

THVD24xxV 柔軟な I/O 電源に対応した、IEC ESD 対応、 $\pm 70V$ 故障保護機能搭載、3V~5.5V RS-485 トランシーバ

1 特長

- TIA/EIA-485A および TIA/EIA-422B 規格の要件に適合またはそれを上回る性能
- 3V~5.5V の入力電源電圧
- 5V 電源で 2.1V を超える差動出力により PROFIBUS に準拠
- ロジック信号インターフェイス用の 1.65V~5.5V 電源
- SLR ピンで選択可能なデータレート:
 - THVD2410V, THVD2412V: 250kbps, 1Mbps
 - THVD2450V, THVD2452V: 20Mbps, 50Mbps
- バス I/O 保護
 - DC $\pm 70V$ バス フォルト
 - $\pm 16kV$ HBM ESD
 - 半二重デバイス: $\pm 15kV$ IEC 61000-4-2 接触および気中放電
 - 全二重デバイス: $\pm 8kV$ IEC 61000-4-2 接触および気中放電
 - $\pm 4kV$ IEC 61000-4-4 高速過渡バースト
- 2 つの速度グレードに対応する半二重および全二重デバイス
- 拡張周囲温度範囲: $-40^{\circ}C \sim 125^{\circ}C$
- 広い動作同相範囲: $\pm 25V$
- レシーバのヒステリシスを大きくすることでノイズ耐性を確保
- 低消費電力
 - 小さいシャットダウン時消費電流: $< 5\mu A$
 - 動作中の静止電流: $< 5.3mA$
- グリッチなしの電源オン / オフによるホット プラグイン機能
- 開放、短絡、アイドル バスのフェイルセーフ
- サーマル シャットダウン
- $-7V \sim 12V$ の同相範囲で 1/8 ユニット負荷 (最大 256 のバス ノード)
- 基板面積を削減できる小型 3mm x 3mm VSON パッケージ、またはドロップイン互換の 14-SOIC パッケージ

2 アプリケーション

- モーター・ドライブ
- ファクトリ・オートメーション / 制御
- HVAC システム
- ビル・オートメーション
- グリッド・インフラストラクチャ
- 電気メーター
- プロセス分析
- ビデオ監視

3 概要

THVD24xxV は、1.65V~5.5V のロジック信号インターフェイス用電源と 3V~5.5V のバス側電源を使用する、 $\pm 70V$ 障害保護機能付き半二重および全二重 RS-422/RS-485 トランシーバです。これらのデバイスはスルーレート選択機能を備えています。このスルーレート選択機能を使うと、SLR ピンの設定に基づいて 2 つの最大速度でこれらのデバイスを使うことができます。

IEC ESD 保護機能を内蔵しているため、システムレベルの外部保護部品は不要です。入力同相範囲が $\pm 25V$ と広いため、長いケーブルを使用する場合やグラウンド ループ電圧が大きい場合でもデータ通信の信頼性を高めることができます。250mV の大きなレシーバ ヒステリシスにより、高いノイズ除去性能を実現します。また、レシーバのフェイルセーフ機能により、入力が開放または短絡した場合、出力が確実に論理 High に固定されます。

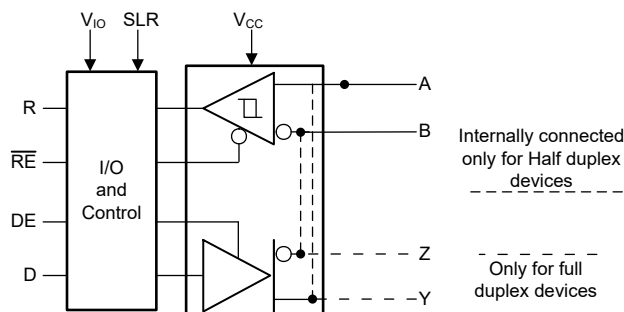
パッケージ情報

| 部品番号 | パッケージ (1) | パッケージ サイズ (2) |
|------------------------|-----------|-----------------|
| THVD2450V THVD2410V | VSON (10) | 3mm x 3mm |
| THVD2412V THVD2452V | SOIC (14) | 8.65mm x 3.91mm |

- (1) 詳細については、[セクション 11](#) を参照してください。
- (2) パッケージ サイズ (長さ x 幅) は公称値であり、該当する場合はピンも含まれます。

表 3-1. 製品情報

| 部品番号 | 二重 | 最大データレート |
|-----------|----|---------------------|
| THVD2410V | 半 | SLR = High, 250kbps |
| THVD2412V | フル | SLR = Low, 1Mbps |
| THVD2450V | 半 | SLR = High, 20Mbps |
| THVD2452V | フル | SLR = Low, 50Mbps |



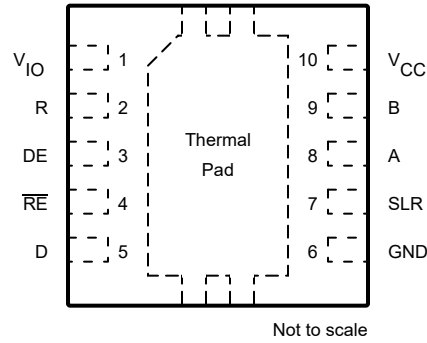
概略回路図



Table of Contents

| | | | |
|--|----|--|----|
| 1 特長 | 1 | 7.1 Overview..... | 19 |
| 2 アプリケーション | 1 | 7.2 Functional Block Diagrams..... | 19 |
| 3 概要 | 1 | 7.3 Feature Description..... | 19 |
| 4 Pin Configuration and Functions | 3 | 7.4 Device Functional Modes..... | 20 |
| 5 Specifications | 5 | 8 Application and Implementation | 22 |
| 5.1 Absolute Maximum Ratings..... | 5 | 8.1 Application Information..... | 22 |
| 5.2 ESD Ratings | 5 | 8.2 Typical Application..... | 22 |
| 5.3 ESD Ratings [IEC]..... | 5 | 8.3 Power Supply Recommendations..... | 28 |
| 5.4 Recommended Operating Conditions..... | 6 | 8.4 Layout..... | 28 |
| 5.5 Thermal Information..... | 6 | 9 Device and Documentation Support | 29 |
| 5.6 Power Dissipation..... | 7 | 9.1 Device Support..... | 29 |
| 5.7 Electrical Characteristics..... | 8 | 9.2 ドキュメントの更新通知を受け取る方法..... | 29 |
| 5.8 Switching Characteristics_250 kbps..... | 10 | 9.3 サポート・リソース..... | 29 |
| 5.9 Switching Characteristics_1 Mbps..... | 11 | 9.4 商標..... | 29 |
| 5.10 Switching Characteristics_20 Mbps..... | 12 | 9.5 静電気放電に関する注意事項..... | 29 |
| 5.11 Switching Characteristics_50 Mbps..... | 13 | 9.6 用語集..... | 29 |
| 5.12 Typical Characteristics..... | 14 | 10 Revision History | 29 |
| 6 Parameter Measurement Information | 17 | 11 Mechanical, Packaging, and Orderable Information | 29 |
| 7 Detailed Description | 19 | | |

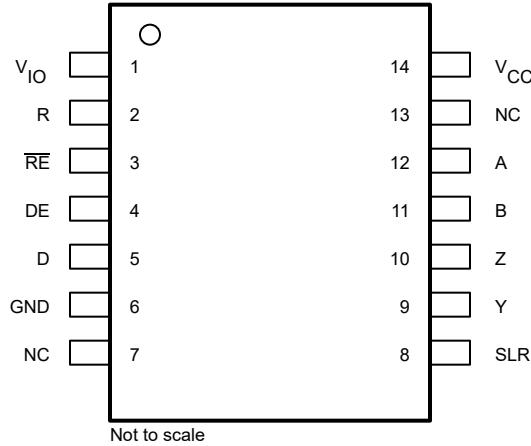
4 Pin Configuration and Functions



**図 4-1. THVD2410V, THVD2450V
10-Pin DRC Package (VSON)
Top View**

表 4-1. Pin Functions

| NO. | NAME | TYPE | DESCRIPTION |
|-----|-----------------|---------------------|---|
| 1 | V _{IO} | Logic Supply | Supply for logic I/O signals (R, RE, D, DE, and SLR) |
| 2 | R | Digital Output | Receive data output |
| 3 | DE | Digital Input | Driver enable input; integrated pull-down |
| 4 | RE | Digital Input | Receiver enable input; integrated pull-up |
| 5 | D | Digital Input | Transmission data input; integrated pull-up |
| 6 | GND | Reference Potential | Local device ground |
| 7 | SLR | Digital Input | Slew rate select. For THVD2410V: Low = 1 Mbps, High = 250 kbps. Defaults to 1 Mbps if SLR is left floating. For THVD2450V: Low = 50 Mbps, High = 20 Mbps. Defaults to 50 Mbps if left floating. |
| 8 | A | Bus I/O | RS 485 bus I/O, A |
| 9 | B | Bus I/O | RS 485 bus I/O, B |
| 10 | V _{CC} | Bus Supply | Bus supply |
| | Thermal Pad | -- | Connect to GND for optimal thermal performance |



**図 4-2. THVD2412V, THVD2452V
 14-Pin SOIC Package (D)
 Top View**

表 4-2. Pin functions

| NO. | NAME | TYPE | DESCRIPTION |
|-----|-----------------|---------------------|---|
| 1 | V _{IO} | Logic supply | 1.65 V to 5.5 V supply for logic I/O signals (R, RE, D, DE and SLR) |
| 2 | R | Digital output | Receive data output |
| 3 | RE | Digital input | Receiver enable input; integrated pull-up |
| 4 | DE | Digital input | Driver enable input; integrated pull-down |
| 5 | D | Digital input | Transmission data input; integrated pull-up |
| 6 | GND | Reference potential | Local device ground |
| 7 | NC | No connect | Not connected internally |
| 8 | SLR | Digital input | Slew rate select. For THVD2412V: Low = 1 Mbps, High = 250 kbps. Defaults to 1 Mbps if SLR is left floating. For THVD2452V: Low = 50 Mbps, High = 20 Mbps. Defaults to 50 Mbps if left floating. |
| 9 | Y | Bus output | RS 485 driver non-inverting output |
| 10 | Z | Bus output | RS 485 driver inverting output |
| 11 | B | Bus input | RS 485 receiver inverting input |
| 12 | A | Bus input | RS 485 receiver non-inverting input |
| 13 | NC | No connect | Not connected internally |
| 14 | V _{CC} | Bus supply | 3 V to 5.5 V bus supply |

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) ⁽¹⁾⁽²⁾

| | | MIN | MAX | UNIT |
|-------------------------|---|------|----------------|------|
| Logic supply voltage | V_{IO} | -0.5 | $V_{CC} + 0.2$ | V |
| Bus supply voltage | V_{CC} | -0.5 | 6.5 | V |
| Bus voltage | Range at any bus pin as differential or common-mode with respect to GND | -70 | 70 | V |
| Input voltage | Range at any logic pin (D, DE, SLR or \overline{RE}) | -0.3 | $V_{IO} + 0.2$ | V |
| Receiver output current | I_O | -24 | 24 | mA |
| Storage temperature | T_{stg} | -65 | 170 | °C |

- 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.
- All voltage values, except differential I/O bus voltages, are with respect to ground terminal.

