

# HIGH-SPEED DIFFERENTIAL LINE DRIVER

Check for Samples: [SN65LVDS31-EP](#)

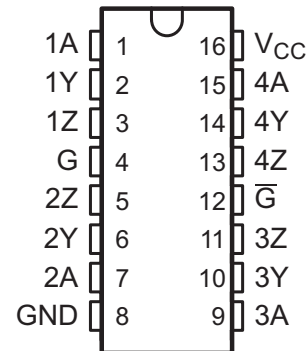
## FEATURES

- Meet or Exceed the Requirements of ANSI TIA/EIA-644 Standard
- Low-Voltage Differential Signaling With Typical Output Voltage of 350 mV and 100-Ω Load
- Typical Output Voltage Rise and Fall Times of 500 ps (400 Mbps)
- Typical Propagation Delay Times of 1.7 ns
- Operate From a Single 3.3-V Supply
- Power Dissipation 25 mW Typical Per Driver at 200 MHz
- Driver at High Impedance When Disabled or With  $V_{CC} = 0$
- Bus-Terminal ESD Protection Exceeds 8 kV
- Low-Voltage TTL (LVTTTL) Logic Input Levels
- Pin Compatible With AM26LS31, MC3487, and  $\mu$ A9638
- Cold Sparring for Space and High Reliability Applications Requiring Redundancy

## SUPPORTS DEFENSE, AEROSPACE, AND MEDICAL APPLICATIONS

- Controlled Baseline
- One Assembly/Test Site
- One Fabrication Site
- Available in Military (–55°C/125°C) Temperature Range
- Extended Product Life Cycle
- Extended Product-Change Notification
- Product Traceability

**D PACKAGE  
(TOP VIEW)**



## DESCRIPTION

The SN65LVDS31 is a differential line driver that implements the electrical characteristics of low-voltage differential signaling (LVDS). This signaling technique lowers the output voltage levels of 5-V differential standard levels (such as TIA/EIA-422B) to reduce the power, increase the switching speeds, and allow operation with a 3.3-V supply rail. This driver will deliver a minimum differential output voltage magnitude of 247 mV into a 100-Ω load when enabled.

The intended application of this device and signaling technique is both point-to-point and multidrop (one driver and multiple receivers) data transmission over controlled impedance media of approximately 100 Ω. The transmission media may be printed-circuit board traces, backplanes, or cables. The ultimate rate and distance of data transfer is dependent upon the attenuation characteristics of the media and the noise coupling to the environment.

The SN65LVDS31 is characterized for operation from –55°C to 125°C.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



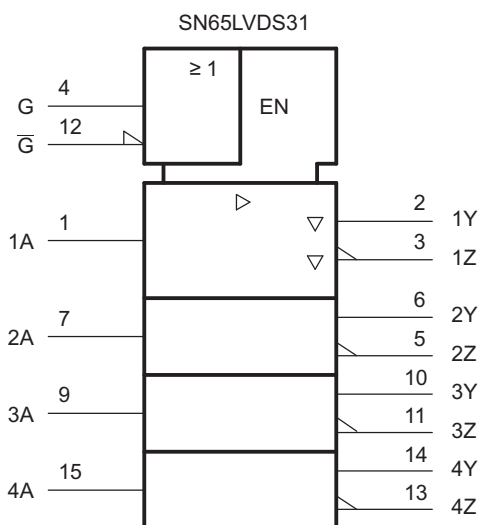
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### ORDERING INFORMATION<sup>(1)</sup>

| T <sub>A</sub> | PACKAGE <sup>(2)</sup> | ORDERABLE PART NUMBER | TOP-SIDE MARKING | VID NUMBER     |
|----------------|------------------------|-----------------------|------------------|----------------|
| –55°C to 125°C | SOIC-D                 | SN65LVDS31MDREP       | LVDS31EP         | V62/07627-01XE |

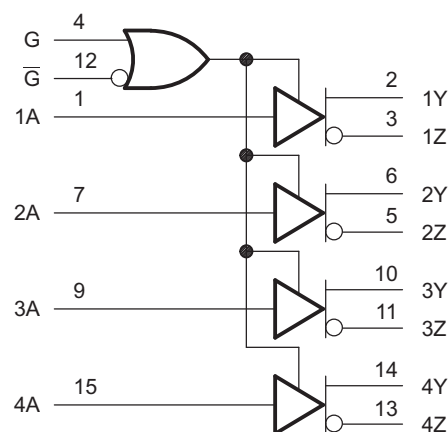
- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).  
 (2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

