

3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

ABSOLUTE MAXIMUM RATINGS

| | |
|--|---|
| Terminal Voltage (with respect to GND) | |
| V _{CC} | -0.3V to 6.0V |
| V _{BATT} | -0.3V to 6.0V |
| All Other Inputs | -0.3V to the higher of V _{CC} or V _{BATT} |
| Continuous Input Current | |
| V _{CC} | 200mA |
| V _{BATT} | 50mA |
| GND | 20mA |
| Output Current | |
| V _{OUT} | 200mA |
| All Other Outputs | 20mA |

| | |
|--|-----------------|
| Continuous Power Dissipation (T _A = +70°C) | |
| 8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) | 727mW |
| 8-Pin SO (derate 5.88mW/°C above +70°C) | 471mW |
| 16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) | 842mW |
| 16-Pin Narrow SO (derate 9.52mW/°C above +70°C) | 696mW |
| Operating Temperature Ranges | |
| MAX793_C_/MAX794C_/MAX795_C_ | 0°C to +70°C |
| MAX793_E_/MAX794E_/MAX795_E_ | -40°C to +85°C |
| Storage Temperature Range | -65°C to +160°C |
| Lead Temperature (soldering, 10sec) | +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_{CC} = 3.17V to 5.5V for the MAX793T/MAX795T, V_{CC} = 3.02V to 5.5V for the MAX793S/MAX795S, V_{CC} = 2.72V to 5.5V for the MAX793R/MAX794/MAX795R, V_{BATT} = 3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|-------------------------------------|---|--|-------------------------|-------------------------|---------------------------|-------|
| Operating Voltage Range, V _{CC} , V _{BATT} (Note 1) | | MAX79_C | | 1.0 | | 5.5 | V |
| | | MAX79_E | | 1.1 | | 5.5 | |
| V _{CC} Supply Current (excluding I _{OUT} , I _{CE} OUT) | I _{SUPPLY} | MAX793/MAX794, M _R = V _{CC} | V _{CC} < 3.6V | | 46 | 60 | μA |
| | | | V _{CC} < 5.5V | | 62 | 80 | |
| | | MAX795 | V _{CC} < 3.6V | | 35 | 50 | |
| | | | V _{CC} < 5.5V | | 49 | 70 | |
| V _{CC} Supply Current in Battery-Backup Mode (excluding I _{OUT}) | I _{SUPPLY} | V _{CC} = 2.1V, V _{BATT} = 2.3V | MAX793/MAX794 | | 32 | 45 | μA |
| | | | MAX795 | | 24 | 35 | |
| BATT Supply Current (excluding I _{OUT}) (Note 2) | | | | | | 1 | μA |
| BATT Leakage Current, Freshness Seal Enabled | | V _{CC} = 0V, V _{OUT} = 0V | | | | 1 | μA |
| Battery Leakage Current (Note 3) | | | | | | 0.5 | μA |
| OUT Output Voltage in Normal Mode | V _{OUT} | I _{OUT} = 75mA | | V _{CC} - 0.3 | V _{CC} - 0.125 | | V |
| | | I _{OUT} = 30mA (Note 4) | | V _{CC} - 0.12 | V _{CC} - 0.050 | | |
| | | I _{OUT} = 250μA (Note 4) | | V _{CC} - 0.001 | V _{CC} - 0.5mV | | |
| OUT Output Voltage in Battery-Backup Mode | V _{OUT} | V _{BATT} = 2.3V | I _{OUT} = 250μA | | V _{BATT} - 0.1 | V _{BATT} - 0.034 | V |
| | | | I _{OUT} = 1mA | | | V _{BATT} - 0.14 | |
| Battery Switch Threshold (V _{CC} falling) | V _{CC} - V _{BATT} | V _{SW} > V _{CC} > 1.75V (Note 5) | | | 20 | 65 | mV |
| | | V _{SW} | V _{BATT} > V _{CC} (Note 6) | MAX793T/MAX795T | 2.69 | 2.82 | |
| | MAX793S/MAX795S | | | 2.55 | 2.68 | 2.80 | |
| | MAX793R/MAX795R/MAX794 | | | 2.30 | 2.41 | 2.52 | |
| Battery Switch Threshold (V _{CC} rising) (Note 7) | V _{CC} - V _{BATT} | This value is identical to the reset threshold, V _{CC} rising for V _{BATT} > V _{RST} | | | | | mV |
| | | V _{BATT} < V _{RST} | | | 25 | 65 | |

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MAX793/MAX794/MAX795

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 3.17V to 5.5V for the MAX793T/MAX795T, V_{CC} = 3.02V to 5.5V for the MAX793S/MAX795S, V_{CC} = 2.72V to 5.5V for the MAX793R/MAX794/MAX795R, V_{BATT} = 3.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|---|------------------------|---|----------------------|---------------------|--------------------|-------|---|
| Reset Threshold (Note 8) | V _{RST} | V _{CC} Falling | MAX793T/MAX795T | 3.00 | 3.075 | 3.15 | V |
| | | | MAX793S/MAX795S | 2.85 | 2.925 | 3.00 | |
| | | | MAX793R/MAX795R | 2.55 | 2.625 | 2.70 | |
| | V _{CC} Rising | MAX793T/MAX795T | 3.00 | 3.085 | 3.17 | | |
| | | MAX793S/MAX795S | 2.85 | 2.935 | 3.02 | | |
| | | MAX793R/MAX795R | 2.55 | 2.635 | 2.72 | | |
| RESET IN Threshold (MAX794 only) | V _{RST IN} | V _{CC} Falling | 1.212 | 1.240 | 1.262 | V | |
| | | V _{CC} Rising | 1.212 | 1.250 | 1.282 | | |
| RESET IN Leakage Current (MAX794 only) | | | -25 | 2 | 25 | nA | |
| Reset Timeout Period | t _{RP} | V _{CC} < 3.6V | 140 | 200 | 280 | ms | |
| LOWLINE-to-Reset Threshold, (V _{LOWLINE} - V _{RST}), V _{CC} Falling | V _{LR} | MAX793 | 30 | 45 | 60 | mV | |
| | | MAX794 | 5 | 15 | 25 | | |
| Low-Line Comparator Hysteresis | | MAX793 | | 10 | | mV | |
| | | MAX794 | | 10 | | mV | |
| LOWLINE Threshold, V _{CC} Rising | V _{LL} | MAX793T/MAX795T | | | 3.23 | V | |
| | | MAX793S/MAX795S | | | 3.08 | | |
| | | MAX793R/MAX795R | | | 2.78 | | |
| | | MAX794 | | | 1.317 | | |
| PFI Input Threshold | V _{TH} | V _{PFI} falling | 1.212 | 1.240 | 1.262 | V | |
| | | V _{PFI} rising | 1.212 | 1.250 | 1.287 | | |
| PFI Input Current | | | -25 | 2 | 25 | nA | |
| PFI Hysteresis, PFI Rising | | | | 10 | 20 | mV | |
| BATT OK Threshold (MAX793) | V _{BOK} | | 2.00 | 2.25 | 2.50 | V | |
| INPUT AND OUTPUT LEVELS | | | | | | | |
| RESET Output Voltage High | V _{OH} | I _{SOURCE} = 300μA, V _{CC} = V _{RST} min | 0.8V _{CC} | 0.86V _{CC} | | V | |
| BATT OK, BATT ON, \overline{WDO} , LOWLINE Output Voltage High | V _{OH} | I _{SOURCE} = 300μA, V _{CC} = V _{RST} max | 0.8V _{CC} | 0.86V _{CC} | | V | |
| \overline{PFO} Output Voltage High | V _{OH} | I _{SOURCE} = 65μA, V _{CC} = V _{RST} max | 0.8V _{CC} | | | V | |
| BATT ON Output Voltage High | V _{OH} | I _{SOURCE} = 100μA, V _{CC} = 2.3V, V _{BATT} = 3V | 0.8V _{BATT} | | | V | |
| RESET Output Leakage Current (Note 9) | I _{LEAK} | V _{CC} = V _{RST} max | -1 | | -1 | μA | |
| \overline{PFO} Output Short to GND Current | I _{SC} | V _{CC} = 3.3V, V \overline{PFO} = 0V | | 180 | 500 | μA | |
| \overline{PFO} , \overline{RESET} , RESET, \overline{WDO} , LOWLINE Output Voltage Low | V _{OL} | I _{SINK} = 1.2mA; \overline{RESET} , $\overline{LOWLINE}$ tested with V _{CC} = V _{RST} min; RESET, BATTOK, \overline{WDO} tested with V _{CC} = V _{RST} max | | 0.08 | 0.2V _{CC} | V | |

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ELECTRICAL CHARACTERISTICS (continued)

($V_{CC} = 3.17V$ to $5.5V$ for the MAX793T/MAX795T, $V_{CC} = 3.02V$ to $5.5V$ for the MAX793S/MAX795S, $V_{CC} = 2.72V$ to $5.5V$ for the MAX793R/MAX794/MAX795R, $V_{BATT} = 3.6V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|-------------------|--|---------------|----------|-------------|----------|
| \overline{RESET} Output Voltage Low | V_{OL} | MAX79_C, $V_{BATT} = V_{CC} = 1.0V$, $I_{SINK} = 40\mu A$ | | 0.13 | 0.3 | V |
| | | MAX79_E, $V_{BATT} = V_{CC} = 1.2V$, $I_{SINK} = 200\mu A$ | | 0.17 | 0.3 | |
| BATT ON Output Voltage Low | V_{OL} | $I_{SINK} = 3.2mA$, $V_{CC} = V_{RST}$ max | | | $0.2V_{CC}$ | V |
| All Inputs Including \overline{PFO} (Note 10) | V_{IH} | V_{RST} max < $V_{CC} < 5.5V$ | | | $0.7V_{CC}$ | V |
| | V_{IL} | | $0.3V_{CC}$ | | | |
| MANUAL RESET INPUT | | | | | | |
| \overline{MR} Pulse Width | t _{MR} | MAX793/MAX794 only | 100 | 50 | | ns |
| \overline{MR} -to-Reset Delay | t _{MD} | MAX793/MAX794 only | | 75 | 250 | ns |
| \overline{MR} Pull-Up Current | | MAX793/MAX794 only, $\overline{MR} = 0V$ | 25 | 70 | 250 | μA |
| CHIP-ENABLE GATING | | | | | | |
| \overline{CE} IN Leakage Current | I _{LEAK} | Disable mode | | ± 10 | | nA |
| \overline{CE} IN-to- \overline{CE} OUT Resistance | | Enable mode, $V_{CC} = V_{RST}$ max | | 46 | | Ω |
| \overline{CE} IN-to- \overline{CE} OUT Propagation Delay | | $V_{CC} = V_{RST}$ max, Figure 9 | | 2 | 7 | ns |
| \overline{CE} OUT Drive from \overline{CE} IN | V_{OH} | $V_{CC} = V_{RST}$ max, $I_{OUT} = -1mA$, $V_{\overline{CE} IN} = V_{CC}$ | $0.8V_{CC}$ | | | V |
| | V_{OL} | $V_{CC} = V_{RST}$ max, $I_{OUT} = 1.6mA$, $V_{\overline{CE} IN} = 0V$ | | | $0.2V_{CC}$ | |
| Reset to \overline{CE} OUT High Delay | | | | 10 | | μs |
| \overline{CE} OUT Output Voltage High (reset active) | V_{OH} | $I_{OH} = 500\mu A$, $V_{CC} < 2.3V$ | $0.8V_{BATT}$ | | | V |
| WATCHDOG (MAX793/MAX794 only) | | | | | | |
| WDI Input Current | | $0V < V_{CC} < 5.5V$ | -1 | 0.01 | 1 | μA |
| Watchdog Timeout Period | t _{WD} | | 1.00 | 1.60 | 2.25 | sec |
| WDI Pulse Width | | | 1.00 | | | ns |

Note 1: V_{CC} supply current, logic input leakage, watchdog functionality (MAX793/MAX794), \overline{MR} functionality (MAX793/MAX794), PFI functionality (MAX793/MAX794), state of \overline{RESET} and $RESET$ (MAX793/MAX794) tested at $V_{BATT} = 3.6V$ and $V_{CC} = 5.5V$. The state of \overline{RESET} is tested at $V_{CC} = V_{CC}$ min.

