



**THE DATASHEET OF  
MAX9691ESA+T**





# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## General Description

The MAX9691/MAX9692/MAX9693 are ultra-fast ECL comparators capable of very short propagation delays. Their design maintains the excellent DC matching characteristics normally found only in slower comparators.

The MAX9691/MAX9692/MAX9693 have differential inputs and complementary outputs that are fully compatible with ECL-logic levels. Output current levels are capable of driving 50Ω terminated transmission lines. The ultra-fast operation makes signal processing possible at frequencies in excess of 600MHz.

The MAX9692/MAX9693 feature a latch-enable (LE) function that allows the comparator to be used in a sample-hold mode. When LE is ECL high, the comparator functions normally. When LE is driven ECL low, the outputs are forced to an unambiguous ECL-logic state, dependent on the input conditions at the time of the latch input transition. If the latch-enable function is not used on either of the two comparators, the appropriate LE input must be connected to ground; the companion LE input must be connected to a high ECL logic level.

These devices are available in SO, QSOP, and tiny μMAX® packages for added space savings.

## Applications

High-Speed Line Receivers  
Peak Detectors  
Threshold Detectors  
High-Speed Triggers

μMAX is a registered trademark of Maxim Integrated Products, Inc.

## Features

- ◆ 1.2ns Propagation Delay
- ◆ 100ps Propagation Delay Skew
- ◆ 150ps Dispersion
- ◆ 0.5ns Latch Setup Time
- ◆ 0.5ns Latch-Enable Pulse Width
- ◆ Available in μMAX and QSOP Packages
- ◆ +5V, -5.2V Power Supplies

## Ordering Information

| PART       | TEMP RANGE     | PIN-PACKAGE |
|------------|----------------|-------------|
| MAX9691EUA | -40°C to +85°C | 8 μMAX      |
| MAX9691ESA | -40°C to +85°C | 8 SO        |
| MAX9691EPA | -40°C to +85°C | 8 PDIP      |

**Note:** Devices are also available in lead(Pb)-free/RoHS-compliant packages. Specify lead-free by adding a "+" after the part number.

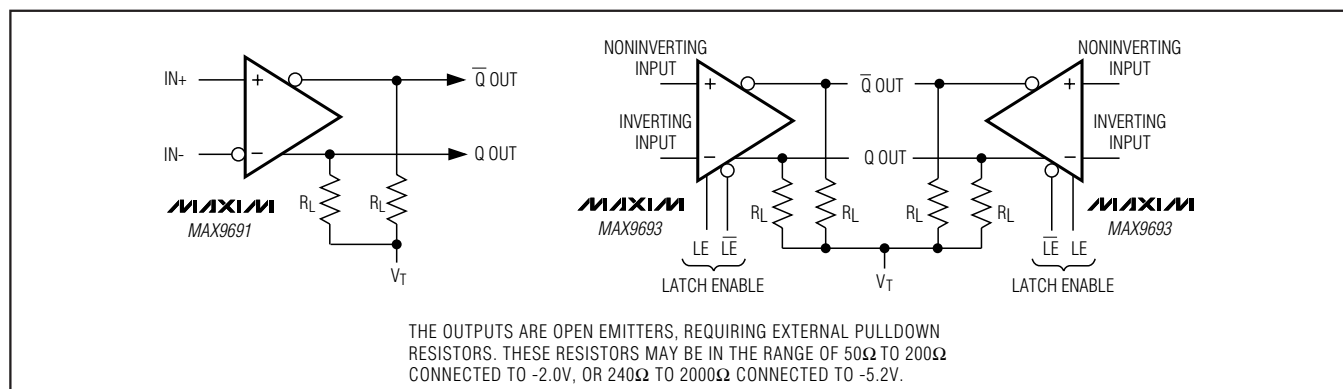
Ordering Information continued at the end of data sheet.

## Selector Guide

| PART    | COMPARATORS PER PACKAGE | LATCH ENABLE | PIN-PACKAGE             |
|---------|-------------------------|--------------|-------------------------|
| MAX9691 | 1                       | No           | 8 μMAX, 8 SO, 8 PDIP    |
| MAX9692 | 1                       | Yes          | 10 μMAX, 16 SO, 16 PDIP |
| MAX9693 | 2                       | Yes          | 16 QSOP, 16 SO, 16 PDIP |

Pin Configurations appear at end of data sheet.

## Functional Diagrams



# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## ABSOLUTE MAXIMUM RATINGS

|  |  |
|--|--|
| Supply Voltage ( $V_{CC}$ )                                    | -0.3V to +6V                               |
| Supply Voltage ( $V_{EE}$ )                                    | -6V to +0.3V                               |
| Input Voltage  | ( $V_{CC} + 0.3V$ ) to ( $V_{EE} - 0.3V$ ) |
| Output Short-Circuit Duration                                  | Continuous                                 |
| Differential Input Voltage                                     | $\pm 5V$                                   |
| Latch Enable   | ( $V_{EE} - 0.3V$ ) to +0.3V               |
| Output Current   | .50mA                                      |
| Input Current  | $\pm 25mA$                                 |
| Continuous Power Dissipation ( $T_A = +70^\circ C$ )           |  |
| 8-Pin $\mu$ MAX (derate 4.8mW/ $^\circ C$ above $70^\circ C$ ) | .387.8mW                                   |
| 8-Pin SO (derate 7.4mW/ $^\circ C$ above $70^\circ C$ )        | .588.2mW                                   |

