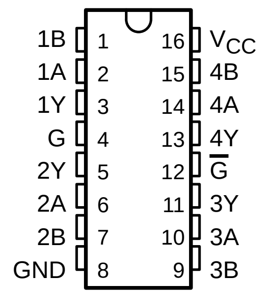
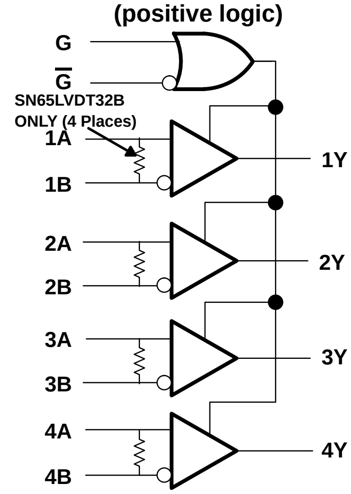
- **Meets or Exceeds the Requirements of ANSI EIA/TIA-644 Standard for Signaling Rates† up to 400 Mbps**
- **Operates With a Single 3.3-V Supply**
- **–2-V to 4.4-V Common-Mode Input Voltage Range**
- **Differential Input Thresholds <50 mV With 50 mV of Hysteresis Over Entire Common-Mode Input Voltage Range**
- **Integrated 110-Ω Line Termination Resistors Offered With the LVDT Series**
- **Propagation Delay Times 4 ns (typ)**
- **Active Fail Safe Assures a High-Level Output With No Input**
- **Bus-Pin ESD Protection Exceeds 15 kV HBM**
- **Inputs Remain High-Impedance on Power Down**
- **Recommended Maximum Parallel Rate of 200 M-Transfers/s**
- **Available in Small-Outline Package With 1,27 mm Terminal Pitch**
- **Pin-Compatible With the AM26LS32, MC3486, or µA9637**

SN65LVDS32B
SN65LVDT32B

D PACKAGE
(TOP VIEW)

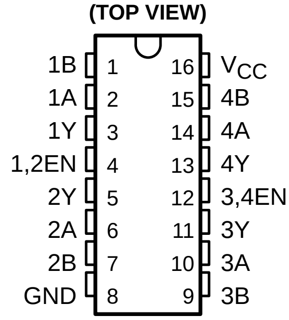


Logic Diagram
(positive logic)

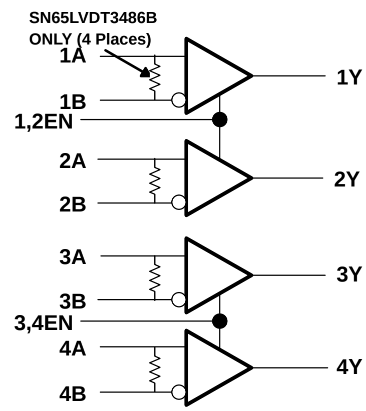


SN65LVDS3486B
SN65LVDT3486B

D PACKAGE
(TOP VIEW)

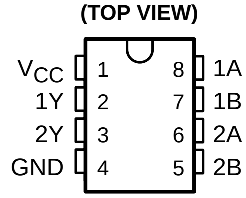


Logic Diagram
(positive logic)

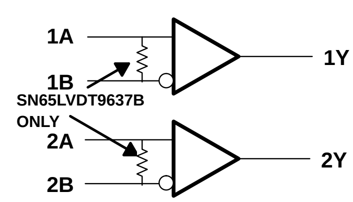


SN65LVDS9637B
SN65LVDT9637B

D PACKAGE
(TOP VIEW)



Logic Diagram
(positive logic)



description

This family of differential line receivers offers improved performance and features that implement the electrical characteristics of low-voltage differential signaling (LVDS). LVDS is defined in the TIA/EIA-644 standard. This improved performance represents the second generation of receiver products for this standard, providing a better overall solution for the cabled environment. This generation of products is an extension to TI's overall product portfolio and is not necessarily a replacement for older LVDS receivers.

Improved features include an input common-mode voltage range 2 V wider than the minimum required by the standard. This will allow longer cable lengths by tripling the allowable ground noise tolerance to 3 V between a driver and receiver. TI has additionally introduced an even wider input common-mode voltage range of –4 to 5 V in their SN65LVDS/T33 and SN65LVDS/T34.

† Signaling rate, 1/t, where t is the minimum unit interval and is expressed in the units bits/s (bits per second)

description (continued)

Precise control of the differential input voltage thresholds now allows for inclusion of 50 mV of input voltage hysteresis to improve noise rejection on slowly changing input signals. The input thresholds are still no more than ±50 mV over the full input common-mode voltage range.

The high-speed switching of LVDS signals almost always necessitates the use of a line impedance matching resistor at the receiving-end of the cable or transmission media. The SN65LVDT series of receivers eliminates this external resistor by integrating it with the receiver. The nonterminated SN65LVDS series is also available for multidrop or other termination circuits.

The receivers can withstand ±15-kV human-body model (HBM) and ±600 V-machine model (MM) electrostatic discharges to the receiver input pins with respect to ground without damage. This provides reliability in cabled and other connections where potentially damaging noise is always a threat.

The receivers also include a (patent pending) fail-safe circuit that will provide a high-level output within 600 ns after loss of the input signal. The most common causes of signal loss are disconnected cables, shorted lines, or powered-down transmitters. This prevents noise from being received as valid data under these fault conditions. This feature may also be used for wired-OR bus signaling.

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

The SN65LVDS32B, SN65LVDT32B, SN65LVDS3486B, SN65LVDT3486B, SN65LVDS9637B, and SN65LVDT9637B are characterized for operation from -40°C to 85°C.

AVAILABLE OPTIONS

PART NUMBER†	NUMBER OF RECEIVERS	TERMINATION RESISTOR†	SYMBOLIZATION
SN65LVDS32BD	4	No	LVDS32B
SN65LVDT32BD	4	Yes	LVDT32B
SN65LVDS3486BD	4	No	LVDS3486
SN65LVDT3486BD	4	Yes	LVDT3486
SN65LVDS9637BD	2	No	DK637B
SN65LVDT9637BD	2	Yes	DR637B

† Add the suffix R for taped and reeled carrier.

