National Semiconductor

LP2982
Micropower SOT, 50 mA Ultra Low-Dropout Regulator

General Description

The LP2982 is a 50 mA, fixed-output voltage regulator designed to provide ultra low dropout and lower noise in battery powered applications.

Using an optimized VIP™ (Vertically Integrated PNP) process, the LP2982 delivers unequaled performance in all specifications critical to battery-powered designs:

Dropout Voltage: Typically 120 mV @ 50 mA load, and 7 mV @ 1 mA load.

Ground Pin Current: Typically 375 μA @ 50 mA load, and 80 μA @ 1 mA load.

Sleep Mode: Less than 1 μA quiescent current when on/off pin is pulled low.

Smallest Possible Size: SOT-23 package uses absolute minimum of board space.

Precision Output: 1.0% tolerance output voltages available (A grade).

Low Noise: By adding an external bypass capacitor, output noise can be reduced to 30 μV (typical).

5.0V, 3.3V, and 3.0V versions available as standard products.

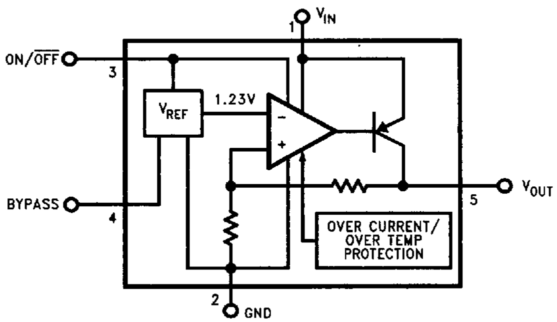
Features

- Ultra low dropout voltage
- Guaranteed 50 mA output current
- Typical dropout voltage 180 mV @ 80 mA
- Smallest possible size (SOT-23 Package)
- Requires minimum external components
- < 1 μA quiescent current when shutdown
- Low ground pin current at all loads
- Output voltage accuracy 1.0% (A Grade)
- High peak current capability (150 mA typical)
- Wide supply voltage range (16V max)
- Low Z_{OUT} 0.3Ω typical (10 Hz to 1 MHz)
- Overtemperature/overcurrent protection
- −40°C to +125°C junction temperature range
- Custom voltages available

Applications

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

Block Diagram



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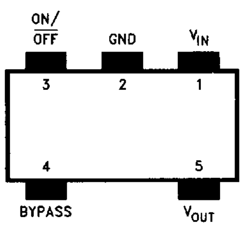
Connection Diagram



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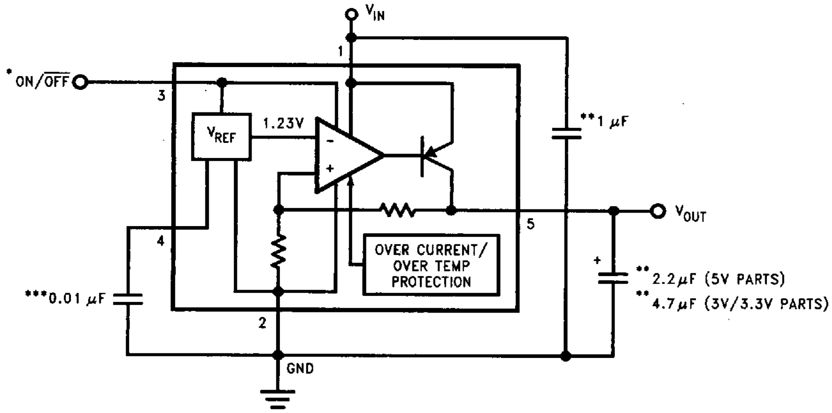
See NS Package Number MA05A

Basic Application Circuit



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*ON/$\overline{\text{OFF}}$ input must be actively terminated. Tie to V_{IN} if this function is not to be used.

**Minimum capacitance is shown to insure stability over full load current range. More capacitance provides superior dynamic performance (see Application Hints).

