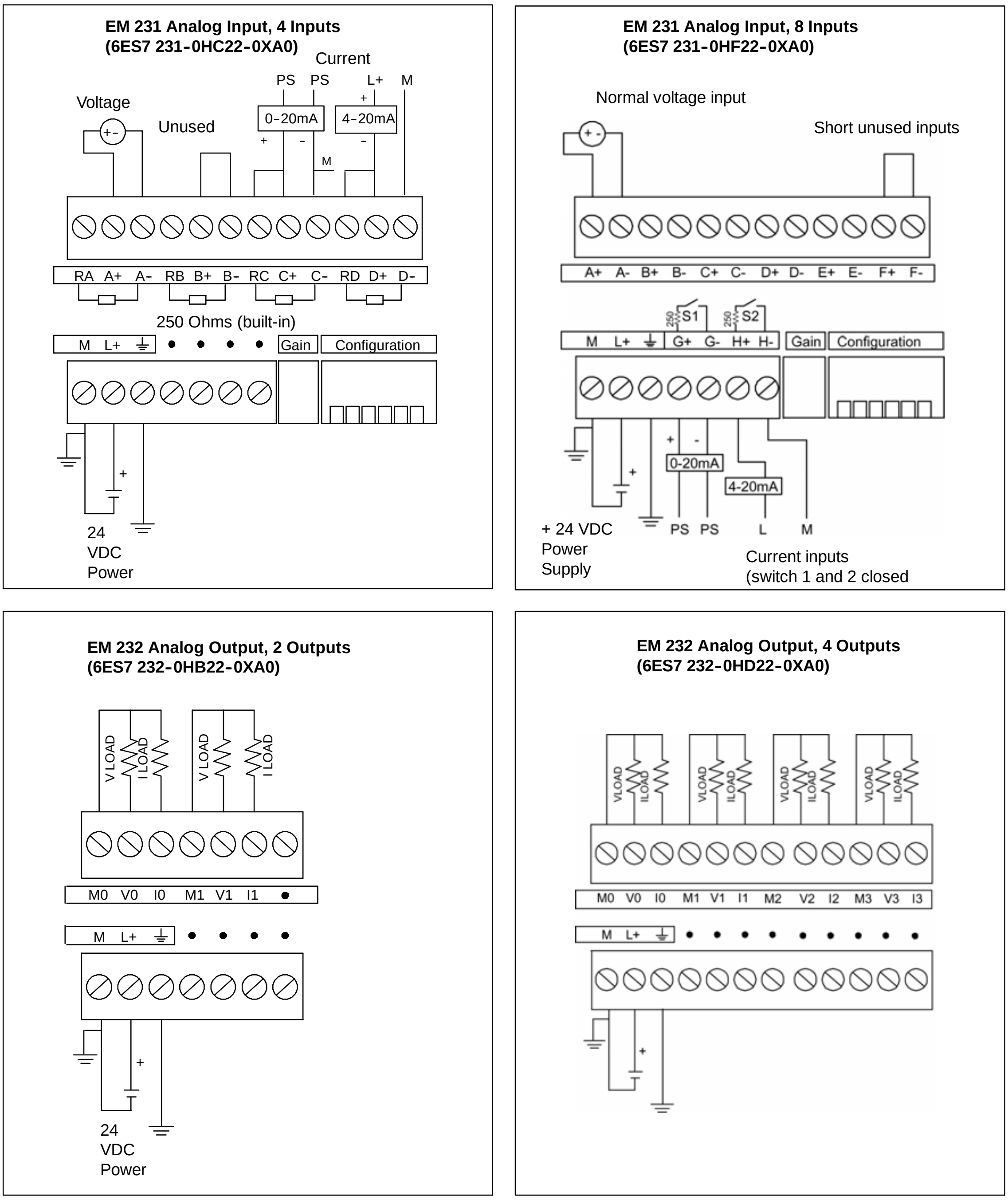


Figure A-13 Wiring Diagrams for Analog Expansion Modules

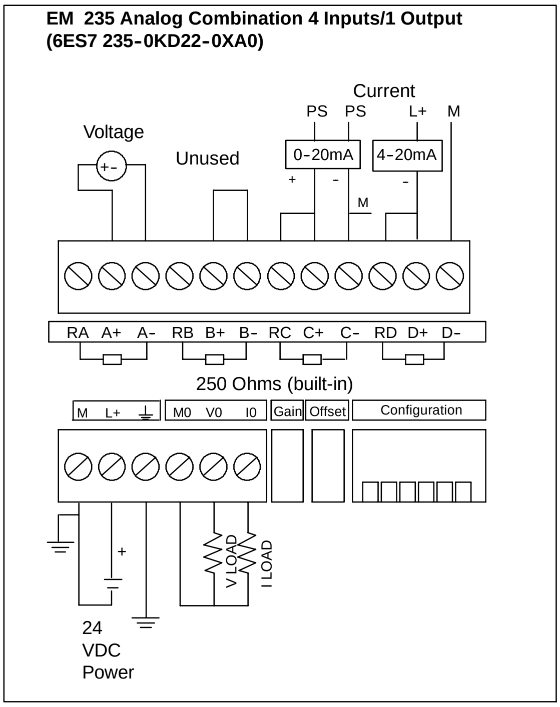


Figure A-14 Wiring Diagrams for Analog Expansion Modules

Analog LED Indicators

The LED indicators for the analog modules are shown in Table A-19.

Table A-19 Analog LED Indicators

LED Indicator	ON	OFF
24 VDC Power Supply Good	No faults	No 24 VDC power

Tip

The state of user power is also reported in Special Memory (SM) bits. For more information, see Appendix D, SMB8 to SMB21 I/O Module ID and Error Registers.

Input Calibration

The calibration adjustments affect the instrumentation amplifier stage that follows the analog multiplexer (see the Input Block Diagram for the EM 231 in Figure A-17 and EM 235 in Figure A-19). Therefore, calibration affects all user input channels. Even after calibration, variations in the component values of each input circuit preceding the analog multiplexer will cause slight differences in the readings between channels connected to the same input signal.

To meet the specifications, you should enable analog input filters for all inputs of the module. Select 64 or more samples to calculate the average value.

To calibrate the input, use the following steps.

1. Turn off the power to the module. Select the desired input range.
2. Turn on the power to the CPU and module. Allow the module to stabilize for 15 minutes.
3. Using a transmitter, a voltage source, or a current source, apply a zero value signal to one of the input terminals.
4. Read the value reported to the CPU by the appropriate input channel.
5. Adjust the OFFSET potentiometer until the reading is zero, or the desired digital data value.
6. Connect a full-scale value signal to one of the input terminals. Read the value reported to the CPU.
7. Adjust the GAIN potentiometer until the reading is 32000, or the desired digital data value.
8. Repeat OFFSET and GAIN calibration as required.

Calibration and Configuration Location for EM 231 and EM 235

Figure A-15 shows the calibration potentiometer and configuration DIP switches located on the right of the bottom terminal block of the module.

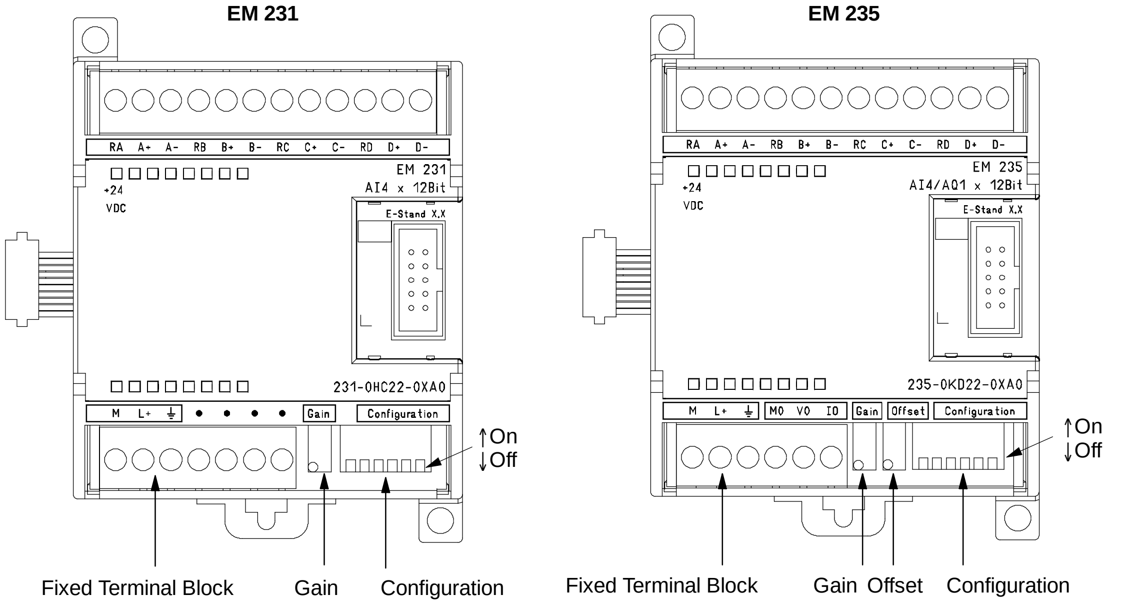


Figure A-15 Calibration Potentiometer and Configuration DIP Switch Location for the EM 231 and EM 235

Configuration for EM 231

Table A-20 and Table A-21show how to configure the the EM 231 modules using the configuration DIP switches. All inputs are set to the same analog input range. In these tables, ON is closed, and OFF is open. The switch settings are read only when the power is turned on.

For the EM 231 Analog Input, 4 Inputs module, switches 1, 2, and 3 select the analog input range (Table A-20).

Table A-20 Configuration Switch Table to Select Analog Input Range for the EM 231 Analog Input, 4 Inputs

Unipolar			**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**		
ON	OFF	ON	0 to 10 V	2.5 mV
	ON	OFF	0 to 5 V	1.25 mV
			0 to 20 mA	5 µA
Bipolar			**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**		
OFF	OFF	ON	±5 V	2.5 mV
	ON	OFF	± 2.5 V	1.25 mV

For the EM 231 Analog Input, 8 Inputs module, switches 3, 4, and 5 select the analog input range. Use Switch 1 and 2 to select the current mode input (Table A-21). Switch 1 ON selects current mode input for Channel 6; OFF selects voltage mode. Switch 2 ON selects current mode input for Channel 7; OFF selects voltage mode.

Table A-21 EM 231 Configuration Switch Table to Select Analog Input Range for the EM 231 Analog Input, 8 Inputs

Unipolar			**Full-Scale Input**	**Resolution**
SW3	**SW4**	**SW5**		
ON	OFF	ON	0 to 10 V	2.5 mV
	ON	OFF	0 to 5 V	1.25 mV
			0 to 20 mA	5 µA
Bipolar			**Full-Scale Input**	**Resolution**
SW3	**SW4**	**SW5**		
OFF	OFF	ON	±5 V	2.5 mV
	ON	OFF	± 2.5 V	1.25 mV

Configuration for EM 235

Table A-22 shows how to configure the EM 235 module using the configuration DIP switches. Switches 1 through 6 select the analog input range and resolution. All inputs are set to the same analog input range and format. Table A-22 shows how to select for unipolar/bipolar (switch 6), gain (switches 4 and 5), and attenuation (switches 1, 2, and 3). In these tables, ON is closed, and OFF is open. The switch settings are read only when the power is turned on.

Table A-22 EM 235 Configuration Switch Table to Select Analog Range and Resolution

Unipolar						**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**		
ON	OFF	OFF	ON	OFF	ON	0 to 50 mV	12.5 μV
OFF	ON	OFF	ON	OFF	ON	0 to 100 mV	25 μV
ON	OFF	OFF	OFF	ON	ON	0 to 500 mV	125 μV
OFF	ON	OFF	OFF	ON	ON	0 to 1 V	250 μV
ON	OFF	OFF	OFF	OFF	ON	0 to 5 V	1.25 mV
ON	OFF	OFF	OFF	OFF	ON	0 to 20 mA	5 μA
OFF	ON	OFF	OFF	OFF	ON	0 to 10 V	2.5 mV
Bipolar						**Full-Scale Input**	**Resolution**
SW1	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**		
ON	OFF	OFF	ON	OFF	OFF	±25 mV	12.5 μV
OFF	ON	OFF	ON	OFF	OFF	±50 mV	25 μV
OFF	OFF	ON	ON	OFF	OFF	±100 mV	50 μV
ON	OFF	OFF	OFF	ON	OFF	±250 mV	125 μV
OFF	ON	OFF	OFF	ON	OFF	±500 mV	250 μV
OFF	OFF	ON	OFF	ON	OFF	±1 V	500 μV
ON	OFF	OFF	OFF	OFF	OFF	±2.5 V	1.25 mV
OFF	ON	OFF	OFF	OFF	OFF	±5 V	2.5 mV
OFF	OFF	ON	OFF	OFF	OFF	±10 V	5 mV

Input Data Word Format for EM 231 and EM 235

Figure A-16 shows where the 12-bit data value is placed within the analog input word of the CPU.

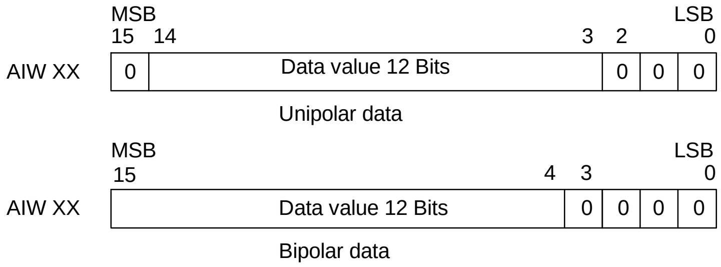


Figure A-16 Input Data Word Format for EM 231 and EM 235

Tip

The 12 bits of the analog-to-digital converter (ADC) readings are left-justified in the data word format. The MSB is the sign bit: zero indicates a positive data word value.

In the unipolar format, the three trailing zeros cause the data word to change by a count of eight for each one-count change in the ADC value.

In the bipolar format, the four trailing zeros cause the data word to change by a count of sixteen for each one count change in the ADC value.

Input Block Diagrams for EM 231 and 235

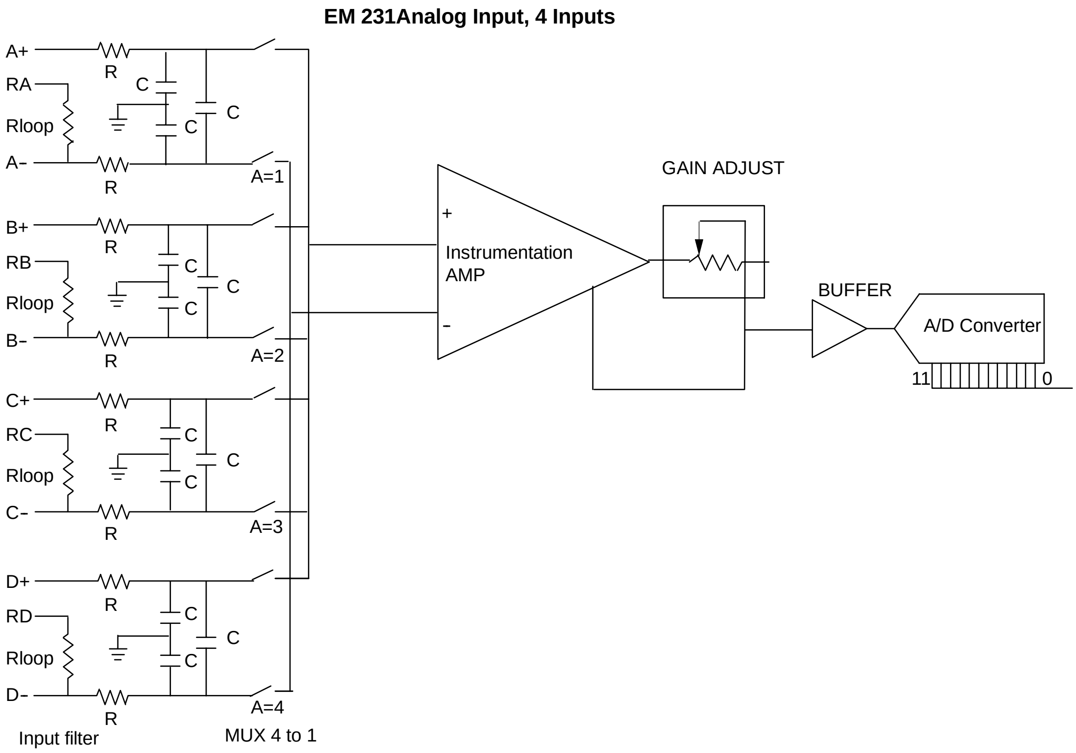


Figure A-17 Input Block Diagram for the EM 231 Analog Input, 4 Inputs

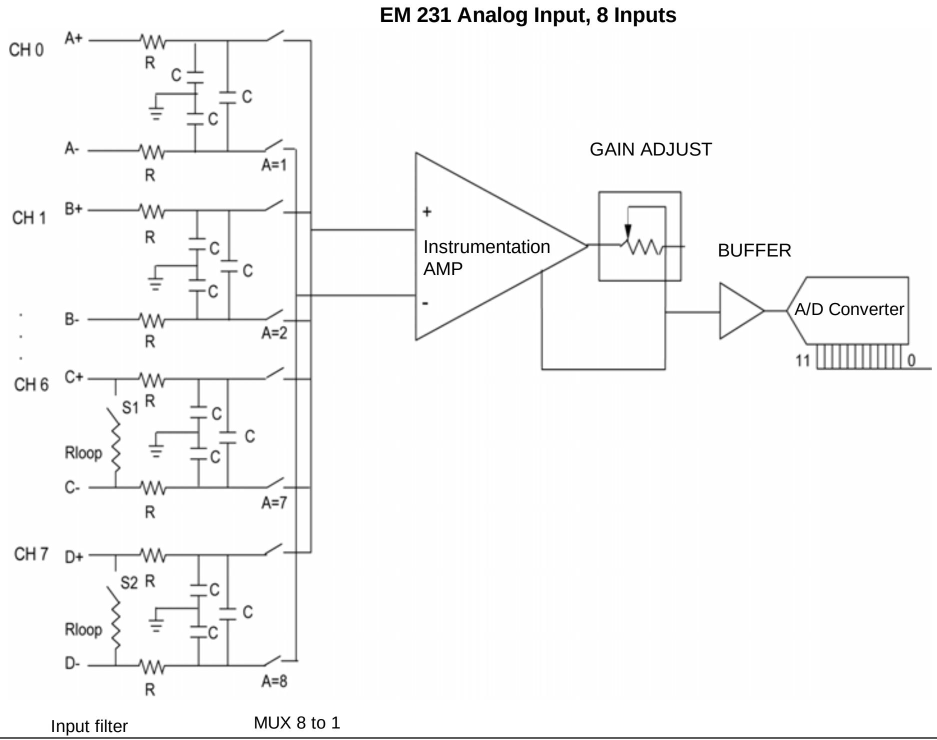


Figure A-18 Input Block Diagram for the EM231 Analog Input, 8 Inputs

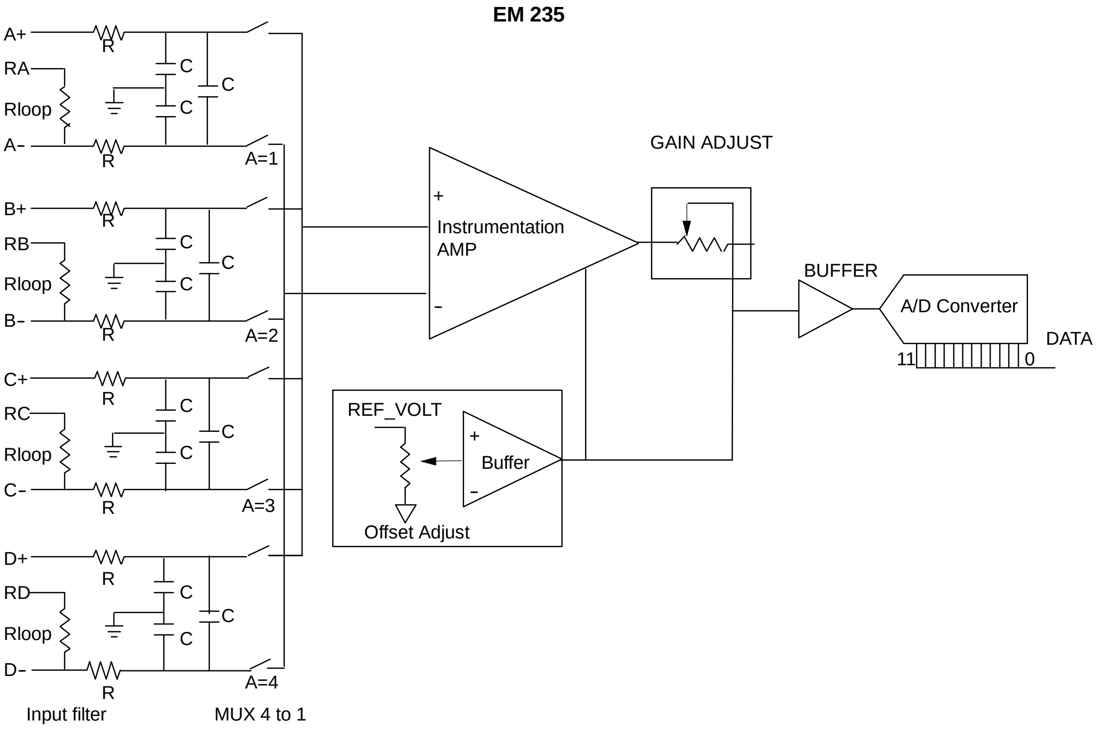


Figure A-19 Input Block Diagram for the EM 235

Output Data Word Format for EM 232 and EM 235

Figure A-20 shows where the 12-bit data value is placed within the analog output word of the CPU.

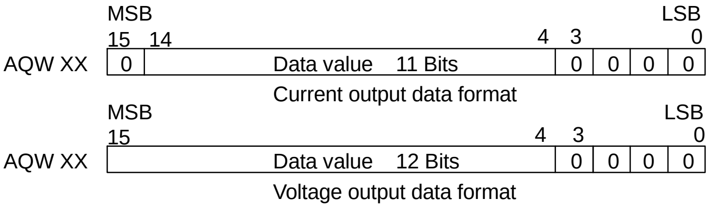


Figure A-20 Output Data Word Format for EM 232 and EM 235

Tip

The 12 bits of the digital-to-analog converter (DAC) readings are left-justified in the output data word format. The MSB is the sign bit: zero indicates a positive data word value. The four trailing zeros are truncated before being loaded into the DAC registers. These bits have no effect on the output signal value.

Output Block Diagram for EM 232 and EM 235

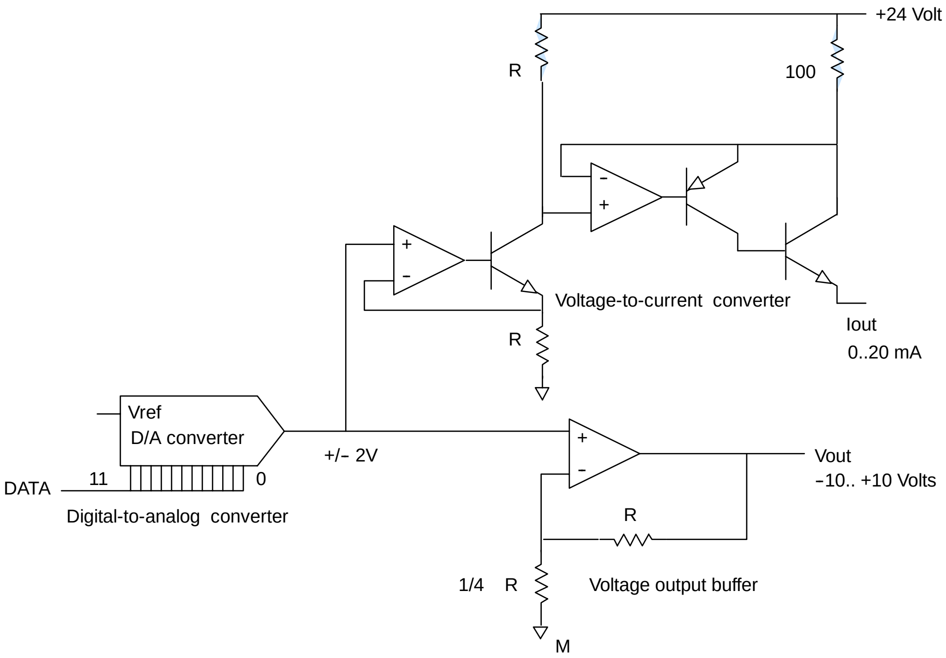


Figure A-21 Output Block Diagram for the EM 232 and EM 235

Installation Guidelines

Use the following guidelines to ensure accuracy and repeatability:

- ❑ Ensure that the 24-VDC Sensor Supply is free of noise and is stable.
- ❑ Use the shortest possible sensor wires.
- ❑ Use shielded twisted pair wiring for sensor wires.
- ❑ Use a braided shield for best noise immunity.
- ❑ Terminate the shield at the Sensor location only.
- ❑ Short the inputs for any unused channels, as shown in Figure A-21.
- ❑ Avoid bending the wires into sharp angles.
- ❑ Use wireways for wire routing.
- ❑ Avoid placing signal wires parallel to high-energy wires. If the two wires must meet, cross them at right angles.
- ❑ Ensure that the input signals are within the common mode voltage specification by isolating the input signals or referencing them to the external 24V common of the analog module.

Tip

The EM 231 and EM 235 expansion modules are not recommended for use with thermocouples.

Understanding the Analog Input Module: Accuracy and Repeatability

The EM 231 and EM 235 analog input modules are low-cost, high-speed 12 bit analog input modules. The modules can convert an analog signal input to its corresponding digital value in 149 μsec. The analog signal input is converted each time your program accesses the analog point. These conversion times must be added to the basic execution time of the instruction used to access the analog input.

The EM 231 and EM 235 provide an unprocessed digital value (no linearization or filtering) that corresponds to the analog voltage or current presented at the module’s input terminals. Since the modules are high-speed modules, they can follow rapid changes in the analog input signal (including internal and external noise).

You can minimize reading-to-reading variations caused by noise for a constant or slowly changing analog input signal by averaging a number of readings. Note that increasing the number of readings used in computing the average value results in a correspondingly slower response time to changes in the input signal.

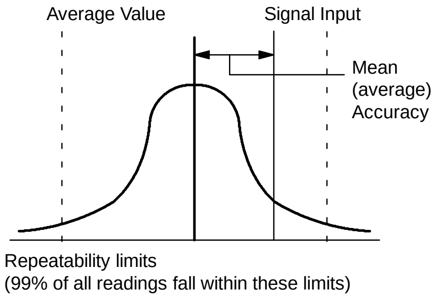


Figure A-22 Accuracy Definitions

Figure A-22 shows the 99% repeatability limits, the mean or average value of the individual readings, and the mean accuracy in a graphical form.

The specifications for repeatability describe the reading-to-reading variations of the module for an input signal that is not changing. The repeatability specification defines the limits within which 99% of the readings will fall. The repeatability is described in this figure by the bell curve.

The mean accuracy specification describes the average value of the error (the difference between the average value of individual readings and the exact value of the actual analog input signal).

Table A-23 gives the repeatability specifications and the mean accuracy as they relate to each of the configurable ranges.

Definitions of the Analog Specifications

- ❑ Accuracy: deviation from the expected value on a given point
- ❑ Resolution: the effect of an LSB change reflected on the output.

Table A-23 EM 231 and EM 235 Specifications

Full Scale Input Range	Repeatability[1]		Mean (average) Accuracy[1,2,3,4,5]	
	% of Full Scale	Counts	% of Full Scale	Counts
EM 231 Specifications				
0 to 5 V	± 0.075%	± 24	± 0.1%	± 32
0 to 20 mA				
0 to 10 V				
± 2.5 V		± 48	± 0.05%	
± 5 V				
EM 235 Specifications				
0 to 50 mV	± 0.075%	± 24	± 0.25%	± 80
0 to 100 mV			± 0.2%	± 64
0 to 500 mV			± 0.05%	± 16
0 to 1 V				
0 to 5 V				
0 to 20 mA				
0 to 10 V				
± 25 mV	± 0.075%	± 48	± 0.25%	± 160
± 50 mV			± 0.2%	± 128
± 100 mV			± 0.1%	± 64
± 250 mV			± 0.05%	± 32
± 500 mV				
± 1 V				
± 2.5 V				
± 5 V				
± 10 V				

[1] Measurements made after the selected input range has been calibrated.

[2] The offset error in the signal near zero analog input is not corrected, and is not included in the accuracy specifications.

[3] There is a channel-to-channel carryover conversion error, due to the finite settling time of the analog multiplexer. The maximum carryover error is 0.1% of the difference between channels.

[4] Mean accuracy includes effects of non-linearity and drift from 0 to 55 degrees C.

[5] Analog input accuracy may deviate up to +/-10% of full scale when subjected to severe RF interferences such as specified in the product standard EN 61131-2:2007. Following the recommended installation guidelines on the previous page can minimize unintended disturbances on analog inputs. For high frequency immunity it is recommended that the cable shield be terminated at both ends.