Function Tables

SN65LVDS32B and SN65LVDT32B

DIFFERENTIAL INPUT	ENABLES		OUTPUT
A-B	**G**	**$\overline{G}$**	**Y**
V_{ID} ≥ -32 mV	H X	X L	H H
-100 mV < V_{ID} ≤ -32 mV	H X	X L	? ?
V_{ID} ≤ -100 mV	H X	X L	L L
X	L	H	Z
Open	H X	X L	H H

H = high level, L = low level, X = irrelevant,
Z = high impedance (off), ? = indeterminate

SN65LVDS3486B and SN65LVDT3486B

DIFFERENTIAL INPUT	ENABLES	OUTPUT
A-B	**EN**	**Y**
V_{ID} ≥ -32 mV	H	H
-100 mV < V_{ID} ≤ -32 mV	H	?
V_{ID} ≤ -100 mV	H	L
X	L	Z
Open	H	H

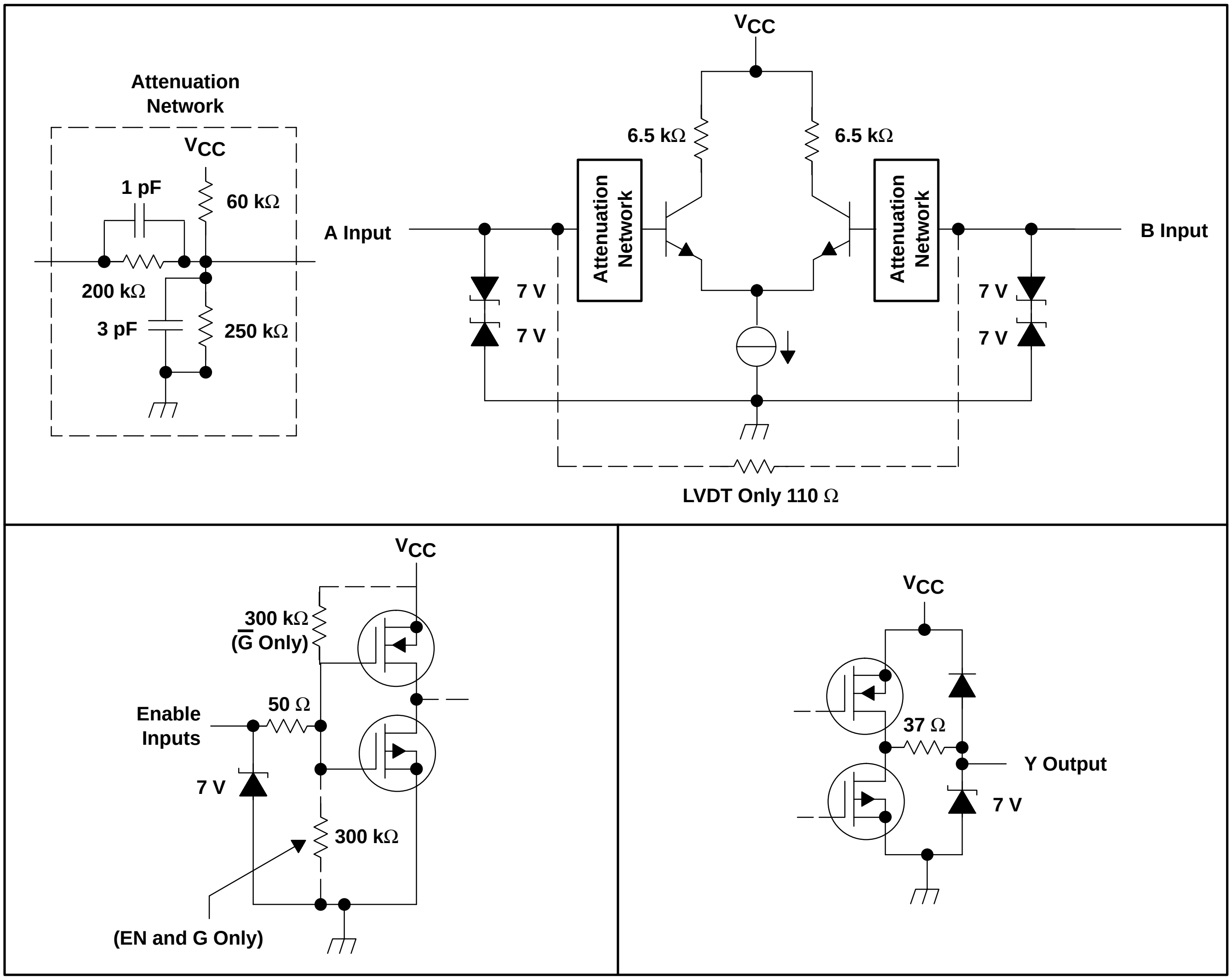
H = high level, L = low level, X = irrelevant,
Z = high impedance (off), ? = indeterminate

SN65LVDS9637B and SN65LVDT9637B

DIFFERENTIAL INPUT	OUTPUT
A-B	**Y**
V_{ID} ≥ -32 mV	H
-100 mV < V_{ID} ≤ -32 mV	?
V_{ID} ≤ -100 mV	L
Open	H

H = high level, L = low level, ? = indeterminate

equivalent input and output schematic diagrams



absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage range, V_{CC} (see Note 1) . . . . –0.5 V to 4 V
Voltage range: Enables or Y . . . . –0.5 V to V_{CC} + 3 V
A or B . . . . –4 V to 6 V
$|V_A – V_B|$ (LVDT) . . . . 1 V
Electrostatic discharge: A, B, and GND (see Note 2) . . . . Class 3, A: 15 kV, B: 600 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

† 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.

NOTES: 1. All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
2. Tested in accordance with MIL-STD-883C Method 3015.7.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	OPERATING FACTOR‡ ABOVE T_A = 25°C	T_A = 85°C POWER RATING
D8	725 mW	5.8 mW/°C	377 mW
D16	950 mW	7.6 mW/°C	494 mW

‡ 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
Supply voltage, V_{CC}		3	3.3	3.6	V
High-level input voltage, V_{IH}	Enables	2			V
Low-level input voltage, V_{IL}	Enables			0.8	V
Magnitude of differential input voltage, $|V_{ID}|$	LVDS	0.1		3	V
	LVDT			0.8	V
Voltage at any bus terminal (separately or common-mode), V_I or V_{IC}		–2		4.4	V
Operating free-air temperature, T_A		–40		85	°C

