

SN65HVD7x 3.3-V Supply RS-485 With IEC ESD Protection

1 Features

- Small-size VSSOP Packages Save Board Space, or SOIC for Drop-in Compatibility
- Bus I/O Protection
 - $>\pm 15$ kV HBM Protection
 - $>\pm 12$ kV IEC 61000-4-2 Contact Discharge
 - $>\pm 4$ kV IEC 61000-4-4 Fast Transient Burst
- Extended Industrial Temperature Range
–40°C to 125°C
- Large Receiver Hysteresis (80 mV) for Noise Rejection
- Low Unit-Loading Allows Over 200 Connected Nodes
- Low Power Consumption
 - Low Standby Supply Current: $< 2 \mu\text{A}$
 - $I_{\text{CC}} < 1 \text{ mA}$ Quiescent During Operation
- 5-V Tolerant Logic Inputs Compatible With 3.3-V or 5-V Controllers
- Signaling Rate Options Optimized for: 250 kbps, 20 Mbps, 50 Mbps

2 Applications

- Factory Automation
- Telecommunications Infrastructure
- Motion Control

3 Description

These devices have robust 3.3-V drivers and receivers in a small package for demanding industrial applications. The bus pins are robust to ESD events with high levels of protection to Human-Body Model and IEC Contact Discharge specifications.

Each of these devices combines a differential driver and a differential receiver which operate from a single 3.3-V power supply. The driver differential outputs and the receiver differential inputs are connected internally to form a bus port suitable for half-duplex (two-wire bus) communication. These devices feature a wide common-mode voltage range making the devices suitable for multi-point applications over long cable runs. These devices are characterized from –40°C to 125°C.

Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---------------------------------------|-----------|-------------------|
| SN65HVD72, SN65HVD75, SN65HVD78 | SOIC (8) | 4.91 mm x 3.90 mm |
| | VSSOP (8) | 3.00 mm x 3.00 mm |
| | VSON (8) | |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application Diagram

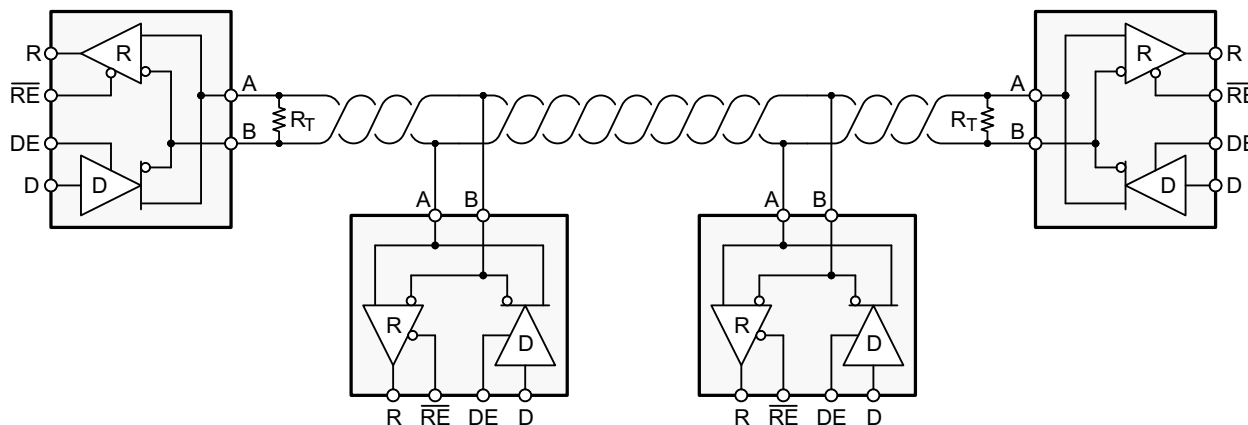


Table of Contents

| | | | |
|---|-----------|--|-----------|
| 1 Features | 1 | 9.1 Overview | 15 |
| 2 Applications | 1 | 9.2 Functional Block Diagram | 15 |
| 3 Description | 1 | 9.3 Feature Description | 15 |
| 4 Revision History | 2 | 9.4 Device Functional Modes | 15 |
| 5 Device Comparison Table | 4 | 10 Application and Implementation | 17 |
| 6 Pin Configuration and Functions | 4 | 10.1 Application Information | 17 |
| 7 Specifications | 5 | 10.2 Typical Application | 18 |
| 7.1 Absolute Maximum Ratings | 5 | 11 Power Supply Recommendations | 24 |
| 7.2 ESD Ratings | 5 | 12 Layout | 25 |
| 7.3 Recommended Operating Conditions | 5 | 12.1 Layout Guidelines | 25 |
| 7.4 Thermal Information | 6 | 12.2 Layout Example | 25 |
| 7.5 Electrical Characteristics | 6 | 13 Device and Documentation Support | 26 |
| 7.6 Power Dissipation | 7 | 13.1 Device Support | 26 |
| 7.7 Switching Characteristics: 250 kbps Device (SN65HVD72) Bit Time $\geq 4 \mu\text{s}$ | 7 | 13.2 Documentation Support | 26 |
| 7.8 Switching Characteristics: 20 Mbps Device (SN65HVD75) Bit Time $\geq 50 \text{ ns}$ | 8 | 13.3 Related Links | 26 |
| 7.9 Switching Characteristics: 50 Mbps Device (SN65HVD78) Bit Time $\geq 20 \text{ ns}$ | 8 | 13.4 Community Resources | 26 |
| 7.10 Typical Characteristics | 9 | 13.5 Trademarks | 26 |
| 8 Parameter Measurement Information | 11 | 13.6 Electrostatic Discharge Caution | 26 |
| 9 Detailed Description | 15 | 13.7 Glossary | 26 |
| | | 14 Mechanical, Packaging, and Orderable Information | 27 |

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision C (September 2013) to Revision D | Page |
|--|----------|
| • Added <i>Pin Configuration and Functions</i> section, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section | 1 |

| Changes from Revision B (June 2012) to Revision C | Page |
|--|-----------|
| • Deleted Feature: $> \pm 12 \text{ kV}$ IEC61000-4-2 Air-Gap Discharge | 1 |
| • Added Footnote 2 to the Absolute Maximum Ratings table | 5 |
| • Changed the Switching Characteristics conditions statement From: 250 kbps devices (SN65HVD70, 71, 72) bit time $> 4 \mu\text{s}$ To: 250 kbps device (SN65HVD72) bit time $\geq 4 \mu\text{s}$ | 7 |
| • Changed the Switching Characteristics conditions statement From: 250 kbps devices (SN65HVD73, 74, 75) bit time $> 50 \text{ ns}$ To: 250 kbps device (SN65HVD75) bit time $\geq 50 \text{ ns}$ | 8 |
| • Changed the Switching Characteristics conditions statement From: 250 kbps devices (SN65HVD76, 77, 78) bit time $> 20 \text{ ns}$ To: 250 kbps device (SN65HVD78) bit time $\geq 20 \text{ ns}$ | 8 |
| • Added note : $R_L = 54 \Omega$ to Figure 6 , Figure 7 , and Figure 8 | 9 |
| • Added the DGK package to the SN65HVD72, 75, 78 Logic Diagram | 15 |
| • Replaced the LOW-POWER STANDBY MODE section | 19 |
| • Added text to the Transient Protection section | 20 |

| Changes from Revision A (May 2012) to Revision B | Page |
|---|----------|
| • Added the SON-8 package and Nodes column to Device Comparison Table | 4 |
| • Changed the Voltage range at A or B Inputs MIN value From: -8 V To: -13 V | 5 |
| • Added footnote for free-air temperature to the Recommended Operating Conditions table | 5 |

| | |
|--|----|
| • Changed the Bus input current (disabled driver) TYP values for HVD78 $V_I = 12\text{ V}$ From: 150 To: 240 and $V_I = -7\text{ V}$ From: -120 To: -180 | 7 |
| • Changed, Thermal Information | 7 |
| • Changed, Thermal Characteristics | 7 |
| • Added TYP values to the Switching Characteristics table | 8 |
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| • Changed the SN65HVD72, 75, 78 Logic Diagram | 15 |
| • Added section: LOW-POWER STANDBY MODE | 19 |

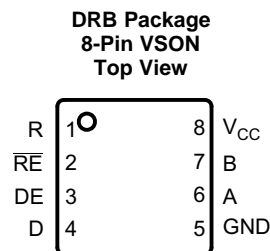
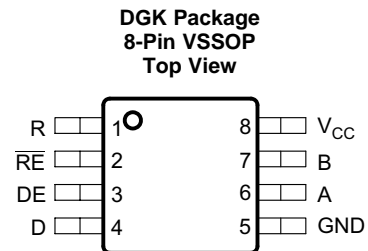
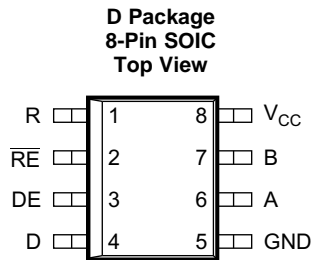
Changes from Original (March 2012) to Revision A
Page

| | |
|---|----|
| • Added VALUEs to the Thermal Characteristics table in the DEVICE INFORMATION section. | 7 |
| • Changed the Switching Characteristics condition statement From: 15 kbps devices (SN65HVD73, 74, 75) bit time > 65 ns To: 20 Mbps devices (SN65HVD73, 74, 75) bit time > 50 ns | 8 |
| • Changed the Switching Characteristics condition statement From: 50 kbps devices (SN65HVD76, 77, 78) bit time > 20 ns To: 50 Mbps devices (SN65HVD76, 77, 78) bit time > 20 ns | 8 |
| • Added Figure 4 to <i>Typical Characteristics</i> | 9 |
| • Added Figure 5 to <i>Typical Characteristics</i> | 9 |
| • Added Figure 6 to <i>Typical Characteristics</i> | 9 |
| • Added Figure 7 to <i>Typical Characteristics</i> | 9 |
| • Added Figure 8 to <i>Typical Characteristics</i> | 9 |
| • Added Figure 9 to <i>Typical Characteristics</i> | 9 |
| • Added <i>Application Information</i> section to data sheet. | 17 |

5 Device Comparison Table

| PART NUMBER | SIGNALING RATE | NODES | DUPLEX | ENABLES |
|-------------|----------------|-------|--------|---------------------|
| SN65HVD72 | Up to 250 kbps | 213 | Half | DE, \overline{RE} |
| SN65HVD75 | Up to 20 Mbps | | | |
| SN65HVD78 | Up to 50 Mbps | 96 | | |

6 Pin Configuration and Functions



Pin Functions

| PIN | | TYPE | DESCRIPTION |
|-----------------|--------|---------------------|--|
| NAME | NUMBER | | |
| A | 6 | Bus I/O | Driver output or receiver input (complementary to B) |
| B | 7 | Bus I/O | Driver output or receiver input (complementary to A) |
| D | 4 | Digital input | Driver data input |
| DE | 3 | Digital input | Active-high driver enable |
| GND | 5 | Reference potential | Local device ground |
| R | 1 | Digital output | Receive data output |
| \overline{RE} | 2 | Digital input | Active-low receiver enable |
| V_{CC} | 8 | Supply | 3-V to 3.6-V supply |

7 Specifications

7.1 Absolute Maximum Ratings

over recommended operating range (unless otherwise specified) ⁽¹⁾

| | MIN | MAX | UNIT |
|---|---------------------------------------|------|--------------------|
| Supply voltage, V_{CC} | -0.5 | 5.5 | V |
| Voltage at A or B inputs | -13 | 16.5 | |
| Input voltage at any logic pin | -0.3 | 5.7 | |
| Voltage input, transient pulse, A and B, through 100 Ω | -100 | 100 | |
| Receiver output current | -24 | 24 | mA |
| Junction temperature, T_J | | 170 | $^{\circ}\text{C}$ |
| Continuous total power dissipation | See Power Dissipation | | |
| Storage temperature, T_{stg} | -65 | 150 | $^{\circ}\text{C}$ |

- (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.

7.2 ESD Ratings

| | | VALUE | UNIT |
|-------------|---|--|-------------|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾ | ± 8000 |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾ | ± 1500 |
| | | JEDEC Standard 22, Test Method A115 (Machine Model), all pins | ± 300 |
| | | IEC 61000-4-2 ESD (Air-Gap Discharge), bus pins and GND ⁽³⁾ | ± 12000 |
| | | IEC 61000-4-2 ESD (Contact Discharge), bus pins and GND | ± 12000 |
| | | IEC 61000-4-4 EFT (Fast transient or burst) bus pins and GND | ± 4000 |
| | IEC 60749-26 ESD (Human Body Model), bus pins and GND | ± 15000 | V |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.
(3) By inference from contact discharge results, see [Application and Implementation](#).

