



LVPECL AND LVDS REPEATER/TRANSLATOR WITH ENABLE

FEATURES

- Low-Voltage PECL Input and Low-Voltage PECL or LVDS Outputs
- Signaling Rates to 4 Gbps or Clock Rates to 2 GHz
 - 120-ps Output Transition Times
 - Less than 45 ps Total Jitter
 - Less than 630 ps Propagation Delay Times

- 2.5-V or 3.3-V Supply Operation
- 2-mm x 2-mm Small-Outline No-Lead Package

APPLICATIONS

- PECL-to-LVDS Translation
- Data or Clock Signal Amplification

DESCRIPTION

The SN65LVDS20 and SN65LVP20 are a high-speed differential receiver and driver connected as a repeater. The receiver accepts low-voltage positive-emitter-coupled logic (PECL) at signaling rates up to 4 Gbps and repeats it as either an LVDS or PECL output signal. The signal path through the device is differential for low radiated emissions and minimal added jitter.

The outputs of the SN65LVDS20 are LVDS levels as defined by TIA/EIA-644-A. The outputs of the SN65LVDP20 are compatible with low-voltage PECL levels. A low-level input to \overline{EN} enables the outputs. A high-level input puts the output into a high-impedance state. Both outputs are designed to drive differential transmission lines with nominally 100- Ω characteristic impedance.

Both devices provide a voltage reference (V_{BB}) of typically 1.35 V below V_{CC} for use in receiving single-ended PECL input signals. When not used, V_{BB} should be unconnected or open.

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

FUNCTION DIAGRAM

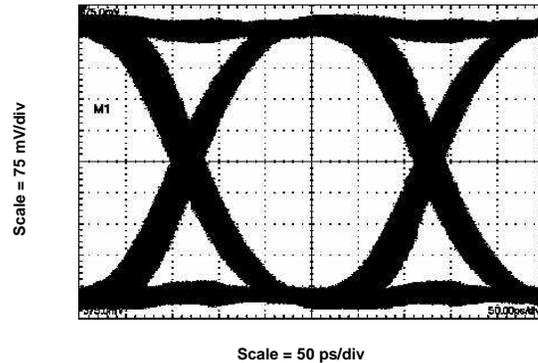
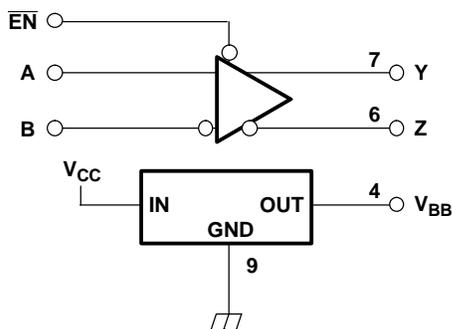


Figure 1. SN65LVDS20 Output Eye Pattern With 4-Gbps PRBS Input



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



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

AVAILABLE OPTIONS⁽¹⁾

| INPUT | OUTPUT | PART NUMBER | PART MARKING |
|--------------|--------|-------------|--------------|
| Differential | LVDS | SN65LVDS20 | E8 |
| Differential | LVPECL | SN65LVP20 | E7 |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

ABSOLUTE MAXIMUM RATINGS

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

| | UNIT |
|---|-------------------------------------|
| V _{CC} Supply voltage ⁽²⁾ | -0.5 V to 4 V |
| V _I Input voltage | -0.5 V to V _{CC} + 0.5 V |
| V _O Output voltage | -0.5 V to V _{CC} + 0.5 V |
| I _O V _{BB} output current | ±0.5 mA |
| HBM electrostatic discharge ⁽³⁾ | ±3 kV |
| CDM electrostatic discharge ⁽⁴⁾ | ±1500 V |
| Continuous power dissipation | See Power Dissipation Ratings Table |

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential voltages, are with respect to network ground (see [Figure 2](#)).
- (3) Tested in accordance with JEDEC Standard 22, Test Method A114-A-7
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101

DISSIPATION RATINGS

| PACKAGE | T _A < 25°C POWER RATING | OPERATING FACTOR ABOVE T _A = 25°C | T _A = 85°C POWER RATING |
|---------|---------------------------------------|---|---------------------------------------|
| DRF | 403 mW | 4.0 mW/°C | 161 mW |

RECOMMENDED OPERATING CONDITIONS

| | MIN | NOM | MAX | UNIT |
|--|---------------------|------------|--|------|
| V _{CC} Supply Voltage | 2.375 | 2.5 or 3.3 | 3.6 | V |
| V _{IC} Common-mode input voltage (V _{IA} + V _{IB})/2 | 1.2 | | V _{CC} - (V _{ID} /2) | V |
| V _{ID} Differential input voltage magnitude, V _{IA} - V _{IB} | 0.08 | | 1 | V |
| V _{IH} High-level input voltage, \overline{EN} | 2 | | V _{CC} | V |
| V _{IL} Low-level input voltage, \overline{EN} | 0 | | 0.8 | V |
| I _O Output current to V _{BB} | -400 ⁽¹⁾ | | 400 | μA |
| R _L Differential load resistance | 90 | | 132 | Ω |
| T _A Operating free-air temperature | -40 | | 85 | °C |