Note 2: Tested at $V_{BATT} = 3.6V$, $V_{CC} = 3.5V$ and $0V$. The battery current will rise to $10\mu A$ over a narrow transition window around $V_{CC} = 1.9V$.

Note 3: Leakage current into the battery is tested under the worst-case conditions at $V_{CC} = 5.5V$, $V_{BATT} = 1.8V$ and $V_{CC} = 1.5V$, $V_{BATT} = 1.0V$.

Note 4: Guaranteed by design.

Note 5: When $V_{SW} > V_{CC} > V_{BATT}$, OUT remains connected to V_{CC} until V_{CC} drops below V_{BATT} . The V_{CC} -to- V_{BATT} comparator has a small 15mV typical hysteresis to prevent oscillation. For $V_{CC} < 1.75V$ (typical), OUT switches to $BATT$ regardless of V_{BATT} .

Note 6: When $V_{BATT} > V_{CC} > V_{SW}$, OUT remains connected to V_{CC} until V_{CC} drops below the battery switch threshold (V_{SW}).

Note 7: OUT switches from $BATT$ to V_{CC} when V_{CC} rises above the reset threshold, if $V_{BATT} > V_{RST}$. In this case, switchover back to V_{CC} occurs at the exact voltage that causes reset to be asserted, however switchover occurs 200ms prior to reset. If $V_{BATT} < V_{RST}$, OUT switches from $BATT$ to V_{CC} when V_{CC} exceeds V_{BATT} .

Note 8: The reset threshold tolerance is wider for V_{CC} rising than for V_{CC} falling to accommodate the 10mV typical hysteresis, which prevents internal oscillation.

Note 9: The leakage current into or out of the \overline{RESET} pin is tested with \overline{RESET} not asserted (\overline{RESET} output high impedance).

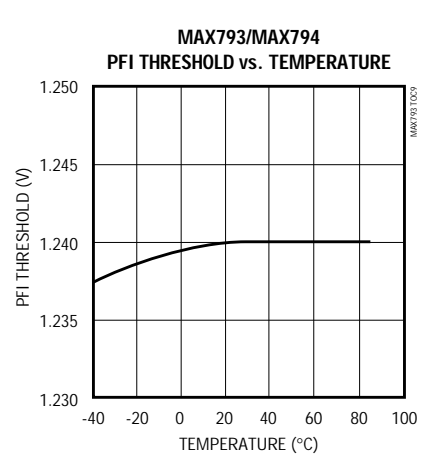
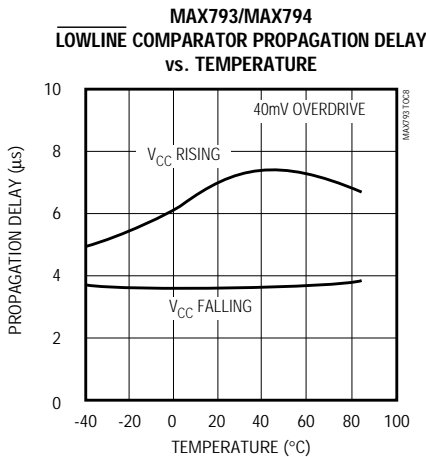
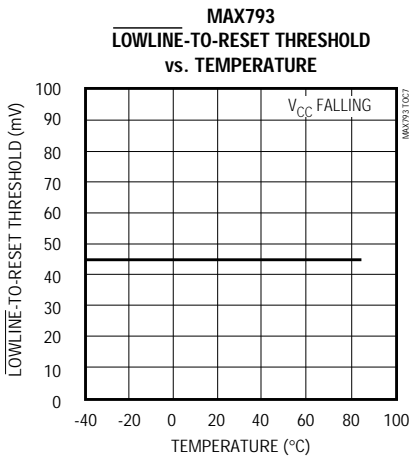
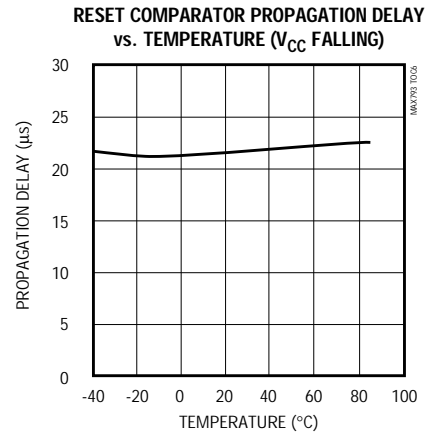
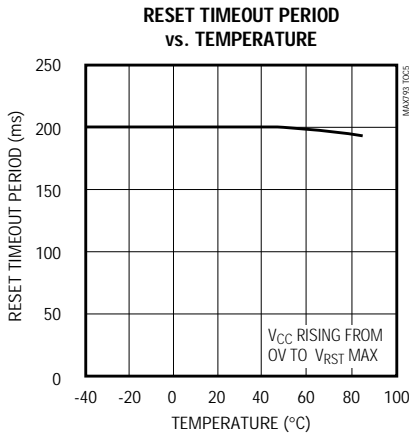
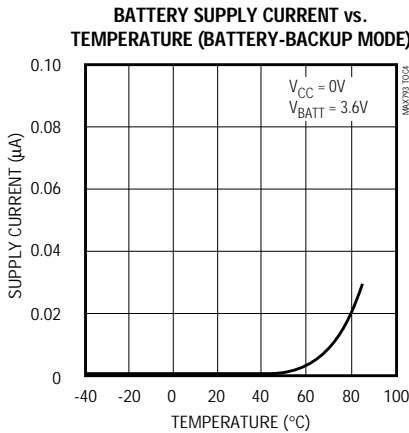
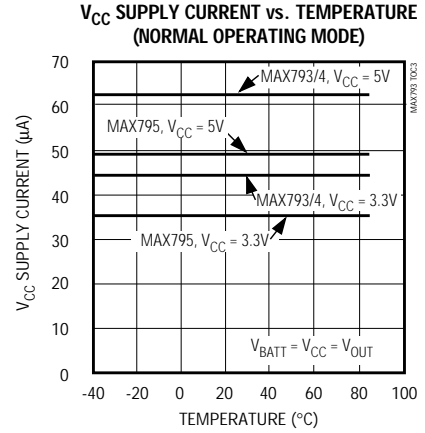
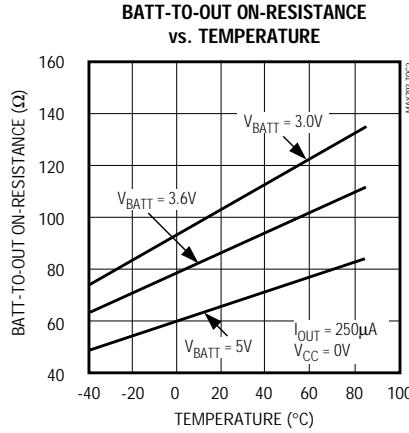
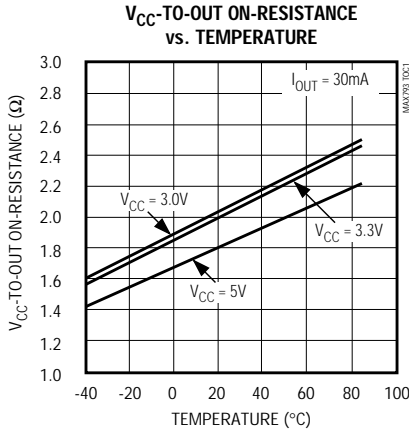
Note 10: \overline{PFO} is normally an output, but is used as an input when activating the battery freshness seal.

3.0V/3.3V/Adjustable Microprocessor Supervisory Circuits

Typical Operating Characteristics

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

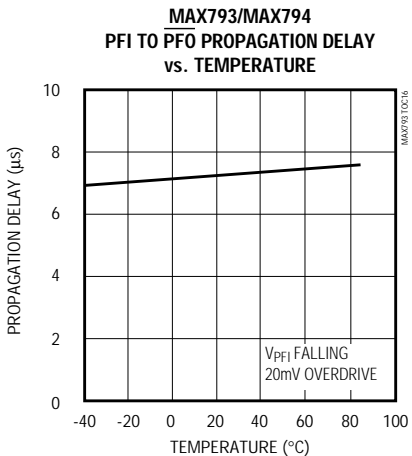
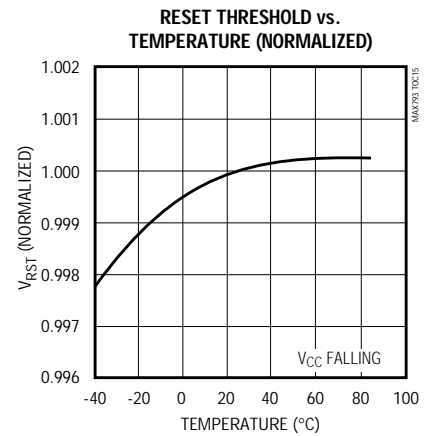
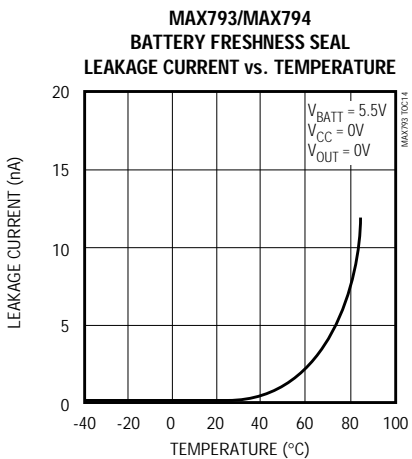
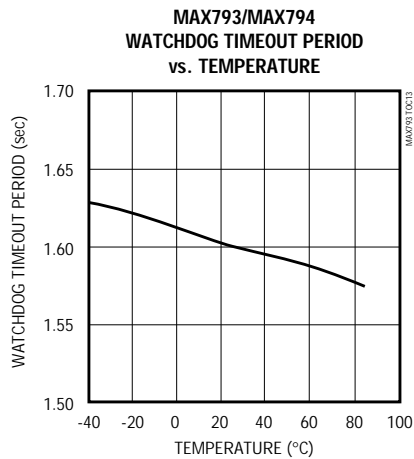
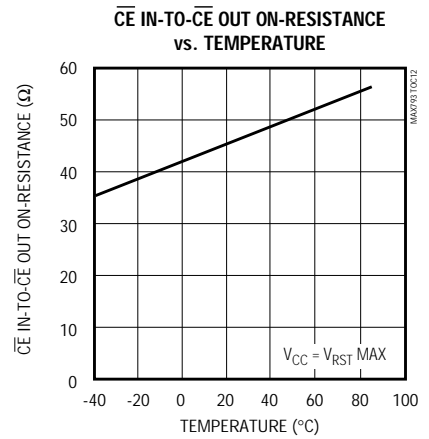
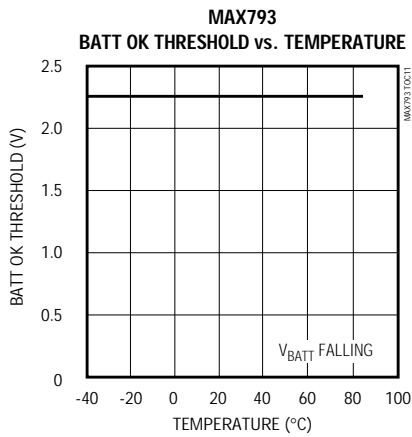
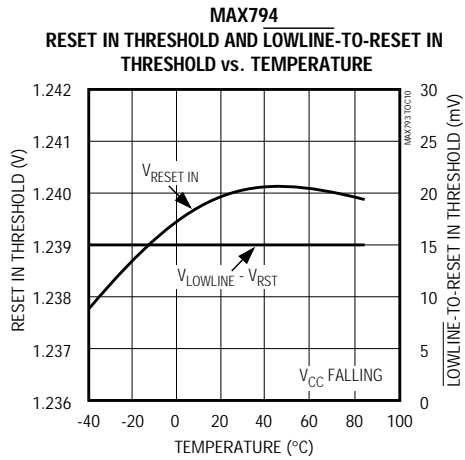
MAX793/MAX794/MAX795



