

X5648/X5649

CPU Supervisor with 64Kbit SPI EEPROM

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
 - $<50\mu A$ max standby current, watchdog on
 - $<1\mu A$ max standby current, watchdog off
 - $<400\mu A$ max active current during read
- 64Kbits 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-lead SOIC, 8-lead PDIP

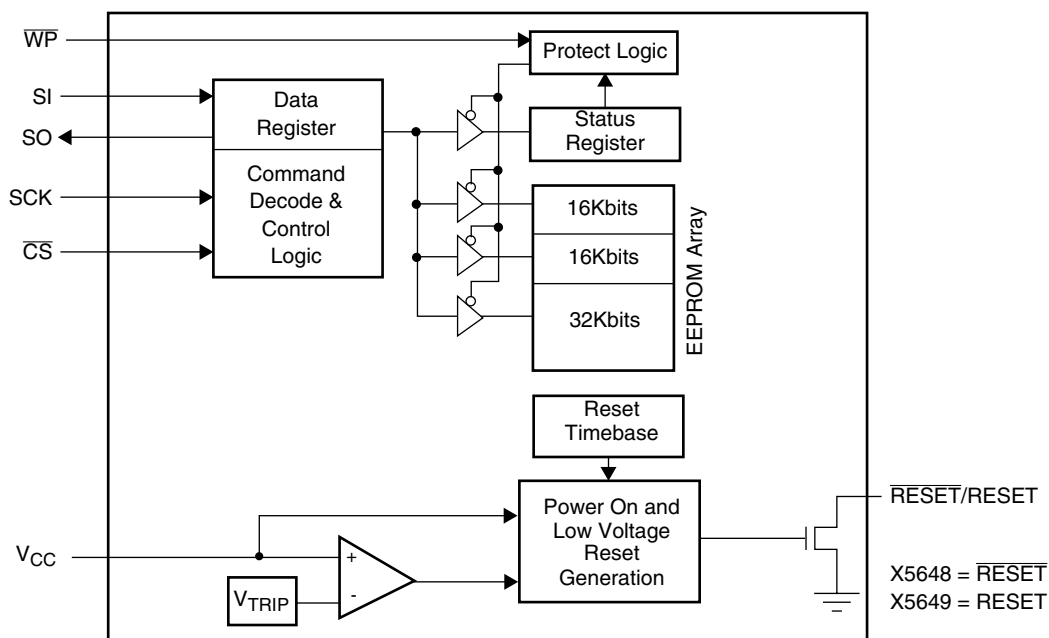
DESCRIPTION

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 $\overline{RESET}/RESET$ active for a period of time. This allows the power supply and oscillator to stabilize before the processor can execute code.

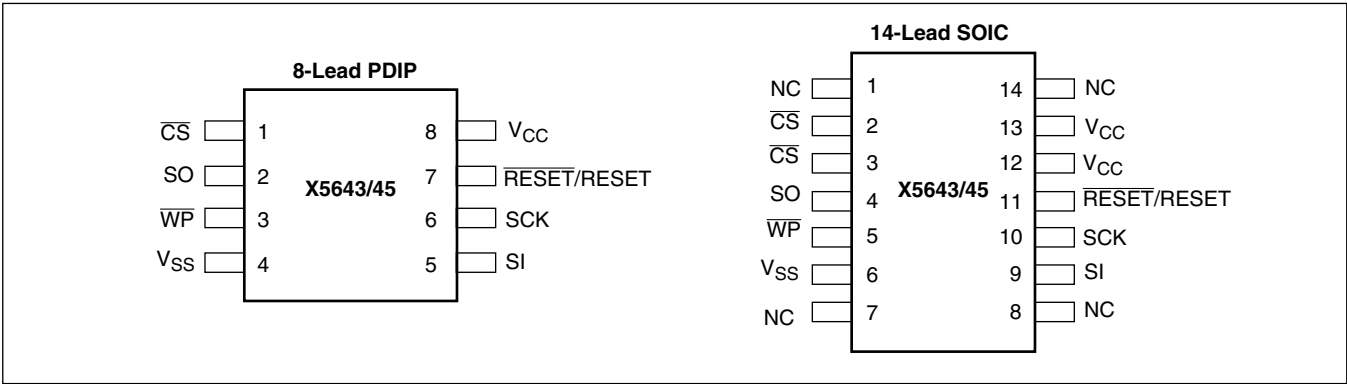
The device's low V_{CC} detection circuitry protects the user's system from low voltage conditions by holding $\overline{RESET}/RESET$ active when V_{CC} falls below a minimum V_{CC} trip point. $\overline{RESET}/RESET$ remains asserted until V_{CC} returns to proper operating level and stabilizes. Five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

BLOCK DIAGRAM



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PIN CONFIGURATION



PIN DESCRIPTION

Pin (PDIP)	Pin (SOIC)	Name	Function
1	2-3	\overline{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	4	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	9	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	10	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	5	\overline{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	6	V_{SS}	Ground
8	12, 13	V_{CC}	Supply Voltage
7	11	RESET/RESET	Reset Output. 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. 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. RESET/RESET goes active on power up at about 1V and remains active for 200ms after the power supply stabilizes.
	1, 7, 8, 14	NC	No internal connections

PRINCIPLES OF OPERATION

Power On Reset

Application of power to the X5648/X5649 activates a power on reset circuit. This circuit goes active at about 1V and pulls the $\overline{\text{RESET}}/\text{RESET}$ 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 $\overline{\text{RESET}}/\text{RESET}$, allowing the processor to begin executing code.

Low Voltage Monitoring

During operation, the X5648/X5649 monitors the V_{CC} level and asserts $\overline{\text{RESET}}/\text{RESET}$ if supply voltage falls below a preset minimum V_{TRIP} . The $\overline{\text{RESET}}/\text{RESET}$ signal prevents the microprocessor from operating in a power fail or brownout condition. The $\overline{\text{RESET}}/\text{RESET}$ 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

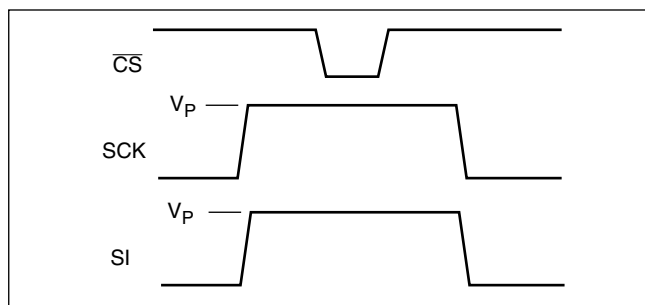
The X5648/X5649 has a standard V_{CC} threshold (V_{TRIP}) voltage. This value will not change over normal operating and storage conditions. However, in applications where the standard V_{TRIP} is not exactly right, or for higher precision in the V_{TRIP} value, the X5648/X5649 threshold may be adjusted.