Thermocouple and RTD Expansion Modules Specifications

Table A-24 Thermocouple and RTD Modules Order Numbers

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 231-7PD22-0XA0	EM 231 Analog Input Thermocouple, 4 Inputs	4 Thermocouple	-	No
6ES7 231-7PF22-0XA0	EM 231 Analog Input Thermocouple, 8 Inputs	8 Thermocouple	-	No
6ES7 231-7PB22-0XA0	EM 231 Analog Input RTD, 2 Inputs	2 RTD	-	No
6ES7 231-7PC22-0XA0	EM 231 Analog Input RTD, 4 Inputs	4 RTD	-	No

Table A-25 Thermocouple and RTD Modules General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 231-7PD22-0XA0	EM 231 Analog Input Thermocouple, 4 Inputs	71.2 x 80 x 62	210 g	1.8 W	87 mA	60 mA
6ES7 231-7PF22-0XA0	EM 231 Analog Input Thermocouple, 8 Inputs	71.2 x 80 x 62	210 g	1.8 W	87 mA	60 mA
6ES7 231-7PB22-0XA0	EM 231 Analog Input RTD, 2 Inputs	71.2 x 80 x 62	210 g	1.8 W	87 mA	60 mA
6ES7 231-7PC22-0XA0	EM 231 Analog Input RTD, 4 Inputs	71.2 x 80 x 62	210 g	1.8 W	87 mA	60 mA

Table A-26 Thermocouple and RTD Modules Specifications

General	6ES7 231-7PD22-0XA0 Thermocouple, 4 Inputs	6ES7 231-7PF22-0XA0 Thermocouple, 8 Inputs	6ES7 231-7PB22-0XA0 RTD, 2 Inputs	6ES7 231-7PC22-0XA0 RTD, 4 Inputs
Isolation				
Field to logic	500 VAC		500 VAC	
Field to 24 VDC	500 VAC		500 VAC	
24 VDC to logic	500 VAC		500 VAC	
Common mode input range (input channel to input channel)	120 VAC		0	
Common mode rejection	> 120 dB at 120 VAC		> 120 dB at 120 VAC	
Input type	Floating TC		Module ground referenced RTD (2, 3, or 4 wire connections)	
Input ranges[1]	TC types (select one per module) S, T, R, E, N, K, J Voltage range : +/- 80 mV		RTD types (select one per module): platinum (Pt), copper (Cu), nickel (Ni), or Resistance See Table A-31 or A-32 for available RTD types.	
Input resolution				
Temperature	0.1° C / 0.1° F		0.1° C / 0.1° F	
Voltage	15 bits plus sign		-	
Resistance	-		15 bits plus sign resistive	
Measuring Principle	Sigma-delta		Sigma-delta	
Module update time: All channels	405 ms	810 ms	405 ms (700 ms for Pt10000)	810 ms (1400 ms for Pt10000)
Wire length	100 meters to sensor max.		100 meters to sensor max.	
Wire loop resistance	100Ω max.		20Ω, 2.7Ω for Cu max.	20Ω, 2.7Ω for 10Ω RTDs
Suppression of interference	85 dB at 50 Hz/60 Hz/ 400 Hz		85 dB at 50 Hz/60 Hz/400 Hz	
Data word format	Voltage: -27648 to + 27648		Resistance: 0 to +27648	
Maximum sensor dissipation	-		1m W	
Input impedance	≥1 MΩ		≥ 10 MΩ	
Maximum input voltage	30 VDC		30 VDC (sense), 5 VDC (source)	30 VDC
Input filter attenuation	-3 db at 21 kHz		-3 db at 3.6 kHz	-3 db at 21 kHz
Basic error	0.1% FS (voltage)		0.1% FS (resistance)	
Repeatability	0.05% FS		0.05% FS	
Cold junction error	±1.5 ° C		-	
LED indicator	2 (External 24 VDC present and System Fail)			
24 VDC supply voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)			

[1] The input range selection (temperature, voltage on resistance) applies to all channels on the module.

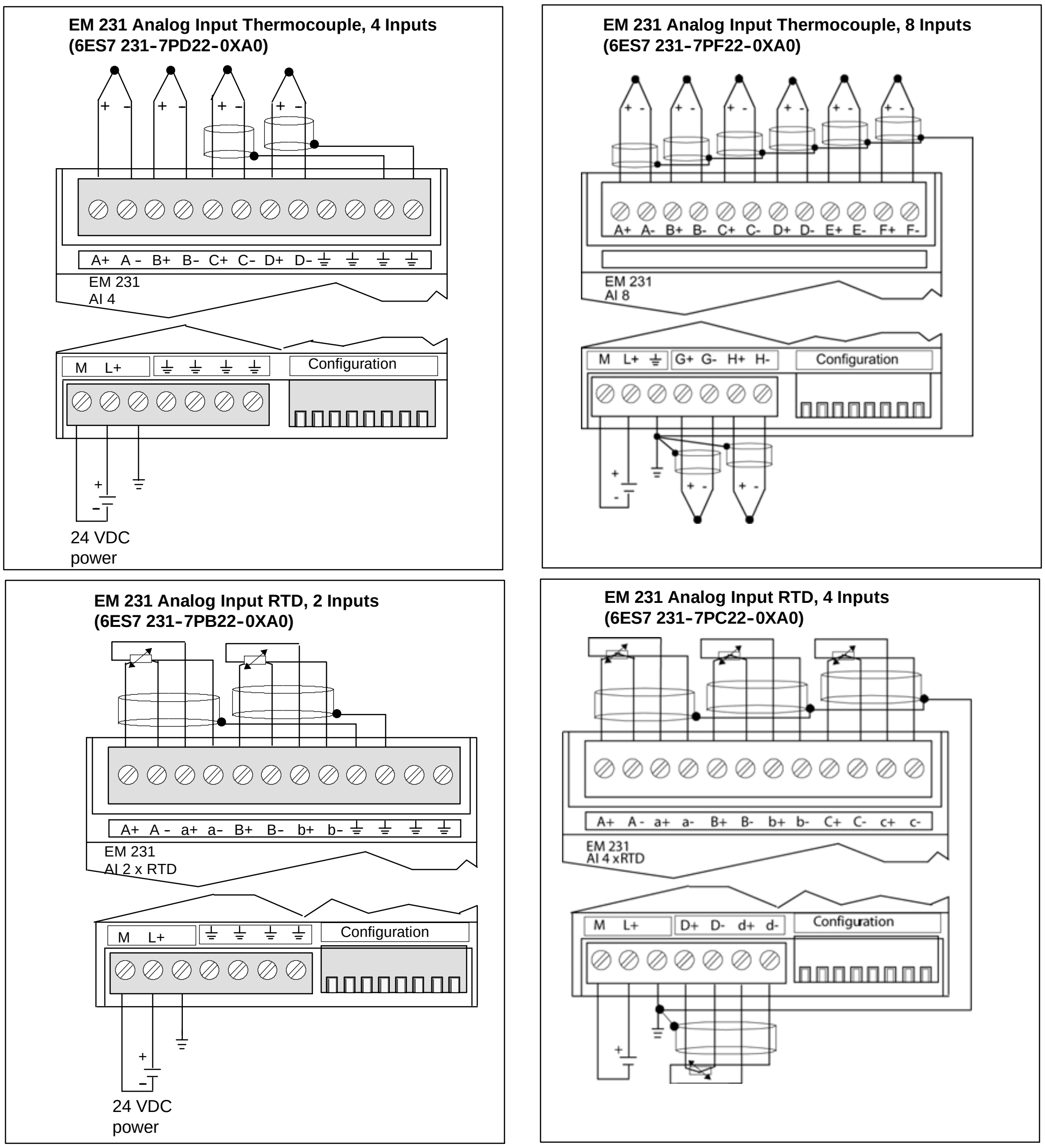


Figure A-23 Connector Terminal Identification for EM 231 Thermocouple and EM 231 RTD Modules

Compatibility

The RTD and Thermocouple modules are designed to work with the CPU 222, CPU 224, CPU 224XP and CPU 226.

Tip

The RTD and Thermocouple modules are designed to give maximum performance when installed in a stable temperature environment.

The EM 231 Thermocouple module, for example, has special cold junction compensation circuitry that measures the temperature at the module connectors and makes necessary changes to the measurement to compensate for temperature differences between the reference temperature and the temperature at the module. If the ambient temperature is changing rapidly in the area where the EM 231 Thermocouple module is installed, additional errors are introduced.

To achieve maximum accuracy and repeatability, Siemens recommends that the S7-200 RTD and Thermocouple modules be mounted in locations that have stable ambient temperature.

Noise Immunity

Use shielded wires for best noise immunity. If a thermocouple input channel is not used, short the unused channel inputs, or connect them in parallel to another channel.

EM 231 Thermocouple Module

The EM 231 Thermocouple module provides a convenient, isolated interface for the S7-200 family to seven thermocouple types: J, K, E, N, S, T, and R. It allows the S7-200 to connect to low level analog signals, ±80mV range. All thermocouples attached to the module must be of the same type.

Thermocouple Basics

Thermocouples are formed whenever two dissimilar metals are electrically bonded to each other. A voltage is generated that is proportional to the junction temperature. This voltage is small; one microvolt could represent many degrees. Measuring the voltage from a thermocouple, compensating for extra junctions, and then linearizing the result forms the basis of temperature measurement using thermocouples.

When you connect a thermocouple to the EM 231 Thermocouple Module, the two dissimilar metal wires are attached to the module at the module signal connector. The place where the two dissimilar wires are attached to each other forms the sensor thermocouple.

Two more thermocouples are formed where the two dissimilar wires are attached to the signal connector. The connector temperature causes a voltage that adds to the voltage from the sensor thermocouple. If this voltage is not corrected, then the temperature reported will deviate from the sensor temperature.

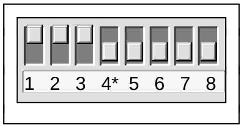
Cold junction compensation is used to compensate for the connector thermocouple. Thermocouple tables are based on a reference junction temperature, usually zero degrees Celsius. The cold junction compensation compensates the connector to zero degrees Celsius. The cold junction compensation restores the voltage added by the connector thermocouples. The temperature of the module is measured internally, then converted to a value to be added to the sensor conversion. The corrected sensor conversion is then linearized using the thermocouple tables.

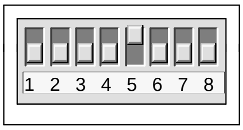
Configuring the EM 231 Thermocouple Module

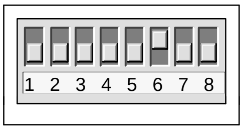
Configuration DIP switches located on the bottom of the module allow you to select the thermocouple type, open wire detect, temperature scale, and cold junction compensation. For the DIP switch settings to take effect, you need to power cycle the PLC and/or the user 24V power supply.

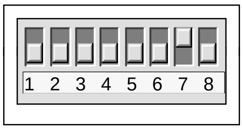
DIP switch 4 is reserved for future use. Set DIP switch 4 to the 0 (down or off) position. Table A-27 shows other DIP switch settings.

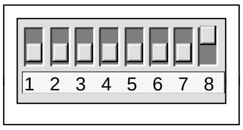
Table A-27 Configuring the Thermocouple Module DIP Switches

Switches 1,2,3	Thermocouple Type	Setting	Description
SW1, 2, 3  Configuration ↑1 – On ↓0 – Off * Set DIP switch 4 to the 0 (down) position.	J (Default)	000	Switches 1 to 3 select the thermocouple type (or mV operation) for all channels on the module. For example, for an E type, thermocouple SW1 = 0, SW2 = 1, SW3 = 1.
	K	001	
	T	010	
	E	011	
	R	100	
	S	101	
	N	110	
	+/–80mV	111	

Switch 5	Open Wire Detect Direction	Setting	Description
SW5  Configuration ↑1 – On ↓0 – Off	Upscale (+3276.7 degrees)	0	0 indicates positive on open wire 1 indicates negative on open wire
	Downscale (–3276.8 degrees)	1	

Switch 6	Open Wire Detect Enable	Setting	Description
SW6  Configuration ↑1 – On ↓0 – Off	Enable	0	Open wire detection is performed by injecting a 25 µA current onto the input terminals. The open wire enable switch enables or disables the current source. The open wire range check is always performed, even when the current source is disabled. The EM 231 Thermocouple module detects open wire if the input signal exceeds approximately ±200mV. When an open wire is detected, the module reading is set to the value selected by the Open Wire Detect.
	Disable	1	

Switch 7	Temperature Scale	Setting	Description
SW7  Configuration ↑1 – On ↓0 – Off	Celsius (°C)	0	The EM 231 Thermocouple module can report temperatures in Celsius or Fahrenheit. The Celsius to Fahrenheit conversion is performed inside the module.
	Fahrenheit (°F)	1	

Switch 8	Cold Junction	Setting	Description
SW8  Configuration ↑1 – On ↓0 – Off	Cold junction compensation enabled	0	Cold junction compensation must be enabled when you are using thermocouples. If cold junction compensation is not enabled, the conversions from the module will be in error because of the voltage that is created when the thermocouple wire is connected to the module connector. Cold junction is automatically disabled when you select the ±80mV range.
	Cold junction compensation disabled	1	

Tip

- The open wire current source could interfere with signals from some low level sources such as thermocouple simulators.
- Input voltages exceeding approximately ±200mV will trigger open wire detection even when the open wire current source is disabled.

Tip

- Module error could exceed specifications while the ambient temperature is changing.
- Exceeding the module ambient temperature range specification could cause the module cold junction to be in error.

Using the Thermocouple: Status Indicators

The EM 231 Thermocouple module provides the PLC with data words that indicate temperatures or error conditions. Status bits indicate range error and user supply/module failure. LEDs indicate the status of the module. Your program should have logic to detect error conditions and respond appropriately for the application. Table A-28 shows the EM 231 Thermocouple status indicators.

Table A-28 EM 231Thermocouple Status Indicators

Error Condition	Channel Data	SF LED Red	24 V LED Green	Range Status Bit[1]	24 VDC User Power Bad[2]
No errors	Conversion data	OFF	ON	0	0
24 V missing	32766	OFF	OFF	0	1
Open wire and current source enabled	–32768/32767	BLINK	ON	1	0
Out of range input	–32768/32767	BLINK	ON	1	0
Diagnostic error[3]	0000	ON	OFF	0	note [3]

[1] Range status bit is bit 3 in module error register byte (SMB9 for Module 1, SMB11 for Module 2, etc.)

[2] User Power Bad status bit is bit 2 in module error register byte (SMB 9, SMB 11, etc., refer to Appendix D)

[3] Diagnostic errors cause a module configuration error. The User Power Bad status bit may or may not be set before the module configuration error.

Tip

The channel data format is two’s complement, 16-bit words. Temperature is presented in 0.1 degree units. For example, if the measured temperature is 100.2 degrees, the reported data is 1002. Voltage data are scaled to 27648. For example, –60.0mV is reported as –20736 (=–60mV/80mV * 27648).

If the PLC has read the data:

□ All 4 channels in the EM 231 Analog Input Thermocouple 4 Inputs are updated every 405 milliseconds.

□ All channels in the EM 231 Analog Input Thermocouple 8 Inputs are updated every 810 milliseconds.

If the PLC does not read the data within one update time, the module reports old data until the next module update after the PLC read. To keep channel data current, it is recommended that the PLC program read data at least as often as the module update rate.

Tip

When you are using the EM 231 Thermocouple module, you should disable analog filtering in the PLC. Analog filtering can prevent error conditions from being detected in a timely manner.

Table A-29 Temperature Ranges (°C) and Accuracy for Thermocouple Types

Data Word (1 digit = 0.1°C)		Type J	Type K	Type T	Type E	Type R, S	Type N	±80mV	
Dec	Hex								
32767	7FFF	>1200.0 °C	>1372.0 °C	>400.0 °C	>1000.0°C	>1768.0°C	>1300.0°C	>94.071mV	OF
↑	↑							↑	↑
32511	7EFF							94.071mV	
:	:								OR
27649	6C01							80.0029mV	
27648	6C00					↑		80mV	
:	:								
17680	4510		↑			1768.0°C			
:	:								NR
13720	3598		1372.0°C				↑		
:	:		overrange						
13000	32C8	↑	1300.0°C				1300.0°C		
:	:								
12000	2EE0	1200.0°C			↑				
:	:								
10000	2710			↑	1000.0°C				
:	:								
4000	0FA0			400.0°C		400.0°C			
:	:								
1	0001	0.1°C	0.1°C	0.1°C	0.1°C	0.1°C	0.1°C	0.0029mV	
0	0000	0.0°C	0.0°C	0.0°C	0.0°C	0.0°C	0.0°C	0.0mV	
−1	FFFF	−0.1°C	−0.1°C	−0.1°C	−0.1°C	−0.1°C	−0.1°C	−0.0029mV	
:	:					underrange			
−500	FE0C					−50.0°C			
−1500	FA24	−150.0°C				↓			
:	:								
−2000	F830	underrange	−200.0°C						
:	:								
−2100	F7CC	−210.0°C							
:	:								
−2400	F6A0				−240.0°C				
:	:		underrange		underrange				
−2550	F60A			−255.0°C					
:	:			underrange					
−2700	F574	↓	−270.0°C	−270.0°C	−270.0°C		−270.0°C		NR
:	:								
−27648	9400		↓	↓	↓		↓	−80.mV	
−27649	93FF							−80.0029mV	
:	:								
−32512	8100							−94.071mV	UR
↓	↓							↓	↓
−32768	8000	<−210.0°C	<−270.0°C	<−270.0°C	<−270.0°C	<−50.0°C	<−270.0°C	<−94.071mV	UF
Accuracy over full span		±0.1%	±0.3%	±0.6%	±0.3%	±0.6%	±0.4%	±0.1%	
Accuracy (normal range without cold junction)		±1.5°C	±1.7°C	±1.4°C	±1.3°C	±3.7°C	±1.6°C	±0.10%	
Cold junction error		±1.5°C	±1.5°C	±1.5°C	±1.5°C	±1.5°C	±1.5°C	N/A	

*OF = Overflow; OR = Overrange; NR = Normal range; UR = Underrange; UF = Underflow

↑ indicates that all analog values greater than this and below the open wire threshold report the overflow data value, 32767 (0x7FFF).
↓ indicates that all analog values less than this and greater than the open wire threshold report the underflow data value, −32768 (0x8000).

Table A-30 Temperature Ranges (°F) for Thermocouple Types

Data Word (1 digit = 0.1°F)		Type J	Type K	Type T	Type E	Type R, S	Type N	±80 mV	
Dec	Hex								
32767	7FFF	>2192.0 °F	>2502.0 °F	>752.0 °F	>1832.0°F	>3214.0°F	>2372.0°F	>94.071mV	OF
↑	↑					↑		↑	↑
32511	7EFF							94.071mV	OR
32140	7D90					3214.0°F			
27649	6C01							80.0029mV	
27648	6C00		↑			2764.8°F		80mV	NR
:	:								
25020	61B8		2502.0°F				↑		
:	:		overrange						
23720	5CA8	↑	2372.0°F				2372.0°F		
:	:								
21920	55A0	2192.0°F			↑				
:	:								
18320	4790			↑	1832.0°F				
:	:								
7520	1D60			752.0°F		752.0°F			
:	:								
320	0140					underrange	32.0°F		
:	:								
1	0001	0.1°F	0.1°F	0.1°F	0.1°F	0.1°F	0.1°F	0.0029mV	
0	0000	0.0°F	0.0°F	0.0°F	0.0°F	0.0°F	0.0°F	0.0mV	
-1	FFFF	-0.1°F	-0.1°F	-0.1°F	-0.1°F	-0.1°F	-0.1°F	-0.0029mV	
:	:								
-580	FDBC					-58.0°F			
:	:								
-2380	F6B4	-238.0°F							
:	:								
-3280	F330	underrange	-328.0°F				underrange		
:	:								
-3460	F27C	-346.0°F				↓			
:	:		underrange						
-4000	F060				-400.0°F				
:	:				underrange				
-4270	EF52			-427.0°F					
:	:			underrange					
-4540	EE44	↓	-454.0°F	-454.0°F	-454.0°F		-454.0°F		
:	:								NR
-27648	9400		↓	↓	↓		↓	-80mV	
-27649	93FF							-80.0029mV	OR
:	:								
-32512	8100							-94.071mV	
↓	↓							↓	↓
-3268	8000	<-346.0° F	<-454.0° F	<-454.0° F	<-454.0° F	<-58.0° F	<-454.0° F	<-94.07 mV	UF

*OF = Overflow; OR = Overrange; NR = Normal range; UR = Underrange; UF = Underflow

↑ indicates that all analog values greater than this and below the open wire threshold report the overflow data value, 32767 (0x7FFF).

↓ indicates that all analog values less than this and greater than the open wire threshold report the underflow data value, -32768 (0x8000).

EM 231 RTD Module

The EM 231 RTD module provides a convenient interface for the S7-200 family to several different RTDs. It also allows the S7-200 to measure three different resistance ranges. All RTDs attached to the module must be of the same type.

Configuring the EM 231 RTD Module

DIP switches enable you to select RTD type, wiring configuration, temperature scale, and burnout direction. The DIP switches are located on the bottom of the module as shown in Figure A-24. For the DIP switch settings to take effect, you need to power cycle the PLC and/or the user 24V power supply.

Select RTD type by setting DIP switches 1, 2, 3, 4, 5 and 6 to correspond to the RTD as shown in Table A-31 and Table A-32. Refer to Table A-33 for other DIP switch settings.

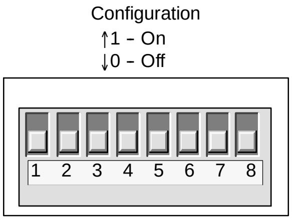


Figure A-24 DIP Switches for the EM 231 RTD Module

Table A-31 Selecting the RTD Type: DIP Switches 1 to 6 for the EM 231 Analog Input RTD 4 Inputs

RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5	SW6	RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5	SW6
100Ω Pt 0.003850 (Default)	0	0	0	0	0	0	100Ω Pt 0.003902	1	0	0	0	0	0
200Ω Pt 0.003850	0	0	0	0	1	0	200Ω Pt 0.003902	1	0	0	0	1	0
500Ω Pt 0.003850	0	0	0	1	0	0	500Ω Pt 0.003902	1	0	0	1	0	0
1000Ω Pt 0.003850	0	0	0	1	1	0	1000Ω Pt 0.003902	1	0	0	1	1	0
100Ω Pt 0.003920	0	0	1	0	0	0	SPARE	1	0	1	0	0	0
200Ω Pt 0.003920	0	0	1	0	1	0	100Ω Ni 0.00672	1	0	1	0	1	0
500Ω Pt 0.003920	0	0	1	1	0	0	120Ω Ni 0.00672	1	0	1	1	0	0
1000Ω Pt 0.003920	0	0	1	1	1	0	1000Ω Ni 0.00672	1	0	1	1	1	0
100Ω Pt 0.00385055	0	1	0	0	0	0	100Ω Ni 0.006178	1	1	0	0	0	0
200Ω Pt 0.00385055	0	1	0	0	1	0	120Ω Ni 0.006178	1	1	0	0	1	0
500Ω Pt 0.00385055	0	1	0	1	0	0	1000Ω Ni 0.006178	1	1	0	1	0	0
1000Ω Pt 0.00385055	0	1	0	1	1	0	10000Ω Pt 0.003850	1	1	0	1	1	0
100Ω Pt 0.003916	0	1	1	0	0	0	10Ω Cu 0.004270	1	1	1	0	0	0
200Ω Pt 0.003916	0	1	1	0	1	0	150Ω FS Resistance	1	1	1	0	1	0
500Ω Pt 0.003916	0	1	1	1	0	0	300Ω FS Resistance	1	1	1	1	0	0
1000Ω Pt 0.003916	0	1	1	1	1	0	600Ω FS Resistance	1	1	1	1	1	0
GOST 50Ω Pt 0.00385055	0	0	0	0	1	1	GOST Cu 50Ω 0.00426	0	1	0	1	1	1
GOST 100Ω Pt 0.00385055	0	0	0	1	0	1	GOST Cu 100Ω 0.00426	0	1	1	0	0	1
GOST 500Ω Pt 0.00385055	0	0	0	1	1	1	GOST Cu 500Ω 0.00426	0	1	1	0	1	1
GOST 10Ω Pt 0.003910	0	0	1	0	0	1	GOST Cu 10Ω 0.00428	0	1	1	1	0	1
GOST 500Ω Pt 0.003910	0	0	1	0	1	1	GOST Cu 50Ω 0.00428	0	1	1	1	1	1
GOST 100Ω Pt 0.003910	0	0	1	1	0	1	GOST Cu 100Ω 0.00428	1	0	0	0	0	1
GOST 500Ω Pt 0.003910	0	0	1	1	1	1	GOST Cu 500Ω 0.00428	1	0	0	0	1	1

Table A-31 Selecting the RTD Type: DIP Switches 1 to 6 for the EM 231 Analog Input RTD 4 Inputs

RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5	SW6	RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5	SW6
GOST 10Ω Pt 0.003910	0	1	0	0	0	1	Spare	1	0	0	1	0	1
LG–Ni 1000Ω Pt 0.005000	0	1	0	0	1	1							

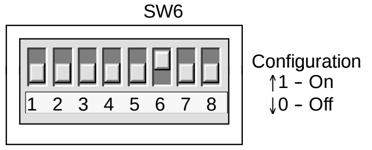
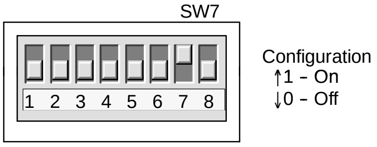
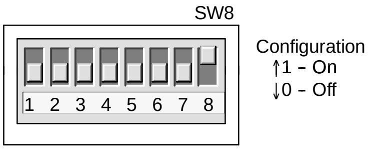
[1] All RTDs represent 0° C. at the listed resistance except for Cu 10 ohm. Cu 10 ohm is 25° C. at 10 ohm and 0° C. at 9.035 ohm.

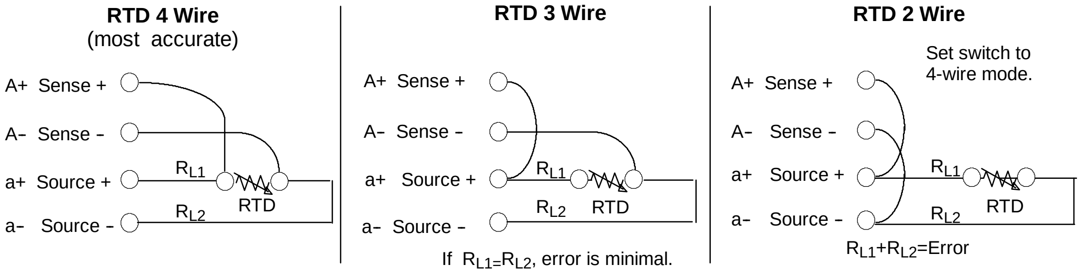
Table A-32 Selecting the RTD Type: DIP Switches 1 to 5 for the EM 231 Analog Input RTD 2 Inputs

RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5	RTD Type and Alpha[1]	SW1	SW2	SW3	SW4	SW5
100Ω Pt 0.003850 (Default)	0	0	0	0	0	100Ω Pt 0.003902	1	0	0	0	0
200Ω Pt 0.003850	0	0	0	0	1	200Ω Pt 0.003902	1	0	0	0	1
500Ω Pt 0.003850	0	0	0	1	0	500Ω Pt 0.003902	1	0	0	1	0
1000Ω Pt 0.003850	0	0	0	1	1	1000Ω Pt 0.003902	1	0	0	1	1
100Ω Pt 0.003920	0	0	1	0	0	SPARE	1	0	1	0	0
200Ω Pt 0.003920	0	0	1	0	1	100Ω Ni 0.00672	1	0	1	0	1
500Ω Pt 0.003920	0	0	1	1	0	120Ω Ni 0.00672	1	0	1	1	0
1000Ω Pt 0.003920	0	0	1	1	1	1000Ω Ni 0.00672	1	0	1	1	1
100Ω Pt 0.00385055	0	1	0	0	0	100Ω Ni 0.006178	1	1	0	0	0
200Ω Pt 0.00385055	0	1	0	0	1	120Ω Ni 0.006178	1	1	0	0	1
500Ω Pt 0.00385055	0	1	0	1	0	1000Ω Ni 0.006178	1	1	0	1	0
1000Ω Pt 0.00385055	0	1	0	1	1	10000Ω Pt 0.003850	1	1	0	1	1
100Ω Pt 0.003916	0	1	1	0	0	10Ω Cu 0.004270	1	1	1	0	0
200Ω Pt 0.003916	0	1	1	0	1	150Ω FS Resistance	1	1	1	0	1
500Ω Pt 0.003916	0	1	1	1	0	300Ω FS Resistance	1	1	1	1	0
1000Ω Pt 0.003916	0	1	1	1	1	600Ω FS Resistance	1	1	1	1	1

[1] All RTDs represent 0° C. at the listed resistance except for Cu 10 ohm. Cu 10 ohm is 25° C. at 10 ohm and 0° C. at 9.035 ohm.

Table A-33 Setting RTD DIP Switches for the EM 231 Analog Input RTD Module

Switch 6 (2 Channel Module Only)	Open Wire Detect/ Out of Range	Setting	Description
 SW6 1 2 3 4 5 6 7 8 Configuration ↑1 – On ↓0 – Off	Upscale (+3276.7 degrees)	0	Indicates positive on open wire or out of range
	Downscale (–3276.8 degrees)	1	Indicates negative on open wire or out of range
Switch 7 (Both Modules)	**Temperature Scale**	**Setting**	**Description**
 SW7 1 2 3 4 5 6 7 8 Configuration ↑1 – On ↓0 – Off	Celsius (°C)	0	The RTD module can report temperatures in Celsius or Fahrenheit. The Celsius to Fahrenheit conversion is performed inside the module.
	Fahrenheit (°F)	1	
Switch 8 (Both Modules)	**Wiring Scheme**	**Setting**	**Description**
 SW8 1 2 3 4 5 6 7 8 Configuration ↑1 – On ↓0 – Off	3-wire	0	You can wire the RTD module to the sensor in three ways (shown in the figure). The most accurate is 4 wire). The least accurate is 2 wire, which is only recommended if errors due to wiring can be ignored in your application.
	2-wire or 4-wire	1	



RTD 4 Wire
(most accurate)

RTD 3 Wire

RTD 2 Wire

Note: R_{L1} = Lead resistance from a+ terminal to the RTD
R_{L2} = Lead resistance from a– terminal to the RTD

Figure A-25 Wiring the RTD to the Sensor by 4, 3, and 2 Wire

EM 231 RTD Status Indicators

The RTD module provides the PLC with data words that indicate temperatures or error conditions. Status bits indicate range error and user supply/module failure. LEDs indicate the status of the module. Your program should have logic to detect error conditions and respond appropriately for the application. Table A-34 shows the status indicators provided by the EM 231 RTD module.

