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X5168, X5169 (Replaces X2526

CPU Supervisor with 16Kbit SPI EEPROM

FN8130
Rev 2.00
June 15, 2006

These devices combine three popular functions, Power-on Reset Control, Supply Voltage Supervision, and Block Lock Protect Serial EEPROM Memory in one package. This combination lowers system cost, reduces board space requirements, and increases reliability.

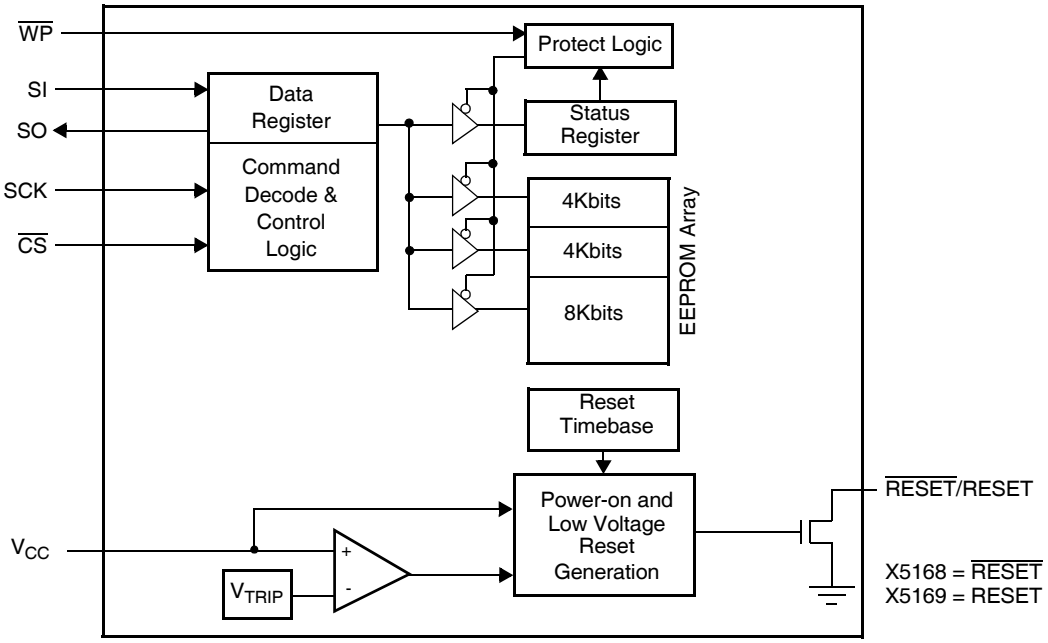
Applying power to the device activates the power-on reset circuit which holds $\overline{\text{RESET}}$/RESET active for a period of time. This allows the power supply and oscillator to stabilize before the processor can execute code.

The device's low V_{CC} detection circuitry protects the user's system from low voltage conditions by holding $\overline{\text{RESET}}$/RESET active when V_{CC} falls below a minimum V_{CC} trip point. $\overline{\text{RESET}}$/RESET remains asserted until V_{CC} returns to proper operating level and stabilizes. Five industry standard V_{TRIP} thresholds are available, however, Intersil's unique circuits allow the threshold to be reprogrammed to meet custom requirements or to fine-tune the threshold in applications requiring higher precision.

Features

- Low V_{CC} Detection and Reset Assertion
  - Five standard reset threshold voltages
  - Re-program low V_{CC} reset threshold voltage using special programming sequence
  - Reset signal valid to V_{CC} = 1V
- Long Battery Life with Low Power Consumption
  - <50µA max standby current, watchdog on
  - <1µA max standby current, watchdog off
  - <400µA max active current during read
- 16Kbits of EEPROM
- Built-in Inadvertent Write Protection
  - Power-up/power-down protection circuitry
  - Protect 0, 1/4, 1/2 or all of EEPROM array with Block Lock™ protection
  - In circuit programmable ROM mode
- 2MHz SPI Interface Modes (0,0 & 1,1)
- Minimize EEPROM Programming Time
  - 32-byte page write mode
  - Self-timed write cycle
  - 5ms write cycle time (typical)
- 2.7V to 5.5V and 4.5V to 5.5V Power Supply Operation
- Available Packages
  - 14 Ld TSSOP, 8 Ld SOIC, 8 Ld PDIP
- Pb-Free Plus Anneal Available (RoHS Compliant)

Block Diagram



Ordering Information

PART NUMBER RESET (ACTIVE LOW)	PART MARKING	PART NUMBER RESET (ACTIVE HIGH)	PART MARKING	V_{CC} RANGE (V)	V_{TRIP} RANGE (V)	TEMP RANGE (°C)	PACKAGE	PKG. DWG #
X5168P-4.5A	X5168P AL	X5169P-4.5A	X5169P AL	4.5-5.5	4.5-4.75	0 to 70	8 Ld PDIP	MDP0031
X5168PZ-4.5A (Note)	X5168P Z AL	X5169PZ-4.5A (Note)	X5169P Z AL			0 to 70	8 Ld PDIP** (Pb-free)	MDP0031
X5168PI-4.5A	X5168P AM	X5169PI-4.5A	X5169P AM			-40 to 85	8 Ld PDIP	MDP0031
X5168PIZ-4.5A (Note)	X5168P Z AM	X5169PIZ-4.5A (Note)	X5169P Z AM			-40 to 85	8 Ld PDIP** (Pb-free)	MDP0031
X5168S8-4.5A	X5168 AL	X5169S8-4.5A	X5169 AL			0 to 70	8 Ld SOIC	MDP0027
X5168S8Z-4.5A (Note)	X5168 Z AL	X5169S8Z-4.5A (Note)	X5169 Z AL			0 to 70	8 Ld SOIC (Pb-free)	MDP0027
X5168S8I-4.5A*	X5168 AM	X5169S8I-4.5A	X5169 AM			-40 to 85	8 Ld SOIC	MDP0027
X5168S8IZ-4.5A* (Note)	X5168 Z AM	X5169S8IZ-4.5A (Note)	X5169 Z AM			-40 to 85	8 Ld SOIC (Pb-free)	MDP0027
X5168V14-4.5A	X5168V AL	X5169V14-4.5A	X5169V AL			0 to 70	14 Ld TSSOP	M14.173
X5168V14Z-4.5A (Note)	X5168V Z AL	X5169V14Z-4.5A (Note)	X5169V Z AL			0 to 70	14 Ld TSSOP (Pb-free)	M14.173
X5168V14I-4.5A	X5168V AM	X5169V14I-4.5A	X5169V AM			-40 to 85	14 Ld TSSOP	M14.173
X5168V14IZ-4.5A (Note)	X5168V Z AM	X5169V14IZ-4.5A (Note)	X5169V Z AM			-40 to 85	14 Ld TSSOP (Pb-free)	M14.173
X5168P	X5168P	X5169P	X5169P	4.5-5.5	4.25-4.5	0 to 70	8 Ld PDIP	MDP0031
X5168PZ (Note)	X5168P Z	X5169PZ (Note)	X5169P Z			0 to 70	8 Ld PDIP** (Pb-free)	MDP0031
X5168PI	X5168P I	X5169PI	X5169P I			-40 to 85	8 Ld PDIP	MDP0031
X5168PIZ (Note)	X5168P Z I	X5169PIZ (Note)	X5169P Z I			-40 to 85	8 Ld PDIP** (Pb-free)	MDP0031
X5168S8*	X5168	X5169S8*	X5169			0 to 70	8 Ld SOIC	MDP0027
X5168S8Z* (Note)	X5168 Z	X5169S8Z* (Note)	X5169 Z			0 to 70	8 Ld SOIC (Pb-free)	MDP0027
X5168S8I*	X5168 I	X5169S8I*	X5169 I			-40 to 85	8 Ld SOIC	MDP0027
X5168S8IZ* (Note)	X5168 Z I	X5169S8IZ* (Note)	X5169 Z I			-40 to 85	8 Ld SOIC (Pb-free)	MDP0027
X5168V14*	X5168V	X5169V14*	X5169V			0 to 70	14 Ld TSSOP	M14.173
X5168V14Z* (Note)	X5168V Z	X5169V14Z* (Note)	X5169V Z			0 to 70	14 Ld TSSOP (Pb-free)	M14.173
X5168V14I*	X5168V I	X5169V14I*	X5169V I			-40 to 85	14 Ld TSSOP	M14.173
X5168V14IZ* (Note)	X5168V Z I	X5169V14IZ* (Note)	X5169V Z I			-40 to 85	14 Ld TSSOP (Pb-free)	M14.173
X5168P-2.7A	X5168P AN	X5169P-2.7A	X5169P AN	2.7-5.5	2.85-3.0	0 to 70	8 Ld PDIP	MDP0031
X5168PZ-2.7A (Note)	X5168P Z AN	X5169PZ-2.7A (Note)	X5169P Z AN			0 to 70	8 Ld PDIP** (Pb-free)	MDP0031
X5168PI-2.7A	X5168P AP	X5169PI-2.7A	X5169P AP			-40 to 85	8 Ld PDIP	MDP0031
X5168PIZ-2.7A (Note)	X5168P Z AP	X5169PIZ-2.7A (Note)	X5169P Z AP			-40 to 85	8 Ld PDIP** (Pb-free)	MDP0031
X5168S8-2.7A*	X5168 AN	X5169S8-2.7A	X5169 AN			0 to 70	8 Ld SOIC	MDP0027
X5168S8Z-2.7A* (Note)	X5168 Z AN	X5169S8Z-2.7A (Note)	X5169 Z AN			0 to 70	8 Ld SOIC (Pb-free)	MDP0027
X5168S8I-2.7A*	X5168 AP	X5169S8I-2.7A	X5169 AP			-40 to 85	8 Ld SOIC	MDP0027
X5168S8IZ-2.7A (Note)	X5168 Z AP	X5169S8IZ-2.7A (Note)	X5169 Z AP			-40 to 85	8 Ld SOIC (Pb-free)	MDP0027

