

## 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
- 1/8<sup>th</sup> 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

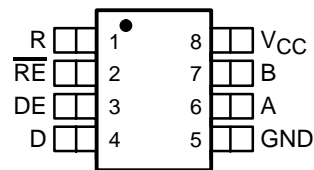
- Data Transmission Over Long or Lossy Lines or Electrically Noisy Environments
- Profibus Line Interface
- Industrial Process Control Networks
- Point-of-Sale (POS) Networks
- Electric Utility Metering
- Building Automation
- Digital Motor Control

### 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.

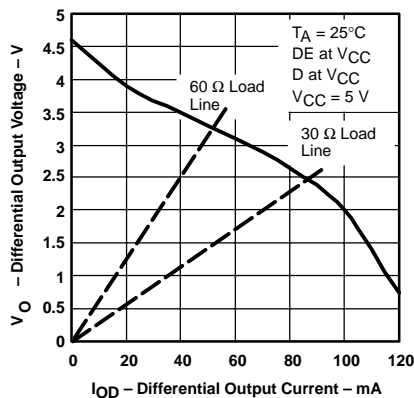
**D OR P PACKAGE  
(TOP VIEW)**



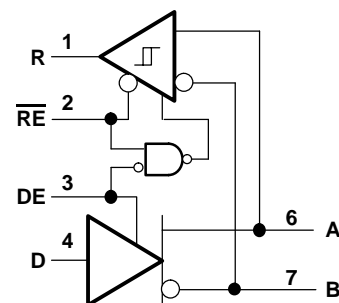
**DIFFERENTIAL OUTPUT VOLTAGE**

**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 <sub>A</sub>	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](http://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 <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR(1) ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 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 <sub>CC</sub>			–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 $\overline{RE}$			–0.5 V to V <sub>CC</sub> + 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 <sub>stg</sub>			–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 <sup>(1)</sup>		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<sup>(1)</sup>

PARAMETER		TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	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		-0.1		0.1	V
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	HVD05		600		mV
		HVD06		500		
		HVD07		900		
$I_{OZ}$	High-impedance output current	See receiver input currents				
$I_I$	Input current	D	-100		0	$\mu$ 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		9	15	mA
		$\overline{RE}$ at $V_{CC}$ , D at $V_{CC}$ DE at 0 V, No load		1	5	$\mu$ A
		$\overline{RE}$ at 0 V, D & DE at $V_{CC}$ , No load		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 <sub>PLH</sub>	Propagation delay time, low-to-high-level output	HVD05	R <sub>L</sub> = 54 Ω, C <sub>L</sub> = 50 pF, See Figure 4		6.5	11	ns		
		HVD06			27	40			
		HVD07			250	400			
t <sub>PHL</sub>	Propagation delay time, high-to-low-level output	HVD05			6.5	11	ns		
		HVD06			27	40			
		HVD07			250	400			
t <sub>r</sub>	Differential output signal rise time	HVD05			2.7	3.6	6	ns	
		HVD06			18	28	55		
		HVD07			150	300	450		
t <sub>f</sub>	Differential output signal fall time	HVD05			2.7	3.6	6	ns	
		HVD06		18	28	55			
		HVD07		150	300	450			
t <sub>sk(p)</sub>	Pulse skew ( t <sub>PHL</sub> – t <sub>PLH</sub>  )	HVD05				2	ns		
		HVD06				2.5			
		HVD07				10			
t <sub>sk(pp)(2)</sub>	Part-to-part skew	HVD05				3.5	ns		
		HVD06				14			
		HVD07				100			
t <sub>PZH1</sub>	Propagation delay time, high-impedance-to-high-level output	HVD05	R <sub>E</sub> at 0 V, R <sub>L</sub> = 110 Ω, See Figure 5			25	ns		
		HVD06				45			
		HVD07				250			
t <sub>PHZ</sub>	Propagation delay time, high-level-to-high-impedance output	HVD05					25	ns	
		HVD06					60		
		HVD07					250		
t <sub>PZL1</sub>	Propagation delay time, high-impedance-to-low-level output	HVD05		R <sub>E</sub> at 0 V, R <sub>L</sub> = 110 Ω, See Figure 6			15	ns	
		HVD06							45
		HVD07							200
t <sub>PLZ</sub>	Propagation delay time, low-level-to-high-impedance output	HVD05						14	ns
		HVD06					90		
		HVD07					550		
t <sub>PZH2</sub>	Propagation delay time, standby-to-high-level output		R <sub>L</sub> = 110 Ω, R <sub>E</sub> at 3 V, See Figure 5				6	μs	
t <sub>PZL2</sub>	Propagation delay time, standby-to-low-level output		R <sub>L</sub> = 110 Ω, R <sub>E</sub> at 3 V, See Figure 6				6	μs	

