



# 25ns, Dual/Quad/Single, Low-Power, TTL Comparators

## General Description

The MAX9107/MAX9108/MAX9109 dual/quad/single, high-speed, low-power voltage comparators are designed for use in systems powered from a single +5V supply. Their 25ns propagation delay (with 10mV input overdrive) is achieved with a power consumption of only 1.75mW per comparator. The wide input common-mode range extends from 200mV below ground to within 1.5V of the positive supply rail.

The MAX9107/MAX9108/MAX9109 outputs are TTL-compatible, requiring no external pullup circuitry. These easy-to-use comparators incorporate internal hysteresis to ensure clean output switching even when the devices are driven by a slow-moving input signal.

The MAX9107/MAX9108/MAX9109 are higher-speed, lower-power, lower-cost upgrades to industry-standard comparators MAX907/MAX908/MAX909. The MAX9109 features an output latch but does not have complementary outputs.

The dual MAX9107 is available in both 8-pin SO and SOT23 packages. The quad MAX9108 is available in 14-pin TSSOP and SO packages while the single MAX9109 is available in an ultra-small 6-pin SC70 package, a space-saving 6-pin SOT23 package and an 8-pin SO package.

## Applications

Battery-Powered Systems	Threshold Detectors/ Discriminators
A/D Converters	Sampling Circuits
Line Receivers	Zero-Crossing Detectors

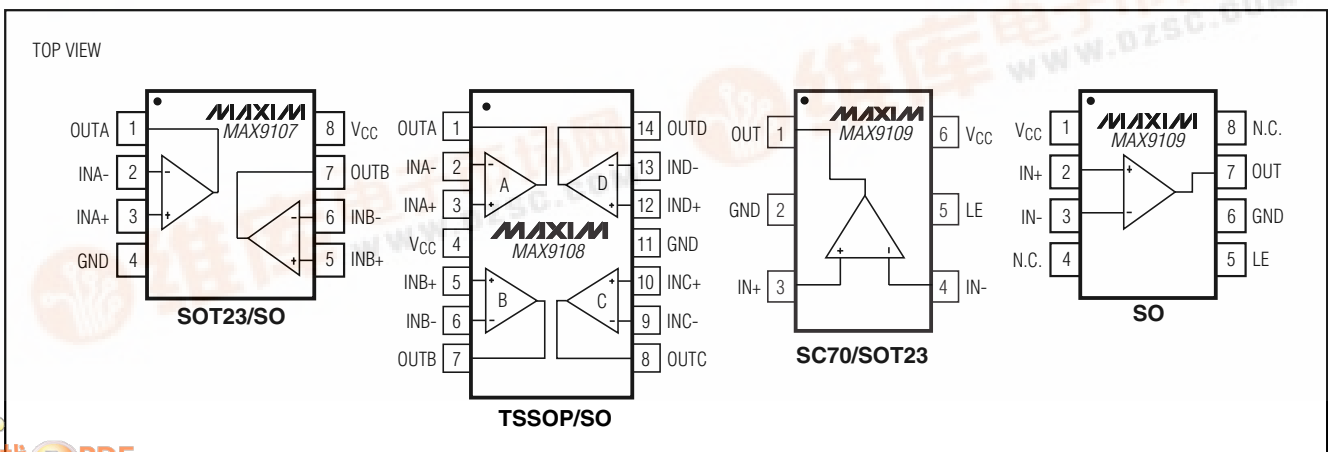
## Features

- ◆ 25ns Propagation Delay
- ◆ 350µA (1.75mW) Supply Current Per Comparator
- ◆ Single 4.5V to 5.5V Supply Operation
- ◆ Wide Input Range Includes Ground
- ◆ Low 500µV Offset Voltage
- ◆ Internal Hysteresis Provides Clean Switching (2mV)
- ◆ TTL-Compatible Outputs
- ◆ Internal Latch (MAX9109 only)
- ◆ No Phase Reversal for Overdriven Inputs
- ◆ Space-Saving Packages:
  - 6-Pin SC70 (MAX9109)
  - 8-Pin SOT23 (MAX9107)
  - 14-Pin TSSOP (MAX9108)

## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX9107EKA-T	-40°C to +85°C	8 SOT23-8	AAIB
MAX9107ESA	-40°C to +85°C	8 SO	—
MAX9108EUD	-40°C to +85°C	14 TSSOP	—
MAX9108ESD	-40°C to +85°C	14 SO	—
MAX9109EXT-T	-40°C to +85°C	6 SC70-6	AAU
MAX9109EUT-T	-40°C to +85°C	6 SOT23-6	AARU
MAX9109ESA	-40°C to +85°C	8 SO	—