|   |                                 |
|---|---------------------------------|
| 8-Pin PDIP (derate 9.1mW/ $^\circ C$ above $70^\circ C$ )       | .727.3mW                        |
| 10-Pin $\mu$ MAX (derate 8.8mW/ $^\circ C$ above $70^\circ C$ ) | .707.3mW                        |
| 16-Pin QSOP (derate 9.6mW/ $^\circ C$ above $70^\circ C$ )      | .771.5mW                        |
| 16-Pin SO (derate 13.3mW/ $^\circ C$ above $70^\circ C$ )       | 1.066.7mW                       |
| 16-Pin PDIP (derate 10.5mW/ $^\circ C$ above $70^\circ C$ )     | .842.1mW                        |
| Operating Temperature Range                                     | $-40^\circ C$ to $+85^\circ C$  |
| Junction Temperature  | $+150^\circ C$                  |
| Storage Temperature Range                                       | $-55^\circ C$ to $+150^\circ C$ |
| Lead Temperature (soldering, 10s)                               | $+300^\circ C$                  |
| Soldering Temperature (reflow)                                  | $+260^\circ C$                  |

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

( $V_{CC} = +5V$ ,  $V_{EE} = -5.2V$ ,  $R_L = 50\Omega$  to  $V_T$ ,  $V_T = -2V$ ,  $LE = 0$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

| PARAMETER                             | SYMBOL                   | CONDITIONS                              | MIN   | TYP | MAX   | UNITS            |
|---------------------------------------|--------------------------|---|-------|-----|-------|------------------|
| Input Offset Voltage                  | $V_{OS}$                 | $T_A = +25^\circ C$                     | -6.5  |     | 6.5   | mV               |
|                                       |                          | $T_A = T_{MIN}$ to $T_{MAX}$            | -11.5 |     | +11.5 |                  |
| Temperature Coefficient               | $\Delta V_{OS}/\Delta T$ |   |       | 10  |       | $\mu V/^\circ C$ |
| Input Offset Current                  | $I_{OS}$                 | $T_A = +25^\circ C$                     |       | 0.2 | 5     | $\mu A$          |
|                                       |                          | $T_A = T_{MIN}$ to $T_{MAX}$            |       |     | 8     |                  |
| Input Bias Current                    | $I_B$                    | $T_A = +25^\circ C$                     |       | 6   | 20    | $\mu A$          |
|                                       |                          | $T_A = T_{MIN}$ to $T_{MAX}$            |       |     | 30    |                  |
| Input Voltage Range                   | $V_{CM}$                 | Note 1                                  | -2.5  |     | +3.0  | V                |
| Common-Mode Rejection Ratio           | CMRR                     | $-2.5V \leq V_{CM} \leq +3.0V$ (Note 1) | 60    | 80  |       | dB               |
| Positive Power-Supply Rejection Ratio | +PSRR                    | $4.5V \leq V_{CC} \leq 5.5V$            |       | 60  |       | dB               |
| Negative Power-Supply Rejection Ratio | -PSRR                    | $-5.7V \leq V_{EE} \leq -4.7V$          |       | 60  |       | dB               |
| Open-Loop Gain                        | AOL                      | $V_{CM} = 0V$                           |       | 70  |       | dB               |
| Differential Input Resistance         | $R_{IN}$                 | $-10mV < V_{IN} < 10mV$                 |       | 60  |       | $k\Omega$        |
| Differential Input Clamp Voltage      |                          |   |       | 1.7 |       | V                |
| Input Capacitance                     | $C_{IN}$                 |   |       | 3   |       | pF               |
| Latch Enable Input Current High       | $I_{IH}(LE)$             | $V_{IH}(LE) = 1.1V$                     |       | 60  | 120   | $\mu A$          |
| Latch Enable Input Current Low        | $I_{IL}(LE)$             | $V_{IL}(LE) = 1.5V$                     |       | 0.2 | 10    | $\mu A$          |
| Latch Enable Logic High Voltage       | $V_{IH}(LE)$             |   | -1.1  |     |       | V                |
| Latch Enable Logic Low Voltage        | $V_{IL}(LE)$             |   |       |     | -1.5  | V                |
| Logic Output High Voltage             | $V_{OH}$                 | $T_A = T_{MIN}$                         | -1.2  |     | -0.87 | V                |
|                                       |                          | $T_A = T_{MAX}$                         | -0.99 |     | -0.70 |                  |
|                                       |                          | $T_A = +25^\circ C$                     | -1.06 |     | -0.76 |                  |
| Logic Output Low Voltage              | $V_{OL}$                 | $T_A = T_{MIN}$                         | -1.93 |     | -1.57 | V                |
|                                       |                          | $T_A = T_{MAX}$                         | -1.89 |     | -1.51 |                  |
|                                       |                          | $T_A = +25^\circ C$                     | -1.89 |     | -1.55 |                  |

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

MAX9691/MAX9692/MAX9693

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5.2V$ ,  $R_L = 50\Omega$  to  $V_T$ ,  $V_T = -2V$ ,  $LE = 0$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

| PARAMETER      | SYMBOL   | CONDITIONS          | MIN                          | TYP | MAX | UNITS |
|----------------|----------|---------------------|------------------------------|-----|-----|-------|
| Supply Current | $I_{CC}$ | MAX9693             | $T_A = +25^\circ C$          | 34  | 46  | mA    |
|                |          |                     | $T_A = T_{MIN}$ to $T_{MAX}$ |     | 50  |       |
|                |          | MAX9691/<br>MAX9692 | $T_A = +25^\circ C$          | 18  | 26  |       |
|                |          |                     | $T_A = T_{MIN}$ to $T_{MAX}$ |     | 36  |       |

