

## LP2980-N Micropower 50-mA Ultra-Low-Dropout Regulator in SOT-23 Package

### 1 Features

- 2.1-V to 16-V Input Voltage Range
- 5-V, 4.7-V, 3.3-V, 3-V, and 2.5-V Output Versions
- Ultra-Low-Dropout Voltage
- Output Voltage Accuracy 0.5% (A Grade)
- Ensured 50-mA Output Current
- Requires Only 1- $\mu$ F External Capacitance
- < 1- $\mu$ A Quiescent Current When Shutdown
- Low Ground Pin Current at All Load Currents
- High Peak Current Capability (150 mA Typical)
- Wide Supply Voltage Range (16 V Maximum)
- Fast Dynamic Response to Line and Load
- Low  $Z_{OUT}$  Over Wide Frequency Range
- Overtemperature and Overcurrent Protection
- -40°C to 125°C Junction Temperature Range

### 2 Applications

- Cellular Phone
- Palmtop/Laptop Computer
- Personal Digital Assistant (PDA)
- Camcorder, Personal Stereo, Camera

### 3 Description

The LP2980-N is a 50-mA, fixed-output voltage regulator designed specifically to meet the requirements of battery-powered applications.

Using an optimized VIP (Vertically Integrated PNP) process, the LP2980-N delivers unequaled performance in all specifications critical to battery-powered designs:

**Dropout voltage:** Typically 120 mV at 50-mA load, and 7 mV at 1-mA load.

**Ground pin current:** Typically 375  $\mu$ A at 50-mA load, and 80  $\mu$ A at 1-mA load.

**Sleep mode:** Less than 1- $\mu$ A quiescent current when ON/OFF pin is pulled to less than 0.18 V.

**Minimum part count:** Requires only a 1- $\mu$ F capacitor on the regulator output.

**Precision output:** Initial output voltage tolerance of  $\pm 0.5\%$  (A grade).

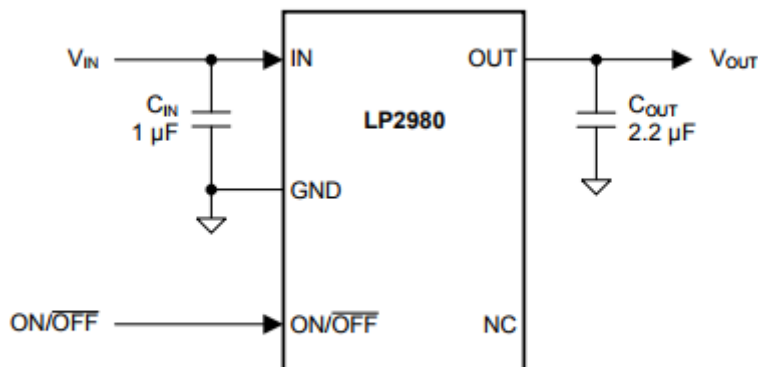
5-V, 4.7-V, 3.3-V, 3-V, and 2.5-V versions available as standard products.

#### Device Information<sup>(1)</sup>

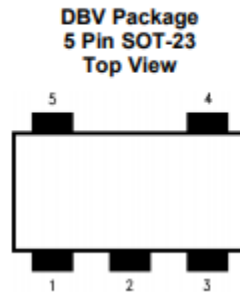
PART NUMBER	PACKAGE	BODY SIZE (NOM)
LP2980-N	SOT-23 (5)	2.90 mm $\times$ 1.60 mm

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

#### Simplified Schematic



## 5 Pin Configuration and Functions



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	IN	I	Input voltage
2	GND	—	Common ground (device substrate)
3	ON/OFF	I	Logic high enable input
4	N/C	—	DO NOT CONNECT. Device pin 4 is reserved for post packaging test and calibration of the LP2980-N $V_{OUT}$ accuracy. Device pin 4 must be left floating. Do not connect to any potential. Do not connect to ground. Any attempt to do pin continuity testing on device pin 4 is discouraged. Continuity test results will be variable depending on the actions of the factory calibration. Aggressive pin continuity testing (high voltage, or high current) on device pin 4 may activate the trim circuitry forcing $V_{OUT}$ to move out of tolerance.
5	OUT	O	Regulated output voltage

## 6 Specifications

### 6.1 Absolute Maximum Ratings<sup>(1)(2)</sup>

	MIN	MAX	UNIT
Operating junction temperature	-40	125	°C
Power dissipation <sup>(3)</sup>	Internally Limited		
Input supply voltage	-0.3	16	V
Shutdown input voltage	-0.3	16	V
Output voltage <sup>(4)</sup>	-0.3	9	V
$I_{OUT}$	Short-circuit protected		
Input-output voltage <sup>(5)</sup>	-0.3	16	V
Storage temperature, $T_{stg}$	-65	150	°C

- (1) *Absolute Maximum Ratings* indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.
- (2) If Military/Aerospace-specified devices are required, contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) The maximum allowable power dissipation is a function of the maximum junction temperature,  $T_{J(MAX)}$ , the junction-to-ambient thermal resistance,  $R_{\theta JA}$ , and the ambient temperature,  $T_A$ . The maximum allowable power dissipation at any ambient temperature is calculated using  $P_{(MAX)} = ((T_{J(MAX)} - T_A) / R_{\theta JA})$ . The value of  $R_{\theta JA}$  for the SOT-23 package is 175.7°C/W. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown.
- (4) If used in a dual-supply system where the regulator load is returned to a negative supply, the LP2980-N output must be diode-clamped to ground.
- (5) The output PNP structure contains a diode between the IN and OUT pins that is normally reverse-biased. Reversing the polarity from  $V_{IN}$  to  $V_{OUT}$  turns on this diode (see [Reverse Current Path](#)).

### 6.2 ESD Ratings

			VALUE	UNIT	
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	All pins except 3 and 4	±2000	V
			Pins 3 and 4	±1000	

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

### 6.3 Recommended Operating Conditions

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

	MIN	MAX	UNIT
Operating junction temperature	-40	125	°C
Input supply voltage	2.1	16	V
Shutdown input voltage	0	V <sub>IN</sub>	

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		LP2980-N	UNIT
		DBV	
		5 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance, High K <sup>(2)</sup>	175.7	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	78	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	30.8	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	2.8	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	30.3	°C/W

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

(2) Thermal resistance value R<sub>θJA</sub> is based on the EIA/JEDEC High-K printed circuit board defined by JESD51-7 - High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages.

### 6.5 Electrical Characteristics

Unless otherwise specified: T<sub>J</sub> = 25°C, V<sub>IN</sub> = V<sub>O(NOM)</sub> + 1 V, I<sub>L</sub> = 1 mA, C<sub>OUT</sub> = 1 μF, V<sub>ON/OFF</sub> = 2 V.<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	LP2980AI-XX <sup>(2)</sup>			LP2980I-XX <sup>(2)</sup>			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
ΔV <sub>O</sub>	I <sub>L</sub> = 1 mA	-0.5		0.5	-1		1	%V <sub>NOM</sub>
	1 mA < I <sub>L</sub> < 50 mA	-0.75		0.75	-1.5		1.5	
	1 mA < I <sub>L</sub> < 50 mA -40°C ≤ T <sub>J</sub> ≤ 125°C	-2.5		2.5	-3.5		3.5	
ΔV <sub>O</sub> ΔV <sub>IN</sub>	V <sub>O(NOM)</sub> + 1 V ≤ V <sub>IN</sub> ≤ 16 V		0.007	0.014		0.007	0.014	%V
	V <sub>O(NOM)</sub> + 1 V ≤ V <sub>IN</sub> ≤ 16 V -40°C ≤ T <sub>J</sub> ≤ 125°C		0.007	0.032		0.007	0.032	
V <sub>IN</sub> - V <sub>O</sub>	I <sub>L</sub> = 0 mA		1	3		1	3	mV
	I <sub>L</sub> = 0 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		1	5		1	5	
	I <sub>L</sub> = 1 mA		7	10		7	10	
	I <sub>L</sub> = 1 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		7	15		7	15	
	I <sub>L</sub> = 10 mA		40	60		40	60	
	I <sub>L</sub> = 10 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		40	90		40	90	
	I <sub>L</sub> = 50 mA		120	150		120	150	
	I <sub>L</sub> = 50 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		120	225		120	225	
I <sub>GND</sub>	I <sub>L</sub> = 0 mA		65	95		65	95	μA
	I <sub>L</sub> = 0 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		65	125		65	125	
	I <sub>L</sub> = 1 mA		80	110		80	110	
	I <sub>L</sub> = 1 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		80	170		80	170	
	I <sub>L</sub> = 10 mA		140	220		140	220	
	I <sub>L</sub> = 10 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		140	460		140	460	
	I <sub>L</sub> = 50 mA		375	600		375	600	
	I <sub>L</sub> = 50 mA, -40°C ≤ T <sub>J</sub> ≤ 125°C		375	1200		375	1200	
	V <sub>ON/OFF</sub> < 0.18 V -40°C ≤ T <sub>J</sub> ≤ 125°C		0	1		0	1	
V <sub>ON/OFF</sub>	High = O/P ON -40°C ≤ T <sub>J</sub> ≤ 125°C	1.6	1.4		1.6	1.4	V	
	Low = O/P OFF -40°C ≤ T <sub>J</sub> ≤ 125°C		0.55	0.18		0.55		0.18