## Pin Configurations



MAX9107/MAX9108/MAX9109

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## ABSOLUTE MAXIMUM RATINGS

### Power-Supply Ranges

Supply Voltage ( $V_{CC}$ to GND) .....	6V
Differential Input Voltage .....	-0.3V to ( $V_{CC} + 0.3V$ )
Common-Mode Input Voltage to GND ...	-0.3V to ( $V_{CC} + 0.3V$ )
Latch-Enable Input Voltage	
(MAX9109 only) .....	-0.3V to ( $V_{CC} + 0.3V$ )
Output Short-Circuit Duration to $V_{CC}$ or GND .....	10s
Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )	
6-Pin SC70 (derate 3.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	245mW
6-Pin SOT23 (derate 8.7mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	696mW

8-Pin SOT23 (derate 9.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	727mW
8-Pin SO (derate 5.9mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	470mW
14-Pin TSSOP (derate 9.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	727mW
14-Pin SO (derate 8.33mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	666mW
Operating Temperature Range .....	-40 $^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature Range .....	-65 $^\circ\text{C}$ to $+150^\circ\text{C}$
Lead Temperature (soldering, 10s) .....	$+300^\circ\text{C}$

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

( $V_{CC} = +5V$ ,  $V_{CM} = 0$ ,  $V_{LE} = 0$  (MAX9109 only),  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	$V_{CC}$	Guaranteed by PSRR	4.5		5.5	V
Input Offset Voltage	$V_{OS}$	(Note 2)	$T_A = +25^\circ\text{C}$		1.6	mV
			$T_A = T_{MIN}$ to $T_{MAX}$		4.0	
Input Hysteresis	$V_{HYST}$	(Note 3)		2		mV
Input Bias Current	$I_B$			125	350	nA
Input Offset Current	$I_{OS}$			25	80	nA
Input Voltage Range	$V_{CMR}$	(Note 4)	-0.2		$V_{CC} - 1.5$	V
Common-Mode Rejection Ratio	CMRR	$V_{CC} = 5.5V$ (Note 5)		50	1000	$\mu\text{V/V}$
Power-Supply Rejection Ratio	PSRR	$4.5V \leq V_{CC} \leq 5.5V$		50	1000	$\mu\text{V/V}$
Output High Voltage	$V_{OH}$	$I_{SOURCE} = 100\mu\text{A}$	3.0	3.5		V
Output Low Voltage	$V_{OL}$	$I_{SINK} = 3.2\text{mA}$		0.35	0.6	V
		$I_{SINK} = 8\text{mA}$		0.4		
Supply Current Per Comparator	$I_{CC}$	$V_{CC} = +5.5V$ , all outputs low		0.35	0.7	mA
Output Rise Time	$t_r$	$V_{OUT} = 0.4V$ to $2.4V$ , $C_L = 10\text{pF}$		12		ns
Output Fall Time	$t_f$	$V_{OUT} = 2.4V$ to $0.4V$ , $C_L = 10\text{pF}$		6		ns

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +5V$ ,  $V_{CM} = 0$ ,  $V_{LE} = 0$  (MAX9109 only),  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay	$t_{PD+}$ , $t_{PD-}$	$V_{IN} = 100mV$ , $V_{OD} = 10mV$		25		ns
Differential Propagation Delay	$\Delta t_{PD}$	$V_{IN} = 100mV$ , $V_{OD} = 10mV$ (Note 6)		1		ns
Propagation Delay Skew	$t_{PDskew}$	$V_{IN} = 100mV$ , $V_{OD} = 10mV$ (Note 7)		5		ns
Latch Input Voltage High	$V_{IH}$	(Note 8)	2.0			V
Latch Input Voltage Low	$V_{IL}$	(Note 8)			0.8	V
Latch Input Current	$I_{IH}$ , $I_{IL}$	(Note 8)		0.4	1	$\mu A$
Latch Setup Time	$t_s$	(Note 8)		2		ns
Latch Hold Time	$t_h$	(Note 8)		2		ns

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

**Note 2:** Input Offset Voltage is defined as the center of the input-referred hysteresis zone. Specified for  $V_{CM} = 0$ . See Figure 1.

**Note 3:** Trip Point is defined as the input voltage required to make the comparator output change state. The difference between upper ( $V_{TRIP+}$ ) and lower ( $V_{TRIP-}$ ) trip points is equal to the width of the input-referred hysteresis zone ( $V_{HYST}$ ). Specified for an input common-mode voltage ( $V_{CM}$ ) of 0. See Figure 1.

