3.3V RS-485 with Flexible I/O Supply and Selectable Speed

Check for Samples: SN65HVD01

FEATURES

- **Exceeds Requirements of TIA-485 Standard**
- **1.65-V to 3.6-V Supply for Data and Enable Signals**
- **3-V to 3.6-V Supply for Bus Signals**
- **SLR Pin Selectable Data Rates: 250 kbps or 20 Mbps**
- **1/8th Unit Load to Support up to 256 Nodes on a Bus**
- **Small 3 mm x 3 mm SON Package**
- **Failsafe Receiver (Bus Open, Bus Shorted, Bus Idle)**
- **Operating Temperature Range: –40°C to 125°C**
- **Bus-Pin Protection More Than:**
  - **± 15kV HBM Protection**
  - **± 16kV IEC61000-4-2 Contact Discharge**
  - **± 16kV IEC61000-4-2 Air Discharge**
  - **4kV IEC61000-4-4 Fast Transient Burst**

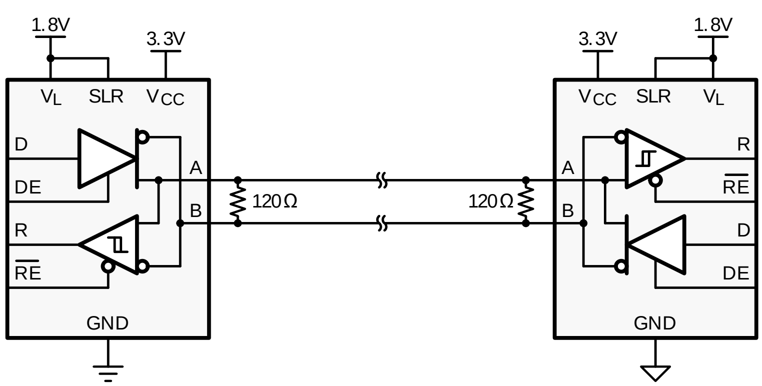
APPLICATIONS

- **Telecom Infrastructure**
- **High-Speed Data Links**
- **Low-Voltage µC Communication**

DESCRIPTION

The SN65HVD01 is a low-power, 250 kbps or 20 Mbps data rate selectable RS-485 transceiver, utilizing a 1.65-V to 3.6-V supply for data and enable signals, and a 3.3 V ± 10% supply for bus signals. The device is designed for applications requiring synchronous (parallel transceiver) signal timing. On-chip transient suppression protects the device against destructive IEC 61000 ESD and EFT transients.

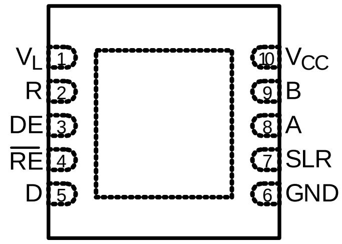
The device combines a differential driver and a differential receiver, connected internally to form a bus port suitable for half-duplex (two-wire bus) communication. The device features a wide common-mode voltage range making it suitable for multi-point applications over long cable runs. The SN65HVD01 is available in a tiny, 3 mm x 3 mm, SON package with operation characterized from -40°C to 125°C.



Typical Application

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.

DRC 10 PIN
(TOP VIEW)



NAME	NO.	I/O	DESCRIPTION
V_L	1	Logic Supply	1.65 V to 3.6 V supply for logic I/O signals ®, $\overline{RE}$, D, DE, and SLR)
R	2	Digital Output	Receive data output
DE	3	Digital Input	Driver enable input
$\overline{RE}$	4	Digital Input	Receiver enable input
D	5	Digital Input	Transmission data input
GND	6	Reference Potential	Local device ground
SLR	7	Digital Input	Slew rate select: Low = 20 Mbps, High = 250 kbps. Defaults to 20 Mbps if SLR is left floating
A	8	Bus I/O	Digital bus I/O, A
B	9	Bus I/O	Digital bus I/O, B
V_{CC}	10	Bus Supply	3 V to 3.6 V supply for A and B bus lines

FUNCTIONAL BLOCK DIAGRAM

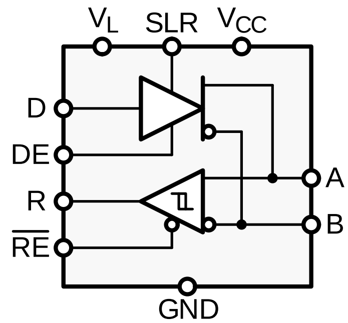


Table 1. DRIVER FUNCTION TABLE

INPUT	ENABLE	OUTPUTS		FUNCTION
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
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Actively drive bus High by default

Table 2. RECEIVER FUNCTION TABLE

DIFFERENTIAL INPUT	ENABLE	OUTPUT	FUNCTION
$V_{ID} = V_A – V_B$	$\overline{RE}$	**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
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

Table 3. SLR-PIN CONFIGURATION

SLR-INPUT	DATA RATE	TYP tr / tf
V_L	250 kbps	800 ns
GND or OPEN	20 Mbps	10 ns

ABSOLUTE MAXIMUM RATINGS[1]

	VALUE		UNIT
	MIN	MAX	
Control supply voltage, V_L	–0.5	4	V
Bus supply voltage, V_{CC}	–0.5	5.5	V
Voltage range at A or B Inputs	–13	16.5	V
Input voltage range at any logic pin	–0.3	5.7	V
Voltage input range, transient pulse, A and B, through 100Ω	–100	100	V
Receiver output current	–12	12	mA
Junction temperature, T_J		170	°C
Storage temperature	–65	150	°C
Continuous total power dissipation	See the Thermal Information table		
IEC 61000-4-2 ESD (Air-Gap Discharge), bus terminals and GND [2]		±16	kV
IEC 61000-4-2 ESD (Contact Discharge), bus terminals and GND		±16	kV
IEC 61000-4-4 EFT (Fast transient or burst) bus terminals and GND		±4	kV
IEC 60749-26 ESD (Human Body Model), bus terminals and GND		±15	kV
JEDEC Standard 22, Test Method A114 (Human Body Model), all pins		±8	kV
JEDEC Standard 22, Test Method C101 (Charged Device Model), all pins		±1.5	kV

(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) 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 the contact discharge test results.

