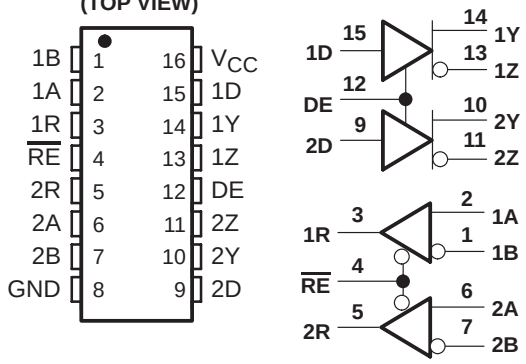
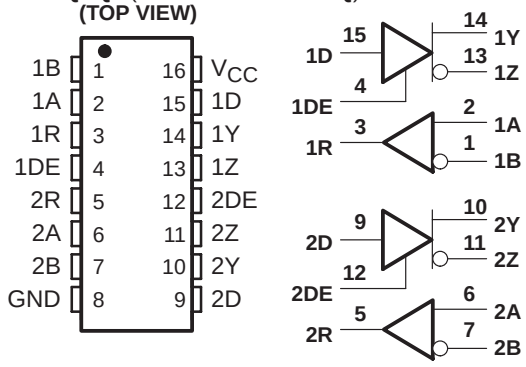
- **Qualified for Automotive Applications**
- **ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Low-Voltage Differential 50-Ω Line Drivers and Receivers**
- **Signaling Rates up to 500 Mbps**
- **Bus-Terminal ESD Exceeds 12 kV**
- **Operates From a Single 3.3 V Supply**
- **Low-Voltage Differential Signaling With Typical Output Voltages of 340 mV With a 50-Ω Load**
- **Valid Output With as Little as 50-mV Input Voltage Difference**
- **Propagation Delay Times**
  - **Driver: 1.7 ns Typ**
  - **Receiver: 3.7 ns Typ**
- **Power Dissipation at 200 MHz**
  - **Driver: 50 mW Typical**
  - **Receiver: 60 mW Typical**
- **LVTTL Input Levels Are 5 V Tolerant**
- **Driver Is High Impedance When Disabled or With V_{CC} < 1.5 V**
- **Receiver Has Open-Circuit Fail Safe**

SN65LVDM050QDQ1 (Marked as **LVDM050Q**)
(TOP VIEW)



SN65LVDM051QDQ1 (Marked as **LVDM051Q**)
(TOP VIEW)



description

The SN65LVDM050, and SN65LVDM051 are differential line drivers and receivers that use low-voltage differential signaling (LVDS) to achieve signaling rates as high as 500 Mbps (per TIA/EIA-644 definition). These circuits are similar to TIA/EIA-644 standard compliant devices (SN65LVDS) counterparts, except that the output current of the drivers is doubled. This modification provides a minimum differential output voltage magnitude of 247 mV across a 50-Ω load simulating two transmission lines in parallel. This allows having data buses with more than one driver or with two line termination resistors. The receivers detect a voltage difference of 50 mV with up to 1 V of ground potential difference between a transmitter and receiver.

The intended application of these devices and signaling techniques is point-to-point and multipoint, baseband data transmission over a controlled impedance media of approximately 100 Ω of characteristic impedance. The transmission media may be printed-circuit board traces, backplanes, or cables.

description (continued)

The SN65LVDM050Q and SN65LVDM051Q are characterized for operation from −40°C to 125°C. Additionally, Q1 suffixed parts are qualified in accordance with AEC-Q100 stress test qualification for integrated circuits.

AVAILABLE OPTIONS†

T_A	PACKAGE‡
	SMALL OUTLINE (D)
−40°C to 125°C	SN65LVDM050QDQ1
	SN65LVDM051QDQ1

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at http://www.ti.com.

‡ Package drawings, thermal data, and symbolization are available at http://www.ti.com/packaging.

NOTE:

The ultimate rate and distance of data transfer is dependent upon the attenuation characteristics of the media, the noise coupling to the environment, and other application-specific characteristics.

Function Tables

SN65LVDM050 and SN65LVDM051 RECEIVER

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

H = high level, L = low level, Z = high impedance, X = don't care

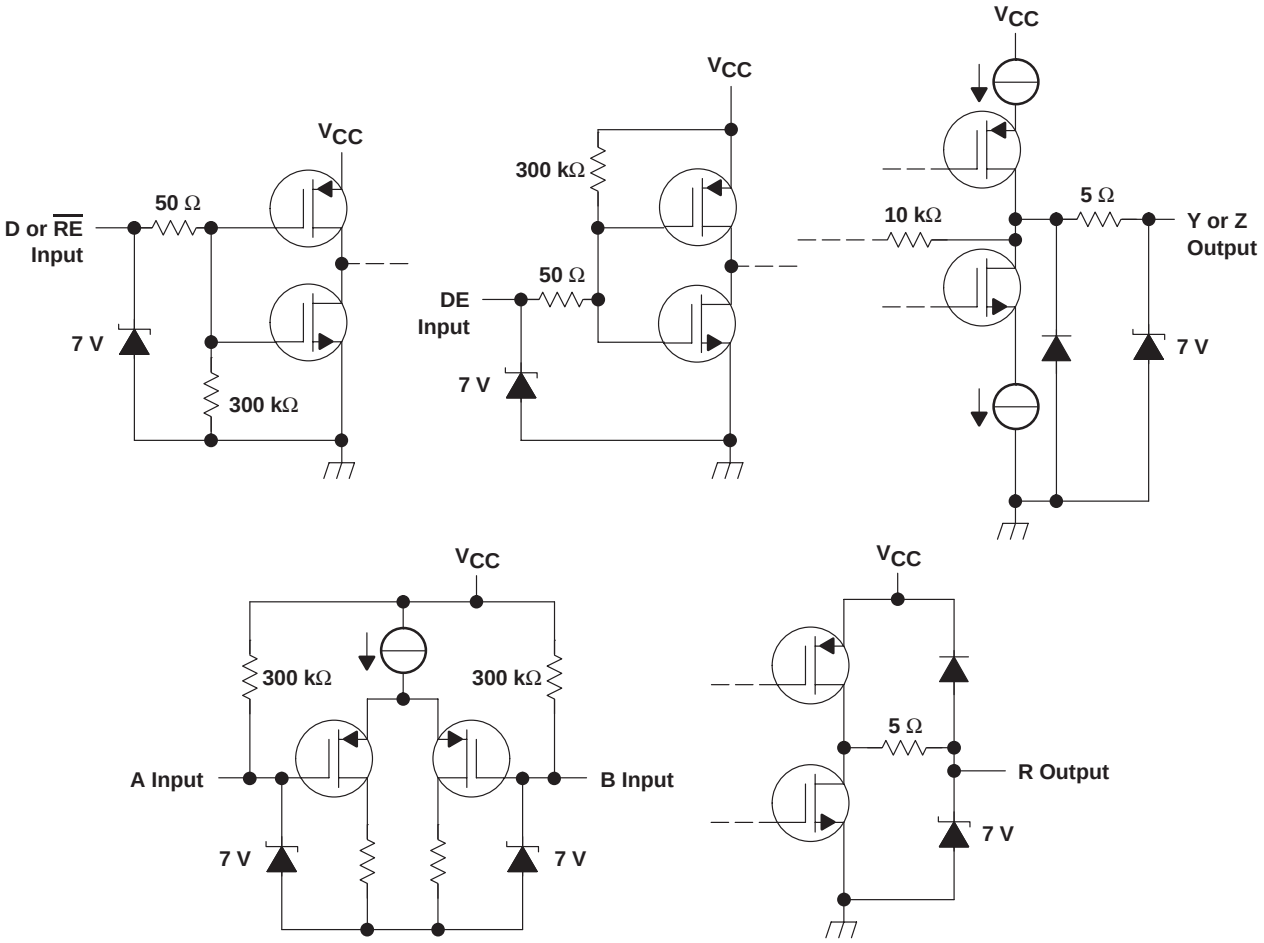
Function Tables (Continued)

