

## FEATURES

- $V_{CC}$  Operation at 3 V and 4.3 V
- 1.8-V Compatible Control-Pin Inputs
- $I_{OFF}$  Supports Partial Power-Down Mode Operation
- $r_{on} = 10 \Omega$  Maximum
- $\Delta r_{on} < 0.35 \Omega$  Typical
- $C_{io(ON)} = 6 \text{ pF}$  Typical
- Low Power Consumption (1  $\mu\text{A}$  Maximum)
- ESD Performance Tested Per JESD 22
  - 6000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
  - 250-V Machine Model (A115-A)
- Wide –3-dB Bandwidth = 1220 MHz Typical
- Packaged in 8-Pin TQFN (1.5 mm  $\times$  1.5 mm)

## APPLICATIONS

- Routes Signals for USB 1.0, 1.1, and 2.0

## DESCRIPTION/ORDERING INFORMATION

The TS3USB31 is a high-bandwidth switch specially designed for the switching of high-speed USB 2.0 signals in handset and consumer applications, such as cell phones, digital cameras, and notebooks with hubs or controllers with limited USB I/Os. The wide bandwidth (750 MHz) of this switch allows signals to pass with minimum edge and phase distortion. The switch is bidirectional and offers little or no attenuation of the high-speed signals at the outputs. It is designed for low bit-to-bit skew and high channel-to-channel noise isolation, and is compatible with various standards, such as high-speed USB 2.0 (480 Mbps).

## ORDERING INFORMATION

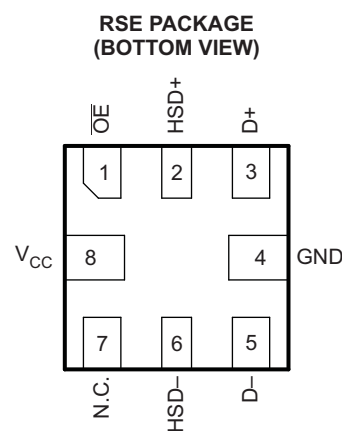
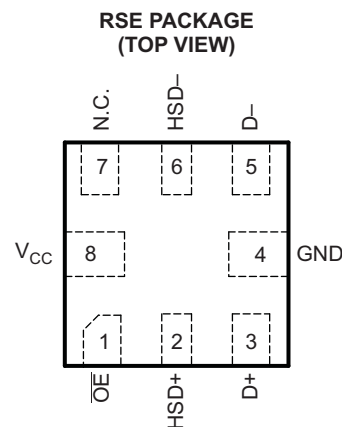
| $T_A$         | PACKAGE <sup>(1)(2)</sup> |               | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|---------------------------|---------------|-----------------------|------------------|
| –40°C to 85°C | QFN – RSE                 | Tape and reel | TS3USB31RSER          | L9               |

(1) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

## PIN DESCRIPTION

| NAME               | DESCRIPTION       |
|--------------------|-------------------|
| $\overline{OE}$    | Bus-switch enable |
| D+, D–, HSD+, HSD– | Data ports        |
| NC                 | No connect        |



N.C. – No internal connection



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.

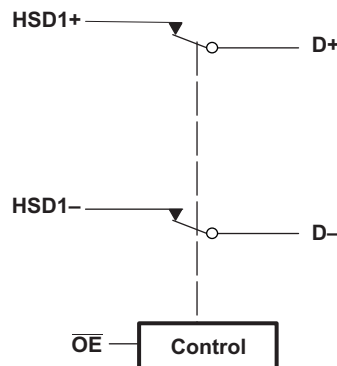
# TS3USB31 HIGH-SPEED USB 2.0 (480-Mbps) 1-PORT SWITCH WITH SINGLE ENABLE

SCDS242D–JULY 2007–REVISED JANUARY 2008

## TRUTH TABLE

| $\overline{OE}$ | FUNCTION            |
|-----------------|---------------------|
| H               | Disconnect          |
| L               | D+, D– = HSD+, HSD– |

## BLOCK DIAGRAM



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

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

|            |   | MIN                      | MAX  | UNIT           |   |
|------------|---|--------------------------|------|----------------|---|
| $V_{CC}$   | Supply voltage range                          | –0.5                     | 7    | V              |   |
| $V_{IN}$   | Control input voltage range <sup>(2)(3)</sup> | –0.5                     | 7    | V              |   |
| $V_{I/O}$  | Switch I/O voltage range <sup>(2)(3)(4)</sup> | HSD+, HSD–               | –0.5 | $V_{CC} + 0.3$ | V |
|            |   | D+, D– when $V_{CC} > 0$ | –0.5 | $V_{CC} + 0.3$ |   |
|            |   | D+, D– when $V_{CC} = 0$ |      | 5.25           |   |
| $I_{IK}$   | Control input clamp current                   | $V_{IN} < 0$             | –50  | mA             |   |
| $I_{I/OK}$ | I/O port clamp current                        | $V_{I/O} < 0$            | –50  | mA             |   |
| $I_{I/O}$  | ON-state switch current <sup>(5)</sup>        |                          | ±64  | mA             |   |
|            | Continuous current through $V_{CC}$ or GND    |                          | ±100 | mA             |   |
| $T_{stg}$  | Storage temperature range                     | –65                      | 150  | °C             |   |

- 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 voltages are with respect to ground, unless otherwise specified.
- The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- $V_I$  and  $V_O$  are used to denote specific conditions for  $V_{I/O}$ .
- $I_I$  and  $I_O$  are used to denote specific conditions for  $I_{I/O}$ .

## PACKAGE THERMAL IMPEDANCE

|               |  | TYP | UNIT |
|---------------|--|-----|------|
| $\theta_{JA}$ | Package thermal impedance <sup>(1)</sup> | 253 | °C/W |

- The package thermal impedance is calculated in accordance with JESD 51-7.

