

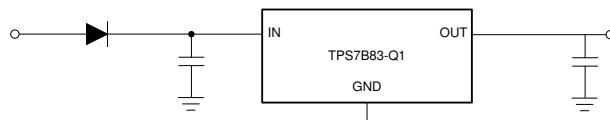
## TPS7B83-Q1 150mA、40V 低压降稳压器

## 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)
- 输出电流：高达 150mA
- 输出电压精度： $\pm 1\%$  (最大值)
- 低压降：
  - 150 mA 时为 230 mV (最大值) ( $V_{OUT} \geq 3.3V$ )
- 低静态电流：
  - 18 $\mu$ A (典型值)
- 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)
- 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：3 引脚 SOT-223

## 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)



典型应用原理图

## 3 说明

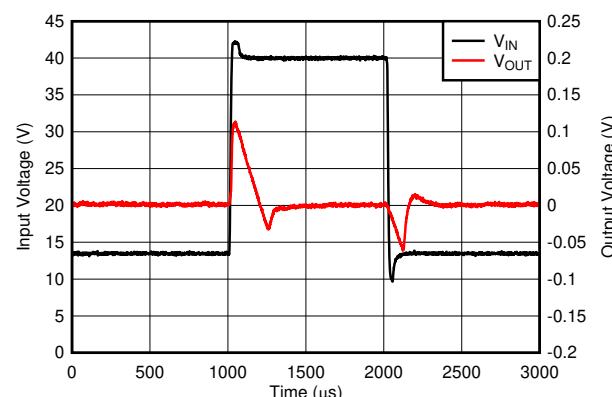
TPS7B83-Q1 是一款低压降线性稳压器，专用于连接汽车应用中的电池。该器件的输入电压范围高达 40V，因此可承受汽车系统可能发生的瞬变 (如负载突降)。此器件的静态电流仅为 18 $\mu$ A，是为备用系统中微控制器 (MCU) 和控制器局域网 (CAN) 收发器等常开型器件供电的出色解决方案。

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  $\pm 1\%$  的直流精度。

## 器件信息(1)

器件型号	封装	封装尺寸 (标称值)
TPS7B83-Q1	SOT-223 (3)	6.50mm × 3.50mm

(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。

线路瞬态响应  
( $V_{IN}$  压摆率 3V/ $\mu$ s)

本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。有关适用的官方英文版本的最新信息，请访问 [www.ti.com](http://www.ti.com)，其内容始终优先。TI 不保证翻译的准确性和有效性。在实际设计之前，请务必参考最新版本的英文版本。

English Data Sheet: [SBV376](#)

## Table of Contents

<b>1 特性</b>	<b>1</b>	7.4 Device Functional Modes.....	<b>14</b>
<b>2 应用</b>	<b>1</b>	<b>8 Application and Implementation</b> .....	<b>15</b>
<b>3 说明</b>	<b>1</b>	8.1 Application Information.....	<b>15</b>
<b>4 Revision History</b>	<b>2</b>	8.2 Typical Application.....	<b>19</b>
<b>5 Pin Configuration and Functions</b>	<b>3</b>	<b>9 Power Supply Recommendations</b> .....	<b>20</b>
<b>6 Specifications</b>	<b>3</b>	<b>10 Layout</b> .....	<b>21</b>
6.1 Absolute Maximum Ratings .....	3	10.1 Layout Guidelines.....	21
6.2 ESD Ratings .....	3	10.2 Layout Example.....	21
6.3 Recommended Operating Conditions .....	4	<b>11 Device and Documentation Support</b> .....	<b>22</b>
6.4 Thermal Information .....	4	11.1 Device Support.....	22
6.5 Electrical Characteristics .....	4	11.2 接收文档更新通知.....	22
6.6 Typical Characteristics.....	6	11.3 支持资源.....	22
<b>7 Detailed Description</b> .....	<b>12</b>	11.4 Trademarks.....	22
7.1 Overview.....	12	11.5 静电放电警告.....	22
7.2 Functional Block Diagram.....	12	11.6 术语表.....	22
7.3 Feature Description.....	13		

## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

DATE	REVISION	NOTES
November 2020	*	Initial release.

## 5 Pin Configuration and Functions

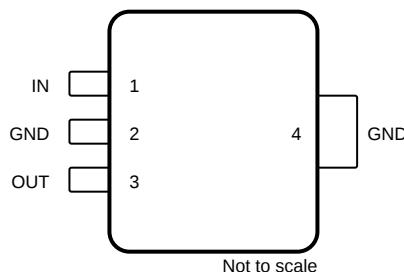


图 5-1. DCY Package, 3-Pin SOT-223, Top View

表 5-1. Pin Functions

PIN		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	DCY		
GND	2, 4	G	Ground pin. Connect this pin to the thermal pad with a low-impedance connection.
IN	1	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 ground, as listed in the <i>Recommended Operating Conditions</i> table and the <i>Input Capacitor</i> section. Place the input capacitor as close to the input of the device as possible.
OUT	3	O	Regulated output voltage pin. A capacitor is required from OUT to ground for stability. For best transient response, use the nominal recommended value or larger ceramic capacitor from OUT to ground; see the <i>Recommended Operating Conditions</i> table and the <i>Output Capacitor</i> section. Place the output capacitor as close to output of the device as possible. If using a high ESR capacitor, decouple the output with a 100-nF ceramic capacitor.

(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
IN	Unregulated input	-0.3	42	V
OUT	Regulated output	-0.3	$V_{IN} + 0.3$ <sup>(2)</sup>	V
$T_A$	Operating ambient temperature	-40	125	°C
$T_J$	Operating junction temperature	-40	150	°C
$T_{stg}$	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  $V_{IN} + 0.3$  V or 20 V, whichever is smaller.

### 6.2 ESD Ratings

$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup>	VALUE	UNIT
		Charged-device model (CDM), per AEC Q100-011	All pins	
			Corner pins	

(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		150	mA
C <sub>OUT</sub>	Output capacitor <sup>(2)</sup>	2.2		220	μF
ESR	Output capacitor ESR requirements <sup>(3)</sup>	0.001		2	Ω
C <sub>IN</sub>	Input capacitor <sup>(1)</sup>	0.1	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.

(3) If using a large ESR capacitor it is recommended to decouple this with a 100-nF ceramic capacitor to improve transient performance.

## 6.4 Thermal Information

	THERMAL METRIC <sup>(1) (2)</sup>	TPS7B83-Q1	UNIT
		DCY	
		3 PINS	
R <sub>θ JA</sub>	Junction-to-ambient thermal resistance <sup>(3)</sup>	77.1	°C/W
R <sub>θ JC(top)</sub>	Junction-to-case (top) thermal resistance	41.7	°C/W
R <sub>θ JB</sub>	Junction-to-board thermal resistance	11.7	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	3.3	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	11.5	°C/W
R <sub>θ JC(bot)</sub>	Junction-to-case (bottom) thermal resistance	11.5	°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.

(3) The 1s0p R<sub>θ JA</sub> is 154.6 °C/W for the DCY package.

## 6.5 Electrical Characteristics

specified at T<sub>J</sub> = - 40°C to +150°C, V<sub>IN</sub> = 13.5 V, I<sub>OUT</sub> = 0 mA, C<sub>OUT</sub> = 2.2 μF, 1 mΩ < C<sub>OUT</sub> ESR < 2 Ω, C<sub>IN</sub> = 1 μF typical values are at T<sub>J</sub> = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
V <sub>OUT</sub>	Regulated output accuracy DCY	V <sub>IN</sub> = V <sub>OUT</sub> + 500 mV to 40 V, I <sub>OUT</sub> = 100 μA to 150 mA <sup>(1)</sup>	T <sub>J</sub> = 25°C T <sub>J</sub> = - 40°C to +150°C	-	0.75	0.75	%	
				- 1		1		
Δ V <sub>OUT(Δ VIN)</sub>	Line regulation	Change in percent of output voltage	V <sub>IN</sub> = V <sub>OUT</sub> + 500 mV to 40 V, I <sub>OUT</sub> = 100 μA			0.2	%	
Δ V <sub>OUT(Δ IOUT)</sub>	Load regulation	Change in percent of output voltage	V <sub>IN</sub> = V <sub>OUT</sub> + 500 mV, I <sub>OUT</sub> = 100 μA to 150 mA			0.2		
Δ V <sub>OUT</sub>	Load transient response settling time <sup>(2) (3)</sup>	C <sub>OUT</sub> = 10 μF	C <sub>OUT</sub> = 10 μF			100	μs	
	Load transient response overshoot, undershoot <sup>(3)</sup>		I <sub>OUT</sub> = 45 mA to 105 mA	- 2%		10%	%V <sub>OUT</sub>	
			I <sub>OUT</sub> = 0 mA to 150 mA	-		10%		

