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SN65HVD7x 3.3-V Full-Duplex RS-485 Transceivers With ± 12 -kV IEC ESD

1 Features

- 1/8 Unit-Load Options Available
 - Up to 256 Nodes on the Bus
- Bus I/O Protection
 - $> \pm 30$ -kV HBM protection
 - $> \pm 12$ -kV IEC61000-4-2 Contact Discharge
 - $> \pm 4$ -kV IEC61000-4-4 Fast Transient Burst
- Extended Industrial Temperature Range: -40°C to 125°C
- Large Receiver Hysteresis (70 mV) for Noise Rejection
- Low Power Consumption
 - < 1.1 -mA Quiescent Current During Operation
 - Low Standby Supply Current: 10 nA Typical, < 5 μA (maximum)
- Glitch-Free Power-Up and Power-Down Protection for Hot-Plugging Applications
- 5-V Tolerant Logic Inputs Compatible With 3.3-V or 5-V Controllers
- Signaling Rate Options Optimized for: 400 kbps (70, 71), 20 Mbps (73, 74), 50 Mbps (76, 77)

2 Applications

- E-meters
- Industrial Automation
- Building Automation
- Security and Surveillance
- Encoders and Decoders

3 Description

These devices extend the RS-485 portfolio with a family of full-duplex transceivers with robust 3.3-V drivers and receivers and high levels of ESD protection. The ESD protection includes $> \pm 30$ -kV HBM and $> \pm 12$ -kV IEC61000-4-2 contact discharge. The large receiver hysteresis of the SN65HVD7x devices provides immunity to conducted differential noise and the wide operating temperature enables reliability in harsh operating environments. The SN65HVD7x devices are offered in a standard SOIC package as well as in a small-footprint MSOP package.

These devices each combine a differential driver and a differential receiver, which operate from a single 3.3-V power supply. Each driver and receiver has separate input and output pins for full-duplex bus communication designs. These devices all feature a wide common-mode voltage range which makes the devices suitable for multi-point applications over long cable runs.

The SN65HVD71, SN65HVD74, and SN65HVD77 devices are fully enabled with no external enabling pins.

The SN65HVD70, SN65HVD73, and SN65HVD76 devices have active-high driver enables and active-low receiver enables. A low, less than 5- μA standby current can be achieved by disabling both the driver and receiver.

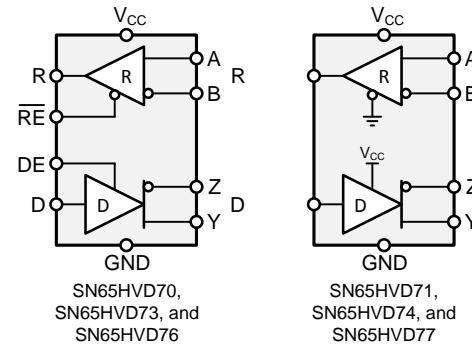
These devices are characterized from -40°C to 125°C .

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN65HVD71	MSOP (8)	3.00 mm \times 3.00 mm
SN65HVD74	SOIC (8)	4.90 mm \times 3.91 mm
SN65HVD77		
SN65HVD70	MSOP (10)	3.00 mm \times 3.00 mm
SN65HVD73	SOIC (14)	8.65 mm \times 3.91 mm
SN65HVD76		

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Block Diagram



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (August 2014) to Revision E	Page
• Updated the MSOP-10 logic diagram	4

Changes from Revision C (July 2014) to Revision D	Page
• Updated the <i>Device Comparison Table</i>	3

Changes from Revision B (July 2014) to Revision C	Page
• Updated SN65HVD70 and SN65HVD71 specifications to production values	3

Changes from Revision A (June 2014) to Revision B	Page
• Updated the <i>Device Comparison Table</i>	3
• SN65HVD74 device status changed from <i>Product Preview</i> to <i>Production Data</i>	3

Changes from Original (May 2014) to Revision A	Page
• Changed device status from <i>Product Preview</i> to <i>Production Data</i> for mixed status	1

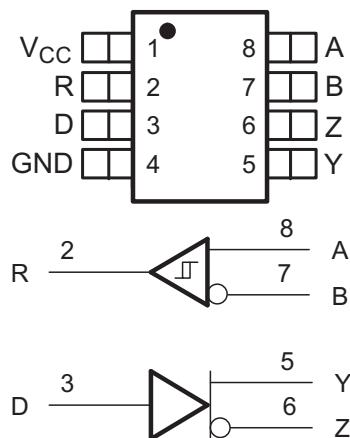
5 Device Comparison Table

PART NUMBER ⁽¹⁾	SIGNALING RATE	DUPLEX	ENABLES	PACKAGE	NODES
SN65HVD70	up to 400 kbps	Full	DE, \overline{RE}	SOIC-14 MSOP-10	256
SN65HVD71	up to 400 kbps	Full	None	SOIC-8 MSOP-8	256
SN65HVD73	up to 20 Mbps	Full	DE, \overline{RE}	SOIC-14 MSOP-10	256
SN65HVD74	up to 20 Mbps	Full	None	SOIC-8 MSOP-8	256
SN65HVD76	up to 50 Mbps	Full	DE, \overline{RE}	SOIC-14 MSOP-10	96
SN65HVD77	up to 50 Mbps	Full	None	SOIC-8 MSOP-8	96

(1) For device status, see the [Mechanical, Packaging, and Orderable Information](#) section.

6 Pin Configuration and Functions

SN65HVD71, SN65HVD74, SN65HVD77
 8-Pin SOIC, D Package, and 8-Pin MSOP, DGK Package
 (Top View)



Pin Functions — SOIC-8 and MSOP-8

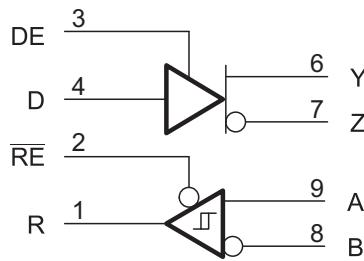
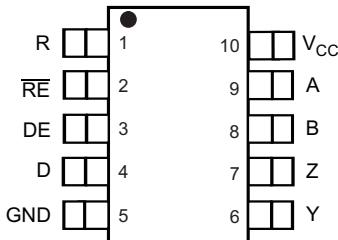
PIN		TYPE	DESCRIPTION
NAME	NO.		
V _{CC}	1	Supply	3-V to 3.6-V supply
R	2	Digital output	Receive data output
D	3	Digital input	Driver data input
GND	4	Reference potential	Local device ground
Y	5	Bus output	Digital bus output, Y (Complementary to Z)
Z	6	Bus output	Digital bus output, Z (Complementary to Y)
B	7	Bus input	Digital bus input, B (Complementary to A)
A	8	Bus input	Digital bus input, A (Complementary to B)

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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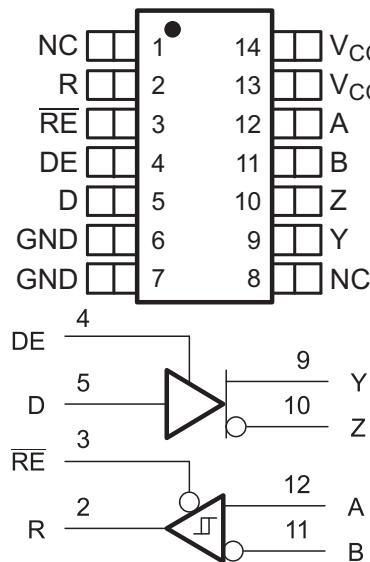
SN65HVD70, SN65HVD73, SN65HVD77
10-Pin MSOP, DGS Package
(Top View)



Pin Functions — MSOP-10

PIN		TYPE	DESCRIPTION
NAME	NO.		
R	1	Digital output	Receive data output
RE	2	Digital input	Receive enable Low
DE	3	Digital input	Driver enable High
D	4	Digital input	Driver data input
GND	5	Reference potential	Local device ground
Y	6	Bus output	Digital bus output, Y (Complementary to Z)
Z	7	Bus output	Digital bus output, Z (Complementary to Y)
B	8	Bus input	Digital bus input, B (Complementary to A)
A	9	Bus input	Digital bus input, A (Complementary to B)
VCC	10	Supply	3-V to 3.6-V supply

SN65HVD70, SN65HVD73, SN65HVD77
14-Pin SOIC, D Package
(Top View)



NC = no internal connection

Pin Functions — SOIC-14

PIN		TYPE	DESCRIPTION
NAME	NO.		
NC	1	No connect	Not connected
	8		
R	2	Digital output	Receive data output
RE	3	Digital input	Receive enable Low
DE	4	Digital input	Driver enable High
D	5	Digital input	Driver data input
GND	6 ⁽¹⁾	Reference potential	Local device ground
	7 ⁽¹⁾		
Y	9	Bus output	Digital bus output, Y (Complementary to Z)
Z	10	Bus output	Digital bus output, Z (Complementary to Y)
B	11	Bus input	Digital bus input, B (Complementary to A)
A	12	Bus input	Digital bus input, A (Complementary to B)
V _{CC}	13 ⁽²⁾	Supply	3-V to 3.6-V supply
	14 ⁽²⁾		

(1) Pin 6 and pin 7 are connected internally.
(2) Pin 13 and pin 14 are connected internally.

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7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply voltage	V _{CC}	-0.5	5.5	V
Voltage	Range at any bus pin (A, B, Y, or Z)	-13	16.5	V
Input voltage	Range at any logic pin (D, DE, or \overline{RE})	-0.3	5.7	V
	Voltage input range, transient pulse, any bus pin (A, B, Y, or Z) through 100 Ω	-100	100	V
Output current	Receiver output	-24	24	mA
Junction temperature, T _J		170		°C
Continuous total power dissipation		See the <i>Thermal Information</i> table		

(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.

7.2 Handling Ratings

			MIN	MAX	UNIT
T _{stg}	Storage temperature range		-65	150	°C
V _(ESD)	Electrostatic discharge	Human body model (HBM), per JEDEC specification JESD22-A114, all pins	-8	8	kV
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins	-1.5	1.5	kV
		Machine model (MM), all pins	-300	300	V
		IEC 61000-4-2 ESD (Air-Gap Discharge), bus pins and GND ⁽¹⁾⁽²⁾	-12	12	kV
		IEC 61000-4-2 ESD (Contact Discharge), bus pins and GND	-12	12	kV
		IEC 61000-4-4 EFT (Fast transient or burst), bus pins and GND	-4	4	kV
		IEC 60749-26 ESD (Human Body Model), bus pins and GND ⁽²⁾	-30	30	kV

(1) By inference from contact-discharge results, see the *Application and Implementation* section

(2) Limited by tester capability.

7.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V _{CC}	Supply voltage	3	3.3	3.6	V
V _I	Input voltage at any bus pin (separately or common mode) ⁽¹⁾	-7		12	V
V _{IH}	High-level input voltage (Driver, driver enable, and receiver enable inputs)	2		V _{CC}	V
V _{IL}	Low-level input voltage (Driver, driver enable, and receiver enable inputs)	0		0.8	V
V _{ID}	Differential input voltage	-12		12	V
I _O	Output current, Driver	-60		60	mA
I _O	Output current, Receiver	-8		8	mA
R _L	Differential load resistance	54		60	Ω
C _L	Differential load capacitance		50		pF
1/t _{UI}	Signaling rate	HVD70, HVD71		400	kbps
		HVD73, HVD74		20	Mbps
		HVD76, HVD77		50	
T _A ⁽²⁾	Operating free-air temperature (See the <i>Application and Implementation</i> for thermal information)	-40		125	°C
T _J	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) Operation is specified for internal (junction) temperatures up to 150°C. Self-heating because of internal power dissipation should be considered for each application. Maximum junction temperature is internally limited by the thermal shut-down (TSD) circuit which disables the driver outputs when the junction temperature reaches 170°C.

7.4 Thermal Information — D Packages

THERMAL METRIC		D (8 PINS)	D (14 PINS)	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	110.7	83.3	°C/W
$R_{\theta JC(\text{top})}$	Junction-to-case (top) thermal resistance	54.7	42.9	
$R_{\theta JB}$	Junction-to-board thermal resistance	51.3	37.8	
Ψ_{JT}	Junction-to-top characterization parameter	9.2	9.3	
Ψ_{JB}	Junction-to-board characterization parameter	50.7	37.5	
$T_{J(\text{TSD})}$	Thermal shut-down junction temperature	170		°C

7.5 Thermal Information — DGS and DGK Packages

THERMAL METRIC		DGS (10 PINS)	DGK (8 PINS)	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	165.5	168.7	°C/W
$R_{\theta JC(\text{top})}$	Junction-to-case (top) thermal resistance	37.7	62.2	
$R_{\theta JB}$	Junction-to-board thermal resistance	86.4	89.5	
Ψ_{JT}	Junction-to-top characterization parameter	1.4	7.4	
Ψ_{JB}	Junction-to-board characterization parameter	84.8	87.9	
$T_{J(\text{TSD})}$	Thermal shut-down junction temperature	170		°C

7.6 Power Dissipation

PARAMETER	TEST CONDITIONS	VALUE	UNITS
PD	Unterminated	$R_L = 300 \Omega$, $C_L = 50 \text{ pF}$ (driver)	150
		HVD70, HVD71	
		180	
	RS-422 load	HVD73, HVD74	
		220	
		190	
	RS-485 load	HVD73, HVD74	
		220	
		250	
		230	
		255	
		285	

7.7 Electrical Characteristics

over recommended operating range (unless otherwise specified)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$ V_{ODL} $	$R_L = 60 \Omega$, 375Ω on each output to -7 V to 12 V , See Figure 15	1.5	2		V
	$R_L = 54 \Omega$ (RS-485), See Figure 16	1.5	2		V
	$R_L = 100 \Omega$ (RS-422) $T_J \geq 0^\circ\text{C}$, $V_{CC} \geq 3.2 \text{ V}$, See Figure 16	2			V
$\Delta V_{ODL} $	$R_L = 54 \Omega$, $C_L = 50 \text{ pF}$, See Figure 16	-50	0	50	mV
$V_{OC(\text{SS})}$	Center of two $27\text{-}\Omega$ load resistors, See Figure 16	1	$V_{CC} / 2$	3	V
ΔV_{OC}		-50	0	50	mV
$V_{OC(\text{PP})}$		500			mV
C_{OD}		15			pF
V_{IT+}	Positive-going receiver differential input voltage threshold	See ⁽¹⁾	-70	-20	mV
V_{IT-}	Negative-going receiver differential input voltage threshold	-200	-140	See ⁽¹⁾	mV
V_{hys}	Receiver differential input voltage threshold hysteresis ($V_{IT+} - V_{IT-}$)	40	70		mV

(1) Under any specific conditions, V_{IT+} is assured to be at least V_{hys} higher than V_{IT-} .