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

(2) t<sub>sk(pp)</sub> 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 <sub>IT+</sub>	Positive-going input threshold voltage	I <sub>O</sub> = −8 mA			−0.01			V
V <sub>IT−</sub>	Negative-going input threshold voltage	I <sub>O</sub> = 8 mA			−0.2			V
V <sub>hys</sub>	Hysteresis voltage (V <sub>IT+</sub> − V <sub>IT−</sub> )				35			mV
V <sub>IK</sub>	Enable-input clamp voltage	I <sub>I</sub> = −18 mA			−1.5			V
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 200 mV,	I <sub>OH</sub> = −8 mA,	See Figure 7	4			V
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = −200 mV,	I <sub>OL</sub> = 8 mA,	See Figure 7	0.4			V
I <sub>OZ</sub>	High-impedance-state output current	V <sub>O</sub> = 0 or V <sub>CC</sub>		$\overline{\text{RE}}$ at V <sub>CC</sub>	−1		1	μA
I <sub>I</sub>	Bus input current	HVD05	Other input at 0 V	V <sub>A</sub> or V <sub>B</sub> = 12 V	0.23	0.5	mA	
				V <sub>A</sub> or V <sub>B</sub> = 12 V, V <sub>CC</sub> = 0 V	0.3	0.5		
				V <sub>A</sub> or V <sub>B</sub> = −7 V	−0.4	−0.13		
				V <sub>A</sub> or V <sub>B</sub> = −7 V, V <sub>CC</sub> = 0 V	−0.4	−0.15		
		HVD06, HVD07	Other input at 0 V	V <sub>A</sub> or V <sub>B</sub> = 12 V	0.06	0.1	mA	
				V <sub>A</sub> or V <sub>B</sub> = 12 V, V <sub>CC</sub> = 0 V	0.08	0.13		
				V <sub>A</sub> or V <sub>B</sub> = −7 V	−0.1	−0.05		
				V <sub>A</sub> or V <sub>B</sub> = −7 V, V <sub>CC</sub> = 0 V	−0.05	−0.03		
I <sub>IH</sub>	High-level input current, $\overline{\text{RE}}$	V <sub>IH</sub> = 2 V			−60	−26.4		μA
I <sub>IL</sub>	Low-level input current, $\overline{\text{RE}}$	V <sub>IL</sub> = 0.8 V			−60	−27.4		μA
C <sub>(diff)</sub>	Differential input capacitance	V <sub>I</sub> = 0.4 sin (4E6πt) + 0.5 V, DE at 0 V			16			pF
I <sub>CC</sub>	Supply current	RE at 0 V, D & DE at 0 V, No load	Receiver enabled and driver disabled		5	10		mA
		RE at V <sub>CC</sub> , DE at 0 V, D at V <sub>CC</sub> , No load	Receiver disabled and driver disabled (standby)		1	5		μA
		RE at 0 V, D & DE at V <sub>CC</sub> , 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 <sub>PLH</sub>	Propagation delay time, low-to-high-level output 1/2 UL	HVD05	V <sub>ID</sub> = –1.5 V to 1.5 V, C <sub>L</sub> = 15 pF, See Figure 8		14.6	25	ns
t <sub>PHL</sub>	Propagation delay time, high-to-low-level output 1/2 UL	HVD05			14.6	25	ns
t <sub>PLH</sub>	Propagation delay time, low-to-high-level output 1/8 UL	HVD06			55	70	ns
		HVD07			55	70	
t <sub>PHL</sub>	Propagation delay time, high-to-low-level output 1/8 UL	HVD06			55	70	ns
		HVD07			55	70	
t <sub>sk(p)</sub>	Pulse skew ( t <sub>PHL</sub> – t <sub>PLH</sub>  )	HVD05				2	ns
		HVD06				4.5	
		HVD07				4.5	
t <sub>sk(pp)</sub> (2)	Part-to-part skew	HVD05				6.5	ns
		HVD06				14	
		HVD07				14	
t <sub>r</sub>	Output signal rise time		C <sub>L</sub> = 15 pF, See Figure 8		2	3	ns
t <sub>f</sub>	Output signal fall time				2	3	
t <sub>PZH1</sub>	Output enable time to high level		C <sub>L</sub> = 15 pF, DE at 3 V, See Figure 9			10	ns
t <sub>PZL1</sub>	Output enable time to low level					10	
t <sub>PHZ</sub>	Output disable time from high level					15	
t <sub>PLZ</sub>	Output disable time from low level					15	
t <sub>PZH2</sub>	Propagation delay time, standby-to-high-level output		C <sub>L</sub> = 15 pF, DE at 0, See Figure 10			6	μs
t <sub>PZL2</sub>	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<sub>sk(pp)</sub> 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

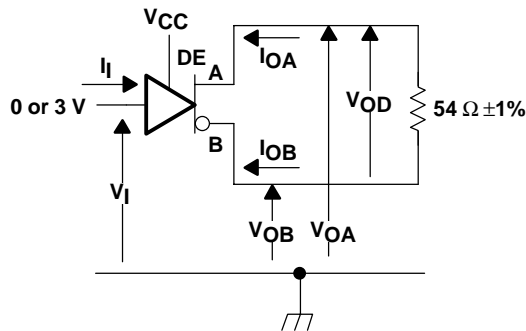


Figure 1. Driver  $V_{OD}$  Test Circuit and Voltage and Current Definitions

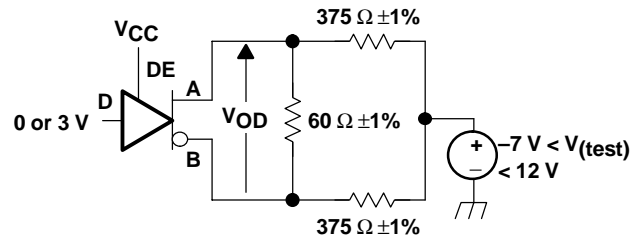
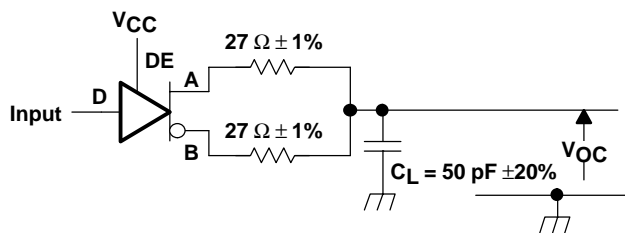