Tip

The channel data format is twos complement, 16-bit words. Temperature is presented in 0.1 degree units. (For example, if the measured temperature is 100.2 degrees, the reported data is 1002.) Resistance data are scaled to 27648. For example, 75% of full scale resistance is reported as 20736.

(225Ω / 300Ω * 27648 = 20736)

Table A-34 EM 231 RTD Status Indicators

Error Condition	Channel Data	SF LED Red	24 V LED Green	Range Status Bit[1]	24 VDC User Power Bad[2]
No errors	Conversion data	OFF	ON	0	0
24 V missing	32766	OFF	OFF	0	1
SW detects open wire	–32768/32767	BLINK	ON	1	0
Out of range input	–32768/32767	BLINK	ON	1	0
Diagnostic error[3]	0000	ON	OFF	0	note[3]

[1] Range status bit is bit 3 in module error register byte (SMB9 for Module 1, SMB11 for Module 2, etc.)
[2] User Power Bad status bit is bit 2 in module error register byte (such as SMB 9, SMB 11, refer to Appendix D.)
[3] Diagnostic errors cause a module configuration error. The User Power Bad status bit may or may not be set before the module configuration error.

If the PLC has read the data:

- All 4 channels in the EM 231 Analog Input RTD 2 Inputs are updated every 405 milliseconds.
- All channels in the EM 231 Analog Input RTD 4 Inputs are updated every 810 milliseconds.

If the PLC does not read the data within one update time, the module reports old data until the next module update after the PLC read. To keep channel data current, it is recommended that the PLC program read data at least as often as the module update rate.

Tip

When you are using the RTD module, be sure to disable analog filtering in the PLC. Analog filtering can prevent error conditions from being detected in a timely manner.

Open wire detection is performed by software internal to the RTD module. Out of range inputs and detected open wire conditions are signaled by setting the range status bit in the SMB and by setting the channel data up or down scale per the switch settings. Open wire detection takes a minimum of three module scan cycles and can take longer, depending on which wire(s) are open. Open Source+ and/or Source– wires are detected in the minimum time. Open Sense+ and/or Sense– wires can take 5 seconds or more to detect. Open sense lines can randomly present valid data, with open wire detected intermittently, especially in electrically noisy environments. Electrical noise can also extend the time it takes to detect the open wire condition. It is recommended that open wire/out of range indications be latched in the application program after valid data has been reported.

Tip

If you have an unused channel, you can wire the that channel with a resistor in place of the RTD to prevent open wire detection from causing the SF LED to blink. The resistor must be the nominal value of the RTD. For example, use 100 ohms for PT100 RTD .

EM 231 RTD Module Ranges

EM 231 RTD temperature ranges and accuracy for each type of RTD module are shown in Tables A-35 and A-36.

Table A-35 Temperature Ranges (°C) and Accuracy for the RTD Module

Decimal	Hex	Pt10000	Pt100, Pt200, Pt500, Pt1000, & GOST 0.003850	GOST 0.003910 Pt10, Pt50, Pt100, Pt500	Ni100, Ni120, Ni1000 LG-Ni1000	Ni100 GOST 0.006170	Cu 10 0.00427	GOST 0.00426 Cu 10 Cu 50 Cu 100 Cu 500	GOST 0.00428 Cu 10 Cu 50 Cu 100 Cu 500	
32767	7FFF									
32766	7FFE									
32511	7EFF									
27649	6C01									
27648	6C00									
25000	61A8									↑
18000	4650									Over-range
15000	3A98			↑						
12950	3296			1295.0° C						
11000	2AF8	↑	↑	1100.0°C						
10000	2710	1000.0° C	1000.0°C							
8500	2134		850.0° C							
6000	1770	600.0° C					↑			
3120	0C30				↑		312.0° C			N
2950	0B86				295.0° C					O
2600	0A28						260.0° C			M
2500	09C4				250.0° C			↑	↑	I
2400	960					↑		240.0° C	240.0° C	N
2124	84C					212.4° C				A
2000	7D0							200.0° C	200.0° C	L
1800	708					180.0° C				
1	0001	0.1° C	0.1° C	0.1° C	0.1° C	0.1° C	0.1° C	0.1° C	0.1° C	R
0	0000	0.0° C	0.0° C	0.0° C	0.0° C	0.0° C	0.0° C	0.0° C	0.0° C	A
-1	FFFF	-0.1° C	-0.1° C	-0.1° C	-0.1° C	-0.1° C	-0.1° C	-0.1° C	-0.1° C	N
500	FE0C							-50.0° C		G
-600	FDA8				-60.0° C	-60.0° C		-60.0° C		E
								↓		
-1050	FBE6				-105.0° C	-105.0° C				
					↓	↓				
-2000	F830	-200.0° C	-200.0° C				-200.0° C		-200.0° C	
-2400	F6A0						-240.0° C		-240.0° C	
-2430	F682	-243.0° C	-243.0° C				↓		↓	
-2600	F5D8	↓	↓	-260.0° C						
-273.2	F554			-273.2° C						
-6000	E890									Under-range
-10500	D6FC									↓
-12000	D120									
-32767	8001									
-32768	8000									
ACCURACY OVER FULL SPAN		±0.4%	±0.1%	±0.5%	±0.2%	±0.5%	±0.2%	±0.3%	±0.3%	
ACCURACY IN NOMINAL RANGE		±4° C	±1° C	±1° C[1]	±0.6° C	±42.8° C	±1° C	±1° C	±1° C	

[1] OF = Overflow; OR = Over range; NR = Nominal range; UR = Under range; UF = Underflow
↑ or ↓ : All analog values exceeding the limits will report the out of range value, 32767 (0x7FFF).
[1]Accuracy decreases below -250 C to as great as 7 C.

[2] Accuracy may deviate up to +/- 1.5% of full-scale when subjected to severe RF interferences such as specified in the generic immunity standard EN 61000-6-2.

Table A-36 Temperature Ranges (°F) and Accuracy for the RTD Module

Decimal	Hex	Pt10000	Pt100, Pt200, Pt500, Pt1000, & GOST 0.003850	GOST 0.003910 Pt10, Pt50, Pt100, Pt500	Ni100, Ni120, Ni1000 LG-Ni1000	Ni100 GOST 0.006170	Cu 10 0.00427	GOST 0.00426 Cu 10 Cu 50 Cu 100 Cu 500	GOST 0.00428 Cu 10 Cu 50 Cu 100 Cu 500	
32767	7FFF									
32766	7FFE									
										↑
										Over-range
				↑						
23630	5C4E			2363.0° F						
20120	4E98	↑	↑	2012.0°F						
18320	4790	1832.0° F	1832.0°F							
15620	3D04		1562.0° F							
11120	2B70	1112.0° F					↑			
5936	1730				↑		593.6° F			N
5630	15FE				563.0° F					O
5000	1388						500.0° F			M
4820	12D4				482.0° F			↑	↑	I
4640	1220					↑		464.0° F	464.0° F	N
4143	102F					414.3° F				A
3920	F50							392.0° F	392.0° F	L
3560	DE8					356.0° F				
1	0001	0.1° F	0.1° F	0.1° F	0.1° F	0.1° F	0.1° F	0.1° F	0.1° F	R
0	0000	0.0° F	0.0° F	0.0° F	0.0° F	0.0° F	0.0° F	0.0° F	0.0° F	A
-1	FFFF	-0.1° F	-0.1° F	-0.1° F	-0.1° F	-0.1° F	-0.1° F	-0.1° F	-0.1° F	N
-580	FDBC							-58.0° F		G
-760	FD08				-76.0° F	-76.0° F		-76.0° F		E
								↓		
-1570	F9DE				-157.0° F	-157.0° F				
					↓	↓				
-3280	F330	-328.0° F	-328.0° F				-328.0° F		-328.0° F	
-4000	F060						-400.0° F		-400.0° F	
-4054	F02A	-405.4° F	-405.4° F				↓		↓	
-4360	EEF8	↓	↓	-436.0° F						
-459.8	EE0A			-459.8° F						
										Under-range
										↓
-32767	8001									
-32768	8000									

OF =Overflow; OR = Over range; NR = Nominal range; UR = Under range; UF = Underflow

↑ or ↓ : All analog values exceeding the limits will report the out of range value, 32767 (0x7FFF).

Table A-37 Representation of the analog values from 150Ω to 600Ω resistive transducers

System		Resistive transducer range			
Decimal	**Hexadecimal**	**150Ω**	**300Ω**	**600Ω**	
32767	7FFF	177.77Ω	355.54Ω	711.09Ω	Overflow
32512	7F00	176.39Ω	352.78Ω	705.55Ω	
32511	7EFF	176.38Ω	352.77Ω	705.53Ω	Overshoot range
27649	6C01	150.01Ω	300.01Ω	600.02Ω	
27648	6C00	150Ω	300Ω	600Ω	Nominal range
20736	5100	112.5Ω	225Ω	450Ω	
1	1	5.43mΩ	10.85mΩ	21.70mΩ	
0	0	0Ω	0Ω	0Ω	
		Negative values are physically impossible			Undershoot range

EM 277 PROFIBUS-DP Module Specifications

Table A-38 EM 277 PROFIBUS-DP Module Order Number

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 277-0AA22-0XA0	EM 277 PROFIBUS-DP	-	-	No

Table A-39 EM 277 PROFIBUS-DP Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 277-0AA22-0XA0	EM 277 PROFIBUS-DP	71 x 80 x 62	175 g	2.5 W	150mA	See below

Table A-40 EM 277 PROFIBUS-DP Module Specifications

General	6ES7 277-0AA22-0XA0
Number of Ports (Limited Power)	1
Electrical interface	RS-485
PROFIBUS-DP/MPI baud rates (set automatically)	9.6, 19.2, 45.45, 93.75, 187.5, and 500 kbaud; 1, 1.5, 3, 6, and 12 Mbaud
Protocols	PROFIBUS-DP slave and MPI slave
Cable Length	
Up to 93.75 kbaud	1200 m
187.5 kbaud	1000 m
500 kbaud	400 m
1 to 1.5 Mbaud	200 m
3 to 12 Mbaud	100 m
Network Capabilities	
Station address settings	0 to 99 (set by rotary switches)
Maximum stations per segment	32
Maximum stations per network	126, up to 99 EM 277 stations
MPI Connections	6 total, 2 reserved (1 for PG and 1 for OP)
24 VDC Input Power Requirements	
Voltage range	20.4 to 28.8 VDC (Class 2, Limited Power, or sensor power from PLC)
Maximum current Module only with port active Add 90 mA of 5V port load Add 120 mA of 24V port load	 30 mA 60 mA 180 mA
Ripple noise (<10 MHz)	<1 V peak to peak (maximum)
Isolation (field to logic)[1]	500 VAC for 1 minute
5 VDC Power on Communications Port	
Maximum current per port	90 mA
Isolation (24 VDC to logic)	500 VAC for 1 minute
24 VDC Power on Communications Port	
Voltage range	20.4 to 28.8 VDC
Maximum current per port	120 mA
Current limit	0.7 to 2.4 A
Isolation	Not isolated, same circuit as input 24 VDC

[1] No power is supplied to module logic by the 24 VDC supply. 24 VDC supplies power for the communications port.

S7-200 CPUs that Support Intelligent Modules

The EM 277 PROFIBUS-DP slave module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table A-41.

Table A-41 EM 277 PROFIBUS-DP Module Compatibility with S7-200 CPUs

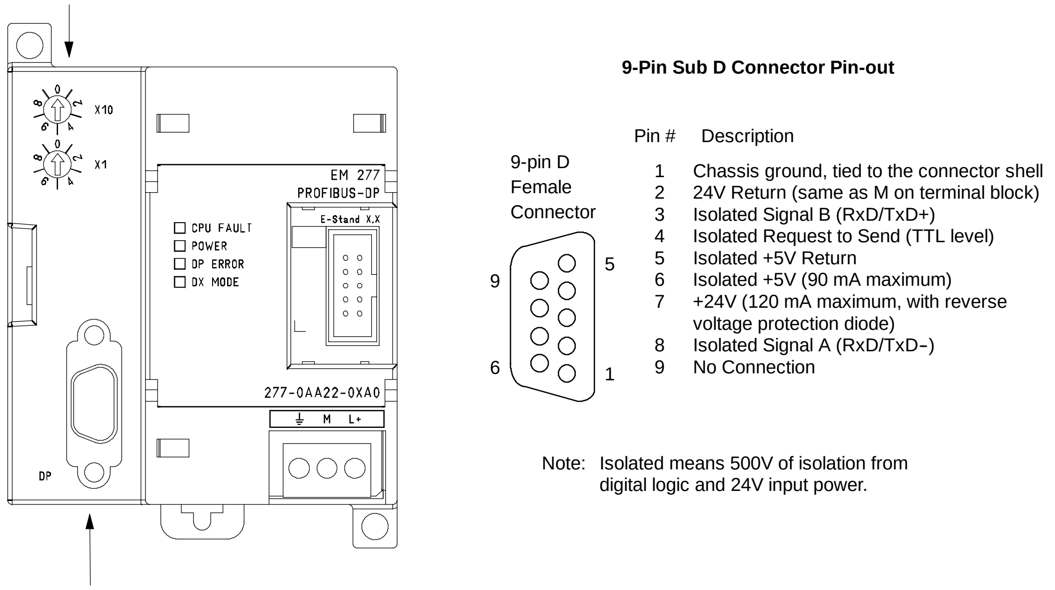
CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel. 2.0 or greater	CPU 224XP DC/DC/DC and CPU 224XP AC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

Address Switches and LEDs

The address switches and status LEDs are located on the front of the module as shown in Figure A-26. The pin-out for the DP slave port connector is also shown. See Table A-45 for a description of the status LEDs.

Front View of EM 277 PROFIBUS-DP

Address Switches:
x10=sets the most significant digit of the address
x1= sets the least significant digit of the address



9-Pin Sub D Connector Pin-out

Pin #	Description
1	Chassis ground, tied to the connector shell
2	24V Return (same as M on terminal block)
3	Isolated Signal B (RxD/TxD+)
4	Isolated Request to Send (TTL level)
5	Isolated +5V Return
6	Isolated +5V (90 mA maximum)
7	+24V (120 mA maximum, with reverse voltage protection diode)
8	Isolated Signal A (RxD/TxD-)
9	No Connection

Note: Isolated means 500V of isolation from digital logic and 24V input power.

DP Slave Port Connector

Figure A-26 EM 277 PROFIBUS-DP

Distributed Peripheral (DP) Standard Communications

PROFIBUS–DP (or DP Standard) is a remote I/O communications protocol defined by the European Standard EN 50170. Devices that adhere to this standard are compatible even though they are manufactured by different companies. DP stands for distributed peripherals, that is, remote I/O. PROFIBUS stands for Process Field Bus.

The EM 277 PROFIBUS–DP module has implemented the DP Standard protocol as defined for slave devices in the following communications protocol standards:

- ❑ EN 50 170 (PROFIBUS) describes the bus access and transfer protocol and specifies the properties of the data transfer medium.
- ❑ EN 50 170 (DP Standard) describes the high-speed cyclic exchange of data between DP masters and DP slaves. This standard defines the procedures for configuration and parameter assignment, explains how cyclic data exchange with distributed I/O functions, and lists the diagnostic options which are supported.

A DP master is configured to know the addresses, slave device types, and any parameter assignment information that the slaves require. The master is also told where to place data that is read from the slaves (inputs) and where to get the data to write to the slaves (outputs). The DP master establishes the network and then initializes its DP slave devices. The master writes the parameter assignment information and I/O configuration to the slave. The master then reads the diagnostics from the slave to verify that the DP slave accepted the parameters and the I/O configuration. The master then begins to exchange I/O data with the slave. Each transaction with the slave writes outputs and reads inputs. The data exchange mode continues indefinitely. The slave devices can notify the master if there is an exception condition and the master then reads the diagnostic information from the slave.

Once a DP master has written the parameters and I/O configuration to a DP slave, and the slave has accepted the parameters and configuration from the master, the master owns that slave. The slave only accepts write requests from the master that owns it. Other masters on the network can read the slave’s inputs and outputs, but they cannot write anything to the slave.

Using the EM 277 to Connect an S7-200 as a DP Slave

The S7-200 CPU can be connected to a PROFIBUS–DP network through the EM 277 PROFIBUS–DP expansion slave module. The EM 277 is connected to the S7-200 CPU through the serial I/O bus. The PROFIBUS network is connected to the EM 277 PROFIBUS–DP module through its DP communications port. This port operates at any PROFIBUS baud rate between 9600 baud and 12 Mbaud. See the Specifications for EM 277 PROFIBUS–DP Module for the baud rates supported.

As a DP slave device, the EM 277 module accepts several different I/O configurations from the master, allowing you to tailor the amount of data transferred to meet the requirements of the application. Unlike many DP devices, the EM 277 module does not transfer only I/O data. Inputs, counter values, timer values, or other calculated values can be transferred to the master by first moving the data to the variable memory in the S7-200 CPU. Likewise, data from the master is stored in variable memory in the S7-200 CPU and can be moved to other data areas.

The DP port of the EM 277 PROFIBUS–DP module can be attached to a DP master on the network and still communicate as an MPI slave with other master devices such as SIMATIC programming devices or S7-300/S7-400 CPUs on the same network. Figure A-27 shows a PROFIBUS network with a CPU 224 and an EM 277 PROFIBUS–DP module.

- The CPU 315–2 is the DP master and has been configured by a SIMATIC programming device with STEP 7 programming software.
- The CPU 224 is a DP slave owned by the CPU 315–2. The ET 200 I/O module is also a slave owned by the CPU 315–2.
- The S7-400 CPU is attached to the PROFIBUS network and is reading data from the CPU 224 by means of XGET instructions in the S7-400 CPU user program.

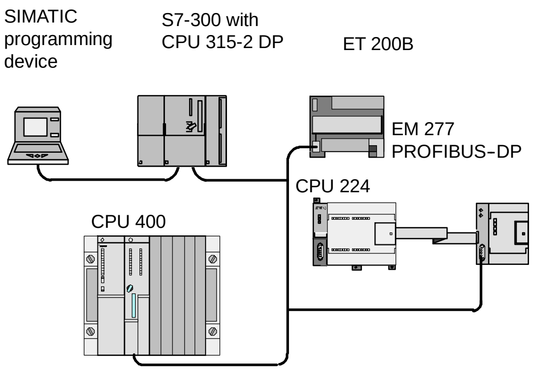


Figure A-27 EM 277 PROFIBUS–DP Module and CPU 224 on a PROFIBUS Network

Configuration

To use the EM 277 PROFIBUS–DP as a DP slave, you must set the station address of the DP port to match the address in the configuration of the master. The station address is set with the rotary switches on the EM 277 module. You must power cycle the CPU after you have made a switch change in order for the new slave address to take effect.

The master device exchanges data with each of its slaves by sending information from its output area to the slave's output buffer (called a "Receive mailbox"). The slave responds to the message from the master by returning an input buffer (called a "Send mailbox") which the master stores in an input area.

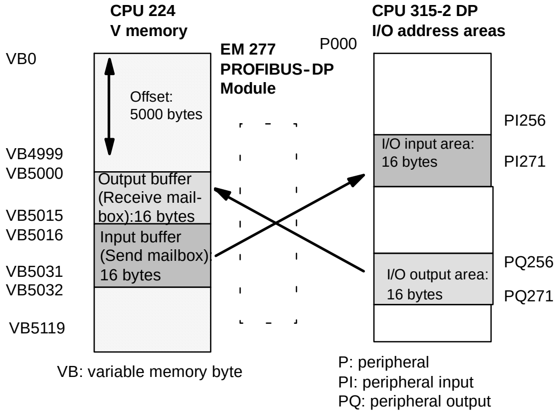


Figure A-28 V Memory and I/O Address Area

Figure A-28 shows an example of the V memory and I/O address area of a PROFIBUS–DP Master.

The EM 277 PROFIBUS–DP can be configured by the DP master to accept output data from the master and return input data to the master. The output and input data buffers reside in the variable memory (V memory) of the S7-200 CPU. When you configure the DP master, you define the byte location in V memory where the output data buffer should start as part of the parameter assignment information for the EM 277. You also define the I/O configuration as the amount of output data to be written to the S7-200 CPU and amount of input data to be returned from the S7-200 CPU. The EM 277 determines the size of the input and output buffers from the I/O configuration. The DP master writes the parameter assignment and I/O configuration information to the EM 277 PROFIBUS DP module. The EM 277 then transfers the V memory address and input and output data lengths to the S7-200 CPU.

Figure A-28 shows a memory model of the V memory in a CPU 224 and the I/O address areas of a DP master CPU. In this example, the DP master has defined an I/O configuration of 16 output bytes and 16 input bytes, and a V memory offset of 5000. The output buffer and input buffer lengths in the CPU 224 (determined from the I/O configuration) are both 16 bytes long. The output data buffer starts at V5000; the input buffer immediately follows the output buffer and begins at V5016. The output data (from the master) is placed in V memory at V5000. The input data (to the master) is taken from the V memory at V5016.

Tip

If you are working with a data unit (consistent data) of three bytes or data units greater than four bytes, you must use SFC14 to read the inputs of the DP slave and SFC15 to address the outputs of the DP slave. For more information, see the S*ystem Software for S7-300 and S7-400 System and Standard Functions Reference Manual*.

Table A-42 lists the configurations that are supported by the EM 277 PROFIBUS–DP module. The default configuration for the EM 277 module is two words of input and two words of output.

Table A-42 EM 277 Configuration Options

Configuration	Inputs to Master	Outputs from Master	Data Consistency
1	1 word	1 word	Word Consistency
2	2 words	2 words	
3	4 words	4 words	
4	8 words	8 words	
5	16 words	16 words	
6	32 words	32 words	
7	8 words	2 words	
8	16 words	4 words	
9	32 words	8 words	
10	2 words	8 words	
11	4 words	16 words	
12	8 words	32 words	
13	2 bytes	2 bytes	Byte Consistency
14	8 bytes	8 bytes	
15	32 bytes	32 bytes	
16	64 bytes	64 bytes	
17	4 bytes	4 bytes	Buffer Consistency
18	8 bytes	8 bytes	
19	12 bytes	12 bytes	
20	16 bytes	16 bytes	

You can configure the location of the input and output buffers to be anywhere in the V memory of the S7-200 CPU. The default address for the input and output buffers is VB0. The location of the input and output buffers is part of the parameter assignment information that the master writes to the S7-200 CPU. You configure the master to recognize its slaves and to write the required parameters and I/O configuration to each of its slaves.

Use the following tools to configure the DP master:

❑ For SIMATIC S5 masters, use COM PROFIBUS Windows software

❑ For SIMATIC S7 masters, use STEP 7 programming software

❑ For SIMATIC 505 masters, use COM PROFIBUS and either TISOFT2 or SoftShop

For detailed information about using these configuration and programming software packages, refer to the manuals for these devices. For detailed information about the PROFIBUS network and its components, refer to the *ET 200 Distributed I/O System Manual*.

Data Consistency

PROFIBUS supports three types of data consistency:

- ❑ Byte consistency ensures that bytes are transferred as whole units.
- ❑ Word consistency ensures that word transfers cannot be interrupted by other processes in the CPU (the two bytes composing the word are always moved together and cannot be split). Use Word consistency if the data values being transferred are integers.

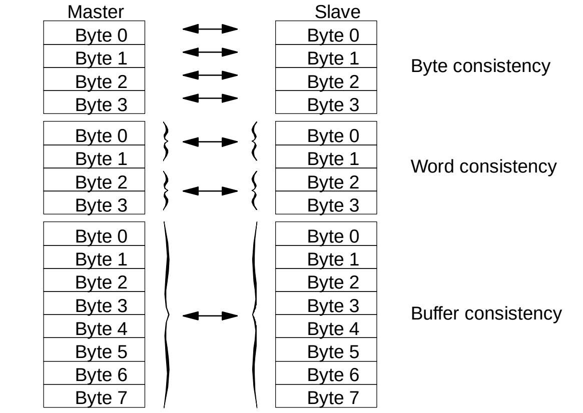


Figure A-29 Byte, Word, and Buffer Data Consistency

- ❑ Buffer consistency ensures that the entire buffer of data is transferred as a single unit, uninterrupted by any other process in the CPU. Buffer consistency should be used if the data values are double words or floating point values or when a group of values all relate to one calculation or item.

You set the data consistency as part of the I/O configuration in the master. The data consistency selection is written to the DP slave as part of the initialization of the slave. Both the DP master and the DP slave use the data consistency selection to be sure that data values (bytes, words, or buffers) are transferred uninterrupted within master and slave. The different types of consistency are shown in Figure A-29.

User Program Considerations

Once the EM 277 PROFIBUS-DP module has been successfully configured by a DP master, the EM 277 and the DP master enter data exchange mode. In data exchange mode, the master writes output data to the EM 277 PROFIBUS-DP module, the EM 277 module then responds with most current S7-200 CPU input data. The EM 277 module continuously updates its inputs from the S7-200 CPU in order to provide the most recent input data to the DP Master. The module then transfers the output data to the S7-200 CPU. The output data from the master is placed into V memory (the output buffer) starting at the address that the DP master supplied during initialization. The input data to the master is taken from the V memory locations (the input buffer) immediately following the output data.

The output data from the master must be moved by the user program in the S7-200 CPU from the output buffer to the data areas where it is to be used. Likewise, the input data to the master must be moved from the various data areas to the input buffer for transfer to the master.

Output data from the DP master is placed into V memory immediately after the user program portion of the scan has been executed. Input data (to the master) is copied from V memory to the EM 277 for transfer to the master at the same time.

Output data from the master is only written into V memory when there is new data available from the master.

Input data to the master are transmitted to the master on the next data exchange with the master.

The starting address of the data buffers in V memory and the size of the buffers must be known at the time the user program for the S7-200 CPU is created.

Status Information

There are 50 bytes of special memory (SM) allocated to each intelligent module based on its physical position. The module updates the SM locations corresponding to the modules' relative position to the CPU (with respect to other modules). If it is the first module, it updates SMB200 through SMB249. If it is the second module, it updates SMB250 through SMB299, and so on. See Table A-43.

Table A-43 Special Memory Bytes SMB200 to SMB549

Special Memory Bytes SMB200 to SMB549						
Intelligent Module in Slot 0	**Intelligent Module in Slot 1**	**Intelligent Module in Slot 2**	**Intelligent Module in Slot 3**	**Intelligent Module in Slot 4**	**Intelligent Module in Slot 5**	**Intelligent Module in Slot 6**
SMB200 to SMB249	SMB250 to SMB299	SMB300 to SMB349	SMB350 to SMB399	SMB400 to SMB449	SMB450 to SMB499	SMB500 to SMB549

These SM locations show default values if DP communications have not been established with a master. After a master has written parameters and I/O configuration to the EM 277 PROFIBUS-DP module, these SM locations show the configuration set by the DP master. You should check the protocol status byte (for example SMB224 for slot 0) to be sure that the EM 277 is currently in data exchange mode with the master before using the information in the SM locations shown in Table A-44, or data in the V memory buffer.

Tip

You cannot configure the EM 277 PROFIBUS-DP I/O buffer sizes or buffer location by writing to SM memory locations. Only the DP master can configure the EM 277 PROFIBUS-DP module for DP operation.

Table A-44 Special Memory Bytes for the EM 277 PROFIBUS-DP

Intelligent Module in Slot 0	...	Intelligent Module in Slot 6	Description
SMB200 to SMB215	...	SMB500 to SMB515	Module name (16 ASCII characters) "EM277 ProfibusDP"
SMB216 to SMB219	...	SMB516 to SMB519	S/W revision number (4 ASCII characters) xxxx
SMW220	...	SMW520	Error code 16#0000 No error 16#0001 No user power 16#0002 to 16#FFFF Reserved
SMB222	...	SMB522	DP slave module's station address as set by address switches (0 – 99 decimal)
SMB223	...	SMB523	Reserved
SMB224	...	SMB524	DP standard protocol status byte MSB LSB 0 | 0 | 0 | 0 | 0 | 0 | S1 | S0 S1 S0 DP Standard status byte description 0 0 DP communications not initiated since power on 0 1 Configuration/parameterization error detected 1 0 Currently in data exchange mode 1 1 Dropped out of data exchange mode
SMB225	...	SMB525	DP standard protocol – address of the slave's master (0 to 126)
SMW226	...	SMW526	DP standard protocol – V memory address of the output buffer as an offset from VB0.
SMB228	...	SMB528	DP standard protocol – number of bytes of output data
SMB229	...	SMB529	DP standard protocol – number of bytes of input data
SMB230 to SMB249	...	SMB530 to SMB549	Reserved – cleared on power up

Note: SM locations are updated each time the DP slave module accepts configuration/ parameterization information. These locations are updated even if a configuration/parameterization error is detected. The locations are cleared on each power up.

LED Status Indicators for the EM 277 PROFIBUS-DP

The EM 277 PROFIBUS-DP module has four status LEDs on the front panel to indicate the operational state of the DP port:

- ❑ After the S7-200 CPU is turned on, the DX MODE LED remains off as long as DP communications are not attempted.
- ❑ Once DP communications have been successfully initiated (the EM 277 PROFIBUS-DP module has entered data exchange mode with the master), the DX MODE LED turns green and remains on until data exchange mode is exited.
- ❑ If DP communications are lost, which forces the EM 277 module to exit data exchange mode, the DX MODE LED turns OFF and the DP ERROR LED turns red. This condition persists until the S7-200 CPU is powered off or data exchange is resumed.
- ❑ If there is an error in the I/O configuration or parameter information that the DP master is writing to the EM 277 module, the DP ERROR LED flashes red.
- ❑ If user 24 VDC is not provided, the POWER LED will be off.

