



WIDE SUPPLY RANGE RS-485 TRANSCEIVER

FEATURES

- Operates With a 3-V to 5.5-V Supply
- Consumes Less Than 90 mW Quiescent Power
- Open-Circuit, Short Circuit, and Idle-Bus Failsafe Receiver
- 1/8th Unit-Load (up to 256 nodes on the bus)
- Bus-Pin ESD Protection Exceeds 16 kV HBM
- Driver Output Voltage Slew-Rate Limited for Optimum Signal Quality at 10 Mbps
- Electrically Compatible With ANSI TIA/EIA-485 Standard

APPLICATIONS

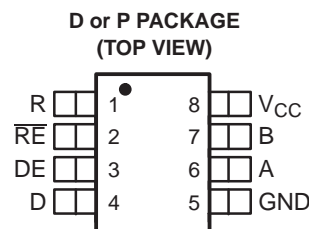
- Data Transmission With Remote Stations Powered From the Host
- Isolated Multipoint Data Buses
- Industrial Process Control Networks
- Point-of-Sale Networks
- Electric Utility Metering

DESCRIPTION

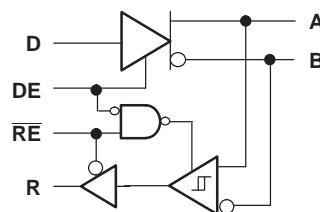
The SN65HVD08 combines a 3-state differential line driver and differential line receiver designed for balanced data transmission and interoperability with ANSI TIA/EIA-485-A and ISO-8482E standard-compliant devices.

The wide supply voltage range and low quiescent current requirements allow the SN65HVD08s to operate from a 5-V power bus in the cable with as much as a 2-V line voltage drop. Busing power in the cable can alleviate the need for isolated power to be generated at each connection of a ground-isolated bus.

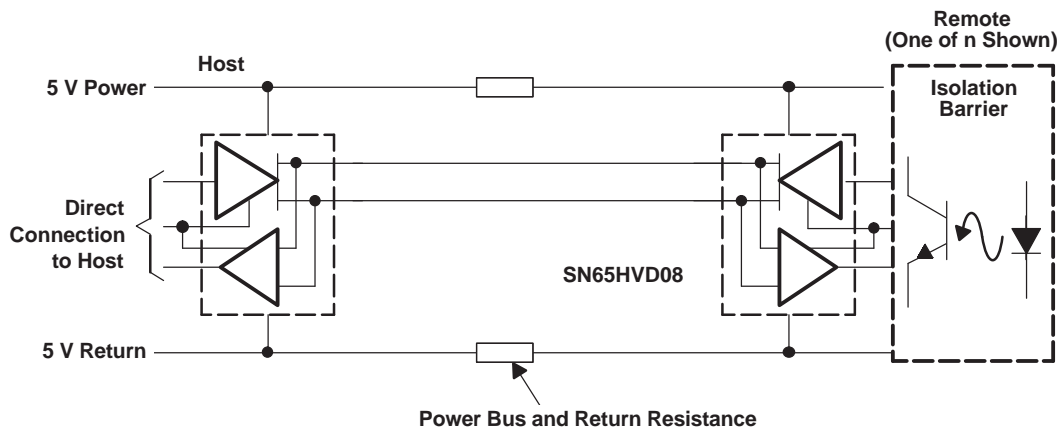
The driver differential outputs and receiver differential inputs connect internally to form a differential input/output (I/O) bus port that is designed to offer minimum loading to the bus whenever the driver is disabled or not powered. The drivers and receivers have active-high and active-low enables respectively, which can be externally connected together to function as a direction control.



LOGIC DIAGRAM (Positive Logic)



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

| PART NUMBER | SPECIFIED TEMPERATURE RANGE | PACKAGE | PACKAGE MARKING |
|-------------|-----------------------------|---------|-----------------|
| SN65HVD08D | –40°C to 85°C | SOIC | VP08 |
| SN65HVD08P | –40°C to 85°C | PDIP | 65HVD08 |
| SN75HVD08D | 0°C to 70°C | SOIC | VN08 |
| SN75HVD08P | 0°C to 70°C | PDIP | 75HVD08 |

PACKAGE DISSIPATION RATINGS

| PACKAGE | $T_A \leq 25^\circ\text{C}$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 85^\circ\text{C}$ POWER RATING |
|----------|--|--|---------------------------------------|
| SOIC (D) | 710 mW | 5.7 mW/°C | 369 mW |
| PDIP (P) | 1000 mW | 8 mW/°C | 520 mW |

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted⁽¹⁾⁽²⁾

| | | | UNIT |
|---|-------------------------------------|---------------|------------------------------|
| Supply voltage, V_{CC} | | | –0.3 V to 6 V |
| Voltage range at A or B | | | –9 V to 14 V |
| Input voltage range at D, DE, R or \overline{RE} | | | –0.5 V to $V_{CC} + 0.5$ V |
| Voltage input range, transient pulse, A and B, through 100 Ω | | | –25 V to 25 V |
| Receiver output current, I_O | | | –11 mA to 11 mA |
| Electrostatic discharge | Human Body Model ⁽³⁾ | A, B, and GND | 16 kV |
| | | All pins | 4 kV |
| | Charged-Device Model ⁽⁴⁾ | All pins | 1 kV |
| Continuous total power dissipation | | | See Dissipation Rating Table |

(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 voltage values, except differential I/O bus voltages, are with respect to network ground terminal.

(3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.

(4) Tested in accordance with JEDEC Standard 22, Test Method C101.