**Note 4:** Inferred from the CMRR test. Note that a correct logic result is obtained at the output, provided that at least one input is within the  $V_{CMR}$  limits. Note also that either or both inputs can be driven to the upper or lower absolute maximum limit without damage to the part.

**Note 5:** Tested over the full-input voltage range ( $V_{CMR}$ ).

**Note 6:** Differential Propagation Delay is specified as the difference between any two channels in the MAX9107/MAX9108 (both outputs making either a low-to-high or a high-to-low transition).

**Note 7:** Propagation Delay Skew is specified as the difference between any single channel's output low-to-high transition ( $t_{PD+}$ ) and high-to-low transition ( $t_{PD-}$ ).

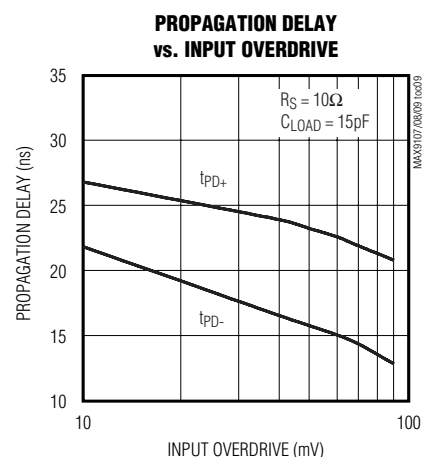
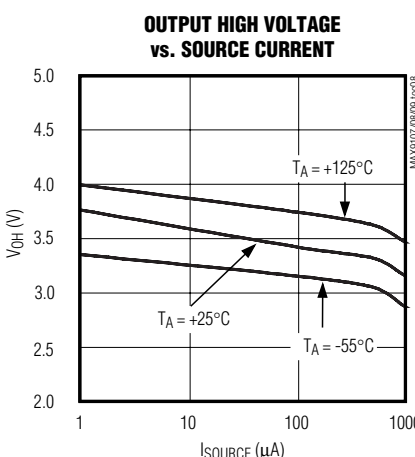
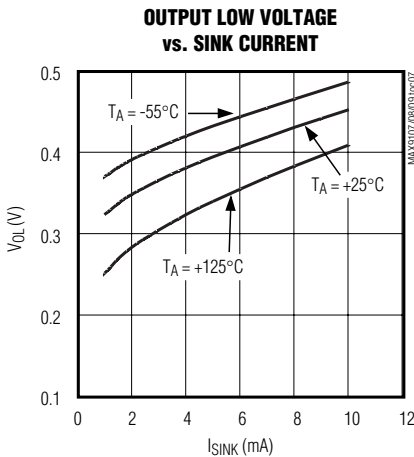
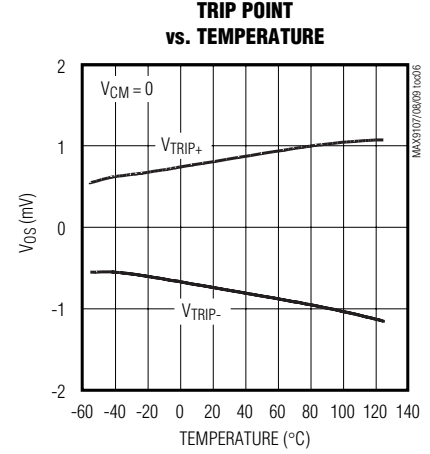
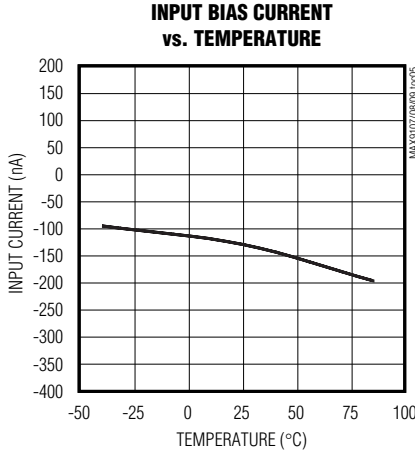
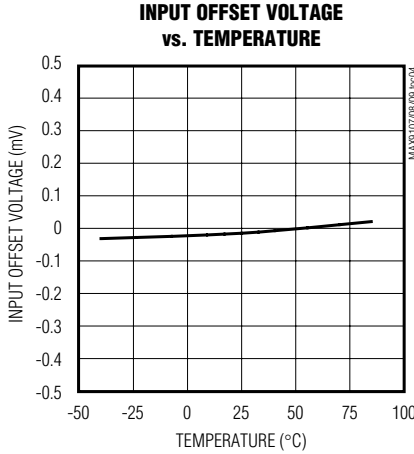
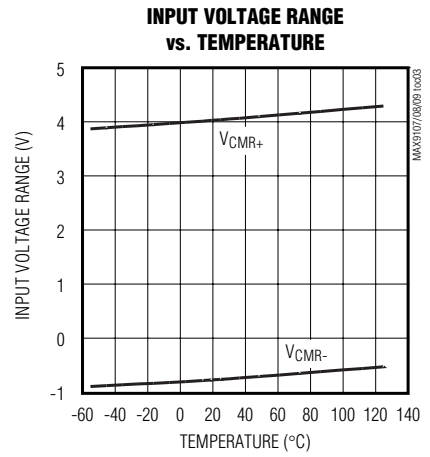
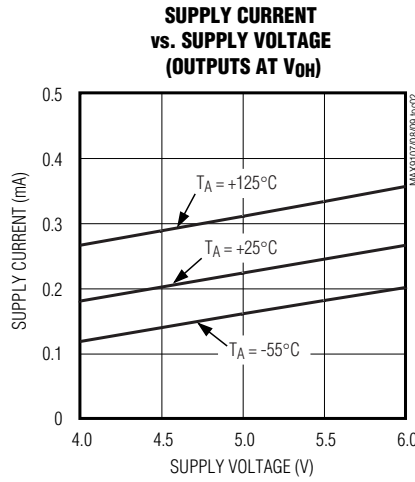
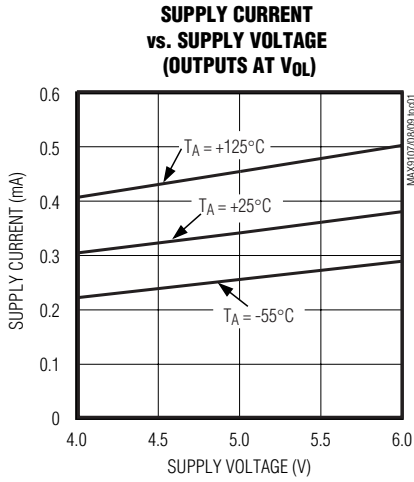
**Note 8:** Latch specifications apply to MAX9109 only. See Figure 2.