(1) The algebraic convention, where the least positive (more negative) value is designated minimum, is used in this data sheet.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|---|--|--|--|------------------------|------------------------|------|
| I _{CC} | Supply current | R _L = 100 Ω, $\overline{\text{EN}}$ at 0 V, Other inputs open | | 35 | 45 | mA |
| | | Outputs unloaded, $\overline{\text{EN}}$ at 0 V, Other inputs open | | 19 | 24 | |
| P _D | Device power dissipation, SN65LVDS20 | R _L = 100 Ω, $\overline{\text{EN}}$ at 0 V, 2-GHz 50%-duty-cycle square-wave input | | 116 | 160 | mW |
| | Device power dissipation, SN65LVP20 | 50 Ω from Y and Z to V _{CC} - 2 V, $\overline{\text{EN}}$ at 0 V, 2-GHz 50%-duty-cycle square-wave input | | 63 | 86 | |
| V _{BB} | Reference voltage | I _{BB} = ±400 μA | V _{CC} - 1.44 | V _{CC} - 1.35 | V _{CC} - 1.25 | V |
| I _{IH} | High-level input current, $\overline{\text{EN}}$ | V _I = 2 V | -20 | | 20 | μA |
| I _{IAH} or I _{IBH} | High-level input current, A or B | V _I = V _{CC} | -20 | | 20 | |
| I _{IL} | Low-level input current, $\overline{\text{EN}}$ | V _I = 0.8 V | -20 | | 20 | |
| I _{IAL} or I _{IBL} | Low-level input current, A or B | V _I = GND | -20 | | 20 | |
| SN65LVDS20 OUTPUT CHARACTERISTICS (see Figure 2) | | | | | | |
| V _{OD} | Differential output voltage magnitude, V _{OY} - V _{OZ} | See Figure 2 | 247 | 340 | 454 | mV |
| Δ V _{OD} | Change in differential output voltage magnitude between logic states | | 50 | | | |
| V _{OC(SS)} | Steady-state common-mode output voltage (see Figure 3) | | 1.125 | | 1.375 | V |
| ΔV _{OC(SS)} | Change in steady-state com- mon-mode output voltage between logic states | See Figure 3 | -50 | | 50 | mV |
| V _{OC(PP)} | Peak-to-peak common-mode output voltage | | 50 | | 100 | |
| I _{OYZ} or I _{OZZ} | High-impedance output current | $\overline{\text{EN}}$ at V _{CC} , V _O = 0 V or V _{CC} | -1 | | 1 | μA |
| I _{OYS} or I _{OZS} | Short-circuit output current | $\overline{\text{EN}}$ at 0 V, V _{OY} or V _{OZ} = 0 V | -62 | | 62 | mA |
| I _{OS(D)} | Differential short-circuit output cur- rent, I _{OY} - I _{OZ} | $\overline{\text{EN}}$ at 0 V, V _{OY} = V _{OZ} | -12 | | 12 | |
| SN65LVP20 OUTPUT CHARACTERISTICS (see Figure 2) | | | | | | |
| V _{OYH} or V _{OZH} | High-level output voltage | 3.3 V; 50 Ω from Y and Z to V _{CC} - 2 V | V _{CC} - 1.05 | | V _{CC} - 0.82 | V |
| V _{OYL} or V _{OZL} | Low-level output voltage | | V _{CC} - 1.83 | | V _{CC} - 1.57 | |
| V _{OYL} or V _{OZL} | Low-level output voltage | | 2.5 V; 50 Ω from Y and Z to V _{CC} - 2 V | V _{CC} - 1.88 | | |
| V _{OD} | Differential output voltage magnitude, V _{OH} - V _{OL} | | 0.6 | 0.8 | 1 | |
| I _{OYZ} or I _{OZZ} | High-impedance output current | $\overline{\text{EN}}$ at V _{CC} , V _O = 0 V or V _{CC} | -1 | | 1 | μA |

(1) Typical values are at room temperature and with a V_{CC} of 3.3 V.

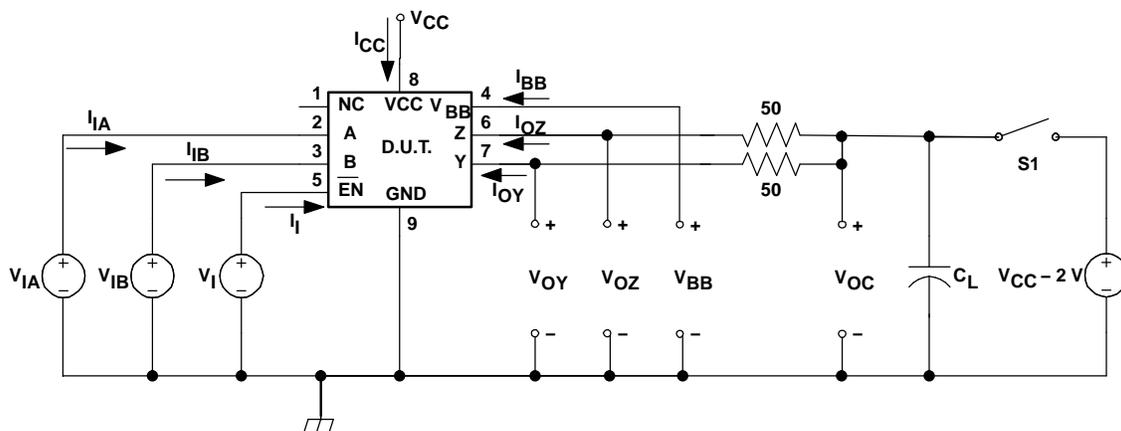
SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|----------------|---|---|-----|--------------------|-----|------|
| t_{PLH} | Differential propagation delay time, low-to-high-level output | See Figure 2 and Figure 4 | 300 | 450 | 630 | ps |
| t_{PHL} | Differential propagation delay time, high-level-to-low-level output | | 300 | 450 | 630 | |
| $t_{SK(P)}$ | Pulse skew, $ t_{PLH} - t_{PHL} $ | | | | 20 | |
| $t_{SK(PP)}$ | Part-to-part skew ⁽²⁾ | $V_{CC} = 3.3\text{ V}$ | | | 80 | ps |
| | | $V_{CC} = 2.5\text{ V}$ | | | 130 | |
| t_r | 20%-to-80% differential signal rise time | LVDS, See Figure 2 and Figure 4 | | 85 | 115 | ps |
| | | LVPECL, See Figure 2 and Figure 4 | | 92 | 120 | |
| t_f | 20%-to-80% differential signal fall time | LVDS, See Figure 2 and Figure 4 | | 85 | 115 | ps |
| | | LVPECL, See Figure 2 and Figure 4 | | 92 | 120 | |
| $t_{jit(per)}$ | RMS period jitter ⁽³⁾ | 2-GHz 50%-duty-cycle square-wave input, See Figure 5 | | 2 | 3 | ps |
| $t_{jit(cc)}$ | Peak cycle-to-cycle jitter ⁽⁴⁾ | | | 13 | 16 | |
| $t_{jit(p-p)}$ | Peak-to-peak jitter | LVDS; 4 Gbps PRBS, 2 ²³ - 1 run length, See Figure 5 | | 37 | 45 | ps |
| $t_{jit(ph)}$ | Intrinsic phase jitter | 155.52 MHz | | 0.62 | | ps |
| | | 622.08 MHz | | 0.14 | | |
| t_{PHZ} | Propagation delay time, high-level-to-high-impedance output | See Figure 2 and Figure 6 | | | 30 | ns |
| t_{PLZ} | Propagation delay time, low-level-to-high-impedance output | | | | 30 | |
| t_{PZH} | Propagation delay time, high-impedance-to-high-level output | | | | 30 | |
| t_{PZL} | Propagation delay time, high-impedance-to-low-level output | | | | 30 | |

- (1) Typical values are at room temperature and with a V_{CC} of 3.3 V.
- (2) Part-to-part skew is the magnitude of the difference in propagation delay times between any specified terminals of two devices when both devices operate with the same supply voltages, at the same temperature, and have identical packages and test circuits.
- (3) Period jitter is the deviation in cycle time of a signal with respect to the ideal period over a random sample of 100,000 cycles.
- (4) Cycle-to-cycle jitter is the variation in cycle time of a signal between adjacent cycles, over a random sample of 1,000 adjacent cycle pairs.

