

300mA CMOS LDO with Shutdown, ERROR Output and Bypass

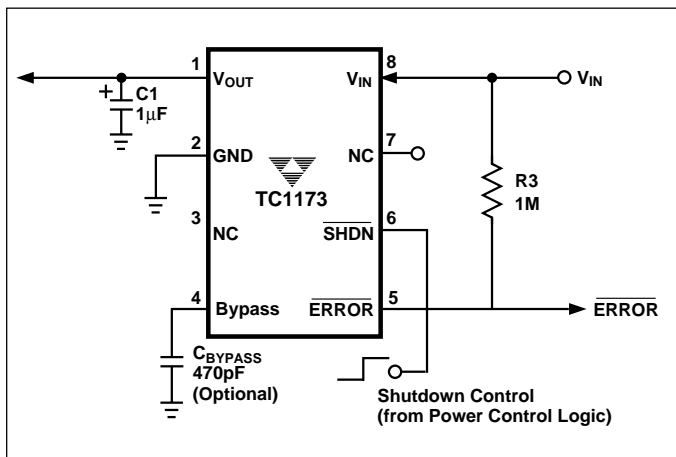
FEATURES

- Extremely Low Supply Current for Longer Battery Life!
- Very Low Dropout Voltage
- Guaranteed 300mA Output
- Standard or Custom Output Voltages
- $\overline{\text{ERROR}}$ Output Can be Used as a Low Battery Detector or Processor Reset Generator
- 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

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC1173 is a precision output (typically $\pm 0.5\%$) CMOS low dropout regulator. Total supply current is typically $50\mu\text{A}$ at full load (*20 to 60 times lower than in bipolar regulators!*).

TC1173 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. An error output (ERROR) is asserted when the TC1173 is out-of-regulation (due to a low input voltage or excessive output current). ERROR can be set as a low battery warning or as a processor RESET signal (with the addition of an external RC network). Supply current is reduced to $0.05\mu\text{A}$ (typical) and V_{OUT} and ERROR fall to zero when the shutdown input is low.

The TC1173 incorporates both over-temperature and over-current protection. The TC1173 is stable with an output capacitor of only $1\mu\text{F}$ and has a maximum output current of 300mA .

ORDERING INFORMATION

Part Number	Package	Junction Temp. Range
TC1173-xxVOA	8-Pin SOIC	-40°C to $+125^{\circ}\text{C}$
TC1173-xxVUA	8-Pin MSOP	-40°C to $+125^{\circ}\text{C}$

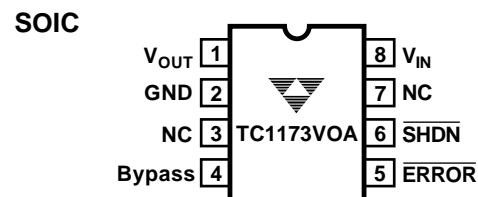
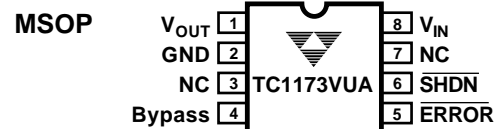
Available Output Voltages:

2.5, 2.8, 3.0, 3.3, 5.0

xx indicates output voltages

Other output voltages are available. Please contact TelCom Semiconductor for details.

PIN CONFIGURATION



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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 = 0.1mA, 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		—	—	6.0	V
I _{OUTMAX}	Maximum Output Current		300	—	—	mA
V _{OUT}	Output Voltage	Note 1	— V_R - 2.5%	V _R ± 0.5%	— V_R + 2.5%	V
ΔV _{OUT} /ΔT	V _{OUT} Temperature Coefficient	Note 2	—	— 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	I _L = 0.1mA to I _{OUTMAX} (Note 3)	—	0.5	2.0	%
V _{IN} – V _{OUT}	Dropout Voltage (Note 4)	I _L = 0.1mA I _L = 100mA I _L = 300mA	—	20 80 240	30 160 480	mV
I _{SS1}	Supply Current	SHDN = V _{IH}	—	50	90	μA
I _{SS2}	Shutdown Supply Current	SHDN = 0V	—	0.05	0.5	μA
PSRR	Power Supply Rejection Ratio	F _{RE} ≤ 1kHz	—	60	—	dB
I _{OUTSC}	Output Short Circuit Current	V _{OUT} = 0V	—	550	650	mA
ΔV _{OUT} ΔP _D	Thermal Regulation	Note 5	—	0.04	—	V/W
eN	Output Noise	F = 1kHz, C _{OUT} = 1μF, R _{LOAD} = 50Ω	—	260	—	nV/√Hz