7.3 Recommended Operating Conditions

| | | MIN | NOM | MAX | UNIT |
|----------------------|--|-----------|-----|----------|--------------------|
| V_{CC} | Supply voltage | 3 | 3.3 | 3.6 | V |
| V_I | Input voltage at any bus terminal (separately or common mode) ⁽¹⁾ | -7 | | 12 | V |
| V_{IH} | High-level input voltage (driver, driver enable, and receiver enable inputs) | 2 | | V_{CC} | V |
| V_{IL} | Low-level input voltage (driver, driver enable, and receiver enable inputs) | 0 | | 0.8 | V |
| V_{ID} | Differential input voltage | -12 | | 12 | V |
| I_O | Output current, driver | -60 | | 60 | mA |
| I_O | Output current, receiver | -8 | | 8 | mA |
| R_L | Differential load resistance | 54 | 60 | | Ω |
| C_L | Differential load capacitance | | 50 | | pF |
| $1/t_{UI}$ | Signaling rate | SN65HVD72 | | 250 | kbps |
| | | SN65HVD75 | | 20 | Mbps |
| | | SN65HVD78 | | 50 | Mbps |
| T_A ⁽²⁾ | Operating free-air temperature (See Thermal Information) | -40 | | 125 | $^{\circ}\text{C}$ |
| T_J | Junction temperature | -40 | | 150 | $^{\circ}\text{C}$ |

- (1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum, is used in this data sheet.
(2) Operation is specified for internal (junction) temperatures up to 150 $^{\circ}\text{C}$. Self-heating due to internal power dissipation should be considered for each application. Maximum junction temperature is internally limited by the thermal shutdown (TSD) circuit which disables the driver outputs when the junction temperature reaches 170 $^{\circ}\text{C}$.

7.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | SN65HVD72, SN65HVD75, SN65HVD78 | | | UNIT |
|-------------------------------|--|---------------------------------|-------------|------------|------|
| | | D (SOIC) | DGK (VSSOP) | DRB (VSON) | |
| | | 8 PINS | | | |
| R _{θJA} | Junction-to-ambient thermal resistance | 110.7 | 168.7 | 40 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 54.7 | 62.2 | 49.6 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | — | — | 3.9 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 51.3 | 89.5 | 15.5 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 9.2 | 7.4 | 0.6 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 50.7 | 87.9 | 15.7 | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

7.5 Electrical Characteristics

over recommended operating range (unless otherwise specified)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------|--|---------------|-----------------------|---------|------|
| V _{OD} | R _L = 60 Ω, 375 Ω on each output to -7 V to 12 V | See Figure 10 | 1.5 | 2 | V |
| | R _L = 54 Ω (RS-485) | See Figure 11 | 1.5 | 2 | |
| | R _L = 100 Ω (RS-422), T _J ≥ 0°C V _{CC} ≥ 3.2 V | | 2 | 2.5 | |
| Δ V _{OD} | Change in magnitude of driver differential output voltage R _L = 54 Ω, C _L = 50 pF | -50 | 0 | 50 | mV |
| V _{OC(SS)} | Steady-state common-mode output voltage Center of two 27-Ω load resistors | 1 | V _{CC} /2 | 3 | V |
| ΔV _{OC} | Change in differential driver output common-mode voltage Center of two 27-Ω load resistors | -50 | 0 | 50 | mV |
| V _{OC(PP)} | Peak-to-peak driver common-mode output voltage Center of two 27-Ω load resistors | | 200 | | mV |
| C _{OD} | Differential output capacitance | | 15 | | pF |
| V _{IT+} | Positive-going receiver differential input voltage threshold | See (1) | -70 | -20 | mV |
| V _{IT-} | Negative-going receiver differential input voltage threshold | -200 | -150 | See (1) | mV |
| V _{HYS} | Receiver differential input voltage threshold hysteresis (V _{IT+} - V _{IT-}) | 50 | 80 | | mV |
| V _{OH} | Receiver high-level output voltage I _{OH} = -8 mA | 2.4 | V _{CC} - 0.3 | | V |
| V _{OL} | Receiver low-level output voltage I _{OL} = 8 mA | | 0.2 | 0.4 | V |
| I _I | Driver input, driver enable, and receiver enable input current | -2 | | 2 | μA |
| I _{OZ} | Receiver output high-impedance current V _O = 0 V or V _{CC} , \overline{RE} at V _{CC} | -1 | | 1 | μA |
| I _{OS} | Driver short-circuit output current | -160 | | 160 | mA |

(1) Under any specific conditions, V_{IT+} is assured to be at least V_{HYS} higher than V_{IT-}.

Electrical Characteristics (continued)

over recommended operating range (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT | |
|-----------|---------------------------------------|--|--|--|------|------|--------------|---------|
| I_I | Bus input current (disabled driver) | $V_{CC} = 3$ to 3.6 V or $V_{CC} = 0$ V DE at 0 V | SN65HVD72 | $V_I = 12$ V | | 75 | 150 | μ A |
| | | | SN65HVD75 | $V_I = -7$ V | -100 | -40 | | |
| | | | SN65HVD78 | $V_I = 12$ V | | 240 | 333 | |
| | | | | $V_I = -7$ V | -267 | -180 | | |
| I_{CC} | Supply current (quiescent) | Driver and receiver enabled | DE = V_{CC} , $\overline{RE} = GND$ No load | | 750 | 950 | μ A | |
| | | | Driver enabled, receiver disabled | DE = V_{CC} , $\overline{RE} = V_{CC}$ No load | 300 | 500 | | |
| | | | Driver disabled, receiver enabled | DE = GND, $\overline{RE} = GND$ No load | 600 | 800 | | |
| | | | Driver and receiver disabled | $\overline{DE} = GND$, D = open $\overline{RE} = V_{CC}$, No load | 0.1 | 2 | | |
| | Supply current (dynamic) | See Typical Characteristics | | | | | | |
| T_{TSD} | Thermal shutdown junction temperature | | | | 170 | | $^{\circ}$ C | |

7.6 Power Dissipation

| PARAMETER | | TEST CONDITIONS | | VALUE | UNIT | |
|-----------|---|-----------------|--|-----------|------|----|
| PD | Power Dissipation driver and receiver enabled, $V_{CC} = 3.6$ V, $T_J = 150^{\circ}$ C 50% duty cycle square-wave signal at signaling rate: <ul style="list-style-type: none"> SN65HVD72 at 250 kbps SN65HVD75 at 20 Mbps SN65HVD78 at 50 Mbps | Unterminated | $R_L = 300 \Omega$ $C_L = 50$ pF (driver) | SN65HVD72 | 120 | mW |
| | | | | SN65HVD75 | 160 | |
| | | | | SN65HVD78 | 200 | |
| | | RS-422 load | $R_L = 100 \Omega$ $C_L = 50$ pF (driver) | SN65HVD72 | 155 | mW |
| | | | | SN65HVD75 | 195 | |
| | | | | SN65HVD78 | 230 | |
| | | RS-485 load | $R_L = 54 \Omega$ $C_L = 50$ pF (driver) | SN65HVD72 | 190 | mW |
| | | | | SN65HVD75 | 230 | |
| | | | | SN65HVD78 | 260 | |

7.7 Switching Characteristics: 250 kbps Device (SN65HVD72) Bit Time $\geq 4 \mu$ s

over recommended operating conditions

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--|--|------------------------------------|---|-----|-----|-----|---------|
| DRIVER | | | | | | | |
| t_r, t_f | Driver differential output rise or fall time | $R_L = 54 \Omega$ $C_L = 50$ pF | See Figure 12 | 0.3 | 0.7 | 1.2 | μ s |
| t_{PHL}, t_{PLH} | Driver propagation delay | | | | | | |
| $t_{SK(P)}$ | Driver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | | | |
| t_{PHZ}, t_{PLZ} | Driver disable time | | | | 0.1 | 0.4 | μ s |
| t_{PZH}, t_{PZL} | Driver enable time | Receiver enabled | See Figure 13 and Figure 14 | | 0.5 | 1 | μ s |
| | | Receiver disabled | | | | | |
| RECEIVER | | | | | | | |
| t_r, t_f | Receiver output rise or fall time | $C_L = 15$ pF | See Figure 15 | | 12 | 30 | ns |
| t_{PHL}, t_{PLH} | Receiver propagation delay time | | | | | | |
| $t_{SK(P)}$ | Receiver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | | | |
| t_{PLZ}, t_{PHZ} | Receiver disable time | | | | | | |
| $t_{PZL(1)}, t_{PZH(1)}, t_{PZL(2)}, t_{PZH(2)}$ | Receiver enable time | Driver enabled | See Figure 16 | | 20 | 50 | ns |
| | | Driver disabled | | | | | |

7.8 Switching Characteristics: 20 Mbps Device (SN65HVD75) Bit Time ≥ 50 ns

over recommended operating conditions

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--|--|--|--|-----|-----|---------------|---------------|
| DRIVER | | | | | | | |
| t_r, t_f | Driver differential output rise or fall time | $R_L = 54 \Omega$ $C_L = 50 \text{ pF}$ | See Figure 12 | 2 | 7 | 14 | ns |
| t_{PHL}, t_{PLH} | Driver propagation delay | | | 7 | 11 | 17 | ns |
| $t_{SK(P)}$ | Driver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 0 | 2 | ns |
| t_{PHZ}, t_{PLZ} | Driver disable time | | See Figure 13 and Figure 14 | | 12 | 50 | ns |
| t_{PZH}, t_{PZL} | Driver enable time | Receiver enabled | | | 10 | 20 | ns |
| | | Receiver disabled | | 3 | 7 | μs | |
| RECEIVER | | | | | | | |
| t_r, t_f | Receiver output rise or fall time | $C_L = 15 \text{ pF}$ | See Figure 15 | | 5 | 10 | ns |
| t_{PHL}, t_{PLH} | Receiver propagation delay time | | | | 60 | 70 | ns |
| $t_{SK(P)}$ | Receiver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 0 | 6 | ns |
| t_{PLZ}, t_{PHZ} | Receiver disable time | | | | 15 | 30 | ns |
| $t_{pZL(1)}, t_{pZH(1)}, t_{pZL(2)}, t_{pZH(2)}$ | Receiver enable time | Driver enabled | See Figure 16 | | 10 | 50 | ns |
| | | Driver disabled | See Figure 17 | | 3 | 8 | μs |

7.9 Switching Characteristics: 50 Mbps Device (SN65HVD78) Bit Time ≥ 20 ns

over recommended operating conditions

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--|--|--|--|-----|-----|-----|---------------|
| DRIVER | | | | | | | |
| t_r, t_f | Driver differential output rise or fall time | $R_L = 54 \Omega$ $C_L = 50 \text{ pF}$ | See Figure 12 | 1 | 3 | 6 | ns |
| t_{PHL}, t_{PLH} | Driver propagation delay | | | | 9 | 15 | ns |
| $t_{SK(P)}$ | Driver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 0 | 1 | ns |
| t_{PHZ}, t_{PLZ} | Driver disable time | | See Figure 13 and Figure 14 | | 10 | 30 | ns |
| t_{PZH}, t_{PZL} | Driver enable time | Receiver enabled | | | 10 | 30 | ns |
| | | Receiver disabled | | | | 8 | μs |
| RECEIVER | | | | | | | |
| t_r, t_f | Receiver output rise or fall time | $C_L = 15 \text{ pF}$ | See Figure 15 | 1 | 3 | 6 | ns |
| t_{PHL}, t_{PLH} | Receiver propagation delay time | | | | | 35 | ns |
| $t_{SK(P)}$ | Receiver pulse skew, $ t_{PHL} - t_{PLH} $ | | | | | 2.5 | ns |
| t_{PLZ}, t_{PHZ} | Receiver disable time | | | | | 8 | 30 |
| $t_{pZL(1)}, t_{pZH(1)}, t_{pZL(2)}, t_{pZH(2)}$ | Receiver enable time | Driver enabled | See Figure 16 | | 10 | 30 | ns |
| | | Driver disabled | See Figure 17 | | 3 | 8 | μs |