PARAMETER MEASUREMENT INFORMATION



- (1) C_L is the instrumentation and test fixture capacitance.
- (2) S1 is open for the SN65LVDS20 and closed for the SN65LVP20.

Figure 2. Output Voltage Test Circuit and Voltage and Current Definitions

PARAMETER MEASUREMENT INFORMATION (continued)

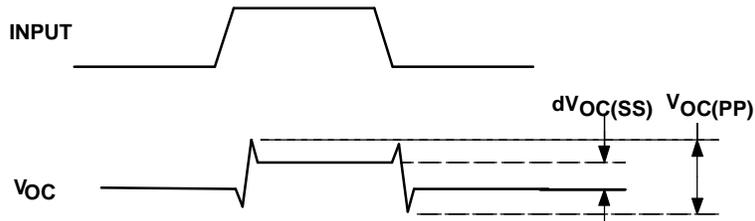


Figure 3. V_{OC} Definitions

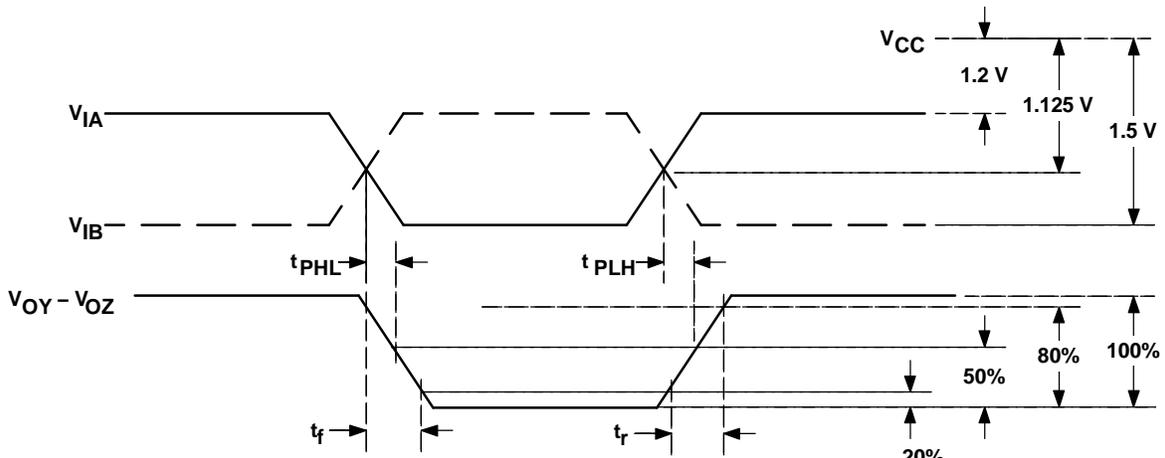


Figure 4. Propagation Delay and Transition Time Test Waveforms

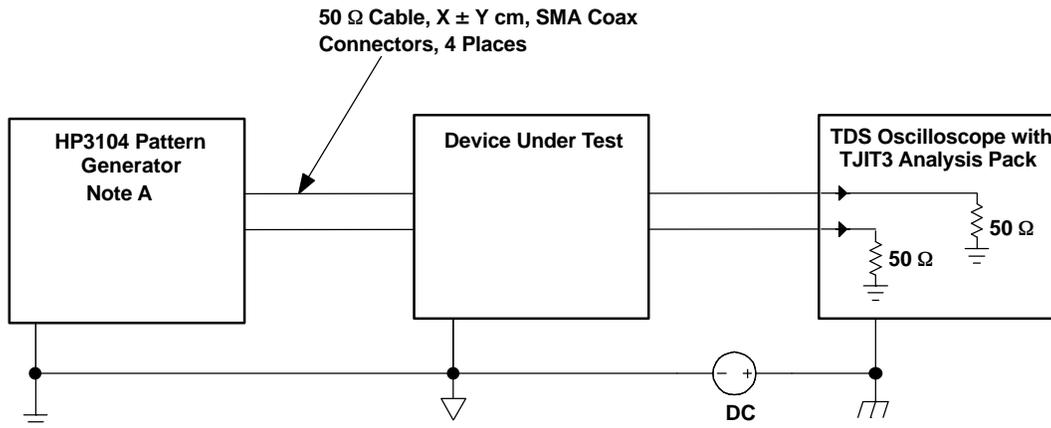


Figure 5. Jitter Measurement Setup

PARAMETER MEASUREMENT INFORMATION (continued)