electrical characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{IT1}	Positive-going differential input voltage threshold		V_{IB} = –2 V or 4.4 V, See Figures 1 and 2			50	mV
V_{IT2}	Negative-going differential input voltage threshold			–50			
V_{IT3}	Differential input fail-safe voltage threshold		See Table 1 and Figure 5	–32		–100	mV
$V_{ID(HYS)}$	Differential input voltage hysteresis, V_{IT1} - V_{IT2}				50		mV
V_{OH}	High-level output voltage		I_{OH} = –4 mA	2.4			V
V_{OL}	Low-level output voltage		I_{OL} = 4 mA			0.4	V
I_{CC}	Supply current	'32B or '3486B	G or EN at V_{CC}, No load, Steady-state		16	23	mA
			G or EN at GND		1.1	5	
		'9637B	No load, Steady-state		8	12	
I_I	Input current (A or B inputs)	SN65LVDS	V_I = 0 V, Other input open			±20	μA
			V_I =2.4 V, Other input open			±20	
			V_I = –2 V, Other input open			±40	
			V_I = 4.4 V, Other input open			±40	
		SN65LVDT	V_I = 0 V, Other input open			±40	μA
			V_I =2.4 V, Other input open			±40	
			V_I =–2 V, Other input open			±80	
			V_I = 4.4 V, Other input open			±80	
I_{ID}	Differential input current (I_{IA} - I_{IB})	SN65LVDS	V_{ID}= 100 mV, V_{IC}= –2 V or 4.4 V, See Figure 1			±3	μA
		SN65LVDT	V_{ID}= 0.2 V, V_{IC}= –2 V or 4.4 V	1.55		2.22	mA
$I_{I(OFF)}$	Power-off input current (A or B inputs)	SN65LVDS	V_A or V_B= 0 V or 2.4 V, V_{CC}= 0 V			±20	μA
			V_A or V_B= –2 V or 4.4 V, V_{CC}= 0 V			±35	
		SN65LVDT	V_A or V_B= 0 V or 2.4 V, V_{CC}= 0 V			±30	
			V_A or V_B= –2 V or 4.4 V, V_{CC}= 0 V			±50	
I_{IH}	High-level input current (enables)		V_{IH} = 2 V			10	μA
I_{IL}	Low-level input current (enables)		V_{IL} = 0.8 V			10	μA
I_{OZ}	High-impedance output current					±10	μA
C_I	Input capacitance, A or B input to GND		V_I = 0.4 sin (4E6πt) + 0.5 V		5		pF

† All typical values are at 25°C and with a 3.3 V supply.

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 3	2.5	4	6	ns
t_{PHL}	Propagation delay time, high-to-low-level output	See Figure 3	2.5	4	6	ns
t_{d1}	Delay time, fail-safe deactivate time	See Figures 3 and 6			9	ns
t_{d2}	Delay time, fail-safe activate time	See Figures 3 and 6	0.3		1.5	µs
$t_{sk(p)}$	Pulse skew ($\|t_{PHL1} – t_{PLH1}\|$)	C_L = 10 pF, See Figure 3		200		ps
$t_{sk(o)}$	Output skew§	C_L = 10 pF, See Figure 3		150		ps
$t_{sk(pp)}$	Part-to-part skew‡	C_L = 10 pF, See Figure 3			1	ns
t_r	Output signal rise time	C_L = 10 pF, See Figure 3		0.8		ns
t_f	Output signal fall time	C_L = 10 pF, See Figure 3		0.8		ns
t_{PHZ}	Propagation delay time, high-level-to-high-impedance output	See Figure 4		5.5	9	ns
t_{PLZ}	Propagation delay time, low-level-to-high-impedance output	See Figure 4		4.4	9	ns
t_{PZH}	Propagation delay time, high-impedance -to-high-level output	See Figure 4		3.8	9	ns
t_{PZL}	Propagation delay time, high-impedance-to-low-level output	See Figure 4		7	9	ns

† All typical values are at 25°C and with a 3.3-V supply.
‡ $t_{sk(pp)}$ is the magnitude of the time 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.
§ $t_{sk(o)}$ is the magnitude of the time difference between the t_{PLH} or t_{PHL} of all receivers of a single device with all of their inputs driven together.

PARAMETER MEASUREMENT INFORMATION

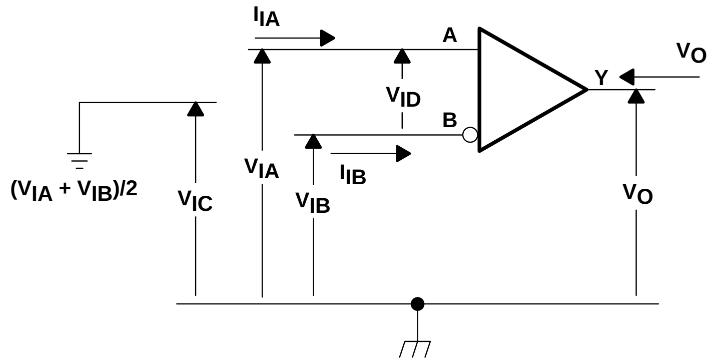
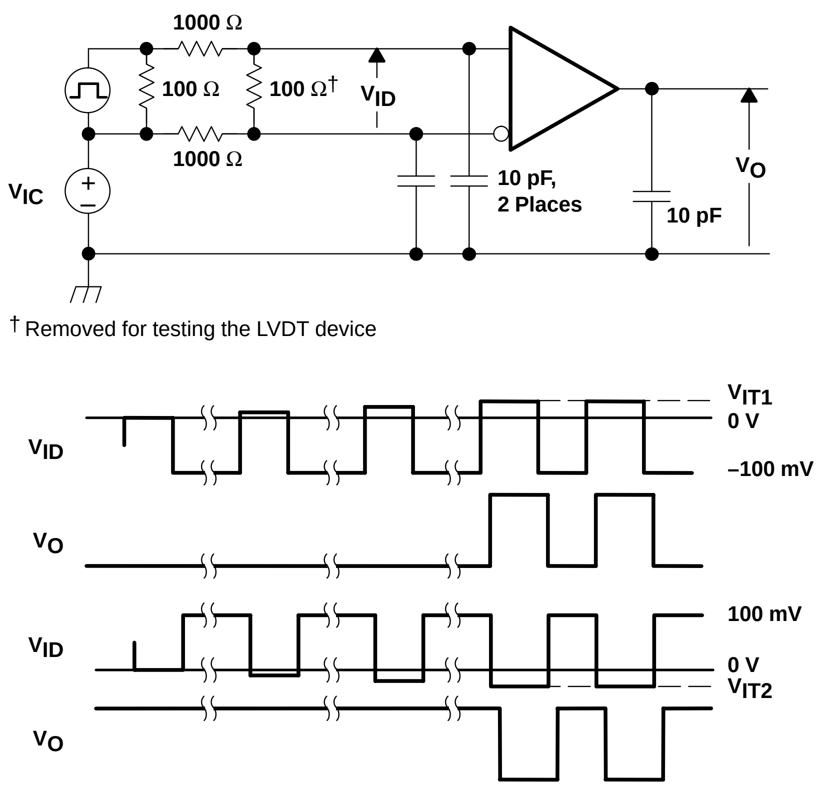