7.10 Typical Characteristics

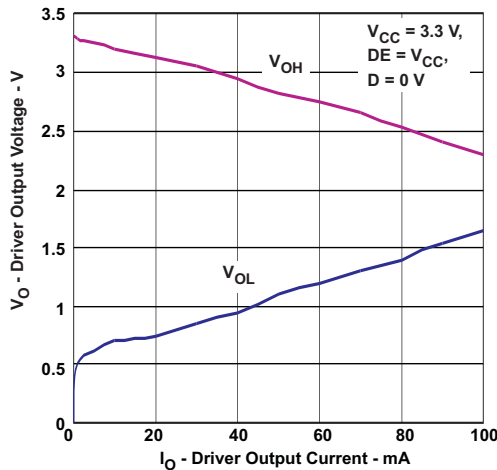


Figure 1. Driver Output Voltage vs Driver Output Current

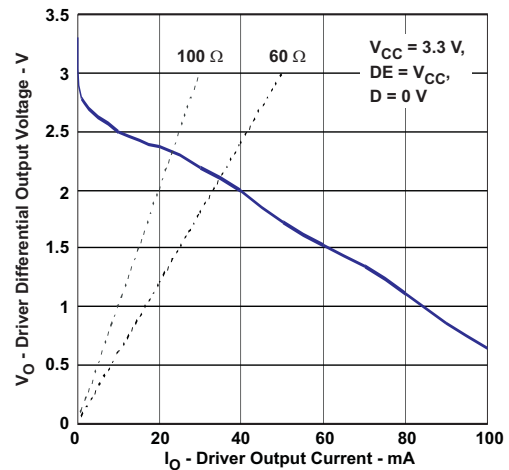


Figure 2. Driver Differential Output Voltage vs Driver Output Current

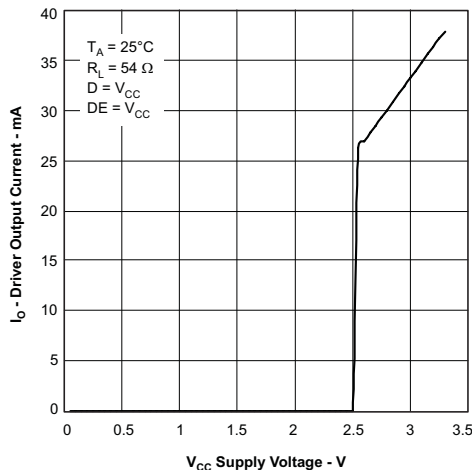


Figure 3. Driver Output Current vs Supply Voltage

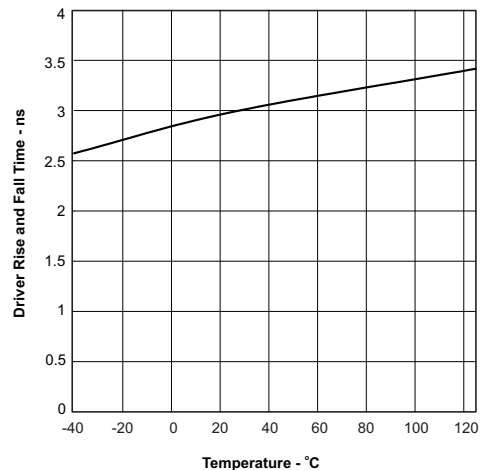


Figure 4. SN65HVD78 Driver Rise or Fall Time vs Temperature

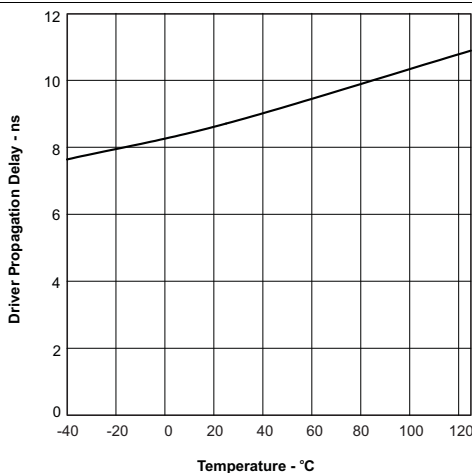


Figure 5. SN65HVD78 Driver Propagation Delay vs Temperature

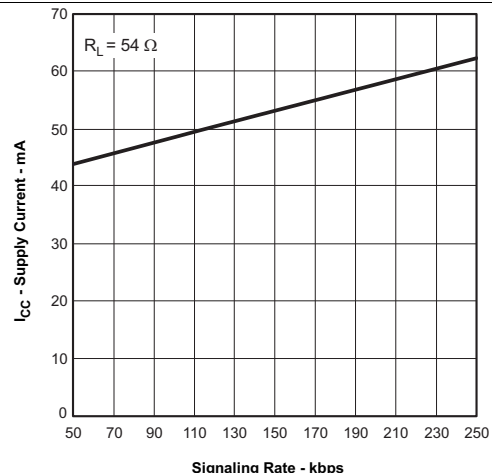


Figure 6. SN65HVD72 Supply Current vs Signal Rate

Typical Characteristics (continued)

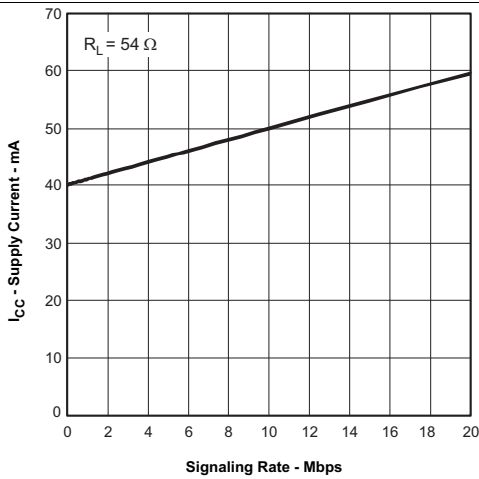


Figure 7. SN65HVD75 Supply Current vs Signal Rate

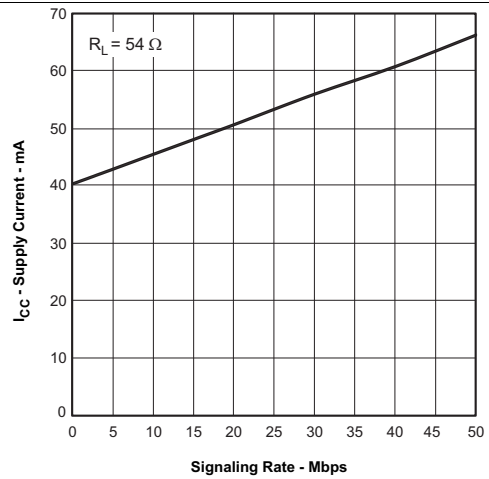


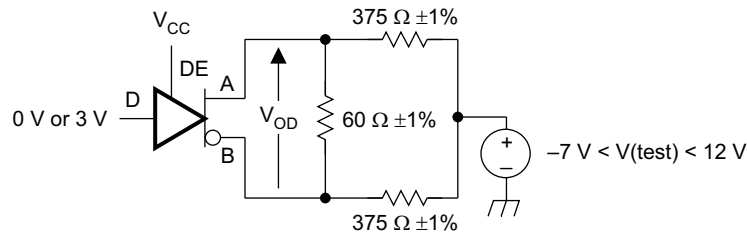
Figure 8. SN65HVD78 Supply Current vs Signal Rate



Figure 9. Receiver Output vs Input

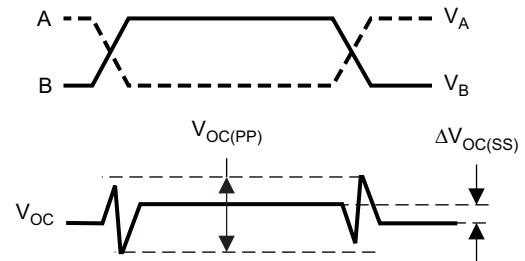
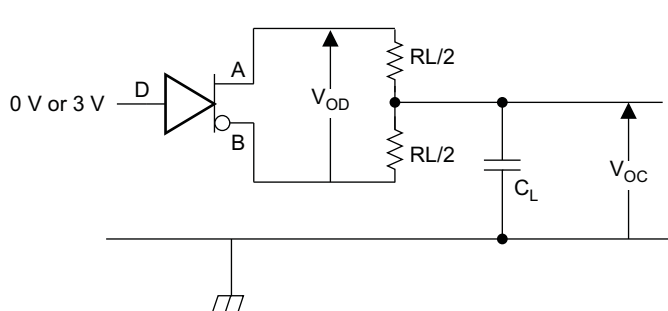
8 Parameter Measurement Information

Input generator rate is 100 kbps, 50% duty cycle, rise or fall time is less than 6 ns, output impedance is 50 Ω .



S0301-01

Figure 10. Measurement of Driver Differential Output Voltage With Common-Mode Load



S0302-01

Figure 11. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

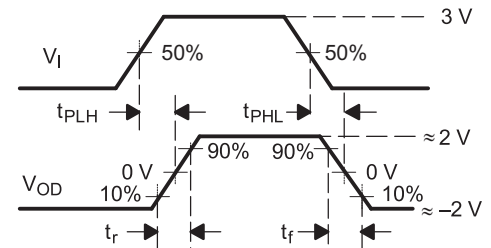
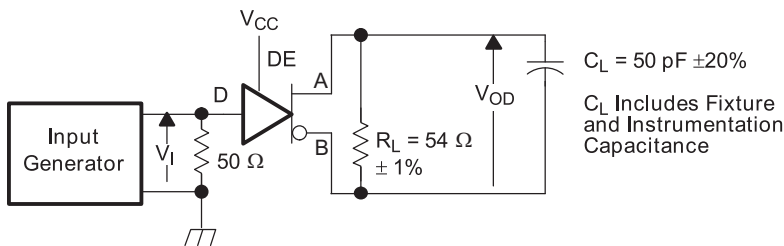
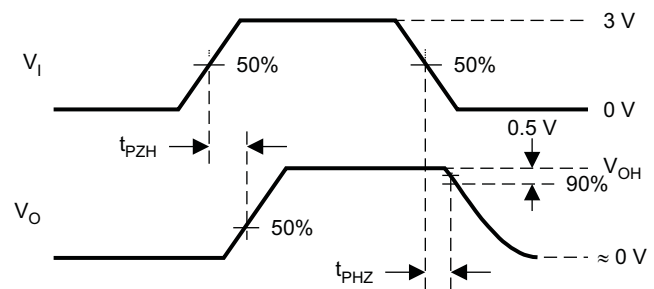
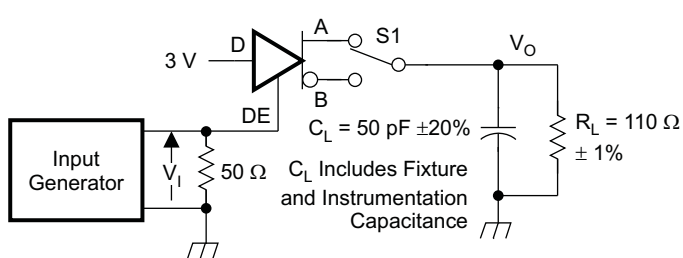


Figure 12. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

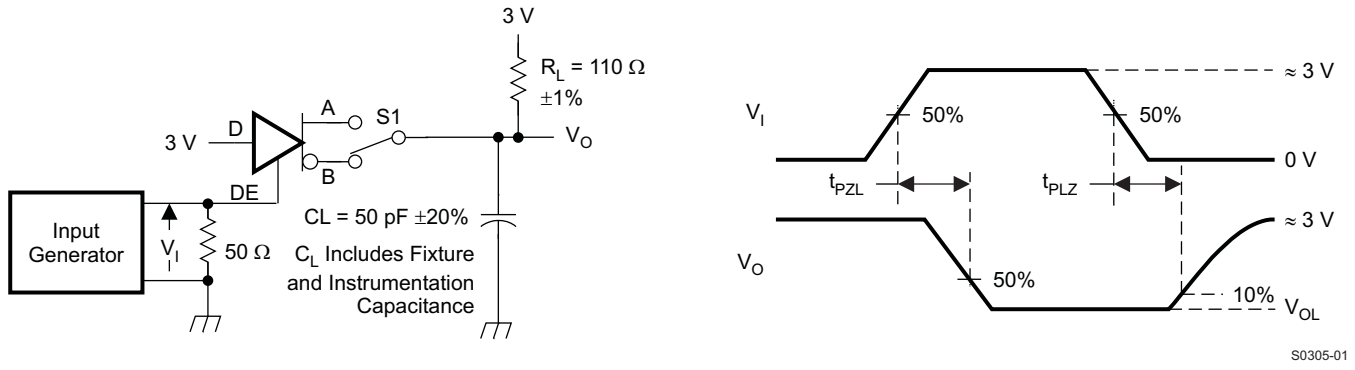


S0304-01

D at 3 V to test non-inverting output, D at 0 V to test inverting output.

Figure 13. Measurement of Driver Enable and Disable Times With Active High Output and Pulldown Load

Parameter Measurement Information (continued)



D at 0 V to test non-inverting output, D at 3 V to test inverting output.

