

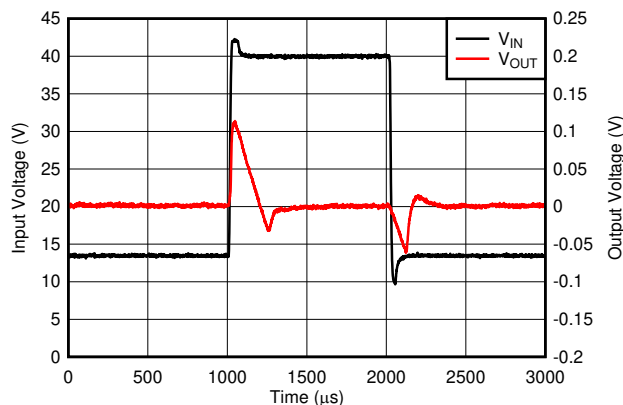
# 具有电源正常状态指示功能的 TPS7B87-Q1 500mA、40V、 低压降稳压器

## 1 特性

- 符合面向汽车应用的 AEC-Q100 标准：
  - 温度等级 1：-40°C 至 +125°C， $T_A$
  - 结温：-40°C 至 +150°C， $T_J$
- 输入电压范围：3V 至 40V (最大 42V)
- 输出电压范围：3.3V 和 5V (固定)
- 最大输出电流：500mA
- 输出电压精度： $\pm 0.85\%$  (最大值)
- 低压降：
  - 450mA 时为 475 mV (最大值)
- 低静态电流：
  - 轻负载时典型值为 17 $\mu$ A
- 出色的线路瞬态响应：
  - 冷启动时出现  $\pm 2\%$   $V_{OUT}$  偏差
  - $\pm 2\%$   $V_{OUT}$  偏差 ( $V_{IN}$  压摆率 1V/ $\mu$ s)
- 具有可编程延迟周期的电源正常状态指示
- 与 2.2 $\mu$ F 或更高的电容器搭配使用时可保持稳定
- 提供功能安全
  - 可帮助进行功能安全系统设计的文档
- 封装选项：
  - 5 引脚 TO-252 封装：29.7°C/W  $R_{\theta JA}$
  - 带有散热焊盘的 8 引脚 HSOIC-8 封装：41.8°C/W  $R_{\theta JA}$

## 2 应用

- 可重新配置仪表组
- 车身控制模块(BCM)
- 常开型电池连接应用：
  - 汽车网关
  - 远程免钥匙进入 (RKE)



线路瞬态响应 ( $V_{IN}$  压摆率 3V/ $\mu$ s)

## 3 说明

TPS7B87-Q1 是一款低压降线性稳压器，专用于连接汽车应用中的电池。该器件的输入电压范围高达 40V，因此可承受汽车系统可能发生的瞬变（如负载突降）。此器件在轻负载下的静态电流仅为 17 $\mu$ A，是为备用系统中微控制器 (MCU) 和控制局域网络 (CAN) 收发器等常开型器件供电的出色解决方案。

该器件具有先进的瞬态响应，因此输出端可对负载或线路变化（例如，在冷启动条件下）作出迅速响应。此外，该器件架构新颖，可在从电压跌落恢复过程中最大限度降低输出过冲幅度。正常运行时，该器件可在整个线路、负载和温度范围内维持  $\pm 0.85\%$  的直流精度。

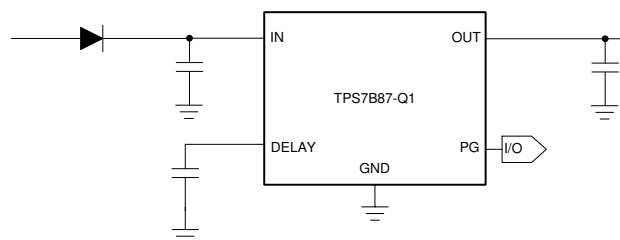
可以通过外部组件调整电源正常状态指示延迟，因此可通过配置延迟时间来适应应用特定的系统。

该器件采用导热封装，可将热量高效传导到电路板上。

### 器件信息<sup>(1)</sup>

| 器件型号       | 封装         | 封装尺寸 (标称值)      |
|------------|------------|-----------------|
| TPS7B87-Q1 | HSOIC (8)  | 4.89mm × 3.90mm |
|            | TO-252 (5) | 6.60mm × 6.10mm |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



输出等于基准电压



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## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

| Changes from Revision * (December 2020) to Revision A (April 2021)                          | Page |
|---------------------------------------------------------------------------------------------|------|
| • 向特性 列表添加了 提供功能安全 要点.....                                                                  | 1    |
| • Updated pin functions table to reflect pin 4 of the HSOIC (DDA) package as an NC pin..... | 3    |

## 5 Pin Configuration and Functions

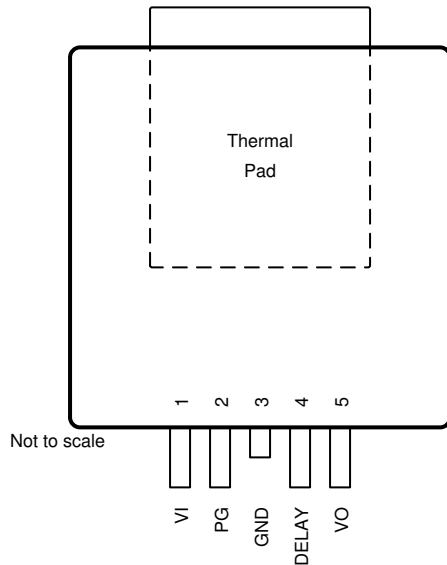


图 5-1. KVV Package, 5-Pin TO-252, Top View

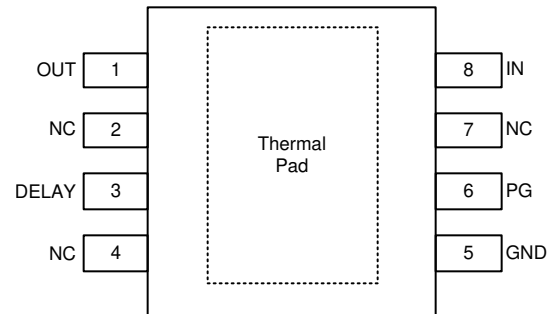


图 5-2. DDA Package, 8-Pin HSOIC, Top View

表 5-1. Pin Functions

| PIN         |     |         | TYPE <sup>(1)</sup> | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------|-----|---------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME        | KVV | DDA     |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| DELAY       | 4   | 3       | I                   | Power-good delay adjustment pin. Connect a capacitor from this pin to GND to set the PG reset delay. Leave this pin floating for a default ( $t_{DLY\_FIX}$ ) delay. See the <a href="#">Power-Good (PG)</a> section for more information. If this functionality is not desired, leave this pin floating because connecting this pin to GND causes a permanent increase in the GND current.                                                                                                          |
| GND         | 3   | 5       | G                   | Ground reference                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| NC          | —   | 2, 4, 7 | —                   | No internal connection. This pin can be left floating or tied to GND for best thermal performance.                                                                                                                                                                                                                                                                                                                                                                                                   |
| PG          | 2   | 6       | I                   | Power-good pin. This pin has an internal pullup resistor. Do not connect this pin to $V_{OUT}$ or any other biased voltage rail. $V_{PG}$ is logic level high when $V_{OUT}$ is above the power-good threshold. See the <a href="#">Power-Good (PG)</a> section for more information.                                                                                                                                                                                                                |
| IN          | 1   | 8       | P                   | Input power-supply voltage pin. For best transient response and to minimize input impedance, use the recommended value or larger ceramic capacitor from IN to GND as listed in the <i>Recommended Operating Conditions</i> table and the <a href="#">Input Capacitor</a> section. Place the input capacitor as close to the input of the device as possible.                                                                                                                                         |
| OUT         | 5   | 1       | O                   | Regulated output voltage pin. A capacitor is required from OUT to GND for stability. For best transient response, use the nominal recommended value or larger ceramic capacitor from OUT to GND; see the <i>Recommended Operating Conditions</i> table and the <a href="#">Output Capacitor</a> section. Place the output capacitor as close to output of the device as possible. If using a high equivalent series resistance (ESR) capacitor, decouple the output with a 100-nF ceramic capacitor. |
| Thermal pad | Pad | Pad     | —                   | Connect the thermal pad to a large area GND plane for improved thermal performance.                                                                                                                                                                                                                                                                                                                                                                                                                  |

(1) I = input; O = output; P = power; G = ground.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

|                  |                                                    | MIN                                          | MAX | UNIT |
|------------------|----------------------------------------------------|----------------------------------------------|-----|------|
| V <sub>IN</sub>  | Unregulated input                                  | - 0.3                                        | 42  | V    |
| V <sub>OUT</sub> | Regulated output                                   | - 0.3 V <sub>IN</sub> + 0.3 V <sup>(2)</sup> |     | V    |
| Delay            | Reset delay input, power-good adjustable threshold | - 0.3                                        | 6   | V    |
| PG               | Power-good outupt                                  | - 0.3                                        | 20  | 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 and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The absolute maximum rating is V<sub>IN</sub> + 0.3 V or 20 V, whichever is smaller

### 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  |      |
|                    |                         | Corner pins                                             | ±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   | TYP | MAX | UNIT |
|--------------------|----------------------------------------------------|-------|-----|-----|------|
| V <sub>IN</sub>    | Input voltage                                      | 3     |     | 40  | V    |
| V <sub>OUT</sub>   | Output voltage                                     | 1.2   |     | 18  | V    |
| I <sub>OUT</sub>   | Output current                                     | 0     |     | 500 | mA   |
| V <sub>Delay</sub> | Delay pin voltage, power-good adjustable threshold | 0     |     | 5.5 | V    |
| V <sub>PG</sub>    | Power-good outupt pin                              | 0     |     | 18  | V    |
| C <sub>OUT</sub>   | Output capacitor <sup>(2)</sup>                    | 2.2   |     | 220 | μF   |
| ESR                | Output capacitor ESR requirements                  | 0.001 |     | 2   | Ω    |
| C <sub>IN</sub>    | Input capacitor <sup>(1)</sup>                     | 0.1   | 1   |     | μF   |
| C <sub>Delay</sub> | Power-good delay capacitor                         |       |     | 1   | μF   |
| T <sub>J</sub>     | Operating junction temperature                     | - 40  |     | 150 | °C   |

- (1) For robust EMI performance the minimum input capacitance is 500 nF.
- (2) Effective output capacitance of 1 μF minimum required for stability.

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> <sup>(2)</sup> |                                              | TPS7B87-Q1 |        | UNIT |
|----------------------------------------------|----------------------------------------------|------------|--------|------|
|                                              |                                              | KVU        | DDA    |      |
|                                              |                                              | 5 PINS     | 8 PINS |      |
| $R_{\theta JA}$                              | Junction-to-ambient thermal resistance       | 29.7       | 41.8   | °C/W |
| $R_{\theta JC(top)}$                         | Junction-to-case (top) thermal resistance    | 40.2       | 55     | °C/W |
| $R_{\theta JB}$                              | Junction-to-board thermal resistance         | 8.6        | 17.3   | °C/W |
| $\psi_{JT}$                                  | Junction-to-top characterization parameter   | 2.9        | 4.5    | °C/W |
| $\psi_{JB}$                                  | Junction-to-board characterization parameter | 8.5        | 17.3   | °C/W |
| $R_{\theta JC(bot)}$                         | Junction-to-case (bottom) thermal resistance | 1.5        | 5.7    | °C/W |

- (1) The thermal data is based on the JEDEC standard high K profile, JESD 51-7. Two-signal, two-plane, four-layer board with 2-oz. copper. The copper pad is soldered to the thermal land pattern. Also, correct attachment procedure must be incorporated.
- (2) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ ,  $C_{IN} = 1\text{ }\mu\text{F}$  typical values are at  $T_J = 25^{\circ}\text{C}$

| PARAMETER                        |                                                              | Test Conditions                                                                                                                                      | MIN                                          | TYP  | MAX   | UNIT               |
|----------------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|------|-------|--------------------|
| $V_{OUT}$                        | Regulated output                                             | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $450\text{ mA}$ , $T_J = 25^{\circ}\text{C}$ <sup>(1)</sup> | -0.85                                        |      | 0.85  | %                  |
|                                  |                                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $500\text{ mA}$ , $T_J = 25^{\circ}\text{C}$ <sup>(1)</sup> | -0.85                                        |      | 0.85  |                    |
|                                  |                                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $450\text{ mA}$ <sup>(1)</sup>                              | -1.15                                        |      | 1.15  |                    |
|                                  |                                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $500\text{ mA}$ <sup>(1)</sup>                              | -1.15                                        |      | 1.15  |                    |
| $\Delta V_{OUT(\Delta I_{OUT})}$ | Load regulation                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $450\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$                                |                                              |      | 0.425 | %                  |
|                                  |                                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$ to $500\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$                                |                                              |      | 0.45  |                    |
| $\Delta V_{OUT(\Delta V_{IN})}$  | Line regulation                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 100\text{ }\mu\text{A}$                                                                |                                              |      | 0.2   | %                  |
| $\Delta V_{OUT}$                 | Load transient response settling time                        | $t_R = t_F = 1\text{ }\mu\text{s}$ ; $C_{OUT} = 10\text{ }\mu\text{F}$ , $V_{OUT} \geq 3.3\text{ V}$                                                 |                                              |      | 100   | $\mu\text{s}$      |
| $\Delta V_{OUT}$                 | Load transient response overshoot, undershoot <sup>(2)</sup> | $t_R = t_F = 1\text{ }\mu\text{s}$ ; $C_{OUT} = 10\text{ }\mu\text{F}$                                                                               | $I_{OUT} = 150\text{ mA}$ to $350\text{ mA}$ |      | -2%   | % $V_{OUT}$        |
|                                  |                                                              |                                                                                                                                                      | $I_{OUT} = 350\text{ mA}$ to $150\text{ mA}$ |      | 10%   |                    |
|                                  |                                                              |                                                                                                                                                      | $I_{OUT} = 0\text{ mA}$ to $500\text{ mA}$   |      | -10%  |                    |
| $I_Q$                            | Quiescent current                                            | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 0\text{ mA}$ , $T_J = 25^{\circ}\text{C}$ <sup>(3)</sup>                               |                                              | 17   | 21    | $\mu\text{A}$      |
|                                  |                                                              | $V_{IN} = V_{OUT} + 1\text{ V}$ to $40\text{ V}$ , $I_{OUT} = 0\text{ mA}$ <sup>(3)</sup>                                                            |                                              |      | 26    |                    |
|                                  |                                                              | $I_{OUT} = 500\text{ }\mu\text{A}$                                                                                                                   |                                              |      | 35    |                    |
| $V_{DO}$                         | Dropout voltage fixed output voltages (DDA Package)          | $I_{OUT} \leq 1\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)} \times 0.95$                                                       |                                              |      | 43    | mV                 |
|                                  |                                                              | $I_{OUT} = 315\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 260  | 360   |                    |
|                                  |                                                              | $I_{OUT} = 450\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 335  | 475   |                    |
|                                  |                                                              | $I_{OUT} = 500\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 360  | 535   |                    |
| $V_{DO}$                         | Dropout voltage fixed output voltages (KVU Package)          | $I_{OUT} \leq 1\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)} \times 0.95$                                                       |                                              |      | 46    | mV                 |
|                                  |                                                              | $I_{OUT} = 315\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 275  | 400   |                    |
|                                  |                                                              | $I_{OUT} = 450\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 360  | 525   |                    |
|                                  |                                                              | $I_{OUT} = 500\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$                                                                    |                                              | 390  | 575   |                    |
| $V_{UVLO(RISING)}$               | Rising input supply UVLO                                     | $V_{IN}$ rising                                                                                                                                      | 2.6                                          | 2.7  | 2.82  | V                  |
| $V_{UVLO(FALLING)}$              | Falling input supply UVLO                                    | $V_{IN}$ falling                                                                                                                                     | 2.38                                         | 2.5  | 2.6   | V                  |
| $V_{UVLO(HYST)}$                 | $V_{UVLO(IN)}$ hysteresis                                    |                                                                                                                                                      |                                              | 230  |       | mV                 |
| $I_{CL}$                         | Output current limit                                         | $V_{IN} = V_{OUT} + 1\text{ V}$ , $V_{OUT}$ short to $90\% \times V_{OUT(NOM)}$                                                                      | 540                                          |      | 780   | mA                 |
| PSRR                             | Power supply rejection ratio                                 | $V_{IN} - V_{OUT} = 1\text{ V}$ , frequency = $1\text{ kHz}$ , $I_{OUT} = 450\text{ mA}$                                                             |                                              | 70   |       | dB                 |
| $R_{PG}$                         | Power-good internal pull up resistor                         |                                                                                                                                                      | 10                                           | 30   | 50    | $k\Omega$          |
| $V_{PG(OL)}$                     | PG pin low level output voltage                              | $V_{OUT} \leq 0.83 \times V_{OUT}$                                                                                                                   |                                              |      | 0.4   | V                  |
| $V_{PG(TH,RISING)}$              | Default power-good threshold                                 | $V_{OUT}$ rising                                                                                                                                     | 85                                           |      | 95    | % $V_{OUT}$        |
| $V_{PG(TH,FALLING)}$             | Default power-good threshold                                 | $V_{OUT}$ falling                                                                                                                                    | 83                                           |      | 93    |                    |
| $V_{PG(HYST)}$                   | Power-good hysteresis                                        |                                                                                                                                                      |                                              | 2    |       |                    |
| $V_{DLY(TH)}$                    | Threshold to release power-good high                         | Voltage at DELAY pin rising                                                                                                                          | 1.17                                         | 1.21 | 1.25  | V                  |
| $I_{DLY(CHARGE)}$                | Delay capacitor charging current                             | Voltage at DELAY pin = $1\text{ V}$                                                                                                                  | 1                                            | 1.5  | 2     | $\mu\text{A}$      |
| $T_J$                            | Junction temperature                                         |                                                                                                                                                      | -40                                          |      | 150   | $^{\circ}\text{C}$ |