***See Application Hints.

Ordering Information

TABLE I. Package Marking and Ordering Information

Output Voltage (V)	Grade	Order Information	Package Marking	Supplied As:
5.0	A	LP2982AIM5X-5.0	L18A	3k Units on Tape and Reel
5.0	A	LP2982AIM5-5.0	L18A	250 Units on Tape and Reel
5.0	STD	LP2982IM5X-5.0	L18B	3k Units on Tape and Reel
5.0	STD	LP2982IM5-5.0	L18B	250 Units on Tape and Reel
3.3	A	LP2982AIM5X-3.3	L19A	3k Units on Tape and Reel
3.3	A	LP2982AIM5-3.3	L19A	250 Units on Tape and Reel
3.3	STD	LP2982IM5X-3.3	L19B	3k Units on Tape and Reel
3.3	STD	LP2982IM5-3.3	L19B	250 Units on Tape and Reel
3.0	A	LP2982AIM5X-3.0	L20A	3k Units on Tape and Reel
3.0	A	LP2982AIM5-3.0	L20A	250 Units on Tape and Reel
3.0	STD	LP2982IM5X-3.0	L20B	3k Units on Tape and Reel
3.0	STD	LP2982IM5-3.0	L20B	250 Units on Tape and Reel

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	−65°C to +150°C
Operating Junction Temperature Range	−40°C to +125°C
Lead Temperature (Soldering, 5 sec.)	260°C
ESD Rating (Note 2)	2 kV
Power Dissipation (Note 3)	Internally Limited
Input Supply Voltage (Survival)	−0.3V to +16V
Input Supply Voltage (Operating)	2.1V to +16V
Shutdown Input Voltage (Survival)	−0.3V to +16V
Output Voltage (Survival, Note 4)	−0.3V to +9V
I_{OUT} (Survival)	Short Circuit Protected
Input-Output Voltage (Survival, Note 5)	−0.3V to +16V

Electrical Characteristics

Limits in standard typeface are for T_J = 25°C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: $V_{IN} = V_{O(NOM)} + 1V$, I_L = 1 mA, C_{IN} = 1 µF, C_{OUT} = 4.7 µF, $V_{ON/OFF}$ = 2V.

Symbol	Parameter	Conditions	Typ	LP2982AI-X.X (Note 6) Min	LP2982AI-X.X (Note 6) Max	LP2982I-X.X (Note 6) Min	LP2982I-X.X (Note 6) Max	Units
V_O	Output Voltage (5.0V Versions)	$V_{IN} = V_{O(NOM)} + 1V$	5.0	4.950	5.050	4.925	5.075	V
		1 mA < I_L < 50 mA	5.0	4.925 **4.875**	5.075 **5.125**	4.900 **4.825**	5.100 **5.175**	
	Output Voltage (3.3V Versions)	$V_{IN} = V_{O(NOM)} + 1V$	3.3	3.267	3.333	3.250	3.350	
		1 mA < I_L < 50 mA	3.3	3.250 **3.217**	3.350 **3.383**	3.234 **3.184**	3.366 **3.416**	
	Output Voltage (3.0V Versions)	$V_{IN} = V_{O(NOM)} + 1V$	3.0	2.970	3.030	2.955	3.045	
		1 mA < I_L < 50 mA	3.0	2.955 **2.925**	3.045 **3.075**	2.940 **2.895**	3.060 **3.105**	
$\frac{\Delta V_O}{\Delta V_{IN}}$	Output Voltage Line Regulation	$V_{O(NOM)} + 1V \le V_{IN} \le 16V$	0.007		0.014 **0.032**		0.014 **0.032**	%/V
$V_{IN}-V_O$	Dropout Voltage (Note 7)	I_L = 0	1		3 **5**		3 **5**	mV
		I_L = 1 mA	7		10 **15**		10 **15**	
		I_L = 10 mA	40		60 **90**		60 **90**	
		I_L = 50 mA	120		150 **225**		150 **225**	
I_{GND}	Ground Pin Current	I_L = 0	65		95 **125**		95 **125**	µA
		I_L = 1 mA	80		110 **170**		110 **170**	
		I_L = 10 mA	140		220 **460**		220 **460**	
		I_L = 50 mA	375		600 **1200**		600 **1200**	
		$V_{ON/OFF}$ < 0.3V	0.01		0.8		0.8	
		$V_{ON/OFF}$ < 0.15V	**0.10**					
$V_{ON/OFF}$	ON/OFF Input Voltage (Note 8)	High = O/P ON	1.4	**2.0**		**2.0**		V
		Low = O/P OFF	0.55		**0.15**		**0.15**	
$I_{ON/OFF}$	ON/OFF Input Current	$V_{ON/OFF}$ = 0	0.01		**−2**		**−2**	µA
		$V_{ON/OFF}$ = 5V	5		**15**		**15**	