SN65LVDM050 and SN65LVDM051 DRIVER

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

H = high level, L = low level, Z = high impedance, X = don't care

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 (D, R, DE, $\overline{RE}$) . . . . . −0.5 V to 6 V
Voltage range (Y, Z, A, and B) . . . . . −0.5 V to 4 V
Electrostatic discharge: Y, Z, A, B , and GND (see Note 2) . . . . . CLass 3, A:12 kV, B:600 V
All . . . . . Class 3, A:7 kV, B:500 V
Continuous power dissipation . . . . . see dissipation rating table
Storage temperature range . . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 250°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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$‡	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D(8)	635 mW	5.1 mW/°C	330 mW	—
D(14)	987 mW	7.9 mW/°C	513 mW	—
D(16)	1110 mW	8.9 mW/°C	577 mW	223 mW
DGK	424 mW	3.4 mW/°C	220 mW	—
PW (14)	736 mW	5.9 mW/°C	383 mW	—
PW (16)	839 mW	6.7 mW/°C	437 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}	2			V
Low-level input voltage, V_{IL}			0.8	V
Magnitude of differential input voltage, $\lvert V_{ID} \rvert$	0.1		0.6	V
Common-mode input voltage, V_{IC} (see Figure 6)	$\frac{\lvert V_{ID} \rvert}{2}$		$2.4 - \frac{\lvert V_{ID} \rvert}{2}$	V
			$V_{CC}-0.8$	
Operating free-air temperature, T_A	−40		125	°C

device electrical characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
I_{CC} Supply current	SN65LVDM050	Drivers and receivers enabled, no receiver loads, driver $R_L = 50\ \Omega$		19	27	mA
		Drivers enabled, receivers disabled, $R_L = 50\ \Omega$		16	24	
		Drivers disabled, receivers enabled, no loads		4	6	
		Disabled		0.5	1	
	SN65LVDM051	Drivers enabled, no receiver loads, driver $R_L = 50\ \Omega$		19	27	mA
		Drivers disabled, No loads		4	6	

† 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
$\lvert V_{OD} \rvert$	Differential output voltage magnitude		R_L = 50 Ω, See Figure 1 and Figure 2	247	340	454	mV
$\Delta\lvert V_{OD} \rvert$	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		mV
I_{IH}	High-level input current	DE	V_{IH} = 5 V		−0.5	−20	µA
		D			2	20	
I_{IL}	Low-level input current	DE	V_{IL} = 0.8 V		−0.5	−10	µA
		D			2	10	
I_{OS}	Short-circuit output current		V_{OY} or V_{OZ} = 0 V		7	10	mA
			V_{OD} = 0 V		7	10	
I_{OZ}	High-impedance output current		V_{OD} = 600 mV			±1	µA
			V_O = 0 V or V_{CC}			±1	
$I_{O(OFF)}$	Power-off output current		V_{CC} = 0 V, V_O = 3.6 V			±1.5	µA
C_{IN}	Input capacitance				3		pF

receiver electrical characteristics over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{IT+}	Positive-going differential input voltage threshold	See Figure 4 and Table 1			50	mV
V_{IT-}	Negative-going differential input voltage threshold		−50			
V_{OH}	High-level output voltage	I_{OH} = −8 mA	2.4			V
V_{OL}	Low-level output voltage	I_{OL} = 8 mA			0.4	V
I_I	Input current (A or B inputs)	V_I = 0	−2	−11	−20	µA
		V_I = 2.4 V	−1.2	−3		
$I_{I(OFF)}$	Power-off input current (A or B inputs)	V_{CC} = 0			±20	µA
I_{IH}	High-level input current (enables)	V_{IH} = 5 V			10	µA
I_{IL}	Low-level input current (enables)	V_{IL} = 0.8 V			10	µA
I_{OZ}	High-impedance output current	V_O = 0 or 5 V			±10	µA
C_I	Input capacitance			5		pF

† 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†	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	R_L = 50Ω, C_L = 10 pF, See Figure 5		1.7	3	ns
t_{PHL}	Propagation delay time, high-to-low-level output			1.7	3	ns
t_r	Differential output signal rise time			0.6	1.2	ns
t_f	Differential output signal fall time			0.6	1.2	ns
$t_{sk(p)}$	Pulse skew ($\|t_{pHL} - t_{pLH}\|$)			750		ps
$t_{sk(o)}$	Channel-to-channel output skew‡			100		ps
$t_{sk(pp)}$	Part-to-part skew§				1	ns
t_{PZH}	Propagation delay time, high-impedance-to-high-level output	See Figure 6		6	10	ns
t_{PZL}	Propagation delay time, high-impedance-to-low-level output			6	10	ns
t_{PHZ}	Propagation delay time, high-level-to-high-impedance output			4	10	ns
t_{PLZ}	Propagation delay time, low-level-to-high-impedance output			5	10	ns

† All typical values are at 25°C and with a 3.3-V supply.
‡ $t_{sk(o)}$ is the maximum delay time difference between drivers on the same device.
§ $t_{sk(pp)}$ 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.

receiver 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	C_L = 10 pF, See Figure 7		3.7	4.5	ns
t_{PHL}	Propagation delay time, high-to-low-level output			3.7	4.5	ns
$t_{sk(p)}$	Pulse skew ($\|t_{pHL} - t_{pLH}\|$)			0.1		ns
$t_{sk(o)}$	Channel-to-channel output skew			0.2		ns
$t_{sk(pp)}$	Part-to-part skew‡				1	ns
t_r	Output signal rise time	C_L = 10 pF, See Figure 7		0.7	1.5	ns
t_f	Output signal fall time			0.9	1.5	ns
t_{PZH}	Propagation delay time, high-level-to-high-impedance output	See Figure 8		2.5		ns
t_{PZL}	Propagation delay time, low-level-to-low-impedance output			2.5		ns
t_{PHZ}	Propagation delay time, high-impedance-to-high-level output			7		ns
t_{PLZ}	Propagation delay time, low-impedance-to-high-level output			4		ns

† All typical values are at 25°C and with a 3.3-V supply.
‡ $t_{sk(pp)}$ 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.

