

70-V Fault-Protected RS-485 Transceivers with 3.3-V to 5-V Operation

FEATURES

- **Bus-Pin Fault Protection to $> \pm 70$ V**
- **Operation With 3.3-V to 5-V Supply Range**
- **± 16 kV HBM Protection on Bus Pins**
- **Reduced Unit Load for up to 320 Nodes**
- **Failsafe Receiver for Open-Circuit, Short-Circuit and Idle-Bus Conditions**
- **Low Power Consumption**
 - **Low Standby Supply Current, 1 μ A Max**
 - **I_{CC} 4 mA Quiescent During Operation**
- **Pin-Compatible With Industry-Standard SN75176**
- **Signaling Rates of 115 kbps, 1 Mbps, and up to 10 Mbps**

APPLICATIONS

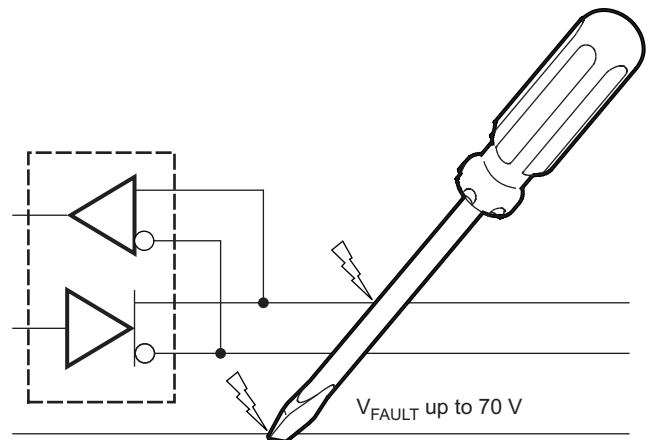
- HVAC Networks
- Security Electronics
- Building Automation
- Telecomm Equipment
- Motion Control
- Industrial Networks

DESCRIPTION

These devices are designed to survive overvoltage faults such as direct shorts to power supplies, mis-wiring faults, connector failures, cable crushes, and tool mis-applications. The internal current-limit circuits allow fault survivability without causing the high bus currents that otherwise might damage external components or power supplies. They are also robust to ESD events, with high levels of protection to the JEDEC or IEC human-body-model specification.

These devices combine a differential driver and a differential receiver, which operate from a single power supply. The driver differential outputs and the receiver differential inputs are connected internally to form a bus port suitable for half-duplex (two-wire bus) communication. This port features a wide common-mode voltage range, making the devices suitable for multipoint applications over long cable runs. These devices are characterized from -40°C to 125°C . These devices are pin-compatible with the industry-standard SN75176 transceiver, making them drop-in upgrades in most systems.

These devices are fully compliant with ANSI TIA/EIA 485-A with a 5-V supply and can operate with a 3.3-V supply with reduced driver output voltage for low-power applications. For applications where operation is required over an extended common-mode voltage range, see the SN65HVD1785 (SLLS872) data sheet.



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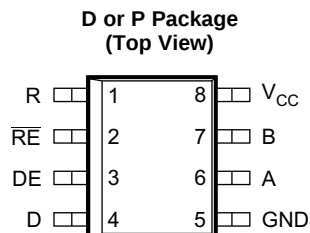
Transceiver	Signaling Rate	Number of Nodes
HVD1780	Up to 115 kbps	Up to 320
HVD1781	Up to 1 Mbps	Up to 320
HVD1782	Up to 10 Mbps	Up to 64



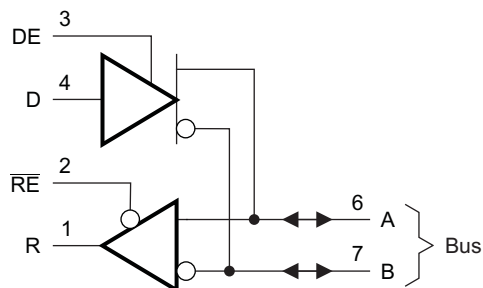
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.



LOGIC DIAGRAM (POSITIVE LOGIC)



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DEVICE INFORMATION

DRIVER FUNCTION TABLE

Input	Enable	Outputs		Driver State
D	DE	A	B	
H	H	H	L	Actively drive bus High
L	H	L	H	Actively drive bus Low
X	L	Z	Z	Driver disabled ⁽¹⁾
X	OPEN	Z	Z	Driver disabled by default ⁽¹⁾
OPEN	H	H	L	Actively drive bus High by default

(1) When both the driver and receiver are disabled, the device enters a low-power standby mode.

RECEIVER FUNCTION TABLE

Differential Input	Enable	Output	Receiver State
$V_{ID} = V_A - V_B$	RE	R	
$V_{IT+} < V_{ID}$	L	H	Receive valid bus High
$V_{IT-} < V_{ID} < V_{IT+}$	L	?	Indeterminate bus state
$V_{ID} < V_{IT-}$	L	L	Receive valid bus Low
X	H	Z	Receiver disabled ⁽¹⁾
X	OPEN	Z	Receiver disabled by default ⁽¹⁾
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

(1) When both the driver and receiver are disabled, the device enters a low-power standby mode.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

	VALUE	UNIT
V_{CC} Supply voltage	–0.5 to 7	V
Voltage range at A and B inputs	–70 to 70	V
Input voltage range at any logic pin	–0.3 to $V_{CC} + 0.3$	V
Voltage input range, transient pulse, A and B, through 100 Ω	–70 to 70	V
Receiver output current	–24 to 24	mA
T_J Junction temperature	170	°C
Continuous total power dissipation	See Dissipation Rating Table	
IEC 60749-26 ESD (human-body model), bus terminals and GND	± 16	kV
JEDEC Standard 22, Test Method A114 (human-body model), bus terminals and GND	± 16	kV
JEDEC Standard 22, Test Method A114 (human-body model), all pins	± 4	kV
JEDEC Standard 22, Test Method C101 (charged-device model), all pins	± 2	kV
JEDEC Standard 22, Test Method A115 (machine model), all pins	± 400	V

- (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.

