

# TPS796 Ultra-Low-Noise, High PSRR, Fast, RF, 1A Low-Dropout Linear Regulator

## 1 Features

- 1A low-dropout regulator with enable
- Available in fixed and adjustable (1.2V to 5.5V)
- Low output noise:
  - 54 $\mu$ V<sub>RMS</sub> (legacy chip)
  - 78 $\mu$ V<sub>RMS</sub> (new chip)
- Stable with a 1 $\mu$ F ceramic capacitor
- Excellent load and line transient response
- Very low dropout voltage: 220mV (typ) at 1A
- Packages:
  - 3mm × 3mm VSON (DRB)
  - SOT223-6 (DCQ)
  - TO-263 (KTT)

## 2 Applications

- [TV applications](#)
- [Building automation](#)
- [Connected peripherals and printers](#)
- [Home theater and entertainment applications](#)

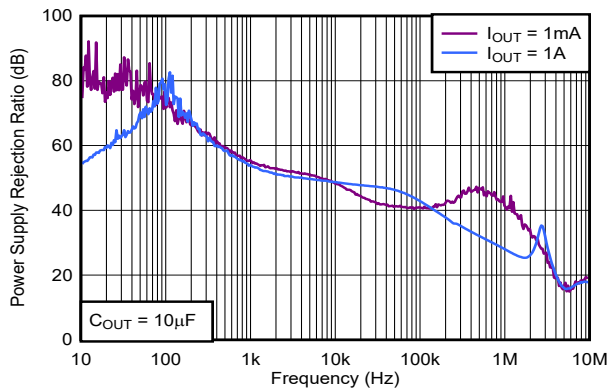
## 3 Description

The TPS796 low-dropout (LDO) low-power linear voltage regulator features high power-supply rejection ratio (PSRR), low-noise, fast start-up, and excellent line and load transient responses in small outline, 3mm × 3mm VSON, SOT223-6, and TO-263 packages. This device is stable with a small, 1 $\mu$ F ceramic capacitor on the output. The TPS796 offers low dropout voltages (for example, 220mV at 1A). Applications with analog components that are noise sensitive (such as portable RF electronics) benefit from the high-PSRR, low-noise features, and need fast response time.

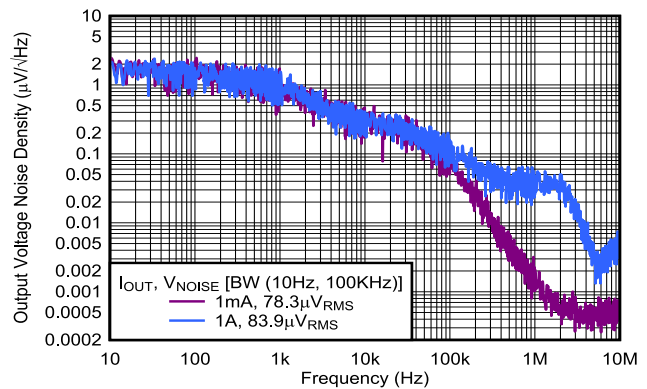
### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
TPS796	DRB (VSON, 8)	3mm × 3mm
	DCQ (SOT-223, 6)	6.5mm × 7.06mm
	KTT (TO-263, 5)	10.16mm × 15.24mm

- (1) For more information, see the [Mechanical, Packaging, and Orderable Information](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Ripple Rejection vs Frequency



Output Spectral Noise Density vs Frequency



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## 4 Pin Configuration and Functions

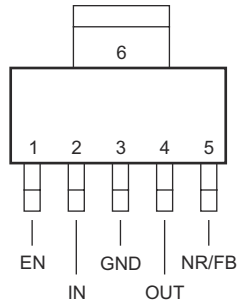


Figure 4-1. DCQ Package, 6-Pin SOT-223 (Top View, Legacy Chip)

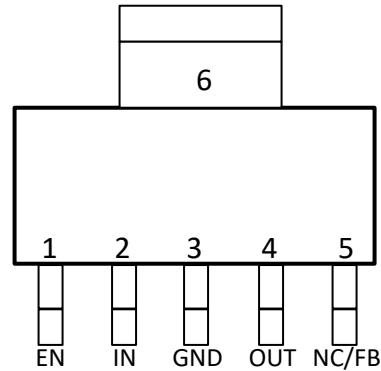


Figure 4-2. DCQ Package, 6-Pin SOT-223 (Top View, New Chip)

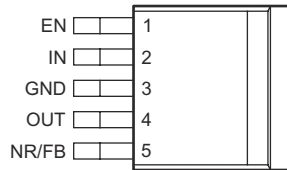


Figure 4-3. KTT Package, 5-Pin TO-263 (Top View, Legacy Chip)

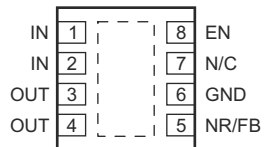


Figure 4-4. DRB Package, 8-Pin VSON (Top View, Legacy Chip)

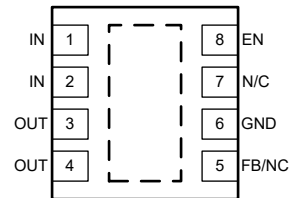


Figure 4-5. DRB Package, 8-Pin VSON (Top View, New Chip)

Table 4-1. Pin Functions

NAME	PIN		TYPE	DESCRIPTION
	SOT-223 TO-263	VSON		
EN	1	8	I	Enable pin. Driving the enable pin (EN) high turns on the regulator. Driving this pin low puts the regulator into shutdown mode. EN can be connected to IN if not used.
FB	5	5	I	Feedback pin. This terminal is the feedback input voltage for the adjustable device.
GND	3, Tab	6, PowerPAD	—	Regulator ground
IN	2	1, 2	I	Input to the device.
N/C	5	7	—	Not internally connected. This pin must either be left open, or tied to GND.
NR	5	5	—	Noise-reduction pin (legacy chip). Connecting an external capacitor to this pin bypasses noise generated by the internal band gap. This bypass improves power-supply rejection and reduces output noise. For a lower noise performance device, consider the <a href="#">TPS7A91</a> .
OUT	4	3, 4	O	Output of the regulator.

## 5 Specifications

### 5.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	Supply, V <sub>IN</sub> (New chip)	-0.3	6.5	V
	Supply, V <sub>IN</sub> (Legacy chip)	-0.3	6	
	Enable, V <sub>EN</sub>	-0.3	V <sub>IN</sub> + 0.3	
	Output, V <sub>OUT</sub>	-0.3	6	
Current	Output, I <sub>OUT</sub>	Internally limited		
Temperature	Operating junction, T <sub>J</sub>	-40	150	°C
	Storage, T <sub>stg</sub>	-65	150	

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime

### 5.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	±2000	V
V <sub>(ESD)</sub>	Electrostatic discharge	Charged device model (CDM), per JEDEC specification JESD22-C101, V all pins <sup>(2)</sup>	±500	V

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 5.3 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
V <sub>IN</sub>	Input supply voltage (legacy chip)		2.7		5.5	V
	Input supply voltage (new chip)		2.7		6.0	
C <sub>IN</sub>	Input capacitor		2.2			μF
C <sub>OUT</sub>	Output capacitor		1 <sup>(1)</sup>		200	
C <sub>FF</sub>	Feed-forward capacitor (new chip)		0	10	100	nF
I <sub>OUT</sub>	Output current		0		1	A
V <sub>EN</sub>	Enable voltage (legacy chip)		0		5.5	V
	Enable voltage (new chip)		0		6.0	
F <sub>EN</sub>	Enable toggle frequency (new chip)				10	kHz
T <sub>J</sub>	Junction Temperature		-40		125	°C

(1) The minimum effective capacitance is 0.47 μF.

### 5.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TPS796				UNIT
		DRB (VSON)	DCQ (SOT223-6)		KTT (TO-263)	
			8 PINS <sup>(2)</sup>	6 PINS <sup>(2)</sup>	6 PINS <sup>(3)</sup>	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	47.8	70.4	71.1	25	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	83	70	41.6	35	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	N/A	N/A	8.8	N/A	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	2.1	6.8	3.5	1.5	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	17.8	30.1	8.5	8.52	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	12.1	6.3	6	0.4	°C/W

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

(2) Legacy chip.

(3) New chip.

## 5.5 Electrical Characteristics

at operating temperature range ( $T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ),  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}$  <sup>(1)</sup>,  $I_{OUT} = 1\text{ mA}$ , and  $C_{OUT} = 10\mu\text{F}$  and  $C_{NR} = 0.01\mu\text{F}$  (Legacy Chip only), unless otherwise noted. All typical values at  $T_J = 25^\circ\text{C}$ .

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{IN}$	Input Voltage	Legacy chip		2.7		5.5	V
		New chip		2.7		6.0	
$V_{FB}$	Internal reference (TPS79601)			1.2	1.225	1.25	V
$I_{OUT}$	Continuous output current			0		1	A
$V_{OUT}$	Output voltage range (TPS79601)			1.225		5.5- $V_{DO}$	V
$V_{OUT}$	Output accuracy	TPS79601	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$ , $V_{OUT(nom)} + 1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ <sup>(1)</sup>	0.98 $V_{OUT(nom)}$		1.02 $V_{OUT(nom)}$	%
$V_{OUT}$	Output accuracy	Fixed $V_{OUT} < 5\text{ V}$	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$ , $V_{OUT(nom)} + 1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ <sup>(1)</sup>	-2.0		2.0	%
$V_{OUT}$	Output accuracy	Fixed $V_{OUT} = 5\text{ V}$	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$ , $V_{OUT(nom)} + 1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ <sup>(1)</sup>	-3.0		3.0	%
$\Delta V_{OUT}/\Delta V_{IN}$	Line regulation	$V_{OUT} + 1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$			0.05	0.12	%/V
$\Delta V_{OUT}/\Delta I_{OUT}$	Load regulation	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$			5		mV
$V_{DO}$	Dropout voltage TPS79628	$V_{IN} = V_{OUT} - 0.1\text{ V}$	$I_{OUT} = 1\text{ A}$		270	365	mV
	Dropout voltage TPS79628DRB		$I_{OUT} = 250\text{ mA}$		52	90	
	Dropout voltage TPS79630		$I_{OUT} = 1\text{ A}$		250	345	
	Dropout voltage TPS79633		$I_{OUT} = 1\text{ A}$		220	325	
	Dropout voltage TPS79650		$I_{OUT} = 1\text{ A}$		220	300	
$I_{CL}$	Output current limit	$V_{OUT} = 0$ (legacy chip)		2.4		4.2	A
$I_{CL}$	Output current limit	$V_{IN} = V_{OUT(nom)} + 1.25\text{ V}$ or $2.0\text{ V}$ (whichever is greater), $V_{OUT} = 0.9 \times V_{OUT(nom)}$ (new chip only) <sup>(2)</sup>		1.04		1.65	A
$I_{SC}$	Short-circuit current limit	$V_{OUT} = 0$ (new chip only)			550		mA
$I_{GND}$	Ground current	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$ (legacy chip)			265	385	$\mu\text{A}$
$I_{GND}$	Ground current	$0\mu\text{A} \leq I_{OUT} \leq 1\text{ A}$ (new chip)			700	1100	$\mu\text{A}$
$I_{SHDN}$	Shutdown current	$V_{EN} = 0\text{ V}$ , $2.7\text{ V} \leq V_{IN} \leq 5.5\text{ V}$			0.07	1	$\mu\text{A}$
$I_{FB}$	Feedback pin current	$V_{FB} = 1.225\text{ V}$				1	$\mu\text{A}$
PSRR	Power-supply rejection ratio	$f = 100\text{ Hz}$ , $I_{OUT} = 10\text{ mA}$ (legacy chip)			59		dB
		$f = 100\text{ Hz}$ , $I_{OUT} = 10\text{ mA}$ (new chip)			64		
		$f = 100\text{ Hz}$ , $I_{OUT} = 1\text{ A}$ (legacy chip)			54		
		$f = 100\text{ Hz}$ , $I_{OUT} = 1\text{ A}$ (new chip)			74		
		$f = 10\text{ kHz}$ , $I_{OUT} = 1\text{ A}$ (legacy chip)			53		
		$f = 10\text{ kHz}$ , $I_{OUT} = 1\text{ A}$ (new chip)			49		
		$f = 100\text{ kHz}$ , $I_{OUT} = 1\text{ A}$ (legacy chip)			42		
		$f = 100\text{ kHz}$ , $I_{OUT} = 1\text{ A}$ (new chip)			42		
$V_n$	Output noise voltage	$BW = 100\text{ Hz to } 100\text{ kHz}$ , $I_{OUT} = 1\text{ A}$	$C_{NR} = 0.001\mu\text{F}$		54		$\mu\text{V}_{RMS}$
			$C_{NR} = 0.0047\mu\text{F}$		46		
			$C_{NR} = 0.01\mu\text{F}$		41		
			$C_{NR} = 0.1\mu\text{F}$		40		
		$BW = 10\text{ Hz to } 100\text{ kHz}$ , $I_{OUT} = 1\text{ A}$	new chip (10		78		$\mu\text{V}_{RMS}$
$t_{str}$	Time, start-up	$R_L = 3\Omega$ , $C_{OUT} = 1\mu\text{F}$	$C_{NR} = 0.001\mu\text{F}$		50		$\mu\text{s}$
		$R_L = 3\Omega$ , $C_{OUT} = 1\mu\text{F}$	$C_{NR} = 0.0047\mu\text{F}$		75		
		$R_L = 3\Omega$ , $C_{OUT} = 1\mu\text{F}$	$C_{NR} = 0.01\mu\text{F}$		110		
$t_{str}$	Time, start-up	$R_L = 3\Omega$ , $C_{OUT} = 1\mu\text{F}$	new chip		550		$\mu\text{s}$
$I_{EN}$	Enable pin current	$V_{EN} = 0\text{ V}$		-1		1	$\mu\text{A}$

## 5.5 Electrical Characteristics (continued)

at operating temperature range ( $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1\text{ V}$  <sup>(1)</sup>,  $I_{OUT} = 1\text{ mA}$ , and  $C_{OUT} = 10\mu\text{F}$  and  $C_{NR} = 0.01\mu\text{F}$ (Legacy Chip only), unless otherwise noted. All typical values at  $T_J = 25^{\circ}\text{C}$ .

