THVD1500 500 kbps RS-485 Transceivers With ±8-kV IEC ESD Protection

1 Features

- Meets or Exceeds the Requirements of the TIA/EIA-485A Standard and the State Grid Corporation of China (SGCC) Part 11 Serial Communication Protocol RS-485 Standard
- 4.5 V to 5.5 V Supply Voltage
- Half-Duplex RS-422/RS-485
- Bus I/O Protection
  - ± 16 kV HBM ESD
  - ± 8 kV IEC 61000-4-2 Contact Discharge
  - ± 10 kV IEC 61000-4-2 Air Gap Discharge
  - ± 2 kV IEC 61000-4-4 Fast Transient Burst
- Extended Industrial Temperature Range: -40°C to 125°C
- Large Receiver Hysteresis for Noise Rejection
- Low Power Consumption
  - Low Standby Supply Current: < 1 µA
  - Quiescent During Operation: < 660 µA
- Glitch-Free Power-Up/Down for Hot Plug-in Capability
- Open, Short, and Idle Bus Failsafe
- 1/8 Unit Load Options (Up to 256 Bus Nodes)
- Low EMI 500 kbps

2 Applications

- Electricity Meters (E-Meters)
- Inverters
- HVAC Systems
- Video Surveillance Systems

3 Description

THVD1500 is a robust half-duplex RS-485 transceiver for industrial applications. The bus pins are immune to high levels of IEC Contact Discharge ESD events eliminating need of additional system level protection components.

The device operates from a single 5-V supply. The wide common-mode voltage range and low input leakage on bus pins make THVD1500 suitable for multi-point applications over long cable runs.

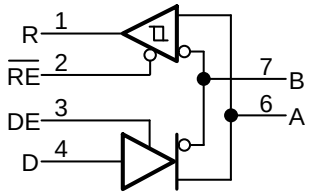
THVD1500 is available in industry standard 8-pin SOIC package for drop-in compatibility. The device is characterized from –40°C to 125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
THVD1500	SOIC (8)	4.90 mm × 3.91 mm

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

Simplified Schematic



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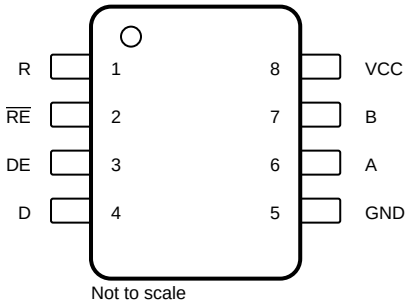
4 Revision History

Changes from Original (July 2018) to Revision A **Page**

- Changed the Title From: 300 kbps RS-485 To: 500 kbps RS-485 ... 1
- Changed *Feature* From: Low EMI 300 kbps To: Low EMI 500 kbps ... 1
- Changed Signaling rate From: 300 kbps To: 500 kbps in the *Recommended Operating Condition* ... 5
- Changed text From: "data transmission up to 300 kbps" To: "data transmission up to 500 kbps" in the *Overview* section ... 13

5 Pin Configuration and Functions

D Package
8-Pin SOIC
Top View



Not to scale

Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
R	1	Digital output	Receive data output
$\overline{RE}$	2	Digital input	Receiver enable, active low (internal 2-MΩ pull-up)
DE	3	Digital input	Driver enable, active high (internal 2-MΩ pull-down)
D	4	Digital input	Driver data input
GND	5	Ground	Local device ground
A	6	Bus input/output	Bus I/O port, A (complementary to B)
B	7	Bus input/output	Bus I/O port, B (complementary to A)
V_{CC}	8	Power	5-V supply

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply voltage	V_{CC}	–0.5	7	V
Bus voltage	Range at any bus pin (A or B)	–18	18	V
Input voltage	Range at any logic pin (D, DE, or $\overline{RE}$)	–0.3	5.7	V
	Transient pulse voltage range at any bus pin (A or B) through 100 Ω	–100	100	
Receiver output current	I_O	–24	24	mA
Junction temperature			170	°C
Absolute ambient temperature, T_A		–55	125	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Contact Discharge, per IEC 61000-4-2	Pins Bus terminals and GND	±8,000	V
		Air Gap Discharge, per IEC 61000-4-2	Pins Bus terminals and GND	±10,000	
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	Pins Bus terminals and GND	±16,000	
			All pins except Bus terminals and GND	±4,000	
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)		±1,500	
		Machine model (MM), per JEDEC JESD22-A115-A		±400	
$V_{(EFT)}$	Electrical fast transient	Per IEC 61000-4-4	Pins Bus terminals	±2,000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5		5.5	V
V_I	Input voltage at any bus terminal (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_{OR}	Output current, Receiver	-8		8	mA
R_L	Differential load resistance	54			Ω
$1/t_{UI}$	Signaling rate			500	kbps
T_A	Operating ambient temperature	-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.

6.4 Thermal Information

THERMAL METRIC (1)		THVD1500 D (SOIC) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	130.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	72.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	73.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	25.0	°C/W
ψ_{JB}	Junction-to-board characterization parameter	72.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	°C/W
$T_{J(TSD)}$	Thermal shut-down temperature	170	°C

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

6.5 Power Dissipation

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

PARAMETER		TEST CONDITIONS		VALUE	UNIT
PD	Driver and receiver enabled, V_{CC} = 5.5 V, T_J = 150 °C, 50% duty cycle square wave at signaling rate	Unterminated R_L = 300 Ω, C_L = 50 pF (driver)	300 kbps	50	mW
		RS-422 load R_L = 100 Ω, C_L = 50 pF (driver)	300 kbps	110	mW
		RS-485 load R_L = 54 Ω, C_L = 50 pF (driver)	300 kbps	170	mW

6.6 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Driver							
$\|V_{OD}\|$	Driver differential output voltage magnitude	R_L = 60 Ω, -7 V ≤ V_{test} ≤ 12 (See Figure 8)		1.5	2		V
		R_L = 100 Ω (See Figure 9)		2	2.5		V
		R_L = 54 Ω (See Figure 9)		1.5	2		V
$\Delta\|V_{OD}\|$	Change in differential output voltage	R_L = 54 Ω or 100 Ω (See Figure 9)		–50		50	mV
V_{OC}	Common-mode output voltage	R_L = 54 Ω or 100 Ω (See Figure 9)		1	V_{CC}/2	3	V
$\Delta V_{OC(SS)}$	Steady-state common-mode output voltage	R_L = 54 Ω or 100 Ω (See Figure 9)		–50		50	mV
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	R_L = 54 Ω or 100 Ω (See Figure 9)			450		mV
I_{OS}	Short-circuit output current	DE = V_{CC}, -7 V ≤ V_O ≤ 12 V, or A pin shorted to B pin		–100		100	mA
Receiver							
I_{I1}	Bus input current	DE = 0 V, V_{CC} = 0 V or 5.5 V	V_I = 12 V		75	100	µA
			V_I = -7 V	-97	-70		µA
R_A, R_B	Bus input impedance	V_A = -7 V, V_B = 12 V and V_A = 12 V, V_B = -7 V (See Figure 14)		96			kΩ
V_{TH+}	Positive-going input threshold voltage			See(1)	–70	–50	mV
V_{TH-}	Negative-going input threshold voltage			–200	–150	See(1)	mV
V_{HYS}	Input hysteresis			20	50		mV
V_{OH}	Output high voltage	I_{OH} = -8 mA		4	V_{CC} - 0.3		V
V_{OL}	Output low voltage	I_{OL} = 8 mA			0.2	0.4	V
I_{OZ}	Output high-impedance current	V_O = 0 V or V_{CC}, $\overline{RE}$ = V_{CC}		-1		1	µA
I_{OSR}	Output short-circuit current	$\overline{RE}$ = 0, DE = 0, See Figure 13				95	mA
Logic							
I_{IN}	Input current (D, DE, $\overline{RE}$)	4.5 V ≤ V_{CC} ≤ 5.5 V		–5	0	5	µA
Supply							
I_{CC}	Supply current (quiescent)	Driver and receiver enabled	$\overline{RE}$ = 0 V, DE = V_{CC}, No load		440	660	µA
		Driver enabled, receiver disabled	$\overline{RE}$ = V_{CC}, DE = V_{CC}, No load		295	420	µA
		Driver disabled, receiver enabled	$\overline{RE}$ = 0 V, DE = 0 V, No load		275	400	µA
		Driver and receiver disabled	$\overline{RE}$ = V_{CC}, DE = 0 V, D = open, No load		0.1	1	µA

