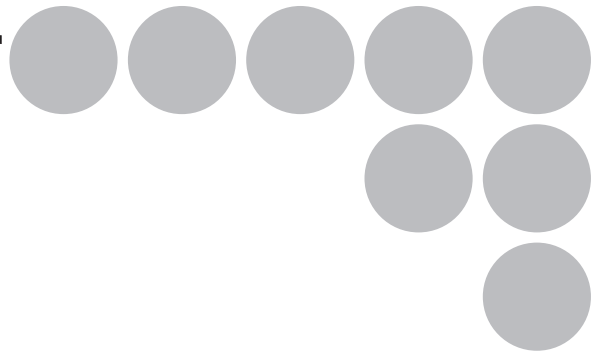


Specialized Vision Sensor for Positioning

FZM1 Series



EtherCAT Communication Manual

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1 What Is EtherCAT?

1-1 Outlines of EtherCAT

Features of EtherCAT

EtherCAT (Ethernet Control Automation Technology) is a high-performance industrial network system based on the Ethernet system that can achieve faster and more efficient communications. Each node achieves a short cycle time by transmitting Ethernet frames at high speed. Furthermore, since EtherCAT, despite being a unique communication protocol, uses the standard Ethernet technology in its physical layer, it has an excellent level of general versatility that allows commercially available Ethernet cables to be used, and can be used not only for large-scale control systems that require high processing speed and system integrity, but also be very effective when used for small to medium scale control systems. The EtherCAT features include the following.

- Ultra high-speed communication at the processing speed of 100 Mbps
The I/O response time between an occurrence of input signal and a transmission of output signal is significantly reduced. Taking full advantage of the optimized Ethernet frame band and the high-speed repeat data transfer method, various data can be transmitted very efficiently.
- Extremely high level of compatibility with Ethernet
EtherCAT is an open network with an extremely high level of compatibility with the conventional Ethernet systems. Accordingly, generic items, such as commercially available Ethernet cables, connectors, and tools, can be used.

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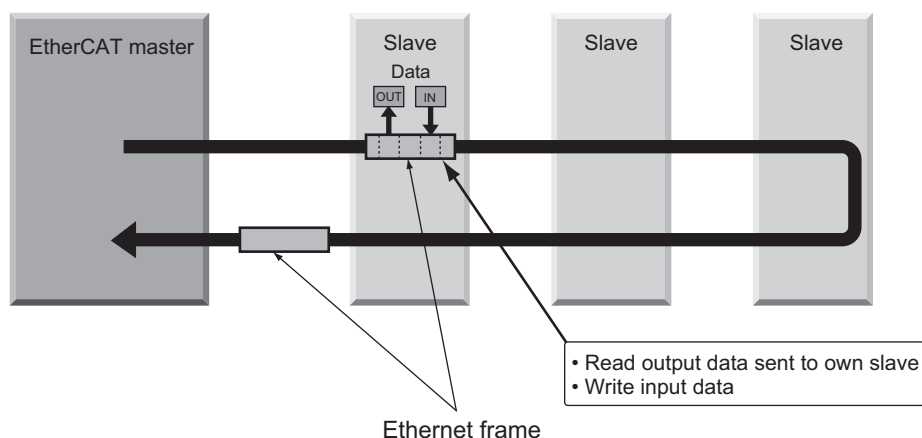
EtherCAT Mechanism

Rather than transmitting data to each slave node within the network, EtherCAT passes the Ethernet frame through each slave node.

When passing through, the data is read and written in units of several nanoseconds to each corresponding area within the frame at each slave node.

Upon passing through all EtherCAT slaves without being stopped along the way, the Ethernet frame transmitted from the EtherCAT master is sent back by the last slave, and returns to the EtherCAT master after passing through all frames again.

With this mechanism, the high-speed data transmission and realtime capability are achieved.

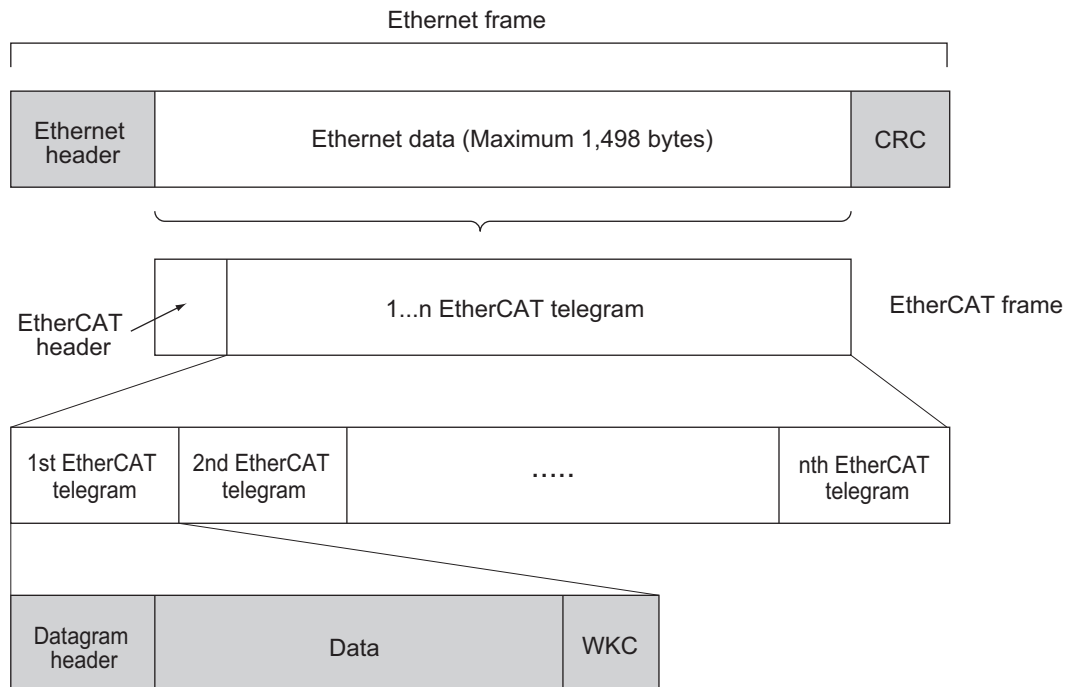


1 What Is EtherCAT?

Periodic data exchange between the EtherCAT master and the EtherCAT slaves is performed by the "EtherCAT telegram" that is stored directly in the Ethernet frame.

Each "EtherCAT telegram" consists of 1 or multiple slave addresses, data, and working counters (check bits).

If an Ethernet frame is compared to a "train," an EtherCAT telegram would be a "compartment."



WKC: Working counter

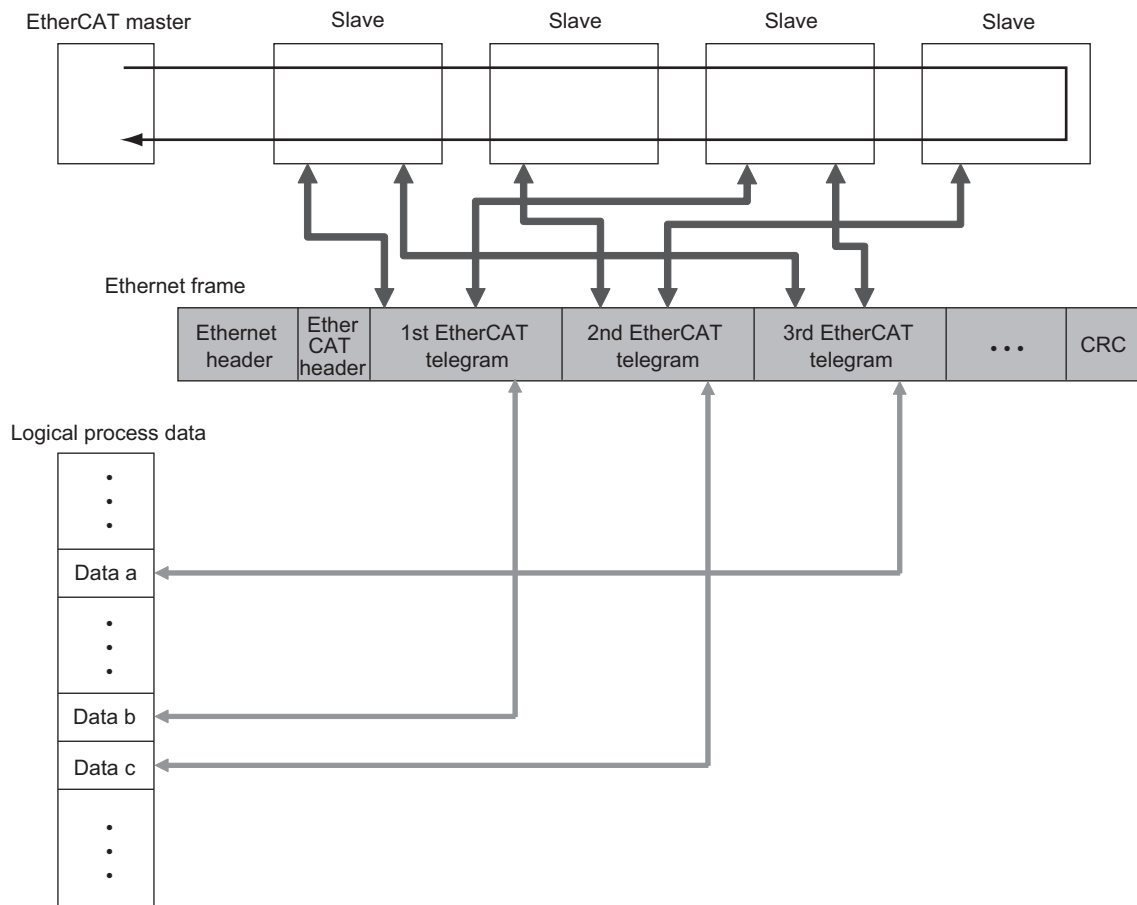
EtherCAT communication types

The following 2 types of communication functions are available with EtherCAT.

- Process data communication function (PDO communication)

This refers to a cyclic (I/O) communication.

A cyclic (I/O) communication between the master and the slaves is achieved by mapping the logical process data space (cyclic data space) to each slave node by the EtherCAT master.



