

## HIGH-SPEED DIFFERENTIAL LINE DRIVERS AND RECEIVERS

### FEATURES

- Typically Meets or Exceeds ANSI TIA/EIA-644-1995 Standard
- Operates From a Single 2.4-V to 3.6-V Supply
- Signaling Rates up to 400 Mbit/s
- Bus-Terminal ESD Exceeds 12 kV
- Low-Voltage Differential Signaling With Typical Output Voltages of 285 mV and a 100-Ω Load
- Propagation Delay Times
  - Driver: 1.7-ns Typical
  - Receiver: 3.7-ns Typical
  - Driver: 25-mW Typical
  - Receiver: 60-mW Typical
- Power Dissipation at 200 MHz
  - Driver: 25-mW Typical
  - Receiver: 60-mW Typical
- LVTTTL Input Levels Are 5-V Tolerant
- Receiver Maintains High Input Impedance
- Receiver Has Open-Circuit Fail Safe
- Available in Thin Shrink Outline Packaging With 20-mil Lead Pitch

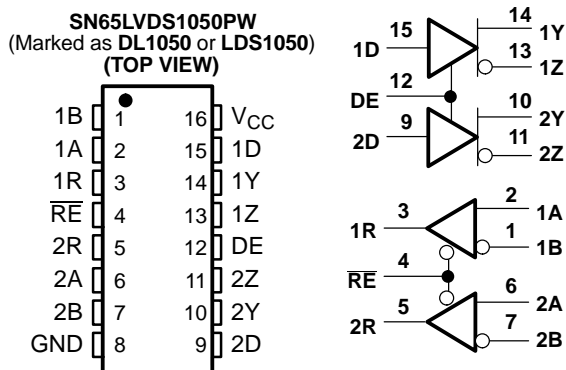
### DESCRIPTION

The SN65LVDS1050 is similar to the SN65LVDS050 except that it is characterized for operation with a lower supply voltage range and packaged in the thin shrink outline package for portable battery-powered applications.

The differential line drivers and receivers use low-voltage differential signaling (LVDS) to achieve signaling rates as high as 400 Mbps. The drivers provide a minimum differential output voltage magnitude of 247 mV into a 100-Ω load and receipt of 100-mV signals with up to 1 V of ground potential difference between a transmitter and receiver.

The intended application of this device and signaling technique is for point-to-point baseband data transmission over controlled impedance media of approximately 100-Ω characteristic impedance. The transmission media may be printed-circuit board traces, backplanes, or cables. Note: The ultimate rate and distance of data transfer is dependent upon the attenuation characteristics of the media, the noise coupling to the environment and other application-specific characteristics.

The SN65LVDS1050 is characterized for operation from -40°C to 85°C.



DRIVER FUNCTION TABLE

INPUTS		OUTPUTS	
D	DE	Y	Z
L	H	L	H
H	H	H	L
Open	H	L	H
X	L	Z	Z

H = high level, L = low level, Z = high impedance,  
X = don't care

RECEIVER FUNCTION TABLE

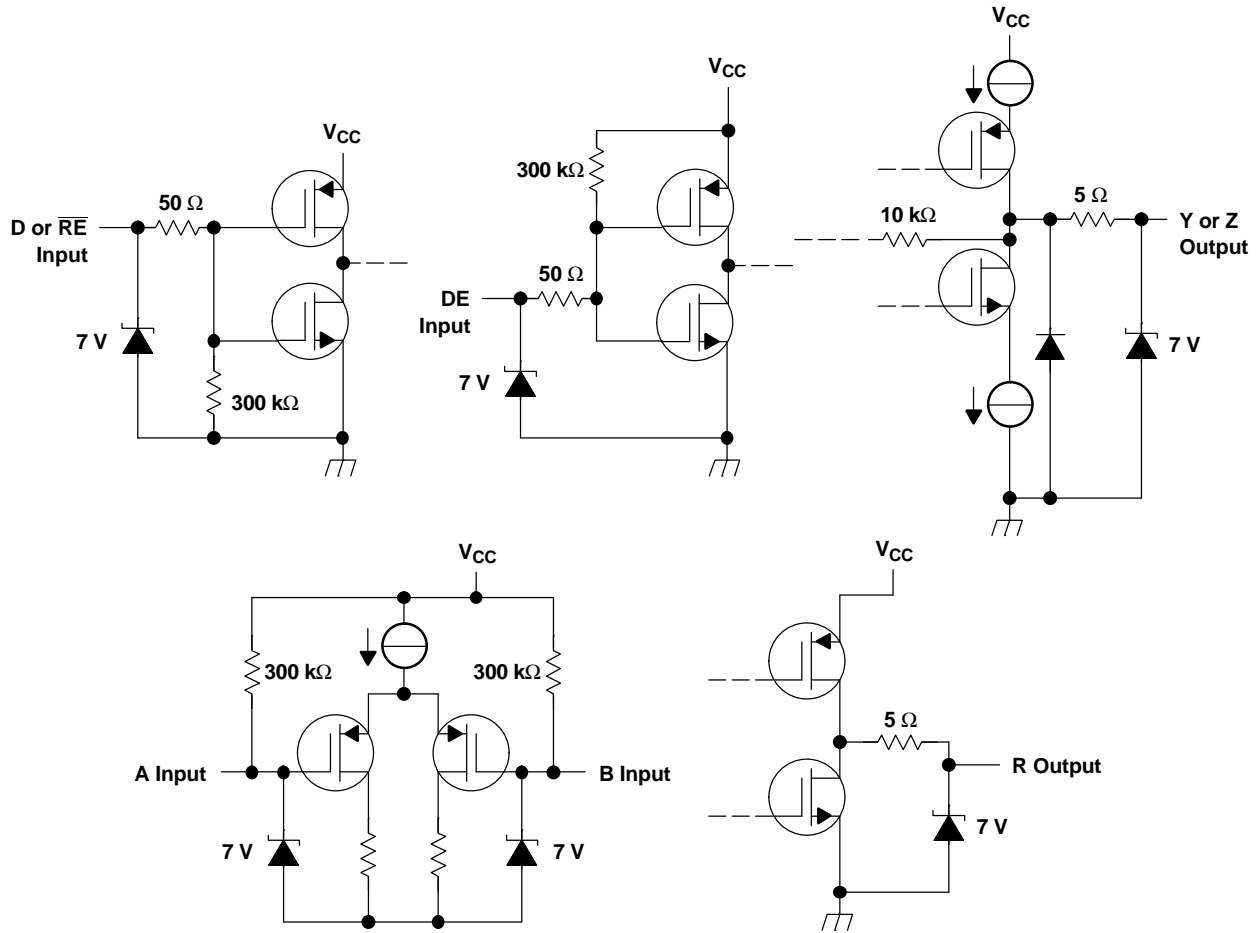
INPUTS		OUTPUT
$V_{ID} = V_A - V_B$	$\overline{RE}$	R
$V_{ID} \geq 100$ mV	L	H
$-100$ mV < $V_{ID} < 100$ mV	L	?
$V_{ID} \leq -100$ mV	L	L
Open	L	H
X	H	Z

H = high level, L = low level, Z = high impedance,  
X = don't care



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.

