具有 ±8kV IEC ESD 保护功能的 THVD1500 500kbps RS-485 收发器

1 特性

- 达到或超出 TIA/EIA-485A 标准和中国国家电网公司 (SGCC) 第 11 部分串行通信协议 RS-485 标准的要求
- 4.5V 至 5.5V 电源电压
- 半双工 RS-422/RS-485
- 总线 I/O 保护
  - ±16kV HBM ESD
  - ±8kV IEC 61000-4-2 接触放电
  - ±10kV IEC 61000-4-2 空气间隙放电
  - ±2kV IEC 61000-4-4 快速瞬变脉冲
- 扩展的工业温度范围：-40°C 至 125°C
- 用于噪声抑制的大接收器滞后
- 低功耗
  - 低待机电源电流：小于 1µA
  - 运行静态电流：小于 660µA
- 适用于热插拔功能的无干扰加电/断电
- 开路、短路和空闲总线失效防护
- 1/8 单位负载选项（多达 256 个总线节点）
- 低 EMI 500kbps

2 应用

- 电量计
- 逆变器
- HVAC 系统
- 视频监控系统

3 说明

THVD1500 是适用于工业应用的强大半双工 RS-485 收发器。这些总线引脚可耐受高级别的 IEC 接触放电 ESD 事件，从而无需使用其他系统级保护组件。

该器件由 5V 单电源供电。总线引脚具备宽共模电压范围和低输入泄漏，因此 THVD1500 适用于长电缆上的多点 应用。

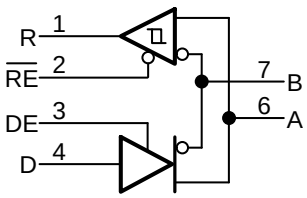
THVD1500 采用可实现简易兼容性的工业标准 8 引脚 SOIC 封装。该器件的温度范围是 -40°C 至 125°C。

器件信息(1)

器件编号	封装	封装尺寸（标称值）
THVD1500	SOIC (8)	4.90mm × 3.91mm

(1) 如需了解所有可用封装，请参阅产品说明书末尾的可订购产品附录。

简化原理图



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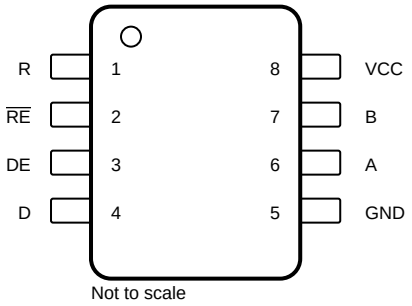
4 修订历史记录

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

- 将标题中的“300kbps RS-485”更改成了“500kbps RS-485” ... 1
- 将特性 中的“低 EMI 300kbps”更改成了“低 EMI 500kbps” ... 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 图 8)		1.5	2		V
		R_L = 100 Ω (See 图 9)		2	2.5		V
		R_L = 54 Ω (See 图 9)		1.5	2		V
$\Delta\|V_{OD}\|$	Change in differential output voltage	R_L = 54 Ω or 100 Ω (See 图 9)		–50		50	mV
V_{OC}	Common-mode output voltage	R_L = 54 Ω or 100 Ω (See 图 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 图 9)		–50		50	mV
$V_{OC(PP)}$	Peak-to-peak common-mode output voltage	R_L = 54 Ω or 100 Ω (See 图 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 图 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 图 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

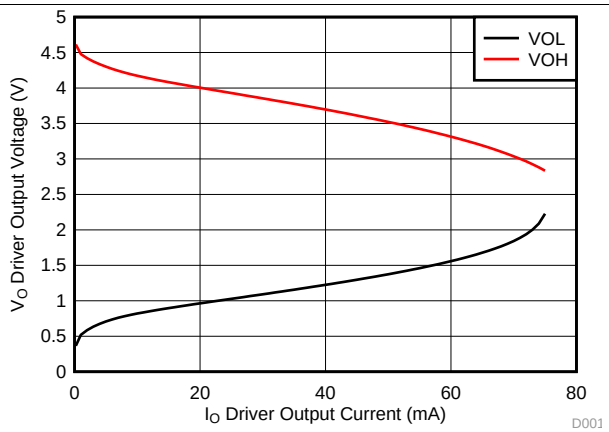
(1) Under any specific conditions, V_{IT+} is assured to be at least V_{HYS} higher than VIT–.

6.7 Switching Characteristics

over recommended operating conditions

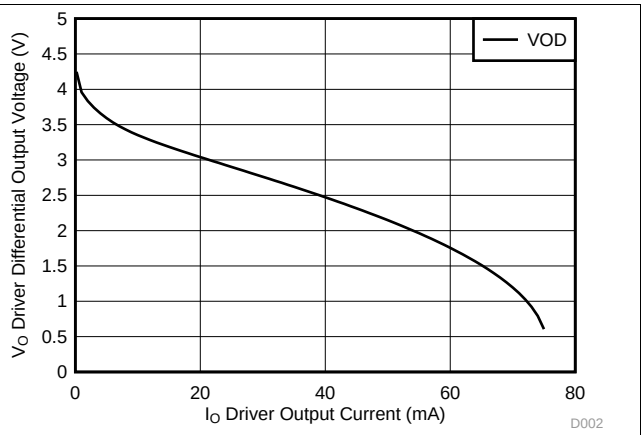
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Driver							
t_r, t_f	Differential output rise/fall time	R_L = 54 Ω, C_L = 50 pF	See 图 10	180	250	450	ns
t_{PHL}, t_{PLH}	Propagation delay				250	350	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$				25	40	ns
t_{PHZ}, t_{PLZ}	Disable time		See 图 11 and 图 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 图 15		15	25	ns
t_{PHL}, t_{PLH}	Propagation delay				70	100	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$				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 图 16		100	175	ns
		DE = 0 V	See 图 17		1	4	µs

