TEXAS INSTRUMENTS
THVD2419, THVD2429
SLLSFP5 – JANUARY 2024

THVD24x9 3V to 5.5V RS-485 Transceivers With Integrated Surge and High Bus-Fault Protection in Small Packages

1 Features

- Meets or exceeds the requirements of the TIA/EIA-485A standard
- 3V to 5.5V Supply Voltage
- Industry's smallest surge-integrated RS-485 device in 9mm^2 package
- V_{IO} Support from 1.65V to V_{CC} supply level
- Bus I/O protection
  - ± 2.5kV IEC 61000-4-5 1.2/50µs surge (SOIC)
  - ± 1.5kV IEC 61000-4-5 1.2/50µs surge (VSON)
  - ± 8kV IEC 61000-4-2 Contact discharge
  - ± 4kV IEC 61000-4-4 Electrical fast transient
  - ± 15kV HBM ESD
  - ± 42V DC bus fault
- Available in two speed grades
  - THVD2419: 250kbps
  - THVD2429: 20Mbps
- Extended ambient temperature range: -40°C to 125°C
- Extended operational common-mode range: ± 25V
- Large receiver hysteresis for noise rejection
- Low Power Consumption
  - Standby supply current: < 3µA
  - Current during operation: < 5.3mA
- Glitch-free power-up and down for hot plug-in capability
- Open, short, and idle bus failsafe
- 1/8 Unit load (up to 256 bus nodes)
- Industry standard 8-pin SOIC for drop-in compatibility
- Small surge-integrated RS-485 device in 3mm x 3mm leadless (VSON) package

2 Applications

- Wireless infrastructure
- Factory automation
- Motor drives
- Building automation
- HVAC
- Grid infrastructure

3 Description

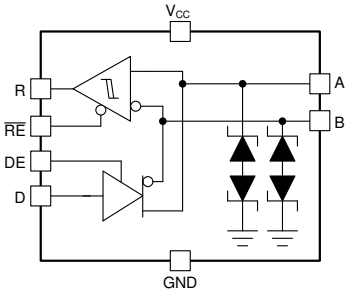
THVD24x9 devices are half-duplex RS-485 transceivers with integrated surge protection. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package as well as small 10-pin VSON package. This feature increases the reliability by providing better immunity to noise transients coupled to the data cable which eliminates the need for external protection components.

THVD24x9 devices in the standard pin-out SOIC package operate from a single 3.3V or 5V supply. In addition, THVD24x9 devices in 10-pin VSON package and the V-versions of SOIC package support an additional V_{IO} supply to operate the IOs from as low as 1.65V supply level. The devices in this family feature a wide common-mode voltage range making them suitable for multi-point applications over long cable runs.

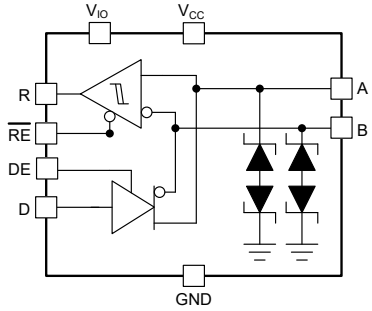
Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
THVD2419, '2429 THVD2419V, '2429V	SOIC (8)	4.9mm × 6mm
THVD2419, '2429	VSON (10)	3mm × 3mm

(1) For more information, see Section 12.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



THVD24x9 Block Diagram (SOIC Package)



THVD24x9 Block Diagram (VSON Package)

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4 Device Comparison Table

PART NUMBER	Package	V_{IO}	SIGNALING RATE	NODES
THVD2419	SOIC-8	No	up to 250kbps	256
THVD2419V		Yes		
THVD2429		No	up to 20Mbps	
THVD2429V		Yes		
THVD2419	VSON-10	Yes	up to 250kbps	
THVD2429			up to 20Mbps	

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5 Pin Configuration and Functions

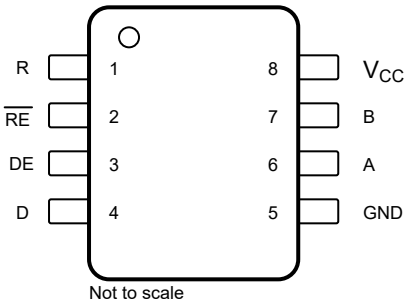

Figure 5-1. THVD2419, THVD2429, 8-Pin (SOIC) (Top View)

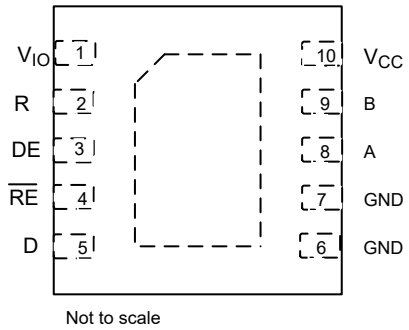

Figure 5-2. THVD2419, THVD2429, 10-Pin (VSON) (Top View)

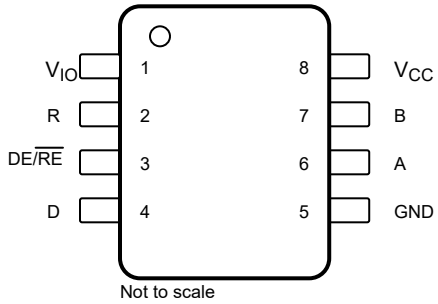

Figure 5-3. THVD2419V, THVD2429V, 8-pin (SOIC) (Top View)

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

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6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Logic supply voltage	$V_{IO\ (DRC\ package\ Only)}$	–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 or $\overline{RE}$) Versions with VIO pin	–0.3	V_{IO} + 0.2	V
Input voltage	Range at any logic pin (D, DE or $\overline{RE}$) D Package	–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]

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge, bus terminals	Contact discharge, per IEC 61000-4-2	Bus terminals and GND	±8,000	V
		Air-gap discharge, per IEC 61000-4-2	Bus terminals and GND	±8,000	
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20 µs CWG (DRC Package)	Bus terminals and GND	±1,500	V
$V_{(SURGE)}$	Surge	Per IEC 61000-4-5, 1.2/50-8/20 µs CWG (D Package)	Bus terminals and GND	±2,500	V

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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 (DRC Package)		1.65		V_{CC}	V
V_{IH}	High-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)	DRC Package, D package with VIO option	0.7*V_{IO}		V_{IO}	V
V_{IL}	Low-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)	DRC Package, D package with VIO option	0		0.3*V_{IO}	V
V_{IH}	High-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)	D Package without VIO option	0.7*V_{CC}		V_{CC}	V
V_{IL}	Low-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)	D Package without VIO option	0		0.3*VCC	V
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)	–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 = 300Ω, C_L = 50pF (driver)	THVD2419	250 kbps	258	mW
			THVD2429	20Mbps	335	
		RS-422 load R_L = 100Ω, C_L = 50pF (driver)	THVD2419	250 kbps	273	mW
			THVD2429	20Mbps	325	
		RS-485 load R_L = 54Ω, C_L = 50pF (driver)	THVD2419	250 kbps	315	mW
			THVD2429	20Mbps	355	

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 = 60Ω, –25V ≤ V_{test} ≤ 25V (See Figure 7-1)		1.5	2.8		V
		R_L = 60Ω, –25V ≤ V_{test} ≤ 25V, 4.5V ≤ V_{CC} ≤ 5.5V (See Figure 7-1)		2.1	3.3		V
		R_L = 100Ω (See Figure 7-2)		2	2.9		V
		R_L = 54Ω (See Figure 7-2)		1.5	2.5		V
$\Delta\|V_{OD}\|$	Change in differential output voltage	R_L = 54Ω or 100Ω (See Figure 7-2)		–50		50	mV
V_{OC}	Common-mode output voltage	R_L = 54Ω or 100Ω (See Figure 7-2)		1	V_{CC}/2	3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage	R_L = 54Ω or 100Ω (See Figure 7-2)		–50		50	mV
I_{OS}	Short-circuit output current	DE = V_{IO}, -42V ≤ (V_A or V_B) ≤ 42V, or A shorted to B		–250		250	mA
Receiver							
I_I	Bus input current	DE = 0 V, V_{CC} and V_{IO} = 0 V or 5.5 V	V_I = 12 V		75	125	µA
			V_I = 25 V		200	250	µA
			V_I = –7 V	–100	–60		µA
			V_I = –25 V	–350	–300		µA
V_{TH+}	Positive-going input threshold voltage(1)	Over common-mode range of ± 25 V		40	125	200	mV
V_{TH-}	Negative-going input threshold voltage(1)			–200	–125	-40	mV
V_{HYS}	Input hysteresis				250		mV
V_{TH_FSH}	Input fail-safe threshold			–40		40	mV
$C_{A,B}$	Input differential capacitance	Measured between A and B, f = 1 MHz			50		pF
V_{OH}	Output high voltage	I_{OH} = –8 mA, V_{IO} = 3 to 3.6 V or 4.5 V to 5.5 V		V_{IO} – 0.4	V_{IO} – 0.2		V
V_{OL}	Output low voltage	I_{OL} = 8 mA, V_{IO} = 3 to 3.6 V or 4.5 V to 5.5 V			0.2	0.4	V
V_{OH}	Output high voltage	I_{OH} = –4 mA, V_{IO} = 1.65 to 1.95 V or 2.25 V to 2.75 V		V_{IO} – 0.4	V_{IO} – 0.2		V
V_{OL}	Output low voltage	I_{OL} = 4 mA, V_{IO} = 1.65 to 1.95 V or 2.25 V to 2.75 V			0.2	0.4	V
I_{OZ}	Output high-impedance current, R pin	V_O = 0 V or V_{IO}, $\overline{RE}$ = V_{IO}		–1		1	µA
Logic							
I_{IN}	Input current (DE , SLR)	DRC: 1.65 V ≤ V_{IO} ≤ 5.5 V, 0 V ≤ V_{IN} ≤ V_{IO} D: 3 V ≤ V_{CC} ≤ 5.5 V, 0 V ≤ V_{IN} ≤ 5.5 V				5	µA
I_{IN}	Input current (D, $\overline{RE}$)	DRC: 1.65 V ≤ V_{IO} ≤ 5.5 V, 0 V ≤ V_{IN} ≤ V_{IO} D: 3 V ≤ V_{CC} ≤ 5.5 V, 0 V ≤ V_{IN} ≤ 5.5 V		–5			µA
Thermal Protection							
T_{SHDN}	Thermal shutdown threshold	Temperature rising		150	170		°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}				170		mV
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

