

50mA, 100mA, 150mA CMOS LDOs with Shutdown and Reference Bypass

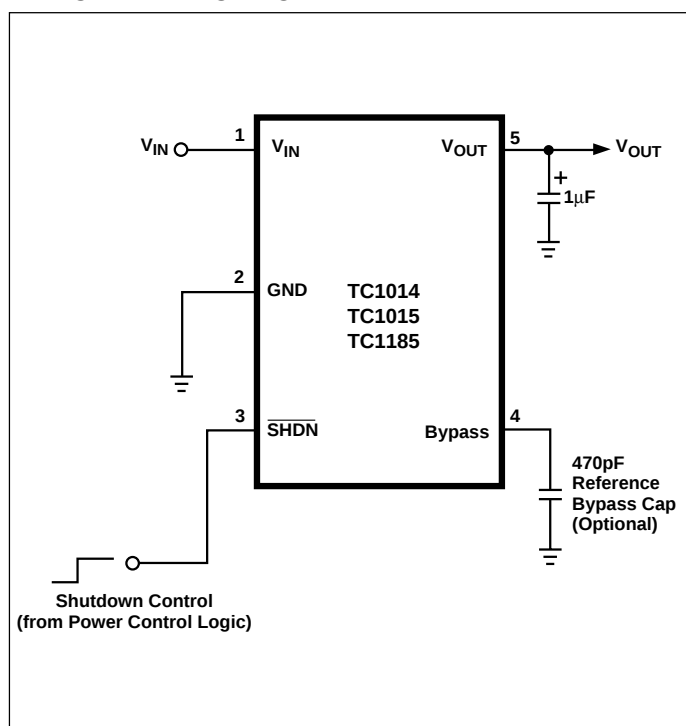
FEATURES

- Extremely Low Supply Current (50 μ A, Typ.)
- Very Low Dropout Voltage
- Guaranteed 50mA, 100mA, and 150mA Output (TC1014, TC1015, and TC1185, Respectively)
- 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

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC1014, TC1015, and TC1185 are high accuracy (typically $\pm 0.5\%$) CMOS upgrades 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 μ A 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 85mV (TC1014), 180mV (TC1015), and 270mV (TC1185) at full load. Supply current is reduced to 0.5 μ A (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 TC1014, TC1015, and TC1185 are stable with an output capacitor of only 1 μ F and have a maximum output current of 50mA, 100mA, and 150mA, respectively. For higher output versions, see the TC1107, TC1108, and TC1173 ($I_{OUT} = 300$ mA) data sheets.

ORDERING INFORMATION

Part Number	Package	Junction Temp. Range
TC1014-xxVCT	5-Pin SOT-23A*	-40°C to +125°C
TC1015-xxVCT	5-Pin SOT-23A*	-40°C to +125°C
TC1185-xxVCT	5-Pin SOT-23A*	-40°C to +125°C

TC1015EV Evaluation Kit for CMOS LDO Family

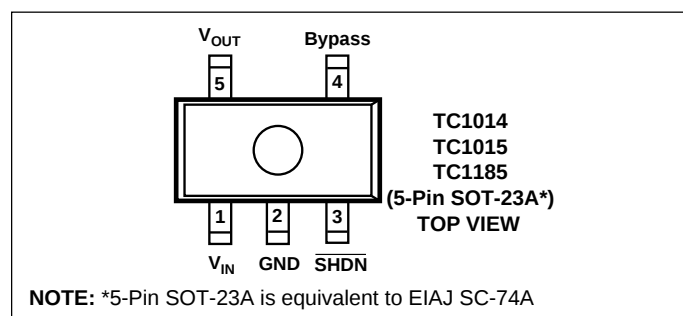
NOTE: *5-Pin SOT-23A is equivalent to EIAJ SC-74A.

Available Output Voltages:

1.8, 2.5, 2.7, 2.8, 2.85, 3.0, 3.3, 3.6, 4.0, 5.0
xx indicates output voltages

Other output voltages are available. Please contact Microchip Technologies for details.

PIN CONFIGURATION



50mA, 100mA, 150mA CMOS LDOs with Shutdown and Reference Bypass

TC1014
TC1015
TC1185

ABSOLUTE MAXIMUM RATINGS*

Input Voltage 6.5V
Output Voltage (– 0.3) to (V_{IN} + 0.3)
Power Dissipation Internally Limited
Operating Temperature – 40°C < T_J < 125°C
Storage Temperature – 65°C to +150°C

Maximum Voltage On Any Pin V_{IN} + 0.3V to – 0.3V
Lead Temperature (Soldering, 10 Sec.) +260°C

*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.

ELECTRICAL CHARACTERISTICS: V_{IN} = V_R + 1V, I_L = 100μA, C_L = 3.3μF, $\overline{\text{SHDN}} > V_{IH}$, T_A = 25°C, unless otherwise noted.
Boldface type specifications apply for junction temperatures of – 40°C to +125°C.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V _{IN}	Input Operating Voltage	Note 1	2.7	—	6.0	V
I _{OUTMAX}	Maximum Output Current	TC1014 TC1015 TC1185	50 100 150	— — —	— — —	mA
V _{OUT}	Output Voltage	Note 2	V_R – 2.5%	V _R ±0.5%	V_R + 2.5%	V
TCV _{OUT}	V _{OUT} Temperature Coefficient	Note 3	— —	20 40	— —	ppm/°C
ΔV _{OUT} /ΔV _{IN}	Line Regulation	(V _R + 1V) ≤ V _{IN} ≤ 6V	—	0.05	0.35	%
ΔV _{OUT} /V _{OUT}	Load Regulation	TC1014; TC1015 TC1185 I _L = 0.1mA to I _{OUTMAX} I _L = 0.1mA to I _{OUTMAX} Note 4	— —	0.5 0.5	2 3	%
V _{IN} – V _{OUT}	Dropout Voltage	I _L = 100μA I _L = 20mA I _L = 50mA TC1015; TC1185 I _L = 100mA I _L = 150mA Note 5	— — — — —	2 65 85 180 270	— — 120 250 400	mV
I _{IN}	Supply Current (Note 8)	$\overline{\text{SHDN}} = V_{IH}$, I _L = 0	—	50	80	μA
I _{INSD}	Shutdown Supply Current	$\overline{\text{SHDN}} = 0V$	—	0.05	0.5	μA
PSRR	Power Supply Rejection Ratio	F _{RE} ≤ 1KHz	—	64	—	dB
I _{OUTSC}	Output Short Circuit Current	V _{OUT} = 0V	—	300	450	mA
ΔV _{OUT} /ΔP _D	Thermal Regulation	Notes 6, 7	—	0.04	—	V/W
T _{SD}	Thermal Shutdown Die Temperature		—	160	—	°C
ΔT _{SD}	Thermal Shutdown Hysteresis		—	10	—	°C
eN	Output Noise	I _L = I _{OUTMAX} , F = 10kHz 470pF from Bypass to GND	—	600	—	nV/√Hz

SHDN Input

V _{IH}	$\overline{\text{SHDN}}$ Input High Threshold	V _{IN} = 2.5V to 6.5V	45	—	—	%V _{IN}
V _{IL}	$\overline{\text{SHDN}}$ Input Low Threshold	V _{IN} = 2.5V to 6.5V	—	—	15	%V _{IN}

- NOTES:**
- The minimum V_{IN} has to meet two conditions: V_{IN} ≥ 2.7V and V_{IN} ≥ V_R + V_{DROPOUT}.
 - V_R is the regulator output voltage setting. For example: V_R = 1.8V, 2.5V, 2.7V, 2.8V, 2.85V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V.
 - $\text{TCV}_{\text{OUT}} = \frac{(V_{\text{OUTMAX}} - V_{\text{OUTMIN}}) \times 10^6}{V_{\text{OUT}} \times \Delta T}$
 - Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 1.0mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
 - Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value at a 1V differential.
 - 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} = 6V for T = 10msec.
 - 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.
 - Apply for Junction Temperatures of –40°C to +85°C.

50mA, 100mA, 150mA CMOS LDOs
with Shutdown and Reference Bypass

TC1014
TC1015
TC1185

PIN DESCRIPTION

Pin No. (5-Pin SOT-23A)	Symbol	Description
1	V _{IN}	Unregulated supply input.
2	GND	Ground terminal.
3	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 0.5μA (max).
4	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.
5	V _{OUT}	Regulated voltage output.

DETAILED DESCRIPTION

The TC1014, TC1015, and TC1185 are precision fixed output voltage regulators. (If an adjustable version is desired, please see the TC1070, TC1071, or TC1187 data sheets.) Unlike bipolar regulators, the TC1014, TC1015, and TC1185 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 1 shows a typical application circuit. The regulator is enabled any time the shutdown input (SHDN) is at or above V_{IH}, and shutdown (disabled) when SHDN is at or below V_{IL}. SHDN may be controlled by a CMOS logic gate, or I/O port of a microcontroller. If the SHDN input is not required, it should be connected directly to the input supply. While in shutdown, supply current decreases to 0.05μA (typical) and V_{OUT} falls to zero volts.

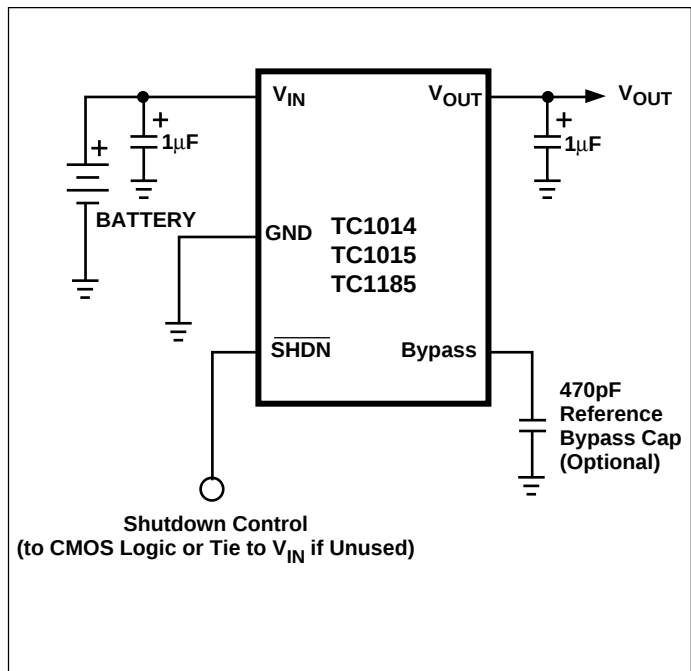


Figure 1. Typical Application Circuit

Bypass Input

A 470pF 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 1μF (min) capacitor from V_{OUT} to ground is required. The output capacitor should have an effective series resistance of 5Ω or less. A 1μF 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 power dissipation:

TC1014
TC1015
TC1185

$$P_D \approx (V_{IN_{MAX}} - V_{OUT_{MIN}}) I_{LOAD_{MAX}}$$

Where:

P_D = Worst case actual power dissipation

$V_{IN_{MAX}}$ = Maximum voltage on V_{IN}

$V_{OUT_{MIN}}$ = Minimum regulator output voltage

$I_{LOAD_{MAX}}$ = Maximum output (load) current

Equation 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-23A package has a θ_{JA} of approximately 220°C/Watt when mounted on a single layer FR4 dielectric copper clad PC board.

$$P_{D_{MAX}} = \frac{(T_{J_{MAX}} - T_{AMAX})}{\theta_{JA}}$$

Where all terms are previously defined.

Equation 2.

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

Given:

$$V_{IN_{MAX}} = 3.0V + 10\%$$

$$V_{OUT_{MIN}} = 2.7V - 2.5\%$$

$$I_{LOAD_{MAX}} = 40mA$$

$$T_{J_{MAX}} = 125^\circ C$$

$$T_{AMAX} = 55^\circ C$$

- Find:
1. Actual power dissipation
 2. Maximum allowable dissipation

Actual power dissipation:

$$\begin{aligned} P_D &\approx (V_{IN_{MAX}} - V_{OUT_{MIN}}) I_{LOAD_{MAX}} \\ &= [(3.0 \times 1.1) - (2.7 \times .975)] 40 \times 10^{-3} \\ &= 26.7mW \end{aligned}$$

Maximum allowable power dissipation:

$$\begin{aligned} P_{D_{MAX}} &= \frac{(T_{J_{MAX}} - T_{AMAX})}{\theta_{JA}} \\ &= \frac{(125 - 55)}{220} \\ &= 318mW \end{aligned}$$

In this example, the TC1014 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.

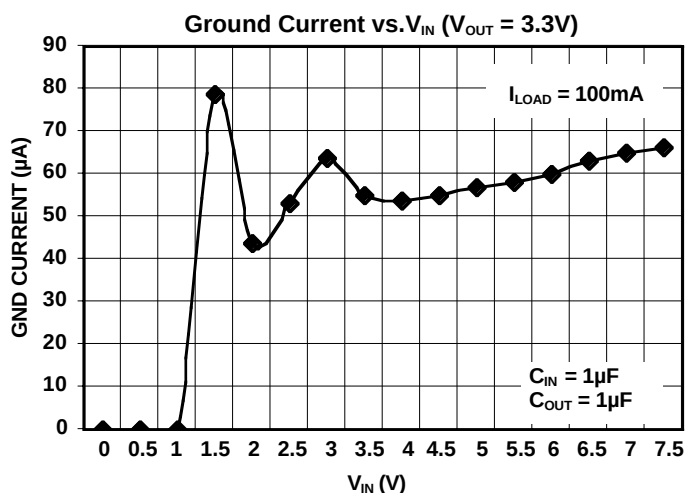
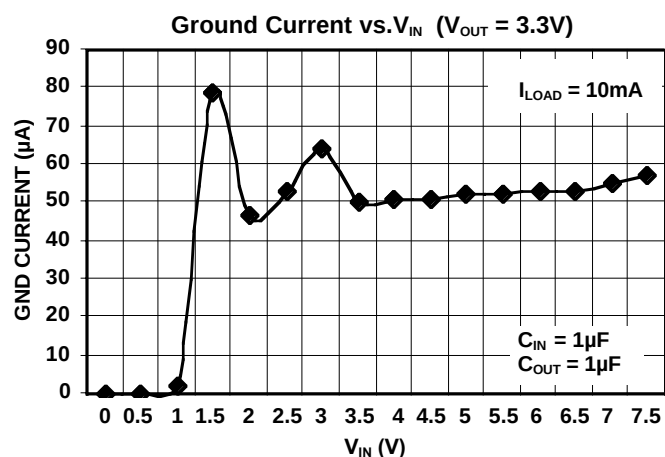
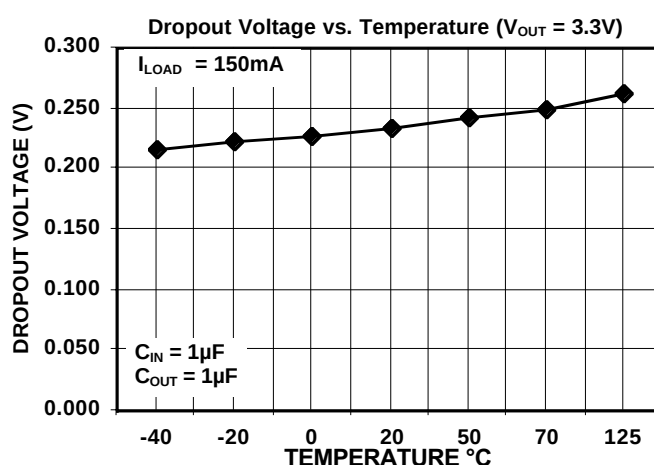
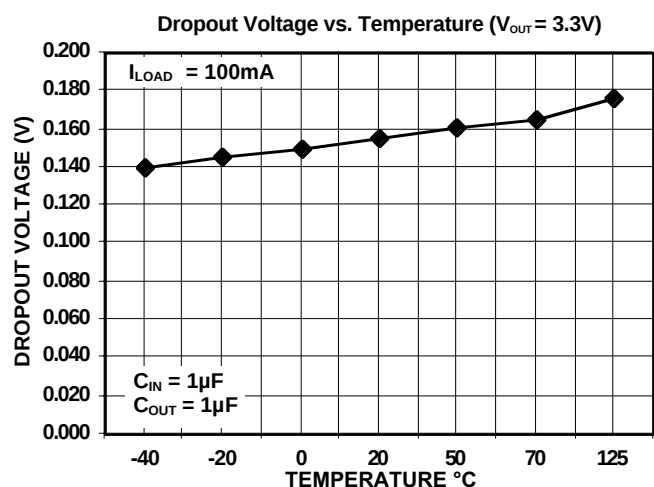
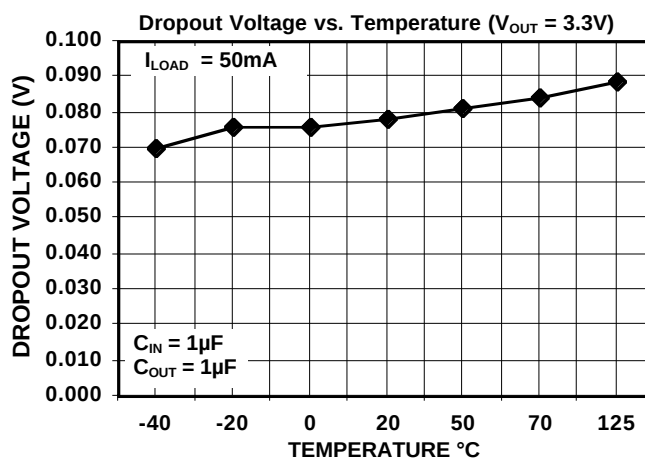
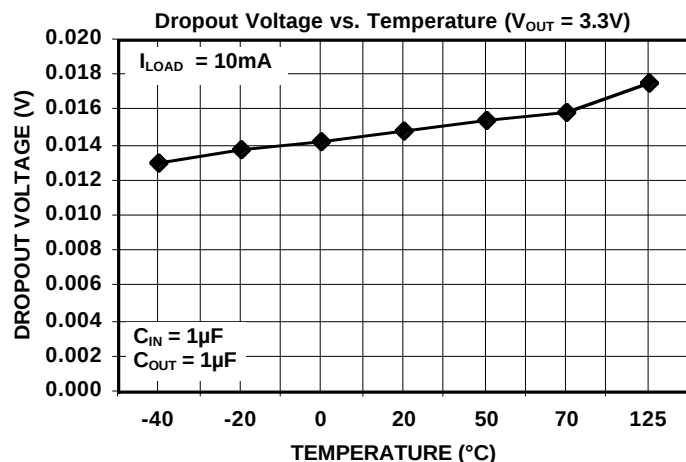
Layout Considerations

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.

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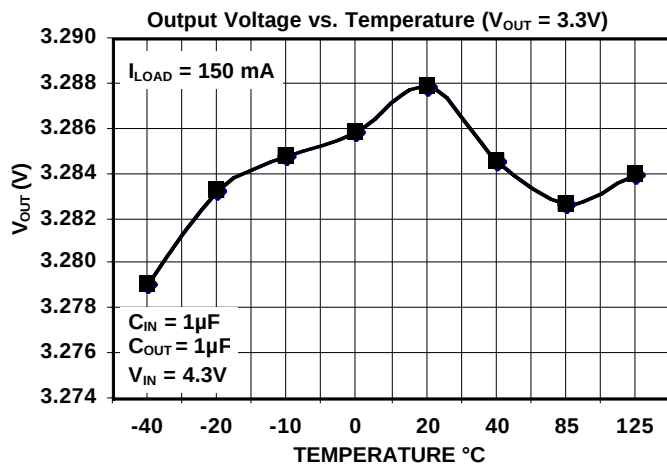
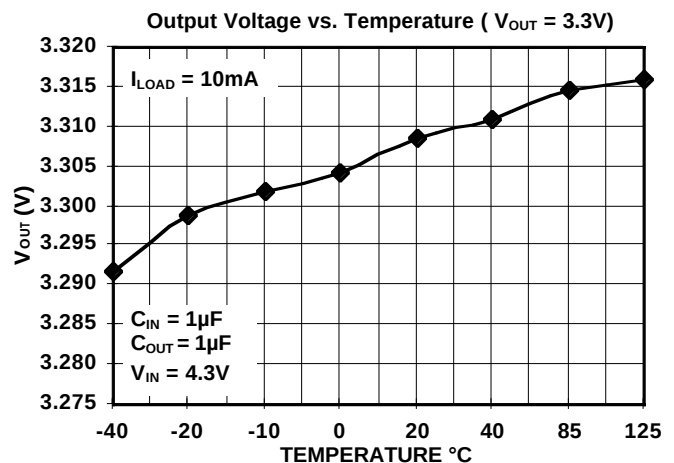
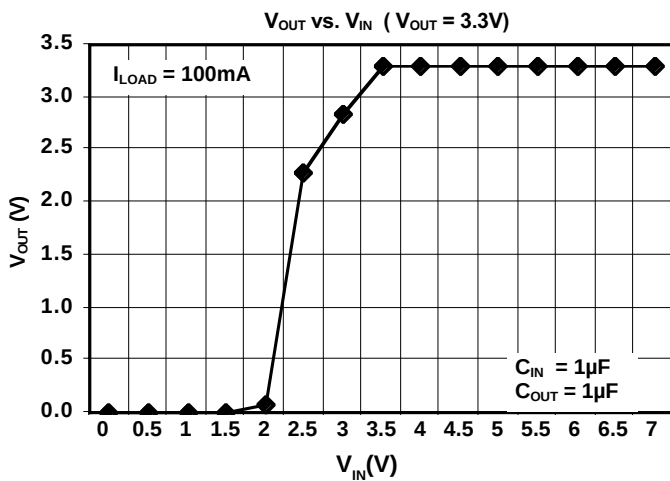
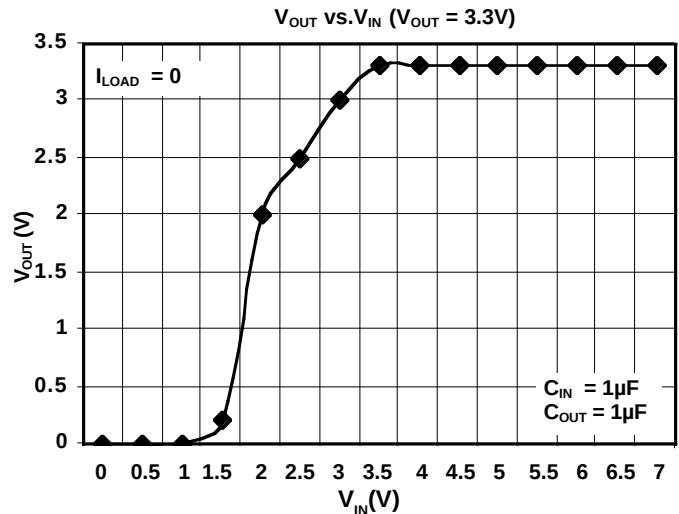
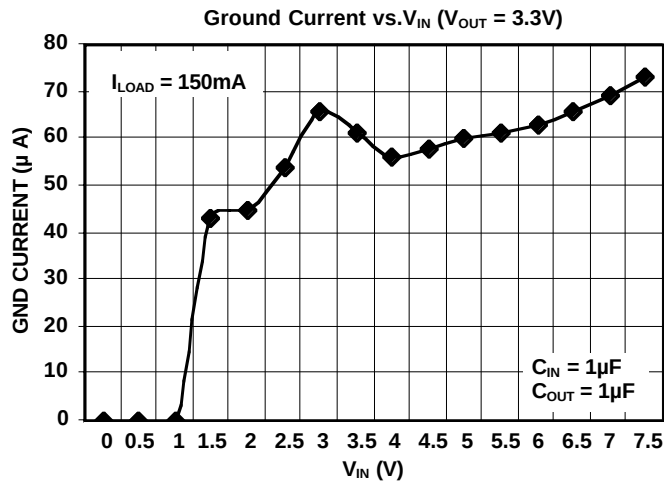
TYPICAL CHARACTERISTICS: (Unless otherwise specified, all parts are measured at Temperature = 25°C)



50mA, 100mA, 150mA CMOS LDOs with Shutdown and Reference Bypass

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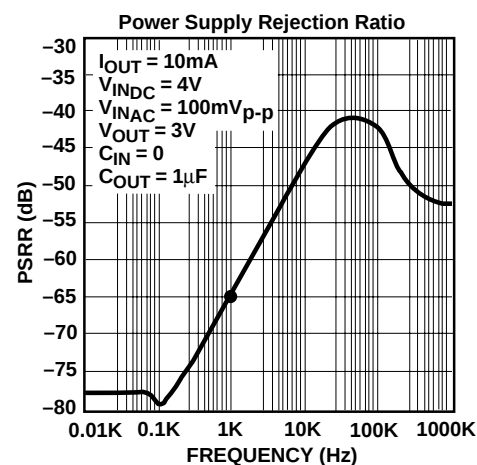
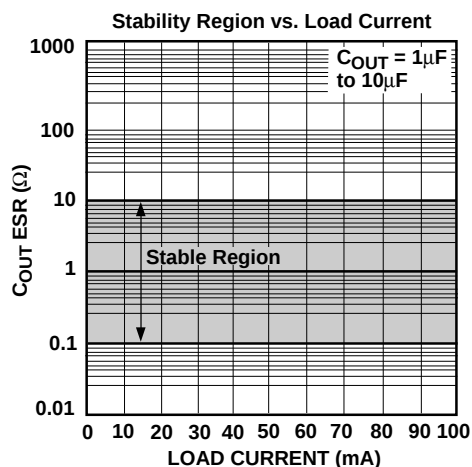
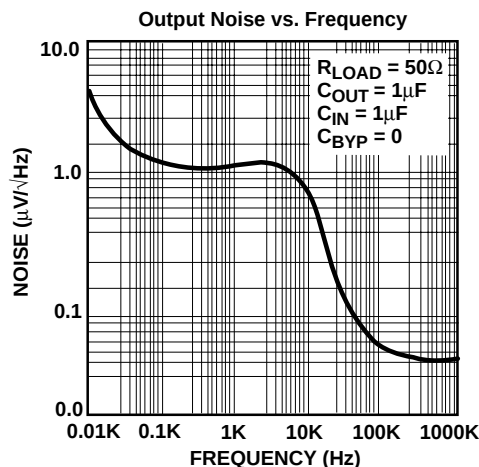
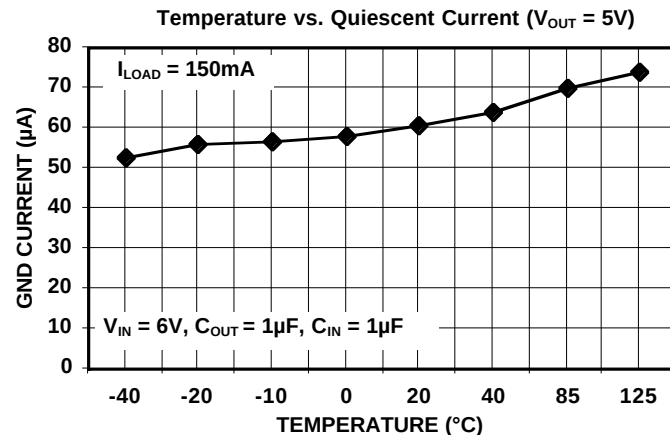
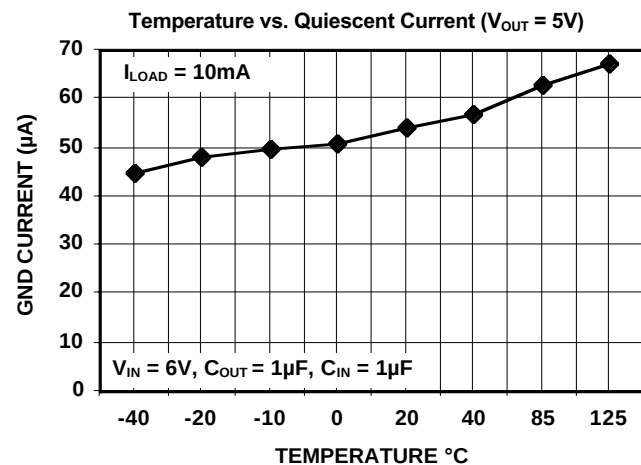
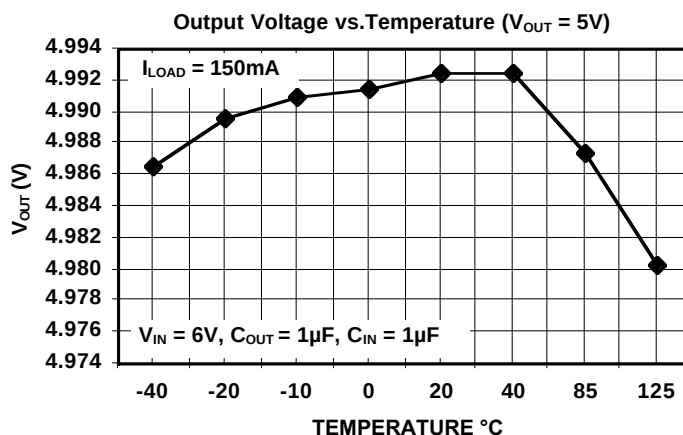
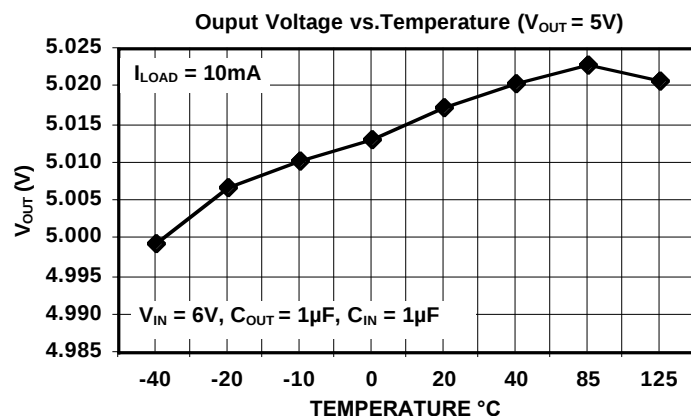
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TYPICAL CHARACTERISTICS



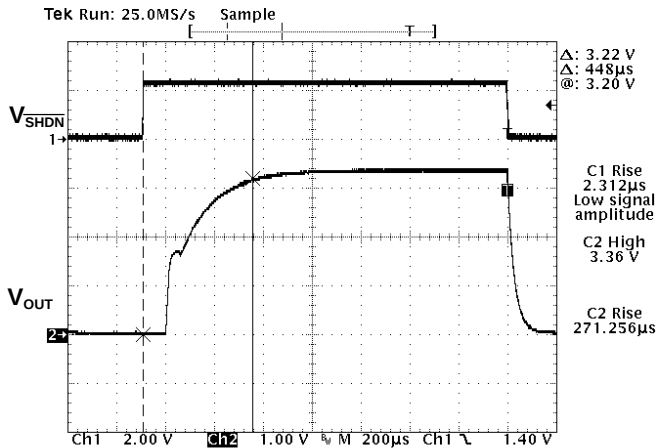
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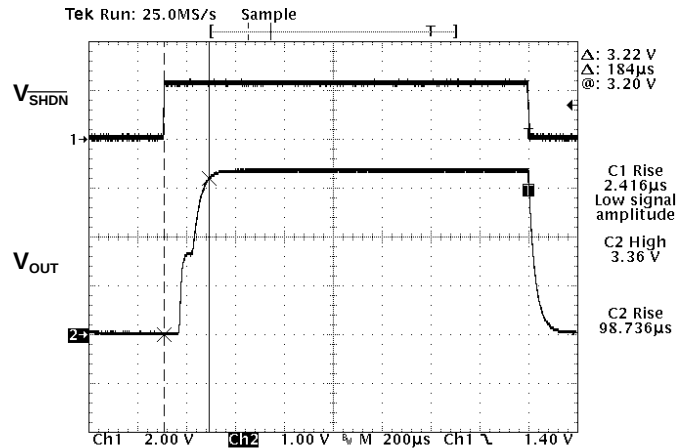
Measure Rise Time of 3.3V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470pF$, $I_{LOAD} = 100mA$
 $V_{IN} = 4.3V$, Temp = 25°C, Rise Time = 448 μs



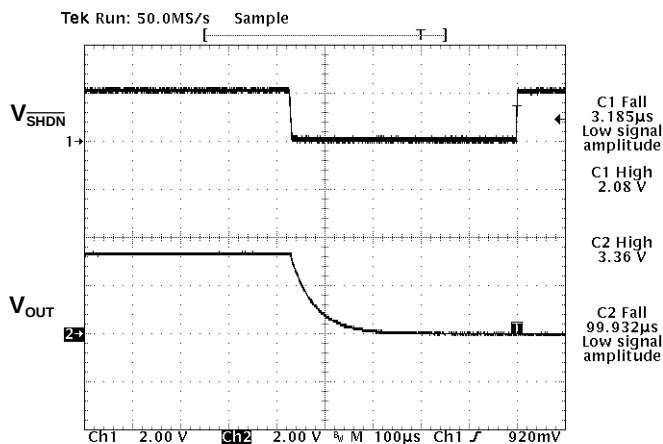
Measure Rise Time of 3.3V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0pF$, $I_{LOAD} = 100mA$
 $V_{IN} = 4.3V$, Temp = 25°C, Rise Time = 184 μs



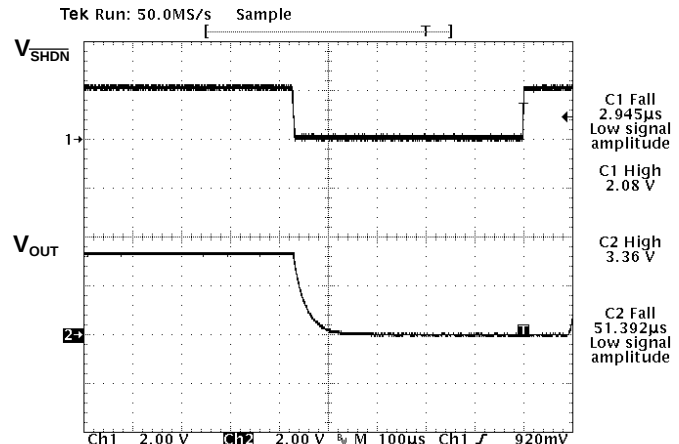
Measure Fall Time of 3.3V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470pF$, $I_{LOAD} = 50mA$
 $V_{IN} = 4.3V$, Temp = 25°C, Fall Time = 100 μs



Measure Fall Time of 3.3V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0pF$, $I_{LOAD} = 100mA$
 $V_{IN} = 4.3V$, Temp = 25°C, Fall Time = 52 μs



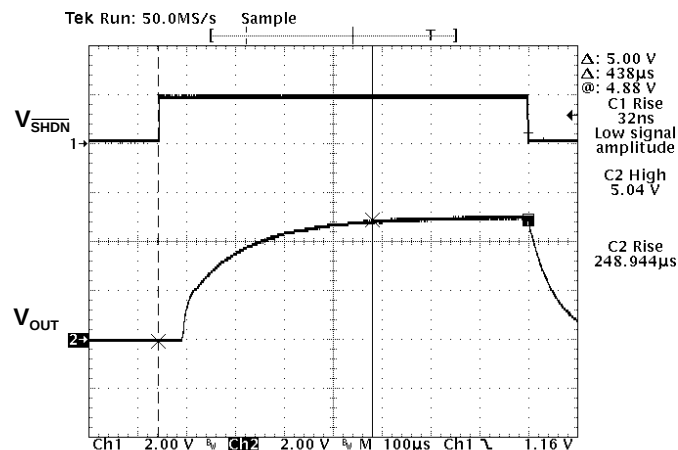
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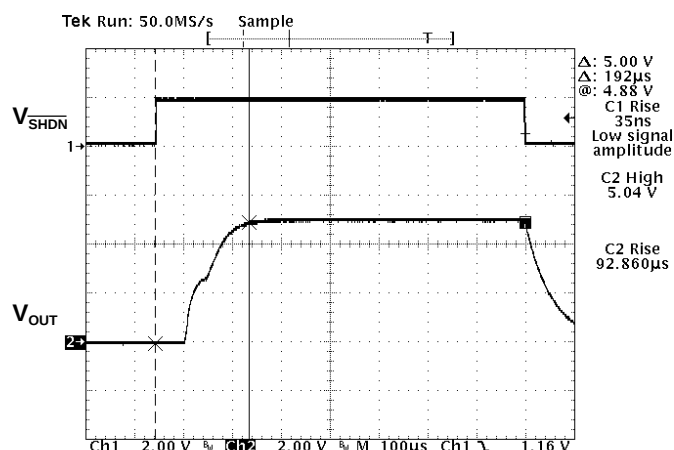
Measure Rise Time of 5.0V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470pF$, $I_{LOAD} = 100mA$
 $V_{IN} = 6V$, Temp = 25°C, Rise Time = 390μs



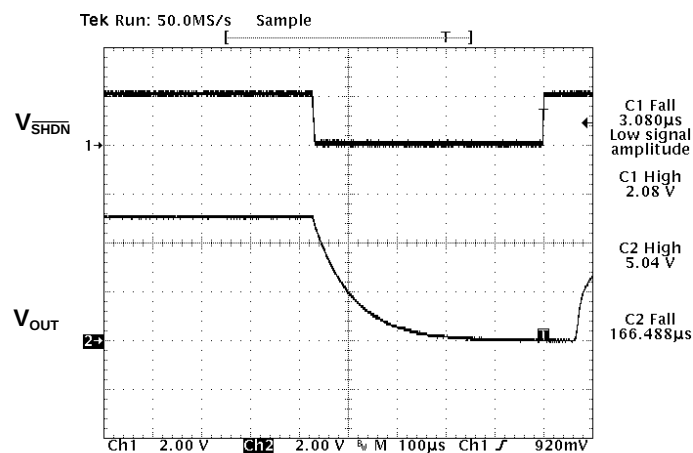
Measure Rise Time of 5.0V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0$, $I_{LOAD} = 100mA$
 $V_{IN} = 6V$, Temp = 25°C, Rise Time = 192μs



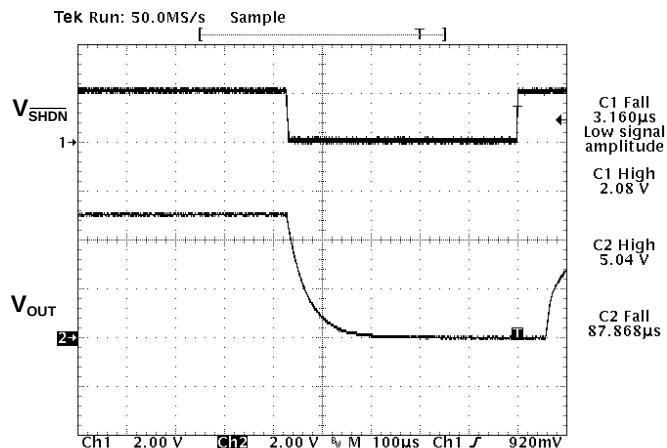
Measure Fall Time of 5.0V LDO with Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 470pF$, $I_{LOAD} = 50mA$
 $V_{IN} = 6V$, Temp = 25°C, Fall Time = 167μs



Measure Fall Time of 5.0V LDO without Bypass Capacitor

Conditions: $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $C_{BYP} = 0pF$, $I_{LOAD} = 100mA$
 $V_{IN} = 6V$, Temp = 25°C, Fall Time = 88μs



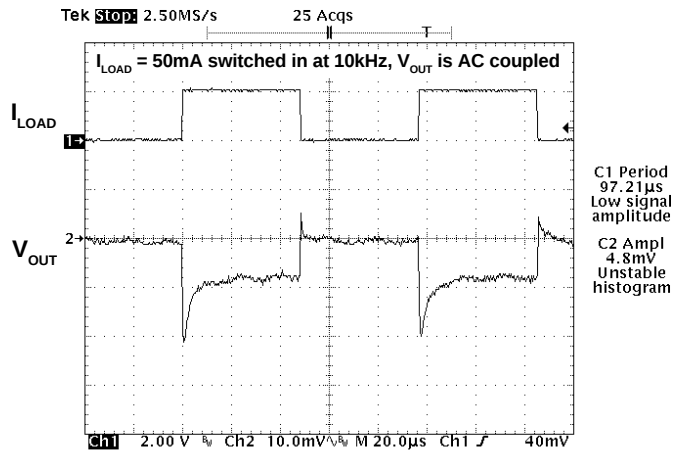
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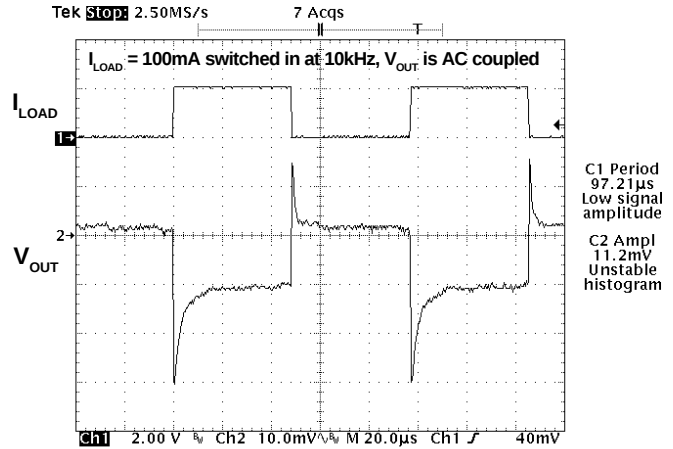
Load Regulation of 3.3V LDO

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



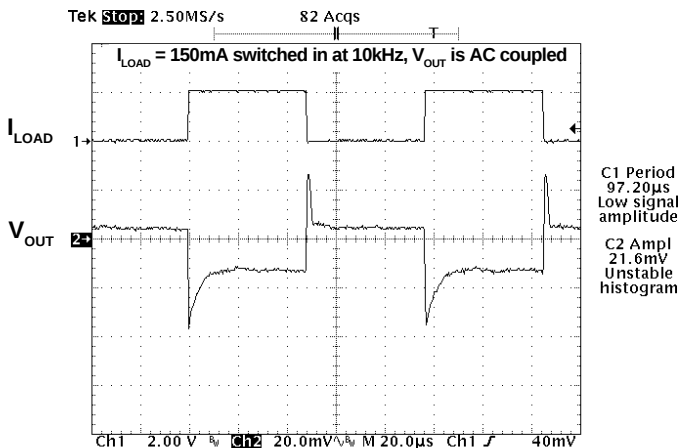
Load Regulation of 3.3V LDO

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



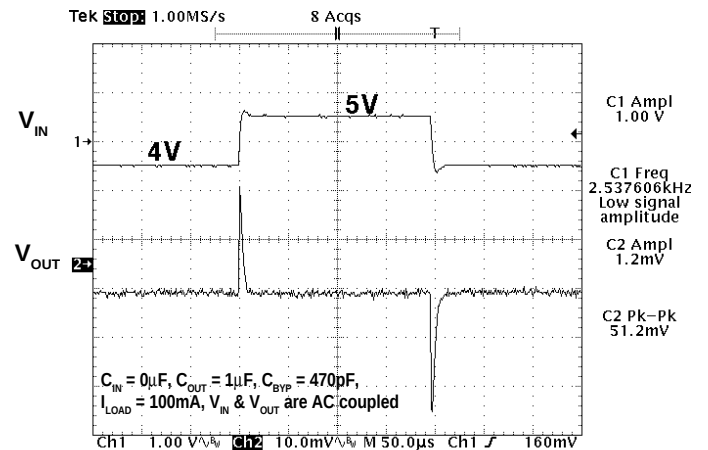
Load Regulation of 3.3V LDO

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



Line Regulation of 3.3V LDO

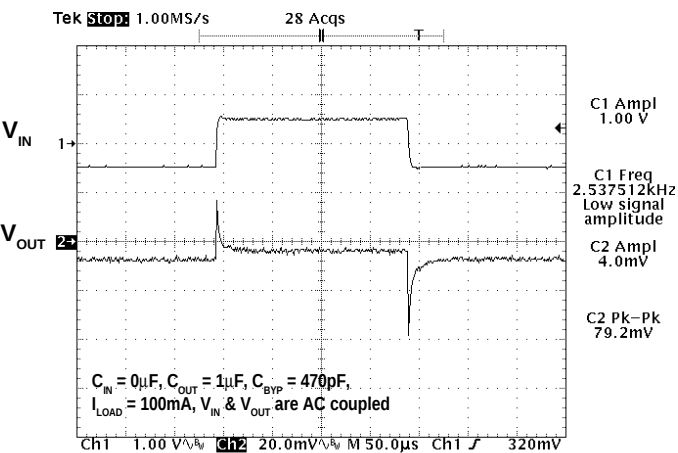
Conditions: $V_{IN} = 4V, +1V$ Squarewave @ 2.5kHz,



TYPICAL CHARACTERISTICS

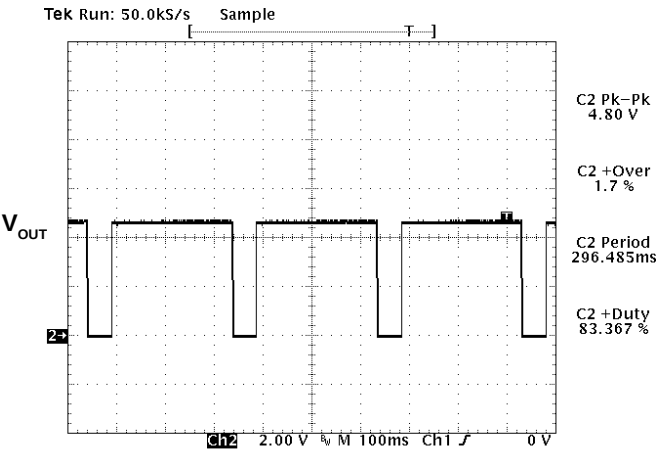
Line Regulation of 5.0V LDO

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



Thermal Shutdown Response of 5.0V LDO

Conditions: $V_{IN} = 6V$, $C_{IN} = 0\mu F$, $C_{OUT} = 1\mu F$

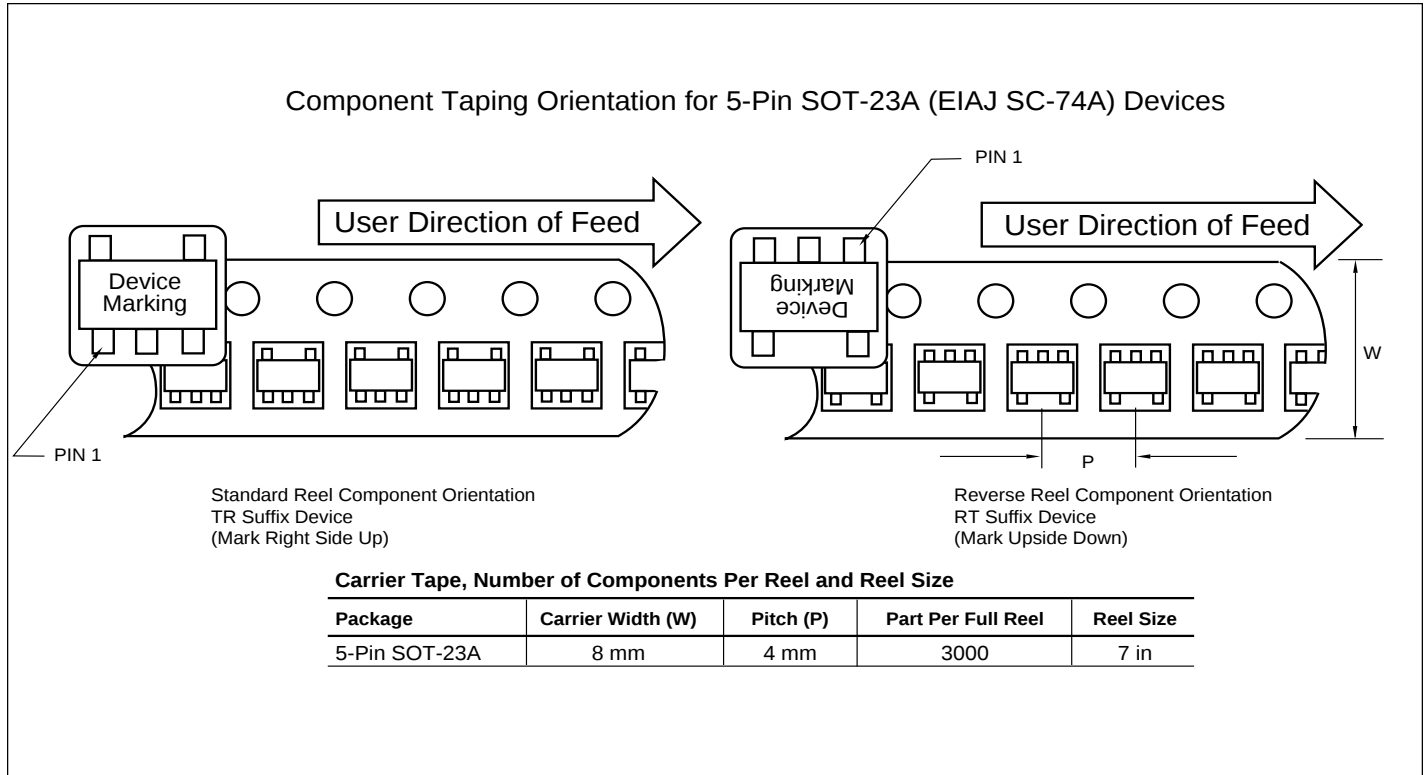


I_{LOAD} was increased until temperature of die reached about 160°C, at which time integrated thermal protection circuitry shuts the regulator off when the temperature exceeds approximately 160°C. The regulator remains off until the temperature drops to approximately 150°C.

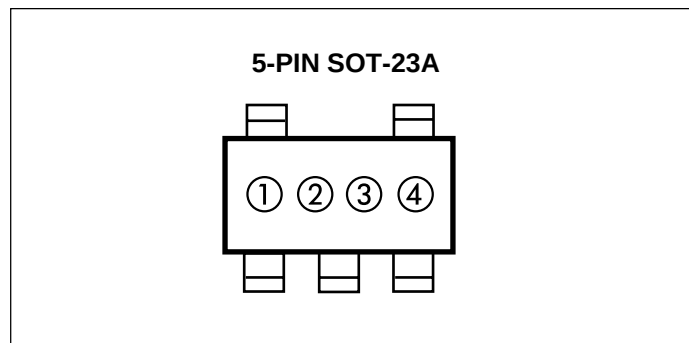
50mA, 100mA, 150mA CMOS LDOs with Shutdown and Reference Bypass

TC1014
TC1015
TC1185

TAPING FORM



MARKING



① & ② b = part number code + temperature range and voltage

(V)	TC1014 Code	TC1015 Code	TC1185 Code
1.8	AY	BY	NY
2.5	A1	B1	N1
2.7	A2	B2	N2
2.8	AZ	BZ	NZ
2.85	A8	B8	N8
3.0	A3	B3	N3
3.3	A5	B5	N5
3.6	A9	B9	N9
4.0	A0	B0	N0
5.0	A7	B7	N7

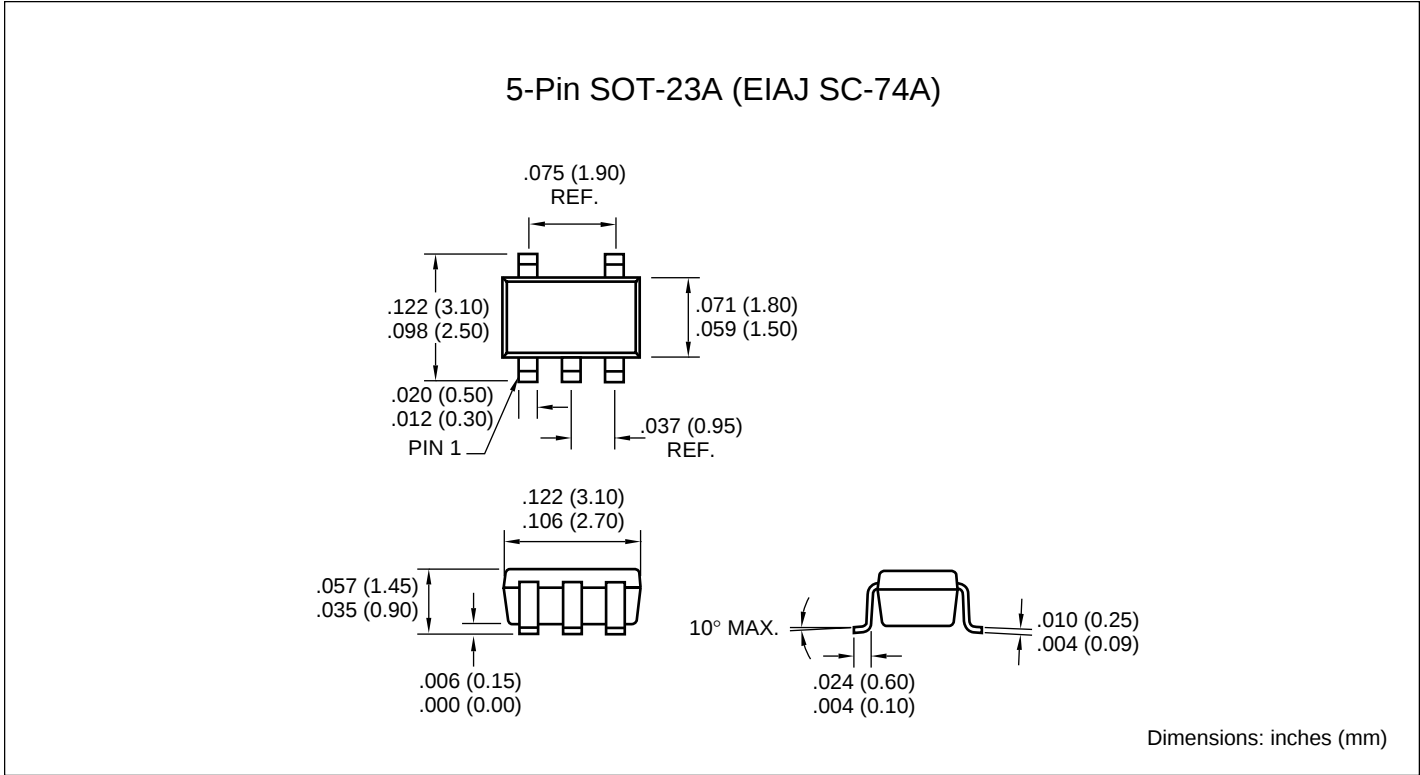
③ represents date code

④ represents lot ID number

50mA, 100mA, 150mA CMOS LDOs
with Shutdown and Reference Bypass

TC1014
TC1015
TC1185

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