PARAMETER MEASUREMENT INFORMATION

driver

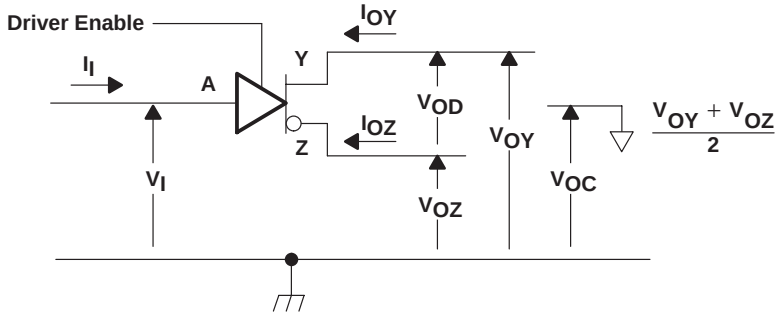
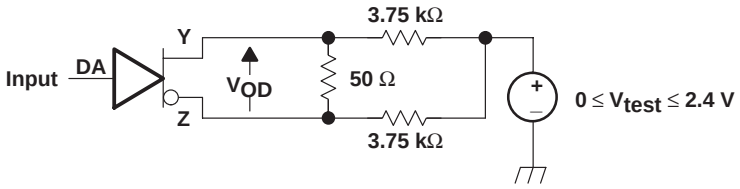
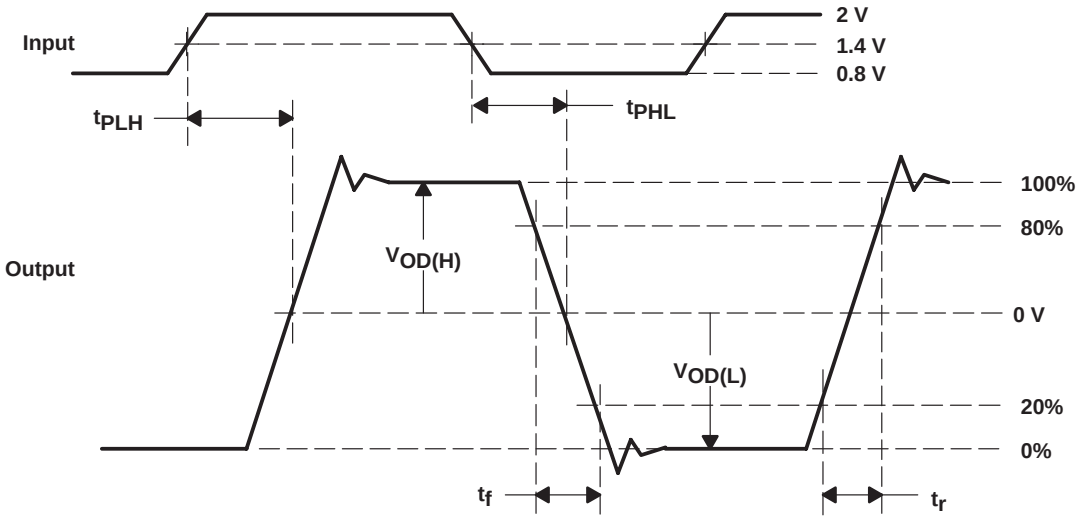


Figure 1. Driver Voltage and Current Definitions



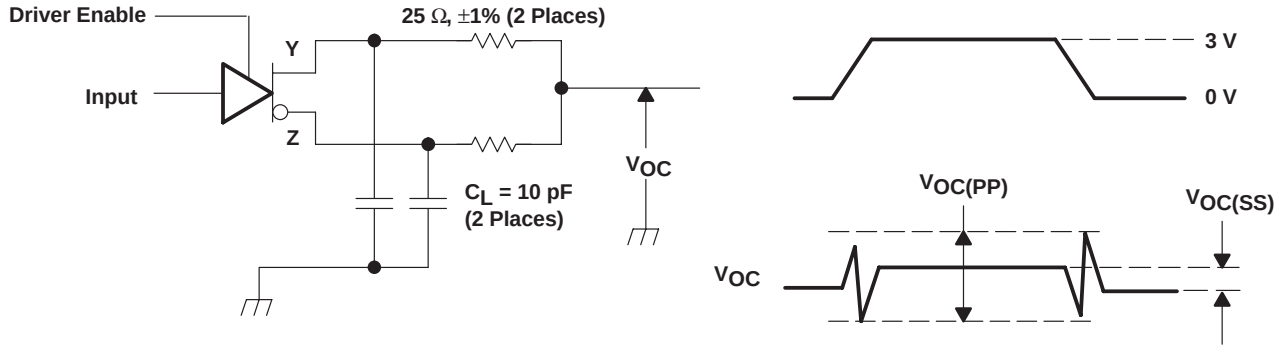


NOTE A: All input pulses are supplied by a generator having the following characteristics: t_r or $t_f \le 1$ ns, pulse repetition rate (PRR) = 50 Mpps, pulse width = 10 ± 0.2 ns . C_L includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

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

PARAMETER MEASUREMENT INFORMATION

driver (continued)



NOTE A: All input pulses are supplied by a generator having the following characteristics: t_r or $t_f \le 1$ ns, pulse repetition rate (PRR) = 50 Mpps, pulse width = 10 ± 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

PARAMETER MEASUREMENT INFORMATION

receiver

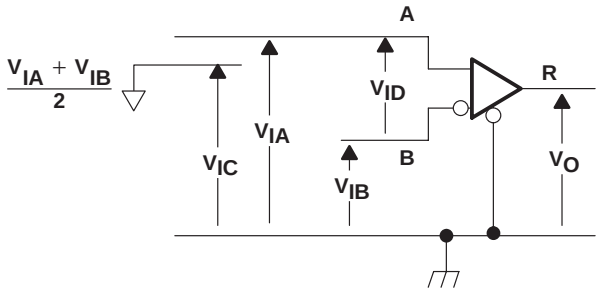


Figure 4. Receiver Voltage Definitions

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}
1.225	1.175	50	1.2
1.175	1.225	−50	1.2
2.375	2.325	50	2.35
2.325	2.375	−50	2.35
0.05	0	50	0.05
0	0.05	−50	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

PARAMETER MEASUREMENT INFORMATION

driver

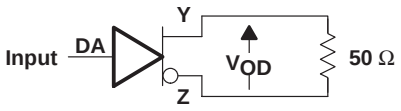
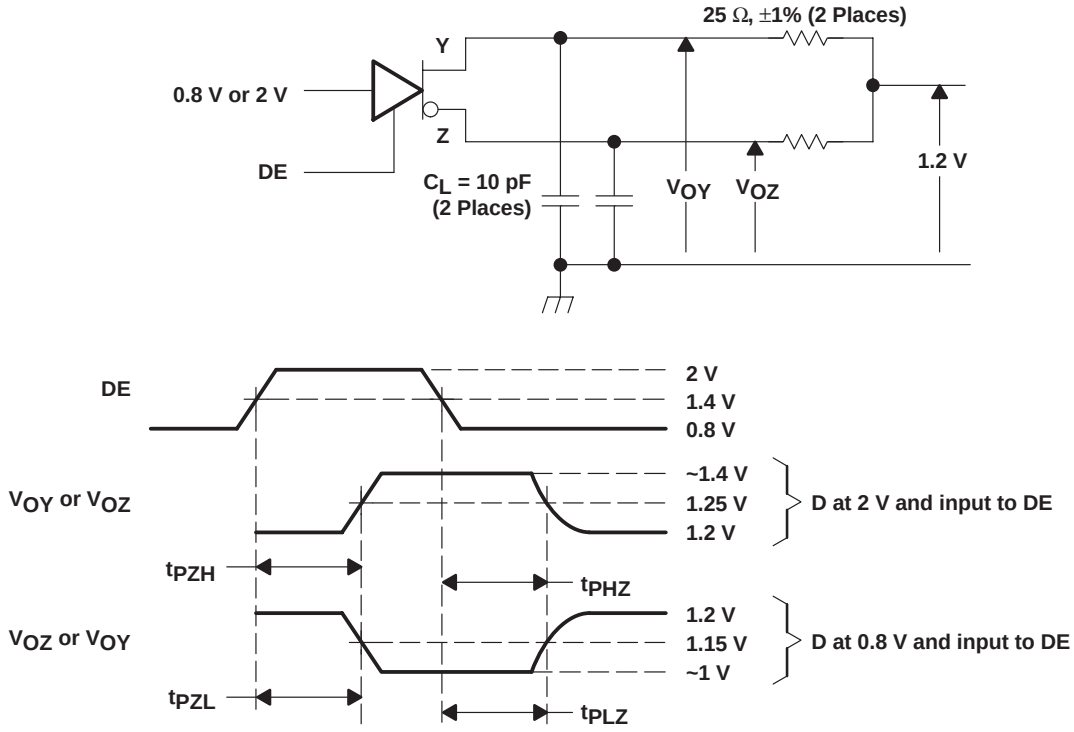


