

## DUAL MULTIPLEXED LVDS REPEATERS

### FEATURES

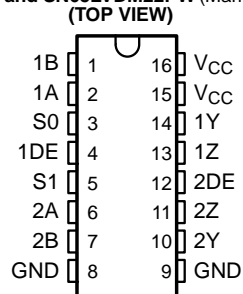
- Meets or Exceeds the Requirements of ANSI TIA/EIA-644-1995 Standard
- Designed for Clock Rates up to 200 MHz (400 Mbps)
- Designed for Data Rates up to 250 Mbps
- Pin Compatible With SN65LVDS122 and SN65LVDT122, 1.5 Gbps 2x2 Crosspoint Switch From TI
- ESD Protection Exceeds 12 kV on Bus Pins
- Operates From a Single 3.3-V Supply
- Low-Voltage Differential Signaling With Output Voltages of 350 mV Into:
  - 100-Ω Load (SN65LVDS22)
  - 50-Ω Load (SN65LVDM22)
- Propagation Delay Time; 4 ns Typ
- Power Dissipation at 400 Mbps of 150 mW
- Bus Pins Are High Impedance When Disabled or With  $V_{CC}$  Less Than 1.5 V
- LVTTTL Levels Are 5 V Tolerant
- Open-Circuit Fail Safe Receiver

### DESCRIPTION

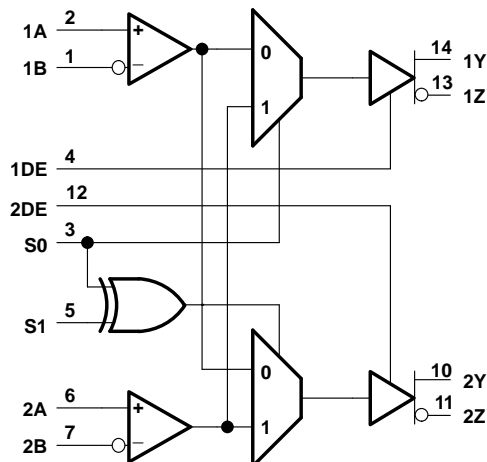
The SN65LVDS22 and SN65LVDM22 are differential line drivers and receivers that use low-voltage differential signaling (LVDS) to achieve signaling rates as high as 400 Mbps. The receiver outputs can be switched to either or both drivers through the multiplexer control signals S0 and S1. This allows the flexibility to perform splitter or signal routing functions with a single device.

The TIA/EIA-644 standard compliant electrical interface provides 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 SN65LVDM22 doubles the output drive current to achieve LVDS levels with a 50-Ω load.

SN65LVDS22D and SN65LVDS22PW (Marked as LVDS22)  
SN65LVDM22D and SN65LVDM22PW (Marked as LVDM22)



### logic diagram (positive logic)



MUX TRUTH TABLE

INPUT		OUTPUT		FUNCTION
S1	S0	1Y/1Z	2Y/2Z	
0	0	1A/1B	1A/1B	Splitter
0	1	2A/2B	2A/2B	Splitter
1	0	1A/1B	2A/2B	Router
1	1	2A/2B	1A/1B	Router



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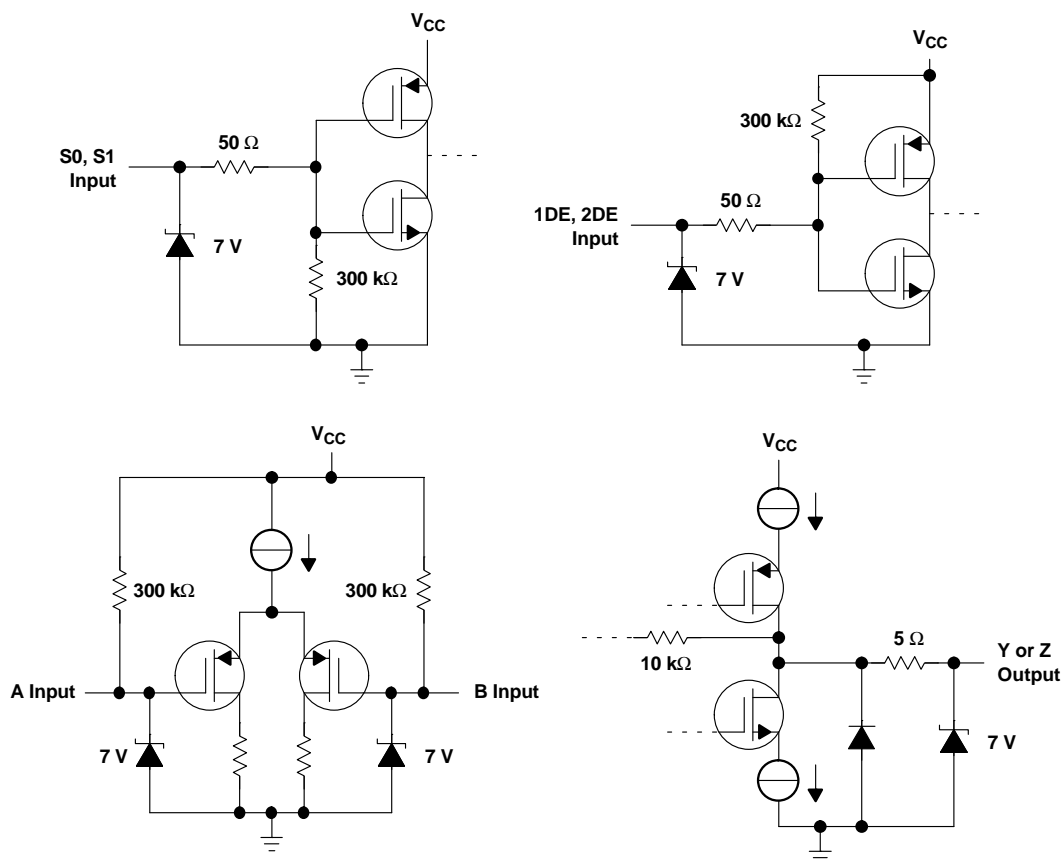
The intended application of these devices and signaling technique is for both point-to-point baseband (single termination) and multipoint (double termination) data transmissions over controlled impedance media. The transmission media may be printed-circuit board traces, backplanes, or cables. (Note: 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 SN65LVDS22 and SN65LVDM22 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .



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.

## EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		UNIT
Supply voltage range, $V_{CC}$ (see Note <sup>(2)</sup> )		–0.5 V to 4 V
Voltage range	(DE, S0, S1)	–0.5 V to 6 V
	(Y, Z, A, and B)	–0.5 V to 4 V
Electrostatic discharge	A, B, Y, Z and GND (see Note <sup>(3)</sup> )	Class 3, A:12 kV, B:600 V
	All pins	Class 3, A:5 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		260°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.

(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 <sup>(1)</sup> ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
D	1110 mW	8.9 mW/°C	577 mW
PW	839 mW	6.7 mW/°C	437 mW

(1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

## RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
$V_{CC}$	Supply voltage	3	3.3	3.6	V
$V_{IH}$	High-level input voltage	S0, S1, 1DE, 2DE		2	V
$V_{IL}$	Low-level input voltage	S0, S1, 1DE, 2DE		0.8	V
$ V_{ID} $	Magnitude of differential input voltage	0.1		0.6	V
$V_{IC}$	Common-mode input voltage (see <a href="#">Figure 1</a> )	$\frac{ V_{ID} }{2}$	$2.4 - \frac{ V_{ID} }{2}$		V
			$V_{CC} - 0.8$		V
$T_A$	Operating free-air temperature	40		85	°C

## TIMING REQUIREMENTS

	PARAMETER	MIN	NOM	MAX	UNIT
$t_{su}$	Input to select setup time	See <a href="#">Figure 6</a>		1.6	ns
$t_h$	Input to select hold time			1	ns
$t_{switch}$	Select to switch output			3.2	ns

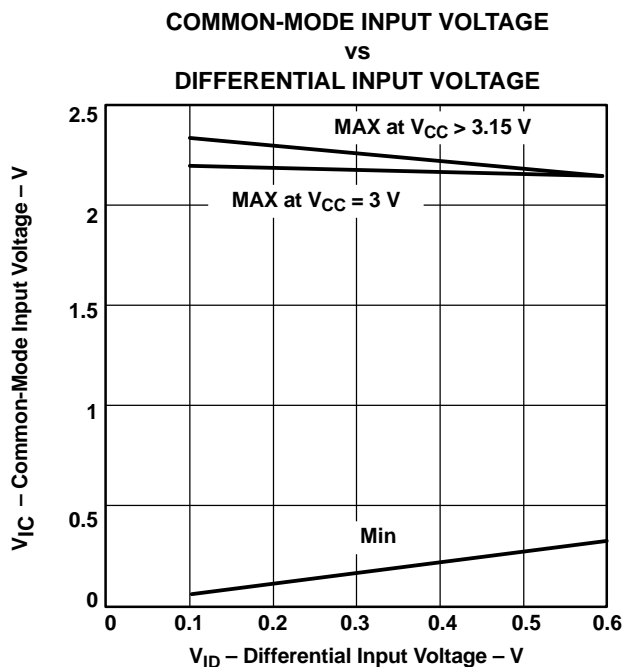


Figure 1. Common-Mode Input Voltage vs Differential Input Voltage

## RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IT+}$ Positive-going differential input voltage threshold				100	mV
$V_{IT-}$ Negative-going differential input voltage threshold		100			mV
$I_I$ Input current (A or B inputs)	$V_I = 0\text{ V}$	2		20	$\mu\text{A}$
	$V_I = 2.4\text{ V}$	1.2			
$I_{I(OFF)}$ Power-off input current (A or B inputs)	$V_{CC} = 0\text{ V}$			20	$\mu\text{A}$