5.2 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 | |

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

5.3 ESD Ratings [IEC]

| | | | | VALUE | UNIT |
|-------------|--|--------------------------------------|-----------------------|---------|------|
| $V_{(ESD)}$ | Electrostatic discharge, Half duplex devices THVD2410V/ 2450V ⁽¹⁾ | Contact discharge, per IEC 61000-4-2 | Bus terminals and GND | ±15,000 | V |
| | | Air-gap discharge, per IEC 61000-4-2 | Bus terminals and GND | ±15,000 | |
| $V_{(ESD)}$ | Electrostatic discharge, Full duplex devices THVD2412V/ 2452V | 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 | |
| $V_{(EFT)}$ | Electrical fast transient | Per IEC 61000-4-4 | Bus terminals | ±4,000 | V |

- For optimised IEC ESD performance, it is recommended to have series resistor ($\geq 50 \Omega$) on all logic inputs to minimize transient currents going into or out of the logic pins.

5.4 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 | 1.65 | | V _{CC} | V |
| V _I | Input voltage at any bus terminal (separately or common mode) ⁽¹⁾ | -25 | | 25 | V |
| V _{IH} | High-level input voltage (driver, driver enable, receiver enable and slew rate select inputs) | 0.7*V _{IO} | | V _{IO} | V |
| V _{IL} | Low-level input voltage (driver, driver enable, receiver enable and slew rate select inputs) | 0 | | 0.3*V _{IO} | V |
| V _{ID} | Differential input voltage bus pins | -25 | | 25 | V |
| I _O | Output current, driver | -60 | | 60 | mA |
| I _{OR} | Output current, receiver | | V _{IO} = 1.8 V or 2.5 V | 4 | mA |
| I _{OR} | Output current, receiver | | V _{IO} = 3.3 V or 5 V | 8 | mA |
| R _L | Differential load resistance | 54 | 60 | | Ω |
| 1/t _{UI} | Signaling rate | THVD2410V, THVD2412V with SLR = V _{IO} | | 250 | kbps |
| | | THVD2410V, THVD2412V with SLR = GND or floating | | 1 | Mbps |
| | | THVD2450V, THVD2452V with SLR = V _{IO} | | 20 | Mbps |
| | | THVD2450V, THVD2452V with SLR = GND or floating | | 50 | 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.

5.5 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | THVD2410V THVD2450V | THVD2412V THVD2452V | UNIT |
|-------------------------------|--|------------------------|------------------------|------|
| | | DRC (VSON) | D (SOIC) | |
| | | 10 PINS | 14 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 46.7 | 87.5 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 47.7 | 41.8 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 19.1 | 43.7 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 0.7 | 8.1 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 19.1 | 43.3 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | 4.6 | N/A | °C/W |

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

5.6 Power Dissipation

| PARAMETER | | TEST CONDITIONS | | VALUE | UNIT | |
|----------------|---|---|----------------------|----------|------|----|
| P _D | Driver and receiver enabled, loopback for full duplex devices (A connected to Y, B connected to Z) V _{CC} = 5.5 V, T _A = 125 °C, square wave at 50% duty cycle | Unterminated R _L = 300 Ω, C _L = 50 pF (driver) | THVD2410V, THVD2412V | 250 kbps | 160 | mW |
| | | | THVD2410V, THVD2412V | 1Mbps | 250 | |
| | | | THVD2450V, THVD2452V | 20Mbps | 310 | |
| | | | THVD2450V, THVD2452V | 50 Mbps | 630 | |
| | | RS-422 load R _L = 100 Ω, C _L = 50 pF (driver) | THVD2410V, THVD2412V | 250 kbps | 170 | mW |
| | | | THVD2410V, THVD2412V | 1Mbps | 250 | |
| | | | THVD2450V, THVD2452V | 20Mbps | 290 | |
| | | | THVD2450V, THVD2452V | 50 Mbps | 570 | |
| | | RS-485 load R _L = 54 Ω, C _L = 50 pF (driver) | THVD2410V, THVD2412V | 250 kbps | 220 | mW |
| | | | THVD2410V, THVD2412V | 1Mbps | 280 | |
| | | | THVD2450V, THVD2452V | 20Mbps | 325 | |
| | | | THVD2450V, THVD2452V | 50 Mbps | 560 | |

5.7 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. ⁽¹⁾

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT | | |
|---------------------------|---|--|----------------------|----------------|------|---------------|-----|----|
| Driver | | | | | | | | |
| $ V_{OD} $ | Driver differential output voltage magnitude | $R_L = 60\ \Omega$, $-25\text{ V} \leq V_{\text{test}} \leq 25\text{ V}$ (See 6-1) | 1.5 | 3.3 | | V | | |
| | | $R_L = 60\ \Omega$, $-25\text{ V} \leq V_{\text{test}} \leq 25\text{ V}$, $4.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ (See 6-1) | 2.1 | 3.3 | | V | | |
| | | $R_L = 100\ \Omega$ (See 6-2) | 2 | 4 | | V | | |
| | | $R_L = 54\ \Omega$ (See 6-2) | 1.5 | 3.5 | | V | | |
| $\Delta V_{OD} $ | Change in differential output voltage | $R_L = 54\ \Omega$ or $100\ \Omega$ (See 6-2) | -50 | | 50 | mV | | |
| V_{OC} | Common-mode output voltage | $R_L = 54\ \Omega$ or $100\ \Omega$ (See 6-2) | 1 | $V_{CC}/2$ | 3 | V | | |
| $\Delta V_{OC(SS)}$ | Change in steady-state common-mode output voltage | $R_L = 54\ \Omega$ or $100\ \Omega$ (See 6-2) | -50 | | 50 | mV | | |
| I_{OS} | Short-circuit output current | $DE = V_{IO}$, $-70\text{ V} \leq (V_A \text{ or } V_B) \leq 70\text{ V}$, or A shorted to B (A,B are driver terminals for half duplex, Y/Z are for full duplex) | -250 | | 250 | mA | | |
| Receiver | | | | | | | | |
| I_I | Bus input current | $DE = 0\text{ V}$, V_{CC} and $V_{IO} = 0\text{ V}$ or 5.5 V | $V_I = 12\text{ V}$ | 90 | 125 | μA | | |
| | | | $V_I = 25\text{ V}$ | 200 | 250 | μA | | |
| | | | $V_I = -7\text{ V}$ | -100 | -80 | μA | | |
| | | | $V_I = -25\text{ V}$ | -350 | -220 | μA | | |
| V_{TH+} | Positive-going input threshold voltage ⁽²⁾ | Over common-mode range of $\pm 25\text{ V}$ | THVD2410V, THVD2450V | | 40 | 125 | 200 | mV |
| V_{TH-} | Negative-going input threshold voltage ⁽²⁾ | Over common-mode range of $\pm 25\text{ V}$ | THVD2410V, THVD2450V | | -200 | -125 | -40 | mV |
| V_{TH+} | Positive-going input threshold voltage ⁽²⁾ | Over common-mode range of $\pm 25\text{ V}$ | THVD2412V, THVD2452V | | 20 | 125 | 200 | mV |
| V_{TH-} | Negative-going input threshold voltage ⁽²⁾ | Over common-mode range of $\pm 25\text{ V}$ | THVD2412V, THVD2452V | | -200 | -125 | -20 | mV |
| V_{HYS} | Input hysteresis | Over common-mode range of $\pm 25\text{ V}$ | | 250 | | mV | | |
| V_{TH_FSH} | Input fail-safe threshold | Over common-mode range of $\pm 25\text{ V}$ | THVD2410V, THVD2450V | | -40 | | 40 | mV |
| V_{TH_FSH} | Input fail-safe threshold | Over common-mode range of $\pm 25\text{ V}$ | THVD2412V, THVD2452V | | -20 | | 20 | mV |
| $C_{A,B}$ | Input differential capacitance | Measured between A and B, $f = 1\text{ MHz}$ | | 50 | | pF | | |
| V_{OH} | Output high voltage | $I_{OH} = -8\text{ mA}$, $V_{IO} = 3\text{ to }3.6\text{ V}$ or $4.5\text{ V to }5.5\text{ V}$ | $V_{IO} - 0.4$ | $V_{IO} - 0.2$ | | V | | |
| V_{OL} | Output low voltage | $I_{OL} = 8\text{ mA}$, $V_{IO} = 3\text{ to }3.6\text{ V}$ or $4.5\text{ V to }5.5\text{ V}$ | | 0.2 | 0.4 | V | | |
| V_{OH} | Output high voltage | $I_{OH} = -4\text{ mA}$, $V_{IO} = 1.65\text{ to }1.95\text{ V}$ or $2.25\text{ V to }2.75\text{ V}$ | $V_{IO} - 0.4$ | $V_{IO} - 0.2$ | | V | | |
| V_{OL} | Output low voltage | $I_{OL} = 4\text{ mA}$, $V_{IO} = 1.65\text{ to }1.95\text{ V}$ or $2.25\text{ V to }2.75\text{ V}$ | | 0.2 | 0.4 | V | | |
| I_{OZ} | Output high-impedance current, R pin | $V_O = 0\text{ V}$ or V_{IO} , $RE = V_{IO}$ | -1 | | 1 | μA | | |
| Logic | | | | | | | | |
| I_{IN} | Input current (DE, SLR) | $1.65\text{ V} \leq V_{IO} \leq 5.5\text{ V}$, $0\text{ V} \leq V_{IN} \leq V_{IO}$ | | | 5 | μA | | |
| I_{IN} | Input current (D, RE) | $1.65\text{ V} \leq V_{IO} \leq 5.5\text{ V}$, $0\text{ V} \leq V_{IN} \leq V_{IO}$ | -5 | | | μA | | |
| Thermal Protection | | | | | | | | |
| T_{SHDN} | Thermal shutdown threshold | Temperature rising | 150 | 180 | | °C | | |
| T_{HYS} | Thermal shutdown hysteresis | | | 10 | | °C | | |
| Supply | | | | | | | | |
| UV_{VCC} (rising) | Rising under-voltage threshold on V_{CC} | | | 2.3 | 2.6 | V | | |

5.7 Electrical Characteristics (続き)

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. ⁽¹⁾

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|-------------------------|---|--|---|------|-----|-----|---------------|
| 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 |
| $UV_{VIO(hys)}$ | Hysteresis on under-voltage of V_{IO} | | | | 120 | | mV |
| I_{CC} | Supply current (quiescent), $V_{CC} = 4.5\text{ V}$ to 5.5 V | Driver and receiver enabled | $\overline{RE} = 0\text{ V}$, $DE = V_{IO}$, 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 | $\overline{RE} = 0\text{ V}$, $DE = 0\text{ V}$, No load | | 1.8 | 2.4 | mA |
| | | Driver and receiver disabled | $\overline{RE} = V_{IO}$, $DE = 0\text{ V}$, $D = \text{open}$, No load | | 0.1 | 1.2 | μA |
| I_{CC} | Supply current (quiescent), $V_{CC} = 3\text{ V}$ to 3.6 V | Driver and receiver enabled | $\overline{RE} = 0\text{ V}$, $DE = V_{IO}$, 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 | $\overline{RE} = 0\text{ V}$, $DE = 0\text{ V}$, No load | | 1.6 | 2.2 | mA |
| | | Driver and receiver disabled | $\overline{RE} = V_{IO}$, $DE = 0\text{ V}$, $D = \text{open}$, No load | | 0.1 | 1 | μA |
| I_{IO} | Logic supply current (quiescent), $V_{IO} = 3$ to 3.6 V | Driver disabled, Receiver enabled, $SLR = \text{GND}$ | $DE = 0\text{ V}$, $\overline{RE} = 0\text{ V}$, No load | | 4.5 | 8.4 | μA |
| | | Driver disabled, Receiver enabled, $SLR = V_{IO}$ | $DE = 0\text{ V}$, $\overline{RE} = 0\text{ V}$, No load | | 3.3 | 8.4 | μA |
| | | Driver disabled, Receiver disabled, $SLR = \text{GND}$ | $DE = 0\text{ V}$, $\overline{RE} = V_{IO}$, No load | | 0.1 | 1 | μA |
| | | Driver disabled, Receiver disabled, $SLR = V_{IO}$ | $DE = 0\text{ V}$, $\overline{RE} = V_{IO}$, No load | | 1.8 | 4 | μA |

- (1) A, B are driver output and receiver input terminals for Half duplex devices; A/B are Receiver input, Y/Z are driver output terminals for Full duplex devices
(2) Under any specific conditions, V_{TH+} is specified to be at least V_{HYS} higher than V_{TH-} .