RECOMMENDED OPERATING CONDITIONS

| | | MIN | NOM | MAX | UNIT |
|--|---|------|-----|----------|------|
| Supply voltage, V_{CC} | | 3 | | 5.5 | V |
| Input voltage at any bus terminal (separately or common mode), $V_I^{(1)}$ | | –7 | | 12 | V |
| High-level input voltage, V_{IH} | Driver, driver enable, and receiver enable inputs | 2.25 | | V_{CC} | V |
| Low-level input voltage, V_{IL} | | 0 | | 0.8 | |
| Differential input voltage, V_{ID} | | –12 | | 12 | |
| High-level output current, I_{OH} | Driver | –60 | | | mA |
| | Receiver | –8 | | | |
| Low-level output current, I_{OL} | Driver | | | 60 | mA |
| | Receiver | | | 8 | |
| Operating free-air temperature, T_A | SN75HVD08 | 0 | | 70 | °C |
| | SN65HVD08 | –40 | | 85 | |

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|---|------|-----|----------|---------------|
| $ V_{OD} $ Driver differential output voltage magnitude | $R_L = 60\ \Omega$, $375\ \Omega$ on each output to –7 V to 12 V, See Figure 1 | 1.5 | | V_{CC} | V |
| $\Delta V_{OD} $ Change in magnitude of driver differential output voltage | $R_L = 54\ \Omega$ | –0.2 | | 0.2 | V |
| $V_{OC(PP)}$ Peak-to-peak driver common-mode output voltage | Center of two 27- Ω load resistors, See Figure 2 | | 0.5 | | V |
| V_{IT+} Positive-going receiver differential input voltage threshold | | | | –10 | mV |
| V_{IT-} Negative-going receiver differential input voltage threshold | | –200 | | | mV |
| V_{hys} Receiver differential input voltage threshold hysteresis ($V_{IT+} - V_{IT-}$) | | | 35 | | mV |
| V_{OH} Receiver high-level output voltage | $I_{OH} = -8\ \text{mA}$ | 2.4 | | | V |
| V_{OL} Receiver low-level output voltage | $I_{OL} = 8\ \text{mA}$ | | | 0.4 | V |
| I_{IH} Driver input, driver enable, and receiver enable high-level input current | | –100 | | 100 | μA |
| I_{IL} Driver input, driver enable, and receiver enable low-level input current | | –100 | | 100 | μA |
| I_{OS} Driver short-circuit output current | $7\ \text{V} < V_O < 12\ \text{V}$ | –265 | | 265 | mA |
| I_I Bus input current (disabled driver) | $V_I = 12\ \text{V}$ | | | 130 | μA |
| | $V_I = -7\ \text{V}$ | –100 | | | |
| | $V_I = 12\ \text{V}$, $V_{CC} = 0\ \text{V}$ | | | 130 | |
| | $V_I = -7\ \text{V}$, $V_{CC} = 0\ \text{V}$ | –100 | | | |
| I_{CC} Supply current | Receiver enabled, driver disabled, no load | | | 10 | mA |
| | Driver enabled, receiver disabled, no load | | | 16 | |
| | Both disabled | | | 5 | μA |
| | Both enabled, no load | | | 16 | mA |

DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--|-----|-----|-----|---------------|
| t_{PHL} Driver high-to-low propagation delay time | $R_L = 54 \Omega$, $C_L = 50 \text{ pF}$, See Figure 3 | 18 | | 40 | ns |
| t_{PLH} Driver low-to-high propagation delay time | | 18 | | 40 | |
| t_r Driver 10%-to-90% differential output rise time | | 10 | | 55 | |
| t_f Driver 90%-to-10% differential output fall time | | 10 | | 55 | |
| $t_{SK(P)}$ Driver differential output pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 2.5 | |
| t_{en} Driver enable time | Receiver enabled, See Figures 4 and 5 | | | 55 | ns |
| | Receiver disabled, See Figures 4 and 5 | | | 6 | μs |
| t_{dis} Driver disable time | Receiver enabled, See Figures 4 and 5 | | | 90 | ns |

RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--------------------------------------|-----|-----|-----|---------------|
| t_{PHL} Receiver high-to-low propagation delay time | $C_L = 15 \text{ pF}$, See Figure 6 | | | 70 | ns |
| t_{PLH} Receiver low-to-high propagation delay time | | | | 70 | |
| t_r Receiver 10%-to-90% differential output rise time | | | | 5 | |
| t_f Receiver 90%-to-10% differential output fall time | | | | 5 | |
| $t_{SK(P)}$ Receiver differential output pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 4.5 | |
| t_{en} Receiver enable time | Driver enabled, See Figure 7 | | | 15 | ns |
| | Driver disabled, See Figure 8 | | | 6 | μs |
| t_{dis} Receiver disable time | Driver enabled, See Figure 7 | | | 20 | ns |

