

THVD14x9x 3-V to 5.5-V RS-485 Transceivers With 4-kV Surge Protection and 1.8-V VIO Capability

1 Features

- Meets or exceeds the requirements of the TIA/EIA-485A standard
- 3-V to 5.5-V Supply Voltage
- V_{IO} Support from 1.65-V to V_{CC} supply level (THVD1439V, THVD1449V)
- Bus I/O protection
 - ± 4 -kV IEC 61000-4-5 1.2/50- μ s surge
 - ± 15 -kV IEC 61000-4-2 Contact discharge
 - ± 15 -kV IEC 61000-4-2 Air-gap discharge
 - ± 4 -kV IEC 61000-4-4 Electrical fast transient
 - ± 15 -kV HBM ESD
 - ± 15 -V DC bus fault
- Available in two speed grades
 - THVD1439, THVD1439V: 250 kbps
 - THVD1449, THVD1449V: 12 Mbps
- Extended ambient temperature range: -40°C to 125°C
- Extended operational common-mode range: ± 12 V
- Large receiver hysteresis for noise rejection
- Low Power Consumption
 - Standby supply current: $< 3\ \mu\text{A}$
 - Current during operation: $< 5\ \text{mA}$
- Glitch-free power-up/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

2 Applications

- [Wireless infrastructure](#)
- [Factory automation](#)
- [Motor drives](#)
- [Building automation](#)
- [HVAC](#)
- [Grid infrastructure](#)

3 Description

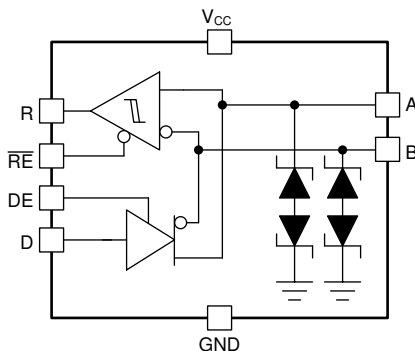
THVD14x9(V) devices are half-duplex RS-485 transceivers with integrated surge protection. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package. This feature increases the reliability by providing better immunity to noise transients coupled to the data cable which eliminates the need for external protection components.

THVD1439 and THVD1449 operate from a single 3.3-V or 5-V supply. The THVD1439V and THVD1449V devices support an additional V_{IO} supply to operate the IOs from as low as 1.65 V 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.

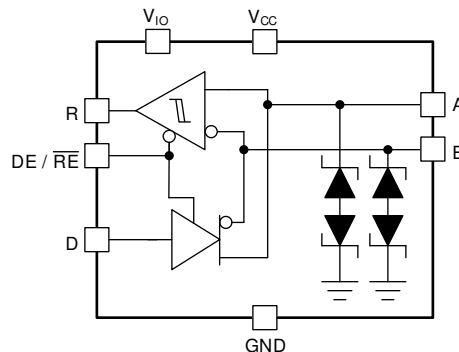
Device Information

| PART NUMBER | PACKAGE ⁽¹⁾ | BODY SIZE (NOM) |
|--|------------------------|--------------------------|
| THVD1439 THVD1439V THVD1449 THVD1449V | SOIC (8) | 4.90 mm \times 3.91 mm |

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



THVD14x9 Block Diagram



THVD14x9V Block Diagram



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4 Revision History

| Changes from Revision A (June 2021) to Revision B (September 2021) | Page |
|--|------|
| • Changed document status from <i>Advanced Information</i> to <i>Production</i> data | 1 |

Device Comparison Table

| PART NUMBER | DUPLEX | ENABLES | V _{IO} | SIGNALING RATE | NODES |
|-------------|--------|---------------------------------|-----------------|----------------|-------|
| THVD1439 | Half | Separate DE and \overline{RE} | No | up to 250 kbps | 256 |
| THVD1439V | | Combined DE / \overline{RE} | Yes | | |
| THVD1449 | | Separate DE and \overline{RE} | No | up to 12 Mbps | |
| THVD1449V | | Combined DE / \overline{RE} | Yes | | |

5 Pin Configuration and Functions

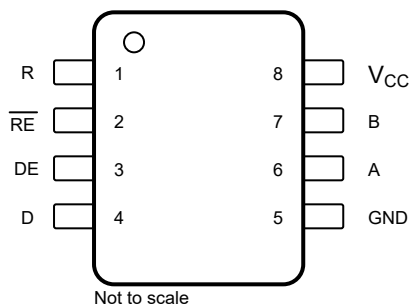


Figure 5-1. THVD1439, THVD1449, 8-Pin (SOIC), Top View

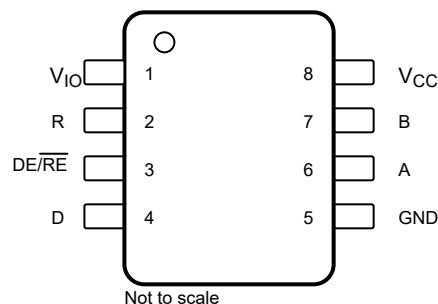


Figure 5-2. THVD1439V, THVD1449V, 8-Pin (SOIC), Top View

| NAME | PIN | | I/O | DESCRIPTION |
|-----------------|-----------------------|-----------------------------|-----|--|
| | THVD1439, THVD1449 | THVD1439 V, THVD1449V | | |
| V _{IO} | - | 1 | P | 1.8-V to 5-V supply for R, D, and RE/DE |
| R | 1 | 2 | O | Receiver data output |
| RE | 2 | - | I | Receiver enable, active low (2 MΩ internal pull-up) |
| DE | 3 | - | I | Driver enable, active high |
| DE/ RE | - | 3 | I | Driver enable (Active high), Receiver enable (Active Low). (2 MΩ internal pull-down) |
| D | 4 | 4 | I | Driver data input |
| GND | 5 | 5 | - | Device ground |
| A | 6 | 6 | I/O | Bus I/O port, A (complementary to B) |
| B | 7 | 7 | I/O | Bus I/O port, B (complementary to A) |
| V _{CC} | 8 | 8 | P | 3.3-V to 5-V supply for the device |

6 Specifications

6.1 Absolute Maximum Ratings

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

| | | MIN | MAX | UNIT |
|-------------------------|---|------|--------------|------|
| Supply voltage | V_{CC} | -0.5 | 7 | V |
| Logic supply voltage | V_{IO} | -0.5 | $V_{CC}+0.2$ | V |
| Bus voltage | Range at any bus pin (A or B) | -15 | 15 | V |
| Input voltage | Range at any logic pin (R, D, DE, or \overline{RE}) THVD1439, THVD1449 | -0.3 | 5.7 | V |
| Input voltage | Range at any logic pin (R, D, DE, or \overline{RE}) THVD1439V, THVD1449V | -0.3 | $V_{IO}+0.2$ | V |
| Receiver output current | I_O | -24 | 24 | mA |
| Storage temperature | T_{stg} | -65 | 150 | °C |

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

6.2 ESD Ratings

| | | | VALUE | UNIT |
|-------------|-------------------------|--|---------|------|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±15,000 | V |
| | | All pins except bus terminals and GND | ±4,000 | |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C102 ⁽²⁾ | ±1,500 | |

- (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 | Contact Discharge, per IEC 61000-4-2 | ±15,000 | V |
| | | Air-Gap Discharge, per IEC 61000-4-2 | ±15,000 | |
| $V_{(EFT)}$ | Electrical fast transient | Per IEC 61000-4-4 | ±4,000 | V |
| $V_{(surge)}$ | Surge | Per IEC 61000-4-5, 1.2/50 μ s | ±4,000 | V |

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} | IO Supply Voltage (V Variant) | | 1.65 | | V _{CC} | V |
| V _I | Input voltage on logic pins (R, D, DE, or RE) | THVD1439, THVD1449 | 0 | | 5.5 | V |
| V _I | | THVD1439V, THVD1449V | 0 | | V _{IO} | V |
| V _I | Input voltage at bus pins (A or B) ⁽¹⁾ | | -12 | | 12 | V |
| V _{IH} | High-level input voltage (R, D, DE, or RE) | THVD1439V, THVD1449V | 0.67 * V _{IO} | | V _{IO} | V |
| V _{IL} | Low-level input voltage (R, D, DE, or RE) | | 0 | 0.33 * V _{IO} | | V |
| V _{IH} | High-level input voltage (R, D, DE, or RE) | THVD1439, THVD1449 | 2 | | 5.5 | V |
| V _{IL} | Low-level input voltage (R, D, DE, or RE) | | 0 | | 0.8 | V |
| V _{ID} | Differential input voltage | | -12 | | 12 | V |
| I _O | Output current, driver | | -60 | | 60 | mA |
| I _{OR} | Output current, receiver | | -8 | | 8 | mA |
| R _L | Differential load resistance | | 54 | | | Ω |
| 1/t _{UI} | Signaling rate | THVD1439, THVD1439V | | | 250 | kbps |
| | | THVD1449, THVD1449V | | | 12 | Mbps |
| T _A | Operating ambient temperature | | -40 | | 125 | °C |

