

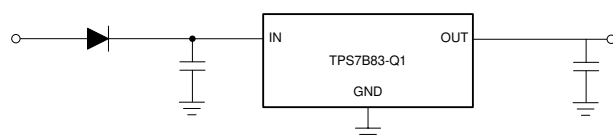
TPS7B83-Q1 150mA、40V、低ドロップアウト・レギュレータ

1 特長

- 車載アプリケーション用に AEC-Q100 認定取得済み
 - 温度グレード 1: -40°C ~ +125°C, T_A
 - 接合部温度: -40°C ~ +150°C, T_J
- 入力電圧範囲: 3V ~ 40V (最大 42V)
- 出力電圧範囲: 3.3V および 5V (固定)
- 出力電流: 最大 150mA
- 出力電圧精度: $\pm 1\%$ 以下
- 低いドロップアウト電圧:
 - 150mA で 230mV 以下 ($V_{OUT} \geq 3.3V$)
- 低い静止電流:
 - 18 μA (標準値)
- 優れたライン過渡応答:
 - V_{OUT} の $\pm 2\%$ の偏差 (コールド・クラック時)
 - V_{OUT} の $\pm 2\%$ の偏差 (1V/ μs の V_{IN} スルーレート)
- 2.2 μF 以上のコンデンサで安定
- 機能安全対応
 - 機能安全システムの設計に役立つ資料を利用可能
- パッケージ: 3 ピン SOT-223

2 アプリケーション

- 再構成可能インストルメント・クラス
- 車体制御モジュール (BCM)
- 常時オンのバッテリー接続アプリケーション:
 - 車載ゲートウェイ
 - リモート・キーレス・エントリ (RKE)



代表的なアプリケーション回路図

3 概要

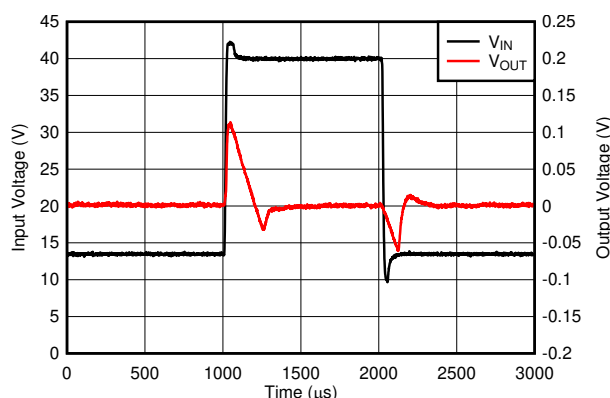
TPS7B83-Q1 は、車載用アプリケーションのバッテリーに接続するように設計された低ドロップアウト・リニア・レギュレータです。このデバイスの入力電圧範囲は 40V まで拡張されているため、車載用システムで予測される過渡事象 (負荷ダンピングなど) にも耐えられます。このデバイスは静止電流がわずか 18 μA であることから、スタンバイ・システムのマイクロコントローラや CAN (コントローラ・エリア・ネットワーク) トランシーバなどの常時オンのコンポーネントへの電力供給に最適なソリューションです。

このデバイスは、負荷やラインの変動 (例: コールド・クラック条件時) に出力が素早く応答できる最先端の過渡応答性能を備えています。またこのデバイスは、ドロップアウトからの回復時に出力オーバーシュートを最小限に抑える革新的なアーキテクチャを採用しています。通常動作時は、ライン、負荷、温度の全範囲にわたって誤差 $\pm 1\%$ 以下の高い DC 精度を維持します。

製品情報(1)

部品番号	パッケージ	本体サイズ (公称)
TPS7B83-Q1	SOT-223 (3)	6.50mm × 3.50mm

- (1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。



ライン過渡応答
(3V/ μs の V_{IN} スルーレート)



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4 Revision History

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

DATE	REVISION	NOTES
November 2020	*	Initial release.

5 Pin Configuration and Functions

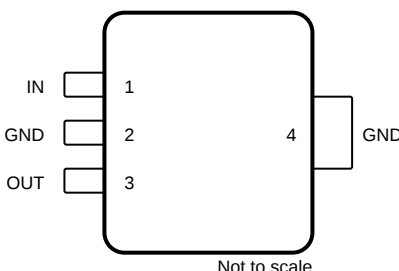


图 5-1. DCY Package, 3-Pin SOT-223, Top View

表 5-1. Pin Functions

PIN		TYPE ⁽¹⁾	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 Input Capacitor 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 Output Capacitor 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)⁽¹⁾

		MIN	MAX	UNIT
IN	Unregulated input	−0.3	42	V
OUT	Regulated output	−0.3	$V_{IN} + 0.3^{(2)}$	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

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 ⁽¹⁾	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±500	
			±750	

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

6.3 Recommended Operating Conditions

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

		MIN	TYP	MAX	UNIT
V_{IN}	Input voltage	3		40	V
V_{OUT}	Output voltage	1.2		18	V
I_{OUT}	Output current	0		150	mA
C_{OUT}	Output capacitor ⁽²⁾	2.2		220	μ F
ESR	Output capacitor ESR requirements ⁽³⁾	0.001		2	Ω
C_{IN}	Input capacitor ⁽¹⁾	0.1	1		μ F
T_J	Operating junction temperature	-40		150	$^{\circ}$ C

(1) For robust EMI performance the minimum input capacitance is 500 nF.

(2) Effective output capacitance of 1 μ F 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 ^{(1) (2)}		TPS7B83-Q1	UNIT
		DCY	
		3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance ⁽³⁾	77.1	$^{\circ}$ C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	41.7	$^{\circ}$ C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	11.7	$^{\circ}$ C/W
Ψ_{JT}	Junction-to-top characterization parameter	3.3	$^{\circ}$ C/W
Ψ_{JB}	Junction-to-board characterization parameter	11.5	$^{\circ}$ C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	11.5	$^{\circ}$ 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 $R_{\theta JA}$ is 154.6 $^{\circ}$ C/W for the DCY package.

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 accuracy DCY	V _{IN} = V _{OUT} + 500 mV to 40 V, I _{OUT} = 100 μA to 150 mA (1)	T _J = 25°C	-0.75		0.75	%
			T _J = -40°C to +150°C	-1		1	
ΔV _{OUT(ΔVIN)}	Line regulation	Change in percent of output voltage	V _{IN} = V _{OUT} + 500 mV to 40 V, I _{OUT} = 100 μA			0.2	%
ΔV _{OUT(ΔIOUT)}	Load regulation	Change in percent of output voltage	V _{IN} = V _{OUT} + 500 mV, I _{OUT} = 100 μA to 150 mA			0.2	
ΔV _{OUT}	Load transient response settling time(2) (3)	C _{OUT} = 10 μF	C _{OUT} = 10 μF			100	μs
	I _{OUT} = 45 mA to 105 mA		-2%		10%	%V _{OUT}	
	Load transient response overshoot, undershoot(3)		I _{OUT} = 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 V , $I_{OUT} = 0\text{ mA}$	$T_J = 25^{\circ}\text{C}$		18	21	μA
			$T_J = -40^{\circ}\text{C}$ 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	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	V
$V_{UVLO(FALLING)}$	Falling input supply UVLO	V_{IN} falling		2.38	2.5	2.6	V
$V_{UVLO(HYST)}$	V_{UVLO} hysteresis				230		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	mA
PSRR	Power-supply ripple rejection	$V_{IN} - V_{OUT} = 500\text{ mV}$, frequency = 1 kHz , $I_{OUT} = 150\text{ mA}$			55		dB
V_n	Output noise voltage	$V_{OUT} = 3.3\text{ V}$, BW = 10 Hz to 100 kHz			280		μV_{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°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)