## RECEIVER/DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$V_{OD}$ Differential output voltage magnitude	See Figure 2	247	340	454	mV
$\Delta V_{OD}$ Change in differential output voltage magnitude between logic states		–50		50	mV
$V_{OC(SS)}$ Steady-state common-mode output voltage	See Figure 3 $R_L = 100\ \Omega$ ('LVDS22), $R_L = 50\ \Omega$ ('LVDM22)	1.125		1.375	V
$\Delta V_{OC(SS)}$ Change in steady-state common-mode output voltage between logic states		–50	3	50	mV
$V_{OC(PP)}$ Peak-to-peak common-mode output voltage				150	mV
$I_{CC}$ Supply current	No Load		8	12	mA
	$R_L = 100\ \Omega$ ('LVDS22)		13	20	
	$R_L = 50\ \Omega$ ('LVDM22)		21	27	
	Disabled		3	6	
$I_{IH}$ High-level input current	DE	$V_{IH} = 5\text{ V}$		–10	$\mu\text{A}$
	S0, S1			20	
$I_{IL}$ Low-level input current	DE	$V_{IL} = 0.8\text{ V}$		–10	$\mu\text{A}$
	S0, S1			10	
$I_{OS}$ Short-circuit output current	$V_{OY}$ or $V_{OZ} = 0\text{ V}$ , $V_{OD} = 0\text{ V}$ ('LVDS22)			–10	mA
				–10	
	$V_{OY}$ or $V_{OZ} = 0\text{ V}$ , $V_{OD} = 0\text{ V}$ ('LVDM22)			–10	
				–10	
$I_{OZ}$ High-impedance output current	$V_{OD} = 600\text{ mV}$		0.015	$\pm 1$	$\mu\text{A}$
	$V_O = 0\text{ V}$ or $V_{CC}$		0.015	$\pm 1$	
$I_{O(OFF)}$ Power-off output current	$V_{CC} = 0\text{ V}$ , $V_O = 3.6\text{ V}$		0.015	$\pm 1$	$\mu\text{A}$
$C_{IN}$ Input capacitance			3		pF

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

## DIFFERENTIAL RECEIVER TO DRIVER SWITCHING CHARACTERISTICS

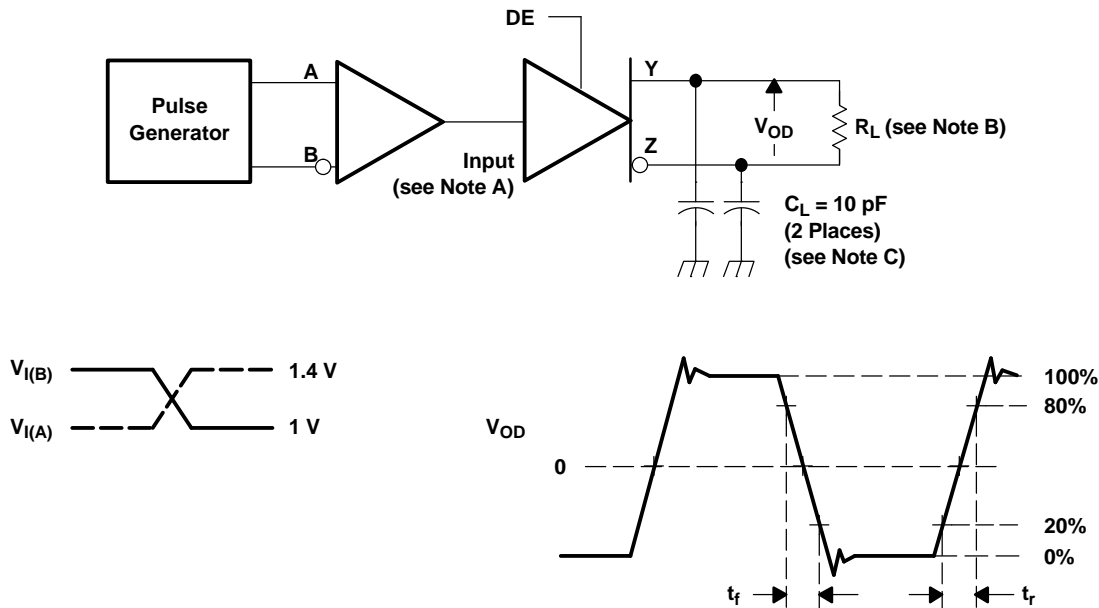
over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$t_{PLH}$	Differential propagation delay time, low-to-high	$C_L = 10$ pF, See Figure 4		4	6	ns
$t_{PHL}$	Differential propagation delay time, high-to-low			4	6	ns
$t_{sk(p)}$	Pulse skew ( $ t_{PHL} - t_{PLH} $ )			0.2		ns
$t_r$	Transition time, low-to-high			1	1.5	ns
$t_f$	Transition time, low-to-high			0.8	1.3	ns
$t_f$	Transition time, high-to-low			1	1.5	ns
$t_f$	Transition time, high-to-low			0.8	1.3	ns
$t_{PHZ}$	Propagation delay time, high-level-to-high-impedance output	See Figure 5		4	10	ns
$t_{PLZ}$	Propagation delay time, low-level-to-high-impedance output			5	10	ns
$t_{PZH}$	Propagation delay time, high-impedance-to-high-level output			5	10	ns
$t_{PZL}$	Propagation delay time, high-impedance-to-low-level output			6	10	ns
$t_{PHL\_R1\_Dx}$	Channel-to-channel skew, receiver to driver <sup>(2)</sup>			0.2		ns
$t_{PLH\_R1\_Dx}$				0.2		
$t_{PHL\_R2\_Dx}$				0.2		
$t_{PLH\_R2\_Dx}$				0.2		
$f_{max}$	Maximum operating frequency	All channels switching		200		MHz

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

(2) These parametric values are measured over supply voltage and temperature ranges recommended for the device.