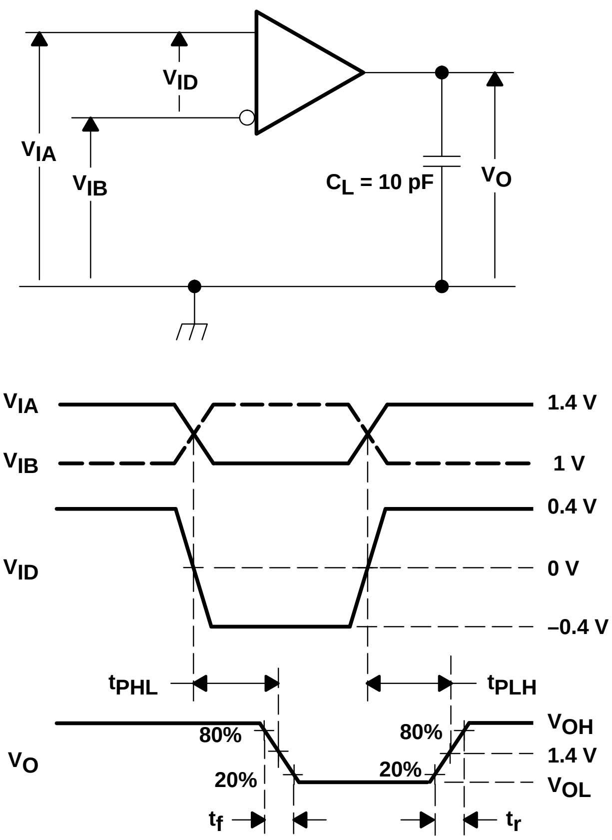
Figure 1. Voltage and Current Definitions



NOTE: Input signal of 3 Mpps, duration of 167 ns, and transition time of <1 ns.

Figure 2. V_{IT1} and V_{IT2} Input Voltage Threshold Test Circuit and Definitions

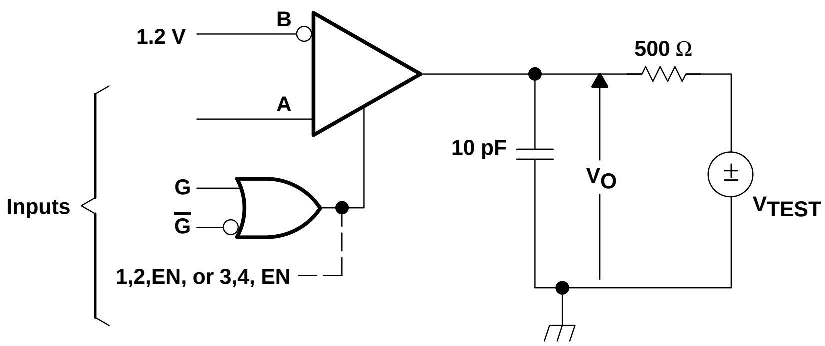
PARAMETER MEASUREMENT INFORMATION



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

Figure 3. Timing Test Circuit and Waveforms

PARAMETER MEASUREMENT INFORMATION



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

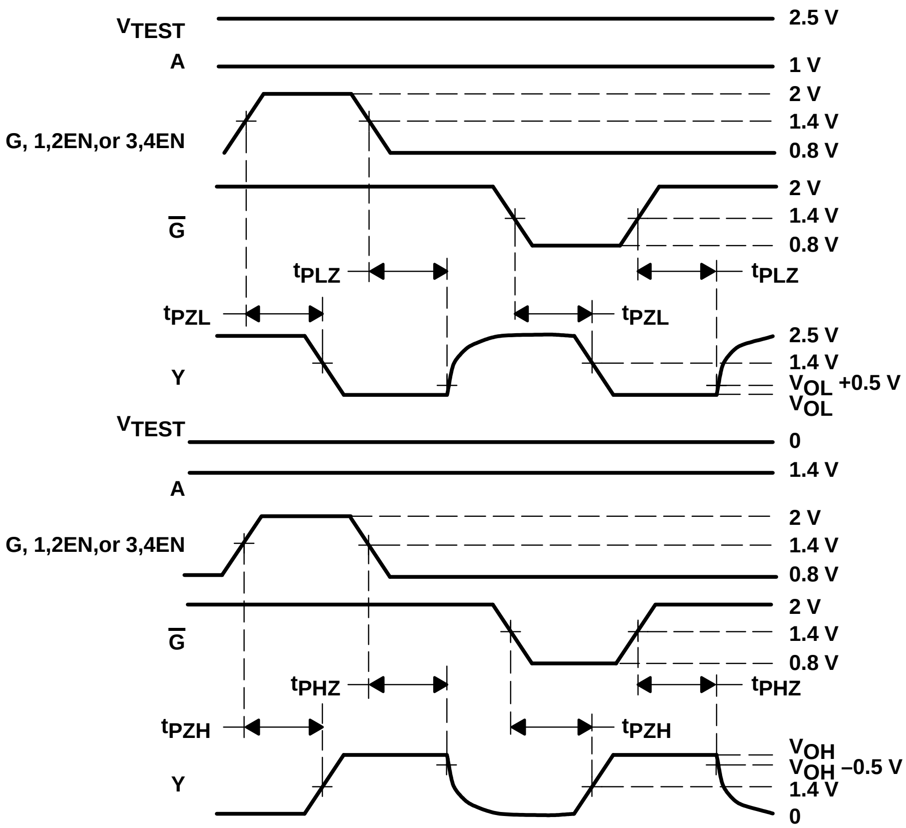


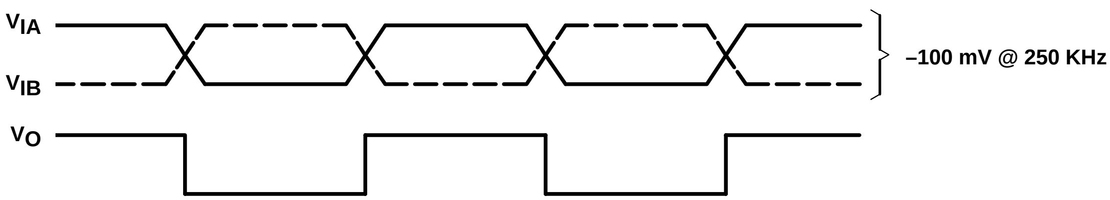
Figure 4. Enable/Disable Time Test Circuit and Waveforms

PARAMETER MEASUREMENT INFORMATION

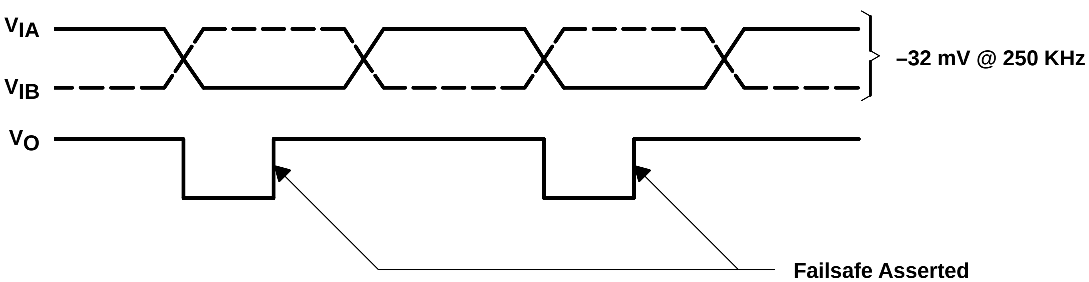
Table 1. Receiver Minimum and Maximum V_{IT3} Input Threshold Test Voltages

