TC1174

300mA CMOS LDO with Shutdown and V_{REF} Bypass

Features

- Extremely Low Supply Current (50µA, Typ.)
- Very Low Dropout Voltage
- 300mA Output Current
- Adjustable Output Voltages
- Power Saving Shutdown Mode
- Bypass Input for Ultra Quiet Operation
- Over Current and Over Temperature Protection
- Space-Saving MSOP Package Option

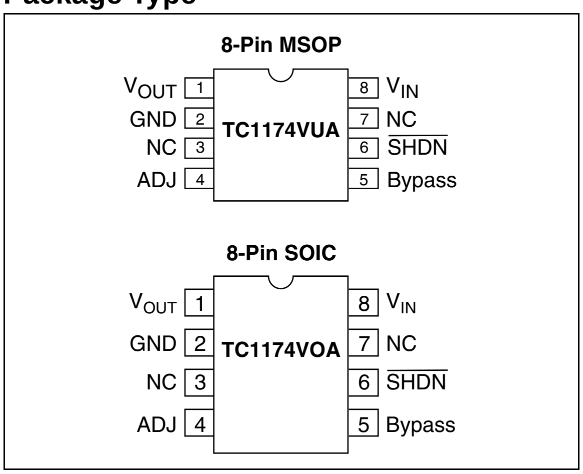
Applications

- 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
TC1174VOA	Adjustable	8-Pin SOIC	-40°C to +125°C
TC1174VUA	Adjustable	8-Pin MSOP	-40°C to +125°C

Package Type



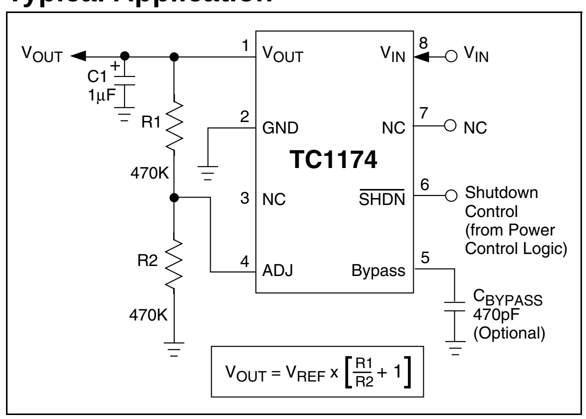
General Description

The TC1174 is an adjustable output CMOS low dropout regulator. Total supply current is typically 50µA at full load (20 to 60 times lower than in bipolar regulators).

TC1174 key features include ultra low noise operation (plus optional Bypass input); very low dropout voltage (typically 270mV at full load) and internal feed-forward compensation for fast response to step changes in load. Supply current is reduced to 0.05µA (typical) and V_{OUT} falls to zero when the shutdown input is low.

The TC1174 incorporates both over temperature and over current protection. The TC1174 is stable with an output capacitor of only 1µF and has a maximum output current of 300mA.

Typical Application



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage 6.5V
Output Voltage.................. (V_{SS} – 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.

TC1174 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: $V_{IN} = V_{OUT}$ + 1V, I_L = 0.1µA, 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	Min	Typ	Max	Units	Test Conditions
V_{IN}	Input Operating Voltage	**2.7**	—	**6.0**	V	**Note 6**
I_{OUTMAX}	Maximum Output Current	**300**	—	—	mA	
V_{REF}	Reference Voltage	**1.165**	1.20	**1.235**	V	
$\Delta V_{OUT}/\Delta T$	V_{OUT} 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	—	1.1	**2.0**	%	I_L = 0.1mA to I_{OUTMAX} **(Note 2)**
$V_{IN}-V_{OUT}$	Dropout Voltage	— — —	20 80 270	**30** **160** **480**	mV	I_L = 0.1mA I_L = 100mA I_L = 300mA **(Note 3)**
I_{SS1}	Supply Current	—	50	**90**	µA	$\overline{SHDN} = V_{IH}$
I_{SS2}	Shutdown Supply Current	—	0.05	0.5	µA	$\overline{SHDN}$ = 0V
PSRR	Power Supply Rejection Ratio	—	60	—	dB	F_{RE} – 1kHz
I_{OUTSC}	Output Short Circuit Current	—	550	650	mA	V_{OUT} = 0V
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	—	0.04	—	V/W	**Note 4**
eN	Output Noise	—	260	—	$nV/\sqrt{Hz}$	F = 10kHz, $I_L = I_{OUTMAX}$ 470pF from Bypass to GND
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold	**45**	—	—	$\%V_{IN}$	
V_{IL}	$\overline{SHDN}$ Input Low Threshold	—	—	**15**	$\%V_{IN}$	
ADJ Input						
I_{ADJ}	Adjustable Input Leakage Current	—	50	—	pA	

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 measured at a 1V differential.