PARAMETER MEASUREMENT INFORMATION

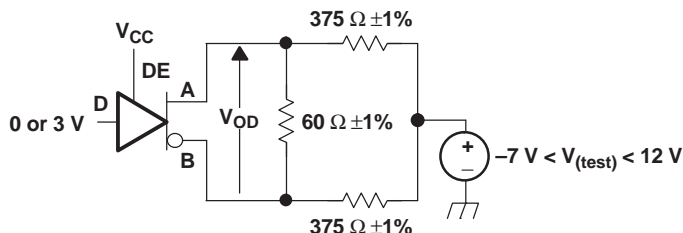


Figure 1. Driver V_{OD} With Common-Mode Loading Test Circuit

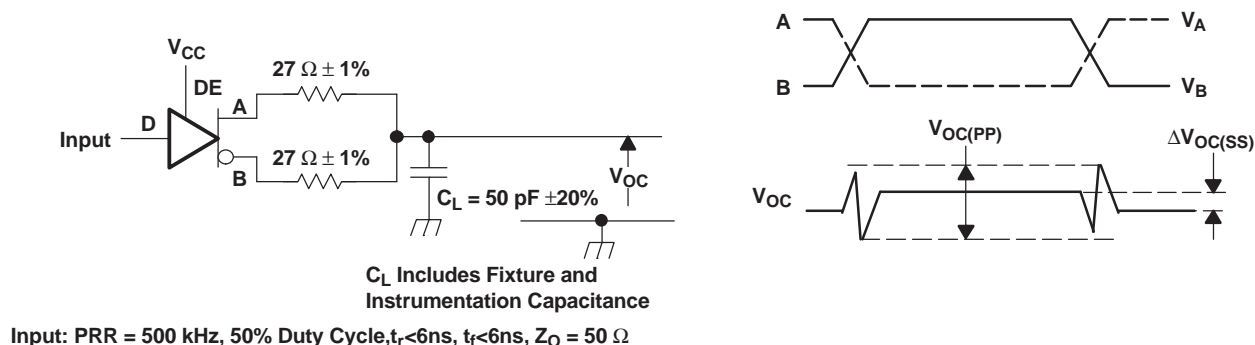
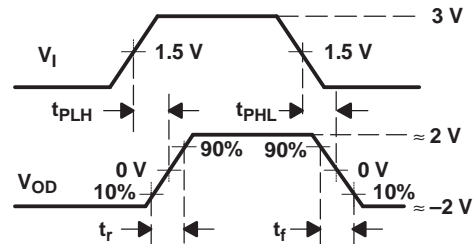
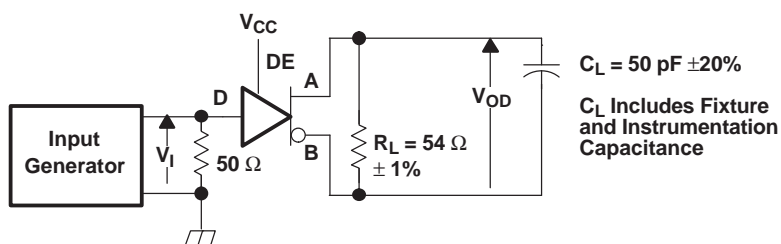


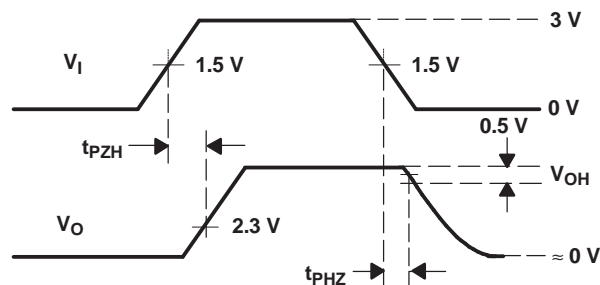
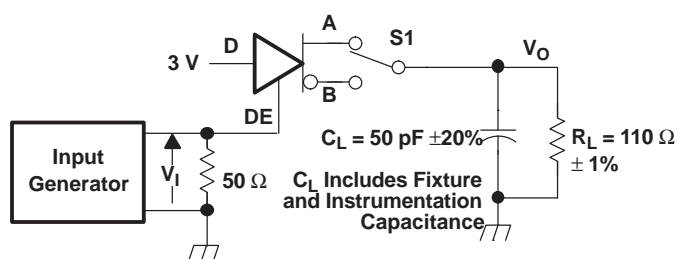
Figure 2. Test Circuit and Definitions for the Driver Common-Mode Output Voltage

PARAMETER MEASUREMENT INFORMATION (continued)



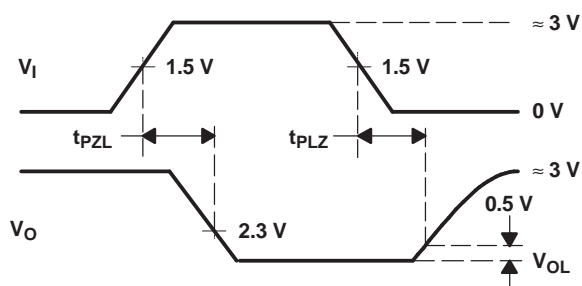
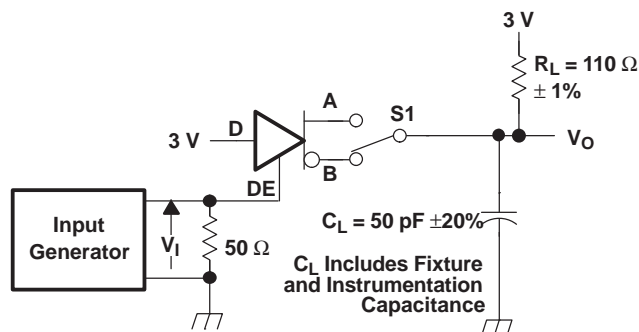
Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6 \text{ ns}$, $t_f < 6 \text{ ns}$, $Z_o = 50 \Omega$

Figure 3. Driver Switching Test Circuit and Voltage Waveforms



Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6 \text{ ns}$, $t_f < 6 \text{ ns}$, $Z_o = 50 \Omega$

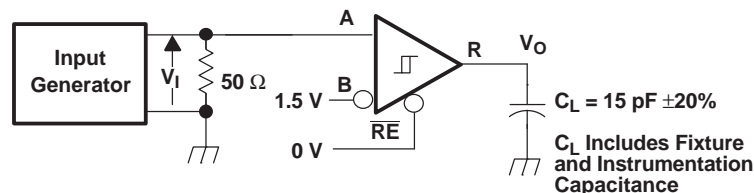
Figure 4. Driver High-Level Enable and Disable Time Test Circuit and Voltage Waveforms



Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6 \text{ ns}$, $t_f < 6 \text{ ns}$, $Z_o = 50 \Omega$

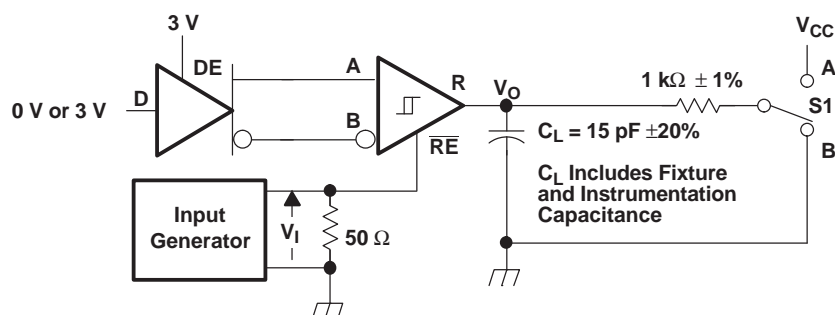
Figure 5. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION (continued)



Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6\text{ ns}$, $t_f < 6\text{ ns}$, $Z_o = 50\ \Omega$

Figure 6. Receiver Switching Test Circuit and Voltage Waveforms



Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6\text{ ns}$, $t_f < 6\text{ ns}$, $Z_o = 50\ \Omega$

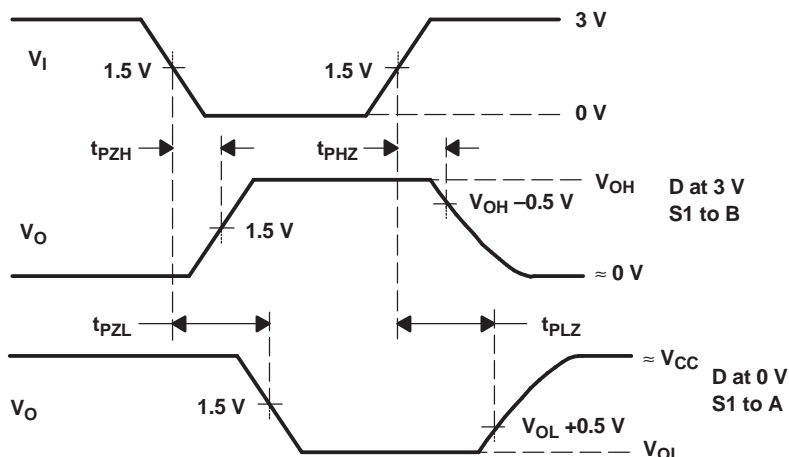


Figure 7. Receiver Enable and Disable Time Test Circuit and Voltage Waveforms With Drivers Enabled

PARAMETER MEASUREMENT INFORMATION (continued)

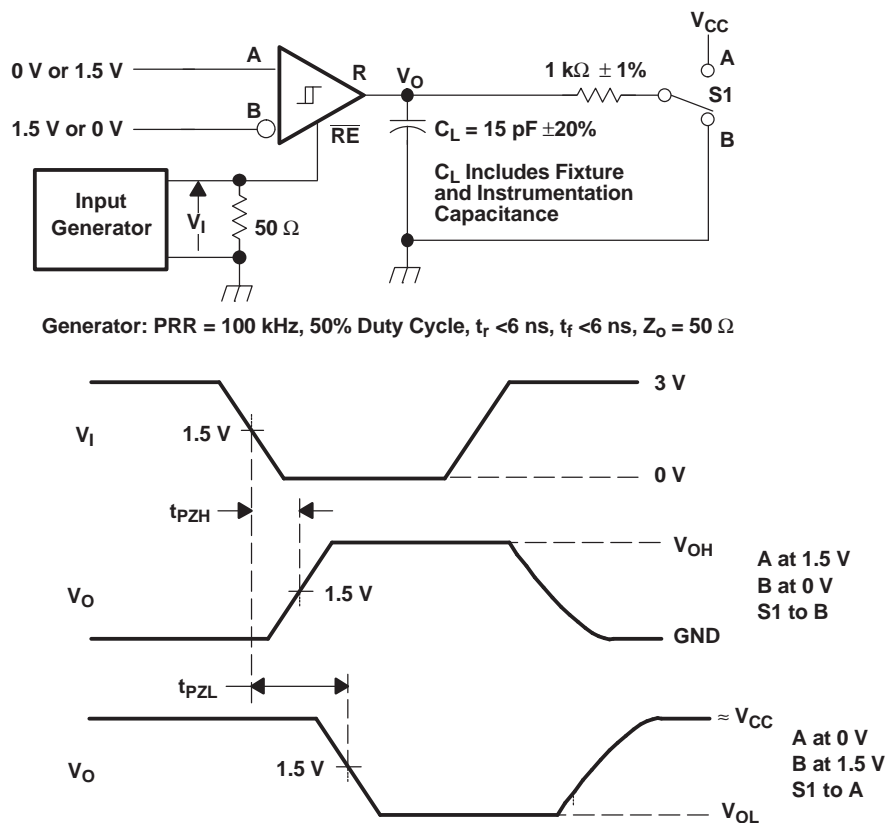


Figure 8. Receiver Enable Time From Standby (Driver Disabled)