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$R_{PULLDOWN}$	Pulldown resistance	$V_{IN} = 3.3\text{V}$ (new chip only)		100			$\Omega$
$V_{UVLO}$	UVLO threshold	$V_{IN}$ rising (legacy chip)		2.25		2.65	V
		$V_{IN}$ rising (new chip)		1.28		1.62	
$V_{UVLO(HYST)}$	UVLO hysteresis	$V_{IN}$ hysteresis (legacy chip)		100			mV
		$V_{IN}$ hysteresis (new Chip)		130			
$V_{EN(HI)}$	High-level enable input voltage	$2.7\text{V}^{(1)} \leq V_{IN} \leq 5.5\text{V}$ (legacy chip)		1.7		$V_{IN}$	V
		$2.7\text{V}^{(1)} \leq V_{IN} \leq 5.5\text{V}$ (new chip)		0.85		$V_{IN}$	
$V_{EN(LOW)}$	Low-level enable input voltage	$2.7\text{V}^{(1)} \leq V_{IN} \leq 5.5\text{V}$ (legacy chip)				0.7	
		$2.7\text{V}^{(1)} \leq V_{IN} \leq 5.5\text{V}$ (new chip)				0.425	
$T_{SD}$	Thermal shutdown temperature	Shutdown, temperature increasing	legacy chip	165			$^{\circ}\text{C}$
$T_{SD}$	Thermal shutdown temperature	Shutdown, temperature increasing	new chip	170			$^{\circ}\text{C}$
$T_{SD}$	Thermal shutdown temperature	Reset, temperature decreasing	legacy chip	140			$^{\circ}\text{C}$
$T_{SD}$	Thermal shutdown temperature	Reset, temperature decreasing	new chip	155			$^{\circ}\text{C}$

- (1) Minimum  $V_{IN} = V_{OUT} + 1\text{V}$  or  $2.7\text{V}$ , whichever is greater.  $V_{OUT(NOM)} = 5\text{V}$  is tested at  $V_{IN(NOM)} = 5.5\text{ V}$   
(2)  $V_{OUT(NOM)} = 5\text{V}$  is tested at  $V_{IN(NOM)} = V_{OUT(NOM)} + 1\text{V}$

### 5.6 Typical Characteristics

at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)

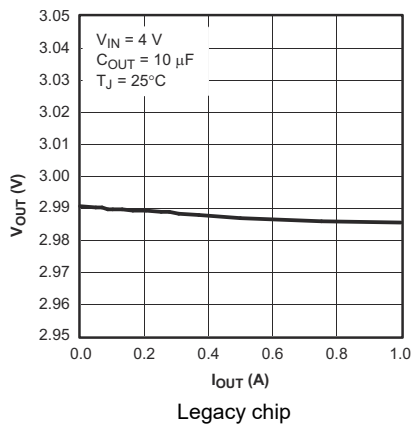


Figure 5-1. TPS79630 Output Voltage vs Output Current

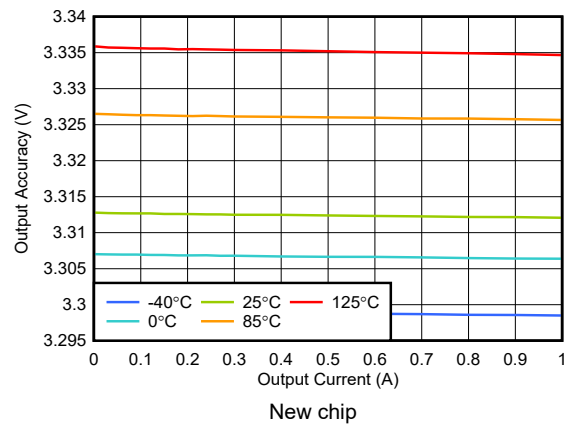


Figure 5-2. TPS79633 Output Voltage vs Output Current

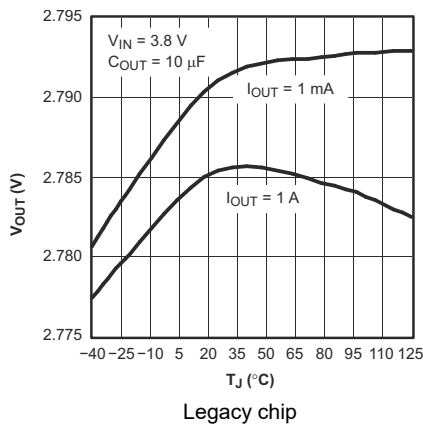


Figure 5-3. TPS79628 Output Voltage vs Junction Temperature

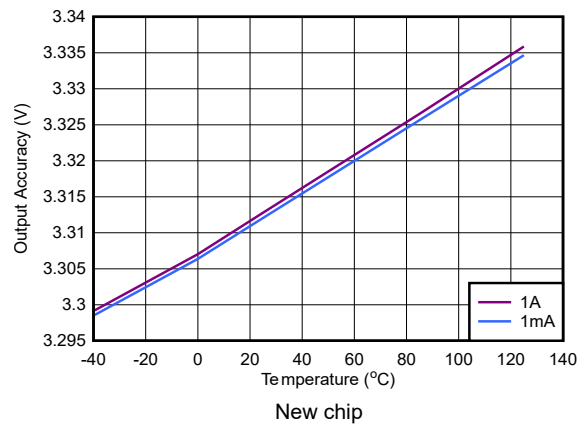


Figure 5-4. TPS79633 Output Voltage vs Junction Temperature

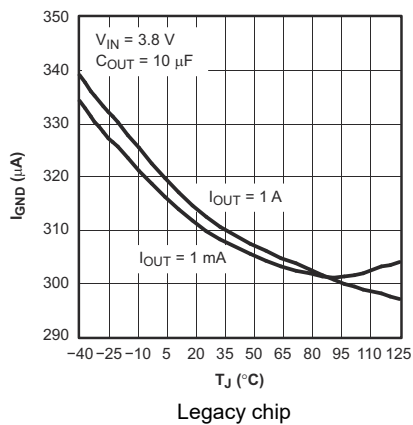


Figure 5-5. TPS79628 Ground Current vs Junction Temperature

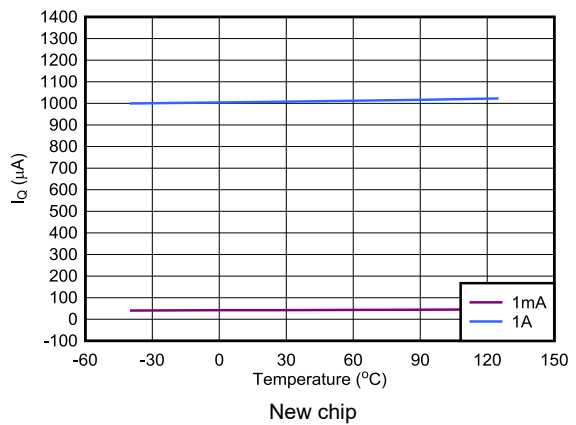


Figure 5-6. TPS79633 Ground Current vs Junction Temperature

### 5.6 Typical Characteristics (continued)

at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)

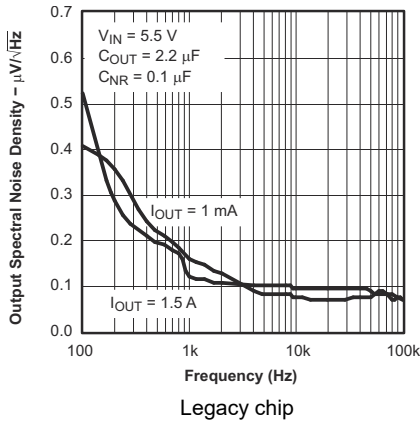


Figure 5-7. TPS79630 Output Spectral Noise Density vs Frequency

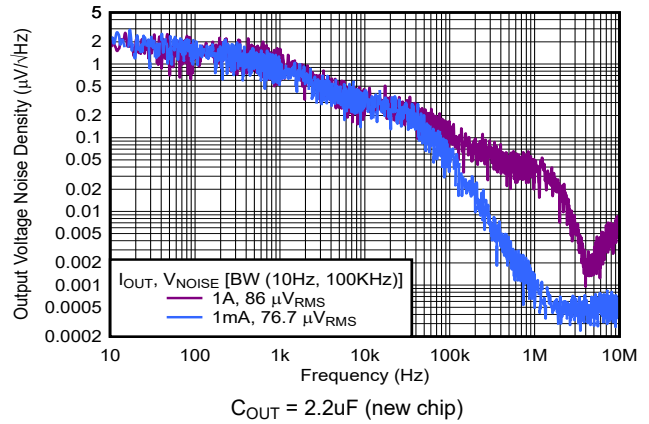


Figure 5-8. TPS79633 Output Spectral Noise Density vs Frequency

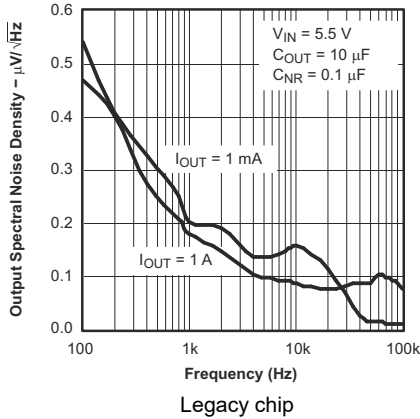


Figure 5-9. TPS79630 Output Spectral Noise Density vs Frequency

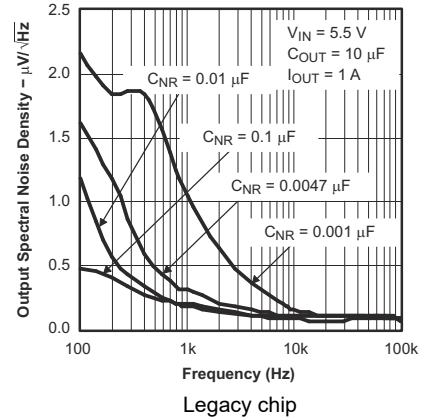


Figure 5-10. TPS79630 Output Spectral Noise Density vs Frequency

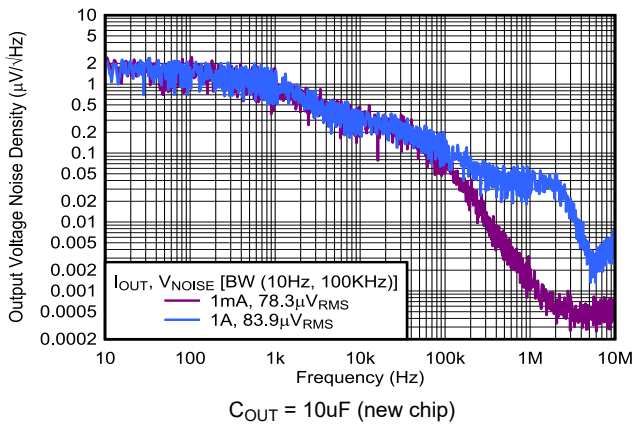


Figure 5-11. TPS79633 Output Spectral Noise Density vs Frequency

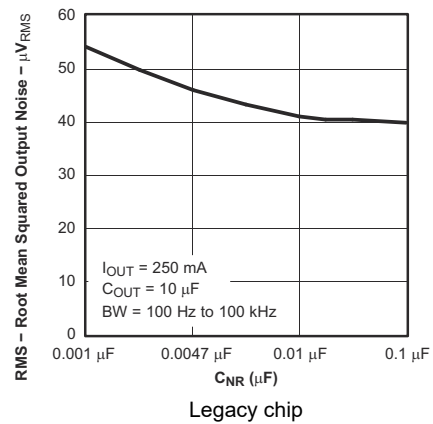
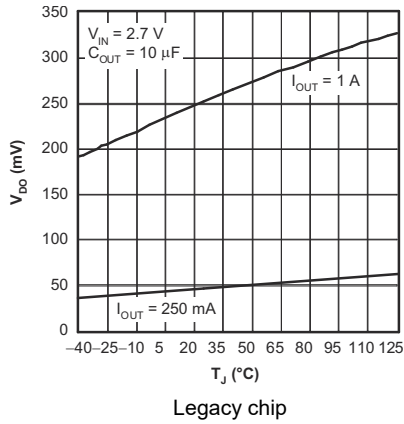


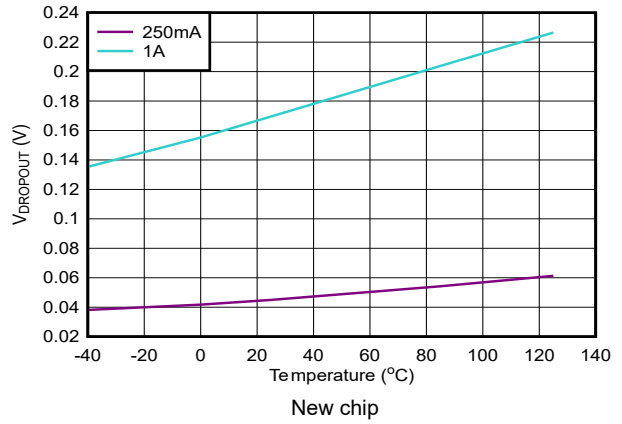
Figure 5-12. TPS79630 Root Mean Squared Output Noise vs Bypass Capacitance

### 5.6 Typical Characteristics (continued)

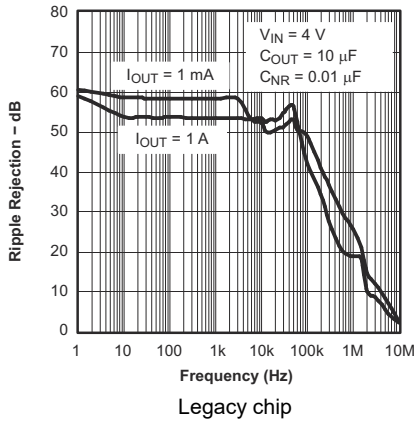
at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)



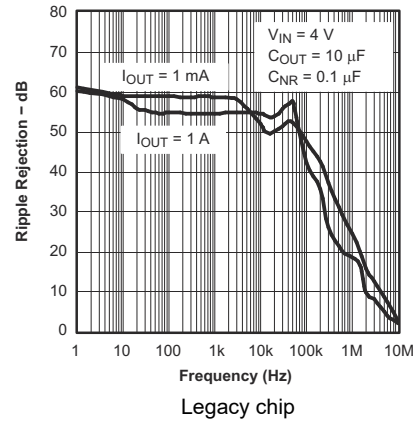
**Figure 5-13. TPS79628 Dropout Voltage vs Junction Temperature**



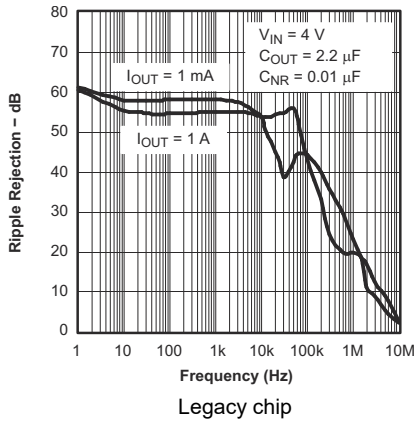
**Figure 5-14. TPS79633 Dropout Voltage vs Junction Temperature**



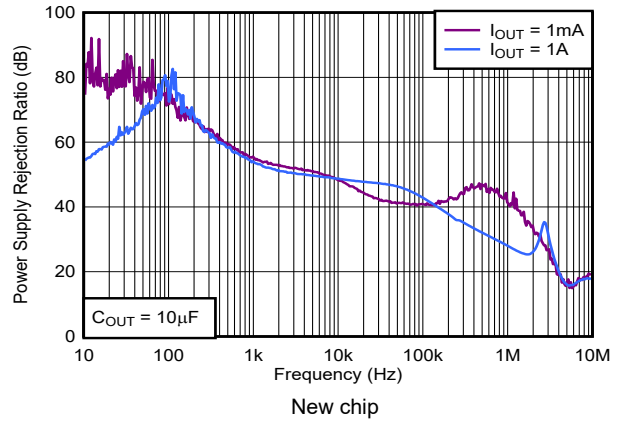
**Figure 5-15. TPS79630 Ripple Rejection vs Frequency**