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



## ABSOLUTE MAXIMUM RATINGS

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

		UNIT
Supply voltage range, $V_{CC}$ (2)		-0.5 V to 4 V
Voltage range (D, R, DE, $\overline{RE}$ )		-0.5 V to 6 V
Voltage range (Y, Z, A, and B)		-0.5 V to 4 V
Electrostatic discharge	Y, Z, A, B, and GND (3)	Class 3, A:12 kV, B:600 V
	All terminals	Class 3, A:7 kV, B:500 V
Continuous power dissipation		See Dissipation Rating Table
Storage temperature range		-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds		250°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 condition beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential I/O bus voltages are with respect to network ground terminal.
- (3) Tested in accordance with MIL-STD-883C Method 3015.7.

## DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
PW	774 mW	6.2 mW/°C	402 mW

## RECOMMENDED OPERATING CONDITIONS (1)

	MIN	NOM	MAX	UNIT
Supply voltage, $V_{CC}$	2.4	2.7	3.6	V
High-level input voltage, $V_{IH}$	2			V
Low-level input voltage, $V_{IL}$			0.8	V
Magnitude of differential input voltage, $ V_{ID} $	0.1		0.6	V
Driver output voltage, $V_{OY}$ or $V_{OZ}$	0		2.4	V
Magnitude of differential output voltage with disabled driver, $ V_{OD(dis)} $			520	mV
Common-mode input voltage, $V_{IC}$ (see Figure 5)	0		$2.4 - \frac{ V_{ID} }{2}$	V
			$V_{CC} - 0.8$	
Operating free-air temperature, $T_A$	40		85	°C

- (1) The common-mode input voltage,  $V_{IC}$ , is not fully 644 compliant when  $V_{CC} = 2.4$  V.

## DEVICE ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
$I_{CC}$ Supply current	Driver and receiver enabled, No receiver load, Driver $R_L = 100 \Omega$		12	20	mA
	Driver enabled, Receiver disabled, $R_L = 100 \Omega$		10	16	
	Driver disabled, Receiver enabled, No load		3	6	
	Disabled		0.5	1	

- (1) All typical values are at 25°C and with a 2.7-V supply.

## DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{OD} $	Differential output voltage magnitude	$R_L=100\Omega$ , See Figure 1 and Figure 2	247	285	454	mV
$\Delta V_{OD} $	Change in differential output voltage magnitude between logic states		50		50	
$V_{OC(SS)}$	Steady-state common-mode output voltage	See Figure 3	1.125		1.375	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage between logic states		50		50	mV
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage			50	150	mV
$I_{IH}$	High-level input current	DE	$V_{IH}=5\text{ V}$	0.5	20	$\mu\text{A}$
		D		2	20	
$I_{IL}$	Low-level input current	DE	$V_{IL}=0.8\text{ V}$	0.5	10	$\mu\text{A}$
		D		2	20	
$I_{OS}$	Short-circuit output current	$V_{OY}$ or $V_{OZ}=0\text{ V}$		3	10	mA
		$V_{OD}=0\text{ V}$		3	10	
$I_{O(OFF)}$	Off-state output current	$DE=0\text{ V}$ , $V_{OY}=V_{OZ}=0\text{ V}$				$\mu\text{A}$
		$DE=V_{CC}$ , $V_{OY}=V_{OZ}=0\text{ V}$ , $V_{CC} < 1.5\text{ V}$	-1		1	
$C_{IN}$	Input capacitance			3		pF

## RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
$V_{ITH+}$	Positive-going differential input voltage threshold	See Figure 5 and Table 1			100	mV
$V_{ITH-}$	Negative-going differential input voltage threshold		100			
$V_{OH}$	High-level output voltage	$I_{OH}=-8\text{ mA}$	2			V
$V_{OL}$	Low-level output voltage	$I_{OL}=8\text{ mA}$			0.4	V
$I_I$	Input current (A or B inputs)	$V_I=0$	2		20	$\mu\text{A}$
		$V_I=2.4\text{ V}$	1.2			
$I_{I(OFF)}$	Power-off input current (A or B inputs)	$V_{CC}=0$			$\pm 20$	$\mu\text{A}$
$I_{IH}$	High-level input current (enables)	$V_{IH}=5\text{ V}$			$\pm 10$	$\mu\text{A}$
$I_{IL}$	Low-level input current (enables)	$V_{IL}=0.8\text{ V}$			$\pm 10$	$\mu\text{A}$
$I_{OZ}$	High-impedance output current	$V_O = 0$ or $5\text{ V}$			$\pm 10$	$\mu\text{A}$

(1) All typical values are at 25°C and with a 2.7-V supply.

## DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
$t_{PLH}$	Propagation delay time, low-to-high-level output		1.7	2.7	ns
$t_{PHL}$	Propagation delay time, high-to-low-level output		1.7	3	ns
$t_r$	Differential output signal rise time	$R_L=100\Omega$ , $C_L=10$ pF, See Figure 2	0.8	1	ns
$t_f$	Differential output signal fall time		0.8	1	ns
$t_{sk(p)}$	Pulse skew ( $t_{pHL} - t_{pLH}$ )		300		ps
$t_{sk(o)}$	Channel-to-channel output skew (2)		150		ps
$t_{en}$	Enable time	See Figure 4	7.8	10	ns
$t_{dis}$	Disable time		6.6	10	ns

(1) All typical values are at 25°C and with a 2.7-V supply.

(2)  $t_{sk(o)}$  is the maximum delay time difference between drivers on the same device.

## RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
$t_{PLH}$	Propagation delay time, low-to-high-level output	$C_L=10$ pF, See Figure 6	3.7	5.2	ns
$t_{PHL}$	Propagation delay time, high-to-low-level output		3.7	4.5	ns
$t_{sk(p)}$	Pulse skew ( $t_{pHL} - t_{pLH}$ )		0.3		ns
$t_r$	Output signal rise time		0.8	1.5	ns
$t_f$	Output signal fall time		0.8	1.5	ns
$t_{PZH}$	Propagation delay time, high-level-to-high-impedance output	See Figure 7	5.4		ns
$t_{PZL}$	Propagation delay time, low-level-to-low-impedance output		6.3		ns
$t_{PHZ}$	Propagation delay time, high-impedance-to-high-level output		6.1		ns
$t_{PLZ}$	Propagation delay time, low-impedance-to-high-level output		6.9		ns

(1) All typical values are at 25°C and with a 2.7-V supply.