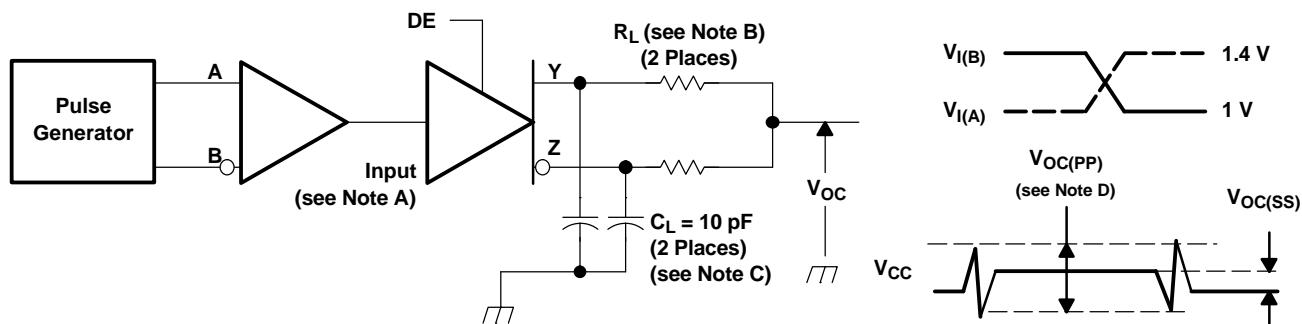
## PARAMETER MEASUREMENT INFORMATION



- 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.
- $R_L = 100 \Omega$  or  $50 \Omega \pm 1\%$
- $C_L$  includes instrumentation and fixture capacitance within 6 mm of the D.U.T.

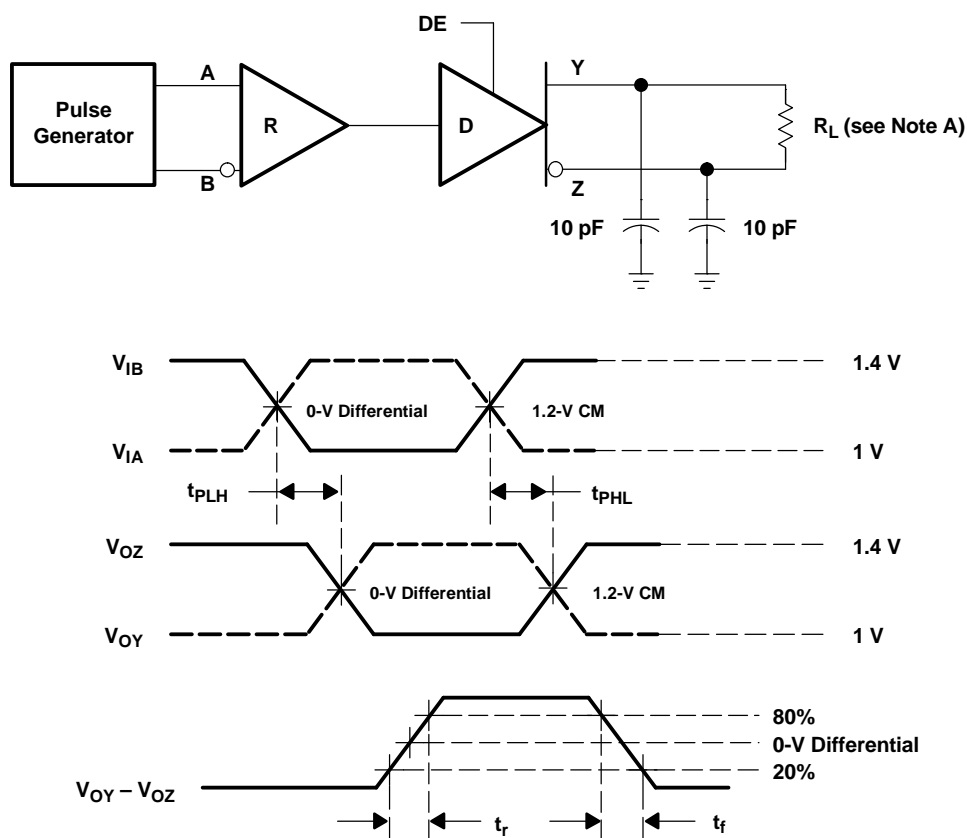
Figure 2. Test Circuit and Voltage Definitions for the Differential Output Signal

## PARAMETER MEASUREMENT INFORMATION (continued)



- 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 =  $10 \pm 0.2 \text{ ns}$ .
- $R_L = 100 \Omega$  or  $50 \Omega \pm 1\%$
- $C_L$  includes instrumentation and fixture capacitance within 6 mm of the D.U.T.
- The measurement of  $V_{OC(PP)}$  is made on test equipment with a -3 dB bandwidth of at least 300 MHz.

