

## HIGH-SPEED DIFFERENTIAL LINE DRIVERS AND RECEIVERS

### FEATURES

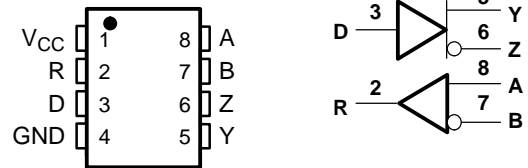
- Meets or Exceeds the Requirements of ANSI TIA/EIA-644-1995 Standard
- Signaling Rates up to 400 Mbps
- Bus-Terminal ESD Exceeds 12 kV
- Operates From a Single 3.3-V Supply
- Low-Voltage Differential Signaling With Typical Output Voltages of 350 mV and a 100-Ω Load
- Propagation Delay Times
  - Driver: 1.7 ns Typ
  - Receiver: 3.7 ns Typ
- Power Dissipation at 200 MHz
  - Driver: 25 mW Typical
  - Receiver: 60 mW Typical
- LVTTTL Input Levels Are 5-V Tolerant
- Receiver Maintains High Input Impedance With  $V_{CC} < 1.5$  V
- Receiver Has Open-Circuit Fail Safe

### DESCRIPTION

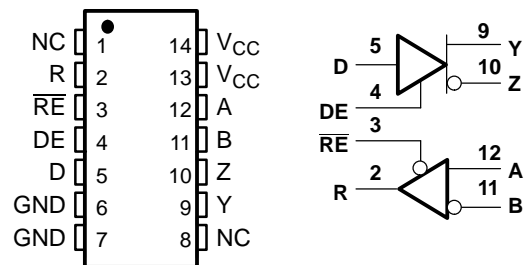
The SN65LVDS179, SN65LVDS180, SN65LVDS050, and SN65LVDS051 are differential line drivers and receivers that use low-voltage differential signaling (LVDS) to achieve signaling rates as high as 400 Mbps. The TIA/EIA-644 standard compliant electrical interface provides a minimum differential output voltage magnitude of 247 mV into a 100-Ω load and receipt of 50-mV signals with up to 1 V of ground potential difference between a transmitter and receiver.

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

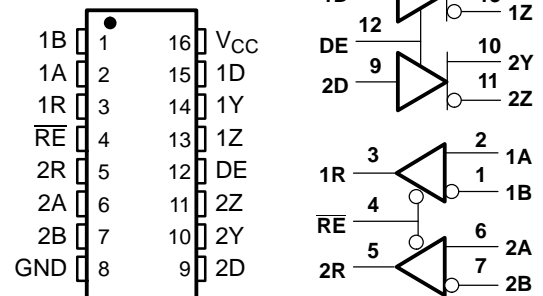
**SN65LVDS179D** (Marked as DL179 or LVD179)  
**SN65LVDS179DGK** (Marked as S79)  
(TOP VIEW)



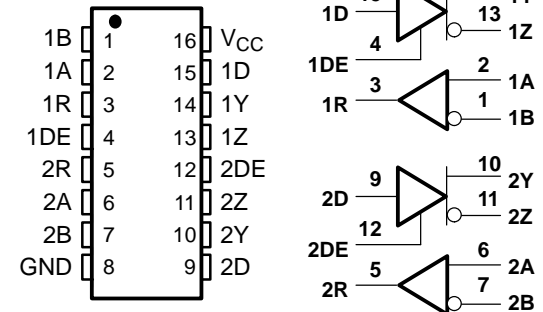
**SN65LVDS180D** (Marked as LVDS180)  
**SN65LVDS180PW** (Marked as LVDS180)  
(TOP VIEW)



**SN65LVDS050D** (Marked as LVDS050)  
**SN65LVDS050PW** (Marked as LVDS050)  
(TOP VIEW)



**SN65LVDS051D** (Marked as LVDS051)  
**SN65LVDS051PW** (Marked as LVDS051)  
(TOP VIEW)



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.

## DESCRIPTION (CONTINUED)

These devices offer various driver, receiver, and enabling combinations in industry-standard footprints. Because these devices are intended for use in simplex or distributed simplex bus structures, the driver enable function does not put the differential outputs into a high-impedance state but rather disconnects the input and reduces the quiescent power used by the device. (For these functions with a high-impedance driver output, see the SN65LVDM series of devices.) All devices are characterized for operation from -40°C to 85°C.

### AVAILABLE OPTIONS<sup>(1)</sup>

PACKAGE		
SMALL OUTLINE (D)	SMALL OUTLINE (DGK)	SMALL OUTLINE (PW)
SN65LVDS050D	—	SN65LVDS050PW
SN65LVDS051D	—	SN65LVDS051PW
SN65LVDS179D	SN65LVDS179DGK	—
SN65LVDS180D	—	SN65LVDS180PW

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

## FUNCTION TABLES

### SN65LVDS179 RECEIVER

INPUTS	OUTPUT <sup>(1)</sup>
$V_{ID} = V_A - V_B$	R
$V_{ID} \geq 50 \text{ mV}$	H
$50 \text{ mV} < V_{ID} < 50 \text{ mV}$	?
$V_{ID} \leq -50 \text{ mV}$	L
Open	H

(1) H = high level, L = low level, ? = indeterminate

### SN65LVDS179 DRIVER<sup>(1)</sup>

INPUT	OUTPUTS	
D	Y	Z
L	L	H
H	H	L
Open	L	H

(1) H = high level, L = low level

SN65LVDS180, SN65LVDS050, and  
SN65LVDS051 RECEIVER<sup>(1)</sup>

INPUTS		OUTPUT
$V_{ID} = V_A - V_B$	$\overline{RE}$	R
$V_{ID} \geq 50 \text{ mV}$	L	H
$50 \text{ mV} < V_{ID} < 50 \text{ mV}$	L	?
$V_{ID} \leq -50 \text{ mV}$	L	L
Open	L	H
X	H	Z

