



# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## General Description

The MAX823/MAX824/MAX825 microprocessor ( $\mu$ P) supervisory circuits combine reset output, watchdog, and manual reset input functions in 5-pin SOT23 and SC70 packages. They significantly improve system reliability and accuracy compared to separate ICs or discrete components. The MAX823/MAX824/MAX825 are specifically designed to ignore fast transients on  $V_{CC}$ .

Seven preprogrammed reset threshold voltages are available (see *Reset Threshold Table*). All three devices have an active-low reset output, which is guaranteed to be in the correct state for  $V_{CC}$  down to 1V. The MAX823 also offers a watchdog input and manual reset input. The MAX824 offers a watchdog input and a complementary active-high reset. The MAX825 offers a manual reset input and a complementary active-high reset. The *Selector Guide* explains the functions offered in this series of parts.

## Applications

Computers and Controllers  
Embedded Controllers  
Intelligent Instruments  
Automotive Systems  
Critical  $\mu$ P Monitoring  
Portable/Battery-Powered Equipment

## Reset Threshold Table

SUFFIX	RESET THRESHOLD (V)
L	4.63
M	4.38
T	3.08
S	2.93
R	2.63
Z (SC70 only)	2.32
Y (SC70 only)	2.19

## Features

- ◆ Precision Monitoring of +2.5V, +3V, +3.3V, and +5V Power Supplies
- ◆ Operating Current: 6 $\mu$ A (MAX823L/M) (SC70)  
2 $\mu$ A (MAX825T/S/R/Z/Y) (SC70)
- ◆ Fully Specified Over Temperature
- ◆ 140ms min Power-On Reset
- ◆ Guaranteed  $\overline{\text{RESET}}$  Valid to  $V_{CC} = 1V$
- ◆ Power-Supply Transient Immunity
- ◆ Watchdog Timer with 1.6s Timeout (MAX823/MAX824)
- ◆ Manual Reset Input (MAX823/MAX825)
- ◆ No External Components

## Ordering Information

PART <sup>†</sup>	TEMP. RANGE	PIN-PACKAGE
MAX823_EXK-T	-40°C to +85°C	5 SC70-5
MAX823_EUK-T	-40°C to +125°C	5 SOT23-5
MAX824_EXK-T	-40°C to +85°C	5 SC70-5

<sup>†</sup>Insert the desired suffix letter (from the Reset Threshold table) into the blank to complete the part number. All devices are available in tape-and-reel only. There is a 2500 piece minimum order increment. Devices are available in both leaded and lead-free packaging. Specify lead-free by replacing "-T" with "+T" when ordering.

Ordering Information continued at end of data sheet.

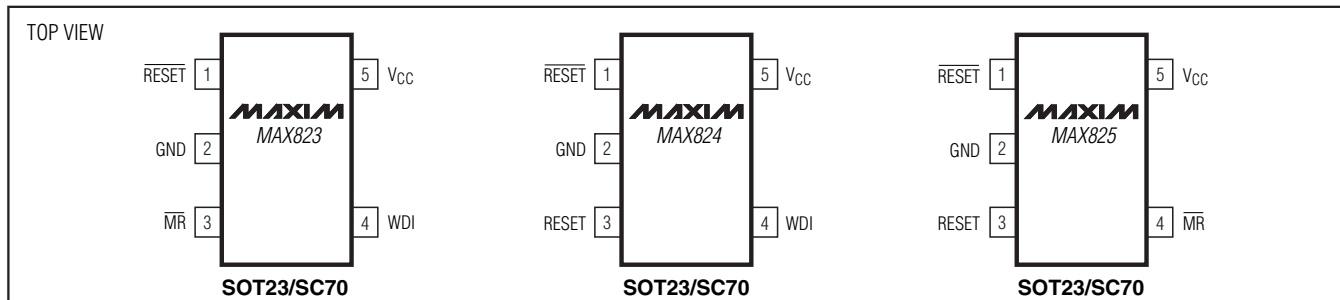
## Selector Guide

FUNCTION	MAX823	MAX824	MAX825
Active-Low Reset	✓	✓	✓
Active-High Reset	—	✓	✓
Watchdog Input	✓	✓	—
Manual Reset Input	✓	—	✓

Typical Operating Circuit appears at end of data sheet.

Marking Information appears at end of data sheet.