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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
$UV_{VIO(hys)}$	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	$\overline{RE}$ = 0 V, DE = V_{IO}, No load		3.5	5.3	mA
		Driver enabled, receiver disabled	$\overline{RE}$ = V_{IO}, DE = V_{IO}, No load		2.5	4.2	mA
		Driver disabled, receiver enabled	$\overline{RE}$ = 0 V, DE = 0 V, No load		1.8	2.4	mA
		Driver and receiver disabled (D package, no VIO pin)	$\overline{RE}$ = V_{CC}, DE = 0 V, D = open, No load		0.1	5	µA
		Driver and receiver disabled (DRC paclkage, with VIO pin)	$\overline{RE}$ = V_{IO}, DE = 0 V, 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	$\overline{RE}$ = 0 V, DE = V_{IO}, No load		3	4.1	mA
		Driver enabled, receiver disabled	$\overline{RE}$ = V_{IO}, DE = V_{IO}, No load		2	3	mA
		Driver disabled, receiver enabled	$\overline{RE}$ = 0 V, DE = 0 V, No load		1.6	2.2	mA
		Driver and receiver disabled (D Package, no VIO)	$\overline{RE}$ = V_{CC}, DE = 0 V, D = open, No load		TBD	4	µA
		Driver and receiver disabled (DRC package, with VIO pin)	$\overline{RE}$ = V_{IO}, DE = 0 V, D = open, No load		TBD	2	µA
I_{IO}	Logic supply current (quiescent), V_{IO} = 3 to 3.6 V, DRC Package	Driver disabled, Receiver enabled	DE = 0 V, $\overline{RE}$ = 0 V, No load		3.3	8.4	µA
		Driver disabled, Receiver disabled	DE = 0 V, $\overline{RE}$ = V_{IO}, No load		0.1	2	µA

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

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6.8 Switching Characteristics_250kbps

250-kbps (THVD2419) 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 = 50 pF See Figure 7-3	V_{CC} = 3 to 3.6 V, Typical at 3.3V	400	650	1200	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V	500	710	1200	ns
t_{PHL}, t_{PLH}	Propagation delay		V_{CC} = 3 to 3.6 V, Typical at 3.3V		525	750	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V		560	770	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$		V_{CC} = 3 to 3.6 V, Typical at 3.3V		30	70	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V		30	70	ns
t_{PHZ}, t_{PLZ}	Disable time	$\overline{RE}$ = X	See Figure 7-4 and Figure 7-5		33	75	ns
t_{PZH}, t_{PZL}	Enable time	$\overline{RE}$ = 0 V			TBD	280	ns
		$\overline{RE}$ = V_{IO}			2	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 Figure 7-6		13	20	ns
t_{PHL}, t_{PLH}	Propagation delay				850	1270	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$				5	45	ns
t_{PHZ}, t_{PLZ}	Disable time	DE = X			30	40	ns
$t_{PZH(1)}$	Enable time	V_{IO} = 3 V to 3.6 V; DE = V_{IO}	See Figure 7-7		90	120	ns
		V_{IO} = 1.65 V to 1.95 V, DE = V_{IO}			TBD	130	ns
$t_{PZL(1)}$		V_{IO} = 3 V to 3.6 V; DE = V_{IO}			900	1320	ns
		V_{IO} = 1.65 V to 1.95 V; DE = V_{IO}			TBD	1320	ns
$t_{PZH(2)}$, $t_{PZL(2)}$	Enable time	DE = 0 V	See Figure 7-8		3.3	5.4	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	C_L = 15 pF	See Figure 7-9	7	11	18	µs
$t_{D(FSO)}$	Delay to exit fail-safe operation			540	850	1260	ns
t_{SHDN}	Time to shutdown	DE = 0 V	See Figure 7-8	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

20-Mbps (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 = 50 pF See Figure 7-3	V_{CC} = 3 to 3.6 V, Typical at 3.3 V	4	8	15	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V	4	TBD	15	ns
t_{PHL}, t_{PLH}	Propagation delay		V_{CC} = 3 to 3.6 V, Typical at 3.3 V	6	15	30	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V	6	TBD	26	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$		V_{CC} = 3 to 3.6 V, Typical at 3.3 V		TBD	3	ns
			V_{CC} = 4.5 to 5.5 V, Typical at 5 V		TBD	3	ns

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20-Mbps (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_{PHZ}, t_{PLZ}	Disable time	$\overline{RE}$ = X	See Figure 7-4 and Figure 7-5		15	35	ns
t_{PZH}, t_{PZL}	Enable time	$\overline{RE}$ = 0 V			8	39	ns
		$\overline{RE}$ = V_{IO}			2	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 Figure 7-6		1.5	6	ns
t_{PHL}, t_{PLH}	Propagation delay	V_{IO} = 3 V to 3.6 V,		TBD	40	57	ns
		V_{IO} = 1.65 V to 1.95 V,		TBD	TBD	60	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL} - t_{PLH} \rvert$	C_L = 15 pF				5.5	ns
t_{PHZ}, t_{PLZ}	Disable time	DE = X			11	22	ns
$t_{PZH(1)}$, $t_{PZL(1)}$	Enable time	DE = V_{IO}	See Figure 7-7		55	82	ns
$t_{PZH(2)}$, $t_{PZL(2)}$	Enable time	DE = 0 V	See Figure 7-8		1.5	4.5	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	C_L = 15 pF	See Figure 7-9	7	11	18	µs
$t_{D(FSO)}$	Delay to exit fail-safe operation			19	25	50	ns
t_{SHDN}	Time to shutdown	DE = 0 V	See Figure 7-8	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

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7 Parameter Measurement Information

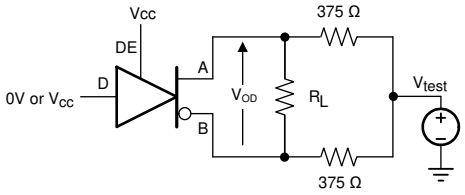


Figure 7-1. Measurement of Driver Differential Output Voltage With Common-Mode Load

