

## Low-Cost, Ultra-Small, 3µA Single-Supply Comparators

### **General Description**

The MAX9075/MAX9077 single/dual comparators are optimized for 3V and 5V single-supply applications. These comparators have a 580ns propagation delay and consume just  $3\mu A$  per comparator. The combination of low-power, single-supply operation down to 2.1V, and ultra-small footprint makes these devices ideal for all portable applications.

The MAX9075/MAX9077 have a common-mode input voltage range of -0.2V to  $V_{CC}$  - 1.2V. Unlike many comparators, there is no differential clamp between the inputs, allowing the differential input voltage range to extend rail-to-rail. All inputs and outputs tolerate a continuous short-circuit fault condition to either rail.

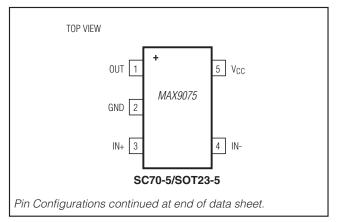
The design of the output stage limits supply-current surges while switching (typical of many other comparators), minimizing power consumption under dynamic conditions. Large internal push-pull output drivers allow rail-to-rail output swing with loads up to 2mA, making these devices ideal for interface with TTL/CMOS logic.

The MAX9075 single comparator is available in 5-pin SC70 and SOT23 packages, while the MAX9077 dual comparator is available in 8-pin SOT23,  $\mu$ MAX®, and SO packages.

#### **Applications**

Battery-Powered Systems
Threshold Detectors/Discriminators
Keyless Entry Systems
IR Receivers
Digital Line Receivers

## Pin Configurations



 $\mu$ MAX is a registered trademark of Maxim Integrated Products, Inc.

#### **Features**

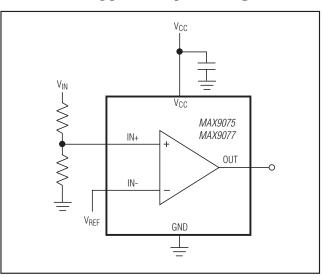
- ♦ 580ns Propagation Delay from Only 3µA
- ♦ 2.1V to 5.5V Single-Supply Operation
- **♦** Ground-Sensing Inputs
- ♦ Rail-to-Rail Outputs
- ♦ No Output Phase Inversion for Overdriven Inputs
- ♦ No Differential Clamp Across Inputs
- Available in Ultra-Small Packages
   5-Pin SC70 (MAX9075)
   8-Pin SOT23 (MAX9077)

#### **Ordering Information**

		,		
PART*	TEMP RANGE	PIN- PACKAGE	TOP MARK	
MAX9075EXK+T	-40°C to +85°C	5 SC70	AAC+	
MAX9075EUK+T	-40°C to +85°C	5 SOT23	ADLX+	
MAX9077EKA+T	-40°C to +85°C	8 SOT23	AAAD+	
MAX9077EUA+	-40°C to +85°C	8 µMAX	_	
MAX9077ESA+	-40°C to +85°C	8 SO	_	
MAX9077MSA/PR2	-55°C to +125°C	8 SO	_	

<sup>+</sup>Denotes a lead(Pb)-free/RoHS-compliant package.

## Typical Operating Circuit



For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maximintegrated.com.

<sup>\*</sup>Denotes a package containing lead(Pb).

T = Tape and reel.

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#### **ABSOLUTE MAXIMUM RATINGS**

Supply Voltage	8-Pin µMAX (derate 4.5mW/°C above +70°C)362mW
V <sub>CC</sub> to GND6V	8-Pin SO (derate 5.88mW/°C above +70°C)471mW
All Other Pins to GND0.3V to (V <sub>CC</sub> + 0.3V)	Operating Temperature Range40°C to +85°C
Current into Input Pins±20mA	Military Operating Temperature Range55°C to +125°C
Duration of Output Short-Circuit to GND or VCCContinuous	Storage Temperature Range65°C to +150°C
Continuous Power Dissipation ( $T_A = +70$ °C)	Lead Temperature (soldering, 10s)+300°C
5-Pin SC70 (derate 3.1mW/°C above +70°C)247mW	Soldering Temperature (reflow)
5-Pin SOT23 (derate 3.1mW/°C above +70°C)247mW	Lead (Pb)-free+260°C
8-Pin SOT23 (derate 5.2mW/°C above +70°C)412mW	Containing lead (Pb)+240°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**

