TC1070/TC1071/TC1187

50mA, 100mA and 150mA Adjustable CMOS LDOs with Shutdown

Features

- Zero Ground Current for Longer Battery Life
- Adjustable Output Voltage
- Very Low Dropout Voltage
- Choice of 50mA (TC1070), 100mA (TC1071) and 150mA (TC1187) Output
- Power-Saving Shutdown Mode
- Over Current and Over Temperature Protection
- Space-Saving 5-Pin SOT-23A Package
- Pin Compatible with Bipolar Regulators

Applications

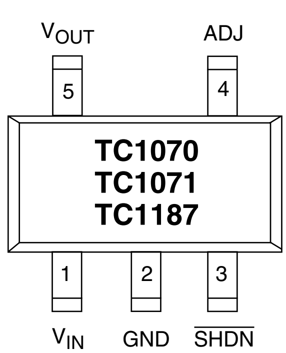
- Battery Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular/GSM/PHS Phones
- Linear Post-Regulators for SMPS
- Pagers

Device Selection Table

Part Number	Output Voltage (V)	Package	Junction Temp. Range
TC1070VCT	Adjustable	5-Pin SOT-23A	-40°C to +125°C
TC1071VCT	Adjustable	5-Pin SOT-23A	-40°C to +125°C
TC1187VCT	Adjustable	5-Pin SOT-23A	-40°C to +125°C

Package Type

5-Pin SOT-23A



NOTE: 5-Pin SOT-23A is equivalent to the EIAJ (SC-74A)

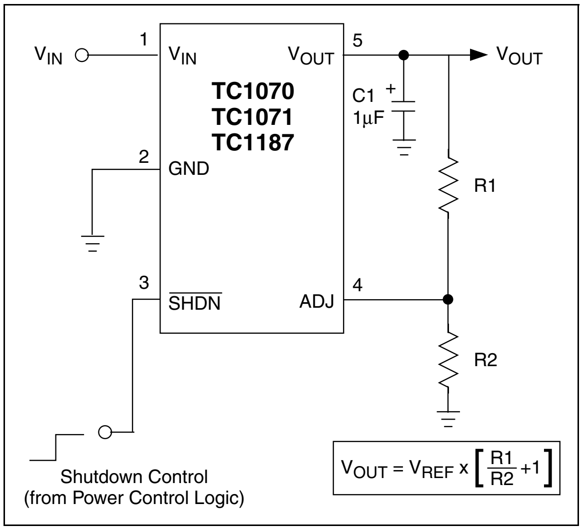
General Description

The TC1070, TC1071 and TC1187 are adjustable LDOs designed to supersede a variety of older (bipolar) voltage regulators. Total supply current is typically 50µA at full load (20 to 60 times lower than in bipolar regulators).

The devices' key features include ultra low noise operation, very low dropout voltage – typically 85mV (TC1070); 180mV (TC1071); and 270mV (TC1187) at full load, and fast response to step changes in load. Supply current is reduced to 0.5µA (max) when the shutdown input is low. The devices incorporate both over-temperature and over-current protection. Output voltage is programmed with a simple resistor divider from V_{OUT} to ADJ to GND.

The TC1070, TC1071 and TC1187 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, please see the TC1174 (I_{OUT} = 300mA) data sheet.

Typical Application



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage 6.5V
Output Voltage.......................... (-0.3V) to (V_{IN} + 0.3V)
Power Dissipation................Internally Limited **(Note 5)**
Maximum Voltage on Any Pin ....V_{IN} +0.3V to -0.3V
Operating Temperature Range...... -40°C < T_J < 125°C
Storage Temperature..........................-65°C to +150°C

*Stresses above 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 above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

TC1070/TC1071/TC1187 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: $V_{IN} = V_{OUT} + 1V$, $I_L = 0.1mA$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of -40°C to +125°C.

