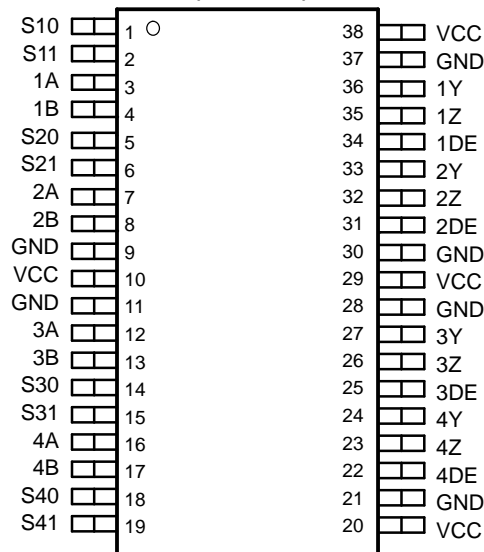


## LVDS 4x4 CROSSPOINT SWITCH

### FEATURES

- Greater Than 2.0 Gbps Operation
- Nonblocking Architecture Allows Each Output to be Connected to Any Input
- **Pk-Pk Jitter:**
  - 60 ps Typical at 2.0 Gbps
  - 110 ps Typical at 2.5 Gbps
- Compatible With ANSI TIA/EIA-644-A LVDS Standard
- Available Packaging 38-Pin TSSOP
- 25 mV of Input Voltage Threshold Hysteresis
- Propagation Delay Times: 800 ps Typical
- Inputs Electrically Compatible With LVPECL, CML and LVDS Signal Levels
- Operates From a Single 3.3-V Supply
- Low Power: 110 mA Typical
- Integrated 110-Ω Line Termination Resistors Available With SN65LVDT250

SN65LVDS250DBT ( Marked as LVDS250)  
SN65LVDT250DBT ( Marked as LVDT250)  
(TOP VIEW)



### APPLICATIONS

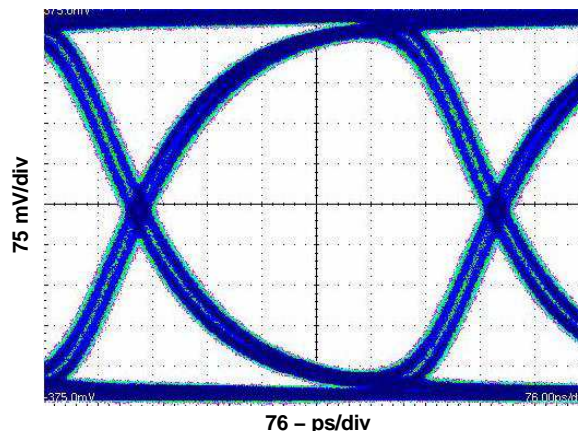
- Clock Buffering/Clock Muxing
- Wireless Base Stations
- High-Speed Network Routing
- Telecom/Datacom

### DESCRIPTION

The SN65LVDS250 and SN65LVDT250 are 4x4 nonblocking crosspoint switches in a flow-through pin-out allowing for ease in PCB layout. Low-voltage differential signaling (LVDS) is used to achieve a high-speed data throughput while using low power. Each of the output drivers includes a 4:1 multiplexer to allow any input to be routed to any output. Internal signal paths are fully differential to achieve the high signaling speeds while maintaining low signal skews. The SN65LVDT250 incorporates 110-Ω termination resistors for those applications where board space is a premium.

The SN65LVDS250 and SN65LVDT250 are characterized for operation from -40°C to 85°C.

### EYE PATTERN



$V_{IC} = 1.2 \text{ V}$   
 $|V_{ID}| = 200 \text{ mV}$   
 2 Gbps  
 Input = PRBS 2<sup>23</sup> -1  
 $V_{CC} = 3.3 \text{ V}$

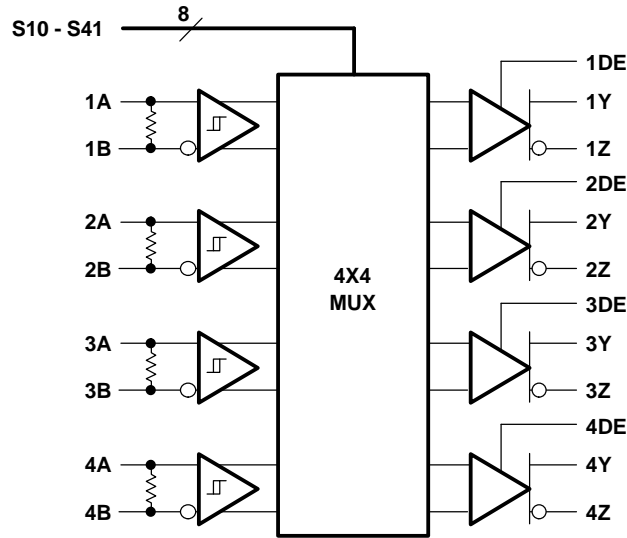


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



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.

