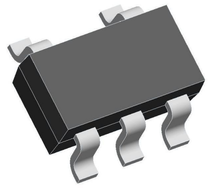
D2985

150mA Low-Noise Ultra Low-Dropout Regulator

General Description



SOT23-5

The D2985 is a 150 mA, fixed-output voltage regulator designed to provide ultra low-dropout and low noise in battery powered applications. The D2985 delivers unequalled performance in all specifications critical to battery-powered designs:

Dropout Voltage: Typically 300mV @ 150mA load, and 7mV @ 1mA load.

Ground Pin Current: Typically 850µA @ 150mA load, and 75µA @ 1mA load.

Enhanced Stability: The D2985 is stable with output capacitor ESR as low as 5mΩ, which allows the use of ceramic capacitors on the output.

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

Smallest Possible Size: SOT-23-5L packages use absolute minimum board space.

Precision Output: 1% tolerance output voltages available(A grade).

Low Noise: By adding a 10nF bypass capacitor, output noise can be reduced to 30µV (typical).

Multiple voltage options, from 2.5V to 5.0V, are available as standard products. Consult factory for custom voltages.

Features

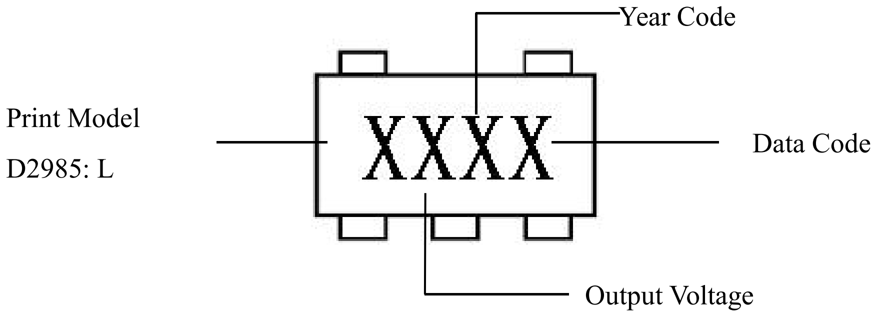
- Ultra low dropout voltage
- Guaranteed 150mA output current
- Smallest possible size (SOT-23-5L package)
- Requires minimum external components
- Stable with low-ESR output capacitor
- <1µA quiescent current when shut down
- Low ground pin current at all loads
- Output voltage accuracy 1% (A Grade)
- High peak current capability
- Wide supply voltage range (16V max)

- Low Z_{OUT}: 0.3Ω typical (10Hz to 1MHz)
- Over temperature / Over current protection
- −40°C to +125°C junction temperature range
- Custom voltages available

Package Information

Part NO.	Package Description	Package Marking	Package Option
D2985	SOT23-5	XXXX	3000/Reel

Marking Information

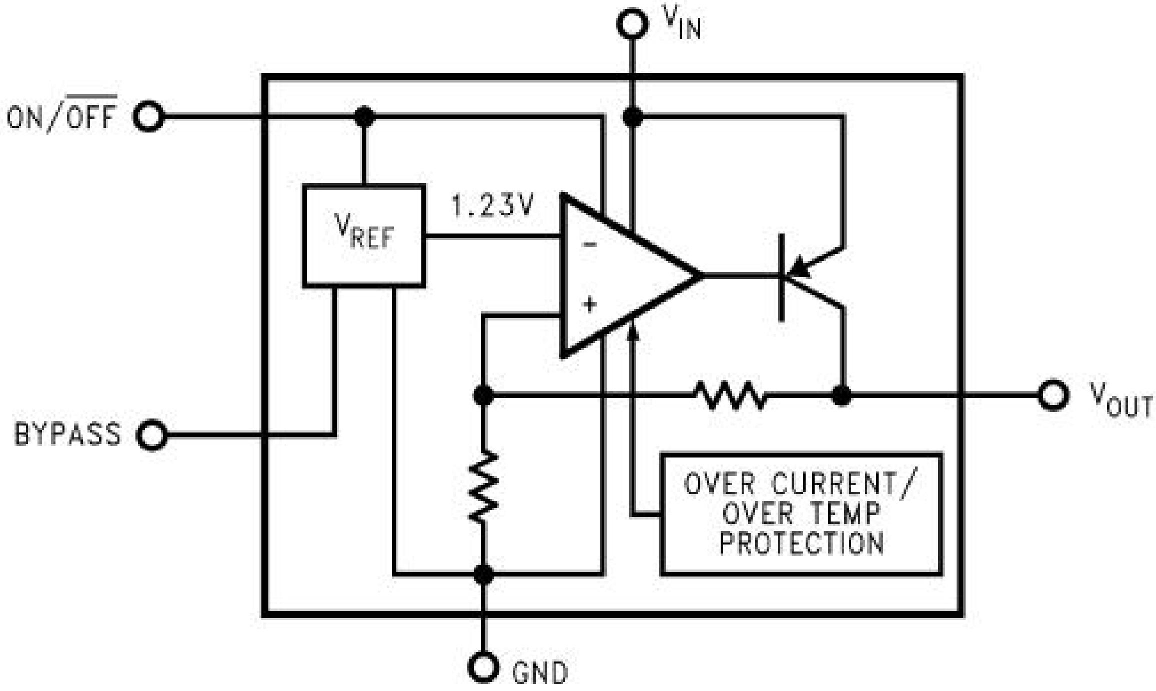


Print Code	Output Voltage (V)	Print Code	Output Voltage (V)	Print Code	Output Voltage (V)
A	2.5	H	3.2	R	4.7
B	2.6	J	3.3	S	4.8
C	2.7	K	3.5	T	5.0
D	2.8	L	3.6	V	5.3
E	2.9	M	3.8	W	6.0
F	3.0	N	4.0	X	6.1
G	3.1	P	4.5	Y	12