**RECOMMENDED OPERATING CONDITIONS<sup>(1)</sup>**

|           |                                  | MIN                                   | MAX      | UNIT |
|-----------|----------------------------------|---------------------------------------|----------|------|
| $V_{CC}$  | Supply voltage                   | 3.0                                   | 4.3      | V    |
| $V_{IH}$  | High-level control input voltage | $V_{CC} = 3\text{ V to }3.6\text{ V}$ | 1.3      | V    |
|           |                                  | $V_{CC} = 4.3\text{ V}$               | 1.7      |      |
| $V_{IL}$  | Low-level control input voltage  | $V_{CC} = 3\text{ V to }3.6\text{ V}$ | 0.5      | V    |
|           |                                  | $V_{CC} = 4.3\text{ V}$               | 0.7      |      |
| $V_{I/O}$ | Data input/output voltage        | 0                                     | $V_{CC}$ | V    |
| $T_A$     | Operating free-air temperature   | –40                                   | 85       | °C   |

(1) All unused control inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

**ELECTRICAL CHARACTERISTICS<sup>(1)</sup>**

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

| PARAMETER                      |                | TEST CONDITIONS  | MIN | TYP <sup>(2)</sup> | MAX  | UNIT |
|--------------------------------|----------------|--|-----|--------------------|------|------|
| $V_{IK}$                       |                | $V_{CC} = 3\text{ V}, I_I = -18\text{ mA}$   |     |                    | –1.2 | V    |
| $I_{IN}$                       | Control inputs | $V_{CC} = 4.3\text{ V}, V_{IN} = 0\text{ to }4.3\text{ V}, V_{CC} = 0\text{ V}$          |     |                    | ±1   | µA   |
| $I_{OZ}$ <sup>(3)</sup>        |                | $V_{CC} = 4.3\text{ V}, V_O = 0\text{ to }3.6\text{ V}, V_I = 0,$ Switch OFF             |     |                    | ±1   | µA   |
| $I_{OFF}$                      | D+ and D–      | $V_{CC} = 0\text{ V}, V_O = 0\text{ to }4.3\text{ V}, V_I = 0,$ $V_{IN} = V_{CC}$ or GND |     |                    | ±2   | µA   |
| $I_{CC}$                       |                | $V_{CC} = 4.3\text{ V}, I_{I/O} = 0,$ Switch ON or OFF                                   |     |                    | 1    | µA   |
| $\Delta I_{CC}$ <sup>(4)</sup> | Control inputs | $V_{CC} = 4.3\text{ V}, V_{IN} = 2.6\text{ V}$   |     |                    | 10   | µA   |
| $C_{in}$                       | Control inputs | $V_{CC} = 0\text{ V}, V_{IN} = V_{CC}$ or GND  |     | 1                  |      | pF   |
| $C_{io(OFF)}$                  |                | $V_{CC} = 3.3\text{ V}, V_{I/O} = 3.3\text{ V or }0,$ Switch OFF                         |     | 2                  |      | pF   |
| $C_{io(ON)}$                   |                | $V_{CC} = 3.3\text{ V}, V_{I/O} = 3.3\text{ V or }0,$ Switch ON                          |     | 6                  |      | pF   |
| $r_{on}$ <sup>(5)</sup>        |                | $V_{CC} = 3\text{ V}, V_I = 0.4\text{ V}, I_O = -8\text{ mA}$                            |     | 6                  | 10   | Ω    |
| $\Delta r_{on}$                |                | $V_{CC} = 3\text{ V}, V_I = 0.4\text{ V}, I_O = -8\text{ mA}$                            |     | 0.35               |      | Ω    |
| $r_{on(Flat)}$                 |                | $V_{CC} = 3\text{ V}, V_I = 0\text{ V or }1\text{ V}, I_O = -8\text{ mA}$                |     | 2                  |      | Ω    |

(1)  $V_{IN}$  and  $I_{IN}$  refer to control inputs.  $V_I, V_O, I_I,$  and  $I_O$  refer to data pins.

(2) All typical values are at  $V_{CC} = 3.3\text{ V}$  (unless otherwise noted),  $T_A = 25^\circ\text{C}$ .

(3) For I/O ports, the parameter  $I_{OZ}$  includes the input leakage current.

(4) This is the increase in supply current for each input that is at the specified TTL voltage level, rather than  $V_{CC}$  or GND.

(5) Measured by the voltage drop between the A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.

**DYNAMIC ELECTRICAL CHARACTERISTICS**

over operating range,  $T_A = -40^\circ\text{C to }85^\circ\text{C}, V_{CC} = 3.3\text{ V} \pm 10\%, \text{GND} = 0\text{ V}$

| PARAMETER  |                   | TEST CONDITIONS  | TYP <sup>(1)</sup> | UNIT |
|------------|-------------------|--|--------------------|------|
| $X_{TALK}$ | Crosstalk         | $R_L = 50\ \Omega, f = 240\text{ MHz},$ See <a href="#">Figure 9</a> | –53                | dB   |
| $O_{IRR}$  | OFF isolation     | $R_L = 50\ \Omega, f = 240\text{ MHz},$ See <a href="#">Figure 8</a> | –30                | dB   |
| BW         | Bandwidth (–3 dB) | $R_L = 50\ \Omega, C_L = 5\text{ pF},$ See <a href="#">Figure 10</a> | 1220               | MHz  |

(1) For Max or Min conditions, use the appropriate value specified under Electrical Characteristics for the applicable device type.