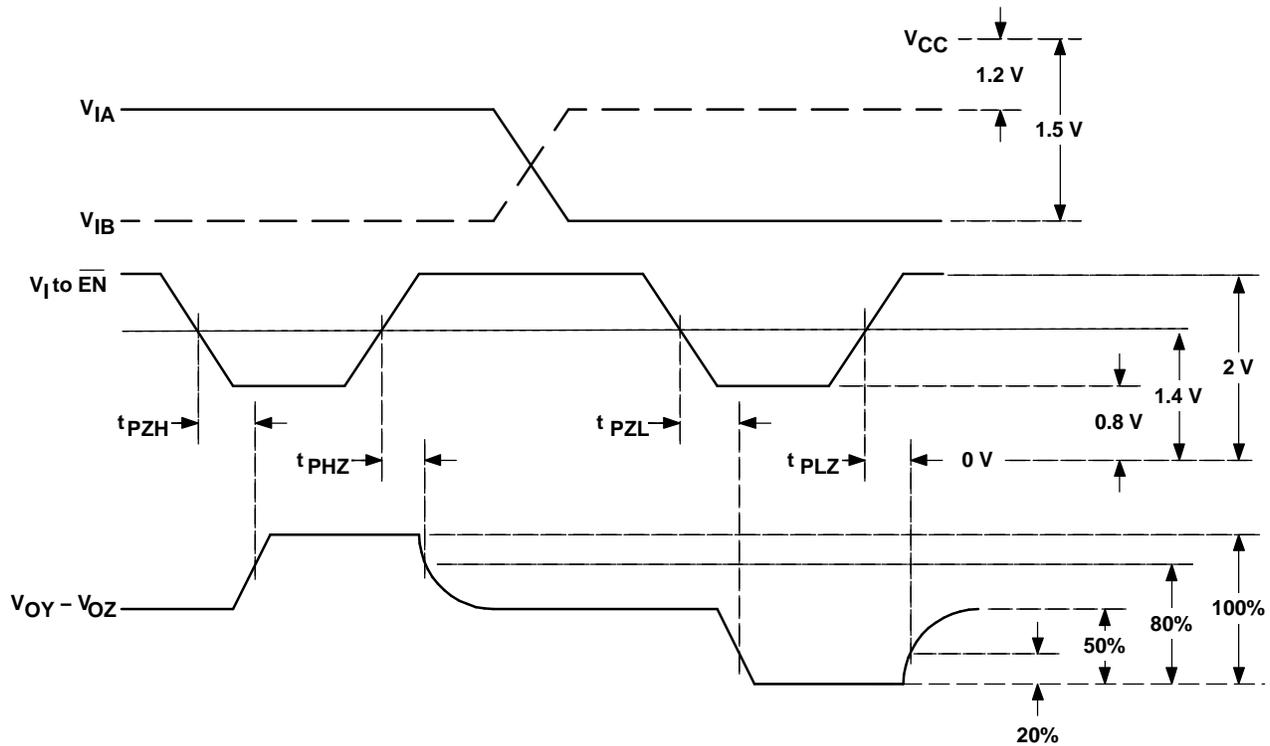


Figure 6. Enable and Disable Time Test Waveforms

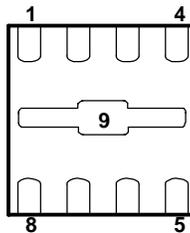
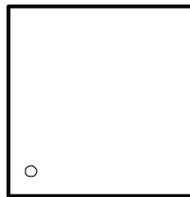
DEVICE INFORMATION

FUNCTION TABLE⁽¹⁾

| A | B | \overline{EN} | Y | Z |
|------|------|-----------------|---|---|
| H | H | L | ? | ? |
| L | H | L | L | H |
| H | L | L | H | L |
| L | L | L | ? | ? |
| X | X | H | Z | Z |
| Open | Open | L | ? | ? |
| X | X | Open | ? | ? |

(1) H = high, L = low, Z = high impedance, ? = indeterminate

TOP VIEW



BOTTOM VIEW

Package Pin Assignments - Numerical Listing

| PIN | SIGNAL | PIN | SIGNAL |
|-----|------------------------|-----|-----------------|
| 1 | NC | 6 | Z |
| 2 | A | 7 | Y |
| 3 | B | 8 | V _{CC} |
| 4 | V _{BB} | 9 | GND |
| 5 | $\overline{\text{EN}}$ | | |

Package Pin Assignments - Alphabetical Listing

| SIGNAL | PIN | SIGNAL | PIN |
|------------------------|-----|-----------------|-----|
| A | 2 | V _{BB} | 4 |
| B | 3 | V _{CC} | 8 |
| $\overline{\text{EN}}$ | 5 | Y | 7 |
| GND | 9 | Z | 6 |
| NC | 1 | | |

TYPICAL CHARACTERISTICS

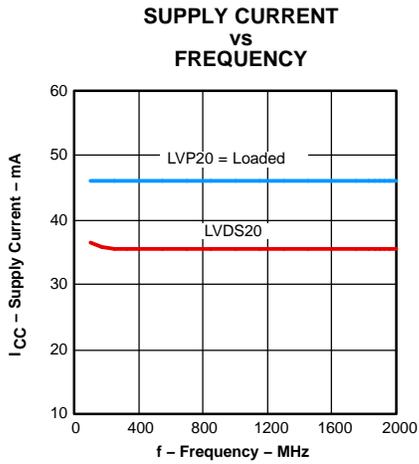


Figure 7.

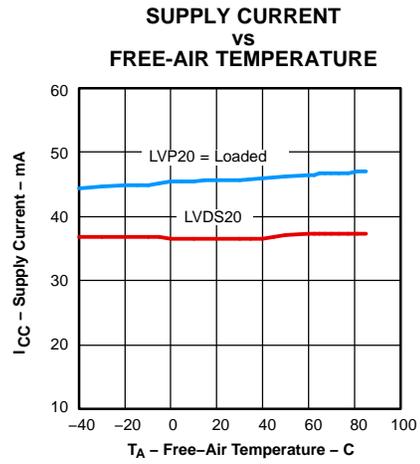


Figure 8.

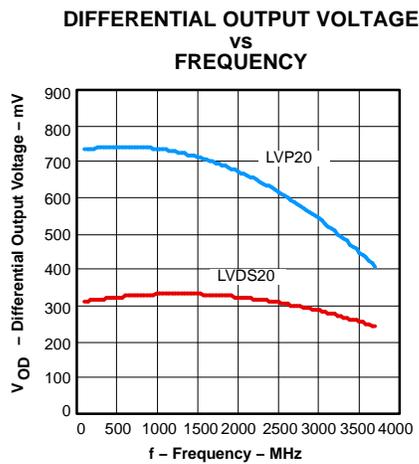


Figure 9.

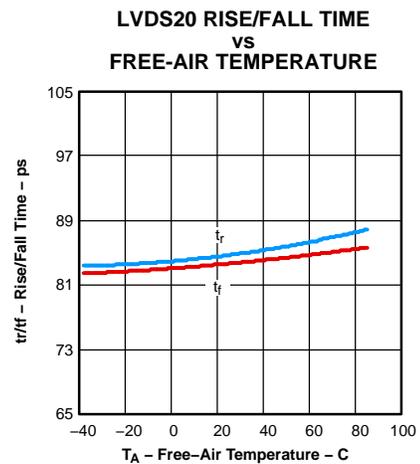


Figure 10.

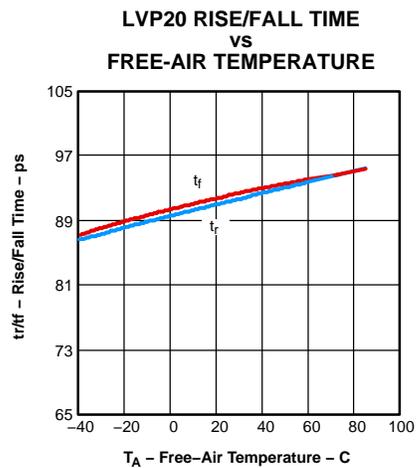


Figure 11.

