



3.3V FULL-DUPLEX RS-485 DRIVERS AND RECEIVERS

FEATURES

- 1/8 Unit-Load Option Available (Up to 256 Nodes on the Bus)
- Bus-Pin ESD Protection Exceeds 15 kV HBM
- Optional Driver Output Transition Times for Signaling Rates ⁽¹⁾ of 1 Mbps, 5 Mbps and 25 Mbps
- Low-Current Standby Mode: < 1 μ A
- Glitch-Free Power-Up and Power-Down Protection for Hot-Plugging Applications
- 5V Tolerant Inputs
- Bus Idle, Open, and Short Circuit Failsafe
- Meets or exceeds the requirements of ANSI TIA/EIA-485-A and RS-422 Compatible
- 5-V Devices available, SN65HVD50-59

APPLICATIONS

- Utility Meters
- DTE/DCE Interfaces
- Industrial, Process, and Building Automation
- Point-of-Sale (POS) Terminals and Networks

DESCRIPTION

The SN65HVD3X devices are 3-state differential line drivers and differential-input line receivers that operate with 3.3-V power supply.

- (1) The signaling rate of a line is the number of voltage transitions that are made per second expressed in the units bps (bits per second).

Each driver and receiver has separate input and output pins for full-duplex bus communication designs. They are designed for balanced transmission lines and interoperability with ANSI TIA/EIA-485A, TIA/EIA-422-B, ITU-T v.11 and ISO 8482:1993 standard-compliant devices.

The SN65HVD30, SN65HVD31, SN65HVD32, SN65HVD36 and SN65HVD37 are fully enabled with no external enabling pins. The SN65HVD36 and SN65HVD37 implement receiver equalization technology for improved performance in long distance applications.

The SN65HVD33, SN65HVD34, SN65HVD35, SN65HVD38, and SN65HVD39 have active-high driver enables and active-low receiver enables. A very low, less than 1 μ A, standby current can be achieved by disabling both the driver and receiver. The SN65HVD38 and SN65HVD39 implement receiver equalization technology for improved performance in long distance applications.

All devices are characterized for operation from -40°C to +85°C.

The SN65HVD36 and SN65HVD38 implement receiver equalization technology for improved jitter performance on differential bus applications with data rates up to 20 Mbps at cable lengths up to 160 meters.

The SN65HVD37 and SN65HVD39 implement receiver equalization technology for improved jitter performance on differential bus applications with data rates in the range of 1 to 5 Mbps at cable lengths up to 1000 meters.

IMPROVED REPLACEMENT FOR:

| Part Number | Replace with |
|-------------|--|
| xxx3491 | SN65HVD33: Better ESD protection (15kV vs 2kV or not specified) Higher Signaling Rate (25Mbps vs 20Mbps) Fractional Unit Load (64 Nodes vs 32) |
| MAX3491E | SN65HVD33: Higher Signaling Rate (25Mbps vs 12Mbps) Fractional Unit Load (64 Nodes vs 32) |
| MAX3076E | SN65HVD33: Higher Signaling Rate (25Mbps vs 16Mbps) Lower Standby Current (1 μ A vs 10 μ A) |
| MAX3073E | SN65HVD34: Higher Signaling Rate (5Mbps vs 500kbps) Lower Standby Current (1 μ A vs 10 μ A) |
| MAX3070E | SN65HVD35: Higher Signaling Rate (1Mbps vs 250kbps) Lower Standby Current (1 μ A vs 10 μ A) |



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.

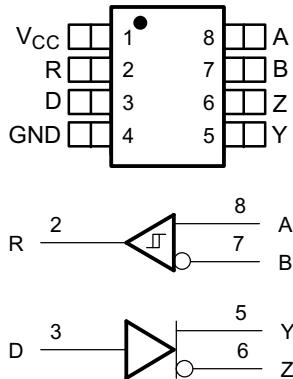


This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

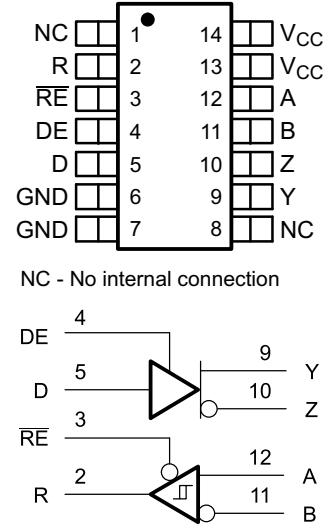
SN65HVD30, SN65HVD31, SN65HVD32, SN65HVD36, SN65HVD37

D PACKAGE (TOP VIEW)



SN65HVD33, SN65HVD34, SN65HVD35, SN65HVD38, SN65HVD39

D PACKAGE (TOP VIEW)



NC - No internal connection

AVAILABLE OPTIONS

| SIGNALING RATE | UNIT LOADS | RECEIVER EQUALIZATION | ENABLES | BASE PART NUMBER | SOIC MARKING |
|----------------|------------|-----------------------|---------|------------------|--------------|
| 25 Mbps | 1/2 | No | No | SN65HVD30 | PREVIEW |
| 5 Mbps | 1/8 | No | No | SN65HVD31 | PREVIEW |
| 1 Mbps | 1/8 | No | No | SN65HVD32 | PREVIEW |
| 25 Mbps | 1/2 | No | Yes | SN65HVD33 | 65HVD33 |
| 5 Mbps | 1/8 | No | Yes | SN65HVD34 | 65HVD34 |
| 1 Mbps | 1/8 | No | Yes | SN65HVD35 | 65HVD35 |
| 25 Mbps | 1/2 | Yes | No | SN65HVD36 | PREVIEW |
| 5 Mbps | 1/8 | Yes | No | SN65HVD37 | PREVIEW |
| 25 Mbps | 1/2 | Yes | Yes | SN65HVD38 | PREVIEW |
| 5 Mbps | 1/8 | Yes | Yes | SN65HVD39 | PREVIEW |

ABSOLUTE MAXIMUM RATINGS

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

| | | UNIT |
|-----------------|---|--------------------|
| V _{CC} | Supply voltage range, V _{CC} | –0.3 V to 6 V |
| | Voltage range at any bus terminal (A, B, Y, Z) | –9 V to 14 V |
| | Voltage input, transient pulse through 100 Ω. See Figure 12 (A, B, Y, Z) ⁽³⁾ | –50 to 50 V |
| V _I | Input voltage range (D, DE, \overline{RE}) | –0.5 V to 7 V |
| | Continuous total power dissipation | Internally limited |
| I _O | Output current (receiver output only, R) | 11 mA |

- 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.
- All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
- This tests survivability only and the output state of the receiver is not specified.

RECOMMENDED OPERATING CONDITIONS

over operating free-air temperature range unless otherwise noted

| PARAMETER | | MIN | NOM | MAX | UNIT |
|-----------------------------------|---|--|-----|-----------------|------|
| V _{CC} | Supply voltage | 3.0 | | 3.6 | |
| V _I or V _{IC} | Voltage at any bus terminal (separately or common mode) | –7 ⁽¹⁾ | | 12 | V |
| 1/t _{UI} | Signaling rate | SN65HVD30, SN65HVD33, SN65HVD36, SN65HVD38 | | 25 | Mbps |
| | | SN65HVD31, SN65HVD34, SN65HVD37, SN65HVD39 | | 5 | |
| | | SN65HVD32, SN65HVD35 | | 1 | |
| R _L | Differential load resistance | 54 | 60 | | Ω |
| V _{IH} | High-level input voltage | | | V _{CC} | |
| V _{IL} | Low-level input voltage | | | 0.8 | V |
| V _{ID} | Differential input voltage | –12 | | 12 | |
| I _{OH} | High-level output current | Driver | –60 | | mA |
| | | Receiver | –8 | | |
| I _{OL} | Low-level output current | Driver | | 60 | mA |
| | | Receiver | | 8 | |
| T _A | Ambient still-air temperature | –40 | | 85 | °C |

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

ELECTROSTATIC DISCHARGE PROTECTION

| PARAMETER | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|-------------------------------------|-----------------------|-----|--------------------|-----|------|
| Human body model | Bus terminals and GND | | ±16 | | kV |
| Human body model ⁽²⁾ | All pins | | ±4 | | |
| Charged-device-model ⁽³⁾ | All pins | | ±1 | | |

- All typical values at 25°C with 3.3-V supply.
- Tested in accordance with JEDEC Standard 22, Test Method A114-A.
- Tested in accordance with JEDEC Standard 22, Test Method C101.

DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|--------------------------|--|---|--|------------------------------|---------------------|---------------|
| $V_{I(K)}$ | Input clamp voltage | $I_I = -18 \text{ mA}$ | -1.5 | | | V |
| $ V_{OD(SS)} $ | Steady-state differential output voltage | $I_O = 0$ | 2.5 | | V_{CC} | |
| | | $R_L = 54 \Omega$, See Figure 1 (RS-485) | 1.5 | 2.0 | | |
| | | $R_L = 100 \Omega$, See Figure 1 ⁽²⁾ (RS-422) | 2.0 | 2.3 | | |
| | | $V_{test} = -7 \text{ V to } 12 \text{ V}$, See Figure 2 | 1.5 | | | |
| $\Delta V_{OD(SS)} $ | Change in magnitude of steady-state differential output voltage between states | $R_L = 54 \Omega$, See Figure 1 and Figure 2 | -0.2 | | 0.2 | |
| $V_{OD(RING)}$ | Differential Output Voltage overshoot and undershoot | $R_L = 54 \Omega$, $C_L = 50 \text{ pF}$, See Figure 5 and Figure 3 | | | $0.05 V_{OD(SS)} $ | |
| $V_{OC(PP)}$ | Peak-to-peak common-mode output voltage | HVD30, HVD33, HVD36, HVD38 | | 0.5 | | |
| | | HVD31, HVD34, HVD37, HVD39, HVD32, HVD35 | See Figure 4 | 0.25 | | |
| $V_{OC(SS)}$ | Steady-state common-mode output voltage | See Figure 4 | 1.6 | | 2.3 | |
| $\Delta V_{OC(SS)}$ | Change in steady-state common-mode output voltage | | -0.05 | | 0.05 | |
| $I_{Z(Z)}$ or $I_{Y(Z)}$ | High-impedance state output current | | $V_{CC} = 0 \text{ V}$, V_Z or $V_Y = 12 \text{ V}$, Other input at 0 V | | 90 | |
| | | | $V_{CC} = 0 \text{ V}$, V_Z or $V_Y = -7 \text{ V}$, Other input at 0 V | -10 | | |
| | | HVD33, HVD34, HVD35, HVD38, HVD39 | $V_{CC} = 5 \text{ V}$ or 0 V , $DE = 0 \text{ V}$, V_Z or $V_Y = 12 \text{ V}$ | Other input at 0 V | | 90 |
| | | | $V_{CC} = 5 \text{ V}$ or 0 V , $DE = 0 \text{ V}$, V_Z or $V_Y = -7 \text{ V}$ | | -10 | |
| $I_{Z(S)}$ or $I_{Y(S)}$ | Short Circuit output Current | | V_Z or $V_Y = -7 \text{ V}$ | Other input at 0 V | -250 | 250 |
| | | | V_Z or $V_Y = 12 \text{ V}$ | | -250 | 250 |
| I_I | Input current | D, DE | 0 | | 100 | μA |
| $C_{(OD)}$ | Differential output capacitance | $V_{OD} = 0.4 \sin(4E6\pi t) + 0.5 \text{ V}$, DE at 0 V | | 16 | | pF |

(1) All typical values are at 25°C and with a 3.3-V supply.

(2) V_{CC} is 3.3 Vdc \pm 5%

DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|--------------------|---|---|-----|--------------------|------|------|
| t _{PLH} | Propagation delay time, low-to-high-level output | HVD30, HVD33, HVD36, HVD38 | 4 | 10 | 18 | ns |
| | | HVD31, HVD34, HVD37, HVD39 | 25 | 38 | 65 | |
| | | HVD32, HVD35 | 120 | 175 | 305 | |
| t _{PHL} | Propagation delay time, high-to-low-level output | HVD30, HVD33, HVD36, HVD38 | 4 | 9 | 18 | ns |
| | | HVD31, HVD34, HVD37, HVD39 | 25 | 38 | 65 | |
| | | HVD32, HVD35 | 120 | 175 | 305 | |
| t _r | Differential output signal rise time | HVD30, HVD33, HVD36, HVD38 | 2.5 | 5 | 12 | ns |
| | | HVD31, HVD34, HVD37, HVD39 | 20 | 37 | 60 | |
| | | HVD32, HVD35 | 120 | 185 | 300 | |
| t _f | Differential output signal fall time | HVD30, HVD33, HVD36, HVD38 | 2.5 | 5 | 12 | ns |
| | | HVD31, HVD34, HVD37, HVD39 | 20 | 35 | 60 | |
| | | HVD32, HVD35 | 120 | 180 | 300 | |
| t _{sk(p)} | Pulse skew (t _{PHL} - t _{PLH}) | HVD30, HVD33, HVD36, HVD38 | | | 2 | ns |
| | | HVD31, HVD34, HVD37, HVD39 | | | 4 | |
| | | HVD32, HVD35 | | | 7 | |
| t _{PZH1} | Propagation delay time, high-impedance-to-high-level output | HVD33, HVD38 | | | 45 | ns |
| | | HVD34, HVD39 | | | 235 | |
| | | HVD35 | | | 490 | |
| t _{PHZ} | Propagation delay time, high-level-to-high-impedance output | HVD33, HVD38 | | | 25 | ns |
| | | HVD34, HVD39 | | | 65 | |
| | | HVD35 | | | 165 | |
| t _{PZL1} | Propagation delay time, high-impedance-to-low-level output | HVD33, HVD38 | | | 35 | ns |
| | | HVD34, HVD39 | | | 190 | |
| | | HVD35 | | | 490 | |
| t _{PLZ} | Propagation delay time, low-level-to-high-impedance output | HVD33, HVD38 | | | 30 | ns |
| | | HVD34, HVD39 | | | 120 | |
| | | HVD35 | | | 290 | |
| t _{PZH2} | Propagation delay time, standby-to-high-level output | R _L = 110 Ω, \overline{RE} at 3 V, D = 3 V and S1 = Y, or D = 0 V and S1 = Z See Figure 6 | | | 4000 | ns |
| t _{PZL2} | Propagation delay time, standby-to-low-level output | R _L = 110 Ω, \overline{RE} at 3 V, D = 3 V and S1 = Z, or D = 0 V and S1 = Y See Figure 7 | | | 4000 | ns |

(1) All typical values are at 25°C and with a 3.3-V supply.

RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT | | |
|----------------|---|--|--|---------------------------------------|--|---------|---------|----|
| V_{IT+} | Positive-going differential input threshold voltage | $I_O = -8$ mA | | | -0.02 | V | | |
| V_{IT-} | Negative-going differential input threshold voltage | $I_O = 8$ mA | | -0.20 | | | | |
| V_{hys} | Hysteresis voltage ($V_{IT+} - V_{IT-}$) | | | 50 | | mV | | |
| V_{IK} | Enable-input clamp voltage | $I_I = -18$ mA | | -1.5 | | V | | |
| V_O | Output voltage | $V_{ID} = 200$ mV, $I_O = -8$ mA, See Figure 8 | | 2.4 | | V | | |
| | | $V_{ID} = -200$ mV, $I_O = 8$ mA, See Figure 8 | | | 0.4 | | | |
| $I_{O(Z)}$ | High-impedance-state output current | $V_O = 0$ or V_{CC} , \overline{RE} at V_{CC} | | -1 | 1 | μ A | | |
| I_A or I_B | Bus input current | HVD31, HVD32, HVD34, HVD35, HVD37, HVD39 | Other input at 0V | V_A or $V_B = 12$ V | 0.05 | 0.10 | mA | |
| | | | | V_A or $V_B = 12$ V, $V_{CC} = 0$ V | 0.06 | 0.10 | | |
| | | | | V_A or $V_B = -7$ V | -0.10 | -0.04 | | |
| | | | | V_A or $V_B = -7$ V, $V_{CC} = 0$ V | -0.10 | -0.03 | | |
| | HVD30, HVD33, HVD36, HVD38 | Other input at 0V | V_A or $V_B = 12$ V | 0.20 | 0.35 | mA | | |
| | | | V_A or $V_B = 12$ V, $V_{CC} = 0$ V | 0.24 | 0.40 | | | |
| | | | V_A or $V_B = -7$ V | -0.35 | -0.18 | | | |
| | | | V_A or $V_B = -7$ V, $V_{CC} = 0$ V | -0.25 | -0.13 | | | |
| I_{IH} | Input current, \overline{RE} | $V_{IH} = 0.8$ V or 2 V | | -60 | | μ A | | |
| C_{ID} | Differential input capacitance | $V_{ID} = 0.4 \sin(4E6\pi t) + 0.5$ V, DE at 0 V | | 15 | | pF | | |
| I_{CC} | Supply current | HVD30, HVD31, HVD32 | D at 0 V or V_{CC} and No Load | | 6.4 | mA | | |
| | | | | HVD36, HVD37 | 7.9 | | | |
| | | HVD33 | \overline{RE} at 0 V, D at 0 V or V_{CC} , DE at 0 V, No load (Receiver enabled and driver disabled) | | 1.8 | mA | | |
| | | | | HVD34, HVD35 | 2.2 | | | |
| | | | | HVD38, HVD39 | 3.8 | | | |
| | | HVD33, HVD34, HVD35, HVD38, HVD39 | \overline{RE} at V_{CC} , D at V_{CC} , DE at 0 V, No load (Receiver disabled and driver disabled) | | 0.022 | 1 | μ A | |
| | | | | HVD33 | | 2.1 | | mA |
| | | | | HVD34, HVD35 | \overline{RE} at 0 V, D at 0 V or V_{CC} , DE at V_{CC} , No load (Receiver enabled and driver enabled) | 6.5 | | |
| | | | | HVD38 | 3.5 | | | |
| | | | | HVD39 | 8.0 | | | |
| | | | | HVD33 | \overline{RE} at V_{CC} , D at 0 V or V_{CC} , DE at V_{CC} , No load (Receiver disabled and driver enabled) | 1.8 | | |
| | | | | HVD34, HVD35 | 6.2 | | | |
| HVD38 | 2.5 | | | | | | | |
| HVD39 | 7.0 | | | | | | | |

(1) All typical values are at 25°C and with a 3.3-V supply.

RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT | |
|-------------|--|--|--|---|------|------|--|
| t_{PLH} | Propagation delay time, low-to-high-level output | HVD30, HVD33, HVD36, HVD38 | | 26 | 45 | ns | |
| | | HVD31, HVD32, HVD34, HVD35, HVD37, HVD39 | | 47 | 70 | | |
| t_{PHL} | Propagation delay time, high-to-low-level output | HVD30, HVD33, HVD36, HVD38 | $V_{ID} = -1.5\text{ V to }1.5\text{ V},$ $C_L = 15\text{ pF},$ See Figure 9 | 29 | 45 | | |
| | | HVD31, HVD32, HVD34, HVD35, HVD37, HVD39 | | 49 | 70 | | |
| $t_{sk(p)}$ | Pulse skew ($ t_{PHL} - t_{PLH} $) | HVD30, HVD33, HVD36, HVD37, HVD38, HVD39 | | 7 | | | |
| | | HVD31, HVD34, HVD32, HVD35 | | 10 | | | |
| t_r | Output signal rise time | | | | 5 | | |
| t_f | Output signal fall time | | | | 6 | | |
| t_{PHZ} | Output disable time from high level | DE at 3 V | | $C_L = 15\text{ pF}$ See Figure 10 | 20 | | |
| t_{PZH1} | Output enable time to high level | DE at 0 V | | | 20 | | |
| t_{PZH2} | Propagation delay time, standby-to-high-level output | DE at 0 V | | | 4000 | | |
| t_{PLZ} | Output disable time from low level | DE at 3 V | | $C_L = 15\text{ pF}$ See Figure 11 | 20 | | |
| t_{PZL1} | Output enable time to low level | DE at 0 V | | | 20 | | |
| t_{PZL2} | Propagation delay time, standby-to-low-level output | DE at 0 V | | | 4000 | | |

(1) All typical values are at 25°C and with a 3.3-V supply

RECEIVER EQUALIZATION CHARACTERISTICS

over recommended operating conditions unless otherwise noted

| PARAMETER | TEST CONDITIONS | DEVICE | MIN | TYP ⁽¹⁾ | MAX | UNIT | | | |
|--------------|---------------------------------|---|---------|--------------------|---------|----------------------|----------------------|----|---------|
| $t_{j(pp)}$ | Peak-to-peak eye-pattern jitter | Pseudo-random NRZ code with a bit pattern length of $2^{16}-1$, Belden 3105A cable | 25 Mbps | 500 m | 0 m | HVD36, HVD38 | PREVIEW | ns | |
| | | | | | 100 m | HVD33 ⁽²⁾ | PREVIEW | | |
| | | | | | 150 m | HVD36, HVD38 | PREVIEW | | |
| | | | | | | HVD33 ⁽²⁾ | PREVIEW | | |
| | | | | | 200 m | HVD36, HVD38 | PREVIEW | | |
| | | | | | | HVD33 ⁽²⁾ | PREVIEW | | |
| | | | | | 10 Mbps | 200 m | HVD33 ⁽²⁾ | | PREVIEW |
| | | | | | | HVD36, HVD38 | PREVIEW | | |
| | | | | | 250 m | HVD33 ⁽²⁾ | PREVIEW | | |
| | | | | | | HVD36, HVD38 | PREVIEW | | |
| | | | | | 300 m | HVD33 ⁽²⁾ | PREVIEW | | |
| | | | | | | HVD36, HVD38 | PREVIEW | | |
| | | | | | 5 Mbps | 500 m | HVD34 ⁽²⁾ | | PREVIEW |
| | | | | | | | HVD37, HVD39 | | PREVIEW |
| | | | | | 3 Mbps | 500 m | HVD33 ⁽²⁾ | | PREVIEW |
| | | | | | | | HVD34 ⁽²⁾ | | PREVIEW |
| HVD36, HVD38 | PREVIEW | | | | | | | | |
| HVD37, HVD39 | PREVIEW | | | | | | | | |
| 1 Mbps | 1000 m | HVD34 ⁽²⁾ | PREVIEW | | | | | | |
| | | HVD37, HVD39 | PREVIEW | | | | | | |

(1) All typical values are at $V_{CC} = 5\text{ V}$, and temperature = 25°C.

(2) The HVD33 and the HVD34 do not have receiver equalization but are specified for comparison.