# TS3USB31 HIGH-SPEED USB 2.0 (480-Mbps) 1-PORT SWITCH WITH SINGLE ENABLE

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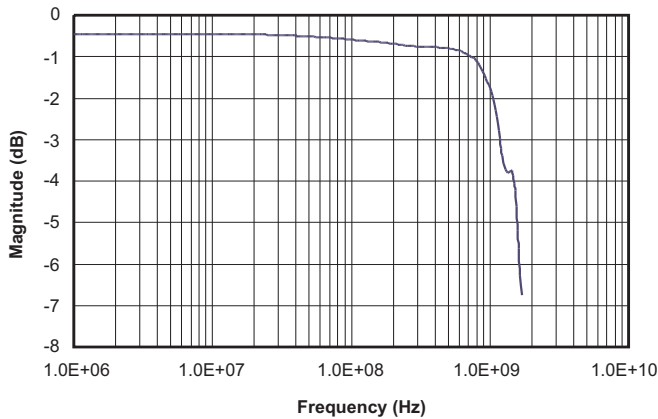
## SWITCHING CHARACTERISTICS

over operating range,  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{CC} = 3.3\text{ V} \pm 10\%$ ,  $\text{GND} = 0\text{ V}$

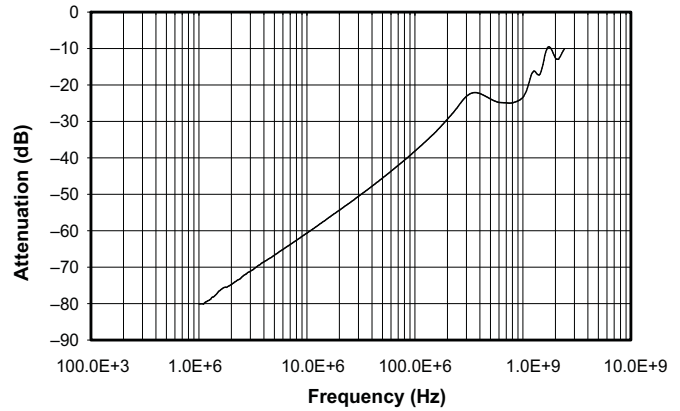
| PARAMETER   |  | TEST CONDITIONS   | MIN | TYP <sup>(1)</sup> | MAX | UNIT |
|-------------|--|---|-----|--------------------|-----|------|
| $t_{pd}$    | Propagation delay <sup>(2)(3)</sup>  | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>See <a href="#">Figure 11</a>                                      |     | 0.25               |     | ns   |
| $t_{ON}$    | Line enable time, $\overline{\text{OE}}$ to D, nD  | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>See <a href="#">Figure 7</a>                                       |     |                    | 30  | ns   |
| $t_{OFF}$   | Line disable time, $\overline{\text{OE}}$ to D, nD   | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>See <a href="#">Figure 7</a>                                       |     |                    | 25  | ns   |
| $t_{SK(O)}$ | Output skew between center port to any other port <sup>(2)</sup>                               | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>See <a href="#">Figure 12</a>                                      |     | 50                 |     | ps   |
| $t_{SK(P)}$ | Skew between opposite transitions of the same output<br>( $t_{PHL} - t_{PLH}$ ) <sup>(2)</sup> | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>See <a href="#">Figure 12</a>                                      |     | 20                 |     | ps   |
| $t_J$       | Total jitter <sup>(2)</sup>  | $R_L = 50\ \Omega$ , $C_L = 5\ \text{pF}$ ,<br>$t_R = t_F = 500\ \text{ps}$ at 480 Mbps<br>(PRBS = $2^{15} - 1$ ) |     | 200                |     | ps   |

- (1) For Max or Min conditions, use the appropriate value specified under Electrical Characteristics for the applicable device type.
- (2) Specified by design
- (3) The bus switch contributes no propagational delay other than the RC delay of the on resistance of the switch and the load capacitance. The time constant for the switch alone is of the order of 0.25 ns for 10-pF load. Since this time constant is much smaller than the rise/fall times of typical driving signals, it adds very little propagational delay to the system. Propagational delay of the bus switch, when used in a system, is determined by the driving circuit on the driving side of the switch and its interactions with the load on the driven side.

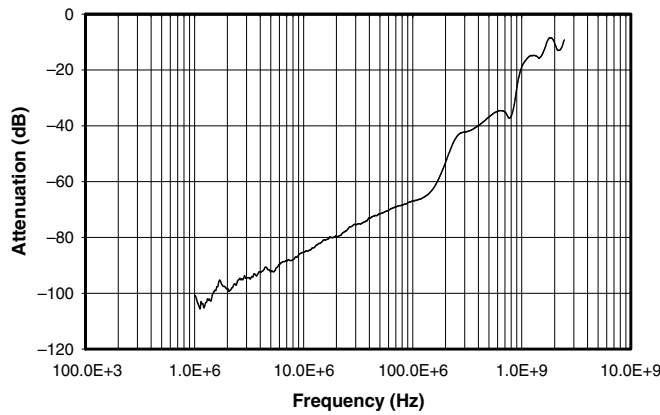
**APPLICATION INFORMATION**



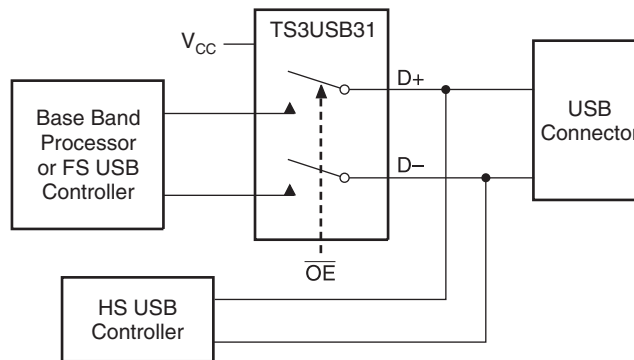
**Figure 1. Insertion Loss**



**Figure 2. OFF Isolation**



**Figure 3. Crosstalk**



**Figure 4. Application Diagram**

# TS3USB31 HIGH-SPEED USB 2.0 (480-Mbps) 1-PORT SWITCH WITH SINGLE ENABLE

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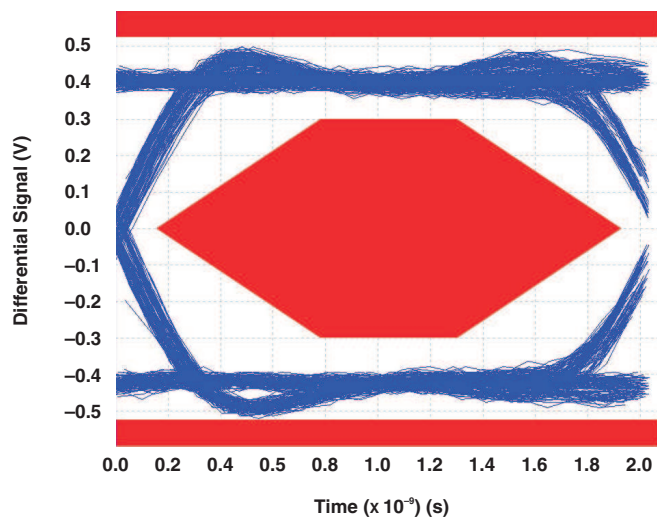