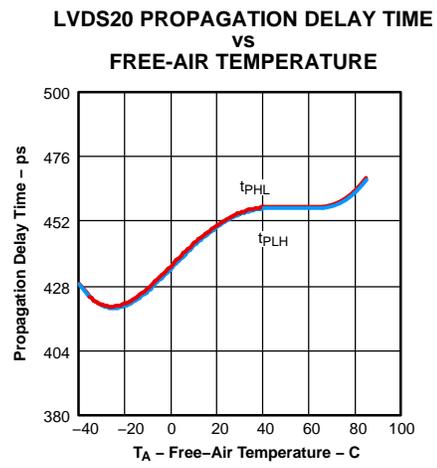


Figure 12.

TYPICAL CHARACTERISTICS (continued)

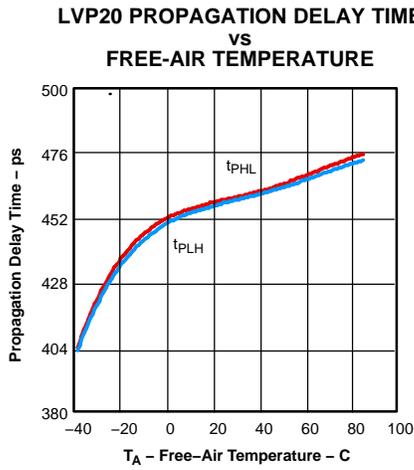


Figure 13.

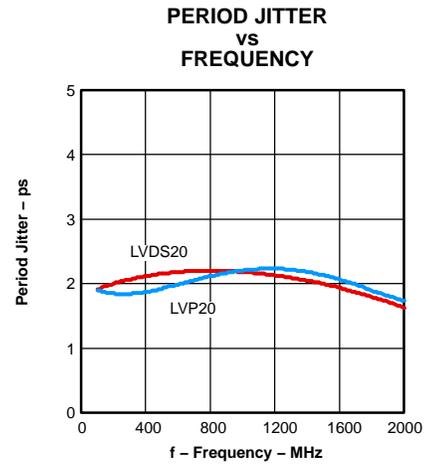


Figure 14.

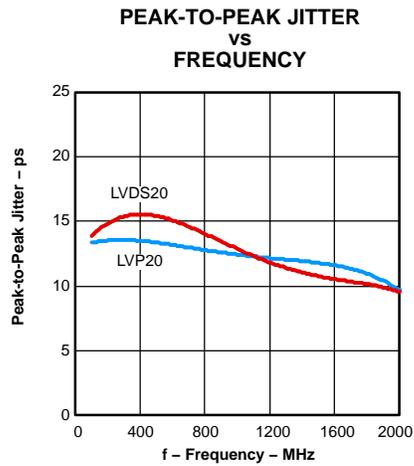


Figure 15.

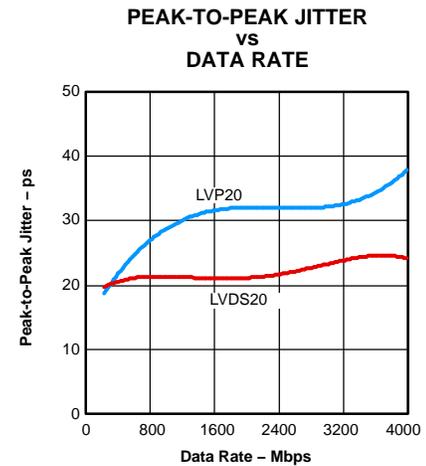


Figure 16.

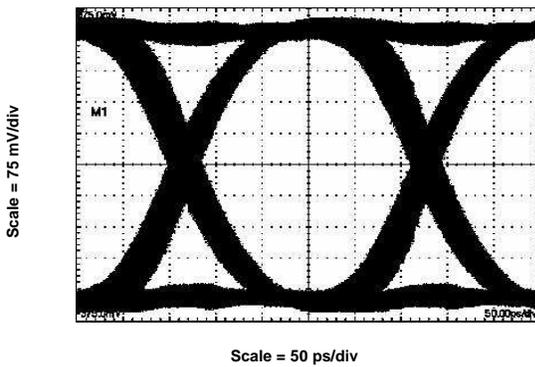


Figure 17. LVDS20 4-Gbps, $2^{23} - 1$ PRBS

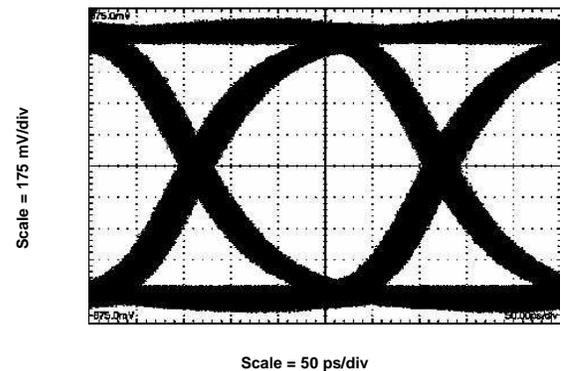


Figure 18. LVP20 4-Gbps, $2^{23} - 1$ PRBS

TYPICAL CHARACTERISTICS (continued)

