HIGH OUTPUT FULL-DUPLEX RS-485 DRIVERS AND RECEIVERS

FEATURES

- **1/8 Unit-Load Option Available (Up to 256 Nodes on the Bus)**
- **Bus-Pin ESD Protection Exceeds 15 kV HBM**
- **Optional Driver Output Transition Times for Signaling Rates(1) of 1 Mbps, 5 Mbps and 25 Mbps**
- **Low-Current Standby Mode < 1 μA**
- **Glitch-Free Power-Up and Power-Down Bus I/Os**
- **Bus Idle, Open, and Short Circuit Failsafe**
- **Designed for RS-422 and RS485 Networks**
- **3.3-V Devices Available, SN65HVD30-39**

(1) The signaling rate of a line is the number of voltage transitions that are made per second expressed in the units bps (bits per second).

APPLICATIONS

- **Utility Meters**
- **Chassis-to-Chassis Interconnects**
- **DTE/DCE Interfaces**
- **Industrial, Process, and Building Automation**
- **Point-of-Sale (POS) Terminals and Networks**

DESCRIPTION

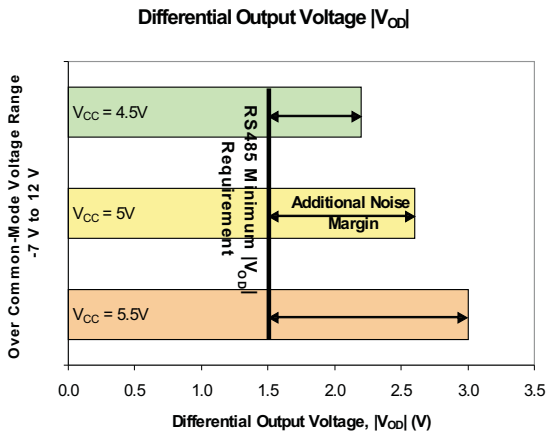
The SN65HVD5X devices are 3-state differential line drivers and differential-input line receivers that operate with a 5-V power supply. Each driver and receiver has separate input and output pins for full-duplex bus communication designs. They are designed for balanced transmission lines and interoperation with ANSI TIA/EIA-485A, TIA/EIA-422-B, ITU-T v.11 and ISO 8482:1993 standard-compliant devices.

The SN65HVD50, SN65HVD51, SN65HVD52, SN65HVD56 and SN65HVD57 are fully enabled with no external enabling pins.

The SN65HVD53, SN65HVD54, SN65HVD55, SN65HVD58, and SN65HVD59 have active-high driver enables and active-low receiver enables. A low, less than 1 μA, standby current is achieved by disabling both the driver and receiver.

All devices are characterized for operation from –40°C to 85°C.

The high output feature of the SN65HVD5x provides more noise margin than the typical RS-485 drivers. The extra noise margin makes applications in long cable and harsh noise environments possible.



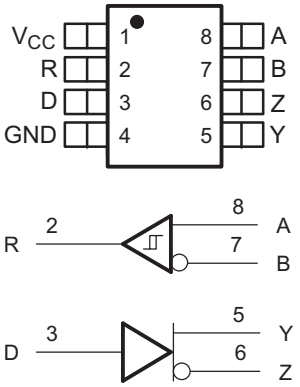
The SN65HVD56 and SN65HVD58 implement receiver equalization technology for improved jitter performance on differential bus applications with data rates up to 20 Mbps at cable lengths up to 160 meters.

The SN65HVD57 and SN65HVD59 implement receiver equalization technology for improved jitter performance on differential bus applications with data rates in the range of 1 to 5 Mbps at cable lengths up to 1000 meters.

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.

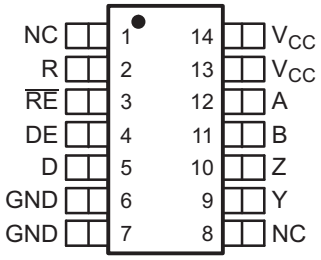
SN65HVD50, SN65HVD51, SN65HVD52, SN65HVD56, SN65HVD57

D PACKAGE (TOP VIEW)

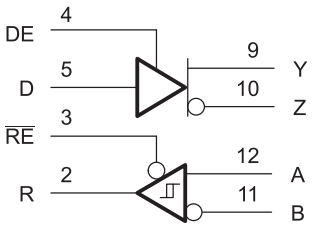


SN65HVD53, SN65HVD54, SN65HVD55, SN65HVD58, SN65HVD59

D PACKAGE (TOP VIEW)



NC - No internal connection



AVAILABLE OPTIONS

SIGNALING RATE	UNIT LOADS	RECEIVER EQUALIZATION	ENABLES	BASE PART NUMBER	SOIC MARKING
25 Mbps		No	No	SN65HVD50	65HVD50
5 Mbps	1/8	No	No	SN65HVD51	65HVD51
1 Mbps	1/8	No	No	SN65HVD52	65HVD52
25 Mbps		No	Yes	SN65HVD53	65HVD53
5 Mbps	1/8	No	Yes	SN65HVD54	65HVD54
1 Mbps	1/8	No	Yes	SN65HVD55	65HVD55
25 Mbps		Yes	No	SN65HVD56	PREVIEW
5 Mbps	1/8	Yes	No	SN65HVD57	PREVIEW
25 Mbps		Yes	Yes	SN65HVD58	PREVIEW
5 Mbps	1/8	Yes	Yes	SN65HVD59	PREVIEW

ABSOLUTE MAXIMUM RATINGS

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

		UNIT
V_{CC}	Supply voltage range	–0.3 V to 6 V
$V_{(A)}$, $V_{(B)}$, $V_{(Y)}$, $V_{(Z)}$	Voltage range at any bus terminal (A, B, Y, Z)	–9 V to 14 V
$V_{(TRANS)}$	Voltage input, transient pulse through 100 Ω. See Figure 12 (A, B, Y, Z)(3)	–50 to 50 V
V_I	Voltage input range (D, DE, $\overline{RE}$)	-0.5 V to 7 V
$P_{D(cont)}$	Continuous total power dissipation	Internally limited(4)
I_O	Output current (receiver output only, R)	11 mA

(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) This tests survivability only and the output state of the receiver is not specified.
(4) The thermal shutdown typically occurs when the junction temperature reaches 165°C.

RECOMMENDED OPERATING CONDITIONS

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

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4.5		5.5	V
V_I or V_{IC}	Voltage at any bus terminal (separately or common mode)		–7(1)		12	V
$1/t_{UI}$	Signaling rate	SN65HVD50, SN65HVD53, SN65HVD56, SN65HVD58			25	Mbps
		SN65HVD51, SN65HVD54, SN65HVD57, SN65HVD59			5	Mbps
		SN65HVD52, SN65HVD55			1	Mbps
R_L	Differential load resistance		54	60		Ω
V_{IH}	High-level input voltage	D, DE, $\overline{RE}$	2		V_{CC}	V
V_{IL}	Low-level input voltage	D, DE, $\overline{RE}$	0		0.8	V
V_{ID}	Differential input voltage		-12		12	V
I_{OH}	High-level output current	Driver	-60			mA
		Receiver	–8			mA
I_{OL}	Low-level output current	Driver			60	mA
		Receiver			8	mA
T_J(2)	Junction temperature		–40		150	°C

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.
(2) See thermal characteristics table for information regarding this specification.

ELECTROSTATIC DISCHARGE PROTECTION

PARAMETER	TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
Human body model	Bus terminals and GND		±16		kV
Human body model(2)	All pins		±4		kV
Charged-device-model(3)	All pins		±1		kV

(1) All typical values at 25°C and with a 5-V supply.
(2) Tested in accordance with JEDEC Standard 22, Test Method A114-A.
(3) Tested in accordance with JEDEC Standard 22, Test Method C101.

DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS		MIN	TYP(1)	MAX	UNIT
$V_{I(K)}$	Input clamp voltage		I_I = –18 mA		–1.5			V
$\|V_{OD(SS)}\|$	Steady-state differential output voltage		I_O = 0		4		V_{CC}	V
			R_L = 54 Ω, See Figure 1 (RS-485)		1.7	2.6		V
			R_L = 100 Ω, See Figure 1 (RS-422)		2.4	3.2		V
			V_{test} = –7 V to 12 V, See Figure 2		1.6			V
$\Delta\|V_{OD(SS)}\|$	Change in magnitude of steady-state differential output voltage between states		R_L = 54 Ω, See Figure 1 and Figure 2		–0.2		0.2	V
$V_{OD(RING)}$	Differential Output Voltage overshoot and undershoot		R_L = 54 Ω, C_L = 50 pF, See Figure 5 See Figure 3 for definition				10%(2)	V
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	HVD50, HVD53, HVD56, HVD58	See Figure 4			0.5		V
		HVD51, HVD54, HVD57, HVD59				0.4		V
		HVD52, HVD55				0.4		V
$V_{OC(SS)}$	Steady-state common-mode output voltage		See Figure 4		2.2		3.3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage				–0.1		0.1	V
$I_{Z(Z)}$ or $I_{Y(Z)}$	High-impedance state output current	HVD50, HVD51, HVD52, HVD56, HVD57	V_{CC} = 0 V, V_Z or V_Y = 12 V, Other input at 0 V				90	µA
			V_{CC} = 0 V, V_Z or V_Y = –7 V, Other input at 0 V		–10			µA
		HVD53, HVD54, HVD55, HVD58, HVD59	V_{CC} = 5 V or 0 V, DE = 0 V V_Z or V_Y = 12 V	Other input at 0 V			90	µA
			V_{CC} = 5 V or 0 V, DE = 0 V V_Z or V_Y = –7 V		–10			µA
$I_{Z(S)}$ or $I_{Y(S)}$	Short-circuit output current(3)		V_Z or V_Y = –7 V	Other input at 0 V	–250		250	mA
			V_Z or V_Y = 12 V		–250		250	mA
I_I	Input current	D, DE			0		100	µA
$C_{(OD)}$	Differential output capacitance		V_{OD} = 0.4 sin (4E6πt) + 0.5 V, DE at 0 V			16		pF

(1) All typical values are at 25°C and with a 5-V supply.
(2) 10% of the peak-to-peak differential output voltage swing, per TIA/EIA-485
(3) Under some conditions of short-circuit to negative voltages, output currents exceeding the ANSI TIA/EIA-485-A maximum current of 250 mA may occur. Continuous exposure may affect device reliability.

DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	HVD50, HVD53, HVD56, HVD58	R_L = 54 Ω, C_L = 50 pF, See Figure 5	4	8	12	ns
		HVD51, HVD54, HVD57, HVD59		20	29	46	
		HVD52, HVD55		90	143	230	
t_{PHL}	Propagation delay time, high-to-low-level output	HVD50, HVD53, HVD56, HVD58		4	8	12	ns
		HVD51, HVD54, HVD57, HVD59		20	30	46	
		HVD52, HVD55		90	143	230	
t_r	Differential output signal rise time	HVD50, HVD53, HVD56, HVD58		3	6	12	ns
		HVD51, HVD54, HVD57, HVD59		20	34	60	
		HVD52, HVD55		120	197	300	
t_f	Differential output signal fall time	HVD50, HVD53, HVD56, HVD58		3	6	11	ns
		HVD51, HVD54, HVD57, HVD59		20	33	60	
		HVD52, HVD55		120	192	300	
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)	HVD50, HVD53, HVD56, HVD58			1.4		ns
		HVD51, HVD54, HVD57, HVD59			1.6		
		HVD52, HVD55			7.4		
$t_{sk(pp)}$ (2)	Part-to-part skew	HVD50, HVD53, HVD56, HVD58			1		ns
		HVD51, HVD54, HVD57, HVD59			4		
		HVD52, HVD55			22		
t_{PZH1}	Propagation delay time, high-impedance-to-high-level output	HVD53, HVD58	R_L = 110 Ω, $\overline{RE}$ at 0 V, See Figure 6 D = 3 V and S1 = Y, D = 0 V and S1 = Z			30	ns
		HVD54, HVD59				180	
		HVD55				380	
t_{PHZ}	Propagation delay time, high-level-to-high-impedance output	HVD53, HVD58				16	ns
		HVD54, HVD59				40	
		HVD55				110	
t_{PZL1}	Propagation delay time, high-impedance-to-low-level output	HVD53, HVD58	R_L = 110 Ω, $\overline{RE}$ at 0 V, See Figure 7 D = 3 V and S1 = Z, D = 0 V and S1 = Y			23	ns
		HVD54, HVD59				200	
		HVD55				420	
t_{PLZ}	Propagation delay time, low-level-to-high-impedance output	HVD53, HVD58				19	ns
		HVD54, HVD59				70	
		HVD55				160	
t_{PZH2}	Propagation delay time, standby-to-high-level output		R_L = 110 Ω, $\overline{RE}$ at 3 V, See Figure 6 D = 3 V and S1 = Y, D = 0 V and S1 = Z			3300	ns
t_{PZL2}	Propagation delay time, standby-to-low-level output		R_L = 110 Ω, $\overline{RE}$ at 3 V, See Figure 7 D = 3 V and S1 = Z, D = 0 V and S1 = Y			3300	ns

(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 recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS		MIN	TYP(1)	MAX	UNIT
V_{IT+}	Positive-going differential input threshold voltage		I_O = –8 mA				–0.02	V
V_{IT-}	Negative-going differential input threshold voltage		I_O = 8 mA		–0.2			V
V_{hys}	Hysteresis voltage (V_{IT+} - V_{IT-})					50		mV
V_{IK}	Enable-input clamp voltage		I_I = –18 mA		–1.5			V
V_O	Output voltage		V_{ID} = 200 mV, I_O = –8 mA, See Figure 8		4			V
			V_{ID} = –200 mV, I_O = 8 mA, See Figure 8				0.3	
$I_{O(Z)}$	High-impedance-state output current		V_O = 0 or V_{CC} $\overline{RE}$ at V_{CC}		–1		1	µA
I_A or I_B	Bus input current	HVD50, HVD53, HVD56, HVD58	V_A or V_B = 12 V	Other input at 0 V		0.19	0.3	mA
			V_A or V_B = 12 V, V_{CC} = 0 V			0.24	0.4	
			V_A or V_B = -7 V		–0.35	–0.19		
			V_A or V_B = -7 V, V_{CC} = 0 V		–0.25	–0.14		
		HVD51, HVD52, HVD54, HVD55, HVD57, HVD59	V_A or V_B = 12 V	Other input at 0 V		0.05	0.1	mA
			V_A or V_B = 12 V, V_{CC} = 0 V			0.06	0.1	
			V_A or V_B = -7 V		–0.1	–0.05		
			V_A or V_B = -7 V, V_{CC} = 0 V		–0.1	–0.03		
I_{IH}	Input current, $\overline{RE}$		V_{IH} = 2 V		–60			µA
			V_{IL} = 0.8 V		–60			µA
C_{ID}	Differential input capacitance		V_{ID} = 0.4 sin (4E6πt) + 0.5 V, DE at 0 V			16		pF
Supply Current								
I_{CC}	Supply current	HVD50	D at 0 V or V_{CC} and No Load				2.7	mA
		HVD51, HVD52					8	
		HVD56, HVD57					9.5	
		HVD53	$\overline{RE}$ at 0 V, D at 0 V or V_{CC}, DE at 0 V, No load (Receiver enabled and driver disabled)				2.3	
		HVD54, HVD55					2.9	
		HVD58, HVD59					4.5	
		HVD53, HVD54, HVD55, HVD58, HVD59	$\overline{RE}$ at V_{CC}, D at V_{CC}, DE at 0 V, No load (Receiver disabled and driver disabled)			0.08	1	µA
		HVD53	$\overline{RE}$ at 0 V, D at 0 V or V_{CC}, DE at V_{CC}, No load (Receiver enabled and driver enabled)				2.7	mA
		HVD54, HVD55					8	
		HVD58					4.3	
		HVD59					9.7	
		HVD53	$\overline{RE}$ at V_{CC}, D at 0 V or V_{CC}, DE at V_{CC} No load (Receiver disabled and driver enabled)				2.3	
		HVD54, HVD55					7.7	
		HVD58					3.2	
		HVD59					8.5	

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

RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions unless otherwise noted

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	HVD50, HVD53, HVD56, HVD58	V_{ID} = -1.5 V to 1.5 V, C_L = 15 pF, See Figure 9		24	40	ns
		HVD51, HVD52, HVD54, HVD55, HVD57, HVD59			43	55	
t_{PHL}	Propagation delay time, high-to-low-level output	HVD50, HVD53, HVD56, HVD58			26	35	
		HVD51, HVD52, HVD54, HVD55, HVD57, HVD59			47	60	
$t_{sk(p)}$	Pulse skew ($\lvert t_{PHL} - t_{PLH} \rvert$)	HVD50, HVD53, HVD56, HVD57, HVD58, HVD59				5	
		HVD51, HVD54, HVD52, HVD55				7	
$t_{sk(pp)}$ (2)	Part-to-part skew	HVD50, HVD53, HVD56, HVD58			5		
		HVD51, HVD54, HVD57, HVD59			6		
		HVD52, HVD55			6		
t_r	Output signal rise time				2.3	4	
t_f	Output signal fall time				2.4	4	
t_{PHZ}	Output disable time from high level		DE at 3 V, C_L = 15 pF See Figure 10			17	
t_{PZH1}	Output enable time to high level					10	
t_{PZH2}	Propagation delay time, standby-to-high-level output		DE at 0 V, C_L = 15 pF See Figure 10			3300	
t_{PLZ}	Output disable time from low level		DE at 3 V, C_L = 15 pF See Figure 11			13	
t_{PZL1}	Output enable time to low level					10	
t_{PZL2}	Propagation delay time, standby-to-low-level output		DE at 0 V, C_L = 15 pF See Figure 11			3300	

(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 EQUALIZATION CHARACTERISTICS

over recommended operating conditions unless otherwise noted(1)

PARAMETER		TEST CONDITIONS				MIN	TYP(2)	MAX	UNIT
$t_{j(pp)}$	Peak-to-peak eye-pattern jitter	Pseudo-random NRZ code with a bit pattern length o 216-1, Belden 3105A cable	25 Mbps	0 m	HVD56, HVD58		PREVIEW		ns
				100 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
				150 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
				200 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
			10 Mbps	200 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
				250 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
				300 m	HVD53		PREVIEW		
					HVD56, HVD58		PREVIEW		
			5 Mbps	500 m	HVD54		PREVIEW		
					HVD57, HVD59		PREVIEW		
			3 Mbps	500 m	HVD53		PREVIEW		
					HVD54		PREVIEW		
					HVD56, HVD58		PREVIEW		
					HVD57, HVD59		PREVIEW		
			1 Mbps	1000 m	HVD54		PREVIEW		
					HVD57, HVD59		PREVIEW		

(1) The HVD53 and HVD54 do not have receiver equalization but are specified for comparison.
(2) All typical values are at V_{CC} = 5 V, and temperature = 25°C.

THERMAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
θ_{JA}	Junction−to−ambient thermal resistance(2)	Low-K board(3), No airflow	HVD50, HVD51, HVD52, HVD56, HVD57		230.8		°C/W
			HVD53, HVD54, HVD55, HVD58, HVD59		162.6		
	Junction−to−ambient thermal resistance(2)	High-K board(4), No airflow	HVD50, HVD51, HVD52, HVD56, HVD57		135.1		
			HVD53, HVD54, HVD55, HVD58, HVD59		92.1		
θ_{JB}	Junction−to−board thermal resistance	High-K board	HVD50, HVD51, HVD52, HVD56, HVD57		44.4		
			HVD53, HVD54, HVD55, HVD58, HVD59		61.1		
θ_{JC}	Junction−to−case thermal resistance	No board	HVD50, HVD51, HVD52, HVD56, HVD57		43.5		
			HVD53, HVD54, HVD55, HVD58, HVD59		58.6		
P_D	Device power dissipation	R_L= 60Ω, C_L = 50 pF, Input to D a 50% duty cycle square wave at indicated signaling rate	HVD50, HVD56 (25Mbps)			420	mW
			HVD51, HVD57 (10Mbps)			404	
			HVD52 (1Mbps)			383	
		R_L= 60Ω, C_L = 50 pF, DE at V_{CC} $\overline{RE}$ at 0 V, Input to D a 50% duty cycle square wave at indicated signaling rate	HVD53, HVD58 (25Mbps)			420	
			HVD54, HVD59 (10Mbps)			404	
			HVD55 (1Mbps)			383	
T_A	Ambient air temperature	Low-K board, No airflow	HVD50, HVD56	–40		55	°C
			HVD51, HVD52, HVD57	–40		84	
			HVD53, HVD54, HVD55, HVD58, HVD59	–40		85	
		High-K board, No airflow	HVD50, HVD51, HVD52, HVD56, HVD57	–40		85	
			HVD53, HVD54, HVD55, HVD58, HVD59	–40		85	
T_{JSD}	Thermal shutdown junction temperature				165		

(1) See *Application Information* section for an explanation of these parameters.
(2) The intent of θ_{JA} specification is solely for a thermal performance comparison of one package to another in a standardized environment. This methodology is not meant to and will not predict the performance of a package in an application-specific environment.
(3) In accordance with the Low-K thermal metric definitions of EIA/JESD51-3.
(4) In accordance with the High-K thermal metric definitions of EIA/JESD51-7.

PARAMETER MEASUREMENT INFORMATION

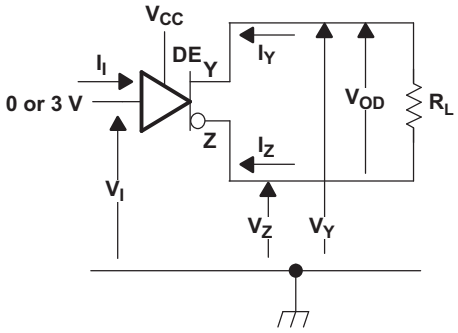


Figure 1. Driver V_{OD} Test Circuit: Voltage and Current Definitions

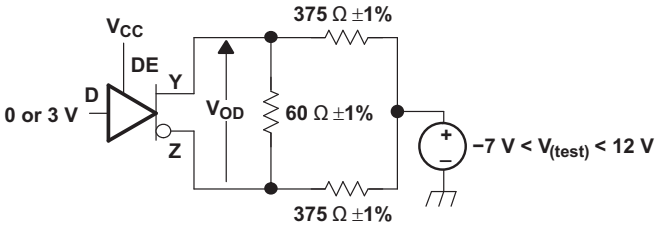


Figure 2. Driver V_{OD} With Common-Mode Loading Test Circuit

PARAMETER MEASUREMENT INFORMATION (continued)

VOD(RING) is measured at four points on the output waveform, corresponding to overshoot and undershoot from the VOD(H) and VOD(L) steady state values.

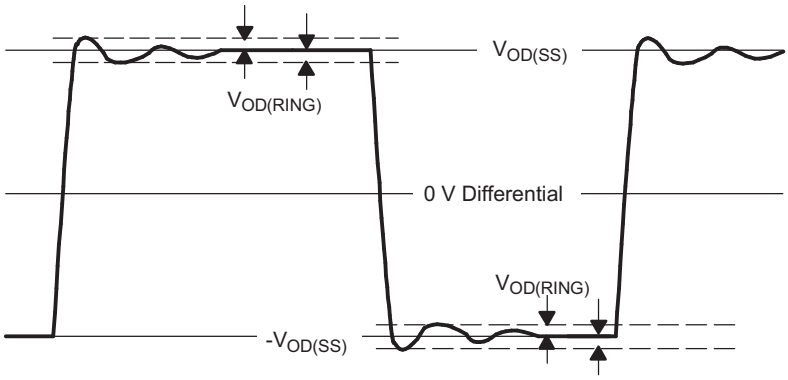
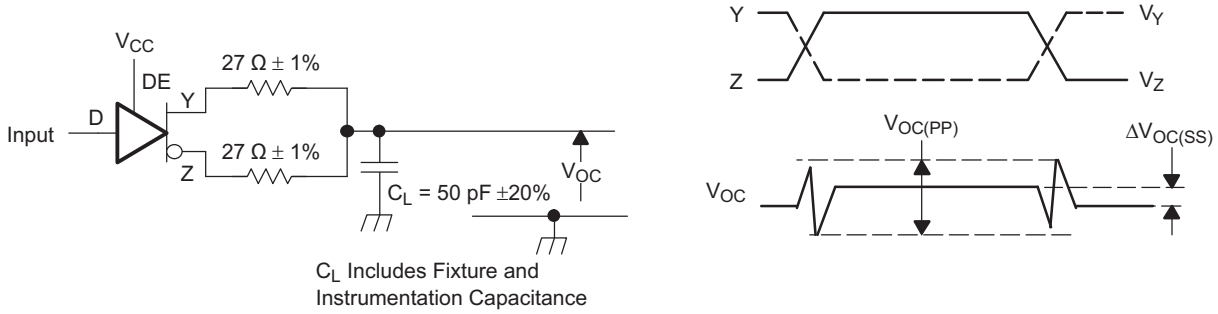
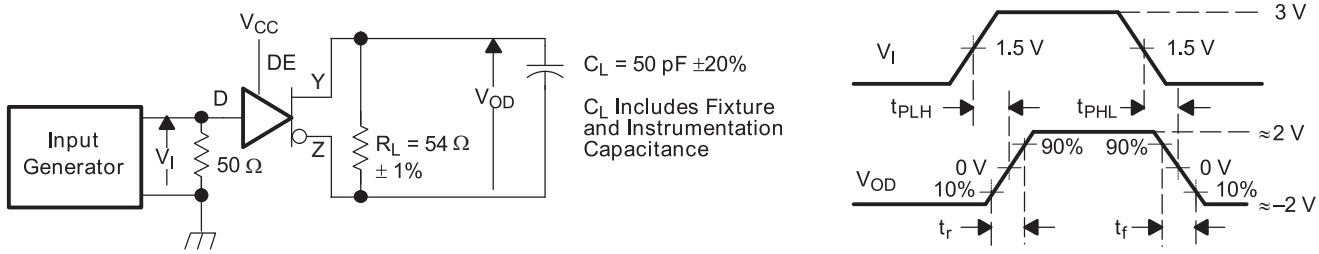


Figure 3. $V_{OD(RING)}$ Waveform and Definitions



Input: PRR = 500 kHz, 50% Duty Cycle,t $_r$<6ns, t_f<6ns, Z_O = 50 Ω

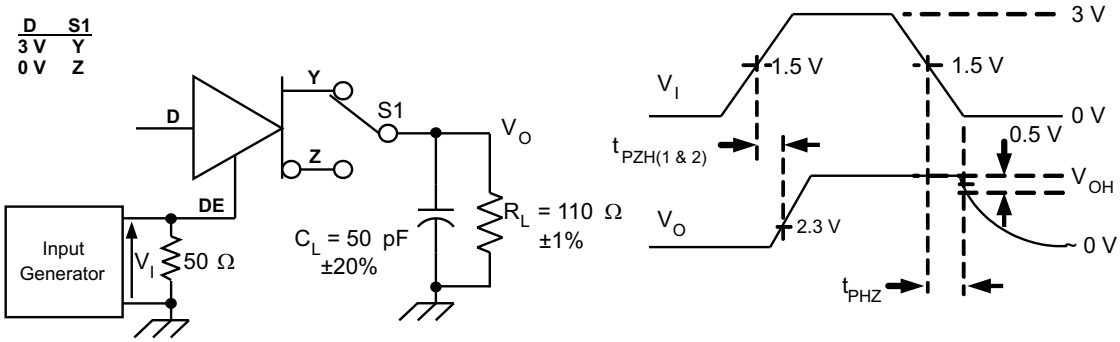
Figure 4. Test Circuit and Definitions for the Driver Common-Mode Output Voltage