**Figure 5-16. TPS79630 Ripple Rejection vs Frequency**



**Figure 5-17. TPS79630 Ripple Rejection vs Frequency**



**Figure 5-18. TPS79633 Ripple Rejection vs Frequency**

### 5.6 Typical Characteristics (continued)

at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)

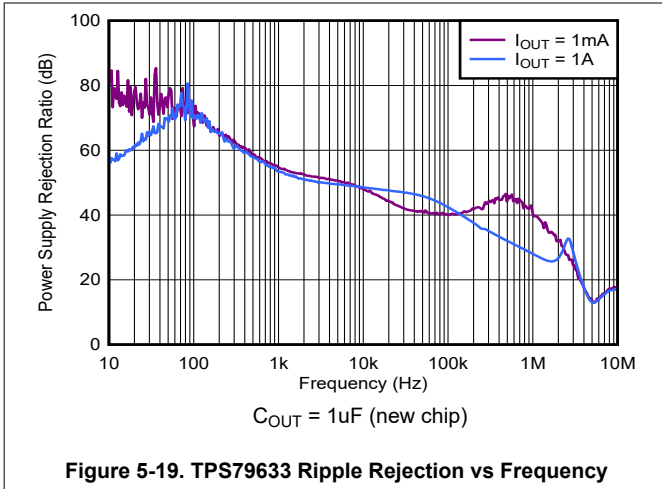


Figure 5-19. TPS79633 Ripple Rejection vs Frequency

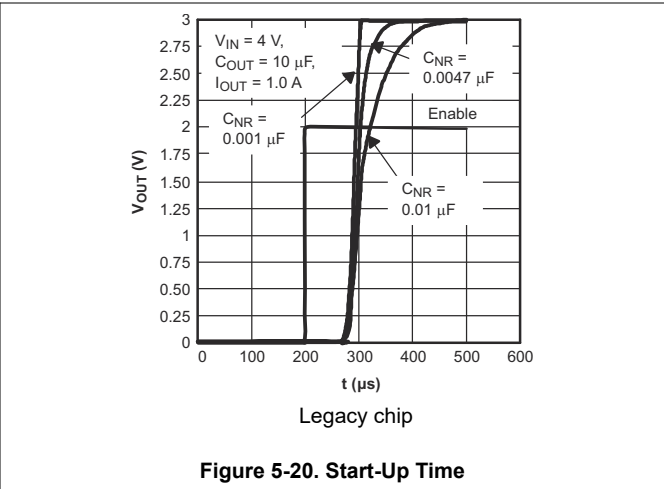


Figure 5-20. Start-Up Time

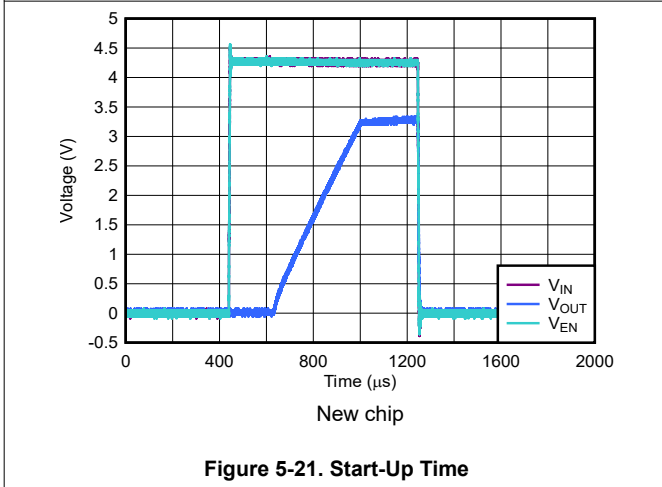


Figure 5-21. Start-Up Time

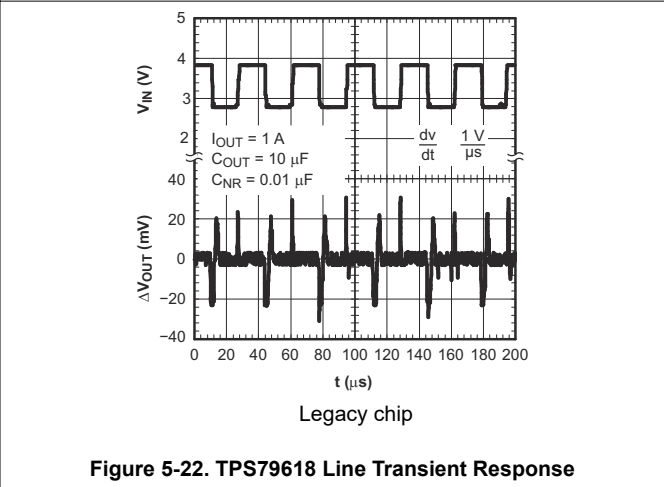


Figure 5-22. TPS79618 Line Transient Response

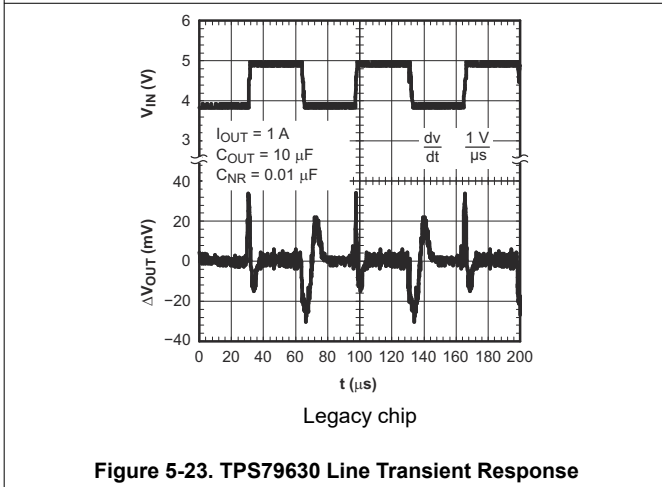


Figure 5-23. TPS79630 Line Transient Response

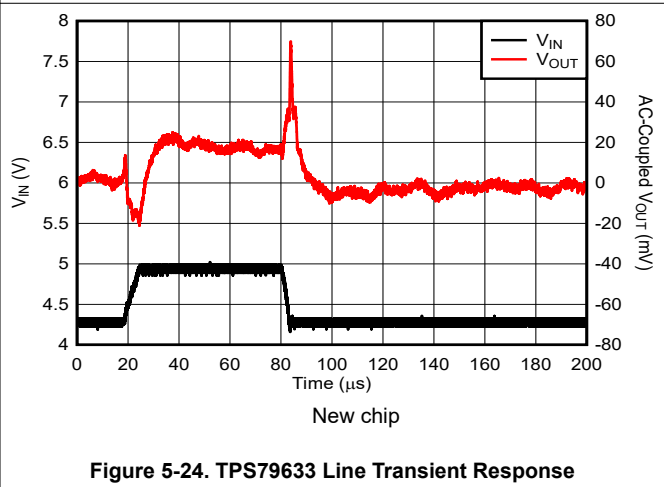


Figure 5-24. TPS79633 Line Transient Response

### 5.6 Typical Characteristics (continued)

at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)

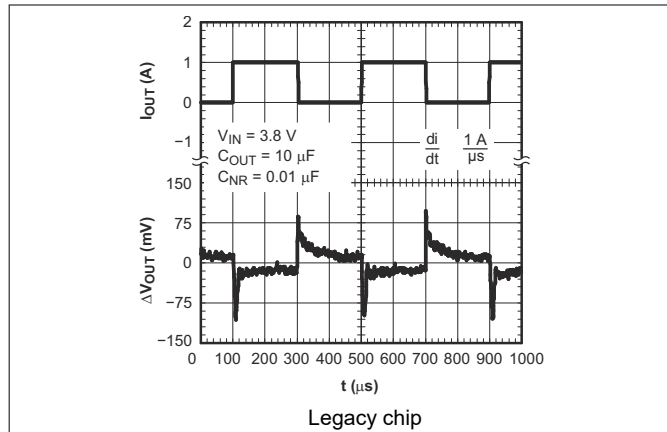


Figure 5-25. TPS79628 Load Transient Response

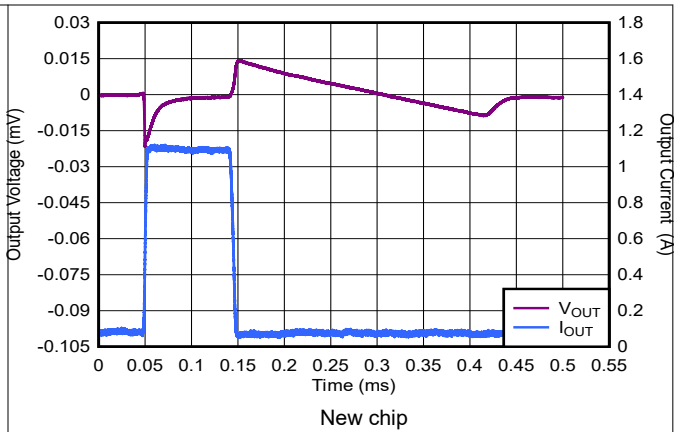


Figure 5-26. TPS79633 Load Transient Response

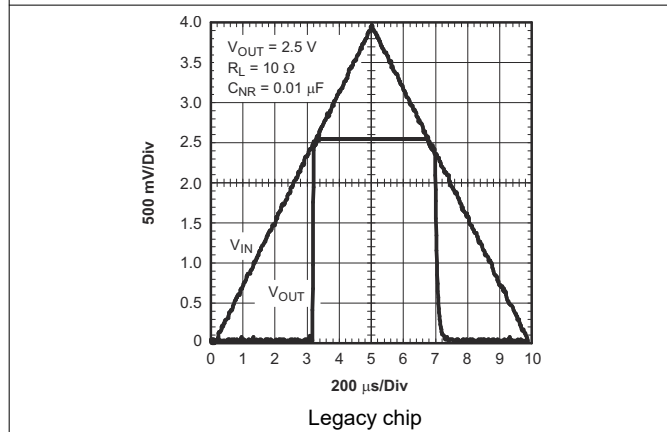


Figure 5-27. TPS79625 Power-Up, Power-Down

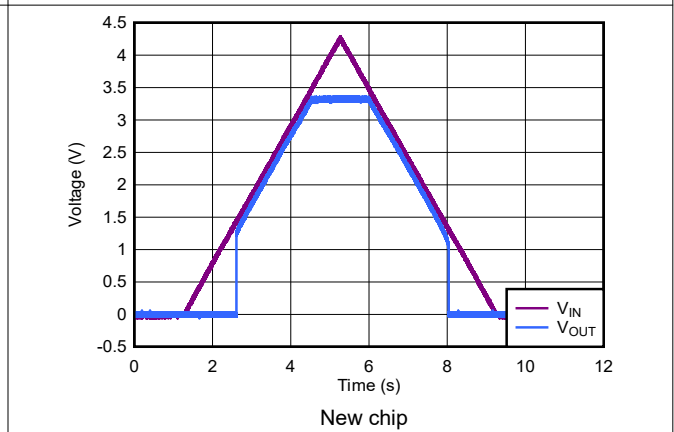


Figure 5-28. TPS79633 Power-Up, Power-Down

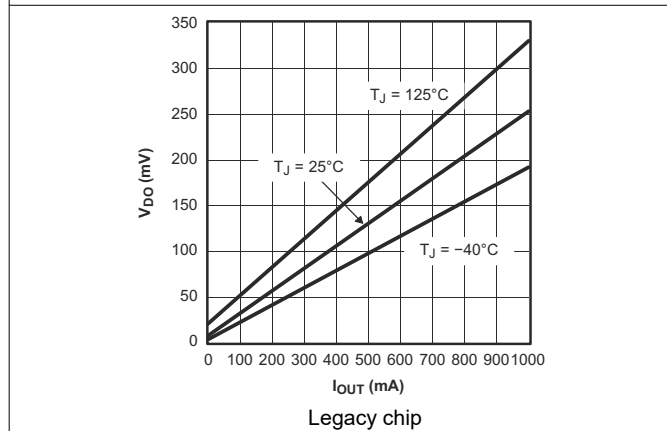


Figure 5-29. TPS79630 Dropout Voltage vs Output Current

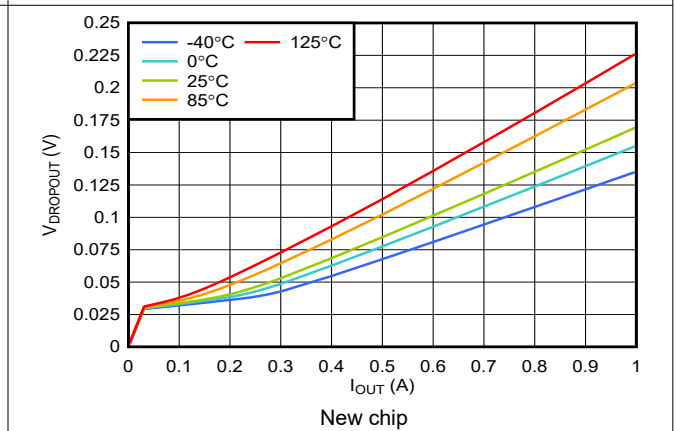
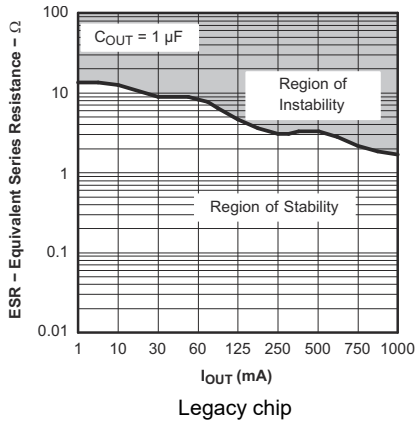


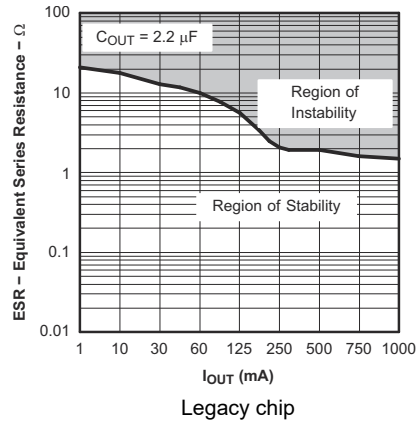
Figure 5-30. TPS79633 Dropout Voltage vs Output Current