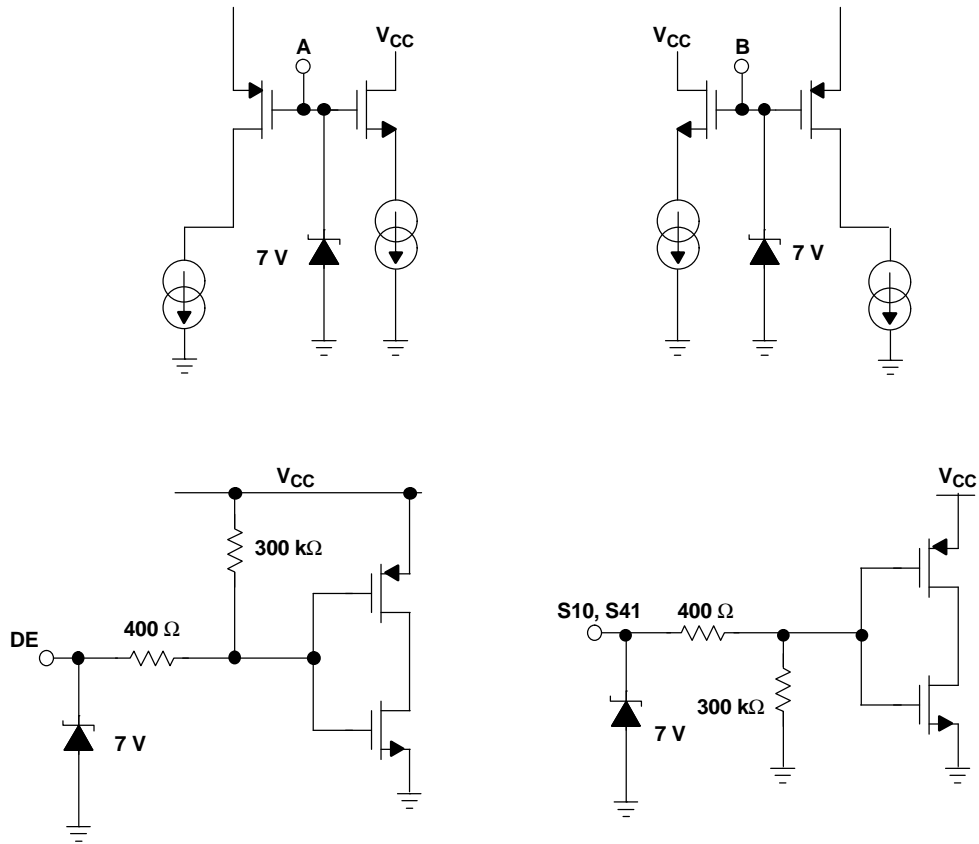
**LOGIC DIAGRAM**



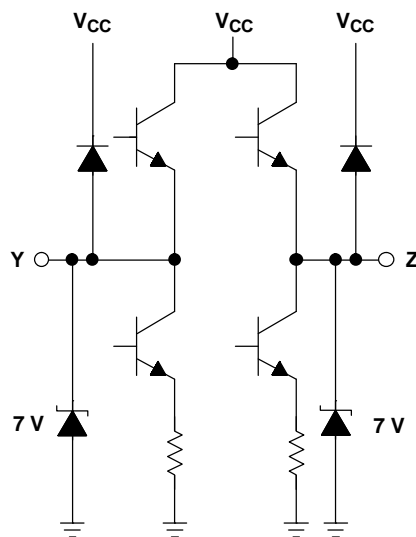
Integrated Termination on LVDT Only

**EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS**

**INPUT LVDS250**



**OUTPUT LVDS250**



**Table 1. CROSSPOINT LOGIC TABLES**

OUTPUT CHANNEL 1			OUTPUT CHANNEL 2			OUTPUT CHANNEL 3			OUTPUT CHANNEL 4		
CONTROL PINS		INPUT SELECTED	CONTROL PINS		INPUT SELECTED	CONTROL PINS		INPUT SELECTED	CONTROL PINS		INPUT SELECTED
S10	S11	1Y/1Z	S20	S21	2Y/2Z	S30	S31	3Y/3Z	S40	S41	4Y/4Z
0	0	1A/1B	0	0	1A/1B	0	0	1A/1B	0	0	1A/1B
0	1	2A/2B	0	1	2A/2B	0	1	2A/2B	0	1	2A/2B
1	0	3A/3B	1	0	3A/3B	1	0	3A/3B	1	0	3A/3B
1	1	4A/4B	1	1	4A/4B	1	1	4A/4B	1	1	4A/4B

**PACKAGE DISSIPATION RATINGS**

PACKAGE	CIRCUIT BOARD MODEL	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR <sup>(1)</sup> ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
TSSOP (DBT)	Low-K <sup>(2)</sup>	1038 mW	9.0 mW/°C	496 mW
TSSOP (DBT)	High-K <sup>(3)</sup>	1772 mW	15.4 mW/°C	847 mW

- (1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.
- (2) In accordance with the Low-K thermal metric definitions of EIA/JESD51-6
- (3) In accordance with the High-K thermal metric definitions of EIA/JESD51-6

**THERMAL CHARACTERISTICS**

PARAMETER	TEST CONDITIONS	VALUE	UNITS
$\Theta_{JB}$ Junction-to-board thermal resistance		40.3	°C/W
$\Theta_{JC}$ Junction-to-case thermal resistance		8.5	
$P_D$ Device power dissipation	$V_{CC} = 3.3\text{ V}, T_A = 25^\circ\text{C}, 1\text{ GHz}$	356	mW
	$V_{CC} = 3.6\text{ V}, T_A = 85^\circ\text{C}, 1\text{ GHz}$	522	mW

**ABSOLUTE MAXIMUM RATINGS**

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

	UNITS		
Supply voltage range, $V_{CC}$	-0.5 V to 4 V		
Voltage range <sup>(2)</sup>	S, DE	-0.5 V to 4 V	
	A, B	-0.5 V to 4 V	
	$ V_A - V_B $ (LVDT only)	1 V	
	Y, Z	-0.5 V to 4 V	
Electrostatic discharge	Human body model <sup>(3)</sup>	All pins	±3 kV
	Charged-device model <sup>(4)</sup>	All pins	±500 V
Continuous power dissipation	See Dissipation Rating 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 I/O bus voltages, are with respect to network ground terminal.
- (3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101.

## RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V <sub>CC</sub>	Supply voltage		3	3.3	3.6	V
V <sub>IH</sub>	High-level input voltage	S10-S41, 1DE-4DE	2		V <sub>CC</sub>	V
V <sub>IL</sub>	Low-level input voltage	S10-S41, 1DE-4DE	0		0.8	V
V <sub>ID</sub>	Magnitude of differential input voltage	LVDS	0.1		1	V
		LVDT	0.1		0.8	V
Input voltage (any combination of common-mode or input signals)			0		3.3	V
T <sub>J</sub>	Junction temperature				140	°C
T <sub>A</sub> <sup>(1)</sup>	Operating free-air temperature		-40		85	°C

(1) Maximum free-air temperature operation is allowed as long as the device maximum junction temperature is not exceeded.

## TIMING SPECIFICATIONS

PARAMETER		MIN	NOM	MAX	UNIT
t <sub>SET</sub>	Input to select setup time		0.6		ns
t <sub>HOLD</sub>	Input to select hold time	See Figure 7		0.2	ns
t <sub>SWITCH</sub>	Select to switch output		1.2	1.6	ns

## INPUT ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted<sup>(1)</sup>

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(1)</sup>	MAX	UNIT
V <sub>IT+</sub>	Positive-going differential input voltage threshold	See Figure 1				100	mV
V <sub>IT-</sub>	Negative-going differential input voltage threshold	See Figure 1		-100			mV
V <sub>ID(HYS)</sub>	Differential input voltage hysteresis				25		mV
I <sub>IH</sub>	High-level input current	1DE-4DE	V <sub>IH</sub> = 2 V	-10			μA
		S10-S41		20			
I <sub>IL</sub>	Low-level input current	1DE-4DE	V <sub>IL</sub> = 0.8 V	-10			μA
		S10-S41		20			
I <sub>I</sub>	Input current (A or B inputs)	V <sub>I</sub> = 0 V or 3.3 V, second input at 1.2 V (other input open for LVDT)		-20		20	μA
I <sub>I(OFF)</sub>	Input current (A or B inputs)	V <sub>CC</sub> ≤ 1.5 V, V <sub>I</sub> = 0 V or 3.3 V, second input at 1.2 V (other input open for LVDT)		-20		20	μA
I <sub>IO</sub>	Input offset current ( I <sub>IA</sub> - I <sub>IB</sub>  ) (LVDS)	V <sub>IA</sub> = V <sub>IB</sub> , 0 ≤ V <sub>IA</sub> ≤ 3.3 V		-6		6	μA
R <sub>T</sub>	Termination resistance (LVDT)	V <sub>ID</sub> = 300 mV, V <sub>IC</sub> = 0 V to 3.3 V		90	110	132	Ω
	Termination resistance (LVDT with power-off)	V <sub>ID</sub> = 300 mV, V <sub>IC</sub> = 0 V to 3.3 V, V <sub>CC</sub> = 1.5 V		90	110	132	
C <sub>I</sub>	Differential input capacitance				2.5		pF

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

## OUTPUT ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{OD} $	Differential output voltage magnitude	See Figure 2	247	350	454	mV
$\Delta V_{OD} $	Change in differential output voltage magnitude between logic states	$V_{ID} = \pm 100$ mV	-50		50	mV
$V_{OC(SS)}$	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
$I_{CC}$	Supply current	$R_L = 100 \Omega$		110	145	mA
$I_{OS}$	Short-circuit output current	$V_{OY}$ or $V_{OZ} = 0$ V	-27		27	mA
$I_{OSD}$	Differential short circuit output current	$V_{OD} = 0$ V	-12		12	mA
$I_{OZ}$	High-impedance output current	$V_O = 0$ V or $V_{CC}$			$\pm 1$	$\mu$ A
$C_O$	Differential output capacitance			2		pF

## SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{PLH}$	Propagation delay time, low-to-high-level output	See Figure 4	700	800	1200	ps
$t_{PHL}$	Propagation delay time, high-to-low-level output		700	800	1200	
$t_r$	Differential output signal rise time (20%-80%)			200	245	
$t_f$	Differential output signal fall time (20%-80%)			200	245	
$t_{sk(p)}$	Pulse skew ( $ t_{PHL} - t_{PLH} $ ) <sup>(1)</sup>			0	50	ps
$t_{sk(o)}$	Channel-to-channel output skew <sup>(2)</sup>				175	ps
$t_{sk(pp)}$	Part-to-part skew <sup>(3)</sup>				300	ps
$t_{jit(per)}$	Period jitter, rms (1 standard deviation) <sup>(4)</sup>	See Figure 6		1	3	ps
$t_{jit(cc)}$	Cycle-to-cycle jitter (peak) <sup>(5)</sup>	See Figure 6		8	17	ps
$t_{jit(pp)}$	Peak-to-peak jitter <sup>(6)</sup>	See Figure 6		60	110	ps
$t_{jit(det)}$	Deterministic jitter, peak-to-peak <sup>(7)</sup>	See Figure 6		48	65	ps
$t_{PHZ}$	Propagation delay, high-level-to-high-impedance output	See Figure 5			6	ns
$t_{PLZ}$	Propagation delay, low-level-to-high-impedance output				6	
$t_{PZH}$	Propagation delay, high-impedance-to-high-level output				300	
$t_{PZL}$	Propagation delay, high-impedance-to-low-level output				300	

(1)  $t_{sk(p)}$  is the magnitude of the time difference between the  $t_{PLH}$  and  $t_{PHL}$  of any output of a single device.

(2)  $t_{sk(o)}$  is the maximum delay time difference between drivers over temperature,  $V_{CC}$ , and process.

(3)  $t_{sk(pp)}$  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.

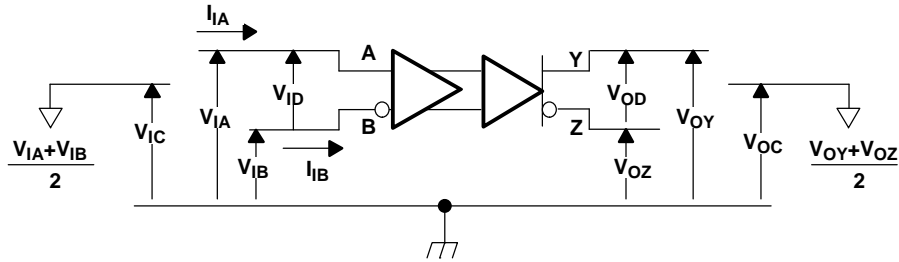
(4) Input voltage =  $V_{ID} = 200$  mV, 50% duty cycle at 1.0 GHz,  $t_r = t_f = 50$  ps (20% to 80%), measured over 1000 samples.

(5) Input voltage =  $V_{ID} = 200$  mV, 50% duty cycle at 1.0 GHz,  $t_r = t_f = 50$  ps (20% to 80%).

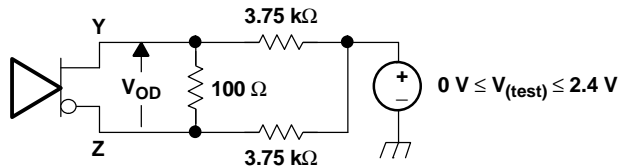
(6) Input voltage =  $V_{ID} = 200$  mV, 2<sup>23</sup>-1 PRBS pattern at 2.0 Gbps,  $t_r = t_f = 50$  ps (20% to 80%), measured over 200k samples.

(7) Input voltage =  $V_{ID} = 200$  mV, 2<sup>7</sup>-1 PRBS pattern at 2.0 Gbps,  $t_r = t_f = 50$  ps (20% to 80%).

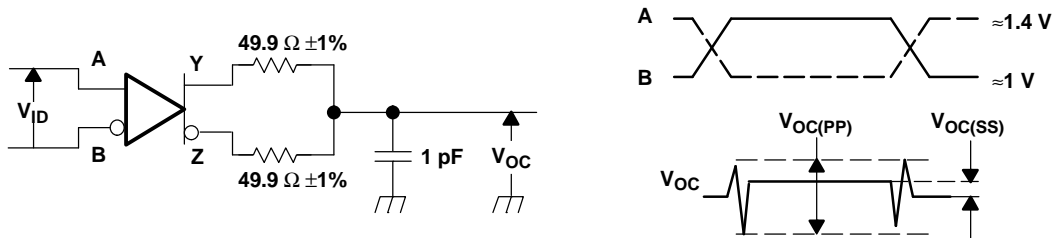
**PARAMETER MEASUREMENT INFORMATION**



**Figure 1. Voltage and Current Definitions**

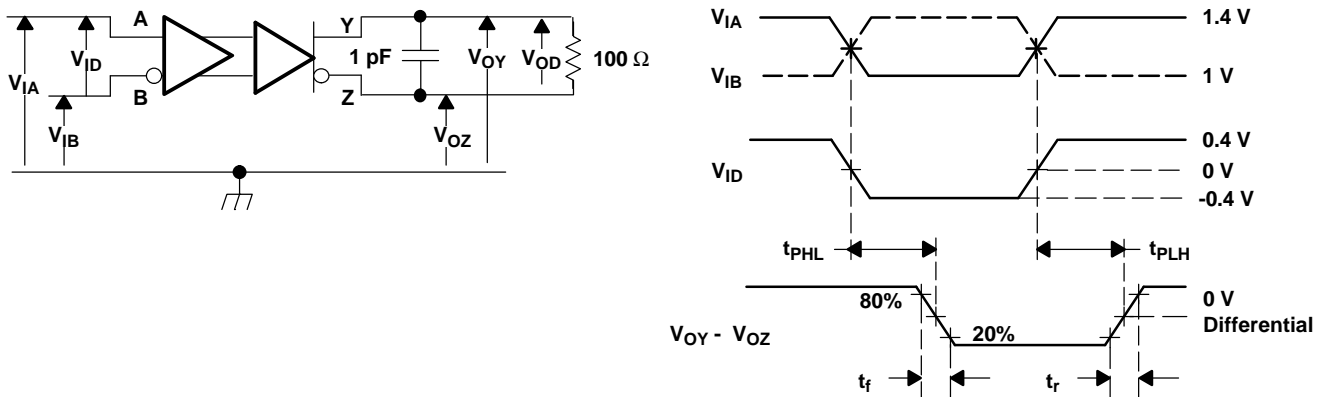


**Figure 2. Differential Output Voltage ( $V_{OD}$ ) Test Circuit**



- A. 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;  $R_L = 100 \Omega$ ;  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the DUT; the measurement of  $V_{OC(PP)}$  is made on test equipment with a -3 dB bandwidth of at least 300 MHz.

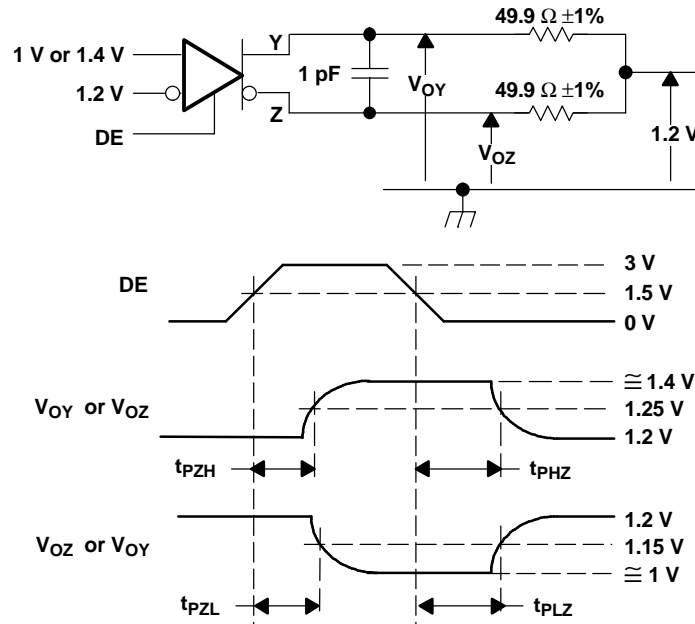
**Figure 3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage**



- A. All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 0.25$  ns, pulse-repetition rate (PRR) = 0.5 Mpps, pulse width =  $500 \pm 10$  ns.  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the DUT.

