

## LMS1485

### 5V Low Power RS-485 Differential Bus Transceiver

#### General Description

The LMS1485 is a low power differential bus/line transceiver designed for high speed bidirectional data communication on multipoint bus transmission lines. It is designed for balanced transmission lines. It meets ANSI Standards TIA/EIA RS422-B, TIA/EIA RS485-A and ITU recommendation and V.11 and X.27.

The LMS1485 combines a TRI-STATE™ differential line driver and differential input receiver, both of which operate from a single 5.0V power supply. The driver and receiver have an active high and active low, respectively, that can be externally connected to function as a direction control. The driver and receiver differential inputs are internally connected to form differential input/output (I/O) bus ports that are designed to offer minimum loading to bus whenever the driver is disabled or when  $V_{CC} = 0V$ . These ports feature wide positive and negative common mode voltage ranges, making the device suitable for multipoint applications in noisy environments.

The LMS1485 is built with National's advanced BiCMOS process and is available in a 8-Pin SOIC package. It is a drop-in socket replacement to ADI's ADM1485 and LTC's LT1485.

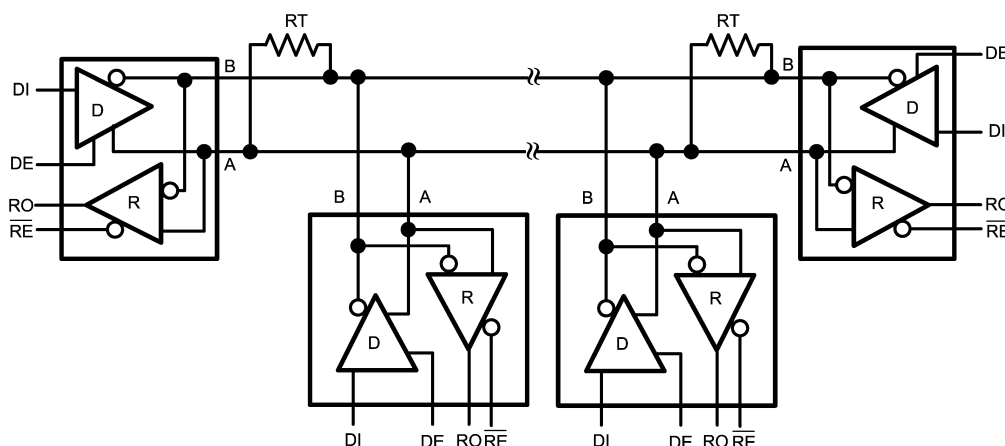
#### Features

- Meet ANSI standard RS-485-A and RS-422-B
- Data rate 30Mbps
- Single supply voltage operation, 5V
- Wide input and output voltage range
- Thermal shutdown protection
- Short circuit protection
- Driver propagation delay 10ns
- Receiver propagation delay 25ns
- High impedance outputs with power off
- Open circuit fail-safe for receiver
- Extended operating temperature range  $-40^{\circ}C$  to  $85^{\circ}C$
- ESD rating 8kV HBM
- Drop-in replacement to ADM1485 and LT1485
- Available in 8-pin SOIC
- Low supply current,  $I_{CC} = 1mA$

#### Applications

- Low power RS-485 systems
- Network hubs, bridges, and routers
- Point of sales equipment (ATM, barcode scanners,...)
- Local area networks (LAN)
- Integrated service digital network (ISDN)
- Industrial programmable logic controllers
- High speed parallel and serial applications
- Multipoint applications with noisy environment

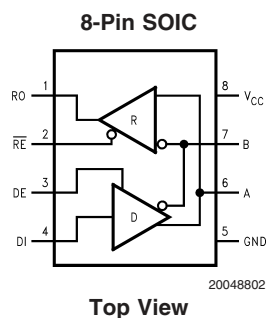
#### Typical Application



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A typical multipoint application is shown in the above figure. Terminating resistors,  $R_T$ , are typically required but only located at the two ends of the cable. Pull up and pull down resistors maybe required at the end of the bus to provide failsafe biasing. The biasing resistors provide a bias to the cable when all drivers are in TRI-STATE, See National Application Note, AN-847 for further information.

