

## CPU Supervisor

### FEATURES

- 200ms power-on reset delay
- Low  $V_{CC}$  detection and reset assertion
  - Five standard reset threshold voltages
  - Adjust low  $V_{CC}$  reset threshold voltage using special programming sequence
  - Reset signal valid to  $V_{CC} = 1V$
- Selectable nonvolatile watchdog timer
  - 0.2, 0.6, 1.4 seconds
  - Off selection
  - Select settings through software
- Long battery life with low power consumption
  - <50 $\mu A$  max standby current, watchdog on
  - <1 $\mu A$  max standby current, watchdog off
- 2.7V to 5.5V operation
- SPI mode 0 interface
- Built-in inadvertent write protection
  - Power-up/power-down protection circuitry
  - Watchdog change latch
- High reliability
- Available packages
  - 8 Ld TSSOP
  - 8 Ld SOIC
  - 8 Ld PDIP
- Pb-free plus anneal available (RoHS compliant)

### DESCRIPTION

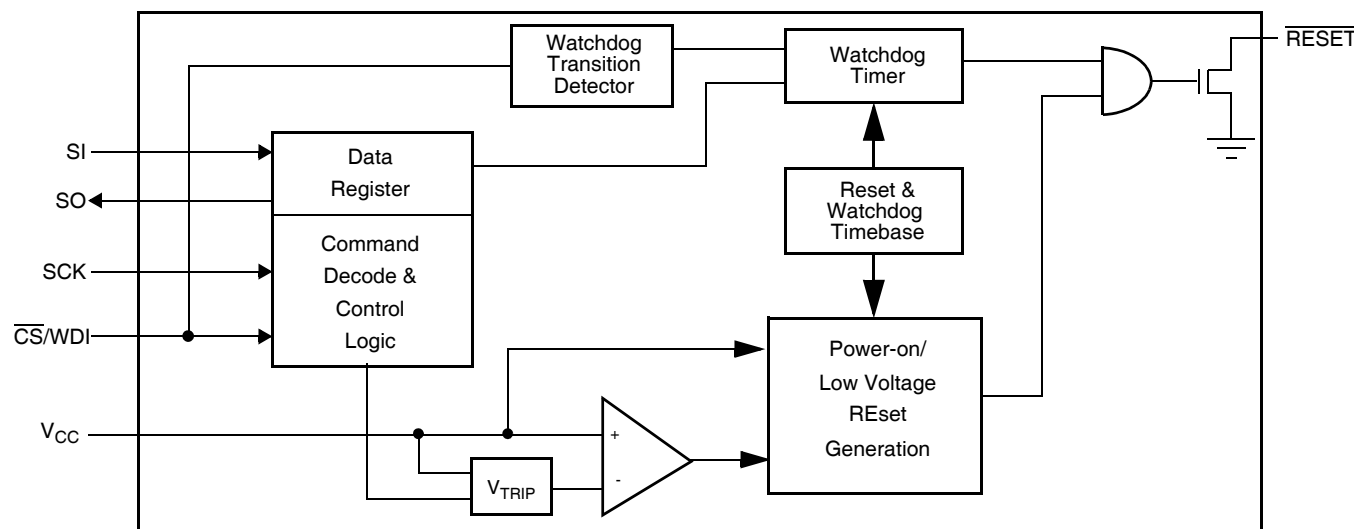
This device combines three popular functions, Power-on Reset, Watchdog Timer, and Supply Voltage Supervision in one package. This combination lowers system cost, reduces board space requirements, and increases reliability.

The watchdog timer provides an independent protection mechanism for microcontrollers. During a system failure, the device will respond with a  $\overline{RESET}$  signal after a selectable time out interval. The user selects the interval from three preset values. Once selected, the interval does not change, even after cycling the power.

The user's system is protected from low voltage conditions by the device's low  $V_{CC}$  detection circuitry. When  $V_{CC}$  falls below the minimum  $V_{CC}$  trip point, the system is reset.  $\overline{RESET}$  is asserted until  $V_{CC}$  returns to proper operating levels 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 for applications requiring higher precision.

The device utilizes Intersil's proprietary Direct Write™ cell for the watchdog timer control bits and the  $V_{TRIP}$  storage element, providing a minimum endurance of 100,000 write cycles and a minimum data retention of 100 years.

### BLOCK DIAGRAM



## Ordering Information

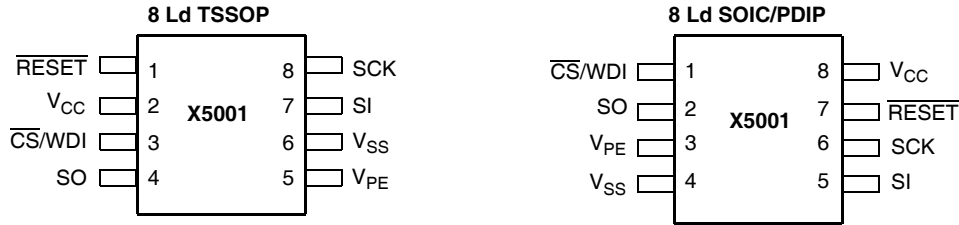
| PART NUMBER           | PART MARKING | V <sub>CC</sub> RANGE (V) | V <sub>TRIP</sub> RANGE | TEMP. RANGE (°C) | PACKAGE                       | PKG. DWG. # |
|-----------------------|--------------|---------------------------|-------------------------|------------------|-------------------------------|-------------|
| X5001P-2.7            | X5001P F     | 2.7 to 5.5                | 2.55 to 2.7             | 0 to 70          | 8 Ld PDIP                     | MDP0031     |
| X5001PZ-2.7 (Note)    | X5001P ZF    |                           |                         | 0 to 70          | 8 Ld PDIP (300 mil) (Pb-free) | MDP0031     |
| X5001PI-2.7           | X5001P G     |                           |                         | -40 to 85        | 8 Ld PDIP                     | MDP0031     |
| X5001PIZ-2.7 (Note)   | X5001P ZG    |                           |                         | -40 to 85        | 8 Ld PDIP (300 mil) (Pb-free) | MDP0031     |
| X5001S8-2.7           | X5001 F      |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8Z-2.7 (Note)   | X5001 ZF     |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |
| X5001S8I-2.7          | X5001 G      |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8IZ-2.7 (Note)  | X5001 ZG     |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |
| X5001V8-2.7           | 501 F        |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm)            | M8.173      |
| X5001V8Z-2.7 (Note)   | 5001 FZ      |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm) (Pb-free)  | M8.173      |
| X5001V8I-2.7          | 501 G        |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)            | M8.173      |
| X5001V8IZ-2.7 (Note)  | 5001 GZ      |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm) (Pb-free)  | M8.173      |
| X5001P-2.7A           | X5001P AN    |                           | 2.85 to 3.0             | 0 to 70          | 8 Ld PDIP                     | MDP0031     |
| X5001PZ-2.7A (Note)   | X5001P ZAN   |                           |                         | 0 to 70          | 8 Ld PDIP (300 mil) (Pb-free) | MDP0031     |
| X5001PI-2.7A          | X5001P AP    |                           |                         | -40 to 85        | 8 Ld PDIP                     | MDP0031     |
| X5001PIZ-2.7A (Note)  | X5001P ZAP   |                           |                         | -40 to 85        | 8 Ld PDIP (300 mil) (Pb-free) | MDP0031     |
| X5001S8-2.7A          | X5001 AN     |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8Z-2.7A (Note)  | X5001 ZAN    |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |
| X5001S8I-2.7A         | X5001 AP     |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8IZ-2.7A (Note) | X5001 ZAP    |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |
| X5001V8-2.7A          | 501 AN       |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm)            | M8.173      |
| X5001V8Z-2.7A (Note)  | 5001 ANZ     |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm) (Pb-free)  | M8.173      |
| X5001V8I-2.7A         | 501 AP       |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)            | M8.173      |
| X5001V8IZ-2.7A (Note) | 5001 APZ     |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm) (Pb-free)  | M8.173      |
| X5001PI               | X5001P I     | 4.5 to 5.5                | 4.25 to 4.5             | -40 to 85        | 8 Ld PDIP                     | MDP0031     |
| X5001PIZ (Note)       | X5001P ZI    |                           |                         | -40 to 85        | 8 Ld PDIP (300 mil) (Pb-free) | MDP0031     |
| X5001S8               | X5001        |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8Z (Note)       | X5001 Z      |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |
| X5001S8I              | X5001 I      |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil)           | MDP0027     |
| X5001S8IZ (Note)      | X5001 ZI     |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil) (Pb-free) | MDP0027     |

