



## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### General Description

The MAX9169/MAX9170 low-jitter, low-voltage differential signaling LVDS/LVTTTL-to-LVDS repeaters are ideal for applications that require high-speed data or clock distribution while minimizing power, space, and noise. The devices accept a single LVDS (MAX9169) or LVTTTL (MAX9170) input and repeat the input at four LVDS outputs. Each differential output drives 100Ω, allowing point-to-point distribution of signals on transmission lines with 100Ω termination at the receiver input. The MAX9169 and MAX9170 are pin compatible with the SN65LVDS104 and SN65LVDS105, respectively, and offer improved pulse-skew performance.

Ultra-low 150ps (max) pulse skew and 200psp-p (max) added deterministic jitter ensure reliable communication in high-speed links that are highly sensitive to timing error, especially those incorporating clock-and-data recovery or serializers and deserializers. The high-speed switching performance guarantees 630Mbps data rate and less than 120ps channel-to-channel skew over the 3.0V to 3.6V operating supply range.

Supply current is 30mA (max) for the MAX9169, and 25mA (max) for the MAX9170. LVDS inputs and outputs conform to the ANSI EIA/TIA-644 standard. A fail-safe feature on the MAX9169 sets the output high when the input is undriven and open, terminated, or shorted. The MAX9169/MAX9170 are offered in 16-pin TSSOP and SO packages, and operate over an extended -40°C to +85°C temperature range.

Refer to the MAX9130 data sheet for an LVDS line receiver in an SC70 package.

### Applications

Point-to-Point Baseband Data Transmission  
Cellular Phone Base Stations  
Add/Drop Muxes  
Digital Cross-Connects  
Network Switches/Routers  
Backplane Interconnect  
Clock Distribution

Pin Configurations appear at end of data sheet.



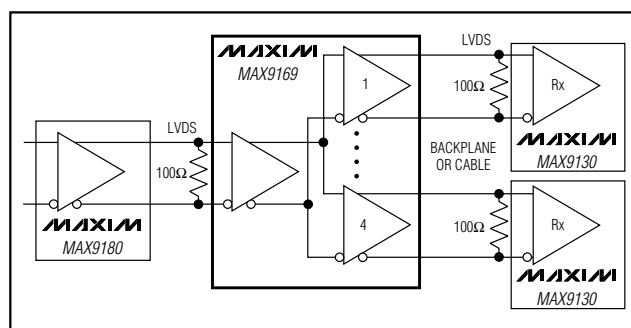
### Features

- ◆ 150ps (max) Pulse Skew
- ◆ 200psp-p (max) Added Deterministic Jitter at 630Mbps (2<sup>23</sup> - 1) PRBS Pattern
- ◆ 8ps<sub>RMS</sub> (max) Added Random Jitter
- ◆ 120ps (max) Channel-to-Channel Skew
- ◆ 630Mbps Data Rate
- ◆ Conforms to ANSI EIA/TIA-644 LVDS Standard
- ◆ 30mA (max) (MAX9169), 25mA (max) (MAX9170) Supply Current, a 15% Improvement vs. Competition
- ◆ LVDS (MAX9169) or +5V Tolerant LVTTTL/LVCMOS (MAX9170) Input Versions
- ◆ Fail-Safe Circuit Sets Output High for Undriven Differential Input
- ◆ Output Rated for 10pF Load
- ◆ Individual Output Enables
- ◆ Single 3.3V Supply
- ◆ Improved Second Source of the SN65LVDS104 (MAX9169)/SN65LVDS105 (MAX9170)
- ◆ 16-Pin SO and TSSOP Packages

### Ordering Information

| PART       | TEMP RANGE     | PIN-PACKAGE | INPUT  |
|------------|----------------|-------------|--------|
| MAX9169ESE | -40°C to +85°C | 16 SO       | LVDS   |
| MAX9169EUE | -40°C to +85°C | 16 TSSOP    | LVDS   |
| MAX9170ESE | -40°C to +85°C | 16 SO       | LVTTTL |
| MAX9170EUE | -40°C to +85°C | 16 TSSOP    | LVTTTL |

### Typical Application Circuit



MAX9169/MAX9170

# 4-Port LVDS and LVTTTL-to-LVDS Repeaters

## ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub> to GND .....-0.5V to +4V  
 Inputs  
   IN+, IN- to GND .....-0.5V to +4V  
   IN, EN\_ to GND .....-0.5V to +6V  
 Outputs  
   OUT\_+, OUT\_- to GND .....-0.5V to +4V  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
   16-Pin SO (derate 8.7mW/°C above +70°C) .....696mW  
   16-Pin TSSOP (derate 9.4mW/°C above +70°C) .....755mW

Storage Temperature Range .....-65°C to +150°C  
 Maximum Junction Temperature .....+150°C  
 ESD Protection  
   Human Body Model (MAX9169)  
     (IN+, IN-, OUT\_+, OUT\_-) .....≥16kV  
   Human Body Model (MAX9170)  
     (OUT\_+, OUT\_-) .....≥10kV  
 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.

## DC ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 3.0V to 3.6V, R<sub>L</sub> = 100Ω ±1%, EN\_ = high, MAX9169 differential input voltage |V<sub>ID</sub>| = 0.05V to 1.2V, LVDS input common-mode voltage V<sub>CM</sub> = |V<sub>ID</sub>|/2 to +2.4V - |V<sub>ID</sub>|/2, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = 3.3V, |V<sub>ID</sub>| = 0.2V, V<sub>CM</sub> = 1.25V, T<sub>A</sub> = +25°C for MAX9169. Typical values are at V<sub>CC</sub> = 3.3V, V<sub>IN</sub> = 0 or V<sub>CC</sub>, T<sub>A</sub> = +25°C for MAX9170.) (Notes 1 and 2)

| PARAMETER   | SYMBOL                                | CONDITIONS   | MIN   | TYP   | MAX   | UNITS |
|---|---------------------------------------|--|-------|-------|-------|-------|
| <b>LVDS INPUTS (IN+, IN-) (MAX9169)</b>                       |                                       |  |       |       |       |       |
| Differential Input High Threshold                             | V <sub>TH</sub>                       |  |       | 5     | 50    | mV    |
| Differential Input Low Threshold                              | V <sub>TL</sub>                       |  | -50   | -5    |       | mV    |
| Input Current<br>(IN+ or IN-, Single Ended)                   | I <sub>IN+</sub> , I <sub>IN-</sub>   | V <sub>IN</sub> = 0V, other input open, Figure 1                             | -2    | -11.8 | -20   | μA    |
|   |                                       | V <sub>IN</sub> = +2.4V, other input open, Figure 1                          | -1.2  | -3.2  |       |       |
| Power-Off Input Current<br>(IN+ or IN-, Single Ended)         | I <sub>INO+</sub> , I <sub>INO-</sub> | V <sub>CC</sub> = +1.5V, V <sub>IN</sub> = +2.4V, other input open, Figure 1 |       | 3.2   | 20    | μA    |
| Input Current   | I <sub>IN+</sub> , I <sub>IN-</sub>   | 0.05V ≤  V <sub>ID</sub>   ≤ 0.6V, Figure 1                                  | -15   |       | +15   | μA    |
|   |                                       | 0.6V <  V <sub>ID</sub>   ≤ 1.2V, Figure 1                                   | -20   |       | +20   |       |
| Power-Off Input Current                                       | I <sub>INO+</sub> , I <sub>INO-</sub> | 0.05V ≤  V <sub>ID</sub>   ≤ 0.6V, V <sub>CC</sub> = 1.5V, Figure 1          | -15   |       | +15   | μA    |
|   |                                       | 0.6V <  V <sub>ID</sub>   ≤ 1.2V, V <sub>CC</sub> = 1.5V, Figure 1           | -20   |       | +20   |       |
| Fail-Safe Input Resistor                                      | R <sub>IN1</sub>                      | V <sub>CC</sub> = 3.6V, 0 or open, Figure 1                                  | 103   | 138   | 190   | kΩ    |
|   | R <sub>IN2</sub>                      | V <sub>CC</sub> = 3.6V, 0 or open, Figure 1                                  | 154   | 210   | 260   |       |
| Input Capacitance   | C <sub>IN</sub>                       | IN+ or IN- to GND (Note 3)   |       | 2.2   |       | pF    |
| <b>+5V TOLERANT LVTTTL/LVCMOS INPUTS (IN, EN_)</b>            |                                       |  |       |       |       |       |
| Input High Voltage  | V <sub>IH</sub>                       |  | 2.0   |       | 5.5   | V     |
| Input Low Voltage   | V <sub>IL</sub>                       |  | 0     |       | 0.8   | V     |
| Input Current   | I <sub>IH</sub>                       | V <sub>IN</sub> = 2V to 5.5V   |       |       | 20    | μA    |
|   | I <sub>IL</sub>                       | V <sub>IN</sub> = 0 to 0.8V  |       |       | 10    |       |
| Input Capacitance (MAX9170)                                   | C <sub>IN</sub>                       | IN to GND (Note 3)   |       | 2.2   |       | pF    |
| <b>LVDS OUTPUTS (OUT_+, OUT_-)</b>                            |                                       |  |       |       |       |       |
| Differential Output Voltage                                   | V <sub>OD</sub>                       | Figures 3, 4, 6, 7   | 250   | 350   | 450   | mV    |
| Change in V <sub>OD</sub> Between Complementary Output States | ΔV <sub>OD</sub>                      | Figures 3, 4, 6, 7   |       | 1.5   | 25    | mV    |
| Steady-State Output Offset Voltage                            | V <sub>OS</sub>                       | Figures 2, 4, 5, 7, 8, 9   | 1.125 | 1.26  | 1.375 | V     |