THERMAL INFORMATION

PARAMETER[1]		SON (DRC)	UNITS
Θ_{JA}	Junction-to-Ambient Thermal Resistance	41.4	°C/ W
$\Theta_{JC(top)}$	Junction-to-Case(top) Thermal Resistance	48.7	
Θ_{JB}	Junction-to-Board Thermal Resistance	18.8	
Ψ_{JT}	Junction-to-Top characterization parameter	0.6	
Ψ_{JB}	Junction-to-Board characterization parameter	19	
$\Theta_{JC(bottom)}$	Junction-to-Case(bottom) Thermal Resistance	3.7	
T_{TSD}	Thermal Shut-down junction temperature	170	°C

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953

DISSIPATION RATINGS

PARAMETER			TEST CONDITIONS		VALUE	UNITS
PD	Power Dissipation driver and receiver enabled, $V_{CC} = V_L = 3.6$ V, $T_J = 150$°C, 50% duty cycle square-wave signal at signaling rate	Unterminated	$R_L = 300\ \Omega$, $C_L = 50$ pF (driver)	250 kbps	125	mW
				20 Mbps	175	
		RS-422 load	$R_L = 100\ \Omega$, $C_L = 50$ pF (driver)	250 kbps	165	mW
				20 Mbps	215	
		RS-485 load	$R_L = 54\ \Omega$, $C_L = 50$ pF (driver)	250 kbps	200	mW
				20 Mbps	250	

RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V_L	Control supply voltage		1.65		3.6	V
V_{CC}	Bus supply voltage		3	3.3	3.6	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, receiver enable inputs, and slew rate select)		0.7×V_L		V_L	V
V_{IL}	Low-level input voltage (Driver, driver enable, receiver enable inputs, and slew rate select)		0		0.3×V_L	V
V_{ID}	Differential input voltage		–12		12	V
I_O	Output current	Driver	–80		80	mA
		Receiver	–2		2	mA
R_L	Differential load resistance		54	60		Ω
C_L	Differential load capacitance			50		pF
$1/t_{UI}$	Signaling rate	SLR = '0'			20	Mbps
		SLR = '1'			250	kbps
T_A (2)	Operating free-air temperature THERMAL INFORMATION		–40		125	°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 due to 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.

ELECTRICAL CHARACTERISTICS

over recommended operating range (unless otherwise specified)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$\|V_{OD}\|$	Driver differential output voltage magnitude	R_L = 60 Ω, 375 Ω on each output to –7 V to 12 V		See Figure 1	1.5	2		V
		R_L = 54 Ω (RS-485)		See Figure 2	1.5	2		V
		R_L = 100 Ω (RS-422) T_J ≥ 0°C, V_{CC} ≥ 3.2V			2			V
$\Delta\|V_{OD}\|$	Change in magnitude of driver differential output voltage	R_L = 54 Ω, C_L = 50 pF			–50	0	50	mV
$V_{OC(SS)}$	Steady-state common-mode output voltage	Center of two 27-Ω load resistors			1	$V_{CC}/2$	3	V
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					500		mV
C_{OD}	Differential output capacitance					15		pF
V_{IT+}	Positive-going receiver differential input voltage threshold				See (1)	–60	–20	mV
V_{IT-}	Negative-going receiver differential input voltage threshold				–200	–130	See (1)	mV
V_{HYS}	Receiver differential input voltage threshold hysteresis ($V_{IT+} - V_{IT-}$)				40	70		mV
V_{OH}	Receiver high-level output voltage	V_L = 1.65 V, I_{OH} = -2 mA			1.3	1.45		V
		V_L = 3 V, I_{OH} = -2 mA			2.8	2.9		
V_{OL}	Receiver low-level output voltage	V_L = 1.65 V, I_{OL} = 2 mA				0.2	0.35	V
		V_L = 3 V, I_{OL} = 2 mA				0.1	0.2	
I_I	Driver input, driver enable, and receiver enable input current				–2		2	µA
I_{OZ}	Receiver output high-impedance current	V_O = 0 V or V_L, $\overline{RE}$ at V_L			–1		1	µA
I_{OS}	Driver short-circuit output current				–150		150	mA
I_I	Bus input current (disabled driver)	V_L = 1.8 V, V_{CC} = 3.3 V, DE at 0 V	V_I = 12 V			85	125	µA
			V_I = –7 V		–100	–60		µA
I_{CC}	Supply current (quiescent)	Driver and Receiver enabled	DE=V_L, RE = GND, No load			750	1100	µA
				T_J ≤ 85°C			1000	µA
		Driver enabled, receiver disabled	DE=V_{CC}, $\overline{RE}$ = V_L, No load			350	650	µA
		Driver disabled, receiver enabled	DE=GND, $\overline{RE}$ = GND, No load			650	800	µA
		Driver and receiver disabled	DE=GND, $\overline{RE}$ = V_L, No load			0.1	5	µA
	Supply current (dynamic)	See the TYPICAL CHARACTERISTICS section						

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

SWITCHING CHARACTERISTICS

over recommended operating conditions

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
DRIVER, SLR = '1', 250 kbps, bit time ≥ 4 µs							
t_r, t_f	Driver differential output rise/fall time	R_L = 54 Ω, C_L = 50 pF	See Figure 3	0.4	0.8	1.2	µs
t_{PHL}, t_{PLH}	Driver propagation delay			0.4	0.8	1.2	µs
$t_{SK(P)}$	Driver pulse skew, $\|t_{PHL} – t_{PLH}\|$					0.2	µs
t_{PHZ}, t_{PLZ}	Driver disable time		See Figure 4 and Figure 5		0.025	0.1	µs
t_{PZH}, t_{PZL}	Driver enable time	Receiver enabled			0.6	1	µs
		Receiver disabled			3.5	8	µs
DRIVER, SLR = '0', 20 Mbps, bit time ≥ 50 ns							
t_r, t_f	Driver differential output rise/fall time	R_L = 54 Ω, C_L = 50 pF	See Figure 3	5	10	15	ns
t_{PHL}, t_{PLH}	Driver propagation delay			6	15	25	ns
$t_{SK(P)}$	Driver pulse skew, $\|t_{PHL} – t_{PLH}\|$					4	ns
t_{PHZ}, t_{PLZ}	Driver disable time		See Figure 4 and Figure 5		20	35	ns
t_{PZH}, t_{PZL}	Driver enable time	Receiver enabled			14	30	ns
		Receiver disabled			3	7	µs
RECEIVER, SLR = 'X'							
t_r, t_f	Receiver output rise/fall time	C_L = 15 pF	See Figure 6		5	15	ns
t_{PHL}, t_{PLH}	Receiver propagation delay time			30	60	90	ns
$t_{SK(P)}$	Receiver pulse skew, $\|t_{PHL} – t_{PLH}\|$					15	ns
t_{PLZ}, t_{PHZ}	Receiver disable time				10	20	ns
$t_{PZL(1)}$, $t_{PZH(1)}$ $t_{PZL(2)}$, $t_{PZH(2)}$	Receiver enable time	Driver enabled	See Figure 7		15	80	ns
		Driver disabled	See Figure 8		3	8	µs

