TC1268

# 500mA Fixed Output, Fast Response CMOS LDO with Shutdown

## Features

- Very Low Dropout Voltage
- 500mA Output Current
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Over Current and Over Temperature Protection
- $\overline{SHDN}$ Input for Active Power Management
- $\overline{ERROR}$ Output to Detect Low Battery
- 5µsec (typical) Wake-up Time from $\overline{SHDN}$

## Applications

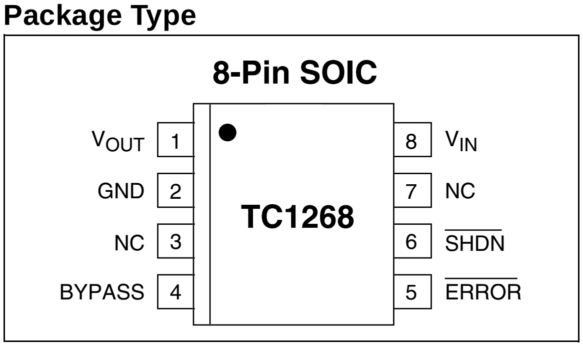
- RAMBUS Memory Module
- Battery-Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular/GSM/PHS Phones
- Linear Post-Regulator for SMPS
- Pagers
- Digital Cameras

## Device Selection Table

| Part Number | Output* Voltage (V) | Package | Junction Temp. Range |
|---|---|---|---|
| TC1268-2.5VOA | 2.5 | 8-Pin SOIC | -40°C to +125°C |

*Other output voltages and package options are available. Please contact Microchip Technology Inc. for details.

## Package Type

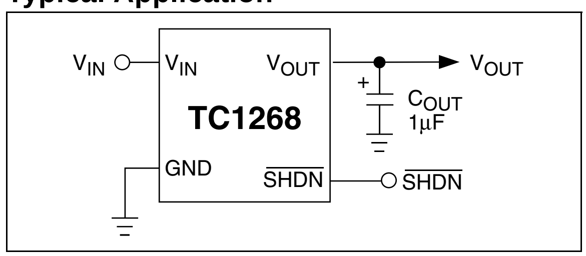



## General Description

The TC1268 is a fixed output, fast turn-on, high accuracy (typically ±0.5%) CMOS low dropout regulator. Designed specifically for battery-operated systems, the TC1268's CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 80µA at full load (20 to 60 times lower than in bipolar regulators).

TC1268's key features include ultra low noise, very low dropout voltage (typically 350mV at full load), and fast response to step changes in load. The TC1268 also has a fast wake-up response time (5µsec typically) when released from shutdown. The TC1268 incorporates both over temperature and over current protection. The TC1268 is stable with an output capacitor of only 1µF and has a maximum output current of 500mA.

## Typical Application



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings*

Input Voltage ........................................................6.5V
Power Dissipation................Internally Limited **(Note 6)**
Maximum Voltage on Any Pin ........$V_{IN}$ +0.3V to -0.3V
Operating Temperature ............... -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.

### TC1268 ELECTRICAL SPECIFICATIONS

**Electrical Characteristics:** $V_{IN} = V_{OUT}$ + 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 | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Operating Voltage | **2.7** | — | **6.0** | V | **Note 8** |
| $I_{OUTMAX}$ | Maximum Output Current | **500** | — | — | mA | |
| $V_{OUT}$ | Output Voltage | —<br>**$V_R$ – 2.5%** | $V_R$ ±0.5%<br>— | —<br>**$V_R$ + 2.5%** | V | **Note 1** |
| $\Delta V_{OUT}/\Delta T$ | $V_{OUT}$ Temperature Coefficient | — | 40 | — | ppm/°C | **Note 2** |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | — | 0.05 | **0.35** | % | $(V_R + 1V) \le V_{IN} \le 6V$ |
| $\Delta V_{OUT}/V_{OUT}$ | Load Regulation | — | 0.002 | **0.01** | %/mA | $I_L$ = 0.1mA to $I_{OUTMAX}$ **(Note 3)** |
| $V_{IN}-V_{OUT}$ | Dropout Voltage | —<br>—<br>—<br>— | 20<br>60<br>200<br>350 | **30**<br>**160**<br>**480**<br>**800** | mV | $I_L$ = 100µA<br>$I_L$ = 100mA<br>$I_L$ = 300mA<br>$I_L$ = 500mA **(Note 4)** |
| $I_{DD}$ | Supply Current (Active Mode) | — | 80 | **130** | µA | $\overline{SHDN} = V_{IH}$, $I_L$ = 0 |
| $I_{SHDN}$ | Supply Current (Shutdown Mode) | — | 5 | — | µA | $\overline{SHDN}$ = 0V |
| $T_{WK}$ | Wake-up Time<br><br>(from Shutdown Mode) | — | 5 | 10 | µsec | $V_{IN}$ = 3.5V, $V_{OUT}$ = 2.5V<br>$C_{IN} = C_{OUT}$ = 1µF<br>$I_L$ = 250mA (See Figure 3-2) |
| $T_S$ | Settling Time<br><br>(from Shutdown Mode) | — | 15 | — | µsec | $V_{IN}$ = 3.5V, $V_{OUT}$ = 2.5V<br>$C_{IN} = C_{OUT}$ = 1µF<br>$I_L$ = 250mA (See Figure 3-2) |
| PSRR | Power Supply Rejection Ratio | — | 64 | — | dB | $F_{RE} \le$ 1kHz |
| $I_{OUTSC}$ | Output Short Circuit Current | — | 1200 | 1400 | mA | $V_{OUT}$ = 0V |
| $\Delta V_{OUT}/\Delta P_D$ | Thermal Regulation | — | 0.04 | — | V/W | **Note 5** |
| eN | Output Noise | — | 260 | — | nV/√Hz | $I_L = I_{OUTMAX}$ |
| **$\overline{SHDN}$ Input** | | | | | | |
| $V_{IH}$ | $\overline{SHDN}$ Input High Threshold | **45** | — | — | $\%V_{IN}$ | |
| $V_{IL}$ | $\overline{SHDN}$ Input Low Threshold | — | — | **15** | $\%V_{IN}$ | |