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5V$ ,  $V_{EE} = -5.2V$ ,  $R_L = 50\Omega$  to  $V_T$ ,  $V_T = -2V$ ,  $LE = 0$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

| PARAMETER                            | SYMBOL                | CONDITIONS                   | MIN | TYP | MAX | UNITS |
|--------------------------------------|-----------------------|------------------------------|-----|-----|-----|-------|
| <b>MAX9691/MAX9692/MAX9693</b>       |                       |                              |     |     |     |       |
| Propagation Delay (Notes 1, 2)       | $t_{pd+}$ , $t_{pd-}$ | $T_A = +25^\circ C$          |     | 1.2 | 1.8 | ns    |
|                                      |                       | $T_A = T_{MIN}$ to $T_{MAX}$ |     |     | 2.0 |       |
| Rise/Fall Time                       | $t_r$ , $t_f$         | 10% to 90%                   |     | 500 |     | ps    |
| Propagation Delay Skew               | $\Delta PD$           |                              |     | 100 |     | ps    |
| Dispersion                           | $P_{DSP}$             | $V_{OD}$ from 10mV to 100mV  |     | 150 |     | ps    |
| <b>MAX9692/MAX9693</b>               |                       |                              |     |     |     |       |
| Latch-Enable Time (Note 1)           | $T_{LE(\pm)}$         | $T_A = +25^\circ C$          |     | 1.0 | 1.8 | ns    |
|                                      |                       | $T_A = T_{MIN}$ to $T_{MAX}$ |     |     | 2.0 |       |
| Latch-Enable Pulse Width (Note 1)    | $t_{pw(LE)}$          |                              |     | 0.5 | 1.0 | ns    |
| Setup Time (Note 1)                  | $t_s$                 |                              |     | 0.5 | 1.0 | ns    |
| Hold Time (Note 1)                   | $t_h$                 |                              |     | 0.5 | 1.0 | ns    |
| Channel-to-Channel Propagation Match | $t_{PDM}$             | Note 2 (MAX9693 only)        |     | 100 |     | ps    |

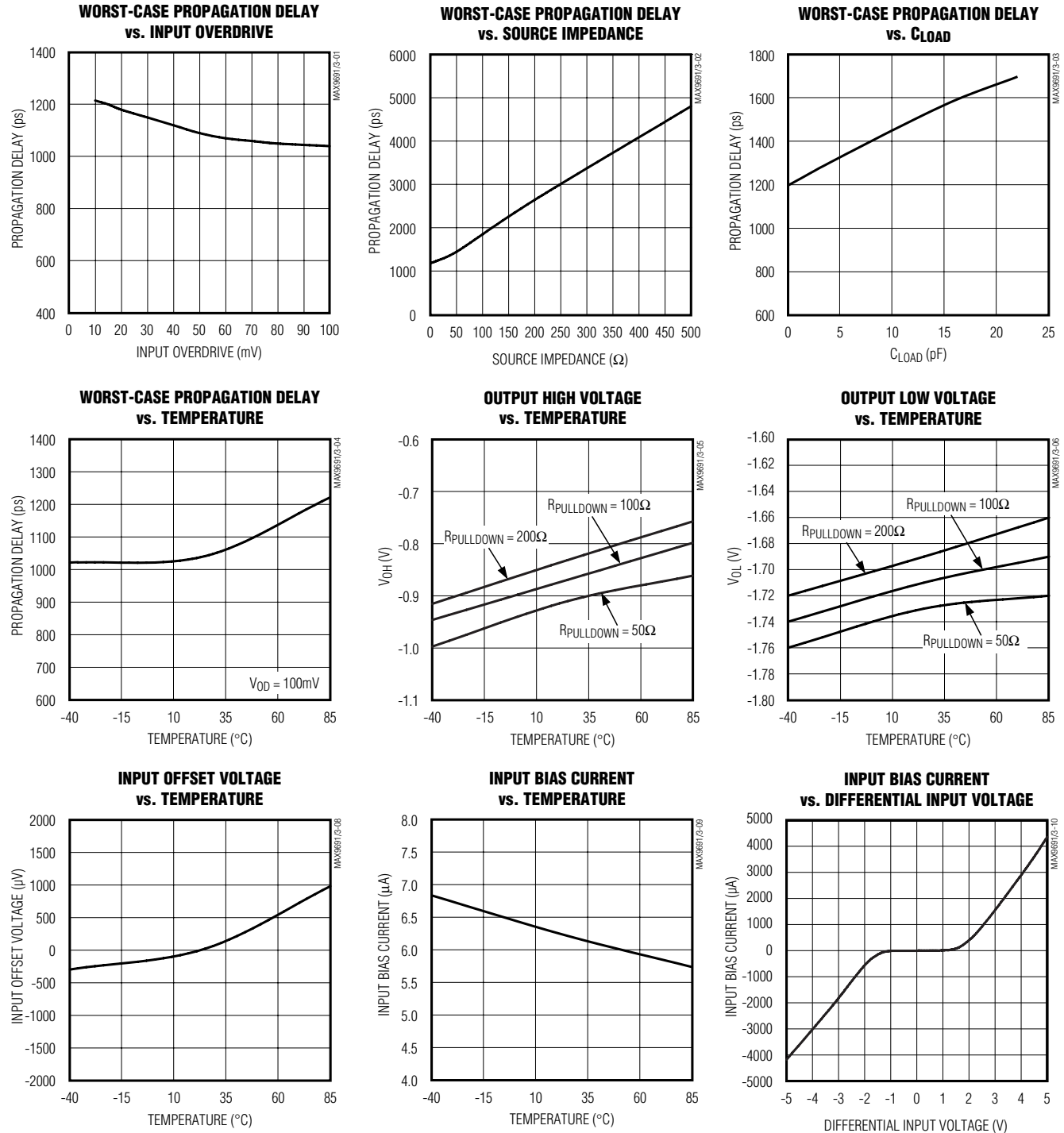
**Note 1:** Guaranteed by design.