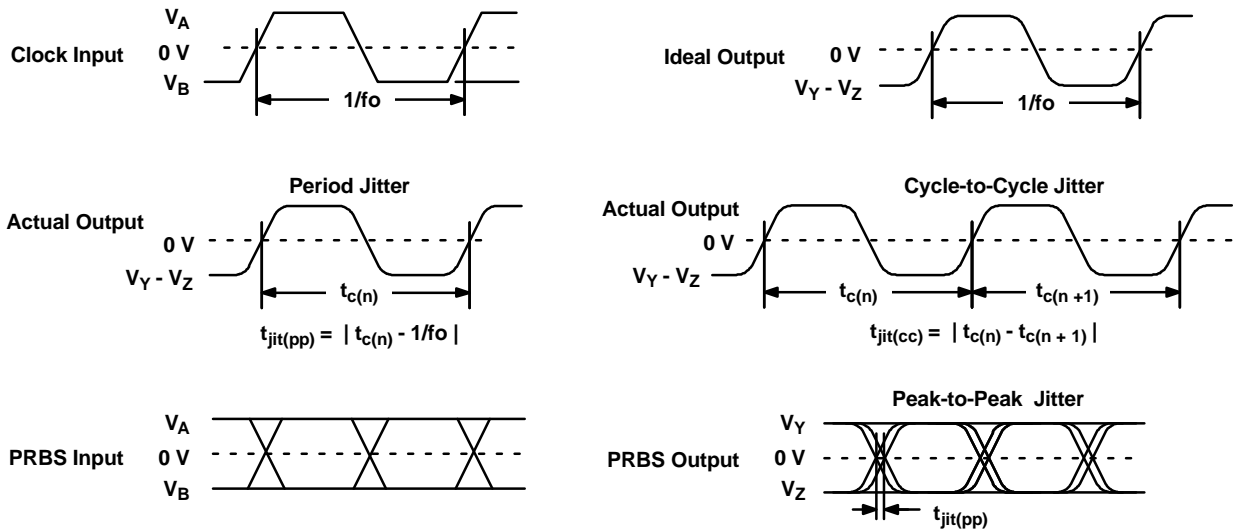
**Figure 4. Timing Test Circuit and Waveforms**

PARAMETER MEASUREMENT INFORMATION (continued)



- A. 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 mm of the DUT.

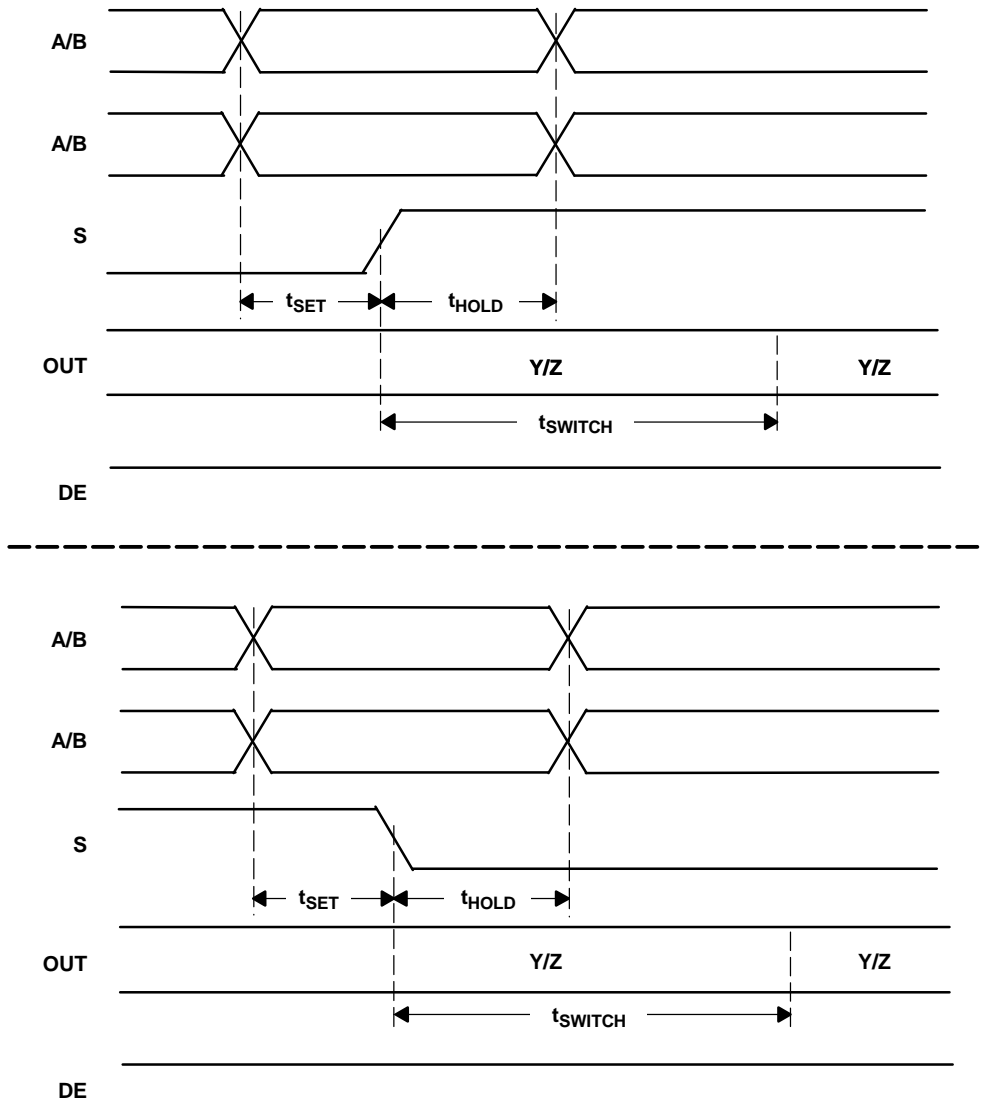
Figure 5. Enable and Disable Time Circuit and Definitions



- A. All input pulses are supplied by an Agilent 81250 Stimulus System.  
B. The measurement is made on a TEK TDS6604 running TDSJIT3 application software.

Figure 6. Driver Jitter Measurement Waveforms

**PARAMETER MEASUREMENT INFORMATION (continued)**



A.  $t_{SET}$  and  $t_{HOLD}$  times specify that data must be in a stable state before and after mux control switches.

**Figure 7. Input to Select for Both Rising and Falling Edge Setup and Hold Times**

TYPICAL CHARACTERISTICS

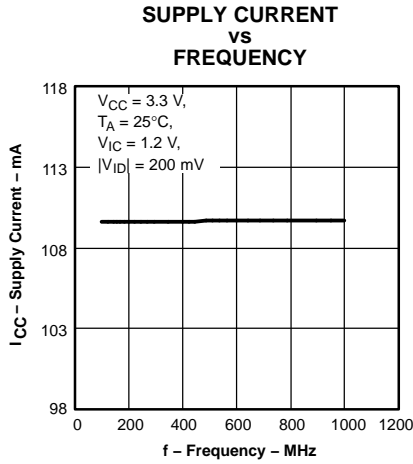


Figure 8.

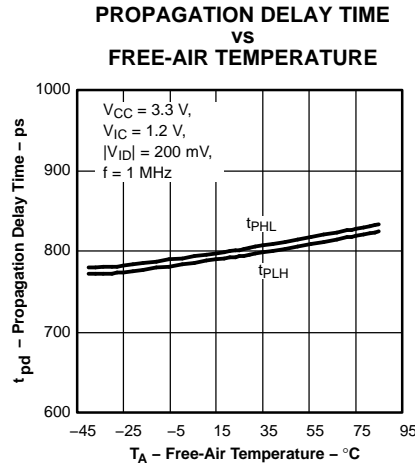


Figure 9.