6.8 Typical Characteristics



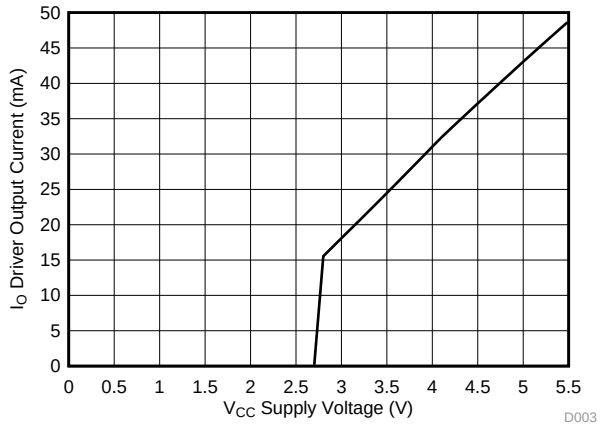
V_{CC} = 5 V DE = V_{CC}

图 1. Driver Output voltage vs Driver Output Current



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

图 2. Driver Differential Output voltage vs Driver Output Current



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

图 3. Driver Output Current vs Supply Voltage

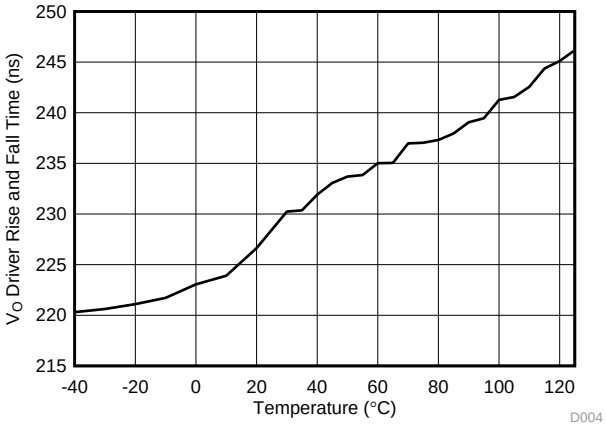


图 4. Driver Rise or Fall Time vs Temperature

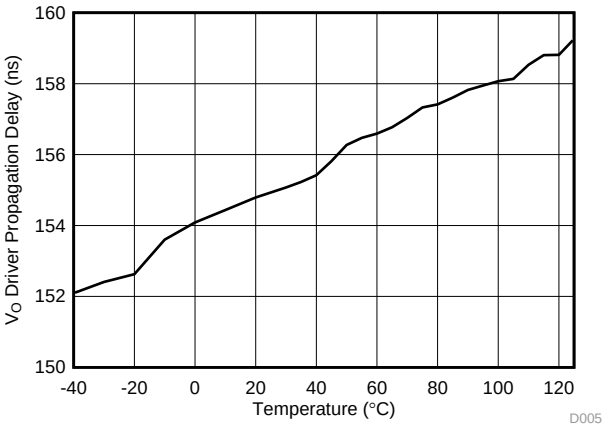
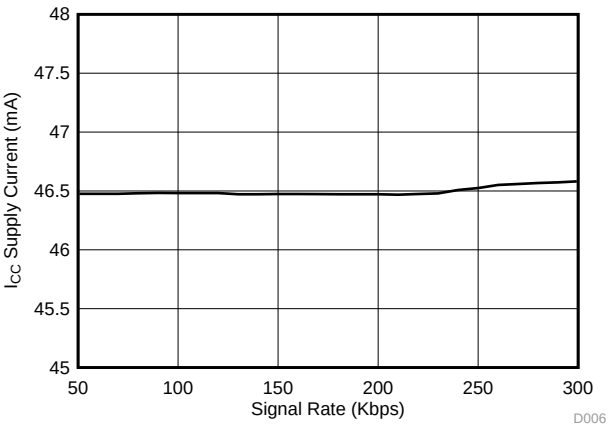


图 5. Driver Propagation Delay vs Temperature



R_L = 54 Ω

图 6. Supply Current vs Signal Rate

Typical Characteristics (接下页)