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 $\overline{\text{CS}}$ pin and the $\overline{\text{WP}}$ pin HIGH. $\overline{\text{RESET}}/\text{RESET}$ and SO pins are left unconnected. Then apply the programming voltage V_P to both SCK and SI and pulse $\overline{\text{CS}}$ 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 $\overline{\text{CS}}$ pin, the $\overline{\text{WP}}$ pin, and the SCK pin HIGH. $\overline{\text{RESET}}/\text{RESET}$ and SO pins are left unconnected. Then apply the programming voltage V_P to the SI pin ONLY and pulse $\overline{\text{CS}}$ LOW then HIGH. Remove V_P and the sequence is complete.

Figure 2. Reset V_{TRIP} Voltage

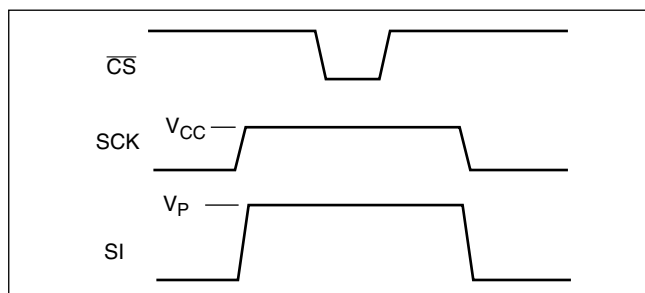
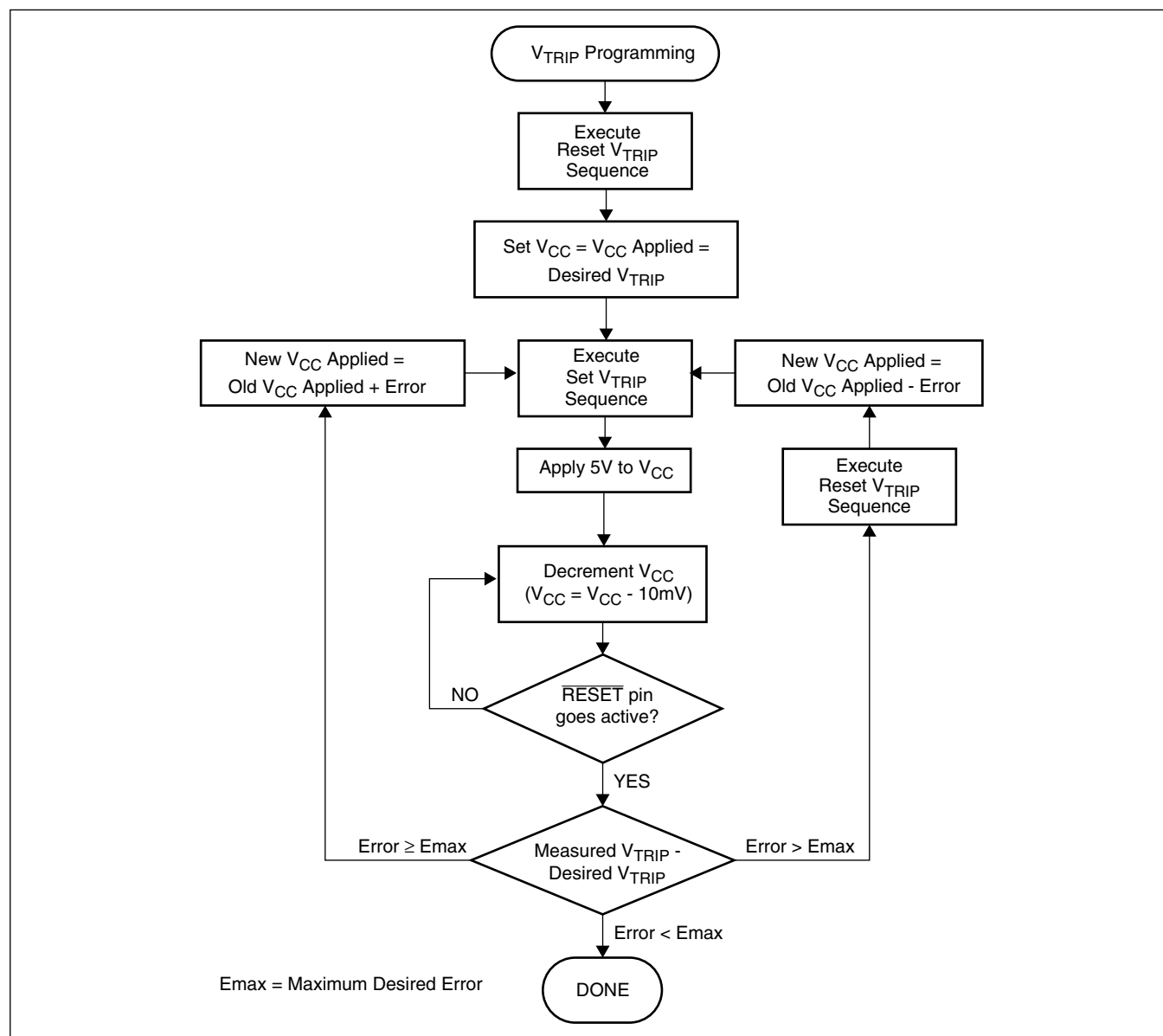


Figure 3. V_{TRIP} Programming Sequence Flow Chart

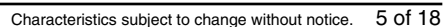


Table 2. Block Protect Matrix

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	X5648/X5649
0	0	None
0	1	\$1800–\$1FFF
1	0	\$1000–\$1FFF
1	1	\$0000–\$1FFF

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 WP pin to provide an in-circuit programmable ROM function (Table 2). WP is LOW and WPEN bit programmed HIGH disables all status register write operations.