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Electrical Characteristics (continued)

over recommended operating range (unless otherwise specified)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
V_{OH}	Receiver high-level output voltage	$I_{OH} = -8 \text{ mA}$		2.4	$V_{CC} - 0.3$		V	
V_{OL}	Receiver low-level output voltage	$I_{OL} = 8 \text{ mA}$			0.2	0.4	V	
I_I	Driver input, driver enable, and receiver enable input current			-3		3	μA	
I_{OZ}	Receiver output high-impedance current	HVD70, HVD73, HVD76	$V_O = 0 \text{ V}$ or V_{CC} , $\overline{RE} = V_{CC}$	-1		1	μA	
I_{OS}	Driver short-circuit output current			-150		150	mA	
I_I Bus input current (disabled driver)		$V_{CC} = 0$ to ROC (max), DE = GND	HVD70, HVD73	$V_I = 12 \text{ V}$	75	125	μA	
				$V_I = -7 \text{ V}$	-100	-40		
			HVD76	$V_I = 12 \text{ V}$	240	333		
				$V_I = -7 \text{ V}$	-267	-180		
I_{CC}	Supply current (quiescent)	Driver and receiver enabled		DE = V_{CC} , $\overline{RE} = \text{GND}$, No load	750	1100	μA	
		Driver enabled, receiver disabled		DE = V_{CC} , $\overline{RE} = V_{CC}$, No load	350	650	μA	
		Driver disabled, receiver enabled		DE = GND, $\overline{RE} = \text{GND}$, No load	650	800	μA	
		Driver and receiver disabled		DE = GND, D = open, $\overline{RE} = V_{CC}$, No load	0.1	5	μA	
Supply current (dynamic)		See the <i>Typical Characteristics</i> section						
T_{SD}	Thermal Shut-down junction temperature					170	$^{\circ}\text{C}$	

7.8 Switching Characteristics — 400 kbps

400-kbps devices (SN65HVD70, SN65HVD71) bit time $\geq 2 \mu\text{s}$ (over recommended operating conditions)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT		
DRIVER									
t_r, t_f	Driver differential output rise/fall time	$R_L = 54 \Omega, C_L = 50 \text{ pF}$	See Figure 17	100	400	750	ns		
t_{PHL}, t_{PLH}	Driver propagation delay			350	550		ns		
$t_{SK(P)}$	Driver pulse skew, $ t_{PHL} - t_{PLH} $				40		ns		
t_{PHZ}, t_{PLZ}	Driver disable time	HVD70	See Figure 18 and Figure 19	50	200		ns		
t_{PZH}, t_{PZL}	Driver enable time			300	750		ns		
				3	8		μs		
RECEIVER									
t_r, t_f	Receiver output rise/fall time	$C_L = 15 \text{ pF}$	See Figure 20	13	25		ns		
t_{PHL}, t_{PLH}	Receiver propagation delay time			70	110		ns		
$t_{SK(P)}$	Receiver pulse skew, $ t_{PHL} - t_{PLH} $				7		ns		
t_{PLZ}, t_{PHZ}	Receiver disable time	HVD70	See Figure 21	45	60		ns		
$t_{PZH(1)}, t_{PZL(1)}$	Receiver enable time			20	115		ns		
$t_{PZH(2)}, t_{PZL(2)}$				3	8		μs		

7.9 Switching Characteristics — 20 Mbps

20-Mbps devices (SN65HVD73, SN65HVD74) bit time ≥ 50 ns (over recommended operating conditions)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DRIVER					
t_r, t_f	Driver differential output rise/fall time			4	7
t_{PHL}, t_{PLH}	Driver propagation delay	$R_L = 54 \Omega, C_L = 50 \text{ pF}$	See Figure 17	4	10
$t_{SK(P)}$	Driver pulse skew, $ t_{PHL} - t_{PLH} $			0	4
t_{PHZ}, t_{PLZ}	Driver disable time	HVD73	See Figure 18 and Figure 19	12	25
t_{PZH}, t_{PZL}	Driver enable time			10	20
				3	8
RECEIVER					
t_r, t_f	Receiver output rise/fall time	$C_L = 15 \text{ pF}$	See Figure 20	5	10
t_{PHL}, t_{PLH}	Receiver propagation delay time			60	90
$t_{SK(P)}$	Receiver pulse skew, $ t_{PHL} - t_{PLH} $			0	5
t_{PLZ}, t_{PHZ}	Receiver disable time	HVD73	See Figure 21 See Figure 22	17	25
$t_{PZL(1)}, t_{PZH(1)}$	Receiver enable time			12	90
$t_{PZL(2)}, t_{PZH(2)}$				3	8

7.10 Switching Characteristics — 50 Mbps

50-Mbps devices (SN65HVD76, SN65HVD77) bit time ≥ 20 ns (over recommended operating conditions)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DRIVER					
t_r, t_f	Driver differential output rise/fall time			2	3
t_{PHL}, t_{PLH}	Driver propagation delay	$R_L = 54 \Omega, C_L = 50 \text{ pF}$	See Figure 17	3	10
$t_{SK(P)}$	Driver pulse skew, $ t_{PHL} - t_{PLH} $			0	3.5
t_{PHZ}, t_{PLZ}	Driver disable time	HVD76	See Figure 18 and Figure 19	10	20
t_{PZH}, t_{PZL}	Driver enable time			10	20
				3	8
RECEIVER					
t_r, t_f	Receiver output rise/fall time	$C_L = 15 \text{ pF}$	See Figure 20	1	3
t_{PHL}, t_{PLH}	Receiver propagation delay time			25	40
$t_{SK(P)}$	Receiver pulse skew, $ t_{PHL} - t_{PLH} $			0	2
t_{PLZ}, t_{PHZ}	Receiver disable time	HVD76	See Figure 21 See Figure 22	8	15
$t_{PZL(1)}, t_{PZH(1)}$	Receiver enable time			8	90
$t_{PZL(2)}, t_{PZH(2)}$				3	8

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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7.11 Typical Characteristics

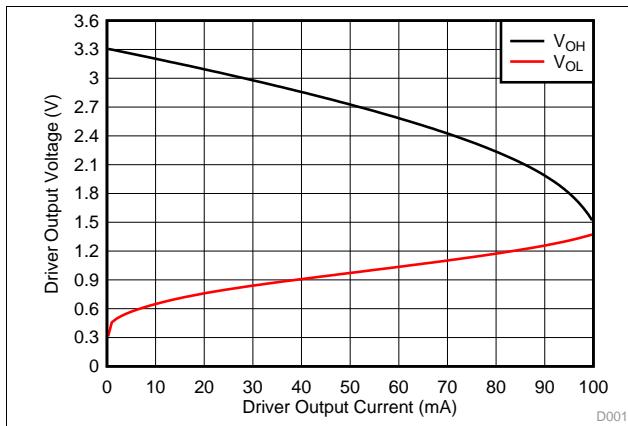


Figure 1. Driver Output Voltage vs Driver Output Current

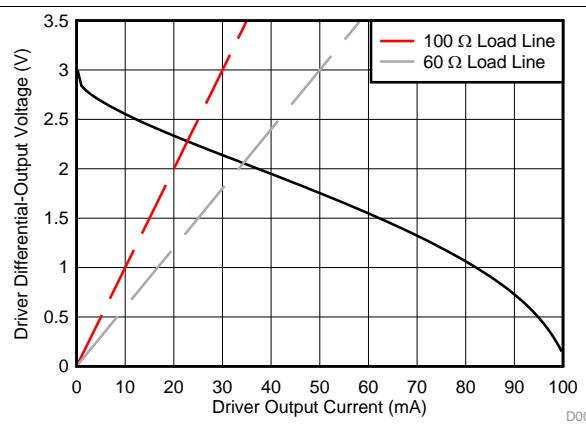


Figure 2. Driver Differential-Output Voltage vs Driver Output Current

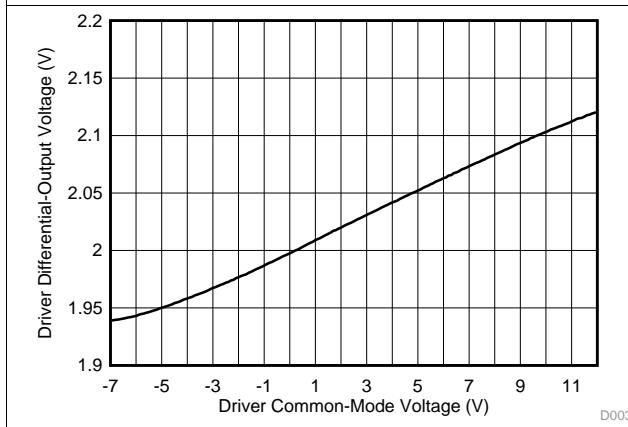


Figure 3. Driver Differential-Output Voltage vs Driver Common-Mode Voltage

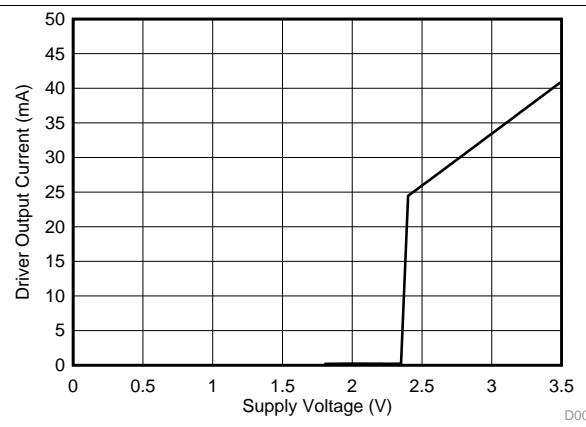


Figure 4. Driver Output Current vs Supply Voltage

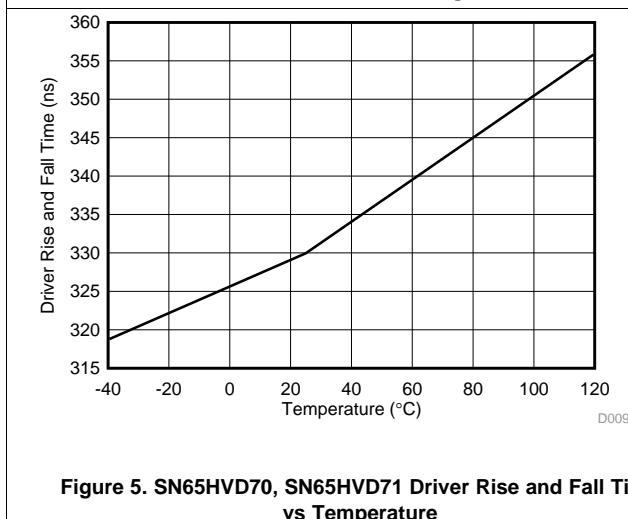


Figure 5. SN65HVD70, SN65HVD71 Driver Rise and Fall Time vs Temperature

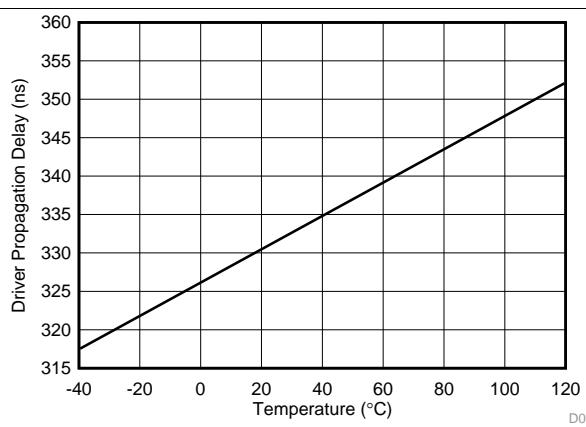


Figure 6. SN65HVD70, SN65HVD71 Driver Propagation Delay vs Temperature

Typical Characteristics (continued)

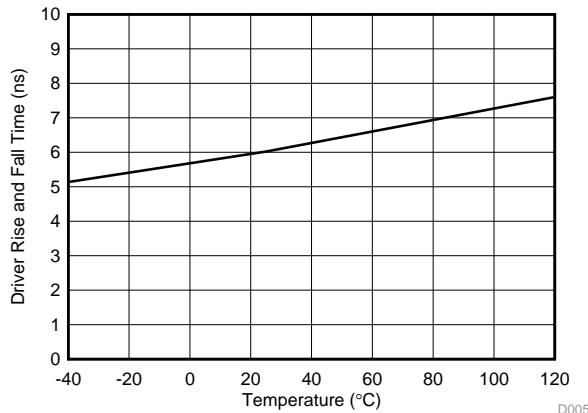


Figure 7. SN65HVD73, SN65HVD74 Driver Rise and Fall Time vs Temperature

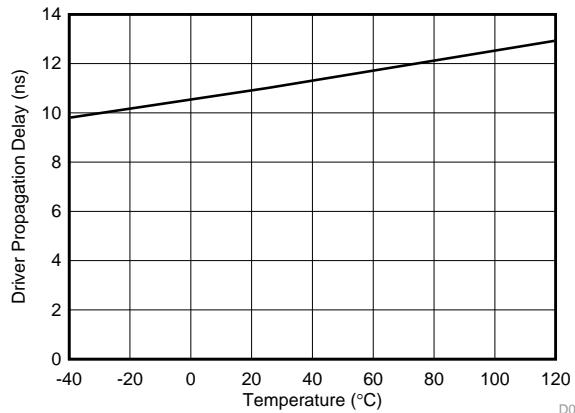


Figure 8. SN65HVD73, SN65HVD74 Driver Propagation Delay vs Temperature

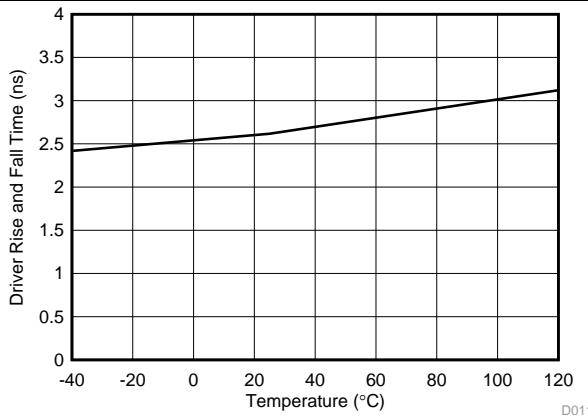


Figure 9. SN65HVD76, SN65HVD77 Driver Rise and Fall Time vs Temperature

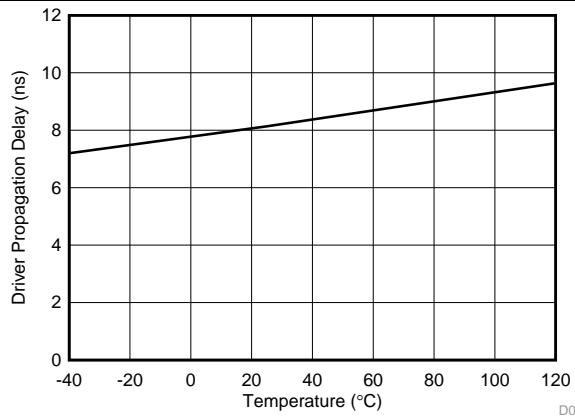


Figure 10. SN65HVD76, SN65HVD77 Driver Propagation Delay vs Temperature

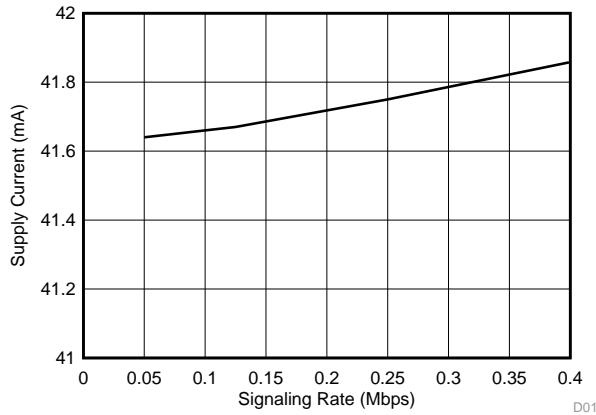


Figure 11. SN65HVD70, SN65HVD71 Supply Current vs Signal Rate

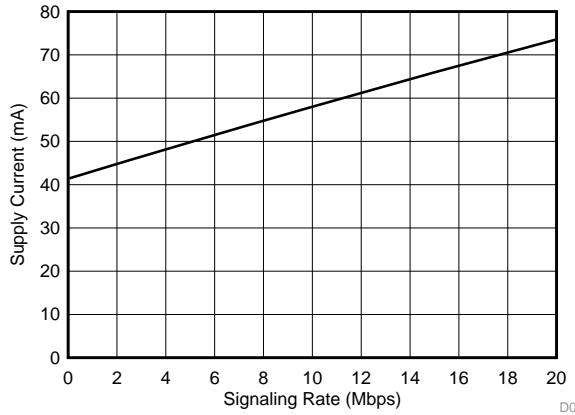


Figure 12. SN65HVD73, SN65HVD74 Supply Current vs Signal Rate

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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Typical Characteristics (continued)