PHASE NOISE OF SN65LVP20

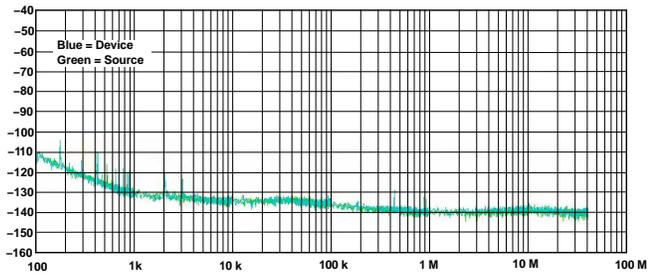


Figure 19. Frequency Offset From 155.52 MHz Carrier

PHASE NOISE OF SN65LVP20

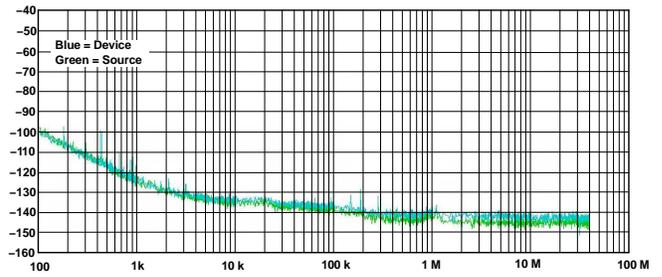
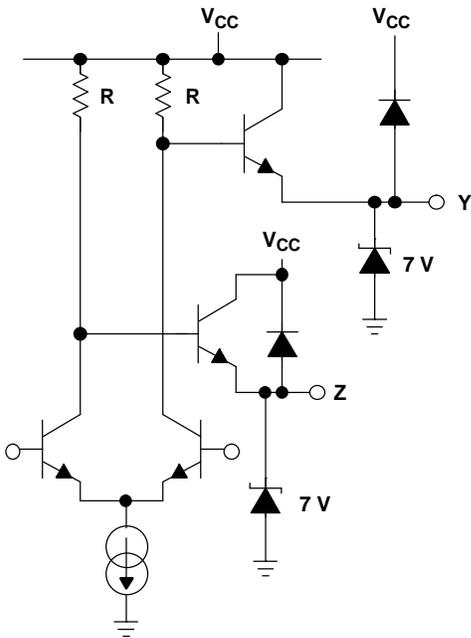


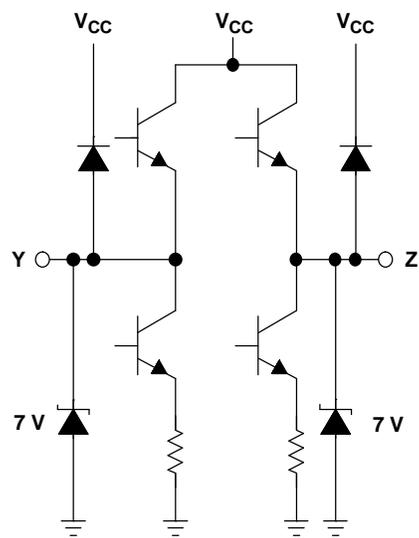
Figure 20. Frequency Offset From 622.08 MHz Carrier

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS

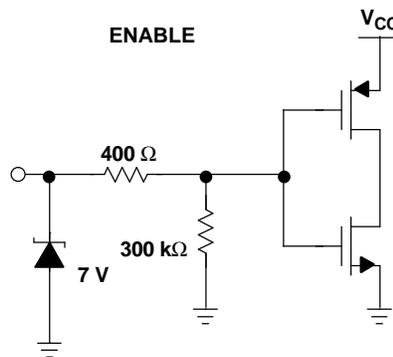
OUTPUT LVP20



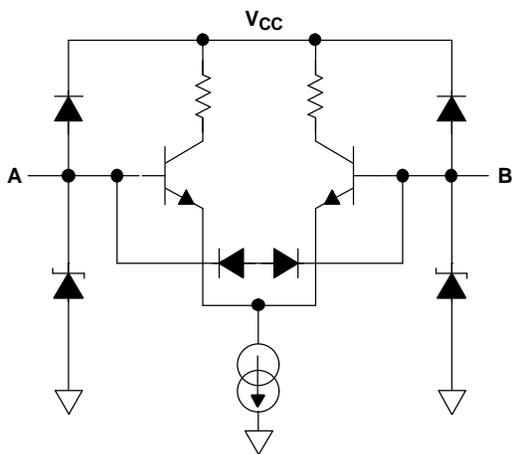
OUTPUT LVDS20



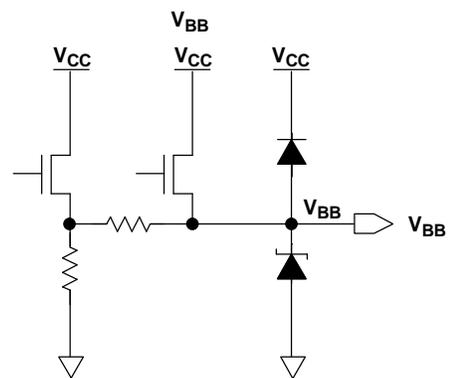
ENABLE



INPUT



OUTPUT



PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|--------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| SN65LVDS20DRFR | Active | Production | WSON (DRF) 8 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E8 |
| SN65LVDS20DRFR.B | Active | Production | WSON (DRF) 8 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E8 |
| SN65LVDS20DRFT | Active | Production | WSON (DRF) 8 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E8 |
| SN65LVDS20DRFT.B | Active | Production | WSON (DRF) 8 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E8 |
| SN65LVDS20DRFTG4 | Active | Production | WSON (DRF) 8 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E8 |
| SN65LVP20DRFR | Active | Production | WSON (DRF) 8 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E7 |
| SN65LVP20DRFR.B | Active | Production | WSON (DRF) 8 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E7 |
| SN65LVP20DRFRG4.B | Active | Production | WSON (DRF) 8 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E7 |
| SN65LVP20DRFT | Active | Production | WSON (DRF) 8 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E7 |
| SN65LVP20DRFT.B | Active | Production | WSON (DRF) 8 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | E7 |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