**Ordering Information** (Continued)

| PART NUMBER           | PART MARKING | V <sub>CC</sub> RANGE (V) | V <sub>TRIP</sub> RANGE | TEMP. RANGE (°C) | PACKAGE                          | PKG. DWG. # |
|-----------------------|--------------|---------------------------|-------------------------|------------------|----------------------------------|-------------|
| X5001V8               | 501          | 4.5 to 5.5                | 4.25 to 4.5             | 0 to 70          | 8 Ld TSSOP (4.4mm)               | M8.173      |
| X5001V8Z (Note)       | 5001 Z       |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm)<br>(Pb-free)  | M8.173      |
| X5001V8I              | 501 I        |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)               | M8.173      |
| X5001V8IZ (Note)      | 5001 IZ      |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)<br>(Pb-free)  | M8.173      |
| X5001PI-4.5A          | X5001P AM    | 4.5 to 5.5                | 4.5 to 4.75             | -40 to 85        | 8 Ld PDIP                        | MDP0031     |
| X5001PIZ-4.5A (Note)  | X5001P ZAM   |                           |                         | -40 to 85        | 8 Ld PDIP (300 mil)<br>(Pb-free) | MDP0031     |
| X5001S8-4.5A          | X5001 AL     |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil)              | MDP0027     |
| X5001S8Z-4.5A (Note)  | X5001 ZAL    |                           |                         | 0 to 70          | 8 Ld SOIC (150 mil)<br>(Pb-free) | MDP0027     |
| X5001S8I-4.5A         | X5001 AM     |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil)              | MDP0027     |
| X5001S8IZ-4.5A (Note) | X5001 ZAM    |                           |                         | -40 to 85        | 8 Ld SOIC (150 mil)<br>(Pb-free) | MDP0027     |
| X5001V8-4.5A          | 501 AL       |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm)               | M8.173      |
| X5001V8Z-4.5A (Note)  | 5001 ALZ     |                           |                         | 0 to 70          | 8 Ld TSSOP (4.4mm)<br>(Pb-free)  | M8.173      |
| X5001V8I-4.5A         | 501 AM       |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)               | M8.173      |
| X5001V8IZ-4.5A (Note) | 5001 AMZ     |                           |                         | -40 to 85        | 8 Ld TSSOP (4.4mm)<br>(Pb-free)  | M8.173      |

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.

## PIN CONFIGURATION



## PIN DESCRIPTION

| Pin<br>(SOIC/PDIP) | Pin<br>TSSOP | Name                       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|--------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                  | 1            | $\overline{\text{CS/WDI}}$ | <p><b>Chip Select Input.</b> <math>\overline{\text{CS}}</math> 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. 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 <math>\overline{\text{CS}}</math> is required.</p> <p><b>Watchdog Input.</b> A HIGH to LOW transition on the WDI pin restarts the Watchdog timer. The absence of a HIGH to LOW transition within the watchdog time out period results in <math>\overline{\text{RESET}}</math>/RESET going active.</p>                                                                       |
| 2                  | 2            | SO                         | <b>Serial Output.</b> 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                         | <b>Serial Input.</b> 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                        | <b>Serial Clock.</b> The Serial Clock controls the serial bus timing for data input and output. The rising edge of SCK latches in the opcode, address, or watchdog bits present on the SI pin. The falling edge of SCK changes the data output on the SO pin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 3                  | 6            | $V_{PE}$                   | <b><math>V_{TRIP}</math> Program Enable.</b> When $V_{PE}$ is LOW, the $V_{TRIP}$ point is fixed at the last valid programmed level. To readjust the $V_{TRIP}$ level, requires that the $V_{PE}$ pin be pulled to a high voltage (15-18V).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4                  | 7            | $V_{SS}$                   | <b>Ground</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 8                  | 14           | $V_{CC}$                   | <b>Supply Voltage</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 7                  | 13           | $\overline{\text{RESET}}$  | <p><b>Reset Output.</b> <math>\overline{\text{RESET}}</math> is an active LOW, open drain output which goes active whenever <math>V_{CC}</math> falls below the minimum <math>V_{CC}</math> sense level. It will remain active until <math>V_{CC}</math> rises above the minimum <math>V_{CC}</math> sense level for 200ms. <math>\overline{\text{RESET}}</math> goes active if the watchdog timer is enabled and <math>\overline{\text{CS/WDI}}</math> remains either HIGH or LOW longer than the selectable watchdog time out period. A falling edge of <math>\overline{\text{CS/WDI}}</math> will reset the watchdog timer. <math>\overline{\text{RESET}}</math> goes active on power-up at 1V and remains active for 200ms after the power supply stabilizes.</p> |
|                    | 3-5,10-12    | NC                         | No internal connections                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

## PRINCIPLES OF OPERATION

### Power-on Reset

Application of power to the X5001 activates a power-on reset circuit. This circuit goes active at 1V and pulls the  $\overline{\text{RESET}}$ /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  $\overline{\text{RESET}}$ , allowing the processor to begin executing code.

### Low Voltage Monitoring

During operation, the X5001 monitors the  $V_{CC}$  level and asserts  $\overline{\text{RESET}}$  if supply voltage falls below a pre-set minimum  $V_{TRIP}$ . The  $\overline{\text{RESET}}$  signal prevents the microprocessor from operating in a power fail or brownout condition. The  $\overline{\text{RESET}}$  signal remains active until the voltage drops below 1V. It also remains active until  $V_{CC}$  returns and exceeds  $V_{TRIP}$  for 200ms.

### Watchdog Timer

The watchdog timer circuit monitors the microprocessor activity by monitoring the WDI input. The microprocessor must toggle the  $\overline{\text{CS}}$ /WDI pin periodically to prevent a  $\overline{\text{RESET}}$  signal. The  $\overline{\text{CS}}$ /WDI pin must be toggled from HIGH to LOW prior to the expiration of the watchdog time out period. The state of two nonvolatile control bits in the watchdog register determine the watchdog timer period.

### Vcc Threshold Reset Procedure

The X5001 is shipped with 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 if higher precision is needed in the  $V_{TRIP}$  value, the X5001 threshold may be adjusted. The procedure is described in the following sections, and requires the application of a high voltage control signal.

### Setting the $V_{TRIP}$ Voltage

This procedure is used to set 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 will directly make the change. If the new setting is to be 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 voltage to the  $V_{CC}$  pin and tie the  $W_{PE}$  pin to the programming voltage  $V_P$ . Then a  $V_{TRIP}$  programming command sequence is sent to the device over the SPI interface. This  $V_{TRIP}$  programming sequence consists of pulling  $\overline{\text{CS}}$  LOW, then clocking in data 03h, 00h and 01h. This is followed by bringing  $\overline{\text{CS}}$  HIGH then LOW and clocking in data 02h, 00h, and 01h (in order) and bringing  $\overline{\text{CS}}$  HIGH. This initiates the  $V_{TRIP}$  programming sequence.  $V_P$  is brought LOW to end the operation.

### Resetting the $V_{TRIP}$ Voltage

This procedure is used to set the  $V_{TRIP}$  to a “native” voltage level. For example, if the current  $V_{TRIP}$  is 4.4V and the new  $V_{TRIP}$  must be 4.0V, then the  $V_{TRIP}$  must be reset. When  $V_{TRIP}$  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 greater than 3V to the  $V_{CC}$  pin and tie the  $W_{PE}$  pin to the programming voltage  $V_P$ . Then a  $V_{TRIP}$  command sequence is sent to the device over the SPI interface. This  $V_{TRIP}$  programming sequence consists of pulling  $\overline{\text{CS}}$  LOW, then clocking in data 03h, 00h and 01h. This is followed by bringing  $\overline{\text{CS}}$  HIGH then LOW and clocking in data 02h, 00h, and 03h (in order) and bringing  $\overline{\text{CS}}$  HIGH. This initiates the  $V_{TRIP}$  programming sequence.  $V_P$  is brought LOW to end the operation.