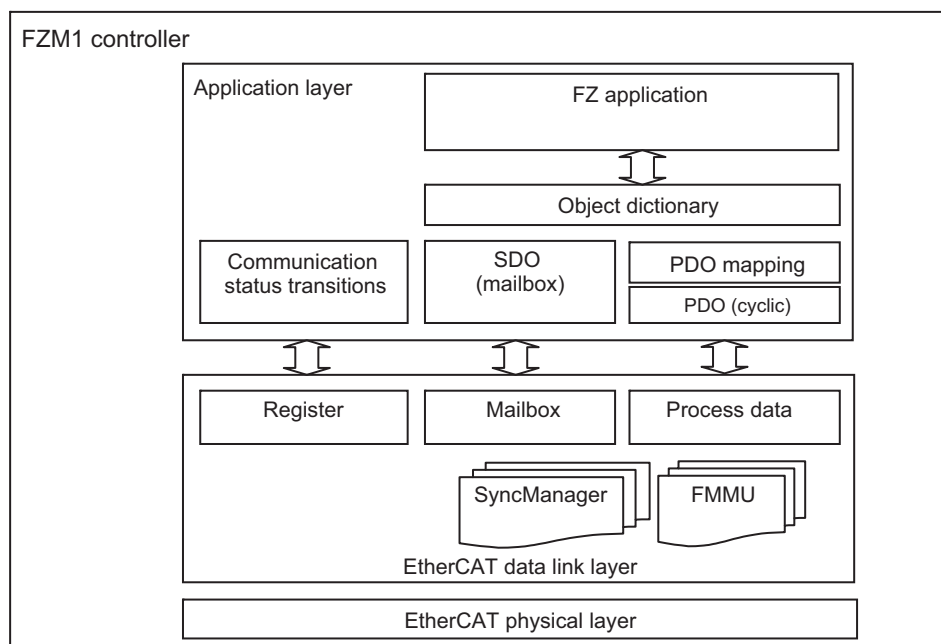
- Mailbox communication function (SDO communication)
This refers to a message communication.
The EtherCAT master sends a command to the slaves, and then the slaves return a response to the EtherCAT master.

Structure of the CAN Application Protocol over EtherCAT (CoE)

Although EtherCAT can transfer multiple protocols, the FZM1 Controller, which is a slave device of EtherCAT, uses "CAN application protocol over EtherCAT (CoE)," a communication interface to be used for the EtherCAT devices, as the Device Profile for the open network standard, "CiA402."

1 What Is EtherCAT?

The CoE structure is illustrated in the figure below.



With CiA402, 2 types of Object Dictionary, SDO (Service Data Object) and PDO (Process Data Object), are available.

PDO consists of a mappable Object Dictionary, and the process data content is defined by the PDO mapping.

PDO is primarily used for cyclic communications to periodically replace the process data.

SDO can read from and write to all object dictionaries, and is used for non-cyclic (event message) communications.

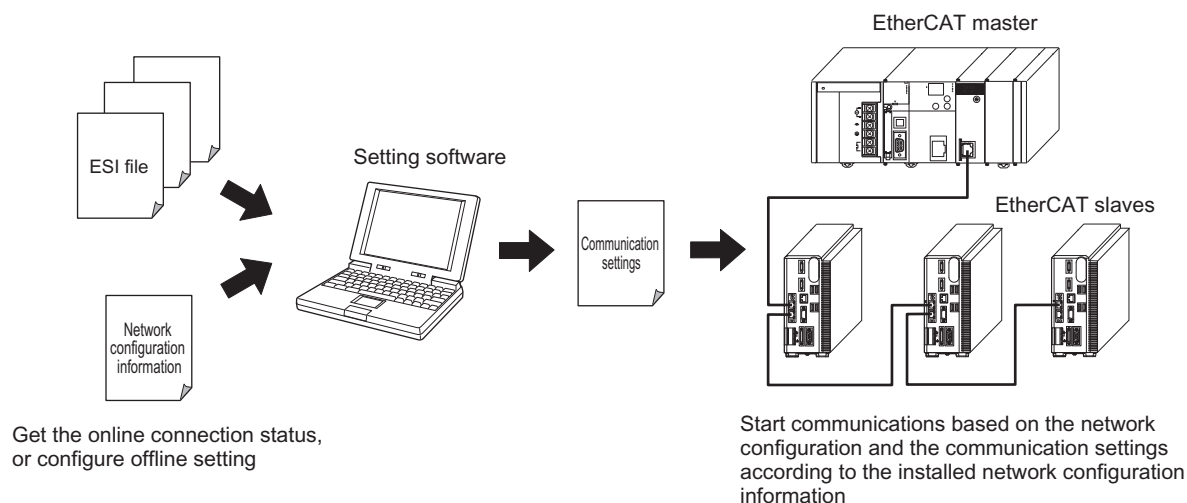
Using the CoE interface to set the SDO and PDO object dictionaries, EtherCAT can provide an EtherCAT device with the same Device Profile as CiA402.

EtherCAT Slave Information File (ESI File)

Information on EtherCAT slave setting is provided in the ESI (EtherCAT Slave Information) file. EtherCAT defines the various communication settings based on the ESI definition information of the connected slaves and the network connection information.

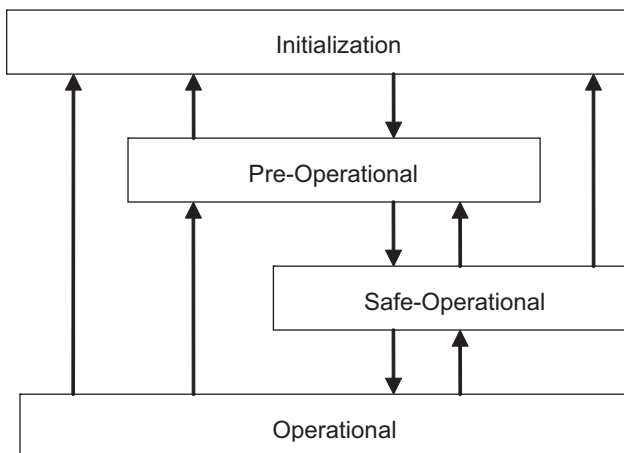
An ESI file can generate communication settings information through a network setup software application.

In addition, a communication network can be established by transferring communication settings to an EtherCAT master device.



Communications Status Transitions

The ESM (EtherCAT State Machine) that expresses a state transition model of the EtherCAT slave communication control is controlled by the EtherCAT master. The following section explains the transitions of communication status after the power supply is turned on.

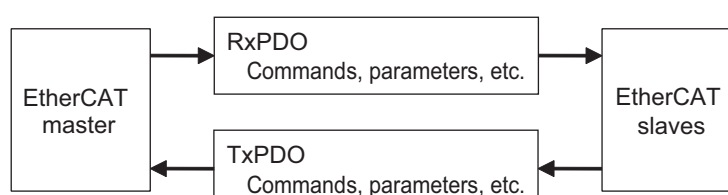


Status	SDO communication	PDO transmission	PDO reception	Contents
Initialization (Init)	Not possible.	Not possible.	Not possible.	Communications are being initialized. Communications are not possible.
Pre-Operational (Pre-Op)	Possible.	Not possible.	Not possible.	Only mailbox (SDO) communications are possible in this status. This status is entered after initialization has been completed. It is used to initialize network settings.
Safe-Operational (Safe-Op)	Possible.	Possible.	Not possible.	In this status, PDO transmissions are possible in addition to mailbox (SDO) communications. Status and other data can be sent from the slaves via cyclic communications.
Operational (Op)	Possible.	Possible.	Possible.	In this status, communications are possible normally. I/O data can be controlled via cyclic communications.

Process Data Objects (PDO)

● Outline

The Process Data Objects (PDOs) are used to transfer data via cyclic communications in realtime. PDOs can be reception PDOs (RxPDOs), which receive data from the EtherCAT master, or transmission PDOs (TxPDOs), which send the current value from the slaves to the EtherCAT master.



1 What Is EtherCAT?

The EtherCAT application layer can have multiple objects to enable transferring of various types of slave process data. The process data contents are described in the "PDO mapping objects" and the "Sync Manager PDO assignment objects."

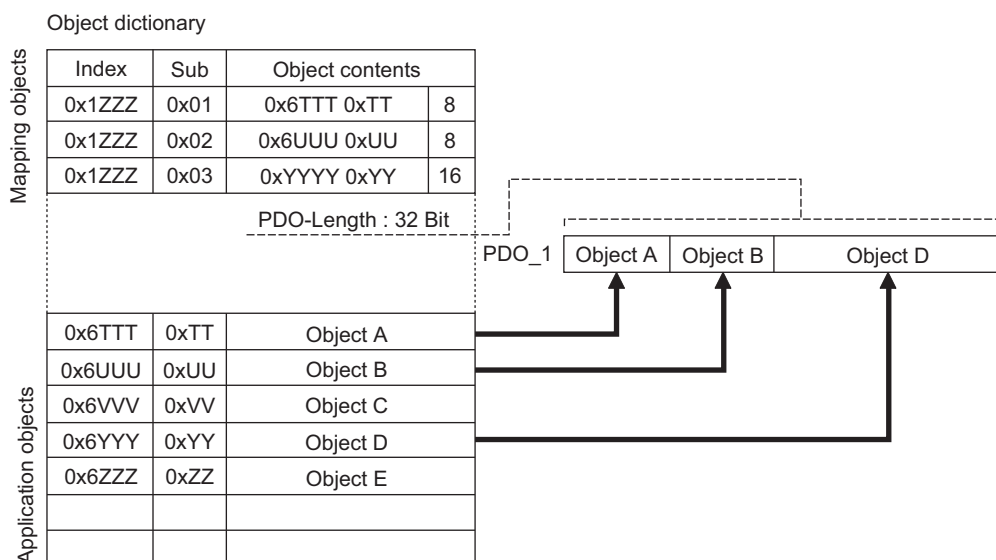
The FZM1 Controller supports the PDO mapping for I/O control.

● PDO mapping settings

The PDO mapping indicates the mapping for application objects (realtime process data) from the Object Dictionary to PDO.

The number of mapped objects is described in Subindex 0 of the mapping table. In this mapping table, the Indexes from 1600 hex to 17FF hex are for RxPDOs, and the Indexes from 1A00 hex to 1BFF hex are for TxPDOs.

The following is an example of a PDO mapping.



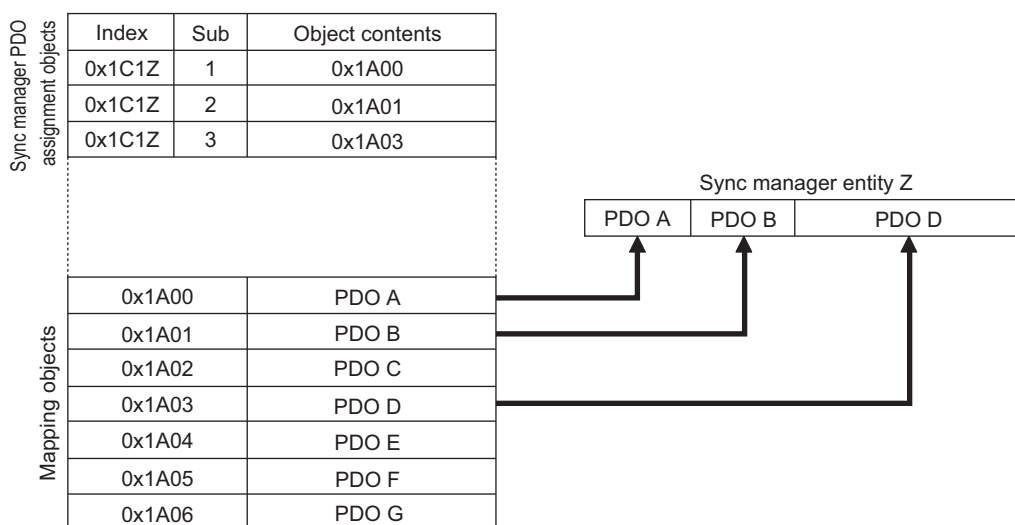
● Sync Manager PDO assignment setting

A Sync Manager channel consists of several PDOs. The Sync Manager PDO assignment objects describe how these PDOs are related to the Sync Manager.