## 6.5 Electrical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ ,  $C_{IN} = 1\text{ }\mu\text{F}$  typical values are at  $T_J = 25^{\circ}\text{C}$

| PARAMETER          |                                | Test Conditions | MIN | TYP | MAX | UNIT               |
|--------------------|--------------------------------|-----------------|-----|-----|-----|--------------------|
| $T_{SD(SHUTDOWN)}$ | Junction shutdown temperature  |                 |     | 175 |     | $^{\circ}\text{C}$ |
| $T_{SD(HYST)}$     | Hysteresis of thermal shutdown |                 |     | 20  |     | $^{\circ}\text{C}$ |

- (1) Power dissipation is limited to 2 W for device production testing purposes. The power dissipation can be higher during normal operation. See the thermal dissipation section for more information on how much power the device can dissipate while maintaining a junction temperature below  $150^{\circ}\text{C}$ .
- (2) Specified by design.
- (3) For the adjustable output this is tested in unity gain and resistor current is not included.

## 6.6 Switching Characteristics

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

| PARAMETER                |                              | TEST CONDITIONS                                         | MIN | TYP | MAX | UNIT          |
|--------------------------|------------------------------|---------------------------------------------------------|-----|-----|-----|---------------|
| <b>TIMING POWER-GOOD</b> |                              |                                                         |     |     |     |               |
| $t_{(DLY\_FIX)}$         | Power-good propagation delay | No capacitor connect at DELAY pin                       |     | 100 |     | $\mu\text{s}$ |
| $t_{(Deglitch)}$         | Power-good deglitch time     | No capacitor connect at DELAY pin                       |     | 90  |     | $\mu\text{s}$ |
| $t_{(DLY)}$              | Power-good propagation delay | Delay capacitor value:<br>$C_{(DELAY)} = 100\text{ nF}$ |     | 80  |     | ms            |

## 6.7 Typical Characteristics

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)

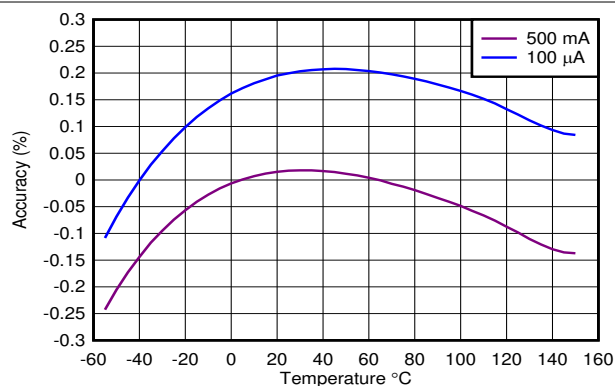
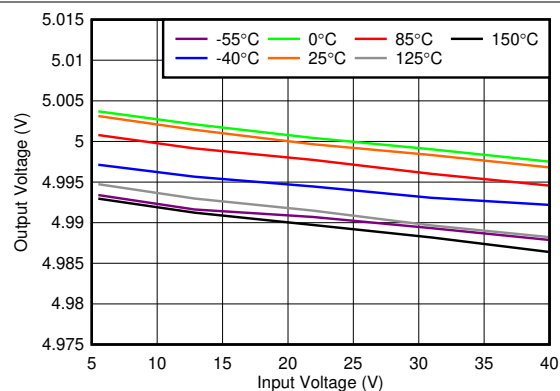
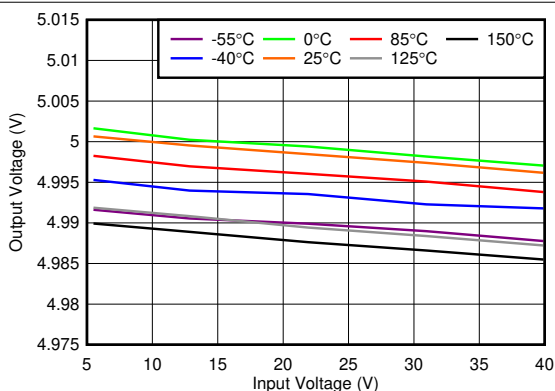


图 6-1. Accuracy vs Temperature



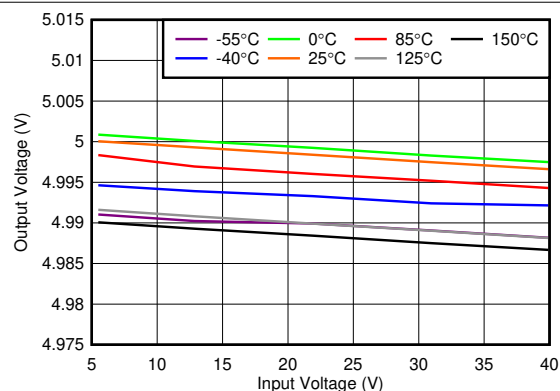
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 150\text{ mA}$

图 6-2. Line Regulation vs  $V_{IN}$



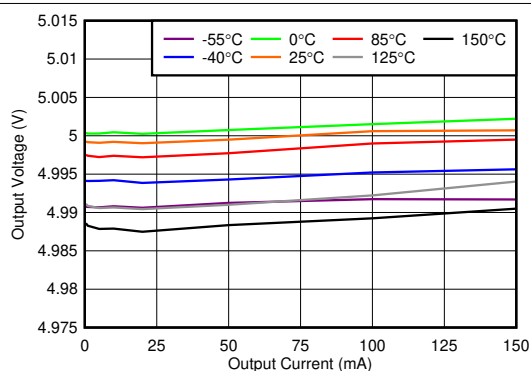
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 5\text{ mA}$

图 6-3. Line Regulation vs  $V_{IN}$



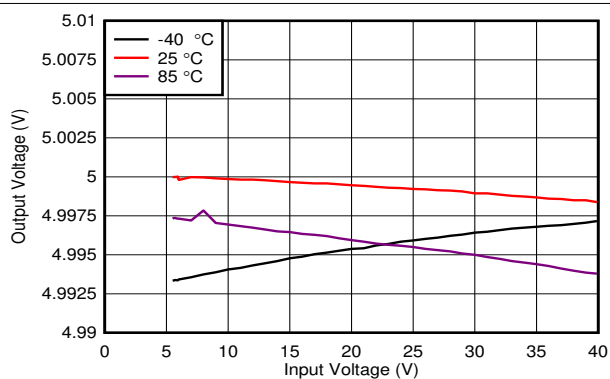
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$

图 6-4. Line Regulation vs  $V_{IN}$



$V_{OUT} = 5\text{ V}$

图 6-5. Load Regulation vs  $I_{OUT}$



$C_{OUT} = 10\text{ }\mu\text{F}$ ,  $V_{OUT} = 5\text{ V}$

图 6-6. Line Regulation at 50 mA

## 6.7 Typical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)

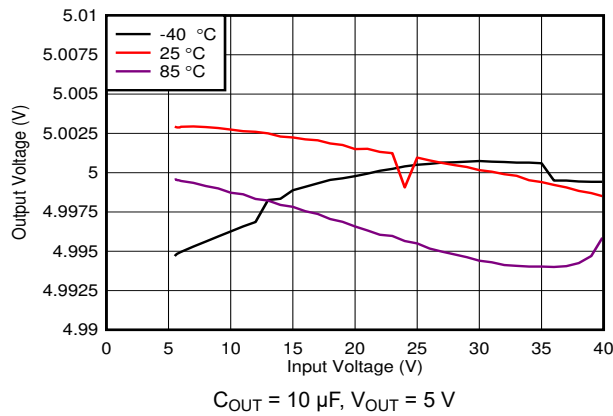


图 6-7. Line Regulation at 100 mA

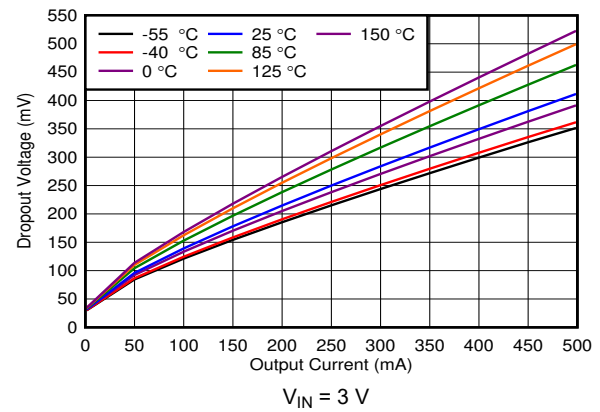


图 6-8. Dropout Voltage ( $V_{DO}$ ) vs  $I_{OUT}$

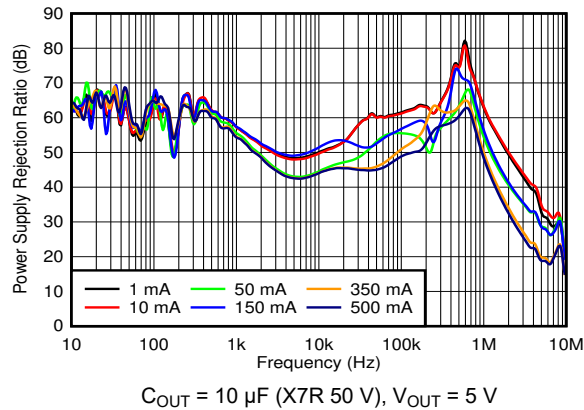


图 6-9. PSRR vs Frequency and  $I_{OUT}$

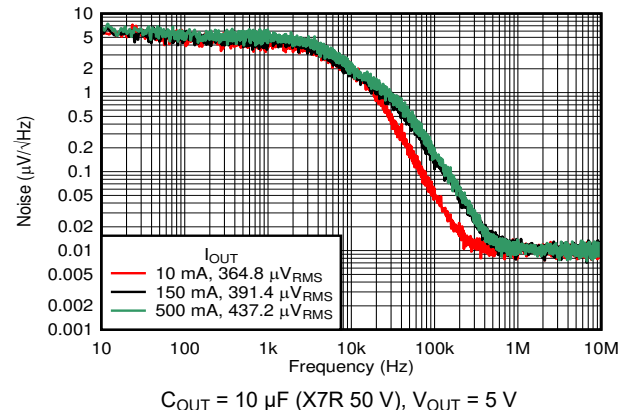


图 6-10. Noise vs Frequency

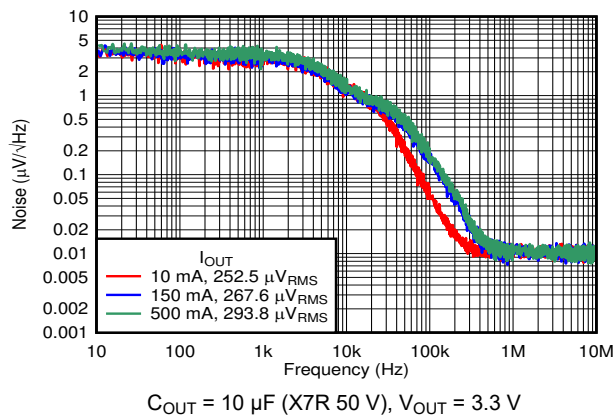


图 6-11. Noise vs Frequency

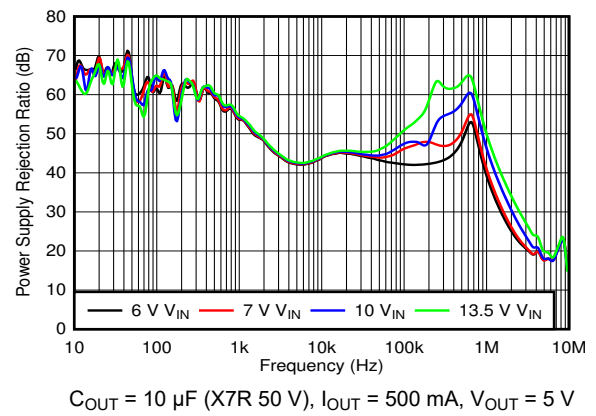
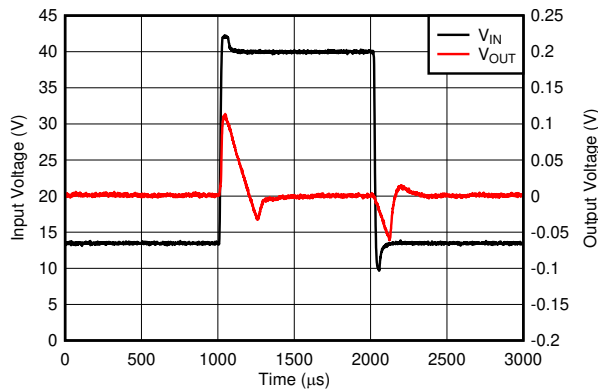


图 6-12. PSRR vs Frequency and  $V_{IN}$

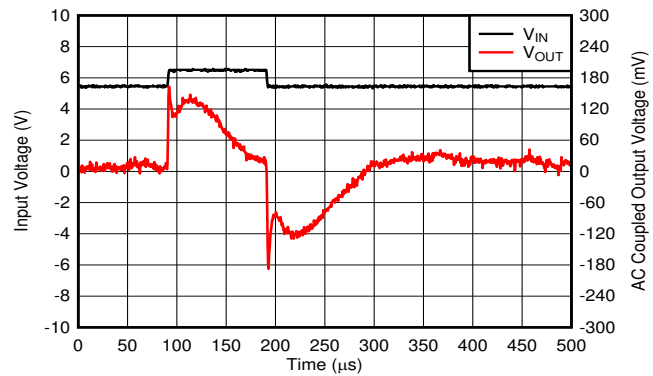
## 6.7 Typical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)