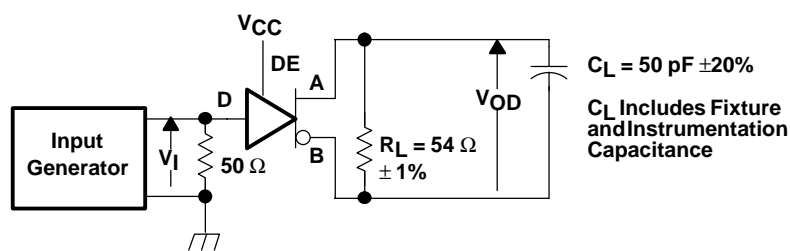
Figure 2. Driver  $V_{OD}$  With Common-Mode Loading Test Circuit



$C_L$  Includes Fixture and Instrumentation Capacitance

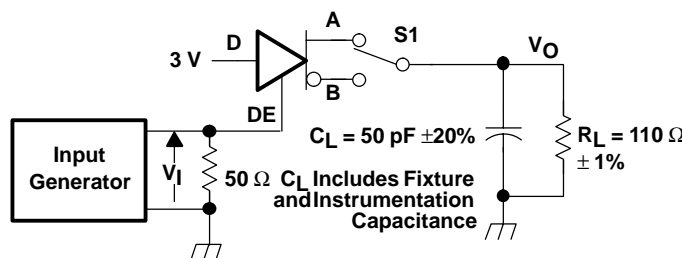
Input: PRR = 500 kHz, 50% Duty Cycle,  $t_r < 6$  ns,  $t_f < 6$  ns,  $Z_O = 50 \Omega$