The number of PDOs is described in Subindex 0 of the Sync Manager PDO assignment table.

In this table, the Index 1C12 hex is for RxPDOs and the Index 1C13 hex is for TxPDOs.

The following is an example of a Sync Manager PDO mapping.



Service Data Objects (SDO)

● Outline

The FZM1 Controller supports SDO communications.

The EtherCAT master can configure parameter settings and monitor statuses by reading data from and writing data to entries within the Object Dictionary via SDO communications.

● Abort codes

The following is a list of abort codes for when an SDO communication error occurs.

Status	Meaning
05030000hex	Toggle bit not changed
05040000hex	SDO protocol timeout
05040001hex	Client/Server command specifier not valid or unknown
05040005hex	Out of memory
06010000hex	Unsupported access to an object
06010001hex	Read access to a write-only object
06010002hex	Write access to a read-only object
06020000hex	The object does not exist in the object directory
06040041hex	The object cannot be mapped to the PDO
06040042hex	The number and length of the objects to be mapped would exceed the PDO length
06040043hex	Reason for general parameter incompatibility
06040047hex	General internal incompatibility in the device
06060000hex	Access failed due to a hardware error
06070010hex	Data type does not match, length of service parameter does not match
06070012hex	Data type does not match, length of service parameter too high
06070013hex	Data type does not match, length of service parameter too low
06090011hex	Subindex does not exist
06090030hex	Value range of parameter exceeded (only for write access)
06090031hex	Value of parameter written too high
06090032hex	Value of parameter written too low
06090036hex	Maximum value is less than minimum value
08000000hex	General error
08000020hex	Data cannot be transferred or stored to the application
08000021hex	Data cannot be transferred or stored to the application because of local control
08000022hex	Data cannot be transferred or stored to the application because of the present device status
08000023hex	Object Dictionary dynamic generation fails or no Object Dictionary is present

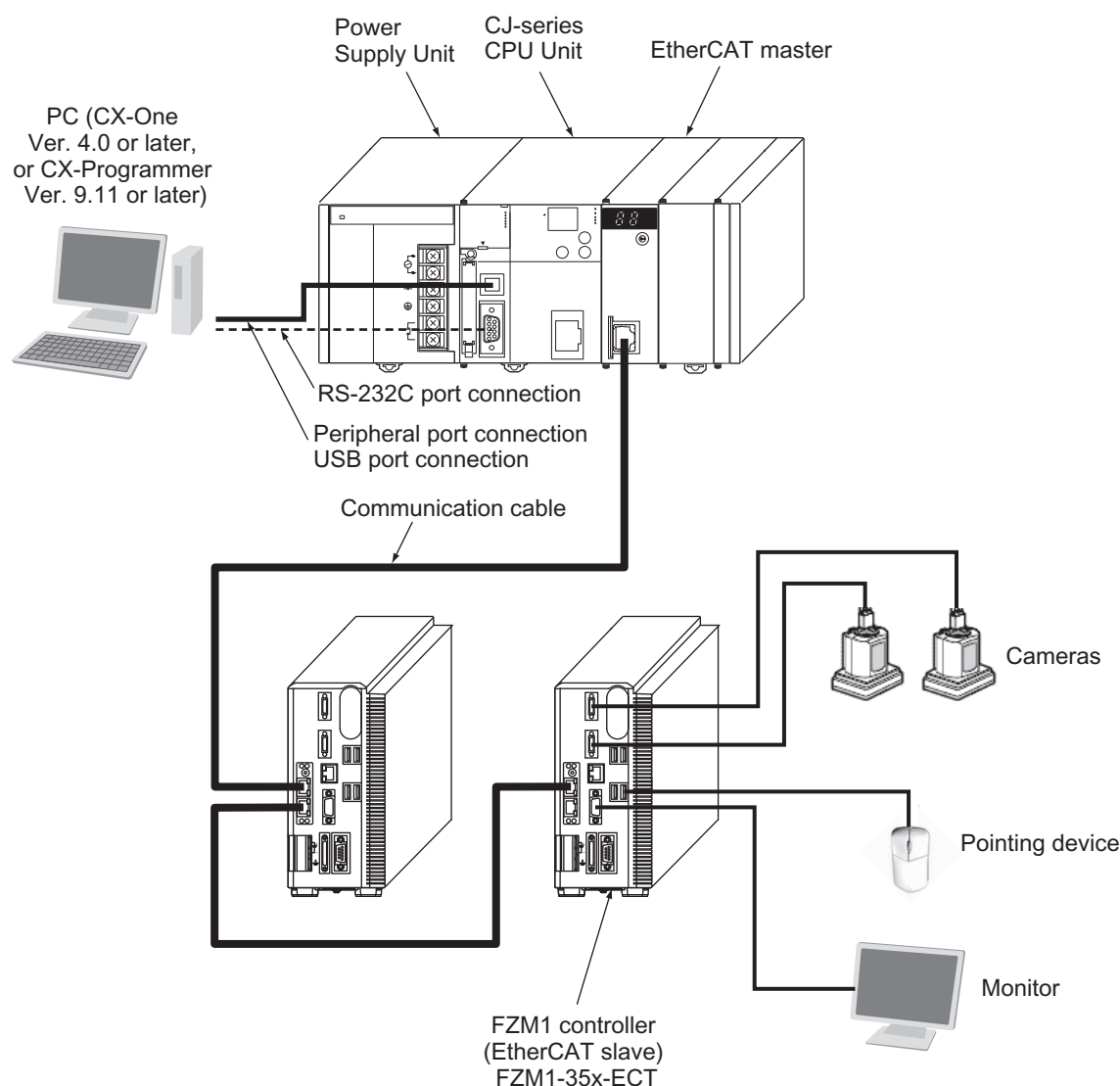
Master and slave communication in DC mode 1

The FZM1 Controller communicates with the EtherCAT master in asynchronous DC mode 1.

1-2 System Configuration

Device Configuration of the FZM1 EtherCAT Communication System

The following is a device configuration of the EtherCAT communication system using the FZM1 Controller.



The outline of each component is described.

● EtherCAT master

It manages the EtherCAT network, monitors slave statuses and exchanges data with the slaves. The following are the devices and systems that can be used as the EtherCAT master in a FZM1 EtherCAT communication system.

Device and System	Manufacturer
Position Control Unit CJ1W-NC281/481/881	OMRON
TwinCAT	BECKHOFF*
Industrial PC, Embedded PC	

* When a master manufactured by BECKHOFF is used, an ESI file for FZM1 (provided by OMRON) is additionally required.

Note that this manual explains the use of Position Control Unit CJ1W-NC281/481/881 manufactured by OMRON as the EtherCAT master. If you are using other devices or systems, see the manual of applicable models.

- **FZM1 Controller (EtherCAT slave)**

It is equivalent to an EtherCAT network slave.

- **PC**

It configures the EtherCAT network and the EtherCAT master settings.

To configure the Position Control Unit CJ1W-NC281/481/881 settings, install FA Integrated Tool Package, CX-One Ver. 4.0 or later (CX-Programmer Ver. 9.11 or later).

- **Monitor**

It displays the FZM1 Controller window.

- **Pointing device**

It is used to operate the FZM1 Controller.

A mouse, trackball, etc. can be used.

Precautions when Using the Position Control Unit as the EtherCAT Master

The following must be noted when a Position Control Unit manufactured by OMRON is to be used as an EtherCAT master.

- **PDO mapping**

To use EtherCAT communications, the command area, response area, and output area of FZ must be assigned to the PLC memory.

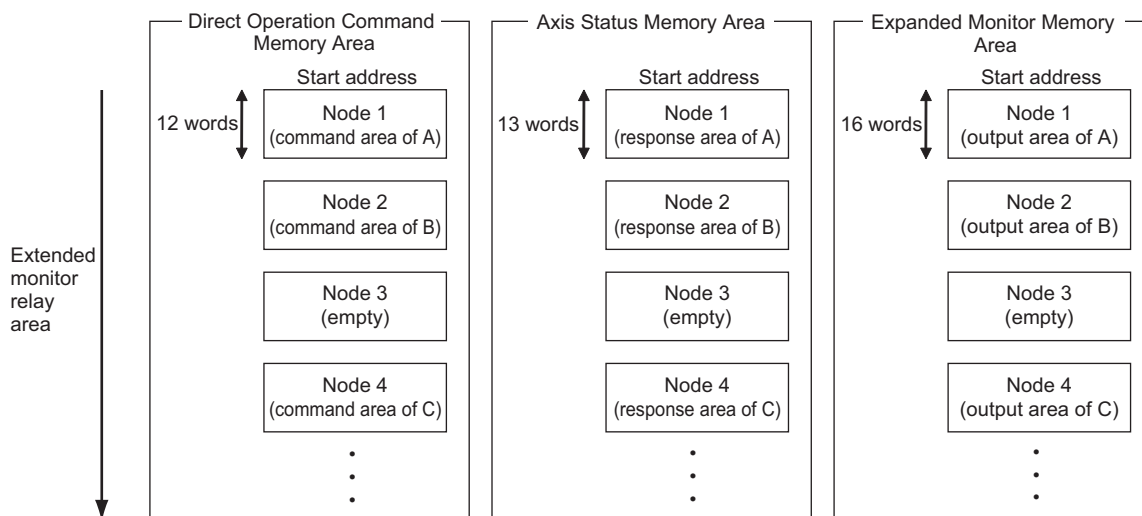
Each area is to be set in the corresponding area in the table below on the Position Control Unit.

FZ-side area	PLC-side area	Max. number of words [CH]
Command area	Direct Operation Command Memory Area	12
Response area	Axis Status Memory Area	13
Output area	Expanded Monitor Memory Area	16

If multiple FZM1 Controllers are connected to a Position Control Unit manufactured by OMRON, these are mapped to a continuous region for each node.

For example, if 3 FZM1 Controllers, A, B and C, are connected to nodes, 1, 2 and 4, a continuous region is mapped in each area as shown in the figure below.

For FZM1 Controller node assignment, specify the setting using the node address setting switch. (See "2-2 FZM1 Controller Specifications" (P12).)



* The maximum number of connected units varies depending on the number of units to be connected.

On the Position Control Unit side, the start area of node 1 in each area is set.

To access the data of other nodes in a ladder program, the address to which an appropriate offset value is added from the start area of node 1 needs to be accessed.