**Note 1:** $V_R$ is the regulator output voltage setting.

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

**3:** 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.

**4:** 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.

**5:** 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.

**6:** 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., $T_A$, $T_J$, $\theta_{JA}$). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see Section 4.0 Thermal Considerations for more details.

**7:** Hysteresis voltage is referenced to $V_R$.

**8:** 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 $I_{OUTMAX}$.

## TC1268 ELECTRICAL SPECIFICATIONS (CONTINUED)

| **Electrical Characteristics:** $V_{IN} = V_{OUT} + 1V$, $I_L = 100\mu A$, $C_L = 3.3\mu F$, $\overline{SHDN} > V_{IH}$, $T_A = 25°C$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of -40°C to +125°C. | | | | | | |
|---|---|---|---|---|---|---|
| **$\overline{ERROR}$ Output** | | | | | | |
| $V_{MIN}$ | Minimum Operating Voltage | 1.0 | — | — | V | |
| $V_{OL}$ | Output Logic Low Voltage | — | — | **400** | mV | 1 mA Flows to $\overline{ERROR}$ |
| $V_{TH}$ | $\overline{ERROR}$ Threshold Voltage | — | 0.95 x $V_R$ | — | V | |

**Note 1:** $V_R$ is the regulator output voltage setting.

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

**3:** 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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**7:** Hysteresis voltage is referenced to $V_R$.

**8:** 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.

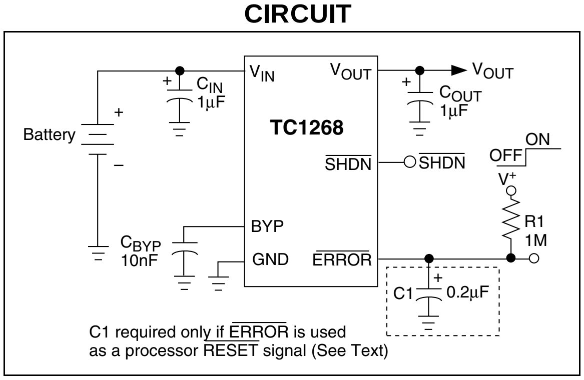
**TABLE 2-1: PIN FUNCTION TABLE**

| Pin No. (8-Pin SOIC) | 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 | $\overline{\text{ERROR}}$ | Out-of-Regulation Flag. (Open drain output). This output goes low when $V_{OUT}$ is out-of-tolerance by approximately -5%. |
| 6 | $\overline{\text{SHDN}}$ | 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 5µA (typical). |
| 7 | NC | No connect. |
| 8 | $V_{IN}$ | Unregulated supply input. |

## 3.0 DETAILED DESCRIPTION

The TC1268 is a precision, fixed output LDO. Unlike bipolar regulators, the TC1268 supply current does not increase with load current. In addition, $V_{OUT}$ remains stable and within regulation over the entire 0mA to $I_{LOADMAX}$ load current range, (an important consideration in RTC and CMOS RAM battery back-up applications). Figure 3-1 shows a typical application circuit.

**FIGURE 3-1: TYPICAL APPLICATION CIRCUIT**




### 3.1 Turn On Response

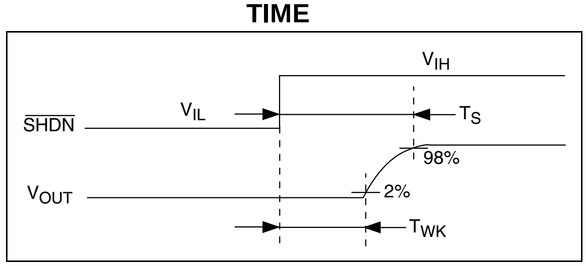
The turn on response is defined as two separate response categories, Wake-up Time ($T_{WK}$) and Settling Time ($T_S$).