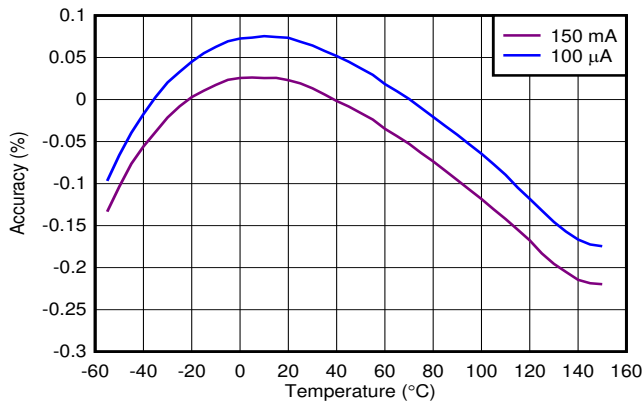
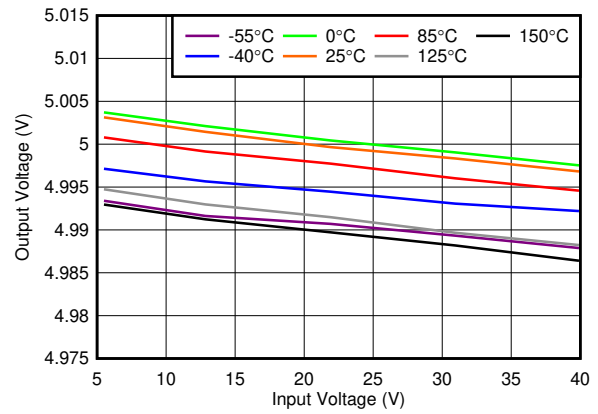
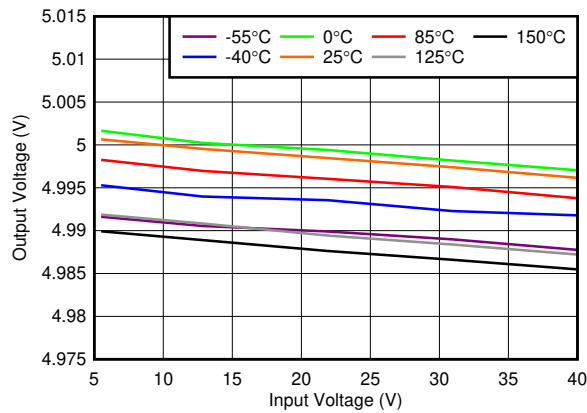


Figure 6-1. Accuracy vs Temperature



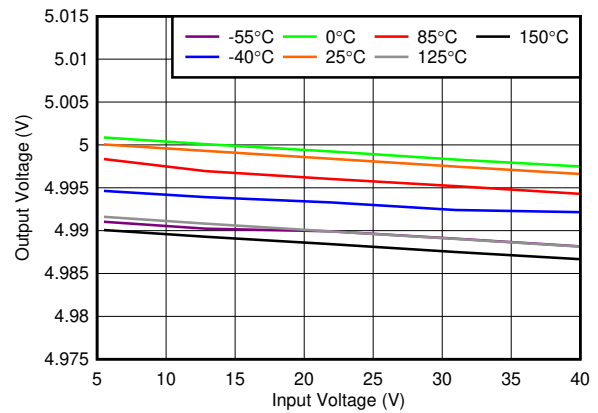
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 150\text{ mA}$

Figure 6-2. Line Regulation vs V_{IN}



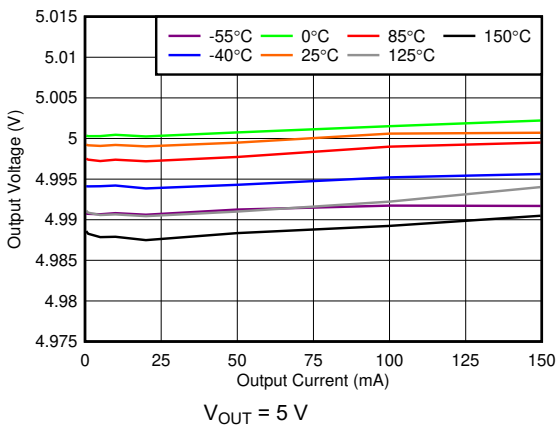
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 5\text{ mA}$

Figure 6-3. Line Regulation vs V_{IN}



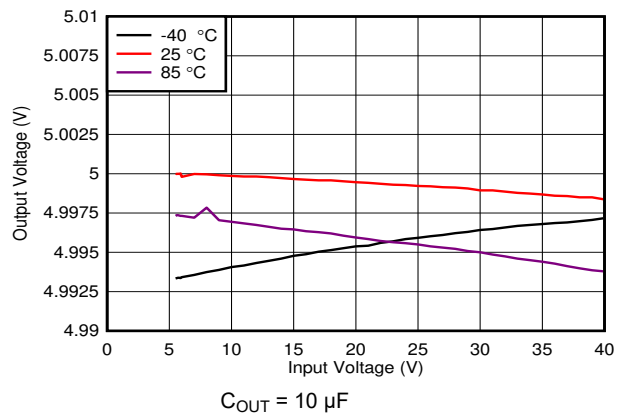
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 1\text{ mA}$

