

General-Purpose, Low-Voltage, Tiny Pack Comparators

General Description

Features

The MAX9647/MAX9648 comparators are drop-in, pin-forpin compatible replacements for the LMX331/LMX331H. The MAX9648 has the added benefit of internal hysteresis to provide noise immunity, preventing output oscillations even with slow moving input signals.

Advantages of the ICs include low supply voltage, small package, and low cost. They also offer a wide supply voltage range, wide operating temperature range, competitive CMRR and PSRR, response time characteristics. input offset, low noise, output saturation voltage, input bias current, and RF immunity.

The ICs are available in both 5-pin SC70 and SOT23 packages.

Applications

Mobile Communications Notebooks and PDAs **Automotive Applications Battery-Powered Electronics** General-Purpose Portable Devices General-Purpose Low-Voltage Applications ♦ Guaranteed +1.8V to +5.5V Performance

- ♦ -40°C to +125°C Automotive Temperature Range
- ♦ Low Supply Current (60µA/Channel at VDD = +5.0V
- **♦ Input Common-Mode Voltage Range Includes** Ground
- ♦ No Phase Reversal for Overdriven Inputs
- **♦ Low Output Saturation Voltage (120mV)**
- ♦ Internal 2mV Hysteresis (MAX9648)
- ♦ 5-Pin SC70 Space-Saving Package (2.0 mm x 2.1 mm x 1.0 mm)

Ordering Information appears at end of data sheet.

For related parts and recommended products to use with this part, refer to www.maxim-ic.com/MAX9647.related.

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ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V _{DD} to V _{SS})0.3V to +6V	Operating Temperature Range40°C to +125°C
All Other Pins(V _{SS} - 0.3V) to (V _{DD} + 0.3V)	Junction Temperature+150°C
Continuous Power Dissipation ($T_A = +70^{\circ}C$)	Storage Temperature Range65°C to +150°C
SC70 (derate 3.1 mW/°C above +70°C)247mW	Lead Temperature (soldering, 10s)+300°C
SOT23 (derate 7.1 mW/°C above +70°C)571mW	Soldering Temperature (reflow)+260°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.

DC ELECTRICAL CHARACTERISTICS—2.7V OPERATION

 $(V_{DD} = 2.7V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	V _{OS}			0.4	7	mV
Input Voltage Hysteresis	V _{HYST}	MAX9648 only		2		mV
Input Offset Voltage Average Temperature Drift	TCV _{OS}			1.5		μV/°C
		$T_A = +25$ °C		±0.0003	±250	
Input Bias Current	IB	$T_A = -40$ °C to $+85$ °C			±400	nA
		$T_A = -40$ °C to $+125$ °C			±400	
		$T_A = +25$ °C		±0.0003	±50	nA
Input Offset Current	I _{OS}	$T_A = -40$ °C to $+85$ °C			±150	
		$T_A = -40^{\circ}\text{C to } + 125^{\circ}\text{C}$			±150	
Input Voltage Range	Voi			-0.1		V
Input voltage hange	V _{CM}			2.0		V
Voltage Gain	A _V	MAX9647 only		500		V/mV
Output Saturation Voltage	V _{SAT}	I _{SINK} ≤ 1mA		25		mV
Output Sink Current	Io	V _O ≤ 1.5V	5	16		mA
Supply Current	IS	(Note 2)		52	100	μΑ
Output Leakage Current		$T_A = +25^{\circ}C$		0.005		
		$T_A = -40$ °C to $+85$ °C			1	μΑ
		$T_A = -40^{\circ}\text{C to } + 125^{\circ}\text{C}$			2	1

AC ELECTRICAL CHARACTERISTICS—2.7V OPERATION

 $(V_{DD} = 2.7V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
Propagation Delay Output	t	Input overdrive = 10mV		70		no	
High to Low (Note 3)	t _{PHL}	Input overdrive = 100mV		50		ns	
Propagation Delay Output		Input overdrive = 10mV		115		no	
Low to High (Note 3)	^t PLH	Input overdrive = 100mV		100		ns	