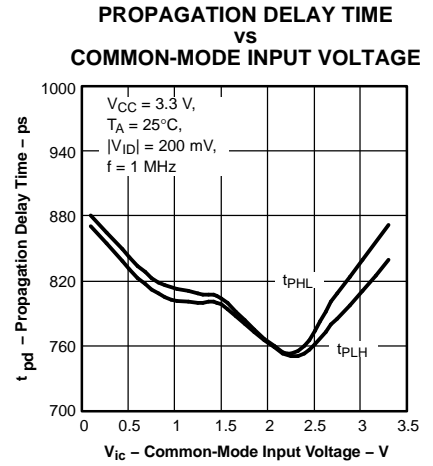


Figure 10.

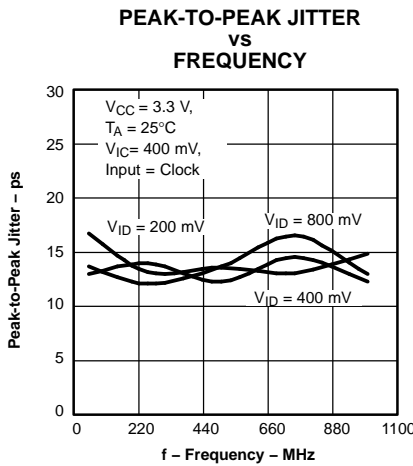


Figure 11.

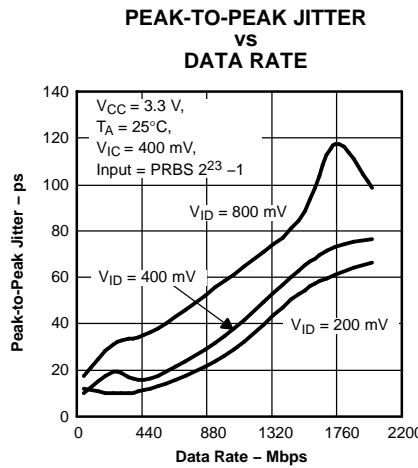


Figure 12.

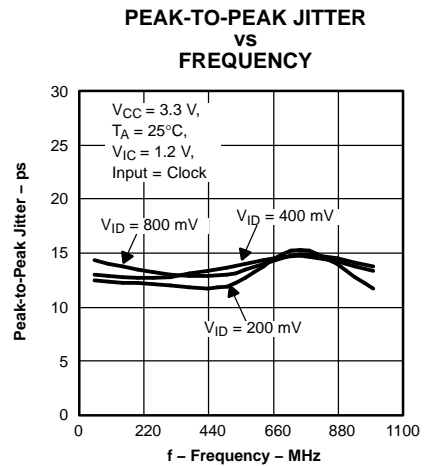


Figure 13.

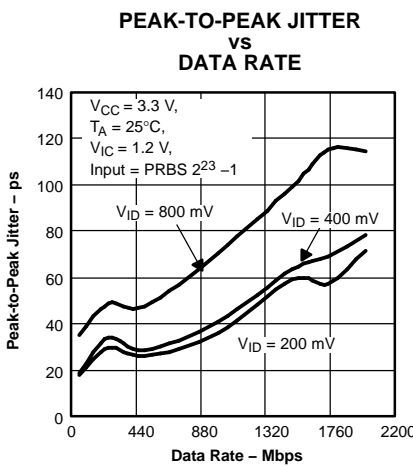


Figure 14.

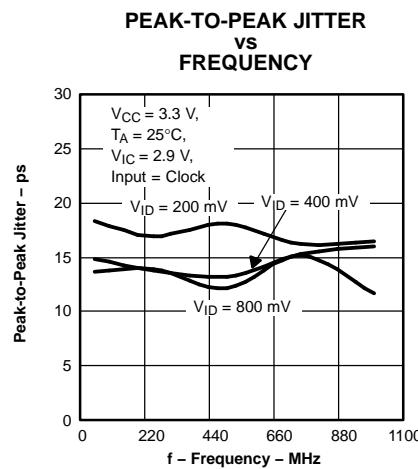


Figure 15.

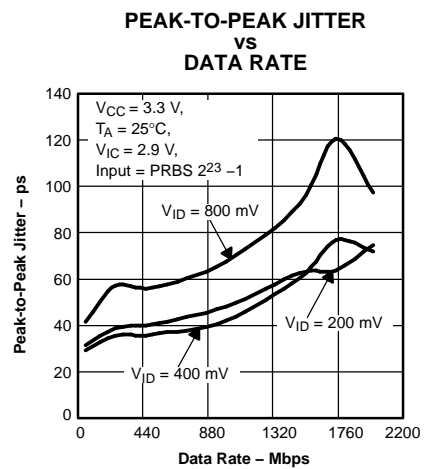


Figure 16.

**TYPICAL CHARACTERISTICS (continued)**

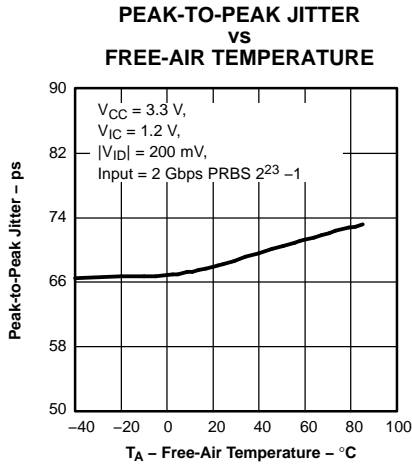


Figure 17.

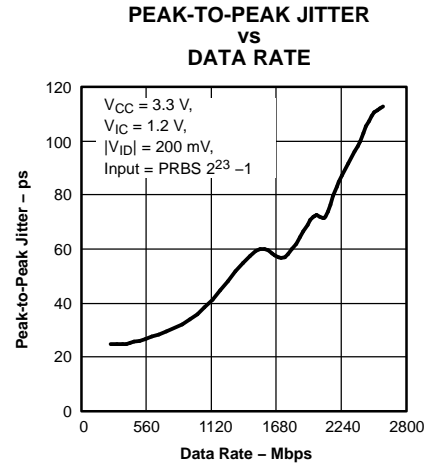


Figure 18.

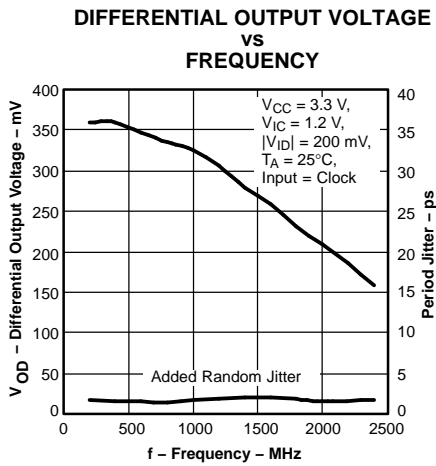
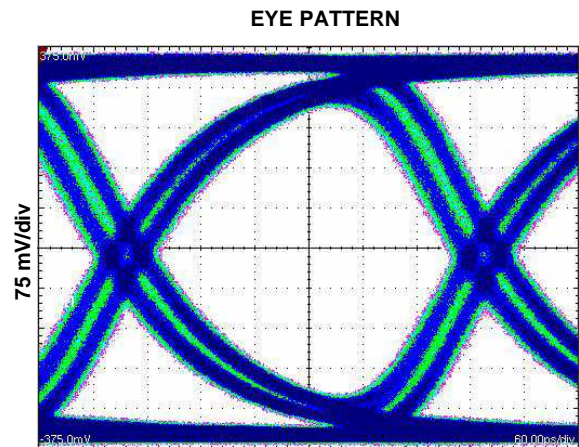


Figure 19.