DEVICE POWER DISSIPATION - P_D

| TEST CONDITIONS | DEVICE | MIN | TYP | MAX | UNIT |
|---|------------------------|-----|-----|-----|------|
| $R_L = 60$, $C_L = 50$ pF, Input to D a 50% duty cycle square wave at indicated signaling rate $T_A = 85^\circ\text{C}$ | HVD30, HVD36 (25 Mbps) | | | 197 | mW |
| | HVD31, HVD37 (5 Mbps) | | | 213 | |
| | HVD32 (1 Mbps) | | | 193 | |
| $R_L = 60$, $C_L = 50$ pF, DE at VCC, \overline{RE} at 0 V, Input to D a 50% duty cycle square wave at indicated signaling rate $T_A = 85^\circ\text{C}$ | HVD33, HVD38 (25 Mbps) | | | 197 | mW |
| | HVD34, HVD39 (5 Mbps) | | | 193 | |
| | HVD35 (1 Mbps) | | | 248 | |

PARAMETER MEASUREMENT INFORMATION

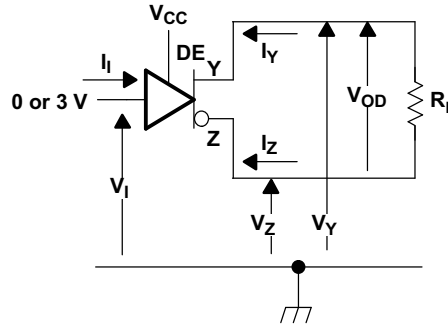


Figure 1. Driver V_{OD} Test Circuit and Voltage and Current Definitions

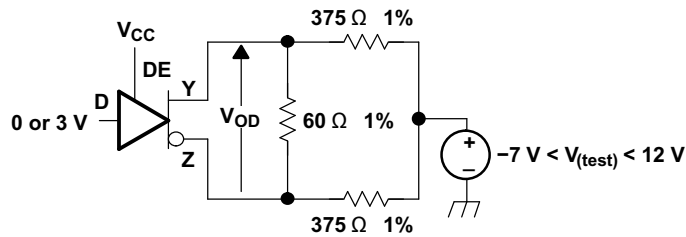


Figure 2. Driver V_{OD} With Common-Mode Loading Test Circuit

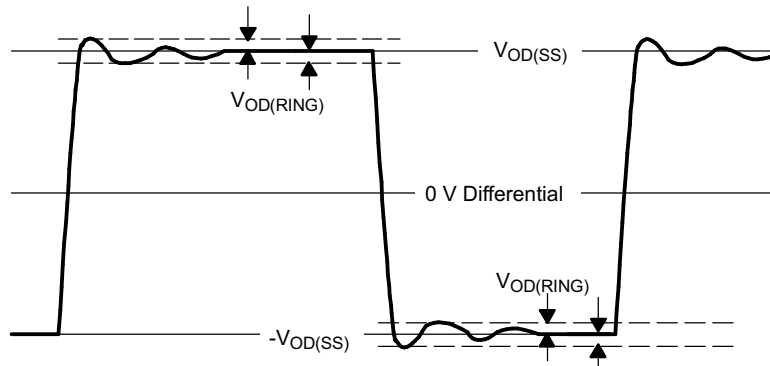
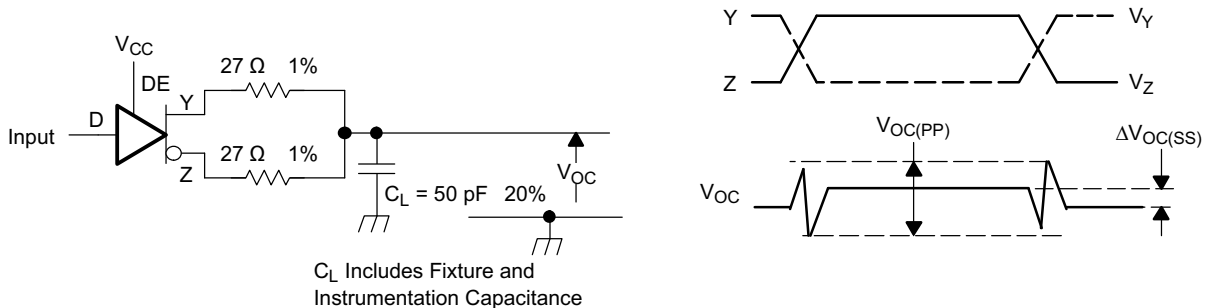


Figure 3. $V_{OD(RING)}$ Waveform and Definitions

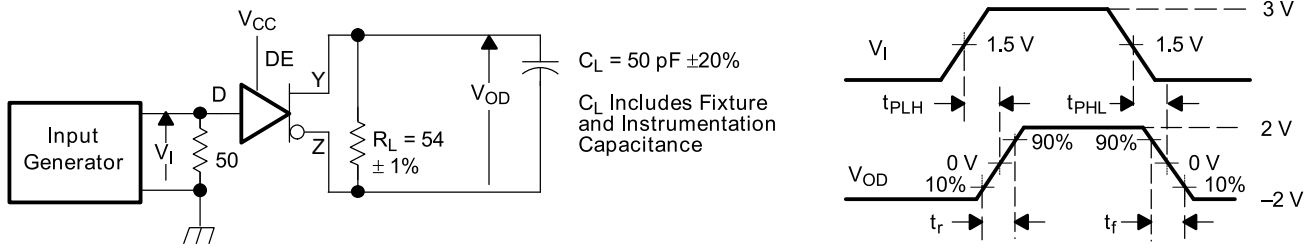
$V_{OD(RING)}$ is measured at four points on the output waveform, corresponding to overshoot and undershoot from the $V_{OD(H)}$ and $V_{OD(L)}$ steady state values.



Input: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6ns$, $t_f < 6ns$, $Z_O = 50 \Omega$

Figure 4. Test Circuit and Definitions for the Driver Common-Mode Output Voltage

PARAMETER MEASUREMENT INFORMATION (continued)



Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6 \text{ ns}$, $t_f < 6 \text{ ns}$, $Z_0 = 50$

