EVALUATION KIT AVAILABLE

TC1014
TC1015
TC1185

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

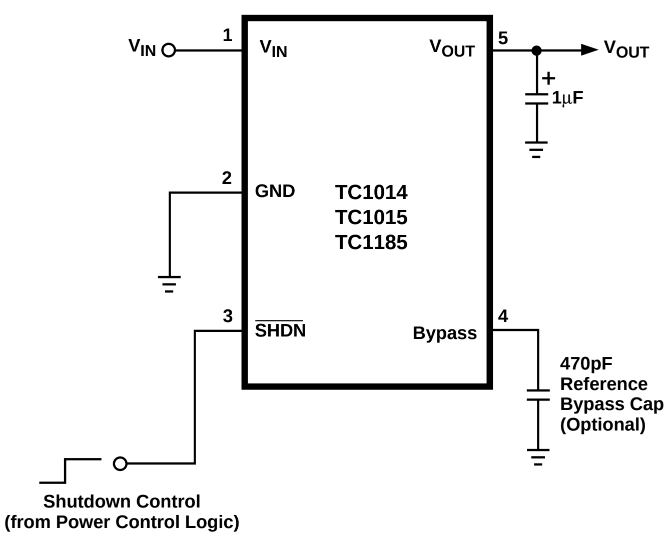
FEATURES

- Extremely Low Supply Current (50µA, 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 ±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 50µA 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 0.5µA (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 1µF 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

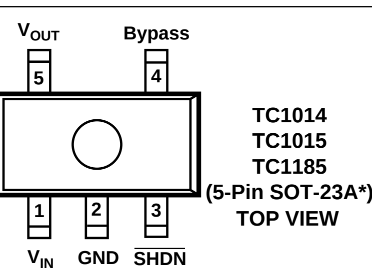
Part Number	Package	Junction Temp. Range
TC1014-xxVCT	5-Pin SOT-23A*	– 40°C to +125°C
TC1015-xxVCT	5-Pin SOT-23A*	– 40°C to +125°C
TC1185-xxVCT	5-Pin SOT-23A*	– 40°C to +125°C
TC1015EV	**Evaluation Kit for CMOS LDO Family**	

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 ouput voltages

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

PIN CONFIGURATION



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

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, $\overline{SHDN} > V_{IH}$, 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
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$(V_R + 1V) \le V_{IN} \le 6V$	—	0.05	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	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 TC1015; TC1185 TC1185	I_L = 100µA I_L = 20mA I_L = 50mA I_L = 100mA I_L = 150mA Note 5	— — — — —	2 65 85 180 270	— — **120** **250** **400**	mV
I_{IN}	Supply Current (Note 8)	$\overline{SHDN} = V_{IH}$, I_L = 0	—	50	**80**	µA
I_{INSD}	Shutdown Supply Current	$\overline{SHDN}$ = 0V	—	0.05	0.5	µA
PSRR	Power Supply Rejection Ratio	$F_{RE} \le$ 1KHz	—	64	—	dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	300	450	mA
$\Delta V_{OUT}/\Delta P_D$	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	—	$nV/\sqrt{Hz}$
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	V_{IN} = 2.5V to 6.5V	45	—	—	$\%V_{IN}$
V_{IL}	$\overline{SHDN}$ Input Low Threshold	V_{IN} = 2.5V to 6.5V	—	—	15	$\%V_{IN}$

NOTES:
1. The minimum V_{IN} has to meet two conditions: $V_{IN} \ge 2.7V$ and $V_{IN} \ge V_R + V_{DROPOUT}$.
2. 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.
3. $TCV_{OUT} = \dfrac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
4. 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.
5. 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.
6. 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.
7. 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.
8. Apply for Junction Temperatures of –40°C to +85°C.

PIN DESCRIPTION

Pin No. (5-Pin SOT-23A)	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 0.5µA (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 ($\overline{SHDN}$) 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 0.05µA (typical) and V_{OUT} falls to zero volts.

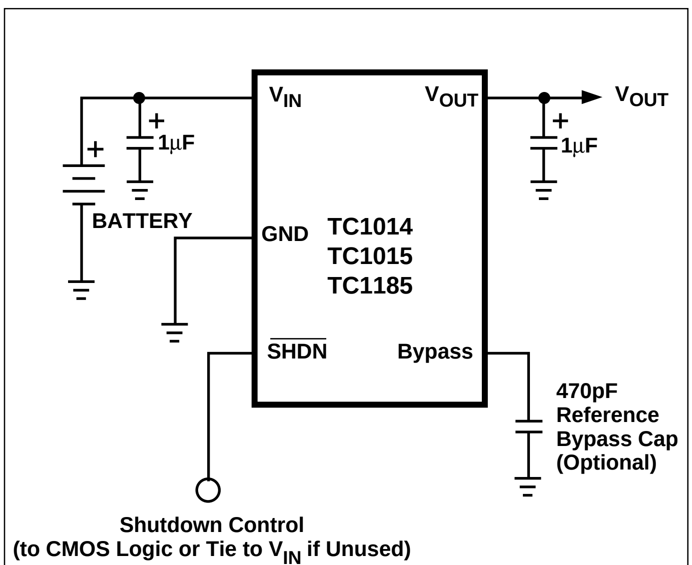


Figure 1. Typical Application Circuit

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:

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

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.

$$P_{D\,MAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$

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_{JMAX} = 125°C
T_{AMAX} = 55°C

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

Actual power dissipation:

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

Maximum allowable power dissipation:

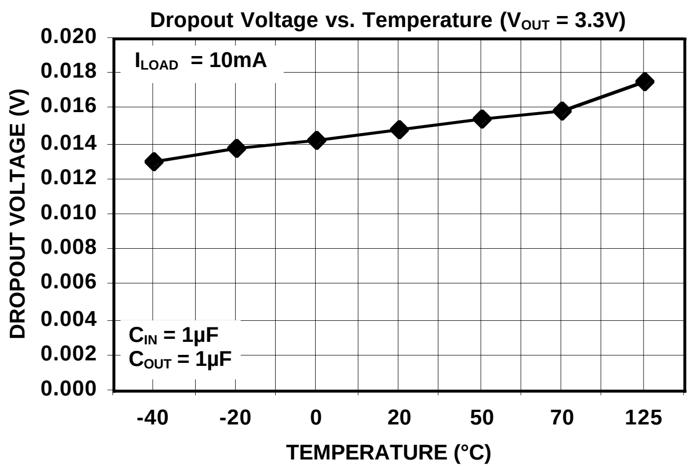
$$P_{D_{MAX}} = \frac{(T_{J_{MAX}} - T_{A_{MAX}})}{\theta_{JA}}$$
$$= \frac{(125 - 55)}{220}$$
$$= 318\text{mW}$$

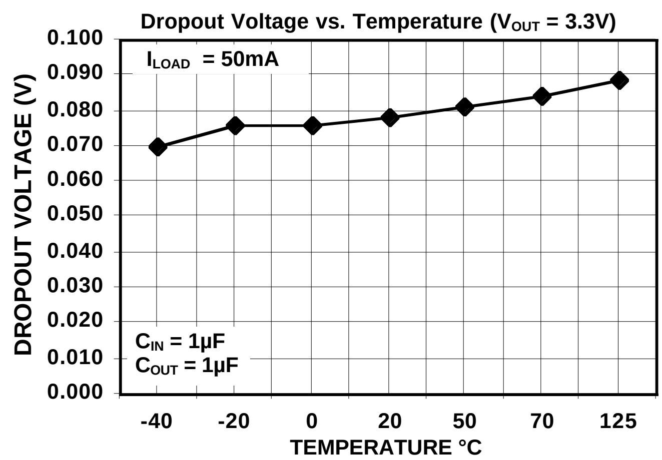
In this example, the TC1014 dissipates a maximum of only 26.7 mW; far below the allowable limit of 318 mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits.

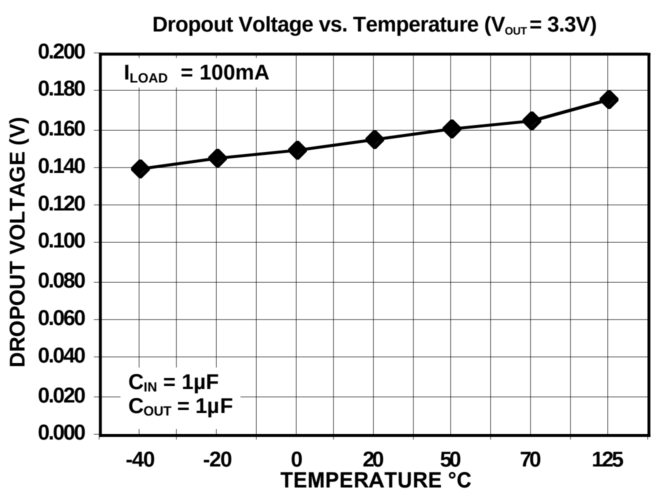
Layout Considerations

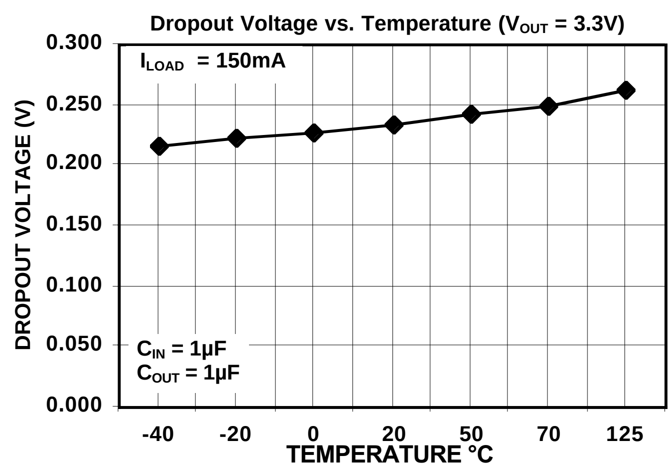
The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and, therefore, increase the maximum allowable power dissipation limit.

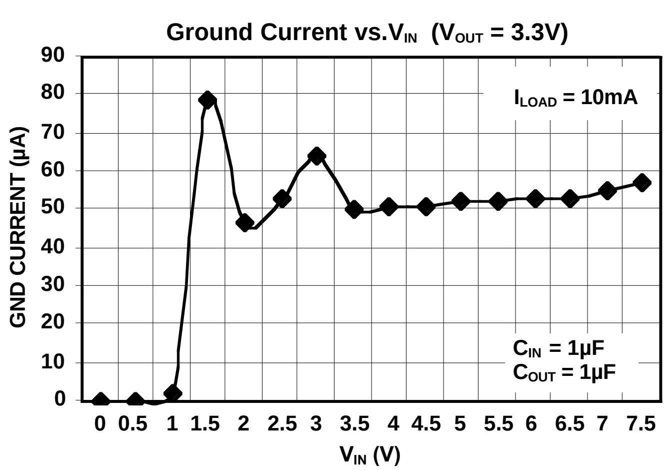
TYPICAL CHARACTERISTICS: (Unless otherwise specified, all parts are measured at Temperature = 25°C)

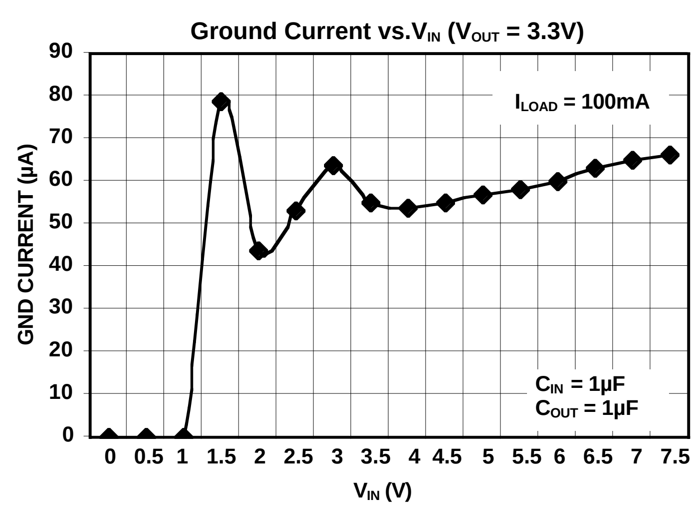




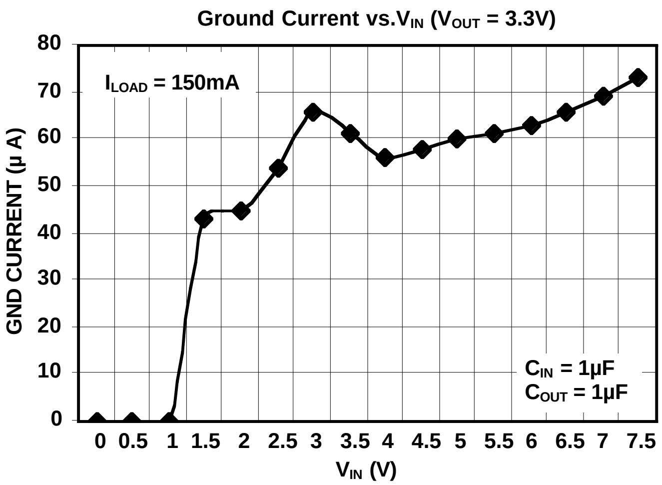


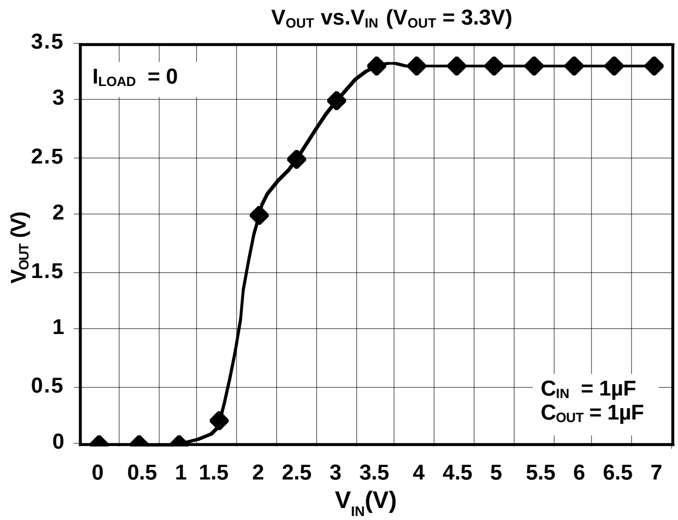


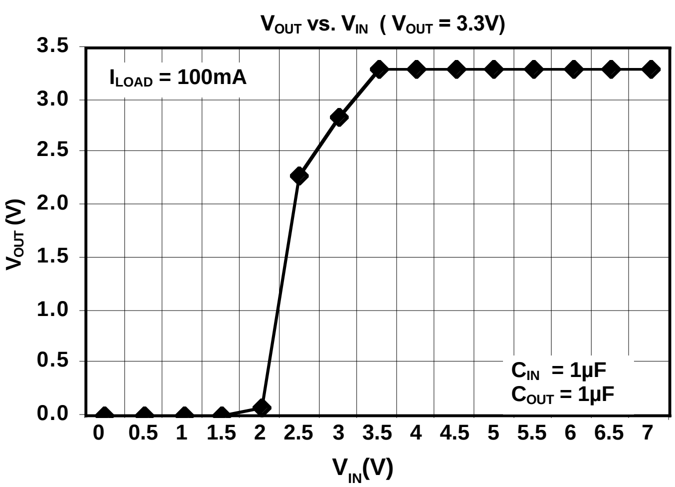


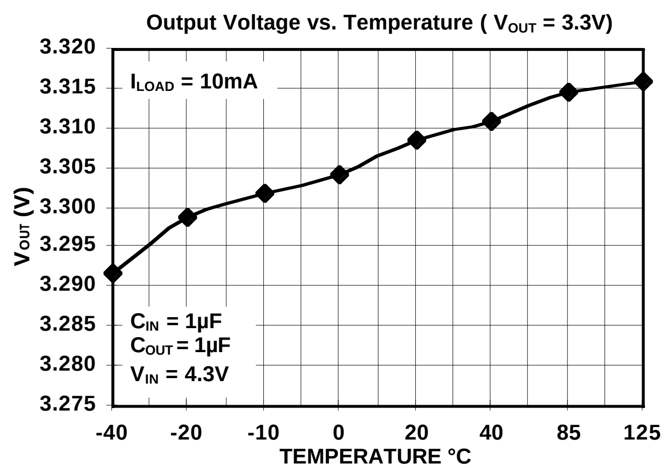


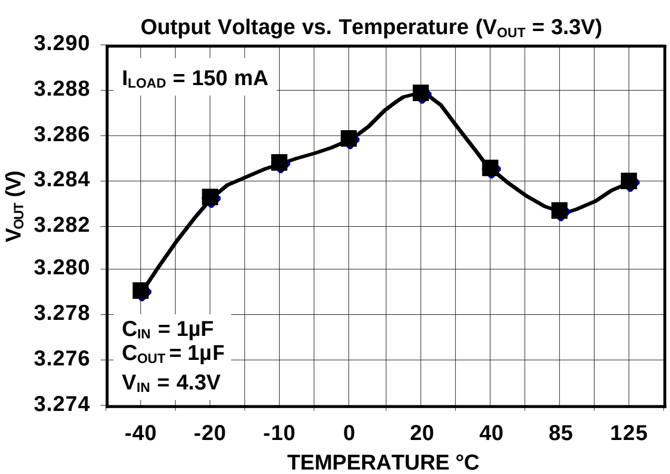
TYPICAL CHARACTERISTICS: (Unless otherwise specified, all parts are measured at Temperature = 25°C





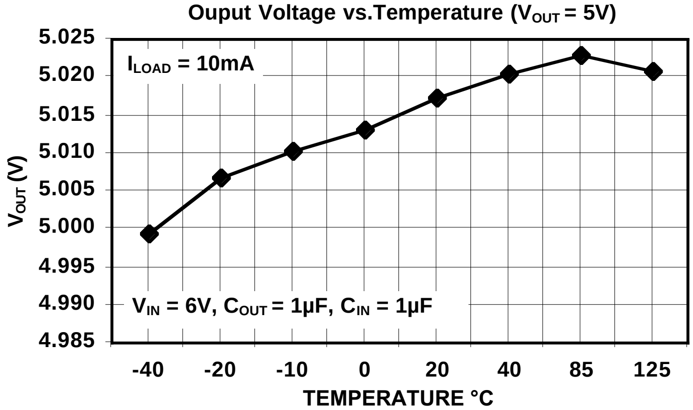




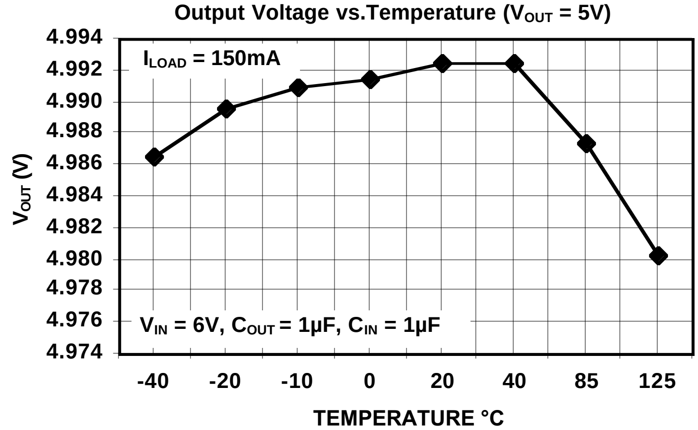


TYPICAL CHARACTERISTICS

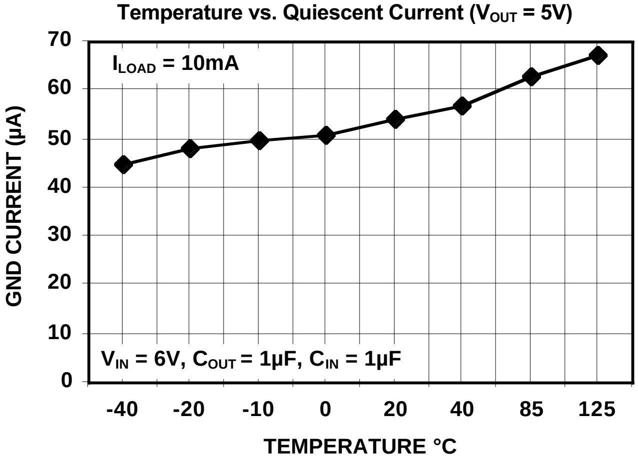
Ouput Voltage vs.Temperature (V_{OUT} = 5V)



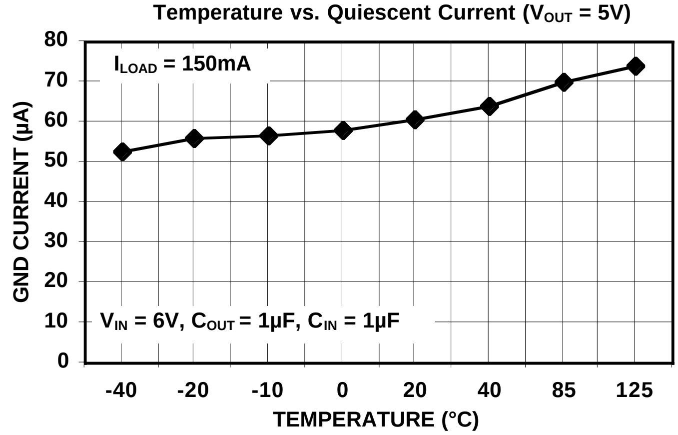
Output Voltage vs.Temperature (V_{OUT} = 5V)



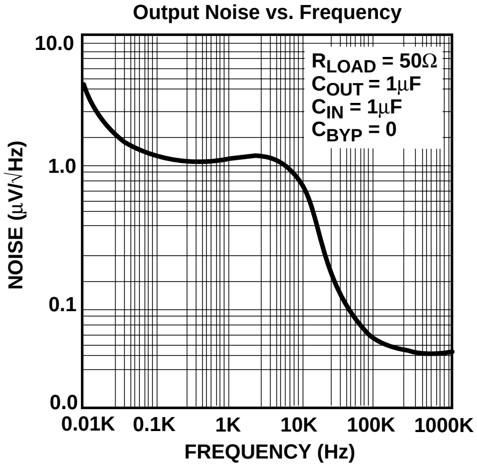
Temperature vs. Quiescent Current (V_{OUT} = 5V)



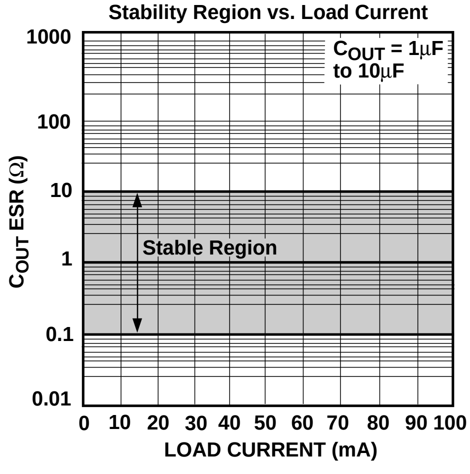
Temperature vs. Quiescent Current (V_{OUT} = 5V)



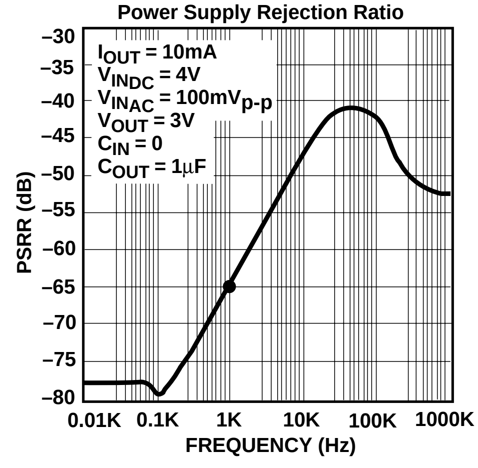
Output Noise vs. Frequency



Stability Region vs. Load Current



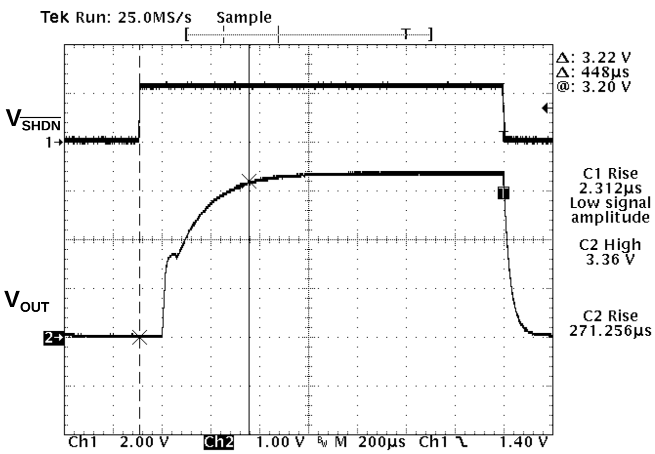
Power Supply Rejection Ratio



TYPICAL CHARACTERISTICS

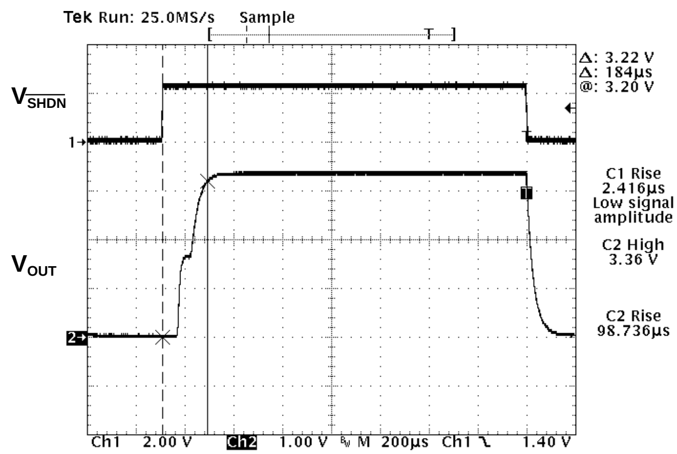
Measure Rise Time of 3.3V LDO with Bypass Capacitor

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



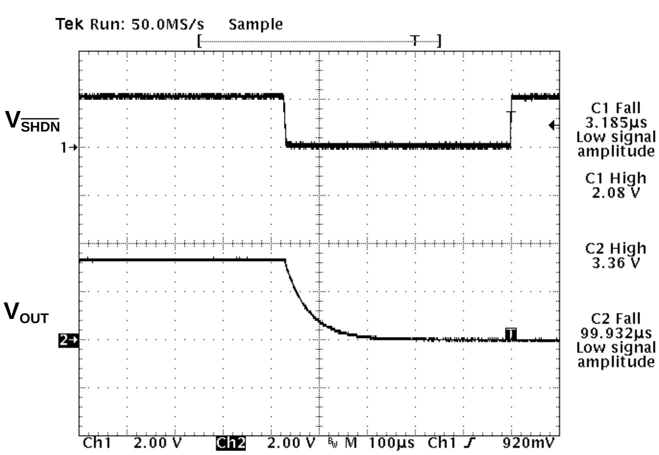
Measure Rise Time of 3.3V LDO without Bypass Capacitor

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



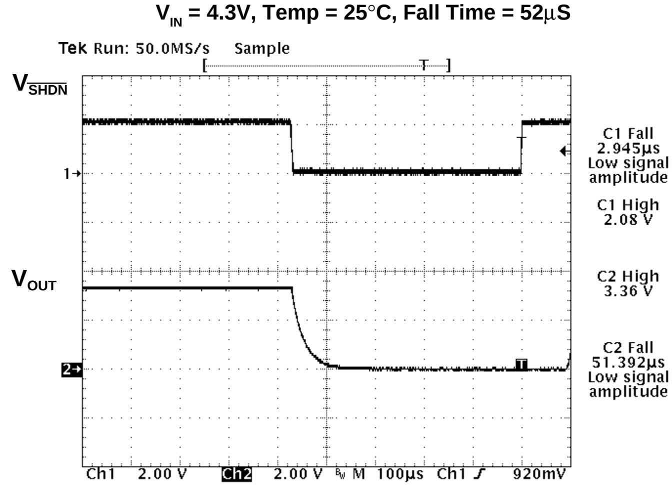
Measure Fall Time of 3.3V LDO with Bypass Capacitor

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



Measure Fall Time of 3.3V LDO without Bypass Capacitor

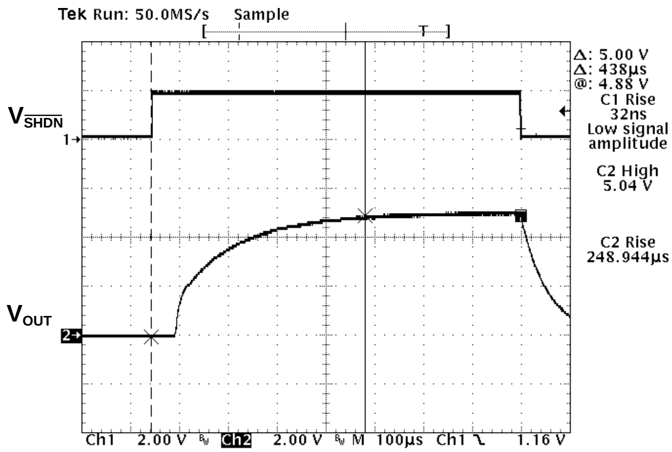
Conditions: C_{IN} = 1µF, C_{OUT} = 1µF, C_{BYP} = 0pF, I_{LOAD} = 100mA
V_{IN} = 4.3V, Temp = 25°C, Fall Time = 52µS



TYPICAL CHARACTERISTICS

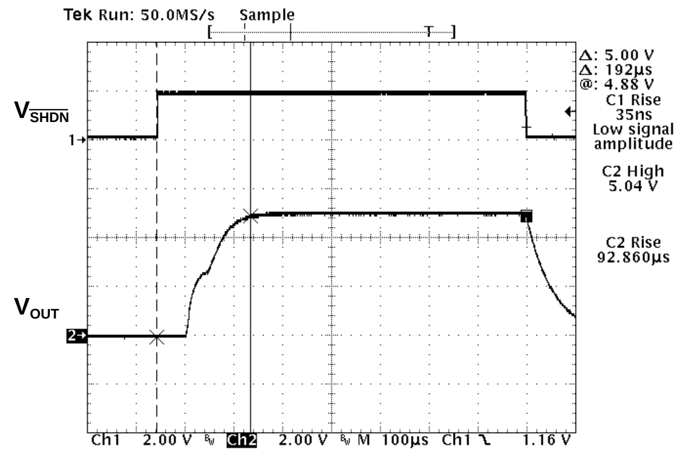
Measure Rise Time of 5.0V LDO with Bypass Capacitor

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



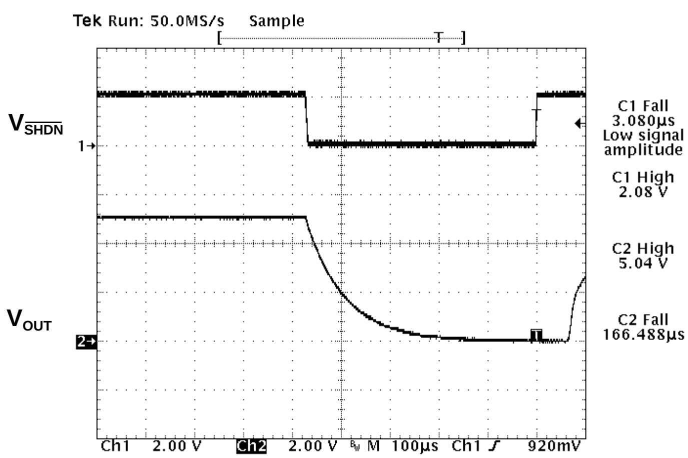
Measure Rise Time of 5.0V LDO without Bypass Capacitor

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



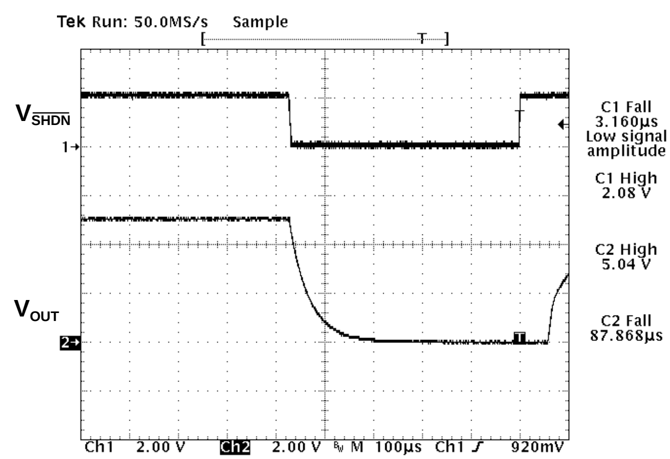
Measure Fall Time of 5.0V LDO with Bypass Capacitor

Conditions: C_{IN} = 1µF, C_{OUT} = 1µF, 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

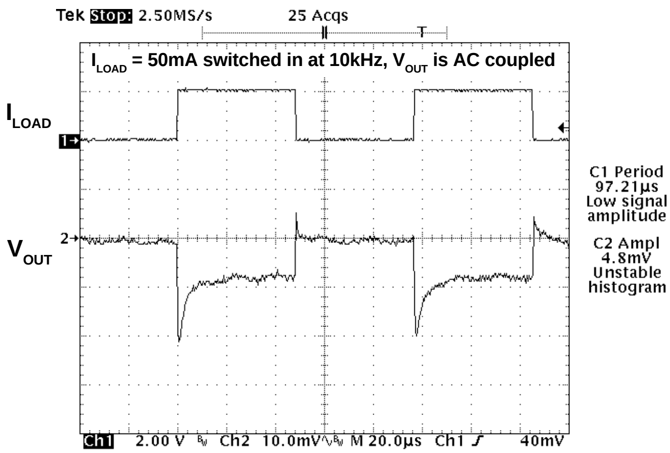
Conditions: C_{IN} = 1µF, C_{OUT} = 1µF, C_{BYP} = 0pF, I_{LOAD} = 100mA
V_{IN} = 6V, Temp = 25°C, Fall Time = 88µS



TYPICAL CHARACTERISTICS

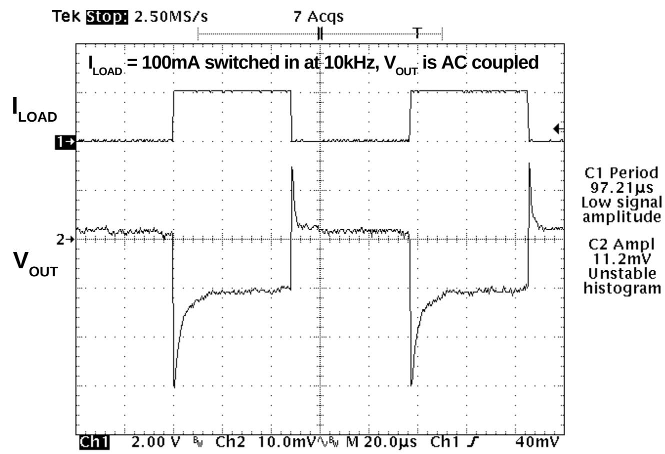
Load Regulation of 3.3V LDO

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



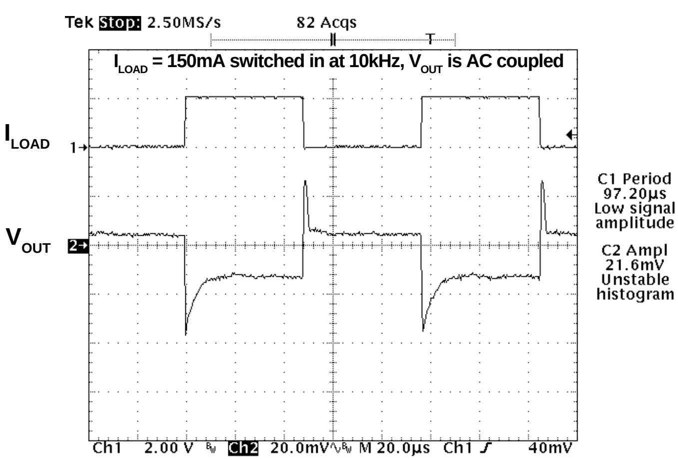
Load Regulation of 3.3V LDO

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



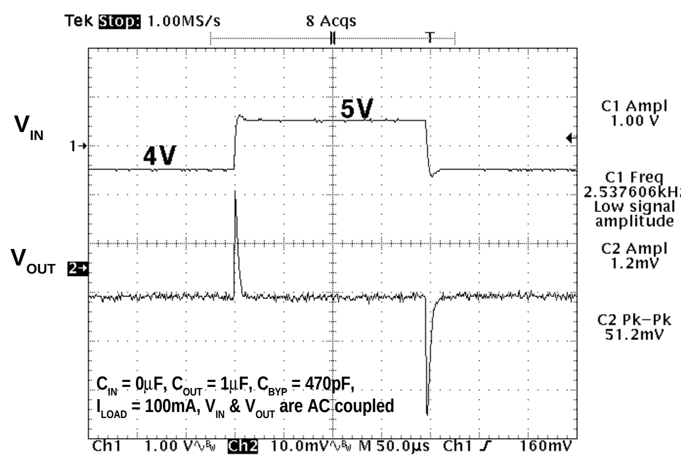
Load Regulation of 3.3V LDO

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



Line Regulation of 3.3V LDO

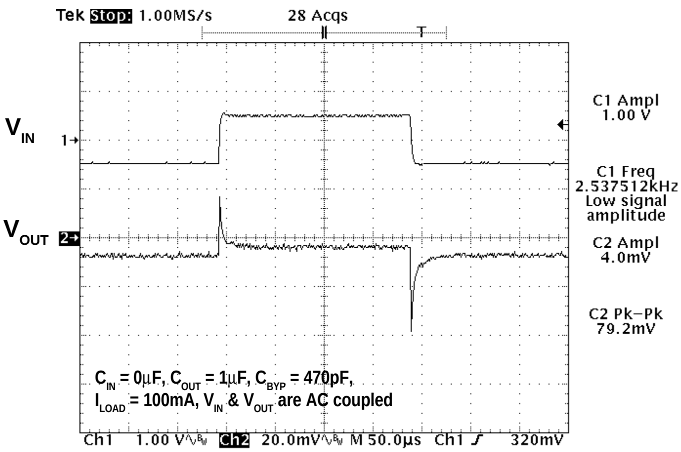
Conditions: V_{IN} = 4V,+ 1V Squarewave @ 2.5kHz,



TYPICAL CHARACTERISTICS

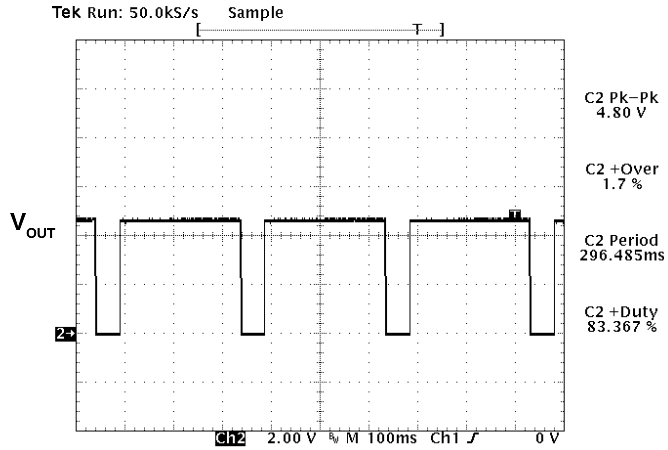
Line Regulation of 5.0V LDO

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



Thermal Shutdown Response of 5.0V LDO

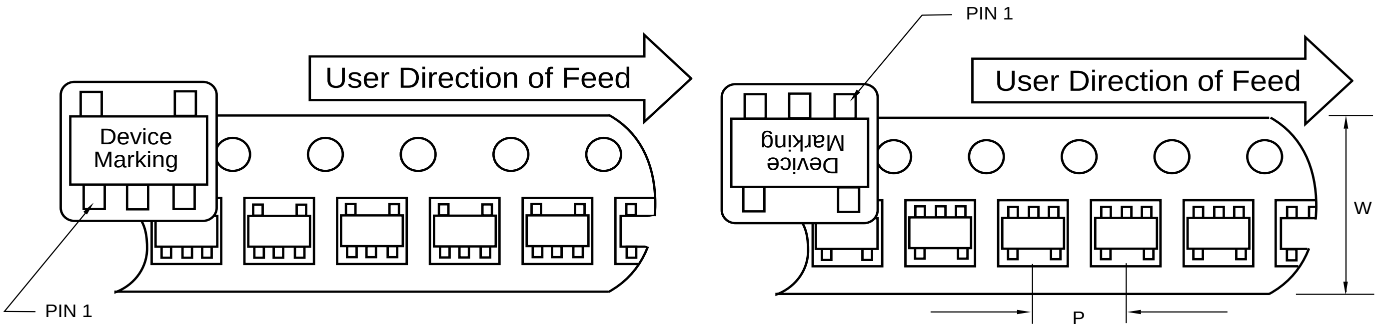
Conditions: V_{IN} = 6V,C_{IN} = 0µF, C_{OUT} = 1µF



I_{LOAD} was increased until temperature 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.

TAPING FORM

Component Taping Orientation for 5-Pin SOT-23A (EIAJ SC-74A) Devices



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

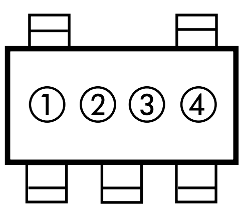
Reverse Reel Component Orientation
RT Suffix Device
(Mark Upside Down)

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
5-Pin SOT-23A	8 mm	4 mm	3000	7 in

MARKING

5-PIN SOT-23A



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

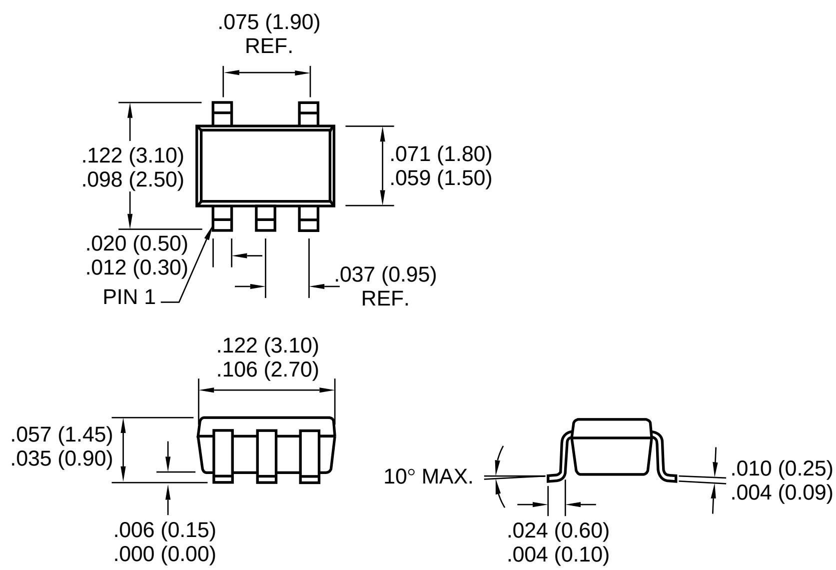
(V)	TC1014 Code	TC1015 Code	TC1185 Code
1.8	AY	BY	NY
2.5	A1	B1	N1
2.7	A2	B2	N2
2.8	AZ	BZ	NZ
2.85	A8	B8	N8
3.0	A3	B3	N3
3.3	A5	B5	N5
3.6	A9	B9	N9
4.0	A0	B0	N0
5.0	A7	B7	N7

③ represents date code

④ represents lot ID number

PACKAGE DIMENSIONS

5-Pin SOT-23A (EIAJ SC-74A)



Dimensions: inches (mm)

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

Rocky Mountain
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-7456

Atlanta
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Austin
Analog Product Sales
8303 MoPac Expressway North
Suite A-201
Austin, TX 78759
Tel: 512-345-2030 Fax: 512-345-6085

Boston
2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Boston
Analog Product Sales
Unit A-8-1 Millbrook Tarry Condominium
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Tel: 978-371-6400 Fax: 978-371-0050

Chicago
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Two Prestige Place, Suite 130
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Mountain View
Analog Product Sales
1300 Terra Bella Avenue
Mountain View, CA 94043-1836
Tel: 650-968-9241 Fax: 650-967-1590

New York
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

China - Beijing
Microchip Technology Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai
Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

Hong Kong
Microchip Asia Pacific
RM 2101, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India
Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, OíShaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Intl. Inc.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea
Tel: 82-2-554-7200 Fax: 82-2-558-5934

ASIA/PACIFIC (continued)

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan
Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Australia
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

Denmark
Microchip Technology Denmark ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Arizona Microchip Technology SARL
Parc díActivite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Arizona Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Germany
Analog Product Sales
Lochhamer Strasse 13
D-82152 Martinsried, Germany
Tel: 49-89-895650-0 Fax: 49-89-895650-22

Italy
Arizona Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

01/09/01