THVD24x9 采用小型封装、具有集成浪涌保护和高总线故障保护功能的 3V 至 5.5V RS-485 收发器

1 特性

- 符合或超出 TIA/EIA-485A 标准要求
- 3V 至 5.5V 电源电压
- 采用 9mm^2 封装、集成浪涌保护功能的业界超小型 RS-485 器件
- V_{IO} 支持从 1.65V 到 V_{CC} 的电源电平
- 总线 I/O 保护
  - ±3kV/42Ω IEC 61000-4-5 1.2/50μs 浪涌 (SOIC)
  - ±1.5kV/42Ω IEC 61000-4-5 1.2/50μs 浪涌 (VSON)
  - ±8kV IEC 61000-4-2 接触放电
  - ±4kV IEC 61000-4-4 电气快速瞬变
  - ±15kV HBM ESD
  - ±42V 直流总线故障
- 有两种速度等级
  - THVD2419：250kbps
  - THVD2429：20Mbps
- 工作环境
  温度范围：-40°C 至 125°C
- 扩展级运行
  共模范围：±25V
- 用于噪声抑制的较大接收器滞后
- 关断模式下的低功耗：< 5μA
- 适用于热插拔功能的无干扰上电和断电
- 开路、短路和空闲总线失效防护
- 1/8 单位负载（多达 256 个总线节点）
- 采用可实现快插兼容性的
  业界通用 8 引脚 SOIC 封装
- 采用 3mm x 3mm 无引线 (VSON) 封装、集成浪涌保护功能的小型 RS-485 器件

2 应用

- 无线基础设施
- 工厂自动化
- 电机驱动器
- 楼宇自动化
- HVAC
- 电网基础设施

3 说明

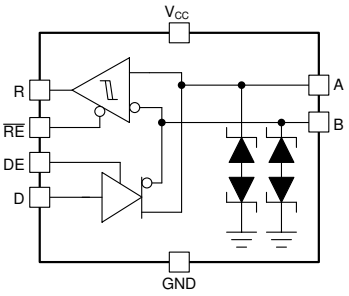
THVD24x9 器件是半双工 RS-485 收发器，集成了浪涌保护功能。浪涌保护是通过在标准 8 引脚 SOIC (D) 封装以及小型 10 引脚 VSON 封装中集成瞬态电压抑制器 (TVS) 二极管实现的。此功能提高了可靠性，可以更好地抵抗耦合到数据电缆的噪声瞬变，而无需外部保护元件。

采用标准引脚排列 SOIC 封装的 THVD24x9 器件由 3.3V 或 5V 单电源供电。此外，采用 10 引脚 VSON 封装的 THVD24x9 器件支持额外的 V_{IO} 电源，可在低至 1.65V 的电源电平下运行 IO。此系列器件具有宽共模电压范围，因而适用于长线缆上的多点应用。

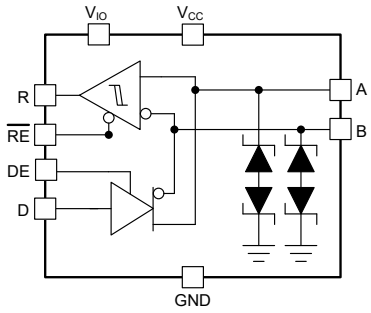
封装信息

器件型号	封装(1)	封装尺寸(2)
THVD2419 THVD2429	SOIC (8)	4.9mm × 6mm
	VSON (10)	3mm × 3mm

(1) 有关更多信息，请参阅节 12。
(2) 封装尺寸（长 × 宽）为标称值，并包括引脚（如适用）。



THVD24x9 方框图（SOIC 封装）



THVD24x9 方框图（VSON 封装）

Table of Contents

4 Device Comparison Table

PART NUMBER	PACKAGE	V_{IO}	SIGNALING RATE	NODES
THVD2419	SOIC-8	No	up to 250kbps	256
THVD2429			up to 20Mbps	
THVD2419	VSON-10	Yes	up to 250kbps	
THVD2429			up to 20Mbps	

5 Pin Configuration and Functions

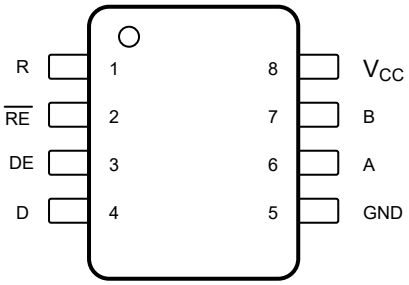


图 5-1. THVD2419, THVD2429, 8-Pin (SOIC) (Top View)

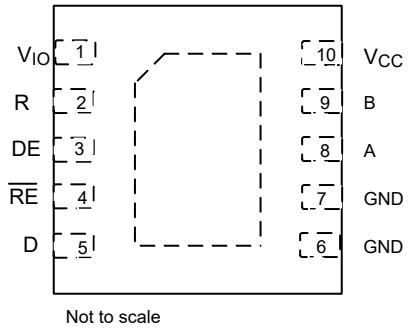


图 5-2. THVD2419, THVD2429, 10-Pin (VSON) (Top View)

PIN			TYPE	DESCRIPTION
NAME	SOIC-8	VSON-10		
V_{IO}	-	1	P	1.8V to 5V supply for R, D, and $\overline{RE}$ and DE
R	1	2	O	Receiver data output
$\overline{RE}$	2	4	I	Receiver enable, active low (integrated pull-up)
DE	3	3	I	Driver enable, active high (integrated pull-down)
D	4	5	I	Driver data input (integrated pull-up)
GND	5	6, 7	-	Device ground
A	6	8	I/O	Bus I/O port, A (complementary to B)
B	7	9	I/O	Bus I/O port, B (complementary to A)
V_{CC}	8	10	P	3.3V to 5V supply for the device

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Logic supply voltage	V_{IO}	–0.5	V_{CC} + 0.2	V
Bus supply voltage	V_{CC}	–0.5	6.5	V
Bus voltage	Range at any bus pin (A or B) as differential or common-mode with respect to GND	–42	42	V
Input voltage	Range at any logic pin (D, DE, SLR or $\overline{RE}$) for devices with VIO pin	–0.3	V_{IO} + 0.2	V
Input voltage	Range at any logic pin (D, DE, SLR or $\overline{RE}$) for devices with no VIO pin	–0.3	V_{CC} + 0.2	V
Receiver output current	I_O	–24	24	mA
Storage temperature	T_{stg}	–65	170	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	Bus terminals and GND	±16,000	V
			All pins except bus terminals and GND	±4,000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)		±1,500	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 ESD Ratings - IEC Specifications

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge, bus terminals	Contact discharge, per IEC 61000-4-2 (1)	Bus terminals and GND	±8,000	V
		Air-gap discharge, per IEC 61000-4-2 (1)	Bus terminals and GND	±15,000	
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20 μs CWG (DRC Package)	Bus terminals and GND	±1500	V
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20 μs CWG (D Package)	Bus terminals and GND	±3,000	V

(1) For optimised IEC ESD performance, it is recommended to have series resistor (≥ 50 Ω) on all logic inputs to minimize transient currents going into or out of the logic pins.

6.4 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		3		5.5	V
V_{IO}	I/O supply voltage (devices with VIO pin)		1.65		V_{CC}	V
V_{IH}	High-level input voltage (D, DE, $\overline{RE}$)	devices with VIO pin	0.7		1	V_{IO}
V_{IL}	Low-level input voltage (D, DE, $\overline{RE}$)	devices with VIO pin	0		0.3	V_{IO}
V_{IH}	High-level input voltage (D, DE, $\overline{RE}$)	devices without VIO pin	0.7		1	V_{CC}
V_{IL}	Low-level input voltage (D, DE, $\overline{RE}$)	devices without VIO pin	0		0.3	V_{CC}
V_I	Input voltage at any bus terminal (separately or common mode)(1)		–25		25	V
V_{ID}	Differential input voltage		–25		25	V
I_O	Output current, driver		–60		60	mA
I_{OR}	Output current, receiver	V_{IO} = 1.8V or 2.5V (devices with VIO pin)	–4		4	mA
I_{OR}	Output current, receiver	V_{IO} = 3.3V or 5V (devices with VIO pin) or V_{CC} = 3.3V or 5V (devices without VIO pin)	–8		8	mA
R_L	Differential load resistance		54	60		Ω
$1/t_{UI}$	Signaling rate	THVD2419			250	kbps
		THVD2429			20	Mbps
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.

6.5 Thermal Information

THERMAL METRIC(1)		THVD2419, THVD2429		UNIT
		DRC (VSON)	D (SOIC)	
		10 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	65.2	117.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	41.7	40.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	36.4	65.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	1.4	3.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	36.3	64.4	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	24.9	N/A	°C/W

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

6.6 Power Dissipation

PARAMETER		TEST CONDITIONS			VALUE	UNIT
P_D	Driver and receiver enabled, V_{CC} = 5.5 V, T_A = 125 °C, square wave at 50% duty cycle	Unterminated R_L = 300 Ω, C_L = 50pF (driver)	THVD2419	250kbps	180	mW
			THVD2429	20Mbps	310	
		RS-422 load R_L = 100 Ω, C_L = 50pF (driver)	THVD2419	250kbps	180	mW
			THVD2429	20Mbps	310	
		RS-485 load R_L = 54 Ω, C_L = 50pF (driver)	THVD2419	250kbps	270	mW
			THVD2429	20Mbps	325	