PACKAGE DISSIPATION RATINGS

PACKAGE ⁽¹⁾	JEDEC THERMAL MODEL	$T_A < 25^\circ\text{C}$ RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ RATING	$T_A = 105^\circ\text{C}$ RATING	$T_A = 125^\circ\text{C}$ RATING (3.3 V ONLY)
SOIC (D) 8-pin	High-K	905 mW	7.25 mW/°C	470 mW	325 mW	180 mW
	Low-K	516 mW	4.1 mW/°C	268 mW	186 mW	103 mW
PDIP (P) 8-pin	High-K	2119 mW	16.9 mW/°C	1100mW	763 mW	426 mW
	Low-K	976 mW	7.8 mW/°C	508 mW	352 mW	196 mW

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

RECOMMENDED OPERATING CONDITIONS

	MIN	NOM	MAX	UNIT
V_{CC} Supply voltage	3.15	5	5.5	V
V_I Input voltage at any bus terminal (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
	–8		8	mA
R_L Differential load resistance	54	60		Ω
C_L Differential load capacitance		50		pF
$1/t_{UI}$ Signaling rate	HVD1780		115	kbps
	HVD1781		1	Mbps
	HVD1782		10	
T_A Operating free-air temperature (See application section for thermal information)	5-V supply		–40	°C
	3.3-V supply		–40	
T_J Junction temperature	–40		150	°C

- (1) By convention, the least positive (most negative) limit is designated as minimum in this data sheet.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
V _{OD} Driver differential output voltage magnitude	R _L = 60 Ω, 4.75 V ≤ V _{CC} 375 Ω on each output to –7 V to 12 V Figure 1	T _A < 85°C		1.5			V
		T _A < 125°C		1.4			
	R _L = 54 Ω, 4.75 V ≤ V _{CC} ≤ 5.25 V	T _A < 85°C		1.7	2		
		T _A < 125°C		1.5			
	R _L = 54 Ω, 3.15 V ≤ V _{CC} ≤ 3.45 V			0.8	1		
Δ V _{OD} Change in magnitude of driver differential output voltage	R _L = 100 Ω, 4.75 V ≤ V _{CC} ≤ 5.25 V	T _A < 85°C		2.2	2.5		mV
		T _A < 125°C		2			
V _{OC(SS)} Steady-state common-mode output voltage	R _L = 54 Ω			–50	0	50	mV
ΔV _{OC} Change in differential driver output common-mode voltage				–50	0	50	mV
V _{OC(PP)} Peak-to-peak driver common-mode output voltage	Center of two 27-Ω load resistors, See Figure 2				500		mV
C _{OD} Differential output capacitance					23		pF
V _{IT+} Positive-going receiver differential input voltage threshold					–100	–35	mV
V _{IT–} Negative-going receiver differential input voltage threshold				–180	–150		
V _{HYS} Receiver differential input voltage threshold hysteresis (V _{IT+} – V _{IT–})				30	50		
V _{OH} Receiver high-level output voltage	I _{OH} = –8 mA			2.4	V _{CC} – 0.3		V
V _{OL} Receiver low-level output voltage	I _{OL} = 8 mA	T _A < 85°C			0.2	0.4	V
		T _A < 125°C				0.5	
I _{I(LOGLC)} Driver input, driver enable, and receiver enable input current				–50		50	μA
I _{OZ} Receiver output high-impedance current	V _O = 0 V or V _{CC} , $\overline{RE}$ at V _{CC}			–1		1	μA
I _{OS} Driver short-circuit output current				–200		200	mA
I _{I(BUS)} Bus input current (disabled driver)	V _{CC} = 3.15 to 5.5 V or V _{CC} = 0 V, DE at 0 V	V _I = 12 V	1780, 1781		75	100	μA
			1782		400	500	
		V _I = –7 V	1780, 1781	–60	–40		
			1782	–400	–300		

ELECTRICAL CHARACTERISTICS (continued)

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I _{CC}	Supply current (quiescent)	Driver and receiver enabled	DE = V _{CC} , RE = GND, no load		4	6	mA
		Driver enabled, receiver disabled	DE = V _{CC} , RE = V _{CC} , no load		3	5	
		Driver disabled, receiver enabled	DE = GND, RE = GND, no load		2	4	
		Driver and receiver disabled, standby mode	DE = GND, D = open, RE = V _{CC} , no load, T _A < 85°C		0.15	1	μA
			DE = GND, D = open, RE = V _{CC} , no load, T _A < 125°C			12	
Supply current (dynamic)		See the <i>Typical Characteristics</i> section					

SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
DRIVER (HVD1780)							
t _r , t _f	Driver differential output rise/fall time	R _L = 54 Ω, C _L = 50 pF, See Figure 3		0.4	1.7	2.6	μs
t _{PHL} , t _{PLH}	Driver propagation delay			0.8		2	μs
t _{SK(P)}	Driver differential output pulse skew, t _{PHL} – t _{PLH}			20		250	ns
t _{PHZ} , t _{PLZ}	Driver disable time		See Figure 4 and Figure 5	0.1		5	μs
t _{PZH} , t _{PZL}	Driver enable time	Receiver enabled		0.2		3	μs
		Receiver disabled		3		12	
DRIVER (HVD1781)							
t _r , t _f	Driver differential output rise/fall time	R _L = 54 Ω, C _L = 50 pF, See Figure 3		50		300	ns
t _{PHL} , t _{PLH}	Driver propagation delay					200	ns
t _{SK(P)}	Driver differential output pulse skew, t _{PHL} – t _{PLH}					25	ns
t _{PHZ} , t _{PLZ}	Driver disable time		See Figure 4 and Figure 5			3	μs
t _{PZH} , t _{PZL}	Driver enable time	Receiver enabled				300	ns
		Receiver disabled				10	μs
DRIVER (HVD1782)							
t _r , t _f	Driver differential output rise/fall time	R _L = 54 Ω, C _L = 50 pF	All V _{CC} and Temp	50		ns	
			V _{CC} > 4.5V and T < 105°C	16			
t _{PHL} , t _{PLH}	Driver propagation delay		See Figure 3	55		ns	
t _{SK(P)}	Driver differential output pulse skew, t _{PHL} – t _{PLH}			10		ns	
t _{PHZ} , t _{PLZ}	Driver disable time				3	μs	
t _{PZH} , t _{PZL}	Driver enable time	Receiver enabled	See Figure 4 and Figure 5	300		ns	
		Receiver disabled		9		μs	
RECEIVER (ALL DEVICES UNLESS OTHERWISE NOTED)							
t _r , t _f	Receiver output rise/fall time	C _L = 15 pF, See Figure 6	All devices	4	15	ns	
t _{PHL} , t _{PLH}	Receiver propagation delay time		HVD1780, HVD1781	100	200	ns	
			HVD1782	80			
t _{SK(P)}	Receiver output pulse skew, t _{PHL} – t _{PLH}		HVD1780, HVD1781	6	20	ns	
			HVD1782	5			
t _{PLZ} , t _{PHZ}	Receiver disable time	Driver enabled, See Figure 7		15	100	ns	
t _{PZL(1)} , t _{PZH(1)} t _{PZL(2)} , t _{PZH(2)}	Receiver enable time	Driver enabled, See Figure 7		80	300	ns	
		Driver disabled, See Figure 8		3	9	μs	

THERMAL INFORMATION

PARAMETER		TEST CONDITIONS	VALUE	UNIT
$R_{\theta JA}$ Junction-to-ambient thermal resistance (no airflow)	SOIC-8	JEDEC high-K model	138	°C/W
		JEDIC low-K model	242	
	DIP-8	JEDEC high-K model	59	
		JEDIC low-K model	128	
$R_{\theta JB}$ Junction-to-board thermal resistance	SOIC-8		62	°C/W
	DIP-8		39	
$R_{\theta JC}$ Junction-to-case thermal resistance	SOIC-8		61	°C/W
	DIP-8		61	
P_D Power dissipation	$V_{CC} = 3.6V$, $T_J = 150^\circ C$, $R_L = 300 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 3.3-V supply, unterminated ⁽¹⁾		75	mW
	$V_{CC} = 3.6V$, $T_J = 150^\circ C$, $R_L = 100 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 3.3-V supply, RS-422 load ⁽¹⁾		95	
	$V_{CC} = 3.6V$, $T_J = 150^\circ C$, $R_L = 54 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 3.3-V supply, RS-485 load ⁽¹⁾		115	
	$V_{CC} = 5.5V$, $T_J = 150^\circ C$, $R_L = 300 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 5-V supply, unterminated ⁽¹⁾		290	
	$V_{CC} = 5.5V$, $T_J = 150^\circ C$, $R_L = 100 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 5-V supply, RS-422 load ⁽¹⁾		320	
	$V_{CC} = 5.5V$, $T_J = 150^\circ C$, $R_L = 54 \Omega$, $C_L = 50 \text{ pF}$ (driver), $C_L = 15 \text{ pF}$ (receiver) 5-V supply, RS-485 load ⁽¹⁾		400	
T_{SD} Thermal-shutdown junction temperature			170	°C

(1) Driver and receiver enabled, 50% duty cycle square-wave signal at signaling rate: 1 Mbps.

APPLICATION INFORMATION

Hot-Plugging

These devices are designed to operate in "hot swap" or "hot pluggable" applications. Key features for hot-pluggable applications are power-up, power-down glitch free operation, default disabled input/output pins, and receiver failsafe. As shown in [Figure 9](#), an internal Power-On Reset circuit keeps the driver outputs in a high-impedance state until the supply voltage has reached a level at which the device will reliably operate. This ensures that no problems will occur on the bus pin outputs as the power supply turns on or turns off.

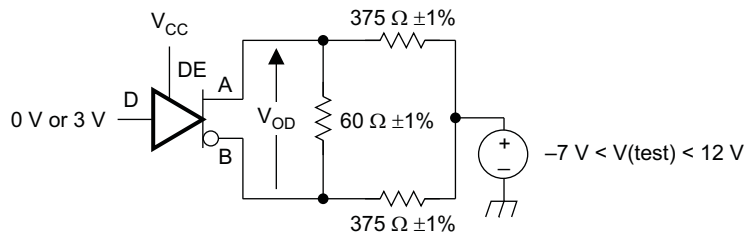
As shown in the device FUNCTION TABLE, the enable inputs have the feature of default disable on both the driver enable and receiver enable. This ensures that the device will neither drive the bus nor report data on the R pin until the associated controller actively drives the enable pins.

Receiver Failsafe

The differential receiver is "failsafe" to invalid bus states caused by open bus conditions such as, a disconnected connector, shorted bus conditions caused by damaged cabling, or idle bus conditions that occur when no driver is actively driving a valid RD-485 bus state on the network. In any of these cases, the differential receiver will output a failsafe HIGH state, so that small noise signals do not cause problems at the receiver output.