Figure 1. Sample  $V_{TRIP}$  Reset Circuit

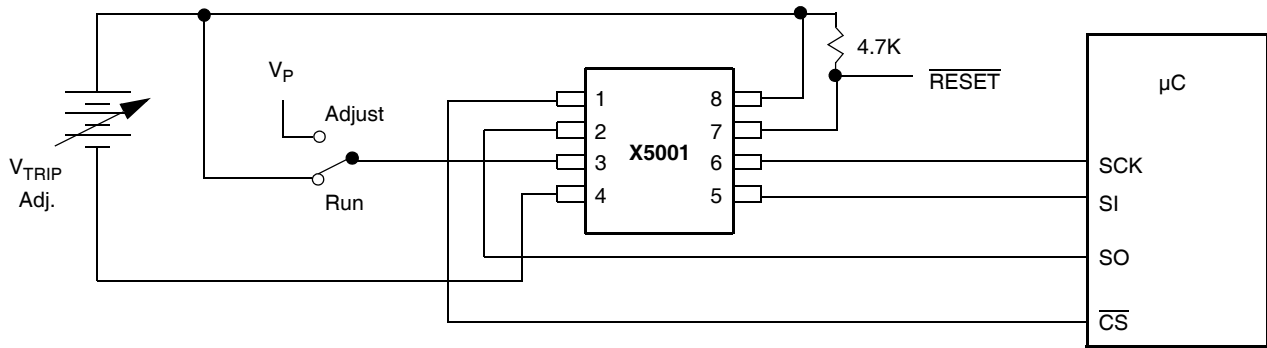


Figure 2. Set  $V_{TRIP}$  Level Sequence ( $V_{CC} = \text{desired } V_{TRIP} \text{ value}$ )

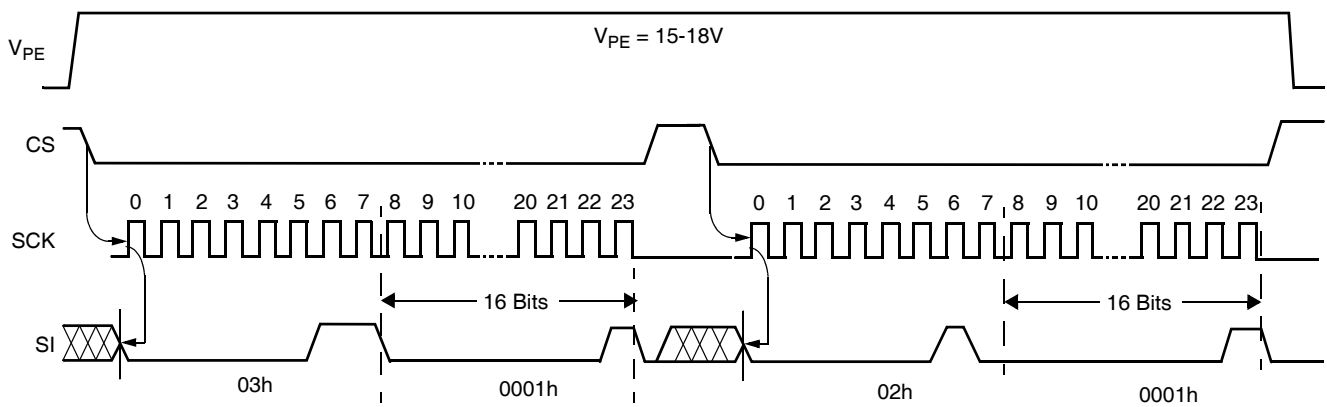


Figure 3. Reset  $V_{TRIP}$  Level Sequence ( $V_{CC} > 3V$ )

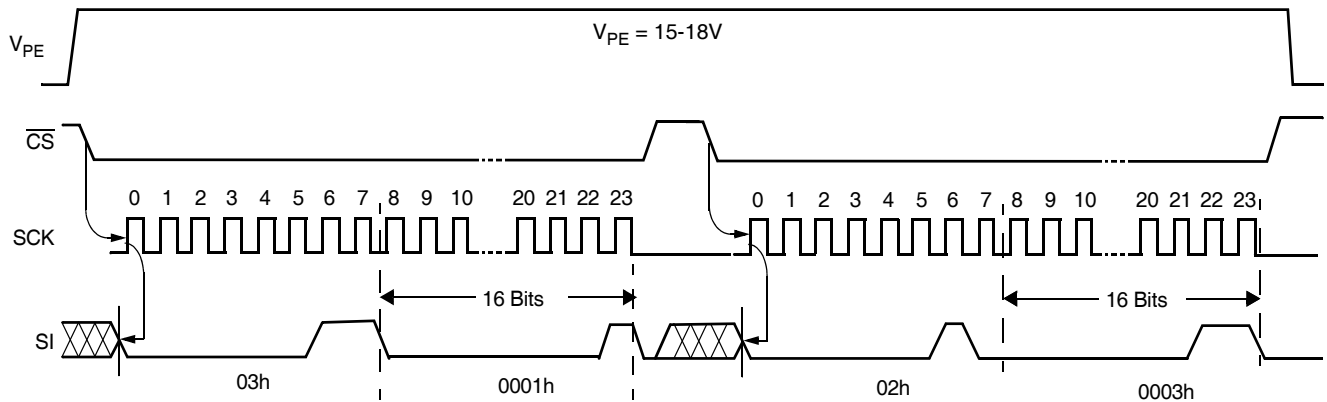
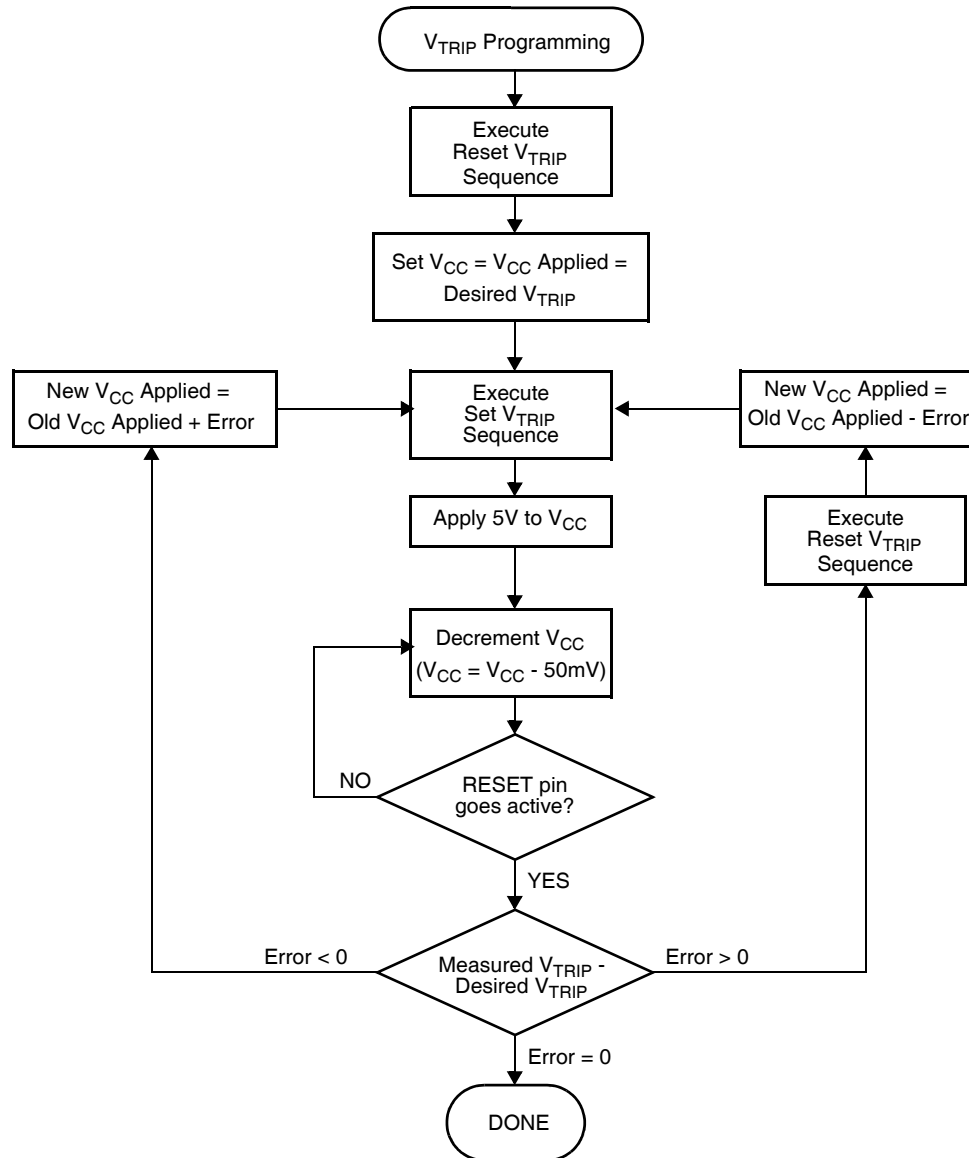


Figure 4.  $V_{TRIP}$  Programming Sequence

## SPI INTERFACE

The device is designed to interface directly with the synchronous Serial Peripheral Interface (SPI) of many popular microcontroller families.