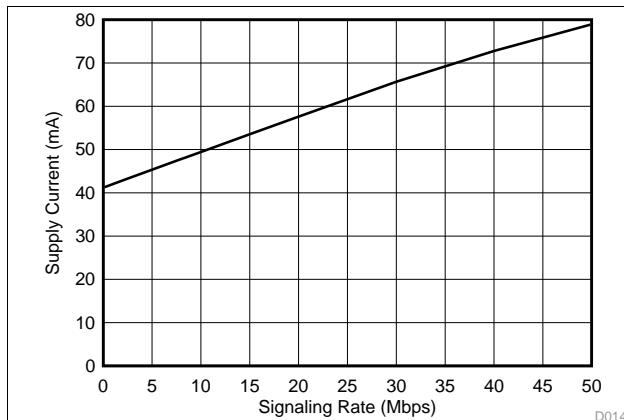


Figure 13. SN65HVD76, SN65HVD77 Supply Current vs Signal Rate

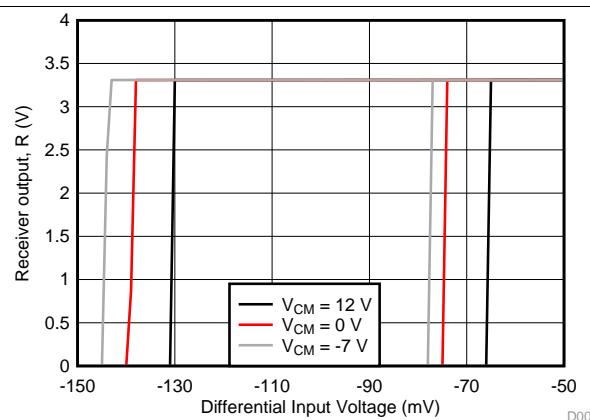


Figure 14. Receiver Output vs Input

8 Parameter Measurement Information

The input generator rate is 100 kbps with 50% duty cycle, than 6-ns rise and fall times, and 50- Ω output impedance.

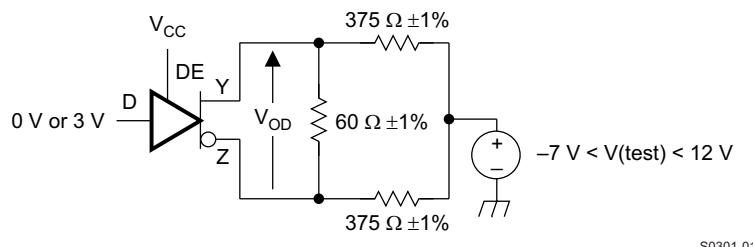


Figure 15. Measurement of Driver Differential Output Voltage With Common-Mode Load

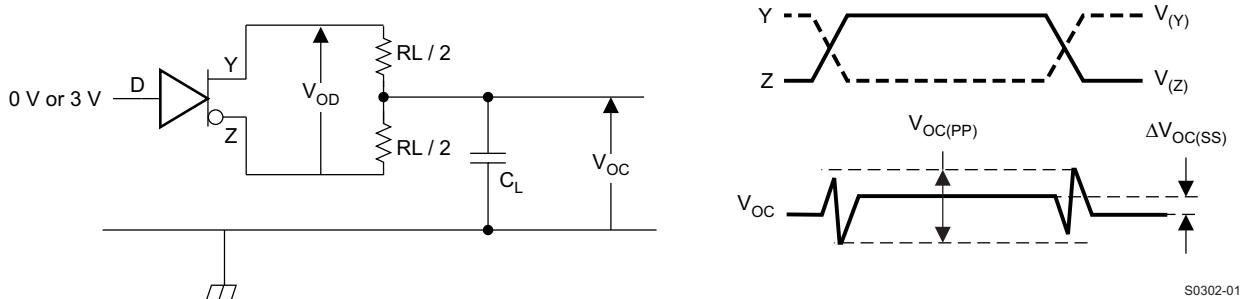


Figure 16. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

Parameter Measurement Information (continued)

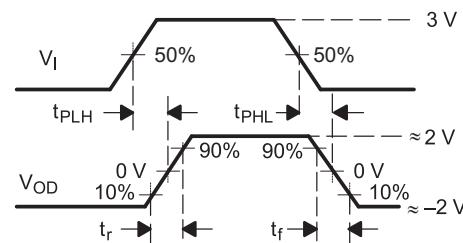
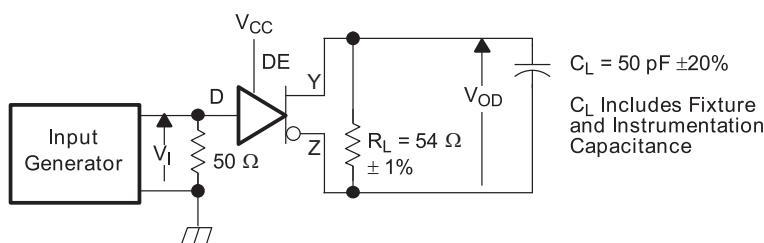
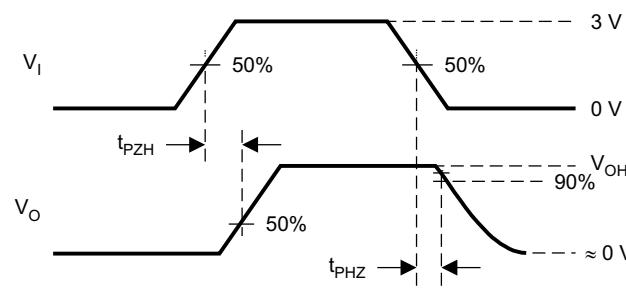
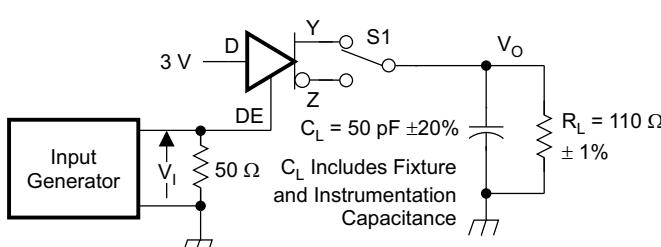


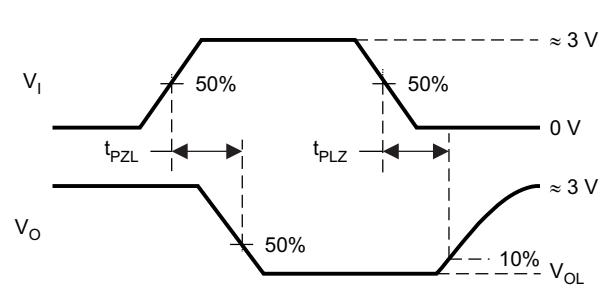
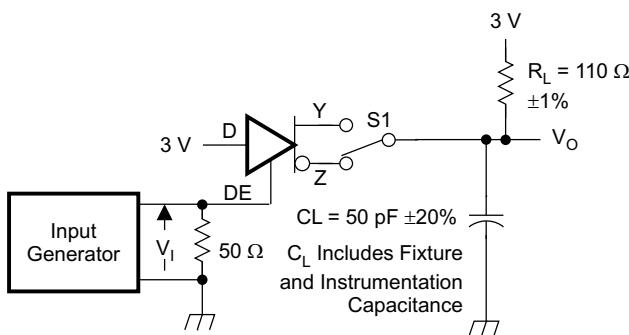
Figure 17. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays



S0304-01

D at 3 V to test non-inverting output, D at 0 V to test inverting output.

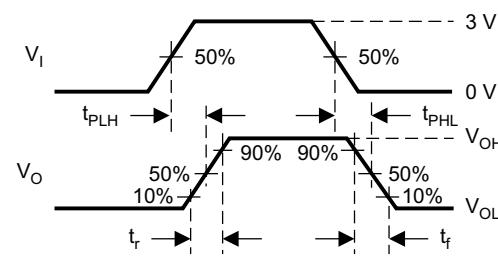
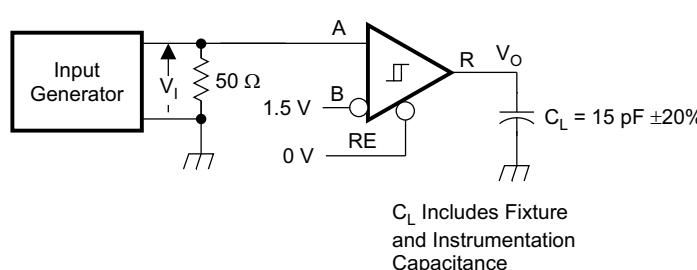
Figure 18. Measurement of Driver Enable and Disable Times with Active-High Output and Pulldown Load



S0305-01

D at 0 V to test non-inverting output, D at 3 V to test inverting output.

Figure 19. Measurement of Driver Enable and Disable Times with Active-Low Output and Pullup Load



S0306-01

Figure 20. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

Parameter Measurement Information (continued)

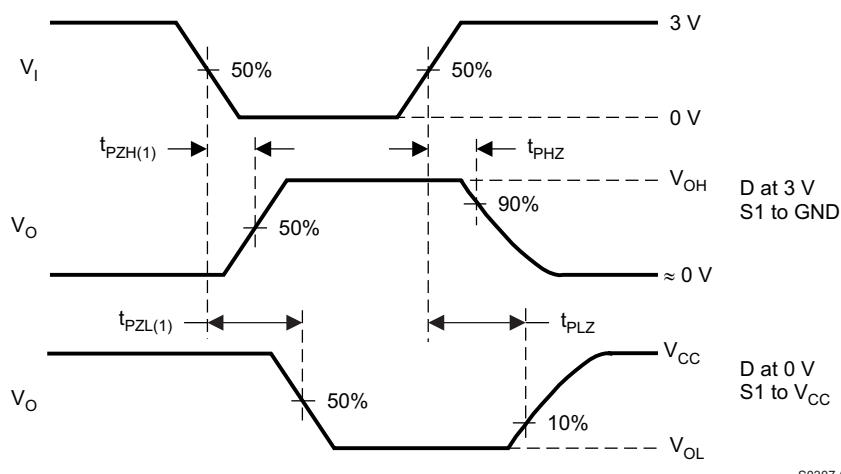
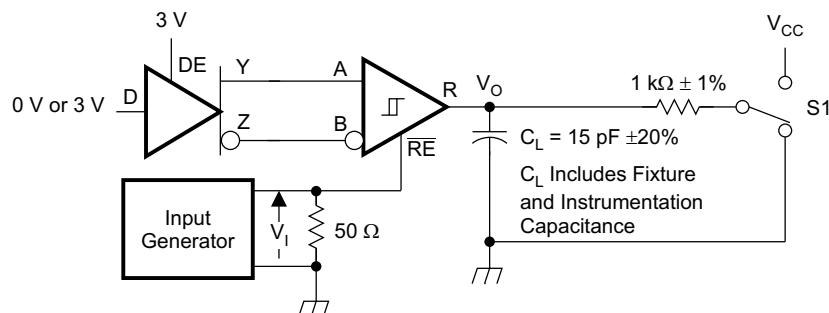


Figure 21. Measurement of Receiver Enable and Disable Times With Driver Enabled

Parameter Measurement Information (continued)

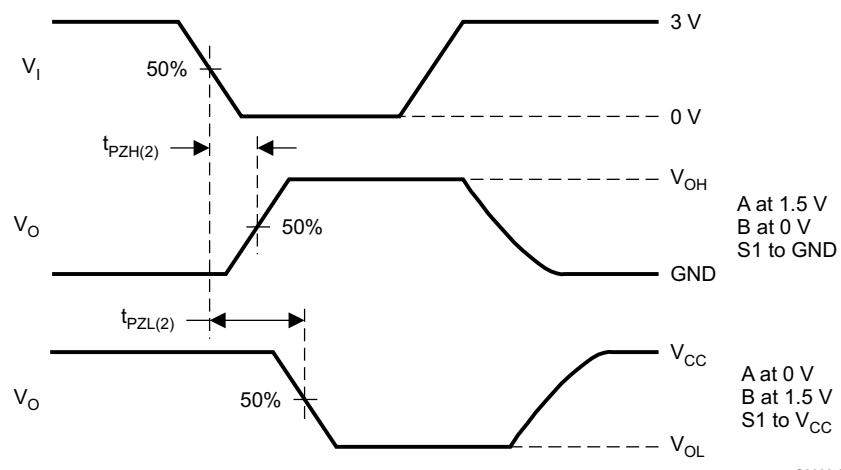
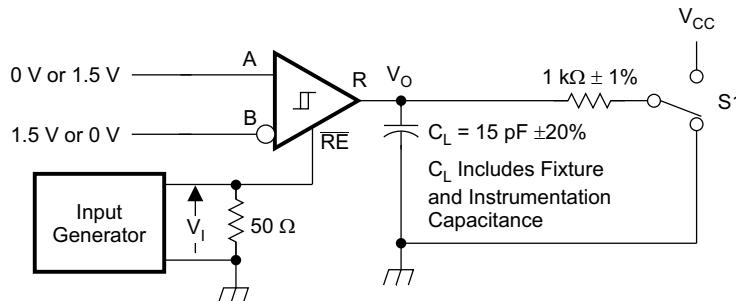


Figure 22. Measurement of Receiver Enable Times With Driver Disabled

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SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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9 Detailed Description

9.1 Overview

The SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, and SN65HVD77 devices are low-power, full-duplex RS-485 transceivers available in three speed grades suitable for data transmission up to 400 kbps, 20 Mbps, and 50 Mbps.