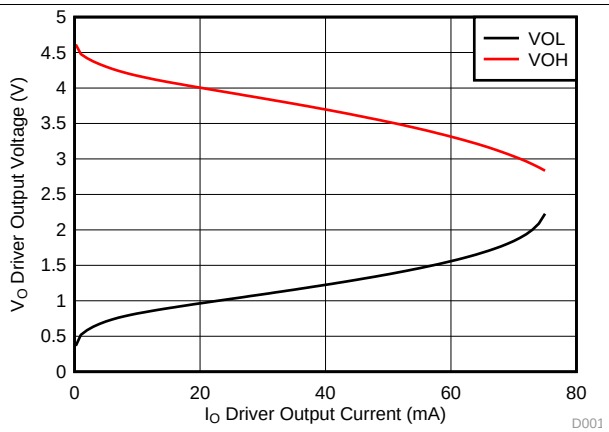
(1) Under any specific conditions, V_{IT+} is assured to be at least V_{HYS} higher than VIT–.

6.7 Switching Characteristics

over recommended operating conditions

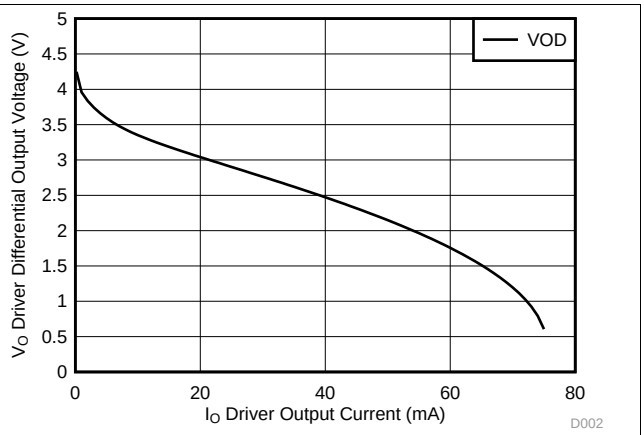
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Driver							
t_r, t_f	Differential output rise/fall time	R_L = 54 Ω, C_L = 50 pF	See Figure 10	180	250	450	ns
t_{PHL}, t_{PLH}	Propagation delay				250	350	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$				25	40	ns
t_{PHZ}, t_{PLZ}	Disable time		See Figure 11 and Figure 12		70	160	ns
t_{PZH}, t_{PZL}	Enable time	$\overline{RE}$ = 0 V			220	400	ns
		$\overline{RE}$ = V_{CC}			1.5	3	µs
Receiver							
t_r, t_f	Differential output rise/fall time	C_L = 15 pF	See Figure 15		15	25	ns
t_{PHL}, t_{PLH}	Propagation delay				70	100	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$				3	7	ns
t_{PHZ}, t_{PLZ}	Disable time				15	30	ns
$t_{PZH(1)}$, $t_{PZL(1)}$, $t_{PZH(2)}$, $t_{PZL(2)}$	Enable time	DE = V_{CC}	See Figure 16		100	175	ns
		DE = 0 V	See Figure 17		1	4	µs