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### DC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 3.0V$  to  $3.6V$ ,  $R_L = 100\Omega \pm 1\%$ ,  $EN_- = \text{high}$ , MAX9169 differential input voltage  $|V_{ID}| = 0.05V$  to  $1.2V$ , LVDS input common-mode voltage  $V_{CM} = |V_{ID}|/2$  to  $+2.4V - |V_{ID}|/2$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = 3.3V$ ,  $|V_{ID}| = 0.2V$ ,  $V_{CM} = 1.25V$ ,  $T_A = +25^\circ C$  for MAX9169. Typical values are at  $V_{CC} = 3.3V$ ,  $V_{IN} = 0$  or  $V_{CC}$ ,  $T_A = +25^\circ C$  for MAX9170.) (Notes 1 and 2)

| PARAMETER  | SYMBOL          | CONDITIONS  | MIN     | TYP       | MAX  | UNITS   |
|--|-----------------|---|---------|-----------|------|---------|
| Change in $V_{OS}$ Between Complementary Output States | $\Delta V_{OS}$ | Figures 2, 4, 5, 7, 8, 9  |         | 1.5       | 25   | mV      |
| Peak-to-Peak Output Offset Voltage                     | $V_{OS(P-P)}$   | Figures 8, 9 (Note 4)   |         | 40        | 150  | mV      |
| Output Voltage   | $V_{OH}$        | Figures 3, 4, 6, 7  |         |           | 1.65 | V       |
|  | $V_{OL}$        | Figures 3, 4, 6, 7  | 0.9     |           |      |         |
| Fail-Safe Differential Output Voltage (MAX9169)        | $V_{OD+}$       | $IN_+$ , $IN_-$ open, undriven and shorted, or undriven and parallel terminated       | +250    | +350      | +450 | mV      |
| High-Impedance Output Current                          | $I_{OZ}$        | $EN_- = \text{low}$ , $V_{OUT+} = +3.6V$ or 0, $V_{OUT-} = +3.6V$ or 0                | -0.5    | 0.01      | +0.5 | $\mu A$ |
| Power-Off Output Current                               | $I_{OFF}$       | $V_{CC} = +1.5V$ , $V_{OUT+} = +3.6V$ or 0, $V_{OUT-} = +3.6V$ or 0                   | -0.5    | 0.01      | +0.5 | $\mu A$ |
| Output Short-Circuit Current                           | $I_{OS}$        | $V_{ID} = +50mV$ or $-50mV$ , $V_{OUT+} = 0$ or $V_{CC}$ , $V_{OUT-} = 0$ or $V_{CC}$ | -10     | $\pm 5.8$ | +10  | mA      |
| Magnitude of Differential Output Short-Circuit Current | $I_{OSD}$       | $V_{ID} = +50mV$ or $-50mV$ , $V_{OD} = 0$ (Note 5)                                   |         | 5.8       | 10   | mA      |
| Output Capacitance                                     | $C_O$           | $OUT_+$ or $OUT_-$ to GND (Note 6)  |         | 3.6       |      | pF      |
| <b>POWER SUPPLY</b>                                    |                 |   |         |           |      |         |
| Supply Current   | $I_{CC}$        | DC, $R_L = 100\Omega$ , Figures 10, 13  | MAX9169 | 22        | 30   | mA      |
|  |                 |   | MAX9170 | 18        | 25   |         |
|  |                 | 315MHz (630Mbps), $R_L = 100\Omega$ , Figures 10, 13                                  | MAX9169 | 43        | 60   |         |
|  |                 |   | MAX9170 | 41        | 55   |         |
| Disabled Supply Current                                | $I_{CCZ}$       | $EN_- = \text{low}$   | MAX9169 | 6.8       | 8.0  | mA      |
|  |                 |   | MAX9170 | 4.3       | 6.4  |         |

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = 3.0V$  to  $3.6V$ ,  $R_L = 100\Omega \pm 1\%$ ,  $C_L = 10pF$ ,  $EN_{-}$  = high, MAX9169 differential input voltage  $|V_{ID}| = 0.15V$  to  $1.2V$ , LVDS input common-mode voltage  $V_{CM} = |V_{ID}/2|$  to  $+2.4V - |V_{ID}/2|$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $|V_{ID}| = 0.2V$ ,  $V_{CM} = 1.25V$ ,  $V_{CC} = 3.3V$ ,  $T_A = +25^{\circ}C$  for MAX9169. Typical values are at  $V_{IN} = 0$  or  $V_{CC}$ ,  $V_{CC} = 3.3V$ ,  $T_A = +25^{\circ}C$  for MAX9170.) (Notes 5, 7, and 8)

| PARAMETER                                       | SYMBOL               | CONDITIONS                       |         | MIN | TYP  | MAX | UNITS |
|---|----------------------|----------------------------------|---------|-----|------|-----|-------|
| Rise Time                                       | t <sub>R</sub>       | Figures 10–15                    |         | 0.6 | 0.8  | 1.2 | ns    |
| Fall Time                                       | t <sub>F</sub>       | Figures 10–15                    |         | 0.6 | 0.8  | 1.2 | ns    |
| Added Deterministic Jitter                      | t <sub>DJ</sub>      | (Note 9)                         |         |     | 110  | 200 | ps    |
| Added Random Jitter                             | t <sub>RJ</sub>      | (Note 10)                        |         |     | 6    | 8   | ps    |
| Differential Propagation Delay<br>High to Low   | t <sub>PHL</sub>     | Figures 10, 11, 13, 14           | MAX9169 | 2.2 | 3.5  | 4.2 | ns    |
|   |                      |                                  | MAX9170 | 1.5 | 2.6  | 3.2 |       |
| Differential Propagation Delay<br>Low to High   | t <sub>PLH</sub>     | Figures 10, 11, 13, 14           | MAX9169 | 2.2 | 3.5  | 4.2 | ns    |
|   |                      |                                  | MAX9170 | 1.5 | 2.6  | 3.2 |       |
| Pulse Skew  t <sub>PLH</sub> - t <sub>PHL</sub> | t <sub>SK</sub> EW   | Figures 10, 11, 13, 14           |         |     | 40   | 250 | ps    |
| Pulse Skew  t <sub>PLH</sub> - t <sub>PHL</sub> | t <sub>SK</sub> (P)  | Figures 10, 12, 13, 15 (Note 11) |         |     | 40   | 150 | ps    |
| Channel-to-Channel Skew<br>(Note 12)            | t <sub>SK</sub> (0)  | MAX9169, Figures 10, 11, 12      |         |     | 25   | 120 | ps    |
|   |                      | MAX9170, Figures 13, 14, 15      |         |     | 15   | 100 |       |
| Differential Part-to-Part Skew<br>(Note 13)     | t <sub>SK</sub> (PP) | MAX9169, Figures 10, 11, 12      |         |     | 0.28 | 1.2 | ns    |
|   |                      | MAX9170, Figures 13, 14, 15      |         |     | 0.19 | 1.2 |       |
| Disable Time                                    | t <sub>PHZ</sub>     | High to high-Z, Figures 16–19    |         |     | 11   | 15  | ns    |
|   | t <sub>PLZ</sub>     | Low to high-Z, Figures 16–19     |         |     | 11.8 | 15  |       |
| Enable Time                                     | t <sub>PZH</sub>     | High-Z to high, Figures 16–19    |         |     | 2.3  | 10  | ns    |
|   | t <sub>PZL</sub>     | High-Z to low, Figures 16–19     |         |     | 5.8  | 10  |       |

**Note 1:** Current into a pin is defined as positive. Current out of a pin is defined as negative. All voltages are referenced to ground except  $V_{TH}$ ,  $V_{TL}$ ,  $V_{ID}$ ,  $V_{OD}$ , and  $\Delta V_{OD}$ .

**Note 2:** Maximum and minimum limits over temperature are guaranteed by design and characterization. Devices are production tested at  $T_A = +25^{\circ}C$ .

**Note 3:** Signal generator output for  $IN_{+}$ ,  $IN_{-}$ , or single-ended  $IN$ :  $V_{IN} = 0.4 \sin(4E6\pi t) + 0.5$ .

**Note 4:** All input pulses are supplied by a generator having the following characteristics:  $t_R$  or  $t_F \leq 1ns$ , pulse repetition rate (PRR) = 0.5 Mpps, pulsewidth =  $500 \pm 10ns$ .

**Note 5:** Guaranteed by design and characterization.

**Note 6:** Signal generator output for  $OUT_{+}$  or  $OUT_{-}$ :  $V_{IN} = 0.4 \sin(4E6\pi t) + 0.5$ ,  $EN_{-}$  = low.

**Note 7:**  $C_L$  includes scope probe and test jig capacitance.

**Note 8:** Signal generator output for differential inputs  $IN_{+}$ ,  $IN_{-}$  (unless otherwise noted): frequency = 50MHz, 49% to 51% duty cycle,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%). Signal generator output for single-ended input  $IN$  (unless otherwise noted): frequency = 50MHz, 49% to 51% duty cycle,  $R_O = 50\Omega$ ,  $V_{IH} = V_{CC}$ ,  $V_{IL} = 0V$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%).

**Note 9:** Signal generator output for MAX9169  $t_{DJ}$ :  $V_{OH} = +1.3V$ ,  $V_{OL} = +1.1V$ , data rate = 630Mbps,  $2^{23}-1$  PRBS,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$  and  $t_F = 1.0ns$  (0% to 100%). Signal generator output for MAX9170  $t_{DJ}$ :  $V_{OH} = V_{CC}$ ,  $V_{OL} = 0V$ , data rate = 630Mbps,  $2^{23}-1$  PRBS,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%).

**Note 10:** Signal generator output for MAX9169  $t_{RJ}$ :  $V_{OH} = +1.3V$ ,  $V_{OL} = +1.1V$ , frequency = 315MHz, 50% duty cycle,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%). Signal generator output for MAX9170  $t_{RJ}$ :  $V_{OH} = V_{CC}$ ,  $V_{OL} = 0V$ , frequency = 315MHz, 50% duty cycle,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%).

**Note 11:** Signal generator output for MAX9169  $t_{SK(P)}$ :  $V_{OH} = +1.4V$ ,  $V_{OL} = +1.0V$ ,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%). Signal generator output for MAX9170  $t_{SK(P)}$ :  $V_{OH} = +3.0$ ,  $V_{OL} = 0V$ ,  $R_O = 50\Omega$ ,  $t_R = 1.0ns$ , and  $t_F = 1.0ns$  (0% to 100%).

**Note 12:**  $t_{SK(0)}$  is the magnitude of the time difference between  $t_{PLH}$  or  $t_{PHL}$  of all drivers of a single device with all of their inputs connected together.