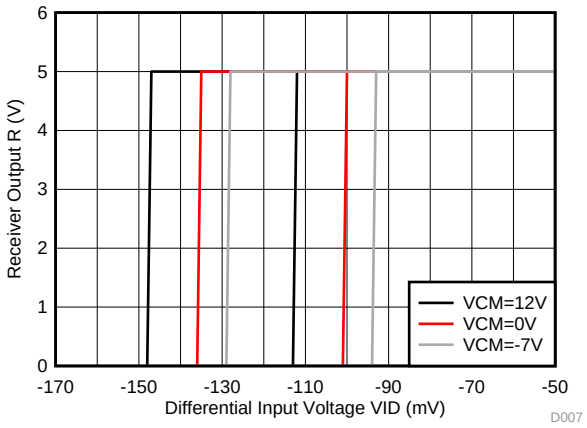


图 7. Receiver Output vs Input

7 Parameter Measurement Information

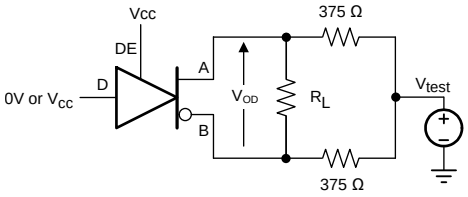


图 8. Measurement of Driver Differential Output Voltage With Common-Mode Load

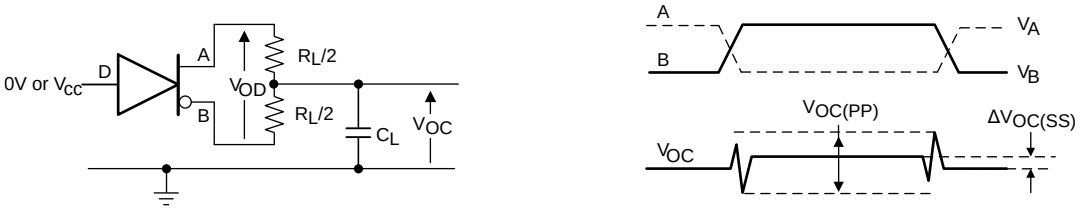


图 9. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

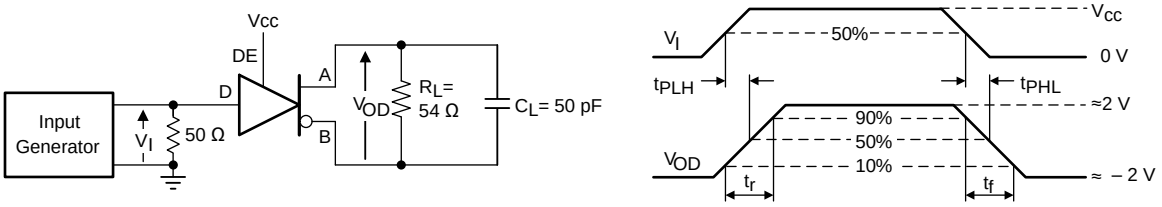


图 10. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

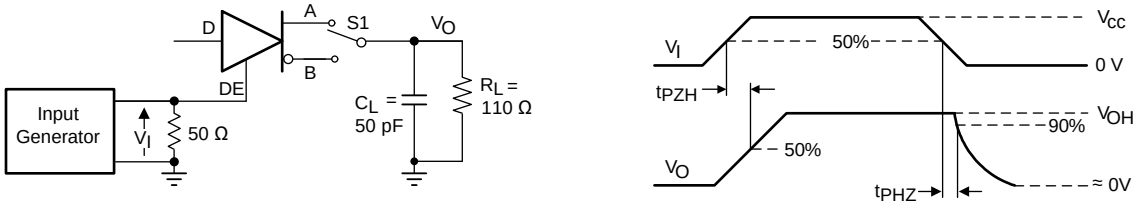


图 11. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

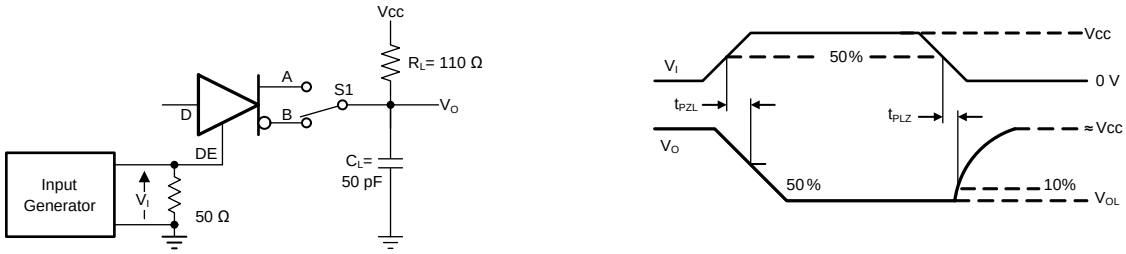


图 12. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

Parameter Measurement Information (接下页)

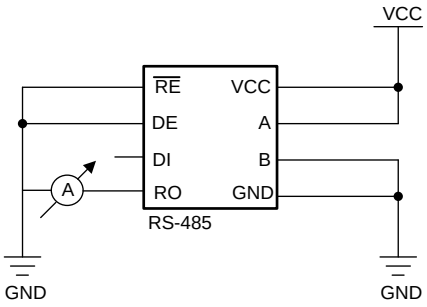
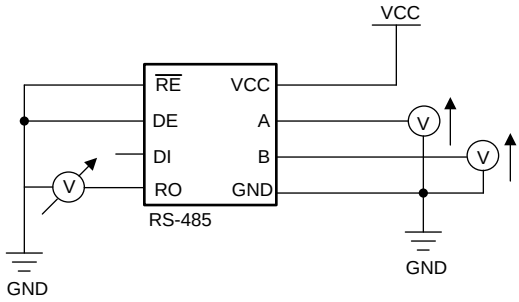


图 13. Measurement of Receiver Output Short Circuit Current



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

图 14. Measurement of Bus Impedance

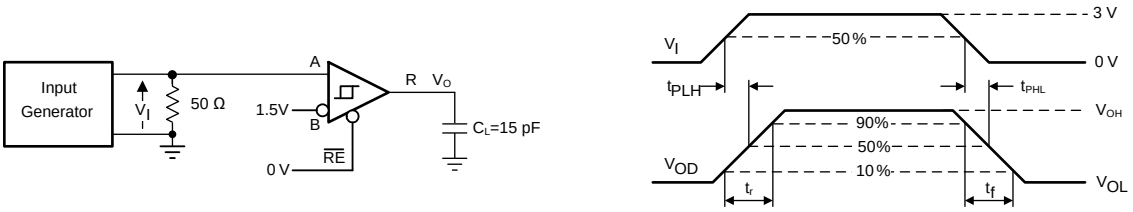


图 15. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

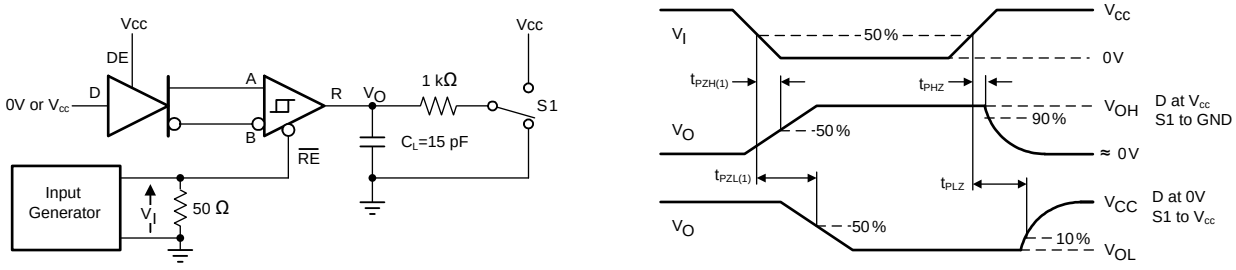


图 16. Measurement of Receiver Enable/Disable Times With Driver Enabled

Parameter Measurement Information (接下页)