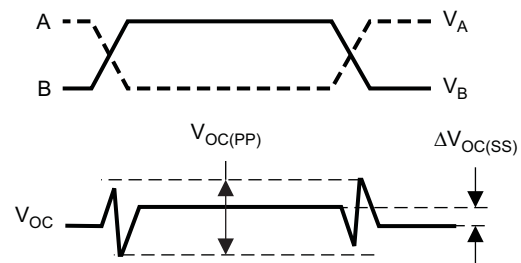
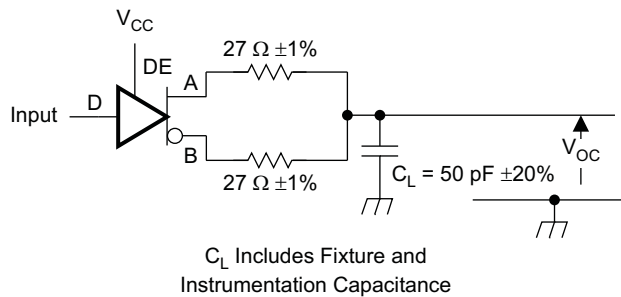
PARAMETER MEASUREMENT INFORMATION

Input generator rate is 100 kbps, 50% duty cycle, rise and fall times less than 6 nsec, output impedance 50 Ω .



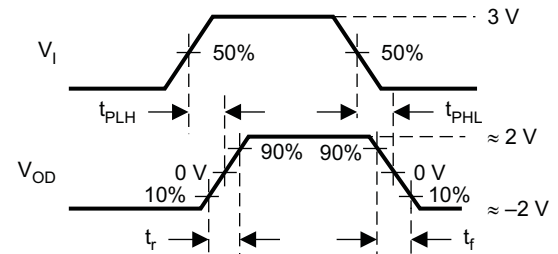
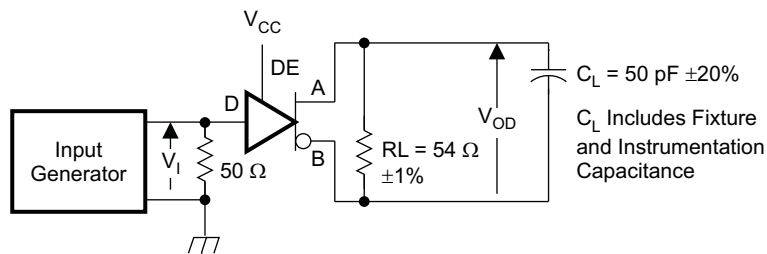
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Figure 1. Measurement of Driver Differential Output Voltage With Common-Mode Load



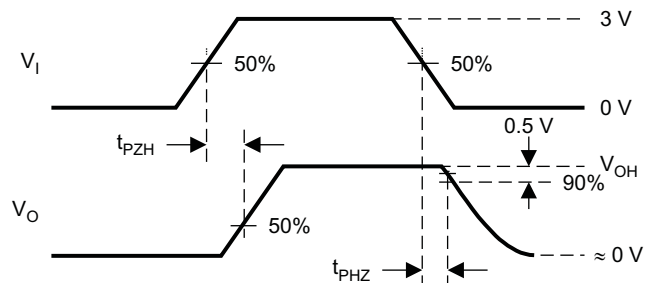
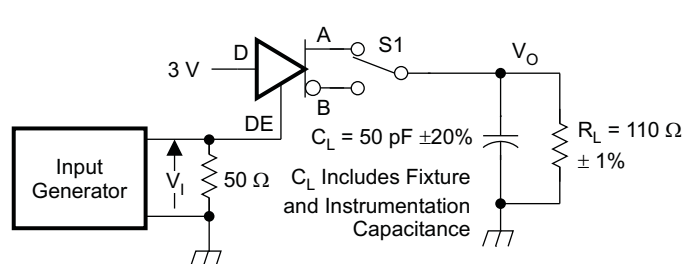
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Figure 2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load



S0303-01

Figure 3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

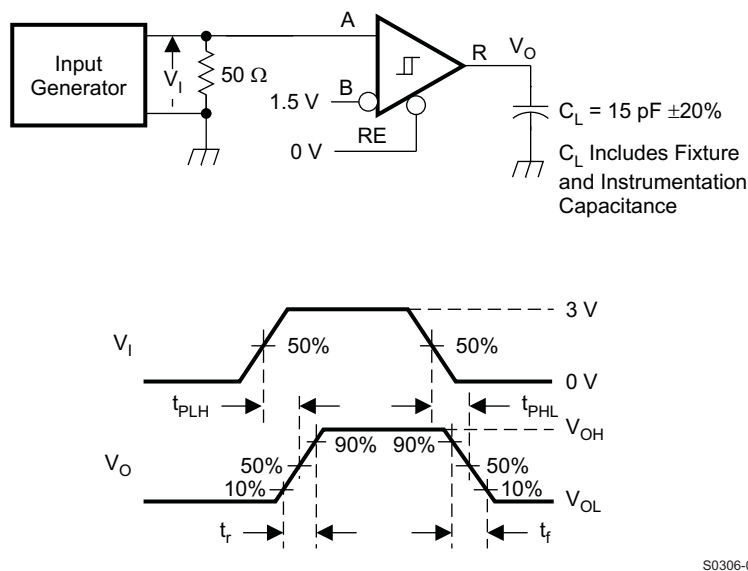
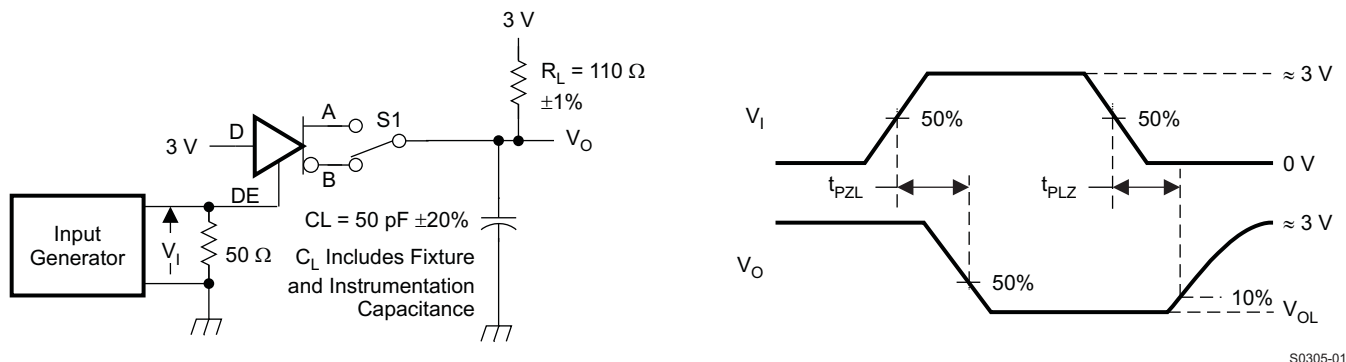