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

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

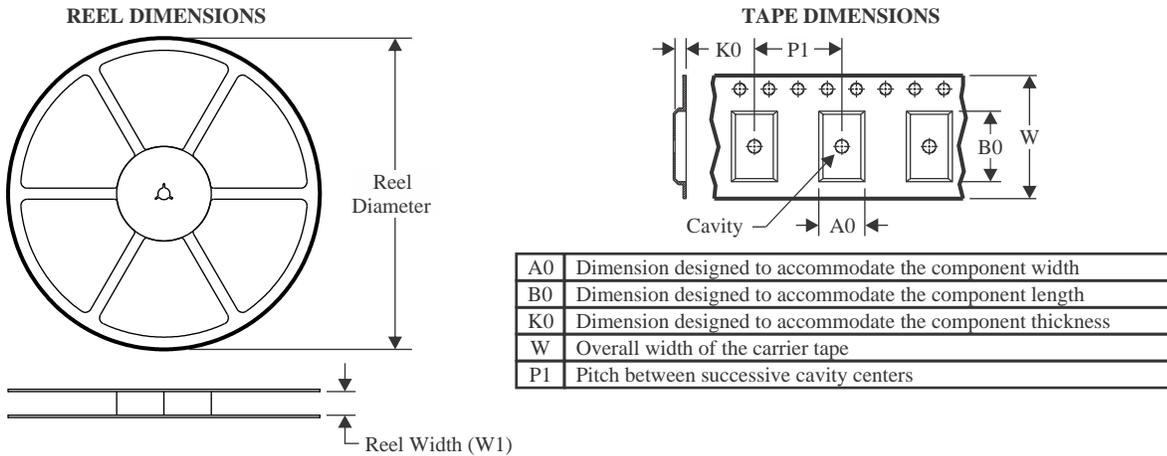
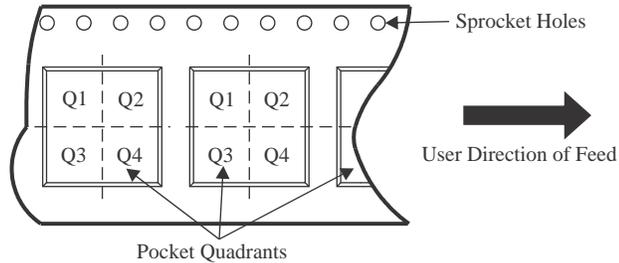
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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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 |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65LVDS20DRFR | WSON | DRF | 8 | 3000 | 330.0 | 8.8 | 2.3 | 2.3 | 1.0 | 4.0 | 8.0 | Q2 |
| SN65LVDS20DRFT | WSON | DRF | 8 | 250 | 330.0 | 8.8 | 2.3 | 2.3 | 1.0 | 4.0 | 8.0 | Q2 |
| SN65LVP20DRFR | WSON | DRF | 8 | 3000 | 330.0 | 8.8 | 2.3 | 2.3 | 1.0 | 4.0 | 8.0 | Q2 |
| SN65LVP20DRFT | WSON | DRF | 8 | 250 | 330.0 | 8.8 | 2.3 | 2.3 | 1.0 | 4.0 | 8.0 | Q2 |

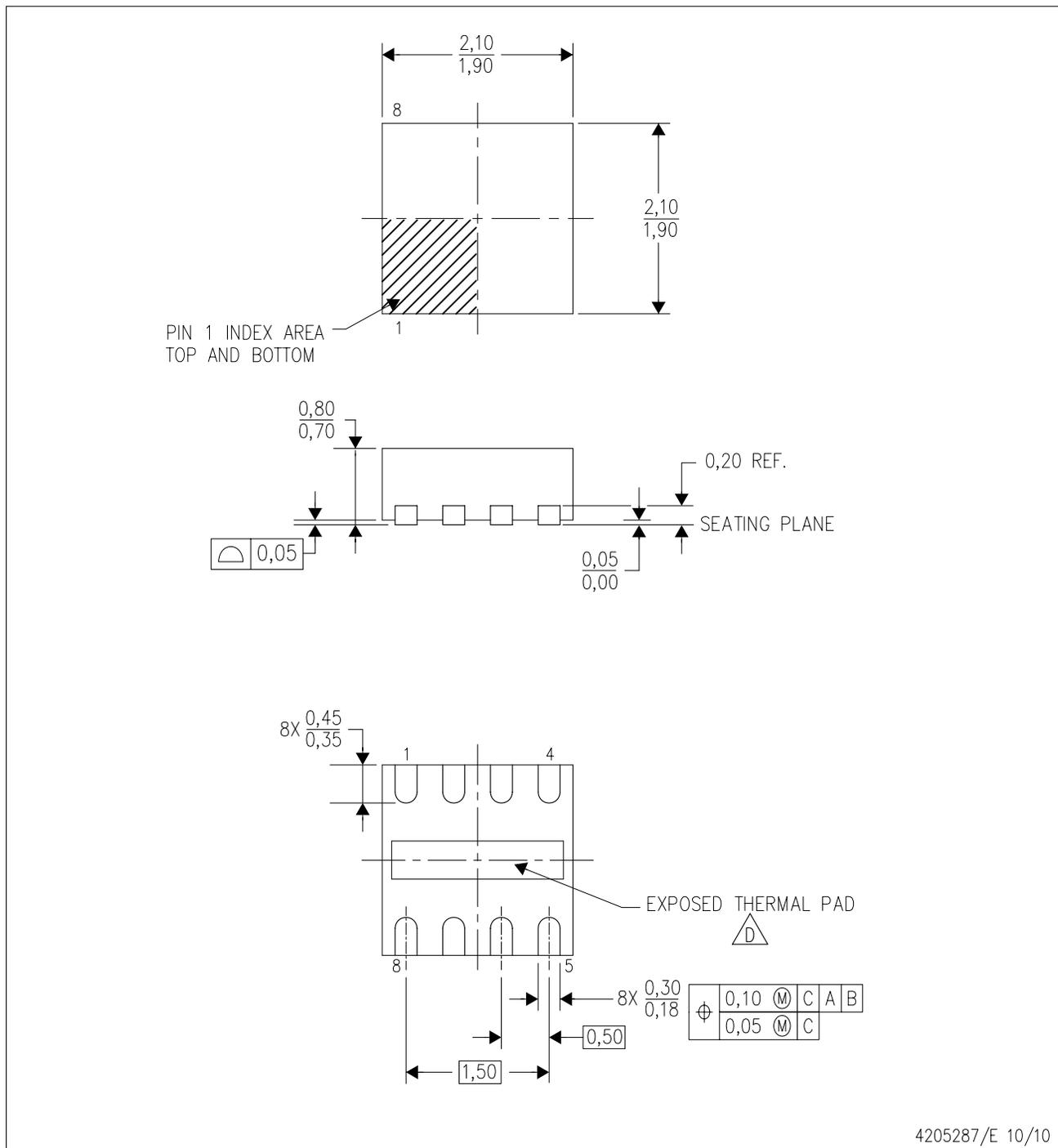
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65LVDS20DRFR | WSON | DRF | 8 | 3000 | 337.0 | 343.0 | 29.0 |
| SN65LVDS20DRFT | WSON | DRF | 8 | 250 | 337.0 | 343.0 | 29.0 |
| SN65LVP20DRFR | WSON | DRF | 8 | 3000 | 337.0 | 343.0 | 29.0 |
| SN65LVP20DRFT | WSON | DRF | 8 | 250 | 337.0 | 343.0 | 29.0 |

DRF (S-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Quad Flatpack, No-Leads (QFN) package configuration.
 -  D. The Package thermal pad must be soldered to the board for thermal and mechanical performance. See product data sheet for details regarding the exposed thermal pad dimensions.
 - E. Falls within JEDEC MO-229.