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,  $Z_O = 50 \Omega$

Figure 4. Driver Switching Test Circuit and Voltage Waveforms



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

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

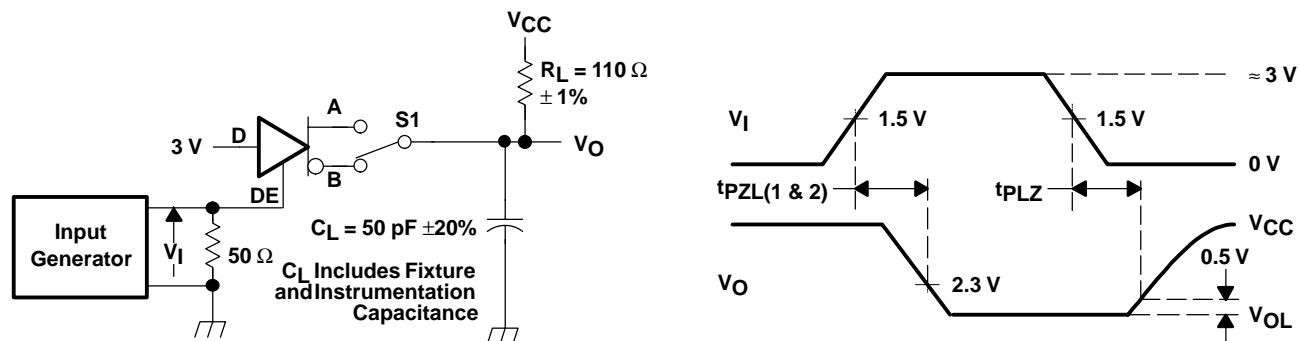


Figure 6. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

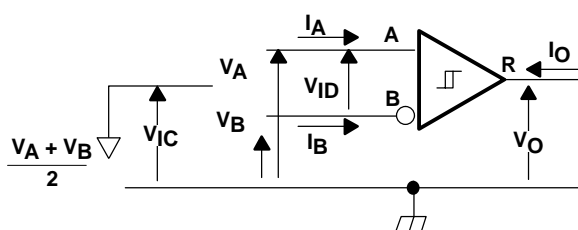


Figure 7. Receiver Voltage and Current Definitions

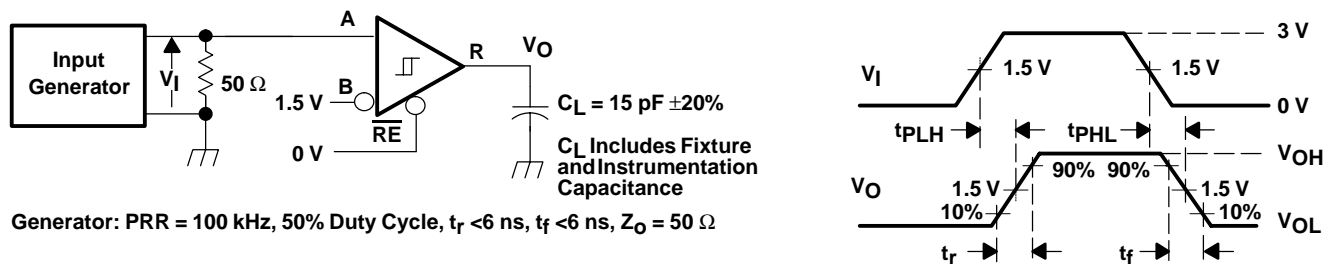


Figure 8. Receiver Switching Test Circuit and Voltage Waveforms



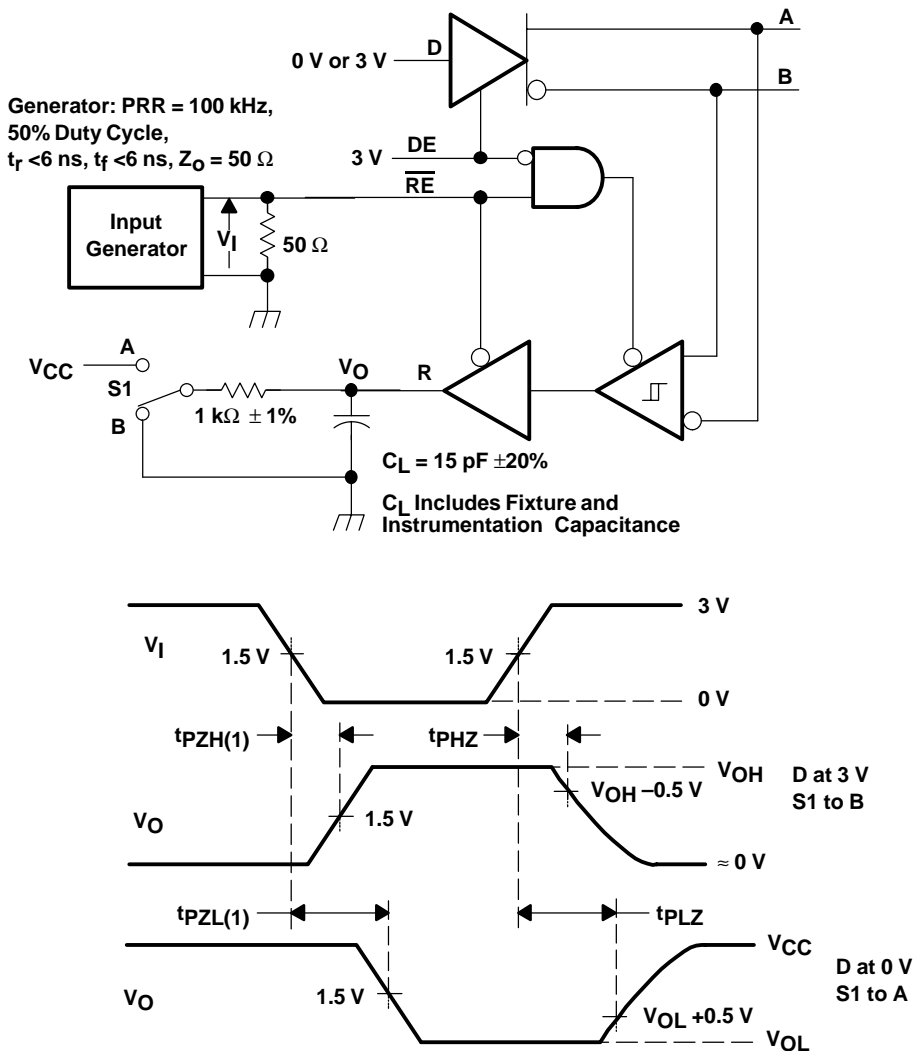


Figure 9. Receiver Enable and Disable Time Test Circuit and Voltage Waveforms With Drivers Enabled

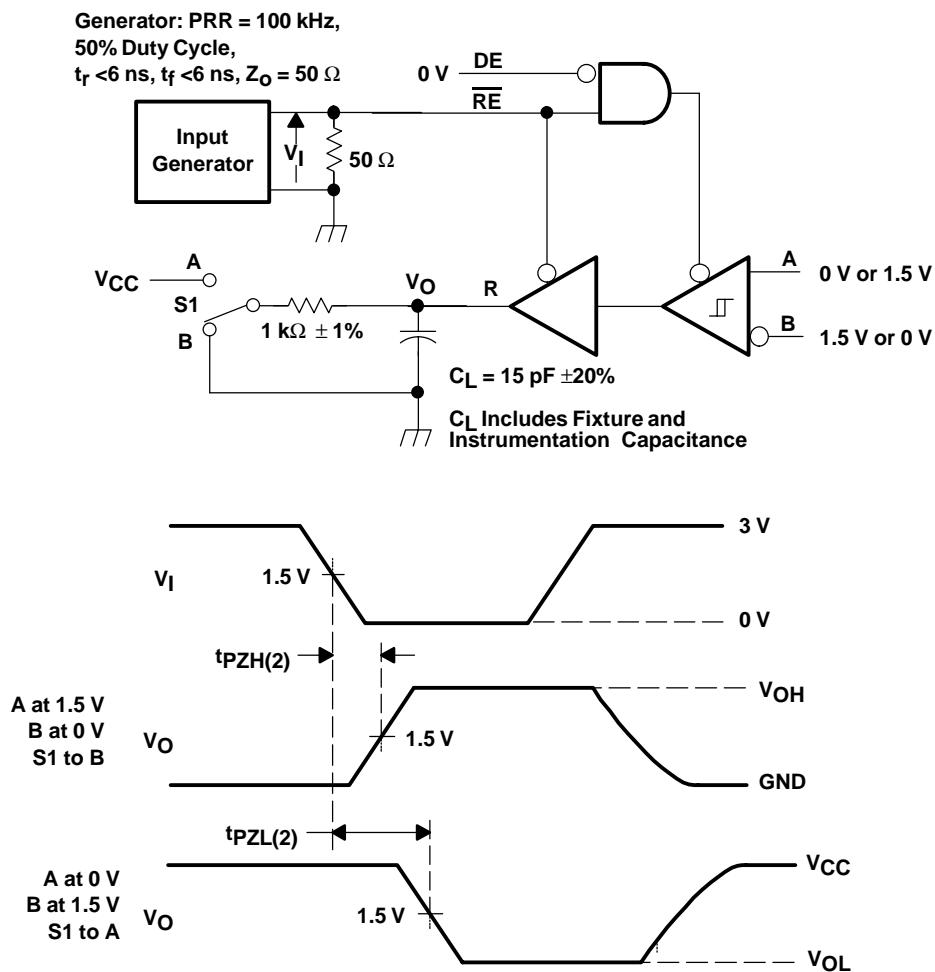
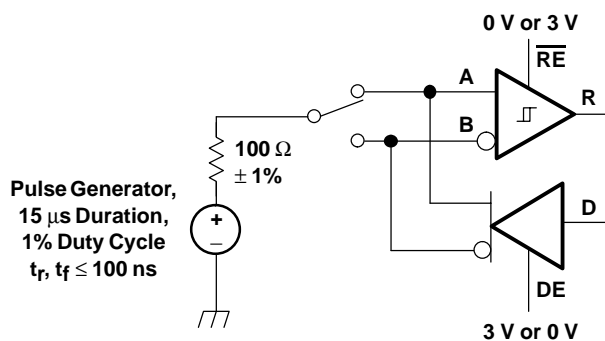