Ordering Information (Continued)

PART NUMBER $\overline{\text{RESET}}$ (ACTIVE LOW)	PART MARKING	PART NUMBER RESET (ACTIVE HIGH)	PART MARKING	V_{CC} RANGE (V)	V_{TRIP} RANGE (V)	TEMP RANGE (°C)	PACKAGE	PKG. DWG #
X5168V14-2.7A	X5168V AN	X5169V14-2.7A	X5168V AN	2.7-5.5	2.85-3.0	0 to 70	14 Ld TSSOP	M14.173
X5168V14Z-2.7A (Note)	X5168V Z AN	X5169V14Z-2.7A (Note)	X5169V Z AN			0 to 70	14 Ld TSSOP (Pb-free)	M14.173
X5168V14I-2.7A	X5168V AP	X5169V14I-2.7A	X5169V AP			-40 to 85	14 Ld TSSOP	M14.173
X5168V14IZ-2.7A (Note)	X5168V Z AP	X5169V14IZ-2.7A (Note)	X5169V Z AP			-40 to 85	14 Ld TSSOP (Pb-free)	M14.173
X5168P-2.7	X5168P F	X5169P-2.7	X5169P F	2.7-5.5	2.55-2.7	0 to 70	8 Ld PDIP	MDP0031
X5168PZ-2.7 (Note)	X5168P Z F	X5169PZ-2.7 (Note)	X5169P Z F				8 Ld PDIP** (Pb-free)	MDP0031
X5168PI-2.7	X5168P G	X5169PI-2.7	X5169P G			-40 to 85	8 Ld PDIP	MDP0031
X5168PIZ-2.7 (Note)	X5168P Z G	X5169PIZ-2.7 (Note)	X5169P Z G				8 Ld PDIP** (Pb-free)	MDP0031
X5168S8-2.7*	X5168 F	X5169S8-2.7*	X5169 F			0 to 70	8 Ld SOIC	MDP0027
X5168S8Z-2.7* (Note)	X5168 Z F	X5169S8Z-2.7* (Note)	X5169 Z F				8 Ld SOIC (Pb-free)	MDP0027
X5168S8I-2.7*	X5168 G	X5169S8I-2.7*	X5169 G			-40 to 85	8 Ld SOIC	MDP0027
X5168S8IZ-2.7* (Note)	X5168 Z G	X5169S8IZ-2.7* (Note)	X5169 Z G				8 Ld SOIC (Pb-free)	MDP0027
X5168V14-2.7*	X5168V F	X5169V14-2.7*	X5169V F			0 to 70	14 Ld TSSOP	M14.173
X5168V14Z-2.7* (Note)	X5168V Z F	X5169V14Z-2.7* (Note)	X5169V Z F			0 to 70	14 Ld TSSOP (Pb-free)	M14.173
X5168V14I-2.7*	X5168V G	X5169V14I-2.7*	X5168V G			-40 to 85	14 Ld TSSOP	M14.173
X5168V14IZ-2.7* (Note)	X5168V Z G	X5169V14IZ-2.7* (Note)	X5168V Z G			-40 to 85	14 Ld TSSOP (Pb-free)	M14.173

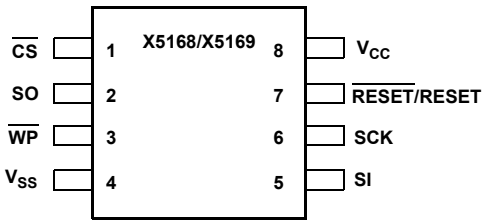
NOTE: Intersil Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.

*Add "-T1" suffix for tape and reel.

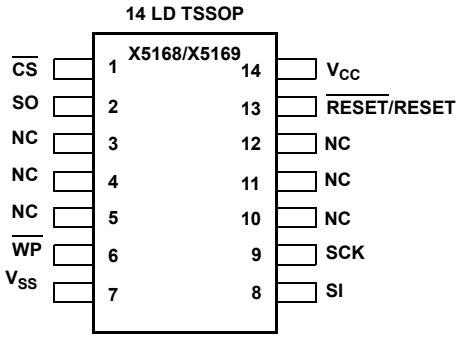
**Pb-free PDIPs can be used for through hole wave solder processing only. They are not intended for use in Reflow solder processing applications.

Pin Configuration

8 LD SOIC/PDIP



14 LD TSSOP



Pin Description

PIN (SOIC/PDIP)	PIN TSSOP	NAME	FUNCTION
1	1	CS	**Chip Select Input.** $\overline{CS}$ HIGH, deselects the device and the SO output pin is at a high impedance state. Unless a nonvolatile write cycle is underway, the device will be in the standby power mode. $\overline{CS}$ LOW enables the device, placing it in the active power mode. Prior to the start of any operation after power-up, a HIGH to LOW transition on $\overline{CS}$ is required.
2	2	SO	**Serial Output.** SO is a push/pull serial data output pin. A read cycle shifts data out on this pin. The falling edge of the serial clock (SCK) clocks the data out.
5	8	SI	**Serial Input.** SI is a serial data input pin. Input all opcodes, byte addresses, and memory data on this pin. The rising edge of the serial clock (SCK) latches the input data. Send all opcodes (Table 1), addresses and data MSB first.
6	9	SCK	**Serial Clock.** The serial clock controls the serial bus timing for data input and output. The rising edge of SCK latches in the opcode, address, or data bits present on the SI pin. The falling edge of SCK changes the data output on the SO pin.
3	6	WP	**Write Protect.** The $\overline{WP}$ pin works in conjunction with a nonvolatile WPEN bit to “lock” the setting of the watchdog timer control and the memory write protect bits.
4	7	V_{SS}	Ground
8	14	V_{CC}	Supply Voltage
7	13	$\overline{RESET}$/ RESET	**Reset Output**. $\overline{RESET}$/RESET is an active LOW/HIGH, open drain output which goes active whenever V_{CC} falls below the minimum V_{CC} sense level. It will remain active until V_{CC} rises above the minimum V_{CC} sense level for 200ms. $\overline{RESET}$/RESET goes active if the watchdog timer is enabled and $\overline{CS}$ remains either HIGH or LOW longer than the selectable watchdog time out period. A falling edge of $\overline{CS}$ will reset the watchdog timer. $\overline{RESET}$/RESET goes active on power-up at about 1V and remains active for 200ms after the power supply stabilizes.
	3-5,10-12	NC	No internal connections

Principles of Operation

Power-on Reset

Application of power to the X5168, X5169 activates a power-on reset circuit. This circuit goes active at about 1V and pulls the $\overline{RESET}$/RESET pin active. This signal prevents the system microprocessor from starting to operate with insufficient voltage or prior to stabilization of the oscillator. When V_{CC} exceeds the device V_{TRIP} value for 200ms (nominal) the circuit releases $\overline{RESET}$/RESET, allowing the processor to begin executing code.

Low Voltage Monitoring

During operation, the X5168, X5169 monitors the V_{CC} level and asserts $\overline{RESET}$/RESET if supply voltage falls below a preset minimum V_{TRIP}. The $\overline{RESET}$/RESET signal prevents the microprocessor from operating in a power fail or brownout condition. The $\overline{RESET}$/RESET signal remains active until the voltage drops below 1V. It also remains active until V_{CC} returns and exceeds V_{TRIP} for 200ms.

V_{CC} Threshold Reset Procedure

The X5168, X5169 has a standard V_{CC} threshold (V_{TRIP}) voltage. This value will not change over normal operating and storage conditions. However, in applications where the standard V_{TRIP} is not exactly right, or for higher precision in the V_{TRIP} value, the X5168, X5169 threshold may be adjusted.