## Connection Diagram



## Ordering Information

| Package    | Part Number | Package Marking | Transport Media          | NSC Drawing |
|------------|-------------|-----------------|--------------------------|-------------|
| 8-Pin SOIC | LMS1485M    | LMS1485M        | 95 Units/Rail            | M08A        |
|            | LMS1485MX   |                 | 2.5k Units Tape and Reel |             |
|            | LMS1485IM   | LMS1485IM       | 95 Units/Rail            |             |
|            | LMS1485IMX  |                 | 2.5k Units Tape and Reel |             |

## Pin Descriptions

| Pin # | I/O | Name            | Function  |
|-------|-----|-----------------|---|
| 1     | O   | RO              | Receiver Output: If $A > B$ by 200 mV, RO will be high; If $A < B$ by 200mV, RO will be low. RO will be high also if the inputs (A and B) are open (non-terminated)                     |
| 2     | I   | $\overline{RE}$ | Receiver Output Enable: RO is enabled when $\overline{RE}$ is low; RO is in TRI-STATE when $\overline{RE}$ is high  |
| 3     | I   | DE              | Driver Output Enable: The driver outputs (A and B) are enabled when DE is high; they are in TRI-STATE when DE is low. Pins A and B also function as the receiver input pins (see below) |
| 4     | I   | DI              | Driver Input: A low on DI forces A low and B high while a high on DI forces A high and B low when the driver is enabled   |
| 5     | N/A | GND             | Ground  |
| 6     | I/O | A               | Non-inverting Driver Output and Receiver Input pin. Driver Output levels conform to RS-485 signaling levels   |
| 7     | I/O | B               | Inverting Driver Output and Receiver Input pin. Driver Output levels conform to RS-485 signaling levels   |
| 8     | N/A | $V_{CC}$        | Power Supply: $4.75V \leq V_{CC} \leq 5.25V$  |

## Truth Table

| DRIVER SECTION   |    |              |   |    |
|------------------|----|--------------|---|----|
| $\overline{RE}$  | DE | DI           | A | B  |
| X                | H  | H            | H | L  |
| X                | H  | L            | L | H  |
| X                | L  | X            | Z | Z  |
| RECEIVER SECTION |    |              |   |    |
| $\overline{RE}$  | DE | A-B          |   | RO |
| L                | L  | $\geq +0.2V$ |   | H  |
| L                | L  | $\leq -0.2V$ |   | L  |
| H                | X  | X            |   | Z  |
| L                | L  | OPEN *       |   | H  |

**Note:** \* = Non Terminated, Open Input only

X = Irrelevant

Z = TRI-STATE

H = High level

L = Low level

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|   |                          |
|---|--------------------------|
| Supply Voltage, $V_{CC}$ (Note 2)                     | 7V                       |
| Input Voltage, $V_{IN}$ (DI, DE, or $\overline{RE}$ ) | -0.3V to $V_{CC} + 0.3V$ |
| Voltage Range at Any Bus Terminal (AB)                | -7V to 12V               |
| Receiver Outputs                                      | -0.3V to $V_{CC} + 0.3V$ |
| Package Thermal Impedance, $\theta_{JA}$              |                          |
| SOIC (Note 3)   | 125°C/W                  |
| Junction Temperature (Note 3)                         | 150°C                    |
| Operating Free-Air Temperature Range, $T_A$           |                          |
| Commercial  | 0°C to 70°C              |
| Industrial  | -40°C to 85°C            |
| Storage Temperature Range                             | -65°C to 150°C           |
| ESD Rating (Note 4) (Note 8)                          | 8kV                      |

ESD Rating (Note 4) (Note 9)

2kV

Soldering Information

Infrared or Convection (20 sec.)

235°C

**Operating Ratings**

|   | Min  | Nom | Max  |   |
|---|------|-----|------|---|
| Supply Voltage, $V_{CC}$                                | 4.75 | 5.0 | 5.25 | V |
| Voltage at any Bus Terminal (Separately or Common Mode) | -7   |     | 12   | V |
| $V_{IN}$ or $V_{IC}$                                    |      |     |      |   |
| High-Level Input Voltage, $V_{IH}$ (Note 5)             | 2    |     |      | V |
| Low-Level Input Voltage, $V_{IL}$ (Note 5)              |      |     | 0.8  | V |
| Differential Input Voltage, $V_{ID}$ (Note 6)           |      |     | ±12  | V |