Figure 5. Timing Test Circuit

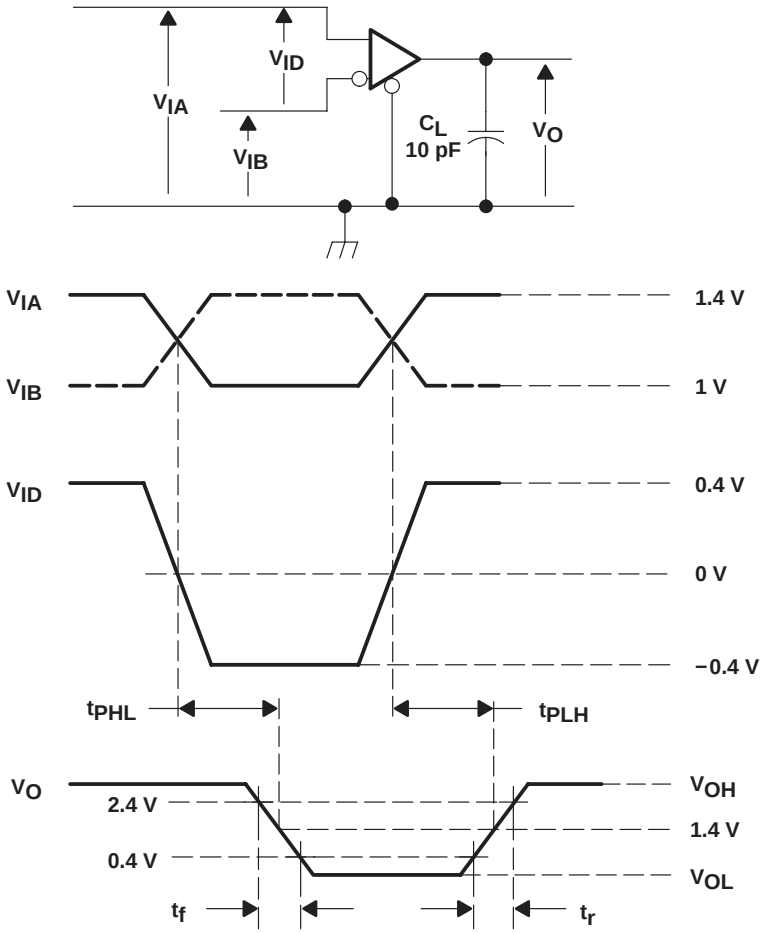


NOTE A: All input pulses are supplied by a generator having the following characteristics: t_r or $t_f \le 1$ ns, pulse repetition rate (PRR) = 0.5 Mpps, pulse width = 500 ± 10 ns . C_L includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 6. Enable and Disable Time Circuit and Definitions

PARAMETER MEASUREMENT INFORMATION

receiver

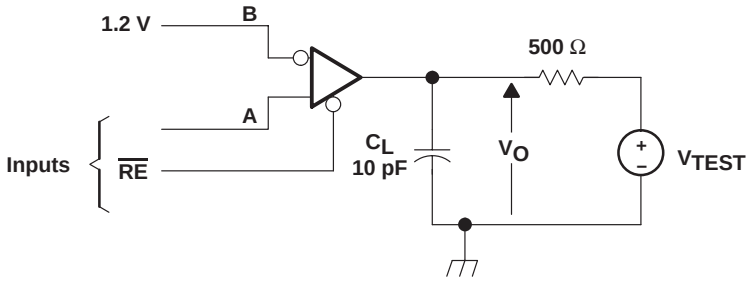


NOTE A: All input pulses are supplied by a generator having the following characteristics: t_r or $t_f \le 1$ ns, pulse repetition rate (PRR) = 50 Mpps, pulse width = 10 ± 0.2 ns. C_L includes instrumentation and fixture capacitance within 0,06 mm of the D.U.T.

Figure 7. Timing Test Circuit and Waveforms

PARAMETER MEASUREMENT INFORMATION

receiver (continued)