Figure 14. Measurement of Driver Enable and Disable Times With Active Low Output and Pullup Load

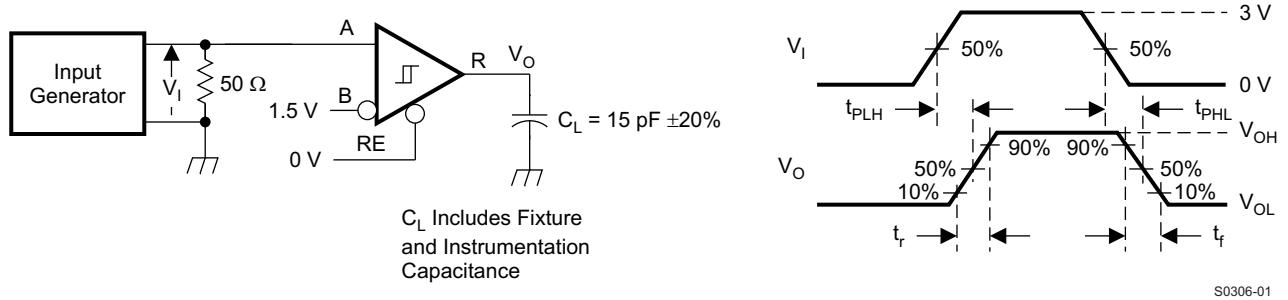
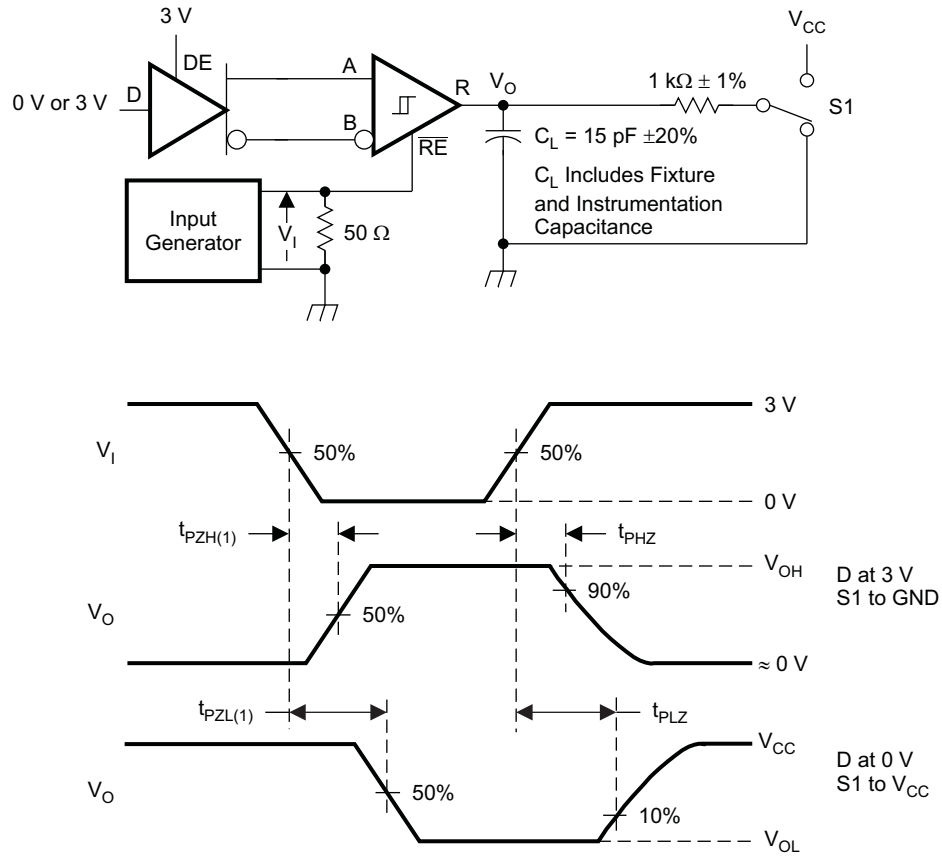


Figure 15. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

Parameter Measurement Information (continued)



S0307-01

Figure 16. Measurement of Receiver Enable and Disable Times With Driver Enabled

Parameter Measurement Information (continued)

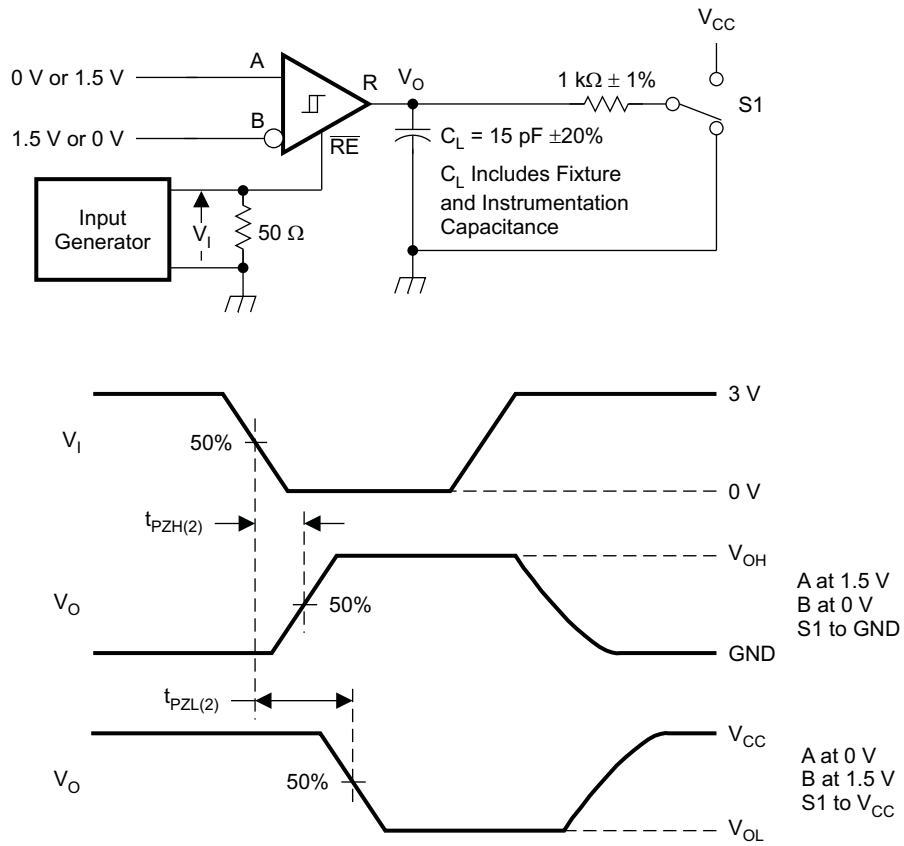


Figure 17. Measurement of Receiver Enable Times With Driver Disabled

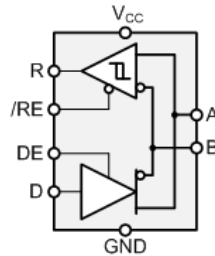
9 Detailed Description

9.1 Overview

The SN65HVD72, SN65HVD75, and SN65HVD78 are low-power, half-duplex RS-485 transceivers available in 3 speed grades suitable for data transmission up to 250 kbps, 20 Mbps, and 50 Mbps.

These devices have active-high driver enables and active-low receiver enables. A standby current of less than 2 μ A can be achieved by disabling both driver and receiver.

9.2 Functional Block Diagram



9.3 Feature Description

Internal ESD protection circuits protect the transceiver against electrostatic discharges (ESD) according to IEC 61000-4-2 of up to ± 12 kV, and against electrical fast transients (EFT) according to IEC 61000-4-4 of up to ± 4 kV.

The SN65HVD7x half-duplex family provides internal biasing of the receiver input thresholds in combination with large input threshold hysteresis. At a positive input threshold of $V_{IT+} = -20$ mV and an input hysteresis of $V_{HYS} = 50$ mV, the receiver output remains logic high under a bus-idle or bus-short condition even in the presence of 140-mV_{PP} differential noise without the need for external failsafe biasing resistors.

Device operation is specified over a wide ambient temperature range from -40°C to 125°C .

9.4 Device Functional Modes

When the driver enable pin, DE, is logic high, the differential outputs A and B follow the logic states at data input D. A logic high at D causes A to turn high and B to turn low. In this case the differential output voltage defined as $V_{OD} = V_A - V_B$ is positive. When D is low, the output states reverse, B turns high, A becomes low, and V_{OD} is negative.

When DE is low, both outputs turn high-impedance. In this condition the logic state at D is irrelevant. The DE pin has an internal pulldown resistor to ground; thus, when left open, the driver is disabled (high-impedance) by default. The D pin has an internal pullup resistor to V_{CC} ; thus, when left open while the driver is enabled, output A turns high and B turns low.

Table 1. Driver Function Table

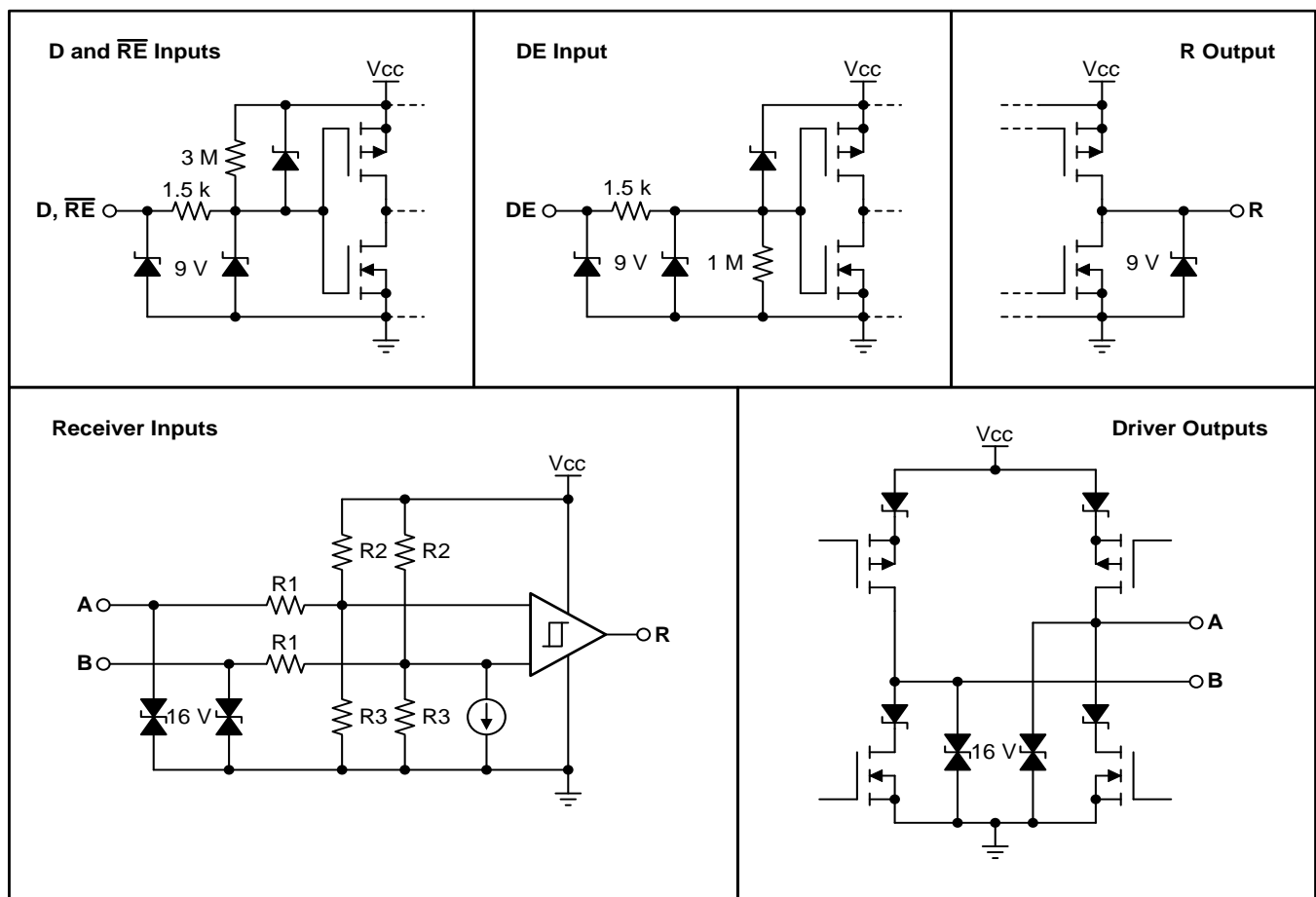
| INPUT | ENABLE | OUTPUTS | | DESCRIPTION |
|-------|--------|---------|---|------------------------------------|
| | | A | B | |
| H | H | H | L | Actively drive bus high |
| L | H | L | H | Actively drive bus low |
| X | L | Z | Z | Driver disabled |
| X | OPEN | Z | Z | Driver disabled by default |
| OPEN | H | H | L | Actively drive bus high by default |

When the receiver enable pin, \overline{RE} , is logic low, the receiver is enabled. When the differential input voltage defined as $V_{ID} = V_A - V_B$ is positive and higher than the positive input threshold, V_{IT+} , the receiver output, R, turns high. When V_{ID} is negative and lower than the negative input threshold, V_{IT-} , the receiver output turns low. If V_{ID} is between V_{IT+} and V_{IT-} , the output is indeterminate.

When \overline{RE} is logic high or left open, the receiver output is high-impedance and the magnitude and polarity of V_{ID} are irrelevant. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), the bus lines are shorted (short-circuit), or the bus is not actively driven (idle bus).