## 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
$I_Q$	Quiescent current	$V_{IN} = V_{OUT} + 500\text{ mV}$ to $40\text{ V}$ , $I_{OUT} = 0\text{ mA}$	$T_J = 25^\circ\text{C}$	18	21	$\mu\text{A}$
			$T_J = -40^\circ\text{C}$ to $+150^\circ\text{C}$		26	
		$I_{OUT} = 500\text{ }\mu\text{A}$	$T_J = -40^\circ\text{C}$ to $+150^\circ\text{C}$		35	
$V_{DO}$	Dropout voltage	$I_{OUT} \leq 1\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)} \times 0.95$			47	$\text{mV}$
		$I_{OUT} = 105\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$		130	180	
		$I_{OUT} = 150\text{ mA}$ , $V_{OUT} \geq 3.3\text{ V}$ , $V_{IN} = V_{OUT(NOM)}$		160	230	
$V_{UVLO(RISING)}$	Rising input supply UVLO	$V_{IN}$ rising	2.6	2.7	2.82	$\text{V}$
$V_{UVLO(FALLING)}$	Falling input supply UVLO	$V_{IN}$ falling	2.38	2.5	2.6	$\text{V}$
$V_{UVLO(HYST)}$	V <sub>UVLO</sub> hysteresis			230		$\text{mV}$
$I_{CL}$	Output current limit	$V_{IN} = V_{OUT(NOM)} + 1\text{ V}$ , $V_{OUT}$ short to $90\% \times V_{OUT(NOM)}$	180	220	260	$\text{mA}$
PSRR	Power-supply ripple rejection	$V_{IN} - V_{OUT} = 500\text{ mV}$ , frequency = 1 kHz, $I_{OUT} = 150\text{ mA}$		55		$\text{dB}$
$V_n$	Output noise voltage	$V_{OUT} = 3.3\text{ V}$ , BW = 10 Hz to 100 kHz		280		$\mu\text{V}_{\text{RMS}}$
$T_{SD(SHUTDOWN)}$	Junction shutdown temperature			175		$^\circ\text{C}$
$T_{SD(HYST)}$	Hysteresis of thermal shutdown			20		$^\circ\text{C}$

- (1) Power dissipation is limited to 2W for IC production testing purposes. The power dissipation can be higher during normal operation. Please 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) The settling time is measured from when  $I_{OUT}$  is stepped from 45mA to 105 mA to when the output voltage recovers to  $V_{OUT} = V_{OUT(NOM)} - 5\text{ mV}$ .
- (3) This specification is specified by design.

## 6.6 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)

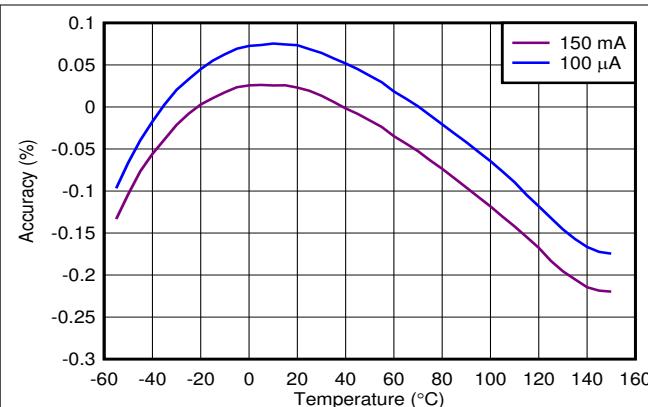


图 6-1. Accuracy vs Temperature

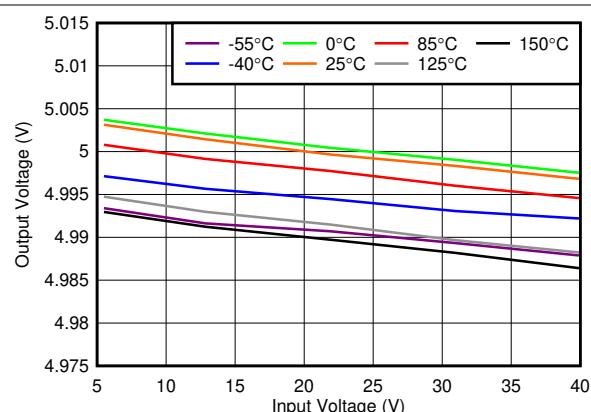
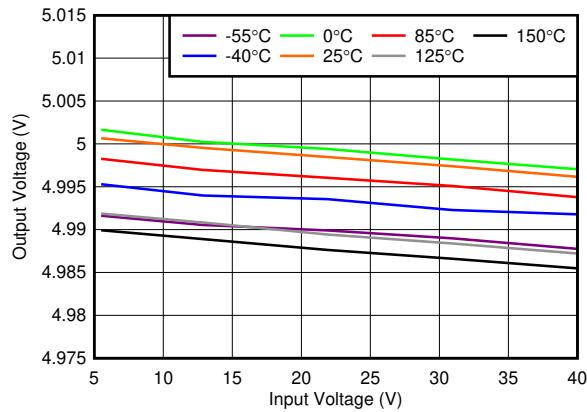
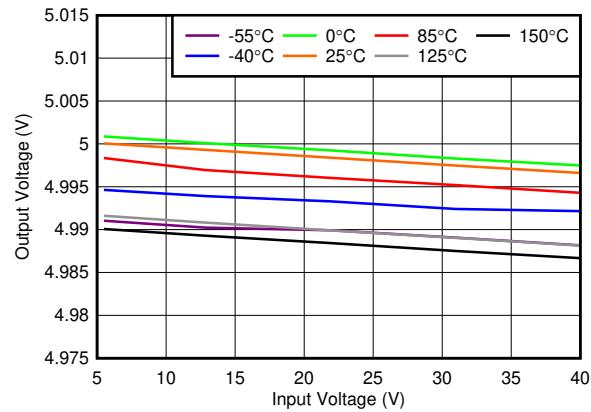
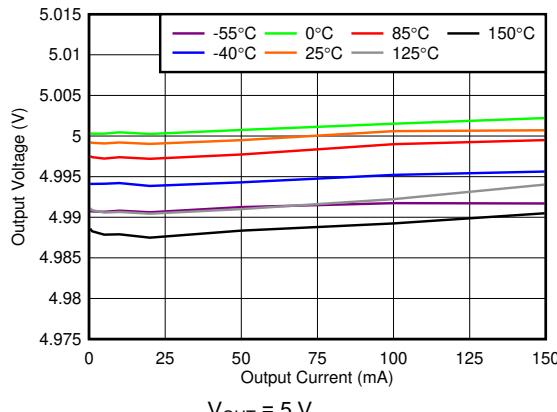
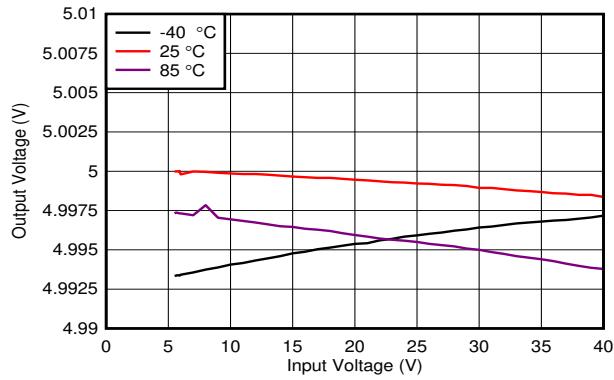
V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 150 mA图 6-2. Line Regulation vs V<sub>IN</sub>V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 5 mA图 6-3. Line Regulation vs V<sub>IN</sub>V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 1 mA图 6-4. Line Regulation vs V<sub>IN</sub>V<sub>OUT</sub> = 5 V图 6-5. Load Regulation vs I<sub>OUT</sub>C<sub>OUT</sub> = 10 μF