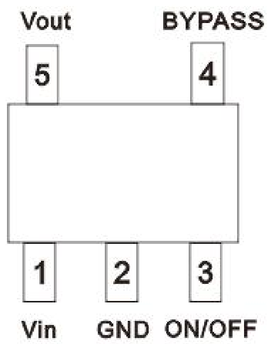
Applications

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

Block Diagram



Pin Connection



Pin Description

Pin Number	Symbol	Function
1	V_{IN}	Input Voltage
2	GND	Common Ground
3	ON/OFF	Logic high enable input
4	BYPASS	Bypass capacitor for low noise operation
5	V_{OUT}	Regulated output voltage

Absolute Maximum Ratings (Ta=25°C) *1

Characteristic	Value	Unit
Input Supply Voltage (survival)	-0.3～+16	V
Input Supply Voltage (operating)	2.5～+16	V
Shutdown input voltage (survival)	-0.3～+16	V
ESD Rating *2	2	kV
Power dissipation *3	Internally limited	
Output voltage (survival) *4	-0.3～+9	V
I_{OUT} (survival)	Short circuit protected	
Input-Output voltage (survival) *5	-0.3～+16	V
Operating Temperature	-40～+125	°C
Storage Temperature	-65～+150	°C
Lead Temp. (soldering, 5 sec.)	260	°C

Electrical Characteristics *10

(unless otherwise specified: 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=1mA, C_{IN}=1μF, C_{OUT}=4.7μF, $V_{ON/OFF}$=2V.)

Characteristics	Symbol	Test conditions	Min	Typ	Max	Unit
Output voltage tolerance	ΔVo	I_L=1mA	-1.5		1.5	%V_{NOM}
		1mA ≤ I_L ≤ 50mA	-2.5 -3.5		2.5 3.5	
		1mA ≤ I_L ≤ 150mA	-3.0 -4.0		3.0 4.0	
Output voltage line regulation	$\frac{\Delta V_O}{\Delta V_{IN}}$	Vo(NOM)+1V ≤ V_{IN} ≤ 16V		0.007	0.014 0.032	%/V
Dropout voltage *7	V_{IN}-Vo	I_L=0		1	3 5	mV
		I_L=1mA		7	10 15	
		I_L=10mA		40	60 90	
		I_L=50mA		120	150 225	
		I_L=150mA		280	350 575	
ON/OFF input voltage *8	V_{ONOFF}	High=O/P ON		1.4	1.6	V
		Low=O/P OFF	0.15	0.55		
ON/OFF input current	$I_{ON/OFF}$	$V_{ON/OFF}$=0V	-2	0.01		μA
		$V_{ON/OFF}$=5V		5	15	
Ground pin current	I_{GND}	I_L=0		65	95 125	μA
		I_L=1mA		75	110 170	
		I_L=10mA		120	220 400	
		I_L=50mA		350	600 1000	
		I_L=150mA		850	1500 2500	
		$V_{ON/OFF}$ < 0.3V		0.01	0.8	
		$V_{ON/OFF}$ < 0.15V		0.05	2	
Output noise voltage (RMS)	e_n	BW=300Hz to 50kHz C_{OUT}=10μF C_{BYPASS}=10nF		30		μV
Ripple rejection	$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	f=1kHz, C_{OUT}=10μF C_{BYPASS}=10nF		45		dB
Short circuit current	Io(SC)	R_L=0(steady state) *9		400		mA
Peak output current	Io(PK)	V_{OUT} ≥ Vo(NOM)-5%		350		mA

*** 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:** The ESD rating of pins 3 and 4 for the SOT-23-5L package, is 1 kV.

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

$$P(MAX) = \frac{T_J(MAX) - T_A}{\theta_{J-A}}$$

Where the value of θ_{JA} for the SOT-23-5L package is 220°C/W in a typical PC board mounting. Exceeding the maximum allowable 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 D2985 output must be diode-clamped to ground.

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

*** 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 Average Outgoing Quality Level (AOQL).

*** 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.

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

*** 9:** The D2985 has foldback current limiting which allows a high peak current when $V_{OUT} > 0.5V$, and then reduces the maximum output current as V_{OUT} is forced to ground (see Typical Performance Characteristics curves).

*** 10:** Exposing the micro SMD device to direct sunlight will cause misoperation. See Application Hints for additional information.

Application Summary

External Capacitors

Like any low-dropout regulator, the D2985 requires external capacitors for regulator stability. These capacitors must be correctly selected for good performance.

Input Capacitor

An input capacitor whose capacitance is ≥ 1 μF is required between the D2985 input and ground (the amount of capacitance may be increased without limit).

This capacitor must be located a distance of not more than 1 cm from the input pin and returned to a clean analog ground. Any good quality ceramic, tantalum, or film capacitor may be used at the input.

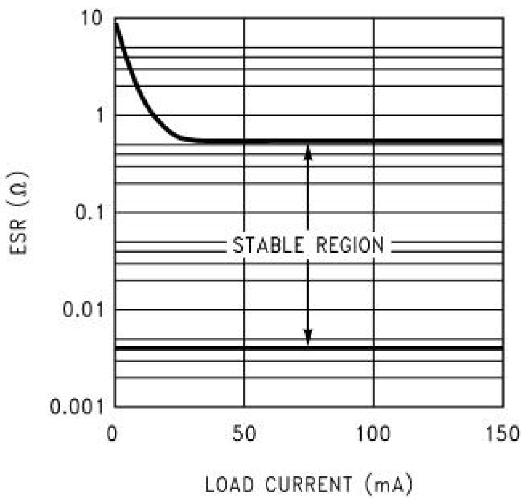
Important: Tantalum capacitors can suffer catastrophic failure due to surge current when connected to a low impedance source of power (like a battery or very large capacitor). If a Tantalum capacitor is used at the input, it must be guaranteed by the manufacturer to have a surge current rating sufficient for the application.

There are no requirements for ESR on the input capacitor, but tolerance and temperature coefficient must be considered when selecting the capacitor to ensure the capacitance will be ≥ 1 μF over the entire operating temperature range.