The SN65HVD71, SN65HVD74, and SN65HVD77 are fully enabled with no external enabling pins. The SN65HVD70, SN65HVD73, and SN65HVD76 have active-high driver enables and active-low receiver enables. A standby current of less than 5 μ A can be achieved by disabling both driver and receiver.

9.2 Functional Block Diagram

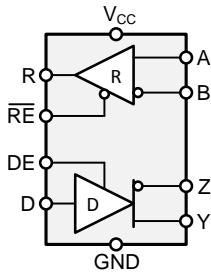


Figure 23. Block Diagram
 SN65HVD70, SN65HVD73, and SN65HVD76

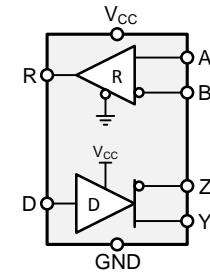


Figure 24. Block Diagram
 SN65HVD71, SN65HVD74, and SN65HVD77

9.3 Feature Description

Internal ESD protection circuits protect the transceiver against Electrostatic Discharges (ESD) according to IEC61000-4-2 of up to ± 12 kV, and against electrical fast transients (EFT) according to IEC61000-4-4 of up to ± 4 kV.

The SN65HVD7x full-duplex family provides internal biasing of the receiver input thresholds in combination with large input-threshold hysteresis. At a positive input threshold of $V_{IT+} = -20$ mV and an input hysteresis of $V_{hys} = 40$ mV, the receiver output remains logic high under a bus-idle or bus-short condition even in the presence of 120 mV_{PP} differential noise without the need for external failsafe biasing resistors.

Device operation is specified over a wide temperature range from -40°C to 125°C .

9.4 Device Functional Modes

For the SN65HVD70, SN65HVD73, and SN65HVD76, when the driver enable pin, DE, is logic high, the differential outputs Y and Z follow the logic states at data input D. A logic high at D causes Y to turn high and Z to turn low. In this case the differential output voltage defined as $V_{OD} = V_{(Y)} - V_{(Z)}$ is positive. When D is low, the output states reverse, Z turns high, Y becomes low, and V_{OD} is negative.

When DE is low, both outputs turn high-impedance. In this condition the logic state at D is irrelevant. The DE pin has an internal pulldown resistor to ground, thus when left open the driver is disabled (high-impedance) by default. The D pin has an internal pullup resistor to V_{CC} , thus, when left open while the driver is enabled, output Y turns high and Z turns low.

Table 1. Driver Function Table SN65HVD70, SN65HVD73, SN65HVD76

INPUT	ENABLE	OUTPUTS		FUNCTION
D	DE	Y	Z	
H	H	H	L	Actively drives the bus high
L	H	L	H	Actively drives the bus low
X	L	Z	Z	Driver disabled
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Actively drives the bus high by default

When the receiver enable pin, \overline{RE} , is logic low, the receiver is enabled. When the differential input voltage defined as $V_{ID} = V_{(A)} - V_{(B)}$ is positive and higher than the positive input threshold, V_{IT+} , the receiver output, R, turns high. When V_{ID} is negative and less than the negative and lower than the negative input threshold, V_{IT-} , the receiver output, R, turns low. If V_{ID} is between V_{IT+} and V_{IT-} the output is indeterminate.

When \overline{RE} is logic high or left open, the receiver output is high-impedance and the magnitude and polarity of VID are irrelevant. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), the bus lines are shorted (short-circuit), or the bus is not actively driven (idle bus).

Table 2. Receiver Function Table SN65HVD70, SN65HVD73, SN65HVD76

DIFFERENTIAL INPUT	ENABLE	OUTPUT	FUNCTION
$V_{ID} = V_{(A)} - V_{(B)}$	\overline{RE}	R	
$V_{IT+} < V_{ID}$	L	H	Receives valid bus High
$V_{IT-} < V_{ID} < V_{IT+}$	L	?	Indeterminate bus state
$V_{ID} < V_{IT-}$	L	L	Receives valid bus Low
X	H	Z	Receiver disabled
X	OPEN	Z	Receiver disabled by default
Open-circuit bus	L	H	Fail-safe high output
Short-circuit bus	L	H	Fail-safe high output
Idle (terminated) bus	L	H	Fail-safe high output

For the SN65HVD71, HVD74, and HVD77, the driver and receiver are fully enabled, thus the differential outputs Y and Z follow the logic states at data input D at all times. A logic high at D causes Y to turn high and Z to turn low. In this case the differential output voltage defined as $V_{OD} = V_{(Y)} - V_{(Z)}$ is positive. When D is low, the output states reverse, Z turns high, Y becomes low, and V_{OD} is negative. The D pin has an internal pullup resistor to V_{CC} , thus, when left open while the driver is enabled, output Y turns high and Z turns low.

Table 3. Driver Function Table SN65HVD71, SN65HVD74, SN65HVD77

INPUT	OUTPUTS		FUNCTION
D	Y	Z	
H	H	L	Actively drives the bus High
L	L	H	Actively drives the bus Low
OPEN	H	L	Actively drives the bus High by default

When the differential input voltage defined as $V_{ID} = V_{(A)} - V_{(B)}$ is positive and higher than the positive input threshold, V_{IT+} , the receiver output, R, turns high. When V_{ID} is negative and less than the negative input threshold, V_{IT-} , the receiver output, R, turns low. If V_{ID} is between V_{IT+} and V_{IT-} the output is indeterminate. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), the bus lines are shorted (short-circuit), or the bus is not actively driven (idle bus).

Table 4. Receiver Function Table SN65HVD71, SN65HVD74, SN65HVD77

DIFFERENTIAL INPUT	OUTPUT	FUNCTION
$V_{ID} = V_{(A)} - V_{(B)}$	R	
$V_{IT+} < V_{ID}$	H	Receives valid bus High
$V_{IT-} < V_{ID} < V_{IT+}$?	Indeterminate bus state
$V_{ID} < V_{IT-}$	L	Receives valid bus Low
Open-circuit bus	H	Fail-safe high output
Short-circuit bus	H	Fail-safe high output
Idle (terminated) bus	H	Fail-safe high output

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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9.4.1 Equivalent Circuits

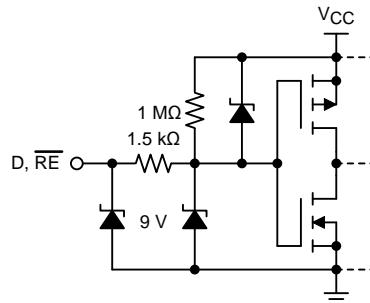


Figure 25. D and \overline{RE} Inputs

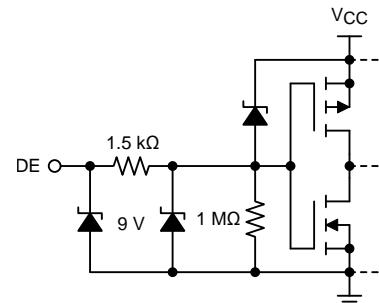


Figure 26. DE Input

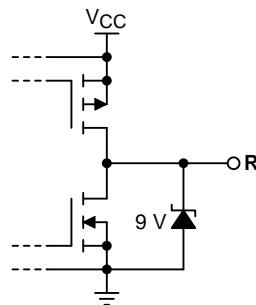


Figure 27. R Output

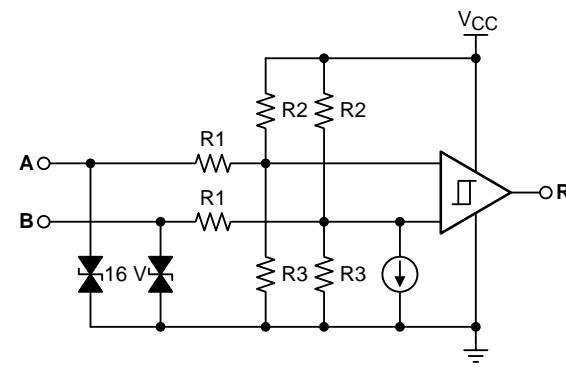


Figure 28. Receiver Inputs

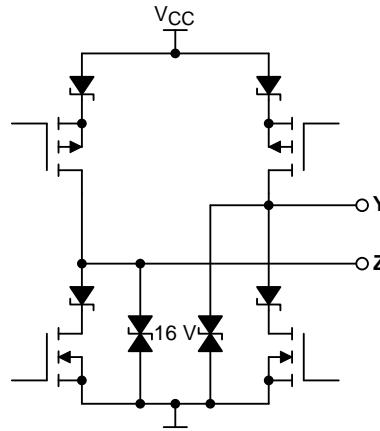


Figure 29. Driver Outputs

10 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The SN65HVD7x family consists of full-duplex RS-485 transceivers commonly used for asynchronous data transmissions. Full-duplex implementation requires two signal pairs (four wires), and allows each node to transmit data on one pair while simultaneously receiving data on the other pair.

To eliminate line reflections, each cable end is terminated with a termination resistor, $R_{(T)}$, whose value matches the characteristic impedance, Z_0 , of the cable. This method, known as parallel termination, allows for higher data rates over longer cable length.

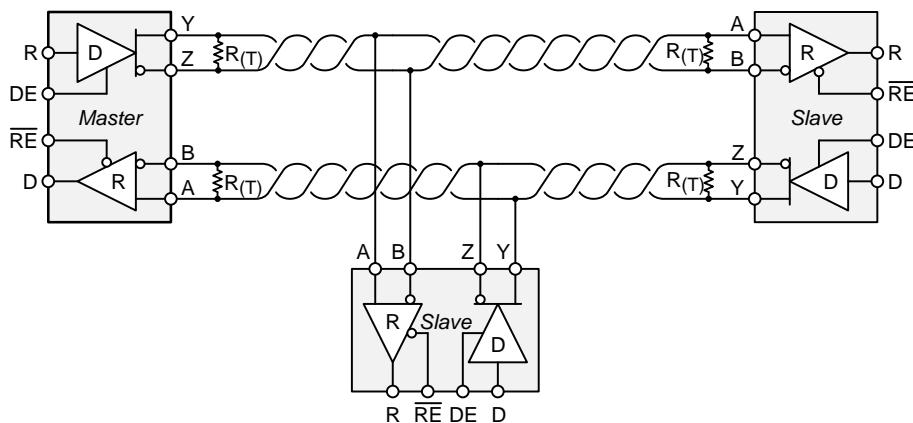


Figure 30. Typical RS-485 Network With SN65HVD7x Full-Duplex Transceivers

10.2 Typical Application

A full-duplex RS-485 network consists of multiple transceivers connecting in parallel to two bus cables. On one signal pair, a master driver transmits data to multiple slave receivers. The master driver and slave receivers may remain fully enabled at all times. On the other signal pair, multiple slave drivers transmit data to the master receiver. To avoid bus contention, the slave drivers must be intermittently enabled and disabled such that only one driver is enabled at any time, as in half-duplex communication. The master receiver may remain fully enabled at all times.

Because the driver may not be disabled, only one driver should be connected to the bus when using the SN65HVD71, SN65HVD74, or SN65HVD77 device.



Figure 31. Full-Duplex Transceiver Configurations

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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Typical Application (continued)

10.2.1 Design Parameters

RS-485 is a robust electrical standard suitable for long-distance networking that may be used in a wide range of applications with varying requirements, such as distance, data rate, and number of nodes.

10.2.1.1 Data Rate and Bus Length

There is an inverse relationship between data rate and cable length, which means the higher the data rate, the shorter the cable length; and conversely, the lower the data rate, the longer the cable length. While most RS-485 systems use data rates between 10 kbps and 100 kbps, some applications require data rates up to 250 kbps at distances of 4000 ft and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

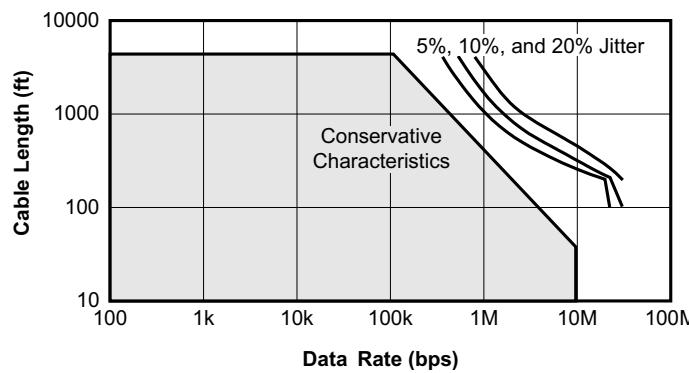


Figure 32. Cable Length vs Data Rate Characteristic

10.2.1.2 Stub Length

When connecting a node to the bus, the distance between the transceiver inputs and the cable trunk, known as the stub, should be as short as possible. Stubs present a non-terminated piece of bus line which can introduce reflections as the length of the stub increases. As a general guideline, the electrical length, or round-trip delay, of a stub should be less than one-tenth of the rise time of the driver, thus giving a maximum physical stub length as shown in [Equation 1](#).

$$L_{(STUB)} \leq 0.1 \times t_r \times v \times c$$

where

- t_r is the 10/90 rise time of the driver
- v is the signal velocity of the cable or trace as a factor of c
- c is the speed of light (3×10^8 m/s)

(1)

Per [Equation 1](#), [Table 5](#) lists the maximum cable-stub lengths for the minimum-driver output rise-times of the SN65HVD7x full-duplex family of transceivers for a signal velocity of 78%.

Table 5. Maximum Stub Length

DEVICE	MINIMUM DRIVER OUTPUT RISE TIME (ns)	MAXIMUM STUB LENGTH	
		(m)	(ft)
SN65HVD70	100	2.34	7.7
SN65HVD71	100	2.34	7.7
SN65HVD73	4	0.1	0.3
SN65HVD74	4	0.1	0.3
SN65HVD76	2	0.05	0.15
SN65HVD77	2	0.05	0.15

10.2.1.3 Bus Loading

The RS-485 standard specifies that a compliant driver must be able to driver 32 unit loads (UL), where 1 unit load represents a load impedance of approximately $12\text{ k}\Omega$. Because the SN65HVD7x family consists of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible.

10.2.1.4 Receiver Failsafe

The differential receivers of the SN65HVD7x family are *failsafe* to invalid bus states caused by the following:

- Open bus conditions, such as a disconnected connector
- Shorted bus conditions, such as cable damage shorting the twisted-pair together
- Idle bus conditions that occur when no driver on the bus is actively driving

In any of these cases, the differential receiver will output a failsafe logic high state so that the output of the receiver is not indeterminate.