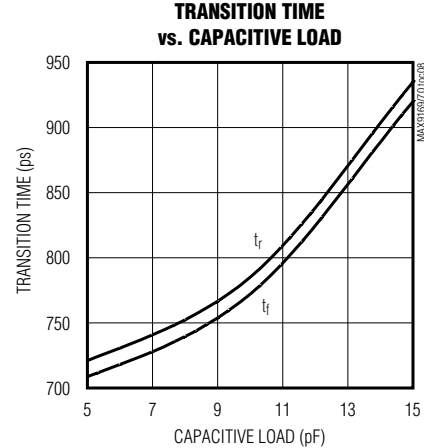
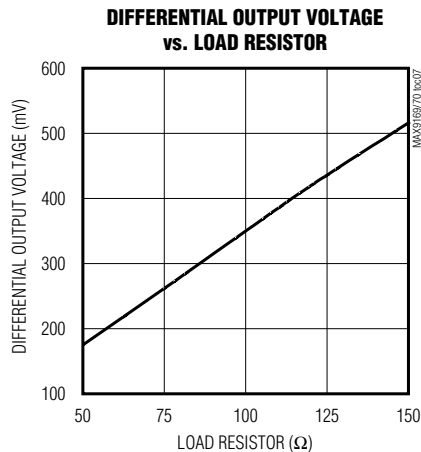
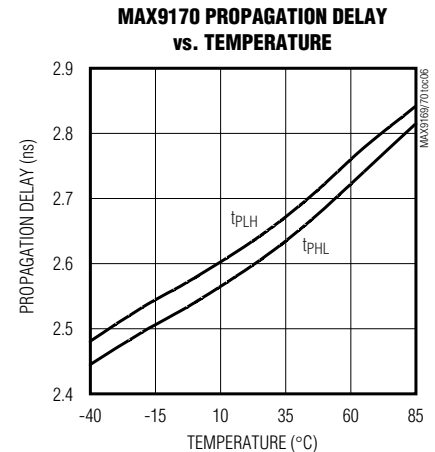
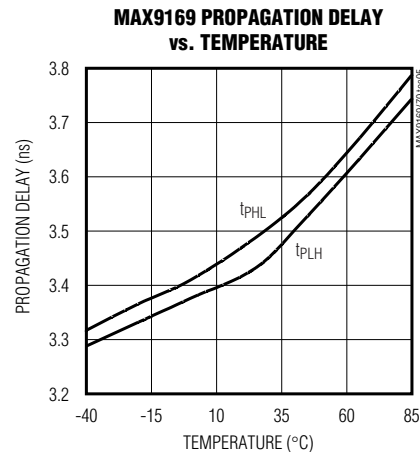
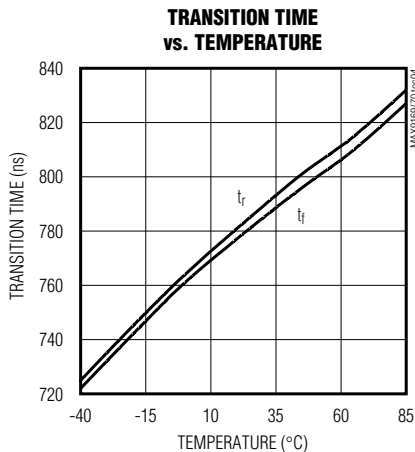
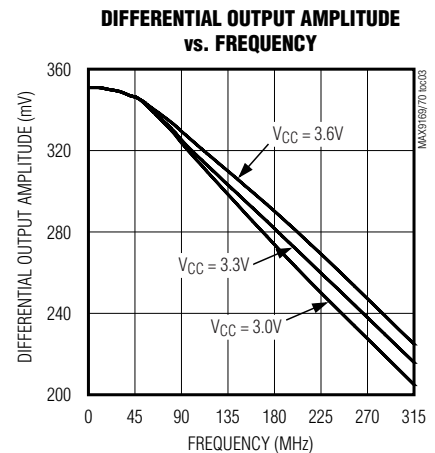
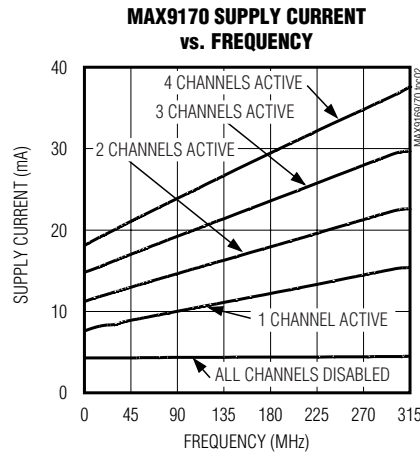
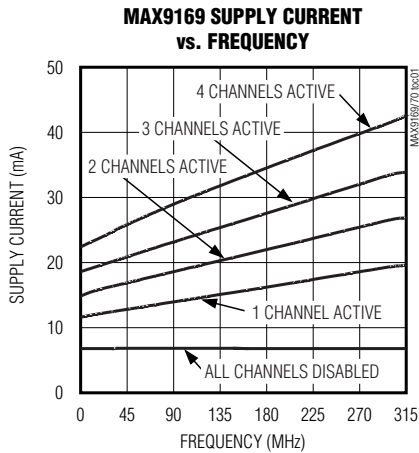
**Note 13:**  $t_{SK(PP)}$  is the magnitude of the difference in propagation delay times between any specified terminals of two devices when both devices operate with the same supply voltages, at the same temperature, and have identical packages and test circuits.

# 4-Port LVDS and LVTTTL-to-LVDS Repeaters

## Typical Operating Characteristics

( $V_{CC} = 3.3V$ ,  $R_L = 100\Omega$ ,  $C_L = 10pF$ ,  $|V_{ID}| = 150mV$ ,  $V_{CM} = 1.25V$ ,  $f_{IN} = 50MHz$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX9169/MAX9170



# 4-Port LVDS and LVTTL-to-LVDS Repeaters

## Pin Description

| PIN     |         | NAME  | FUNCTION   |
|---------|---------|-------|--|
| MAX9169 | MAX9170 |       |  |
| 1       | 1       | EN1   | OUT1+/OUT1- Enable. +5V tolerant LVTTL/LVCMOS input. Set EN1 high to enable OUT1+/OUT1-. Set EN1 low to disable OUT1+/OUT1- (high-impedance mode). Integrated pulldown to GND. |
| 2       | 2       | EN2   | OUT2+/OUT2- Enable. +5V tolerant LVTTL/LVCMOS input. Set EN2 high to enable OUT2+/OUT2-. Set EN2 low to disable OUT2+/OUT2- (high-impedance mode). Integrated pulldown to GND. |
| 3       | 3       | EN3   | OUT3+/OUT3- Enable. +5V tolerant LVTTL/LVCMOS input. Set EN3 high to enable OUT3+/OUT3-. Set EN3 low to disable OUT3+/OUT3- (high-impedance mode). Integrated pulldown to GND. |
| 4       | 4       | VCC   | Power-Supply Voltage. Bypass with 0.1μF and 0.001μF capacitors to ground.  |
| 5       | 5       | GND   | Ground   |
| 6       | —       | IN+   | Noninverting Differential LVDS Input   |
| 7       | —       | IN-   | Inverting Differential LVDS Input  |
| 8       | 8       | EN4   | OUT4+/OUT4- Enable. +5V tolerant LVTTL/LVCMOS input. Set EN4 high to enable OUT4+/OUT4-. Set EN4 low to disable OUT4+/OUT4- (high-impedance mode). Integrated pulldown to GND. |
| 9       | 9       | OUT4- | Inverting Differential LVDS Output   |
| 10      | 10      | OUT4+ | Noninverting Differential LVDS Output  |
| 11      | 11      | OUT3- | Inverting Differential LVDS Output   |
| 12      | 12      | OUT3+ | Noninverting Differential LVDS Output  |
| 13      | 13      | OUT2- | Inverting Differential LVDS Output   |
| 14      | 14      | OUT2+ | Noninverting Differential LVDS Output  |
| 15      | 15      | OUT1- | Inverting Differential LVDS Output   |
| 16      | 16      | OUT1+ | Noninverting Differential LVDS Output  |
| —       | 6       | IN    | Data Input, 5V Tolerant LVTTL/LVCMOS. Integrated pulldown to GND.  |
| —       | 7       | N.C.  | No Connection  |

**Table 1. MAX9169 Input/Output Functions**

| INPUT                        |             | OUTPUT   |
|------------------------------|-------------|----------|
| $V_{ID} = V_{IN+} - V_{IN-}$ | EN_         | $V_{OD}$ |
| X                            | Low or open | High-Z   |
| +50mV                        | High        | High     |
| -50mV                        | High        | Low      |
| Open                         | High        | High     |
| Undriven short               | High        | High     |
| Undriven parallel terminated | High        | High     |

**Table 2. MAX9170 Input/Output Functions**

| INPUT    |             | OUTPUT   |
|----------|-------------|----------|
| $V_{IN}$ | EN_         | $V_{OD}$ |
| X        | Low or open | High-Z   |
| High     | High        | High     |
| Low      | High        | Low      |
| Open     | High        | Low      |

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Detailed Description

LVDS is a signaling method for point-to-point and multidrop data communication over a controlled-impedance medium as defined by the ANSI TIA/EIA-644 and IEEE 1596.3 standards. LVDS uses a lower voltage swing than other common standards, achieving higher data rates with reduced power consumption, while reducing EMI emissions and system susceptibility to noise.

The MAX9169/MAX9170 are 630Mbps, four-port repeaters for high-speed, low-power applications. The MAX9169 accepts an LVDS input and has a fail-safe input circuit. The MAX9170 features a +5V tolerant single-ended LVTTTL/LVCMOS input. Both devices repeat the input at four LVDS outputs. The MAX9169 detects differential signals as low as 50mV and as high as 1.2V over a  $|V_{ID}|/2$  to 2.4V -  $|V_{ID}|/2$  common-mode range. The MAX9170's +5V tolerant LVTTTL/LVCMOS input includes circuitry to hold the decision threshold constant at +1.5V over temperature and supply voltage.

The MAX9169/MAX9170 outputs use a current-steering configuration to generate a 2.5mA to 4.5mA output current. This current-steering approach induces less ground bounce and shoot-through current, enhancing noise margin and system speed performance. The outputs are short-circuit current limited and are high impedance when disabled or when the device is not powered.

The MAX9169/MAX9170 current-steering output requires a resistive load to terminate the signal and complete the transmission loop. Because the devices switch the direction of current flow and not voltage levels, the output voltage swing is determined by the value of the termination resistor multiplied by the output current. With a typical 3.5mA output current, the MAX9169/MAX9170 produce a 350mV output voltage when driving a transmission line terminated with a 100Ω resistor ( $3.5\text{mA} \times 100\Omega = 350\text{mV}$ ). Logic states are determined by the direction of current flow through the termination resistor.

#### Fail-Safe Circuitry

The fail-safe feature of the MAX9169 sets the outputs high when the differential input is:

- Open
- Undriven and shorted
- Undriven and terminated

Without a fail-safe circuit, when the input is undriven, noise at the input may switch the outputs and it may appear to the system that data is being sent. Open or undriven terminated input conditions can occur when a cable is disconnected or cut, or when an LVDS driver output is in high impedance. A shorted input can occur because of cable failure.

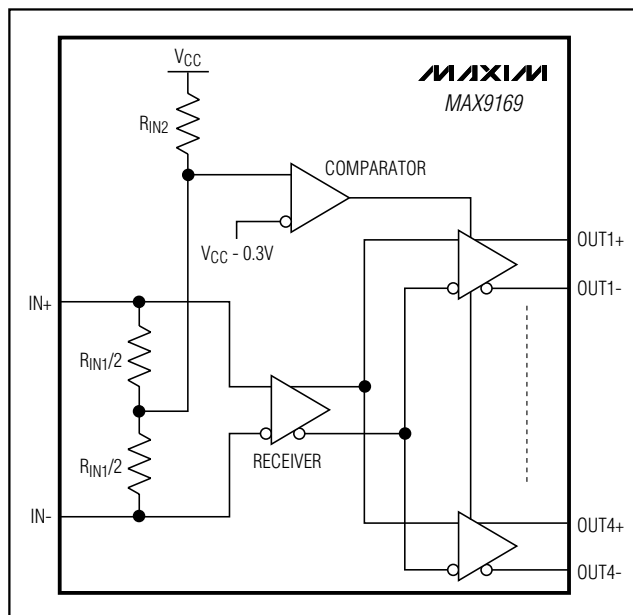


Figure 1. MAX9169 Input Fail-Safe Circuit

When the input is driven with signals meeting the LVDS standard, the input common-mode voltage is less than  $V_{CC} - 0.3\text{V}$  and the fail-safe circuit is not activated (Figure 1). If the input is open, undriven and shorted, or undriven and parallel terminated, an internal resistor in the fail-safe circuit pulls both the inputs above  $V_{CC} - 0.3\text{V}$ , activating the fail-safe circuit and forcing the outputs high.

