



# Microprocessor and Nonvolatile Memory Supervisory Circuits

## General Description

The MAX792/MAX820 microprocessor ( $\mu$ P) supervisory circuits provide the most functions for power-supply and watchdog monitoring in systems without battery backup. Built-in features include the following:

- $\mu$ P reset: Assertion of RESET and  $\overline{\text{RESET}}$  outputs during power-up, power-down, and brownout conditions.  $\overline{\text{RESET}}$  is guaranteed valid for  $V_{CC}$  down to 1V.
- Manual-reset input.
- Two-stage power-fail warning: A separate low-line comparator compares  $V_{CC}$  to a preset threshold 120mV above the reset threshold; the low-line and reset thresholds can be programmed externally.
- Watchdog fault output: Assertion of  $\overline{\text{WDO}}$  if the watchdog input is not toggled within a preset timeout period.
- Pulsed watchdog output: Advance warning of impending  $\overline{\text{WDO}}$  assertion from watchdog timeout that causes hardware shutdown.
- Write protection of CMOS RAM, EEPROM, or other memory devices.

The MAX792 and MAX820 are identical, except the MAX820 guarantees higher low-line and reset threshold accuracy ( $\pm 2\%$ ).

## Applications

Computers  
Controllers  
Intelligent Instruments  
Critical  $\mu$ P Power Monitoring

## Features

- ◆ Manual-Reset Input
- ◆ 200ms Power-OK/Reset Time Delay
- ◆ Independent Watchdog Timer—Preset or Adjustable
- ◆ On-Board Gating of Chip-Enable Signals
- ◆ Memory Write-Cycle Completion
- ◆ 10ns (max) Chip-Enable Gate Propagation Delay
- ◆ Voltage Monitor for Overvoltage Warning
- ◆  $\pm 2\%$  Reset and Low-Line Threshold Accuracy (MAX820, external programming mode)

## Ordering Information

| PART**     | TEMP. RANGE  | PIN-PACKAGE    |
|------------|--------------|----------------|
| MAX792_CPE | 0°C to +70°C | 16 Plastic DIP |
| MAX792_CSE | 0°C to +70°C | 16 Narrow SO   |
| MAX792_C/D | 0°C to +70°C | Dice*          |

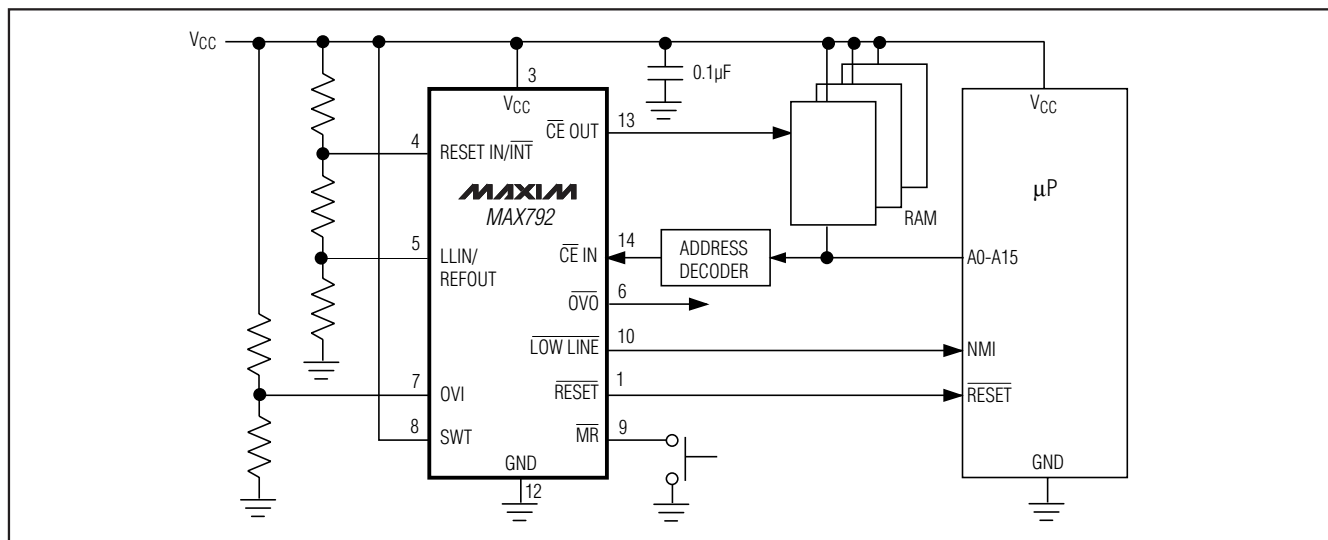
Ordering Information continued at end of data sheet.

\* Dice are tested at  $T_A = +25^\circ\text{C}$ , DC parameters only.

\*\* These parts offer a choice of five different reset threshold voltages. Select the letter corresponding to the desired nominal reset threshold voltage and insert it into the blank to complete the part number. Devices in PDIP, SO and  $\mu$ MAX packages are available in both lead-free and lead-free packaging. Specify lead free by adding the + symbol at the end of the part number when ordering. Lead free not available for CERDIP package.

| SUFFIX | RESET THRESHOLD (V) |
|--------|---------------------|
| L      | 4.62                |
| M      | 4.37                |
| T      | 3.06                |
| S      | 2.91                |
| R      | 2.61                |

## Typical Operating Circuit



Maxim Integrated Products 1

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MAX792/MAX820

# Microprocessor and Nonvolatile Memory Supervisory Circuits

## ABSOLUTE MAXIMUM RATINGS

|                                                       |                                   |
|-------------------------------------------------------|-----------------------------------|
| Input Voltage (with respect to GND)                   |                                   |
| V <sub>CC</sub> .....                                 | -0.3V to +6V                      |
| All Other Inputs .....                                | -0.3V to (V <sub>CC</sub> + 0.3V) |
| Input Current                                         |                                   |
| GND .....                                             | 25mA                              |
| All Other Outputs .....                               | 25mA                              |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C) |                                   |
| Plastic DIP (derate 10.53mW/°C above +70°C) .....     | 842mW                             |
| Narrow SO (derate 9.52mW/°C above +70°C) .....        | 762mW                             |
| CERDIP (derate 10.00mW/°C above +70°C) .....          | 800mW                             |

Operating Temperature Ranges:

|                                         |                 |
|-----------------------------------------|-----------------|
| MAX792_C_/MAX820_C_ .....               | 0°C to +70°C    |
| MAX792_E_/MAX820_E_ .....               | -40°C to +85°C  |
| MAX792_MJE_/MAX820_MJE_ .....           | -55°C to +125°C |
| Storage Temperature Range .....         | -65°C to +160°C |
| Lead Temperature (soldering, 10s) ..... | +300°C          |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 2.75V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

| PARAMETER                                                                 | CONDITIONS                                                              | MIN                   | TYP                     | MAX   | UNITS |
|---------------------------------------------------------------------------|-------------------------------------------------------------------------|-----------------------|-------------------------|-------|-------|
| Operating Voltage Range<br>(Note 1)                                       |                                                                         | 2.75                  |                         |       | V     |
| Supply Current                                                            |                                                                         |                       | 70                      | 150   | μA    |
| <b>RESET COMPARATOR</b>                                                   |                                                                         |                       |                         |       |       |
| Reset Threshold Voltage—<br>Internal Threshold Mode<br>(V <sub>TH</sub> ) | MAX792L, MAX820L                                                        | 4.50                  | 4.62                    | 4.75  | V     |
|                                                                           | MAX792M, MAX820M                                                        | 4.25                  | 4.37                    | 4.50  |       |
|                                                                           | MAX792R, MAX820R                                                        | 2.55                  | 2.61                    | 2.70  |       |
|                                                                           | MAX792S, MAX820S                                                        | 2.85                  | 2.91                    | 3.00  |       |
|                                                                           | MAX792T, MAX820T                                                        | 3.00                  | 3.06                    | 3.15  |       |
|                                                                           | MAX820L, T <sub>A</sub> = +25°C, V <sub>CC</sub> falling                | 4.55                  |                         | 4.70  |       |
|                                                                           | MAX820M, T <sub>A</sub> = +25°C, V <sub>CC</sub> falling                | 4.30                  |                         | 4.45  |       |
|                                                                           | MAX820R, T <sub>A</sub> = +25°C, V <sub>CC</sub> falling                | 2.55                  |                         | 2.66  |       |
|                                                                           | MAX820S, T <sub>A</sub> = +25°C, V <sub>CC</sub> falling                | 2.85                  |                         | 2.96  |       |
|                                                                           | MAX820T, T <sub>A</sub> = +25°C, V <sub>CC</sub> falling                | 3.00                  |                         | 3.11  |       |
| Reset Threshold Voltage<br>External Threshold Mode (V <sub>TH</sub> )     | MAX792, V <sub>CC</sub> = 5V or V <sub>CC</sub> = 3V                    | 1.25                  | 1.30                    | 1.35  | V     |
|                                                                           | MAX820, V <sub>CC</sub> = 5V or V <sub>CC</sub> = 3V                    | 1.274                 | 1.30                    | 1.326 |       |
| RESET IN/ $\overline{\text{INT}}$ Mode Threshold<br>(Note 2)              | Internal threshold mode                                                 |                       |                         | 60    | mV    |
| RESET IN/ $\overline{\text{INT}}$ Leakage Current                         |                                                                         |                       | ±0.01                   | ±25   | nA    |
| Reset Threshold Hysteresis                                                |                                                                         |                       | 0.016 × V <sub>TH</sub> |       | V     |
| Reset Comparator Delay                                                    | V <sub>CC</sub> falling                                                 |                       | 70                      |       | μs    |
| Reset Active Timeout Period                                               | V <sub>CC</sub> rising                                                  | 140                   | 200                     | 280   | ms    |
| $\overline{\text{RESET}}$ Output Voltage                                  | I <sub>SINK</sub> = 50μA, V <sub>CC</sub> = 1V, V <sub>CC</sub> falling |                       | 0.01                    | 0.3   | V     |
|                                                                           | I <sub>SINK</sub> = 1.6mA                                               |                       | 0.1                     | 0.4   |       |
|                                                                           | I <sub>SOURCE</sub> = 1mA                                               | V <sub>CC</sub> - 1   |                         |       |       |
|                                                                           | I <sub>SOURCE</sub> = 100μA                                             | V <sub>CC</sub> - 0.5 |                         |       |       |
| RESET Output Voltage                                                      | I <sub>SINK</sub> = 1.6mA                                               |                       | 0.1                     | 0.4   | V     |
|                                                                           | I <sub>SOURCE</sub> = 1mA                                               | V <sub>CC</sub> - 1   |                         |       |       |
|                                                                           | I <sub>SOURCE</sub> = 100μA                                             | V <sub>CC</sub> - 0.5 |                         |       |       |