General-Purpose, Low-Voltage, Tiny Pack Comparators

DC ELECTRICAL CHARACTERISTICS-5.0V OPERATION

 $(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
		$T_A = +25^{\circ}C$			0.4	7	
Input Offset Voltage	Vos	$T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$				9	mV
		$T_A = -40^{\circ}C \text{ to } +1$	25°C			9	1
Input Voltage Hysteresis		MAX9648 only			2		mV
Input Offset Voltage Average Temperature Drift	TCV _{OS}				1.5		μV/°C
		$T_A = +25^{\circ}C$			±0.007	±250	
Input Bias Current	IB	$T_A = -40^{\circ}\text{C to } +8$	35°C			±400	nA
		$T_A = -40^{\circ}\text{C to } + 1$	25°C			±400	1
		$T_A = +25^{\circ}C$			±0.007	±50	
Input Offset Current	los	$T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$				±150	nA
		$T_A = -40$ °C to +125°C				±150	0
Input Voltage Range	V				-0.1		V
Input Voltage Hange	V _{CM}				4.2		V
Voltage Gain	A _V	MAX9647 only		20	500		V/mV
			$T_A = +25^{\circ}C$		120	400	
Output Saturation Voltage	V _{SAT}	I _{SINK} ≤ 4mA	$T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$			700	mV
			$T_A = -40^{\circ}\text{C to} + 125^{\circ}\text{C}$			700]
Output Sink Current	Io	V _O ≤ 1.5V		10	35		mA
		$T_A = +25^{\circ}C$			60	120	
Supply Current (Note 2)	Is	$T_A = -40$ °C to +85°C				150	μΑ
		$T_A = -40$ °C to +125°C				170	1
		T _A = +25°C			0.005		
Output Leakage Current		$T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$				1	μΑ
		$T_A = -40^{\circ}\text{C to } + 1$	25°C			2	1

AC ELECTRICAL CHARACTERISTICS-5.0V OPERATION

 $(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
Propagation Delay Output	+	Input overdrive = 10mV		70		20	
High to Low (Note 3)	t _{PHL}	Input overdrive = 100mV		50		ns	
Propagation Delay Output	+	Input overdrive = 10mV		110		20	
Low to High (Note 3)	^t PLH	Input overdrive = 100mV		100		ns	

General-Purpose, Low-Voltage, Tiny Pack Comparators

DC ELECTRICAL CHARACTERISTICS—1.8V OPERATION

 $(V_{DD} = 1.8V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Vos			0.4	5	mV
Input Voltage Hysteresis		MAX9648 only		2		mV
Input Offset Voltage Average Temperature Drift	TCV _{OS}			1.5		μV/°C
Input Bias Current	IB			0.0003		nA
Input Offset Current	Ios			0.0003		nA
Input Voltage Range	V _{CM}			-0.1		V
input voltage hange	vCM			1		V
Output Saturation Voltage	V _{SAT}	I _{SINK} ≤ 1mA		56		mV
Power-Supply Rejection Ratio	PSRR	$V_{DD} = 1.8V \text{ to } 5.5V$	60	90		dB
Output Sink Current	Io	V _O ≤ 1.5V		6.4		mA
Supply Current	IS	(Note 2)		50	100	μΑ
Output Leakage Current				0.001		μΑ

AC ELECTRICAL CHARACTERISTICS—1.8V OPERATION

 $(V_{DD} = 1.8V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega$ connected to V_{DD} , typical values are at $T_A = +25$ °C, unless otherwise noted. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
Propagation Delay Output	+	Input overdrive = 10mV		70		no	
High to Low (Note 3)	^t PHL	Input overdrive = 100mV		60		ns	
Propagation Delay Output	+	Input overdrive = 10mV		120		20	
Low to High (Note 3)	^t PLH	Input overdrive = 100mV		110		ns	

Note 1: All devices are production tested at T_A = +25°C. All temperature limits are guaranteed by design.

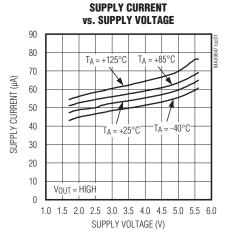
Note 2: Supply current when output is high.

Note 3: Input overdrive is the overdrive voltage beyond the offset and hysteresis-determined trip points.

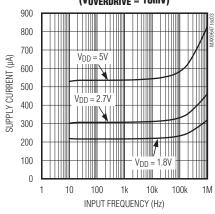
General-Purpose, Low-Voltage, Tiny Pack Comparators

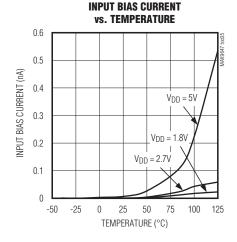
Typical Operating Characteristics

 $(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega, C_L = 10pF, overdrive = 100mV, T_A = +25°C, unless otherwise noted.)$

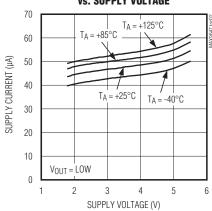


SUPPLY CURRENT vs. FREQUENCY (Voverdrive = 10mV)