3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

Typical Operating Characteristics (continued)

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



3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

Pin Description

MAX793/MAX794/MAX795

| PIN | | NAME | FUNCTION |
|-------------------|--------|----------------------|--|
| MAX793/ MAX794 | MAX795 | | |
| 1 | 1 | OUT | Supply Output for CMOS RAM. When V_{CC} rises above the reset threshold or above V_{BATT} , OUT is connected to V_{CC} through an internal P-channel MOSFET switch. When V_{CC} falls below V_{SW} and V_{BATT} , BATT connects to OUT. |
| 2 | 2 | V_{CC} | Main Supply Input |
| 3 | — | BATT OK (MAX793) | Battery Status Output. High in normal operating mode when V_{BATT} exceeds V_{BOK} , otherwise low. V_{BATT} is checked continuously. Disabled and logic low while V_{CC} is below V_{SW} . |
| | | RESET IN (MAX794) | Reset Input. Connect to an external resistor divider to select the reset threshold. The reset threshold can be programmed anywhere in the V_{SW} to 5.5V range. |
| 4 | — | PFI | Power-Fail Comparator Input. When PFI is less than V_{PFT} or when V_{CC} falls below V_{SW} , \overline{PFO} goes low; otherwise, \overline{PFO} remains high (see <i>Power-Fail Comparator</i> section). Connect to V_{CC} if unused. |
| 5 | 3 | BATT ON | Logic Output/External Bypass Switch-Driver Output. High when OUT switches to BATT. Low when OUT switches to V_{CC} . Connect the base/gate of PNP/PMOS transistor to BATT ON for I_{OUT} requirements exceeding 75mA. |
| 6 | 4 | GND | Ground |
| 7 | — | \overline{PFO} | Power-Fail Comparator Output. When PFI is less than V_{PFT} or when V_{CC} falls below V_{SW} , \overline{PFO} goes low; otherwise, \overline{PFO} remains high. \overline{PFO} is also used to enable the battery freshness seal (see <i>Battery Freshness Seal</i> , and <i>Power-Fail Comparator</i> sections). |
| 8 | — | \overline{MR} | Manual Reset Input. A logic low on \overline{MR} asserts reset. Reset remains asserted as long as \overline{MR} is low and for 200ms after \overline{MR} returns high. The active-low input has an internal 70 μ A pull-up current. In can be driven from a TTL- or CMOS-logic line or shorted to ground with a switch. Leave open if unused. |
| 9 | — | \overline{WDO} | Watchdog Output. \overline{WDO} goes low if WDI remains either high or low for longer than the watchdog timeout period. \overline{WDO} returns high on the next transition of WDI. \overline{WDO} is a logic high for $V_{SW} < V_{CC} < V_{RST}$, and low when V_{CC} is below V_{SW} . |
| 10 | — | WDI | Watchdog Input. If WDI remains either high or low for longer than the watchdog timeout period, the internal watchdog timer runs out and \overline{WDO} goes low. \overline{WDO} returns high on the next transition of WDI. Connect \overline{WDO} to \overline{MR} to generate a reset due to a watchdog fault. |
| 11 | 5 | \overline{CE} IN | Chip-Enable Input. The input to the chip-enable gating circuit. Connect to GND if unused |
| 12 | 6 | \overline{CE} OUT | Chip-Enable Output. \overline{CE} OUT goes low only when \overline{CE} IN is low and reset is not asserted. If \overline{CE} IN is low when reset is asserted, \overline{CE} OUT will remain low for 10 μ s or until \overline{CE} IN goes high, whichever occurs first. \overline{CE} OUT is pulled up to OUT. |
| 13 | — | RESET | Active-High Reset Output. Sources and sinks current. RESET is the inverse of \overline{RESET} . |
| 14 | — | $\overline{LOWLINE}$ | Early Power-Fail Warning Output. Low when V_{CC} falls to V_{LR} . This output can be used to generate an NMI to provide early warning of imminent power-failure. |
| 15 | 7 | \overline{RESET} | Open-Drain, Active-Low Reset Output. Pulses low for 200ms when triggered, and stays low whenever V_{CC} is below the reset threshold or when \overline{MR} is a logic low. It remains low for 200ms after either V_{CC} rises above the reset threshold, the watchdog triggers a reset (WDO connected to \overline{MR}), or \overline{MR} goes low to high. |
| 16 | 8 | BATT | Backup-Battery Input. When V_{CC} falls below V_{SW} and V_{BATT} , OUT switches from V_{CC} to BATT. When V_{CC} rises above the reset threshold or above V_{BATT} , OUT reconnects to V_{CC} . V_{BATT} may exceed V_{CC} . Connect V_{CC} , OUT, and BATT together if no battery is used. |

3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

Detailed Description

General Timing Characteristics

The MAX793/MAX794/MAX795 are designed for 3.3V and 3V systems, and provide a number of supervisory functions (see the *Selector Guide* on the front page). Figures 1 and 2 show the typical timing relationships of the various outputs during power-up and power-down with typical V_{CC} rise and fall times.

Manual Reset Input (MAX793/MAX794)

Many microprocessor-based products require manual-reset capability, allowing the operator, a test technician, or external logic circuitry to initiate a reset. On the MAX793/MAX794, a logic low on \overline{MR} asserts reset. Reset remains asserted while \overline{MR} is low, and for t_{RP} (200ms) after it returns high. During the first half of the reset time-

out period (t_{RP}), the state of \overline{MR} is ignored if \overline{PFO} is externally forced low, to facilitate enabling the battery freshness seal. \overline{MR} has an internal 70 μ A pull-up current, so it can be left open if it is not used. This input can be driven with TTL- or CMOS-logic levels, or with open-drain/collector outputs. Connect a normally open momentary switch from \overline{MR} to GND to create a manual-reset function; external debounce circuitry is not required. If \overline{MR} is driven from long cables or the device is used in a noisy environment, connect a 0.1 μ F capacitor from \overline{MR} to ground to provide additional noise immunity.

Reset Outputs

A microprocessor's (μ P's) reset input starts the μ P in a known state. These MAX793/MAX794/MAX795 μ P supervisory circuits assert a reset to prevent code execution errors during power-up, power-down, and

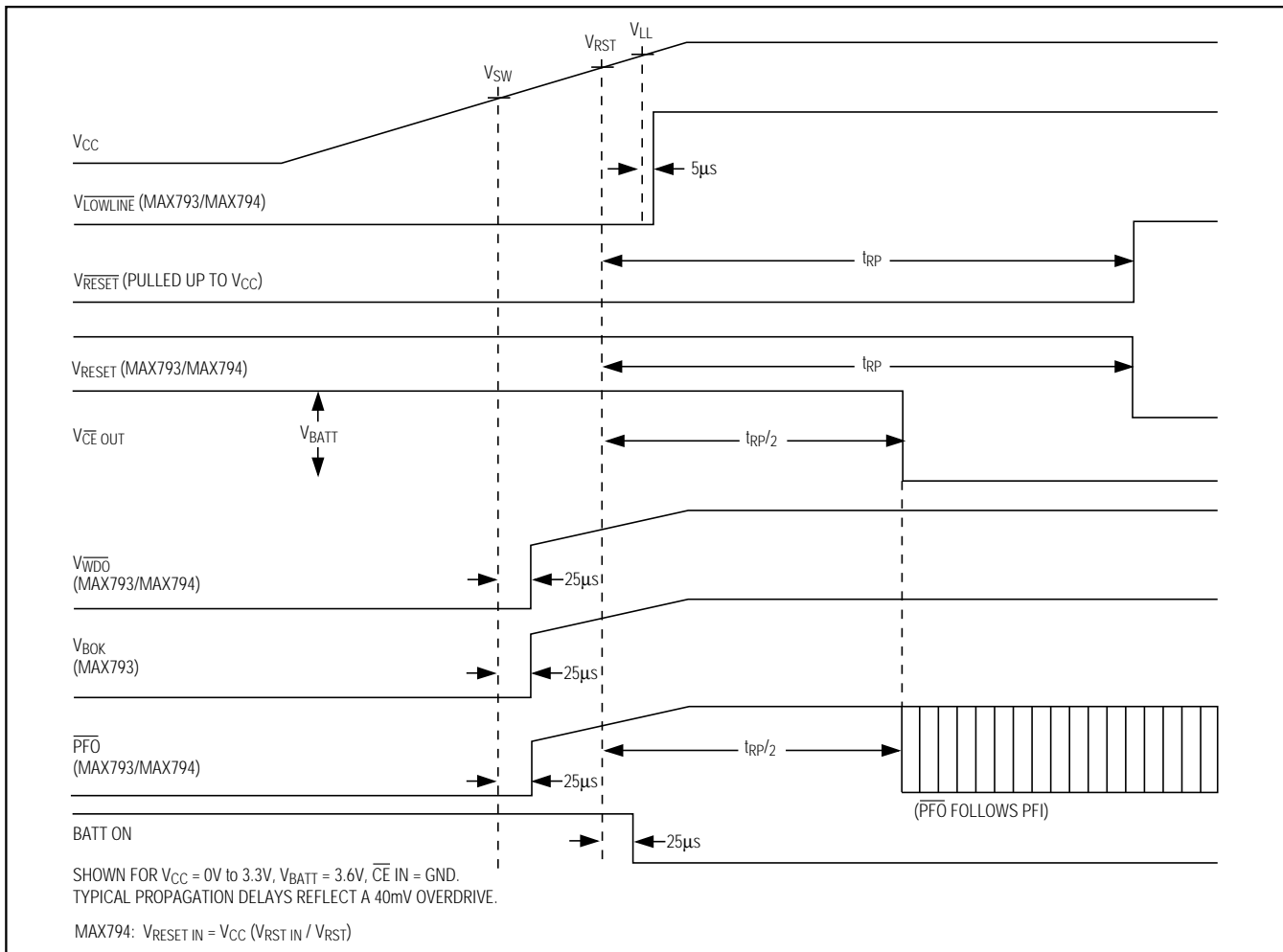


Figure 1. Timing Diagram, V_{CC} Rising

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brownout conditions. $\overline{\text{RESET}}$ is guaranteed to be a logic low for $0\text{V} < V_{\text{CC}} < V_{\text{RST}}$, provided V_{BATT} is greater than 1V . Without a backup battery ($V_{\text{BATT}} = V_{\text{CC}} = V_{\text{OUT}}$), $\overline{\text{RESET}}$ is guaranteed valid for $V_{\text{CC}} \geq 1\text{V}$. Once V_{CC} exceeds the reset threshold, an internal timer keeps $\overline{\text{RESET}}$ low for the reset timeout period (t_{RP}); after this interval, $\overline{\text{RESET}}$ becomes high impedance (Figure 2). $\overline{\text{RESET}}$ is an open-drain output, and requires a pull-up resistor to V_{CC} (Figure 3). Use a $4.7\text{k}\Omega$ to $1\text{M}\Omega$ pull-up resistor that will provide sufficient current to assure the proper logic levels to the μP .

If a brownout condition occurs (V_{CC} dips below the reset threshold), $\overline{\text{RESET}}$ goes low. Each time $\overline{\text{RESET}}$ is asserted, it stays low for the reset timeout period. Any time V_{CC} goes below the reset threshold, the internal timer restarts.