DEVICE INFORMATION

Function Tables DRIVER

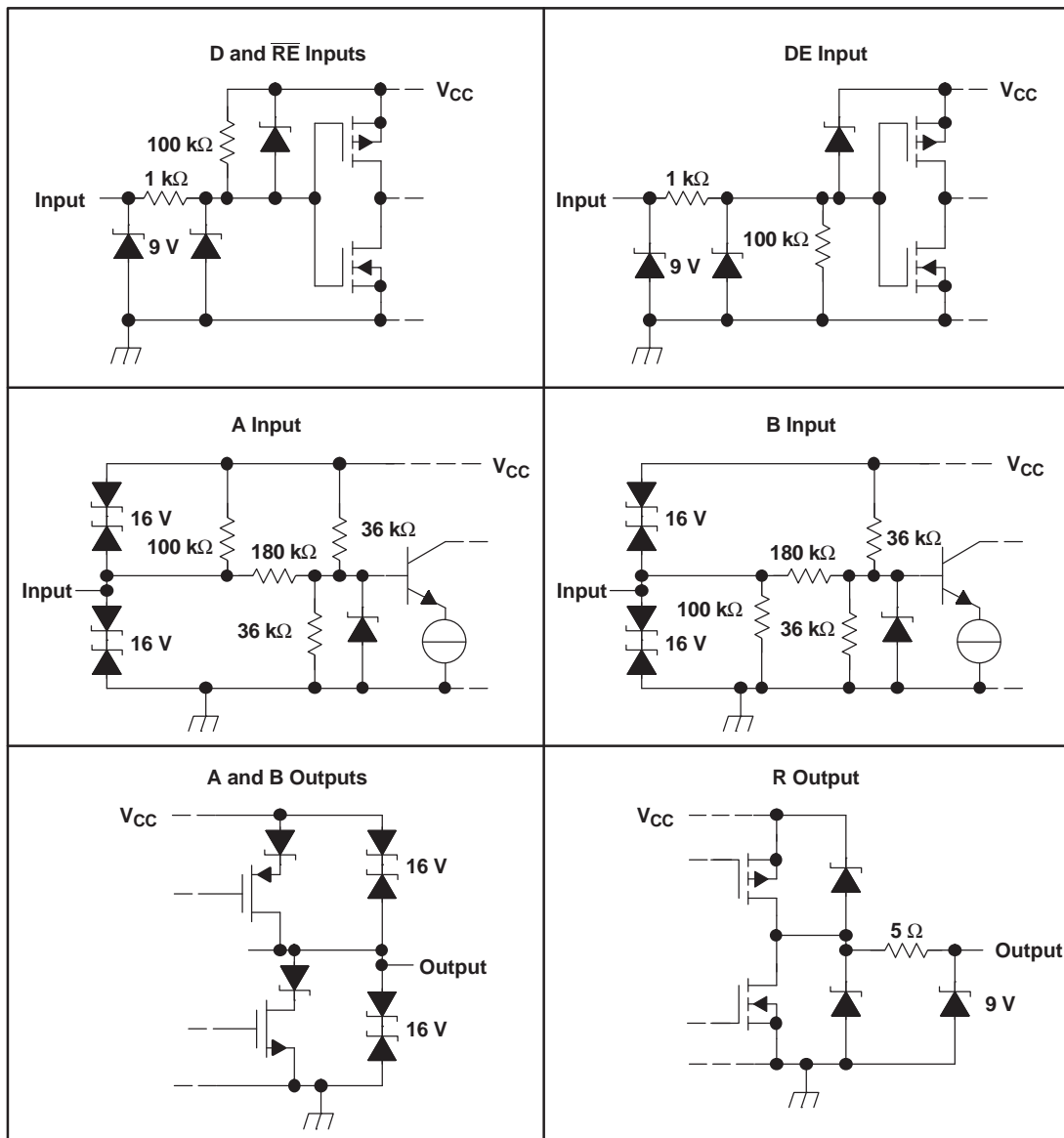
| INPUT D | ENABLE DE | OUTPUTS A B | |
|------------|--------------|----------------|---|
| H | H | H | L |
| L | H | L | H |
| X | L | Z | Z |
| Open | H | H | L |

RECEIVER

| DIFFERENTIAL INPUTS $V_{ID} = V_A - V_B$ | ENABLE ⁽¹⁾ RE | OUTPUT ⁽¹⁾ R |
|---|-----------------------------|----------------------------|
| $V_{ID} \leq -0.2\text{ V}$ | L | L |
| $-0.2\text{ V} < V_{ID} < -0.01\text{ V}$ | L | ? |
| $-0.01\text{ V} \leq V_{ID}$ | L | H |
| X | H | Z |
| Open Circuit | L | H |
| Short Circuit | L | H |

(1) H = high level; L = low level; Z = high impedance; X = irrelevant;
? = indeterminate

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



TYPICAL CHARACTERISTICS

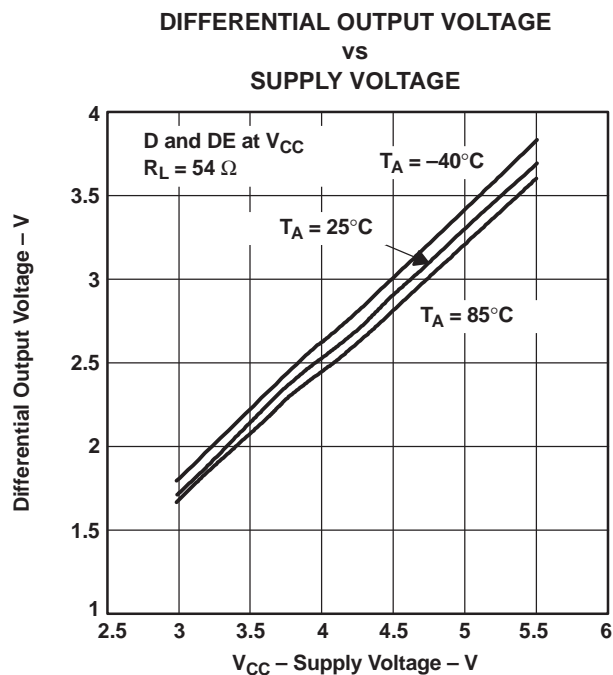


Figure 9.