Output Capacitor

The D2985 is designed specifically to work with ceramic output capacitors, utilizing circuitry which allows the regulator to be stable across the entire range of output current with an output capacitor whose ESR is as low as 5 mΩ. It may also be possible to use Tantalum or film capacitors at the output, but these are not as attractive for reasons of size and cost (see next section Capacitor Characteristics).

The output capacitor must meet the requirement for minimum amount of capacitance and also have an ESR (equivalent series resistance) value which is within the stable range. Curves are provided which show the stable ESR range as a function of load current (see ESR graph below).



Important: The output capacitor must maintain its ESR within the stable region over the full operating temperature range of the application to assure stability.

The D2985 requires a minimum of 2.2 μF on the output(output capacitor size can be increased without limit). It is important to remember that capacitor tolerance and variation with temperature must be taken into consideration when selecting an output capacitor so that the minimum required amount of output capacitance is provided over the full operating temperature range. It should be noted that ceramic capacitors can exhibit large changes in capacitance with temperature (see next section, *Capacitor Characteristics*).

The output capacitor must be located not more than 1 cm from the output pin and returned to a clean analog ground.

Noise Bypass Capacitor

Connecting a 10nF capacitor to the Bypass pin significantly reduces noise on the regulator output. It should be noted that the capacitor is connected directly to a high-impedance circuit in the bandgap reference.

Because this circuit has only a few microamperes flowing in it, any significant loading on this node will cause a change in the regulated output voltage. For this reason, DC leakage current through the noise bypass capacitor must never exceed 100nA, and should be kept as low as possible for best output voltage accuracy.

The types of capacitors best suited for the noise bypass capacitor are ceramic and film. High-quality ceramic capacitors with either NPO or COG dielectric typically have very low leakage. 10nF polypropolene and polycarbonate film capacitors are available in small surface-mount packages and typically have extremely low leakage current.

Capacitor Characteristics

The D2985 was designed to work with ceramic capacitors on the output to take advantage of the benefits they offer: for capacitance values in the 2.2µF to 4.7µF range, ceramics are the least expensive and also have the lowest ESR values (which makes them best for eliminating high frequency noise). The ESR of a typical 2.2µF ceramic capacitor is in the range of 10mΩ to 20mΩ, which easily meets the ESR limits required for stability by the D2985. One disadvantage of ceramic capacitors is that their capacitance can vary with temperature. Most large value ceramic capacitors (≥ 2.2µF) are manufactured with the Z5U or Y5V temperature characteristic, which results in the capacitance dropping by more than 50% as the temperature goes from 25°C to 85°C.

This could cause problems if a 2.2µF capacitor were used on the output since it will drop down to approximately 1µF at high ambient temperatures (which could cause the D2985 to oscillate). If Z5U or Y5V capacitors are used on the output, a minimum capacitance value of 4.7µF must be observed.

A better choice for temperature coefficient in ceramic capacitors is X7R, which holds the capacitance within ±15%. Unfortunately, the larger values of capacitance are not offered by all manufacturers in the X7R dielectric.

Tantalum

Tantalum capacitors are less desirable than ceramics for use as output capacitors because they are more expensive when comparing equivalent capacitance and voltage ratings in the1 µF to 4.7µF range.

Another important consideration is that Tantalum capacitors have higher ESR values than equivalent size ceramics. This means that while it may be possible to find a Tantalum capacitor with an ESR value within the stable range, it would have to be larger in capacitance (which means bigger and more costly) than a ceramic capacitor with the same ESR value.

It should also be noted that the ESR of a typical Tantalum will increase about 2:1 as the temperature goes from 25°C down to −40°C, so some guard band must be allowed.

On/off Input Operation

The D2985 is shut off by driving the ON/OFF input low, and turned on by pulling it high. If this feature is not to be used, the ON/OFF input should be tied to VIN to keep the regulator output on at all times.

To assure 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 listed in the Electrical Characteristics section under $V_{ON/OFF}$. To prevent mis-operation, the turn-on (and turn-off) voltage signals applied to the ON/OFF input must have a slew rate which is≥ 40 mV/µs.

Caution: the regulator output voltage can not be guaranteed if a slow-moving AC (or DC) signal is applied that is in the range between the specified turn-on and turn-off voltages listed under the electrical specification $V_{ON/OFF}$ (see Electrical Characteristics).

Reverse Input-output Voltage

The PNP power transistor used as the pass element in the D2985 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.

However, if the output is pulled above the input, 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 V_{IN} (and out the ground pin), which can damage the part.

In any application where the output may be pulled above the input, an external Schottky diode must be connected from V_{IN} to V_{OUT} (cathode on V_{IN}, anode on V_{OUT}), to limit the reverse voltage across the D2985 to 0.3V (see Absolute Maximum Ratings).

Micro Smd Mounting

The micro SMD package requires specific mounting techniques which are detailed in National Semiconductor Application Note # 1112. Referring to the section Surface Mount Technology (SMT) Assembly Considerations, it should be noted that the pad style which must be used with the 5-pin package is the NSMD (non-solder mask defined) type.

