

# TPS22996H-Q1 5.5V、4A、13mΩ オン抵抗、デュアル チャネル車載用ロード スイッチ

## 1 特長

- 統合型デュアル チャネル負荷スイッチ
- 入力電圧範囲:  $0.6V \sim V_{BIAS}$
- $V_{BIAS}$  電圧範囲:  $2.5V \sim 5.5V$
- オン抵抗:
  - $R_{ON} = 13m\Omega$  (標準値)  
( $V_{IN} = 0.6V \sim 5V$ ,  $V_{BIAS} = 5V$ )
- チャンネルごとに 4A の最大連続スイッチング電流
- 静止電流:
  - 18 $\mu A$  (標準値、両チャンネル)  
( $V_{IN} = V_{BIAS} = 5V$ )
  - 13 $\mu A$  (標準値、単一チャンネル)  
( $V_{IN} = V_{BIAS} = 5V$ )
- 耐湿性:
  - 以下の条件において、デバイスは機能 (オン、オフ、保護) を維持しますが、タイミング仕様は影響を受けます。
    - グランドへ 100k $\Omega$  短絡
    - 電源へ 100k $\Omega$  短絡
- 制御入力スレッシュホールドにより、1.2V、1.8V、2.5V、3.3V ロジックを使用可能
- 立ち上がり時間を設定可能
- サーマル シャットダウン
- クイック出力放電 (QOD)

## 2 アプリケーション

- インフォテインメント
- クラスタ
- 先進運転支援システム (ADAS)

## 3 概要

TPS22996H-Q1 は、ターンオン制御付きのデュアル チャネル ロード スイッチです。入力電圧範囲  $0.6V \sim 5.5V$  で動作する 2 つの N チャネル MOSFET を備えており、各チャンネル最大 4A の連続電流をサポートできます。各スイッチは、低電圧制御信号と直接インターフェイス可能なオン入力とオフ入力 (ON1 および ON2) により独立して制御されます。このデバイスは、接合部温度がスレッシュホールドを超えたときにサーマル シャットダウンでスイッチを切断できます。接合部温度が安全範囲で安定化すると、スイッチが再びオンになります。このデバイスは、スイッチがオフになったときクイック出力放電を行えるように、230 $\Omega$  のオンチップ負荷抵抗を備えています。

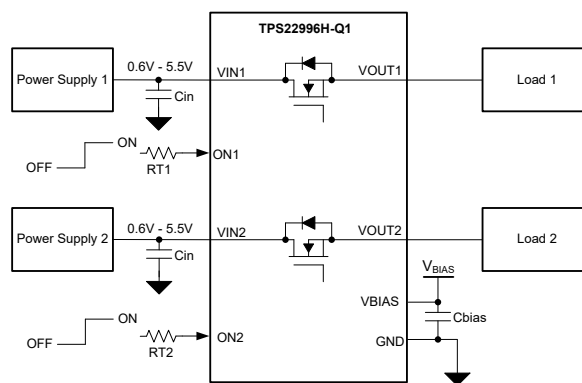
TPS22996H-Q1 のピンは高湿度条件に耐性があるため、デバイスはどのピンからでも GND や電源に対して 100k $\Omega$  の短絡状態で機能できます。

TPS22996H-Q1 は、省スペースの  $2.1mm \times 1.2mm$  8-DYC パッケージで供給されます。周囲温度  $-40^{\circ}C \sim 125^{\circ}C$  での動作が規定されています。

### パッケージ情報

| 部品番号      | パッケージ <sup>(1)</sup> | パッケージ サイズ <sup>(2)</sup> |
|-----------|----------------------|--------------------------|
| TPS22996H | DYC (SOT, 8)         | $2.1mm \times 1.2mm$     |

- 利用可能なすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。
- パッケージ サイズ (長さ  $\times$  幅) は公称値であり、該当する場合はピンも含まれます。



アプリケーション回路



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## 4 Pin Configuration and Functions

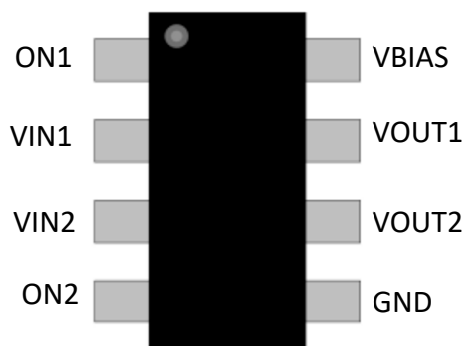


図 4-1. DYC Package, 8-Pin SOT (Top View)

表 4-1. Pin Functions

| PIN |       | I/O    | DESCRIPTION                                                                                                                                                                                                                                                                                   |
|-----|-------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NO. | NAME  |        |                                                                                                                                                                                                                                                                                               |
| 1   | ON1   | Input  | Active-high switch 1 control input. Connect series resistor to set Slew Rate. Do not leave floating. See <a href="#">セクション 7.3.7</a> for more information.                                                                                                                                    |
| 2   | VIN1  | Input  | Switch 1 input. Recommended voltage range for these pins for optimal $R_{ON}$ performance is 0.6V to $V_{BIAS}$ . Place an optional decoupling capacitor between these pins and GND to reduce $V_{IN1}$ dip during turnon of the channel. See <a href="#">セクション 8.2</a> for more information. |
| 3   | VIN2  | Input  | Switch 2 input. Recommended voltage range for these pins for optimal $R_{ON}$ performance is 0.6V to $V_{BIAS}$ . Place an optional decoupling capacitor between these pins and GND to reduce $V_{IN2}$ dip during turnon of the channel. See <a href="#">セクション 8.2</a> for more information. |
| 4   | ON2   | Input  | Active-high switch 2 control input. Connect series resistor to set slew rate. Do not leave floating. See <a href="#">セクション 7.3.7</a> for more information.                                                                                                                                    |
| 5   | GND   | —      | Device ground.                                                                                                                                                                                                                                                                                |
| 6   | VOUT2 | Output | Switch 2 output.                                                                                                                                                                                                                                                                              |
| 7   | VOUT1 | Output | Switch 1 output.                                                                                                                                                                                                                                                                              |
| 8   | VBIAS | Input  | Bias voltage. Power supply to the device. Recommended voltage range for this pin is 2.5V to 5.5V. See <a href="#">セクション 8.1</a> .                                                                                                                                                             |

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                      |                                                                        | MIN  | MAX | UNIT |
|----------------------|------------------------------------------------------------------------|------|-----|------|
| V <sub>IN1,2</sub>   | Input Voltage                                                          | −0.3 | 6   | V    |
| V <sub>OUT1,2</sub>  | Output Voltage                                                         | −0.3 | 6   | V    |
| V <sub>ON1,2</sub>   | ON Pin Voltage                                                         | −0.3 | 6   | V    |
| V <sub>BIAS</sub>    | Bias Voltage                                                           | −0.3 | 6   | V    |
| I <sub>MAX</sub>     | Maximum continuous current per channel                                 |      | 4   | A    |
| I <sub>MAX,PLS</sub> | Maximum pulsed current switch per channel, pulse <300μs, 3% duty cycle |      | 5.5 | A    |
| T <sub>J</sub>       | Junction temperature                                                   |      | 150 | °C   |
| T <sub>stg</sub>     | Storage temperature                                                    | −65  | 150 | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Rating* 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 Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 5.2 ESD Ratings

|                    |                         |                                                                                  | VALUE | UNIT |
|--------------------|-------------------------|----------------------------------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup><br>HBM ESD               | ±2000 | V    |
|                    |                         | Charged-device model (CDM), per AEC Q100-011 CDM ESD, VIN1,VIN2,VOUT1,VOUT2 pins | ±500  |      |
|                    |                         | Charged-device model (CDM), per AEC Q100-011 CDM ESD, ON1,ON2,VBIAS pins         | ±750  | V    |

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 5.3 Recommended Operating Conditions

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

|                     |                              | MIN | NOM | MAX               | UNIT |
|---------------------|------------------------------|-----|-----|-------------------|------|
| V <sub>IN1,2</sub>  | Input Voltage                | 0.6 |     | V <sub>BIAS</sub> | V    |
| V <sub>BIAS</sub>   | Bias Voltage                 | 2.5 |     | 5.5               | V    |
| V <sub>ON1,2</sub>  | ON Pin Voltage               | 0   |     | 5.5               | V    |
| V <sub>OUT1,2</sub> | Output Voltage               | 0   |     | V <sub>IN</sub>   | V    |
| V <sub>IH</sub>     | High-Level Input Voltage, ON | 1.2 |     | 5.5               | V    |
| V <sub>IL</sub>     | Low-Level Input Voltage, ON  | 0   |     | 0.5               | V    |
| T <sub>A</sub>      | Ambient Temperature          | −40 |     | 125               | °C   |

### 5.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TPS22996H-Q1 | UNIT |
|-------------------------------|----------------------------------------------|--------------|------|
|                               |                                              | DYC          |      |
|                               |                                              | 8 PINS       |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 108.7        | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 73.2         | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 17.5         | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 2.5          | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 17.3         | °C/W |

| THERMAL METRIC <sup>(1)</sup> |                                              | TPS22996H-Q1 | UNIT |
|-------------------------------|----------------------------------------------|--------------|------|
|                               |                                              | DYC          |      |
|                               |                                              | 8 PINS       |      |
| $R_{\theta JC(bot)}$          | 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.