5.8 Switching Characteristics_250 kbps

250-kbps (THVD2410V, THVD2412V with SLR = V_{IO}) over recommended operating conditions. All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. (1)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--------------------------|------------------------------------|---|--|-----|-----|---------------|---------------|
| Driver | | | | | | | |
| t_r, t_f | Differential output rise/fall time | $R_L = 54\ \Omega, C_L = 50\text{ pF}$ See 6-3 | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3V | 450 | 560 | 1200 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 500 | 625 | 1200 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3V | | 500 | 720 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 540 | 770 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3V | | 10 | 70 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 10 | 70 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $\overline{RE} = X$ | | 40 | 75 | ns | |
| t_{PZH}, t_{PZL} | Enable time | $\overline{RE} = 0\text{ V}$ | See 6-4 and 6-5 | 70 | 280 | ns | |
| | | $\overline{RE} = V_{IO}$ | | 2.5 | 4.5 | μs | |
| t_{SHDN} | Time to shutdown | $\overline{RE} = V_{IO}$ | | 50 | 500 | ns | |
| Receiver | | | | | | | |
| t_r, t_f | Output rise/fall time | $C_L = 15\text{ pF}$ | See 6-6 | | 7 | 20 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | | | 800 | 1270 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 5 | 45 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $DE = X$ | | 30 | 40 | ns | |
| $t_{PZH(1)}$ | Enable time | $V_{IO} = 3\text{ V to }3.6\text{ V}; DE = V_{IO}$ | See 6-7 | | 90 | 120 | ns |
| | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}; DE = V_{IO}$ | | | 100 | 130 | ns |
| $t_{PZL(1)}$ | | $V_{IO} = 3\text{ V to }3.6\text{ V}; DE = V_{IO}$ | | | 900 | 1320 | ns |
| | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}; DE = V_{IO}$ | | | 900 | 1320 | ns |
| $t_{PZH(2)}, t_{PZL(2)}$ | Enable time | $DE = 0\text{ V}$ | See 6-8 | 3.3 | 5.4 | μs | |
| $t_{D(OFS)}$ | Delay to enter fail-safe operation | $C_L = 15\text{ pF}$ | See 6-9 | 7 | 11 | 18 | μs |
| $t_{D(FSO)}$ | Delay to exit fail-safe operation | | | 540 | 800 | 1260 | ns |
| t_{SHDN} | Time to shutdown | $DE = 0\text{ V}$ | See 6-8 | 50 | 500 | ns | |

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

5.9 Switching Characteristics_1 Mbps

1Mbps (THVD2410V, THVD2412V with SLR = 0) over recommended operating conditions. All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. (1)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--------------------------|------------------------------------|---|--|-----|-----|------|---------------|
| Driver | | | | | | | |
| t_r, t_f | Differential output rise/fall time | $R_L = 54\ \Omega, C_L = 50\text{ pF}$ See 6-3 | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 125 | 150 | 300 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 130 | 160 | 300 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | | 160 | 240 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 185 | 280 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | | 2 | 20 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 2 | 15 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $RE = X$ | | | 40 | 95 | ns |
| t_{PZH}, t_{PZL} | Enable time | $RE = 0\text{ V}$ | See 6-4 and 6-5 | | 90 | 275 | ns |
| | | $RE = V_{IO}$ | | | 3 | 4.6 | μs |
| t_{SHDN} | Time to shutdown | $RE = V_{IO}$ | | | 50 | 500 | ns |
| Receiver | | | | | | | |
| t_r, t_f | Output rise/fall time | $C_L = 15\text{ pF}$ | See 6-6 | | 7 | 15 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | | | 50 | 85 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | | | 4 | 12.5 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $DE = X$ | | | 30 | 40 | ns |
| $t_{PZH(1)}, t_{PZL(1)}$ | Enable time | $V_{IO} = 3\text{ V to }3.6\text{ V}; DE = V_{IO}$ | See 6-7 | | 90 | 120 | ns |
| | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}; DE = V_{IO}$ | | | 90 | 130 | ns |
| $t_{PZH(2)}, t_{PZL(2)}$ | Enable time | $DE = 0\text{ V}$ | See 6-8 | | 3 | 4.5 | μs |
| $t_{D(OFS)}$ | Delay to enter fail-safe operation | $C_L = 15\text{ pF}$ | See 6-9 | | 7 | 10 | μs |
| $t_{D(FSO)}$ | Delay to exit fail-safe operation | | | | 27 | 40 | 60 |
| t_{SHDN} | Time to shutdown | $DE = 0\text{ V}$ | See 6-8 | | 50 | 500 | ns |

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

5.10 Switching Characteristics_20 Mbps

20-Mbps (THVD2450V, THVD2452V with SLR = V_{IO}) over recommended operating conditions. All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. (1)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--------------------------|------------------------------------|---|--|-----|-----|-----|---------------|
| Driver | | | | | | | |
| t_r, t_f | Differential output rise/fall time | $R_L = 54\ \Omega, C_L = 50\text{ pF}$ See 6-3 | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 4 | 8 | 15 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 4 | 7 | 15 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 6 | 12 | 30 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 4 | 9 | 26 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | | 1 | 3 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 1 | 3 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $RE = X$ | | | 17 | 35 | ns |
| t_{PZH}, t_{PZL} | Enable time | $RE = 0\text{ V}$ | | | 14 | 39 | ns |
| | | $RE = V_{IO}$ | See 6-4 and 6-5 | | 3 | 4.5 | μs |
| t_{SHDN} | Time to shutdown | $RE = V_{IO}$ | | 50 | | 500 | ns |
| Receiver | | | | | | | |
| t_r, t_f | Output rise/fall time | $C_L = 15\text{ pF}$ | | | 1.5 | 6 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | $V_{IO} = 3\text{ V to }3.6\text{ V}$ | See 6-6 | 25 | 33 | 58 | ns |
| | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}$ | | 25 | 35 | 60 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | $C_L = 15\text{ pF}$ | | | 0.5 | 5 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $DE = X$ | | | 12 | 25 | ns |
| $t_{PZH(1)}, t_{PZL(1)}$ | Enable time | $DE = V_{IO}$ | See 6-7 | | 50 | 82 | ns |
| $t_{PZH(2)}, t_{PZL(2)}$ | Enable time | $DE = 0\text{ V}$ | See 6-8 | | 2.8 | 5 | μs |
| $t_{D(OFS)}$ | Delay to enter fail-safe operation | $C_L = 15\text{ pF}$ | See 6-9 | 7 | 10 | 18 | μs |
| $t_{D(FSO)}$ | Delay to exit fail-safe operation | | | 19 | 32 | 50 | ns |
| t_{SHDN} | Time to shutdown | $DE = 0\text{ V}$ | See 6-8 | 50 | | 500 | ns |

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

5.11 Switching Characteristics_50 Mbps

50-Mbps (THVD2450V, THVD2452V with SLR = 0) over recommended operating conditions. All typical values are at 25°C and supply voltage of $V_{CC} = 5\text{ V}$, $V_{IO} = 3.3\text{ V}$, unless otherwise noted. (1)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|--------------------------|------------------------------------|---|--|-----|-----|-----|---------------|
| Driver | | | | | | | |
| t_r, t_f | Differential output rise/fall time | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 1 | 5 | 7 | ns |
| | | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 1 | 5 | 6 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | $R_L = 54\ \Omega$, $C_L = 50\text{ pF}$ See 6-3 | $V_{IO} = 3\text{ V to }3.6\text{ V}$, $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 5 | 11 | 19 | ns |
| | | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}$, $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | 7 | 12 | 22 | ns |
| | | | $V_{IO} = 3\text{ V to }3.6\text{ V}$, $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 4 | 8 | 15 | ns |
| | | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}$, $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | 6 | 10 | 19 | ns |
| | | | $V_{CC} = 3\text{ to }3.6\text{ V}$, Typical at 3.3 V | | 1 | 3 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | | $V_{CC} = 4.5\text{ to }5.5\text{ V}$, Typical at 5 V | | 1 | 3 | ns |
| | | | | | | | |
| t_{PHZ}, t_{PLZ} | Disable time | $RE = X$ | | | 14 | 30 | ns |
| t_{PZH}, t_{PZL} | Enable time | $RE = 0\text{ V}$; $V_{IO} = 1.65\text{ V to }1.95\text{ V}$, 2.25 V to 2.75 V $RE = 0\text{ V}$; $V_{IO} = 3\text{ V to }V_{CC}\text{ V}$ $RE = V_{IO}$ | See 6-4 and 6-5 | | 20 | 35 | ns |
| | | | | | 15 | 32 | ns |
| | | | | | 2.5 | 4.5 | μs |
| t_{SHDN} | Time to shutdown | $RE = V_{IO}$ | | 50 | | 500 | ns |
| Receiver | | | | | | | |
| t_r, t_f | Output rise/fall time | | See 6-6 | | 1.5 | 6 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | $C_L = 15\text{ pF}$ | $V_{IO} = 3\text{ V to }3.6\text{ V}$, See 6-6 | 25 | 33 | 58 | ns |
| t_{PHL}, t_{PLH} | Propagation delay | | $V_{IO} = 1.65\text{ V to }1.95\text{ V}$, See 6-6 | 25 | 35 | 60 | ns |
| $t_{SK(P)}$ | Pulse skew, $ t_{PHL} - t_{PLH} $ | $C_L = 15\text{ pF}$ | See 6-6 | | 0.5 | 5 | ns |
| t_{PHZ}, t_{PLZ} | Disable time | $DE = X$ | | | 12 | 25 | ns |
| $t_{PZH(1)}, t_{PZL(1)}$ | Enable time | $DE = V_{IO}$ | $V_{IO} = 1.65\text{ V to }1.95\text{ V}$, See 6-7 | | 50 | 82 | ns |
| | | | $V_{IO} = 3\text{ V to }3.6\text{ V}$, See 6-7 | | 50 | 75 | ns |
| $t_{PZH(2)}, t_{PZL(2)}$ | Enable time | $DE = 0\text{ V}$ | See 6-8 | | 2.8 | 5 | μs |
| $t_{D(OFS)}$ | Delay to enter fail-safe operation | $C_L = 15\text{ pF}$ | See 6-9 | 7 | 10 | 18 | μs |
| $t_{D(FSO)}$ | Delay to exit fail-safe operation | | | 19 | 32 | 50 | ns |
| t_{SHDN} | Time to shutdown | $DE = 0\text{ V}$ | See 6-8 | 50 | | 500 | ns |