## Pin Configurations



# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> .....	-0.3V to +6.0V	5-Pin SOT23 (derate 7.1mW/°C above +70°C).....	571mW
All Other Pins .....	-0.3V to (V <sub>CC</sub> + 0.3V)	Operating Temperature Range	
Input Current, All Pins Except RESET and $\overline{\text{RESET}}$ .....	20mA	MAX82_EXK .....	-40°C to +85°C
Output Current, RESET, $\overline{\text{RESET}}$ .....	20mA	MAX82_EUK .....	-40°C to +125°C
Continuous Power Dissipation (T <sub>A</sub> = +70°C)		Storage Temperature Range .....	-65°C to +150°C
5-Pin SC70 (derate 3.1mW/°C above +70°C).....	247mW	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> = +4.75V to +5.5V for MAX82\_L, V<sub>CC</sub> = +4.5V to +5.5V for MAX82\_M, V<sub>CC</sub> = +3.15V to +3.6V for MAX82\_T, V<sub>CC</sub> = +3V to +3.6V for MAX82\_S, V<sub>CC</sub> = +2.7V to +3.6V for MAX82\_R, V<sub>CC</sub> = +2.38V to +2.75V for MAX82\_Z, V<sub>CC</sub> = +2.25V to +2.75V for MAX82\_Y, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, T<sub>A</sub> = -40°C to +85°C (SC70), T<sub>A</sub> = -40°C to +125°C (SOT23), unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Voltage Range	V <sub>CC</sub>	T <sub>A</sub> = 0°C to +70°C		1.0		5.5	V
		T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		1.2			
Supply Current (SOT23 Only)	I <sub>SUPPLY</sub>	WDI and $\overline{\text{MR}}$ unconnected	MAX823L/M MAX824L/M		10	24	μA
			MAX823T/S/R/Z/Y MAX824T/S/R/Z/Y		5	12	
		$\overline{\text{MR}}$ unconnected	MAX825L/M		4.5	12	
			MAX825T/S/R/Z/Y		3	8	
Supply Current (SC70 Only)	I <sub>SUPPLY</sub>	WDI and $\overline{\text{MR}}$ unconnected	MAX823L/M MAX824L/M		6	17	μA
			MAX823T/S/R/Z/Y MAX824T/S/R/Z/Y		4	12	
		$\overline{\text{MR}}$ unconnected	MAX825L/M		3	8	
			MAX825T/S/R/Z/Y		2	6	
Reset Threshold	V <sub>RST</sub>	MAX82_L	T <sub>A</sub> = +25°C	4.56	4.63	4.70	V
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	4.50		4.75	
		MAX82_M	T <sub>A</sub> = +25°C	4.31	4.38	4.45	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	4.25		4.50	
		MAX82_T	T <sub>A</sub> = +25°C	3.04	3.08	3.11	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	3.00		3.15	
		MAX82_S	T <sub>A</sub> = +25°C	2.89	2.93	2.96	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	2.85		3.00	
		MAX82_R	T <sub>A</sub> = +25°C	2.59	2.63	2.66	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	2.55		2.70	
		MAX82_Z (SC70 only)	T <sub>A</sub> = +25°C	2.28	2.32	2.35	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	2.25		2.38	
		MAX82_Y (SC70 only)	T <sub>A</sub> = +25°C	2.16	2.19	2.22	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	2.13		2.25	

# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

MAX823/MAX824/MAX825

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +4.75V$  to  $+5.5V$  for MAX82\_L,  $V_{CC} = +4.5V$  to  $+5.5V$  for MAX82\_M,  $V_{CC} = +3.15V$  to  $+3.6V$  for MAX82\_T,  $V_{CC} = +3V$  to  $+3.6V$  for MAX82\_S,  $V_{CC} = +2.7V$  to  $+3.6V$  for MAX82\_R,  $V_{CC} = +2.38V$  to  $+2.75V$  for MAX82\_Z,  $V_{CC} = +2.25V$  to  $+2.75V$  for MAX82\_Y,  $T_A = T_{MIN}$  to  $T_{MAX}$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$  (SC70),  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$  (SOT23), unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Reset Threshold Hysteresis		MAX82_L/M		10		mV
		MAX82_T/S/R/Z/Y		5		
Reset Threshold Temperature Coefficient				40		ppm/ $^{\circ}C$
Reset Timeout Period	$t_{RP}$		140	200	280	ms
$V_{CC}$ to $\overline{RESET}$ Delay		$V_{RST} - V_{CC} = 100mV$		20		$\mu s$
$\overline{RESET}$ Output Voltage	$V_{OH}$	MAX82_L/M, $V_{CC} = V_{RST} \text{ max}$ , $I_{SOURCE} = 120\mu A$	$V_{CC} - 1.5$			V
		MAX82_T/S/R/Z/Y, $V_{CC} = V_{RST} \text{ max}$ , $I_{SOURCE} = 30\mu A$	$0.8 \times V_{CC}$			
	$V_{OL}$	MAX82_L/M, $V_{CC} = V_{RST} \text{ min}$ , $I_{SINK} = 3.2mA$			0.4	
		MAX82_T/S/R/Z/Y, $V_{CC} = V_{RST} \text{ min}$ , $I_{SINK} = 1.2mA$			0.3	
		$T_A = 0^{\circ}C$ to $+70^{\circ}C$ , $V_{CC} = 1V$ , $V_{CC}$ falling, $I_{SINK} = 50\mu A$			0.3	
		$T_A = T_{MIN}$ to $T_{MAX}$ , $V_{CC} = 1.2V$ , $V_{CC}$ falling, $V_{BATT} = 0V$ , $I_{SINK} = 100\mu A$				
$\overline{RESET}$ Output Short-Circuit Current (Note 2)	$I_{SOURCE}$	MAX82_L/M, $\overline{RESET} = 0V$ , $V_{CC} = 5.5V$			800	$\mu A$
		MAX82_T/S/R/Z/Y, $\overline{RESET} = 0V$ , $V_{CC} = 3.6V$			400	
RESET Output Voltage	$V_{OH}$	$V_{CC} > 1.8V$ , $I_{SOURCE} = 150\mu A$	$0.8 \times V_{CC}$			V
	$V_{OL}$	MAX824L/M, MAX825L/M, $V_{CC} = V_{RST} \text{ max}$ , $I_{SINK} = 3.2mA$			0.4	
		MAX824T/S/R/Z/Y, MAX825T/S/R/Z/Y, $V_{CC} = V_{RST} \text{ max}$ , $I_{SINK} = 1.2mA$			0.3	
<b>WATCHDOG INPUT (MAX823/MAX824)</b>						
Watchdog Timeout Period	$t_{WD}$		1.12	1.60	2.40	s
WDI Pulse Width	$t_{WDI}$	$V_{IL} = 0.4V$ , $V_{IH} = 0.8 \times V_{CC}$	50			ns
WDI Input Voltage (Note 3)	$V_{IL}$		$0.3 \times V_{CC}$			V
	$V_{IH}$		$0.7 \times V_{CC}$			
WDI Input Current (Note 4)		WDI = $V_{CC}$ , time average		120	160	$\mu A$
		WDI = 0, time average	-20	-15		

## 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

### ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +4.75V$  to  $+5.5V$  for MAX82\_L,  $V_{CC} = +4.5V$  to  $+5.5V$  for MAX82\_M,  $V_{CC} = +3.15V$  to  $+3.6V$  for MAX82\_T,  $V_{CC} = +3V$  to  $+3.6V$  for MAX82\_S,  $V_{CC} = +2.7V$  to  $+3.6V$  for MAX82\_R,  $V_{CC} = +2.38V$  to  $+2.75V$  for MAX82\_Z,  $V_{CC} = +2.25V$  to  $+2.75V$  for MAX82\_Y,  $T_A = T_{MIN}$  to  $T_{MAX}$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$  (SC70),  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$  (SOT23), unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>MANUAL RESET INPUT (MAX823/MAX825)</b>						
$\overline{MR}$ Input Voltage	$V_{IL}$			0.3 × $V_{CC}$		V
	$V_{IH}$		0.7 × $V_{CC}$			
$\overline{MR}$ Pulse Width			1.0			μs
$\overline{MR}$ Noise Immunity (pulse width with no reset)			100			ns
$\overline{MR}$ to Reset Delay			500			ns
$\overline{MR}$ Pullup Resistance (internal)			35	52	75	kΩ

**Note 1:** Over-temperature limits are guaranteed by design and not production tested.

**Note 2:** The RESET short-circuit current is the maximum pullup current when RESET is driven low by a μP bidirectional reset pin.

**Note 3:** WDI is internally serviced within the watchdog period if WDI is left unconnected.

**Note 4:** The WDI input current is specified as the average input current when the WDI input is driven high or low. The WDI input is designed to drive a three-stated output device with a 10μA maximum leakage current and a maximum capacitive load of 200pF. This output device must be able to source and sink at least 200μA when active.