 $(V_{CC} = 5V, V_{CM} = 0V, T_A = T_{MIN} \text{ to } T_{MAX}, \text{ unless otherwise noted. Typical values are at } T_A = +25^{\circ}C.) \text{ (Note 1)}$ 

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Supply Voltage Range	Vcc	Inferred from PSRR		2.1		5.5	V
Supply Current per Comparator		V <sub>CC</sub> = 5V	T <sub>A</sub> = +25°C		3	5.2	μΑ
	Icc		$T_A = T_{MIN}$ to $T_{MAX}$			7.5	
		V <sub>CC</sub> = 3V			2.4		
Power-Supply Rejection Ratio	PSRR	$2.1V \le V_{CC} \le 5.5V$		54	77		dB
Common-Mode Voltage Range	V <sub>CMR</sub>	(Note 2)		0		V <sub>CC</sub> - 1.2	V
Input Offset Voltage	Vos				±1	±8	mV
Input Offset Current	los				1		nA
Input Bias Current	IB	V <sub>CM</sub> = 0.2V (Note 3)			-5	-20	nA
Input Capacitance	CIN				3		рF
Common-Mode Rejection Ratio	CMRR	$0V \le V_{CM} \le (V_{CC} - 1.2V)$		60	82		dB
OUT_ Output-Voltage High	V <sub>OH</sub>	I <sub>SOURCE</sub> = 2mA		V <sub>CC</sub> - 0.4			V
OUT_ Output-Voltage Low	Vol	I <sub>SINK</sub> = 2mA				0.4	V
Propagation Delay Low to High	t <sub>PD+</sub>	C <sub>LOAD</sub> = 10pF, overdrive = 100mV			580		ns
Propagation Delay High to Low	t <sub>PD-</sub>	C <sub>LOAD</sub> = 10pF, overdrive = 100mV			250		ns
Rise/Fall Time		C <sub>LOAD</sub> = 10pF			1.6		ns

Note 1: All devices are 100% production tested at  $T_A = +25^{\circ}C$ . All temperature limits are guaranteed by design.

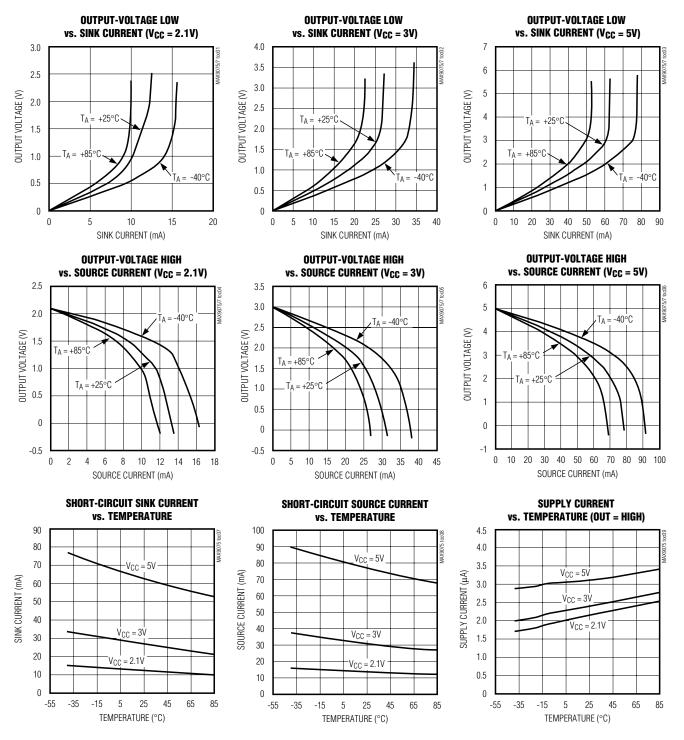
**Note 2:** Inferred from CMRR. Either input can be driven to the absolute maximum limit without output inversion, as long as the other input is within the input voltage range.

Note 3: Guaranteed by design.

