



TPS22949x Current-Limited Load Switch With Low Noise Regulation Capability

1 Features

- Integrated Current Limiter
 - Input Voltage Range: 1.62 V to 4.5 V
 - Low ON-Resistance
 - $r_{ON} = 300\text{-m}\Omega$ at $V_{IN} = 4.5\text{ V}$
 - $r_{ON} = 350\text{-m}\Omega$ at $V_{IN} = 3.3\text{ V}$
 - $r_{ON} = 400\text{-m}\Omega$ at $V_{IN} = 2.5\text{ V}$
 - $r_{ON} = 600\text{-m}\Omega$ at $V_{IN} = 1.8\text{ V}$
 - Integrated 100-mA Minimum Current Limit
 - Undervoltage Lockout
 - Fast-Current Limit Response Time
 - Integrated Fault Blanking and Auto Restart
- Stable Without Current Limiter Output Capacitor (TPS22949A Only)
- Integrated Low-Noise RF LDO
 - Input Voltage Range: 1.62 V to 4.5 V
 - Low Noise: 50 μVrms (10 Hz to 100 kHz)
 - 80-dB V_{IN} PSRR (10 Hz to 10 kHz)
 - Fast Start-Up Time: 130 μs
 - Low Dropout 100 mV at $I_{load} = 100\text{ mA}$
 - Integrated Output Discharge
 - Stable With 2.2- μF Output Capacitor
- 1.8-V Compatible Control Input Threshold
- ESD Performance Tested Per JESD 22
 - 3500 V Human Body Model (A114-B, Class II)
 - 1000 V Charged Device Model (C101)
- Tiny 8-Terminal YZP Package (1.9 mm $\times$ 0.9 mm, 0.5-mm Pitch, 0.5-mm Height) and WSON-8 (DRG) 3.0 mm $\times$ 3.0 mm

2 Applications

- Fingerprint Module Protection
- Portable Consumer Electronics
- Smart Phones
- Notebooks
- Control Access Systems

3 Description

The TPS22949 and TPS22949A are devices that provide protection to systems and loads in high-current conditions. The device contains a 500-m Ω current-limited P-channel MOSFET that can operate over an input voltage range of 1.62 V to 4.5 V as well as a low-dropout (LDO) regulator with a fixed output voltage of 1.8 V.

The switch is controlled by an on/off input (EN1), which can interface directly with low-voltage control signals. When the switch current reaches the maximum limit, the TPS22949/TPS22949A operates in a constant-current mode to prohibit excessive currents from causing damage. If the constant current condition persists after 12 ms, these devices shut off the switch and pull the fault signal pin (OC) low. The TPS22949/TPS22949A has an auto-restart feature that turns the switch on again after 70 ms if the EN1 pin is still active.

The output of the current limiter is internally connected to an RF low-dropout (LDO) regulator that offers good AC performance with very low ground current, good power supply rejection ratio (PSRR), low noise, fast start-up, and excellent line and load transient response. The output of the regulator is stable with ceramic capacitors. This LDO uses a precision voltage reference and feedback loop to achieve overall accuracy of 2% over all load, line, process, and temperature variations.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS22949	DSBGA (8)	1.90 mm $\times$ 0.90 mm
TPS22949A	DSBGA (8)	1.90 mm $\times$ 0.90 mm
	WSON (8)	3.00 mm $\times$ 3.00 mm

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

Typical Application Schematic

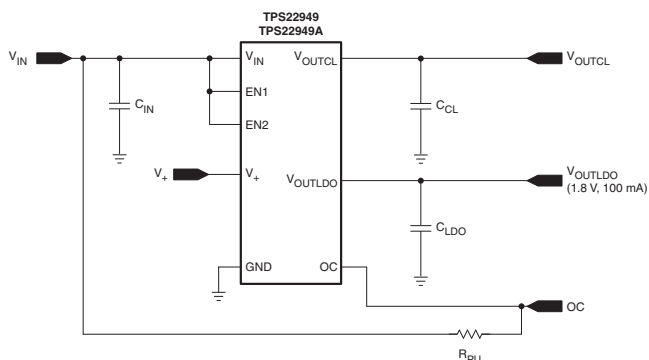


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4 Revision History

Changes from Revision C (January 2010) to Revision D

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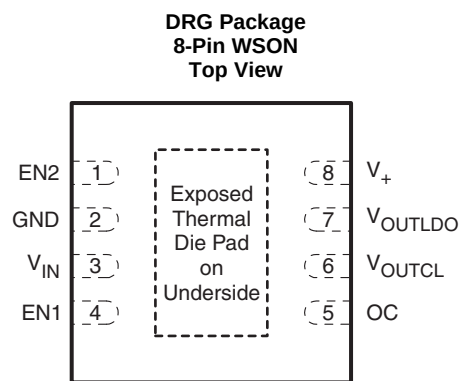
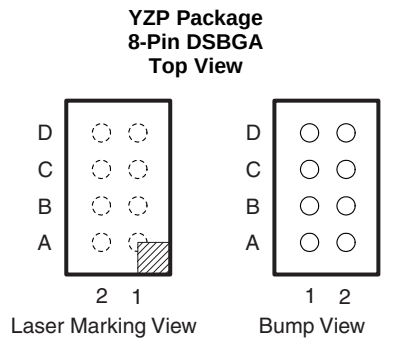
• Added ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section	1
• Deleted Dissipation Ratings table	5

5 Description (continued)

The TPS22949A integrates additional internal circuitry that increases the current limit of the switch during the power-up sequence. This feature allows the TPS22949A to operate without a storage capacitor at the input of the LDO.

The TPS22949 and TPS22949A are available in a space-saving 8-terminal WCSP (YZP) or in an 8-pin WSON package (DRG). Both devices are characterized for operation over the free-air temperature range of -40°C to 85°C .

6 Pin Configuration and Functions



The exposed center pad, if used, must be connected as a secondary GND or left electrically open.

Pin Functions

PIN			I/O	DESCRIPTION
NAME	DSBGA	WSON		
EN1	D2	4	I	Power switch control input. Active high. Do not leave floating.
EN2	A2	1	I	LDO control input. Active high. Do not leave floating.
GND	B2	2	—	Ground
OC	D1	5	O	Overcurrent output flag. Active low, open-drain output that indicates an overcurrent, supply undervoltage, or overtemperature state.
V ₊	A1	8	I	Supply voltage
V _{IN}	C2	3	I	Supply input. Input to the power switch; bypass this input with a ceramic capacitor to ground.
V _{OUTCL}	C1	6	O	Switch output. Output of the power switch
V _{OUTLDO}	B1	7	O	LDO output. Output of the RF LDO fixed to 1.8 V ⁽¹⁾ .

(1) Output voltages from 0.9 V to 3.6 V in 50-mV increments are available through the use of innovative factory EEPROM programming; minimum order quantities may apply. Contact factory for details and availability.

YZP Package Pin Assignments

D	EN1	OC
C	V _{IN}	V _{OUTCL}
B	GND	V _{OUTLDO}
A	EN2	V ₊
	2	1

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

			MIN	MAX	UNIT
V_I	Input voltage	V_{IN} , EN1, EN2, V_+	–0.3	6	V
V_{OUTCL}	Current limiter output voltage			$V_{IN} + 0.3$	V
T_J	Operating junction temperature		–40	105	°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, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±3500
		Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1000

- (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.

7.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage ⁽¹⁾	1.62		4.5	V
V_{OUTCL}	Current limiter output voltage			V_{IN}	V
V_+	Supply voltage	2.6		5.5	V
C_{IN}	Input capacitor	1			µF
T_A	Ambient free-air temperature	–40		85	°C
CONTROL INPUTS (EN1, EN2)					
V_{IH}	High-level input voltage	1.4		5.5	V
V_{IL}	Low-level input voltage			0.4	V

- (1) See the [Application and Implementation](#).

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPS22949x		UNIT
		YZP [DSBGA]	DRG [WSON]	
		8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	105.8	51.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	1.6	65.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	10.8	25.9	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	3.1	1.3	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	10.8	26	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	6.1	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

7.5 Electrical Characteristics

 $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
I_{GND}	Ground pin current	EN1 and EN2 = V_+ $V_+ = V_{\text{OUT}} + 1.4\text{ V}$ or 2.5 V , whichever $> 5.5\text{ V}$, $V_{\text{OUTCL}} \geq V_{\text{OUTLDO}} + 0.5\text{ V}$ $I_{\text{OUT2}} = 0\text{ mA}$		85	110	μA
I_{GNDCL}	Ground pin current (current limiter only)	EN1 = V_+ and EN2 = 0		40	75	μA
$I_{\text{GND(OFF)}}$	OFF-state ground pin current	EN1 and EN2 = GND, $V_{\text{OUTCL}} = \text{Open}$, $V_{\text{OUTLDO}} = \text{Open}$	$V_{\text{IN}} = V_+ = 3.3\text{ V}$		2	μA
			$V_{\text{IN}} = 3.6\text{ V}$, $V_+ = 5.5\text{ V}$		6	
I_{EN2}	Enable pin 2 current, enabled	VEN2 = $V_+ = 5.5\text{ V}$, $V_{\text{IN}} = 4.5\text{ V}$			1	μA
I_{EN1}	Enable pin 1 current, enabled	VEN1 = $V_+ = 5.5\text{ V}$, $V_{\text{IN}} = 4.5\text{ V}$			1	μA
Thermal shutdown	Shutdown threshold (T_A)	TPS22949		122		$^{\circ}\text{C}$
		TPS22949A		135		
	Return from shutdown	TPS22949		112		
		TPS22949A		120		
	Hysteresis	TPS22949		10		
		TPS22949A		10		

(1) Typical values are at $V_{\text{IN}} = 3.3\text{ V}$ and $T_A = 25^{\circ}\text{C}$.

7.6 Current Limiter Electrical Characteristics

over operating free-air temperature range, $V_+ = 3.3\text{ V}$, EN1 = V_+ , EN2 = GND (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T _A	YZP PACKAGE			DRG PACKAGE			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
r _{ON}	ON-state resistance	I _{OUT} = 20 mA	V _{IN} = 4.5 V	25°C	0.3	0.4		0.4	0.5	Ω	
				Full		0.5		0.6			
			V _{IN} = 3.3 V	25°C	0.35	0.6		0.45	0.7		
				Full		0.7		0.8			
			V _{IN} = 2.5 V	25°C	0.4	0.7		0.5	0.8		
				Full		0.8		0.9			
			V _{IN} = 1.8 V	25°C	0.6	0.9		0.7	1		
				Full		1.0		1.1			
V _{IN} = 1.62 V	25°C	0.7	1.0		0.8	1.1					
	Full		1.1			1.2					
I _{LIM}	Current limit	V _{OUT} = 3 V	V _{IN} = 3.3 V	Full	100	150	200	100	150	200	mA
I _{LIM (INRUSH)}	Power-ON inrush current limit (TPS22949A only)	V _{OUT} = 3 V	V _{IN} = 3.3 V	Full	750			750			
UVLO-CL	Undervoltage shutdown	V _{IN} increasing			1.39	1.49	1.59	1.39	1.49	1.59	V
	Undervoltage shutdown hysteresis				30			30			mV
	OC output logic low voltage	I _{SINK} = 10 mA	V _{IN} = 4.5 V	Full	0.1	0.3		0.1	0.3	V	
			V _{IN} = 1.8 V		0.2	0.4		0.2	0.4		

7.7 Low-Noise LDO Regulator Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{OUTLDO}	Output voltage ⁽¹⁾		1.76	1.8	1.84	V
$\Delta V_{OUTLDO}/\Delta V_{IN}$	V _{IN} line regulation	V _{IN} = V _{OUTLDO} + 0.5 V to 4.5 V, I _{OUT} = 1 mA		±0.1		%/V
	V _{IN} line transient	ΔV_{IN} = 400 mV, t _r = t _f = 1 μs		±2		mV
$\Delta V_{OUTLDO}/\Delta V_{+}$	V ₊ line regulation	V _{IN} = V _{OUTLDO} + 1.4 V or 2.5 V, whichever is > 5.5 V, I _{OUT} = 1 mA		±0.1		%/V
	V ₊ line transient	ΔV_{IN} = 600 mV, t _r = t _f = 1 μs		±5		mV
$\Delta V_{OUTLDO}/\Delta I_{OUT2}$	Load regulation	I _{OUT2} = 0 to 100 mA (no load to full load)		±0.01		%/V
	Load transient	I _{OUT2} = 0 to 100 mA, t _r = t _f = 1 μs		±35		mV
V _{DO}	Dropout voltage (V _{DO} = V _{IN} – V _{OUTLDO})	V _{IN} = V _{OUTLDO(NOM)} – 0.1 V, V ₊ – V _{OUTLDO(NOM)} = 1.4 V, I _{OUT} = 100 mA		110	200	mV
V _{IN} PSRR	Power supply rejection ratio	V _{OUTCL} – V _{OUTLDO} ≥ 0.5 V, V ₊ = V _{OUTLDO} + 1.4 V, I _{OUT} = 100 mA,	f = 10 Hz	75		dB
			f = 100 Hz	75		
			f = 1 kHz	80		
			f = 10 kHz	80		
			f = 100 kHz	85		
			f = 1 MHz	85		
V ₊ PSRR	Power supply rejection ratio	V _{OUTCL} – V _{OUTLDO} ≥ 0.5 V, V ₊ = V _{OUTLDO} + 1.4 V, I _{OUT} = 100 mA,	f = 10 Hz	80		dB
			f = 100 Hz	80		
			f = 1 kHz	75		
			f = 10 kHz	65		
			f = 100 kHz	55		
			f = 1 MHz	35		
V _N	Output noise voltage	V ₊ ≥ 2.5 V, V _{OUTLDO} = V _{OUTCL} + 0.5 V	BW = 10 Hz to 100 kHz		50	μVrms
t _{STR}	Start-up time	V _{OUT} = 95%, V _{OUT(NOM)} , I _{OUT} = 100 mA, C _{OUT} = 2.2 μF		130	250	μs
UVLO-V ₊	Undervoltage lockout	V ₊ rising	2.3	2.45	2.55	V
	Hysteresis	V ₊ falling		150		mV

(1) LDO output voltage is fixed at 1.8 V. However, output voltages from 0.9 V to 3.6 V in 50-mV increments are available through the use of innovative factory EEPROM programming; minimum order quantities may apply. Contact factory for details and availability.