Electrical Characteristics

Limits in standard typeface are for T_J = 25°C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: $V_{IN} = V_{O(NOM)} + 1V$, I_L = 1 mA, C_{IN} = 1 µF, C_{OUT} = 4.7 µF, $V_{ON/OFF}$ = 2V. (Continued)

Symbol	Parameter	Conditions	Typ	LP2982AI-X.X (Note 6)		LP2982I-X.X (Note 6)		Units
				Min	Max	Min	Max	
$I_{O(PK)}$	Peak Output Current	$V_{OUT} \geq V_{O(NOM)} - 5\%$	150	100		100		mA
$V_{IN}-V_O$	Dropout Voltage	I_L = 80 mA	180		225 **325**		225 **325**	mV
I_{GND}	Ground Pin Current	I_L = 80 mA	525		750 **1400**		750 **1400**	µA
e_n	Output Noise Voltage (RMS)	BW = 300 Hz–50 kHz, C_{OUT} = 10 µF C_{BYPASS} = 0.01 µF	30					µV
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Ripple Rejection	f = 1 kHz C_{OUT} = 10 µF	45					dB
$I_{O(MAX)}$	Short Circuit Current	R_L = 0 (Steady State) (Note 9)	150					mA

Note 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.

Note 2: The ESD rating of pins 3 and 4 is 1 kV.

Note 3: The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(MAX)}$, the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using:

$$P\,(MAX) = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

The value of θ_{JA} for the SOT-23 package is 300°C/W. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown.

Note 4: If used in a dual-supply system where the regulator load is returned to a negative supply, the LP2982 output must be diode-clamped to ground.

Note 5: The output PNP structure contains a diode between the V_{IN} and V_{OUT} terminals that is normally reverse-biased. Reversing the polarity from V_{IN} to V_{OUT} will turn on this diode.

Note 6: Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's Averaging Outgoing Level (AOQL).

Note 7: Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below the value measured with a 1V differential.

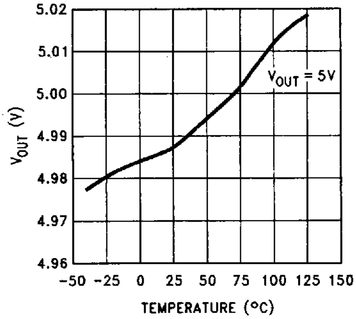
Note 8: The ON/OFF inputs must be properly driven to prevent possible misoperation. For details, refer to Application Hints.

Note 9: See Typical Performance Characteristics curves.

Typical Performance Characteristics

Unless otherwise specified: T_A = 25°C, V_{IN} = $V_{O(NOM)}$ + 1V, C_{OUT} = 4.7 μF, C_{IN} = 1 μF, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

Output Voltage vs Temperature



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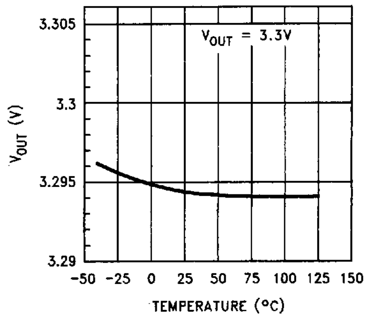
Output Voltage vs Temperature



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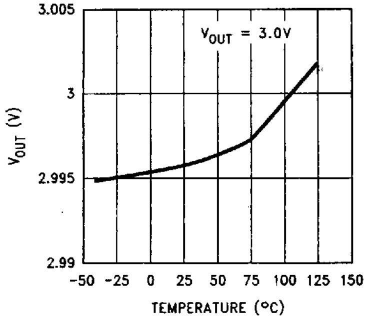
Output Voltage vs Temperature



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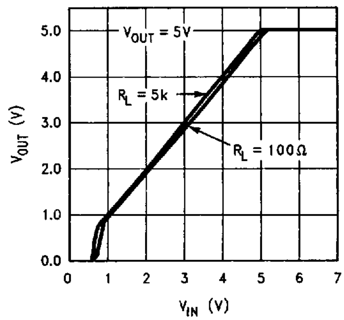
Dropout Characteristics