PARAMETER MEASUREMENT INFORMATION

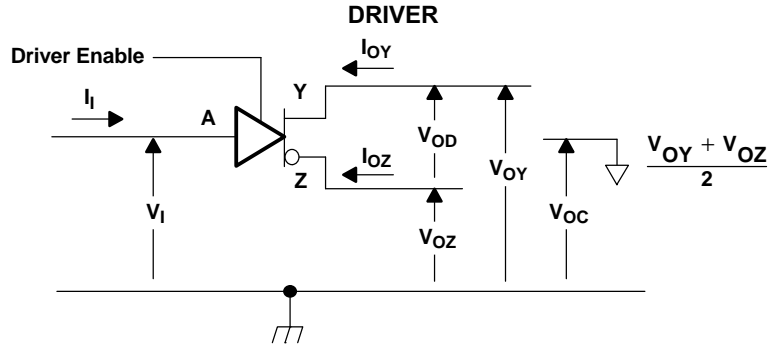
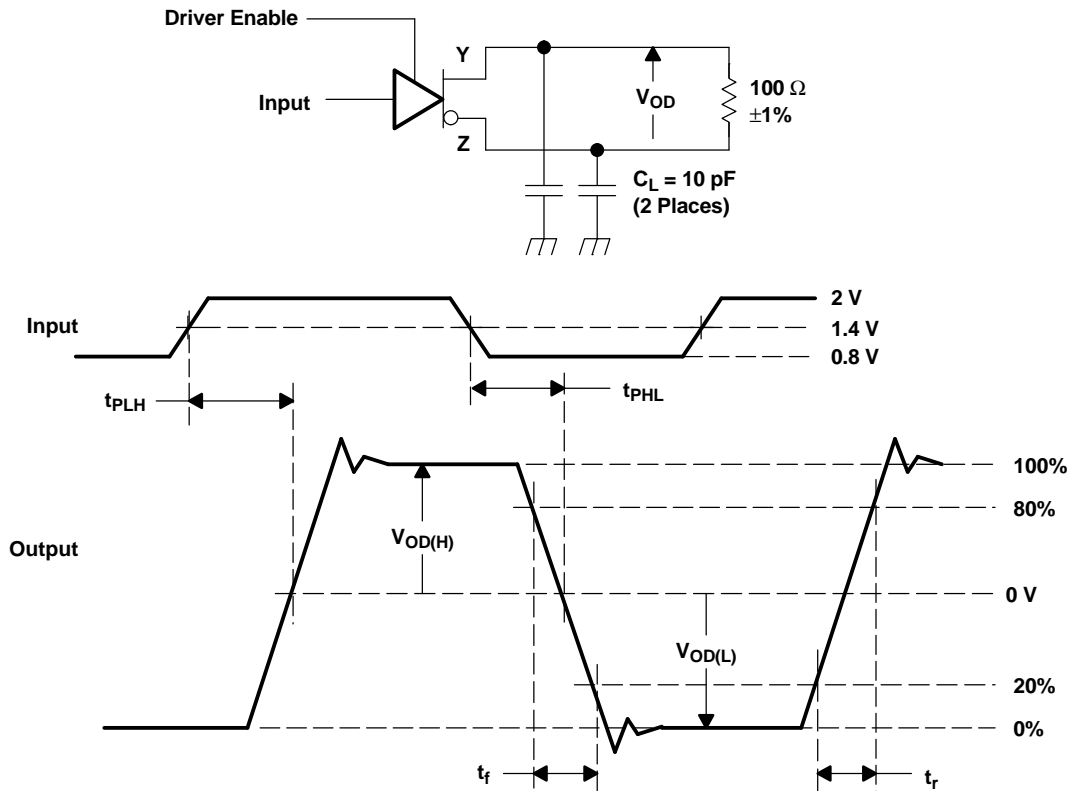
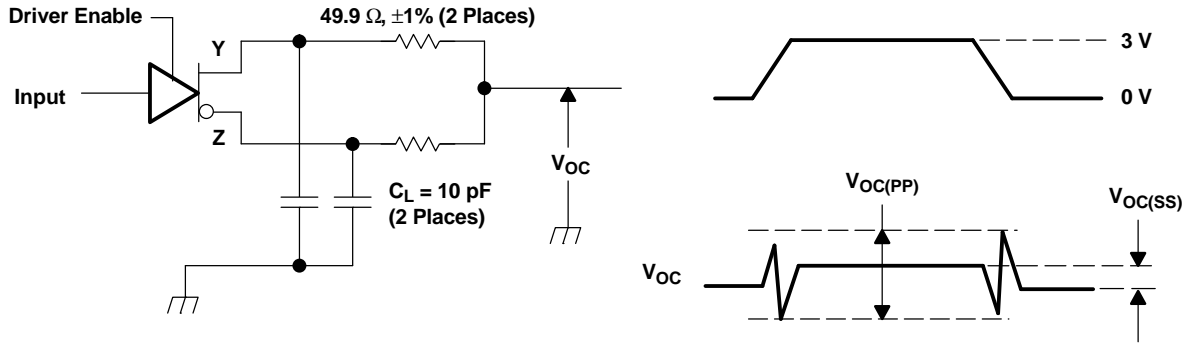


Figure 1. Driver Voltage and Current Definitions



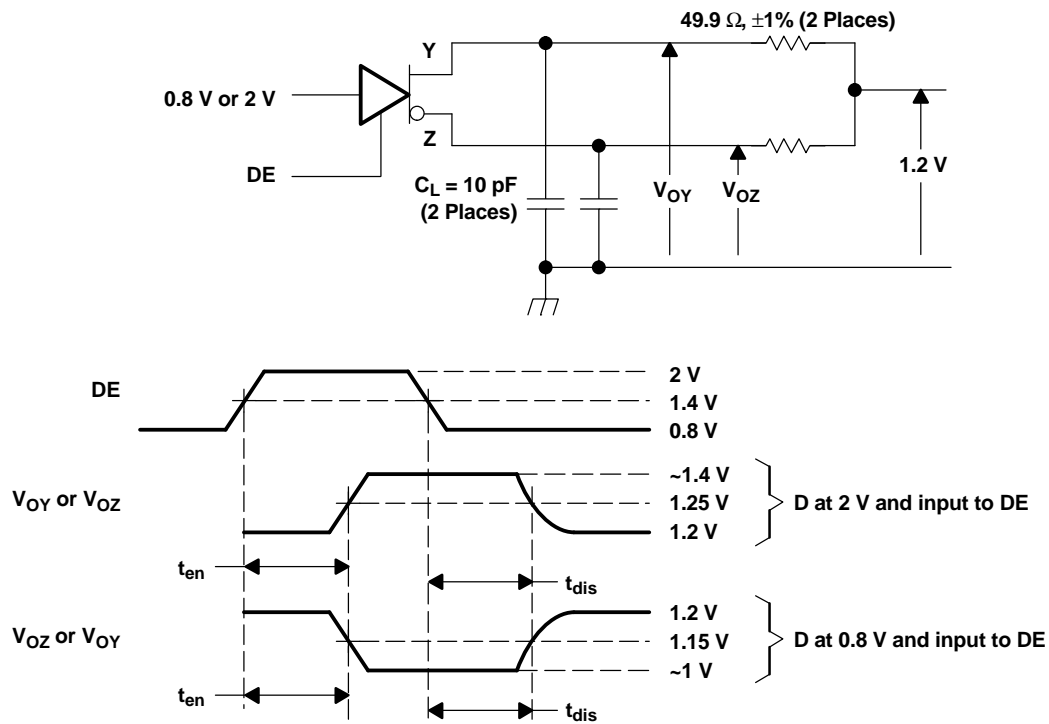
All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2$  ns.  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 2. Test Circuit, Timing, and Voltage Definitions for the Differential Output Signal



All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2$  ns. C<sub>L</sub> includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T. The measurement of V<sub>Oc(PP)</sub> is made on test equipment with a -3 dB bandwidth of at least 300 MHz.

