



# Microprocessor Supervisory Circuits

**MAX696/MAX697**

## General Description

The MAX696/MAX697 supervisory circuits reduce the complexity and number of components required for power-supply monitoring and battery-control functions in microprocessor ( $\mu$ P) systems. These include  $\mu$ P reset and backup-battery switchover, watchdog timer, CMOS RAM write protection, and power-failure warning. The MAX696/MAX697 significantly improve system reliability and accuracy compared to that obtained with separate ICs or discrete components.

The MAX696 and MAX697 are supplied in 16-pin packages and perform six functions:

- 1) A reset output during power-up, power-down, and brownout conditions. The threshold for this "low-line" reset is adjustable by an external voltage-divider.
- 2) A reset pulse if the optional watchdog timer has not been toggled within a specified time.
- 3) Individual outputs for low-line and watchdog fault conditions.
- 4) The reset time may be left at its default value of 50ms, or may be varied with an external capacitor or clock pulses.
- 5) A separate 1.3V threshold detector for power-fail warning, low-battery detection, or to monitor a power supply other than  $V_{CC}$ .

The MAX696 also has battery-backup switching for CMOS RAM, CMOS microprocessor, or other low-power logic.

The MAX697 lacks battery-backup switching, but has write-protection pins ( $\overline{CE}$  IN and  $\overline{CE}$  OUT) for CMOS RAM or EPROM. In addition, it consumes less than 250 microamperes.

## Applications

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

*Typical Operating Circuit appears at end of data sheet.*

*Pin Configurations continued at end of data sheet.*

## Features

- ◆ Adjustable Low-Line Monitor and Power-Down Reset
- ◆ Power-OK/Reset Time Delay
- ◆ Watchdog Timer—100ms, 1.6s, or Adjustable
- ◆ Minimum Component Count
- ◆ 1 $\mu$ A Standby Current
- ◆ Battery-Backup Power Switching (MAX696)
- ◆ On-Board Gating of Chip-Enable Signals (MAX697)
- ◆ Separate Monitor for Power-Fail or Low-Battery Warning

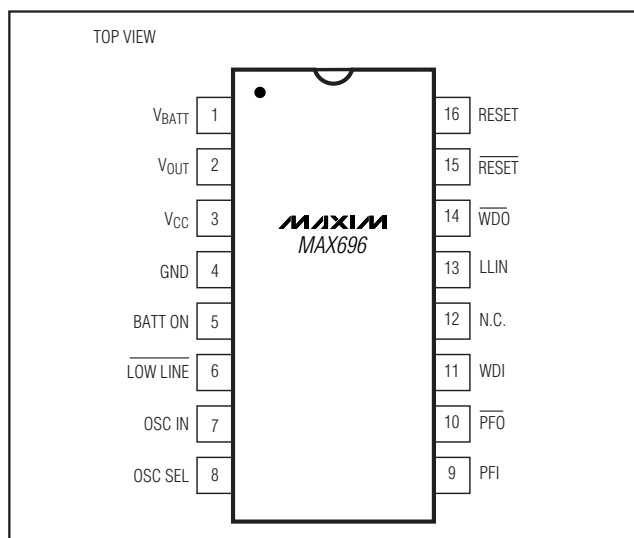
## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX696C/D	0°C to +70°C	Dice
MAX696CPE	0°C to +70°C	16 PDIP
MAX696CWE	0°C to +70°C	16 Wide SO
MAX696EPE	-40°C to +85°C	16 PDIP
MAX696EJE	-40°C to +85°C	16 CERDIP
MAX696EWE	-40°C to +85°C	16 Wide SO
MAX696MJE	-55°C to +125°C	16 CERDIP

*Ordering Information continued at end of data sheet.*

*Devices in PDIP and SO packages are available in both lead-ed 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.*

## Pin Configurations



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## ABSOLUTE MAXIMUM RATINGS

Terminal Voltage (with respect to GND)		Rate-of-Rise, $V_{BATT}$ , $V_{CC}$ .....	100V/ $\mu$ s
$V_{CC}$ .....	-0.3V to +6V	Operating Temperature Range	
$V_{BATT}$ .....	-0.3V to +6V	C Suffix .....	0°C to +70°C
All Other Inputs (Note 1) .....	-0.3V to ( $V_{OUT} + 0.5V$ )	E Suffix .....	-40°C to +85°C
Input Current		M Suffix .....	-55°C to +125°C
$V_{CC}$ .....	200mA	Power Dissipation ( $T_A = +70^\circ\text{C}$ )	
$V_{BATT}$ .....	50mA	16-Pin PDIP (derated 7mW/ $^\circ\text{C}$ above +70°C) .....	600mW
GND .....	20mA	16-Pin SO (derated 7mW/ $^\circ\text{C}$ above +70°C) .....	600mW
Output Current		16-Pin CERDIP (derated 10mW/ $^\circ\text{C}$ above +85°C) .....	600mW
$V_{OUT}$ .....	Short-Circuit Protected	Storage Temperature Range .....	-65°C to +160°C
All Other Outputs .....	20mA	Lead Temperature (soldering, 10s) .....	+300°C

**Note 1:** The input voltage limits on PFI and WDI may be exceeded providing the input current is limited to less than 10mA.

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

( $V_{CC}$  = full operating range,  $V_{BATT} = 2.8V$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
Operating Voltage Range	$T_A = \text{full}$	MAX696 $V_{CC}$	3.0		5.5	V
		MAX696 $V_{BATT}$	2.0		$V_{CC} - 0.3V$	
		MAX697 $V_{CC}$	3.0		5.5	
Supply Current (MAX697)	$T_A = \text{full}$		160	300	$\mu\text{A}$	
<b>BATTERY-BACKUP SWITCHING (MAX696)</b>						
$V_{OUT}$ Output Voltage	$I_{OUT} = 1\text{mA}$ , $T_A = \text{full}$	$V_{CC} - 0.3$	$V_{CC} - 0.1$		V	
	$I_{OUT} = 50\text{mA}$ , $T_A = \text{full}$	$V_{CC} - 0.5$	$V_{CC} - 0.25$			
$V_{OUT}$ in Battery-Backup Mode	$I_{OUT} = 250\mu\text{A}$ , $V_{CC} < (V_{BATT} - 0.2V)$ , $T_A = \text{full}$	$V_{BATT} - 0.1$	$V_{BATT} - 0.02$		V	
Supply Current (Excludes $I_{OUT}$ )	$I_{OUT} = 1\text{mA}$		1.5	4	mA	
	$I_{OUT} = 50\text{mA}$		2.5	7		
Supply Current in Battery-Backup Mode	$V_{CC} = 0V$ , $V_{BATT} = 2.8V$ , $T_A = +25^\circ\text{C}$		0.6	1	$\mu\text{A}$	
	$V_{CC} = 0V$ , $V_{BATT} = 2.8V$ , $T_A = \text{full}$			10		
Battery Standby Leakage Current	$5.5V > V_{CC} > (V_{BATT} + 0.3V)$	$T_A = +25^\circ\text{C}$	-100	+20	nA	
		$T_A = \text{full}$	-1.00	+0.02	$\mu\text{A}$	
Battery Switchover Threshold $V_{CC} - V_{BATT}$	Power-up		70		mV	
	Power-down		50			
Battery Switchover Hysteresis			20		mV	
BATT ON Output Voltage	$I_{SINK} = 1.6\text{mA}$			0.4	V	
BATT ON Output Short-Circuit Current	BATT ON = $V_{OUT} = 2.4V$ sink current		7		mA	
	BATT ON = $V_{OUT}$ , $V_{CC} = 0V$	0.5	2.5	25.0		$\mu\text{A}$
<b>RESET AND WATCHDOG TIMER</b>						
Low-Line Voltage Threshold ( $LL_{IN}$ )	$V_{CC} = +5V$ , $+3V$ ; $T_A = \text{full}$	1.25	1.30	1.35	V	

