

HIGH OUTPUT RS-485 TRANSCEIVERS

FEATURES

- Minimum Differential Output Voltage of 2.5 V Into a 54-Ω Load
- Open-Circuit, Short-Circuit, and Idle-Bus Failsafe Receiver
- 1/8th Unit-Load Option Available (Up to 256 Nodes on the Bus)
- Bus-Pin ESD Protection Exceeds 16 kV HBM
- Driver Output Slew Rate Control Options
- Electrically Compatible With ANSI TIA/EIA-485-A Standard
- Low-Current Standby Mode . . . 1 μA Typical
- Glitch-Free Power-Up and Power-Down Protection for Hot-Plugging Applications
- Pin Compatible With Industry Standard SN75176

APPLICATIONS

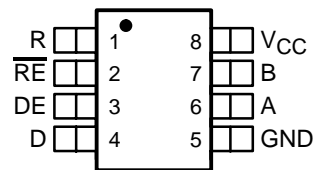
- Data Transmission Over Long or Lossy Lines or Electrically Noisy Environments
- Profibus Line Interface
- Industrial Process Control Networks
- Point-of-Sale (POS) Networks
- Electric Utility Metering
- Building Automation
- Digital Motor Control

DESCRIPTION

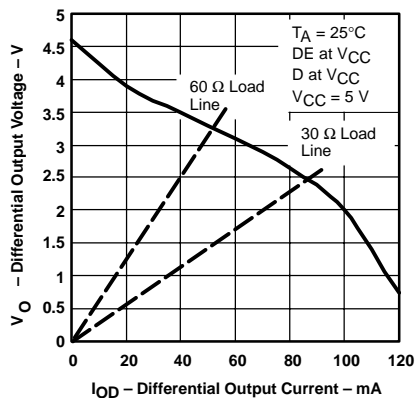
The SN65HVD05, SN75HVD05, SN65HVD06, SN75HVD06, SN65HVD07, and SN75HVD07 combine a 3-state differential line driver and differential line receiver. They are designed for balanced data transmission and interoperate with ANSI TIA/EIA-485-A and ISO 8482E standard-compliant devices. The driver is designed to provide a differential output voltage greater than that required by these standards for increased noise margin. The drivers and receivers have active-high and active-low enables respectively, which can be externally connected together to function as direction control.

The driver differential outputs and receiver differential inputs connect internally to form a differential input/output (I/O) bus port that is designed to offer minimum loading to the bus whenever the driver is disabled or not powered. These devices feature wide positive and negative common-mode voltage ranges, making them suitable for party-line applications.

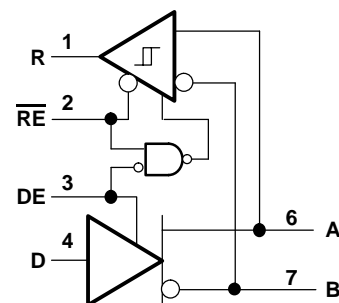
D OR P PACKAGE
(TOP VIEW)



DIFFERENTIAL OUTPUT VOLTAGE
vs
DIFFERENTIAL OUTPUT CURRENT



LOGIC DIAGRAM
(POSITIVE LOGIC)



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.

ORDERING INFORMATION(1)

SIGNALING RATE	UNIT LOAD	DRIVER OUTPUT SLOPE CONTROL	T _A	PART NUMBER(2)		MARKED AS	
						PLASTIC DUAL-IN-LINE PACKAGE (PDIP)	SMALL OUTLINE IC (SOIC) PACKAGE
40 Mbps	1/2	No	-40°C to 85°C	SN65HVD05D	SN65HVD05P	65HVD05	VP05
10 Mbps	1/8	Yes		SN65HVD06D	SN65HVD06P	65HVD06	VP06
1 Mbps	1/8	Yes		SN65HVD07D	SN65HVD07P	65HVD07	VP07
40 Mbps	1/2	No	-0°C to 70°C	SN75HVD05D	SN75HVD05P	75HVD05	VN05
10 Mbps	1/8	Yes		SN75HVD06D	SN75HVD06P	75HVD06	VN06
1 Mbps	1/8	Yes		SN75HVD07D	SN75HVD07P	75HVD07	VN07

- (1) For the most current specification and package information, refer to our web site at www.ti.com.
 (2) The D package is available taped and reeled. Add an R suffix to the device type (i.e., SN65HVD05DR).

PACKAGE DISSIPATION RATINGS (SEE FIGURE 12 AND FIGURE 13)

PACKAGE	T _A ≤ 25°C POWER RATING	DERATING FACTOR(1) ABOVE T _A = 25°C	T _A = 70°C POWER RATING	T _A = 85°C POWER RATING
D(2)	710 mW	5.7 mW/°C	455 mW	369 mW
D(3)	1282 mW	10.3 mW/°C	821 mW	667 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW

- (1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.
 (2) Tested in accordance with the Low-K thermal metric definitions of EIA/JESD51-3
 (3) Tested in accordance with the High-K thermal metric definitions of EIA/JESD51-7

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted(1) (2)

			SN65HVD05, SN65HVD06, SN65HVD07 SN75HVD05, SN75HVD06, SN75HVD07
Supply voltage range, V _{CC}			-0.3 V to 6 V
Voltage range at A or B			-9 V to 14 V
Input voltage range at D, DE, R or RE			-0.5 V to V _{CC} + 0.5 V
Voltage input range, transient pulse, A and B, through 100 Ω (see Figure 11)			-50 V to 50 V
Electrostatic discharge	Human body model(3)	A, B, and GND	16 kV
		All pins	4 kV
	Charged-device model(4)	All pins	1 kV
Continuous total power dissipation			See Dissipation Rating Table
Storage temperature range, T _{stg}			-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 JEDEC Standard 22, Test Method A114-A.
 (4) Tested in accordance with JEDEC Standard 22, Test Method C101.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}		4.5		5.5	V
Voltage at any bus terminal (separately or common mode) V_I or V_{IC}		-7 ⁽¹⁾		12	V
High-level input voltage, V_{IH}	D, DE, \overline{RE}	2			V
Low-level input voltage, V_{IL}	D, DE, \overline{RE}			0.8	V
Differential input voltage, V_{ID} (see Figure 7)		-12		12	V
High-level output current, I_{OH}	Driver	-100			mA
	Receiver	-8			
Low-level output current, I_{OL}	Driver			100	mA
	Receiver			8	
Operating free-air temperature, T_A	SN65HVD05	-40		85	°C
	SN65HVD06				
	SN65HVD07				
	SN75HVD05	0		70	°C
	SN75HVD06				
	SN75HVD07				

