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

FEATURES

- **Extremely Low Supply Current (50µA, Typ.)**
- **Very Low Dropout Voltage**
- **Guaranteed 300mA Output**
- **Adjustable Output Voltage**
- **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-Regulator for SMPS**
- **Pagers**

GENERAL DESCRIPTION

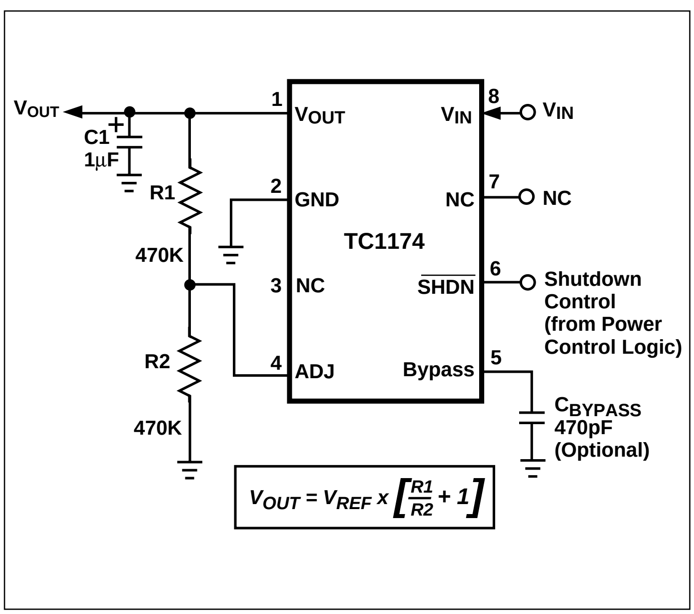
The TC1174 is an adjustable output CMOS low dropout regulator. Total supply current is typically 50µA at full load *(20 to 60 times lower than in bipolar regulators*!).

TC1174 key features include ultra low noise operation (plus optional Bypass input); very low dropout voltage (typically 240mV 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.

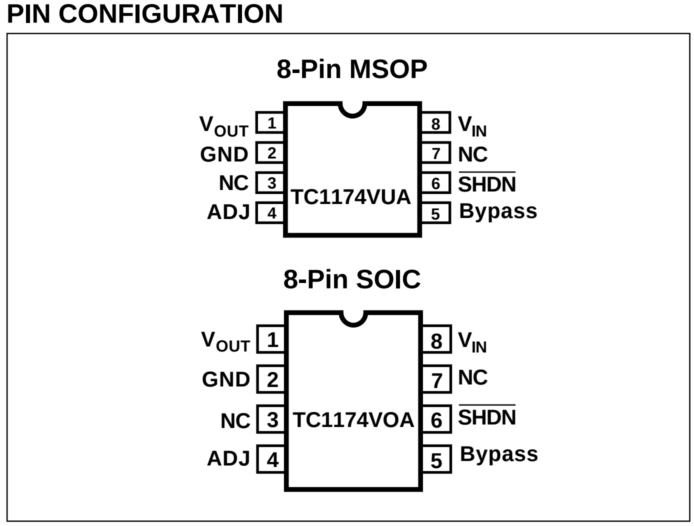
ORDERING INFORMATION

Part Number	Output Voltage (V)	Package	Junction Temperature Range
TC1174VOA	Adjustable	8-Pin SOIC	– 40 to +125°C
TC1174VUA	Adjustable	8-PIn MSOP	– 40 to +125°C

TYPICAL APPLICATION



PIN CONFIGURATION



ABSOLUTE MAXIMUM RATINGS*

Input Voltage 6.5V
Output Voltage .... (V_{SS} – 0.3) to (V_{IN} + 0.3)
Power Dissipation .... Internally Limited (Note 7)
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.) .... +300°C

*Absolute Maximum Ratings indicate device operation limits beyond damage may occur. Device operation beyond the limits listed in Electrical Characteristics is not recommended.