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}.

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2.0 PIN DESCRIPTIONS

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

TABLE 2-1: PIN FUNCTION TABLE

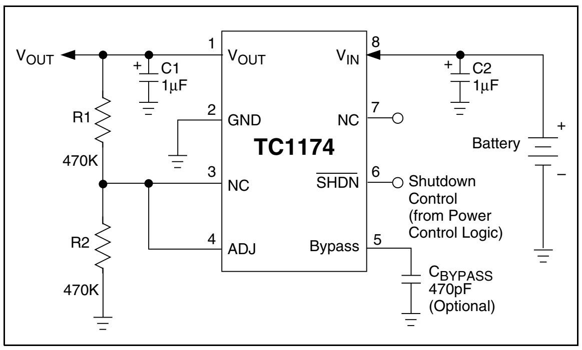
Pin No. (8-Pin SOIC) (8-Pin MSOP)	Symbol	Description
1	V_{OUT}	Regulated voltage output.
2	GND	Ground terminal.
3	NC	No connect.
4	ADJ	Output voltage adjust terminal. Output voltage setting is programmed with a resistor divider from V_{OUT} to this input. A capacitor may also be added to this input to reduce output noise.
5	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.
6	$\overline{SHDN}$	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 0.05µA (typical).
7	NC	No connect.
8	V_{IN}	Unregulated supply input.

3.0 DETAILED DESCRIPTION

The TC1174 is an adjustable low drop-out regulator. Unlike bipolar regulators, the TC1174's 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.

FIGURE 3-1: TYPICAL APPLICATION CIRCUIT



3.1 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.

3.2 Output Capacitor

A 1µF (min) capacitor from V_{OUT} to ground is required. The output capacitor should have an effective series resistance greater than 0.1Ω and less than 5.0Ω. 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.

3.3 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 TC1174 is from V_{REF} to (V_{IN} – 0.05V).

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4.0 THERMAL CONSIDERATIONS

4.1 Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 150°C. The regulator remains off until the die temperature drops to approximately 140°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 8-Pin SOIC package has a θ_{JA} of approximately 160°C/Watt, while the 8-Pin MSOP package has a θ_{JA} of approximately 200°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 – 0.5%
$I_{LOADMAX}$ = 250mA
T_{JMAX} = 125°C
T_{AMAX} = 55°C
8-Pin MSOP Package

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

Actual power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN}) I_{LOADMAX}$$
$$= [(3.0 \times 1.1) - (2.7 \times .995)] 250 \times 10^{-3}$$
$$= 155\text{mW}$$

Maximum allowable power dissipation:

$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$
$$= \frac{(125 - 55)}{200}$$
$$= 350\text{mW}$$

In this example, the TC1174 dissipates a maximum of 155mW; below the allowable limit of 350mW. In a similar manner, Equation 4-1 and Equation 4-2 can be used to calculate maximum current and/or input voltage limits. For example, the maximum allowable V_{IN} is found by substituting the maximum allowable power dissipation of 350mW into Equation 4-1, from which V_{INMAX} = 4.1V.

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.