Table A-45 summarizes the status indications signified by the EM 277 status LEDs.

Table A-45 EM 277 PROFIBUS-DP Module Status LEDs

LED	OFF	RED	FLASHING RED	GREEN
CPU FAULT	Module is good	Internal Module Failure	--	--
POWER	No 24 VDC User Power	--	--	24 VDC User Power Good
DP ERROR	No Error	Left Data Exchange Mode	Parameterization/ Configuration Error	--
DX MODE	Not in Data Exchange Mode	--	--	In Data Exchange Mode

Note: When the EM 277 PROFIBUS-DP module is used exclusively as an MPI slave, only the green Power LED is on.

Additional Configuration Features

The EM 277 PROFIBUS-DP module can be used as a communications interface to other MPI masters, whether or not it is being used as a PROFIBUS-DP slave. The module can provide a connection from the S7-300/400 to the S7-200 using the XGET/XPUT functions of the S7-300/400. STEP 7-Micro/WIN and a network card (such as the CP5611) using the MPI or PROFIBUS parameter set, an OP device or the TD 200 (Rel. 2.0 or greater, order number 6ES7 272-0AA20-0YA0) can be used to communicate with the S7-200 through the EM 277 PROFIBUS-DP module.

A maximum of six connections (six devices) in addition to the DP master can be connected to the EM 277 PROFIBUS-DP module. One connection is reserved for a programming device (PG) and one is reserved for an operator panel (OP). The other four connections can be used by any MPI master. In order for the EM 277 PROFIBUS-DP module to communicate with multiple masters, all masters must be operating at the same baud rate. See the Figure A-30 for one possible network configuration.

When the EM 277 PROFIBUS-DP module is used for MPI communications, the MPI master must use the station address of the module for all messages that are sent to the S7-200 to which the module is connected. MPI messages sent to the EM 277 PROFIBUS-DP module are passed on to the S7-200.

The EM 277 PROFIBUS-DP module is a slave module and cannot be used for communications between S7-200 PLCs using the NETR and NETW functions. The EM 277 PROFIBUS-DP module cannot be used for Freeport communications.

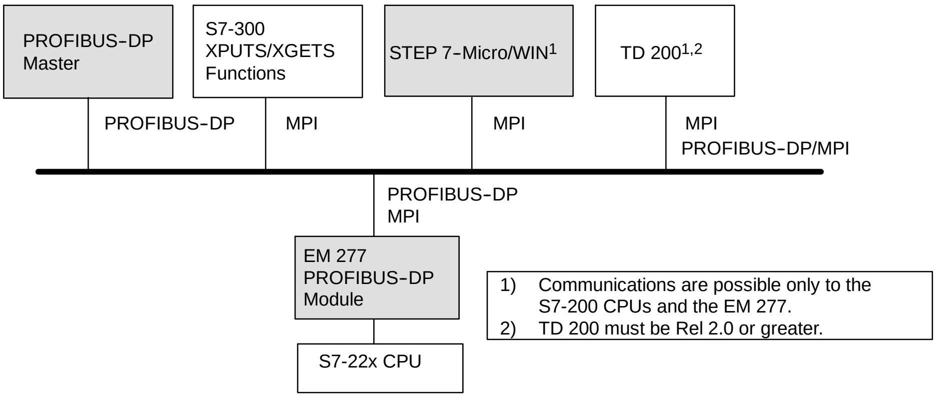


Figure A-30 PROFIBUS-DP/MPI Network

Device Database File: GSD

Different PROFIBUS devices have different performance characteristics. These characteristics differ with respect to functionality (for example, the number of I/O signals and diagnostic messages) or bus parameters, such as transmission speed and time monitoring. These parameters vary for each device type and vendor, and are usually documented in a technical manual. To help you achieve a simple configuration of PROFIBUS, the performance characteristics of a particular device are specified in an electronic data sheet called a device database file, or GSD file. Configuration tools based on GSD files allow simple integration of devices from different vendors in a single network.

The device database file provides a comprehensive description of the characteristics of a device in a precisely defined format. These GSD files are prepared by the vendor for each type of device and made available to the PROFIBUS user. The GSD file allows the configuration system to read in the characteristics of a PROFIBUS device and use this information when configuring the network.

The latest versions of the COM PROFIBUS or STEP 7 software include configuration files for the EM 277 PROFIBUS-DP Module. If your version of software does not include a configuration file for the EM 277, you can access the latest GSD file (SIEM089D.GSD) at website www.profibus.com.

If you are using a non-Siemens master device, refer to the documentation provided by the manufacturer on how to configure the master device by using the GSD file.

```
;=================================================
; GSD File for the EM 277 PROFIBUS-DP with a DPC31
; MLFB  : 6ES7 277-0AA2.-0XA0
; DATE  : 26-March-2001
;=================================================
#Profibus_DP
;General parameters
GSD_Revision         = 1
Vendor_Name          = ″Siemens″
Model_Name           = ″EM 277 PROFIBUS-DP″
Revision             = ″V1.02″
Ident_Number         = 0x089D
Protocol_Ident       = 0
Station_Type         = 0
FMS_supp             = 0
Hardware_Release     = ″1.00″
Software_Release     = ″1.02″
9.6_supp             = 1
19.2_supp            = 1
45.45_supp           = 1
93.75_supp           = 1
187.5_supp           = 1
500_supp             = 1
1.5M_supp            = 1
3M_supp              = 1
6M_supp              = 1
12M_supp             = 1
MaxTsdr_9.6          = 60
MaxTsdr_19.2         = 60
MaxTsdr_45.45        = 250
MaxTsdr_93.75        = 60
MaxTsdr_187.5        = 60
MaxTsdr_500          = 100
MaxTsdr_1.5M         = 150
MaxTsdr_3M           = 250
MaxTsdr_6M           = 450
MaxTsdr_12M          = 800
Redundancy           = 0
Repeater_Ctrl_Sig    = 2
24V_Pins             = 2

; Slave-Specification:
OrderNumber=″6ES7 277-0AA2.-0XA0″
Periphery=″SIMATIC S5″
Slave_Family=10@TdF@SIMATIC

Freeze_Mode_supp     = 1
Sync_Mode_supp       = 1
Set_Slave_Add_Supp   = 0
Auto_Baud_supp       = 1
Min_Slave_Intervall  = 1
Fail_Safe            = 0
Max_Diag_Data_Len    = 6
Modul_Offset         = 0
Modular_Station      = 1
Max_Module           = 1
Max_Input_len        = 128
Max_Output_len       = 128
Max_Data_len         = 256

; UserPrmData-Definition
ExtUserPrmData=1 ″I/O Offset in the V-memory″
Unsigned16 0 0-10239
EndExtUserPrmData
; UserPrmData: Length and Preset:
User_Prm_Data_Len=3
User_Prm_Data= 0,0,0
Max_User_Prm_Data_Len=3
Ext_User_Prm_Data_Const(0)=0x00,0x00,0x00
Ext_User_Prm_Data_Ref(1)=1
```

```
;===============================================
; Continuation of GSD File
;===============================================

; Module Definition List
Module = ″2 Bytes Out/ 2 Bytes In      -″ 0x31
EndModule
Module = ″8 Bytes Out/ 8 Bytes In      -″ 0x37
EndModule
Module  =  ″32  Bytes  Out/  32  Bytes  In       -″
0xC0,0x1F,0x1F
EndModule
Module  =  ″64  Bytes  Out/  64  Bytes  In       -″
0xC0,0x3F,0x3F
EndModule
Module = ″1 Word Out/ 1 Word In        -″ 0x70
EndModule
Module = ″2 Word Out/ 2 Word In        -″ 0x71
EndModule
Module = ″4 Word Out/ 4 Word In        -″ 0x73
EndModule
Module = ″8 Word Out/ 8 Word In        -″ 0x77
EndModule
Module = ″16 Word Out/ 16 Word In      -″ 0x7F
EndModule
Module  =  ″32  Word  Out/  32  Word  In          -″
0xC0,0x5F,0x5F
EndModule
Module  =  ″2  Word  Out/  8  Word  In            -″
0xC0,0x41,0x47
EndModule
Module  =  ″4  Word  Out/  16  Word  In           -″
0xC0,0x43,0x4F
EndModule
Module  =  ″8  Word  Out/  32  Word  In           -″
0xC0,0x47,0x5F
EndModule
Module  =  ″8  Word  Out/  2  Word  In            -″
0xC0,0x47,0x41
EndModule
Module  =  ″16  Word  Out/  4  Word  In           -″
0xC0,0x4F,0x43
EndModule
Module  =  ″32  Word  Out/  8  Word  In           -″
0xC0,0x5F,0x47
EndModule
Module = ″4 Byte buffer I/O            -″ 0xB3
EndModule
Module = ″8 Byte buffer I/O            -″ 0xB7
EndModule
Module = ″12 Byte buffer I/O           -″ 0xBB
EndModule
Module = ″16 Byte buffer I/O           -″ 0xBF
EndModule
```

Figure A-31 Listing of the GSD File for the EM 277 PROFIBUS Module

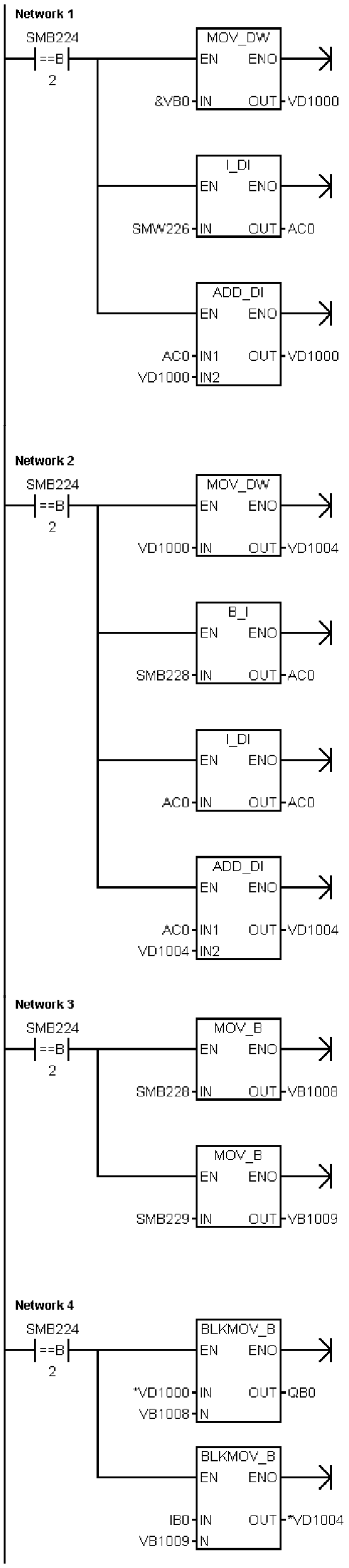
Sample Program for DP Communications to a CPU

A sample program in Statement List for the PROFIBUS–DP module in slot 0 for a CPU that uses the DP port information in SM memory is shown below. The program determines the location of the DP buffers from SMW226 and the sizes of the buffers from SMB228 and SMB229. This information is used to copy the data in the DP output buffer to the process-image output register of the CPU. Similarly, the data in the process-image input register of the CPU are copied into the V memory input buffer.

In the following sample program for a DP module in position 0, the DP configuration data in the SM memory area provides the configuration of the DP slave. The program uses the following data:

SMW220	DP Module Error Status
SMB224	DP Status
SMB225	Master Address
SMW226	V memory offset of outputs
SMB228	Number of bytes of output data
SMB229	Number of bytes of input data
VD1000	Output Data Pointer
VD1004	Input Data Pointer

Example of DP Communications to a CPU



```
Network 1      //Calculate the Output data pointer.
               //If in data exchange mode:
               //1.  Output buffer is an offset from VB0
               //2.  Convert Vmem offset to double integer
               //3.  Add to VB0 address to get output data
               //      pointer.

LDB=      SMB224, 2
MOVD      &VB0, VD1000
ITD       SMW226, AC0
+D        AC0, VD1000

Network 2      //Calculate the Input data pointer.
               //If in data exchange mode:
               //1.  Copy the output data pointer
               //2.  Get the number of output bytes
               //3.  Add to output data pointer to get
               //     starting input data pointer.

LDB=      SMB224, 2
MOVD      VD1000, VD1004
BTI       SMB228, AC0
ITD       AC0, AC0
+D        AC0, VD1004

Network 3      //Set amount of data to be copied.
               //If in data exchange mode:
               //1.  Get number of output bytes to copy
               //2.  Get number of input bytes to copy

LDB=   SMB224, 2
MOVB   SMB228, VB1008
MOVB   SMB229, VB1009

Network 4      //Transfer Master outputs to CPU
               //outputs. Copy CPU inputs to the
               //Master inputs. If in data exchange mode:
               //1.  Copy Master outputs to CPU outputs
               //2.  Copy CPU inputs to Master inputs

LDB=      SMB224, 2
BMB       *VD1000, QB0, VB1008
BMB       IB0, *VD1004, VB1009
```

EM 241 Modem Module Specifications

Table A-46 EM 241 Modem Module Order Number

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 241-1AA22-0XA0	EM 241 Modem Module	-	8[1]	No

[1] Eight Q outputs are used as logical controls of the modem function and do not directly control any external signals.

Table A-47 EM 241 Modem Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 241-1AA22-0XA0	EM 241 Modem Module	71.2 x 80 x 62	190 g	2.1 W	80 mA	70 mA

Table A-48 EM 241 Modem Module Specifications

General	6ES7 241-1AA22-0XA0
Telephone Connection	
Isolation (phone line to logic and field power)	1500 VAC (Galvanic)
Physical connection	RJ11 (6 position, 4 wire)
Modem standards	Bell 103, Bell 212, V.21, V.22, V.22 bis, V.23c, V.32, V.32 bis, V.34 (default)
Security features	Password Callback
Dialing	Pulse or Tone
Messaging Protocols	Numeric TAP (alphanumeric) UCP commands 1, 30, 51
Industrial Protocols	Modbus PPI
24 VDC Input Power Requirements	
Voltage range Isolation (field power to logic)	20.4 to 28.8 VDC 500 VAC for 1 minute

The EM 241 Modem Module replaces the function of an external modem connected to the communications port of the CPU. With an EM 241 installed in your S7-200 system, all you need to communicate with your CPU from a remote location is a personal computer with an external modem and STEP 7-Micro/WIN.

See Chapter 7, Communicating over a Network, for information on configuring. See Chapter 10, Creating a Program for the Modem Module for programming and advanced features of the module.

Modem Expansion

You can use the STEP 7-Micro/WIN Modem Expansion Wizard to configure an EM 241 Modem Module. See Chapter 10 for more information about the Modem Expansion Wizard.

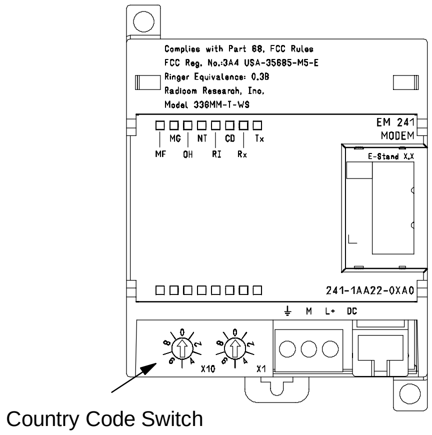


Figure A-32 EM 241 Modem Module Terminal Block Diagram

S7-200 CPUs that Support Intelligent Modules

The EM 241 Modem module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table A-49.

Table A-49 EM 241 Modem Module Compatibility with S7-200 CPUs

CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel 2.0 or greater	CPU 224XP DC/DC/DC and CPU 224XP DC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

Installing the EM 241

Follow these steps to install the EM 241:

1. Snap the EM 241 on the DIN rail and plug in the ribbon cable.
2. Connect 24 VDC from the CPU sensor supply or external source, and connect the ground terminal to your system earth ground.
3. Plug the phone line into the RJ11 jack.
4. Set the country code switches according to Table A-50. You must set the switches before power is applied to the CPU for the correct country code to be read.
5. Power the CPU. The green MG (Module Good) light should come on.

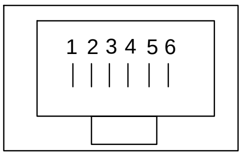
Your EM 241 is now ready to communicate.

Table A-50 Country Codes Supported by EM 241

Code	Country	Telecom Standard
00	Australia	ACA TS–002
01	Austria	CTR21
02	Belgium	CTR21
05	Canada	IC CS03
06	China	GB3482
08	Denmark	CTR21
09	Finland	CTR21
10	France	CTR21
11	Germany	CTR21
12	Greece	CTR21
16	Ireland	CTR21
18	Italy	CTR21
22	Luxembourg	CTR21
25	Netherlands	CTR21
26	New Zealand	PTC 200
27	Norway	CTR21
30	Portugal	CTR21
34	Spain	CTR21
35	Sweden	CTR21
36	Switzerland	CTR21
38	U.K.	CTR21
39	U.S.A.	FCC Part 68

RJ11 Jack

Figure A-33 shows the details of the RJ11 Jack. You can use adaptors to other standard telephone connectors. Refer to your adaptor connector documentation for more information.



Pin	Description
3	Ring
4	Tip

Reverse connection is allowed.

Figure A-33 View of RJ11 Jack

Caution

Lightning surges or other unexpected high voltages on the telephone line can damage your EM 241 Modem Module.

Use a commercially available telephone line surge protector, such as are commonly sold for protection of personal computer modems. Surge protectors can be damaged as they protect your EM 241 Modem Module. Choose a surge protector with a positive indicator that shows it is functional.

Check your surge protector regularly to ensure that your EM 241 Modem Module continues to be protected.

EM 253 Position Module Specifications

Table A-51 EM 253 Position Module Order Number

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6ES7 253-1AA22-0XA0	EM 253 Position Module	-	8[1]	Yes

[1] Eight Q outputs are used as logical controls of the motion function and do not directly control any external signals.

Table A-52 EM 253 Position Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	+24 VDC
6ES7 253-1AA22-0XA0	EM 253 Position Module	71.2 x 80 x 62	0.190 kg	2.5 W	190 mA	See below

Table A-53 EM 253 Position Module Specifications

General	6ES7 253-1AA22-0XA0
Input Features	
Number of inputs	**5 points**
Input type	
All except ZP	Sink/Source (IEC Type 1 sink, except ZP)
ZP	Sink only, current limiting for wide voltage range
Input Voltage	
Maximum Continuous permissible	
STP, RPS, LMT+, LMT-	30 VDC
ZP	30 VDC at 20 mA, maximum
Surge (all inputs)	35 VDC for 0.5 sec.
Rated Value	
STP, RPS, LMT+, LMT-	24 VDC at 4 mA, nominal
ZP	24 VDC at 15 mA, nominal
Logic “1” signal (minimum)	
STP, RPS, LMT+, LMT-	15 VDC at 2.5 mA, minimum
ZP	3 VDC at 8.0 mA, minimum
Logic “0” signal (maximum)	
STP, RPS, LMT+, LMT-	5 VDC at 1 mA, maximum
ZP	1 VDC at 1 mA, maximum
Isolation (field to logic)	
Optical Isolation (Galvanic)	500 VAC for 1 minute
Isolation groups of	1 point for STP, RPS, and ZP 2 points for LMT+ and LMT-
Input Delay Times	
STP, RPS, LMT+, LMT-	0.2 ms to 12.8 ms, user selectable
ZP (countable pulse width)	2 μsec minimum
Connection of 2 Wire Proximity Sensor (Bero)	
Permissible leakage current	1 mA, maximum
Cable Length	
Unshielded	
STP, RPS, LMT+, LMT-	30 meters
ZP	Not recommended
Shielded	
STP, RPS, LMT+, LMT-	100 meters
ZP	10 meters
Number of inputs on simultaneously	All at 55° C (horizontal), All at 45° C (vertical)

Table A-53 EM 253 Position Module Specifications, continued

General	6ES7 253–1AA22–0XA0	
Output Features		
Number of integrated outputs	6 points (4 signals)	
Output type		
P0+, P0–, P1+, P1–	RS422/485 driver	
P0, P1, DIS, CLR	Open drain	
Output voltage		
P0, P1, RS–422 drivers, differential output voltage		
Open circuit	3.5 V typical	
Into optocoupler diode with 200Ω series resistance	2.8 V minimum	
100Ω load	1.5 V minimum	
54Ω load	1.0 V minimum	
P0, P1, DIS, CLR open drain		
recommended voltage, open circuit	5 VDC, available from module	
permissible voltage, open circuit	30 VDC[1]	
Sink current	50 mA maximum	
On state resistance	15Ω maximum	
Off state leakage current, 30 VDC	10 μA maximum	
Internal Pull up resistor, output drain to T1	3.3K Ω[2]	
Output current		
Number of output groups	1	
Outputs on simultaneously	All at 55° C (horizontal), All at 45° C (vertical)	
Leakage current per point		
P0, P1, DIS, CLR	10 μA maximum	
Overload Protection	No	
Isolation (field to logic)		
Optical Isolation (Galvanic)	500 VAC for 1 minute	
Output delay		
DIS, CLR: Off to On / On to Off	30 μs, maximum	
Pulse distortion		
P0, P1, outputs, RS–422 drivers, 100 Ω external load	75 ns maximum	
P0, P1 outputs, open drain, 5 V / 470 Ω external load	300 ns maximum	
Switching frequency		
P0+, P0–, P1+, P1–, P0 and P1	200 kHz	
Cable length		
Unshielded	Not recommended	
Shielded	10 meters	
Power Supply		
L+ supply voltage	11 to 30 VDC (Class 2, Limited Power, or sensor power from PLC)	
Logic supply output	+5 VDC +/– 10%, 200 mA maximum	
L+ supply current vs. 5 VDC load		
Load current	12 VDC Input	24 VDC Input
0 mA (no load)	120 mA	70 mA
200 mA (rated load)	300 mA	130 mA
Isolation		
L+ power to logic	500 VAC for 1 minute	
L+ power to inputs	500 VAC for 1 minute	
L+ power to outputs	None	
Reverse Polarity	L+ input and +5V output are diode-protected. Placing a positive voltage on any M terminal with respect to output point connections can result in potentially damaging current flow.	

[1] Operation of open drain outputs above 5 VDC may increase radio frequency emissions above permissible limits. Radio frequency containment measures may be required for your system or wiring.

[2] Depending on your pulse receiver and cable, an additional external pull up resistor may improve pulse signal quality and noise immunity.

S7-200 CPUs that Support Intelligent Modules

The EM 253 Position module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table A-54.

Table A-54   EM 253 Position Module Compatibility with S7-200 CPUs

CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel 2.0 or greater	CPU 224XP DC/DC/DC and CPU 224XP DC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

EM 253 Position Module Status LEDs

The Status LEDs for the Position Modules are shown in Table A-55.

Table A-55   Position Module Status LEDs

Local I/O	LED	Color	Function Description
–	MF	Red	Illuminated when module detects a fatal error
–	MG	Green	Illuminated when there is no module fault, and flashes at 1 Hz rate when a configuration error is detected
–	PWR	Green	Illuminated when 24 VDC is supplied on the L+ and M terminals of the module
Input	STP	Green	Illuminated when the stop input is on
Input	RPS	Green	Illuminated when the reference point switch input is on
Input	ZP	Green	Illuminated when the zero pulse input is on
Input	LMT–	Green	Illuminated when the negative limit input is on
Input	LMT +	Green	Illuminated when the positive limit input is on
Output	P0	Green	Illuminated when the P0 output is pulsing
Output	P1	Green	Illuminated when the P1 output is pulsing or when this output indicates positive motion
Output	DIS	Green	Illuminated when the DIS output is active
Output	CLR	Green	Illuminated when the clear deviation counter output is active

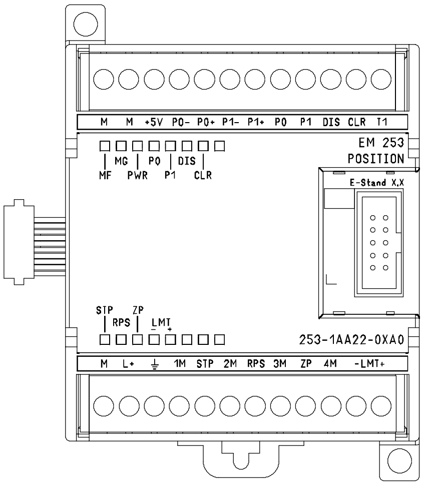

M M +5V P0– P0+ P1– P1+ P0 P1 DIS CLR T1
EM 253
POSITION
MG
P0
DIS
MF
PWR
P1
CLR
E-Stand X.X
STP
ZP
RPS
LMT
253-1AA22-0XA0
M L+ 1M STP 2M RPS 3M ZP 4M -LMT+

Figure A-34   EM 253 Position Module

Wiring Diagrams

In the following schematic figures, the terminals are not in order. See Figure A-34 for terminal arrangement.

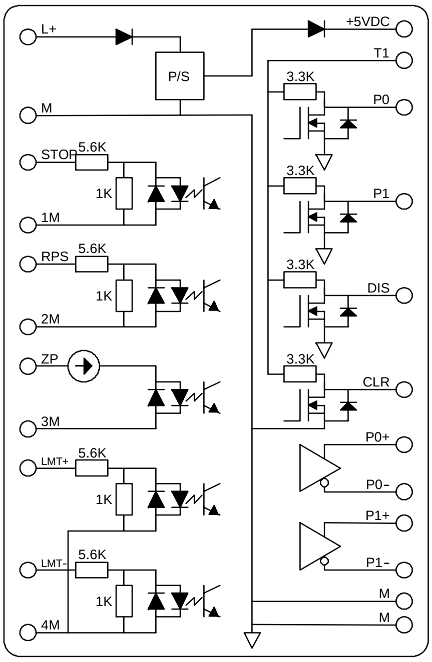
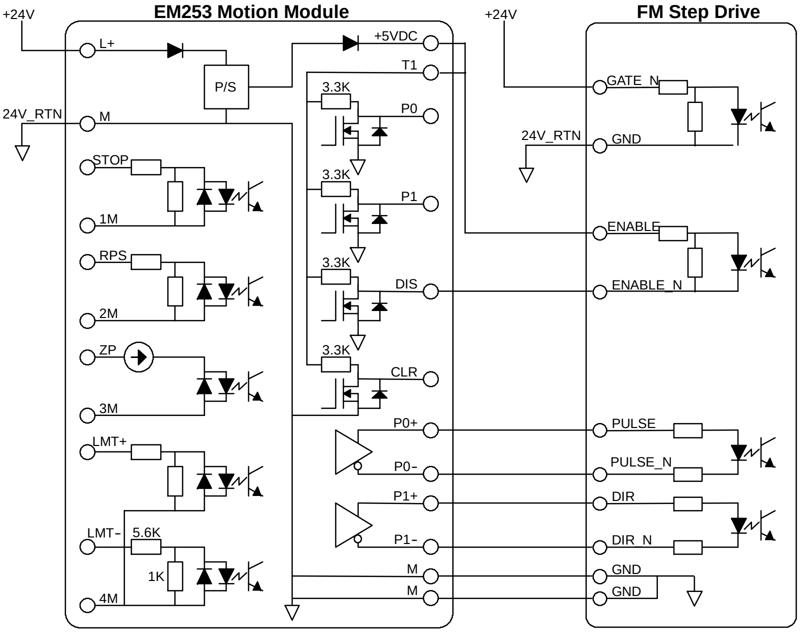
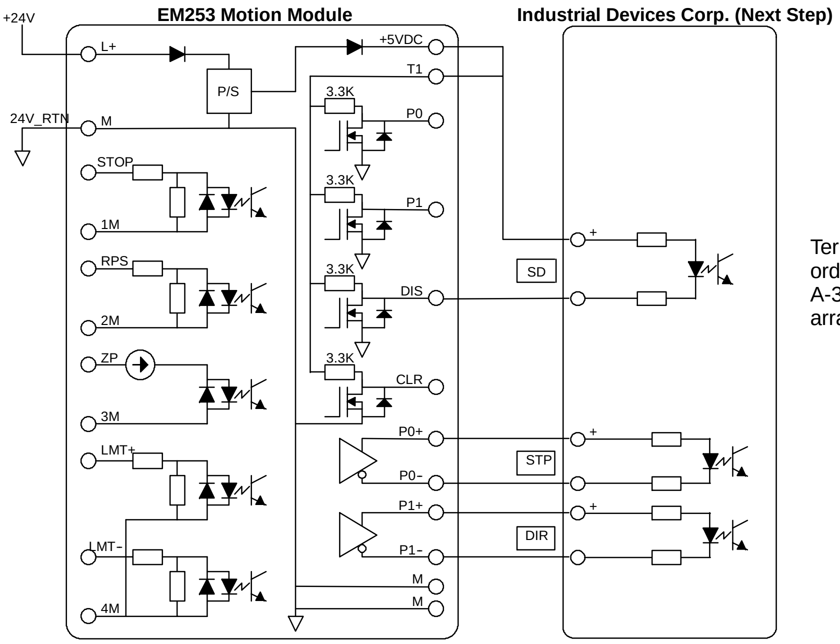


Figure A-35 Internal Schematic for the Inputs and Outputs of the EM 253 Position Module



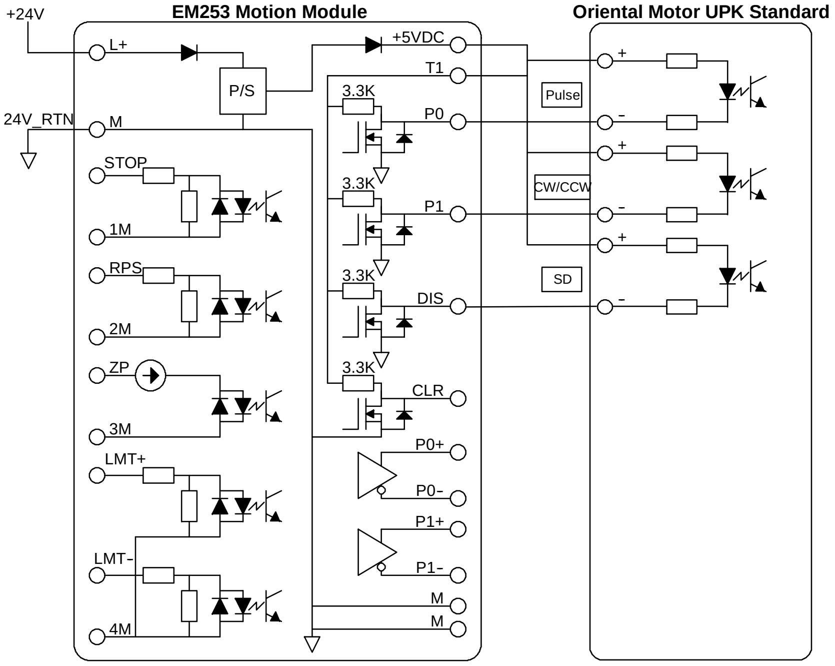
Terminals are not in order. See Figure A-34 for terminal arrangement.