Receiver failsafe is accomplished by offsetting the receiver thresholds such that the *input indeterminate* range does not include zero volts differential. In order to comply with the RS-422 and RS-485 standards, the receiver output must output a high when the differential input V_{ID} is more positive than 200 mV, and must output a Low when V_{ID} is more negative than -200 mV. The receiver parameters which determine the failsafe performance are V_{IT+} , V_{IT-} , and V_{hys} (the separation between V_{IT+} and V_{IT-}). As shown in the [Electrical Characteristics](#) table, differential signals more negative than -200 mV will always cause a low receiver output, and differential signals more positive than 200 mV will always cause a high receiver output.

When the differential input signal is close to zero, it is still above the V_{IT+} threshold, and the receiver output will be High. Only when the differential input is more than V_{hys} below V_{IT+} will the receiver output transition to a Low state. Therefore, the noise immunity of the receiver inputs during a bus fault conditions includes the receiver hysteresis value, V_{hys} , as well as the value of V_{IT+} .

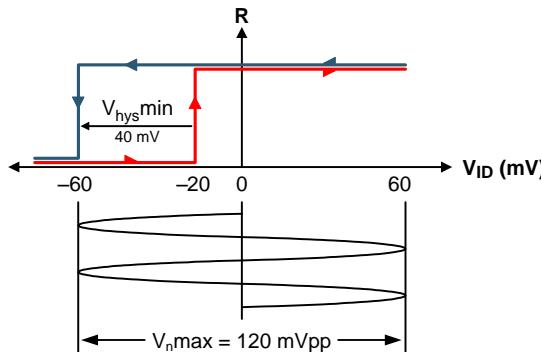


Figure 33. SN65HVD7x Noise Immunity Under Bus Fault Conditions

10.2.1.5 Transient Protection

The bus pins of the SN65HVD7x full-duplex transceiver family include on-chip ESD protection against $\pm 30\text{-kV}$ HBM and $\pm 12\text{-kV}$ IEC 61000-4-2 contact discharge. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance, $C_{(S)}$, and 78% lower discharge resistance, $R_{(D)}$, of the IEC model produce significantly higher discharge currents than the HBM model.

As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method. Although IEC air-gap testing is less repeatable than contact testing, air discharge protection levels are inferred from contact discharge test results.

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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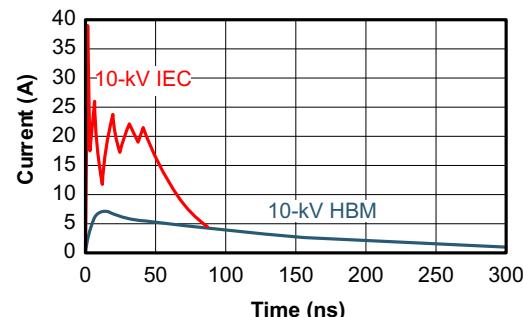
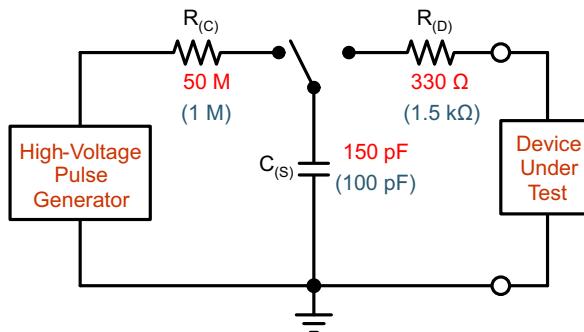


Figure 34. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

The on-chip implementation of IEC ESD protection significantly increases the robustness of equipment. Common discharge events occur because of human contact with connectors and cables. Designers may choose to implement protection against longer duration transients, typically referred to as surge transients.

EFTs are generally caused by relay-contact bounce or the interruption of inductive loads. Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuit switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems.

Figure 35 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The left hand diagram shows the relative pulse-power for a 0.5kV surge transient and 4-kV EFT transient, both of which dwarf the 10-kV ESD transient visible in the lower-left corner. 500-V surge transients are representative of events that may occur in factory environments in industrial and process automations.

The right hand diagram shows the pulse-power of a 6-kV surge transient, relative to the same 0.5-kV surge transient. 6-kV surge transients are most likely to occur in power generation and power-grid systems.

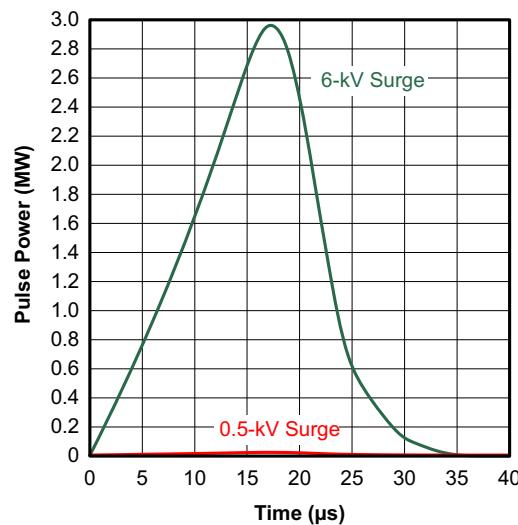
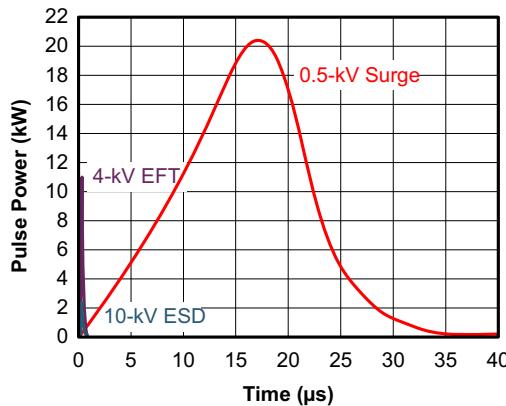


Figure 35. Power Comparison of ESD, EFT, and Surge Transients

In the case of surge transients, high-energy content is characterized by long pulse duration and slow decaying pulse power. The electrical energy of a transient that is dumped into the internal protection cells of a transceiver is converted into thermal energy, which heats and destroys the protection cells, thus destroying the transceiver. Figure 36 shows the large differences in transient energies for single ESD, EFT, surge transients, and an EFT pulse train that is commonly applied during compliance testing.

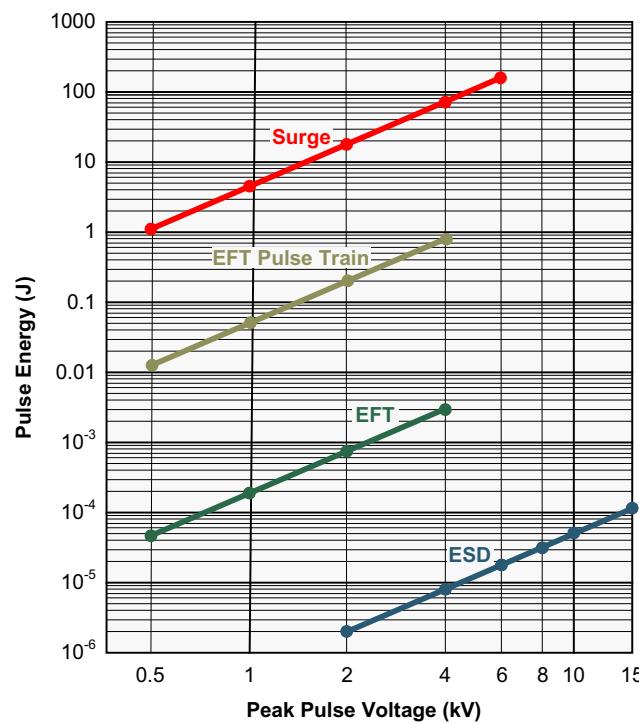


Figure 36. Comparison of Transient Energies

10.2.2 Detailed Design Procedure

In order to protect bus nodes against high-energy transients, the implementation of external transient protection devices is therefore necessary. [Figure 37](#) shows a protection circuit against 16-kV ESD, 4-kV EFT, and 1-kV surge transients.

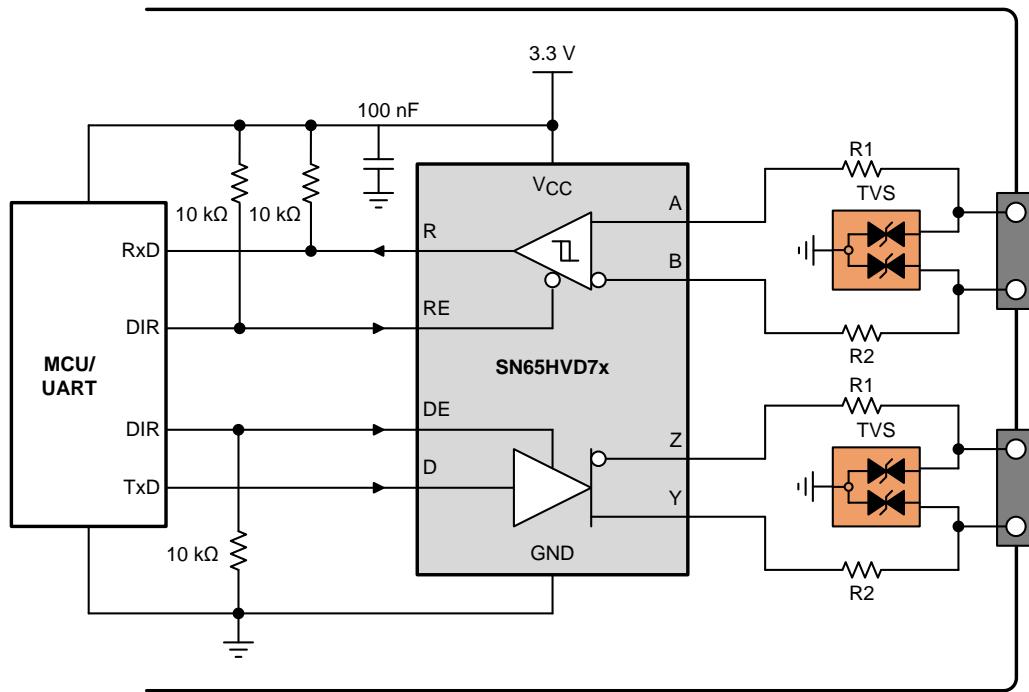


Figure 37. Transient Protection Against ESD, EFT, and Surge transients

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

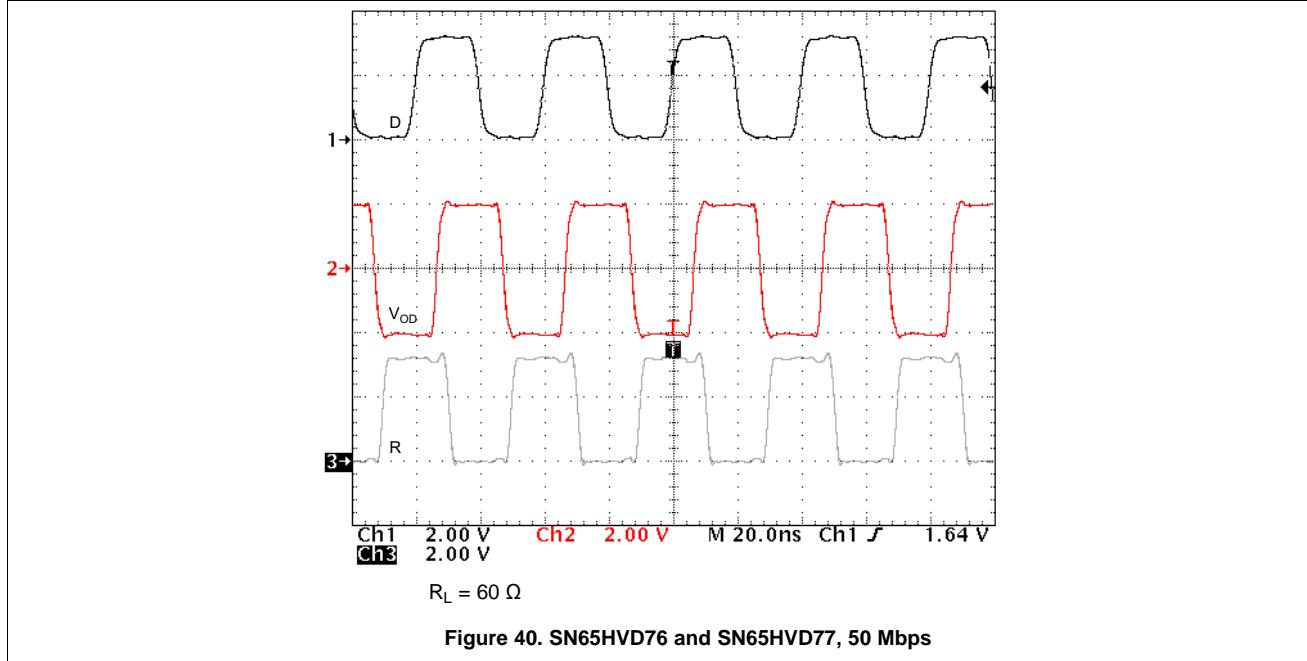
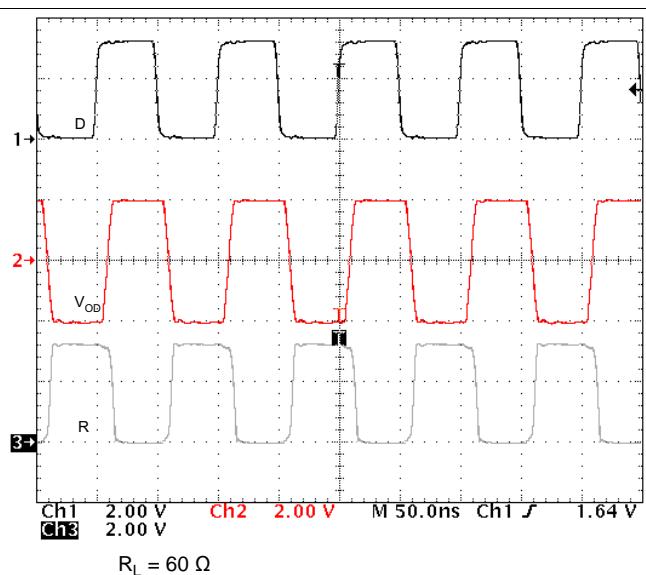
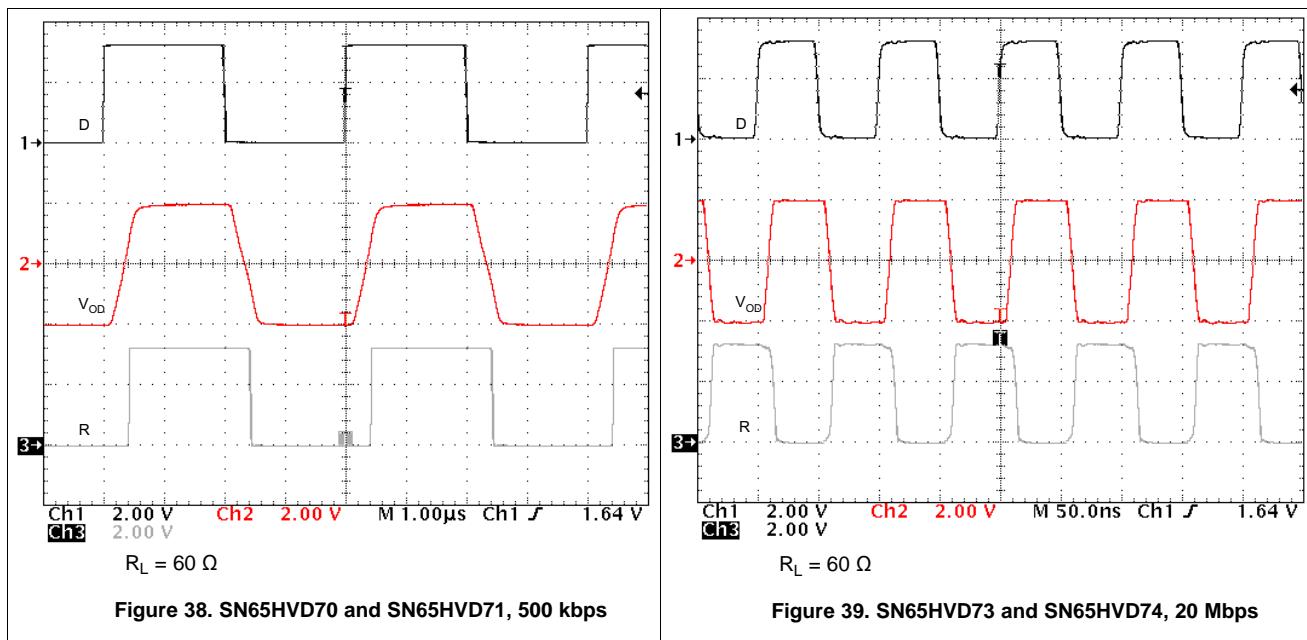
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Table 6. Bill of Materials