Figure 10. Receiver Enable Time From Standby (Driver Disabled)



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

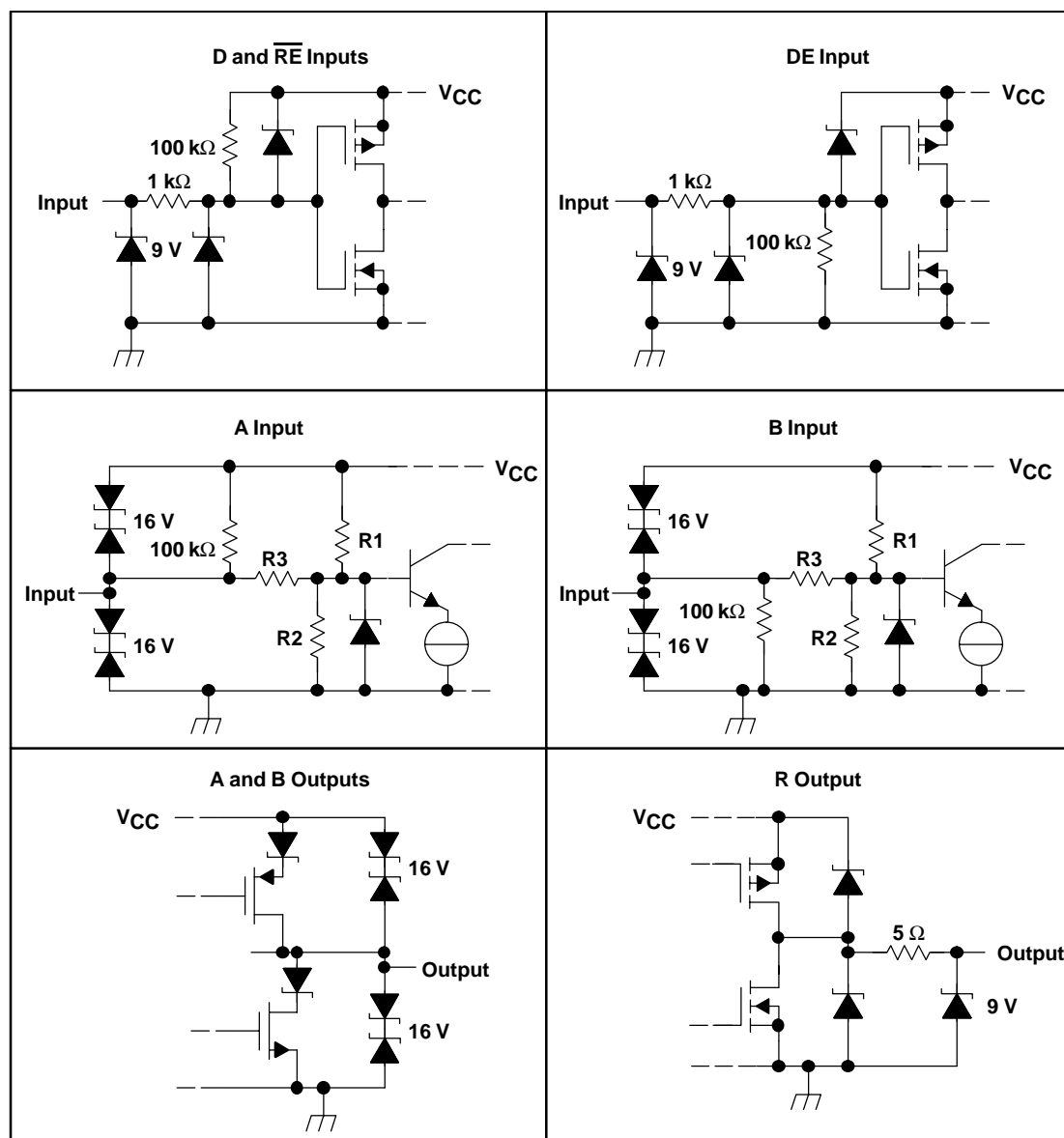
INPUT	ENABLE	OUTPUTS	
D	DE	A	B
H	H	H	L
L	H	L	H
X	L	Z	Z
Open	H	H	L
X	Open	Z	Z

### RECEIVER

DIFFERENTIAL INPUTS $V_{ID} = V_A - V_B$	ENABLE $\overline{RE}$	OUTPUT 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

