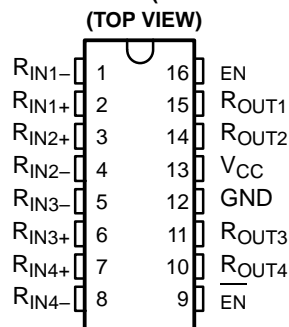


## LVDS QUAD DIFFERENTIAL LINE RECEIVER

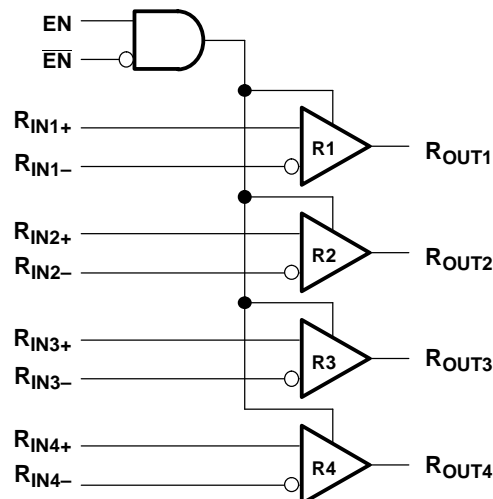
### FEATURES

- >400 Mbps (200 MHz) Signaling Rates
- Flow-Through Pinout Simplifies PCB Layout
- 50 ps Channel-to-Channel Skew (Typ)
- 200 ps Differential Skew (Typ)
- Propagation Delay Times 2.7 ns (Typ)
- 3.3-V Power Supply Design
- High Impedance LVDS Inputs on Power Down
- Low-Power Dissipation (40 mW at 3.3 V Static)
- Accepts Small Swing (350 mV) Differential Signal Levels
- Supports Open, Short, and Terminated Input Fail-Safe
- Industrial Operating Temperature Range (–40°C to 85°C)
- Conforms to TIA/EIA-644 LVDS Standard
- Available in SOIC and TSSOP Packages
- Pin-Compatible With DS90LV048A From National

SN65LVDS048AD (Marked as LVDS048A)  
SN65LVDS048APW (Marked as DL048A)



### functional diagram



### DESCRIPTION

The SN65LVDS048A is a quad differential line receiver that implements the electrical characteristics of low-voltage differential signaling (LVDS). This signaling technique lowers the output voltage levels of 5-V differential standard levels (such as EIA/TIA-422B) to reduce the power, increase the switching speeds, and allow operation with a 3.3-V supply rail. Any of the quad differential receivers will provide a valid logical output state with a  $\pm 100$ -mV differential input voltage within the input common-mode voltage range. The input common-mode voltage range allows 1 V of ground potential difference between two LVDS nodes.

The intended application of this device and signaling technique is for point-to-point baseband data transmission over controlled impedance media of approximately 100  $\Omega$ . 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, the noise coupling to the environment, and other system characteristics.

The SN65LVDS048A is characterized for operation from –40°C to 85°C.



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.