图 6-6. Line Regulation at 50 mA

## 6.6 Typical Characteristics (continued)

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

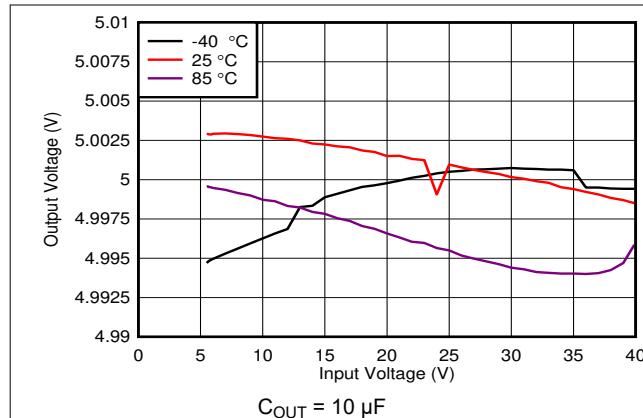


图 6-7. Line Regulation at 100 mA

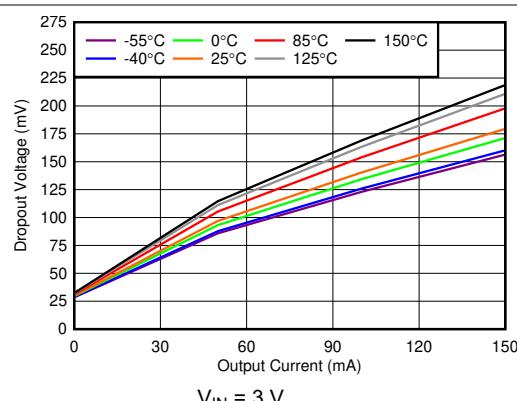
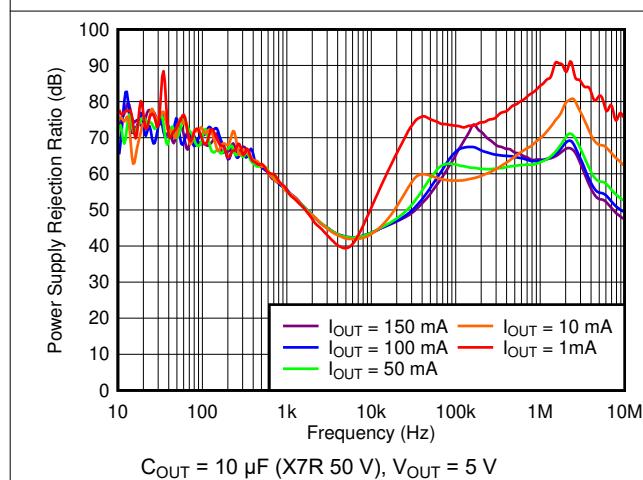
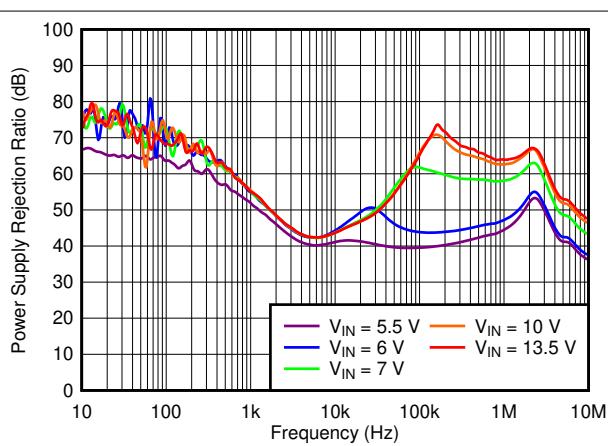


图 6-8. Dropout Voltage ( $V_{DO}$ ) vs  $I_{OUT}$



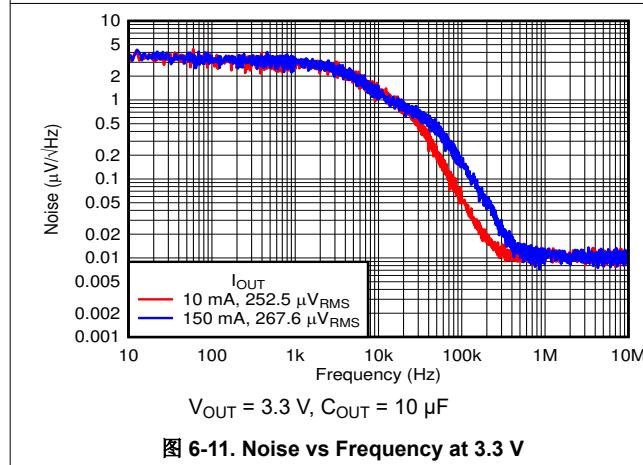
$C_{OUT} = 10\text{ }\mu\text{F}$  (X7R 50 V),  $V_{OUT} = 5\text{ V}$

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



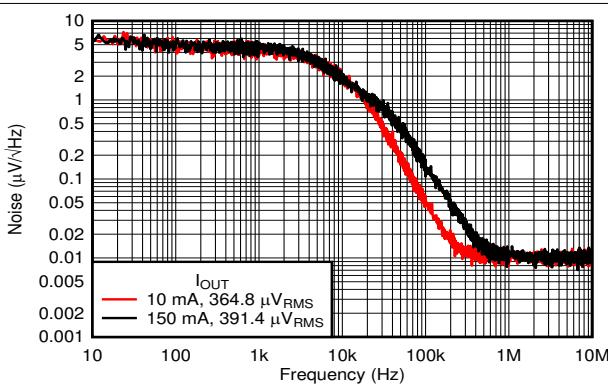
$C_{OUT} = 10\text{ }\mu\text{F}$  (X7R 50 V),  $I_{OUT} = 150\text{ mA}$ ,  $V_{OUT} = 5\text{ V}$

图 6-10. PSRR vs Frequency and  $V_{IN}$



$V_{OUT} = 3.3\text{ V}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-11. Noise vs Frequency at 3.3 V

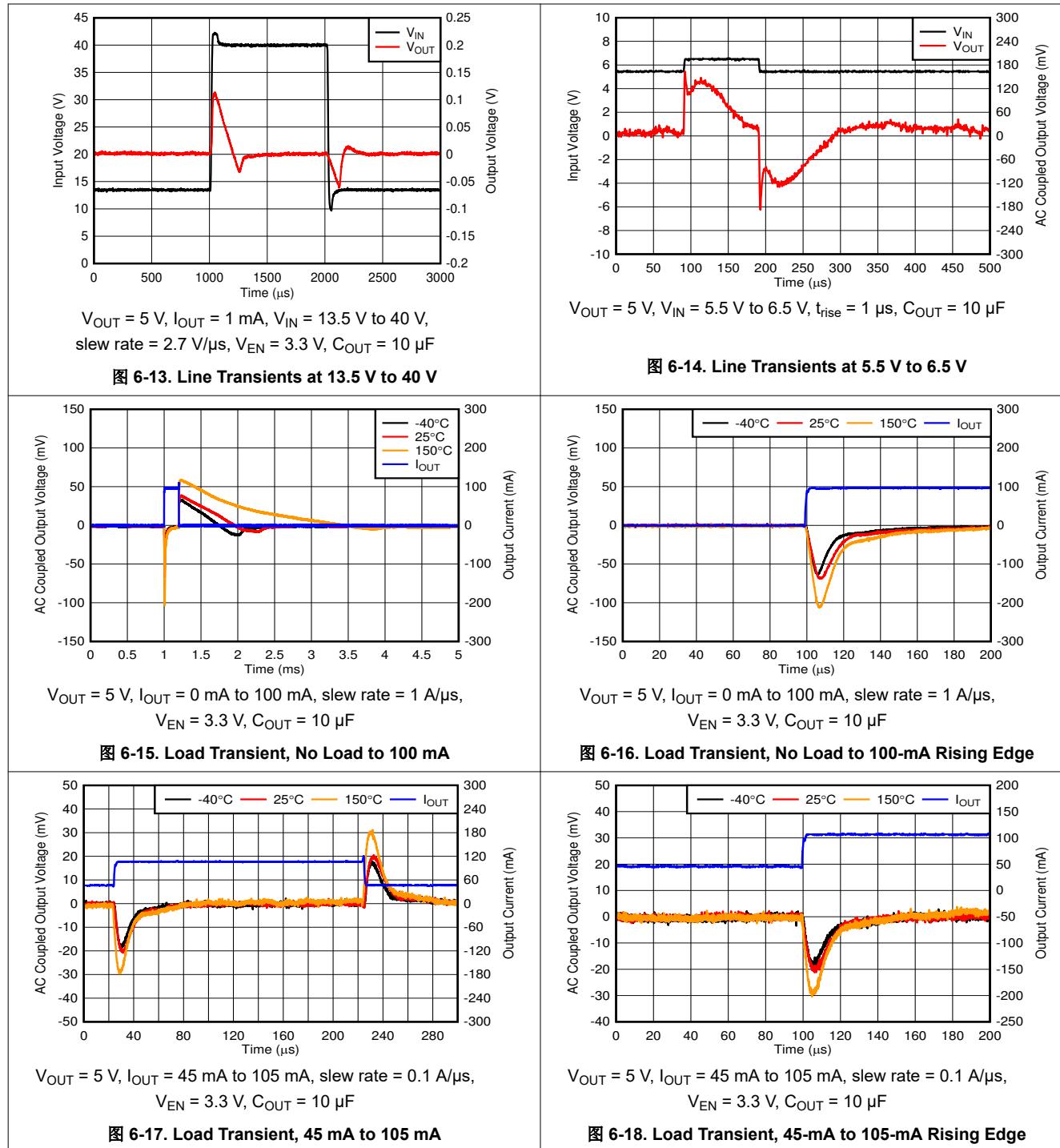


$V_{OUT} = 5\text{ V}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$

图 6-12. Noise vs Frequency at 5.0 V

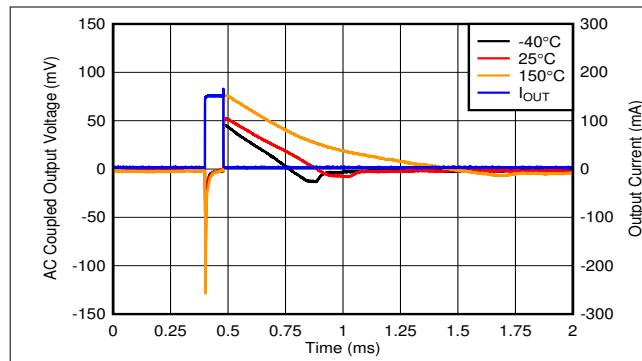
## 6.6 Typical Characteristics (continued)