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## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = full operating range, V<sub>BATT</sub> = 2.8V, T<sub>A</sub> = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Reset Timeout Delay	Figure 6, OSC SEL HIGH, V <sub>CC</sub> = 5V	35	50	70	ms
Watchdog Timeout Period, Internal Oscillator	Long period, V <sub>CC</sub> = 5V	1.00	1.6	2.25	s
	Short period, V <sub>CC</sub> = 5V	70	100	140	ms
Watchdog Timeout Period, External Clock	Long period	4032		4097	Clock cycles
	Short period	960		1025	
Minimum WDI Input Pulse Width	V <sub>IL</sub> = 0.4V, V <sub>IH</sub> = 3.5V, V <sub>CC</sub> = 5V	200			ns
RESET and RESET Output Voltage (Note 2)	ISINK = 400μA, V <sub>CC</sub> = 2V, V <sub>BATT</sub> = 0V			0.4	V
	ISINK = 1.6mA, 3V < V <sub>CC</sub> < 5.5V			0.4	
	ISOURCE = 1μA, V <sub>CC</sub> = 5V	3.5			
LOW LINE and WDO Output Voltage	ISINK = 800μA, T <sub>A</sub> = full			0.4	V
	ISOURCE = 1μA, V <sub>CC</sub> = 5V, T <sub>A</sub> = full	3.5			
Output Short-Circuit Current	RESET, RESET, WDO, LOW LINE	1	3	25	μA
WDI Input Threshold	V <sub>CC</sub> = 5V (Note 3)	Logic-low		0.8	V
		Logic-high (MAX696)	3.5		
		Logic-high (MAX697)	3.8		
WDI Input Current	WDI = V <sub>OUT</sub>		20	50	μA
	WDI = 0V	-50	-15		
<b>POWER-FAIL DETECTOR</b>					
PFI Input Threshold	V <sub>CC</sub> = 3V, 5V	1.2	1.3	1.4	V
PFI - LLIN Threshold Difference	V <sub>CC</sub> = 3V, 5V		±15	±50	mV
PFI Input Current			±0.01	±25	nA
LLIN Input Current	MAX697	-25	±0.01	+25	nA
	MAX696	-500	±0.01	+25	
PFO Output Voltage	ISINK = 1.6mA			0.4	V
	ISOURCE = 1μA, V <sub>CC</sub> = 5V	3.5			
PFO Short-Circuit Source Current	PFI = 0V, PFO = 0V	1	3	25	μA
<b>CHIP-ENABLE GATING (MAX697)</b>					
CE IN Thresholds	V <sub>IL</sub>			0.8	V
	V <sub>IH</sub> , V <sub>CC</sub> = 5V	3.0			
CE IN Pullup Current			3		μA
CE OUT Output Voltage	ISINK = 1.6mA			0.4	V
	ISOURCE = 800μA	V <sub>CC</sub> - 0.5V			
	ISOURCE = 1μA, V <sub>CC</sub> = 0V	V <sub>CC</sub> - 0.05V			
CE Propagation Delay	V <sub>CC</sub> = 5V		80	150	ns
<b>OSCILLATOR</b>					
OSC IN Input Current			±2		μA
OSC SEL Input Pullup Current			5		μA
OSC IN Frequency Range	OSC SEL = 0V	0		250	kHz
OSC IN Frequency with External Capacitor	OSC SEL = 0V, C <sub>OSC</sub> = 47pF		4		kHz

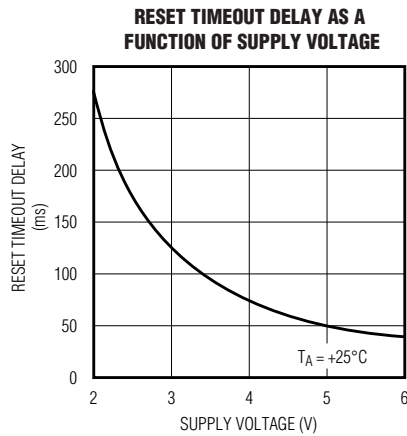
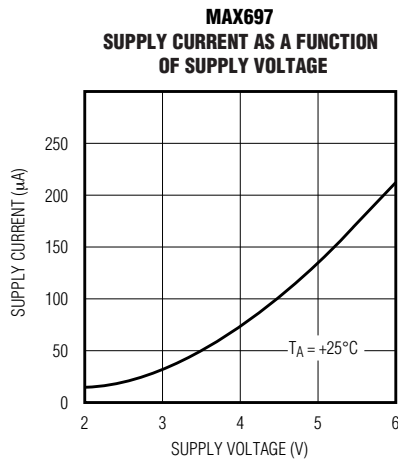
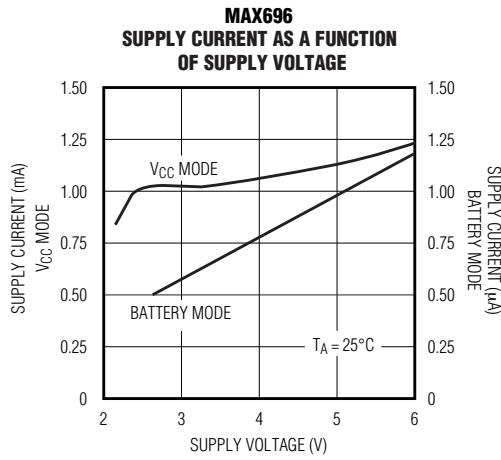
**Note 2:** T<sub>A</sub> = full operating range.

**Note 3:** WDI is guaranteed to be in the mid-level (inactive) state if WDI is floating and V<sub>CC</sub> is in the operating voltage range. WDI is internally biased to 38% of V<sub>CC</sub> with an impedance of approximately 125kΩ.

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## Typical Operating Characteristics

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



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## Pin Description

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PIN		NAME	FUNCTION
MAX696	MAX697		
1	—	V <sub>BATT</sub>	Backup-Battery Input. Connect to ground if a backup battery is not used.
2	—	V <sub>OUT</sub>	The higher of V <sub>CC</sub> or V <sub>BATT</sub> is internally switched to V <sub>OUT</sub> . Connect V <sub>OUT</sub> to V <sub>CC</sub> if V <sub>OUT</sub> and V <sub>BATT</sub> are not used.
3	3	V <sub>CC</sub>	+5V Input
4	5	GND	0V Ground Reference for All Signals
5	—	BATT ON	BATT ON goes High when V <sub>OUT</sub> is Internally Switched to the V <sub>BATT</sub> Input. It goes low when V <sub>OUT</sub> is internally switched to V <sub>CC</sub> . The output typically sinks 7mA and can directly drive the base of an external pnp transistor to increase the output current above the 50mA rating of V <sub>OUT</sub> .
6	6	$\overline{\text{LOW LINE}}$	$\overline{\text{LOW LINE}}$ goes Low when LL <sub>IN</sub> Falls Below 1.3V. It returns high as soon as LL <sub>IN</sub> rises above 1.3V. See Figure 5.
7	7	OSC IN	OSC IN Sets the Reset Delay Timing and Watchdog Timeout Period when OSC SEL Floats or is Driven Low. The timing can also be adjusted by connecting an external capacitor to this pin. See Figure 7. When OSC SEL is high, OSC IN selects between fast and slow watchdog timeout periods
8	8	OSC SEL	When OSC SEL is Unconnected or Driven High, the Internal Oscillator Sets the Reset Time Delay and Watchdog Timeout Period. When OSC SEL is low, the external oscillator input, OSC IN, is enabled. OSC SEL has a 3 $\mu$ A internal pullup. See Table 1.
9	9	PFI	PFI is the Noninverting Input to the Power-Fail Comparator. When PFI is less than 1.3V, $\overline{\text{PFO}}$ goes low. Connect PFI to GND or V <sub>OUT</sub> when not used. See Figure 1.
10	10	$\overline{\text{PFO}}$	$\overline{\text{PFO}}$ is the Output of the Power-Fail Comparator. It goes low when PFI is less than 1.3V. The comparator is turned off and $\overline{\text{PFO}}$ goes low when V <sub>CC</sub> is below V <sub>BATT</sub> .
11	11	WDI	The Watchdog Input, WDI, is a Three-Level Input. If WDI remains either high or low for longer than the watchdog timeout period, $\overline{\text{RESET}}$ pulses low and $\overline{\text{WDO}}$ goes low. The watchdog timer is disabled when WDI is left floating or is driven to mid-supply. The timer resets with each transition at the watchdog timer input.
12	2	N.C.	No Connection. Leave this pin open.
13	4	LL <sub>IN</sub>	Low-Line Input. LL <sub>IN</sub> is the CMOS input to a comparator whose other input is a precision 1.3V reference. The output is $\overline{\text{LOW LINE}}$ and is also connected to the reset pulse generator. See Figure 2.
14	14	$\overline{\text{WDO}}$	The Watchdog Output, $\overline{\text{WDO}}$ , goes Low if WDI Remains either High or Low for Longer than the Watchdog Timeout Period. $\overline{\text{WDO}}$ is set high by the next transition at WDI. If WDI is unconnected or at mid-supply, $\overline{\text{WDO}}$ remains high. $\overline{\text{WDO}}$ also goes high when $\overline{\text{LOW LINE}}$ goes low.
15	15	$\overline{\text{RESET}}$	$\overline{\text{RESET}}$ goes Low whenever LL <sub>IN</sub> Falls Below 1.3V or V <sub>CC</sub> Falls Below the V <sub>BATT</sub> Input Voltage. $\overline{\text{RESET}}$ remains low for 50ms after LL <sub>IN</sub> goes above 1.3V. $\overline{\text{RESET}}$ also goes low for 50ms if the watchdog timer is enabled but not serviced within its timeout period. The $\overline{\text{RESET}}$ pulse width can be adjusted as shown in Table 1.
16	16	RESET	RESET is an Active-High Output. It is the inverse of $\overline{\text{RESET}}$ .

