

## TPS7B70-Q1 Automotive, 300-mA, 40-V, Low- $I_Q$ LDO With Power Good

### 1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade 1:  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  Ambient Operating Temperature Range
  - Device HBM ESD Classification Level 2
  - Device CDM ESD Classification Level C4B
- Device Junction Temperature Range:  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$
- Maximum Output Current: 300 mA
- 4-V to 40-V Wide  $V_{\text{IN}}$  Input-Voltage Range With up to 45-V Transients
- Fixed 3.3-V and 5-V Outputs
- Maximum Dropout Voltage: 400 mV at 300 mA
- Stable With Output Capacitor in Wide Range of Capacitance ( $4.7\ \mu\text{F}$  to  $500\ \mu\text{F}$ ) and ESR ( $0.001\ \Omega$  to  $20\ \Omega$ )
- Low Quiescent Current ( $I_{\text{Q}}$ )
  - $< 4\ \mu\text{A}$  When EN is Low (Shutdown Mode)
  - $19\ \mu\text{A}$  Typical at Light Loads With VINT High
- Fully Adjustable Power-Good Threshold and Power-Good Delay Timing
- Low Input-Voltage Tracking to UVLO
- Integrated Fault Protection
  - Overload Current-Limit Protection
  - Thermal Shutdown
- 16-Pin HTSSOP PowerPAD™ Package
  - Thermal Resistance ( $R_{\theta\text{JA}}$ ):  $39.7^{\circ}\text{C/W}$

### 2 Applications

- Body Control Modules (BCM)
- EV and HEV Battery Management Systems
- Transmission Control Units (TCU)
- Head Units
- Electrical Power Steering (EPS)

### 3 Description

The TPS7B70-Q1 is a 300-mA, low-dropout linear regulator (LDO) that operates from an automotive battery. The device has only  $19\ \mu\text{A}$  of quiescent current at light loads. Thus, the TPS7B70-Q1 is an excellent selection to supply power to always-on components, such as microcontrollers (MCUs) and controller area network (CAN) transceivers.

The input voltage range of the TPS7B70-Q1 extends thru 40 V. This voltage helps the device withstand transient conditions, such as load-dump. The device also has a power good (PG) pin to tell the system when the output voltage is in regulation. To achieve the necessary operation, you can adjust the PG threshold voltage and delay. The threshold voltage of the PG signal is adjusted through external resistors. Adjust the delay with an external capacitor.

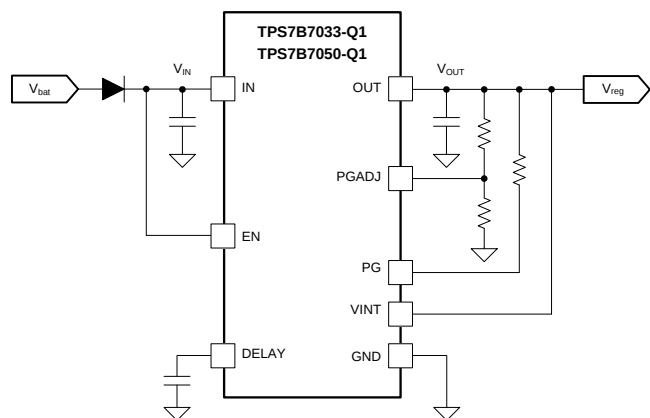
This device operates in ambient temperatures from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , and with junction temperatures from  $-40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ . This device also has a thermally conductive package that enables sustained operation despite significant dissipation across the device, a typical property of off-battery operation. These features, along with included current limit and thermal shutdown protection, make the TPS7B70-Q1 an excellent selection to supply power to automotive system components.

#### Device Information<sup>(1)</sup>

| PART NUMBER | OUTPUT VOLTAGE | PACKAGE     |
|-------------|----------------|-------------|
| TPS7B70-Q1  | 3.3 V or 5 V   | HTSSOP (16) |

(1) For all available packages, see the package option addendum at the end of the data sheet.

#### Typical Application



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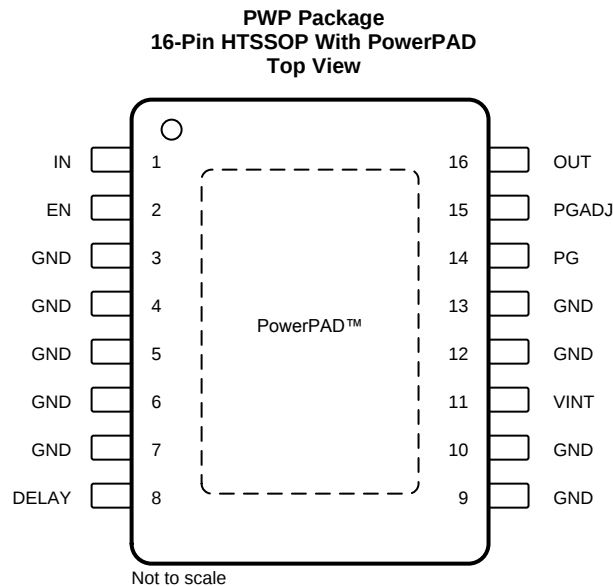
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## 4 Revision History

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

| Changes from Original (August 2018) to Revision A                                       | Page     |
|-----------------------------------------------------------------------------------------|----------|
| • Changed device status from <i>Advance Information</i> to <i>Production Data</i> ..... | <b>1</b> |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN      |                              | I/O | DESCRIPTION                                                                                                                                                                                                            |
|----------|------------------------------|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME     | NO.                          |     |                                                                                                                                                                                                                        |
| DELAY    | 8                            | O   | Power-good delay adjustment pin. Connect this pin through a capacitor to ground to adjust the power-good delay time.                                                                                                   |
| EN       | 2                            | I   | Device enable pin. Pull this pin down to low-level voltage to disable the device. Pull this pin up to high-level voltage to enable the device.                                                                         |
| GND      | 3, 4, 5, 6, 7, 9, 10, 12, 13 | —   | Ground reference                                                                                                                                                                                                       |
| IN       | 1                            | I   | Device input power supply pin                                                                                                                                                                                          |
| OUT      | 16                           | O   | Device 3.3-V or 5-V regulated output-voltage pin                                                                                                                                                                       |
| PG       | 14                           | O   | Power-good pin. Open-drain output pin. Pull this pin up to $V_{OUT}$ or to a reference through a resistor. When the output voltage is not ready, this pin is pulled down to ground.                                    |
| PGADJ    | 15                           | O   | Power-good threshold-adjustment pin. Connect a resistor divider between the PGADJ and OUT pins to set the power-good threshold. Connect this pin to ground to set the threshold to 91.6% of output voltage $V_{OUT}$ . |
| VINT     | 11                           | I   | Internal voltage rail. Tie this pin above 2 V for lowest $I_{GND}$ .                                                                                                                                                   |
| PowerPAD | —                            | —   | Solder thermal pad to board to improve the thermal performance.                                                                                                                                                        |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)(2)</sup>

|                  |                                         |        | MIN  | MAX | UNIT |
|------------------|-----------------------------------------|--------|------|-----|------|
|                  | Unregulated input                       | IN, EN | −0.3 | 45  | V    |
|                  | Power-good delay-timer output           | DELAY  | −0.3 | 7   | V    |
|                  | Regulated output                        | OUT    | −0.3 | 7   | V    |
|                  | Power-good output voltage               | PG     | −0.3 | 7   | V    |
|                  | V-internal                              | VINT   | −0.3 | 7   | V    |
|                  | Power-good threshold-adjustment voltage | PGADJ  | −0.3 | 7   | V    |
| T <sub>J</sub>   | Operating junction temperature          |        | −40  | 150 | °C   |
| T <sub>stg</sub> | Storage temperature                     |        | −65  | 150 | °C   |

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

### 6.2 ESD Ratings

|                    |                         |                                                         | VALUE | UNIT |
|--------------------|-------------------------|---------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup> | ±2000 | V    |
|                    |                         | Charged-device model (CDM), per AEC Q100-011            | ±500  |      |
|                    |                         |                                                         | ±750  |      |

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

### 6.3 Recommended Operating Conditions

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

|                  |                      |              | MIN | NOM | MAX             | UNIT |
|------------------|----------------------|--------------|-----|-----|-----------------|------|
|                  | Unregulated input    | IN           | 4   |     | 40              | V    |
|                  | 40-V pins            | EN           | 0   |     | V <sub>IN</sub> | V    |
|                  | Regulated output     | OUT          | 0   |     | 5.5             | V    |
|                  | Power good           | PG           | 0   |     | 5.5             | V    |
|                  | Low voltage pins     | PGADJ, DELAY | 0   |     | 5.5             | V    |
| I <sub>OUT</sub> | Output current       |              | 0   |     | 300             | mA   |
| T <sub>A</sub>   | Ambient temperature  |              | −40 |     | 125             | °C   |
| T <sub>J</sub>   | Junction temperature |              | −40 |     | 150             | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | TPS7B70-Q1   | UNIT |
|-------------------------------|----------------------------------------------|--------------|------|
|                               |                                              | PWP (HTSSOP) |      |
|                               |                                              | 16 PINS      |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 39.7         | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 28.9         | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 23.8         | °C/W |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 1.3          | °C/W |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 23.7         | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 3.1          | °C/W |