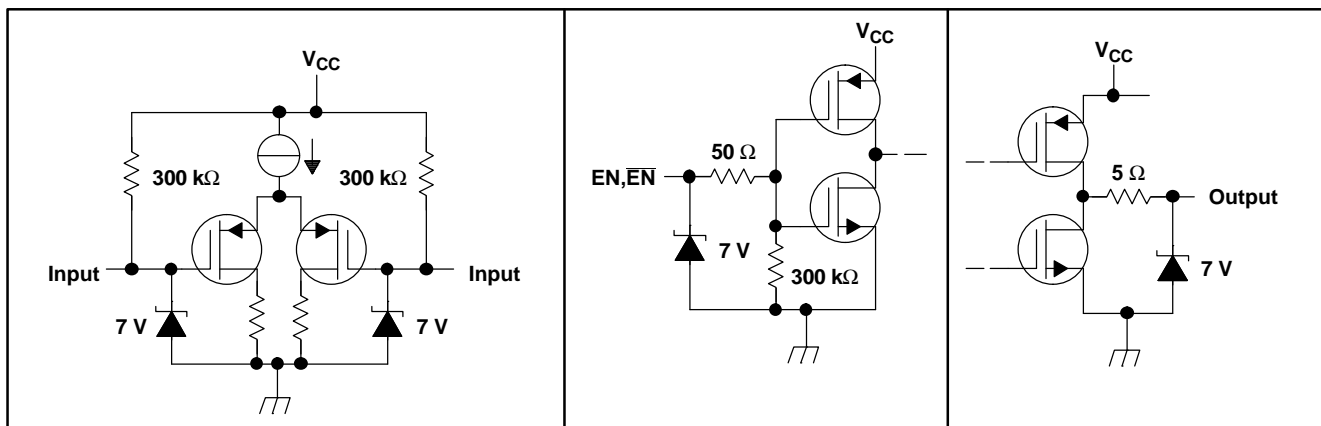


These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**TRUTH TABLE<sup>(1)</sup>**

DIFFERENTIAL INPUT	ENABLES		OUTPUT
$R_{IN+} - R_{IN-}$	EN	$\overline{EN}$	$R_{OUT}$
$V_{ID} \geq 100 \text{ mV}$	H	L or OPEN	H
$V_{ID} \leq -100 \text{ mV}$			L
Open/short or terminated			H
X	All other conditions		Z

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

**EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS****ABSOLUTE MAXIMUM RATINGS**

over operating free-air temperature range (unless otherwise noted)<sup>(1)(2)</sup>

	UNIT
$V_{CC}$ Supply voltage range	–0.3 V to 4 V
$V_I(R_{IN+}, R_{IN-})$ Input voltage range	–0.3 V to 4 V
Enable input voltage (EN, $\overline{EN}$ )	–0.3 V to ( $V_{CC} + 0.3 \text{ V}$ )
$V_O(R_{OUT})$ Output voltage	–0.3 V to ( $V_{CC} + 0.3 \text{ V}$ )
Bus-pin ( $R_{IN+}, R_{IN-}$ ) electrostatic discharge <sup>(3)</sup>	> 10 kV
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	OPERATING FACTOR <sup>(1)</sup> ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
D	950 mW	7.6 mW/°C	494 mW
PW	774 mW	6.2 mW/°C	402 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
Receiver input voltage	GND		3	V
$V_{IC}$ Common-mode input voltage	$\frac{ V_{ID} }{2}$	$2.4 - \frac{ V_{ID} }{2}$	$V_{CC} - 0.8$	V
$T_A$ Operating free-air temperature	-40	25	85	°C

## ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(2)</sup>	MAX	UNIT
V <sub>IT+</sub>	Differential input high threshold voltage	V <sub>CM</sub> = 1.2 V, 0.05 V, 2.35 V <sup>(3)</sup>		100			mV
V <sub>IT−</sub>	Differential input low threshold voltage			−100			
V <sub>(CMR)</sub>	Common mode voltage range	V <sub>ID</sub> = 200 mV pk to pk <sup>(4)</sup>		0.1		2.3	V
I <sub>IN</sub>	Input current	V <sub>IN</sub> = 2.8 V	V <sub>CC</sub> = 3.6 V or 0 V	−20	±1	20	μA
		V <sub>IN</sub> = 0 V		−20	±1	20	μA
		V <sub>IN</sub> = 3.6 V, V <sub>CC</sub> = 0 V		−20	±1	20	μA
V <sub>OH</sub>	Output high voltage	I <sub>OH</sub> = −0.4 mA, V <sub>ID</sub> = 200 mV		2.7	3.2		V
		I <sub>OH</sub> = −0.4 mA, input terminated		2.7	3.2		V
		I <sub>OH</sub> = −0.4 mA, input shorted		2.7	3.2		V
V <sub>OL</sub>	Output low voltage	I <sub>OL</sub> = 2 mA, V <sub>ID</sub> = −200 mV			0.05	0.25	V
I <sub>OS</sub>	Output short circuit current	Enabled, V <sub>OUT</sub> = 0 V <sup>(5)</sup>			−65	−100	mA
I <sub>O(Z)</sub>	Output 3-state current	Disabled, V <sub>OUT</sub> = 0 V or V <sub>CC</sub>		−1		1	μA
V <sub>IH</sub>	Input high voltage			2.0		V <sub>CC</sub>	V
V <sub>IL</sub>	Input low voltage			GND		0.8	V
I <sub>I</sub>	Input current (enables)	V <sub>IN</sub> = 0 V or V <sub>CC</sub> , Other input = V <sub>CC</sub> or GND		−10		10	μA
V <sub>IK</sub>	Input clamp voltage	I <sub>CL</sub> = −18 mA		−1.5	−0.8		V
I <sub>CC</sub>	No load supply current, receivers enabled	EN = V <sub>CC</sub> , Inputs open			8	15	mA
I <sub>CC(Z)</sub>	No load supply current, receivers disabled	EN = GND, Inputs open			0.6	1.5	mA