Figure 5. Eye Pattern: 480-Mbps USB Signal With No Switch (Through Path)

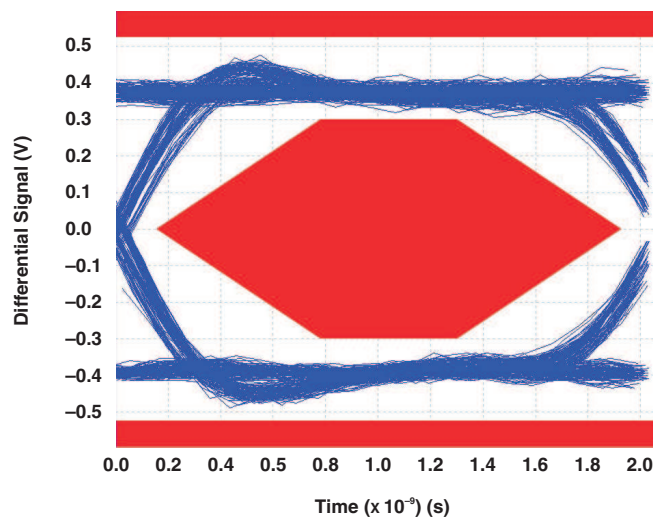
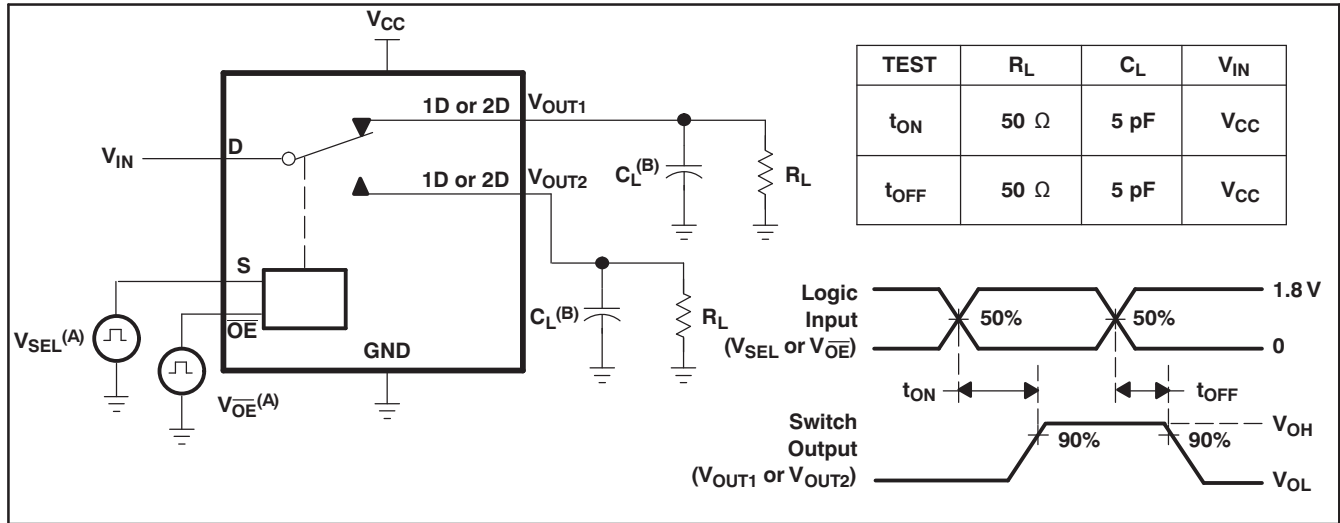
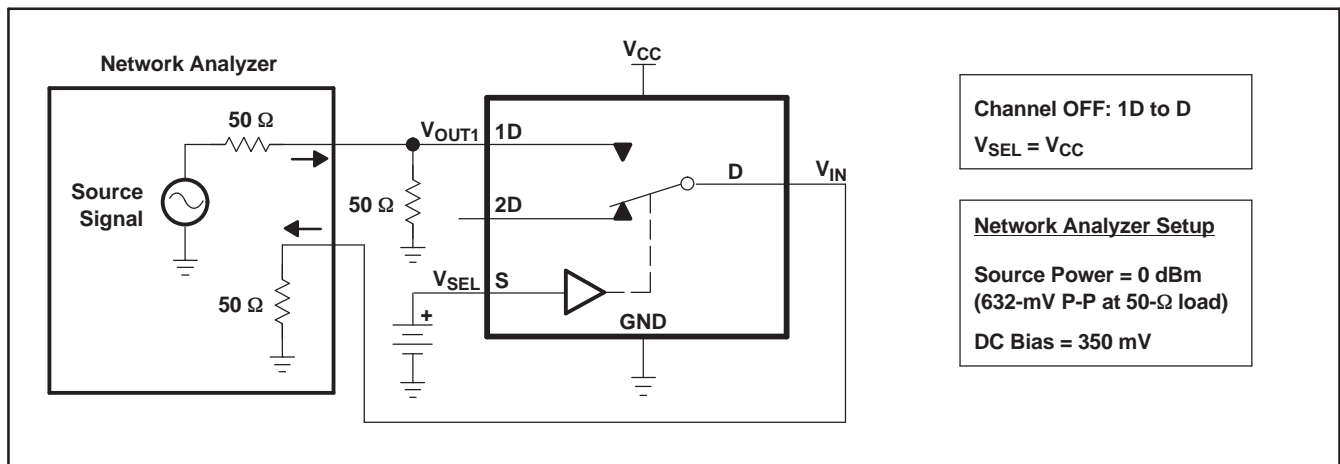