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

## 6.5 Electrical Characteristics

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ ,  $C_{OUT} \geq 4.7\text{ }\mu\text{F}$ , and  $1\text{ m}\Omega < \text{ESR} < 20\text{ }\Omega$  (unless otherwise noted)

| PARAMETER                       |                                                                         | TEST CONDITIONS                                                                                                               | MIN   | TYP  | MAX  | UNIT                  |
|---------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------|------|------|-----------------------|
| SUPPLY VOLTAGE AND CURRENT (IN) |                                                                         |                                                                                                                               |       |      |      |                       |
| I <sub>(SLEEP)</sub>            | Input sleep current                                                     | EN = off                                                                                                                      |       |      | 4.5  | μA                    |
| I <sub>(GND)</sub>              | Input quiescent current                                                 | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V to 40 V, EN = on, VINT > 2 V, I <sub>OUT</sub> < 1 mA, −40°C ≤ T <sub>J</sub> ≤ 85°C |       | 19   | 29.6 | μA                    |
| V <sub>(UVLO)</sub>             | Undervoltage lockout, falling                                           | Ramp V <sub>IN</sub> down until output is turned off                                                                          |       |      | 2.6  | V                     |
| V <sub>(UVLO_HYST)</sub>        | UVLO hysteresis                                                         |                                                                                                                               |       | 0.5  |      | V                     |
| ENABLE INPUT (EN)               |                                                                         |                                                                                                                               |       |      |      |                       |
| V <sub>IL</sub>                 | Low-level input voltage                                                 |                                                                                                                               |       |      | 0.7  | V                     |
| V <sub>IH</sub>                 | High-level input voltage                                                |                                                                                                                               | 2     |      |      | V                     |
| V <sub>hys</sub>                | Hysteresis                                                              |                                                                                                                               |       | 150  |      | mV                    |
| REGULATED OUTPUT (OUT)          |                                                                         |                                                                                                                               |       |      |      |                       |
|                                 |                                                                         |                                                                                                                               |       |      |      |                       |
| V <sub>OUT</sub>                | Regulated output                                                        | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V to 40 V, I <sub>OUT</sub> = 0 mA to 300 mA, −40°C ≤ T <sub>J</sub> ≤ 125°C           | −2%   |      | 2%   |                       |
|                                 |                                                                         | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V to 40 V, I <sub>OUT</sub> = 0 mA to 300 mA                                           | −2.5% |      | 2.5% |                       |
| ΔV <sub>OUT(ΔVIN)</sub>         | Line regulation                                                         | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V to 40 V, I <sub>OUT</sub> = 1 mA                                                     |       |      | 10   | mV                    |
| ΔV <sub>OUT(ΔIOUT)</sub>        | Load regulation                                                         | I <sub>OUT</sub> = 1 mA to 300 mA                                                                                             |       |      | 20   | mV                    |
| V <sub>(dropout)</sub>          | Dropout voltage (V <sub>IN</sub> − V <sub>OUT</sub> ) <sup>(1)(2)</sup> | I <sub>OUT</sub> = 300 mA                                                                                                     |       | 300  | 400  | mV                    |
|                                 |                                                                         | I <sub>OUT</sub> = 200 mA                                                                                                     |       | 170  | 325  |                       |
| I <sub>(LIM)</sub>              | Output current limit                                                    | V <sub>OUT</sub> shorted to ground, V <sub>IN</sub> = 5.6 V                                                                   | 301   | 680  | 1000 | mA                    |
|                                 |                                                                         |                                                                                                                               |       |      |      |                       |
| PSRR                            | Power-supply ripple rejection <sup>(3)</sup>                            | I <sub>OUT</sub> = 100 mA, C <sub>OUT</sub> = 10 μF, frequency (f) = 100 Hz                                                   |       | 60   |      | dB                    |
|                                 |                                                                         | I <sub>OUT</sub> = 100 mA, C <sub>OUT</sub> = 10 μF, frequency (f) = 100 kHz                                                  |       | 40   |      |                       |
| POWER GOOD (PG, PGADJ)          |                                                                         |                                                                                                                               |       |      |      |                       |
| V <sub>OL(PG)</sub>             | PG output, low voltage                                                  | I <sub>OL</sub> = 5 mA, PG pulled low                                                                                         |       |      | 0.4  | V                     |
| I <sub>lkg(PG)</sub>            | PG pin leakage current                                                  | PG pulled to V <sub>OUT</sub> through a 10-kΩ resistor                                                                        |       |      | 1    | μA                    |
| V <sub>(PG_TH)</sub>            | Default power-good threshold                                            | V <sub>OUT</sub> powered above the internally set tolerance, PGADJ pin shorted to ground                                      | 88.6  | 91.6 | 93.6 | % of V <sub>OUT</sub> |
| V <sub>(PG_HYST)</sub>          | Power-good hysteresis                                                   | V <sub>OUT</sub> falling below the internally set tolerance hysteresis                                                        |       | 2    |      | % of V <sub>OUT</sub> |

(1) This test is done with  $V_{OUT}$  in regulation, measuring the  $V_{IN} - V_{OUT}$  when  $V_{OUT}$  drops by 100 mV from the rated output voltage at the specified load.

(2) Dropout is not measured for  $V_{OUT} = 3.3\text{ V}$  in this test because  $V_{IN}$  must be 4 V or greater for proper operation.

(3) Design information—not tested, determined by characterization.

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## Electrical Characteristics (continued)

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ ,  $C_{OUT} \geq 4.7\text{ }\mu\text{F}$ , and  $1\text{ m}\Omega < \text{ESR} < 20\text{ }\Omega$  (unless otherwise noted)

| PARAMETER                |                                                 | TEST CONDITIONS                   | MIN   | TYP | MAX   | UNIT               |
|--------------------------|-------------------------------------------------|-----------------------------------|-------|-----|-------|--------------------|
| <b>PGADJ</b>             |                                                 |                                   |       |     |       |                    |
| $V_{(\text{PGADJ\_TH})}$ | Switching voltage for the power-good adjust pin | $V_{OUT}$ is falling              | 1.067 | 1.1 | 1.133 | V                  |
| <b>POWER-GOOD DELAY</b>  |                                                 |                                   |       |     |       |                    |
| $I_{(\text{DLY\_CHG})}$  | DELAY capacitor charging current                |                                   | 3     | 5   | 10    | $\mu\text{A}$      |
| $V_{(\text{DLY\_TH})}$   | DELAY pin threshold to release PG high          | Voltage at DELAY pin is ramped up | 0.95  | 1   | 1.05  | V                  |
| $I_{(\text{DLY\_DIS})}$  | DELAY capacitor discharging current             | $V_{\text{DELAY}} = 1\text{ V}$   | 0.5   |     |       | mA                 |
| <b>TEMPERATURE</b>       |                                                 |                                   |       |     |       |                    |
| $T_{(\text{SD})}$        | Junction shutdown temperature                   |                                   |       | 175 |       | $^{\circ}\text{C}$ |
| $T_{(\text{HYST})}$      | Hysteresis of thermal shutdown                  |                                   |       | 25  |       | $^{\circ}\text{C}$ |

## 6.6 Switching Characteristics

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_I = 14\text{ V}$ ,  $C_O \geq 4.7\text{ }\mu\text{F}$ , and  $1\text{ m}\Omega < \text{ESR} < 20\text{ }\Omega$  (unless otherwise noted)

| PARAMETER                       |                          | TEST CONDITIONS                                             | MIN | TYP | MAX | UNIT          |
|---------------------------------|--------------------------|-------------------------------------------------------------|-----|-----|-----|---------------|
| <b>POWER-GOOD DELAY (DELAY)</b> |                          |                                                             |     |     |     |               |
| $t_{(\text{DEGLITCH})}$         | Power-good deglitch time |                                                             |     | 180 | 250 | $\mu\text{s}$ |
| $t_{(\text{DLY\_FIX})}$         | Fixed power-good delay   | No capacitor connect at DELAY pin                           |     | 248 | 900 | $\mu\text{s}$ |
| $t_{(\text{DLY})}$              | Power-good delay         | Delay capacitor value: $C_{(\text{DELAY})} = 100\text{ nF}$ |     | 20  |     | ms            |