PARAMETER MEASUREMENT INFORMATION

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

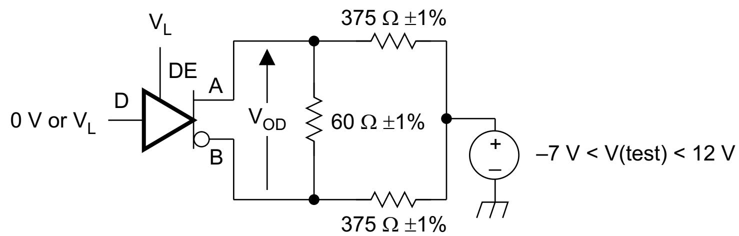


Figure 1. Measurement of Driver Differential Output Voltage with Common-Mode Load

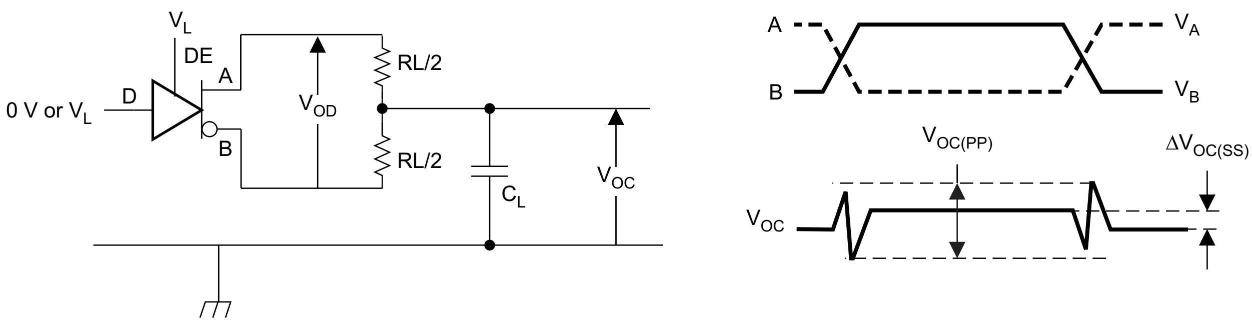


Figure 2. Measurement of Driver Differential and Common-Mode Output with RS-485 Load

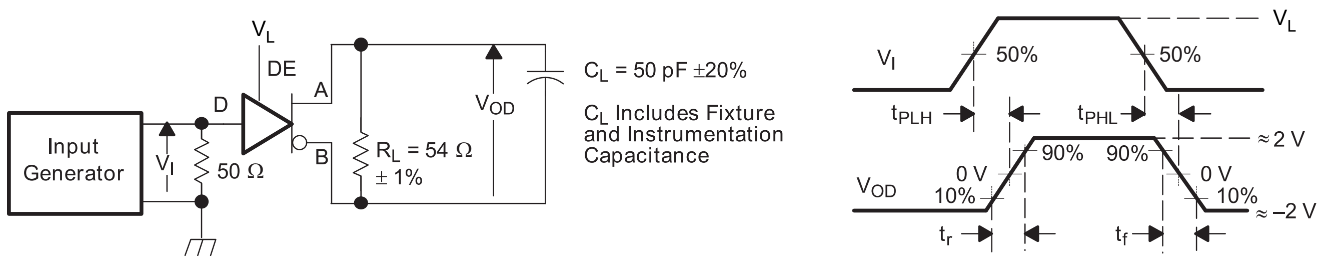
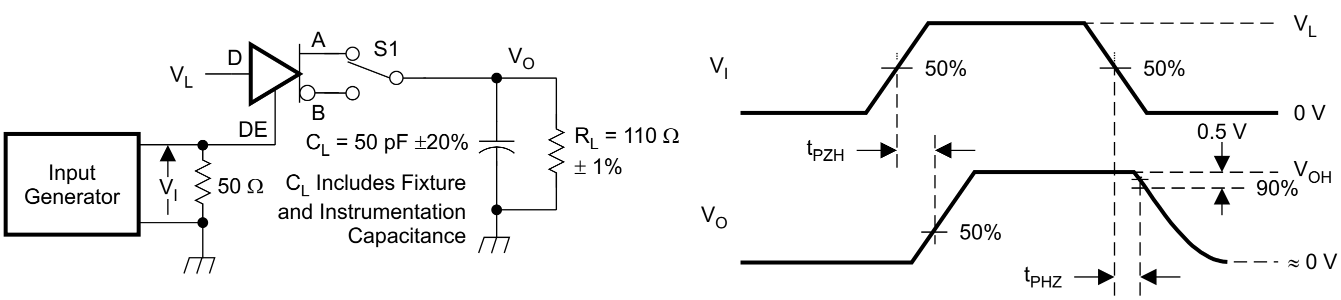


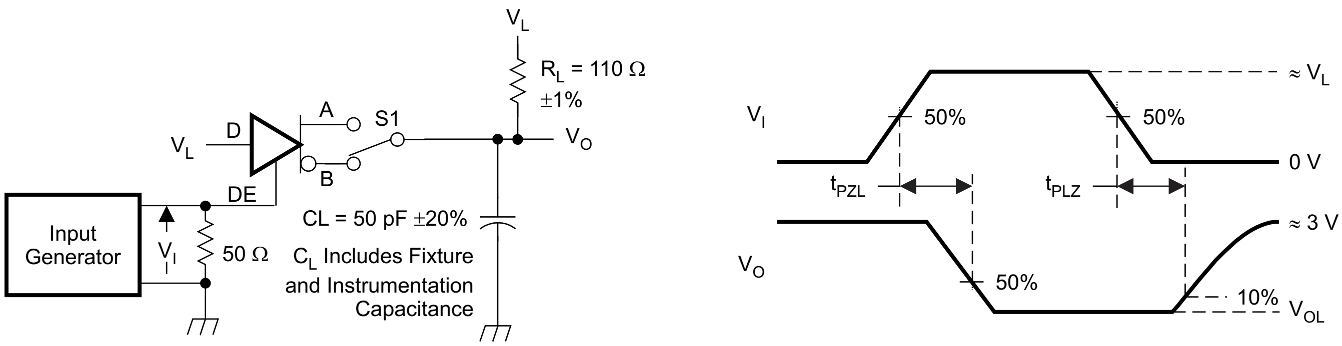
Figure 3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays



D at V_L 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 Pull-Down Load

PARAMETER MEASUREMENT INFORMATION (continued)



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

Figure 5. Measurement of Driver Enable and Disable Times with Active Low Output and Pull-Up Load

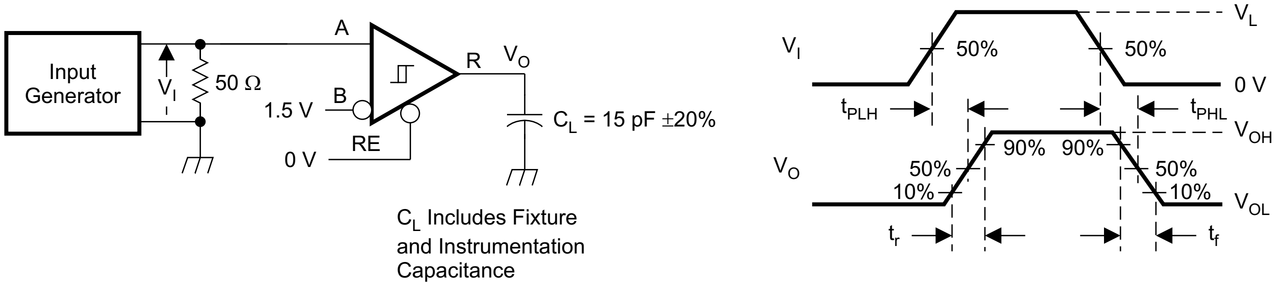


Figure 6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

PARAMETER MEASUREMENT INFORMATION (continued)

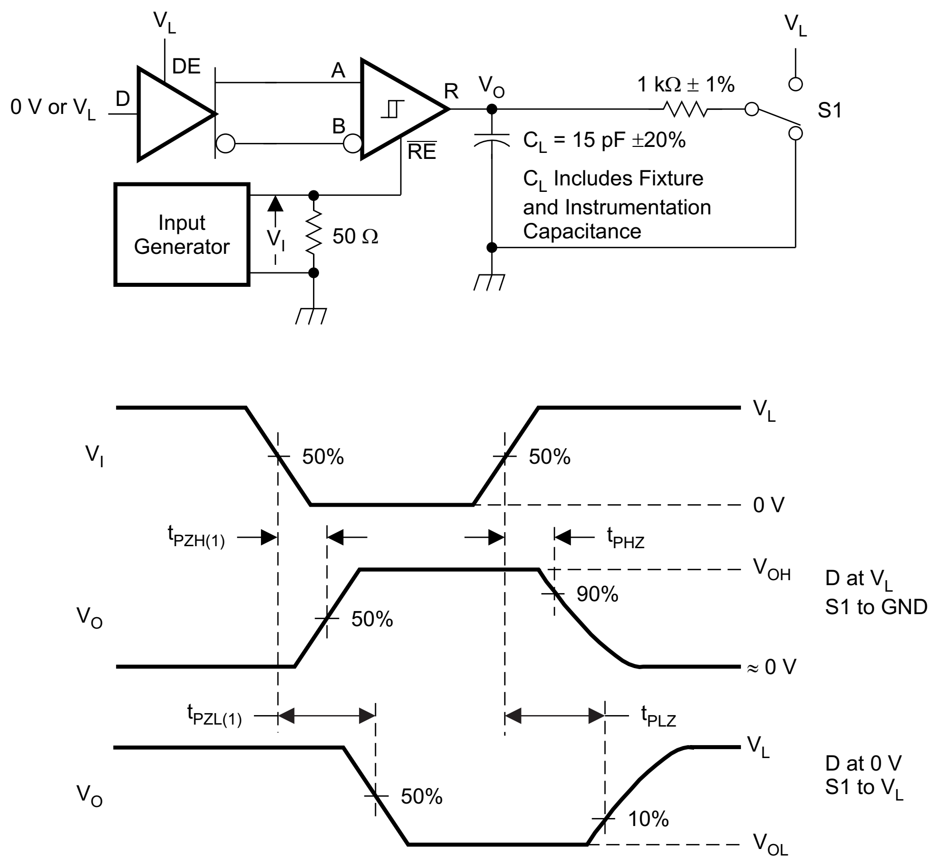


Figure 7. Measurement of Receiver Enable/Disable Times with Driver Enabled

PARAMETER MEASUREMENT INFORMATION (continued)