Table 2. Receiver Function Table

| DIFFERENTIAL INPUT | ENABLE | OUTPUT | DESCRIPTION |
|------------------------------|-----------------|--------|------------------------------|
| $V_{ID} = V_A - V_B$ | \overline{RE} | R | |
| $V_{IT+} < V_{ID}$ | L | H | Receive valid bus high |
| $V_{IT-} < V_{ID} < V_{IT+}$ | L | ? | Indeterminate bus state |
| $V_{ID} < V_{IT-}$ | L | L | Receive valid bus low |
| X | H | Z | Receiver disabled |
| X | OPEN | Z | Receiver disabled by default |
| Open-circuit bus | L | H | Failsafe high output |
| Short-circuit bus | L | H | Failsafe high output |
| Idle (terminated) bus | L | H | Failsafe high output |


Figure 18. Equivalent Input and Output Circuit Diagrams

10 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The SN65HVD72, SN65HVD75, and SN65HVD78 are half-duplex RS-485 transceivers commonly used for asynchronous data transmission. The driver and receiver enable pins allow for the configuration of different operating modes.

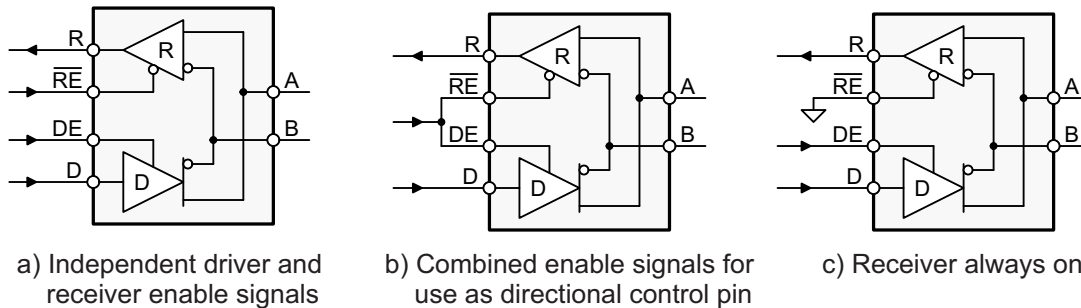


Figure 19. Transceiver Configurations

Using independent enable lines provides the most flexible control as it allows for the driver and the receiver to be turned on and off individually. While this configuration requires two control lines, it allows for selective listening into the bus traffic, whether the driver is transmitting data or not.

Combining the enable signals simplifies the interface to the controller by forming a single direction-control signal. In this configuration, the transceiver operates as a driver when the direction-control line is high, and as a receiver when the direction-control line is low.

Additionally, only one line is required when connecting the receiver-enable input to ground and controlling only the driver-enable input. In this configuration, a node not only receives the data from the bus, but also the data it sends and can verify that the correct data have been transmitted.

10.2 Typical Application

An RS-485 bus consists of multiple transceivers connected in parallel to a bus cable. To eliminate line reflections, each cable end is terminated with a termination resistor, R_T , whose value matches the characteristic impedance, Z_0 , of the cable. This method, known as parallel termination, allows for relatively high data rates over long cable lengths.

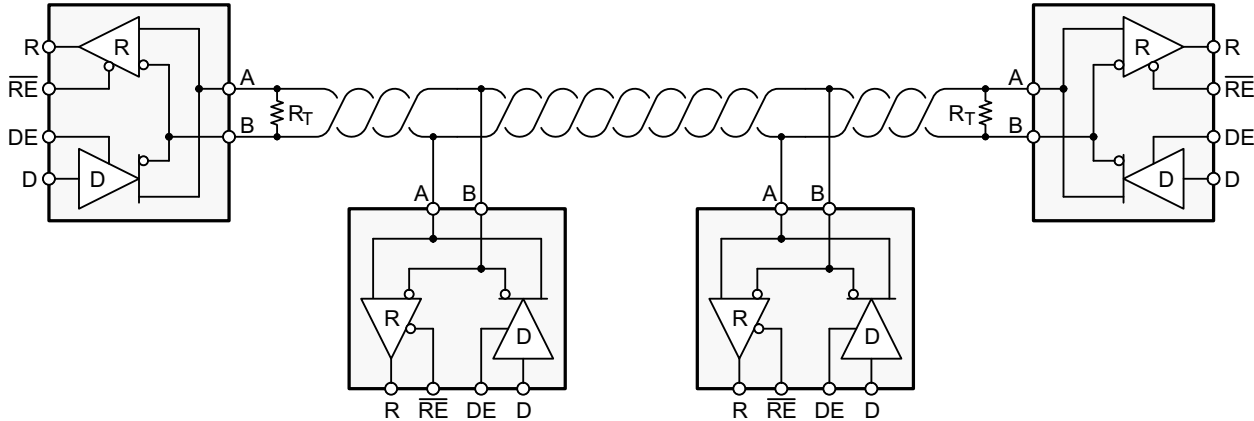


Figure 20. Typical RS-485 Network With SN65HVD7x Transceivers

Common cables used are unshielded twisted pair (UTP), such as low-cost CAT-5 cable with $Z_0 = 100 \Omega$, and RS-485 cable with $Z_0 = 120 \Omega$. Typical cable sizes are AWG 22 and AWG 24.

The maximum bus length is typically given as 4000 ft or 1200 m, and represents the length of an AWG 24 cable whose cable resistance approaches the value of the termination resistance, thus reducing the bus signal by half or 6 dB. Actual maximum usable cable length depends on the signaling rate, cable characteristics, and environmental conditions.

10.2.1 Design Requirements

RS-485 is a robust electrical standard suitable for long-distance networking that may be used in a wide range of applications with varying requirements, such as distance, data rate, and number of nodes.

10.2.1.1 Data Rate and Bus Length

There is an inverse relationship between data rate and bus length, meaning the higher the data rate, the shorter the cable length; and conversely, the lower the data rate, the longer the cable may be without introducing data errors. While most RS-485 systems use data rates between 10 kbps and 100 kbps, some applications require data rates up to 250 kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

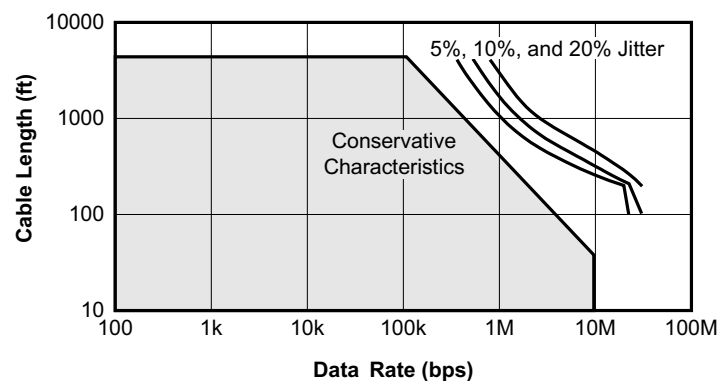


Figure 21. Cable Length vs Data Rate Characteristic

Typical Application (continued)

10.2.1.2 Stub Length

When connecting a node to the bus, the distance between the transceiver inputs and the cable trunk, known as the stub, should be as short as possible. Stubs present a non-terminated piece of bus line which can introduce reflections as the length of the stub increases. As a general guideline, the electrical length, or round-trip delay, of a stub should be less than one-tenth of the rise time of the driver, thus giving a maximum physical stub length as shown in [Equation 1](#).

$$L_{\text{stub}} \leq 0.1 \times t_r \times v \times c$$

where:

- t_r is the 10/90 rise time of the driver
 - c is the speed of light (3×10^8 m/s)
 - v is the signal velocity of the cable or trace as a factor of c
- (1)

Per [Equation 1](#), [Table 3](#) shows the maximum cable-stub lengths for the minimum driver output rise times of the SN65HVD7x half-duplex family of transceivers for a signal velocity of 78%.

Table 3. Maximum Stub Length

| DEVICE | MINIMUM DRIVER OUTPUT RISE TIME (ns) | MAXIMUM STUB LENGTH | |
|-----------|---|---------------------|------|
| | | (m) | (ft) |
| SN65HVD72 | 300 | 7 | 23 |
| SN65HVD75 | 2 | 0.05 | 0.16 |
| SN65HVD78 | 1 | 0.025 | 0.08 |

10.2.1.3 Bus Loading

The RS-485 standard specifies that a compliant driver must be able to drive 32 unit loads (UL), where 1 unit load represents a receiver input current of 1 mA at 12 V, or a load impedance of approximately 12 k Ω . Because the SN65HVD72 and SN65HVD75 have a receiver input current of 150 μ A at 12 V, they are 3/20 UL transceivers, and no more than 213 transceivers should be connected to the bus. Similarly, the SN65HVD78 has a receiver input current of 333 μ A at 12 V and is a 1/3 UL transceiver, meaning no more than 96 transceivers should be connected to the bus.

10.2.1.4 Receiver Failsafe

The differential receiver is failsafe to invalid bus states caused by:

- Open bus conditions such as a disconnected connector
- Shorted bus conditions such as cable damage shorting the twisted-pair together, or
- Idle bus conditions that occur when no driver on the bus is actively driving

In any of these cases, the differential receiver will output a failsafe logic high so that the output of the receiver is not indeterminate.

Receiver failsafe is accomplished by offsetting the receiver thresholds such that the input-indeterminate range does not include zero volts differential. To comply with the RS-422 and RS-485 standards, the receiver output must output a high when the differential input V_{ID} is more positive than 200 mV, and must output a low when V_{ID} is more negative than -200 mV. The receiver parameters which determine the failsafe performance are V_{IT+} , V_{IT-} , and V_{HYS} (the separation between V_{IT+} and V_{IT-}). As shown in [Electrical Characteristics](#), differential signals more negative than -200 mV will always cause a low receiver output, and differential signals more positive than 200 mV will always cause a high receiver output.

When the differential input signal is close to zero, it is still above the maximum V_{IT+} threshold of -20 mV, and the receiver output will be high. Only when the differential input is more than V_{HYS} below V_{IT+} will the receiver output transition to a low state. Therefore, the noise immunity of the receiver inputs during a bus fault condition includes the receiver hysteresis value, V_{HYS} , as well as the value of V_{IT+} .

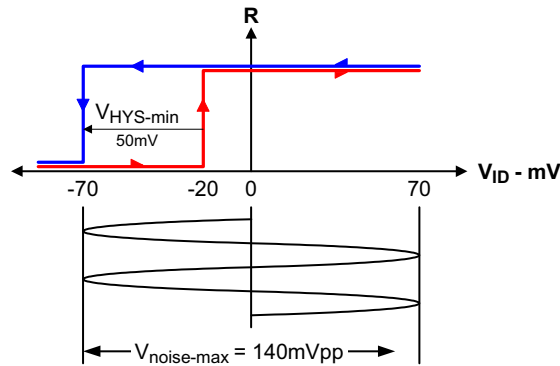


Figure 22. SN65HVD7x Noise Immunity

10.2.1.5 Transient Protection

The bus pins of the SN65HVD7x transceiver family possess on-chip ESD protection against ± 15 -kV human body model (HBM) and ± 12 -kV IEC 61000-4-2 contact discharge. The IEC-ESD test is far more severe than the HBM-ESD test. The 50% higher charge capacitance, C_S , and 78% lower discharge resistance, R_D , of the IEC-model produce significantly higher discharge currents than the HBM-model.

As stated in the IEC 61000-4-2 standard, contact discharge is the preferred test method; although IEC air-gap testing is less repeatable than contact testing, air discharge protection levels are inferred from the contact discharge test results.

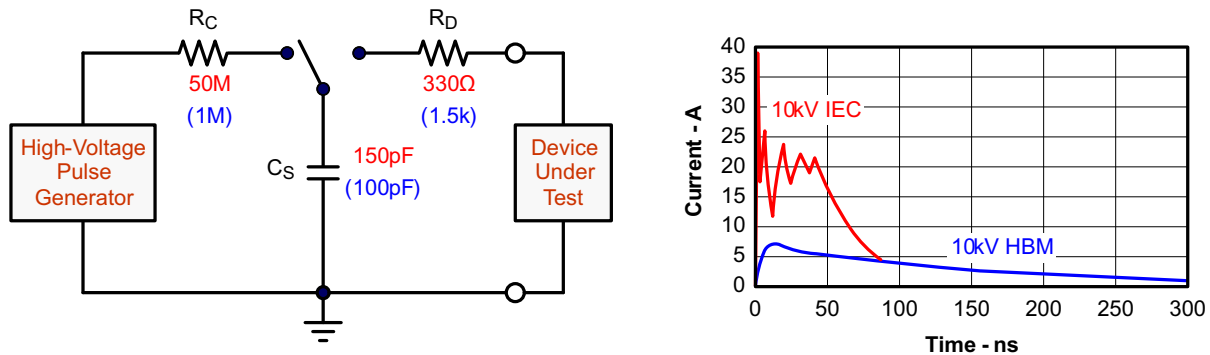


Figure 23. HBM and IEC-ESD Models and Currents in Comparison (HBM Values in Parenthesis)

The on-chip implementation of IEC ESD protection significantly increases the robustness of equipment. Common discharge events occur due to human contact with connectors and cables. Designers may choose to implement protection against longer duration transients, typically referred to as surge transients.