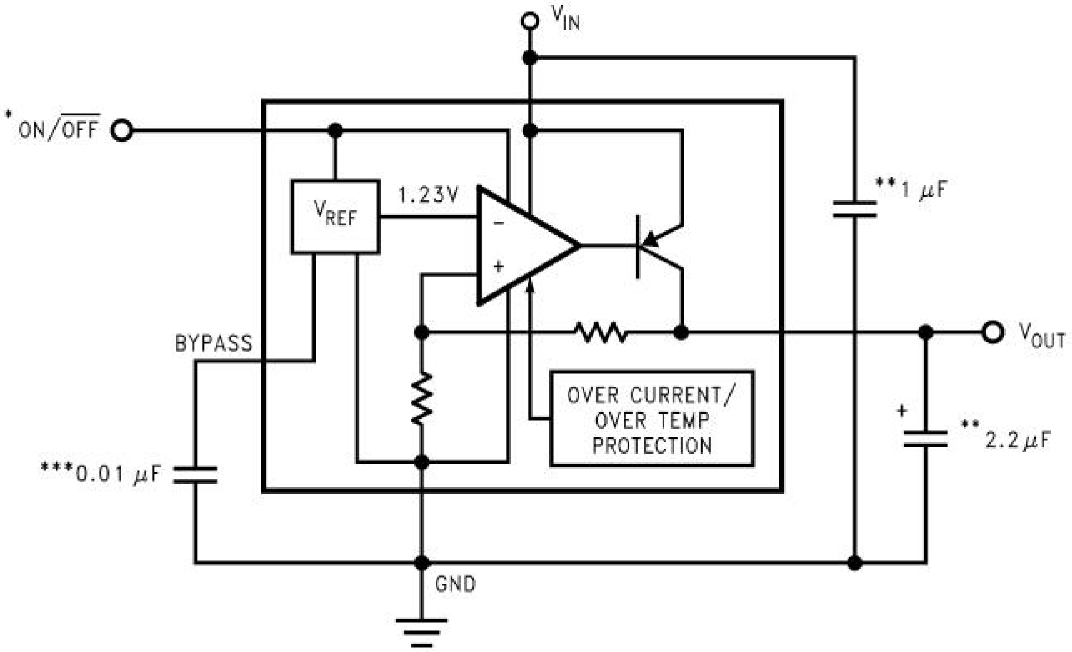
For best results during assembly, alignment ordinals on the PC board may be used to facilitate placement of the micro SMD device.

Micro Smd Light Sensitivity

Exposing the micro SMD device to direct sunlight will cause misoperation of the device. Light sources such as Halogen lamps can also affect electrical performance if brought near to the device.

The wavelenghts which have the most detrimental effect are reds and infra-reds, which means that the fluorescent lighting used inside most buildings has very little effect on performance. A micro SMD test board was brought to within 1 cm of a fluorescent desk lamp and the effect on the regulated output voltage was negligible, showing a deviation of less than 0.1% from nominal.

Application Current



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

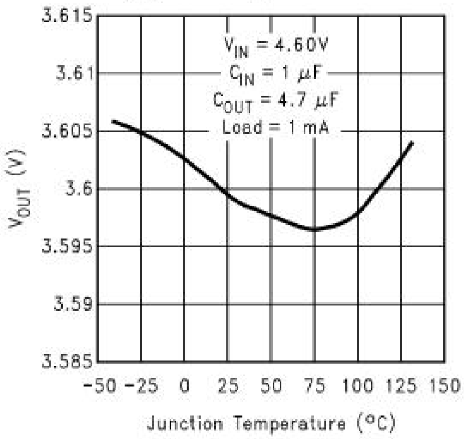
**Minimum capacitance is shown to ensure stability (may be increased without limit). Ceramic capacitor required for output

***Reduces output noise (may be omitted if application is not noise critical). Use ceramic or film type with very low leakage current

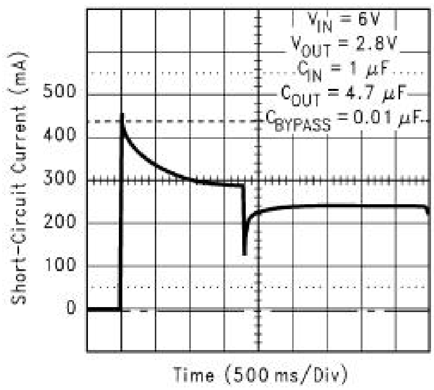
Typical Characteristics

Unless otherwise specified: C_{IN} = 1μF, C_{OUT} = 4.7μF, V_{IN} = V_{OUT}($_{NOM}$) +1, T_A = 25°C, ON/OFF pin is tied to V_{IN}.