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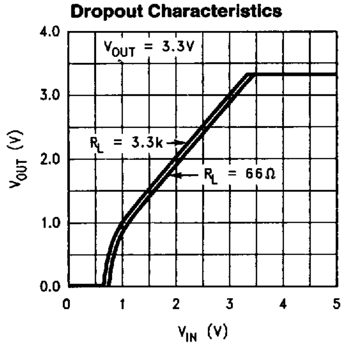
Dropout Characteristics



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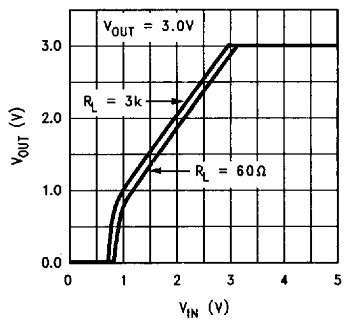
Dropout Characteristics



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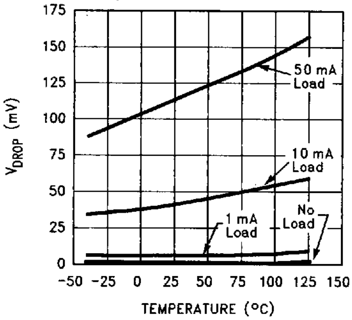
Typical Performance Characteristics (Continued)

Unless otherwise specified: T_A = 25°C, V_{IN} = $V_{O(NOM)}$ + 1V, C_{OUT} = 4.7 μF, C_{IN} = 1 μF, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

Dropout Voltage vs Temperature



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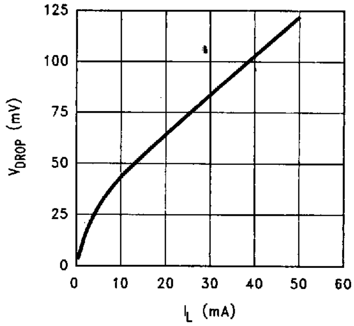
Dropout Voltage vs Load Current



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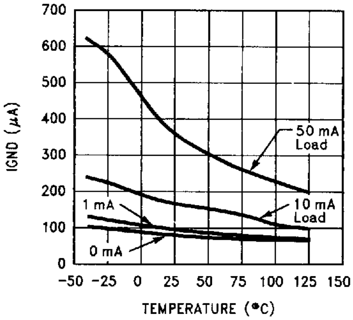
Ground Pin Current vs Temperature



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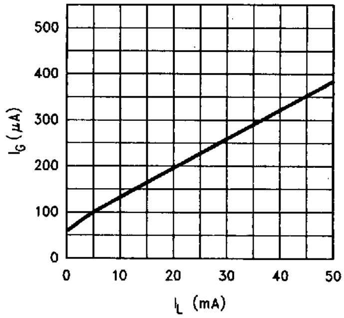
Ground Pin Current vs Load Current



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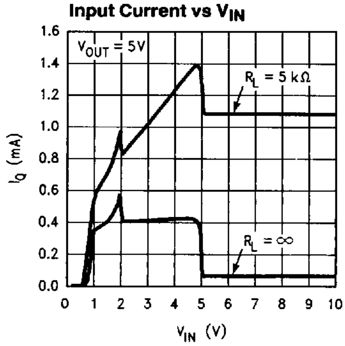
Input Current vs V_{IN}



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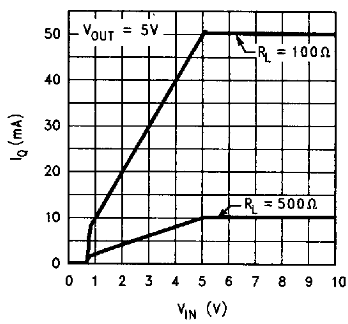
Input Current vs V_{IN}