## 5.5 Electrical Characteristics

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

| PARAMETER                   |                                                      | TEST CONDITIONS                                                                                                |                        | T <sub>A</sub>         | MIN            | TYP   | MAX | UNIT |    |
|-----------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------------|------------------------|----------------|-------|-----|------|----|
| Power Supplies and Currents |                                                      |                                                                                                                |                        |                        |                |       |     |      |    |
| I <sub>Q,VBIAS</sub>        | V <sub>BIAS</sub> Quiescent Current (Both channels)  | I <sub>OUT1</sub> = I <sub>OUT2</sub> = 0mA, V <sub>IN1,2</sub> = V <sub>ON1,2</sub> = 5V                      |                        | 25°C                   | 18             |       |     | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 85°C          | 18             |       | 22  | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 125°C         |                |       | 25  | μA   |    |
| I <sub>Q,VBIAS</sub>        | V <sub>BIAS</sub> Quiescent Current (Single-channel) | I <sub>OUT1</sub> = I <sub>OUT2</sub> = 0mA, V <sub>ON2</sub> = 0V, V <sub>IN1,2</sub> = V <sub>IN1</sub> = 5V |                        | 25°C                   | 13             |       |     | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 85°C          | 13             |       | 17  | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 125°C         |                |       | 19  | μA   |    |
| I <sub>SD,VBIAS</sub>       | V <sub>BIAS</sub> Shutdown Current                   | V <sub>ON1,2</sub> = 0V, V <sub>OUT1,2</sub> = 0V                                                              |                        | 25°C                   | 0.005          |       | 1   | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 85°C          | 0.005          |       | 1   | μA   |    |
|                             |                                                      |                                                                                                                |                        | -40°C to 125°C         | 0.005          |       | 1   | μA   |    |
| I <sub>SD,VIN</sub>         | V <sub>IN</sub> Shutdown Current (per channel)       | V <sub>ON</sub> = 0V, V <sub>OUT</sub> = 0V                                                                    |                        | V <sub>IN</sub> = 5V   | 25°C           | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 1    | μA |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 3.3V | 25°C           | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 1    | μA |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 1.8V | 25°C           | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 1    | μA |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 0.6V | 25°C           | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  | 0.002 |     | 0.8  | μA |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 1    | μA |
| I <sub>ON</sub>             | ON Pin Leakage Current                               |                                                                                                                | V <sub>ON</sub> = 5.5V | -40°C to 125°C         |                |       | 0.1 | μA   |    |
| Resistance Characteristics  |                                                      |                                                                                                                |                        |                        |                |       |     |      |    |
| R <sub>ON</sub>             | On-Resistance                                        | I <sub>OUT</sub> = -200mA                                                                                      |                        | V <sub>IN</sub> = 5V   | 25°C           | 13    |     | 15   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  |       |     | 18   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 22   | mΩ |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 3.3V | 25°C           | 13    |     | 15   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  |       |     | 18   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 22   | mΩ |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 1.8V | 25°C           | 13    |     | 15   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  |       |     | 18   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 22   | mΩ |
|                             |                                                      |                                                                                                                |                        | V <sub>IN</sub> = 0.6V | 25°C           | 13    |     | 15   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 85°C  |       |     | 18   | mΩ |
|                             |                                                      |                                                                                                                |                        |                        | -40°C to 125°C |       |     | 22   | mΩ |
| V <sub>ON,VIH</sub>         | VIH                                                  | V <sub>IN</sub> = 5V                                                                                           | V <sub>IN</sub> = 5V   | -55°C to 125°C         | 1.2            |       |     | V    |    |

## 5.5 Electrical Characteristics (続き)

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

| PARAMETER           |                             | TEST CONDITIONS                                               |                      | T <sub>A</sub> | MIN | TYP  | MAX | UNIT |
|---------------------|-----------------------------|---------------------------------------------------------------|----------------------|----------------|-----|------|-----|------|
| V <sub>ON,VIL</sub> | VIL                         | V <sub>IN</sub> = 5V                                          | V <sub>IN</sub> = 5V | -55°C to 125°C |     | 0.65 |     | V    |
| V <sub>ON,HYS</sub> | ON Pin Hysteresis           | V <sub>IN</sub> = 5V                                          |                      | -55°C to 125°C |     | 90   |     | mV   |
| R <sub>I</sub>      | Internal On Pin Resistance  | V <sub>ON</sub> = 5V                                          | V <sub>ON</sub> = 5V | -55°C to 125°C |     | 12.5 |     | kΩ   |
| R <sub>PD</sub>     | Output Pulldown Resistance  | V <sub>IN</sub> = V <sub>OUT</sub> = 5V, V <sub>ON</sub> = 0V |                      | -40°C to 125°C |     | 230  | 300 | Ω    |
| T <sub>SD</sub>     | Thermal Shutdown            | Junction Temperature Rising                                   |                      | -              |     | 175  |     | °C   |
| T <sub>SD,HYS</sub> | Thermal Shutdown Hysteresis | Junction Temperature Falling                                  |                      | -              |     | 20   |     | °C   |

## 5.6 Switching Characteristics

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

| PARAMETER                           |               | TEST CONDITIONS                                                         | MIN | TYP  | MAX | UNIT |
|-------------------------------------|---------------|-------------------------------------------------------------------------|-----|------|-----|------|
| <b>VIN = VON = VBIAS = 5V</b>       |               |                                                                         |     |      |     |      |
| t <sub>ON</sub>                     | Turn ON Time  | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 946  |     | μs   |
| t <sub>OFF</sub>                    | Turn OFF Time | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 2.1  |     | μs   |
| t <sub>R</sub>                      | Rise Time     | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 626  |     | μs   |
| t <sub>F</sub>                      | Fall Time     | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 2.1  |     | μs   |
| t <sub>D</sub>                      | Delay Time    | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 320  |     | μs   |
| <b>VIN = 0.6V, VON = VBIAS = 5V</b> |               |                                                                         |     |      |     |      |
| t <sub>ON</sub>                     | Turn ON Time  | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA, |     | 587  |     | μs   |
| t <sub>OFF</sub>                    | Turn OFF Time | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 2.1  |     | μs   |
| t <sub>R</sub>                      | Rise Time     | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 203  |     | μs   |
| t <sub>F</sub>                      | Fall Time     | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 2.52 |     | μs   |
| t <sub>D</sub>                      | Delay Time    | R <sub>L</sub> = 10Ω, C <sub>L</sub> = 0.1μF, I <sub>ON</sub> = 100 μA  |     | 384  |     | μs   |