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

DRIVER ELECTRICAL CHARACTERISTICS

over operating free-air temperature range unless otherwise noted⁽¹⁾

PARAMETER		TEST CONDITIONS		MIN	TYP ⁽¹⁾	MAX	UNIT
V_{IK}	Input clamp voltage	$I_I = -18$ mA		-1.5			V
$ V_{OD} $	Differential output voltage	No Load				V_{CC}	V
		$R_L = 54 \Omega$, See Figure 1		2.5			
		$V_{test} = -7$ V to 12 V, See Figure 2		2.2			
$\Delta V_{OD} $	Change in magnitude of differential output voltage	See Figure 1 and Figure 2		-0.2		0.2	V
$V_{OC(SS)}$	Steady-state common-mode output voltage	See Figure 3		2.2		3.3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage	See Figure 3		-0.1		0.1	V
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	HVD05	See Figure 3		600		mV
		HVD06		500			
		HVD07		900			
I_{OZ}	High-impedance output current	See receiver input currents					
I_I	Input current	D		-100		0	μ A
		DE		0		100	
I_{OS}	Short-circuit output current	-7 V $\leq V_O \leq 12$ V		-250		250	mA
$C_{(diff)}$	Differential output capacitance	$V_{ID} = 0.4 \sin(4E6\pi t) + 0.5$ V, DE at 0 V			16		pF
I_{CC}	Supply current	\overline{RE} at V_{CC} , D & DE at V_{CC} , No load	Receiver disabled and driver enabled		9	15	mA
		\overline{RE} at V_{CC} , D at V_{CC} DE at 0 V, No load	Receiver disabled and driver disabled (standby)		1	5	μ A
		\overline{RE} at 0 V, D & DE at V_{CC} , No load	Receiver enabled and driver enabled		9	15	mA

(1) All typical values are at 25°C and with a 5-V supply.

DRIVER SWITCHING CHARACTERISTICS NIL

over operating free-air temperature range unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT	
t _{PLH}	Propagation delay time, low-to-high-level output	HVD05		6.5	11	ns	
		HVD06		27	40		
		HVD07		250	400		
t _{PHL}	Propagation delay time, high-to-low-level output	HVD05		6.5	11	ns	
		HVD06		27	40		
		HVD07		250	400		
t _r	Differential output signal rise time	HVD05	R _L = 54 Ω, C _L = 50 pF, See Figure 4	2.7	3.6	6	ns
		HVD06		18	28	55	
		HVD07		150	300	450	
t _f	Differential output signal fall time	HVD05	R _L = 54 Ω, C _L = 50 pF, See Figure 4	2.7	3.6	6	ns
		HVD06		18	28	55	
		HVD07		150	300	450	
t _{sk(p)}	Pulse skew (t _{PHL} – t _{PLH})	HVD05			2	ns	
		HVD06			2.5		
		HVD07			10		
t _{sk(pp)} (2)	Part-to-part skew	HVD05			3.5	ns	
		HVD06			14		
		HVD07			100		
t _{PZH1}	Propagation delay time, high-impedance-to-high-level output	HVD05	RE at 0 V, R _L = 110 Ω, See Figure 5			25	ns
		HVD06				45	
		HVD07				250	
t _{PHZ}	Propagation delay time, high-level-to-high-impedance output	HVD05	RE at 0 V, R _L = 110 Ω, See Figure 5			25	ns
		HVD06				60	
		HVD07				250	
t _{PZL1}	Propagation delay time, high-impedance-to-low-level output	HVD05	RE at 0 V, R _L = 110 Ω, See Figure 6			15	ns
		HVD06				45	
		HVD07				200	
t _{PLZ}	Propagation delay time, low-level-to-high-impedance output	HVD05	RE at 0 V, R _L = 110 Ω, See Figure 6			14	ns
		HVD06				90	
		HVD07				550	
t _{PZH2}	Propagation delay time, standby-to-high-level output		R _L = 110 Ω, RE at 3 V, See Figure 5			6	μs
t _{PZL2}	Propagation delay time, standby-to-low-level output		R _L = 110 Ω, RE at 3 V, See Figure 6			6	μs

(1) All typical values are at 25°C and with a 5-V supply.

(2) 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 ELECTRICAL CHARACTERISTICS

over operating free-air temperature range unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP ⁽¹⁾	MAX	UNIT
V _{IT+}	Positive-going input threshold voltage	I _O = -8 mA				-0.01	V
V _{IT-}	Negative-going input threshold voltage	I _O = 8 mA		-0.2			V
V _{hys}	Hysteresis voltage (V _{IT+} - V _{IT-})				35		mV
V _{IK}	Enable-input clamp voltage	I _I = -18 mA		-1.5			V
V _{OH}	High-level output voltage	V _{ID} = 200 mV, I _{OH} = -8 mA,	See Figure 7	4			V
V _{OL}	Low-level output voltage	V _{ID} = -200 mV, I _{OL} = 8 mA,	See Figure 7			0.4	V
I _{OZ}	High-impedance-state output current	V _O = 0 or V _{CC}	$\overline{\text{RE}}$ at V _{CC}	-1		1	μA
I _I	Bus input current	HVD05	Other input at 0 V	V _A or V _B = 12 V	0.23	0.5	mA
				V _A or V _B = 12 V, V _{CC} = 0 V	0.3	0.5	
				V _A or V _B = -7 V	-0.4	-0.13	
				V _A or V _B = -7 V, V _{CC} = 0 V	-0.4	-0.15	
		HVD06, HVD07	Other input at 0 V	V _A or V _B = 12 V	0.06	0.1	mA
				V _A or V _B = 12 V, V _{CC} = 0 V	0.08	0.13	
				V _A or V _B = -7 V	-0.1	-0.05	
				V _A or V _B = -7 V, V _{CC} = 0 V	-0.05	-0.03	
I _{IH}	High-level input current, $\overline{\text{RE}}$	V _{IH} = 2 V		-60	-26.4		μA
I _{IL}	Low-level input current, $\overline{\text{RE}}$	V _{IL} = 0.8 V		-60	-27.4		μA
C _(diff)	Differential input capacitance	V _I = 0.4 sin(4E6πt) + 0.5 V, DE at 0 V			16		pF
I _{CC}	Supply current	RE at 0 V, D & DE at 0 V, No load	Receiver enabled and driver disabled	5	10		mA
		RE at V _{CC} , DE at 0 V, D at V _{CC} , No load	Receiver disabled and driver disabled (standby)	1	5		μA
		RE at 0 V, D & DE at V _{CC} , No load	Receiver enabled and driver enabled	9	15		mA

(1) All typical values are at 25°C and with a 5-V supply.