$I_{ON/OFF}$	ON/OFF input current	$V_{ON/OFF} = 0\text{ V}$	0	-1	0	-1	$\mu\text{A}$
		$V_{ON/OFF} = 5\text{ V}$ $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	5	15	5	15	
$I_{O(PK)}$	Peak output current	$V_{OUT} \geq V_{O(NOM)} - 5\%$	100	150	100	150	$\text{mA}$
$e_n$	Output noise voltage (RMS)	$\text{BW} = 300\text{ Hz to } 50\text{ kHz}$ $C_{OUT} = 10\ \mu\text{F}$	160		160		$\mu\text{V}$
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Ripple rejection	$f = 1\text{ kHz}$ $C_{OUT} = 10\ \mu\text{F}$	63		63		$\text{dB}$

- (1) Minimum and maximum limits are ensured through test, design, or statistical correlation over the junction temperature ( $T_J$ ) range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , unless otherwise stated. Typical values represent the most likely parametric norm at  $T_A = 25^{\circ}\text{C}$ , and are provided for reference purposes only.
- (2) Limits are 100% production tested at  $25^{\circ}\text{C}$ . Limits over the operating temperature range are ensured through correlation using statistical quality control (SQC) methods. The limits are used to calculate average outgoing quality level (AOQL).
- (3) Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below the value measured with a 1-V differential.
- (4) The ON/OFF inputs must be properly driven to prevent misoperation. For details, see *ON/OFF Input Operation*.

## Electrical Characteristics (continued)

Unless otherwise specified:  $T_J = 25^{\circ}\text{C}$ ,  $V_{IN} = V_{O(NOM)} + 1\text{ V}$ ,  $I_L = 1\text{ mA}$ ,  $C_{OUT} = 1\ \mu\text{F}$ ,  $V_{ON/OFF} = 2\text{ V}$ .<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	LP2980AI-XX <sup>(2)</sup>			LP2980I-XX <sup>(2)</sup>			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
$I_{O(MAX)}$	Short-circuit current $R_L = 0\ \Omega$ (steady state) <sup>(5)</sup>	150			150			$\text{mA}$

- (5) See related curve(s) in *Typical Characteristics* section.

## 6.6 Typical Characteristics

Unless otherwise specified:  $T_A = 25^{\circ}\text{C}$ ,  $V_{IN} = V_{O(NOM)} + 1\text{ V}$ ,  $C_{OUT} = 2.2\ \mu\text{F}$ , all voltage options, ON/OFF pin tied to  $V_{IN}$ .

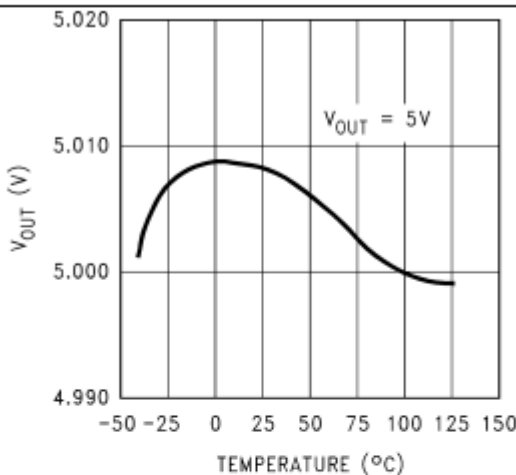


Figure 1. Output Voltage vs Temperature

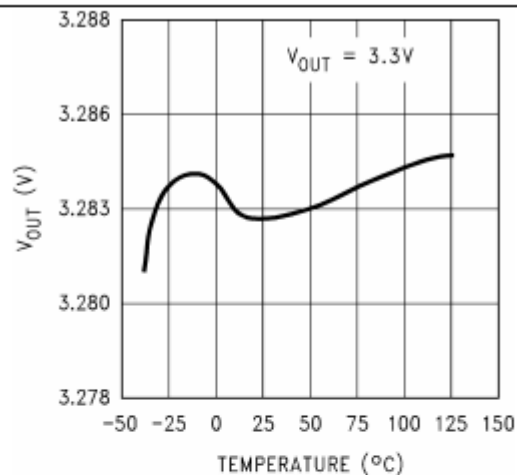


Figure 2. Output Voltage vs Temperature

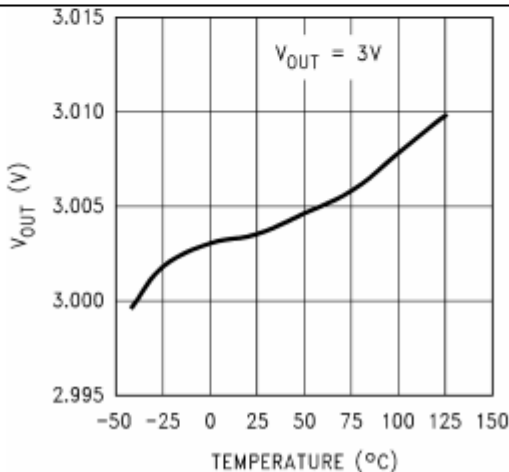


Figure 3. Output Voltage vs Temperature

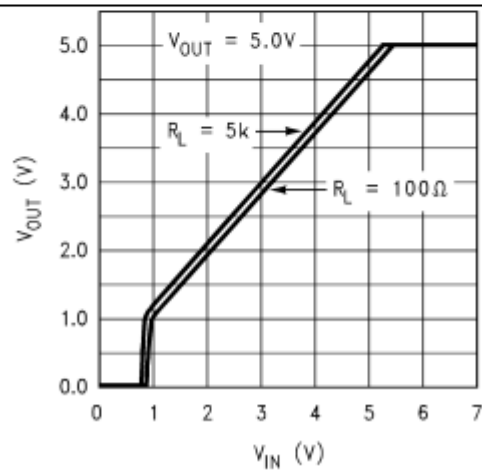


Figure 4. Dropout Characteristics

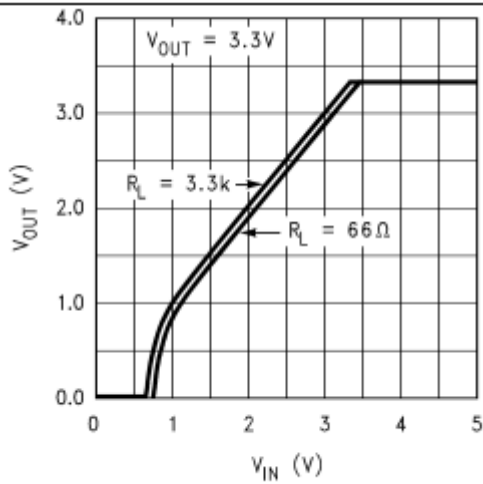


Figure 5. Dropout Characteristics

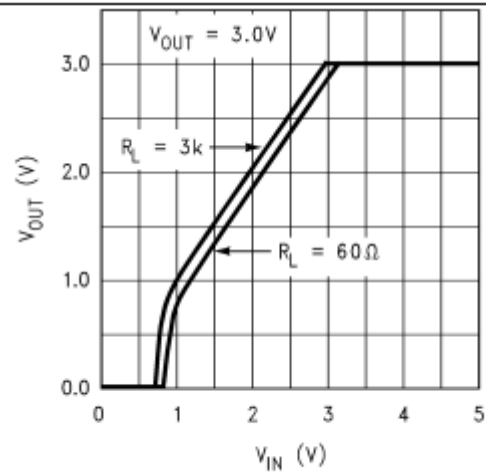


Figure 6. Dropout Characteristics

Unless otherwise specified:  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = V_{O(NOM)} + 1\text{ V}$ ,  $C_{OUT} = 2.2\ \mu\text{F}$ , all voltage options, ON/OFF pin tied to  $V_{IN}$ .