Setting the V_{TRIP} Voltage

This procedure sets the V_{TRIP} to a higher voltage value. For example, if the current V_{TRIP} is 4.4V and the new V_{TRIP} is 4.6V, this procedure directly makes the change. If the new setting is lower than the current setting, then it is necessary to reset the trip point before setting the new value.

To set the new V_{TRIP} voltage, apply the desired V_{TRIP} threshold to the V_{CC} pin and tie the $\overline{CS}$ pin and the $\overline{WP}$ pin HIGH. $\overline{RESET}$/RESET and SO pins are left unconnected. Then apply the programming voltage V_P to both SCK and SI and pulse $\overline{CS}$ LOW then HIGH. Remove V_P and the sequence is complete.

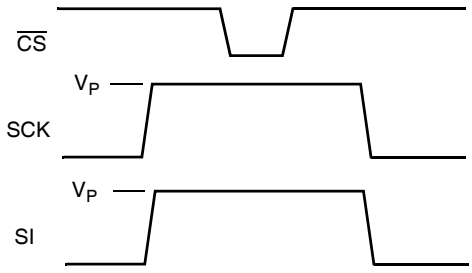


FIGURE 1. SET V_{TRIP} VOLTAGE

Resetting the V_{TRIP} Voltage

This procedure sets the V_{TRIP} to a “native” voltage level. For example, if the current V_{TRIP} is 4.4V and the V_{TRIP} is reset, the new V_{TRIP} is something less than 1.7V. This procedure must be used to set the voltage to a lower value.

To reset the V_{TRIP} voltage, apply a voltage between 2.7 and 5.5V to the V_{CC} pin. Tie the $\overline{CS}$ pin, the $\overline{WP}$ pin, and the SCK pin HIGH. $\overline{RESET}$/RESET and SO pins are left unconnected. Then apply the programming voltage V_P to the SI pin ONLY and pulse $\overline{CS}$ LOW then HIGH. Remove V_P and the sequence is complete.

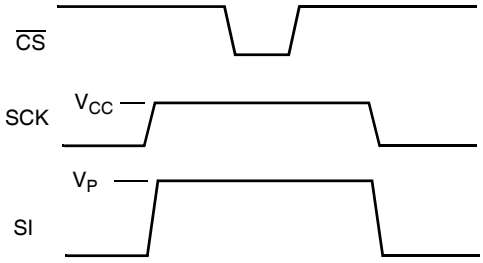


FIGURE 2. RESET V_{TRIP} VOLTAGE

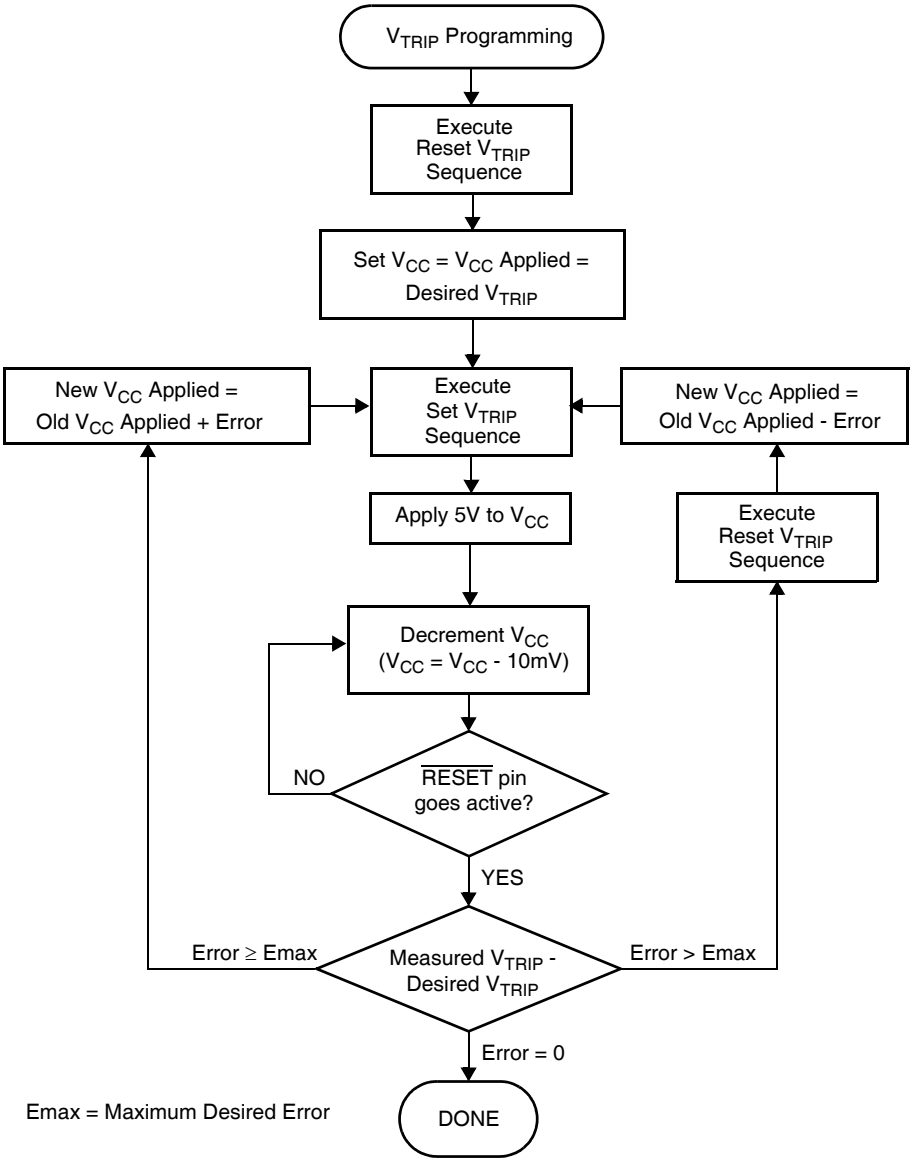


FIGURE 3. V_{TRIP} PROGRAMMING SEQUENCE FLOW CHART

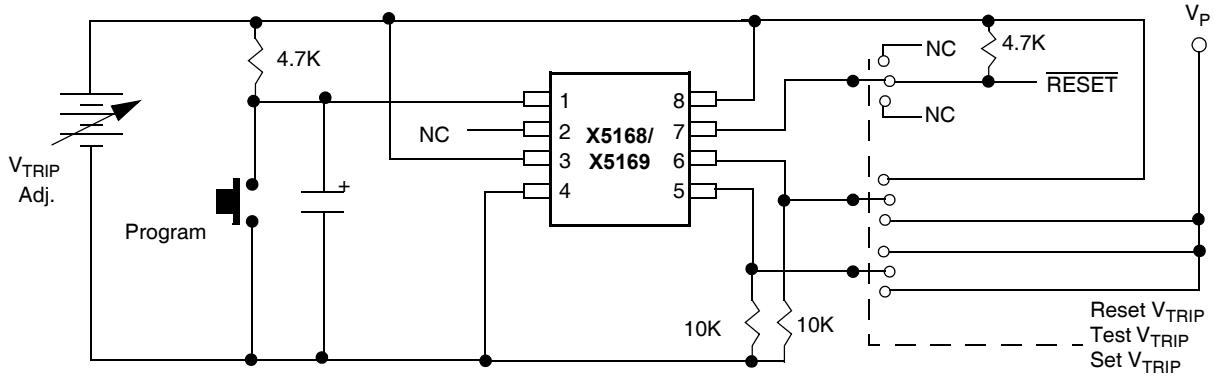


FIGURE 4. SAMPLE V_{TRIP} RESET CIRCUIT

SPI Serial Memory

The memory portion of the device is a CMOS serial EEPROM array with Intersil's block lock protection. The array is internally organized as x 8. The device features a Serial Peripheral Interface (SPI) and software protocol allowing operation on a simple four-wire bus.

The device utilizes Intersil's proprietary Direct Write™ cell, providing a minimum endurance of 100,000 cycles and a minimum data retention of 100 years.

The device is designed to interface directly with the synchronous Serial Peripheral Interface (SPI) of many popular microcontroller families. It contains an 8-bit instruction register that is accessed via the SI input, with data being clocked in on the rising edge of SCK. $\overline{CS}$ must be LOW during the entire operation.

All instructions (Table 1), addresses and data are transferred MSB first. Data input on the SI line is latched on the first rising edge of SCK after $\overline{CS}$ goes LOW. Data is output on the SO line by the falling edge of SCK. SCK is static, allowing the user to stop the clock and then start it again to resume operations where left off.

Write Enable Latch

The device contains a write enable latch. This latch must be SET before a write operation is initiated. The WREN instruction will set the latch and the WRDI instruction will reset the latch (Figure 3). This latch is automatically reset upon a power-up condition and after the completion of a valid write cycle.