**Electrical Characteristics**

Over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| Symbol                  | Parameter  | Conditions  | Min  | Typ | Max  | Units |
|-------------------------|--|---|------|-----|------|-------|
| <b>Driver Section</b>   |  |   |      |     |      |       |
| $V_{OD}$                | Differential Output Voltage                        | $R = \infty$ (Figure 1)                           |      |     | 5    | V     |
| $V_{OD1}$               | Differential Output Voltage                        | $R = 50\Omega$ (Figure 1), RS-422                 | 2    |     | 5    | V     |
| $V_{OD2}$               | Differential Output Voltage                        | $R = 27\Omega$ (Figure 1), RS-485                 | 1.5  |     | 5    | V     |
| $V_{OD3}$               | Differential Output Voltage                        | $V_{TEST} = -7V$ to $+12V$ (Figure 2)             | 1.5  |     | 5    | V     |
| $\Delta V_{OD}$         | Change in Magnitude of Differential Output Voltage | $R = 27\Omega$ or $50\Omega$ (Figure 1), (Note 7) | -0.2 |     | 0.2  | V     |
| $V_{OC}$                | Common-Mode Output Voltage                         | $R = 27\Omega$ or $50\Omega$ (Figure 1), (Note 7) |      |     | 3    | V     |
| $\Delta V_{OC}$         | Change in Magnitude of Common-Mode Output Voltage  | $R = 27\Omega$ or $50\Omega$ (Figure 1), (Note 7) | -0.2 |     | 0.2  | V     |
| $I_{OSD}$               | Short-Circuit Output Current                       | $V_O = \text{High}, -7V \leq V_{CM} \leq +12V$    | -250 |     | 250  | mA    |
|                         |  | $V_O = \text{Low}, -7V \leq V_{CM} \leq +12V$     | -250 |     | 250  |       |
| $V_{INL}$               | CMOS Input Logic Threshold Low                     | DE, DI, $\overline{RE}$                           |      |     | 0.8  | V     |
| $V_{INH}$               | CMOS Input Logic Threshold High                    | DE, DI, $\overline{RE}$                           | 2    |     |      | V     |
| $I_{IN}$                | Logic Input Current                                | DE, DI  | -1   |     | 1    | μA    |
| <b>Receiver Section</b> |  |   |      |     |      |       |
| $V_{TH}$                | Differential Input Threshold Voltage               | $-7V \leq V_{CM} \leq +12V$                       | -0.2 |     | +0.2 | V     |
| $\Delta V_{TH}$         | Input Hysteresis Voltage ( $V_{TH+} - V_{TH-}$ )   | $V_{CM} = 0$                                      |      | 70  |      | mV    |
| $R_{IN}$                | Input Resistance                                   | $-7V \leq V_{CM} \leq +12V$                       | 12   |     |      | kΩ    |
| $I_{IN}$                | Input Current (A, B)                               | $V_{IN} = 12V$                                    |      |     | 1    | mA    |
|                         |  | $V_{IN} = -7V$                                    | -0.8 |     |      |       |
| $I_{RE}$                | Logic Enable Input Current                         | $\overline{RE}$                                   | -1   |     | 1    | μA    |
| $V_{OL}$                | CMOS Low-Level Output Voltage                      | $I_{OL} = 4mA$                                    |      |     | 0.4  | V     |