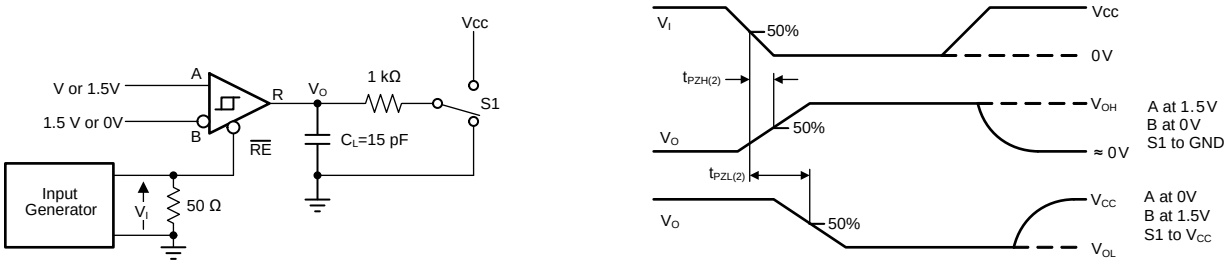


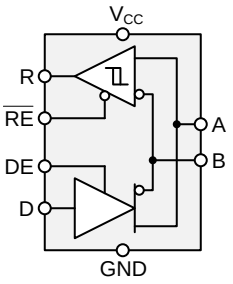
图 17. Measurement of Receiver Enable Times With Driver Disabled

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.

表 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).

表 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

注

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.

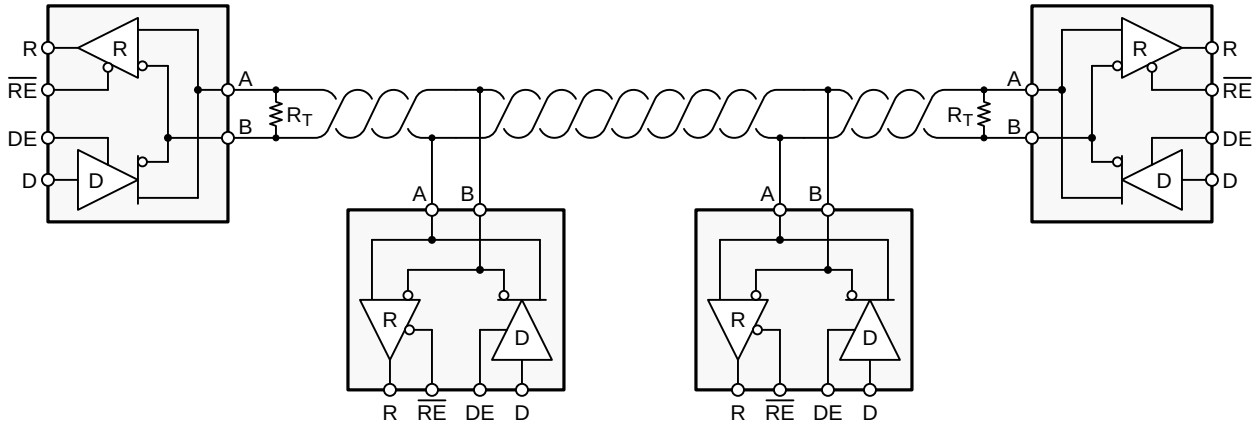


图 18. Typical RS-485 Network With Half-Duplex Transceivers

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 (接下页)

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 公式 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 (接下页)

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.

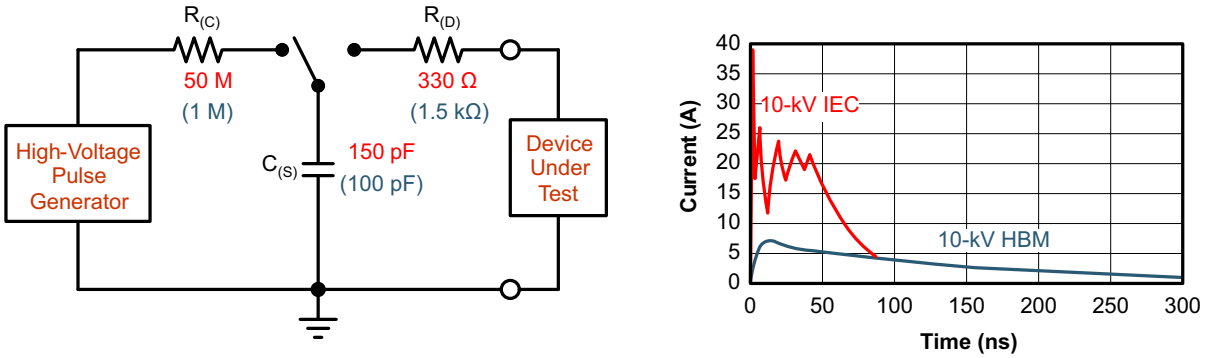


图 19. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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.

图 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.