In Circuit Programmable ROM Mode

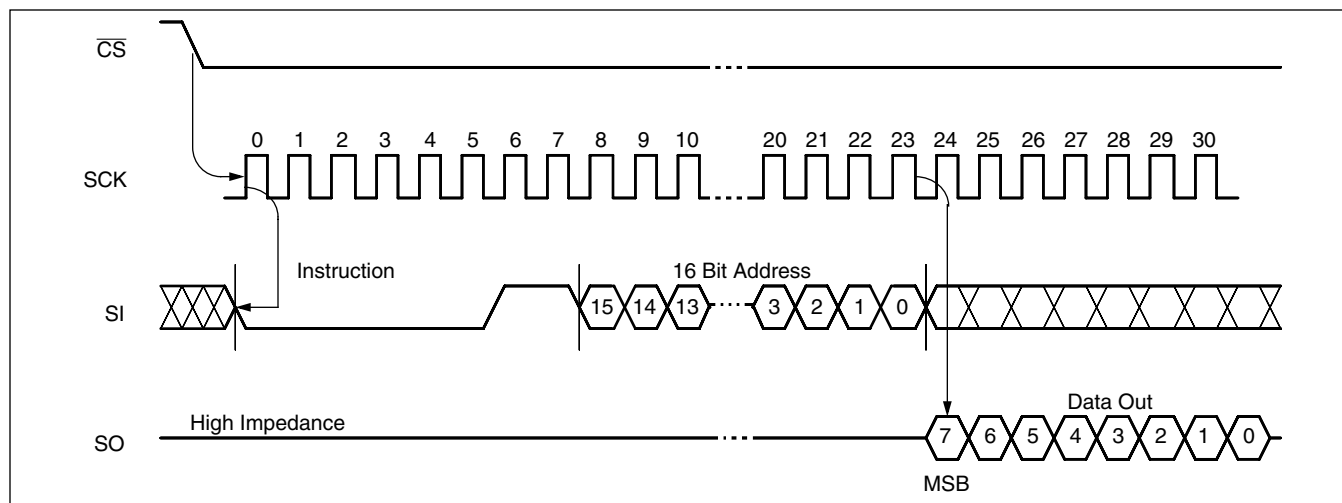
This mechanism protects the block lock and watchdog bits from inadvertent corruption.

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.

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- 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

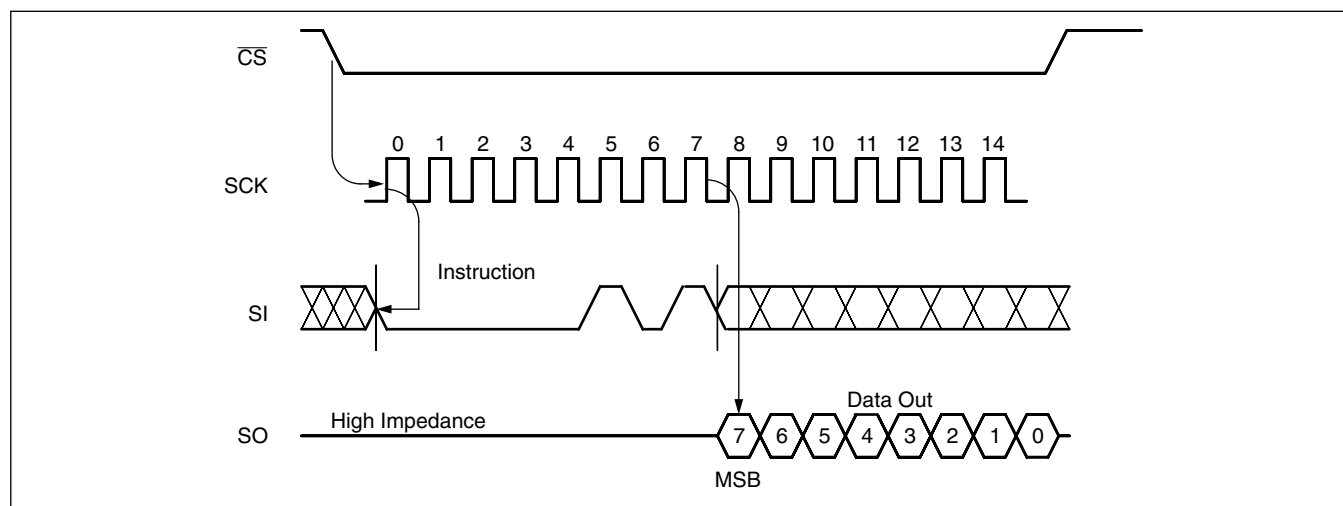
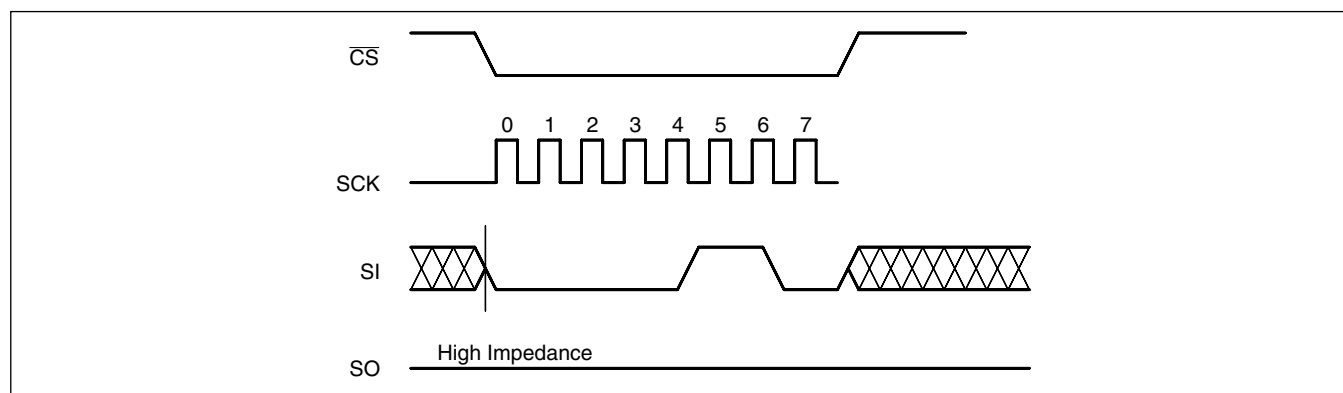