## Electrical Characteristics (Continued)

Over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| Symbol                                 | Parameter                         | Conditions   | Min | Typ | Max | Units |
|--|-----------------------------------|--|-----|-----|-----|-------|
| V <sub>OH</sub>                        | CMOS High-Level Output Voltage    | I <sub>OH</sub> = −4mA   | 4   |     |     | V     |
| I <sub>OSR</sub>                       | Short-Circuit Output Current      | V <sub>O</sub> = GND or V <sub>CC</sub>                                    | 7   |     | 85  | mA    |
| I <sub>OZ</sub>                        | Tristate Output Leakage Current   | 0.4V ≤V <sub>O</sub> ≤+2.4V  | −1  |     | 1   | μA    |
| Power Supply Current                   |                                   |  |     |     |     |       |
| I <sub>CC</sub>                        | Supply Current                    | Driver Enabled, Output = No Load, Digital Inputs = GND or V <sub>CC</sub>  |     | 1.1 | 2.2 | mA    |
|  |                                   | Driver Disabled, Output = No Load, Digital Inputs = GND or V <sub>CC</sub> |     | 1   | 2.2 | mA    |
| Switching Characteristics              |                                   |  |     |     |     |       |
| Driver                                 |                                   |  |     |     |     |       |
| T <sub>PLH</sub> ,<br>T <sub>PHL</sub> | Propagation Delay Input to Output | R <sub>L</sub> = 54Ω, C <sub>L</sub> = 100pF<br>(Figure 3, Figure 7)       |     | 11  | 20  | ns    |
| T <sub>SKEW</sub>                      | Driver Output Skew                | R <sub>L</sub> = 54Ω, C <sub>L</sub> = 100pF<br>(Figure 3, Figure 7)       |     | 1   |     | ns    |
| T <sub>R</sub> ,<br>T <sub>F</sub>     | Driver Rise and Fall Time         | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 100pF<br>(Figure 3, Figure 7)      |     | 5   | 10  | ns    |
| T <sub>ENABLE</sub>                    | Driver Enable to Ouput Valid Time | (Figure 4, Figure 8)   |     | 18  | 32  | ns    |
| T <sub>DISABLE</sub>                   | Output Disable Time               | (Figure 4, Figure 8)   |     | 20  | 40  | ns    |
| Receiver                               |                                   |  |     |     |     |       |
| T <sub>PLH</sub> ,<br>T <sub>PHL</sub> | Propagation Delay Input to Output | C <sub>L</sub> = 15pF<br>(Figure 5, Figure 7)                              | 18  | 33  | 55  | ns    |
| T <sub>SKEW</sub>                      | Receiver Output Skew              | (Figure 5, Figure 7)   |     | 2   |     | ns    |
| T <sub>ENABLE</sub>                    | Receiver Enable Time              | (Figure 6, Figure 10)  |     | 6   | 25  | ns    |
| T <sub>DISABLE</sub>                   | Receiver Disable Time             | (Figure 6, Figure 10)  |     | 15  | 25  | ns    |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics

**Note 2:** All voltage values, except differential I/O bus voltage, are with respect to network ground terminal.

**Note 3:** The maximum power dissipation is a function of  $T_{J(\text{MAX})}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(\text{MAX})} - T_A)/\theta_{JA}$ . All numbers apply for packages soldered directly into a PC board.

**Note 4:** ESD rating based upon human body model, 100pF discharged through 1.5k $\Omega$ .

**Note 5:** Voltage limits apply to DI, DE,  $\overline{RE}$  pins.

**Note 6:** Differential input/output bus voltage is measured at the non-inverting terminal A with respect to the inverting terminal B.

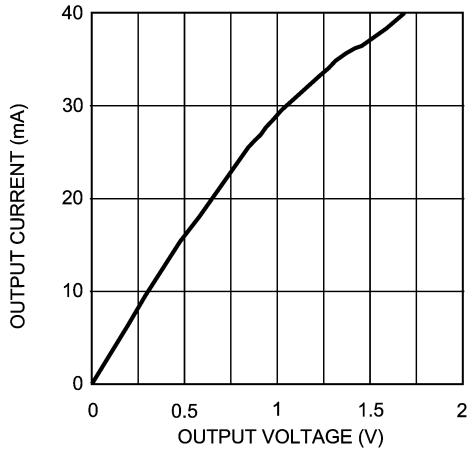
**Note 7:**  $|\Delta V_{OD}|$  and  $|\Delta V_{OC}|$  are changes in magnitude of  $V_{OD}$  and  $V_{OC}$ , respectively when the input changes from high to low levels.