### Applications Information

#### Supply Bypassing

Bypass  $V_{CC}$  with high-frequency surface-mount ceramic 0.1μF and 0.001μF capacitors in parallel as close to the device as possible, with the smaller value capacitor closest to the  $V_{CC}$  pin. Use multiple parallel vias to minimize parasitic inductance.

#### Traces, Cables, and Connectors

The characteristics of differential input and output connections affect the performance of the MAX9169/MAX9170. Use controlled-impedance traces, cables, and connectors with matched characteristic impedance.

Ensure that noise couples as common mode by running the traces of a differential pair close together. Reduce within-pair skew by matching the electrical length of the traces of a differential pair. Excessive skew can result in a degradation of magnetic field cancellation. Maintain a constant distance between traces of a differential pair to avoid discontinuities in differen-



## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

tial impedance. Minimize the number of vias to further prevent impedance discontinuities.

Avoid the use of unbalanced cables, such as ribbon cable. Balanced cables, such as twisted pair, offer superior signal quality and tend to generate less EMI due to canceling effects. Balanced cables tend to pick up noise as common mode, which is rejected by the LVDS receiver.

### Termination

The MAX9169/MAX9170 LVDS outputs are specified for a  $100\Omega$  load but can drive  $90\Omega$  to  $132\Omega$  to accommo-

date various types of interconnect. The termination resistor at the driven receiver should match the differential characteristic impedance of the interconnect and be located close to the receiver input. Use a  $\pm 1\%$  surface-mount termination resistor.

### Board Layout

A four-layer PC board with separate layers for power, ground, and LVDS signals is recommended. Keep LVTTTL/LVCMOS signals separated from the LVDS signals to prevent crosstalk to the LVDS lines.