Figure A-36 Connecting an EM 253 Position Module to a SIMATIC FM Step Drive



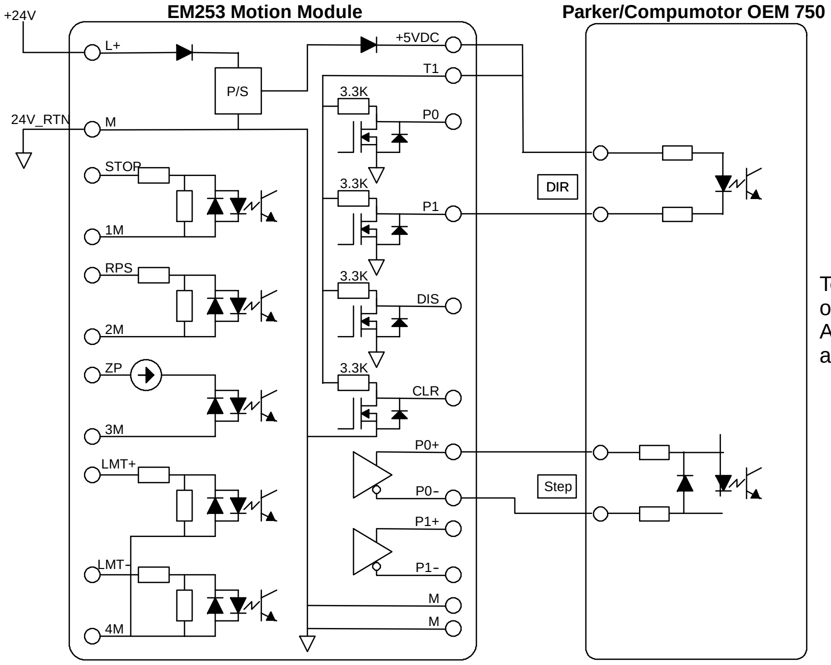
Terminals are not in order. See Figure A-34 for terminal arrangement.

Figure A-37 Connecting an EM 253 Position Module to a Industrial Devices Corp. (Next Step)



Terminals are not in order. See Figure A-34 for terminal arrangement.

Figure A-38 Connecting an EM 253 Position Module to an Oriental Motor UPK Standard



Terminals are not in order. See Figure A-34 for terminal arrangement.

Figure A-39 Connecting an EM 253 Position Module to a Parker/Compumotor OEM 750

(CP 243–1) Ethernet Module Specifications

Table A-56 (CP 243–1) Ethernet Module Order Number

Order Number	Expansion Module	EM Inputs	EM Outputs	Removable Connector
6GK7 243–1EX00–OXE0	(CP 243–1) Ethernet Module	–	8[1]	No

[1] Eight Q outputs are used as logical controls of Ethernet function and do not directly control any external signals.

Table A-57 (CP 243–1) Ethernet Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirement	
					+5 VDC	+24 VDC
6GK7 243–1EX00–OXE0	(CP 243–1) Ethernet Module	71.2 x 80 x 62	approx. 150 g	1.75 W	55 mA	60 mA

Table A-58 (CP 243–1) Ethernet Module Specifications

General	6GK7 243–1EX00–0XE0
Transmission Rate	**10 Mbits/s and 100 Mbits/s**
Flash memory size	1 Mbyte
SDRAM memory size	8 Mbyte
Interface Connection to Industrial Ethernet (10/100 Mbit/s)	8-pin RJ45 socket
Input voltage	20.4 to 28.8 VDC
Maximum connections	Maximum of 8 S7 connections (XPUT/XGET and READ/WRITE) plus 1 connection to STEP 7–Micro/WIN per (CP 243–1) Ethernet Module[2]
Starting time or restart time after a reset	Approx. 10 seconds
User data quantities	As client: up to 212 bytes for XPUT/XGET As server: up to 222 bytes for XGET or READ up to 212 bytes for XPUT or WRITE

[2] Only one (CP 243–1) Ethernet module should be connected per S7–200 CPU.

The (CP 243–1) Ethernet module is a communications processor used for connecting the S7-200 system to Industrial Ethernet (IE). The S7-200 can be remotely configured, programmed and diagnosed via Ethernet using STEP 7 Micro/WIN. The S7-200 can communicate with another S7–200, S7-300, or S7-400 controller via Ethernet. It can also communicate with an OPC server.

Industrial Ethernet is designed for industry. It can be used with either noise-free industrial twisted pair (ITP) technology, or the Industry-standard twisted pair (TP) technology. Industrial Ethernet can be implemented to offer a wide range of application specific uses, such as switching, high-speed redundancy, fast connects, and redundant networks. Using the (CP 243–1) Ethernet module, the S7-200 PLC is made compatible with a wide range of existing products that support Ethernet.

S7-200 CPUs that Support Intelligent Modules

The (CP 243–1) Ethernet module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table A-49.

Table A-59 (CP 243–1) Ethernet Module Compatibility with S7-200 CPUs

CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel. 2.00 or greater	CPU 224XP DC/DC/DC and CPU 224XP AC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

The (CP 243–1) Ethernet module is delivered with a preset, unique worldwide MAC address that cannot be changed.

Functions

The (CP 243–1) Ethernet module independently handles data traffic over the Industrial Ethernet.

- Communication is based on TCP/IP
- For communication between S7-200 CPUs and other S7 control systems or PCs via Ethernet, communication services are available as Client and Server. Up to eight connects can be operated.
- The implementation of PC applications is possible by integration of the S7-OPC Server
- The (CP 243–1) Ethernet module allows direct access of the S7-200 programming software, STEP 7–Micro/WIN to S7-200 via Ethernet

Configuration

Ethernet

You can use the STEP 7–Micro/WIN Ethernet Wizard to configure the (CP 243–1) Ethernet module to connect an S7-200 PLC to an Ethernet network. The Ethernet wizard helps you define the parameters for the (CP 243–1) Ethernet module and then places the configuration instructions in your project instruction folder. To start the Ethernet Wizard, select the **Tools > Ethernet Wizard** menu command. The wizard uses the following information: IP Address, Subnet Mask, Gateway Address, and communications connection type.

Connections

The (CP 243–1) Ethernet module has the following connections. The connections are located under the covers of the front doors.

- Terminal block for 24 VDC supply voltage and ground connection
- 8-in RJ45 socket for Ethernet connection
- Plug connector for I/O bus
- Integrated ribbon cable with socket for I/O bus

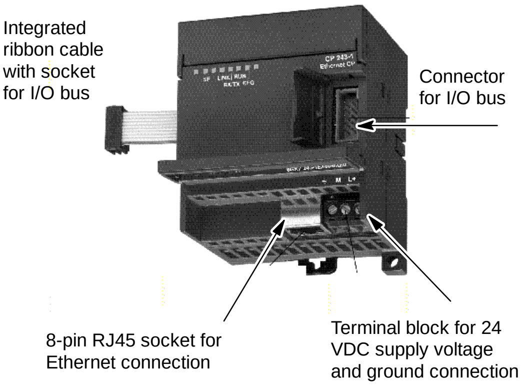

Integrated ribbon cable with socket for I/O bus
Connector for I/O bus
8-pin RJ45 socket for Ethernet connection
Terminal block for 24 VDC supply voltage and ground connection

Figure A-40 Connecting the (CP 243–1) Ethernet Module

Additional Information

For more information about the (CP 243–1) Ethernet module, refer to the *SIMATIC NET CP 243–1 Communications Processor for Industrial Ethernet Technical Manual.*

(CP 243-1 IT) Internet Module Specifications

Table A-60 (CP 243-1 IT) Internet Module Order Number

Order Number	Expansion Module	EM Inputs	EM Outputs	Removable Connector
6GK7 243-1GX00-OXE0	(CP 243-1 IT) Internet Module	-	8[1]	No

[1] Eight Q outputs are used as logical controls of the IT function and do not directly control any external signals.

Table A-61 (CP 243-1 IT) Internet Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements +5 VDC	+24 VDC
6GK7 243-1GX00-OXE0	(CP 243-1 IT) Internet Module	71.2 x 80 x 62	approx. 150 g	1.75 W	55 mA	60 mA

Table A-62 (CP 243-1 IT) Internet Module Specifications

General	6GK7 243-1GX00-0XE0
Transmission speed	10 Mbit/s and 100 Mbits/s
Flash memory size	8 Mbytes as ROM for firmware of the (CP 243-1 IT) Internet module, 8 Mbytes as RAM for the file system
SDRAM memory size	16 Mbyte
Guaranteed life of flash memory for the file system	1 million write or delete operations
Interface Connection to Industrial Ethernet (10/100 Mbit/s)	 8-pin RJ45 socket
Input voltage	20.4 to 28.8 VDC
Maximum connections	Maximum of 8 S7 connections (XPUT/XGET and READ/WRITE) plus 1 connection to STEP 7-Micro/WIN per (CP 243-1 IT) Internet module[1]
Maximum number of IT connections	1 for FTP server 1 for FTP client 1 for e-mail client 4 for HTTP connections
Starting time or restart time after a reset	Approx. 10 seconds
User data quantities	Client: up to 212 bytes for XPUT/XGET Server: up to 222 bytes for XGET or READ up to 212 bytes for XPUT or WRITE
E-mail size, maximum	1024 characters
File system: Path length including file size and drive names File name length Directory nesting depth	 254 characters maximum 99 characters maximum 49 maximum
Server ports available: HTTP FTP command channel FTP data channels for FTP server S7 connection establishment S7 server	 80 21 3100 to 3199 102 3000 to 3008

[1] Only one (CP 243-1 IT) Internet module should be connected per S7-200 CPU.

The (CP 243–1 IT) Internet module is a communications processor used for connecting the S7-200 system to Industrial Ethernet (IE). The S7-200 can be remotely configured, programmed and diagnosed via Ethernet using STEP 7 Micro/WIN. The S7-200 can communicate with another S7–200, S7-300, or S7-400 controller via Ethernet. It can also communicate with an OPC server.

The IT functions of the (CP 243–1 IT) Internet module form the basis for monitoring and, if necessary, also manipulating automation systems with a WEB browser from a networked PC. Diagnostic messages can be e-mailed from a system. Using the IT functions, it is easy to exchange entire files with other computer and controller systems.

Industrial Ethernet is the network for the process control level and the cell level of the SIMATIC NET open communication system. Physically, Industrial Ethernet is an electrical network based on shielded, coaxial lines, twisted pair cables and an optical network of fiber optic conductors. Industrial Ethernet is defined by the International Standard IEEE 802.3.

S7-200 CPUs that Support Intelligent Modules

The (CP 243–1 IT) Internet module is an intelligent expansion module designed to work with the S7-200 CPUs shown in Table A-63.

Table A-63 (CP 243–1 IT) Internet Module Compatibility with S7-200 CPUs

CPU	Description
CPU 222 Rel. 1.10 or greater	CPU 222 DC/DC/DC and CPU 222 AC/DC/Relay
CPU 224 Rel. 1.10 or greater	CPU 224 DC/DC/DC and CPU 224 AC/DC/Relay
CPU 224XP Rel. 2.00 or greater	CPU 224XP DC/DC/DC and CPU 224XP AC/DC/Relay
CPU 226 Rel. 1.00 or greater	CPU 226 DC/DC/DC and CPU 226 AC/DC/Relay

The (CP 243–1 IT) Internet module has the following features:

- ❑ The (CPU 243–1 IT) Internet module is fully compatible with the (CP 243–1) Ethernet module. User programs written for the (CP 243–1) Ethernet module can also be run on the (CP 243–1 IT) Internet module.

The (CP 243–1 1T) Internet module is delivered with a preset, unique worldwide MAC address that cannot be changed.

Tip

Only one (CP 243–1 IT) Internet module should be connected per S7-200 CPU. If more than one (CP 243–1 IT) Internet module is connected, the S7-200 CPU may not operate properly.

Functions

The (CP 243–1 IT) Internet module offers the following functions:

- ❑ S7 Communication is based on TCP/IP
- ❑ IT communication
- ❑ Configuration
- ❑ Watchdog timer
- ❑ Ability of preset MAC addresses (48–bit value) to be addressed

Configuration

Internet

You can use the STEP 7-Micro/WIN Internet Wizard to configure the (CP 243-1 IT) Internet module to connect an S7-200 PLC to an Ethernet/Internet network. The (CP 243-1 IT) Internet module has additional web server functionality that can be configured with the Internet Wizard. To start the Internet Wizard, select the **Tools > Internet Wizard** menu command.

Connections

The (CP 243-1 IT) Internet module has the following connections. The connections are located under the covers of the front doors.

- ❑ Terminal block for 24 VDC supply voltage and ground connection
- ❑ 8-in RJ45 socket for Ethernet connection
- ❑ Plug connector for I/O bus
- ❑ Integrated ribbon cable with socket for I/O bus

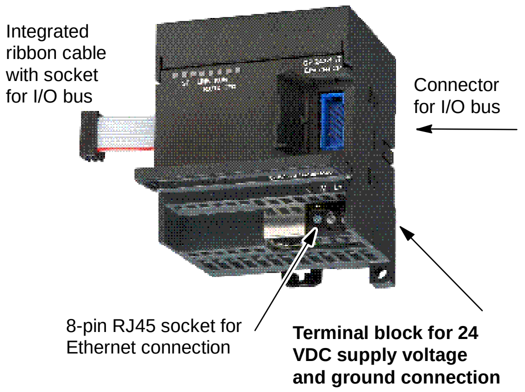

Integrated ribbon cable with socket for I/O bus
Connector for I/O bus
8-pin RJ45 socket for Ethernet connection
Terminal block for 24 VDC supply voltage and ground connection

Figure A-41 Connecting the (CP 243-1 IT) Internet Module

Additional Information

For more information about the (CP 243-1 IT) Internet module, refer to the *SIMATIC NET CP 243-1 IT Communications Processor for Industrial Ethernet and Information Technology Technical Manual.*

(CP 243-2) AS-Interface Module Specifications

Table A-64 (CP 243-2) AS-Interface Module Order Number

Order Number	Expansion Model	EM Inputs	EM Outputs	Removable Connector
6GK7 243-2AX01-0XA0	(CP 243-2) AS-Interface Module	8 Digital and 8 Analog	8 Digital and8 Analog	Yes

Table A-65 (CP 243-2) AS-Interface Module General Specifications

Order Number	Module Name and Description	Dimensions (mm) (W x H x D)	Weight	Dissipation	VDC Requirements	
					+5 VDC	From AS-Interface
6GK7 243-2AX01-0XA0	(CP 243-2) AS-Interface Module	71 x 80 x 62	approx. 250 g	3.7 W	220 mA	100 mA

Table A-66 (CP 243-2) AS-Interface Module Specifications

General	6GK7 243-2AX01-0XA0
Cycle time	5 ms with 31 slaves 10 ms with 62 AS-I slaves using the extended addressing mode
Configuration	Set button on the front panel, or use the total configuration command (refer to the description of the AS-I commands in the *CP 243-2 AS-I Interface Master* manual)
AS-I master profiles supported	M1e
Attachment to the AS-I cable	Via an S7-200 terminal block. Permitted current loading from terminal 1 to 3 or from terminal 2 to 4 maximum 3 A.
Address range	One digital module with 8 digital inputs and 8 digital outputs, and One analog module with 8 analog inputs and 8 analog outputs

Features

You can operate up to two AS-Interface modules on the S7-200 at the same time, significantly increasing the number of available digital and analog inputs/outputs (maximum 124 digital input/124 digital output on AS-Interface per CP). Setup times are reduced because of the ability to configure at the touch of a button. LEDs reduce downtime in the event of an error by displaying status of the CP and of all connected slaves, and by monitoring AS-Interface main voltage.

The AS-Interface Module has the following features:

- Supports analog modules
- Supports all master functions and allows connections for up to 62 AS-Interface slaves
- LEDs in the front plate display operating status and availability of connected slaves.
- LEDs in the front plate display errors (including AS-Interface voltage error, configuration error)
- Two terminals allow direct connection of the AS-Interface cable.
- Two buttons display the status information of the slaves, switch operating mode, and adopt the existing configuration as the SET configuration.

AS-i

You can use the STEP 7-Micro/WIN AS-i Wizard to configure the (CP 243-2) AS-Interface module. The AS-Interface Wizard helps you use the data from an AS-Interface network in your configuration. To start the AS-i Wizard, select the **Tools > AS-i Wizard** menu command.

Operation

In the process image of the S7-200, the AS–Interface Module occupies a digital input byte (status byte), a digital output byte (control byte), 8 analog input and 8 analog output words. The AS–Interface Module uses two logical module positions. You can use the status and the control byte to set the mode of the AS–Interface Module using a user program. Depending on its mode, the AS–Interface stores either the I/O data of the AS–Interface slave, diagnostics values, or enables master calls (for example, changing a slave address) in the analog address area of the S7-200.

All the connected AS–Interface slaves can be configured at the touch of a button. Further configuration of the CP is not necessary.

> **Caution**
>
> When you use the AS–Interface Module, you must disable analog filtering in the CPU.
>
> If analog filtering is not disabled in the CPU, the digital point data will be destroyed, and error conditions will not be returned as bit values in the analog word.
>
> Ensure that analog filtering in the CPU is disabled.

Functions

The CP 243–2 is the AS–Interface master for the M1e master class, which means that it supports all the specified functions. This makes it possible to operate up to 31 digital slaves on the AS–Interface by means of double address assignment (A–B). The CP 243–2 can be set to two different modes:

- Standard mode: access to the I/O data of the AS–Interface slave
- Extended mode: master calls (for example, write parameters) or diagnostic value request

Connections

The AS–Interface Module has the following connections:

- Two connections to the AS–Interface Module cable (bridged internally)
- One connection for functional ground

The terminals are located under the cover of the front panel as shown in Figure A-42.

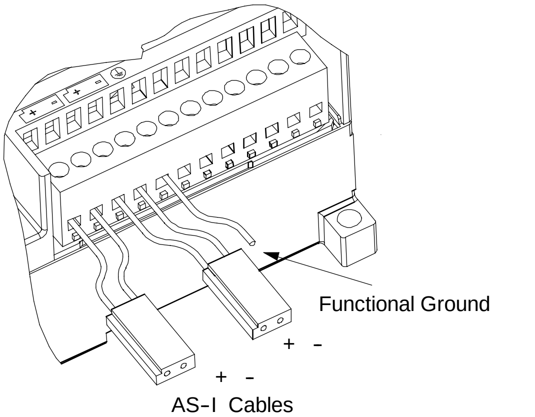


Figure A-42 Connecting the AS–Interface Module Cable

> **Caution**
>
> The load capacity of the AS–Interface Module contacts is a maximum of 3 A. If this value is exceeded on the AS–Interface Module cable, the AS–Interface must not be looped into the AS–I cable, but must be connected by a separate cable (in this case, only one pair of terminals of the AS–Interface Module is used). The AS–Interface must be connected to the grounding conductor via the ground terminal.

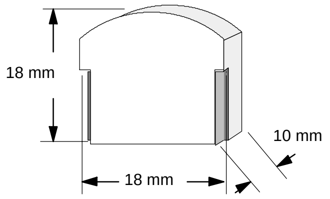
> **Tip**
>
> The AS–Interface Module has a connection for functional ground. This connector should be connected to the PE conductor with as little resistance as possible.

Additional Information

For more information about the CP 243–2 AS–Interface Master, refer to the *SIMATIC NET CP 243–2 AS-Interface Master manual.*

Optional Cartridges

Cartridge	Description	Order Number
Memory cartridge	Memory cartridge, 64K (user program, recipe, and data logging)	6ES7 291–8GF23–0XA0
Memory cartridge	Memory cartridge, 256K (user program, recipe, and data logging)	6ES7 291–8GH23–0XA0
Real-Time Clock with battery	Clock cartridge accuracy: 2 minutes/month at 25°C, 7 minutes/month at 0°C to 55°C	6ES7 297–1AA23–0XA0
Battery cartridge	Battery cartridge Data retention time: 200 days typical Shelf life: 5 years	6ES7 291–8BA20–0XA0

General Features		Dimensions
Battery	3 V, 30 mA hour, Renata CR 1025	
Size	9.9 mm x 2.5 mm	
Type	Lithium < 0.6 g	

Memory Cartridge

There are restrictions for using memory cartridges between CPUs of a different model. Memory cartridges programmed in a particular model number CPU can be read by CPUs with the same or higher model number as shown in Table A-67:

Table A-67 Memory Cartridge Model Number Read Restrictions

Memory Cartridge Programmed In A ...	Can Be Read By A ...
CPU 221	CPU 221, CPU 222, CPU 224, CPU 224XP, CPU 224XPsi, and CPU 226
CPU 222	CPU 222, CPU 224, CPU 224XP, CPU 224XPsi, and CPU 226
CPU 224	CPU 224, CPU 224XP, CPU 224XPsi, and CPU 226
CPU 224XP	CPU 224XP, CPU 224XPsi, and CPU 226
CPU 226	CPU 226

The 64K and 256K memory cartridges are designed to work only with the new CPUs that have the order number as shown here: 6ES7 21x–xx23–0XB0. Each “x” means that this digit is a don’t care.

You may have user programs stored on 32K memory cartridges originally programmed by older CPUs (version “20”, “21”, or “22”). These cartridges can be read by the new CPUs, subject to the model number restrictions in Table A-67.

Real Time Clock Cartridge

The Real Time Clock cartridge (6ES7 297–1AA23–0XA0) is designed to work only with the “23” CPUs. The earlier version of the Real Time Clock cartridge (6ES7 297–1AA20–0XA0) is not physically or electrically compatible with the “23” CPUs.

I/O Expansion Cable

General Features (6ES7 290-6AA20-0XA0)	
Cable length	0.8 m
Weight	25 g
Connector type	10 pin ribbon

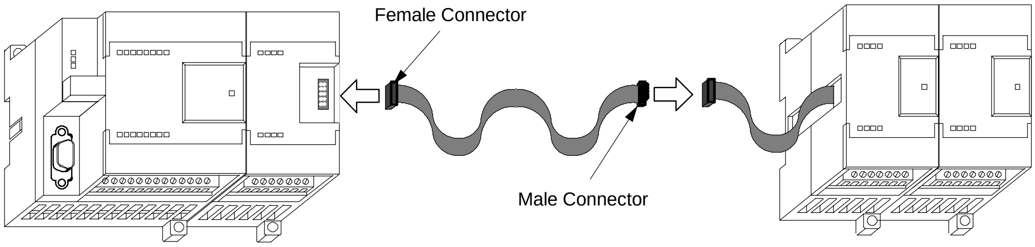


Figure A-43 Typical Installation of the I/O Expansion Cable

Tip

Only one expansion cable is allowed in a CPU/expansion module chain.

RS-232/PPI Multi-Master Cable and USB/PPI Multi-Master Cable

Table A-68 RS-232/PPI Multi-Master Cable and USB/PPI Multi-Master Cable Specifications

Description **Order Number**	**S7-200 RS-232/PPI Multi-Master Cable** **6ES7 901-3CB30-0XA0**	**S7-200 USB/PPI Multi-Master Cable** **6ES7-901-3DB30-0XA0**
General Characteristics		
Supply voltage	14.4 to 28.8 VDC	14.4 to 28.8 VDC
Supply current at 24 V nominal supply	60 mA RMS max.	50 mA RMS max.
Direction change delay: RS-232 stop bit edge received to RS-485 transmission disabled	–	–
Isolation	RS-485 to RS-232: 500 VDC	RS-485 to USB: 500 VDC
RS-485 Side Electrical Characteristics		
Common mode voltage range	–7 V to +12 V, 1 second, 3 V RMS continuous	–7 V to +12 V, 1 second, 3 V RMS continuous
Receiver input impedance	5.4 K Ω min. including termination	5.4 K Ω min. including termination
Termination/bias	10K Ω to +5 V on B, PROFIBUS pin 3 10K Ω to GND on A, PROFIBUS pin 8	10K Ω to +5 V on B, PROFIBUS pin 3 10K Ω to GND on A, PROFIBUS pin 8
Receiver threshold/sensitivity	+/–0.2 V, 60 mV typical hysteresis	+/–0.2 V, 60 mV typical hysteresis
Transmitter differential output voltage	2 V min. at R_L=100 Ω, 1.5 V min. at R_L=54 Ω	2 V min. at R_L=100 Ω, 1.5 V min. at R_L=54 Ω
RS-232 Side Electrical Characteristics		
Receiver input impedance	3K Ω min.	–
Receiver threshold/sensitivity	0.8 V min. low, 2.4 V max. high 0.5 V typical hysteresis	–
Transmitter output voltage	+/– 5 V min. at R_L=3K Ω	–
USB Side Electrical Characteristics		
Full speed (12 MB/s), Human Interface Device (HID)		
Supply current at 5V	–	50 mA max.
Power down current	–	400 uA max.

Features

The S7-200 RS-232/PPI Multi-Master Cable comes factory set for optimal performance with the STEP 7–Micro/WIN 3.2 Service Pack 4 (or later) programming package. The factory setting for this cable is different than for the PC/PPI cables. Refer to Figure 1 to configure the cable for your application.

You can configure the S7-200 RS-232/PPI Multi-Master Cable to operate the same as the PC/PPI cable and to be compatible with any version of a STEP 7–Micro/WIN programming package by setting Switch 5 to the PPI/Freeport setting and then selecting your required baud rate.

The USB cable requires STEP 7–Micro/WIN 3.2 Service Pack 4 (or later) programming package for operation.

Tip

For more information about using these cables, refer to Chapter 7, Communicating over a Network.

S7-200 RS-232/PPI Multi-Master Cable

Table A-69 S7-200 RS-232/PPI Multi–Master Cable – Pin-outs for RS-485 to RS-232 Local Mode Connector

RS-485 Connector Pin-out		RS-232 Local Connector Pin-out	
Pin Number	Signal Description	Pin Number	Signal Description
1	No connect	1	Data Carrier Detect (DCD) (not used)
2	24 V Return (RS-485 logic ground)	2	Receive Data (RD) (output from PC/PPI cable)
3	Signal B (RxD/TxD+)	3	Transmit Data (TD) (input to PC/PPI cable)
4	RTS (TTL level)	4	Data Terminal Ready (DTR)[1]
5	No connect	5	Ground (RS-232 logic ground)
6	No connect	6	Data Set Ready (DSR)[1]
7	24 V Supply	7	Request To Send (RTS) (not used)
8	Signal A (RxD/TxD–)	8	Clear To Send (CTS) (not used)
9	Protocol select	9	Ring Indicator (RI) (not used)

[1] Pins 4 and 6 are connected internally.

Table A-70 S7-200 RS-232/PPI Multi–Master Cable – Pin-outs for RS-485 to RS-232 Remote Mode Connector

RS-485 Connector Pin-out		RS-232 Remote Connector Pin-out[1]	
Pin Number	Signal Description	Pin Number	Signal Description
1	No connect	1	Data Carrier Detect (DCD) (not used)
2	24 V Return (RS-485 logic ground)	2	Receive Data (RD) (input to PC/PPI cable)
3	Signal B (RxD/TxD+)	3	Transmit Data (TD) (output from PC/PPI cable)
4	RTS (TTL level)	4	Data Terminal Ready (DTR)[2]
5	No connect	5	Ground (RS-232 logic ground)
6	No connect	6	Data Set Ready (DSR)[2]
7	24 V Supply	7	Request To Send (RTS) (output from PC/PPI cable)
8	Signal A (RxD/TxD–)	8	Clear To Send (CTS) (not used)
9	Protocol select	9	Ring Indicator (RI) (not used)

[1] A conversion from female to male, and a conversion from 9-pin to 25-pin is required for modems.
[2] Pins 4 and 6 are connected internally.

Use the S7-200 RS-232/PPI Multi-Master Cable with STEP 7–Micro/WIN as a replacement for the PC/PPI cable or for Freeport operation

For connection directly to your personal computer:

- ❑ Set the PPI/Freeport mode (Switch 5=0)
- ❑ Set the baud rate (Switches 1, 2, and 3)
- ❑ Set Local (Switch 6=0). The Local setting is the same as setting the PC/PPI cable to DCE.
- ❑ Set the 11 Bit (Switch 7=0)

For connection to a modem:

- ❑ Set the PPI/Freeport mode (Switch 5=0)
- ❑ Set the baud rate (Switches 1, 2, and 3)
- ❑ Set Remote (Switch 6=1). The Remote setting is the same as setting the PC/PPI cable to DTE.
- ❑ Set the 10 Bit or 11 Bit (Switch 7) to match the number of bits per character setting of your modem.