- (1) Current into device pin is defined as positive. Current out of the device is defined as negative. All voltages are referenced to ground, unless otherwise specified.
- (2) All typical values are at  $25^\circ\text{C}$  and with a 3.3-V supply.
- (3)  $V_{CC}$  is always higher than  $R_{IN+}$  and  $R_{IN-}$  voltage.  $R_{IN-}$  and  $R_{IN+}$  have a voltage range of  $-0.2\text{ V}$  to  $V_{CC} - V_{ID}/2$ . To be compliant with ac specifications the common voltage range is  $0.1\text{ V}$  to  $2.3\text{ V}$ .
- (4) The  $V_{CMR}$  range is reduced for larger  $V_{ID}$ . Example: If  $V_{ID} = 400\text{ mV}$ , the  $V_{CMR}$  is  $0.2\text{ V}$  to  $2.2\text{ V}$ . The fail-safe condition with inputs shorted is not supported over the common-mode range of  $0\text{ V}$  to  $2.4\text{ V}$ , but is supported only with inputs shorted and no external common-mode voltage applied. A  $V_{ID}$  up to  $V_{CC} - 0\text{ V}$  may be applied to the  $R_{IN+}$  and  $R_{IN-}$  inputs with the common-mode voltage set to  $V_{CC}/2$ . Propagation delay and differential pulse skew decrease when  $V_{ID}$  is increased from  $200\text{ mV}$  to  $400\text{ mV}$ . Skew specifications apply for  $200\text{ mV} < V_{ID} < 800\text{ mV}$  over the common-mode range.
- (5) Output short circuit current ( $I_{OS}$ ) is specified as magnitude only, minus sign indicates direction only. Only one output should be shorted at a time. Do not exceed maximum junction temperature specification.

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

PARAMETER	TEST CONDITIONS	MIN	TYP <sup>(2)</sup>	MAX	UNIT
$t_{PHL}$ Differential propagation delay, high-to-low	$C_L = 15\text{ pF}$ $V_{ID} = 200\text{ mV}$ (see Figure 1 and Figure 2)	1.9	2.7	3.7	ns
$t_{PLH}$ Differential propagation delay, low-to-high		1.9	2.9	3.7	ns
$t_{SK(p)}$ Differential pulse skew ( $t_{PHLD} - t_{PLHD}$ ) <sup>(3)</sup>			200	450	ps
$t_{SK(o)}$ Differential channel-to-channel skew; same device <sup>(4)</sup>			50	500	ps
$t_{SK(pp)}$ Differential part-to-part skew <sup>(5)</sup>				1	ns
$t_{SK(lim)}$ Differential part-to-part skew <sup>(6)</sup>				1.5	ns
$t_r$ Rise time			0.5	1	ns
$t_f$ Fall time	$R_L = 2\text{ K } \Omega$ $C_L = 15\text{ pF}$ (see Figure 3 and Figure 4)		0.5	1	ns
$t_{PHZ}$ Disable time high to Z			8	9	ns
$t_{PLZ}$ Disable time low to Z			6	8	ns
$t_{PZH}$ Enable time Z to high			8	10	ns
$t_{PZL}$ Enable time Z to low			7	8	ns
$f_{(MAX)}$ Maximum operating frequency <sup>(7)</sup>	All channels switching	200	250		MHz

(1) Generator waveform for all tests unless otherwise specified:  $f = 1\text{ MHz}$ ,  $Z_O = 50\text{ } \Omega$ ,  $t_r$  and  $t_f$  (0%–100%)  $\leq 3\text{ ns}$  for  $R_{IN}$ .