**Note 2:**  $V_{IN} = 100mV$ ,  $V_{OD} = 10mV$ .

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Typical Operating Characteristics

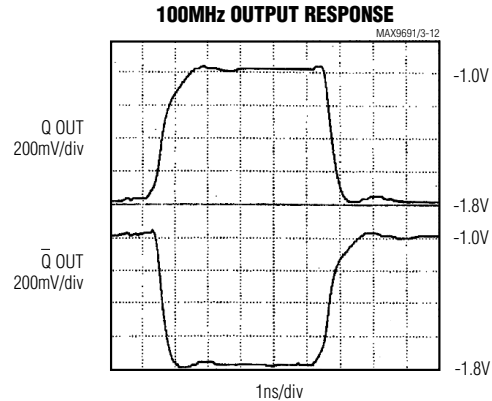
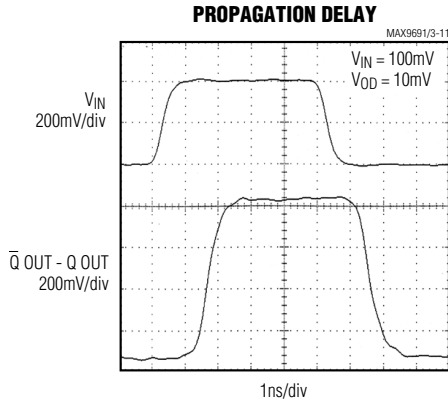
( $V_{CC} = +5V$ ,  $V_{EE} = -5.2V$ ,  $R_L = 50\Omega$  to  $V_T$ ,  $V_T = -2V$ ,  $V_{OD} = 10mV$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5.2V$ ,  $R_L = 50\Omega$  to  $V_T$ ,  $V_T = -2V$ ,  $V_{OD} = 10mV$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Pin Description

| PIN     |                      |                            |         | NAME           | FUNCTION   |
|---------|----------------------|----------------------------|---------|----------------|--|
| MAX9691 | MAX9692<br>$\mu$ MAX | MAX9692<br>PDIP/SO         | MAX9693 |                |  |
| 1       | 1                    | 2                          | 11      | $V_{CC}$       | Positive Supply. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 2       | 2                    | 3                          | —       | IN+            | Positive Input   |
| 3       | 3                    | 4                          | —       | IN-            | Negative Input   |
| 4       | 6                    | 8                          | 6       | $V_{EE}$       | Negative Supply. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 5       | 7                    | 11                         | —       | Q OUT          | Output   |
| 6       | 8                    | 12                         | —       | $\bar{Q} OUT$  | Complimentary Output   |
| 7       | 9                    | 16                         | —       | GND2           | Device Ground  |
| 8       | 10                   | 1                          | —       | GND1           | Device Ground  |
| —       | 4                    | 5, 7, 9, 10,<br>13, 14, 15 | —       | N.C.           | No Connection. Not internally connected.                     |
| —       | 5                    | 6                          | —       | LE             | Latch Enable Input   |
| —       | —                    | —                          | 1       | Q OUTA         | Channel A Output   |
| —       | —                    | —                          | 2       | $\bar{Q} OUTA$ | Channel A Complimentary Output                               |
| —       | —                    | —                          | 3, 14   | GND            | Device Ground  |
| —       | —                    | —                          | 4       | LEA            | Channel A Latch Enable Input                                 |
| —       | —                    | —                          | 5       | $\bar{LEA}$    | Channel A Latch Enable Complimentary Input                   |
| —       | —                    | —                          | 7       | INA-           | Channel A Negative Input                                     |
| —       | —                    | —                          | 8       | INA+           | Channel A Positive Input                                     |
| —       | —                    | —                          | 9       | INB+           | Channel B Positive Input                                     |
| —       | —                    | —                          | 10      | INB-           | Channel B Negative Input                                     |
| —       | —                    | —                          | 12      | $\bar{LEB}$    | Channel B Latch Enable Complimentary Input                   |
| —       | —                    | —                          | 13      | LEB            | Channel B Latch Enable Input                                 |
| —       | —                    | —                          | 15      | $\bar{Q} OUTB$ | Channel B Complimentary Output                               |
| —       | —                    | —                          | 16      | Q OUTB         | Channel B Output   |

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Applications Information

### Layout

Because of the MAX9691/MAX9692/MAX9693s' large gain-bandwidth characteristic, special precautions must be taken to use them. A PC board with a ground plane is mandatory. Mount 0.01 $\mu$ F ceramic decoupling capacitors as close to the power-supply pins as possible, and process the ECL outputs in microstrip fashion, consistent with the load termination of 50 $\Omega$  to 200 $\Omega$  (for  $V_T = -2V$ ). For low-impedance applications, microstrip layout and terminations at the input may also be helpful. Pay close attention to the bandwidth of the decoupling and terminating components. Chip components can be used to minimize lead inductance. Connect GND1 and GND2 together to a solid copper ground plane for the MAX9691/MAX9692. GND1 biases the input gain stages, while GND2 biases the ECL output stage. If the LE function is not used, connect the LE pin to GND (MAX9692/MAX9693) and the complementary  $\overline{LE}$  to ECL logic high level (MAX9693 only). Do not leave the inputs of an unused comparator floating for the MAX9693.

### Input Slew-Rate Requirements

As with all high-speed comparators, the high gain-bandwidth product of these devices creates oscillation

problems when the input goes through the linear region. For clean switching without oscillation or steps in the output waveform, the input must meet certain minimum slew-rate requirements. The tendency of the part to oscillate is a function of the layout and source impedance of the circuit employed. Poor layout and larger source impedance will increase the minimum slew-rate requirement.