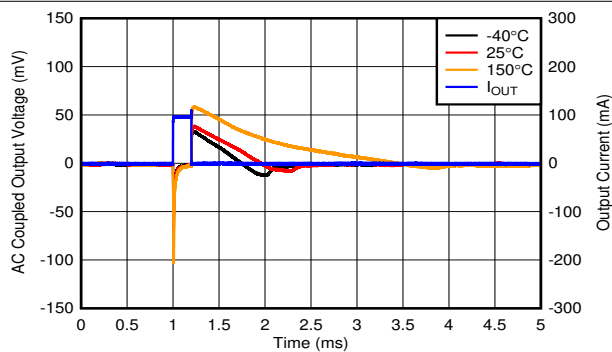
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 1\text{ mA}$ ,  $V_{IN} = 13.5\text{ V}$  to  $45\text{ V}$ ,  
slew rate =  $2.7\text{ V}/\mu\text{s}$

图 6-13. Line Transients



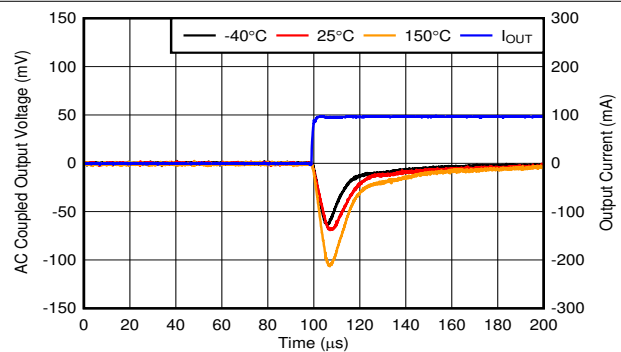
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 100\text{ mA}$ ,  $V_{IN} = 5.5\text{ V}$  to  $6.5\text{ V}$ ,  
rise time =  $1\text{ }\mu\text{s}$

图 6-14. Line Transients



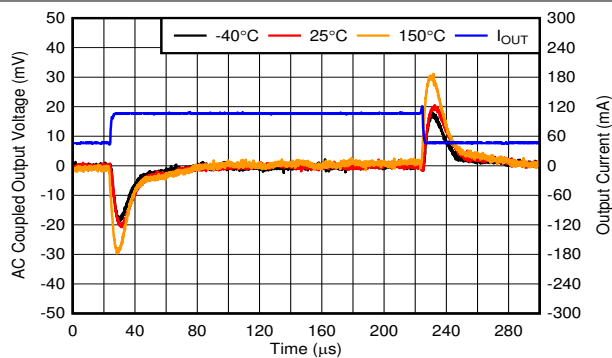
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$  to  $100\text{ mA}$ , slew rate =  $1\text{ A}/\mu\text{s}$ ,  
 $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-15. Load Transient, No Load to 100 mA



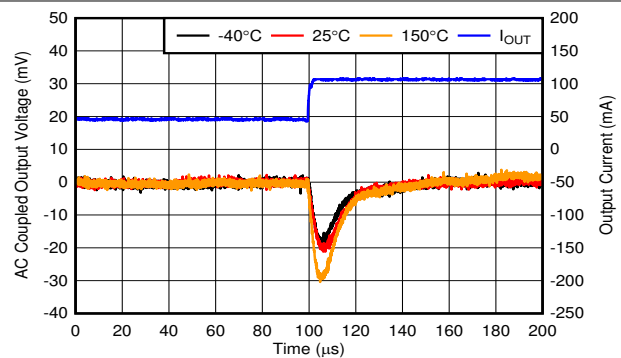
$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$  to  $100\text{ mA}$ , slew rate =  $1\text{ A}/\mu\text{s}$ ,  
 $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-16. Load Transient, No Load to 100-mA Rising Edge



$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 45\text{ mA}$  to  $105\text{ mA}$ , slew rate =  $0.1\text{ A}/\mu\text{s}$ ,  
 $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-17. Load Transient, 45 mA to 105 mA



$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 45\text{ mA}$  to  $105\text{ mA}$ , slew rate =  $0.1\text{ A}/\mu\text{s}$ ,  
 $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-18. Load Transient, 45-mA to 105-mA Rising Edge

## 6.7 Typical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)

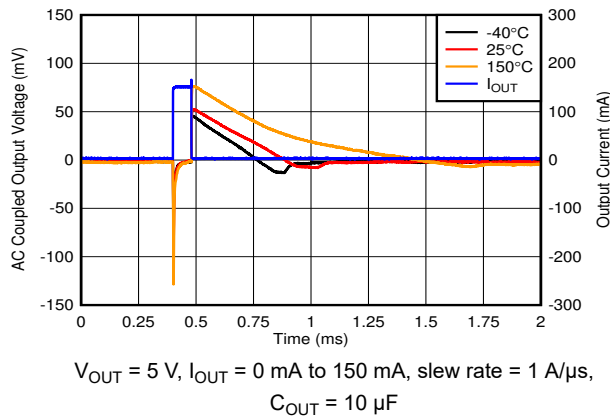


图 6-19. Load Transient, No Load to 150-mA

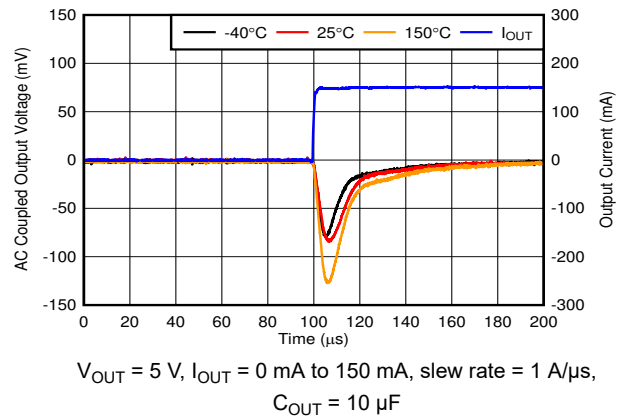


图 6-20. Load Transient, No Load to 150-mA Rising Edge

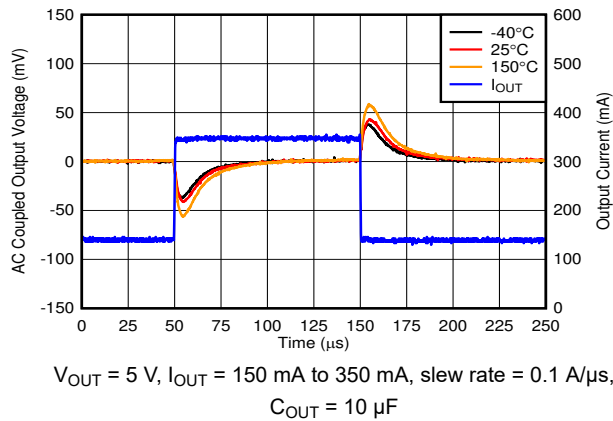


图 6-21. Load Transient, 150-mA to 350-mA

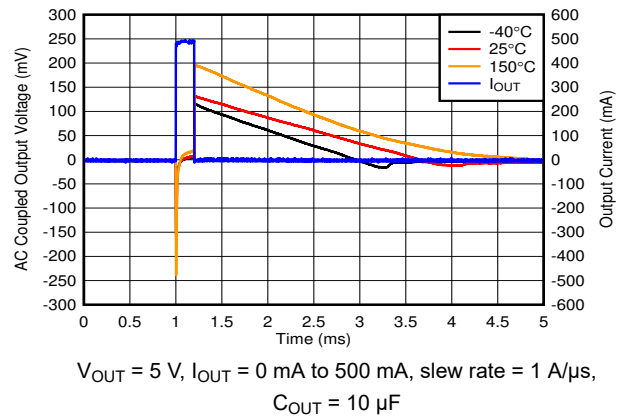


图 6-22. Load Transient, No Load to 500 mA

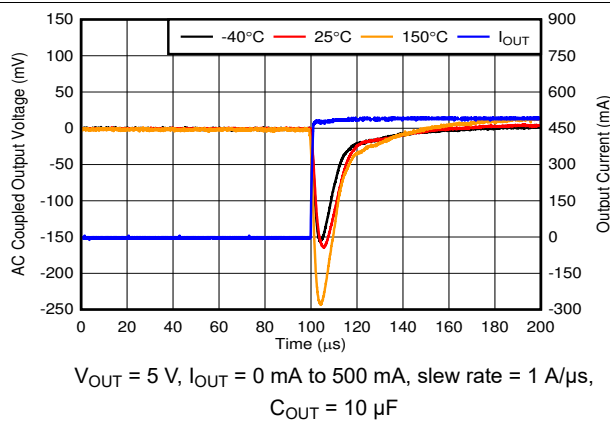


图 6-23. Load Transient, No Load to 500-mA Rising Edge

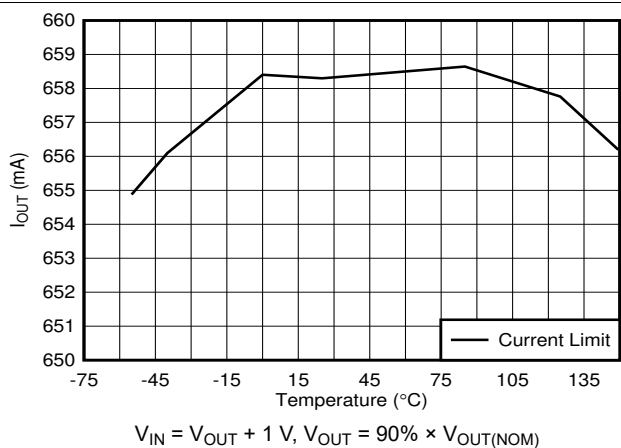


图 6-24. Output Current Limit vs Temperature

## 6.7 Typical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)

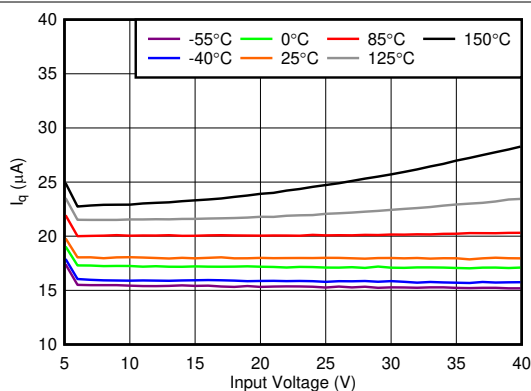


图 6-25. Quiescent Current ( $I_Q$ ) vs  $V_{IN}$

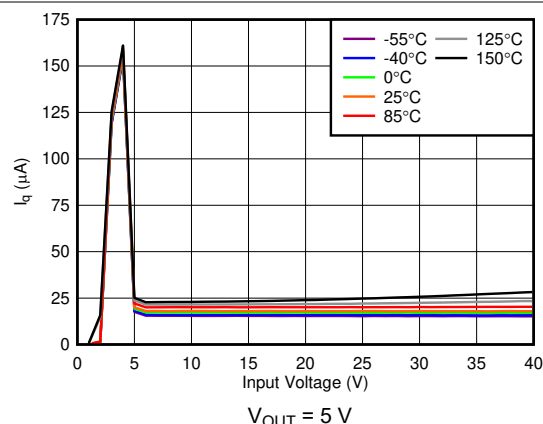


图 6-26. Quiescent Current ( $I_Q$ ) vs  $V_{IN}$

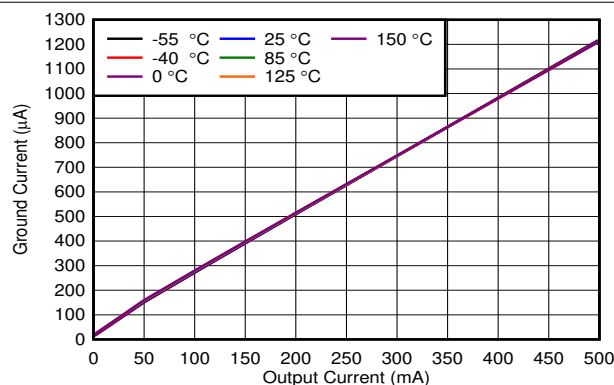


图 6-27. Ground Current ( $I_{GND}$ ) vs  $I_{OUT}$

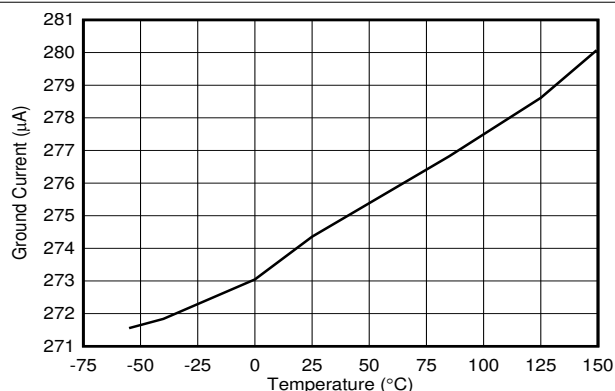


图 6-28. Ground Current at 100 mA

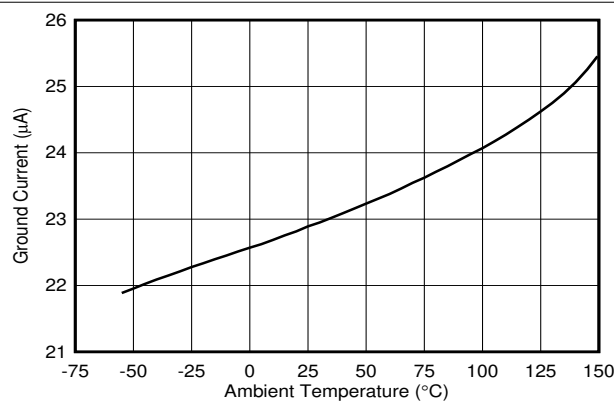


图 6-29. Ground Current at 500  $\mu\text{A}$

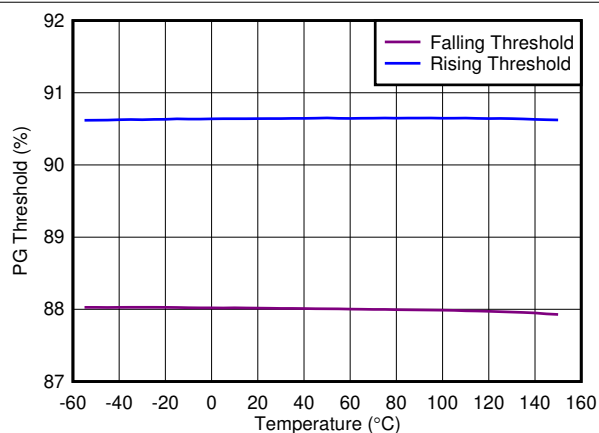


图 6-30. PG Threshold vs Temperature

## 6.7 Typical Characteristics (continued)

specified at  $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{IN} = 13.5\text{ V}$ ,  $I_{OUT} = 100\text{ }\mu\text{A}$ ,  $C_{OUT} = 2.2\text{ }\mu\text{F}$ ,  $1\text{ m}\Omega < C_{OUT}\text{ ESR} < 2\text{ }\Omega$ , and  $C_{IN} = 1\text{ }\mu\text{F}$  (unless otherwise noted)