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

(3)  $t_{SK(p)}|t_{PLH} - t_{PHL}|$  is the magnitude difference in differential propagation delay time between the positive going edge and the negative going edge of the same channel.(4)  $t_{SK(o)}$  is the differential channel-to-channel skew of any event on the same device.(5)  $t_{SK(pp)}$  is the differential part-to-part skew, and is defined as the difference between the minimum and the maximum specified differential propagation delays. This specification applies to devices at the same VCC and within 5°C of each other within the operating temperature range.(6)  $t_{SK(lim)}$  part-to-part skew, is the differential channel-to-channel skew of any event between devices. This specification applies to devices over recommended operating temperature and voltage ranges, and across process distribution.  $t_{SK(lim)}$  is defined as  $|Min - Max|$  differential propagation delay.(7)  $f_{(MAX)}$  generator input conditions:  $t_r = t_f < 1\text{ ns}$  (0% to 100%), 50% duty cycle, 0 V to 3 V. Output criteria: duty cycle = 45% to 55%,  $V_{OD} > 250\text{ mV}$ , all channels switching

## PARAMETER MEASUREMENT INFORMATION

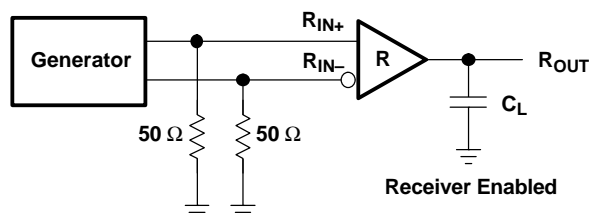


Figure 1. Receiver Propagation Delay and Transition Time Test Circuit

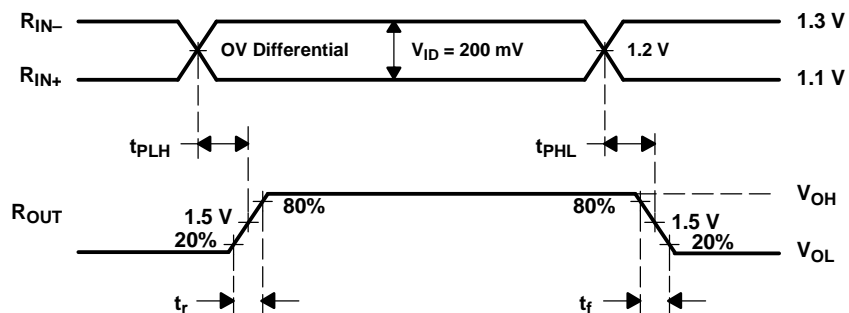
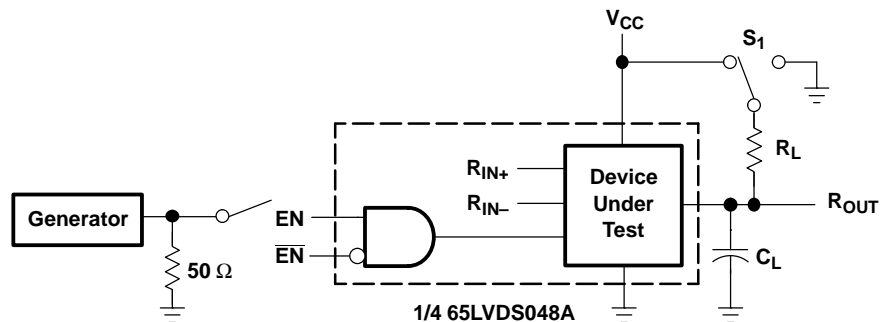