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

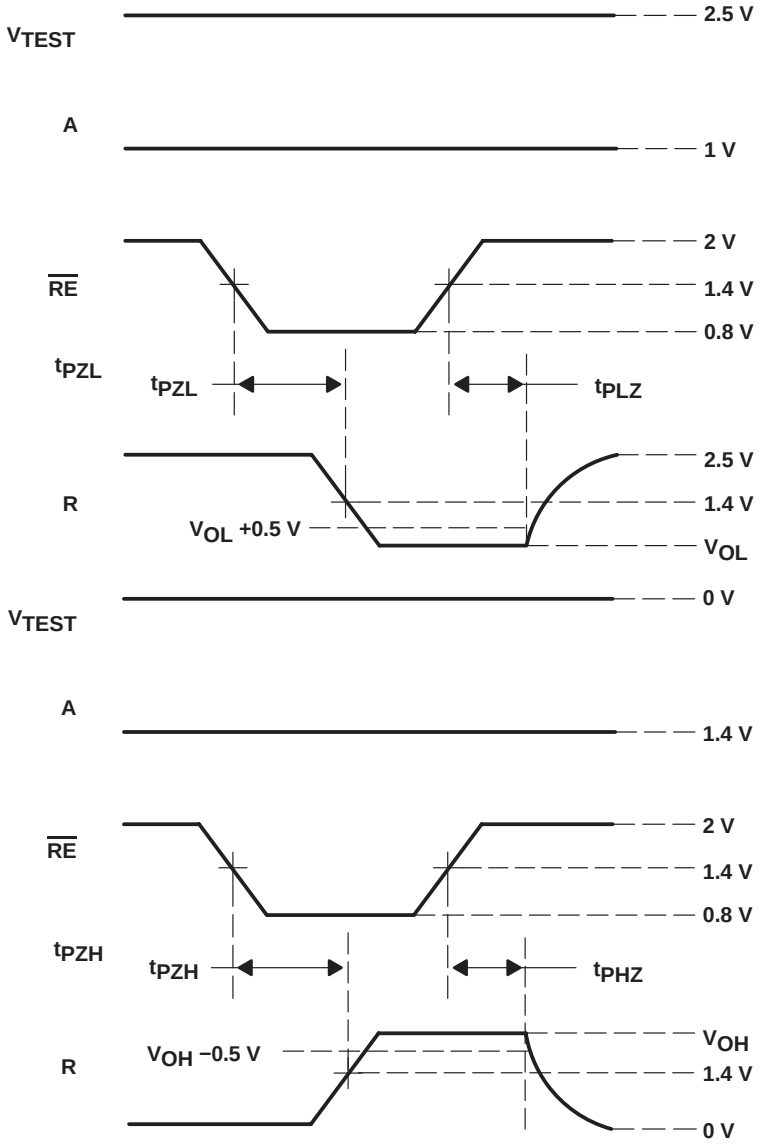


Figure 8. Enable/Disable Time Test Circuit and Waveforms

TYPICAL CHARACTERISTICS

COMMON-MODE INPUT VOLTAGE vs SUPPLY VOLTAGE

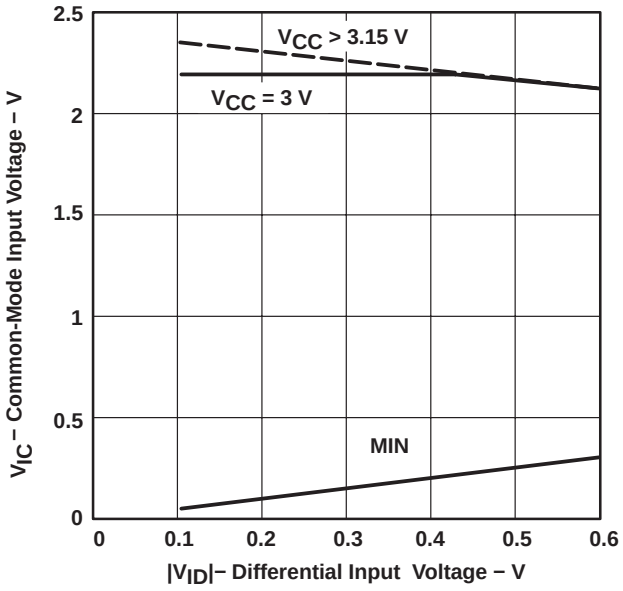


Figure 9

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

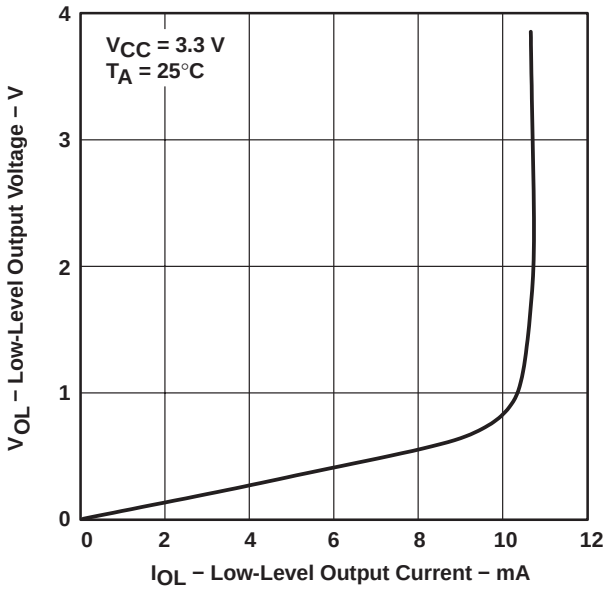


Figure 10

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

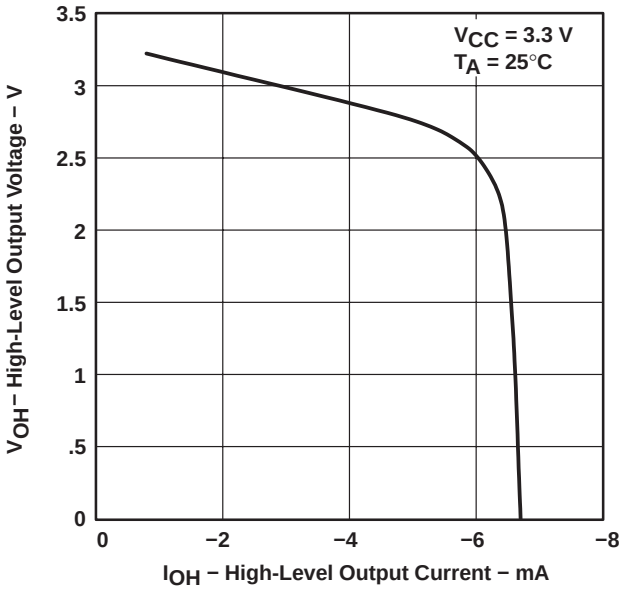


Figure 11

TYPICAL CHARACTERISTICS

RECEIVER
HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

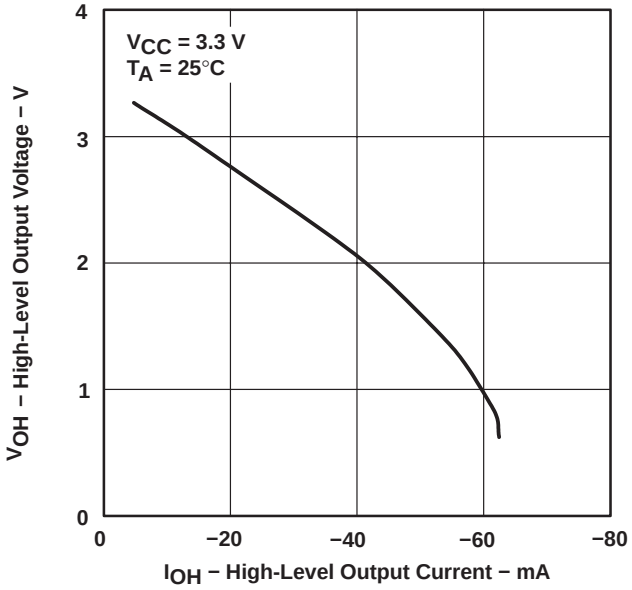


Figure 12

RECEIVER
LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

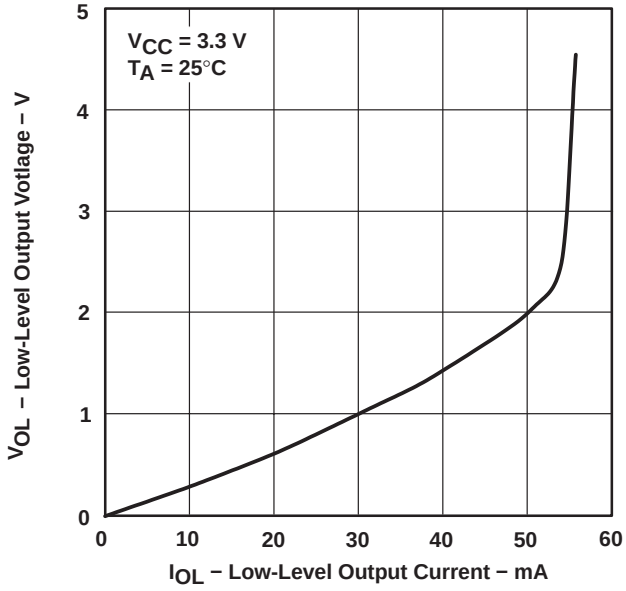


Figure 13

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

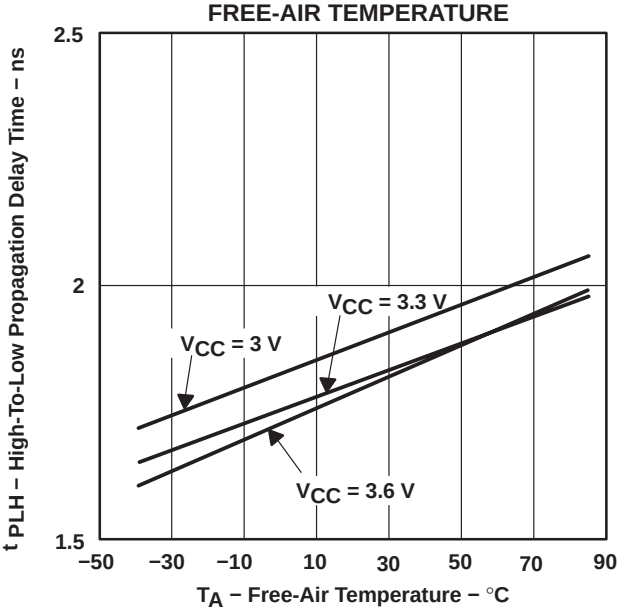


Figure 14

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

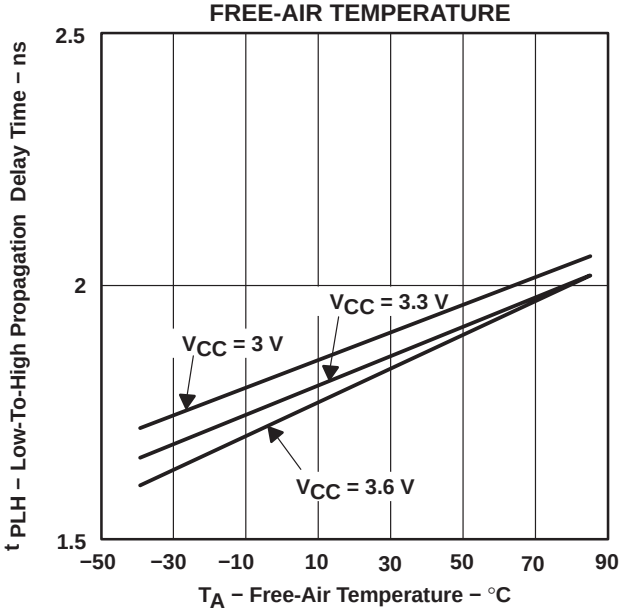