● Number of connected slaves

The number of slaves that can be connected vary depending on the type of Position Control Unit to be used as the EtherCAT master.

EtherCAT master in use	Max. number of connected units
2-axis Unit (CJ1W-NC281)	2 units
4-axis Unit (CJ1W-NC481)	4 units
8-axis Unit (CJ1W-NC881)	8 units

● Cycle

Besides the EtherCAT communication cycles, communication cycles as a Position Control Unit need to be taken into consideration.

EtherCAT master in use	Signal cycle	Control cycle
2-axis Unit (CJ1W-NC281)	Minimum 0.25 ms	1.5 ms
4-axis Unit (CJ1W-NC481)	Minimum 0.25 ms	1 to 2-axis control: 0.5 ms 3 to 4-axis control: 1 ms
8-axis Unit (CJ1W-NC881)	1 to 4-axis control: Minimum 0.25 ms 5 to 8-axis control: Minimum 0.5 ms	1 to 2-axis control: 0.5 ms 3 to 4-axis control: 1 ms 5 to 8-axis control: 2 ms

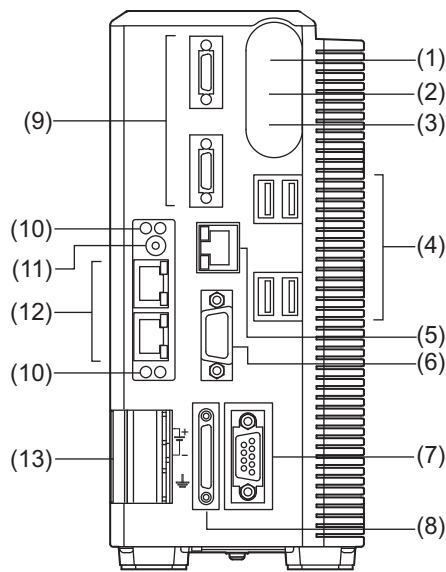
2 Specifications

2-1 EtherCAT Communications Specifications

The EtherCAT communications specifications are as follows.

Item	Specification
Communication protocol	Protocol specialized for EtherCAT
Communication standards	IEC61158 Type12
Modulation method	Baseband
Transmission rate	100 Mbps
Physical layer	100BASE-TX (IEEE802.3)
Connectors	RJ45 × 2 ECAT IN: EtherCAT input ECAT OUT: EtherCAT output
Communications media	Category 5 or higher (A cable with double, aluminum tape and braided shielding is recommended.)
Communications distance	Distance between nodes (slaves): 100 m max.
Noise resistance	Conform to IEC 61000-4-4, 1 kV or higher
Process data	Fixed PDO mapping
Mailbox (CoE)	SDO requests, SDO responses, and SDO information
Distributed Clocks	Synchronization in DC mode DC cycle: 250 μs, 500 μs, 1 ms, 2 ms, 4 ms
LED indicators	L/A IN (Link/Activity IN) × 1 L/A OUT (Link/Activity OUT) × 1 ECAT RUN × 1 ECAT ERR × 1

2-2 FZM1 Controller Specifications



Item	Name	Function
(1)	[POWER] LED	Lights when the power is supplied.
(2)	[RUN] LED	Lights during the measurement mode.
(3)	[ERROR] LED	Lights when an error occurs.
(4)	USB connectors	Connected to a trackball, mouse, and/or USB memory.
(5)	Ethernet connector	Connects the Ethernet communication cable.
(6)	Monitor connector	Connects the monitor.
(7)	Connector for RS-232C/422	Connects to an external device such as a PC and a PLC.
(8)	I/O connector	Connects to an external device such as a sync sensor and a PLC.
(9)	Camera connectors	Connects a camera.
(10)	Status LED	Displays the current EtherCAT network communication status. For specifications, see "2-4 Status LED Indicators Specifications" (P14).
(11)	Node address setting switch	Sets the node addresses of the slaves. Node addresses from 1 to 9 can be set. When this is set to 0, the node address is automatically set.
(12)	EtherCAT connectors	Connects the EtherCAT communication cables. For specifications, see "2-3 EtherCAT Communication Cables and Connector Specifications" (P13).
(13)	Power supply and grounding terminal	Connects the DC power supply and the grounding wire.

2-3 EtherCAT Communication Cables and Connector Specifications

EtherCAT Communication Cables Specifications

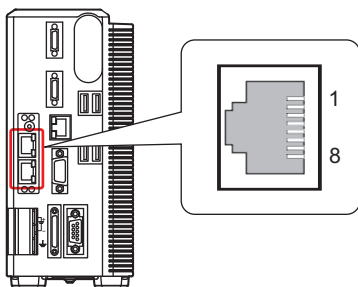
Product name	Remarks
Twisted-pair cable ^{*1} (Can include the following connector)	100BASE-TX compatible (Category 5 or higher) Double-shielded (aluminum tape and braided) ^{*2} Straight cable
RJ45 connector ^{*3}	Category 5 or higher Shielding-compatible

^{*1} The maximum cable length between connected nodes is 100 m. However, some cables are specified for less than 100 m. In general, if the conductors are twisted wire rather than solid wire, transmission performance will be lower, and reliable communications at a distance of 100 m may not be possible. For details, consult the cable manufacturer.

^{*2} Ethernet cables of category 5 or higher can be used regardless of whether they are shielded or not. However, we recommend a cable with double, aluminum tape and braided shielding to ensure sufficient noise resistance.

^{*3} When selecting a connector, confirm that it is applicable to the cable that will be used. Confirm the following items: Conductor size, conductor type (solid wire or twisted wire), number of twisted pairs (2 or 4), outer diameter, etc.

EtherCAT Connector Specifications



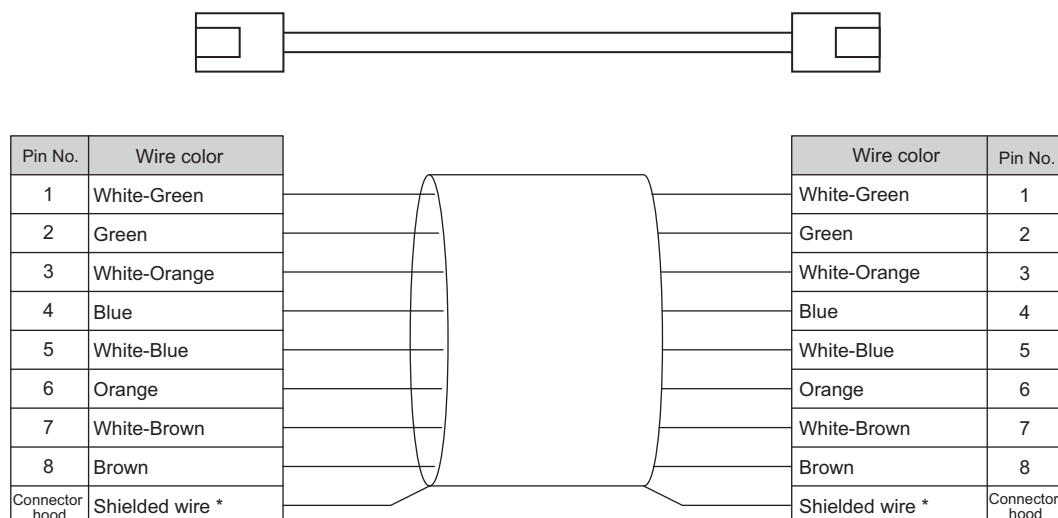
The specifications are as follows.

- Electrical characteristics: IEEE802.3 standard
- Connector structure: RJ45 8-pin modular connector (conforms to ISO 8877)
- Terminal array

Pin No.	Signal name	Abbreviation
1	Send data +	TD +
2	Send data -	TD -
3	Receive data +	RD +
4	Not used	—
5	Not used	—
6	Receive data -	RD -
7	Not used	—
8	Not used	—
Hood	Protective ground	FG

Connecting the EtherCAT Communication Cables and the Connectors

When connecting the communication cables and the connectors, connect them with a straight wiring method as shown below.



* Connect the shielded wire of the cable to the connector hood at both ends of the cable.

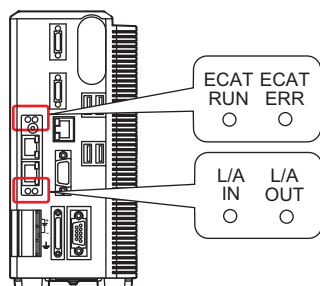


General Information

There are 2 types of Ethernet cable connection standards, namely, "T568A" and "T568B." Although the figure above is based on the "T568A" connection method, the connection method based on the "T568B" standard can also be used.

2-4 Status LED Indicators Specifications

The status LED specifications are as follows.



● [ECAT RUN] LED

Displays the operating status.

Color	Status	Contents
Green	OFF	Initialization status
	Blinking	Pre-Operational status
	Single flash	Safe-Operational status
	ON	Operational status

● [ECAT ERR] LED

Displays the error content.

Color	Status	Contents
Red	OFF	No error
	Blinking	Communication setting error or PDO mapping error
	Single flash	Synchronization error or communications data error
	Double flash	Application WDT timeout
	ON	PDI WDT timeout

● [L/A IN] LED

Displays the input status.

Color	Status	Contents
Green	OFF	Link not established in physical layer
	Flickering	In operation after establishing link
	ON	Link established in physical layer

● [L/A OUT] LED

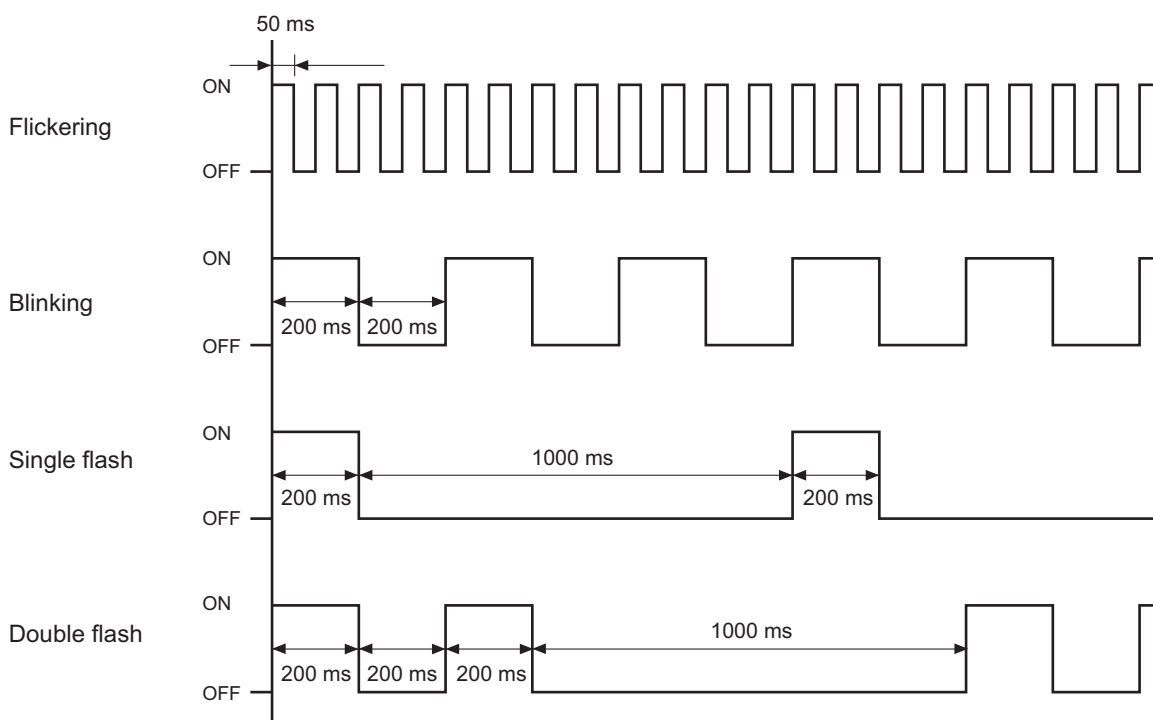
Displays the output status.