# Microprocessor and Nonvolatile Memory Supervisory Circuits

MAX792/MAX820

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = 2.75V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

| PARAMETER                                                               | CONDITIONS                                                              | MIN                   | TYP                    | MAX   | UNITS |
|-------------------------------------------------------------------------|-------------------------------------------------------------------------|-----------------------|------------------------|-------|-------|
| <b>LOW-LINE COMPARATOR</b>                                              |                                                                         |                       |                        |       |       |
| Low-Line Threshold Voltage<br>(Internal Threshold Mode)—V <sub>TH</sub> | MAX792/MAX820L/M                                                        | 50                    | 120                    | 210   | mV    |
|                                                                         | MAX792/MAX820R/S/T                                                      | 40                    | 100                    | 210   |       |
| Low-Line Threshold Voltage<br>(External Programming Mode)               | MAX792, V <sub>CC</sub> = 5V OR V <sub>CC</sub> = 3V                    | 1.25                  | 1.30                   | 1.35  | V     |
|                                                                         | MAX820, V <sub>CC</sub> = 5V OR V <sub>CC</sub> = 3V                    | 1.274                 | 1.30                   | 1.326 |       |
| Low-Line Hysteresis<br>(Internal Threshold Mode)                        |                                                                         |                       | 20                     |       | mV    |
| LLIN/REFOUT Leakage Current<br>External Programming Mode                |                                                                         |                       | ±0.01                  | ±25   | nA    |
| Low-Line Comparator Delay                                               | V <sub>CC</sub> falling                                                 |                       | 450                    |       | μs    |
| $\overline{\text{LOWLINE}}$ Voltage                                     | I <sub>SINK</sub> = 3.2mA                                               |                       |                        | 0.4   | V     |
|                                                                         | I <sub>SOURCE</sub> = 1μA                                               | V <sub>CC</sub> - 1   |                        |       |       |
| $\overline{\text{LOWLINE}}$ Short-Circuit Current                       | Output source current, V <sub>CC</sub> = 5.5V                           |                       | 10                     | 50    | μA    |
| <b>WATCHDOG FUNCTION</b>                                                |                                                                         |                       |                        |       |       |
| Watchdog Timeout Period                                                 | SWT connected to V <sub>CC</sub> , V <sub>CC</sub> = 5V                 | 1.00                  | 1.60                   | 2.25  | sec   |
|                                                                         | SWT connected to V <sub>CC</sub> , V <sub>CC</sub> = 3V                 | 1.00                  | 1.60                   | 2.25  |       |
|                                                                         | 4.7nF capacitor connected from SWT to GND,<br>V <sub>CC</sub> = 3V      |                       | 70                     |       | ms    |
|                                                                         | 4.7nF capacitor connected from SWT to GND,<br>V <sub>CC</sub> = 5V      |                       | 100                    |       |       |
| Watchdog Input Pulse Width                                              | V <sub>IL</sub> = 0V, V <sub>IH</sub> = V <sub>CC</sub>                 | V <sub>CC</sub> = 5V  | 100                    |       | ns    |
|                                                                         |                                                                         | V <sub>CC</sub> = 3V  | 300                    |       |       |
| $\overline{\text{WDO}}$ Output Voltage                                  | I <sub>SINK</sub> = 50μA, V <sub>CC</sub> = 1V, V <sub>CC</sub> falling |                       | 0.01                   | 0.30  | V     |
|                                                                         | I <sub>SINK</sub> = 1.6mA                                               |                       | 0.1                    | 0.4   |       |
|                                                                         | I <sub>SOURCE</sub> = 1mA                                               | V <sub>CC</sub> - 1   |                        |       |       |
|                                                                         | I <sub>SOURCE</sub> = 100μA                                             | V <sub>CC</sub> - 0.5 |                        |       |       |
| $\overline{\text{WDPO}}$ to $\overline{\text{WDO}}$ Delay               |                                                                         |                       | 70                     |       | ns    |
| $\overline{\text{WDPO}}$ Duration                                       |                                                                         | 0.5                   | 1.7                    | 6.0   | ms    |
| $\overline{\text{WDPO}}$ Output Voltage                                 | I <sub>SINK</sub> = 50μA, V <sub>CC</sub> = 1V, V <sub>CC</sub> falling |                       | 0.01                   | 0.3   | V     |
|                                                                         | I <sub>SINK</sub> = 1.6mA                                               |                       | 0.1                    | 0.4   |       |
|                                                                         | I <sub>SOURCE</sub> = 1mA                                               | V <sub>CC</sub> - 1   |                        |       |       |
|                                                                         | I <sub>SOURCE</sub> = 100μA                                             | V <sub>CC</sub> - 0.5 |                        |       |       |
| WDI Threshold Voltage                                                   | V <sub>CC</sub> = 4.25V                                                 | V <sub>IH</sub>       | 0.75 × V <sub>CC</sub> |       | V     |
|                                                                         |                                                                         | V <sub>IL</sub>       |                        | 0.8   |       |
|                                                                         | V <sub>CC</sub> = 2.55V                                                 | V <sub>IH</sub>       | 0.9 × V <sub>CC</sub>  |       |       |
|                                                                         |                                                                         | V <sub>IL</sub>       |                        | 0.2   |       |
| WDI Input Current                                                       |                                                                         |                       |                        | ±1    | μA    |

# Microprocessor and Nonvolatile Memory Supervisory Circuits

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +2.75V$  to  $+5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

| PARAMETER                                               | CONDITIONS                                            |                                                   | MIN                    | TYP    | MAX  | UNITS |
|---------------------------------------------------------|-------------------------------------------------------|---------------------------------------------------|------------------------|--------|------|-------|
| OVERVOLTAGE COMPARATOR                                  |                                                       |                                                   |                        |        |      |       |
| OVI Input Threshold                                     | V <sub>CC</sub> = 5V or V <sub>CC</sub> = 3V          |                                                   | 1.25                   | 1.30   | 1.35 | V     |
| OVI Leakage Current                                     |                                                       |                                                   |                        | ±0.01  | ±25  | nA    |
| $\overline{OVO}$ Output Voltage                         | I <sub>SINK</sub> = 3.2mA                             |                                                   | 0.4                    |        |      | V     |
|                                                         | I <sub>SOURCE</sub> = 1μA                             |                                                   | V <sub>CC</sub> - 1    |        |      |       |
| $\overline{OVO}$ Short-Circuit Current                  | Output source current, V <sub>CC</sub> = 5.5V         |                                                   |                        | 10     | 50   | μA    |
| OVI to $\overline{OVO}$ Delay                           | V <sub>OD</sub> = 100mV, OVI rising                   |                                                   |                        | 13     |      | μs    |
|                                                         | V <sub>OD</sub> = 100mV, OVI falling                  |                                                   |                        | 55     |      |       |
| CHIP-ENABLE GATING                                      |                                                       |                                                   |                        |        |      |       |
| $\overline{CE}$ IN Threshold Voltage                    | V <sub>CC</sub> = 4.25V                               | V <sub>IH</sub>                                   | 0.75 × V <sub>CC</sub> |        |      | V     |
|                                                         |                                                       | V <sub>IL</sub>                                   | 0.8                    |        |      |       |
|                                                         | V <sub>CC</sub> = 2.55V                               | V <sub>IH</sub>                                   | 0.75 × V <sub>CC</sub> |        |      |       |
|                                                         |                                                       | V <sub>IL</sub>                                   | 0.2                    |        |      |       |
| $\overline{CE}$ IN Leakage Current                      | Disabled mode                                         |                                                   |                        | ±0.005 | ±1   | μA    |
| $\overline{CE}$ IN to $\overline{CE}$ OUT Resistance    | Enabled mode                                          | V <sub>CC</sub> = 5V                              |                        | 75     | 150  | Ω     |
|                                                         |                                                       | V <sub>CC</sub> = 3V                              |                        | 150    | 300  |       |
| $\overline{CE}$ OUT Short-Circuit Current               | Disabled mode, $\overline{CE}_{OUT}$ = 0V             | V <sub>CC</sub> = 5V                              | 0.5                    |        | 2.5  | mA    |
|                                                         |                                                       | V <sub>CC</sub> = 3V                              | 0.05                   | 0.2    | 0.4  |       |
| Chip-Enable Propagation Delay (Note 3)                  | 50Ω source impedance driver, C <sub>LOAD</sub> = 50pF | V <sub>CC</sub> = 5V                              |                        | 6      | 10   | ns    |
|                                                         |                                                       | V <sub>CC</sub> = 3V                              |                        | 8      | 13   |       |
| Chip-Enable Output Voltage High (Reset Active)          | I <sub>OUT</sub> = -100μA                             |                                                   | V <sub>CC</sub> - 1    |        |      | V     |
|                                                         | I <sub>OUT</sub> = 10μA                               |                                                   | V <sub>CC</sub> - 0.5  |        |      |       |
| Reset Active to $\overline{CE}$ OUT High                | V <sub>CC</sub> falling                               |                                                   |                        | 15     |      | μs    |
| MANUAL RESET                                            |                                                       |                                                   |                        |        |      |       |
| $\overline{MR}$ Minimum Pulse Width                     |                                                       |                                                   | 25                     |        |      | μs    |
| $\overline{MR}$ to $\overline{RESET}$ Propagation Delay |                                                       |                                                   |                        | 12     |      | μs    |
| $\overline{MR}$ Threshold Range                         |                                                       |                                                   | 1.1                    | 1.3    | 1.5  | V     |
| $\overline{MR}$ Pull-Up Current                         | $\overline{MR}$ = 0V                                  | V <sub>CC</sub> = 4.25V to V <sub>CC</sub> = 5.5V | 5                      | 23     | 80   | μA    |
|                                                         |                                                       | V <sub>CC</sub> = 2.5V                            | 1                      |        |      |       |

**Note 1:** The minimum operating voltage is 2.75V; however, the MAX792R and MAX820R are guaranteed to operate down to their preset reset thresholds.