## 6.7 Typical Characteristics

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ , and  $V_{EN} \geq 2\text{ V}$  (unless otherwise noted)

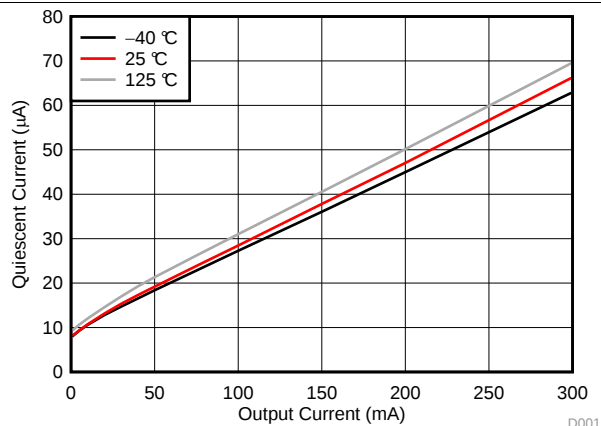


Figure 1. Ground Current vs Output Current

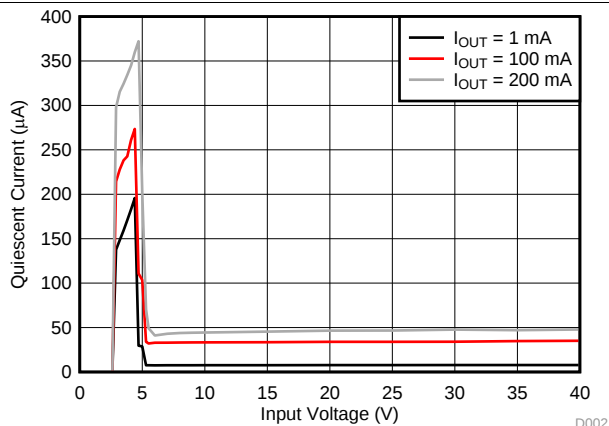


Figure 2. Ground Current vs Input Voltage

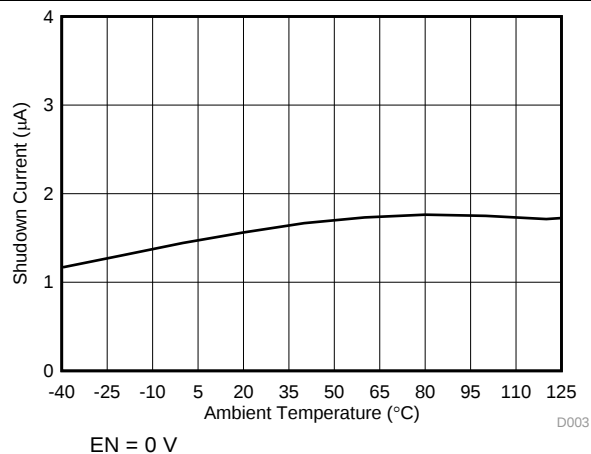


Figure 3. Shutdown Current vs Ambient Temperature

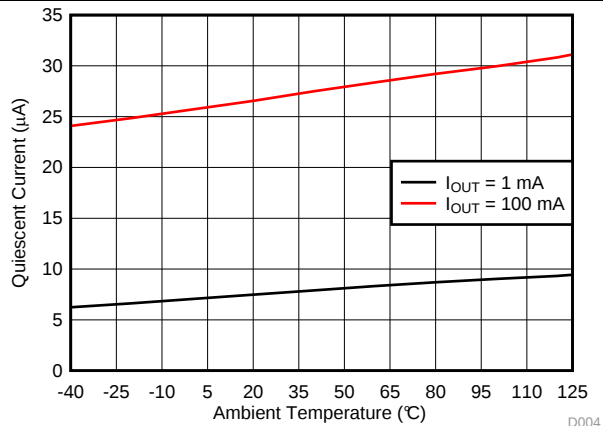


Figure 4. Ground Current vs Ambient Temperature

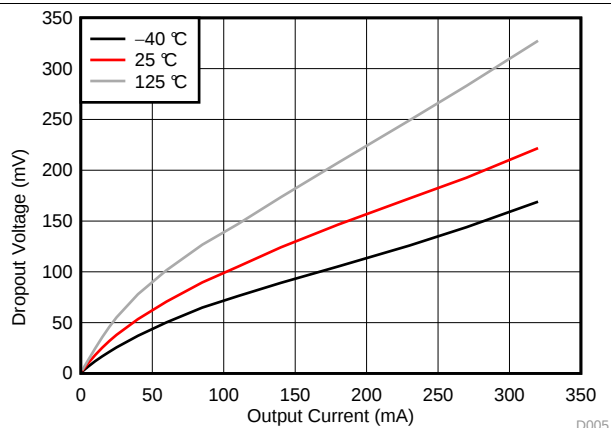


Figure 5. Dropout Voltage vs Output Current

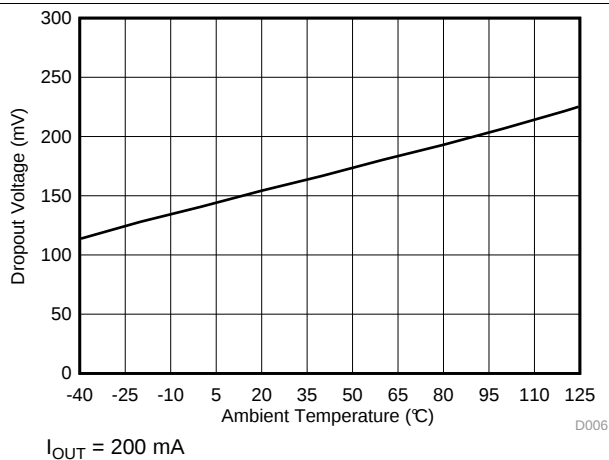


Figure 6. Dropout Voltage vs Ambient Temperature

## Typical Characteristics (continued)

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ , and  $V_{EN} \geq 2\text{ V}$  (unless otherwise noted)