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NOTE: D at 3 V to test non-inverting output, D at 0 V to test inverting output.

Figure 4. Measurement of Driver Enable and Disable Times With Active High Output and Pulldown Load

PARAMETER MEASUREMENT INFORMATION (continued)



PARAMETER MEASUREMENT INFORMATION (continued)

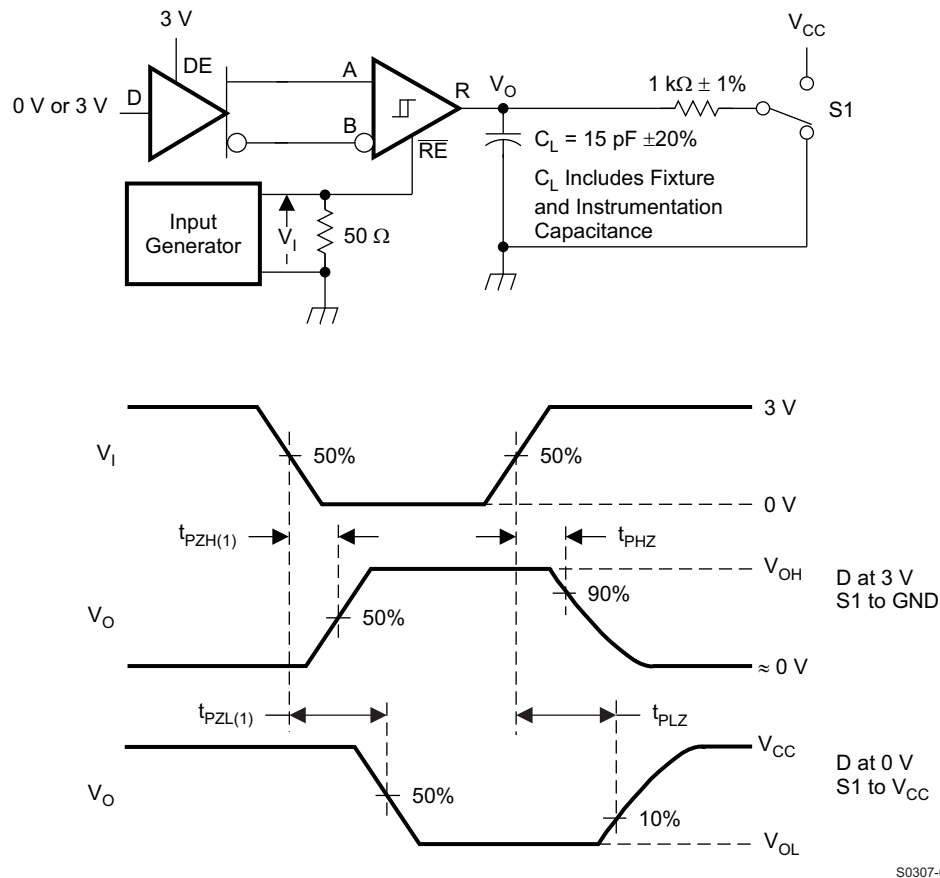
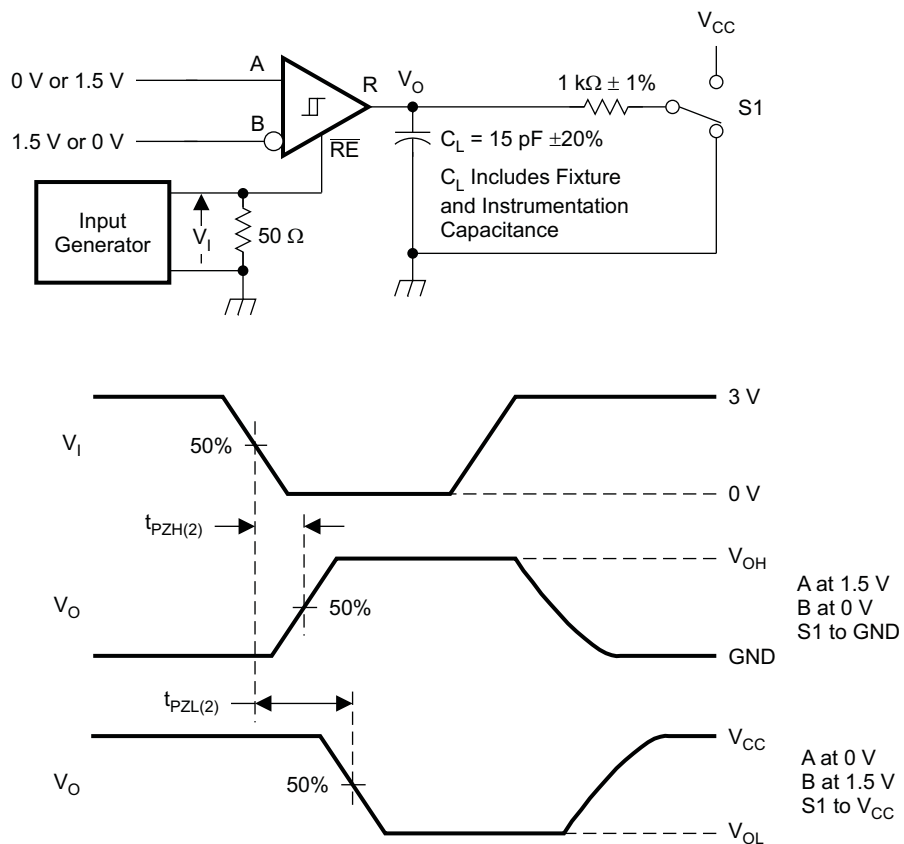