Figure 7. Write Enable Latch Sequence



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Figure 8. Write Sequence

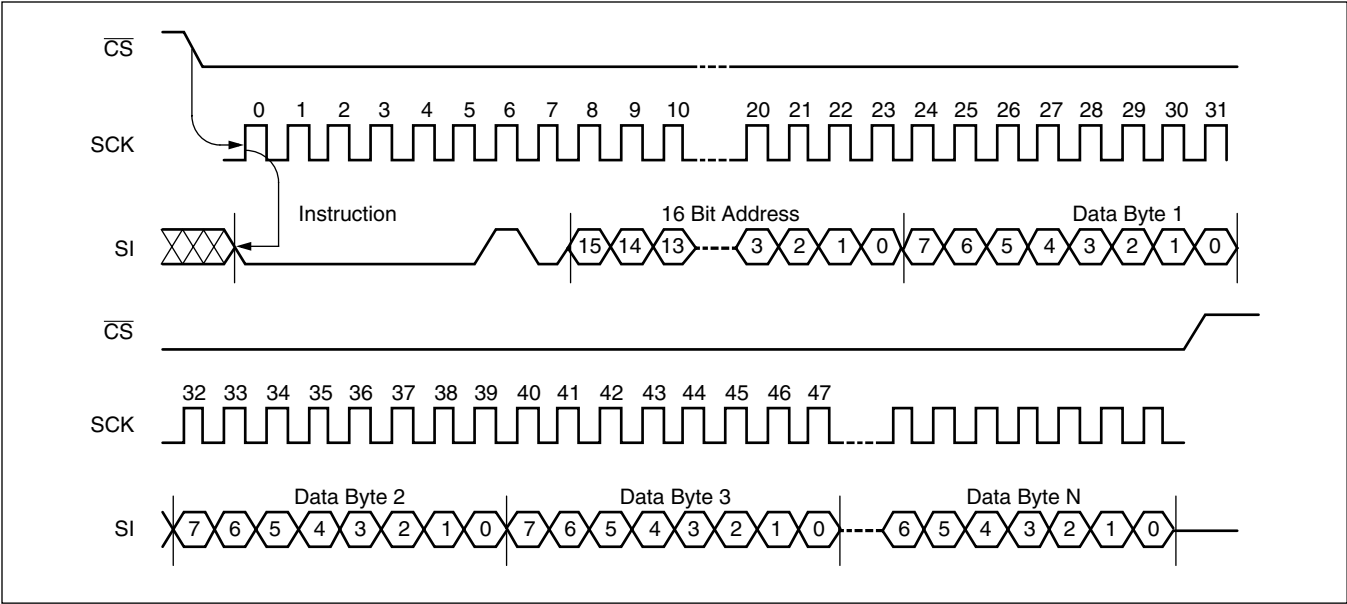
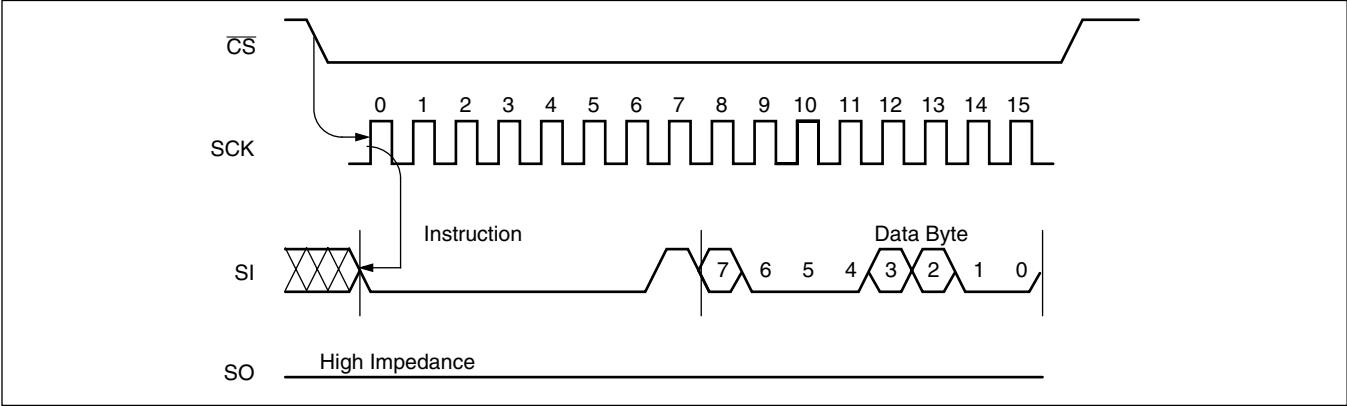


Figure 9. Status Register Write Sequence



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

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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
D.C. Output Current..... 5mA
Lead temperature (soldering, 10 seconds).....300°C

COMMENT

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.

RECOMMENDED OPERATING CONDITIONS

Temperature	Min.	Max.
Commercial	0°C	70°C
Industrial	-40°C	+85°C

Voltage Option	Supply Voltage
-2.7 or -2.7A	2.7V to 5.5V
BLank or -4.5A	4.5V-5.5V

D.C. OPERATING CHARACTERISTICS (Over the recommended operating conditions unless otherwise specified.)

Symbol	Parameter	Limits			Unit	Test Conditions
		Min.	Typ.	Max.		
I_{CC1}	V_{CC} write current (active)			5	mA	$SCK = V_{CC} \times 0.1/V_{CC} \times 0.9$ @ 2MHz, SO = Open
I_{CC2}	V_{CC} read current (active)			0.4	mA	$SCK = V_{CC} \times 0.1/V_{CC} \times 0.9$ @ 2MHz, SO = Open
I_{SB}	V_{CC} standby current WDT = OFF			1	μ A	$\overline{CS} = V_{CC}$, $V_{IN} = V_{SS}$ or V_{CC} , $V_{CC} = 5.5V$
I_{LI}	Input leakage current		0.1	10	μ A	$V_{IN} = V_{SS}$ to V_{CC}
I_{LO}	Output leakage current		0.1	10	μ A	$V_{OUT} = V_{SS}$ to V_{CC}
$V_{IL}^{(1)}$	Input LOW voltage	-0.5		$V_{CC} \times 0.3$	V	
$V_{IH}^{(1)}$	Input HIGH voltage	$V_{CC} \times 0.7$		$V_{CC} + 0.5$	V	
V_{OL1}	Output LOW voltage			0.4	V	$V_{CC} > 3.3V$, $I_{OL} = 2.1mA$
V_{OL2}	Output LOW voltage			0.4	V	$2V < V_{CC} \leq 3.3V$, $I_{OL} = 1mA$
V_{OL3}	Output LOW voltage			0.4	V	$V_{CC} \leq 2V$, $I_{OL} = 0.5mA$
V_{OH1}	Output HIGH voltage	$V_{CC} - 0.8$			V	$V_{CC} > 3.3V$, $I_{OH} = -1.0mA$
V_{OH2}	Output HIGH voltage	$V_{CC} - 0.4$			V	$2V < V_{CC} \leq 3.3V$, $I_{OH} = -0.4mA$
V_{OH3}	Output HIGH voltage	$V_{CC} - 0.2$			V	$V_{CC} \leq 2V$, $I_{OH} = -0.25mA$
V_{OLS}	Reset output LOW voltage			0.4	V	$I_{OL} = 1mA$