The watchdog output ($\overline{\text{WDO}}$) can also be used to initiate a reset. See the *Watchdog Output* section.

The $\overline{\text{RESET}}$ output is the inverse of the $\overline{\text{RESET}}$ output, and it can both source and sink current.

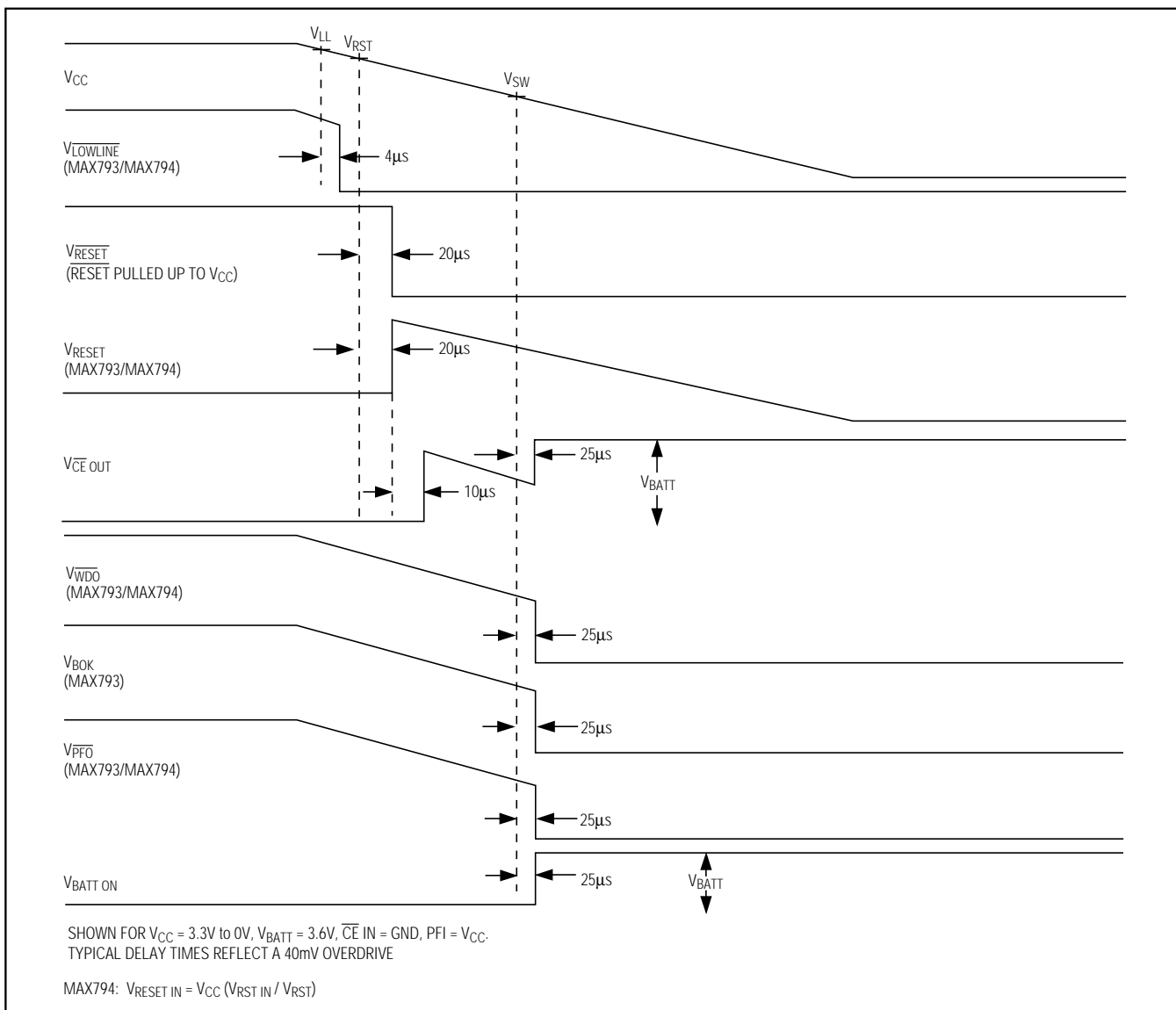


Figure 2. Timing Diagram, V_{CC} Falling

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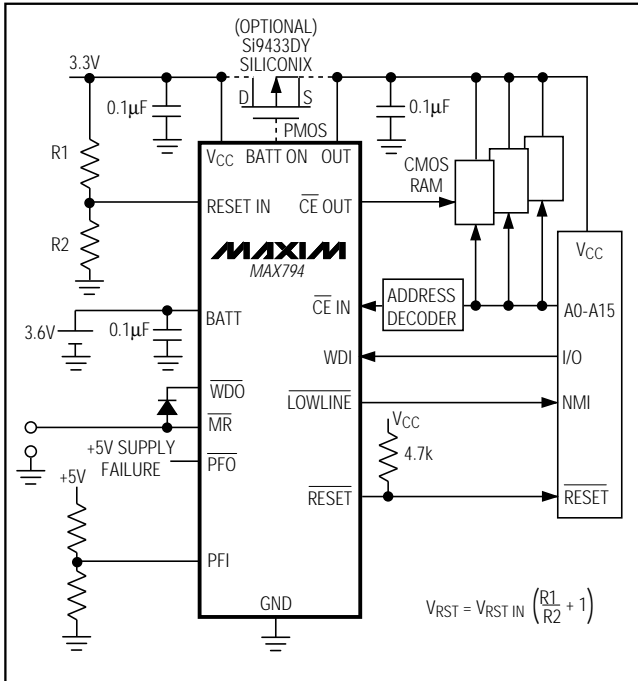


Figure 3. MAX794 Standard Application Circuit

Reset Threshold

The MAX793T/MAX795T are intended for 3.3V systems with a $\pm 5\%$ power-supply tolerance and a 10% systems tolerance. Except when \overline{MR} is asserted, reset will not assert as long as the power supply remains above 3.15V (3.3V - 5%). Reset is guaranteed to assert before the power supply falls below 3.0V (3.3V - 10%).

The MAX793S/MAX795S are designed for 3.3V $\pm 10\%$ power supplies. Except when \overline{MR} is asserted, they are guaranteed not to assert reset as long as the supply remains above 3.0V (3.0V is just above 3.3V - 10%). Reset is guaranteed to assert before the power supply falls below 2.85V (3.3V - 14%).

The MAX793R/MAX795R are optimized to monitor 3.0V $\pm 10\%$ power supplies. Reset will not occur until V_{CC} falls below 2.7V (3.0V - 10%), but is guaranteed to occur before the supply falls below 2.55V (3.0V - 15%).

Program the MAX794's reset threshold with an external voltage divider to RESET IN. The reset-threshold tolerance will be a combination of the RESET IN tolerance and the tolerance of the resistors used to make the external voltage divider. Calculate the reset threshold as follows:

$$V_{RST} = V_{RST\ IN} (R1 / R2 + 1)$$

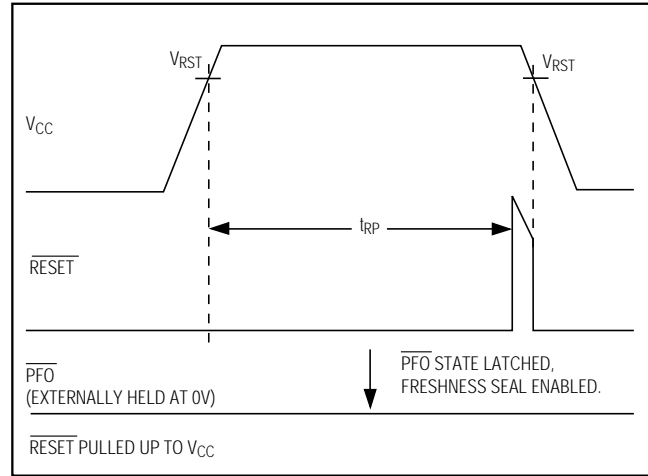


Figure 4. Battery Freshness Seal Enable Timing

Using the standard application circuit (Figure 3), the reset threshold may be programmed anywhere in the range of V_{SW} (the battery switch threshold) to 5.5V. Reset is asserted when V_{CC} falls below V_{SW} .

Battery Freshness Seal

The MAX793/MAX794's battery freshness seal disconnects the backup battery from internal circuitry until it is needed. This allows an OEM to ensure that the backup battery connected to BATT will be fresh when the final product is put to use. To enable the freshness seal, connect a battery to BATT, ground PFO, bring V_{CC} above the reset threshold and hold it there until reset is deasserted following the reset timeout period, then bring V_{CC} back down again (Figure 4). Once the battery freshness seal is enabled (disconnecting the backup battery from the internal circuitry and anything connected to OUT), it remains enabled until V_{CC} is brought above V_{RST} . Note that connecting \overline{PFO} to \overline{MR} will not interfere with battery freshness seal operation.

BATT OK Output (MAX793)

BATT OK indicates the status of the backup battery. When reset is not asserted, the MAX793 checks the battery voltage continuously. If V_{BATT} is below V_{BOK} (2.0V min), BATT OK goes low; otherwise, it remains pulled up to V_{CC} . BATT OK also goes low when V_{CC} goes below V_{SW} .

Watchdog Input (MAX793/MAX794)

In the MAX793/MAX794, the watchdog circuit monitors the μP 's activity. If the μP does not toggle the watchdog input (WDI) within 1.6sec, \overline{WDO} goes low. The internal 1.6sec timer is cleared and \overline{WDO} returns high

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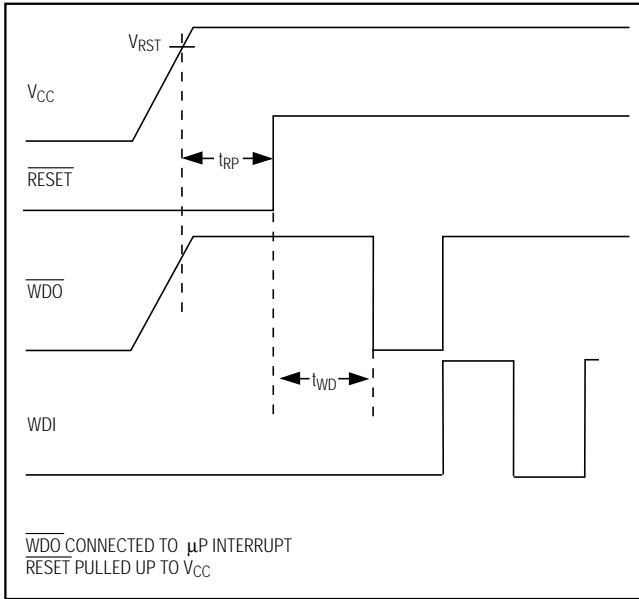


Figure 5. Watchdog Timing Relationship

either when a reset occurs or when a transition (low-to-high or high-to-low) takes place at WDI. As long as reset is asserted, the timer remains cleared and does not count. As soon as reset is released or WDI changes state, the timer starts counting (Figure 5). WDI can detect pulses as short as 100ns. Unlike the 5V MAX690 family, the watchdog function **cannot** be disabled.

Watchdog Output (MAX793/MAX794)

In the MAX793/MAX794, \overline{WDO} remains high (\overline{WDO} is pulled up to V_{CC}) if there is a transition or pulse at WDI during the watchdog timeout period. \overline{WDO} goes low if no transition occurs at WDI during the watchdog timeout period. The watchdog function is disabled and \overline{WDO} is a logic high when reset is asserted if V_{CC} is above V_{SW} . \overline{WDO} is a logic low when V_{CC} is below V_{SW} .