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



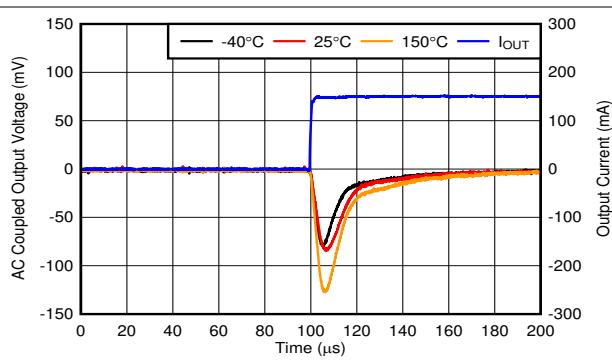
## 6.6 Typical Characteristics (continued)

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



$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$  to  $150\text{ mA}$ , slew rate =  $1\text{ A}/\mu\text{s}$ ,  
 $V_{EN} = 3.3\text{ V}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$

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



$V_{OUT} = 5\text{ V}$ ,  $I_{OUT} = 0\text{ mA}$  to  $150\text{ mA}$ , slew rate =  $1\text{ A}/\mu\text{s}$ ,  $V_{EN} = 3.3\text{ V}$ ,  $C_{OUT} = 10\text{ }\mu\text{F}$