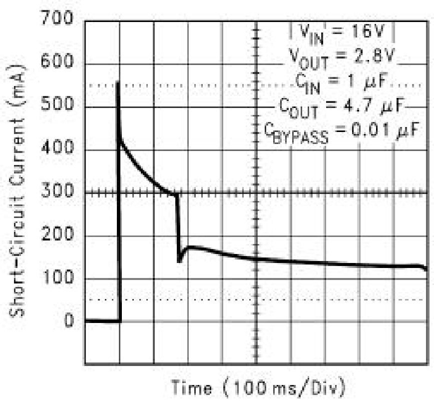
V_{OUT} vs Temperature



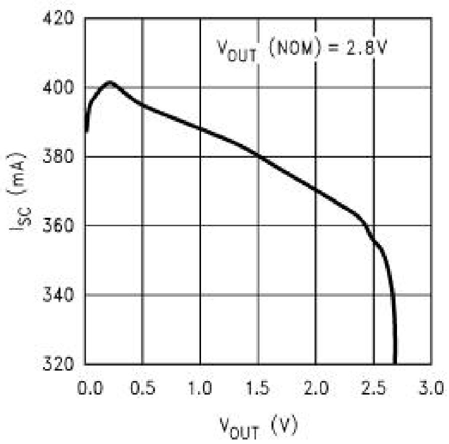
Short-Circuit Current



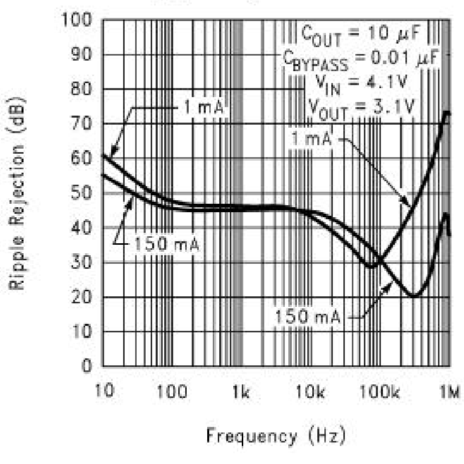
Short-Circuit Current



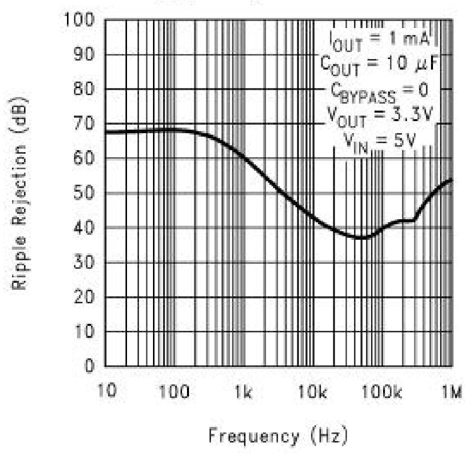
Short Circuit Current vs Output Voltage



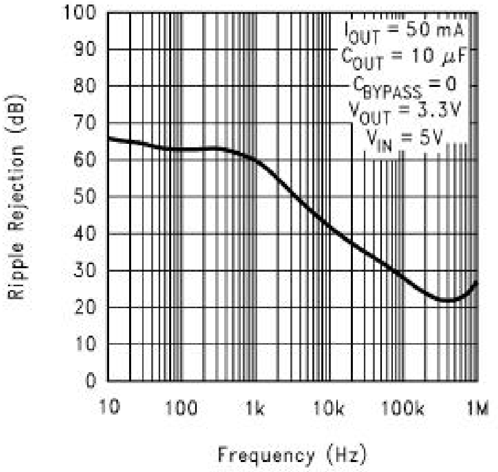
Ripple Rejection



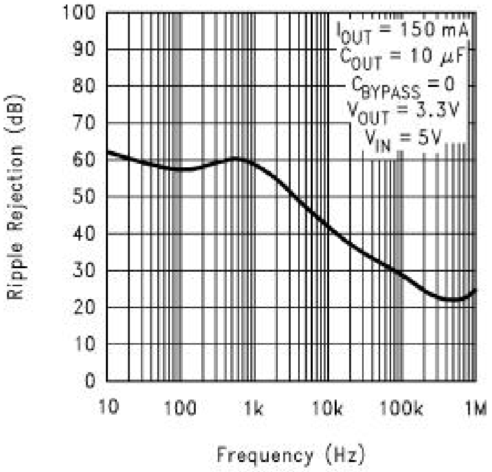
Ripple Rejection



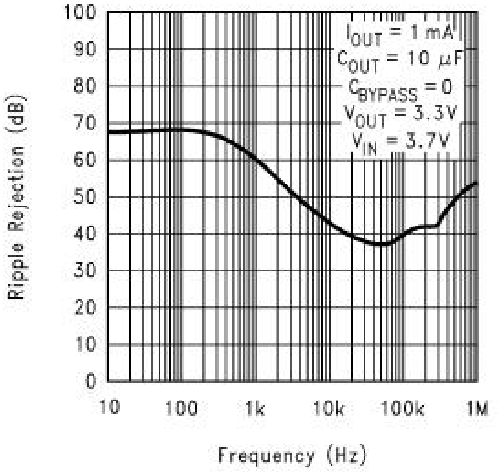
Ripple Rejection



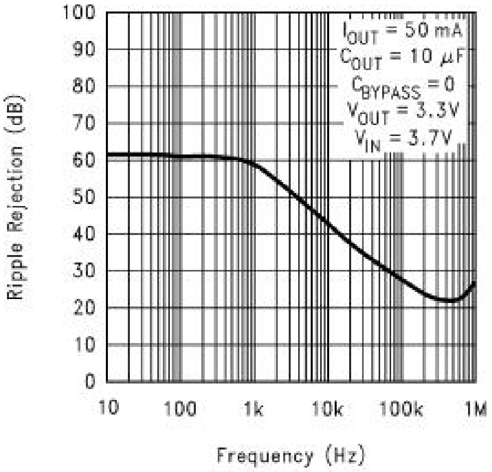
Ripple Rejection



Ripple Rejection



Ripple Rejection



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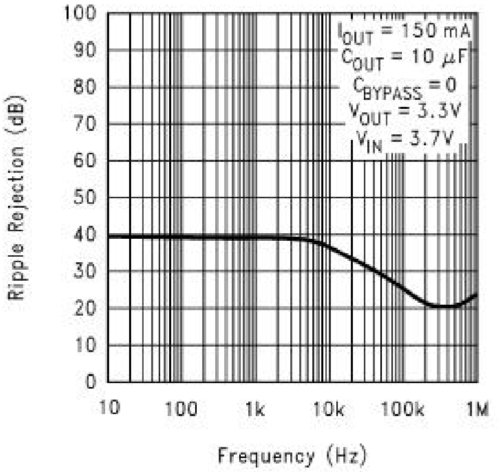
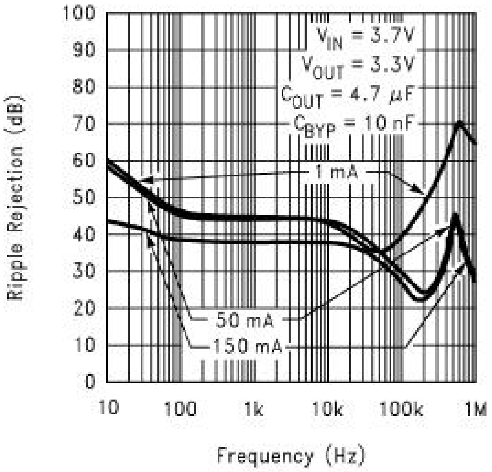
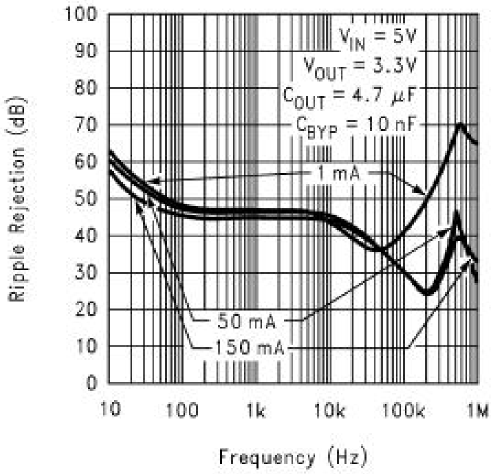