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
V_{IN}	Input Operating Voltage	**2.7**	—	**6.0**	V	**Note 6**
I_{OUTMAX}	Maximum Output Current	**50** **100** **150**	— — —	— — —	mA	TC1070 TC1071 TC1187
V_{OUT}	Adjustable Output Voltage Range	V_{REF}	—	5.5	V	
V_{REF}	Reference Voltage	**1.165**	1.20	**1.235**	V	
$\Delta V_{REF}/\Delta T$	V_{REF} Temperature Coefficient	—	**40**	—	ppm/°C	**Note 1**
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	—	0.05	**0.35**	%	$(V_R + 1V) \le V_{IN} \le 6V$
$\Delta V_{OUT}/V_{OUT}$	Load Regulation TC1070; TC1071 TC1187	— —	0.5 0.5	**2** **3**	%	I_L = 0.1mA to I_{OUTMAX} I_L = 0.1mA to I_{OUTMAX} **(Note 2)**
$V_{IN}-V_{OUT}$	Dropout Voltage TC1071; TC1187 TC1187	— — — — —	2 65 85 180 270	— — **120** **250** **400**	mV	I_L = 0.1mA I_L = 20mA I_L = 50mA I_L = 100mA I_L = 150mA **(Note 3)**
I_{IN}	Supply Current	—	50	80	µA	$\overline{SHDN} = V_{IH}$, $I_L = 0$
I_{INSD}	Shutdown Supply Current	—	0.05	0.5	µA	$\overline{SHDN}$ = 0V
PSRR	Power Supply Rejection Ratio	—	64	—	dB	$F_{RE} \le 1kHz$
I_{OUTSC}	Output Short Circuit Current	—	300	450	mA	V_{OUT} = 0V
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	—	0.04	—	V/W	**Note 4**
T_{SD}	Thermal Shutdown Die Temperature	—	160	—	°C	
ΔT_{SD}	Thermal Shutdown Hysteresis	—	10	—	°C	
eN	Output Noise	—	260	—	$nV/\sqrt{Hz}$	$I_L = I_{OUTMAX}$

Note 1: $TC\ V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$

2: Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value.

4: 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 = 10 msec.

5: 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 Section 4.0 Thermal Considerations for more details..

6: The minimum V_{IN} has to justify the conditions: $V_{IN} \ge V_R + V_{DROPOUT}$ and $V_{IN} \ge 2.7V$ for I_L = 0.1mA to I_{OUTMAX}.

TC1070/TC1071/TC1187 ELECTRICAL SPECIFICATIONS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{OUT} + 1V$, $I_L = 0.1mA$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of -40°C to +125°C.

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	**45**	—	—	$\%V_{IN}$	V_{IN} = 2.5V to 6.5V
V_{IL}	$\overline{SHDN}$ Input Low Threshold	—	—	**15**	$\%V_{IN}$	V_{IN} = 2.5V to 6.5V
ADJ Input						
I_{ADJ}	Adjust Input Leakage Current	—	50	—	pA	

Note 1: $TC\ V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$

2: Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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4: 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 = 10 msec.

5: 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 Section 4.0 Thermal Considerations for more details.

6: The minimum V_{IN} has to justify the conditions: $V_{IN} \geq V_R + V_{DROPOUT}$ and $V_{IN} \geq 2.7V$ for $I_L = 0.1mA$ to I_{OUTMAX}.

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

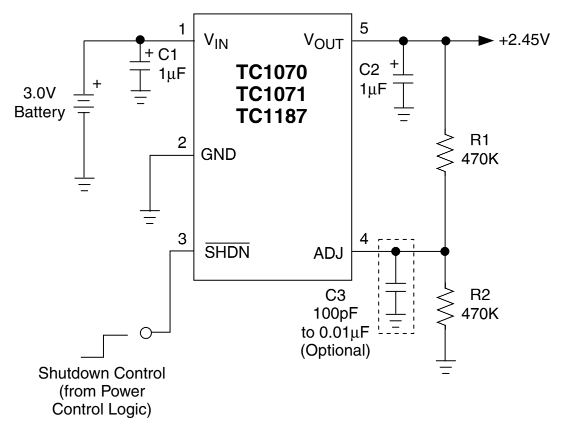
Pin No. (5-Pin SOT-23A)	Symbol	Description
1	V_{IN}	Unregulated supply input.
2	GND	Ground terminal.
3	$\overline{SHDN}$	Shutdown control input. The regulator is fully enabled when a logic high is applied to this input. The regulator enters shutdown when a logic low is applied to this input. During shutdown, output voltage falls to zero and supply current is reduced to 0.5 µA (max).
4	ADJ	Output voltage adjust terminal. Output voltage setting is programmed with a resistor divider from V_{OUT} to this input. A capacitor may also be added to this input to reduce output noise (See Section 3.2, Output Capacitor).
5	V_{OUT}	Regulated voltage output.

3.0 DETAILED DESCRIPTION

The TC1070, TC1071 and TC1187 are adjustable fixed output voltage regulators. (If a fixed version is desired, please see the TC1014/TC1015/TC1185 data sheet.) Unlike bipolar regulators, the TC1070, TC1071 and TC1187 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation over the entire 0mA to I_{OUTMAX} operating load current range, (an important consideration in RTC and CMOS RAM battery back-up applications).

Figure 3-1 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), V_{OUT} falls to zero volts.

FIGURE 3-1: BATTERY-OPERATED SUPPLY



3.1 Adjust Input

The output voltage setting is determined by the values of R1 and R2 (Figure 3-1). The ohmic values of these resistors should be between 470K and 3M to minimize bleeder current.

The output voltage setting is calculated using the following equation.

EQUATION 3-1:

$$V_{OUT} = V_{REF} \times \left[\frac{R1}{R2} + 1\right]$$

The voltage adjustment range of the TC1070, TC1071 and TC1187 is from V_{REF} to (V_{IN} – 0.05V). If so desired, a small capacitor (100pF to 0.01µF) may be added to the ADJ input to further reduce output noise.

3.2 Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is recommended. The output capacitor should have an effective series resistance greater than 0.1Ω and less than 5.0Ω, and a resonant frequency above 1MHz. 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.

4.0 THERMAL CONSIDERATIONS

4.1 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.

4.2 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:

EQUATION 4-1:

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

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

The maximum allowable power dissipation (Equation 4-2) is a function of the maximum ambient temperature (T_{AMAX}), the maximum allowable die temperature (T_{JMAX}) 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.

EQUATION 4-2:

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

Where all terms are previously defined.

Equation 4-1 can be used in conjunction with Equation 4-2 to ensure regulator thermal operation is within limits. For example:

Given:

V_{INMAX} = 3.0V ±10%
V_{OUTMIN} = 2.7V – 2%
$I_{LOADMAX}$ = 40mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C

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

Actual power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN})I_{LOADMAX}$$
$$= [(3.0 \times 1.10) - (2.7 \times .0.98)]40 \times 10^{-3}$$
$$= 26.2\text{mW}$$

Maximum allowable power dissipation:

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

In this example, the TC1070 dissipates a maximum of 26.2mW; below the allowable limit of 318mW. In a similar manner, Equation 4-1 and Equation 4-2 can be used to calculate maximum current and/or input voltage limits.

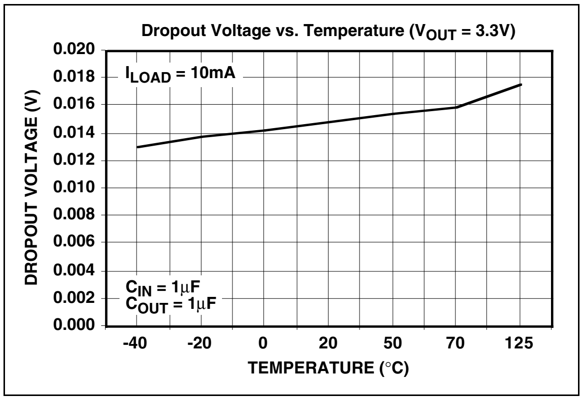
4.3 Layout Considerations

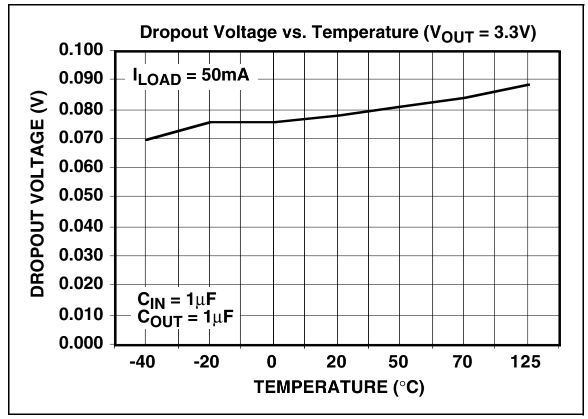
The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and therefore increase the maximum allowable power dissipation limit.

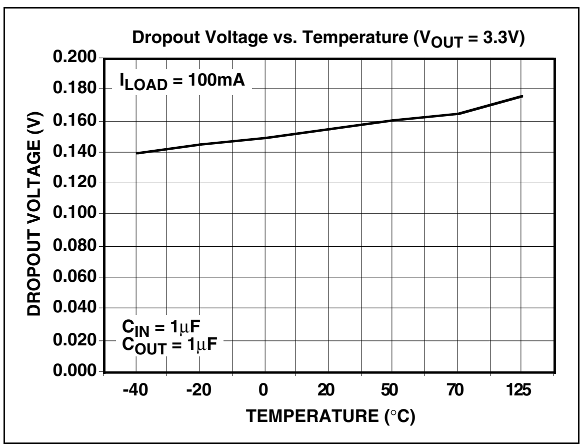
5.0 TYPICAL CHARACTERISTICS

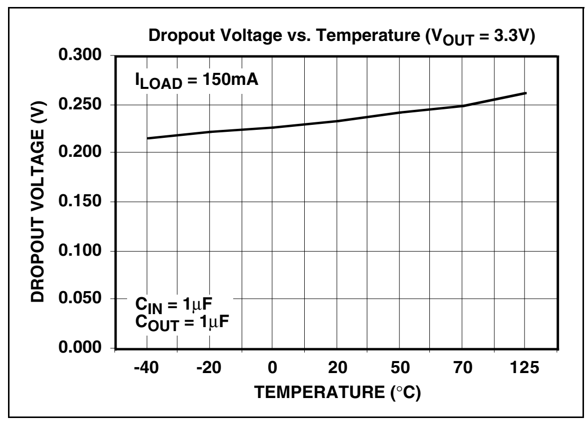
(Unless Otherwise Specified, All Parts Are Measured At Temperature = 25°C)

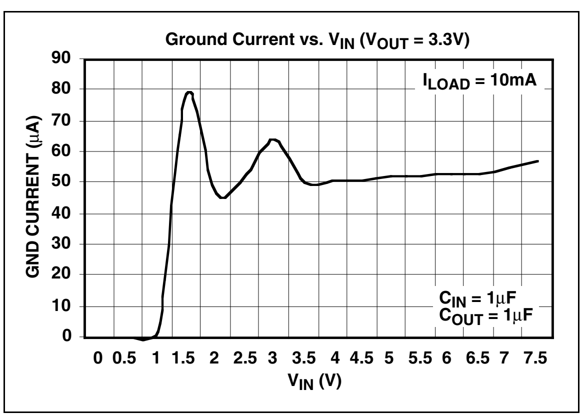
Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

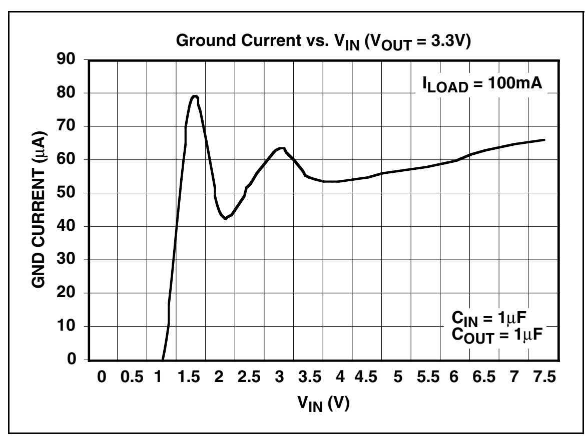






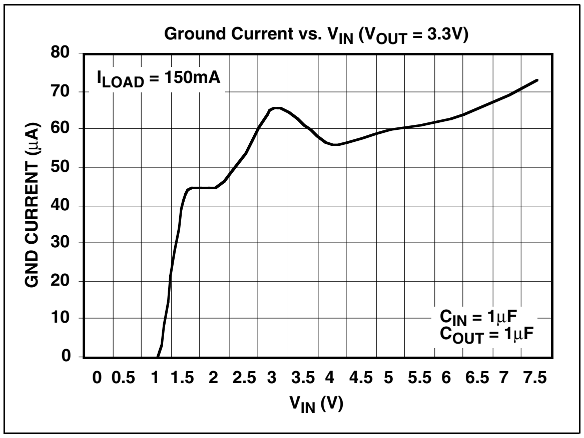


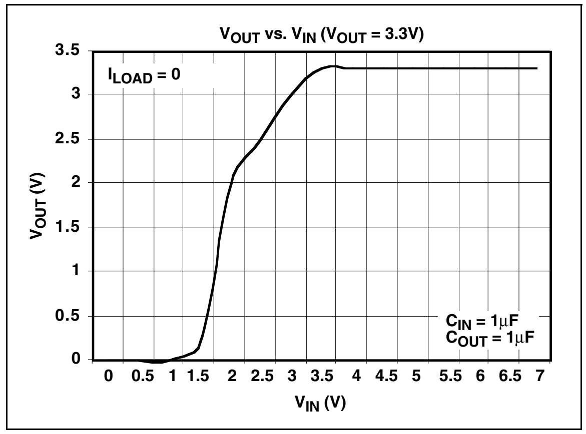


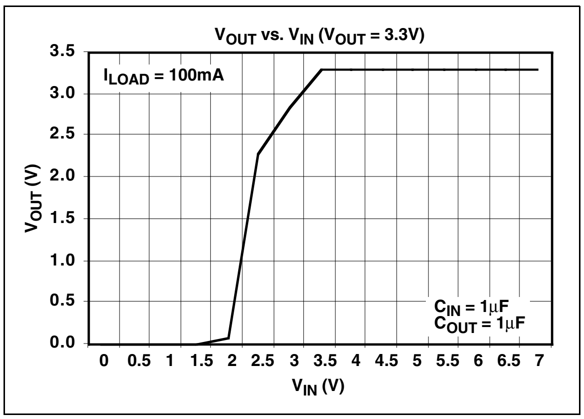


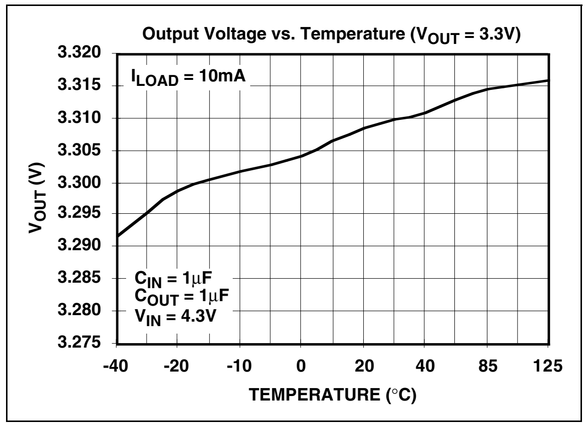
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

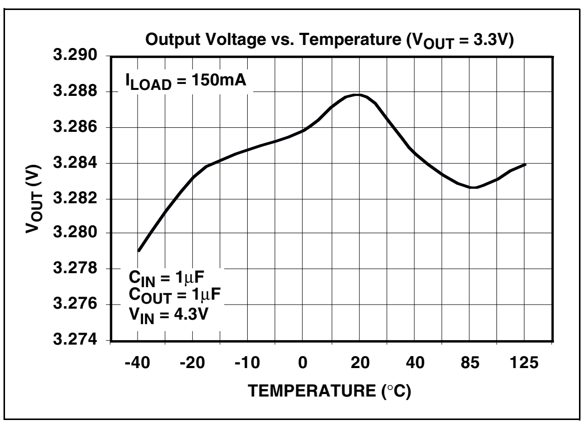
(Unless Otherwise Specified, All Parts Are Measured At Temperature = 25°C)





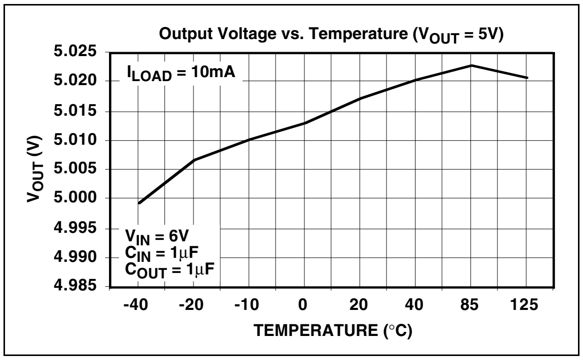


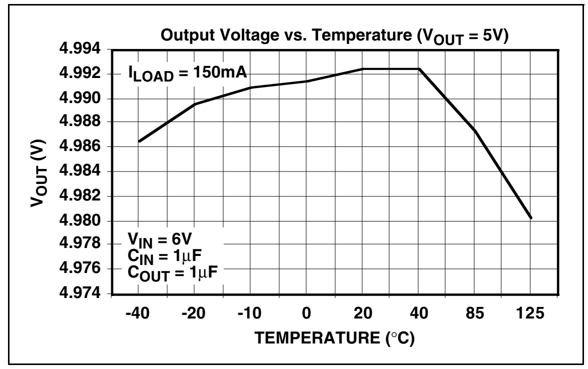


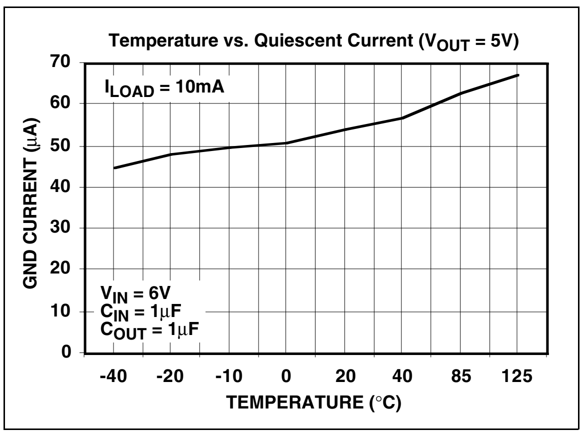


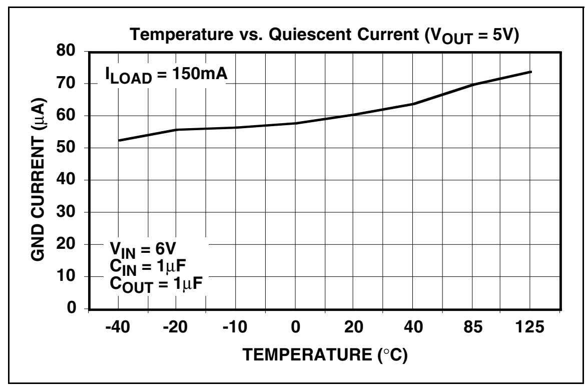
5.0 TYPICAL CHARACTERISTICS (CONTINUED)

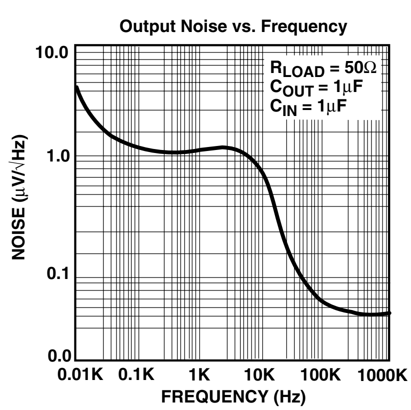
(Unless Otherwise Specified, All Parts Are Measured At Temperature = 25°C)

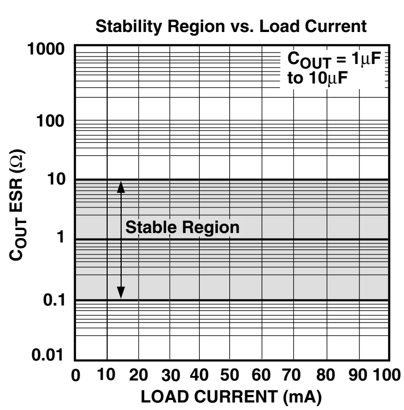


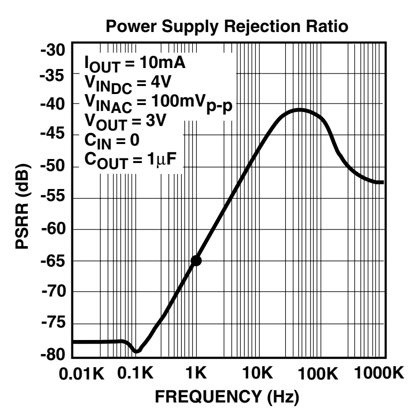








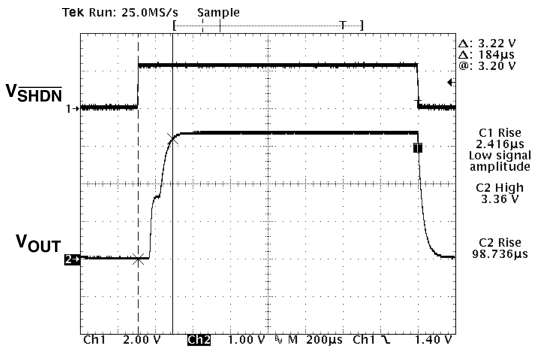




5.0 TYPICAL CHARACTERISTICS (CONTINUED)

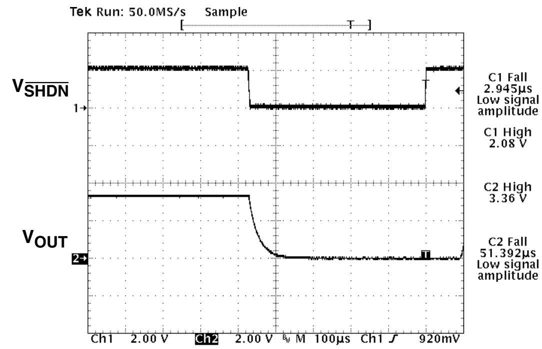
Measure Rise Time of 3.3V LDO

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



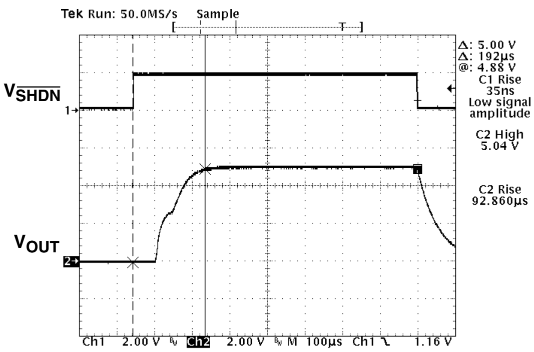
Measure Fall Time of 3.3V LDO

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



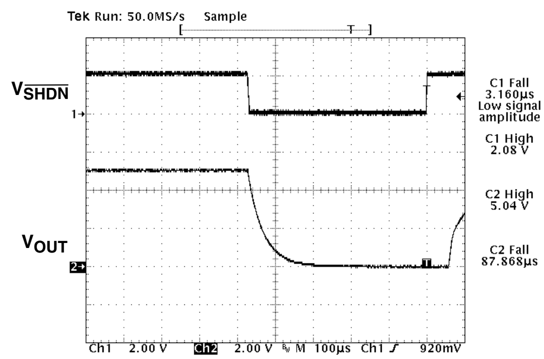
Measure Rise Time of 5.0V LDO

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



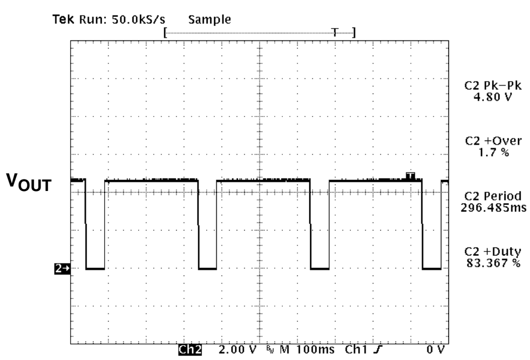
Measure Fall Time of 5.0V LDO

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



Thermal Shutdown Response of 5.0V LDO

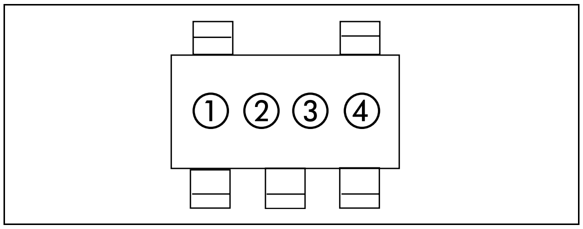
Conditions: V_{IN} = 6V, C_{IN} = 0µF, C_{OUT} = 1µF



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.

6.0 PACKAGING INFORMATION

6.1 Package Marking Information



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

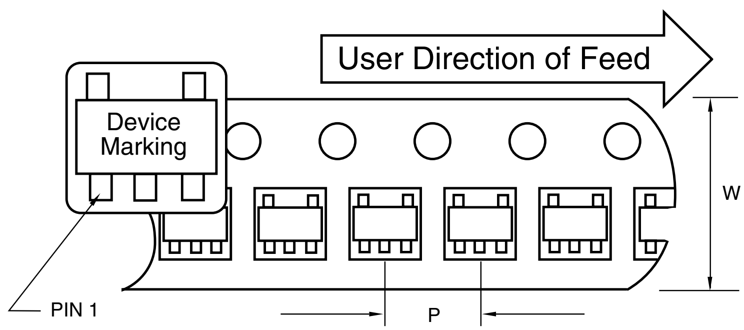
(V)	TC1070 Code	TC1071 Code	TC1187 Code
Adjustable	BA	BB	R9

"3" represents year and quarter code

"4" represents lot ID number

6.2 Taping Form

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



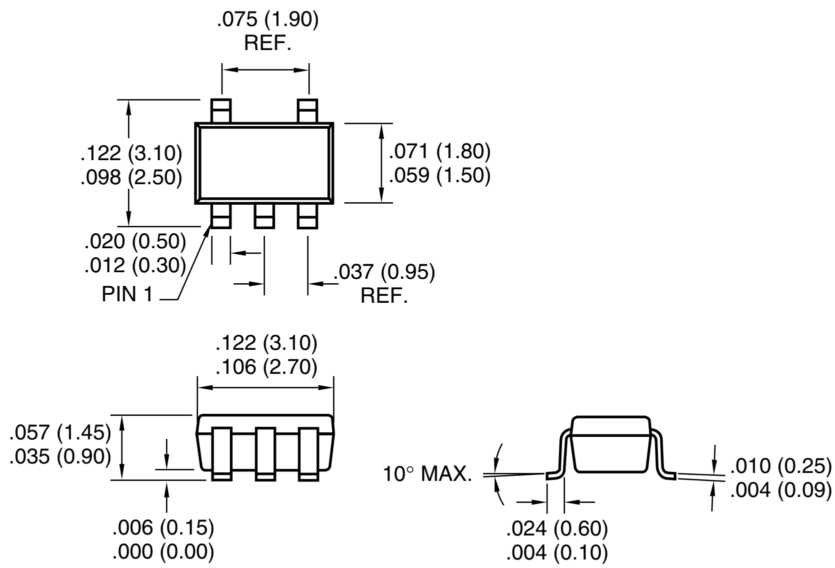
Standard Reel Component Orientation
TR Suffix Device
(Mark Right Side Up)

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

6.3 Package Dimensions

SOT-23A-5



Dimensions: inches (mm)

SALES AND SUPPORT

Data Sheets
Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

New Customer Notification System
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NOTES:

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