ELECTRICAL CHARACTERISTICS:

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{IN}	Input Operating Voltage		—	—	**6.0**	V
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	Note 1	—	**40**	—	ppm/°C
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	$(V_R + 1V) \leq V_{IN} \leq 6V$	—	0.05	**0.35**	%
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	I_L = 0.1mA to I_{OUTMAX} (Note 2)	—	1.1	**2.0**	%
$V_{IN} – V_{OUT}$	Dropout Voltage (Note 4)	I_L = 0.1mA I_L = 100mA I_L = 300mA	—	20 80 270	**30** **160** **480**	mV
II_{SS1}	Supply Current	$\overline{SHDN} = V_{IH}$	—	50	**90**	µA
I_{SS2}	Shutdown Supply Current	$\overline{SHDN}$ = 0V	—	0.05	0.5	µA
PSRR	Power Supply Rejection Ratio	$F_{RE} \leq$ 1kHz	—	60		dB
I_{OUTSC}	Output Short Circuit Current	V_{OUT} = 0V	—	550	650	mA
$\Delta V_{OUT}/\Delta P_D$	Thermal Regulation	Note 4	—	0.04	—	V/W
eN	Output Noise	F= 10kHz, $I_L = I_{OUTMAX}$ 470pF from Bypass to GND	—	260	—	nV/√Hz
$\overline{SHDN}$ 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}	Adjust Input Leakage Current		—	50	—	pA

NOTES:
1. $T_C V_{OUT} = \frac{(V_{OUTMAX} – V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$
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 = 10msec.
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

DETAILED DESCRIPTION

The TC1174 is an adjustable low dropout regulator. Unlike bipolar regulators, the TC1174 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). TC1174 pin functions are detailed below:

PIN DESCRIPTIONS

Pin No.	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 (see text).
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

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.

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.

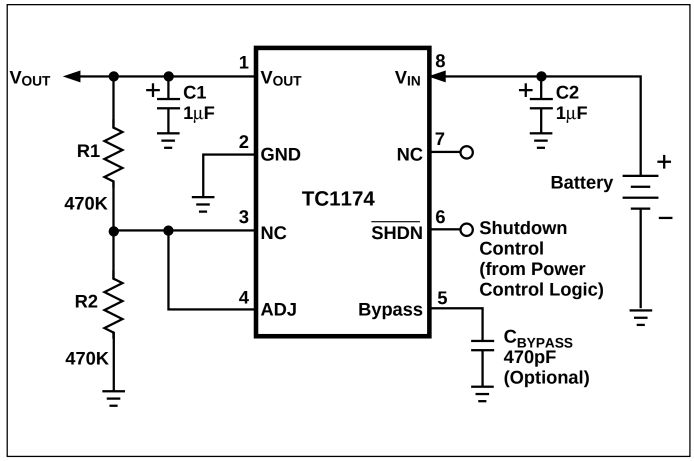


Figure 1: Typical Application Circuit

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.

Adjust Input

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

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

Equation 1.

The voltage adjustment range of the TC1174 is from V_{REF} to (V_{IN} – 0.05V).

Thermal Considerations

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.

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

Equation 2.

The maximum *allowable* power dissipation (Equation 3) 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 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***; both 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.

Equation 3.

Equation 2 can be used in conjunction with Equation 3 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:

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

Maximum allowable power dissipation:

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

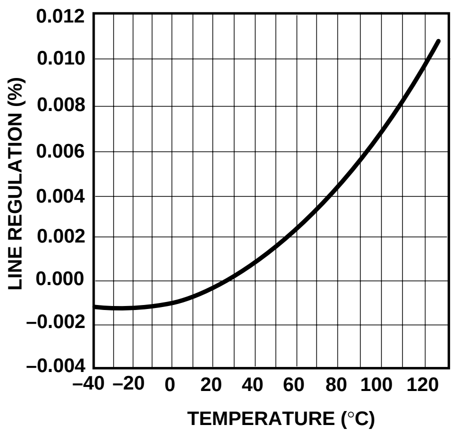
In this example, the TC1174 dissipates a maximum of only 155mW; far below the allowable limit of 350mW. In a similar manner, Equation 2 and Equation 3 can be used to calculate maximum current and/or input voltage limits. For example, the maximum allowable V_{IN} is found by substituting the maximum allowable power dissipation of 350mW into Equation 2, from which V_{INMAX} = 4.1V.