Figure 1 shows a high-speed receiver application with 50 $\Omega$  input and output termination. With this configuration, in which a ground plane and microstrip PC board are used, the minimum slew rate for clean output switching is 1V/ $\mu$ s.

In many applications, adding regenerative feedback will assist the input signal through the linear region, which will lower the minimum slew-rate requirement considerably. For example, with the addition of positive feedback components,  $R_f = 1k\Omega$  and  $C_f = 10pF$ , the minimum slew-rate requirement can be reduced by a factor of four.

As high-speed receivers, the MAX9691/MAX9692/MAX9693 are capable of processing signals in excess of 600MHz. Figure 2 is a 100MHz example with an input signal level of 14mVRMS.

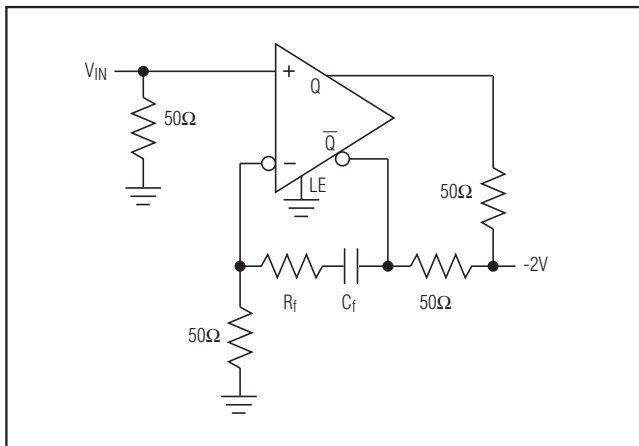


Figure 1. Regenerative Feedback—High-Speed Receiver with 50 $\Omega$  Input and Output Termination

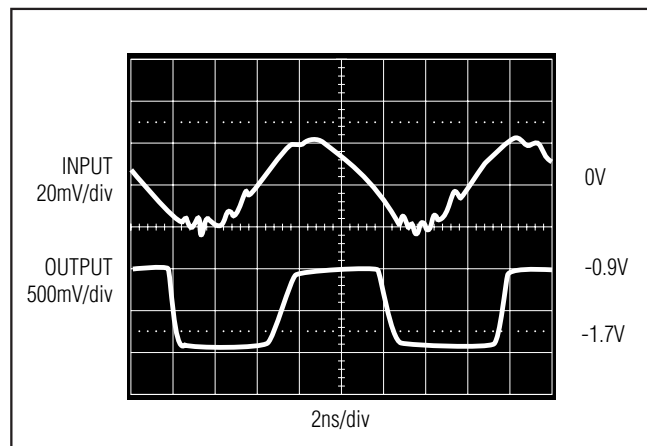


Figure 2. Signal Processed at 100MHz with Input Signal Level of 14mVRMS

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

MAX9691/MAX9692/MAX9693

The timing diagram (Figure 3) illustrates the series of events that complete the compare function, under worst-case conditions. The top line of the diagram illustrates two latch-enable pulses. Each pulse is high for the compare function and low for the latch function. The first pulse demonstrates the compare function; part of the input action takes place during the compare mode. The second pulse demonstrates a compare function interval during which there is no change in the input.

The leading edge of the input signal (illustrated as a large-amplitude, small-overdrive pulse) switches the comparator after time interval  $t_{pd}$ . Output Q and  $\bar{Q}$  tran-

sistors are similar in timing. The input signal must occur at time  $t_s$  before the latch falling edge, and must be maintained for time  $t_h$  after the edge to be acquired. After  $t_h$ , the output is no longer affected by the input status until the latch is again strobed. A minimum latch pulse width of  $t_{pw(LE)}$  is needed for the strobe operation, and the output transitions occur after a time  $t_{LE(\pm)}$ .

The MAX9691/MAX9692/MAX9693 will not false trip (i.e., output invert) if one of the inputs is in the valid common-mode range while the other input is outside the common-mode range.