Figure 6. Eye Pattern: 480-Mbps USB Signal With Switch NO Path

**PARAMETER MEASUREMENT INFORMATION**

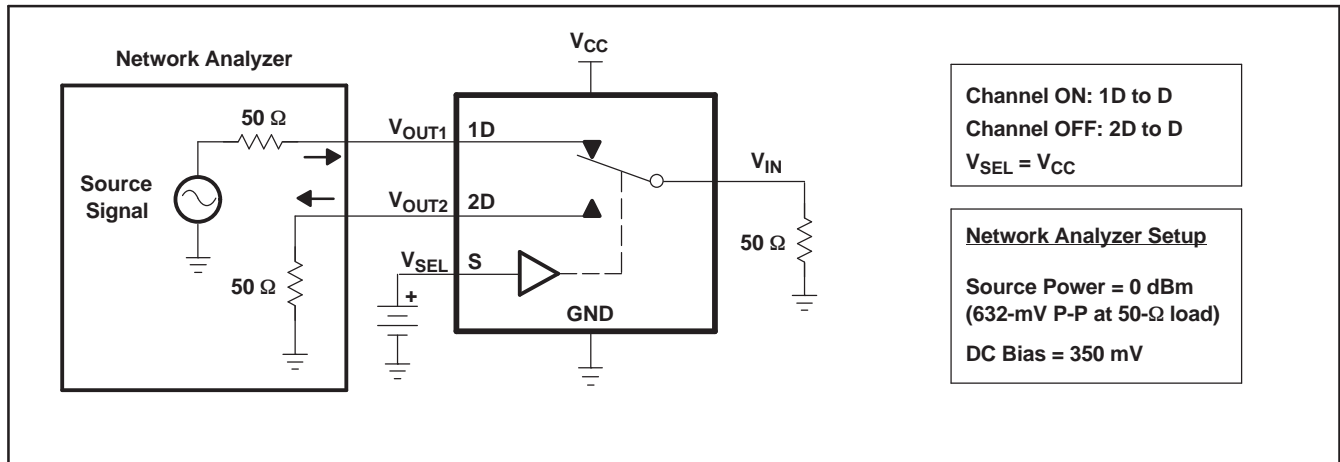


**Figure 7. Turn-On (t<sub>ON</sub>) and Turn-Off Time (t<sub>OFF</sub>)**

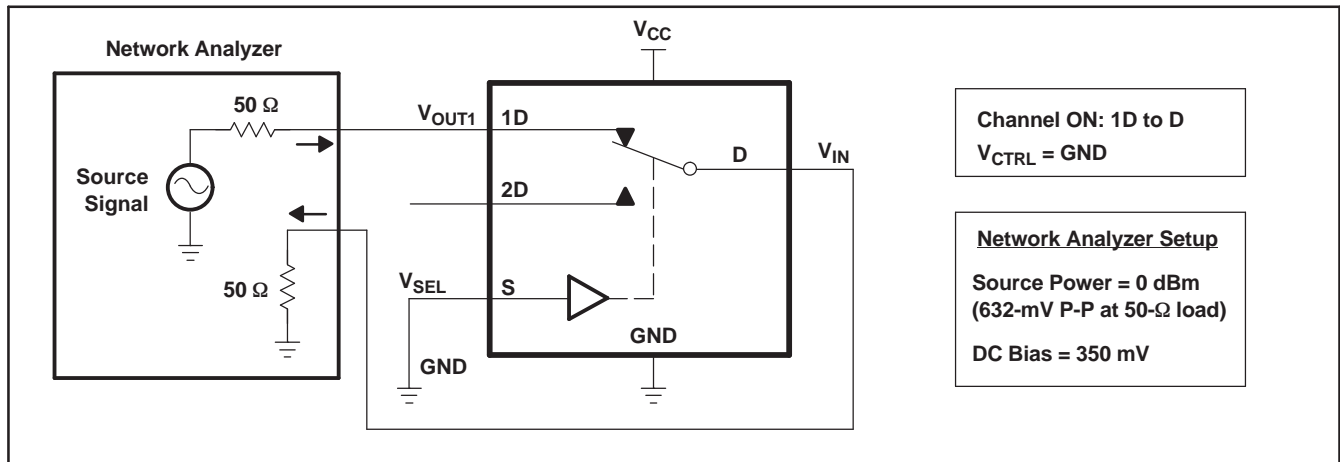


**Figure 8. OFF Isolation (O<sub>IRR</sub>)**

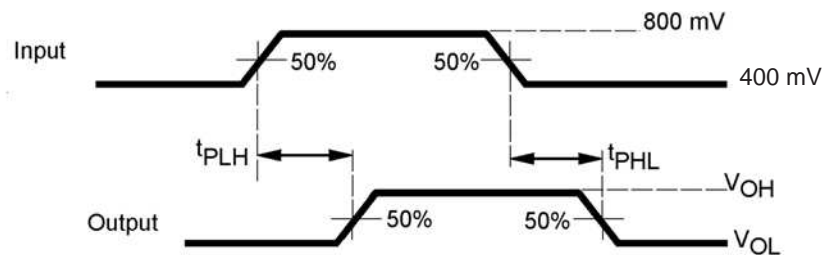
**PARAMETER MEASUREMENT INFORMATION (continued)**