Status Register

The RDSR instruction provides access to the status register. The status register may be read at any time, even during a write cycle. The status register is formatted as follows:

7	6	5	4	3	2	1	0
WPEN	FLB	0	0	BL1	BL0	WEL	WIP

The Write-In-Progress (WIP) bit is a volatile, read only bit and indicates whether the device is busy with an internal nonvolatile write operation. The WIP bit is read using the RDSR instruction. When set to a "1", a nonvolatile write operation is in progress. When set to a "0", no write is in progress.

TABLE 1. INSTRUCTION SET

INSTRUCTION NAME	INSTRUCTION FORMAT*	OPERATION
WREN	0000 0110	Set the write enable latch (enable write operations)
SFLB	0000 0000	Set flag bit
WRDI/RFLB	0000 0100	Reset the write enable latch/reset flag bit
RDSR	0000 0101	Read status register
WRSR	0000 0001	Write status register (watchdog, block lock, WPEN and flag bits)
READ	0000 0011	Read data from memory array beginning at selected address
WRITE	0000 0010	Write data to memory array beginning at selected address

Note: *Instructions are shown MSB in leftmost position. Instructions are transferred MSB first.

TABLE 2. BLOCK PROTECT MATRIX

WREN CMD	STATUS REGISTER	DEVICE PIN	BLOCK	BLOCK	STATUS REGISTER
WEL	WPEN	WP#	PROTECTED BLOCK	UNPROTECTED BLOCK	WPEN, BL0, BL1 WD0, WD1
0	X	X	Protected	Protected	Protected
1	1	0	Protected	Writable	Protected
1	0	X	Protected	Writable	Writable
1	X	1	Protected	Writable	Writable

The Write Enable Latch (WEL) bit indicates the status of the write enable latch. When WEL = 1, the latch is set HIGH and when WEL = 0 the latch is reset LOW. The WEL bit is a volatile, read only bit. It can be set by the WREN instruction and can be reset by the WRDS instruction.

The block lock bits, BL0 and BL1, set the level of block lock protection. These nonvolatile bits are programmed using the WRSR instruction and allow the user to protect one quarter, one half, all or none of the EEPROM array. Any portion of the array that is block lock protected can be read but not written. It will remain protected until the BL bits are altered to disable block lock protection of that portion of memory.

STATUS REGISTER BITS		ARRAY ADDRESSES PROTECTED
BL1	BL0	X5168/X5169
0	0	None
0	1	$0600-$07FF
1	0	$0400-$07FF
1	1	$0000-$07FF

The FLAG bit shows the status of a volatile latch that can be set and reset by the system using the SFLB and RFLB instructions. The flag bit is automatically reset upon power-up.

The nonvolatile WPEN bit is programmed using the WRSR instruction. This bit works in conjunction with the $\overline{WP}$ pin to provide an in-circuit programmable ROM function (Table 2).

$\overline{WP}$ is LOW and WPEN bit programmed HIGH disables all status register write operations.

In Circuit Programmable ROM Mode

This mechanism protects the block lock and watchdog bits from inadvertent corruption.

In the locked state (programmable ROM mode) the $\overline{WP}$ pin is LOW and the nonvolatile bit WPEN is “1”. This mode disables nonvolatile writes to the device’s status register.

Setting the $\overline{WP}$ pin LOW while WPEN is a “1” while an internal write cycle to the status register is in progress will not stop this write operation, but the operation disables subsequent write attempts to the status register.

When $\overline{WP}$ is HIGH, all functions, including nonvolatile writes to the status register operate normally. Setting the WPEN bit in the status register to “0” blocks the $\overline{WP}$ pin function, allowing writes to the status register when $\overline{WP}$ is HIGH or LOW. Setting the WPEN bit to “1” while the $\overline{WP}$ pin is LOW activates the programmable ROM mode, thus requiring a change in the $\overline{WP}$ pin prior to subsequent status register changes. This allows manufacturing to install the device in a system with $\overline{WP}$ pin grounded and still be able to program the status register. Manufacturing can then load configuration data, manufacturing time and other parameters into the EEPROM, then set the portion of memory to be protected by setting the block lock bits, and finally set the “OTP mode” by setting the WPEN bit. Data changes now require a hardware change.

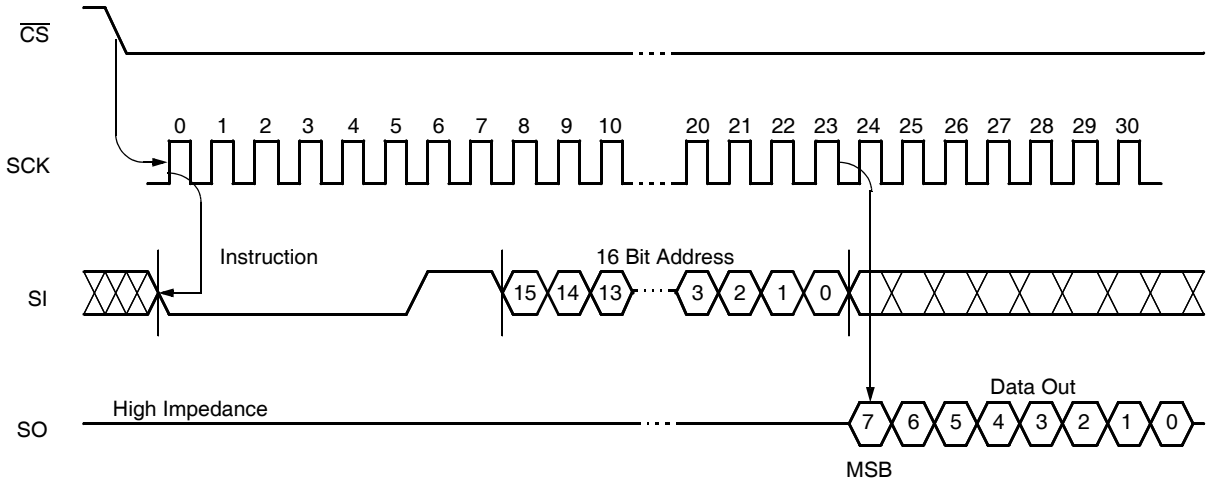


FIGURE 5. READ EEPROM ARRAY SEQUENCE

Read Sequence

When reading from the EEPROM memory array, $\overline{CS}$ is first pulled low to select the device. The 8-bit READ instruction is transmitted to the device, followed by the 16-bit address. After the READ opcode and address are sent, the data stored in the memory at the selected address is shifted out on the SO line. The data stored in memory at the next address can be read sequentially by continuing to provide clock pulses. The address is automatically incremented to the next higher address after each byte of data is shifted out. When the highest address is reached, the address counter rolls over to address $0000 allowing the read cycle to be continued indefinitely. The read operation is terminated by taking $\overline{CS}$ high. Refer to the read EEPROM array sequence (Figure 1).

To read the status register, the $\overline{CS}$ line is first pulled low to select the device followed by the 8-bit RDSR instruction. After the RDSR opcode is sent, the contents of the status register are shifted out on the SO line. Refer to the read status register sequence (Figure 2).

Write Sequence

Prior to any attempt to write data into the device, the “Write Enable” Latch (WEL) must first be set by issuing the WREN instruction (Figure 3). $\overline{CS}$ is first taken LOW, then the WREN instruction is clocked into the device. After all eight bits of the instruction are transmitted, $\overline{CS}$ must then be taken HIGH. If the user continues the write operation without taking $\overline{CS}$ HIGH after issuing the WREN instruction, the write operation will be ignored.

To write data to the EEPROM memory array, the user then issues the WRITE instruction followed by the 16 bit address and then the data to be written. Any unused address bits are specified to be “0’s”. The WRITE operation minimally takes 32 clocks. $\overline{CS}$ must go low and remain low for the duration of the operation. If the address counter reaches the end of a page and the clock continues, the counter will roll back to the first address of the page and overwrite any data that may have been previously written.

For the page write operation (byte or page write) to be completed, $\overline{CS}$ can only be brought HIGH after bit 0 of the last data byte to be written is clocked in. If it is brought HIGH at any other time, the write operation will not be completed (Figure 4).

To write to the status register, the WRSR instruction is followed by the data to be written (Figure 5). Data bits 0 and 1 must be “0”.

While the write is in progress following a status register or EEPROM sequence, the status register may be read to check the WIP bit. During this time the WIP bit will be high.

Operational Notes

The device powers-up in the following state:

- The device is in the low power standby state.
- A HIGH to LOW transition on $\overline{CS}$ is required to enter an active state and receive an instruction.
- SO pin is high impedance.
- The write enable latch is reset.
- The flag bit is reset.
- Reset signal is active for t_{PURST}.

Data Protection

The following circuitry has been included to prevent inadvertent writes:

- A WREN instruction must be issued to set the write enable latch.
- $\overline{CS}$ must come HIGH at the proper clock count in order to start a nonvolatile write cycle.