6.7 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of V_{CC} = 5V, V_{IO} = 3.3V , unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Driver							
$\|V_{OD}\|$	Driver differential output voltage magnitude	R_L = 60 Ω , – 25V ≤ V_{test} ≤ 25V (See 图 7-1)		1.5	2.8		V
		R_L = 60 Ω , – 25V ≤ V_{test} ≤ 25V, 4.5V ≤ V_{CC} ≤ 5.5V (See 图 7-1)		2.1	3.3		V
		R_L = 100 Ω (See 图 7-2)		2	2.9		V
		R_L = 54 Ω (See 图 7-2)		1.5	2.5		V
$\Delta\|V_{OD}\|$	Change in differential output voltage	R_L = 54 Ω or 100 Ω (See 图 7-2)		– 50		50	mV
V_{OC}	Common-mode output voltage			1	V_{CC}/2	3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage			– 50		50	mV
I_{OS}	Short-circuit output current	DE = V_{IO}, -42V ≤ (V_A or V_B) ≤42 V, or A shorted to B		– 250		250	mA
Receiver							
I_I	Bus input current	DE = 0V, V_{CC} and V_{IO} = 0V or 5.5V	V_I = 12V		90	125	μA
			V_I = 25V		200	250	μA
			V_I = – 7V	– 100	– 80		μA
			V_I = – 25V	– 350	– 240		μA
V_{TH+}	Positive-going input threshold voltage(1)	Over common-mode range of ± 25V		20	125	200	mV
V_{TH-}	Negative-going input threshold voltage(1)			– 200	– 125	-20	mV
V_{HYS}	Input hysteresis				250		mV
V_{TH_FSH}	Input fail-safe threshold			– 20		20	mV
$C_{A,B}$	Input differential capacitance	Measured between A and B, f = 1MHz			50		pF
V_{OH}	Output high voltage	I_{OH} = – 8mA, V_{IO} = 3 to 3.6V or 4.5V to 5.5V		V_{IO} – 0.4	V_{IO} – 0.2		V
V_{OL}	Output low voltage	I_{OL} = 8mA, V_{IO} = 3 to 3.6V or 4.5V to 5.5V			0.2	0.4	V
V_{OH}	Output high voltage	I_{OH} = – 4mA, V_{IO} = 1.65 to 1.95V or 2.25V to 2.75V		V_{IO} – 0.4	V_{IO} – 0.2		V
V_{OL}	Output low voltage	I_{OL} = 4mA, V_{IO} = 1.65 to 1.95V or 2.25V to 2.75V			0.2	0.4	V
I_{OZ}	Output high-impedance current, R pin	V_O = 0V or V_{IO}, $\overline{RE}$ = V_{IO}		– 1		1	μA
Logic							
I_{IN}	Input current (DE , SLR)	DRC: 1.65V ≤ V_{IO} ≤ 5.5V, 0V ≤ V_{IN} ≤ V_{IO} D: 3V ≤ V_{CC} ≤ 5.5V, 0 V ≤ V_{IN} ≤ 5.5V				5	μA
I_{IN}	Input current (D, $\overline{RE}$)	DRC: 1.65V ≤ V_{IO} ≤ 5.5V, 0V ≤ V_{IN} ≤ V_{IO} D: 3V ≤ V_{CC} ≤ 5.5V, 0 V ≤ V_{IN} ≤ 5.5V		– 5			μA
Thermal Protection							
T_{SHDN}	Thermal shutdown threshold	Temperature rising		150	180		°C
T_{HYS}	Thermal shutdown hysteresis				10		°C
Supply							
UV_{VCC} (rising)	Rising under-voltage threshold on V_{CC}				2.3	2.6	V
UV_{VCC} (falling)	Falling under-voltage threshold on V_{CC}			1.95	2.2		V
$UV_{VCC(hys)}$	Hysteresis on under-voltage of V_{CC}				150		mV

6.7 Electrical Characteristics（续）

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of V_{CC} = 5V, V_{IO} = 3.3V , unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
UV_{VIO} (rising)	Rising under-voltage threshold on V_{IO}				1.4	1.6	V
UV_{VIO} (falling)	Falling under-voltage threshold on V_{IO}			1.2	1.3		V
$UV_{VIO(hys)}$	Hysteresis on under-voltage of V_{IO}				120		mV
I_{CC}	Supply current (quiescent), V_{CC} = 4.5 V to 5.5 V	Driver and receiver enabled	$\overline{RE}$ = 0V, DE = V_{IO}, No load		3.5	5.7	mA
		Driver enabled, receiver disabled	$\overline{RE}$ = V_{IO}, DE = V_{IO}, No load		2.5	4.4	mA
		Driver disabled, receiver enabled	$\overline{RE}$ = 0V, DE = 0V, No load		1.8	2.4	mA
		Driver and receiver disabled (devices without VIO pin)	$\overline{RE}$ = V_{CC}, DE = 0V, D = open, No load		1.7	5	µA
		Driver and receiver disabled (devices with VIO pin)	$\overline{RE}$ = V_{IO}, DE = 0V, D = open, No load		0.1	3	µA
I_{CC}	Supply current (quiescent), V_{CC} = 3 V to 3.6 V	Driver and receiver enabled	$\overline{RE}$ = 0V, DE = V_{IO}, No load		3	4.6	mA
		Driver enabled, receiver disabled	$\overline{RE}$ = V_{IO}, DE = V_{IO}, No load		2.2	3.3	mA
		Driver disabled, receiver enabled	$\overline{RE}$ = 0V, DE = 0V, No load		1.6	2.2	mA
		Driver and receiver disabled (Devices without VIO pin)	$\overline{RE}$ = V_{CC}, DE = 0V, D = open, No load		1	4	µA
		Driver and receiver disabled (Devices with VIO pin)	$\overline{RE}$ = V_{IO}, DE = 0V, D = open, No load		1	2	µA
I_{IO}	Logic supply current (quiescent), V_{IO} = 3 to 3.6 V, Devices with VIO pin	Driver disabled, Receiver enabled	DE = 0V, $\overline{RE}$ = 0V, No load		3.3	8.4	µA
		Driver disabled, Receiver disabled	DE = 0V, $\overline{RE}$ = V_{IO}, No load		0.1	2	µA

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

6.8 Switching Characteristics 250kbps

250kbps (THVD2419) over recommended operating conditions. All typical values are at 25°C and supply voltage of V_{CC} = 5V , V_{IO} = 3.3V, unless otherwise noted. (1)

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 7-3	V_{CC} = 3 to 3.6V, Typical at 3.3V	400	625	1200	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V	500	725	1200	ns
t_{PHL}, t_{PLH}	Propagation delay	R_L = 54 Ω , C_L = 50 pF See 图 7-3			510	750	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$				5	70	ns
t_{PHZ}, t_{PLZ}	Disable time	See 图 7-4 and 图 7-5	$\overline{RE}$ = X		45	75	ns
t_{PZH}, t_{PZL}	Enable time		$\overline{RE}$ = 0V		80	290	ns
			$\overline{RE}$ = V_{IO}		2.5	4.5	µs
t_{SHDN}	Time to shutdown		$\overline{RE}$ = V_{IO}	50		500	ns
Receiver							
t_r, t_f	Output rise/fall time	C_L = 15 pF See 图 7-6			3	20	ns
t_{PHL}, t_{PLH}	Propagation delay				750	1270	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$				5	45	ns
t_{PHZ}, t_{PLZ}	Disable time	DE = X			30	40	ns
$t_{PZH(1)}$	Enable time				80	130	ns
$t_{PZL(1)}$	Enable time	See 图 7-7			800	1320	ns
$t_{PZH(2)}$, $t_{PZL(2)}$	Enable time	See 图 7-8	DE = 0V		3	5.4	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	See 图 7-9	C_L = 15pF	7	11	18	µs
$t_{D(FSO)}$	Delay to exit fail-safe operation			540	750	1260	ns
t_{SHDN}	Time to shutdown	See 图 7-8	DE = 0V	50		500	ns

(1) A, B are driver output and receiver input terminals for Half duplex devices. A, B are RX input, Y/Z are driver output terminals for Full duplex device

6.9 Switching Characteristics 20Mbps

20Mbps (THVD2429) over recommended operating conditions. All typical values are at 25°C and supply voltage of V_{CC} = 5 V, V_{IO} = 3.3 V, unless otherwise noted. (1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Driver							
t_r, t_f	Differential output rise/fall time	R_L = 54 Ω , C_L = 50pF See 图 7-3		3.5	5	15	ns
t_{PHL}, t_{PLH}	Propagation delay	R_L = 54 Ω , C_L = 50pF See 图 7-3		6	15	30	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$	R_L = 54 Ω , C_L = 50pF See 图 7-3			0.5	3	ns
t_{PHZ}, t_{PLZ}	Disable time	See 图 7-4 and 图 7-5	$\overline{RE}$ = X		20	35	ns
t_{PZH}, t_{PZL}	Enable time		$\overline{RE}$ = 0V		16	40	ns
			$\overline{RE}$ = V_{IO}		2.5	4.5	µs
t_{SHDN}	Time to shutdown		$\overline{RE}$ = V_{IO}	50		500	ns
Receiver							
t_r, t_f	Output rise/fall time	C_L = 15pF, See 图 7-6			1.5	6	ns
t_{PHL}, t_{PLH}	Propagation delay			25	35	60	ns
$t_{SK(P)}$	Pulse skew, $\|t_{PHL} - t_{PLH}\|$					5.5	ns
t_{PHZ}, t_{PLZ}	Disable time	DE = X			18	25	ns
$t_{PZH(1)}$, $t_{PZL(1)}$	Enable time	See 图 7-7	DE = V_{IO}		55	82	ns

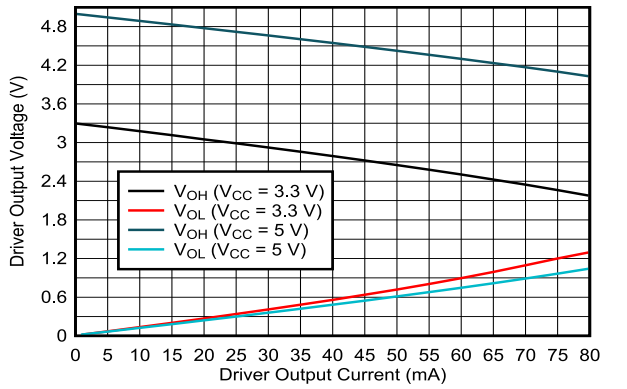
6.9 Switching Characteristics 20Mbps（续）

20Mbps (THVD2429) over recommended operating conditions. All typical values are at 25°C and supply voltage of V_{CC} = 5 V, V_{IO} = 3.3 V, unless otherwise noted. (1)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{PZH(2)}$, $t_{PZL(2)}$	Enable time	See 图 7-8	DE = 0V		2.5	4.5	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	See 图 7-9	C_L = 15pF	7	10	18	µs
$t_{D(FSO)}$	Delay to exit fail-safe operation			19	35	50	ns
t_{SHDN}	Time to shutdown	See 图 7-8	DE = 0V	50		500	ns

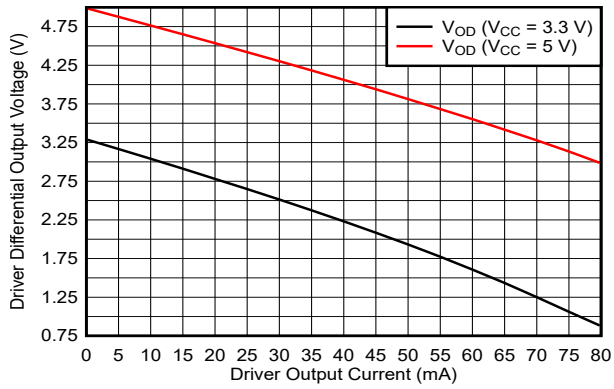
(1) A, B are driver output and receiver input terminals for Half duplex devices. A, B are RX input, Y/Z are driver output terminals for Full duplex device