SHDN Input

V _{IH}	SHDN Input High Threshold	45	—	—	%V _{IN}
V _{IL}	SHDN Input Low Threshold	—	—	15	%V _{IN}

ERROR Output

V _{MIN}	Minimum Operating Voltage	1.0	—	—	V	
V _{OL}	Output Logic Low Voltage	1mA Flows to ERROR	—	—	400	mV
V _{TH}	ERROR Threshold Voltage		—	0.95 x V _R	V	
V _{OL}	ERROR Positive Hysteresis	Note 7	—	50	mV	

NOTES: 1. V_R is the user-programmed regulator output voltage setting.

$$2. T_C V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$$

- Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1mA 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 measured 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.
- Hysteresis voltage is referenced to V_R.

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DETAILED DESCRIPTION

The TC1173 is a fixed output, low drop-out regulator. Unlike bipolar regulators, the TC1173 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). TC1173 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	Bypass	Reference bypass input. Connecting a 470pF to this input further reduces output noise.
5	ERROR	Out-of-Regulation Flag (Open Drain Output). This output goes low when V_{OUT} is out-of-tolerance by approximately -5%.
6	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 0.05 μ A (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 (SHDN) is above V_{IH} , and shutdown (disabled) when SHDN is at or below V_{IL} .

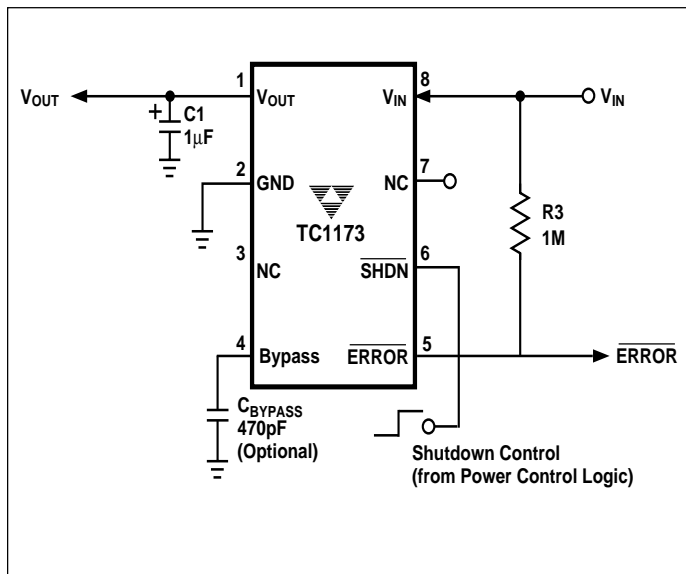


Figure 1: Typical Application Circuit

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 0.05 μ A (typical), V_{OUT} falls to zero and ERROR is disabled.

ERROR Output

ERROR is driven low whenever V_{OUT} falls out of regulation by more than -5% (typical). This condition may be caused by low input voltage, output current limiting, or thermal limiting.

The ERROR threshold is 5% below rated V_{OUT} regardless of the programmed output voltage value (e.g., ERROR = V_{OL} at 4.75V (typ) for a 5.0V regulator and 2.85V (typ) for a 3.0V regulator). ERROR output operation is shown in Figure 2. Note that ERROR is active when V_{OUT} is at or below V_{TH} , and inactive when V_{OUT} is above $V_{TH} + V_H$.

As shown in Figure 1, ERROR can be used as a battery low flag, or as a processor RESET signal (with the addition of timing capacitor C2). R1 x C3 should be chosen to maintain ERROR below V_{IH} of the processor RESET input for at least 200msec to allow time for the system to stabilize. Pull-up resistor R1 can be tied to V_{OUT} , V_{IN} or any other voltage less than ($V_{IN} + 0.3V$.)