**Note 2:** Pulling  $\overline{RESET}$  IN/ $\overline{INT}$  below 60mV selects internal threshold mode and connects the internal voltage divider to the reset and low-line comparators. External programming mode allows an external resistor divider to set the low-line and reset thresholds (see Figure 4).

**Note 3:** The Chip-Enable Propagation delay is measured from the 50% point at  $\overline{CE}$  IN to the 50% point at  $\overline{CE}$  OUT.

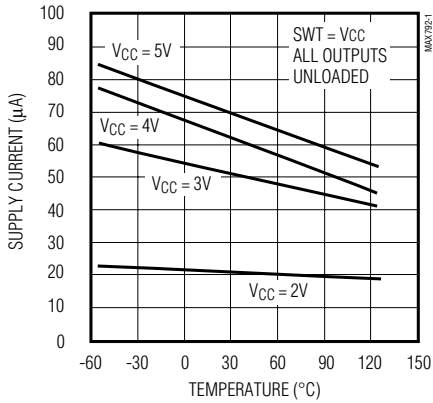
# Microprocessor and Nonvolatile Memory Supervisory Circuits

## Typical Operating Characteristics

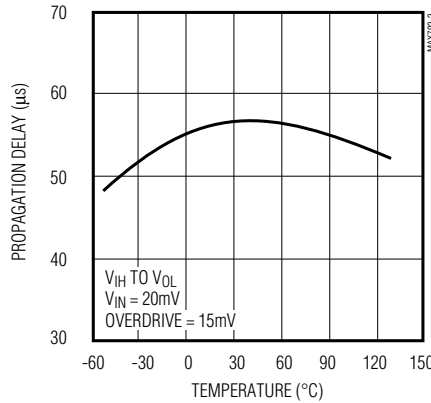
( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

MAX792/MAX820

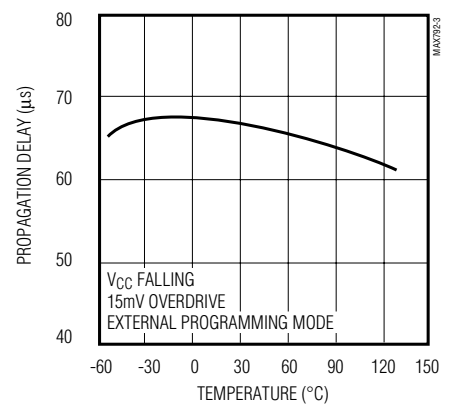
**SUPPLY CURRENT vs. TEMPERATURE**



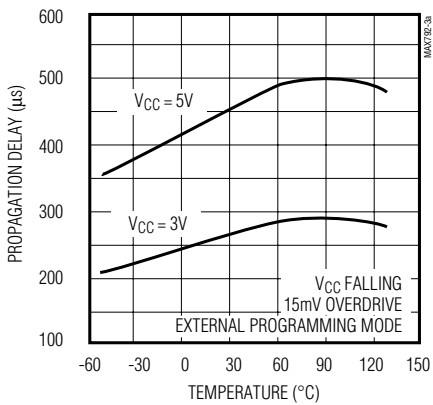
**OVERVOLTAGE COMPARATOR  
PROPAGATION DELAY vs. TEMPERATURE**



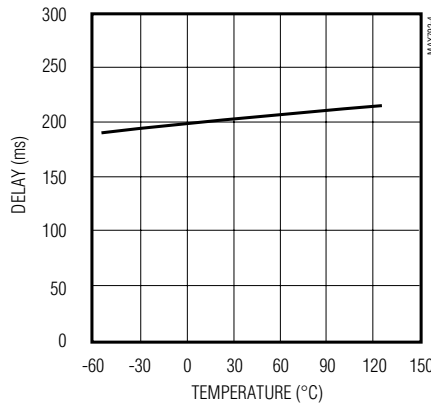
**RESET COMPARATOR  
PROPAGATION DELAY vs. TEMPERATURE**



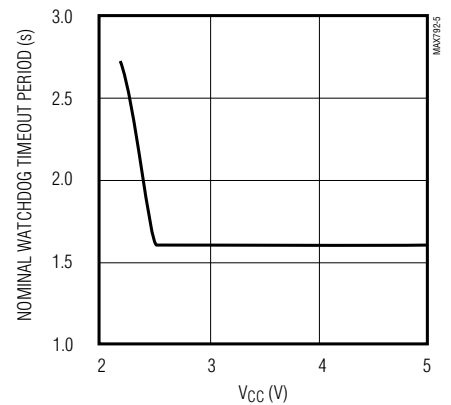
**LOW-LINE COMPARATOR  
PROPAGATION DELAY vs. TEMPERATURE**



**POWER-UP RESET DELAY  
vs. TEMPERATURE**



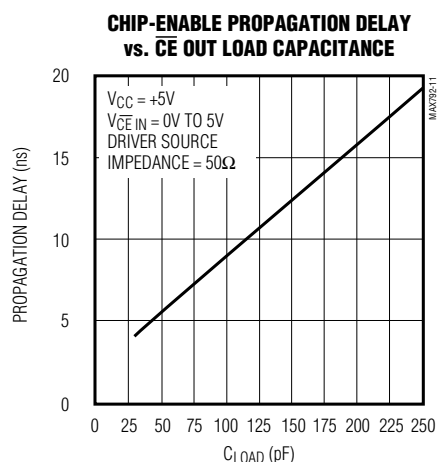
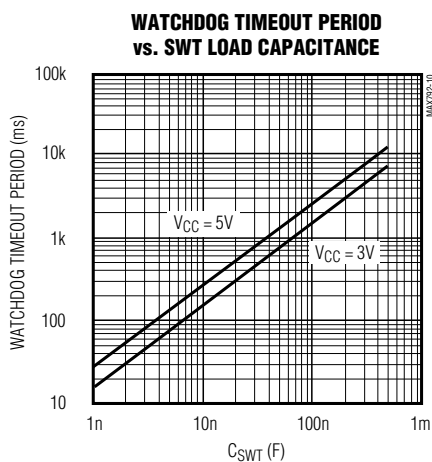
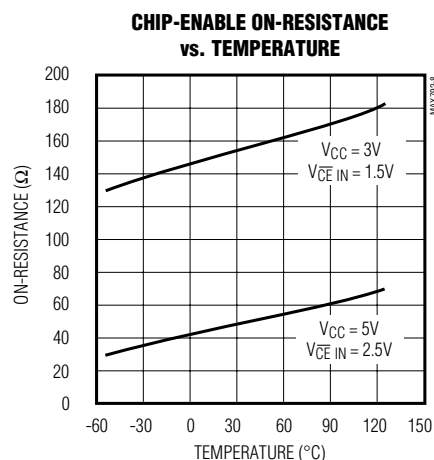
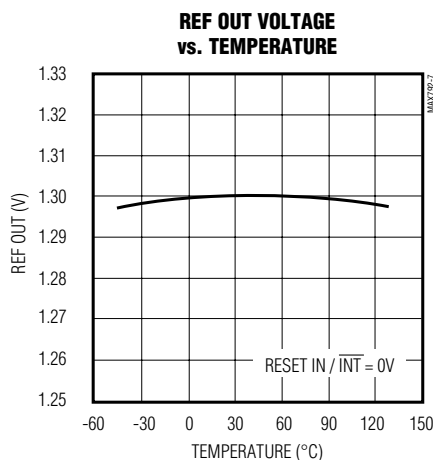
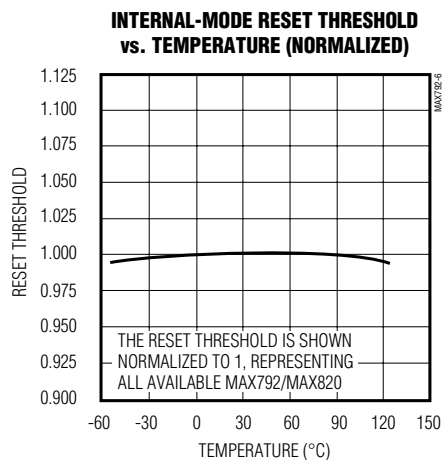
**NOMINAL WATCHDOG TIMEOUT  
PERIOD vs. VCC**