### 5.6 Typical Characteristics (continued)

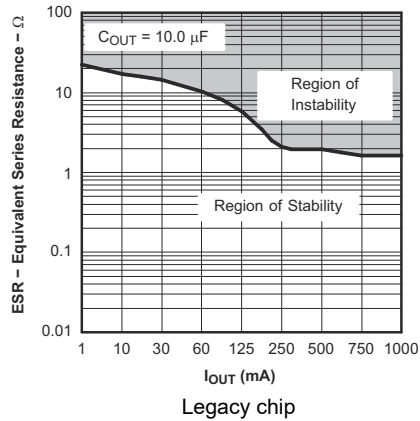
at  $V_{EN} = V_{IN}$ ,  $V_{IN} = V_{OUT(nom)} + 1V$ ,  $I_{OUT} = 1mA$ ,  $C_{OUT} = 10\mu F$ ,  $C_{NR} = 0.01\mu F$ ,  $C_{IN} = 2.2\mu F$ , and  $T_J = 25^\circ C$  (unless otherwise noted)



**Figure 5-31. TPS79630 Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current**



**Figure 5-32. TPS79630 Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current**



**Figure 5-33. TPS79630 Typical Regions of Stability Equivalent Series Resistance (ESR) vs Output Current**

## 6 Detailed Description

### 6.1 Overview

The TPS796 low-dropout (LDO) regulator combines the high performance required of many RF and precision analog applications with low current consumption. High PSRR is provided by a high-gain, high-bandwidth error loop with good supply rejection at very low headroom ( $V_{IN} - V_{OUT}$ ). A noise-reduction pin is provided to bypass noise generated by the band-gap reference and to improve PSRR, while a quick-start circuit quickly charges this capacitor at start-up. This device features thermal and overcurrent protection, and is fully specified from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

### 6.2 Functional Block Diagrams

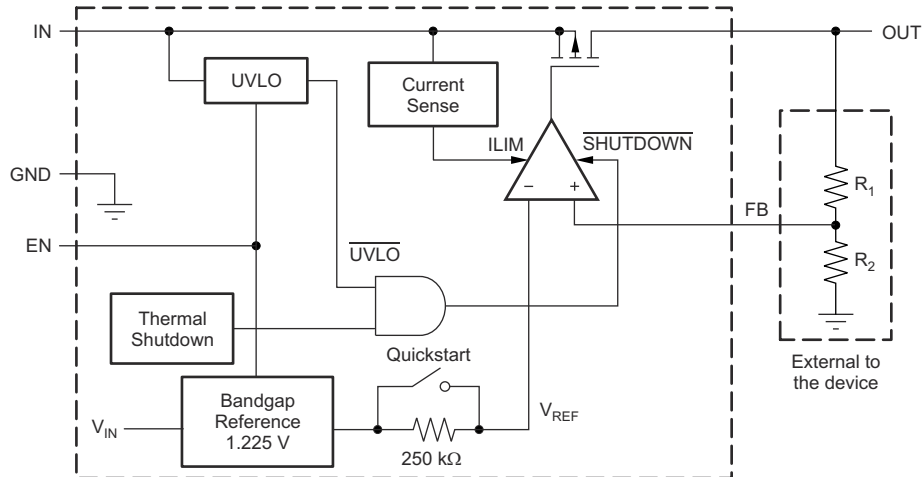


Figure 6-1. Functional Block Diagram: Adjustable Version (Legacy Chip)

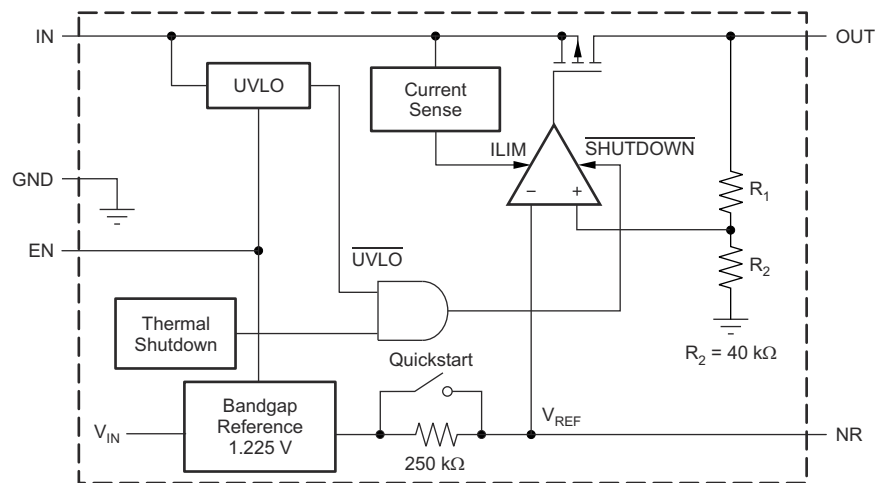
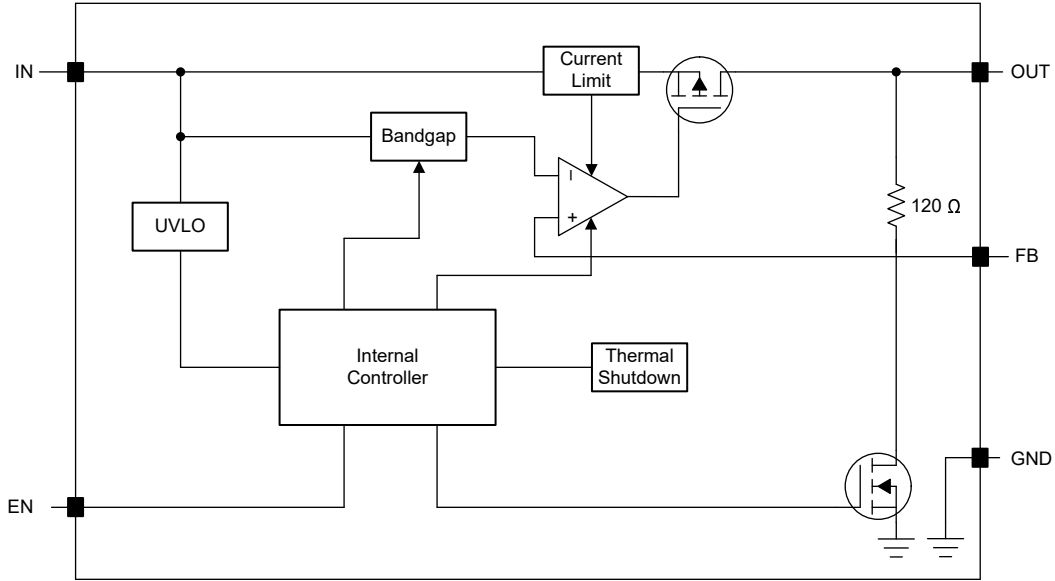
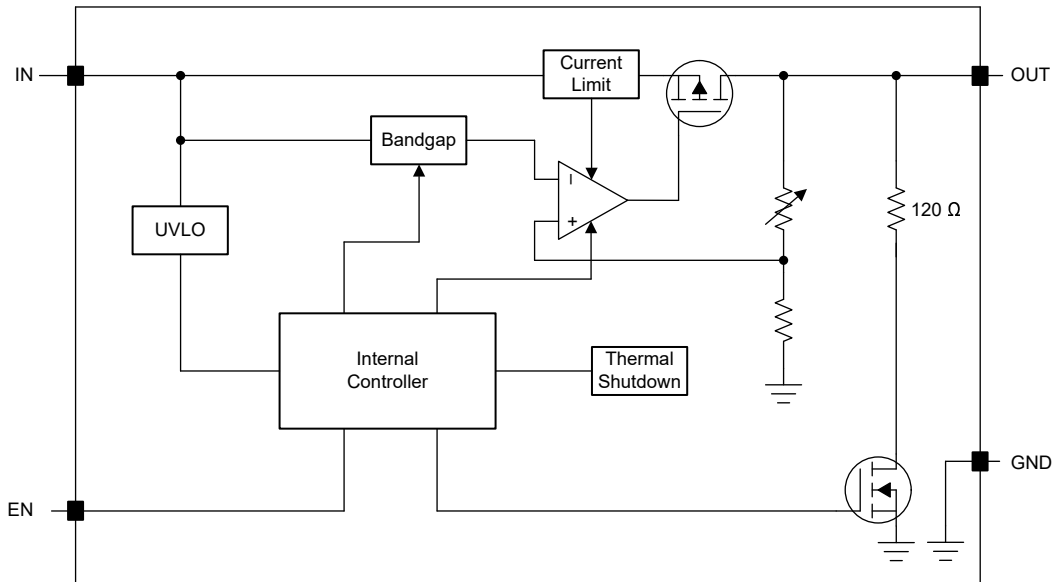


Figure 6-2. Functional Block Diagram: Fixed Version (Legacy Chip)



**Figure 6-3. Functional Block Diagram: Adjustable Version (New Chip)**



**Figure 6-4. Functional Block Diagram: Fixed Version (New Chip)**

## 6.3 Feature Description

### 6.3.1 Active Discharge (New Chip)

The device has an internal pulldown MOSFET that connects an  $R_{\text{PULLDOWN}}$  resistor to ground when the device is disabled to actively discharge the output voltage. The active discharge circuit is activated by the enable pin.

Do not rely on the active discharge circuit to discharge the output voltage after the input supply has collapsed because reverse current can possibly flow from the output to the input. This reverse current flow can cause damage to the device, especially when a large output capacitor is used. Limit reverse current to no more than 5% of the device rated current for a short period of time.

### 6.3.2 Shutdown

The enable pin (EN) is active high. Enable the device by forcing the EN pin to exceed  $V_{\text{EN}(\text{high})}$ . Turn off the device by forcing the EN pin to drop below the maximum EN pin low-level input voltage (see the [Electrical Characteristics](#) table). If shutdown capability is not required, connect EN to IN.

### 6.3.3 Start-Up

The TPS796 (legacy chip) uses a start-up circuit to quickly charge the noise reduction capacitor,  $C_{\text{NR}}$ , if present (see the [Functional Block Diagrams](#)). This circuit allows for the combination of very low output noise and fast start-up times. The NR pin is high impedance so a low leakage  $C_{\text{NR}}$  capacitor must be used; most ceramic capacitors are appropriate for this configuration.

For the fastest start-up, apply  $V_{\text{IN}}$  first, and then drive the enable pin (EN) high. If EN is tied to IN, start-up is somewhat slower. To make sure that  $C_{\text{NR}}$  is fully charged during start-up, use a 0.1- $\mu\text{F}$  or smaller capacitor.

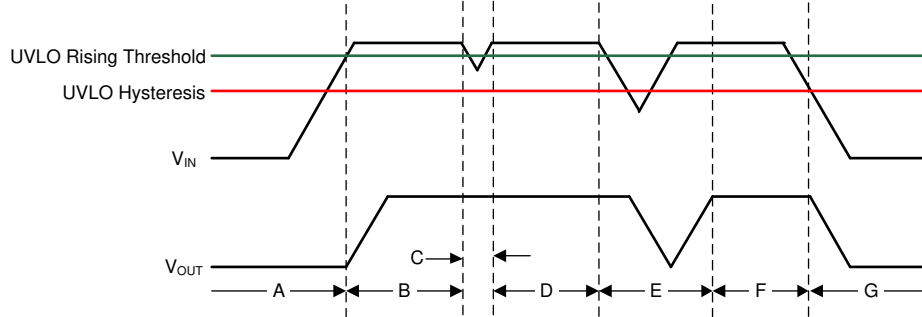
The TPS796 (new chip) uses an internal soft-start time to reduce inrush current.

### 6.3.4 Undervoltage Lockout (UVLO)

The TPS796 uses an undervoltage lockout circuit to keep the output shut off until internal circuitry is operating properly. The UVLO circuit has hysteresis to help reject input voltage drops when the regulator first turns on (see the [Electrical Characteristics](#) table).

The UVLO circuit makes sure that the device stays disabled before the input supply reaches the minimum operational voltage range, and makes sure that the device shuts down when the input supply collapses. [Figure 6-5](#) shows the UVLO circuit response to various input voltage events. The diagram can be separated into the following parts:

- Region A: The device does not start until the input reaches the UVLO rising threshold.
- Region B: Normal operation, regulating device.
- Region C: Brownout event above the UVLO falling threshold (UVLO rising threshold – UVLO hysteresis). The output may fall out of regulation but the device remains enabled.
- Region D: Normal operation, regulating device.
- Region E: Brownout event below the UVLO falling threshold. The device is disabled in most cases and the output falls because of the load and active discharge circuit. The device is reenabled when the UVLO rising threshold is reached by the input voltage and a normal start-up follows.
- Region F: Normal operation followed by the input falling to the UVLO falling threshold.
- Region G: The device is disabled when the input voltage falls below the UVLO falling threshold to 0 V. The output falls because of the load and active discharge circuit.



**Figure 6-5. Typical UVLO Operation**

### 6.3.5 Regulator Protection

The TPS796 (legacy chip) PMOS-pass transistor has a built-in back diode that conducts reverse current when the input voltage drops below the output voltage (for example, during power-down). Current is conducted from the output to the input and is not internally limited. If extended reverse voltage operation is anticipated, external limiting may be appropriate.

#### 6.3.5.1 Current Limit

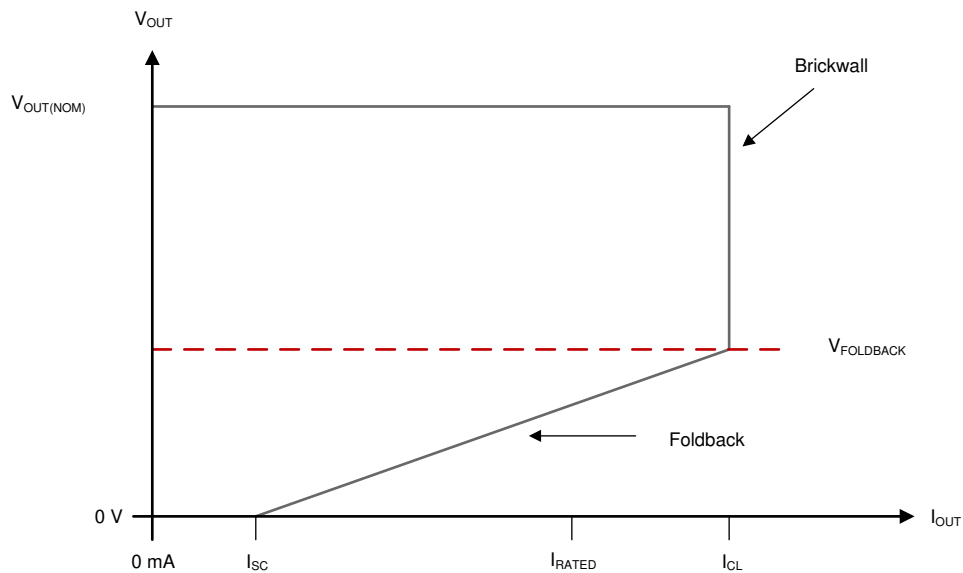
During normal operation, the TPS796 (legacy chip) limits output current to approximately 2.8 A. When current limiting engages, the output voltage scales back linearly until the overcurrent condition ends. While current limiting is designed to prevent gross device failure, care should be taken not to exceed the power dissipation ratings of the package

For the new chip, 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 hybrid brick-wall-foldback scheme. The current limit transitions from a brick-wall scheme to a foldback scheme at the foldback voltage ( $V_{FOLDBACK}$ ). In a high-load current fault with the output voltage above  $V_{FOLDBACK}$ , the brick-wall scheme limits the output current to the current limit ( $I_{CL}$ ). When the voltage drops below  $V_{FOLDBACK}$ , a foldback current limit activates that scales back the current as the output voltage approaches GND. When the output is shorted, the device supplies a typical current called the short-circuit current limit ( $I_{SC}$ ).  $I_{CL}$  and  $I_{SC}$  are listed in the *Electrical Characteristics* table.