**Note 8:** ESD rating applies to pins 6 and 7

**Note 9:** ESD rating applies to pins 1, 2, 3, 4, 5 and 8

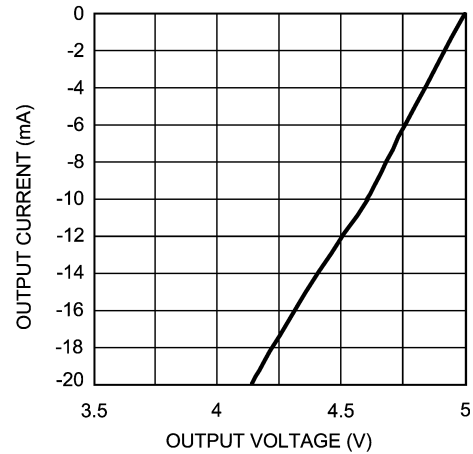
# Typical Performance Characteristics

Receiver Output Low Voltage vs. Output Current



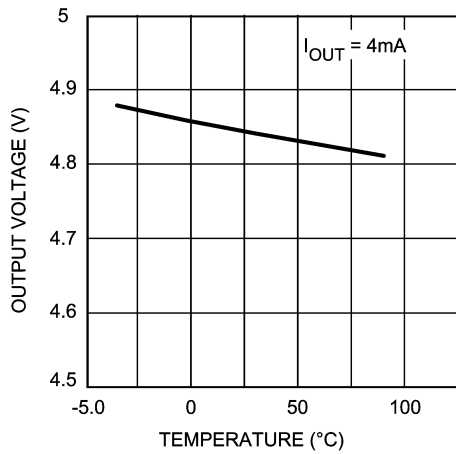
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Receiver Output High Voltage vs. Output Current



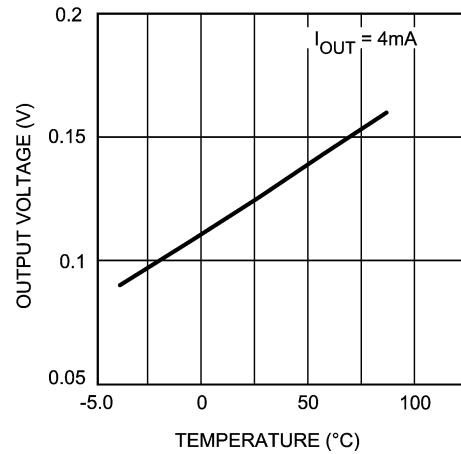
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Receiver Output High Voltage vs. Temperature



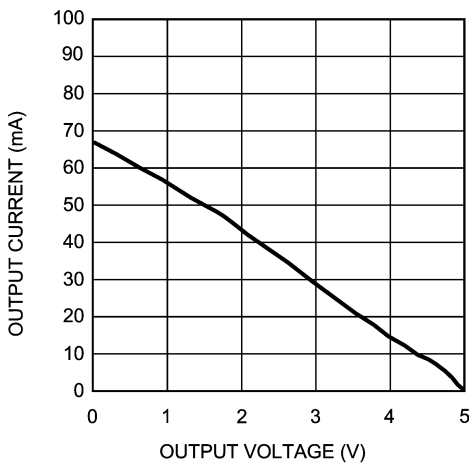
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Receiver Output Low Voltage vs. Temperature



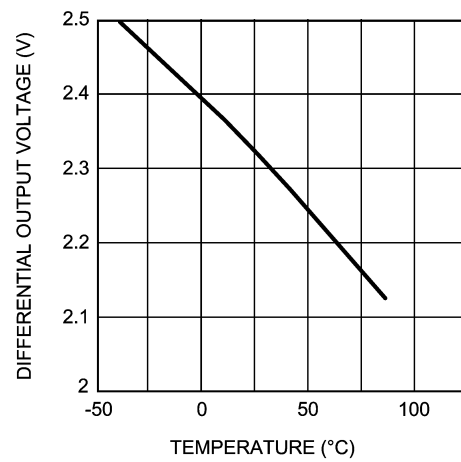
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Driver Differential Output Voltage vs. Output Current



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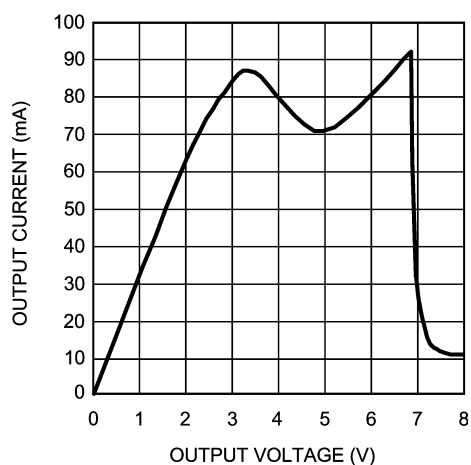
Driver Differential Output Voltage vs. Temperature  
 $R_L = 54\Omega$