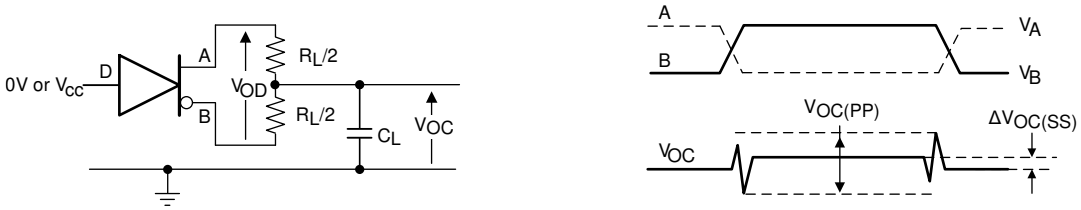


Figure 7-2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

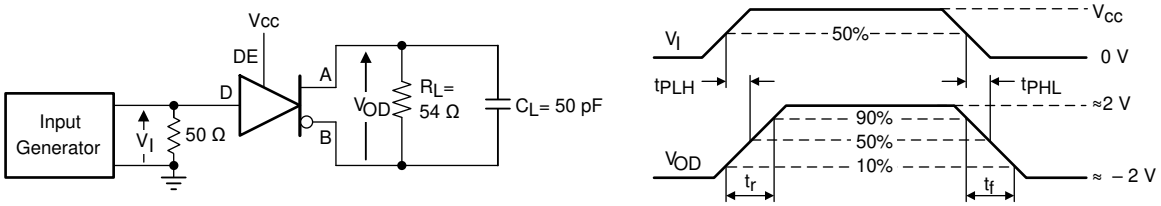


Figure 7-3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

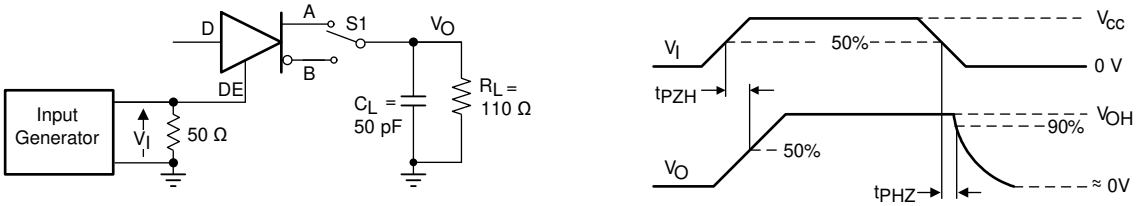


Figure 7-4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

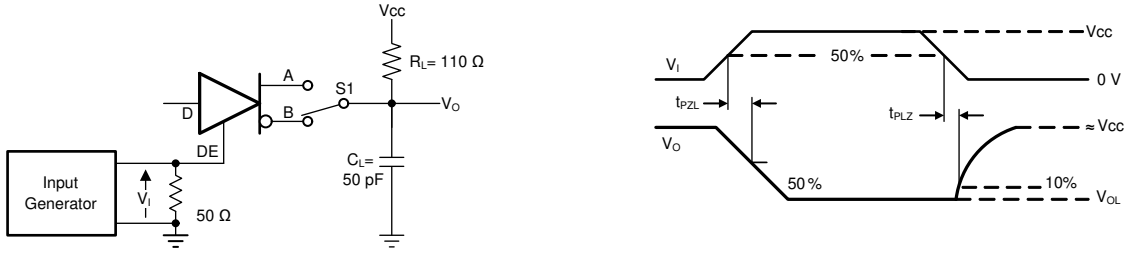


Figure 7-5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

ADVANCE INFORMATION

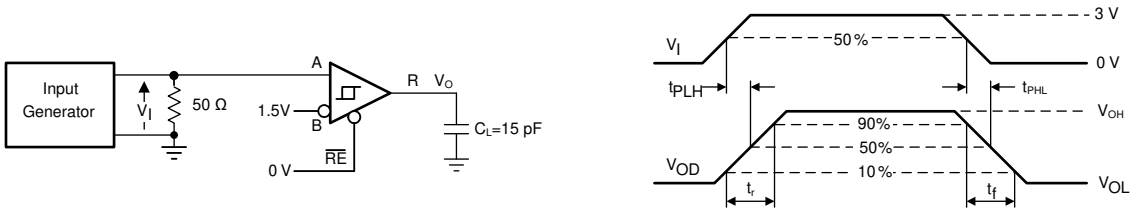


Figure 7-6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

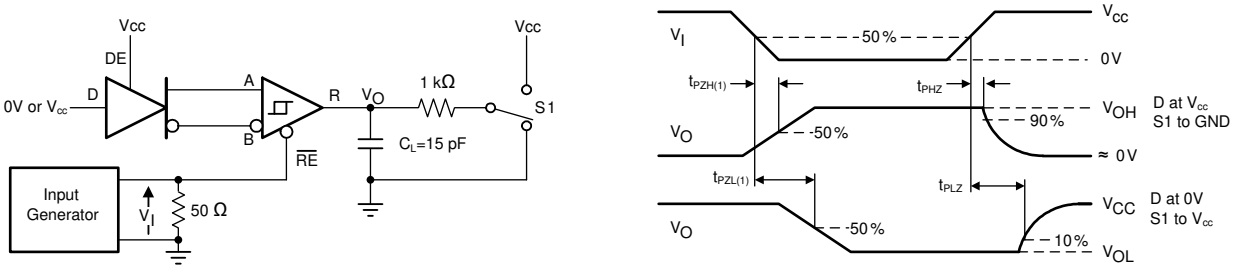


Figure 7-7. Measurement of Receiver Enable/Disable Times With Driver Enabled

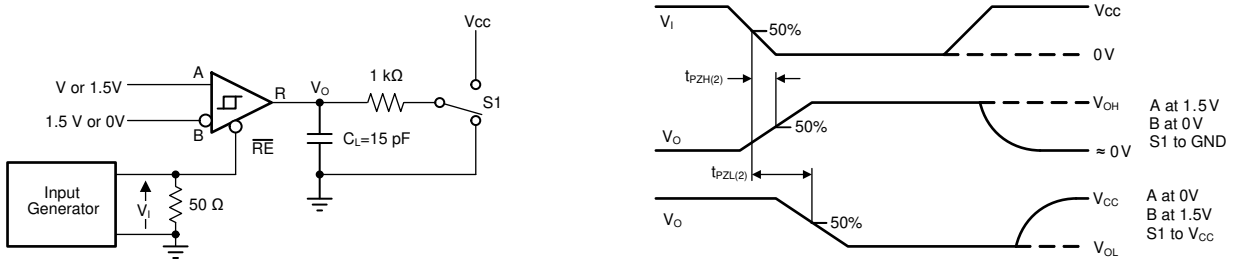


Figure 7-8. Measurement of Receiver Enable Times With Driver Disabled

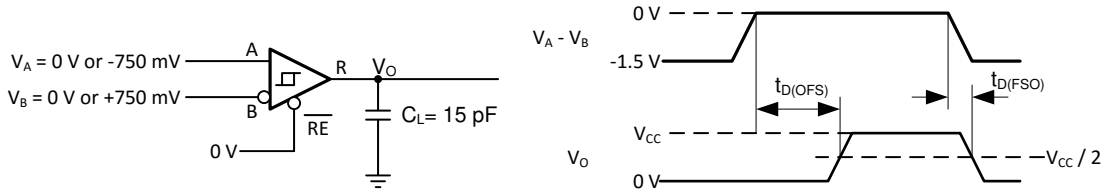


Figure 7-9. Fail-Safe Delay Measurements

ADVANCE INFORMATION

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 12Mbps 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. THVD2419V and THVD2429V devices in the SOIC package have a single enable/disable pin (DE/$\overline{RE}$) that either enables the driver or the receiver at a time.

8.2 Functional Block Diagrams

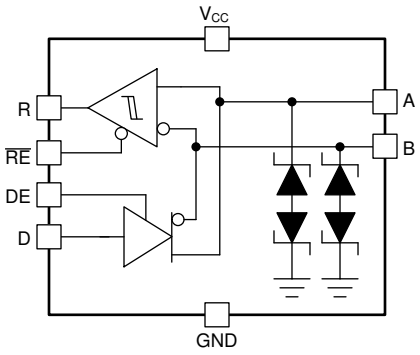


Figure 8-1. THVD2419 and THVD2429 Block Diagram (SOIC Package)

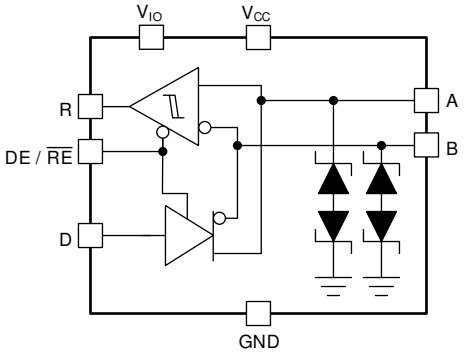


Figure 8-2. THVD2419V and THVD2429V Block Diagram (SOIC Package with VIO pin)

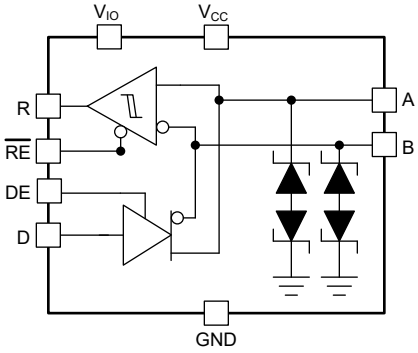


Figure 8-3. THVD2419 and THVD2429 Block Diagram (VSON Package)

ADVANCE INFORMATION

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.

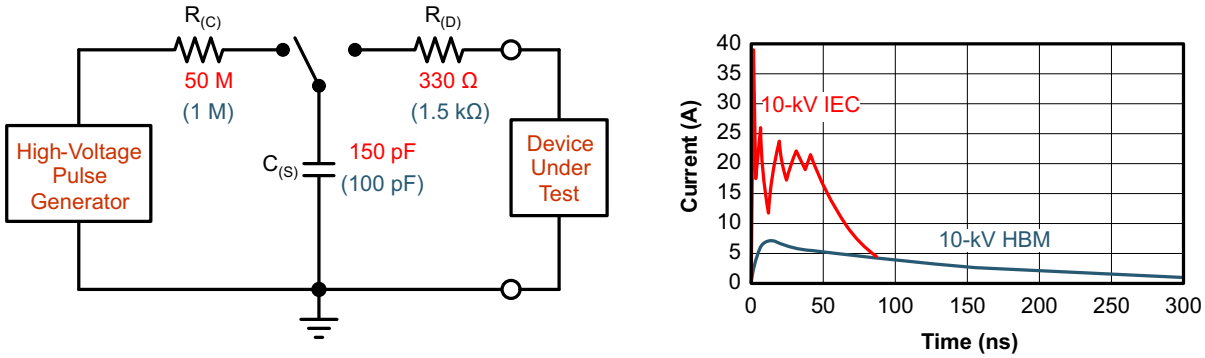


Figure 8-4. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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. Figure 8-5 shows the voltage waveforms in to 50Ω termination as defined by the IEC standard.