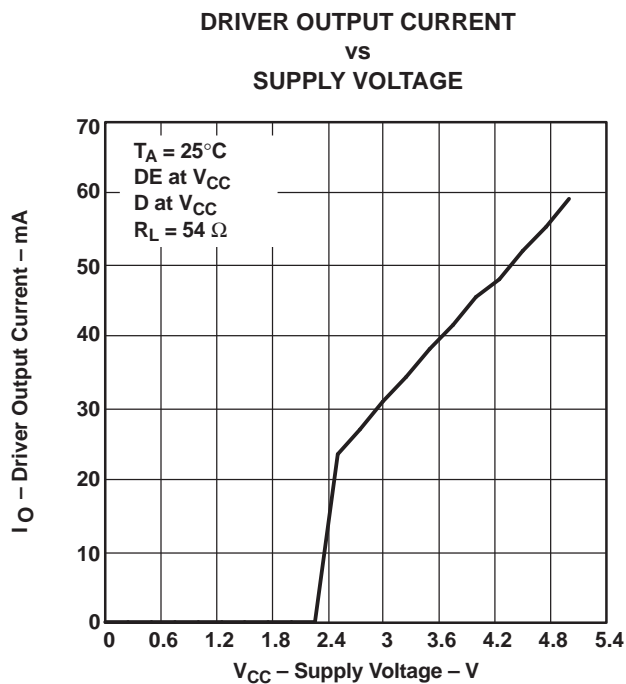


Figure 10.

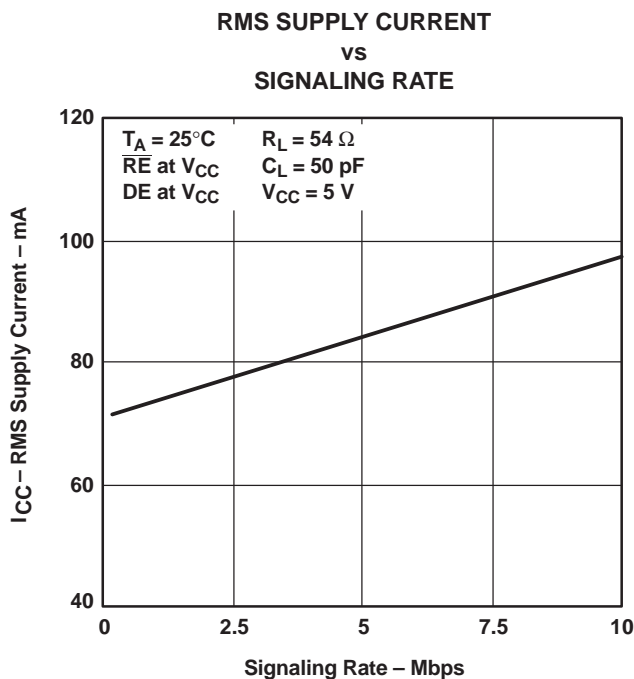


Figure 11.

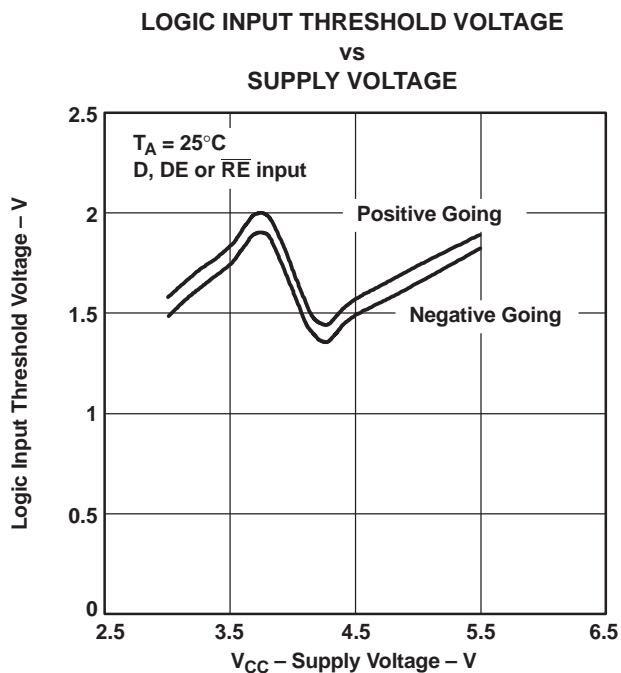
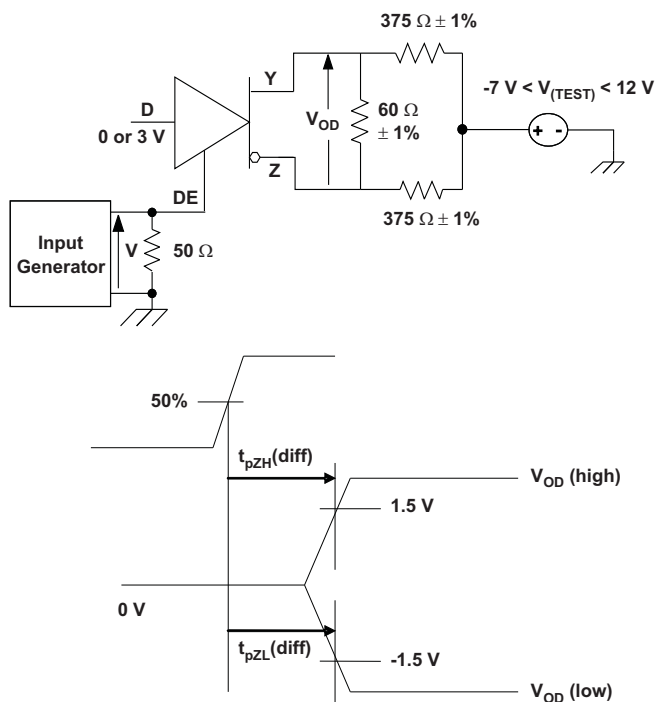
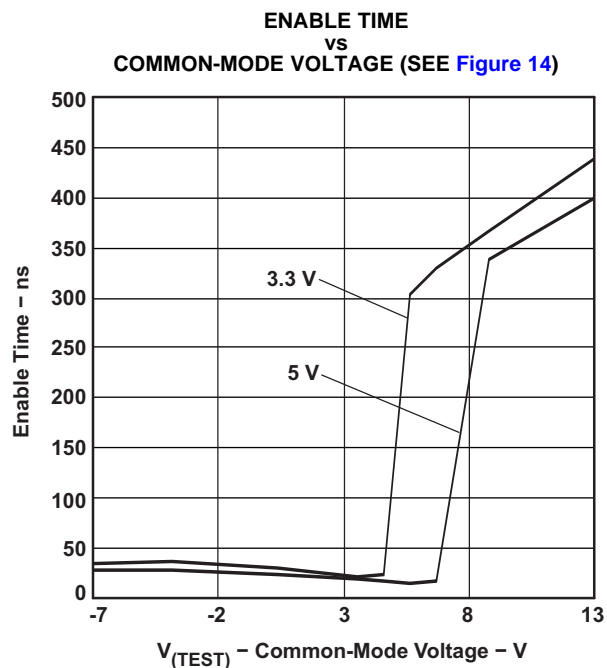


