**Obsolete Device**

# TC1025

## Linear Building Block – Dual Low Power Comparator

### Features

- Rail-to-Rail Inputs and Outputs
- Optimized for Single Supply Operation
- Small Packages: 8-Pin MSOP, 8-Pin SOIC or 8-Pin PDIP
- Ultra Low Input Bias Current: Less than 100pA
- Low Quiescent Current: 8µA (Typ.)
- Operates Down to $V_{DD}$ = 1.8V

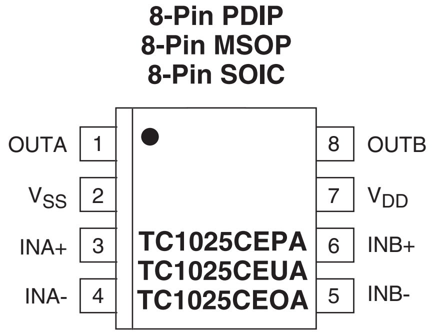
### Applications

- Power Management Circuits
- Battery Operated Equipment
- Consumer Products

### Device Selection Table

| Part Number | Package | Temperature Range |
|---|---|---|
| TC1025CEPA | 8-Pin PDIP | -40°C to +85°C |
| TC1025CEUA | 8-Pin MSOP | -40°C to +85°C |
| TC1025CEOA | 8-Pin SOIC | -40°C to +85°C |

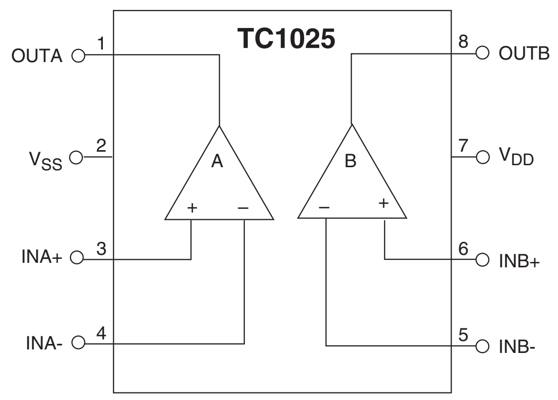
### Package Types



### General Description

The TC1025 is a dual low-power comparator with a typical supply current of 8µA and operation ensured to $V_{DD}$ = 1.8V. Input and output signal swing is rail-to-rail. Available in a space-saving 8-pin MSOP package, the TC1025 consumes half the board area required by a standard 8-Pin SOIC package. It is also available in 8-Pin SOIC and PDIP packages. It is ideal for applications requiring high integration, small-size and low power.

### Functional Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### ABSOLUTE MAXIMUM RATINGS*

Supply Voltage ....................................................6.0V
Voltage on Any Pin..........($V_{SS}$ – 0.3V) to ($V_{DD}$ + 0.3V)
Junction Temperature...................................... +150°C
Operating Temperature Range.............-40°C to +85°C
Storage Temperature Range .............-55°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.

### TC1025 ELECTRICAL SPECIFICATIONS

**Electrical Characteristics:** Typical values apply at 25°C and $V_{DD}$ = 3.0V. Minimum and maximum values apply for $T_A$ = -40° to +85°C, and $V_{DD}$ = 1.8V to 5.5V, unless otherwise specified.