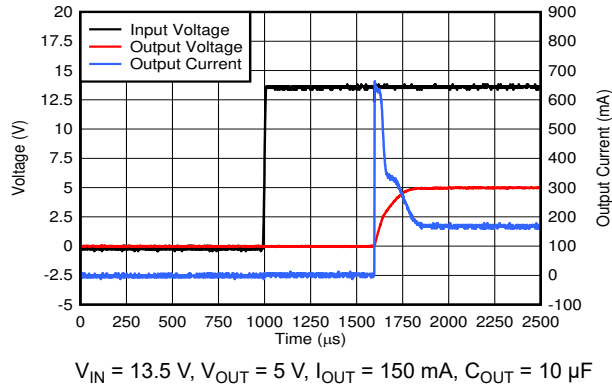


图 6-31. Startup Plot Inrush Current

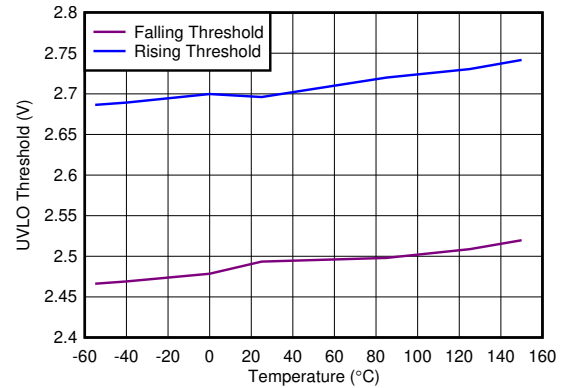


图 6-32. Undervoltage Lockout (UVLO) Threshold vs Temperature

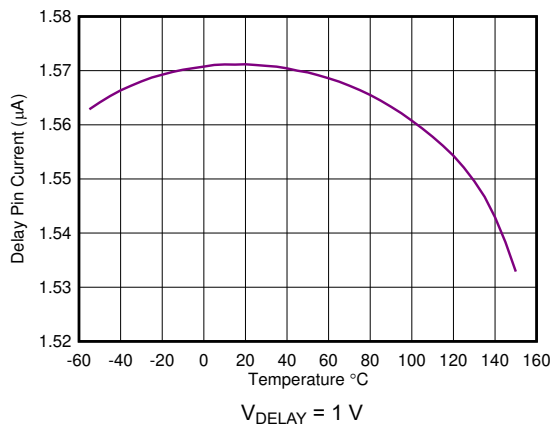


图 6-33. Delay Pin Current vs Temperature

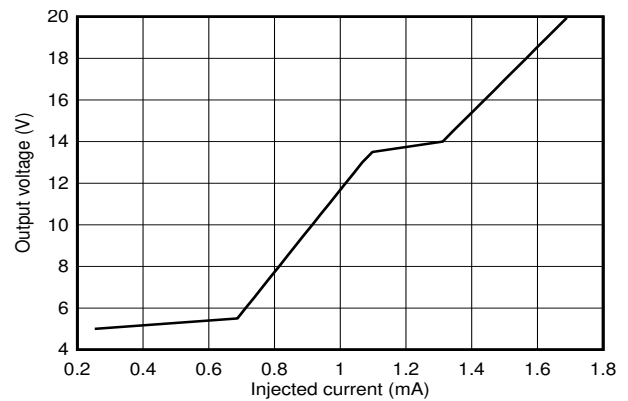


图 6-34. Output Voltage vs Injected Current

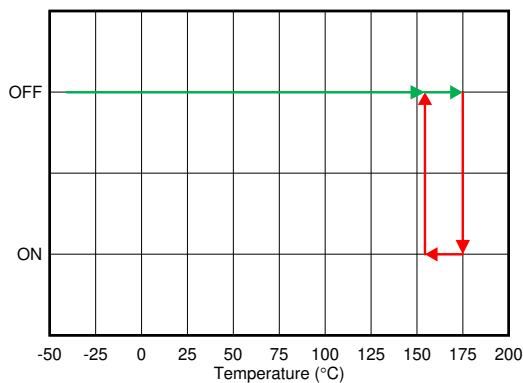


图 6-35. Thermal Shutdown

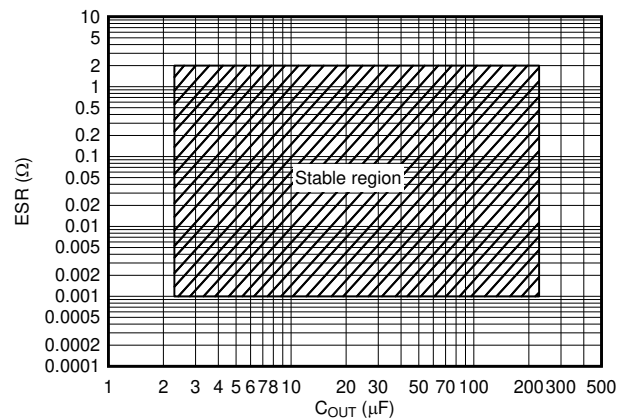


图 6-36. Stability, ESR vs  $C_{OUT}$

## 7 Detailed Description

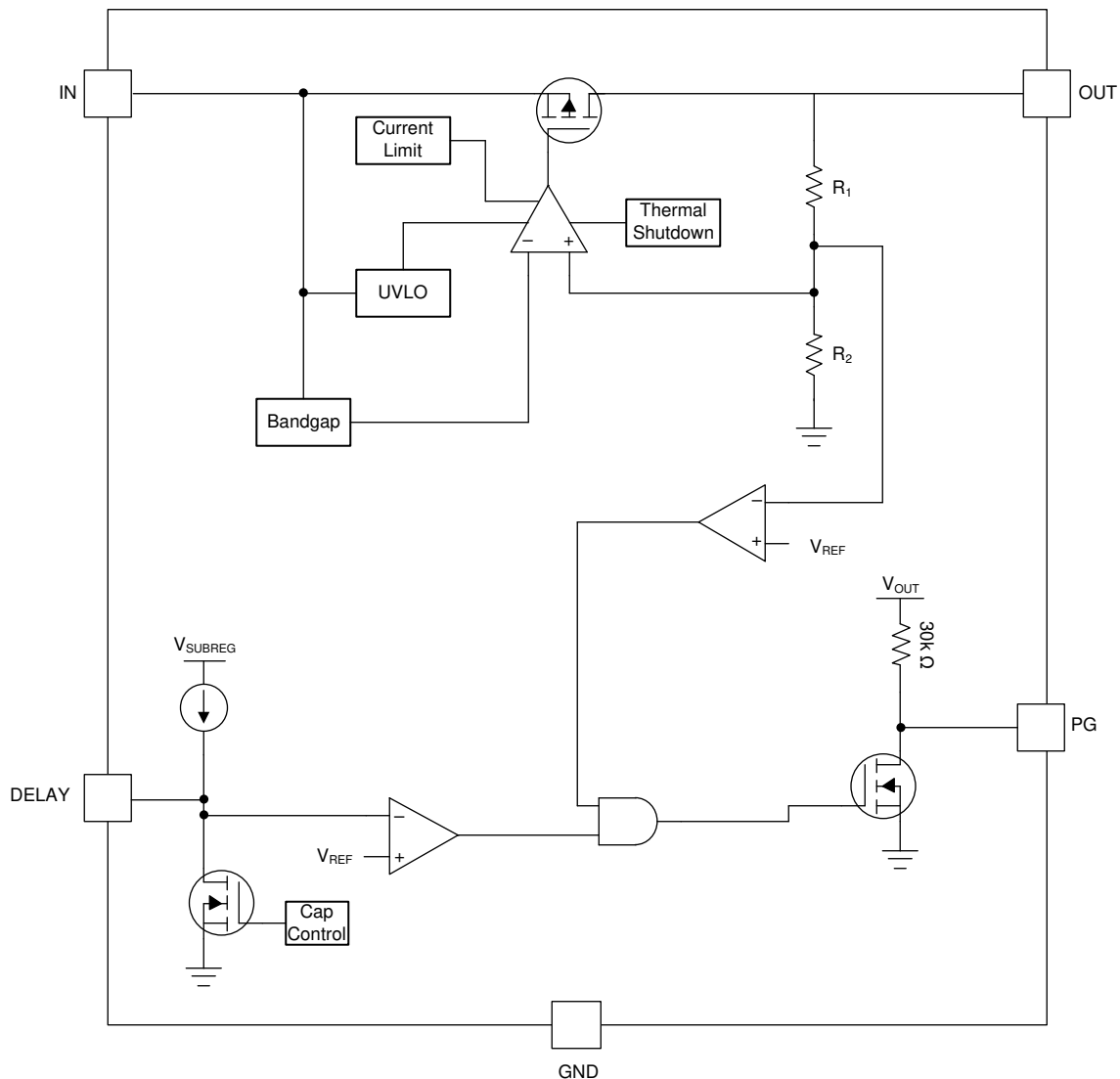
## 7.1 Overview

The TPS7B87-Q1 is a low-dropout linear regulator (LDO) with improved transient performance that allows for quick response to changes in line or load conditions. The device also features a novel output overshoot reduction feature that minimizes output overshoot during cold-crank conditions.

The integrated power-good and delay features allow for the system to notify down-stream components when the power is good and assist in sequencing requirements.

During normal operation, the device has a tight DC accuracy of  $\pm 0.85\%$  over line, load, and temperature. The increased accuracy allows for the powering of sensitive analog loads or sensors.

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Power-Good (PG)

The PG signal provides an easy solution to meet demanding sequencing requirements because PG alerts when the output nears its nominal value. PG can be used to signal other devices in a system when the output voltage is near, at, or above the set output voltage ( $V_{OUT(nom)}$ ). 图 7-1 shows a simplified schematic. The PG signal is an internal pullup resistor to the nominal output voltage and is active high. The PG circuit sets the PG pin into a high-impedance state to indicate that the power is good.

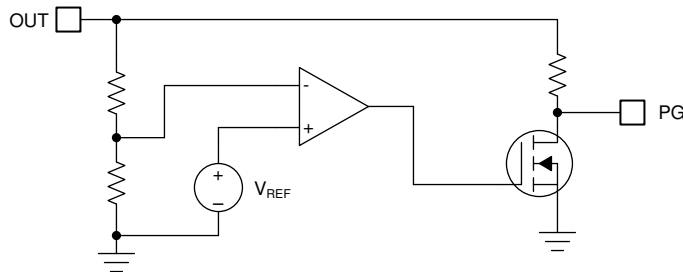


图 7-1. Simplified Power-Good Schematic

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

The power-good delay period is a function of the external capacitor on the DELAY pin. The adjustable delay configures the amount of time required before the PG pin becomes high. This delay is configured by connecting an external capacitor from this pin to GND. 图 7-2 shows the typical timing diagram for the power-good delay pin. If the DELAY pin is left floating, the power-good delay is  $t_{(DLY\_FIX)}$ . For more information on how to program the PG delay, see the [Setting the Adjustable Power-Good Delay](#) section.

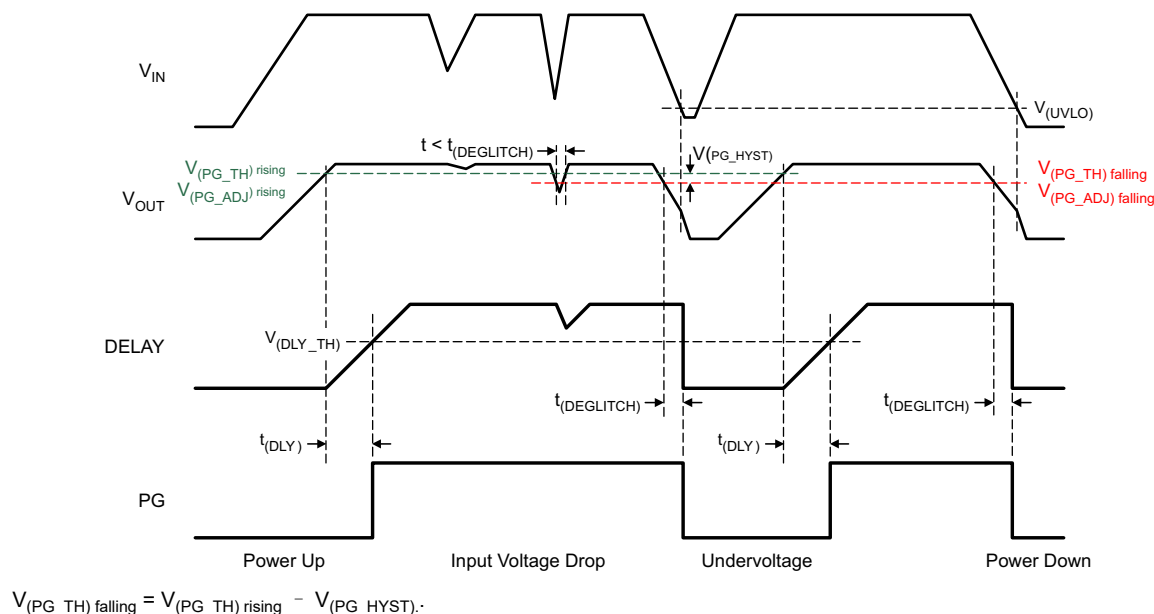


图 7-2. Typical Power-Good Timing Diagram

### 7.3.3 Undervoltage Lockout

The device has an independent undervoltage lockout (UVLO) circuit that monitors the input voltage, allowing a controlled and consistent turn on and off of the output voltage. To prevent the device from turning off if the input drops during turn on, the UVLO has hysteresis as specified in the *Electrical Characteristics* table.

### 7.3.4 Thermal Shutdown

The device contains a thermal shutdown protection circuit to disable the device when the junction temperature ( $T_J$ ) of the pass transistor rises to  $T_{SD(shutdown)}$  (typical). Thermal shutdown hysteresis assures that the device resets (turns on) when the temperature falls to  $T_{SD(reset)}$  (typical).

The thermal time-constant of the semiconductor die is fairly short, thus the device may cycle on and off when thermal shutdown is reached until power dissipation is reduced. Power dissipation during startup can be high from large  $V_{IN} - V_{OUT}$  voltage drops across the device or from high inrush currents charging large output capacitors. Under some conditions, the thermal shutdown protection disables the device before startup completes.

For reliable operation, limit the junction temperature to the maximum listed in the *Recommended Operating Conditions* table. Operation above this maximum temperature causes the device to exceed its operational specifications. Although the internal protection circuitry of the device is designed to protect against thermal overall conditions, this circuitry is not intended to replace proper heat sinking. Continuously running the device into thermal shutdown or above the maximum recommended junction temperature reduces long-term reliability.

### 7.3.5 Current Limit

The device has an internal current limit circuit that protects the regulator during transient high-load current faults or shorting events. The current limit is a brickwall scheme. In a high-load current fault, the brickwall scheme limits the output current to the current limit ( $I_{CL}$ ).  $I_{CL}$  is listed in the *Electrical Characteristics* table.

The output voltage is not regulated when the device is in current limit. When a current limit event occurs, the device begins to heat up because of the increase in power dissipation. When the device is in brickwall current limit, the pass transistor dissipates power  $[(V_{IN} - V_{OUT}) \times I_{CL}]$ . If thermal shutdown is triggered, the device turns off. After the device cools down, the internal thermal shutdown circuit turns the device back on. If the output current fault condition continues, the device cycles between current limit and thermal shutdown. For more information on current limits, see the [Know Your Limits application report](#).

图 7-3 shows a diagram of the current limit.

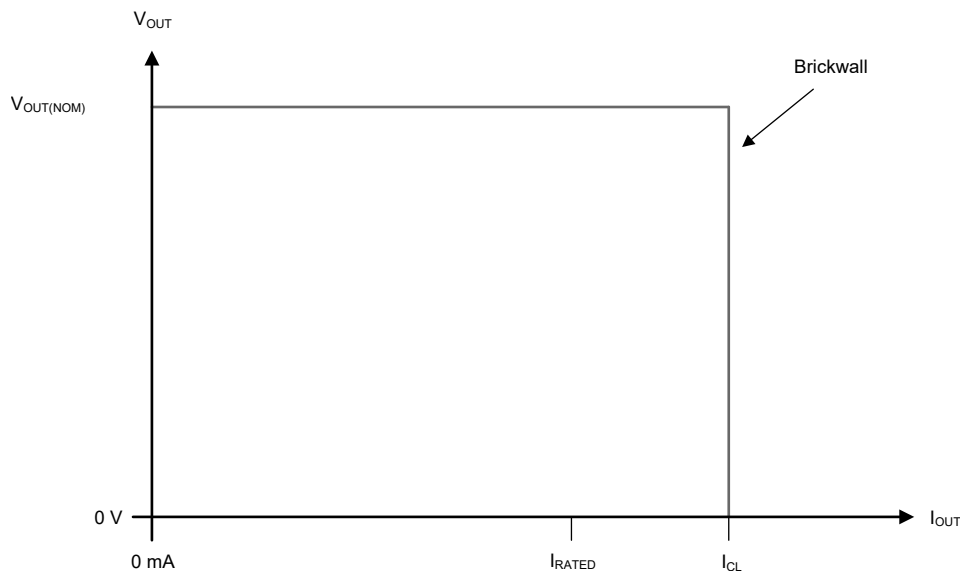


图 7-3. Current Limit

## 7.4 Device Functional Modes

### 7.4.1 Device Functional Mode Comparison

The *Device Functional Mode Comparison* table shows the conditions that lead to the different modes of operation. See the *Electrical Characteristics* table for parameter values.