DEVICE	FUNCTION	ORDER NUMBER	MANUFACTURER
XCVR	3.3-V, full-duplex RS-485 transceiver	SN65HVD7xD	TI
R1	10- Ω , pulse-proof thick-film resistor	CRCW0603010RJNEAHP	Vishay
R2			
TVS	Bidirectional 400-W transient suppressor	CDSOT23-SM712	Bourns

10.2.3 Application Curves



11 Power Supply Recommendations

To ensure reliable operation at all data rates and supply voltages, each supply should be buffered with a 100-nF ceramic capacitor located as close to the supply pins as possible. The TPS76333 is a linear voltage regulator suitable for the 3.3-V supply.

12 Layout

12.1 Layout Guidelines

On-chip IEC-ESD protection is good for laboratory and portable equipment but never sufficient for EFT and surge transients occurring in industrial environments. Therefore robust and reliable bus node design requires the use of external transient protection devices.

Because ESD and EFT transients have a wide frequency bandwidth from approximately 3-MHz to 3-GHz, high-frequency layout techniques must be applied during PCB design.

For successful PCB design, begin with the design of the protection circuit (see [Figure 41](#)).

1. Place the protection circuitry close to the bus connector to prevent noise transients from penetrating your board.
2. Use V_{CC} and ground planes to provide low-inductance. Note that high-frequency currents follow the path of least inductance and not the path of least impedance.
3. Design the protection components into the direction of the signal path. Do not force the transient currents to divert from the signal path to reach the protection device.
4. Apply 100-nF to 220-nF bypass capacitors as close as possible to the V_{CC} -pins of transceiver, UART, controller ICs on the board (see [Figure 41](#)).
5. Use at least two vias for V_{CC} and ground connections of bypass capacitors and protection devices to minimize effective via-inductance (see [Figure 41](#)).
6. Use 1-k Ω to 10-k Ω pullup and pulldown resistors for enable lines to limit noise currents in these lines during transient events (see [Figure 41](#)).
7. Insert pulse-proof resistors into the A and B bus lines if the TVS clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors limit the residual clamping current into the transceiver and prevent it from latching up (see [Figure 41](#)).
8. While pure TVS protection is sufficient for surge transients up to 1 kV, higher transients require metal-oxide varistors (MOVs) which reduce the transients to a few hundred volts of clamping voltage, and transient blocking units (TBUs) that limit transient current to less than 1 mA.

SN65HVD70, SN65HVD71, SN65HVD73, SN65HVD74, SN65HVD76, SN65HVD77

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12.2 Layout Example

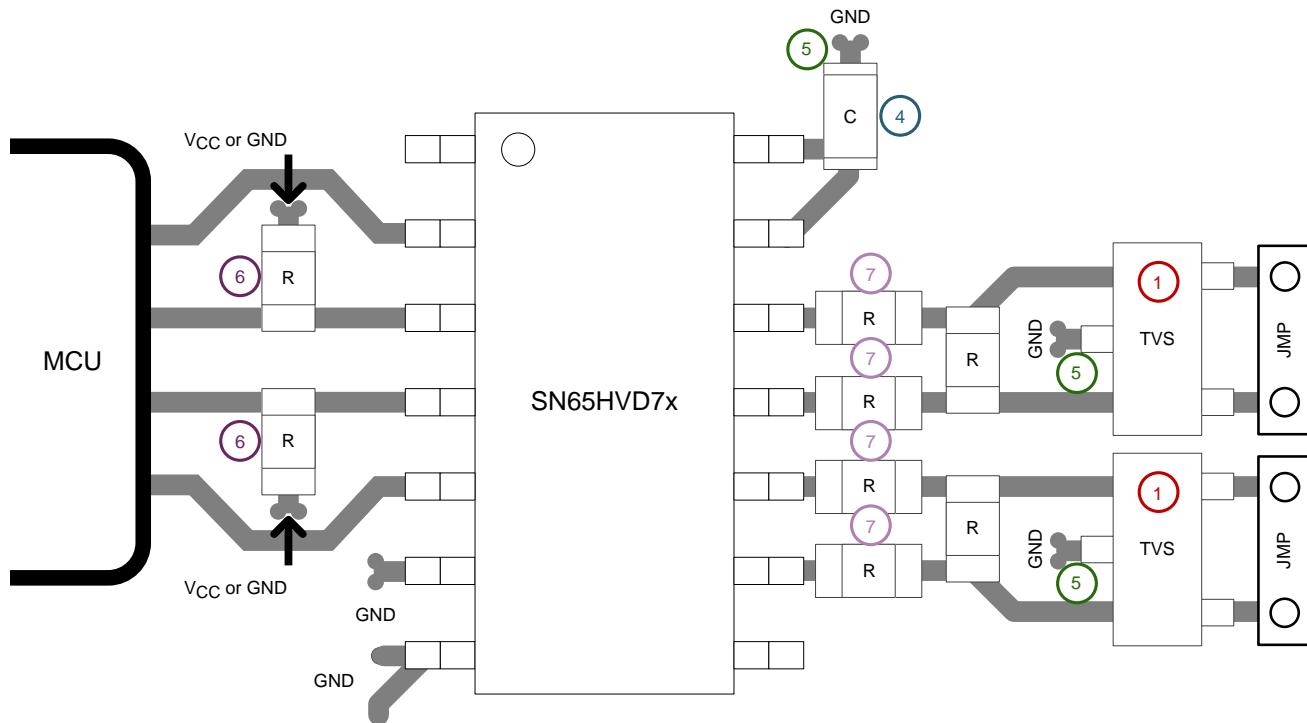


Figure 41. SN65HVD7x Layout Example

13 Device and Documentation Support

13.1 Device Support

13.1.1 Third-Party Products Disclaimer

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13.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 7. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
SN65HVD70	Click here				
SN65HVD71	Click here				
SN65HVD73	Click here				
SN65HVD74	Click here				
SN65HVD76	Click here				
SN65HVD77	Click here				

13.3 Trademarks

All trademarks are the property of their respective owners.

13.4 Electrostatic Discharge Caution

 This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.
 ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

13.5 Glossary

[SLYZ022 — TI Glossary](#)

This glossary lists and explains terms, acronyms, and definitions.

14 Mechanical, Packaging, and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65HVD70D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD70	Samples
SN65HVD70DGS	ACTIVE	VSSOP	DGS	10	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	VD70	Samples
SN65HVD70DGSR	ACTIVE	VSSOP	DGS	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD70	Samples
SN65HVD70DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD70	Samples
SN65HVD71D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD71	Samples
SN65HVD71DGK	ACTIVE	VSSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD71	Samples
SN65HVD71DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD71	Samples
SN65HVD71DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD71	Samples
SN65HVD73D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD73	Samples
SN65HVD73DGS	ACTIVE	VSSOP	DGS	10	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD73	Samples
SN65HVD73DGSR	ACTIVE	VSSOP	DGS	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD73	Samples
SN65HVD73DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD73	Samples
SN65HVD74D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD74	Samples
SN65HVD74DGK	ACTIVE	VSSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD74	Samples
SN65HVD74DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD74	Samples
SN65HVD74DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD74	Samples
SN65HVD76D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD76	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65HVD76DGS	ACTIVE	VSSOP	DGS	10	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD76	Samples
SN65HVD76DGSR	ACTIVE	VSSOP	DGS	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	VD76	Samples
SN65HVD76DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD76	Samples
SN65HVD77D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD77	Samples
SN65HVD77DGK	ACTIVE	VSSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD77	Samples
SN65HVD77DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	VD77	Samples
SN65HVD77DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	HVD77	Samples

(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.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

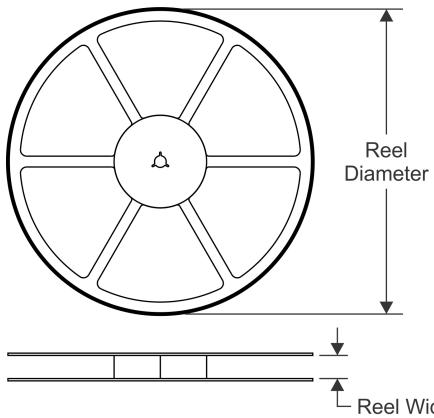
⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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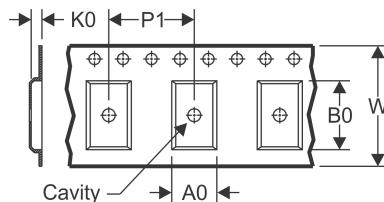
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

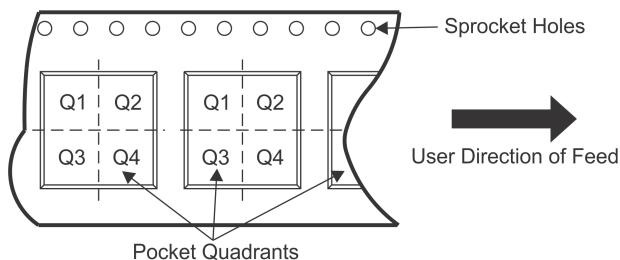


TAPE DIMENSIONS



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

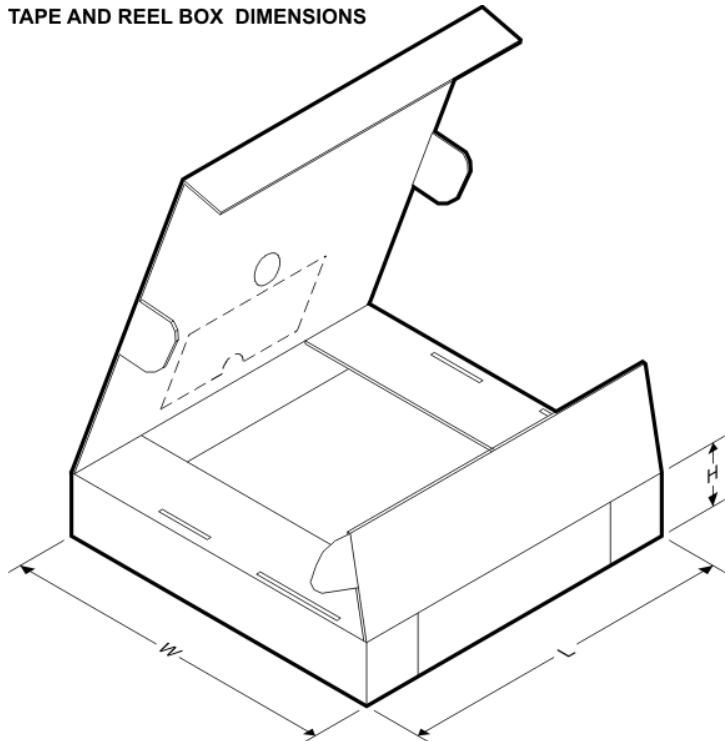
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN65HVD70DGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
SN65HVD70DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD71DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
SN65HVD73DGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
SN65HVD74DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
SN65HVD76DGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
SN65HVD76DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN65HVD77DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