7.8 Current Limiter Switching Characteristics

V_{IN} = 3.3 V, T_A = 25°C, R_L = 500 Ω, C_L = 0.1 μF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t _{ON}	Turnon time	R _L = 500 Ω, C _{CL} = 0.1 μF		95		μs
t _{OFF}	Turnoff time	R _L = 500 Ω, C _{CL} = 0.1 μF		2		μs
t _r	V _{OUT} rise time	R _L = 500 Ω, C _{CL} = 0.1 μF		25		μs
t _f	V _{OUT} fall time	R _L = 500 Ω, C _{CL} = 0.1 μF		10		μs
t _{BLANK}	Overcurrent blanking time		6	12	18	ms
t _{RSTRT}	Auto-restart time		40	80	120	ms
t _{INRUSH}	Power-ON inrush current limit time (TPS22949A only)	R _L = 500 Ω, C _{CL} = 0.1 μF		150		μs
Short-circuit response time		V _{IN} = V _{EN1} = 3.3 V, moderate overcurrent condition		11		μs
		V _{IN} = V _{EN1} = 3.3 V, hard short		5		

7.9 Typical Characteristics

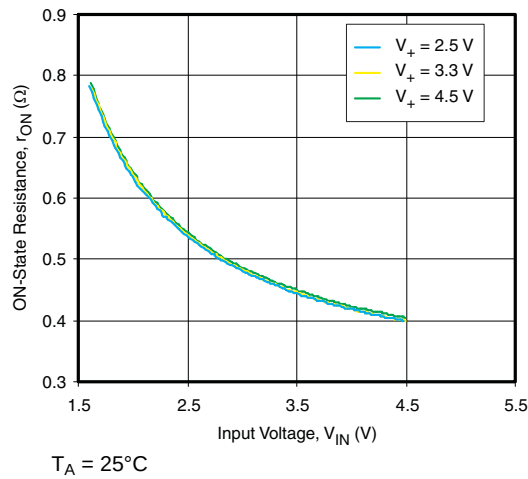


Figure 1. ON-State Resistance vs Input Voltage

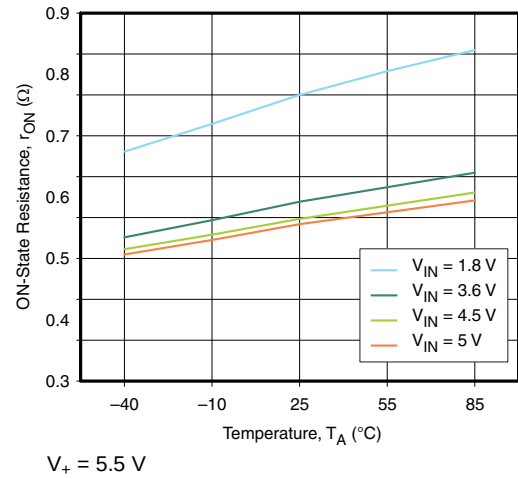


Figure 2. ON-State Resistance vs Temperature,

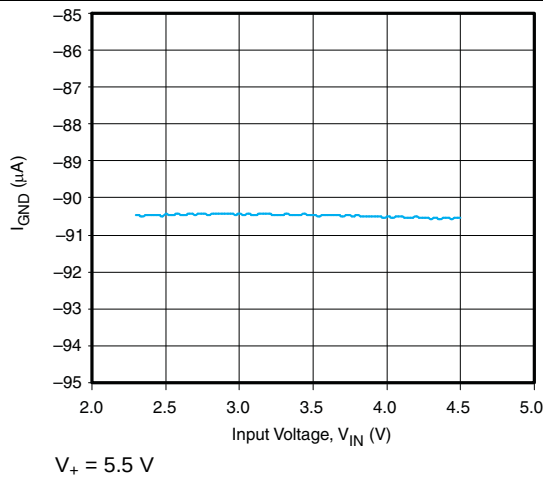


Figure 3. Ground Pin Current vs Input Voltage

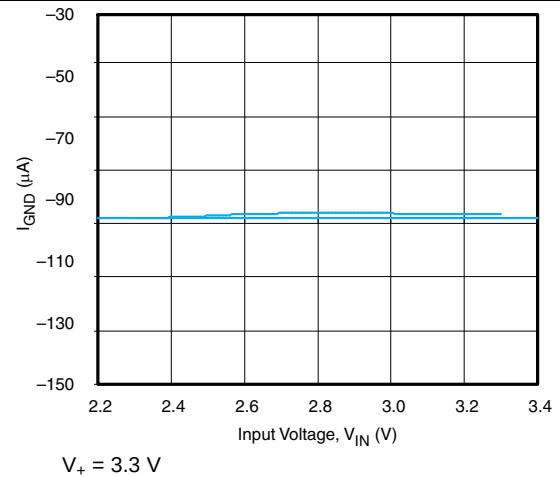


Figure 4. Ground Pin Current vs Input Voltage

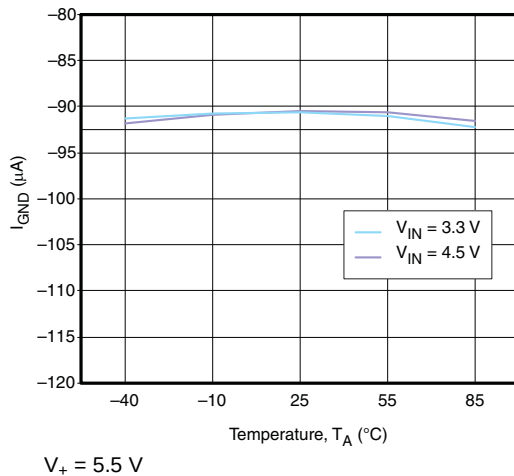


Figure 5. Ground Pin Current vs Temperature

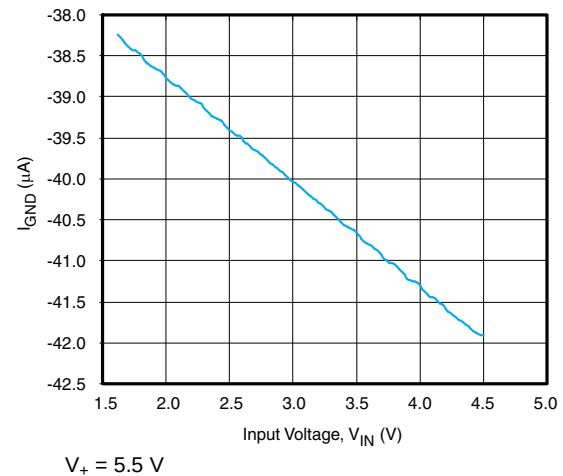


Figure 6. Ground Pin Current vs Input Voltage
(Current Limiter Only)

Typical Characteristics (continued)

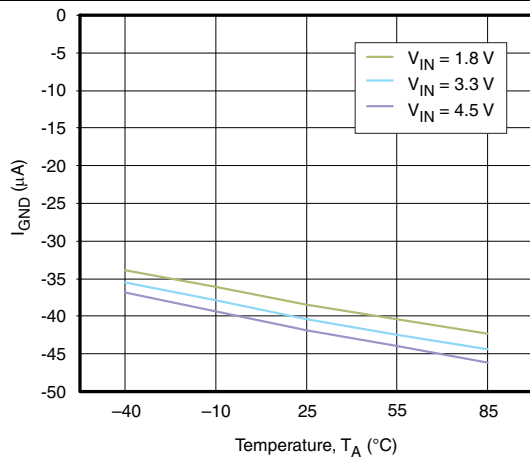


Figure 7. Ground Pin Current vs Temperature (Current Limiter Only)