6.8 Typical Characteristics



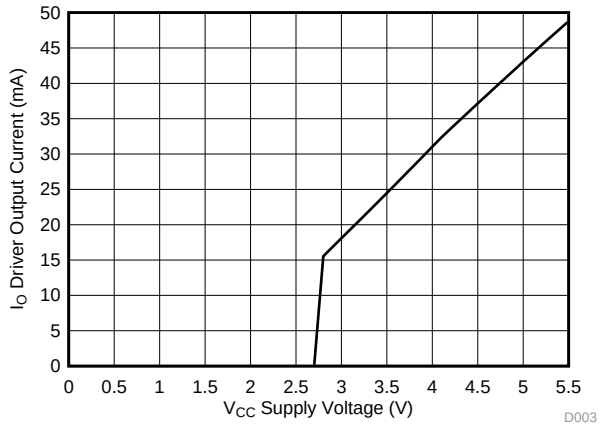
V_{CC} = 5 V DE = V_{CC}

Figure 1. Driver Output voltage vs Driver Output Current



V_{CC} = 5 V DE = V_{CC} D = 0 V

Figure 2. Driver Differential Output voltage vs Driver Output Current



R_L = 54 Ω DE = V_{CC} D = V_{CC}
T_A = 25°C

Figure 3. Driver Output Current vs Supply Voltage

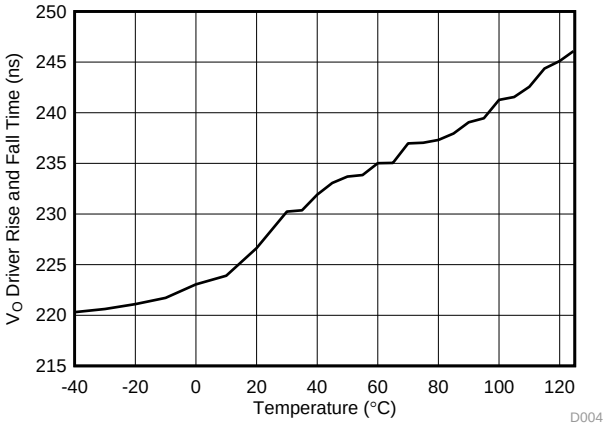


Figure 4. Driver Rise or Fall Time vs Temperature

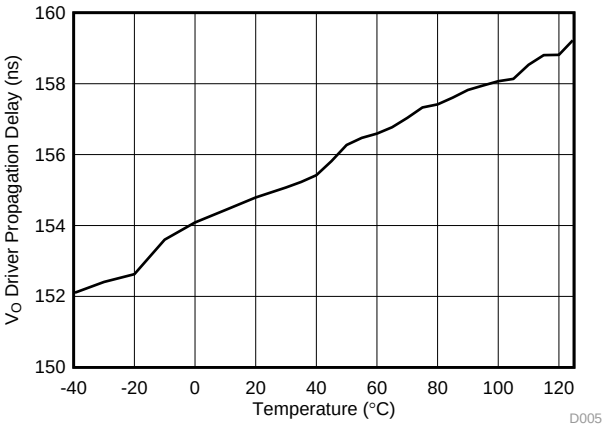
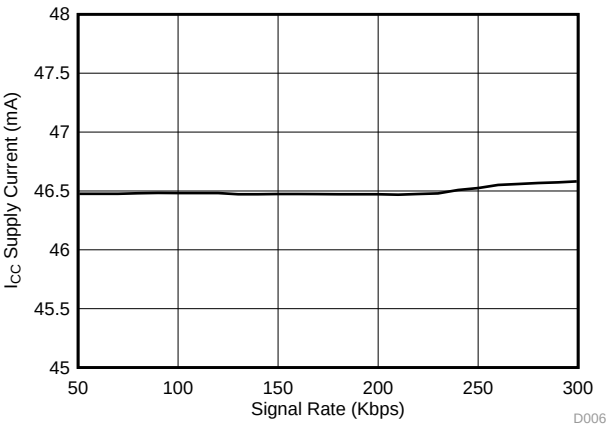


Figure 5. Driver Propagation Delay vs Temperature



R_L = 54 Ω

Figure 6. Supply Current vs Signal Rate

Typical Characteristics (continued)

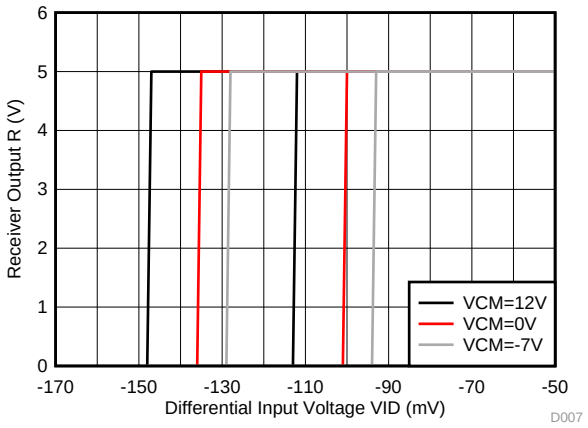


Figure 7. Receiver Output vs Input

7 Parameter Measurement Information

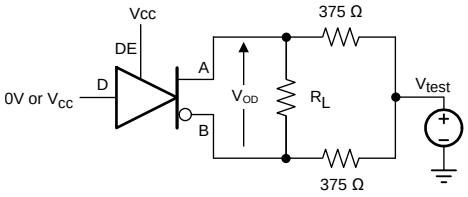


Figure 8. Measurement of Driver Differential Output Voltage With Common-Mode Load

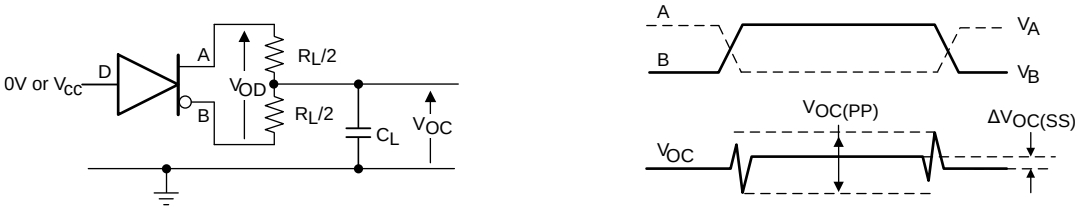


Figure 9. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

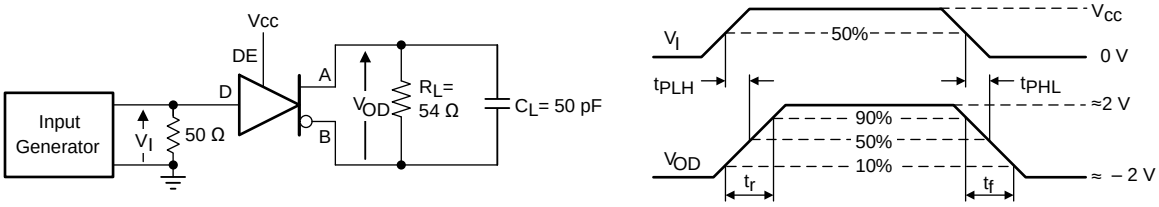


Figure 10. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

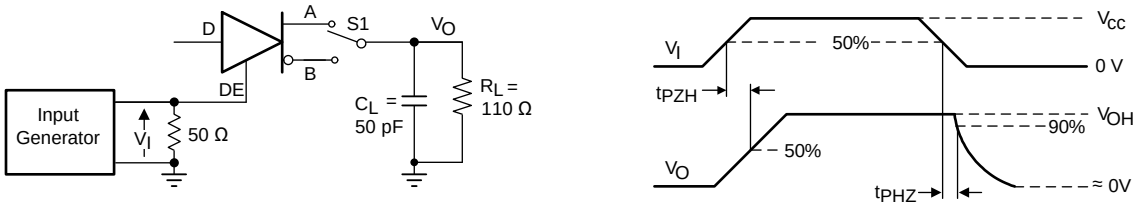


Figure 11. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

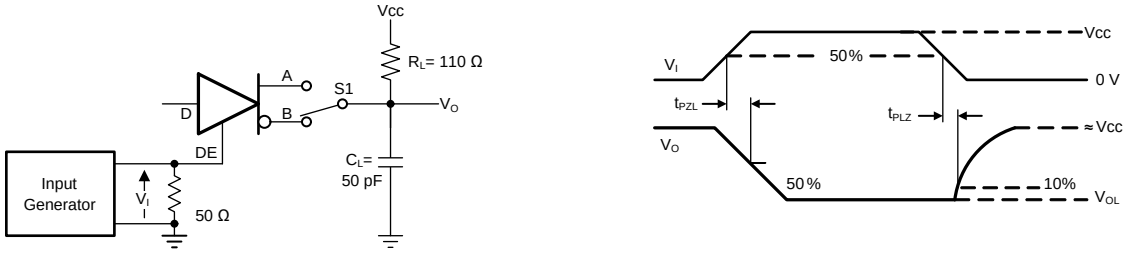


Figure 12. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

Parameter Measurement Information (continued)

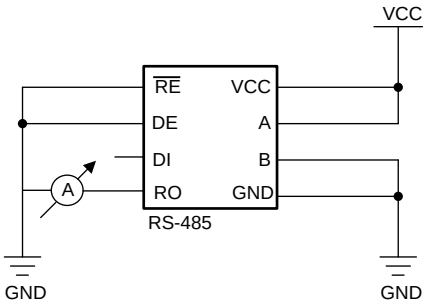
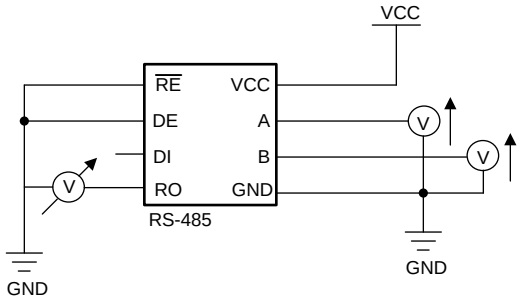