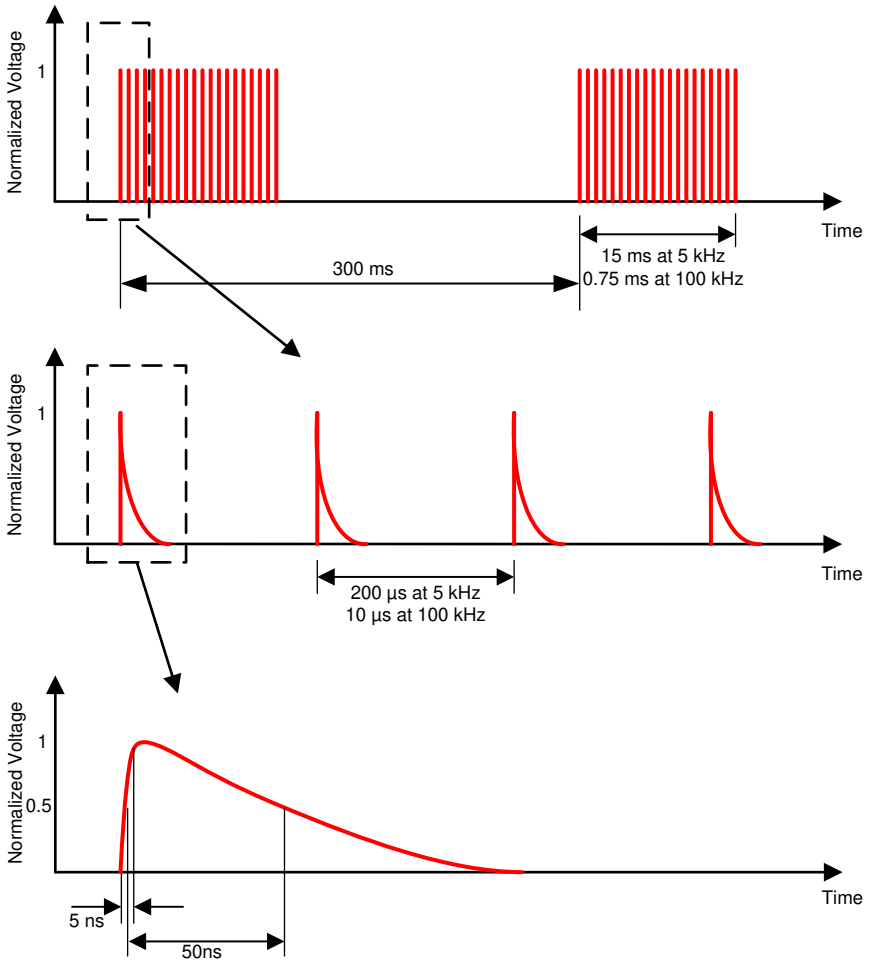


Figure 8-5. EFT Voltage Waveforms

Internal ESD protection circuits of the THVD24x9(V) 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.

Figure 8-6 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.

ADVANCE INFORMATION

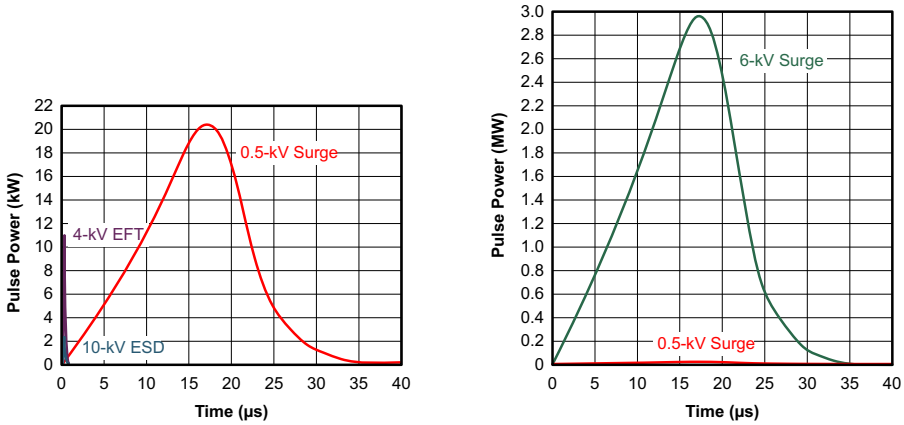


Figure 8-6. Power Comparison of ESD, EFT, and Surge Transients

Figure 8-7 shows the test setup used to validate THVD24x9 surge performance according to the IEC 61000-4-5 1.2/50µs surge pulse.

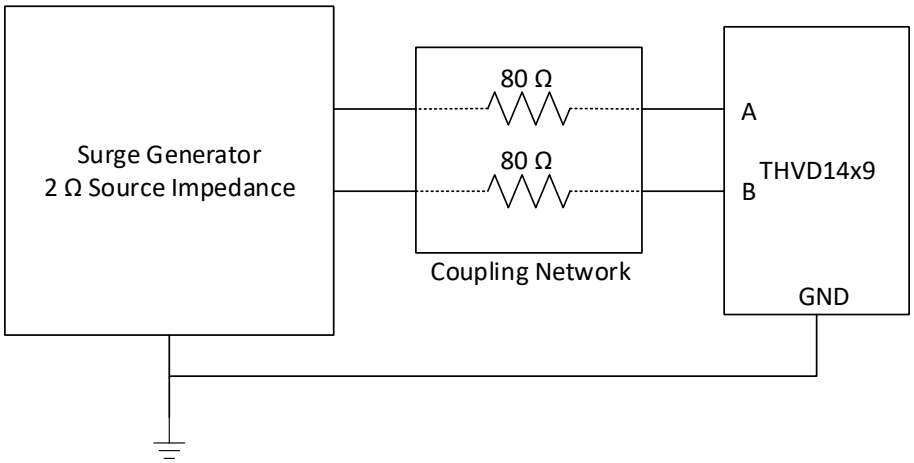


Figure 8-7. THVD24x9 Surge Test Setup

THVD24x9 product family is robust up to ±2.5kV 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(V) 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 $|V_{TH\_FSH}|$.

ADVANCE INFORMATION

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.

Table 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).

Table 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

ADVANCE INFORMATION

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, 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.

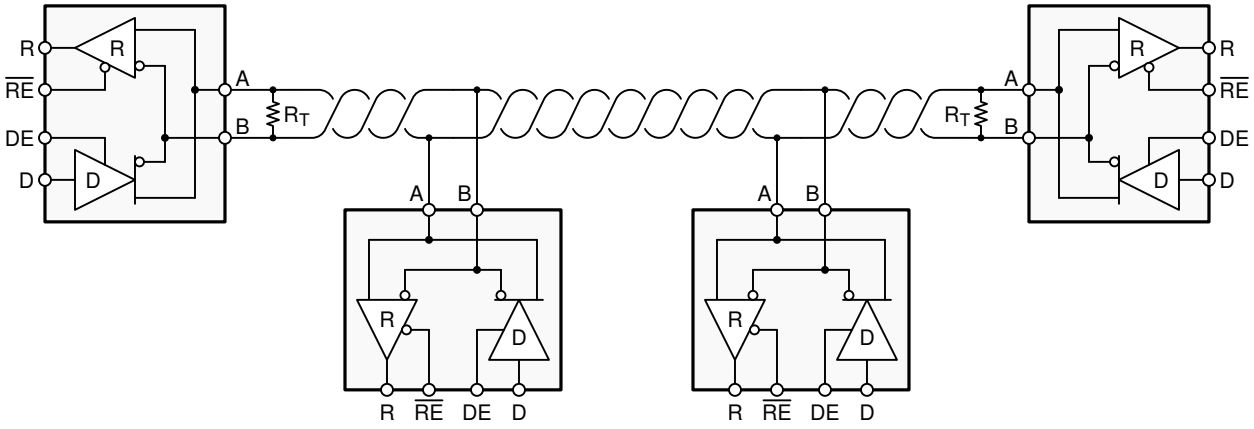


Figure 9-1. Typical RS-485 Network With Half-Duplex Transceivers

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%.