# Microprocessor and Nonvolatile Memory Supervisory Circuits

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



# Microprocessor and Nonvolatile Memory Supervisory Circuits

## Pin Description

MAX792/MAX820

| PIN | NAME                              | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | $\overline{\text{RESET}}$         | Active-Low Reset Output goes low whenever $V_{CC}$ falls below the reset threshold in internal threshold programming mode, or RESET IN falls below 1.30V in external threshold programming mode. $\overline{\text{RESET}}$ remains low for 200ms typ after the threshold is exceeded on power-up.                                                                                                                                         |
| 2   | RESET                             | Reset is the inverse of $\overline{\text{RESET}}$ .                                                                                                                                                                                                                                                                                                                                                                                       |
| 3   | $V_{CC}$                          | Input Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4   | RESET IN/ $\overline{\text{INT}}$ | Reset-Input/Internal-Mode Select. Connect this input to GND to select internal threshold mode. Select external programming mode by pulling this input 600mV or higher through an external voltage divider.                                                                                                                                                                                                                                |
| 5   | LLIN/REF OUT                      | Low-Line Input/Reference Output connects directly to the low-line comparator in external programming mode ( $\text{RESET IN}/\overline{\text{INT}} \geq 600\text{mV}$ ). Connects directly to the internal 1.30V reference in internal threshold mode ( $\text{RESET IN}/\overline{\text{INT}} \leq 60\text{mV}$ ).                                                                                                                       |
| 6   | $\overline{\text{OVO}}$           | Overvoltage Comparator Output goes low when OVI is greater than 1.30V. This is an uncommitted comparator and has no effect on any other internal circuitry.                                                                                                                                                                                                                                                                               |
| 7   | OVI                               | Inverting Input to the Overvoltage Comparator. When OVI is greater than 1.30V, $\overline{\text{OVO}}$ goes low. Connect OVI to GND or $V_{CC}$ when not used.                                                                                                                                                                                                                                                                            |
| 8   | SWT                               | Set Watchdog-Timeout Input. Connect this input to $V_{CC}$ to select the default 1.6sec watchdog timeout period. Connect a capacitor between this input and GND to select another watchdog-timeout period. Watchdog timeout period = $k \times (\text{capacitor value in nF})\text{mV}$ , where $k = 27$ for $V_{CC} = 5\text{V}$ and $k = 16.2$ for $V_{CC} = 3\text{V}$ . If the watchdog function is unused, connect SWT to $V_{CC}$ . |
| 9   | $\overline{\text{MR}}$            | Manual-Reset Input. This input can be tied to an external momentary pushbutton switch, or to a logic gate output. Internally pulled up to $V_{CC}$ .                                                                                                                                                                                                                                                                                      |
| 10  | $\overline{\text{LOW LINE}}$      | Low-Line Output. $\overline{\text{LOW LINE}}$ goes low 120mV above the reset threshold in internal threshold mode, or when LLIN/REFOUT goes below 1.30V in external programming mode.                                                                                                                                                                                                                                                     |
| 11  | WDI                               | Watchdog Input. If WDI remains either high or low for longer than the watchdog timeout period, $\overline{\text{WDPO}}$ pulses low and $\overline{\text{WDO}}$ goes low. $\overline{\text{WDO}}$ remains low until the next transition at WDI. Connect to GND or $V_{CC}$ if unused.                                                                                                                                                      |
| 12  | GND                               | Ground                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 13  | $\overline{\text{CE OUT}}$        | Chip-Enable Output. $\overline{\text{CE OUT}}$ goes low only when $\overline{\text{CE IN}}$ is low and reset is not asserted. If $\overline{\text{CE IN}}$ is low when reset is asserted, $\overline{\text{CE OUT}}$ will stay low for 15 $\mu\text{s}$ or until $\overline{\text{CE IN}}$ goes high, whichever occurs first.                                                                                                             |
| 14  | $\overline{\text{CE IN}}$         | Chip-Enable Input—the input to the chip-enable transmission gate. Connect to GND or $V_{CC}$ if not used.                                                                                                                                                                                                                                                                                                                                 |
| 15  | $\overline{\text{WDO}}$           | Watchdog Output. $\overline{\text{WDO}}$ goes low if WDI remains either high or low longer than the watchdog timeout period. $\overline{\text{WDO}}$ returns high on the next transition at WDI.                                                                                                                                                                                                                                          |
| 16  | $\overline{\text{WDPO}}$          | Watchdog-Pulse Output. Upon the absence of a transition at WDI, $\overline{\text{WDPO}}$ will pulse low for a minimum of 500 $\mu\text{s}$ . $\overline{\text{WDPO}}$ precedes $\overline{\text{WDO}}$ by typically 70ns.                                                                                                                                                                                                                 |

# Microprocessor and Nonvolatile Memory Supervisory Circuits

## Detailed Description

### Manual-Reset Input

Many  $\mu$ P-based products require manual-reset capability, allowing the operator to initiate a reset. The manual/external-reset input ( $\overline{MR}$ ) can connect directly to a switch without an external pull-up resistor or debouncing network.  $\overline{MR}$  internally connects to a 1.30V comparator, and has a high-impedance pull-up to  $V_{CC}$ , as shown in Figure 1. The propagation delay from asserting  $\overline{MR}$  to reset asserted is typically 12 $\mu$ s. Pulsing  $\overline{MR}$  low for a minimum of 25 $\mu$ s asserts the reset function (see *Reset Function* section). The reset output remains active as long as  $\overline{MR}$  is held low, and the reset timeout period begins after  $\overline{MR}$  returns high (Figure 2). To provide extra noise immunity in high-noise environments, pull  $\overline{MR}$  up to  $V_{CC}$  with a 100k $\Omega$  resistor.

Use  $\overline{MR}$  as either a digital logic input or as a second low-line comparator. Normal TTL/CMOS levels can be wire-OR connected via pull-down diodes (Figure 3), and open-drain/collector outputs can be wire-ORed directly.

### Monitoring the Regulated Supply

The MAX792/MAX820 offer two modes for monitoring the regulated supply and providing reset and non-maskable interrupt (NMI) signals to the  $\mu$ P: internal threshold mode uses the factory preset low-line and reset thresholds, and external programming mode allows the low-line and reset thresholds to be programmed externally using a resistor voltage divider (Figure 4).

### Internal Threshold Mode

Connecting the reset-input/internal-mode select pin (RESET IN/ $\overline{INT}$ ) to ground selects internal threshold mode (Figure 4a). In this mode, the low-line and reset thresholds are factory preset by an internal voltage divider (Figure 1) to the threshold voltages specified in the *Electrical Characteristics* (Reset Threshold Voltage and Low-Line Threshold Voltage). Connect the low-line output ( $\overline{LOWLINE}$ ) to the  $\mu$ P NMI pin, and connect the active-high reset output (RESET) or active-low reset output ( $\overline{RESET}$ ) to the  $\mu$ P reset input pin.

Additionally, the low-line input/reference-output pin (LLIN/REFOUT) connects to the internal 1.30V reference in internal threshold mode. Buffer LLIN/REFOUT with a high-impedance buffer to use it with external circuitry. In this mode, when  $V_{CC}$  is falling,  $\overline{LOWLINE}$  is guaranteed to be asserted prior to reset assertion.

### External Programming Mode

Connecting RESET IN/ $\overline{INT}$  to a voltage above 600mV selects external programming mode. In this mode, the low-line and reset comparators disconnect from the internal voltage divider and connect to LLIN/REFOUT and RESET IN/ $\overline{INT}$ , respectively (Figure 1). This mode allows flexibility in determining where in the operating voltage range the NMI and reset are generated. Set the low-line and reset thresholds with an external resistor divider, as in Figure 4b or Figure 4c. RESET typically remains valid for  $V_{CC}$  down to 2.5V; RESET is guaranteed to be valid with  $V_{CC}$  down to 1V.

Calculate the values for the resistor voltage divider in Figure 4b using the following equations:

- 1)  $R3 = (1.30 \times V_{CC \text{ MAX}}) / (V_{\text{LOW LINE}} \times I_{\text{MAX}})$
- 2)  $R2 = [(1.30 \times V_{CC \text{ MAX}}) / (V_{\text{RESET}} \times I_{\text{MAX}})] - R3$
- 3)  $R1 = (V_{CC \text{ MAX}} / I_{\text{MAX}}) - (R2 + R3)$

First choose the desired maximum current through the voltage divider ( $I_{\text{MAX}}$ ) when  $V_{CC}$  is at its highest ( $V_{CC \text{ MAX}}$ ). There are two things to consider here. First,  $I_{\text{MAX}}$  contributes to the overall supply current for the circuit, so you would generally make it as small as possible. Second,  $I_{\text{MAX}}$  cannot be too small or leakage currents will adversely affect the programmed threshold voltages; 5 $\mu$ A is often appropriate. Determine R3 after you have chosen  $I_{\text{MAX}}$ . Use the value for R3 to determine R2, then use both R2 and R3 to determine R1.

For example, to program a 4.75V low-line threshold and a 4.4V reset threshold, first choose  $I_{\text{MAX}}$  to be 5 $\mu$ A when  $V_{CC} = 5.5$ V and substitute into equation 1.

$$R3 = (1.30 \times 5.5) / (4.75 \times 5\text{E-}6) = 301.05\text{k}\Omega.$$

301k $\Omega$  is the nearest standard 0.1% value. Substitute into equation 2:

$$R2 = [(1.30 \times 5.5) / (4.4 \times 5\text{E-}6)] - 301\text{k}\Omega = 23.95\text{k}\Omega.$$

The nearest 0.1% resistor value is 23.7k $\Omega$ . Finally, substitute into equation 3:

$$R1 = (5.5/5\text{E-}6) - (23.7\text{k}\Omega + 301\text{k}\Omega) = 775\text{k}\Omega.$$

The nearest 0.1% value resistor is 787k $\Omega$ . Determine the actual low-line threshold by rearranging equation 1 and plugging in the standard resistor values. The actual low-line threshold is 4.75V and the actual reset threshold is 4.40V. An additional resistor allows the MAX792/MAX820 to monitor the unregulated supply and provide an NMI before the regulated supply begins to fall (Figure 4c).

Both of these thresholds will vary from circuit to circuit with resistor tolerance, reference variation, and comparator offset variation. The initial thresholds for each circuit will also vary with temperature due to reference and offset drift. For highest accuracy, use the MAX820.