### Logic Symbol



This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

### SN65LVDS31 Logic Diagram (Positive Logic)



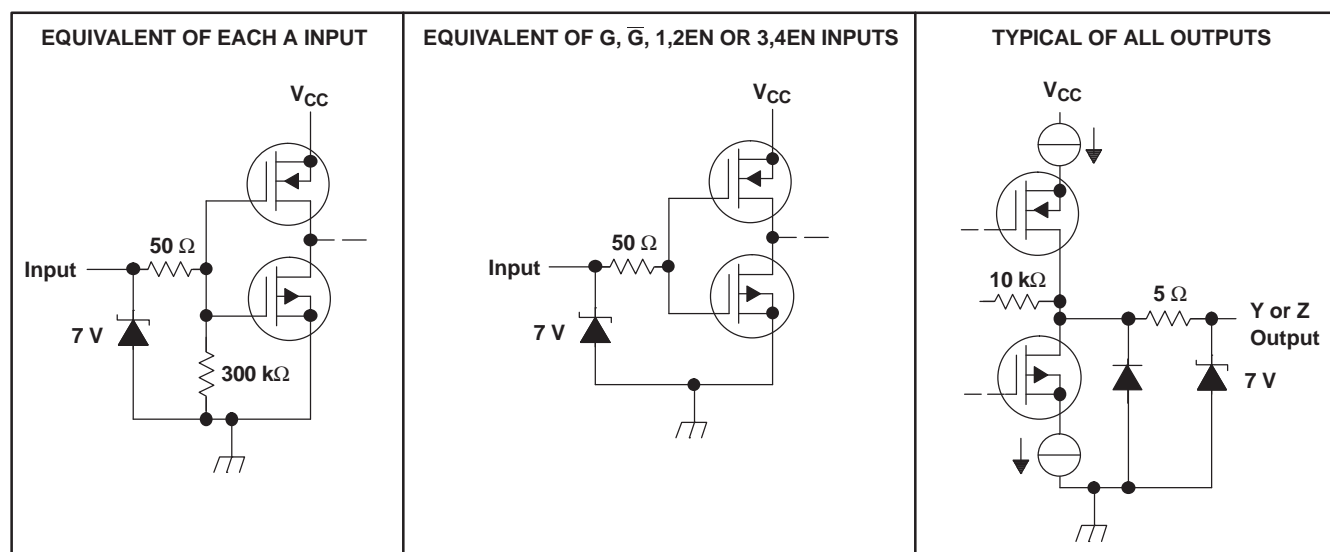
## FUNCTION TABLE

**Table 1. SN65LVDS31<sup>(1)</sup>**

| INPUT<br>A | ENABLES |   | OUTPUTS |   |
|------------|---------|---|---------|---|
|            | G       | G | Y       | Z |
| H          | H       | X | H       | L |
| L          | H       | X | L       | H |
| H          | X       | L | H       | L |
| L          | X       | L | L       | H |
| X          | L       | H | Z       | Z |
| Open       | H       | X | L       | H |
| Open       | X       | L | L       | H |

(1) H = high level, L = low level, X = irrelevant, Z = high impedance (off)

## EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

over operating free-air temperature range (unless otherwise noted)

|  | UNIT                         |
|--|------------------------------|
| $V_{CC}$ Supply voltage range <sup>(2)</sup>                 | –0.5 V to 4 V                |
| $V_I$ Input voltage range                                    | –0.5 V to $V_{CC} + 0.5$ V   |
| Continuous total power dissipation                           | See Dissipation Rating Table |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | 260°C                        |
| $\theta_{JA}$ Thermal resistance, junction-to-ambient        | 73°C/W                       |
| $\theta_{JC}$ Thermal resistance, junction-to-case           | 36.9°C/W                     |
| $T_{stg}$ Storage temperature range                          | –65°C to 150°C               |

- (1) 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 under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages, except differential I/O bus voltages, are with respect to the network ground terminal.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR <sup>(1)</sup><br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|---------|---|--|--|--|---|
| D (16)  | 950 mW                                      | 7.6 mW/°C  | 608 mW                                   | 494 mW                                   | 190 mW                                    |

- (1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

**RECOMMENDED OPERATING CONDITIONS**

|                                      | MIN | NOM | MAX | UNIT |
|--------------------------------------|-----|-----|-----|------|
| $V_{CC}$ Supply voltage              | 3   | 3.3 | 3.6 | V    |
| $V_{IH}$ High-level input voltage    | 2   |     |     | V    |
| $V_{IL}$ Low-level input voltage     |     |     | 0.8 | V    |
| $T_A$ Operating free-air temperature | –55 |     | 125 | °C   |