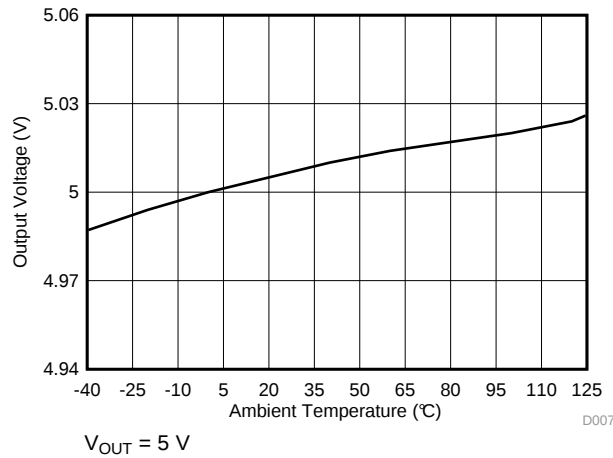


Figure 7. Output Voltage vs Ambient Temperature

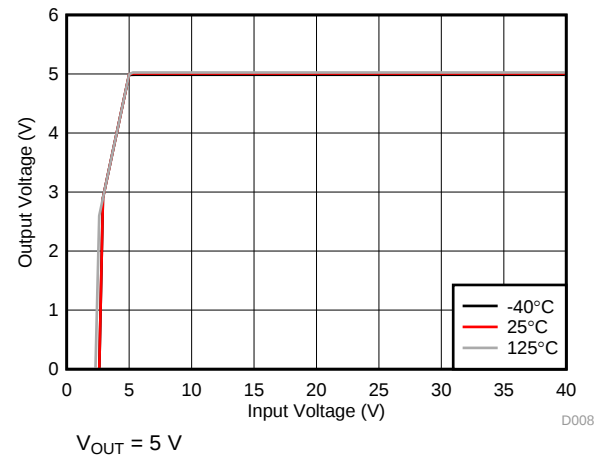


Figure 8. Output Voltage vs Input Voltage

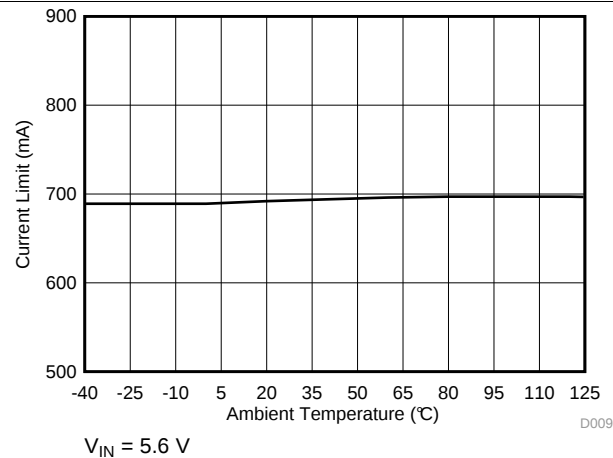


Figure 9. Output Current Limit ( $I_{LIM}$ ) vs Ambient Temperature

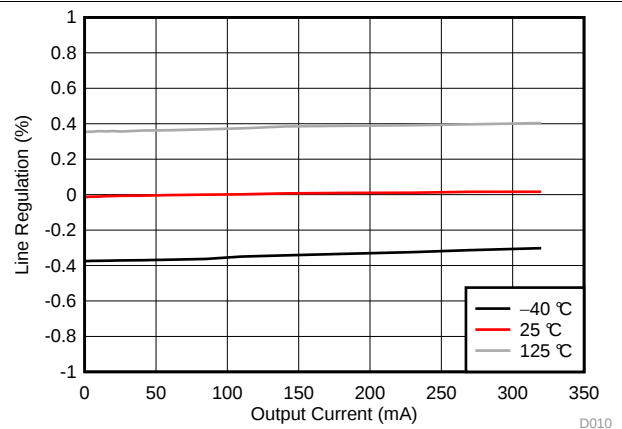


Figure 10. Load Regulation

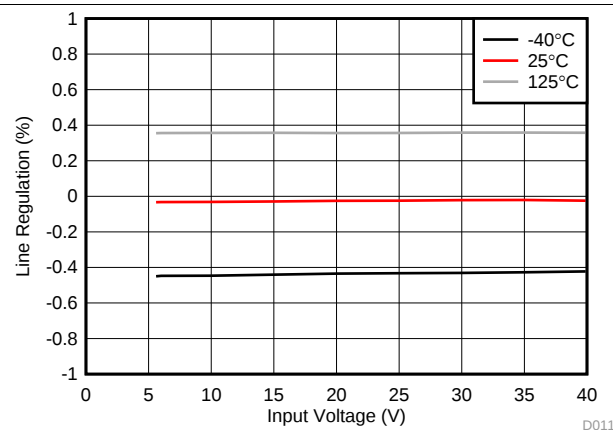


Figure 11. Line Regulation

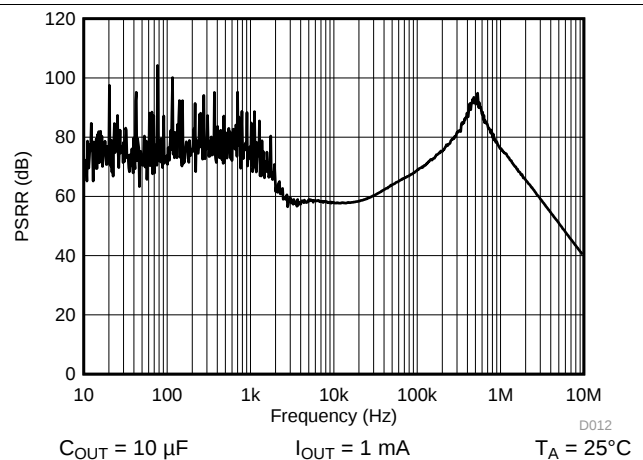


Figure 12. PSRR vs Frequency

## Typical Characteristics (continued)

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ , and  $V_{EN} \geq 2\text{ V}$  (unless otherwise noted)