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### **Typical Operating Characteristics**

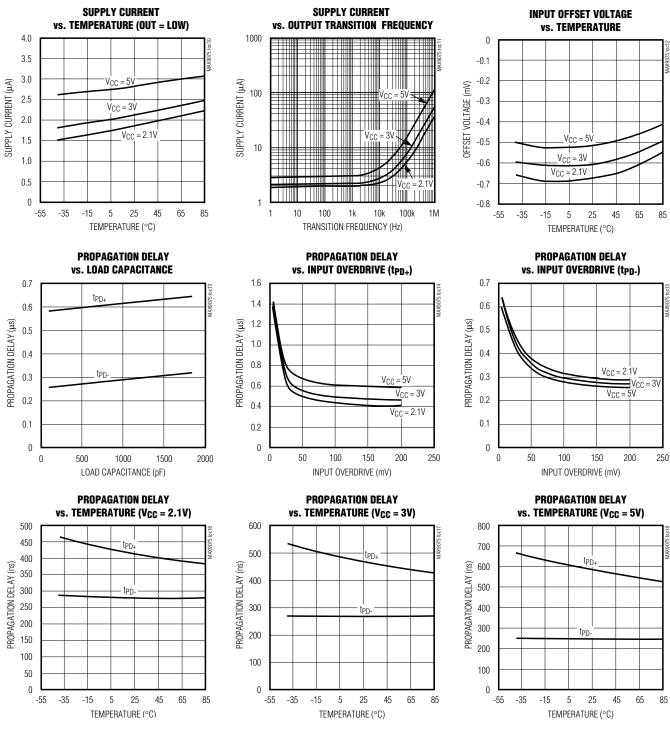
( $V_{CC} = 5V$ ,  $V_{CM} = 0V$ , 100mV overdrive,  $T_A = +25$ °C, unless otherwise noted.)



# Low-Cost, Ultra-Small, 3µA Single-Supply Comparators

## Typical Operating Characteristics (continued)

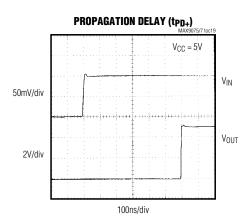
 $(V_{CC} = 5V, V_{CM} = 0V, 100mV \text{ overdrive}, T_A = +25^{\circ}C, \text{ unless otherwise noted.})$ 

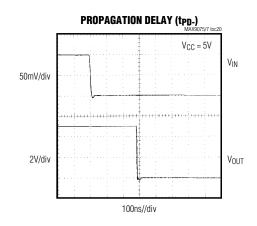


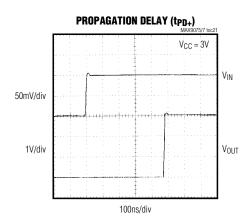
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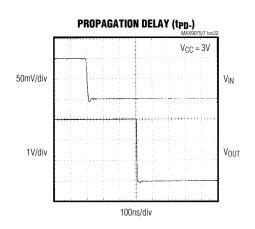
## Typical Operating Characteristics (continued)

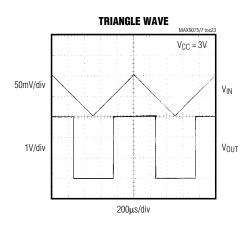
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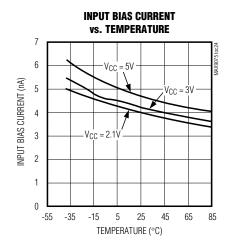












## Low-Cost, Ultra-Small, 3µA Single-Supply Comparators

### **Pin Description**

	Р	rIN			
MAX9075		MAX9077		NAME	FUNCTION
SOT23	SC70	μMAX/SO	SOT23		
1	1	_	_	OUT	Comparator Output
_	_	1	1	OUTA	Output of Comparator A
2	2	4	2	GND	Ground
3	3	_	_	IN+	Noninverting Comparator Input
_	_	3	4	INA+	Noninverting Input of Comparator A
4	4	_	_	IN-	Inverting Comparator Input
_	_	2	3	INA-	Inverting Input of Comparator A
5	5	8	8	Vcc	Positive Supply Voltage
_	_	5	5	INB+	Noninverting Input of Comparator B
_	_	6	6	INB-	Inverting Input of Comparator B
_	_	7	7	OUTB	Output of Comparator B

### **Detailed Description**

The MAX9075/MAX9077 feature a 580ns propagation delay from an ultra-low supply current of only 3µA per comparator. These devices are capable of single-supply operation in the 2.1V to 5.5V range. Large internal output drivers allow rail-to-rail output swing with up to 2mA loads. Both comparators offer a push-pull output that sinks and sources current.

#### **Comparator Output**

The MAX9075/MAX9077 are designed to maintain a low-supply current during repeated transitions by limiting the shoot-through current.

#### **Noise Considerations, Comparator Input**

The input common-mode voltage range for these devices extends from 0V to V<sub>CC</sub> - 1.2V. Unlike many other comparators, the MAX9075/MAX9077 can operate at any differential input voltage within these limits. Input bias current is typically -5nA if the input voltage is between the supply rails.