Generator: PRR = 500 kHz, 50% Duty Cycle, t_r <6 ns, t_f <6 ns, Z_o = 50 Ω

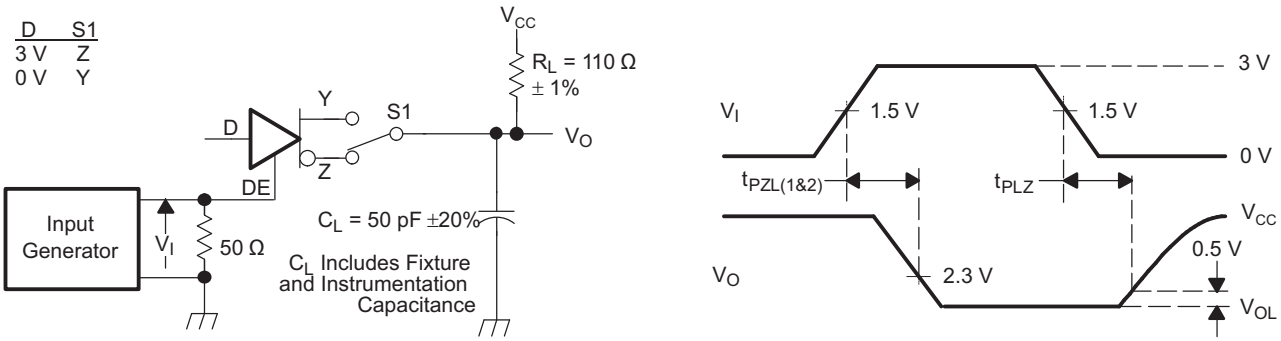
Figure 5. Driver Switching Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION (continued)



Generator: PRR = 500kHz, 50% Duty Cycle, t_r<6 ns, t_f < 6ns, Z_0 = 50 Ω
C_L Includes Fixture and Instrumentation Capacitance

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



Generator: PRR = 500 kHz, 50% Duty Cycle, t_r <6 ns, t_f <6 ns, Z_o = 50 Ω

Figure 7. Driver Low-Level Output Enable and Disable Time Test Circuit and Voltage Waveforms

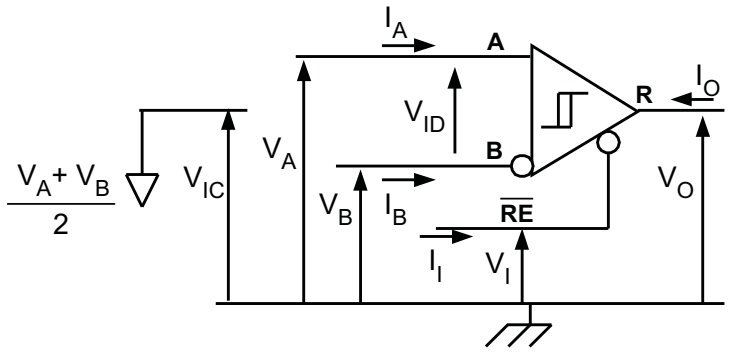


Figure 8. Receiver Voltage and Current Definitions

PARAMETER MEASUREMENT INFORMATION (continued)

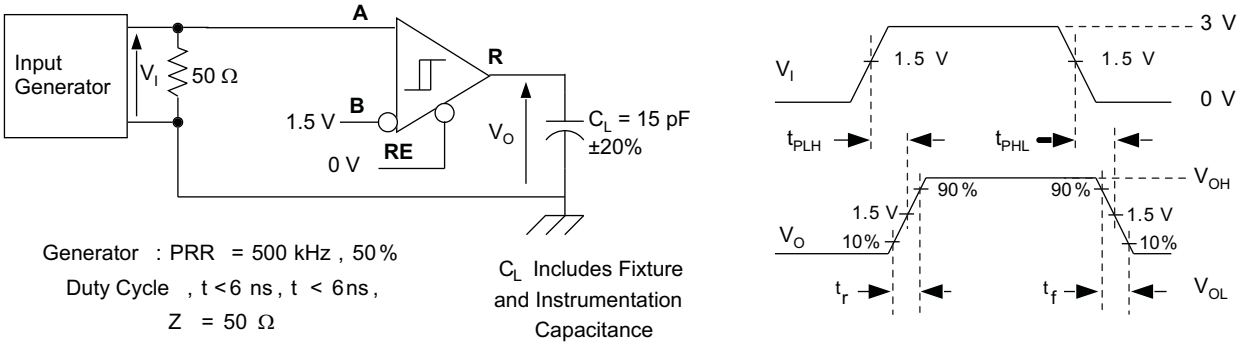
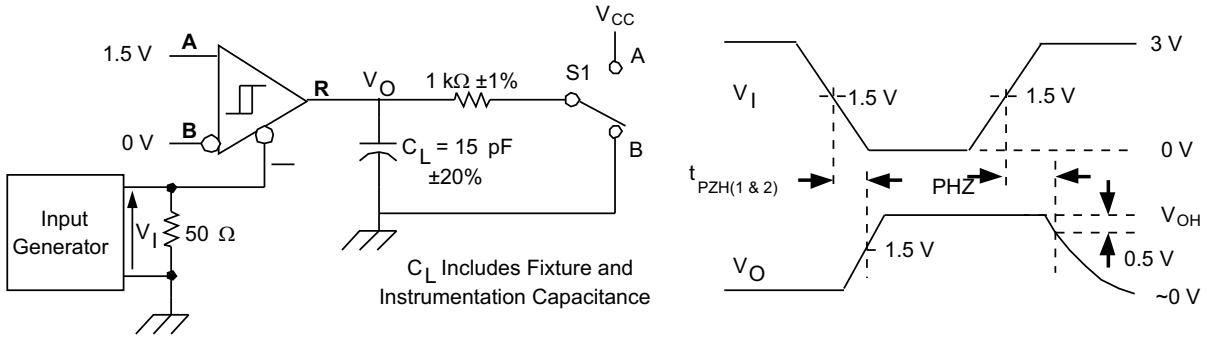
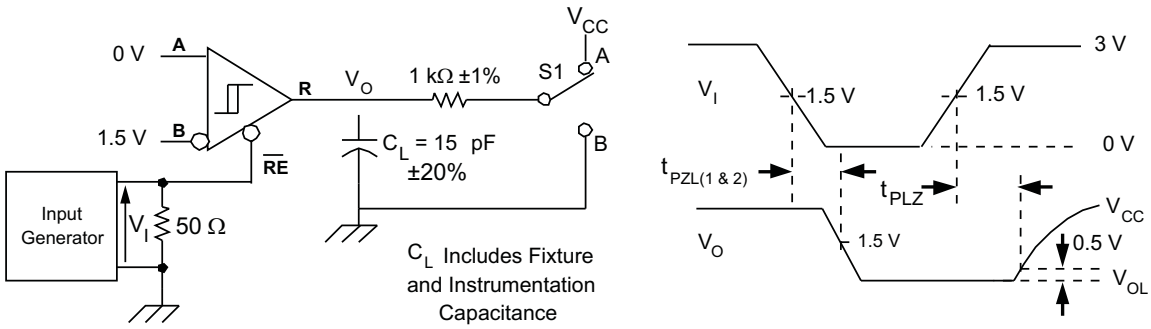


Figure 9. Receiver Switching Test Circuit and Voltage Waveforms



Generator: P_{RR} = 500 kHz, 50%, Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

Figure 10. Receiver High-Level Enable and Disable Time Test Circuit and Voltage Waveforms



Generator: P_{RR} = 500 kHz, 50%, Duty Cycle, t_r < 6 ns, t_f < 6 ns, Z_0 = 50 Ω

Figure 11. Receiver Low-Level Enable and Disable Time Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION (continued)

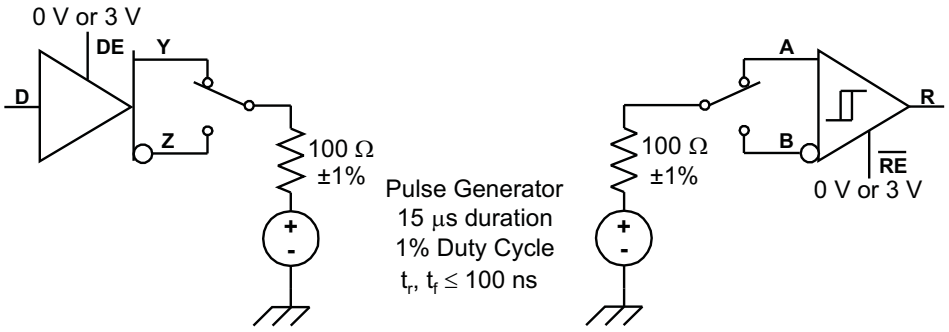


Figure 12. Test Circuit, Transient Overvoltage Test

DEVICE INFORMATION

LOW-POWER STANDBY MODE

When both the driver and receiver are disabled (DE low and $\overline{RE}$ high) the device is in standby mode. If the enable inputs are in this state for less than 60 ns, the device does not enter standby mode. This guards against inadvertently entering standby mode during driver/receiver enabling. Only when the enable inputs are held in this state for 300 ns or more, the device is assured to be in standby mode. In this low-power standby mode, most internal circuitry is powered down, and the supply current is typically less than 1 nA. When either the driver or the receiver is re-enabled, the internal circuitry becomes active.