**ELECTRICAL CHARACTERISTICS**

over operating free-air temperature range (unless otherwise noted)

| PARAMETER  | TEST CONDITIONS                                   | MIN   | TYP <sup>(1)</sup> | MAX      | UNIT          |
|--|---|-------|--------------------|----------|---------------|
| $V_{OD}$ Differential output voltage magnitude   | $R_L = 100\ \Omega$ , See Figure 2                | 247   | 340                | 454      | mV            |
| $\Delta V_{OD}$ Change in differential output voltage magnitude between logic states       | $R_L = 100\ \Omega$ , See Figure 2                | –50   |                    | 50       | mV            |
| $V_{OC(SS)}$ Steady-state common-mode output voltage                                       | See Figure 3                                      | 1.125 | 1.2                | 1.375    | V             |
| $\Delta V_{OC(SS)}$ Change in steady-state common-mode output voltage between logic states | See Figure 3                                      | –50   |                    | 50       | mV            |
| $V_{OC(PP)}$ Peak-to-peak common-mode output voltage                                       | See Figure 3                                      |       | 50                 |          | mV            |
| $I_{CC}$ Supply current  | $V_I = 0.8$ V or 2 V, Enabled, No load            |       | 9                  | 20       | mA            |
|  | $V_I = 0.8$ or 2 V, $R_L = 100\ \Omega$ , Enabled |       | 25                 | 35       |               |
|  | $V_I = 0$ or $V_{CC}$ , Disabled                  |       | 0.25               | 1        |               |
| $I_{IH}$ High-level input current  | $V_{IH} = 2$                                      |       | 4                  | 20       | $\mu\text{A}$ |
| $I_{IL}$ Low-level input current   | $V_{IL} = 0.8$ V                                  |       | 0.1                | 10       | $\mu\text{A}$ |
| $I_{OS}$ Short-circuit output current  | $V_{O(Y)}$ or $V_{O(Z)} = 0$                      |       | –4                 | –24      | mA            |
|  | $V_{OD} = 0$                                      |       |                    | $\pm 12$ |               |
| $I_{OZ}$ High-impedance output current   | $V_O = 0$ or 2.4 V                                |       |                    | $\pm 1$  | $\mu\text{A}$ |
| $I_{O(OFF)}$ Power-off output current  | $V_{CC} = 0$ , $V_O = 2.4$ V                      |       |                    | $\pm 4$  | $\mu\text{A}$ |
| $C_i$ Input capacitance  |   |       | 3                  |          | pF            |

- (1) All typical values are at  $T_A = 25^\circ\text{C}$  and with  $V_{CC} = 3.3$  V.

## SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER   | TEST CONDITIONS   | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|---|---|-----|--------------------|-----|------|
| $t_{PLH}$ Propagation delay time, low-to-high-level output            | $R_L = 100\ \Omega$ , $C_L = 10\ \text{pF}$ ,<br>See Figure 2 | 0.5 | 1.4                | 4   | ns   |
| $t_{PHL}$ Propagation delay time, high-to-low-level output            |   | 1   | 1.7                | 4.5 | ns   |
| $t_r$ Differential output signal rise time (20% to 80%)               |   |     | 0.5                |     | ns   |
| $t_f$ Differential output signal fall time (80% to 20%)               |   |     | 0.5                |     | ns   |
| $t_{sk(p)}$ Pulse skew ( $ t_{PHL} - t_{PLH} $ )                      |   |     | 0.3                | 0.6 | ns   |
| $t_{sk(o)}$ Channel-to-channel output skew <sup>(2)</sup>             |   |     | 0.3                | 0.8 | ns   |
| $t_{PZH}$ Propagation delay time, high-impedance-to-high-level output | See Figure 4  |     | 5.4                | 17  | ns   |
| $t_{PZL}$ Propagation delay time, high-impedance-to-low-level output  |   |     | 2.5                | 17  | ns   |
| $t_{PHZ}$ Propagation delay time, high-level-to-high-impedance output |   |     | 8.1                | 18  | ns   |
| $t_{PLZ}$ Propagation delay time, low-level-to-high-impedance output  |   |     | 7.3                | 17  | ns   |

(1) All typical values are at  $T_A = 25^\circ\text{C}$  and with  $V_{CC} = 3.3\ \text{V}$ .

(2)  $t_{sk(o)}$  is the maximum delay time difference between drivers on the same device.