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

6.5 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | THVD1439 THVD1439V THVD1449 THVD1449V | UNIT |
|-------------------------------|--|--|------|
| | | D (SOIC) | |
| | | 8 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 120.7 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 50.3 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 62.8 | °C/W |
| Ψ _{JT} | Junction-to-top characterization parameter | 7.5 | °C/W |
| Ψ _{JB} | Junction-to-board characterization parameter | 62.2 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | 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

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

| PARAMETER | | TEST CONDITIONS | | | VALUE | UNIT |
|-----------|---|---|----------|----------|-------|------|
| PD | Driver and receiver enabled, V _{CC} = 5.5 V, T _A = 125 °C, 50% duty cycle square wave at signaling rate | Unterminated R _L = 300 Ω, C _L = 50 pF (driver) | THVD1439 | 250 kbps | 160 | mW |
| | | | THVD1449 | 12 Mbps | 290 | |
| | | RS-422 load R _L = 100 Ω, C _L = 50 pF (driver) | THVD1439 | 250 kbps | 190 | mW |
| | | | THVD1449 | 12 Mbps | 290 | |
| | | RS-485 load R _L = 54 Ω, C _L = 50 pF (driver) | THVD1439 | 250 kbps | 250 | mW |
| | | | THVD1449 | 12 Mbps | 320 | |

6.7 Electrical Characteristics

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

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|----------------------|---|--|--|---|---------------------|-----|------|
| Driver | | | | | | | |
| V _{OD} | Driver differential output voltage magnitude | R _L = 60 Ω, -12 V ≤ V _{test} ≤ 12 V (See Figure 7-1) | | 1.5 | 2 | | V |
| | | R _L = 60 Ω, -12 V ≤ V _{test} ≤ 12 V, 4.5 V ≤ V _{CC} ≤ 5.5 V (See Figure 7-1) | | 2.1 | | | V |
| | | R _L = 100 Ω (See Figure 7-2) | | 2 | 2.5 | | V |
| | | R _L = 54 Ω (See Figure 7-2) | | 1.5 | 2 | | V |
| Δ V _{OD} | Change in differential output voltage | R _L = 54 Ω (See Figure 7-2) | | −50 | | 50 | mV |
| V _{OC} | Common-mode output voltage | R _L = 54 Ω (See Figure 7-2) | | 1 | V _{CC} / 2 | 3 | V |
| ΔV _{OC(ss)} | Change in steady-state common-mode output voltage | R _L = 54 Ω (See Figure 7-2) | | −50 | | 50 | mV |
| I _{OS} | Short-circuit output current | DE = V _{CC} , -12 V ≤ V _O ≤ 12 V | | −250 | | 250 | mA |
| Receiver | | | | | | | |
| I _I | Bus input current | DE = 0 V, V _{CC} = 0 V or 5.5 V | V _I = 12 V | | 75 | 135 | μA |
| | | | V _I = -7 V | −100 | −40 | | |
| | | | V _I = -12 V | −135 | −75 | | |
| V _{TH+} | Positive-going input threshold voltage ⁽¹⁾ | Over common-mode range of ±12 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 |
| V _{OH} | Output high voltage | THVD1439V, THVD1449V | I _{OH} = -4 mA; V _{IO} = 1.65 V - 3 V | V _{IO} − 0.4 V _{IO} − 0.2 | | V | |
| | | | I _{OH} = -8 mA; V _{IO} = 3 V - 5.5 V | | | | |
| | | THVD1439, THVD1449 | I _{OH} = -8 mA | V _{CC} − 0.4 V _{CC} − 0.2 | | | |
| V _{OL} | Output low voltage | THVD1439V, THVD1449V | I _{OL} = 8 mA; V _{IO} = 3 V - 5.5 V | 0.2 | | 0.4 | V |
| | | | I _{OL} = 4 mA; V _{IO} = 1.65 V - 3 V | | | | |
| | | THVD1439, THVD1449 | I _{OL} = 8 mA | | | | |
| I _{OZ} | Output high-impedance current | V _O = 0 V or V _{CC} , $\overline{\text{RE}}$ = V _{CC} | | −1 | | 1 | μA |
| Logic | | | | | | | |
| I _{IN} | Input current (D, DE, $\overline{\text{RE}}$) | THVD1439V, THVD1449V | 3 V ≤ V _{CC} ≤ 5.5 V, 1.65 ≤ V _{IO} ≤ V _{CC} V, 0 V ≤ V _{IN} ≤ V _{IO} | −5 | | 5 | μA |
| | | THVD1439, THVD1449 | 3 V ≤ V _{CC} ≤ 5.5 V, 0 V ≤ V _{IN} ≤ V _{CC} | −5 | | 5 | μA |
| Thermal Protection | | | | | | | |
| T _{SHDN} | Thermal shutdown threshold | Temperature rising | | 150 | 170 | | °C |
| T _{HYS} | Thermal shutdown hysteresis | | | | 10 | | °C |

6.7 Electrical Characteristics (continued)

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

| PARAMETER | | TEST CONDITIONS | | | MIN | TYP | MAX | UNIT |
|-----------------|--------------------------------|------------------------|---|---|-----|-----|-----|------|
| Supply | | | | | | | | |
| I _{CC} | Supply current (quiescent) | V _{CC} =3.6 V | Driver and receiver enabled (THVD1439, THVD1449) | $\overline{RE} = 0\text{ V}$, DE = V _{CC} , No load | | 3 | 4 | mA |
| | | | Driver enabled, receiver disabled | $\overline{RE} = V_{CC}$, DE = V _{CC} , No load | | 2 | 3 | mA |
| | | | Driver disabled, receiver enabled | $\overline{RE} = 0\text{ V}$, DE = 0 V, No load | | 1.7 | 2.2 | mA |
| | | | Driver and receiver disabled (THVD1439, THVD1449) | $\overline{RE} = V_{CC}$, DE = 0 V, D = open, No load | | 0.1 | 1.5 | μA |
| | Supply current (quiescent) | V _{CC} =5.5 V | Driver and receiver enabled (THVD1439, THVD1449) | $\overline{RE} = 0\text{ V}$, DE = V _{CC} , No load | | 3.5 | 5 | mA |
| | | | Driver enabled, receiver disabled | $\overline{RE} = V_{CC}$, DE = V _{CC} , No load | | 2.5 | 3.8 | mA |
| | | | Driver disabled, receiver enabled | $\overline{RE} = 0\text{ V}$, DE = 0 V, No load | | 1.8 | 2.4 | mA |
| | | | Driver and receiver disabled (THVD1439, THVD1449) | $\overline{RE} = V_{CC}$, DE = 0 V, D = open, No load | | 0.2 | 3 | μA |
| I _{IO} | VIO supply current (quiescent) | THVD1439V, THVD1449V | Driver Enabled | DE/ \overline{RE} =V _{IO} , D=open, No load | | | 5 | μA |
| | | | Receiver enabled | DE/ \overline{RE} = 0 V, D=open, No load | | | 5 | μA |

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

6.8 Switching Characteristics (THVD1439, THVD1439V)

250-kbps devices (THVD1439, 39V), over recommended operating conditions. All typical values are at 25 °C.

| 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 | 300 | 570 | 1200 | ns |
| t _{PHL} , t _{PLH} | Propagation delay | | | | 450 | 650 | ns |
| t _{SK(P)} | Pulse skew, t _{PHL} – t _{PLH} | | | | | 50 | ns |
| t _{PHZ} , t _{PLZ} | Disable time | | See Figure 7-4 and Figure 7-5 | | 25 | 125 | ns |
| t _{PZH} , t _{PZL} | Enable time | RE = 0 V | | | 240 | 600 | ns |
| | | RE = V _{CC} | | | 2 | 4 | μs |
| t _{SHDN} | Pulse width (logic low) on DE pin to initiate device shutdown | RE = V _{CC} | | | 300 | | ns |
| Receiver | | | | | | | |
| t _r , t _f | Differential output rise/fall time | C _L = 15 pF | See Figure 7-6 | | 9 | 25 | ns |
| t _{PHL} , t _{PLH} | Propagation delay | | | | 70 | 110 | ns |
| t _{SK(P)} | Pulse skew, t _{PHL} – t _{PLH} | | | | | 7 | ns |
| t _{PHZ} , t _{PLZ} | Disable time | | | | 22 | 60 | ns |
| t _{PZH(1)} , t _{PZL(1)} , t _{PZH(2)} , t _{PZL(2)} | Enable time | DE = V _{CC} | See Figure 7-7 | | 120 | 185 | ns |
| | | | DE = 0 V | See Figure 7-8 | | 4 | 10 |
| t _{D(OFS)} | Delay to enter fail-safe operation | C _L = 15 pF | See Figure 7-9 | 14 | 20 | 36 | μs |
| t _{D(FSO)} | Delay to exit fail-safe operation | | | | 25 | 40 | 66 |
| t _{SHDN} | RE pulse width to initiate device shutdown | DE = 0 V | | | 300 | | ns |