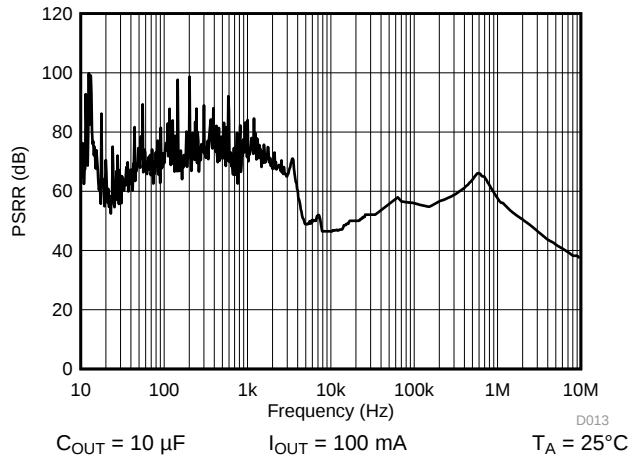


Figure 13. PSRR vs Frequency

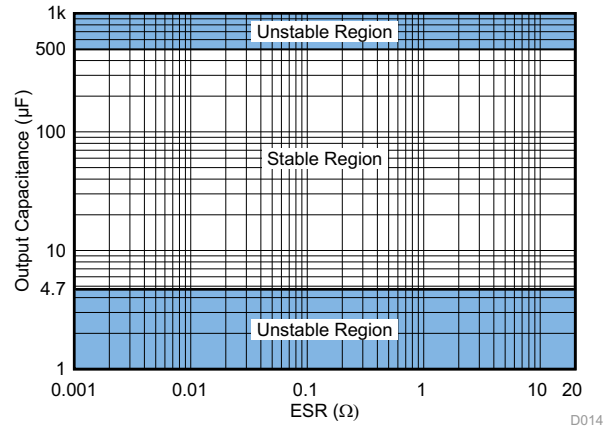


Figure 14. ESR Stability vs Output Capacitance

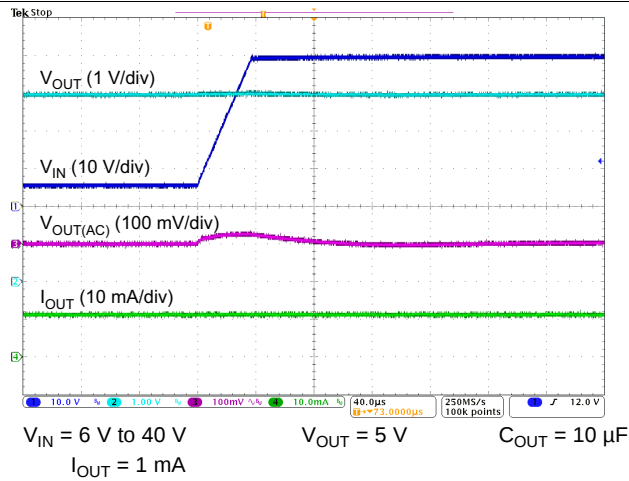


Figure 15. Line Transient

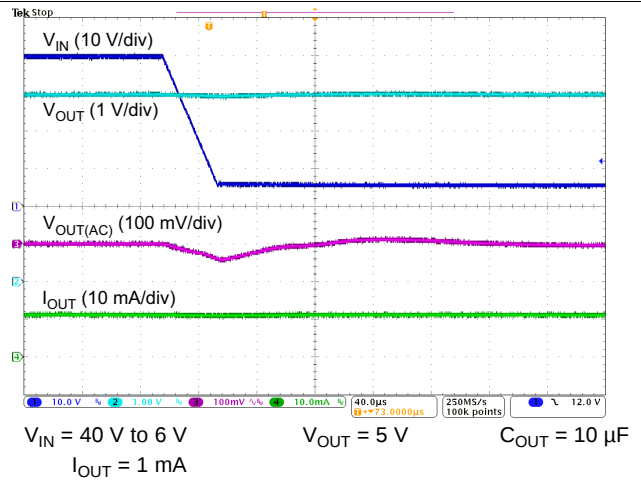


Figure 16. Line Transient

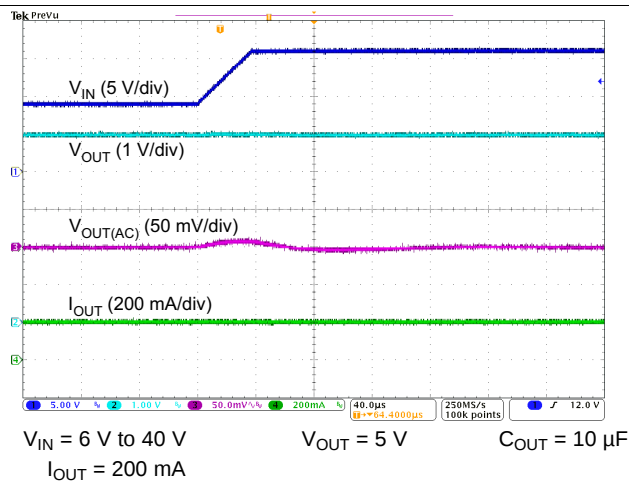


Figure 17. Line Transient

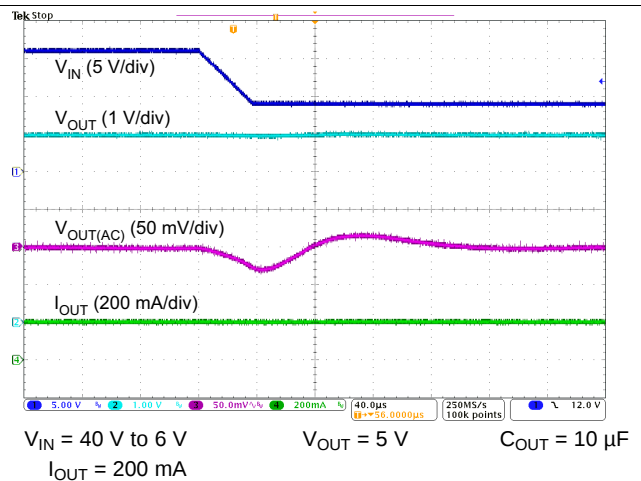


Figure 18. Line Transient

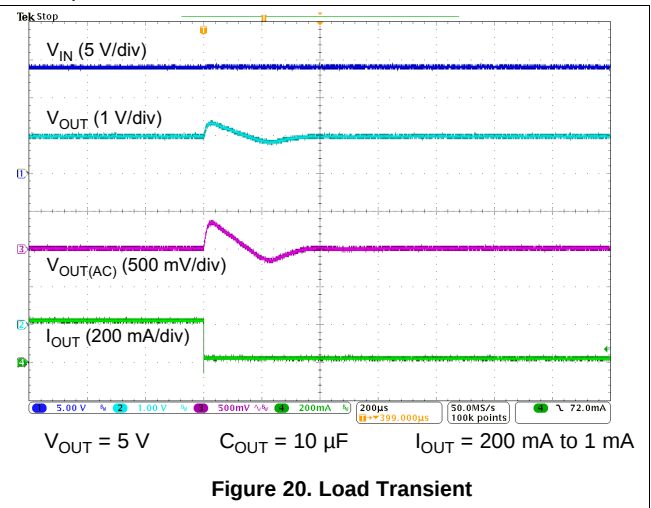
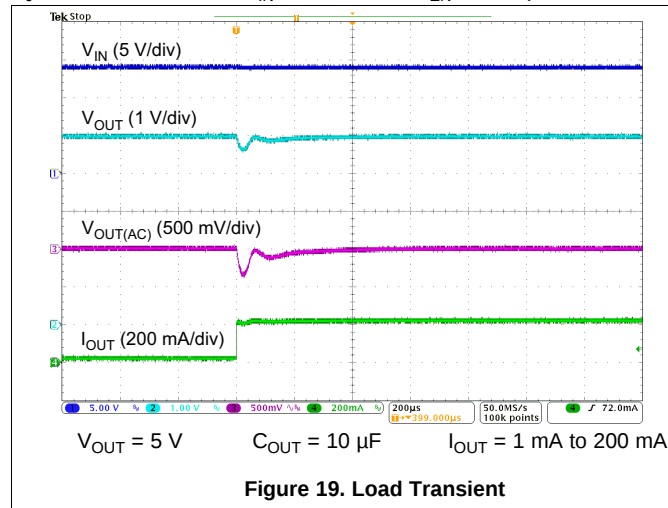
# TPS7B70-Q1

SLVSEK5A – AUGUST 2018 – REVISED OCTOBER 2018

www.ti.com

## Typical Characteristics (continued)

$T_J = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ ,  $V_{IN} = 14\text{ V}$ , and  $V_{EN} \geq 2\text{ V}$  (unless otherwise noted)





## Feature Description (continued)

### 7.3.2 Adjustable Power-Good Threshold (PG, PGADJ)

The PG pin is an open-drain output with an external pullup resistor to the regulated supply, and the PGADJ pin is a power-good threshold adjustment pin. Connecting the PGADJ pin to GND sets the power-good threshold value to the default,  $V_{(PG\_TH)}$ . When  $V_{OUT}$  exceeds the default power-good threshold, the PG output turns high after the power-good delay has expired. When  $V_{OUT}$  falls below  $V_{(PG\_TH)} - V_{(PG\_HYST)}$ , the PG output turns low after a short deglitch time.

The power-good threshold is also adjustable from 1.1 V to 5 V by using an external resistor divider between PGADJ and OUT. Equation 1 calculates the threshold:

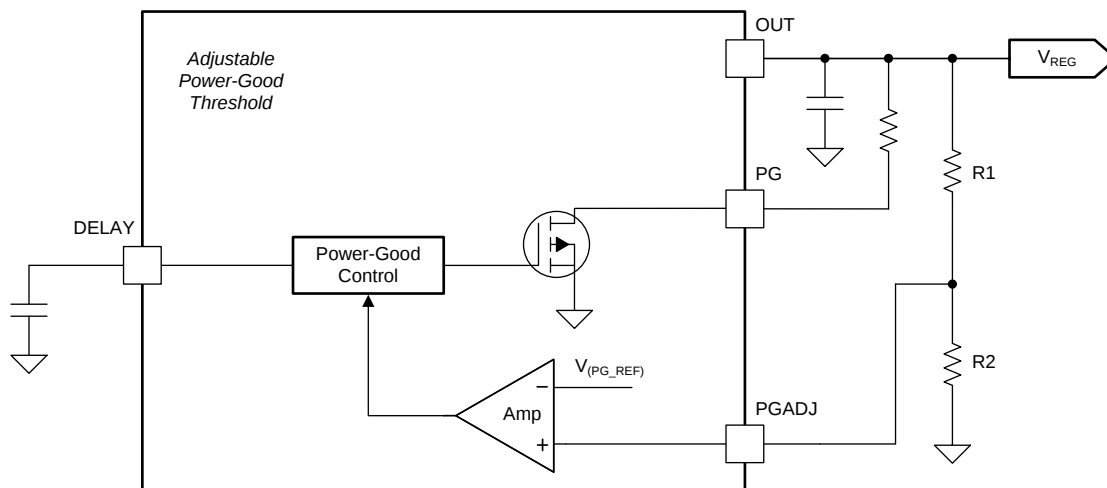
$$V_{(PG\_ADJ) \text{ falling}} = V_{(PGADJ\_TH) \text{ falling}} \times \frac{R1 + R2}{R2}$$

$$V_{(PG\_ADJ) \text{ rising}} = \left[ V_{(PGADJ\_TH) \text{ falling}} + 26 \text{ mV (typ)} \right] \times \frac{R1 + R2}{R2}$$

where:

- $V_{(PG\_ADJ)}$  is the adjustable power-good threshold
- $V_{(PG\_REF)}$  is the internal comparator reference voltage of the PGADJ pin, 1.1 V typical, 2% accuracy specified under all conditions (1)

By setting the power-good threshold  $V_{(PG\_ADJ)}$  when  $V_{OUT}$  exceeds this threshold, the PG output turns high after the power-good delay has expired. When  $V_{OUT}$  falls below  $V_{(PG\_ADJ)} - V_{(PG\_HYST)}$ , the PG output turns low after a short deglitch time. Figure 21 shows a block diagram of this threshold.



**Figure 21. Adjustable Power-Good Threshold**

### 7.3.3 Adjustable Power-Good Delay Timer (DELAY)

The power-good delay,  $t_{(DLY)}$ , is the time from when PGADJ is greater than  $V_{(PG\_REF)}$  until the PG pin goes high. The power-good delay is a function of the value of the external capacitor that is connected to the DELAY pin ( $C_{DELAY}$ ). Connecting an external capacitor from this pin to GND sets the power-good delay. The constant current charges an external capacitor until the voltage exceeds a threshold to trip an internal comparator, and Equation 2 determines the power-good delay. Figure 22 illustrates a timing diagram for power-good power-up conditions.

$$t_{(DLY)} = \frac{C_{DELAY} \times 1 \text{ V}}{5 \mu\text{A}}$$

where

- $t_{(DLY)}$  is the adjustable power-good delay
- $C_{DELAY}$  is the value of the power-good delay capacitor (2)