Figure 3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage



All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns. C<sub>L</sub> includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 4. Driver Enable and Disable Time Circuit and Definitions

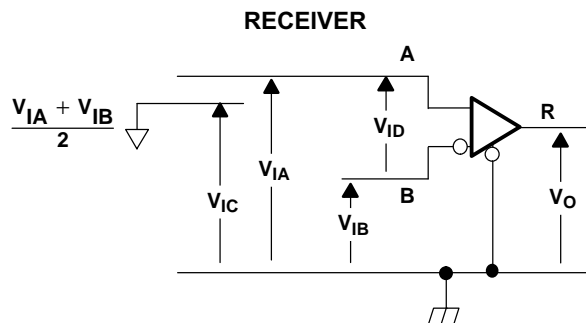
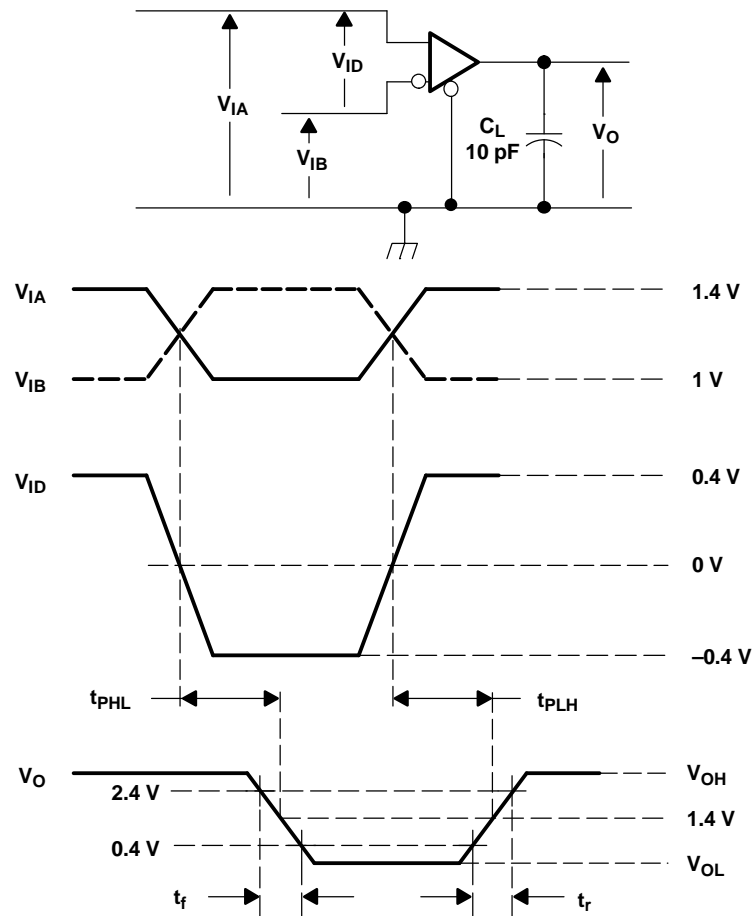


Figure 5. Receiver Voltage Definitions

Table 1. Receiver Minimum and Maximum Input Threshold Test Voltages

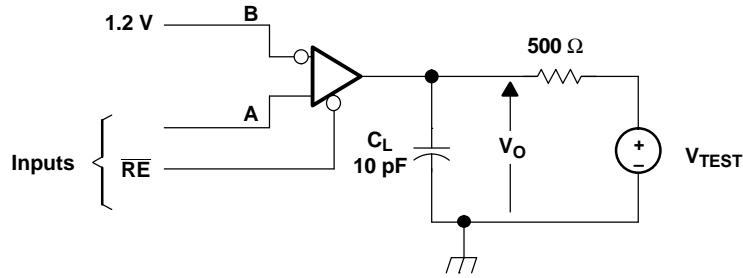
APPLIED VOLTAGES (V)		RESULTING DIFFERENTIAL INPUT VOLTAGE (mV)	RESULTING COMMON-MODE INPUT VOLTAGE (V)
$V_{IA}$	$V_{IB}$	$V_{ID}$	$V_{IC}$
1.25	1.15	100	1.2
1.15	1.25	100	1.2
2.4	2.3	100	2.35
2.3	2.4	100	2.35
0.1	0	100	0.05
0	0.1	100	0.05
1.5	0.9	600	1.2
0.9	1.5	600	1.2
2.4	1.8	600	2.1
1.8	2.4	600	2.1
0.6	0	600	0.3
0	0.6	600	0.3





All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1 \text{ ns}$ , pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2 \text{ ns}$ .  $C_L$  includes instrumentation and fixture capacitance within 0,06 m of the D.U.T.

**Figure 6. Timing Test Circuit and Waveforms**



All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  ns, pulse repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns.  $C_L$  includes instrumentation and fixture capacitance within 0,06 m of the D.U.T.