Figure 13. Measurement of Receiver Output Short Circuit Current



$$R_A, R_B = \frac{12 - (-7)}{|I_{V_a}| + |I_{V_b}|}$$

Figure 14. Measurement of Bus Impedance

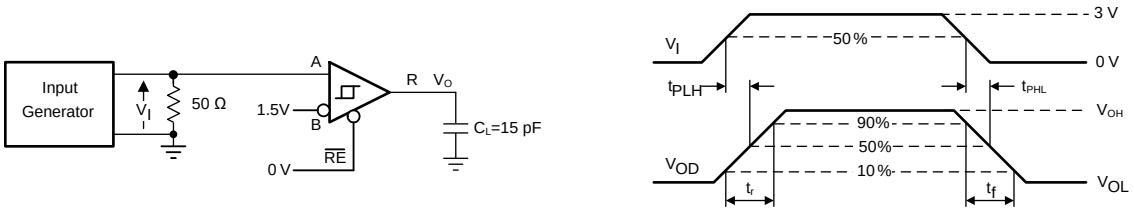


Figure 15. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

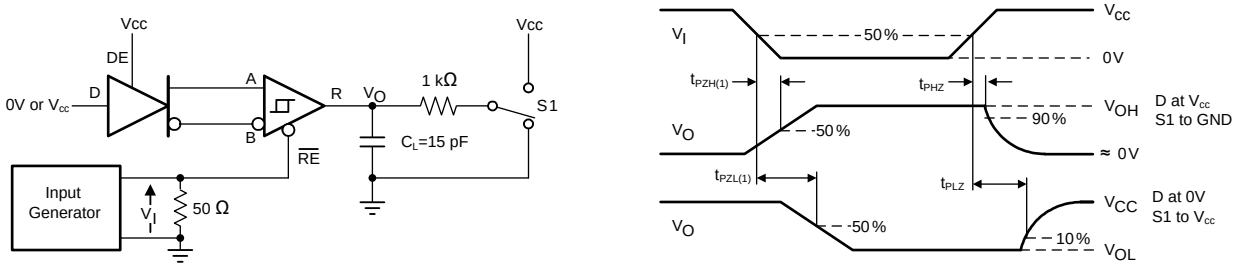


Figure 16. Measurement of Receiver Enable/Disable Times With Driver Enabled

Parameter Measurement Information (continued)

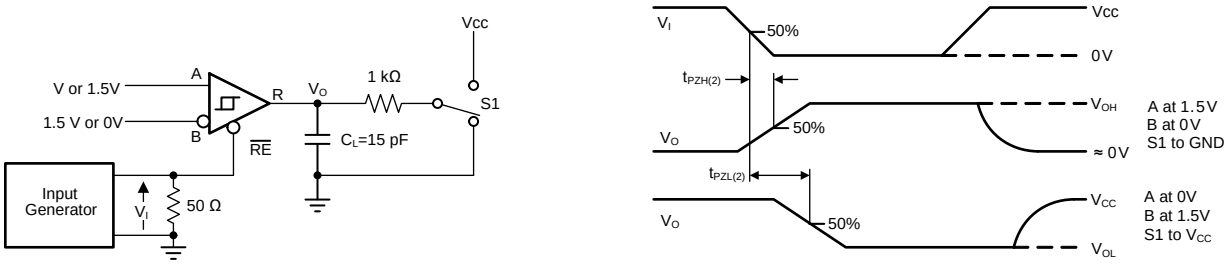


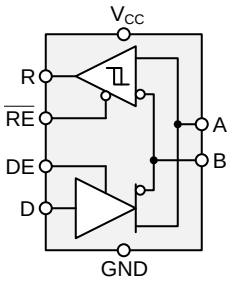
Figure 17. Measurement of Receiver Enable Times With Driver Disabled

8 Detailed Description

8.1 Overview

The THVD1500 is a low-power, half-duplex RS-485 transceiver suitable for data transmission up to 500 kbps.

8.2 Functional Block Diagrams



8.3 Feature Description

Internal ESD protection circuits protect the transceiver against Electrostatic Discharges (ESD) according to IEC 61000-4-2 of up to ±8 kV (Contact Discharge), ±10 kV (Air Gap Discharge) and against electrical fast transients (EFT) according to IEC 61000-4-4 of up to ±2 kV.

The THVD1500 provides internal biasing of the receiver input thresholds in combination with large input-threshold hysteresis. With a positive input threshold of V_{IT+} = –50 mV and an input hysteresis of V_{HYS} = 50 mV, the receiver output remains logic high under a bus-idle or bus-short conditions without the need for external failsafe biasing resistors. Device operation is specified over a wide temperature range from –40°C to 125°C.

8.4 Device Functional Modes

When the driver enable pin, DE, is logic high, the differential outputs A and B follow the logic states at data input D. A logic high at D causes A to turn high and B to turn low. In this case, the differential output voltage defined as $V_{OD} = V_A – V_B$ is positive. When D is low, the output states reverse, B turns high, A 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 pull-down resistor to ground, thus when left open the driver is disabled (high-impedance) by default. The D pin has an internal pull-up resistor to V_{CC}, thus, when left open while the driver is enabled, output A turns high and B turns low.

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

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 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 V_{ID} 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

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

9 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.

9.1 Application Information

The THVD1500 is a half-duplex RS-485 transceiver commonly used for asynchronous data transmissions. The driver and receiver enable pins allow for the configuration of different operating modes.

9.2 Typical Application

An RS-485 bus consists of multiple transceivers connecting in parallel to a bus cable. 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.

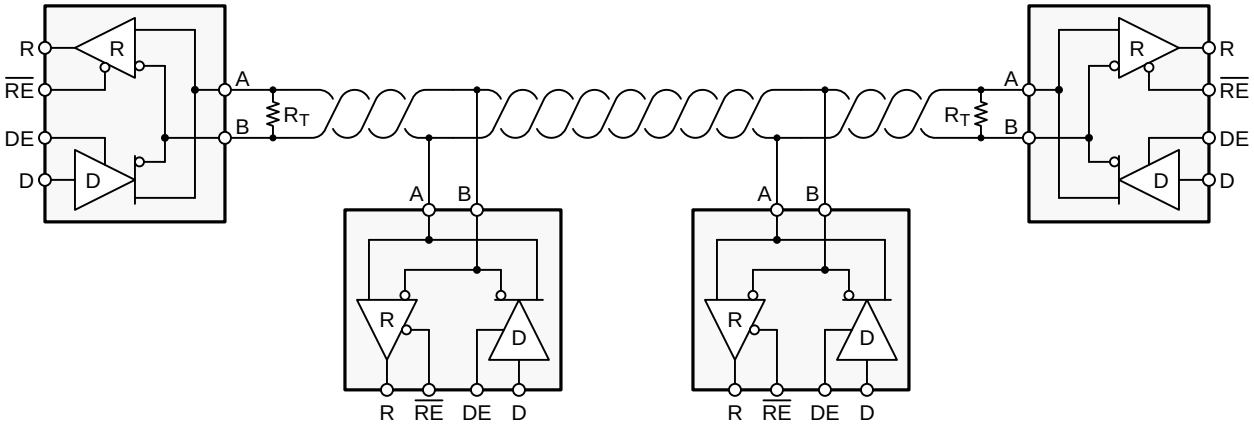


Figure 18. Typical RS-485 Network With Half-Duplex Transceivers

9.2.1 Design Requirements

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.