Figure 6-4. Line Regulation vs V_{IN}



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

Figure 6-5. Load Regulation vs I_{OUT}



$C_{OUT} = 10\text{ }\mu\text{F}$

Figure 6-6. Line Regulation at 50 mA

6.6 Typical Characteristics (continued)

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

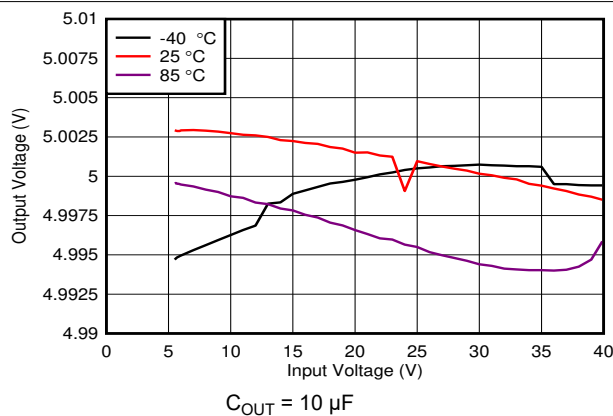


Figure 6-7. Line Regulation at 100 mA

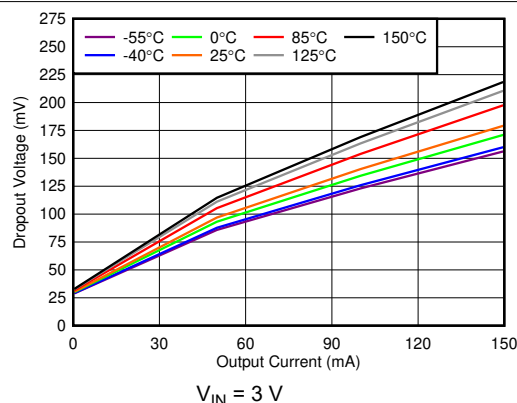


Figure 6-8. Dropout Voltage (V_{DO}) vs I_{OUT}

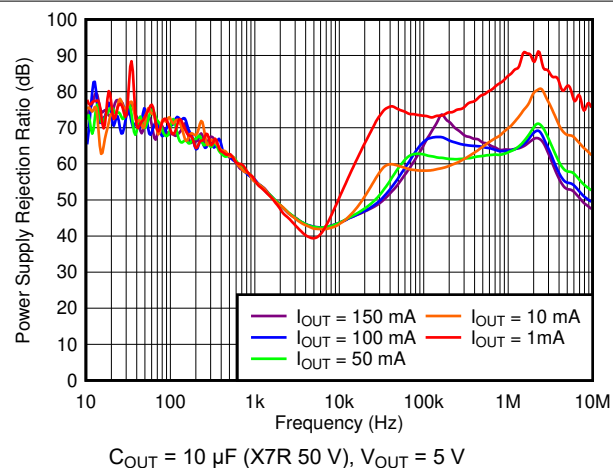


Figure 6-9. PSRR vs Frequency and I_{OUT}

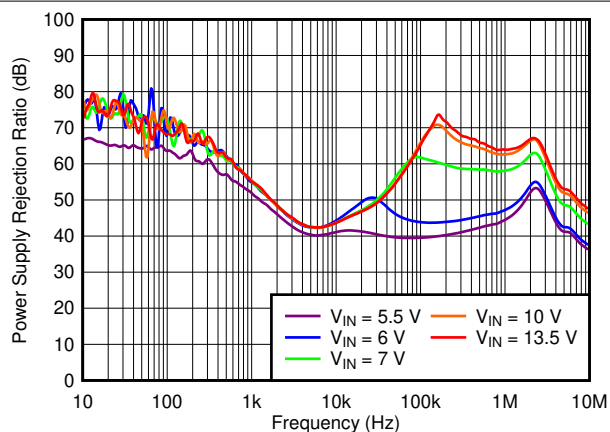


Figure 6-10. PSRR vs Frequency and V_{IN}

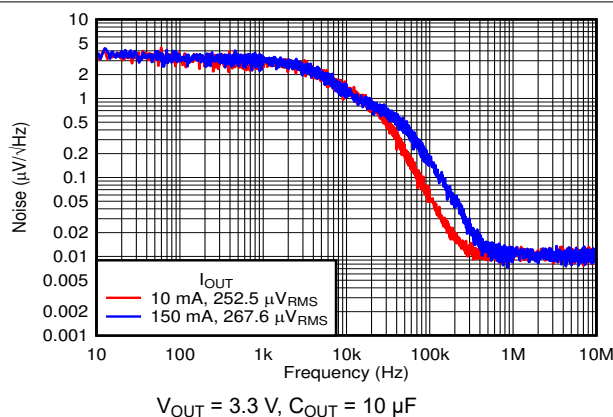


Figure 6-11. Noise vs Frequency at 3.3 V

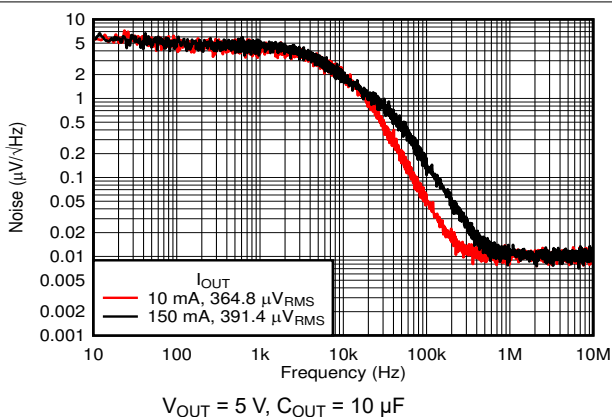
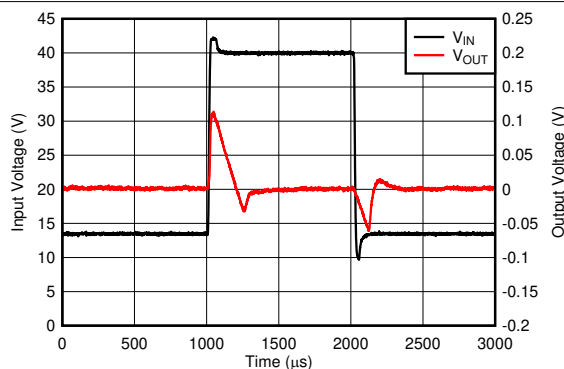


Figure 6-12. Noise vs Frequency at 5.0 V

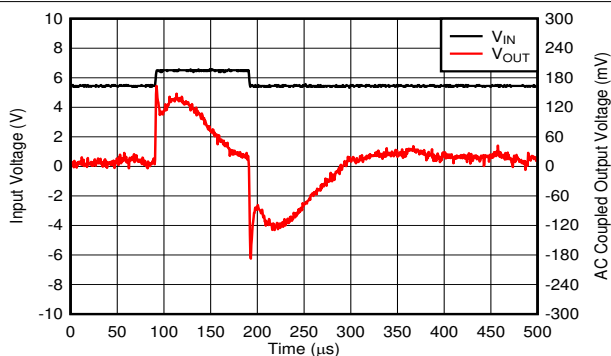
6.6 Typical Characteristics (continued)

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



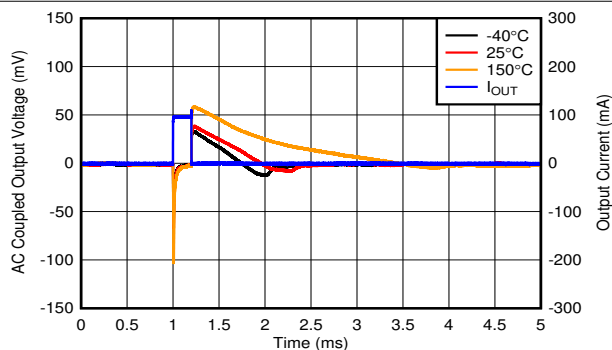
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 1\text{ mA}$, $V_{IN} = 13.5\text{ V}$ to 40 V ,
slew rate = $2.7\text{ V}/\mu\text{s}$, $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

6-13. Line Transients at 13.5 V to 40 V



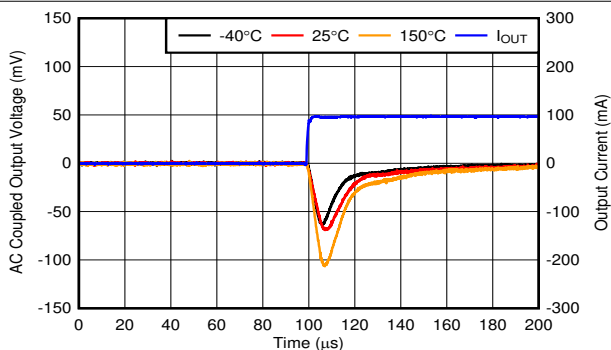
$V_{OUT} = 5\text{ V}$, $V_{IN} = 5.5\text{ V}$ to 6.5 V , $t_{rise} = 1\text{ }\mu\text{s}$, $C_{OUT} = 10\text{ }\mu\text{F}$

6-14. Line Transients at 5.5 V to 6.5 V



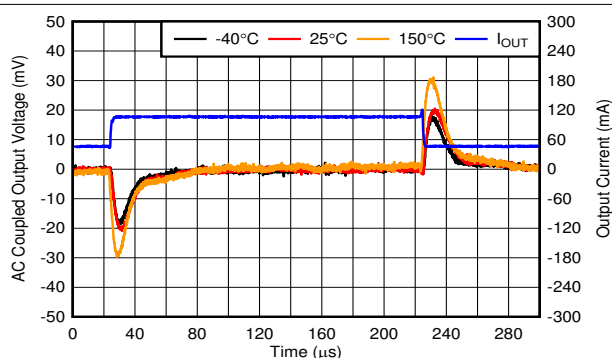
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 0\text{ mA}$ to 100 mA , slew rate = $1\text{ A}/\mu\text{s}$,
 $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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



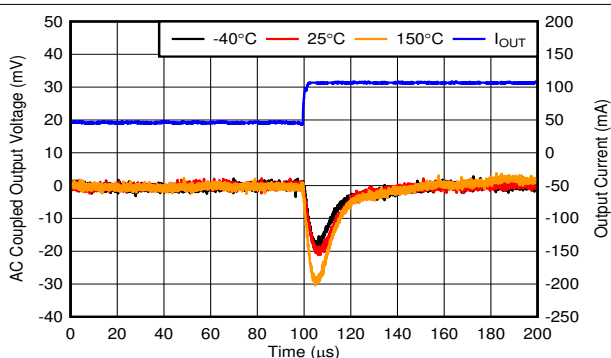
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 0\text{ mA}$ to 100 mA , slew rate = $1\text{ A}/\mu\text{s}$,
 $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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



$V_{OUT} = 5\text{ V}$, $I_{OUT} = 45\text{ mA}$ to 105 mA , slew rate = $0.1\text{ A}/\mu\text{s}$,
 $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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

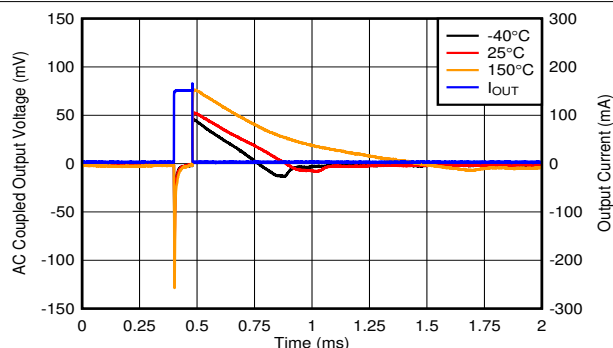


$V_{OUT} = 5\text{ V}$, $I_{OUT} = 45\text{ mA}$ to 105 mA , slew rate = $0.1\text{ A}/\mu\text{s}$,
 $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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