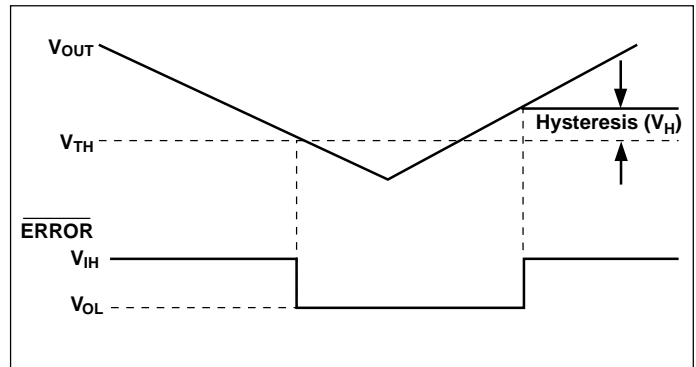


Figure 2: ERROR Output Operation

Output Capacitor

A 1 μ F (min) capacitor from V_{OUT} to ground is recommended. The output capacitor should have an effective series resistance of 5 Ω or less. A 1 μ F 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.

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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.

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 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 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 2.

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

GIVEN: $V_{INMAX} = 3.0V \pm 10\%$
 $V_{OUTMIN} = 2.7V \pm 0.5\%$
 $I_{LOADMAX} = 250mA$
 $T_{JMAX} = 125^\circ C$
 $T_{AMAX} = 55^\circ C$
 $\theta_{JA} = 200^\circ C/W$
 8-Pin MSOP Package

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