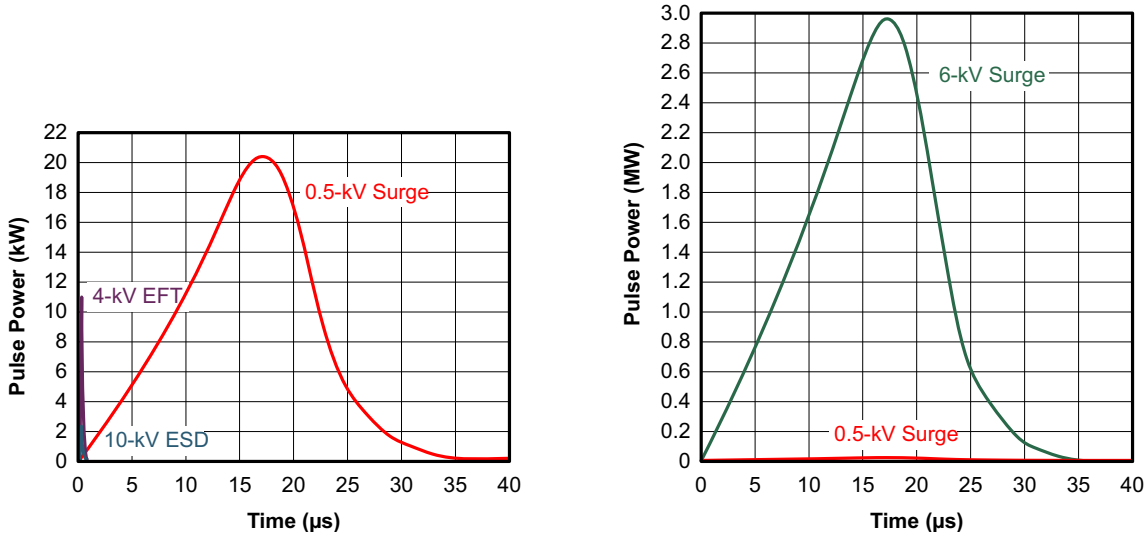


图 20. Power Comparison of ESD, EFT, and Surge Transients

Typical Application (接下页)

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. 图 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.

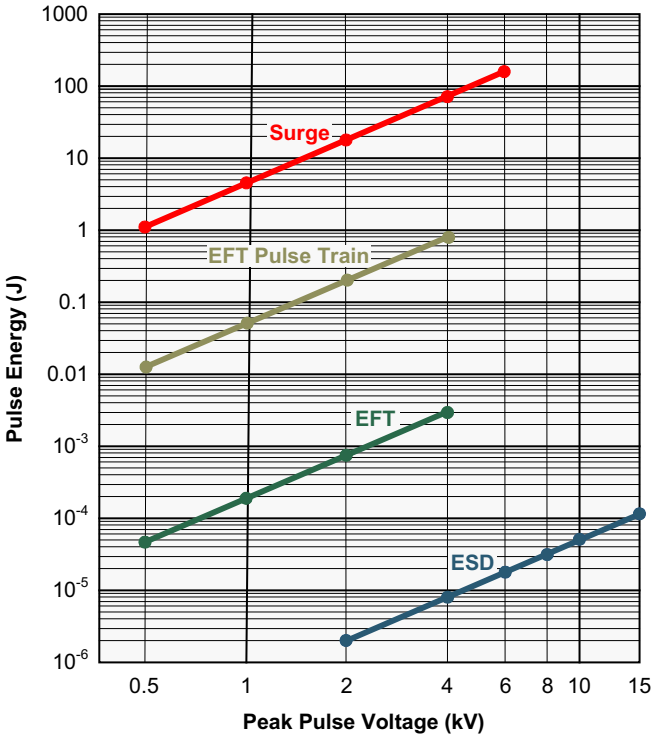


图 21. Comparison of Transient Energies

Typical Application (接下页)

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. 图 22 suggest a protection circuit against 1 kV surge (IEC 61000-4-5) transients. 表 3 shows the associated Bill of Materials.

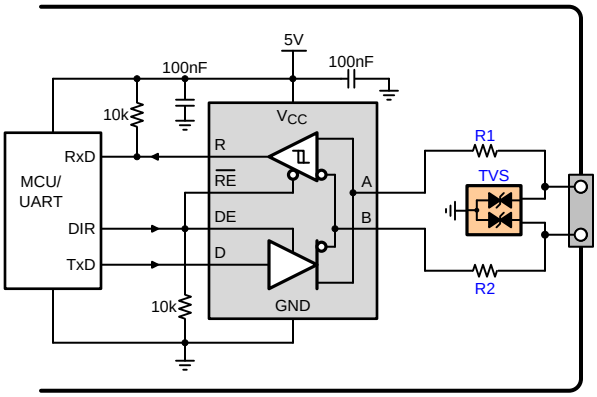
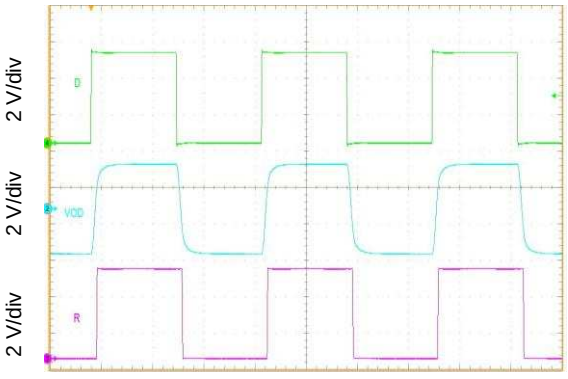


图 22. Transient Protection Against ESD, EFT, and Surge Transients for Half-Duplex Devices