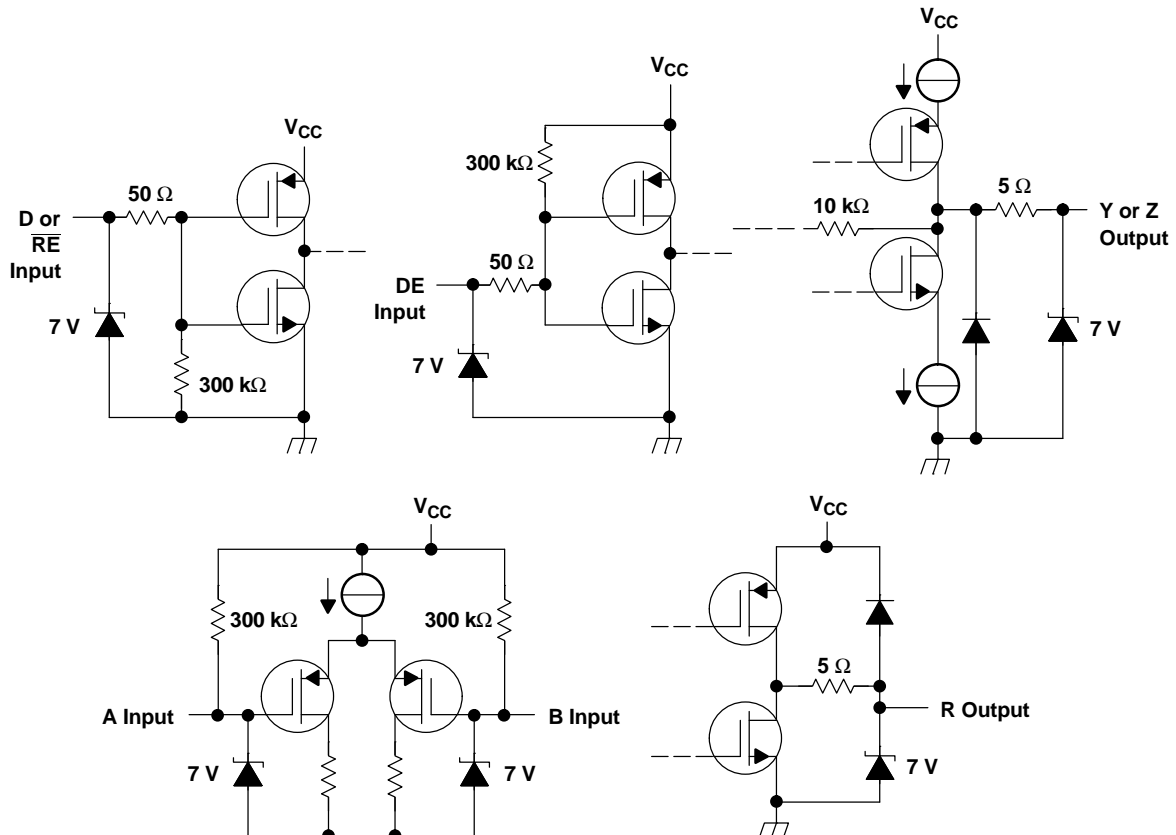
(1) H = high level, L = low level, Z = high impedance, X = don't care, ? = indeterminate

SN65LVDS180, SN65LVDS050, and  
SN65LVDS051 DRIVER<sup>(1)</sup>

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

(1) H = high level, L = low level, Z = high impedance, X = don't care, Off = no output

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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

		UNIT
$V_{CC}$ (see <sup>(2)</sup> )	Supply voltage range	–0.5 V to 4 V
	Voltage range:	D, R, DE, RE
		Y, Z, A, and B
$ V_{OD} $	Differential output voltage:	1 V
	Electrostatic discharge:	Y, Z, A, B, and GND (see <sup>(3)</sup> )
		All
	Continuous power dissipation	See Dissipation Rating Table
	Storage temperature range	–65°C to 150°C
	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	250°C

- (1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other 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 ABOVE $T_A = 25^\circ\text{C}$ <sup>(1)</sup>	$T_A = 85^\circ\text{C}$ POWER RATING
PW(14)	736 mW	5.9 mW/°C	383 mW
PW(16)	839 mW	6.7 mW/°C	437 mW
D(8)	635 mW	5.1 mW/°C	330 mW/°C
D(14)	987 mW	7.9 mW/°C	513 mW/°C
D(16)	1110 mW	8.9 mW/°C	577 mW/°C
DGK	424 mW	3.4 mW/°C	220 mW

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

## RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
$V_{CC}$	Supply voltage	3	3.3	3.6	V
$V_{IH}$	High-level input voltage	2			V
$V_{IL}$	Low-level input voltage			0.8	V
$ V_{ID} $	Magnitude of differential input voltage	0.1		0.6	V
$ V_{OD}(\text{dis}) $	Magnitude of differential output voltage with disabled driver			520	mV
$V_{OY}$ or $V_{OZ}$	Driver output voltage	0		2.4	V
$V_{IC}$	Common-mode input voltage (see Figure 5)	$\frac{ V_{ID} }{2}$	$2.4 - \frac{ V_{ID} }{2}$		V
			$V_{CC}-0.8$		
$T_A$	Operating free-air temperature	–40		85	°C

## DEVICE ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT	
$I_{CC}$	Supply current	SN65LVDS179	No receiver load, driver $R_L = 100 \Omega$		9	12	mA
		SN65LVDS180	Driver and receiver enabled, no receiver load, driver $R_L = 100 \Omega$		9	12	
			Driver enabled, receiver disabled, $R_L = 100 \Omega$		5	7	
			Driver disabled, receiver enabled, no load		1.5	2	
			Disabled		0.5	1	
			SN65LVDS050	Drivers and receivers enabled, no receiver loads, driver $R_L = 100 \Omega$		12	20
		Drivers enabled, receivers disabled, $R_L = 100 \Omega$		10	16		
		Drivers disabled, receivers enabled, no loads		3	6		
		Disabled		0.5	1		
		SN65LVDS051	Drivers enabled, No receiver loads, driver $R_L = 100 \Omega$		12	20	mA
			Drivers disabled, no loads		3	6	

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

## DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{OD} $	Differential output voltage magnitude	$R_L = 100 \Omega$ , See Figure 3 and Figure 2	247	340	454	mV
$\Delta V_{OD} $	Change in differential output voltage magnitude between logic states		-50		50	
$V_{OC(SS)}$	Steady-state common-mode output voltage	See Figure 3	1.125	1.2	1.375	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage between logic states		-50		50	mV
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage		50		150	mV
$I_{IH}$	High-level input current	DE	$V_{IH} = 5 V$	-0.5	-20	$\mu A$
		D		2	20	
$I_{IL}$	Low-level input current	DE	$V_{IL} = 0.8 V$	-0.5	-10	$\mu A$
		D		2	10	
$I_{OS}$	Short-circuit output current	$V_{OY}$ or $V_{OZ} = 0 V$		3	10	mA
		$V_{OD} = 0 V$		3	10	
$I_{O(OFF)}$	Off-state output current	DE = 0V $V_{OY} = V_{OZ} = 0V$		-1	1	$\mu A$
		DE = $V_{CC}$ $V_{OY} = V_{OZ} = 0V$ , $V_{CC} < 1.5 V$				
$C_{IN}$	Input capacitance			3		pF

## RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
V <sub>IT+</sub>	Positive-going differential input voltage threshold	See Figure 5 and Table 1			50	mV
V <sub>IT-</sub>	Negative-going differential input voltage threshold		-50			
V <sub>OH</sub>	High-level output voltage	I <sub>OH</sub> = -8 mA	2.4			V
		I <sub>OH</sub> = -4 mA	2.8			
V <sub>OL</sub>	Low-level output voltage	I <sub>OL</sub> = 8 mA			0.4	V
I <sub>I</sub>	Input current (A or B inputs)	V <sub>I</sub> = 0	-2	-11	-20	μA
		V <sub>I</sub> = 2.4 V	-1.2	-3		
I <sub>I(OFF)</sub>	Power-off input current (A or B inputs)	V <sub>CC</sub> = 0			±20	μA
I <sub>IH</sub>	High-level input current (enables)	V <sub>IH</sub> = 5 V			±10	μA
I <sub>IL</sub>	Low-level input current (enables)	V <sub>IL</sub> = 0.8 V			±10	μA
I <sub>OZ</sub>	High-impedance output current	V <sub>O</sub> = 0 or 5 V			±10	μA
C <sub>I</sub>	Input capacitance			5		pF

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

## DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
t <sub>PLH</sub>	Propagation delay time, low-to-high-level output	R <sub>L</sub> = 100 Ω, C <sub>L</sub> = 10 pF, See Figure 2		1.7	2.7	ns
t <sub>PHL</sub>	Propagation delay time, high-to-low-level output			1.7	2.7	ns
t <sub>r</sub>	Differential output signal rise time			0.8	1	ns
t <sub>f</sub>	Differential output signal fall time			0.8	1	ns
t <sub>sk(p)</sub>	Pulse skew ( $ t_{pHL} - t_{pLH} $ ) <sup>(2)</sup>			300		ps
t <sub>sk(o)</sub>	Channel-to-channel output skew <sup>(3)</sup>			150		ps
t <sub>en</sub>	Enable time	See Figure 4		4.3	10	ns
t <sub>dis</sub>	Disable time			3.1	10	ns

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

(2) t<sub>sk(p)</sub> is the magnitude of the time difference between the high-to-low and low-to-high propagation delay times at an output.

(3) t<sub>sk(o)</sub> is the magnitude of the time difference between the outputs of a single device with all of their inputs connected together.

## RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

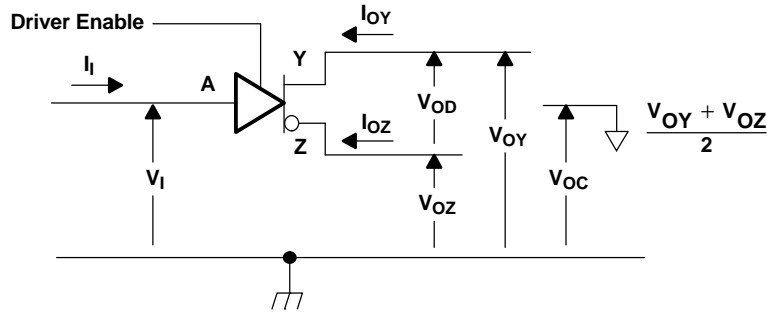
PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
t <sub>PLH</sub>	Propagation delay time, low-to-high-level output	C <sub>L</sub> = 10 pF, See Figure 6		3.7	4.5	ns
t <sub>PHL</sub>	Propagation delay time, high-to-low-level output			3.7	4.5	ns
t <sub>sk(p)</sub>	Pulse skew ( $ t_{pHL} - t_{pLH} $ ) <sup>(2)</sup>			0.3		ns
t <sub>r</sub>	Output signal rise time			0.7	1.5	ns
t <sub>f</sub>	Output signal fall time			0.9	1.5	ns
t <sub>PZH</sub>	Propagation delay time, high-level-to-high-impedance output	See Figure 7		2.5		ns
t <sub>PZL</sub>	Propagation delay time, low-level-to-low-impedance output			2.5		ns
t <sub>PHZ</sub>	Propagation delay time, high-impedance-to-high-level output			7		ns
t <sub>PLZ</sub>	Propagation delay time, low-impedance-to-high-level output			4		ns

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

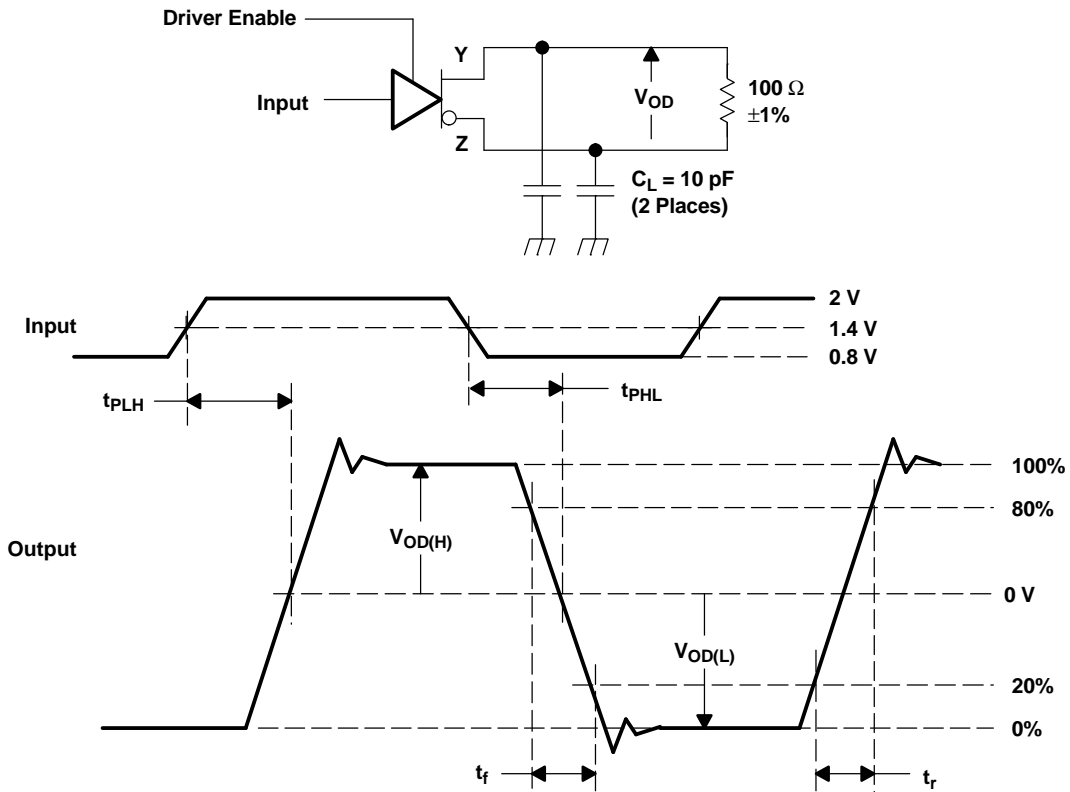
(2) t<sub>sk(p)</sub> is the magnitude of the time difference between the high-to-low and low-to-high propagation delay times at an output.