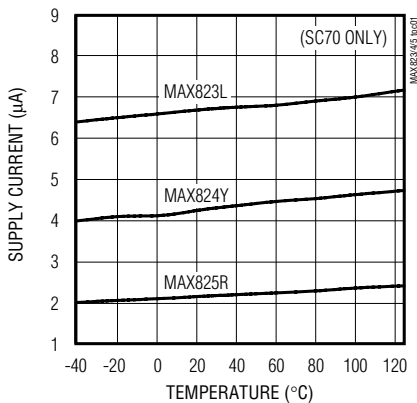
# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Typical Operating Characteristics

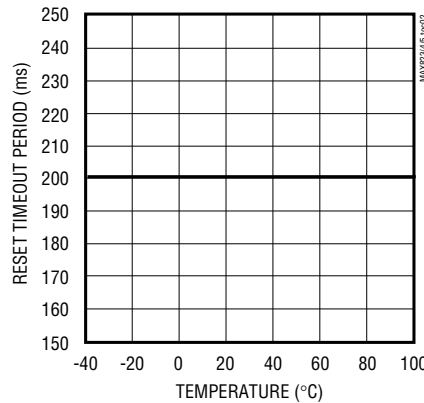
MAX823\_-,  $V_{CC} = +5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX823/MAX824/MAX825

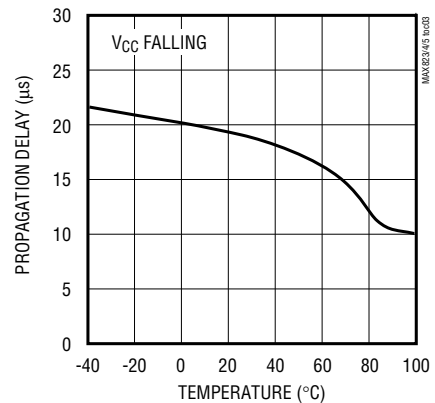
**$V_{CC}$  SUPPLY CURRENT vs. TEMPERATURE**



**RESET TIMEOUT PERIOD vs. TEMPERATURE**



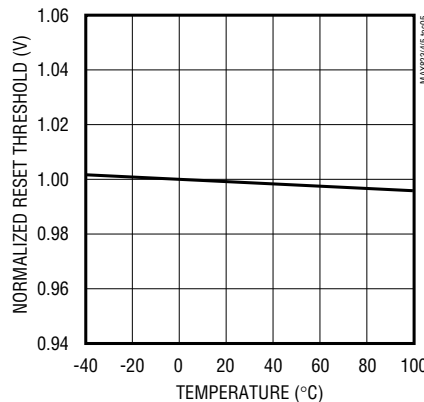
**RESET COMPARATOR PROPAGATION DELAY vs. TEMPERATURE**



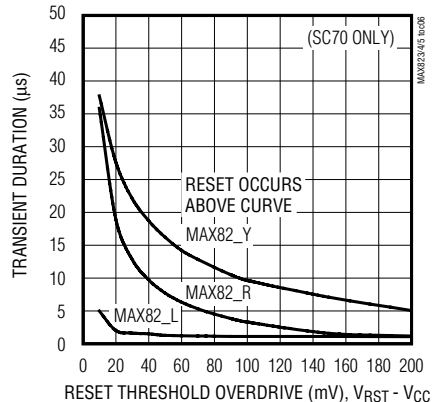
**WATCHDOG TIMEOUT PERIOD vs. TEMPERATURE**



**NORMALIZED RESET THRESHOLD VOLTAGE vs. TEMPERATURE**



**MAXIMUM  $V_{CC}$  TRANSIENT DURATION vs. RESET THRESHOLD OVERDRIVE**



# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Pin Description

PIN			NAME	FUNCTION
MAX823	MAX824	MAX825		
1	1	1	$\overline{\text{RESET}}$	Active-Low Reset Output. Pulses low for 200ms when triggered, and remains low whenever $V_{CC}$ is below the reset threshold or when $\overline{\text{MR}}$ is a logic low. It remains low for 200ms after one of the following occurs: $V_{CC}$ rises above the reset threshold, the watchdog triggers a reset, or $\overline{\text{MR}}$ goes low to high.
2	2	2	GND	Ground
3	—	4	$\overline{\text{MR}}$	Manual Reset Input. A logic low on $\overline{\text{MR}}$ asserts reset. Reset remains asserted as long as $\overline{\text{MR}}$ is held low and for 200ms after $\overline{\text{MR}}$ returns high. The active-low input has an internal 52k $\Omega$ pullup resistor. It can be driven from a CMOS logic line or shorted to ground with a switch. Leave open or connect to $V_{CC}$ if unused.
—	3	3	RESET	Active-High Reset Output. Inverse of $\overline{\text{RESET}}$ .
4	4	—	WDI	Watchdog Input. If WDI remains either high or low for longer than the watchdog timeout period, the internal watchdog timer runs out and a reset is triggered. The internal watchdog timer clears whenever reset is asserted, or whenever WDI sees a rising or falling edge. If WDI is left unconnected or is connected to a three-stated buffer output, the watchdog feature is disabled.
5	5	5	$V_{CC}$	Supply Voltage