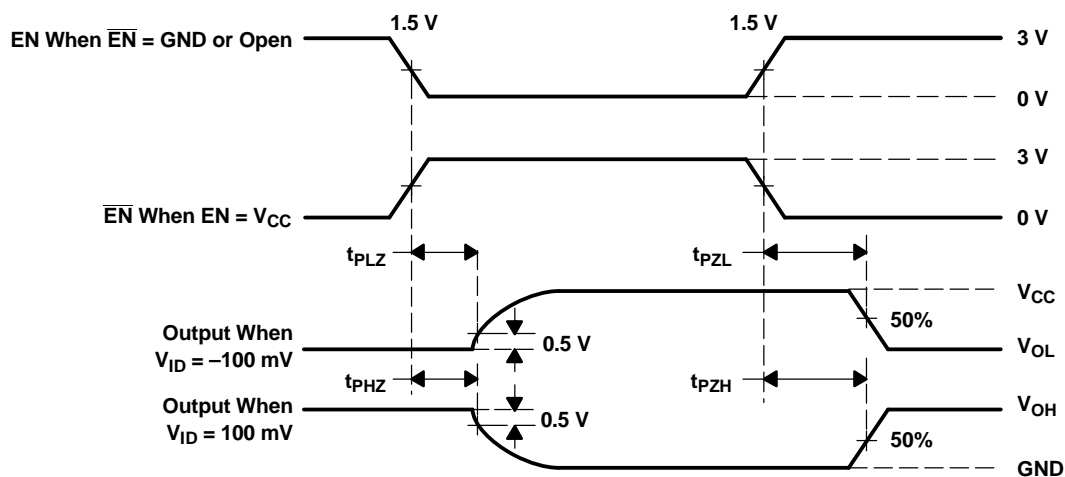
Figure 2. Receiver Propagation Delay and Transition Time Waveforms

**PARAMETER MEASUREMENT INFORMATION (continued)**

$C_L$  Includes Load and Test Jig Capacitance.

$S_1 = V_{CC}$  for  $t_{PZL}$  and  $t_{PLZ}$  Measurements.

$S_1 = GND$  for  $t_{PZH}$  and  $t_{PHZ}$  Measurements.

**Figure 3. Receiver 3-State Delay Test Circuit****Figure 4. Receiver 3-State Delay Waveforms**

## TYPICAL CHARACTERISTICS

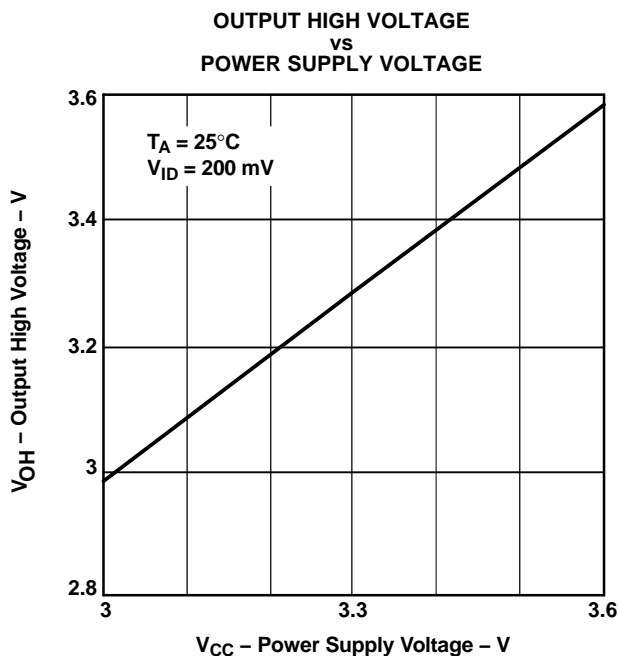


Figure 5.

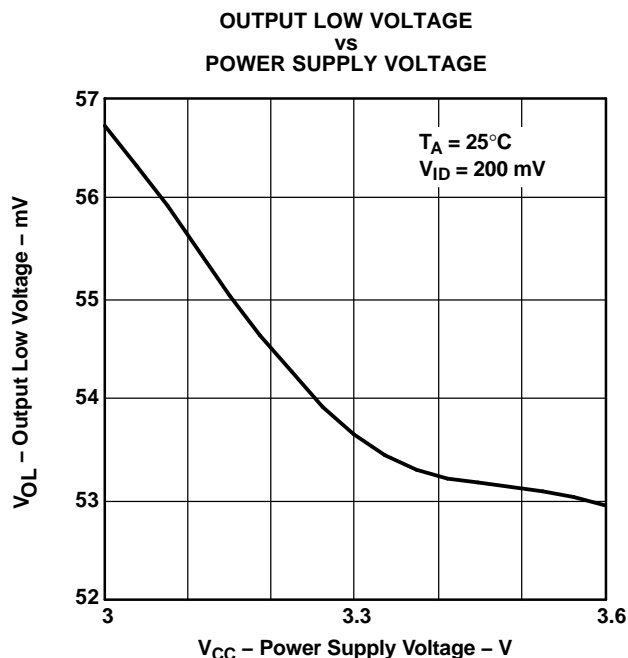


Figure 6.