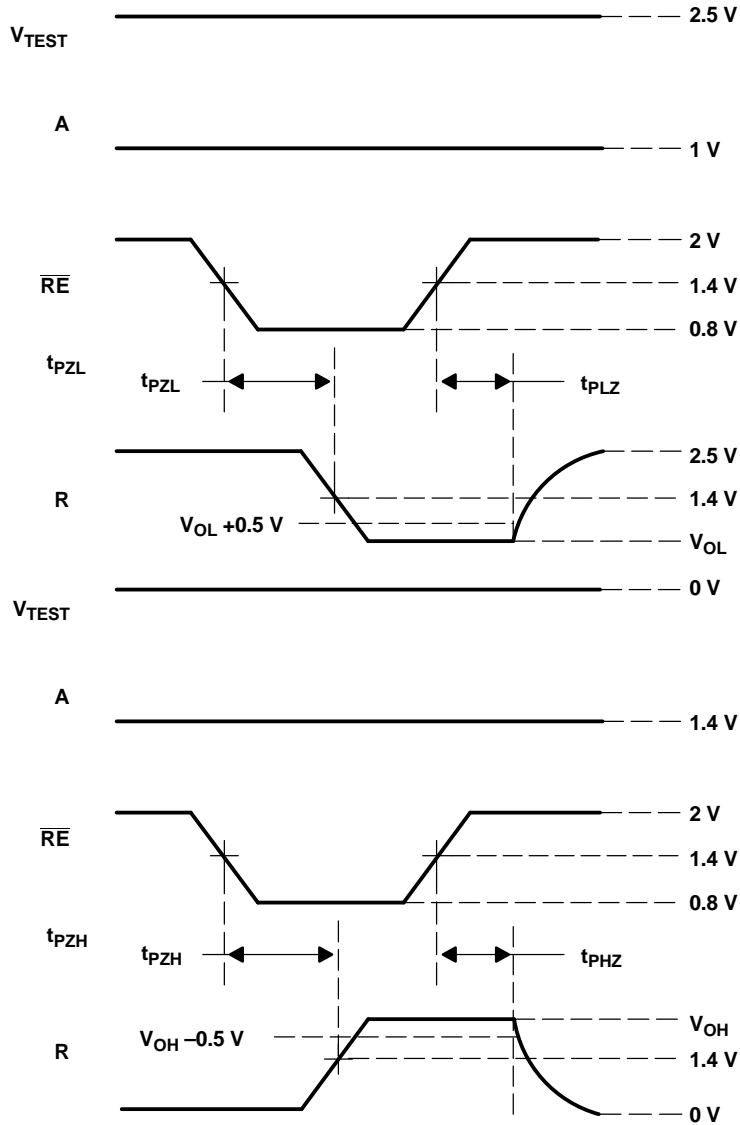


Figure 7. Enable/Disable Time Test Circuit and Waveforms

**TYPICAL CHARACTERISTICS**

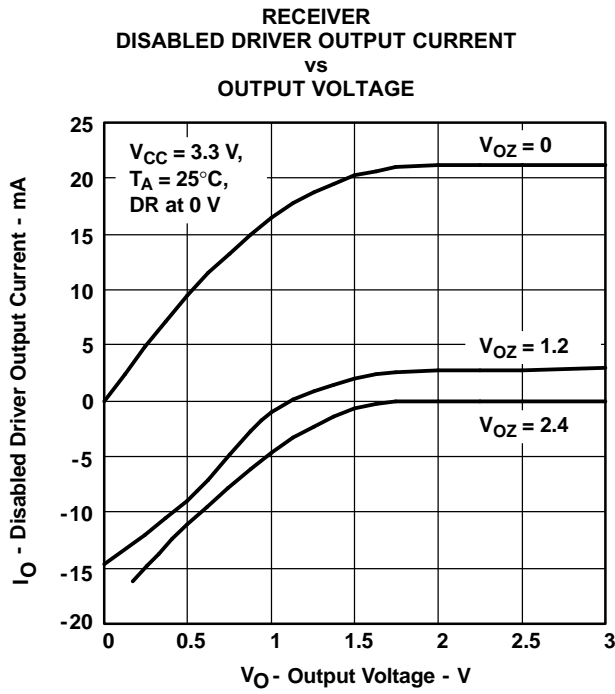


Figure 8.

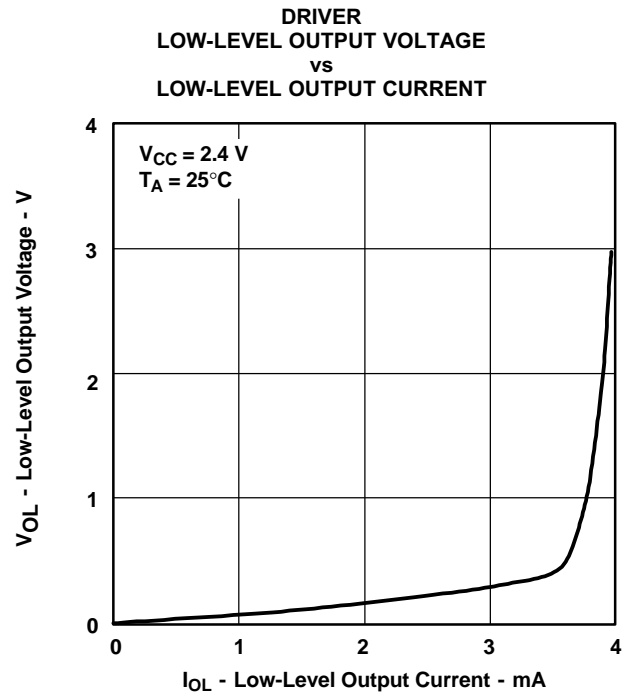


Figure 9.

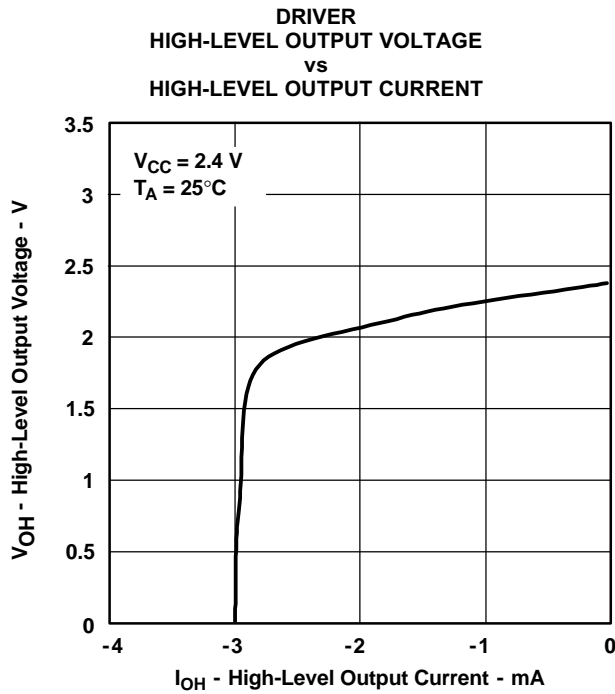


Figure 10.