MAX9107/MAX9108/MAX9109

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## Typical Operating Characteristics

( $V_{CC} = 5V$ ,  $V_{CM} = 0$ ,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

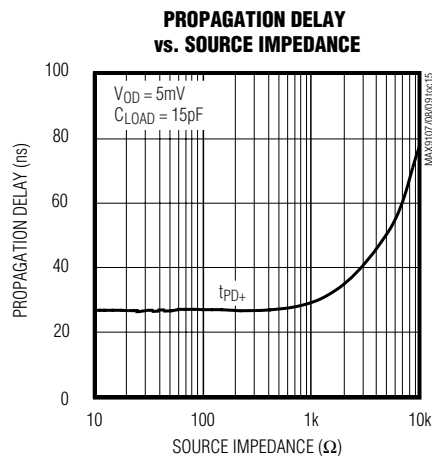
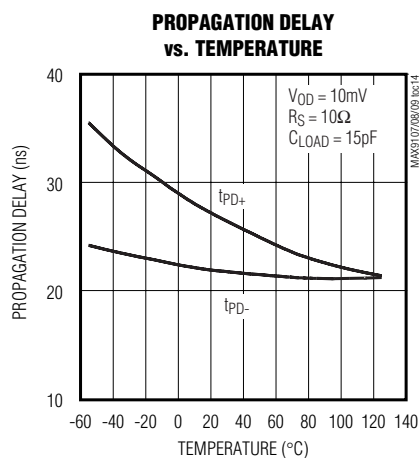
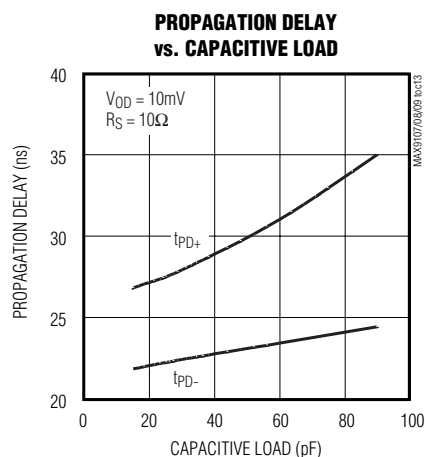
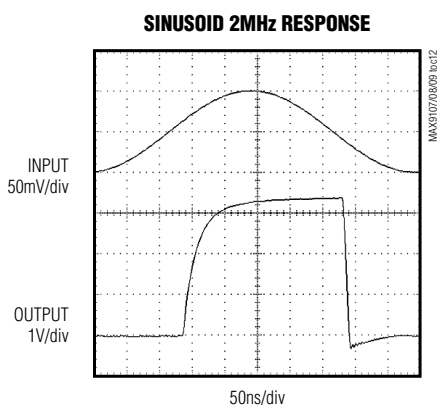
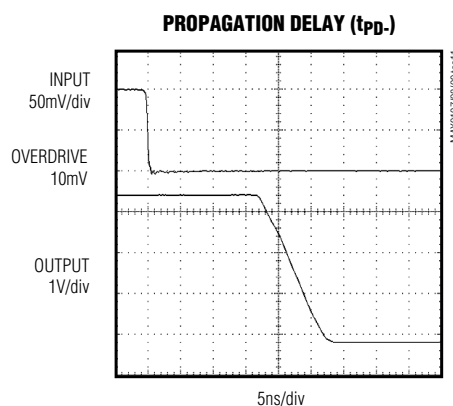
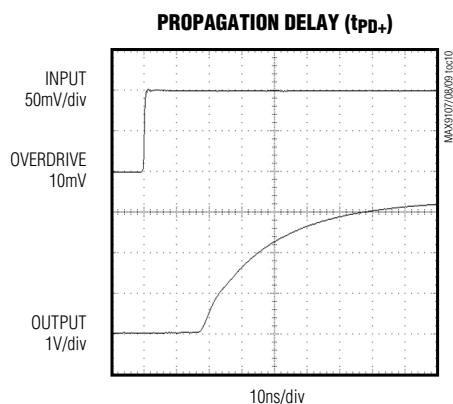