9.2.1.1 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 300 kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

Typical Application (continued)

9.2.1.2 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.

$$L_{(STUB)} \leq 0.1 \times t_r \times v \times c \quad (1)$$

where

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

9.2.1.3 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 kΩ. Because the THVD1500 consists of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible.

9.2.1.4 Receiver Failsafe

The differential receivers of the THVD1500 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+}.

Typical Application (continued)

9.2.1.5 Transient Protection

The bus pins of the THVD1500 transceiver family include on-chip ESD protection against ±16-kV HBM and ±8-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.

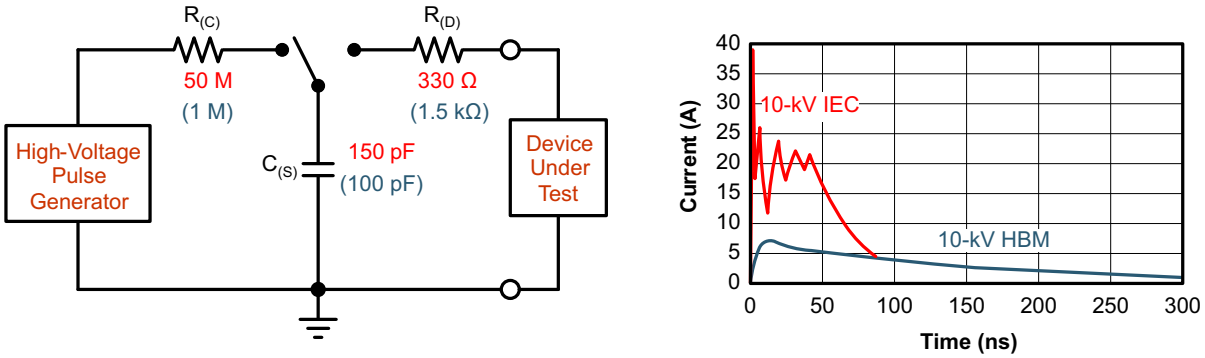


Figure 19. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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 20 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 0.5-kV 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.

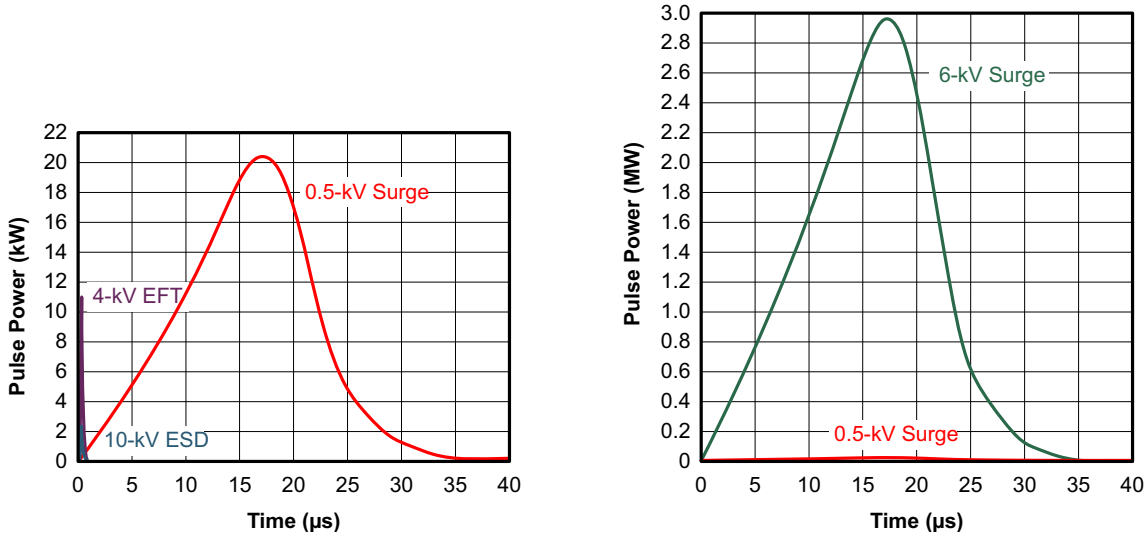


Figure 20. Power Comparison of ESD, EFT, and Surge Transients

Typical Application (continued)

In the event 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 21 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.

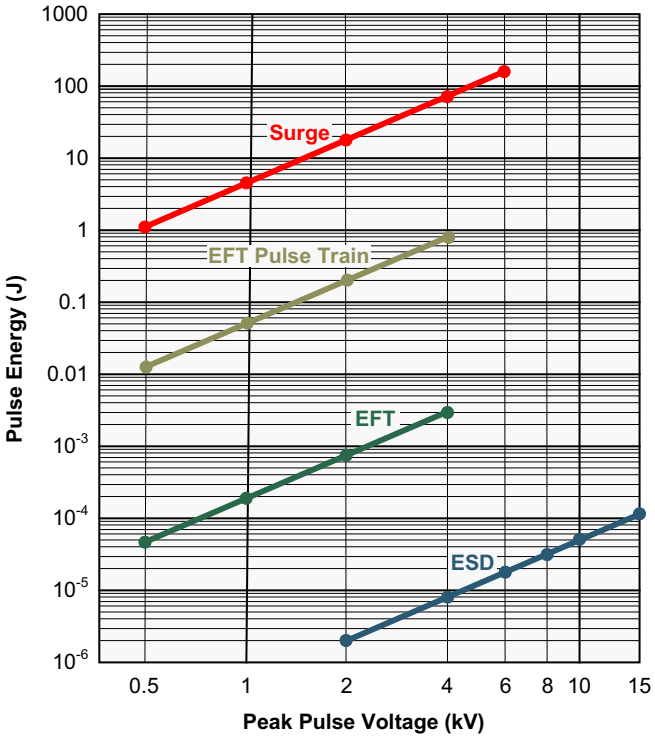


Figure 21. Comparison of Transient Energies

Typical Application (continued)

9.2.2 Detailed Design Procedure

In order to protect bus nodes against high-energy transients, the implementation of external transient protection devices is necessary. Figure 22 suggest a protection circuit against 1 kV surge (IEC 61000-4-5) transients. Table 3 shows the associated Bill of Materials.