## 5.7 Typical DC Characteristics

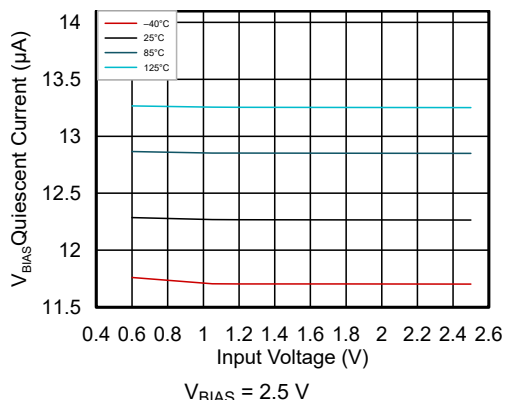


Figure 5-1.  $V_{BIAS}$  Quiescent Current vs Input Voltage Single Channel

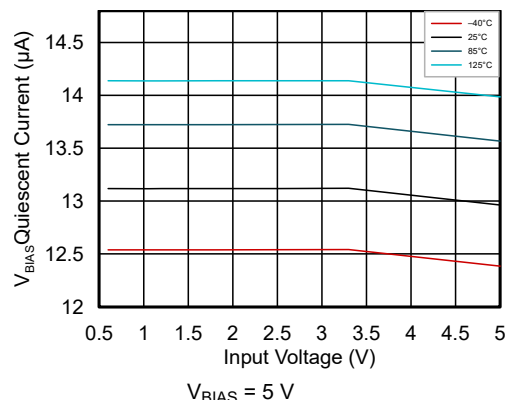


Figure 5-2.  $V_{BIAS}$  Quiescent Current vs Input Voltage Single Channel

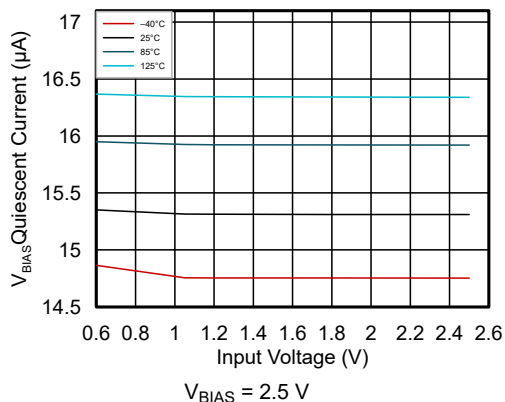


Figure 5-3.  $V_{BIAS}$  Quiescent Current vs Input Voltage Both Channel

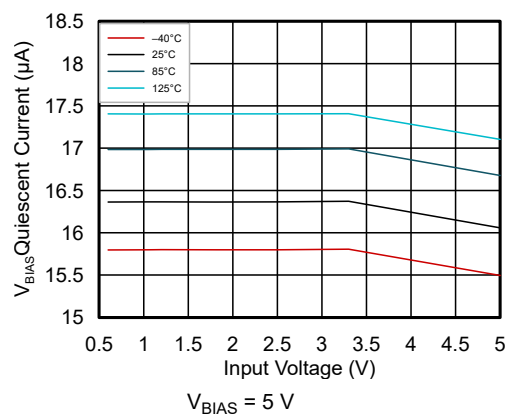


Figure 5-4.  $V_{BIAS}$  Quiescent Current vs Input Voltage Both Channel

## 5.8 Typical AC Characteristics

### AC Characteristics

$C_{IN} = 1 \mu F$ ,  $C_L = 0.1 \mu F$ ,  $R_L = 10 \Omega$ ,  $V_{ON} = 5 V$ ,  $I_{ON} = 100 \mu A$  unless otherwise noticed

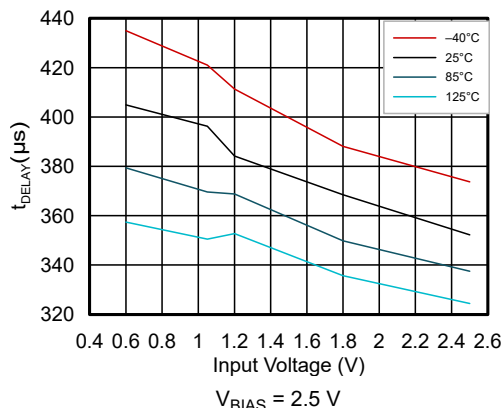


図 5-5. Delay Time vs Input Voltage

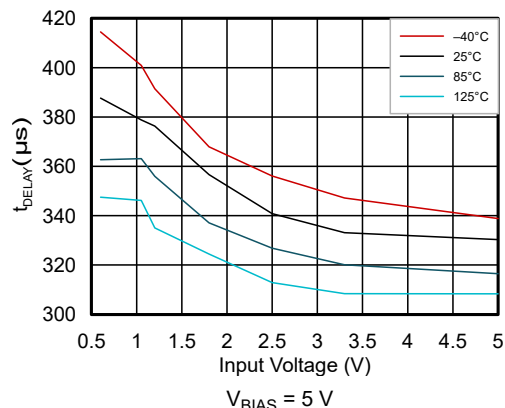


図 5-6. Delay Time vs Input Voltage

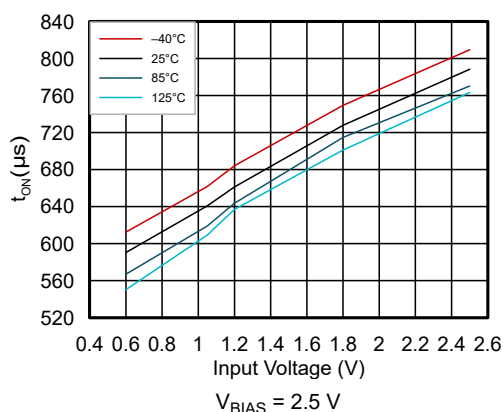


図 5-7. Turnon Time vs Input Voltage

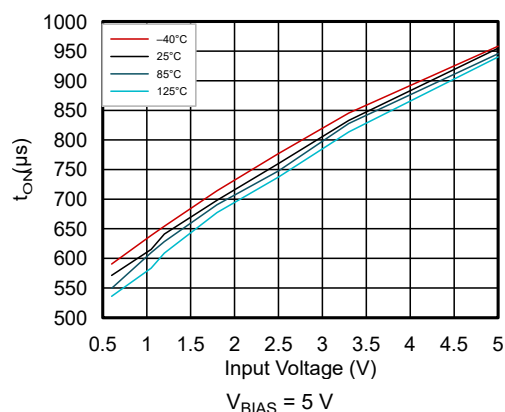


図 5-8. Turnon Time vs Input Voltage

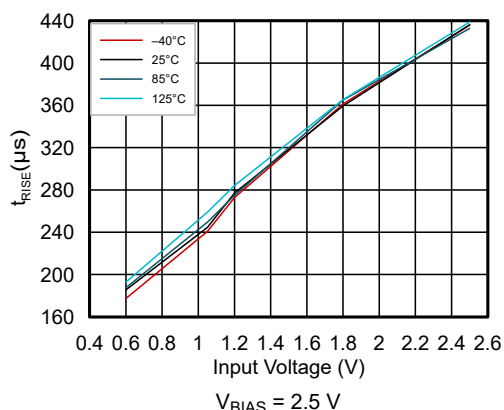


図 5-9. Rise Time vs Input Voltage

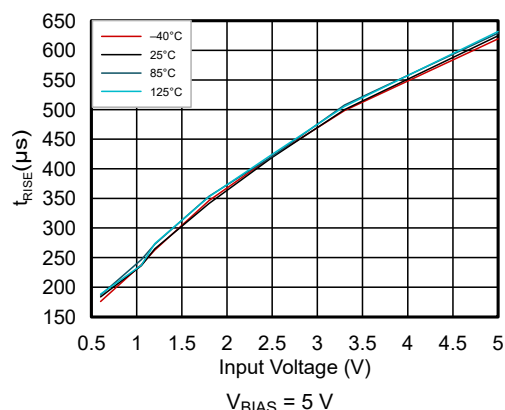
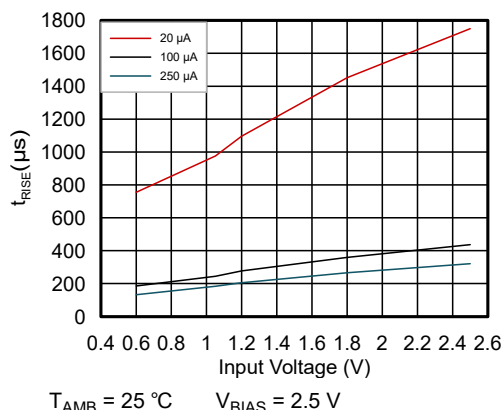
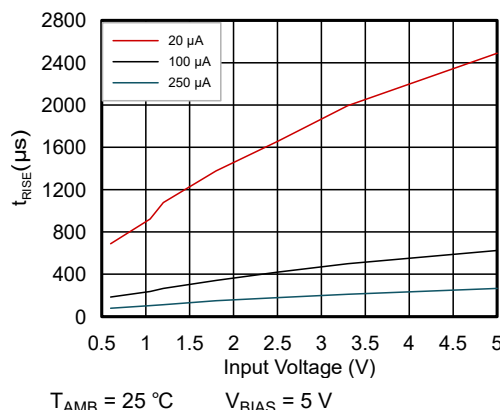