# 25ns, Dual/Quad/Single, Low-Power, TTL Comparators

## Typical Operating Characteristics (continued)

( $V_{CC} = 5V$ ,  $V_{CM} = 0$ ,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX9107/MAX9108/MAX9109



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## Pin Description

PIN				NAME	FUNCTION
MAX9107	MAX9108	MAX9109			
		SC70/SOT23	SO		
1	1	—	—	OUTA	Channel A Output
2	2	—	—	INA-	Channel A Inverting Input
3	3	—	—	INA+	Channel A Noninverting Input
7	7	—	—	OUTB	Channel B Output
6	6	—	—	INB-	Channel B Inverting Input
5	5	—	—	INB+	Channel B Noninverting Input
—	8	—	—	OUTC	Channel C Output
—	9	—	—	INC-	Channel C Inverting Input
—	10	—	—	INC+	Channel C Noninverting Input
—	14	—	—	OUTD	Channel D Output
—	13	—	—	IND-	Channel D Inverting Input
—	12	—	—	IND+	Channel D Noninverting Input
—	—	1	7	OUT	Output
—	—	3	2	IN+	Noninverting Input
—	—	4	3	IN-	Inverting Input
8	4	6	1	V <sub>CC</sub>	Positive Supply
4	11	2	6	GND	Ground
—	—	5	5	LE	Latch Enable. The latch is transparent when LE is low.
—	—	—	4, 8	N.C.	No Connection. Not internally connected.

## Detailed Description

### Timing

Noise or undesired parasitic AC feedback cause most high-speed comparators to oscillate in the linear region (i.e., when the voltage on one input is at or near the voltage on the other input). The MAX9107/MAX9108/MAX9109 eliminate this problem by incorporating an internal hysteresis of 2mV. When the two comparator input voltages are equal, hysteresis effectively causes one comparator input voltage to move quickly past the other, thus taking the input out of the region where oscillation occurs. Standard comparators require that hysteresis be added through the use of external resistors. The MAX9107/MAX9108/MAX9109's fixed internal hysteresis eliminates these resistors. To increase hysteresis and noise margin even more, add positive feedback with two resistors as a voltage divider from the output to the noninverting input.

Adding hysteresis to a comparator creates two trip points: one for the input voltage rising and one for the

input voltage falling (Figure 1). The difference between these two input-referred trip points is the hysteresis. The average of the trip points is the offset voltage.

Figure 1 illustrates the case where IN- is fixed and IN+ is varied. If the inputs were reversed, the figure would look the same, except the output would be inverted.

The MAX9109 includes an internal latch, allowing the result of a comparison to be stored. If LE is low, the latch is transparent (i.e., the comparator operates as though the latch is not present). The state of the comparator output is latched when LE is high (Figure 2).