表 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

图 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

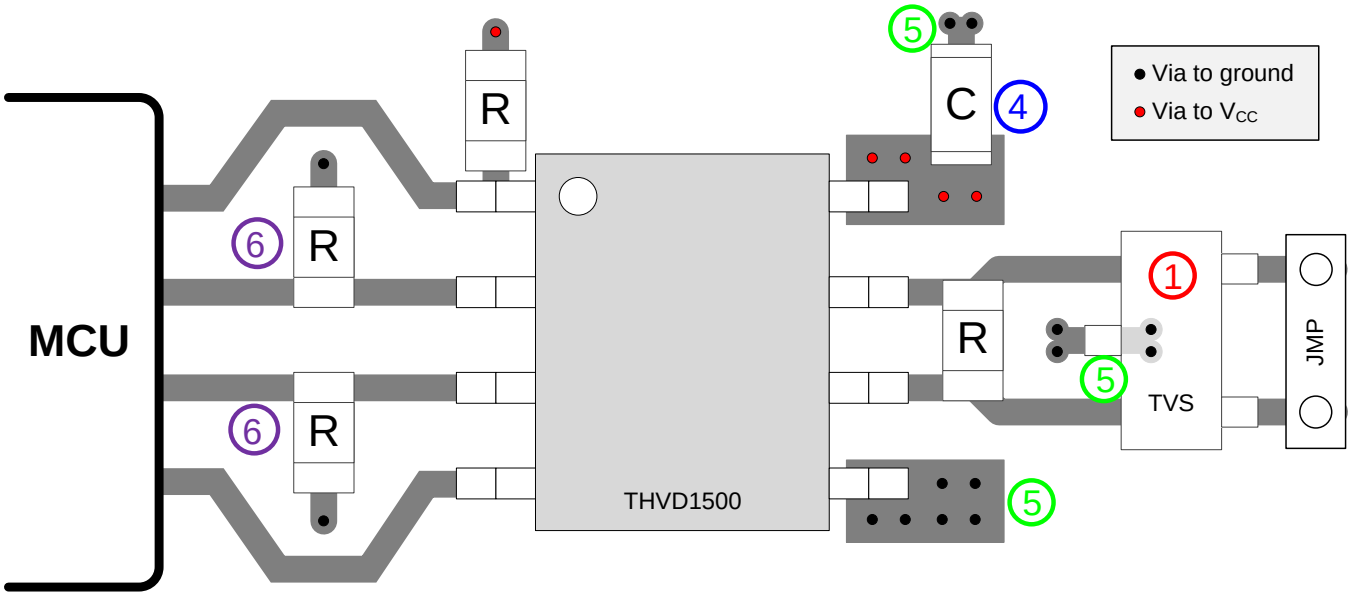


图 24. Layout Example

12 器件和文档支持

12.1 器件支持

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12.6 静电放电警告

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12.7 术语表

SLYZ022 — *TI 术语表*。

这份术语表列出并解释术语、缩写和定义。

13 机械、封装和可订购信息

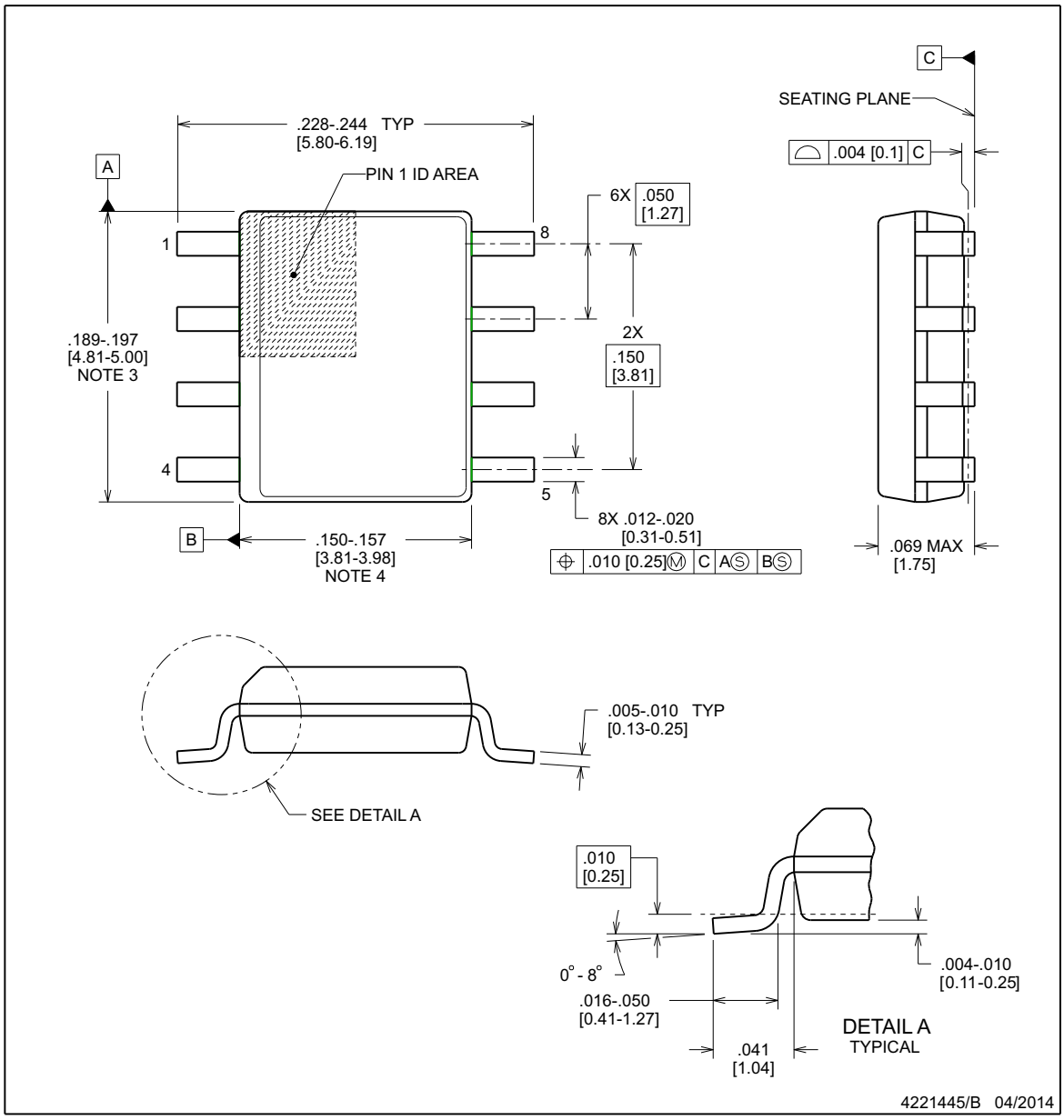
以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此产品说明书的浏览器版本，请查阅左侧的导航栏。