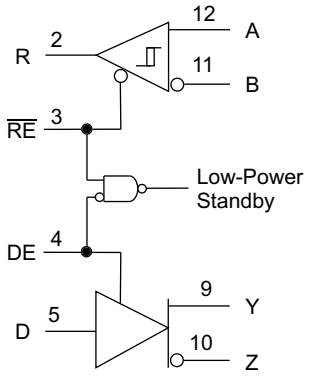


Figure 13. Low-Power Standby Logic Diagram

If only the driver is re-enabled (DE transitions to high) the driver outputs are driven according to the D input after the enable times given by t_{PZH2} and t_{PZL2} in the driver switching characteristics. If the D input is open when the driver is enabled, the driver outputs defaults to A high and B low, in accordance with the driver failsafe feature.

If only the receiver is re-enabled ($\overline{RE}$ transitions to low) the receiver output is driven according to the state of the bus inputs (A and B) after the enable times given by t_{PZH2} and t_{PZL2} in the receiver switching characteristics. If there is no valid state on the bus the receiver responds as described in the failsafe operation section.

If both the receiver and driver are re-enabled simultaneously, the receiver output is driven according to the state of the bus inputs (A and B) and the driver output is driven according to the D input. Note that the state of the active driver affects the inputs to the receiver. Therefore, the receiver outputs are valid as soon as the driver outputs are valid.

FUNCTION TABLES

SN65HVD53, SN65HVD54, SN65HVD55, SN65HVD58, SN65HVD59 DRIVER

INPUTS		OUTPUTS	
D	**DE**	**Y**	**Z**
H	H	H	L
L	H	L	H
X	L or open	Z	Z
Open	H	L	H

SN65HVD53, SN65HVD54, SN65HVD55, SN65HVD58, SN65HVD59 RECEIVER

DIFFERENTIAL INPUTS $V_{ID} = V_{(A)} - V_{(B)}$	ENABLE $\overline{RE}$	OUTPUT R
$V_{ID} \le -0.2$ V	L	L
-0.2 V $< V_{ID} < -0.02$ V	L	?
-0.02 V $\le V_{ID}$	L	H
X	H or open	Z
Open Circuit	L	H
Idle circuit	L	H
Short Circuit, $V_{(A)} = V_{(B)}$	L	H

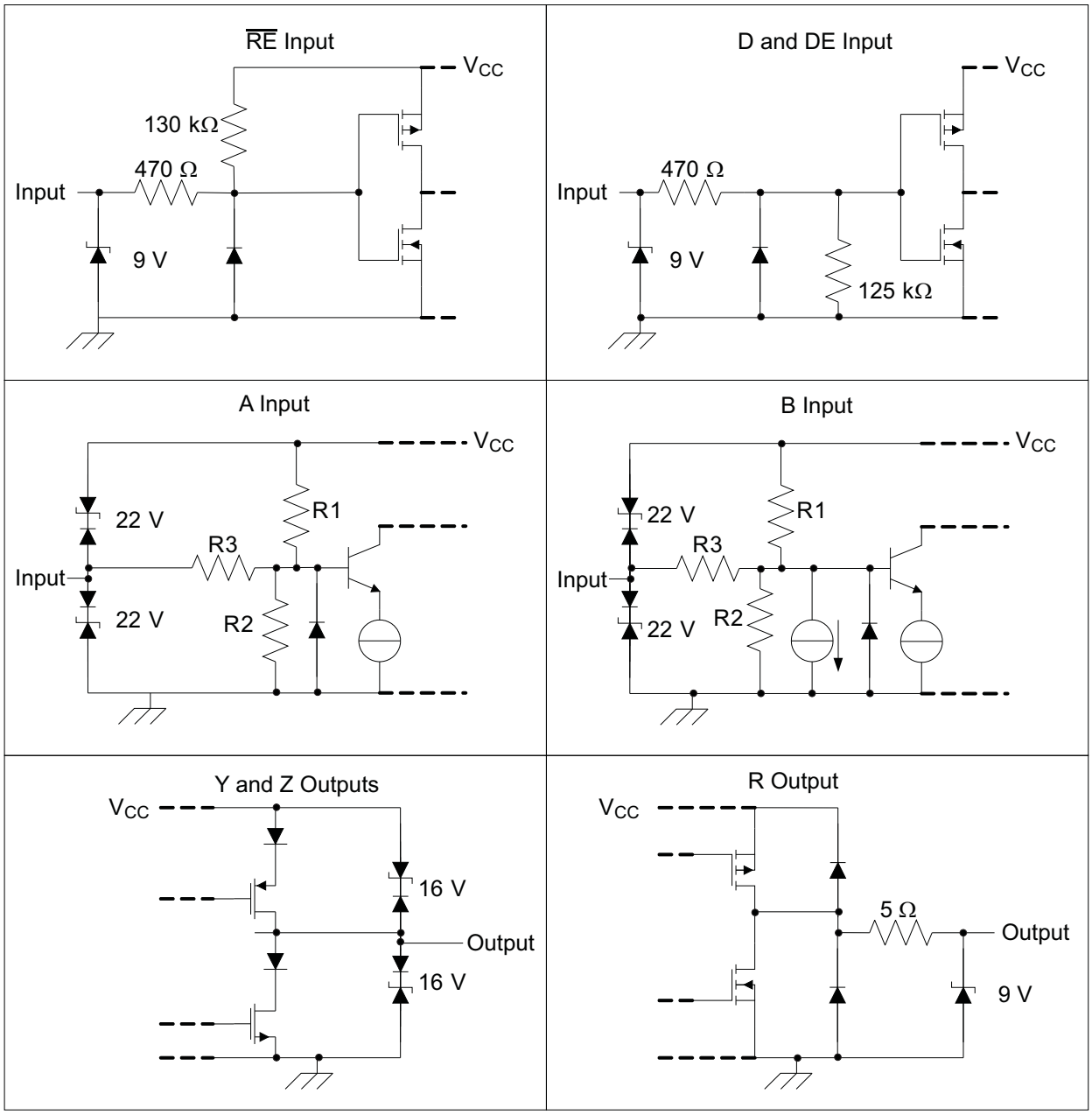
SN65HVD50, SN65HVD51, SN65HVD52, SN65HVD56, SN65HVD57 DRIVER

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

SN65HVD50, SN65HVD51, SN65HVD52, SN65HVD56, SN65HVD57 RECEIVER

DIFFERENTIAL INPUTS $V_{ID} = V_{(A)} - V_{(B)}$	OUTPUT R
$V_{ID} \le -0.2$ V	L
-0.2 V $< V_{ID} < -0.02$ V	?
-0.02 V $\le V_{ID}$	H
Open Circuit	H
Idle circuit	H
Short Circuit, $V_{(A)} = V_{(B)}$	H

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



	R1/R2	R3
SN65HVD50, SN65HVD53, SN65HVD56, SN65HVD58	9 kΩ	45 kΩ
SN65HVD51, SN65HVD52, SN65HVD54, SN65HVD55 SN65HVD57, SN65HVD58, SN65HVD59	36 kΩ	180 kΩ

TYPICAL CHARACTERISTICS

HVD50, HVD53
RMS SUPPLY CURRENT
vs
SIGNALING RATE

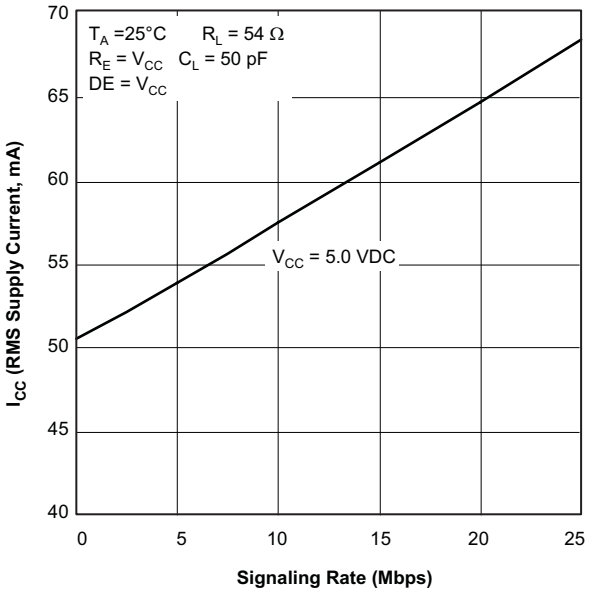


Figure 14.

HVD51, HVD54
RMS SUPPLY CURRENT
vs
SIGNALING RATE

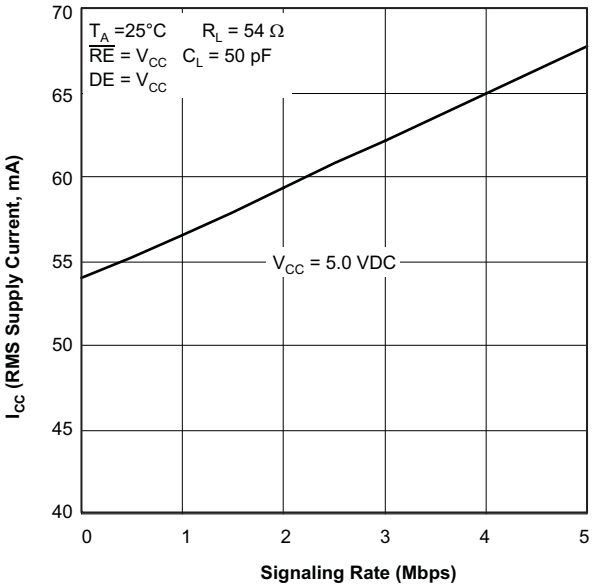


Figure 15.