If a system reset is desired on every watchdog fault, simply diode-OR connect \overline{WDO} to \overline{MR} (Figure 6). When a watchdog fault occurs in this mode, \overline{WDO} goes low, pulling \overline{MR} low, which causes a reset pulse to be issued. Ten microseconds after reset is asserted, the watchdog timer clears and \overline{WDO} returns high. This delay results in a 10 μ s pulse at \overline{WDO} , allowing external circuitry to “capture” a watchdog fault indication. A continuous high or low on WDI will cause 200ms reset pulses to be issued every 1.6sec.

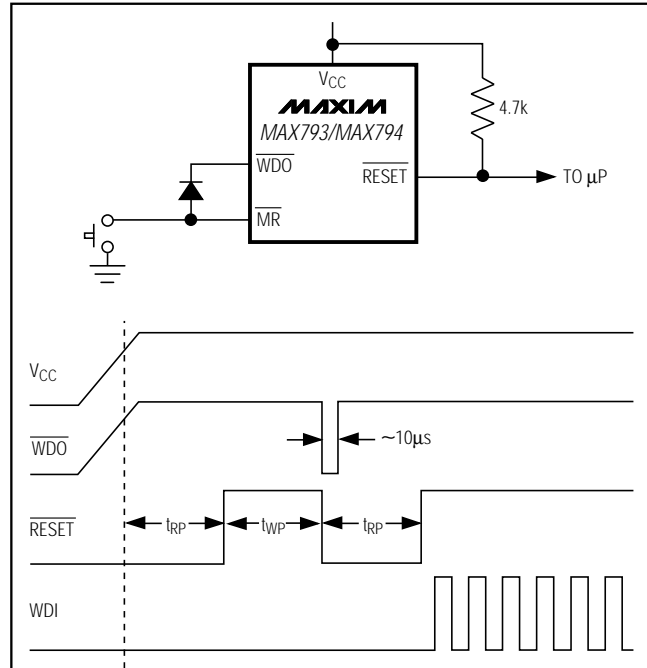


Figure 6. Generating a Reset on Each Watchdog Fault

Chip-Enable Signal Gating

Internal gating of chip-enable (CE) signals prevents erroneous data from corrupting CMOS RAM in the event of an undervoltage condition. The MAX793/MAX794/MAX795 use a series transmission gate from \overline{CE} IN to \overline{CE} OUT (Figure 7). 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 short CE propagation delay from \overline{CE} IN to \overline{CE} OUT enables these μ P supervisors to be used with most μ Ps. If \overline{CE} IN is low when reset asserts, \overline{CE} OUT remains low for typically 10 μ s to permit completion of the current write cycle.

Chip-Enable Input

The CE transmission gate is disabled and \overline{CE} IN is high impedance (disabled mode) while reset is asserted. During a power-down sequence when V_{CC} passes the reset threshold, the CE transmission gate disables and \overline{CE} IN immediately becomes high impedance if the voltage at \overline{CE} IN is high. If \overline{CE} IN is low when reset asserts, the CE transmission gate will disable at the moment \overline{CE} IN goes high, or 10 μ s after reset asserts, whichever occurs first (Figure 8). This permits the current write cycle to complete during power-down.

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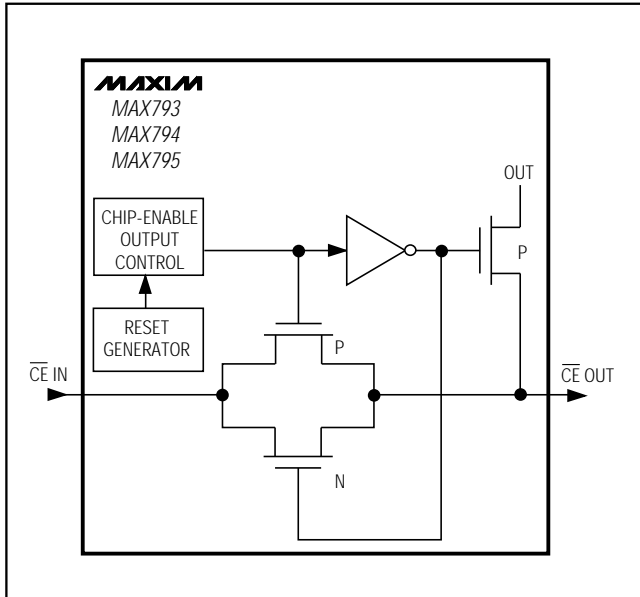


Figure 7. Chip-Enable Transmission Gate

The CE transmission gate remains disabled and \overline{CE} IN remains high impedance (regardless of \overline{CE} IN activity) for the first half of the reset timeout period ($t_{RP} / 2$), any time a reset is generated. While disabled, \overline{CE} IN is high impedance. When the CE transmission gate is enabled, the impedance of \overline{CE} IN appears as a 46 Ω resistor in series with the load at \overline{CE} OUT.

The propagation delay through the CE transmission gate depends on V_{CC} , the source impedance of the drive connected to \overline{CE} IN, and the loading on \overline{CE} OUT (see the Chip-Enable Propagation Delay vs. \overline{CE} OUT Load Capacitance graph in the *Typical Operating Characteristics*). The CE propagation delay is production tested from the 50% point on \overline{CE} IN to the 50% point on \overline{CE} OUT using a 50 Ω driver and 50pF of load capacitance (Figure 9). For minimum propagation delay, minimize the capacitive load at \overline{CE} OUT, and use a low-output-impedance driver.

Chip-Enable Output

When the CE transmission gate is enabled, the impedance of \overline{CE} OUT is equivalent to a 46 Ω resistor in series with the source driving \overline{CE} IN. In the disabled mode, the transmission gate is off and an active pull-up connects \overline{CE} OUT to OUT (Figure 8). This pull-up turns off when the transmission gate is enabled.

Early Power-Fail Warning (MAX793/MAX794)

Critical systems often require an early warning indicating that power is failing. This warning provides time for the μ P to store vital data and take care of any additional “housekeeping” functions, before the power supply gets too far out of tolerance for the μ P to operate reliably. The MAX793/MAX794 offer two methods of achieving this early warning. If access to the unregulated supply is feasible, the power-fail comparator input (PFI) can be connected to the unregulated supply

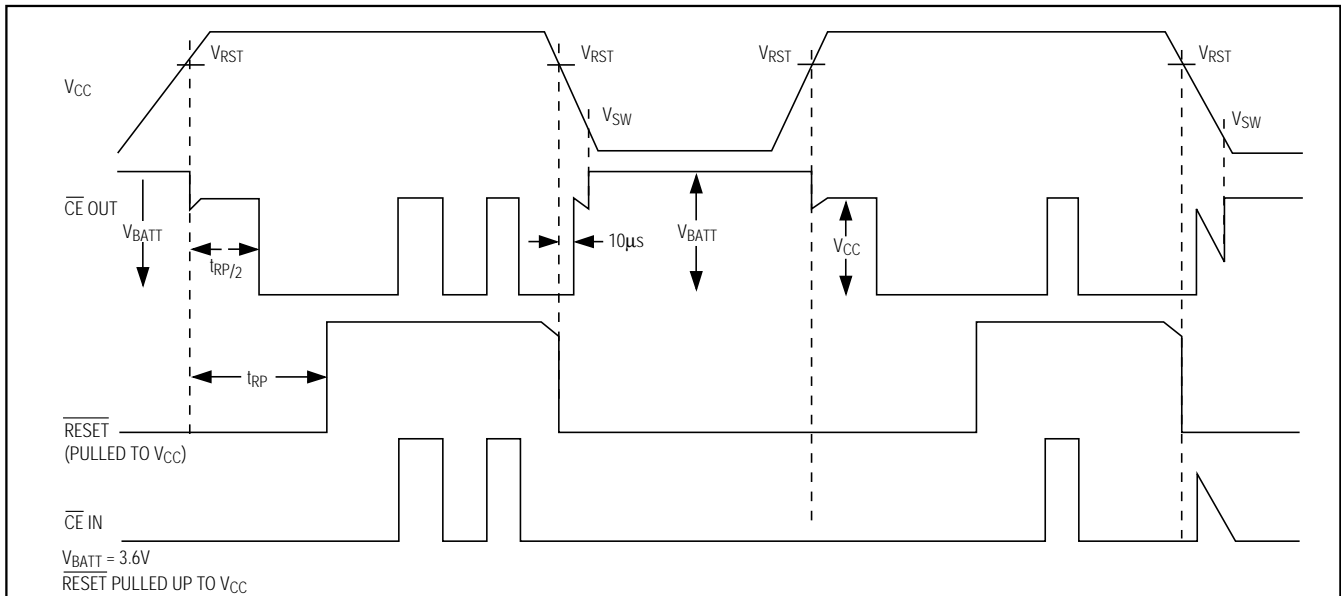


Figure 8. Chip-Enable Timing

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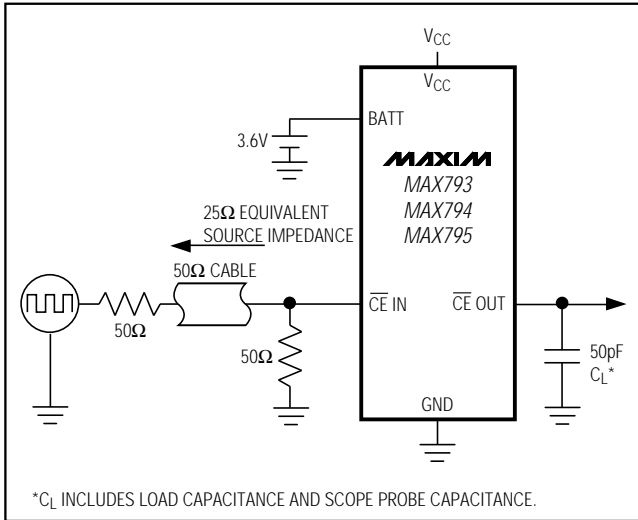


Figure 9. CE Propagation Delay Test Circuit

through a voltage divider, with the power-fail comparator output ($\overline{\text{PFO}}$) providing the NMI to the μP (Figure 10). If there is no easy access to the unregulated supply, the $\overline{\text{LOWLINE}}$ output can be used to generate an NMI to the μP (see $\overline{\text{LOWLINE}}$ Output section).

$\overline{\text{LOWLINE}}$ Output (MAX793/MAX794)

The low-line comparator monitors V_{CC} with a threshold voltage typically 45mV above the reset threshold (10mV of hysteresis) for the MAX793, and 15mV above RESET IN (4mV of hysteresis) for the MAX794. For normal operation (V_{CC} above the reset threshold), $\overline{\text{LOWLINE}}$ is

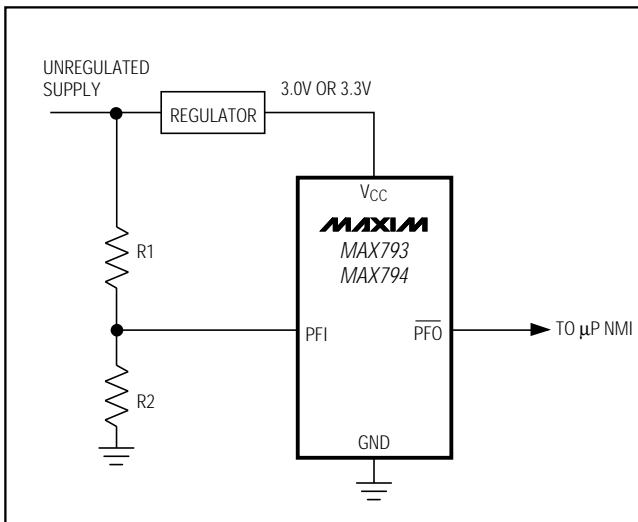


Figure 10. Using the Power-Fail Comparator to Generate Power-Fail Warning

pulled to V_{CC} . Use $\overline{\text{LOWLINE}}$ to provide an NMI to the μP when power begins to fall.