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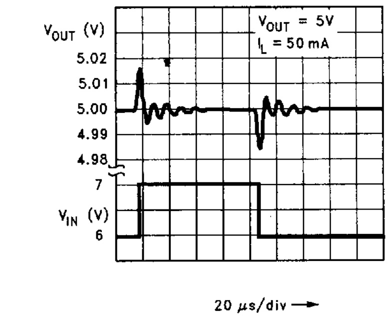
Typical Performance Characteristics (Continued)

Unless otherwise specified: $T_A = 25°C$, $V_{IN} = V_{O(NOM)} + 1V$, $C_{OUT} = 4.7\ \mu F$, $C_{IN} = 1\ \mu F$, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

Line Transient Response



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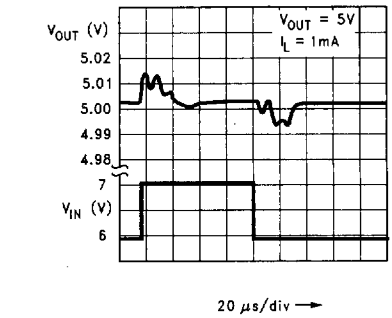
Line Transient Response



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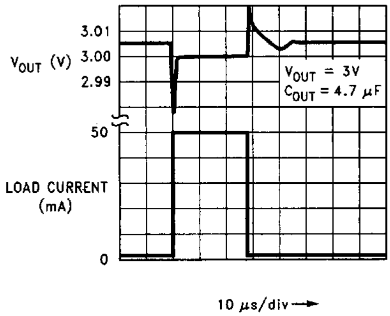
Load Transient Response



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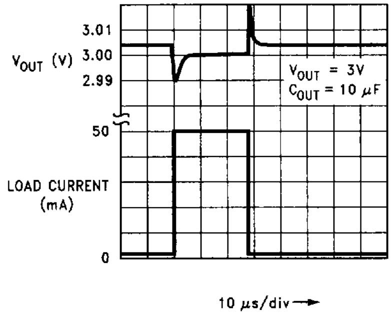
Load Transient Response



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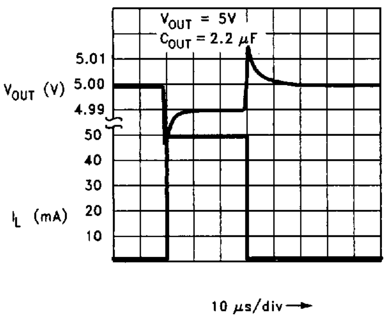
Load Transient Response



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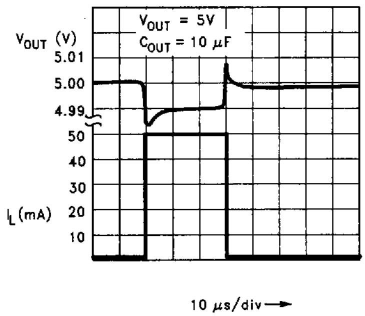
Load Transient Response



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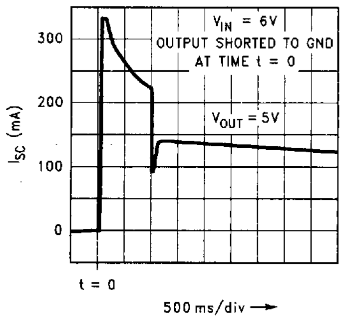
Typical Performance Characteristics (Continued)

Unless otherwise specified: T_A = 25°C, V_{IN} = $V_{O(NOM)}$ + 1V, C_{OUT} = 4.7 μF, C_{IN} = 1 μF, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

Short Circuit Current



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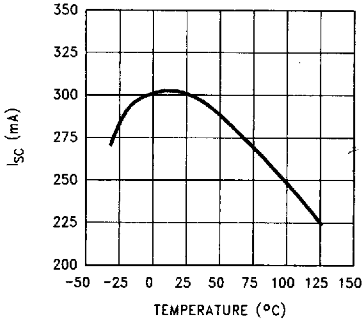
Instantaneous Short Circuit Current vs Temperature



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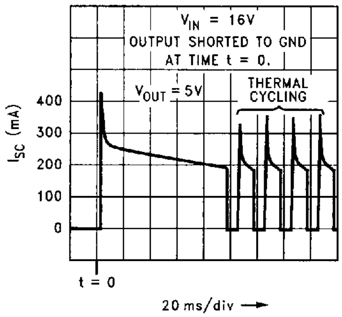
Short Circuit Current



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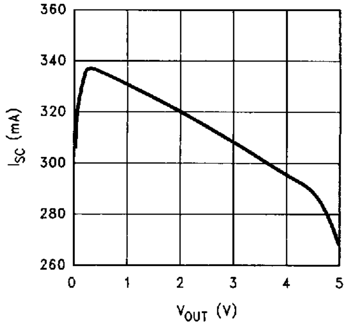
Instantaneous Short Circuit Current vs Output Voltage



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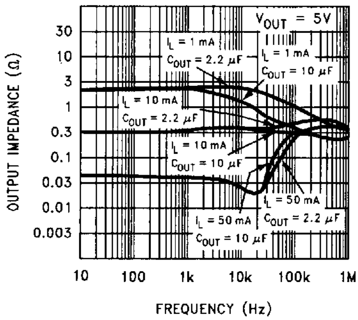
Output Impedance vs Frequency



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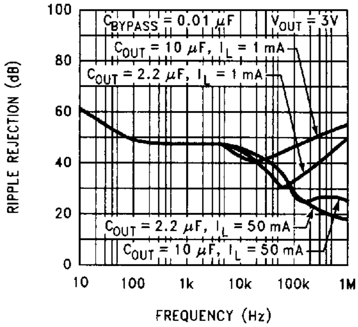
Ripple Rejection

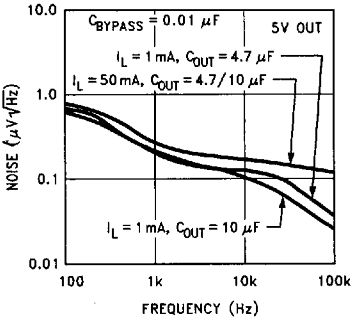


TL/H/12679-41

Typical Performance Characteristics (Continued)

Unless otherwise specified: T_A = 25°C, V_{IN} = $V_{O(NOM)}$ + 1V, C_{OUT} = 4.7 µF, C_{IN} = 1 µF, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

Output Noise Density



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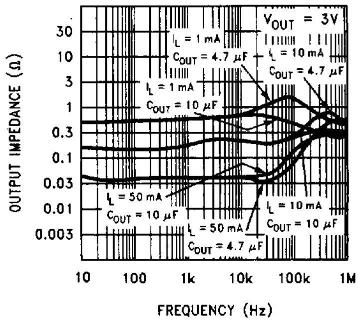
Output Impedance vs Frequency



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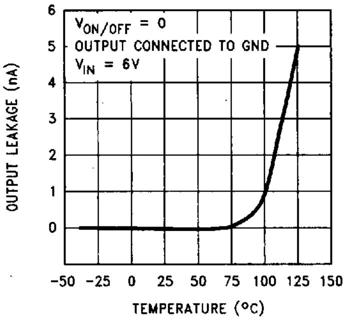
Input to Output Leakage vs Temperature



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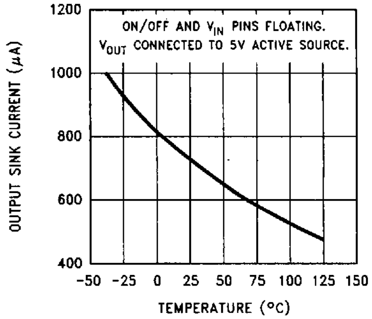
Output Reverse Leakage vs Temperature



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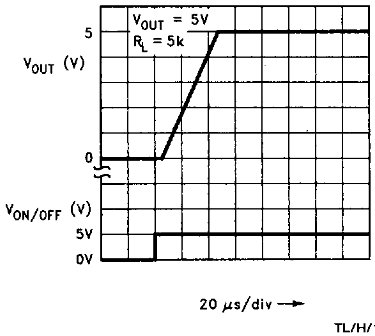
Turn-On Waveform



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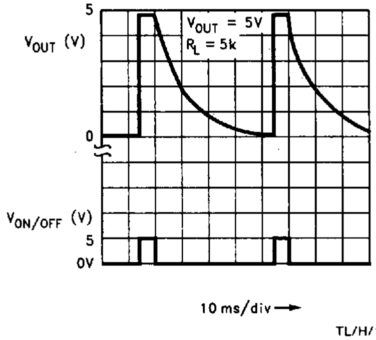
Turn-Off Waveform