HVD52, HVD55
RMS SUPPLY CURRENT
vs
SIGNALING RATE

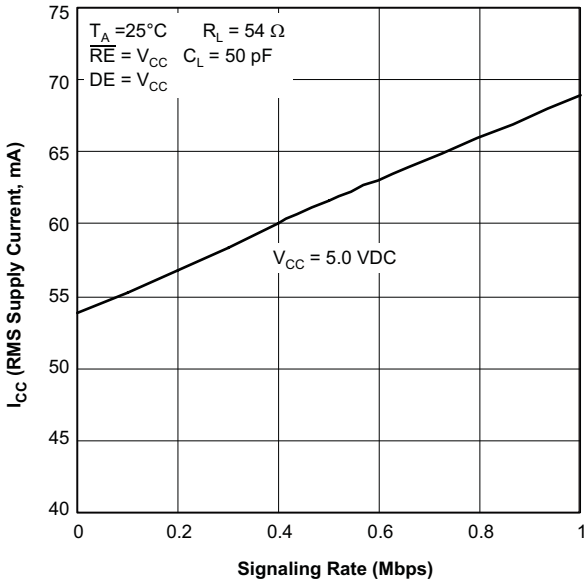


Figure 16.

TYPICAL CHARACTERISTICS (continued)

HVD50, HVD53
BUS INPUT CURRENT
vs
INPUT VOLTAGE

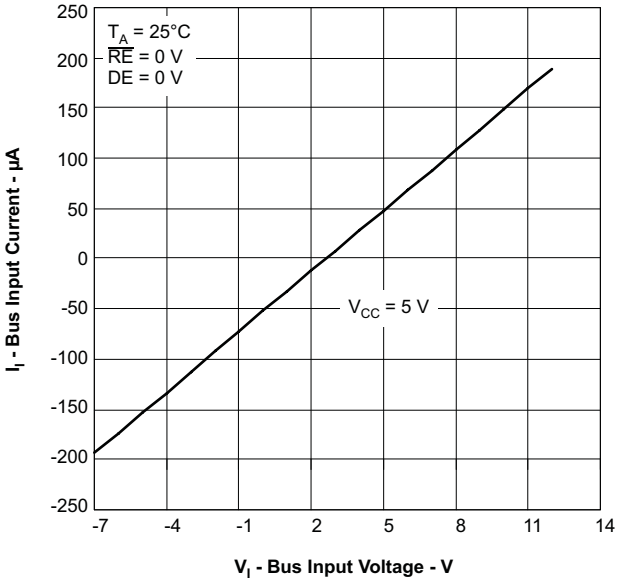


Figure 17.

HVD51, HVD52, HVD54, HVD55
BUS INPUT CURRENT
vs
INPUT VOLTAGE

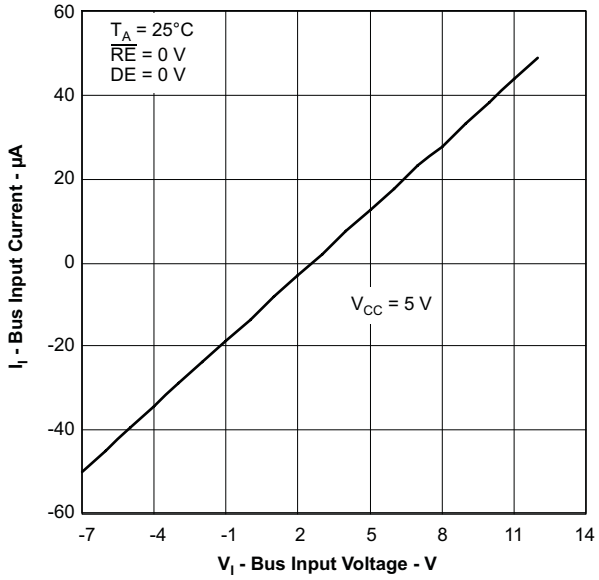


Figure 18.

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

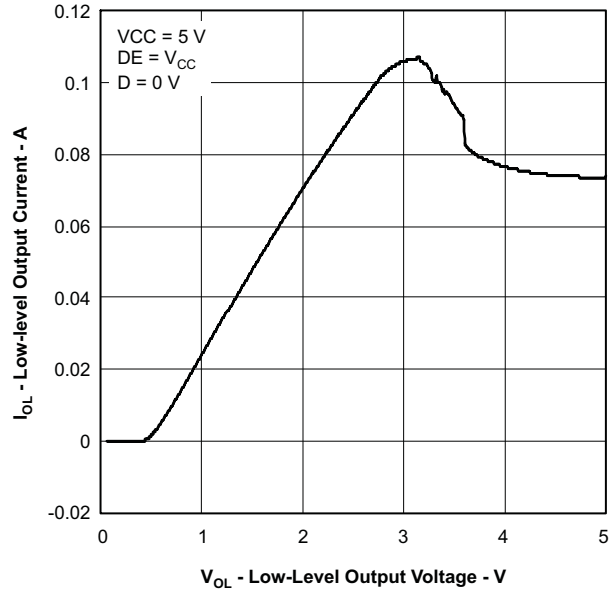


Figure 19.

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

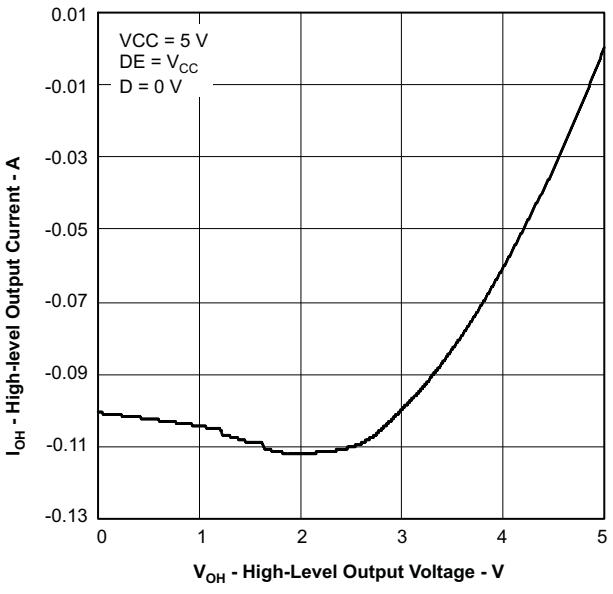


Figure 20.

TYPICAL CHARACTERISTICS (continued)

DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

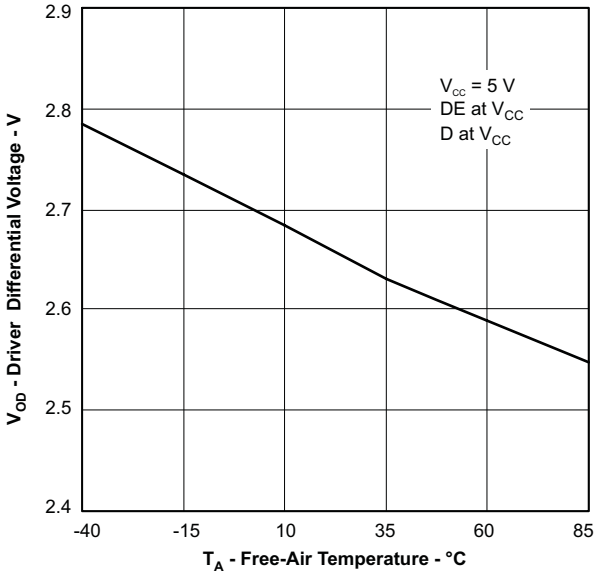


Figure 21.

DRIVER OUTPUT CURRENT vs SUPPLY VOLTAGE

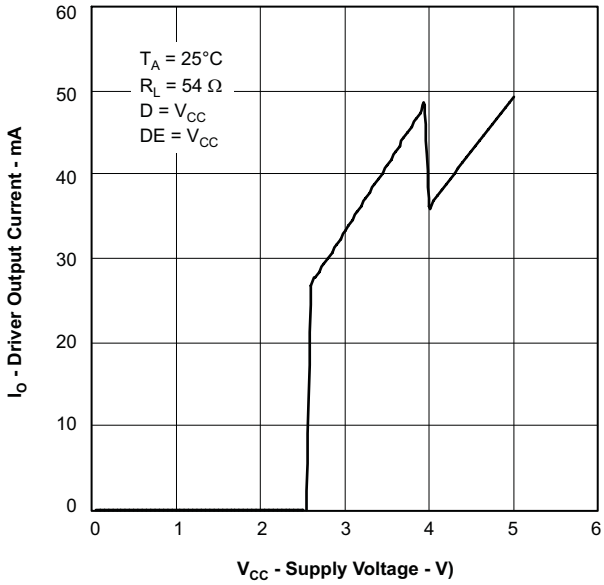


Figure 22.