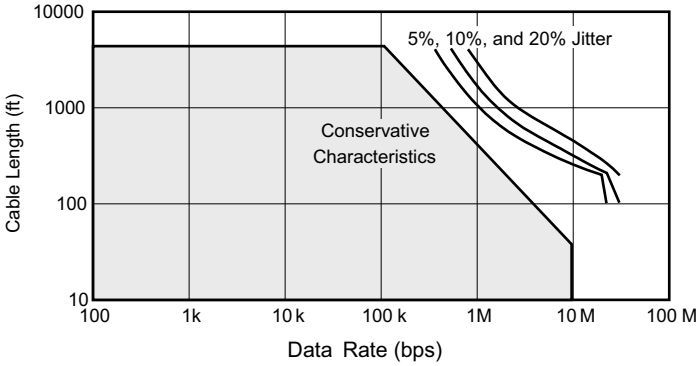


Figure 9-2. Cable Length vs Data Rate Characteristic

Even higher data rates are achievable (that is, 12Mbps for the THVD2429(V)) 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 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 12kΩ. Because the THVD24x9(V) devices consist of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible.

ADVANCE INFORMATION

9.2.2 Detailed Design Procedure

RS-485 transceivers operate in noisy industrial environments typically require surge protection at the bus pins. Figure 9-3 compares 4kV surge protection implementation with a regular RS-485 transceiver (such as THVD14x0) against with the THVD24x9(V). The internal TVS protection of the THVD24x9(V) achieves ±2.5kV IEC 61000-4-5 surge protection (SOIC package) without any additional external components, reducing system level bill of materials.

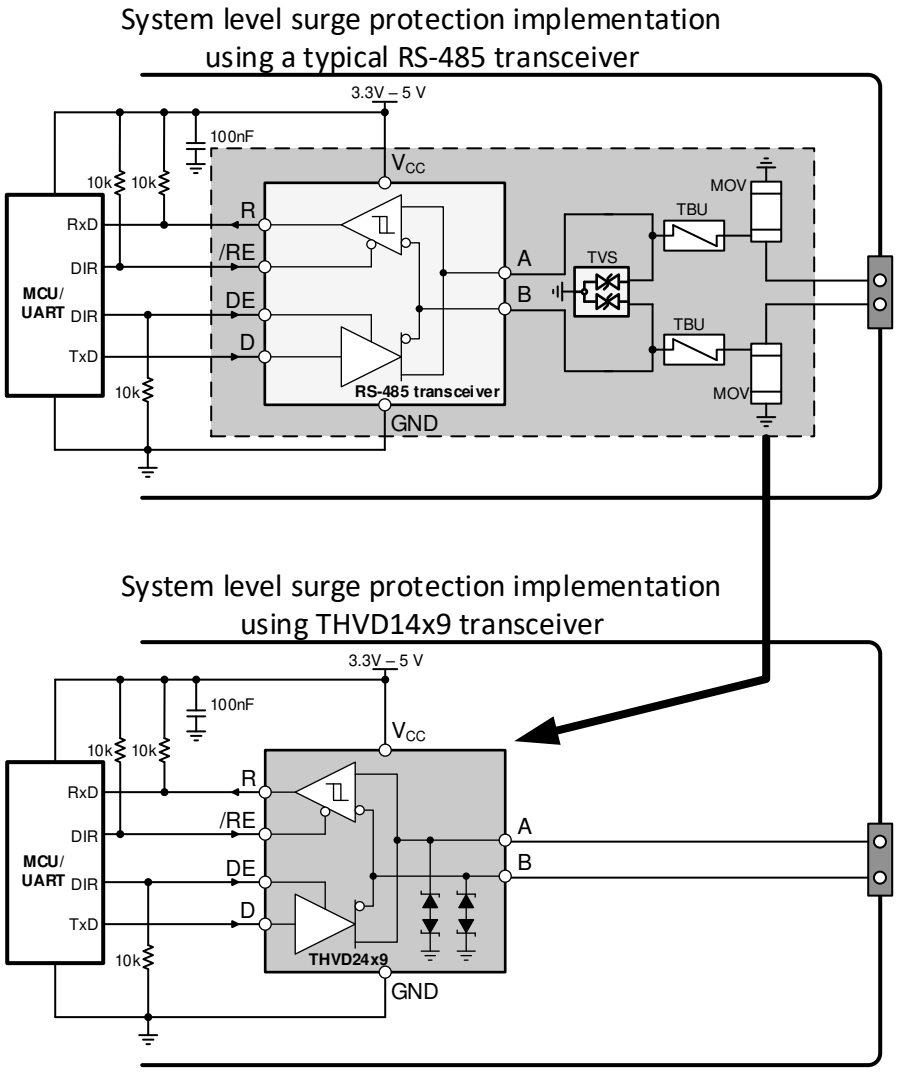
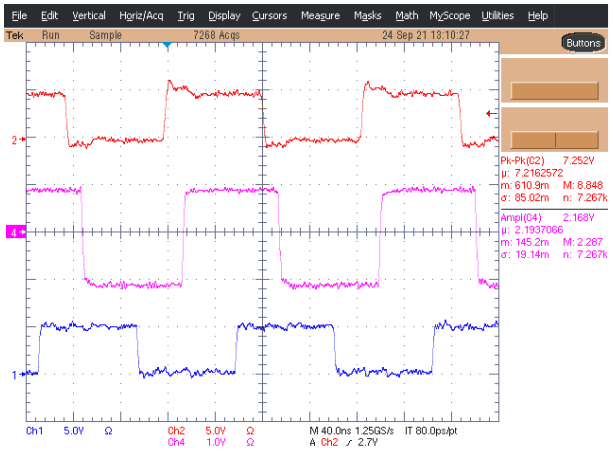


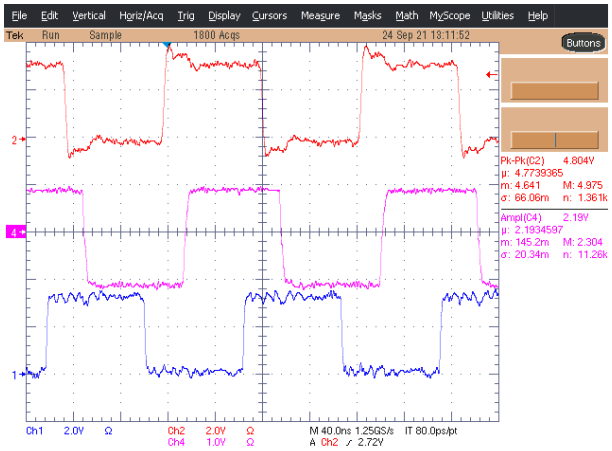
Figure 9-3. Implementation of System-Level Surge Protection Using THVD24x9(V)

9.2.3 Application Curves



Ch 2: D Input, Ch4: V_{OD} VCC = 5V Data rate: 12Mbps
Ch1: R Output

Figure 9-4. THVD2429 Waveforms with 54Ω Termination and V_{CC} = 5V



Ch 2: D Input, Ch4: V_{AB} V_{CC} = 3.3V Data rate: 12Mbps
Ch1: R Output

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

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.

ADVANCE INFORMATION

9.4 Layout

9.4.1 Layout Guidelines

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

1. 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. Apply 100nF to 220nF decoupling capacitors as close as possible to the V_{CC} pins of transceiver, UART and/or controller ICs on the board.
2. Use at least two vias for V_{CC} 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

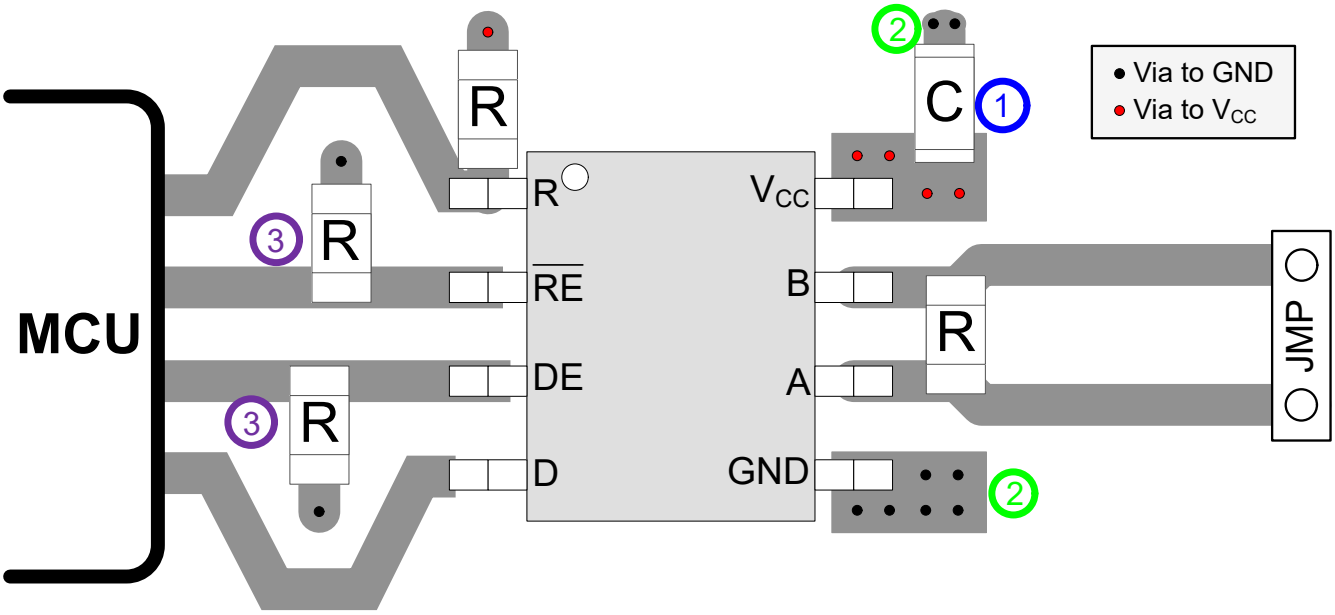


Figure 9-6. THVD2419, THVD2429 Layout Example (SOIC Package)