Figure 5. Driver Switching Test Circuit and Voltage Waveforms

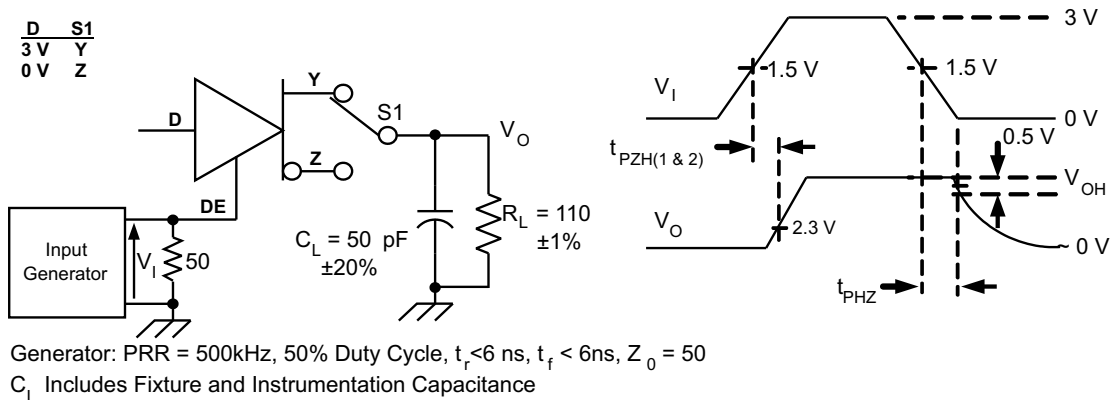


Figure 6. Driver High-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

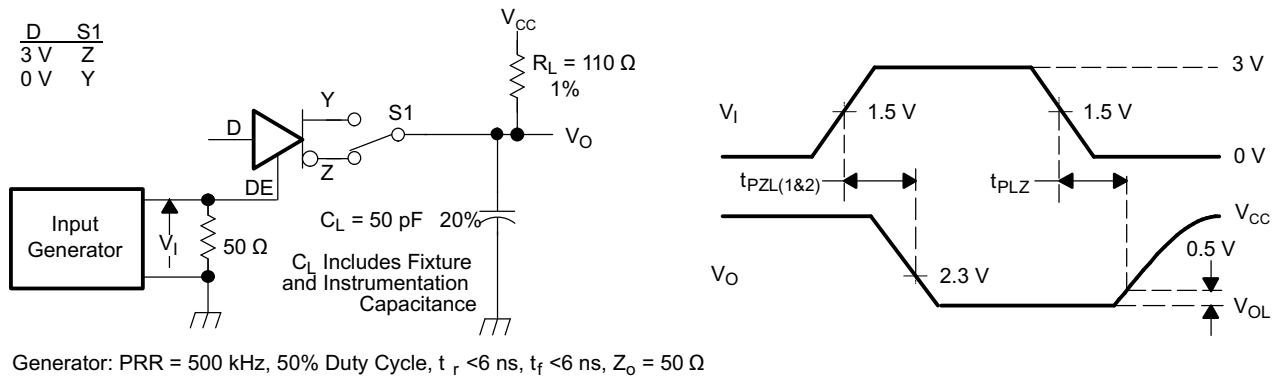


Figure 7. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

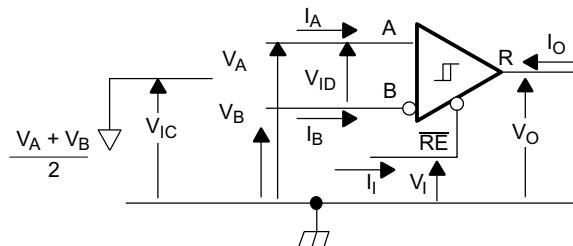


Figure 8. Receiver Voltage and Current Definitions

PARAMETER MEASUREMENT INFORMATION (continued)

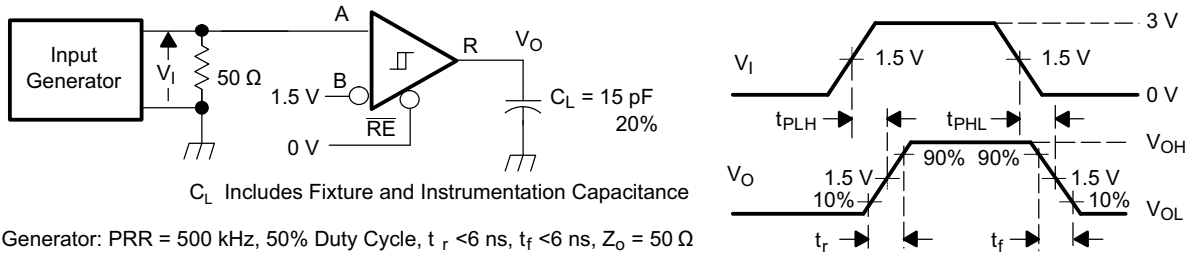


Figure 9. Receiver Switching Test Circuit and Voltage Waveforms

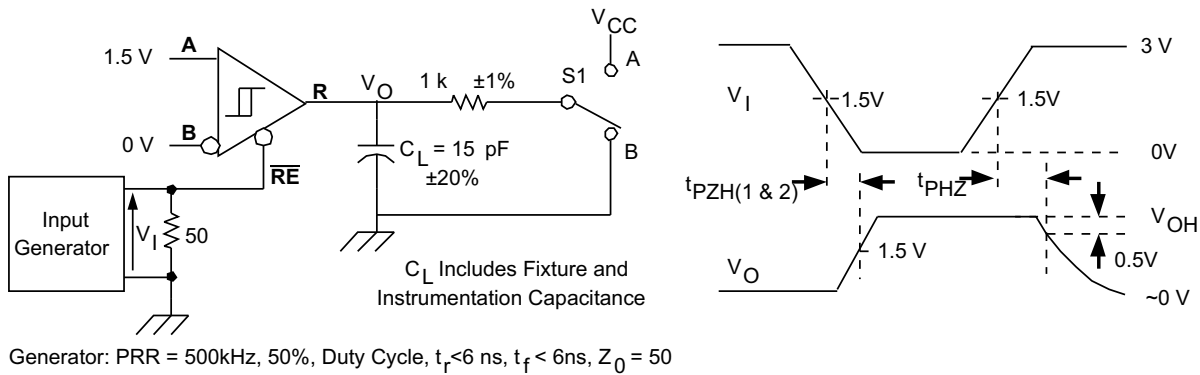


Figure 10. Receiver High-Level Enable and Disable Time Test Circuit and Voltage Waveforms

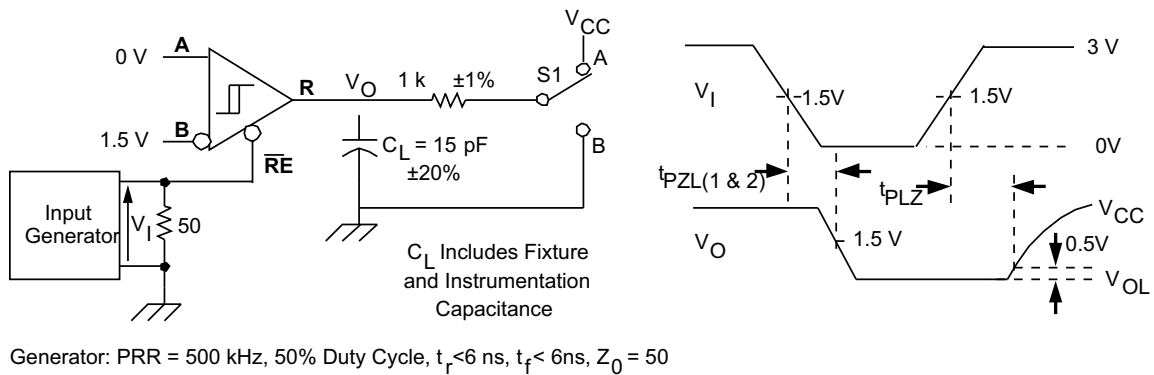


Figure 11. Receiver Enable Time From Standby (Driver Disabled)

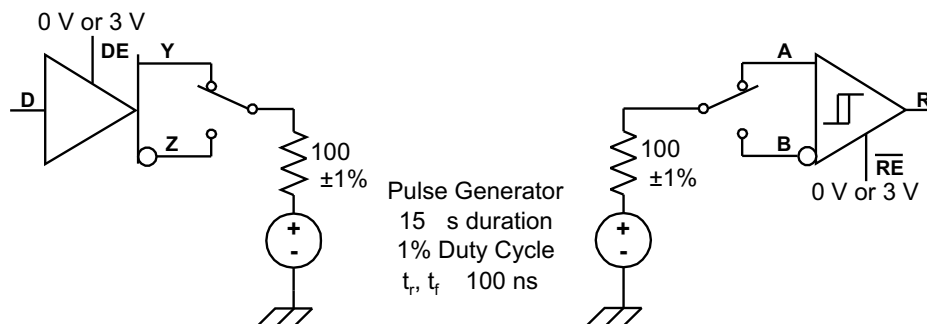


Figure 12. Test Circuit, Transient Over Voltage Test

DEVICE INFORMATION

LOW-POWER SHUTDOWN MODE

When both the driver and receiver are disabled (\overline{RE} high and \overline{DE} low) the device is in shutdown mode. If the enable inputs are in this state for less than 60 ns, the device does not enter shutdown mode. This guards against inadvertently entering shutdown mode during driver/receiver enabling. Only when the enable inputs are held in this state for 300 ns or more, the device is assured to be in shutdown mode. In this low-power shutdown mode, most internal circuitry is powered down, and the supply current is typically less than 1 nA. When either the driver or the receiver is re-enabled, the internal circuitry becomes active.

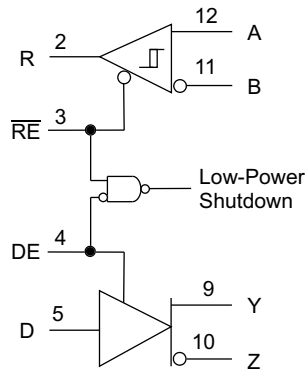


Figure 13. Low-Power Shutdown Logic Diagram

If only the driver is re-enabled (\overline{DE} transitions to high) the driver outputs are driven according to the D input after the enable times given by t_{PZH2} and t_{PZL2} in the driver switching characteristics. If the D input is open when the driver is enabled, the driver outputs default to A high and B low, in accordance with the driver failsafe feature.