## Test Circuits and Timing Diagrams

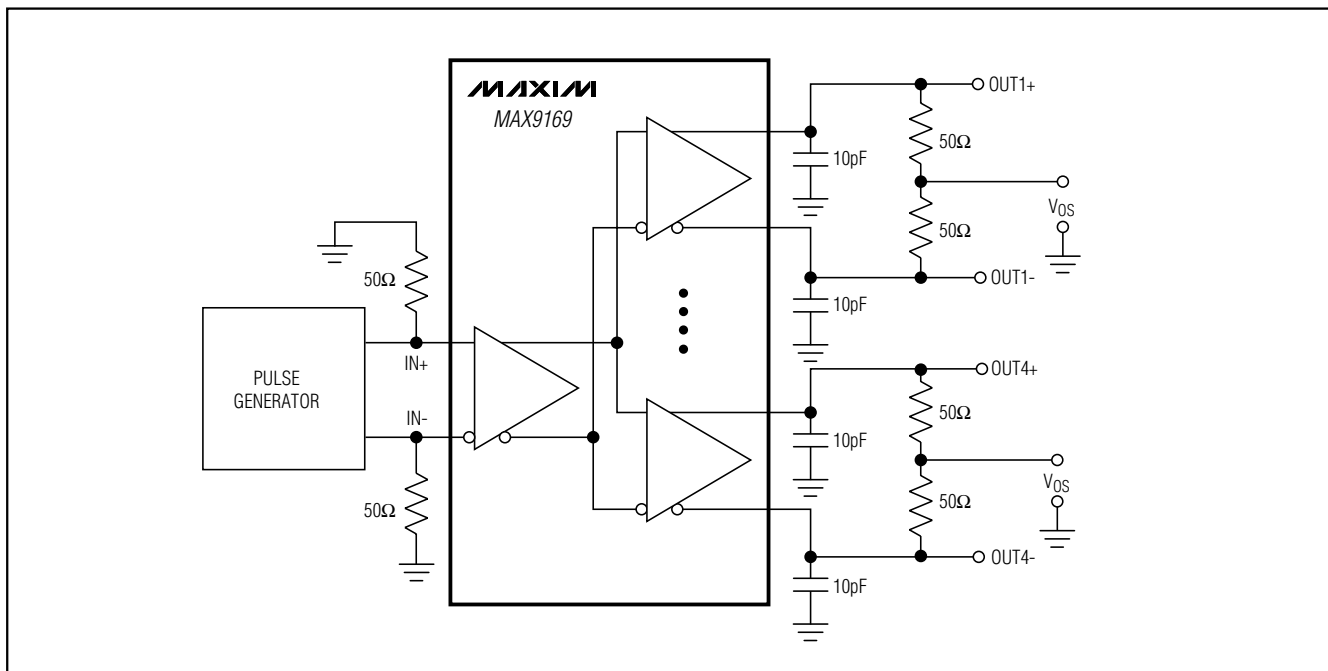


Figure 2. MAX9169 Output Offset Voltage Test Circuit



## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

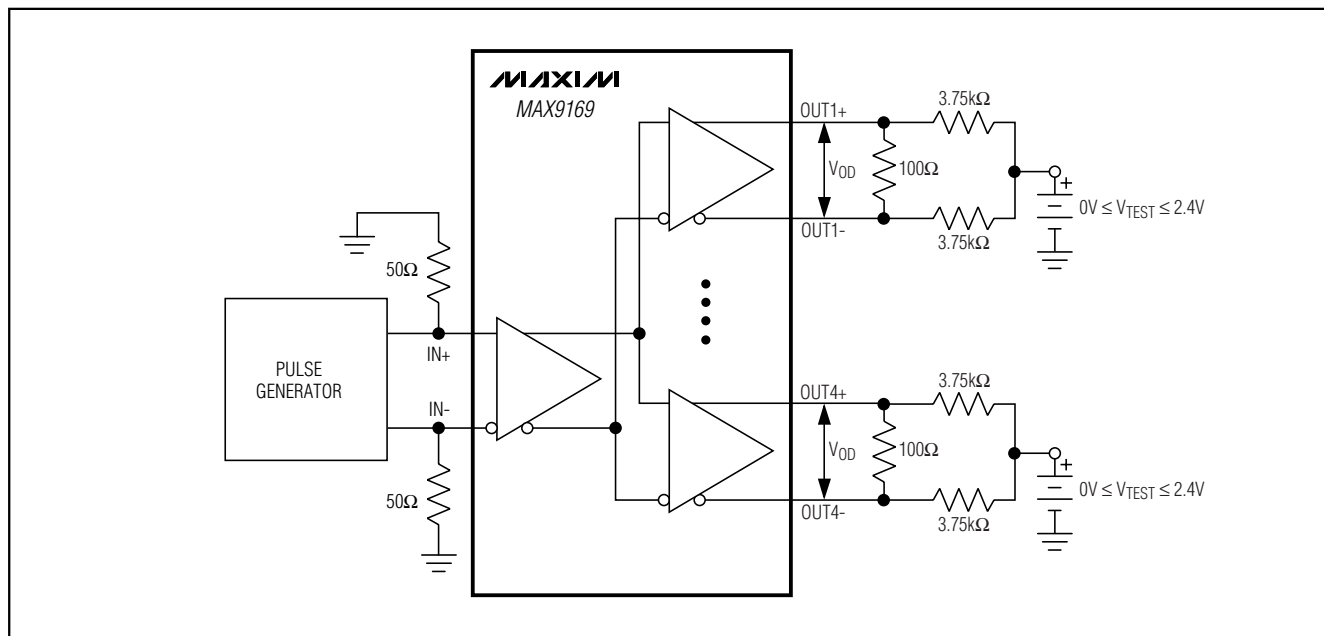


Figure 3. MAX9169 Differential Output Voltage Test Circuit

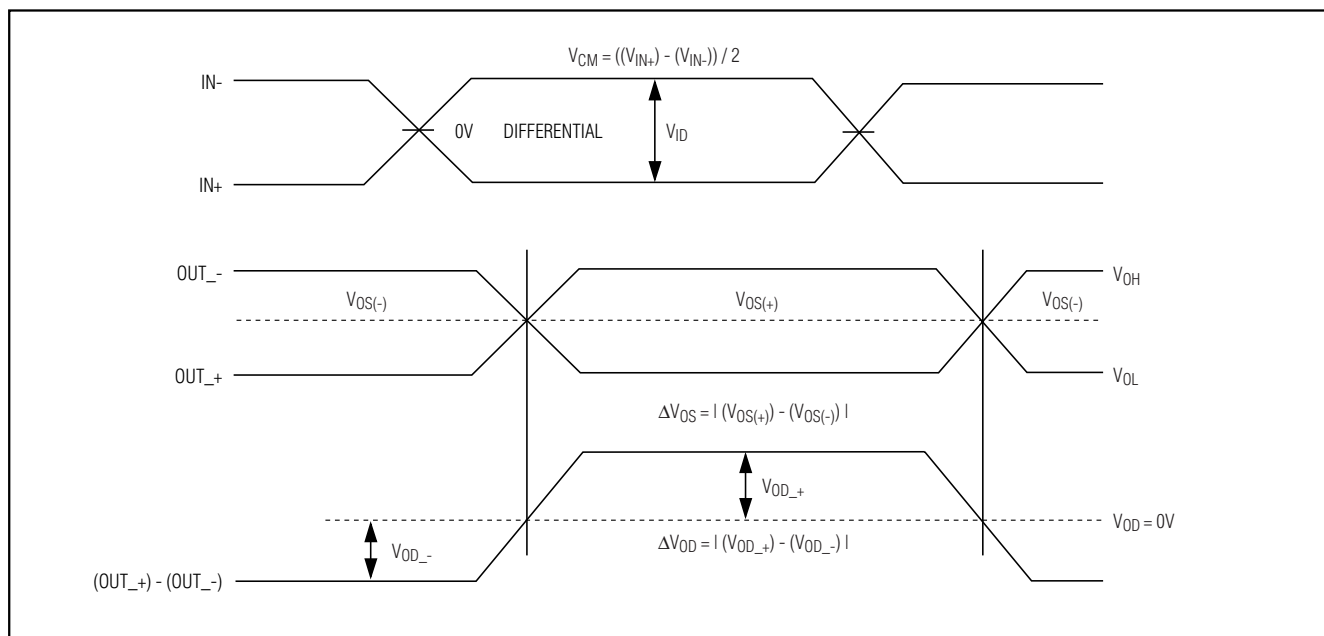


Figure 4. MAX9169 Output DC Parameters

## 4-Port LVDS and LVTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

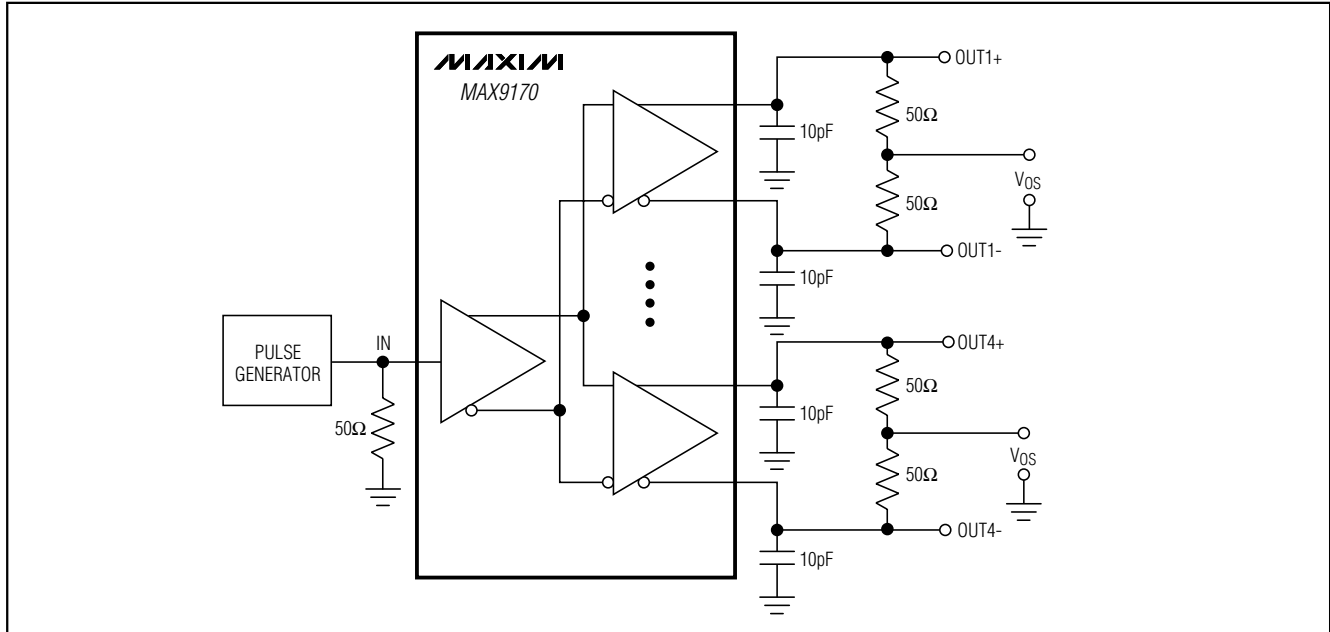


Figure 5. MAX9170 Output Offset Voltage Test Circuit

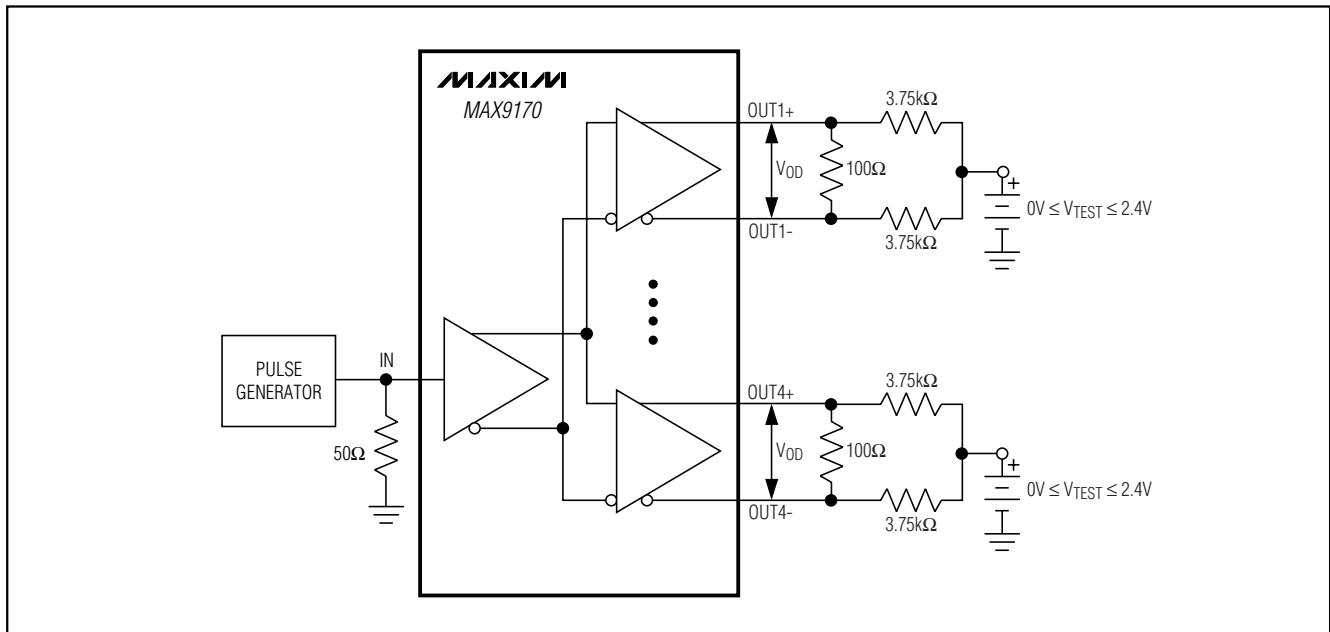
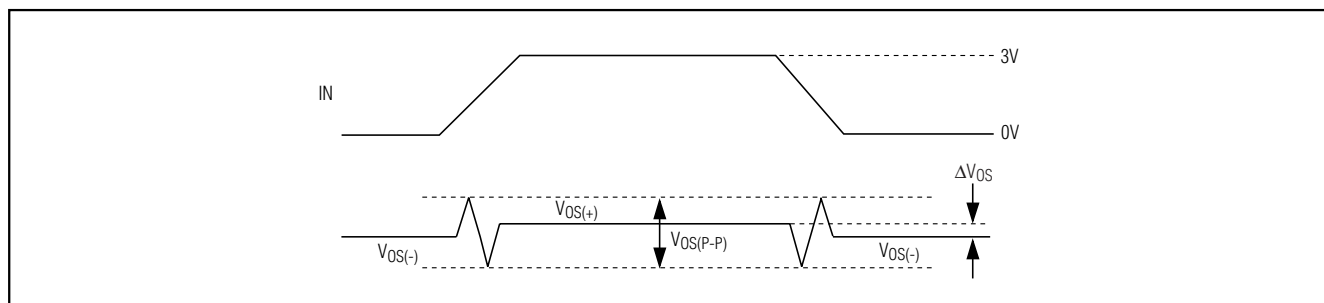
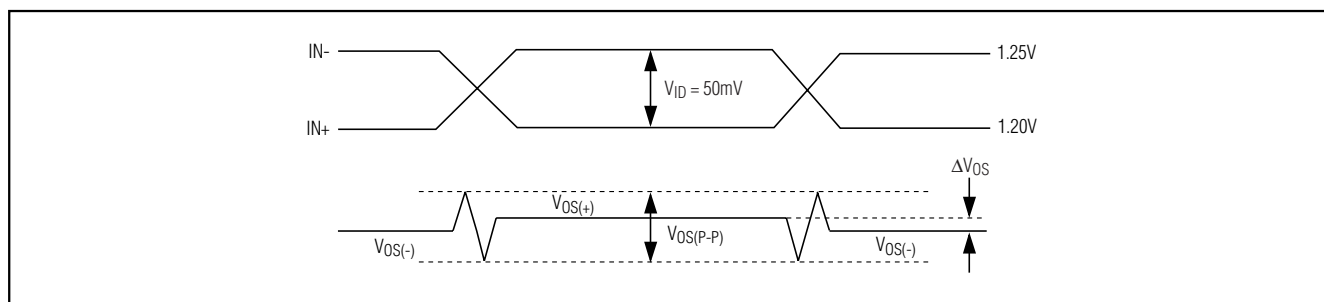
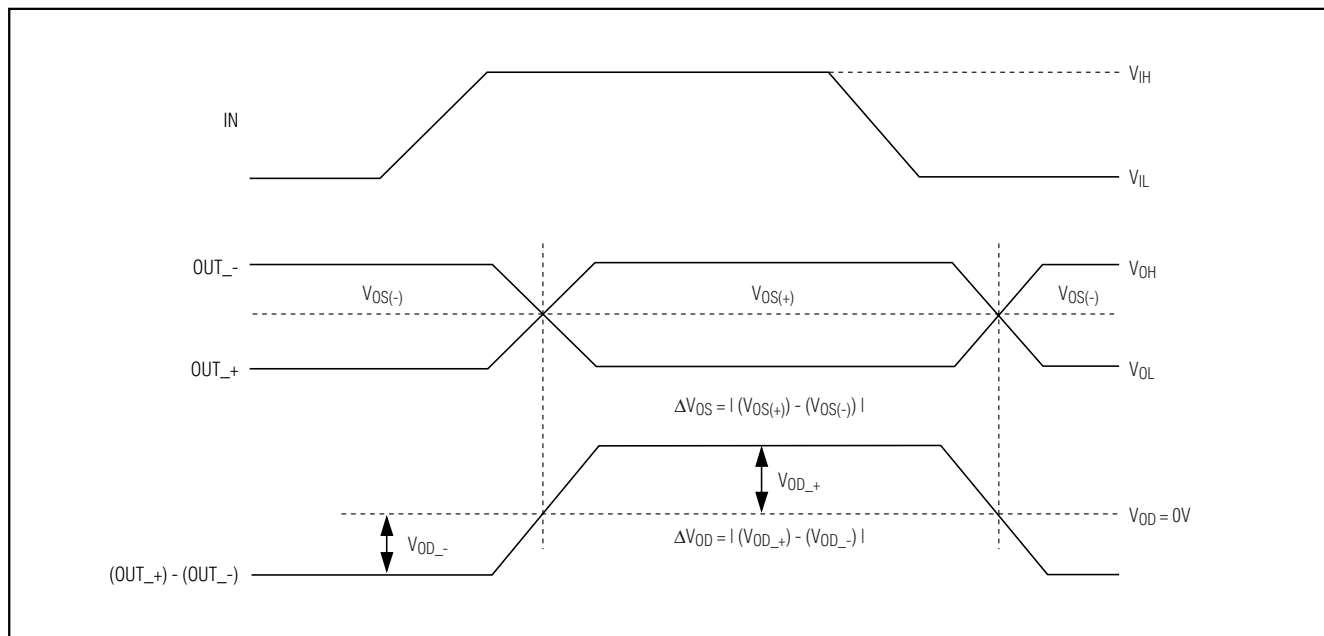