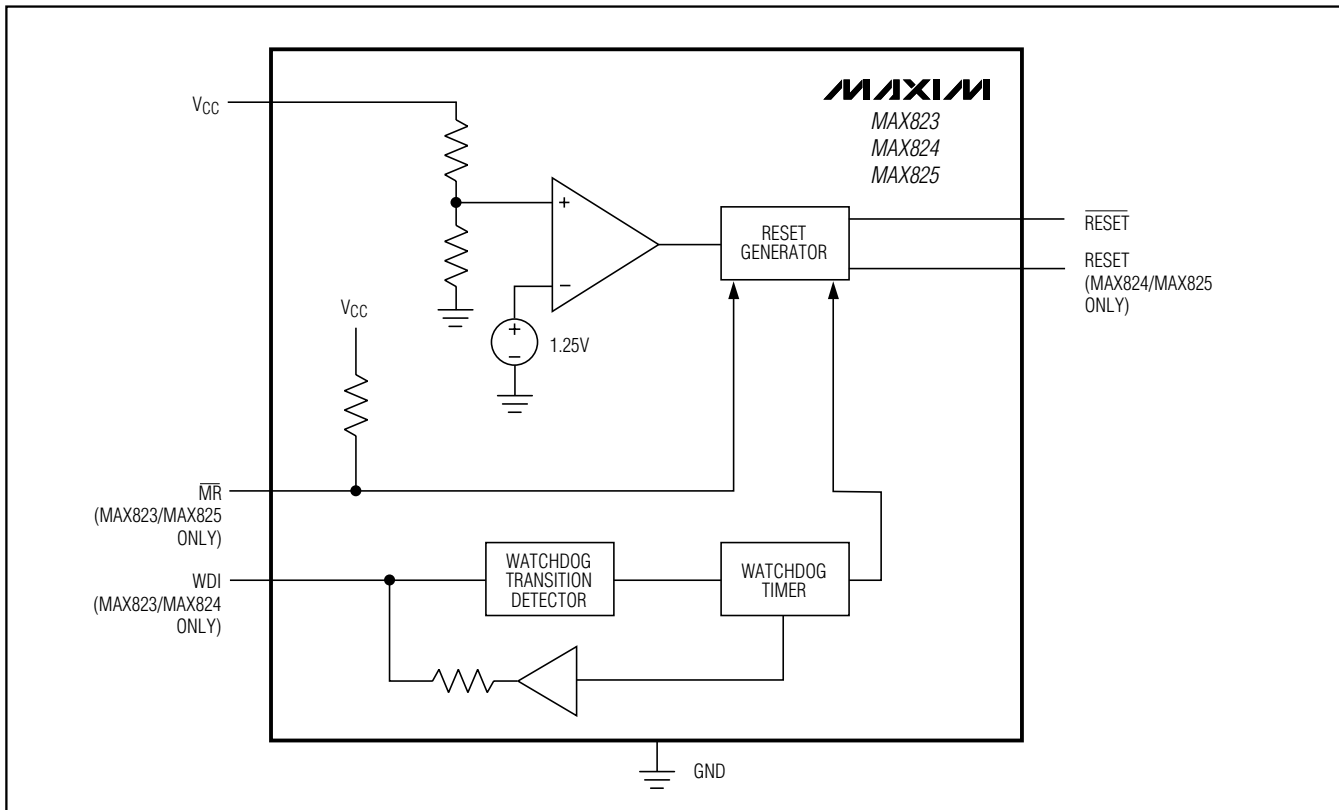


Figure 1. Functional Diagram

# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Detailed Description

### RESET Output

A microprocessor's ( $\mu\text{P}$ 's) reset input starts the  $\mu\text{P}$  in a known state. The MAX823/MAX824/MAX825  $\mu\text{P}$  supervisory circuits assert a reset to prevent code-execution errors during power-up, power-down, and brownout conditions.  $\overline{\text{RESET}}$  is guaranteed to be a logic low for  $V_{\text{CC}}$  down to 1V. Once  $V_{\text{CC}}$  exceeds the reset threshold, an internal timer keeps  $\overline{\text{RESET}}$  low for the specified reset timeout period ( $t_{\text{RP}}$ ); after this interval,  $\overline{\text{RESET}}$  returns high (Figure 2).

If a brownout condition occurs ( $V_{\text{CC}}$  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  $V_{\text{CC}}$  goes below the reset threshold the internal timer restarts.  $\overline{\text{RESET}}$  both sources and sinks current.  $\overline{\text{RESET}}$  on the MAX824/MAX825 is the inverse of  $\overline{\text{RESET}}$ .