## PARAMETER MEASUREMENT INFORMATION

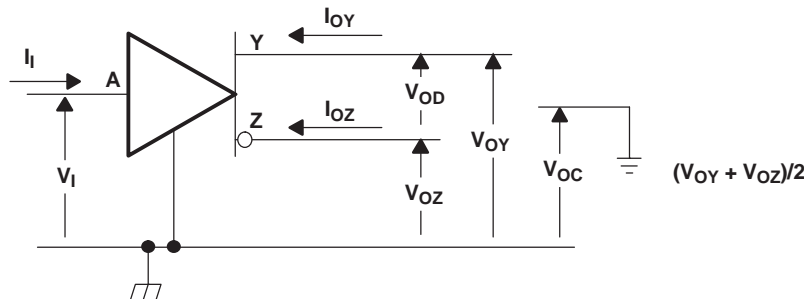
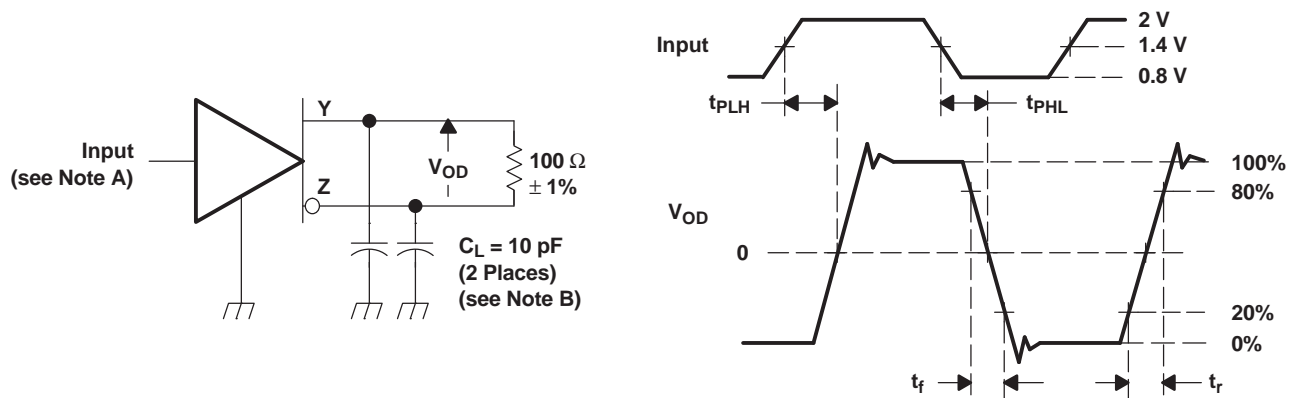


Figure 1. Voltage and Current Definitions

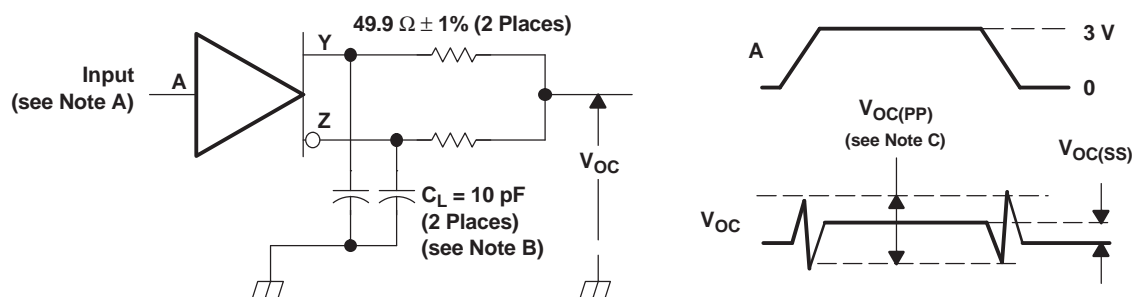


NOTES: A. All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1\ \text{ns}$ , pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2\ \text{ns}$ .