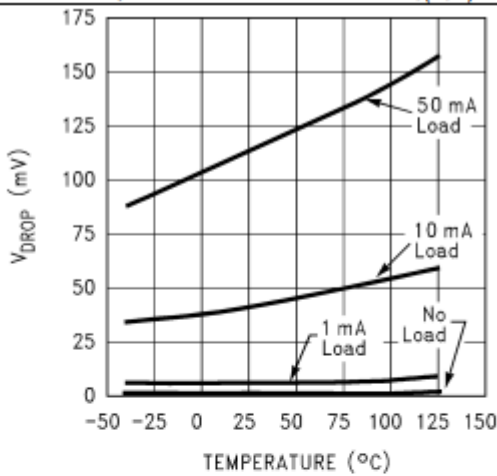


Figure 7. Dropout Voltage vs Temperature

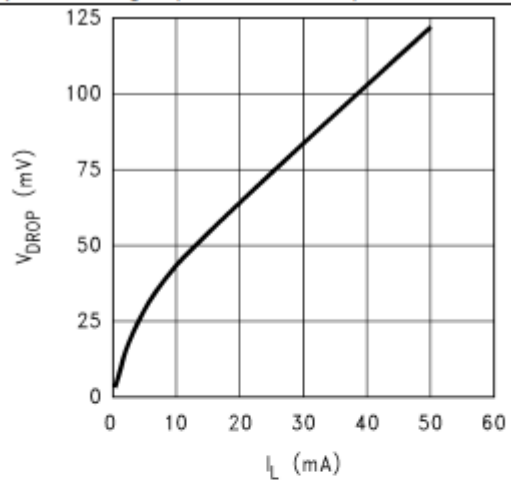


Figure 8. Dropout Voltage vs Load Current

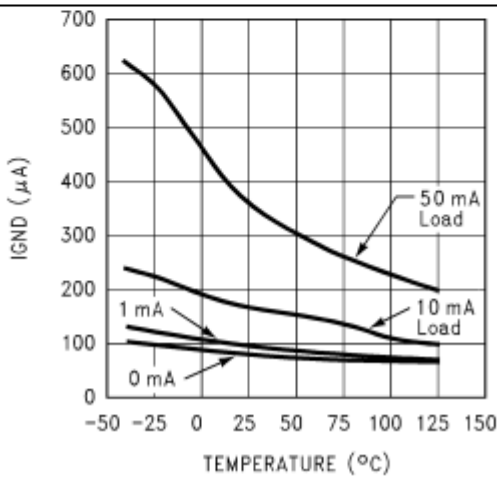


Figure 9. Ground Pin Current vs Temperature

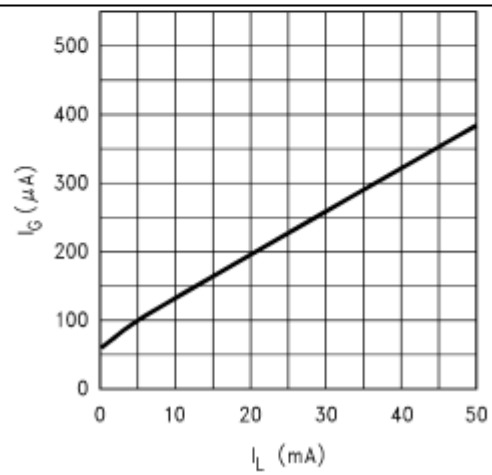


Figure 10. Ground Pin Current vs Load Current

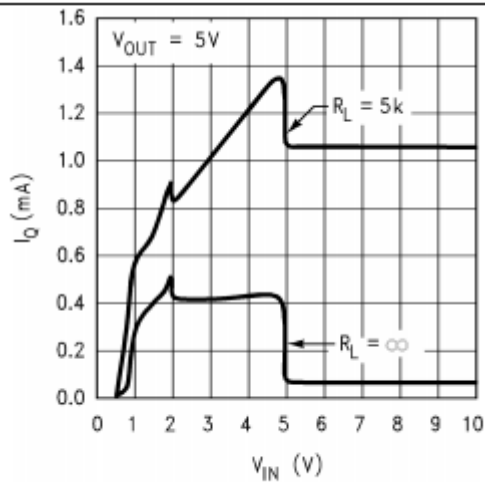


Figure 11. Input Current vs  $V_{IN}$

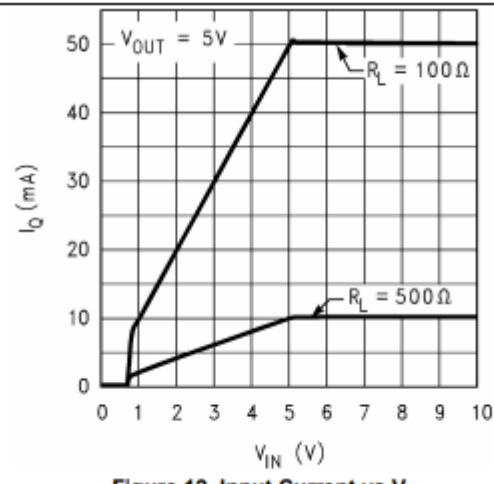


Figure 12. Input Current vs  $V_{IN}$

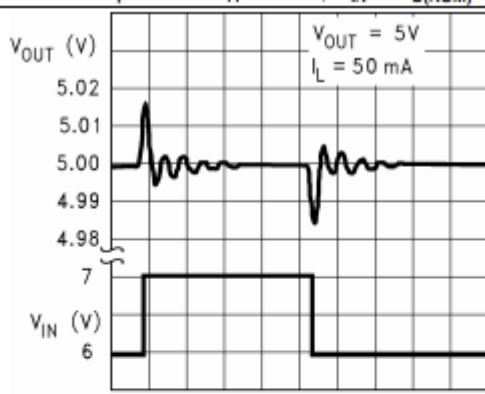


Figure 13. Line Transient Response

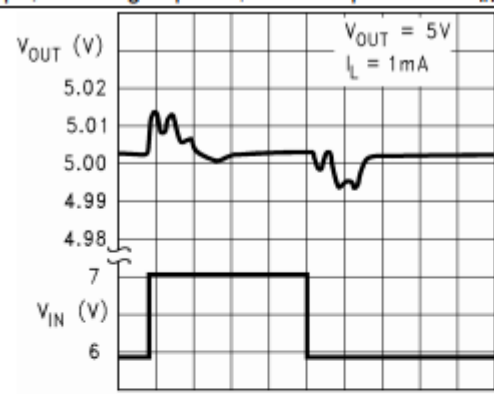


Figure 14. Line Transient Response

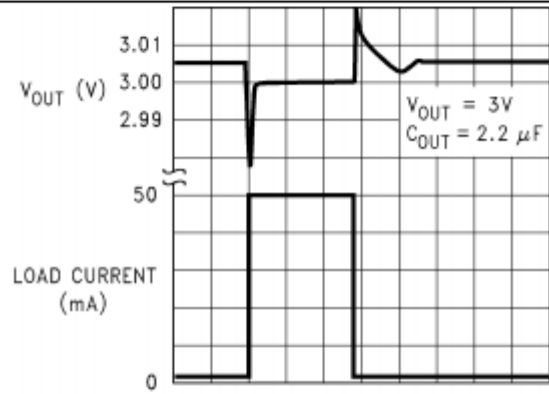


Figure 15. Load Transient Response

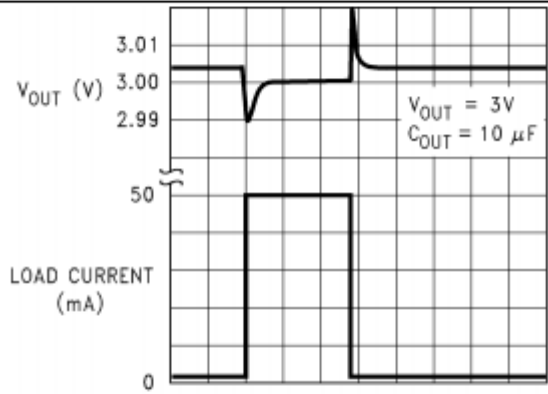


Figure 16. Load Transient Response

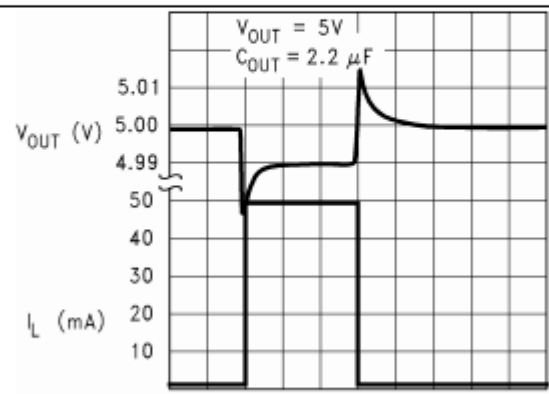


Figure 17. Load Transient Response

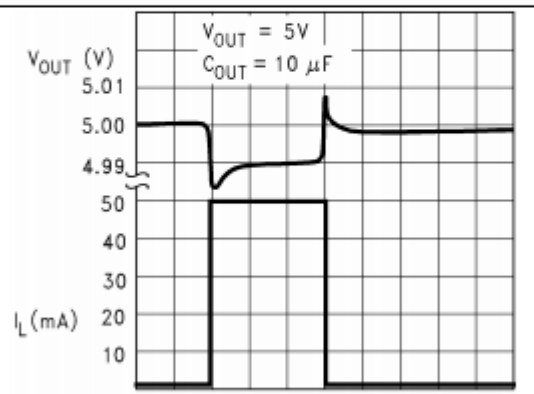


Figure 18. Load Transient Response

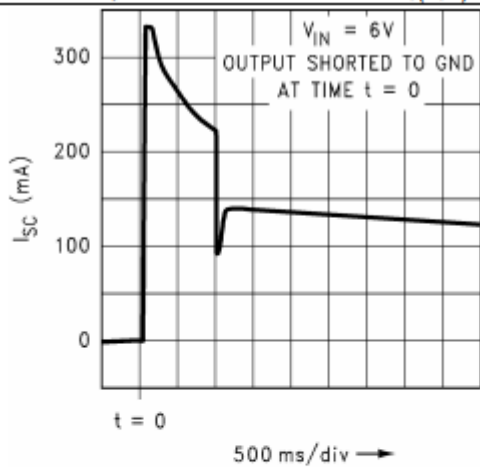


Figure 19. Short Circuit Current

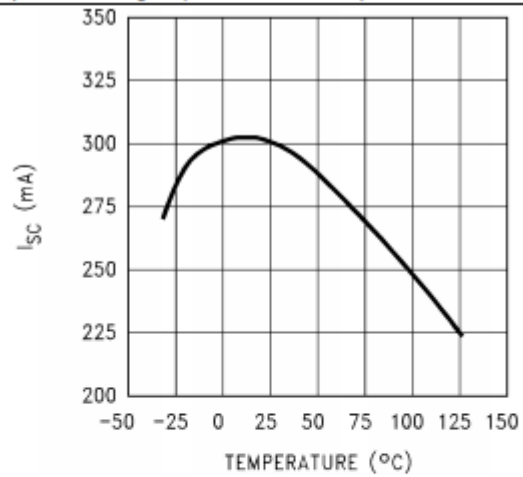


Figure 20. Instantaneous Short Circuit Current vs Temperature

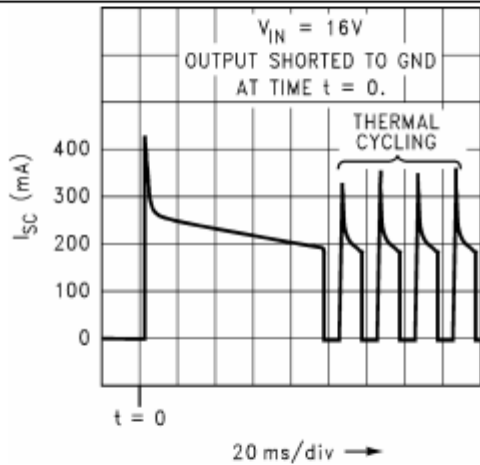


Figure 21. Short Circuit Current

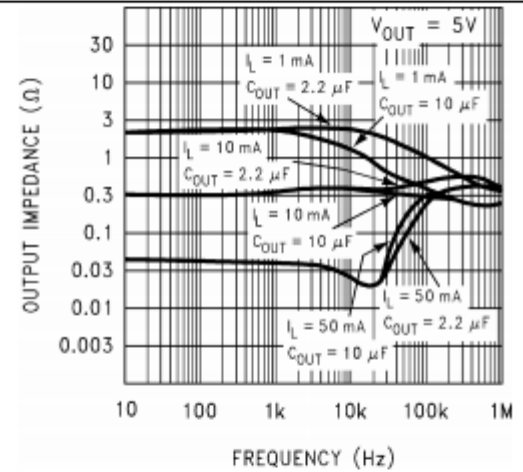


Figure 22. Output Impedance vs Frequency

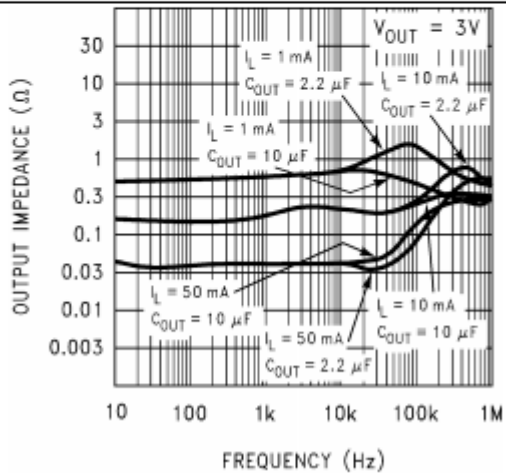


Figure 23. Output Impedance vs Frequency

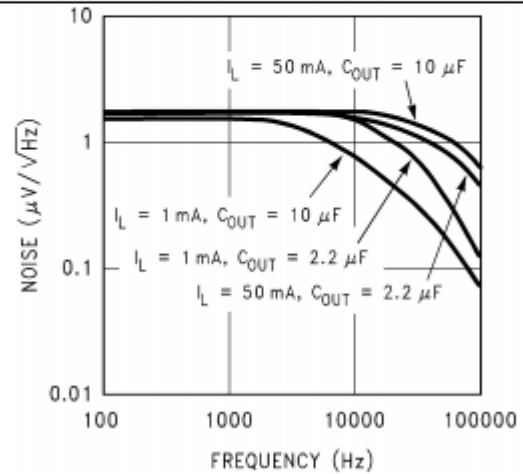


Figure 24. Output Noise Density

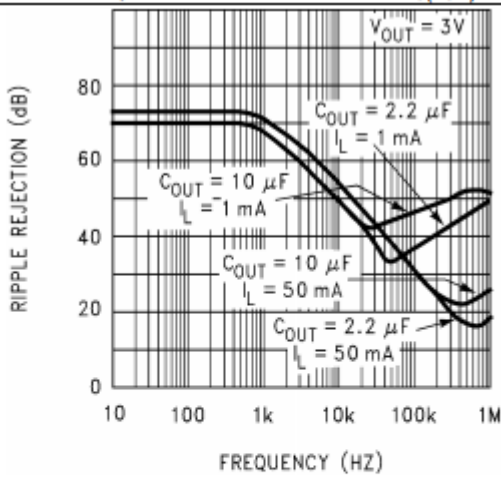


Figure 25. Ripple Rejection

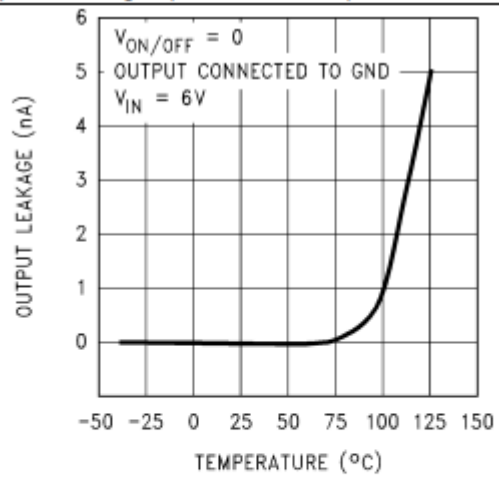


Figure 26. Input to Output Leakage vs Temperature

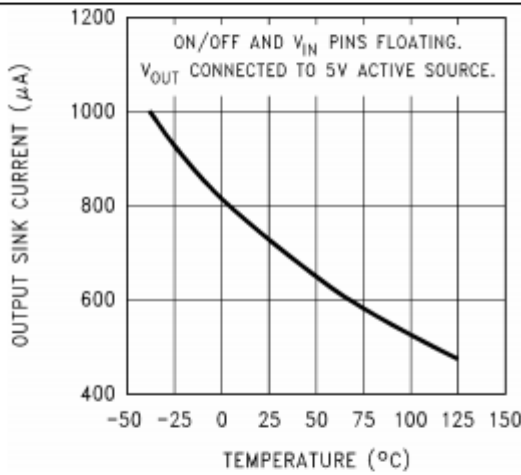


Figure 27. Output Reverse Leakage vs Temperature

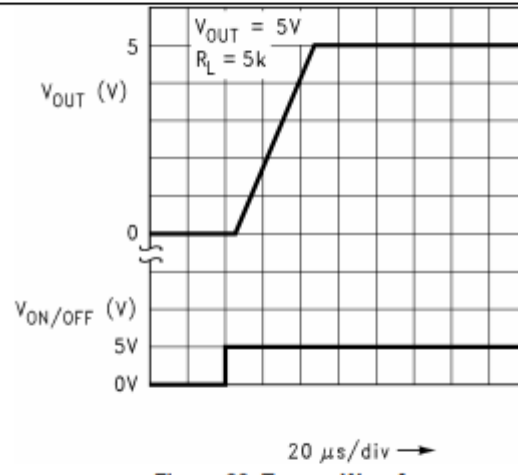
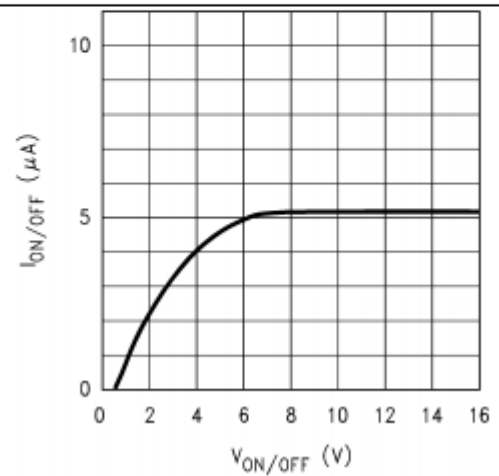
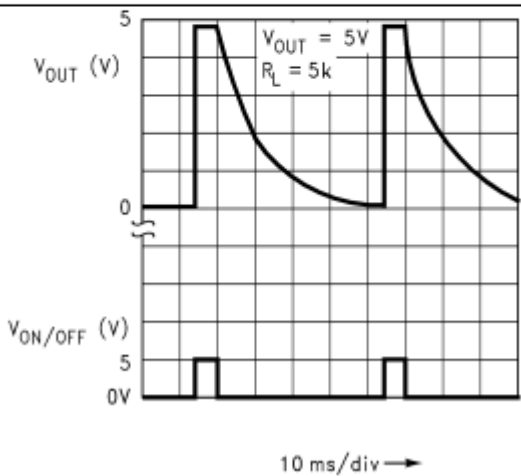


Figure 28. Turnon Waveform





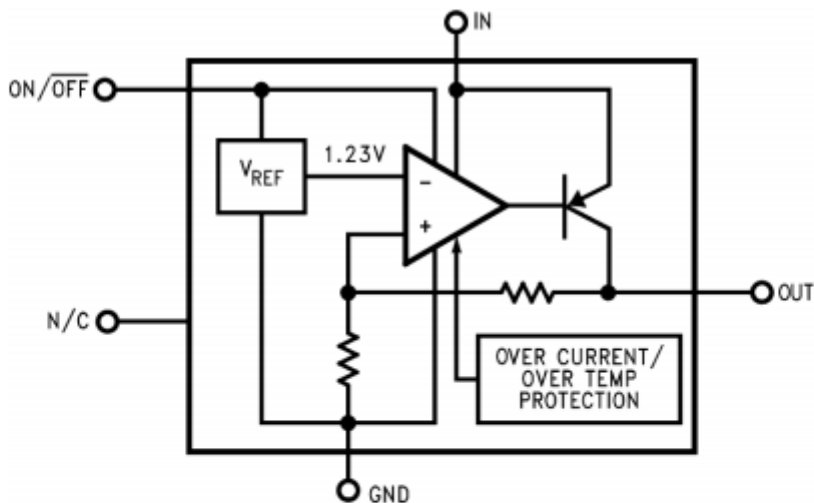
## 7 Detailed Description

### 7.1 Overview

The LP2980-N is a 50-mA, fixed-output voltage regulator designed specifically to meet the requirements of battery-powered applications. Available in output voltages from 2.5 V to 5 V, the device has an initial output voltage tolerance of  $\pm 0.5\%$  for the A grade (1% for the non-A version). Using an optimized vertically integrated PNP (VIP) process, the LP2980-N contains these features to facilitate battery-powered designs:

- Fixed 5-V, 4.7-V, 3.3-V, 3-V, and 2.5-V output versions
- Low-dropout voltage, typical dropout of 120 mV at 50-mA load current and 7 mV at 1-mA load
- Low ground current, typically 370  $\mu\text{A}$  at 50-mA load and 80  $\mu\text{A}$  at 1-mA load
- A sleep mode feature is available, allowing the regulator to consume less than 1  $\mu\text{A}$  typically when the ON/OFF pin is pulled to less than 0.18 V.
- Overtemperature protection and overcurrent protection circuitry is designed to safeguard the device during unexpected conditions.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Multiple Voltage Options

To meet the different application requirements, the LP2980-N provides multiple fixed output options from 2.5 V to 5 V.

#### 7.3.2 High-Accuracy Output Voltage

With special careful design to minimize all contributions to the output voltage error, the LP2980-N distinguishes itself as a very high-accuracy output voltage micropower LDO. This includes a tight initial tolerance (0.5% typical), extremely good line regulation (0.007%/V typical), and a very low output voltage temperature coefficient, making the part an ideal low-power voltage reference.

#### 7.3.3 Ultra-Low-Dropout Voltage

Generally speaking, the dropout voltage often refers to the voltage difference between the input and output voltage ( $V_{DO} = V_{IN} - V_{OUT}$ ), where the main current pass-FET is fully on in the ohmic region of operation and is characterized by the classic  $R_{DS(ON)}$  of the FET. VDO indirectly specifies a minimum input voltage above the nominal programmed output voltage at which the output voltage is expected to remain within its accuracy boundary.

## Feature Description (continued)

### 7.3.4 Low Ground Current

LP2980-N uses a vertical PNP process which allows for quiescent currents that are considerably lower than those associated with traditional lateral PNP regulators, typically 370  $\mu\text{A}$  at 150-mA load and 80  $\mu\text{A}$  at 1-mA load.