Figure 7. Measurement of Receiver Enable/Disable Times With Driver Enabled

PARAMETER MEASUREMENT INFORMATION (continued)



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Figure 8. Measurement of Receiver Enable Times With Driver Disabled

TYPICAL CHARACTERISTICS

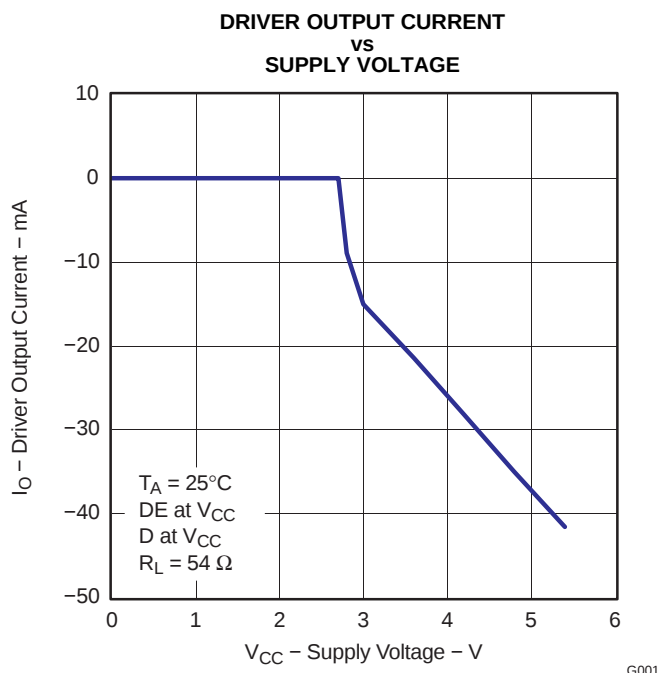


Figure 9.

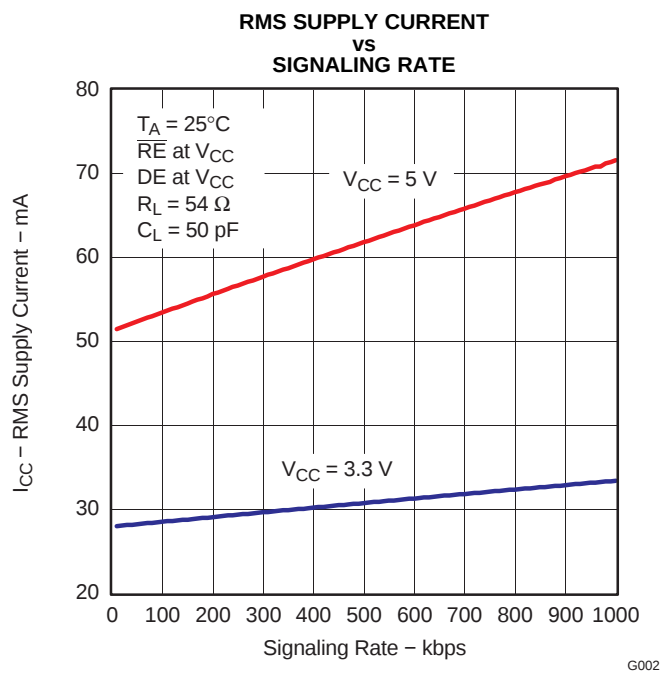


Figure 10.

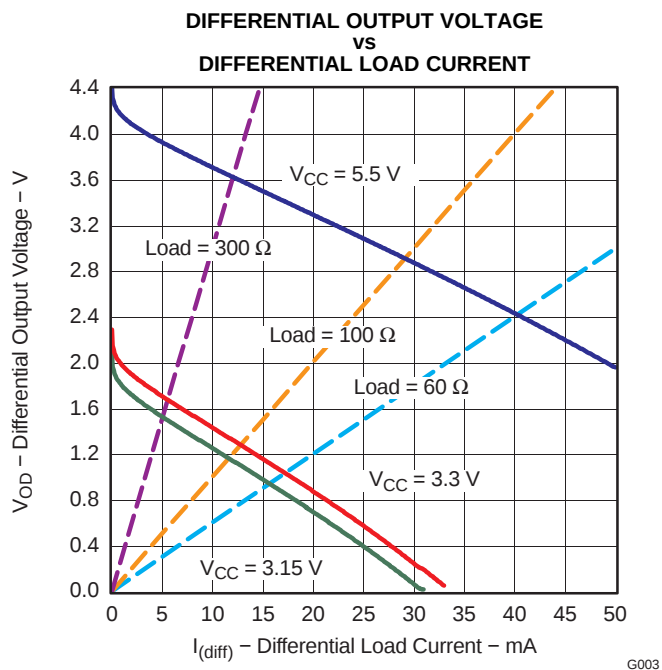


Figure 11.