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

5.12 Typical Characteristics

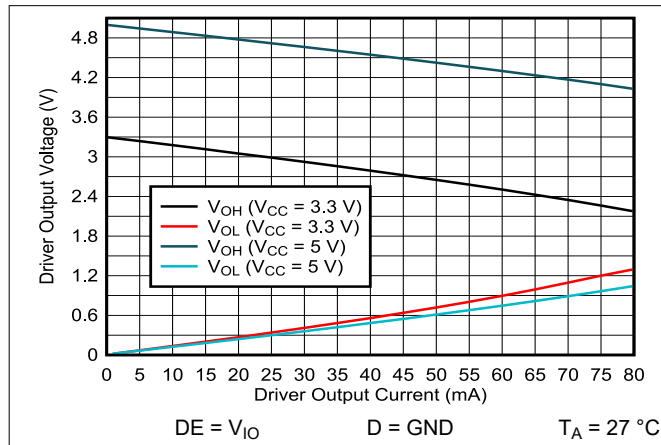


图 5-1. Driver Output Voltage vs Driver Output Current

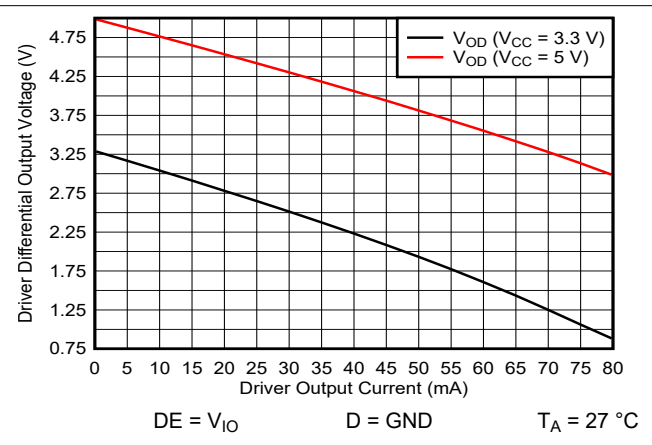


图 5-2. Driver Differential Output voltage vs Driver Output Current

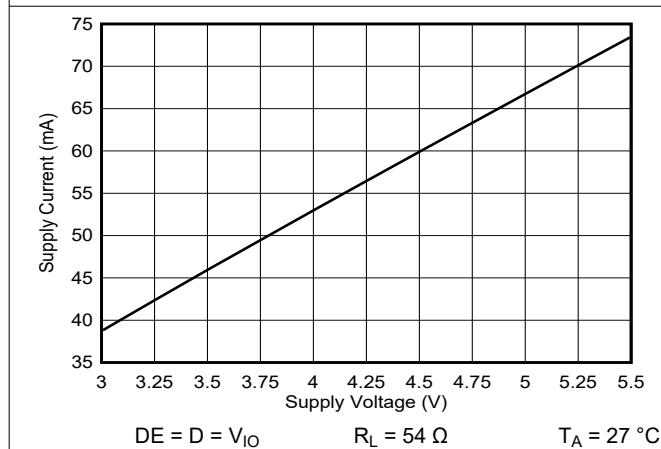


图 5-3. Supply Current vs Supply Voltage

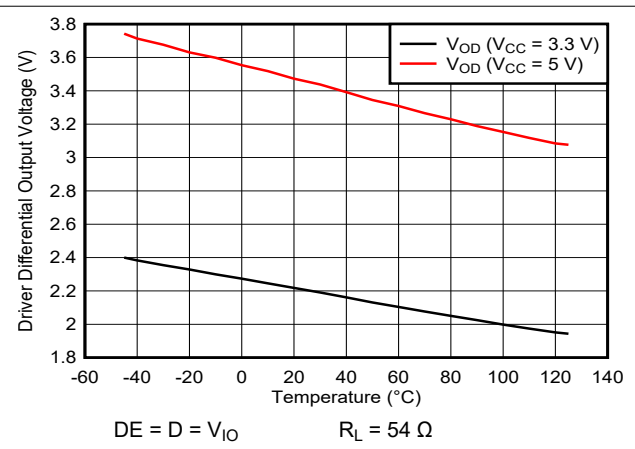


图 5-4. Driver differential output voltage vs Temperature

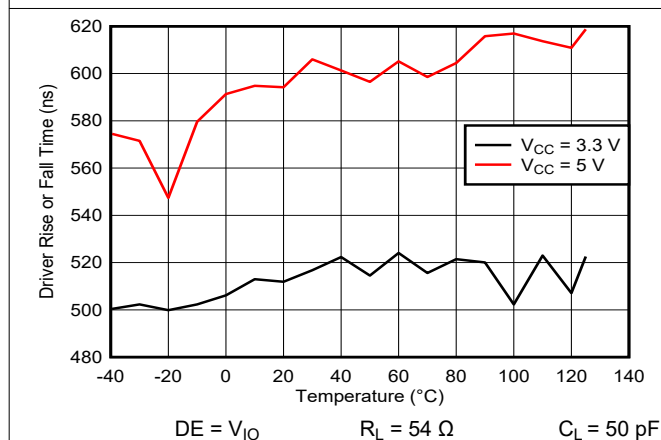


图 5-5. THVD2410V 250kbps Driver rise or fall time vs Temperature

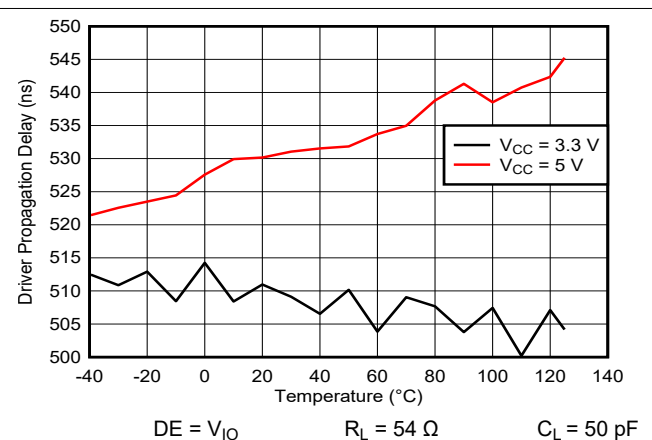
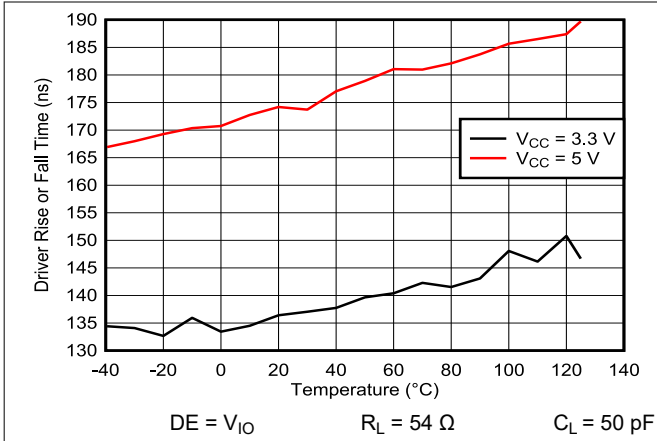
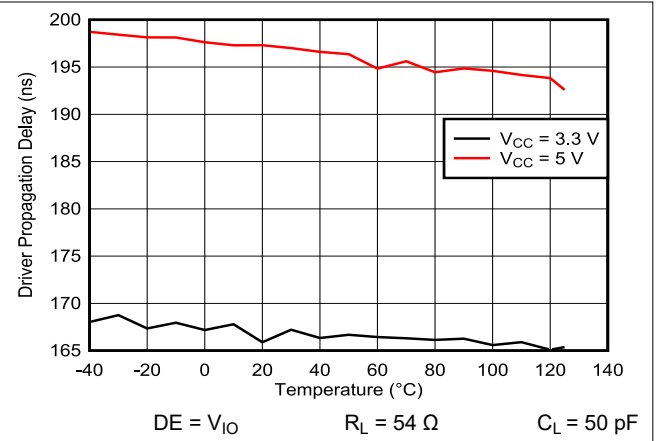


图 5-6. THVD2410V 250kbps Driver propagation delay vs Temperature

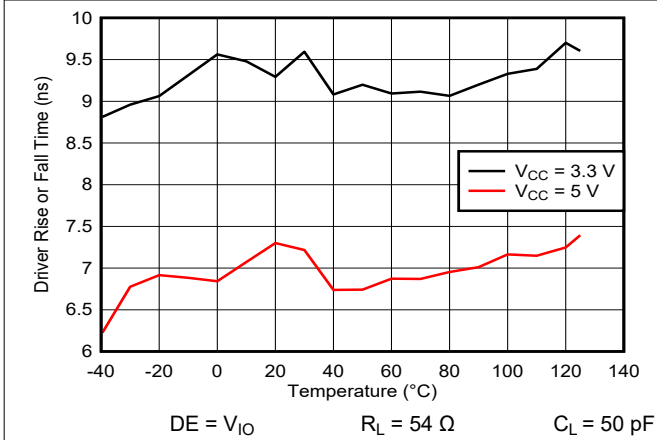
5.12 Typical Characteristics (continued)



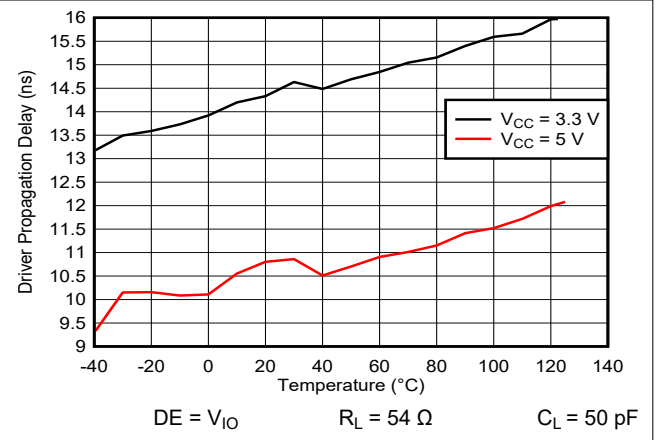
5-7. THVD2410V 1Mbps Driver rise or fall time vs Temperature



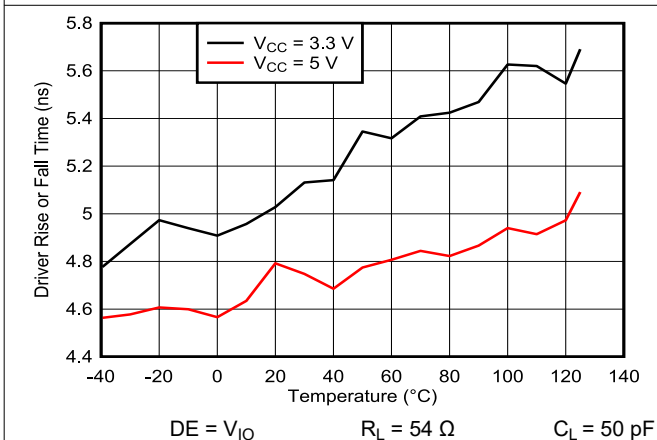
5-8. THVD2410V 1Mbps Driver propagation delay vs Temperature



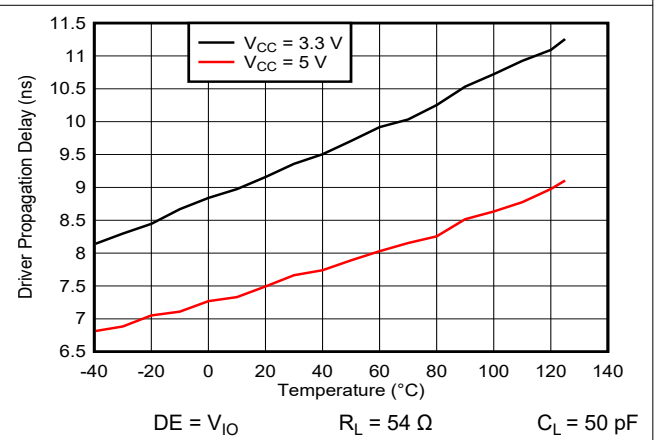
5-9. THVD2450V 20Mbps Driver rise or fall time vs Temperature