The device monitors the  $\overline{CS}/WDI$  line and asserts  $\overline{RESET}$  output if there is no activity within user selectable timeout period. The device also monitors the  $V_{CC}$  supply and asserts the  $\overline{RESET}$  if  $V_{CC}$  falls below a preset minimum ( $V_{TRIP}$ ). The device contains an 8-bit watchdog timer register to control the watchdog time out period. The current settings are accessed via the SI and SO pins.

All instructions (Table 1) 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.

**Watchdog Timer Register**

| 7 | 6 | 5 | 4               | 3               | 2 | 1 | 0 |
|---|---|---|-----------------|-----------------|---|---|---|
| 0 | 0 | 0 | WD <sub>1</sub> | WD <sub>0</sub> | 0 | 0 | 0 |

**Watchdog Timer Control Bits**

The watchdog timer control bits, WD<sub>0</sub> and WD<sub>1</sub>, select the watchdog time out period. These nonvolatile bits are programmed with the set watchdog timer (SWDT) instruction.

| Watchdog Control Bits |     | Watchdog Time Out<br>(Typical) |
|-----------------------|-----|--------------------------------|
| WD1                   | WD0 |                                |
| 0                     | 0   | 1.4 seconds                    |
| 0                     | 1   | 600 milliseconds               |
| 1                     | 0   | 200 milliseconds               |
| 1                     | 1   | disabled                       |

**Write Watchdog Register Operation**

Changing the watchdog timer register is a two step process. First, the change must be enabled by setting the watchdog change latch (see below). This instruction is followed by the set watchdog timer (SWDT) instruction, which includes the data to be written (Figure 5). Data bits 3 and 4 contain the watchdog settings and data bits 0, 1, 2, 5, 6 and 7 must be "0".

**Watchdog Change Latch**

The watchdog change latch must be SET before a Write watchdog timer operation is initiated. The Enable Watchdog Change (EWDC) instruction will set the latch and the Disable Watchdog Change (DWDC) instruction will reset the latch (Figure 6). This latch is automatically reset upon a power-up condition and after the completion of a valid nonvolatile write cycle.

**Read Watchdog Timer Register Operation**

If there is not a nonvolatile write in progress, the read watchdog timer instruction returns the setting of the watchdog timer control bits. The other bits are reserved and will return '0' when read. See Figure 3.

If a nonvolatile write is in progress, the read watchdog timer register Instruction returns a HIGH on SO. When the nonvolatile write cycle is completed, a separate read watchdog timer instruction should be used to determine the current status of the watchdog control bits.

**RESET Operation**

The RESET (X5001) output is designed to go LOW whenever V<sub>CC</sub> has dropped below the minimum trip point and/or the watchdog timer has reached its programmable time out limit.

The RESET output is an open drain output and requires a pull-up resistor.

**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 CS is required to enter an active state and receive an instruction.
- SO pin is high impedance.
- The watchdog change latch is reset.
- The RESET signal is active for t<sub>PURST</sub>.

**Data Protection**

The following circuitry has been included to prevent inadvertent writes:

- A EWDC instruction must be issued to enable a change to the watchdog timeout setting.
- CS must come HIGH at the proper clock count in order to implement the requested changes to the watchdog timeout setting.

**Table 1. Instruction Set Definition**

| Instruction Format | Instruction Name and Operation                                                                                                                                                          |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0000 0110          | <b>EWDC: Enable Watchdog Change Operation</b>                                                                                                                                           |
| 0000 0100          | <b>DWDC: Disable Watchdog Change Operation</b>                                                                                                                                          |
| 0000 0001          | <b>SWDT: Set Watchdog Timer control bits:</b><br>Instruction followed by contents of register: 000(WD <sub>1</sub> ) (WD <sub>0</sub> )000<br>See Watchdog Timer Settings and Figure 7. |
| 0000 0101          | <b>RWDT: Read Watchdog Timer Control Bits</b>                                                                                                                                           |

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

Figure 5. Read Watchdog Timer Setting

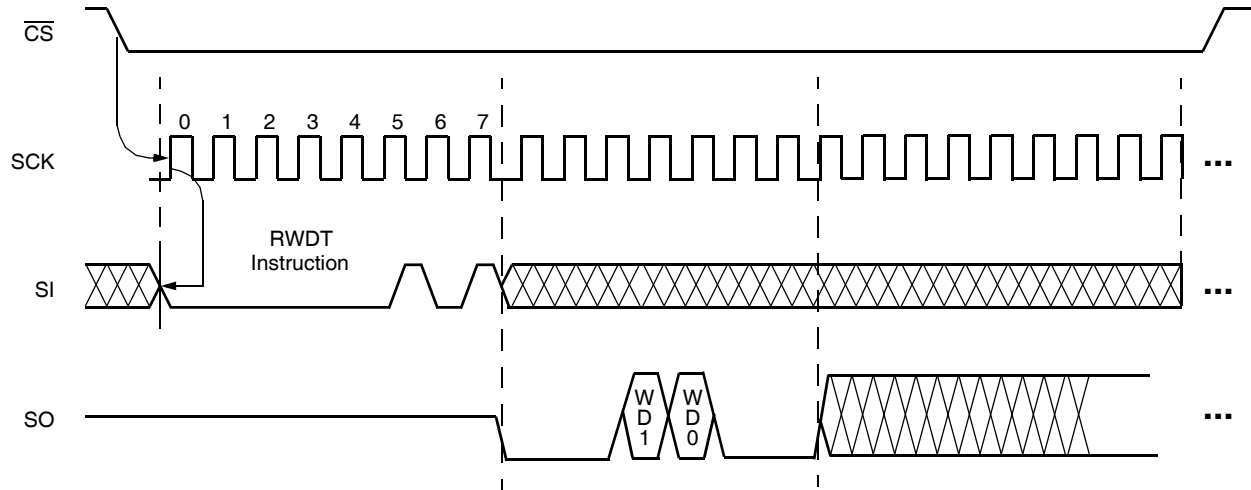


Figure 6. Enable Watchdog Change/Disable Watchdog Change Sequence

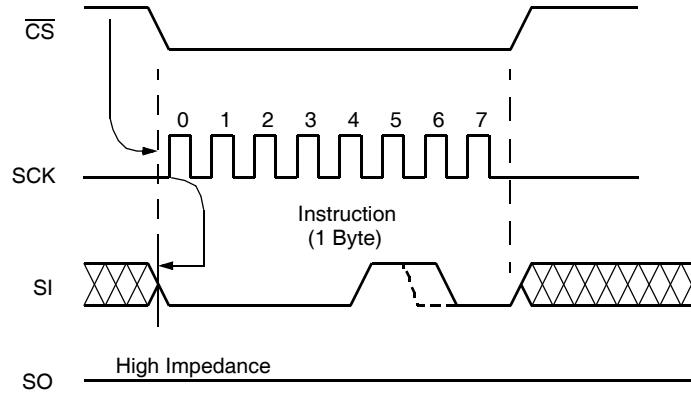
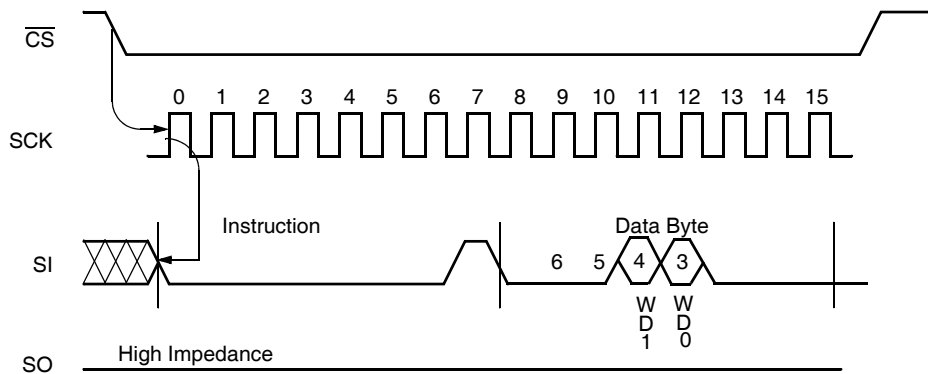
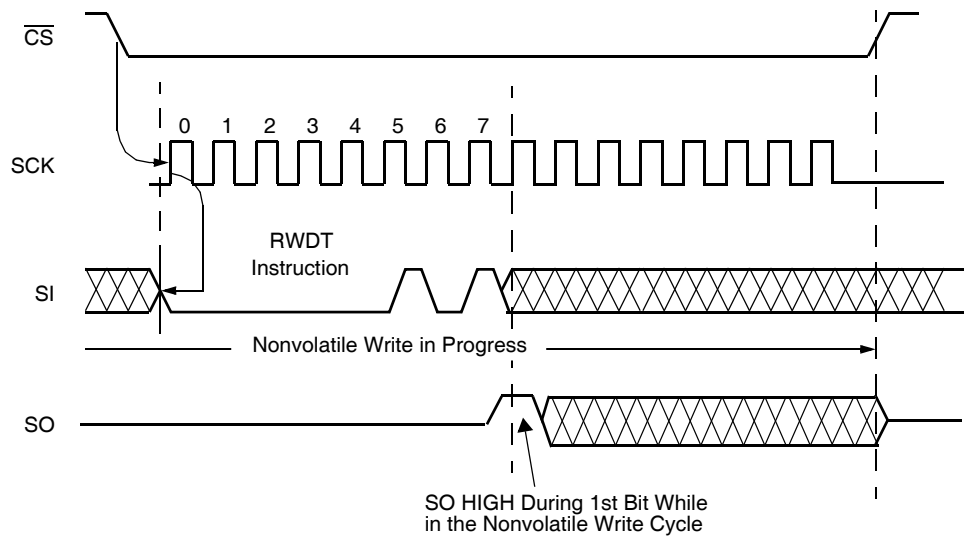