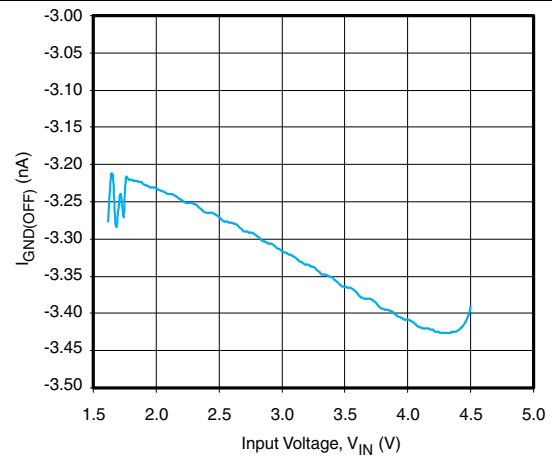


Figure 8. OFF-State Ground Current vs Input Voltage

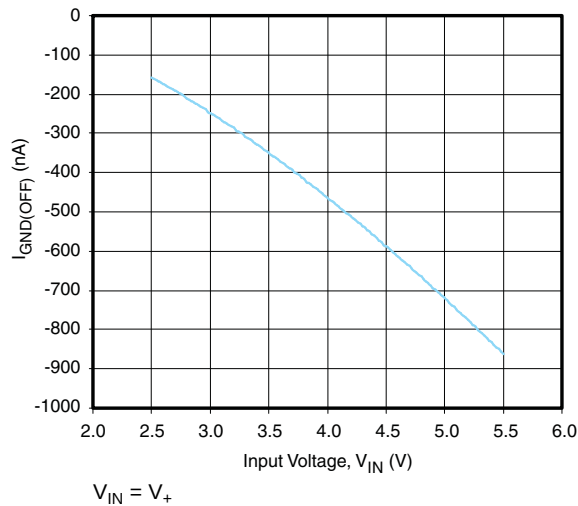


Figure 9. OFF-State Ground Current vs Input Voltage

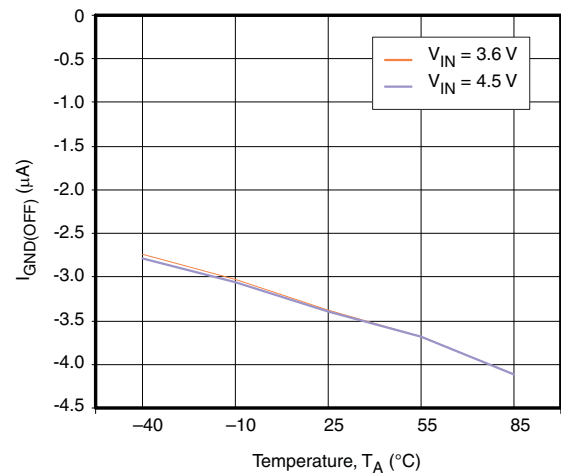


Figure 10. OFF-State Ground Current vs Temperature

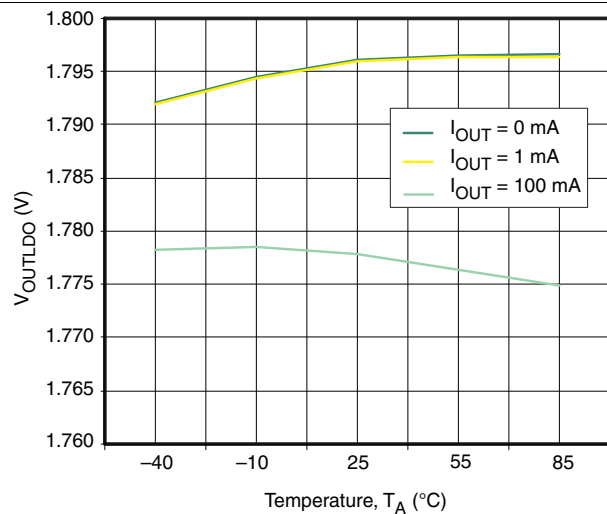


Figure 11. Output Voltage vs Temperature

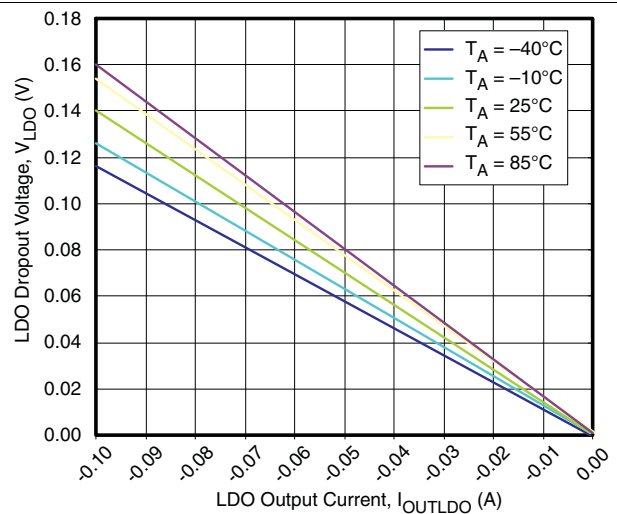
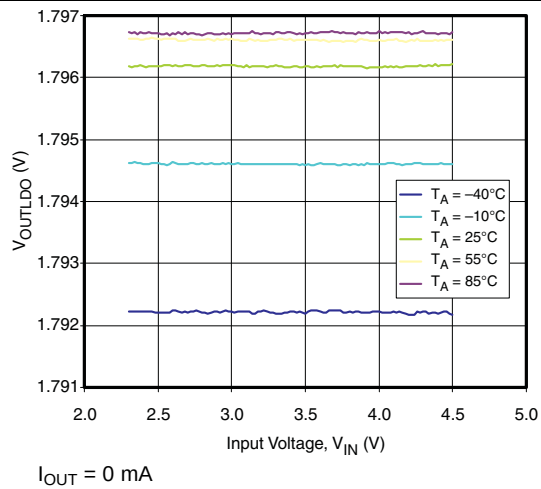
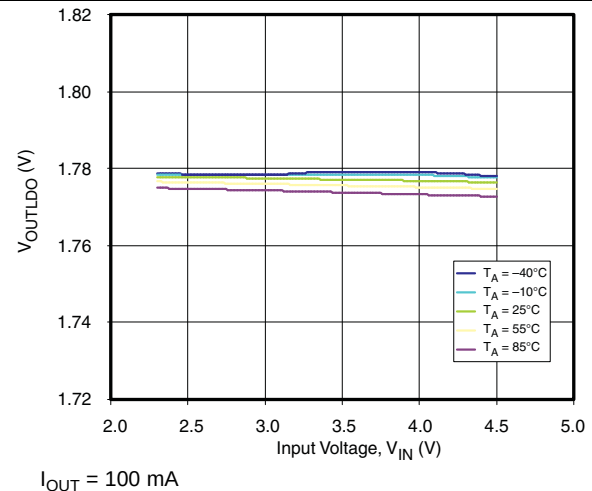
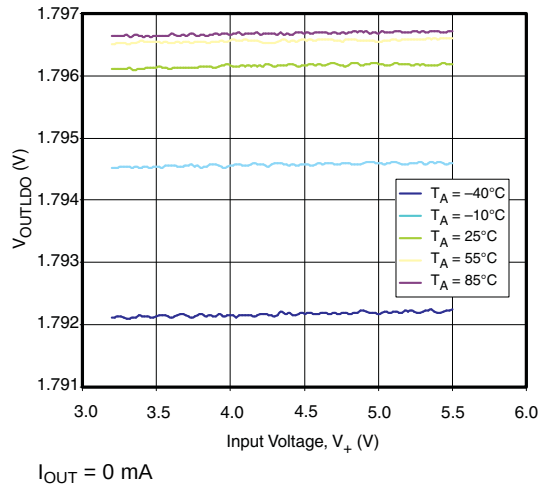
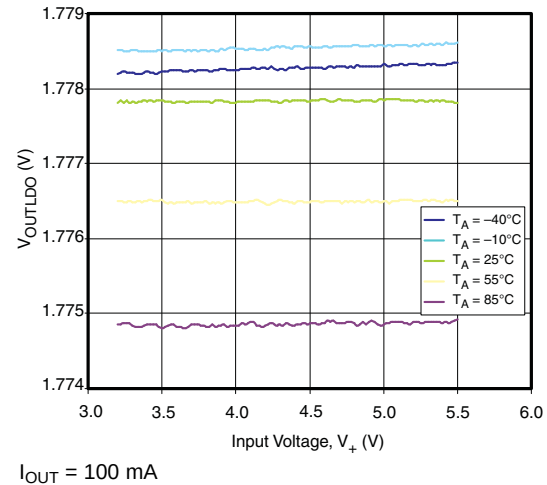
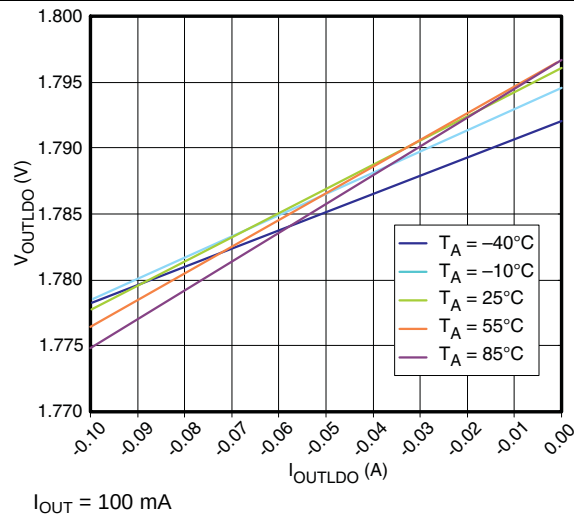
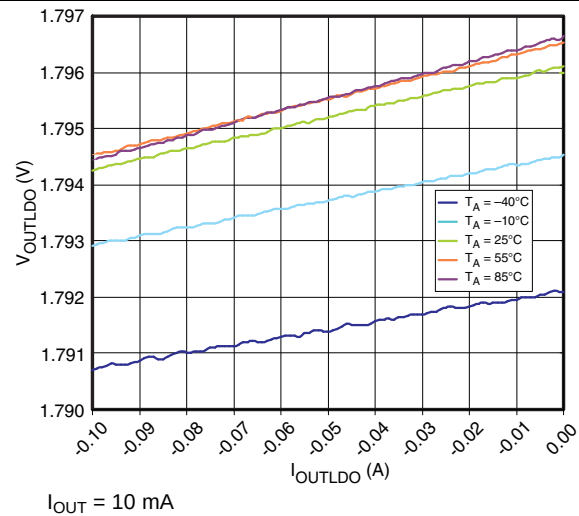


Figure 12. LDO Dropout Voltage vs Output Current

Typical Characteristics (continued)


Figure 13. Input Voltage, V_{IN} , Line Regulation

Figure 14. Input Voltage, V_{IN} , Line Regulation

Figure 15. Input Voltage, V_+ , Line Regulation

Figure 16. Input Voltage, V_+ , Line Regulation

Figure 17. Load Regulation

Figure 18. Load Regulation Under Light Loads

Typical Characteristics (continued)