RECEIVER SWITCHING CHARACTERISTICS

over operating free-air temperature range unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t _{PLH}	Propagation delay time, low-to-high-level output 1/2 UL	HVD05		14.6	25	ns
t _{PHL}	Propagation delay time, high-to-low-level output 1/2 UL	HVD05		14.6	25	ns
t _{PLH}	Propagation delay time, low-to-high-level output 1/8 UL	HVD06		55	70	ns
		HVD07		55	70	
t _{PHL}	Propagation delay time, high-to-low-level output 1/8 UL	HVD06	V _{ID} = -1.5 V to 1.5 V, C _L = 15 pF, See Figure 8	55	70	ns
		HVD07		55	70	
t _{sk(p)}	Pulse skew (t _{PHL} - t _{PLH})	HVD05			2	ns
		HVD06			4.5	
		HVD07			4.5	
t _{sk(pp)} ⁽²⁾	Part-to-part skew	HVD05			6.5	ns
		HVD06			14	
		HVD07			14	
t _r	Output signal rise time	C _L = 15 pF, See Figure 8		2	3	ns
t _f	Output signal fall time			2	3	
t _{PZH1}	Output enable time to high level	C _L = 15 pF, DE at 3 V, See Figure 9			10	ns
t _{PZL1}	Output enable time to low level				10	
t _{PHZ}	Output disable time from high level				15	
t _{PLZ}	Output disable time from low level				15	
t _{PZH2}	Propagation delay time, standby-to-high-level output	C _L = 15 pF, DE at 0, See Figure 10			6	μs
t _{PZL2}	Propagation delay time, standby-to-low-level output				6	

(1) All typical values are at 25°C and with a 5-V supply.

(2) 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

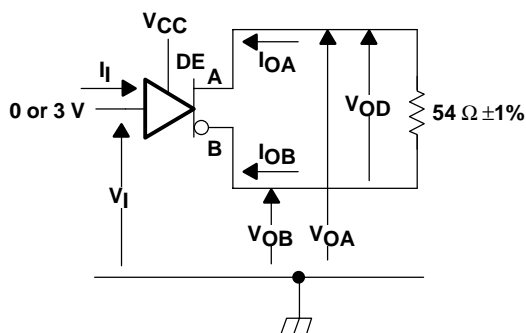


Figure 1. Driver V_{OD} Test Circuit and Voltage and Current Definitions

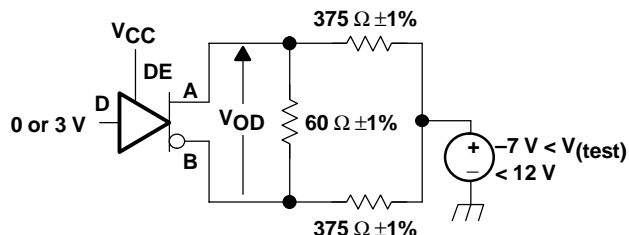
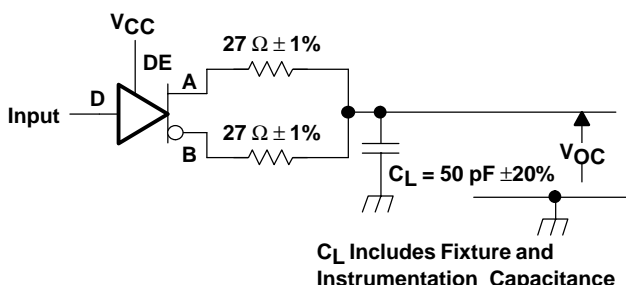
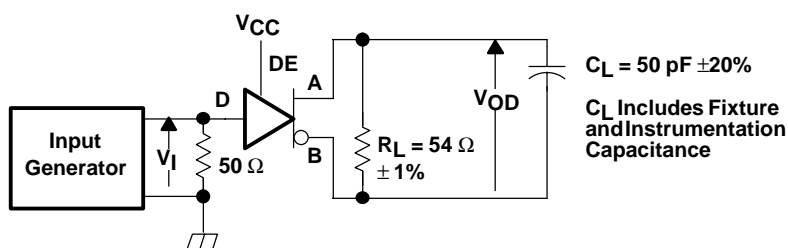
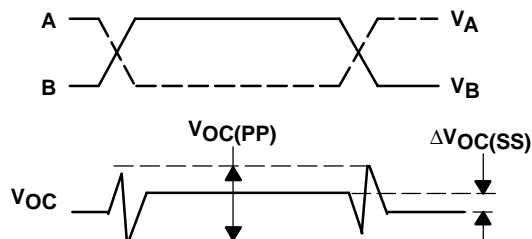


Figure 2. Driver V_{OD} With Common-Mode Loading Test Circuit



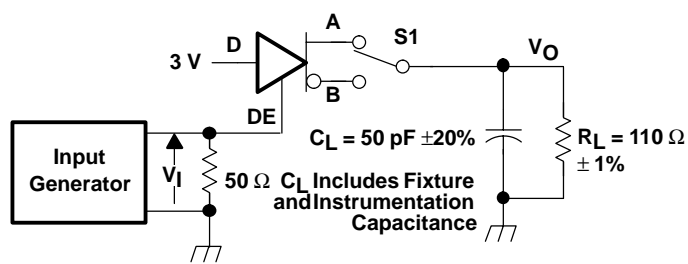
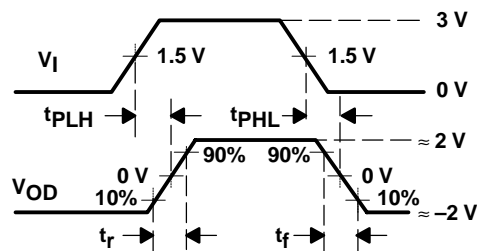
Input: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6$ ns, $t_f < 6$ ns, $Z_0 = 50 \Omega$

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



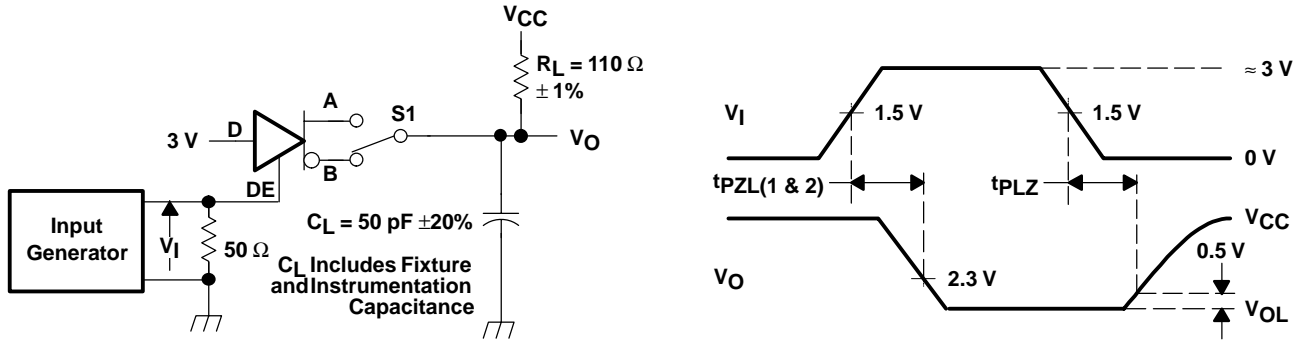
Generator: PRR = 500 kHz, 50% Duty Cycle, $t_r < 6$ ns, $t_f < 6$ ns, $Z_0 = 50 \Omega$

Figure 4. Driver Switching Test Circuit and Voltage Waveforms



Generator: PRR = 100 kHz, 50% Duty Cycle, $t_r < 6$ ns, $t_f < 6$ ns, $Z_0 = 50 \Omega$