Figure 12.

TYPICAL CHARACTERISTICS (continued)



The time $t_{pZL}(x)$ is the measure from DE to $V_{OD}(x)$. V_{OD} is valid when it is greater than 1.5 V.

APPLICATION INFORMATION

As electrical loads are physically distanced from their power source, the effects of supply and return line impedance and the resultant voltage drop must be accounted. If the supply regulation at the load cannot be maintained to the circuit requirements, it forces the use of remote sensing, additional regulation at the load, bigger or shorter cables, or a combination of these. The SN65HVD08 eases this problem by relaxing the supply requirements to allow for more variation in the supply voltage over typical RS-485 transceivers.

SUPPLY SOURCE IMPEDANCE

In the steady state, the voltage drop from the source to the load is simply the wire resistance times the load current as modeled in Figure 15.

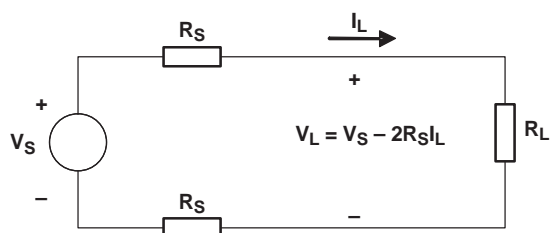


Figure 15. Steady-State Circuit Model

For example, if you were to provide 5-V $\pm 5\%$ supply power to a remote circuit with a maximum load requirement of 0.1 A (one SN65HVD08), the voltage at the load would fall below the 4.5-V minimum of most 5-V circuits with as little as 5.8 m of 28-GA conductors. Table 1 summarizes wire resistance and the length for 4.5 V and 3 V at the load with 0.1 A of load current. The maximum lengths would scale linearly for higher or lower load currents.

Table 1. Maximum Cable Lengths for Minimum Load Voltages at 0.1 A Load

| WIRE SIZE | RESISTANCE | 4.5 V LENGTH AT 0.1 A | 3-v LENGTH AT 0.1 A |
|-----------|-------------------------|-----------------------|---------------------|
| 28 Gage | 0.213 Ω/m | 5.8 m | 41.1 m |
| 24 Gage | 0.079 Ω/m | 15.8 m | 110.7 m |
| 22 Gage | 0.054 Ω/m | 23.1 m | 162.0 m |
| 20 Gage | 0.034 Ω/m | 36.8 m | 257.3 m |
| 18 Gage | 0.021 Ω/m | 59.5 m | 416.7 m |

Under dynamic load requirements, the distributed inductance and capacitance of the power lines may

not be ignored and decoupling capacitance at the load is required. The amount depends upon the magnitude and frequency of the load current change but, if only powering the SN65HVD08, a 0.1 μF ceramic capacitor is usually sufficient.

OPTO-ISOLATED DATA BUSES

Long RS-485 circuits can create large ground loops and pick up common-mode noise voltages in excess of the range tolerated by standard RS-485 circuits. A common remedy is to provide galvanic isolation of the data circuit from earth or local grounds.

Transformers, capacitors, or phototransistors most often provide isolation of the bus and the local node. Transformers and capacitors require changing signals to transfer the information over the isolation barrier and phototransistors (opto-isolators) can pass steady-state signals. Each of these methods incurs additional costs and complexity, the former in clock encoding and decoding of the data stream and the latter in requiring an isolated power supply.

Quite often, the cost of isolated power is repeated at each node connected to the bus as shown in Figure 16. The possibly lower-cost solution is to generate this supply once within the system and then distribute it along with the data line(s) as shown in Figure 17.