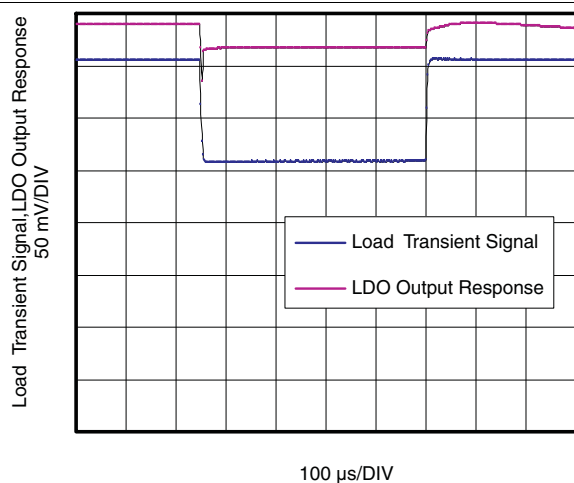


Figure 19. Load Transient

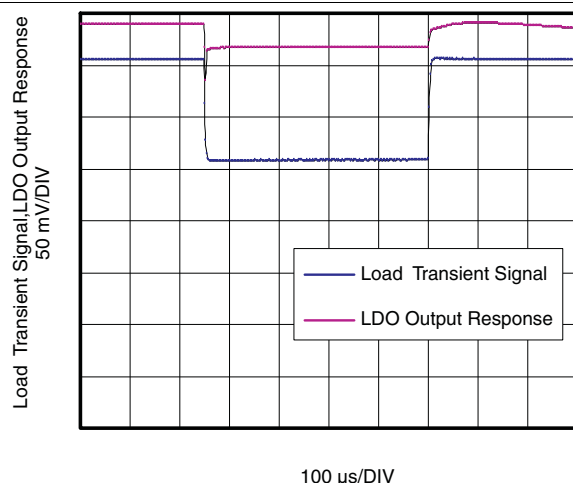


Figure 20. V_{IN} Load Transient

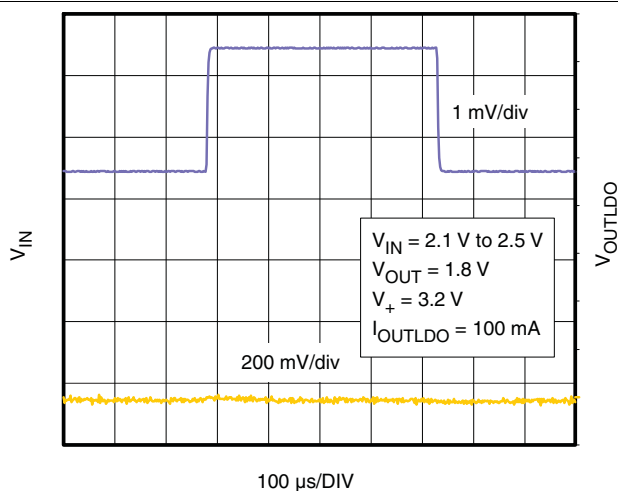


Figure 21. V₊ Load Transient

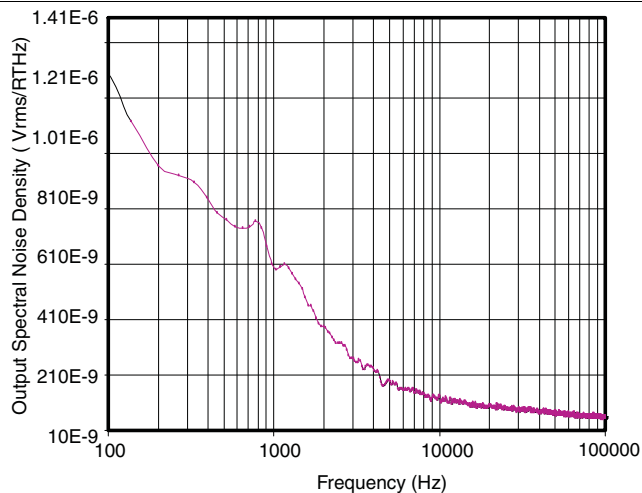


Figure 22. Output Spectral Noise Density vs Frequency

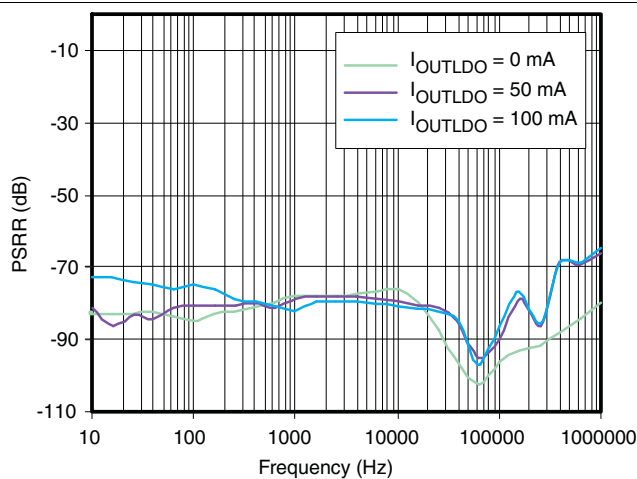


Figure 23. PSRR vs Frequency

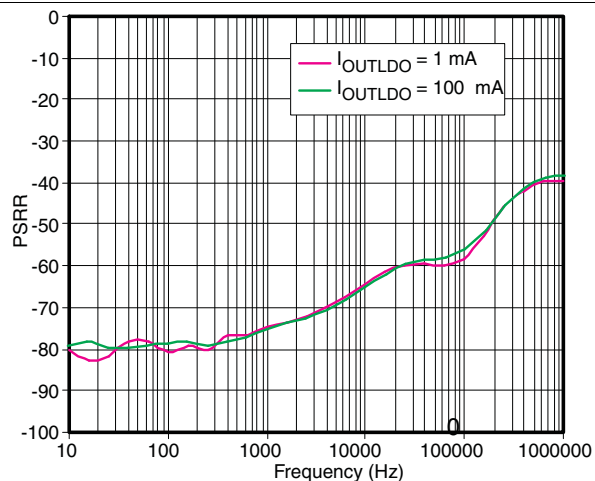
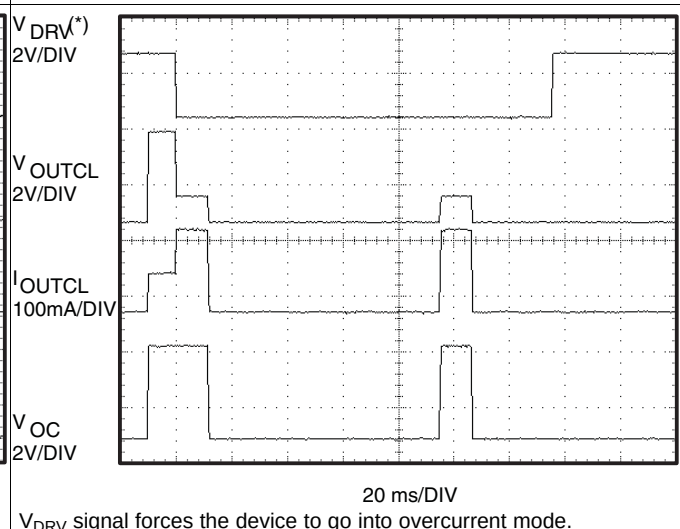
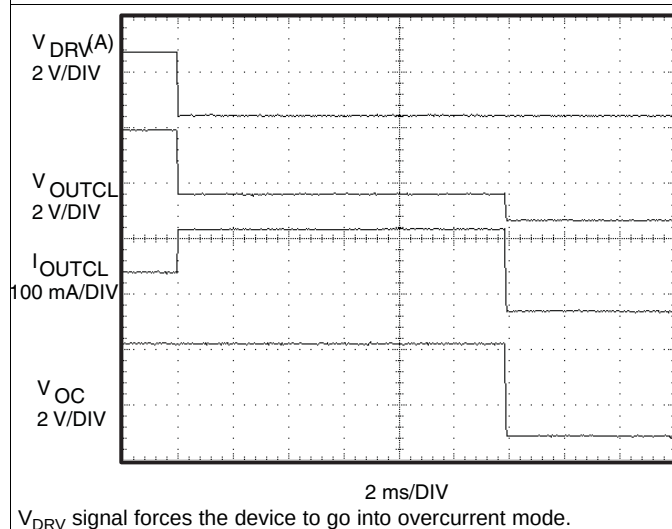
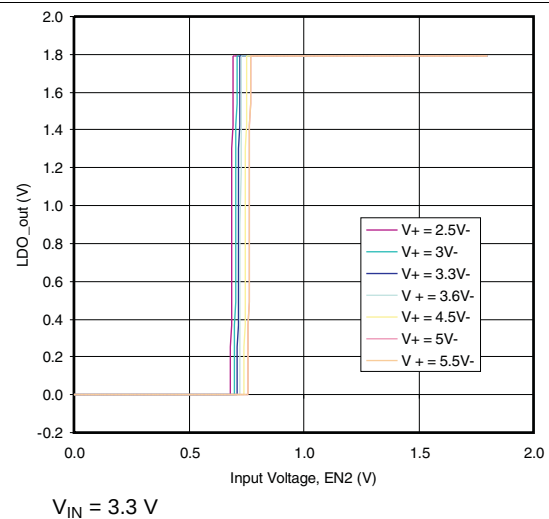
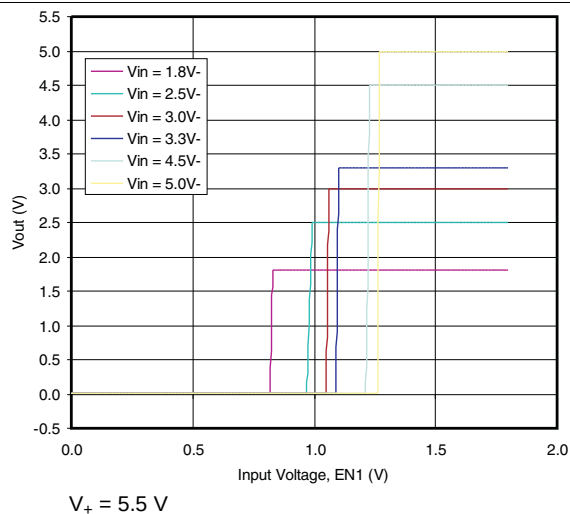
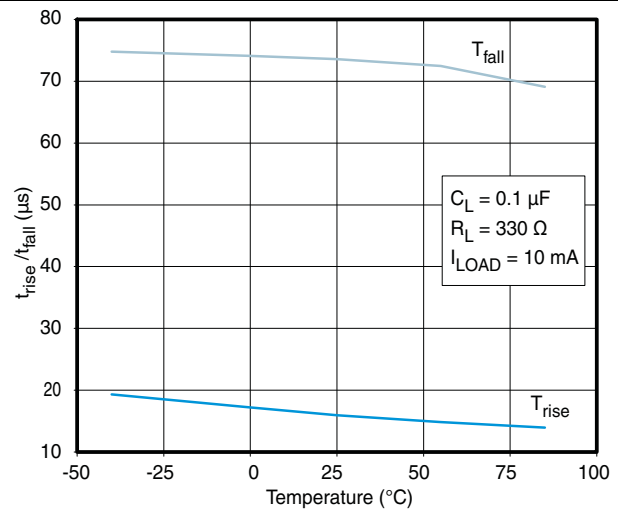
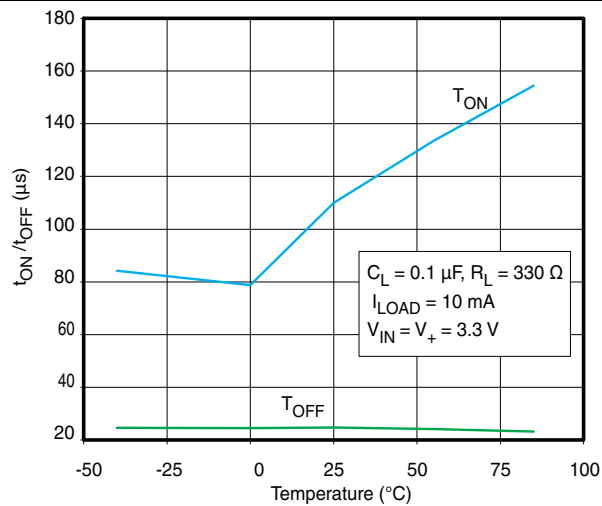


Figure 24. V₊ PSRR vs Frequency

Typical Characteristics (continued)



Typical Characteristics (continued)

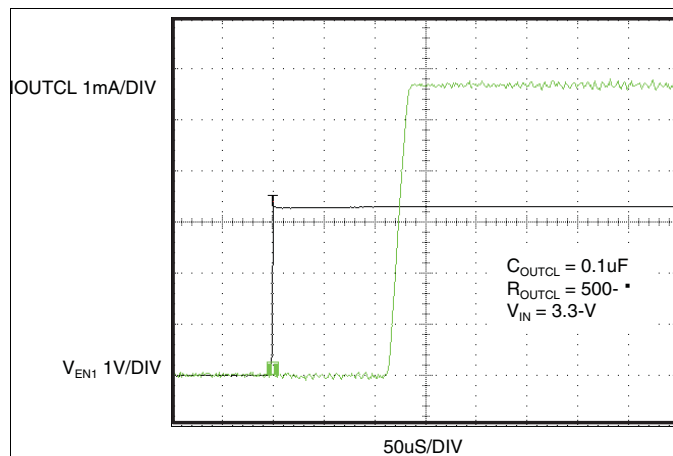


Figure 31. Current Limiter t_{ON} Response

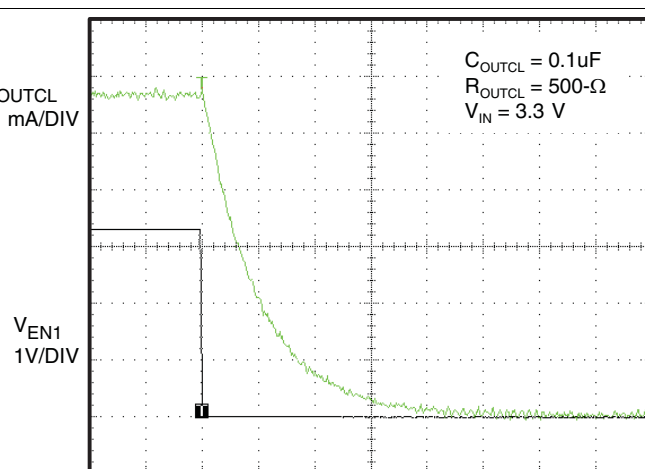


Figure 32. Current Limiter t_{OFF} Response

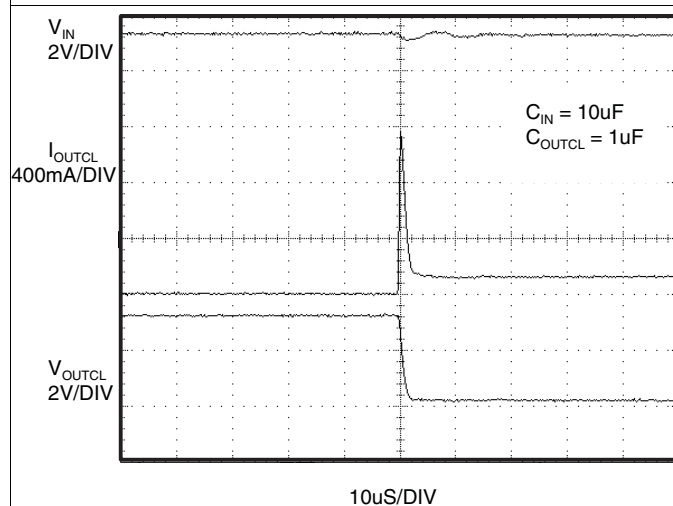


Figure 33. Short-Circuit Response Time (V_{OUTCL} Shorted to GND)

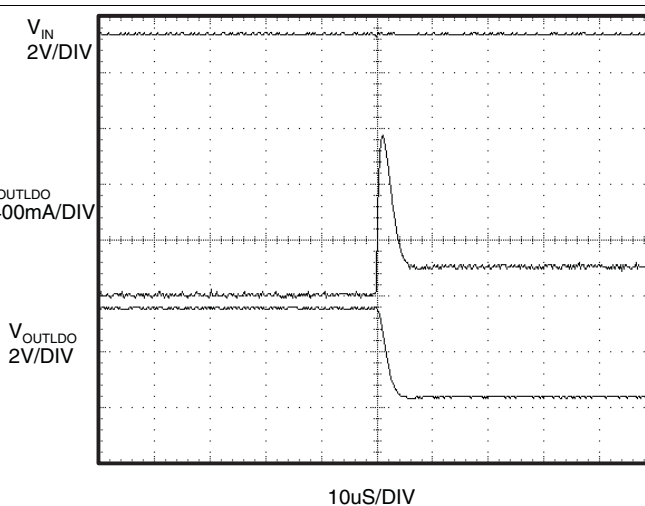


Figure 34. Short-Circuit Response Time (V_{OUTLDO} Shorted to GND)