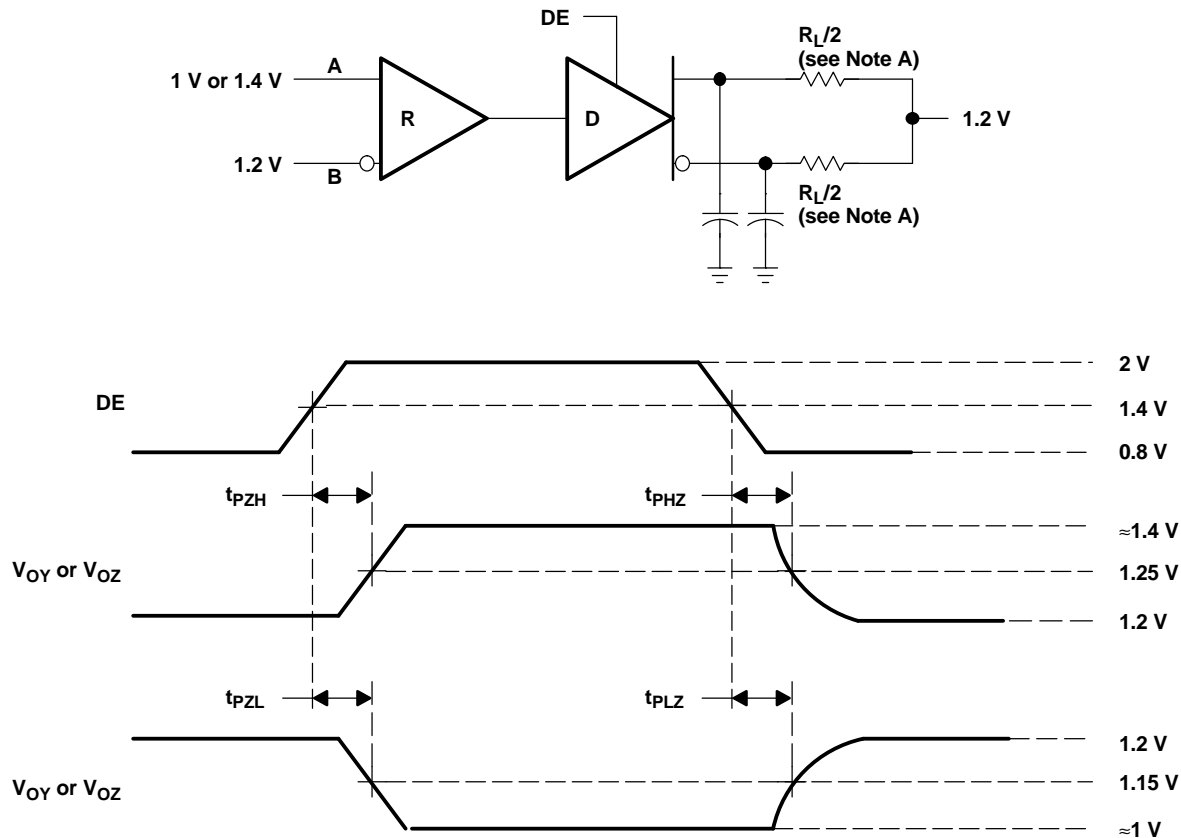
**Figure 3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage**



- $R_L = 100 \Omega$  or  $50 \Omega \pm 1\%$
- All input pulses are supplied by a generator having the following characteristics: pulse repetition rate (PRR) = 50 Mpps, pulse width =  $10 \pm 0.2 \text{ ns}$ .

**Figure 4. Differential Receiver to Driver Propagation Delay and Driver Transition Time Waveforms**

PARAMETER MEASUREMENT INFORMATION (continued)

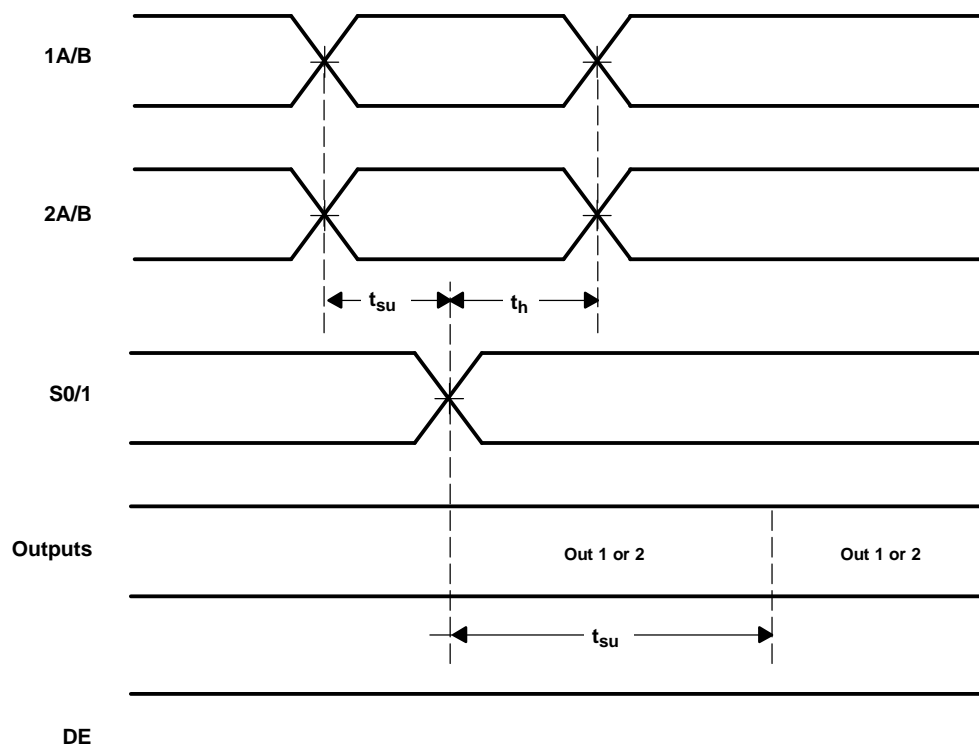


- A.  $R_L = 100 \Omega$  or  $50 \Omega \pm 1\%$
- B. All input pulses are supplied by a generator having the following characteristics: pulse repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns.