Use the S7-200 RS-232/PPI Multi-Master Cable with STEP 7-Micro/WIN 3.2 Service Pack 4 (or later)

For connection directly to your personal computer:

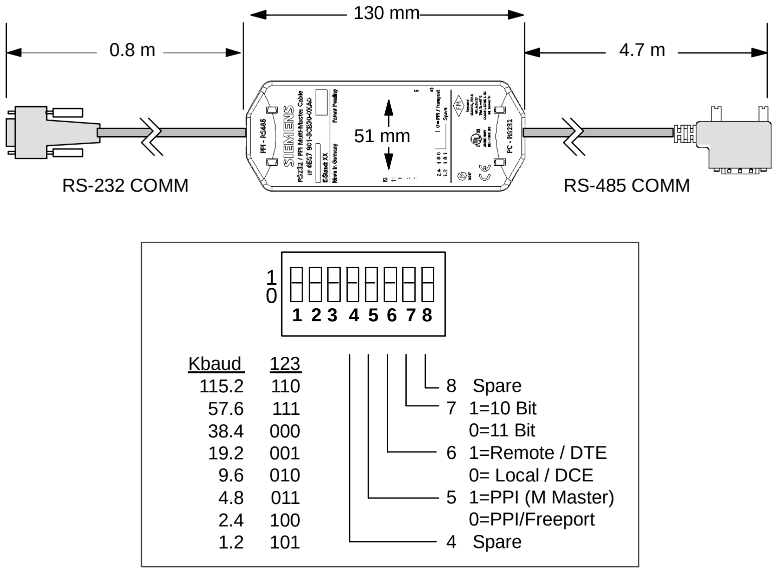
- ❑ Set the PPI mode (Switch 5=1)
- ❑ Set Local (Switch 6=0)
- ❑ Set 11-bit mode (Switch 7=0)

For connection to a modem:

- ❑ Set the PPI mode (Switch 5=1)
- ❑ Set Remote (Switch 6=1)
- ❑ Set 11-bit mode (Switch 7=0)

Tip
All other switches other than those noted above do not matter when using PPI mode.

Figure A-44 shows the S7-200 RS-232/PPI Multi-Master Cable dimensions, label and LEDs.



Kbaud	123
115.2	110
57.6	111
38.4	000
19.2	001
9.6	010
4.8	011
2.4	100
1.2	101

LED	Color	Description
Tx	Green	RS-232 transmit indicator
Rx	Green	RS-232 receive indicator
PPI	Green	RS-485 transmit indicator

Figure A-44 S7-200 RS-232/PPI Multi-Master Cable Dimensions, Label and LEDs

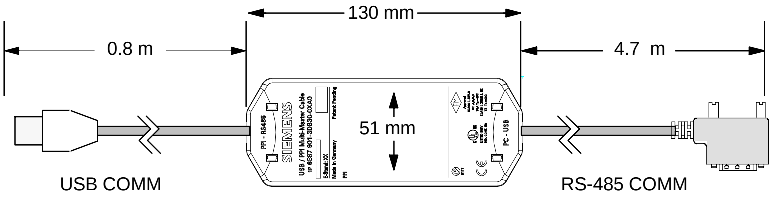
S7-200 USB/PPI Multi-Master Cable

To use the USB cable, you must have STEP 7–Micro/WIN 3.2 Service Pack 4 (or later) installed. It is recommended that you use the USB cable only with an S7-200 CPU22x or later. The USB cable does not support Freeport communications or downloading the TP Designer to the TP070.

Table A-71 S7-200 USB/PPI Multi-Master Cable – Pin-outs for the RS-485 to USB Series “A” Connector

RS-485 Connector Pin-out		USB Connector Pin-out	
Pin Number	**Signal Description**	**Pin Number**	**Signal Description**
1	No connect	1	USB – DataP
2	24 V Return (RS-485 logic ground)	2	USB – DataM
3	Signal B (RxD/TxD+)	3	USB 5V
4	RTS (TTL level)	4	USB logic ground
5	No connect		
6	No connect		
7	24 V Supply		
8	Signal A (RxD/TxD–)		
9	Protocol select (low = 10 bit)		

Figure A-45 shows the S7-200 USB/PPI Multi-Master Cable dimensions and LEDs.



LED	Color	Description
Tx	Green	USB transmit indicator
Rx	Green	USB receive indicator
PPI	Green	RS-485 transmit indicator

Figure A-45 S7-200 USB/PPI Multi-Master Cable Dimensions and LEDs

Input Simulators

Order Number	8 Position Simulator 6ES7 274-1XF00-0XA0	14 Position Simulator 6ES7 274-1XH00-0XA0	24 Position Simulator 6ES7 274-1XK00-0XA0
Size (L x W x D)	61 x 33.5 x 22 mm	91.5 x 35.5 x 22 mm	148.3 x 35.5 x 22 mm
Weight	0.02 Kg	0.03 Kg	0.04 Kg
Points	8	14	24

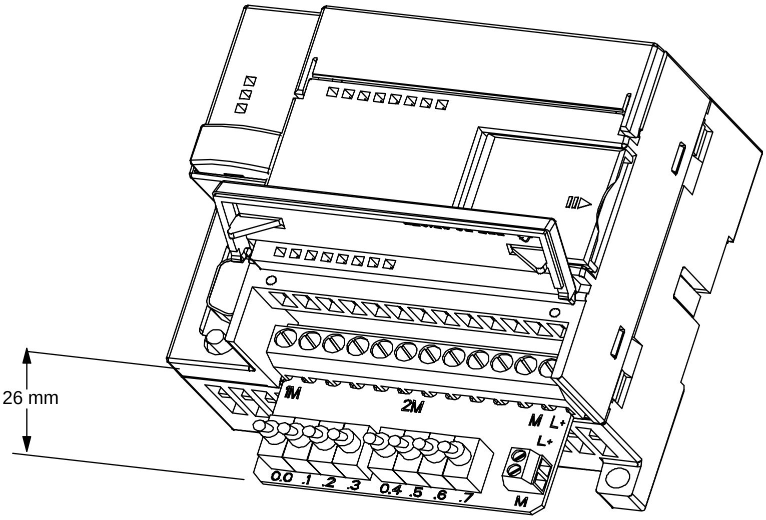


Figure A-46 Installation of the Input Simulator

Warning

These input simulators are not approved for use in Class I DIV 2 or Class I Zone 2 hazardous locations. The switches present a potential spark hazard.

Do not use input simulators in Class I DIV 2 or Class I Zone 2 hazardous locations.

Calculating a Power Budget

B

The S7-200 CPU has an internal power supply that provides power for the CPU itself, for any expansion modules, and for other 24 VDC user power requirements. Use the following information as a guide for determining how much power (or current) the S7-200 CPU can provide for your configuration.

Power Requirements

Each S7-200 CPU supplies both 5 VDC and 24 VDC power:

- ❑ Each CPU has a 24 VDC sensor supply that can supply 24 VDC for local input points or for relay coils on the expansion modules. If the power requirement for 24 VDC exceeds the power budget of the CPU, you can add an external 24 VDC power supply to provide 24 VDC to the expansion modules. You must manually connect the 24 VDC supply to the input points or relay coils.
- ❑ The CPU also provides 5 VDC power for the expansion modules when an expansion module is connected. If the 5 VDC power requirements for expansion modules exceeds the power budget of the CPU, you must remove expansion modules until the requirement is within the power budget.

The specifications in Appendix A provide information about the power budgets of the CPUs and the power requirements of the expansion modules.

Tip

If the CPU power budget is exceeded, you may not be able to connect the maximum number of modules allowed for your CPU.

Warning

Connecting an external 24 VDC power supply in parallel with the S7-200 DC Sensor Supply can result in a conflict between the two supplies as each seeks to establish its own preferred output voltage level.

The result of this conflict can be shortened lifetime or immediate failure of one or both power supplies, with consequent unpredictable operation of the PLC system. Unpredictable operation could result in death or serious injury to personnel, and/or damage to equipment.

The S7-200 DC Sensor Supply and any external power supply should provide power to different points. A single connection of the commons is allowed.

Calculating a Sample Power Requirement

Table B-1 shows a sample calculation of the power requirements for an S7-200 that includes the following:

- S7-200 CPU 224 AC/DC/Relay
- 3 each EM 223 8 DC In/8 Relay Out
- 1 each EM 221 8 DC In

This installation has a total of 46 inputs and 34 outputs.

Tip
The CPU has already allocated the power required to drive the internal relay coils. You do not need to include the internal relay coil power requirements in a power budget calculation.

The S7-200 CPU in this example provides sufficient 5 VDC current for the expansion modules, but does not provide enough 24 VDC current from the sensor supply for all of the inputs and expansion relay coils. The I/O requires 400 mA and the S7-200 CPU provides only 280 mA. This installation requires an additional source of at least 120 mA at 24 VDC power to operate all the included 24 VDC inputs and outputs.

Table B-1 Power Budget Calculations for a Sample Configuration

CPU Power Budget	**5 VDC**	**24 VDC**
CPU 224 AC/DC/Relay	660 mA	280 mA

minus

System Requirements	**5 VDC**		**24 VDC**	
CPU 224, 14 inputs			14 * 4 mA =	56 mA
3 EM 223, 5 V power required	3 * 80 mA =	240 mA		
1 EM 221, 5V power required	1 * 30 mA =	30 mA		
3 EM 223, 8 inputs each			3 * 8 * 4 mA =	96 mA
3 EM 223, 8 relay coils each			3 * 8 * 9 mA =	216 mA
1 EM 221, 8 inputs each			8 * 4 mA =	32 mA
Total Requirements		270 mA		400 mA

equals

Current Balance	**5 VDC**		**24 VDC**	
Current Balance Total		390 mA		[120 mA]

Calculating Your Power Requirement

Use the table below to determine how much power (or current) the S7-200 CPU can provide for your configuration. Refer to Appendix A for the power budgets of your CPU model and the power requirements of your expansion modules.

Power Budget	**5 VDC**	**24 VDC**

minus

System Requirements	**5 VDC**	**24 VDC**
Total Requirements		

equals

Current Balance	**5 VDC**	**24 VDC**
Current Balance Total		

C

Error Codes

The information about error codes is provided to help you identify problems with your S7-200 CPU.

In This Chapter

Fatal Error Codes and Messages

Fatal errors cause the S7-200 to stop the execution of your program. Depending on the severity of the error, a fatal error can render the S7-200 incapable of performing any or all functions. The objective for handling fatal errors is to bring the S7-200 to a safe state from which the S7-200 can respond to interrogations about the existing error conditions.

The S7–200 performs the following tasks when a fatal error is detected:

❏ Changes to STOP mode

❏ Turns on both the SF/DIAG (Red) LED and the Stop LED

❏ Turns off the outputs

The S7-200 remains in this condition until the fatal error is corrected. To view the error codes, select the **PLC > Information** menu command from the main menu bar. Table C-1 provides a list with descriptions for the fatal error codes that can be read from the S7-200.

Table C-1 Fatal Error Codes and Messages Read from the S7–200

Error Code	Description
0000	No fatal errors present
0001	User program checksum error
0002	Compiled ladder program checksum error
0003	Scan watchdog time-out error
0004	Permanent memory failed
0005	Permanent memory checksum error on user program
0006	Permanent memory checksum error on configuration (SDB0) parameters
0007	Permanent memory checksum error on force data
0008	Permanent memory checksum error on default output table values
0009	Permanent memory checksum error on user data, DB1
000A	Memory cartridge failed
000B	Memory cartridge checksum error on user program.
000C	Memory cartridge checksum error on configuration (SDB0) parameters
000D	Memory cartridge checksum error on force data
000E	Memory cartridge checksum error on default output table values
000F	Memory cartridge checksum error on user data, DB1
0010	Internal software error
0011[1]	Compare contact indirect addressing error
0012[1]	Compare contact illegal floating point value
0013	Program is not understood by this S7-200
0014[1]	Compare contact range error

[1] The compare contact errors are the only errors that generate both fatal and non-fatal error conditions. The reason for the generation of the non-fatal error condition is to save the program address of the error.

Run-Time Programming Problems

Your program can create non-fatal error conditions (such as addressing errors) during the normal execution of the program. In this case, the S7-200 generates a non-fatal run-time error code. Table C-2 lists the descriptions of the non-fatal error codes.

Table C-2 Run-Time Programming Problems

Error Code	Description
0000	No fatal errors present; no error
0001	HSC box enabled before executing HDEF box
0002	Conflicting assignment of input interrupt to a point already assigned to a HSC
0003	Conflicting assignment of inputs to an HSC already assigned to input interrupt or other HSC
0004	Attempted execution of an instruction that is not allowed in an interrupt routine
0005	Attempted execution of a second HSC/PLS with the same number before completing the first (HSC/PLS in an interrupt routine conflicts with HSC/PLS in main program)
0006	Indirect addressing error
0007	TODW (Time-of-Day Write) or TODR (Time-of-Day Read) data error
0008	Maximum user subroutine nesting level exceeded
0009	Simultaneous execution of XMT/RCV instructions on Port 0
000A	Attempt to redefine a HSC by executing another HDEF instruction for the same HSC
000B	Simultaneous execution of XMT/RCV instructions on Port 1
000C	Clock cartridge not present for access by TODR, TODW, or communications
000D	Attempt to redefine pulse output while it is active
000E	Number of PTO profile segment was set to 0
000F	Illegal numeric value in compare contact instruction
0010	Command is not allowed in current PTO mode of operation
0011	Illegal PTO command code
0012	Illegal PTO profile table
0013	Illegal PID loop table
0091	Range error (with address information): check the operand ranges
0092	Error in count field of an instruction (with count information): verify the maximum count size
0094	Range error writing to non-volatile memory with address information
009A	Attempt to switch to Freeport mode while in a user interrupt
009B	Illegal index (string operation in which a starting position value of 0 is specified)
009F	Memory cartridge missing or not responding

Compile Rule Violations

When you download a program, the S7-200 compiles the program. If the S7-200 detects that the program violates a compile rule (such as an illegal instruction), the S7-200 aborts the download and generates a non-fatal, compile-rule error code. Table C-3 lists the descriptions of the error codes that are generated by violations of the compile rules.

Table C-3 Compile Rule Violations

Error Code	Compile Errors (Non-Fatal)
0080	Program too large to compile; reduce program size
0081	Stack underflow; split network into multiple networks.
0082	Illegal instruction; check instruction mnemonics.
0083	Missing MEND or instruction not allowed in main program: add MEND instruction, or remove incorrect instruction.
0084	Reserved
0085	Missing FOR; add FOR instruction or delete NEXT instruction.
0086	Missing NEXT; add NEXT instruction or delete FOR instruction.
0087	Missing label (LBL, INT, SBR); add the appropriate label.
0088	Missing RET or instruction not allowed in a subroutine: add RET to the end of the subroutine or remove incorrect instruction.
0089	Missing RETI or instruction not allowed in an interrupt routine: add RETI to the end of the interrupt routine or remove incorrect instruction.
008A	Reserved
008B	Illegal JMP to or from an SCR segment
008C	Duplicate label (LBL, INT, SBR); rename one of the labels.
008D	Illegal label (LBL, INT, SBR); ensure the number of labels allowed was not exceeded.
0090	Illegal parameter; verify the allowed parameters for the instruction.
0091	Range error (with address information); check the operand ranges.
0092	Error in the count field of an instruction (with count information); verify the maximum count size.
0093	FOR/NEXT nesting level exceeded.
0095	Missing LSCR instruction (Load SCR)
0096	Missing SCRE instruction (SCR End) or disallowed instruction before the SCRE instruction
0097	User program contains both unnumbered and numbered EV/ED instructions
0098	Illegal edit in RUN mode (edit attempted on program with unnumbered EV/ED instructions)
0099	Too many hidden program segments (HIDE instructions)
009B	Illegal index (string operation in which a starting position value of 0 is specified)
009C	Maximum instruction length exceeded
009D	Illegal parameter detected in SDB0
009E	Too many PCALL strings
009F to 00FF	Reserved

D

Special Memory (SM) Bits

Special memory bits provide a variety of status and control functions, and also serve as a means of communicating information between the S7-200 and your program. Special memory bits can be used as bits, bytes, words, or double words.

In This Chapter

SMB0: Status Bits

As described in Table D-1, SMB0 contains eight status bits that are updated by the S7-200 at the end of each scan cycle.

Table D-1 Special Memory Byte SMB0 (SM0.0 to SM0.7)

SM Bits	Description (Read Only)
SM0.0	This bit is always on.
SM0.1	This bit is on for the first scan cycle. One use is to call an initialization subroutine.
SM0.2	This bit is turned on for one scan cycle if retentive data was lost. This bit can be used as either an error memory bit or as a mechanism to invoke a special startup sequence.
SM0.3	This bit is turned on for one scan cycle when RUN mode is entered from a power-up condition. This bit can be used to provide machine warm-up time before starting an operation.
SM0.4	This bit provides a clock pulse that is on for 30 seconds and off for 30 seconds, for a duty cycle time of 1 minute. It provides an easy-to-use delay, or a 1-minute clock pulse.
SM0.5	This bit provides a clock pulse that is on for 0.5 seconds and then off for 0.5 seconds, for a duty cycle time of 1 second. It provides an easy-to-use delay or a 1-second clock pulse.
SM0.6	This bit is a scan cycle clock which is on for one scan cycle and then off for the next scan cycle. This bit can be used as a scan counter input.
SM0.7	This bit reflects the position of the Mode switch (off is TERM position, and on is RUN position). If you use this bit to enable Freeport mode when the switch is in the RUN position, normal communications with the programming device can be enabled by switching to the TERM position.

SMB1: Status Bits

As described in Table D-2, SMB1 contains various potential error indicators. These bits are set and reset by instructions at execution time.

Table D-2 Special Memory Byte SMB1 (SM1.0 to SM1.7)

SM Bits	Description (Read Only)
SM1.0	This bit is turned on by the execution of certain instructions when the result of the operation is zero.
SM1.1	This bit is turned on by the execution of certain instructions either when an overflow results or when an illegal numeric value is detected.
SM1.2	This bit is turned on when a negative result is produced by a math operation.
SM1.3	This bit is turned on when division by zero is attempted.
SM1.4	This bit is turned on when the Add to Table instruction attempts to overfill the table.
SM1.5	This bit is turned on when either LIFO or FIFO instructions attempt to read from an empty table.
SM1.6	This bit is turned on when an attempt to convert a non-BCD value to binary is made.
SM1.7	This bit is turned on when an ASCII value cannot be converted to a valid hexadecimal value.

SMB2: Freeport Receive Character

SMB2 is the Freeport receive character buffer. As described in Table D-3, each character received while in Freeport mode is placed in this location for easy access from the ladder logic program.

Tip

SMB2 and SMB3 are shared between Port 0 and Port 1. When the reception of a character on Port 0 results in the execution of the interrupt routine attached to that event (interrupt event 8), SMB2 contains the character received on Port 0, and SMB3 contains the parity status of that character. When the reception of a character on Port 1 results in the execution of the interrupt routine attached to that event (interrupt event 25), SMB2 contains the character received on Port 1 and SMB3 contains the parity status of that character.

Table D-3 Special Memory Byte SMB2

SM Byte	Description (Read Only)
SMB2	This byte contains each character that is received from Port 0 or Port 1 during Freeport communications.

SMB3: Freeport Parity Error

SMB3 is used for Freeport mode and contains a parity error bit that is set when a parity error is detected on a received character. As shown in Table D-4, SM3.0 turns on when a parity error is detected. Use this bit to discard the message.

Table D-4 Special Memory Byte SMB3 (SM3.0 to SM3.7)

SM Bits	Description (Read Only)
SM3.0	Parity error from Port 0 or Port 1 (0 = no error; 1 = error was detected)
SM3.1 to SM3.7	Reserved

SMB4: Queue Overflow

As described in Table D-5, SMB4 contains the interrupt queue overflow bits, a status indicator showing whether interrupts are enabled or disabled, and a transmitter-idle memory bit. The queue overflow bits indicate either that interrupts are happening at a rate greater than can be processed, or that interrupts were disabled with the global interrupt disable instruction.

Table D-5 Special Memory Byte SMB4 (SM4.0 to SM4.7)

SM Bits	Description (Read Only)
SM4.0[1]	This bit is turned on when the communications interrupt queue has overflowed.
SM4.1[1]	This bit is turned on when the input interrupt queue has overflowed.
SM4.2[1]	This bit is turned on when the timed interrupt queue has overflowed.
SM4.3	This bit is turned on when a run-time programming problem is detected.
SM4.4	This bit reflects the global interrupt enable state. It is turned on when interrupts are enabled.
SM4.5	This bit is turned on when the transmitter is idle (Port 0).
SM4.6	This bit is turned on when the transmitter is idle (Port 1).
SM4.7	This bit is turned on when something is forced.

[1] Use status bits 4.0, 4.1, and 4.2 only in an interrupt routine. These status bits are reset when the queue is emptied, and control is returned to the main program.

SMB5: I/O Status

As described in Table D-6, SMB5 contains status bits about error conditions that were detected in the I/O system. These bits provide an overview of the I/O errors detected.

Table D-6 Special Memory Byte SMB5 (SM5.0 to SM5.7)

SM Bits	Description (Read Only)
SM5.0	This bit is turned on if any I/O errors are present.
SM5.1	This bit is turned on if too many digital I/O points have been connected to the I/O bus.
SM5.2	This bit is turned on if too many analog I/O points have been connected to the I/O bus.
SM5.3	This bit is turned on if too many intelligent I/O modules have been connected to the I/O bus.
SM5.4 to SM5.7	Reserved.

SMB6: CPU ID Register

As described in Table D-7, SMB6 is the identification register for the S7-200 CPU. SM6.4 to SM6.7 identify the type of S7-200 CPU. SM6.0 to SM6.3 are reserved for future use.

Table D-7 Special Memory Byte SMB6

SM Bits	Description (Read Only)
Format	MSB 7 … LSB 0 x x x x r r r r CPU ID register
SM6.0 to SM6.3	Reserved
SM6.4 to SM6.7	xxxx = 0000 = CPU 222 0010 = CPU 224 / CPU 224XP 0110 = CPU 221 1001 = CPU 226

SMB7: Reserved

SMB7 is reserved for future use.

SMB8 to SMB21: I/O Module ID and Error Registers

SMB8 through SMB21 are organized in byte pairs for expansion modules 0 to 6. As described in Table D-8, the even-numbered byte of each pair is the module-identification register. These bytes identify the module type, the I/O type, and the number of inputs and outputs. The odd-numbered byte of each pair is the module error register. These bytes provide an indication of any errors detected in the I/O for that module.

Table D-8 Special Memory Bytes SMB8 to SMB21

SM Byte	Description (Read Only)
Format	Even-Number Byte: Module ID Register MSB 7 … LSB 0 m t t a i i q q m: Module present 0 = Present, 1 = Not present tt: Module type 00 Non-intelligent I/O module 01 Intelligent module 10 Reserved 11 Reserved a: I/O type 0 = Discrete, 1 = Analog ii: Inputs 00 No inputs 01 2 AI or 8 DI 10 4 AI or 16 DI 11 8 AI or 32 DI qq: Outputs 00 No outputs 01 2 AQ or 8 DQ 10 4 AQ or 16 DQ 11 8 AQ or 32 DQ Odd-Number Byte: Module Error Register MSB 7 … LSB 0 c 0 0 b r p f t c: Configuration error 0 = no error, 1 = error b: Bus fault or parity error r: Out-of-range error p: No user power error f: Blown fuse error t: Terminal block loose error
SMB8 SMB9	Module 0 ID register Module 0 error register
SMB10 SMB11	Module 1 ID register Module 1 error register
SMB12 SMB13	Module 2 ID register Module 2 error register
SMB14 SMB15	Module 3 ID register Module 3 error register
SMB16 SMB17	Module 4 ID register Module 4 error register
SMB18 SMB19	Module 5 ID register Module 5 error register
SMB20 SMB21	Module 6 ID register Module 6 error register

SMW22 to SMW26: Scan Times

As described in Table D-9, SMW22**,** SMW24, and SMW26 provide scan time information: minimum scan time, maximum scan time, and last scan time in milliseconds.

Table D-9 Special Memory Words SMW22 to SMW26

SM Word	Description (Read Only)
SMW22	Scan time of the last scan cycle in milliseconds
SMW24	Minimum scan time in milliseconds recorded since entering the RUN mode
SMW26	Maximum scan time in milliseconds recorded since entering the RUN mode

SMB28 and SMB29: Analog Adjustment

As described in Table D-10, SMB28 holds the digital value that represents the position of analog adjustment 0. SMB29 holds the digital value that represents the position of analog adjustment 1.

Table D-10 Special Memory Bytes SMB28 and SMB29

SM Byte	Description (Read Only)
SMB28	This byte stores the value entered with analog adjustment 0. This value is updated once per scan in STOP/RUN.
SMB29	This byte stores the value entered with analog adjustment 1. This value is updated once per scan in STOP/RUN.

SMB30 and SMB130: Freeport Control Registers

SMB30 controls the Freeport communications for port 0; SMB130 controls the Freeport communications for port 1. You can read and write to SMB30 and SMB130. As described in Table D-11, these bytes configure the respective communications ports for Freeport operation and provide selection of either Freeport or system protocol support.

Table D-11 Special Memory Byte SMB30

Port 0	Port 1	Description
Format of SMB30	Format of SMB130	Freeport mode control byte MSB 7 … LSB 0 p p d b b b m m
SM30.0 and SM30.1	SM130.0 and SM130.1	mm: Protocol selection 00 =Point-to-Point Interface protocol (PPI/slave mode) 01 =Freeport protocol 10 =PPI/master mode 11 =Reserved (defaults to PPI/slave mode) Note: When you select code mm = 10 (PPI master), the S7-200 will become a master on the network and allow the NETR and NETW instructions to be executed. Bits 2 through 7 are ignored in PPI modes.
SM30.2 to SM30.4	SM130.2 to SM130.4	bbb: Freeport Baud rate 000 =38,400 baud 001 =19,200 baud 010 =9,600 baud 011 =4,800 baud 100 =2,400 baud 101 =1,200 baud 110 =115,200 baud 111 =57,600 baud
SM30.5	SM130.5	d: Data bits per character 0 =8 bits per character 1 =7 bits per character
SM30.6 and SM30.7	SM130.6 and SM130.7	pp: Parity select 00 =no parity 01 =even parity 10 =no parity 11 =odd parity

SMB31 and SMW32: Permanent Memory (EEPROM) Write Control

You can save a value stored in V memory to permanent memory under the control of your program. To do this, load the address of the location to be saved in SMW32. Then, load SMB31 with the command to save the value. Once you have loaded the command to save the value, you do not change the value in V memory until the S7-200 resets SM31.7, indicating that the save operation is complete.

At the end of each scan, the S7-200 checks to see if a command to save a value to permanent memory was issued. If the command was issued, the specified value is saved to permanent memory.

As described in Table D-12, SMB31 defines the size of the data to be saved to permanent memory and provides the command that initiates a save operation. SMW32 stores the starting address in V memory for the data to be saved to permanent memory.

Table D-12 Special Memory Byte SMB31 and Special Memory Word SMW32

SM Byte	Description
Format	SMB31: Software command — MSB 7 … LSB 0: | c | 0 | 0 | 0 | 0 | 0 | s | s | SMW32: V memory address — MSB 15 … LSB 0: V memory address
SM31.0 and SM31.1	ss: Size of the data 00 =byte 10 =word 01 =byte 11 =double word
SM31.7	c: Save to permanent memory 0 =No request for a save operation to be performed 1 =User program requests to save data The S7-200 resets this bit after each save operation.
SMW32	The V memory address for the data to be saved is stored in SMW32. This value is entered as an offset from V0. When a save operation is executed, the value in this V memory address is saved to the corresponding V memory location in the permanent memory.

SMB34 and SMB35: Time Interval Registers for Timed Interrupts

As described in Table D-13, SMB34 specifies the time interval for timed interrupt 0, and SMB35 specifies the time interval for timed interrupt 1. You can specify the time interval (in 1-ms increments) from 1 ms to 255 ms. The time-interval value is captured by the S7-200 at the time the corresponding timed interrupt event is attached to an interrupt routine. To change the time interval, you must reattach the timed interrupt event to the same or to a different interrupt routine. You can terminate the timed interrupt event by detaching the event.

Table D-13 Special Memory Bytes SMB34 and SMB35

SM Byte	Description
SMB34	This byte specifies the time interval (in 1-ms increments from 1 ms to 255 ms) for timed interrupt 0.
SMB35	This byte specifies the time interval (in 1-ms increments from 1 ms to 255 ms) for timed interrupt 1.

SMB36 to SMB65: HSC0, HSC1, and HSC2 Register

As described in Table D-14, SMB36 through SM65 are used to monitor and control the operation of high-speed counters HSC0, HSC1, and HSC2.