**表 7-1. Device Functional Mode Comparison**

| OPERATING MODE                                          | PARAMETER                                                   |                          |                          |
|---------------------------------------------------------|-------------------------------------------------------------|--------------------------|--------------------------|
|                                                         | $V_{IN}$                                                    | $I_{OUT}$                | $T_J$                    |
| Normal operation                                        | $V_{IN} > V_{OUT(nom)} + V_{DO}$ and $V_{IN} > V_{IN(min)}$ | $I_{OUT} < I_{OUT(max)}$ | $T_J < T_{SD(shutdown)}$ |
| Dropout operation                                       | $V_{IN(min)} < V_{IN} < V_{OUT(nom)} + V_{DO}$              | $I_{OUT} < I_{OUT(max)}$ | $T_J < T_{SD(shutdown)}$ |
| Disabled<br>(any true condition<br>disables the device) | $V_{IN} < V_{UVLO}$                                         | Not applicable           | $T_J > T_{SD(shutdown)}$ |

### 7.4.2 Normal Operation

The device regulates to the nominal output voltage when the following conditions are met:

- The input voltage is greater than the nominal output voltage plus the dropout voltage ( $V_{OUT(nom)} + V_{DO}$ )
- The output current is less than the current limit ( $I_{OUT} < I_{CL}$ )
- The device junction temperature is less than the thermal shutdown temperature ( $T_J < T_{SD}$ )

### 7.4.3 Dropout Operation

If the input voltage is lower than the nominal output voltage plus the specified dropout voltage, but all other conditions are met for normal operation, the device operates in dropout mode. In this mode, the output voltage tracks the input voltage. During this mode, the transient performance of the device becomes significantly degraded because the pass transistor is in the ohmic or triode region, and acts as a switch. Line or load transients in dropout can result in large output-voltage deviations.

When the device is in a steady dropout state (defined as when the device is in dropout,  $V_{IN} < V_{OUT(NOM)} + V_{DO}$ , directly after being in a normal regulation state, but *not* during startup), the pass transistor is driven into the ohmic or triode region. When the input voltage returns to a value greater than or equal to the nominal output voltage plus the dropout voltage ( $V_{OUT(NOM)} + V_{DO}$ ), the output voltage can overshoot for a short period of time while the device pulls the pass transistor back into the linear region.

### 7.4.4 Disabled

The output of the device can be shutdown by forcing the input voltage below the UVLO falling threshold (see the *Electrical Characteristics* table). When disabled, the pass transistor is turned off and internal circuits are shutdown.

## 8 Application and Implementation

### Note

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

### 8.1 Application Information

#### 8.1.1 Input and Output Capacitor Selection

The TPS7B87-Q1 requires an output capacitor of 2.2  $\mu\text{F}$  or larger (1  $\mu\text{F}$  or larger capacitance) for stability and an equivalent series resistance (ESR) between 0.001  $\Omega$  and 2  $\Omega$ . For best transient performance, use X5R- and X7R-type ceramic capacitors because these capacitors have minimal variation in value and ESR over temperature. When choosing a capacitor for a specific application, be mindful of the DC bias characteristics for the capacitor. Higher output voltages cause a significant derating of the capacitor. For best performance, the maximum recommended output capacitance is 220  $\mu\text{F}$ .

Although an input capacitor is not required for stability, good analog design practice is to connect a capacitor from IN to GND. Some input supplies have a high impedance, thus placing the input capacitor on the input supply helps reduce the input impedance. This capacitor counteracts reactive input sources and improves transient response, input ripple, and PSRR. If the input supply has a high impedance over a large range of frequencies, several input capacitors can be used in parallel to lower the impedance over frequency. Use a higher-value capacitor if large, fast, rise-time load transients are anticipated, or if the device is located several inches from the input power source.

#### 8.1.2 Dropout Voltage

Dropout voltage ( $V_{\text{DO}}$ ) is defined as the input voltage minus the output voltage ( $V_{\text{IN}} - V_{\text{OUT}}$ ) at the rated output current ( $I_{\text{RATED}}$ ), where the pass transistor is fully on.  $I_{\text{RATED}}$  is the maximum  $I_{\text{OUT}}$  listed in the *Recommended Operating Conditions* table. The pass transistor is in the ohmic or triode region of operation, and acts as a switch. The dropout voltage indirectly specifies a minimum input voltage greater than the nominal programmed output voltage at which the output voltage is expected to stay in regulation. If the input voltage falls to less than the nominal output regulation, then the output voltage falls as well.

For a CMOS regulator, the dropout voltage is determined by the drain-source on-state resistance ( $R_{\text{DS(ON)}}$ ) of the pass transistor. Therefore, if the linear regulator operates at less than the rated current, the dropout voltage for that current scales accordingly. The following equation calculates the  $R_{\text{DS(ON)}}$  of the device.

$$R_{\text{DS(ON)}} = \frac{V_{\text{DO}}}{I_{\text{RATED}}} \quad (1)$$

#### 8.1.3 Reverse Current

Excessive reverse current can damage this device. Reverse current flows through the intrinsic body diode of the pass transistor instead of the normal conducting channel. At high magnitudes, this current flow degrades the long-term reliability of the device.

Conditions where reverse current can occur are outlined in this section, all of which can exceed the absolute maximum rating of  $V_{\text{OUT}} \leq V_{\text{IN}} + 0.3 \text{ V}$ .

- If the device has a large  $C_{\text{OUT}}$  and the input supply collapses with little or no load current
- The output is biased when the input supply is not established
- The output is biased above the input supply

If reverse current flow is expected in the application, external protection is recommended to protect the device. Reverse current is not limited in the device, so external limiting is required if extended reverse voltage operation is anticipated.

#### 8.1.4 Power Dissipation ( $P_D$ )

Circuit reliability requires consideration of the device power dissipation, location of the circuit on the printed circuit board (PCB), and correct sizing of the thermal plane. The PCB area around the regulator must have few or no other heat-generating devices that cause added thermal stress.

To first-order approximation, power dissipation in the regulator depends on the input-to-output voltage difference and load conditions. The following equation calculates power dissipation ( $P_D$ ).

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (2)$$

##### Note

Power dissipation can be minimized, and therefore greater efficiency can be achieved, by correct selection of the system voltage rails. For the lowest power dissipation use the minimum input voltage required for correct output regulation.

For devices with a thermal pad, the primary heat conduction path for the device package is through the thermal pad to the PCB. Solder the thermal pad to a copper pad area under the device. This pad area must contain an array of plated vias that conduct heat to additional copper planes for increased heat dissipation.

The maximum power dissipation determines the maximum allowable ambient temperature ( $T_A$ ) for the device. According to the following equation, power dissipation and junction temperature are most often related by the junction-to-ambient thermal resistance ( $R_{\theta JA}$ ) of the combined PCB and device package and the temperature of the ambient air ( $T_A$ ).

$$T_J = T_A + (R_{\theta JA} \times P_D) \quad (3)$$

Thermal resistance ( $R_{\theta JA}$ ) is highly dependent on the heat-spreading capability built into the particular PCB design, and therefore varies according to the total copper area, copper weight, and location of the planes. The junction-to-ambient thermal resistance listed in the *Thermal Information* table is determined by the JEDEC standard PCB and copper-spreading area, and is used as a relative measure of package thermal performance.

##### 8.1.4.1 Thermal Performance Versus Copper Area

The most used thermal resistance parameter  $R_{\theta JA}$  is highly dependent on the heat-spreading capability built into the particular PCB design, and therefore varies according to the total copper area, copper weight, and location of the planes. The  $R_{\theta JA}$  recorded in the *Thermal Information* table in the [Specifications](#) section is determined by the JEDEC standard (see [Figure 8-1](#)), PCB, and copper-spreading area, and is only used as a relative measure of package thermal performance. For a well-designed thermal layout,  $R_{\theta JA}$  is actually the sum of the package junction-to-case (bottom) thermal resistance ( $R_{\theta JCBot}$ ) plus the thermal resistance contribution by the PCB copper.

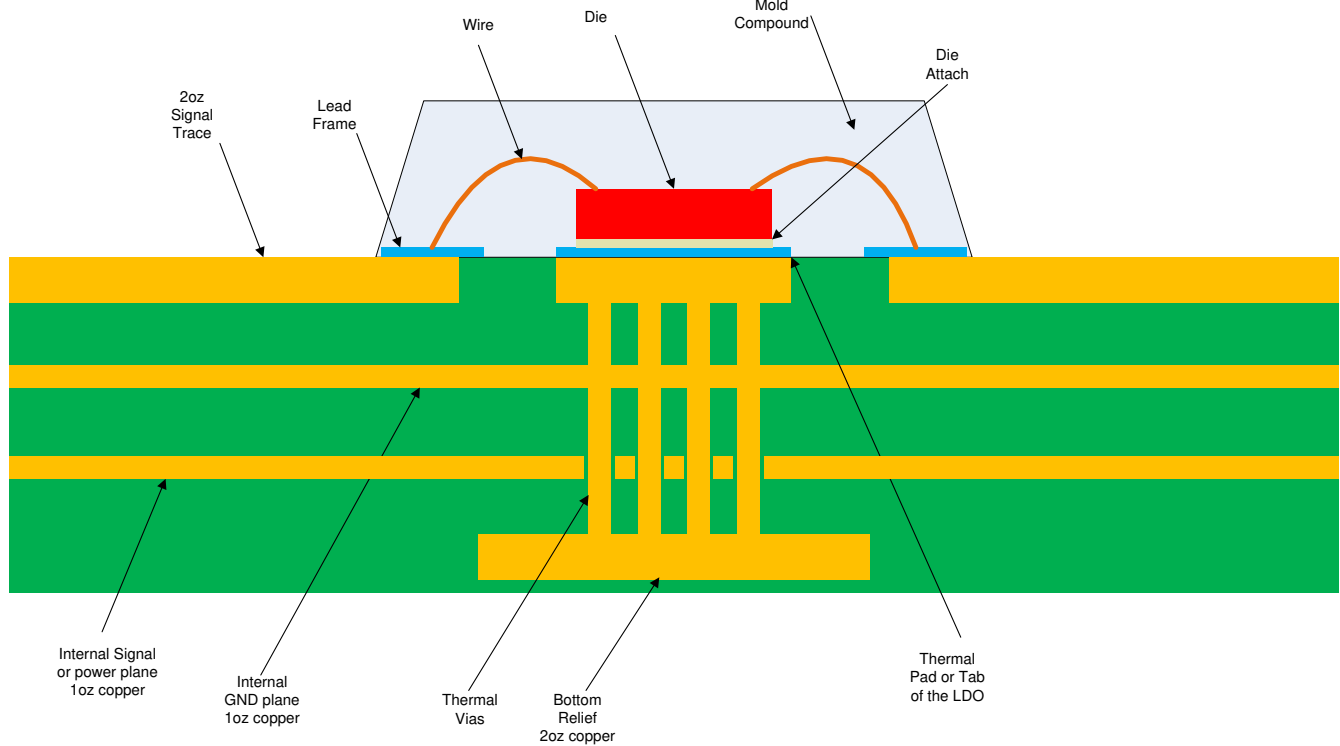
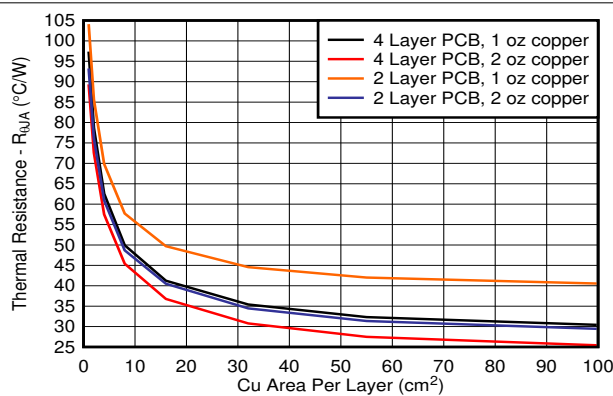
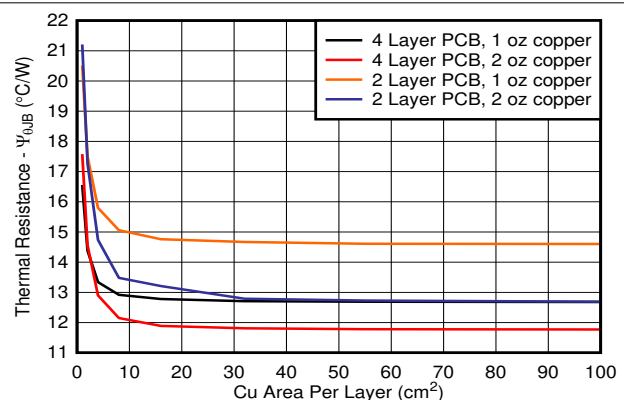


图 8-1. JEDEC Standard 2s2p PCB

图 8-2 through 图 8-5 illustrate the functions of  $R_{\theta JA}$  and  $\psi_{JB}$  versus copper area and thickness. These plots are generated with a 101.6-mm x 101.6-mm x 1.6-mm PCB of two and four layers. For the 4-layer board, inner planes use 1-oz copper thickness. Outer layers are simulated with both 1-oz and 2-oz copper thickness. A 2x3 (DDA package) or a 3x4 (KVU package) array of thermal vias with a 300- $\mu$ m drill diameter and 25- $\mu$ m copper plating is located beneath the thermal pad of the device. The thermal vias connect the top layer, the bottom layer and, in the case of the 4-layer board, the first inner GND plane. Each of the layers has a copper plane of equal area.