Figure 6. MAX9170 Differential Output Voltage Test Circuit

## 4-Port LVDS and LVTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)



## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

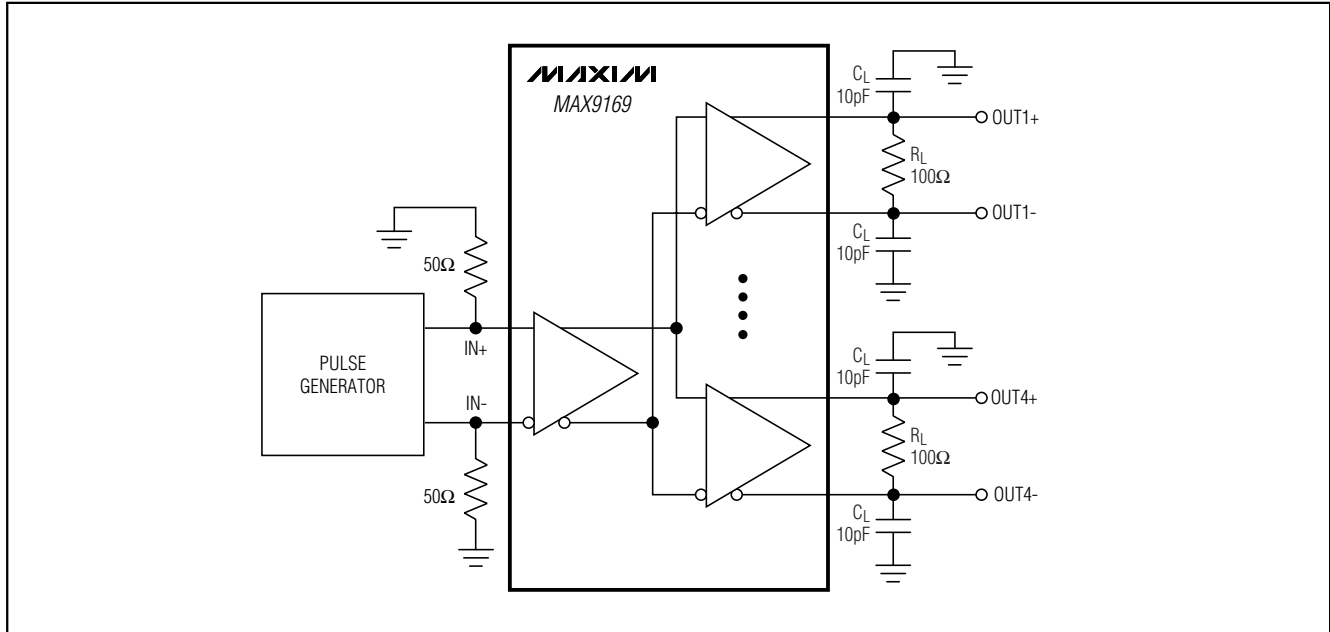


Figure 10. MAX9169 Propagation Delay and Transition Time Test Circuit

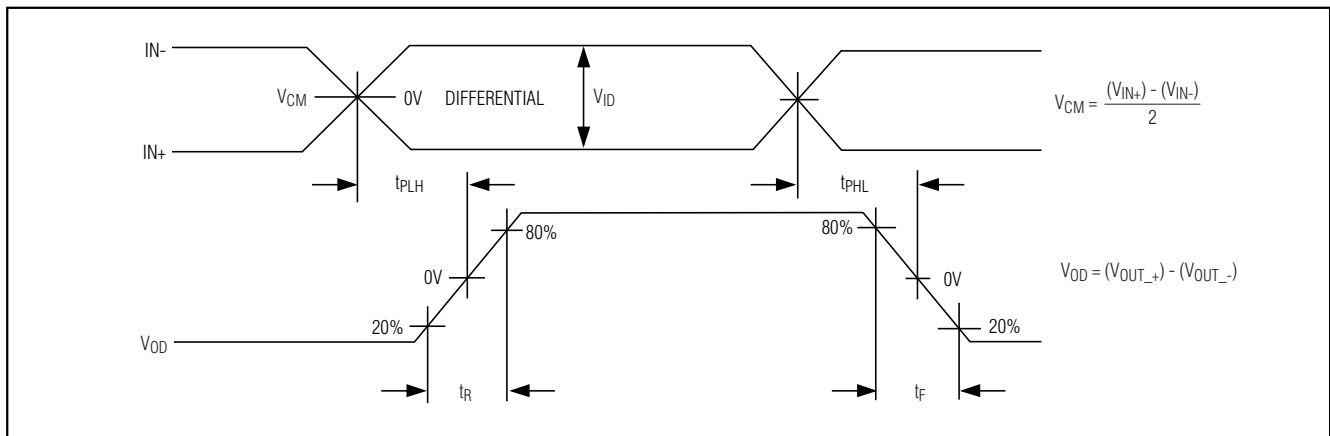


Figure 11. MAX9169 Propagation Delay and Transition Time Waveforms

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

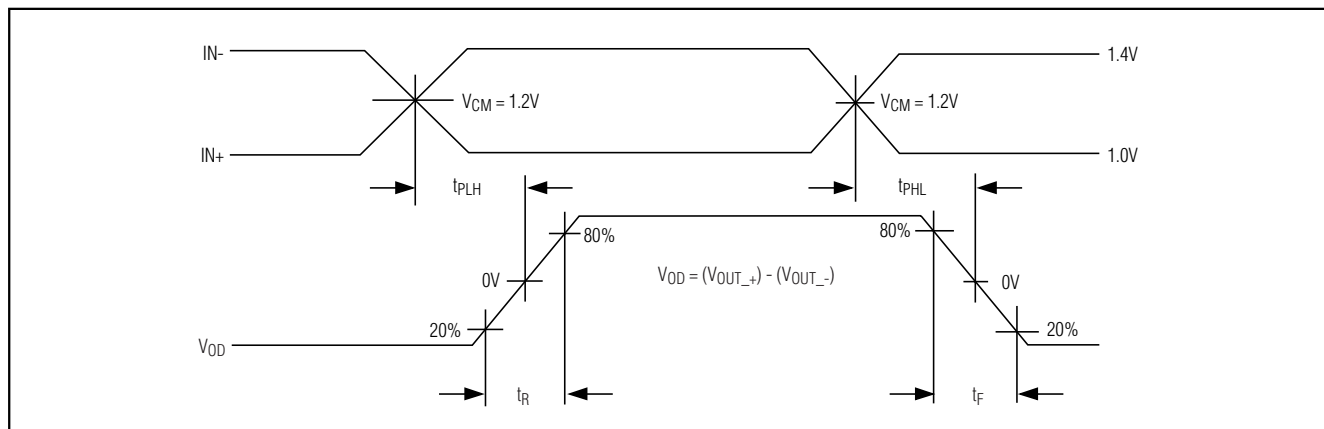


Figure 12. MAX9169 Propagation Delay and Transition Time Waveforms,  $t_{SK(p)}$

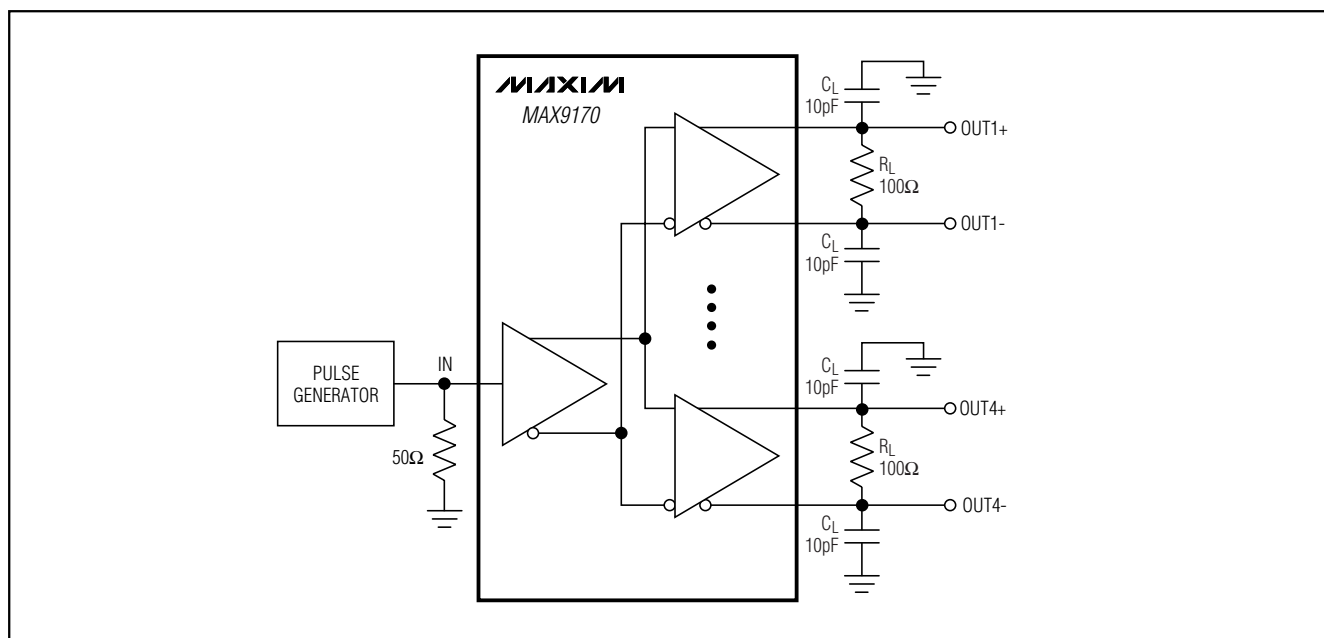


Figure 13. MAX9170 Propagation Delay and Transition Time Test Circuit