Figure 5. Driver High-Level Enable and Disable Time Test Circuit and Voltage Waveforms



Generator: PRR = 100 kHz, 50% Duty Cycle, $t_r < 6$ ns, $t_f < 6$ ns, $Z_0 = 50 \Omega$

Figure 6. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

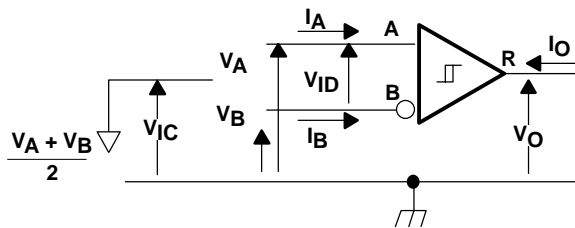
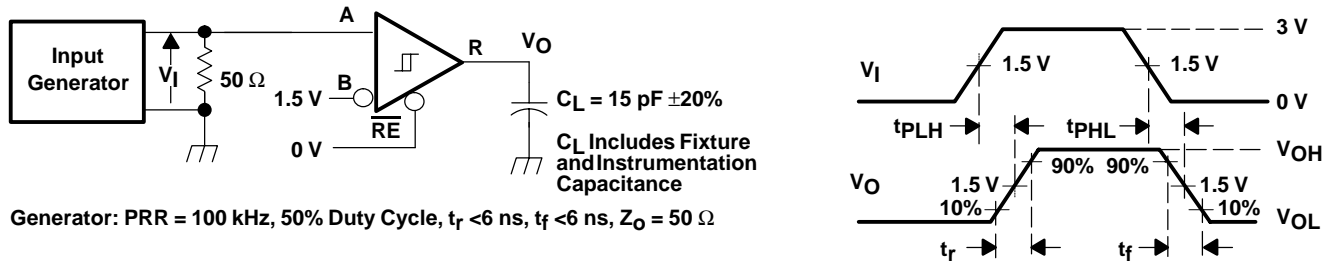


Figure 7. Receiver Voltage and Current Definitions



Generator: PRR = 100 kHz, 50% Duty Cycle, $t_r < 6$ ns, $t_f < 6$ ns, $Z_0 = 50 \Omega$

Figure 8. Receiver Switching Test Circuit and Voltage Waveforms

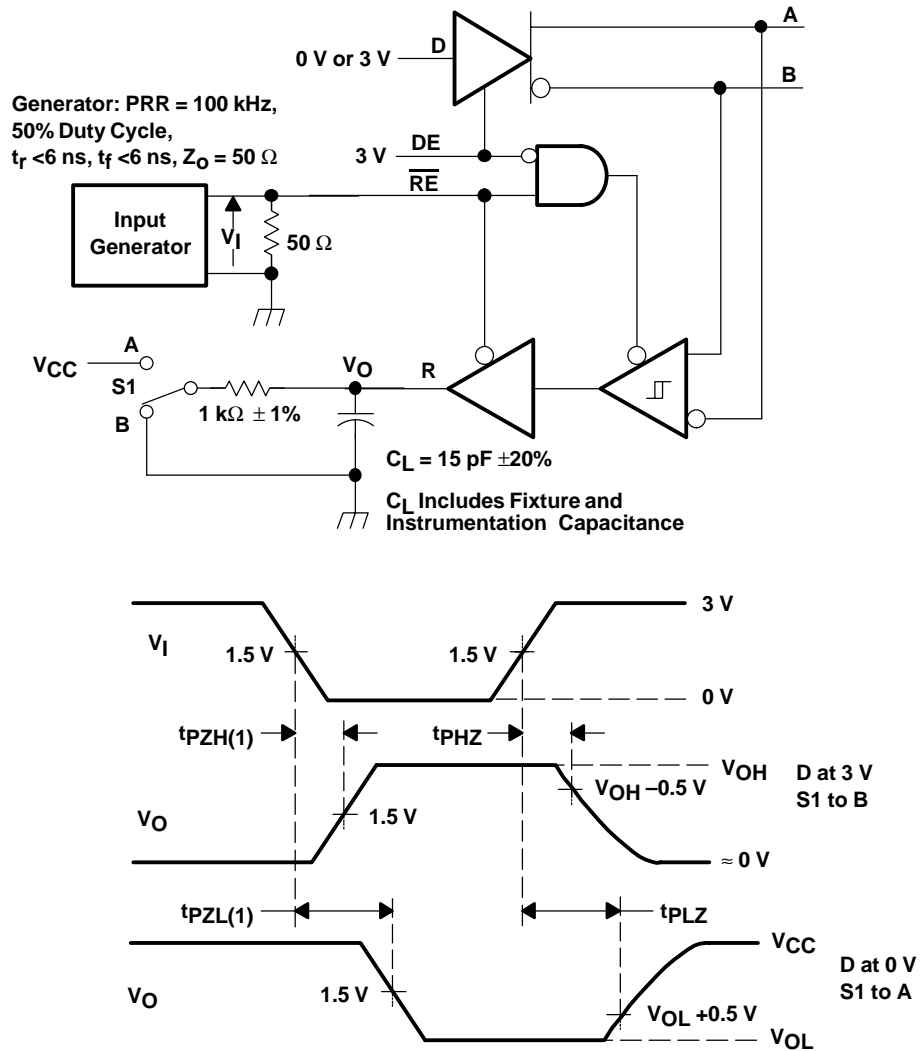


Figure 9. Receiver Enable and Disable Time Test Circuit and Voltage Waveforms With Drivers Enabled