## Applications Information

### Circuit Layout

Because of the MAX9107/MAX9108/MAX9109's high gain bandwidth, special precautions must be taken to realize the full high-speed capability. A printed circuit board with a good, low-inductance ground plane is mandatory. Place the decoupling capacitor (a 0.1µF ceramic capacitor is a good choice) as close to V<sub>CC</sub> as

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MAX9107/MAX9108/MAX9109

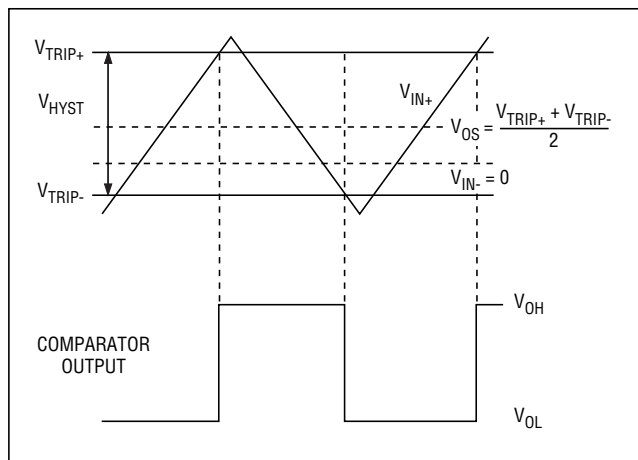


Figure 1. Input and Output Waveforms, Noninverting Input Varied

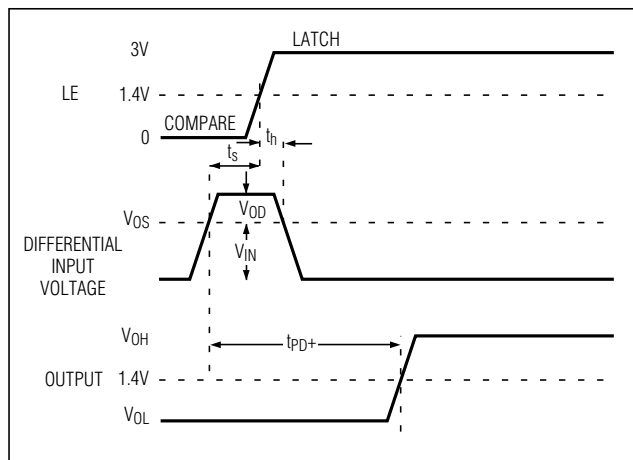


Figure 2. MAX9109 Timing Diagram

possible. Pay close attention to the decoupling capacitor's bandwidth, keeping leads short. Short lead lengths on the inputs and outputs are also essential to avoid unwanted parasitic feedback around the comparators. Solder the device directly to the printed circuit board instead of using a socket.

### Overdriving the Inputs

The inputs to the MAX9107/MAX9108/MAX9109 may be driven to the voltage limits given in the *Absolute Maximum Ratings*. If the inputs are overdriven, there is no output phase reversal.

### Battery-Operated Infrared Data Link

In Figure 3, the circuit allows reception of infrared data. The MAX4400 converts the photodiode current to a voltage, and the MAX9109 determines whether the amplifier output is high enough to be called a "1." The current consumption of this circuit is minimal: the MAX4400 and MAX9109 require typically 410µA and 350µA, respectively.

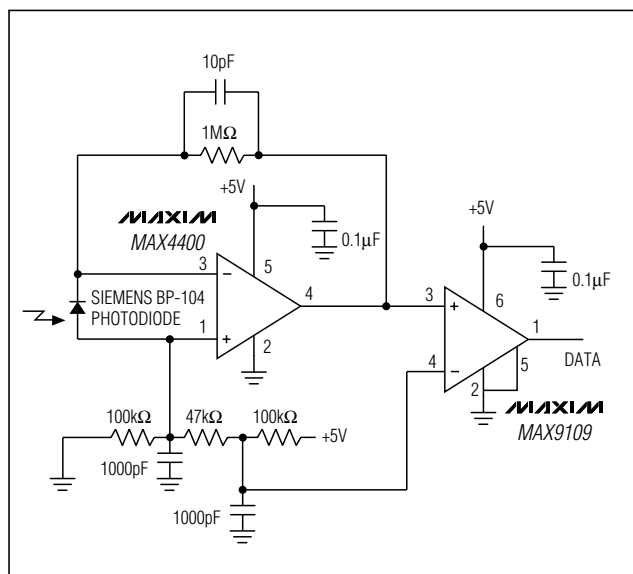


Figure 3. Battery-Operated Infrared Data Link Consumes Only 760µA

### Chip Information

MAX9107 TRANSISTOR COUNT: 262  
 MAX9108 TRANSISTOR COUNT: 536  
 MAX9109 TRANSISTOR COUNT: 140  
 PROCESS: Bipolar

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## Package Information

SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.28	0.45
C	0.09	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.10	0.60
e		0.65 ref
e1		1.95 ref
α	0°	10°