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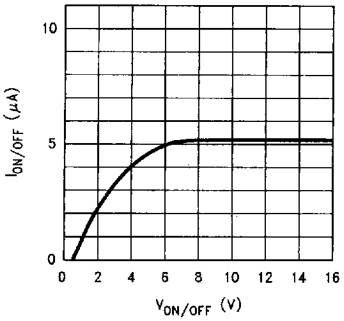
Typical Performance Characteristics (Continued)

Unless otherwise specified:
T_A = 25°C, V_{IN} = $V_{O(NOM)}$ + 1V, C_{OUT} = 4.7 µF, C_{IN} = 1 µF, all voltage options, ON/$\overline{OFF}$ pin tied to V_{IN}.

ON/OFF Pin Current vs $V_{ON/OFF}$



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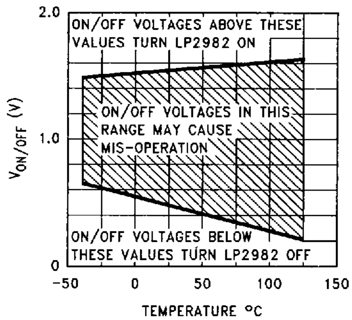
ON/OFF Threshold vs Temperature



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Application Hints

EXTERNAL CAPACITORS

Like any low-dropout regulator, the external capacitors used with the LP2982 must be carefully selected to assure regulator loop stability.

INPUT CAPACITOR: An input capacitor whose value is ≥ 1 µF is required with the LP2982 (amount of capacitance can be increased without limit).

This capacitor must be located a distance of not more than 0.5″ from the input pin of the LP2982 and returned to a clean analog ground. Any good quality ceramic or tantalum can be used for this capacitor.

OUTPUT CAPACITOR: The output capacitor must meet both the requirement for minimum amount of capacitance and E.S.R. (equivalent series resistance) value. Curves are provided which show the allowable ESR range as a function of load current for various output voltages and capacitor values (refer to *Figures 1, 2*).

IMPORTANT: The output capacitor must maintain its ESR in the stable region over the full operating temperature to assure stability. Also, capacitor tolerance and variation with temperature must be considered to assure the minimum amount of capacitance is provided at all times.

This capacitor should be located not more than 0.5″ from the output pin of the LP2982 and returned to a clean analog ground.

LOW-CURRENT OPERATION: In applications where the load current is < 1 mA, special consideration must be given to the output capacitor.

Circuitry inside the LP2982 is specially designed to reduce operating (quiescent) current at light loads down to about 65 µA.

The mode of operation which yields this very low quiescent current also means that the output capacitor ESR is critical.

For optimum stability and minimum output noise, it is recommended that a 10Ω resistor be placed in series with the output capacitor in any applications where I_L < 1 mA.

CAPACITOR CHARACTERISTICS

TANTALUM: Tantalum capacitors offer the best value for considerations of size, cost, and electrical performance. Most good quality tantalums can be used with the LP2982, but check the manufacturer's data sheet to be sure the ESR is in range.

It is important to remember that ESR increases sharply at lower temperatures (< 10°C) and a capacitor that is near the upper limit for stability at room temperature can cause instability when it gets cold.

In applications which must operate at very low temperatures, it may be necessary to parallel the output tantalum capacitor with a ceramic capacitor to prevent the ESR from going up too high (see next section for important information on ceramic capacitors).

CERAMIC: Ceramic capacitors are typically larger and more costly than tantalum for a given capacitance, however they have a much lower ESR (and they do not exhibit the low temperature increase seen in tantalum and aluminum electrolytics).

It should be warned that the ESR of a ceramic can be low enough to go below the minimum stable value for the LP2982. A good 2.2 µF ceramic was measured and found to have an ESR of about 15 mΩ, which is low enough to cause oscillations.

This means that in many cases, large value (≥ 1 µF) ceramics should not be used on the LP2982 output (the limiting value of ceramic capacitance which can be used will be dictated by the ESR).