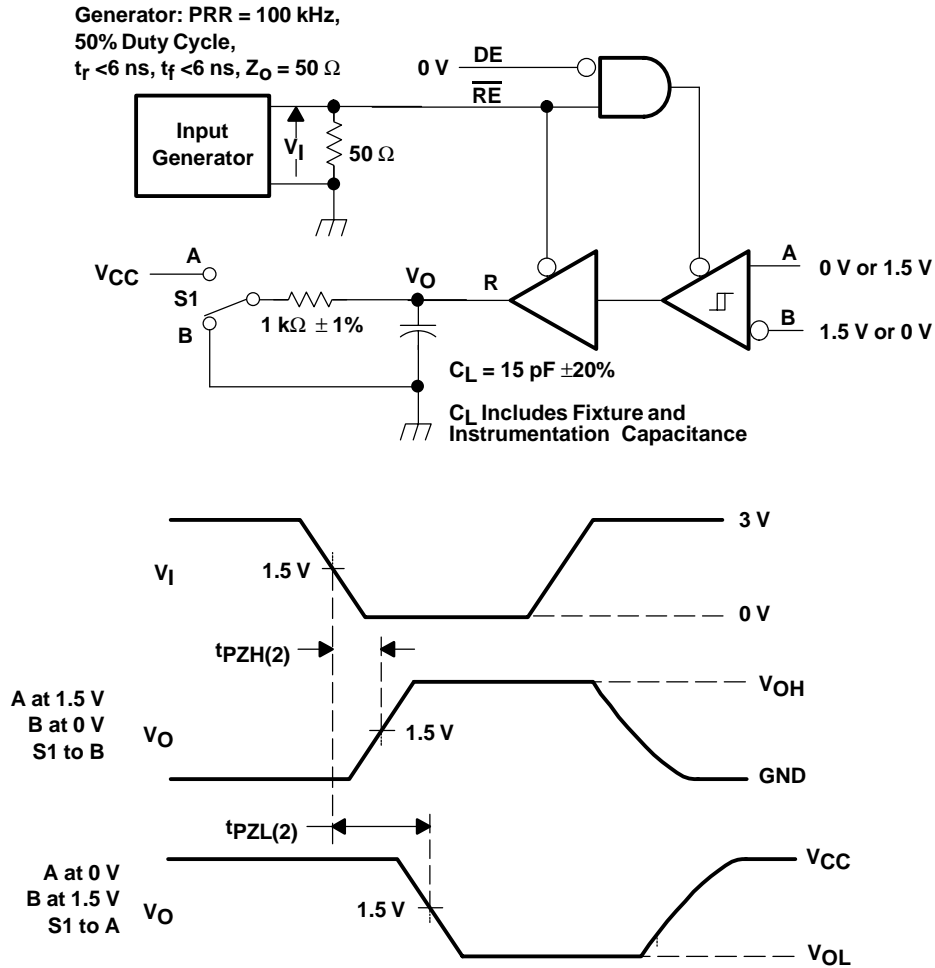
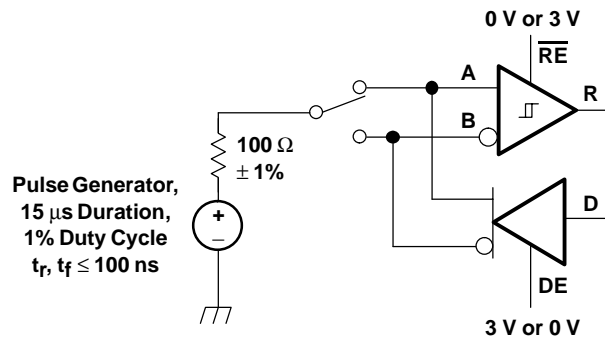


Figure 10. Receiver Enable Time From Standby (Driver Disabled)



NOTE: This test is conducted to test survivability only. Data stability at the R output is not specified.

Figure 11. Test Circuit, Transient Over Voltage Test

FUNCTION TABLES

DRIVER

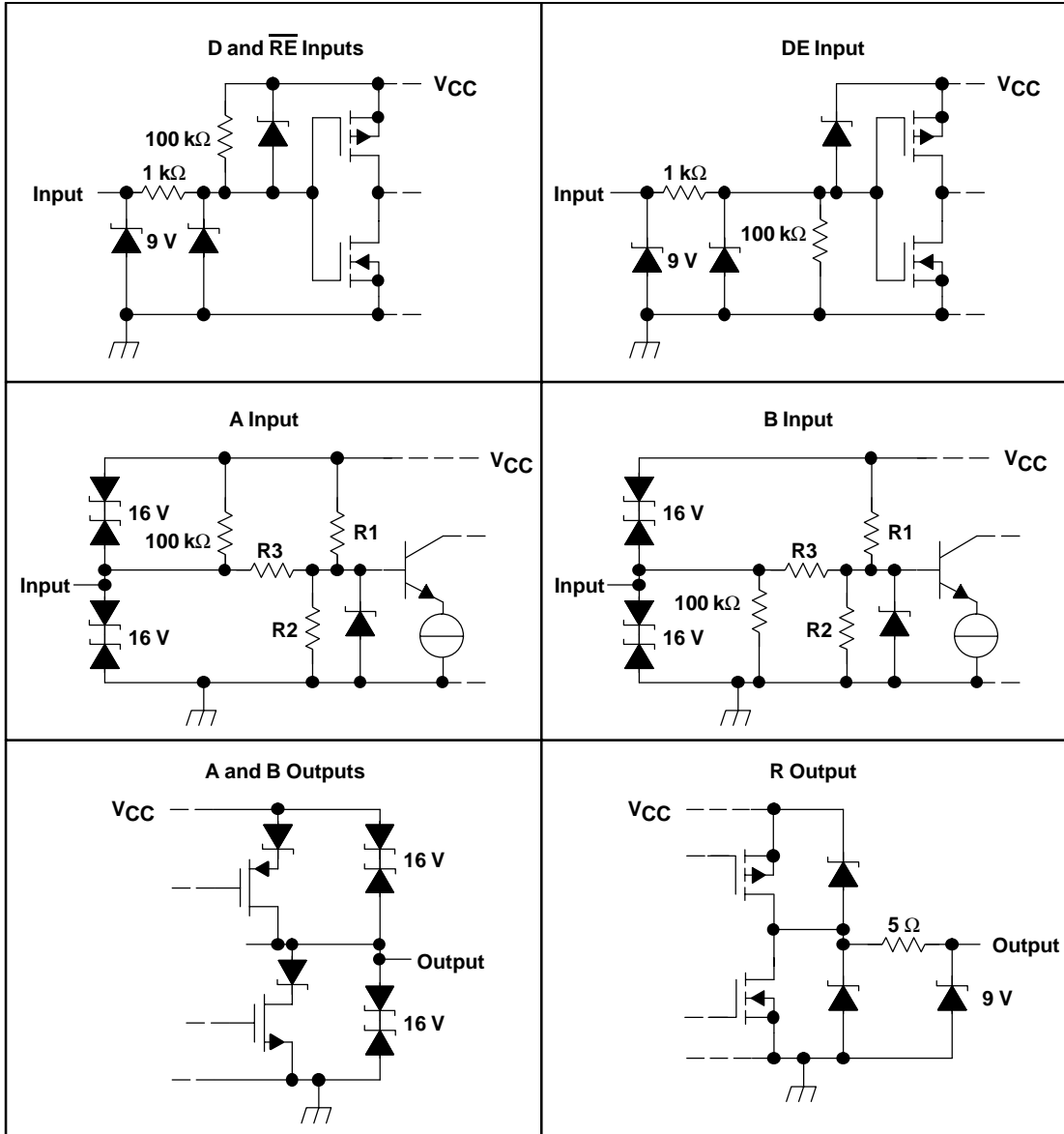
INPUT	ENABLE	OUTPUTS	
	DE	A	B
H	H	H	L
L	H	L	H
X	L	Z	Z
Open	H	H	L
X	Open	Z	Z

RECEIVER

DIFFERENTIAL INPUTS	ENABLE	OUTPUT
$V_{ID} = V_A - V_B$	\overline{RE}	R
$V_{ID} \leq -0.2\text{ V}$	L	L
$-0.2\text{ V} < V_{ID} < -0.01\text{ V}$	L	?
$-0.01\text{ V} \leq V_{ID}$	L	H
X	H	Z
Open Circuit	L	H
Short Circuit	L	H
X	Open	Z