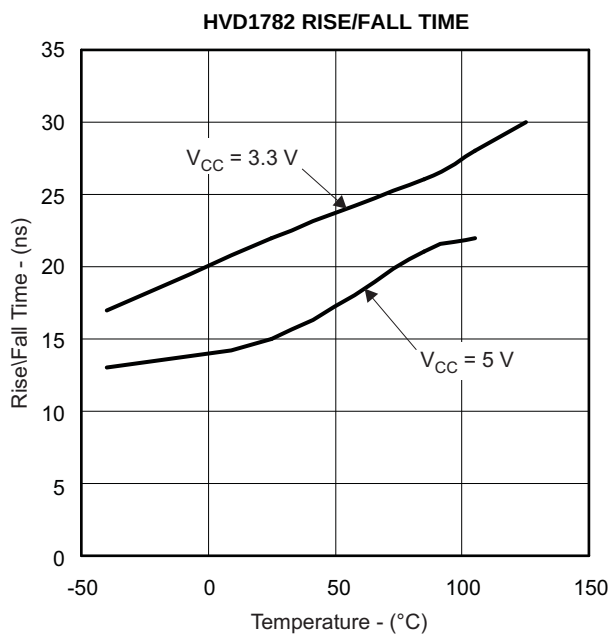


Figure 12.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
SN65HVD1780D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1780DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1780DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1780DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1780P	ACTIVE	PDIP	P	8	50	TBD	CU NIPDAU	N / A for Pkg Type
SN65HVD1781D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1781DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1781DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1781DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1781P	ACTIVE	PDIP	P	8	50	TBD	CU NIPDAU	N / A for Pkg Type
SN65HVD1782D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1782DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1782DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1782DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1782P	ACTIVE	PDIP	P	8	50	TBD	CU NIPDAU	N / A for Pkg Type

⁽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.

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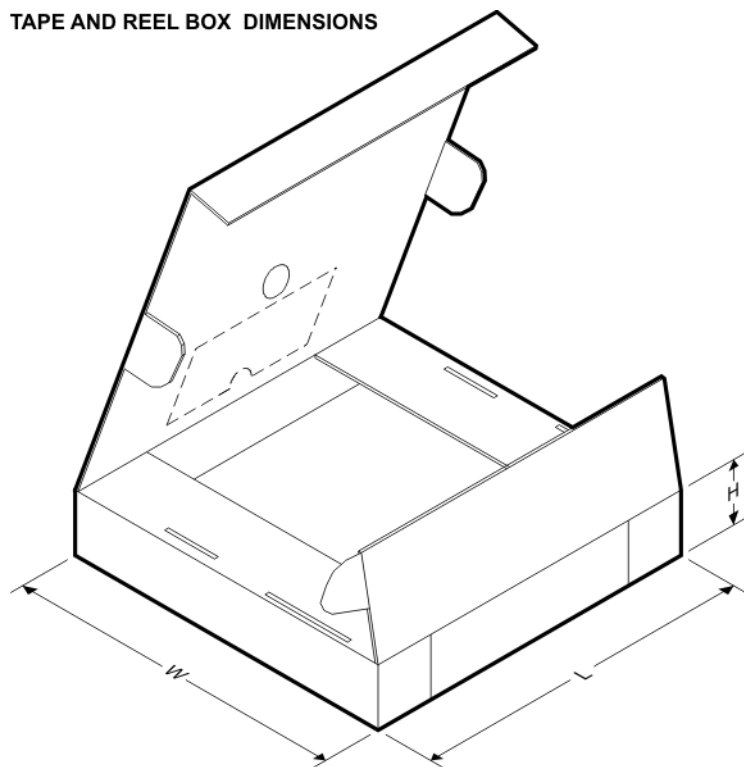
TAPE AND REEL INFORMATION



*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
SN65HVD1780DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD1781DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
SN65HVD1782DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