**PARAMETER MEASUREMENT INFORMATION**

**DRIVER**



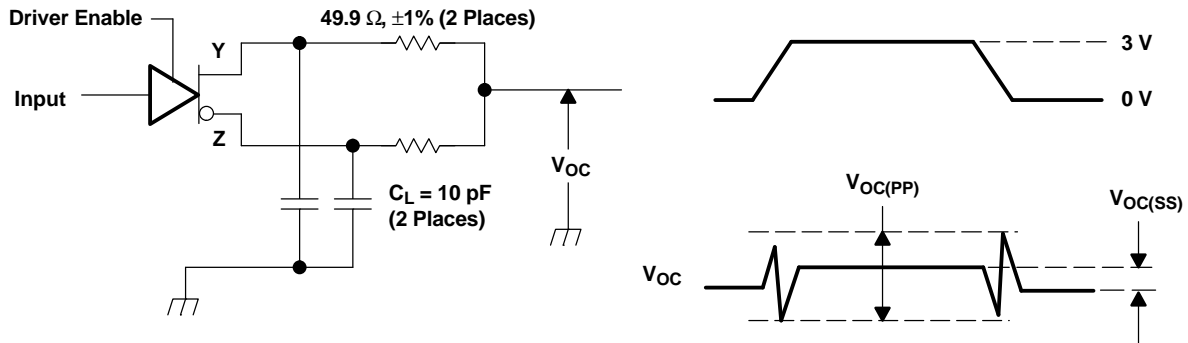
**Figure 1. Driver Voltage and Current Definitions**



- 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) = 50 Mpps, pulse width =  $10 \pm 0.2$  ns.  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

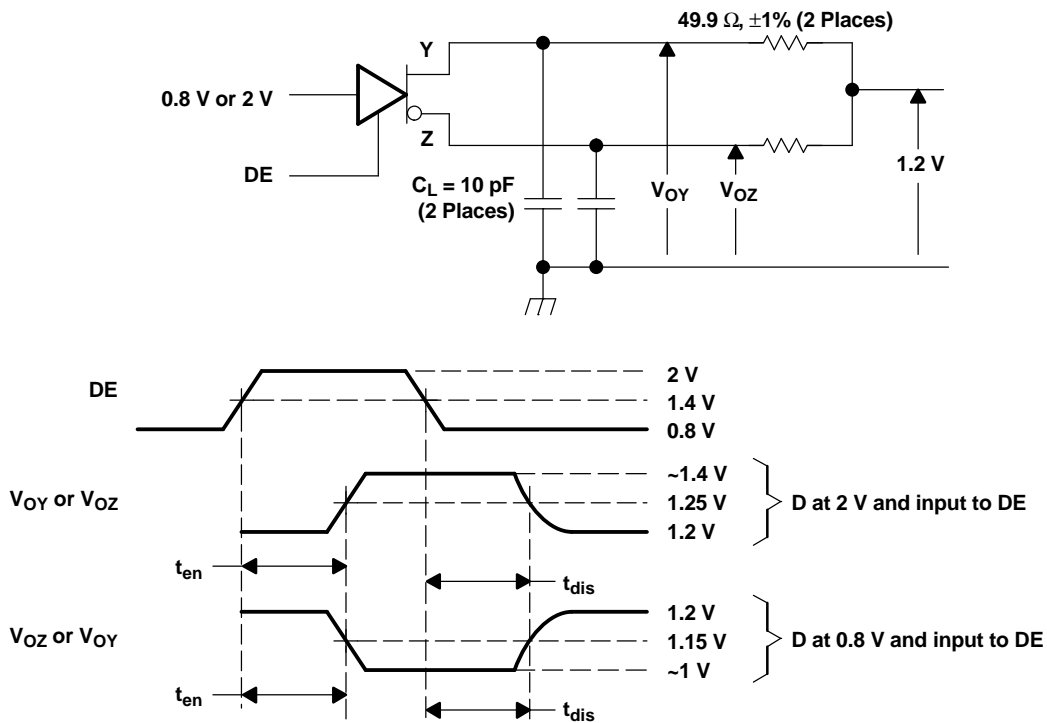
**Figure 2. Test Circuit, Timing, and Voltage Definitions for the Differential Output Signal**

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) = 50 Mpps, pulse width =  $10 \pm 0.2$  ns.  $C_L$  includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T. The measurement of  $V_{OC(PP)}$  is made on test equipment with a  $-3$ -dB bandwidth of at least 300 MHz.

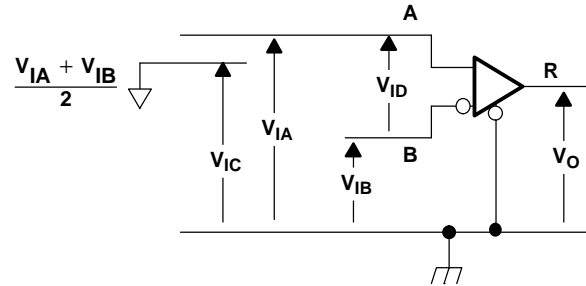
Figure 3. Test Circuit and Definitions for the Driver Common-Mode Output Voltage



- A. All input pulses are supplied by a generator having the following characteristics:  $t_r$  or  $t_f \leq 1$  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 D.U.T.