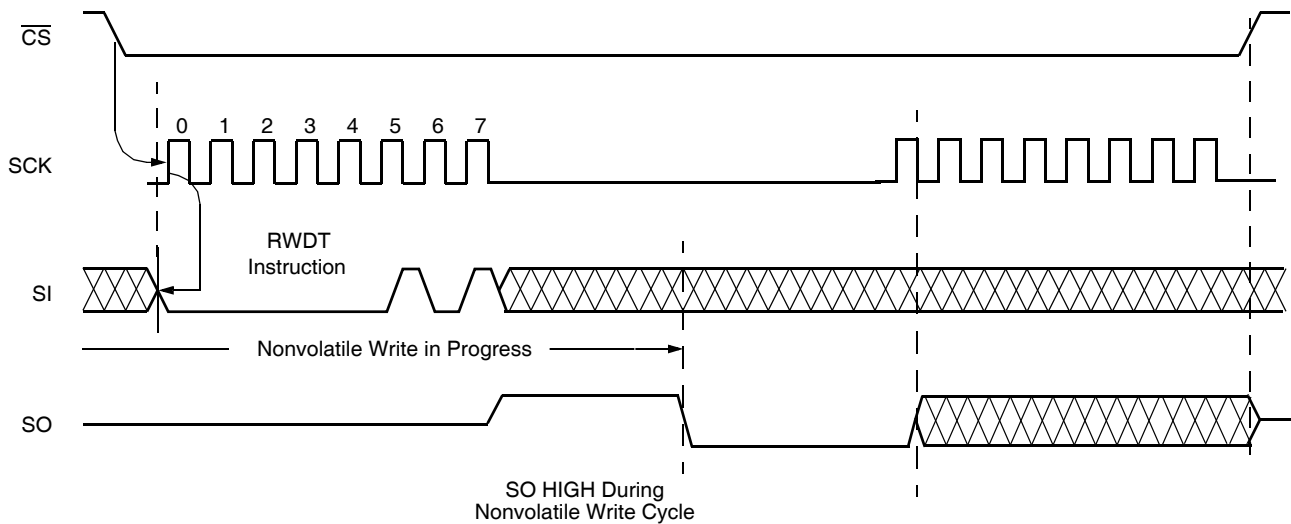
Figure 7. Write Watchdog Timer Sequence



**Figure 8. Read Nonvolatile Status (Option 1)** (Used to determine end of Watchdog Timer store operation)



**Figure 9. Read Nonvolatile Status (Option 2)** (Used to determine end of Watchdog Timer store operation)



**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, 10s) ..... 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 datasheet) 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 |

| Voltage Option | Supply Voltage Limits |
|----------------|-----------------------|
| -1.8           | 1.8V to 3.6V          |
| -2.7 or -2.7A  | 2.7V to 5.5V          |
| -4.5 or -4.5A  | 4.5V to 5.5V          |

Note: PT= Package, Temperature

**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      | $SCK = V_{CC} \times 0.1/V_{CC} \times 0.9$ @ 5MHz, $SO = \text{Open}$     |
| $I_{CC2}$      | $V_{CC}$ read current (Active)   |                     |     | 0.4                 | mA      | $SCK = V_{CC} \times 0.1/V_{CC} \times 0.9$ @ 5MHz, $SO = \text{Open}$     |
| $I_{SB1}$      | $V_{CC}$ standby current WDT=OFF |                     |     | 1                   | $\mu A$ | $\overline{CS} = V_{CC}$ , $V_{IN} = V_{SS}$ or $V_{CC}$ , $V_{CC} = 5.5V$ |
| $I_{SB2}$      | $V_{CC}$ standby current WDT=ON  |                     |     | 50                  | $\mu A$ | $\overline{CS} = V_{CC}$ , $V_{IN} = V_{SS}$ or $V_{CC}$ , $V_{CC} = 5.5V$ |
| $I_{SB3}$      | $V_{CC}$ standby current WDT=ON  |                     |     | 20                  | $\mu A$ | $CS = V_{CC}$ , $V_{IN} = V_{SS}$ or $V_{CC}$ , $V_{CC} = 3.6V$            |
| $I_{LI}$       | Input leakage current            |                     | 0.1 | 10                  | $\mu A$ | $V_{IN} = V_{SS}$ to $V_{CC}$                                              |
| $I_{LO}$       | Output leakage current           |                     | 0.1 | 10                  | $\mu A$ | $V_{OUT} = V_{SS}$ 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       | $2V < V_{CC} < 3.3V$ , $I_{OL} = 1mA$                                      |
| $V_{OL3}$      | 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       | $V_{CC} \leq 2V$ , $I_{OH} = -0.25mA$                                      |
| $V_{OLRS}$     | Reset output LOW voltage         |                     |     | 0.4                 | V       | $I_{OL} = 1mA$                                                             |

## POWER-UP TIMING

| Symbol          | Parameter                   | Min. | Max. | Unit |
|-----------------|-----------------------------|------|------|------|
| $t_{PUR}^{(2)}$ | Power-up to read operation  |      | 1    | ms   |
| $t_{PUW}^{(2)}$ | Power-up to write operation |      | 5    | ms   |

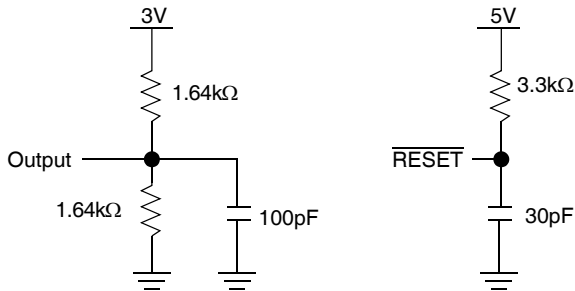
CAPACITANCE ( $T_A = +25^\circ\text{C}$ ,  $f = 1\text{MHz}$ ,  $V_{CC} = 5\text{V}$ )

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

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



## 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)

## Data Input Timing

| Symbol         | Parameter                            | 1.8V-3.6V |      | 2.7V-5.5V |      | Unit          |
|----------------|--------------------------------------|-----------|------|-----------|------|---------------|
|                |                                      | Min.      | Max. | Min.      | Max. |               |
| $f_{SCK}$      | Clock frequency                      | 0         | 1    | 0         | 2    | MHz           |
| $t_{CYC}$      | Cycle time                           | 1000      |      | 500       |      | ns            |
| $t_{LEAD}$     | $\overline{\text{CS}}$ lead time     | 400       |      | 200       |      | ns            |
| $t_{LAG}$      | $\overline{\text{CS}}$ lag time      | 400       |      | 200       |      | ns            |
| $t_{WH}$       | Clock HIGH time                      | 400       |      | 200       |      | ns            |
| $t_{WL}$       | Clock LOW time                       | 400       |      | 200       |      | ns            |
| $t_{SU}$       | Data setup time                      | 100       |      | 50        |      | ns            |
| $t_H$          | Data hold time                       | 100       |      | 50        |      | ns            |
| $t_{RI}^{(3)}$ | Input rise time                      |           | 2    |           | 2    | $\mu\text{s}$ |
| $t_{FI}^{(3)}$ | Input fall time                      |           | 2    |           | 2    | $\mu\text{s}$ |
| $t_{CS}$       | $\overline{\text{CS}}$ deselect time | 250       |      | 150       |      | ns            |
| $t_{WC}^{(4)}$ | Write cycle time                     |           | 10   |           | 10   | ms            |

## Data Output Timing

| Symbol         | Parameter                   | 1.8V-3.6V |      | 2.7V-5.5V |      | Unit |
|----------------|-----------------------------|-----------|------|-----------|------|------|
|                |                             | Min.      | Max. | Min.      | Max. |      |
| $f_{SCK}$      | Clock frequency             | 0         | 1    | 0         | 2    | MHz  |
| $t_{DIS}$      | Output disable time         |           | 400  |           | 200  | ns   |
| $t_V$          | Output valid from clock low |           | 400  |           | 200  | ns   |
| $t_{HO}$       | Output hold time            | 0         |      | 0         |      | ns   |
| $t_{RO}^{(3)}$ | Output rise time            |           | 300  |           | 150  | ns   |
| $t_{FO}^{(3)}$ | Output fall time            |           | 300  |           | 150  | 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.