H = high level; L = low level; Z = high impedance; X = irrelevant; ? = indeterminate

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



	R1/R2	R3
SN65HVD05	9 kΩ	45 kΩ
SN65HVD06	36 kΩ	180 kΩ
SN65HVD07	36 kΩ	180 kΩ

TYPICAL CHARACTERISTICS

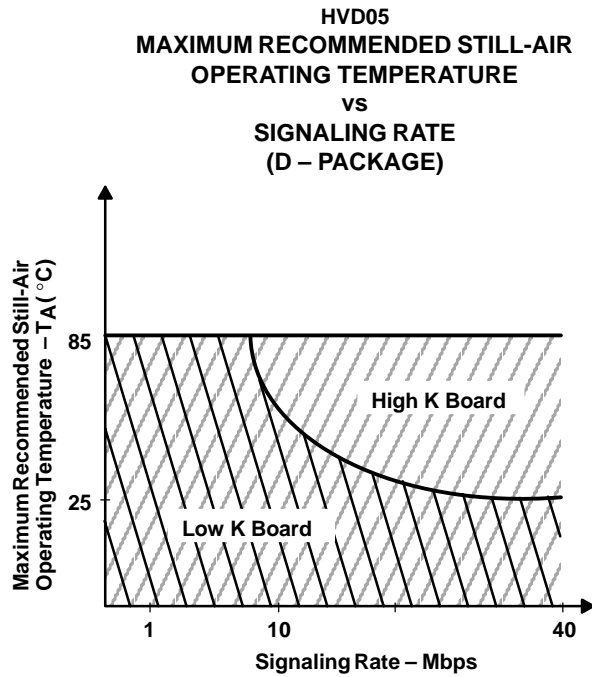


Figure 12

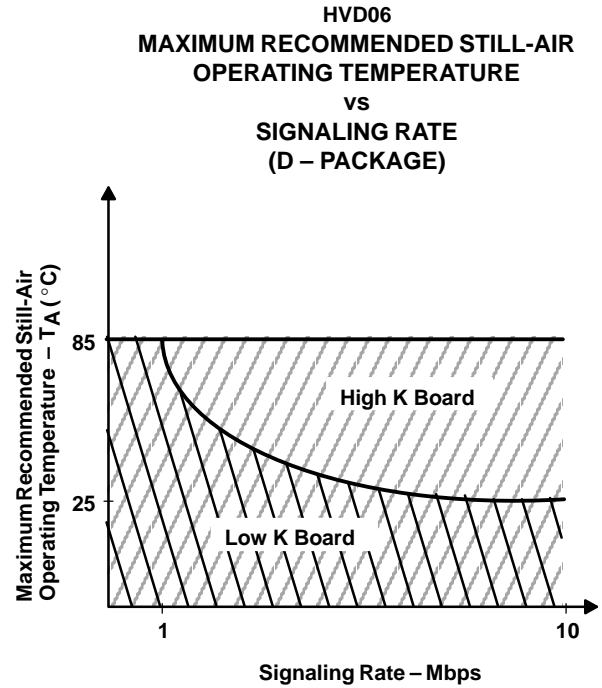


Figure 13

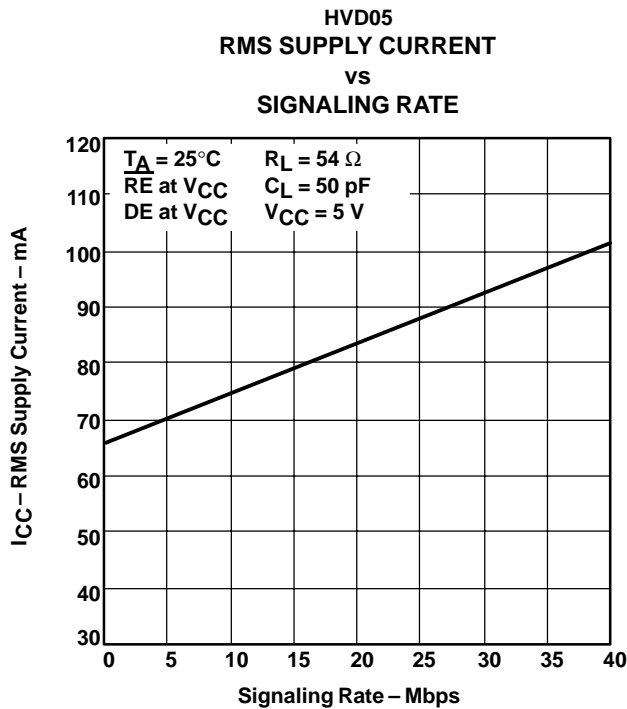


Figure 14

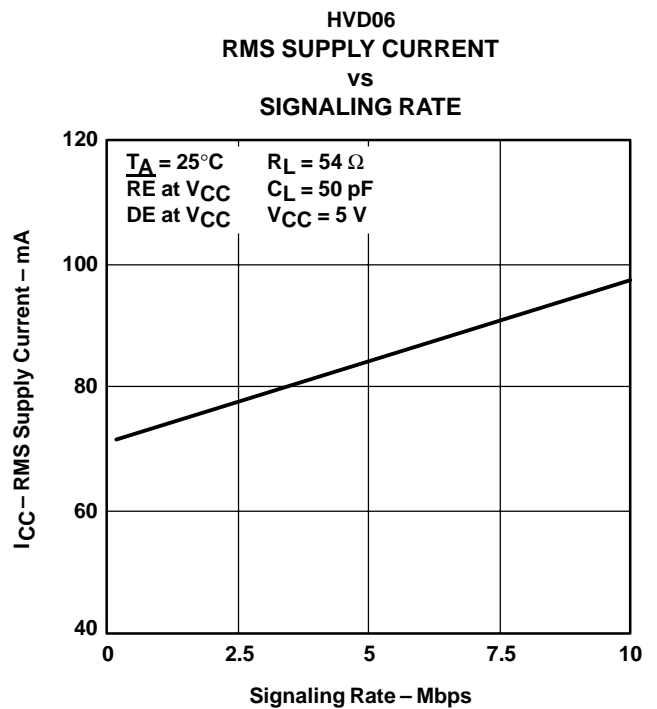


Figure 15

HVD07
 RMS SUPPLY CURRENT
 vs
 SIGNALING RATE

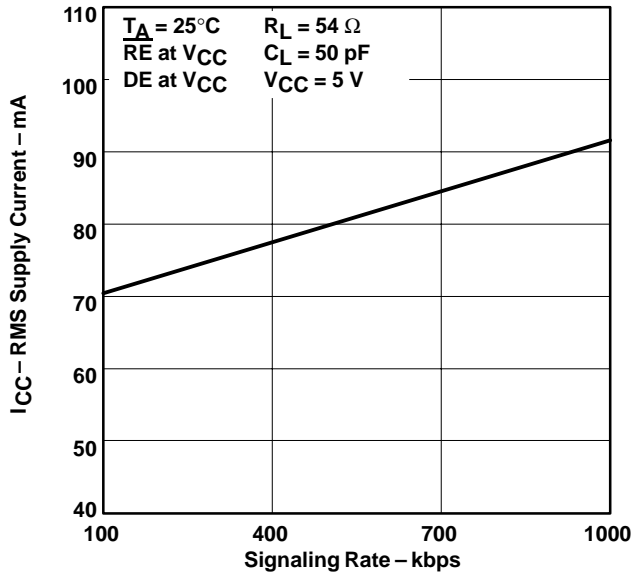


Figure 16

BUS INPUT CURRENT
 vs
 BUS INPUT VOLTAGE