### 7.3.5 Sleep Mode

When pulling the  $\overline{\text{ON/OFF}}$  pin to low level, LP2980-N enters sleep mode, and less than 1- $\mu\text{A}$  quiescent current is consumed. This function is designed for the application which needs a sleep mode to effectively enhance battery life cycle.

### 7.3.6 Short-Circuit Protection (Current Limit)

The internal current-limit circuit is used to protect the LDO against high-load current faults or shorting events. The LDO is not designed to operate in a steady-state current limit. During a current-limit event, the LDO sources constant current. Therefore, the output voltage falls when load impedance decreases. If a current limit occurs and the resulting output voltage is low, excessive power may be dissipated across the LDO resulting in a thermal shutdown of the output. A foldback feature limits the short-circuit current to protect the regulator from damage under all load conditions. If OUT is forced below 0 V before EN goes high and the load current required exceeds the foldback current limit, the device may not start up correctly.

### 7.3.7 Thermal Protection

The LP2980-N contains a thermal shutdown protection circuit to turn off the output current when excessive heat is dissipated in the LDO. The thermal time-constant of the semiconductor die is fairly short, and thus the output cycles on and off at a high rate when thermal shutdown is reached until the power dissipation is reduced. The internal protection circuitry of the LM2980-N is designed to protect against thermal overload conditions. The circuitry is not intended to replace proper heat sinking. Continuously running the device into thermal shutdown degrades its reliability.

## 7.4 Device Functional Modes

### 7.4.1 Operation with $V_{\text{OUT(TARGET)}} + 1 \text{ V} \leq V_{\text{IN}} < 16 \text{ V}$

The device operates if the input voltage is equal to, or exceeds,  $V_{\text{OUT(TARGET)}} + 0.6 \text{ V}$ . At input voltages below the minimum  $V_{\text{IN}}$  requirement, the device does not operate correctly and output voltage may not reach target value.

### 7.4.2 Operation With $\overline{\text{ON/OFF}}$ Control

If the voltage on the  $\overline{\text{ON/OFF}}$  pin is less than 0.18 V, the device is disabled, and the shutdown current does not exceed 1  $\mu\text{A}$ . Raising  $\overline{\text{ON/OFF}}$  above 1.6 V initiates the start-up sequence of the device.