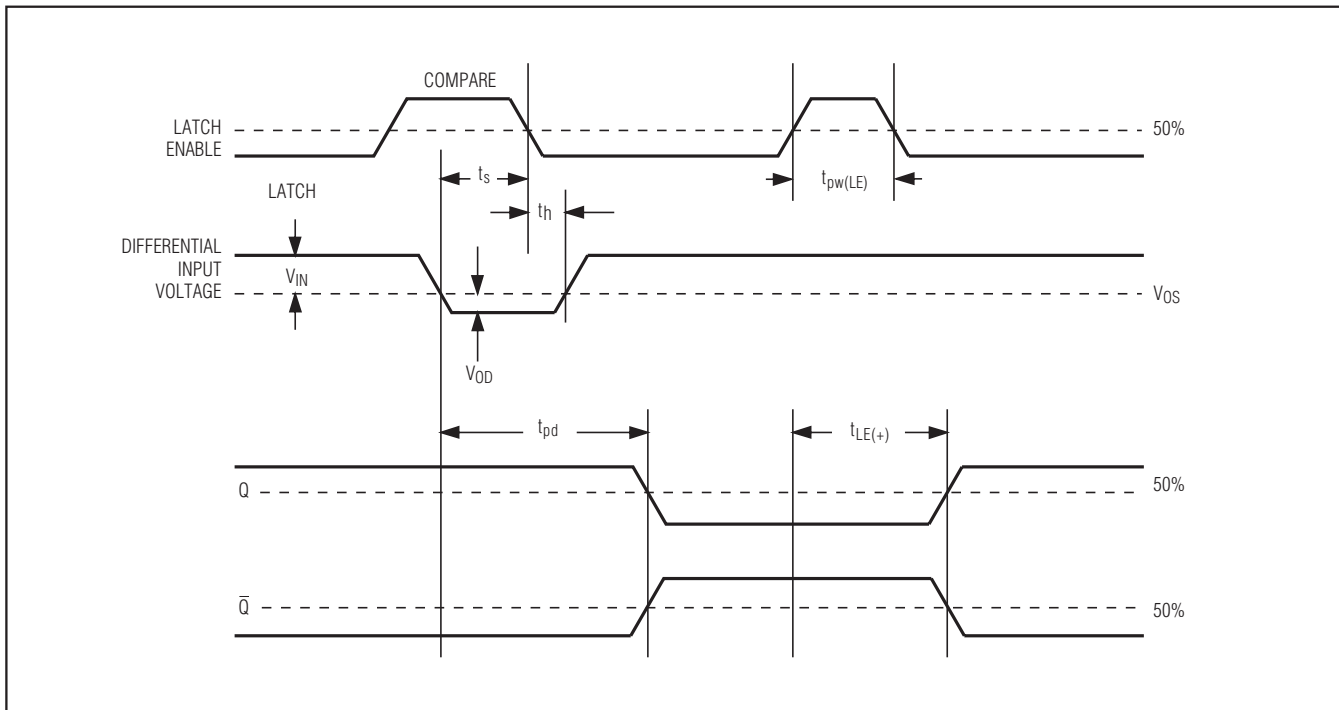


Figure 3. Timing Diagram

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Definition of Terms

|                    |  |
|--------------------|--|
| V <sub>OS</sub>    | Input Offset Voltage. The voltage required between the input terminals to obtain 0V differential at the output.  |
| V <sub>IN</sub>    | Input Voltage Pulse Amplitude  |
| V <sub>OD</sub>    | Input Voltage Overdrive  |
| t <sub>pd+</sub>   | Input to Output High Delay. The propagation delay measured from the time the input signal crosses the input offset voltage to the 50% point of an output low-to-high transition.             |
| t <sub>pd-</sub>   | Input to Output Low Delay. The propagation delay measured from the time the input signal crosses the input offset voltage to the 50% point of an output high-to-low transition.              |
| t <sub>LE(+)</sub> | Latch-Enable to Output High Delay. The propagation delay measured from the 50% point of the latch-enable signal low-to-high transition to the 50% point of an output low-to-high transition. |
| t <sub>LE(-)</sub> | Latch-Enable to Output Low Delay. The propagation delay measured from the 50% point of the latch-enable signal low-to-high transition to the 50% point of an output high-to-low transition.  |

|                     |  |
|---------------------|--|
| t <sub>pw(LE)</sub> | Latch-Enable Pulse Width. The minimum time the latch-enable signal must be high to acquire and hold an input signal.   |
| t <sub>s</sub>      | Setup Time. The minimum time before the negative transition of the latch-enable pulse that an input signal must be present to be acquired and held at the outputs.     |
| t <sub>h</sub>      | Hold Time. The minimum time after the negative transition of the latch-enable signal that an input signal must remain unchanged to be acquired and held at the output. |
| Δ <sub>pd</sub>     | Propagation Delay Skew. The difference in propagation delay between the Q and $\bar{Q}$ outputs crossing each other in both directions.                                |
| P <sub>DSP</sub>    | Propagation Delay Dispersion. The change in propagation delay as a result of the overdrive of the input signal varying.  |
| t <sub>pdm</sub>    | Propagation Delay Match (MAX9693 only). The difference in propagation delay between two separate channels.   |