B.  $C_L$  includes instrumentation and fixture capacitance within 6 mm of the D.U.T.

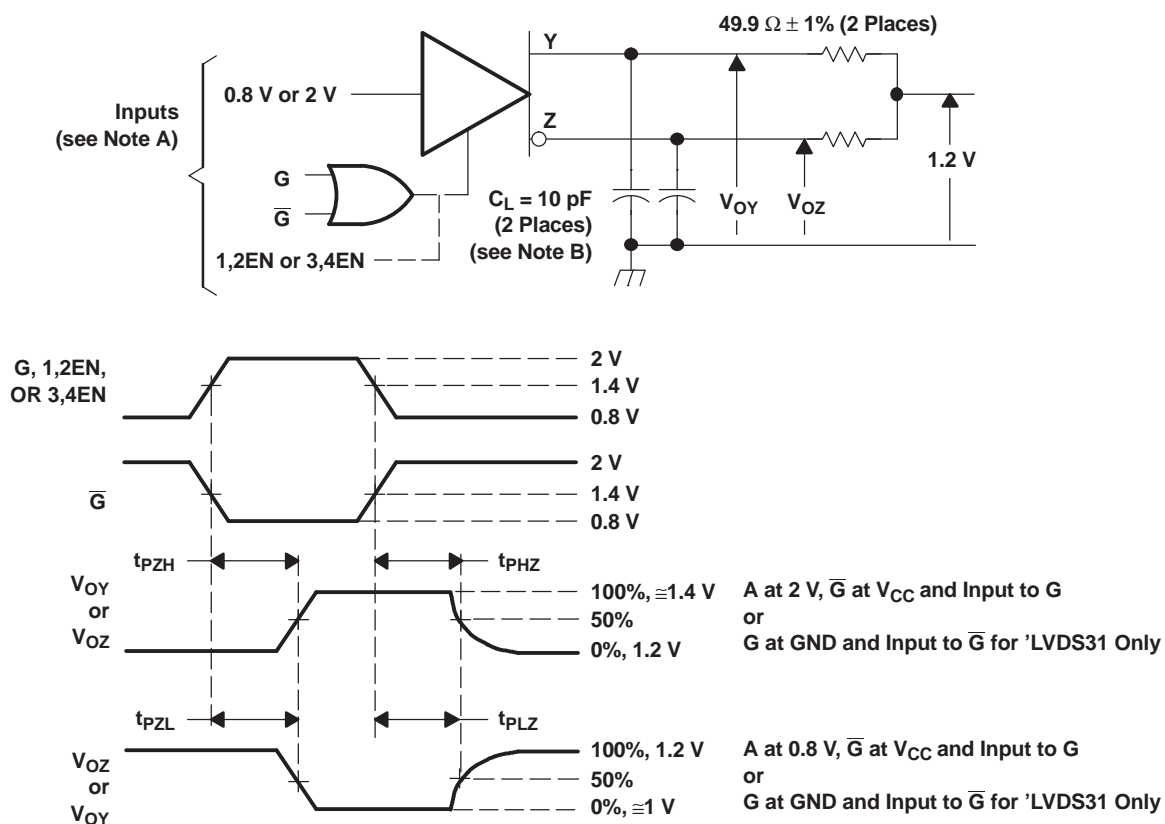
Figure 2. Test Circuit, Timing, and Voltage Definitions for the Differential Output Signal

### PARAMETER MEASUREMENT INFORMATION (continued)



- NOTES: A. All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2$  ns.  
 B.  $C_L$  includes instrumentation and fixture capacitance within 6 mm of the D.U.T.  
 C. The measurement of  $V_{OC(PP)}$  is made on test equipment with a  $-3$ -dB bandwidth of at least 300 MHz.

**Figure 3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage**



- NOTES: A. All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f < 1$  ns, pulse repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns.  
 B.  $C_L$  includes instrumentation and fixture capacitance within 6 mm of the D.U.T.

**Figure 4. Enable-/Disable-Time Circuit and Definitions**

## TYPICAL CHARACTERISTICS

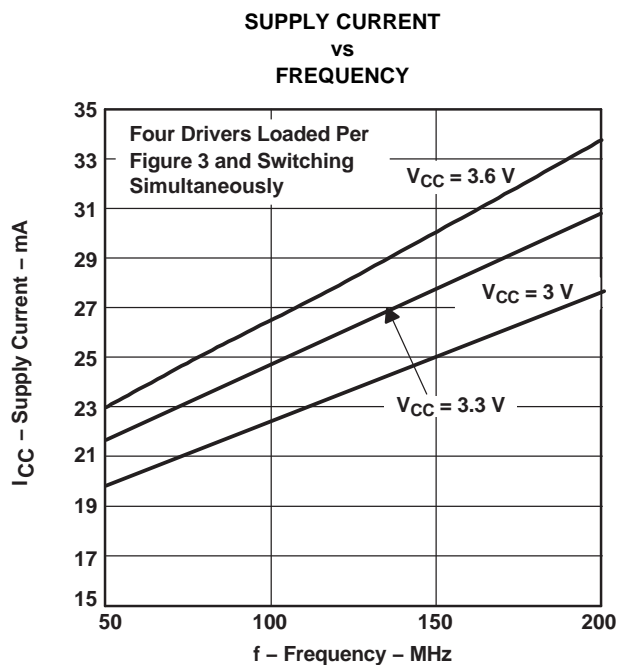


Figure 5.