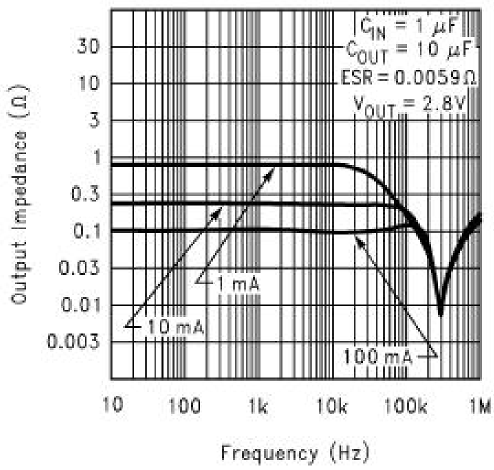
Ripple Rejection



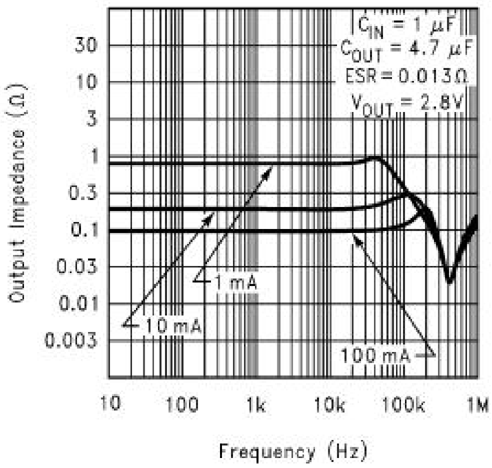
Ripple Rejection



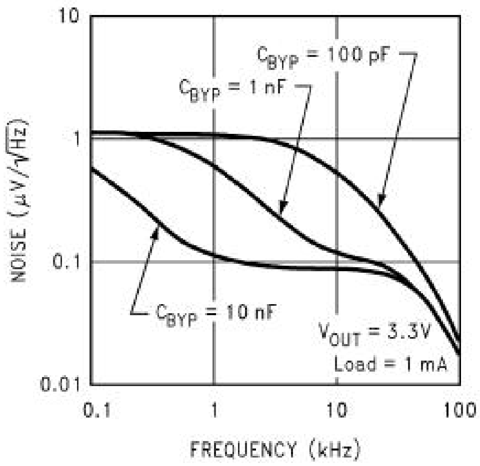
Output Impedance vs Frequency



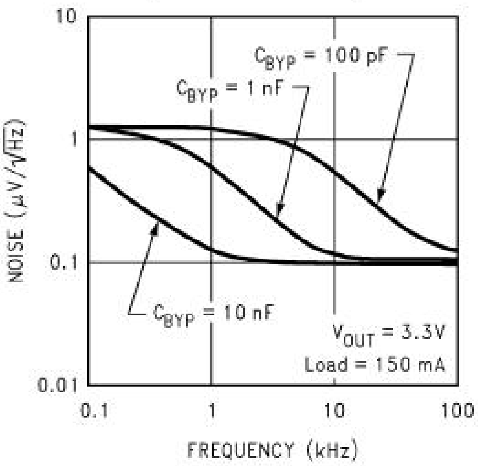
Output Impedance vs Frequency



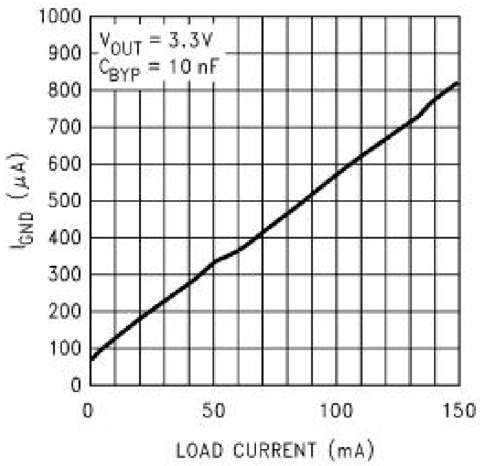
Output Noise Density



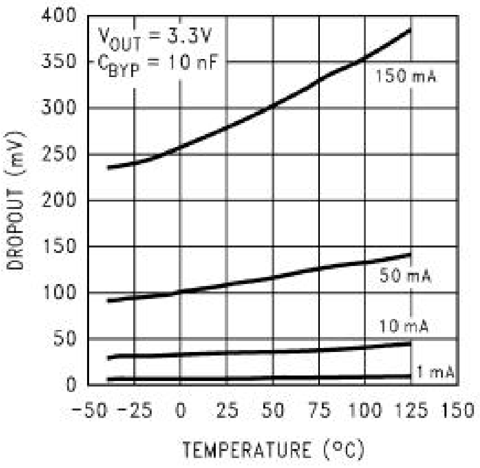
Output Noise Density



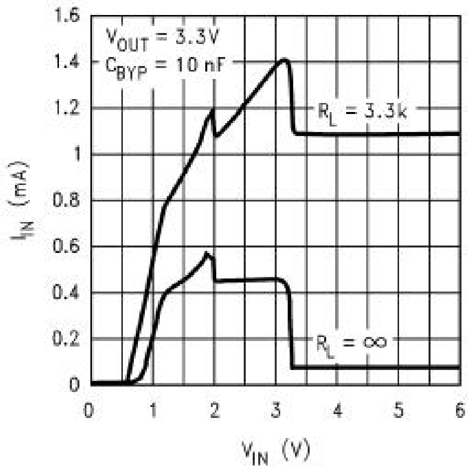
Ground Pin vs Load Current



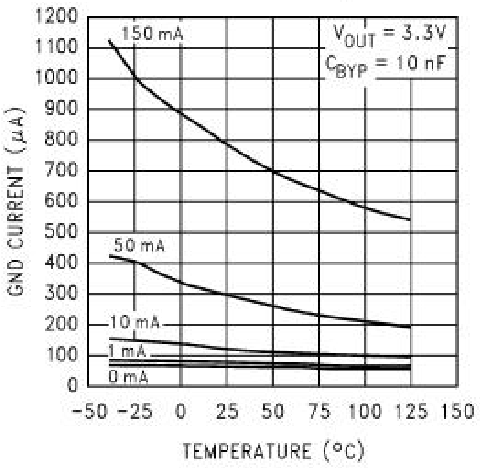
Dropout Voltage vs Temperature



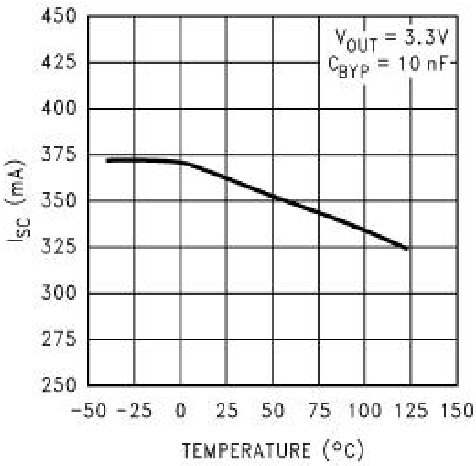
Input Current vs Pin