## Chip Information

PROCESS: BiCMOS

## Ordering Information (continued)

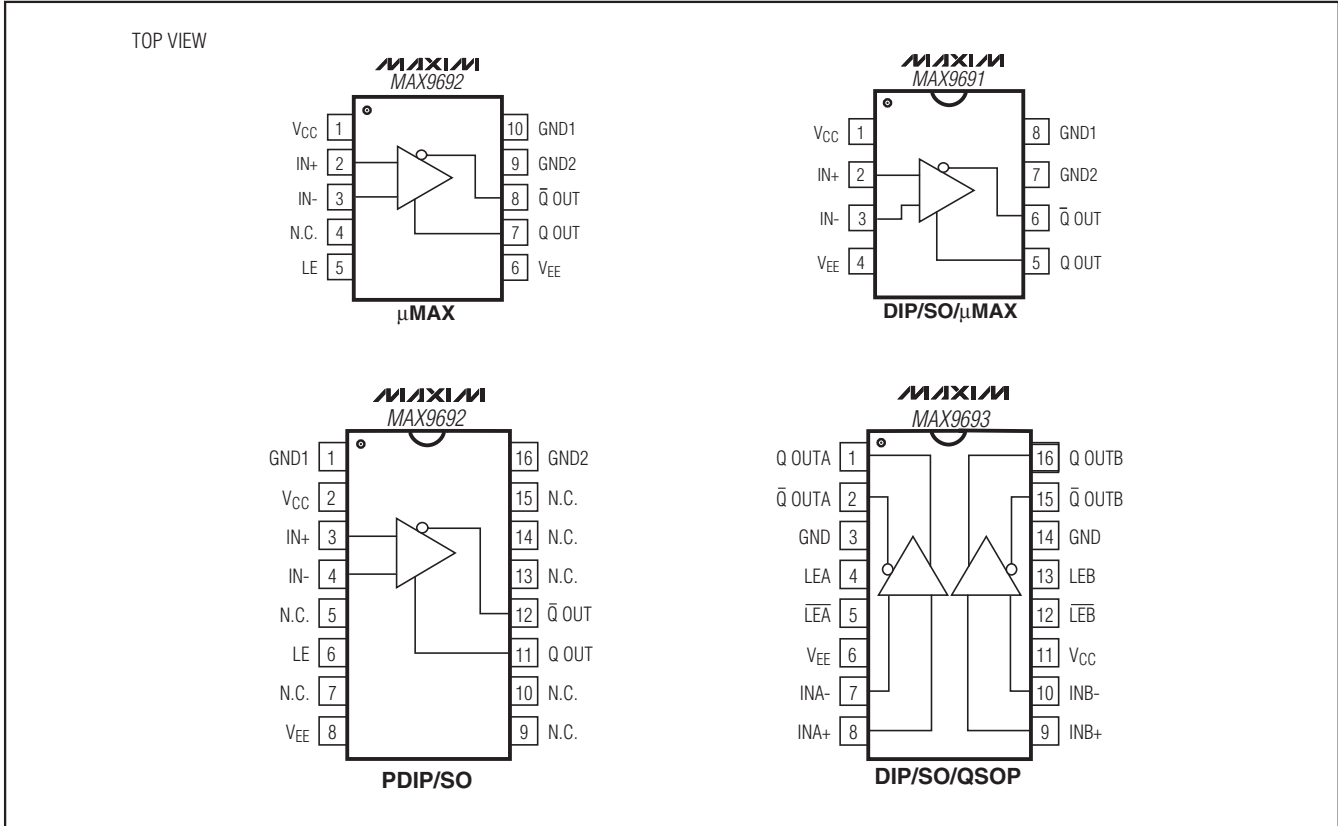
| PART       | TEMP RANGE     | PIN-PACKAGE  |
|------------|----------------|--------------|
| MAX9692EUB | -40°C to +85°C | 10 μMAX      |
| MAX9692ESE | -40°C to +85°C | 16 Narrow SO |
| MAX9692EPE | -40°C to +85°C | 16 PDIP      |
| MAX9693ESE | -40°C to +85°C | 16 Narrow SO |
| MAX9693EEE | -40°C to +85°C | 16 QSOP      |
| MAX9693EPE | -40°C to +85°C | 16 PDIP      |

**Note:** Devices are also available in lead(Pb)-free/RoHS-compliant packages. Specify lead-free by adding a "+" after the part number.

# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Pin Configurations

MAX9691/MAX9692/MAX9693



## Package Information

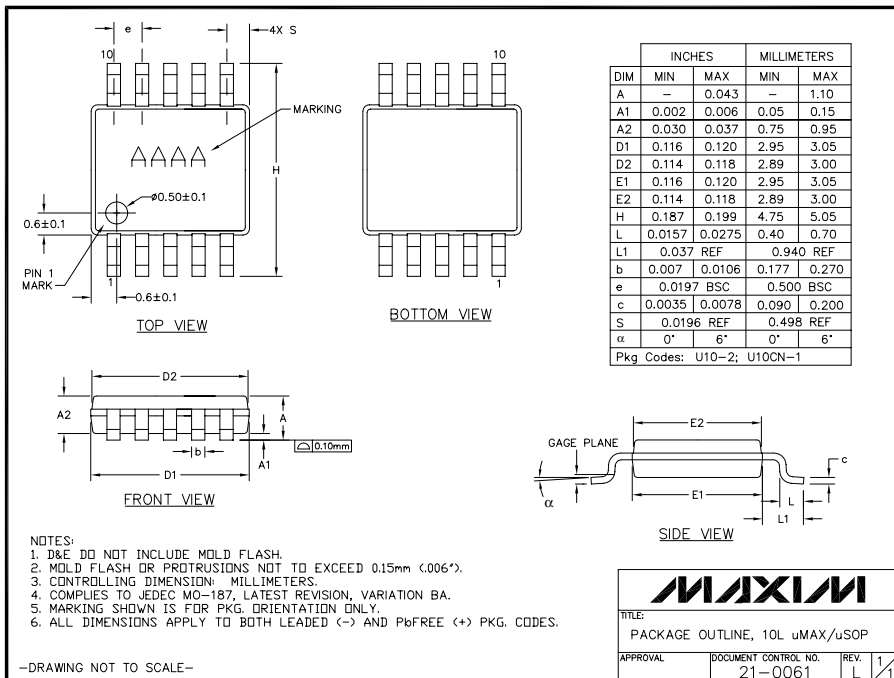
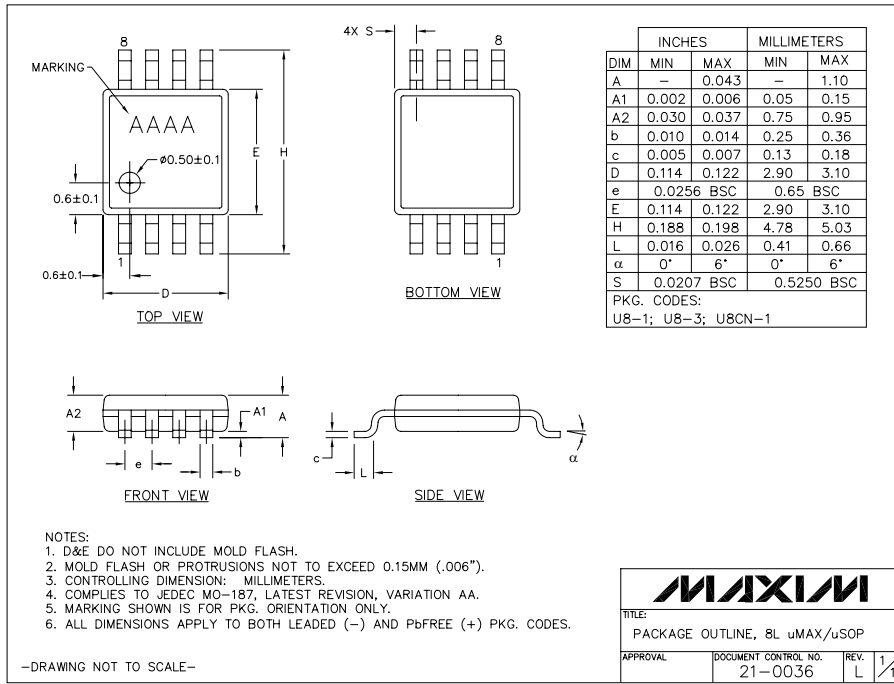
For the latest package outline information and land patterns (footprints), go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains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