PACKAGE OUTLINE

D0008B

SOIC - 1.75 mm max height

SOIC



NOTES:

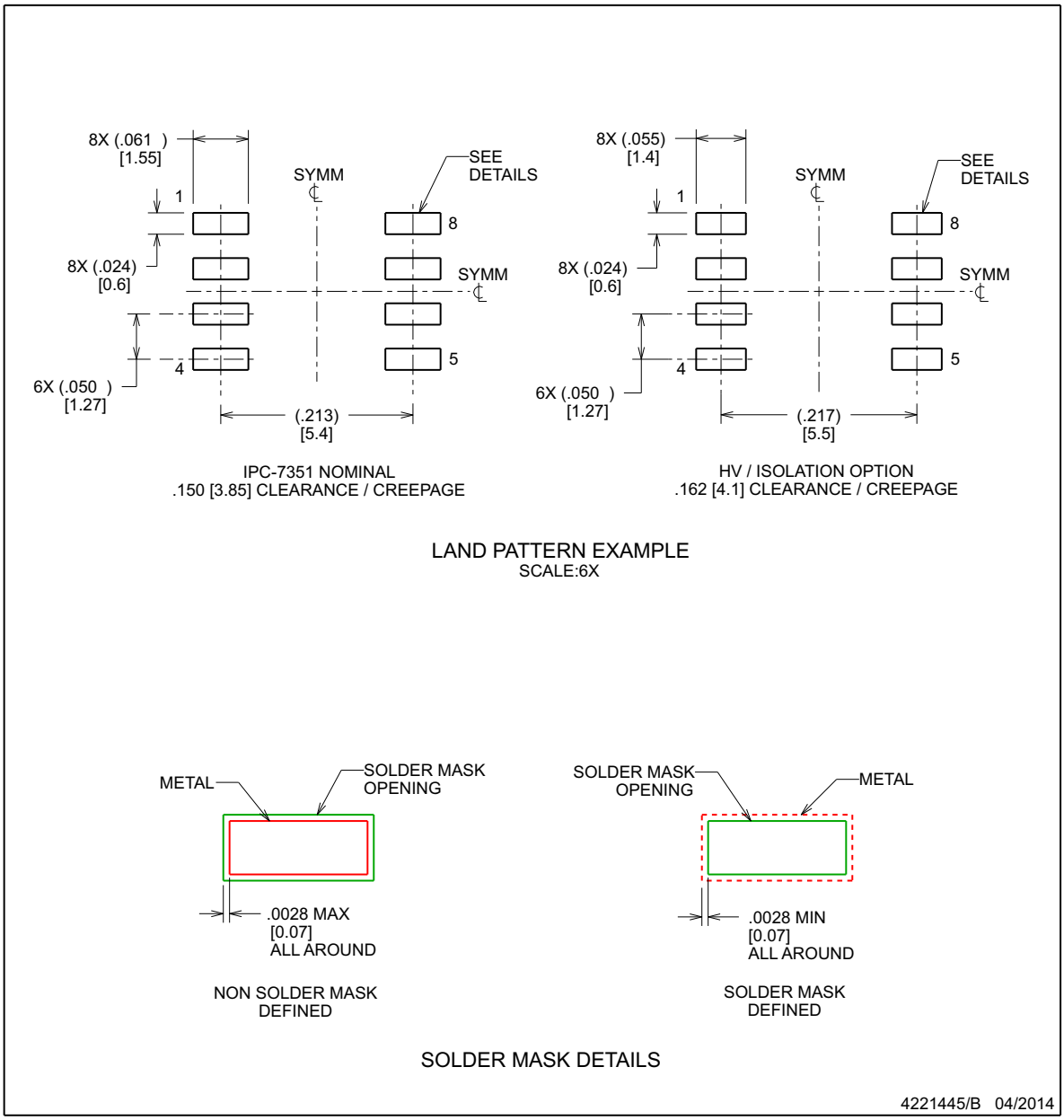
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate 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)

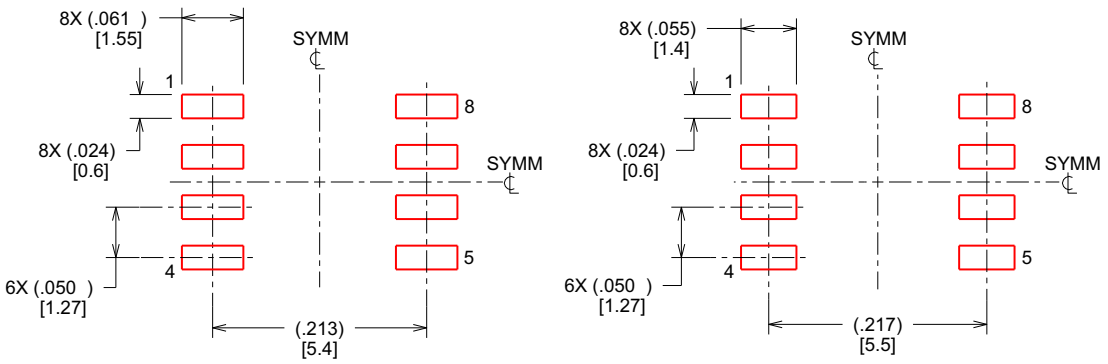
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008B

SOIC - 1.75 mm max height

SOIC



IPC-7351 NOMINAL
.150 [3.85] CLEARANCE / CREEPAGE

HV / ISOLATION OPTION
.162 [4.1] CLEARANCE / CREEPAGE

SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.127 MM] THICK STENCIL
SCALE:6X

4221445/B 04/2014

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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
THVD1500D	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	VD1500	Samples
THVD1500DR	ACTIVE	SOIC	D	8	2500	RoHS & Green	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.