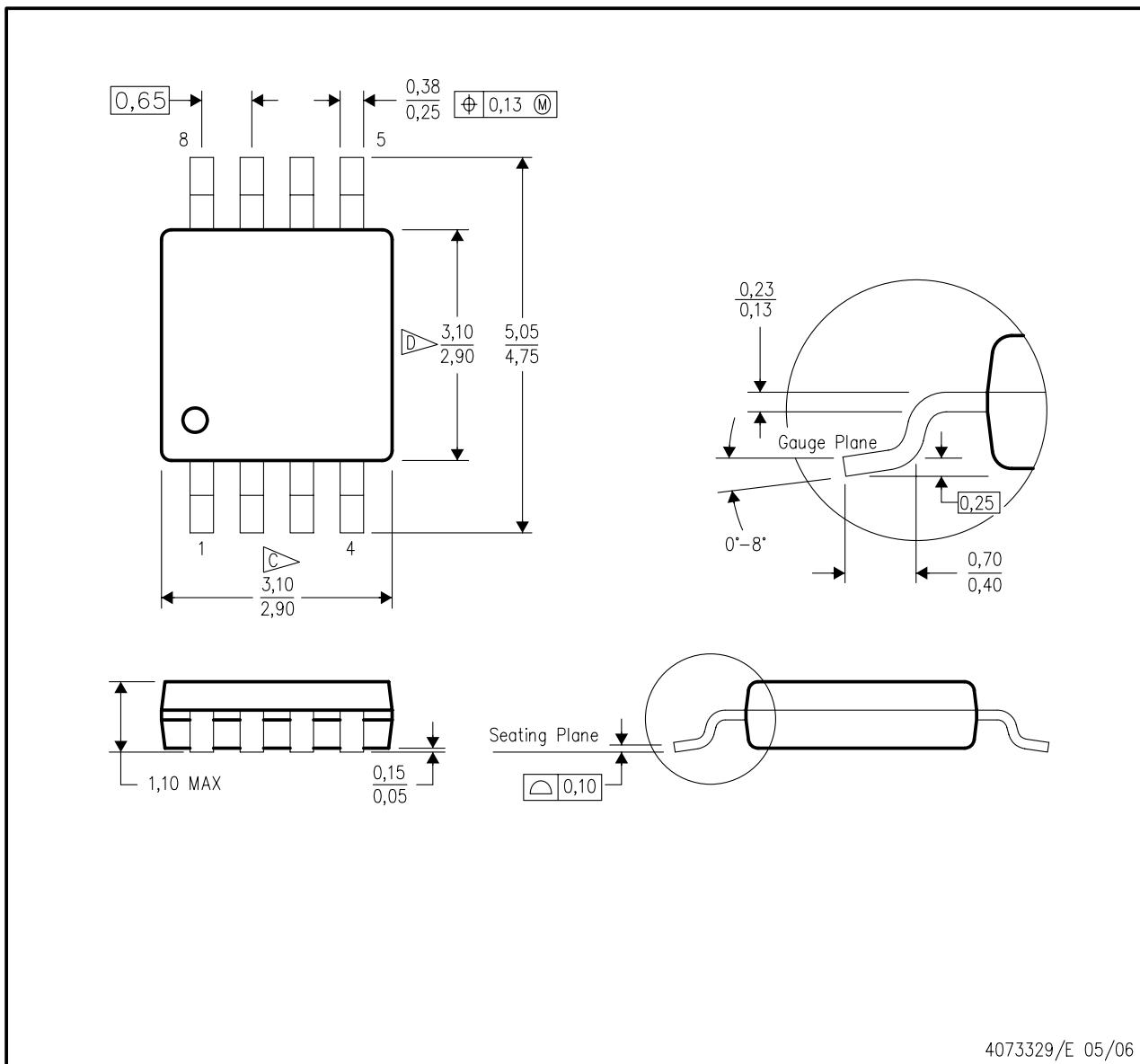
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65HVD70DGSR	VSSOP	DGS	10	2500	364.0	364.0	27.0
SN65HVD70DR	SOIC	D	14	2500	333.2	345.9	28.6
SN65HVD71DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
SN65HVD73DGSR	VSSOP	DGS	10	2500	364.0	364.0	27.0
SN65HVD74DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
SN65HVD76DGSR	VSSOP	DGS	10	2500	366.0	364.0	50.0
SN65HVD76DR	SOIC	D	14	2500	333.2	345.9	28.6
SN65HVD77DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0

MECHANICAL DATA

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4073329/E 05/06

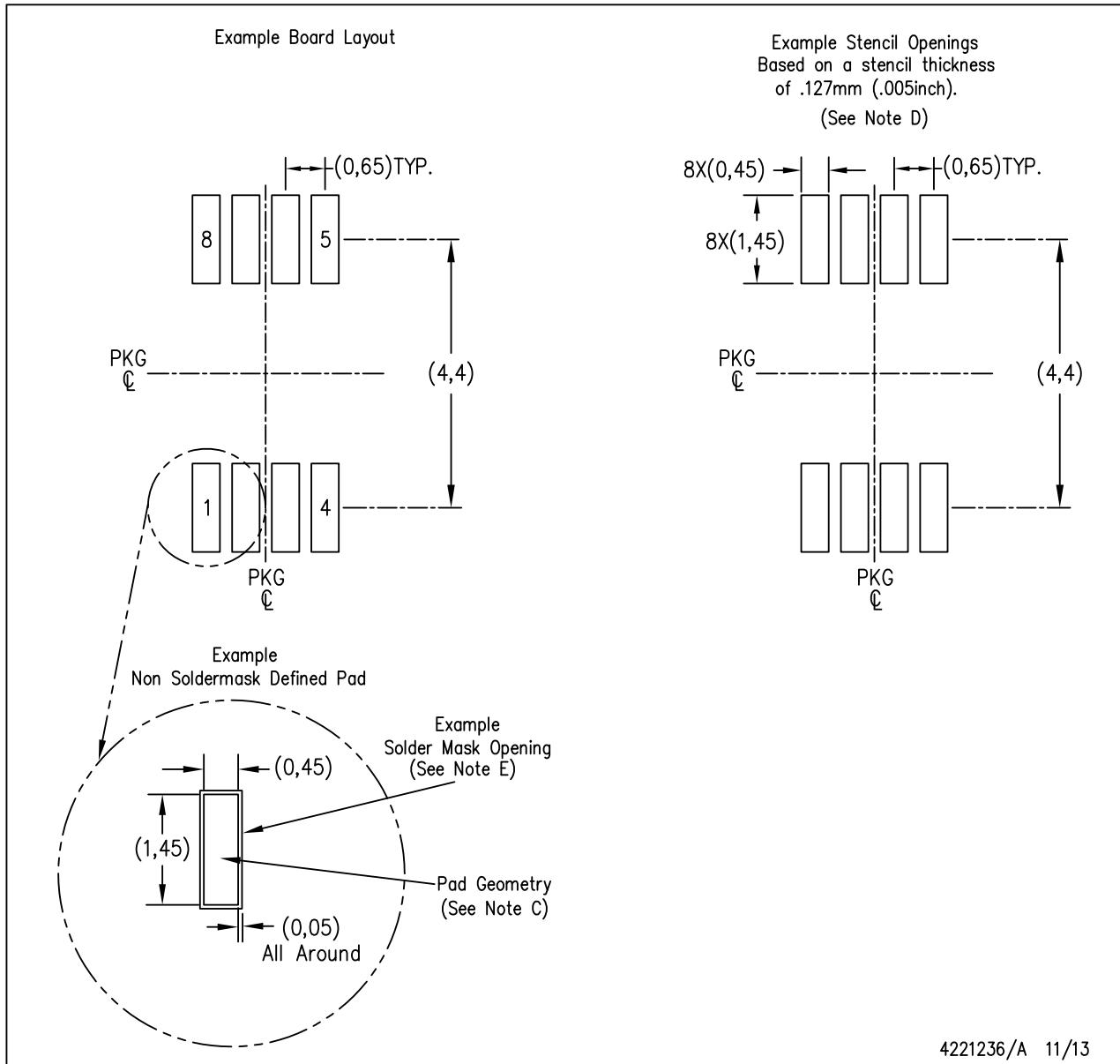
NOTES:

- A. All linear dimensions are in 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 0.15 per end.
- D** Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

LAND PATTERN DATA

DGK (S-PDSO-G8)

PLASTIC SMALL OUTLINE PACKAGE



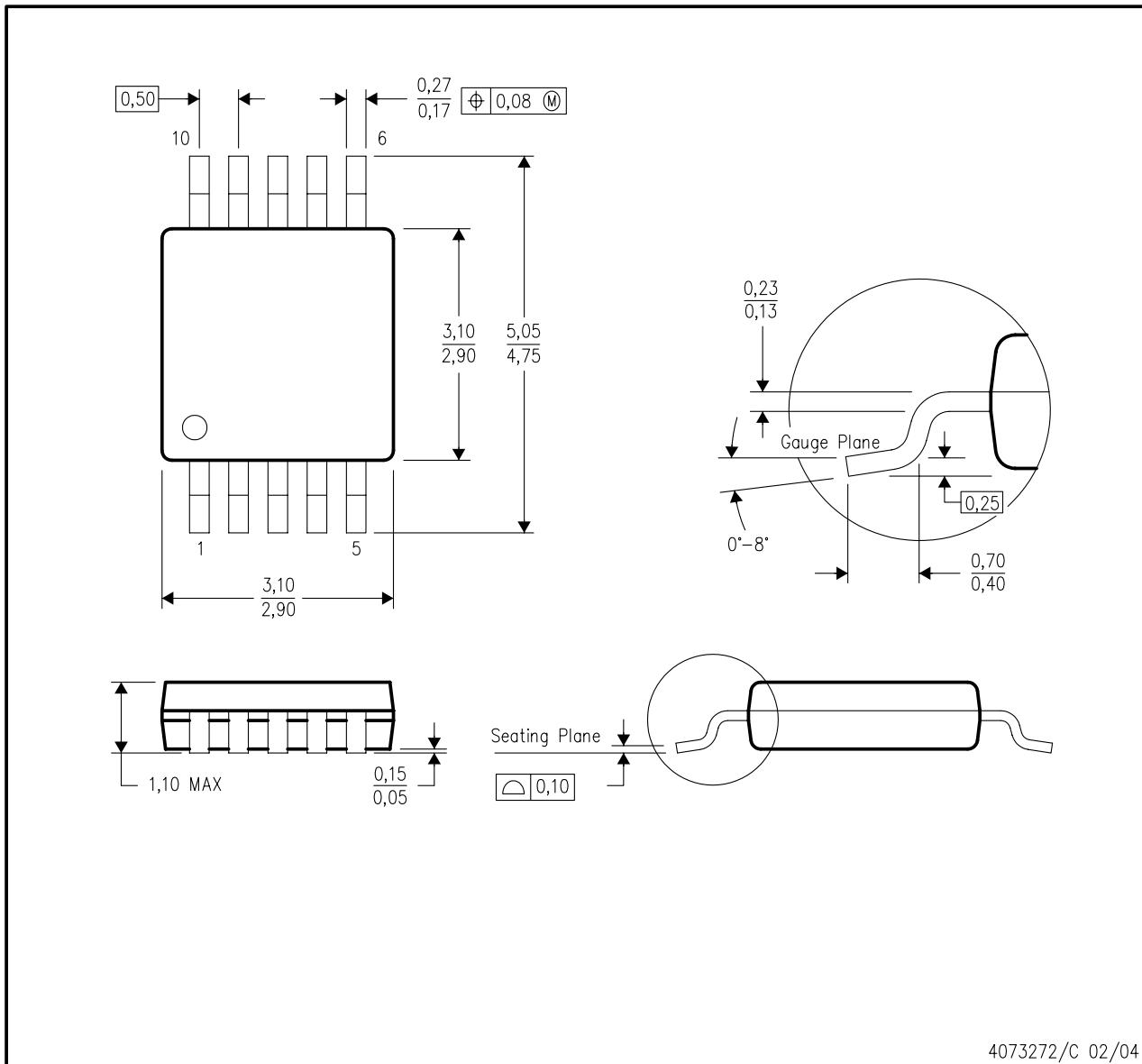
NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- 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 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

MECHANICAL DATA

DGS (S-PDSO-G10)

PLASTIC SMALL-OUTLINE PACKAGE



4073272/C 02/04

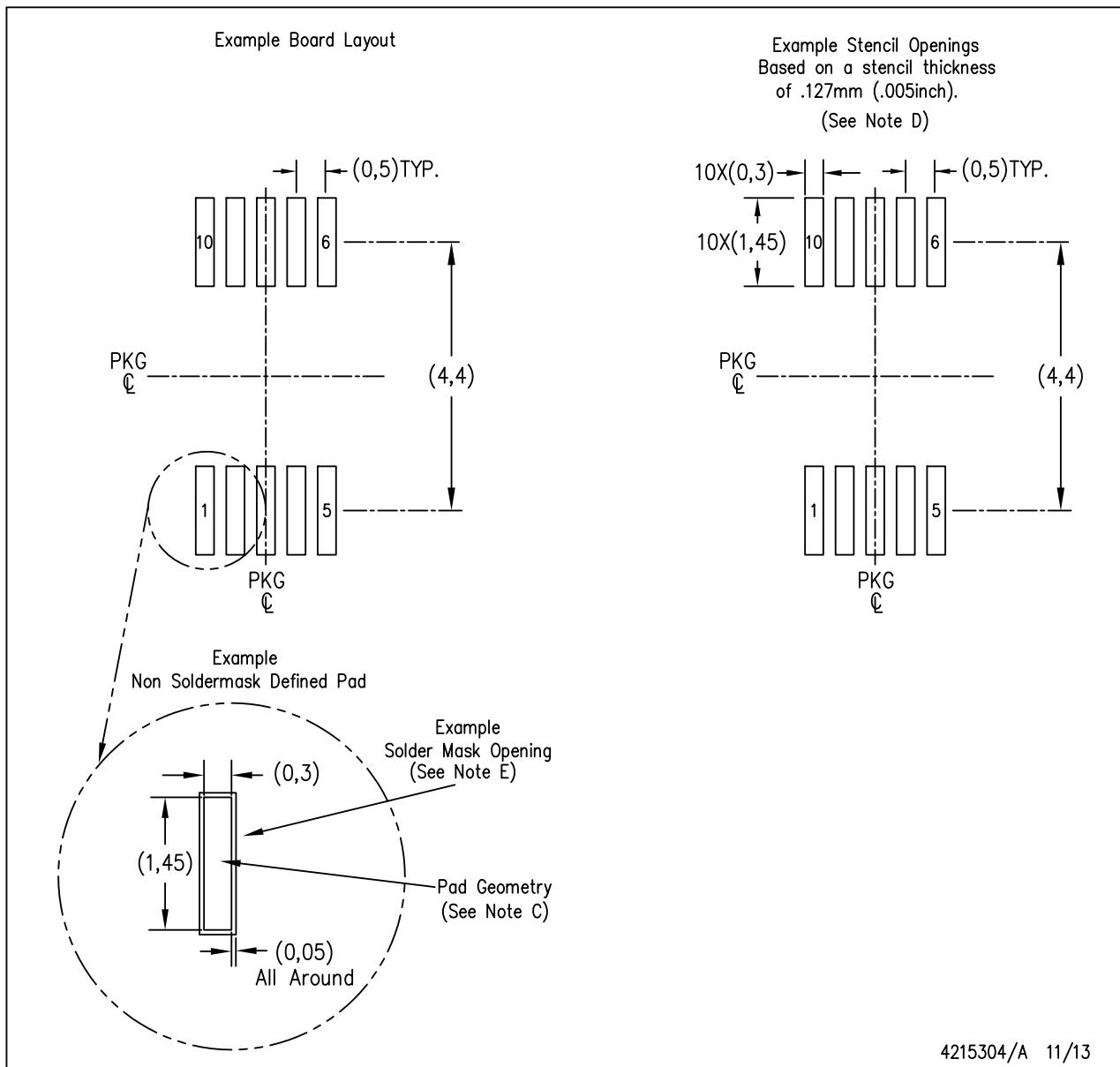
NOTES:

- All linear dimensions are in millimeters.
- This drawing is subject to change without notice.
- Body dimensions do not include mold flash or protrusion.
- Falls within JEDEC MO-187 variation BA.