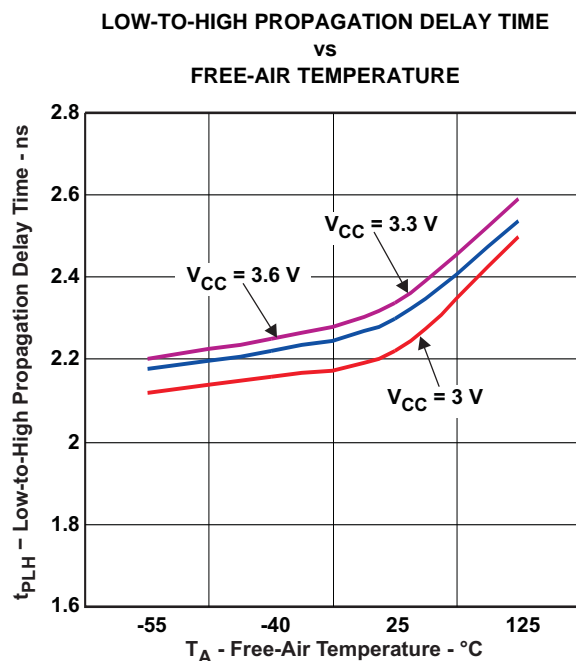


Figure 6.

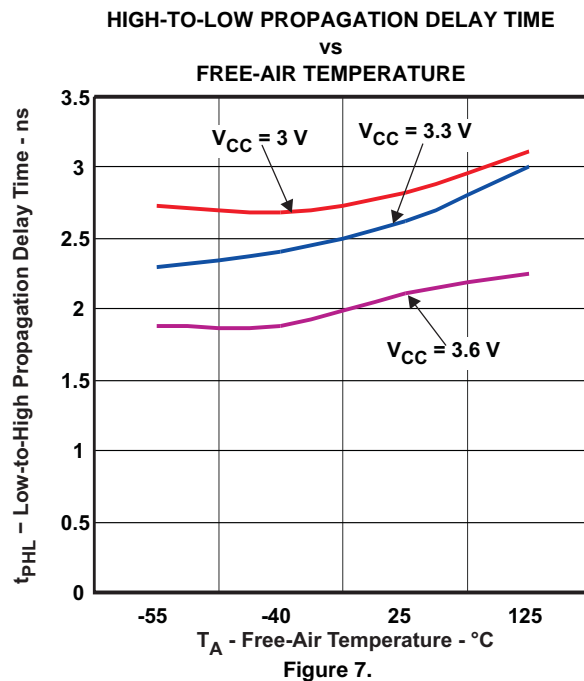
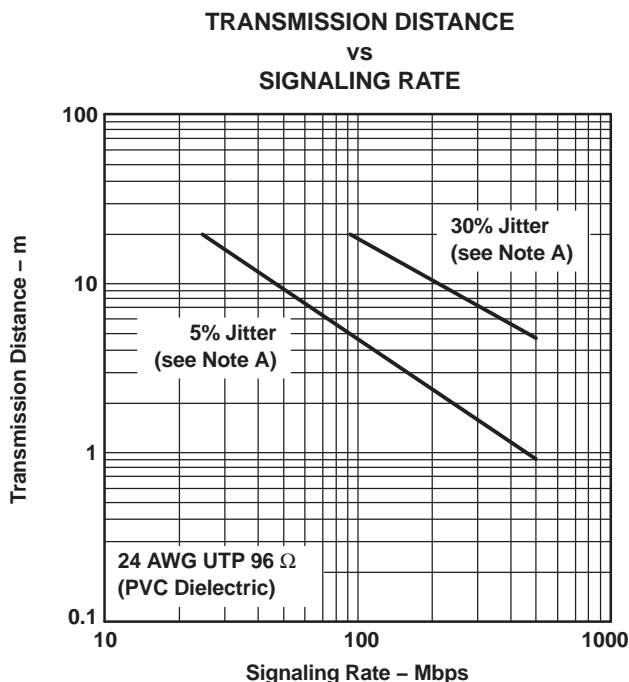


Figure 7.

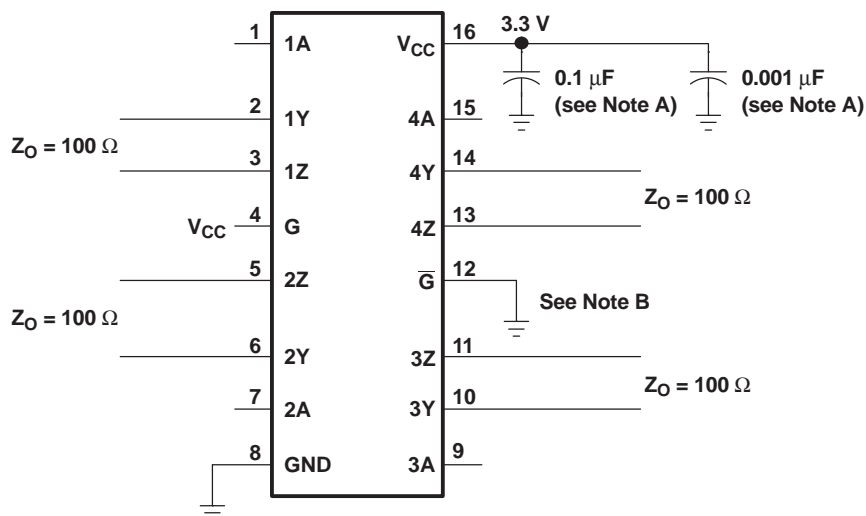
## APPLICATION INFORMATION

The SN65LVDS31 is generally used as a building block for high-speed point-to-point data transmission where ground differences are less than 1 V. The SN65LVDS31 can interoperate with RS-422, PECL, and IEEE-P1596. Drivers/receivers approach ECL speeds without the power and dual supply requirements.