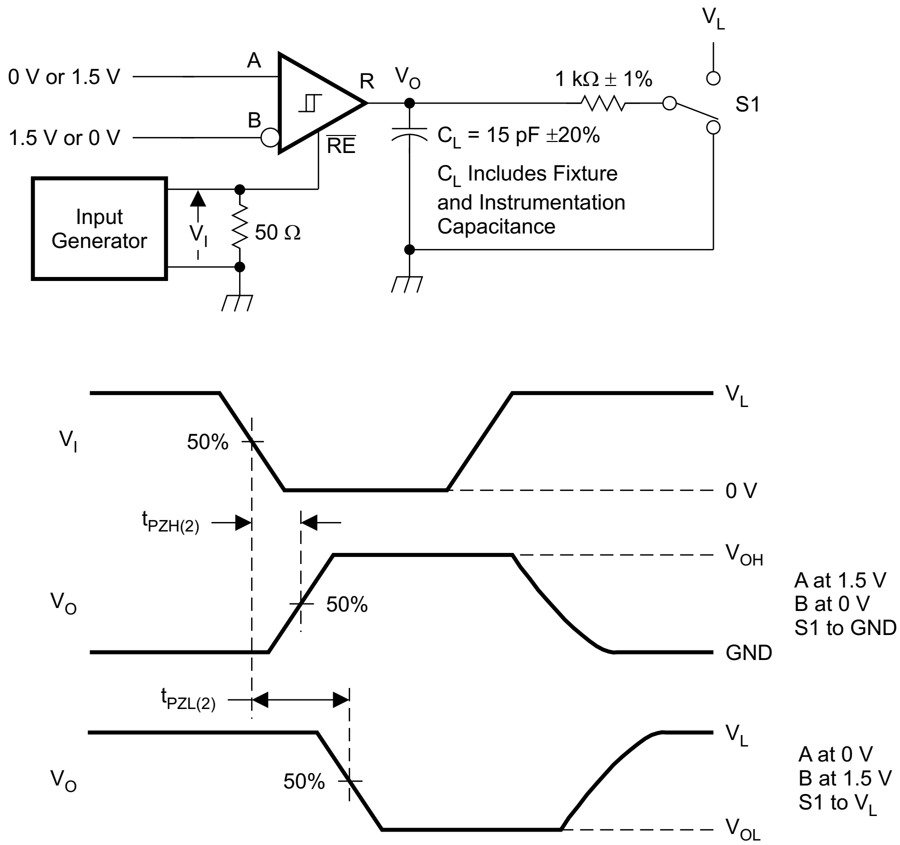


Figure 8. Measurement of Receiver Enable Times with Driver Disabled

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS

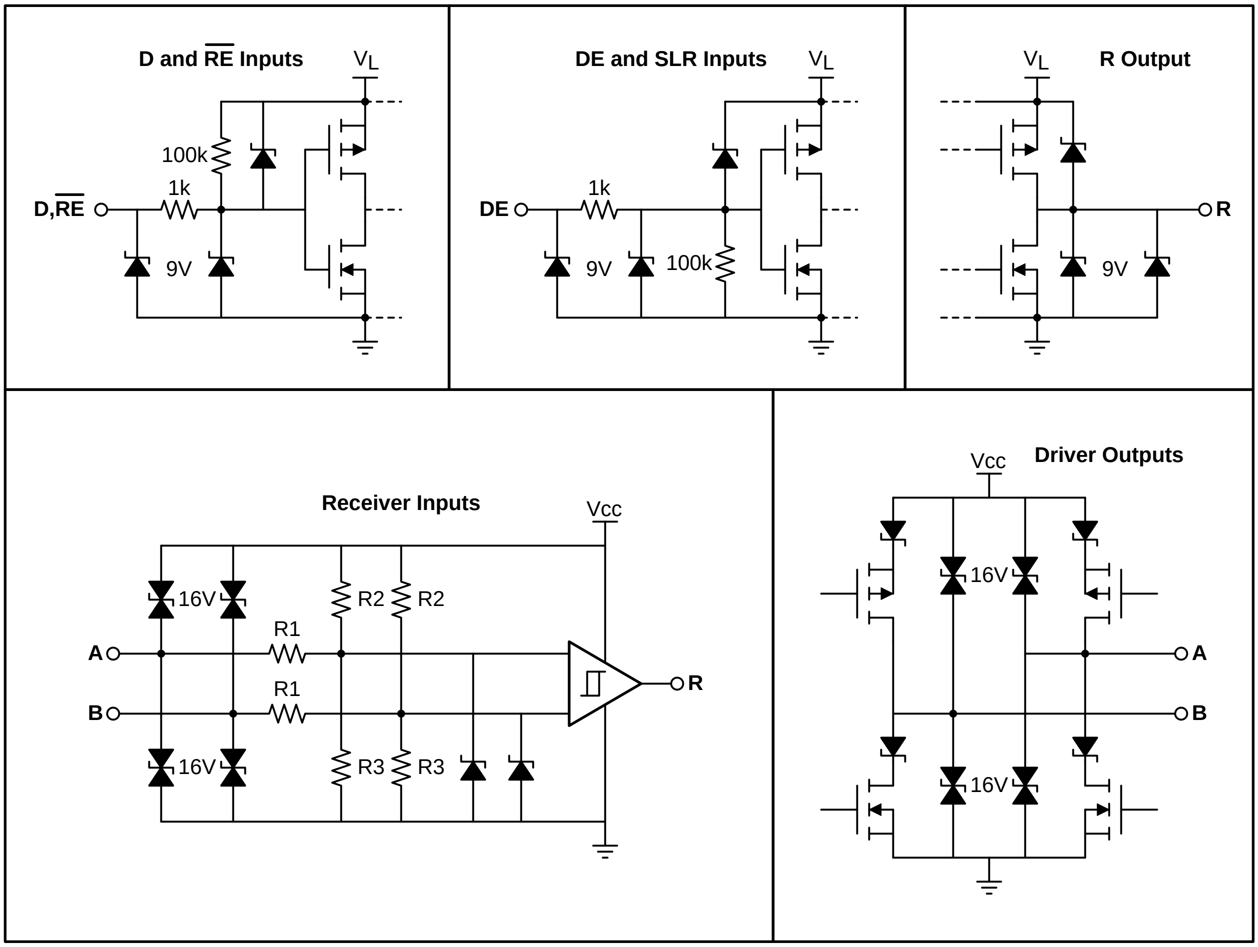


Figure 9. Equivalent Input and Output Schematic Diagrams

TYPICAL CHARACTERISTICS

DIFFERENTIAL DRIVER OUTPUT VOLTAGE vs DRIVER OUTPUT CURRENT

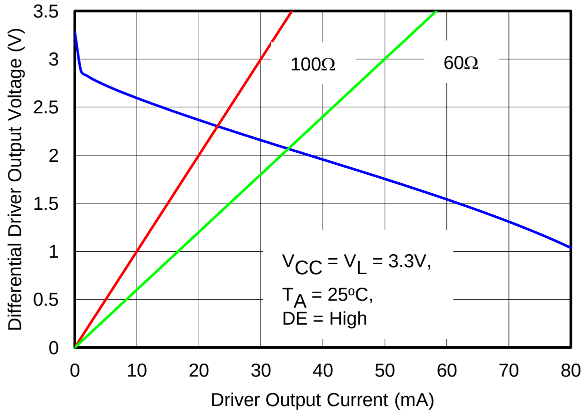


Figure 10.

DIFFERENTIAL DRIVER OUTPUT VOLTAGE vs DRIVER COMMON MODE LOAD VOLTAGE

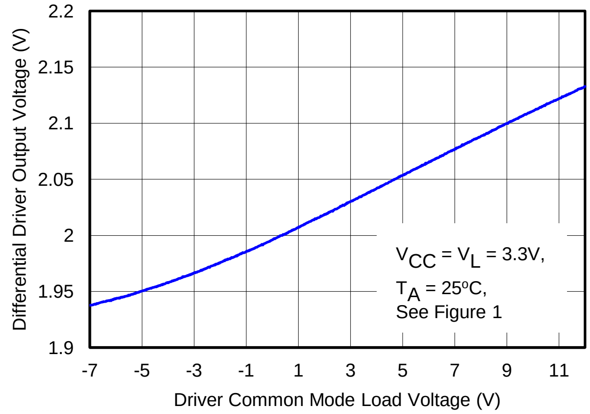


Figure 11.