LAND PATTERN DATA

DGS (S-PDSO-G10)

PLASTIC SMALL OUTLINE PACKAGE



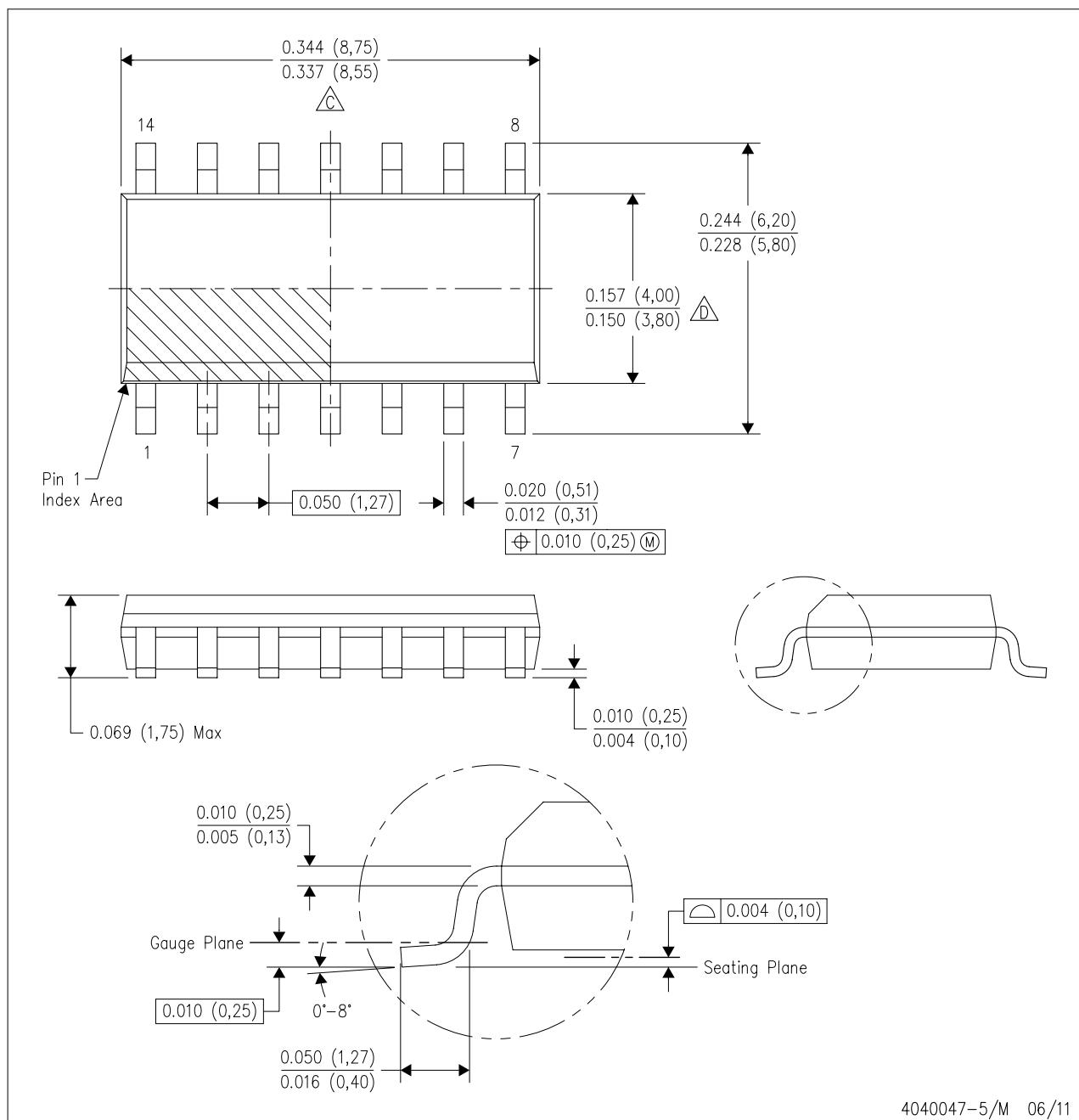
NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- 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 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

MECHANICAL DATA

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



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 0.006 (0,15) each side.

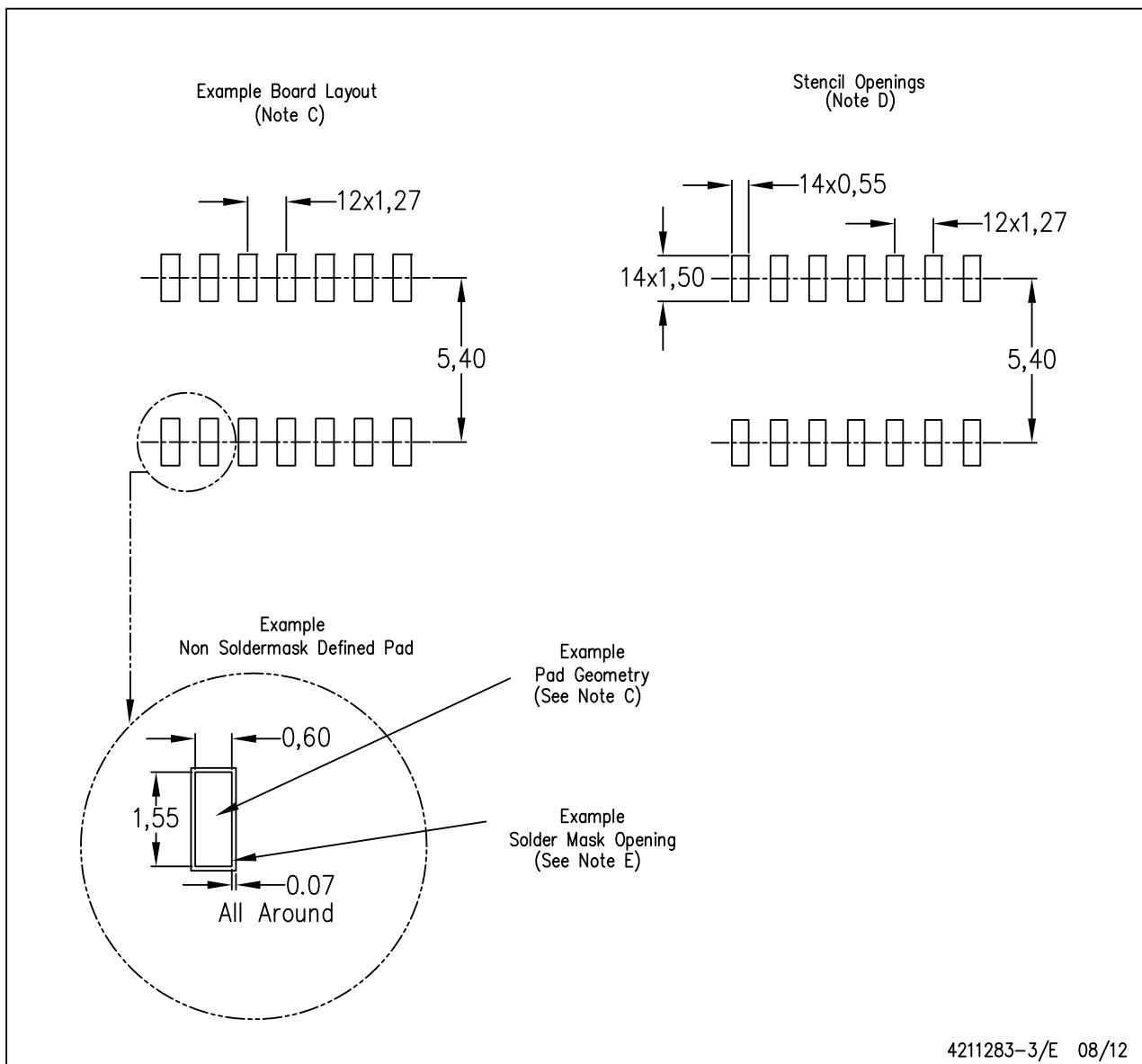
D Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.

E. Reference JEDEC MS-012 variation AB.

LAND PATTERN DATA

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



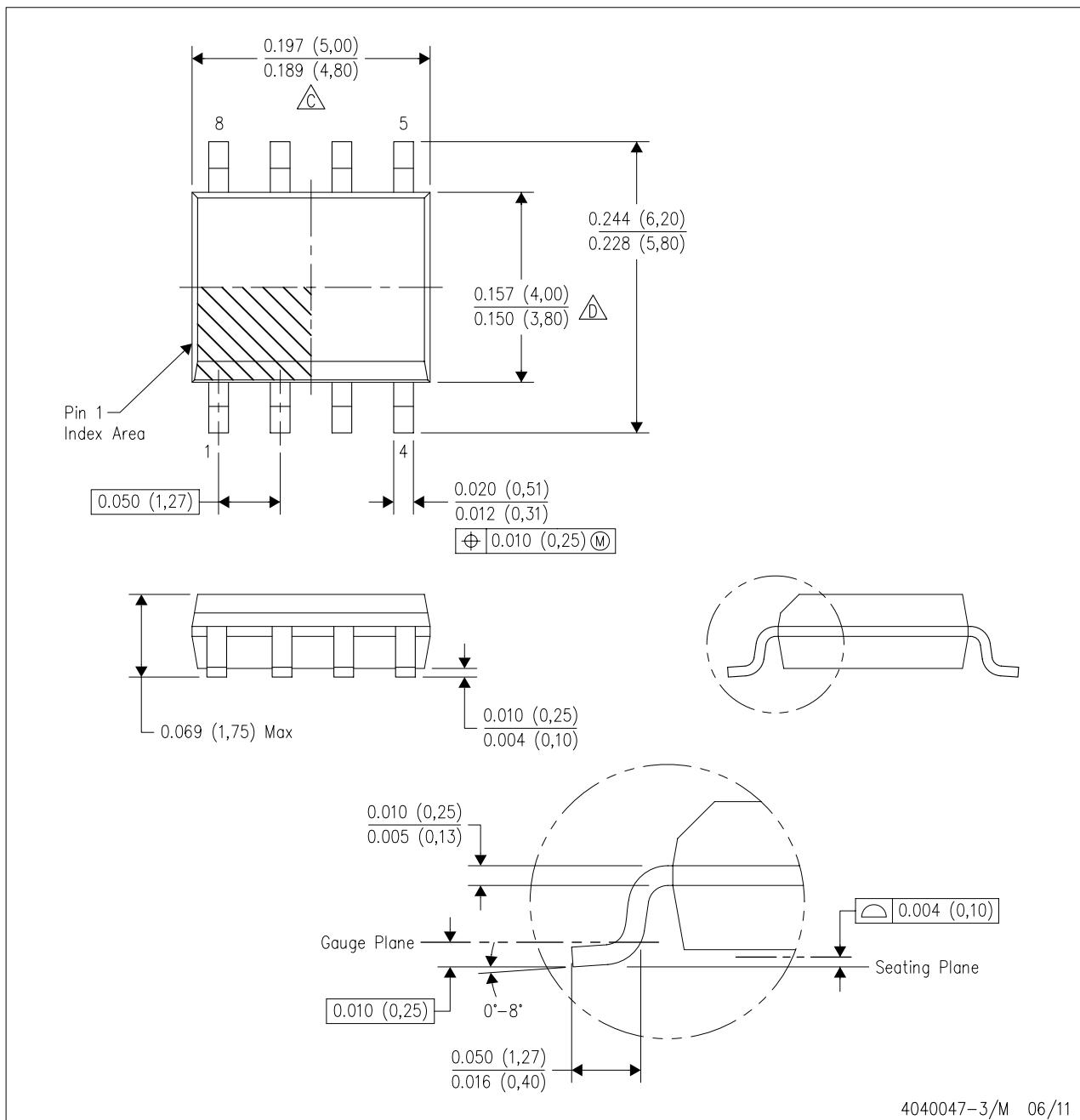
NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- 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 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

MECHANICAL DATA

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



4040047-3/M 06/11

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.

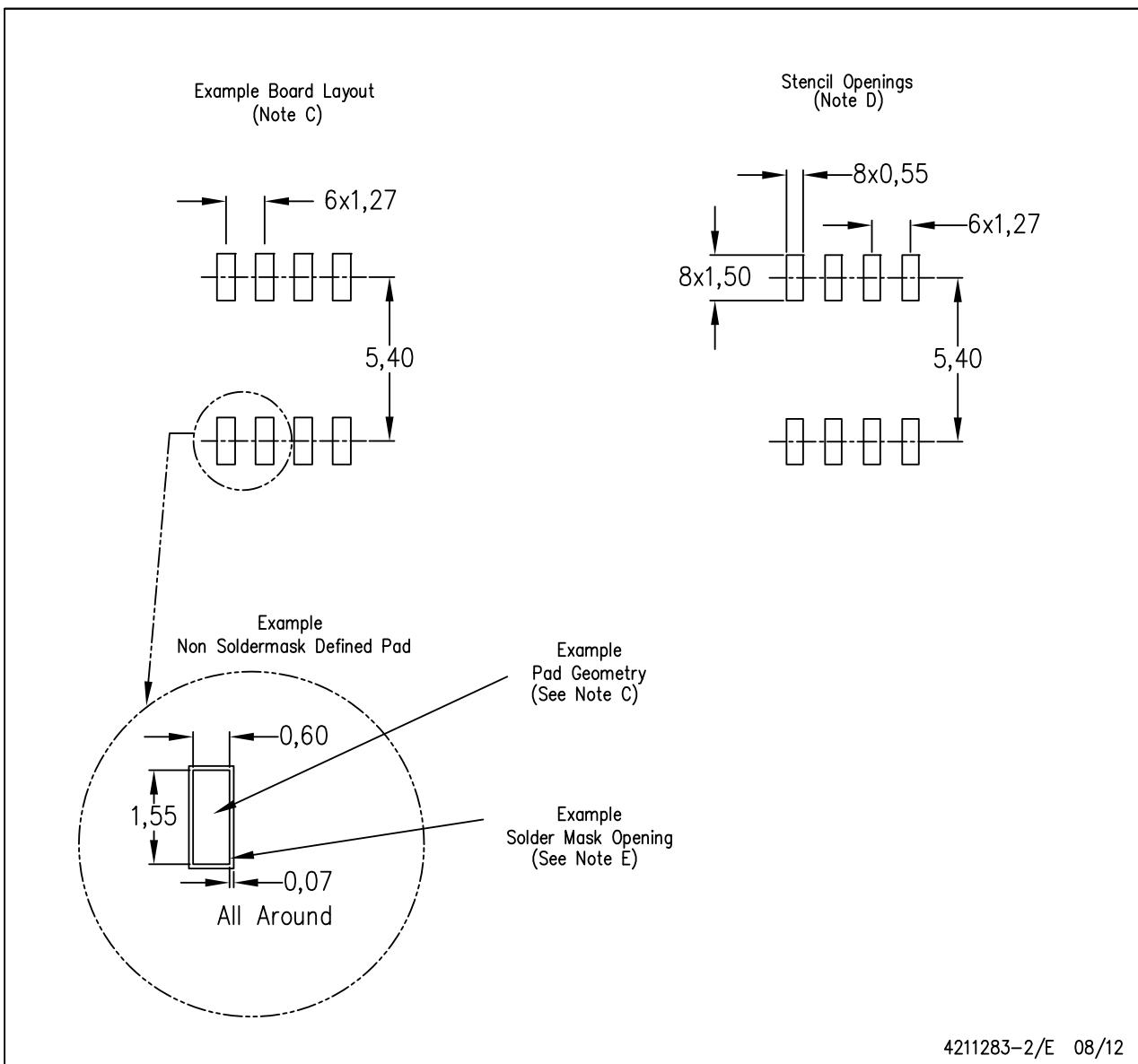
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.

D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AA.

LAND PATTERN DATA

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- 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 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

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