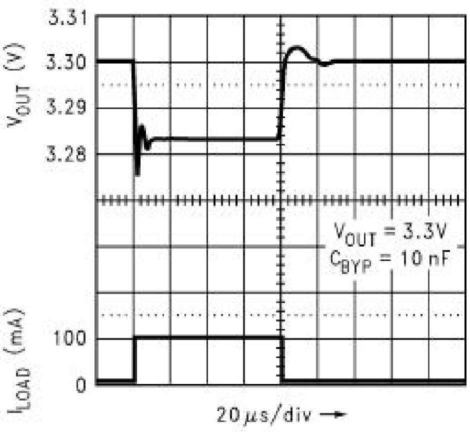
GND Pin Current vs Temperature



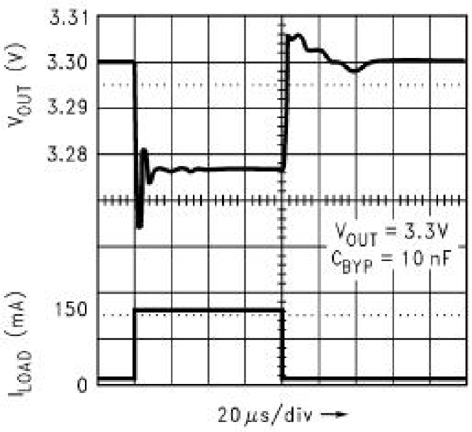
Instantaneous Short Circuit Current



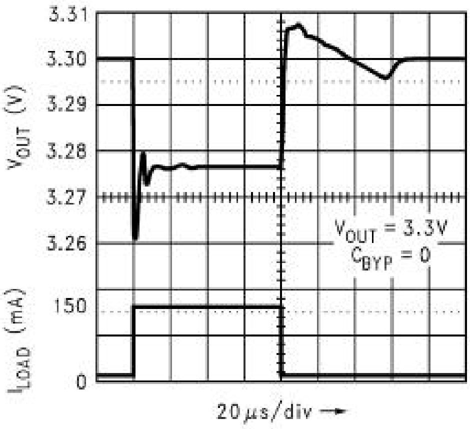
Load Transient Response



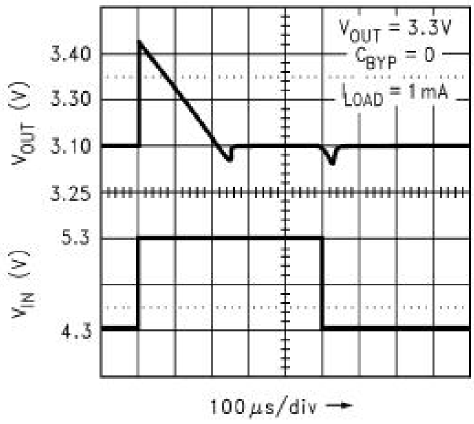
Load Transient Response



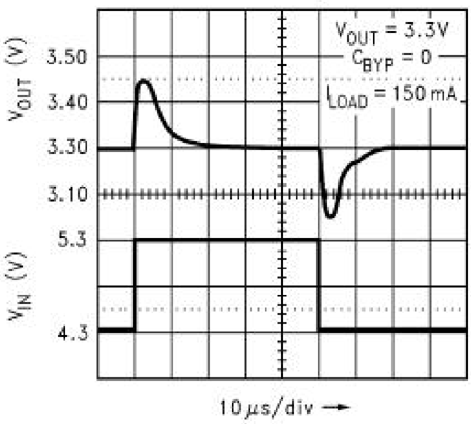
Load Transient Response



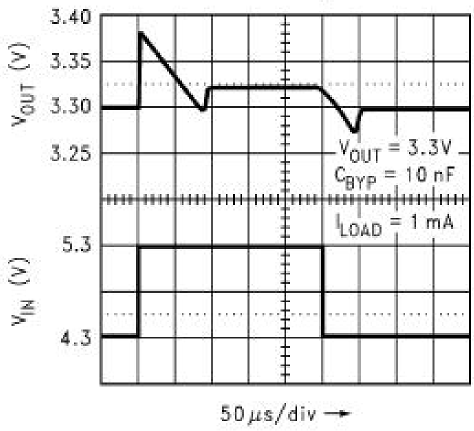
Line Transient Response



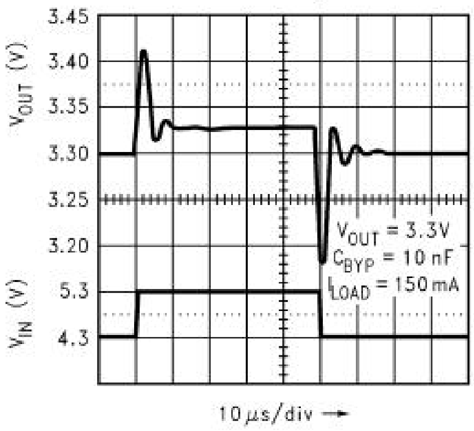
Line Transient Response



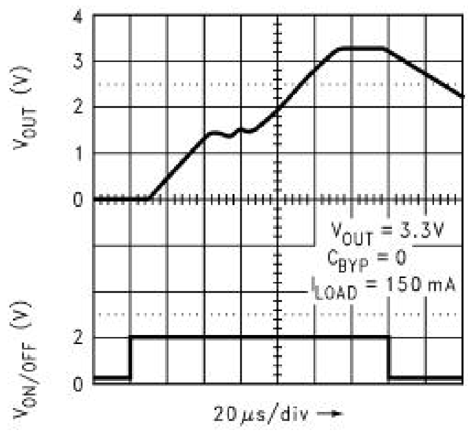
Line Transient Response



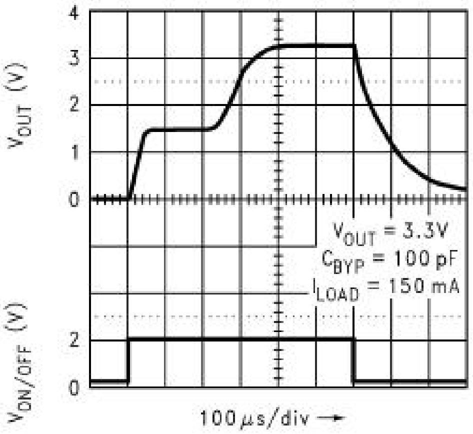
Line Transient Response