6.9 Switching Characteristics (THVD1449, THVD1449V)

12-Mbps devices (THVD1449, 49V), over recommended operating conditions. All typical values are at 25 °C.

| 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 | 2 | 12 | 25 | ns | |
| t _{PHL} , t _{PLH} | Propagation delay | | | 7 | 10 | 25 | ns | |
| t _{SK(P)} | Pulse skew, t _{PHL} – t _{PLH} | | | | | 3.5 | ns | |
| t _{PHZ} , t _{PLZ} | Disable time | See Figure 7-4 and Figure 7-5 | | | 25 | 75 | ns | |
| t _{PZH} , t _{PZL} | Enable time | | | RE = 0 V | | 18 | 65 | ns |
| | | | | RE = V _{CC} | | 2 | 4 | μs |
| t _{SHDN} | Pulse width (logic low) on DE pin to initiate device shutdown | RE = V _{CC} | | | 300 | | ns | |
| Receiver | | | | | | | | |
| t _r , t _f | Differential output rise/fall time | C _L = 15 pF | See Figure 7-6 | | 3 | 10 | ns | |
| t _{PHL} , t _{PLH} | Propagation delay | | | 30 | 60 | 110 | ns | |
| t _{SK(P)} | Pulse skew, t _{PHL} – t _{PLH} | | | | | 4 | ns | |
| t _{PHZ} , t _{PLZ} | Disable time | | | | 10 | 30 | ns | |
| t _{PZH(1)} , t _{PZL(1)} , t _{PZH(2)} , t _{PZL(2)} | Enable time | DE = V _{CC} | See Figure 7-7 | | 90 | 130 | ns | |
| | | | DE = 0 V | See Figure 7-8 | | 4 | 10 | μs |
| t _{D(OFS)} | Delay to enter fail-safe operation | C _L = 15 pF | See Figure 7-9 | 14 | 20 | 36 | μs | |
| t _{D(FSO)} | Delay to exit fail-safe operation | | | 25 | 35 | 55 | ns | |
| t _{SHDN} | Pulse width (logic high) on RE pin to initiate device shutdown | DE = 0 V | | | 300 | | ns | |