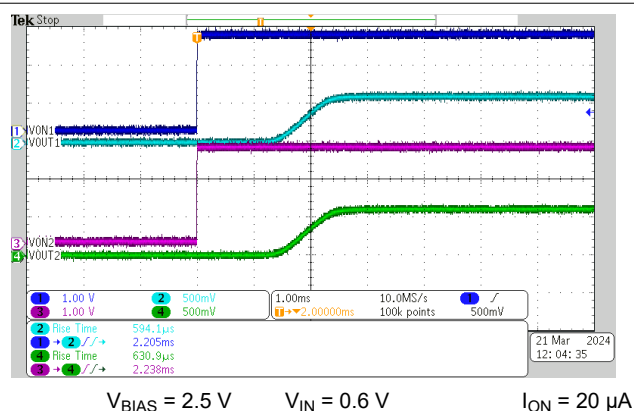
図 5-10. Rise Time vs Input Voltage



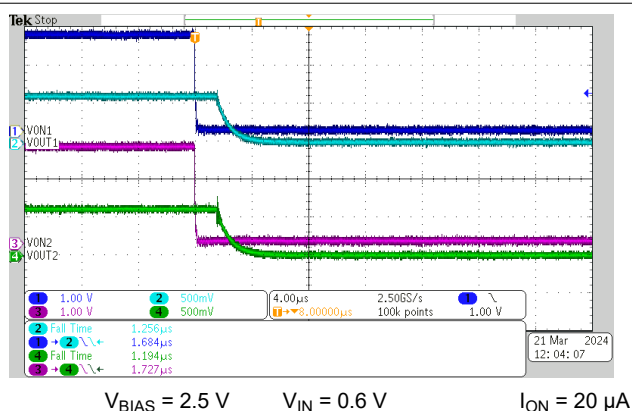
5-11. Rise Time vs Input Voltage with Different  $I_{\text{ON}}$



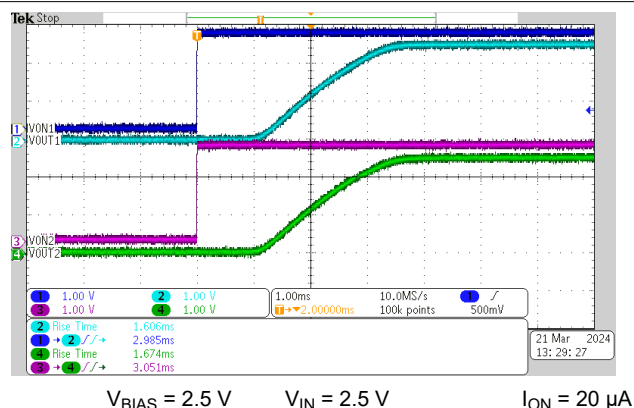
5-12. Rise Time vs Input Voltage with Different  $I_{\text{ON}}$



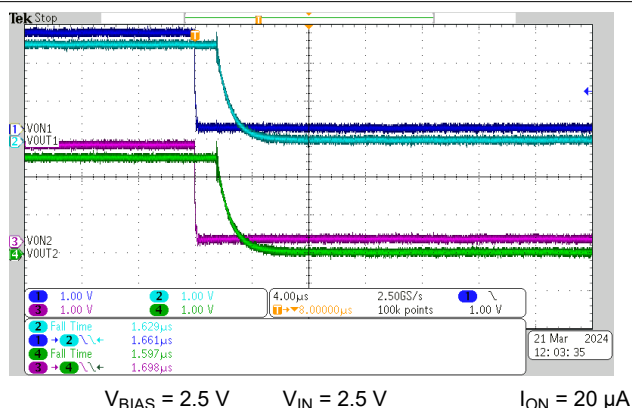
5-13. Turnon Response Time



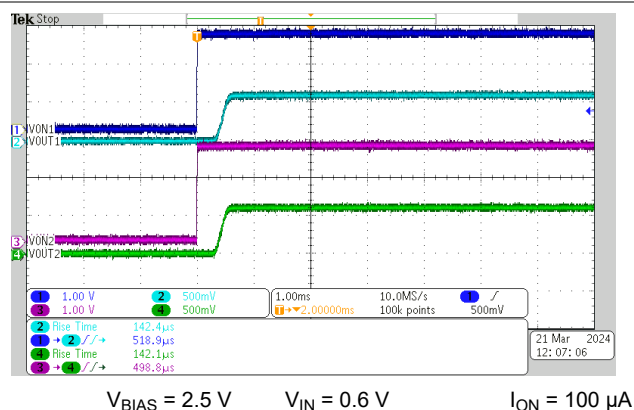
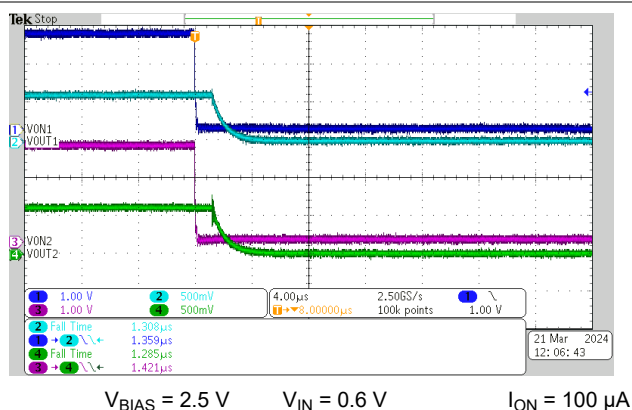
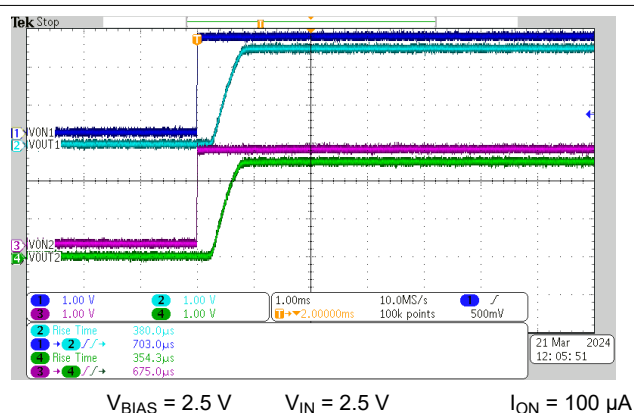
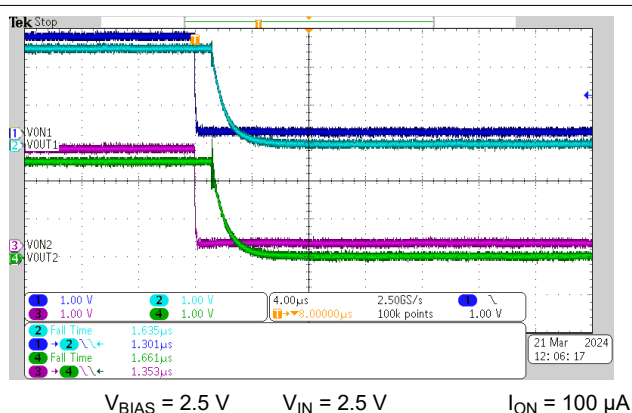
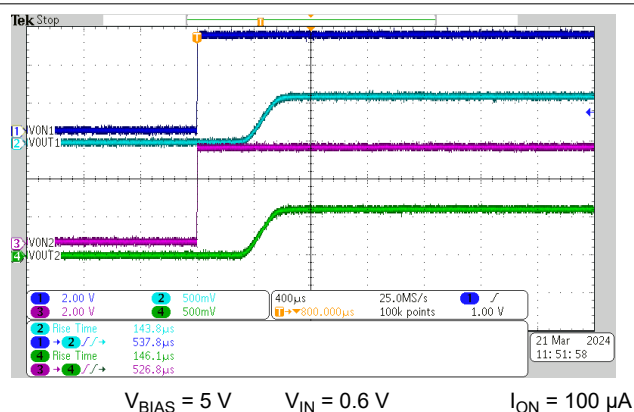
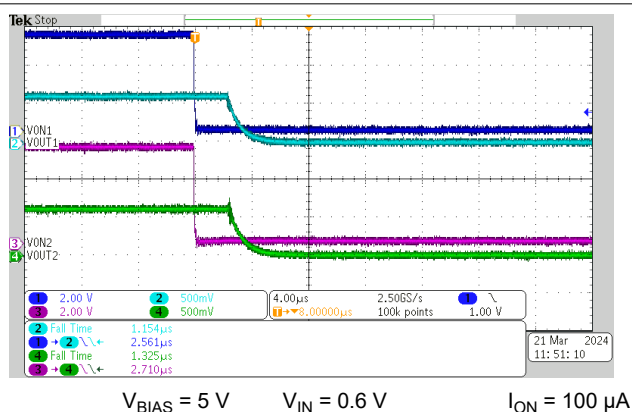
5-14. Turnoff Response Time