APPLIED VOLTAGES†		RESULTANT INPUTS		
V_{IA} (mV)	V_{IB} (mV)	V_{ID} (mV)	V_{IC} (mV)	Output
–2000	–1900	–100	–1950	L
–2000	–1968	–32	–1984	H
4300	4400	–100	4350	L
4368	4400	–32	4384	H

† These voltages are applied for a minimum of 1.5 µs.



a) No Failsafe



b) Failsafe Asserted

Figure 5. V_{IT3} Failsafe Threshold Test

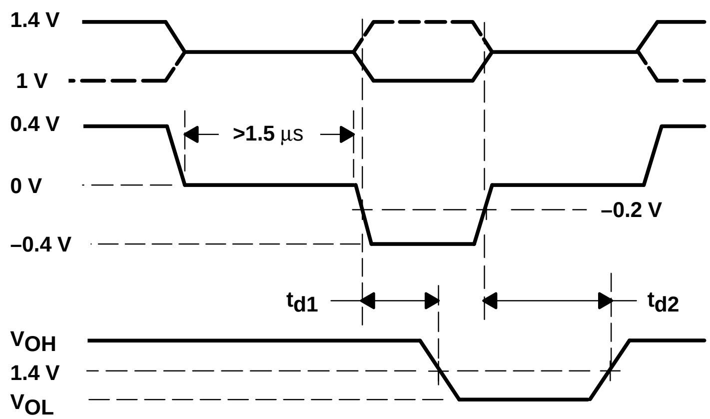


Figure 6. Waveforms for Failsafe Activate and Deactivate

TYPICAL CHARACTERISTICS

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

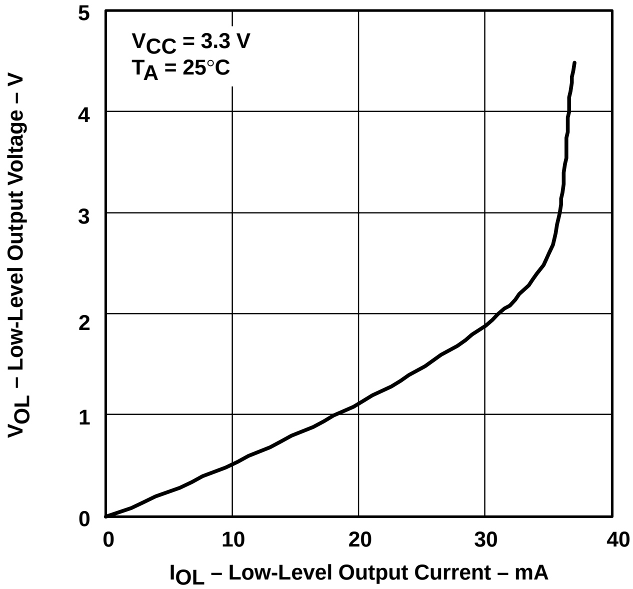


Figure 7

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

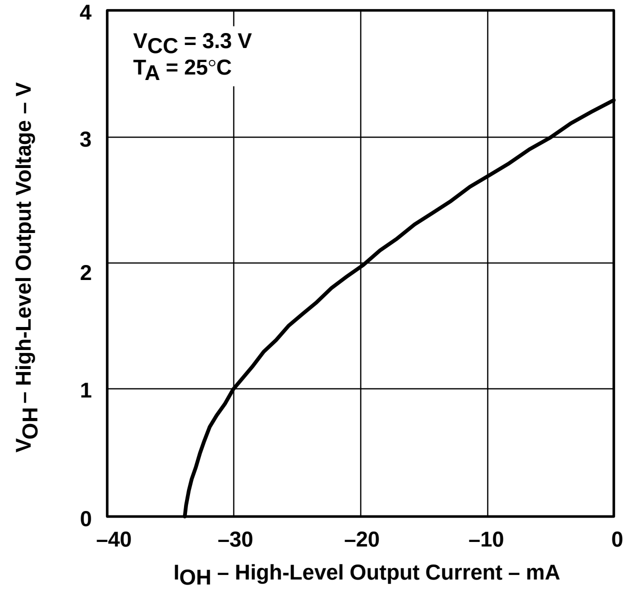


Figure 8

LOW-TO-HIGH PROPAGATION DELAY TIME vs FREE-AIR TEMPERATURE

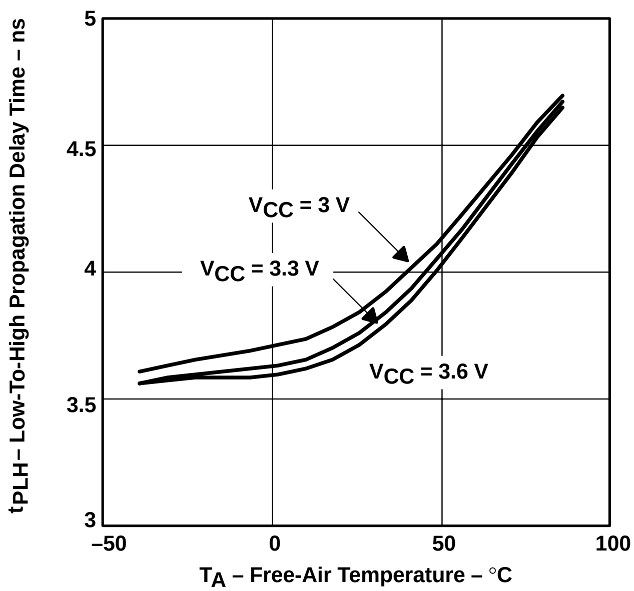


Figure 9

HIGH-TO-LOW PROPAGATION DELAY TIME vs FREE-AIR TEMPERATURE

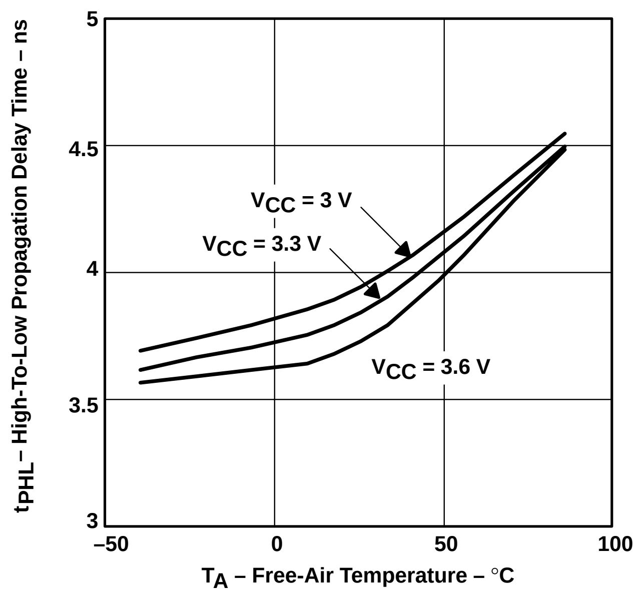


Figure 10

TYPICAL CHARACTERISTICS

SUPPLY CURRENT
vs
FREQUENCY

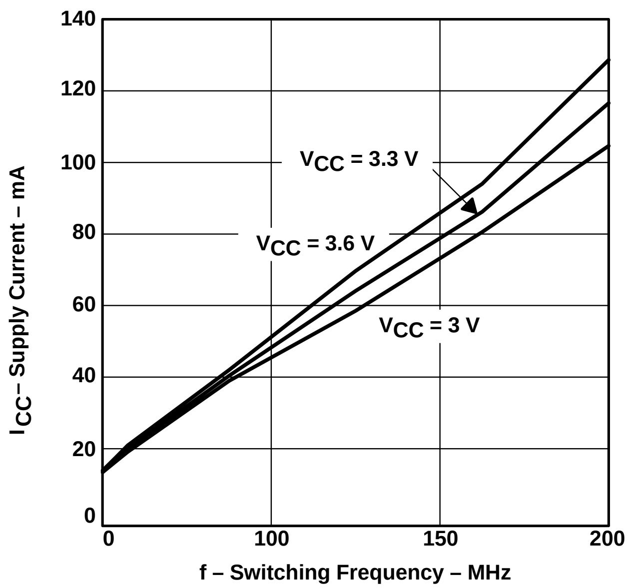
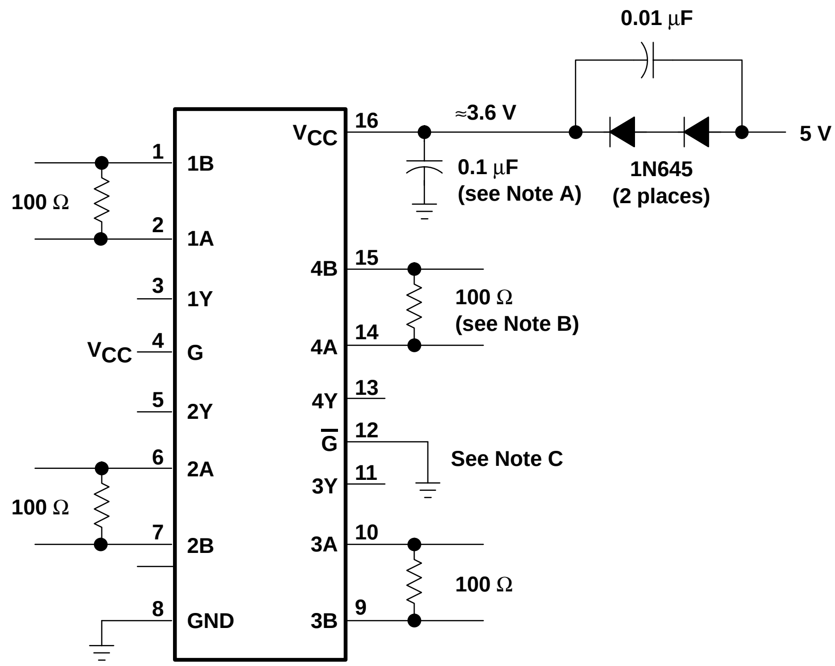


Figure 11

APPLICATION INFORMATION



NOTES: A. Place a 0.1-µF Z5U ceramic, mica or polystyrene dielectric, 0805 size, chip capacitor between V_{CC} and the ground plane. The capacitor should be located as close as possible to the device terminals.
B. The termination resistance value should match the nominal characteristic impedance of the transmission media with ±10%.
C. Unused enable inputs should be tied to V_{CC} or GND as appropriate.

Figure 12. Operation with 5-V Supply

related information