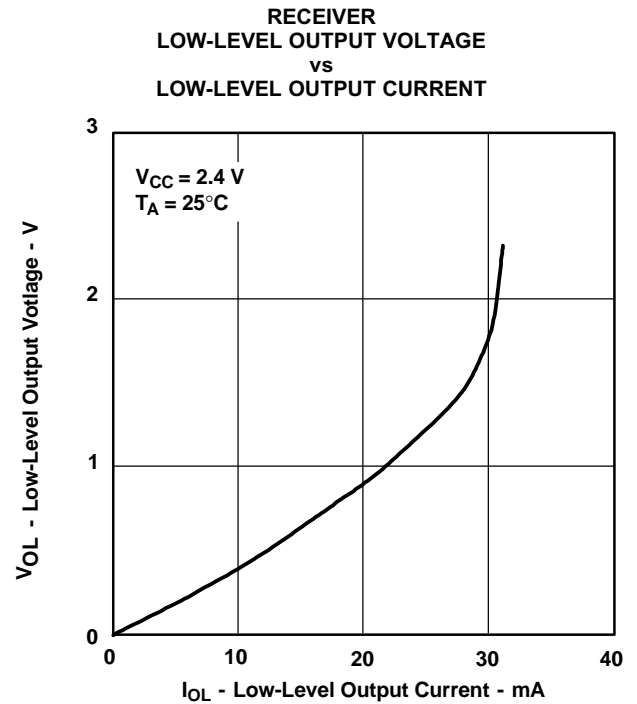
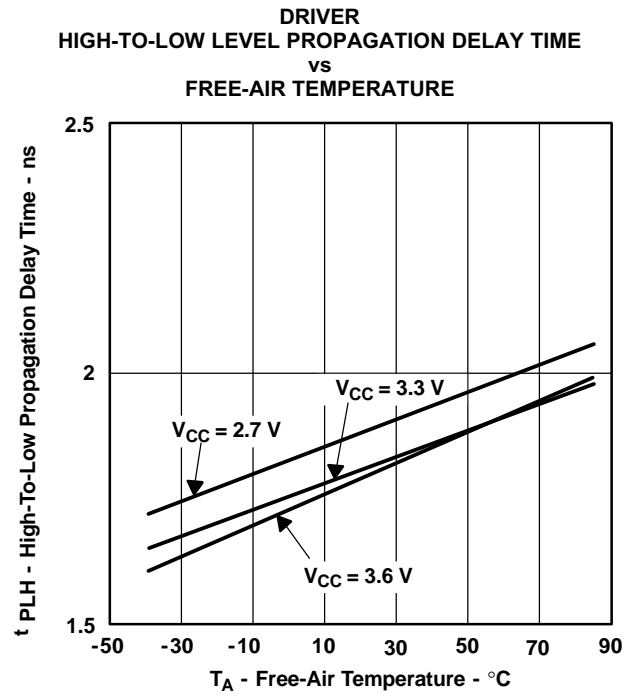
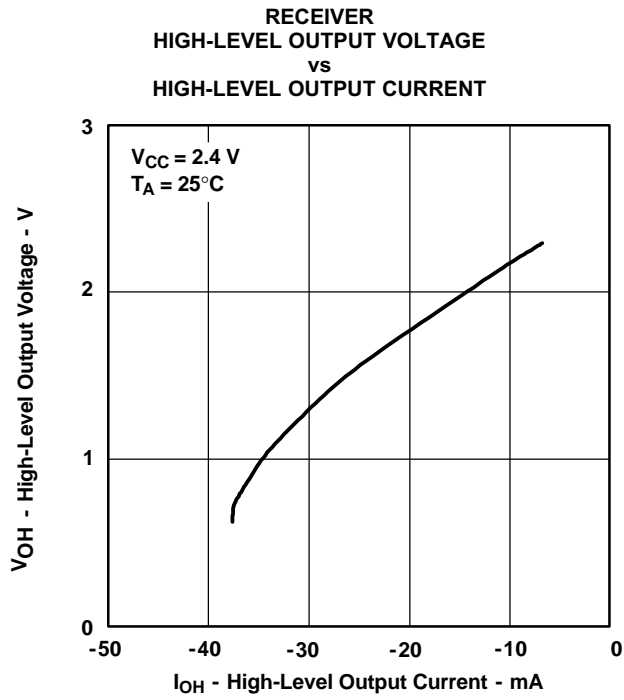


Figure 11.



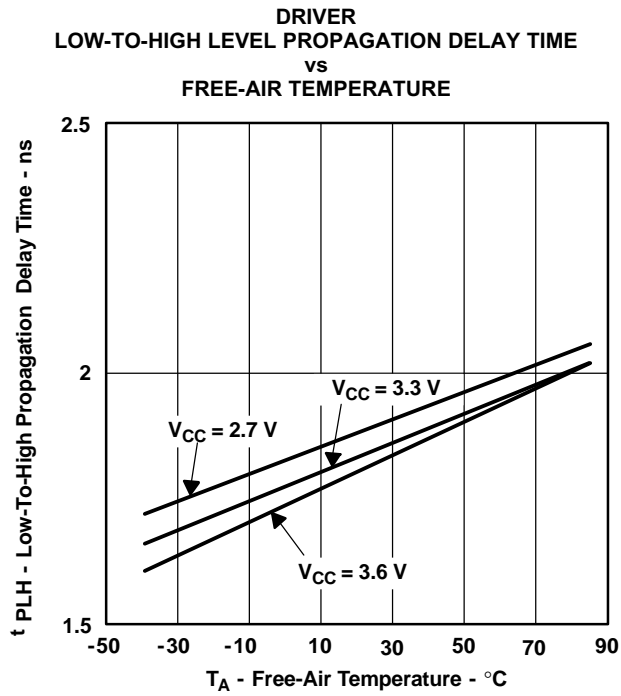


Figure 14.

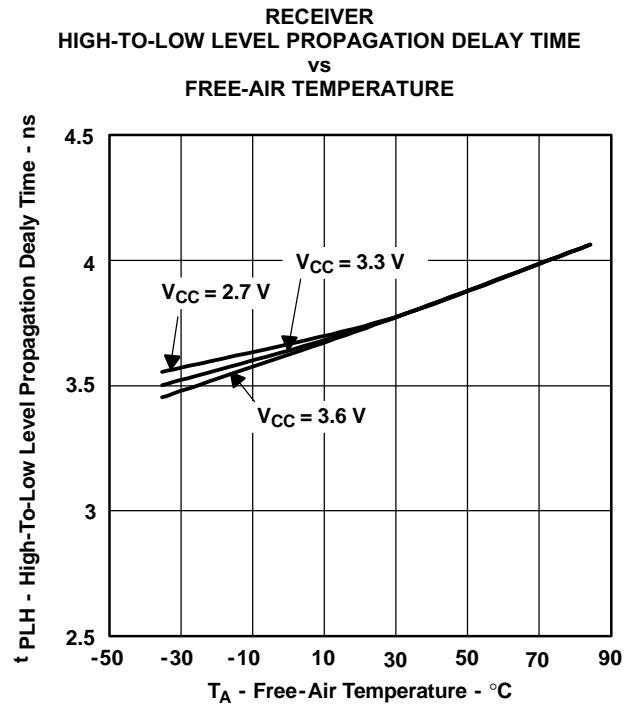


Figure 15.

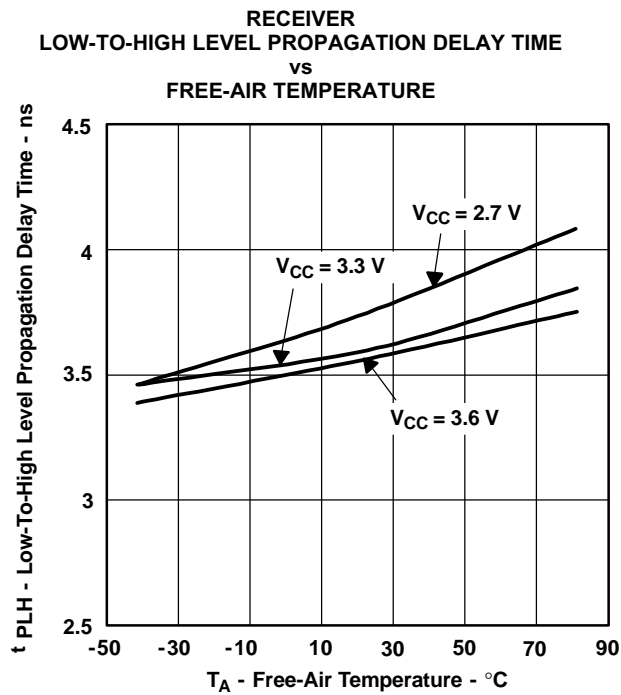


Figure 16

## APPLICATION INFORMATION

The devices are generally used as building blocks for high-speed point-to-point data transmission. Ground differences are less than 1 V with a low common-mode output and balanced interface for very low noise emissions. Devices can interoperate with RS-422, PECL, and IEEE-P1596. Drivers/Receivers maintain ECL speeds without the power and dual supply requirements.