Actual power dissipation:

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

Maximum allowable power dissipation:

$$\begin{aligned} P_D &\approx \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}} \\ &= \frac{(125 - 55)}{200} \\ &= \underline{350mW} \end{aligned}$$

In this example, the TC1173 dissipates a maximum of only 155mW; far below the allowable limit of 350mW. In a similar manner, Equation 1 and Equation 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 1, from which $V_{INMAX} = 4.1V$.

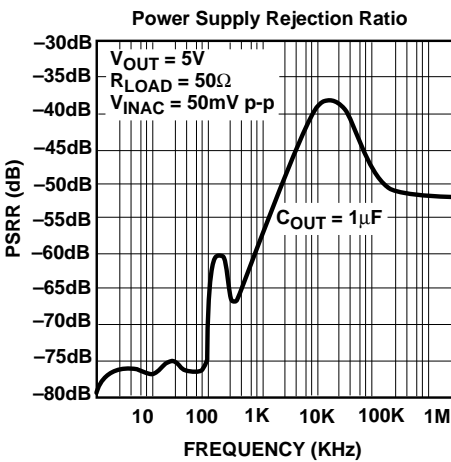
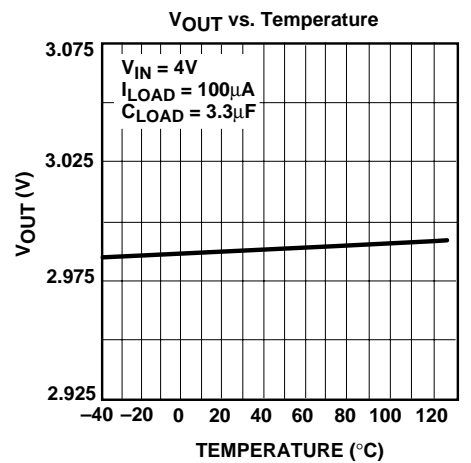
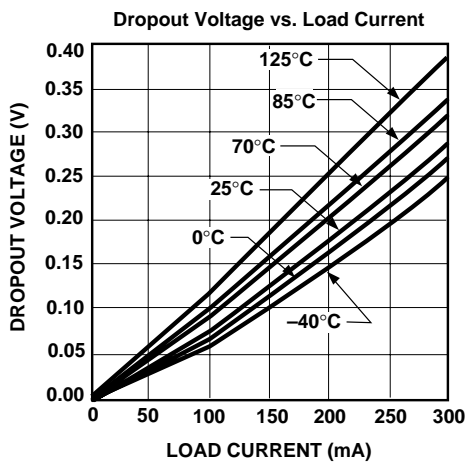
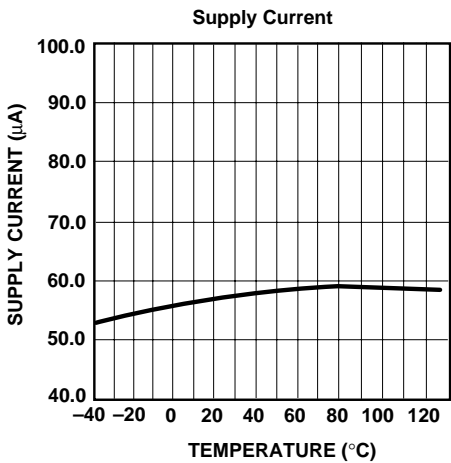
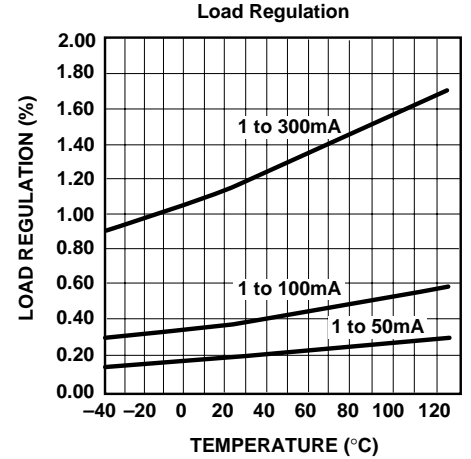
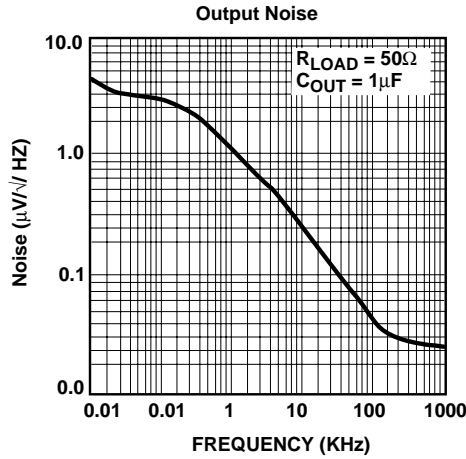
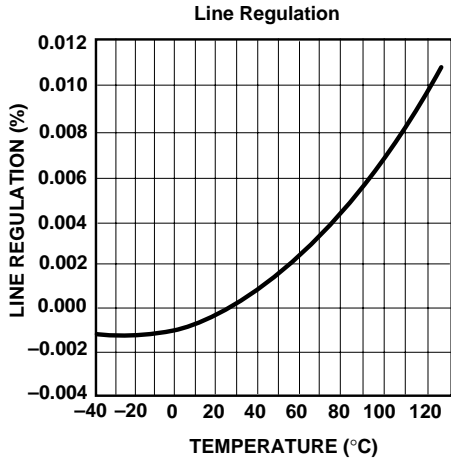
Layout Considerations