ADVANCE INFORMATION

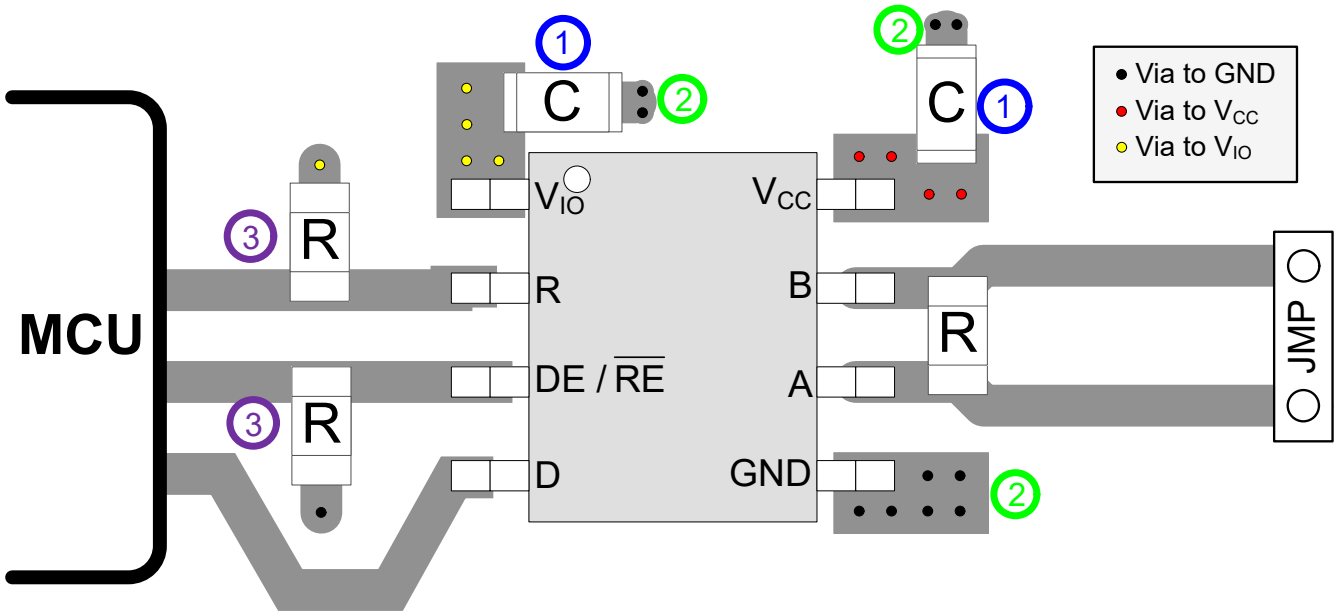


Figure 9-7. THVD2419V THVD2429V Layout Example (SOIC Package with VIO pin)

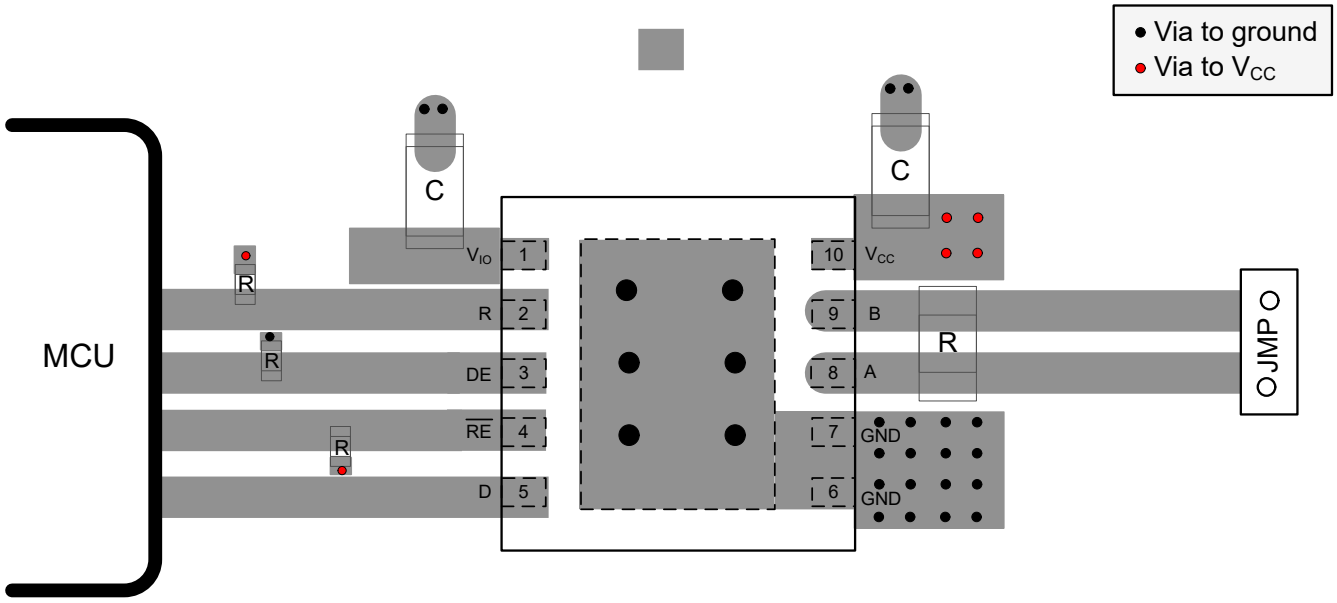


Figure 9-8. THVD2419, THVD2429 Layout Example (VSON Package)

ADVANCE INFORMATION

10 Device and Documentation Support

10.1 Device Support

10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

10.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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.

10.4 Trademarks

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

10.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

10.6 Glossary

TI Glossary — This glossary lists and explains terms, acronyms, and definitions.

11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
January 2024	*	Initial Release

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.

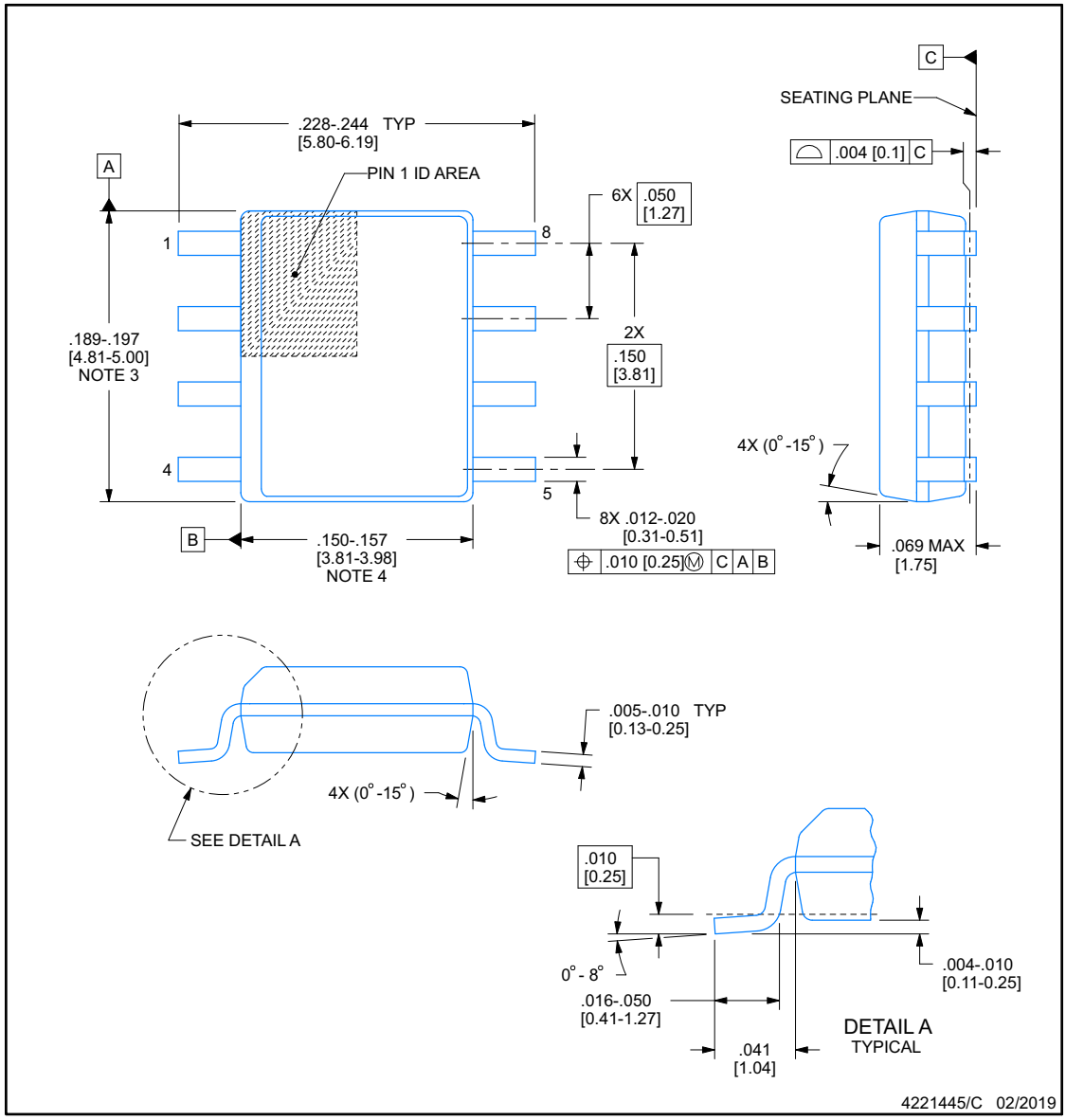
ADVANCE INFORMATION

PACKAGE OUTLINE

D0008B

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.