CAPACITANCE $T_A = +25^\circ C$, $f = 1MHz$, $V_{CC} = 5V$

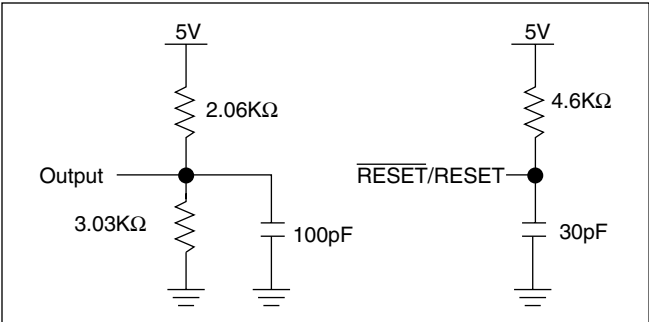
Symbol	Test	Max.	Unit	Conditions
$C_{OUT}^{(2)}$	Output capacitance (SO, \overline{RESET} /RESET)	8	pF	$V_{OUT} = 0V$
$C_{IN}^{(2)}$	Input capacitance (SCK, SI, \overline{CS} , \overline{WP})	6	pF	$V_{IN} = 0V$

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.

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EQUIVALENT A.C. LOAD CIRCUIT AT 5V V_{CC}



A.C. TEST CONDITIONS

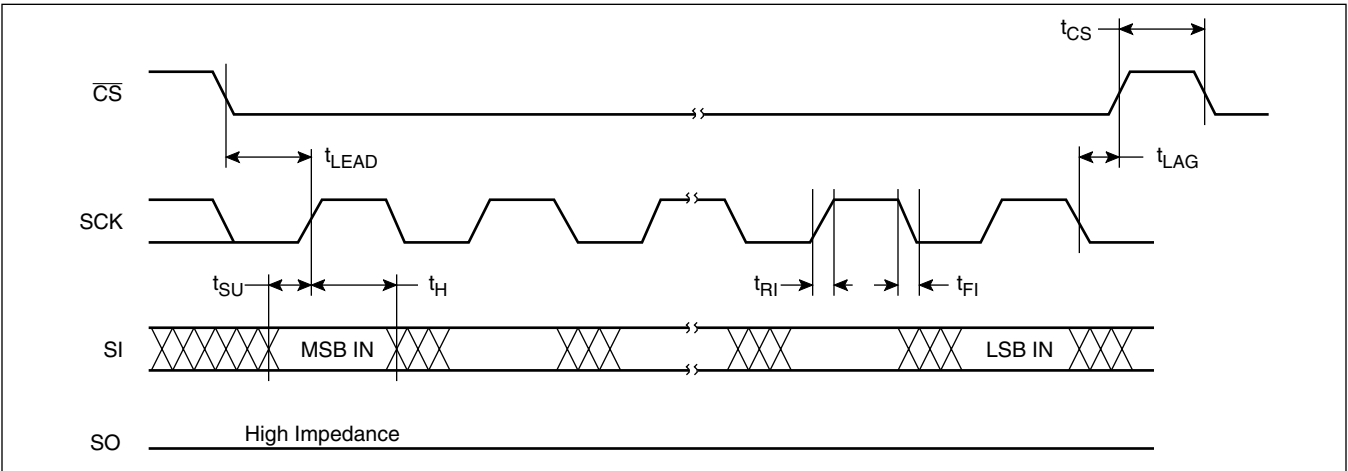
Input pulse levels	$V_{CC} \times 0.1$ to $V_{CC} \times 0.9$
Input rise and fall times	10ns
Input and output timing level	$V_{CC} \times 0.5$

A.C. CHARACTERISTICS (Over recommended operating conditions, unless otherwise specified)

Serial Input Timing

Symbol	Parameter	2.7–5.5V		Unit
		Min.	Max.	
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	250		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



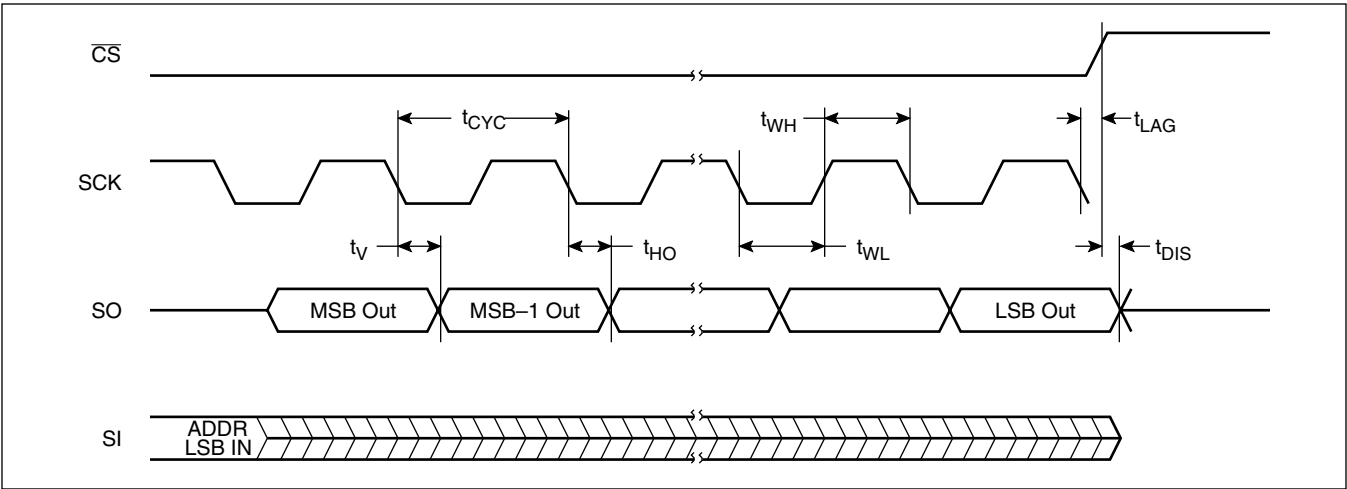
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Serial Output Timing