Figure 5. Enable and Disable Timing Circuit



# PARAMETER MEASUREMENT INFORMATION (continued)



NOTE:  $t_{su}$  and  $t_h$  times specify that data must be in a stable state before and after MUX control switches.

**Figure 6. Input-to-Select for Both Rising and Falling Edge Setup and Hold Times**

## TYPICAL CHARACTERISTICS

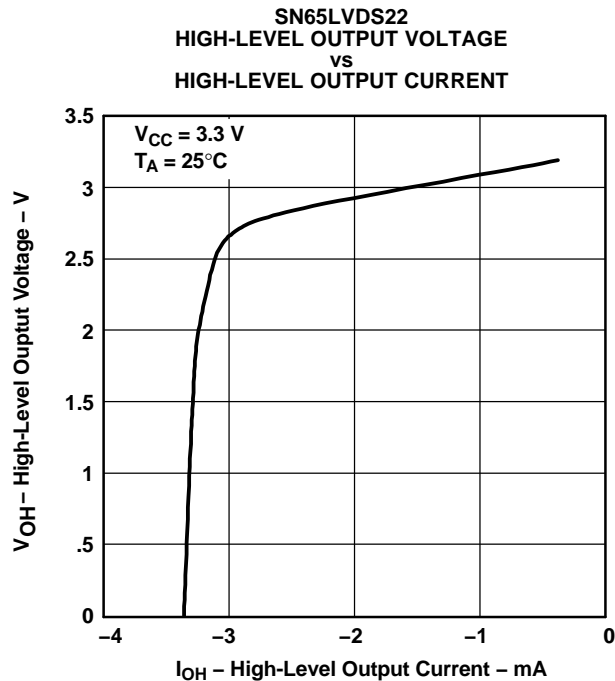


Figure 7.

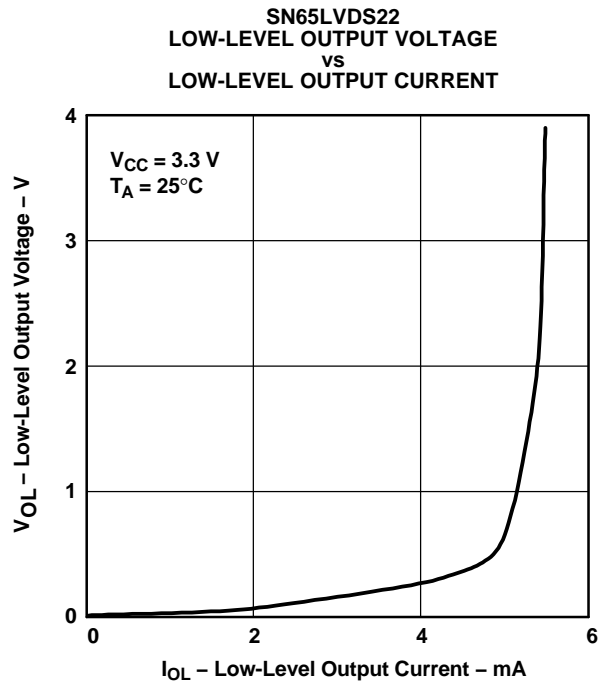


Figure 8.

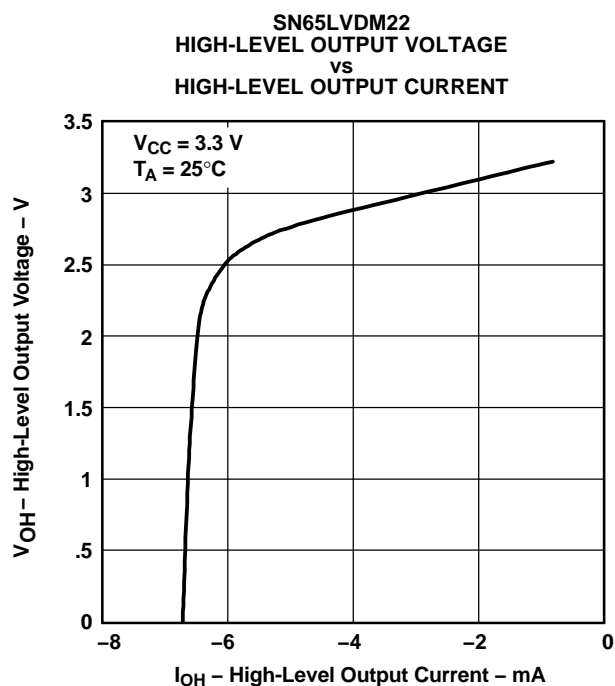


Figure 9.