6.10 Typical Characteristics



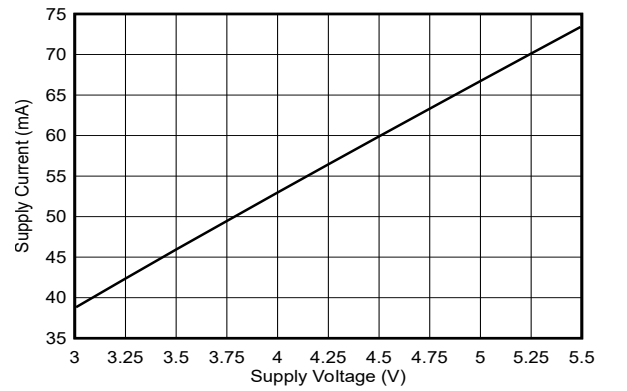
DE = V_{IO} or V_{CC} D = 0V T_A = 25°C

图 6-1. Driver Output Voltage vs Driver Output Current



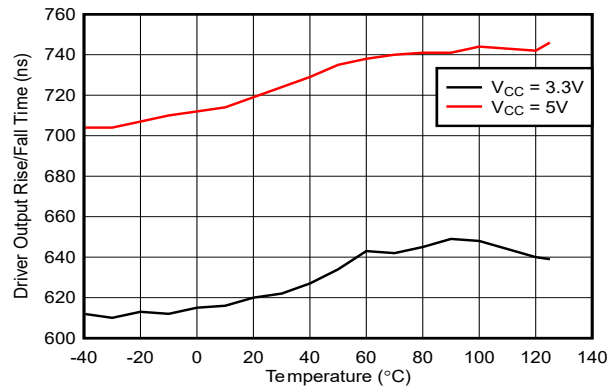
DE = V_{IO} or V_{CC} D = 0V T_A= 25°C

图 6-2. Driver Differential Output voltage vs Driver Output Current



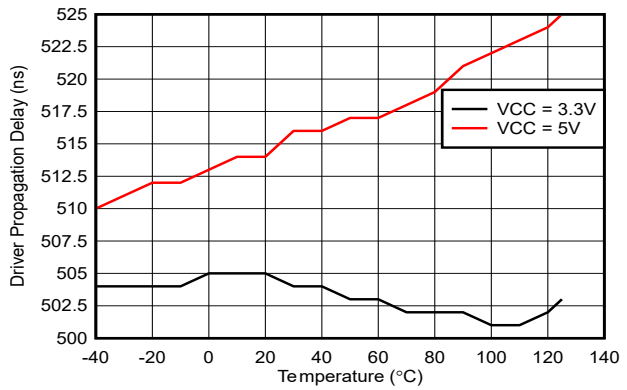
T_A = 25°C R_L = 54 Ω DE = D = V_{IO} or V_{CC}

图 6-3. Driver Output Current vs Supply Voltage



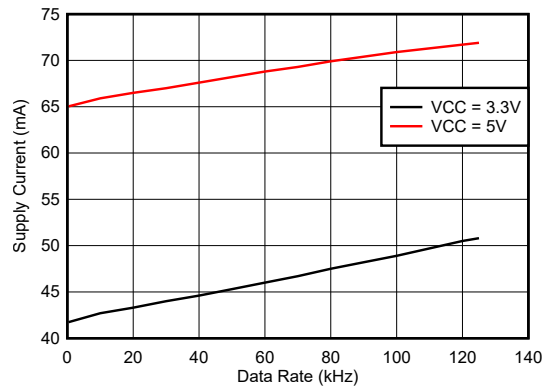
DE = V_{IO} or V_{CC} R_L = 54 Ω C_L = 50pF

图 6-4. THVD2419 Driver Rise or Fall Time vs Temperature



DE = V_{IO} or V_{CC} R_L = 54 Ω C_L = 50pF

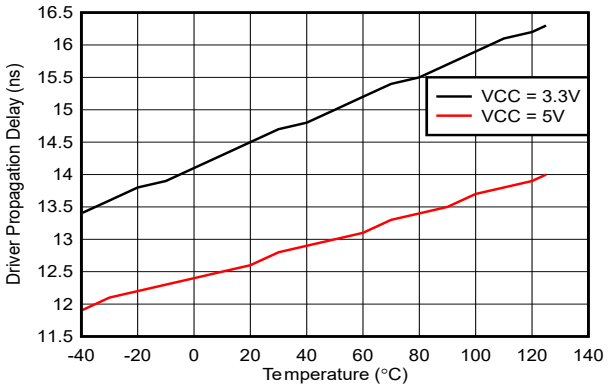
图 6-5. THVD2419 Driver Propagation Delay vs Temperature



T_A = 25°C R_L = 54 Ω

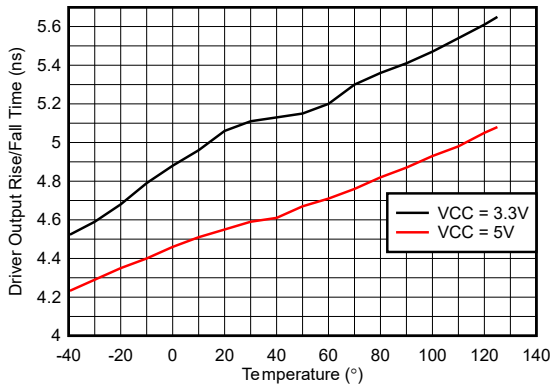
图 6-6. THVD2419 Supply Current vs Signal Rate

6.10 Typical Characteristics (continued)



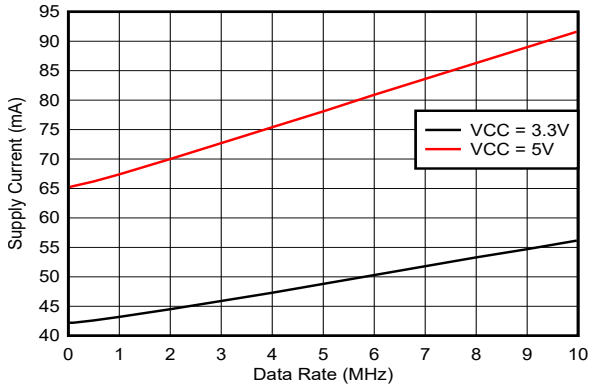
DE = V_{IO} or V_{CC} R_L = 50 Ω C_L = 50pF

图 6-7. THVD2429 Driver Propagation Delay vs Temperature



DE = V_{IO} or V_{CC} R_L = 50 Ω C_L = 50pF

图 6-8. THVD2429 Driver Rise or Fall Time vs Temperature



T_A = 25°C R_L = 54 Ω

图 6-9. THVD2429 Supply Current vs Signal Rate

7 Parameter Measurement Information

备注

Note: Digital input/output supply in the diagrams below could either be V_{CC} (devices without V_{IO} pin) or V_{IO} (devices with VIO pin)