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## Pin Description (continued)

PIN		NAME	FUNCTION
MAX696	MAX697		
—	1	TEST	Used During Maxim Manufacture Only. Always ground this pin.
—	12	$\overline{CE}$ OUT	$\overline{CE}$ OUT goes low only when $\overline{CE}$ IN is low and $LL_{IN}$ is above 1.3V. See Figure 5.
—	13	$\overline{CE}$ IN	The Input to the $\overline{CE}$ Gating Circuit. Connect to GND or $V_{OUT}$ if not used.

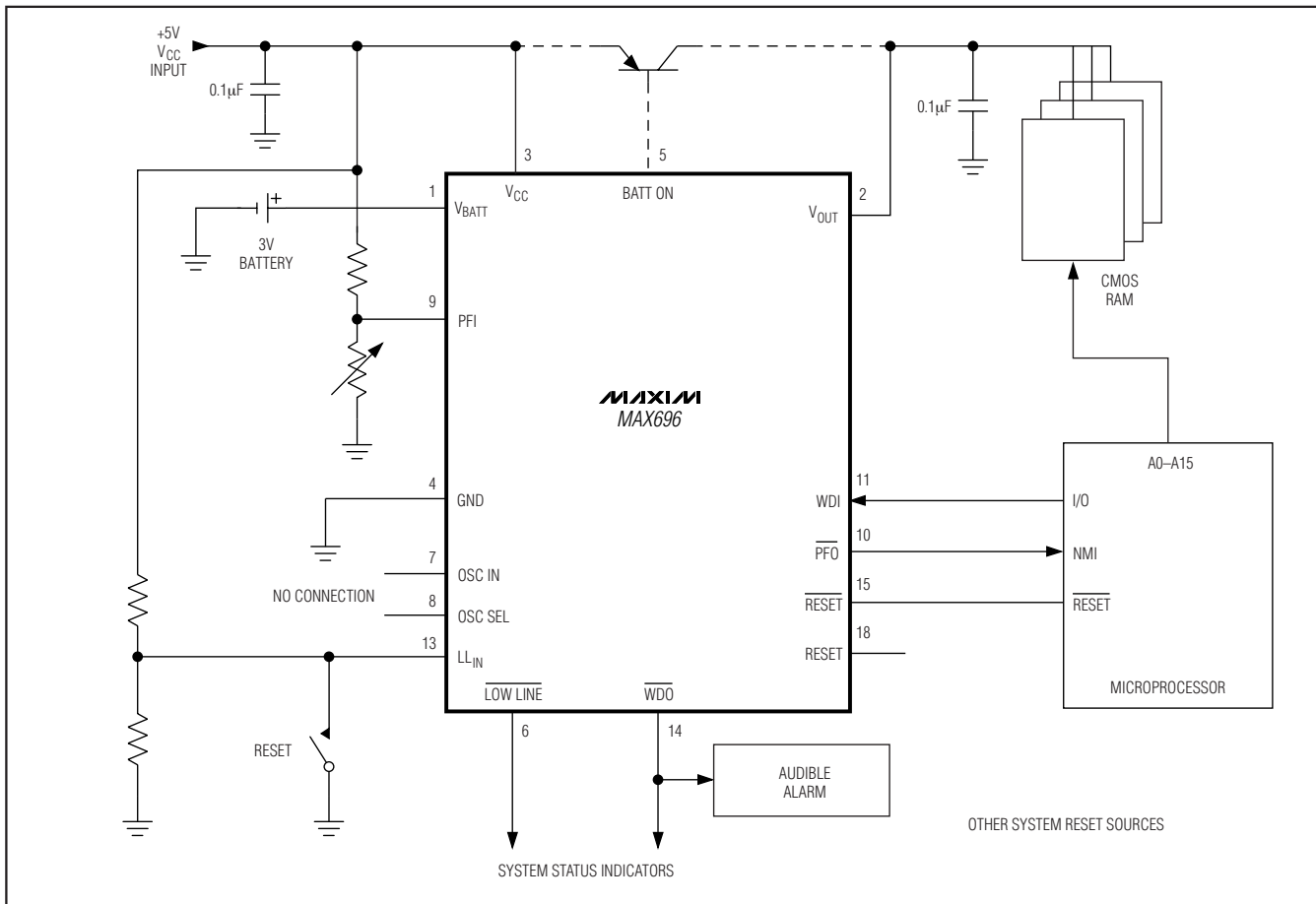


Figure 1. MAX696 Typical Application

## Typical Applications

### MAX696

A typical connection for the MAX696 is shown in Figure 1. CMOS RAM is powered from  $V_{OUT}$ .  $V_{OUT}$  is internally connected to  $V_{CC}$  when power is present, or to  $V_{BATT}$  when  $V_{CC}$  is less than the battery voltage.  $V_{OUT}$  can supply 50mA from  $V_{CC}$ , but if more current is required, an external pnp transistor can be added. When  $V_{CC}$  is higher than  $V_{BATT}$ , the BATT ON output goes low, providing

7mA of base drive for the external transistor. When  $V_{CC}$  is lower than  $V_{BATT}$ , an internal 200 $\Omega$  MOSFET connects the backup battery to  $V_{OUT}$ . The quiescent current in the battery-backup mode is 1 $\mu$ A maximum when  $V_{CC}$  is between 0V and ( $V_{BATT} - 700mV$ ).

### Reset Output

A voltage detector monitors  $V_{CC}$  and generates a  $\overline{RESET}$  output to hold the microprocessor's  $\overline{RESET}$  line low when  $LL_{IN}$  is below 1.3V. An internal monostable holds  $\overline{RESET}$

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low for 50ms after  $LL_{IN}$  rises above 1.3V. This prevents repeated toggling of  $\overline{RESET}$  even if the  $V_{CC}$  power drops out and recovers with each power line cycle.

The crystal oscillator normally used to generate the clock for microprocessors takes several milliseconds to start. Since most microprocessors need several clock cycles to reset,  $\overline{RESET}$  must be held low until the microprocessor clock oscillator has started. The power-up  $\overline{RESET}$  pulse lasts 50ms to allow for this oscillator startup time. An inverted, active-high  $\overline{RESET}$  output is also supplied.

## Power-Fail Detector

The MAX696 issues a nonmaskable interrupt (NMI) to the microprocessor when a power failure occurs. The power line is monitored by two external resistors connected to the power-fail input (PFI). When the voltage at PFI falls below 1.3V, the power-fail output ( $\overline{PFO}$ ) drives the processor's NMI input low. An earlier power-fail warning can be generated if the unregulated DC input of the regulator is available for monitoring.

## Watchdog Timer

The microprocessor drives the watchdog input (WDI) with an I/O line. When OSC IN and OSC SEL are unconnected, the microprocessor must toggle the WDI pin once every 1.6 seconds to verify proper software execution. If a hardware or software failure occurs so that WDI is not toggled, the MAX696 will issue a 50ms  $\overline{RESET}$  pulse after 1.6 seconds. This typically restarts the microprocessor's power-up routine. A new  $\overline{RESET}$  pulse is issued every 1.6 seconds until WDI is again strobed.