# Microprocessor and Nonvolatile Memory Supervisory Circuits

**MAX792/MAX820**

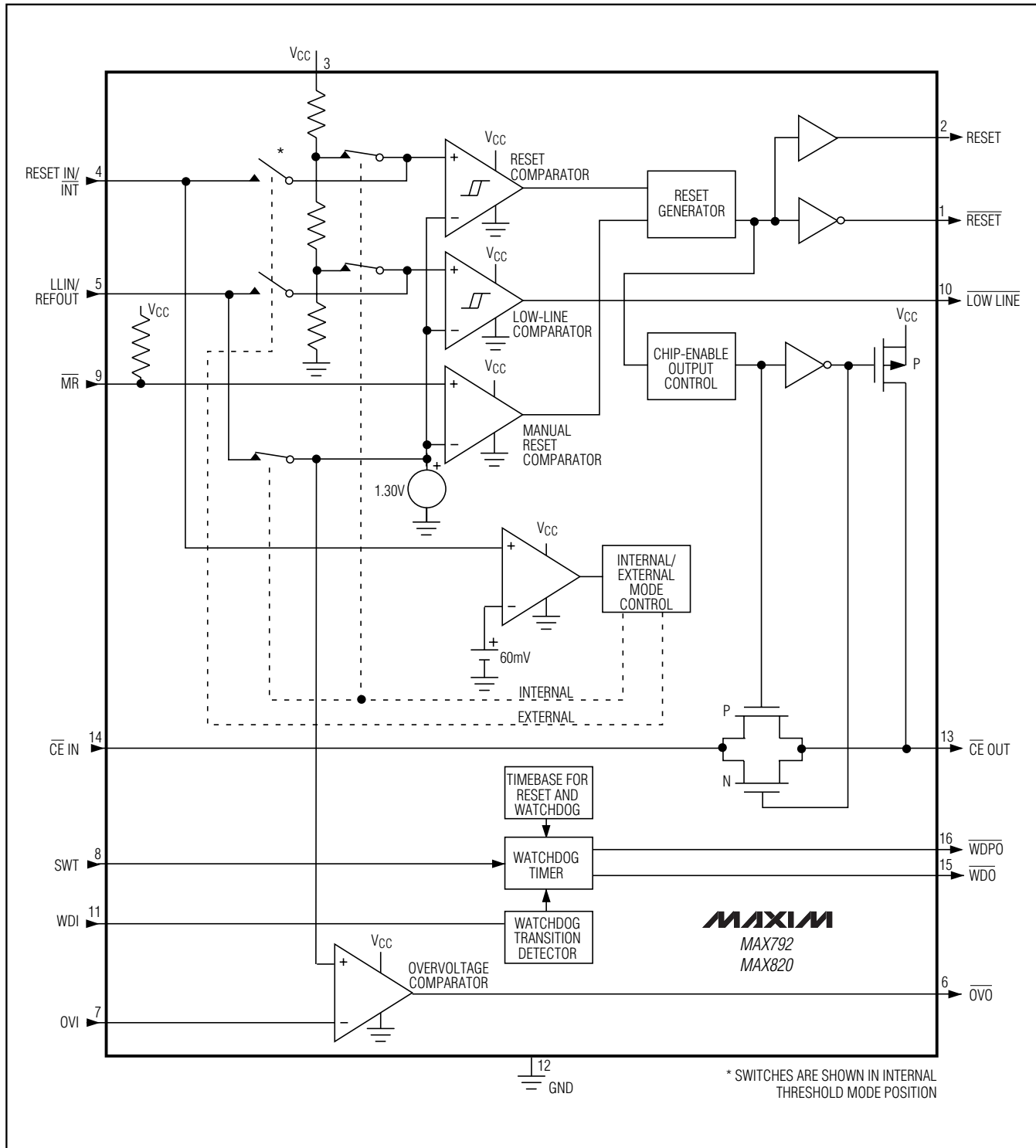


Figure 1. MAX792/MAX820 Block Diagram

# Microprocessor and Nonvolatile Memory Supervisory Circuits

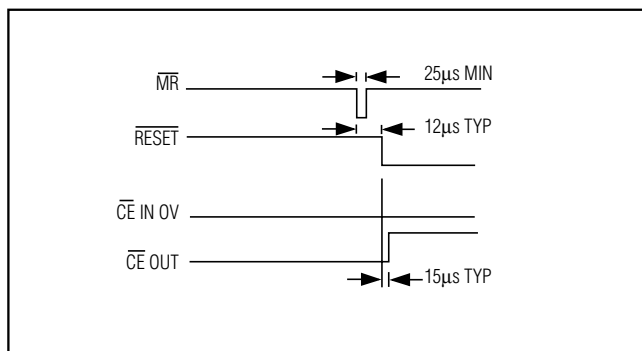


Figure 2. Manual-Reset Timing Diagram

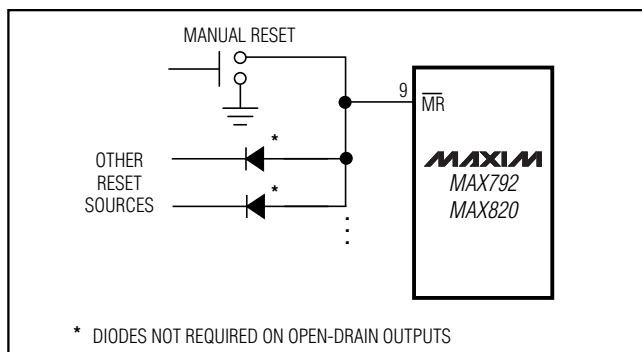


Figure 3. Diode "OR" connections allow multiple reset sources to connect to  $\overline{MR}$ .

## Low-Line Output

In internal threshold mode, the low-line comparator monitors  $V_{CC}$  with a threshold voltage typically 120mV above the reset threshold, and with 15mV of hysteresis. For normal operation ( $V_{CC}$  above the reset threshold),  $\overline{LOWLINE}$  is pulled to  $V_{CC}$ . Use  $\overline{LOWLINE}$  to provide an NMI to the  $\mu P$ , as described in the previous section, when  $V_{CC}$  begins to fall (Figure 4).

## Reset Function

The MAX792/MAX820 provide both RESET and  $\overline{RESET}$  outputs. The RESET and  $\overline{RESET}$  outputs ensure that the  $\mu P$  powers up in a known state, and prevent code-execution errors during power-up, power-down, or brownout conditions.

The reset function will be asserted during the following conditions:

- 1)  $V_{CC}$  less than the programmed reset threshold.
- 2)  $\overline{MR}$  less than 1.30V typ.
- 3) Reset remains asserted for 200ms typ after  $V_{CC}$  rises above the reset threshold or after  $\overline{MR}$  has exceeded 1.30V typ.

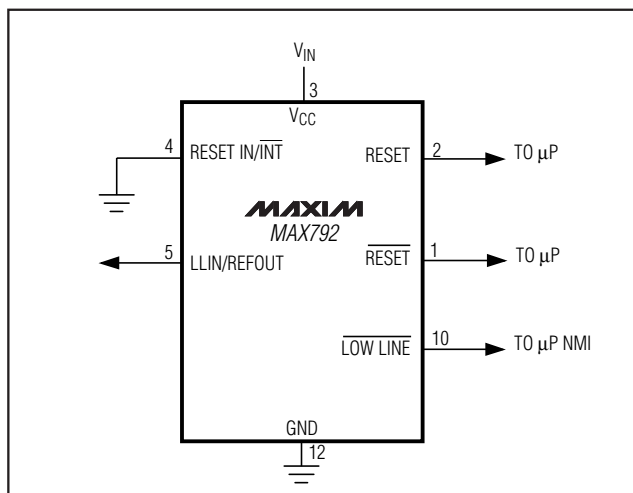


Figure 4a. Connection for Internal Threshold Mode

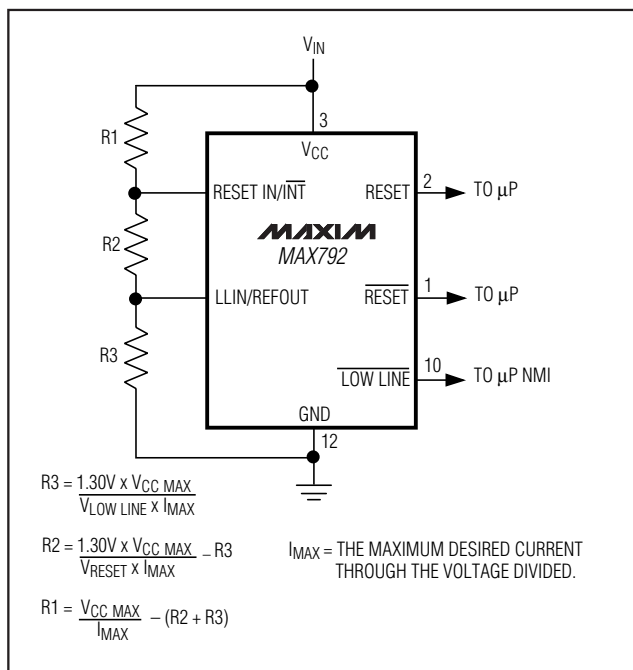


Figure 4b. Connection for External Threshold Programming Mode

When reset is asserted, all the internal counters are reset, the watchdog output ( $\overline{WDO}$ ) and watchdog-pulse output ( $\overline{WDPO}$ ) are set high, and the set watchdog-time-out input (SWT) is set to ( $V_{CC} - 0.6V$ ) if it is not already connected to  $V_{CC}$  (for internal timeouts). The chip-enable transmission gate is also disabled while reset is asserted; the chip-enable input ( $\overline{CE\ IN}$ ) becomes high impedance and the chip-enable output ( $\overline{CE\ OUT}$ ) is pulled up to  $V_{CC}$ .

# Microprocessor and Nonvolatile Memory Supervisory Circuits

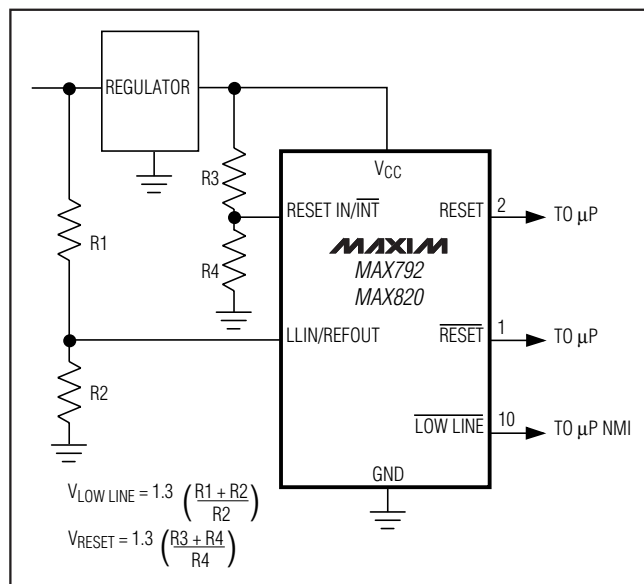


Figure 4c. Alternative Connection for External Programming Mode

## Reset Outputs (RESET and RESET)

The RESET output is active low and typically sinks 1.6mA at 0.1V. When deasserted, RESET sources 1.6mA at typically  $V_{CC} - 1.5V$ . The RESET output is the inverse of RESET. RESET is guaranteed to be valid down to  $V_{CC} = 1V$ , and an external 10kΩ pull-down resistor on RESET ensures that it will be valid with  $V_{CC}$  down to GND (Figure 5). As  $V_{CC}$  goes below 1V, the gate drive to the RESET output switch reduces accordingly, increasing the  $r_{DS(ON)}$  and the saturation voltage. The 10kΩ pull-down resistor ensures that the parallel combination of switch plus resistor will be around 10kΩ and the saturation voltage will be below 0.4V while sinking 40μA. When using an external pull-down resistor of 10kΩ, the high state for the RESET output with  $V_{CC} = 4.75V$  is typically 4.60V.