6.10 Typical Characteristics

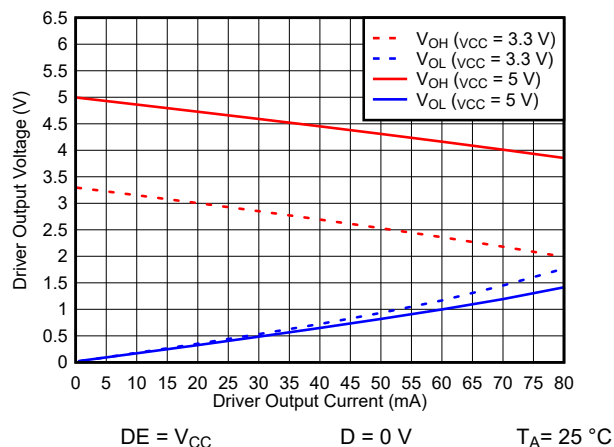


Figure 6-1. Driver Output Voltage vs Driver Output Current

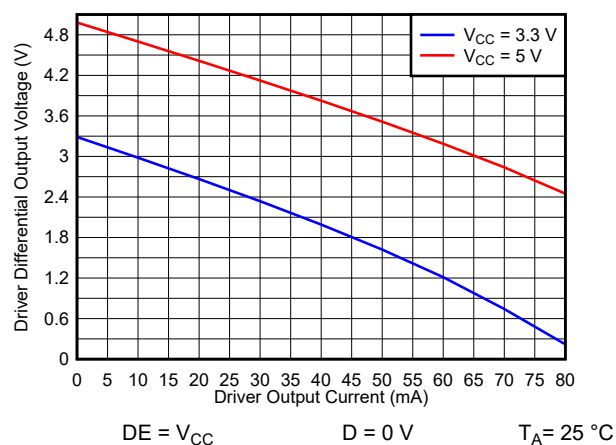


Figure 6-2. Driver Differential Output voltage vs Driver Output Current

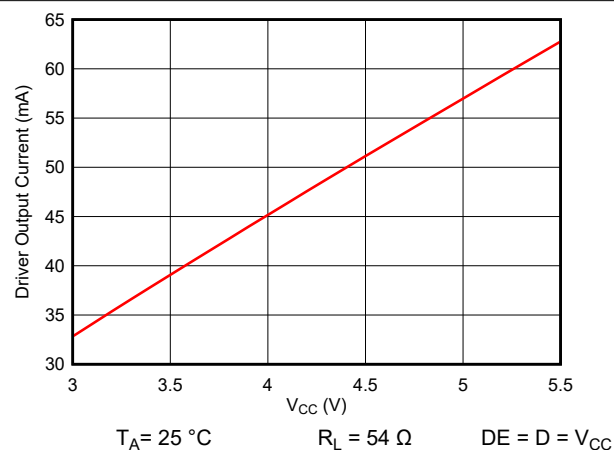


Figure 6-3. Driver Output Current vs Supply Voltage

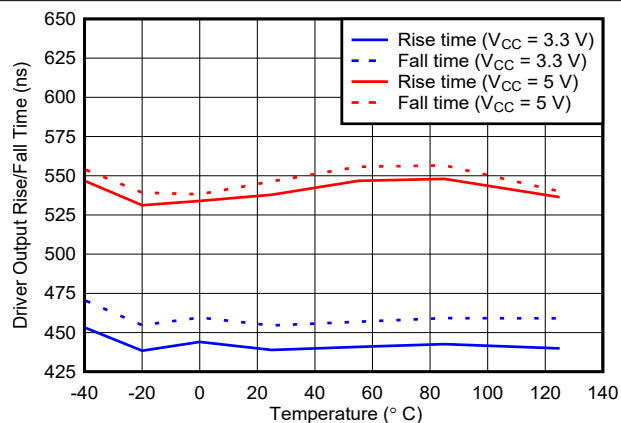


Figure 6-4. THVD1439, THVD1439V Driver Rise or Fall Time vs Temperature

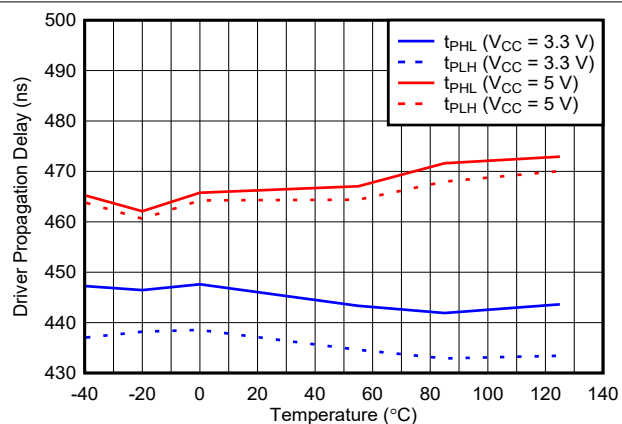


Figure 6-5. THVD1439, THVD1439V Driver Propagation Delay vs Temperature

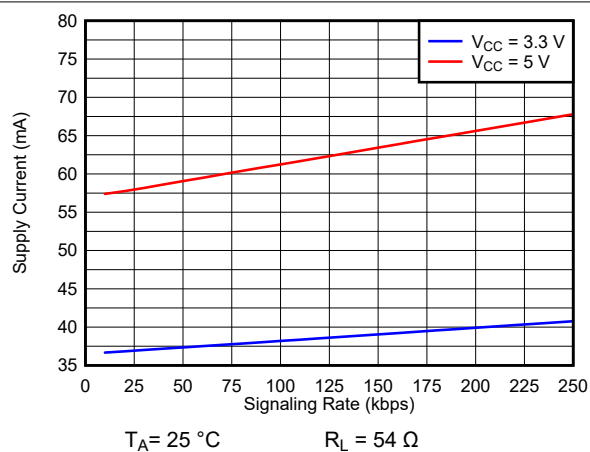


Figure 6-6. THVD1439, THVD1439V Supply Current vs Signal Rate

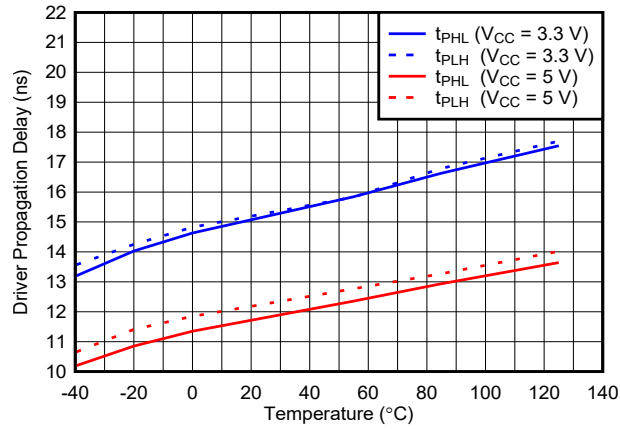


Figure 6-7. THVD1449, THVD1449V Driver Propagation Delay vs Temperature

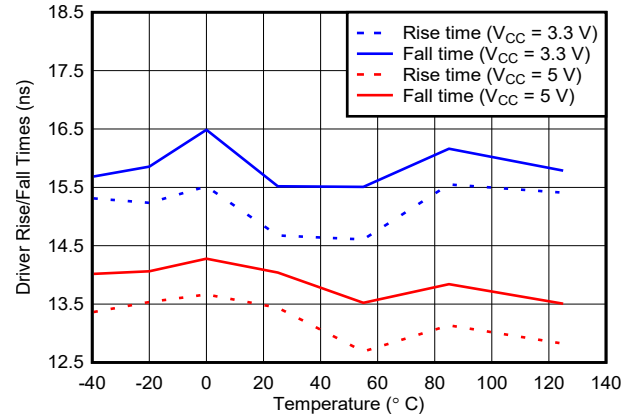


Figure 6-8. THVD1449, THVD1449V Driver Rise or Fall Time vs Temperature

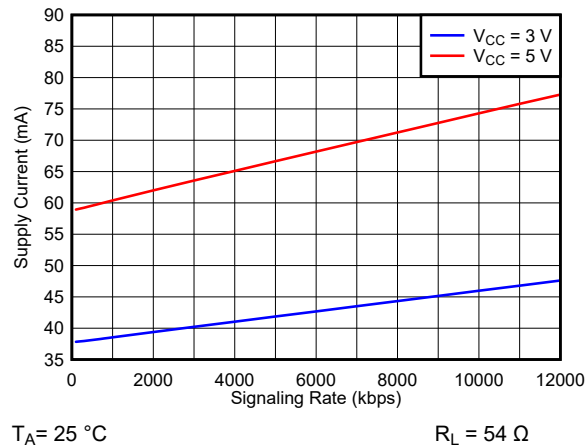


Figure 6-9. THVD1449, THVD1449V Supply Current vs Signal Rate

7 Parameter Measurement Information

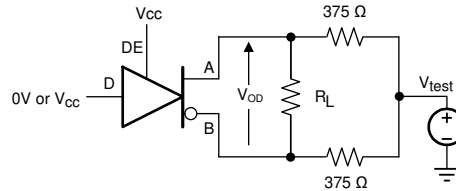


Figure 7-1. Measurement of Driver Differential Output Voltage With Common-Mode Load

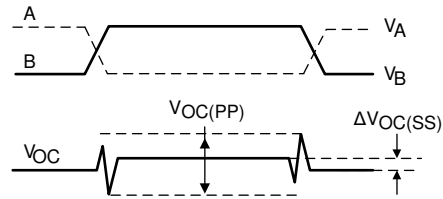
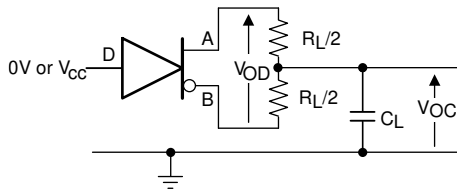


Figure 7-2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

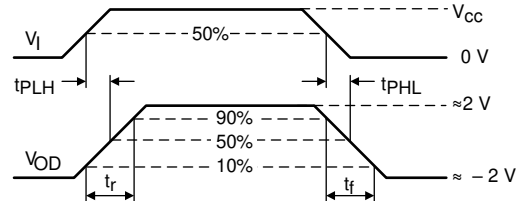
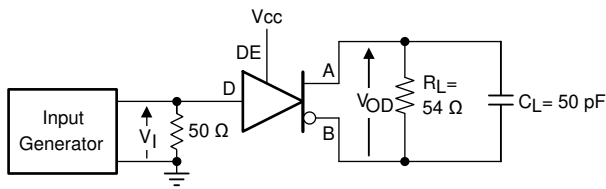


Figure 7-3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

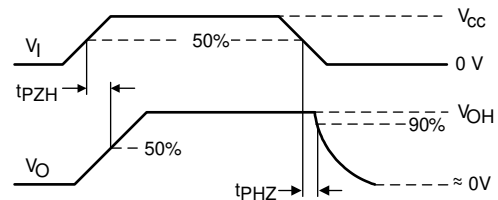
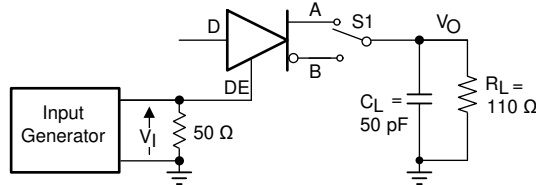


Figure 7-4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

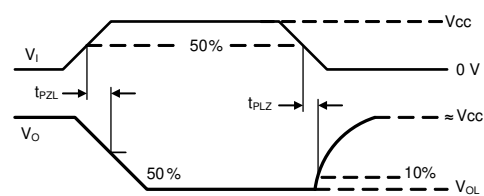
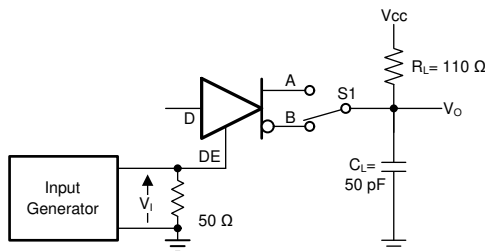


Figure 7-5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

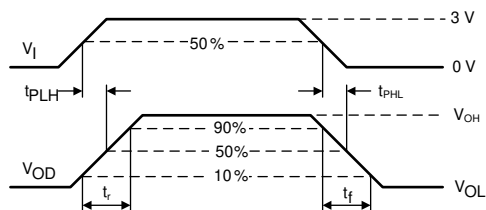
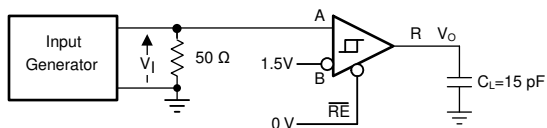


Figure 7-6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

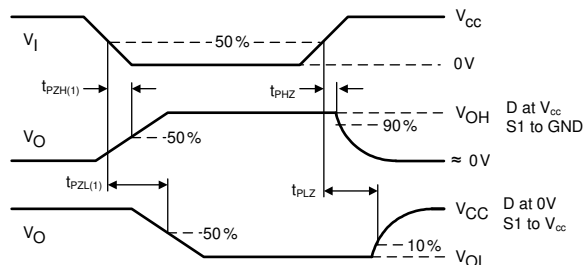
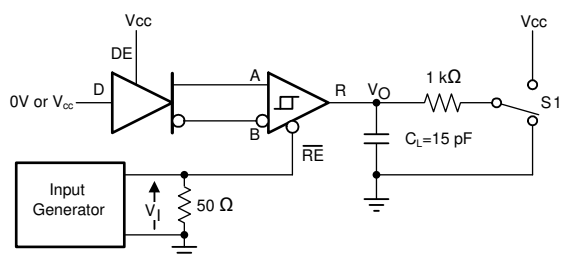


Figure 7-7. Measurement of Receiver Enable/Disable Times With Driver Enabled

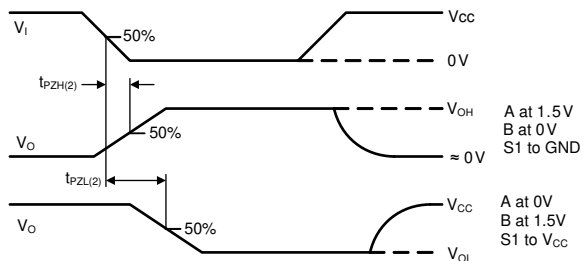
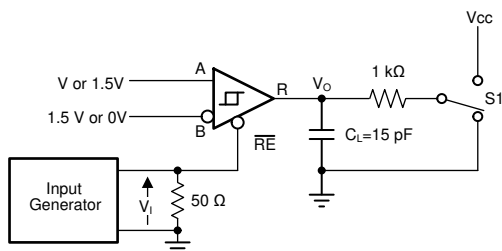
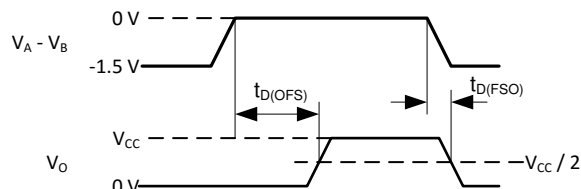
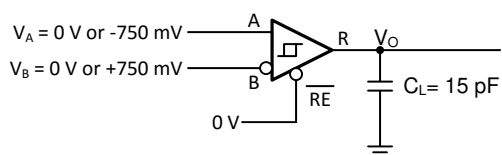


Figure 7-8. Measurement of Receiver Enable Times With Driver Disabled



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Figure 7-9. Fail-Safe Delay Measurements

8 Detailed Description

8.1 Overview

THVD14x9(V) devices are surge-protected, half duplex RS-485 transceivers available in two speed grades suitable for data transmission up to 250 kbps and 12 Mbps respectively. Surge protection is achieved by integrating transient voltage suppressor (TVS) diodes in the standard 8-pin SOIC (D) package.