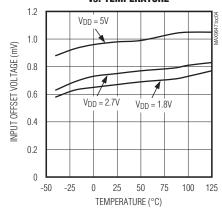




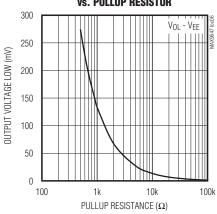
SUPPLY CURRENT vs. SUPPLY VOLTAGE



INPUT OFFSET VOLTAGE vs. TEMPERATURE



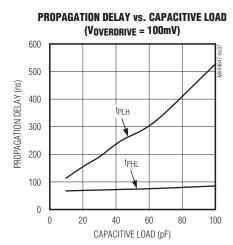
OUTPUT VOLTAGE LOW vs. PULLUP RESISTOR

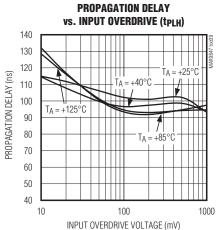


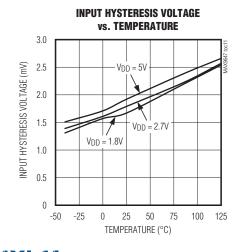
General-Purpose, Low-Voltage, Tiny Pack Comparators

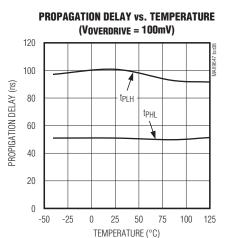
Typical Operating Characteristics (continued)

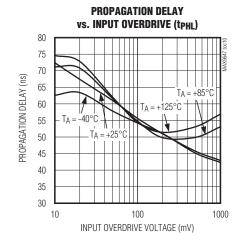
 $(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1k\Omega, C_L = 10pF, overdrive = 100mV, T_A = +25°C, unless otherwise noted.)$

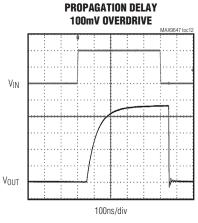








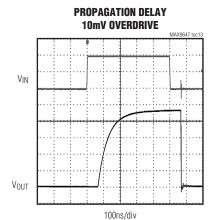


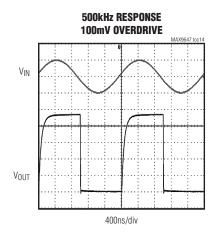


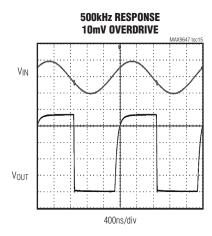
General-Purpose, Low-Voltage, **Tiny Pack Comparators**

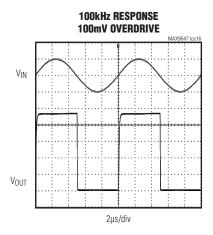
Typical Operating Characteristics (continued)

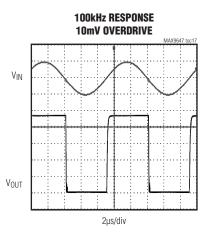
 $(V_{DD}=5V,\,V_{SS}=0V,\,V_{CM}=0V,\,R_{L}=5.1k\Omega,\,C_{L}=10pF,\,overdrive=100mV,\,T_{A}=+25^{\circ}C,\,unless\,\,otherwise\,\,noted.)$

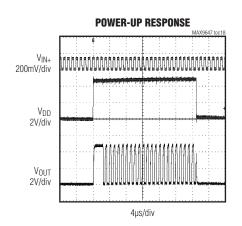






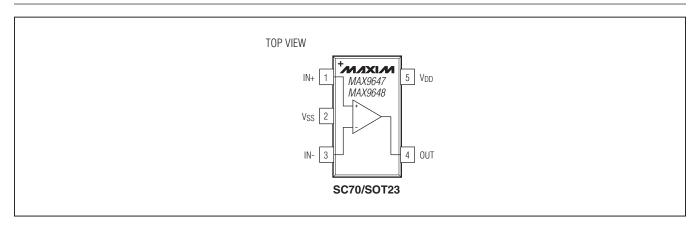






General-Purpose, Low-Voltage, Tiny Pack Comparators

Pin Configuration



Pin Description

PIN	NAME	FUNCTION
1	IN+	Noninverting Input
2	V _{SS}	Negative Supply (Connect to GND)
3	IN-	Inverting Input
4	OUT	Comparator Output (Open Drain)
5	V _{DD}	Positive Supply

Detailed Description

The MAX9647/MAX9648 are low-cost, general-purpose comparators that have a single-supply +1.8V to +5V operating voltage range. The common-mode input range extends from -0.1V below the negative supply to within +0.7V of the positive supply. They require approximately 60µA per comparator with a 5V supply and 52µA with a 2.7V supply.

The MAX9648 has 2mV of hysteresis for noise immunity. This significantly reduces the chance of output oscillations even with slow moving input signals. The ICs are ideal for automotive applications because they operate from -40°C to +125°C. See the Typical Operating Characteristics.