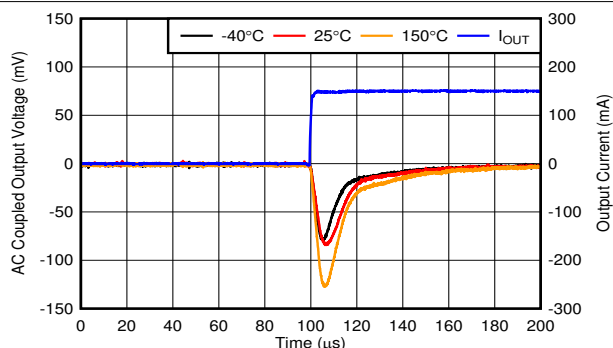
6.6 Typical Characteristics (continued)

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



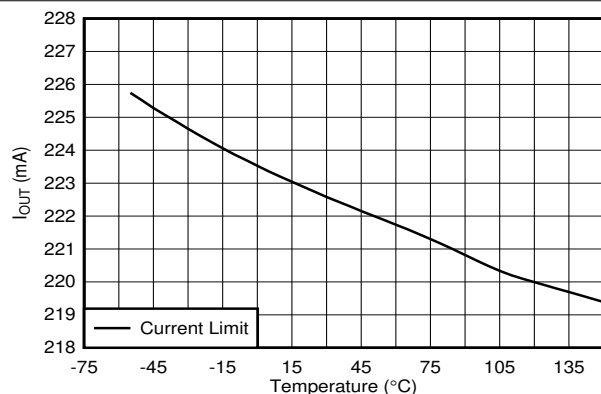
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 0\text{ mA}$ to 150 mA , slew rate = $1\text{ A}/\mu\text{s}$,
 $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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



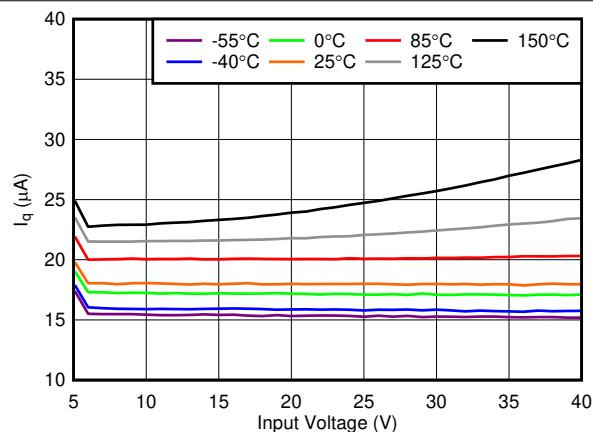
$V_{OUT} = 5\text{ V}$, $I_{OUT} = 0\text{ mA}$ to 150 mA , slew rate = $1\text{ A}/\mu\text{s}$, $V_{EN} = 3.3\text{ V}$, $C_{OUT} = 10\text{ }\mu\text{F}$

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



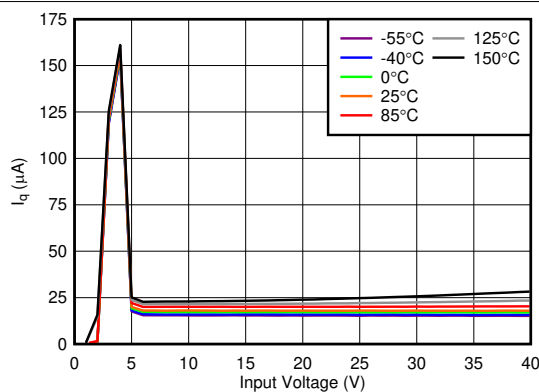
$V_{IN} = V_{OUT} + 1\text{ V}$, $V_{OUT} = 90\% \times V_{OUT(NOM)}$