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

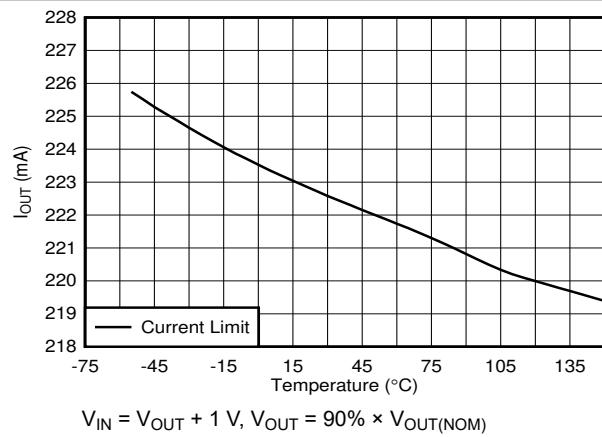


图 6-21. Output Current Limit vs Temperature

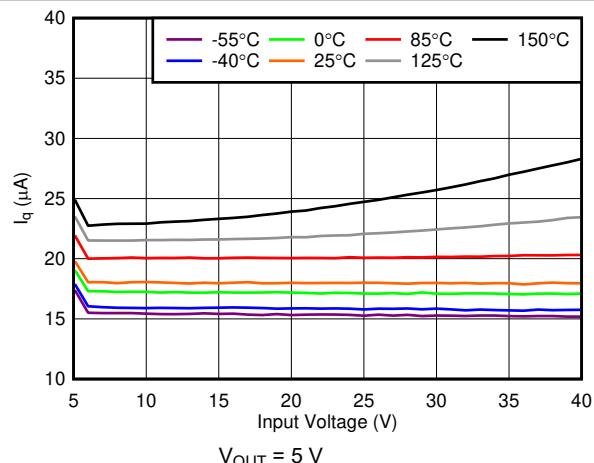


图 6-22. Quiescent Current (I\_Q) vs V\_IN

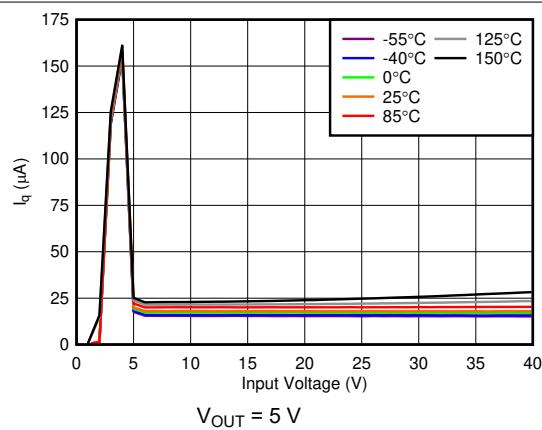


图 6-23. Quiescent Current (I\_Q) vs V\_IN

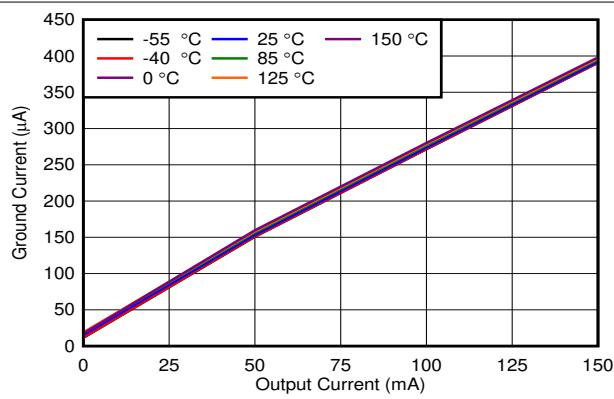


图 6-24. Ground Current (I\_GND) vs I\_OUT

## 6.6 Typical Characteristics (continued)

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

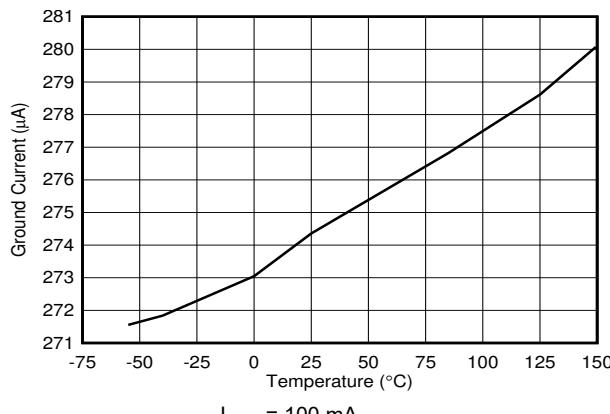


图 6-25. Ground Current

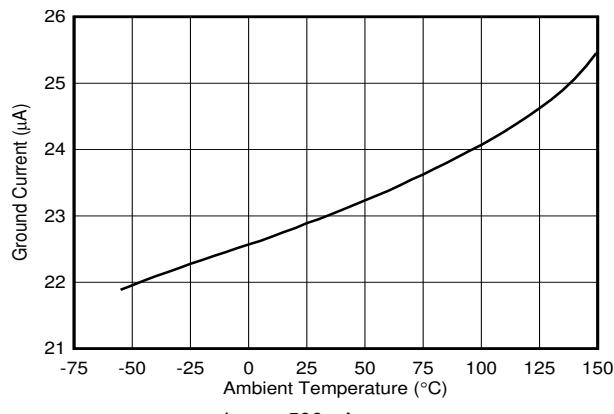


图 6-26. Ground Current

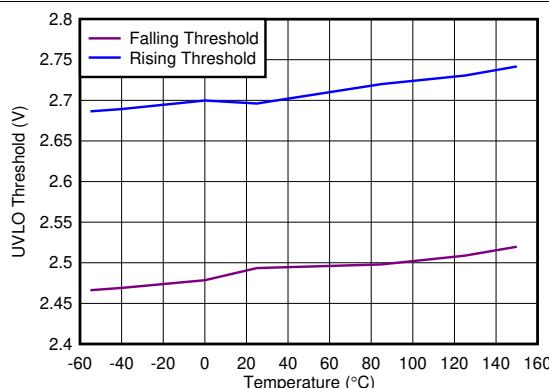


图 6-27. Undervoltage Lockout (UVLO) Threshold vs Temperature

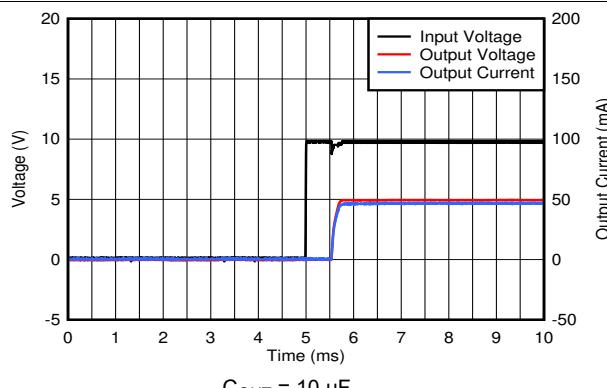


图 6-28. Startup Plot

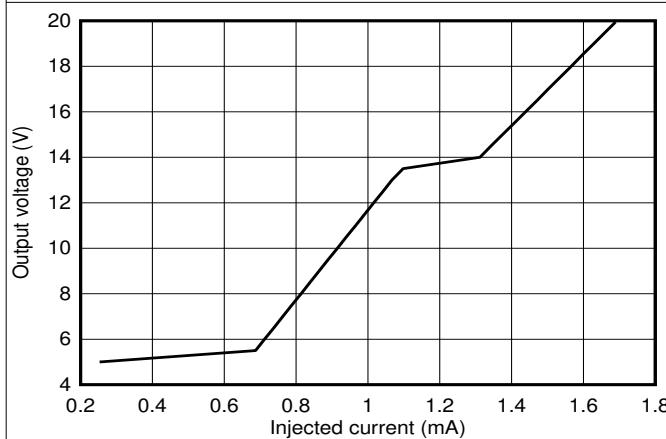


图 6-29. Output Voltage vs Injected Current

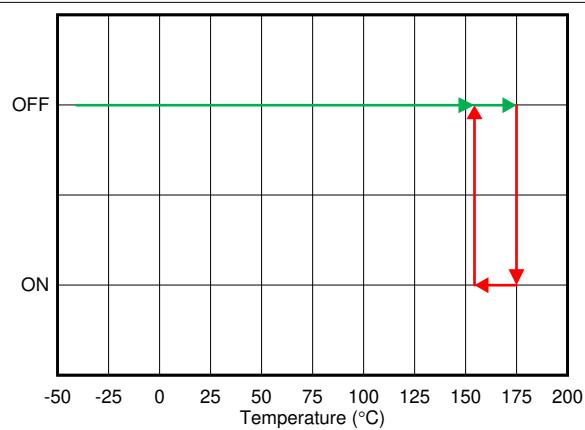


图 6-30. Thermal Shutdown

## 6.6 Typical Characteristics (continued)

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

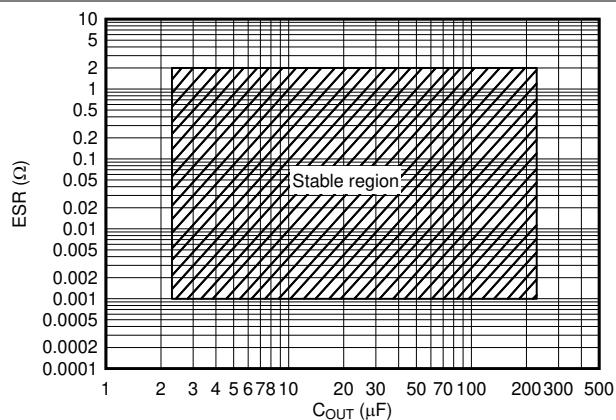


图 6-31. Stability ESR vs  $C_{OUT}$

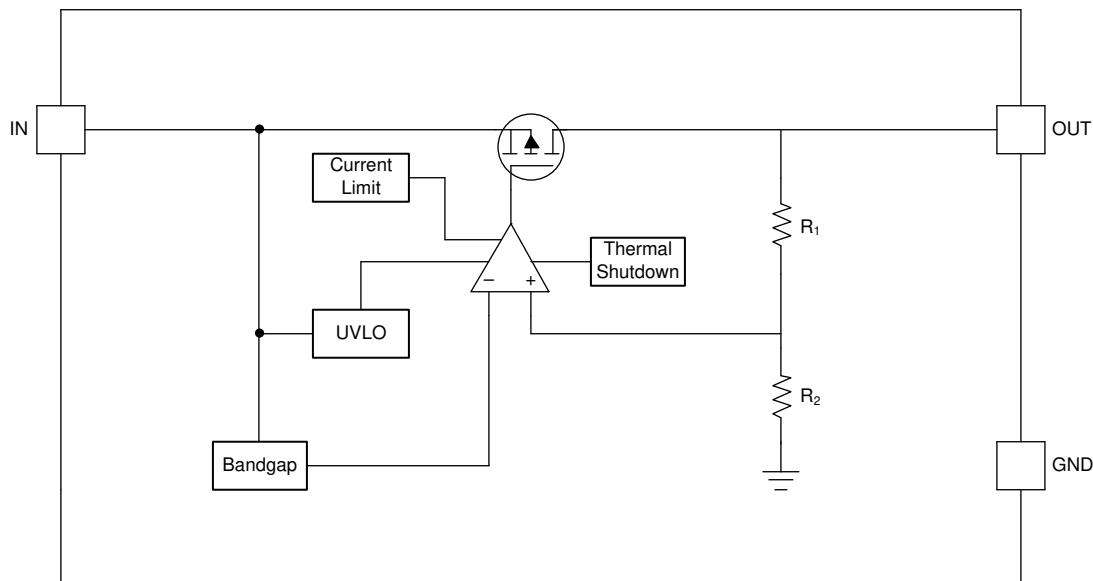
## 7 Detailed Description

## 7.1 Overview

The TPS7B83-Q1 is a low-dropout linear regulator (LDO) designed to connect to the battery in automotive applications. The device has an input voltage range extending to 40 V, which allows the device to withstand transients (such as load dumps) that are anticipated in automotive systems. With only a 18- $\mu$ A quiescent current at light loads, the device is an optimal solution for powering always-on components.

The device has a state-of-the-art transient response that allows the output to quickly react to changes in the load or line (for example, during cold-crank conditions). Additionally, the device has a novel architecture that minimizes output overshoot when recovering from dropout. During normal operation, the device has a tight DC accuracy of  $\pm 1\%$  over line, load, and temperature.

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 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.

### 7.3.2 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.

### 7.3.3 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 7-1 shows a diagram of the current limit.

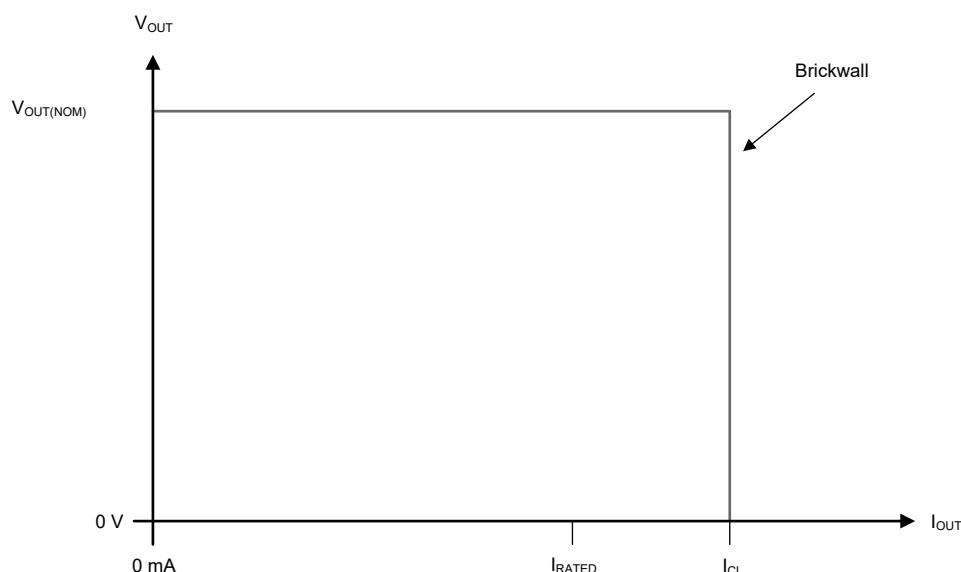


图 7-1. Current Limit

## 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 (any true condition 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 ( $T_J < T_{SD}$ )
- The enable voltage has previously exceeded the enable rising threshold voltage and has not yet decreased to less than the enable falling threshold

### 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.

## 8 Application and Implementation

### Note

以下应用部分的信息不属于 TI 组件规范，TI 不担保其准确性和完整性。客户应负责确定 TI 组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 TPS7B83-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 the 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 ( $V_{DO}$ ) is defined as the input voltage minus the output voltage ( $V_{IN} - V_{OUT}$ ) at the rated output current ( $I_{RATED}$ ), where the pass transistor is fully on.  $I_{RATED}$  is the maximum  $I_{OUT}$  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 ( $R_{DS(ON)}$ ) 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  $R_{DS(ON)}$  of the device.

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

#### 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  $V_{OUT} \leq V_{IN} + 0.3 \text{ V}$ .

- If the device has a large  $C_{OUT}$  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 [图 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.