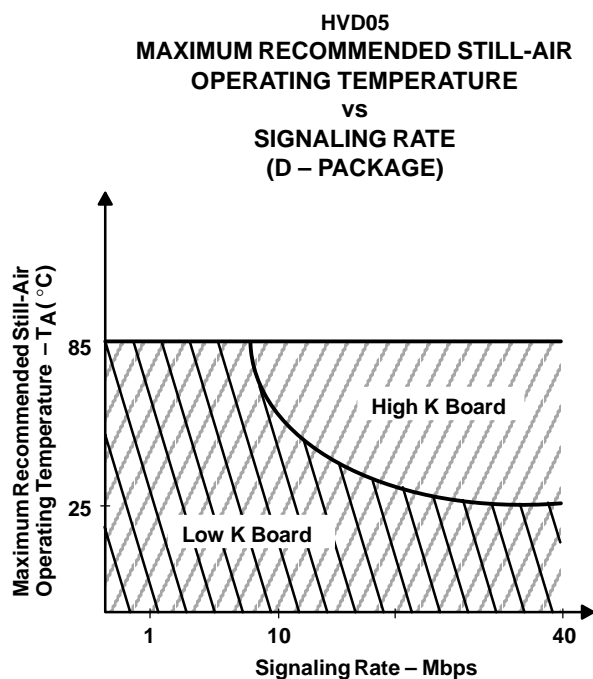


Figure 12

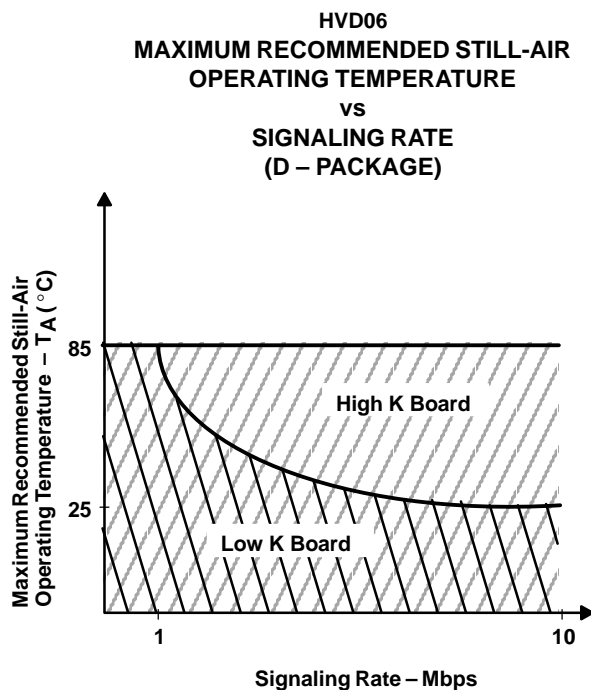


Figure 13

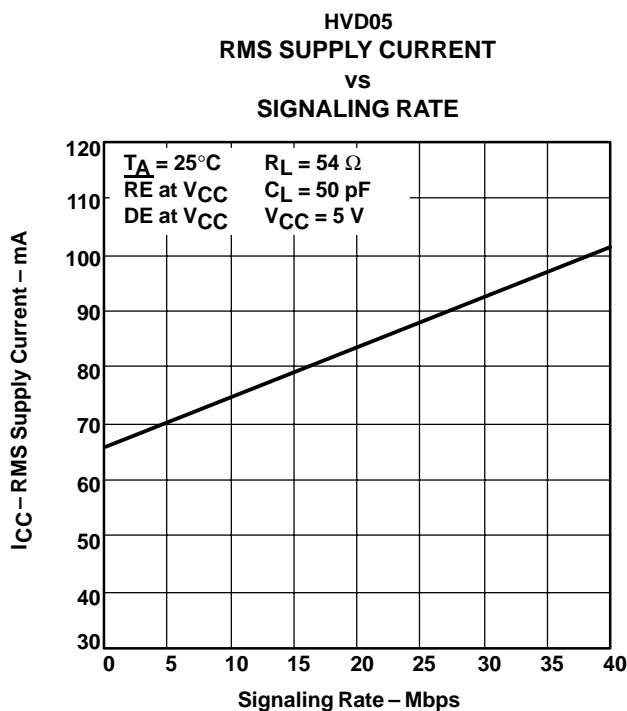


Figure 14

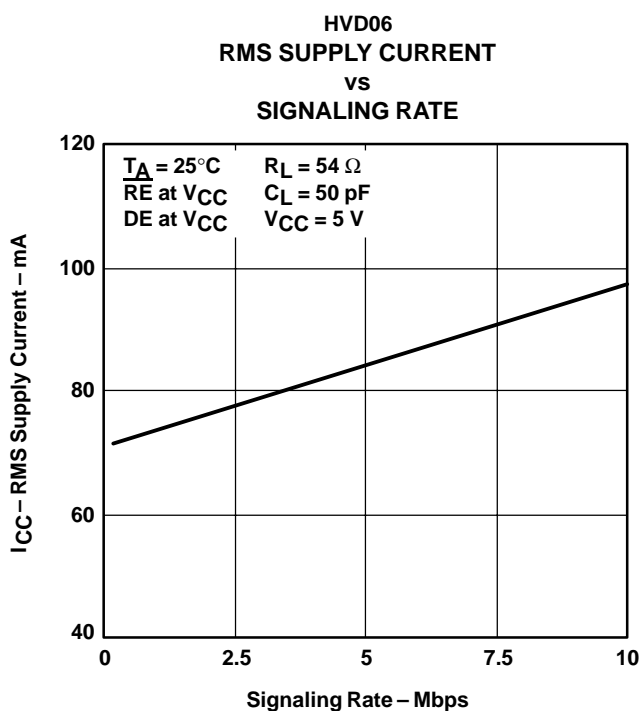


Figure 15

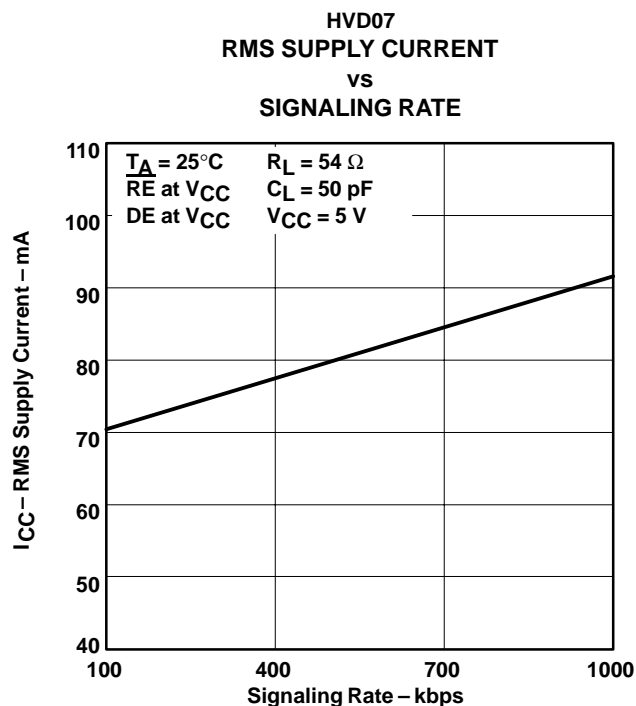


Figure 16

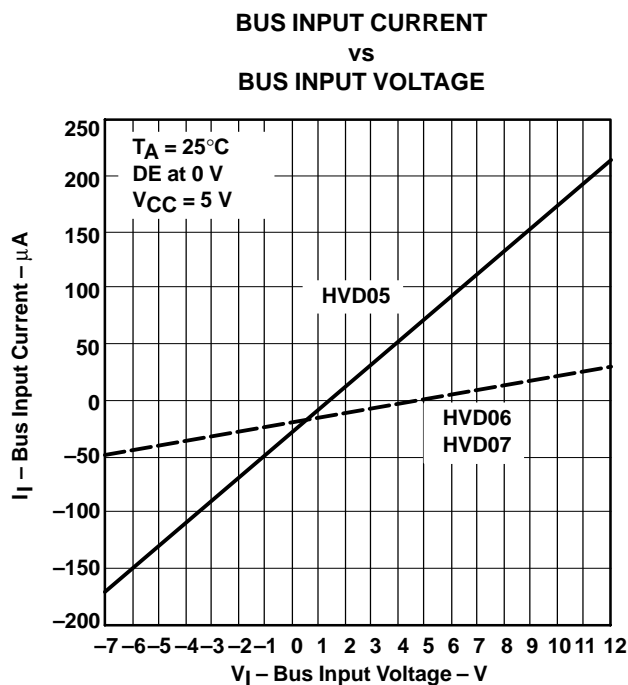