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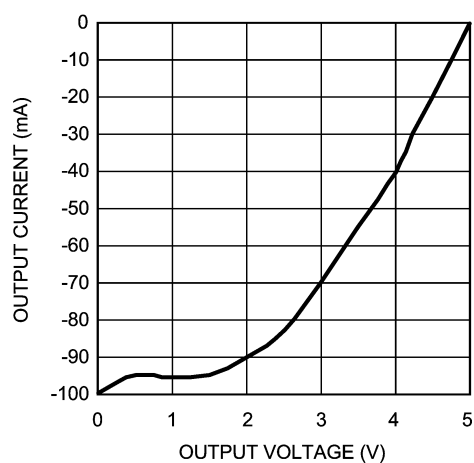
# Typical Performance Characteristics (Continued)

## Driver Output Low Voltage vs. Output Current



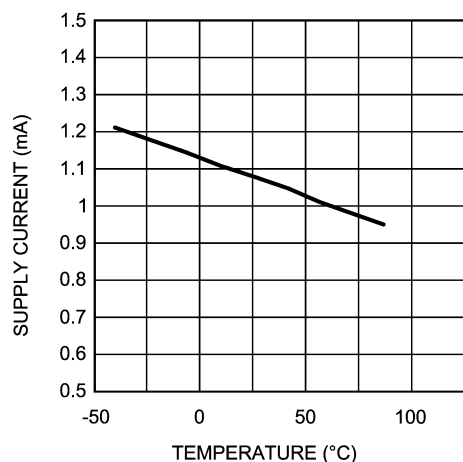
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## Driver Output High Voltage vs. Output Current



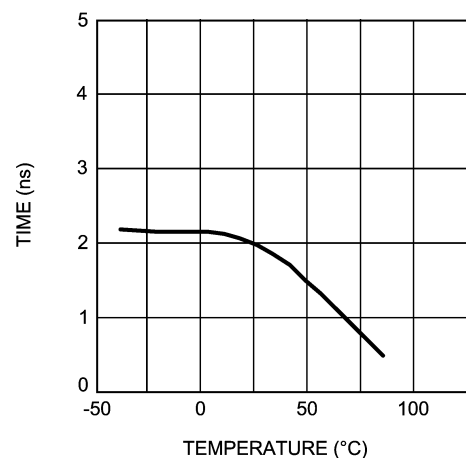
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## Supply Current vs. Temperature



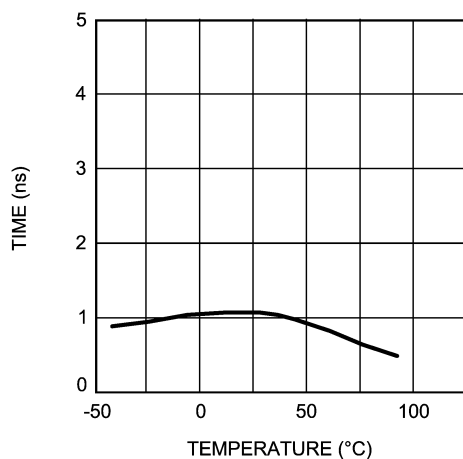
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## Receiver Skew vs. Temperature



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## Driver Skew vs. Temperature



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# Parameter Measuring Information