The watchdog output ( $\overline{WDO}$ ) goes low if the watchdog timer is not serviced within its timeout period. Once  $\overline{WDO}$  goes low, it remains low until a transition occurs at WDI while  $\overline{RESET}$  is high. The watchdog timer feature can be disabled by leaving WDI unconnected. OSC IN and OSC SEL also allow other watchdog timing options, as shown in Table 1 and Figure 7.

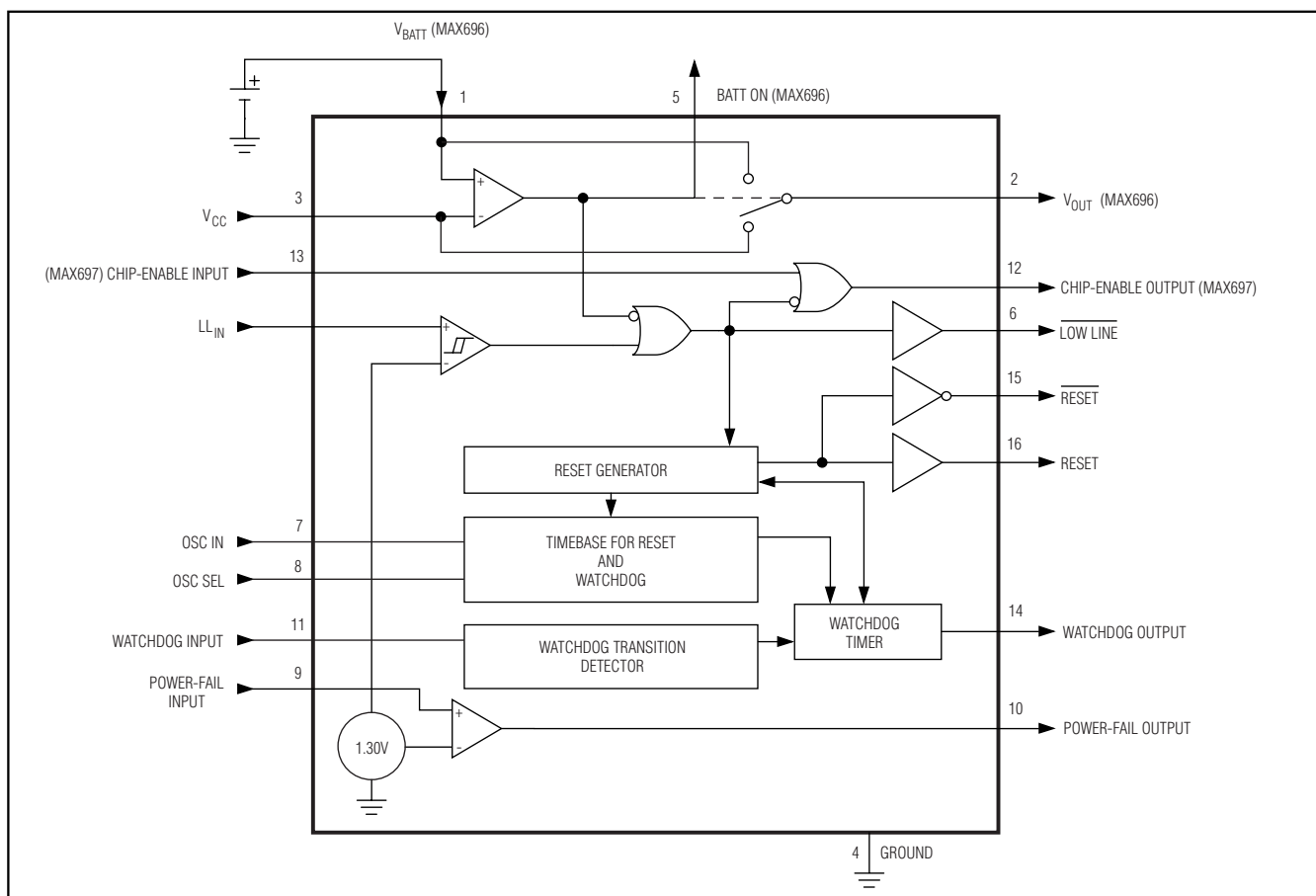


Figure 2. MAX696/MAX697 Block Diagram

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## MAX697

The MAX697 is nearly identical to the MAX696. The MAX697 lacks the battery-backup feature, so it does not have the VBATT, VOUT, or BATT ON pins. This allows the MAX697 to consume less than 250 microamperes, and it allows the inclusion of RAM write-protection pins. See Figure 2.

## Detailed Description

### Battery Switchover and VOUT (MAX696)

The battery-switchover circuit compares  $V_{CC}$  to the  $V_{BATT}$  input, and connects  $V_{OUT}$  to whichever is higher. Switchover occurs when  $V_{CC}$  is 50mV greater than  $V_{BATT}$  as  $V_{CC}$  falls, and when  $V_{CC}$  is 70mV more than  $V_{BATT}$  as  $V_{CC}$  rises (see Figure 3). The switchover comparator has 20mV of hysteresis to prevent repeated, rapid switching if  $V_{CC}$  falls very slowly or remains nearly equal to the battery voltage.

When  $V_{CC}$  is higher than  $V_{BATT}$ ,  $V_{CC}$  is internally switched to  $V_{OUT}$  with a low-saturation pnp transistor.  $V_{OUT}$  has 50mA output current capability. Use an external pnp pass transistor in parallel with the internal transistor if the out-

put current requirement at  $V_{OUT}$  exceeds 50mA or if a lower  $V_{CC} - V_{OUT}$  voltage differential is desired. The BATT ON output can directly drive the base of the external transistor.

It should be noted that the MAX696 need only supply the average current drawn by the CMOS RAM if there is adequate filtering. Many RAM data sheets specify a 75mA maximum supply current, but this peak current spike lasts only 100ns. A 0.1 $\mu$ F bypass capacitor at  $V_{OUT}$  supplies the high instantaneous current, while  $V_{OUT}$  need only supply the average load current, which is much less. A capacitance of 0.1 $\mu$ F or greater must be connected to the  $V_{OUT}$  terminal to ensure stability.

A 200 $\Omega$  MOSFET connects the  $V_{BATT}$  input to  $V_{OUT}$  during battery backup. This MOSFET has very low input-to-output differential (dropout voltage) at the low current levels required for battery backup of CMOS RAM or other low-power CMOS circuitry. When  $V_{CC}$  equals  $V_{BATT}$ , the supply current is typically 12 $\mu$ A. When  $V_{CC}$  is between 0V and ( $V_{BATT} - 700$ mV), the typical supply current is only 600nA (typ), 1 $\mu$ A (max).