ENABLE TIME vs COMMON-MODE VOLTAGE (SEE Figure 24)

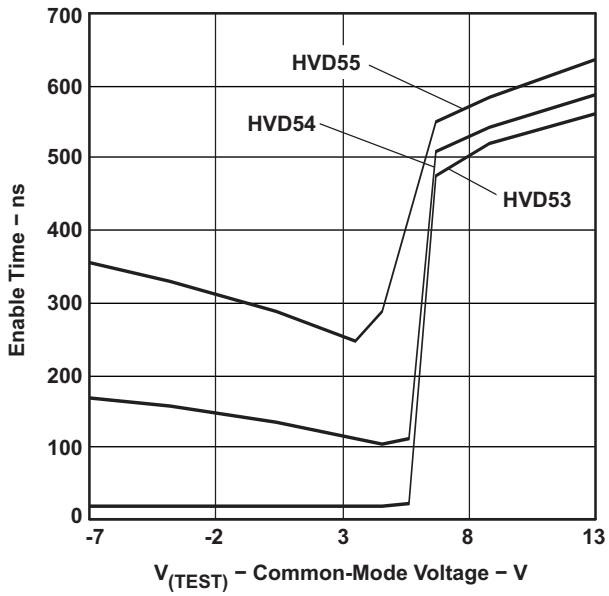


Figure 23.

TYPICAL CHARACTERISTICS (continued)

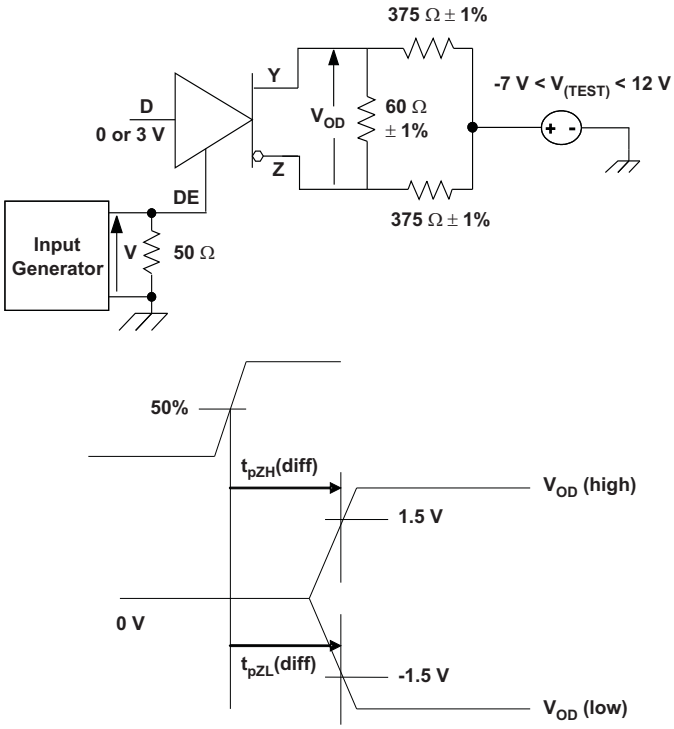


Figure 24. Driver Enable Time From DE to V_{OD}

The time $t_{pZL}(x)$ is the measure from DE to $V_{OD}(x)$. V_{OD} is valid when it is greater than 1.5 V.

APPLICATION INFORMATION

THERMAL CHARACTERISTICS OF IC PACKAGES

θ_{JA} **(Junction-to-Ambient Thermal Resistance)** is defined as the difference in junction temperature to ambient temperature divided by the operating power.

θ_{JA} is not a constant and is a strong function of:

- the PCB design (50% variation)
- altitude (20% variation)
- device power (5% variation)

θ_{JA} can be used to compare the thermal performance of packages if the specific test conditions are defined and used. Standardized testing includes specification of PCB construction, test chamber volume, sensor locations, and the thermal characteristics of holding fixtures. θ_{JA} is often misused when it is used to calculate junction temperatures for other installations.

TI uses two test PCBs as defined by JEDEC specifications. The low-k board gives *average* in-use condition thermal performance, and it consists of a single copper trace layer 25 mm long and 2-oz thick. The high-k board gives best *case* in-use condition, and it consists of two 1-oz buried power planes with a single copper trace layer 25 mm long and 2-oz thick. A 4% to 50% difference in θ_{JA} can be measured between these two test cards

θ_{JC} **(Junction-to-Case Thermal Resistance)** is defined as difference in junction temperature to case divided by the operating power. It is measured by putting the mounted package up against a copper block cold plate to force heat to flow from die, through the mold compound into the copper block.

θ_{JC} is a useful thermal characteristic when a heatsink applied to package. It is *not* a useful characteristic to predict junction temperature because it provides pessimistic numbers if the case temperature is measured in a nonstandard system and junction temperatures are backed out. It can be used with θ_{JB} in 1-dimensional thermal simulation of a package system.

θ_{JB} **(Junction-to-Board Thermal Resistance)** is defined as the difference in the junction temperature and the PCB temperature at the center of the package (closest to the die) when the PCB is clamped in a cold-plate structure. θ_{JB} is only defined for the high-k test card.

θ_{JB} provides an overall thermal resistance between the die and the PCB. It includes a bit of the PCB thermal resistance (especially for BGA's with thermal balls) and can be used for simple 1-dimensional network analysis of package system, see Figure 25.

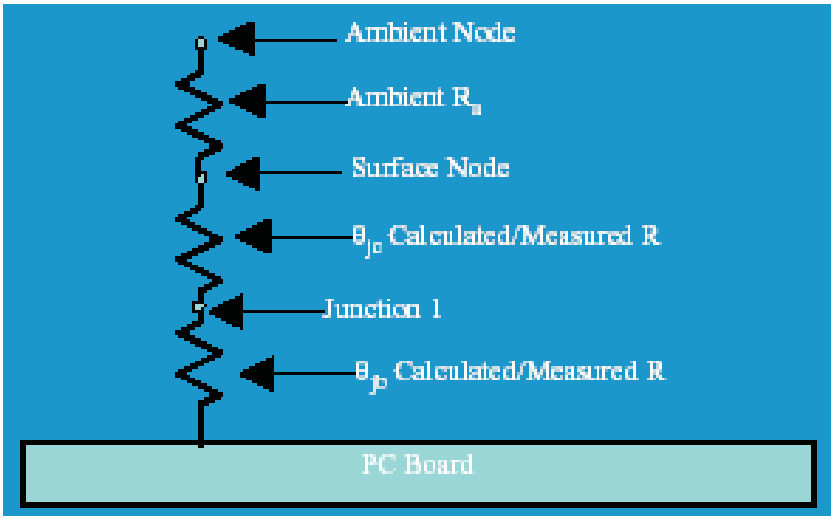


Figure 25. Thermal Resistance

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN65HVD50D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD50DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD50DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD50DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD51D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD51DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD51DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD51DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD52D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD52DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD52DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD52DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD53D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD53DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD53DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD53DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD54D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD54DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD54DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD54DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD55D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD55DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD55DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD55DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

(1) The marketing status values are defined as follows:

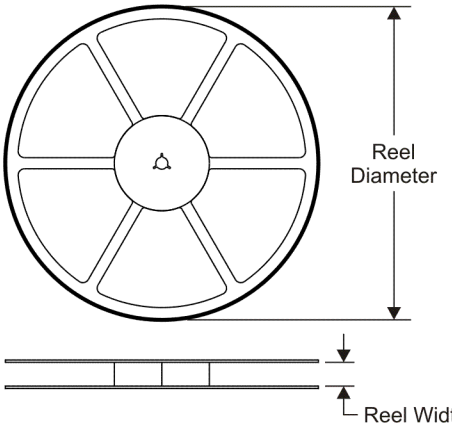
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new 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)

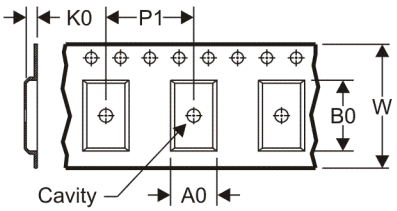
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

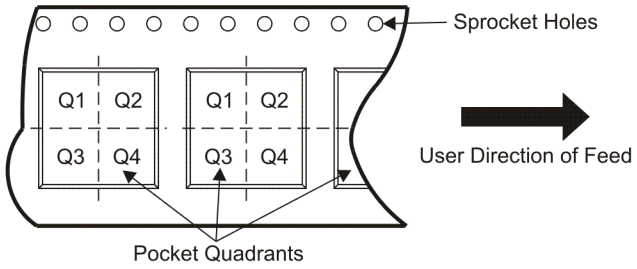


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

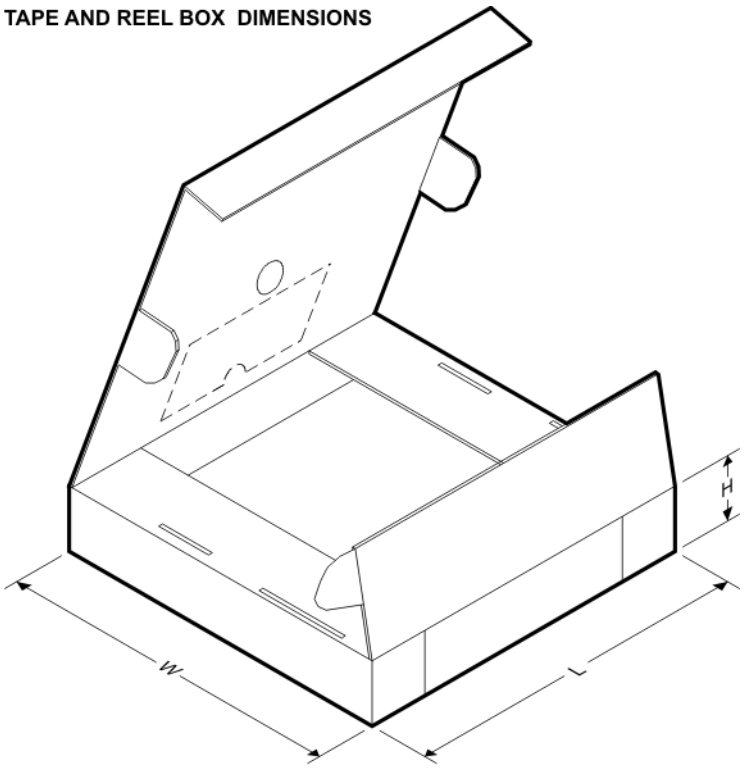
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN65HVD50DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD51DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD52DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD53DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD54DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD55DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