If only the receiver is re-enabled (\overline{RE} transitions to low) the receiver output is driven according to the state of the bus inputs (A and B) after the enable times given by t_{PZH2} and t_{PZL2} in the receiver switching characteristics. If there is no valid state on the bus the receiver responds as described in the failsafe operation section.

If both the receiver and driver are re-enabled simultaneously, the receiver output is driven according to the state of the bus inputs (A and B) and the driver output is driven according to the D input. Note that the state of the active driver affects the inputs to the receiver. Therefore, the receiver outputs are valid as soon as the driver outputs are valid.

**DEVICE INFORMATION (continued)
FUNCTION TABLES**

**SN65HVD33, SN65HVD34, SN65HVD35, SN65HVD38,
SN65HVD39 DRIVER**

| INPUTS | | OUTPUTS | |
|--------|-----------|---------|---|
| D | DE | Y | Z |
| H | H | H | L |
| L | H | L | H |
| X | L or open | Z | Z |
| Open | H | L | H |

**SN65HVD33, SN65HVD34, SN65HVD35, SN65HVD38,
SN65HVD39 RECEIVER**

| DIFFERENTIAL INPUTS $V_{ID} = V_A - V_B$ | ENABLE RE | OUTPUT R |
|---|--------------|-------------|
| $V_{ID} \leq -0.2 \text{ V}$ | L | L |
| $-0.2 \text{ V} < V_{ID} < -0.02 \text{ V}$ | L | ? |
| $-0.02 \text{ V} \leq V_{ID}$ | L | H |
| X | H or open | Z |
| Open Circuit | L | H |
| Idle circuit | L | H |
| Short Circuit, $V_A = V_B$ | L | H |

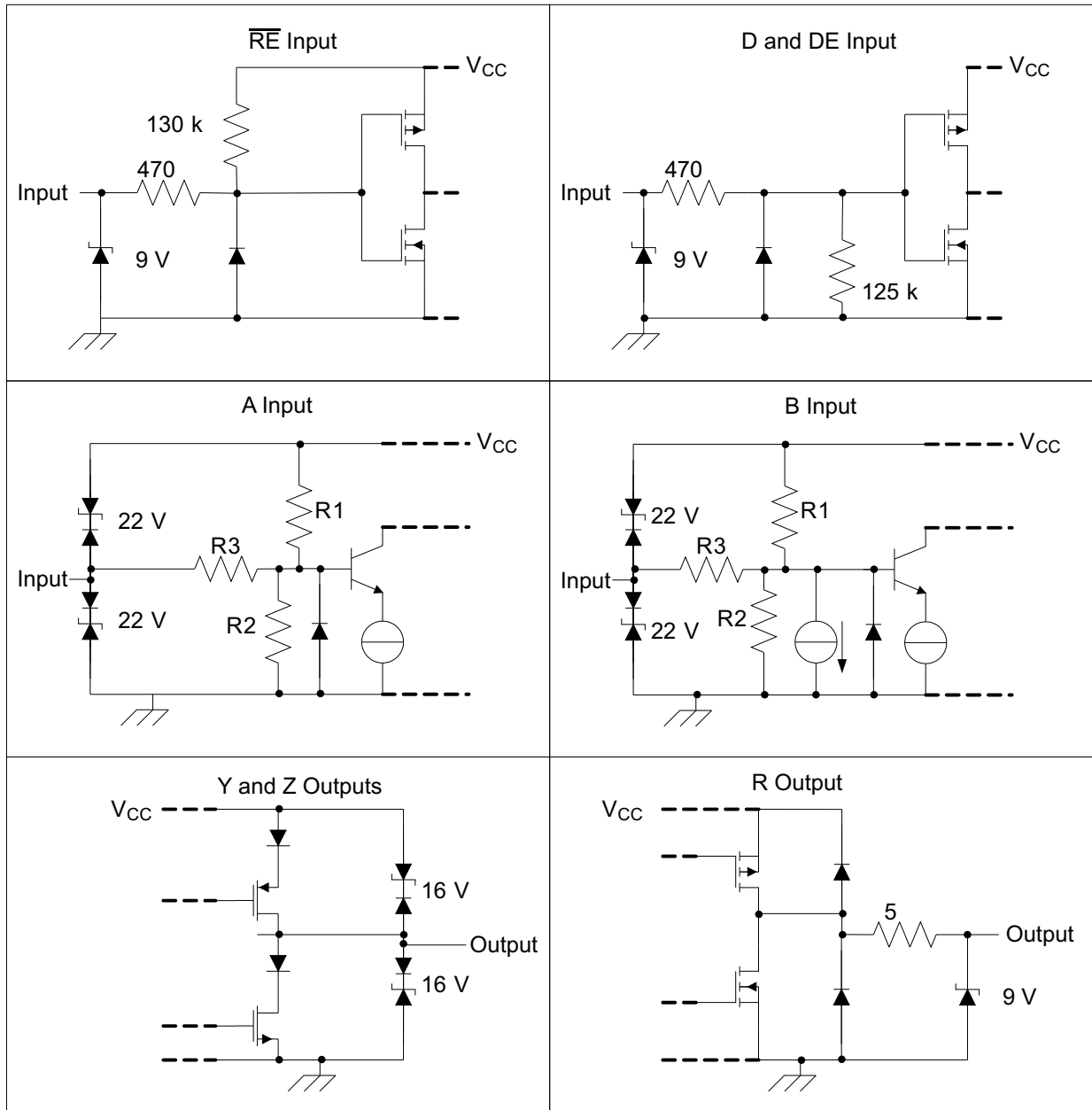
**SN65HVD30, SN65HVD31, SN65HVD32, SN65HVD36,
SN65HVD37 DRIVER**

| INPUT D | OUTPUTS | |
|------------|---------|---|
| | Y | Z |
| H | H | L |
| L | L | H |
| Open | L | H |

**SN65HVD30, SN65HVD31, SN65HVD32, SN65HVD36,
SN65HVD37 RECEIVER**

| DIFFERENTIAL INPUTS $V_{ID} = V_A - V_B$ | OUTPUT R |
|---|-------------|
| $V_{ID} \leq -0.2 \text{ V}$ | L |
| $-0.2 \text{ V} < V_{ID} < -0.02 \text{ V}$ | ? |
| $-0.02 \text{ V} \leq V_{ID}$ | H |
| Open Circuit | H |
| Idle circuit | H |
| Short Circuit, $V_A = V_B$ | H |

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



| | R1/R2 | R3 |
|---|-------|--------|
| SN65HVD30, SN65HVD33, SN65HVD36, SN65HVD38 | 9 kΩ | 45 kΩ |
| SN65HVD31, SN65HVD32, SN65HVD34, SN65HVD35, SN65HVD37, SN65HVD38, SN65HVD39 | 36 kΩ | 180 kΩ |

TYPICAL CHARACTERISTICS

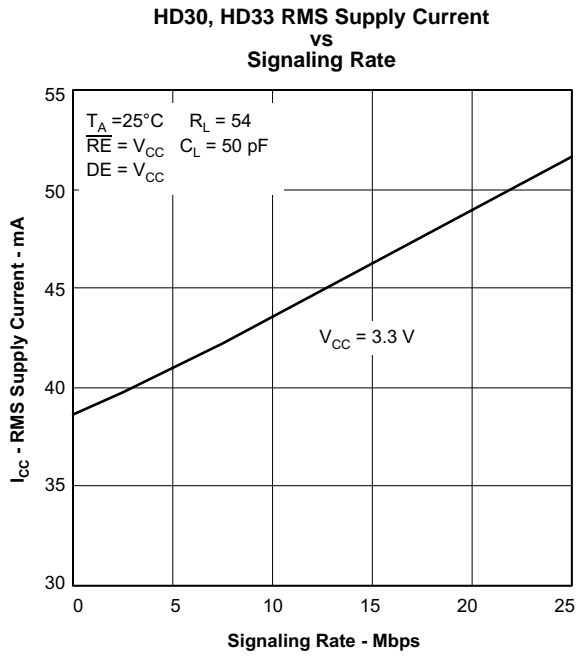


Figure 14.