### Manual Reset Input (MAX823/MAX825)

Many  $\mu\text{P}$ -based products require manual reset capability, allowing the operator, a test technician, or external logic circuitry to initiate a reset. On the MAX823/MAX825, a logic low on  $\overline{\text{MR}}$  asserts reset. Reset remains asserted while  $\overline{\text{MR}}$  is low, and for  $t_{\text{RP}}$  (200ms nominal) after it returns high.  $\overline{\text{MR}}$  has an internal 52k $\Omega$  pullup resistor, so it can be left open if not used. This input can be driven with CMOS logic levels or with open-drain/collector outputs. Connect a normally open momentary switch from  $\overline{\text{MR}}$  to GND to create a manual-reset function; external debounce circuitry is not required. If  $\overline{\text{MR}}$  is driven from long cables or the device is used in a noisy environment, connect a 0.1 $\mu\text{F}$  capacitor from  $\overline{\text{MR}}$  to GND to provide additional noise immunity.

### Watchdog Input (MAX823/MAX824)

In the MAX823/MAX824, the watchdog circuit monitors the  $\mu\text{P}$ 's activity. If the  $\mu\text{P}$  does not toggle the watchdog input (WDI) within  $t_{\text{WD}}$  (1.6s), reset asserts. The internal 1.6s timer is cleared by either a reset pulse or by toggling WDI, which detects pulses as short as 50ns. While reset is asserted, the timer remains cleared and does not count. As soon as reset is released, the timer starts counting (Figure 3).

Disable the watchdog function by leaving WDI unconnected or by three-stating the driver connected to WDI. The watchdog input is internally driven low during the first 7/8 of the watchdog timeout period and high for the last 1/8 of the watchdog timeout period. When WDI is left unconnected, this internal driver clears the 1.6s timer every 1.4s. When WDI is three-stated or unconnected, the maximum allowable leakage current is 10 $\mu\text{A}$  and the maximum allowable load capacitance is 200pF.

## Applications Information

### Watchdog Input Current

The MAX823/MAX824 WDI inputs are internally driven through a buffer and series resistor from the watchdog counter (Figure 1). When WDI is left unconnected, the watchdog timer is serviced within the watchdog timeout period by a low-high-low pulse from the counter chain. For minimum watchdog input current (minimum overall power consumption), leave WDI low for the majority of the watchdog timeout period, pulsing it low-high-low once within the first 7/8 of the watchdog timeout period to reset the watchdog timer. If WDI is externally driven high for the majority of the timeout period, up to 160 $\mu\text{A}$  can flow into WDI.

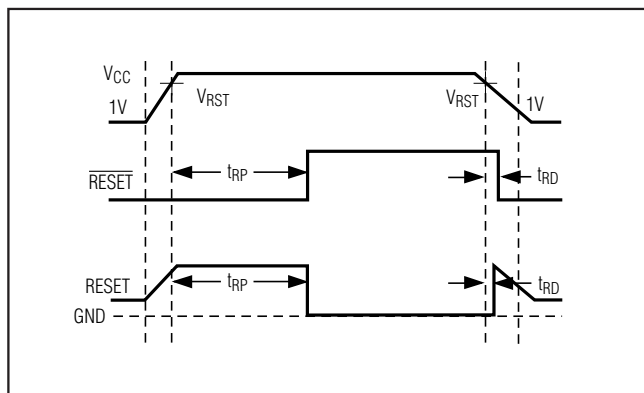


Figure 2. Reset Timing Diagram

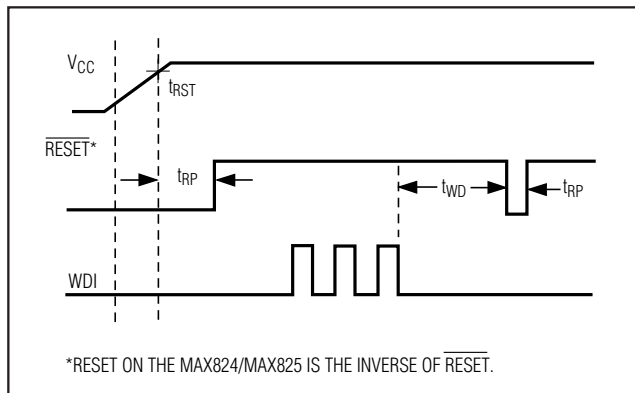


Figure 3. MAX823/MAX824 Watchdog Timing Relationship

# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Interfacing to $\mu$ Ps with Bidirectional Reset Pins

The  $\overline{\text{RESET}}$  output maximum pullup current is 800 $\mu$ A for L/M versions (400 $\mu$ A for T/S/R/Z/Y versions). This allows  $\mu$ Ps with bidirectional resets, such as the 68HC11, to force  $\overline{\text{RESET}}$  low when the MAX823/MAX824/MAX825 are pulling  $\overline{\text{RESET}}$  high (Figure 4).