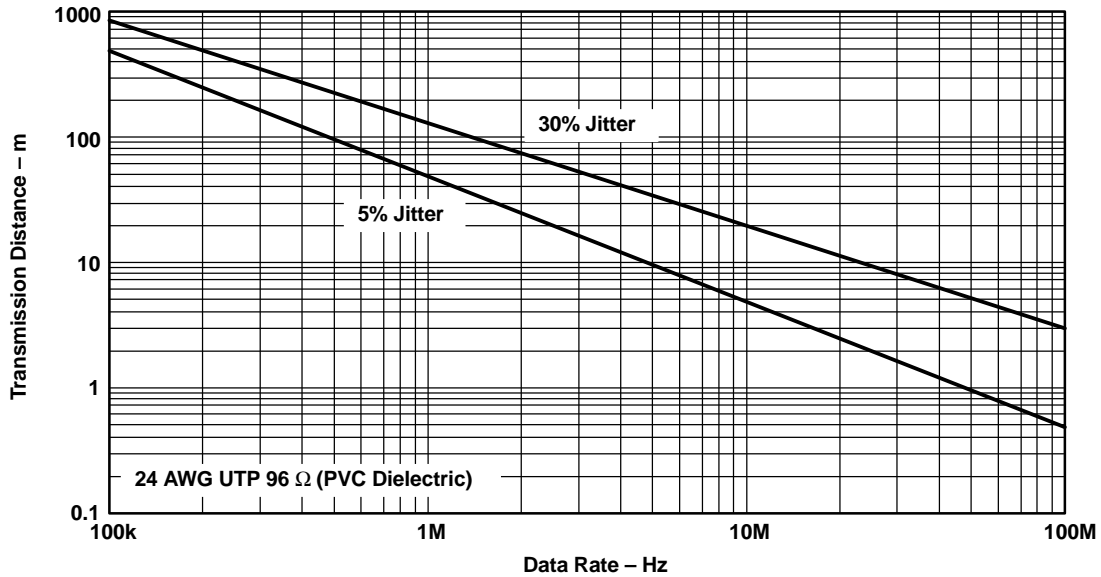
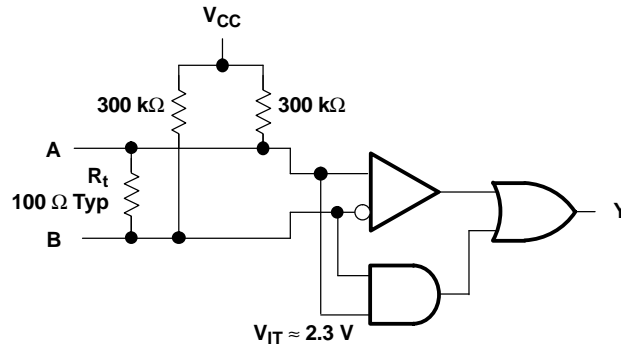


Figure 17. Data Transmission Distance Versus Rate

### Fail Safe

One of the most common problems with differential signaling applications is how the system responds when no differential voltage is present on the signal pair. The LVDS receiver is like most differential line receivers, in that its output logic state can be indeterminate when the differential input voltage is between -100 mV and 100 mV and within its recommended input common-mode voltage range. TI's LVDS receiver is different in how it handles the open-input circuit situation, however.

Open-circuit means that there is little or no input current to the receiver from the data line itself. This could be when the driver is in a high-impedance state or the cable is disconnected. When this occurs, the LVDS receiver pulls each line of the signal pair to near  $V_{CC}$  through 300-kΩ resistors as shown in Figure 11. The fail-safe feature uses an AND gate with input voltage thresholds at about 2.3 V to detect this condition and force the output to a high-level, regardless of the differential input voltage.



**Figure 18. Open-Circuit Fail Safe of the LVDS Receiver**

It is only under these conditions that the output of the receiver is valid with less than a 100-mV differential input voltage magnitude. The presence of the termination resistor,  $R_t$ , does not affect the fail-safe function as long as it is connected as shown in the figure. Other termination circuits may allow a dc current to ground that could defeat the pullup currents from the receiver and the fail-safe feature.

**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>
SN65LVDS1050PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDS1050PWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDS1050PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDS1050PWRG4	ACTIVE	TSSOP	PW	16	2000	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)

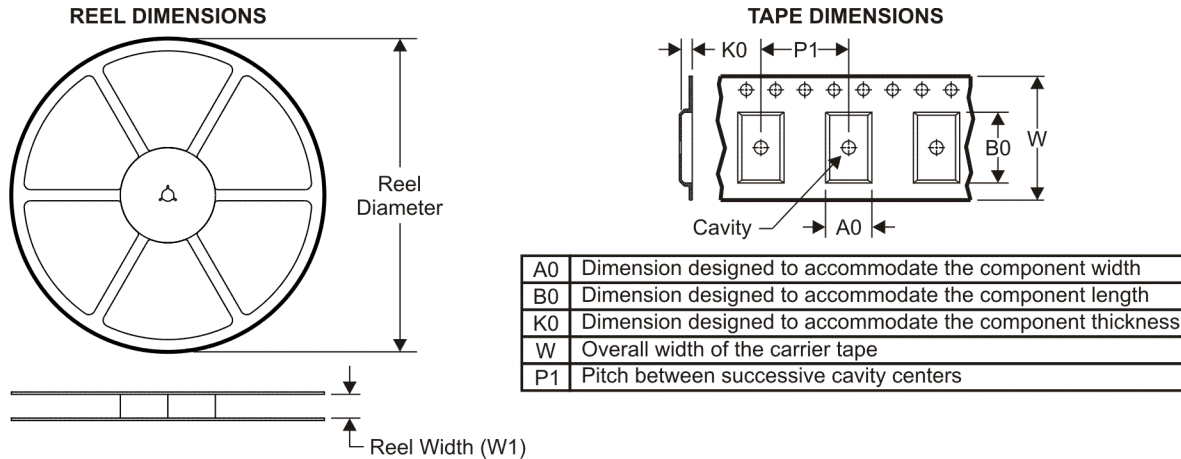
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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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
SN65LVDS1050PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**