Figure 10. Data Output Timing

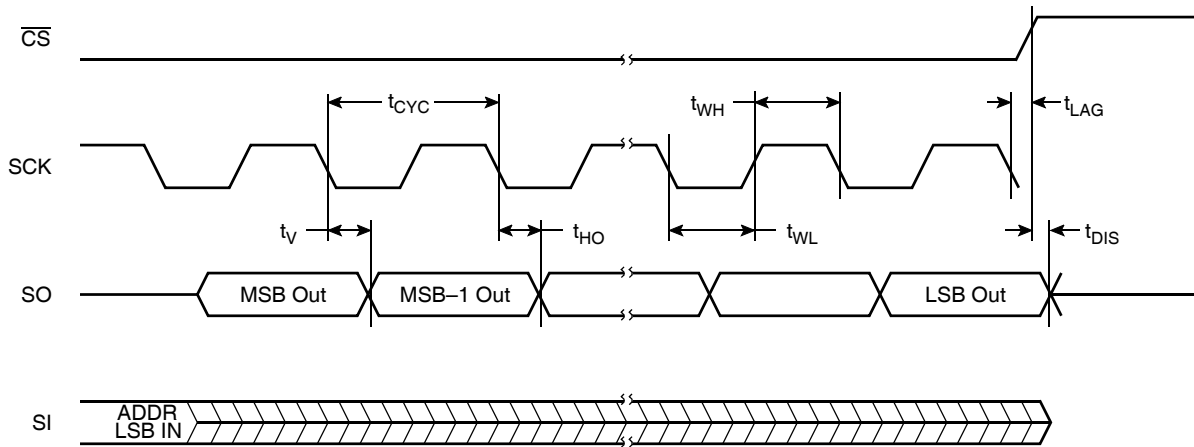
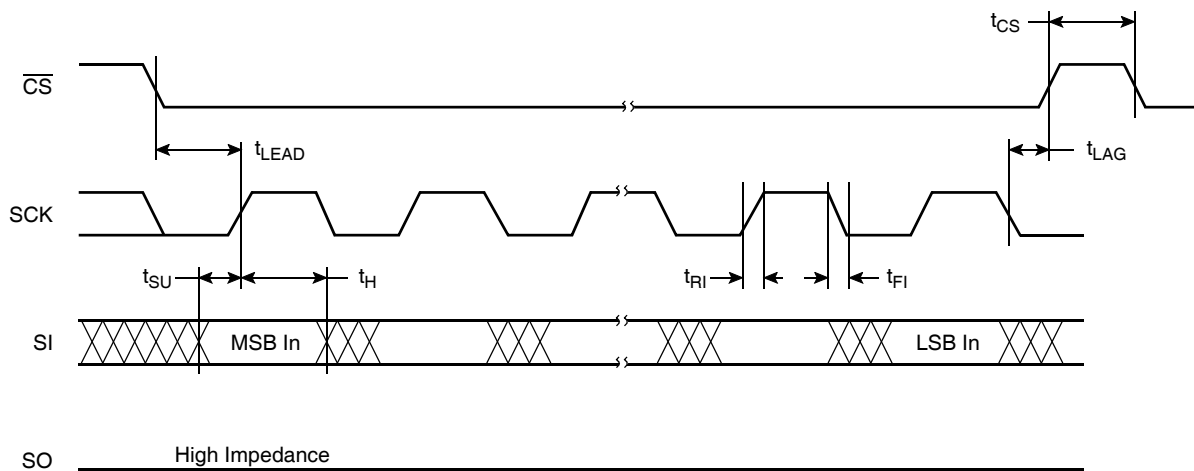


Figure 11. Data Input Timing



## SYMBOL TABLE

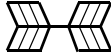
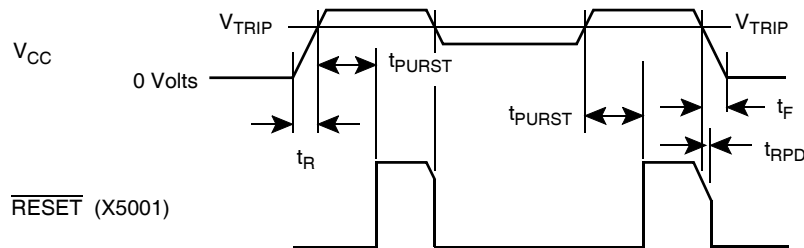
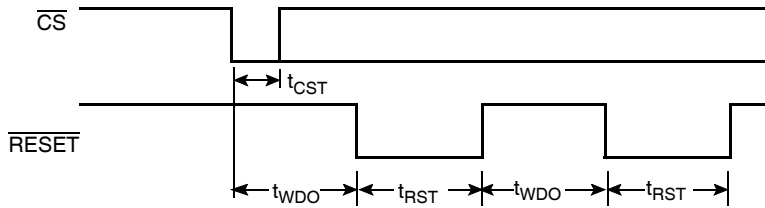
| WAVEFORM                                                                          | INPUTS                      | OUTPUTS                       |
|-----------------------------------------------------------------------------------|-----------------------------|-------------------------------|
|  | 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 |

Figure 12. Power-Up and Power-Down Timing

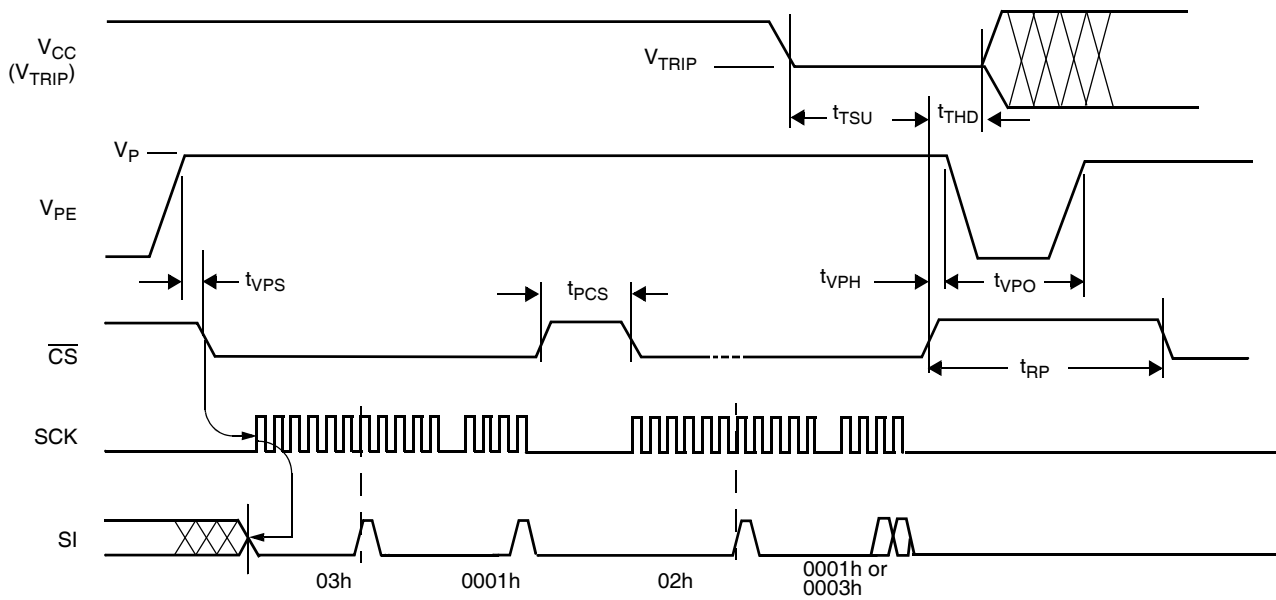
**RESET Output Timing**

| Symbol          | Parameter                              | Min. | Typ. | Max. | Unit |
|-----------------|----------------------------------------|------|------|------|------|
| $V_{TRIP}$      | Reset trip point voltage, X5001PT-4.5A | 4.50 | 4.63 | 4.75 | V    |
|                 | Reset trip point voltage, X5001PT-4.5  | 4.25 | 4.38 | 4.50 |      |
|                 | Reset trip point voltage, X5001PT-2.7A | 2.85 | 2.92 | 3.00 |      |
|                 | Reset trip point voltage, X5001PT-2.7  | 2.55 | 2.63 | 2.70 |      |
|                 | Reset trip point voltage, X5001PT-1.8  | 1.70 | 1.75 | 1.80 |      |
| $t_{PURST}$     | Power-up reset timeout                 | 100  | 200  | 280  | ms   |
| $t_{RPD}^{(5)}$ | $V_{CC}$ detect to reset/output        |      |      | 500  | ns   |
| $t_F^{(5)}$     | $V_{CC}$ fall time                     | 0.1  |      |      | ns   |
| $t_R^{(5)}$     | $V_{CC}$ rise time                     | 0.1  |      |      | ns   |
| $V_{RVALID}$    | Reset valid $V_{CC}$                   | 1    |      |      | V    |