**Figure 9. Crosstalk ( $X_{TALK}$ )**



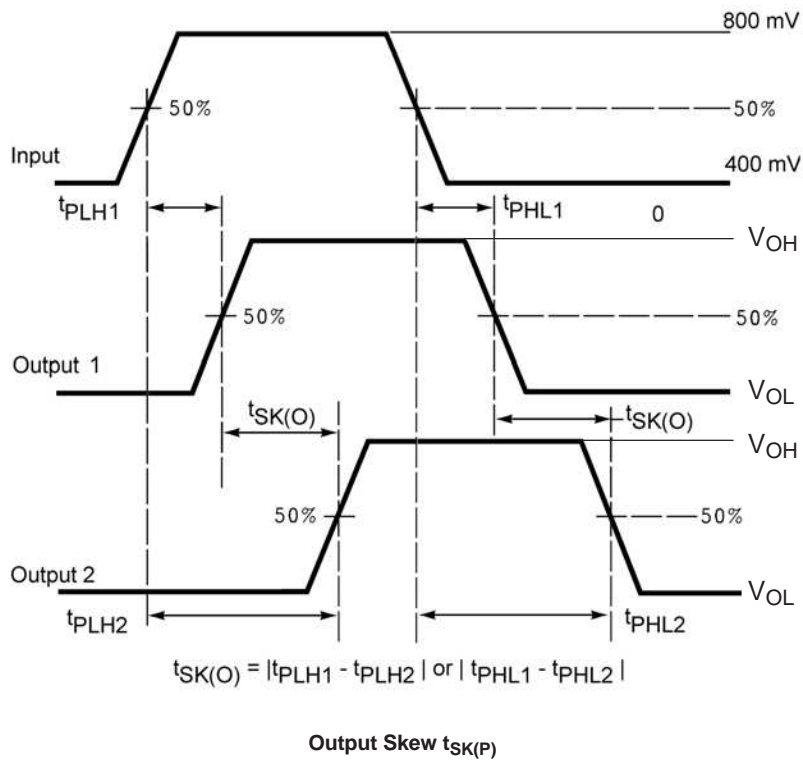
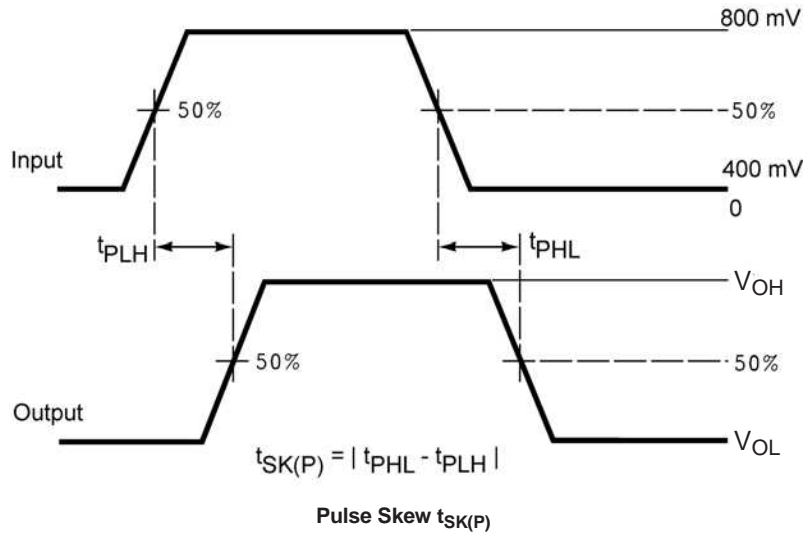
**Figure 10. Bandwidth (BW)**