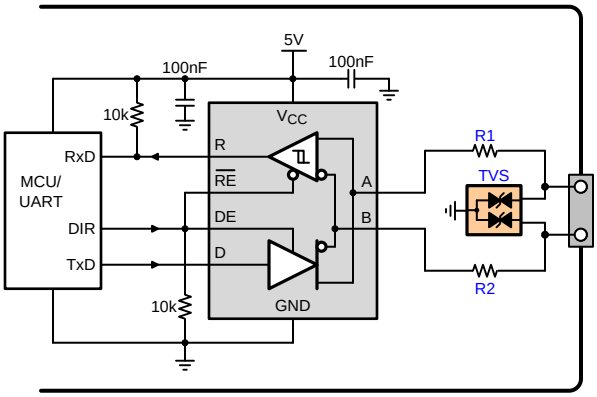
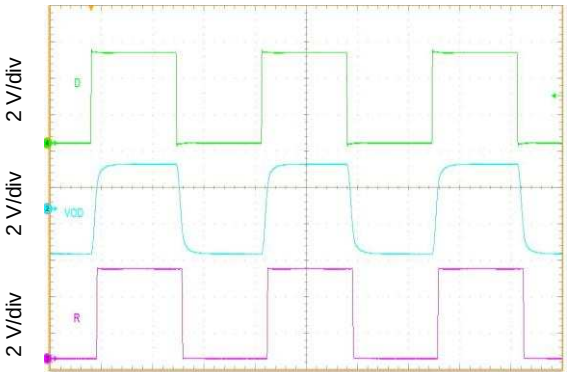


Figure 22. Transient Protection Against ESD, EFT, and Surge Transients for Half-Duplex Devices

Table 3. Bill of Materials

DEVICE	FUNCTION	ORDER NUMBER	MANUFACTURER
XCVR	RS-485 transceiver	THVD1500	TI
R1	10-Ω, pulse-proof thick-film resistor	CRCW0603010RJNEAHP	Vishay
R2			
TVS	Bidirectional 400-W transient suppressor	CDSOT23-SM712	Bourns

9.2.3 Application Curves



Data Rate = 300 Kbps

Figure 23. TBD

10 Power Supply Recommendations

To ensure reliable operation at all data rates and supply voltages, each supply should be decoupled with a 100 nF ceramic capacitor located as close to the supply pins as possible. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes.

11 Layout

11.1 Layout Guidelines

Robust and reliable bus node design often requires the use of external transient protection devices in order to protect against surge transients that may occur in industrial environments. Since these transients have a wide frequency bandwidth (from approximately 3 MHz to 300 MHz), high-frequency layout techniques should be applied during PCB design.

1. Place the protection circuitry close to the bus connector to prevent noise transients from propagating across the board.
2. Use V_{CC} and ground planes to provide low inductance. Note that high-frequency currents tend to follow the path of least impedance and not the path of least resistance.
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 and/or controller ICs on the board.
5. Use at least two vias for V_{CC} and ground connections of bypass capacitors and protection devices to minimize effective via inductance.
6. Use 1-kΩ to 10-kΩ pullup and pulldown resistors for enable lines to limit noise currents in theses lines during transient events.
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.
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.

11.2 Layout Example

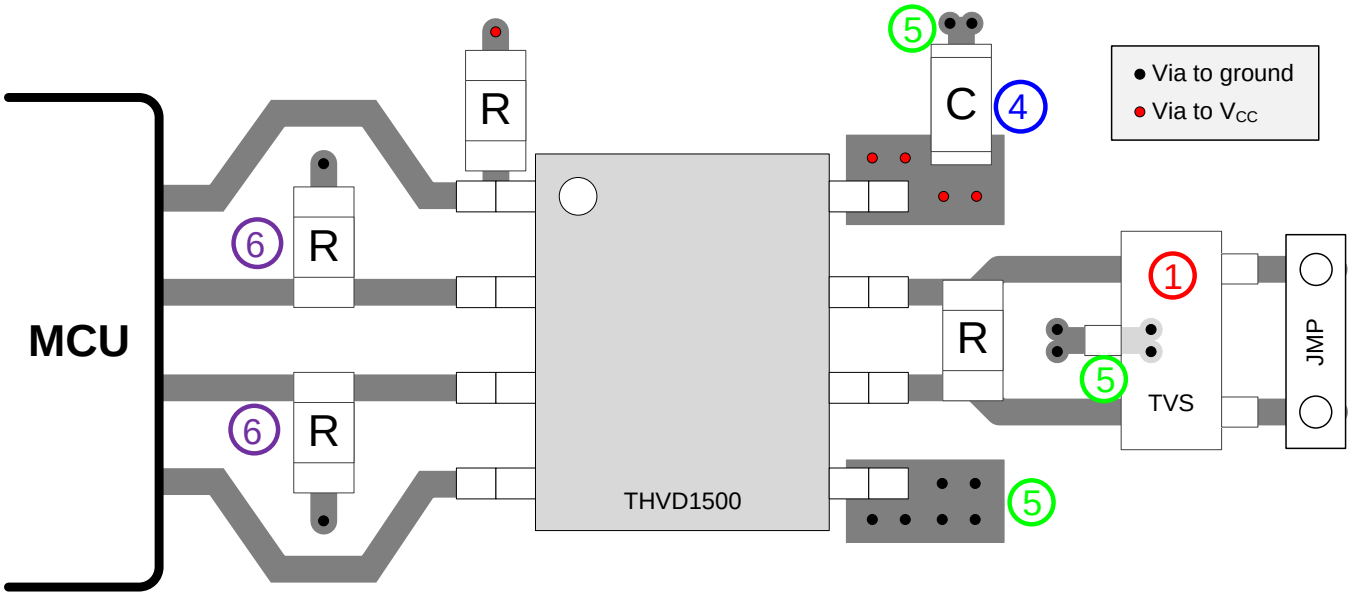


Figure 24. Layout Example

12 Device and Documentation Support

12.1 Device Support

12.2 Third-Party Products Disclaimer

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12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document..

12.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.6 Electrostatic Discharge Caution

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.

12.7 Glossary

SLYZ022 — *TI Glossary*.