Although the comparators have a very high gain, useful gain is limited by noise. The comparator has a wideband peak-to-peak noise of approximately 70µV.

### **Applications Information**

#### **Adding Hysteresis**

Hysteresis extends the comparator's noise margin by increasing the upper threshold and decreasing the lower threshold. A voltage divider from the output of the comparator sets the trip voltage. Therefore, the trip voltage is related to the output voltage. Set the hysteresis with three resistors using positive feedback, as shown in Figure 1.

The design procedure is as follows:

- 1) Choose R3. The leakage current of IN+ may cause a small error; however, the current through R3 can be approximately 500nA and still maintain accuracy. The added supply current due to the circuit at the trip point is VCC/R3;  $10M\Omega$  is a good practical value for R3, as this keeps the current well below the supply current of the chip.
- 2) Choose the hysteresis voltage (VHYS), which is the voltage between the upper and lower thresholds. In this example, choose VHYS = 50mV and assume VREF = 1.2V and VCC = 5V.
- 3) Calculate R1 as follows:

 $R1 = R3 \times V_{HYS}/V_{CC} = 10M\Omega \times 0.05/5 = 100k\Omega$ 

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- 4) Choose the threshold voltage for V<sub>IN</sub> rising (V<sub>THR</sub>). In this example, choose V<sub>THR</sub> = 3V.
- 5) Calculate R2 as follows:

R2 =  $1/{[V_{THR}/(V_{REF} \times R1)]} - 1/R1 - 1/R3$  =  $1/{[3 / (1.2 \times 100 k\Omega)]} - 1/100 k\Omega - 1/100 MΩ$  =  $67.114 k\Omega$ 

A 1% preferred value is  $64.9k\Omega$ .

6) Verify the threshold voltages with these formulas: V<sub>IN</sub> rising:

$$V_{THR} = V_{REF} \times R1 (1/R1 + 1/R2 + 1/R3)$$

VIN falling:

$$V_{THF} = V_{THR} - (R1 \times V_{CC})/R3$$

7) Check the error due to input bias current (5nA). If the error is too large, reduce R3 and recalculate.

$$V_{TH} = I_B (R1 \times R2 \times R3)/(R1 + R2 + R3) = 0.2mV$$

#### **Board Layout and Bypassing**

Use 10nF power-supply bypass capacitors. Use 100nF bypass capacitors when supply impedance is high, when supply leads are long, or when excessive noise is expected on the supply lines. Minimize signal trace lengths to reduce stray capacitance. Minimize the capacitive coupling between IN- and OUT. For slow-moving input signals (rise time > 1ms) use a 1nF capacitor between IN+ and IN-.

#### **Chip Information**

PROCESS: BICMOS

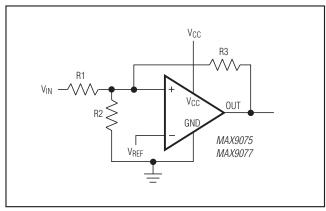
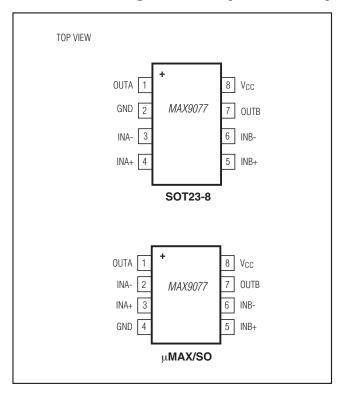


Figure 1. Adding Hysteresis

### \_Pin Configurations (continued)



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## **Package Information**

For the latest package outline information and land patterns (footprints), go to <a href="www.maximintegrated.com/packages">www.maximintegrated.com/packages</a>. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
5 SC70	X5+1	<u>21-0076</u>	<u>90-0188</u>
5 SOT23	U5+1	<u>21-0057</u>	<u>90-0174</u>
8 SOT23	K8+2	21-0078	<u>90-0176</u>
8 μMAX	U8+1	<u>21-0036</u>	<u>90-0092</u>
8 S0	S8+4	21-0041	<u>90-0096</u>

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### **Revision History**

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	0/99	Initial release	_
3	1/07	Revised Absolute Maximum Ratings	2
4	12/12	Added MAX9077MSA/PR2 to <i>Ordering Information</i> and updated for lead-free notation. Revised <i>Absolute Maximum Ratings, Electrical Characteristics</i> , and the <i>Noise Considerations, Comparator Input</i> section.	1, 2, 6



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