## 8 Application and Implementation

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### NOTE

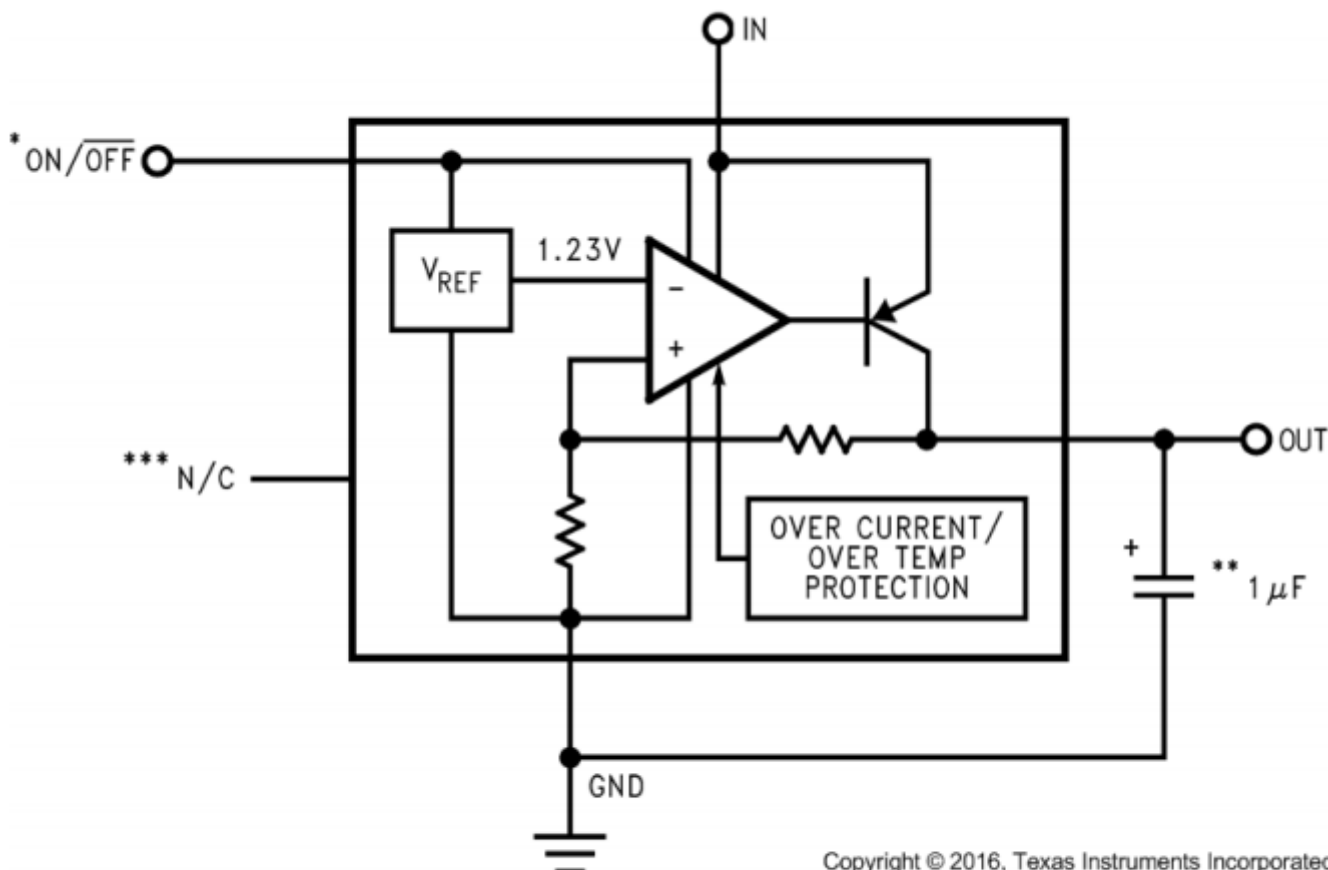
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

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### 8.1 Application Information

The LP2980-N is a linear voltage regulator operating from 2.1 V to 16 V on the input and regulates voltages between 2.5 V to 5 V with 0.5% accuracy and 50-mA maximum output current. Efficiency is defined by the ratio of output voltage to input voltage because the LP2980-N is a linear voltage regulator. To achieve high efficiency, the dropout voltage ( $V_{\text{IN}} - V_{\text{OUT}}$ ) must be as small as possible, thus requiring a very-low-dropout LDO. Successfully implementing an LDO in an application depends on the application requirements. If the requirements are simply input voltage and output voltage, compliance specifications (such as internal power dissipation or stability) must be verified to ensure a solid design. If timing, startup, noise, power supply rejection ratio (PSRR), or any other transient specification is required, then the design becomes more challenging. This section discusses the implementation and behavior of the LP2980-N LDO.

## 8.2 Typical Application



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\*ON/OFF input must be actively terminated. Tie to IN if this function is not to be used.

\*\*Minimum output capacitance is 1  $\mu\text{F}$  to ensure stability over full load current range. More capacitance provides superior dynamic performance and additional stability margin (see *Output Capacitor Recommendation*).

\*\*\*Do not make connections to this pin.

## Typical Application (continued)

### 8.2.1 Design Requirements

PARAMETER	DESIGN REQUIREMENT
Input voltage	5 V $\pm 10\%$ , provided by the DC-DC converter switching at 1 MHz
Output voltage	3.3 V $\pm 5\%$
Output current	50 mA (maximum), 1 mA (minimum)
RMS noise, 300 Hz to 50 kHz	< 1 mV <sub>RMS</sub>
PSRR at 1 kHz	> 40 dB

### 8.2.2 Detailed Design Procedure

At 50-mA loading, the dropout of the LP2980-N has 225-mV maximum dropout over temperature, thus an 1700-mV headroom is sufficient for operation over both input and output voltage accuracy. The efficiency of the LP2980-N in this configuration is  $V_{\text{OUT}} / V_{\text{IN}} = 66.7\%$ . To achieve the smallest form factor, the SOT-23 package is selected. Input and output capacitors are selected in accordance with the *Output Capacitor Recommendation* section. With an efficiency of 66.7% and a 50-mA maximum load, the internal power dissipation is 85 mW, which corresponds to a 14.9°C junction temperature rise for the SOT-23 package. With an 85°C maximum ambient temperature, the junction temperature is at 99.9°C.

#### 8.2.2.1 Output Capacitor Recommendation

Like any low-dropout regulator, the LP2980-N requires an output capacitor to maintain regulator loop stability. This capacitor must be selected to meet the requirements of minimum capacitance and equivalent series resistance (ESR) range. It is not difficult to find capacitors which meet the criteria of the LP2980-N, as the acceptable capacitance and ESR ranges are wider than for most other LDOs.

In general, the capacitor value must be at least 1  $\mu\text{F}$  (over the actual ambient operating temperature), and the ESR must be within the range indicated in Figure 31, Figure 32, and Figure 33. It should be noted that, although a maximum ESR is shown in these figures, it is very unlikely to find a capacitor with an ESR that high.

### 8.2.2.1.1 Tantalum Capacitors

Surface-mountable solid tantalum capacitors offer a good combination of small physical size for the capacitance value, and an ESR in the range needed by the LP2980-N.

The results of testing the LP2980-N stability with surface-mount solid tantalum capacitors show good stability with values of at least 1  $\mu\text{F}$ . The value can be increased to 2.2  $\mu\text{F}$  (or more) for even better performance, including transient response and noise.

Small value tantalum capacitors that have been verified as suitable for use with the LP2980-N are shown in Table 1. Capacitance values can be increased without limit.

### 8.2.2.1.2 Aluminum Electrolytic Capacitors

Although probably not a good choice for a production design, because of relatively large physical size, an aluminum electrolytic capacitor can be used in the design prototype for an LP2980-N regulator. A value of at least 1  $\mu\text{F}$  should be used, and the ESR must meet the conditions of Figure 31, Figure 32, and Figure 33. If the operating temperature drops below 0°C, the regulator may not remain stable, as the ESR of the aluminum electrolytic capacitor will increase and may exceed the limits indicated in Figure 31, Figure 32, and Figure 33.

**Table 1. Surface-Mount Tantalum Capacitor Selection Guide**

1- $\mu\text{F}$ SURFACE-MOUNT TANTALUM CAPACITORS	
MANUFACTURER	PART NUMBER
Kemet	T491A105M010AS
NEC	NRU105M10
Siemens	B45196-E3105-K
Nichicon	F931C105MA
Sprague	293D105X0016A2T

2.2- $\mu\text{F}$ SURFACE-MOUNT TANTALUM CAPACITORS	
MANUFACTURER	PART NUMBER
Kemet	T491A225M010AS
NEC	NRU225M06
Siemens	B45196/2.2/10/10
Nichicon	F930J225MA
Sprague	293D225X0010A2T

### 8.2.2.1.3 Multilayer Ceramic Capacitors

Surface-mountable multilayer ceramic capacitors may be an attractive choice because of their relatively small physical size and excellent RF characteristics. However, they sometimes have ESR values lower than the minimum required by the LP2980-N, and relatively large capacitance change with temperature. The manufacturer's data sheet for the capacitor should be consulted before selecting a value.

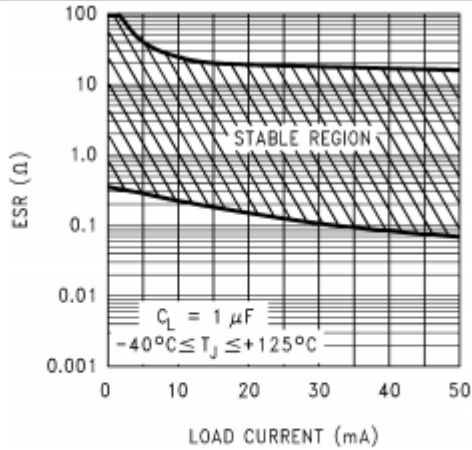
Test results of LP2980-N stability using multilayer ceramic capacitors show that a minimum value of 2.2  $\mu\text{F}$  is usually needed for the 5-V regulator. For the lower output voltages, or for better performance, a higher value should be used, such as 4.7  $\mu\text{F}$ .