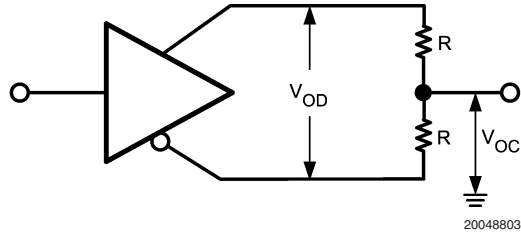


FIGURE 1. Test Circuit for  $V_{OD}$  and  $V_{OC}$

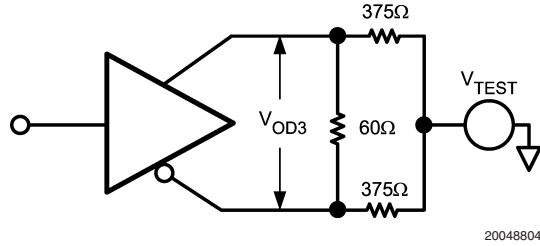


FIGURE 2. Test Circuit for  $V_{OD3}$

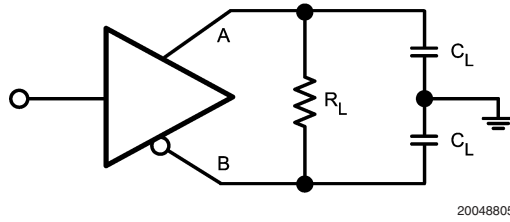


FIGURE 3. Test Circuit for Driver Propagation Delay

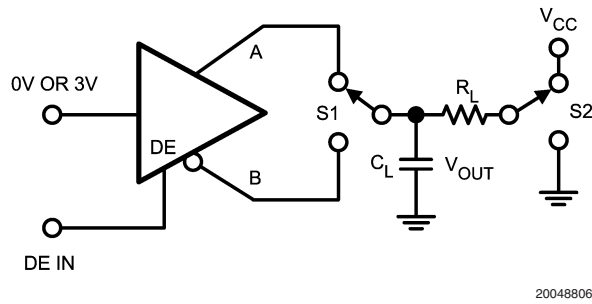


FIGURE 4. Test Circuit for Driver Enable / Disable

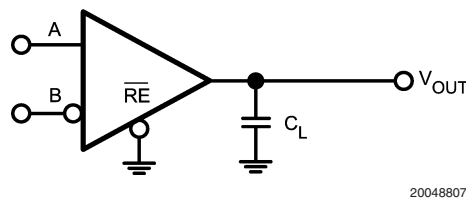
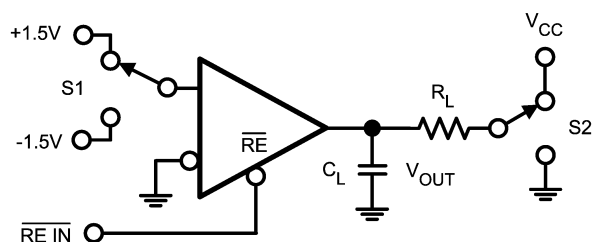


FIGURE 5. Test Circuit for Receiver Propagation Delay

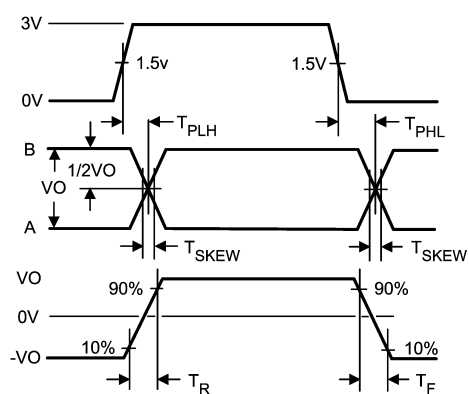
## Parameter Measuring Information (Continued)



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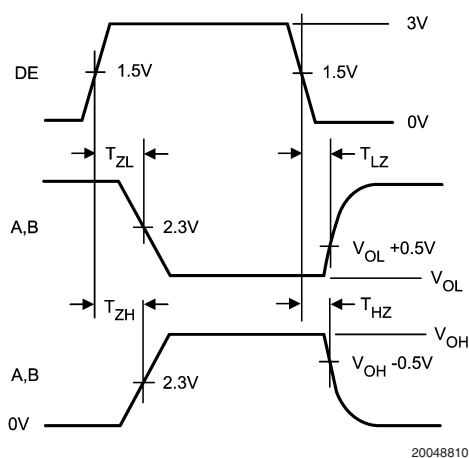
FIGURE 6. Test Circuit for Receiver Enable / Disable

## Switching Characteristics



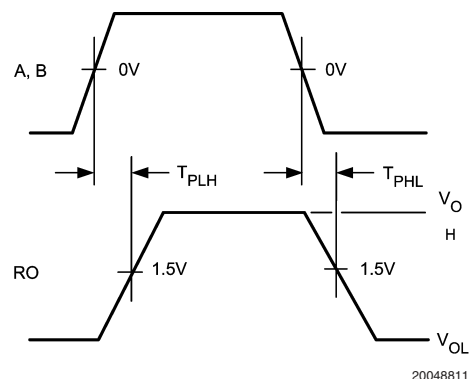
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FIGURE 7. Driver Propagation Delay, Rise / Fall Time