EFTs are generally caused by relay-contact bounce or the interruption of inductive loads. Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuit switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems.

Figure 24 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The left-hand diagram shows the relative pulse-power for a 0.5-kV surge transient and 4-kV EFT transient, both of which dwarf the 10-kV ESD transient visible in the lower-left corner. 500-V surge transients are representative of events that may occur in factory environments in industrial and process automation.

The right-hand diagram shows the pulse-power of a 6-kV surge transient, relative to the same 0.5-kV surge transient. 6-kV surge transients are most likely to occur in power generation and power-grid systems.

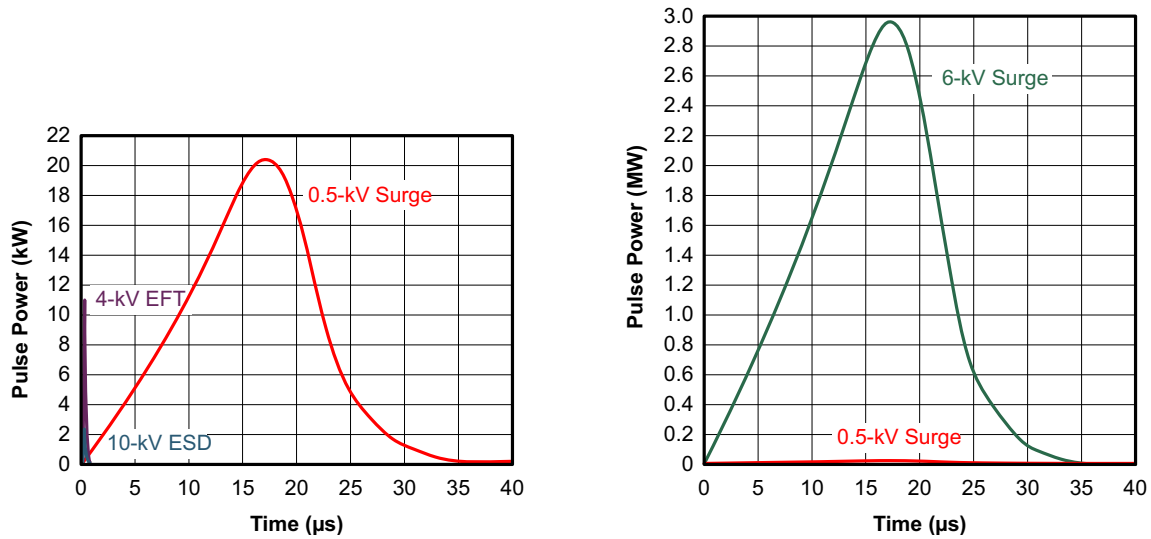


Figure 24. Power Comparison of ESD, EFT, and Surge Transients

In the case of surge transients, high-energy content is characterized by long pulse duration and slow decaying pulse power. The electrical energy of a transient that is dumped into the internal protection cells of a transceiver is converted into thermal energy which heats and destroys the protection cells, thus destroying the transceiver. Figure 25 shows the large differences in transient energies for single ESD, EFT, and surge transients, as well as for an EFT pulse train, commonly applied during compliance testing.

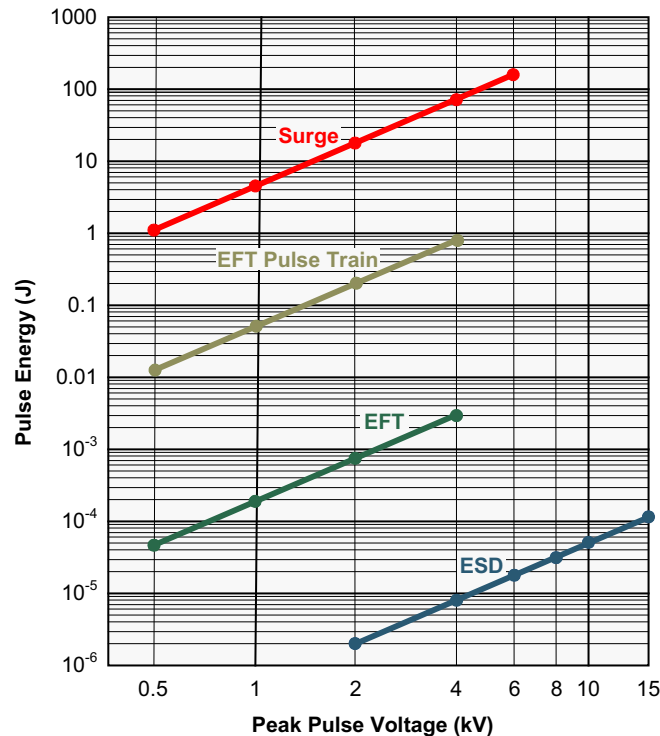


Figure 25. Comparison of Transient Energies

10.2.2 Detailed Design Procedure

10.2.2.1 External Transient Protection

To protect bus nodes against high-energy transients, the implementation of external transient protection devices is necessary. [Figure 26](#) suggests two circuits that provide protection against light and heavy surge transients, in addition to ESD and EFT transients. [Table 4](#) presents the associated bill of materials.

Table 4. Bill of Materials

| DEVICE | FUNCTION | ORDER NUMBER | MANUFACTURER |
|------------|---|-------------------|--------------|
| XCVR | 3.3-V, 250-kbps RS-485 Transceiver | SN65HVD72D | TI |
| R1, R2 | 10-Ω, Pulse-Proof Thick-Film Resistor | CRCW060310RJNEAHP | Vishay |
| TVS | Bidirectional 400-W Transient Suppressor | CDSOT23-SM712 | Bourns |
| TBU1, TBU2 | Bidirectional Surge Suppressor | TBU-CA-065-200-WH | Bourns |
| MOV1, MOV2 | 200-mA Transient Blocking Unit, 200-V, Metal-Oxide Varistor | MOV-10D201K | Bourns |

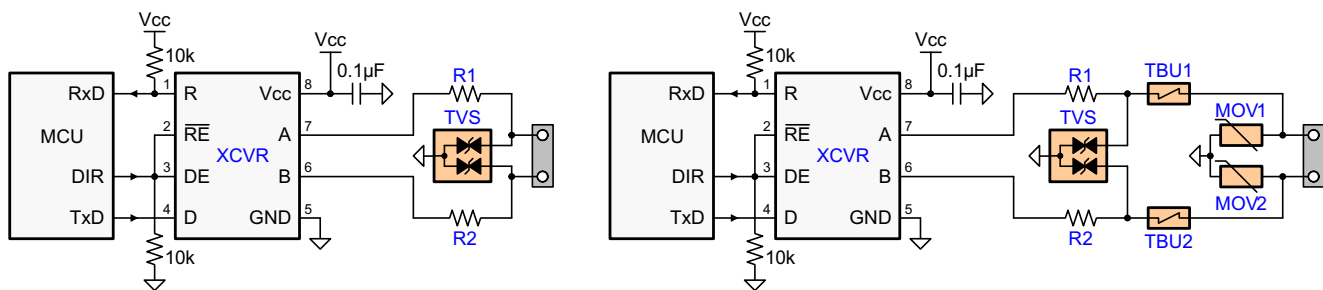


Figure 26. Transient Protections against ESD, EFT, and Surge Transients

The left-hand circuit provides surge protection of $\geq 500\text{-V}$ surge transients, while the right-hand circuit can withstand surge transients of up to 5 kV.

10.2.2.2 Isolated Bus Node Design

Many RS-485 networks use isolated bus nodes to prevent the creation of unintended ground loops and their disruptive impact on signal integrity. An isolated bus node typically includes a microcontroller that connects to the bus transceiver via a multi-channel, digital isolator (Figure 27).

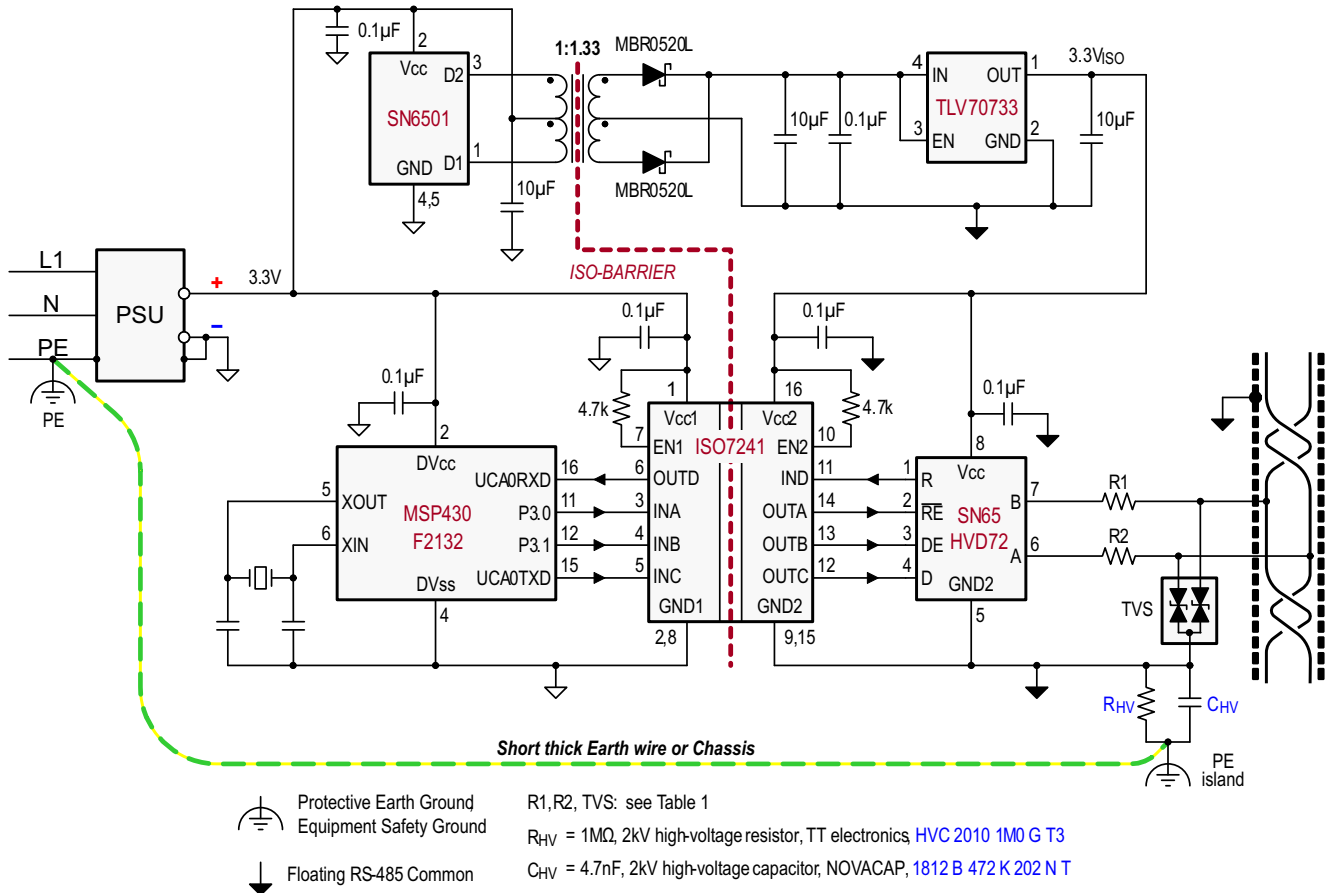


Figure 27. Isolated Bus Node with Transient Protection

Power isolation is accomplished using the push-pull transformer driver SN6501 and a low-cost LDO, TLV70733.

Signal isolation uses the quadruple digital isolator ISO7241. Notice that both enable inputs, EN₁ and EN₂, are pulled up via 4.7 kΩ resistors to limit their input currents during transient events.

While the transient protection is similar to the one in Figure 26 (left circuit), an additional high-voltage capacitor is used to divert transient energy from the floating RS-485 common further towards Protective Earth (PE) ground. This is necessary as noise transients on the bus are usually referred to Earth potential.