Figure 4. Enable and Disable Time Circuit and Definitions

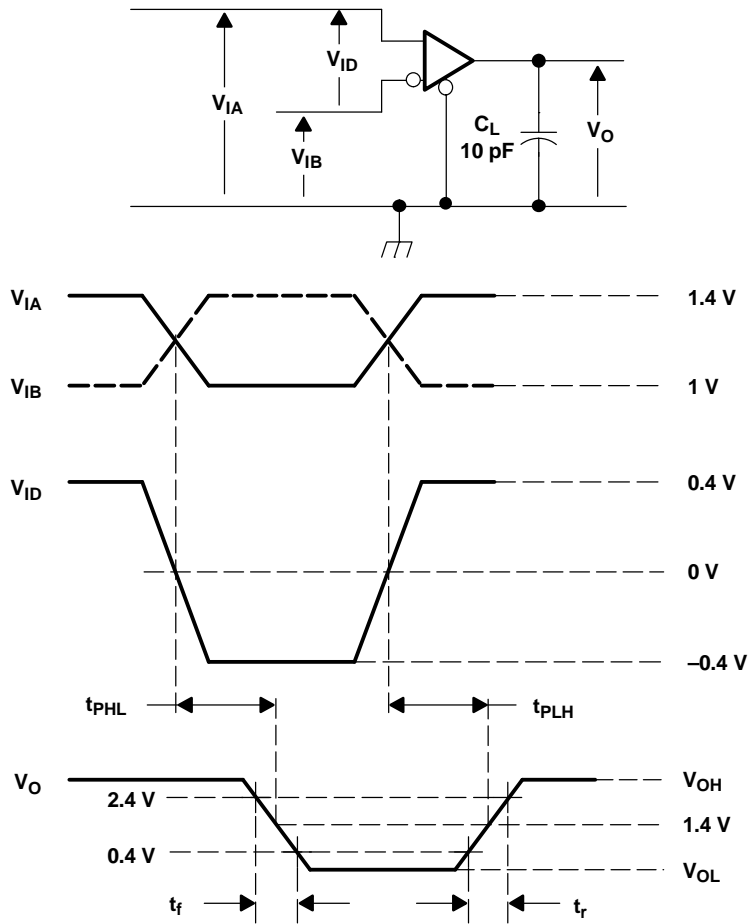
**PARAMETER MEASUREMENT INFORMATION (continued)**  
**RECEIVER**



**Figure 5. Receiver Voltage Definitions**

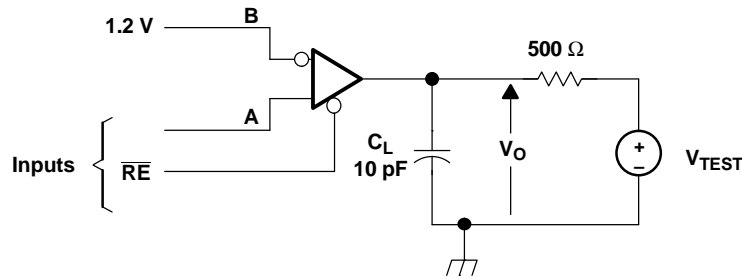
**Table 1. Receiver Minimum and Maximum Input Threshold Test Voltages**

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



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

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



- 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 m of the D.U.T.

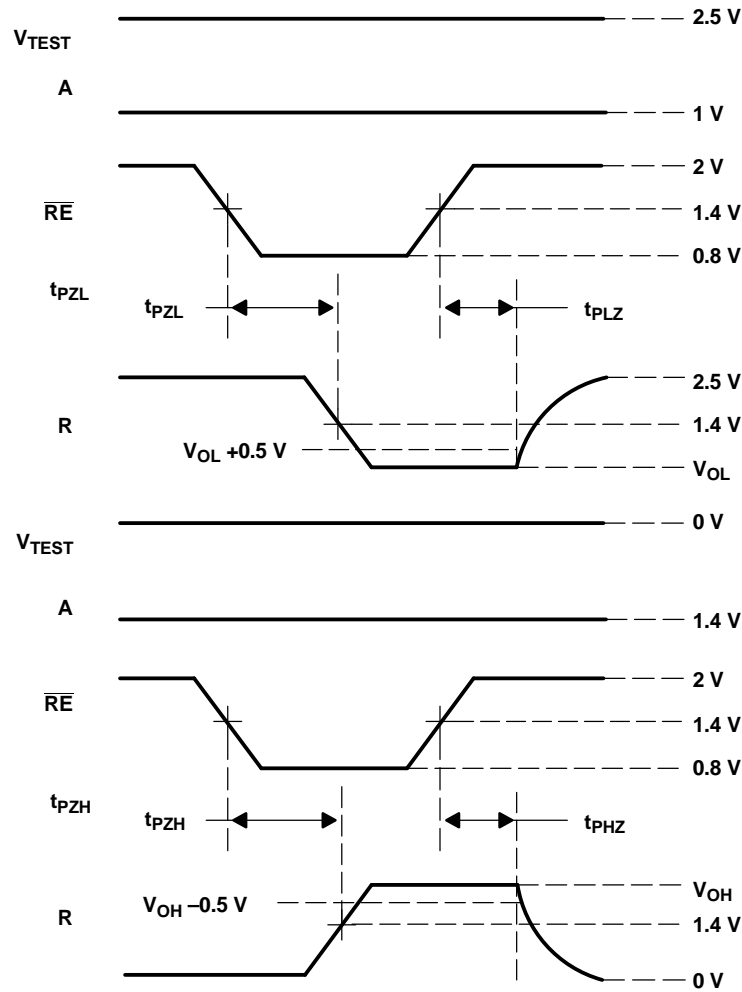


Figure 7. Enable/Disable Time Test Circuit and Waveforms

**TYPICAL CHARACTERISTICS**

DISABLED DRIVER OUTPUT CURRENT  
 vs  
 OUTPUT VOLTAGE

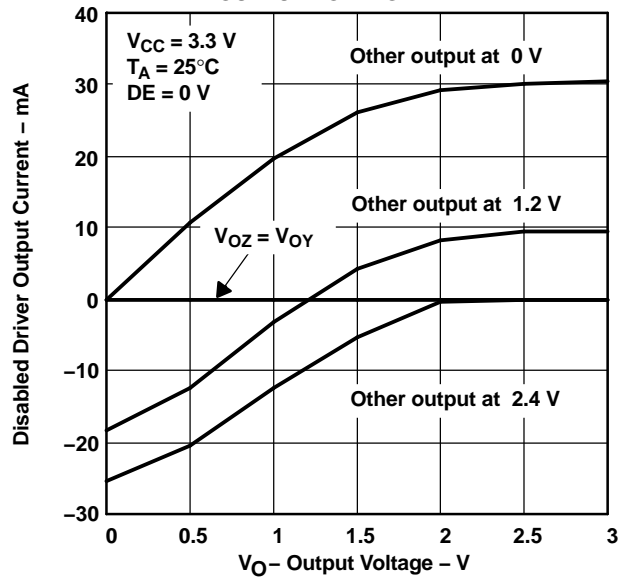


Figure 8.