Multilayer ceramic capacitors that have been verified as suitable for use with the LP2980-N are shown in Table 2.

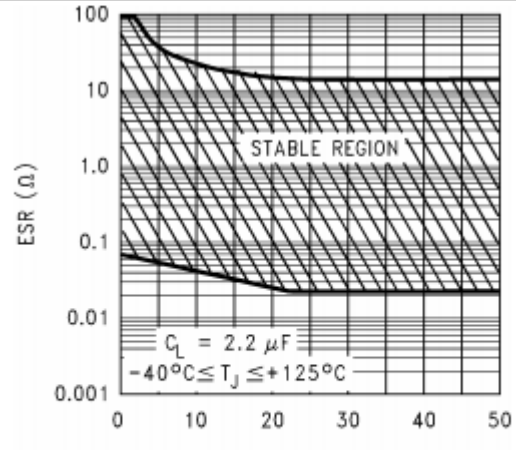
**Table 2. Surface-Mount Multilayer Ceramic Capacitor Selection Guide**

2.2- $\mu$ F SURFACE-MOUNT CERAMIC	
MANUFACTURER	PART NUMBER
Token	1E225ZY5U-C203
Murata	GRM42-6Y5V225Z16

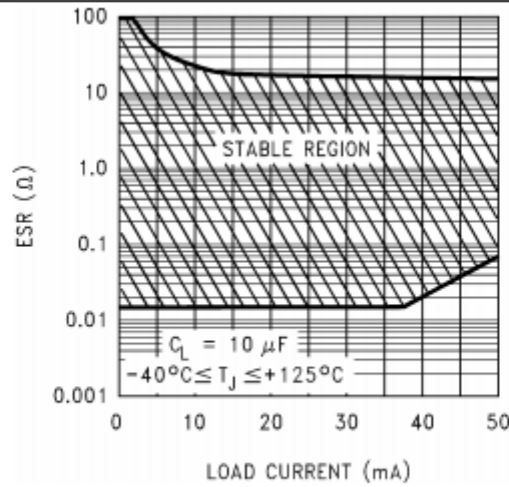
4.7- $\mu$ F SURFACE-MOUNT CERAMIC	
MANUFACTURER	PART NUMBER
Token	1E475ZY5U-C304



**Figure 31. 1- $\mu$ F ESR Range**



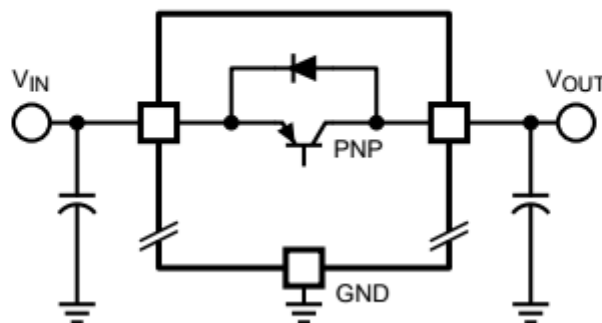
**Figure 32. 2.2- $\mu$ F ESR Range**



**Figure 33. 10- $\mu$ F ESR Range**

### 8.2.2.2 Reverse Current Path

The internal PNP power transistor used as the pass element in the LP2980-N has an inherent diode connected between the regulator output and input. During normal operation (where the input voltage is higher than the output) this diode is reverse biased (see Figure 34).



**Figure 34. LP2980-N Reverse Current Path**

However, if the input voltage is more than a  $V_{BE}$  below the output voltage, this diode will turn on and current will flow into the regulator output. In such cases, a parasitic SCR can latch which will allow a high current to flow into the  $V_{IN}$  pin and out the ground pin, which can damage the part.

The internal diode can also be turned on if the input voltage is abruptly stepped down to a voltage which is a  $V_{BE}$  below the output voltage.

In any application where the output voltage may be higher than the input voltage, an external Schottky diode must be connected from  $V_{IN}$  to  $V_{OUT}$  (cathode on  $V_{IN}$ , anode on  $V_{OUT}$ , see Figure 35), to limit the reverse voltage across the LP2980-N to 0.3 V (see *Absolute Maximum Ratings*).

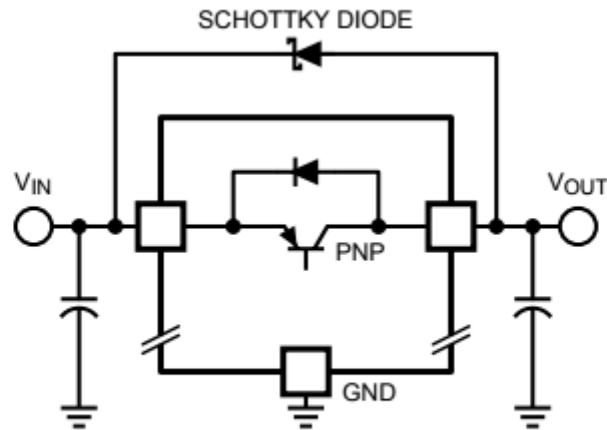


Figure 35. Adding External Schottky Diode Protection

### 8.2.2.3 ON/OFF Input Operation

The LP2980-N is shut off by pulling the  $\overline{\text{ON/OFF}}$  input low, and turned on by driving the input high. If this feature is not to be used, the  $\overline{\text{ON/OFF}}$  input must be tied to IN to keep the regulator on at all times (the  $\overline{\text{ON/OFF}}$  input must not be left floating).

To ensure proper operation, the signal source used to drive the  $\overline{\text{ON/OFF}}$  input must be able to swing above and below the specified turn-on and turn-off voltage thresholds which ensure an ON or OFF state (see *Electrical Characteristics*).

The  $\overline{\text{ON/OFF}}$  signal may come from either a totem-pole output, or an open-collector output with a pull-up resistor to the LP2980-N input voltage or another logic supply. The high-level voltage may exceed the LP2980-N input voltage, but must remain within the absolute maximum ratings for the  $\overline{\text{ON/OFF}}$  pin.

It is also important that the turn-on and turn-off voltage signals applied to the  $\overline{\text{ON/OFF}}$  input have a slew rate that is greater than 40 mV/ $\mu\text{s}$ .

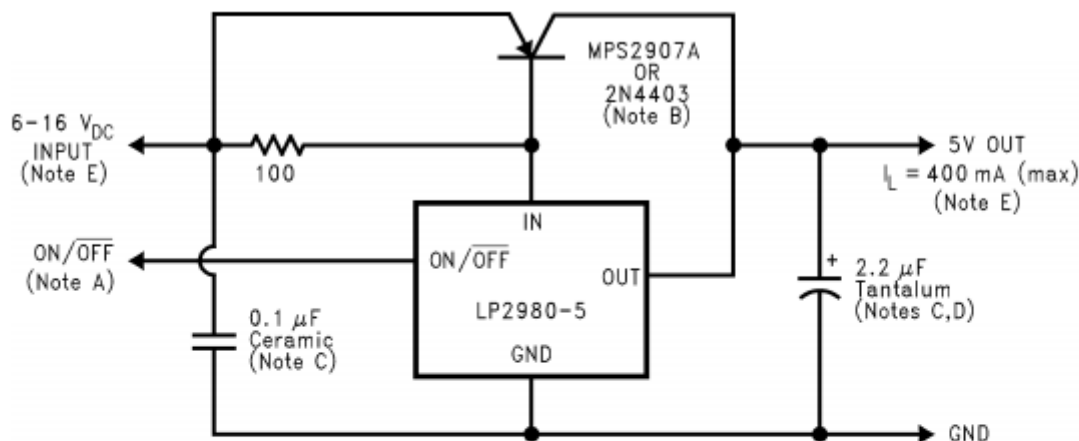
#### NOTE

The regulator shutdown function will not operate correctly if a slow-moving signal is used to drive the  $\overline{\text{ON/OFF}}$  input.

### 8.2.2.4 Increasing Output Current

The LP2980-N can be used to control higher-current regulators, by adding an external PNP pass transistor. With the PNP transistors shown in Figure 36, the output current can be as high as 400 mA, as long as the input voltage is held within the Safe Operation Boundary Curves shown below in Figure 37.

To ensure regulation, the minimum input voltage of this regulator is 6 V. This headroom is the sum of the  $V_{BE}$  of the external transistor and the dropout voltage of the LP2980-N.



**Figure 36. 5-V and 400-mA Regulator**

**Notes:**

Note A: Drive this input with a logic signal (see *ON/OFF Input Operation*). If the shutdown function is not to be used, tie the ON/OFF pin directly to the IN pin.