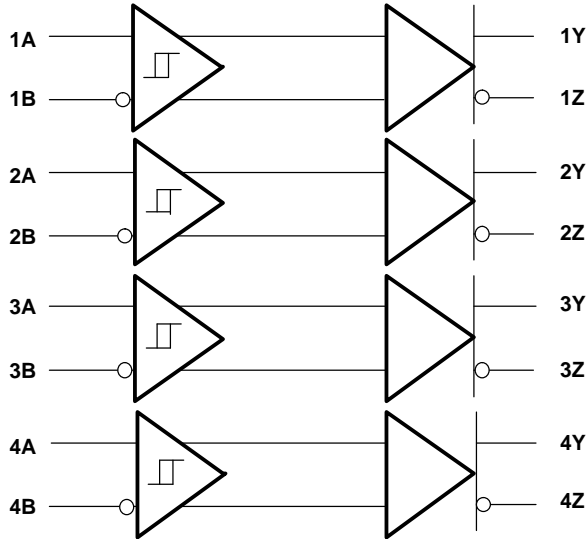
60 – ps/div  
 VIC = 1.2 V, |VID| = 200 mV, 2.5 Gbps,  
 Input = PRBS 2<sup>23</sup> - 1, VCC = 3.3 V

Figure 20.

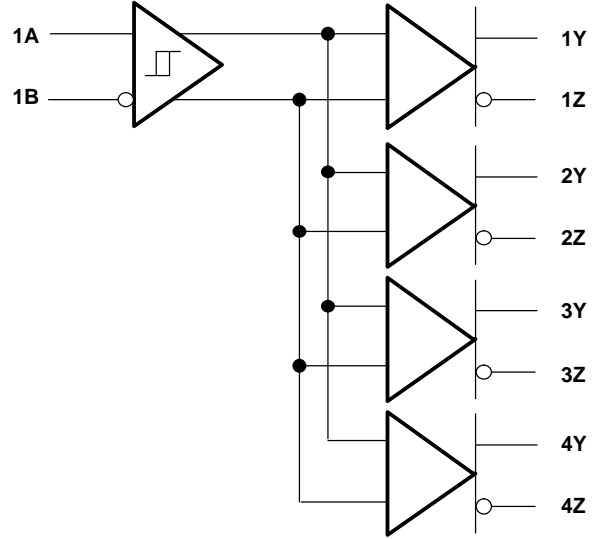
APPLICATION INFORMATION

CONFIGURATION EXAMPLES

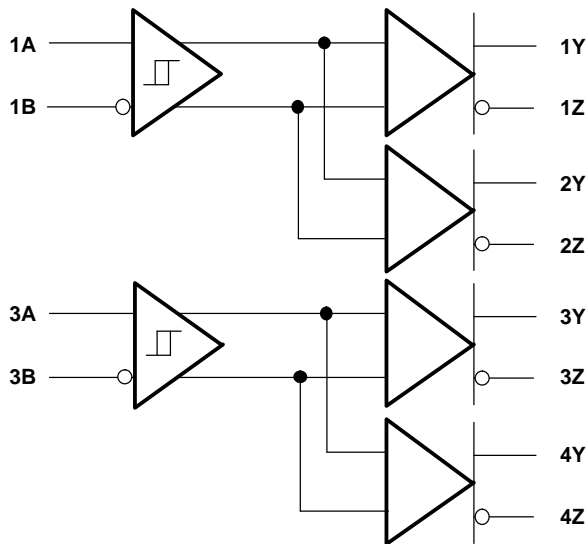
S10	S11	S20	S21
0	0	0	1
S30	S31	S40	S41
1	0	1	1



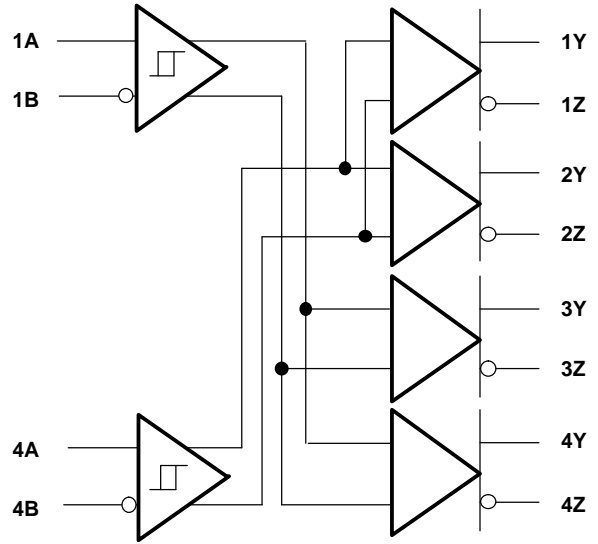
S10	S11	S20	S21
0	0	0	0
S30	S31	S40	S41
0	0	0	0



S10	S11	S20	S21
0	0	0	0
S30	S31	S40	S41
1	0	1	0

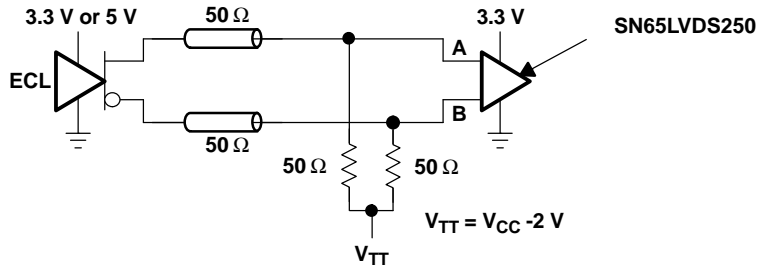


S10	S11	S20	S21
1	1	1	1
S30	S31	S40	S41
0	0	0	0

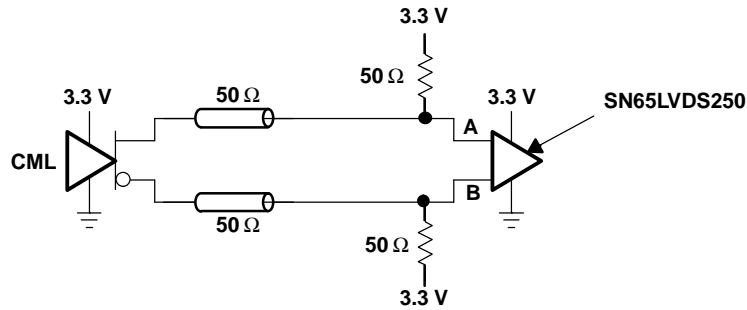


**APPLICATION INFORMATION (continued)**

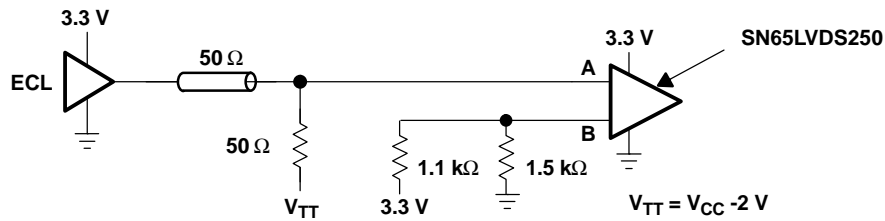
**TYPICAL APPLICATION CIRCUITS (ECL, PECL, LVDS, etc.)**



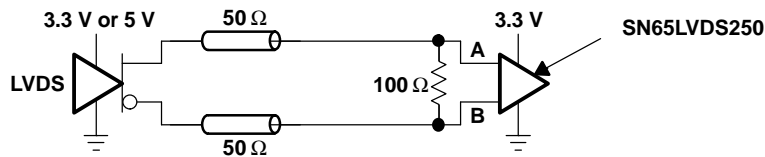
**Figure 21. Low-Voltage Positive Emitter-Coupled Logic (LVPECL)**



**Figure 22. Current-Mode Logic (CML)**



**Figure 23. Single-Ended (LVPECL)**



**Figure 24. Low-Voltage Differential Signaling (LVDS)**

**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
SN65LVDS250DBT	ACTIVE	TSSOP	DBT	38	50	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LVDS250	<a href="#">Samples</a>
SN65LVDS250DBTR	ACTIVE	TSSOP	DBT	38	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LVDS250	<a href="#">Samples</a>
SN65LVDS250DBTRG4	ACTIVE	TSSOP	DBT	38	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LVDS250	<a href="#">Samples</a>
SN65LVDT250DBT	ACTIVE	TSSOP	DBT	38	50	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LVDT250	<a href="#">Samples</a>
SN65LVDT250DBTR	ACTIVE	TSSOP	DBT	38	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	LVDT250	<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.