THVD1439 and THVD1449 devices have active-high driver enables and active-low receiver enables. A standby current of less than 1.5 μA ($V_{CC} = 3.6\text{ V}$) can be achieved by disabling both driver and receiver. THVD1439V and THVD1449V have a single enable/disable pin that either enables the driver or the receiver at a time.

8.2 Functional Block Diagrams

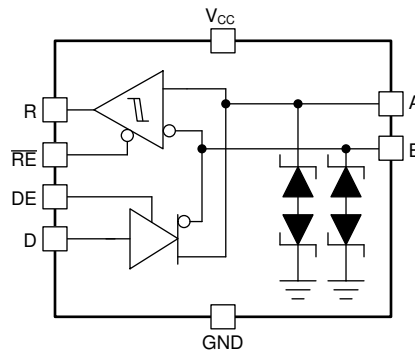


Figure 8-1. THVD1439 and THVD1449 Block Diagram

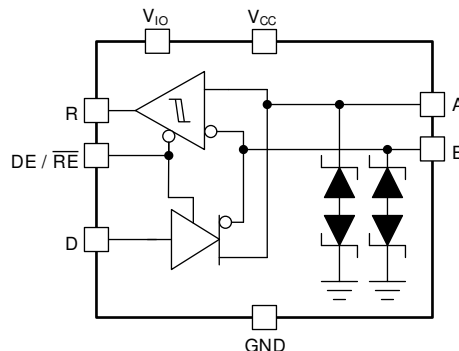


Figure 8-2. THVD1439V and THVD1449V Block Diagram

8.3 Feature Description

8.3.1 Electrostatic Discharge (ESD) Protection

The bus pins of the THVD14x9(V) transceiver family include on-chip ESD protection against $\pm 15\text{-kV}$ HBM and $\pm 15\text{-kV}$ IEC 61000-4-2 contact discharge. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance, $C_{(S)}$, and 78% lower discharge resistance, $R_{(D)}$, of the IEC model produce significantly higher discharge currents than the HBM model. As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method.

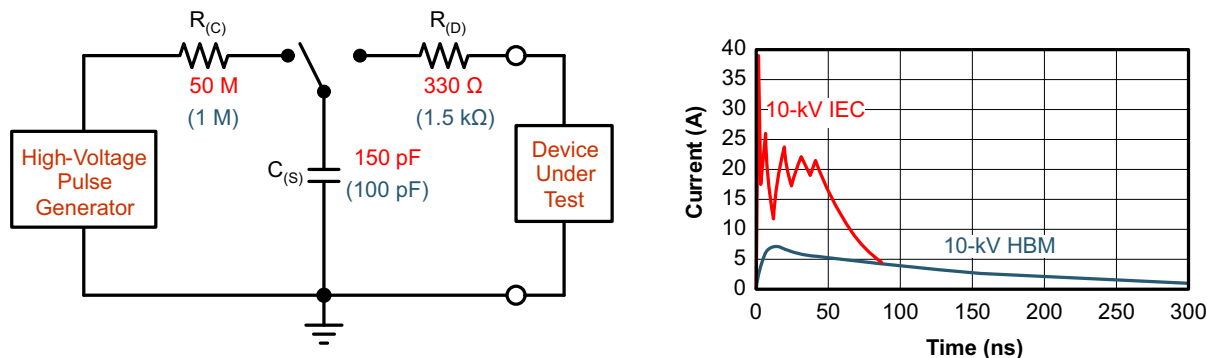


Figure 8-3. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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. Figure 8-4 shows the voltage waveforms in to 50-Ω termination as defined by the IEC standard.

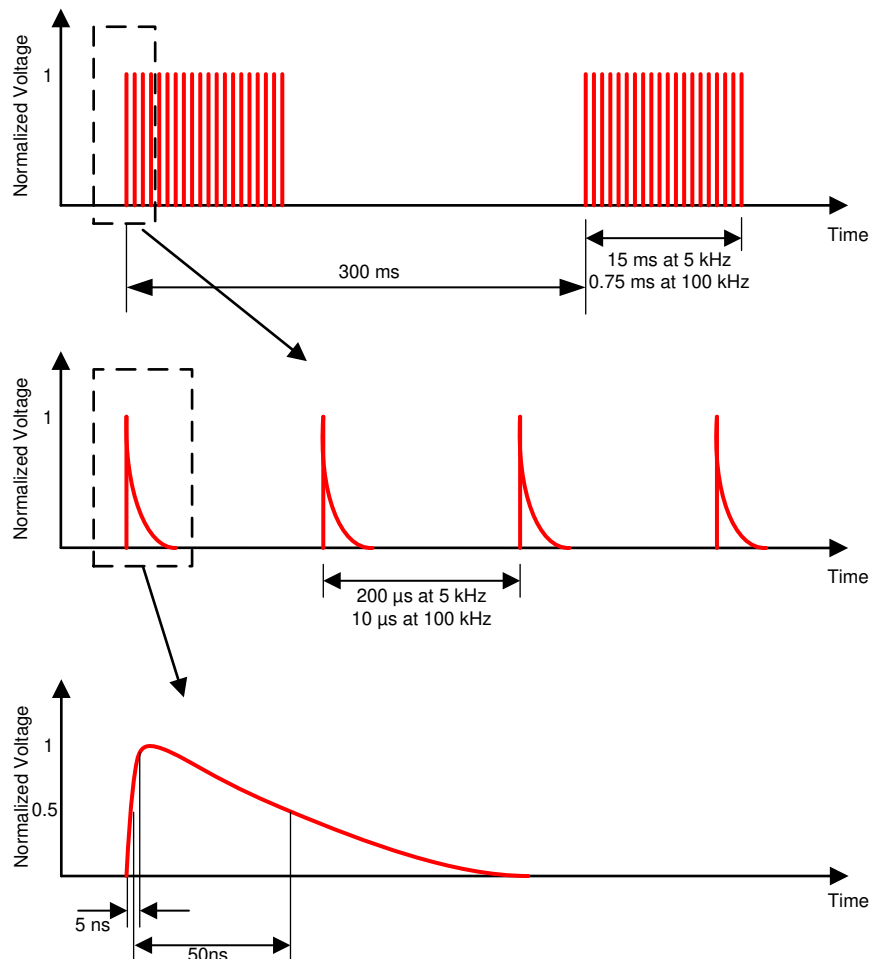


Figure 8-4. EFT Voltage Waveforms

Internal ESD protection circuits of the THVD14x9(V) protect the transceivers against ± 4 -kV 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 8-5 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 0.5-kV surge transient and 4-kV EFT transient, both of which dwarf the 10-kV ESD transient visible in the lower-left corner. 500-V surge transients are representative of events that may occur in factory environments in industrial and process automation.