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 8 $\mu$ MAX  | U8+1         | <a href="#">21-0036</a> | <a href="#">90-0092</a> |
| 8 SO         | S8+2         | <a href="#">21-0041</a> | <a href="#">90-0096</a> |
| 8 PDIP       | P8+5         | <a href="#">21-0043</a> | —                       |
| 10 $\mu$ MAX | U10+2        | <a href="#">21-0061</a> | <a href="#">90-0330</a> |
| 16 QSOP      | E16+1        | <a href="#">21-0055</a> | <a href="#">90-0167</a> |
| 16 SO        | S16+3        | <a href="#">21-0041</a> | <a href="#">90-0097</a> |
| 16 PDIP      | P16+1        | <a href="#">21-0043</a> | —                       |

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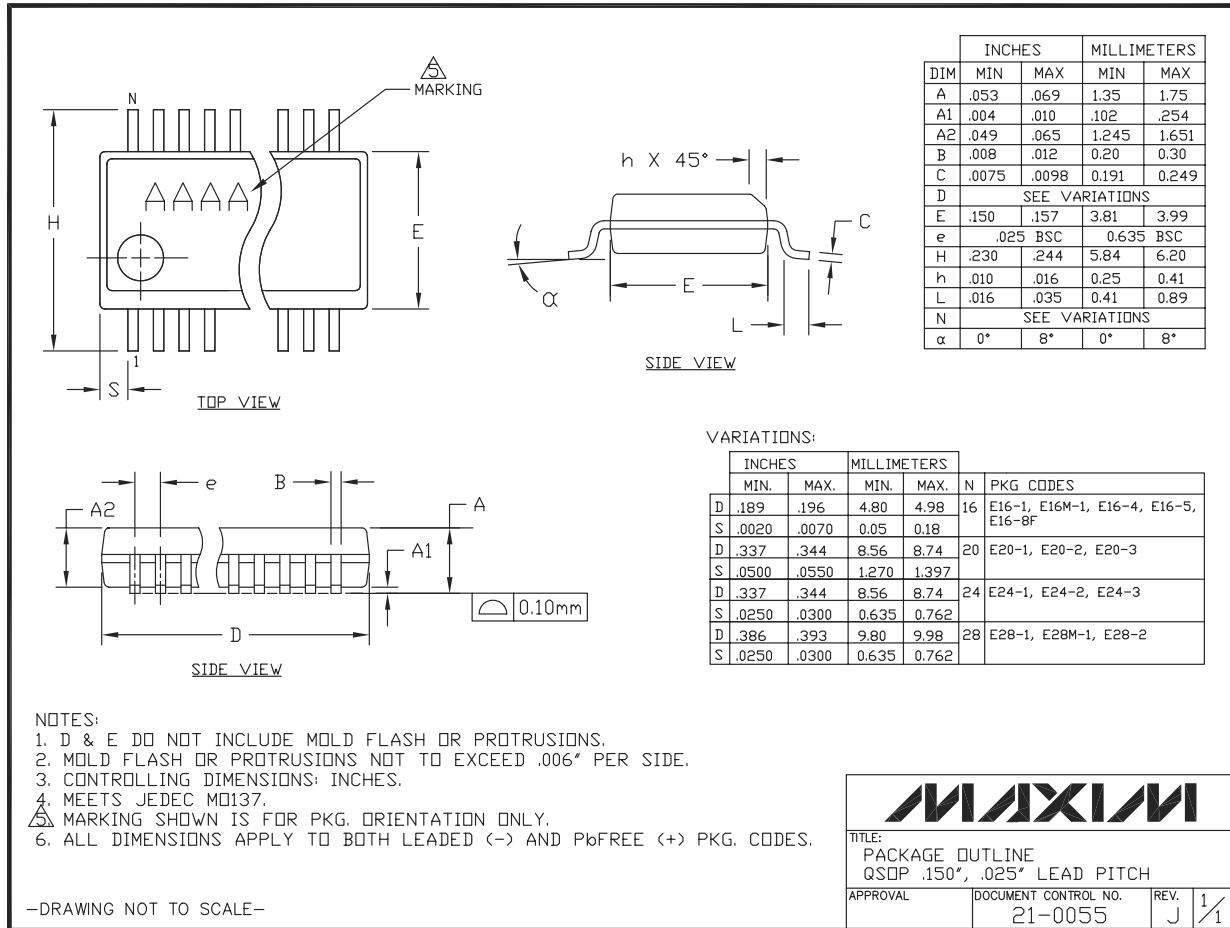


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MAX9691/MAX9692/MAX9693



# Single/Dual, Ultra-Fast, ECL-Output Comparators with Latch Enable

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION  | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0               | 8/00          | Initial release  | —             |
| 1               | 10/02         | Updated Ordering Information.  | 7             |
| 2               | 1/12          | Revised <i>Ordering Information</i> , <i>Absolute Maximum Ratings</i> , and <i>Pin Description</i> . | 1, 2, 5, 7    |

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