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

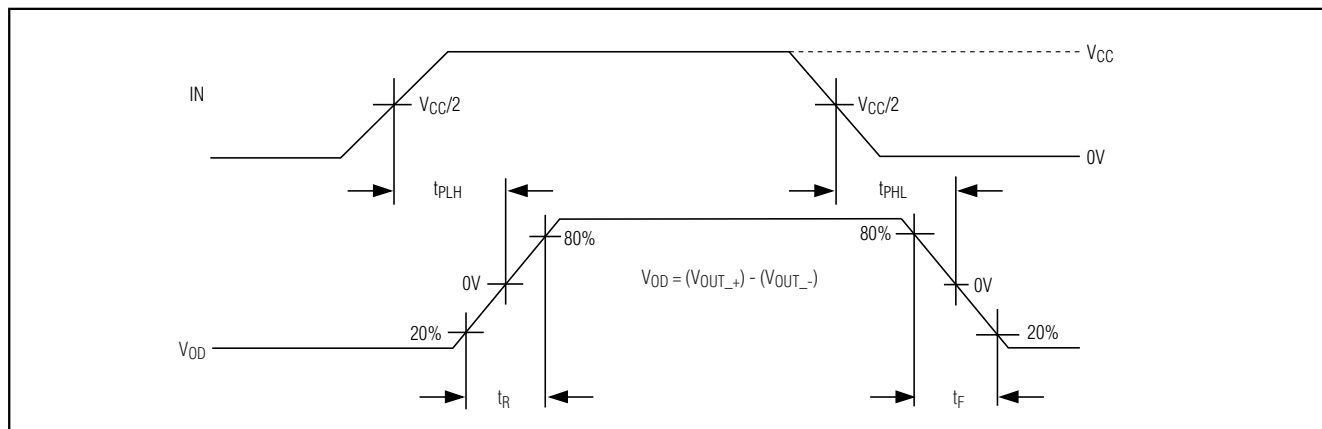


Figure 14. MAX9170 Propagation Delay and Transition Time Waveforms

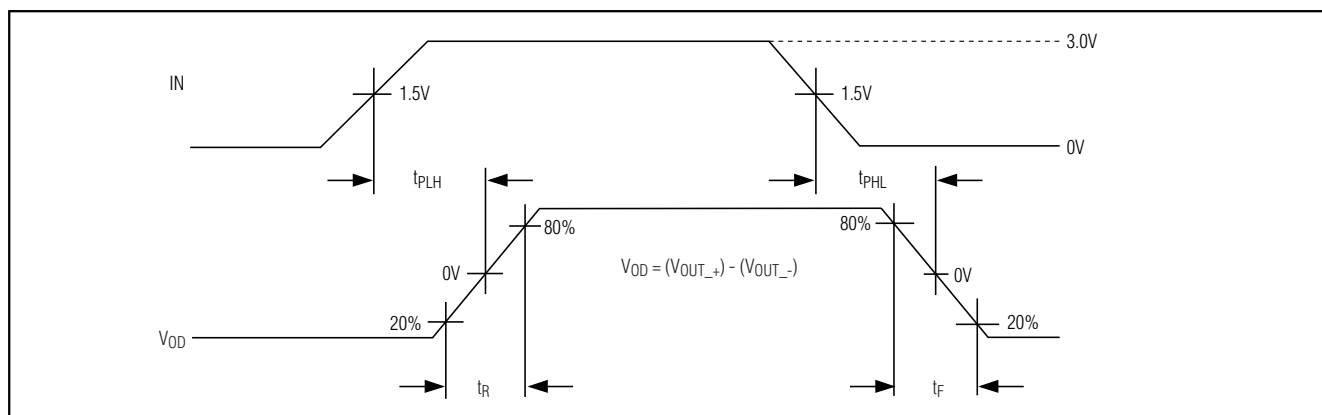


Figure 15. MAX9170 Propagation Delay and Transition Time Waveforms,  $t_{SK(p)}$

## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

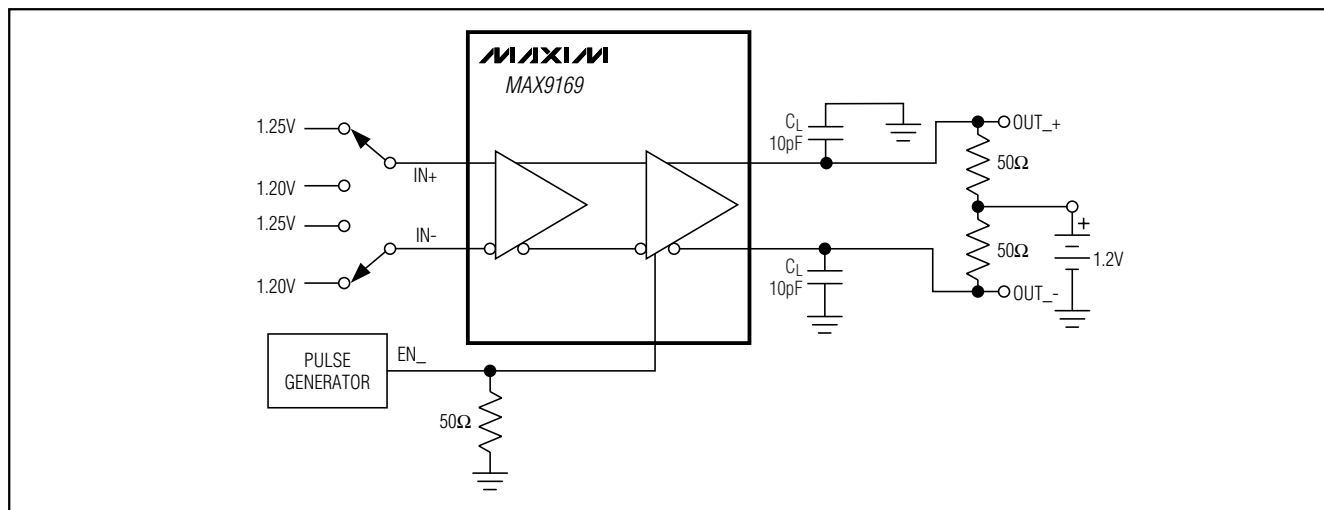


Figure 16. MAX9169 Enable and Disable Time Test Circuit

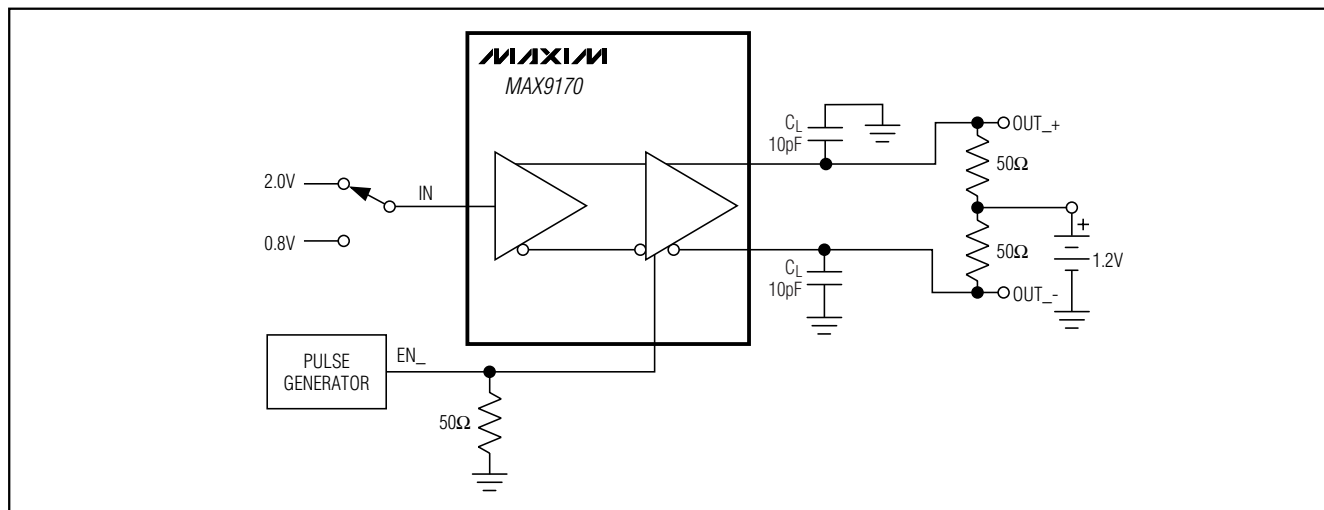


Figure 17. MAX9170 Enable and Disable Time Test Circuit

MAX9169/MAX9170



## 4-Port LVDS and LVTTTL-to-LVDS Repeaters

### Test Circuits and Timing Diagrams (continued)

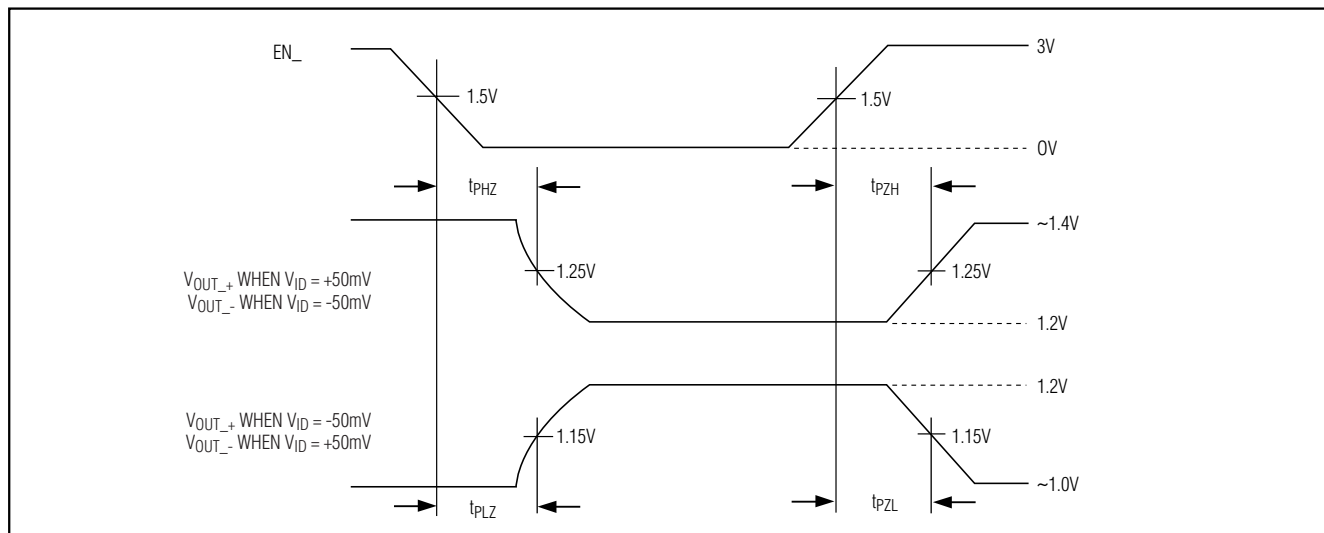


Figure 18. MAX9169 Enable and Disable Time Waveforms