Layout Considerations

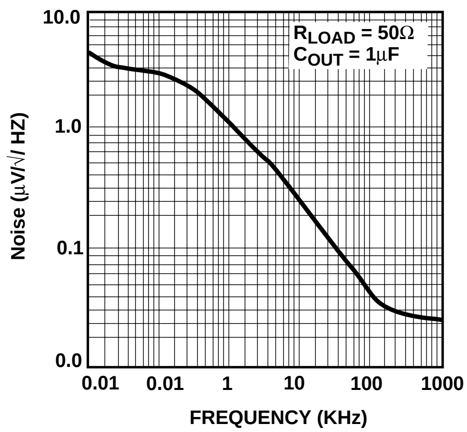
The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and, therefore, increase the maximum allowable power dissipation limit.

TYPICAL CHARACTERISTICS

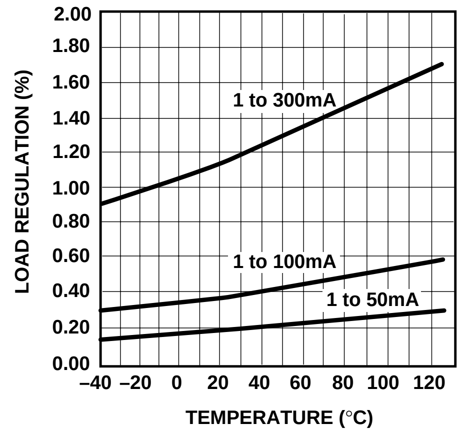
Line Regulation



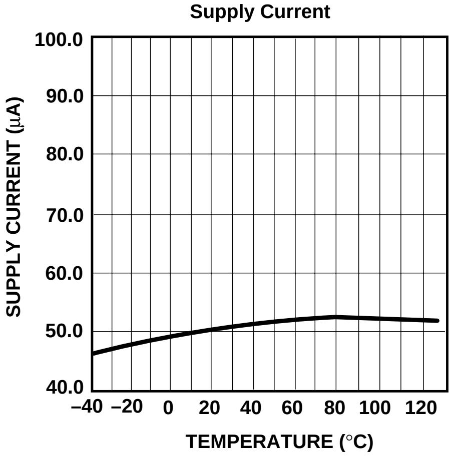
Output Noise



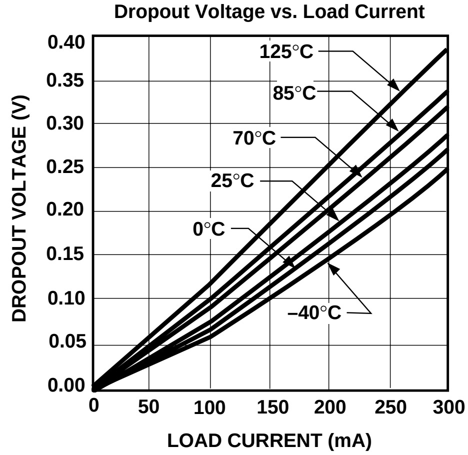
Load Regulation