In most battery-operated portable systems, reserve energy in the battery provides ample time to complete the shutdown routine once the low-line warning is encountered and before reset asserts. If the system must also contend with a more rapid V_{CC} fall time, such as when the main battery is disconnected or a high-side switch is opened during normal operation, use capacitance on the V_{CC} line to provide time to execute the shutdown routine (Figure 11).

First, calculate the worst-case time required for the system to perform its shutdown routine. Then, with the worst-case shutdown time, the worst-case load current, and the minimum low-line to reset threshold ($V_{\text{LR min}}$), calculate the amount of capacitance required to allow the shutdown routine to complete before reset is asserted:

$$C_{\text{HOLD}} > I_{\text{LOAD}} \times t_{\text{SHDN}} / V_{\text{LR}}$$

where I_{LOAD} is the current being drained from the capacitor, V_{LR} is the low-line to reset threshold difference ($V_{\text{LL}} - V_{\text{RST}}$), and t_{SHDN} is the time required for the system to complete an orderly shutdown routine.

Power-Fail Comparator (MAX793/MAX794)

The MAX793/MAX794's PFI input is compared to an internal reference. If PFI is less than the power-fail threshold (V_{PFT}), $\overline{\text{PFO}}$ goes low. The power-fail comparator is intended for use as an undervoltage detector to signal a falling power supply (Figure 12). However, the comparator does not need to be dedicated to this function because it is completely separate from the rest of the circuitry.

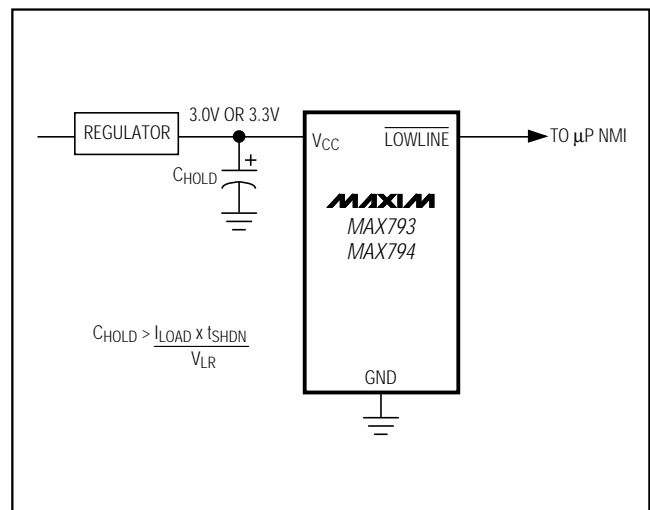


Figure 11. Using $\overline{\text{LOWLINE}}$ to Provide Power-Fail Warning to the μP

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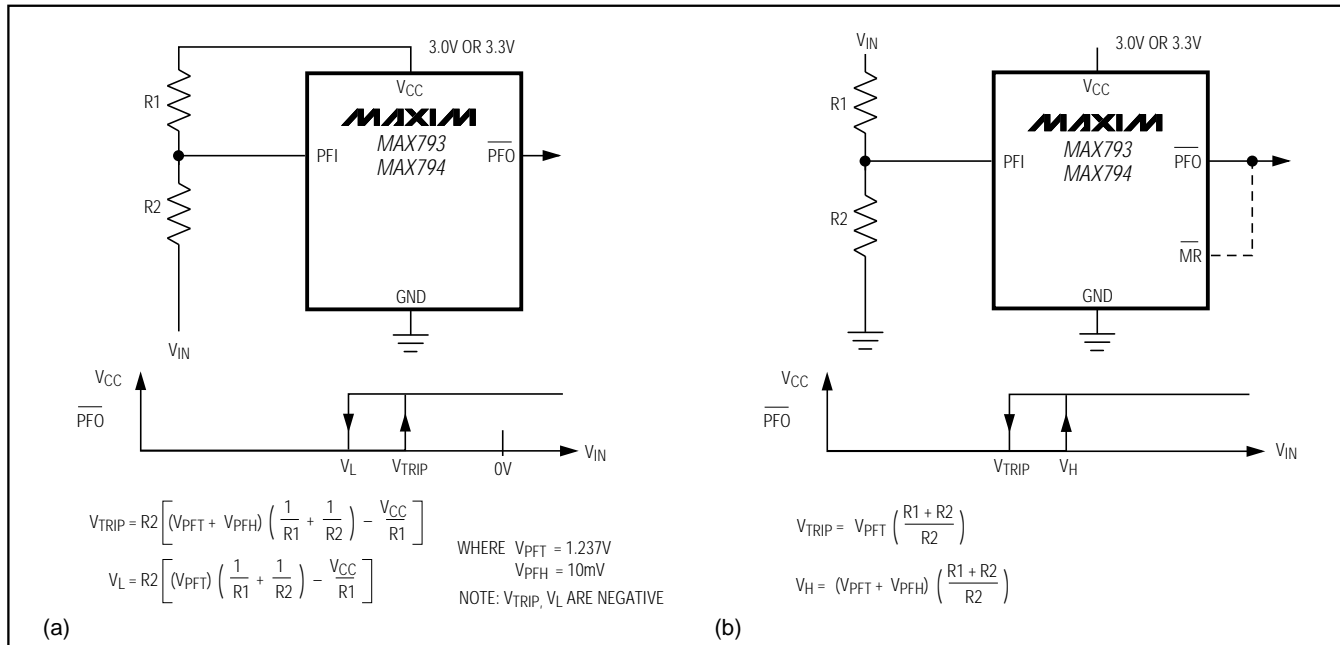


Figure 12. Using the Power-Fail Comparator to Monitor an Additional Power Supply: (a) V_{IN} Is Negative, (b) V_{IN} Is Positive

The power-fail comparator turns off and \overline{PFO} goes low when V_{CC} falls below V_{SW} on power-down. During the first half of the reset timeout period (t_{RP}), \overline{PFO} is forced high, irrespective of V_{PFI} . At the beginning of the second half of t_{RP} , the power-fail comparator is enabled and \overline{PFO} follows PFI . If the comparator is unused, connect PFI to V_{CC} and leave PFO unconnected. \overline{PFO} may be connected to \overline{MR} so that a low voltage on PFI will generate a reset (Figure 12b). In this configuration, when the monitored voltage causes PFI to fall below V_{PFT} , \overline{PFO} pulls \overline{MR} low, causing a reset to be asserted. Reset remains asserted as long as \overline{PFO} holds \overline{MR} low, and for 200ms after \overline{PFO} pulls \overline{MR} high when the monitored supply is above the programmed threshold.

Backup-Battery Switchover

In the event of a brownout or power failure, it may be necessary to preserve the contents of RAM. With a backup battery installed at $BATT$, the devices automatically switch RAM to backup power when V_{CC} falls. In order to allow the backup battery (e.g., a 3.6V lithium cell) to have a higher voltage than V_{CC} , this family of μP supervisors (designed for 3.3V and 3V systems) does not always connect $BATT$ to OUT when V_{BATT} is greater than V_{CC} . $BATT$ connects to OUT (through a 140 Ω switch) either when V_{CC} falls below V_{SW} and

V_{BATT} is greater than V_{CC} , or when V_{CC} falls below 1.75V (typ) regardless of the $BATT$ voltage.

Switchover at V_{SW} ensures that battery-backup mode is entered before V_{OUT} gets too close to the 2.0V minimum required to reliably retain data in most CMOS RAM, (switchover at higher V_{CC} voltages would decrease backup-battery life). When V_{CC} recovers, switchover is deferred either until V_{CC} crosses V_{BATT} if V_{BATT} is below V_{RST} , or when V_{CC} rises above the reset threshold (V_{RST}) if V_{BATT} is above V_{RST} . This power-up switchover technique prevents V_{CC} from charging the backup battery through OUT when using an external transistor driven by $BATT ON$. OUT connects to V_{CC} through a 4 Ω (max) PMOS power switch when V_{CC} crosses the reset threshold (Figure 13).

BATT ON (MAX793/MAX794)

$BATT ON$ is high when OUT is connected to $BATT$. Although $BATT ON$ can be used as a logic output to indicate the battery switchover status, it is most often used as a gate or base drive for an external pass transistor for high-current applications (see *Driving an External Switch with BATT ON* in the *Applications Information* section). When V_{CC} exceeds V_{RST} on power-up, $BATT ON$ sinks 3.2mA at 0.4V. In battery-backup mode, this terminal sources 100 μA from $BATT$.

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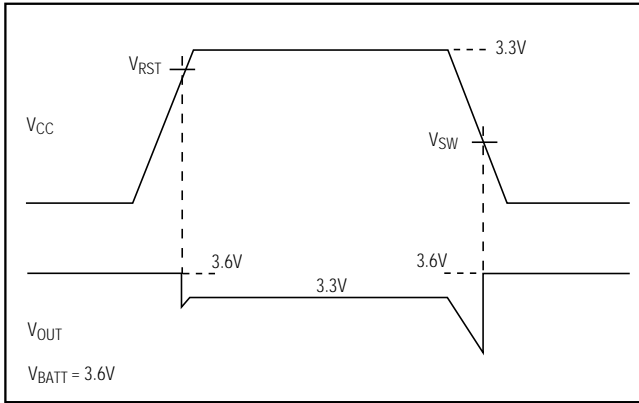


Figure 13. Battery Switchover Timing

Table 1. Input and Output Status in Battery-Backup Mode

| PIN NAME | STATUS |
|----------|---|
| OUT | Connected to BATT through an internal 140Ω switch |
| VCC | Disconnected from OUT |
| BATT ON | Pulled up to BATT |
| BATT OK | Logic low |
| PFI | Disabled |
| PFO | Logic low |
| MR | Disabled, but still pulled up to VCC |
| WDO | Logic low |
| WDI | Disabled |
| RESET | Logic low |
| RESET | Pulled up to VCC |
| BATT | Connected to OUT |
| LOWLINE | Logic low |
| CE IN | High impedance |
| CE OUT | Pulled to BATT |

Applications Information

These μP supervisory circuits are not short-circuit protected. Shorting VOUT to ground, excluding power-up transients such as charging a decoupling capacitor, destroys the device. Decouple both VCC and BATT pins to ground by placing 0.1μF ceramic capacitors as close to the device as possible.

Driving an External Switch with BATT ON

BATT ON can be directly connected to the base of a PNP transistor or the gate of a PMOS transistor. The PNP connection is straightforward: connect the emitter

to VCC, the collector to OUT, and the base to BATT ON (Figure 14a). No current-limiting resistor is required, but a resistor connecting the base of the PNP to BATT ON can be used to limit the current drawn from VCC, prolonging battery life in portable equipment.

If you are using a PMOS transistor, however, it must be connected backwards from the traditional method. Connect the gate to BATT ON, the drain to VCC, and the source to OUT (Figure 14b). This method orients the body diode from VCC to OUT and prevents the backup battery from discharging through the FET when its gate is high. Two PMOS transistors in the Siliconix LITTLE FOOT™ series are specified with VGS down to -2.7V. The Si9433DY has a maximum 100mΩ drain-source on-resistance with 2.7V of gate drive and a 2A drain-source current. The Si9434DY specifies a 60mΩ drain-source on-resistance with 2.7V of gate drive and a 5.1A drain-source current.

Using a SuperCap™ as a Backup Power Source

SuperCaps™ are capacitors with extremely high capacitance values (e.g., order of 0.47F) for their size. Figure 15 shows two ways to use a SuperCap as a backup power source. The SuperCap can be connected through a diode to the 3V input (Figure 15a); or, if a 5V supply is also available, the SuperCap can be charged up to the 5V supply (Figure 15b), allowing a longer backup period. Since VBATT can exceed VCC while VCC is above the reset threshold, there are no special precautions when using these μP supervisors with a SuperCap.