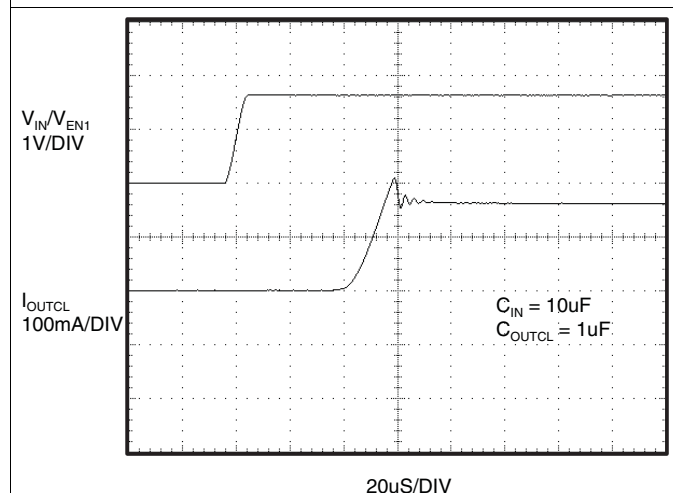


Figure 35. Short-Circuit Response Time (Switch Power Up to Hard Short) (TPS22949)

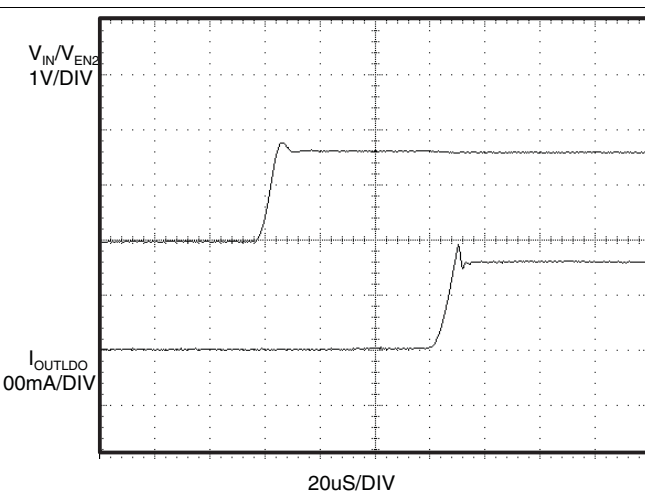
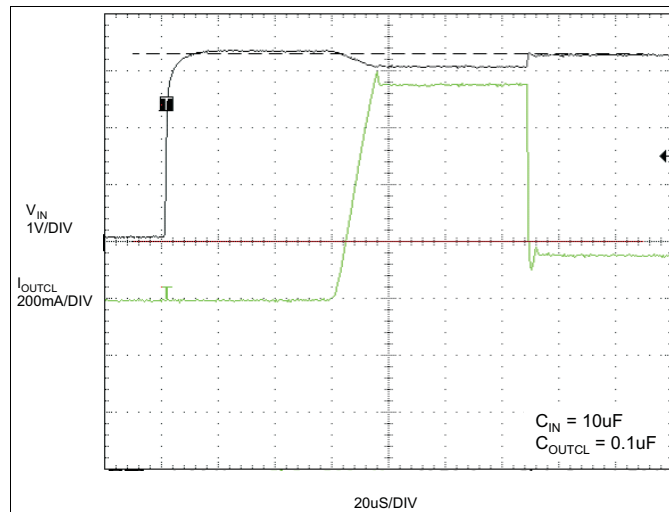
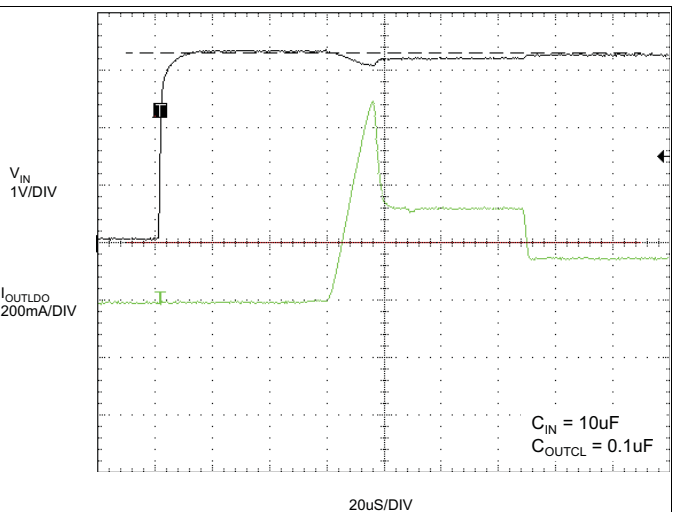
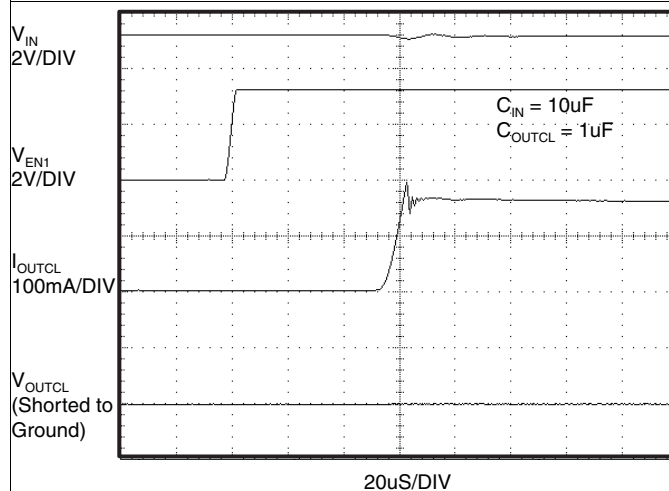
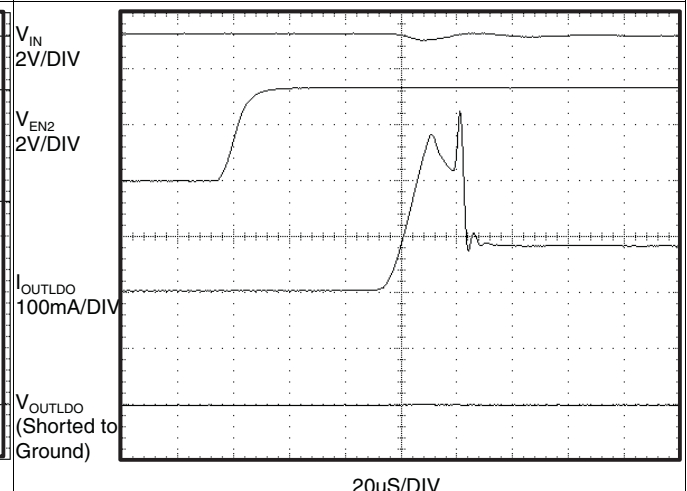


Figure 36. Short-Circuit Response Time (LDO Power Up to Hard Short) (TPS22949)

Typical Characteristics (continued)

Figure 37. Short-Circuit Response Time (Switch Power Up to Hard Short) (TPS22949A)

Figure 38. Short-Circuit Response Time (LDO Power Up to Hard Short) (TPS22949A)

Figure 39. Current Limit Response Time (Current Limiter)

Figure 40. Current Limit Response Time (LDO)

8 Detailed Description

8.1 Overview

The TPS22949 and TPS22949A are devices that provide protection to systems and loads in high-current conditions. The device contains a 500-mΩ current-limited P-channel MOSFET that can operate over an input voltage range of 1.62 V to 4.5 V. In addition, these devices feature a low-dropout regulator (LDO) with a fixed output voltage of 1.8 V. When the switch current reaches the maximum limit, the TPS22949/TPS22949A operates in a constant-current mode to prohibit excessive currents from causing damage. The fault signal pin (OC) will signal the constant current condition if it persists after 12 ms. The output of the current limiter is internally connected to the LDO.

8.2 Functional Block Diagram

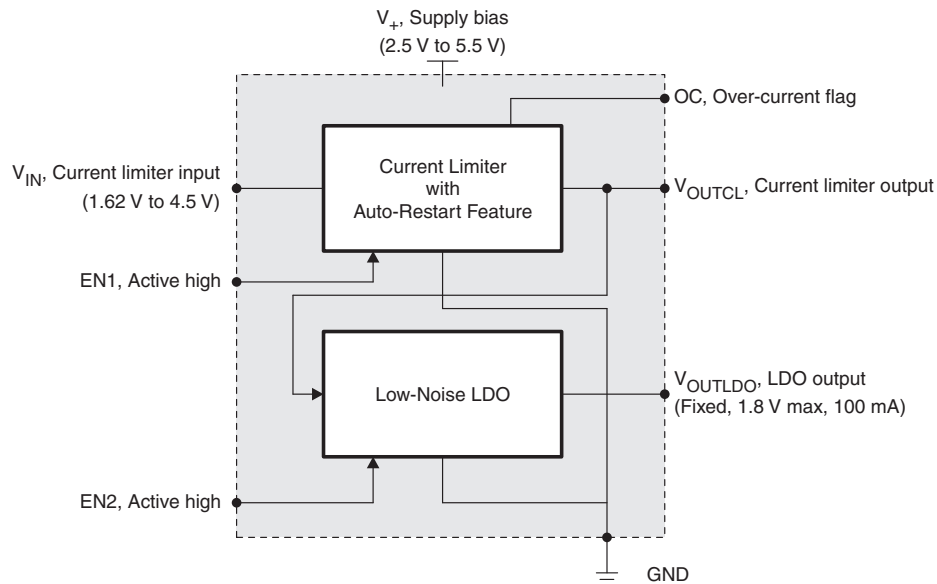
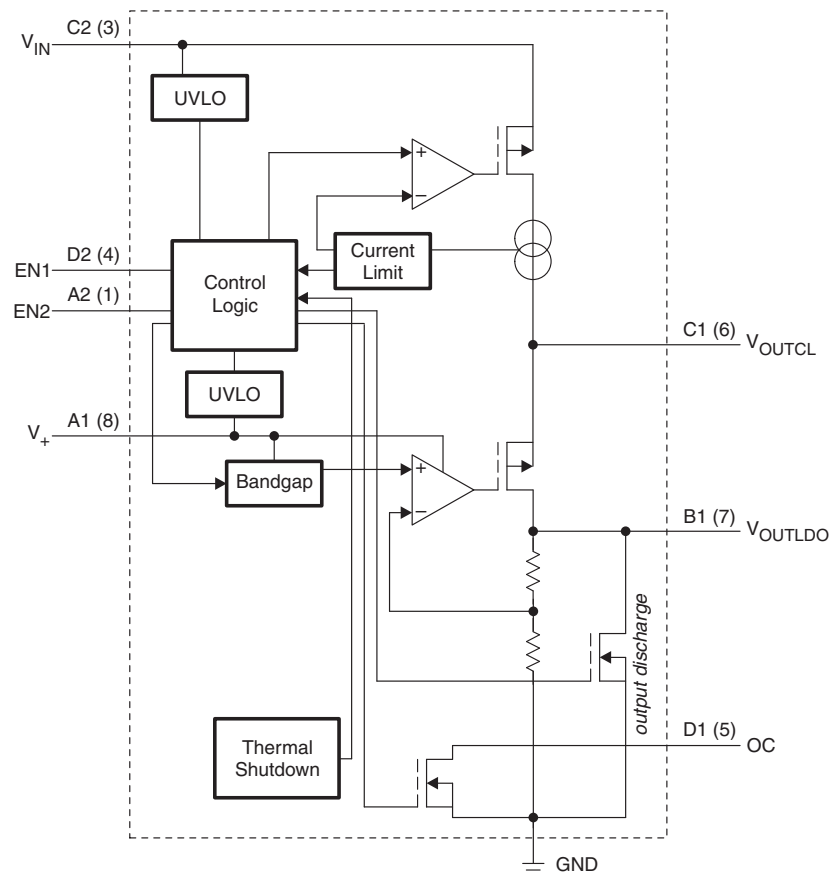


Figure 41. Simplified Block Diagram



8.4 Device Functional Modes

[Table 1](#) summarizes the LDO state as determined by the EN1 and EN2 pins.

Table 1. Function Table

STATE OF THE DEVICE	EN1	EN2
Current limiter and LDO disabled	0	X
Current limiter enabled and LDO disabled	1	0
Current limiter and LDO enabled	1	1

9 Application and Implementation

NOTE

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

9.1 Application Information

This application illustrates the TPS22949 and TPS22949A configured with a 100-mA sinking load with both enables tied to the same input voltage.