IBIS modeling is available for this device. Please contact the local TI sales office or the TI Web site at *www.ti.com* for more information.

For more application guidelines, please see the following documents:

- *Low-Voltage Differential Signalling Design Notes* (TI literature number SLLA014)
- *Interface Circuits for TIA/EIA-644* (LVDS) (SLLA038)
- *Reducing EMI With LVDS* (SLLA030)
- *Slew Rate Control of LVDS Circuits* (SLLA034)
- *Using an LVDS Receiver With RS-422 Data* (SLLA031)
- *Evaluating the LVDS EVM* (SLLA033)

APPLICATION INFORMATION

terminated failsafe

A differential line receiver commonly has a fail-safe circuit to prevent it from switching on input noise. Current LVDS fail-safe solutions require either external components with subsequent reduction in signal quality or integrated solutions with limited application. This family of receivers has a new integrated fail-safe that solves the limitations seen in present solutions. A detailed theory of operation is presented in application note *The Active Fail-Safe Feature of the SN65LVDS32A,* literature number SLLA082.

Figure 13 shows one receiver channel with active fail-safe. It consists of a main receiver that can respond to a high-speed input differential signal. Also connected to the input pair are two fail-safe receivers that form a window comparator. The window comparator has a much slower response than the main receiver and detects when the input differential falls below 80 mV. A 600-ns fail-safe timer filters the window comparator outputs. When fail-safe is asserted, the fail-safe logic drives the main receiver output to logic high.