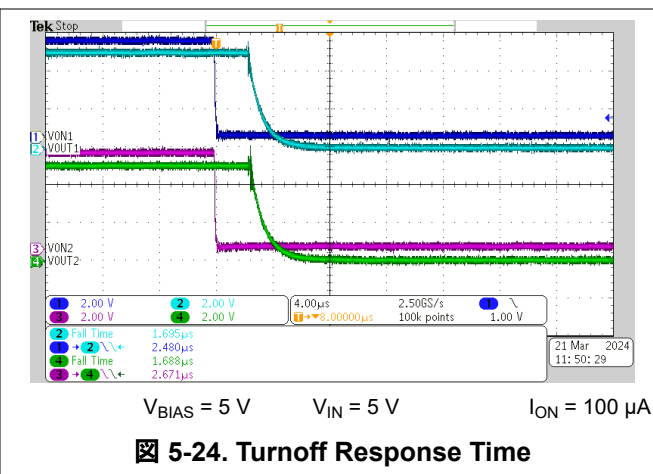
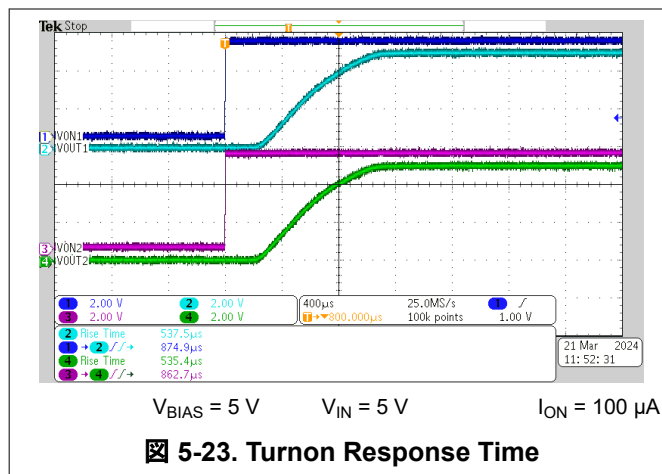


5-15. Turnon Response Time



5-16. Turnoff Response Time


 5-17. Turnon Response Time

 5-18. Turnoff Response Time

 5-19. Turnon Response Time

 5-20. Turnoff Response Time

 5-21. Turnon Response Time

 5-22. Turnoff Response Time



## 6 Parameter Measurement Information

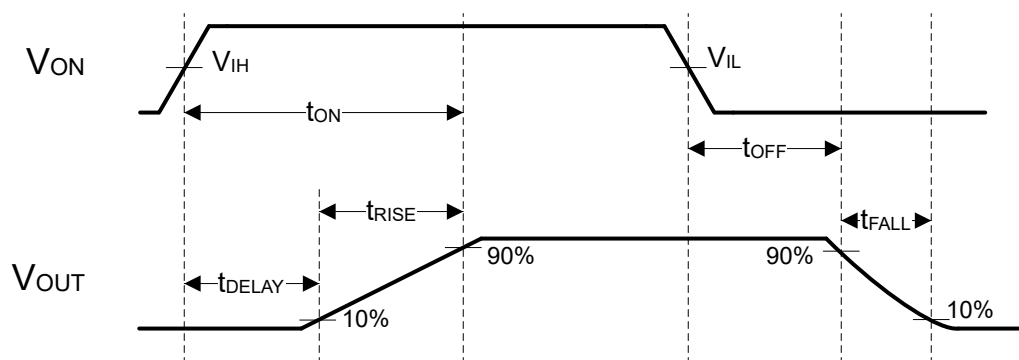


図 6-1.  $t_{ON}$  and  $t_{OFF}$  Waveforms

## 7 Detailed Description

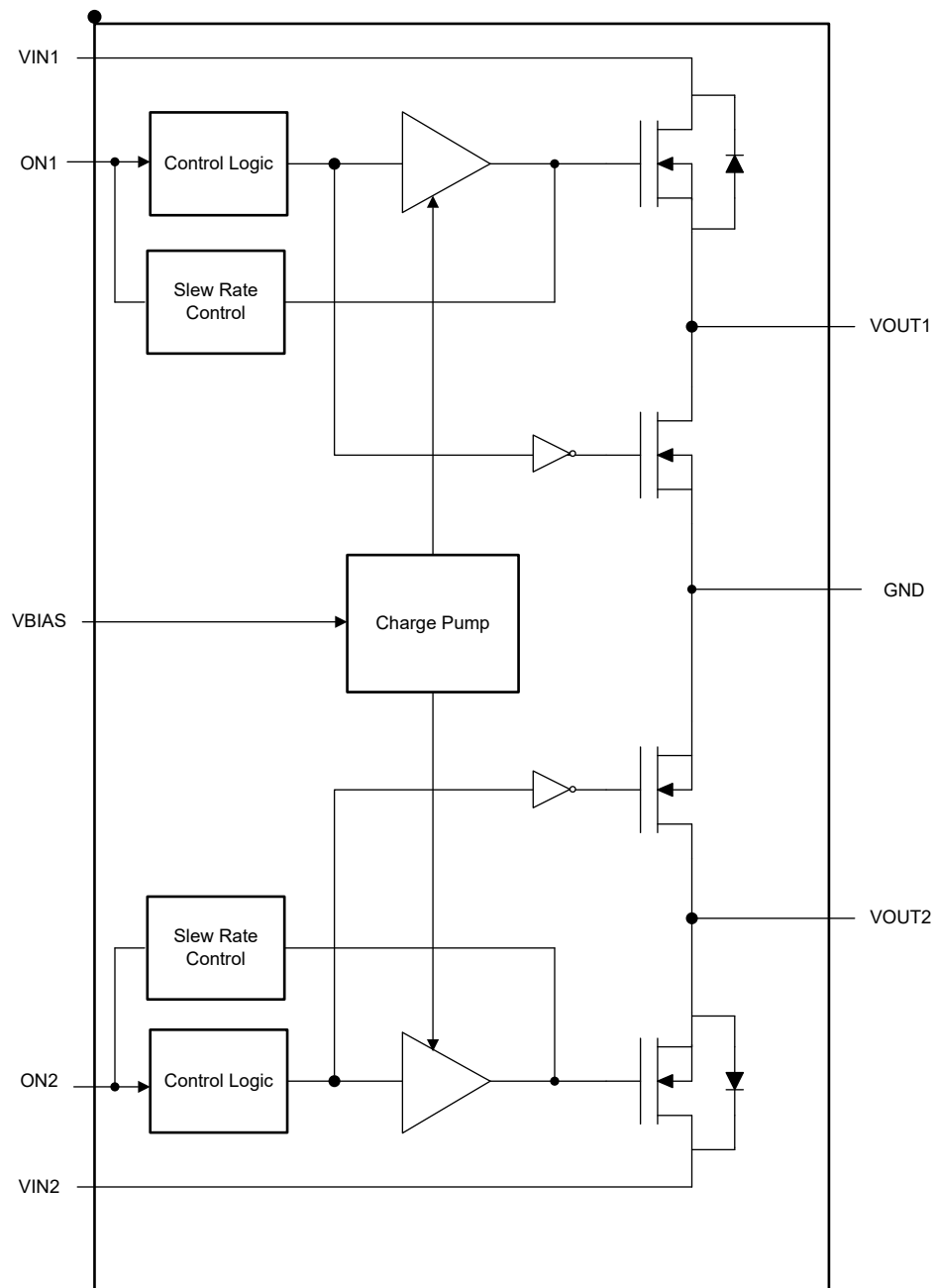
### 7.1 Overview

The TPS22996H-Q1 is a 5.5V, dual-channel, 13mΩ (typical)  $R_{ON}$  load switch in a 8-pin DYC package. Each channel can support a maximum continuous current of 4A and is controlled by an on and off GPIO-compatible input. To reduce the voltage drop in high current rails, the device implements N-channel MOSFETs. Note that the ON pins must be connected and cannot be left floating. The device has a configurable slew rate for applications that require specific rise-time, which controls the inrush current. By controlling the inrush current, power supply sag can be reduced during turnon. Furthermore, the slew rate is proportional to the series resistor used on the ONx pin. See [セクション 7.3.7](#) to determine the correct resistor value for a desired rise time.

The internal circuitry is powered by the  $V_{BIAS}$  pin, which supports voltages from 2.5V to 5.5V. This circuitry includes the charge pump, QOD, and control logic. When a voltage is applied to  $V_{BIAS}$ , and the ON<sub>1,2</sub> pins transition to a low state, the QOD functionality is activated. This connects  $V_{OUT1}$  and  $V_{OUT2}$  to ground through the on-chip resistor. The typical pulldown resistance ( $R_{PD}$ ) is 230Ω.

During the off state, the device prevents downstream circuits from pulling high standby current from the supply. The integrated control logic, driver, power supply, and output discharge FET eliminates the need for any external components, reducing solution size and bill of materials (BOM) count.