Figure 17

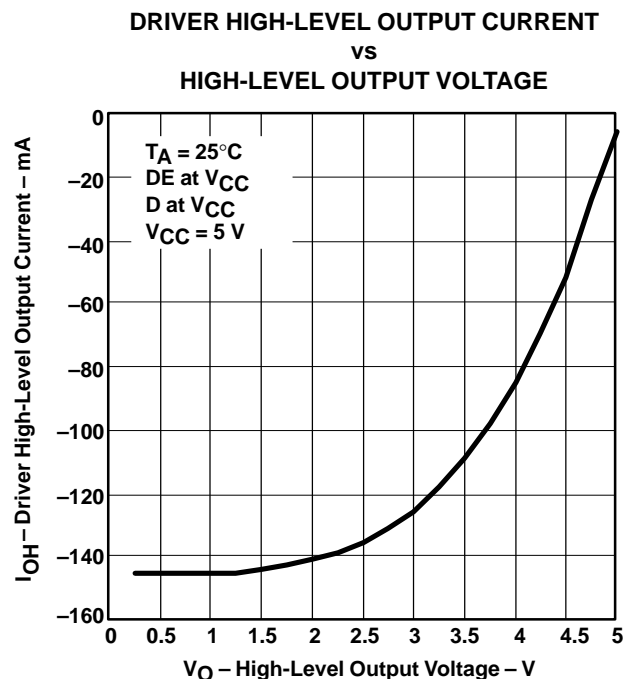


Figure 18

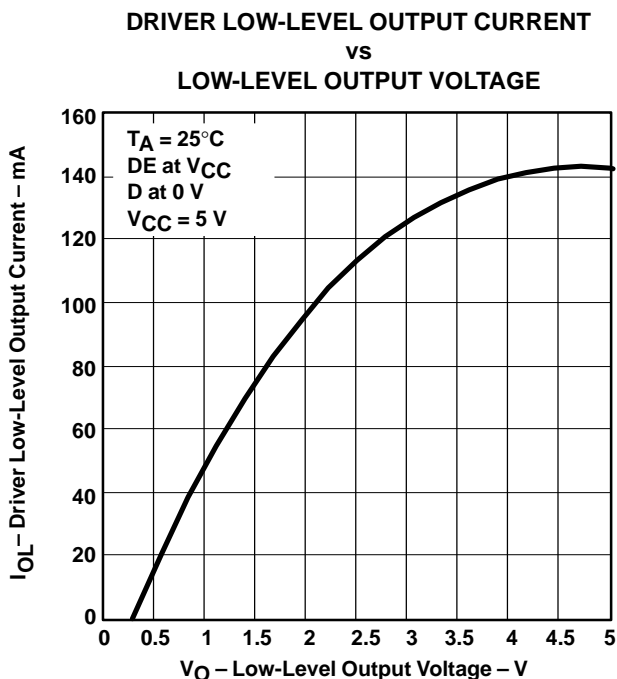


Figure 19

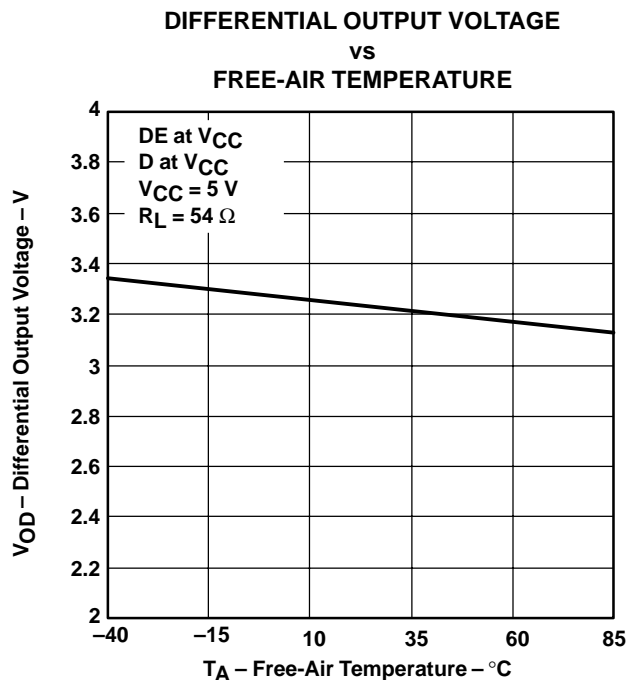


Figure 20

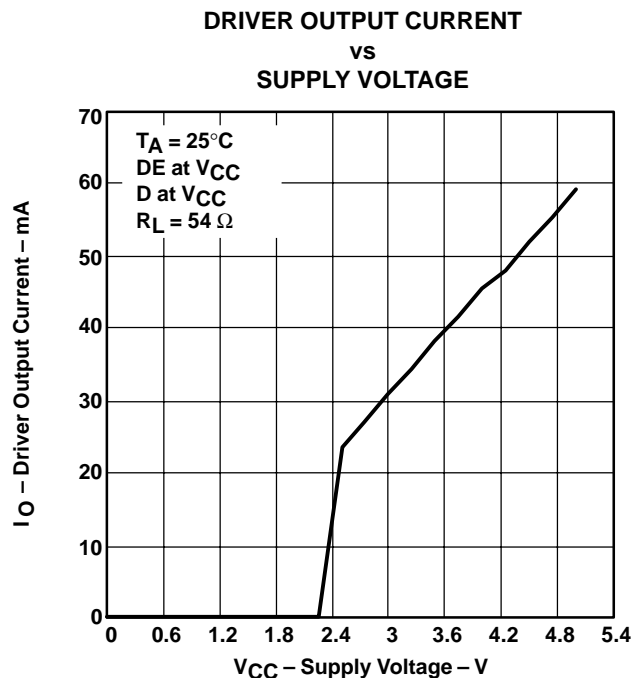


Figure 21

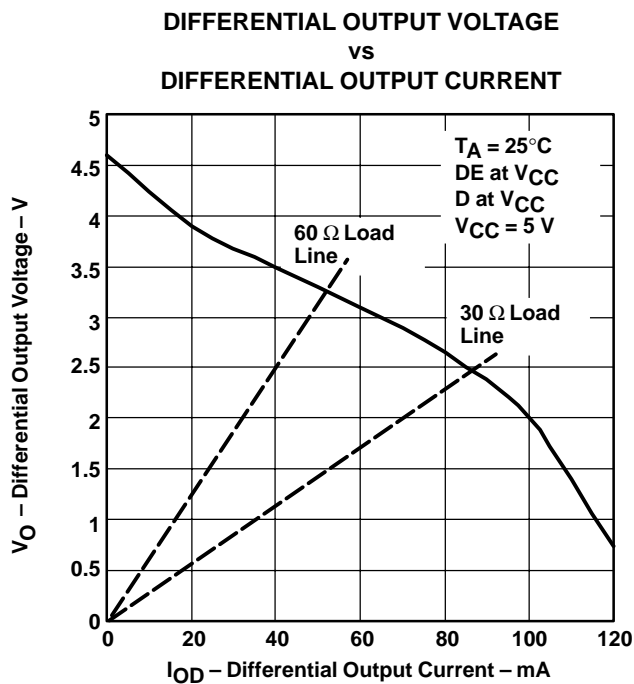
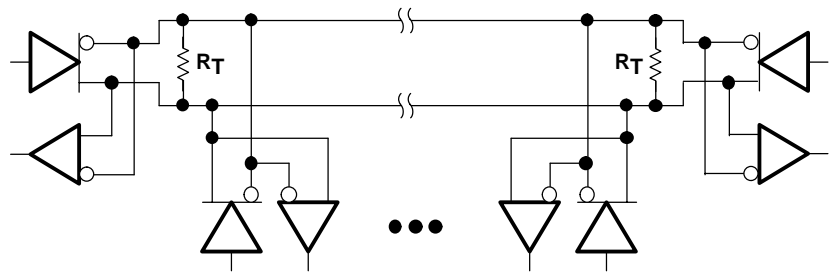


Figure 22

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

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## D (R-PDSO-G8)

## PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MS-012 variation AA.

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