**Figure 11. Propagation Delay**

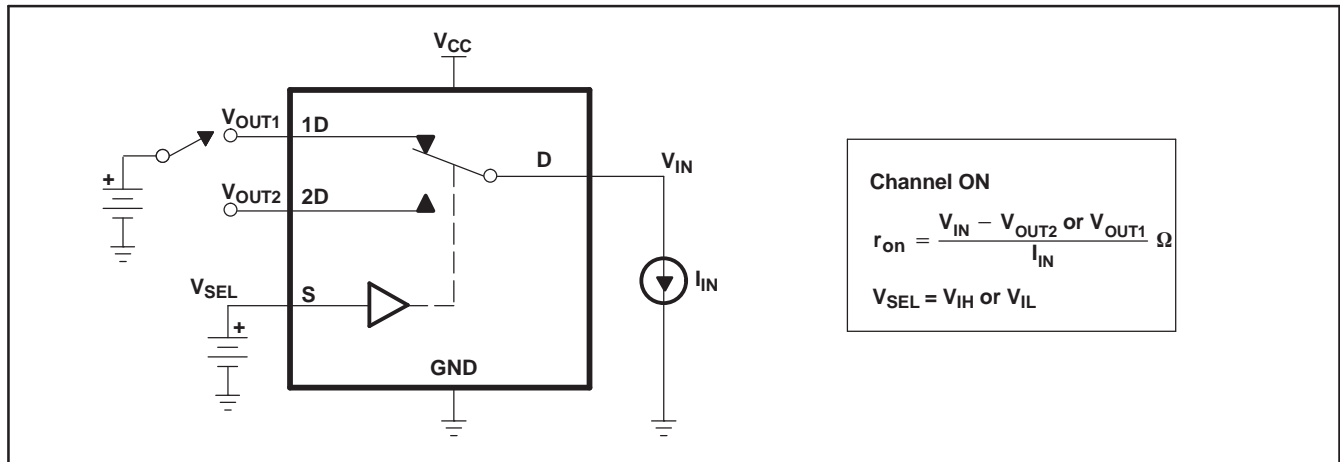


**PARAMETER MEASUREMENT INFORMATION (continued)**

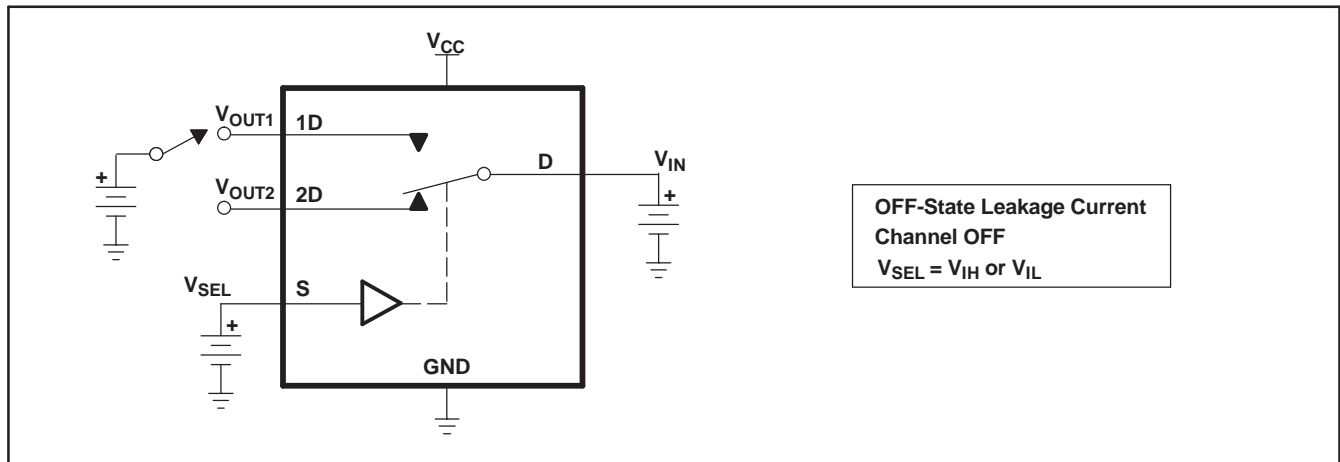


**Figure 12. Skew Test**

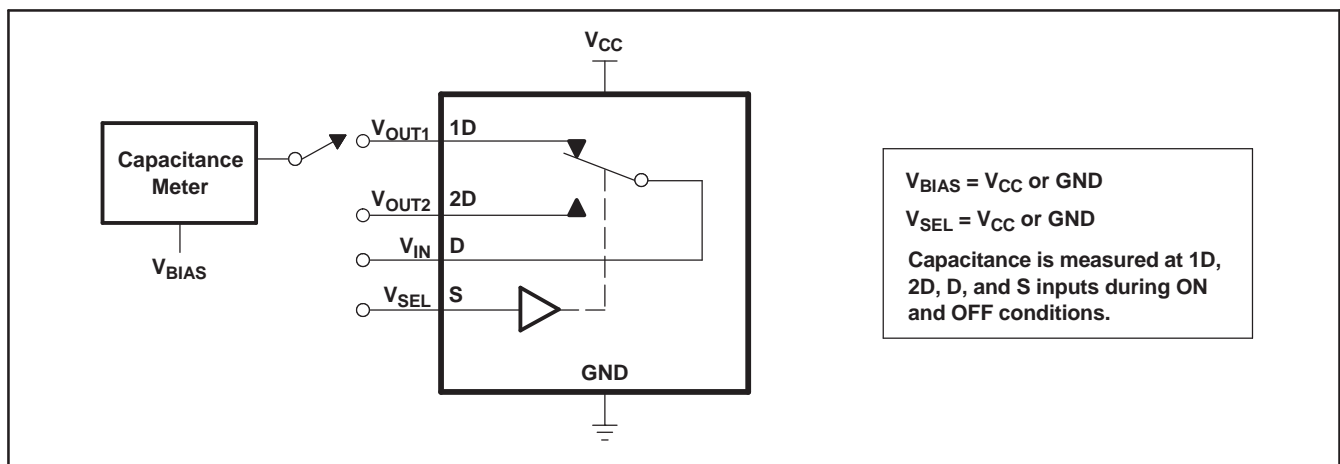
**PARAMETER MEASUREMENT INFORMATION (continued)**



**Figure 13. ON-State Resistance ( $r_{on}$ )**



**Figure 14. OFF-State Leakage Current**



**Figure 15. Capacitance**

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TS3USB31RSER     | ACTIVE                | UQFN         | RSE             | 8    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS3USB31RSERG4   | ACTIVE                | UQFN         | RSE             | 8    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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**TAPE AND REEL INFORMATION**

**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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 180.0              | 9.5                | 1.7     | 2.3     | 0.75    | 4.0     | 8.0    | Q2            |
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 179.0              | 8.4                | 1.7     | 1.7     | 0.76    | 4.0     | 8.0    | Q2            |
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 180.0              | 8.4                | 1.6     | 1.6     | 0.66    | 4.0     | 8.0    | Q2            |

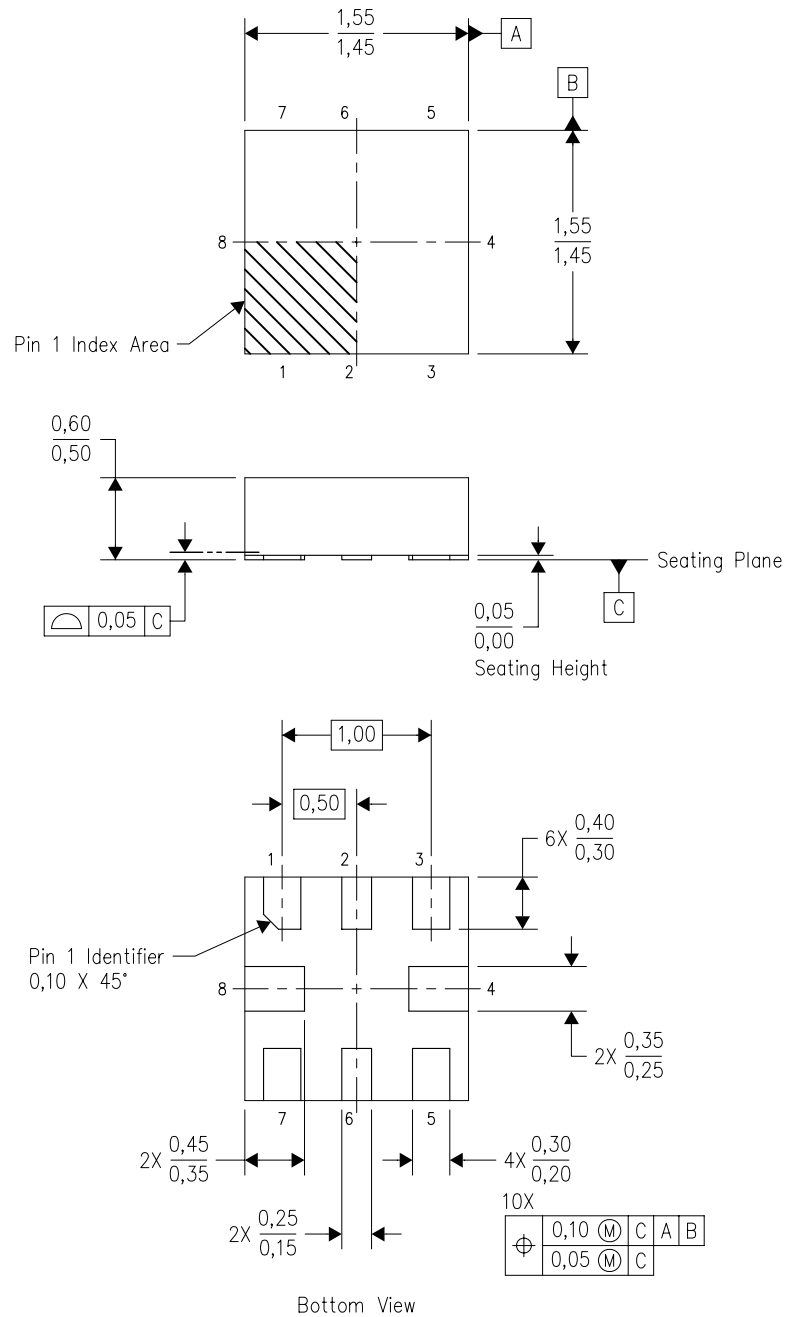
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 180.0       | 180.0      | 30.0        |
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 203.0       | 203.0      | 35.0        |
| TS3USB31RSER | UQFN         | RSE             | 8    | 3000 | 202.0       | 201.0      | 28.0        |