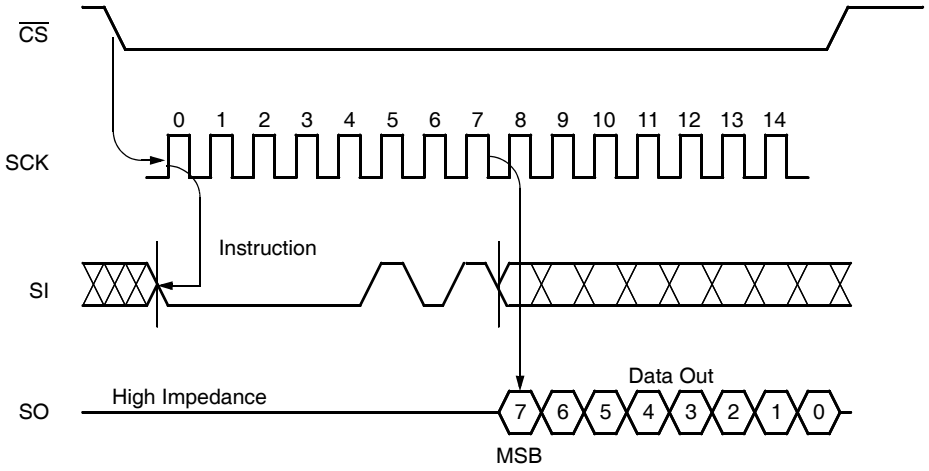


FIGURE 6. READ STATUS REGISTER SEQUENCE

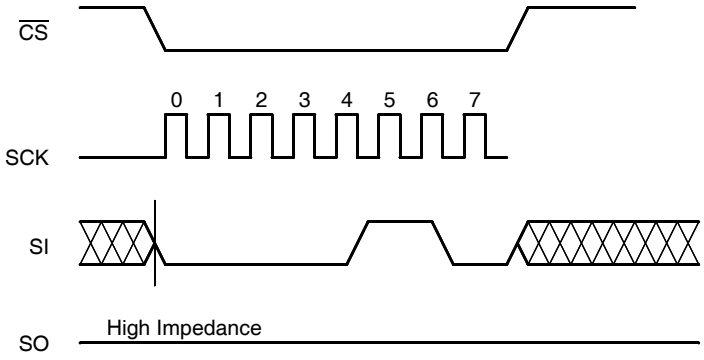


FIGURE 7. WRITE ENABLE LATCH SEQUENCE

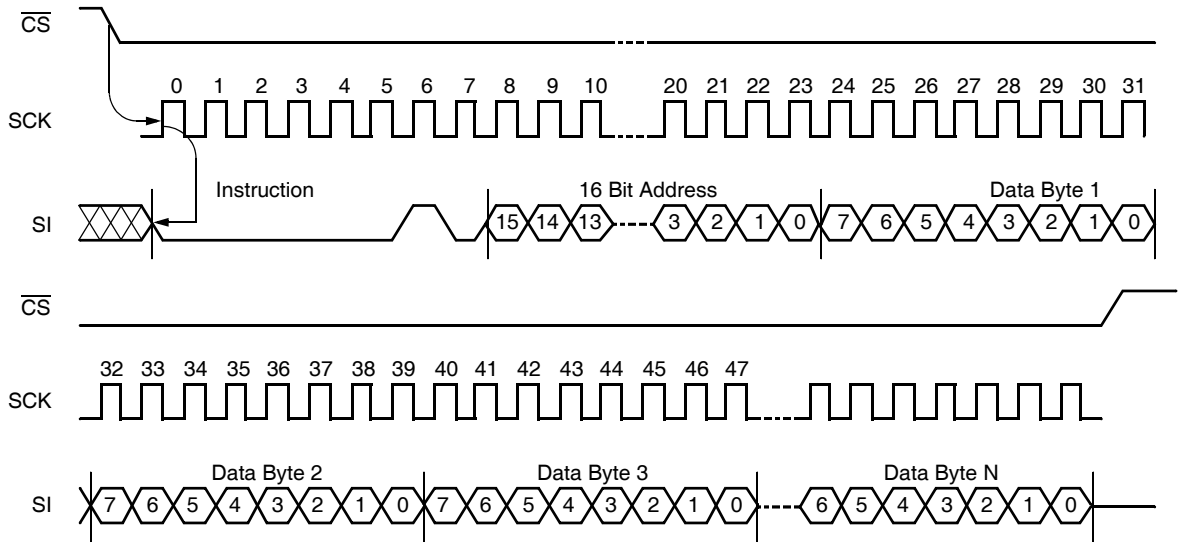


FIGURE 8. WRITE SEQUENCE

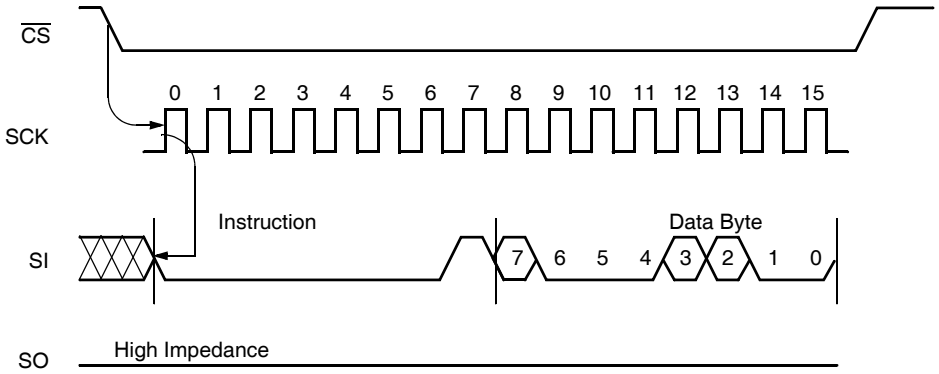


FIGURE 9. STATUS REGISTER WRITE SEQUENCE

Symbol Table

WAVEFORM	INPUTS	OUTPUTS
	Must be steady	Will be steady
	May change from LOW to HIGH	Will change from LOW to HIGH
	May change from HIGH to LOW	Will change from HIGH to LOW
	Don't Care: Changes Allowed	Changing: State Not Known
	N/A	Center Line is High Impedance

Absolute Maximum Ratings

Temperature Under Bias . . . . . -65°C to +135°C
Storage Temperature . . . . . -65°C to +150°C
Voltage on any Pin with Respect to V_{SS} . . . . . -1.0V to +7V
DC Output Current. 5mA
Lead Temperature (Soldering, 10s) . . . . . 300°C

Recommended Operating Conditions

Temperature Range
Commercial . . . . . 0°C to +70°C
Industrial. . . . . -40°C to +85°C
Supply Voltage Limits
-2.7 or -2.7A. . . . . 2.7V to 5.5V
Blank or -4.5A 4.5V-5.5V

CAUTION: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only; the functional operation of the device (at these or any other conditions above those listed in the operational sections of this specification) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability

DC Electrical Specifications

Over the recommended operating conditions unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
I_{CC1}	V_{CC} write current (active)	SCK = V_{CC} x 0.1/V_{CC} x 0.9 @ 2MHz, SO = Open			5	mA
I_{CC2}	V_{CC} read current (active)	SCK = V_{CC} x 0.1/V_{CC} x 0.9 @ 2MHz, SO = Open			0.4	mA
I_{SB}	V_{CC} standby current WDT = OFF	$\overline{CS}$ = V_{CC}, V_{IN} = V_{SS} or V_{CC}, V_{CC} = 5.5V			1	µA
I_{LI}	Input leakage current	V_{IN} = V_{SS} to V_{CC}		0.1	10	µA
I_{LO}	Output leakage current	V_{OUT} = V_{SS} to V_{CC}		0.1	10	µA
V_{IL} (NOTE 1)	Input LOW voltage		-0.5		V_{CC} x 0.3	V
V_{IH} (NOTE 1)	Input HIGH voltage		V_{CC} x 0.7		V_{CC} + 0.5	V
V_{OL1}	Output LOW voltage	V_{CC} > 3.3V, I_{OL} = 2.1mA			0.4	V
V_{OL2}	Output LOW voltage	2V < V_{CC} ≤ 3.3V, I_{OL} = 1mA			0.4	V
V_{OL3}	Output LOW voltage	V_{CC} ≤ 2V, I_{OL} = 0.5mA			0.4	V
V_{OH1}	Output HIGH voltage	V_{CC} > 3.3V, I_{OH} = -1.0mA	V_{CC} - 0.8			V
V_{OH2}	Output HIGH voltage	2V < V_{CC} ≤ 3.3V, I_{OH} = -0.4mA	V_{CC} - 0.4			V
V_{OH3}	Output HIGH voltage	V_{CC} ≤ 2V, I_{OH} = -0.25mA	V_{CC} - 0.2			V
V_{OLS}	Reset output LOW voltage	I_{OL} = 1mA			0.4	V

Capacitance

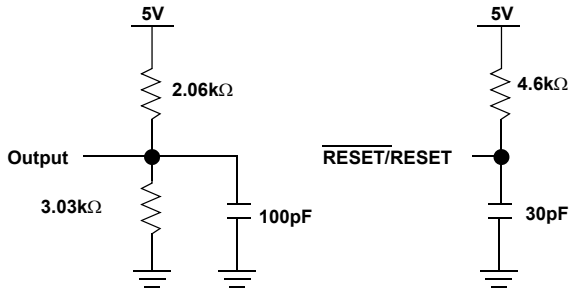
T_A = +25°C, f = 1MHz, V_{CC} = 5V.