If ceramic capacitors are used on the output, they should be used in parallel with a tantalum that provides most of the output capacitance. Remember that when a tantalum and ceramic are put in parallel, the effective ESR seen by the LP2982 output is the parallel value resulting from the ESR of each capacitor.

ALUMINUM: Because of large physical size, aluminum electrolytics are not typically used with the LP2982. They must meet the same ESR requirements over the operating temperature range, which is more difficult because of their large increase in ESR at cold temperature.

An aluminum electrolytic can exhibit an ESR increase of as much as 50X when going from 20°C to −40°C. Also, some aluminum electrolytics are not operational below −25°C because the electrolyte can freeze.

Application Hints (Continued)

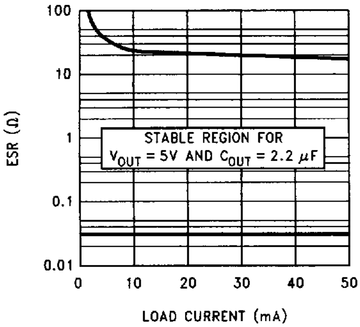

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FIGURE 1. 5V/2.2 μF ESR Curves

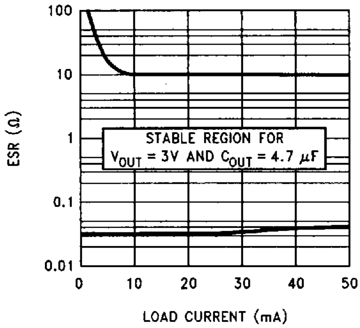

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FIGURE 2. 3V/4.7 μF ESR Curves

BYPASS CAPACITOR

The 0.01 μF capacitor connected to the bypass pin to reduce noise must have very low leakage.

The current flowing out of the bypass pin comes from the bandgap reference, which is used to set the output voltage.

This capacitor leakage current causes the output voltage to decline by an amount proportional to the current. Typical values are −0.015%/nA @ −40°C, −0.021%/nA @ 25°C, and −0.035%/nA @ +125°C.

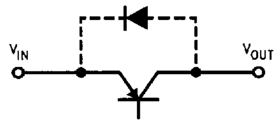
This data is valid up to a maximum leakage current of about 500 nA, beyond which the bandgap is so severly loaded that it can not function.

Care must be taken to ensure that the capacitor selected will not have excessive leakage current over the operating temperature range of the application.

A high quality ceramic capacitor which uses either NPO or COG type dielectric material will typically have very low leakage. Small surface mount polypropolene or polycarbonate film capacitors also have extremely low leakage, but are slightly larger than ceramics.

REVERSE CURRENT PATH

The power transistor used in the LP2982 has an inherent diode connected between the regulator input and output (see below).



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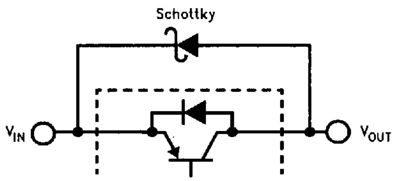
If the output is forced above the input by more than a V_{BE}, this diode will become forward biased and current will flow from the V_{OUT} terminal to V_{IN}. This current must be limited to < 100 mA to prevent damage to the part.

The internal diode can also be turned on by abruptly stepping the input voltage to a value below the output voltage.

To prevent regulator mis-operation, a Schottky diode should be used in any application where input/output voltage conditions can cause the internal diode to be turned on (see below).



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As shown, the Schottky diode is connected in parallel with the internal parasitic diode and prevents it from being turned on by limiting the voltage drop across it to about 0.3V.

ON/OFF INPUT OPERATION

The LP2982 is shut off by pulling the ON/OFF input low, and turned on by driving the input high. If this feature is not to be used, the ON/OFF input should be tied to V_{IN} to keep the regulator on at all times (the ON/OFF input must **not** be left floating).

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

The ON/OFF signal may come from either a totem-pole output, or an open-collector output with pull-up resistor to the LP2982 input voltage or another logic supply. The high-level voltage may exceed the LP2982 input voltage, but must remain within the Absolute Maximum Ratings for the ON/OFF pin.

It is also important that the turn-on/turn-off voltage signals applied to the ON/OFF input have a slew rate which is greater than 40 mV/μs.

Important: the regulator shutdown function will operate incorrectly if a slow-moving signal is applied to the ON/OFF input.