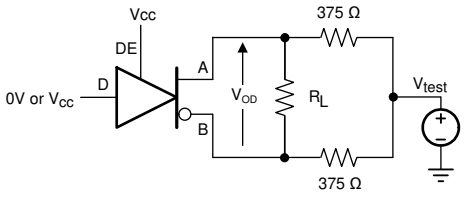


图 7-1. Measurement of Driver Differential Output Voltage With Common-Mode Load

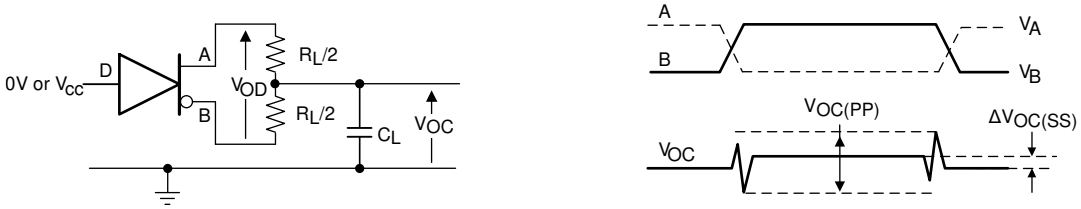


图 7-2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

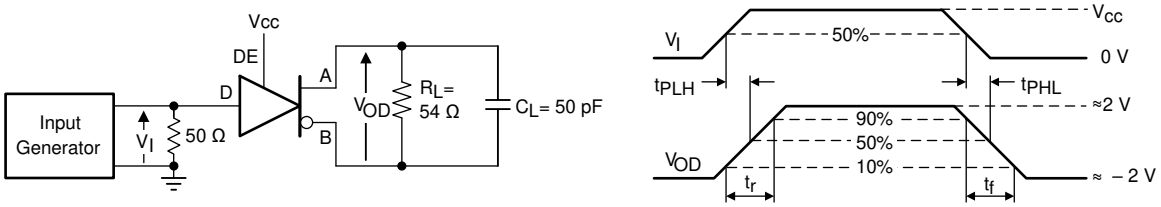


图 7-3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

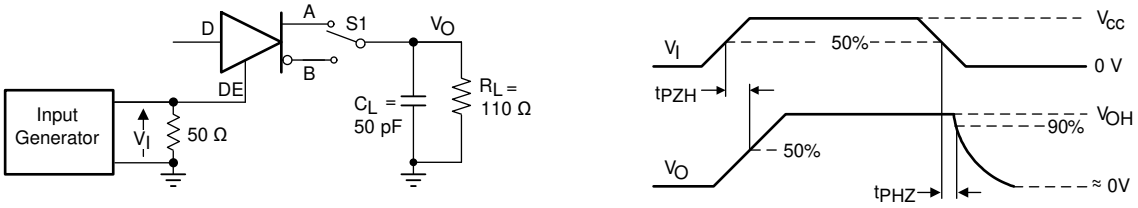


图 7-4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

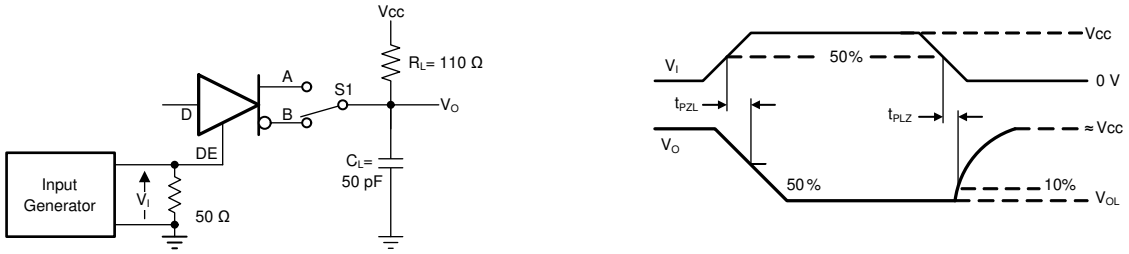


图 7-5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

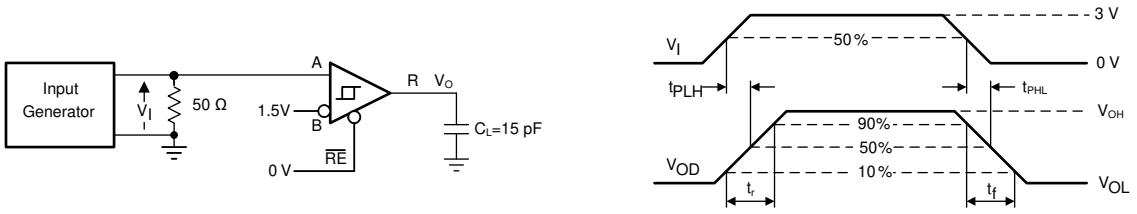


图 7-6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

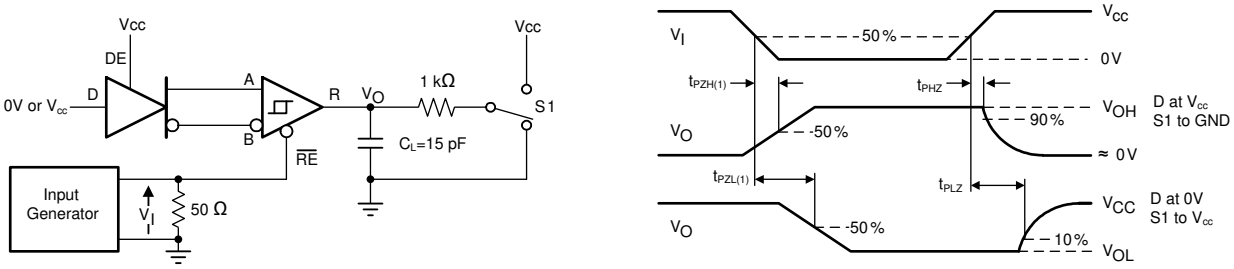


图 7-7. Measurement of Receiver Enable/Disable Times With Driver Enabled

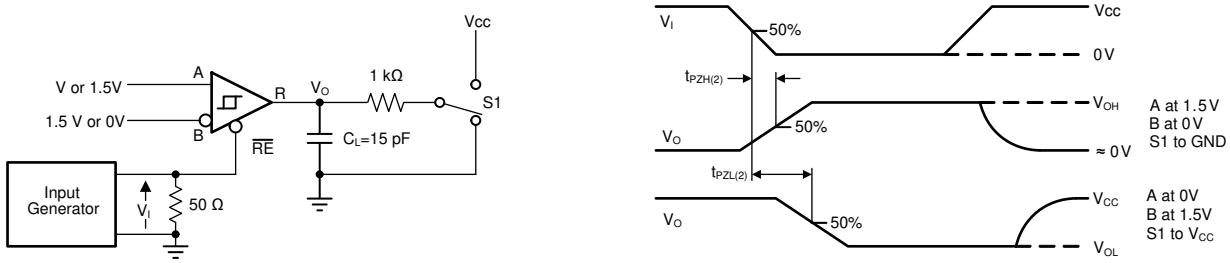


图 7-8. Measurement of Receiver Enable Times With Driver Disabled

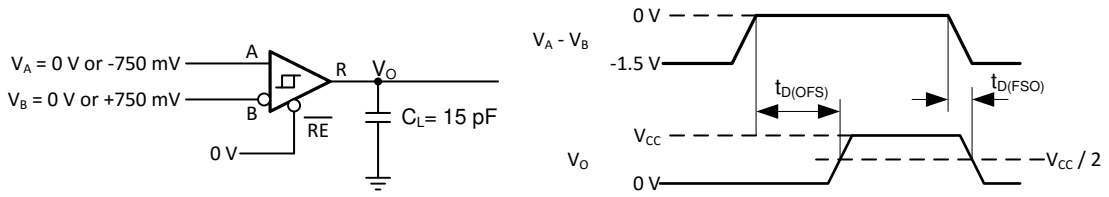


图 7-9. Fail-Safe Delay Measurements

8 Detailed Description

8.1 Overview

THVD24x9 devices are surge-protected, half duplex RS-485 transceivers available in two speed grades suitable for data transmission up to 250kbps and 20Mbps respectively. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package and a small 10-pin leadless package.

THVD2419 and THVD2429 devices have active-high driver enables and active-low receiver enables. A low standby current can be achieved by disabling both driver and receiver.

8.2 Functional Block Diagrams

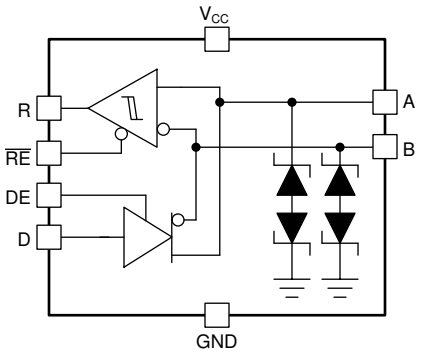


图 8-1. THVD2419 and THVD2429 Block Diagram (SOIC Package)

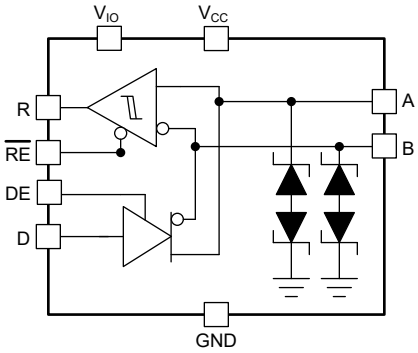


图 8-2. THVD2419 and THVD2429 Block Diagram (VSON Package)

8.3 Feature Description

8.3.1 Electrostatic Discharge (ESD) Protection

The bus pins of the THVD24x9 transceiver family include on-chip ESD protection against ±15kV HBM and ±8kV IEC 61000-4-2 contact discharge. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance, $C_{(S)}$, and 78% lower discharge resistance, $R_{(D)}$, of the IEC model produce significantly higher discharge currents than the HBM model. As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method.

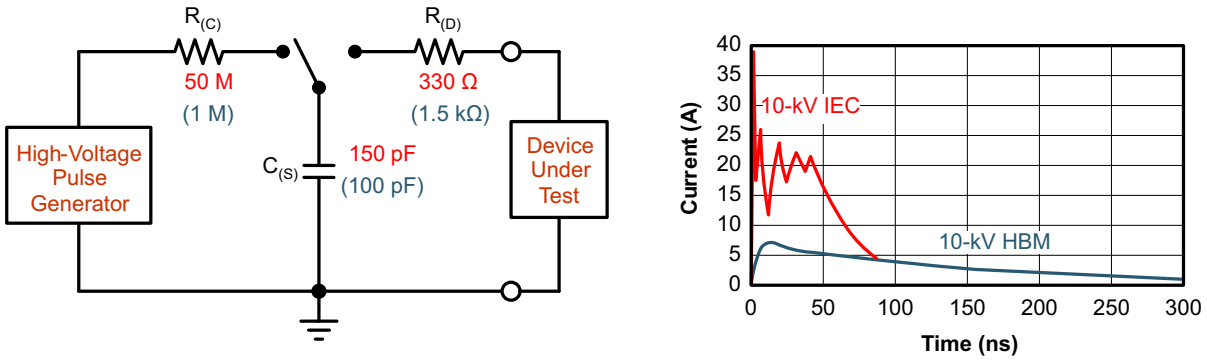


图 8-3. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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.

8.3.2 Electrical Fast Transient (EFT) Protection

Inductive loads such as relays, switch contactors, or heavy-duty motors can create high-frequency bursts during transition. The IEC 61000-4-4 test is intended to simulate the transients created by such switching of inductive loads on AC power lines. 图 8-4 shows the voltage waveforms in to 50 Ω termination as defined by the IEC standard.

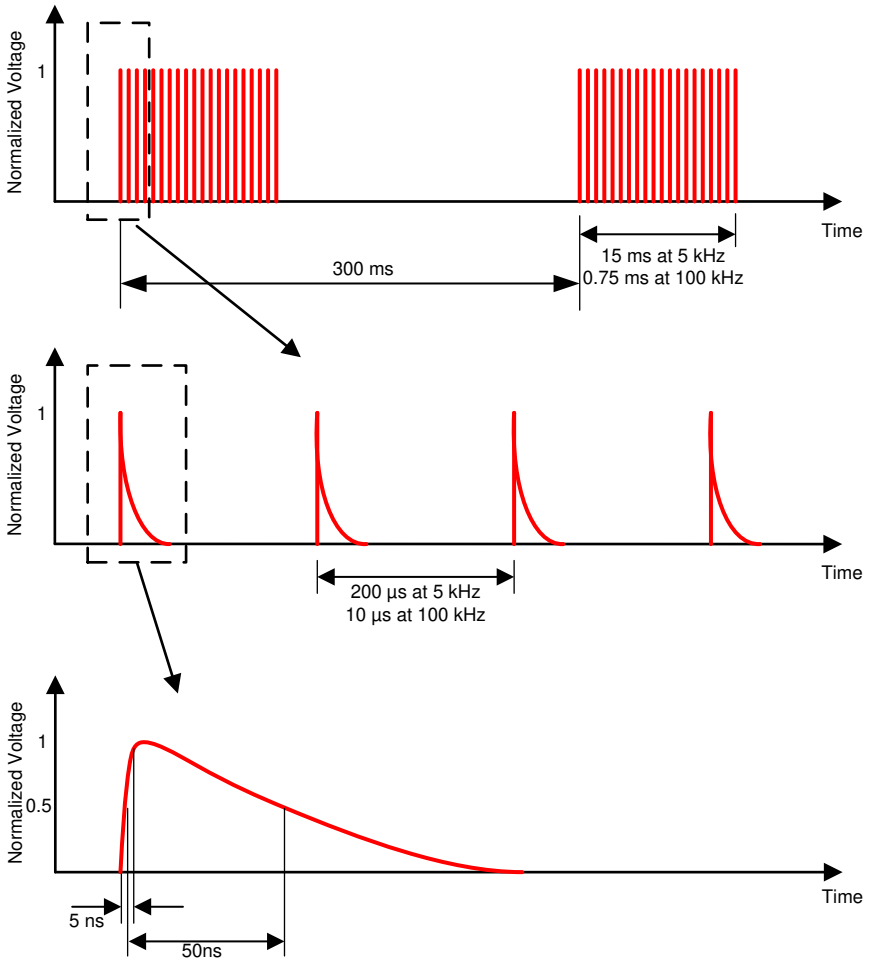


图 8-4. EFT Voltage Waveforms

Internal ESD protection circuits of the THVD24x9 protect the transceivers against ±4kV EFT. With careful system design, one could achieve EFT Criterion A (no data loss when transient noise is present).