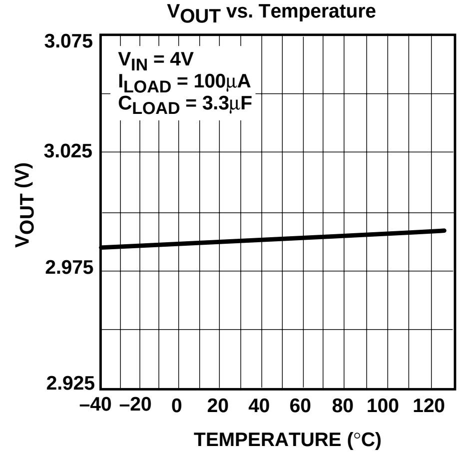
Supply Current



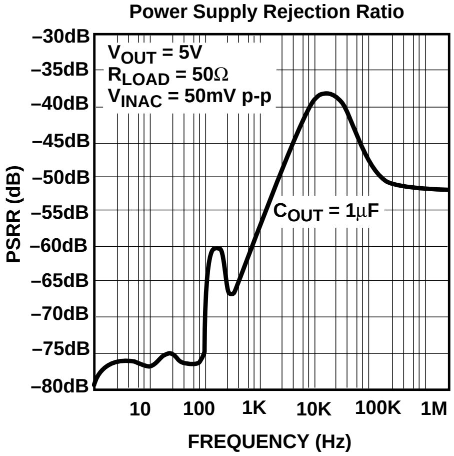
Dropout Voltage vs. Load Current



V_{OUT} vs. Temperature

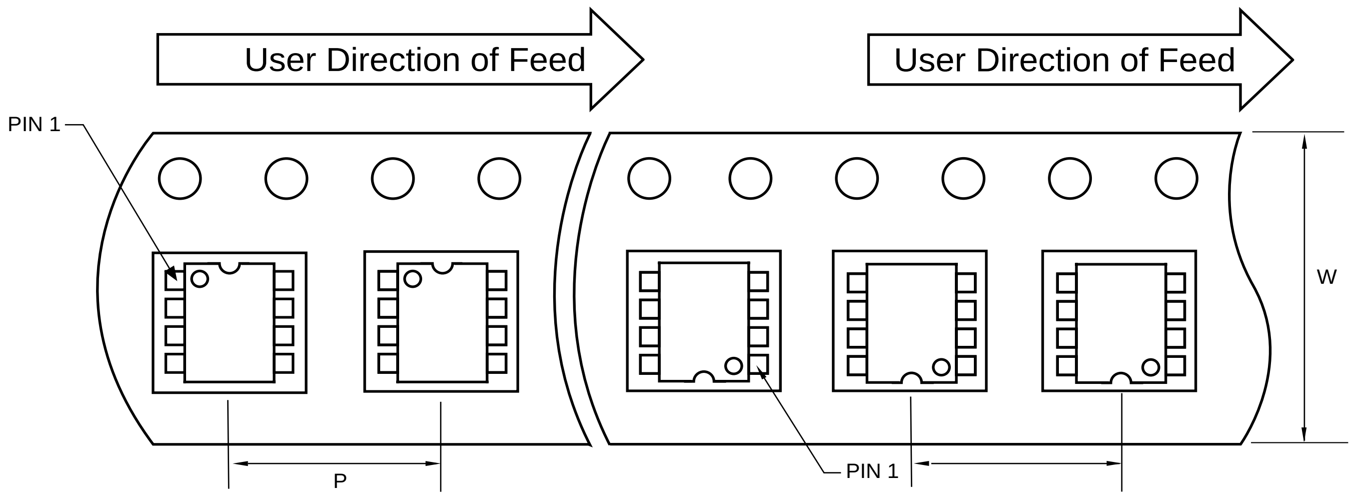


Power Supply Rejection Ratio



TAPE AND REEL

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



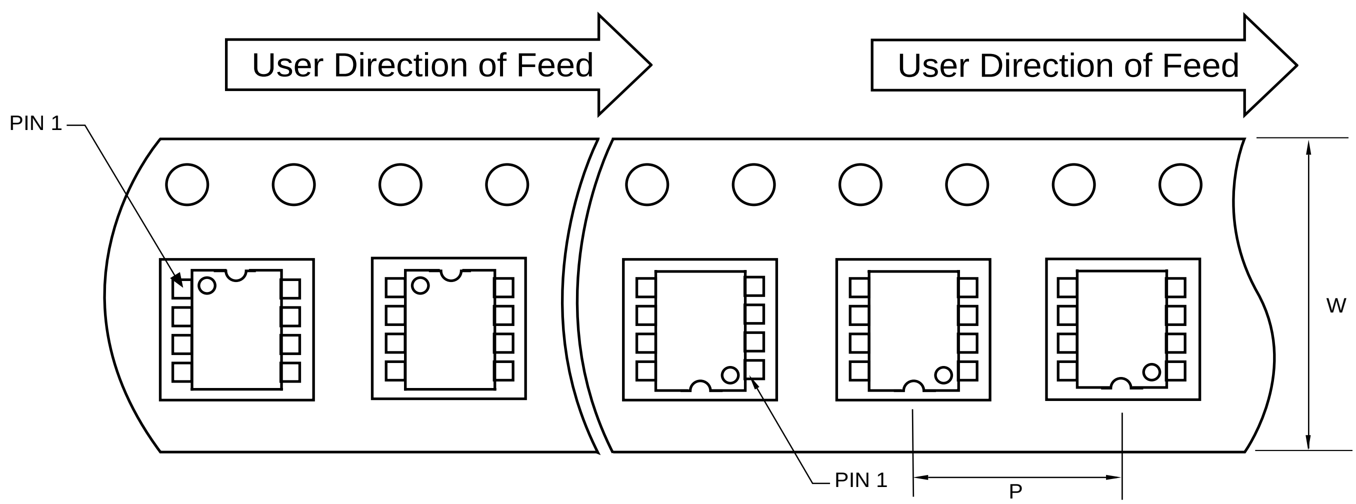
Standard Reel Component Orientation for TR Suffix Device