THERMAL PAD MECHANICAL DATA

DRF (S-PWSON-N8)

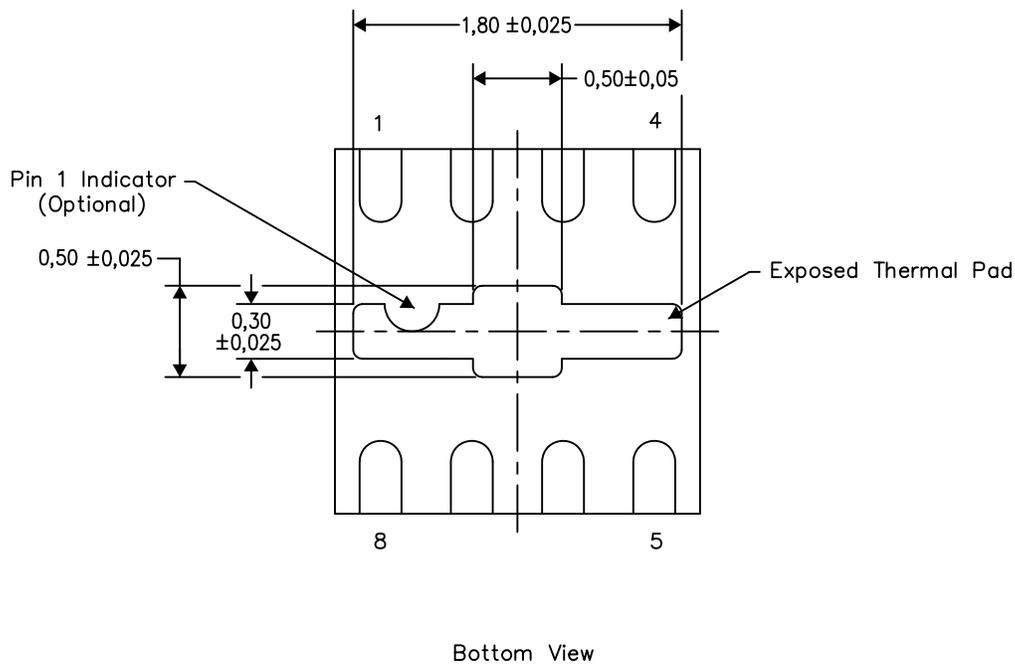
PLASTIC SMALL OUTLINE NO-LEAD

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/SOIC 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.



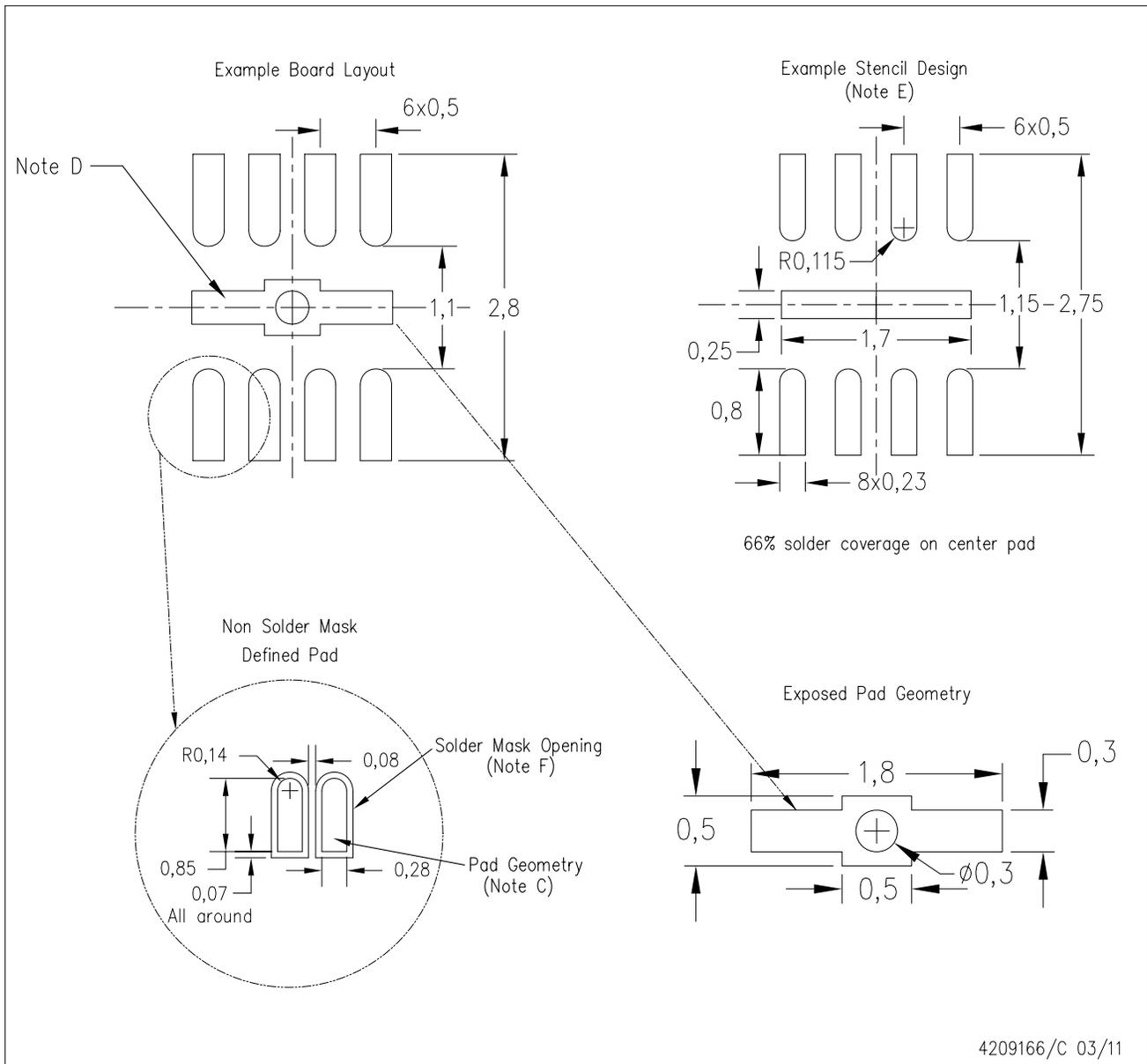
Exposed Thermal Pad Dimensions

4206840/H 12/14

NOTE: A. All linear dimensions are in millimeters

DRF (S-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



- 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, Quad Flat-Pack 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 minimum solder mask web tolerances between signal pads.

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