## Feature Description (continued)

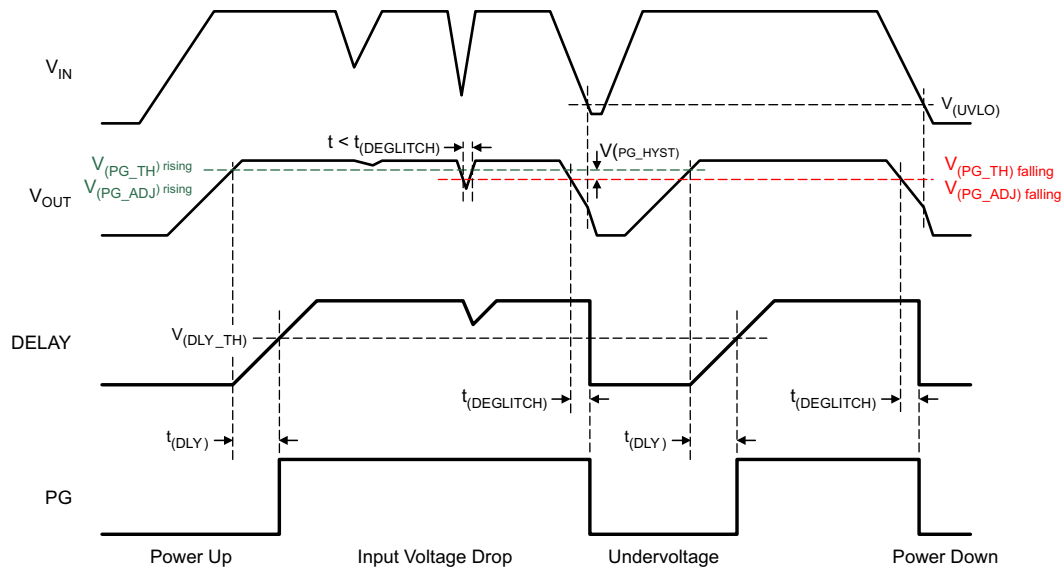


Figure 22. Power-Up and Conditions for Activation of Power Good

If the DELAY pin is open, the default delay time is  $t_{(DLY\_FIX)}$ .

### 7.3.4 Undervoltage Shutdown

This device has an integrated undervoltage lockout (UVLO) circuit that shuts down the output if the input voltage falls below an internal UVLO threshold,  $V_{(UVLO)}$ . The UVLO circuit makes sure that the regulator does not latch into an unknown state during low-input-voltage conditions. If the input voltage has a negative transient that drops below the UVLO threshold and recovers, the regulator shuts down and powers up with a normal power-up sequence after the input voltage rises above the required level.

### 7.3.5 Current Limit

The TPS7B70-Q1 has current-limit protection to keep the device in a safe operating area when an overload or output short-to-ground condition occurs. This feature protects the device from excessive power dissipation. For example, during a short-circuit condition on the output, fault protection limits the current through the pass element to  $I_{(LIM)}$  to protect the device from excessive power dissipation.

### 7.3.6 Thermal Shutdown

This device incorporates a thermal shutdown (TSD) circuit as a protection from overheating. For continuous normal operation, the junction temperature must not exceed the TSD trip point. If the junction temperature exceeds the TSD trip point, the output turns off. When the junction temperature falls below  $T_{(SD)} - T_{(HYST)}$ , the output turns on again.

## 7.4 Device Functional Modes

### 7.4.1 Operation With Input Voltage Less Than 4 V

The device normally operates with input voltages above 4 V. The device can also operate at lower input voltages; the maximum UVLO voltage is 2.6 V. At input voltages below the actual UVLO voltage, the device does not operate.

### 7.4.2 Operation With Input Voltage Greater Than 4 V

If the input voltage is greater than the output set value plus the device dropout voltage when the input voltage is greater than 4 V, then the output voltage is equal to the set value. Otherwise, the output voltage is equal to the input voltage minus the dropout voltage.

## 8 Application and Implementation

### NOTE

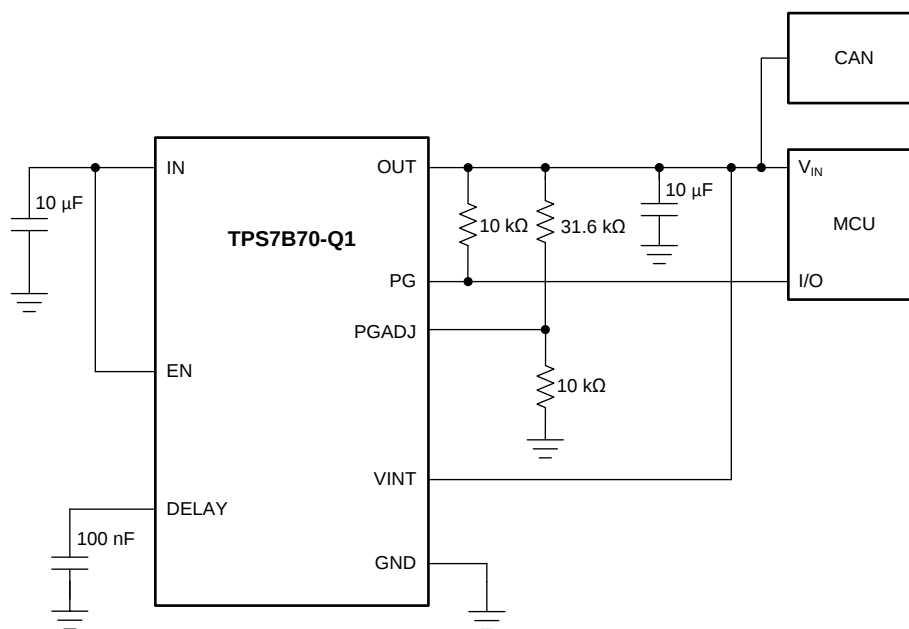
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

### 8.1 Application Information

The TPS7B70-Q1 is a 300-mA low-dropout linear regulator with ultra-low quiescent current. The PSpice transient model is available for download on the product folder and can be used to evaluate the basic function of the device.

### 8.2 Typical Application

Figure 23 shows a typical application circuit for the TPS7B70-Q1. Different values of external components can be used, depending on the end application. An application may require a larger output capacitor during fast load steps to prevent a large drop on the output voltage. Use a low-ESR ceramic capacitor with a dielectric of type X7R.



**Figure 23. Supply Power to an MCU**

## Typical Application (continued)

### 8.2.1 Design Requirements

For this design, the TPS7B70-Q1 must be able to supply a CAN transceiver and an MCU from a 12-V automotive battery. To provide good MCU operation, the PG pin must trip when the output is at 95% of the nominal value. The PG pin must have a 20-ms delay in order to avoid shutting down as a result of temporary glitches.

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Input Capacitor

A 10-μF capacitor in parallel with a 0.1-μF ceramic bypass capacitor is placed at the input in order to keep the input voltage stable. The input can tolerate transients up to 40 V, so the input capacitors have a 50-V voltage rating.

#### 8.2.2.2 Output Capacitor

For this application, a 10-μF X7R ceramic capacitor is used to provide good output transient performance and good loop stability.

#### 8.2.2.3 Power-Good Threshold

The power-good threshold is set by connecting PGADJ to GND, or by connecting PGADJ to a resistor divider from OUT to GND. The [Adjustable Power-Good Threshold \(PG, PGADJ\)](#) section provides the method to setup the power-good threshold. Rearranging [Equation 1](#) yields [Equation 3](#), and solves the values of R1 and R2 that are needed to get the 95% falling threshold. In this design, R2 is a 10-kΩ resistor. Solving [Equation 3](#) for R1 gives a value of 33.18 kΩ. This value is not a standard 1% resistor value, so a 31.6-kΩ resistor is chosen for R1.

$$R1 = R2 \left( \frac{V_{(PGADJ)falling}}{V_{(PTGADJ\_TH)falling}} \right) \quad (3)$$

#### 8.2.2.4 Power-Good Delay, $t_{(DLY)}$

Set the power-good delay with an external capacitor ( $C_{DELAY}$ ) to ground. Calculate the correct capacitance with [Equation 2](#). This application requires a delay of 20 ms, so solve for the correct capacitance required to get this delay. As shown in [Equation 4](#), rearrange [Equation 2](#) to solve for  $C_{DELAY}$ .