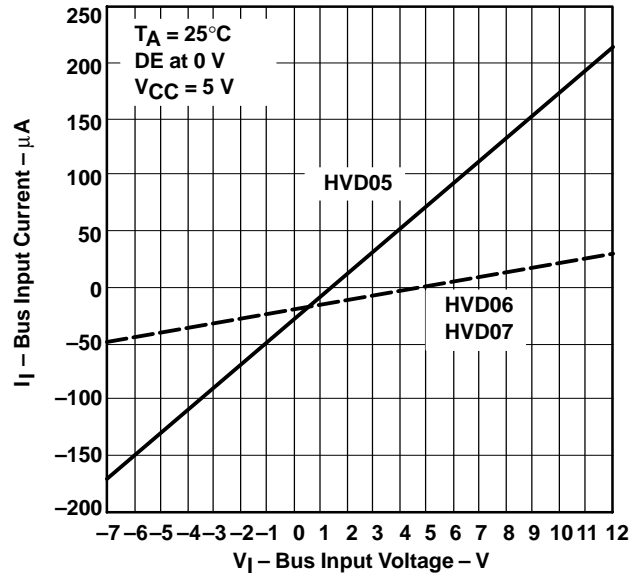


Figure 17

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

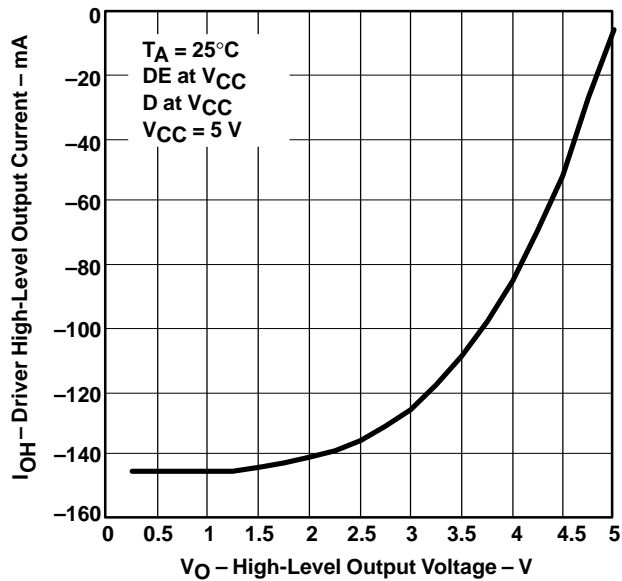


Figure 18

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

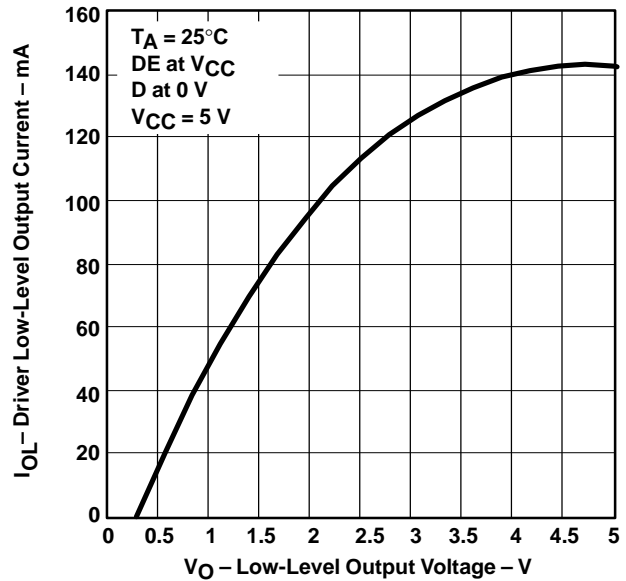


Figure 19

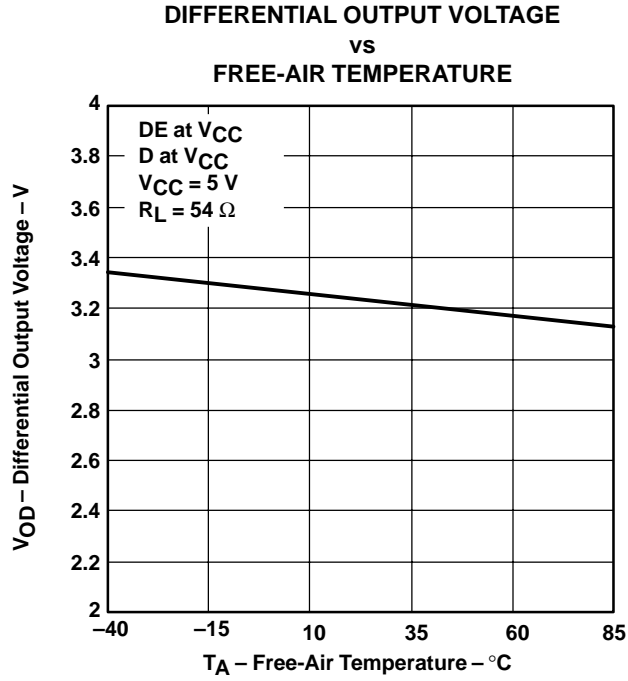


Figure 20

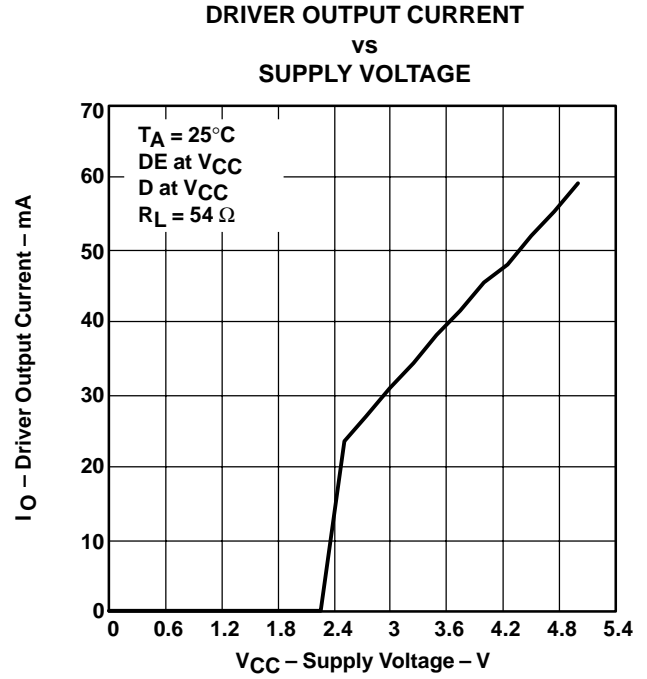


Figure 21

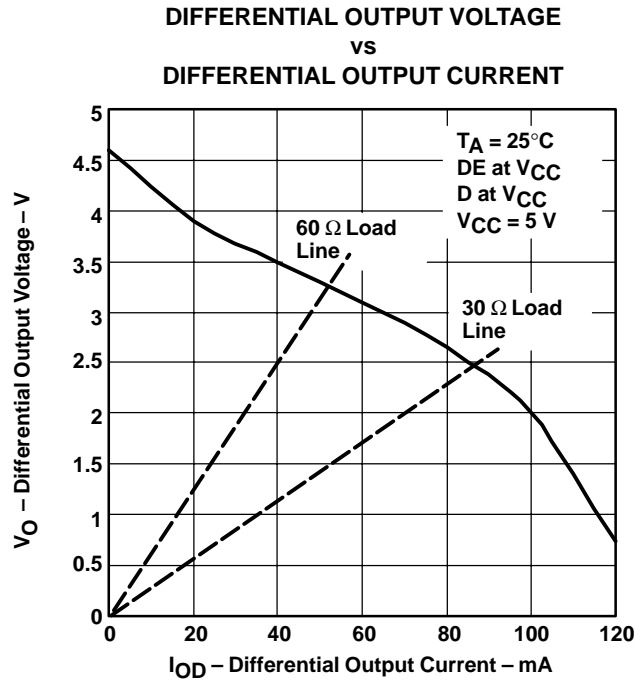
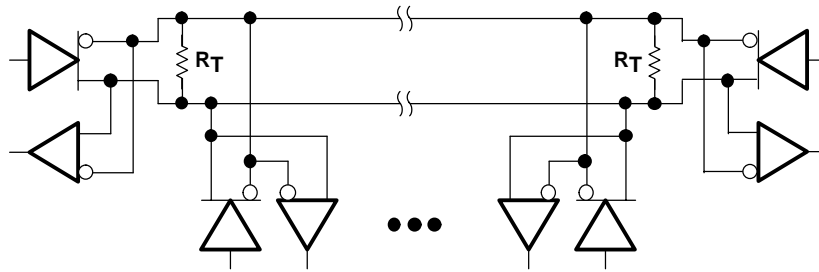


Figure 22

APPLICATION INFORMATION



Device	Number of Devices on Bus
HVD05	64
HVD06	256
HVD07	256