FIG 6-21. Output Current Limit vs Temperature



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

FIG 6-22. Quiescent Current (I_Q) vs V_{IN}



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

FIG 6-23. Quiescent Current (I_Q) vs V_{IN}

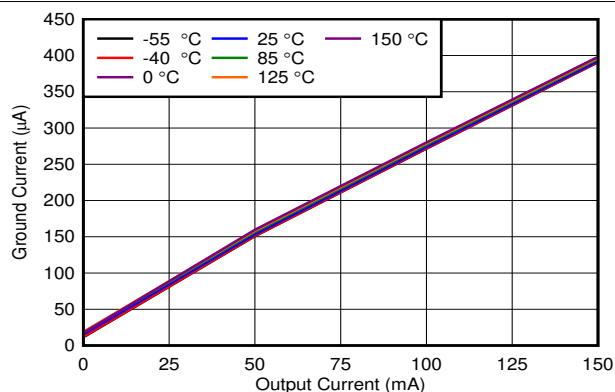


FIG 6-24. Ground Current (I_{GND}) vs I_{OUT}

6.6 Typical Characteristics (continued)

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

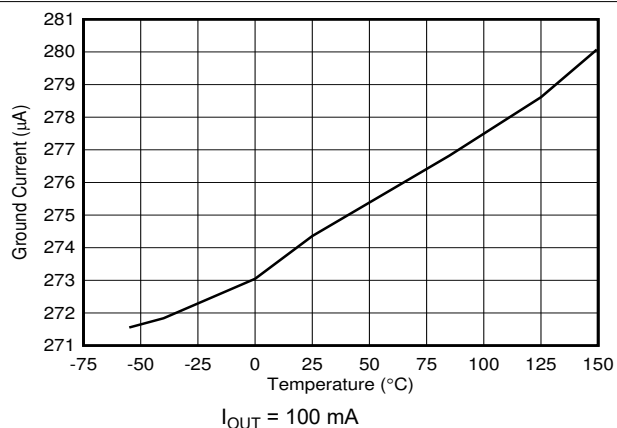


FIG 6-25. Ground Current

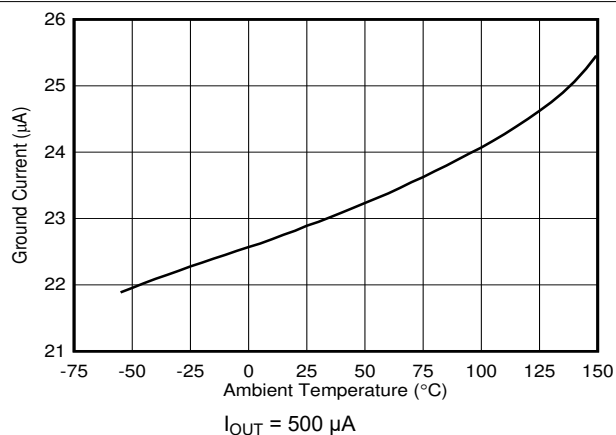


FIG 6-26. Ground Current

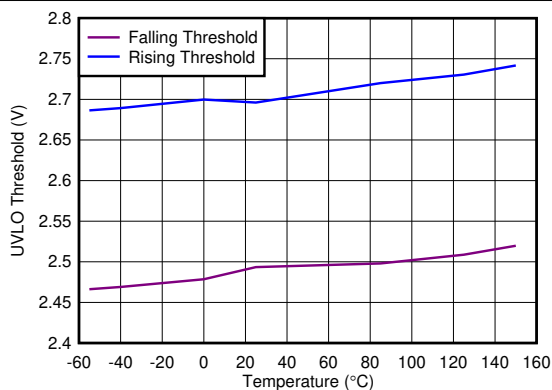


FIG 6-27. Undervoltage Lockout (UVLO) Threshold vs Temperature

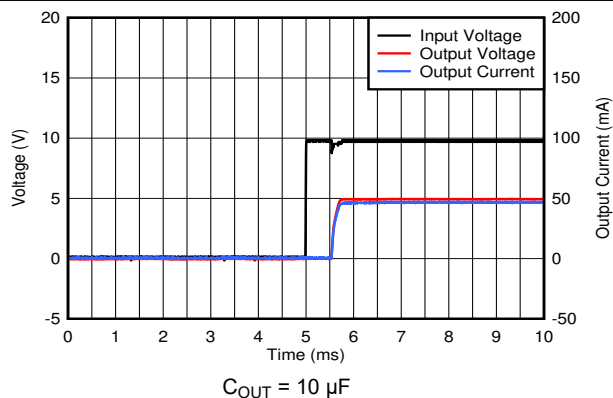


FIG 6-28. Startup Plot

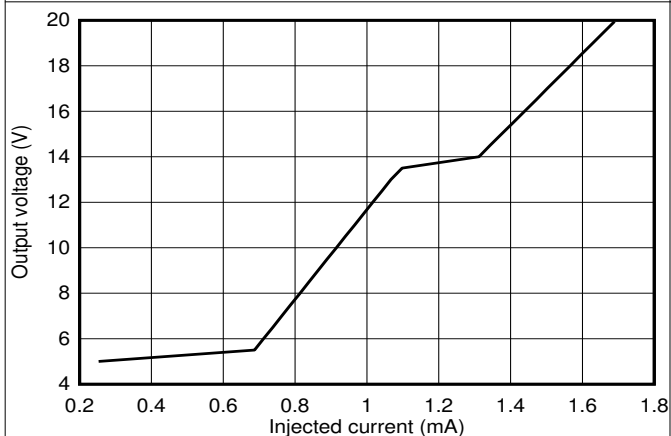


FIG 6-29. Output Voltage vs Injected Current

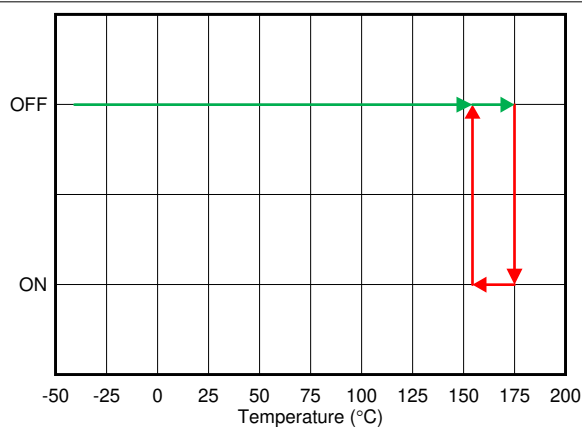


FIG 6-30. Thermal Shutdown

6.6 Typical Characteristics (continued)

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

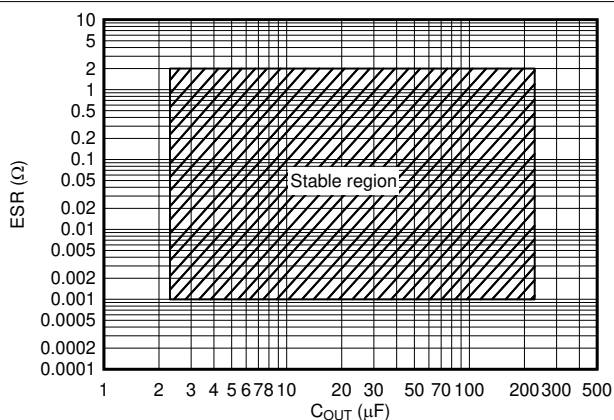


FIG 6-31. Stability ESR vs C_{OUT}

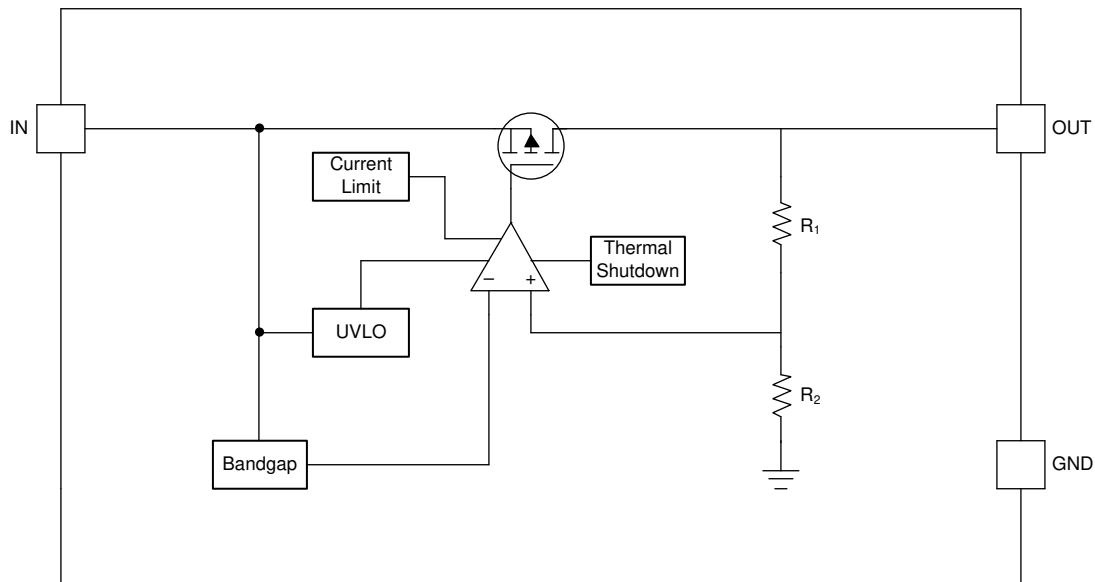
7 Detailed Description

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- μ 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](#).

Figure 7-1 shows a diagram of the current limit.

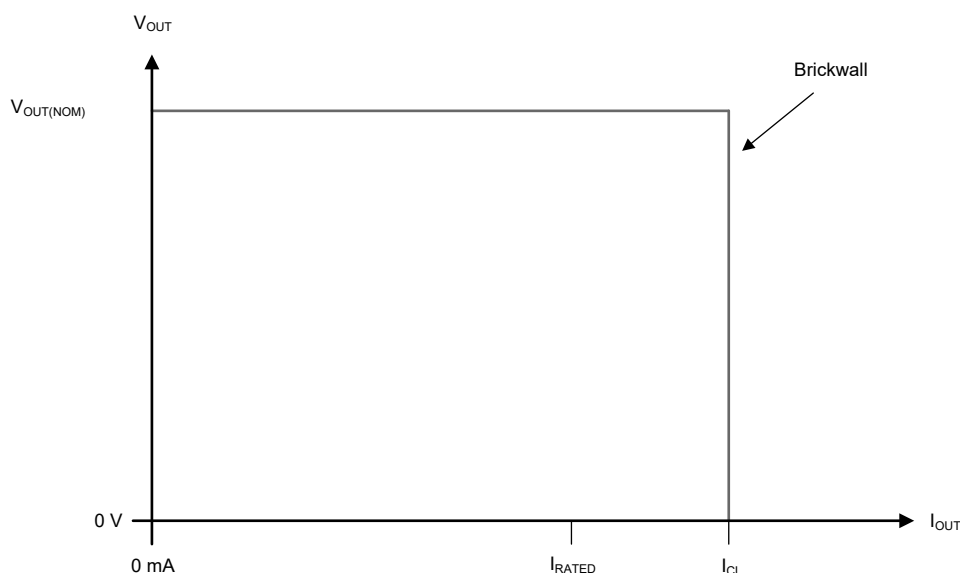


Figure 7-1. Current Limit

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

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくことになります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

8.1 Application Information

8.1.1 Input and Output Capacitor Selection

The TPS7B83-Q1 requires an output capacitor of 2.2 μF or larger (1 μF or larger capacitance) for stability and an equivalent series resistance (ESR) between 0.001 Ω and 2 Ω . 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 μF .

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 ($V_{\text{IN}} - V_{\text{OUT}}$) 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 ($R_{\text{DS(ON)}}$) 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_{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.