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 ON and OFF Control

The ON pins control the state of the switch. Asserting ON high enables the switch. ON is active high with a low threshold, making it capable of interfacing with low-voltage signals. The ON pin is compatible with standard GPIO logic threshold. It can be used with any microcontroller with 1.2V or higher GPIO voltage. This pin cannot be left floating and must be tied either high or low for proper functionality.

### 7.3.2 Input Capacitor (Optional)

To limit the voltage drop on the input supply caused by transient inrush currents when the switch turns on into a discharged load capacitor, a capacitor needs to be placed between VIN and GND. A 1μF ceramic capacitor,  $C_{IN}$ ,

placed close to the pins is usually sufficient. Higher values of  $C_{IN}$  can be used to further reduce the voltage drop during high-current application. When switching heavy loads, it is recommended to have an input capacitor about 10 times higher than the output capacitor to avoid excessive voltage drop.

### 7.3.3 Output Capacitor (Optional)

Due to the integrated body diode in the NMOS switch, a  $C_{IN}$  greater than  $C_L$  is highly recommended. A  $C_L$  greater than  $C_{IN}$  can cause  $V_{OUT}$  to exceed  $V_{IN}$  when the system supply is removed. This could result in current flow through the body diode from VOUT to VIN. A  $C_{IN}$  to  $C_L$  ratio of 10 to 1 is recommended for minimizing  $V_{IN}$  dip caused by inrush currents during startup, however a 10 to 1 ratio for capacitance is not required for proper functionality of the device. A ratio smaller than 10 to 1 (such as 1 to 1) could cause slightly more  $V_{IN}$  dip upon turnon due to inrush currents. This can be mitigated by increasing the  $R_T$  resistance on the ON pin for a longer rise time (see [セクション 7.3.7](#)).

### 7.3.4 Quick Output Discharge

When the switch is disabled, an internal discharge resistance is connected between VOUT and GND to remove the remaining charge from the output. This resistance prevents the output from floating while the switch is disabled. For best results, it is recommended that the device gets disabled before  $V_{BIAS}$  falls below the minimum recommended voltage.

### 7.3.5 Humidity Resistance

TPS22996H-Q1 is designed to be resistant to humidity, which is replicated by 100kΩ short between any pin to either GND or power. Under such humidity conditions, our device is able to function correctly with ON, OFF and thermal shutdown. However, the timing parameter will be affected by the short condition, and will deviate from the typical value listed in the *Electrical Characteristics* table (see [セクション 5.5](#)).

### 7.3.6 Thermal Shutdown

Thermal shutdown protects the part from internally or externally generated excessive temperatures. When the device temperature exceeds  $T_{SD}$ , the switch is turned off. The switch automatically turns on again if the temperature of the die drops  $T_{SD,HYS}$  below the  $T_{SD}$  threshold.

### 7.3.7 Adjustable Rise Time

TPS22996H-Q1 integrates a unique architecture for adjusting the rise time. The device senses the current flowing into the ON1 and ON2 ( $I_{ON}$ ) pins and utilizes the information to set the rise time. This allows the user to adjust the rise time by connecting a series resistance that is determined by the ON pin voltage. Refer to [表 7-1](#) for reference on setting the resistor.

**表 7-1. Typical Rise Time ( $V_{BIAS} = 5V$ )**

| $I_{ON}$ | $V_{IN} = 0.6V$ | $V_{IN} = 1.8V$ | $V_{IN} = 2.5V$ | $V_{IN} = 3.3V$ | $V_{IN} = 5V$ |
|----------|-----------------|-----------------|-----------------|-----------------|---------------|
| 20μA     | 764μs           | 1380μs          | 1700μs          | 1955μs          | 2350μs        |
| 100μA    | 203μs           | 343μs           | 426μs           | 500μs           | 626μs         |
| 250μA    | 85μs            | 148μs           | 180μs           | 208μs           | 265μs         |

**表 7-2. Typical Rise Time ( $V_{BIAS} = 3.3V$ )**

| $I_{ON}$ | $V_{IN} = 0.6V$ | $V_{IN} = 1.8V$ | $V_{IN} = 2.5V$ | $V_{IN} = 3.3V$ |
|----------|-----------------|-----------------|-----------------|-----------------|
| 20μA     | 738μs           | 1420μs          | 1735μs          | 2040μs          |
| 100μA    | 191μs           | 360μs           | 437μs           | 512μs           |
| 250μA    | 88μs            | 239μs           | 170μs           | 204μs           |

The following equation can be used to estimate the series resistance required to meet the desired rise time.

$$R_{TX} = 1000 \times (V_{ONx\_GPIO} - 1.2V) / I_{ONx} - R_i \quad (1)$$

where:

- $R_{TX}$  = Channel  $\times$  series resistance in  $k\Omega$ .
- $R_i$  = Internal ON pin resistance  $k\Omega$ .
- $V_{ONx\_GPIO}$  = Channel  $\times$  GPIO voltage connected to ONx pin in V.
- $I_{ONx}$  = Current flowing into the ONx pin in  $\mu A$ .

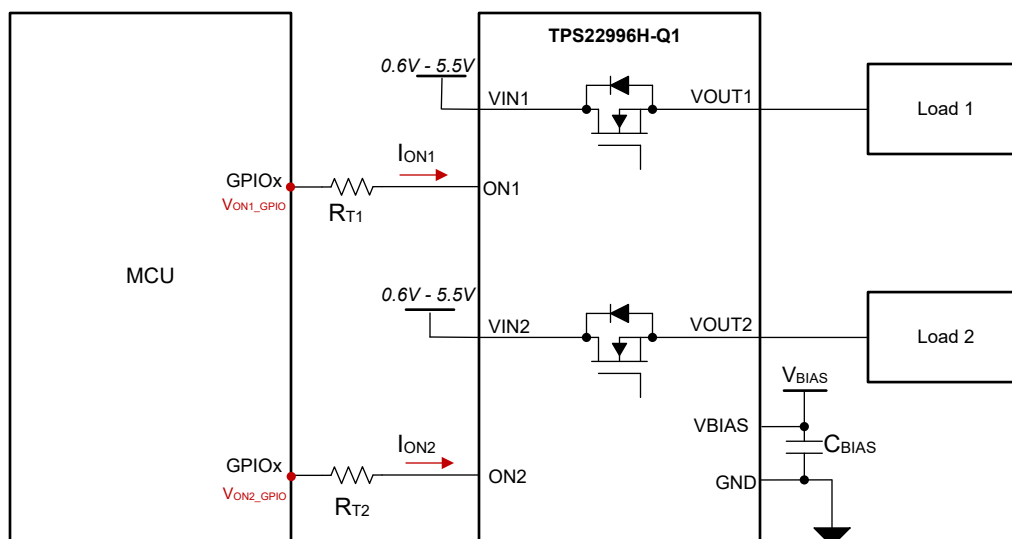


図 7-1. TPS22996H-Q1 Adjustable Rise Time Configuration

## 7.4 Device Functional Modes

表 7-3 lists the TPS22996H-Q1 functions.

表 7-3. TPS22996H-Q1 Functions Table

| ON | VIN to VOUT | VOUT |
|----|-------------|------|
| L  | Off         | GND  |
| H  | On          | VIN  |

## 8 Application and Implementation

### 注

以下のアプリケーションに関するセクションの情報は、TI の部品仕様の一部ではなく、TI はこれらの情報の正確性や完全性を保証しません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくことになります。また、お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

### 8.1 Application Information

This section highlights some of the design considerations for implementing the device in various applications.

### 8.2 Typical Application

This application demonstrates how the TPS22996H-Q1 can be used to limit the inrush current when powering on downstream modules.