5-10. THVD2450V 20Mbps Driver propagation delay vs Temperature

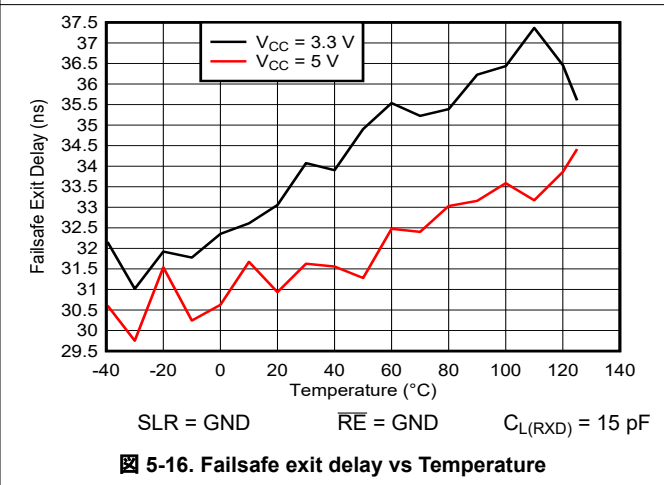
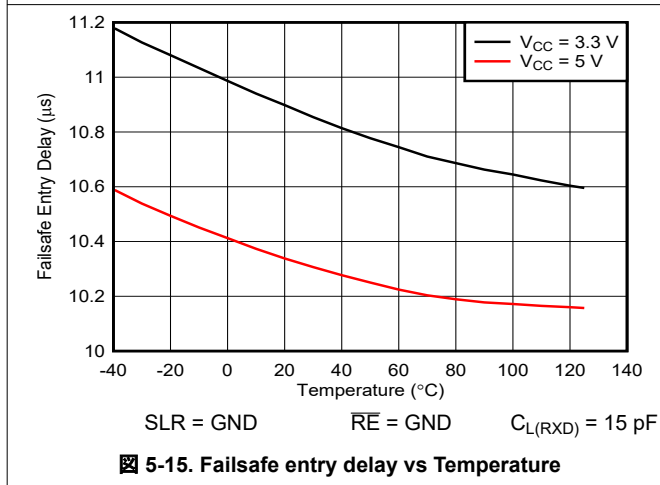
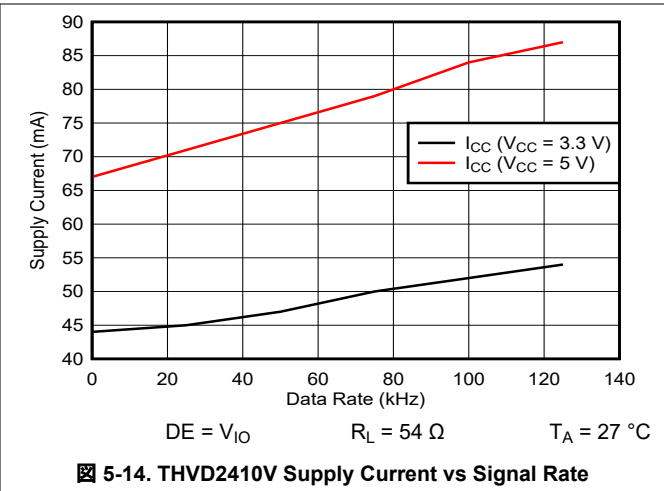
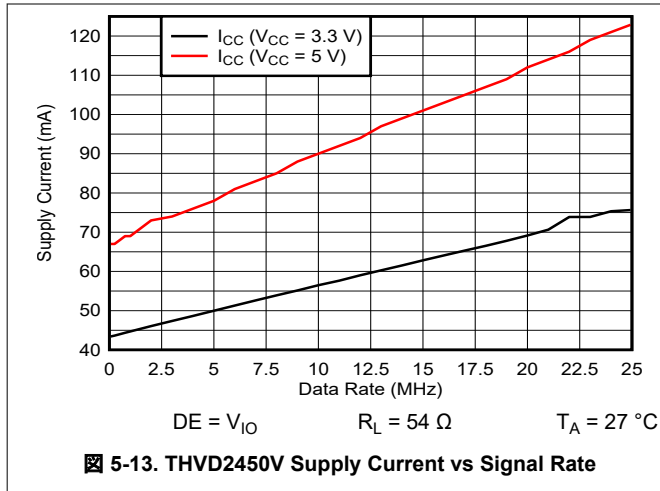


5-11. THVD2450V 50Mbps Driver rise or fall time vs Temperature



5-12. THVD2450V 50Mbps Driver propagation delay vs Temperature

5.12 Typical Characteristics (continued)



6 Parameter Measurement Information

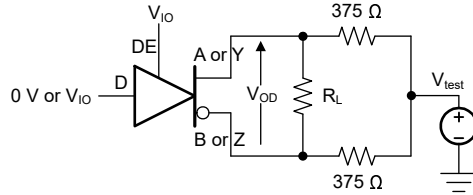


Figure 6-1. Measurement of Driver Differential Output Voltage With Common-Mode Load

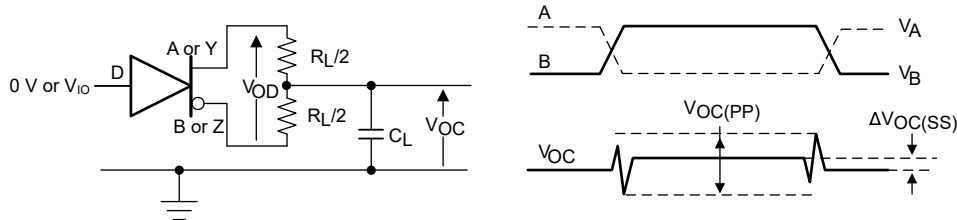


Figure 6-2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

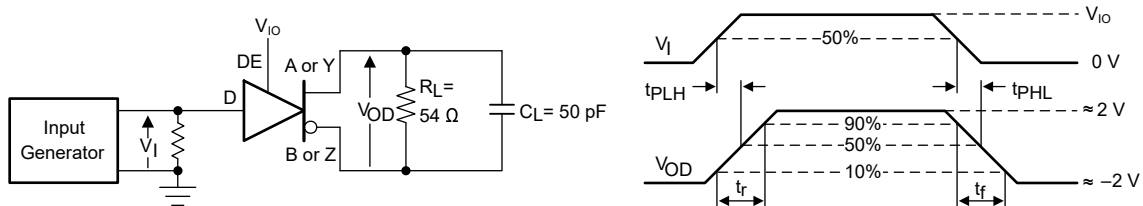


Figure 6-3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

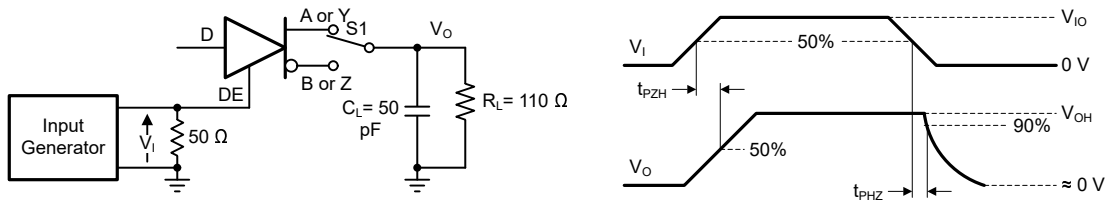


Figure 6-4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

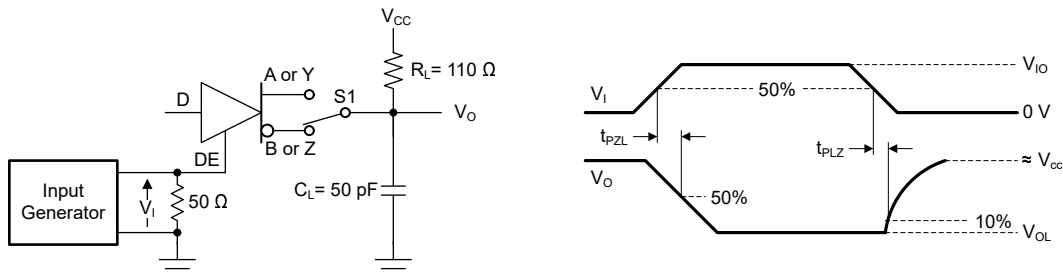


Figure 6-5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

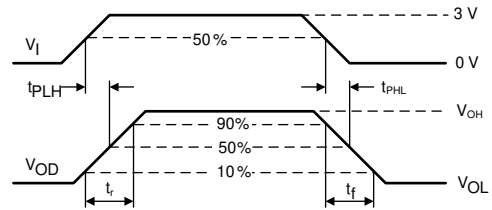
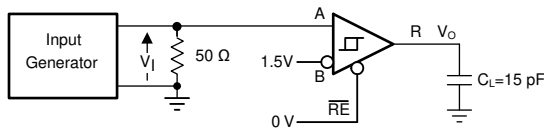


Figure 6-6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

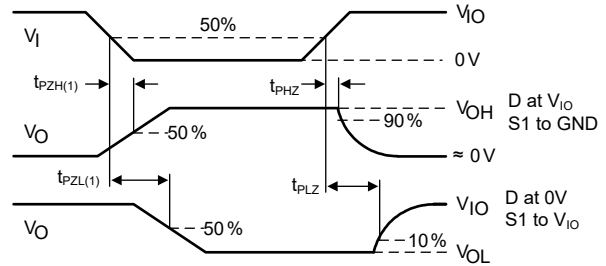
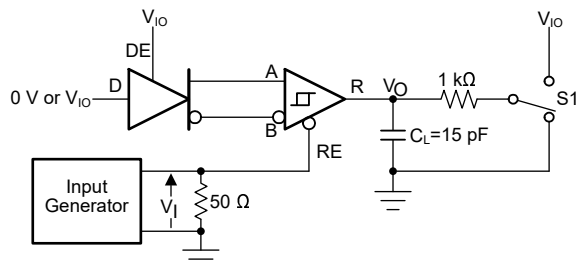


Figure 6-7. Measurement of Receiver Enable/Disable Times With Driver Enabled

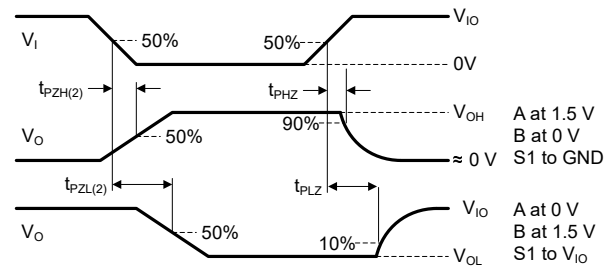
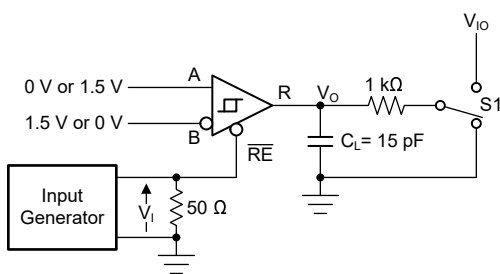


Figure 6-8. Measurement of Receiver Enable Times With Driver Disabled

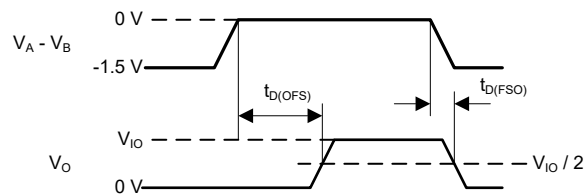
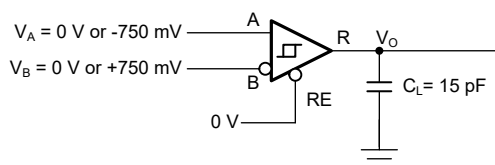


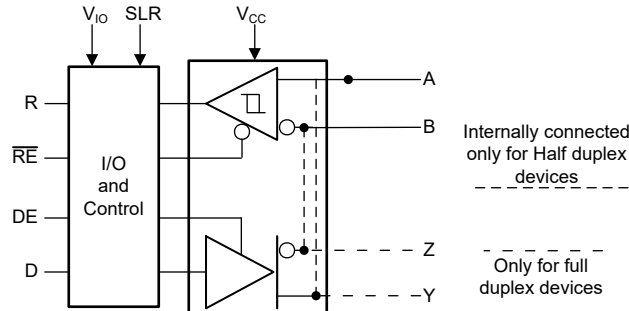
Figure 6-9. Measurement of Fail-Safe Delay

7 Detailed Description

7.1 Overview

THVD24xxV are $\pm 70\text{V}$ bus fault-protected, $\pm 25\text{V}$ common-mode voltage range capable half and full-duplex RS-485 transceivers. The devices have active-high driver enable and active-low receiver enable logic. Each device has SLR pin which allows it to be used for two different maximum speed settings. This is beneficial as customers can qualify one device and use it in two different end-applications. The devices also have flexible I/O supply pin V_{IO} which enables digital interface voltage range, from 1.65V to 5.5V, different from bus voltage supply 3V to 5.5V.