**OBSELETE:** 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.

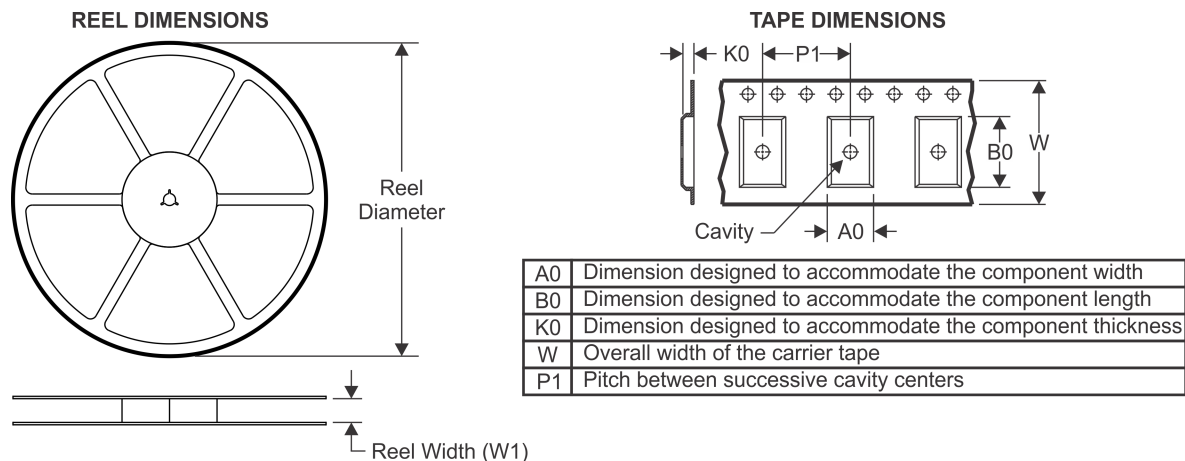
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

(6) 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**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**

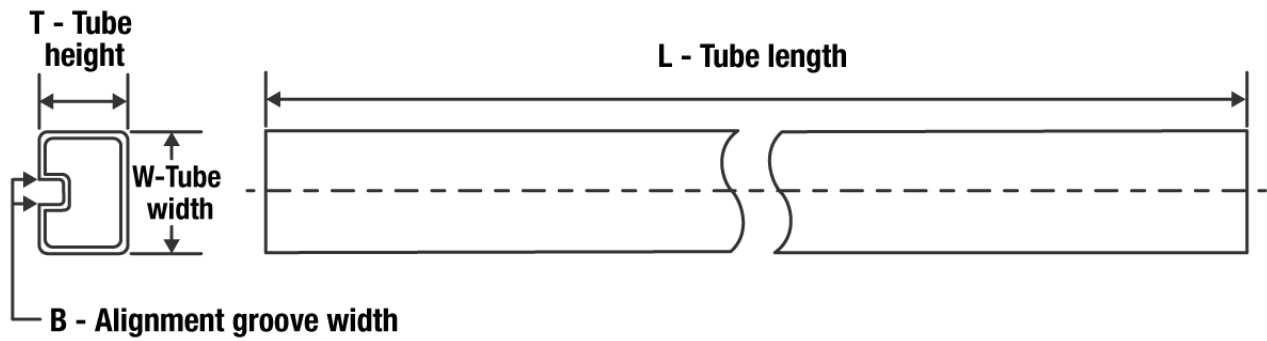

\*All dimensions are nominal

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
SN65LVDS250DBTR	TSSOP	DBT	38	2000	330.0	16.4	6.9	10.2	1.8	12.0	16.0	Q1
SN65LVDT250DBTR	TSSOP	DBT	38	2000	330.0	16.4	6.9	10.2	1.8	12.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVDS250DBTR	TSSOP	DBT	38	2000	350.0	350.0	43.0
SN65LVDT250DBTR	TSSOP	DBT	38	2000	350.0	350.0	43.0

**TUBE**


\*All dimensions are nominal

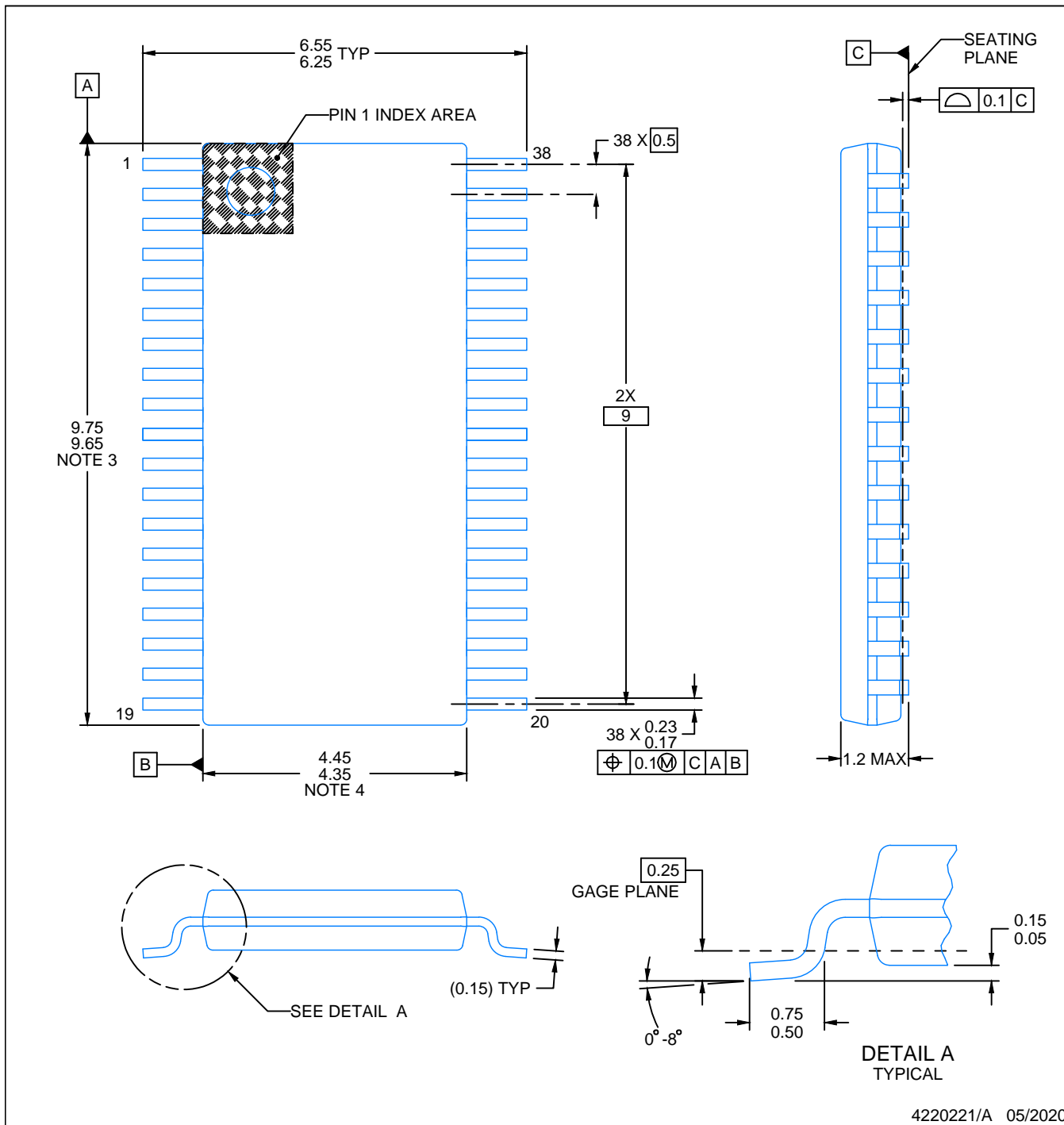
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
SN65LVDS250DBT	DBT	TSSOP	38	50	530	10.2	3600	3.5
SN65LVDT250DBT	DBT	TSSOP	38	50	530	10.2	3600	3.5