Figure 15

TYPICAL CHARACTERISTICS

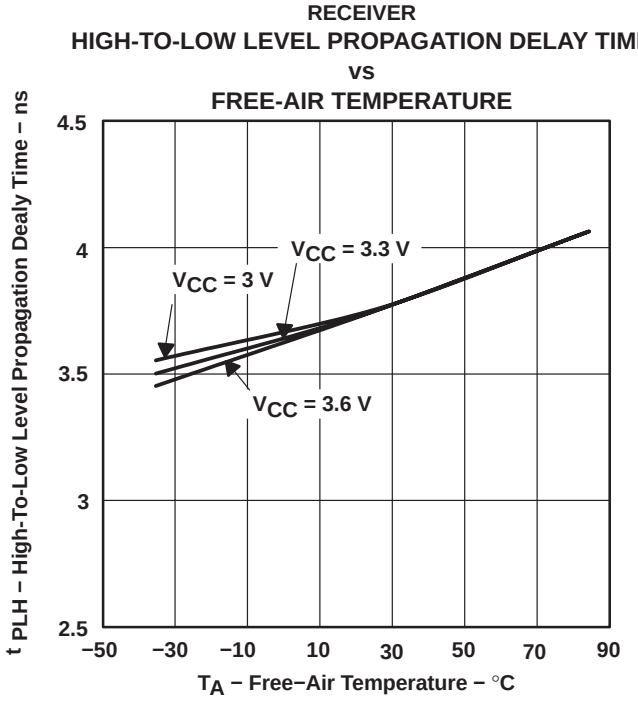


Figure 16

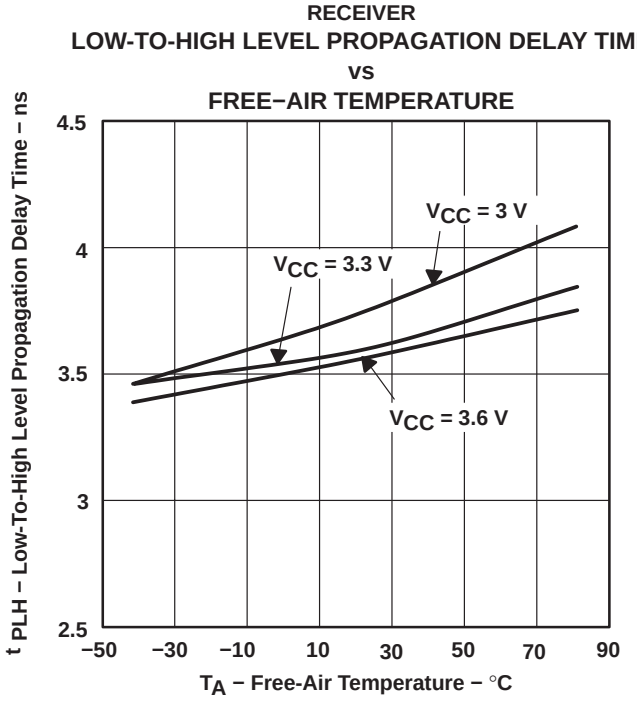


Figure 17

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 very 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.

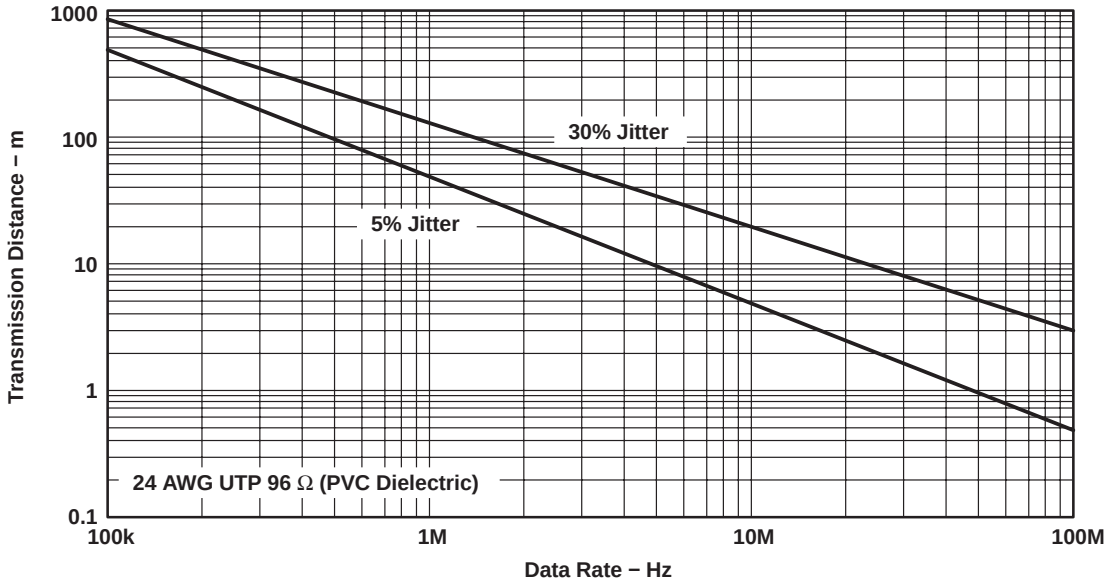


Figure 18. Data Transmission Distance Versus Rate

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 −50 mV and 50 mV and within its recommended input common-mode voltage range. TI's LVDS receiver is different, however, in how it handles the open-input circuit situation.

Open-circuit means that there is little or no input current to the receiver from the data line itself. This could be when the driver is in a high-impedance state or the cable is disconnected. When this occurs, the LVDS receiver pulls each line of the signal pair to near V_{CC} through 300-kΩ resistors as shown in Figure 18. 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.