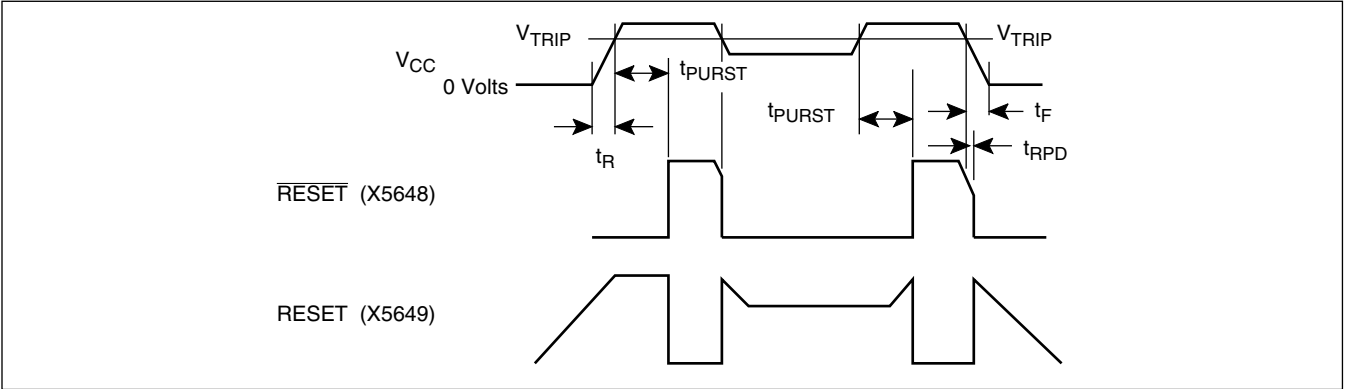
Symbol	Parameter	2.7–5.5V		Unit
		Min.	Max.	
f_{SCK}	Clock frequency	0	2	MHz
t_{DIS}	Output disable time		250	ns
t_V	Output valid from clock low		250	ns
t_{HO}	Output hold time	0		ns
$t_{RO}^{(3)}$	Output rise time		100	ns
$t_{FO}^{(3)}$	Output fall time		100	ns

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



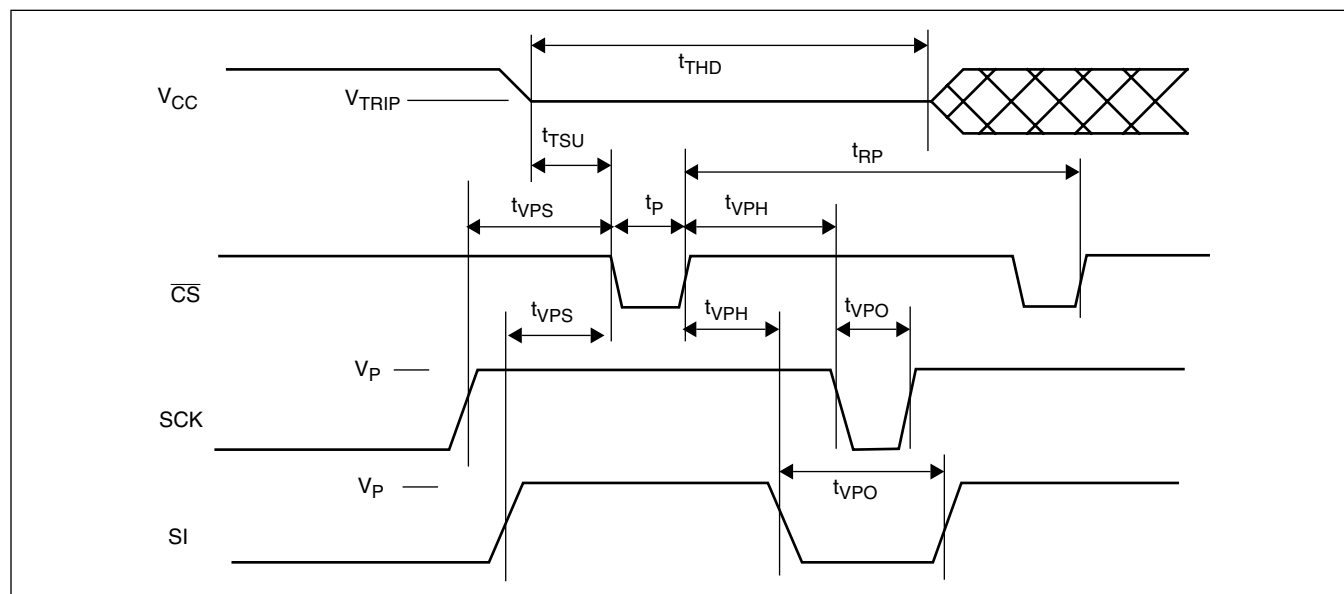
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RESET Output Timing

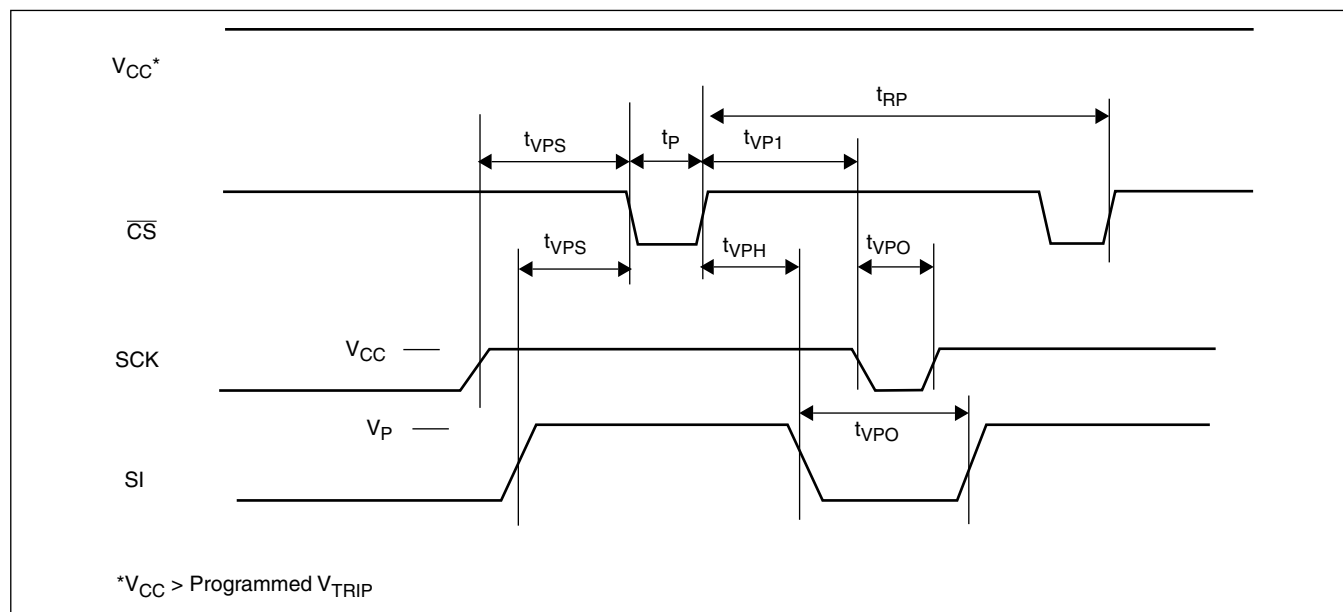
Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{TRIP}	Reset trip point voltage, X5648-4.5A, X5648-4.5A	4.5	4.63	4.75	V
	Reset trip point voltage, X5648, X5649	4.25	4.38	4.5	
	Reset trip point voltage, X5648-2.7A, X5649-2.7A	2.85	2.93	3.0	
	Reset trip point voltage, X5648-2.7, X5649-2.7	2.55	2.63	2.7	
V_{TH}	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			μ s
$t_R^{(5)}$	V_{CC} rise time	100			μ s
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