8.3.3 Surge Protection

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 8-5 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The diagram on the left shows the relative pulse-power for a 0.5kV surge transient and 4kV EFT transient, both of which dwarf the 10kV ESD transient visible in the lower-left corner. 500V surge transients are representative of events that may occur in factory environments in industrial and process automation.

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

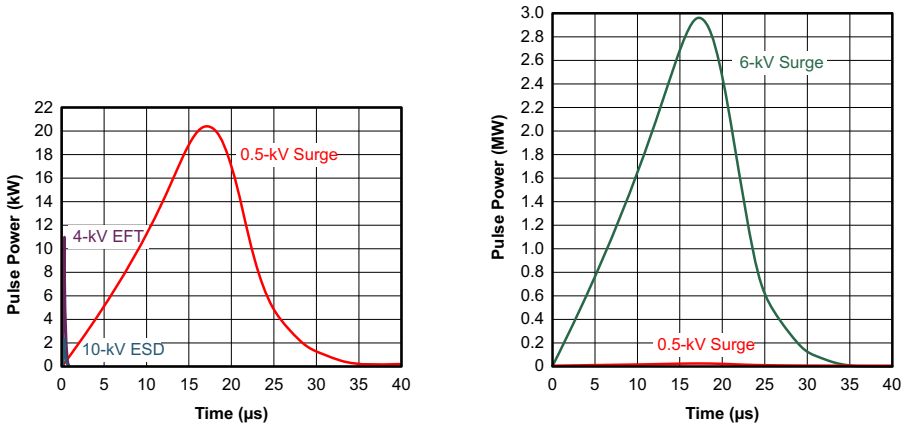


图 8-5. Power Comparison of ESD, EFT, and Surge Transients

图 8-6 shows the test setup used to validate THVD24x9 surge performance according to the IEC 61000-4-5 1.2/50 µs surge pulse.

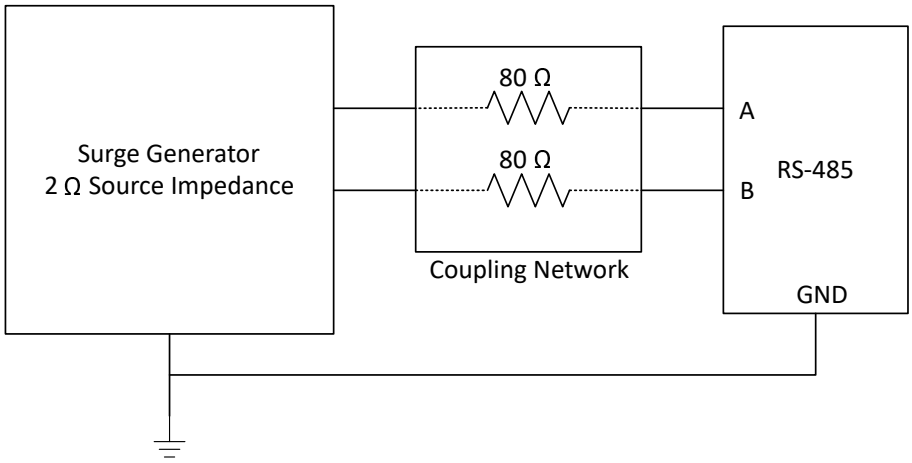


图 8-6. THVD24x9 Surge Test Setup

THVD24x9 product family is robust up to ±3kV surge transients without the need for any external components. The bus pin voltage is clamped by the integrated surge protection diodes such that the internal circuitry is not damaged during the surge event.

8.3.4 Enhanced Receiver Noise Immunity

The differential receivers of THVD24x9 family feature fully symmetric thresholds to maintain duty cycle of the signal even with small input amplitudes. In addition, 250mV (typical) hysteresis displays excellent noise immunity.

8.3.5 Failsafe Receiver

The differential receivers of the THVD24x9 family are failsafe to invalid bus states caused by the following:

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

In any of these cases, the receiver outputs a fail-safe logic high state if the input amplitude stays for longer than $t_{D(OFS)}$ at less than $|V_{TH\_FSH}|$.

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. 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. 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 8-1. 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 higher than the positive input threshold, V_{TH+}, the receiver output, R, turns high. When V_{ID} is lower than the negative input threshold, V_{TH-}, the receiver output, R, turns low. If V_{ID} is between V_{TH+} and V_{TH-} 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 to one another (short-circuit), or the bus is not actively driven (idle bus).

表 8-2. Receiver Function Table

DIFFERENTIAL INPUT	ENABLE	OUTPUT	FUNCTION
$V_{ID} = V_A - V_B$	$\overline{RE}$	R	
$V_{TH+} < V_{ID}$	L	H	Receive valid bus high
$V_{TH-} < V_{ID} < V_{TH+}$	L	Indeterminate	Indeterminate bus state
$V_{ID} < V_{TH-}$	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

备注

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, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

THVD24x9 are half-duplex RS-485 transceivers with integrated system-level surge protection. Standard 8-pin SOIC (D) package allows drop-in replacement into existing systems and eliminate system-level protection components.

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, with a value that matches the characteristic impedance, Z_0, of the cable. This method, known as parallel termination, allows for higher data rates over longer cable length.

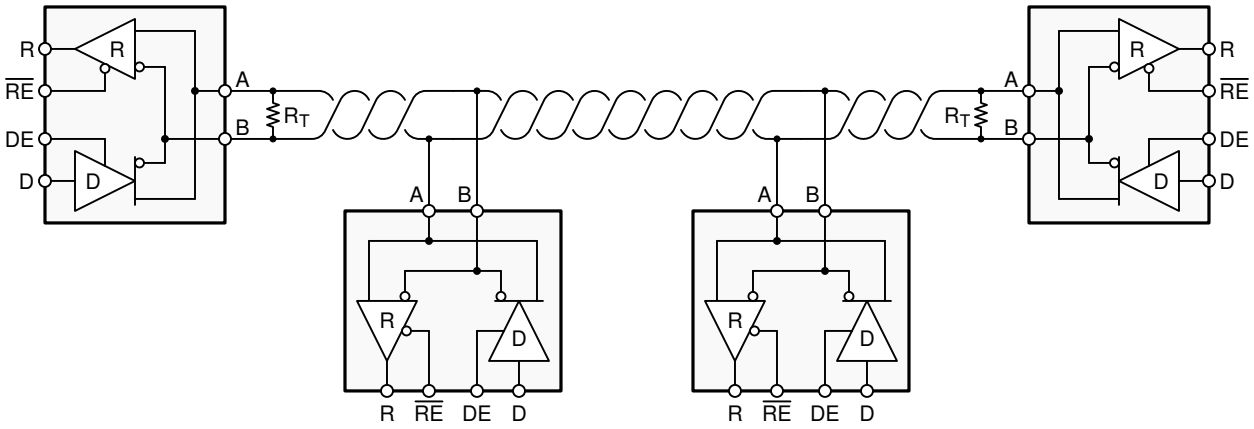


图 9-1. Typical RS-485 Network With Half-Duplex Transceivers

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 short the cable length; and conversely, the lower the data rate, the longer the cable length. While most RS-485 systems use data rates between 10kbps and 100kbps, some applications require data rates up to 250kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

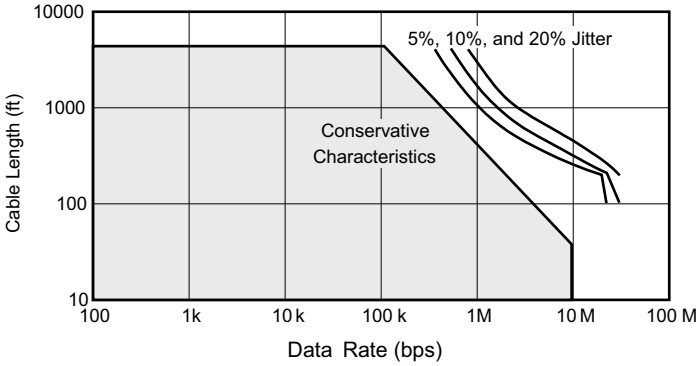


图 9-2. Cable Length vs Data Rate Characteristic

Even higher data rates are achievable (that is, 20Mbps for the THVD2429) in cases where the interconnect is short enough (or has suitably low attenuation at signal frequencies) to not degrade the data.

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 方程式 1.

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

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 12kΩ. Because the THVD24x9 devices consist of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible.

9.2.2 Detailed Design Procedure

RS-485 transceivers operate in noisy industrial environments typically require surge protection at the bus pins. 图 9-3 compares the surge protection implementation with a regular RS-485 transceiver (a), against that with a surge-integrated RS-485 transceiver (b), such as the THVD24x9 family. The internal TVS protection of the THVD24x9 achieves up to ±3kV IEC 61000-4-5 surge protection (SOIC package) without any additional external components, reducing system level bill of materials.