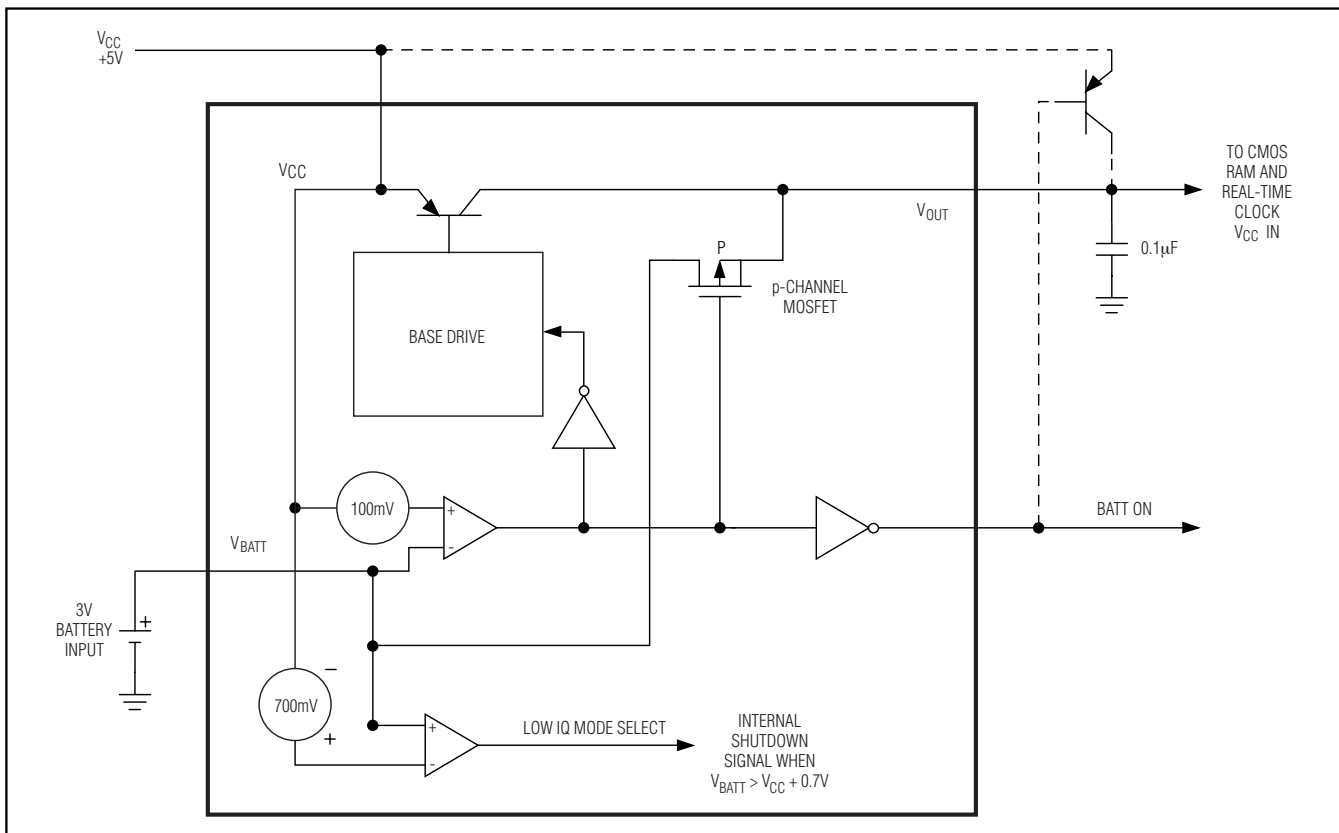


Figure 3. MAX696 Battery-Switchover Block Diagram



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The MAX696 operates with battery voltages from 2.0V to 4.25V. The battery voltage should not be within 0.5V of  $V_{CC}$ , or switchover may occur. High-value capacitors, either standard electrolytic or the farad-size double-layer capacitors, can also be used for short-term memory backup. The capacitor charging voltage should include a diode to limit the fully charged voltage to approximately 0.5V less than  $V_{CC}$ . The charging resistor for rechargeable batteries should be connected to  $V_{OUT}$  since this eliminates the discharge path that exists if the resistor is connected to  $V_{CC}$ .

A small leakage current of typically 10nA (20nA max) flows out of the  $V_{BATT}$  terminal. This current varies with the amount of current that is drawn from  $V_{OUT}$ , but its polarity is such that the backup battery is always slightly charged, and is never discharged while  $V_{CC}$  is in its operating voltage range. This extends the shelf life of the backup battery by compensating for its self-discharge current. Also note that this current poses no problem when lithium batteries are used for backup since the maximum current (20nA) is safe for even the smallest lithium cells.

If the battery-switchover section is not used, connect  $V_{BATT}$  to GND and connect  $V_{OUT}$  to  $V_{CC}$ . Table 2 shows the state of the inputs and output in the low-power battery-backup mode.

## Reset Output

$\overline{RESET}$  is an active-low output that goes low whenever  $LL_{IN}$  falls below 1.3V. It remains low until  $LL_{IN}$  rises above 1.312V for 50ms. (See Figures 4 and 5.)

The guaranteed minimum and maximum low-line thresholds of the MAX696/MAX697 are 1.2V and 1.4V. The  $LL_{IN}$  comparator has approximately 12mV of hysteresis.

The response time of the reset voltage comparator is about 100 $\mu$ s.  $LL_{IN}$  should be bypassed to ensure that glitches do not activate the  $\overline{RESET}$  output.

$\overline{RESET}$  also goes low if the watchdog timer is enabled and  $WDI$  remains either high or low longer than the watchdog timeout period.  $\overline{RESET}$  has an internal 3 $\mu$ A pullup, and can either connect to an open-collector reset bus or directly drive a CMOS gate without an external pullup resistor.