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

13 Mechanical, Packaging, and Orderable Information

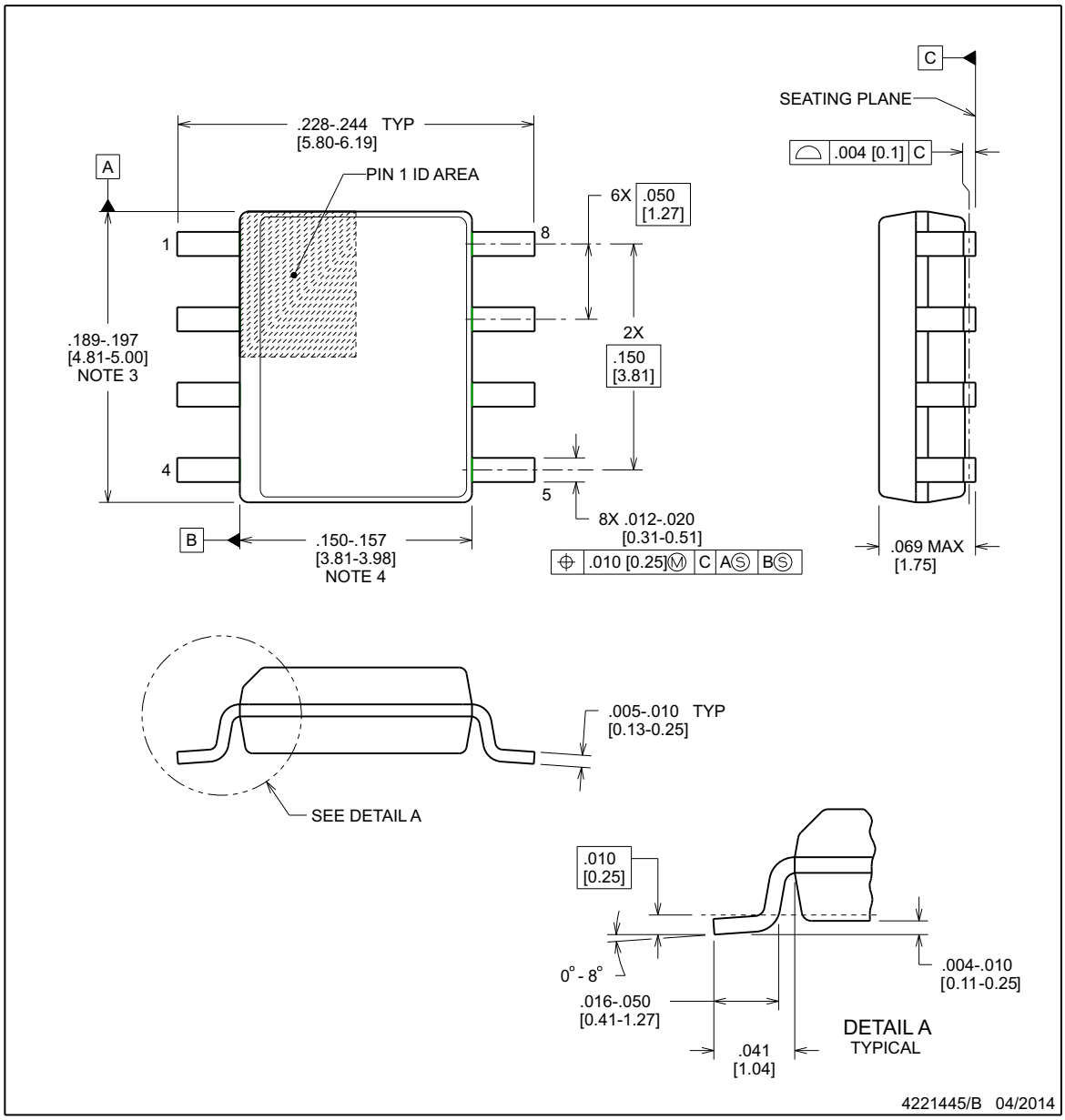
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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

PACKAGE OUTLINE

D0008B

SOIC - 1.75 mm max height

SOIC



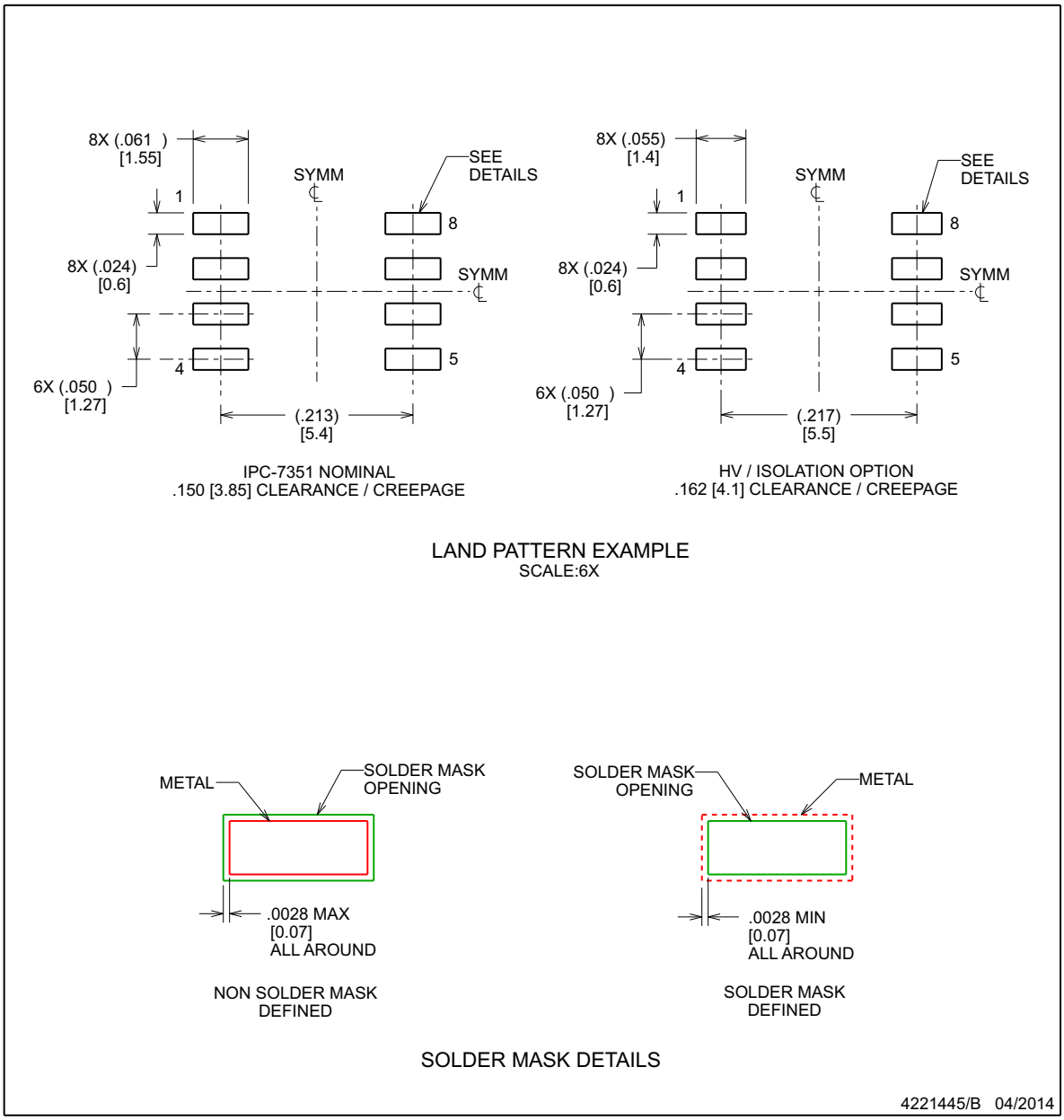
NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15], per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008B — **SOIC - 1.75 mm max height**

SOIC



NOTES: (continued)