## Overvoltage Comparator

The overvoltage comparator is an uncommitted comparator that has no effect on the operation of other chip functions. Use this input to provide overvoltage indication by connecting a voltage divider from the input supply, as in Figure 6.

Connect OVI to ground if the overvoltage function is not used. OVO goes low when OVI goes above 1.30V. With OVI below 1.30V, OVO is actively pulled to  $V_{CC}$  and can source 1μA.

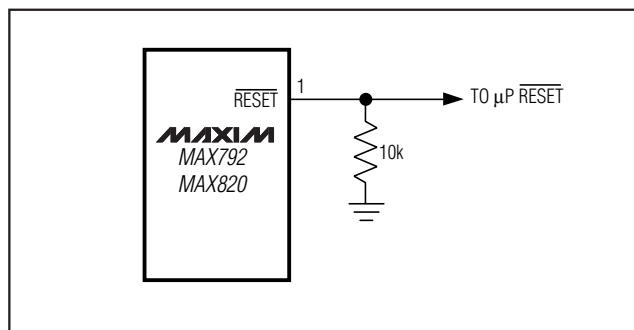


Figure 5. Adding an external pull-down resistor ensures RESET is valid with  $V_{CC}$  down to GND.

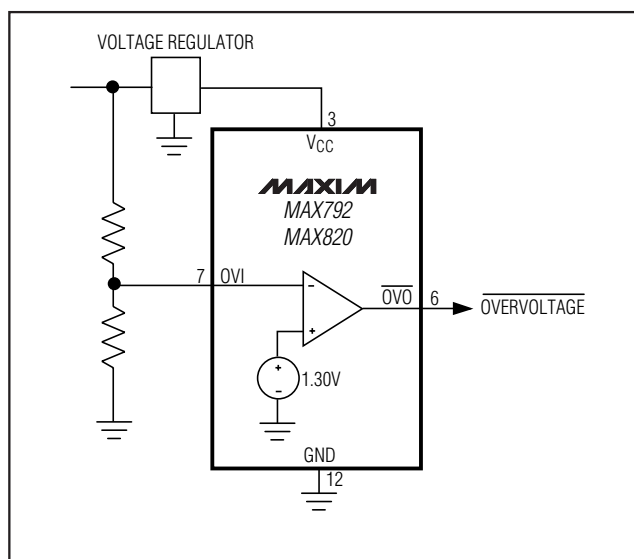


Figure 6. Detecting an Overvoltage Condition

## Watchdog Function

The watchdog monitors μP activity via the watchdog input (WDI). If the μP becomes inactive, WDO and WDPO are asserted. To use the watchdog function, connect WDI to a μP bus line or I/O line. If WDI remains high or low for longer than the watchdog timeout period (1.6s nominal), WDPO and WDO are asserted, indicating a software fault condition (see Watchdog-Pulse Output and Watchdog Output sections).

## Watchdog Input

If the watchdog function is unused, connect WDI to  $V_{CC}$  or GND. A change of state (high-to-low, low-to-high, or a minimum 100ns pulse) at WDI during the watchdog period resets the watchdog timer. The watchdog timer

## **Microprocessor and Nonvolatile Memory Supervisory Circuits**

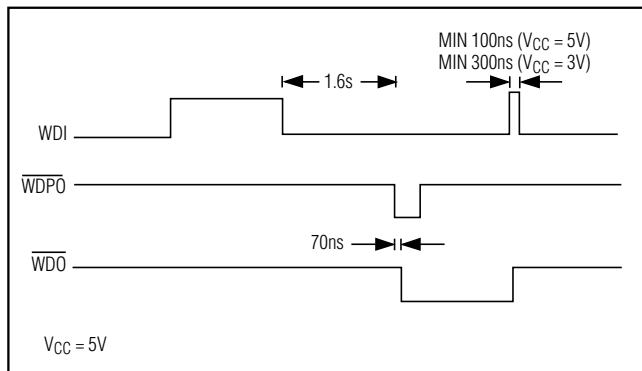


Figure 7.  $WDI$ ,  $\overline{WDO}$ , and  $\overline{WDPO}$  Timing Diagram

default is 1.6s. Select alternative timeout periods by connecting an external capacitor from SWT to GND (see *Selecting an Alternative Watchdog Timeout* section). When  $V_{CC}$  is below the reset threshold, the watchdog function is disabled.

### Watchdog Output

$\overline{\text{WDO}}$  remains high if there is a transition or pulse at WDI during the watchdog timeout period. The watchdog function is disabled and  $\overline{\text{WDO}}$  is a logic high when  $V_{\text{CC}}$  is below the reset threshold. If a system reset is desired on every watchdog fault, simply diode-OR connect  $\overline{\text{WDO}}$  to  $\overline{\text{MR}}$  (Figure 8). When a watchdog fault occurs in this mode,  $\overline{\text{WDO}}$  goes low, pulling  $\overline{\text{MR}}$  low and causing a reset pulse to be issued. As soon as reset is asserted, the watchdog timer clears and  $\overline{\text{WDO}}$  goes high. With  $\overline{\text{WDO}}$  connected to  $\overline{\text{MR}}$ , a continuous high or low on WDI will cause 200ms reset pulses to be issued every 1.6sec (SWT connected to  $V_{\text{CC}}$ ). When reset is not asserted, if no transition occurs at WDI during the watchdog timeout period,  $\overline{\text{WDO}}$  goes low 70ns after the falling edge of  $\overline{\text{WDPO}}$  and remains low until the next transition at WDI (Figure 7). A single additional flip-flop can force the system into a hardware shutdown if there are two successive watchdog faults (Figure 8). When the MAX792/MAX820 are operated from a 5V supply,  $\overline{\text{WDO}}$  has a 2 x TTL output characteristic.

### Watchdog-Pulse Output

As described in the preceding section,  $\overline{\text{WDPO}}$  can be used as the clock input to an external D flip-flop. Upon the absence of a watchdog edge or pulse at WDI at the end of a watchdog timeout period,  $\overline{\text{WDPO}}$  will pulse low for 1.7ms. The falling edge of  $\overline{\text{WDPO}}$  precedes  $\overline{\text{WDO}}$  by 70ns. Since  $\overline{\text{WDO}}$  is high when  $\overline{\text{WDPO}}$  goes low, the flip-flop's Q output remains high after  $\overline{\text{WDO}}$  goes low (Figure 8). If the watchdog timer is not reset by a transition at

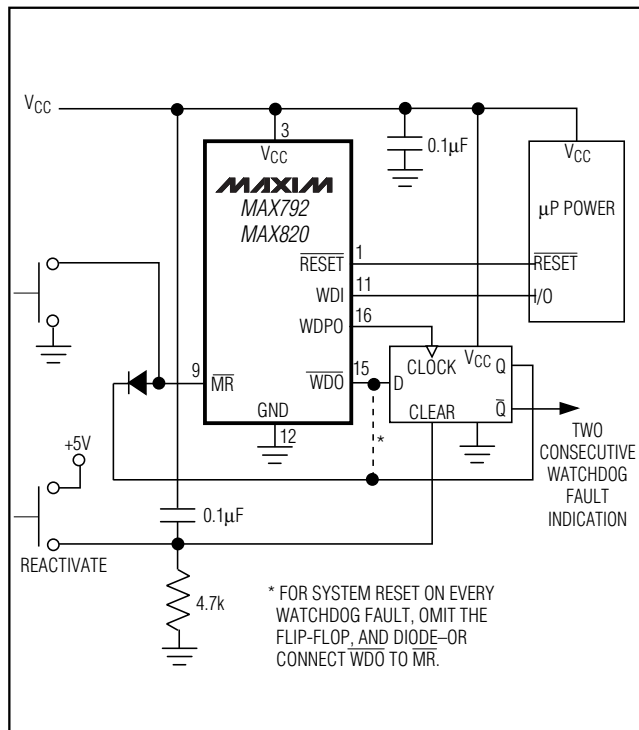


Figure 8. Two consecutive watchdog faults latch the system in reset.

WDI,  $\overline{\text{WDO}}$  remains low and the next  $\overline{\text{WDPO}}$  following a second watchdog timeout period clocks a logic low to the Q output, pulling  $\overline{\text{MR}}$  low and causing the MAX792/MAX820 latch in reset. If the watchdog timer is reset by a transition at WDI,  $\overline{\text{WDO}}$  will go high and the flip-flop's Q output will remain high. Thus a system shutdown is only caused by two successive watchdog faults.

### Selecting an Alternative Watchdog Timeout Period

The SWT input controls the watchdog timeout period. Connecting SWT to V<sub>CC</sub> selects the internal 1.6sec watchdog timeout period. Select an alternative watchdog timeout period by connecting a capacitor between SWT and GND. Do not leave SWT floating and do not connect it to ground. The following formula determines the watchdog timeout period:

$$\text{Watchdog Timeout Period} = k \times (\text{capacitor value in nF}) \text{ms}$$

where  $k = 27$  for  $V_{CC} = 3V$ , and  $k = 16.2$  for  $V_{CC} = 5V$ .

This applies for capacitor values in excess of 4.7nF. If the watchdog function is unused, connect SWT to V<sub>CC</sub>.

# Microprocessor and Nonvolatile Memory Supervisory Circuits

MAX792/MAX820

## Chip-Enable Signal Gating

The MAX792/MAX820 provide internal gating of chip-enable (CE) signals, which prevents erroneous data from corrupting CMOS RAM in the event of an under-voltage condition. The MAX792/MAX820 use a series transmission gate from  $\overline{\text{CE}}$  IN to  $\overline{\text{CE}}$  OUT (Figure 1).

During normal operation (reset not asserted), the CE transmission gate is enabled and passes all CE transitions. When reset is asserted, this path becomes disabled, preventing erroneous data from corrupting the CMOS RAM. The 10ns max CE propagation delay from  $\overline{\text{CE}}$  IN to  $\overline{\text{CE}}$  OUT enables the MAX792/MAX820 to be used with most  $\mu$ Ps. If  $\overline{\text{CE}}$  IN is low when reset asserts,  $\overline{\text{CE}}$  OUT remains low for a short period to permit completion of the current write cycle.

## Chip-Enable Input

The CE transmission gate is disabled and  $\overline{\text{CE}}$  IN is high impedance (disabled mode) while reset is asserted.