TRANSITION TIME vs TEMPERATURE

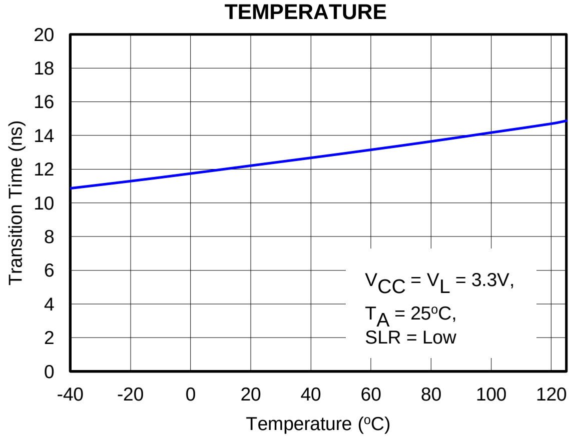


Figure 12.

TRANSITION TIME vs TEMPERATURE

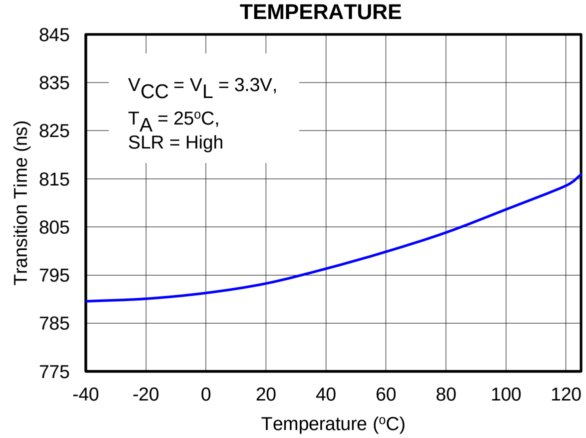


Figure 13.

PROPAGATION DELAY vs TEMPERATURE

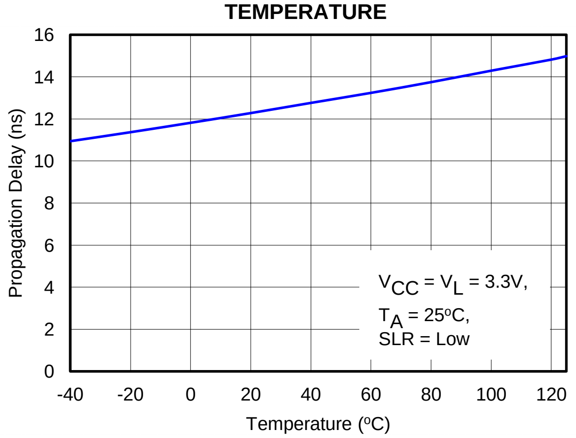


Figure 14.

PROPAGATION DELAY vs TEMPERATURE

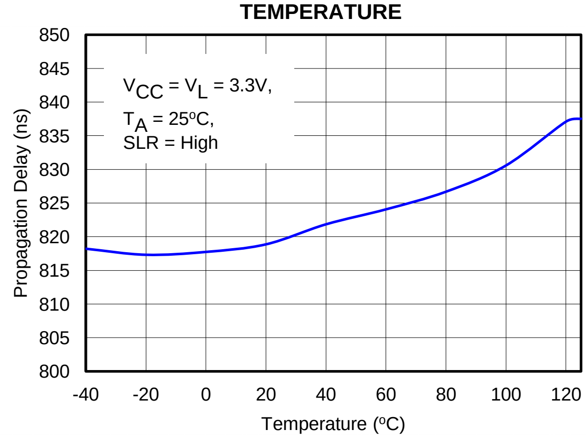


Figure 15.

TYPICAL CHARACTERISTICS (continued)

SUPPLY CURRENT vs SIGNALING RATE

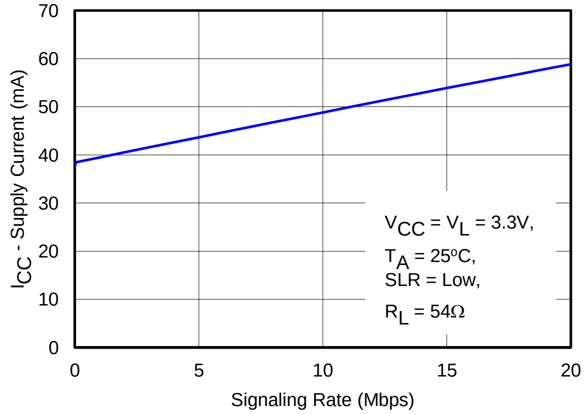


Figure 16.

SUPPLY CURRENT vs SIGNALING RATE

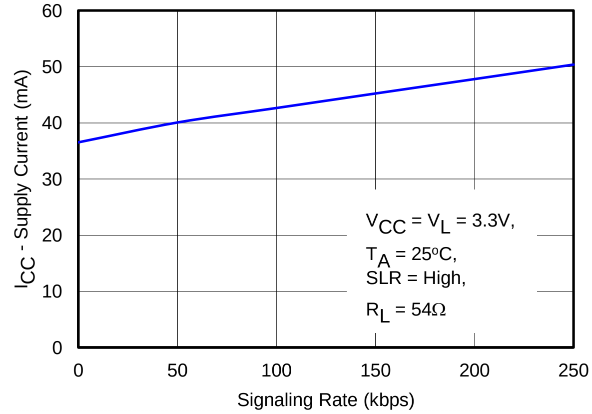


Figure 17.

REVISION HISTORY

Changes from Revision C (November 2013) to Revision D — **Page**

- Changed Feature From: Small 3 mm x 3 mm VQFN Package To: Small 3 mm x 3 mm SON Package 1
- Changed Feature From: Bus-Pin Protection: To: Bus-Pin Protection More Than: 1
- Changed Feature From: ≤ 15kV To: ±15 kV HBM Protection 1
- Changed Feature From: ≤ 15kV To: ±16 kV Contact Discharge 1
- Changed Feature From: ≤ 15kV To: ±16 kV Air Discharge 1
- Changed DESCRIPTION text From: 3 mm x 3 mm, VQFN package To: 3 mm x 3 mm, SON package 1
- Changed the ABSOLUTE MAXIMUM RATINGS for IEC 61000-4-2 ESD (Air-Gap Discharge) From MAX = ±15 To: MAX = ±16 4
- Changed the ABSOLUTE MAXIMUM RATINGS for IEC 61000-4-2 ESD (Contact Discharge) From MAX = ±15 To: MAX = ±16 4
- Changed the THERMAL INFORMATION table package From VQFN (DRC) To; SON (DRC) 4