9.1.1 Input Voltage

The input voltage (V_{IN}) of the current limiter is set from 1.62 V to 4.5 V, however if both the current limiter and the LDO are enabled, the user must be careful to keep the input voltage (V_{IN}) greater than 1.8 V + (voltage drop through the switch) + (voltage drop through the LDO); otherwise, the LDO does not have a high enough internal input signal to operate properly.

A current limiter input voltage ramp time less than the blanking time (approximately 10 ms typical) is recommended. If the ramp time extends beyond the blanking period, then the current limiter goes into recycle, and the system may not start or operate properly.

9.1.2 Input/Output Capacitors

Although an input capacitor is not required for stability of on the input pin (V_{IN}), it is good analog design practice to connect a 0.1- μ F to 1- μ F low equivalent series resistance (ESR) capacitor across the IN pin input supply near the regulator. This capacitor counteracts reactive input sources and improves transient response, noise rejection, and ripple rejection. A higher value capacitor may be necessary if large, fast rise time load transients are anticipated, or if the device is located close to the power source. If source impedance is not sufficiently low, a 0.1- μ F input capacitor may be necessary to ensure stability. The V_+ bias pin does not require an input capacitor because it does not source high currents. However, if source impedance is not sufficiently low, a small 0.1- μ F bypass capacitor is recommended.

A 0.1- μ F capacitor C_{CL} , must be placed between V_{OUTCL} and GND. This capacitor prevents parasitic board inductances from forcing V_{OUTCL} below GND when the switch turns off.

9.2 Typical Application

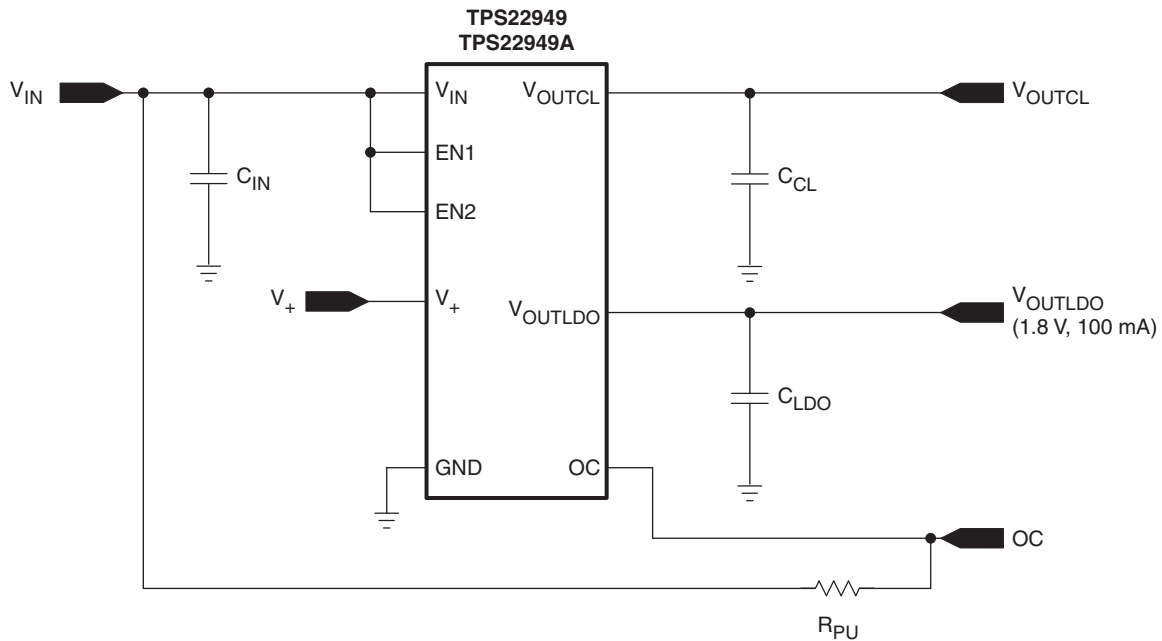


Figure 43. TPS22949/TPS22949A Typical Application With Both Enable Pins Tied to the Input Voltage

9.2.1 Design Requirements

For this design example, use the parameters listed in [Table 2](#) as the input parameters.

Table 2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
V _{IN}	3.3 V
V ₊	3.3 V
C _{IN}	4.7 μF
C _{LDO}	2.2 μF

9.2.2 Detailed Design Procedure

9.2.2.1 Start-Up Sequence

For the TPS22949, the total output capacitance must be kept below a maximum value, C_{CL(max)}, to prevent the part from registering an overcurrent condition and turning off the switch. The maximum output capacitance can be determined from [Equation 1](#):

$$C_{CL} = I_{LIM(MAX)} \times t_{BLANK(MIN)} \div V_{IN} \quad (1)$$

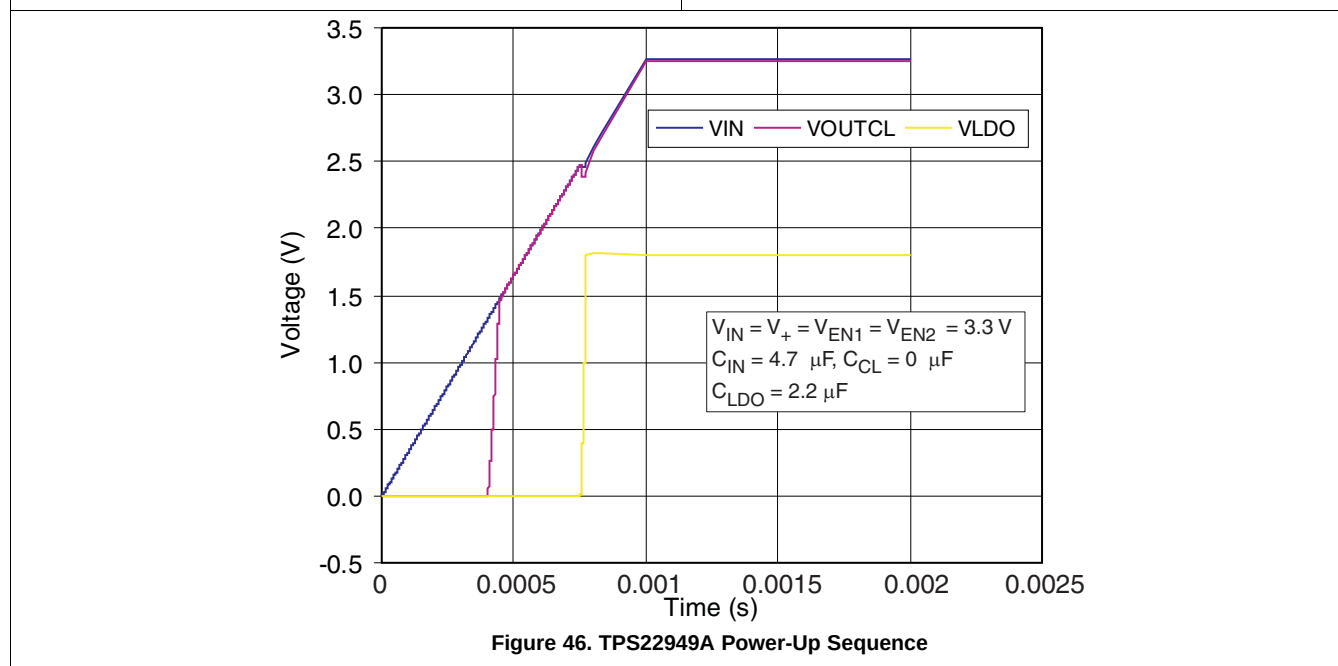
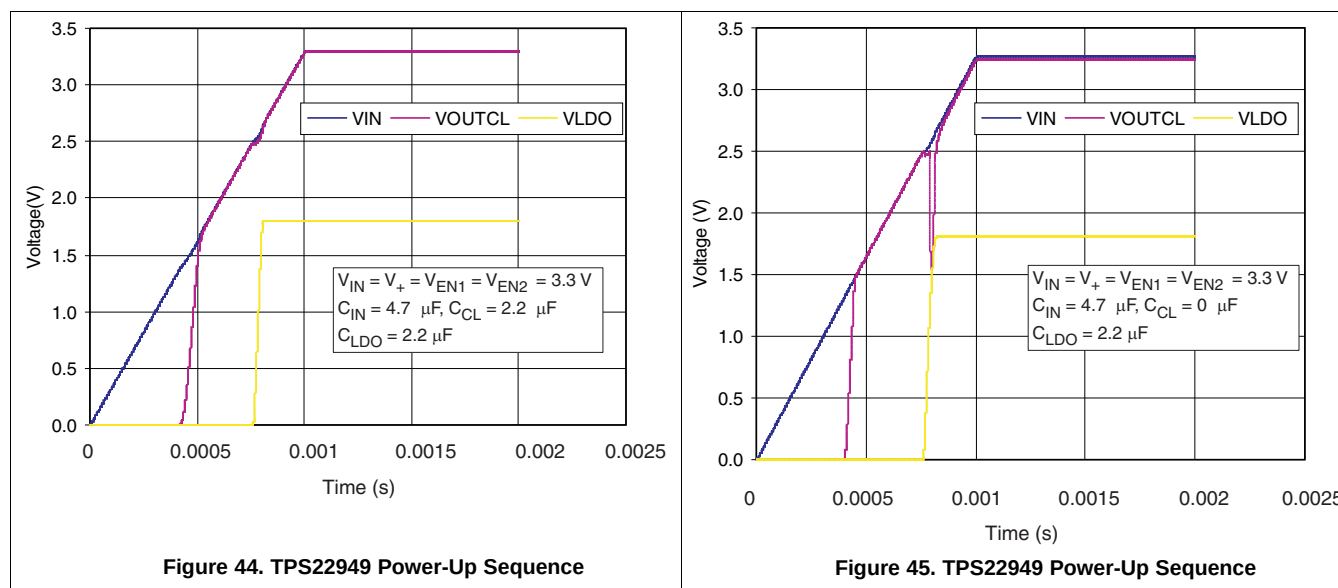
Due to the integral body diode in the PMOS switch, a C_{IN} greater than C_{CL} is highly recommended. A C_{CL} greater than C_{IN} can cause V_{OUTCL} to exceed V_{IN} when the system supply is removed. This could result in current flow through the body diode from V_{OUTCL} to V_{IN}.

On TPS22949, a storage capacitor (C_{CL}) at the output of the current limiter is recommended to provide enough current to the LDO during the start-up sequence. The storage capacitor is needed to reduce the amount of inrush current supplied through the current-limited load switch to the LDO during the power-up sequence (see [Figure 44](#)). If the C_{CL} capacitor is too small, the inrush current needed to start the LDO and charge C_{LDO} could be interpreted by the current limiter as an overcurrent and, therefore, trigger the current-limiting feature of the switch. The switch would then try to limit the current to the 100-mA limit, and the user would see an undesired drop on the supply line (see [Figure 45](#)).

On TPS22949A, the storage capacitor (C_{CL}) is not required. TPS22949A integrates an additional internal circuitry that increases the current limit of the switch to approximately 750 mA (that is, $I_{LIM(INRUSH)}$) for about 250 μ s (that is, t_{INRUSH}), initiated when the internal circuitry of the LDO is operating properly (that is, when the UVLO of the LDO bias (V_+) is disabled ($V_+ > 2.6$ V)). Because the current limit is increased during the power-up sequence, a potential inrush current through the LDO is not interpreted by the current limiter as an overcurrent. The current needed by the LDO is then be supplied by the input capacitor (C_{IN}) of the current limiter (see Figure 45).

The TPS22949 LDO (V_{OUTLDO}) is designed to be stable with standard ceramic capacitors with values of 2.2 μ F or larger at the output. X5R- and X7R-type capacitors are best because they have minimal variation in value and ESR over temperature. Maximum ESR must be less than 250 m Ω . Figure 43, Figure 44, and Figure 45 illustrate the behavior of the TPS22949 and TPS22949A with a 100-mA sinking load and different capacitor values for a typical application where both enables are tied to the same input voltage (see Figure 43).