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.

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TYPICAL CHARACTERISTICS

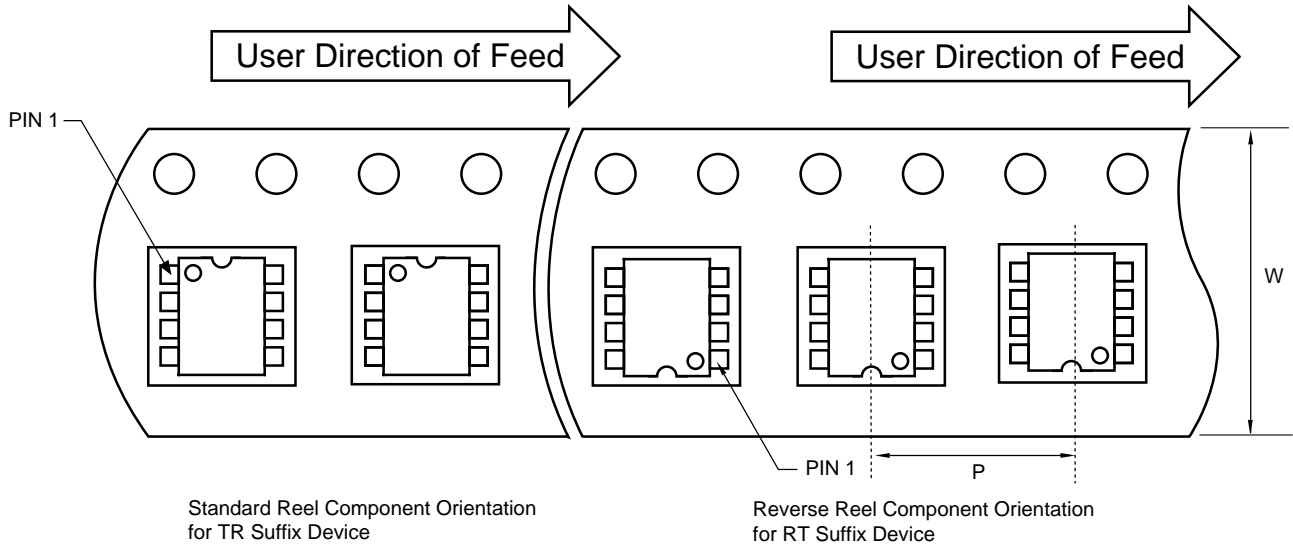


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TAPE AND REEL DIAGRAMS

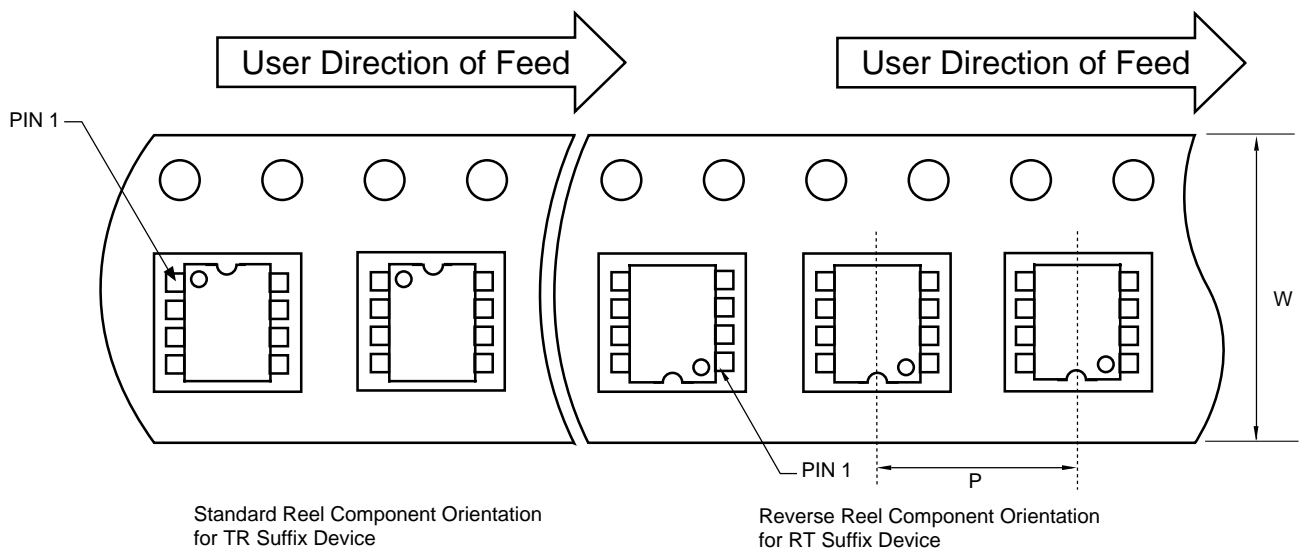
Component Taping Orientation for 8-Pin SOIC (Narrow) Devices



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



Carrier Tape, Number of Components Per Reel and Reel Size

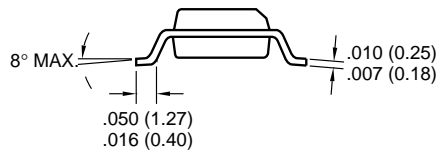
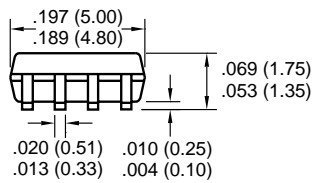
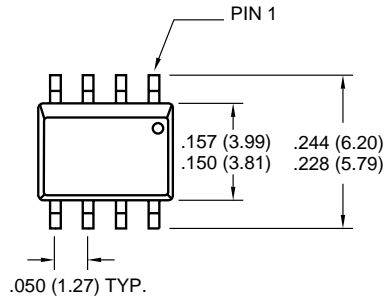
Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

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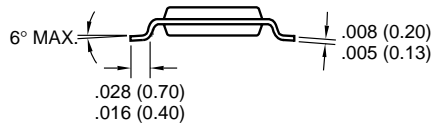
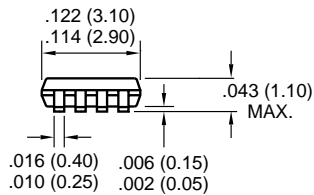
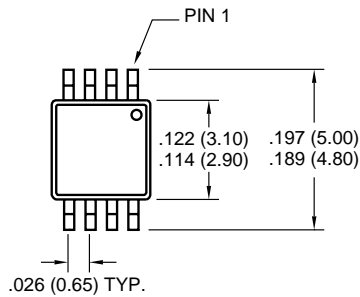
TC1173

PACKAGE DIMENSIONS

8-Pin SOIC (Narrow)



8-Pin MSOP



Dimensions: inches (mm)

Sales Offices

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