Color	Status	Contents
Green	OFF	Link not established in physical layer
	Flickering	In operation after establishing link
	ON	Link established in physical layer



General Information

The timing of each flashing of the LED is as follows.



3 Starting Procedures

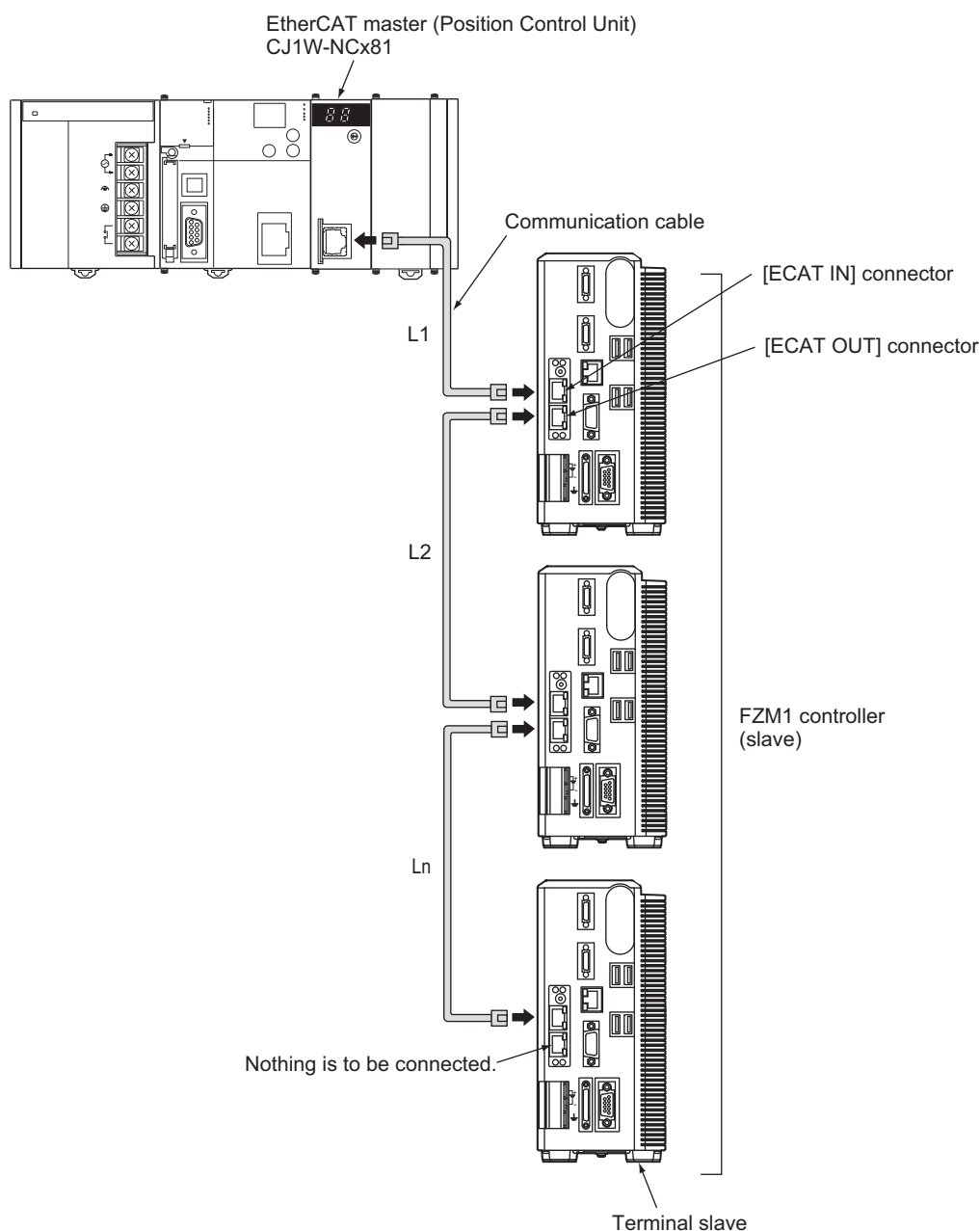
This chapter explains the starting procedures of an EtherCAT communication system using FZM1 Controllers.

3-1 Connecting Communication Cables

Although any wiring is allowed in an EtherCAT network regardless of the connection type, connect the cables in a daisy chain scheme in front and back of the FZM1 Controllers.

Connect the communication cable from the EtherCAT master to the [ECAT IN] connector of the slave, and connect the communication cable to the next slave to the [ECAT OUT] connector.

Note that nothing is to be connected to the [ECAT OUT] connector of the last slave of the network.



Set the length of each cable between slaves (L1, L2, ... Ln in the figure) to 100 m or less. Be sure to connect the communication cable until it clicks when securely connected.

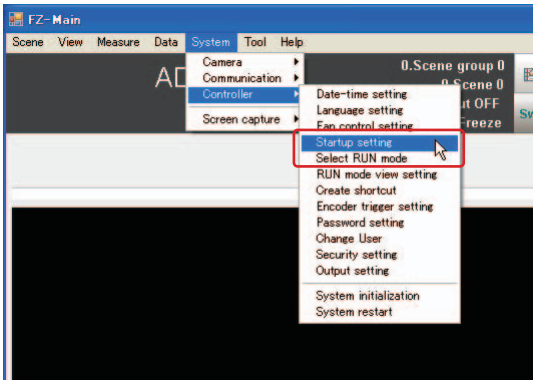
3-2 EtherCAT Connection Setting

The following section explains the setting method to connect the FZM1 Controller to EtherCAT.

Startup Setting

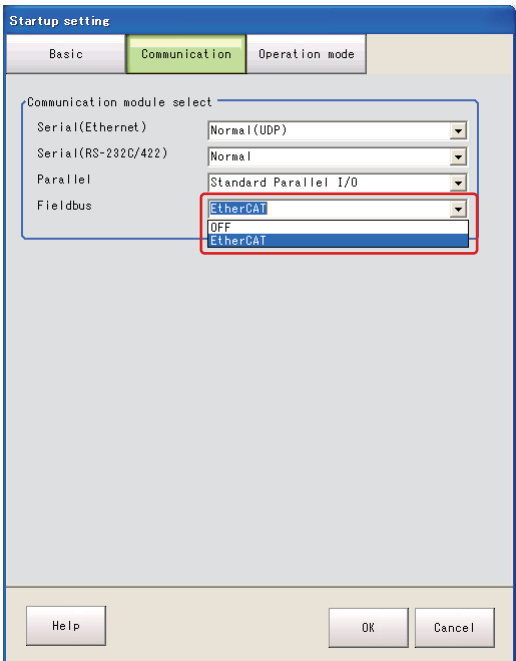
Set the communication mode when the FZM1 Controller is started.

- 1. Using the node address setting switch (see (11) in "2-2 FZM1 Controller Specifications" (P12)), set the node address of the FZM1 Controller.
- 2. Start the FZM1 Controller.
- 3. From the menu bar, select [System] - [Controller] - [Startup setting].



The [Startup setting] window appears.

- 4. Upon selecting the [Communication] tab, select [EtherCAT] for [Fieldbus] in [Communication module select].

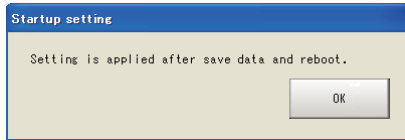


Selection items	Contents
OFF	EtherCAT communication is not executed.
EtherCAT	EtherCAT communication is executed.

3 Starting Procedures

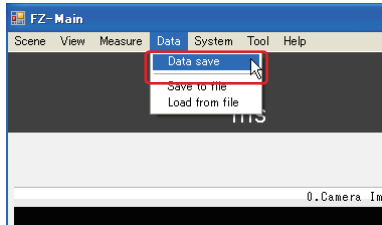
5. Click [OK].

The following message appears.

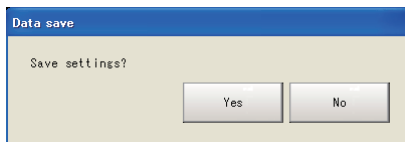


6. Click [OK].

7. From the menu bar, select [Data] - [Data save].

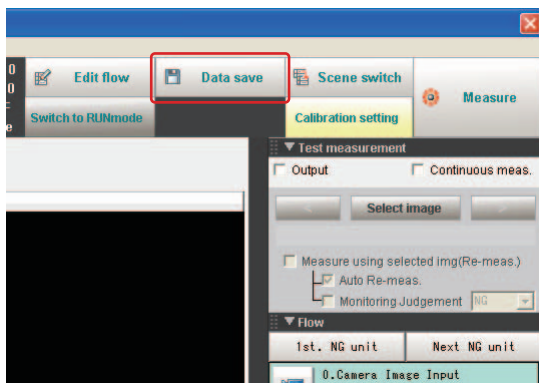


The following message appears to confirm to save the settings to the unit.



General Information

The same confirmation message also appears and you can save the settings to the unit when you click [Data save] on the toolbar.



8. Click [Yes].

9. Restart the FZM1 Controller.

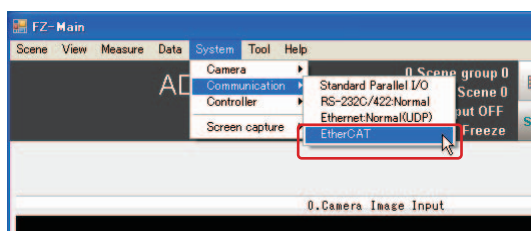
Important

- The EtherCAT communication settings are applied only after they are saved and the FZM1 Controller is restarted. Be sure to save the settings and restart the controller.
- If the EtherCAT communication module is set to [EtherCAT], [PLC Link (SYSMAC CS/CJ/CP/One)]/[PLC Link (MELSEC QnU/Q/QnAS)] of [Serial(Ethernet)] and [Serial(RS-232C/422)] cannot be set.