图 8-2.  $R_{\theta JA}$  vs Copper Area (DDA Package)图 8-3.  $\psi_{JB}$  vs Copper Area (DDA Package)

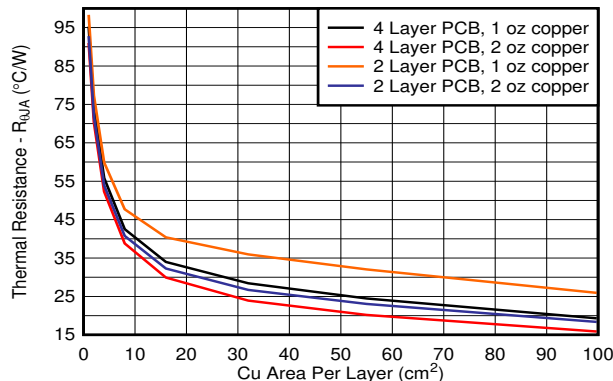


图 8-4.  $R_{\theta JA}$  vs Copper Area (KVU Package)

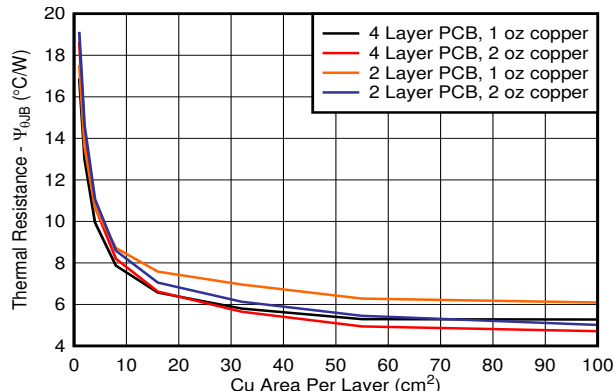


图 8-5.  $\Psi_{JB}$  vs Copper Area (KVU Package)

#### 8.1.4.2 Power Dissipation Versus Ambient Temperature

图 8-6 is based off of a JESD51-7 4-layer, high-K board. The allowable power dissipation was estimated using the following equation. As discussed in the [An empirical analysis of the impact of board layout on LDO thermal performance application report](#), thermal dissipation can be improved in the JEDEC high-K layout by adding top layer copper and increasing the number of thermal vias. If a good thermal layout is used, the allowable thermal dissipation can be improved by up to 50%.

$$T_A + R_{\theta JA} \times P_D \leq 150^{\circ}\text{C} \quad (4)$$

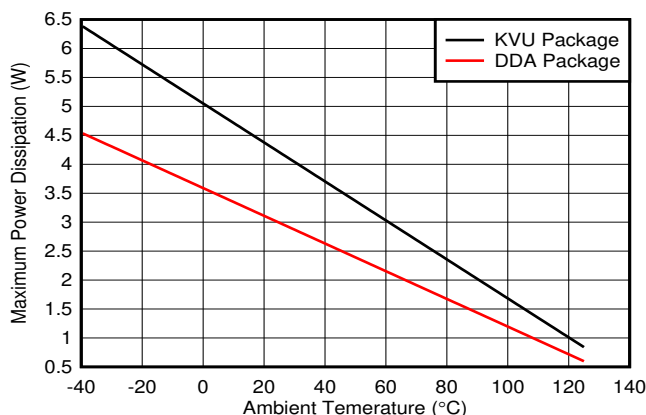


图 8-6. TPS7B87-Q1 Allowable Power Dissipation

#### 8.1.5 Estimating Junction Temperature

The JEDEC standard now recommends the use of psi ( $\Psi$ ) thermal metrics to estimate the junction temperatures of the linear regulator when in-circuit on a typical PCB board application. These metrics are not thermal resistance parameters and instead offer a practical and relative way to estimate junction temperature. These psi metrics are determined to be significantly independent of the copper area available for heat-spreading. The *Thermal Information* table lists the primary thermal metrics, which are the junction-to-top characterization parameter ( $\Psi_{JT}$ ) and junction-to-board characterization parameter ( $\Psi_{JB}$ ). These parameters provide two methods for calculating the junction temperature ( $T_J$ ), as described in the following equations. Use the junction-to-top characterization parameter ( $\Psi_{JT}$ ) with the temperature at the center-top of device package ( $T_T$ ) to calculate the junction temperature. Use the junction-to-board characterization parameter ( $\Psi_{JB}$ ) with the PCB surface temperature 1 mm from the device package ( $T_B$ ) to calculate the junction temperature.

$$T_J = T_T + \psi_{JT} \times P_D \quad (5)$$

where:

- $P_D$  is the dissipated power
- $T_T$  is the temperature at the center-top of the device package

$$T_J = T_B + \psi_{JB} \times P_D \quad (6)$$

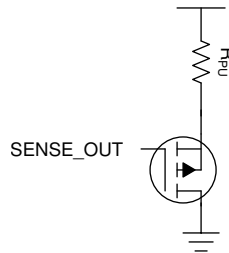
where

- $T_B$  is the PCB surface temperature measured 1 mm from the device package and centered on the package edge

For detailed information on the thermal metrics and how to use them, see the [Semiconductor and IC Package Thermal Metrics application report](#).

### 8.1.6 Pulling Up the PG Pin to a Different Voltage

Because the power-good (PG) pin is pulled up internally to the output rail, this pin cannot be pulled up to any voltage or wire AND'd like a typical open-drain PG output can be. If this signal must be pulled up to another logic level then an external circuit can be implemented using a PMOS transistor and a pullup resistor. Implementing the circuit shown in [图 8-7](#) allows the outputs to be pulled up to any logic rail. If a PMOS transistor is used make sure to pick a transistor with a low threshold voltage as this will determine the output low voltage. this can also be done with a NMOS transistor, but it inverts the logic. This implementation also allows the outputs to be AND'd together like the traditional power-good pins.



**图 8-7. Additional Components for the PG Pin to be Pulled Up to Another Rail**

## 8.1.7 Power-Good

### 8.1.7.1 Setting the Adjustable Power-Good Delay

The power-good delay time can be set in two ways: either by floating the DELAY pin or by connecting a capacitor from this pin to GND. When the DELAY pin is floating, the time defaults to  $t_{(DLY\_FIX)}$ . The delay time is set by the following equation if a capacitor is connected between the DELAY pin and GND.

$$t = t_{(DLY\_FIX)} + C_{DELAY} \left( \frac{V_{DLY(TH)}}{I_{DLY(CHARGE)}} \right) \quad (7)$$

## 8.2 Typical Application

图 8-8 shows a typical application circuit for the TPS7B87-Q1. TI recommends a low-ESR ceramic capacitor with a dielectric of type X5R or X7R.

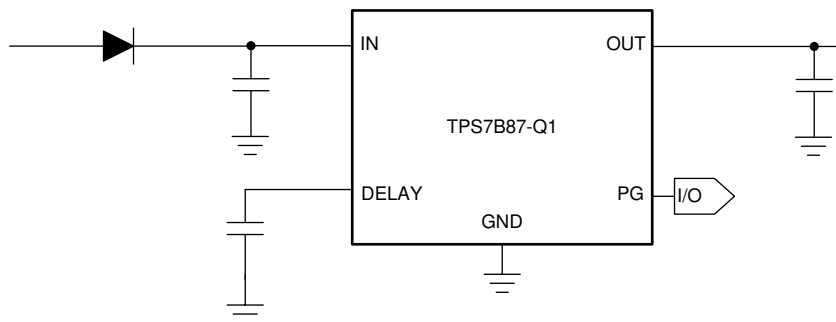


图 8-8. Typical Application Schematic for the TPS7B87-Q1

### 8.2.1 Design Requirements

For this design example, use the parameters listed in 表 8-1 as the input parameters.

表 8-1. Design Parameters

| DESIGN PARAMETER           | EXAMPLE VALUE |
|----------------------------|---------------|
| Input voltage range        | 6 V to 40 V   |
| Output voltage             | 5 V           |
| Output current             | 350 mA        |
| Output capacitor           | 10 $\mu$ F    |
| Power-good delay capacitor | 100 nF        |

### 8.2.2 Detailed Design Procedure

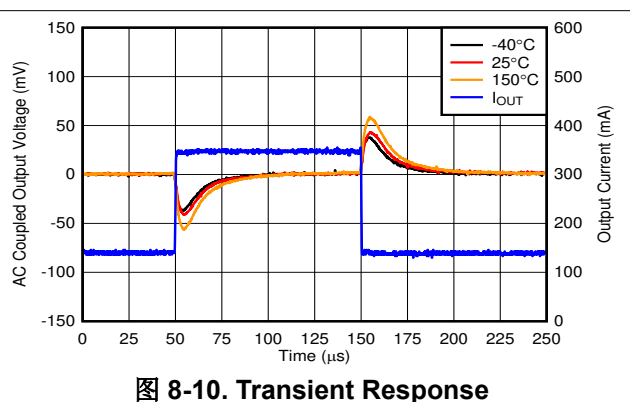
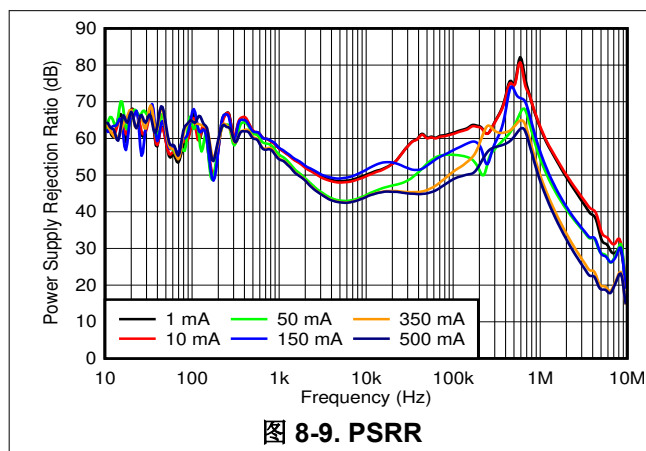
#### 8.2.2.1 Input Capacitor

The device requires an input decoupling capacitor, the value of which depends on the application. The typical recommended value for the decoupling capacitor is 1  $\mu$ F. The voltage rating must be greater than the maximum input voltage.

#### 8.2.2.2 Output Capacitor

The device requires an output capacitor to stabilize the output voltage. The capacitor value must be between 2.2  $\mu$ F and 200  $\mu$ F and the ESR range must be between 1 m $\Omega$  and 2  $\Omega$ . For this design, a low ESR, 10- $\mu$ F ceramic capacitor was used to improve transient performance.

### 8.2.3 Application Curves



## 9 Power Supply Recommendations

This device is designed for operation from an input voltage supply with a range between 3 V and 40 V. This input supply must be well regulated. If the input supply is located more than a few inches from the TPS7B87-Q1, add an electrolytic capacitor with a value of 22  $\mu$ F and a ceramic bypass capacitor at the input.

## 10 Layout

### 10.1 Layout Guidelines

For best overall performance, place all circuit components on the same side of the circuit board and as near as practical to the respective LDO pin connections. Place ground return connections to the input and output capacitor, and to the LDO ground pin as close as possible to each other, connected by a wide, component-side, copper surface. The use of vias and long traces to the input and output capacitors is strongly discouraged and negatively affects system performance. TI also recommends a ground reference plane either embedded in the PCB itself or located on the bottom side of the PCB opposite the components. This reference plane serves to assure accuracy of the output voltage, shield noise, and behaves similarly to a thermal plane to spread (or sink) heat from the LDO device when connected to the thermal pad. In most applications, this ground plane is necessary to meet thermal requirements.

#### 10.1.1 Package Mounting

Solder pad footprint recommendations for the TPS7B87-Q1 are available at the end of this document and at [www.ti.com](http://www.ti.com).

#### 10.1.2 Board Layout Recommendations to Improve PSRR and Noise Performance

As depicted in [Figure 10-1](#) and [Figure 10-2](#), place the input and output capacitors close to the device for the layout of the TPS7B87-Q1. In order to enhance the thermal performance, place as many vias as possible around the device. These vias improve the heat transfer between the different GND planes in the PCB.

To improve AC performance such as PSRR, output noise, and transient response, TI recommends a board design with separate ground planes for  $V_{IN}$  and  $V_{OUT}$ , with each ground plane connected only at the GND pin of the device. In addition, the ground connection for the output capacitor must connect directly to the GND pin of the device.

Minimize equivalent series inductance (ESL) and ESR in order to maximize performance and ensure stability. Place each capacitor as close as possible to the device and on the same side of the PCB as the regulator itself.

Do not place any of the capacitors on the opposite side of the PCB from where the regulator is installed. TI strongly discourages the use of vias and long traces to connect the capacitors because they may negatively affect system performance and even cause instability.

If possible, and to ensure the maximum performance specified in this document, use the same layout pattern used for the TPS7B87-Q1 evaluation board, available at [www.ti.com](http://www.ti.com).

## 10.2 Layout Examples

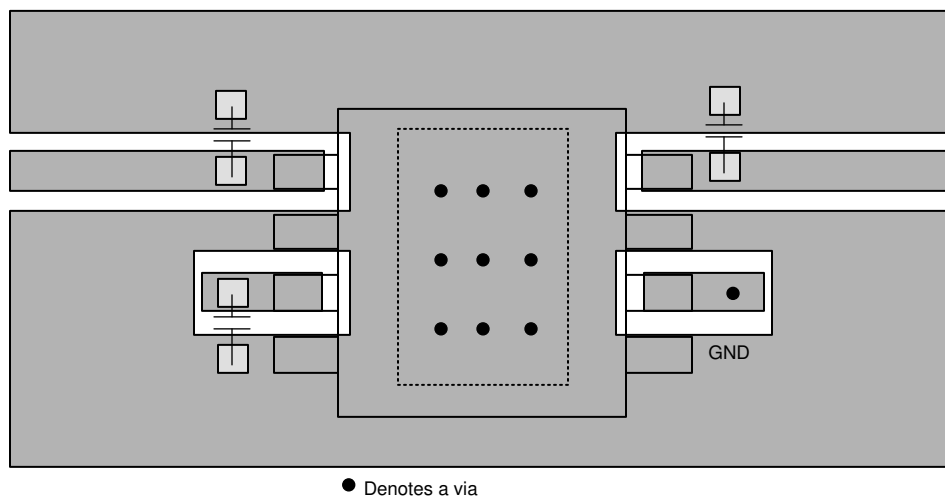


图 10-1. DDA Package Fixed Output

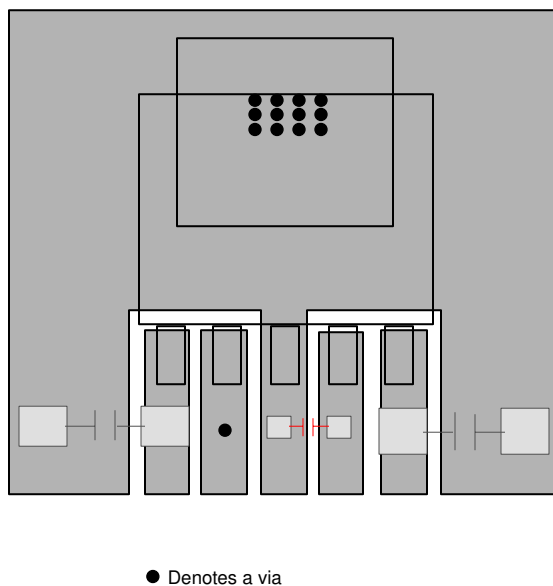


图 10-2. KVV Package Fixed Output

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Device Nomenclature

表 11-1. Device Nomenclature<sup>(1)</sup>

| PRODUCT          | V <sub>OUT</sub>                                                                                                                                                                                                                                                                                                                    |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TPS7B87xxQyyyRQ1 | <p><b>xx</b> is the nominal output voltage (for example, 33 = 3.3 V V; 50 = 5.0 V).</p> <p><b>yyy</b> is the package designator.</p> <p><b>Q</b> indicates that this device is a grade-1 device in accordance with the AEC-Q100 standard.</p> <p><b>Q1</b> indicates that this device is an automotive grade (AEC-Q100) device.</p> |

(1) For the most current package and ordering information see the Package Option Addendum at the end of this document, or visit the device product folder on [www.ti.com](http://www.ti.com).

#### 11.1.2 Development Support

For the PSpice model, see the [TPS7B4250 PSpice Transient Model](#).