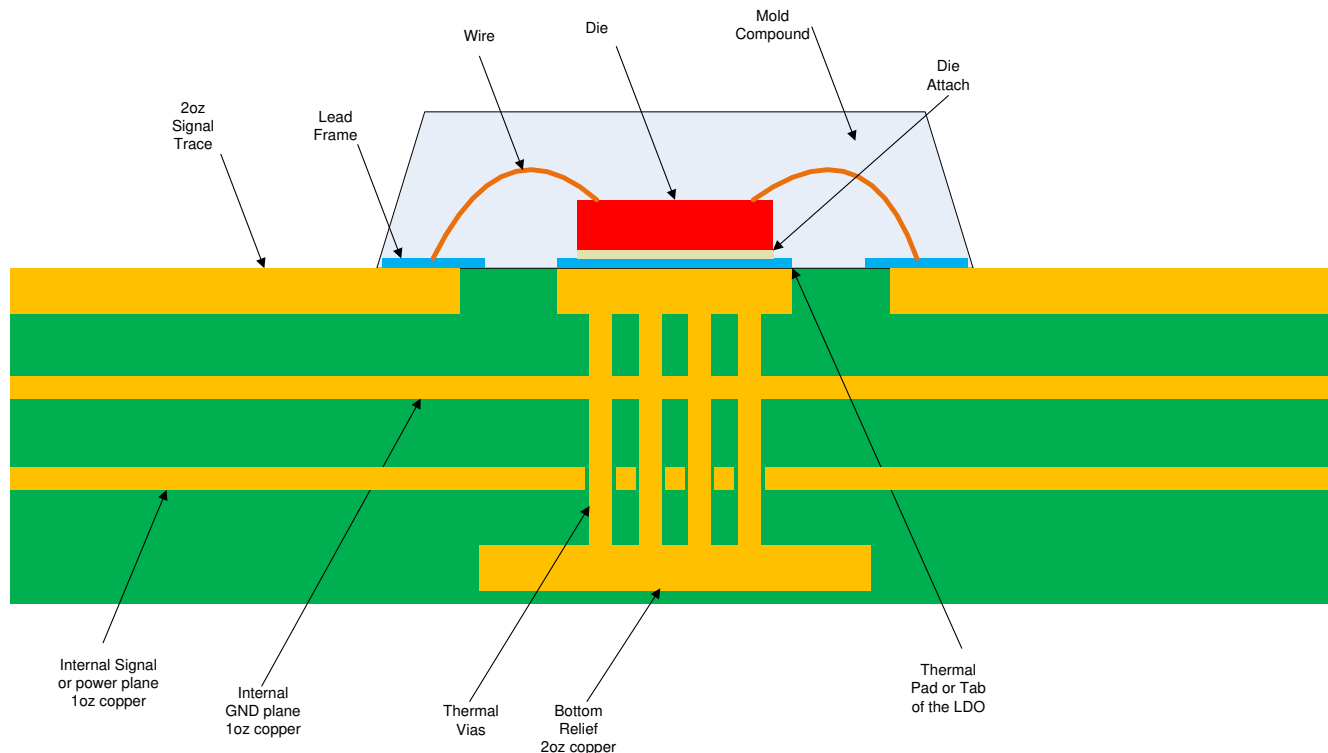
The maximum power dissipation determines the maximum allowable ambient temperature (T_A) for the device. According to the following equation, power dissipation and junction temperature are most often related by the junction-to-ambient thermal resistance ($R_{\theta JA}$) of the combined PCB and device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

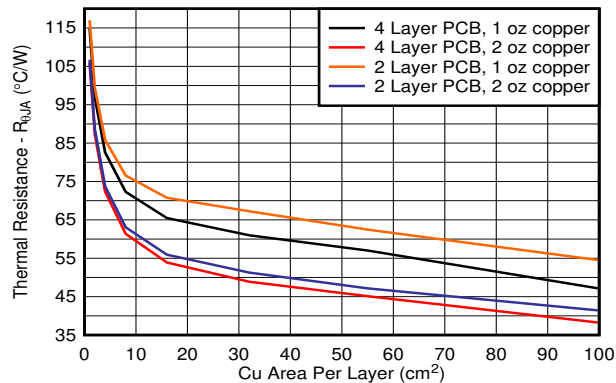
8.1.4.1 Thermal Performance Versus Copper Area

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.

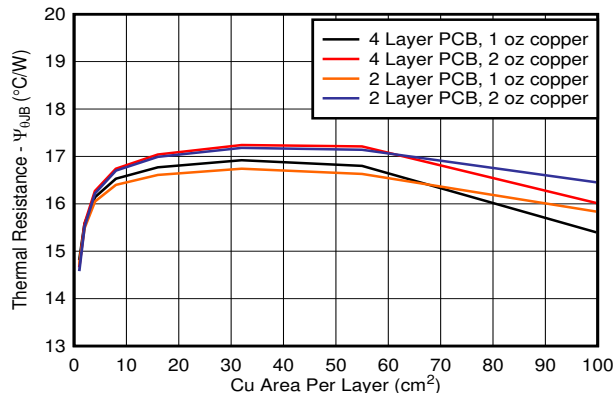


8-1. JEDEC Standard 2s2p PCB

8-2 and 8-3 depict the functions of $R_{\theta JA}$ and ψ_{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- μ m drill diameter and 25- μ 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.



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



8-3. ψ_{JB} vs Copper Area 2s2p DCY Package

8.1.5 Estimating Junction Temperature

The JEDEC standard now recommends the use of psi (Ψ) 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 (ψ_{JT}) and junction-to-board characterization parameter (ψ_{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 (ψ_{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 (ψ_{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

Figure 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.

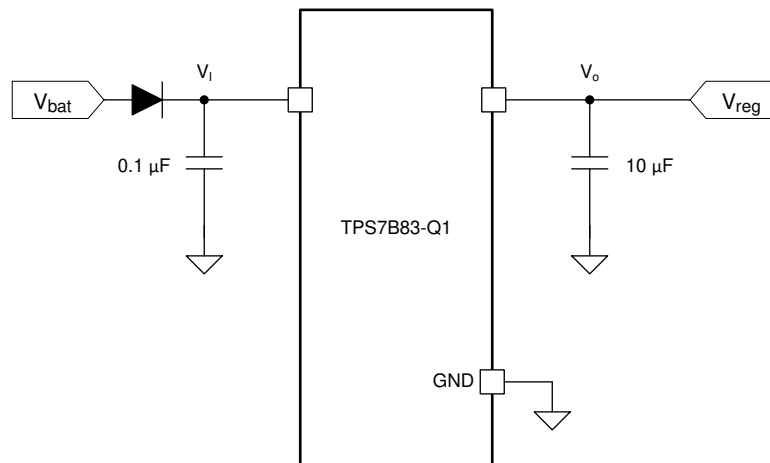


Figure 8-4. Typical Application Schematic for the TPS7B83-Q1

8.2.1 Design Requirements

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

Table 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 µF

8.2.2 Detailed Design Procedure

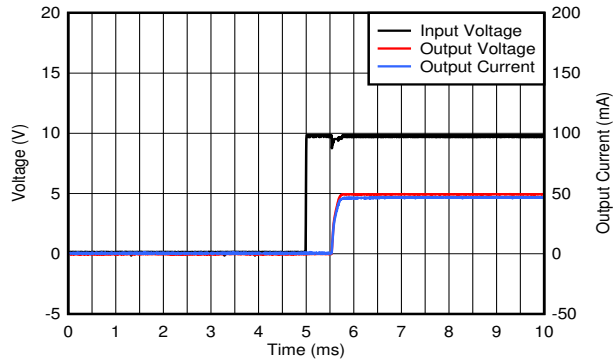
8.2.2.1 Input Capacitor

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 µF. The voltage rating must be greater than the maximum input voltage.

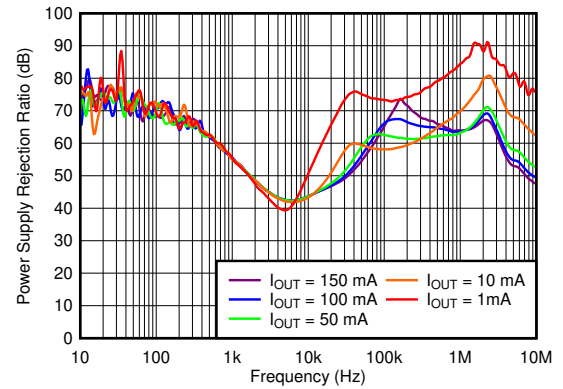
8.2.2.2 Output Capacitor

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

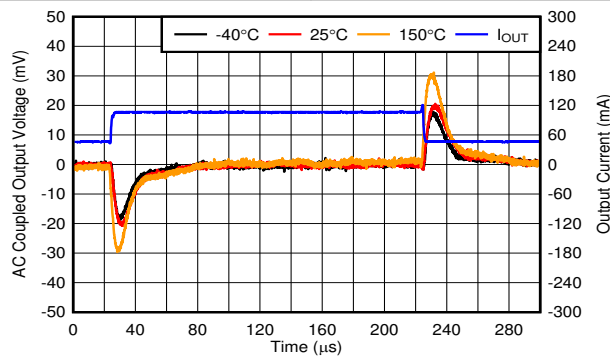
8.2.3 Application Curves



8-5. Power-Up Waveform



8-6. PSRR



8-7. Transient Response

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.

10.1.2 Board Layout Recommendations to Improve PSRR and Noise Performance

As depicted in  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.