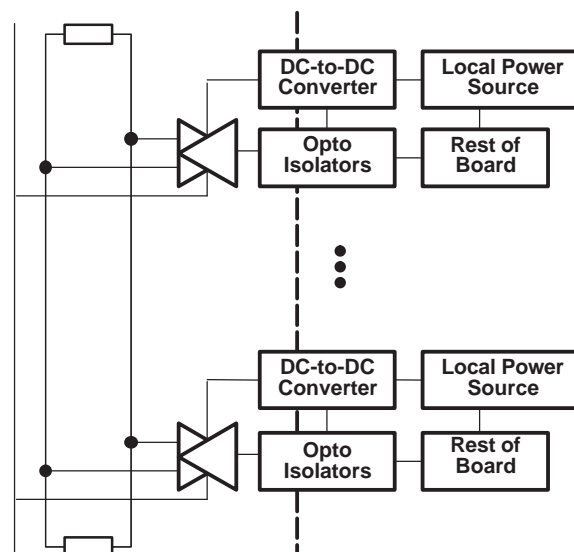


Figure 16. Isolated Power at Each Node

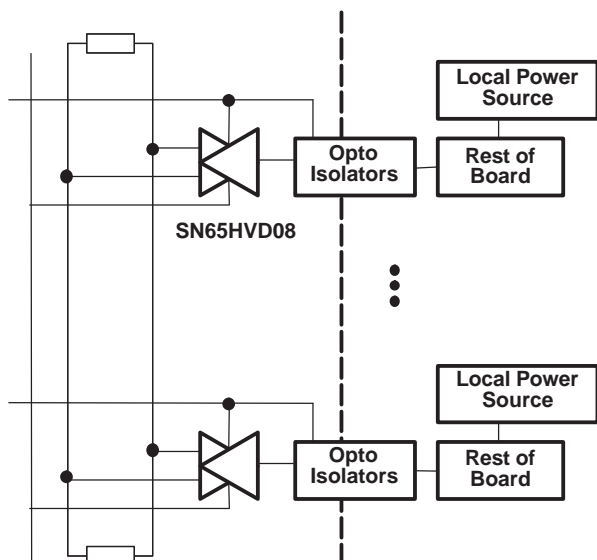


Figure 17. Distribution of Isolated Power

The features of the SN65HVD08 are particularly good for the application of [Figure 17](#). Due to added supply source impedance, the low quiescent current requirements and wide supply voltage tolerance allow for the poorer load regulation.

AN OPTO ALTERNATIVE

The ISO150 is a two-channel, galvanically isolated data coupler capable of data rates of 80 Mbps. Each channel can be individually programmed to transmit data in either direction.

Data is transmitted across the isolation barrier by coupling complementary pulses through high-voltage 0.4-pF capacitors. Receiver circuitry restores the pulses to standard logic levels. Differential signal transmission rejects isolation-mode voltage transients up to 1.6 kV/ms.

ISO150 avoids the problems commonly associated with opto-couplers. Optically-isolated couplers require high current pulses and allowance must be made for LED aging. The ISO150's Bi-CMOS circuitry operates at 25 mW per channel with supply voltage range matching that of the SN65HVD08 of 3 V to 5.5 V.

[Figure 18](#) shows a typical circuit.

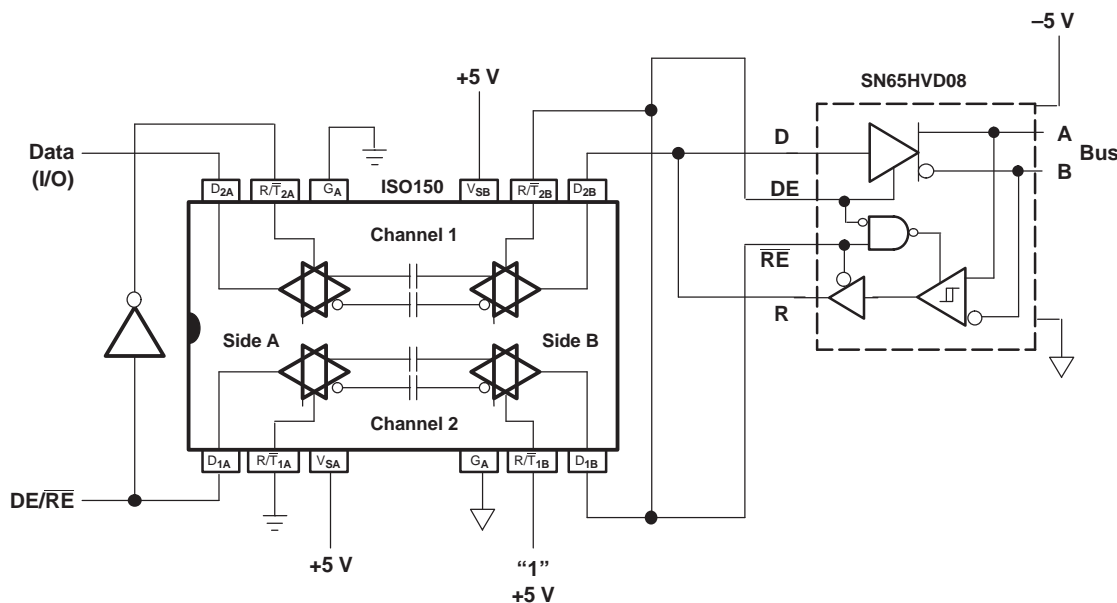


Figure 18. Isolated RS-485 Interface

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| SN65HVD08D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD08DG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD08DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD08DRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD08P | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| SN65HVD08PE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| SN75HVD08D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN75HVD08DG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN75HVD08DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN75HVD08DRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN75HVD08P | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| SN75HVD08PE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |

⁽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.

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TAPE AND REEL INFORMATION



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65HVD08DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| SN75HVD08DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65HVD08DR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| SN75HVD08DR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-001 variation BA.

D (R-PDSO-G8)

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 AA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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