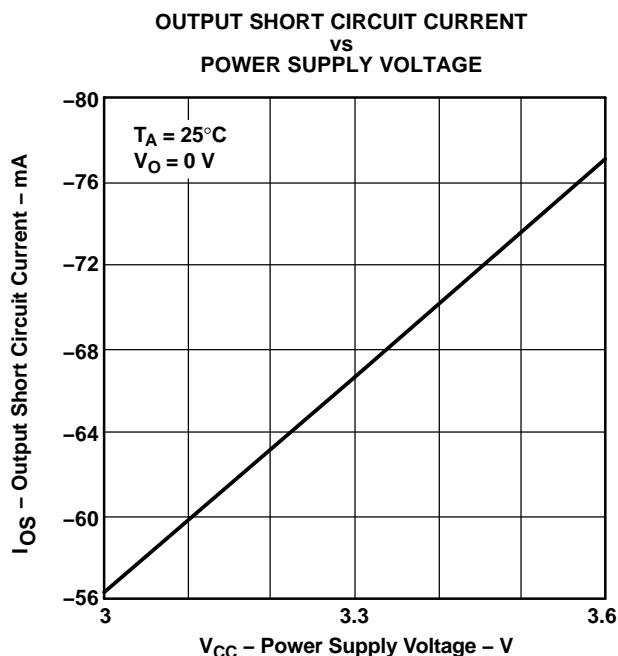


Figure 7.

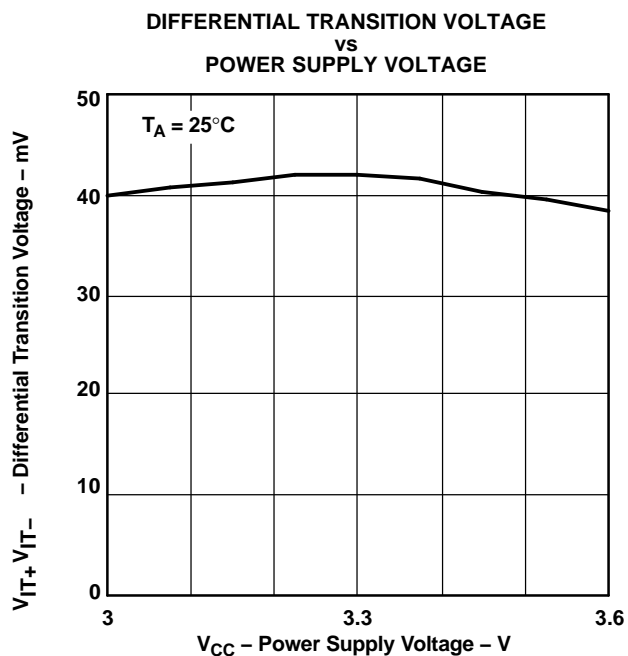


Figure 8.

**TYPICAL CHARACTERISTICS (continued)**

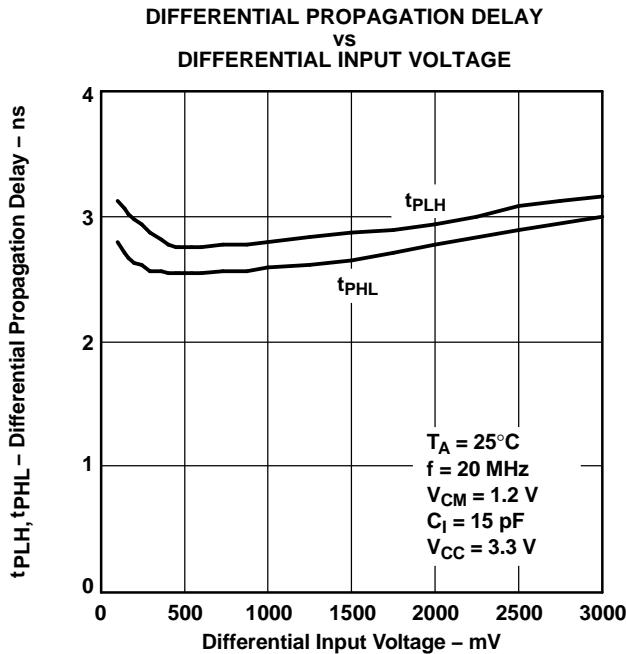


Figure 9.