DRIVER  
 LOW-LEVEL OUTPUT VOLTAGE  
 vs  
 LOW-LEVEL OUTPUT CURRENT

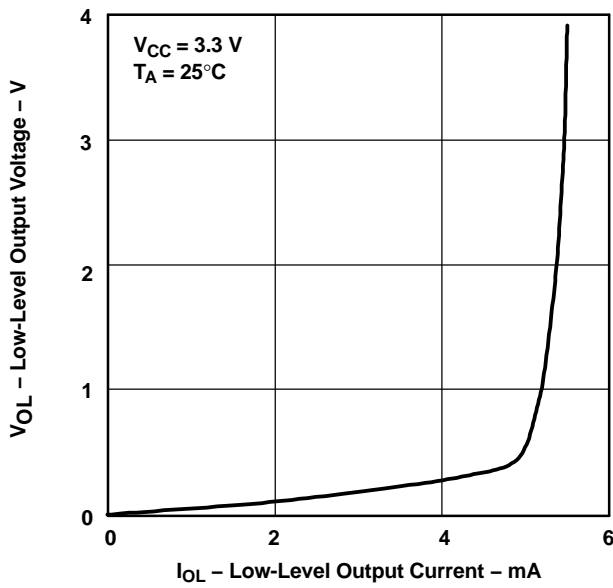


Figure 9.

DRIVER  
 HIGH-LEVEL OUTPUT VOLTAGE  
 vs  
 HIGH-LEVEL OUTPUT CURRENT

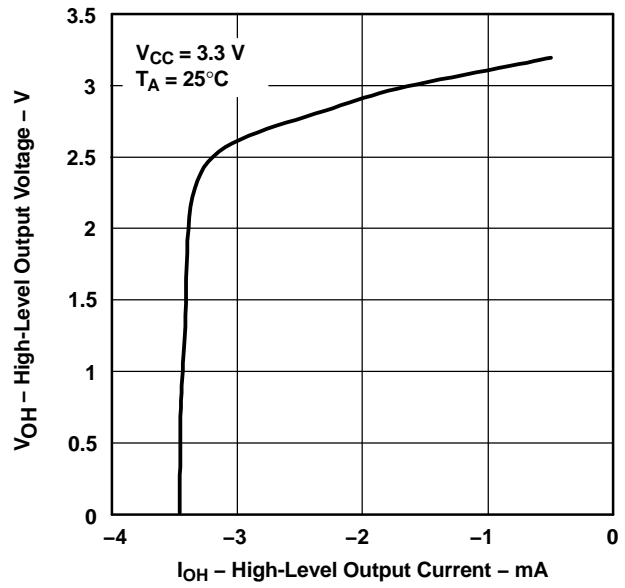


Figure 10.

**TYPICAL CHARACTERISTICS (continued)**

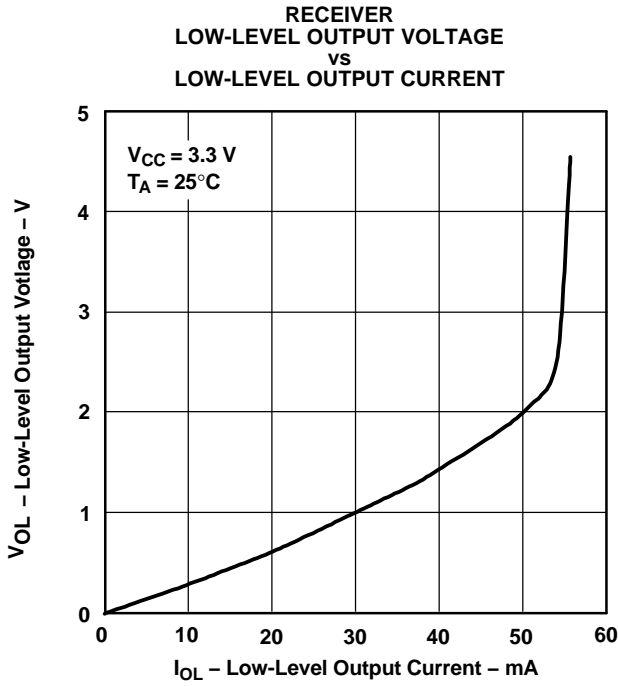


Figure 11.

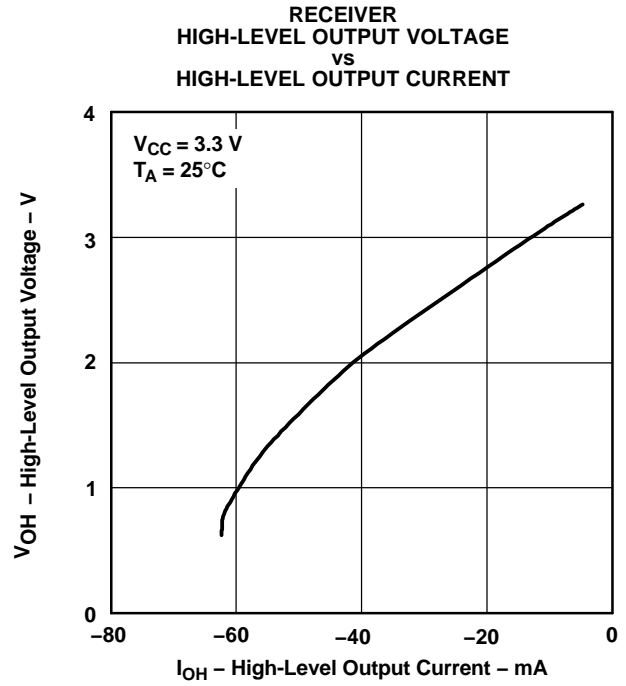


Figure 12.