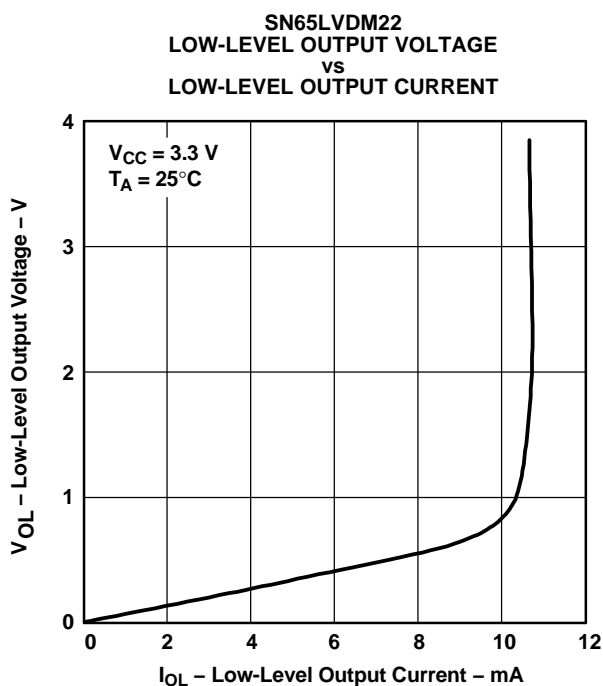


Figure 10.

## APPLICATION INFORMATION

### 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  $-100\text{ mV}$  and  $100\text{ mV}$  and within its recommended input common-mode voltage range. However, TI's LVDS receiver is different in how it handles the open-input circuit situation.

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  $300\text{-k}\Omega$  resistors as shown in Figure 11. The fail-safe feature uses an AND gate with input voltage thresholds at about  $2.3\text{ V}$  to detect this condition and force the output to a high-level regardless of the differential input voltage.

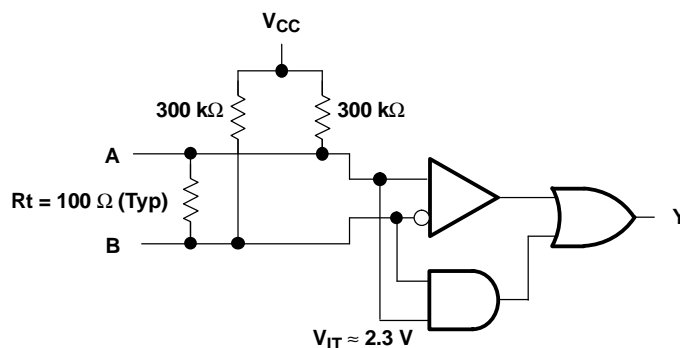


Figure 11. Open-Circuit Fail Safe of the LVDS Receiver

It is only under these conditions that the output of the receiver is valid with less than a  $100\text{ mV}$  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 Figure 11. 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 (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65LVDM22D	ACTIVE	SOIC	D	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDM22	<a href="#">Samples</a>
SN65LVDM22DG4	ACTIVE	SOIC	D	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDM22	<a href="#">Samples</a>
SN65LVDM22PW	ACTIVE	TSSOP	PW	16	90	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDM22	<a href="#">Samples</a>
SN65LVDS22D	ACTIVE	SOIC	D	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDS22	<a href="#">Samples</a>
SN65LVDS22DR	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDS22	<a href="#">Samples</a>
SN65LVDS22PW	ACTIVE	TSSOP	PW	16	90	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDS22	<a href="#">Samples</a>
SN65LVDS22PWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVDS22	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

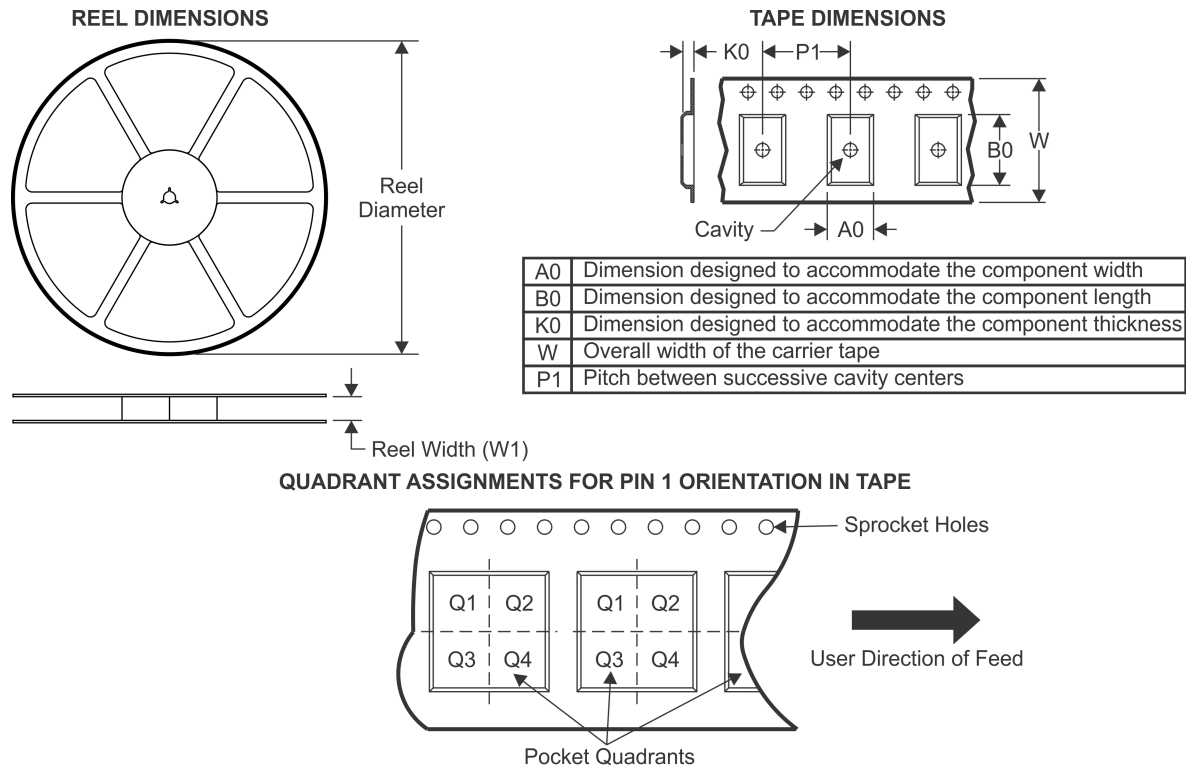
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices 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.