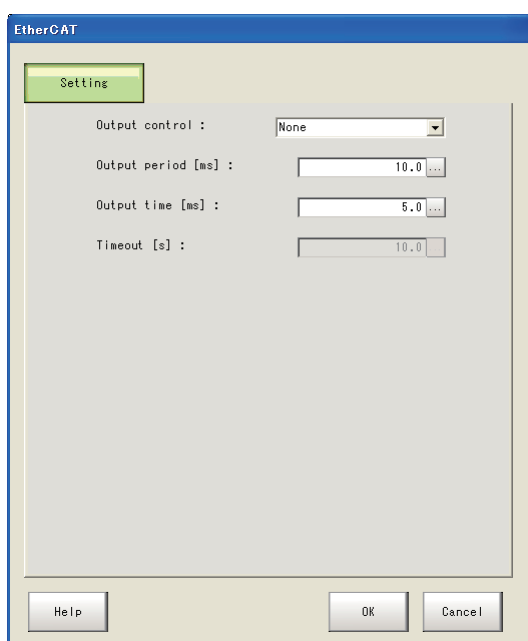
Communication Settings

Set the communication mode when the FZM1 Controller is started.

1. **Start the FZM1 Controller.**
2. **From the menu bar, select [System] - [Communication] - [EtherCAT].**



The [EtherCAT] window appears.



3. **Specify each of the following settings as necessary.**

Setting item	Setting value [Factory default]	Contents	
Output control	[None] Handshaking	OFF	Outputs measurement result without synchronizing with an external device.
		Handshaking	Outputs measurement result while synchronizing with an external device.
If [Output control] above is set to [None]			
Output period [ms]	2.0 to 5000.0ms [10.0 ms]	Sets the measurement result output cycle.	
Output time [ms]	1.0 to 1000.0 ms [5.0 ms]	Sets the measurement result output time period.	
If [Output control] above is set to [Handshaking]			
Timeout [s]	0.5 to 120.0 s [10.0 s]	Sets the time for timeout. If there is no response from the external device within the time specified here, a timeout error occurs.	

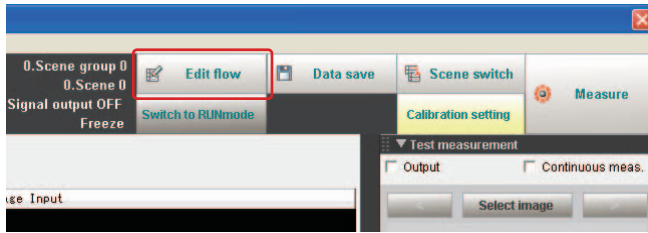
For details of these settings, see "4-4 Timing Chart" (P30).

4. **Click [OK].**

Properties Settings

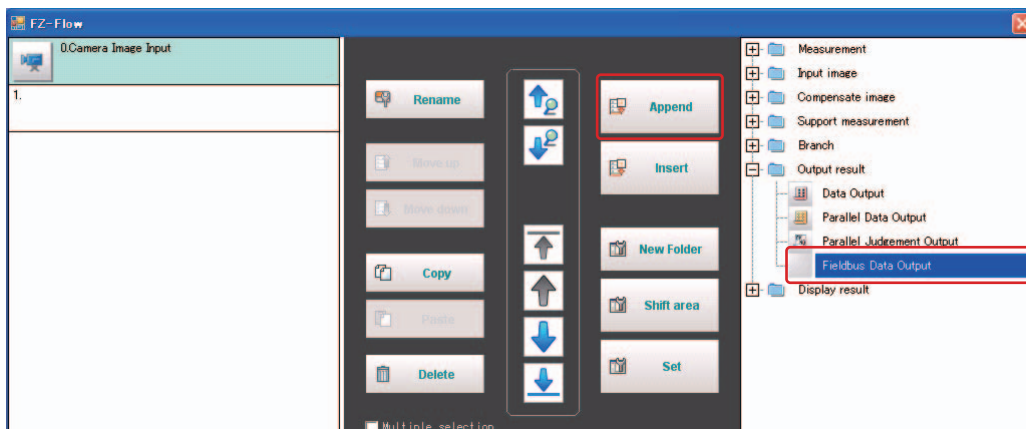
Set the EtherCAT communication contents on the properties setting window of the FZM1 Controller.

1. **Start the FZM1 Controller.**
2. **Click [Edit flow] on the toolbar.**



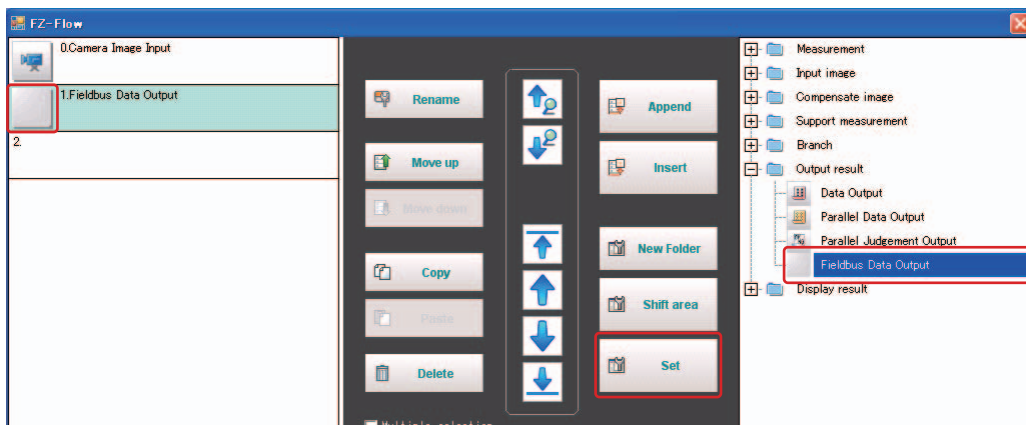
The edit flow window appears.

3. **From the processing item tree, select [Output result] - [Fieldbus Data Output], and click [Append].**



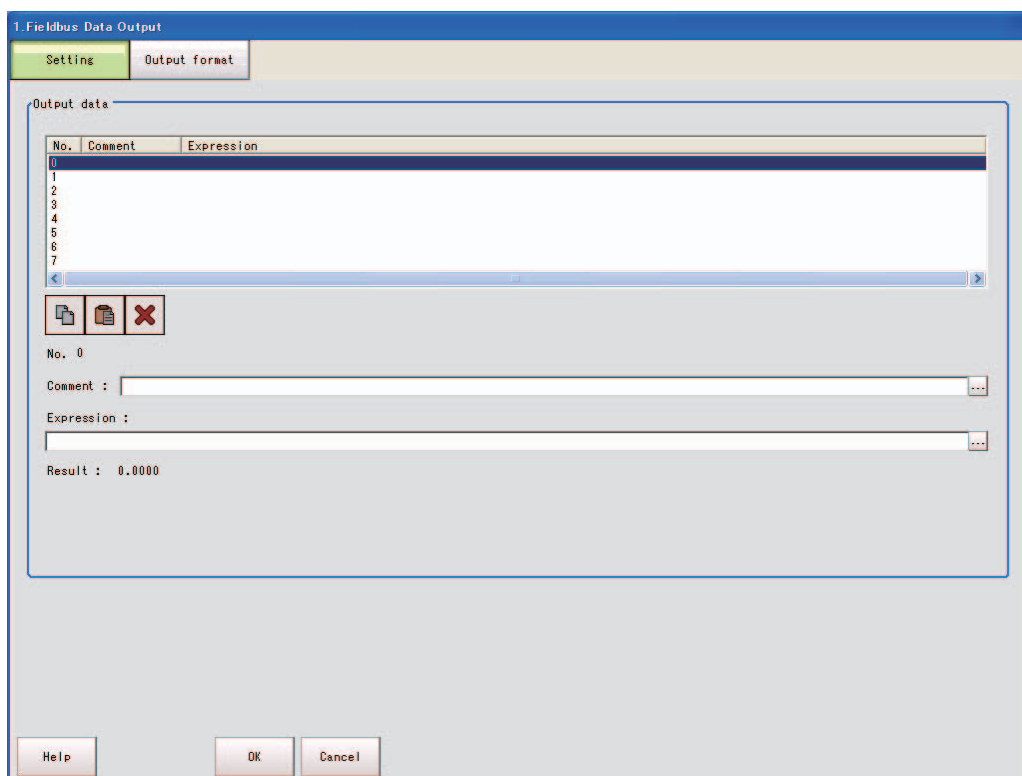
Processing item, [Fieldbus Data Output], is added to the unit list (flow).

4. **Click the [Fieldbus Data Output] icon on the unit list, or select [Fieldbus Data Output] from the processing item tree, and click [Set].**

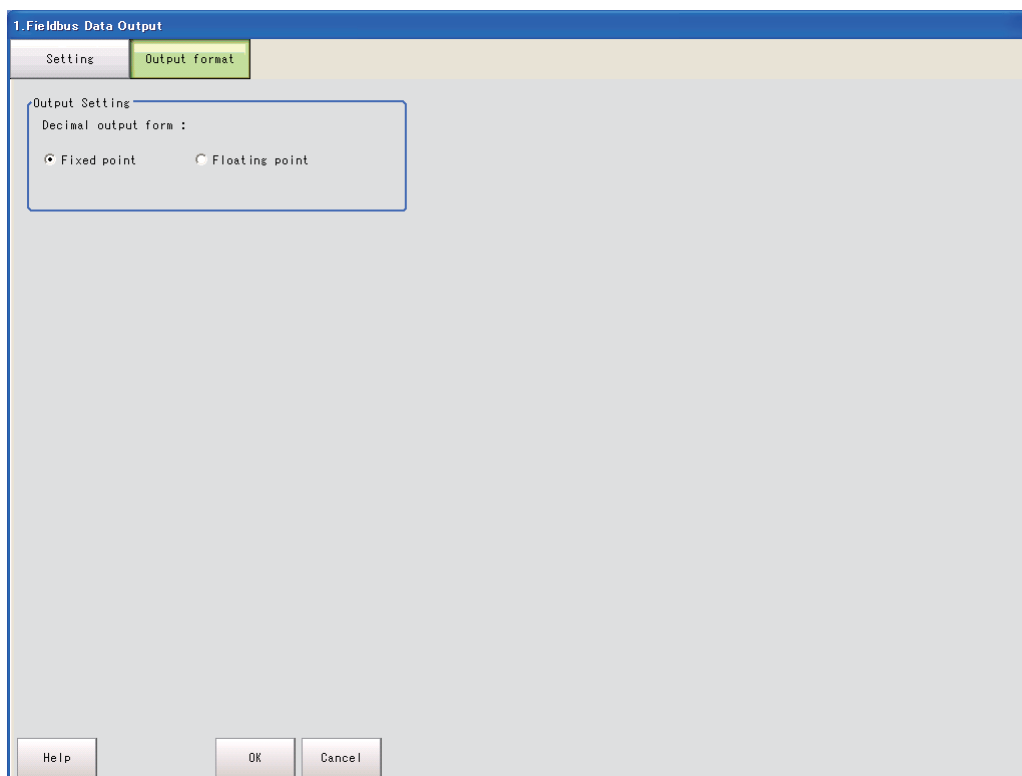


The [Fieldbus Data Output] properties setting window appears.