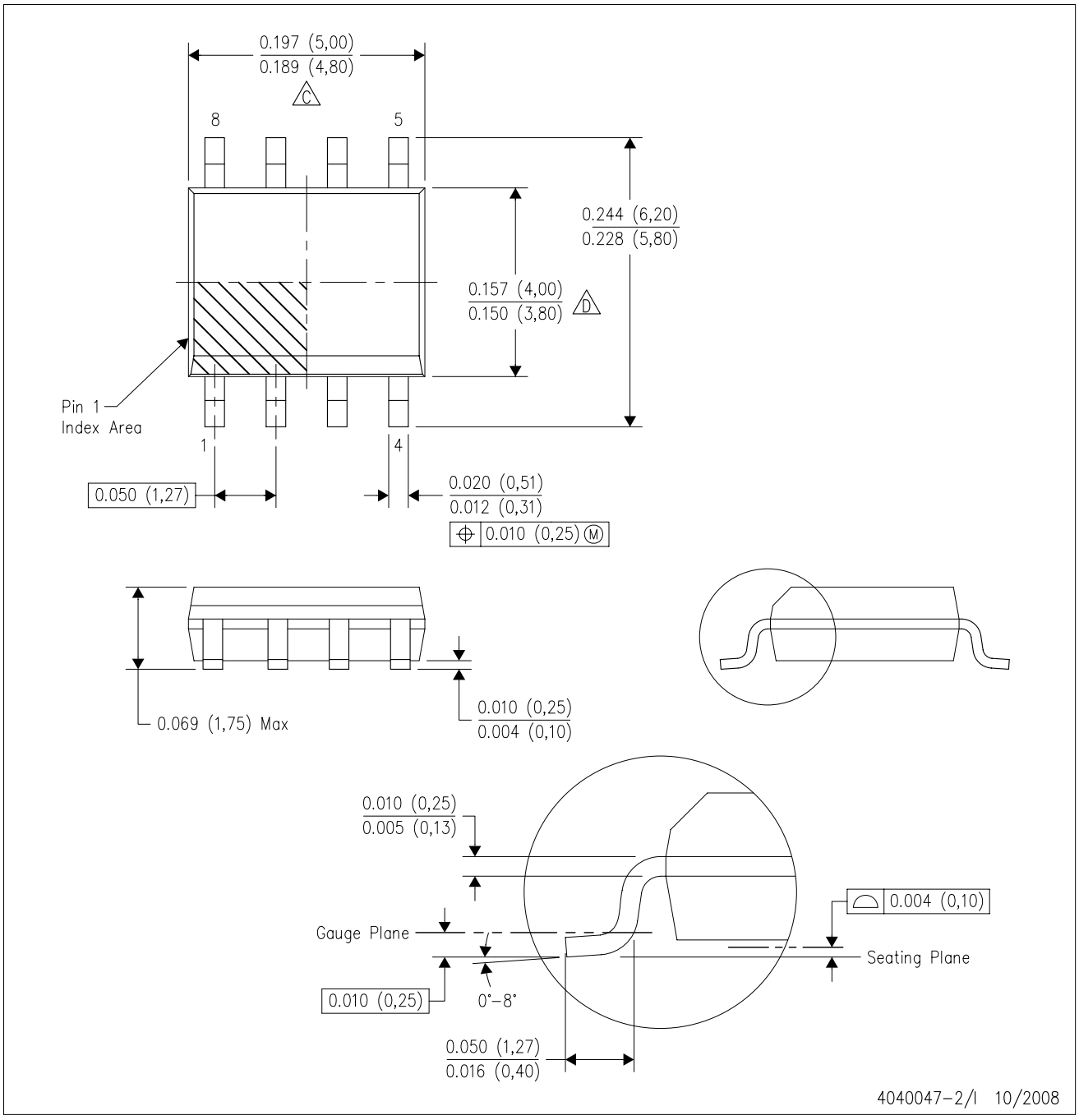
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

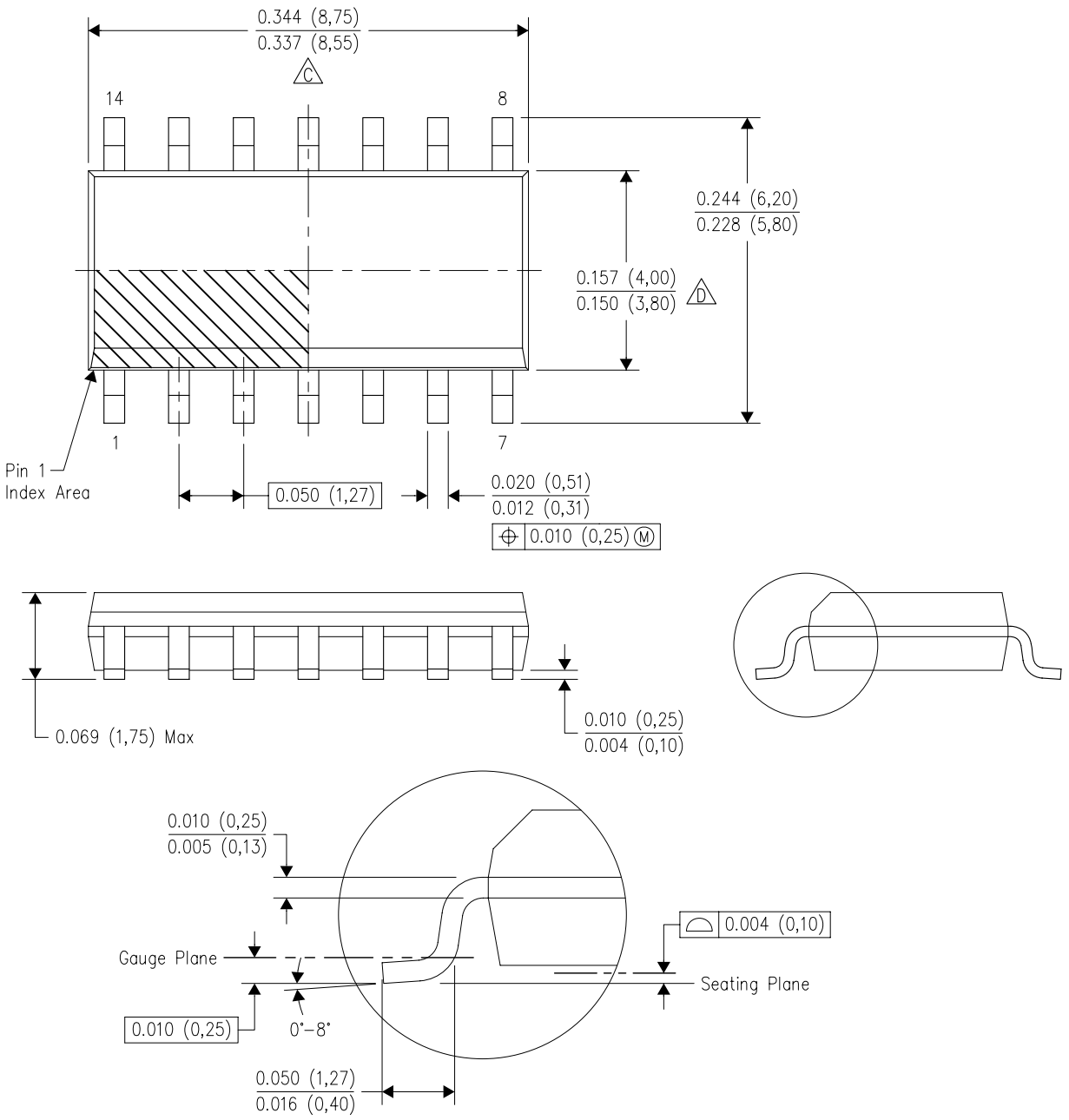
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65HVD50DR	SOIC	D	8	2500	346.0	346.0	29.0
SN65HVD51DR	SOIC	D	8	2500	346.0	346.0	29.0
SN65HVD52DR	SOIC	D	8	2500	346.0	346.0	29.0
SN65HVD53DR	SOIC	D	14	2500	346.0	346.0	33.0
SN65HVD54DR	SOIC	D	14	2500	346.0	346.0	33.0
SN65HVD55DR	SOIC	D	14	2500	346.0	346.0	33.0

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 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 AA.

D (R–PDSO–G14) 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 AB.

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