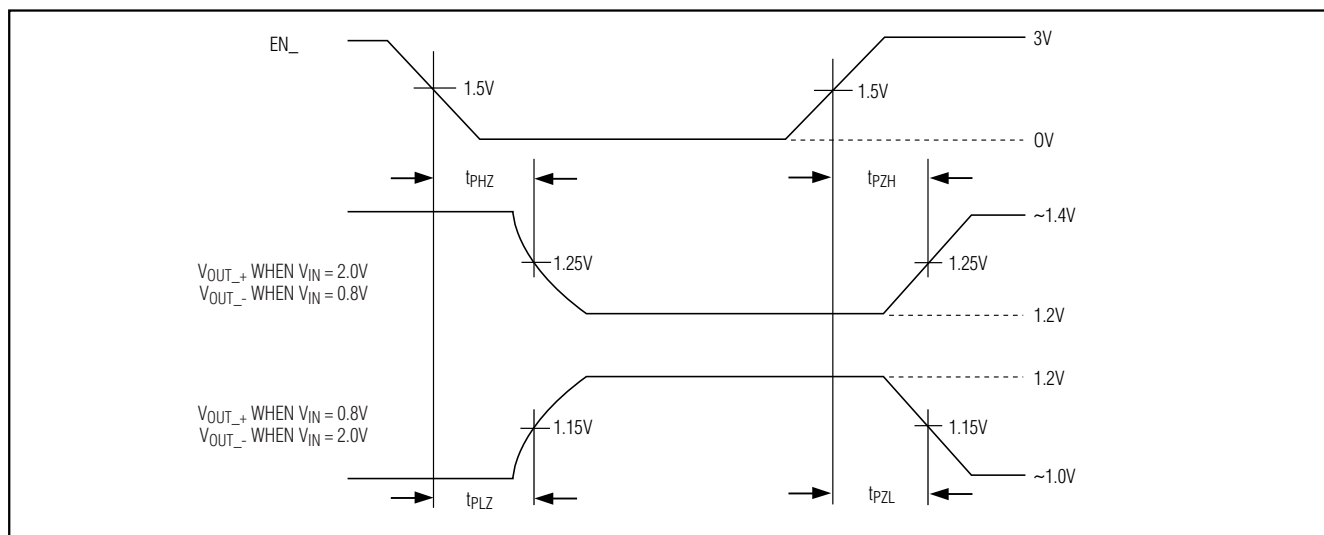
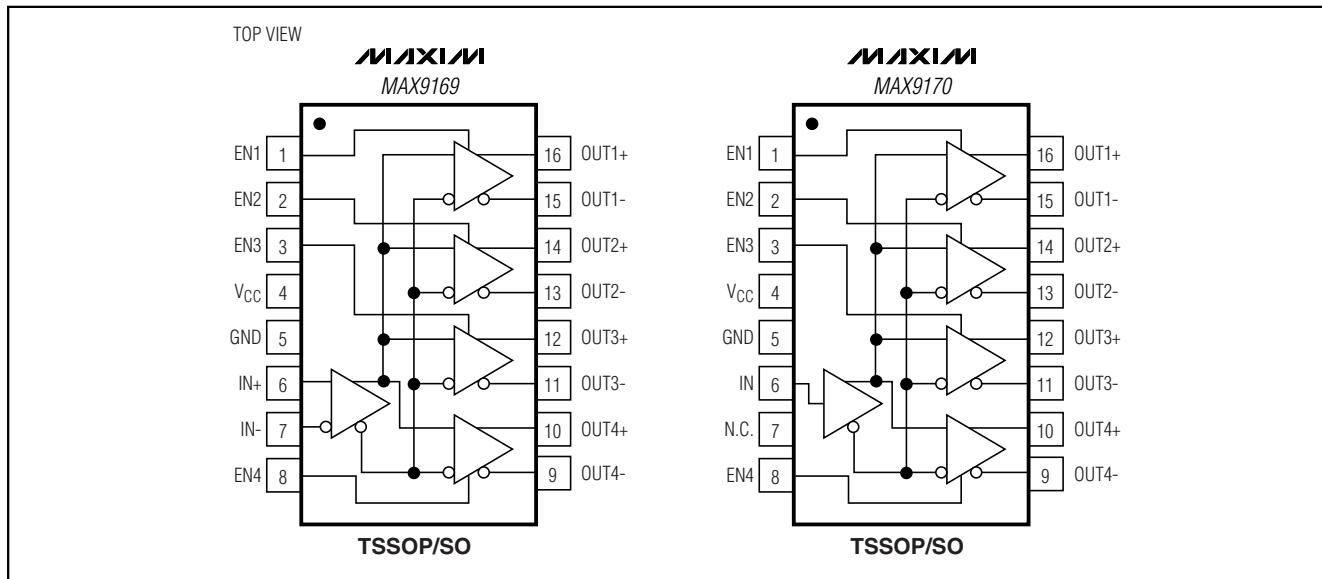


Figure 19. MAX9170 Enable and Disable Time Waveforms

# 4-Port LVDS and LVTTL-to-LVDS Repeaters

## Pin Configurations



MAX9169/MAX9170

## Chip Information

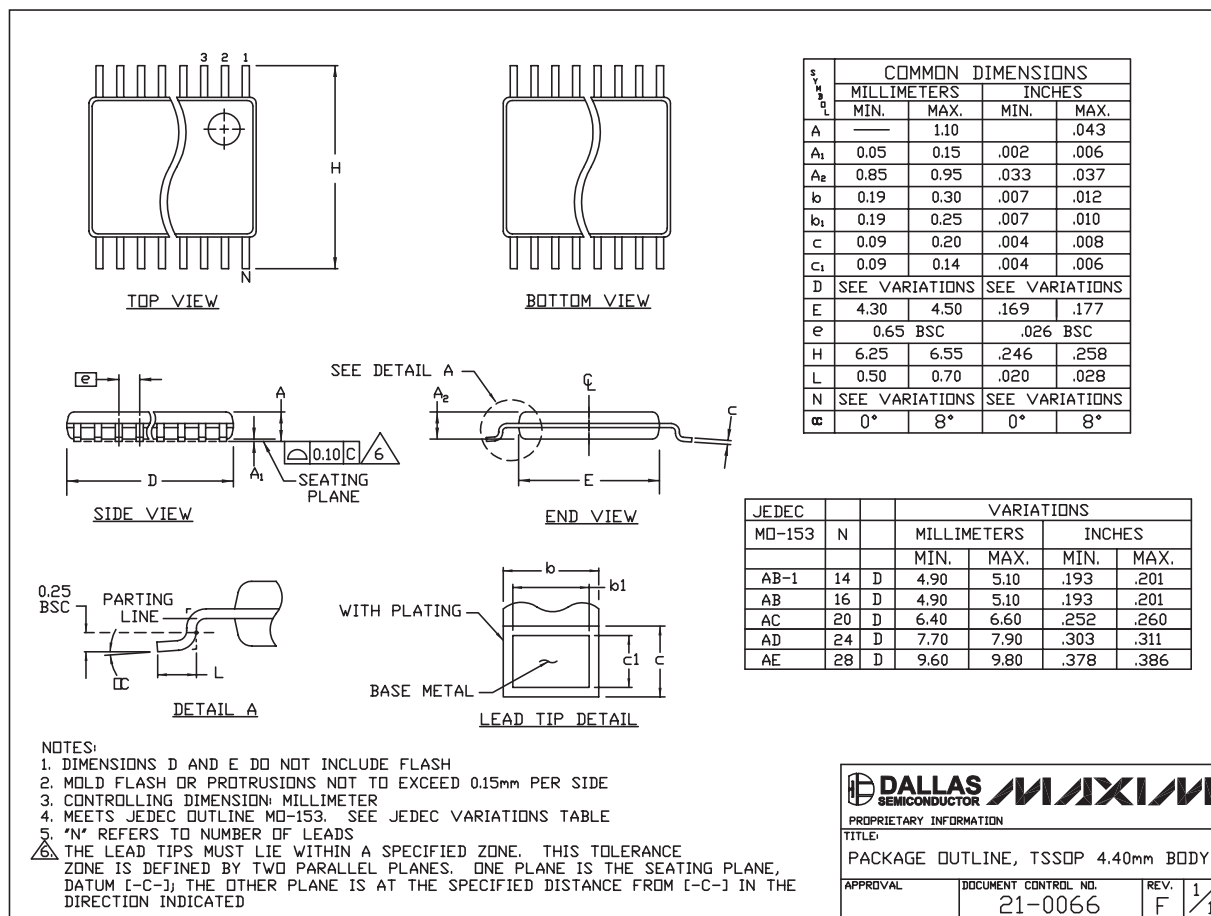
TRANSISTOR COUNT: 1187

PROCESS: CMOS

# 4-Port LVDS and LVTTTL-to-LVDS Repeaters

## 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).)

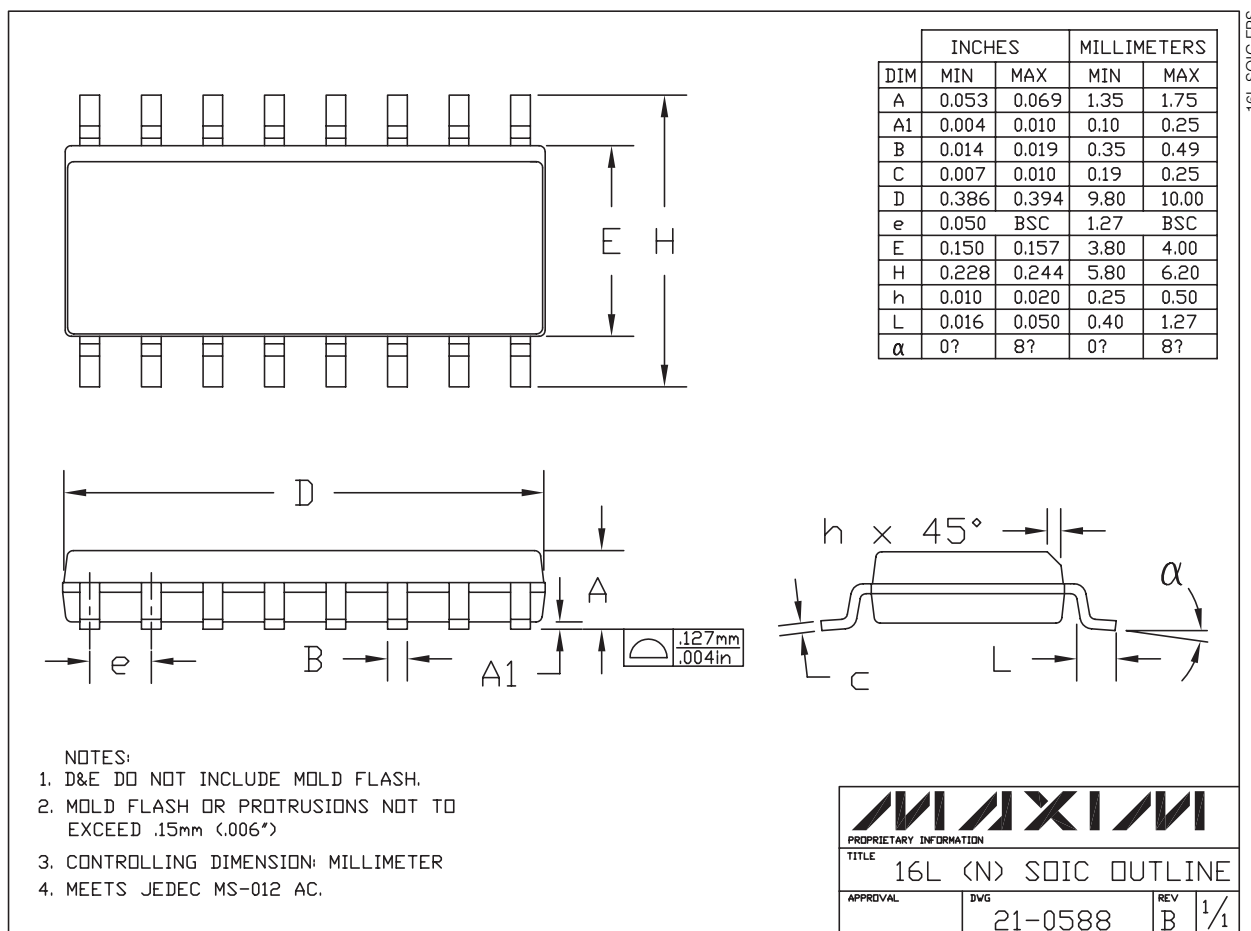


TSSOP4, 40mm, EPS

# 4-Port LVDS and LVTTTL-to-LVDS Repeaters

## Package Information (continued)

(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).)



MAX9169/MAX9170

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