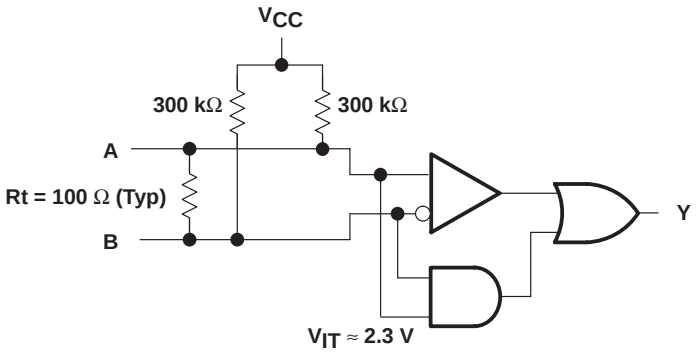


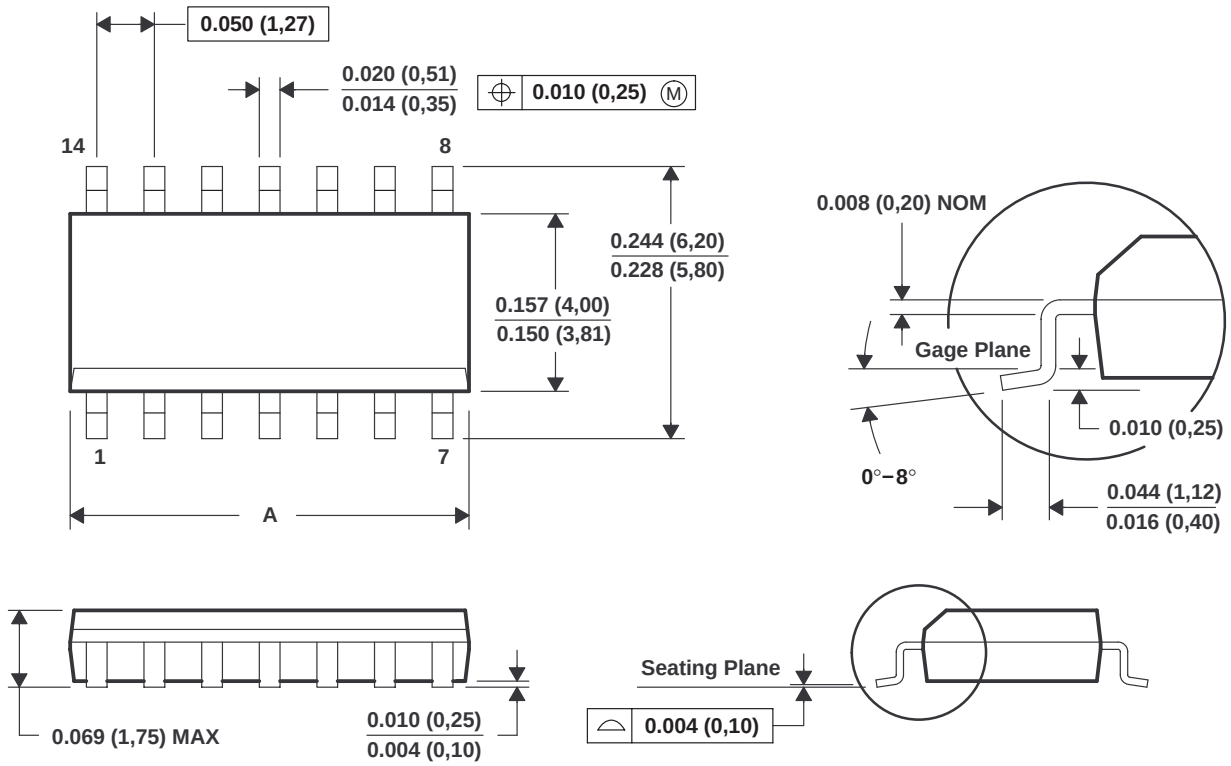
Figure 19. Open-Circuit Fail Safe of the LVDS Receiver

It is only under these conditions that the output of the receiver is valid with less than a 50-mV differential input voltage magnitude. The presence of the termination resistor, Rt, 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.

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)

4040047/D 10/96

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).
D. Falls within JEDEC MS-012

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN65LVDM050QDG4Q1	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDM050QDQ1	ACTIVE	SOIC	D	16	40	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65LVDM050QDRG4Q1	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDM050QDRQ1	ACTIVE	SOIC	D	16	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65LVDM051QDG4Q1	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDM051QDQ1	ACTIVE	SOIC	D	16	40	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65LVDM051QDRG4Q1	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65LVDM051QDRQ1	ACTIVE	SOIC	D	16	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
SN65LVDM051QPWQ1	OBSOLETE	TSSOP	PW	16		TBD	Call TI	Call TI
SN65LVDM051QPWRQ1	OBSOLETE	TSSOP	PW	16		TBD	Call TI	Call TI

(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 - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
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.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

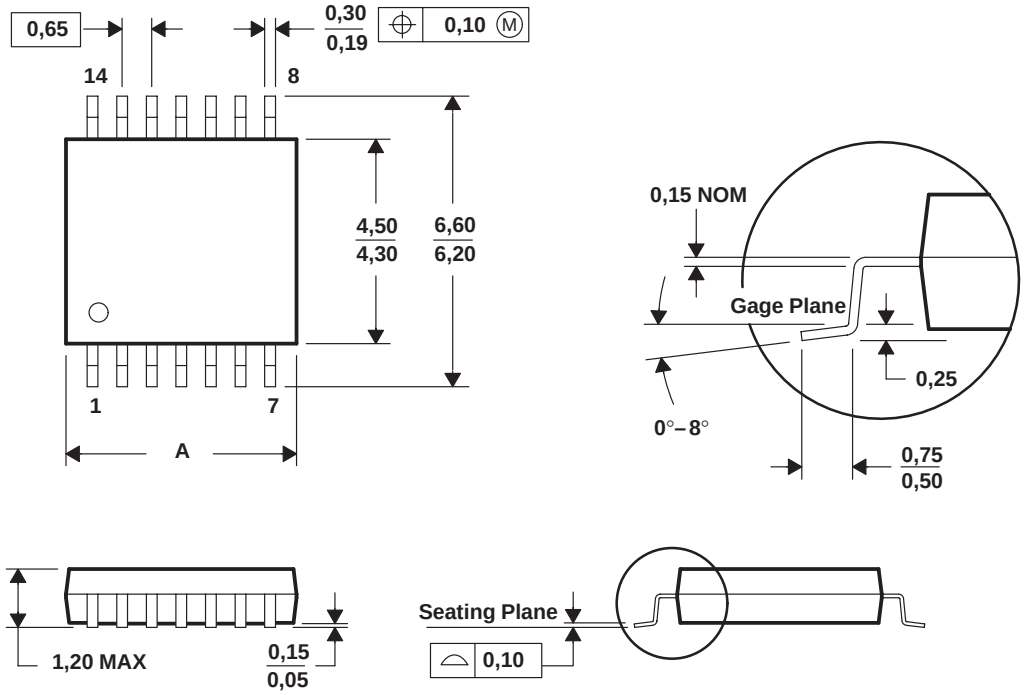
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