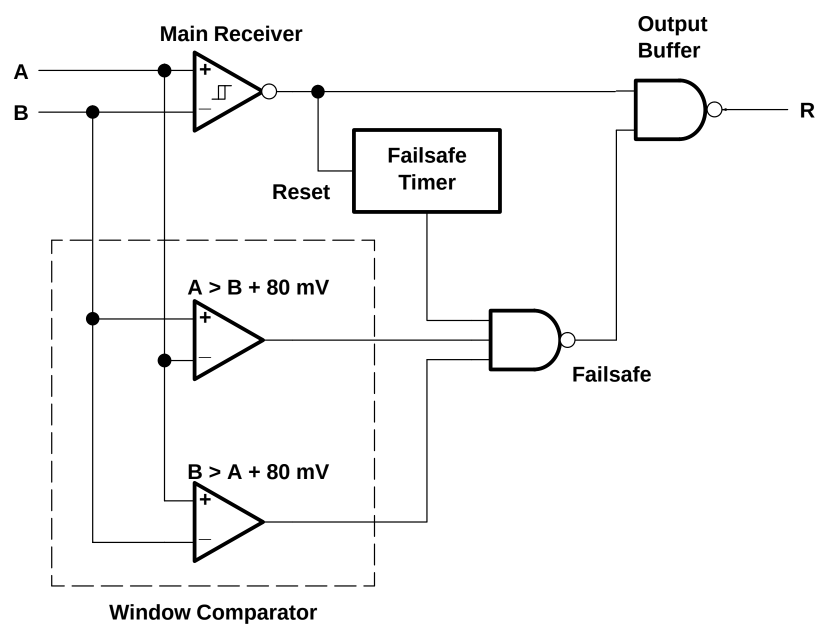


Figure 13. Receiver With Terminated Failsafe

APPLICATION INFORMATION

ECL/PECL-to-LVTTL conversion with TI's LVDS receiver

The various versions of emitter-coupled logic (i.e. ECL, PECL and LVPECL) are often the physical layer of choice for system designers. Designers know of the established technology and that it is capable of high-speed data transmission. In the past, system requirements often forced the selection of ECL. Now technologies like LVDS provide designers with another alternative. While the total exchange of ECL for LVDS may not be a design option, designers have been able to take advantage of LVDS by implementing a small resistor divider network at the input of the LVDS receiver. TI has taken the next step by introducing a wide common-mode LVDS receiver (no divider network required) which can be connected directly to an ECL driver with only the termination bias voltage required for ECL termination (V_{CC} – 2 V).

Figures 14 and 15 show the use of an LV/PECL driver driving 5 meters of CAT–5 cable and being received by TI's wide common-mode receiver and the resulting eye pattern. The values for R3 are required in order to provide a resistor path to ground for the LV/PECL driver. With no resistor divider, R1 simply needs to match the characteristic load impedance of 50 Ω. The R2 resistor is a small value and is intended to minimize any possible common-mode current reflections.

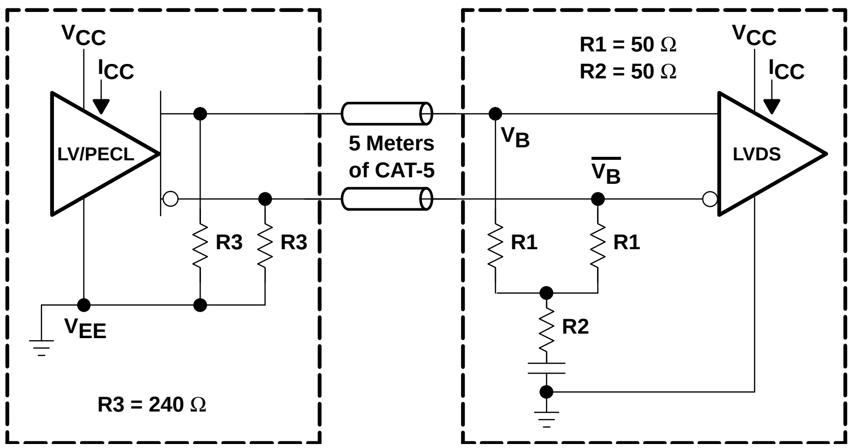


Figure 14. LVPECL or PECL to Remote Wide Common-Mode LVDS Receiver

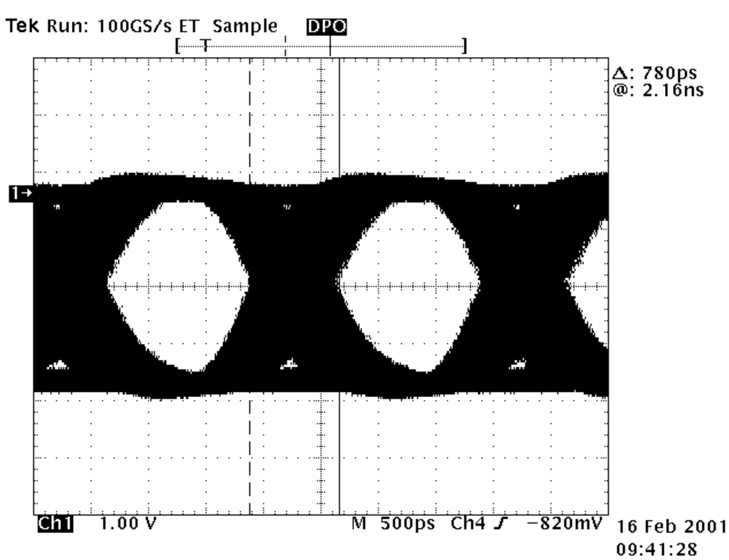


Figure 15. LV/PECL to Remote SN65LVDS32B at 500 Mbps Receiver Output (CH1)

APPLICATION INFORMATION

test conditions

- V_{CC} = 3.3 V
- T_A = 25°C (ambient temperature)
- All four channels switching simultaneously with NRZ data. Scope is pulse-triggered simultaneously with NRZ data.

equipment

- Tektronix PS25216 programmable power supply
- Tektronix HFS 9003 stimulus system
- Tektronix TDS 784D 4-channel digital phosphor oscilloscope – DPO