For this device,  $V_{FOLDBACK} = 0.4 \times V_{OUT(NOM)}$ .

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 brick-wall current limit, the pass transistor dissipates power  $[(V_{IN} - V_{OUT}) \times I_{CL}]$ . When the device output is shorted and the output is below  $V_{FOLDBACK}$ , the pass transistor dissipates power  $[(V_{IN} - V_{OUT}) \times I_{SC}]$ . 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 note](#).

Figure 6-6 shows a diagram of the foldback current limit.



**Figure 6-6. Foldback Current Limit**

### 6.3.5.2 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  $T_{SD(\text{shutdown})}$  (typical). Thermal shutdown hysteresis assures that the device resets (turns on) when the temperature falls to  $T_{SD(\text{reset})}$  (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.

## 6.4 Device Functional Modes

Table 6-1 provides a quick comparison between the normal, dropout, and disabled modes of operation.

**Table 6-1. Device Functional Mode Comparison**

OPERATING MODE	PARAMETER			
	$V_{IN}$	EN	$I_{OUT}$	$T_J$
Normal	$V_{IN} > V_{OUT(nom)} + V_{DO}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{CL}$	$T_J < T_{SD}$
Dropout	$V_{IN} < V_{OUT(nom)} + V_{DO}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{CL}$	$T_J < T_{SD}$
Disabled	$V_{IN} < V_{UVLO}$	$V_{EN} < V_{EN(LO)}$	—	$T_J > T_{SD}$

### 6.4.1 Normal Operation

The device regulates to the nominal output voltage under the following conditions:

- The input voltage is greater than the nominal output voltage plus the dropout voltage ( $V_{OUT(nom)} + V_{DO}$ ).
- The enable voltage has previously exceeded the enable rising threshold voltage and not yet decreased below the enable falling threshold.
- The output current is less than the current limit ( $I_{OUT} < I_{CL}$ ).
- The device junction temperature is less than the thermal shutdown temperature ( $T_J < T_{SD}$ ).

### 6.4.2 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 device is in a triode state and no longer controls the current through the LDO. 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 start-up), 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.

### 6.4.3 Disabled

The device is disabled under the following conditions:

- The enable voltage is less than the enable falling threshold voltage or has not yet exceeded the enable rising threshold.
- The device junction temperature is greater than the thermal shutdown temperature ( $T_J > T_{SD}$ ).

The TPS796 (new chip), when disabled, the output voltage is actively discharged to ground by an internal discharge circuit from the output to ground.

## 7 Application and Implementation

### Note

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

### 7.1 Application Information

The TPS796 low-dropout (LDO) regulator is optimized for use in noise-sensitive equipment. The device features extremely low dropout voltages, high PSRR, ultra-low output noise, low quiescent current, and enable input to reduce supply currents to less than 1  $\mu\text{A}$  when the regulator is turned off.

#### 7.1.1 Recommended Capacitor Types

The device is designed to be stable using low equivalent series resistance (ESR) ceramic capacitors at the input and output. Multilayer ceramic capacitors have become the industry standard for these types of applications and are recommended, but must be used with good judgment. Ceramic capacitors that employ X7R-, X5R-, and C0G-rated dielectric materials provide relatively good capacitive stability across temperature, whereas the use of Y5V-rated capacitors is discouraged because of large variations in capacitance.

Regardless of the ceramic capacitor type selected, the effective capacitance varies with operating voltage and temperature. As a rule of thumb, expect the effective capacitance to decrease by as much as 50%. The input and output capacitors recommended in the *Recommended Operating Conditions* table account for an effective capacitance of approximately 50% of the nominal value.

#### 7.1.2 Input and Output Capacitor Requirements

A 2.2  $\mu\text{F}$  or larger ceramic input bypass capacitor, connected between IN and GND and located close to the TPS796, is required for stability and improves transient response, noise rejection, and ripple rejection. A higher-value input capacitor may be necessary if large, fast-rise-time load transients are anticipated and the device is located several inches from the power source.

Like most low dropout regulators, the TPS796 requires an output capacitor connected between OUT and GND to stabilize the internal control loop. The minimum recommended capacitor is 1  $\mu\text{F}$ . Any 1  $\mu\text{F}$  or larger ceramic capacitor is suitable.

#### 7.1.3 Feed-forward Capacitor ( $C_{FF}$ )

For the adjustable-voltage version device, a feed-forward capacitor ( $C_{FF}$ ) can be connected from the OUT pin to the FB pin.  $C_{FF}$  improves transient, noise, and PSRR performance, but is not required for regulator stability. Recommended  $C_{FF}$  values are listed in the *Recommended Operating Conditions* table. A higher capacitance  $C_{FF}$  can be used; however, the start-up time increases. For a detailed description of  $C_{FF}$  tradeoffs, see the [Pros and Cons of Using a Feedforward Capacitor with a Low-Dropout Regulator application note](#).

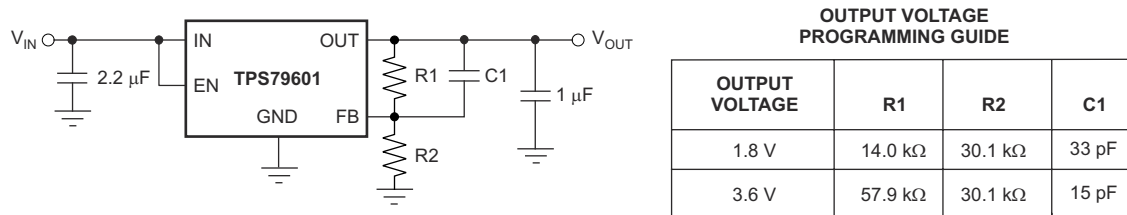
For the legacy chip, the  $C_{FF}$  can be estimated by [Equation 1](#):

$$C1 = \frac{(3 \times 10^{-7}) \times (R1 + R2)}{(R1 \times R2)} \quad (1)$$

The suggested value of this capacitor for several resistor ratios is shown in the table in [Figure 7-1](#). If this capacitor is not used (such as in a unity-gain configuration) then the minimum recommended output capacitor is 2.2  $\mu\text{F}$  instead of 1  $\mu\text{F}$ .

### 7.1.4 Adjustable Configuration

The output voltage of the TPS79601 adjustable regulator is programmed using an external resistor divider, as Figure 7-1 shows.



**Figure 7-1. Typical Application, Adjustable Output**

The output voltage is calculated using Equation 2:

$$V_{OUT} = V_{REF} \times \left( 1 + \frac{R1}{R2} \right) \quad (2)$$

where:

- $V_{REF} = 1.2246$  V typical (the internal reference voltage)

For the TPS796 (legacy chip), resistors  $R_1$  and  $R_2$  should be chosen for approximately 40 μA divider current. Lower value resistors can be used for improved noise performance, but the device wastes more power. Higher values should be avoided, as leakage current at FB increases the output voltage error.

The recommended design procedure is to choose  $R_2 = 30.1$  kΩ to set the divider current at 40 μA,  $C_1 = 15$  pF for stability, and then calculate  $R_1$  using Equation 3:

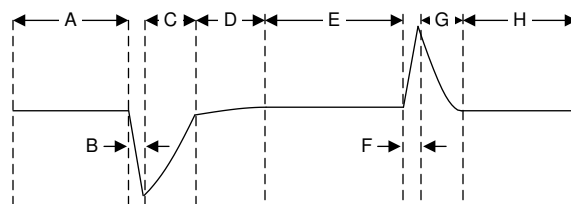
$$R1 = \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) \times R2 \quad (3)$$

Similarly, for the TPS796 (new chip), to disregard the effect of the FB pin current error term and to achieve best accuracy, choose  $R_2$  to be equal to or smaller than 550 kΩ so that the current flowing through  $R_1$  and  $R_2$  is at least five times larger than the  $I_{FB}$  current listed in the *Electrical Characteristics* table. Lowering the value of  $R_2$  increases the immunity against noise injection. Increasing the value of  $R_2$  reduces the quiescent current for achieving higher efficiency at low load currents. Equation 4 calculates the setting that provides the maximum feedback divider series resistance.

$$(R_1 + R_2) \leq V_{OUT} / (I_{FB} \times 5) \quad (4)$$

### 7.1.5 Load Transient Response

The load-step transient response is the output voltage response by the LDO to a step in load current, whereby output voltage regulation is maintained. There are two key transitions during a load transient response: the transition from a light to a heavy load and the transition from a heavy to a light load. The regions shown in Figure 7-2 are broken down as follows. Regions A, E, and H are where the output voltage is in steady-state.



**Figure 7-2. Load Transient Waveform**

During transitions from a light load to a heavy load, the:

- Initial voltage dip is a result of the depletion of the output capacitor charge and parasitic impedance to the output capacitor (region B)
- Recovery from the dip results from the LDO increasing the sourcing current, and leads to output voltage regulation (region C)
- Initial voltage rise results from the LDO sourcing a large current, and leads to the output capacitor charge to increase (region F)
- Recovery from the rise results from the LDO decreasing the sourcing current in combination with the load discharging the output capacitor (region G)

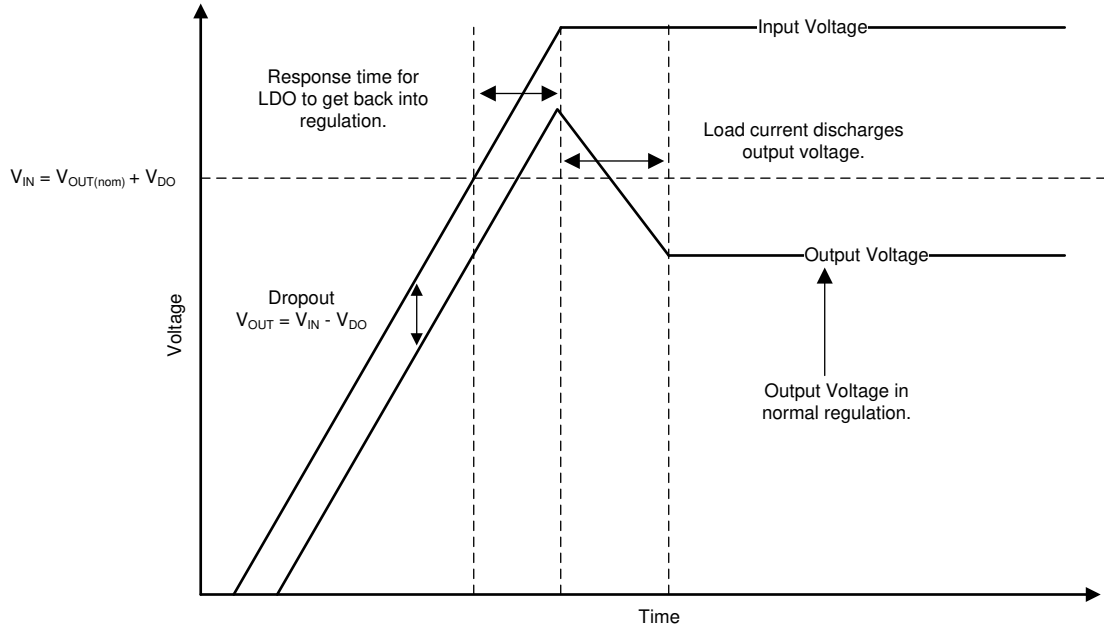
A larger output capacitance reduces the peaks during a load transient but slows down the response time of the device. A larger DC load also reduces the peaks because the amplitude of the transition is lowered and a higher current discharge path is provided for the output capacitor.

### 7.1.6 Dropout Voltage

The TPS796 uses a PMOS-pass transistor to achieve a low dropout voltage. When  $(V_{IN} - V_{OUT})$  is less than the dropout voltage ( $V_{DO}$ ), the PMOS-pass transistor is in the linear region of operation and  $r_{DS(on)}$  of the PMOS-pass transistor is the input-to-output resistance. Because the PMOS transistor behaves like a resistor in dropout,  $V_{DO}$  approximately scales with the output current.

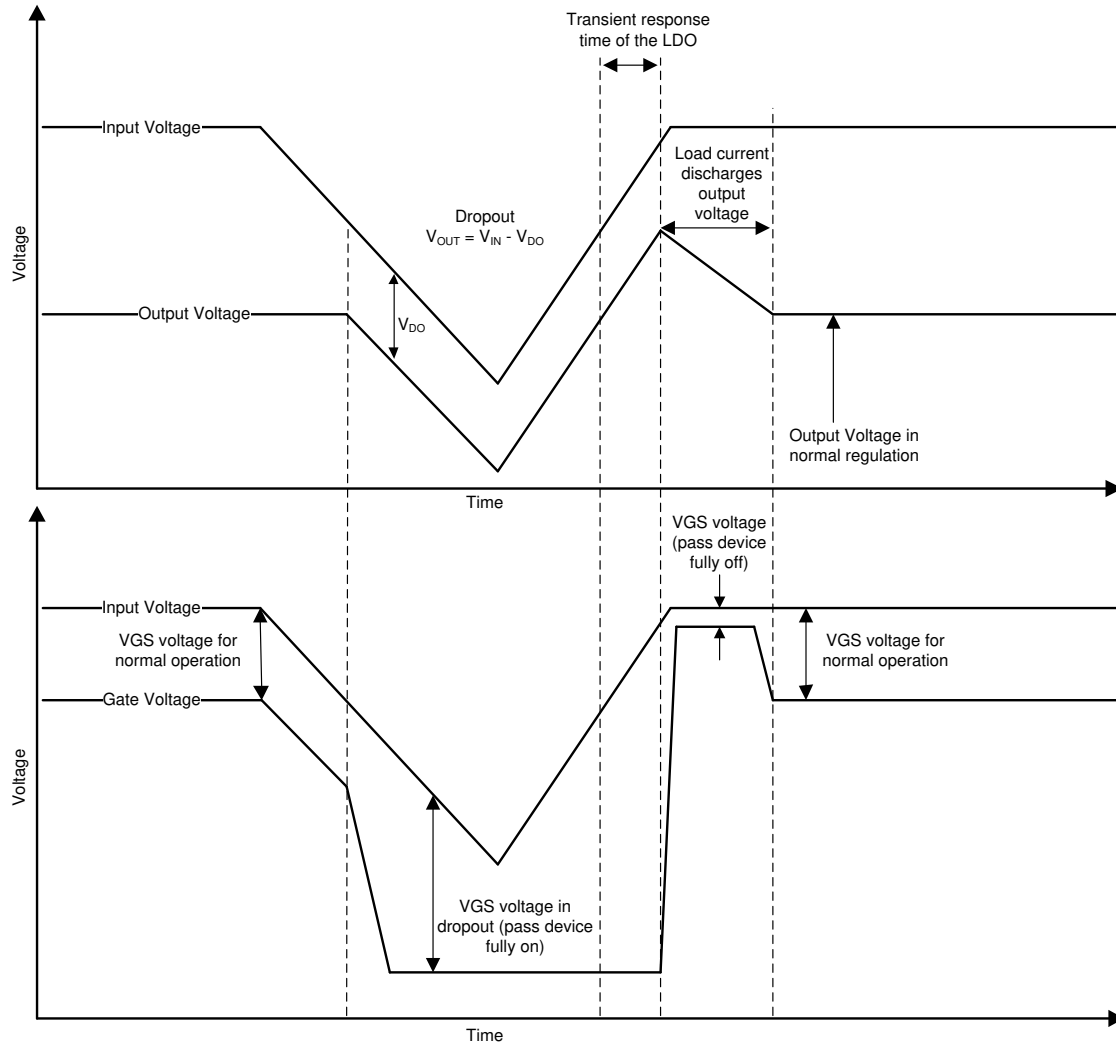
### 7.1.6.1 Exiting Dropout

Some applications have transients that place the LDO into dropout, such as slower ramps on  $V_{IN}$  during start-up. As with other LDOs, the output can overshoot on recovery from these conditions. A ramping input supply causes an LDO to overshoot on start-up, as shown in Figure 7-3, when the slew rate and voltage levels are in the correct range. Use an enable signal to avoid this condition.