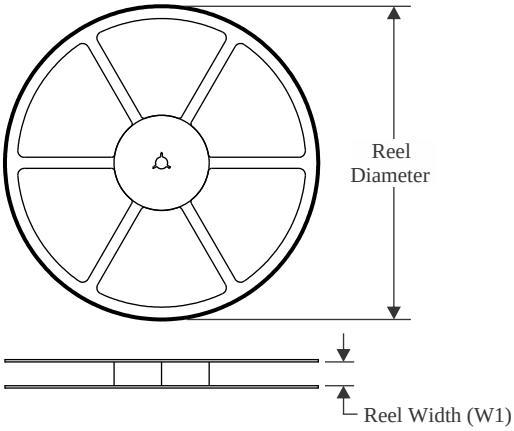
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

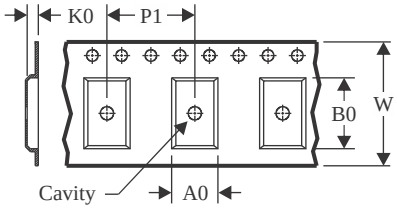
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

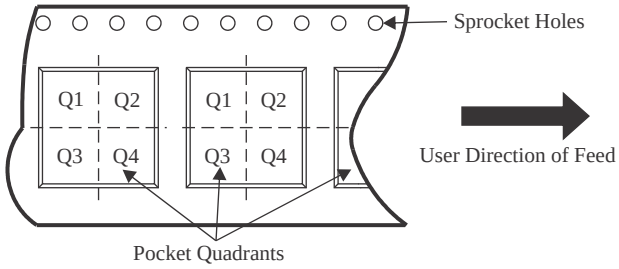


TAPE DIMENSIONS



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

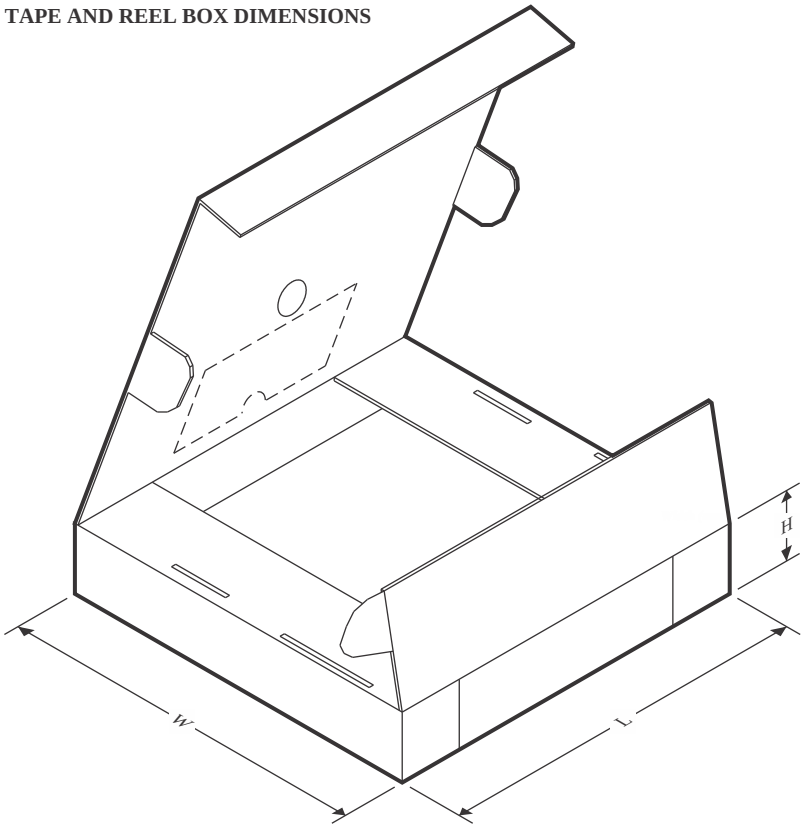
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
THVD1500DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

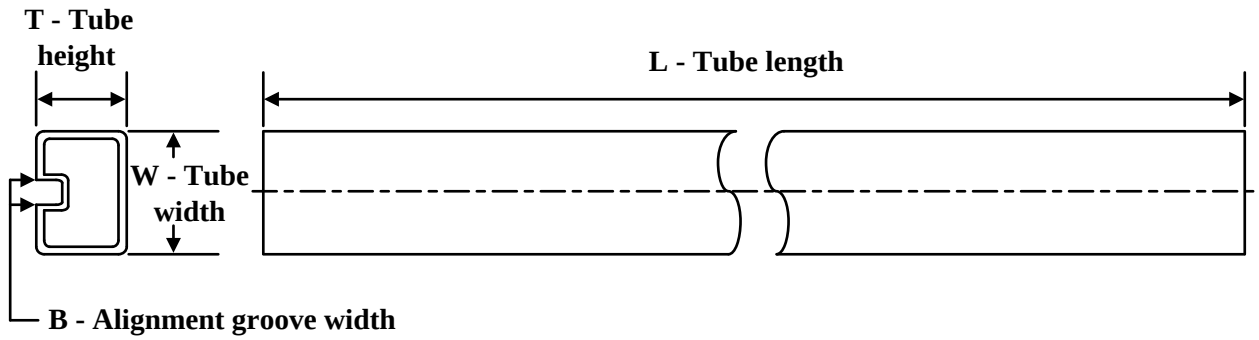
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
THVD1500DR	SOIC	D	8	2500	340.5	336.1	25.0
THVD1500DR	SOIC	D	8	2500	356.0	356.0	35.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
THVD1500D	D	SOIC	8	75	507	7.85	3750	2.24

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