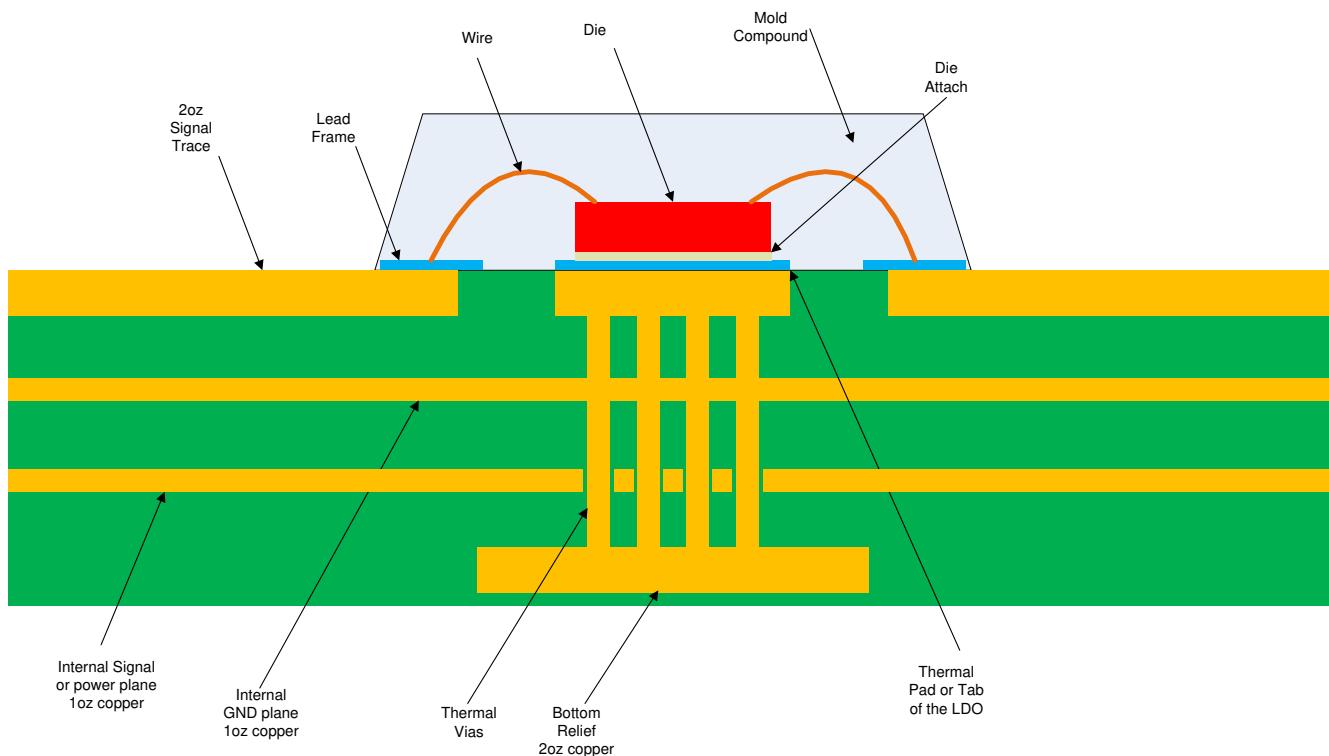


图 8-1. JEDEC Standard 2s2p PCB

图 8-2 and 图 8-3 depict 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 four-layer board, the inner planes use a 1-oz copper thickness. Outer layers are simulated with both a 1-oz and 2-oz copper thickness. A 4 x 4 array of thermal vias of 300- $\mu\text{m}$  drill diameter and 25- $\mu\text{m}$  Cu 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.

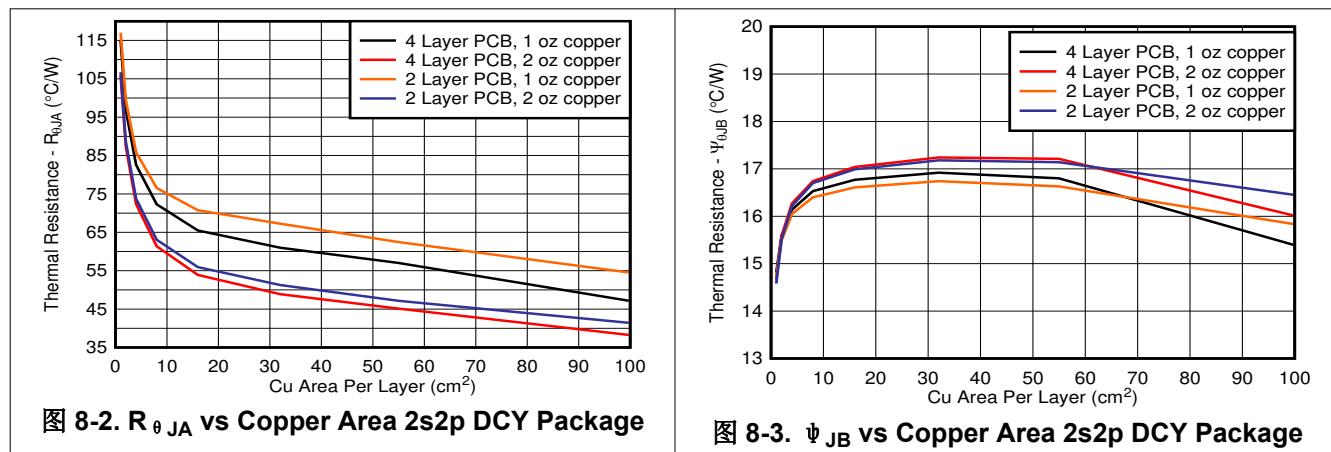


图 8-2.  $R_{\theta JA}$  vs Copper Area 2s2p DCY Package

图 8-3.  $\psi_{JB}$  vs Copper Area 2s2p DCY Package

### 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.

$$T_J = T_T + \Psi_{JT} \times P_D \quad (4)$$

where:

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

$$T_J = T_B + \Psi_{JB} \times P_D \quad (5)$$

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](#).

## 8.2 Typical Application

图 8-4 shows a typical application circuit for the TPS7B83-Q1. Use different values of external components, depending on the end application. An application may require a larger output capacitor during fast load steps in order to prevent a reset from occurring. TI recommends a low-ESR ceramic capacitor with a dielectric of type X5R or X7R.

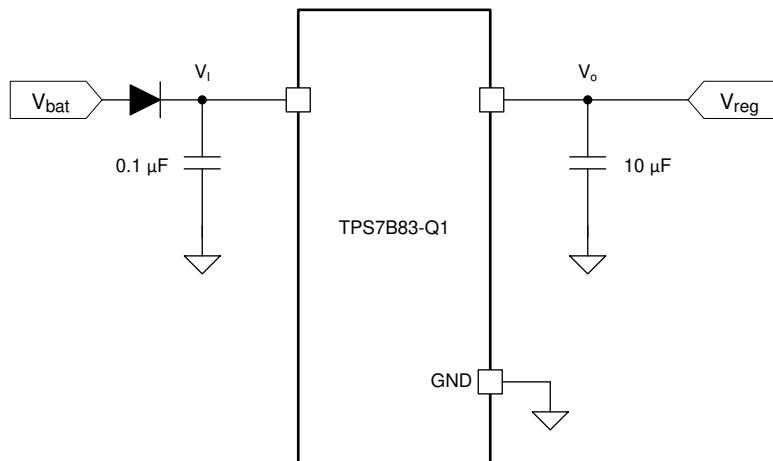


图 8-4. Typical Application Schematic for the TPS7B83-Q1

### 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	100 mA
Output capacitor	10 $\mu F$

### 8.2.2 Detailed Design Procedure

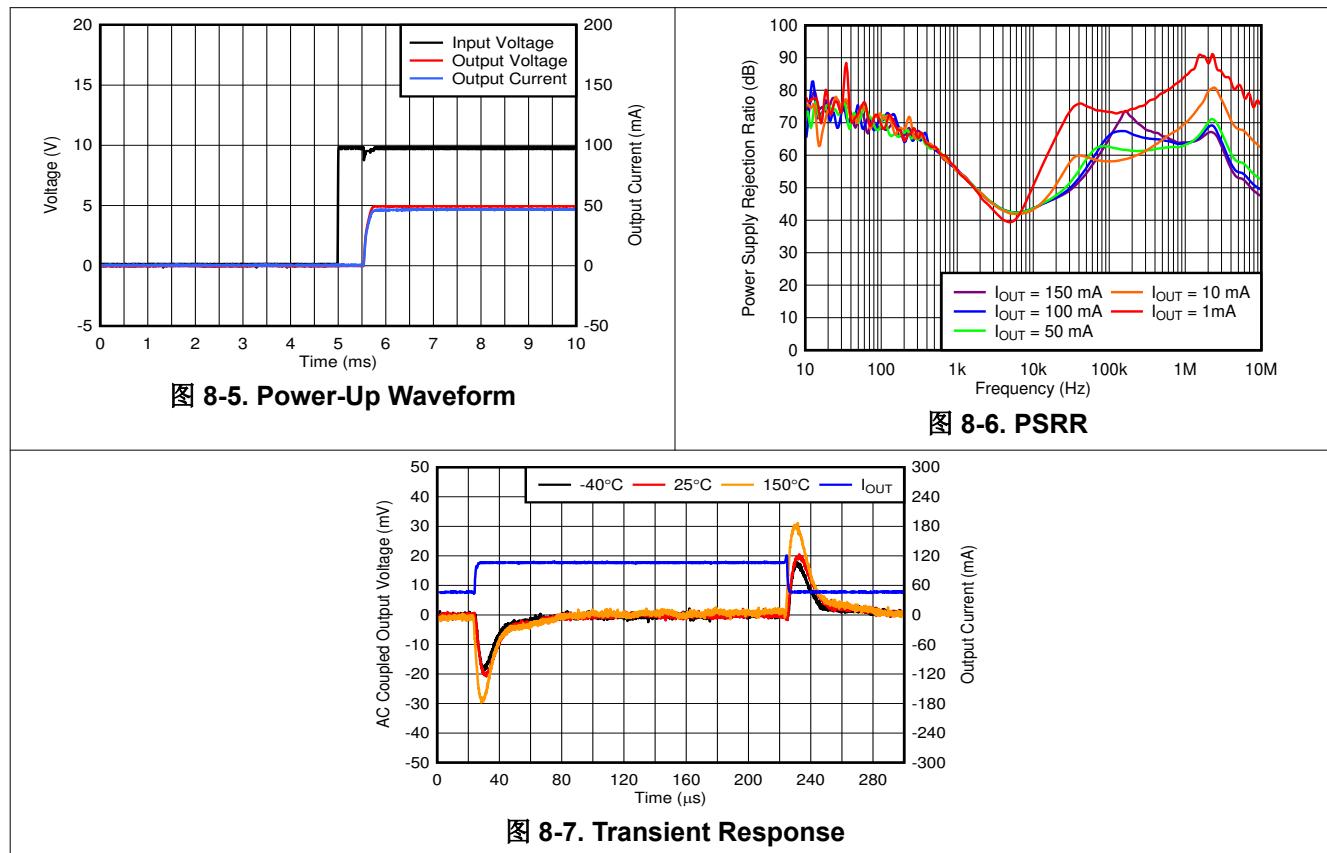
#### 8.2.2.1 Input Capacitor

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 TPS7B83-Q1, add an electrolytic capacitor 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 TPS7B83-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 [图 10-1](#), place the input and output capacitors close to the device for the layout of the TPS7B83-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 IN and 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 these can negatively impact system performance and may even cause instability.