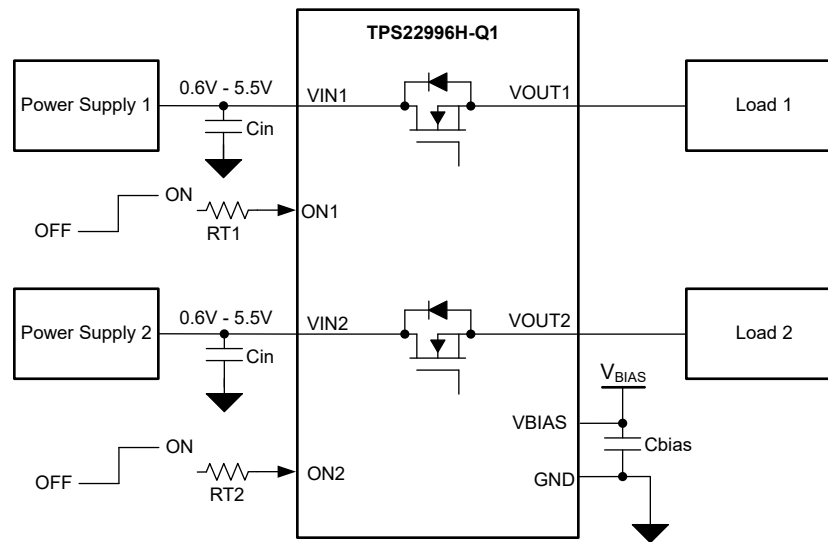


図 8-1. Typical Application Circuit

表 8-1. Component Descriptions

| DESIGN PARAMETER  | TYPICAL VALUES | DESCRIPTION                           |
|-------------------|----------------|---------------------------------------|
| C <sub>IN</sub>   | 1μF            | Filtering voltage transients          |
| C <sub>OUT</sub>  | 100nF          | Filtering voltage transients          |
| C <sub>BIAS</sub> | 0.1μF          | Filtering voltage transients          |
| RT1, RT2          | 10kΩ           | Series resistor for rise time control |

### 8.2.1 Design Requirements

表 8-2 shows the TPS22996H-Q1 design parameters.

表 8-2. Design Parameters

| DESIGN PARAMETER  | VALUE        |
|-------------------|--------------|
| $V_{\text{BIAS}}$ | 5V           |
| $V_{\text{IN}}$   | 5V           |
| Rise Time         | 1000 $\mu$ s |

### 8.2.2 Detailed Design Procedure

The design in this example is trying to achieve 1000μs rise time for power sequencing, with both  $V_{BIAS}$  and  $V_{IN}$  to be 5V. From 表 7-1, the  $I_{ON}$  needs to be between 20μA and 100μA. To find the  $I_{ON}$  needed to achieve 1000μs rise time, linear interpolation can be used to estimate as below:

$$T_R = (T_{R2} - T_{R1}) / (I_{ON2} - I_{ON1}) * (I_{ON} - I_{ON1}) + T_{R1} \quad (2)$$

where:

- $T_R$  is the desired  $T_R$ , which is 1000μs
- $I_{ON}$  is the desired  $I_{ON}$
- $T_{R1}$  is the first  $T_R$  used for linear interpolation, which is 2350μs
- $T_{R2}$  is the second  $T_R$  used for linear interpolation, which is 626μs
- $I_{ON1}$  is the first  $I_{ON}$  used for linear interpolation, which is 20μA
- $I_{ON2}$  is the second  $I_{ON}$  used for linear interpolation, which is 100μA

$I_{ON}$  is calculated to be 82.6μA. To find the  $R_T$  value, plug in the parameters in 式 1.

$$R_T = 1000 \times (5V - 1.2V) / 82.6\mu A - 12.5k\Omega = 33.5k\Omega$$

By using the standard resistor value closest to 33.5kΩ, the typical rise time can be calculated for the actual resistor value used on board.

### 8.3 Power Supply Recommendations

The device is designed to operate from a  $V_{BIAS}$  range of 2.5V to 5.5V and a  $V_{IN}$  range of 0.6V to  $V_{BIAS}$ .

### 8.4 Layout

#### 8.4.1 Layout Guidelines

For best performance, all traces must be as short as possible. To be most effective, the input and output capacitors must be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for  $V_{IN}$ ,  $V_{OUT}$ , and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

#### 8.4.2 Layout Example

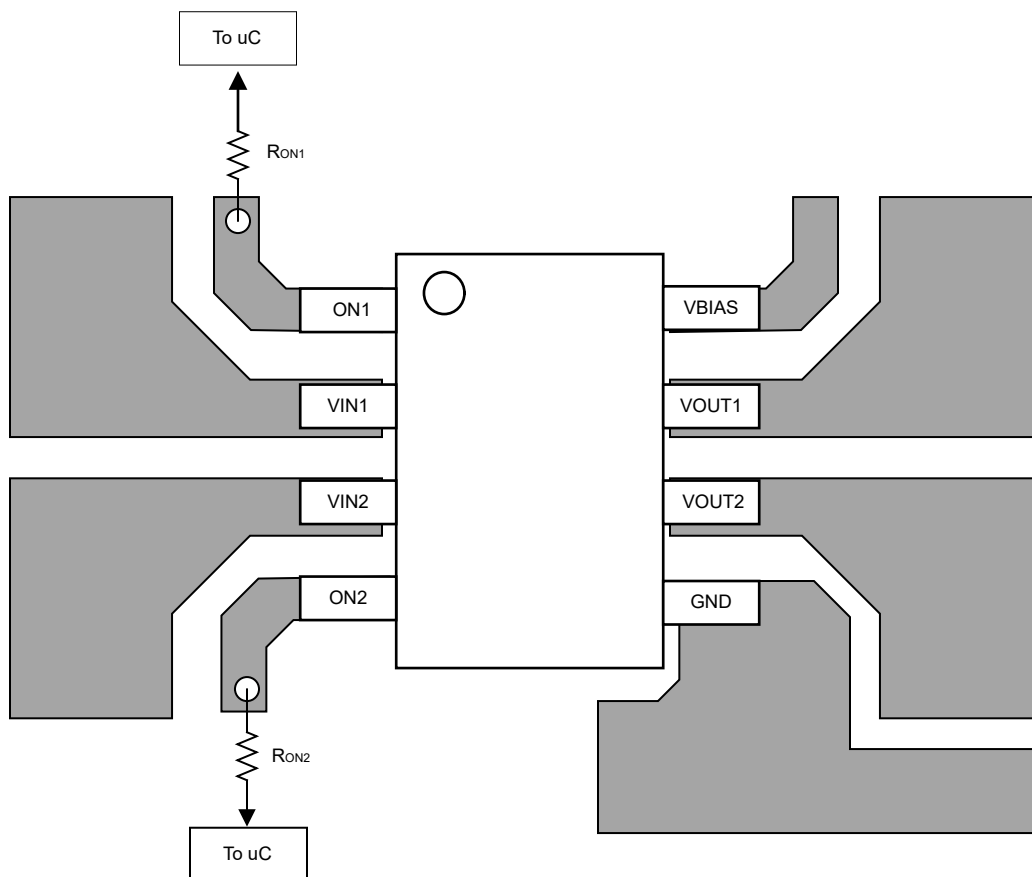


図 8-2. TPS22996H Layout Example

#### 8.4.3 Power Dissipation

The maximum IC junction temperature must be restricted to 150°C under normal operating conditions. To calculate the maximum allowable power dissipation,  $P_{D(max)}$  for a given output current and ambient temperature, use 式 3.

$$P_{D(max)} = \frac{T_{J(max)} - T_A}{\theta_{JA}} \quad (3)$$

where

- $P_{D(max)}$  is the maximum allowable power dissipation.

- $T_{J(max)}$  is the maximum allowable junction temperature (150°C for the TPS22996H).
- $T_A$  is the ambient temperature of the device.
- $\theta_{JA}$  is the junction to air thermal impedance. See [セクション 5.4](#). This parameter is highly dependent upon board layout.

## 9 Device and Documentation Support

### 9.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[www.tij.co.jp](http://www.tij.co.jp) のデバイス製品フォルダを開いてください。[通知] をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取ることができます。変更の詳細については、改訂されたドキュメントに含まれている改訂履歴をご覧ください。

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### 9.5 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

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Changes from Revision * (March 2024) to Revision A (October 2024) | Page |
|-------------------------------------------------------------------|------|
| • ドキュメントのステータスを「事前情報」から「量産データ」 .....                              | 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 without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.

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## PACKAGING INFORMATION

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins    | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|-------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">TPS22996HQDYCRQ1</a> | Active        | Production           | SOT-5X3 (DYC)   8 | 4000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 996HQ               |
| TPS22996HQDYCRQ1.A               | Active        | Production           | SOT-5X3 (DYC)   8 | 4000   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 996HQ               |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS22996HQDYCRQ1 | SOT-5X3      | DYC             | 8    | 4000 | 180.0              | 8.4                | 2.75    | 1.9     | 0.8     | 4.0     | 8.0    | Q3            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS22996HQDYCRQ1 | SOT-5X3      | DYC             | 8    | 4000 | 210.0       | 185.0      | 35.0        |



**SOT - 0.6 mm max height**

## PLASTIC SMALL OUTLINE



1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.