Note: (5) This parameter is periodically sampled and not 100% tested.  
PT = Package, Temperature

Figure 13.  $\overline{\text{CS}}$  vs.  $\overline{\text{RESET}}$  Timing**RESET Output Timing**

| Symbol           | Parameter                                                      | Min. | Typ. | Max. | Unit |
|------------------|----------------------------------------------------------------|------|------|------|------|
| $t_{\text{WDO}}$ | Watchdog timeout period,<br>$\text{WD}_1 = 1, \text{WD}_0 = 0$ | 100  | 200  | 300  | ms   |
|                  | $\text{WD}_1 = 0, \text{WD}_0 = 1$                             | 450  | 600  | 800  | ms   |
|                  | $\text{WD}_1 = 0, \text{WD}_0 = 0$                             | 1    | 1.4  | 2    | sec  |
| $t_{\text{CST}}$ | $\overline{\text{CS}}$ pulse width to reset the watchdog       | 400  |      |      | ns   |
| $t_{\text{RST}}$ | Reset Timeout                                                  | 100  | 200  | 300  | ms   |

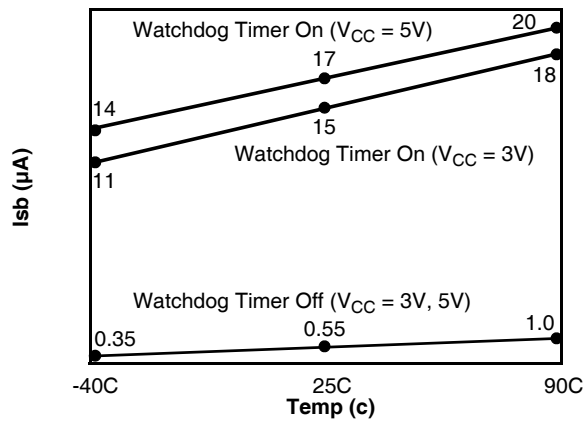
**V<sub>TRIP</sub> Programming Timing Diagram**

**V<sub>TRIP</sub> Programming Parameters**

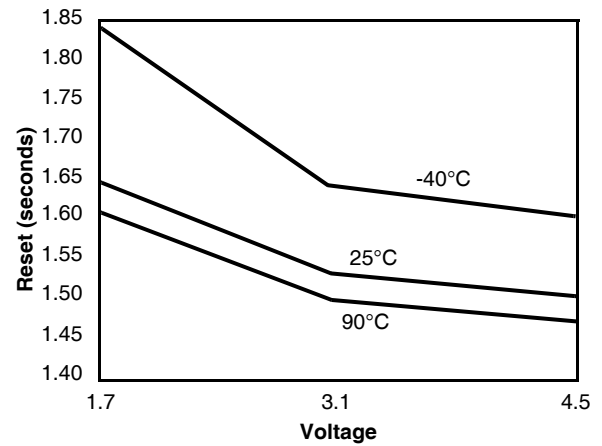
| Parameter         | Description                                                                                                                                 | Min. | Max. | Unit |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|
| t <sub>VPS</sub>  | V <sub>TRIP</sub> program enable voltage setup time                                                                                         | 1    |      | μs   |
| t <sub>VPH</sub>  | V <sub>TRIP</sub> program enable voltage hold time                                                                                          | 1    |      | μs   |
| t <sub>PCS</sub>  | V <sub>TRIP</sub> programming $\overline{CS}$ inactive time                                                                                 | 1    |      | μs   |
| t <sub>TSU</sub>  | V <sub>TRIP</sub> setup time                                                                                                                | 1    |      | μs   |
| t <sub>THD</sub>  | V <sub>TRIP</sub> hold (stable) time                                                                                                        | 10   |      | ms   |
| t <sub>WC</sub>   | V <sub>TRIP</sub> write cycle time                                                                                                          |      | 10   | ms   |
| t <sub>VPO</sub>  | V <sub>TRIP</sub> program enable voltage Off time (between successive adjustments)                                                          | 0    |      | μs   |
| t <sub>RP</sub>   | V <sub>TRIP</sub> program recovery period (between successive adjustments)                                                                  | 10   |      | ms   |
| V <sub>P</sub>    | Programming voltage                                                                                                                         | 15   | 18   | V    |
| V <sub>TRAN</sub> | V <sub>TRIP</sub> programmed voltage range                                                                                                  | 1.7  | 5.0  | V    |
| V <sub>ta1</sub>  | Initial V <sub>TRIP</sub> program voltage accuracy (V <sub>CC</sub> applied-V <sub>TRIP</sub> ) (programmed at 25°C)                        | -0.1 | +0.4 | V    |
| V <sub>ta2</sub>  | Subsequent V <sub>TRIP</sub> program voltage accuracy [(V <sub>CC</sub> applied-V <sub>ta1</sub> )-V <sub>TRIP</sub> . Programmed at 25°C.] | -25  | +25  | mV   |
| V <sub>tr</sub>   | V <sub>TRIP</sub> program voltage repeatability (Successive program operations. Programmed at 25°C.)                                        | -25  | +25  | mV   |
| V <sub>tv</sub>   | V <sub>TRIP</sub> program variation after programming (0-75°C). (programmed at 25°C)                                                        | -25  | +25  | mV   |

V<sub>TRIP</sub> programming parameters are periodically sampled and are not 100% tested.

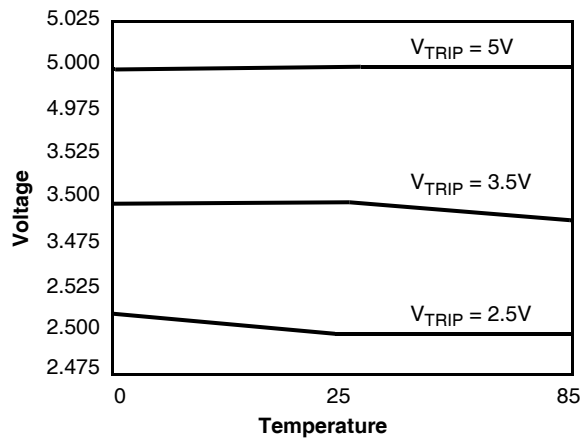
**V<sub>CC</sub> Supply Current vs. Temperature (I<sub>SB</sub>)**



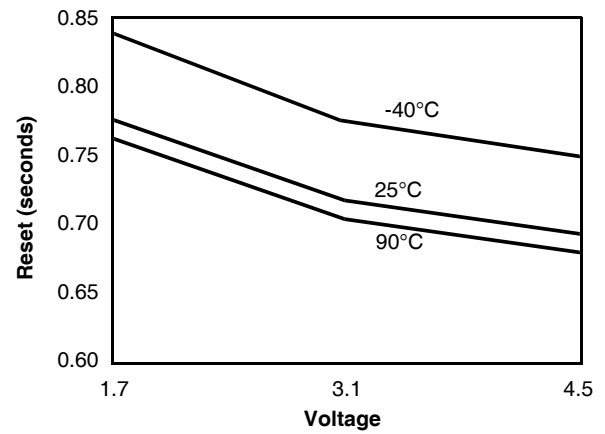
**t<sub>WDO</sub> vs. Voltage/Temperature (WD1, 0 = 1, 1)**