- A. This parameter is the percentage of distortion of the unit interval (UI) with a pseudorandom data pattern.

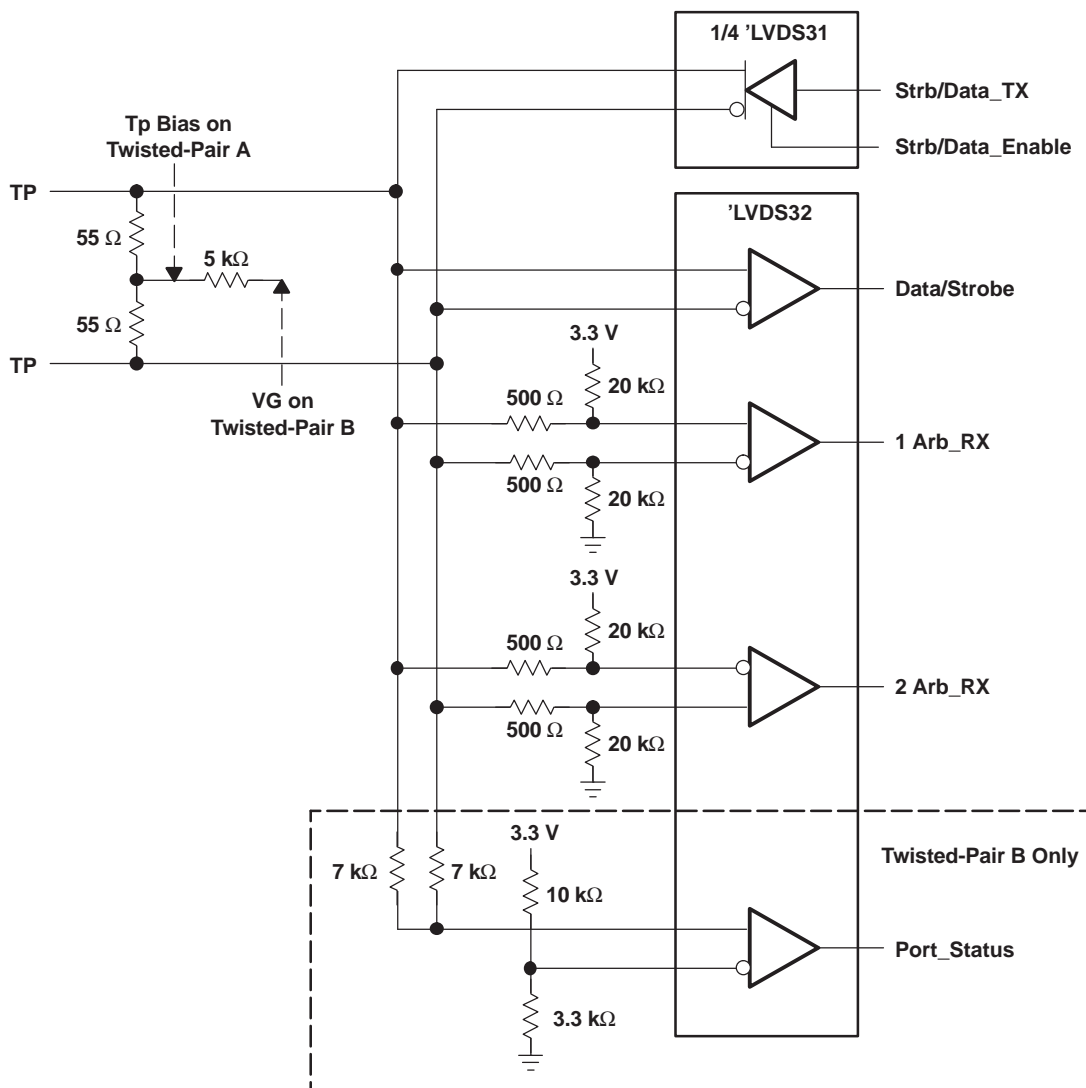
**Figure 8. Typical Transmission Distance Versus Signaling Rate**



- NOTES: A. Place a 0.1- $\mu$ F and a 0.001- $\mu$ F Z5U ceramic, mica, or polystyrene dielectric, 0805 size, chip capacitor between V<sub>CC</sub> and the ground plane. The capacitors should be located as close as possible to the device terminals.
- B. Unused enable inputs should be tied to V<sub>CC</sub> or GND, as appropriate.