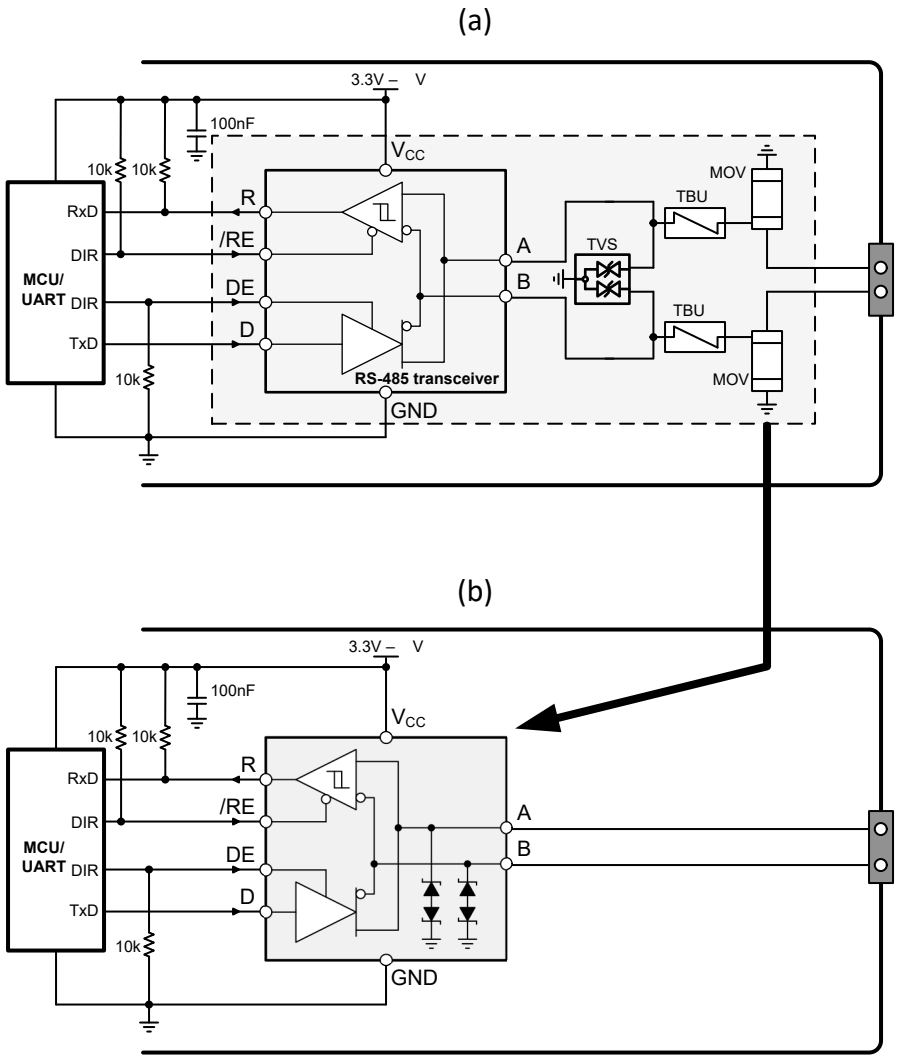
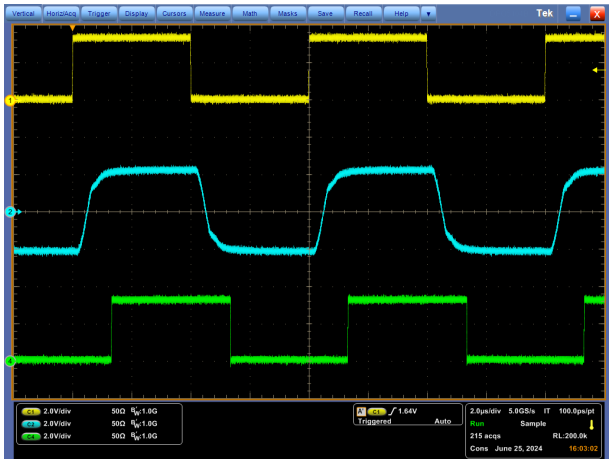


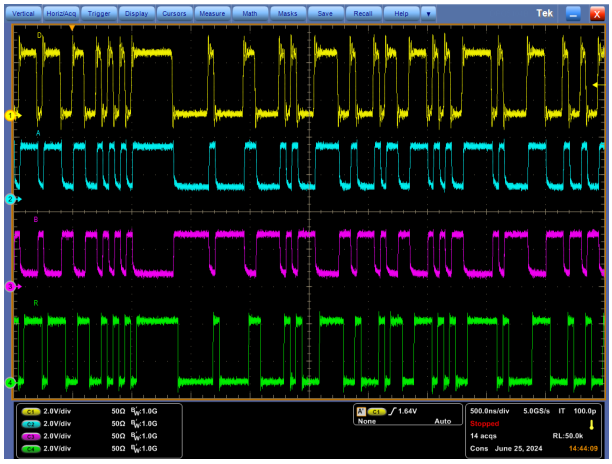
图 9-3. Implementation of System-Level Surge Protection Using THVD24x9

9.2.3 Application Curves



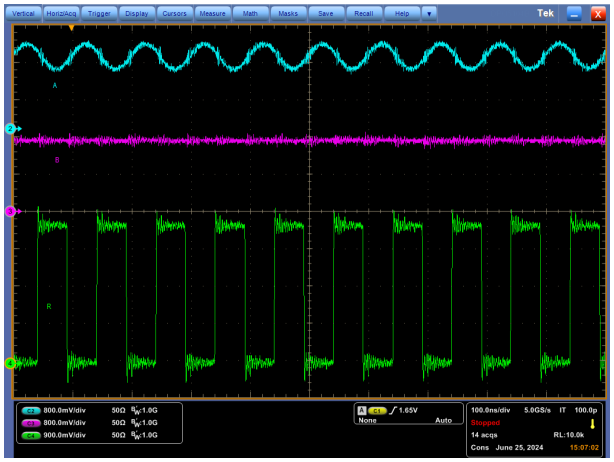
Ch 1: D Input, Ch2: V_A Ch3: V_B Ch4: R V_{CC} = 3.3V
Output Data rate: 20Mbps

图 9-4. THVD2419 Waveforms with 54 Ω Termination and V_{CC} = 3.3V



Ch 1: D Input, Ch2: V_A Ch3: V_B Ch4: R V_{CC} = 3.3V
Output Data rate: 20Mbps

图 9-5. THVD2429 Waveforms with 54 Ω Termination and V_{CC} = 3.3V



Ch 2: Input A (±200mV sine input over 1.5V DC offset)
Ch3: Input B (1.5V)
Ch 4: Output R

图 9-6. THVD2429 Receiver Waveform with ±200mV V_{ID}

9.3 Power Supply Recommendations

For reliable operation at all data rates and supply voltages, each supply should be decoupled with a 100nF 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.

9.4 Layout

9.4.1 Layout Guidelines

Additional external protection components generally are not needed when using THVD24x9 transceivers.

1. Use V_{CC}/V_{IO} 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. Apply 100nF to 220nF decoupling capacitors as close as possible to the V_{CC}/V_{IO} pins of transceiver, UART and/or controller ICs on the board.
2. Use at least two vias for V_{CC}/V_{IO} and ground connections of decoupling capacitors to minimize effective via inductance.
3. Use 1kΩ to 10kΩ pull-up and pull-down resistors for enable lines to limit noise currents in these lines during transient events.

9.4.2 Layout Example

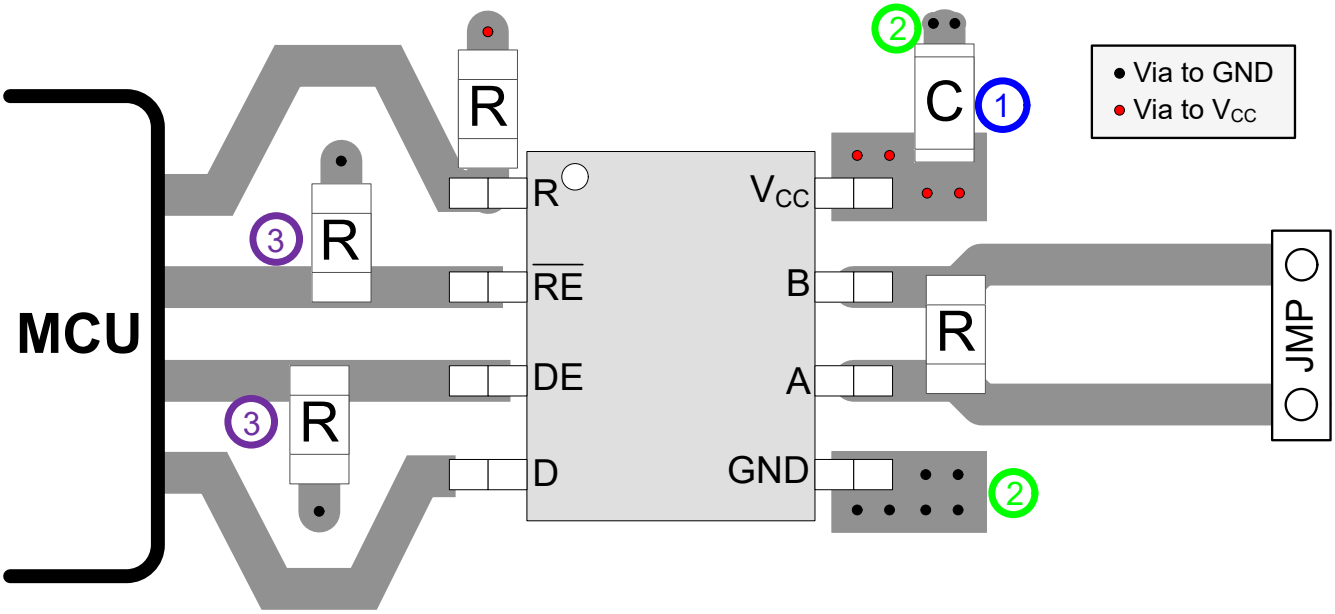


图 9-7. THVD2419, THVD2429 Layout Example (SOIC Package)

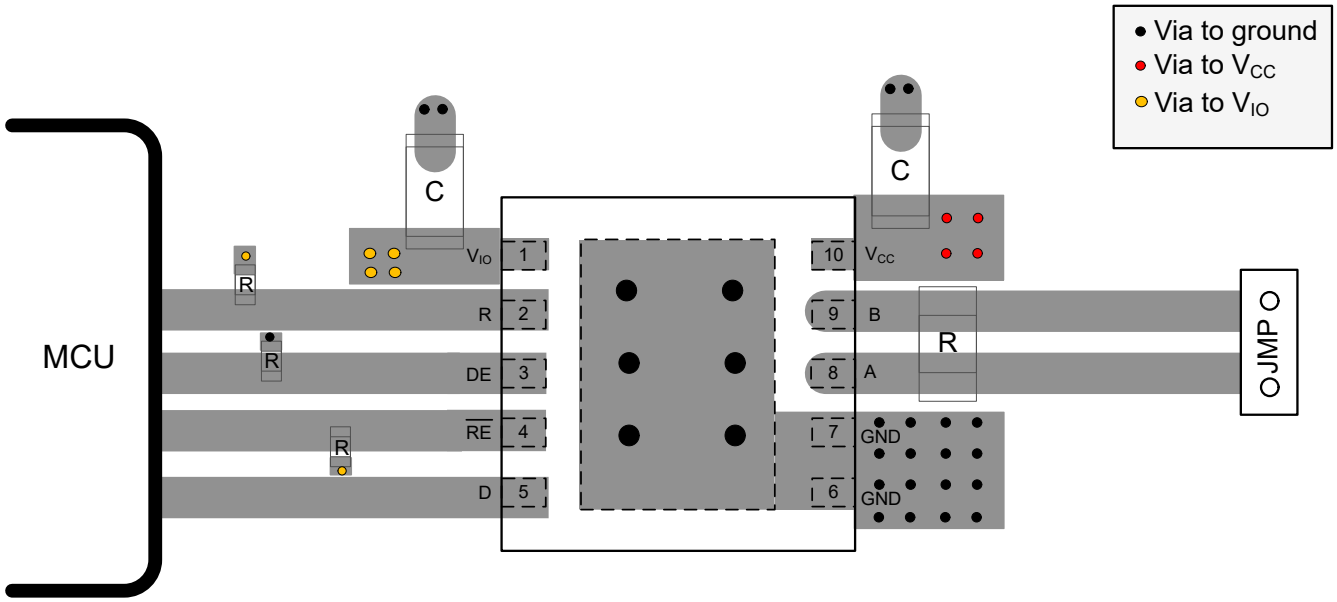


图 9-8. THVD2419, THVD2429 Layout Example (VSON Package)