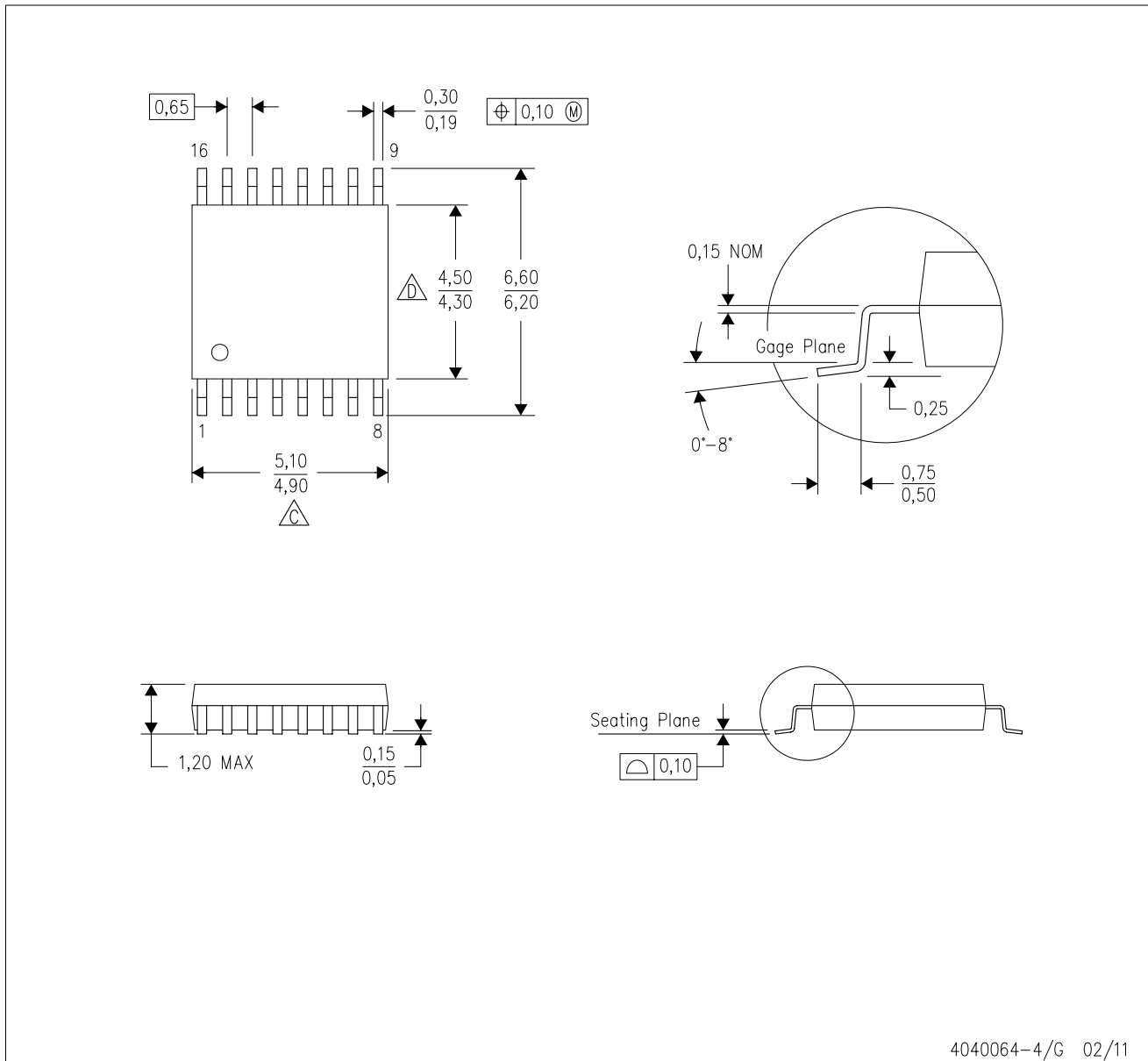


\*All dimensions are nominal



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVDS1050PWR	TSSOP	PW	16	2000	346.0	346.0	29.0

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

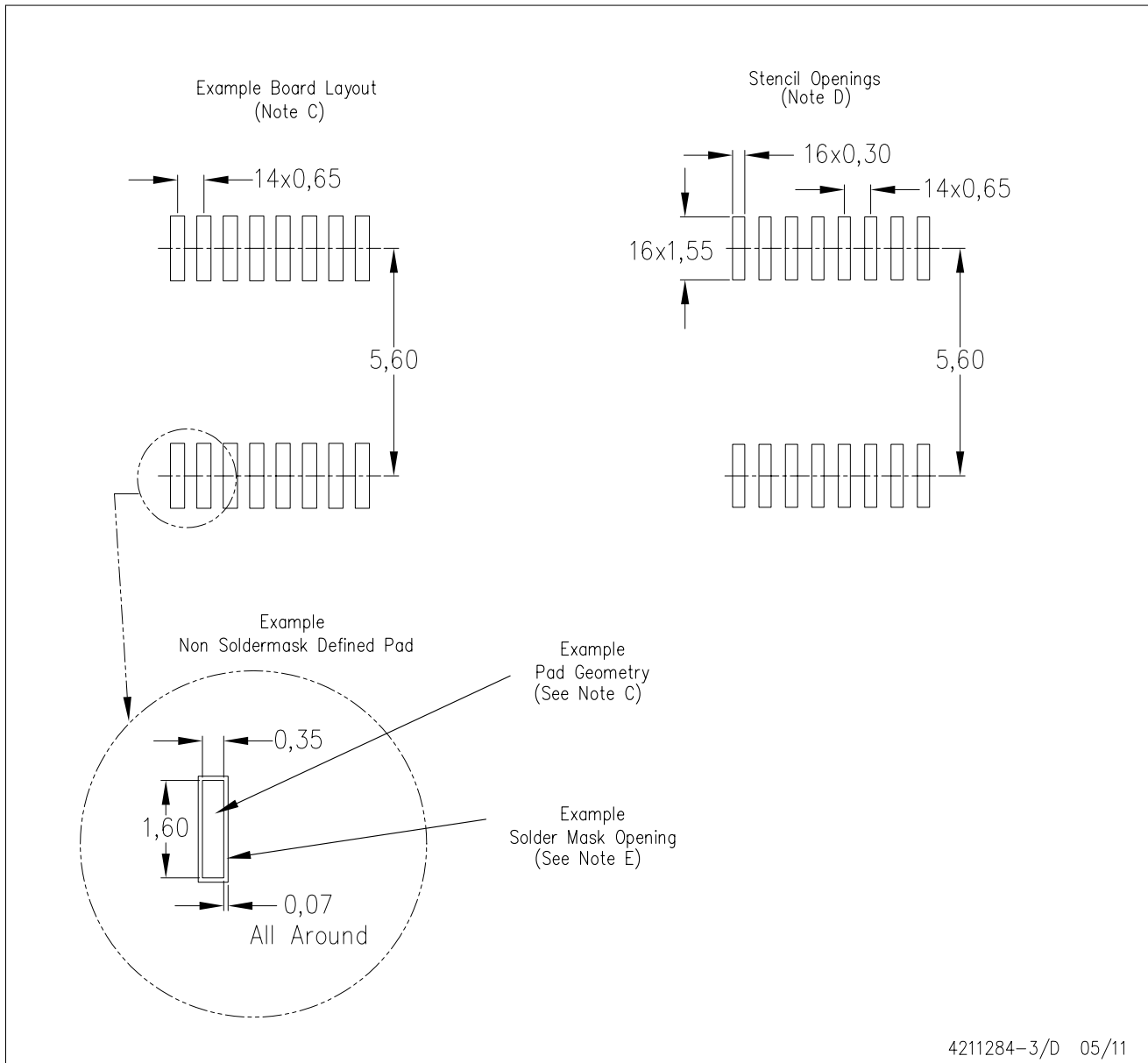


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- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  -  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  -  Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- 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.

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