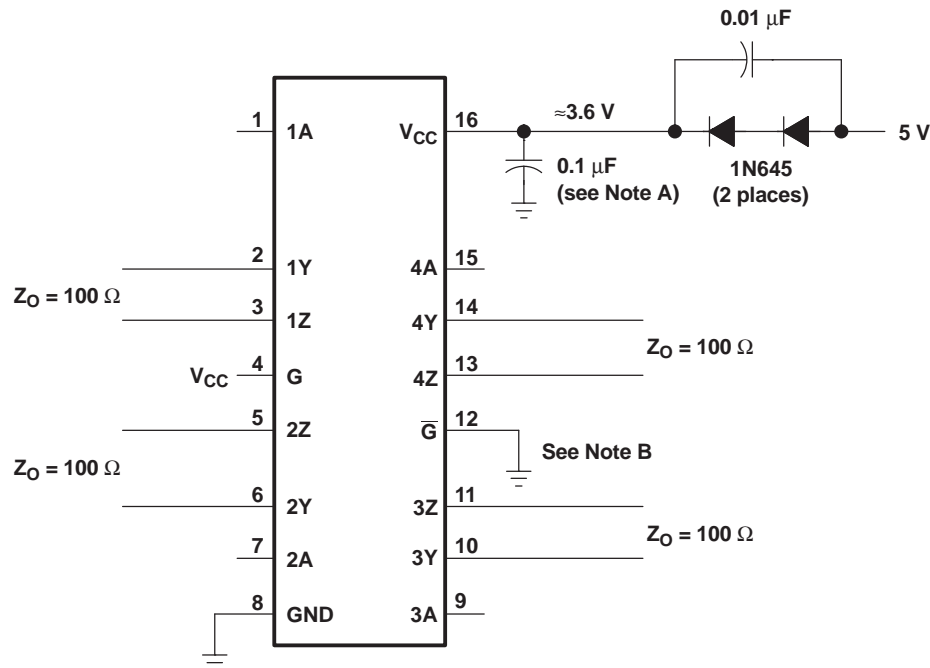
**Figure 9. Typical Application Circuit Schematic**





- NOTES: A. Resistors are leadless, thick film (0603), 5% tolerance.  
 B. Decoupling capacitance is not shown, but recommended.  
 C.  $V_{CC}$  is 3 V to 3.6 V.  
 D. The differential output voltage of the 'LVDS31 can exceed that specified by IEEE1394.

**Figure 10. 100-Mbps IEEE 1394 Transceiver**



- A. Place a 0.1-μF Z5U ceramic, mica, or polystyrene dielectric, 0805 size, chip capacitor between  $V_{CC}$  and the ground plane. The capacitor should be located as close as possible to the device terminals.
- B. Unused enable inputs should be tied to  $V_{CC}$  or GND, as appropriate.

**Figure 11. Operation With 5-V Supply**

## COLD SPARING

Systems using cold sparing have a redundant device electrically connected without power supplied. To support this configuration, the spare must present a high-input impedance to the system so that it does not draw appreciable power. In cold sparing, voltage may be applied to an I/O before and during power up of a device. When the device is powered off,  $V_{CC}$  must be clamped to ground and the I/O voltages applied must be within the specified recommended operating conditions.

## RELATED INFORMATION

IBIS modeling is available for this device. Contact the local TI sales office or the TI Web site at [www.ti.com](http://www.ti.com) for more information.

For more application guidelines, see the following documents:

- *Low-Voltage Differential Signaling Design Notes* ([SLLA014](#))
- *Interface Circuits for TIA/EIA-644 (LVDS)* ([SLLA038](#))
- *Reducing EMI With LVDS* ([SLLA030](#))
- *Slew Rate Control of LVDS Circuits* ([SLLA034](#))
- *Using an LVDS Receiver With RS-422 Data* ([SLLA031](#))
- *Evaluating the LVDS EVM* ([SLLA033](#))

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| SN65LVDS31MDREP  | ACTIVE        | SOIC         | D                  | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -55 to 125   | LVDS31EP                 | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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### OTHER QUALIFIED VERSIONS OF SN65LVDS31-EP :

- Catalog: [SN65LVDS31](#)

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NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AC.

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### Products

|                              |  |
|------------------------------|--|
| Audio                        | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers                   | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters              | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity        | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Automotive and Transportation | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
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