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

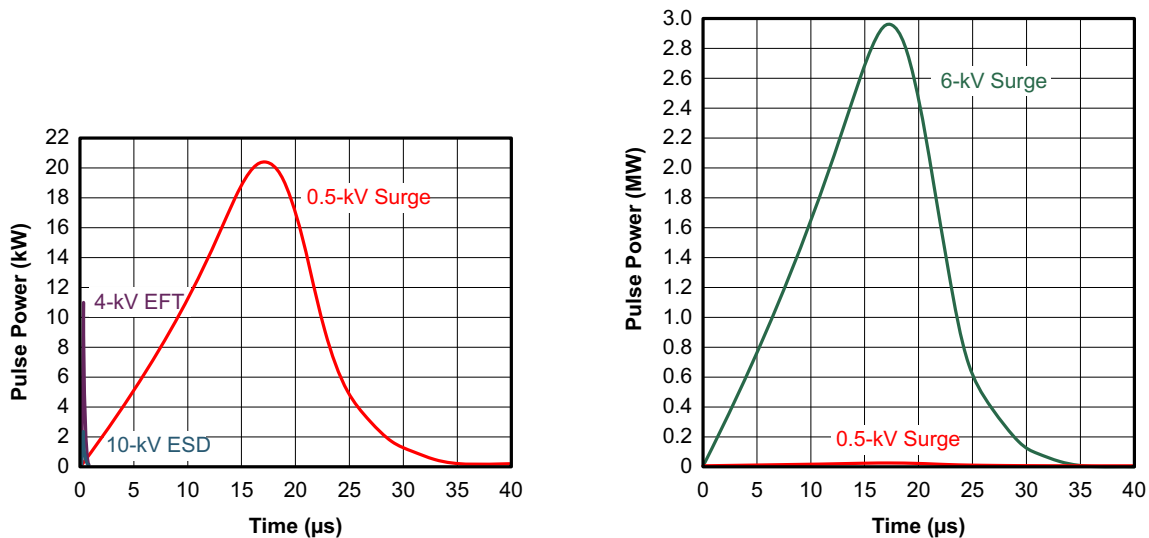


Figure 8-5. Power Comparison of ESD, EFT, and Surge Transients

Figure 8-6 shows the test setup used to validate THVD14x9 surge performance according to the IEC 61000-4-5 1.2/50-μs surge pulse.

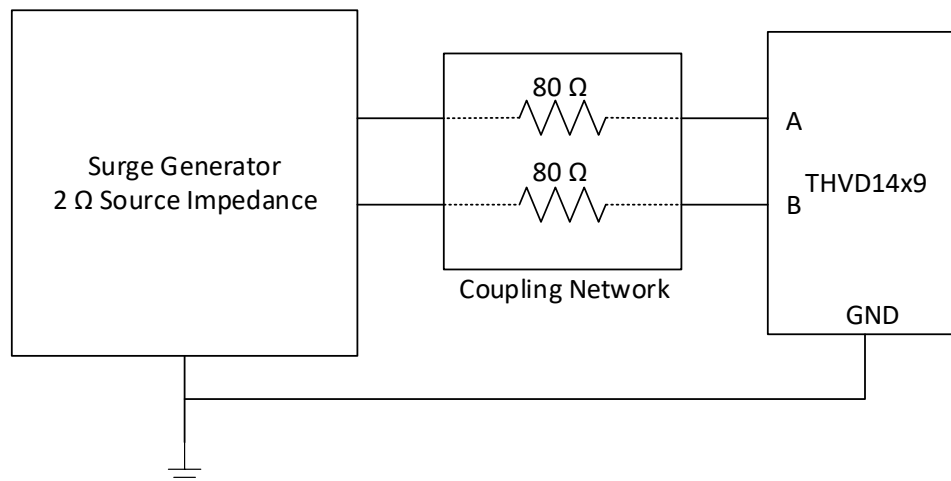


Figure 8-6. THVD14x9(V) Surge Test Setup

THVD14x9(V) product family is robust to ± 4 -kV surge transients without the need for any external components. The transient current and voltage waveforms resulting from a +4-kV surge test as described in Figure 8-6 are shown in Figure 8-7. The bus pin voltage is clamped by the integrated surge protection diodes such that the internal circuitry is not damaged during the surge event. The clamping voltage at the bus pins for versus the total current from the surge generator is shown in Figure 8-8.

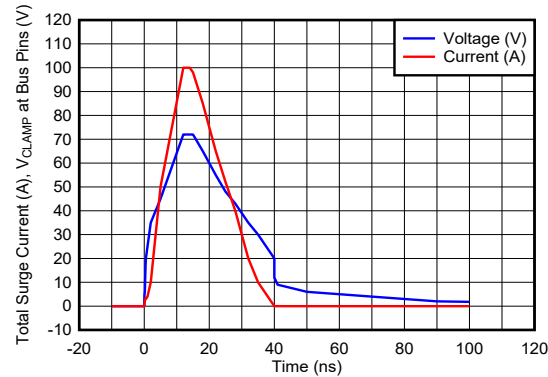


Figure 8-7. Transient current and voltage waveforms from +4-kV Surge Test. The current waveform is the total current output from the generator and the voltage waveform is the voltage at A or B pin of the transceiver.

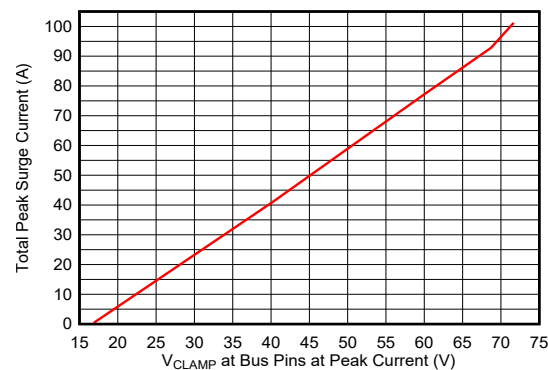


Figure 8-8. Clamping voltage at bus pins vs total surge current from the surge generator

8.3.4 Enhanced Receiver Noise Immunity

The differential receivers of THVD14x9(V) family feature fully symmetric thresholds to maintain duty cycle of the signal even with small input amplitudes. In addition, 250 mV (typical) hysteresis guarantees excellent noise immunity.

8.3.5 Failsafe Receiver

The differential receivers of the THVD14x9(V) 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 will output 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. In this case the differential output voltage defined as $V_{OD} = V_A - V_B$ is positive. When D is low, the output states reverse: B turns high, A becomes low, and V_{OD} is negative.

When DE is low, both outputs turn high-impedance. In this condition the logic state at D is irrelevant. The DE pin has an internal pull-down resistor to ground, thus when left open the driver is disabled (high-impedance) by default. The D pin has an internal pull-up resistor to V_{CC} , thus, when left open while the driver is enabled, output A turns high and B turns low.

Table 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 |

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

THVD14x9(V) 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.

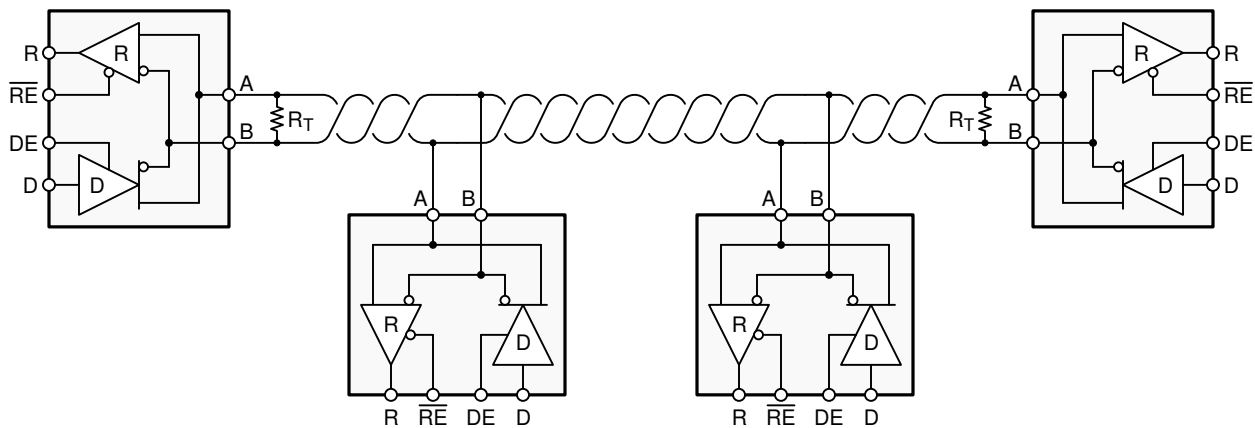


Figure 9-1. Typical RS-485 Network With Half-Duplex Transceivers

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

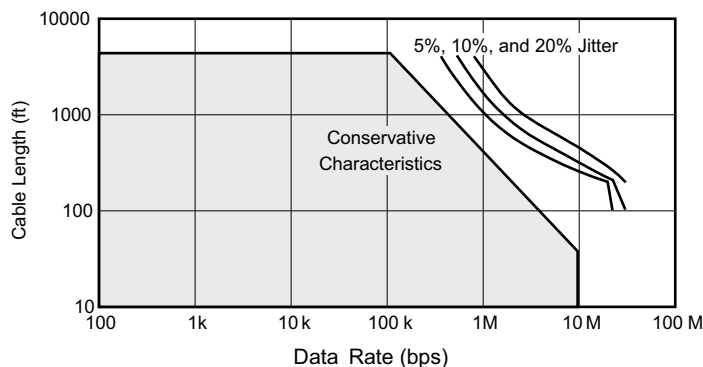


Figure 9-2. Cable Length vs Data Rate Characteristic

Even higher data rates are achievable (that is, 12 Mbps for the THVD1449(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 12 kΩ. Because the THVD14x9(V) 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. [Figure 9-3](#) compares 4-kV surge protection implementation with a regular RS-485 transceiver (such as THVD14x0) against with the THVD14x9(V). The internal TVS protection of the THVD14x9(V) achieves ± 4 -kV IEC 61000-4-5 surge protection without any additional external components, reducing system level bill of materials.