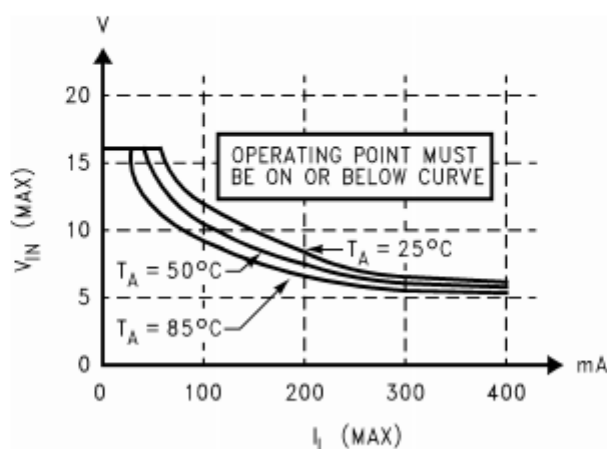
Note B: Recommended devices (other PNP transistors can be used if the current gain and voltage ratings are similar).

Note C: Capacitor is required for regulator stability. Minimum size is shown, and may be increased without limit.

Note D: Increasing the output capacitance improves transient response and increases phase margin.

Note E: Maximum safe input voltage and load current are limited by power dissipation in the PNP pass transistor and the maximum ambient temperature for the specific application. If a TO-92 transistor such as the MPS2907A is used, the thermal resistance from junction-to-ambient is 180°C/W in still air.

Assuming a maximum allowable junction temperature of 150°C for the MPS2907A device, the following curves show the maximum  $V_{IN}$  and  $I_L$  values that may be safely used for several ambient temperatures.



**Figure 37. Safe Operation Boundary Curves for Figure 36**

With limited input voltage range, the LP2980-N can control a 3.3-V, 3-A regulator with the use of a high current-gain external PNP pass transistor as shown in Figure 38. If the regulator is to be loaded with the full 3 A, heat sinking will be required on the pass transistor to keep it within its rated temperature range. See Figure 39. For best load regulation at the high load current, the LP2980-N output voltage connection should be made as close to the load as possible.

Although this regulator can handle a much higher load current than can the LP2980-N alone, it can be shut down in the same manner as the LP2980-N. When the ON/OFF control is brought low, the converter will be in shutdown, and will draw less than 1  $\mu\text{A}$  from the source.

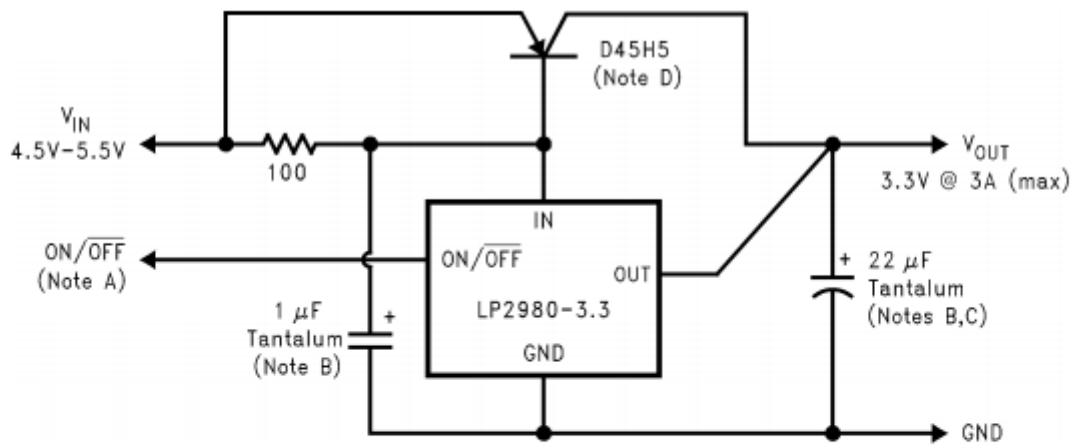


Figure 38. 5 V to 3.3 V at 3-A Converter

**NOTES:**

Note A: Drive this input with a logic signal (see *ON/OFF Input Operation*). If the shutdown function is not to be used, tie the ON/OFF pin directly to the IN pin.

Note B: Capacitor is required for regulator stability. Minimum size is shown, and may be increased without limit.

Note C: Increasing the output capacitance improves transient response and increases phase margin.

Note D: A heatsink may be required for this transistor. The maximum allowable value for thermal resistance of the heatsink is dependent on ambient temperature and load current (see curves in Figure 39). Once the value is obtained from the graph, a heatsink must be selected which has a thermal resistance equal to or lower than this value. If the value is above 60°C/W, no heatsink is required.

For these curves, a maximum junction temperature of 150°C is assumed for the pass transistor. The case-to-heatsink attachment thermal resistance is assumed to be 1.5°C/W. All calculations are for 5.5-V input voltage (which is worst-case for power dissipation).

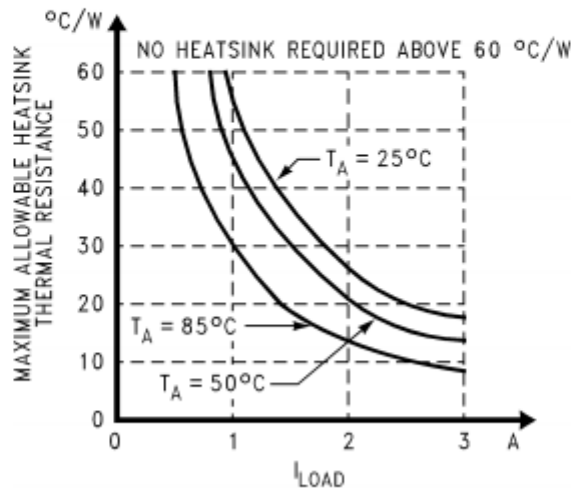


Figure 39. Heatsink Thermal Resistance Requirements for Figure 38



### 8.2.3 Application Curve

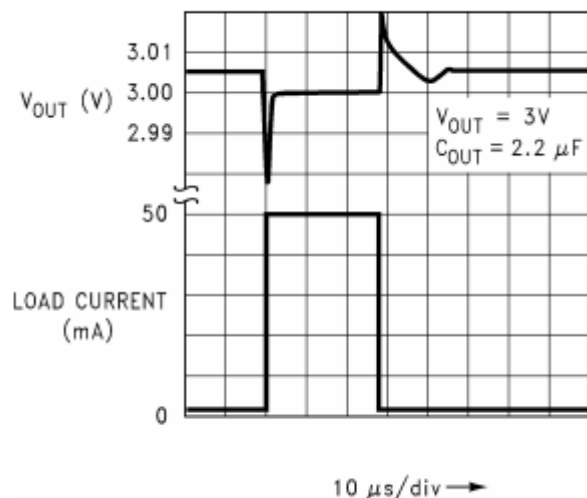


Figure 40. Load Transient Response

## 9 Power Supply Recommendations

The LP2980-N is designed to operate from an input voltage supply range between 2.1 V and 16 V. The input voltage range provides adequate headroom for the device to have a regulated output. This input supply must be well regulated. If the input supply is noisy, additional input capacitors with low ESR can help improve the output noise performance.

## 10 Layout

### 10.1 Layout Guidelines

For best overall performance, place all circuit components on the same side of the circuit board and as near as practical to the respective LDO pin connections. Place ground return connections to the input and output capacitors, and to the LDO ground pin as close as possible to each other, connected by a wide, component-side, copper surface. The use of vias and long traces to create LDO circuit connections is strongly discouraged and negatively affects system performance. This grounding and layout scheme minimizes inductive parasitics, and thereby reduces load-current transients, minimizes noise, and increases circuit stability. A ground reference plane is also recommended and is either embedded in the PCB itself or located on the bottom side of the PCB opposite the components. This reference plane serves to assure accuracy of the output voltage, shield noise, and behaves similar to a thermal plane to spread (or sink) heat from the LDO device. In most applications, this ground plane is necessary to meet thermal requirements.

### 10.2 Layout Example

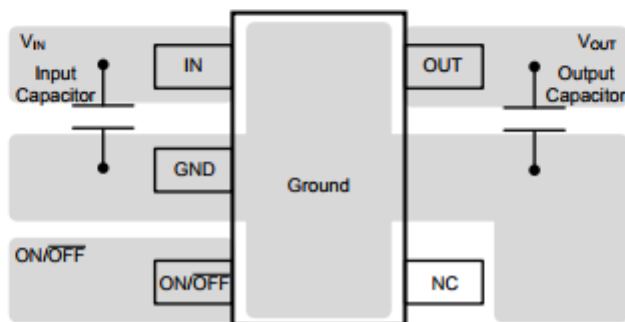


Figure 41. LP2980-N Layout Example

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Third-Party Products Disclaimer

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

### 11.4 Trademarks

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### 11.5 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.

### 11.6 Glossary

SLYZ022 — *TI Glossary*.

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

## 12 Mechanical, Packaging, and Orderable Information

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