**Figure 7-3. Start-Up Into Dropout**

Line transients out of dropout can also cause overshoot on the output of the regulator. These overshoots are caused by the error amplifier having to drive the gate capacitance of the pass element and bring the gate back to the correct voltage for proper regulation. Figure 7-4 illustrates what is happening internally with the gate voltage and how overshoot can be caused during operation. When the LDO is placed in dropout, the gate voltage ( $V_{GS}$ ) is pulled all the way down to ground to give the pass device the lowest on-resistance as possible. However, if a line transient occurs when the device is in dropout, the loop is not in regulation and can cause the output to overshoot until the loop responds and the output current pulls the output voltage back down into regulation. If these transients are not acceptable, then continue to add input capacitance in the system until the transient is slow enough to reduce the overshoot.



**Figure 7-4. Line Transients From Dropout**

### 7.1.7 Noise Reduction Pin (legacy chip)

The internal voltage reference is a key source of noise in an LDO regulator. The TPS796 (legacy chip) has a noise-reduction (NR) pin that is connected to the voltage reference through a 250-k $\Omega$  internal resistor. The 250-k $\Omega$  internal resistor, in conjunction with an external bypass capacitor connected to the NR pin, creates a low-pass filter to reduce the voltage reference noise and, therefore, the noise at the regulator output. For the regulator to operate properly, the current flow out of the NR pin must be at a minimum, because any leakage current creates an IR drop across the internal resistor, thus creating an output error. Therefore, the bypass capacitor must have minimal leakage current. The bypass capacitor should be no more than 0.1  $\mu$ F to make sure the capacitor is fully charged during the quick-start time provided by the internal switch shown in the functional block diagram of the legacy chip [Figure 6-2](#). The output starts up slower as the bypass capacitance increases due to the RC time constant at the bypass pin that is created by the internal 250-k $\Omega$  resistor and external capacitor.

### 7.1.8 Power Dissipation ( $P_D$ )

Knowing the device power dissipation and proper sizing of the thermal plane that is connected to the tab or pad is critical to avoiding thermal shutdown and ensuring reliable operation.

As a first-order approximation, power dissipation of the device depends on input voltage and load conditions. Use [Equation 5](#) to approximate  $P_D$ :

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (5)$$

Power dissipation can be minimized and greater efficiency can be achieved by using the lowest possible input voltage necessary to achieve the required output voltage regulation.

The main heat conduction path for the device is through the thermal pad on the package or the GND pad for the SOT-223 (DCQ) and TO-263 (KTT) packages. As such, the thermal pad and GND pad must be soldered to a copper pad area under the device. This pad area contains an array of plated vias that conduct heat to any inner plane areas or to a bottom-side copper plane. That tab should be connected to ground.

The maximum power dissipation determines the maximum allowable junction temperature ( $T_J$ ) for the device. According to Equation 6, 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 ( $T_A$ ). Equation 7 rearranges Equation 6 for output current.

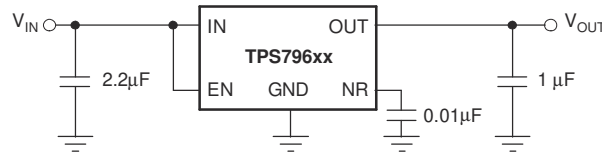
$$T_J = T_A + (R_{\theta JA} \times P_D) \quad (6)$$

$$I_{OUT} = (T_J - T_A) / [R_{\theta JA} \times (V_{IN} - V_{OUT})] \quad (7)$$

Unfortunately, this 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  $R_{\theta JA}$  recorded in the *Recommended Operating Conditions* table is determined by the JEDEC standard, PCB, and copper-spreading area, and is only used as a relative measure of package thermal performance.

## 7.2 Typical Application

A typical application circuit is shown in Figure 7-5.



**Figure 7-5. Typical Application Circuit**

### 7.2.1 Design Requirements

Table 7-1 lists the design parameters.

**Table 7-1. Design Parameters**

PARAMETER	DESIGN REQUIREMENT
Input voltage	4.3V
Output voltage	3.3V
Maximum output current	700mA
Output capacitor	10µF

### 7.2.2 Detailed Design Procedure

For this design example, a fixed 3.3V device is selected. The device is powered with a 4.3V rail, to maintain a 1V headroom between  $V_{IN}$  and  $V_{OUT}$  to make sure the device stays in regulation under all load and temperature conditions for the design. The load requires a minimum of 600mA up to 1A with a PSRR of 40dB at 100kHz.

### 7.2.3 Application Curves

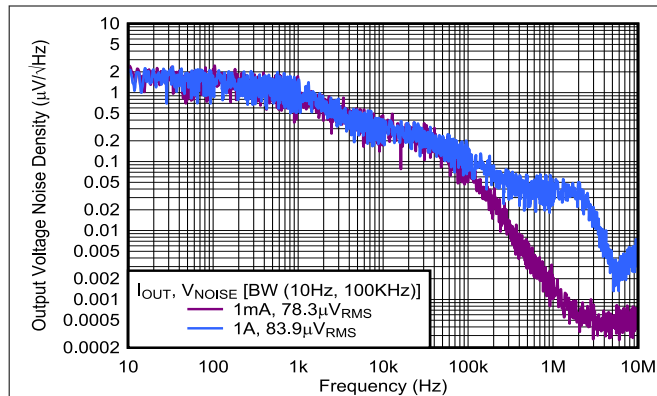


Figure 7-6. TPS796 Output Spectral Noise Density vs Frequency

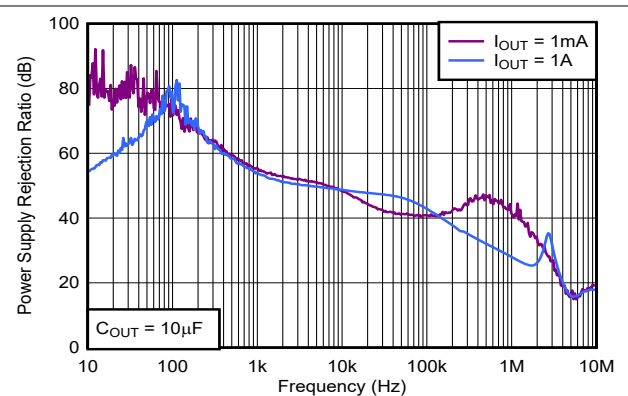


Figure 7-7. TPS796 PSRR vs Frequency

### 7.2.4 Best Design Practices

Place at least one 1- $\mu$ F ceramic capacitor as close as possible to the OUT pin of the regulator.

Do not place the output capacitor more than 10 mm away from the regulator.

Connect a 2.2- $\mu$ F low equivalent series resistance (ESR) capacitor across the IN pin and GND input of the regulator.

Do not exceed the absolute maximum ratings.

## 7.3 Power Supply Recommendations

These devices are designed to operate from an input voltage supply range between 2.7 V and 5.5 V. The input voltage range provides adequate headroom in order for the device to have a regulated output. This input supply is well-regulated and stable. If the input supply is noisy, additional input capacitors with low ESR can help improve the output noise performance.

## 7.4 Layout

### 7.4.1 Layout Guidelines

#### 7.4.1.1 Board Layout Recommendation to Improve PSRR and Noise Performance

To improve AC measurements like PSRR, output noise, and transient response, design the board with separate ground planes for  $V_{IN}$  and  $V_{OUT}$ , with each ground plane connected only at the ground pin of the device. In addition, the ground connection for the bypass capacitor should connect directly to the ground pin of the device.

#### 7.4.1.2 Regulator Mounting

The tab of the SOT223-6 package is electrically connected to ground. For best thermal performance, the tab of the surface-mount version should be soldered directly to a circuit-board copper area. Increasing the copper area improves heat dissipation.

Solder pad footprint recommendations for the devices are presented in the [Solder Pad Recommendations for Surface-Mount Devices](#) application note, available from the TI web site ([www.ti.com](http://www.ti.com)).

#### 7.4.1.3 Estimating Junction Temperature

Using the thermal metrics  $\Psi_{JT}$  and  $\Psi_{JB}$ , as shown in the *Thermal Information* table, the junction temperature can be estimated with corresponding formulas (given in [Equation 8](#)). For backwards compatibility, an older  $R_{\theta JC, Top}$  parameter is listed as well.

$$\Psi_{JT}: T_J = T_T + \Psi_{JT} \cdot P_D$$

$$\Psi_{JB}: T_J = T_B + \Psi_{JB} \cdot P_D$$

(8)

where:

- $P_D$  is the power dissipation shown by [Equation 8](#).
- $T_T$  is the temperature at the center-top of the device package
- $T_B$  is the PCB temperature measured 1mm away from the device package *on the PCB surface* (as [Figure 7-9](#) shows).

---

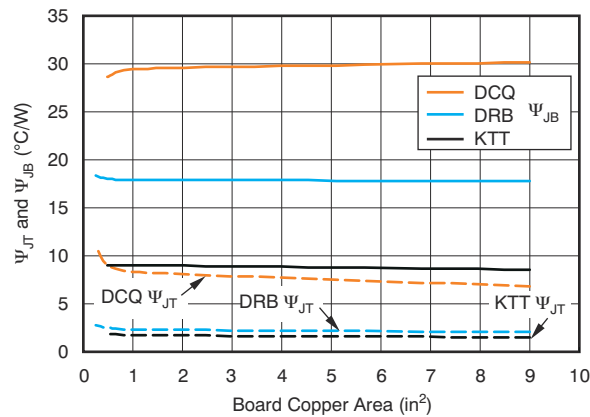
**Note**

Both  $T_T$  and  $T_B$  can be measured on actual application boards using a thermo-gun (an infrared thermometer).

---

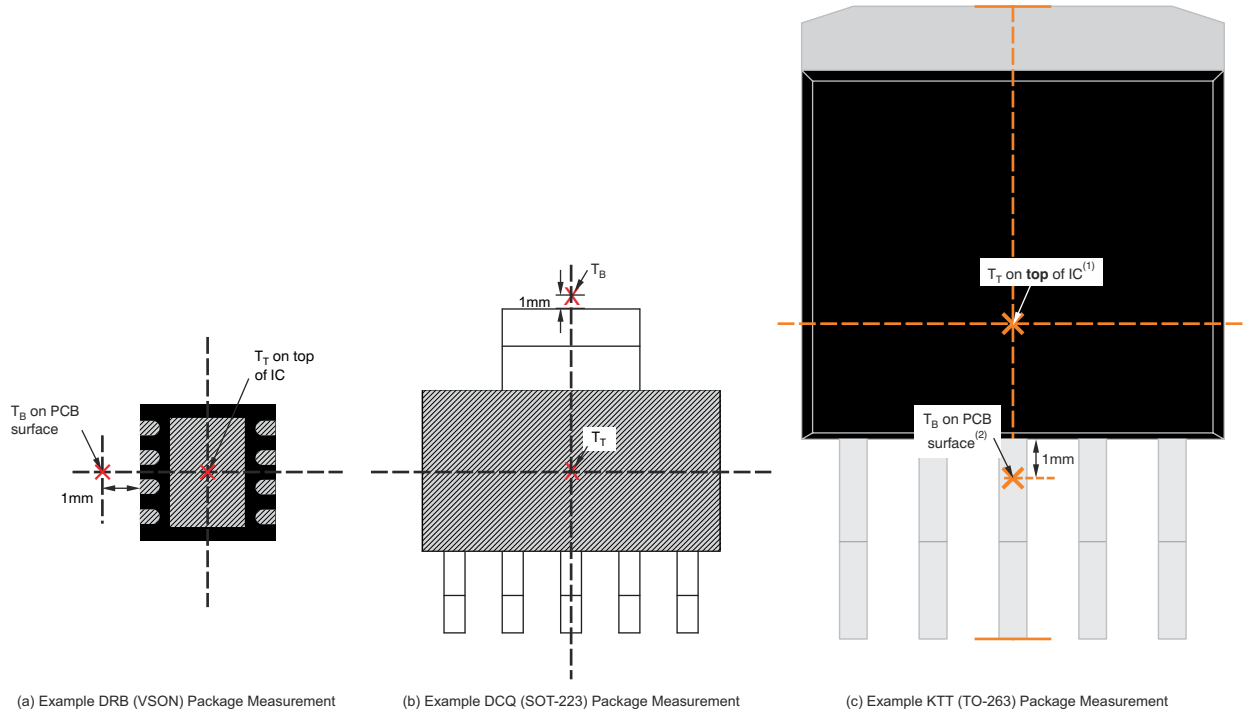
For more information about measuring  $T_T$  and  $T_B$ , see the [Using New Thermal Metrics application note](#), available at [www.ti.com](http://www.ti.com).

By referring to [Figure 7-8](#), the new thermal metrics ( $\Psi_{JT}$  and  $\Psi_{JB}$ ) have very little dependency on board size. That is, using  $\Psi_{JT}$  or  $\Psi_{JB}$  with [Equation 8](#) is a good way to estimate  $T_J$  by simply measuring  $T_T$  or  $T_B$ , regardless of the application board size.