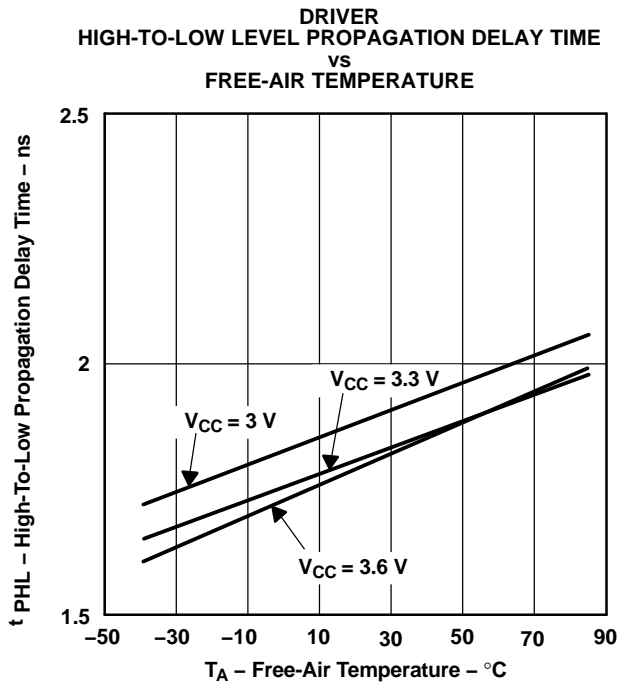


Figure 13.

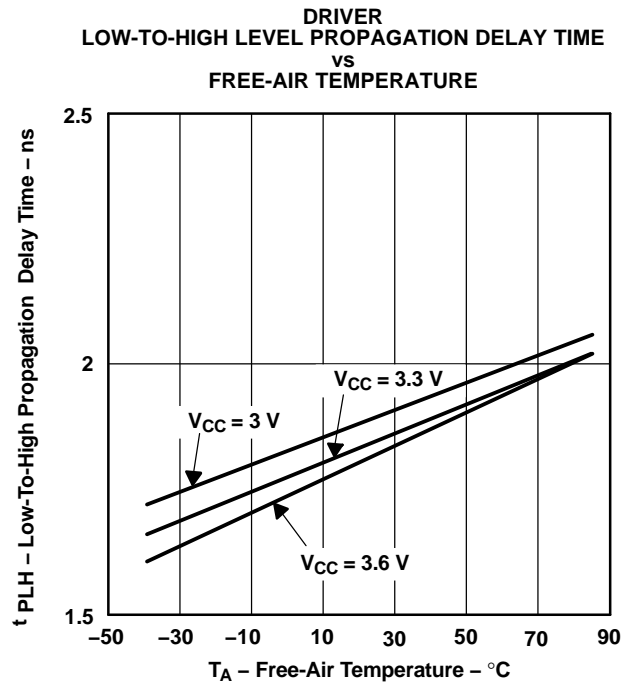


Figure 14.

TYPICAL CHARACTERISTICS (continued)

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

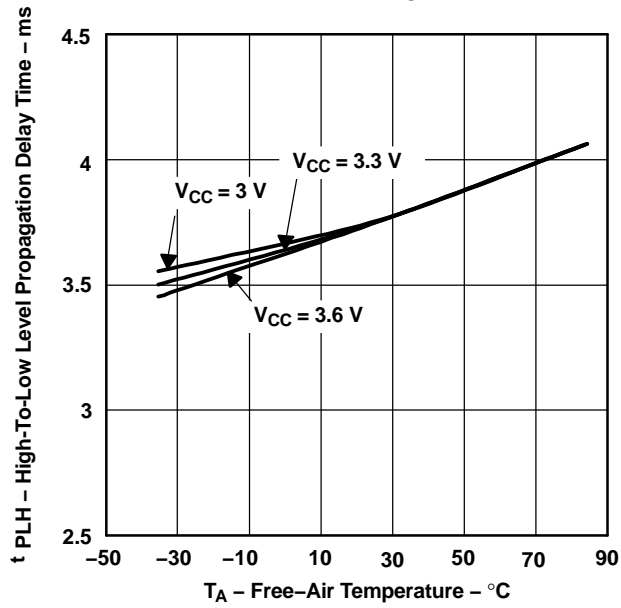


Figure 15.

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

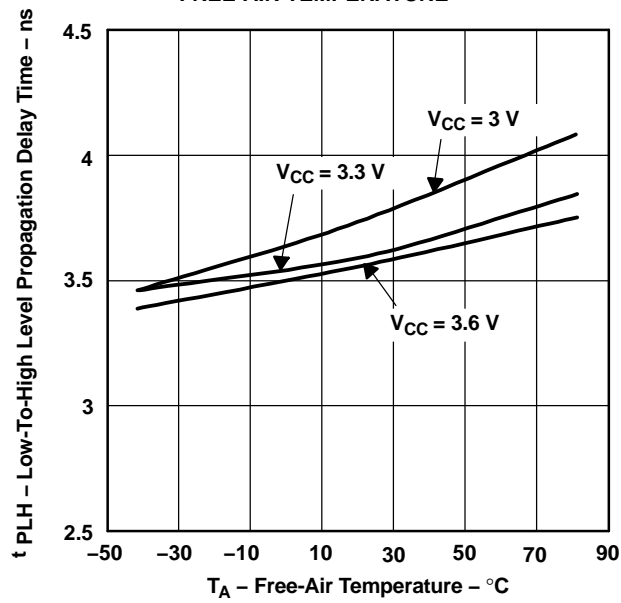


Figure 16.