10 Device and Documentation Support

10.1 Device Support

10.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*通知* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

10.3 支持资源

TI E2E™ 中文支持论坛是工程师的重要参考资料，可直接从专家处获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题，获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的使用条款。

10.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
所有商标均为其各自所有者的财产。

10.5 静电放电警告

静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

10.6 术语表

TI 术语表	本术语表列出并解释了术语、首字母缩略词和定义。

11 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision * (January 2024) to Revision A (August 2024)	Page
• 将文档从“预告信息”更改为*量产* 数据	1

12 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
THVD2419DR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2419 D2419
THVD2419DR.A	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2419 D2419
THVD2419DR.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	-	Call TI	Call TI	-40 to 125	
THVD2419DRCR	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2419
THVD2419DRCR.A	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2419
THVD2419DRCR.B	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	-	Call TI	Call TI	-40 to 125	
THVD2429DR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2429 D2429
THVD2429DR.A	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TV2429 D2429
THVD2429DR.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	-	Call TI	Call TI	-40 to 125	
THVD2429DRCR	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2429
THVD2429DRCR.A	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T2429
THVD2429DRCR.B	Active	Production	VSON (DRC) | 10	5000 | LARGE T&R	-	Call TI	Call TI	-40 to 125	

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

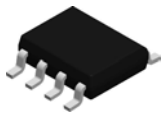
(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

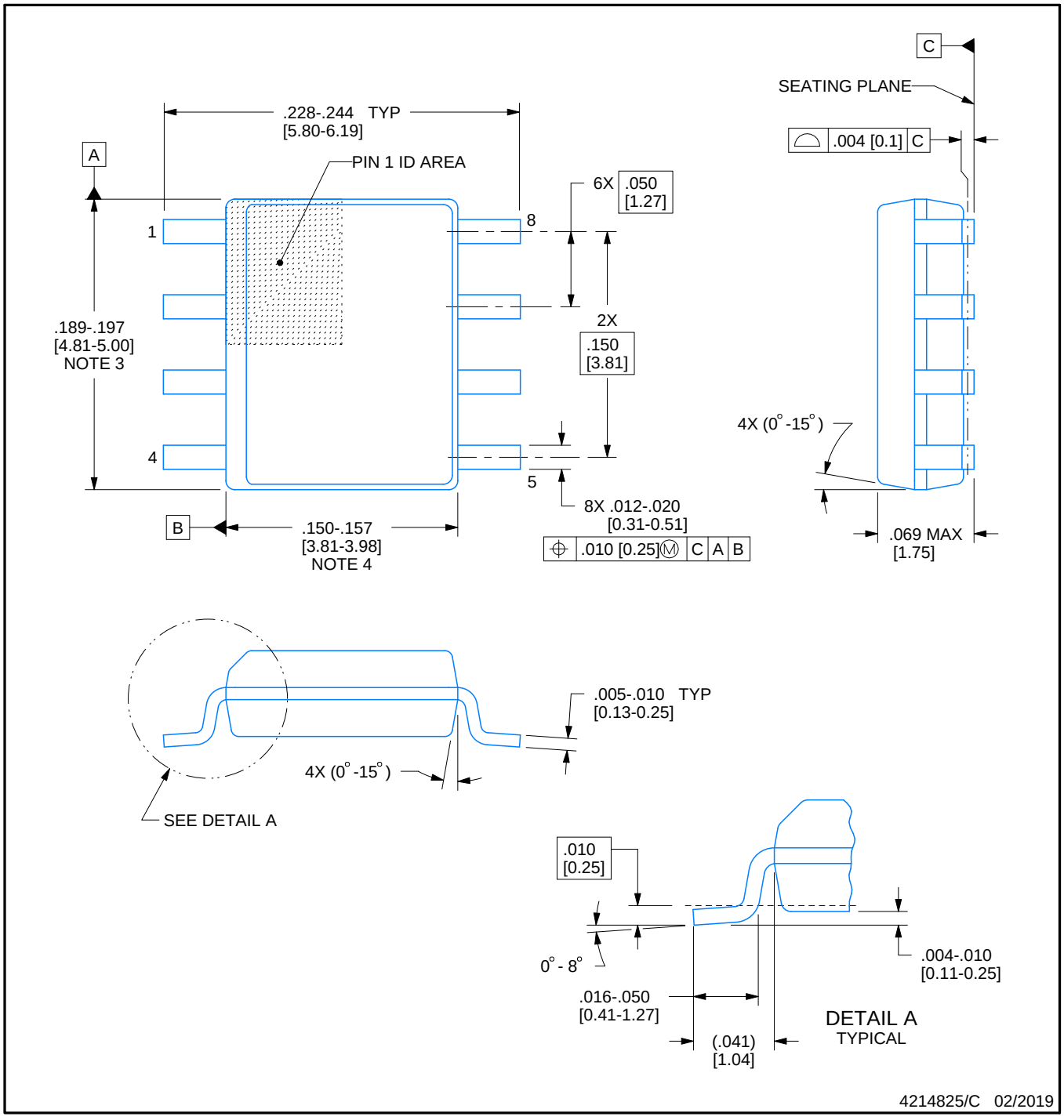


PACKAGE OUTLINE

D0008A

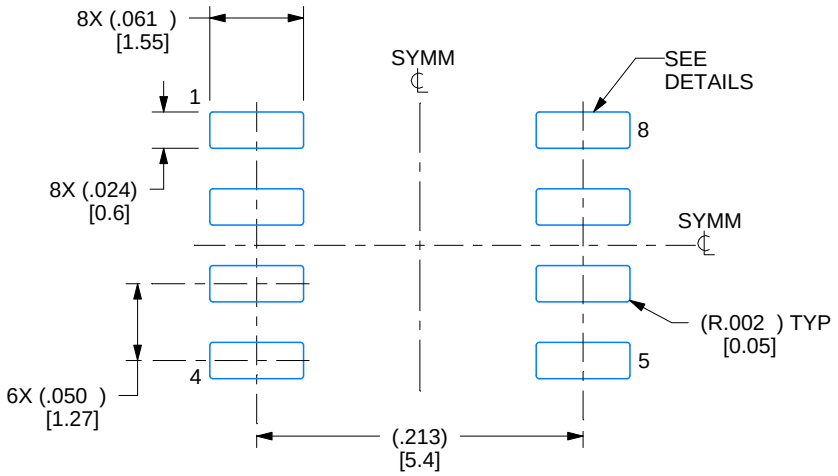
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

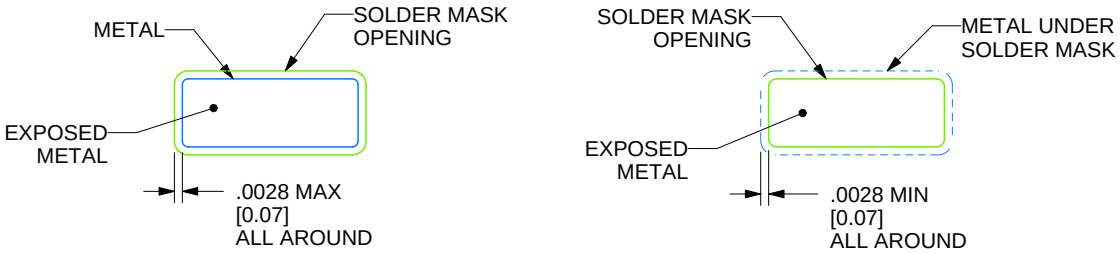


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

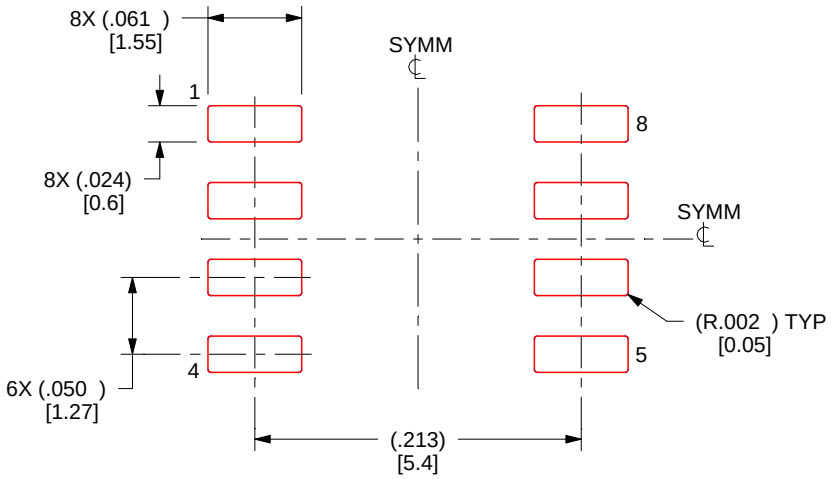
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

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.