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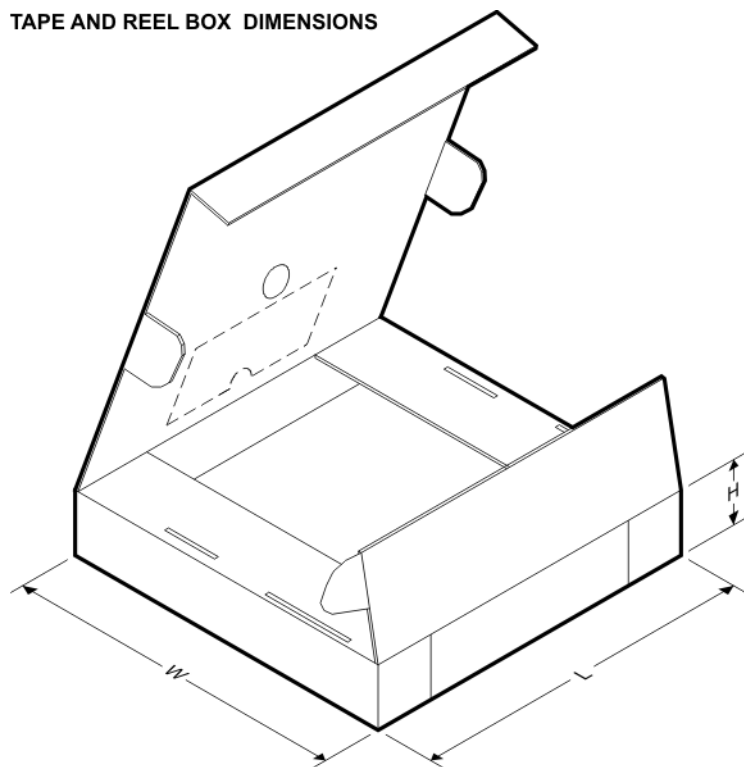
## TAPE AND REEL INFORMATION



\*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
SN65LVDS22DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN65LVDS22PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

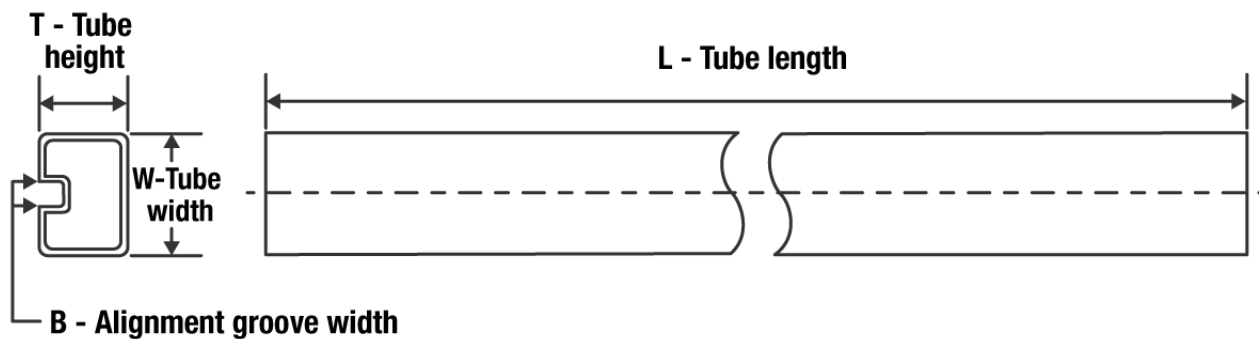
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVDS22DR	SOIC	D	16	2500	350.0	350.0	43.0
SN65LVDS22PWR	TSSOP	PW	16	2000	350.0	350.0	43.0

## TUBE



\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
SN65LVDM22D	D	SOIC	16	40	505.46	6.76	3810	4
SN65LVDM22DG4	D	SOIC	16	40	505.46	6.76	3810	4
SN65LVDM22PW	PW	TSSOP	16	90	530	10.2	3600	3.5
SN65LVDS22D	D	SOIC	16	40	505.46	6.76	3810	4
SN65LVDS22PW	PW	TSSOP	16	90	530	10.2	3600	3.5



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