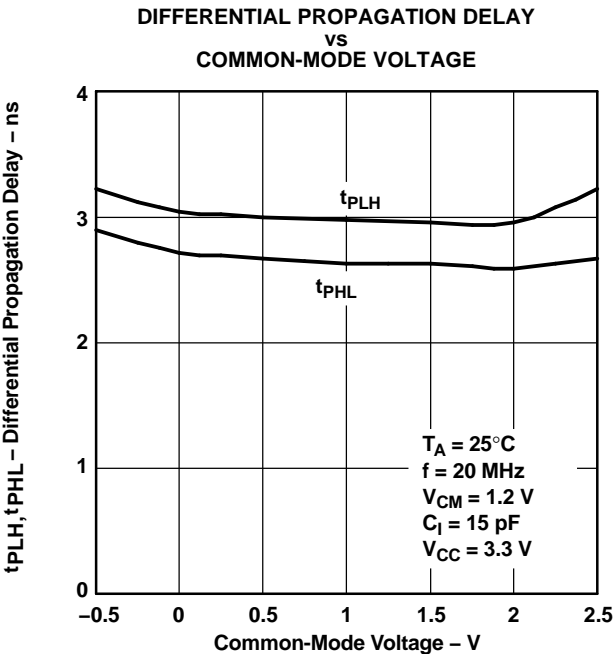


Figure 10.

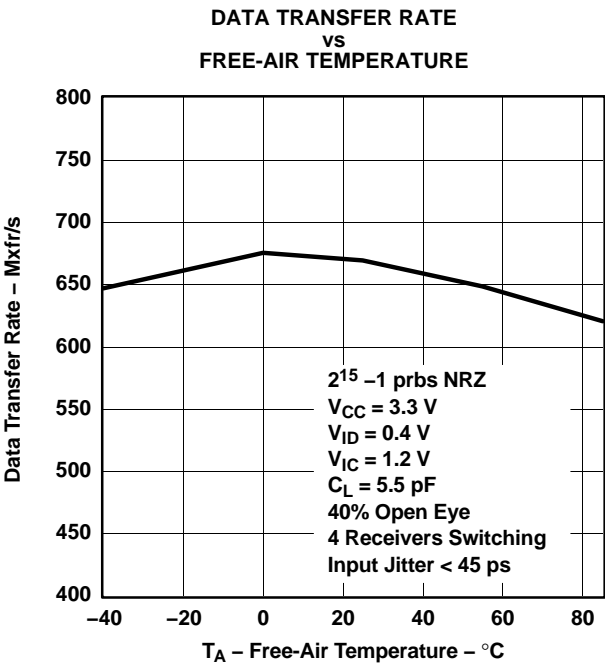


Figure 11.



## 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. 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 will pull each line of the signal pair to near  $V_{CC}$  through  $300\text{-k}\Omega$  resistors as shown in Figure 10. 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.

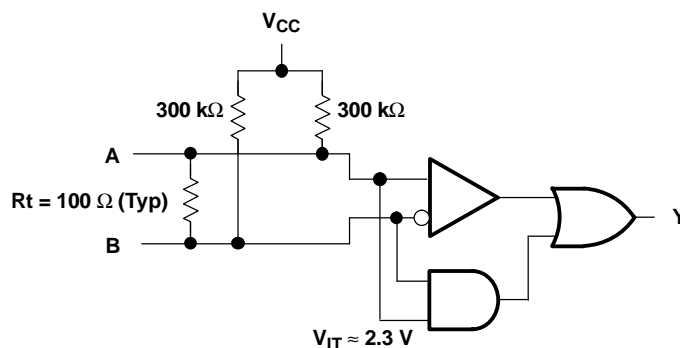


Figure 12. Open-Circuit Fail Safe of the LVDS Receiver

It is only under these conditions that the output of the receiver will be 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 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.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated