NCP4515

100 mA CMOS LDO with Shutdown and Reference Bypass

The NCP4515 is a high accuracy (typically ±0.5%) CMOS upgrade for older (bipolar) low dropout regulators such as the LP2980. Designed specifically for battery–operated systems, the devices' CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 50 µA at full load (20 to 60 times lower than in bipolar regulators).

Key features for the devices include ultra low–noise operation (plus optional Bypass input), fast response to step changes in load, and very low dropout voltage, typically 180 mV at full load. Supply current is reduced to 0.5 µA (max) and V_{OUT} falls to zero when the shutdown input is low. The devices also incorporate both over–temperature and over–current protection.

The NCP4515 is stable with an output capacitor of only 1.0 µF and has a maximum output current of 50 mA, 100 mA, and 150 mA, respectively. For higher output versions, see the NCP4569 (I_{OUT} = 300 mA) data sheet.

Features

- Extremely Low Supply Current (50 µA, Typ.)
- Very Low Dropout Voltage
- Guaranteed 100 mA Output
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Power–Saving Shutdown Mode
- Reference Bypass Input for Ultra Low–Noise Operation
- Over–Current and Over–Temperature Protection
- Space–Saving 5–Pin SOT–23A Package
- Pin Compatible Upgrades for Bipolar Regulators

Applications

- Battery–Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular/GSM/PHS Phones
- Linear Post–Regulator for SMPS
- Pagers

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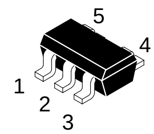
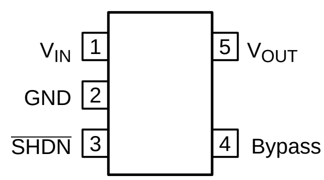


SOT–23
SN SUFFIX
CASE 1212

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 14 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 14 of this data sheet.

February, 2001 – Rev. 0

Publication Order Number:
NCP4515/D

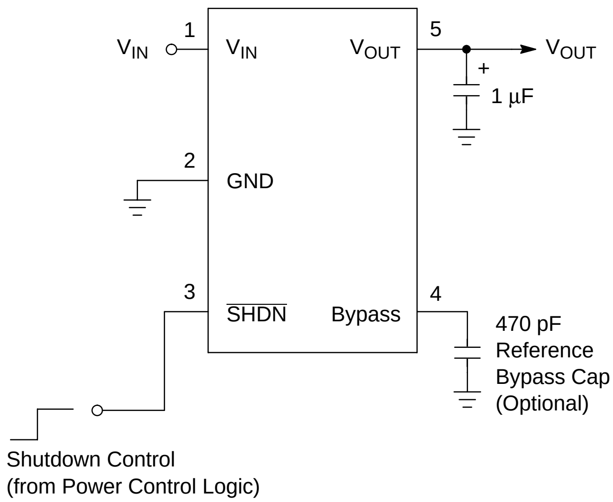


Figure 1. Typical Application

ABSOLUTE MAXIMUM RATINGS*

Rating		Symbol	Value	Unit
Input Voltage		–	6.5	V
Output Voltage		–	–0.3 to V_{IN} + 0.3	V
Power Dissipation		–	Internally Limited	–
Operating Temperature		T_A	–40 < T_J < 125	°C
Storage Temperature		T_{stg}	–65 to +150	°C
Maximum Voltage on any Pin		–	V_{IN} + 0.3 to – 0.3	V
Lead Temperature (Soldering, 10 Sec.)		–	+260	°C
ESD Withstand Voltage	Human Body Model (Note 1.)	V_{ESD}	> 2000	V
Latch–Up Performance (Note 2.)	Positive Negative	$I_{LATCH–UP}$	> 250 > 250	mA

*Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

1. Tested to EIA/JESD22–A114–A
2. Tested to EIA/JESD78

ELECTRICAL CHARACTERISTICS ($V_{IN} = V_R + 1.0$ V, $I_L = 100$ μA, $C_L = 3.3$ μF, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of –40°C to +125°C.)

Characteristics	Test Conditions	Symbol	Min	Typ	Max	Unit
Input Operating Voltage	Note 3.	V_{IN}	**2.7**	–	**6.0**	V
Maximum Output Current	–	I_{OUTMAX}	**100**	–	–	mA
Output Voltage	Note 4.	V_{OUT}	**V_R – 2.5%**	$V_R \pm 0.5\%$	**V_R + 2.5%**	V
V_{OUT} Temperature Coefficient	Note 5.	TCV_{OUT}	– –	20 **40**	– –	ppm/°C
Line Regulation	$(V_R + 1.0\text{ V}) \leq V_{IN} \leq 6.0$ V	$\Delta V_{OUT}/\Delta V_{IN}$	–	0.05	**0.35**	%
Load Regulation	$I_L = 0.1$ mA to I_{OUTMAX} Note 6.	$\Delta V_{OUT}/V_{OUT}$	–	0.5	**2.0**	%
Dropout Voltage	$I_L = 100$ μA $I_L = 20$ mA $I_L = 50$ mA $I_L = 100$ mA Note 7.	$V_{IN} - V_{OUT}$	– – – –	2.0 65 85 180	– – **120** **250**	mV
Supply Current (Note 10.)	$\overline{SHDN} = V_{IH}$, $I_L = 0$	I_{IN}	–	50	**80**	μA
Shutdown Supply Current	$\overline{SHDN} = 0$ V	I_{INSD}	–	0.05	0.5	μA
Power Supply Rejection Ratio	$F_{RE} \leq 1.0$ kHz	PSRR	–	64	–	dB
Output Short Circuit Current	$V_{OUT} = 0$ V	I_{OUTSC}	–	300	450	mA
Thermal Regulation	Note 8., 9.	$\Delta V_{OUT}/\Delta P_D$	–	0.04	–	V/W
Thermal Shutdown Die Temperature	–	T_{SD}	–	160	–	°C
Thermal Shutdown Hysteresis	–	ΔT_{SD}	–	10	–	°C
Output Noise	$I_L = I_{OUTMAX}$, F = 10 kHz 470 pF from Bypass to GND	eN	–	600	–	$nV/\sqrt{Hz}$
$\overline{SHDN}$ Input						
$\overline{SHDN}$ Input High Threshold	$V_{IN} = 2.5$ V to 6.5 V	V_{IH}	45	–	–	$\%V_{IN}$
$\overline{SHDN}$ Input Low Threshold	$V_{IN} = 2.5$ V to 6.5 V	V_{IL}	–	–	15	$\%V_{IN}$

3. The minimum V_{IN} has to meet two conditions: $V_{IN} \geq 2.7$ V and $V_{IN} \geq V_R + V_{DROPOUT}$.
4. V_R is the regulator output voltage setting. For example: V_R = 1.8 V, 2.5 V, 2.7 V, 2.8 V, 2.85 V, 3.0 V, 3.3 V, 3.6 V, 4.0 V, 5.0 V.
5. $T_C V_{OUT} = \dfrac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
6. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 1.0 mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
7. Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value at a 1.0 V differential.
8. Thermal Regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to I_{LMAX} at $V_{IN} = 6.0$ V for T = 10 msec.
9. The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction–to–air (i.e. T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see *Thermal Considerations* section of this data sheet for more details.
10. Apply for Junction Temperatures of –40°C to +85°C.

PIN DESCRIPTION

Pin Number	Symbol	Description
1	V_{IN}	Unregulated supply input.
2	GND	Ground terminal.
3	$\overline{SHDN}$	Shutdown control input. The regulator is fully enabled when a logic high is applied to this input. The regulator enters shutdown when a logic low is applied to this input. During shutdown, output voltage falls to zero, and supply current is reduced to 0.5 μA (max).
4	Bypass	Reference bypass input. Connecting a 470 pF to this input further reduces output noise.
5	V_{OUT}	Regulated voltage output.

DETAILED DESCRIPTION

The NCP4515 is a precision fixed output voltage regulator. Unlike bipolar regulators, the NCP4515 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation at very low load currents (an important consideration in RTC and CMOS RAM battery back–up applications).

Figure 2 shows a typical application circuit. The regulator is enabled any time the shutdown input ($\overline{SHDN}$) is at or above V_{IH}, and shutdown (disabled) when $\overline{SHDN}$ is at or below V_{IL}. $\overline{SHDN}$ may be controlled by a CMOS logic gate, or I/O port of a microcontroller. If the $\overline{SHDN}$ input is not required, it should be connected directly to the input supply. While in shutdown, supply current decreases to 0.05 μA (typical) and V_{OUT} falls to zero volts.

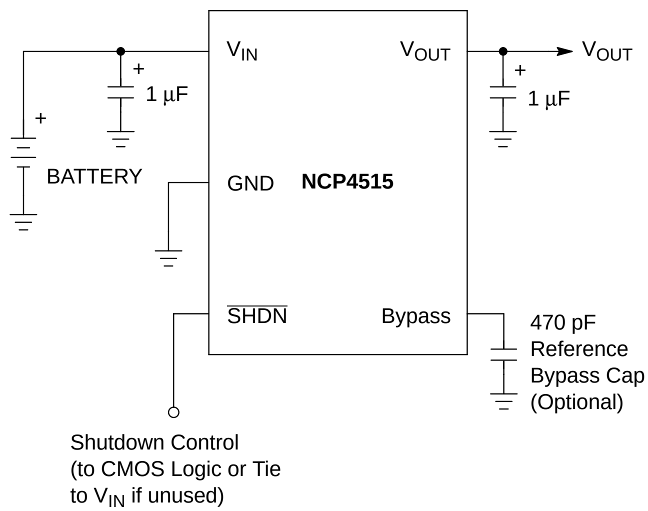


Figure 2. Typical Application Circuit

Bypass Input

A 470 pF capacitor connected from the Bypass input to ground reduces noise present on the internal reference, which in turn significantly reduces output noise. If output noise is not a concern, this input may be left unconnected. Larger capacitor values may be used, but results in a longer time period to rated output voltage when power is initially applied.

Output Capacitor

A 1.0 μF (min) capacitor from V_{OUT} to ground is required. The output capacitor should have an effective series resistance of 5.0 Ω or less. A 1.0 μF capacitor should be connected from V_{IN} to GND if there is more than 10 inches of wire between the regulator and the AC filter capacitor, or if a battery is used as the power source. Aluminum electrolytic or tantalum capacitor types can be used. (Since many aluminum electrolytic capacitors freeze at approximately –30°C, solid tantalums are recommended for applications operating below –25°C.) When operating from sources other than batteries, supply–noise rejection and transient response can be improved by increasing the value of the input and output capacitors and employing passive filtering techniques.

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 160°C. The regulator remains off until the die temperature drops to approximately 150°C.

Power Dissipation

The amount of power the regulator dissipates is primarily a function of input and output voltage, and output current. The following equation is used to calculate worst case *actual* power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN}) I_{LOADMAX}$$

Where : P_D = worst case actual power dissipation
V_{INMAX} = maximum voltage on V_{IN}
V_{OUTMIN} = minimum regulator output voltage
$I_{LOADMAX}$ = maximum output (load) current

(eq. 1)

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature (T_{AMAX}), the maximum allowable die temperature (125°C), and the thermal resistance from junction–to–air (θ_{JA}). The 5–Pin SOT–23 package has a θ_{JA} of approximately **200°C/Watt** when mounted on a single layer FR4 dielectric copper clad PC board.

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$

Where all terms are previously defined. (eq. 2)

Equation 1 can be used in conjunction with Equation 2 to ensure regulator thermal operation is within limits. For example:

GIVEN : V_{INMAX} = 3.0 V ± 10%
V_{OUTMIN} = 2.7 V − 2.5%
$I_{LOADMAX}$ = 40 mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C

FIND : 1. Actual power dissipation.
2. Maximum allowable dissipation.

Actual power dissipation :

$$P_D \approx (V_{INMAX} - V_{OUTMIN}) I_{LOADMAX}$$
$$= [(3.0 \times 1.1) - (2.7 \times .975)]\ 40 \times 10^{-3}$$
$$= \underline{26.7\ mW}$$

Maximum allowable power dissipation :

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$
$$= \frac{(125 - 55)}{220}$$
$$= \underline{318\ mW}$$

In this example, the NCP4515 dissipates a maximum of only 26.7 mW; far below the allowable limit of 318 mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits.

Layout Considerations

The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and, therefore, increase the maximum allowable power dissipation limit.

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

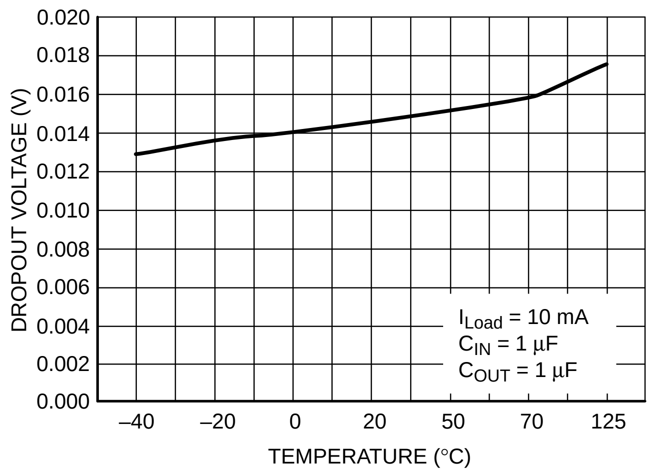


Figure 3. Dropout Voltage vs. Temperature (V_{OUT} = 3.3 V)

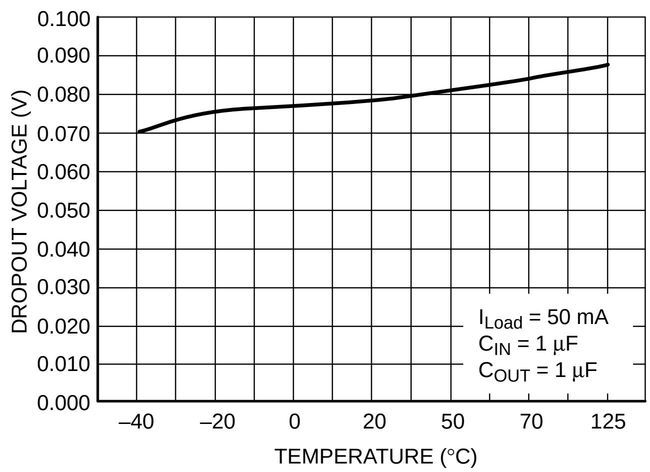


Figure 4. Dropout Voltage vs. Temperature (V_{OUT} = 3.3 V)

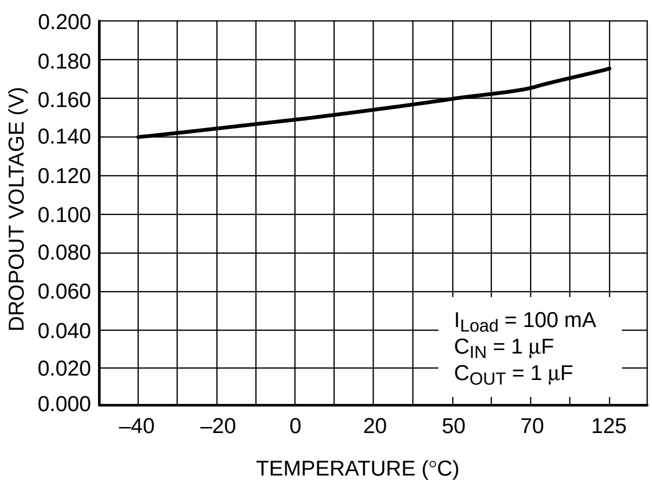


Figure 5. Dropout Voltage vs. Temperature (V_{OUT} = 3.3 V)

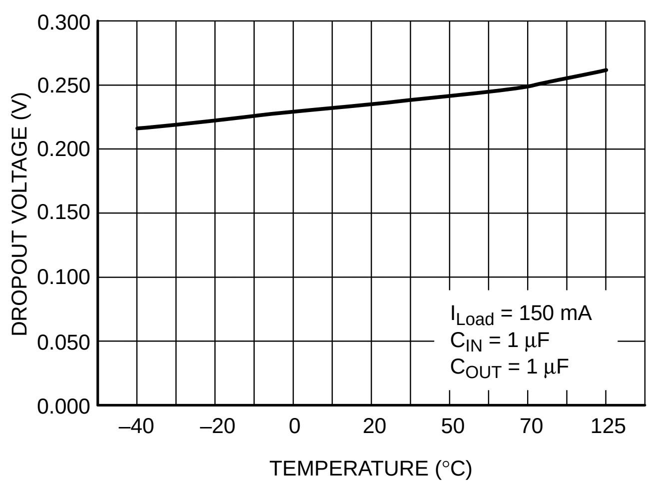


Figure 6. Dropout Voltage vs. Temperature (V_{OUT} = 3.3 V)

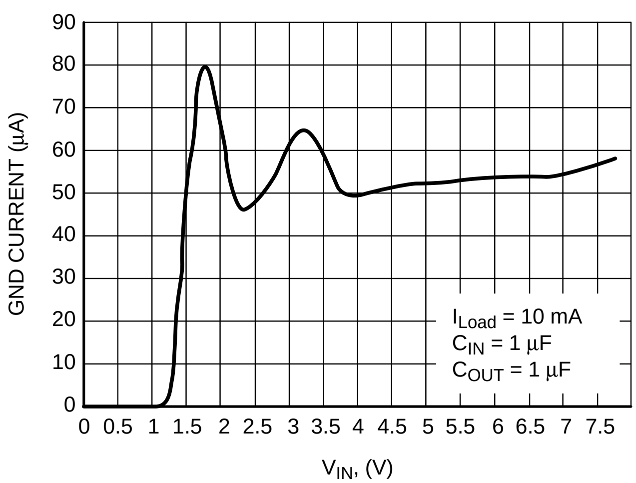


Figure 7. Ground Current vs. V_{IN} (V_{OUT} = 3.3 V)

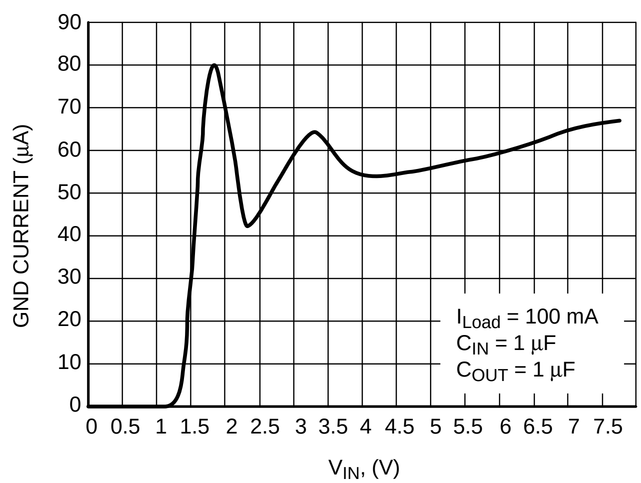


Figure 8. Ground Current vs. V_{IN} (V_{OUT} = 3.3 V)

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

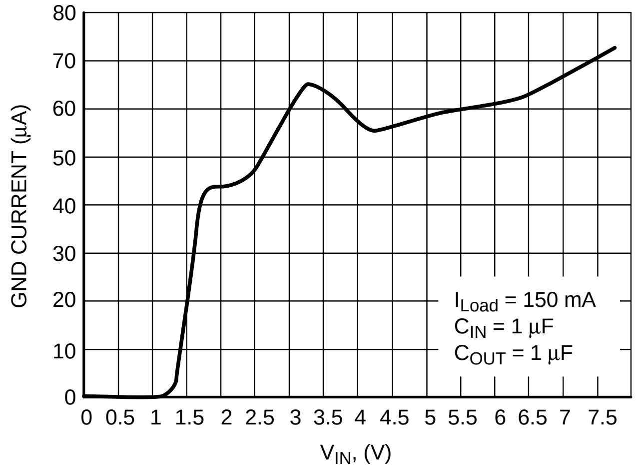


Figure 9. Ground Current vs. V_{IN} (V_{OUT} = 3.3 V)

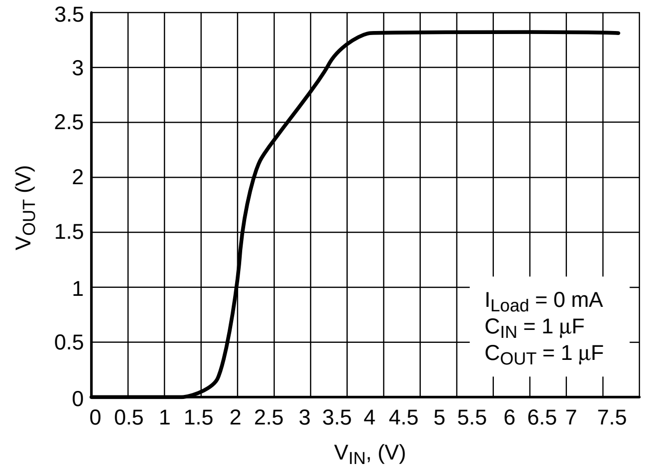


Figure 10. V_{OUT} vs. V_{IN} (V_{OUT} = 3.3 V)

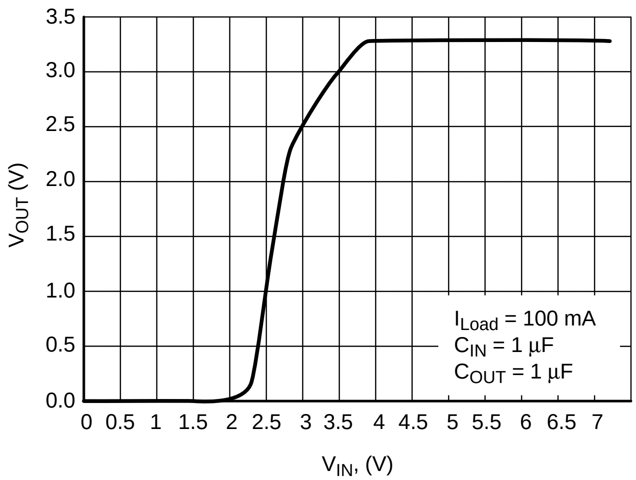


Figure 11. V_{OUT} vs. V_{IN} (V_{OUT} = 3.3 V)

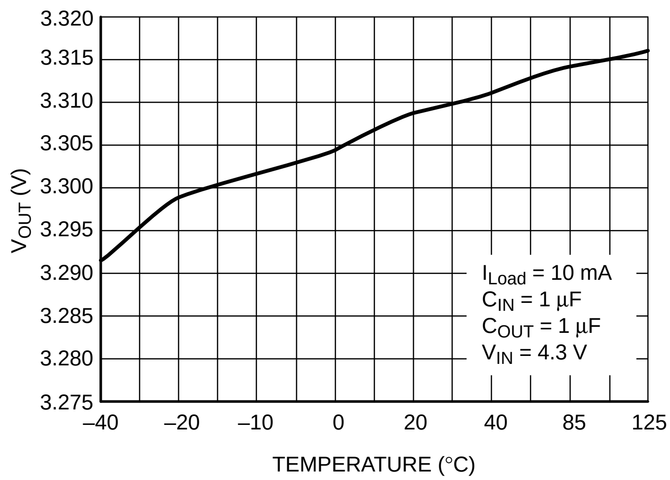


Figure 12. Output Voltage vs. Temperature (V_{OUT} = 3.3 V)

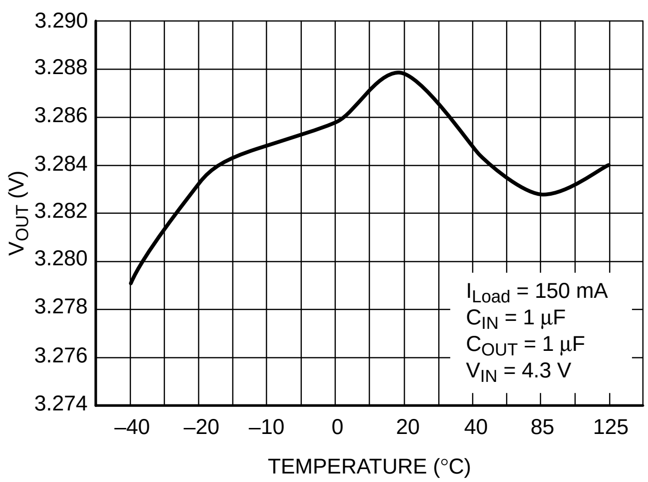


Figure 13. Output Voltage vs. Temperature (V_{OUT} = 3.3 V)

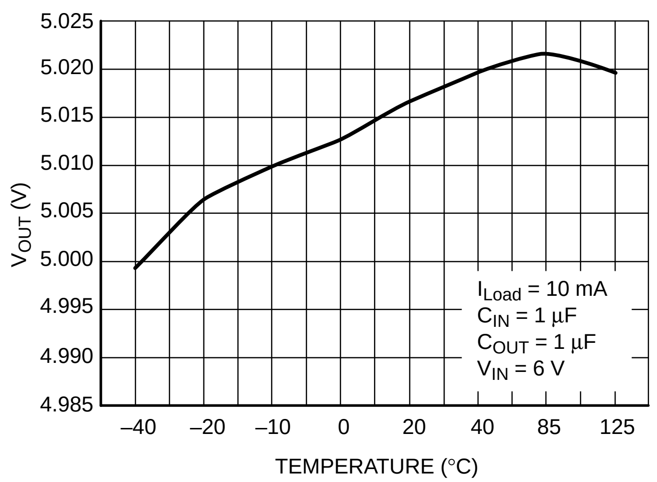


Figure 14. Output Voltage vs. Temperature (V_{OUT} = 5 V)

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

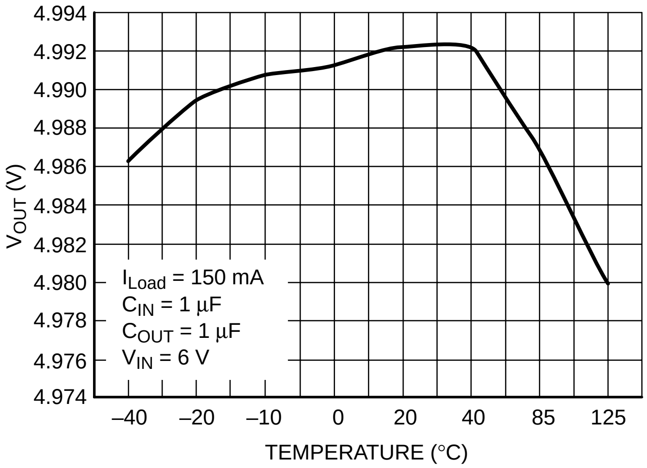


Figure 15. Output Voltage vs. Temperature (V_{OUT} = 5 V)

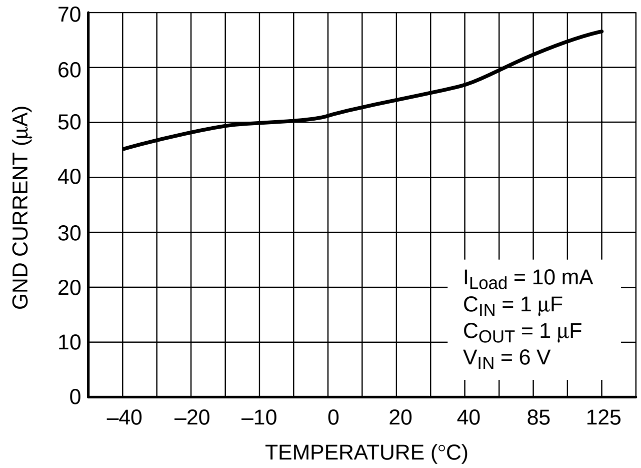


Figure 16. Temperature vs. Quiescent Current (V_{OUT} = 5 V)

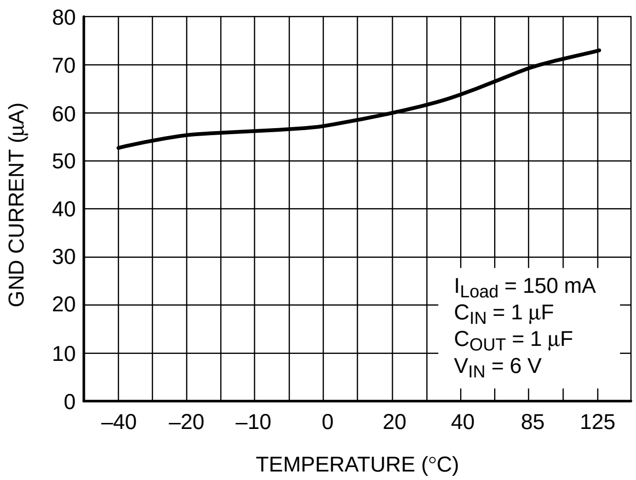


Figure 17. Temperature vs. Quiescent Current (V_{OUT} = 5 V)

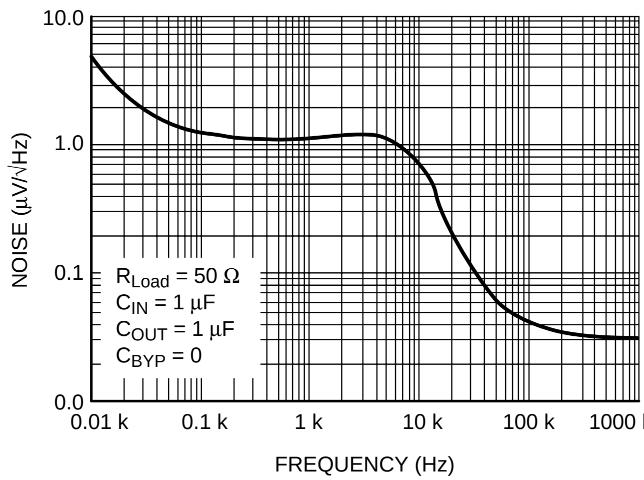


Figure 18. Output Noise vs. Frequency

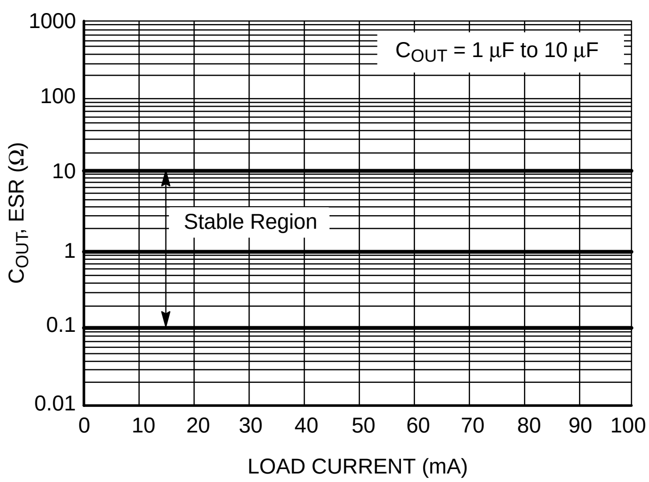


Figure 19. Stability Region vs. Load Current

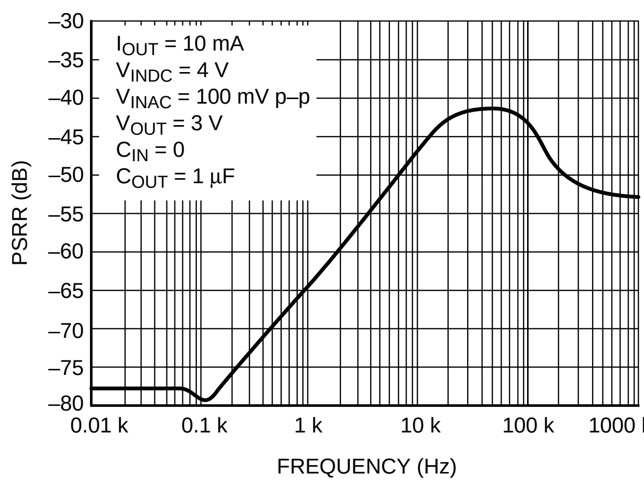
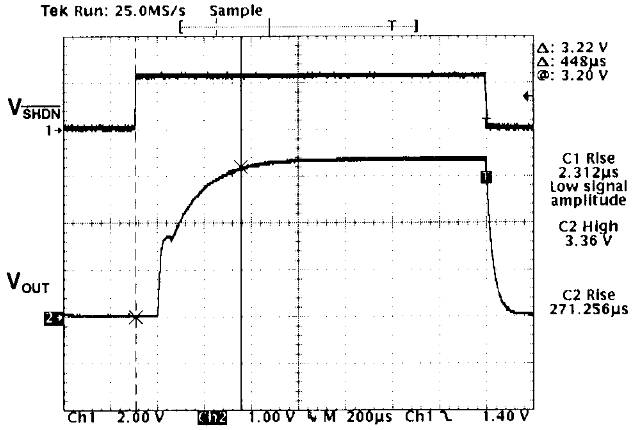
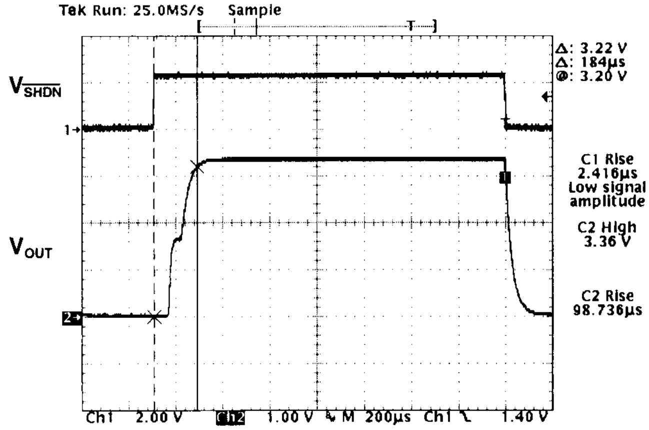


Figure 20. Power Supply Rejection Ratio



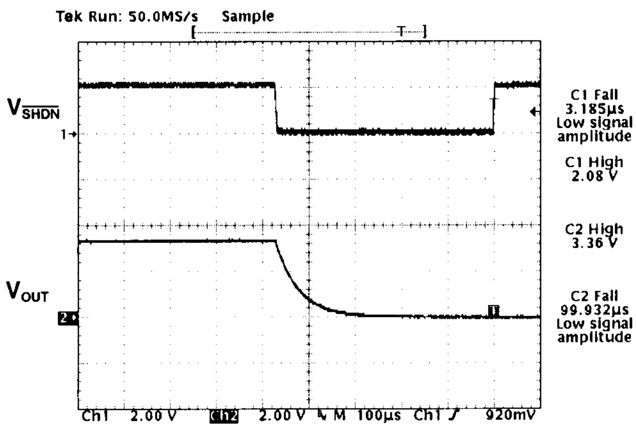
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 470 pF
I_{LOAD} = 100 mA, V_{IN} = 4.3 V, Temp = 25°C
Rise Time = 448 μS

Figure 21. Measure Rise Time of 3.3 V LDO with Bypass Capacitor



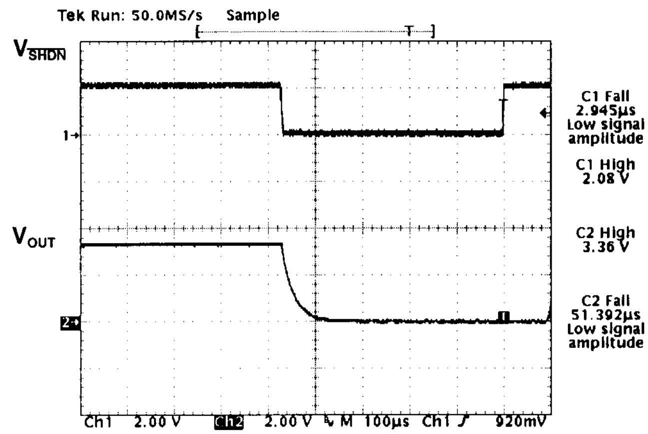
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 0 pF
I_{LOAD} = 100 mA, V_{IN} = 4.3 V, Temp = 25°C
Rise Time = 184 μS

Figure 22. Measure Rise Time of 3.3 V LDO without Bypass Capacitor



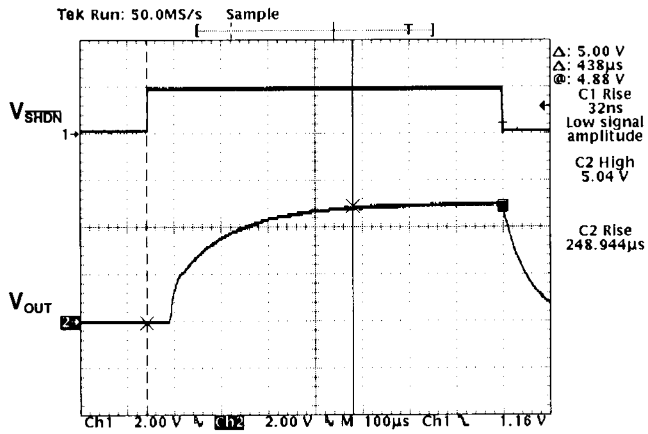
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 470 pF
I_{LOAD} = 50 mA, V_{IN} = 4.3 V, Temp = 25°C
Fall Time = 100 μS

Figure 23. Measure Fall Time of 3.3 V LDO with Bypass Capacitor



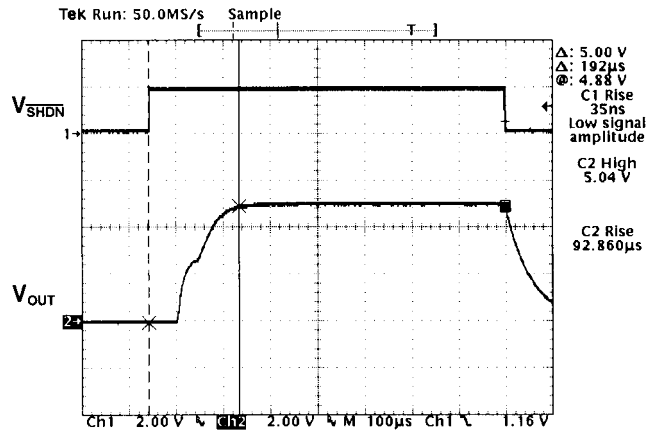
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 0 pF
I_{LOAD} = 100 mA, V_{IN} = 4.3 V, Temp = 25°C
Fall Time = 52 μS

Figure 24. Measure Fall Time of 3.3 V LDO without Bypass Capacitor



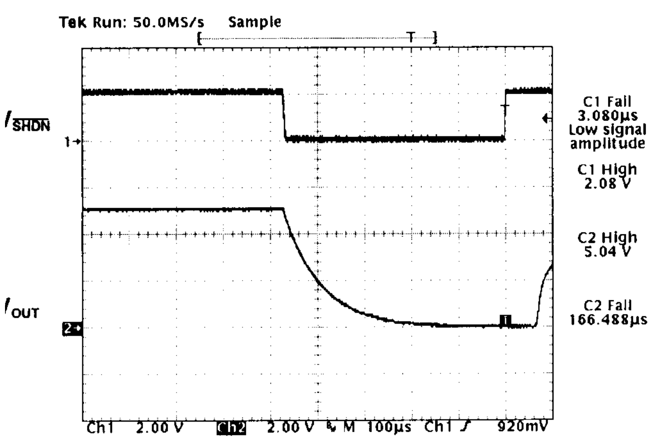
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 470 pF
I_{LOAD} = 100 mA, V_{IN} = 6 V, Temp = 25°C
Rise Time = 390 μS

Figure 25. Measure Rise Time of 5.0 V LDO with Bypass Capacitor



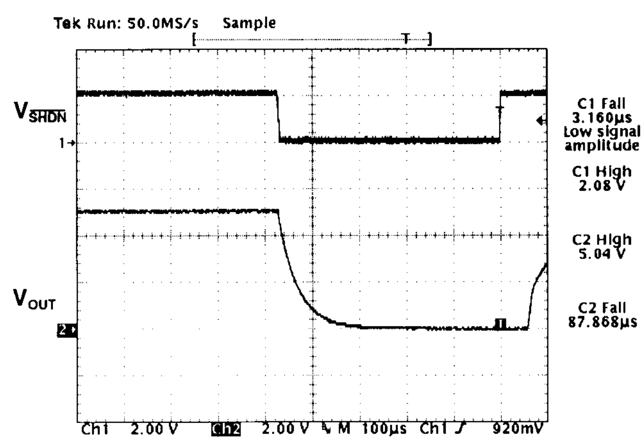
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 0 pF
I_{LOAD} = 100 mA, V_{IN} = 6 V, Temp = 25°C
Rise Time = 192 μS

Figure 26. Measure Rise Time of 5.0 V LDO without Bypass Capacitor



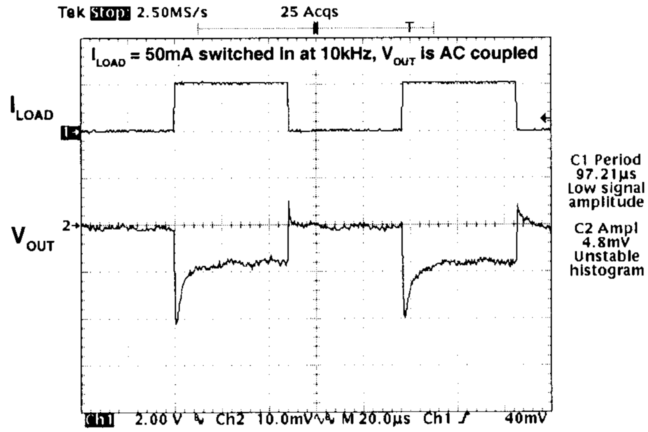
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 470 pF
I_{LOAD} = 50 mA, V_{IN} = 6 V, Temp = 25°C
Fall Time = 167 μS

Figure 27. Measure Fall Time of 5.0 V LDO with Bypass Capacitor



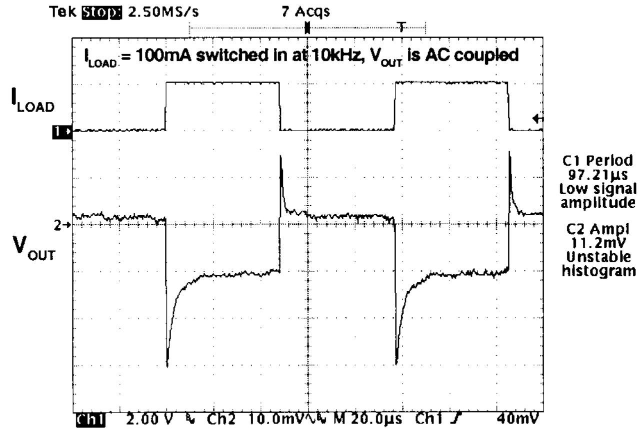
Conditions:
C_{IN} = 1 μF, C_{OUT} = 1 μF, C_{BYP} = 0 pF
I_{LOAD} = 100 mA, V_{IN} = 6 V, Temp = 25°C
Fall Time = 88 μS

Figure 28. Measure Fall Time of 5.0 V LDO without Bypass Capacitor



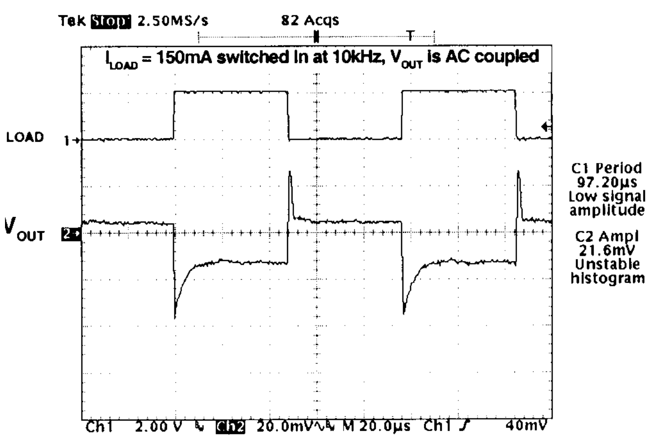
Conditions:
C_{IN} = 1 µF, C_{OUT} = 2.2 µF, C_{BYP} = 470 pF
V_{IN} = V_{OUT} + 0.25 V, Temp = 25°C

Figure 29. Load Regulation of 3.3 V LDO



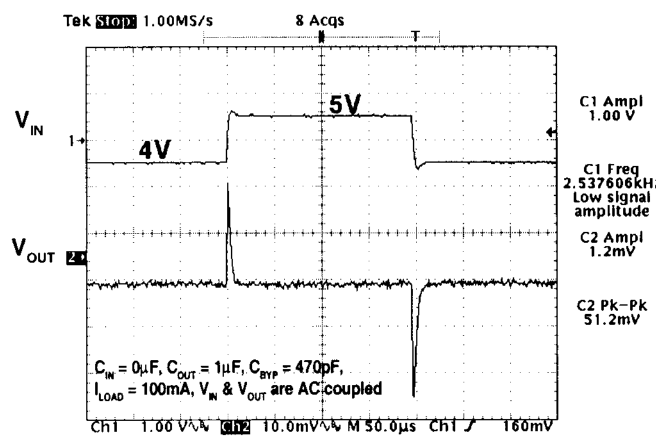
Conditions:
C_{IN} = 1 µF, C_{OUT} = 2.2 µF, C_{BYP} = 470 pF
V_{IN} = V_{OUT} + 0.25 V, Temp = 25°C