Table D-14 Special Memory Bytes SMB36 to SMD62

SM Byte	Description
SM36.0 to SM36.4	Reserved
SM36.5	HSC0 current counting direction status bit: 1 = counting up
SM36.6	HSC0 current value equals preset value status bit: 1 = equal
SM36.7	HSC0 current value is greater than preset value status bit: 1 = greater than
SM37.0	Active level control bit for Reset: 0= Reset is active high, 1 = Reset is active low
SM37.1	Reserved
SM37.2	Counting rate selection for quadrature counters:0=4x counting rate; 1=1 x counting rate
SM37.3	HSC0 direction control bit: 1 = count up
SM37.4	HSC0 update the direction: 1 = update direction
SM37.5	HSC0 update the preset value: 1 = write new preset value to HSC0 preset
SM37.6	HSC0 update the current value: 1 = write new current value to HSC0 current
SM37.7	HSC0 enable bit: 1 = enable
SMD38	HSC0 new current value
SMD42	HSC0 new preset value
SM46.0 to SM46.4	Reserved
SM46.5	HSC1 current counting direction status bit: 1 = counting up
SM46.6	HSC1 current value equals preset value status bit: 1 = equal
SM46.7	HSC1 current value is greater than preset value status bit: 1 = greater than
SM47.0	HSC1 active level control bit for reset: 0 = active high, 1 = active low
SM47.1	HSC1 active level control bit for start: 0 = active high, 1 = active low
SM47.2	HSC1 quadrature counter rate selection: 0 = 4x rate, 1 = 1x rate
SM47.3	HSC1 direction control bit: 1 = count up
SM47.4	HSC1 update the direction: 1 = update direction
SM47.5	HSC1 update the preset value: 1 = write new preset value to HSC1 preset
SM47.6	HSC1 update the current value: 1 = write new current value to HSC1 current
SM47.7	HSC1 enable bit: 1 = enable
SMD48	HSC1 new current value
SMD52	HSC1 new preset value
SM56.0 to SM56.4	Reserved
SM56.5	HSC2 current counting direction status bit: 1 = counting up
SM56.6	HSC2 current value equals preset value status bit: 1 = equal
SM56.7	HSC2 current value is greater than preset value status bit: 1 = greater than
SM57.0	HSC2 active level control bit for reset: 0 = active high, 1 = active low
SM57.1	HSC2 active level control bit for start: 0 = active high, 1 = active low
SM57.2	HSC2 quadrature counter rate selection: 0 = 4x rate, 1 = 1x rate
SM57.3	HSC2 direction control bit: 1 = count up
SM57.4	HSC2 update the direction: 1 = update direction
SM57.5	HSC2 update the preset value: 1 = write new preset value to HSC2 preset
SM57.6	HSC2 update the current value: 1 = write new current value to HSC2 current
SM57.7	HSC2 enable bit: 1 = enable
SMD58	HSC2 new current value
SMD62	HSC2 new preset value

SMB66 to SMB85: PTO/PWM Registers

As described in Table D-15, SMB66 through SMB85 are used to monitor and control the pulse train output and pulse width modulation functions. See the information on pulse output high-speed output instructions in Chapter 6 for a complete description of these bits.

Table D-15 Special Memory Bytes SMB66 to SMB85

SM Byte	Description
SM66.0 to SM66.3	Reserved
SM66.4	PTO0 profile aborted: 0 = no error, 1 = aborted due to a delta calculation error
SM66.5	PTO0 profile aborted: 0 = not aborted by user command, 1 = aborted by user command
SM66.6	PTO0/PWM pipeline overflow (cleared by the system when using external profiles, otherwise must be reset by user): 0 = no overflow, 1 = pipeline overflow
SM66.7	PTO0 idle bit: 0 = PTO in progress, 1 = PTO idle
SM67.0	PTO0/PWM0 update the cycle time value: 1 = write new cycle time
SM67.1	PWM0 update the pulse width value: 1 = write new pulse width
SM67.2	PTO0 update the pulse count value: 1 = write new pulse count
SM67.3	PTO0/PWM0 time base: 0 = 1 μs/tick, 1 = 1 ms/tick
SM67.4	Update PWM0 synchronously: 0 = asynchronous update, 1 = synchronous update
SM67.5	PTO0 operation: 0 = single segment operation (cycle time and pulse count stored in SM memory), 1 = multiple segment operation (profile table stored in V memory)
SM67.6	PTO0/PWM0 mode select: 0 = PTO, 1 = PWM
SM67.7	PTO0/PWM0 enable bit: 1 = enable
SMW68	PTO0/PWM0 cycle time value (2 to 65,535 units of time base);
SMW70	PWM0 pulse width value (0 to 65,535 units of the time base);
SMD72	PTO0 pulse count value (1 to $2^{32}-1$);
SM76.0 to SM76.3	Reserved
SM76.4	PTO1 profile aborted: 0 = no error, 1 = aborted because of delta calculation error
SM76.5	PTO1 profile aborted: 0 = not aborted by user command, 1 = aborted by user command
SM76.6	PTO1/PWM pipeline overflow (cleared by the system when using external profiles, otherwise must be reset by the user): 0 = no overflow, 1 = pipeline overflow
SM76.7	PTO1 idle bit: 0 = PTO in progress, 1 = PTO idle
SM77.0	PTO1/PWM1 update the cycle time value: 1 = write new cycle time
SM77.1	PWM1 update the pulse width value: 1 = write new pulse width
SM77.2	PTO1 update the pulse count value: 1 = write new pulse count
SM77.3	PTO1/PWM1 time base: 0 = 1 μs/tick, 1 = 1 ms/tick
SM77.4	Update PWM1 synchronously: 0 = asynchronous update, 1 = synchronous update
SM77.5	PTO1 operation: 0 = single segment operation (cycle time and pulse count stored in SM memory), 1 = multiple segment operation (profile table stored in V memory)
SM77.6	PTO1/PWM1 mode select: 0 = PTO, 1 = PWM
SM77.7	PTO1/PWM1 enable bit: 1 = enable
SMW78	PTO1/PWM1 cycle time value (2 to 65,535 units of the time base);
SMW80	PWM1 pulse width value (0 to 65,535 units of the time base);
SMD82	PTO1 pulse count value (1 to $2^{32}-1$);

SMB86 to SMB94, and SMB186 to SMB194: Receive Message Control

As described in Table D-16, SMB86 through SMB94 and SMB186 through SMB194 are used to control and read the status of the Receive Message instruction.

Table D-16 Special Memory Bytes SMB86 to SMB94, and SMB186 to SMB194

Port 0	Port 1	Description
SMB86	SMB186	Receive Message status byte MSB 7 LSB 0 n r e 0 0 t c p n: 1 = Receive message terminated by user disable command r: 1 = Receive message terminated: error in input parameters or missing start or end condition e: 1 = End character received t: 1 = Receive message terminated: timer expired c: 1 = Receive message terminated: maximum character count achieved p 1 = Receive message terminated because of a parity error
SMB87	SMB187	Receive Message control byte MSB 7 LSB 0 en sc ec il c/m tmr bk 0 en: 0 =Receive Message function is disabled. 1 =Receive Message function is enabled. The enable/disable receive message bit is checked each time the RCV instruction is executed. sc: 0 =Ignore SMB88 or SMB188. 1 =Use the value of SMB88 or SMB188 to detect start of message. ec: 0 =Ignore SMB89 or SMB189. 1 =Use the value of SMB89 or SMB189 to detect end of message. il: 0 =Ignore SMW90 or SMW190. 1 =Use the value of SMW90 or SMW190 to detect an idle line condition. c/m: 0 =Timer is an inter-character timer. 1 =Timer is a message timer. tmr: 0 =Ignore SMW92 or SMW192. 1 =Terminate receive if the time period in SMW92 or SMW192 is exceeded. bk: 0 =Ignore break conditions. 1 =Use break condition as start of message detection.
SMB88	SMB188	Start of message character
SMB89	SMB189	End of message character
SMW90	SMW190	Idle line time period given in milliseconds. The first character received after idle line time has expired is the start of a new message.
SMW92	SMW192	Inter-character/message timer time-out value (in milliseconds). If the time period is exceeded, the receive message is terminated.
SMB94	SMB194	Maximum number of characters to be received (1 to 255 bytes). Note: This range must be set to the expected maximum buffer size, even if the character count message termination is not used.

SMW98: Errors on the Expansion I/O Bus

As described in Table D-17, SMW98 gives you information about the number of errors on the expansion I/O bus.

Table D-17 Special Memory Bytes SMW98

SM Byte	Description
SMW98	This location is incremented each time a parity error is detected on the expansion I/O bus. It is cleared upon power up, and can be cleared by the user.

SMB130: Freeport Control Register *(see SMB30)*

Refer to Table D-11.

SMB131 to SMB165: HSC3, HSC4, and HSC5 Register

As described in Table D-18, SMB131 through SMB165 are used to monitor and control the operation of high-speed counters HSC3, HSC4, and HSC5.

Table D-18 Special Memory Bytes SMB131 to SMB165

SM Byte	Description
SMB131 to SMB135	Reserved
SM136.0 to SM136.4	Reserved
SM136.5	HSC3 current counting direction status bit: 1 = counting up
SM136.6	HSC3 current value equals preset value status bit: 1 = equal
SM136.7	HSC3 current value is greater than preset value status bit: 1 = greater than
SM137.0 to SM137.2	Reserved
SM137.3	HSC3 direction control bit: 1 = count up
SM137.4	HSC3 update direction: 1 = update direction
SM137.5	HSC3 update preset value: 1 = write new preset value to HSC3 preset
SM137.6	HSC3 update current value: 1 = write new current value to HSC3 current
SM137.7	HSC3 enable bit: 1 = enable
SMD138	HSC3 new current value
SMD142	HSC3 new preset value
SM146.0 to SM146.4	Reserved
SM146.5	HSC4 current counting direction status bit: 1 = counting up
SM146.6	HSC4 current value equals preset value status bit: 1 = equal
SM146.7	HSC4 current value is greater than preset value status bit: 1 = greater than
SM147.0	Active level control bit for Reset: 0 = Reset is active high, 1 = Reset is active low
SM147.1	Reserved
SM147.2	Counting rate selection for quadrature counters: 0 = 4x counting rate, 1 = 1x counting rate
SM147.3	HSC4 direction control bit: 1 = count up
SM147.4	HSC4 update direction: 1 = update direction
SM147.5	HSC4 update preset value: 1 = write new preset value to HSC4 preset
SM147.6	HSC4 update current value: 1 = write new current value to HSC4 current
SM147.7	HSC4 enable bit: 1 = enable
SMD148	HSC4 new current value
SMD152	HSC4 new preset value
SM156.0 to SM156.4	Reserved

Table D-18 Special Memory Bytes SMB131 to SMB165, continued

SM Byte	Description
SM156.5	HSC5 current counting direction status bit: 1 = counting up
SM156.6	HSC5 current value equals preset value status bit: 1 = equal
SM156.7	HSC5 current value is greater than preset value status bit: 1 = greater than
SM157.0 to SM157.2	Reserved
SM157.3	HSC5 direction control bit: 1 = count up
SM157.4	HSC5 update direction: 1 = update direction
SM157.5	HSC5 update preset value: 1 = write new preset value to HSC5 preset
SM157.6	HSC5 update current value: 1 = write new current value to HSC5 current
SM157.7	HSC5 enable bit: 1 = enable
SMD158	HSC5 new current value
SMD162	HSC5 new preset value

SMB166 to SMB185: PTO0, PTO1 Profile Definition Table

As described in Table D-19, SMB166 through SMB185 are used to show the number of active profile steps and the address of the profile table in V memory.

Table D-19 Special Memory Bytes SMB166 to SMB185

SM Byte	Description
SMB166	Current entry number of the active profile step for PTO0
SMB167	Reserved
SMW168	V memory address of the profile table for PTO0 given as an offset from V0.
SMB170	Linear PTO0 status byte
SMB171	Linear PTO0 result byte
SMD172	Specifies the frequency to be generated when the Linear PTO0 generator is operated in manual mode. The frequency is specified as a double integer value in Hz. SMB172 is MSB and SMB175 is LSB
SMB176	Current entry number of the active profile step for PTO1
SMB177	Reserved
SMW178	V memory address of the profile table for PTO1 given as an offset from V0.
SMB180	Linear PTO1 status byte
SMB181	Linear PTO1 result byte
SMD182	Specifies the frequency to be generated when the Linear PTO1 generator is operated in manual mode. The frequency is specified as a double integer value in Hz. SMB182 is MSB and SMB178 is LSB

SMB186 to SMB194: Receive Message Control *(see SMB86 to SMB94)*

Refer to Table D-16.

SMB200 to SMB549: Intelligent Module Status

As shown in Table D-20, SMB200 through SMB549 are reserved for information provided by intelligent expansion modules, such as the EM 277 PROFIBUS-DP module. For information about how your module uses SMB200 through SMB549, refer to Appendix A for the specifications of your specific module.

For an S7-200 CPU with firmware prior to version 1.2, you must install the intelligent module next to the CPU in order to ensure compatibility.

Table D-20 Special Memory Bytes SMB200 to SMB549

Special Memory Bytes SMB200 to SMB549							
Intelligent Module in Slot 0	Intelligent Module in Slot 1	Intelligent Module in Slot 2	Intelligent Module in Slot 3	Intelligent Module in Slot 4	Intelligent Module in Slot 5	Intelligent Module in Slot 6	Description
SMB200 to SMB215	SMB250 to SMB265	SMB300 to SMB315	SMB350 to SMB365	SMB400 to SMB415	SMB450 to SMB465	SMB500 to SMB515	Module name (16 ASCII characters)
SMB216 to SMB219	SMB266 to SMB269	SMB316 to SMB319	SMB366 to SMB369	SMB416 to SMB419	SMB466 to SMB469	SMB516 to SMB519	S/W revision number (4 ASCII characters)
SMW220	SMW270	SMW320	SMW370	SMW420	SMW470	SMW520	Error code
SMB222 to SMB249	SMB272 to SMB299	SMB322 to SMB349	SMB372 to SMB399	SMB422 to SMB449	SMB472 to SMB499	SMB522 to SMB549	Information specific to the particular module type

E

SIMATIC S7-200 Order Numbers

CPUs	Order Number
CPU 221 DC/DC/DC 6 Inputs/4 Outputs	6ES7 211–0AA23–0XB0
CPU 221 AC/DC/Relay 6 Inputs/4 Relays	6ES7 211–0BA23–0XB0
CPU 222 DC/DC/DC 8 Inputs/6 Outputs	6ES7 212–1AB23–0XB0
CPU 222 AC/DC/Relay 8 Inputs/6 Relays	6ES7 212–1BB23–0XB0
CPU 224 DC/DC/DC 14 Inputs/10 Outputs	6ES7 214–1AD23–0XB0
CPU 224 AC/DC/Relay 14 Inputs/10 Relays	6ES7 214–1BD23–0XB0
CPU 224XP DC/DC/DC 14 Inputs/10 Outputs	6ES7 214–2AD23–0XB0
CPU 224XP AC/DC/Relay 14 Inputs/10 Relays	6ES7 214–2BD23–0XB0
CPU 224XPsi DC/DC/DC 14 Inputs/10 Outputs	6ES7 214–2AS23–0XB0
CPU 226 DC/DC/DC 24 Inputs/16 Outputs	6ES7 216–2AD23–0XB0
CPU 226 AC/DC/Relay 24 Inputs/16 Relays	6ES7 216–2BD23–0XB0
Expansion Modules	**Order Number**
EM 221 24 VDC Digital 8 Inputs	6ES7 221–1BF22–0XA0
EM 221 Digital 8 AC Inputs (8 x 120/230 VAC)	6ES7 221–1EF22–0XA0
EM 221 Digital Input 16 x 24 VDC	6ES7 221–1BH22–0XA0
EM 222 24 VDC Digital 8 Outputs	6ES7 222–1BF22–0XA0
EM 222 Digital Output 8 x Relay	6ES7 222–1HF22–0XA0
EM 222 Digital 8 AC Outputs (8 x 120/230 VAC)	6ES7 222–1EF22–0XA0
EM 222 Digital Output 4 x 24 VDC – 5A	6ES7 222–1BD22–0XA0
EM 222 Digital Output 4 x Relays –10A	6ES7 222–1HD22–0XA0
EM 223 24 VDC Digital Combination 4 Inputs/4 Outputs	6ES7 223–1BF22–0XA0
EM 223 24 VDC Digital Combination 4 Inputs/4 Relay Outputs	6ES7 223–1HF22–0XA0
EM 223 24 VDC Digital Combination 8 Inputs/8 Outputs	6ES7 223–1BH22–0XA0
EM 223 24 VDC Digital Combination 8 Inputs/8 Relay Outputs	6ES7 223–1PH22–0XA0
EM 223 24 VDC Digital Combination 16 Inputs/16 Outputs	6ES7 223–1BL22–0XA0
EM 223 24 VDC Digital Combination 16 Inputs/16 Relay Outputs	6ES7 223–1PL22–0XA0
EM 223 24 VDC Digital Combination 32 Inputs/32 Outputs	6ES7 223–1BM22–0XA0
EM 223 24 VDC Digital Combination 32 Inputs/32 Relay Outputs	6ES7 223–1PM22–0XA0
EM 231 Analog Input, 4 Inputs	6ES7 231–0HC22–0XA0
EM 231 Analog Input, 8 Inputs	6ES7 231–0HF22–0XA0
EM 231 Analog Input RTD, 2 Inputs	6ES7 231–7PB22–0XA0
EM 231 Analog Input RTD, 4 Inputs	6ES7 231–7PC22–0XA0
EM 231 Analog Input Thermocouple, 4 Inputs	6ES7 231–7PD22–0XA0
EM 231 Analog Input Thermocouple, 8 Inputs	6ES7 231–7PF22–0XA0
EM 232 Analog Output, 2 Outputs	6ES7 232–0HB22–0XA0
EM 232 Analog Output, 4 Outputs	6ES7 232–0HD22–0XA0
EM 235 Analog Combination 4 Inputs/1 Output	6ES7 235–0KD22–0XA0
EM 241 Modem Module	6ES7 241–1AA22–0XA0
EM 253 Position Module	6ES7 253–1AA22–0XA0

Expansion Modules	Order Number
SIWAREX MS Micro Scale Module (includes manual)	7MH4 930–0AA01
SINAUT MD720–3 GSM/GPRS Modem	6NH9 720–3AA00
SINAUT ANT 794–4MR Antenna GSM Quadband AMD UMTS	6NH9 860–1AA00
Communications Modules	**Order Number**
EM 277 PROFIBUS–DP Module	6ES7 277–0AA22–0XA0
CP 243–2 AS Interface Module	6GK7 243–2AX01–0XA0
CP 243–1 Ethernet Module (with electronic documentation on CD)	6GK7 243–1EX00–0XE0
CP 243–1 IT Internet Module (with electronic documentation on CD)	6GK7 243–1GX00–0XE0
Cartridges and Cables	**Order Number**
Memory Cartridge, 64K (user program, recipe, and data logging)	6ES7 291–8GF23–0XA0
Memory Cartridge, 256K (user program, recipe, and data logging)	6ES7 291–8GH23–0XA0
Real-Time Clock with battery Cartridge (CPU 221 and CPU 222)	6ES7 297–1AA23–0XA0
Battery Cartridge	6ES7 291–8BA20–0XA0
I/O Bus Extension Cable, 0.8 meters	6ES7 290–6AA20–0XA0
Programming Cable, RS-232/PPI Multi-Master	6ES7 901–3CB30–0XA0
Programming Cable, USB/PPI Multi-Master	6ES7 901–3DB30–0XA0
P/C Adapter, USB	6ES7 972–0CB20–0XA0
SIWAREX MS – SIWATOOL MS Cable	7MH4 702–8CB
Software	**Order Number**
STEP 7–Micro/WIN (V4.0) Individual License (CD-ROM)	6ES7 810–2CC03–0YX0
STEP 7–Micro/WIN (V4.0) Upgrade License (CD-ROM)	6ES7 810–2CC03–0YX3
STEP 7–Micro/WIN Add-on: STEP 7–Micro/WIN 32 Instruction Library, V1.1 (CD-ROM)	6ES7 830–2BC00–0YX0
S7-200 PC Access V1.0 (OPC Server) Individual License	6ES7 840–2CC01–0YX0
S7-200 PC Access V1.0 (OPC Server) Multi-copy License	6ES7 840–2CC01–0YX1
WinCC flexible 2007 Micro Individual License (DVD–ROM without license key)	6AV6 610–0AA01–2CA8
WinCC flexible 2007 Micro Upgrade License (DVD–ROM without license key)	6AV6 610–0AA01–2CE8
WinCC flexible 2007 Compact Individual License (DVD–ROM with license key)	6AV6 611–0AA51–2CA5
WinCC flexible 2007 Compact Upgrade License (DVD–ROM with license key)	6AV6 611–0AA51–2CE5
SIWATOOL MS Configuration software or SIWAREX MS Micro Scale	7MH4 930–0AK01
SINAUT MICRO SC 8 Single License for 1 Installation	6NH9 910–0AA10–0AA3
SINAUT MICRO SC 64 Single License for 1 Installation	6NH9 910–0AA10–0AA6
SINAUT MICRO SC 256 Single License for 1 Installation	6NH9 910–0AA10–0AA8

Communications Cards	Order Number
CP 5411: Short AT ISA	6GK1 541–1AA00
CP 5512: PCMCIA Type II	6GK1 551–2AA00
CP 5611: PCI card (version 3.0 or greater)	6GK1 561–1AA00

Manuals	Order Number
S7-200 Programmable Controller System Manual (German)	6ES7 298–8FA24–8AH0
S7-200 Programmable Controller System Manual (English)	6ES7 298–8FA24–8BH0
S7-200 Programmable Controller System Manual (French)	6ES7 298–8FA24–8CH0
S7-200 Programmable Controller System Manual (Spanish)	6ES7 298–8FA24–8DH0
S7-200 Programmable Controller System Manual (Italian)	6ES7 298–8FA24–8EH0
S7–200 Programmable Controller System Manual (Chinese)	6ES7 298–8FA24–8FH0
S7–200 Programmable Controller System Manual (Korean)	6ES7 298–8FA24–8GH0
S7-200 Point-to-Point Interface Communication Manual (English/German)	6ES7 298–8GA00–8XH0
CP 243–2 AS-Interface Master Manual (English)	6GK7 243–2AX00–8BA0
OP 73micro and TP 177micro User Manual (English)	6AV6 691–1DF01–0AB0
WinCC flexible 2005 Micro User’s Manual	6AV6 691–1AA01–0AB0
SIMATIC HMI Manual Collection	6AV6 691–1SA01–0AX0
Cables, Network Connectors, and Repeaters	**Order Number**
MPI Cable	6ES7 901–0BF00–0AA0
PROFIBUS Network Cable	6XV1 830–0AH10
Network Bus Connector with Programming Port Connector, Vertical Cable Outlet	6ES7 972–0BB11–0XA0
Network Bus Connector (no programming port connector), Vertical Cable Outlet	6ES7 972–0BA11–0XA0
RS-485 Bus Connector with 35° Cable Outlet (no programming port connector)	6ES7 972–0BA40–0XA0
RS-485 Bus Connector with 35° Cable Outlet (with programming port connector)	6ES7 972–0BB40–0XA0
Terminal Block (7 position)	6ES7 292–1AD20–0AA0
Terminal Block (12 position)	6ES7 292–1AE20–0AA0
Terminal Block (14 position)	6ES7 292–1AF20–0AA0
Terminal Block (18 position)	6ES7 292–1AG20–0AA0
RS-485 IP 20 Repeater, Isolated	6ES7 972–0AA00–0XA0
TD/CPU Connecting Cable	6ES7 901–3EB10–0XA0
Human Machine Interface	**Order Number**
TD 100C Operator Interface[1]	6ES7 272–1BA10–0YA1
TD 200 Operator Interface	6ES7 272–0AA30–0YA1
TD 200C Operator Interface[1]	6ES7 272–1AA10–0YA1
TD400C Operator Interface[1]	6AV6 640–0AA00–0AX1
TD 100C Blank faceplate material, A4 size (10 sheets/package)	6ES7 272–1BF00–7AA0
TD 200C Blank faceplate material, A4 size (10 sheets/package)	6ES7 272–1AF00–7AA0
TD400C Blank faceplate material, A4 size (10 sheets/package)	6AV6 671–0AP00–0AX0
OP 73micro Operator Panel	6AV6 640–0BA11–0AX0
TP177micro Touch Panel	6AV6 640–0CA11–0AX0
Miscellaneous	**Order Number**
12-Position Fan Out Connector of CPU 221 and CPU 222 (package of 10)	6ES7 290–2AA00–0XA0
Front Door Spare Part Kit for 22x CPU and EM, (4 pieces of each type)	6ES7 291–3AX20–0XA0
Simulator Module, 8 DI Switches, DC Input, for CPU 221 and 222	6ES7 274 1XF00–0XA0
Simulator Module, 14 DI Switches, DC Input, for CPU 224 and 224XP	6ES7 274 1XH00–0XA0
Simulator Module, 24 DI Switches, DC Input, for CPU 226	6ES7 274 1XK00–0XA0

[1] Includes one blank faceplate overlay for customization. For additional blank faceplate overlays, order the blank faceplate material for your TD device.

Execution Times for STL Instructions

Instruction execution times are very important if your application has time-critical functions. The instruction execution times are shown in Table F-2.

Tip

When you use the execution times in Table F-2, you should consider the effect of power flow to the instruction, the effect of indirect addressing, and the use of certain memory areas on these execution times. These factors can directly effect the listed execution times.

Effect of Power Flow

Table F-2 shows the time required for executing the logic or function of the instruction when power flow is present (Top of Stack = 1 or ON) for that instruction.

When power flow is not present, then the execution time for that instruction is 1 μs.

Effect of Indirect Addressing

Table F-2 shows the time required for executing the logic, or function, of the instruction when you use direct addressing of the operands and constants.

When instructions use indirectly addressed operands, the execution time for the instruction increases by 14 μs for each indirectly addressed operand used in the instruction.

Effect of Accessing Certain Memory Areas

Accessing certain memory areas, such as AI, AQ, L, and accumulators require additional execution time.

Table F-1 shows the additional time that must be added to an instruction's execution time when these memory areas are specified in an operand.

Table F-1 Adder for Accessing Memory Areas

Memory Area	Execution Time Adder
Local Analog Input (AI) filtering disabled filtering enabled	 9.4 μs 8.4 μs
Expansion Analog Input (AI) filtering disabled filtering enabled	 134 μs 8.4 μs
Local Analog Output (AQ) Expansion Analog Output (AQ)	92 μs 48 μs
Local memory (L)	2.8 μs
Accumulators (AC)	2.8 μs

Table F-2 Instruction Execution Times

Instruction	μs
= Using: I SM, T, C, V, S, Q, M L	0.24 1.3 10.5
+D	29
–D	29
*D	47
/D	250
+I	25
–I	25
*I	37
/I	64
=I Using: Local outputs Expansion outputs	16 24
+R	71 Typ 99 Max
–R	72 Typ 100 Max
*R	56 Typ 166 Max
/R	177 Typ 230 Max
A Using: I SM, T, C, V, S, Q, M L	0.22 0.72 6.1
AB <=, =, >=, >, <, <>	18
AD <=, =, >=, >, <, <>	27
AENO	0.4
AI Using: Local inputs Expansion inputs	15 21
ALD	0.22
AN Using: I SM, T, C, V, S, Q, M L	0.22 0.72 6.1
ANDB	19
ANDD	30
ANDW	25
ANI Using: Local inputs Expansion inputs	15 21
AR <=, =, >=, >, <, <>	29
AS=, <> Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of characters compared	 33 6.3
ATCH	12
ATH Time = Base + (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 23 31 10.2
ATT	36
AW <=, =, >=, >, <, <>	23
BCDI	35
BITIM	16
BIR Using: Local inputs Expansion inputs	23 30
BIW Using: Local outputs Expansion outputs	24 32
BMB Time = Base + (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 10 28 5.7
BMD Time= Base + (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 11 29 10.6
BMW Time= Base + (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 10 28 8.6
BTI	16
CALL Using no parameters: Using parameters: Time = Base + Σ (operand time) Base Operand time bit (input, output) byte (input, output) word (input, output) Dword (input, output) Note: processing of output operands occurs during the return from the subroutine	9 14 10, 11 8, 7 10, 9 12, 10
CEVNT	24
CFND Maximum Time = Base + N1 ∗ ((LM1 ∗ N2) + LM2) Base Length multiplier 1 (LM1) Length multiplier 2 (LM2) N1 is length of the source string N2 is the length of the character set string	 35 8.6 9.5
CITIM	23
COS	900 Typ 1070 Max
CRET Power flow present Power flow not present	16 0.8
CRETI Power flow not present	0.2
CSCRE	3.1
CTD On transition of count input Otherwise	27 19
CTU On transition of count input Otherwise	31 19
CTUD On transition of count input Otherwise	37 24
DECB	16
DECD	22
DECO	19
DECW	20
DISI	9
DIV	67

Instruction	µs
DLED	14
DTA	302
DTI	21
DTCH	12
DTR	35 Typ 40 Max
DTS	305
ED	8
ENCO	24 Max
END Power flow not present	0.2
ENI	11
EU	8
EXP	720 Typ 860 Max
FIFO Time = Base + (length ∗ LM) Base Length multiplier (LM)	 30 7
FILL Time= Base + (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 15 29 3.2
FND <, =, >, <> Time = Base+(length ∗ LM) Base Length multiplier (LM)	 39 6.5
FOR Time = Base+(Number of loops ∗ LM) Base Loop multiplier (LM)	 35 28
GPA	16
HDEF	18
HSC	30
HTA Time= Base+ (length ∗ LM) Base (constant length) Base (variable length) Length multiplier (LM)	 20 28 5.2
IBCD	52
INCB	15
INCD	22
INCW	20
INT Typical with 1 interrupt	24
INVB	16
INVD	22
INVW	20
ITA	136
ITB	17
ITD	20
ITS	139
JMP	1.8
LBL	0.22

Instruction	µs
LD Using: I SM, T, C, V, S, Q, M L	0.22 0.8 6
LDB <=, =, >=, >, <, <>	18
LDD <=, =, >=, >, <, <>	27
LDI Using: Local inputs Expansion inputs	15 21
LDN Using: I SM, T, C, V, S, Q, M L	0.3 0.9 6.1
LDNI Using: Local inputs Expansion inputs	15 21
LDR<=, =, >=, >, <, <>	29
LDS	0.22
LDS=, <> Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of characters compared	 33 6.3
LDW <=, =, >=, >, <, <>	24
LIFO	37
LN	680 Typ 820 Max
LPP	0.22
LPS	0.24
LRD	0.22
LSCR	7.3
MOVB	15
MOVD	20
MOVR	20
MOVW	18
MUL	37
NETR	99
NETW Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of bytes to send	 95 4
NEXT	0
NOP	0.22
NOT	0.22
O Using: I SM, T, C, V, S, Q, M L	0.22 0.72 6.4
OB <=, =, >=, >, <, <>	18
OD <=, =, >=, >, <, <>	26
OI Using: Local inputs Expansion inputs	15 21
OLD	0.22
ON Using: I SM, T, C, V, S, Q, M L	0.22 0.72 6.4