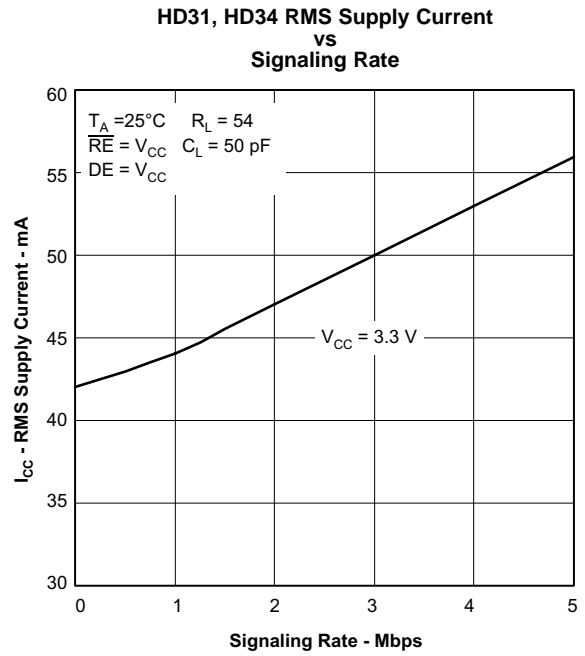


Figure 15.

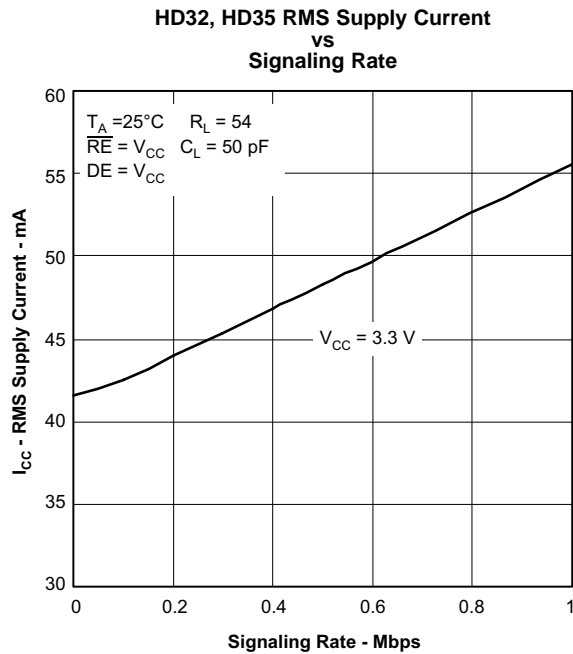
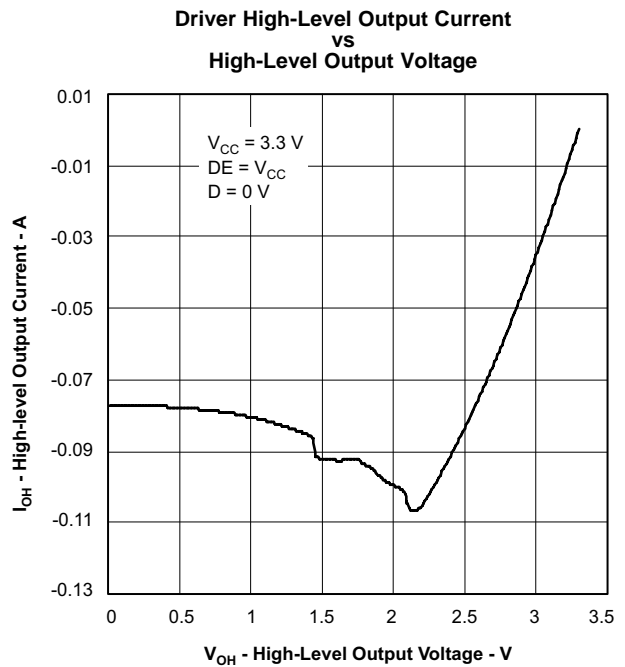
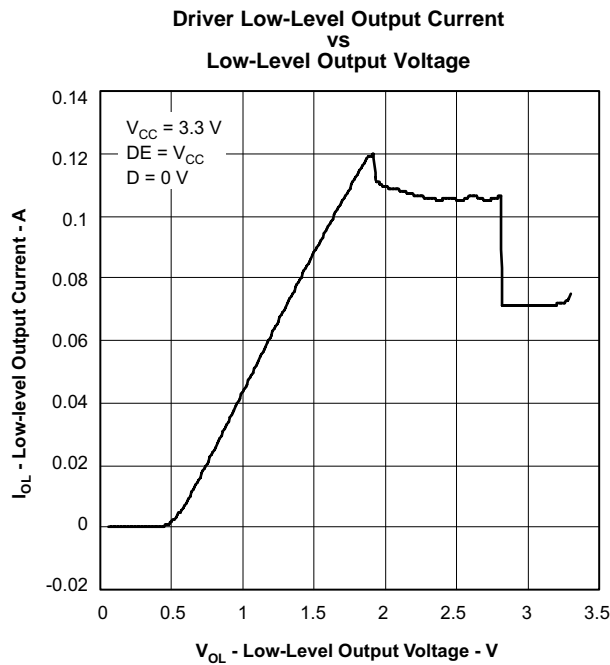
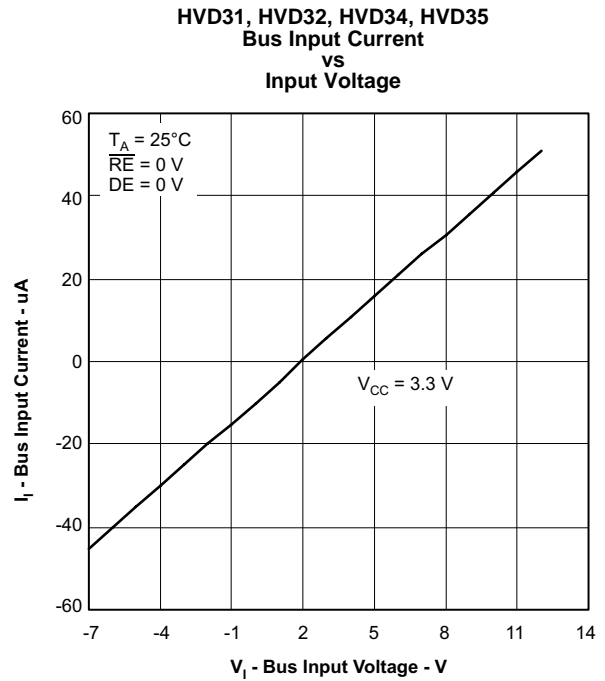
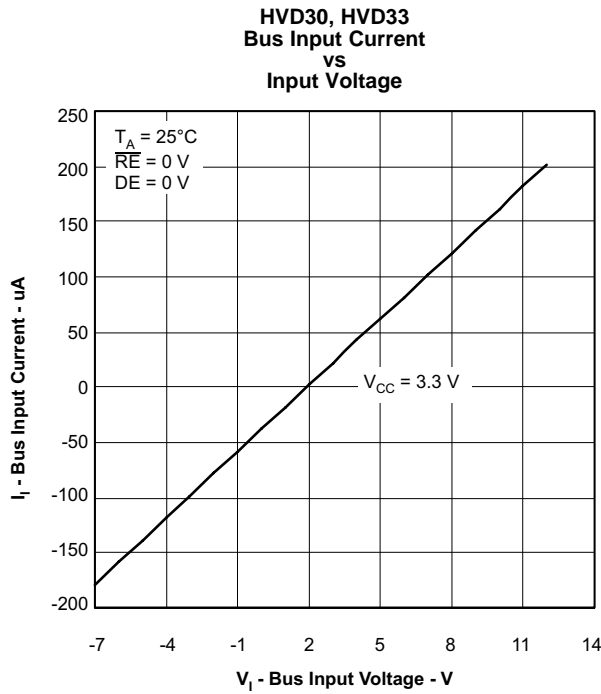
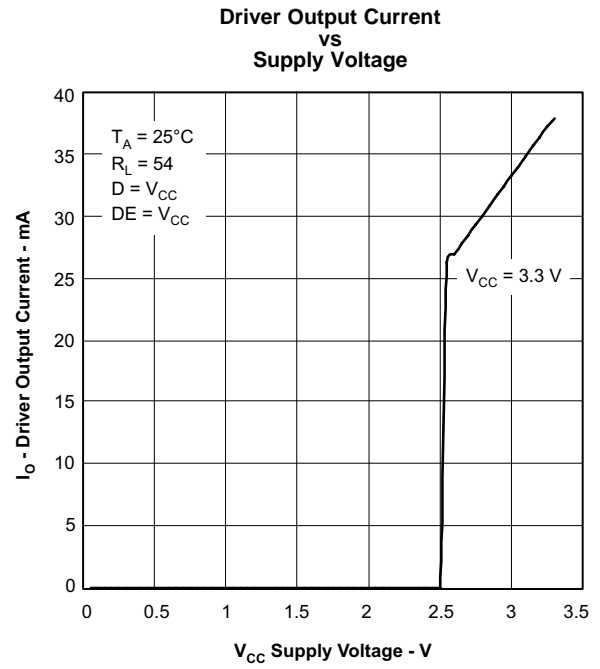
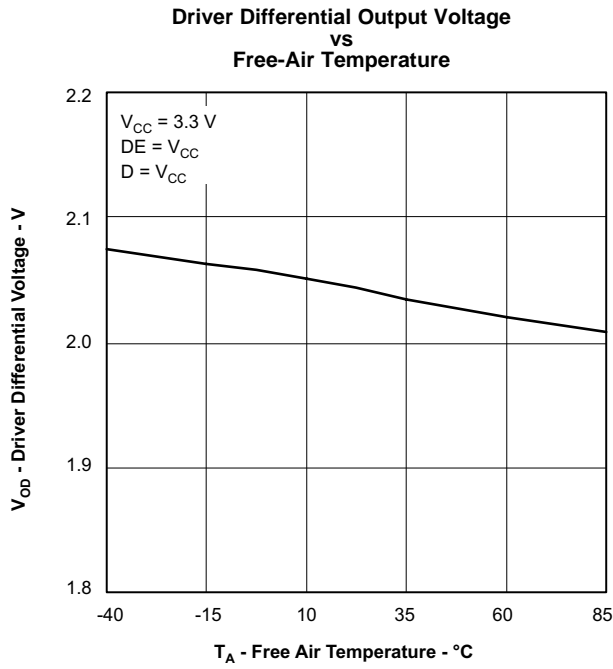


Figure 16.

TYPICAL CHARACTERISTICS (continued)



TYPICAL CHARACTERISTICS (continued)



PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| SN65HVD33D | PREVIEW | SOIC | D | 14 | 50 | TBD | Call TI | Call TI |
| SN65HVD33DR | PREVIEW | SOIC | D | 14 | 2500 | TBD | Call TI | Call TI |
| SN65HVD34D | PREVIEW | SOIC | D | 14 | 50 | TBD | Call TI | Call TI |
| SN65HVD34DR | PREVIEW | SOIC | D | 14 | 50 | TBD | Call TI | Call TI |
| SN65HVD35D | PREVIEW | SOIC | D | 14 | 50 | TBD | Call TI | Call TI |
| SN65HVD35DR | PREVIEW | SOIC | D | 14 | 2500 | TBD | Call TI | Call TI |

⁽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) 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.

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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PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| SN65HVD33D | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD33DG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD33DR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD33DRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD34D | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD34DG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD34DR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD34DRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD35D | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD35DG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD35DR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| SN65HVD35DRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

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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.

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)

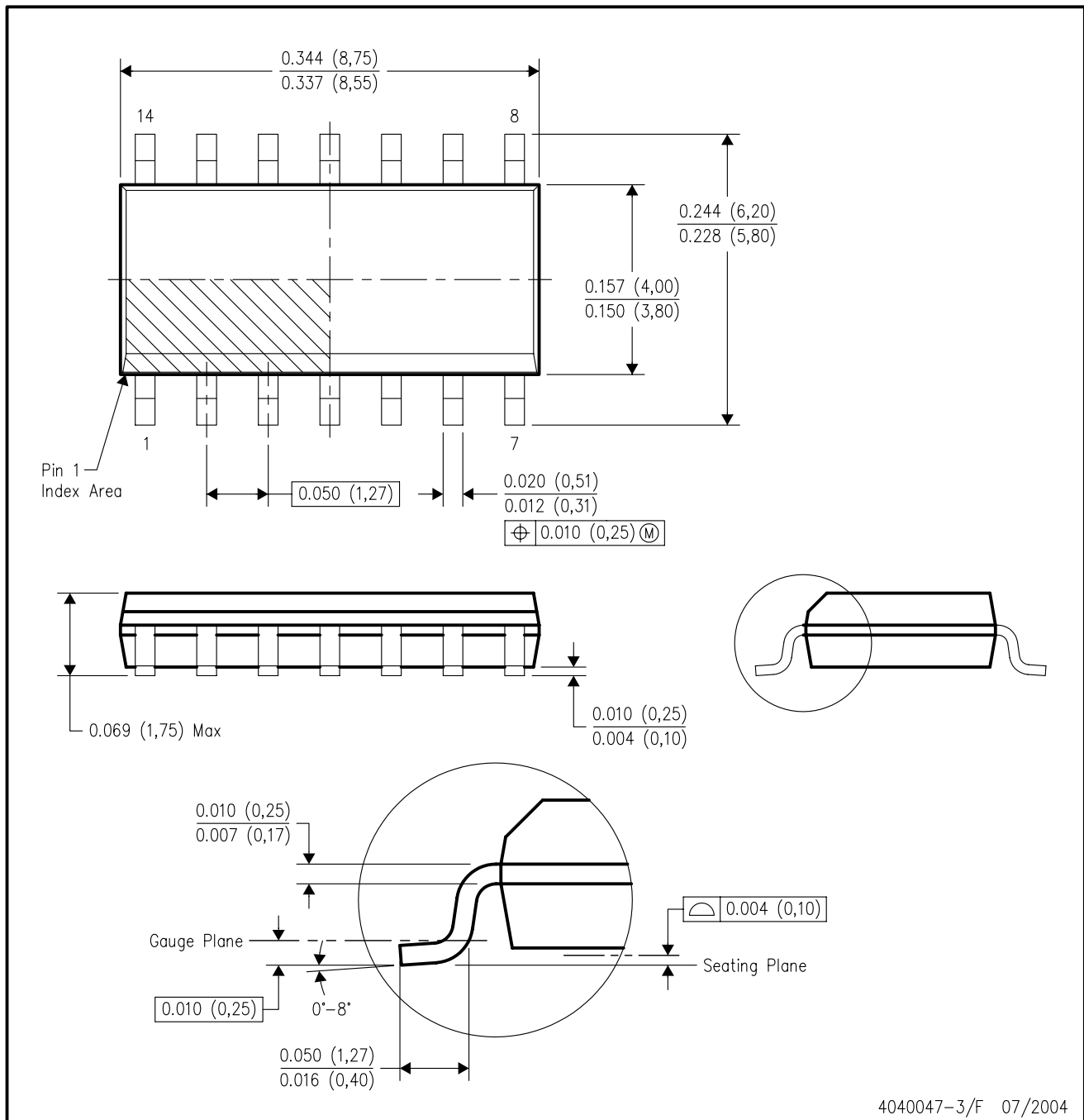
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



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- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-012 variation AB.

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