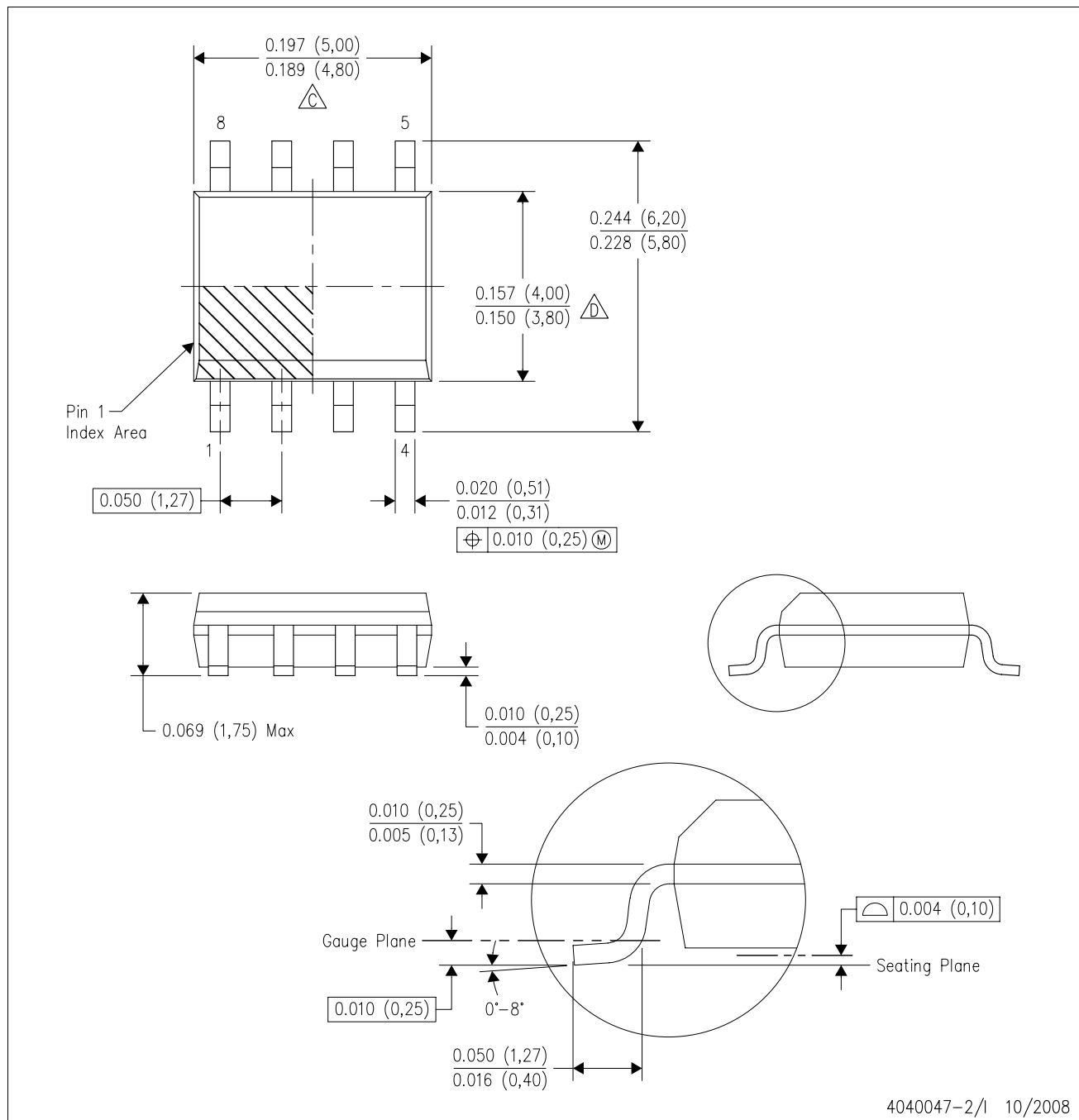


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65HVD1780DR	SOIC	D	8	2500	346.0	346.0	29.0
SN65HVD1781DR	SOIC	D	8	2500	346.0	346.0	29.0
SN65HVD1782DR	SOIC	D	8	2500	346.0	346.0	29.0

D (R-PDSO-G8)

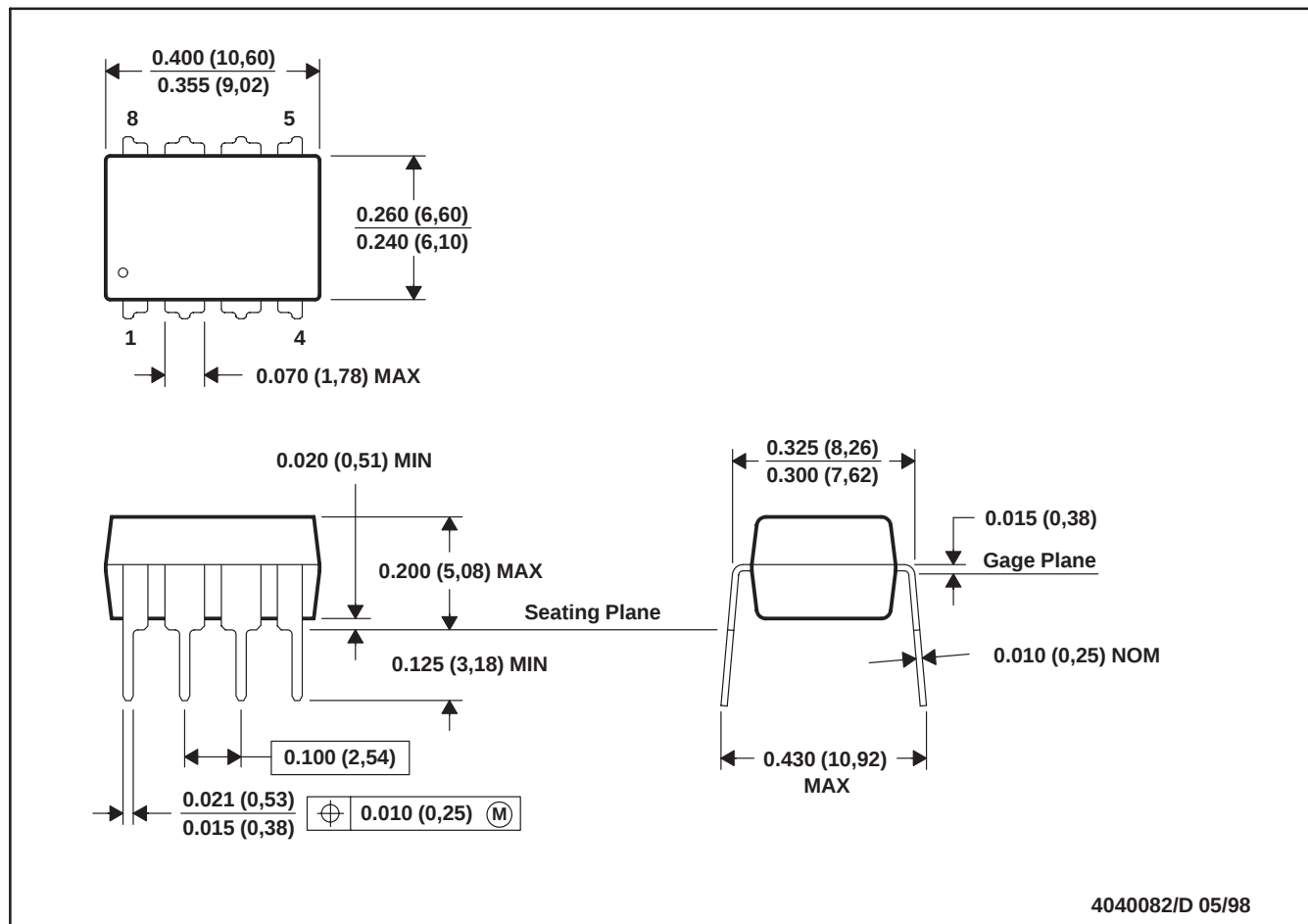
PLASTIC SMALL-OUTLINE PACKAGE



- 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.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



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

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