Applications Information

Hysteresis

Many comparators oscillate in the linear region of operation because of noise or undesired parasitic feedback. This tends to occur when the voltage on one input is egual or very close to the voltage on the other input. The MAX9648 has internal hysteresis to counter parasitic effects and noise.

The hysteresis in a comparator creates two trip points: one for the rising input voltage and one for the falling input voltage (Figure 1). The difference between the trip points is the hysteresis. When the comparator's input voltages are equal, the hysteresis effectively causes one comparator input to move quickly past the other, thus taking the input out of the region where oscillation occurs. This provides clean output transitions for noisy, slow-moving input signals.

General-Purpose, Low-Voltage, Tiny Pack Comparators

Additional hysteresis can be generated with two resistors using positive feedback (Figure 2). Use the following procedure to calculate resistor values:

1) Find output voltage when output is high:

2) Find the trip points of the comparator using these formulas:

$$V_{TH} = V_{REF} + ((V_{OUT(HIGH)} - V_{REF})R2)/(R1 + R2)$$

 $V_{TI} = V_{REF}(1 - (R2/(R1 + R2)))$

where V_{TH} is the threshold voltage at which the comparator switches its output from high to low as V_{IN} rises above the trip point, and V_{TI} is the threshold voltage at which the comparator switches its output from low to high as V_{IN} drops below the trip point.

3) The hysteresis band is:

$$V_{HYST} = V_{TH} - V_{TI} = V_{DD}(R2/(R1 + R2))$$

In this example, let $V_{DD} = 5V$, $V_{REF} = 2.5V$, $I_{LOAD} =$ 50nA, and $R_L = 5.1k\Omega$.

$$V_{OUT(HIGH)} = 5.0V - (50 \times 10^{-9} \times 5.1 \times 10^{3}\Omega) \approx 5.0V$$

 $V_{TH} = 2.5 + 2.5(R2/(R1 + R2))$
 $V_{TI} = 2.5(1 - (R2/(R1 + R2)))$

Select R2. In this example, choose $1k\Omega$. Select V_{HYST}. In this example, choose 50mV. Solve for R1.

$$V_{HYST} = V_{OUT(HIGH)}(R2/(R1 + R2))V$$

 $0.050V = 5(1000/(R1 + 1000))V$

where R1
$$\approx$$
 100k Ω , V_{TH} = 2.525V, and V_{TL} = 2.475V

Choose R1 and R2 to be large enough as not to exceed the amount of current the reference can supply.

The source current required is $V_{RFF}/(R1 + R2)$.

The sink current is (V_{OUT(HIGH)} - V_{REF}) x (R1 + R2).

Choose R_I to be large enough to avoid drawing excess current, yet small enough to supply the necessary current to drive the load. R_{I} should be between $1k\Omega$ and $10k\Omega$. Choose R1 to be much larger than R_I to avoid lowering Vout(HIGH) ir raising Vout(LOW).

Board Layout and Bypassing

Use $0.1\mu F$ bypass capacitors from V_{DD} to V_{SS} . To maximize performance, minimize stray inductance by putting this capacitor close to the V_{DD} pin and reducing trace lengths. For slow moving input signals (rise time > 1ms), use a 1nF capacitor between IN+ and IN- to reduce high frequency noise.

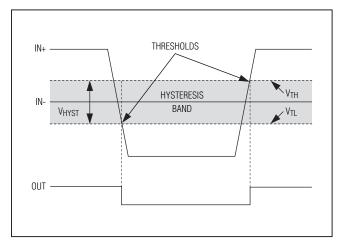


Figure 1. Threshold Hysteresis Band (Not to Scale)

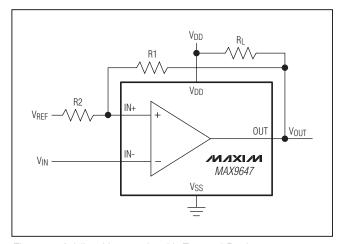


Figure 2. Adding Hysteresis with External Resistors

General-Purpose, Low-Voltage, Tiny Pack Comparators

Chip Information

Package Information

PROCESS: BiCMOS

For the latest package outline information and land patterns (footprints), go to www.maxim-ic.com/packages. 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	21-0057	90-0174

Ordering Information

PART	TEMP RANGE	PIN- PACKAGE	TOP MARK
MAX9647AXK+T	-40°C to +125°C	5 SC70	+AUS
MAX9647AUK+T	-40°C to +125°C	5 SOT23	+AFLM
MAX9648AXK+T	-40°C to +125°C	5 SC70	+AUT
MAX9648AUK+T	-40°C to +125°C	5 SOT23	+AFLN

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

T = Tape and reel.

General-Purpose, Low-Voltage, Tiny Pack Comparators

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/11	Initial release	_
1	1/12	Revised the Typical Operating Characteristics.	6

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.