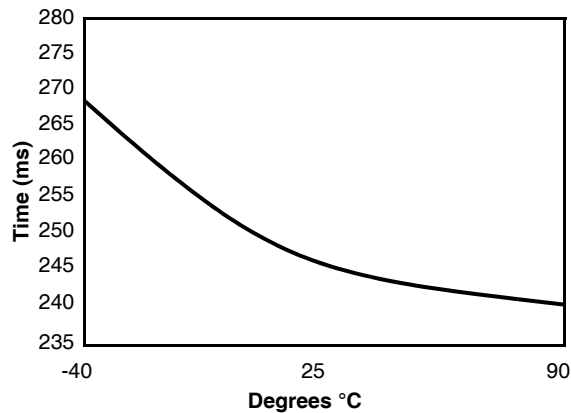
**V<sub>TRIP</sub> vs. Temperature (programmed at 25°C)**



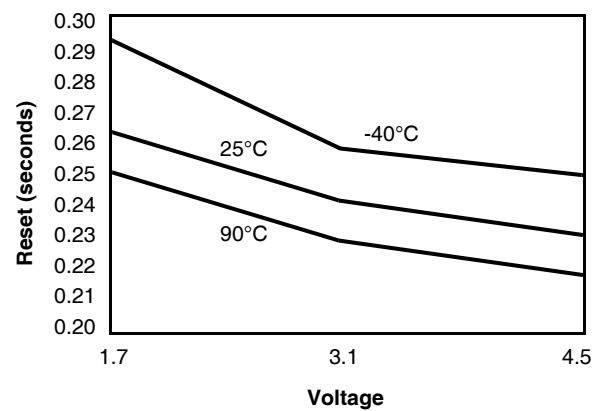
**t<sub>WDO</sub> vs. Voltage/Temperature (WD1, 0 = 1, 0)**



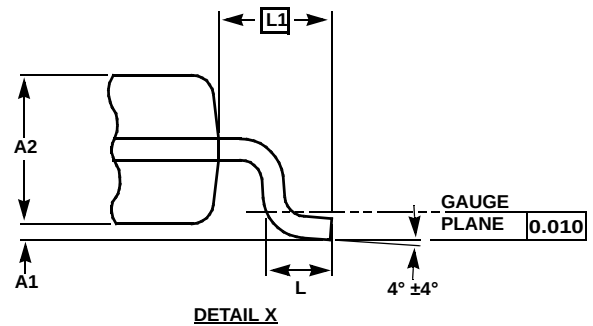
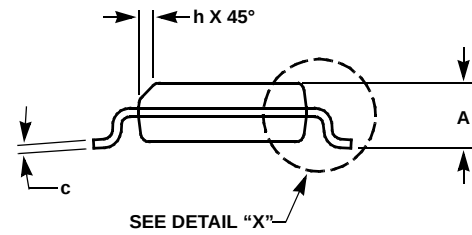
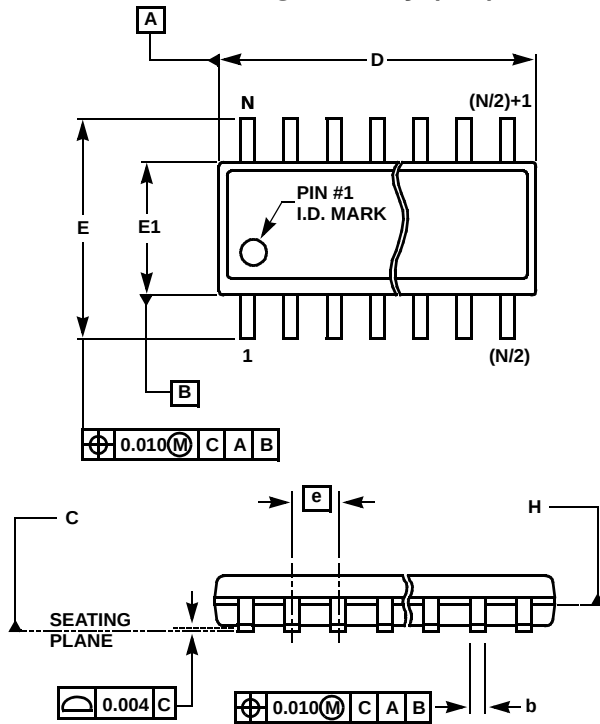
**t<sub>PURST</sub> vs. Temperature**



**t<sub>WDO</sub> vs. Voltage/Temperature (WD1, 0 0 = 0, 1)**



## Small Outline Package Family (SO)



### MDP0027

#### SMALL OUTLINE PACKAGE FAMILY (SO)

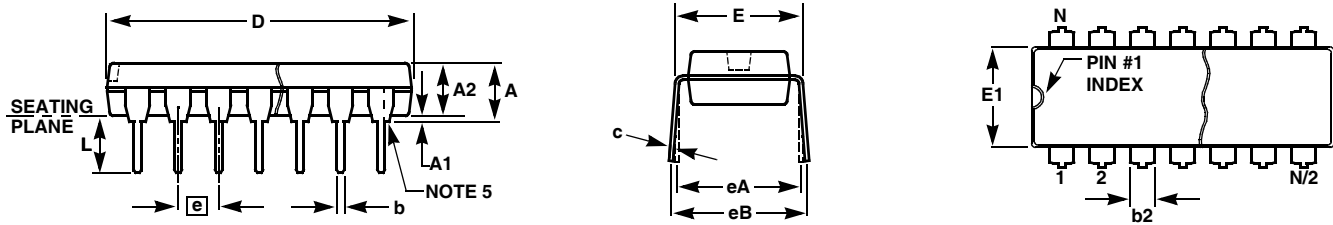
| SYMBOL | SO-8  | SO-14 | SO16<br>(0.150") | SO16 (0.300")<br>(SOL-16) | SO20<br>(SOL-20) | SO24<br>(SOL-24) | SO28<br>(SOL-28) | TOLERANCE | NOTES |
|--------|-------|-------|------------------|---------------------------|------------------|------------------|------------------|-----------|-------|
| 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

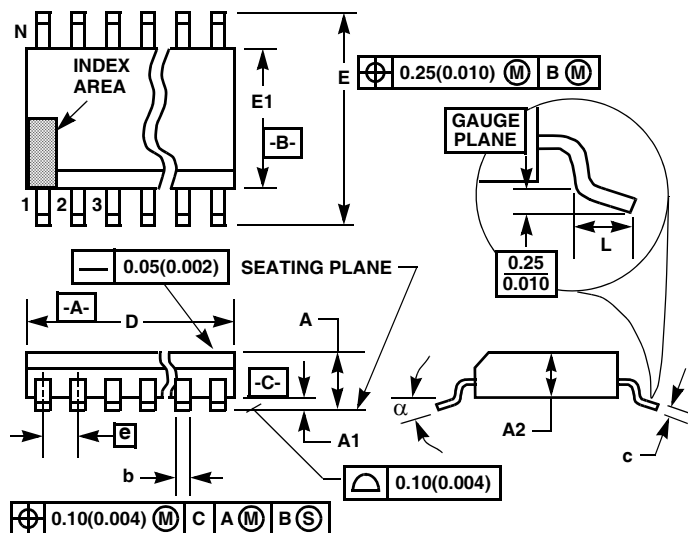
| SYMBOL | PDIP8 | PDIP14 | PDIP16 | PDIP18 | PDIP20 | TOLERANCE       | NOTES |
|--------|-------|--------|--------|--------|--------|-----------------|-------|
| A      | 0.210 | 0.210  | 0.210  | 0.210  | 0.210  | MAX             |       |
| A1     | 0.015 | 0.015  | 0.015  | 0.015  | 0.015  | MIN             |       |
| A2     | 0.130 | 0.130  | 0.130  | 0.130  | 0.130  | $\pm 0.005$     |       |
| b      | 0.018 | 0.018  | 0.018  | 0.018  | 0.018  | $\pm 0.002$     |       |
| 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  | $\pm 0.010$     | 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  | $\pm 0.005$     | 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  | $\pm 0.025$     |       |
| L      | 0.125 | 0.125  | 0.125  | 0.125  | 0.125  | $\pm 0.010$     |       |
| 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:

- These package dimensions are within allowable dimensions of JEDEC MO-153-AC, Issue E.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- 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.
- Dimension "E1" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.15mm (0.006 inch) per side.
- The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
- "L" is the length of terminal for soldering to a substrate.
- "N" is the number of terminal positions.
- Terminal numbers are shown for reference only.
- 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).
- Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact. (Angles in degrees)

### M8.173

#### 8 LEAD THIN SHRINK NARROW BODY 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     | 0.051  | 0.80        | 1.05 | -     |
| b      | 0.0075    | 0.0118 | 0.19        | 0.30 | 9     |
| c      | 0.0035    | 0.0079 | 0.09        | 0.20 | -     |
| D      | 0.116     | 0.120  | 2.95        | 3.05 | 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      | 8         |        | 8           |      | 7     |
| α      | 0°        | 8°     | 0°          | 8°   | -     |

Rev. 1 12/00

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