SYMBOL	TEST	CONDITIONS	MAX.	UNIT
C_{OUT} (NOTE 2)	Output capacitance (SO, $\overline{RESET}$/RESET)	V_{OUT} = 0V	8	pF
C_{IN} (NOTE 2)	Input capacitance (SCK, SI, $\overline{CS}$, $\overline{WP}$)	V_{IN} = 0V	6	pF

NOTES:

1. V_{IL} min. and V_{IH} max. are for reference only and are not tested.
2. This parameter is periodically sampled and not 100% tested.

Equivalent A.C. Load Circuit at 5V V_{CC}



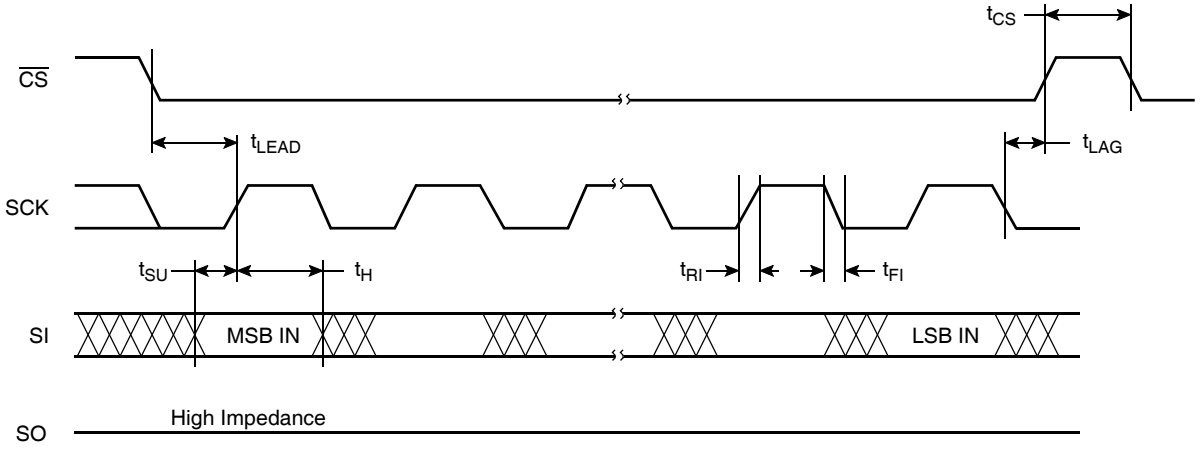
A.C. Test Conditions

Input pulse levels	V_{CC} x 0.1 to V_{CC} x 0.9
Input rise and fall times	10ns
Input and output timing level	V_{CC} x 0.5

AC Electrical Specifications (Over recommended operating conditions, unless otherwise specified.)

SYMBOL	PARAMETER	2.7-5.5V		UNIT
		MIN	MAX	
SERIAL INPUT TIMING				
f_{SCK}	Clock frequency	0	2	MHz
t_{CYC}	Cycle time	500		ns
t_{LEAD}	$\overline{CS}$ lead time	250		ns
t_{LAG}	$\overline{CS}$ lag time	250		ns
t_{WH}	Clock HIGH time	200		ns
t_{WL}	Clock LOW time	200		ns
t_{SU}	Data setup time	50		ns
t_H	Data hold time	50		ns
t_{RI}(3)	Input rise time		100	ns
t_{FI}(3)	Input fall time		100	ns
t_{CS}	$\overline{CS}$ deselect time	500		ns
t_{WC}(4)	Write cycle time		10	ms

Serial Input Timing

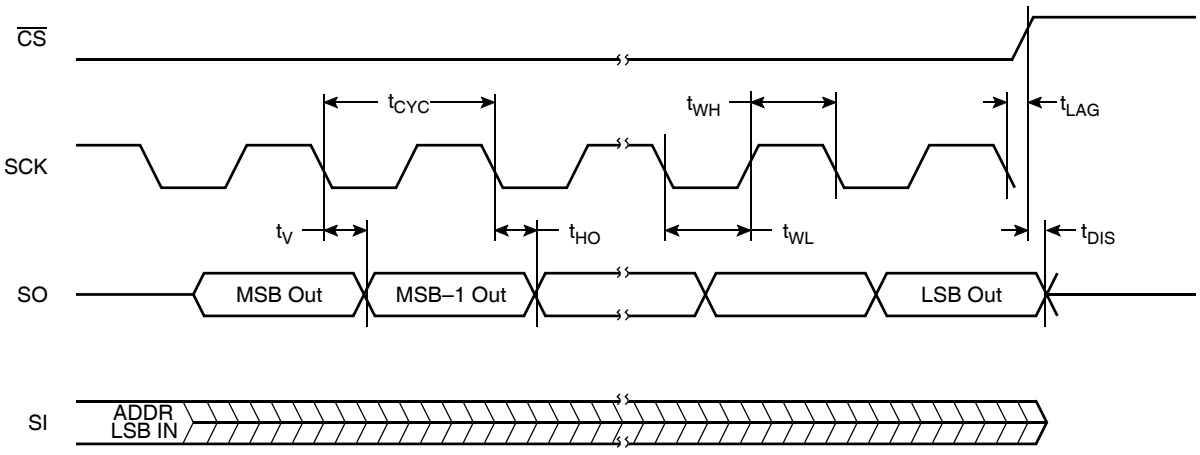


Serial Output Timing

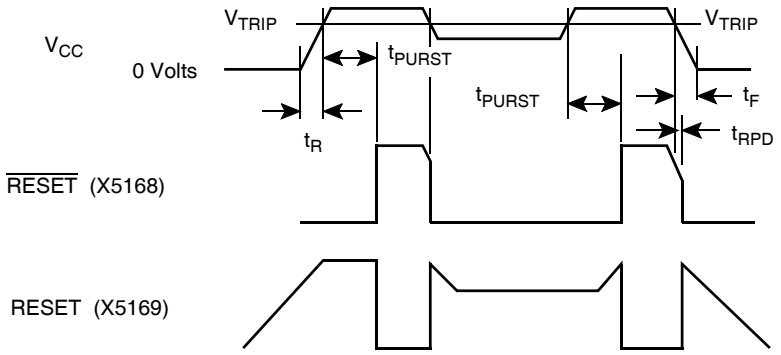
SYMBOL	PARAMETER	2.7-5.5V		UNIT
		MIN	MAX	
f_{SCK}	Clock frequency	0	2	MHz
t_{DIS}	Output disable time		250	ns
t_V	Output valid from clock low		200	ns
t_{HO}	Output hold time	0		ns
t_{RO}(3)	Output rise time		100	ns
t_{FO}(3)	Output fall time		100	ns

Notes: (3) This parameter is periodically sampled and not 100% tested.
(4) t_{WC} is the time from the rising edge of $\overline{CS}$ after a valid write sequence has been sent to the end of the self-timed internal nonvolatile write cycle.