Operation without a Backup Power Source

These μP supervisors were designed for battery-backed applications. If a backup battery is not used, connect BATT, OUT, and VCC together, or use a different μP supervisor. See the μP Supervisory Circuits table at the end of this data sheet.

Replacing the Backup Battery

The backup power source can be removed while VCC remains valid, without danger of triggering a reset pulse, provided that BATT is decoupled with a 0.1μF capacitor to ground. As long as VCC stays above the reset threshold, battery-backup mode cannot be entered.

™ LITTLE FOOT is a trademark of Siliconix Inc.
SuperCap is a trademark of Baknor Industries.

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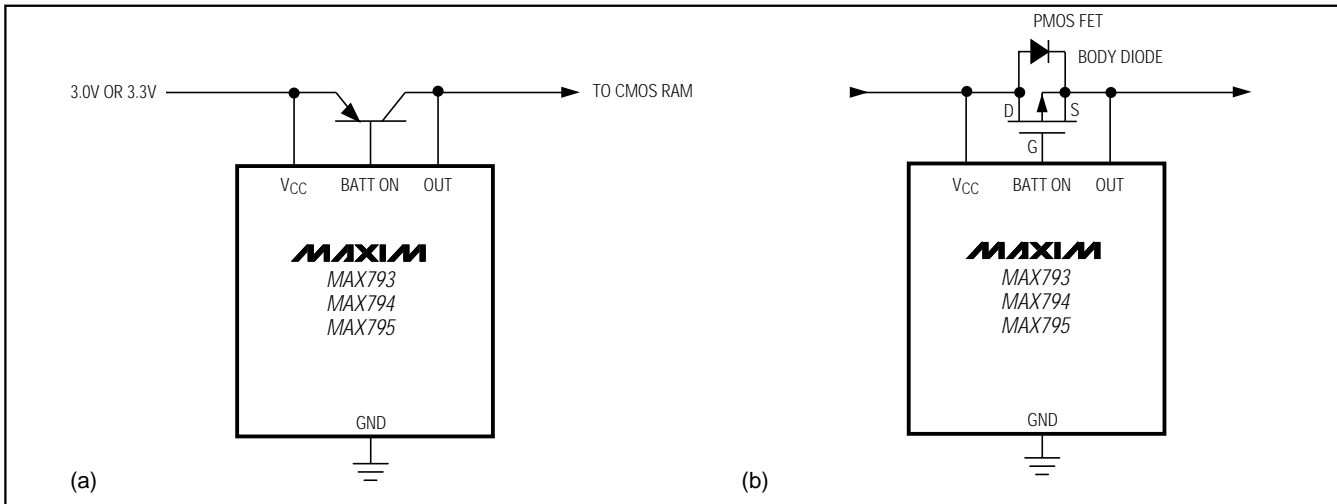


Figure 14. Driving an External Transistor with BATT ON

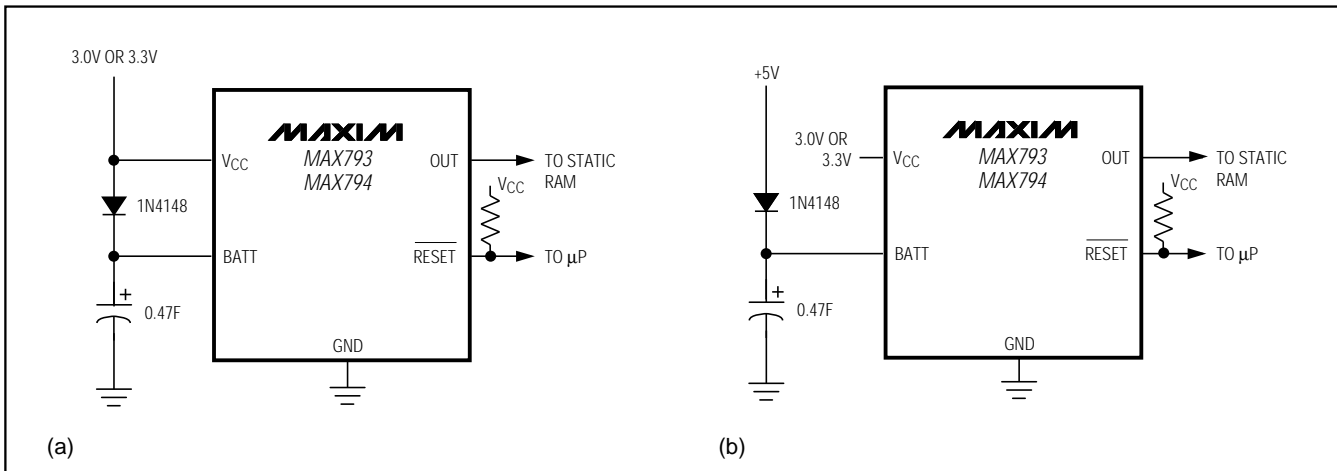


Figure 15. Using a SuperCap™ as a Backup Source

Erratum

Initial versions of the MAX793 and MAX794 have a logic design error that can cause the loss of output voltage (OUT) when V_{CC} is absent even though a backup battery is connected to the BATT input. Applications that do not use the \overline{MR} input (including all MAX795 applications) are unaffected by this phenomenon. Also, applications that do not use \overline{PFO} are unaffected if PFI is tied to V_{CC} .

The loss of output voltage is caused by the IC incorrectly entering the battery "freshness seal" mode. Normally, freshness seal mode is activated by grounding \overline{PFO} during a power-up reset timeout period. Then, the removal of V_{CC} powers the IC down without connecting the backup battery to OUT.

The IC decides whether or not to enter freshness seal mode during all reset timeout periods. During a power-up reset timeout period (which occurs when V_{CC} is raised above the MAX793's reset threshold or the voltage on the MAX794's RESET IN pin is raised above the RESET IN threshold), the IC momentarily disconnects the \overline{PFO} pin from the comparator output and lightly pulls \overline{PFO} up to V_{CC} . The voltage level on the \overline{PFO} pin is then tested and, if it is low, freshness seal mode is chosen. (\overline{PFO} is reconnected to the comparator output before the end of the reset timeout period.)

However, when a reset is initiated by \overline{MR} , the \overline{PFO} pin incorrectly remains connected to the comparator output during the entire timeout period and is not pulled up. If the comparator is driving \overline{PFO} low during an \overline{MR} reset

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MAX793/MAX794/MAX795

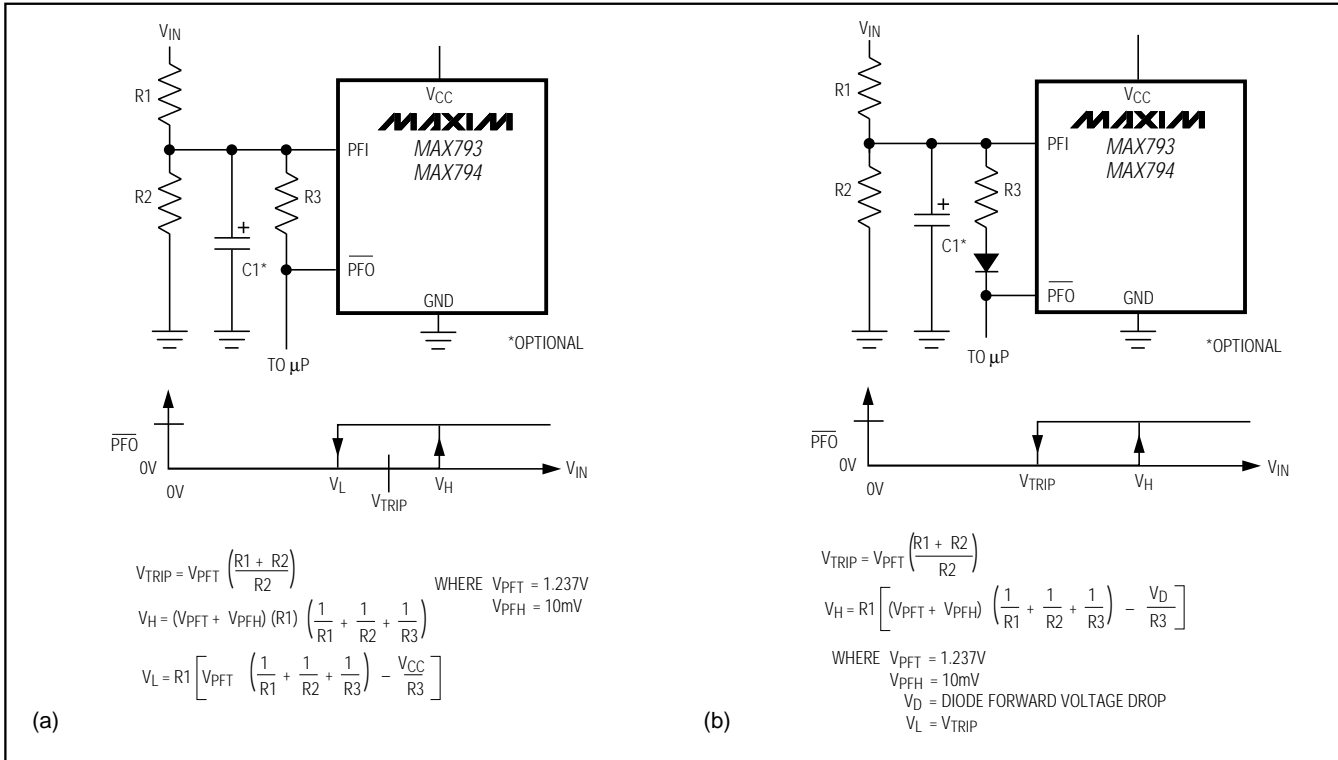


Figure 16. Adding Hysteresis to the Power-Fail Comparator: (a) Symmetrical Hysteresis, (b) Hysteresis Only on Rising V_{IN}

timeout period (because PFI is below the PFI threshold), the IC will test the voltage level on \overline{PFO} , find that it is low, and incorrectly decide to enter freshness seal mode. If V_{CC} is later removed, the backup battery will not be connected to OUT and any devices powered by OUT will lose power.

Applications that do not use the \overline{PFO} comparator need not be affected by this problem. Simply connect PFI to V_{CC} and \overline{PFO} will be driven high during all reset timeout periods. Freshness seal mode can be entered only when \overline{PFO} is low.

The IC is under revision to correct this problem. The revised IC will disable \overline{PFO} during all reset timeout periods including \overline{MR} -initiated ones. This revision will not affect applications that either do not use \overline{MR} or do not use \overline{PFO} , but could affect applications that require the use of the \overline{PFO} output during \overline{MR} -initiated reset timeout periods. The revised ICs are expected to be available in late 1996. For technical assistance, please contact Maxim Applications at 1-800-998-8800 or at <http://www.maxim-ic.com>.

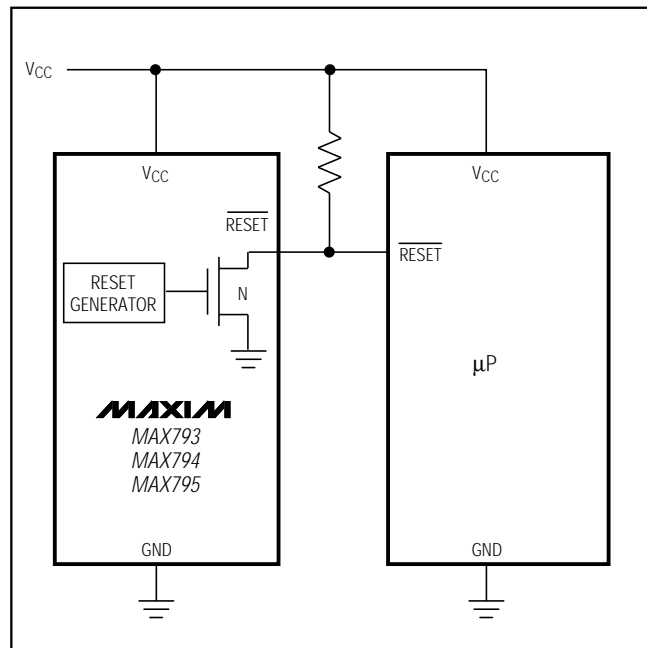


Figure 17. Interfacing to μP s with Bidirectional Reset I/O

3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

Adding Hysteresis to the Power-Fail Comparator (MAX793/MAX794)

The power-fail comparator has a typical input hysteresis of 10mV. This is sufficient for most applications where a power-supply line is being monitored through an external voltage divider (see the section *Monitoring an Additional Power Supply*).