If possible, and to ensure the maximum performance specified in this document, use the same layout pattern used for the TPS7B83-Q1 evaluation board, available at [www.ti.com](http://www.ti.com).

### 10.2 Layout Example

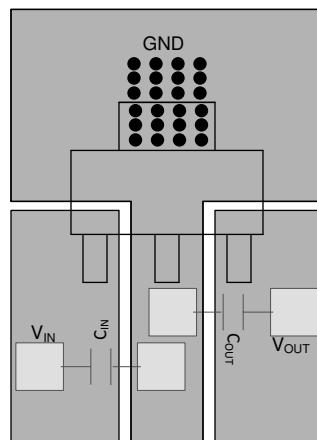


图 10-1. SOT-223 (DCY) Layout

## 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>
TPS7B83xxQDCYRQ1	<p>xx is the nominal output voltage (for example, 33 = 3.3 V V; 50 = 5.0 V).</p> <p>Q indicates that this device is a grade-1 device in accordance with the AEC-Q100 standard.</p> <p>Q1 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).

### 11.2 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。

### 11.3 支持资源

[TI E2E™ 支持论坛](#)是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 [《使用条款》](#)。

### 11.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

所有商标均为其各自所有者的财产。

### 11.5 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

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。

### 11.6 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。

### 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.

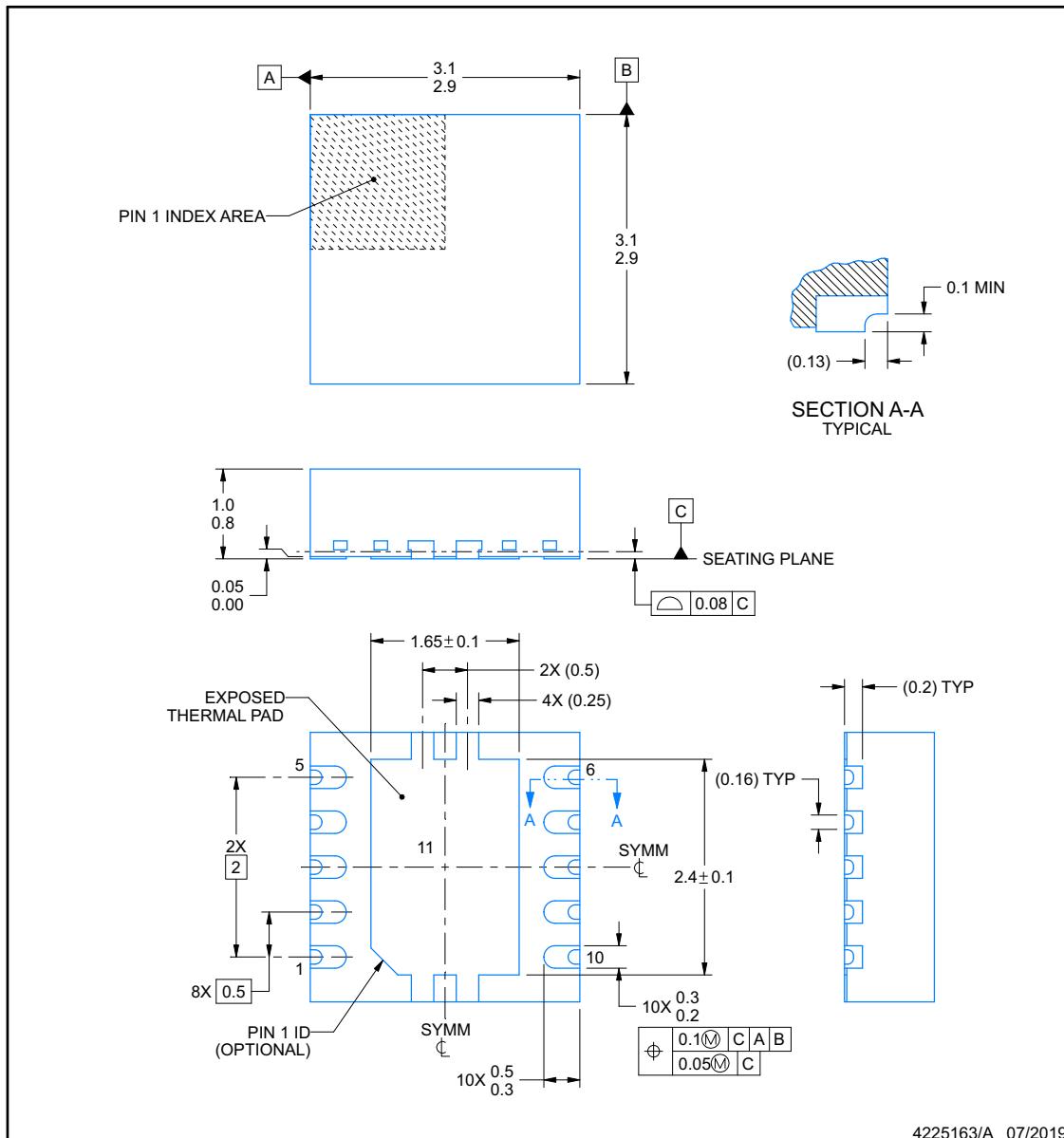
**DRC0010U**



## PACKAGE OUTLINE

## VSON - 1 mm max height

**PLASTIC SMALL OUTLINE - NO LEAD**



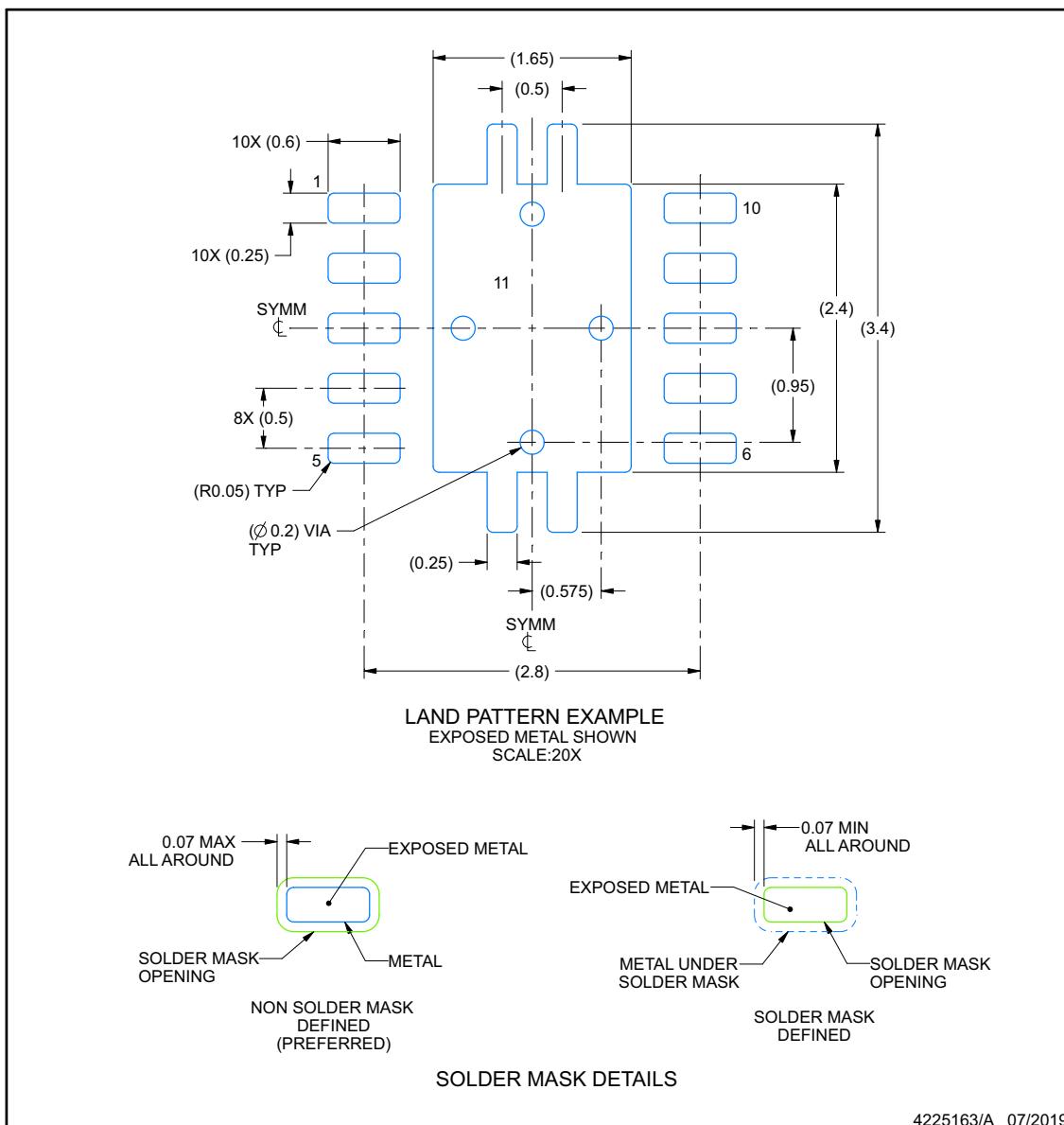
## NOTES:

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. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

## EXAMPLE BOARD LAYOUT

**DRC0010U**
**VSON - 1 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



NOTES: (continued)

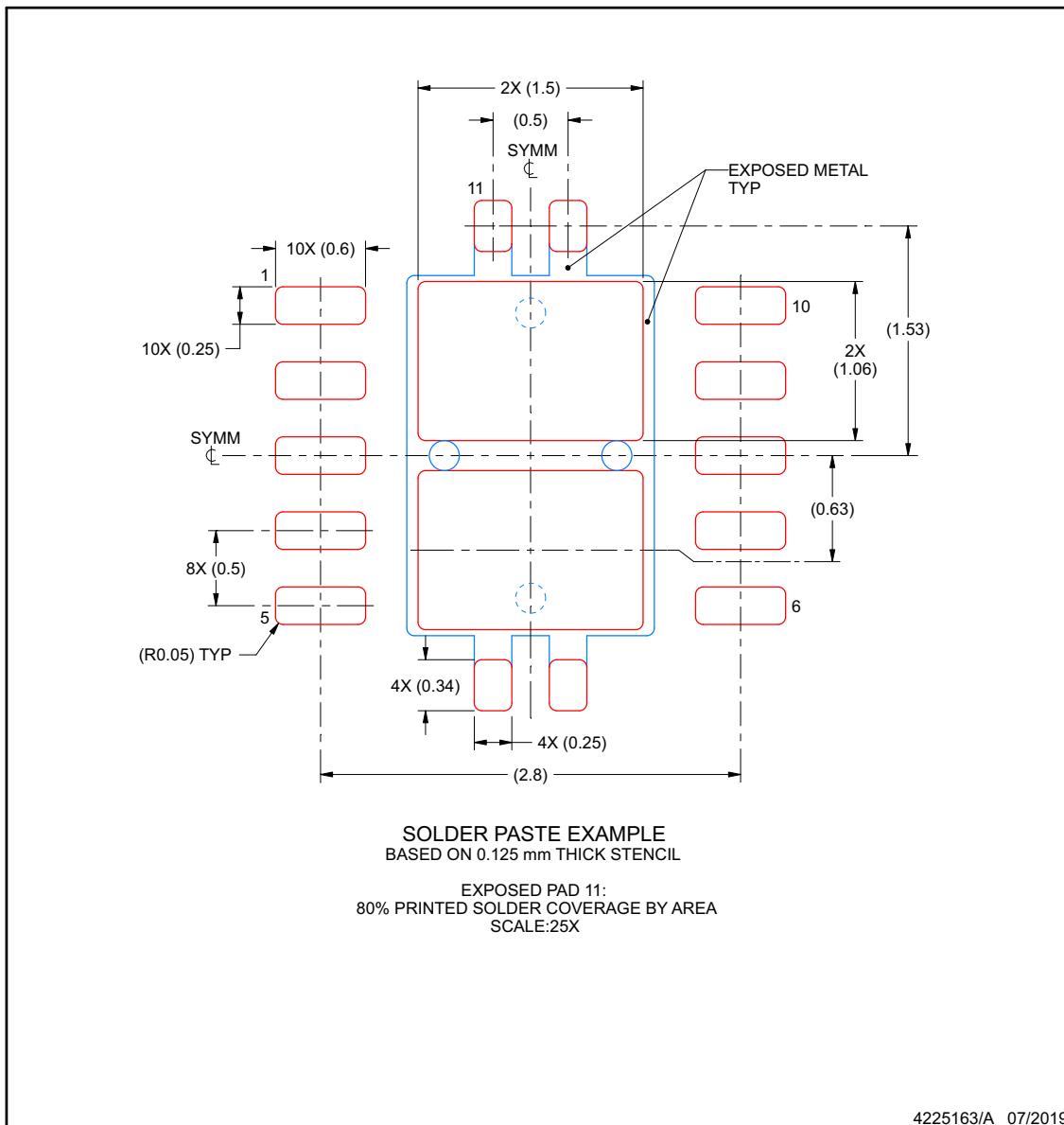
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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

## EXAMPLE STENCIL DESIGN

**DRC0010U**

**VSON - 1 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



4225163/A 07/2019

NOTES: (continued)

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

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS7B8333QDCYRQ1	ACTIVE	SOT-223	DCY	4	2500	RoHS & Green	NIPDAU   SN	Level-2-260C-1 YEAR	-40 to 125	7B8333	Samples
TPS7B8333QDCYRQ1M3	ACTIVE	SOT-223	DCY	4	2500	RoHS & Green	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333	Samples
TPS7B8350QDCYRQ1	ACTIVE	SOT-223	DCY	4	2500	RoHS & Green	NIPDAU   SN	Level-2-260C-1 YEAR	-40 to 125	7B8350	Samples
TPS7B8350QDCYRQ1M3	ACTIVE	SOT-223	DCY	4	2500	RoHS & Green	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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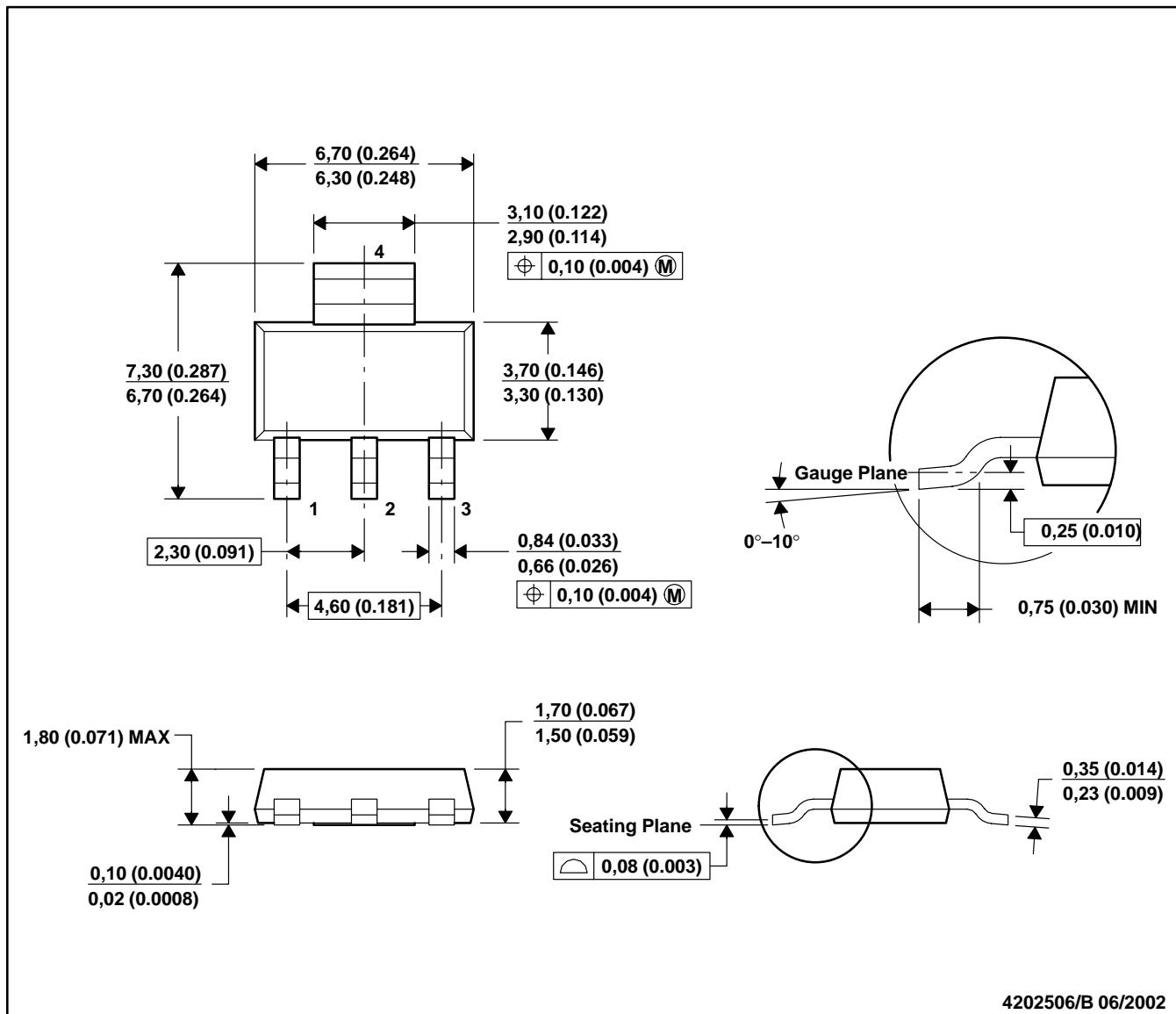
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## DCY (R-PDSO-G4)

## PLASTIC SMALL-OUTLINE



NOTES: A. All linear dimensions are in millimeters (inches).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion.  
 D. Falls within JEDEC TO-261 Variation AA.

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