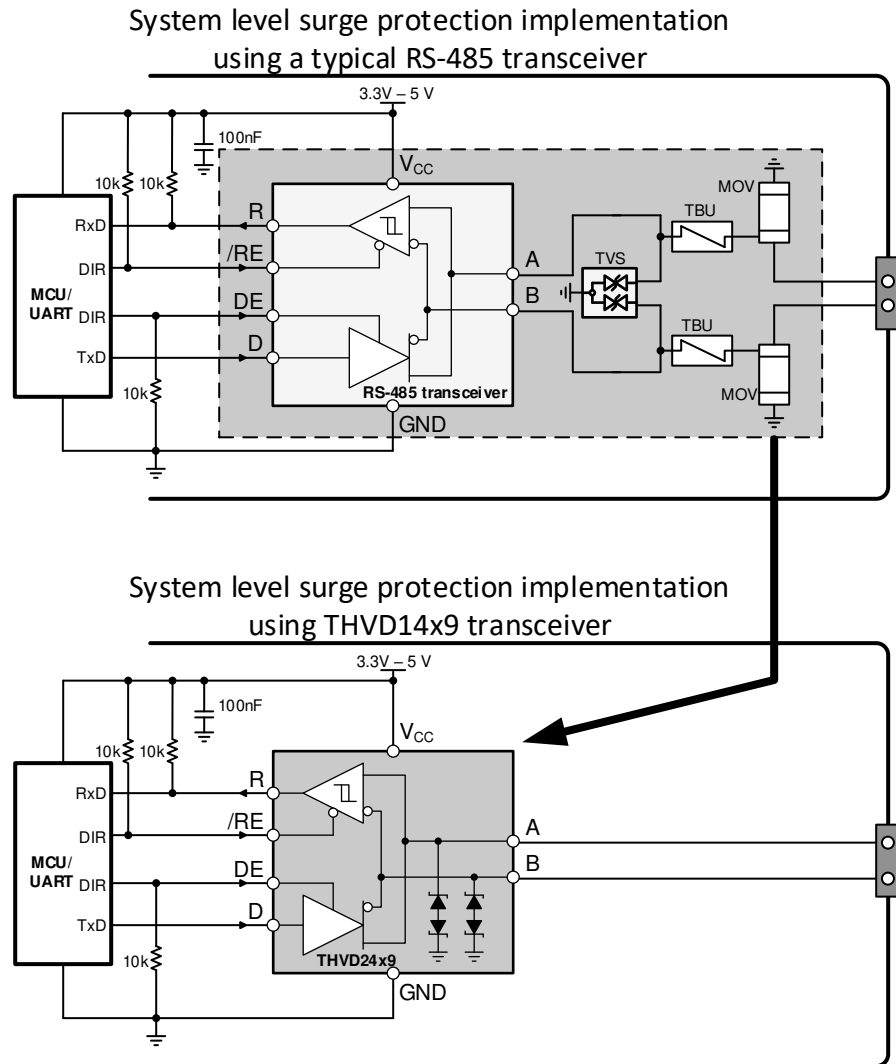
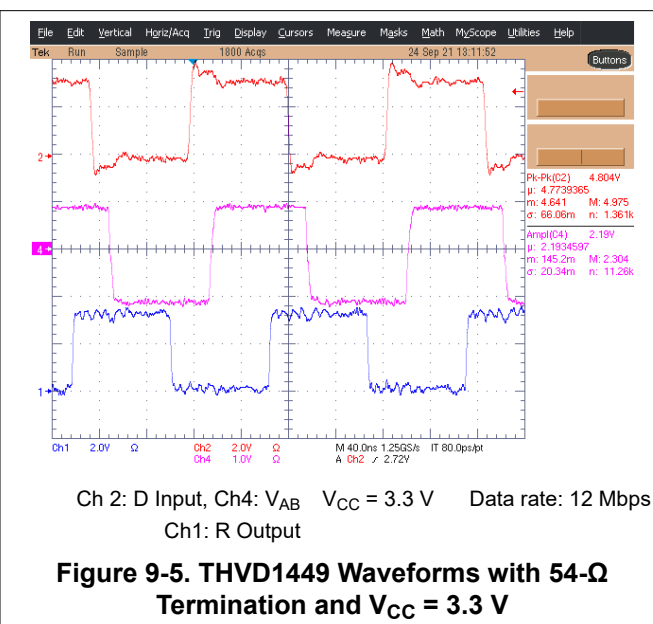
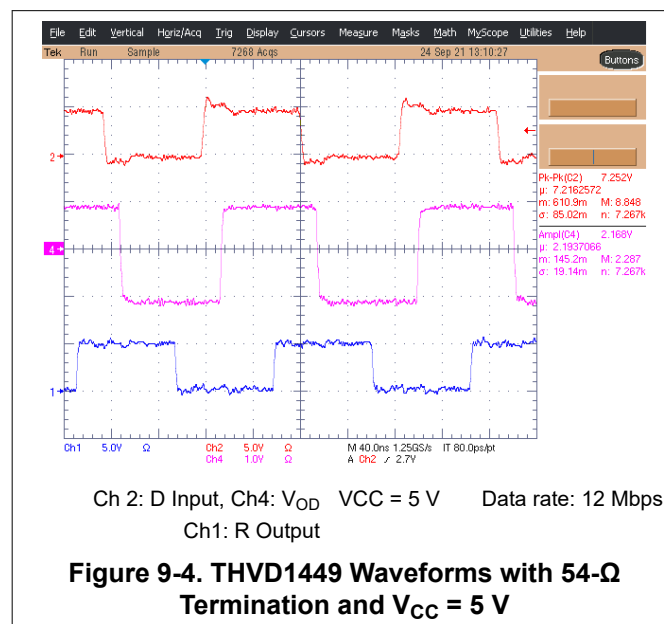


Figure 9-3. Implementation of System-Level Surge Protection Using THVD14x9(V)

9.2.3 Application Curves



10 Power Supply Recommendations

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

11 Layout

11.1 Layout Guidelines

Additional external protection components generally are not needed when using THVD14x9(V) 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 100-nF to 220-nF 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 1-k Ω to 10-k Ω pull-up and pull-down resistors for enable lines to limit noise currents in these lines during transient events.