7.2 Functional Block Diagrams



7-1. THVD2410 and THVD2450 Block Diagram

7.3 Feature Description

7.3.1 $\pm 70\text{ V}$ Fault Protection

THVD24xxV transceivers have extended bus fault protection compared to standard RS-485 devices. Transceivers that operate in rugged industrial environments are often exposed to voltage transients greater than the -7 V to $+12\text{ V}$ defined by the TIA/EIA-485A standard. To protect against such conditions, the generic RS-485 devices with lower absolute maximum ratings requires expensive external protection components. To simplify system design and reduce overall system cost, THVD24xxV devices are protected up to $\pm 70\text{ V}$ without the need for any external components.

7.3.2 Integrated IEC ESD and EFT Protection

Internal ESD protection circuits protect the transceivers against electrostatic discharges (ESD) according to IEC 61000-4-2 of up to $\pm 15\text{ kV}$ contact and air discharge (for half-duplex devices) and up to $\pm 8\text{ kV}$ contact and air discharge (for full-duplex devices). Bus structures also protect against electrical fast transients (EFT) according to IEC 61000-4-4 for up to $\pm 4\text{ kV}$. With careful system design, integrated bus structures can enable EFT Criterion A at the system level (minimum to no data loss when transient noise is present).

7.3.3 Driver Overvoltage and Overcurrent Protection

The THVD24xxV drivers are protected against any DC supply shorts in the range of -70 V to $+70\text{ V}$. The devices internally limit the short circuit current to $\pm 250\text{ mA}$ in order to comply with the TIA/EIA-485A standard. In addition, a fold-back current limiting circuit further reduces the driver short circuit current to less than $\pm 5\text{ mA}$ if the output fault voltage exceeds $|\pm 25\text{ V}|$.

All devices feature thermal shutdown protection that disables the driver and the receiver if the junction temperature exceeds the T_{SHDN} threshold due to excessive power dissipation.

7.3.4 Enhanced Receiver Noise Immunity

The differential receivers of THVD24xxV feature fully symmetric thresholds to maintain duty cycle of the signal even with small input amplitudes. In addition, 250 mV (typical) hysteresis provides noise immunity. When the device is in slew rate limited mode of 250 kbps , typical 700 ns of glitch filter in receiver signal chain prevents high frequency noise pulses from the bus to appear on R pin.

7.3.5 Receiver Fail-Safe Operation

The receivers are fail-safe 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 $|V_{TH_FSH}|$.

7.3.6 Low-Power Shutdown Mode

Driving \overline{DE} low and \overline{RE} high for longer than 500 ns puts the devices into the shutdown mode. If either DE goes high or \overline{RE} goes low, the counters reset. The devices does not enter the shutdown mode if the enable pins are in disable state for less than 50 ns. This feature prevents the devices from accidentally going into shutdown mode due to skew between DE and \overline{RE} .

7.4 Device Functional Modes

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

表 7-1. Driver Function Table

| INPUT | ENABLE | OUTPUTS | | FUNCTION |
|-------|--------|---------|-----|------------------------------------|
| D | DE | A/Y | B/Z | |
| H | H | H | L | Actively drive bus high |
| L | H | L | H | Actively drive bus low |
| X | L | Z | Z | Driver disabled |
| X | OPEN | Z | Z | Driver disabled by default |
| OPEN | H | H | L | Actively drive bus high by default |

When the receiver enable pin, \overline{RE} , is logic low, the receiver is enabled. When the differential input voltage defined as $V_{ID} = V_A - V_B$ is higher than the positive input threshold, V_{TH+} , the receiver output, R, turns high. When V_{ID} is lower than the negative input threshold, V_{TH-} , the receiver output, R, turns low. If V_{ID} is between V_{TH+} and V_{TH-} the output is indeterminate.

When \overline{RE} is logic high or left open, the receiver output is high-impedance and the magnitude and polarity of V_{ID} are irrelevant. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), the bus lines are shorted to one another (short-circuit), or the bus is not actively driven (idle bus).

表 7-2. 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 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 |

表 7-3 shows SLR (slew rate select) pin functionality. SLR has intergated pull-down, so the device remains in higher speed mode until SLR is pulled high which limits the slew rate and puts the device in slower speed mode.

表 7-3. SLR pin control

| Device | Functionality w.r.t SLR pin |
|----------------------|---|
| THVD2410V, THVD2412V | SLR = Low or floating: Both transmitter (TX) and receiver (RX) maximum speed is 1 Mbps SLR = High: Both TX and RX maximum speed is limited to 250 kbps |
| THVD2450V, THVD2452V | SLR = Low or floating: Both transmitter (TX) and receiver (RX) maximum speed is 50 Mbps SLR = High: Both TX and RX maximum speed is limited to 20 Mbps |

Table shows the device behavior in undervoltage scenarios:

表 7-4. Supply Function Table

| V_{CC} | V_{IO} | Driver Output | Receiver Output |
|------------------------------|------------------------------|-------------------------------|---------------------------------------|
| $> UV_{VCC}(\text{rising})$ | $> UV_{VIO}(\text{rising})$ | Determined by DE and D inputs | Determined by \overline{RE} and A-B |
| $< UV_{VCC}(\text{falling})$ | $> UV_{VIO}(\text{rising})$ | High impedance | High impedance |
| $> UV_{VCC}(\text{rising})$ | $< UV_{VIO}(\text{falling})$ | High impedance | High impedance |
| $< UV_{VCC}(\text{falling})$ | $< UV_{VIO}(\text{falling})$ | High impedance | High impedance |

8 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

THVD24xxV are fault-protected, half- and full-duplex RS-485 transceivers commonly used for asynchronous data transmissions. For these devices, the driver and receiver enable pins allow for the configuration of different operating modes.

8.2 Typical Application

An RS-485 bus consists of multiple transceivers connecting in parallel to a bus cable. To eliminate line reflections, each cable end is terminated with a termination resistor, R_T , whose value matches the characteristic impedance, Z_0 , of the cable. This method, known as parallel termination, generally allows for higher data rates over longer cable length.

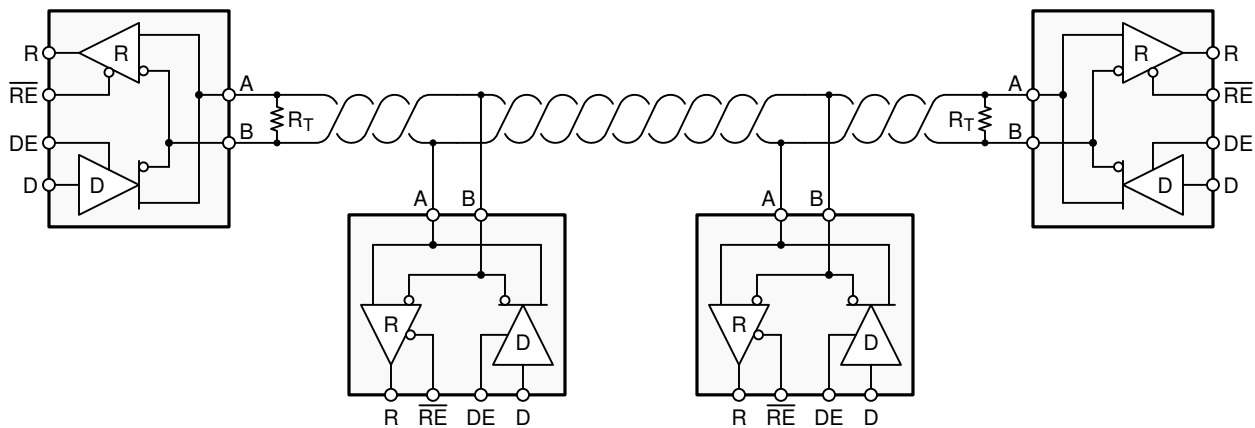


図 8-1. Typical RS-485 Network With Half-Duplex Transceivers

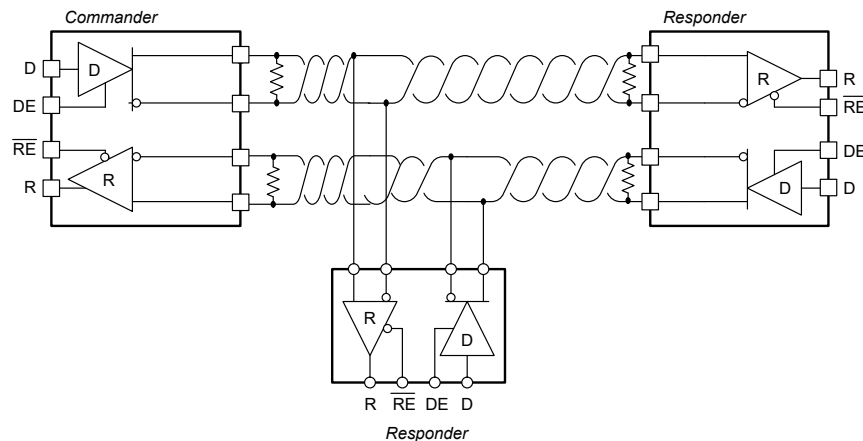


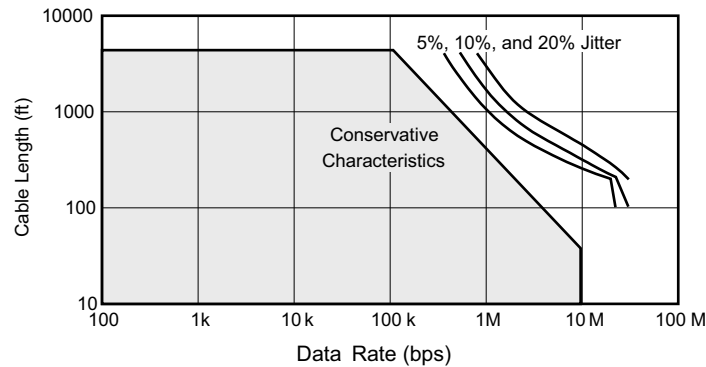
図 8-2. Typical RS-485 Network with Full-Duplex transceivers

8.2.1 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.