During a power-down sequence when  $V_{\text{CC}}$  passes the reset threshold, the CE transmission gate disables and  $\overline{\text{CE}}$  IN immediately becomes high impedance if the voltage at  $\overline{\text{CE}}$  IN is high. If  $\overline{\text{CE}}$  IN is low when reset is asserted, the CE transmission gate will disable at the moment  $\overline{\text{CE}}$  IN goes high or 15 $\mu$ s after reset is asserted, whichever occurs first (Figure 9). This permits the current write cycle to complete during power-down.

During a power-up sequence, the CE transmission gate remains disabled and  $\overline{\text{CE}}$  IN remains high impedance regardless of  $\overline{\text{CE}}$  IN activity, until reset is deasserted following the reset timeout period.

While disabled,  $\overline{\text{CE}}$  IN is high impedance. When the CE transmission gate is enabled, the impedance of  $\overline{\text{CE}}$  IN will appear as a 75 $\Omega$  ( $V_{\text{CC}} = 5\text{V}$ ) resistor in series with the load at  $\overline{\text{CE}}$  OUT.

The propagation delay through the CE transmission gate depends on  $V_{\text{CC}}$ , the source impedance of the drive connected to  $\overline{\text{CE}}$  IN, and the loading on  $\overline{\text{CE}}$  OUT (see the Chip-Enable Propagation Delay vs.  $\overline{\text{CE}}$  OUT Load Capacitance graph in the *Typical Operating Characteristics*). The CE propagation delay is production tested from the 50% point on  $\overline{\text{CE}}$  IN to the 50% point on  $\overline{\text{CE}}$  OUT using a 50 $\Omega$  driver and 50pF of load capacitance (Figure 10). For minimum propagation delay, minimize the capacitive load at  $\overline{\text{CE}}$  OUT, and use a low-output-impedance driver.

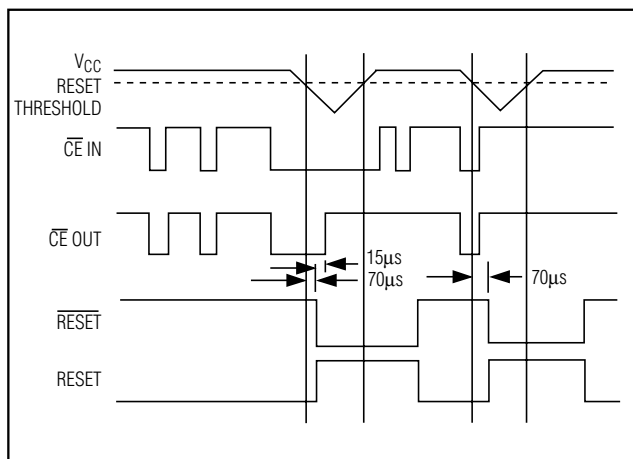


Figure 9. Reset and Chip-Enable Timing

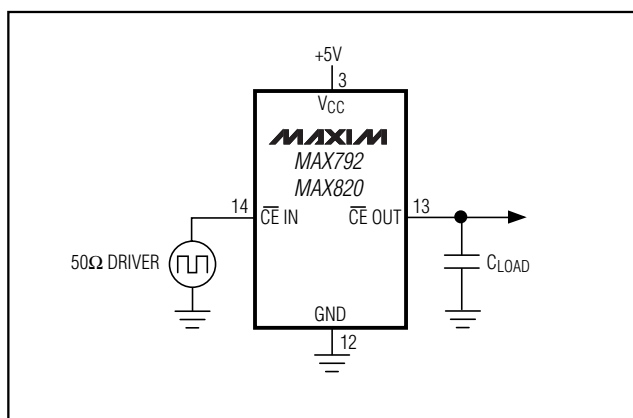


Figure 10. CE Propagation Delay Test Circuit

## Chip-Enable Output

When the CE transmission gate is enabled, the impedance of  $\overline{\text{CE}}$  OUT is equivalent to 75 $\Omega$  in series with the source driving  $\overline{\text{CE}}$  IN. In the disabled mode, the 75 $\Omega$  transmission gate is off and an active pull-up connects from  $\overline{\text{CE}}$  OUT to  $V_{\text{CC}}$ . This source turns off when the transmission gate is enabled.

## Applications Information

Connect a 0.1 $\mu$ F ceramic capacitor from  $V_{\text{CC}}$  to GND, as close to the device pins as possible. This reduces the probability of resets due to high-frequency power-supply transients. In a high-noise environment, additional bypass capacitance from  $V_{\text{CC}}$  to ground may be required. If long leads connect to the chip inputs, ensure that these lines are free from ringing, etc., which would forward bias the chip's protection diodes.

# Microprocessor and Nonvolatile Memory Supervisory Circuits

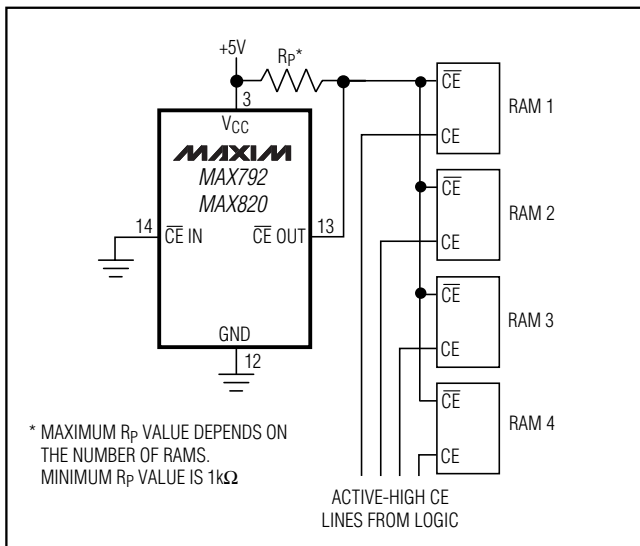


Figure 11. Alternate CE Gating

## Alternative Chip-Enable Gating

Using memory devices with both CE and  $\overline{\text{CE}}$  inputs allows the MAX792/MAX820 CE propagation delay to be bypassed. To do this, connect  $\overline{\text{CE}}$  IN to ground, pull up  $\overline{\text{CE}}$  OUT to  $V_{CC}$ , and connect  $\overline{\text{CE}}$  OUT to the  $\overline{\text{CE}}$  input of each memory device (Figure 11). The CE input of each memory device then connects directly to the chip-select logic, which does not have to be gated by the MAX792/MAX820.

## Interfacing to $\mu\text{Ps}$ with Bidirectional Reset Inputs

$\mu\text{Ps}$  with bidirectional reset pins, such as the Motorola 68HC11 series, can contend with the MAX792/MAX820  $\overline{\text{RESET}}$  output. If, for example, the MAX792/MAX820  $\overline{\text{RESET}}$  output is asserted high and the  $\mu\text{P}$  wants to pull it low, indeterminate logic levels may result. To avoid this, connect a 4.7k $\Omega$  resistor between the MAX792/MAX820  $\overline{\text{RESET}}$  output and the  $\mu\text{P}$  reset I/O, as in Figure 12. Buffer the MAX792/MAX820  $\overline{\text{RESET}}$  output to other system components.

## Negative-Going $V_{CC}$ Transients

While issuing resets to the  $\mu\text{P}$  during power-up, power-down, and brownout conditions, these supervisors are relatively immune to short-duration negative-going  $V_{CC}$  transients (glitches). It is usually undesirable to reset the  $\mu\text{P}$  when  $V_{CC}$  experiences only small glitches.

Figure 13 shows maximum transient duration vs. reset-comparator overdrive, for which reset pulses are **not** generated. The graph was produced using negative-

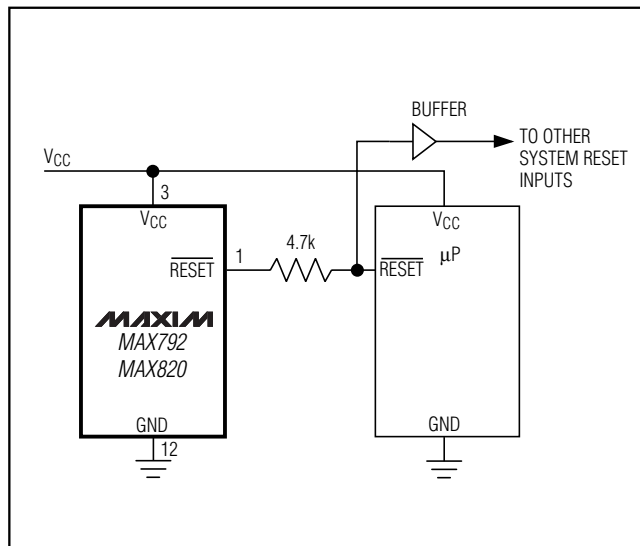


Figure 12. Interfacing to  $\mu\text{Ps}$  with Bidirectional  $\overline{\text{RESET}}$  Pins

going  $V_{CC}$  pulses, starting at 5V and ending below the reset threshold by the magnitude indicated (reset-comparator overdrive). The graph shows the maximum pulse width a negative-going  $V_{CC}$  transient may typically have without causing a reset pulse to be issued. As the amplitude of the transient increases (i.e., goes farther below the reset threshold), the maximum allowable pulse width decreases. Typically, a  $V_{CC}$  transient that goes 100mV below the reset threshold and lasts for 30 $\mu\text{s}$  or less will not cause a reset pulse to be issued.

A 100nF bypass capacitor mounted close to the  $V_{CC}$  pin provides additional transient immunity.