RSE (S-PUQFN-N8)

PLASTIC QUAD FLATPACK NO-LEAD

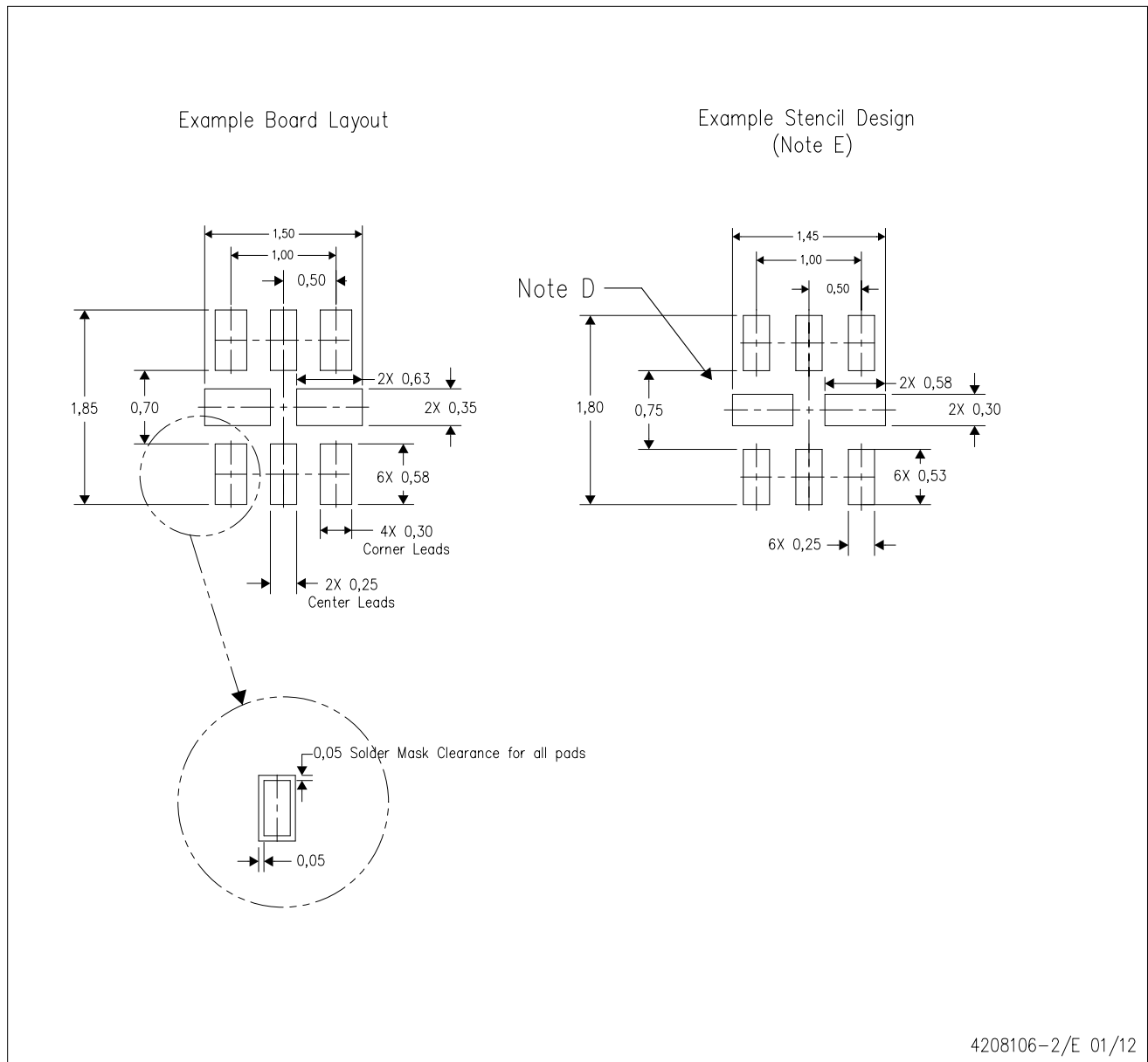


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- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - QFN (Quad Flatpack No-Lead) package configuration.
  - This package complies to JEDEC MO-288 variation UECD.

RSE (S-PUQFN-N8)

PLASTIC QUAD FLATPACK NO-LEAD



- 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. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
  - E. Maximum stencil thickness 0,127 mm (5 mils). All linear dimensions are in millimeters.
  - F. 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.
  - G. Side aperture dimensions over-print land for acceptable area ratio > 0.66. Customer may reduce side aperture dimensions if stencil manufacturing process allows for sufficient release at smaller opening.

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|                               |  |
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