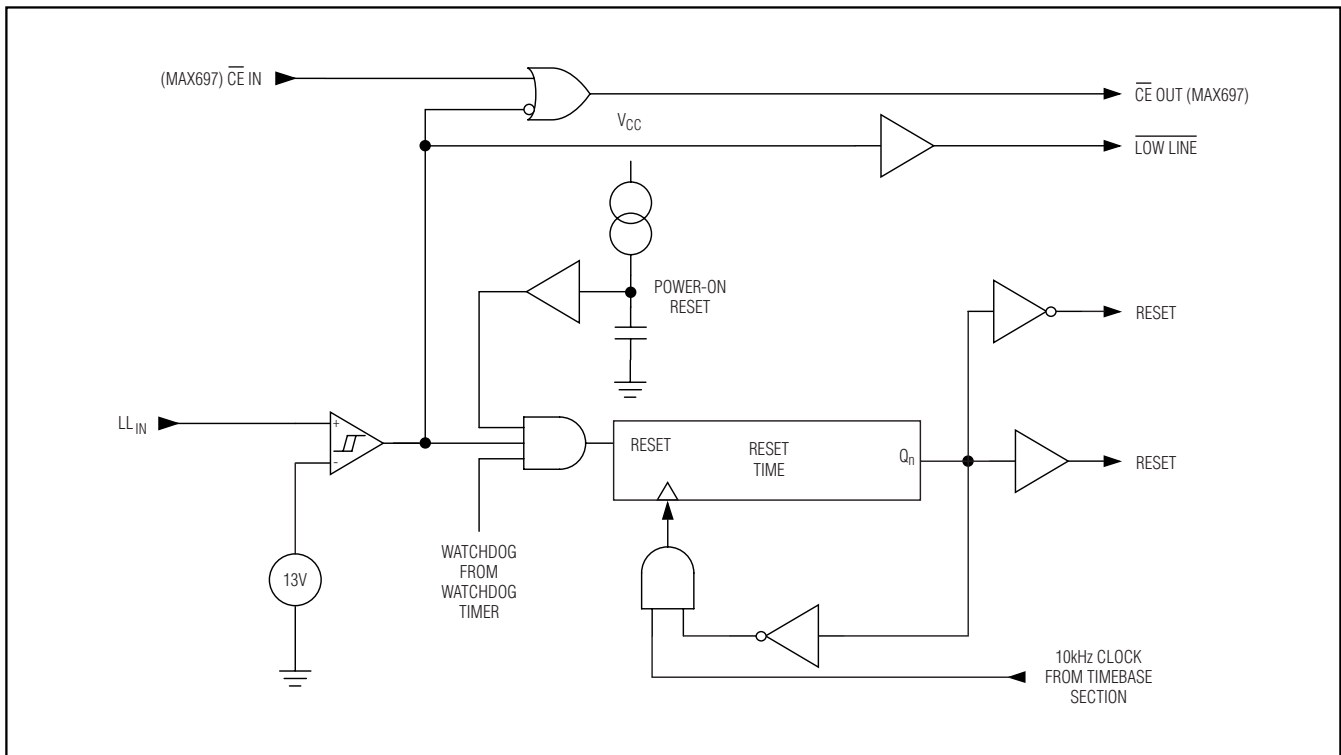


Figure 4. Reset Block Diagram

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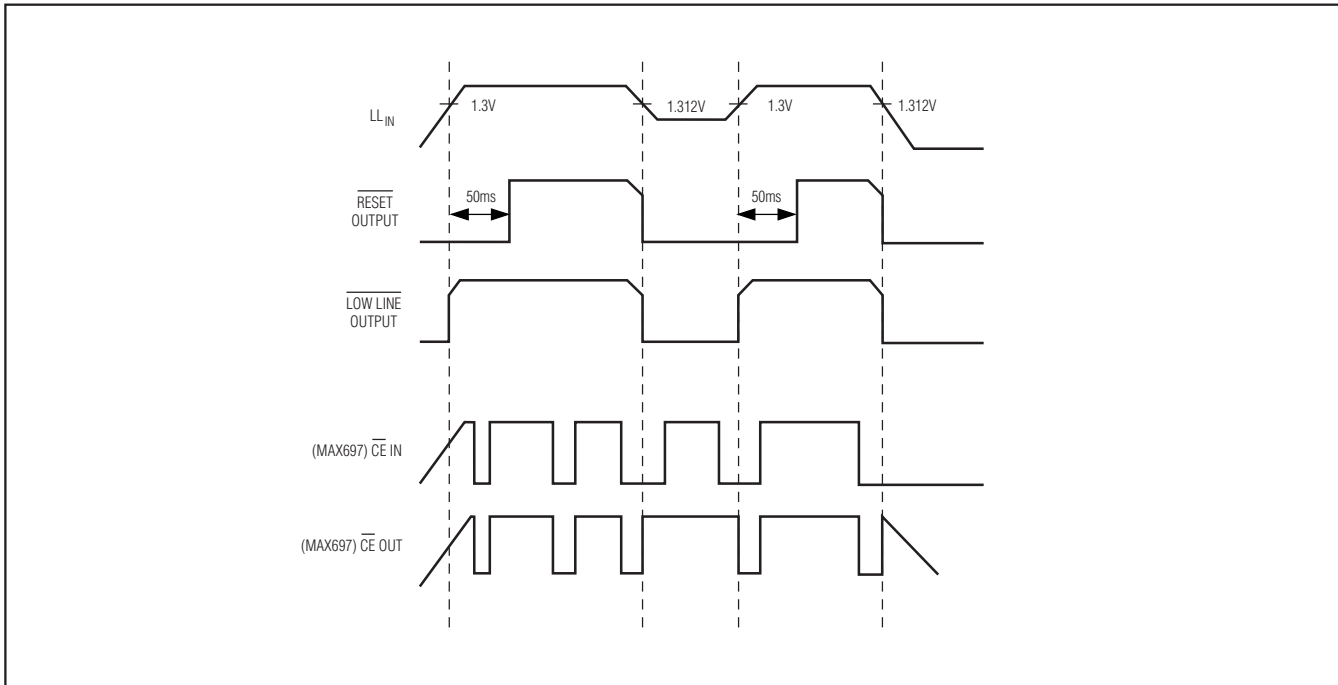


Figure 5. MAX697 Reset Timing

### **$\overline{CE}$ Gating and RAM Write Protection**

The MAX697 uses two pins to control the  $\overline{CE}$  or  $\overline{WRITE}$  inputs of CMOS RAMs. When  $LL_{IN}$  is  $> 1.3V$ ,  $\overline{CE}$  OUT is a buffered replica of  $\overline{CE}$  IN, with a 50ns propagation delay. If  $LL_{IN}$  input falls below 1.3V (1.2V min, 1.4V max), an internal gate forces  $\overline{CE}$  OUT high, independent of  $\overline{CE}$  IN. The  $\overline{CE}$  output is also forced high when  $V_{CC}$  is less than  $V_{BATT}$ . (See Figure 4.)

$\overline{CE}$  OUT typically drives the  $\overline{CE}$ ,  $\overline{CS}$ , or  $\overline{WRITE}$  input of battery backed up CMOS RAM. This ensures the integrity of the data in memory by preventing write operations when  $V_{CC}$  is at an invalid level. Similar protection of EEPROMs can be achieved by using the  $\overline{CE}$  OUT to drive the  $\overline{STORE}$  or  $\overline{WRITE}$  inputs of an EEPROM, EAROM, or NOVRAM.

If the 50ns typical propagation delay of  $\overline{CE}$  OUT is too long, connect  $\overline{CE}$  IN to GND and use the resulting  $\overline{CE}$  OUT to control a high-speed external logic gate. A second alternative is to AND the  $\overline{LOW LINE}$  output with the  $\overline{CE}$  or  $\overline{WR}$  signal. An external logic gate and the  $\overline{RESET}$  output of the MAX696/MAX697 can also be used for CMOS RAM write protection.

### **1.25V Comparator and Power-Fail Warning**

The power-fail input (PFI) is compared to an internal 1.3V reference. The power-fail output ( $\overline{PFO}$ ) goes low when the voltage at PFI is less than 1.3V. Typically PFI is driven by an external voltage-divider that senses either the unregulated DC input to the system's  $V_{CC}$  regulator or the regulated output. The voltage-divider ratio can be chosen so the voltage at PFI falls below 1.3V several milliseconds before the  $LL_{IN}$  falls below 1.3V.  $\overline{PFO}$  is normally used to interrupt the microprocessor so that data can be stored in RAM before  $LL_{IN}$  falls below 1.3V and the  $\overline{RESET}$  output goes low.

The power-fail detector can also monitor the backup battery to warn of a low-battery condition. To conserve battery power, the power-fail detector comparator is turned off and  $\overline{PFO}$  is forced low when  $V_{CC}$  is lower than the  $V_{BATT}$  input voltage.

### **Watchdog Timer and Oscillator**

The watchdog circuit monitors the activity of the microprocessor. If the microprocessor does not toggle the watchdog input (WDI) within the selected timeout period, a 50ms  $\overline{RESET}$  pulse is generated. Since many systems cannot service the watchdog timer immediately after a reset, the MAX696/MAX697 have a longer timeout period after a reset is issued. The normal timeout period

# Microprocessor Supervisory Circuits

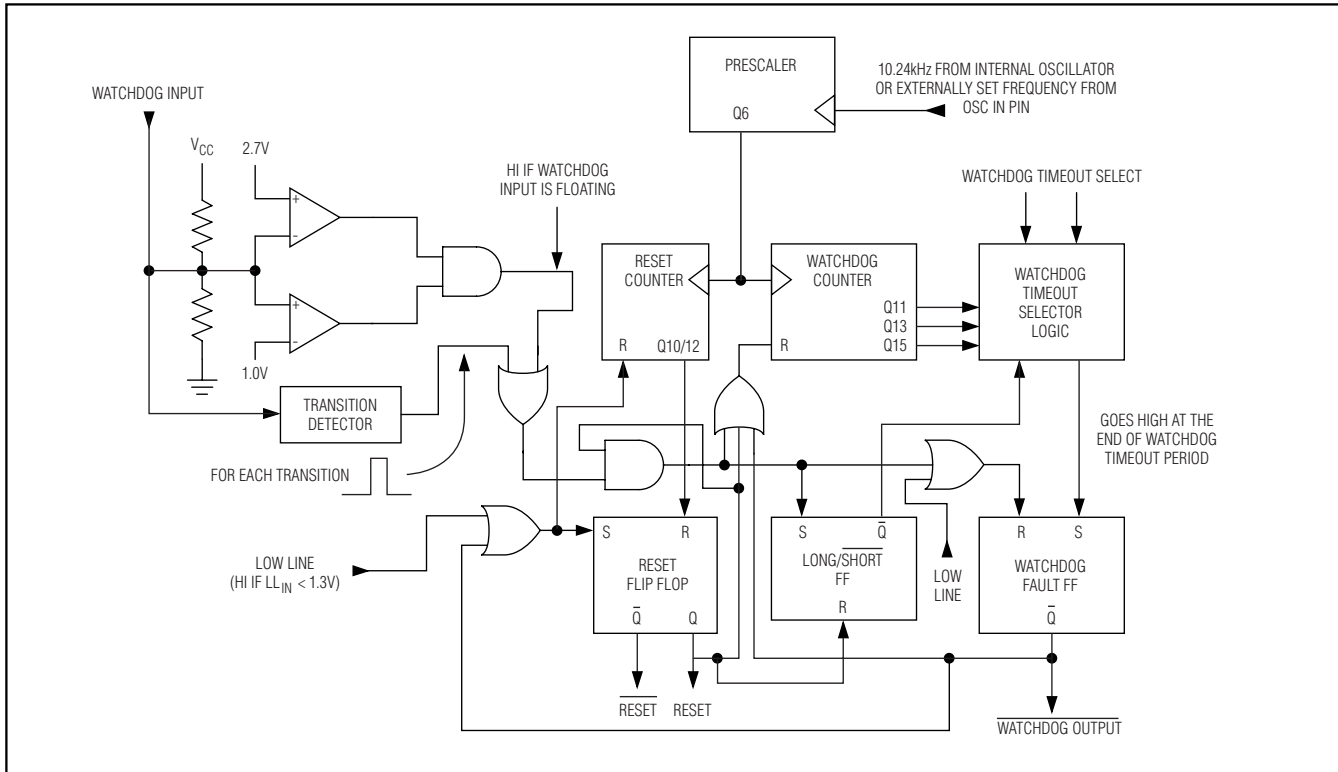


Figure 6. Watchdog Timer Block Diagram

becomes effective following the first transition of WDI after  $\overline{\text{RESET}}$  has gone high. The watchdog timer is restarted at the end of reset, whether the reset was caused by lack of activity on WDI or by  $\text{LL}_{\text{IN}}$  falling below 1.3V. If WDI remains either high or low, reset pulses will be issued every 1.6s. The watchdog monitor can be deactivated by floating the watchdog input (WDI).