### 11.2 Documentation Support

#### 11.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [Various Applications for Voltage-Tracking LDO application report](#)
- Texas Instruments, [TPS7B4250 Evaluation Module user's guide](#)
- Texas Instruments, [TPS7B5250-Q1 Pin FMEA application report](#)

### 11.3 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](http://ti.com) 上的器件产品文件夹。点击 [订阅更新](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 11.7 术语表

**TI 术语表** 本术语表列出并解释了术语、首字母缩略词和定义。

## 12 Mechanical, Packaging, and Orderable Information

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

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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="#">TPS7B8733QDDARQ1</a>   | Active        | Production           | SO PowerPAD (DDA)   8 | 2500   LARGE T&R      | Yes         | NIPDAU   NIPDAUAG                    | Level-2-260C-1 YEAR               | -40 to 150   | 7B8733              |
| TPS7B8733QDDARQ1.A                 | Active        | Production           | SO PowerPAD (DDA)   8 | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 150   | 7B8733              |
| <a href="#">TPS7B8733QKVURQ1</a>   | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8733              |
| TPS7B8733QKVURQ1.A                 | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8733              |
| <a href="#">TPS7B8733QKVURQ1R2</a> | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8733              |
| TPS7B8733QKVURQ1R2.A               | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8733              |
| <a href="#">TPS7B8750QDDARQ1</a>   | Active        | Production           | SO PowerPAD (DDA)   8 | 2500   LARGE T&R      | Yes         | NIPDAUAG                             | Level-2-260C-1 YEAR               | -40 to 150   | 7B8750              |
| TPS7B8750QDDARQ1.A                 | Active        | Production           | SO PowerPAD (DDA)   8 | 2500   LARGE T&R      | Yes         | NIPDAUAG                             | Level-2-260C-1 YEAR               | -40 to 150   | 7B8750              |
| <a href="#">TPS7B8750QKVURQ1</a>   | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8750              |
| TPS7B8750QKVURQ1.A                 | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8750              |
| <a href="#">TPS7B8750QKVURQ1R2</a> | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8750              |
| TPS7B8750QKVURQ1R2.A               | Active        | Production           | TO-252 (KVU)   5      | 2500   LARGE T&R      | Yes         | SN                                   | Level-3-260C-168 HR               | -40 to 150   | 7B8750              |

<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

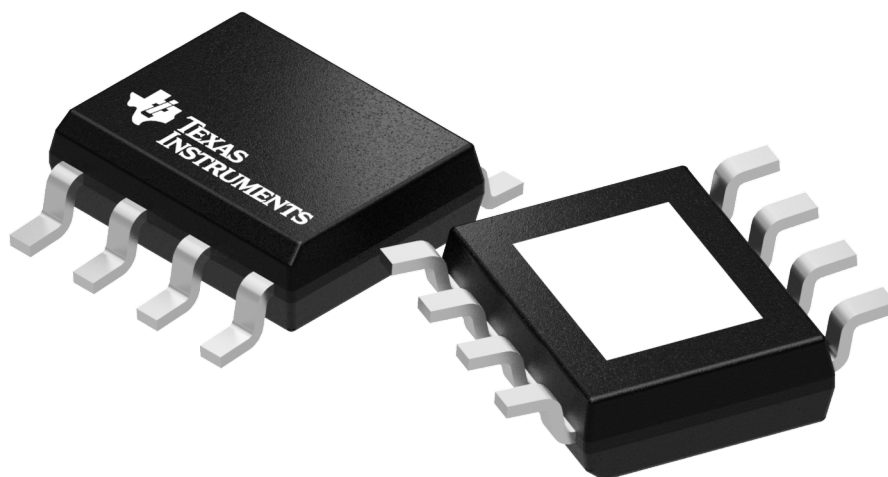
| Device             | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS7B8733QKVURQ1   | TO-252       | KVU             | 5    | 2500 | 330.0              | 16.4               | 6.9     | 10.5    | 2.7     | 8.0     | 16.0   | Q3            |
| TPS7B8733QKVURQ1R2 | TO-252       | KVU             | 5    | 2500 | 330.0              | 16.4               | 6.9     | 10.5    | 2.7     | 8.0     | 16.0   | Q2            |
| TPS7B8750QDDARQ1   | SO PowerPAD  | DDA             | 8    | 2500 | 330.0              | 12.8               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TPS7B8750QKVURQ1   | TO-252       | KVU             | 5    | 2500 | 330.0              | 16.4               | 6.9     | 10.5    | 2.7     | 8.0     | 16.0   | Q3            |
| TPS7B8750QKVURQ1R2 | TO-252       | KVU             | 5    | 2500 | 330.0              | 16.4               | 6.9     | 10.5    | 2.7     | 8.0     | 16.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device             | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS7B8733QKVURQ1   | TO-252       | KVU             | 5    | 2500 | 340.0       | 340.0      | 38.0        |
| TPS7B8733QKVURQ1R2 | TO-252       | KVU             | 5    | 2500 | 340.0       | 340.0      | 38.0        |
| TPS7B8750QDDARQ1   | SO PowerPAD  | DDA             | 8    | 2500 | 366.0       | 364.0      | 50.0        |
| TPS7B8750QKVURQ1   | TO-252       | KVU             | 5    | 2500 | 340.0       | 340.0      | 38.0        |
| TPS7B8750QKVURQ1R2 | TO-252       | KVU             | 5    | 2500 | 340.0       | 340.0      | 38.0        |



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

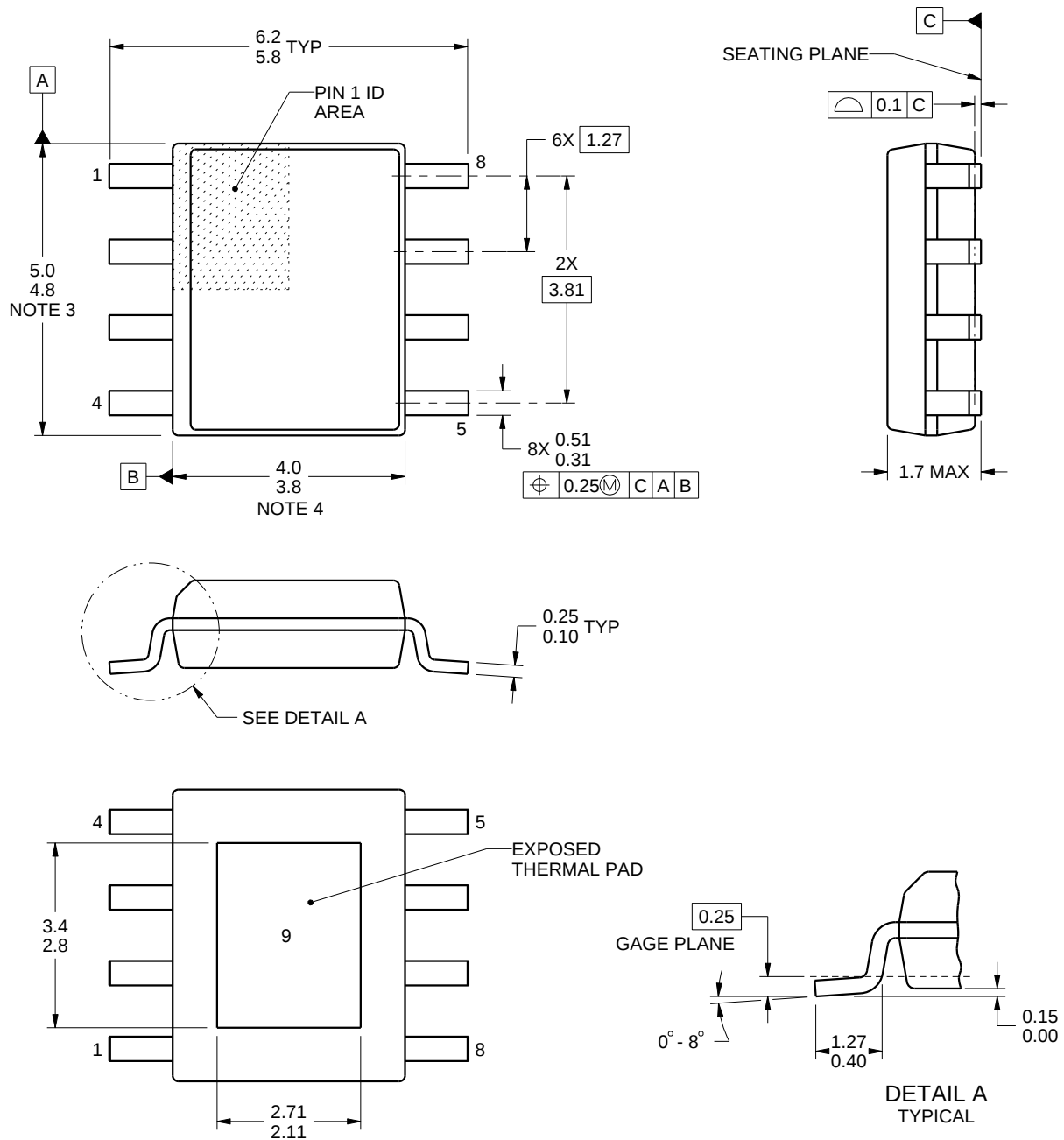
DDA0008B



# PACKAGE OUTLINE

PowerPAD™ SOIC - 1.7 mm max height

PLASTIC SMALL OUTLINE



4214849/A 08/2016

## NOTES:

PowerPAD is a trademark of Texas Instruments.

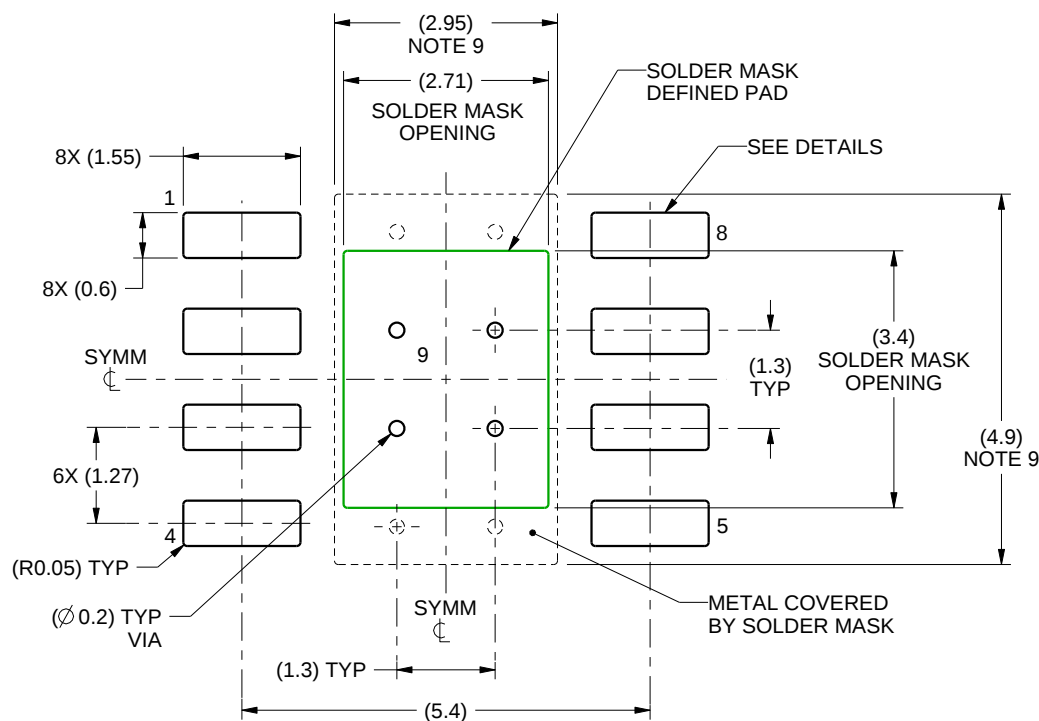
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MS-012.

# EXAMPLE BOARD LAYOUT

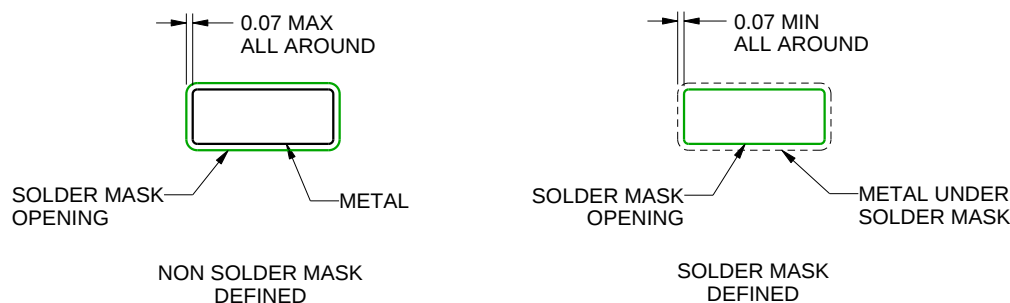
DDA0008B

PowerPAD™ SOIC - 1.7 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
PADS 1-8

4214849/A 08/2016

NOTES: (continued)

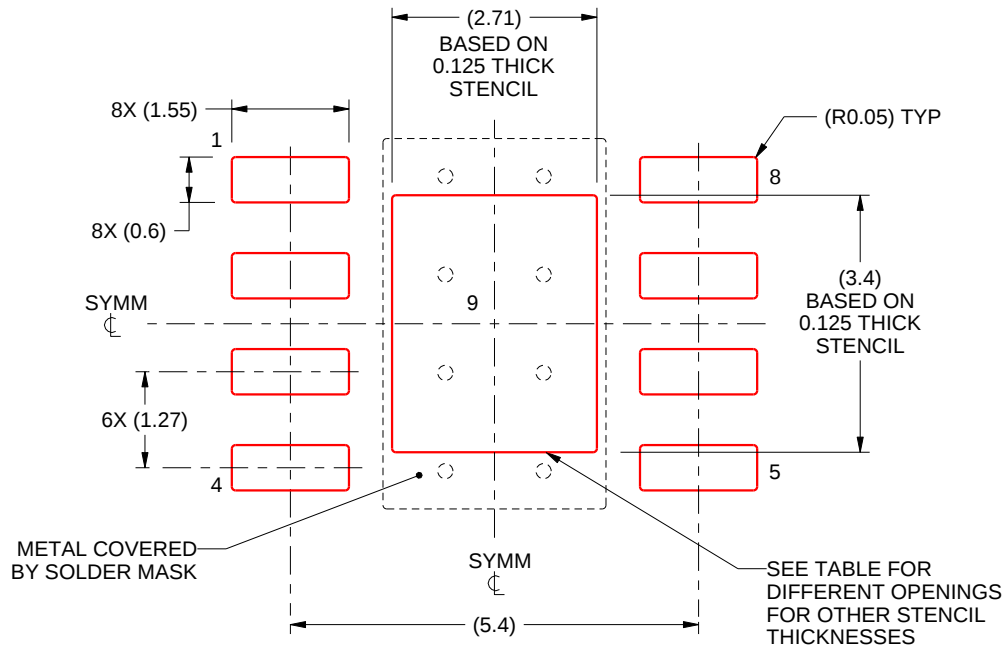
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 ([www.ti.com/lit/slma002](http://www.ti.com/lit/slma002))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

# EXAMPLE STENCIL DESIGN

DDA0008B

PowerPAD™ SOIC - 1.7 mm max height

PLASTIC SMALL OUTLINE



**SOLDER PASTE EXAMPLE**  
EXPOSED PAD  
100% PRINTED SOLDER COVERAGE BY AREA  
SCALE:10X

| STENCIL THICKNESS | SOLDER STENCIL OPENING |
|-------------------|------------------------|
| 0.1               | 3.03 X 3.80            |
| 0.125             | 2.71 X 3.40 (SHOWN)    |
| 0.150             | 2.47 X 3.10            |
| 0.175             | 2.29 X 2.87            |