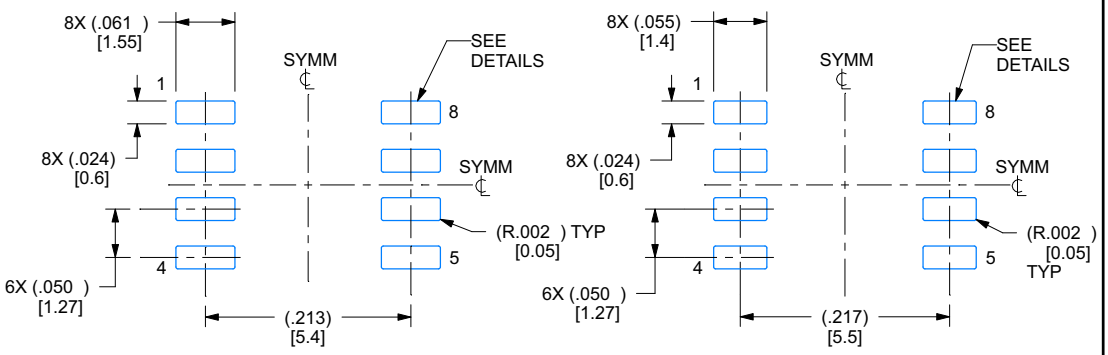
ADVANCE INFORMATION

EXAMPLE BOARD LAYOUT

D0008B

SOIC - 1.75 mm max height

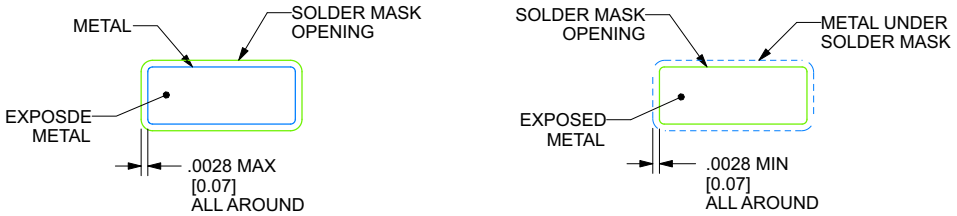
SMALL OUTLINE INTEGRATED CIRCUIT



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

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

LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:6X



NON SOLDER MASK
DEFINED

SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4221445/C 02/2019

NOTES: (continued)

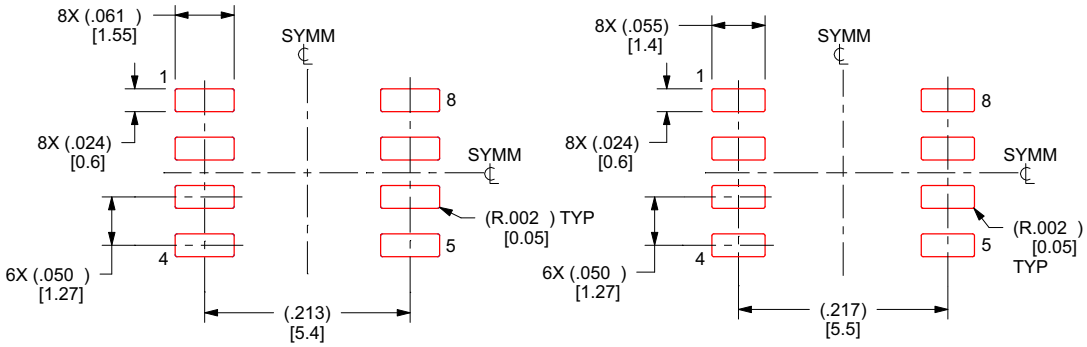
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008B

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



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

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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.

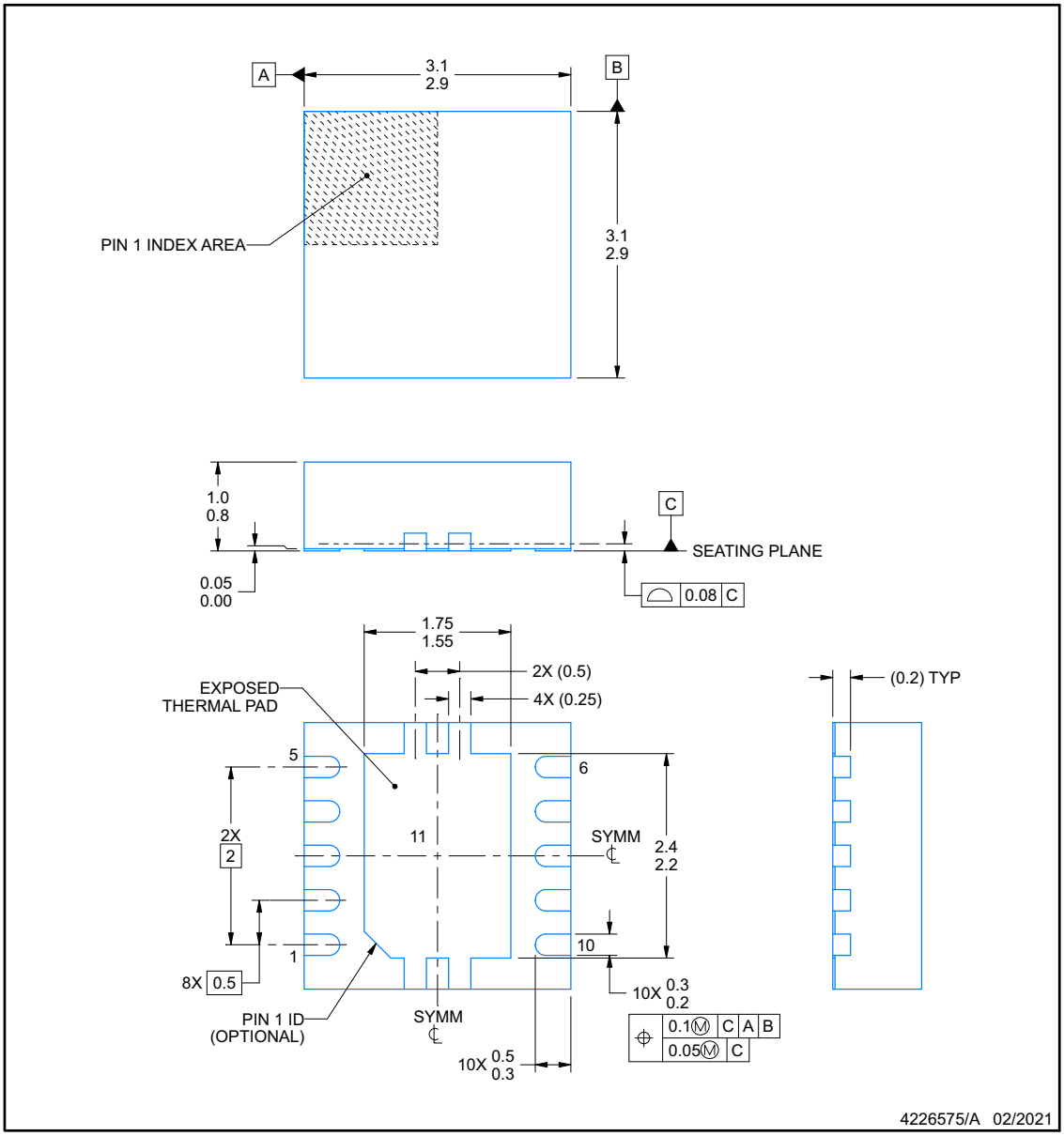
ADVANCE INFORMATION

PACKAGE OUTLINE

DRC0010V

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



NOTES:

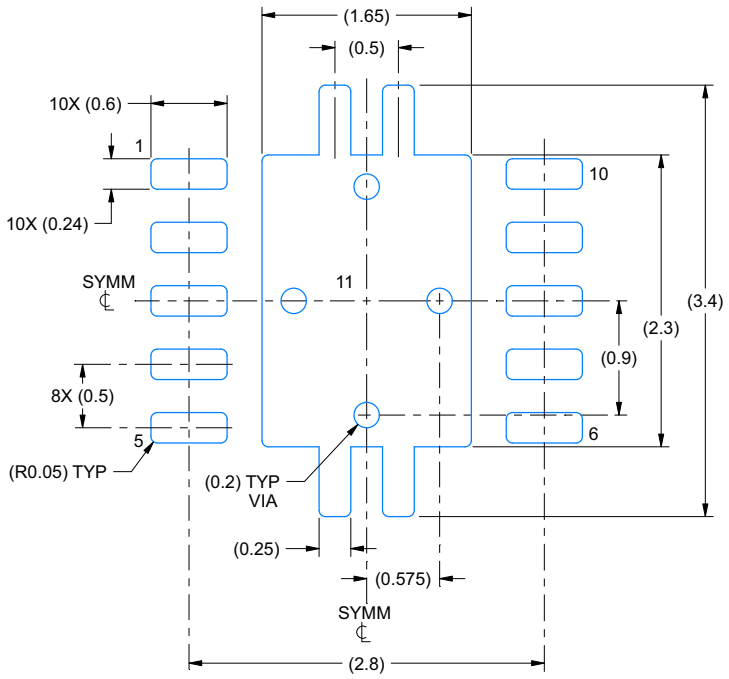
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical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

EXAMPLE BOARD LAYOUT

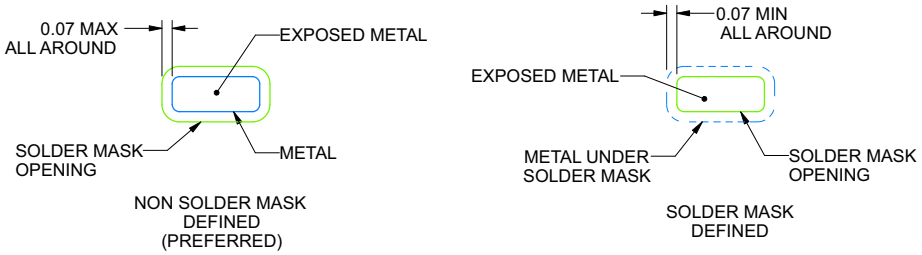
DRC0010V

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

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NOTES: (continued)

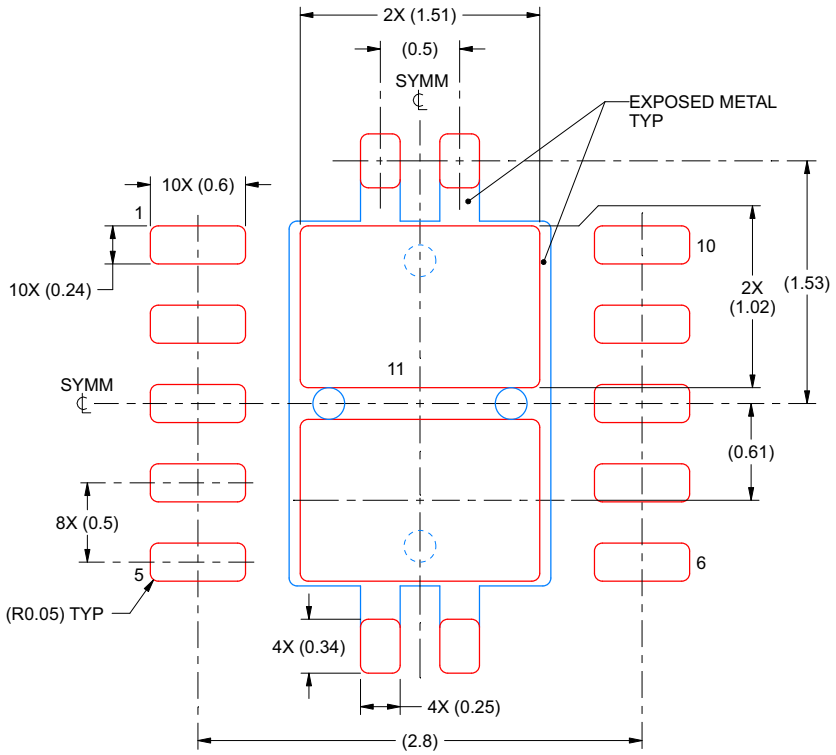
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

ADVANCE INFORMATION

EXAMPLE STENCIL DESIGN

DRC0010V — **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

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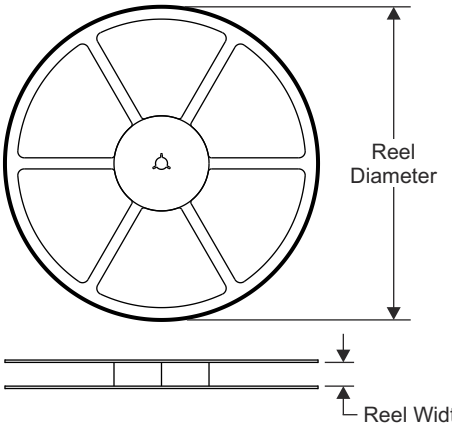
NOTES: (continued)

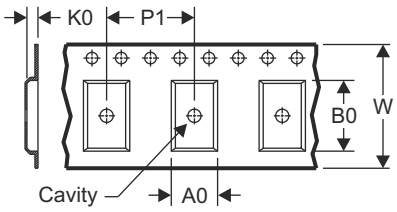
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

12.1 Tape and Reel Information

REEL DIMENSIONS

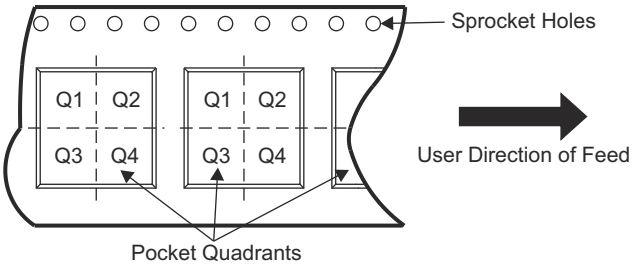


TAPE DIMENSIONS



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

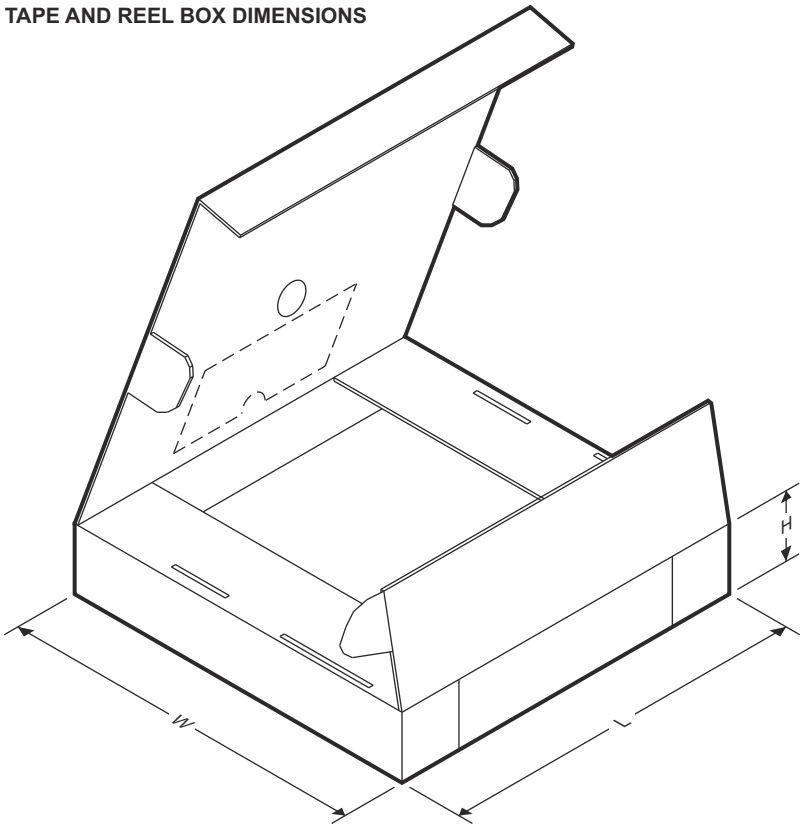


Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
PTHVD2419DR PTHVD2419VDR PTHVD2429DR PTHVD2429VDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
PTHVD2419DRCR PTHVD2429DRCR	VSON	DRC	10	5000	330.0	12.4	3.3	3.3	1.1	8.0	9.1	Q2

ADVANCE INFORMATION

ADVANCE INFORMATION

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PTHVD2419DR PTHVD2419VDR PTHVD2429DR PTHVD2429VDR	SOIC	D	8	2500	340.5	338.1	20.6
PTHVD2419DRCR PTHVD2429DRCR	VSON	DRC	10	5000	367.0	367.0	35.0

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
PTHVD2419DRCR	ACTIVE	VSON	DRC	10	5000	TBD	Call TI	Call TI	-40 to 125		Samples
PTHVD2429DRCR	ACTIVE	VSON	DRC	10	5000	TBD	Call TI	Call TI	-40 to 125		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.

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