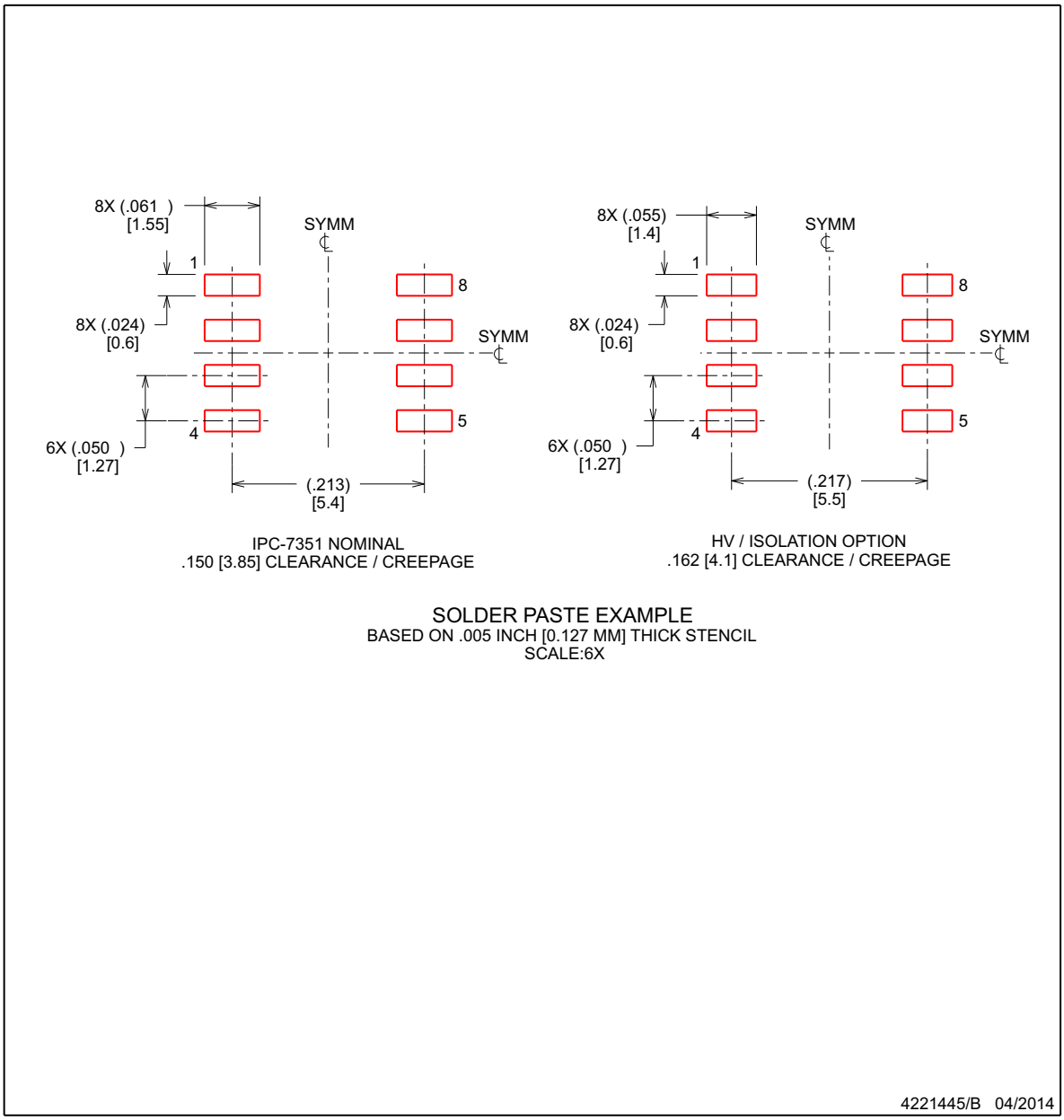
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008B

SOIC - 1.75 mm max height

SOIC



NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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
THVD1500D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VD1500	Samples
THVD1500DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	VD1500	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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

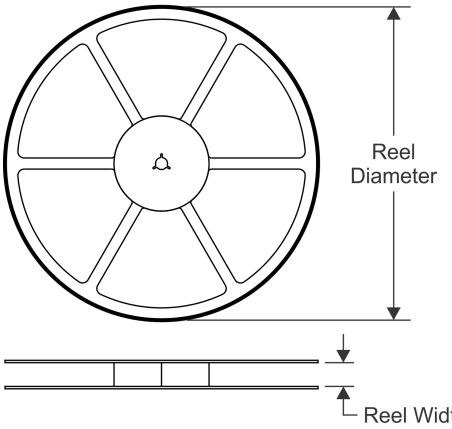
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

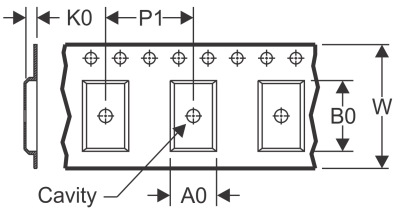
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

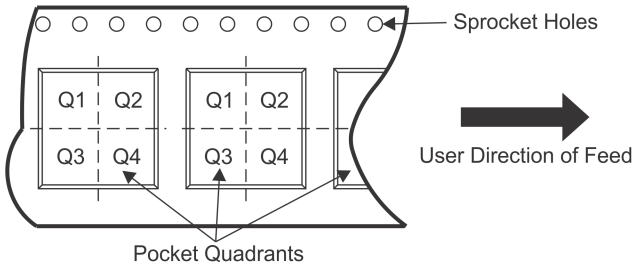


TAPE DIMENSIONS



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

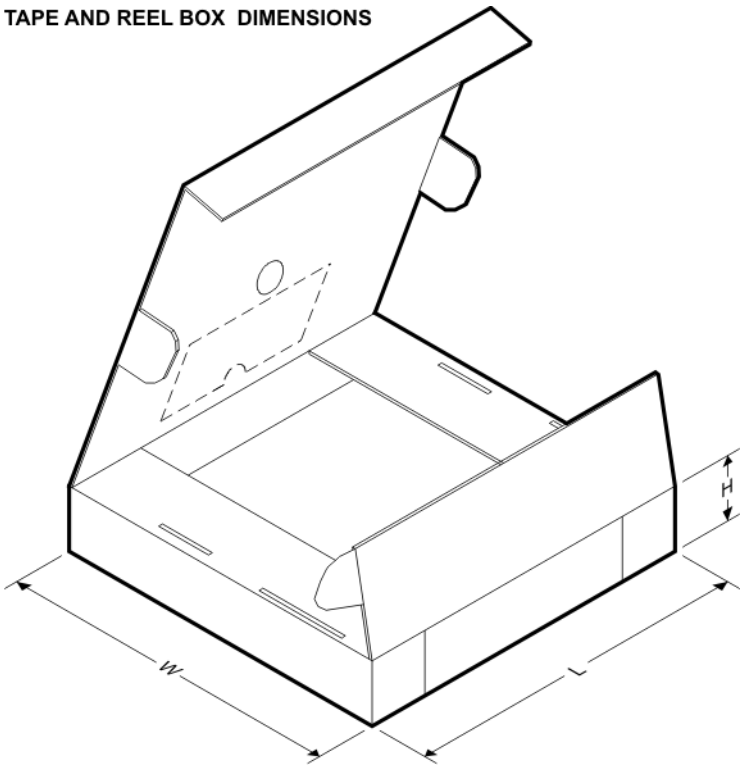
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
THVD1500DR	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)
THVD1500DR	SOIC	D	8	2500	340.5	338.1	20.6

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