9.2.3 Application Curves



9.3 System Examples

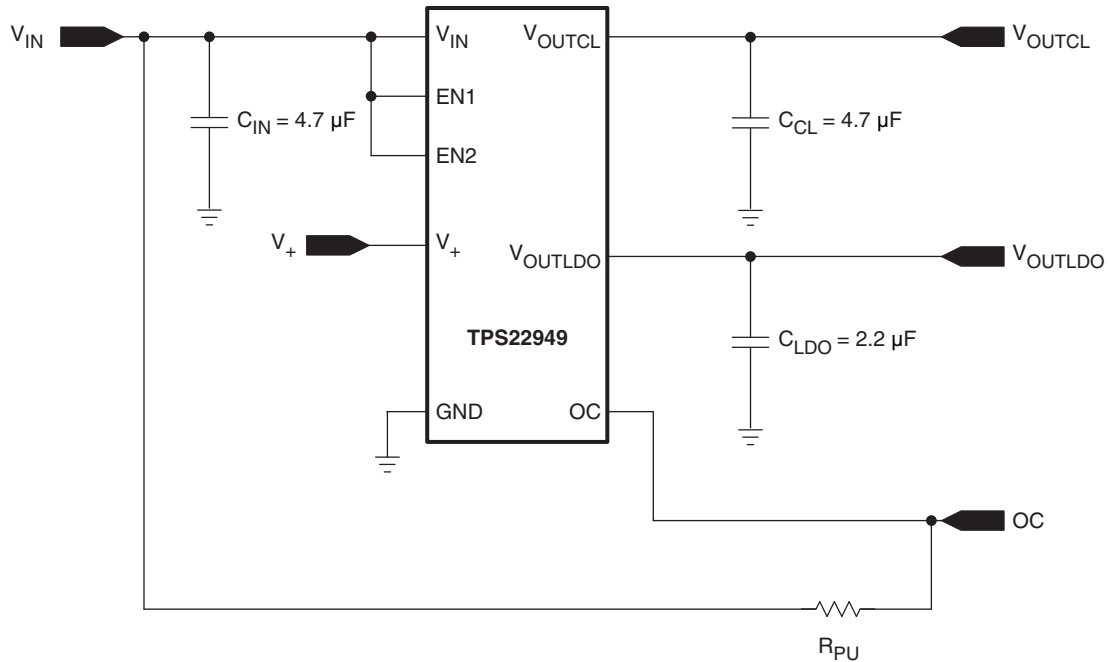


Figure 47. TPS22949 Typical Application Schematic

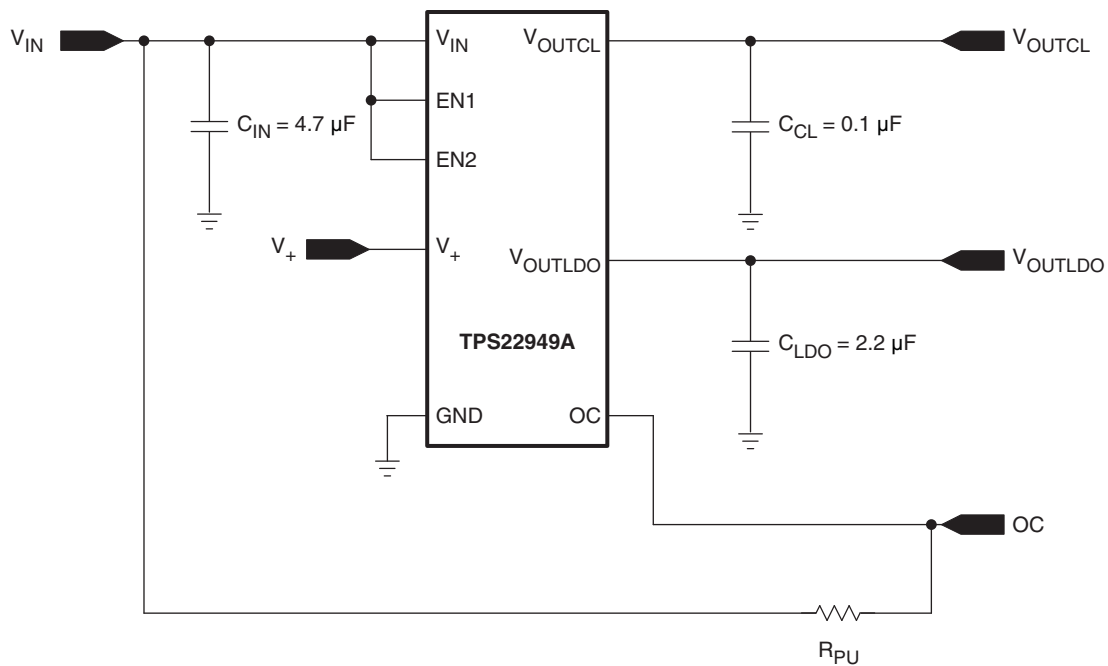


Figure 48. TPS22949A Typical Application Schematic

10 Power Supply Recommendations

The device is designed to operate from a $V+$ range of 2.6 V to 5.5 V and V_{IN} range of 1.62 V to 4.5 V (without using the LDO) or >1.8 V to 4.5 V (when using the LDO). This supply must be placed as close to the device pin as possible with the recommended input bypass capacitor. If the supply is located more than a few inches from the device pins, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. If additional bulk capacitance is required, an electrolytic, tantalum, or ceramic capacitor of 10 μ F may be sufficient.

11 Layout

11.1 Layout Guidelines

For best performance, all traces must be as short as possible. To be most effective, the input and output capacitors must be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for V_{IN} , $V+$, V_{OUTLDO} , V_{OUTCL} , and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

11.2 Layout Example

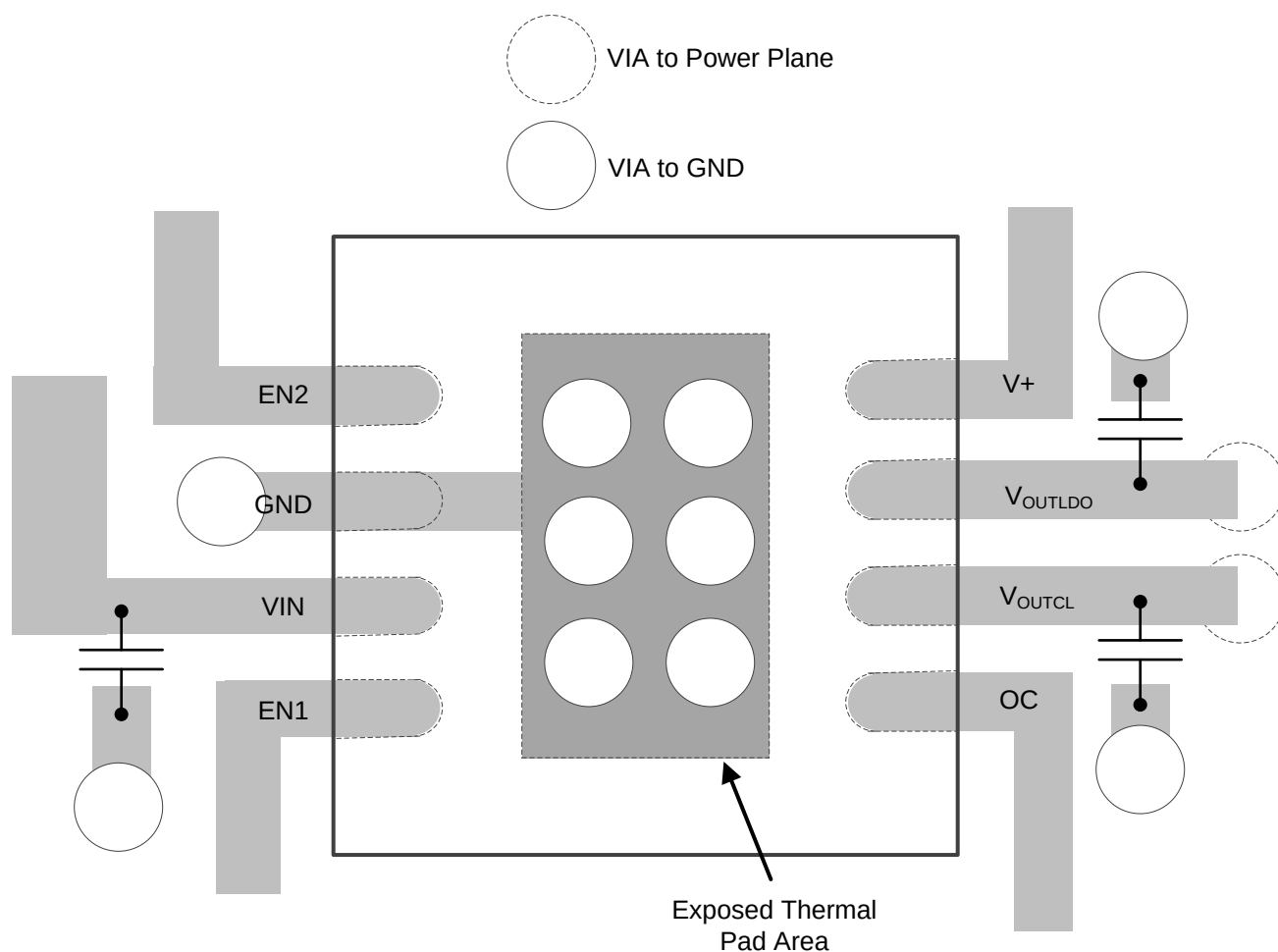


Figure 49. Layout Schematic

12 Device and Documentation Support

12.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 3. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS22949	Click here	Click here	Click here	Click here	Click here
TPS22949A	Click here	Click here	Click here	Click here	Click here

12.2 Community Resources

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

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

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

12.3 Trademarks

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

12.4 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.5 Glossary

SLYZ022 — *TI Glossary*.

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

13 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)
TPS22949ADRGR	Active	Production	SON (DRG) 8	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZUG
TPS22949ADRGR.B	Active	Production	SON (DRG) 8	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZUG
TPS22949ADRGRG4	Active	Production	SON (DRG) 8	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZUG
TPS22949ADRGRG4.B	Active	Production	SON (DRG) 8	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZUG

⁽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.

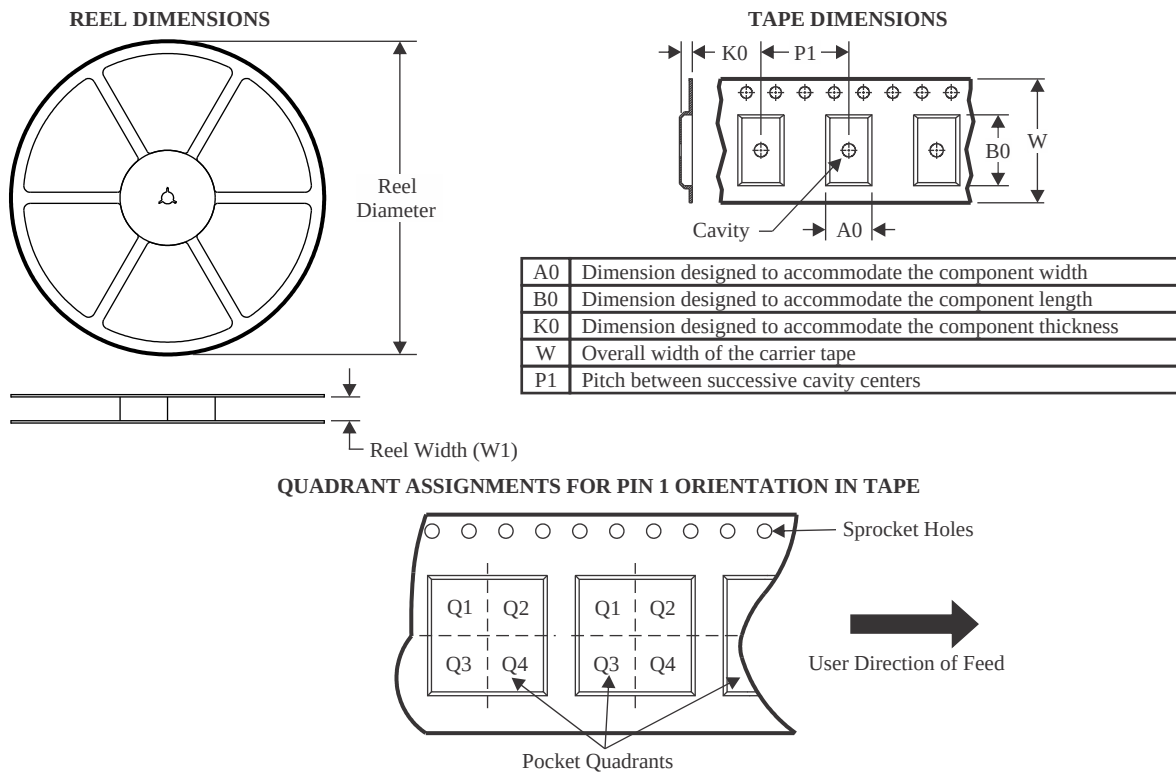
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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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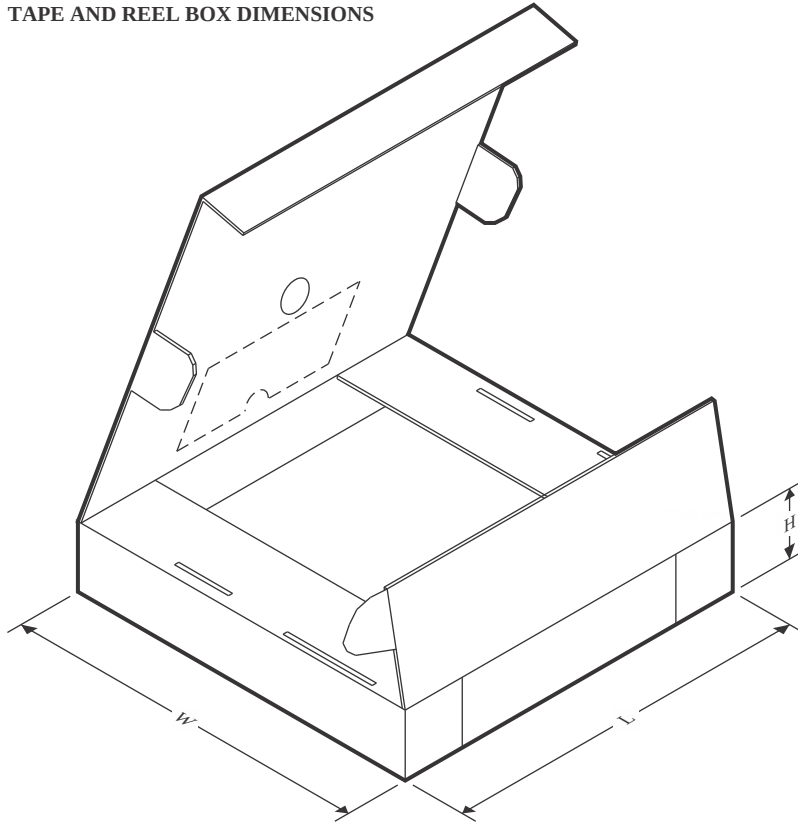
TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS22949ADRGR	SON	DRG	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TPS22949ADRGRG4	SON	DRG	8	3000	330.0	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)
TPS22949ADRGR	SON	DRG	8	3000	356.0	356.0	35.0
TPS22949ADRGRG4	SON	DRG	8	3000	356.0	356.0	35.0