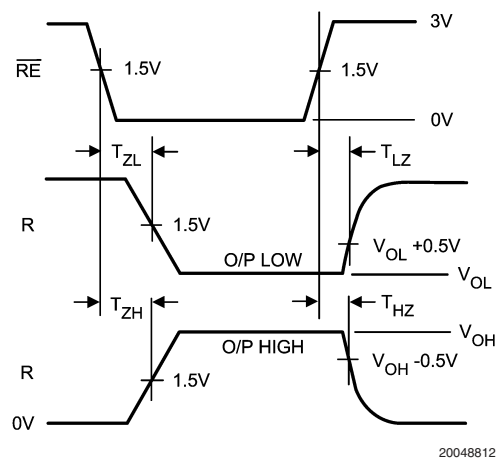
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FIGURE 8. Driver Enable / Disable Time



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FIGURE 9. Receiver Propagation Delay



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FIGURE 10. Receiver Enable / Disable Time



## Application Information

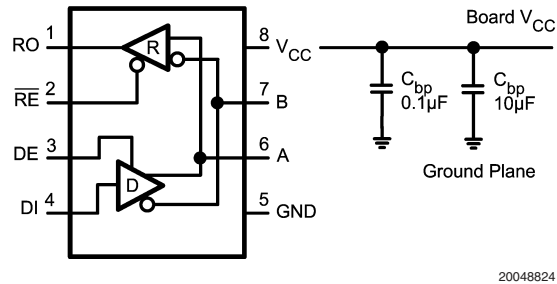
### POWER LINE NOISE FILTERING

A factor to consider in designing power and ground is noise filtering. A noise filtering circuit is designed to prevent noise generated by the integrated circuit (IC) as well as noise entering the IC from other devices. A common filtering method is to place by-pass capacitors ( $C_{bp}$ ) between the power and ground lines.

Placing a by-pass capacitor ( $C_{bp}$ ) with the correct value at the proper location solves many power supply noise problems. Choosing the correct capacitor value is based upon the desired noise filtering range. Since capacitors are not

ideal, they may act more like inductors or resistors over a specific frequency range. Thus, many times two by-pass capacitors may be used to filter a wider bandwidth of noise. It is highly recommended to place a larger capacitor, such as  $10\mu\text{F}$ , between the power supply pin and ground to filter out low frequencies and a  $0.1\mu\text{F}$  to filter out high frequencies.

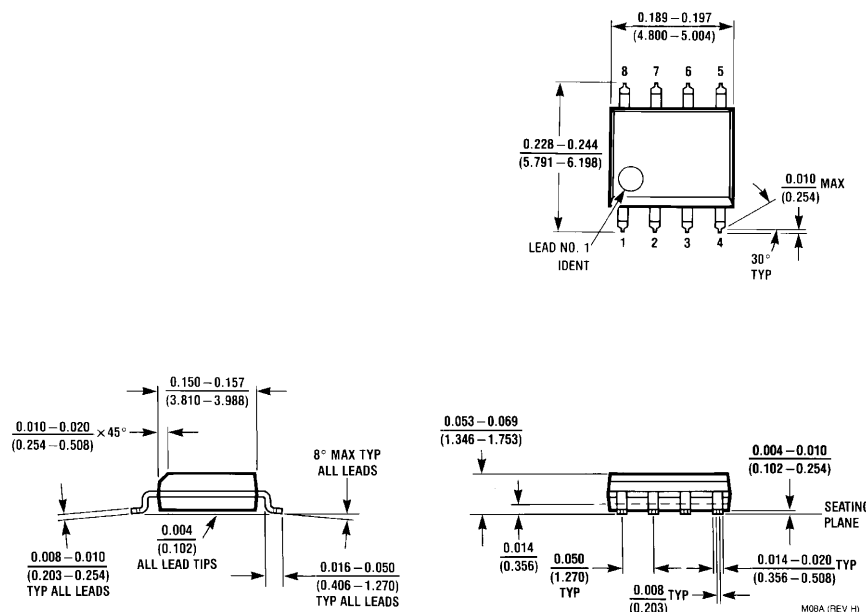
By pass-capacitors must be mounted as close as possible to the IC to be effective. Long leads produce higher impedance at higher frequencies due to stray inductance. Thus, this will reduce the by-pass capacitor's effectiveness. Surface mounted chip capacitors are the best solution because they have lower inductance.



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FIGURE 11. Placement of by-pass Capacitors,  $C_{bp}$

## Physical Dimensions inches (millimeters) unless otherwise noted



**8-Pin SOIC**  
**NS Package Number M08A**

### LIFE SUPPORT POLICY

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