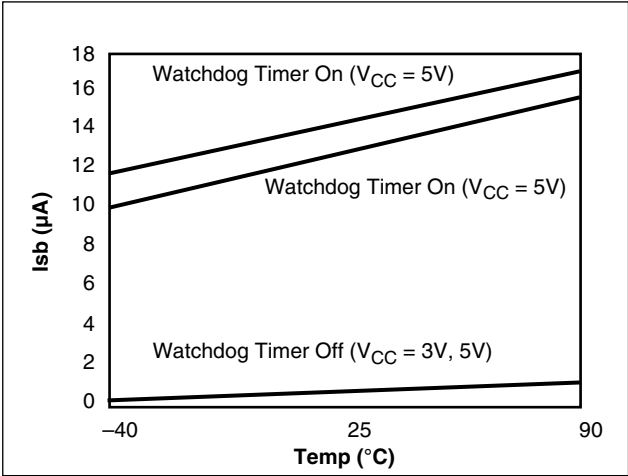
V_{TRIP} Programming Specifications V_{CC} = 1.7–5.5V; Temperature = 0°C to 70°C

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

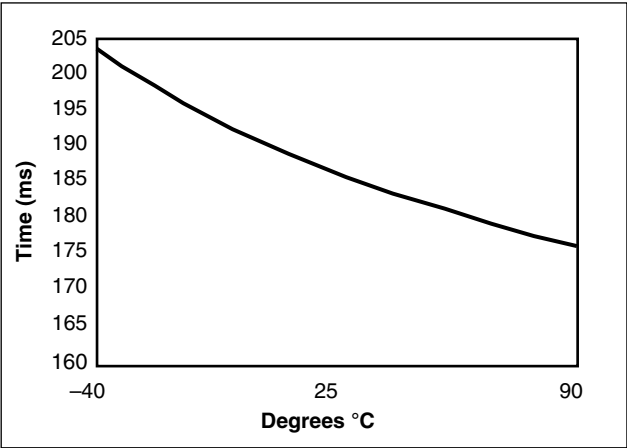
V_{TRIP} programming parameters are periodically sampled and are not 100% tested.

TYPICAL PERFORMANCE

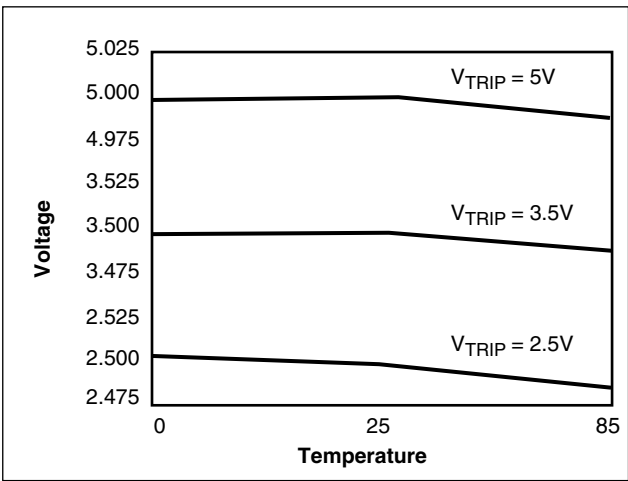
V_{CC} Supply Current vs. Temperature (I_{SB})