The TC1268 has a fast Wake-up Time (5µsec typical) when released from shutdown. See Figure 3-2 for the Wake-up Time designated as $T_{WK}$. The Wake-up Time is defined as the time it takes for the output to rise to 2% of the $V_{OUT}$ value after being released from shutdown.

The total turn on response is defined as the Settling Time ($T_S$), see Figure 3-2. Settling Time (inclusive with $T_{WK}$) is defined as the condition when the output is within 2% of its fully enabled value (15µsec typical) when released from shutdown. The settling time of the output voltage is dependent on load conditions and output capacitance on $V_{OUT}$ (RC response).

The Wake-up Time ($T_{WK}$) is an important parameter to consider when using the TC1268 in RAMBUS applications. In this application, the bus voltage is held at 2.5V by a switching regulator during normal power conditions and can be switched to low power mode, where the TC1268 takes over and supplies the same 2.5V, but at a much lower current (300mA). In order to not see the bus voltage drop during the transition from high power to low power, the TC1268 has a very fast wake-up time of 5µsec to support the 2.5V rail. This makes the TC1268 ideal for applications involving RAMBUS.

**FIGURE 3-2: WAKE-UP RESPONSE TIME**



## 3.2 Bypass Input

A 10nF 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 this results in a longer time period to achieve the rated output voltage, once power is initially applied.

## 3.3 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 5Ω, 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.

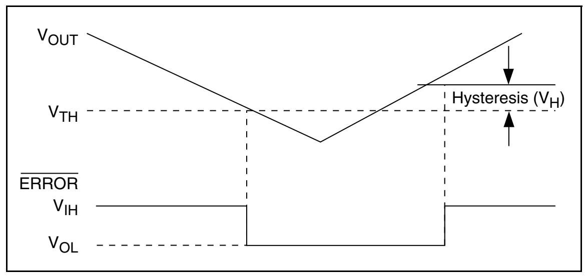
## 3.4 $\overline{\text{ERROR}}$ Output

$\overline{\text{ERROR}}$ 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 $\overline{\text{ERROR}}$ threshold is 5% below rated $V_{OUT}$, regardless of the programmed output voltage value (e.g., $\overline{\text{ERROR}} = V_{OL}$ at 2.375V (typ.) for a 2.5V regulator). $\overline{\text{ERROR}}$ output operation is shown in Figure 3-3. Note that $\overline{\text{ERROR}}$ 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 3-1, $\overline{\text{ERROR}}$ can be used as a battery low flag, or as a processor $\overline{\text{RESET}}$ signal (with the addition of timing capacitor C1). R1 x C1 should be chosen to maintain $\overline{\text{ERROR}}$ below $V_{IH}$ of the processor $\overline{\text{RESET}}$ 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 3-3: $\overline{\text{ERROR}}$ OUTPUT OPERATION**



## 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 ($\theta_{JA}$).

**EQUATION 4-2:**

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

Where all terms are previously defined.

Table 4-1 shows various values of $\theta_{JA}$ for the TC1268 package.

**TABLE 4-1: THERMAL RESISTANCE GUIDELINES FOR TC1268 IN 8-PIN SOIC PACKAGE**

| Copper Area (Topside)* | Copper Area (Backside) | Board Area | Thermal Resistance ($\theta_{JA}$) |
|---|---|---|---|
| 2500 sq mm | 2500 sq mm | 2500 sq mm | 60°C/W |
| 1000 sq mm | 2500 sq mm | 2500 sq mm | 60°C/W |
| 225 sq mm | 2500 sq mm | 2500 sq mm | 68°C/W |
| 100 sq mm | 2500 sq mm | 2500 sq mm | 74°C/W |

*Pin 2 is ground. Device is mounted on topside.

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

Given:

$V_{INMAX}$ = 3.3V ± 10%
$V_{OUTMIN}$ = 2.5V ± 0.5%
$I_{LOADMAX}$ = 275mA
$T_{JMAX}$ = 125°C
$T_{AMAX}$ = 95°C
$\theta_{JA}$ = 60°C/W

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

Actual power dissipation:

$$P_D \approx (V_{INMAX} - V_{OUTMIN}) I_{LOADMAX}$$
$$= [(3.3 \times 1.1) - (2.5 \times .995)]275 \times 10^{-3}$$
$$= 314\text{mW}$$

Maximum allowable power dissipation:

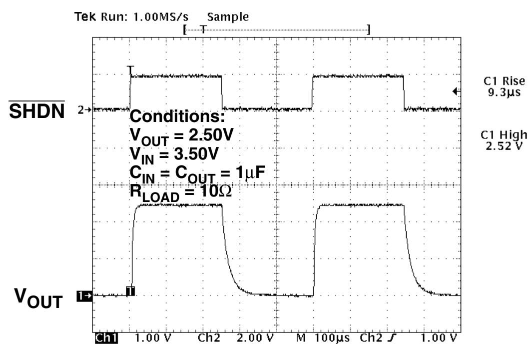
$$P_{DMAX} = \frac{(T_{JMAX} - T_{AMAX})}{\theta_{JA}}$$
$$= \frac{(125 - 95)}{60}$$
$$= 500\text{mW}$$

In this example, the TC1268 dissipates a maximum of 314mW; below the allowable limit of 500mW. 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 500mW into Equation 4-1, from which $V_{INMAX}$ = 3.94V.

## 5.0 TYPICAL CHARACTERISTICS

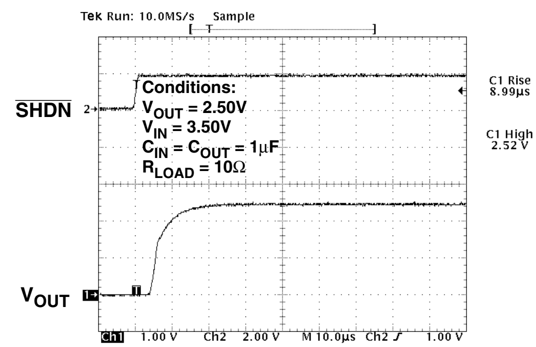
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be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

**Fast Response TC1268**




**100µsec/DIV; 15µsec Rise Time**

**Fast Response TC1268**




**10µsec/DIV; 15µsec Rise Time**

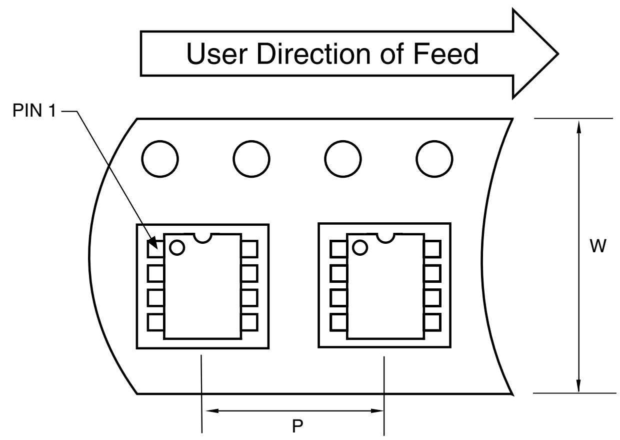
# 6.0 PACKAGING INFORMATION

## 6.1 Package Marking Information

Package marking data not available at this time.

## 6.2 Taping Form

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



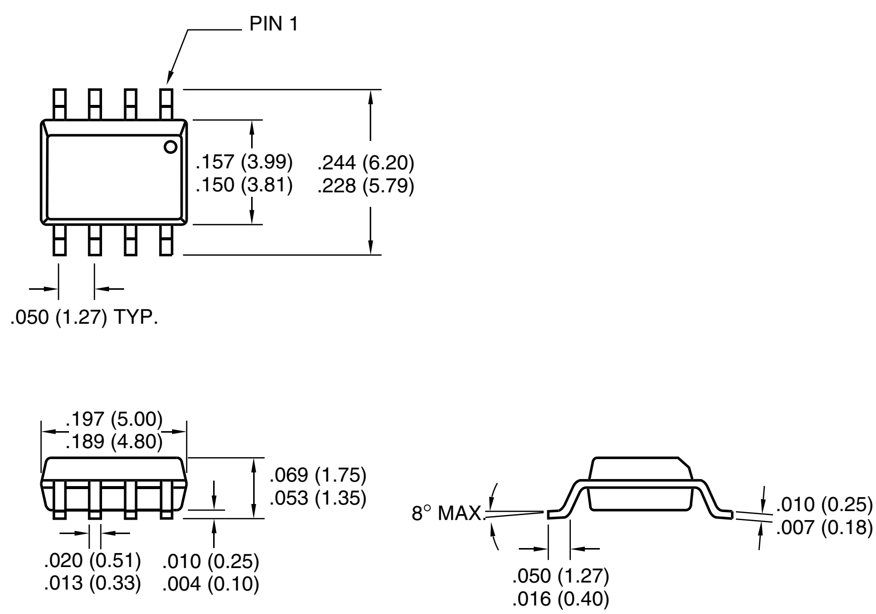

Standard Reel Component Orientation
for TR Suffix Device

**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 SOIC**




**Dimensions: inches (mm)**

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