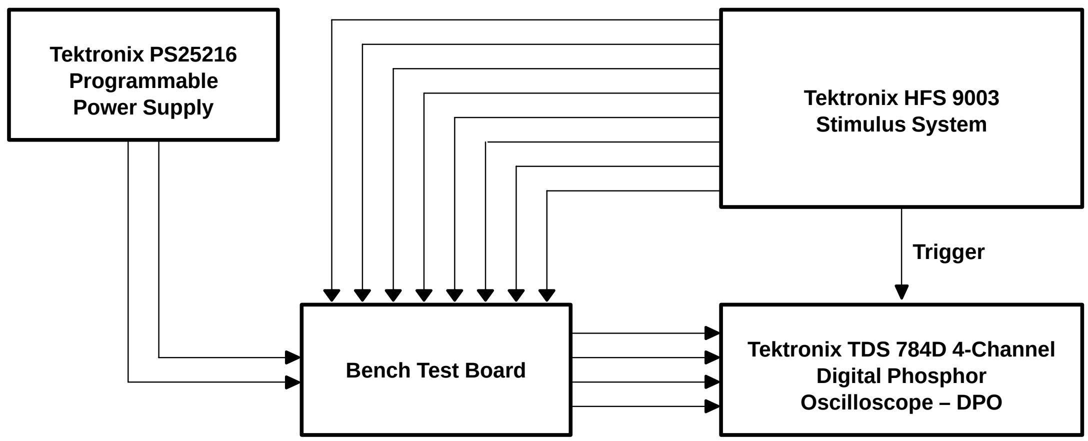


Figure 16. Equipment Setup

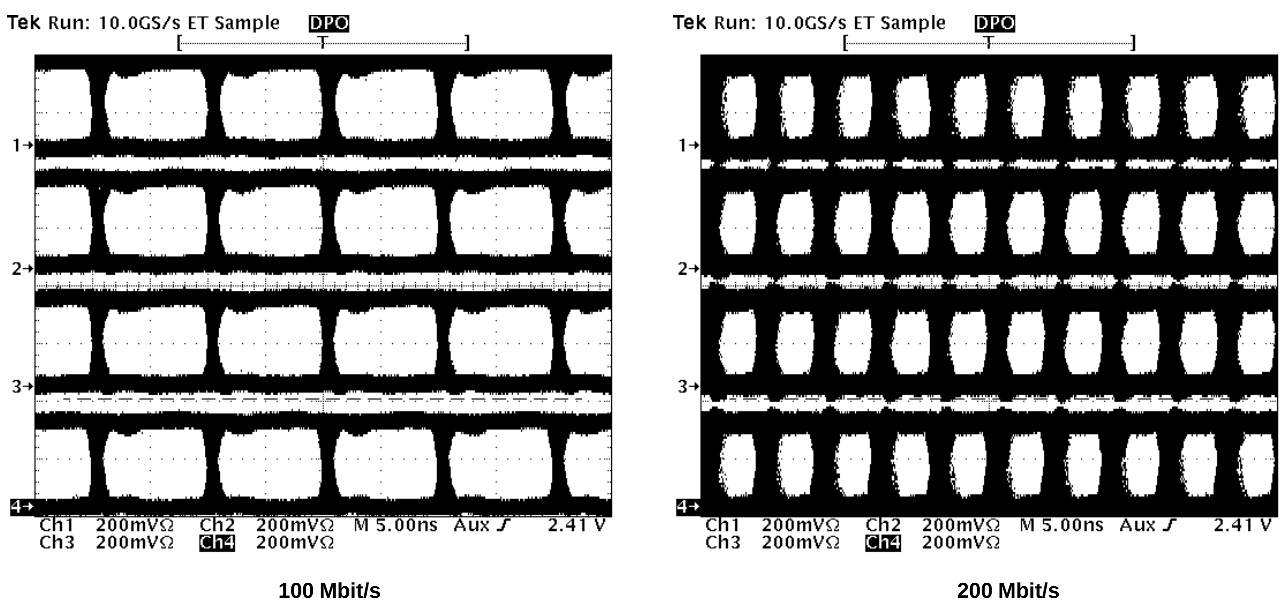
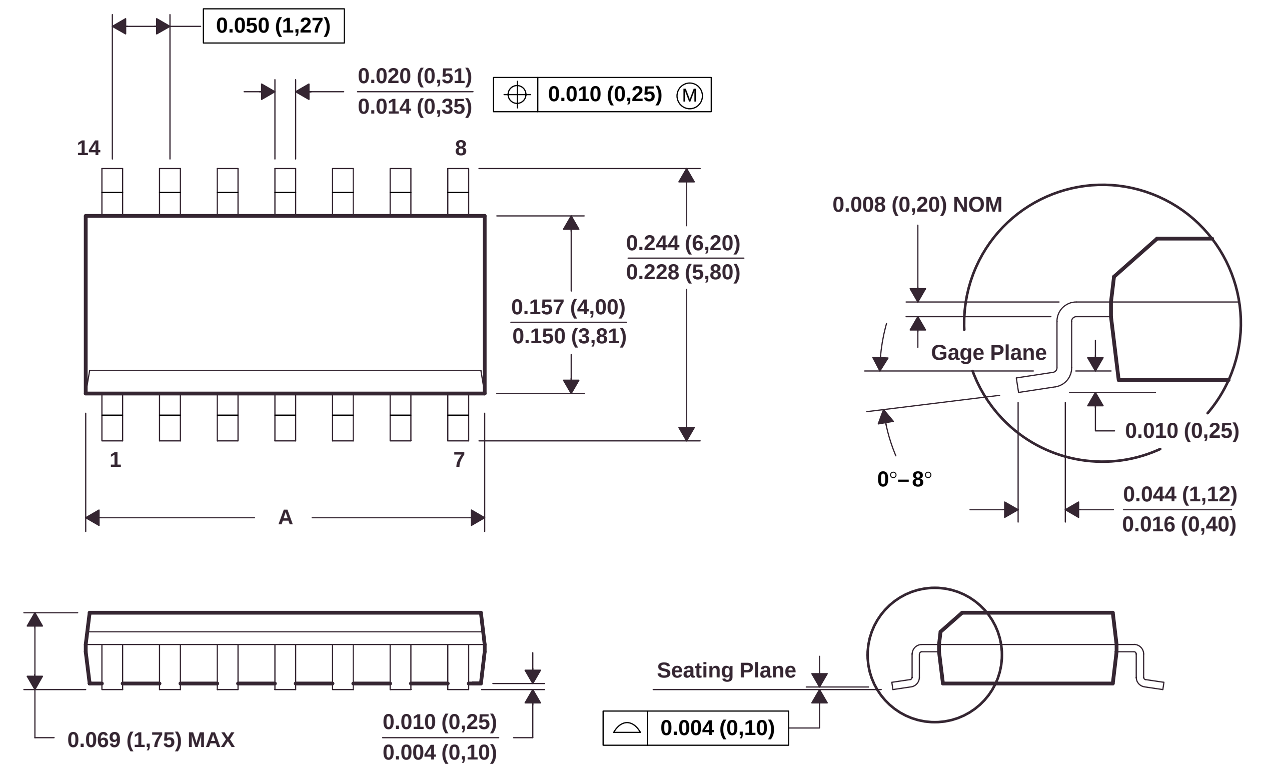


Figure 17. Typical Eye Pattern SN65LVDS32B

MECHANICAL DATA

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PIN SHOWN



DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

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NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).

PACKAGING INFORMATION

Orderable Device	Status [(1)]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [(2)]	Lead/Ball Finish	MSL Peak Temp [(3)]
SN65LVDS32BD	ACTIVE	SOIC	D	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDS32BDR	ACTIVE	SOIC	D	16	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDS3486BD	ACTIVE	SOIC	D	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDS3486BDR	ACTIVE	SOIC	D	16	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDS9637BD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDS9637BDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT32BD	ACTIVE	SOIC	D	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT32BDR	ACTIVE	SOIC	D	16	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT3486BD	ACTIVE	SOIC	D	16	40	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT3486BDR	ACTIVE	SOIC	D	16	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT9637BD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
SN65LVDT9637BDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM

[(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)] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
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.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[(3)] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.