Standard Reel Component Orientation for RT 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

Component Taping Orientation for 8-Pin MSOP Devices



Standard Reel Component Orientation for TR Suffix Device

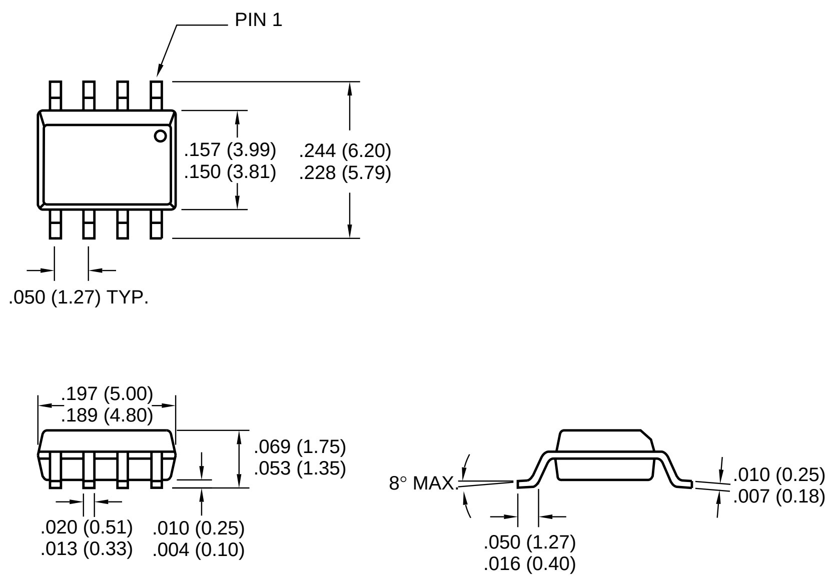
Reverse Reel Component Orientation for RT Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

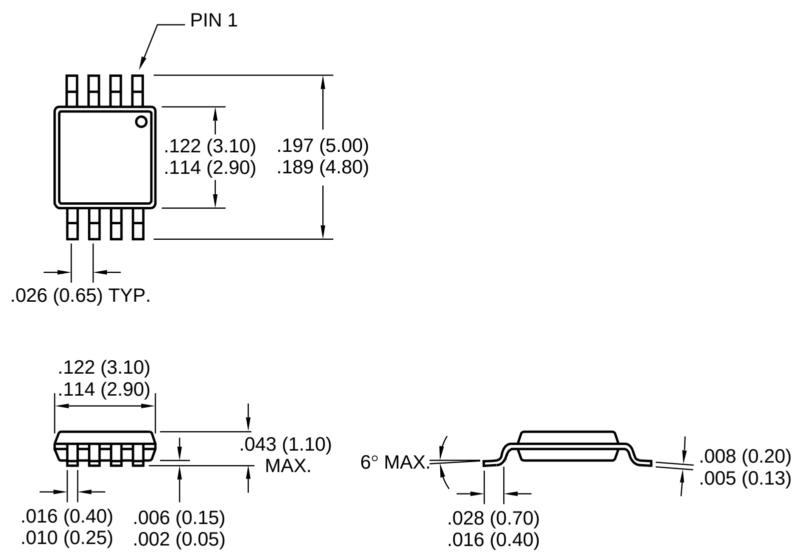
Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

PACKAGE DIMENSIONS

8-Pin SOIC (Narrow)



8-Pin MSOP



Dimensions: inches (mm)

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