# PACKAGE OUTLINE

**DBT0038A**

**TSSOP - 1.2 mm max height**

SMALL OUTLINE PACKAGE



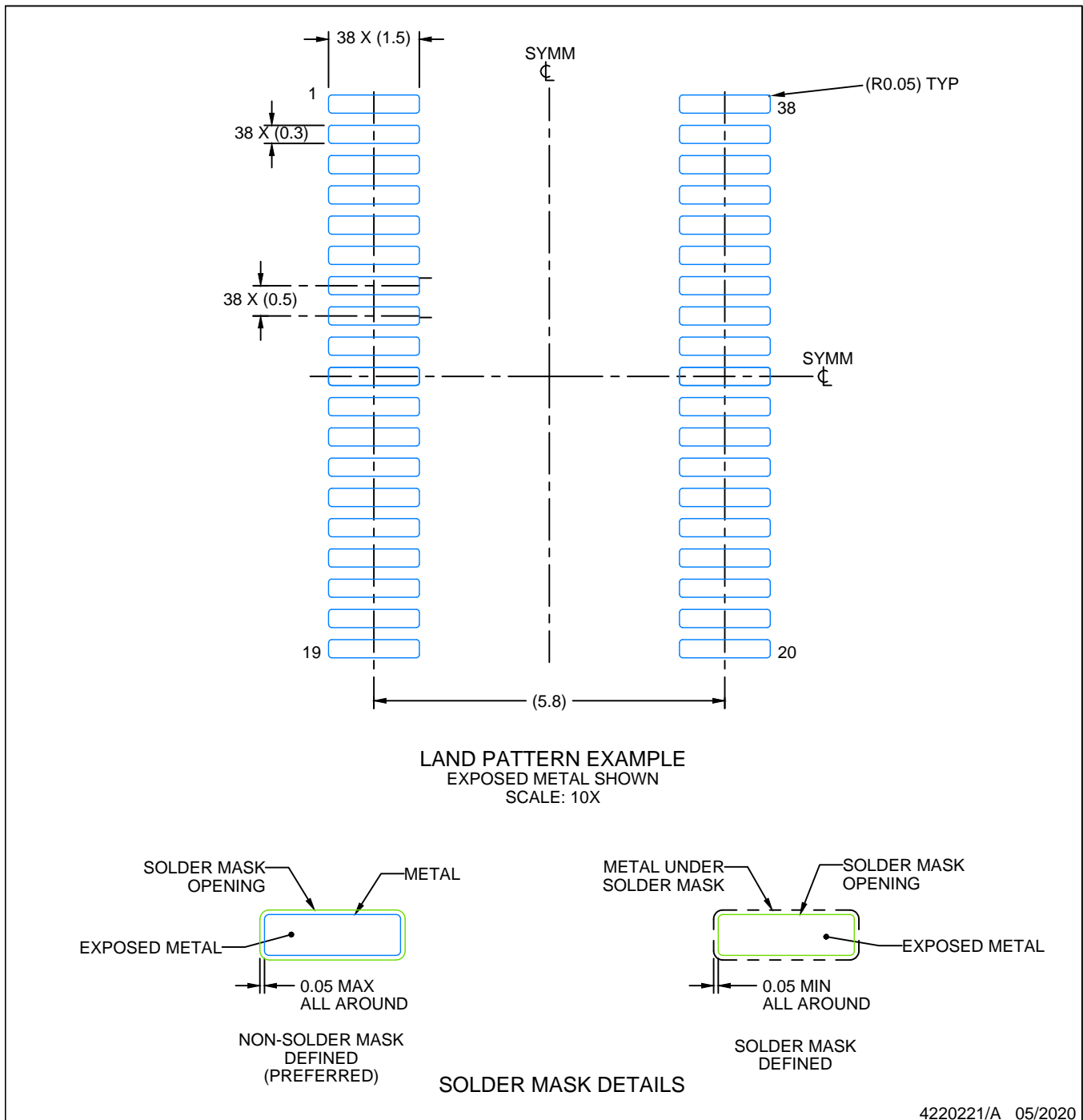
4220221/A 05/2020

# EXAMPLE BOARD LAYOUT

DBT0038A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

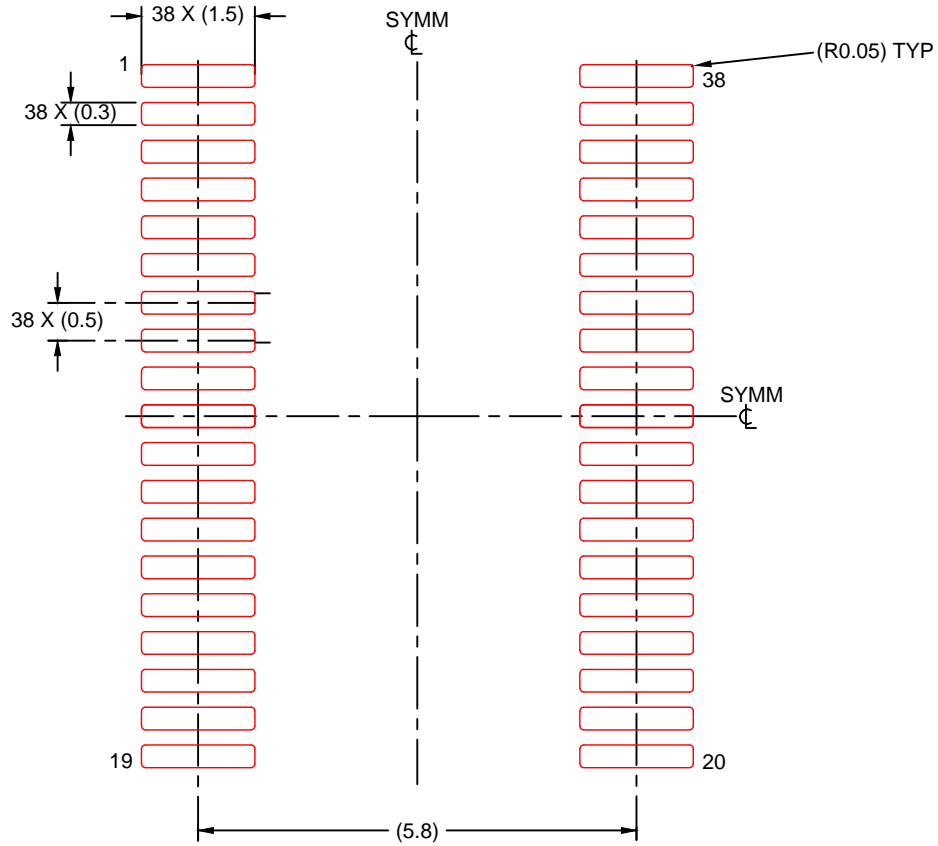
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DBT0038A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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