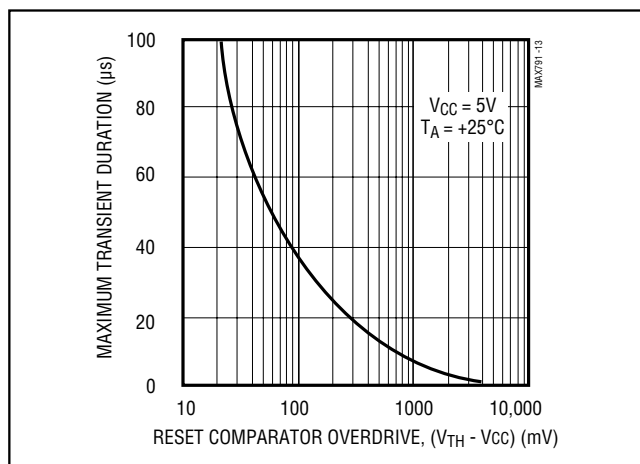


Figure 13. Maximum Transient Duration Without Causing a Reset Pulse vs. Reset-Comparator Overdrive

# Microprocessor and Nonvolatile Memory Supervisory Circuits

MAX792/MAX820

## Ordering Information (continued)

| PART**            | TEMP. RANGE     | PIN-PACKAGE    |
|-------------------|-----------------|----------------|
| MAX792_EPE        | -40°C to +85°C  | 16 Plastic DIP |
| MAX792_ESE        | -40°C to +85°C  | 16 Narrow SO   |
| MAX792_EJE        | -40°C to +85°C  | 16 Cerdip      |
| MAX792_MJE        | -55°C to +125°C | 16 Cerdip      |
| <b>MAX820_CPE</b> | -0°C to +70°C   | 16 Plastic DIP |
| MAX820_CSE        | -0°C to +70°C   | 16 Narrow SO   |
| MAX820_EPE        | -40°C to +85°C  | 16 Plastic DIP |
| MAX820_ESE        | -40°C to +85°C  | 16 Narrow SO   |
| MAX820_EJE        | -40°C to +85°C  | 16 Cerdip      |
| MAX820_MJE        | -55°C to +125°C | 16 Cerdip      |

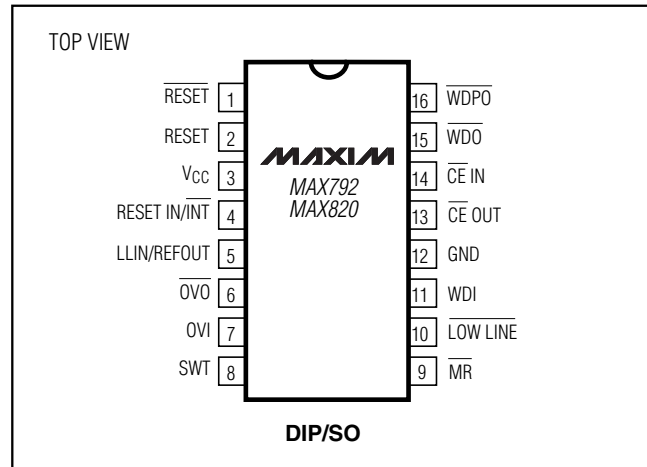
\* Dice are tested at  $T_A = +25^\circ\text{C}$ , DC parameters only.

\*\* These parts offer a choice of five different reset threshold voltages. Select the letter corresponding to the desired nominal reset threshold voltage and insert it into the blank to complete the part number.

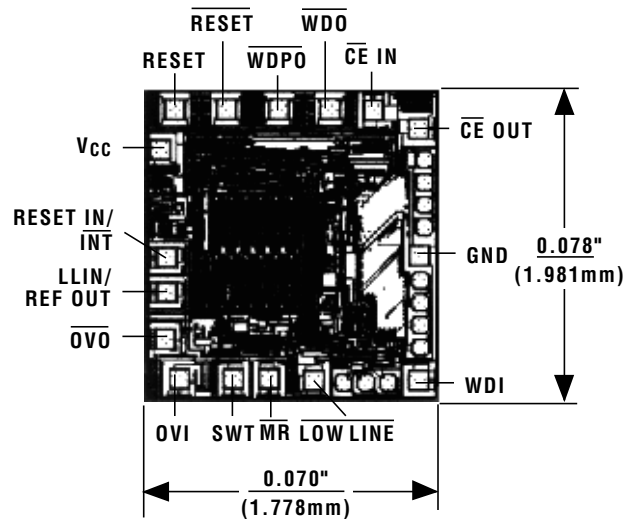
Devices in PDIP, SO and  $\mu\text{MAX}$  packages are available in both leaded and lead-free packaging. Specify lead free by adding the + symbol at the end of the part number when ordering. Lead free not available for Cerdip package.

| SUFFIX | RESET THRESHOLD (V) |
|--------|---------------------|
| L      | 4.62                |
| M      | 4.37                |
| T      | 3.06                |
| S      | 2.91                |
| R      | 2.61                |

## Pin Configuration



## Chip Topography



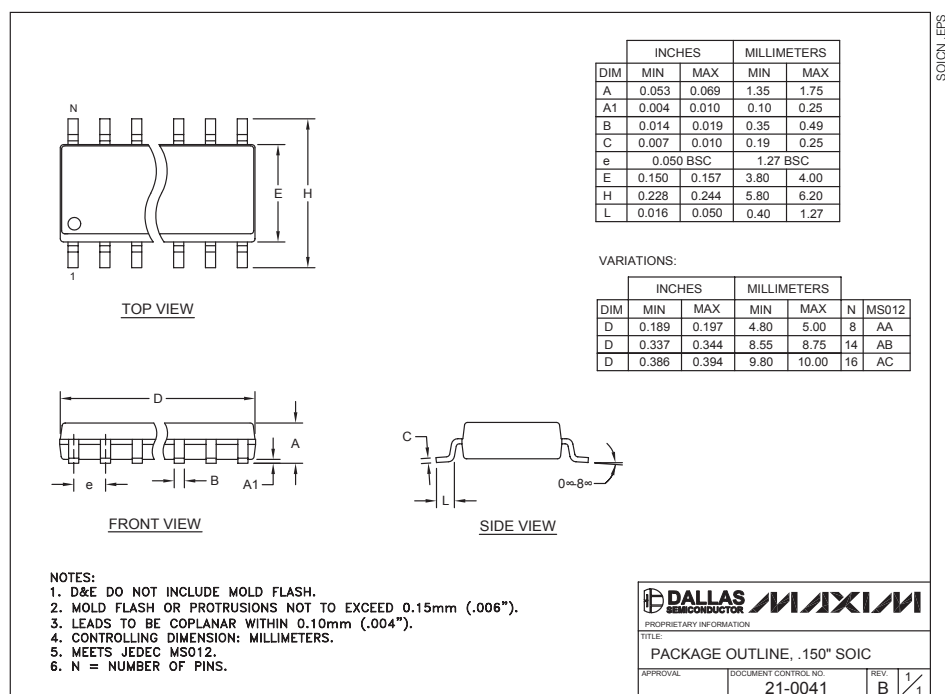
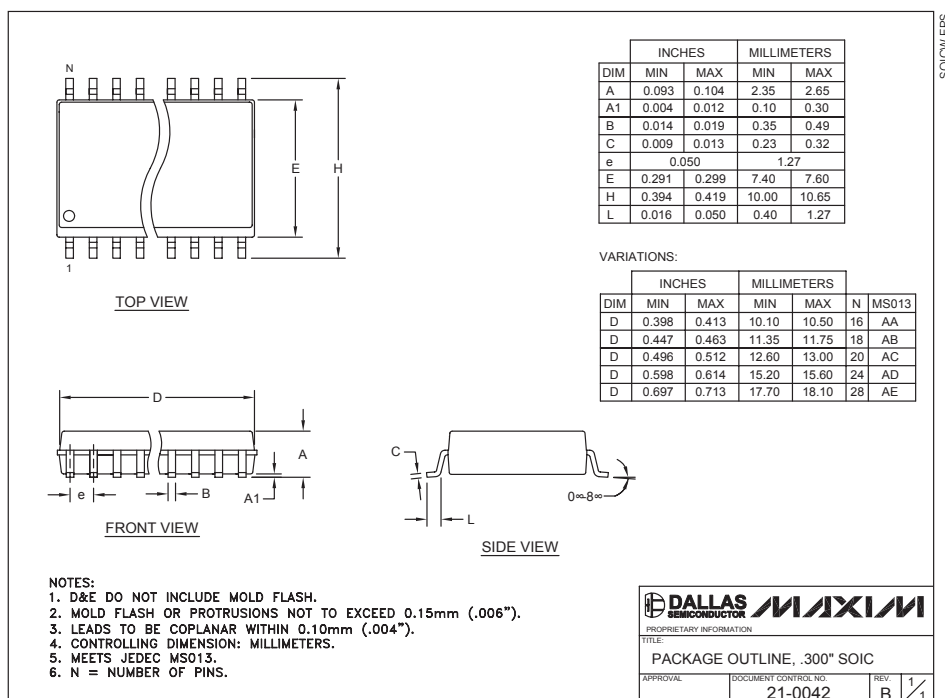
TRANSISTOR COUNT: 950

SUBSTRATE CONNECTED TO  $V_{CC}$



# Microprocessor and Nonvolatile Memory Supervisory Circuits

## Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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[NCP305LSQ16T1G](#) [NCP305LSQ17T1G](#) [NCP305LSQ18T1G](#) [NCP305LSQ24T1G](#) [NCP305LSQ25T1G](#) [NCP305LSQ29T1G](#)  
[NCP305LSQ31T1G](#) [NCP305LSQ32T1G](#) [NCP308MT250TBG](#) [NCP308SN300T1G](#) [NCP391FCALT2G](#) [NCV303LSN42T1G](#)  
[NCV308SN330T1G](#) [CAT1161LI-25-G](#) [CAT853STBI-T3](#) [MAX1232CPA](#) [MAX705CPA](#) [CAT1026LI-30-G](#) [CAT1320LI-25-G](#) [CAT872-30ULGT3](#) [LA-ispPAC-POWR1014-01TN48E](#) [NCP304HSQ18T1G](#) [NCP304HSQ29T1G](#) [NCP304LSQ27T1G](#) [NCP304LSQ29T1G](#)  
[NCP304LSQ45T1G](#) [NCP305LSQ26T1G](#) [NCP305LSQ35T1G](#) [NCP305LSQ37T1G](#) [NCP308MT300TBG](#) [NCV300LSN36T1G](#)  
[NCV302LSN30T1G](#) [NCV303LSN16T1G](#) [NCV303LSN22T1G](#) [NCV303LSN27T1G](#) [NCV33161DMR2G](#) [TC54VN2402EMB713](#)  
[MCP1316T-44NE/OT](#) [MCP1316MT-45GE/OT](#) [MCP1316MT-23LI/OT](#) [MCP1316T-26LE/OT](#) [MAX8997EWW+](#) [MAX821RUS+T](#)  
[MAX6725AKASYD3-LF-T](#)