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

These supervisors are relatively immune to short-duration, negative-going  $V_{CC}$  transients (glitches), which usually do not require the entire system to shut down. Resets are issued to the  $\mu$ P during power-up, power-down, and brownout conditions.

The *Typical Operating Characteristics* show a graph of the MAX823's Maximum  $V_{CC}$  Transient Duration vs. Reset Threshold Overdrive, for which reset pulses are **not** generated. The graph was produced using negative-going  $V_{CC}$  pulses, starting at 5V and ending below the reset threshold by the magnitude indicated (reset threshold overdrive). The graph shows the maximum pulse width that a negative-going  $V_{CC}$  transient can typically have without triggering a reset pulse. As the amplitude of the transient increases (i.e., goes farther below the reset threshold), the maximum allowable pulse width decreases.

An optional 0.1 $\mu$ F bypass capacitor mounted close to  $V_{CC}$  provides additional transient immunity.

## Watchdog Software Considerations (MAX823/MAX824)

One way to help the watchdog timer monitor software execution more closely is to set and reset 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 inside the loop, keeping the watchdog from timing out.

Figure 5 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. As described in the *Watchdog Input Current* section, this scheme results in higher time average WDI input current than does leaving WDI low for the majority of the timeout period and periodically pulsing it low-high-low.