**Figure 7-8.  $\Psi_{JT}$  And  $\Psi_{JB}$  vs Board Size**

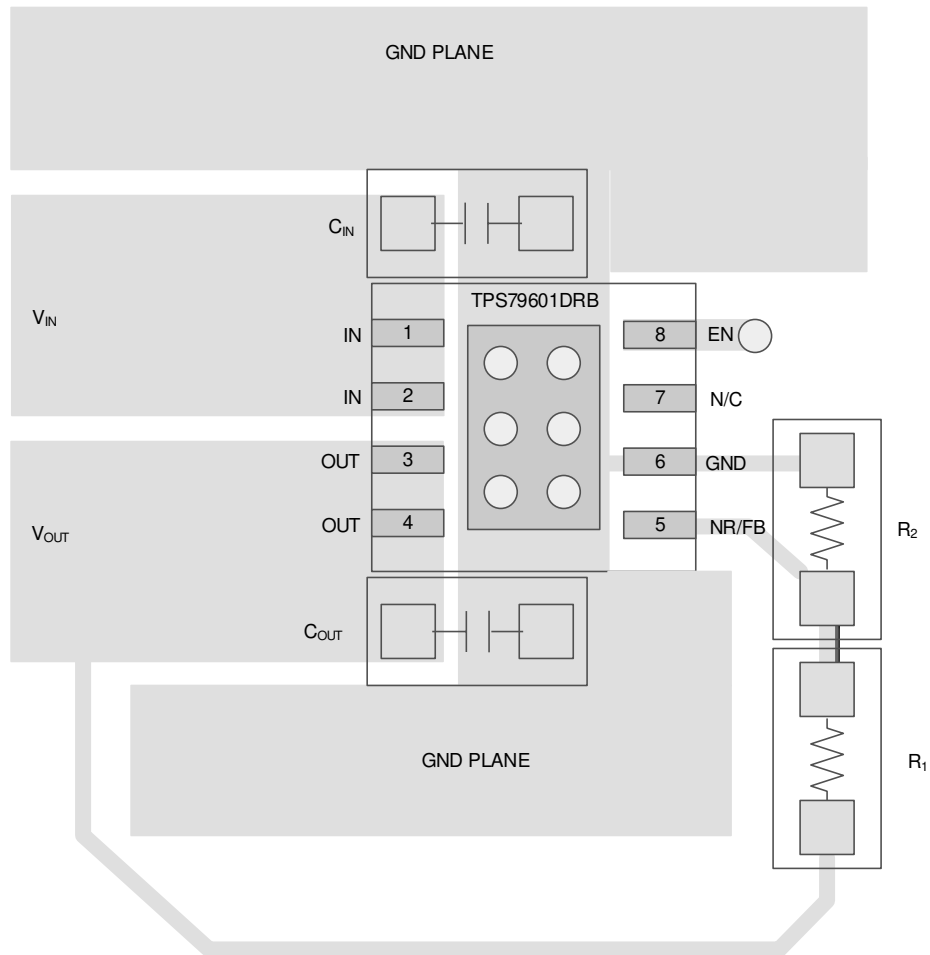
For a more detailed discussion of why TI does not recommend using  $\theta_{JC(top)}$  to determine thermal characteristics, see the [Using New Thermal Metrics application report](#), available for download at [www.ti.com](http://www.ti.com). For further information, see the [Semiconductor and IC Package Thermal Metrics application note](#), also available on the TI website.



- A.  $T_T$  is measured at the center of both the X- and Y-dimensional axes.
- B.  $T_B$  is measured **below** the package lead on the PCB surface.

**Figure 7-9. Measuring Points For  $T_T$  and  $T_B$**

### 7.4.2 Layout Examples



**Figure 7-10. TPS79601 (Adjustable-Voltage Version): DRB Layout Example**

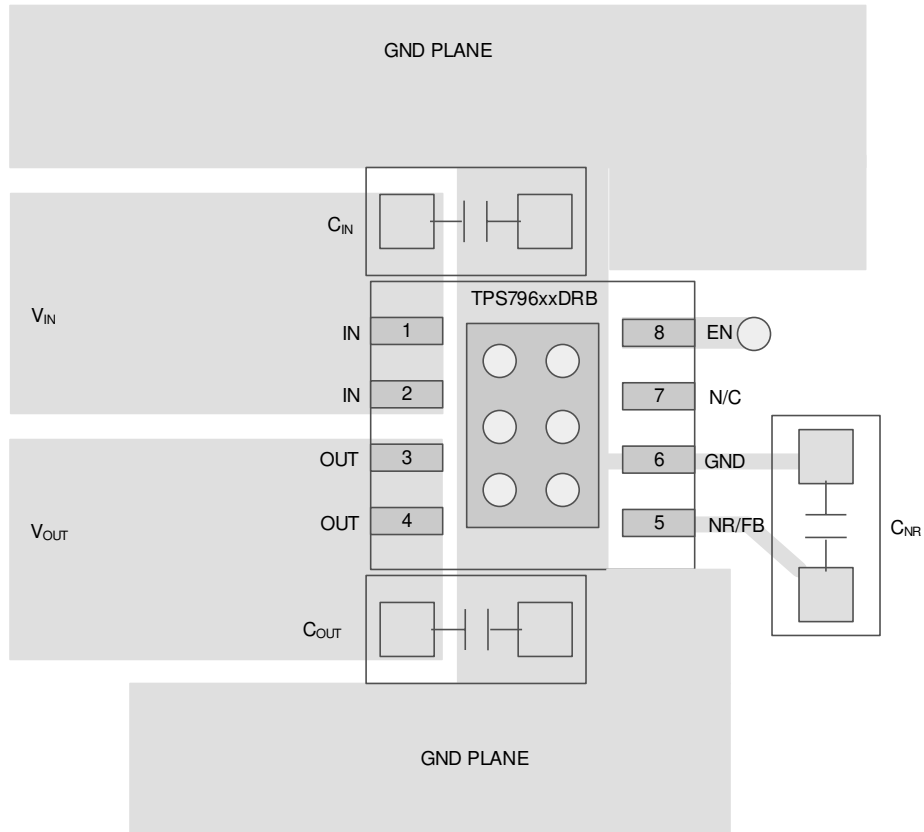


Figure 7-11. TPS796xx (Fixed-Voltage Versions): DRB Layout Example

## 8 Device and Documentation Support

### 8.1 Device Support

#### 8.1.1 Development Support

##### 8.1.1.1 Evaluation Modules

An evaluation module (EVM) is available to assist in the initial circuit performance evaluation using the TPS796. The [TPS79601DRBEVM evaluation module](#) can be requested at the TI website through the product folders or purchased directly from the [TI eStore](#).

##### 8.1.1.2 Spice Models

Computer simulation of circuit performance using SPICE is often useful when analyzing the performance of analog circuits and systems. A SPICE model for the TPS796 is available through the product folders under simulation models.

#### 8.1.2 Device Nomenclature

**Table 8-1. Available Options**

PRODUCT <sup>(1)</sup>	DESCRIPTION
TPS796xx(x)yyy z M3	<p><b>xx(x)</b> is the nominal output voltage (for example, 28 = 2.8 V, 285 = 2.85 V, 01 = Adjustable).  <b>yyy</b> is the package designator.  <b>z</b> is the package quantity. <b>M3</b> is a suffix designator for devices that only use the latest manufacturing flow (CSO: RFB). Devices without this suffix ship with the legacy chip (CSO: DLN) or the new chip (CSO: RFB). The reel packaging label provides CSO information to distinguish which chip is being used. The device performance for new and legacy chips is denoted throughout the document.</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 at [www.ti.com](http://www.ti.com).

### 8.2 Documentation Support

#### 8.2.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Using New Thermal Metrics application note](#)
- Texas Instruments, [Semiconductor and IC Package Thermal Metrics application note](#)
- Texas Instruments, [TPS799xxEVM-105 user's guide](#)
- Texas Instruments, [Solder Pad Recommendations for Surface-Mount Devices application note](#)

### 8.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 8.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 8.5 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
 All trademarks are the property of their respective owners.

## 8.6 Electrostatic Discharge Caution



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

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

## 8.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 9 Revision History

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

Changes from Revision P (January 2015) to Revision Q (June 2025)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Changed device name to condensed <i>TPS796</i> to consolidate all voltage option devices under one device name.....	1
• Changed entire document to align with current family format.....	1
• Added new silicon (M3) devices to document.....	1
• Added nomenclature distinguishing between new chip and legacy chip information throughout document.....	1
• Changed <i>Features</i> , <i>Applications</i> , and <i>Description</i> sections.....	1
• Changed <i>Pin Configuration and Functions</i> section.....	3
• Added new silicon curves to <i>Typical Characteristics</i> section .....	8
• Added new chip block diagrams to <i>Functional Block Diagrams</i> section.....	14
• Added <i>Active Discharge (New Chip)</i> section.....	16
• Changed <i>Shutdown</i> section.....	16
• Changed <i>Undervoltage Lockout (UVLO)</i> section.....	16
• Changed <i>Regulator Protection</i> section and added subsections.....	17
• Added steady dropout state discussion in second paragraph to <i>Dropout Operation</i> section.....	19
• Added subsections to <i>Application Information</i> .....	20
• Changed <i>Design Parameters</i> table.....	25
• Changed <i>Detailed Design Procedure</i> section.....	25
• Changed <i>Application Curves</i> section.....	26
• Changed title from <i>Do's and Don'ts</i> to <i>Best Design Practices</i> .....	26
• Added <i>Estimating Junction Temperature</i> section.....	26
• Added M3 information to <i>Available Options</i> table.....	31

Changes from Revision O (November 2013) to Revision P (January 2015)	Page
• Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes, Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section .....	1
• Changed front-page figure; updated graph style, replaced device pinouts with application circuits .....	1
• Changed <i>Pin Configuration and Functions</i> section; updated table format and added pinout drawings.....	3
• Added condition statement to <a href="#">Section 5.6</a> .....	8

## 10 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.

**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)
<a href="#">TPS79601DCQ</a>	Active	Production	SOT-223 (DCQ)   6	78   TUBE	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79601
TPS79601DCQ.A	Active	Production	SOT-223 (DCQ)   6	78   TUBE	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79601
<a href="#">TPS79601DCQG4</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79601
<a href="#">TPS79601DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79601
TPS79601DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79601
<a href="#">TPS79601DRBR</a>	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
TPS79601DRBR.A	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
TPS79601DRBRG4	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
<a href="#">TPS79601DRBT</a>	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
TPS79601DRBT.A	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
TPS79601DRBTG4	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	CES
<a href="#">TPS79601KTTR</a>	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79601
TPS79601KTTR.A	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79601
TPS79601KTTRG3	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79601
<a href="#">TPS79613DRBR</a>	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	CCT
TPS79613DRBR.A	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	CCT
<a href="#">TPS79618DCQ</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79618
<a href="#">TPS79618DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79618
TPS79618DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79618
<a href="#">TPS79618KTTR</a>	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-	TPS 79618
TPS79618KTTR.A	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79618
<a href="#">TPS79625DCQ</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79625
<a href="#">TPS79625DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79625
TPS79625DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79625
<a href="#">TPS79625KTTR</a>	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-	TPS 79625

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)
TPS79625KTTR.A	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79625
<a href="#">TPS79628DCQ</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79628
<a href="#">TPS79628DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79628
TPS79628DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79628
<a href="#">TPS79630DCQ</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79630
<a href="#">TPS79630DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79630
TPS79630DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79630
<a href="#">TPS79630KTTR</a>	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-	TPS 79630
TPS79630KTTR.A	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79630
<a href="#">TPS79633DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79633
TPS79633DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	PS79633
<a href="#">TPS79633DCQRG4</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79633
<a href="#">TPS79633KTTR</a>	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-	TPS 79633
TPS79633KTTR.A	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79633
TPS79633KTTRG3	Active	Production	DDPAK/ TO-263 (KTT)   5	500   LARGE T&R	Yes	SN	Level-2-260C-1 YEAR	-40 to 125	TPS 79633
<a href="#">TPS79650DCQ</a>	Obsolete	Production	SOT-223 (DCQ)   6	-	-	Call TI	Call TI	-40 to 125	PS79650
<a href="#">TPS79650DCQR</a>	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79650
TPS79650DCQR.A	Active	Production	SOT-223 (DCQ)   6	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PS79650
<a href="#">TPS79650DRBR</a>	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BYZ
TPS79650DRBR.A	Active	Production	SON (DRB)   8	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BYZ
<a href="#">TPS79650DRBT</a>	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BYZ
TPS79650DRBT.A	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BYZ
TPS79650DRBTG4	Active	Production	SON (DRB)   8	250   SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	BYZ

<sup>(1)</sup> **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.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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.

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

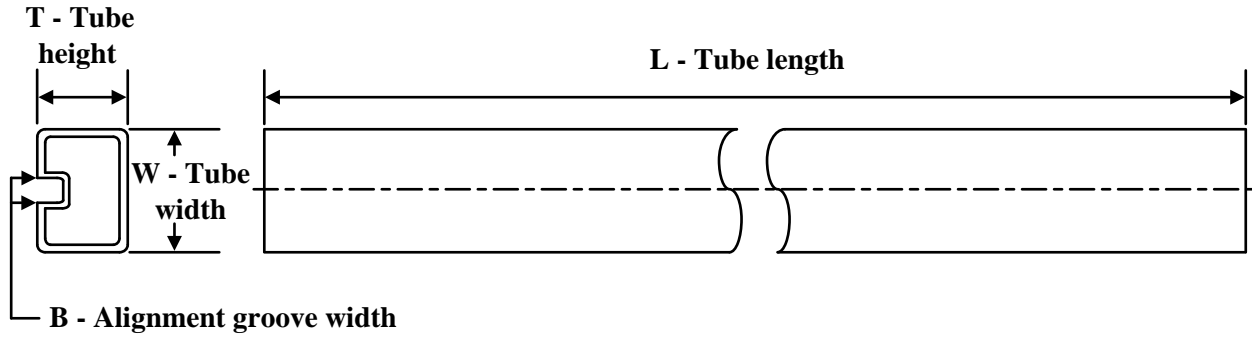
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS79601DCQR	SOT-223	DCQ	6	2500	330.0	12.4	6.85	7.3	1.88	8.0	12.0	Q3
TPS79601DRBR	SON	DRB	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TPS79601DRBT	SON	DRB	8	250	180.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TPS79601KTTR	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.9	16.1	4.9	16.0	24.0	Q2
TPS79613DRBR	SON	DRB	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TPS79618DCQR	SOT-223	DCQ	6	2500	330.0	12.4	6.85	7.3	1.88	8.0	12.0	Q3
TPS79618KTTR	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.9	16.1	4.9	16.0	24.0	Q2
TPS79625DCQR	SOT-223	DCQ	6	2500	330.0	12.4	6.85	7.3	1.88	8.0	12.0	Q3
TPS79625KTTR	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.9	16.1	4.9	16.0	24.0	Q2
TPS79628DCQR	SOT-223	DCQ	6	2500	330.0	12.4	7.1	7.45	1.88	8.0	12.0	Q3
TPS79630DCQR	SOT-223	DCQ	6	2500	330.0	12.4	7.1	7.45	1.88	8.0	12.0	Q3
TPS79630KTTR	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.9	16.1	4.9	16.0	24.0	Q2
TPS79633DCQR	SOT-223	DCQ	6	2500	330.0	12.4	6.85	7.3	1.88	8.0	12.0	Q3