GENERIC PACKAGE VIEW

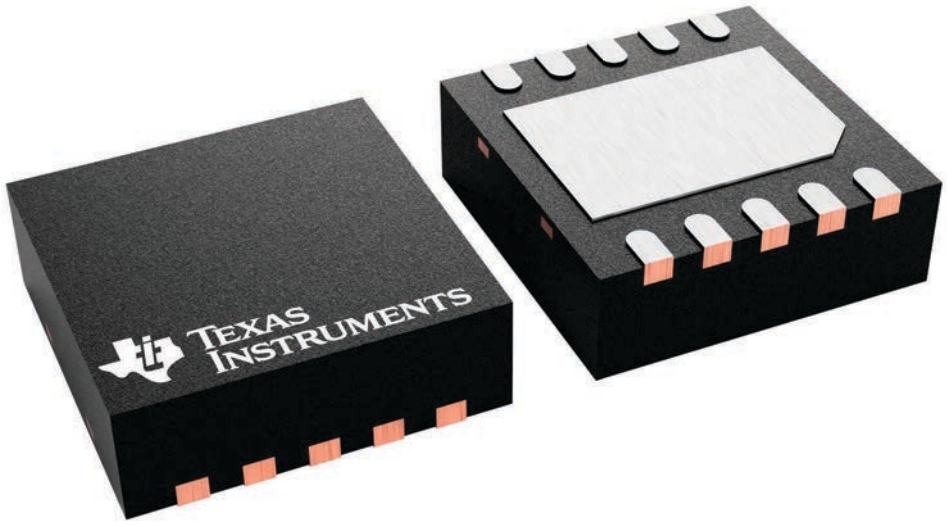
DRC 10

VSON - 1 mm max height

3 x 3, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



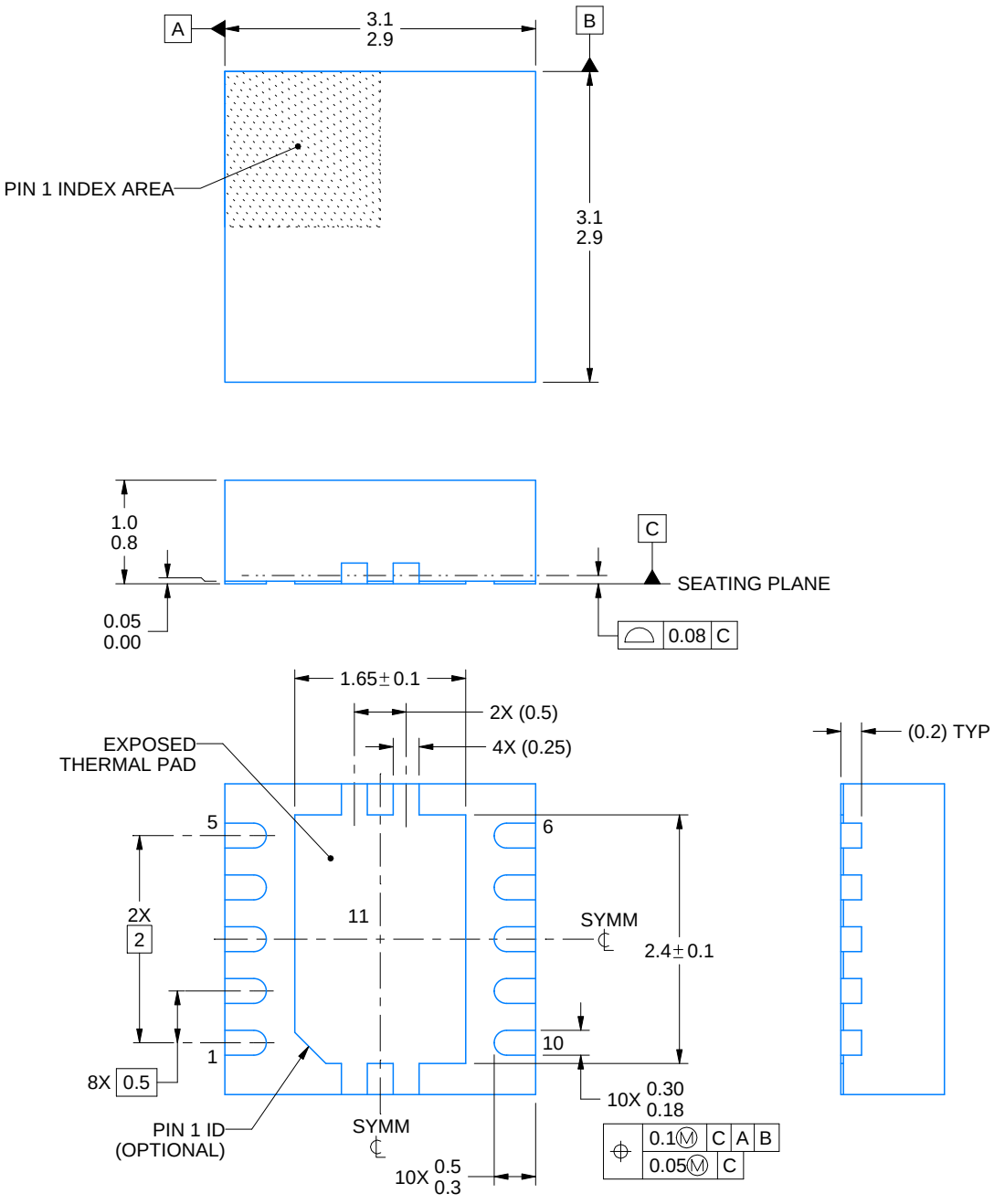
4226193/A

DRC0010J

PACKAGE OUTLINE

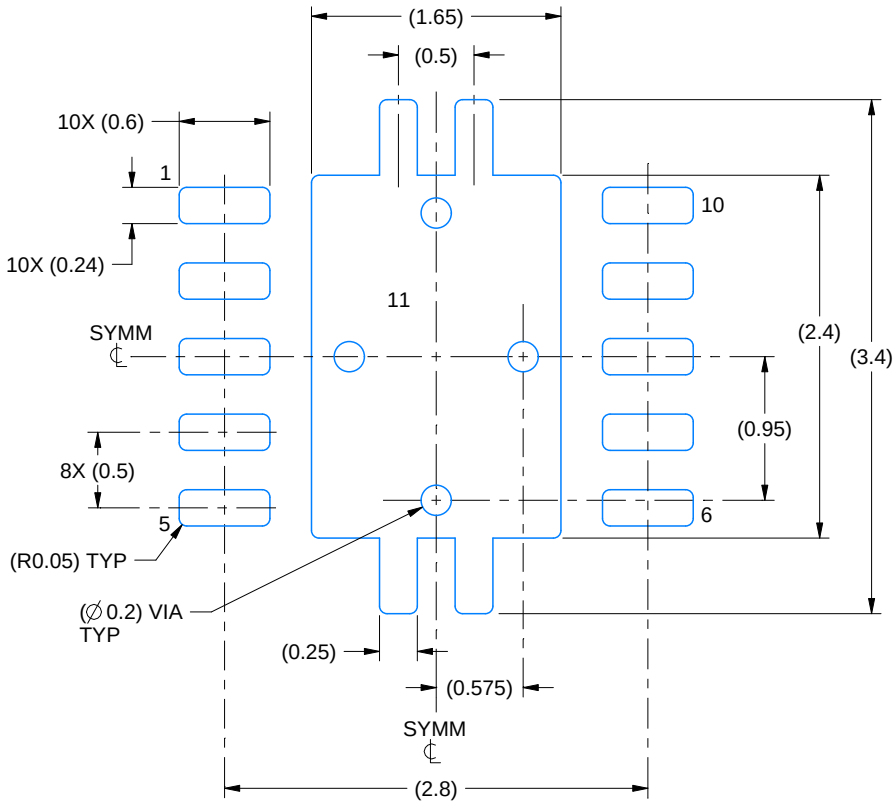
VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

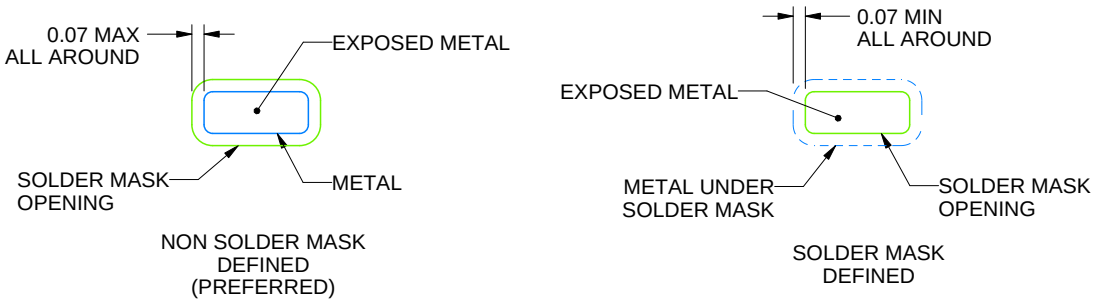


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

4218878/B 07/2018

NOTES: (continued)

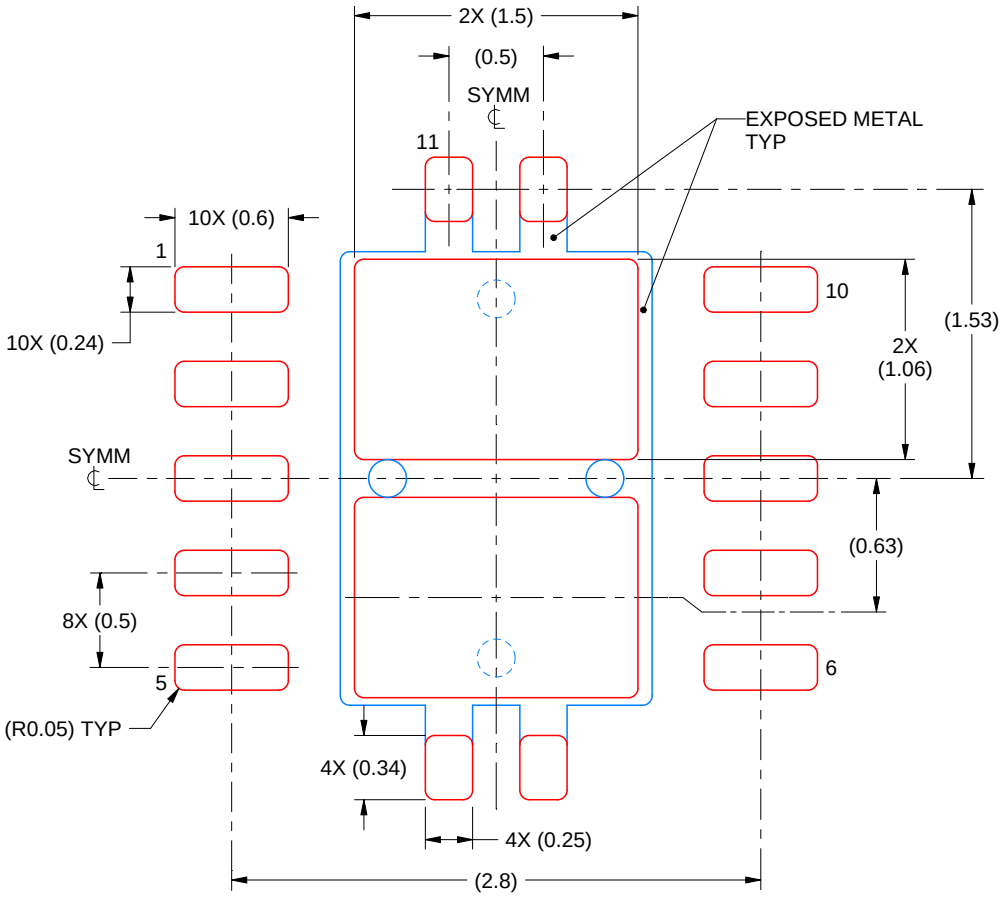
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 11:
80% PRINTED SOLDER COVERAGE BY AREA
SCALE:25X

4218878/B 07/2018

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做出任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 TI 销售条款)、TI 通用质量指南 或 ti.com 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。 除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

最后更新日期：2025 年 10 月