8.2.1.1 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%.



8-3. Cable Length vs Data Rate Characteristic

Even higher data rates are achievable (that is, 50 Mbps for the THVD24xxV) in cases where the interconnect is short enough (or has suitably low attenuation at signal frequencies) to not degrade the data.

8.2.1.2 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 of varying phase 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 式 1.

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

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

8.2.1.3 Bus Loading

The RS-485 standard specifies that a compliant driver must be able to drive 32 unit loads (UL), where 1 unit load represents a load impedance of approximately 12 k Ω . Because the THVD24xxV devices consist of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible for a limited common mode range of - 7 V to 12 V.

8.2.1.4 Transient Protection

The bus pins of the THVD24xxV transceivers include on-chip ESD protection against ± 16 -kV HBM and ± 15 -kV IEC 61000-4-2 contact discharge for half-duplex devices ± 8 -kV for full-duplex devices. 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.

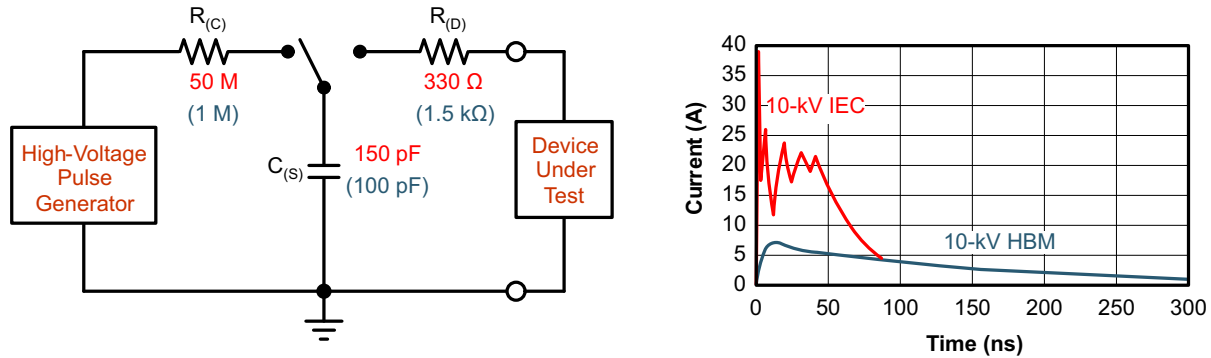


Figure 8-4. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

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. Designers may choose to implement protection against longer duration transients, typically referred to as surge transients.

EFTs are generally caused by relay-contact bounce or the interruption of inductive loads. Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuit switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems.

Figure 8-5 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The left side of the diagram shows the relative pulse-power for a 0.5-kV surge transient and 4-kV EFT transient, both of which exceeds 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 right side of the diagram shows the pulse power of a 6-kV surge transient, relative to the same 0.5-kV surge transient. 6-kV surge transients are may occur in power generation and power-grid systems.

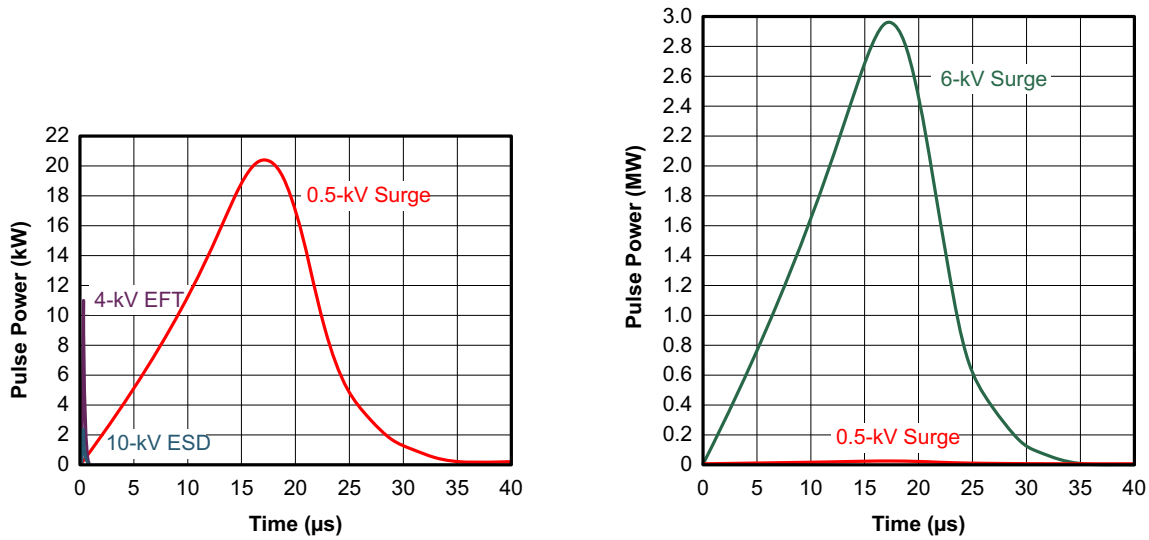


Figure 8-5. Power Comparison of ESD, EFT, and Surge Transients

For surge transients, high-energy content is characterized by long pulse duration and slow decaying pulse power. The electrical energy of a transient that is dumped into the internal protection cells of a transceiver is converted into thermal energy, which heats and destroys the protection cells, thus destroying the transceiver. Figure 8-6 shows the large differences in transient energies for single ESD, EFT, surge transients, and an EFT pulse train that is commonly applied during compliance testing.

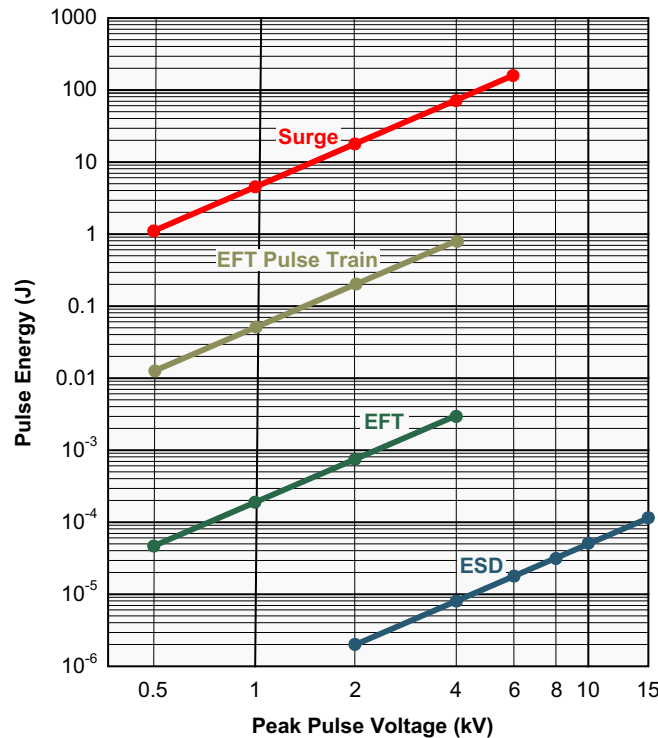
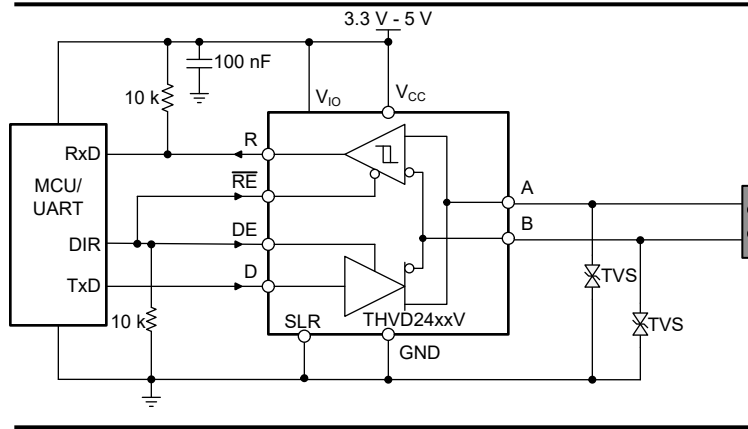


Figure 8-6. Comparison of Transient Energies

8.2.2 Detailed Design Procedure

☒ 8-7 suggests a protection circuit against 1kV surge (IEC 61000-4-5) transients. 表 8-1 shows the associated bill of materials. SMAJ30CA TVS diodes are rated to operate up to 30V. This makes sure the protection diodes do not conduct if a direct RS-485 bus shorts to 24V DC industrial power rail.



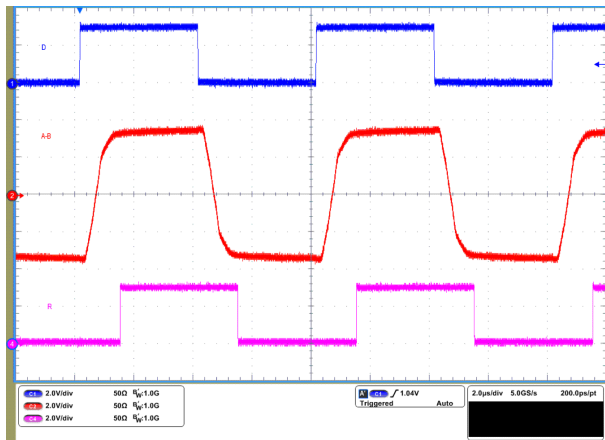
☒ 8-7. Transient Protection Against Surge Transients for Half-Duplex Devices

表 8-1. Components List

| DEVICE | FUNCTION | ORDER NUMBER | MANUFACTURER ⁽¹⁾ |
|--------|---|------------------------|-----------------------------|
| XCVR | RS-485 transceiver | THVD2410V or THVD2450V | TI |
| TVS | Bidirectional 400W transient suppressor | SMAJ30CA | Littelfuse |

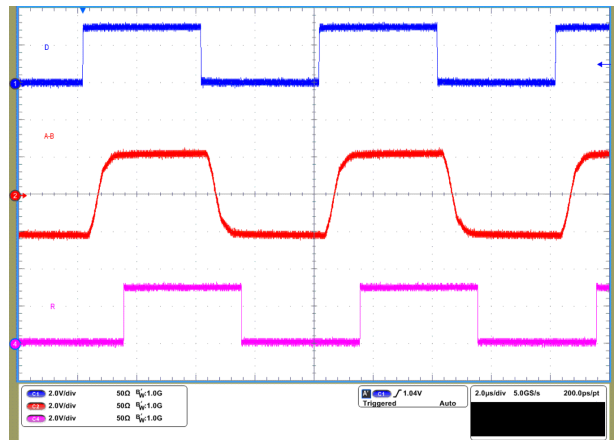
(1) See [Third-Party Products](#)

8.2.3 Application Curves



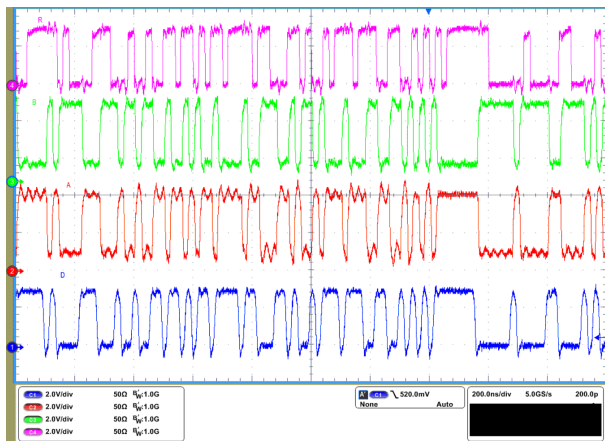
50% duty square wave on D pin at 250 kbps
SLR = V_{IO} $R_L = 54 \Omega$ DE = V_{IO}