11.2 Layout Example

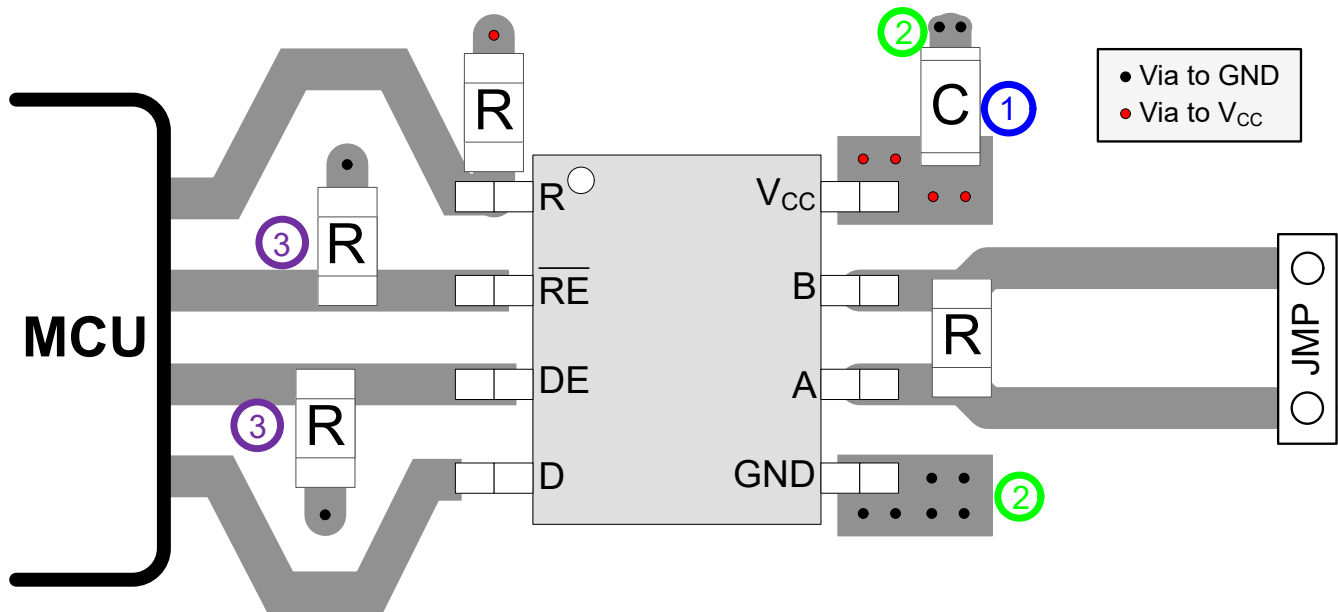


Figure 11-1. THVD1439, THVD1449 Layout Example

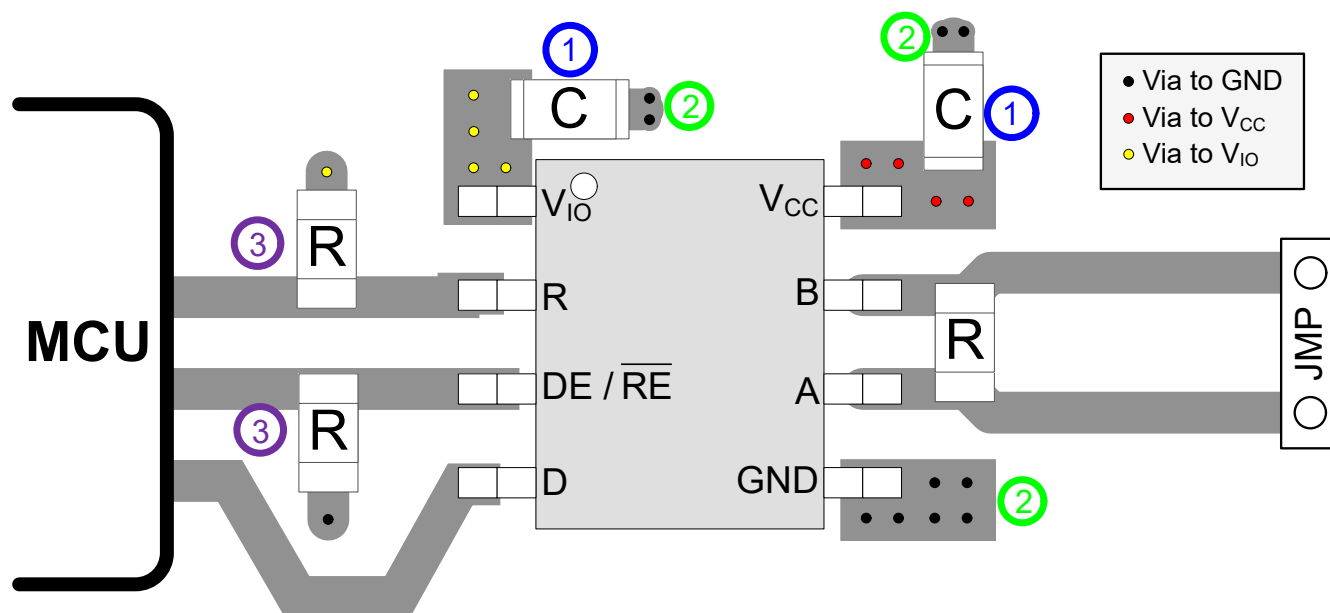


Figure 11-2. THVD1439V THVD1449V Layout Example

12 Device and Documentation Support

12.1 Device Support

12.2 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.

12.3 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](#).

12.4 Trademarks

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12.5 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.

12.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

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) |
|-----------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| THVD1439DR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1439 |
| THVD1439DR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1439 |
| THVD1439VDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | 1439V |
| THVD1439VDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | 1439V |
| THVD1449DR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1449 |
| THVD1449DR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1449 |
| THVD1449VDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1449V |
| THVD1449VDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAUAG | Level-3-260C-168 HR | -40 to 125 | T1449V |

(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.

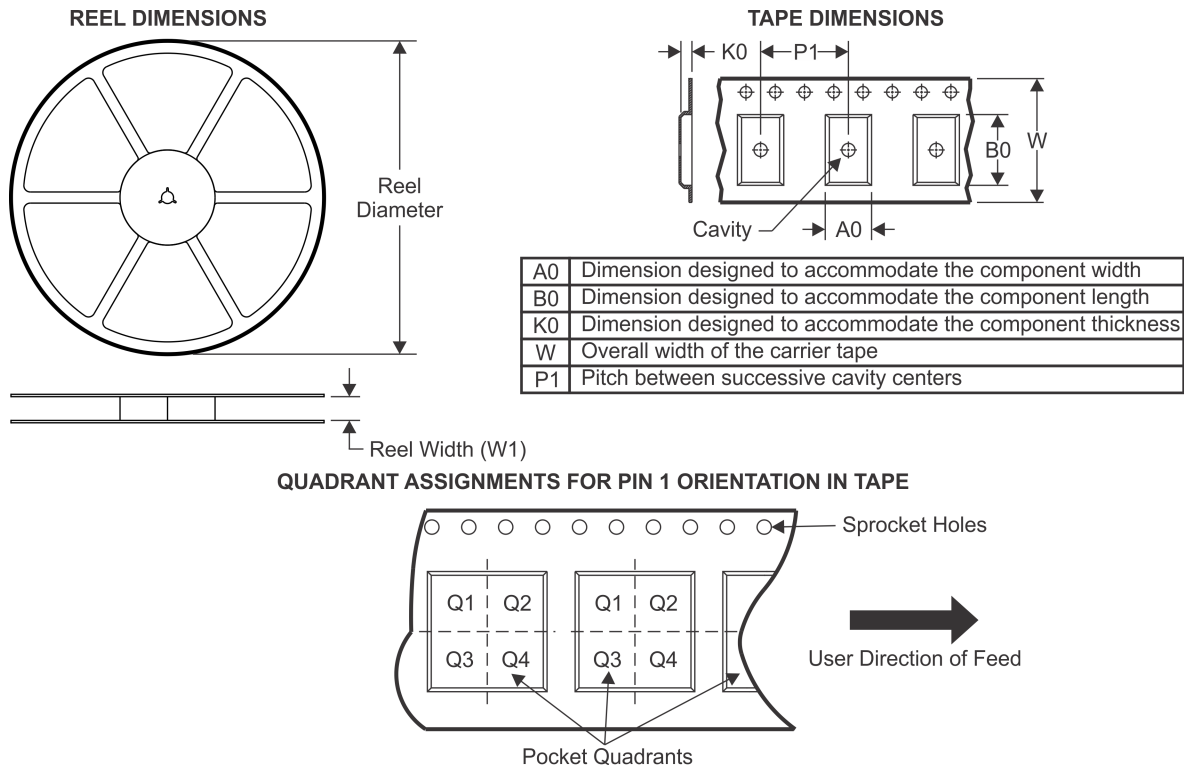
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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.

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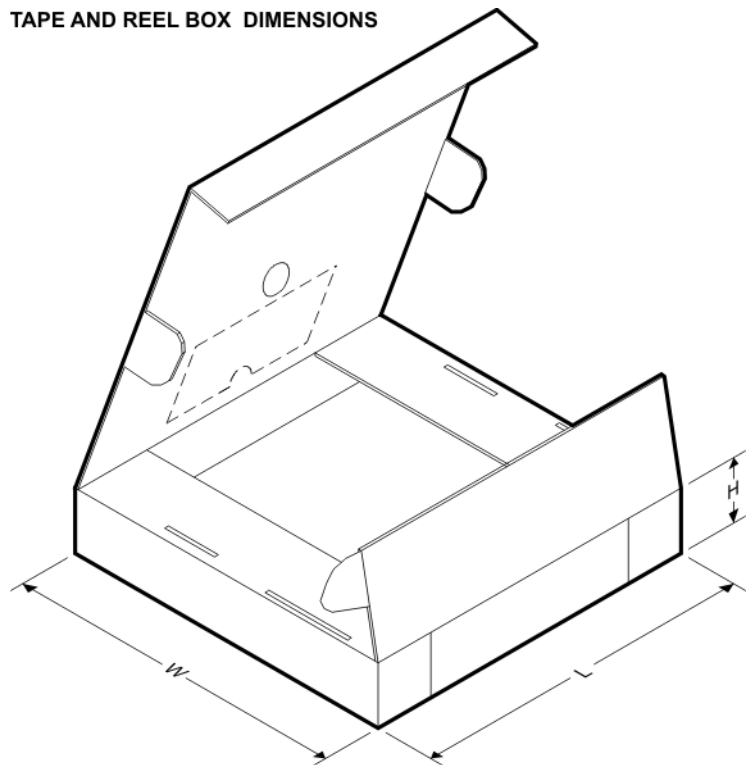
TAPE AND REEL INFORMATION



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| THVD1439DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| THVD1439VDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| THVD1449DR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| THVD1449VDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| THVD1439DR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| THVD1439VDR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| THVD1449DR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| THVD1449VDR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |

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