If additional noise margin is desired, connect a resistor between $\overline{\text{PFO}}$ and PFI as shown in Figure 16a. Select the ratio of R1 and R2 such that PFI sees V_{PFT} when V_{IN} falls to its trip point (V_{TRIP}). R3 adds the additional hysteresis and should typically be more than 10 times the value of R1 or R2. The hysteresis window extends both above (V_{H}) and below (V_{L}) the original trip point (V_{TRIP}).

Connecting an ordinary signal diode in series with R3, as shown in Figure 16b, causes the lower trip point (V_{L}) to coincide with the trip point without hysteresis (V_{TRIP}), so the entire hysteresis window occurs above V_{TRIP} . This method provides additional noise margin without compromising the accuracy of the power-fail threshold when the monitored voltage is falling. It is useful for accurately detecting when a voltage falls past a threshold. The current through R1 and R2 should be at least $1\mu\text{A}$ to ensure that the 25nA (max over temperature) PFI input current does not shift the trip point. R3 should be larger than $82\text{k}\Omega$ so it does not load down the $\overline{\text{PFO}}$ pin. Capacitor C1 is optional, and adds noise rejection.

Monitoring an Additional Power Supply

These μP supervisors can monitor either positive or negative supplies using a resistor voltage divider to

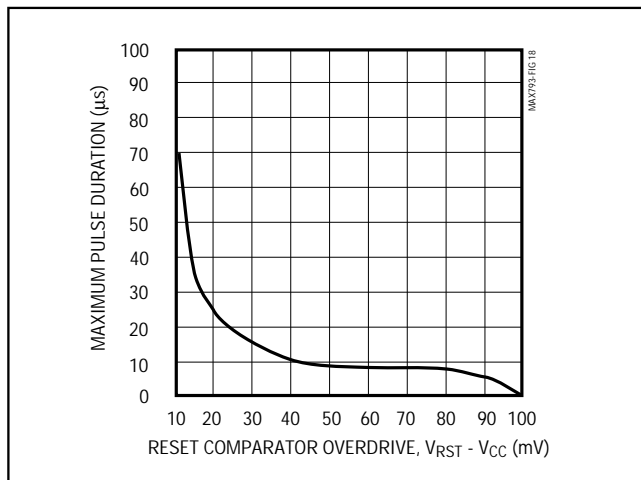


Figure 18. Maximum Transient Duration without Causing a Reset Pulse vs. Reset Comparator Overdrive

PFI. $\overline{\text{PFO}}$ can be used to generate an interrupt to the μP or to cause reset to assert (Figure 12).

Interfacing to μPs with Bidirectional Reset Pins

Since the $\overline{\text{RESET}}$ output is open drain, the MAX793/MAX794/MAX795 interface easily with μPs that have bidirectional reset pins, such as the Motorola 68HC11. Connecting the $\overline{\text{RESET}}$ output of the μP supervisor directly to the $\overline{\text{RESET}}$ input of the microcontroller with a single pull-up resistor allows either device to assert reset (Figure 17).

Negative-Going V_{CC} Transients

These supervisors are relatively immune to short-duration negative-going V_{CC} transients (glitches) while issuing resets to the μP during power-up, power-down, and brownout conditions. Therefore, resetting the μP when V_{CC} experiences only small glitches is usually not recommended.

Figure 18 shows maximum transient duration vs. reset-comparator overdrive, for which reset pulses are **not** generated. The graph was produced using negative-going V_{CC} pulses, starting at 3.3V 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 can typically

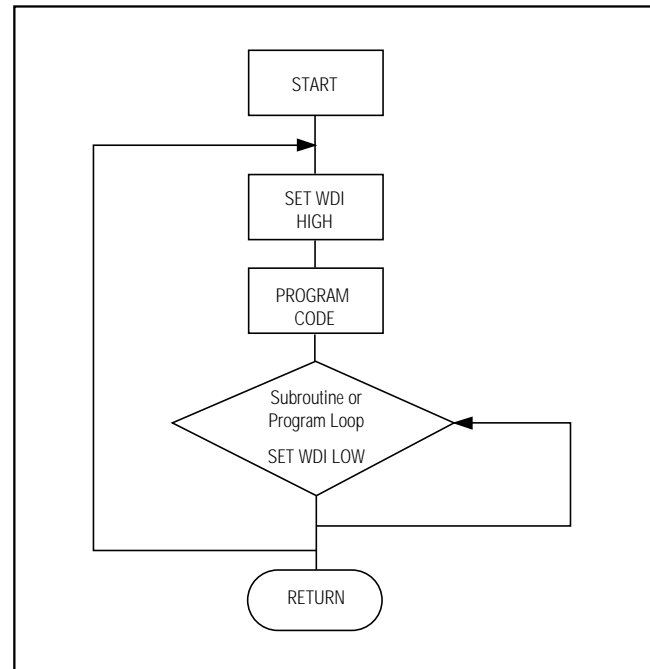


Figure 19. Watchdog Flow Diagram

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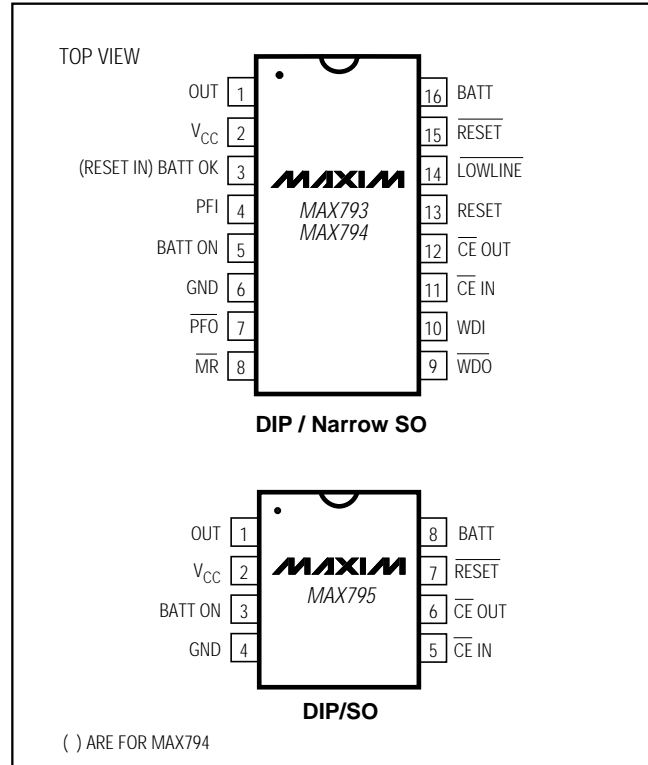
have without causing a reset pulse to be issued. As the amplitude of the transient increases (i.e., goes farther below the reset threshold), the maximum allowable pulse width decreases. Typically, a VCC transient that goes 40mV below the reset threshold and lasts for 10µs or less will not cause a reset pulse to be issued.

A 0.1µF bypass capacitor mounted close to the VCC pin provides additional transient immunity.

Watchdog Software Considerations

There is a way to help the watchdog timer monitor software execution more closely, which involves setting and resetting the watchdog input at different points in the program rather than “pulsing” the watchdog input high-low-high or low-high-low. This technique avoids a “stuck” loop, in which the watchdog timer would continue to be reset within the loop, keeping the watchdog from timing out. Figure 19 shows an example of a flow diagram where the I/O driving the watchdog input is set high at the beginning of the program, set low at the beginning of every subroutine or loop, then set high again when the program returns to the beginning. If the program should “hang” in any subroutine, the problem would quickly be corrected, since the I/O is continually set low and the watchdog timer is allowed to time out, causing a reset or interrupt to be issued.

Pin Configurations



MAX793/MAX794/MAX795

Ordering Information (continued)

| PART* | TEMP. RANGE | PIN-PACKAGE |
|------------|----------------|----------------|
| MAX794CPE | 0°C to +70°C | 16 Plastic DIP |
| MAX794CSE | 0°C to +70°C | 16 Narrow SO |
| MAX794EPE | -40°C to +85°C | 16 Plastic DIP |
| MAX794ESE | -40°C to +85°C | 16 Narrow SO |
| MAX795_CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX795_CSA | 0°C to +70°C | 8 SO |
| MAX795_EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX795_ESA | -40°C to +85°C | 8 SO |

* The MAX793/MAX795 offer a choice of reset threshold voltage. Select the letter corresponding to the desired reset threshold voltage range (T = 3.00V to 3.15V, S = 2.85V to 3.00V, R = 2.55V to 2.70V) and insert it into the blank to complete the part number. The MAX794's reset threshold is adjustable.

Chip Information

TRANSISTOR COUNT: 1271

3.0V/3.3V Adjustable Microprocessor Supervisory Circuits

Package Information

**Plastic DIP
PLASTIC
DUAL-IN-LINE
PACKAGE
(0.300 in.)**

| DIM | INCHES | | MILLIMETERS | |
|-----|--------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | — | 0.200 | — | 5.08 |
| A1 | 0.015 | — | 0.38 | — |
| A2 | 0.125 | 0.175 | 3.18 | 4.45 |
| A3 | 0.055 | 0.080 | 1.40 | 2.03 |
| B | 0.016 | 0.022 | 0.41 | 0.56 |
| B1 | 0.045 | 0.065 | 1.14 | 1.65 |
| C | 0.008 | 0.012 | 0.20 | 0.30 |
| D1 | 0.005 | 0.080 | 0.13 | 2.03 |
| E | 0.300 | 0.325 | 7.62 | 8.26 |
| E1 | 0.240 | 0.310 | 6.10 | 7.87 |
| e | 0.100 | — | 2.54 | — |
| eA | 0.300 | — | 7.62 | — |
| eB | — | 0.400 | — | 10.16 |
| L | 0.115 | 0.150 | 2.92 | 3.81 |

| PKG. | DIM | PINS | INCHES | | MILLIMETERS | |
|------|-----|------|--------|-------|-------------|-------|
| | | | MIN | MAX | MIN | MAX |
| P | D | 8 | 0.348 | 0.390 | 8.84 | 9.91 |
| P | D | 14 | 0.735 | 0.765 | 18.67 | 19.43 |
| P | D | 16 | 0.745 | 0.765 | 18.92 | 19.43 |
| P | D | 18 | 0.885 | 0.915 | 22.48 | 23.24 |
| P | D | 20 | 1.015 | 1.045 | 25.78 | 26.54 |
| N | D | 24 | 1.14 | 1.265 | 28.96 | 32.13 |

21-0043A

**Narrow SO
SMALL-OUTLINE
PACKAGE
(0.150 in.)**

| DIM | INCHES | | MILLIMETERS | |
|-----|--------|-------|-------------|------|
| | MIN | MAX | MIN | MAX |
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
| e | 0.050 | | 1.27 | |
| H | 0.228 | 0.244 | 5.80 | 6.20 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |

| DIM | PINS | INCHES | | MILLIMETERS | |
|-----|------|--------|-------|-------------|-------|
| | | MIN | MAX | MIN | MAX |
| D | 8 | 0.189 | 0.197 | 4.80 | 5.00 |
| D | 14 | 0.337 | 0.344 | 8.55 | 8.75 |
| D | 16 | 0.386 | 0.394 | 9.80 | 10.00 |

21-0041A

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