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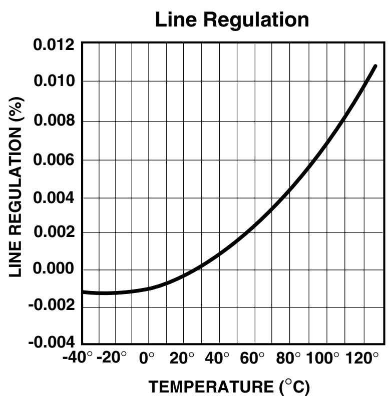
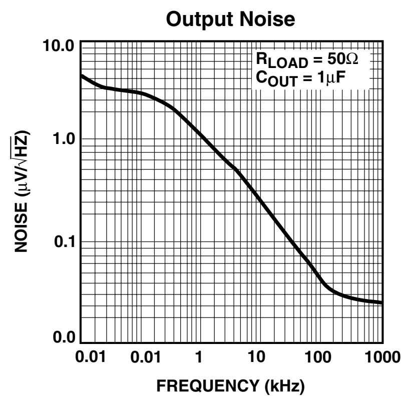
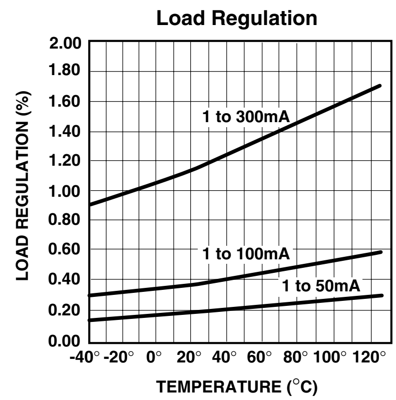
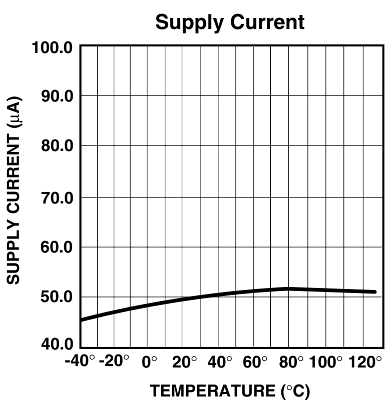
5.0 TYPICAL CHARACTERISTICS

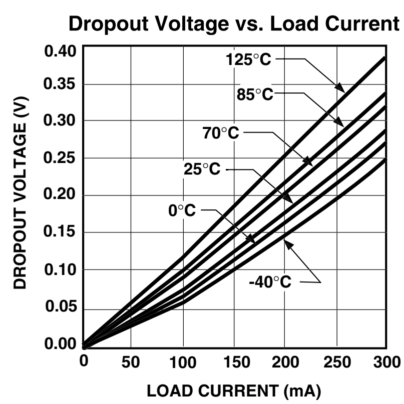
Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside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

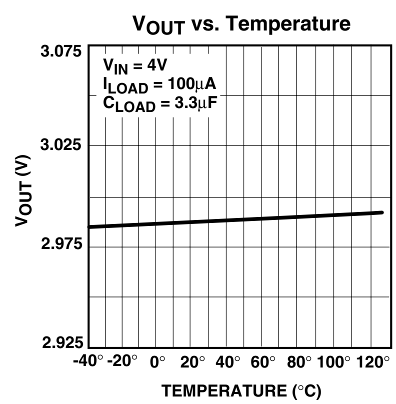












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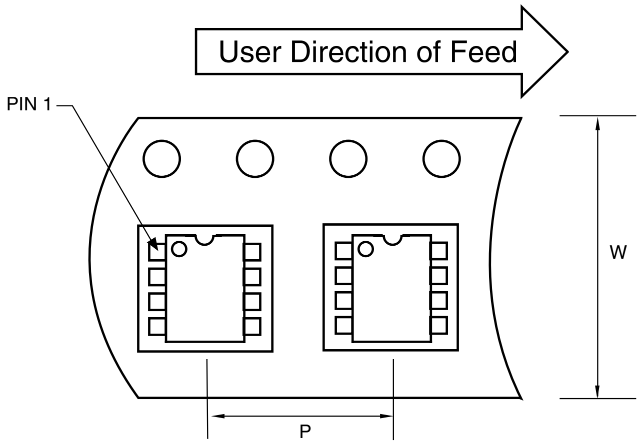
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

Package marking data not available at this time.

6.2 Taping Form

Component Taping Orientation for 8-Pin MSOP Devices

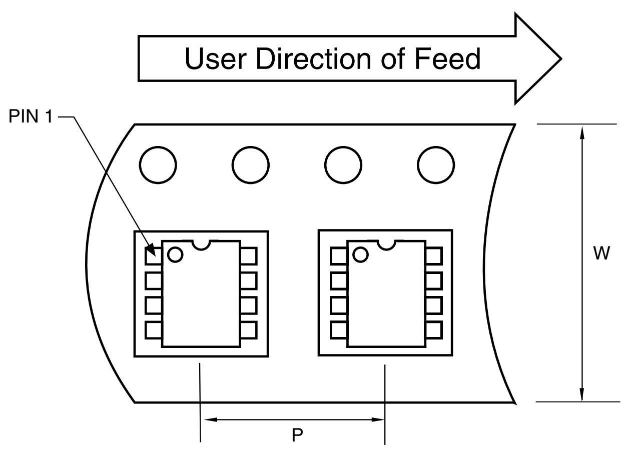


Standard Reel Component Orientation
for TR Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices



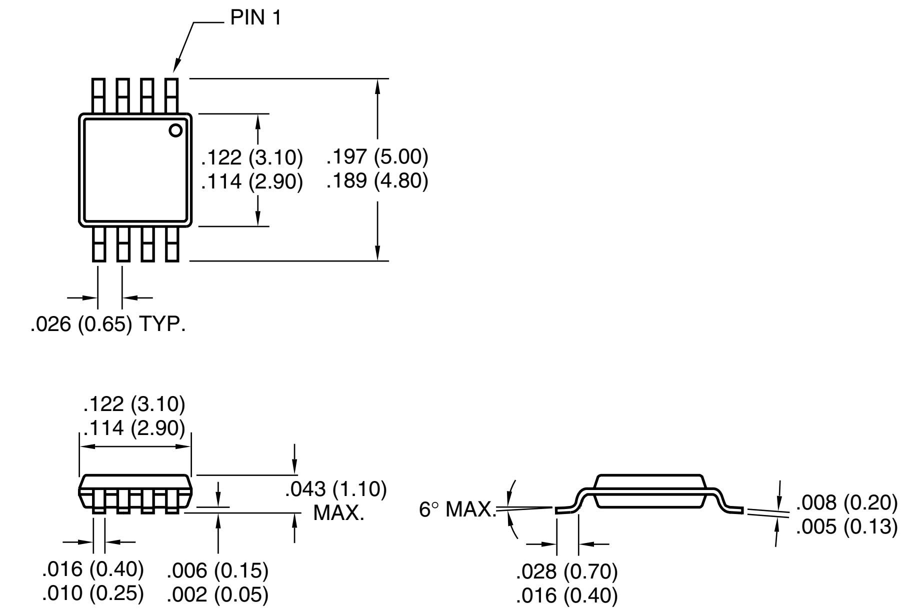
Standard Reel Component Orientation
for TR Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

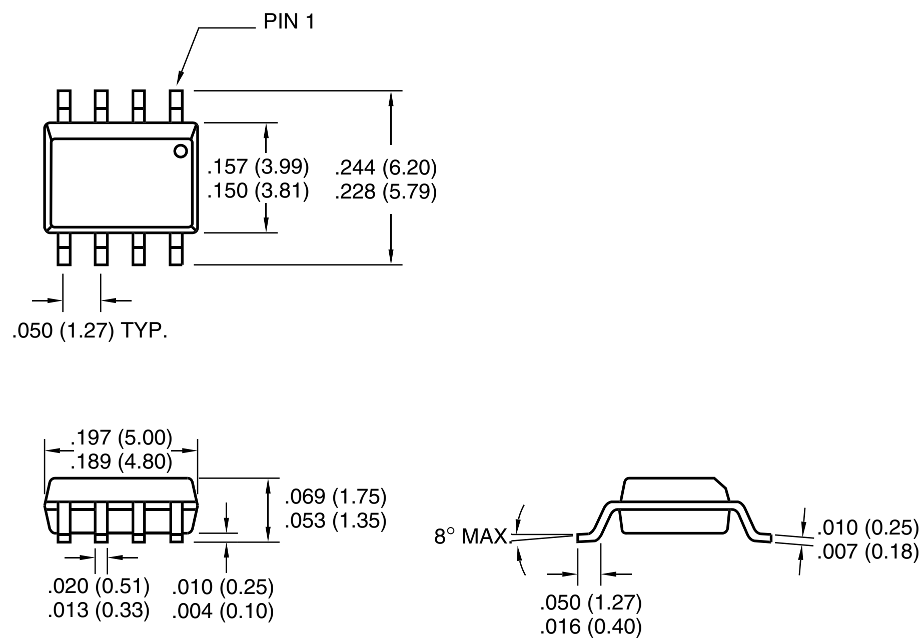
6.3 Package Dimensions

8-Pin MSOP



Dimensions: inches (mm)

8-Pin SOIC



Dimensions: inches (mm)

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