Instruction		µs
ONI	Using: Local inputs Expansion inputs	15 21
OR<=, =, >=, >, <, <>		29
ORB		19
ORD		29
ORW		25
OS=, < >	Time + Base + (LM ∗ N) Base Length multiplier (LM) N is the number of characters compared	 33 6.3
OW <=, =, >=, >, <, <>		24
PID	Typical Manual-to-auto transition Coefficient recalculation Auto-tune	400 800 Max 770 Max 650 Max
PLS:	Using: PWM PTO single segment PTO multiple segment	31 36 50
R	Length=1 and specified as a constant Base for Counters (C) Base for Timers (T) Base for all others Otherwise: Time = Base + (length ∗ LM) Base for Counters Base for Timers (T) Base for all others Length multiplier (LM) for operand C Length multiplier (LM) for operand T Length multiplier (LM) for all others If length stored as variable, add to base	 9.3 16 2.9 8.6 8.3 14 5.1 9.9 0.5 17
RCV		51
RET		16
RI	Time = Base + (length ∗ LM) Base Length multiplier (LM) using local outputs Length multiplier (LM) using expansion outputs If length stored as a variable, add to Base	 8.9 13 21 17
RLB	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 23 0.2
RLD	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 28 1.4
RLW	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 27 0.9
ROUND		56 Typ 110 Max
RRB	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 22 0.5
RRD	Time = Base + (LM ∗ N) Base Length multiplier (LM)) N is the shift count	 28 1.7

Instruction		µs
RRW	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 26 1.2
RTA	Time = Base + (LM ∗ N) Base (for first digit in result) Length multiplier (LM) N is the number of additional digits in result	 149 96
RTS	Time = Base + (LM ∗ N) Base (for first digit in result x) Length multiplier (LM) N is the number of additional digits in result	 154 96
S	For length = 1 and specified as a constant Otherwise: Time = Base + (length ∗ LM) Base Length multiplier (LM) If length is stored as a variable, add to Base	2.9 14 0.5 17
SCAT	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of appended characters	 30 5.3
SCPY	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of copied characters	27 4.6
SCRE		0.24
SCRT		10
SEG		15
SFND	Maximum Time = Base +((N1–N2) ∗ LM2) +(N2 ∗ LM1) Base Length multiplier 1 (LM1) Length multiplier 2 (LM2) N1 is the length of the source string N2 is the length of the search string	 39 7.6 6.8
SHRB	Time = Base + (length ∗ LM1) + ((length /8) ∗ LM2) Base (constant length) Base (variable length) Length multiplier 1 (LM1) Length multiplier 2 (LM2)	 48 52 1.0 1.5
SI	Time = Base + (length ∗ LM) Base LM using local output LM using expansion output If length is stored as a variable, add to Base	 8.9 13 21 17
SIN		900 Typ 1070 Max
SLB	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 23 0.2
SLD	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the shift count	 29 1.1

Instruction		µs
SLEN		21
SLW	Time = Base + (LM + N) Base Length multiplier (LM)) N is the shift count	 27 0.6
SPA		371
SQRT		460 Typ 550 Max
SRB	Time = Base + (LM + N) Base Length multiplier (LM)) N is the shift count	 22 0.6
SRD	Time = Base + (LM + N) Base Length multiplier (LM)) N is the shift count	 28 1.5
SRW	Time = Base + (LM + N) Base Length multiplier (LM)) N is the shift count	 27 1
SSCPY	Time = Base + (LM ∗ N) Base Length multiplier (LM) N is the number of copied characters	 42 5.3
STD	Time = Base + (LM ∗ N) Base (for 1st source character) Length multiplier (LM) N is the number of additional source characters	 69 27
STI	Time = Base + (LM ∗ N) Base (for 1st source character) Length multiplier (LM) N is the number of additional source characters	 58 27

Instruction		µs
STOP	Power flow not present	4
STR	Time = Base + (LM ∗ N) Base (for 1st source character) Length multiplier (LM) N is the number of additional source characters	 51 81
SWAP		17
TAN		1080 Typ 1300 Max
TODR		331
TODRX	 Daylight Saving Time correction	391 Typ 783 Typ
TODW		436
TODWX		554
TOF		36
TON		33
TONR		32
TRUNC		53 Typ 106 Max
WDR		7
XMT		42
XORB		19
XORD		29
XORW		25

G

S7-200 Quick Reference Information

To help you find information more easily, this section summarizes the following information:

❑ Special Memory Bits

❑ Descriptions of Interrupt Events

❑ Summary of S7-200 CPU Memory Ranges and Features

❑ High-Speed Counters HSC0, HSC1, HSC2, HSC3, HSC4, HSC5

❑ S7-200 Instructions

Table G-1 Special Memory Bits

Special Memory Bits			
SM0.0	Always On	SM1.0	Result of operation = 0
SM0.1	First Scan	SM1.1	Overflow or illegal value
SM0.2	Retentive data lost	SM1.2	Negative result
SM0.3	Power up	SM1.3	Division by 0
SM0.4	30 s off / 30 s on	SM1.4	Table full
SM0.5	0.5 s off / 0.5 s on	SM1.5	Table empty
SM0.6	Off 1 scan / on 1 scan	SM1.6	BCD to binary conversion error
SM0.7	Switch in RUN position	SM1.7	ASCII to hex conversion error

Table G-2 Interrupt Events in Priority Order

Event Number	Interrupt Description	Priority Group	Priority in Group
8	Port 0: Receive character	Communications (highest)	0
9	Port 0: Transmit complete		0
23	Port 0: Receive message complete		0
24	Port 1: Receive message complete		1
25	Port 1: Receive character		1
26	Port 1: Transmit complete		1
19	PTO 0 complete interrupt	Discrete (middle)	0
20	PTO 1 complete interrupt		1
0	I0.0, Rising edge		2
2	I0.1, Rising edge		3
4	I0.2, Rising edge		4
6	I0.3, Rising edge		5
1	I0.0, Falling edge		6
3	I0.1, Falling edge		7
5	I0.2, Falling edge		8
7	I0.3, Falling edge		9
12	HSC0 CV=PV (current value = preset value)		10
27	HSC0 direction changed		11
28	HSC0 external reset		12
13	HSC1 CV=PV (current value = preset value)		13
14	HSC1 direction input changed		14
15	HSC1 external reset		15
16	HSC2 CV=PV		16
17	HSC2 direction changed		17
18	HSC2 external reset		18
32	HSC3 CV=PV (current value = preset value)		19
29	HSC4 CV=PV (current value = preset value)		20
30	HSC4 direction changed		21
31	HSC4 external reset		22
33	HSC5 CV=PV (current value = preset value)		23
10	Timed interrupt 0	Timed (lowest)	0
11	Timed interrupt 1		1
21	Timer T32 CT=PT interrupt		2
22	Timer T96 CT=PT interrupt		3

Table G-3 Memory Ranges and Features for the S7-200 CPUs

Description	CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
User program size with run mode edit without run mode edit	4096 bytes 4096 bytes	4096 bytes 4096 bytes	8192 bytes 12288 bytes	12288 bytes 16384 bytes	16384 bytes 24576 bytes
User data size	2048 bytes	2048 bytes	8192 bytes	10240 bytes	10240 bytes
Process-image input register	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7
Process-image output register	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7
Analog inputs (read only)	AIW0 to AIW30	AIW0 to AIW30	AIW0 to AIW62	AIW0 to AIW62	AIW0 to AIW62
Analog outputs (write only)	AQW0 to AQW30	AQW0 to AQW30	AQW0 to AQW62	AQW0 to AQW62	AQW0 to AQW62
Variable memory (V)	VB0 to VB2047	VB0 to VB2047	VB0 to VB8191	VB0 to VB10239	VB0 to VB10239
Local memory (L)[1]	LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63
Bit memory (M)	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7
Special Memory (SM)	SM0.0 to SM179.7	SM0.0 to SM299.7	SM0.0 to SM549.7	SM0.0 to SM549.7	SM0.0 to SM549.7
Read only	SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7
Timers	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)
Retentive on-delay 1 ms	T0, T64	T0, T64	T0, T64	T0, T64	T0, T64
10 ms	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68
100 ms	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95
On/Off delay 1 ms	T32, T96	T32, T96	T32, T96	T32, T96	T32, T96
10 ms	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100
100 ms	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255
Counters	C0 to C255	C0 to C255	C0 to C255	C0 to C255	C0 to C255
High-speed counters	HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5
Sequential control relays (S)	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7
Accumulator registers	AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3
Jumps/Labels	0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
Call/Subroutine	0 to 63	0 to 63	0 to 63	0 to 63	0 to 127
Interrupt routines	0 to 127	0 to 127	0 to 127	0 to 127	0 to 127
Positive/negative transitions	256	256	256	256	256
PID loops	0 to 7	0 to 7	0 to 7	0 to 7	0 to 7
Ports	Port 0	Port 0	Port 0	Port 0, Port 1	Port 0, Port 1

[1] LB60 to LB63 are reserved by STEP 7‑Micro/WIN, version 3.0 or later.

Table G-4 High-Speed Counters HSC0, HSC3, HSC4, and HSC5

Mode	HSC0			HSC3	HSC4			HSC5
	Clk	Direction	Reset	Clk	Clk	Direction	Reset	Clk
0	I0.0			I0.1	I0.3			I0.4
1	I0.0		I0.2		I0.3		I0.5	
2								
3	I0.0	I0.1			I0.3	I0.4		
4	I0.0	I0.1	I0.2		I0.3	I0.4	I0.5	
5								
Mode	**HSC0**				**HSC4**			
	Clk Up	**Clk Down**	**Reset**		**Clk Up**	**Clk Down**	**Reset**	
6	I0.0	I0.1			I0.3	I0.4		
7	I0.0	I0.1	I0.2		I0.3	I0.4	I0.5	
8								
Mode	**HSC0**				**HSC4**			
	Phase A	**Phase B**	**Reset**		**Phase A**	**Phase B**	**Reset**	
9	I0.0	I0.1			I0.3	I0.4		
10	I0.0	I0.1	I0.2		I0.3	I0.4	I0.5	
11								
Mode	**HSC0**			**HSC3**				
	Clk			**Clk**				
12	Q0.0			Q0.1				

Table G-5 High-Speed Counters HSC1 and HSC2

Mode	HSC1				HSC2			
	Clk	Clk Down	Reset	Start	Clk	Direction	Reset	Start
0	I0.6				I1.2			
1	I0.6		I1.0		I1.2		I1.4	
2	I0.6		I1.0	I1.1	I1.2		I1.4	I1.5
3	I0.6	I0.7			I1.2	I1.3		
4	I0.6	I0.7	I1.0		I1.2	I1.3	I1.4	
5	I0.6	I0.7	I1.0	I1.1	I1.2	I1.3	I1.4	I1.5
Mode	**HSC1**				**HSC2**			
	Clk Up	**Clk Down**	**Reset**	**Start**	**Clk Up**	**Clk Down**	**Reset**	**Start**
6	I0.6	I0.7	I1.0		I1.2	I1.3		
7	I0.6	I0.7	I1.0		I1.2	I1.3	I1.4	
8	I0.6	I0.7	I1.0	I1.1	I1.2	I1.3	I1.4	I1.5
Mode	**Phase A**	**Phase B**	**Reset**	**Start**	**Phase A**	**Phase B**	**Reset**	**Start**
9	I0.6	I0.7			I1.2	I1.3		
10	I0.6	I0.7	I1.0		I1.2	I1.3	I1.4	
11	I0.6	I0.7	I1.0	I1.1	I1.2	I1.3	I1.4	I1.5

Boolean Instructions

LD	Bit	Load
LDI	Bit	Load Immediate
LDN	Bit	Load Not
LDNI	Bit	Load Not Immediate
A	Bit	AND
AI	Bit	AND Immediate
AN	Bit	AND Not
ANI	Bit	AND Not Immediate
O	Bit	OR
OI	Bit	OR Immediate
ON	Bit	OR Not
ONI	Bit	OR Not Immediate
LDBx	IN1, IN2	Load result of Byte Compare IN1 (x:<, <=,=, >=, >, <>I) IN2
ABx	IN1, IN2	AND result of Byte Compare IN1 (x:<, <=,=, >=, >, <>) IN2
OBx	IN1, IN2	OR result of Byte Compare IN1 (x:<, <=,=, >=, >, <>) IN2
LDWx	IN1, IN2	Load result of Word Compare IN1 (x:<, <=,=, >=, >, <>) IN2
AWx	IN1, IN2	AND result of Word Compare IN1 (x:<, <=,=, >=, >, <>)I N2
OWx	IN1, IN2	OR result of Word Compare IN1 (x:<, <=,=, >=, >, <>) IN2
LDDx	IN1, IN2	Load result of DWord Compare IN1 (x:<, <=,=, >=, >, <>) IN2
ADx	IN1, IN2	AND result of DWord Compare IN1 (x:<, <=,=, >=, >, <>)IN2
ODx	IN1, IN2	OR result of DWord Compare IN1 (x:<, <=,=, >=, >, <>) IN2
LDRx	IN1, IN2	Load result of Real Compare IN1 (x:<, <=,=, >=, >, <>) IN2
ARx	IN1, IN2	AND result of Real Compare IN1 (x:<, <=,=, >=, >, <>) IN2
ORx	IN1, IN2	OR result of Real Compare IN1 (x:<, <=,=, >=, >, <>) IN2
NOT		Stack Negation
EU		Detection of Rising Edge
ED		Detection of Falling Edge
=	Bit	Assign Value
=I	Bit	Assign Value Immediate
S	Bit, N	Set bit Range
R	Bit, N	Reset bit Range
SI	Bit, N	Set bit Range Immediate
RI	Bit, N	Reset bit Range Immediate
LDSx	IN1, IN2	Load result of String Compare IN1 (x: =, <>) IN2
ASx	IN1, IN2	AND result of String Compare IN1 (x: =, <>) IN2
OSx	IN1, IN2	OR result of String Compare IN1 (x: =, <>) IN2
ALD		And Load
OLD		Or Load
LPS		Logic Push (stack control)
LRD		Logic Read (stack control)
LPP		Logic Pop (stack control)
LDS	N	Load Stack (stack control)
AENO		And ENO

Math, Increment, and Decrement instructions

+I	IN1, OUT	Add Integer, Double Integer or Real IN1+OUT=OUT
+D	IN1, OUT	
+R	IN1, OUT	
–I	IN1, OUT	Subtract Integer, Double Integer, or Real OUT–IN1=OUT
–D	IN1, OUT	
–R	IN1, OUT	
MUL	IN1, OUT	Multiply Integer (16*16–>32)
*I	IN1, OUT	Multiply Integer, Double Integer, or Real IN1 * OUT = OUT
*D	IN1, OUT	
*R	IN1, IN2	
DIV	IN1, OUT	Divide Integer (16/16–>32)
/I	IN1, OUT	Divide Integer, Double Integer, or Real OUT / IN1 = OUT
/D,	IN1, OUT	
/R	IN1, OUT	
SQRT	IN, OUT	Square Root
LN	IN, OUT	Natural Logarithm
EXP	IN, OUT	Natural Exponential
SIN	IN, OUT	Sine
COS	IN, OUT	Cosine
TAN	IN, OUT	Tangent
INCB	OUT	Increment Byte, Word or DWord
INCW	OUT	
INCD	OUT	
DECB	OUT	Decrement Byte, Word, or DWord
DECW	OUT	
DECD	OUT	
PID	TBL, LOOP	PID Loop

Timer and Counter Instructions

TON	Txxx, PT	On-Delay Timer
TOF	Txxx, PT	Off-Delay Timer
TONR	Txxx, PT	Retentive On-Delay Timer
BITIM	OUT	Beginning Interval Timer
CITIM	IN, OUT	Calculate Interval Timer
CTU	Cxxx, PV	Count Up
CTD	Cxxx, PV	Count Down
CTUD	Cxxx, PV	Count Up/Down

Real Time Clock Instructions

TODR	T	Read Time of Day clock
TODW	T	Write Time of Day clock
TODRX	T	Read Real Time Clock Extended
TODWX	T	Set Real Time Clock Extended

Program Control Instructions

END		Conditional End of Program
STOP		Transition to STOP Mode
WDR		WatchDog Reset (300 ms)
JMP	N	Jump to defined Label
LBL	N	Define a Label to Jump to
CALL	N [N1,...]	Call a Subroutine [N1, ... up to 16 optional parameters]
CRET		Conditional Return from SBR
FOR	INDX,INIT,FINAL	For/Next Loop
NEXT		
LSCR	N	Load, Transition, Conditional End, and End Sequence Control Relay
SCRT	N	
CSCRE		
SCRE		
DLED	IN	Diagnostic LED

Move, Shift, and Rotate Instructions

MOVB	IN, OUT	Move Byte, Word, DWord, Real
MOVW	IN, OUT	
MOVD	IN, OUT	
MOVR	IN, OUT	
BIR	IN, OUT	Move Byte Immediate Read
BIW	IN, OUT	Move Byte Immediate Write
BMB	IN, OUT, N	Block Move Byte, Word, DWord
BMW	IN, OUT, N	
BMD	IN, OUT, N	
SWAP	IN	Swap Bytes
SHRB	DATA, S_BIT, N	Shift Register Bit
SRB	OUT, N	Shift Right Byte, Word, DWord
SRW	OUT, N	
SRD	OUT, N	
SLB	OUT, N	Shift Left Byte, Word, DWord
SLW	OUT, N	
SLD	OUT, N	
RRB	OUT, N	Rotate Right Byte, Word, DWord
RRW	OUT, N	
RRD	OUT, N	
RLB	OUT, N	Rotate Left Byte, Word, DWord
RLW	OUT, N	
RLD	OUT, N	

Logical Instructions

ANDB	IN1, OUT	Logical AND of Byte, Word, and DWord
ANDW	IN1, OUT	
ANDD	IN1, OUT	
ORB	IN1, OUT	Logical OR of Byte, Word, and DWord
ORW	IN1, OUT	
ORD	IN1, OUT	
XORB	IN1, OUT	Logical XOR of Byte, Word, and DWord
XORW	IN1, OUT	
XORD	IN1, OUT	
INVB	OUT	Invert Byte, Word and DWord
INVW	OUT	(1's complement)
INVD	OUT	

String Instructions

SLEN	IN, OUT	String Length
SCAT	IN, OUT	Concatenate String
SCPY	IN, OUT	Copy String
SSCPY	IN, INDX, N, OUT	Copy Substring from String
CFND	IN1, IN2, OUT	Find First Character within String
SFND	IN1, IN2, OUT	Find String within String

Table, Find, and Conversion Instructions

ATT	DATA, TBL	Add data to table
LIFO	TBL, DATA	Get data from table
FIFO	TBL, DATA	
FND=	TBL, PTN, INDX	Find data value in table that matches comparison
FND<>	TBL, PTN, INDX	
FND<	TBL, PTN, INDX	
FND>	TBL, PTN, INDX	
FILL	IN, OUT, N	Fill memory space with pattern
BCDI	OUT	Convert BCD to Integer
IBCD	OUT	Convert Integer to BCD
BTI	IN, OUT	Convert Byte to Integer
ITB	IN, OUT	Convert Integer to Byte
ITD	IN, OUT	Convert Integer to Double Integer
DTI	IN, OUT	Convert Double Integer to Integer
DTR	IN, OUT	Convert DWord to Real
TRUNC	IN, OUT	Convert Real to Double Integer
ROUND	IN, OUT	Convert Real to Double Integer
ATH	IN, OUT, LEN	Convert ASCII to Hex
HTA	IN, OUT, LEN	Convert Hex to ASCII
ITA	IN, OUT, FMT	Convert Integer to ASCII
DTA	IN, OUT, FM	Convert Double Integer to ASCII
RTA	IN, OUT, FM	Convert Real to ASCII
DECO	IN, OUT	Decode
ENCO	IN, OUT	Encode
SEG	IN, OUT	Generate 7-segment pattern
ITS	IN, FMT, OUT	Convert Integer to String
DTS	IN, FMT, OUT	Convert Double Integer to String
RTS	IN, FMT, OUT	Convert Real to String
STI	STR, INDX, OUT	Convert Substring to Integer
STD	STR, INDX, OUT	Convert Substring to Double Integer
STR	STR, INDX, OUT	Convert Substring to Real

Interrupt Instructions

CRETI		Conditional Return from Interrupt
ENI		Enable Interrupts
DISI		Disable Interrupts
ATCH	INT, EVNT	Attach Interrupt routine to event
DTCH	EVNT	Detach event

Communications Instructions

XMT	TBL, PORT	Freeport transmission
RCV	TBL, PORT	Freeport receive message
NETR	TBL, PORT	Network Read
NETW	TBL, PORT	Network Write
GPA	ADDR, PORT	Get Port Address
SPA	ADDR, PORT	Set Port Address

High-Speed Instructions

HDEF	HSC, MODE	Define High-Speed Counter mode
HSC	N	Activate High-Speed Counter
PLS	Q	Pulse Output

H

S7-200CN Products

In This Chapter

Certifications and Approvals for S7-200CN Products

CE Labeling of S7-200CN Products

The S7-200CN products fulfill the requirements and protection guidelines of the following EU directives.

- ❑ EC Directive 73/23/EEC “Low–voltage directive”
- ❑ EC Directive 89/336/EEC “EMC directive”

After July 2009 the following applies:

- ❑ EC Directive 2004/108/EC (EMC Directive) “Electromagnetic Compatibility”

Standards of S7-200CN Products

The S7-200CN products fulfill the requirement and criteria of IEC 61131–2, Programmable controllers – Equipment requirements. Check the markings on the actual S7-200CN product for the specific Agency approvals and Certifications.

S7-200CN Products

A cross-reference of SIMATIC S7-200 products to S7-200CN products is shown in the following table. For wiring and performance specifications, refer to the cross-referenced SIMATIC S7-200 product in Appendix A. Check the markings on the actual S7-200CN product for the specific Agency approvals and Certifications.

Table H-1 Cross Reference for SIMATIC S7-200 Products to S7-200CN Products

Model Name and Description	S7-200 SIMATIC Product	S7-200CN Product
CPU 222 DC/DC/DC, 8 Inputs/6 Outputs	6ES7 212-1AB23-0XB0	6ES7 212-1AB23-0XB8
CPU 222 AC/DC/Relay 8 Inputs/ 6 Relays	6ES7 212-1BB23-0XB0	6ES7 212-1BB23-0XB8
CPU 224 DC/DC/DC 14 Inputs/ 10 Outputs	6ES7 214-1AD23-0XB0	6ES7 214-1AD23-0XB8
CPU 224 AC/DC/Relay14 Inputs/ 10 Relays	6ES7 214-1BD23-0XB0	6ES7 214-1BD23-0XB8
CPU 224XP DC/DC/DC 14 Inputs/10 Outputs	6ES7 214-2AD23-0XB0	6ES7 214-2AD23-0XB8
CPU 224XPsi DC/DC/DC 14 Inputs/10 Outputs	6ES7 214-2AS23-0XB0	6ES7 214-2AS23-0XB8
CPU 224XP AC/DC/Relay 14 Inputs/10 Relays	6ES7 214-2BD23-0XB0	6ES7 214-2BD23-0XB8
CPU 226 DC/DC/DC 24 Inputs/16 Outputs	6ES7 216-2AD23-0XB0	6ES7 216-2AD23-0XB8
CPU 226 AC/DC/Relay 24 Inputs/16 Relays	6ES7 216-2BD23-0XB0	6ES7 216-2BD23-0XB8
EM 221 Digital Input 8 x 24 VDC	6ES7 221-1BF22-0XA0	6ES7 221-1BF22-0XA8
EM 221 Digital Input 16 x 24 VDC	6ES7 221-1BH22-0XA0	6ES7 221-1BH22-0XA8
EM 222 Digital Output 8 x 24 VDC	6ES7 222-1BF22-0XA0	6ES7 222-1BF22-0XA8
EM 222 Digital Output 8 x Relays	6ES7 222-1HF22-0XA0	6ES7 222-1HF22-0XA8
EM 223 24 VDC Digital Comb 4 Inputs/4 Outputs	6ES7 223-1BF22-0XA0	6ES7 223-1BF22-0XA8
EM 223 24 VDC Digital Comb 4 Inputs/4 Relay Outputs	6ES7 223-1HF22-0XA0	6ES7 223-1HF22-0XA8
EM 223 24 VDC Digital Comb 8 Inputs/8 Outputs	6ES7 223-1BH22-0XA0	6ES7 223-1BH22-0XA8
EM 223 24 VDC Digital Comb 8 Inputs/8 Relay Outputs	6ES7 223-1PH22-0XA0	6ES7 223-1PH22-0XA8
EM 223 24 VDC Digital Comb 16 Inputs/16 Outputs	6ES7 223-1BL22-0XA0	6ES7 223-1BL22-0XA8
EM 223 24 VDC Digital Comb 16 Inputs/16 Relay Outputs	6ES7 223-1PL22-0XA0	6ES7 223-1PL22-0XA8
EM 223 24 VDC Digital Comb 32 Inputs/32 Outputs	6ES7 223-1BM22-0XA0	6ES7 223-1BM22-0XA8
EM 223 24 VDC Digital Comb 32 Inputs/32 Relay Outputs	6ES7 223-1PM22-0XA0	6ES7 223-1PM22-0XA8
EM 231 Analog Input, 4 Inputs	6ES7 231-0HC22-0XA0	6ES7 231-0HC22-0XA8
EM 235 Analog Combination 4 Inputs/1 Output	6ES7 235-0KD22-0XA0	6ES7 235-0KD22-0XA8
EM 232 Analog Output, 2 Outputs	6ES7 232-0HB22-0XA0	6ES7 232-0HB22-0XA8
EM 231 Analog Input RTD, 2 Inputs	6ES7 231-7PB22-0XA0	6ES7 231-7PB22-0XA8
EM 231 Analog Input Thermocouple, 4 Inputs	6ES7 231-7PD22-0XA0	6ES7 231-7PD22-0XA8

To

SIEMENS ENERGY & AUTOMATION INC
ATTN: TECHNICAL COMMUNICATIONS
ONE INTERNET PLAZA
PO BOX 4991
JOHNSON CITY TN USA 37602–4991

From

Name: _

Job Title: _

Company Name: _

Street: _

City and State: _

Country: _

Telephone: _

Please check any industry that applies to you:

❐ Automotive
❐ Chemical
❐ Electrical Machinery
❐ Food
❐ Instrument and Control
❐ Non-electrical Machinery
❐ Petrochemical

❐ Pharmaceutical
❐ Plastic
❐ Pulp and Paper
❐ Textiles
❐ Transportation
❐ Other ___________________________

Remarks Form

Your comments and recommendations will help us to improve the quality and usefulness of our publications. Please take the first available opportunity to fill out this questionnaire and return it to Siemens.

Please give each of the following questions your own personal mark within a range from 1 (very good) to 5 (very poor).

1. Do the contents meet your requirements? □
2. Is the information you need easy to find? □
3. Is the text easy to understand? □
4. Does the level of technical detail meet your requirements? □
5. Please rate the quality of the graphics and tables. □

Additional comments:

_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _
_ _

S7-200 Memory Ranges and Features

Description		CPU 221	CPU 222	CPU 224	CPU 224XP CPU 224XPsi	CPU 226
User program size						
with run mode edit		4096 bytes	4096 bytes	8192 bytes	12288 bytes	16384 bytes
without run mode edit		4096 bytes	4096 bytes	12288 bytes	16384 bytes	24576 bytes
User data size		2048 bytes	2048 bytes	8192 bytes	10240 bytes	10240 bytes
Process-image input register		I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7	I0.0 to I15.7
Process-image output register		Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7	Q0.0 to Q15.7
Analog inputs (read only)		AIW0 to AIW30	AIW0 to AIW30	AIW0 to AIW62	AIW0 to AIW62	AIW0 to AIW62
Analog outputs (write only)		AQW0 to AQW30	AQW0 to AQW30	AQW0 to AQW62	AQW0 to AQW62	AQW0 to AQW62
Variable memory (V)		VB0 to VB2047	VB0 to VB2047	VB0 to VB8191	VB0 to VB10239	VB0 to VB10239
Local memory (L)[1]		LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63	LB0 to LB63
Bit memory (M)		M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7	M0.0 to M31.7
Special Memory (SM)		SM0.0 to SM179.7	SM0.0 to SM299.7	SM0.0 to SM549.7	SM0.0 to SM549.7	SM0.0 to SM549.7
Read only		SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7	SM0.0 to SM29.7
Timers		256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)	256 (T0 to T255)
Retentive on-delay	1 ms	T0, T64	T0, T64	T0, T64	T0, T64	T0, T64
	10 ms	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68	T1 to T4, and T65 to T68
	100 ms	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95	T5 to T31, and T69 to T95
On/Off delay	1 ms	T32, T96	T32, T96	T32, T96	T32, T96	T32, T96
	10 ms	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100	T33 to T36, and T97 to T100
	100 ms	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255	T37 to T63, and T101 to T255
Counters		C0 to C255	C0 to C255	C0 to C255	C0 to C255	C0 to C255
High-speed counters		HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5	HC0 to HC5
Sequential control relays (S)		S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7	S0.0 to S31.7
Accumulator registers		AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3	AC0 to AC3
Jumps/Labels		0 to 255	0 to 255	0 to 255	0 to 255	0 to 255
Call/Subroutine		0 to 63	0 to 63	0 to 63	0 to 63	0 to 127
Interrupt routines		0 to 127	0 to 127	0 to 127	0 to 127	0 to 127
Positive/negative transitions		256	256	256	256	256
PID loops		0 to 7	0 to 7	0 to 7	0 to 7	0 to 7
Ports		Port 0	Port 0	Port 0	Port 0, Port 1	Port 0, Port 1

[1] LB60 to LB63 are reserved by STEP 7-Micro/WIN, version 3.0 or later.