The watchdog output ( $\overline{\text{WDO}}$ ) goes low if the watchdog timer times out, and it remains low until set high by the next transition on the watchdog input.  $\overline{\text{WDO}}$  is also set high when  $\text{LL}_{\text{IN}}$  goes below 1.3V.

The watchdog timeout period defaults to 1.6s and the reset pulse width defaults to 50ms. The MAX696 and MAX697 allow these times to be adjusted per Table 1.

The internal oscillator is enabled when OSC SEL is high or floating. In this mode, OSC IN selects between the 1.6s and 100ms watchdog timeout periods. In either case, immediately after a reset, the timeout period is 1.6s. This gives the microprocessor time to reinitialize the system. WD transmissions while  $\overline{\text{RESET}}$  is low are ignored. If OSC IN is low, then the 100ms watchdog period becomes effective after the first transition of WDI. The software should be written so the I/O port driving WDI is left in its power-up reset state until the initialization routines are completed and the microprocessor is able to toggle WDI at the minimum 70ms watchdog timeout period.

# Microprocessor Supervisory Circuits

## Applications Information

### Adding Hysteresis to the Power-Fail Comparator

Since the power-fail comparator circuit is noninverting, hysteresis can be added by connecting a resistor between the PFO output and the PFI input as shown in Figure 7. When PFO is low, resistor R3 sinks current from the summing junction at the PFI pin. When PFO is high, the series combination of R3 and R4 source current into the PFI summing junction.

### Alternate Watchdog Input Drive Circuits

The watchdog feature can be enabled and disabled under program control by driving WDI with a three-state

buffer (Figure 8). The drawback to this circuit is that a software fault may erroneously three-state the buffer, thereby preventing the MAX696/MAX697 from detecting that the microprocessor is no longer working. In most cases, a better method is to extend the watchdog period rather than disabling the watchdog. See Figure 9. When the control input is high, the OSC SEL pin is low and the watchdog timeout is set by the external capacitor. A 0.01µF capacitor sets a watchdog timeout delay of 100s. When the control input is low, the OSC SEL pin is driven high, selecting the internal oscillator. The 100ms or the 1.6s period is chosen, depending on which diode in Figure 9 is used.

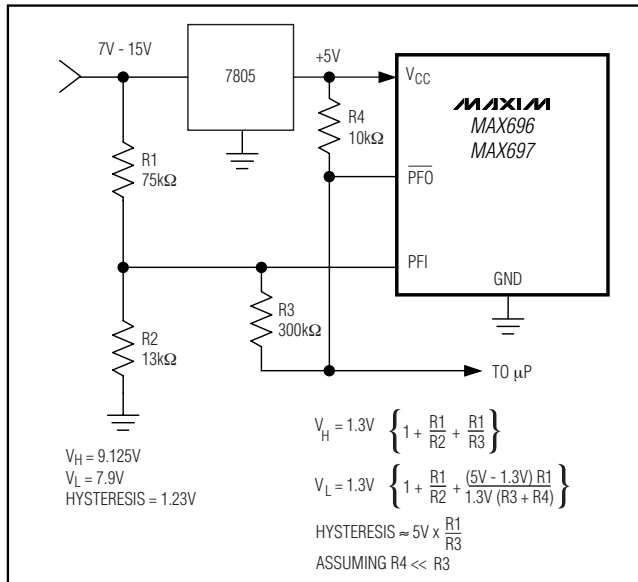


Figure 7. Adding Hysteresis to the Power-Fail Voltage Comparator

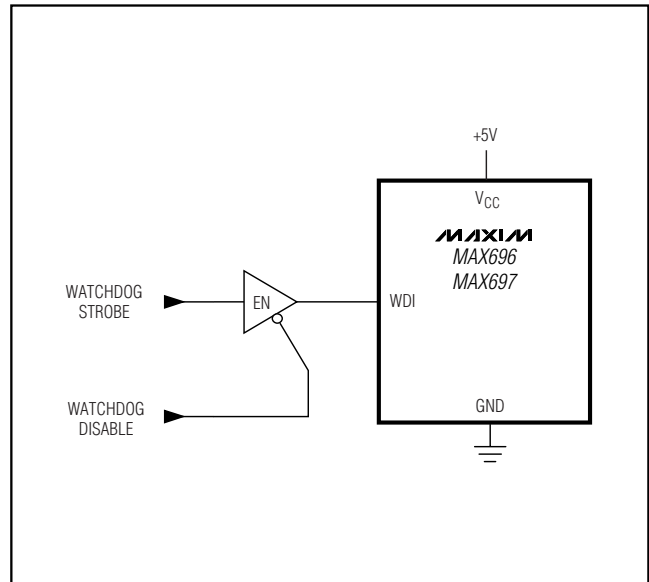


Figure 8. Disabling the Watchdog Under Program Control

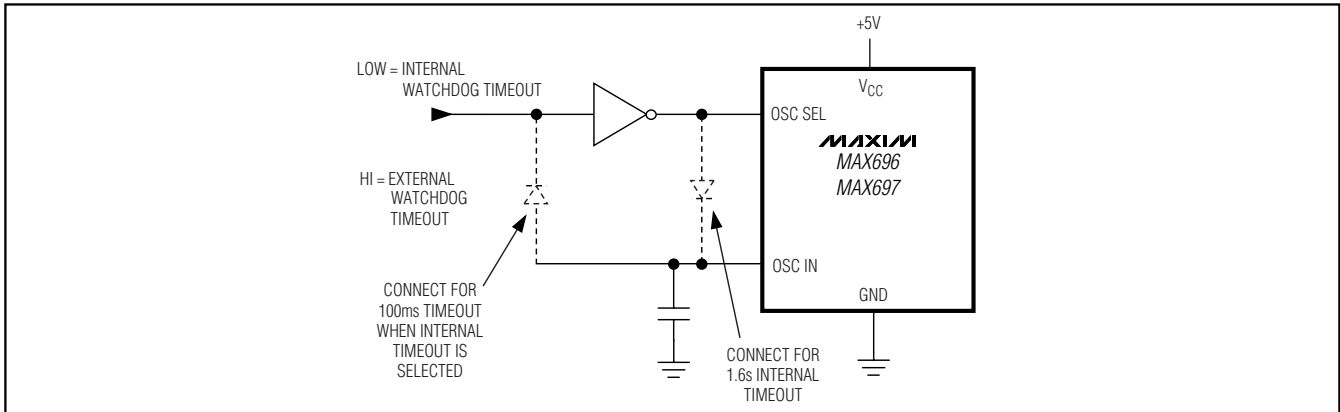


Figure 9. Selecting Internal or External Watchdog Timeout

# Microprocessor Supervisory Circuits

**Table 1. MAX696 and MAX697 Reset Pulse Width and Watchdog Timeout Selections (Notes 1, 2)**

OSC SEL (Note 3)	OSC IN	WATCHDOG TIMEOUT PERIOD		RESET TIMEOUT PERIOD
		NORMAL	IMMEDIATELY AFTER RESET	
Low	External Clock Input	1024 clocks	4096 clocks	512 clocks
Low	External Capacitor	400ms/47pF x C	1.6s/47pF x C	200ms/47pF x C
High/Floating	Low	100ms	1.6s	50ms
High/Floating	Floating	1.6s	1.6s	50ms

**Note 1:** When the MAX696/MAX697 OSC SEL pin is low, OSC IN can be driven by an external clock signal, or an external capacitor can be connected between OSC IN and GND. The nominal internal oscillator frequency is 10.24kHz. The nominal oscillator frequency with external capacitor is  $f_{OSC} \text{ (Hz)} = 184,000/C_{OSC} \text{ (pF)}$ .