Serial Output Timing



Power-Up and Power-Down Timing

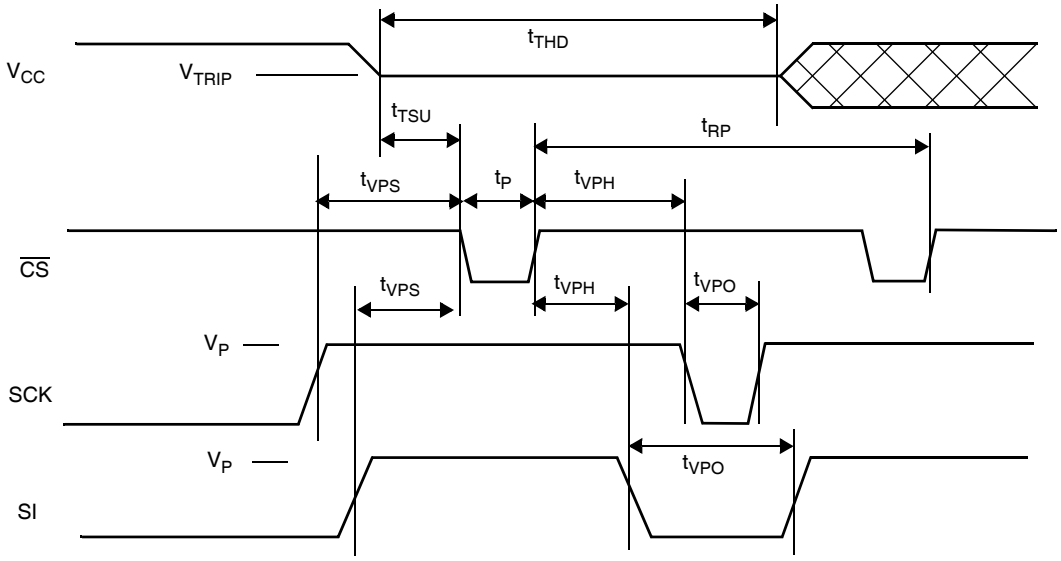


$\overline{RESET}$ Output Timing

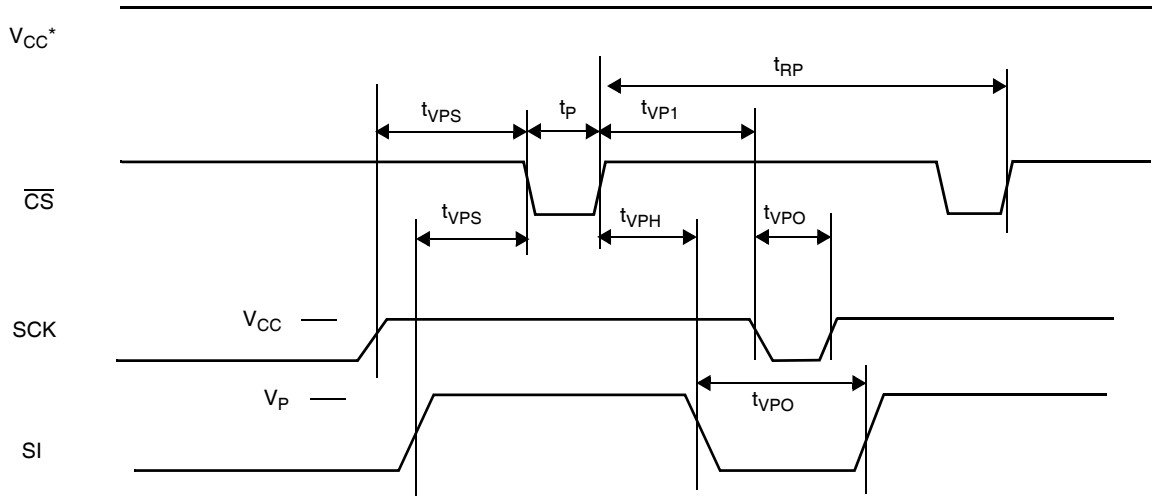
SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{TRIP}	Reset trip point voltage, X5168-4.5A, X5168-4.5A Reset trip point voltage, X5168, X5169 Reset trip point voltage, X5168-2.7A, X5169-2.7A Reset trip point voltage, X5168-2.7, X5169-2.7	4.5 4.25 2.85 2.55	4.63 4.38 2.93 2.63	4.75 4.5 3.0 2.7	V
V_{TH}	V_{TRIP} hysteresis (HIGH to LOW vs. LOW to HIGH V_{TRIP} voltage)		20		mV
t_{PURST}	Power-up reset time out	100	200	280	ms
t_{RPD}(5)	V_{CC} detect to reset/output			500	ns
t_F(5)	V_{CC} fall time	100			µs
t_R(5)	V_{CC} rise time	100			µs
V_{RVALID}	Reset valid V_{CC}	1			V

Note: (5) This parameter is periodically sampled and not 100% tested.

V_{TRIP} Set Conditions



V_{TRIP} Reset Conditions



*V_{CC} > Programmed V_{TRIP}

V_{TRIP} Programming Specifications

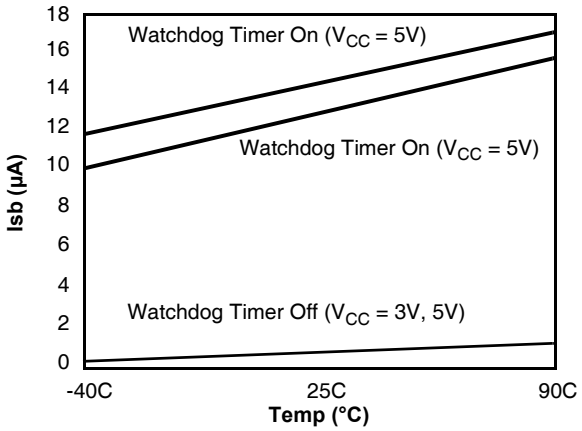
V_{CC} = 1.7-5.5V; Temperature = 0°C to 70°C

PARAMETER	DESCRIPTION	MIN	MAX	UNIT
t_{VPS}	SCK V_{TRIP} program voltage setup time	1		µs
t_{VPH}	SCK V_{TRIP} program voltage hold time	1		µs
t_P	V_{TRIP} program pulse width	1		µs
t_{TSU}	V_{TRIP} level setup time	10		µs
t_{THD}	V_{TRIP} level hold (stable) time	10		ms
t_{WC}	V_{TRIP} write cycle time		10	ms
t_{RP}	V_{TRIP} program cycle recovery period (between successive programming cycles)	10		ms
t_{VPO}	SCK V_{TRIP} program voltage off time before next cycle	0		ms
V_P	Programming voltage	15	18	V
V_{TRAN}	V_{TRIP} programmed voltage range	1.7	5.0	V
V_{ta1}	Initial V_{TRIP} program voltage accuracy (V_{CC} applied-V_{TRIP}) (programmed at 25°C)	-0.1	+0.4	V
V_{ta2}	Subsequent V_{TRIP} program voltage accuracy [(V_{CC} applied-V_{ta1})-V_{TRIP}] (programmed at 25°C)	-25	+25	mV
V_{tr}	V_{TRIP} program voltage repeatability (successive program operations) (programmed at 25°C)	-25	+25	mV
V_{tv}	V_{TRIP} Program variation after programming (0-75°C). (programmed at 25°C)	-25	+25	mV

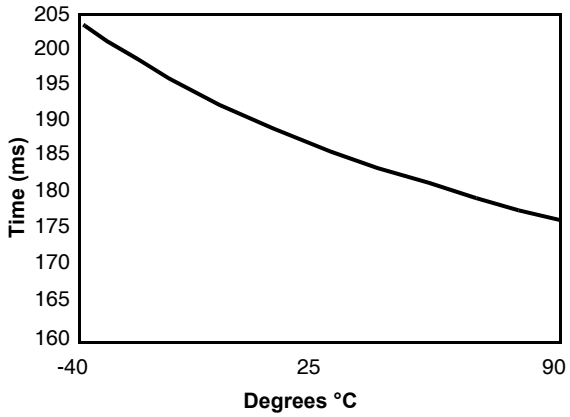
V_{TRIP} programming parameters are periodically sampled and are not 100% tested.

Typical Performance

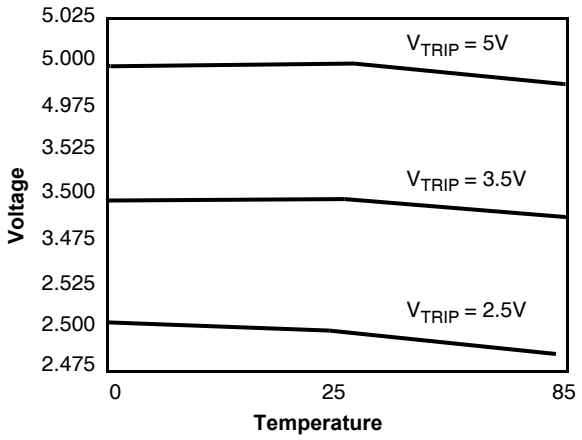
V_{CC} Supply Current vs. Temperature (I_{SB})