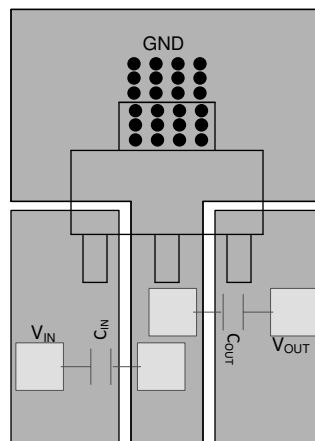
To improve ac performance such as PSRR, output noise, and transient response, TI recommends a board design with separate ground planes for IN and OUT, with each ground plane connected only at the GND pin of the device. In addition, the ground connection for the output capacitor must connect directly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

10.2 Layout Example



 **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⁽¹⁾

PRODUCT	V _{OUT}
TPS7B83xxQDCYRQ1	xx is the nominal output voltage (for example, 33 = 3.3 V V; 50 = 5.0 V). Q indicates that this device is a grade-1 device in accordance with the AEC-Q100 standard. Q1 indicates that this device is an automotive grade (AEC-Q100) device.

(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.

11.2 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、ti.com のデバイス製品フォルダを開いてください。「更新の通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

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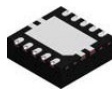
ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

11.6 用語集

TI 用語集 この用語集には、用語や略語の一覧および定義が記載されています。

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.

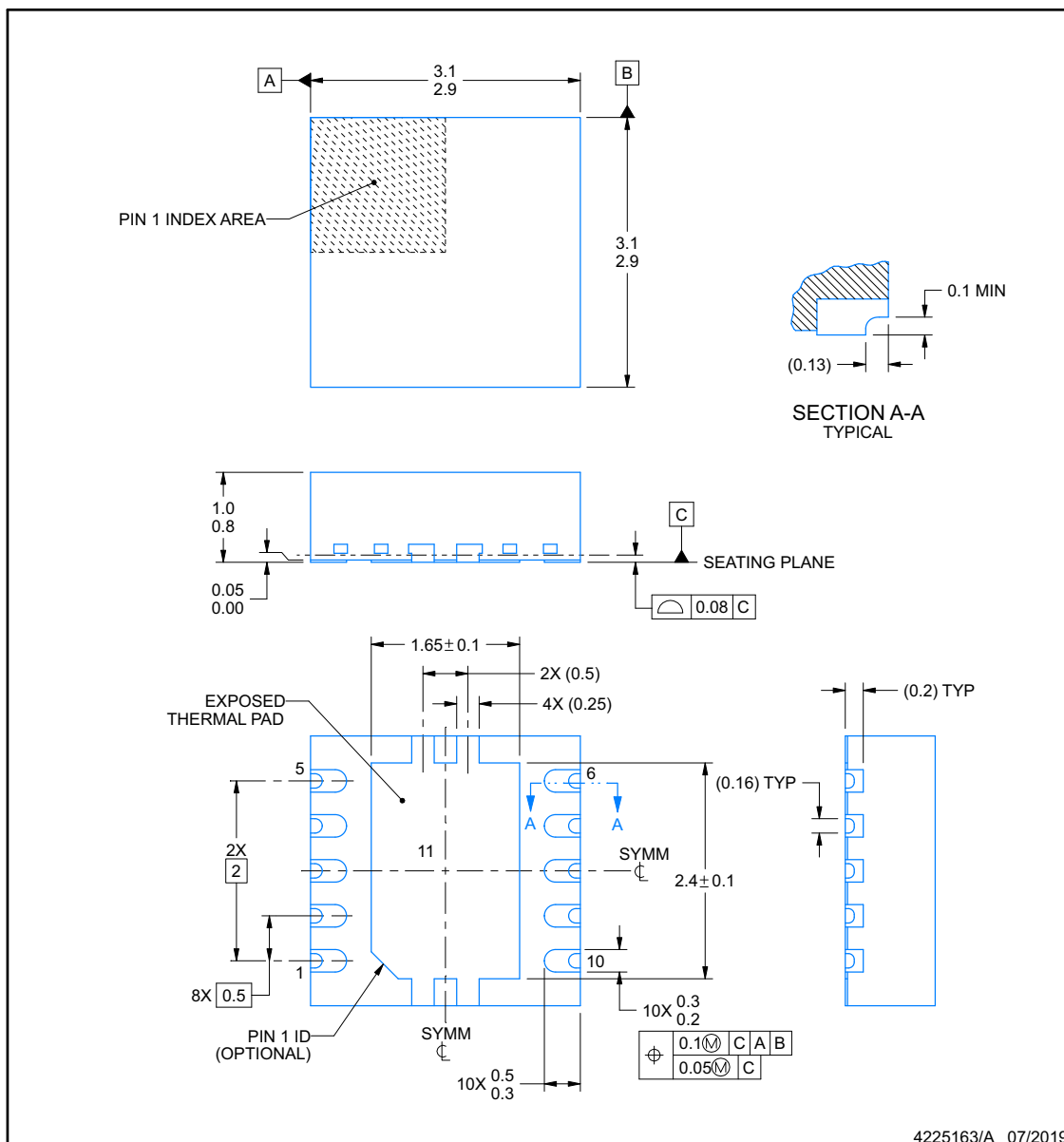


DRC0010U

PACKAGE OUTLINE

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

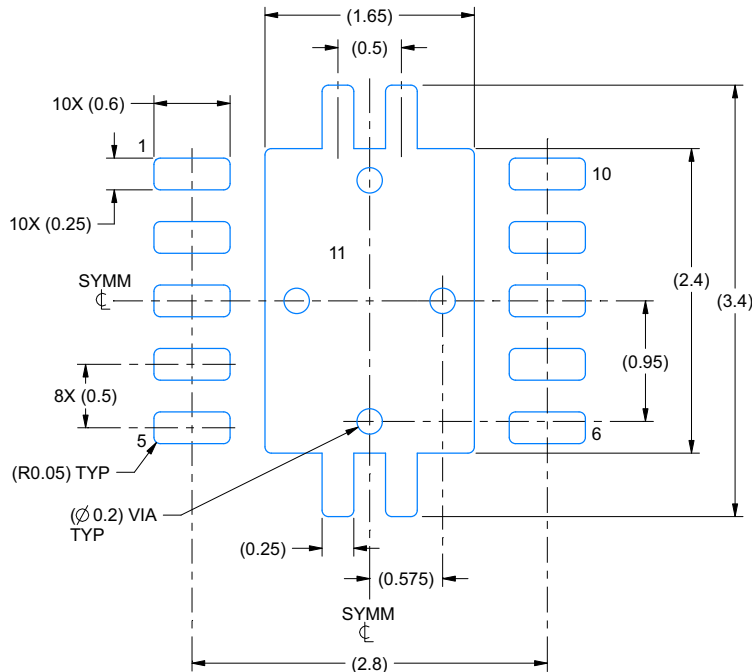


NOTES:

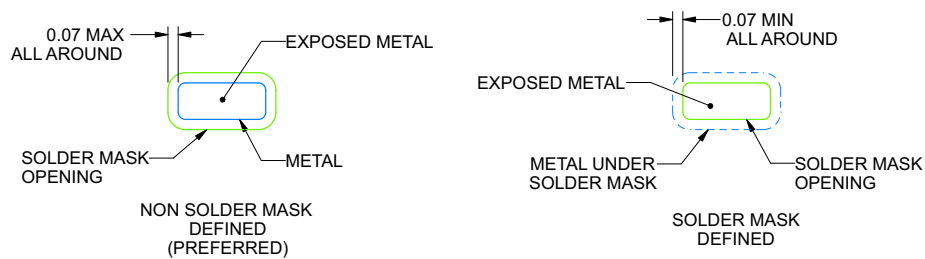
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

EXAMPLE BOARD LAYOUT**DRC0010U****VSON - 1 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

4225163/A 07/2019

NOTES: (continued)