OTHER QUALIFIED VERSIONS OF SN65LVDM050-Q1, SN65LVDM051-Q1 :
- Catalog: SN65LVDM050, SN65LVDM051

NOTE: Qualified Version Definitions:
- Catalog - TI's standard catalog product

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

14 PINS SHOWN

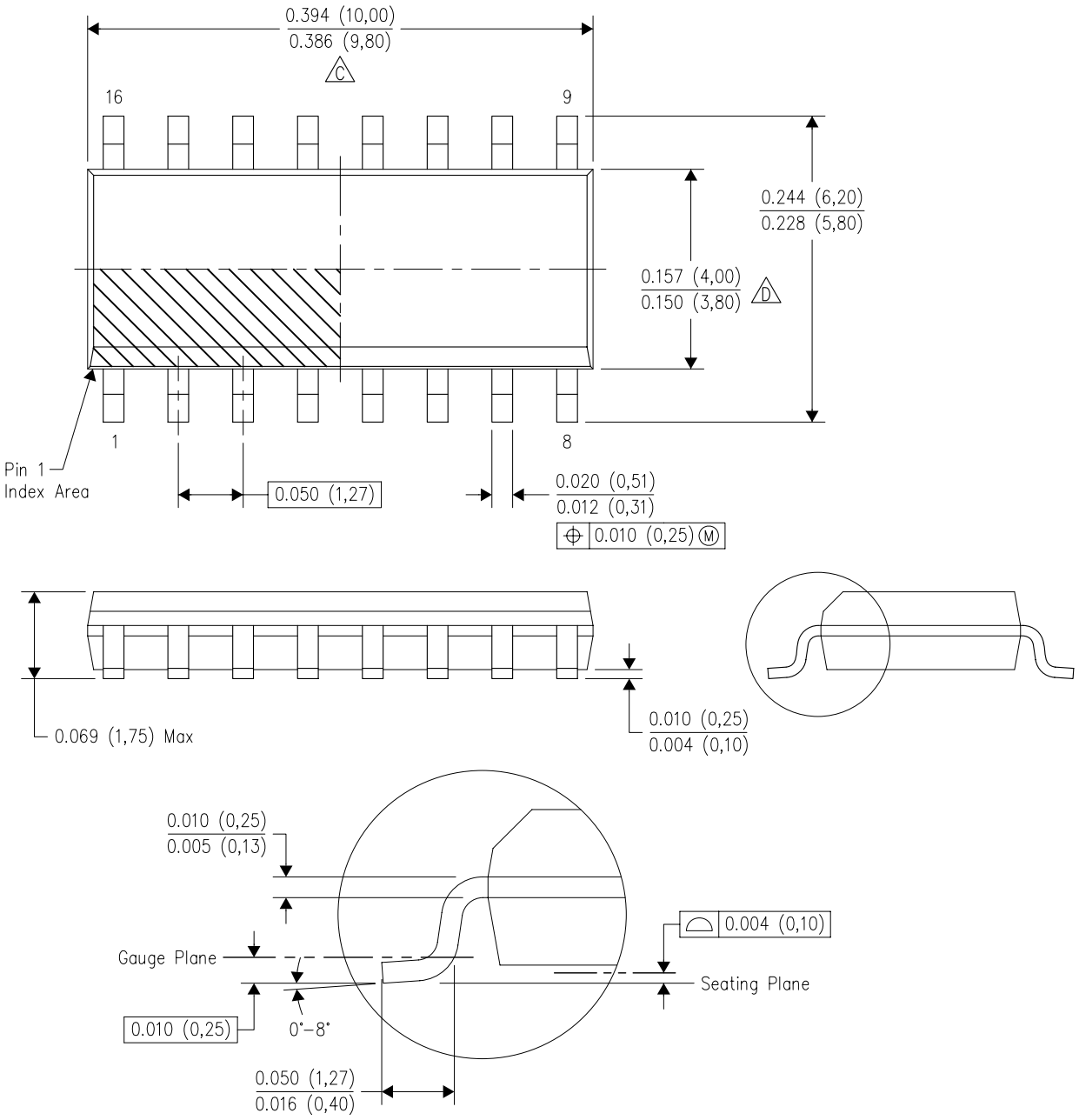


DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

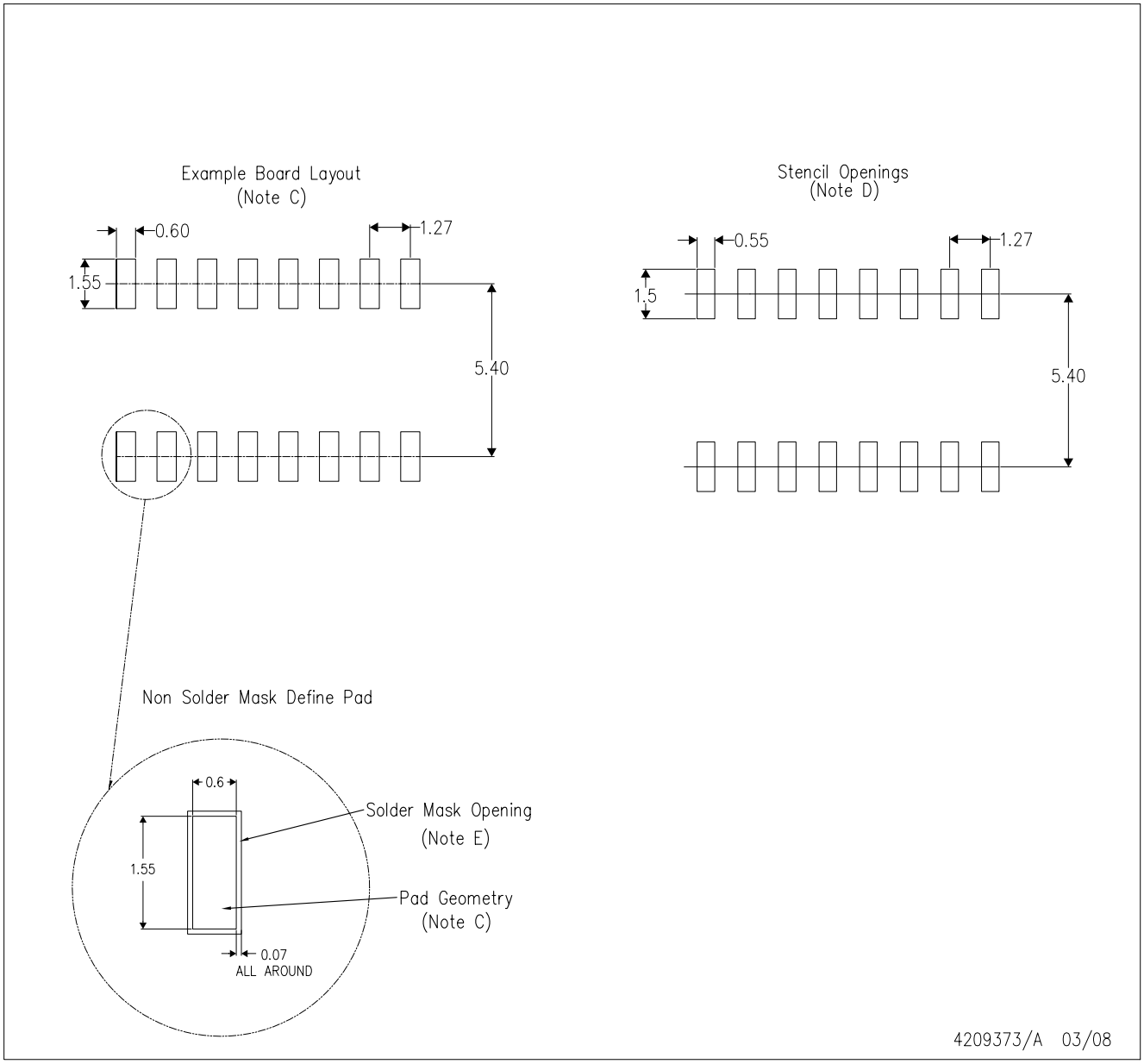
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

D (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS–012 variation AC.

D(R–PDSO–G16)



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Refer to IPC7351 for alternate board design.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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