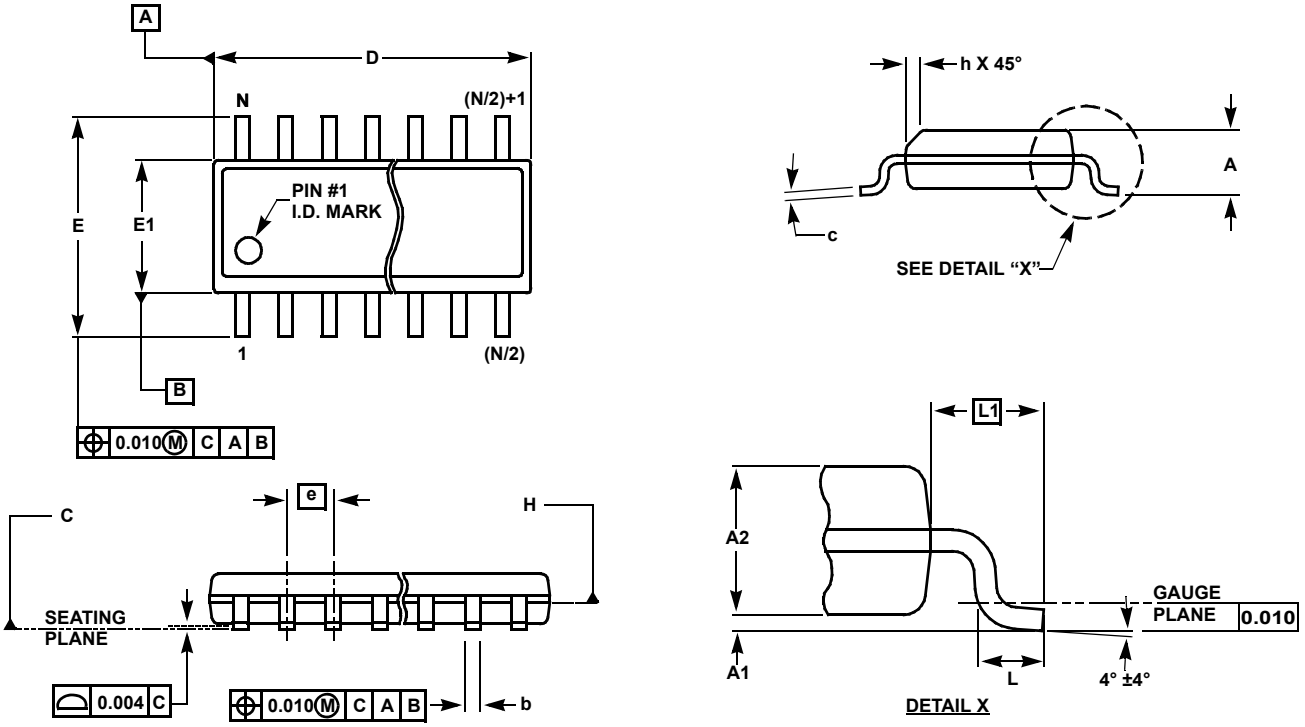
t_{PURST} vs. Temperature



V_{TRIP} vs. Temperature (programmed at 25°C)



Small Outline Package Family (SO)



MDP0027

SMALL OUTLINE PACKAGE FAMILY (SO)

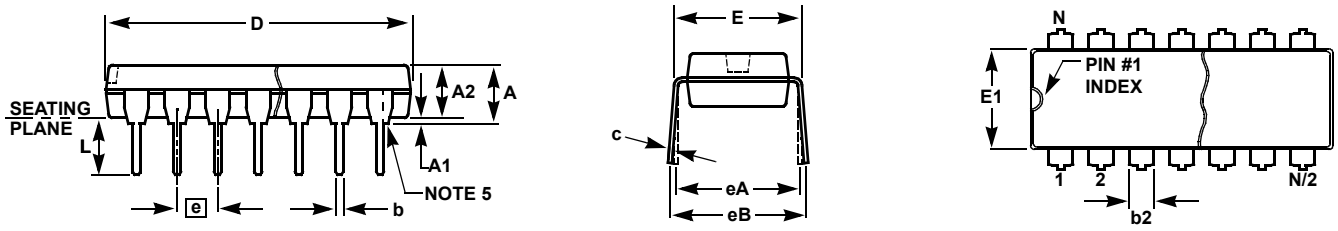
SYMBOL	SO-8	SO-14	SO16 (0.150")	SO16 (0.300") (SOL-16)	SO20 (SOL-20)	SO24 (SOL-24)	SO28 (SOL-28)	TOLERANCE	NOTES
A	0.068	0.068	0.068	0.104	0.104	0.104	0.104	MAX	-
A1	0.006	0.006	0.006	0.007	0.007	0.007	0.007	±0.003	-
A2	0.057	0.057	0.057	0.092	0.092	0.092	0.092	±0.002	-
b	0.017	0.017	0.017	0.017	0.017	0.017	0.017	±0.003	-
c	0.009	0.009	0.009	0.011	0.011	0.011	0.011	±0.001	-
D	0.193	0.341	0.390	0.406	0.504	0.606	0.704	±0.004	1, 3
E	0.236	0.236	0.236	0.406	0.406	0.406	0.406	±0.008	-
E1	0.154	0.154	0.154	0.295	0.295	0.295	0.295	±0.004	2, 3
e	0.050	0.050	0.050	0.050	0.050	0.050	0.050	Basic	-
L	0.025	0.025	0.025	0.030	0.030	0.030	0.030	±0.009	-
L1	0.041	0.041	0.041	0.056	0.056	0.056	0.056	Basic	-
h	0.013	0.013	0.013	0.020	0.020	0.020	0.020	Reference	-
N	8	14	16	16	20	24	28	Reference	-

Rev. L 2/01

NOTES:

1. Plastic or metal protrusions of 0.006" maximum per side are not included.
2. Plastic interlead protrusions of 0.010" maximum per side are not included.
3. Dimensions "D" and "E1" are measured at Datum Plane "H".
4. Dimensioning and tolerancing per ASME Y14.5M-1994

Plastic Dual-In-Line Packages (PDIP)



MDP0031
PLASTIC DUAL-IN-LINE PACKAGE

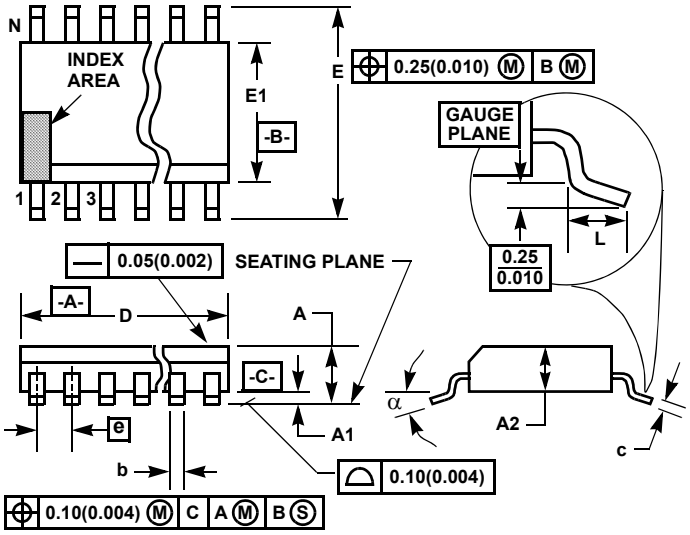
SYMBOL	PDIP8	PDIP14	PDIP16	PDIP18	PDIP20	TOLERANCE	NOTES
A	0.210	0.210	0.210	0.210	0.210	MAX	
A1	0.015	0.015	0.015	0.015	0.015	MIN	
A2	0.130	0.130	0.130	0.130	0.130	±0.005	
b	0.018	0.018	0.018	0.018	0.018	±0.002	
b2	0.060	0.060	0.060	0.060	0.060	+0.010/-0.015	
c	0.010	0.010	0.010	0.010	0.010	+0.004/-0.002	
D	0.375	0.750	0.750	0.890	1.020	±0.010	1
E	0.310	0.310	0.310	0.310	0.310	+0.015/-0.010	
E1	0.250	0.250	0.250	0.250	0.250	±0.005	2
e	0.100	0.100	0.100	0.100	0.100	Basic	
eA	0.300	0.300	0.300	0.300	0.300	Basic	
eB	0.345	0.345	0.345	0.345	0.345	±0.025	
L	0.125	0.125	0.125	0.125	0.125	±0.010	
N	8	14	16	18	20	Reference	

Rev. B 2/99

NOTES:

1. Plastic or metal protrusions of 0.010” maximum per side are not included.
2. Plastic interlead protrusions of 0.010” maximum per side are not included.
3. Dimensions E and eA are measured with the leads constrained perpendicular to the seating plane.
4. Dimension eB is measured with the lead tips unconstrained.
5. 8 and 16 lead packages have half end-leads as shown.

Thin Shrink Small Outline Plastic Packages (TSSOP)



NOTES:

1. These package dimensions are within allowable dimensions of JEDEC MO-153-AC, Issue E.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E1” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.15mm (0.006 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. Dimension “b” does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm (0.003 inch) total in excess of “b” dimension at maximum material condition. Minimum space between protrusion and adjacent lead is 0.07mm (0.0027 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact. (Angles in degrees)

M14.173

14 LEAD THIN SHRINK SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.047	-	1.20	-
A1	0.002	0.006	0.05	0.15	-
A2	0.031	0.041	0.80	1.05	-
b	0.0075	0.0118	0.19	0.30	9
c	0.0035	0.0079	0.09	0.20	-
D	0.195	0.199	4.95	5.05	3
E1	0.169	0.177	4.30	4.50	4
e	0.026 BSC		0.65 BSC		-
E	0.246	0.256	6.25	6.50	-
L	0.0177	0.0295	0.45	0.75	6
N	14		14		7
α	0°	8°	0°	8°	-

Rev. 2 4/06

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