t_{PURST} vs. Temperature

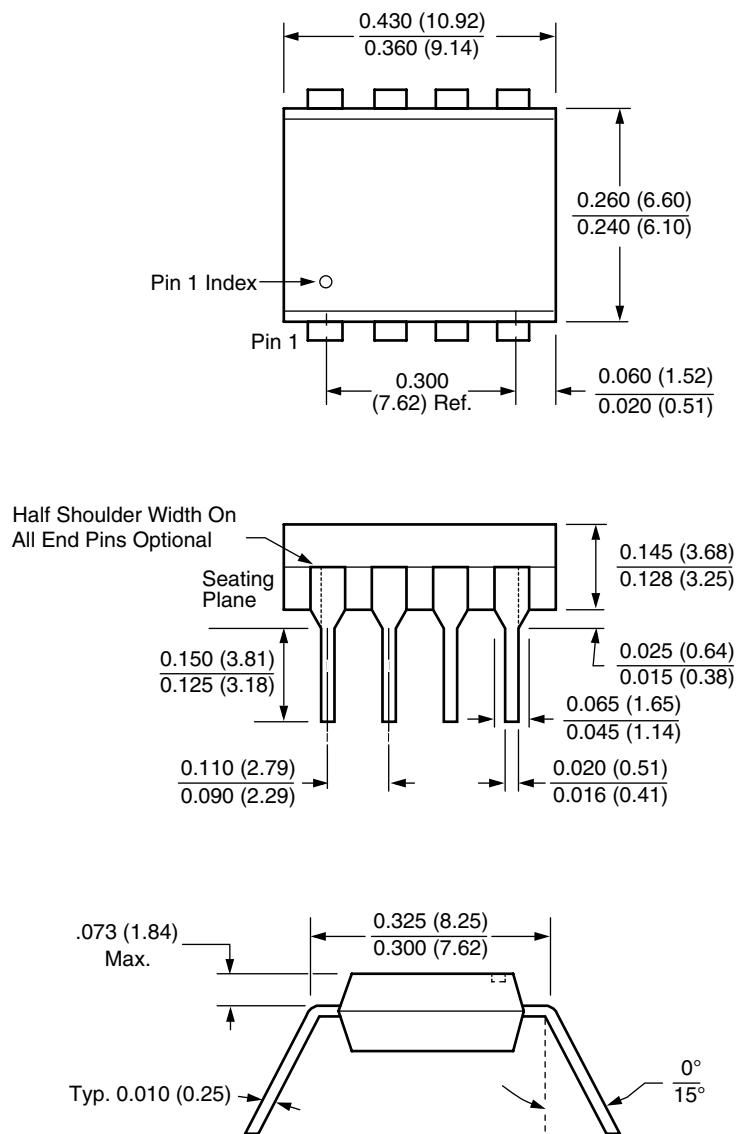


V_{TRIP} vs. Temperature (programmed at 25°C)



PACKAGING INFORMATION

8-Lead Plastic Dual In-Line Package Type P

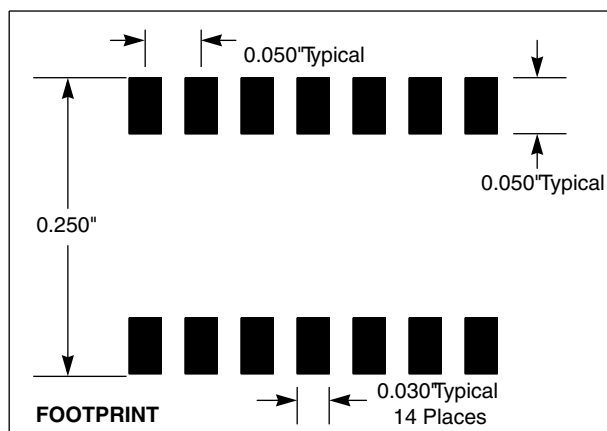
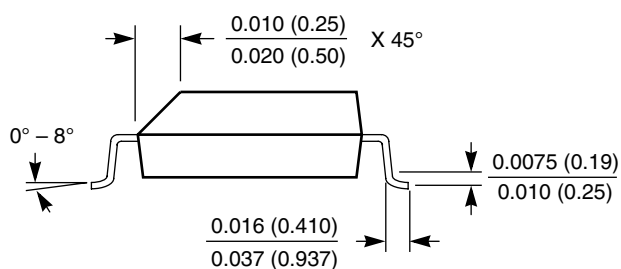
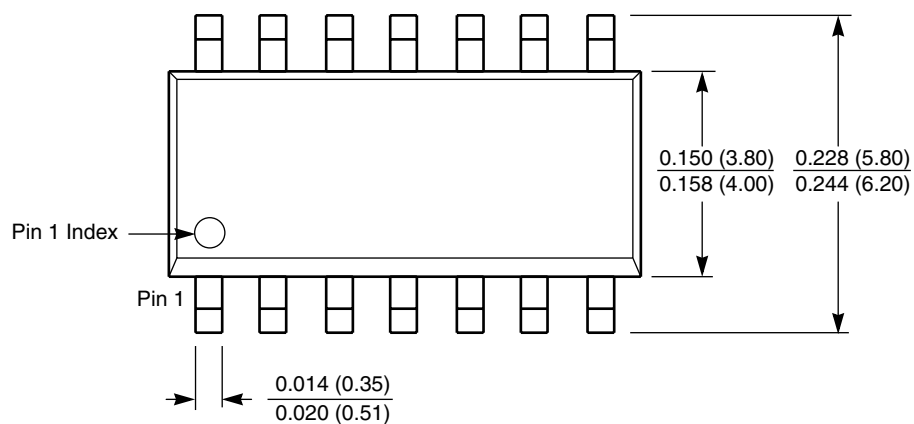


NOTE:

1. ALL DIMENSIONS IN INCHES (IN PARENTHESES IN MILLIMETERS)
2. PACKAGE DIMENSIONS EXCLUDE MOLDING FLASH

PACKAGING INFORMATION

14-Lead Plastic, SOIC, Package Code S14



NOTE: ALL DIMENSIONS IN INCHES (IN PARENTHESES IN MILLIMETERS)

X5648/X5649

Ordering Information

V _{CC} Range	V _{TRIP} Range	Package	Operating Temperature Range	Part Number RESET (Active LOW)	Part Number RESET (Active HIGH)
4.5-5.5V	4.5.4.75	8 pin PDIP	0–70°C	X5648P-4.5A	X5649P-4.5A
		14L SOIC	0–70°C	X5648S14-4.5A	X5649S14-4.5A
			-40–85°C	X5648S14I-4.5A	X5649S14I-4.5A
4.5-5.5V	4.25.4.5	8 pin PDIP	0–70°C	X5648P	X5649P
		14L SOIC	0–70°C	X5648S14	X5649S14
			-40–85°C	X5648S14I	X5649S14I
2.7-5.5V	2.85-3.0	14L SOIC	0–70°C	X5648S14-2.7A	X5649S14-2.7A
2.7-5.5V	2.55-2.7	14L SOIC	0–70°C	X5648S14-2.7	X5649S14-2.7

Part Mark Information

<div>X5648/49 W X</div>	Blank = 14-Lead SOIC P = 8 Pin DIP
	Blank = 5V ±10%, 0°C to +70°C, V _{TRIP} = 4.25-4.5 AL = 5V ±10%, 0°C to +70°C, V _{TRIP} = 4.5-4.75 I = 5V ±10%, -40°C to +85°C, V _{TRIP} = 4.25-4.5 AM = 5V ±10%, -40°C to +85°C, V _{TRIP} = 4.5-4.75 F = 2.7V to 5.5V, 0°C to +70°C, V _{TRIP} = 2.55-2.7 AN = 2.7V to 5.5V, 0°C to +70°C, V _{TRIP} = 2.85-3.0 G = 2.7V to 5.5V, -40°C to +85°C, V _{TRIP} = 2.55-2.7 AP = 2.7V to 5.5V, -40°C to +85°C, V _{TRIP} = 2.85-3.0

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In situations where semiconductor component failure may endanger life, system designers using this product should design the system with appropriate error detection and correction, redundancy and back-up features to prevent such an occurrence.

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- A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.