2. This drawing is subject to change without notice.

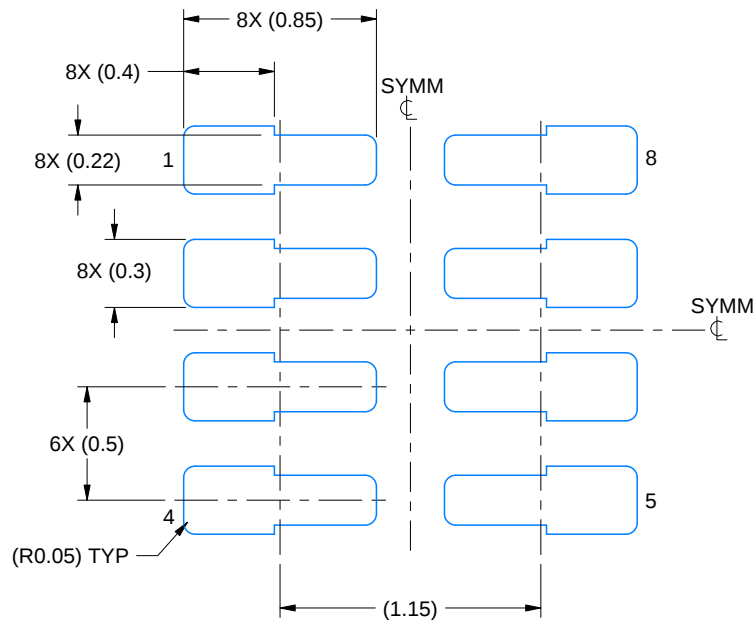
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

# EXAMPLE BOARD LAYOUT

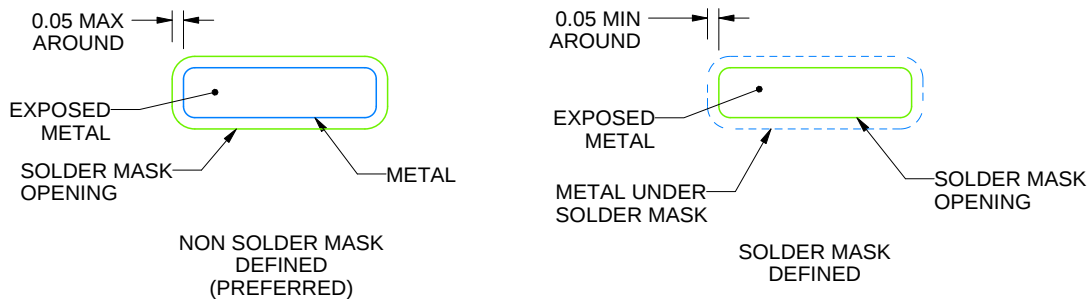
DYC0008A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:30X



SOLDERMASK DETAILS

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NOTES: (continued)

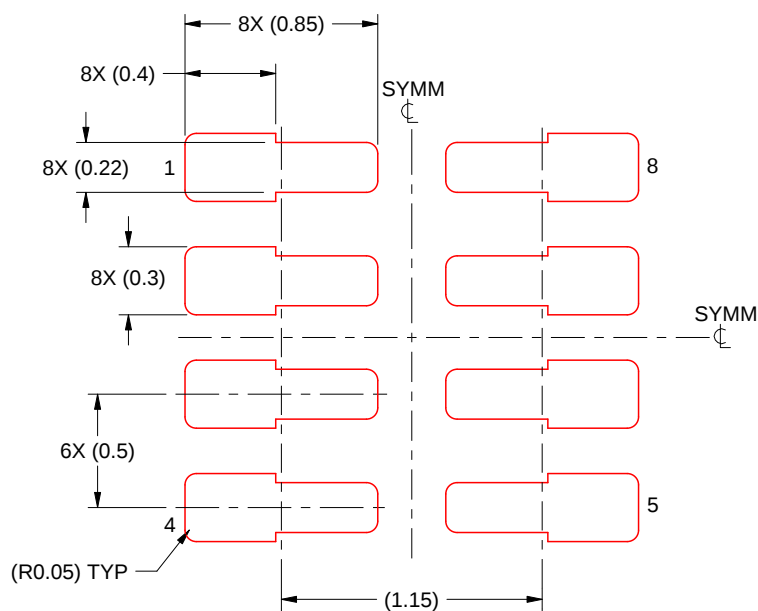
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
6. Land pattern design aligns to IPC-610, Bottom Termination Component (BTC) solder joint inspection criteria.

# EXAMPLE STENCIL DESIGN

DYC0008A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE  
BASED ON 0.1 mm THICK STENCIL  
SCALE:30X

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NOTES: (continued)

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

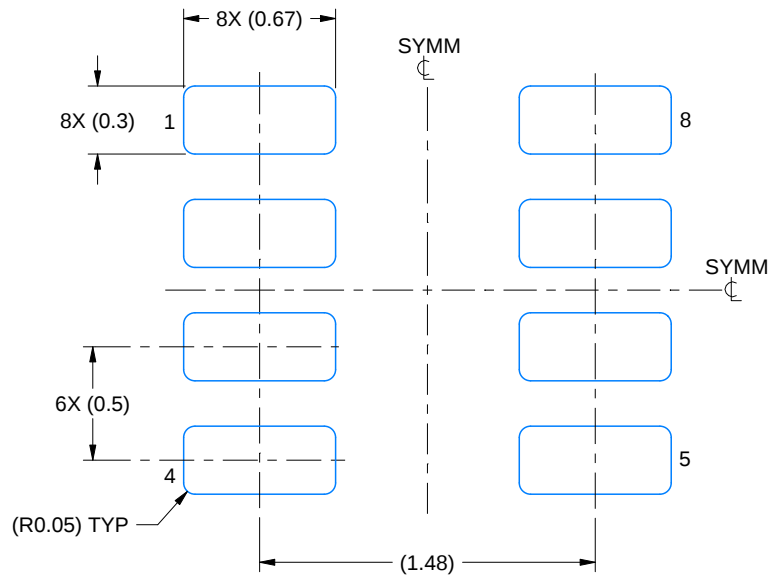


# EXAMPLE BOARD LAYOUT

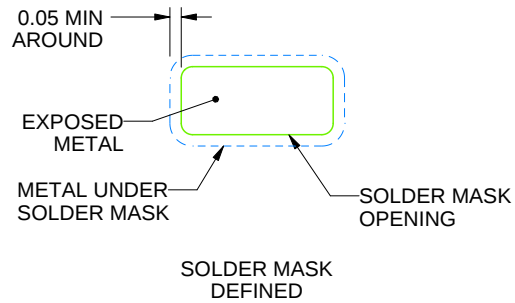
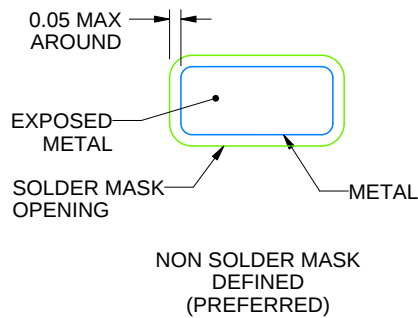
DRL0008A

SOT-5X3 - 0.6 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:30X



SOLDERMASK DETAILS

4224486/G 11/2024

NOTES: (continued)

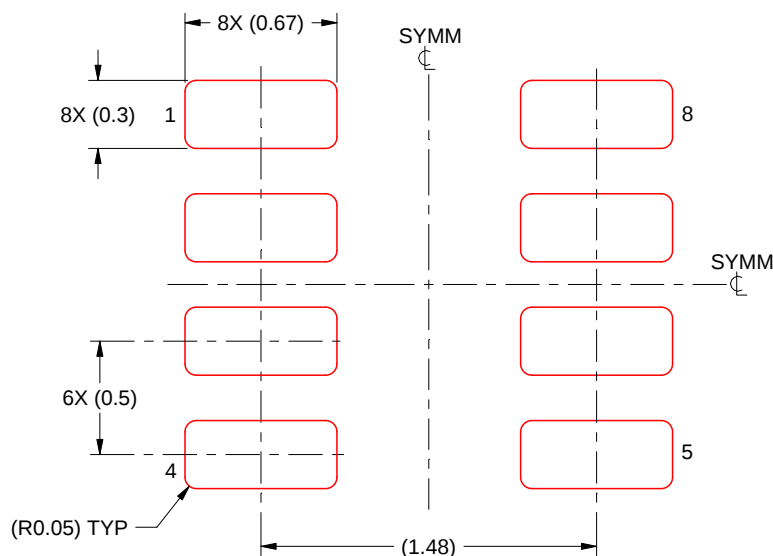
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. Land pattern design aligns to IPC-610, Bottom Termination Component (BTC) solder joint inspection criteria.

## EXAMPLE STENCIL DESIGN

DRL0008A

SOT-5X3 - 0.6 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE  
BASED ON 0.1 mm THICK STENCIL  
SCALE:30X

4224486/G 11/2024

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.

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