- [Setting] tab



- [Output format] tab



5. Specify each of the following settings as necessary.

Setting item	Setting value [Factory default]	Contents
[Setting] tab		Output data (up to 8) can be selected, and a comment and an expression can be set for each data.
Comment	–	Set a comment (such as an explanation of the expression) for the output data.
Expression	–	Set the expression for the output data.
[Output format] tab		Set the output data format.
Decimal output form	Fixed point Floating point	Set the output format of the data. - Fixed point: Integer portion of the value 1,000 times the data (decimal number) is output. - Floating point: Data is output in a single-precision floating point format.

6. Click [OK].

3-3 External Reference Table

No.	Data name	Set/Get	Data range
0	Judgement	Get only	0: No judgement (not yet measured) 1: Judgement result OK -1: Judgement result NG
5 to 12	Data 0 to data 7	Get only	ASCII: -99999999.9999 to 99999999.9999 Binary: -2147483.648 to 2147483.647
150	Output format	Set/Get	0: Fixed point 1: Floating point

4 Communication Specifications

This chapter explains the EtherCAT communication specifications with an FZM1 Controller.

4-1 PDO Mapping Specifications

- Master (Position Control Unit) to slave (FZM1 Controller)
 - Command area

Address	CH	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Type	Contents
0	0	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	STEP	EXE	UDINT	Control signal (32 bits)
2	1	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	DSA		
4	2	Command code (32 bits)																UDINT	Command code Common with the PLC link
6	3																		
8	4	(Integer) Parameter 1																DINT	Data (Parameter)
10	5																		
12	6	(Integer) Parameter 2																DINT	
14	7																		
16	8	(Integer) Parameter 3																DINT	
18	9																		

- Slave (FZM1 Controller) to master (Position Control Unit)
 - Response area

Address	CH	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Type	Contents
0	0	ERR	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	RUN	OR	READY	BUSY	FLG	UDINT	Control signal (32 bits)
2	1	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	GATE		
4	2	Command code (32 bits)																UDINT	Command code Common with the PLC link
6	3																		
8	4	Response code (32 bits)																UDINT	Response code Common with the PLC link
10	5																		
12	6	Response data (32 bits)																DINT	
14	7																		

- Output area

0	0	Data 1 (32 bits)	DINT	
2	1			
4	2	Data 2 (32 bits)	DINT	
6	3			
8	4	Data 3 (32 bits)	DINT	
10	5			
12	6	Data 4 (32 bits)	DINT	
14	7			
16	8	Data 5 (32 bits)	DINT	
18	9			
20	10	Data 6 (32 bits)	DINT	
22	11			
24	12	Data 7 (32 bits)	DINT	
26	13			
28	14	Data 8 (32 bits)	DINT	
30	15			

4-2 Control Signal Specifications

Control Signal Types

● Receive objects (master to slave)

The control signals for receive objects from the master (Position Control Unit) to the slave (FZM1 Controller) are as follows.

Signal name	Name	Function
EXE	Command execution	Set this to ON when executing commands. This is set to OFF with an FLG signal ON input.
STEP	Measurement step execution	Set this to ON when executing measurements. This is set to OFF with a READY signal OFF input.
DSA	Data output request	Set this to ON when requesting data output. This is set to OFF with a GATE signal ON input.

● Send object (slave to master)

The control signals for send objects from the slave (FZM1 Controller) to the master (Position Control Unit) are as follows.

Signal name	Name	Function
FLG	Command completion	This is set to ON upon completion of the command. This is set to OFF with an EXE signal OFF input.
BUSY	Busy	This is set to ON when the FZM1 Controller is measuring or a scene is being switched. This is set to OFF when the operation ends.
GATE	Data output completion	This is set to ON upon completion of the data output. This is set to OFF with a DSA signal OFF input.
READY	Ready	This is set to ON when the STEP signal can be input. This is set to OFF when the STEP signal cannot be input.
OR	Overall judgement result	This is set to ON when the overall judgement result is NG. This is set to OFF when the overall judgement result is OK.
ERR	Error	This is set to ON when an FZM1 Controller error is detected. This is set to OFF when normal.
RUN	RUN window	This is set to ON when the FZM1 Controller is displaying the RUN window. This is set to OFF when it is displaying windows other than RUN window.

4-3 Command Specifications

Command that Can Be Used

Command code		Function
+2CH	+3CH	
Normal command		
1020	0010	Start continuous measurement
1030	0010	End continuous measurement
2010	0010	Clear measurement value
3010	0010	Save to unit
F010	0010	Restart
Scene control command		
1000	0020	Get scene number
2000	0020	Get scene group number
1000	0030	Switch scene
2000	0030	Switch scene group number
Get or Change setting command		
1000	0040	Get unit data
1000	0050	Set unit data

Command Details

● Start continuous measurement (Command code: 1020 0010)

Start a continuous measurement.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0010	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0001	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0010	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0001	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	

● Stop continuous measurement (Command code: 1030 0010)

Stop the continuous measurement.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0011	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0001	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0011	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0001	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	

● Clear measurement value (Command code: 2010 0010)

Clear all measurement results.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0010	0000	0001	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0001	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0010	0000	0001	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0001	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	

● Save to unit (Command code: 3010 0010)

Save the current system data and scene group.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0011	0000	0001	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0001	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0011	0000	0001	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0001	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	

● Restart (Command code: F010 0010)

Restart the controller.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	1111	0000	0001	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0001	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
No response as it is restarted.						

● Get scene number (Command code: 1000 0020)

Get the current scene number and return it to the unit.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0000	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0010	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0010	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	
	+6	0000	0000	0000	0000	Response data (UDINT) Acquired scene number
	+7	0000	0000	0000	0000	

● Get scene group number (Command code: 2000 0020)

Get the current scene group number and return it to the unit.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0010	0000	0000	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0010	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0010	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0010	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	
	+6	0000	0000	0000	0000	Response data (UDINT) Get scene group number.
	+7	0000	0000	0000	0000	

● Switch scene (Command code: 1000 0030)

Switch to the scene of the specified number.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0000	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0011	0000	
	+4	0000	0000	0000	0000	Scene number (UDINT)
	+5	0000	0000	0000	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0001	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
	+3	0000	0000	0011	0000	
	+4	0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
	+5	0000	0000	0000	0000	

● Switch scene group (Command code: 2000 0030)

Switch to the scene group of the specified number.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
	+2	0010	0000	0000	0000	Command code: 4-byte binary data (UDINT)
	+3	0000	0000	0011	0000	
	+4	0000	0000	0000	0000	Scene group number (UDINT)
	+5	0000	0000	0000	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
+2		0010	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
+3		0000	0000	0010	0000	
+4		0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
+5		0000	0000	0000	0000	

● Get unit data (Command code: 1000 0040)

Get the data of the specified unit and number.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
+2		0001	0000	0000	0000	Command code: 4-byte binary data (UDINT)
+3		0000	0000	0100	0000	
+4		0000	0000	0000	0000	Unit number (UDINT)
+5		0000	0000	0000	0000	
+6		0000	0000	0000	0000	Data number (UDINT)
+7		0000	0000	0000	0000	

Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
+2		0001	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
+3		0000	0000	0100	0000	
+4		0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
+5		0000	0000	0000	0000	
+6		0000	0000	0000	0000	Get data (DINT: Value multiplied by 1,000)
+7		0000	0000	0000	0000	

● Set unit data (Command code: 1000 0050)

Set the data of the specified unit and number, and return it to the unit.

Command	Command area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
+2		0001	0000	0000	0000	Command code: 4-byte binary data (UDINT)
+3		0000	0000	0101	0000	
+4		0000	0000	0000	0000	Unit number (UDINT)
+5		0000	0000	0000	0000	
+6		0000	0000	0000	0000	Data number (UDINT)
+7		0000	0000	0000	0000	
+8		0000	0000	0000	0000	Data to be set (DINT: Value multiplied by 1,000)
+9		0000	0000	0000	0000	

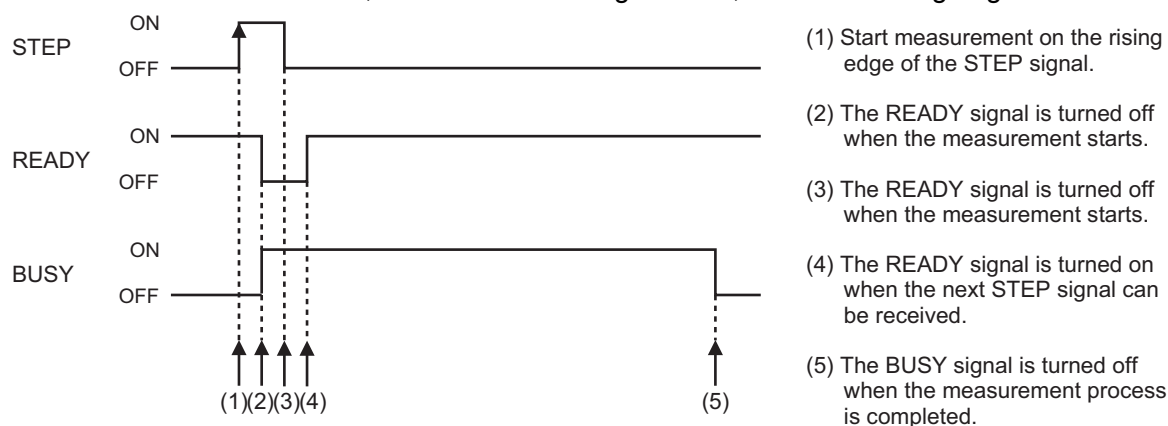
Response	Response area Starting CH	bit				Contents
		15-12	11-8	7-4	3-0	
+2		0001	0000	0000	0000	Command code (UDINT) Stores the command code of the response.
+3		0000	0000	0101	0000	
+4		0000	0000	0000	0000	Response code (UDINT) Command execution result 0: OK/-1: Error
+5		0000	0000	0000	0000	

4-4 Timing Chart

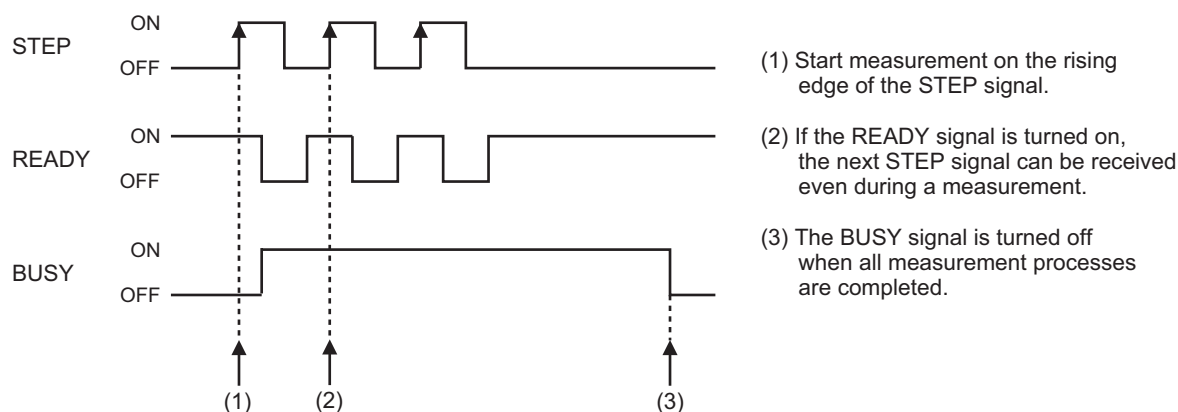
The following is a timing chart for the signals.