**NOTE:**  
 1. ALL DIMENSIONS ARE IN MILLIMETERS.  
 2. FDDT LENGTH MEASURED REFERENCE TO FLAT FOOT SURFACE PARALLEL TO DATUM 'A'.  
 3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.  
 4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.  
 5. EIAJ REF. NUMBER SC-74 (6 LEAD VERSION)  
 6. COPLANARITY 4 MILS. MAX.  
 7. PIN 1 I.D. DOT IS 0.3 MM Ø MIN. LOCATED ABOVE PIN 1.

**MAXIM**  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE OUTLINE, SOT 23, 8L  
 APPROVAL: DOCUMENT CONTROL NO. 21-0078 REV B 1/1

SOT 23, 8L EPS

COMMON DIMENSIONS				
SYMBOL	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.05	0.15	.002	.043
A1	0.85	0.95	.033	.037
A2	0.19	0.30	.007	.012
b	0.19	0.25	.007	.010
bl	0.090	0.20	.0035	.008
c	0.090	0.135	.0035	.0053
D	SEE VARIATIONS SEE VARIATIONS			
E	4.30	4.50	.169	.177
e	0.65 BSC .026 BSC			
H	6.25	6.50	.246	.256
L	0.50	0.70	.020	.028
N	SEE VARIATIONS SEE VARIATIONS			
Y	2.65	3.15	.104	.124
α	0°	8°	0°	8°

JEDEC	MO-153	N	VARIATIONS			
			MILLIMETERS		INCHES	
			MIN.	MAX.	MIN.	MAX.
AB	14	D	4.90	5.10	.193	.201
AC	16	D	4.90	5.10	.193	.201
AC-EP	16	D	4.90	5.10	.193	.201
		X	2.85	3.15	.112	.124
AD	20	D	6.40	6.60	.252	.260
AD-EP	20	D	6.40	6.60	.252	.260
		X	4.00	4.24	.157	.171
AE	24	D	7.70	7.90	.303	.311
AF	28	D	9.60	9.80	.378	.386
AF-EP		D	9.60	9.80	.378	.386
		X	5.35	5.65	.211	.222

**NOTES:**  
 1. DIMENSIONS D AND E DO NOT INCLUDE FLASH.  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 mm PER SIDE.  
 3. CONTROLLING DIMENSION: MILLIMETER.  
 4. MEETS JEDEC OUTLINE MO-153 VARIATIONS AB, AC, AD, AE, AF.  
 5. DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.  
 6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