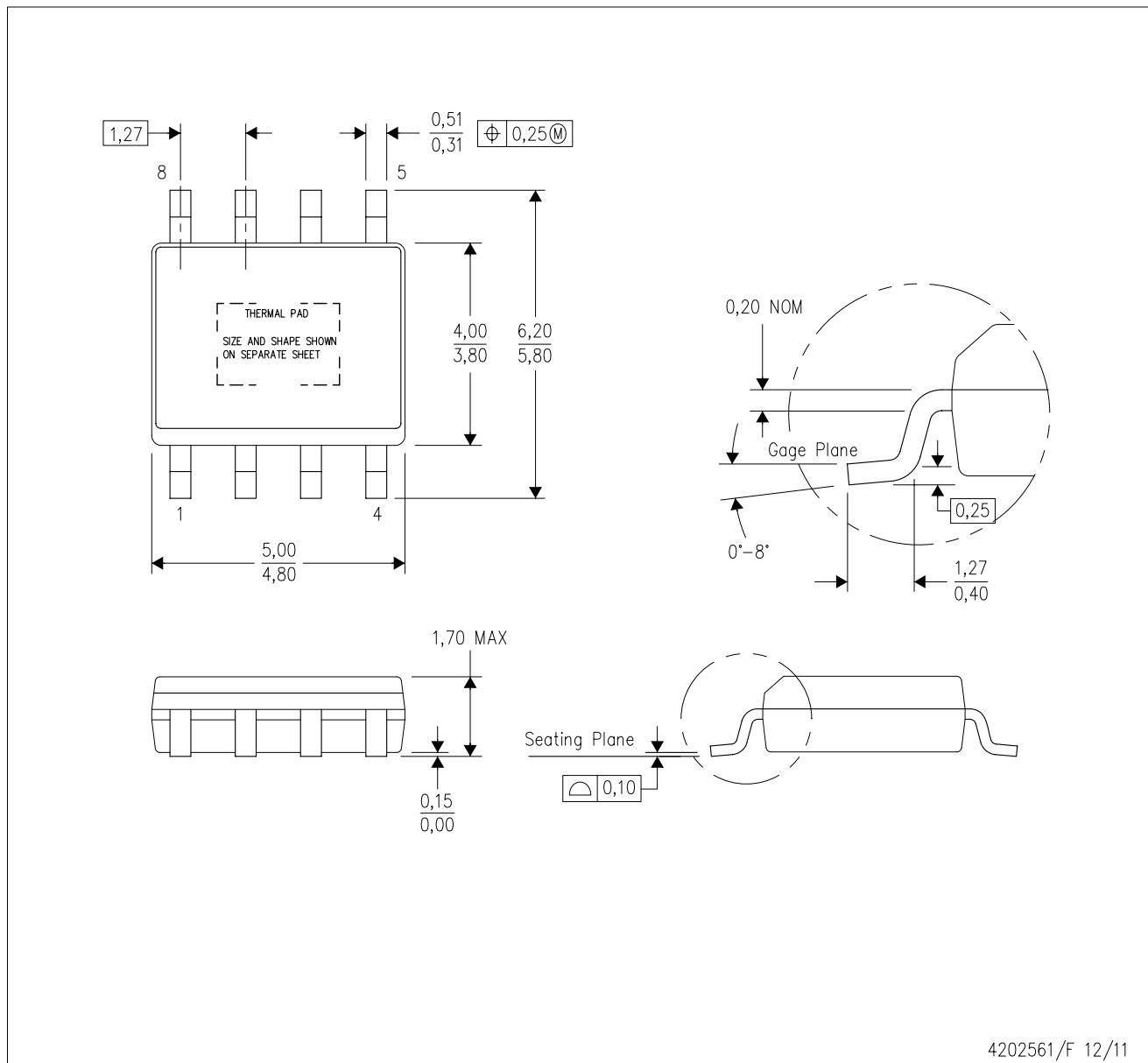
4214849/A 08/2016

NOTES: (continued)

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

DDA (R-PDSO-G8)

PowerPAD™ PLASTIC SMALL-OUTLINE



- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5-1994.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0,15.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - This package complies to JEDEC MS-012 variation BA

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DDA (R-PDSO-G8)

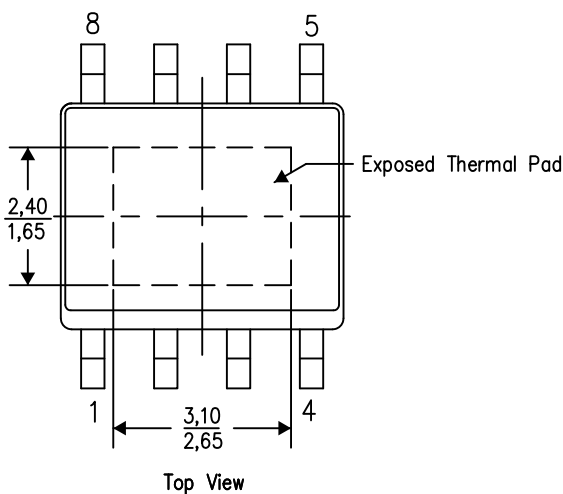
PowerPAD™ PLASTIC SMALL OUTLINE

## THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached to a printed circuit board (PCB). The thermal pad must be soldered directly to the PCB. After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



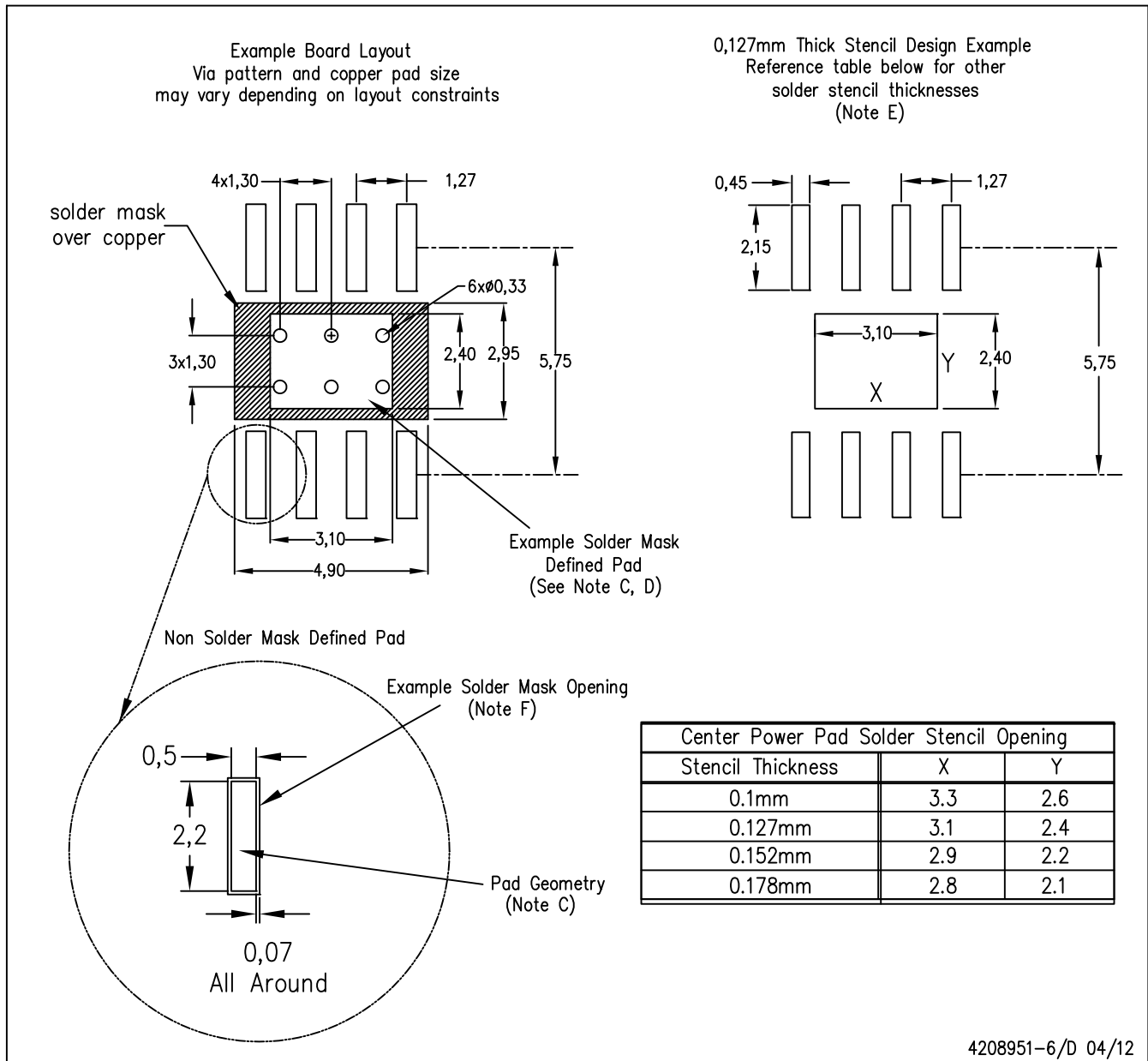
4206322-6/L 05/12

NOTE: A. All linear dimensions are in millimeters

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DDA (R-PDSO-G8)

PowerPAD™ PLASTIC SMALL OUTLINE

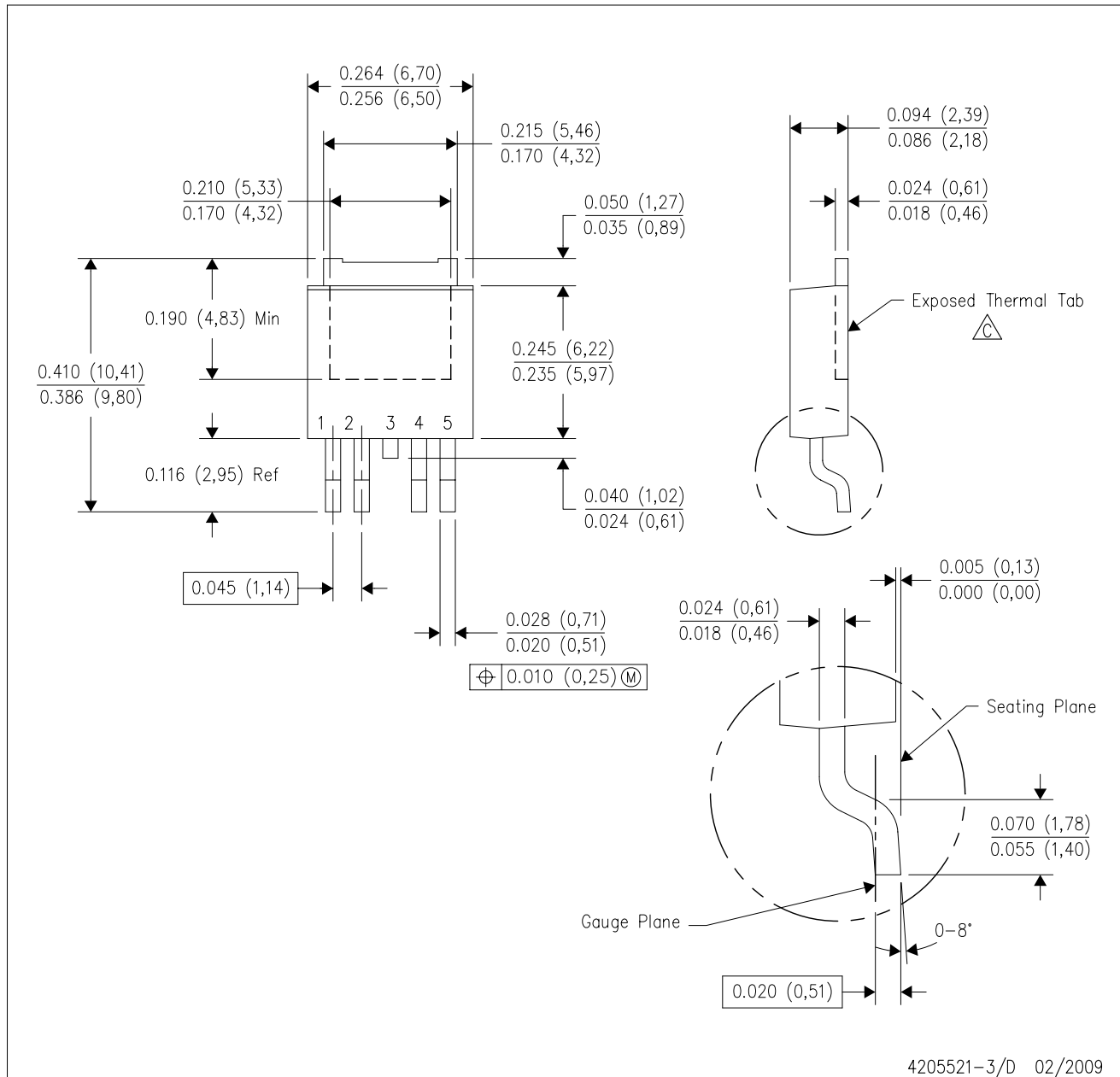


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PowerPAD is a trademark of Texas Instruments.

KVU (R-PSFM-G5)

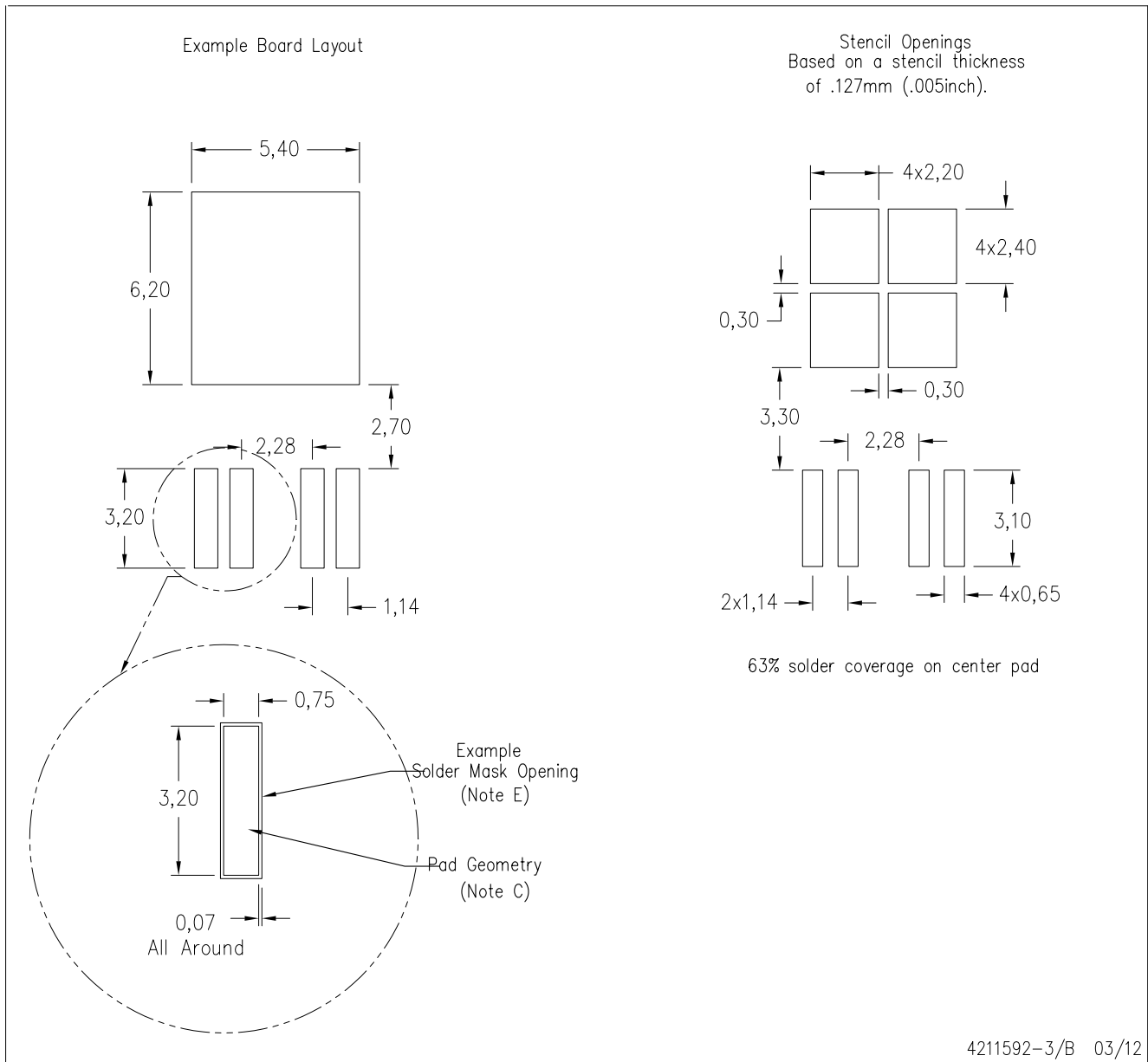
PLASTIC FLANGE-MOUNT PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. The center lead is in electrical contact with the exposed thermal tab.
  - D. Body Dimensions do not include mold flash or protrusions. Mold flash and protrusion shall not exceed 0.006 (0,15) per side.
  - E. Falls within JEDEC TO-252 variation AD.

KVU (R-PSFM-G5)

PLASTIC FLANGE MOUNT PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-SM-782 is an alternate information source for PCB land pattern designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in thermal pad.

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