Changes from Revision B (October 2013) to Revision C — **Page**

- Changed from Product Preview to Production Data 1

Changes from Revision A (October 2013) to Revision B — **Page**

- Added 8 Typical Characteristics curves 13

Changes from Original (July 2013) to Revision A — **Page**

- Changed Feature From: 1.8-V to 3.3-V Supply for Data and Enable Signals To: 1.65-V to 3.6-V Supply for Data and Enable Signals 1
- Changed Feature From: 3.3 V Supply for Bus Signals To: 3-V to 3.6-V Supply for Bus Signals 1
- Changed Feature From: Selectable Data Rates: 250 kbps or 20 Mbps To: SLR Pin Selectable Data Rates: 250 kbps or 20 Mbps 1
- Changed the list of APPLICATIONS 1
- Changed the DESCRIPTION 1
- Changed From: 100 Ω resistors To: 120 Ω resistors in the Typical Application circuit 1
- Changed the ELECTRICAL CHARACTERISTICS table values 6
- Changed the SWITCHING CHARACTERISTICS table values 7
- Changed V_{CC} and 3 V to V_L in Figure 1 through Figure 8 8
- Changed Figure 9 12
- Deleted the Application Information section 12

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
SN65HVD01DRCR	ACTIVE	SON	DRC	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD01	Samples
SN65HVD01DRCT	ACTIVE	SON	DRC	10	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	HVD01	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.

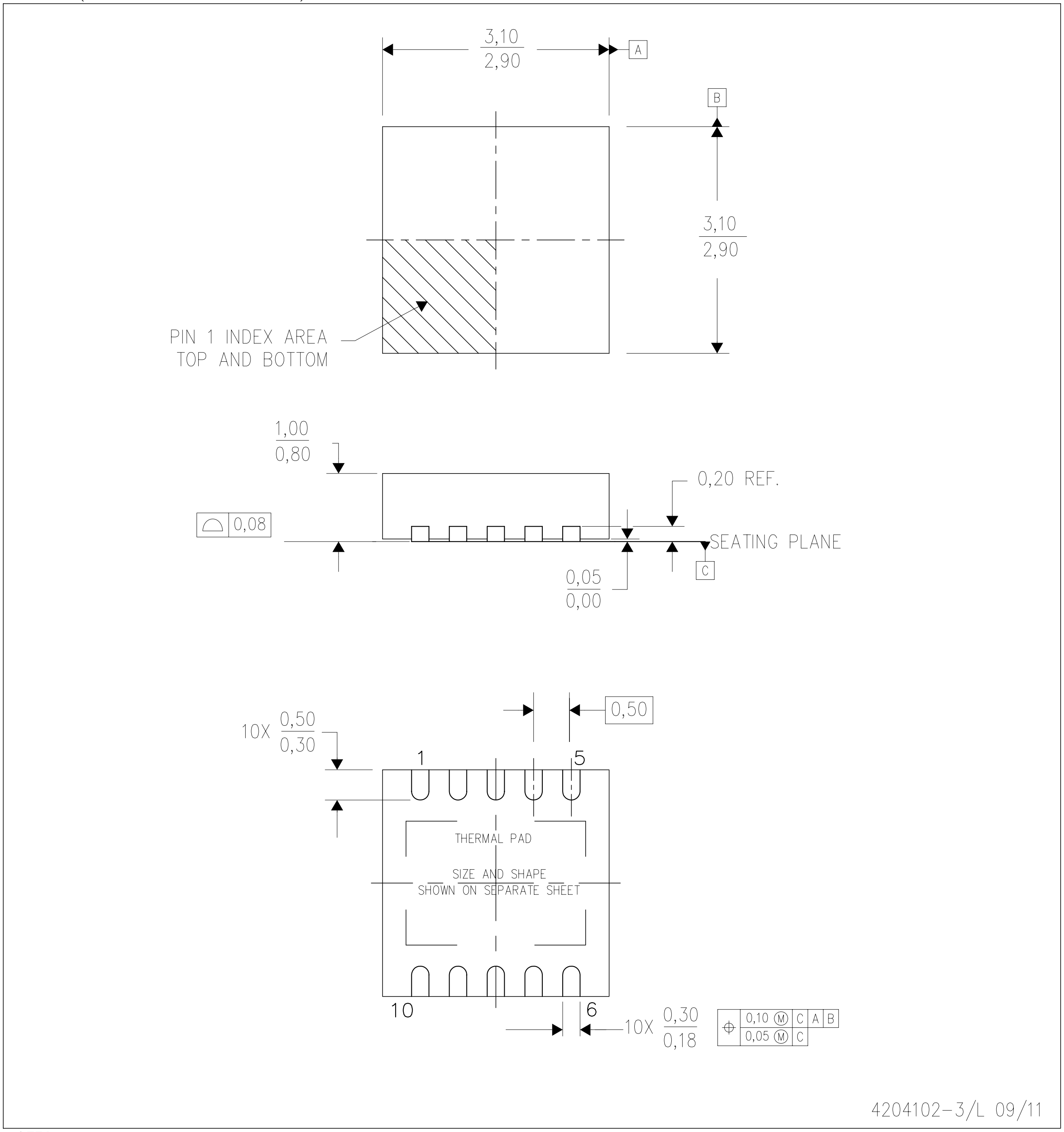
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

DRC (S-PVSON-N10) PLASTIC SMALL OUTLINE NO-LEAD



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
B. This drawing is subject to change without notice.
C. Small Outline No-Lead (SON) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance, if present.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions, if present