Executing Measurement with STEP Signal

It is executed in the parallel I/O method where the command is executed independent of data output. The measurement is executed, not on the STEP signal level, but on the rising edge.



Note that multiple image input as shown in the figure below is possible with STEP signal.



- Maximum number of loading with multiple image input

Controller model	0.3 million pixel camera	2 million pixel camera	5 million pixel camera
FZM1-35x-ECT	16	4	—

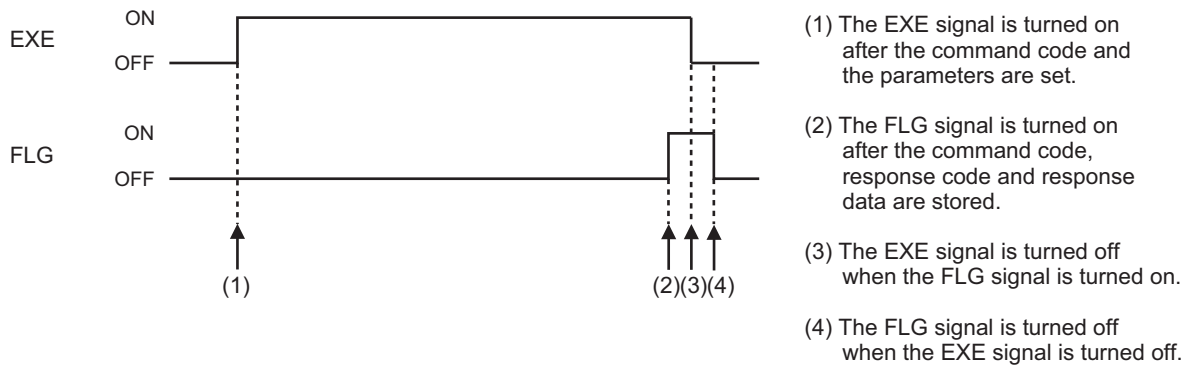
For details on multiple image input, see "6 Methods for Connecting and Communicating with External Devices" - "About Multiple Image Input Function" in "Vision Sensor FZ3 Series User's Manual" (catalog number Z290-E1).

Precautions for Correct Use

The OFF time of the READY signal is the camera image input time. If the cycle time is extremely slow on the PLC side, the READY signal OFF may not be recognized.
If the READY signal OFF cannot be recognized, set the STEP signal to OFF after an appropriate period of time.

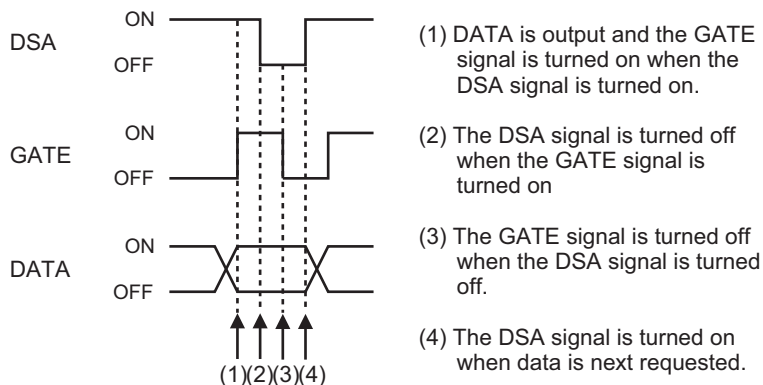
Command Execution with EXE Signal

Execute commands in the same manner as the conventional PLC link.



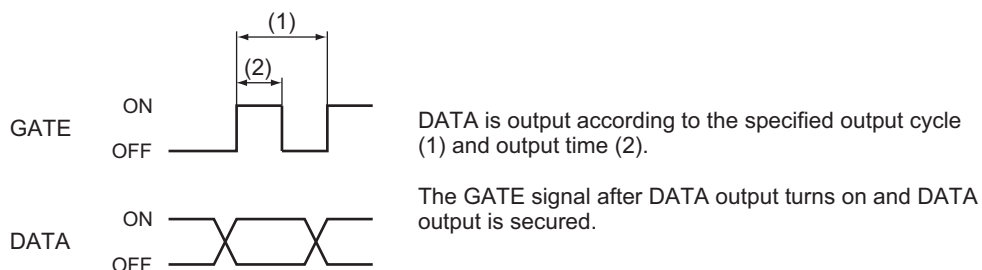
Data Output (With Handshaking)

Establish a handshaking of DSA signal and GATE signal.



Data Output (Without Handshaking)

Output data in the specified cycle and time.



5 Appendix

5-1 EtherCAT Terms

Use the following EtherCAT terms for reference.

Term	Abbreviation	Description
Object	–	Abstract representation of a particular component within a device, which consists of data, parameters, and methods.
Object Dictionary	OD	Data structure that contains description of data type objects, communication objects and application objects.
Service data object	SDO	CoE asynchronous mailbox communications where all objects in the Object Dictionary can be read and written.
Index	–	Address of an object
Subindex	–	Sub-address of an object
Process data	–	Collection of application objects designated to be transferred periodically or aperiodically for the purpose of measurement and control.
Process Data Object	PDO	Structure described by mapping parameters containing one or several process data entities.
Receive PDO	RxPDO	A Process Data Object received by an EtherCAT slave.
Transmit PDO	TxPDO	A Process Data Object sent from an EtherCAT slave.
Sync Manager	SM	Collection of control elements to coordinate access to concurrently used objects.
Distributed Clocks	DC	A distributed clock method to synchronize slaves with the master.
Device Profile	–	Collection of device class application parameters and function descriptions.
Fieldbus Memory Management Unit	FMMU	A function to establish one or multiple communications between a logical address and a physical memory location.
Physical device internal interface	PDI	A series of elements to access data link services from the application layer.
CAN in Automation	CiA	CiA is the international users' and manufacturers' group that develops and supports higher-layer protocols.
CAN application protocol over EtherCAT	CoE	CAN application protocol service on EtherCAT
EEPROM	EEPROM	Electrically erasable PROM.
EtherCAT Technology Group	ETG	The ETG is an organization that promotes open source development and dissemination of EtherCAT.
EtherCAT Slave Controller	ESC	A controller for EtherCAT slave communication.
EtherCAT State Machine	ESM	EtherCAT communication state transitions.
EtherCAT Slave Information	ESI	An XML file that contains setting information of an EtherCAT slave.

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16. **Property; Confidentiality.** Any intellectual property in the Products is the exclusive property of Omron Companies and Buyer shall not attempt to duplicate it in any way without the written permission of Omron. Notwithstanding any charges to Buyer for engineering or tooling, all engineering and tooling shall remain the exclusive property of Omron. All information and materials supplied by Omron to Buyer relating to the Products are confidential and proprietary, and Buyer shall limit distribution thereof to its trusted employees and strictly prevent disclosure to any third party.
17. **Export Controls.** Buyer shall comply with all applicable laws, regulations and licenses regarding (i) export of products or information; (ii) sale of products to "forbidden" or other proscribed persons; and (iii) disclosure to non-citizens of regulated technology or information.
18. **Miscellaneous.** (a) **Waiver.** No failure or delay by Omron in exercising any right and no course of dealing between Buyer and Omron shall operate as a waiver of rights by Omron. (b) **Assignment.** Buyer may not assign its rights hereunder without Omron's written consent. (c) **Law.** These Terms are governed by the law of the jurisdiction of the home office of the Omron company from which Buyer is purchasing the Products (without regard to conflict of law principles). (d) **Amendment.** These Terms constitute the entire agreement between Buyer and Omron relating to the Products, and no provision may be changed or waived unless in writing signed by the parties. (e) **Severability.** If any provision hereof is rendered ineffective or invalid, such provision shall not invalidate any other provision. (f) **Setoff.** Buyer shall have no right to set off any amounts against the amount owing in respect of this invoice. (g) **Definitions.** As used herein, "including" means "including without limitation"; and "Omron Companies" (or similar words) mean Omron Corporation and any direct or indirect subsidiary or affiliate thereof.

Certain Precautions on Specifications and Use

1. **Suitability of Use.** Omron Companies shall not be responsible for conformity with any standards, codes or regulations which apply to the combination of the Product in the Buyer's application or use of the Product. At Buyer's request, Omron will provide applicable third party certification documents identifying ratings and limitations of use which apply to the Product. This information by itself is not sufficient for a complete determination of the suitability of the Product in combination with the end product, machine, system, or other application or use. Buyer shall be solely responsible for determining appropriateness of the particular Product with respect to Buyer's application, product or system. Buyer shall take application responsibility in all cases but the following is a non-exhaustive list of applications for which particular attention must be given:
 - (i) Outdoor use, uses involving potential chemical contamination or electrical interference, or conditions or uses not described in this document.
 - (ii) Use in consumer products or any use in significant quantities.
 - (iii) Energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
 - (iv) Systems, machines and equipment that could present a risk to life or property. Please know and observe all prohibitions of use applicable to this Product.
 NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY OR IN LARGE QUANTITIES WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON'S PRODUCT IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.
2. **Programmable Products.** Omron Companies shall not be responsible for the user's programming of a programmable Product, or any consequence thereof.
3. **Performance Data.** Data presented in Omron Company websites, catalogs and other materials is provided as a guide for the user in determining suitability and does not constitute a warranty. It may represent the result of Omron's test conditions, and the user must correlate it to actual application requirements. Actual performance is subject to the Omron's Warranty and Limitations of Liability.
4. **Change in Specifications.** Product specifications and accessories may be changed at any time based on improvements and other reasons. It is our practice to change part numbers when published ratings or features are changed, or when significant construction changes are made. However, some specifications of the Product may be changed without any notice. When in doubt, special part numbers may be assigned to fix or establish key specifications for your application. Please consult with your Omron's representative at any time to confirm actual specifications of purchased Product.
5. **Errors and Omissions.** Information presented by Omron Companies has been checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical or proofreading errors or omissions.



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