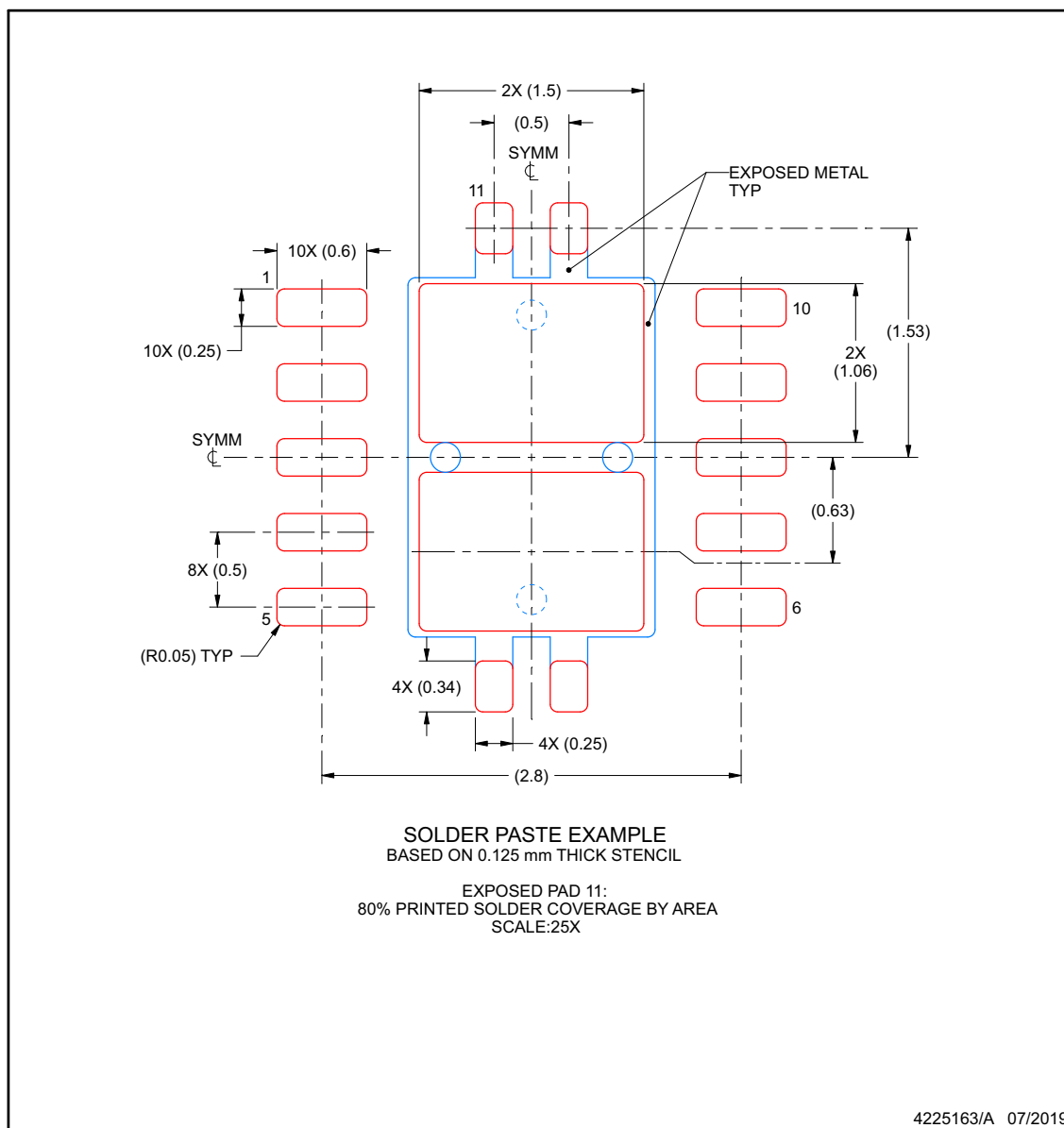
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown 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



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 part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS7B8333QDCYRQ1	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8333QDCYRQ1.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8333QDCYRQ1M3	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8333QDCYRQ1M3.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8333QDCYRQ1W	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8333QDCYRQ1W.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8333
TPS7B8350QDCYRQ1	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350
TPS7B8350QDCYRQ1.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350
TPS7B8350QDCYRQ1M3	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350
TPS7B8350QDCYRQ1M3.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350
TPS7B8350QDCYRQ1W	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350
TPS7B8350QDCYRQ1W.A	Active	Production	SOT-223 (DCY) 4	2500 LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	7B8350

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

⁽²⁾ **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.

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

⁽⁴⁾ **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.

⁽⁵⁾ **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.

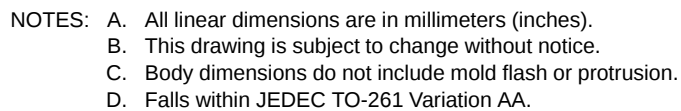
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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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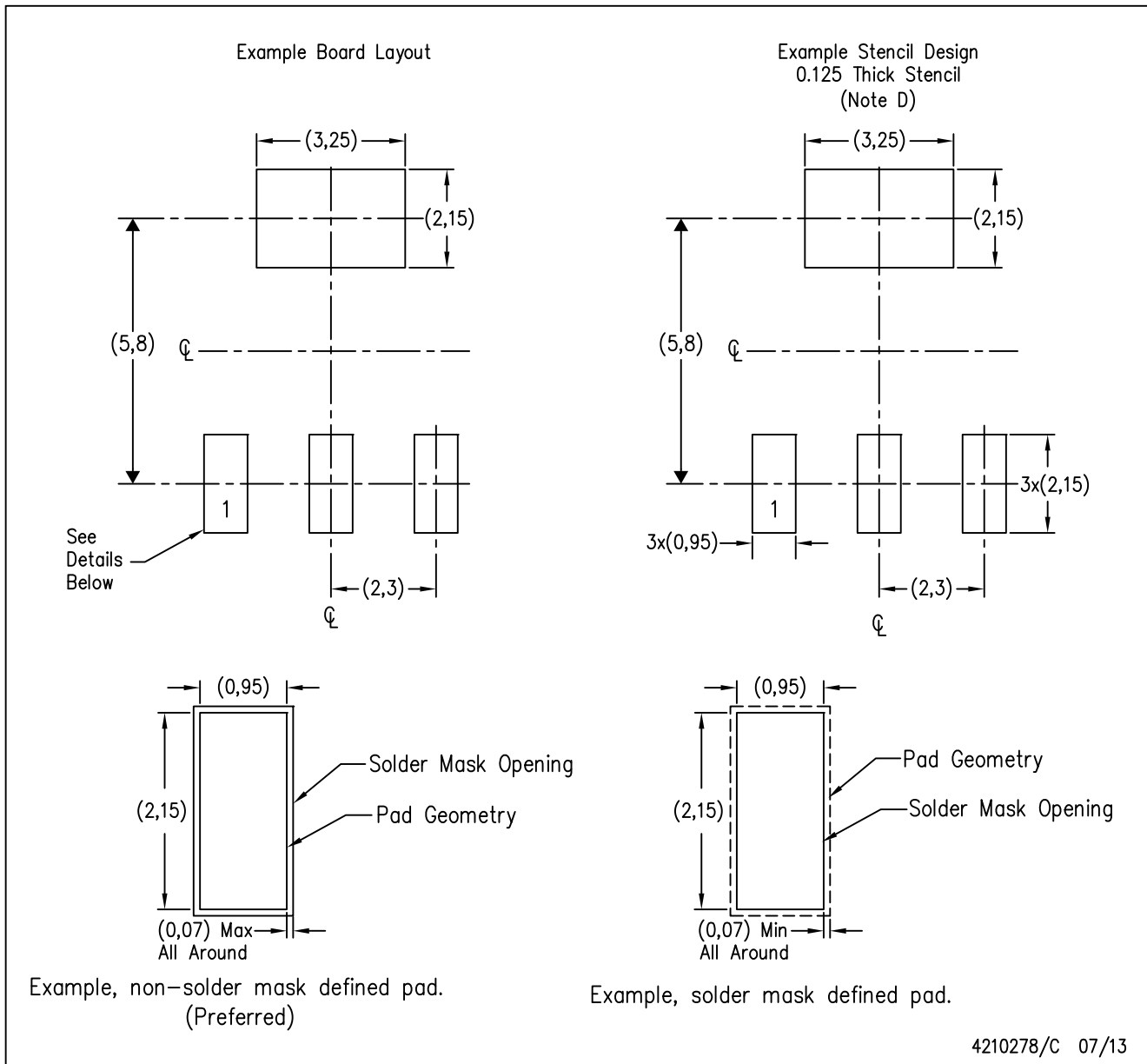
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

PLASTIC SMALL-OUTLINE



DCY (R-PDSO-G4)

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.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil recommendations. Refer to IPC 7525 for stencil design considerations.

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