GENERIC PACKAGE VIEW

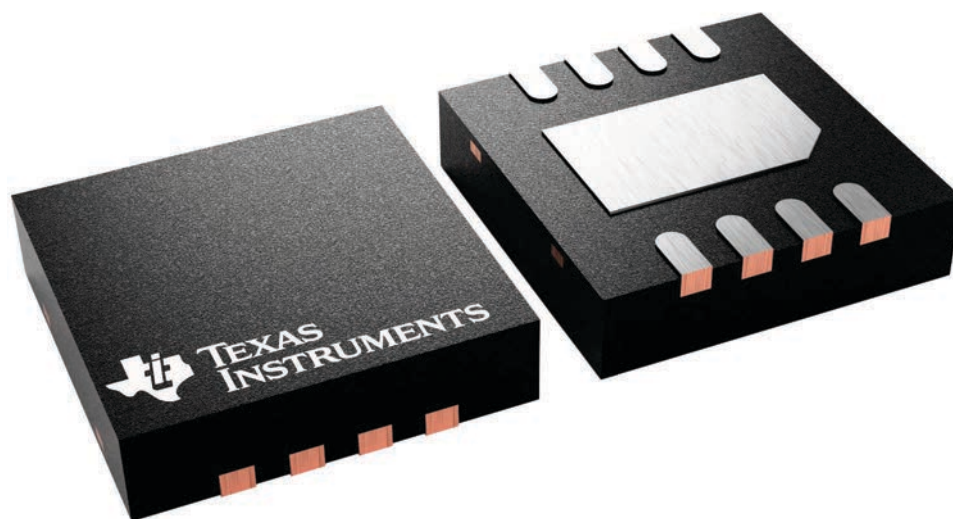
DRG 8

WSON - 0.8 mm max height

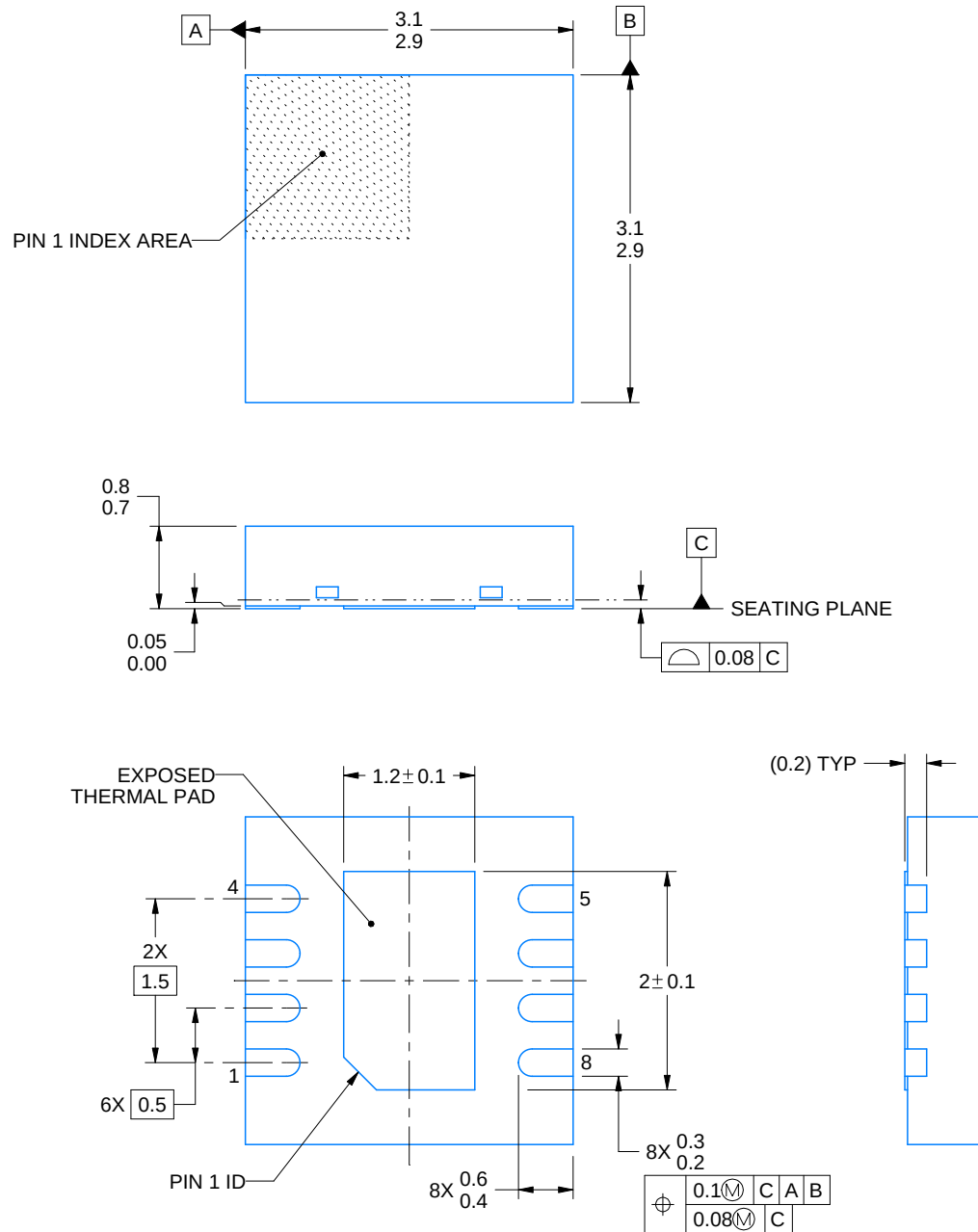
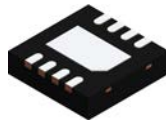
3 x 3, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4225794/A



4218885/A 03/2020

NOTES:

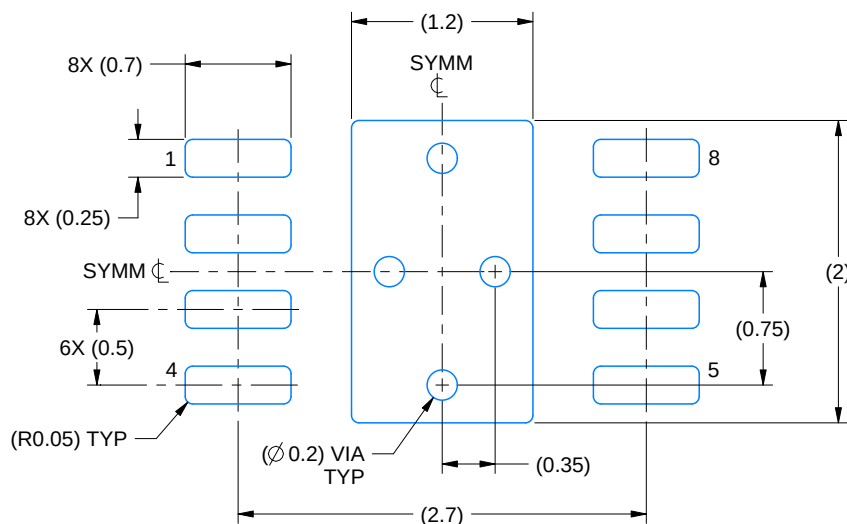
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

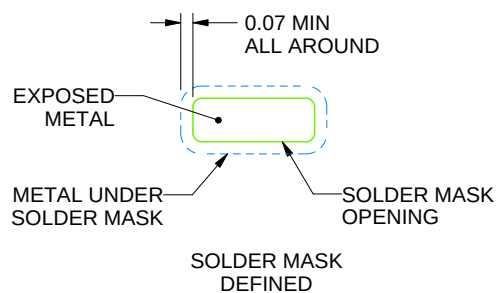
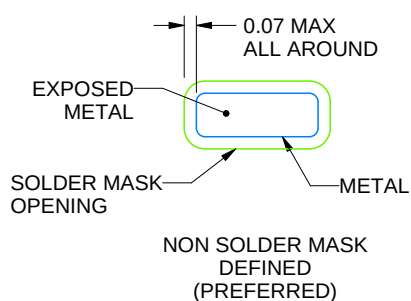
DRG0008A

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X



SOLDER MASK DETAILS

4218885/A 03/2020

NOTES: (continued)

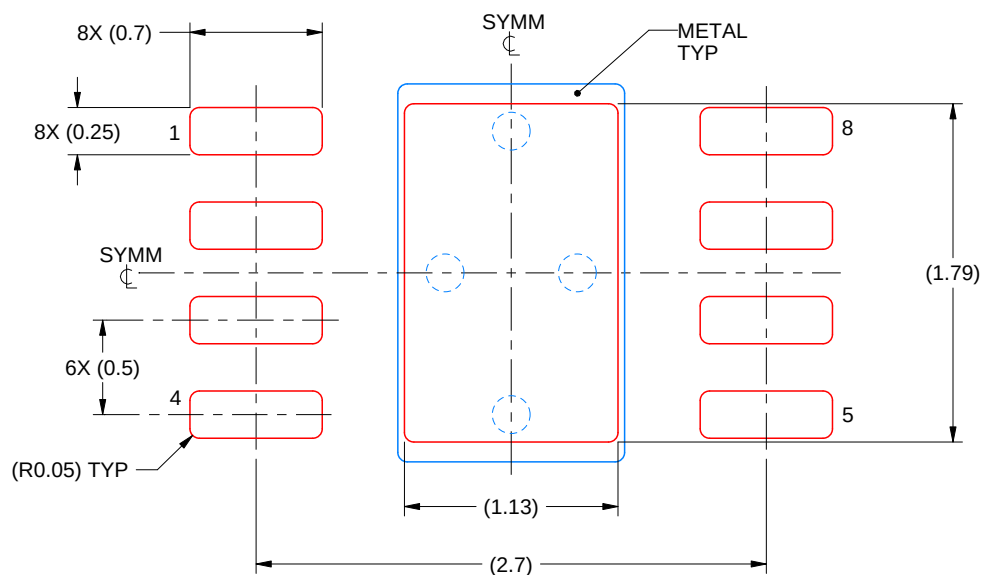
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

EXAMPLE STENCIL DESIGN

DRG0008A

WSO - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
84% PRINTED SOLDER COVERAGE BY AREA
SCALE:25X

4218885/A 03/2020

NOTES: (continued)

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

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