$$C_{DELAY} = t_{DLY} \times 5\mu A \quad (4)$$

### 8.2.3 Application Curve

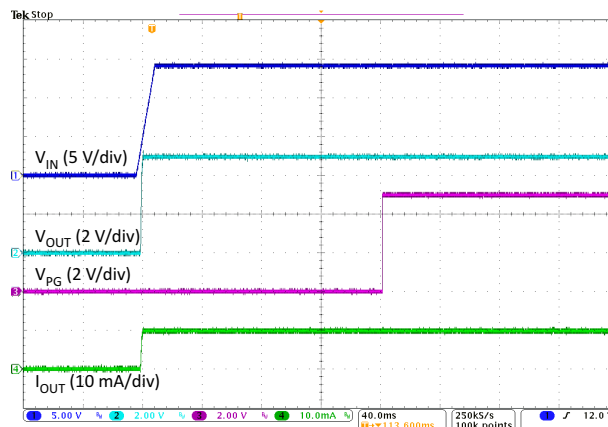


Figure 24. Power-Up Waveform

## 9 Power Supply Recommendations

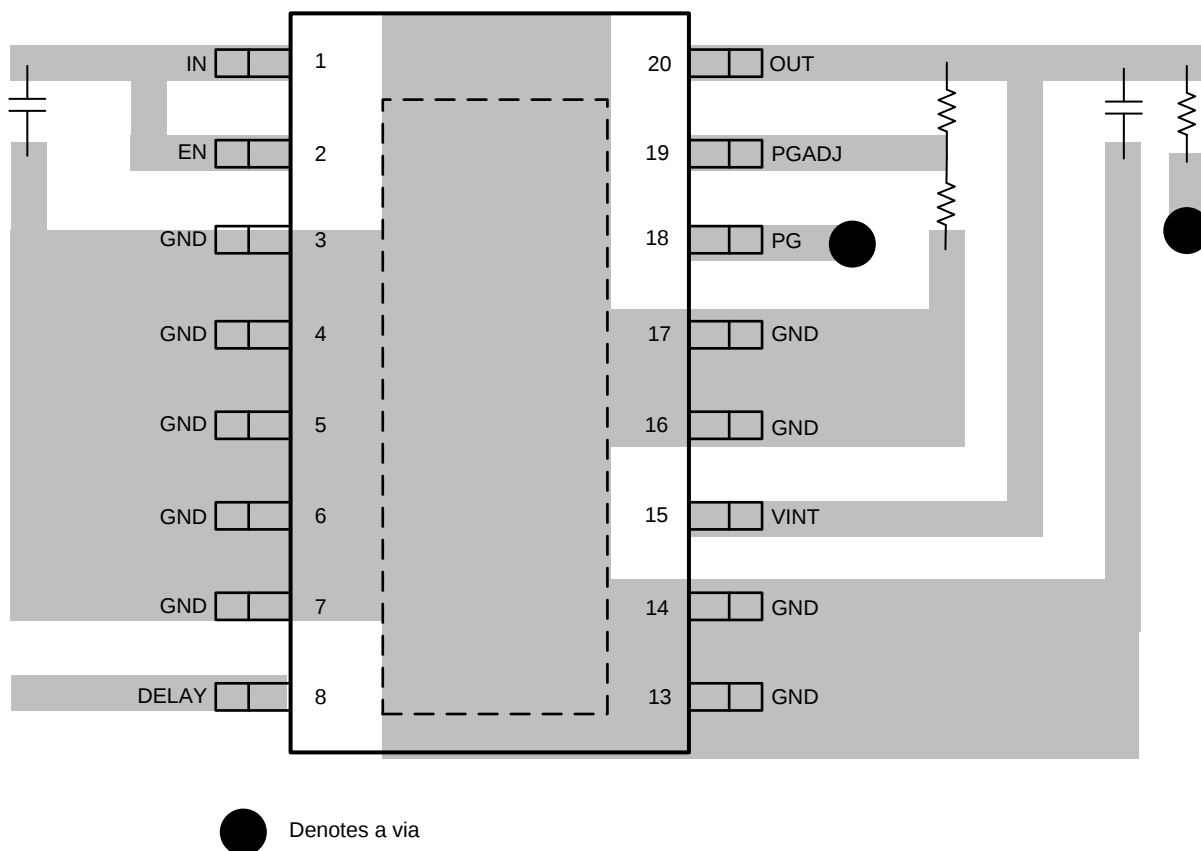
The device is designed to operate from an input-voltage supply range from 4 V to 40 V. This input supply must be well regulated. If the input supply is located more than a few inches from the TPS7B70-Q1, add a capacitor with a value of  $\geq 10\ \mu\text{F}$  with a  $0.1\text{-}\mu\text{F}$  ceramic bypass capacitor in parallel at the input.

## 10 Layout

### 10.1 Layout Guidelines

For LDO power supplies, especially high-voltage and high-current supplies, layout is an important step. If the layout is not carefully designed, the regulator cannot deliver enough output current because of thermal limitations. To improve the thermal performance of the device and maximize the current output at high ambient temperature, spread out the thermal pad as much as possible, and put enough thermal vias on the thermal pad. [Figure 25](#) shows an example layout.

### 10.2 Layout Example



**Figure 25. Layout Example**

## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation see the following:

Texas Instruments, [TPS7B70EVM-008 Evaluation Module user's guide](#)

### 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 11.4 Trademarks

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### 11.5 Electrostatic Discharge Caution



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

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

### 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

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

## 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="#">TPS7B7033QPWPRQ1</a> | Active        | Production           | HTSSOP (PWP)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 7B7033Q             |
| TPS7B7033QPWPRQ1.A               | Active        | Production           | HTSSOP (PWP)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 7B7033Q             |
| <a href="#">TPS7B7050QPWPRQ1</a> | Active        | Production           | HTSSOP (PWP)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 7B7050Q             |
| TPS7B7050QPWPRQ1.A               | Active        | Production           | HTSSOP (PWP)   16 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 125   | 7B7050Q             |

<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

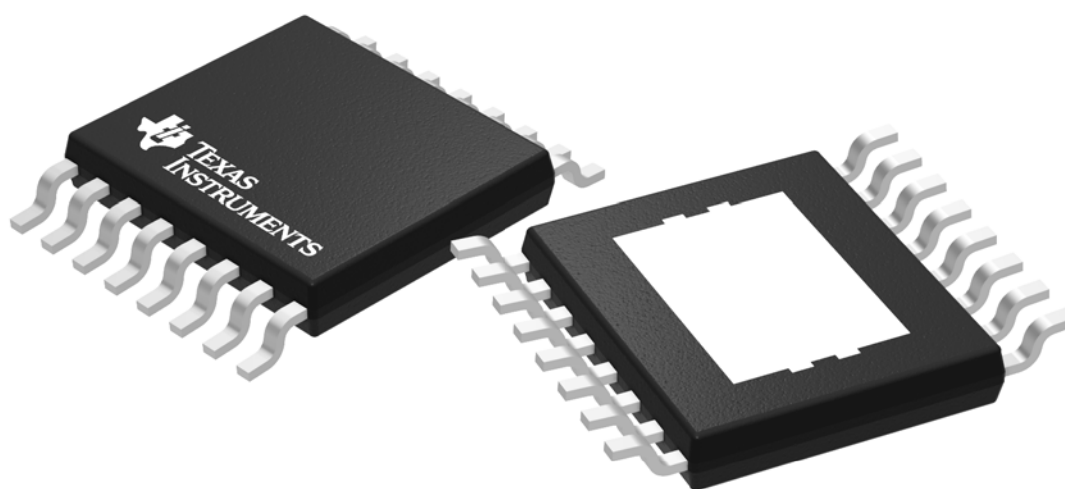
| Device           | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS7B7033QPWPRQ1 | HTSSOP       | PWP             | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TPS7B7050QPWPRQ1 | HTSSOP       | PWP             | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

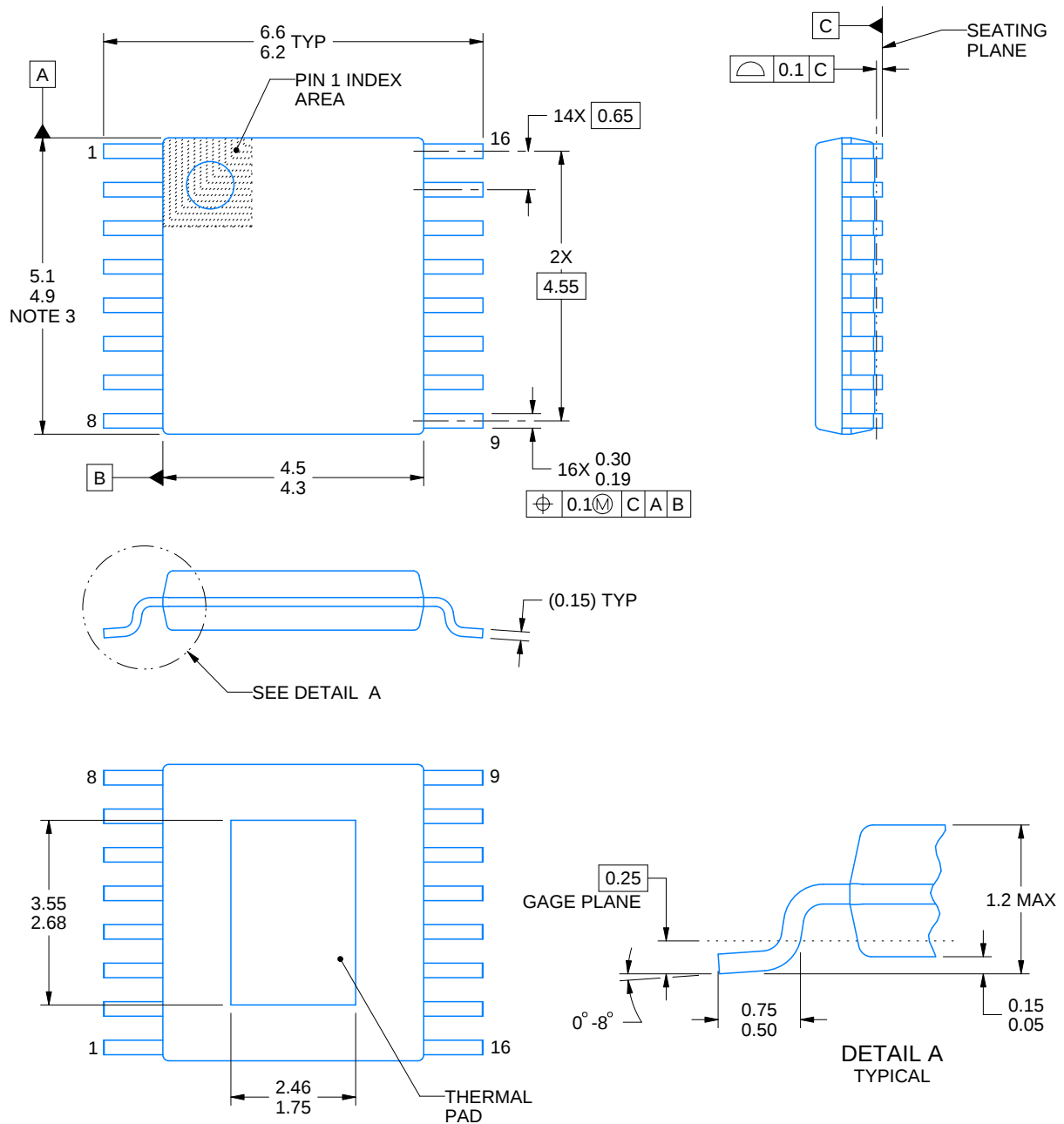
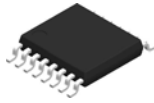