**MAXIM**  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH  
 APPROVAL: DOCUMENT CONTROL NO. 21-0066 REV C 1/1

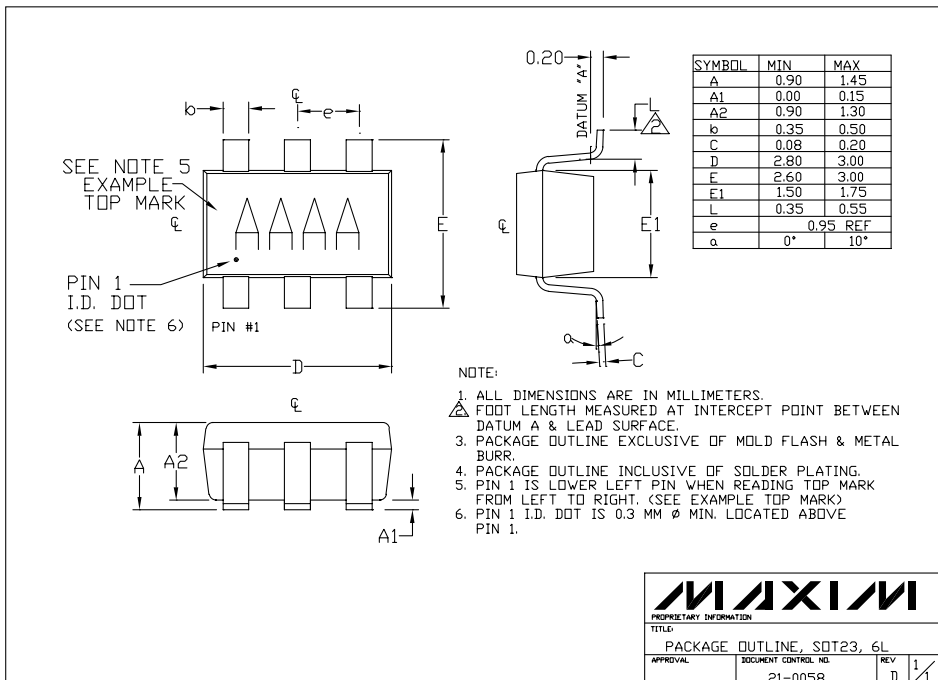
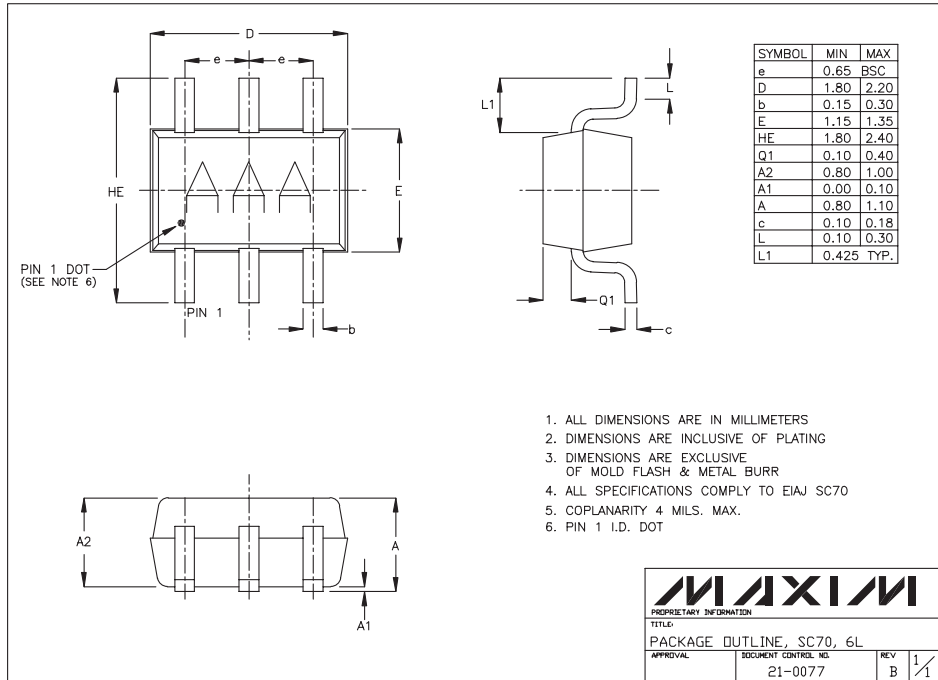
TSSOP-EP



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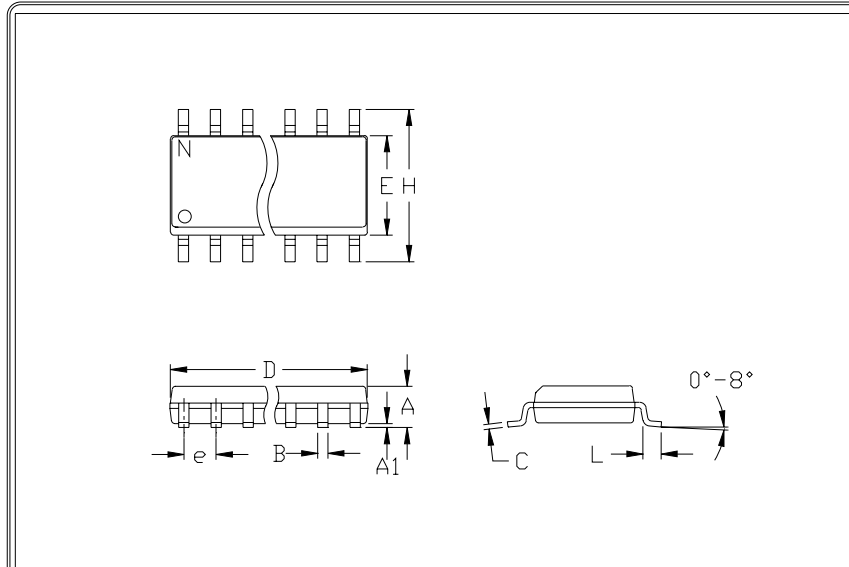
## Package Information (continued)

MAX9107/MAX9108/MAX9109



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## Package Information (continued)



	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	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS		N	MS012
	MIN	MAX	MIN	MAX		
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS



PACKAGE FAMILY OUTLINE: SOIC .150"



21-0041 A  
DOCUMENT CONTROL NUMBER REV

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.