Figure 30. Load Regulation of 3.3 V LDO



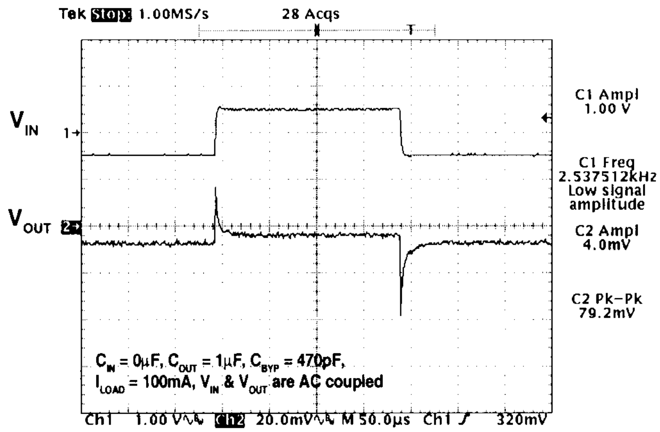
Conditions:
C_{IN} = 1 µF, C_{OUT} = 2.2 µF, C_{BYP} = 470 pF
V_{IN} = V_{OUT} + 0.25 V, Temp = 25°C

Figure 31. Load Regulation of 3.3 V LDO



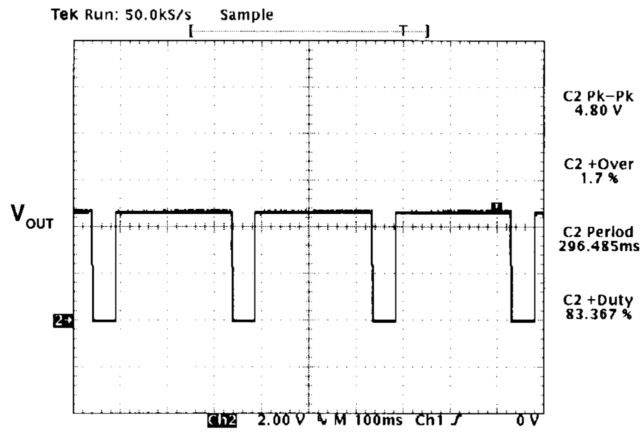
Conditions:
V_{IN} = 4 V, + 1 V Squarewave @ 2.5 kHz

Figure 32. Line Regulation of 3.3 V LDO



Conditions:
V_{IN} = 6 V, + 1 V Squarewave @ 2.5 kHz

Figure 33. Line Regulation of 5.0 V LDO

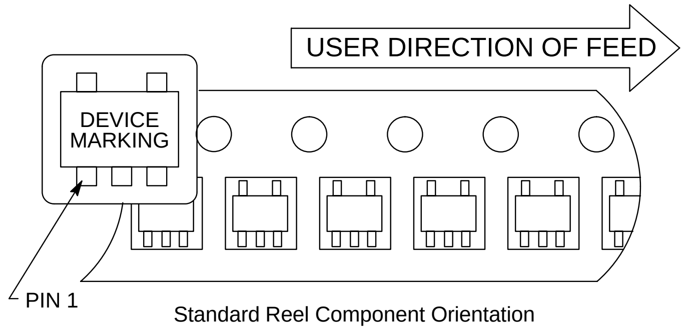


Conditions:
V_{IN} = 6 V, C_{IN} = 0 μF, C_{OUT} = 1 μF

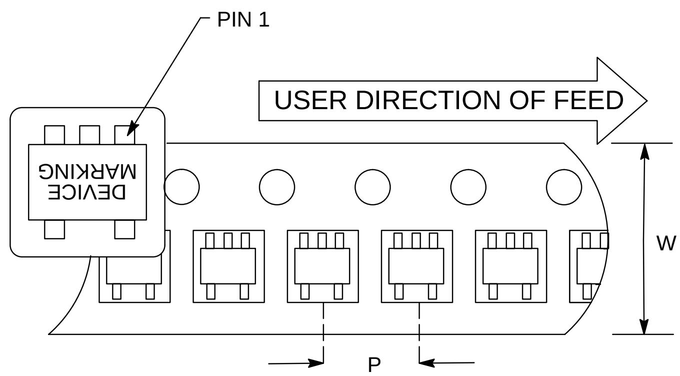
Figure 34. Thermal Shutdown Response of 5.0 V LDO

I_{LOAD} was increased until temperrature of die reached about 160°C, at which time integrated thermal protection circuitry shuts the regulator off when die temperature exceeds approximately 160°C. The regulator remains off until die temperature drops to approximately 150°C

Component Taping Orientation for 5–Pin SOT–23 Devices



Standard Reel Component Orientation
TR Suffix Device
(Mark Right Side Up)

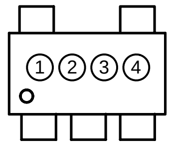


Reverse Reel Component Orientation
RT Suffix Device
(Mark Upside Down)

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
SOT–23	8 mm	4 mm	3000	7 inches

MARKING DIAGRAM



① and ② = Two Letter Part Number Codes + Temperature Range and Voltage

③ = Date Code

④ = Lot ID Number

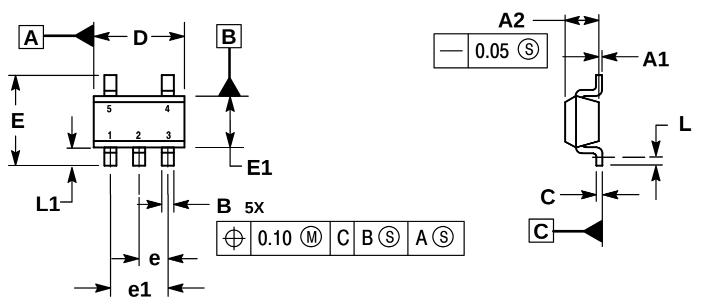
ORDERING INFORMATION

Device	Voltage Option*	Marking ① and ②	Package	Junction Temperature Range	Shipping
NCP4515SNxxT1	1.8 2.8 2.85 3.0 3.3	BY BZ B8 B3 B5	SOT–23	–40°C to + 125°C	3000 Tape & Reel

xx Indicates Output Voltages
*Other output voltages are available. Please contact ON Semiconductor for details.

PACKAGE DIMENSIONS

SOT–23
SN SUFFIX
CASE 1212–01
ISSUE O



NOTES:
1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DATUM C IS A SEATING PLANE.

	MILLIMETERS	
DIM	MIN	MAX
A1	0.00	0.10
A2	1.00	1.30
B	0.30	0.50
C	0.10	0.25
D	2.80	3.00
E	2.50	3.10
E1	1.50	1.80
e	0.95 BSC	
e1	1.90 BSC	
L	0.20	---
L1	0.45	0.75

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