\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS7B7033QPWPRQ1 | HTSSOP       | PWP             | 16   | 2000 | 350.0       | 350.0      | 43.0        |
| TPS7B7050QPWPRQ1 | HTSSOP       | PWP             | 16   | 2000 | 350.0       | 350.0      | 43.0        |



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



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## NOTES:

PowerPAD is a trademark of Texas Instruments.

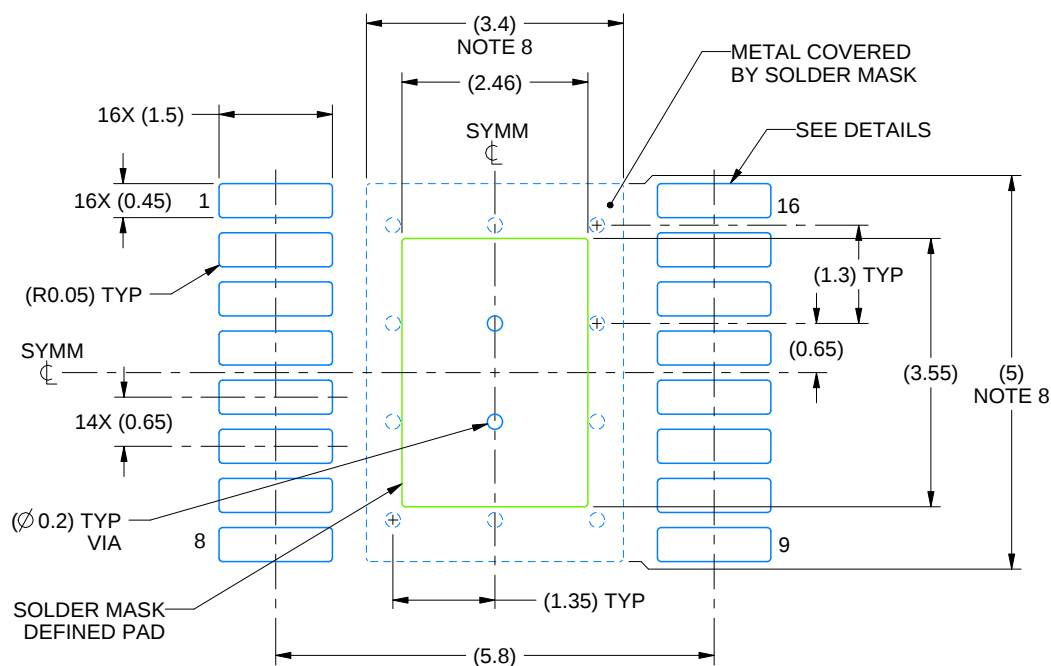
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

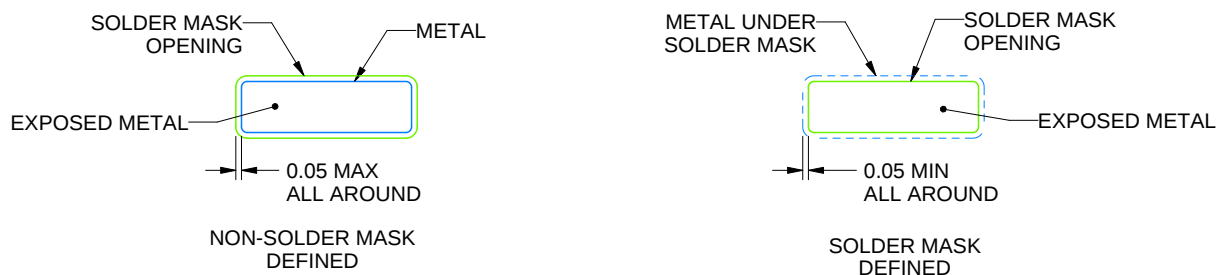
PWP0016J

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

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NOTES: (continued)

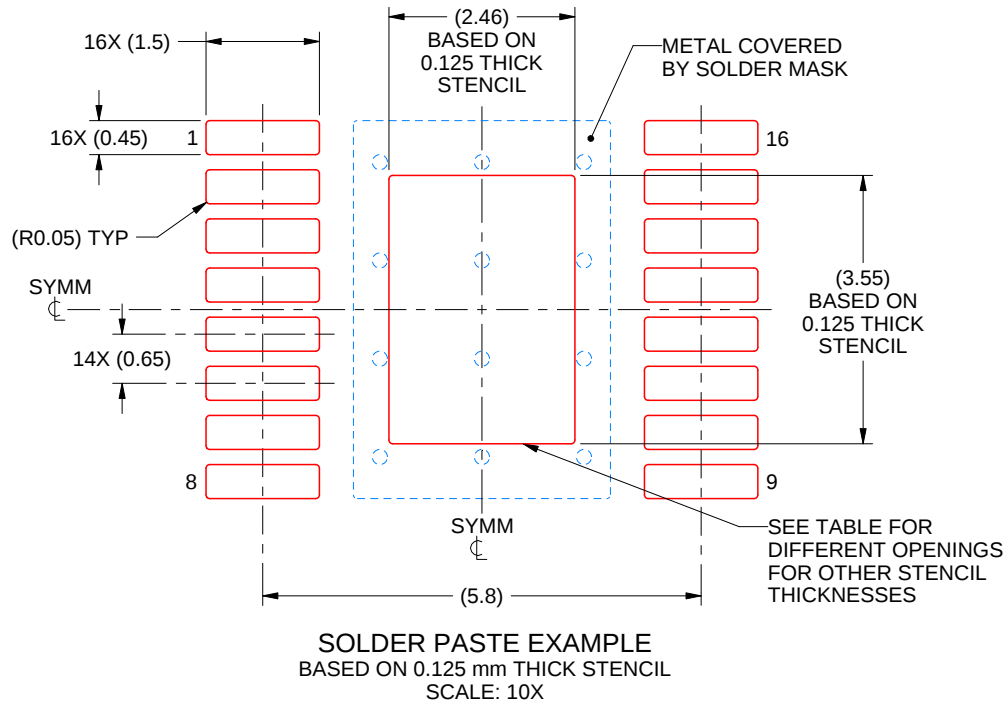
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 ([www.ti.com/lit/slma002](http://www.ti.com/lit/slma002)) and SLMA004 ([www.ti.com/lit/slma004](http://www.ti.com/lit/slma004)).
8. Size of metal pad may vary due to creepage requirement.
9. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

PWP0016J

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



| STENCIL THICKNESS | SOLDER STENCIL OPENING |
|-------------------|------------------------|
| 0.1               | 2.75 X 3.97            |
| 0.125             | 2.46 X 3.55 (SHOWN)    |
| 0.15              | 2.25 X 3.24            |
| 0.175             | 2.08 X 3.00            |

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NOTES: (continued)

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

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