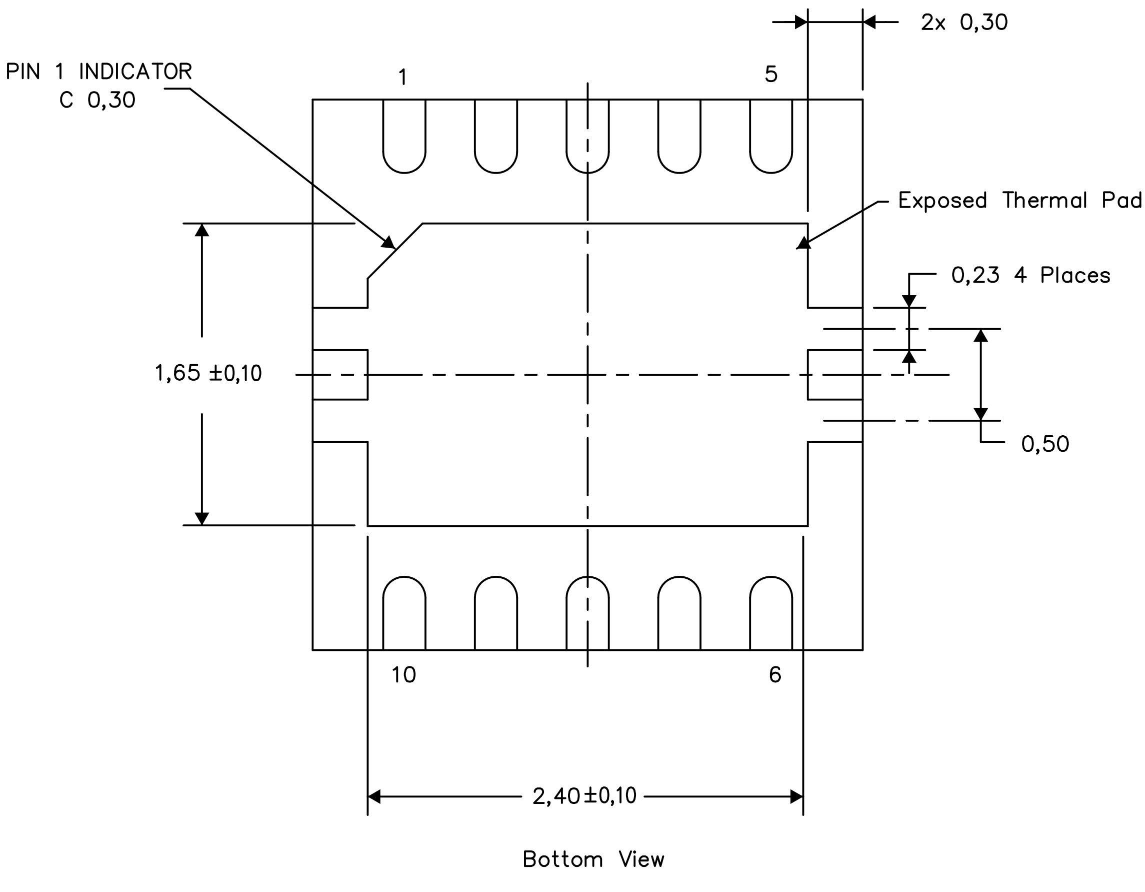
DRC (S–PVSON–N10) PLASTIC SMALL OUTLINE NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

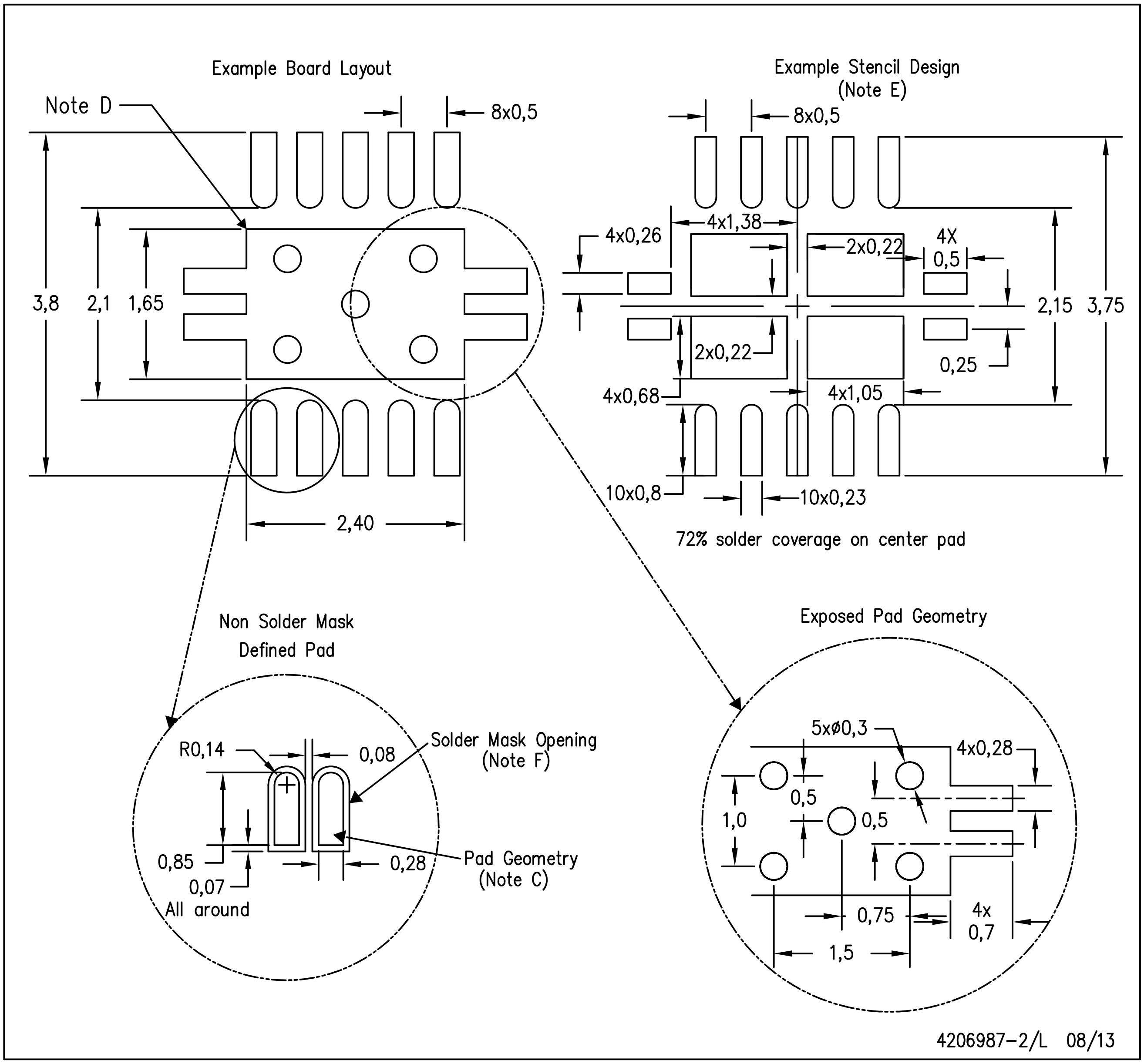


Exposed Thermal Pad Dimensions

4206565–3/S 07/13

NOTE: A. All linear dimensions are in millimeters

DRC (S–PVSON–N10) PLASTIC SMALL OUTLINE NO–LEAD



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. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http: //www.ti.com>.
- E. 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 stencil design considerations.
- F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

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.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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