**Note 2:** See the *Electrical Characteristics* table for minimum and maximum timing values.

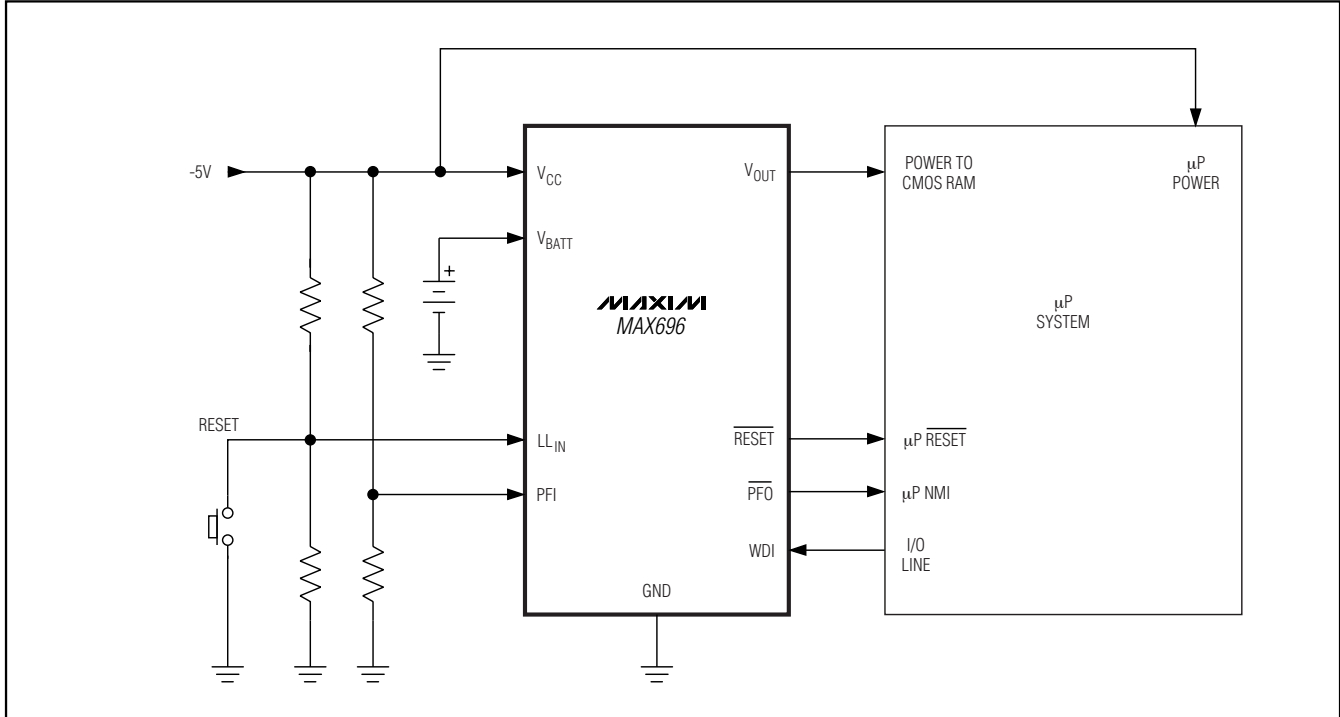
**Note 3:** High for the OSC SEL pin should be connected to  $V_{OUT}$ , not  $V_{CC}$  (on the MAX696).

**Table 2. Input and Output Status in Battery-Backup Mode**

I/O	STATUS
$V_{BATT}$ , $V_{OUT}$	$V_{BATT}$ is connected to $V_{OUT}$ with an internal MOSFET (MAX696 only).
$\overline{\text{RESET}}$	Logic-low.
RESET	Logic-high. The open-circuit output voltage is equal to $V_{OUT}$ .
$\overline{\text{LOW LINE}}$	Logic-low.
BATT ON	Logic-high (MAX696 only).
WDI	WDI is internally disconnected from its internal pullup and does not source or sink current as long as its input voltage is between GND and $V_{OUT}$ . The input voltage does not affect supply current.
$\overline{\text{WDO}}$	Logic-high.
PFI	The power-fail comparator is turned off and the power-fail input voltage has no effect on the power-fail output.
$\overline{\text{PFO}}$	Logic-low.
$\overline{\text{CE IN}}$	$\overline{\text{CE IN}}$ is internally disconnected from its internal pullup and does not source or sink current as long as its input voltage is between GND and $V_{OUT}$ . The input voltage does not affect supply current (MAX696 only).
$\overline{\text{CE OUT}}$	Logic-high (MAX697 only).
OSC IN	OSC IN is ignored.
OSC SEL	OSC SEL is ignored.
$V_{CC}$	Approximately 12 $\mu$ A is drawn from the $V_{BATT}$ input when $V_{CC}$ is between ( $V_{BATT} + 100\text{mV}$ ) and ( $V_{BATT} - 700\text{mV}$ ). The supply current is 1 $\mu$ A maximum when $V_{CC}$ is less than $V_{BATT} - 700\text{mV}$ .

# Microprocessor Supervisory Circuits

## Typical Operating Circuit

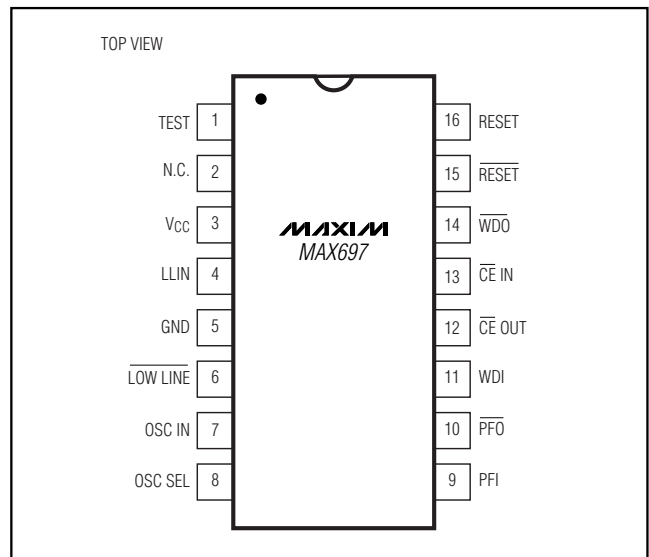


### Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX697C/D	0°C to +70°C	Dice
MAX697CPE	0°C to +70°C	16 PDIP
MAX697CWE	0°C to +70°C	16 Wide SO
MAX697EPE	-40°C to +85°C	16 PDIP
MAX697EJE	-40°C to +85°C	16 CERDIP
MAX697EWE	-40°C to +85°C	16 Wide SO
MAX697MJE	-55°C to +125°C	16 CERDIP

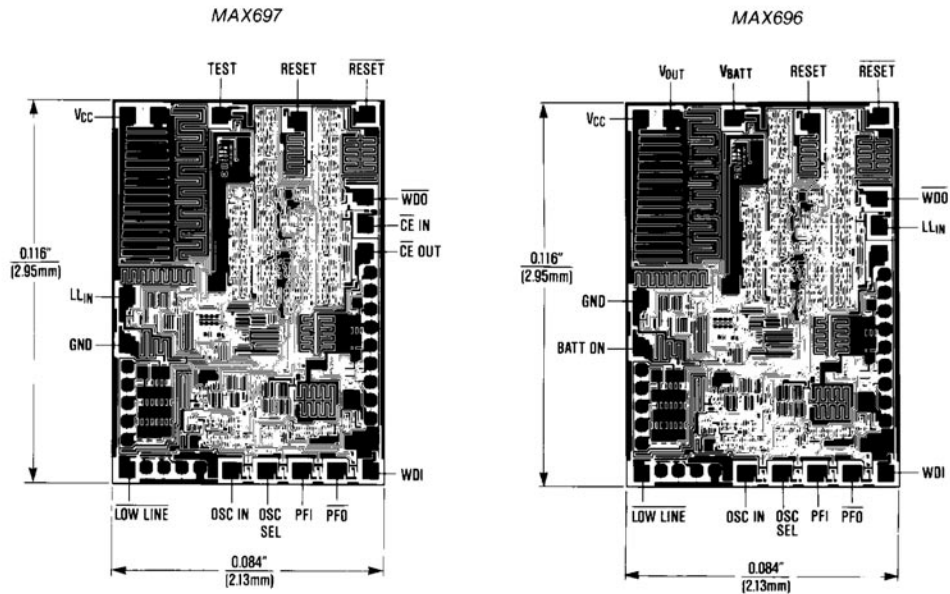
Devices in PDIP and SO packages are available in both leaded and lead-free packaging. Specify lead free by adding the + symbol at the end of the part number when ordering. Lead free not available for CERDIP package.

### Pin Configurations (continued)



# Microprocessor Supervisory Circuits

## Chip Topography



MAX696/MAX697

## Package Information

For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).

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