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS79633KTTR	DDPAK/ TO-263	KTT	5	500	330.0	24.4	10.9	16.1	4.9	16.0	24.0	Q2
TPS79650DCQR	SOT-223	DCQ	6	2500	330.0	12.4	7.1	7.45	1.88	8.0	12.0	Q3
TPS79650DRBR	SON	DRB	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TPS79650DRBT	SON	DRB	8	250	180.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS79601DCQR	SOT-223	DCQ	6	2500	356.0	356.0	36.0
TPS79601DRBR	SON	DRB	8	3000	353.0	353.0	32.0
TPS79601DRBT	SON	DRB	8	250	210.0	185.0	35.0
TPS79601KTTR	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
TPS79613DRBR	SON	DRB	8	3000	353.0	353.0	32.0
TPS79618DCQR	SOT-223	DCQ	6	2500	356.0	356.0	36.0
TPS79618KTTR	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
TPS79625DCQR	SOT-223	DCQ	6	2500	356.0	356.0	36.0
TPS79625KTTR	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
TPS79628DCQR	SOT-223	DCQ	6	2500	346.0	346.0	29.0
TPS79630DCQR	SOT-223	DCQ	6	2500	346.0	346.0	29.0
TPS79630KTTR	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
TPS79633DCQR	SOT-223	DCQ	6	2500	356.0	356.0	36.0
TPS79633KTTR	DDPAK/TO-263	KTT	5	500	367.0	367.0	45.0
TPS79650DCQR	SOT-223	DCQ	6	2500	346.0	346.0	29.0
TPS79650DRBR	SON	DRB	8	3000	356.0	356.0	35.0
TPS79650DRBT	SON	DRB	8	250	210.0	185.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
TPS79601DCQ	DCQ	SOT-223	6	78	543	8.6	3606.8	2.67
TPS79601DCQ.A	DCQ	SOT-223	6	78	543	8.6	3606.8	2.67

**DRB 8**

**GENERIC PACKAGE VIEW**

**VSON - 1 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



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

4203482/L

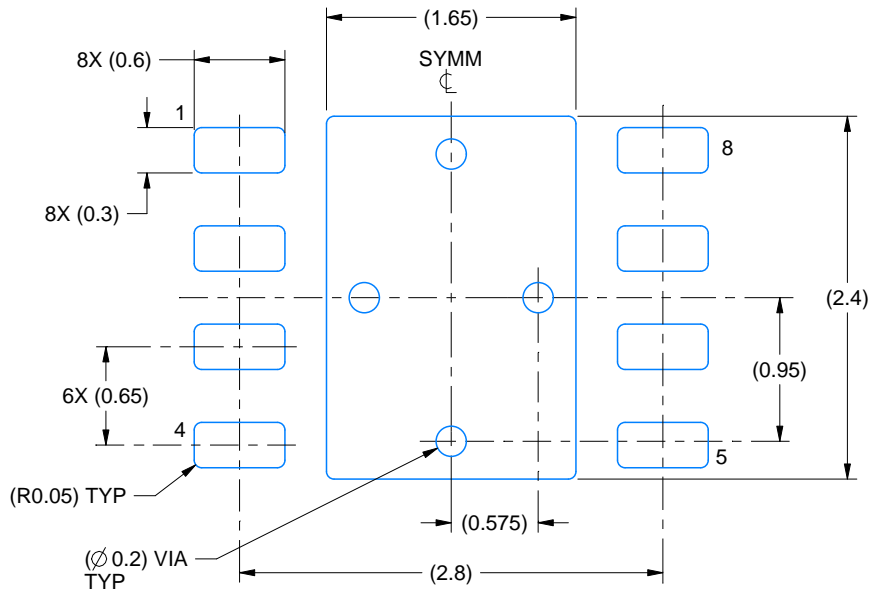


# EXAMPLE BOARD LAYOUT

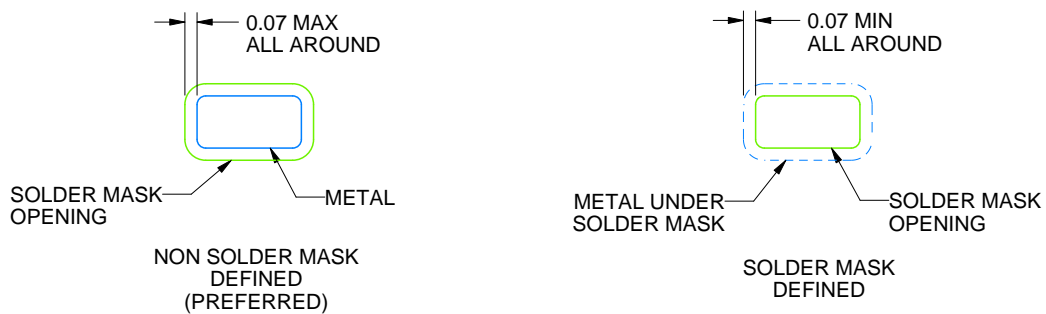
DRB0008B

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

4218876/A 12/2017

NOTES: (continued)

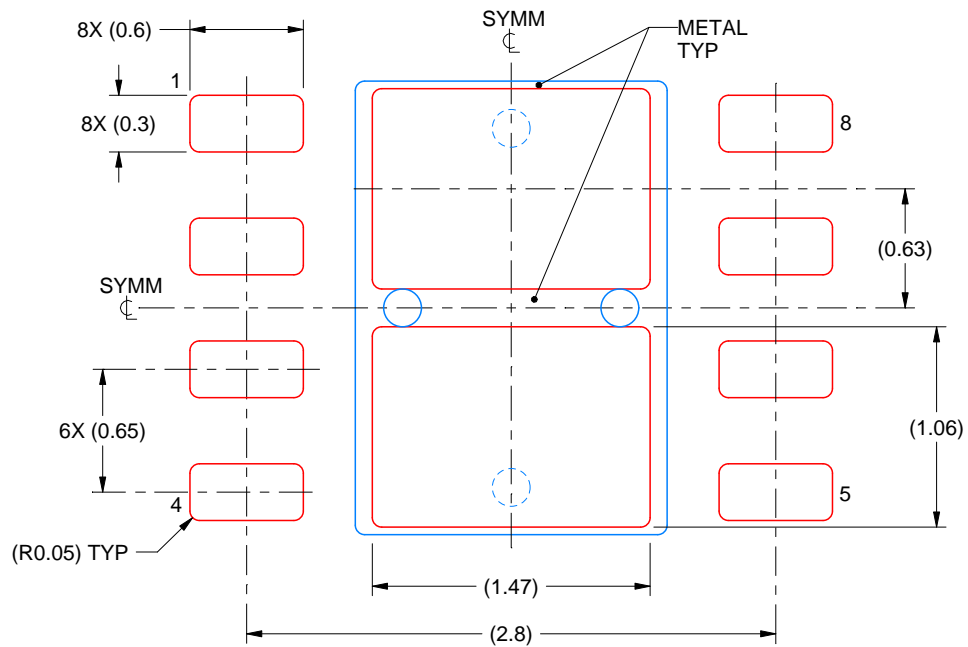
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DRB0008B

VSON - 1 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD  
81% PRINTED SOLDER COVERAGE BY AREA  
SCALE:25X

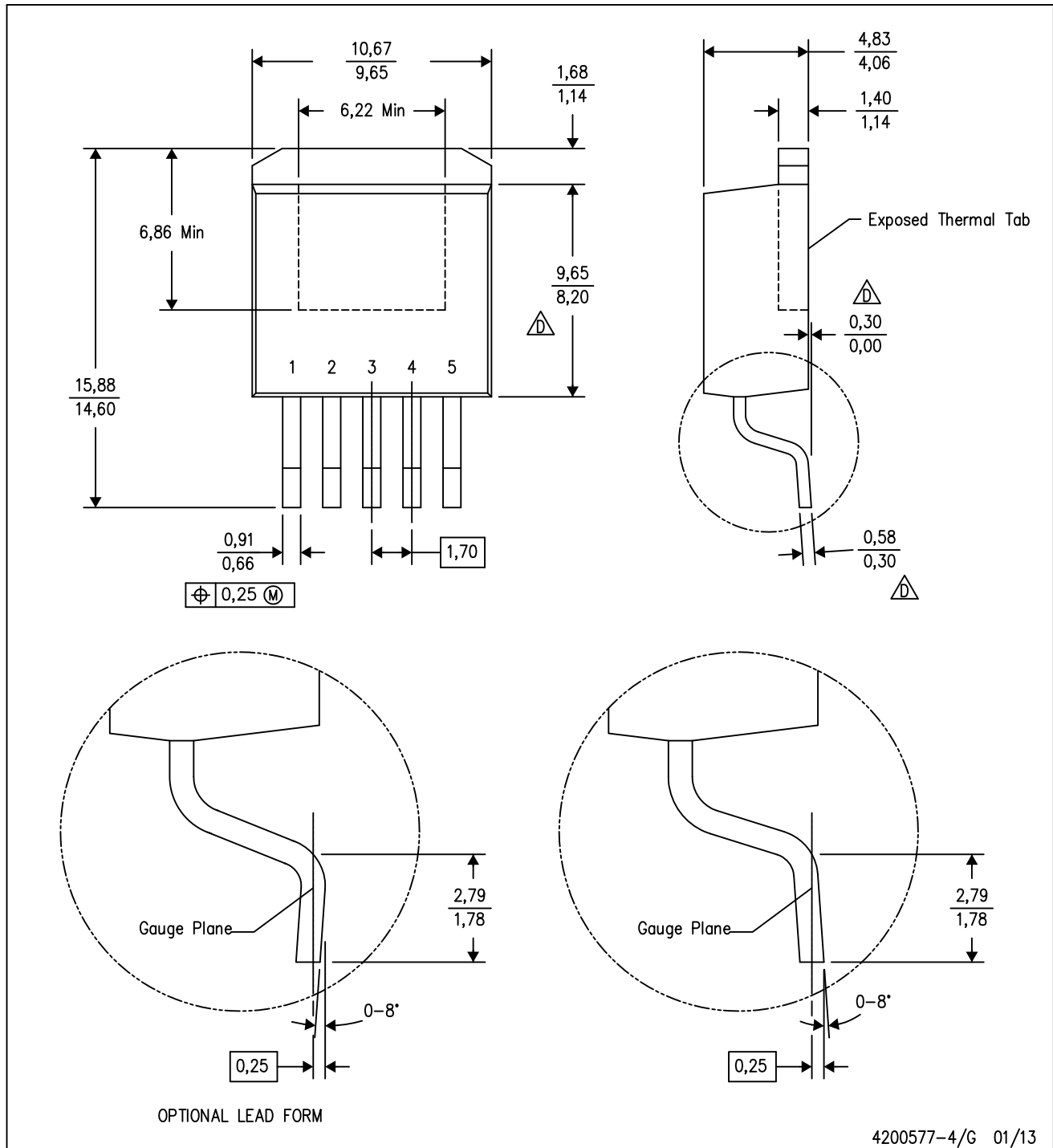
4218876/A 12/2017

NOTES: (continued)

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

KTT (R-PSFM-G5)

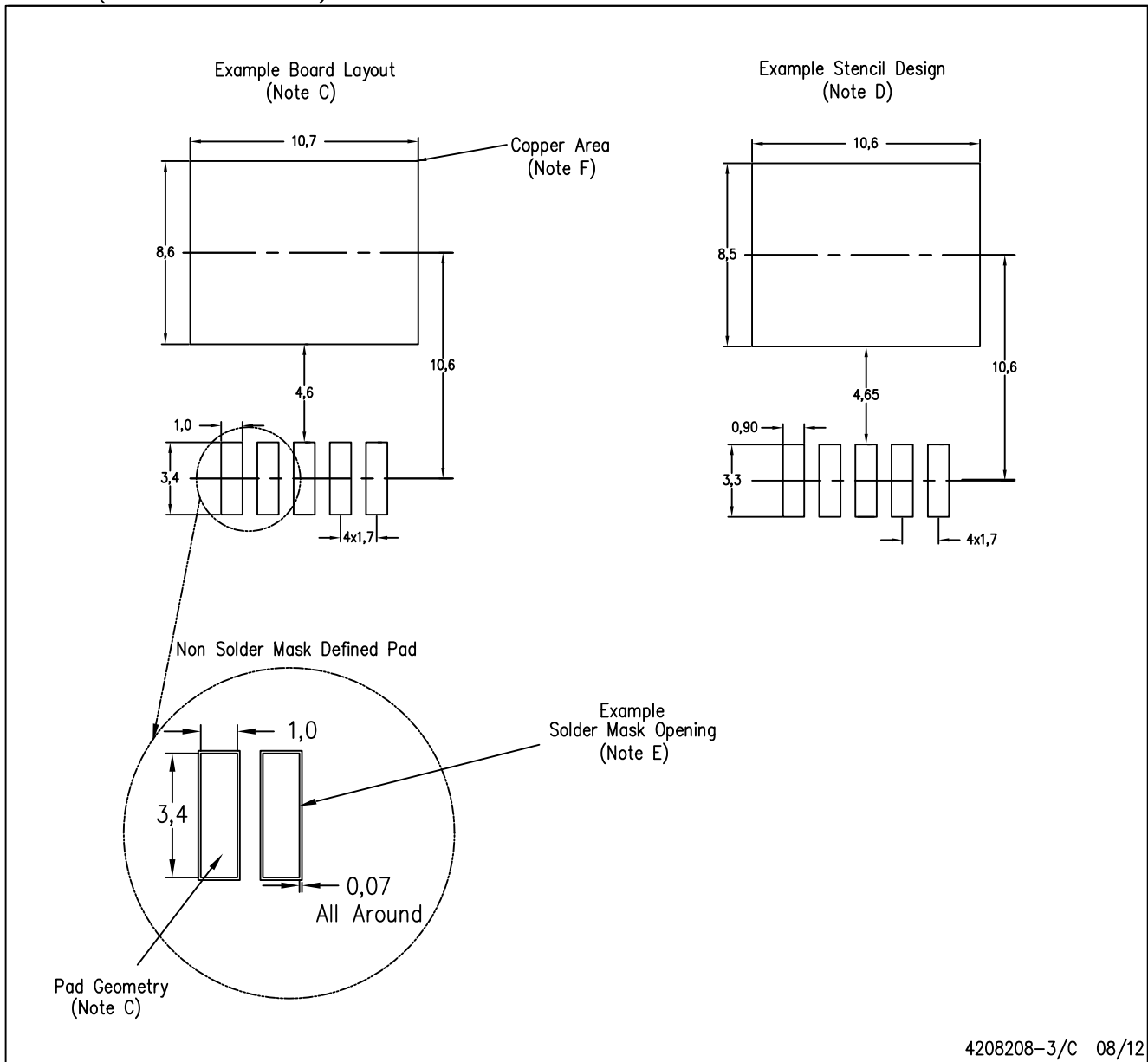
PLASTIC FLANGE-MOUNT PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash or protrusion not to exceed 0.005 (0,13) per side.
- △ Falls within JEDEC TO-263 variation BA, except minimum lead thickness, maximum seating height, and minimum body length.

KTT (R-PSFM-G5)

PLASTIC FLANGE-MOUNT PACKAGE



4208208-3/C 08/12

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-SM-782 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
  - This package is designed to be soldered to a thermal pad on the board. Refer to the Product Datasheet for specific thermal information, via requirements, and recommended thermal pad size. For thermal pad sizes larger than shown a solder mask defined pad is recommended in order to maintain the solderable pad geometry while increasing copper area.







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