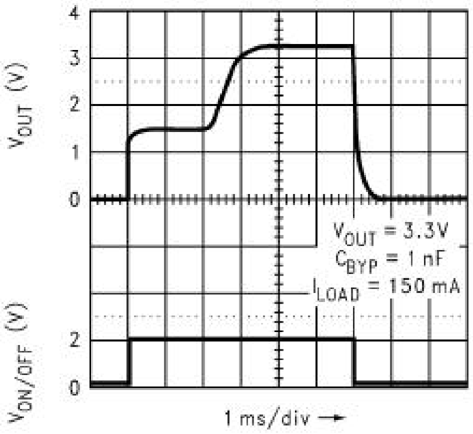
Turn-On Time



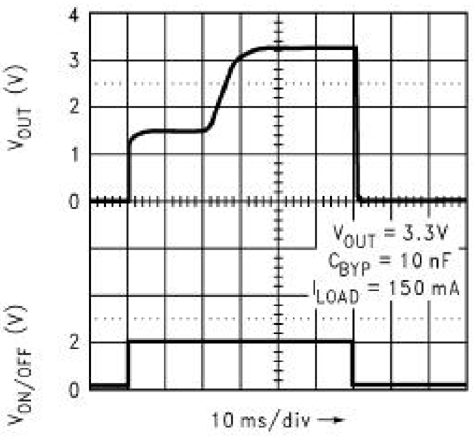
Turn-On Time



Turn-On Time

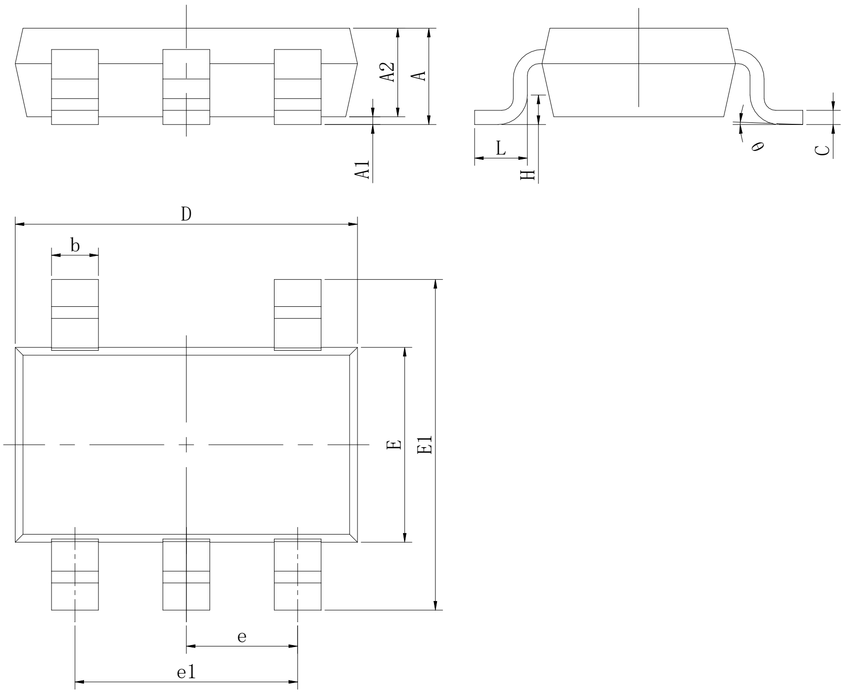


Turn-On Time



Outline Dimensions

SOT23-5: Unit:mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.900	0.028	0.035
A1	0.000	0.100	0.000	0.004
A2	0.700	0.800	0.028	0.031
b	0.350	0.500	0.014	0.020
c	0.080	0.200	0.003	0.008
D	2.820	3.020	0.111	0.119
E	1.600	1.700	0.063	0.067
E1	2.650	2.950	0.104	0.116
e	0.95（BSC）		0.037(BSC)	
e1	1.90（BSC）		0.075(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Statements

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