### APPLICATION INFORMATION

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

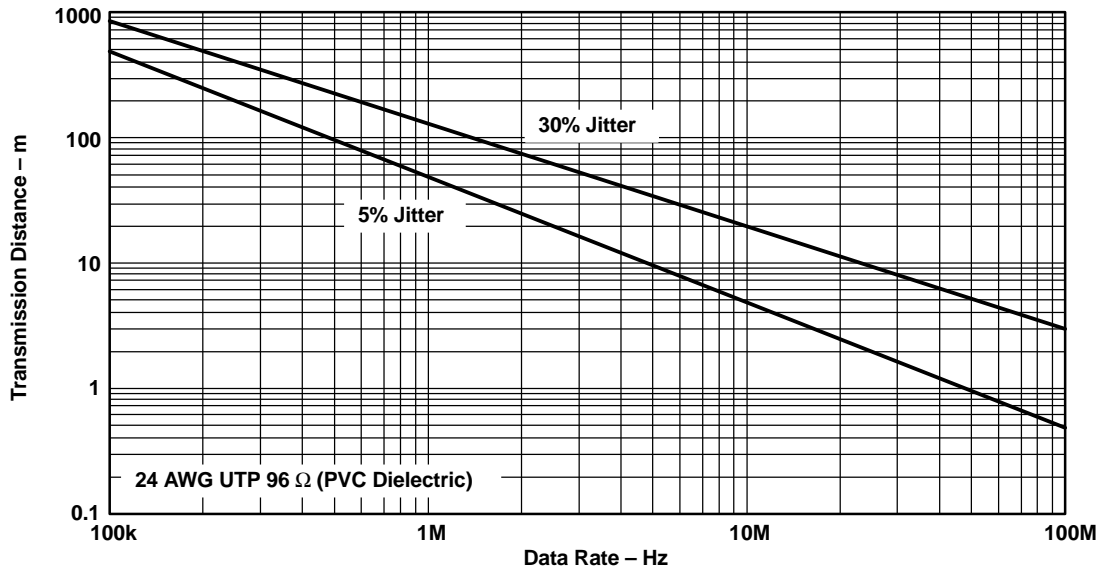


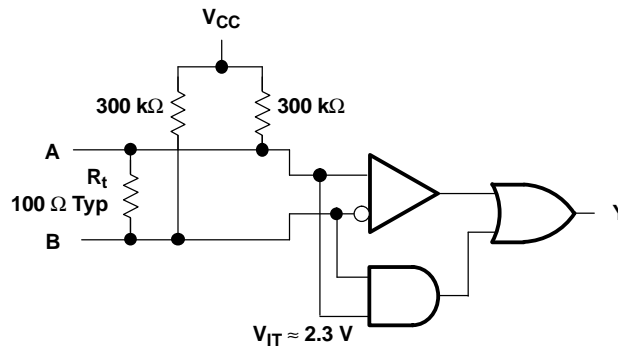
Figure 17. Data Transmission Distance Versus Rate

## APPLICATION INFORMATION (continued)

### FAIL SAFE

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

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



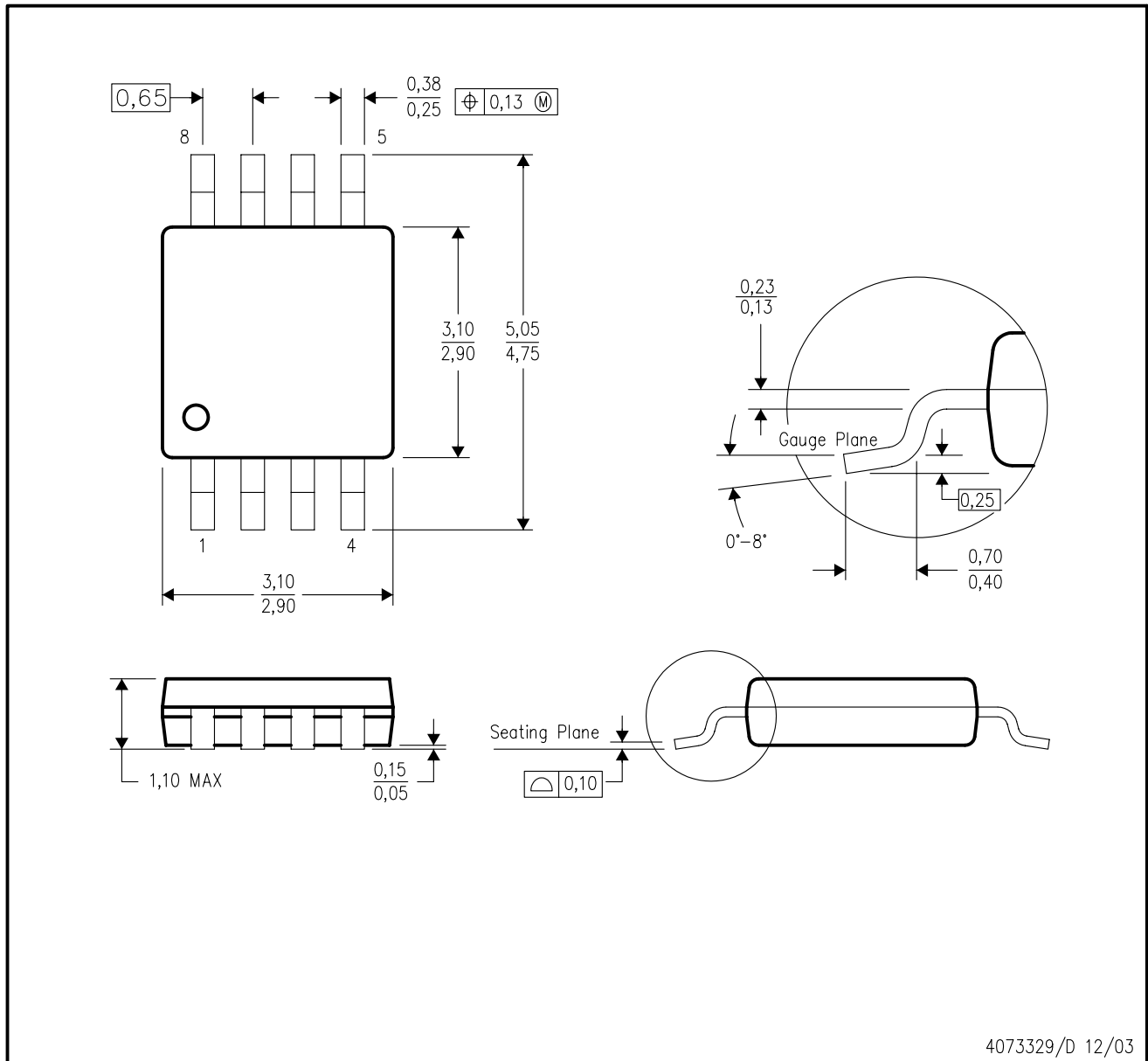
**Figure 18. Open-Circuit Fail Safe of the LVDS Receiver**

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



DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-187 variation AA.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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