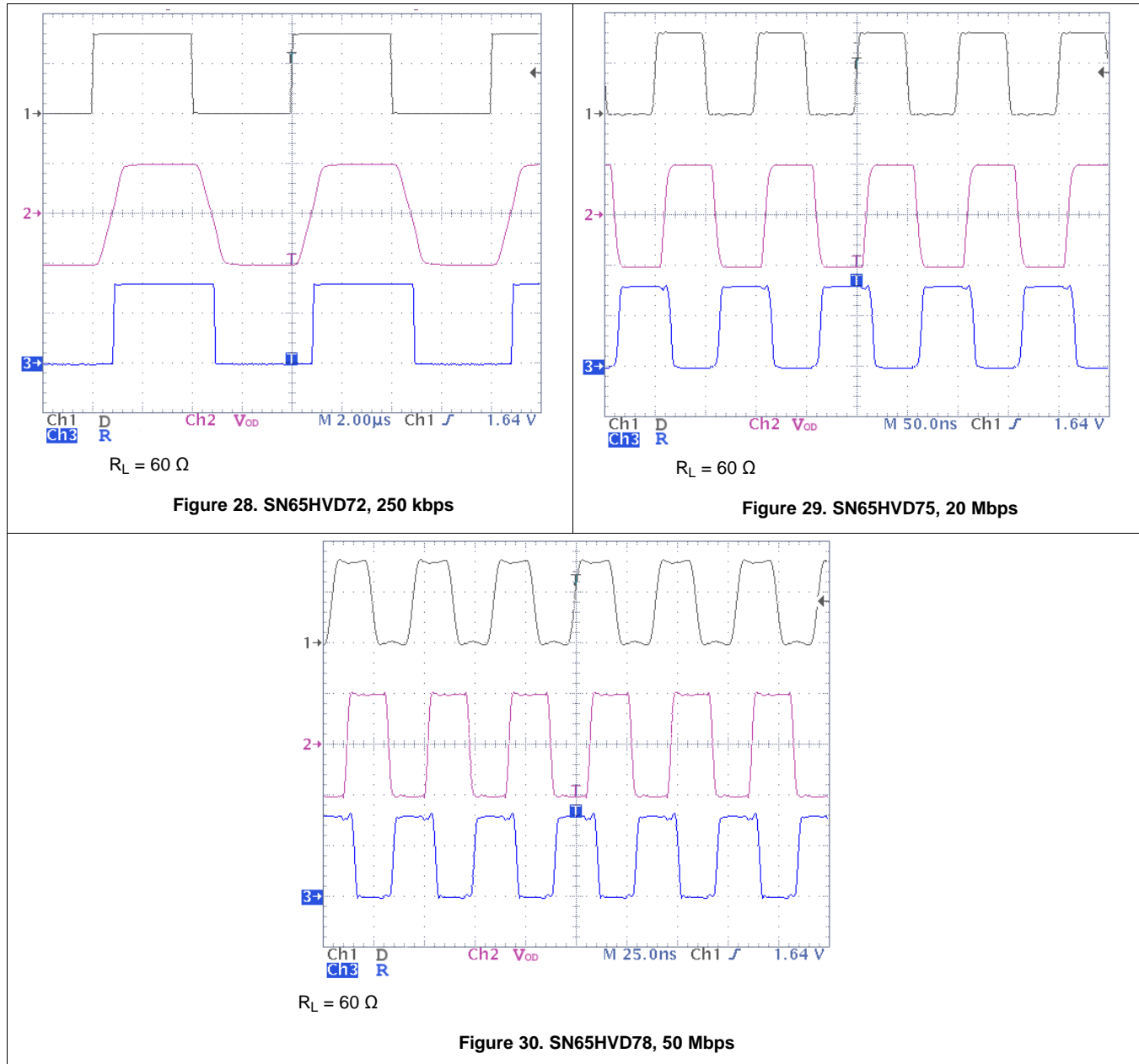
R_{HV} refers to a high voltage resistor, and in some applications even a varistor. This resistance is applied to prevent charging of the floating ground to dangerous potentials during normal operation.

Occasionally varistors are used instead of resistors to rapidly discharge C_{HV}, if it is expected that fast transients might charge C_{HV} to high-potentials.

Note that the PE island represents a copper island on the PCB for the provision of a short, thick Earth wire connecting this island to PE ground at the entrance of the power supply unit (PSU).

In equipment designs using a chassis, the PE connection is usually provided through the chassis itself. Typically the PE conductor is tied to the chassis at one end while the high-voltage components, C_{HV} and R_{HV}, are connecting to the chassis at the other end.

10.2.3 Application Curves



11 Power Supply Recommendations

To assure reliable operation at all data rates and supply voltages, each supply should be buffered with a 100-nF ceramic capacitor located as close to the supply pins as possible. The TPS76333 is a linear voltage regulator suitable for the 3.3 V supply.

See the [SN6501](#) data sheet for isolated power supply designs.

12 Layout

12.1 Layout Guidelines

On-chip IEC ESD protection is sufficient for laboratory and portable equipment but often insufficient for EFT and surge transients occurring in industrial environments. Therefore, robust and reliable bus node design requires the use of external transient protection devices.

Because ESD and EFT transients have a wide frequency bandwidth from approximately 3 MHz to 3 GHz, high-frequency layout techniques must be applied during PCB design.

For a successful PCB design, start with the design of the protection circuit in mind.

1. Place the protection circuitry close to the bus connector to prevent noise transients from entering the board.
2. Use V_{CC} and ground planes to provide low-inductance. Note that high-frequency currents follow the path of least inductance and not the path of least impedance.
3. Design the protection components into the direction of the signal path. Do not force the transients currents to divert from the signal path to reach the protection device.
4. Apply 100-nF to 220-nF bypass capacitors as close as possible to the V_{CC} pins of transceiver, UART, and controller ICs on the board.
5. Use at least two vias for V_{CC} and ground connections of bypass capacitors and protection devices to minimize effective via-inductance.
6. Use 1-k Ω to 10-k Ω pullup or pulldown resistors for enable lines to limit noise currents in these lines during transient events.
7. Insert pulse-proof series resistors into the A and B bus lines if the TVS clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors limit the residual clamping current into the transceiver and prevent it from latching up.
8. While pure TVS protection is sufficient for surge transients up to 1 kV, higher transients require metal-oxide varistors (MOVs) which reduce the transients to a few hundred volts of clamping voltage, and transient blocking units (TBUs) that limit transient current to 200 mA.

12.2 Layout Example

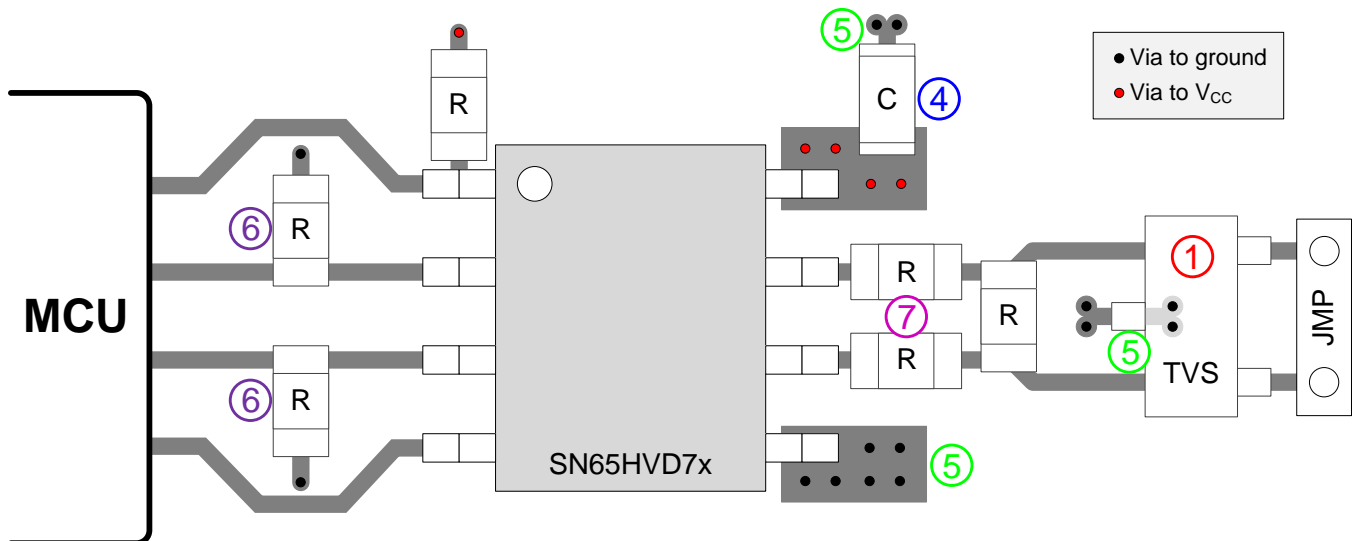


Figure 31. SN65HVD7x Half-Duplex Layout Example

13 Device and Documentation Support

13.1 Device Support

13.1.1 Third-Party Products Disclaimer

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13.2 Documentation Support

13.2.1 Related Documentation

For related documentation see the following:

SN6501 Transformer Driver for Isolated Power Supplies, [SLLSEA0](#)

13.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 5. Related Links

| PARTS | PRODUCT FOLDER | SAMPLE & BUY | TECHNICAL DOCUMENTS | TOOLS & SOFTWARE | SUPPORT & COMMUNITY |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| SN65HVD72 | Click here | Click here | Click here | Click here | Click here |
| SN65HVD75 | Click here | Click here | Click here | Click here | Click here |
| SN65HVD78 | Click here | Click here | Click here | Click here | Click here |

13.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

13.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

13.6 Electrostatic Discharge Caution



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.

13.7 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

14 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| SN65HVD72D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD72 | Samples |
| SN65HVD72DGK | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD72 | Samples |
| SN65HVD72DGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD72 | Samples |
| SN65HVD72DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD72 | Samples |
| SN65HVD72DRBR | ACTIVE | SON | DRB | 8 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD72 | Samples |
| SN65HVD72DRBT | ACTIVE | SON | DRB | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD72 | Samples |
| SN65HVD75D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD75 | Samples |
| SN65HVD75DGK | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD75 | Samples |
| SN65HVD75DGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD75 | Samples |
| SN65HVD75DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD75 | Samples |
| SN65HVD75DRBR | ACTIVE | SON | DRB | 8 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD75 | Samples |
| SN65HVD75DRBT | ACTIVE | SON | DRB | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD75 | Samples |
| SN65HVD78D | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD78 | Samples |
| SN65HVD78DGK | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD78 | Samples |
| SN65HVD78DGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | HVD78 | Samples |
| SN65HVD78DR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | HVD78 | Samples |
| SN65HVD78DRBR | ACTIVE | SON | DRB | 8 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD78 | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|----------------|
| SN65HVD78DRBT | ACTIVE | SON | DRB | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | HVD78 | Samples |

(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) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65HVD72DGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| SN65HVD72DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| SN65HVD72DRBR | SON | DRB | 8 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| SN65HVD72DRBT | SON | DRB | 8 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| SN65HVD75DGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| SN65HVD75DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| SN65HVD75DRBR | SON | DRB | 8 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| SN65HVD75DRBT | SON | DRB | 8 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| SN65HVD78DGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| SN65HVD78DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| SN65HVD78DRBR | SON | DRB | 8 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| SN65HVD78DRBT | SON | DRB | 8 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |

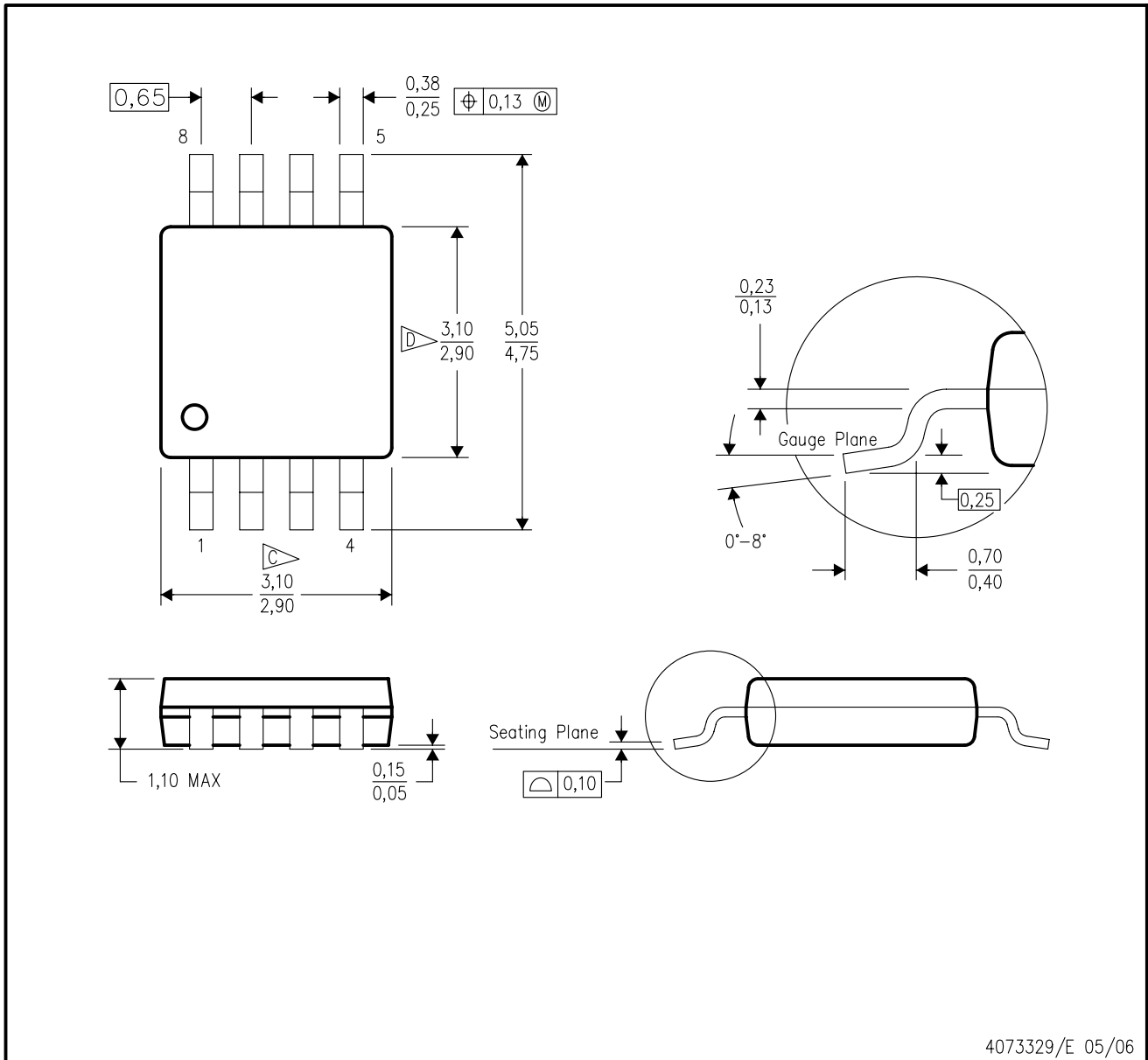
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65HVD72DGKR | VSSOP | DGK | 8 | 2500 | 364.0 | 364.0 | 27.0 |
| SN65HVD72DR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| SN65HVD72DRBR | SON | DRB | 8 | 3000 | 367.0 | 367.0 | 35.0 |
| SN65HVD72DRBT | SON | DRB | 8 | 250 | 210.0 | 185.0 | 35.0 |
| SN65HVD75DGKR | VSSOP | DGK | 8 | 2500 | 364.0 | 364.0 | 27.0 |
| SN65HVD75DR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| SN65HVD75DRBR | SON | DRB | 8 | 3000 | 367.0 | 367.0 | 35.0 |
| SN65HVD75DRBT | SON | DRB | 8 | 250 | 210.0 | 185.0 | 35.0 |
| SN65HVD78DGKR | VSSOP | DGK | 8 | 2500 | 364.0 | 364.0 | 27.0 |
| SN65HVD78DR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| SN65HVD78DRBR | SON | DRB | 8 | 3000 | 367.0 | 367.0 | 35.0 |
| SN65HVD78DRBT | SON | DRB | 8 | 250 | 210.0 | 185.0 | 35.0 |

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



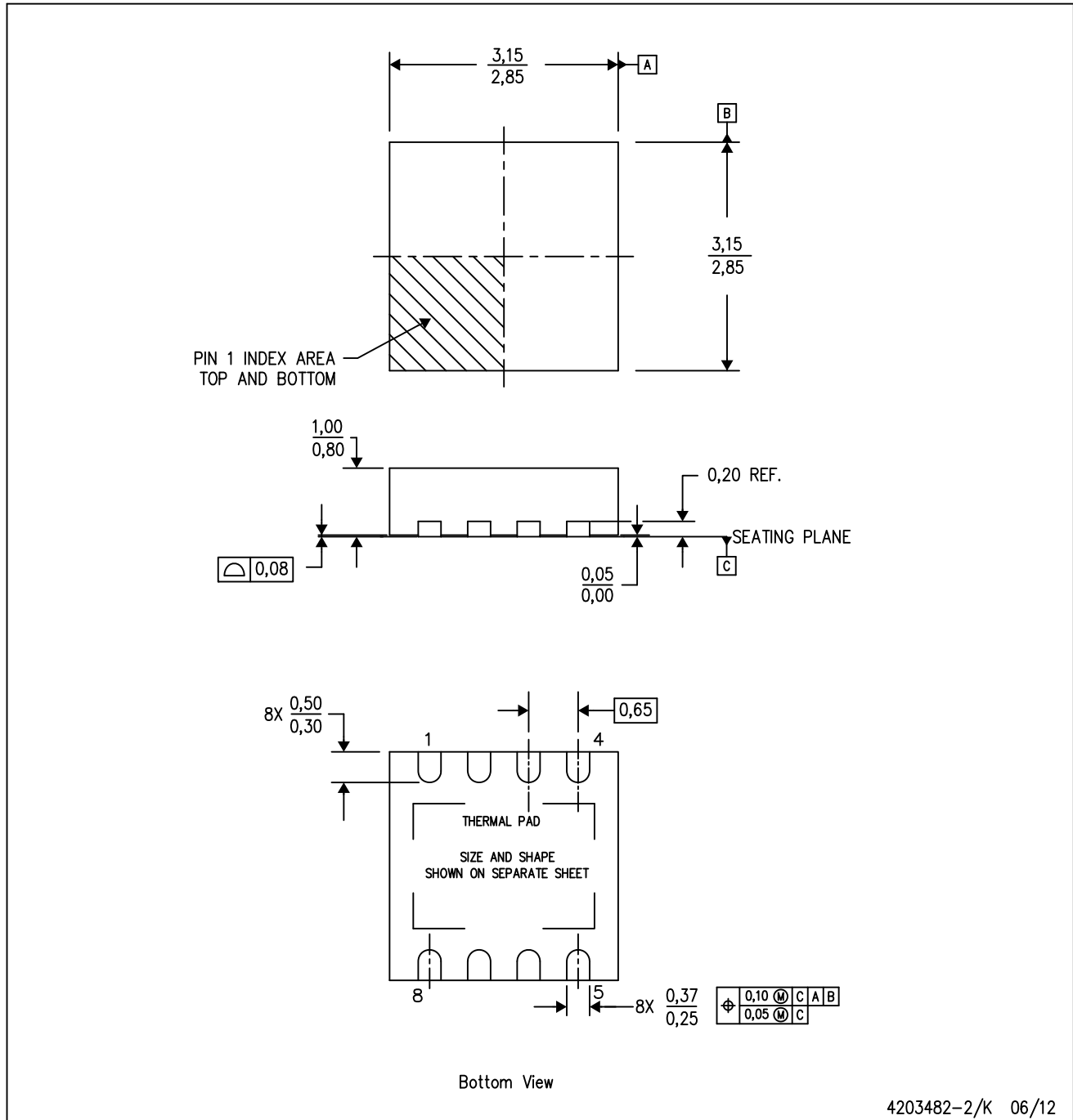
- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
 - E. Falls within JEDEC MO-187 variation AA, except interlead flash.



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - 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.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DRB (S-PVSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



4203482-2/K 06/12

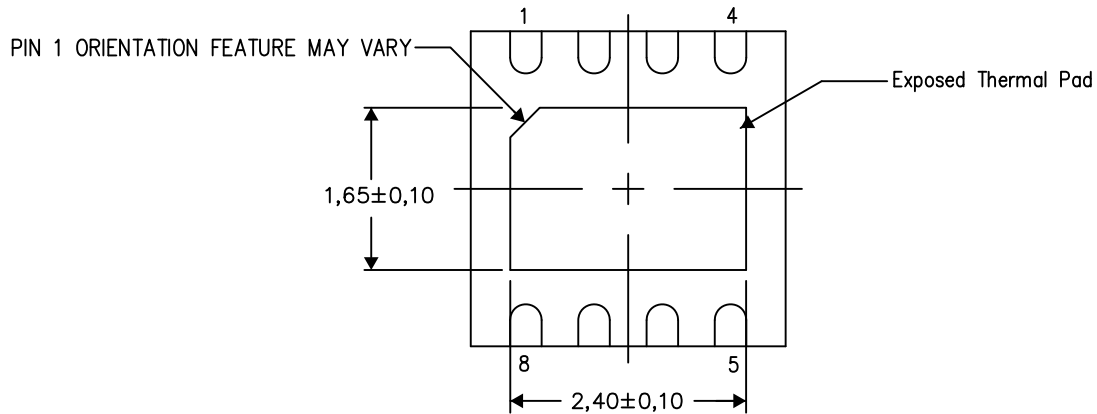
- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - Small Outline No-Lead (SON) package configuration.
 - The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

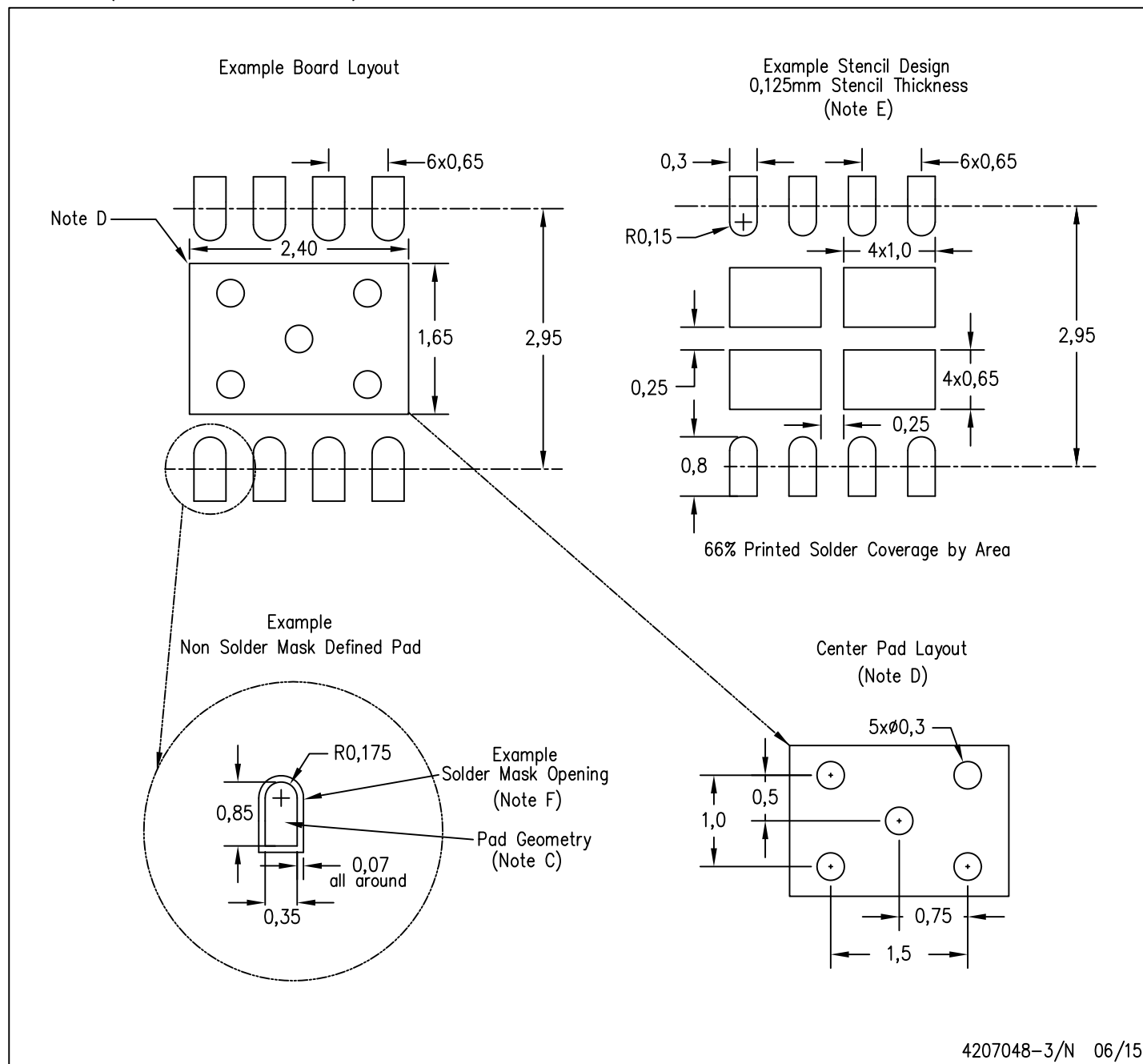


Bottom View

Exposed Thermal Pad Dimensions

4206340-3/S 07/15

NOTE: All linear dimensions are in millimeters



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - 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 stencil design considerations.
 - Customers should contact their board fabrication site for solder mask tolerances.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



4040047-3/M 06/11

- 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



4211283-2/E 08/12

- 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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