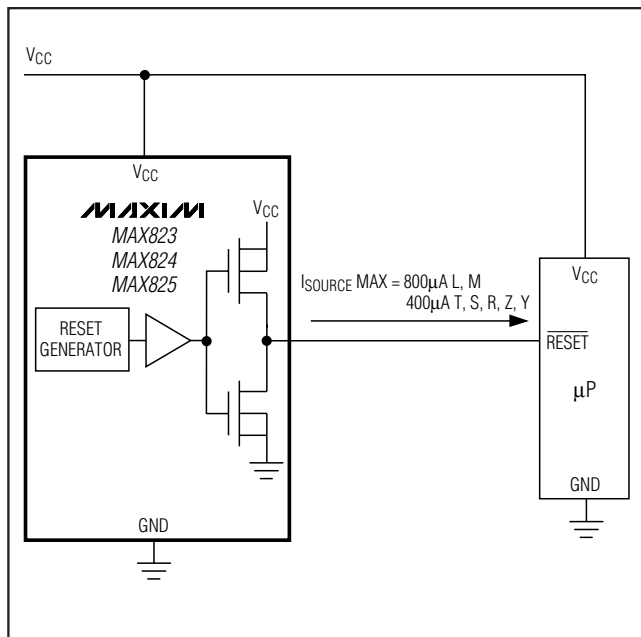


Figure 4. Interfacing to  $\mu$ Ps with Bidirectional Resets

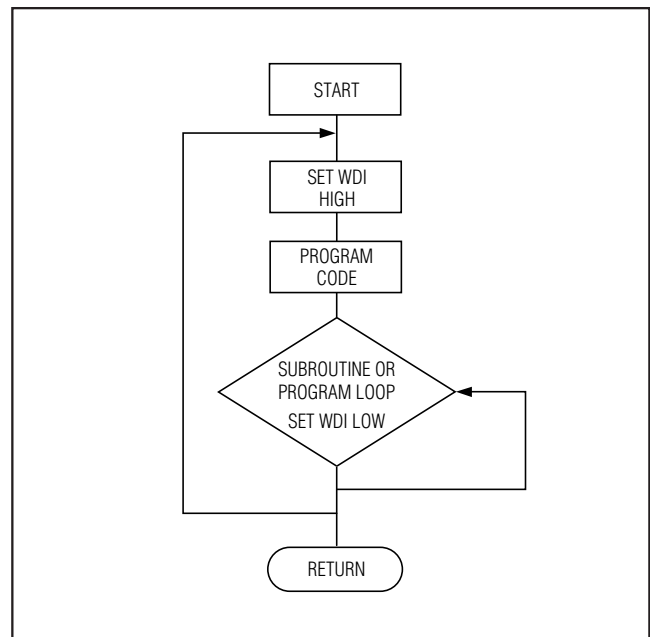


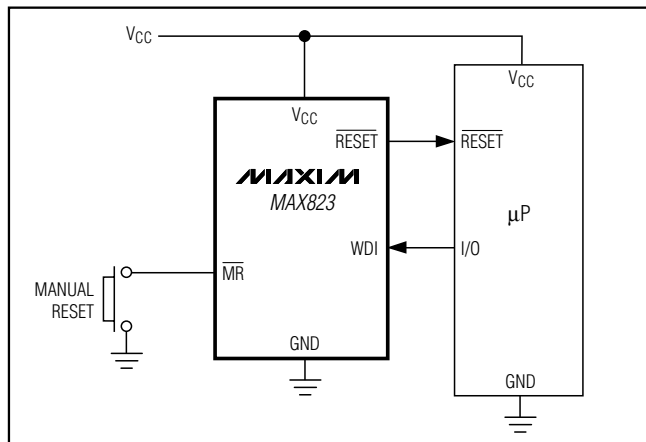
Figure 5. Watchdog Flow Diagram



# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Typical Operating Circuit

## Chip Information



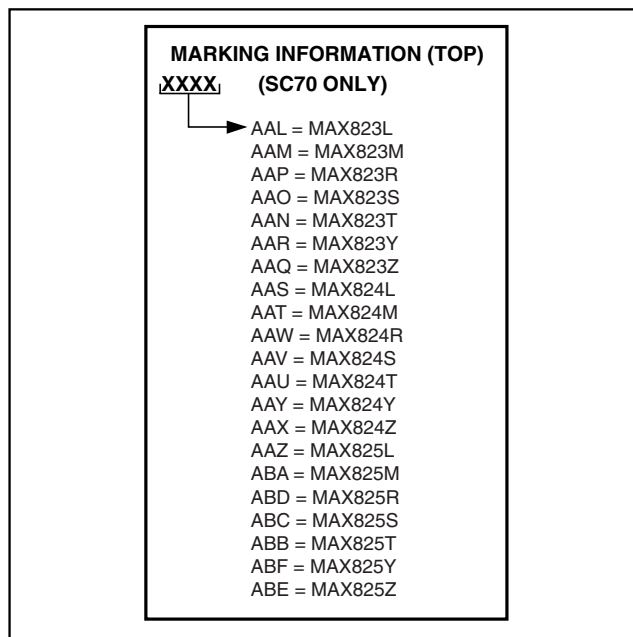
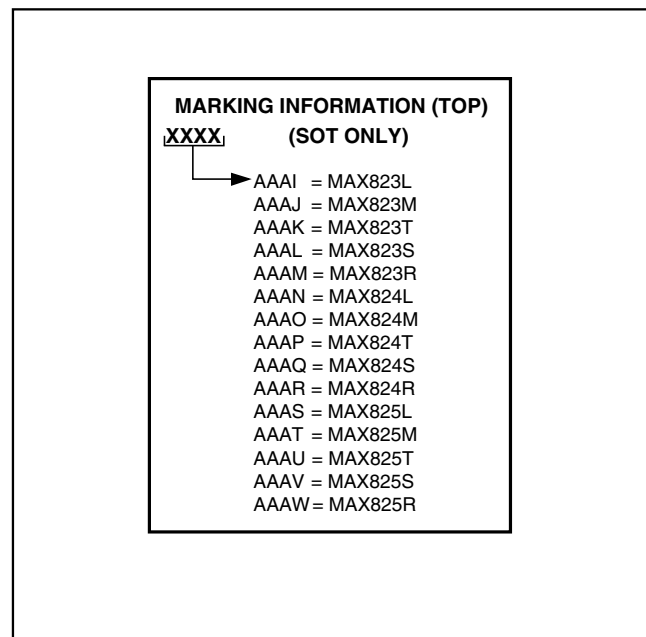
TRANSISTOR COUNT: 607  
 PROCESS TECHNOLOGY: BiCMOS

## Ordering Information (continued)

PART <sup>†</sup>	TEMP. RANGE	PIN-PACKAGE
MAX824_EUK-T	-40°C to +125°C	5 SOT23-5
<b>MAX825_EXK-T</b>	-40°C to +85°C	5 SC70-5
MAX825_EUK-T	-40°C to +125°C	5 SOT23-5

<sup>†</sup>Insert the desired suffix letter (from the Reset Threshold table) into the blank to complete the part number. All devices are available in tape-and-reel only. There is a 2,500 piece minimum order increment. Devices are available in both leaded and lead-free packaging. Specify lead-free by replacing "-T" with "+T" when ordering.

## Marking Information



# 5-Pin Microprocessor Supervisory Circuits With Watchdog Timer and Manual Reset

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



SOT-23 5L.EPS

**DALLAS SEMICONDUCTOR** **MAXIM**  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE OUTLINE, SOT-23, 5L  
 APPROVAL: \_\_\_\_\_ DOCUMENT CONTROL NO. 21-0057 REV. E 1/1

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