NOTE: The line should be terminated at both ends with its characteristic impedance ($R_T = Z_0$). Stub lengths off the main line should be kept as short as possible.

Figure 23. Typical Application Circuit

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE

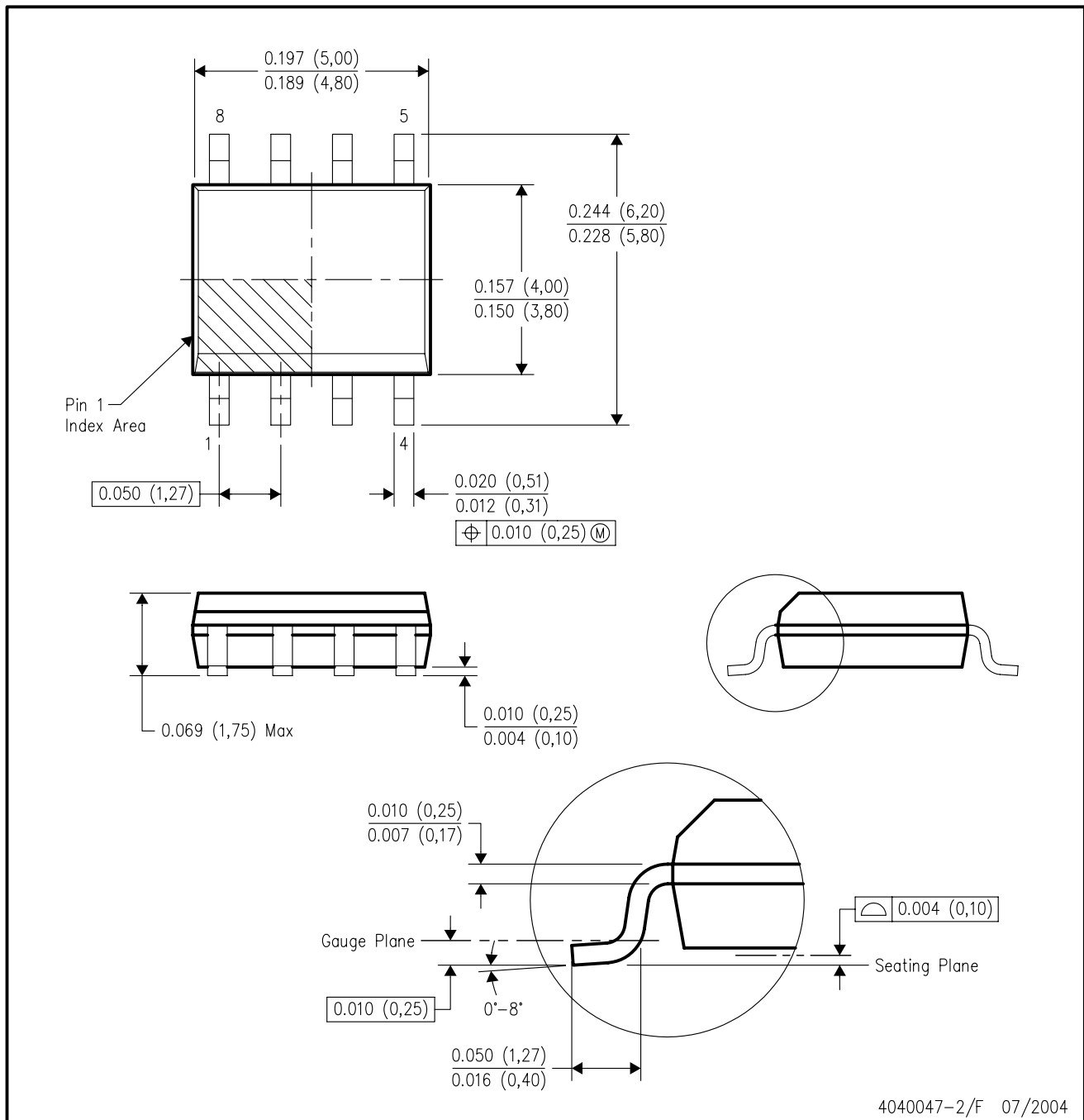


- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- 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 variation AA.

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 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.

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.

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

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265