8-8. THVD2410V Waveforms at $V_{CC} = 5 V$



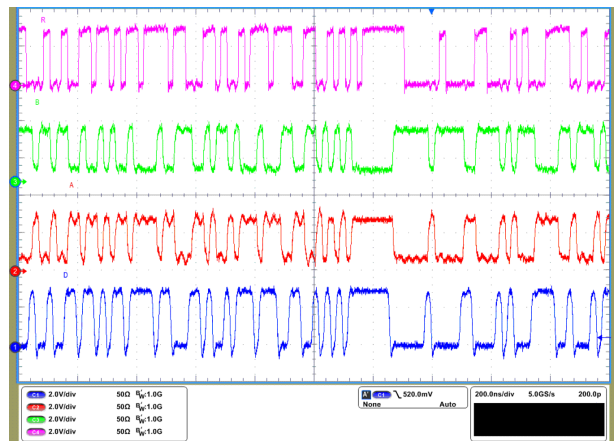
50% duty square wave on D pin at 250 kbps
SLR = V_{IO} $R_L = 54 \Omega$ DE = V_{IO}

8-9. THVD2410V Waveforms at $V_{CC} = 3.3 V$



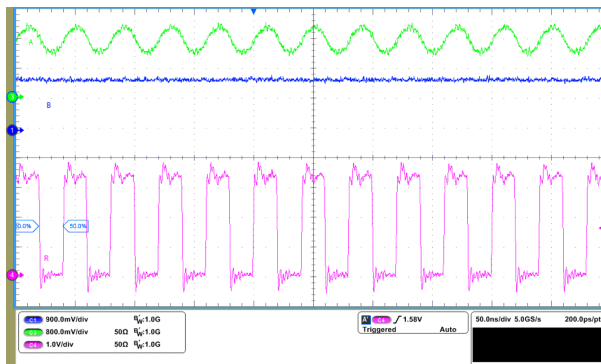
Random (PRBS7) data on D pin at 50 Mbps
SLR = GND $R_L = 54 \Omega$ DE = V_{IO}

8-10. THVD2450V Waveforms at $V_{CC} = 5 V$



Random (PRBS7) data on D pin at 50 Mbps
SLR = GND $R_L = 54 \Omega$ DE = V_{IO}

8-11. THVD2450V Waveforms at $V_{CC} = 3.3 V$



A pin given $\pm 200\text{mV } V_{ID}$ with DC offset of 1.5 V
 $\overline{RE} = \text{GND}$ B pin at 1.5 V

8-12. THVD2450V Receiver Waveform with $\pm 200 \text{ mV } V_{ID}$

8.3 Power Supply Recommendations

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

8.4 Layout

8.4.1 Layout Guidelines

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

1. Place the protection circuitry close to the bus connector to prevent noise transients from propagating across the board.
2. Use V_{CC} and ground planes to provide low inductance. Note that high-frequency currents tend to follow the path of least impedance and not the path of least resistance.
3. Design the protection components into the direction of the signal path. Do not force the transient currents to divert from the signal path to reach the protection device.
4. Apply 100nF to 220nF decoupling capacitors as close as possible to the V_{CC} and V_{IO} pins of transceiver, UART and/or controller ICs on the board.
5. Use at least two vias for V_{CC} and ground connections of decoupling capacitors and protection devices to minimize effective via inductance.
6. Use 1k Ω to 10k Ω pull-up and pull-down resistors for enable/SLR lines to limit noise currents in these lines during transient events.
7. Insert pulse-proof resistors into the A/Y and B/Z bus lines if the TVS clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors limit the residual clamping current into the transceiver and prevent it from latching up.

8.4.2 Layout Example

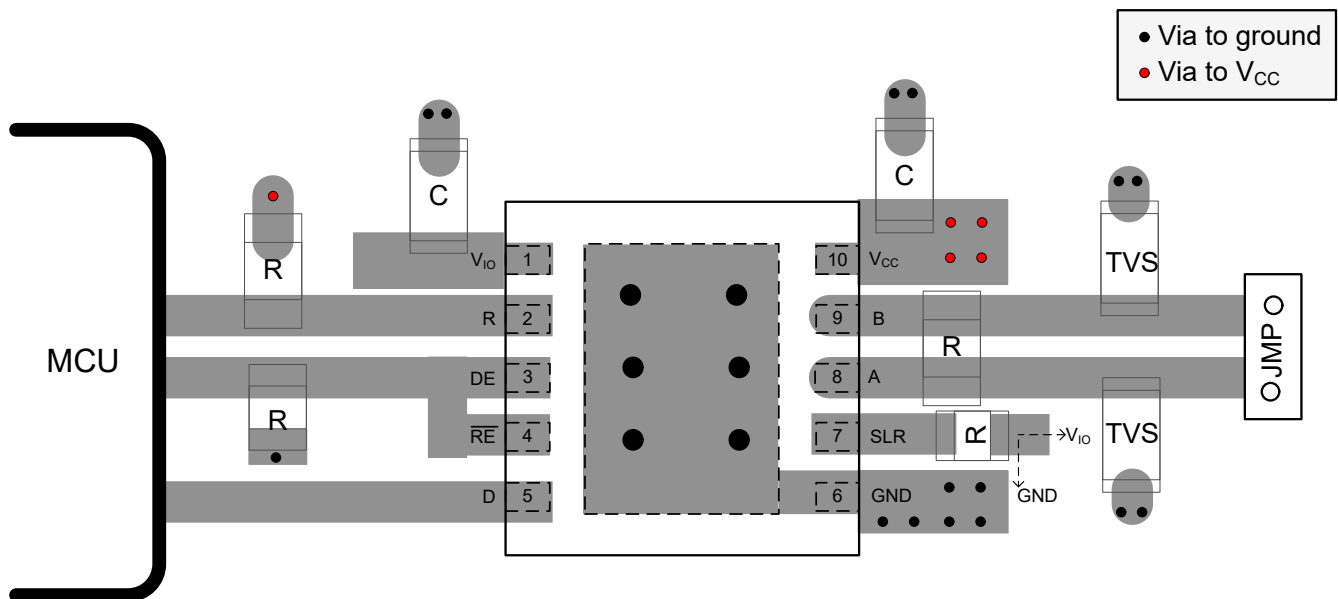


図 8-13. Half-Duplex Layout Example

9 Device and Documentation Support

9.1 Device Support

9.1.1 サード・パーティ製品に関する免責事項

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9.6 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

10 Revision History

| Changes from Revision A (February 2023) to Revision B (March 2024) | Page |
|--|------|
| • 「製品情報」表の THVD2412V および THVD2452V から「製品プレビュー」の注を削除..... | 1 |
| • Changed output A and B to: A/Y and B/Z in the <i>Device Functional Modes</i> | 20 |

| Changes from Revision * (December 2022) to Revision A (February 2023) | Page |
|---|------|
| • 「パッケージ情報」表の THVD2410V から「製品プレビュー」の注を削除..... | 1 |

11 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.

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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 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| THVD2410VDRCR | ACTIVE | VSON | DRC | 10 | 5000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2410 | Samples |
| THVD2412VDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2412V | Samples |
| THVD2450VDRCR | ACTIVE | VSON | DRC | 10 | 5000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2450 | Samples |
| THVD2452VDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2452V | 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.

OBSELETE: 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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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| THVD2410VDRCR | VSON | DRC | 10 | 5000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| THVD2412VDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| THVD2450VDRCR | VSON | DRC | 10 | 5000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| THVD2452VDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| THVD2410VDRCR | VSON | DRC | 10 | 5000 | 367.0 | 367.0 | 35.0 |
| THVD2412VDR | SOIC | D | 14 | 2500 | 353.0 | 353.0 | 32.0 |
| THVD2450VDRCR | VSON | DRC | 10 | 5000 | 367.0 | 367.0 | 35.0 |
| THVD2452VDR | SOIC | D | 14 | 2500 | 353.0 | 353.0 | 32.0 |



D0014A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. 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 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

EXAMPLE BOARD LAYOUT

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

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

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4220718/A 09/2016

NOTES: (continued)

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

GENERIC PACKAGE VIEW

DRC 10

VSON - 1 mm max height

3 x 3, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

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



4226193/A

EXAMPLE BOARD LAYOUT

DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

4218878/B 07/2018

NOTES: (continued)

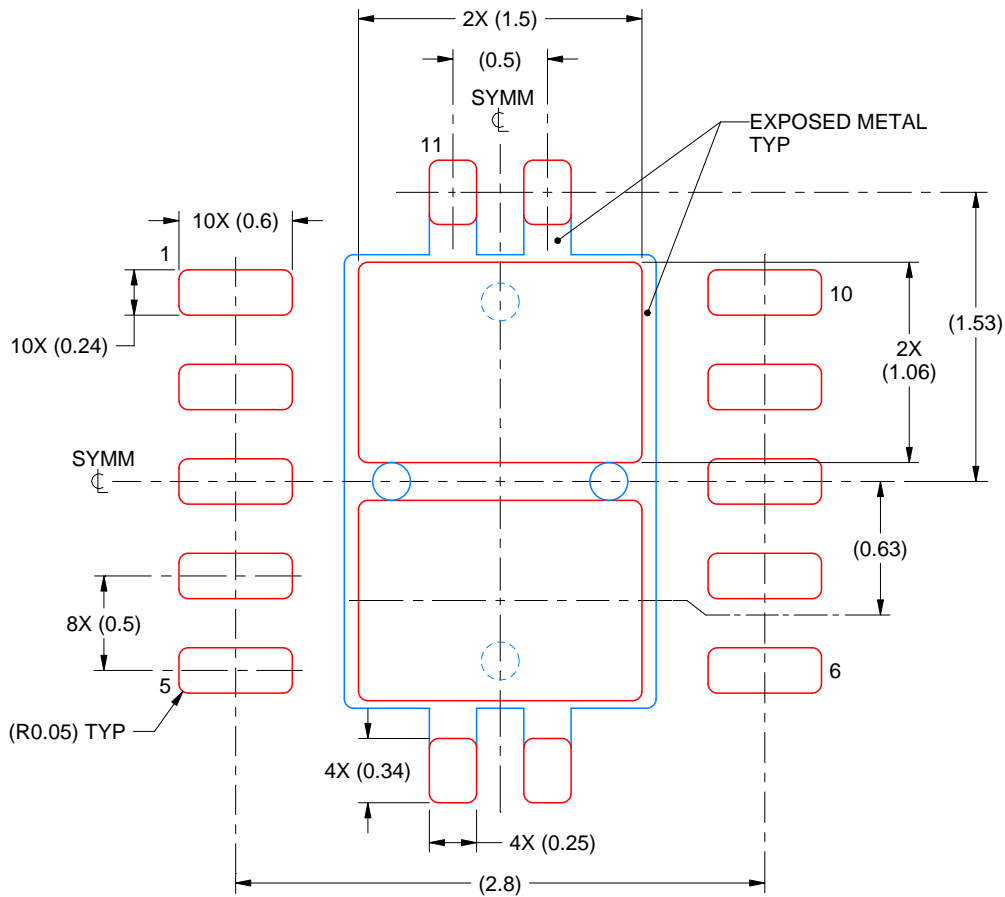
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

EXAMPLE STENCIL DESIGN

DRC0010J

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

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

4218878/B 07/2018

NOTES: (continued)

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

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