| Symbol | Parameter | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Supply Voltage | 1.8 | — | 5.5 | V | |
| $I_Q$ | Supply Current | — | 8 | 12 | µA | |
| **Comparator** | | | | | | |
| $V_{ICMR}$ | Common Mode Input Range | $V_{SS}$ – 0.2 | — | $V_{DD}$ + 0.2 | V | |
| $V_{OS}$ | Input Offset Voltage | -5<br>-5 | — | +5<br>+5 | mV<br>mV | $V_{DD}$ = 3V, $V_{CM}$ = 1.5V, $T_A$ = 25°C |
| $I_B$ | Input Bias Current | -100 | — | 100 | pA | $T_A$ = 25°C, IN+,IN- = $V_{DD}$ to $V_{SS}$ |
| $V_{OH}$ | Output High Voltage | $V_{DD}$ – 0.3 | — | — | V | $R_L$ = 10kΩ to $V_{SS}$ |
| $V_{OL}$ | Output Low Voltage | — | — | 0.3 | V | $R_L$ = 10kΩ to $V_{DD}$ |
| CMRR | Common Mode Rejection Ratio | 66 | — | — | dB | $T_A$ = 25°C, $V_{DD}$ = 5V<br>$V_{CM}$ = $V_{DD}$ to $V_{SS}$ |
| PSRR | Power Supply Rejection Ratio | 60 | — | — | dB | $T_A$ = 25°C, $V_{CM}$ = 1.2V<br>$V_{DD}$ = 1.8V to 5V |
| $I_{SRC}$ | Output Source Current | 1 | — | — | mA | IN+ = $V_{DD}$, IN- = $V_{SS}$,<br>Output Shorted to $V_{SS}$<br>$V_{DD}$ = 1.8V |
| $I_{SINK}$ | Output Sink Current | 2 | — | — | mA | IN+ = $V_{SS}$, IN- = $V_{DD}$,<br>Output Shorted to $V_{DD}$<br>$V_{DD}$ = 1.8V |
| $t_{PD1}$ | Response Time | — | 4 | — | µsec | 100mV Overdrive, $C_L$ = 100pF |
| $t_{PD2}$ | Response Time | — | 6 | — | µsec | 10mV Overdrive, $C_L$ = 100pF |

## 2.0 PIN DESCRIPTION

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

### TABLE 2-1: PIN FUNCTION TABLE

| Pin No. (8-Pin PDIP) (8-Pin MSOP) (8-Pin SOIC) | Symbol | Description |
|---|---|---|
| 1 | OUTA | Comparator output. |
| 2 | $V_{SS}$ | Negative power supply. |
| 3 | INA+ | Non inverting input. |
| 4 | INA- | Inverting input. |
| 5 | INB- | Inverting input. |
| 6 | INB+ | Non inverting input. |
| 7 | $V_{DD}$ | Positive power supply. |
| 8 | OUTB | Comparator input. |

## 3.0 DETAILED DESCRIPTION

The TC1025 is one of a series of very low-power, linear building block products targeted at low-voltage, single-supply applications. The TC1025 minimum operating voltage is 1.8V, and typical supply current is only 8µA. It combines two comparators in a single package.

### 3.1 Comparators

The TC1025 contains two comparators. The comparator's input range extends beyond both supply voltages by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven.

The comparators exhibit propagation delay and supply current which are largely independent of supply voltage. The low input bias current and offset voltage make them suitable for high impedance precision applications.

## 4.0 TYPICAL APPLICATIONS

The TC1025 lends itself to a wide variety of applications, particularly in battery-powered systems. Typically, it finds application in power management, processor supervisory, and interface circuitry.

### 4.1 External Hysteresis (Comparator)

Hysteresis can be set externally with two resistors using positive feedback techniques (see Figure 4-1). The design procedure for setting external comparator hysteresis is as follows:

1. Choose the feedback resistor $R_C$. Since the input bias current of the comparator is at most 100pA, the current through $R_C$ can be set to 100nA (i.e., 1000 times the input bias current) and retain excellent accuracy. The current through $R_C$ at the comparator's trip point is $V_R/R_C$ where $V_R$ is a stable reference voltage.
2. Determine the hysteresis voltage ($V_{HY}$) between the upper and lower thresholds.
3. Calculate $R_A$ as follows:

**EQUATION 4-1:**

$$R_A = R_C\left(\frac{V_{HY}}{V_{DD}}\right)$$

4. Choose the rising threshold voltage for $V_{SRC}$ ($V_{THR}$).
5. Calculate $R_B$ as follows:

**EQUATION 4-2:**

$$R_B = \frac{1}{\left[\left(\frac{V_{THR}}{V_R \times R_A}\right) - \frac{1}{R_A} - \frac{1}{R_C}\right]}$$

6. Verify the threshold voltages with these formulas:

$V_{SRC}$ rising:

**EQUATION 4-3:**

$$V_{THR} = (V_R)(R_A)\left[\left(\frac{1}{R_A}\right) + \left(\frac{1}{R_B}\right) + \left(\frac{1}{R_C}\right)\right]$$

$V_{SRC}$ falling:

**EQUATION 4-4:**

$$V_{THF} = V_{THR} - \left[\left(\frac{R_A \times V_{DD}}{R_C}\right)\right]$$

## 4.2 32.768 kHz “Time of Day Clock” Crystal Controlled Oscillator

A very stable oscillator driver can be designed by using a crystal resonator as the feedback element. Figure 4-2 shows a typical application circuit using this technique to develop clock driver for a Time Of Day (TOD) clock chip. The value of $R_A$ and $R_B$ determine the DC voltage level at which the comparator trips – in this case one-half of $V_{DD}$. The RC time constant of $R_C$ and $C_A$ should be set several times greater than the crystal oscillator’s period, which will ensure a 50% duty cycle by maintaining a DC voltage at the inverting comparator input equal to the absolute average age of the output signal.

## 4.3 Non-Retriggerable One Shot Multivibrator

Using two comparators, a non-retriggerable one shot multivibrator can be designed using the circuit configuration of Figure 4-3. A key feature of this design is that the pulse width is independent of the magnitude of the supply voltage because the charging voltage and the intercept voltage are a fixed percentage of $V_{DD}$. In addition, this one shot is capable of pulse width with as much as a 99% duty cycle and exhibits input lockout to ensure that the circuit will not retrigger before the output pulse has completely timed out. The trigger level is the voltage required at the input to raise the voltage at node A higher than the voltage at node B, and is set by the resistive divider R4 and R10 and the impedance network composed of R1, R2 and R3. When the one shot has been triggered, the output of CMPTR2 is high, causing the reference voltage at the non-inverting input of CMPTR1 to go to $V_{DD}$. This prevents any additional input pulses from disturbing the circuit until the output pulse has timed out.

The value of the timing capacitor C1 must be small enough to allow CMPTR1 to discharge C1 to a diode voltage before the feedback signal from CMPTR2 (through R10) switches CMPTR1 to its high state and allows C1 to start an exponential charge through R5. Proper circuit action depends upon rapidly discharging C1 through the voltage set by R6, R9 and D2 to a final voltage of a small diode drop. Two propagation delays after the voltage on C1 drops below the level on the non-inverting input of CMPTR2, the output of CMPTR1 switches to the positive rail and begins to charge C1 through R5. The time delay which sets the output pulse width results from C1 charging to the reference voltage set by R6, R9 and D2, plus four comparator propagation delays. When the voltage across C1 charges beyond the reference, the output pulse returns to ground and the input is again ready to accept a trigger signal.

## 4.4 Oscillators and Pulse Width Modulators

Microchip’s linear building block comparators adapt well to oscillator applications for low frequencies (less than 100kHz). Figure 4-4 shows a symmetrical square wave generator using a minimum number of components. The output is set by the RC time constant of R4 and C1, and the total hysteresis of the loop is set by R1, R2 and R3. The maximum frequency of the oscillator is limited only by the large signal propagation delay of the comparator in addition to any capacitive loading at the output which degrades the slew rate. To analyze this circuit, assume that the output is initially high. For this to occur, the voltage at the inverting input must be less than the voltage at the non-inverting input. Therefore, capacitor C1 is discharged. The voltage at the non-inverting input ($V_H$) is:

**EQUATION 4-5:**

$$V_H = \frac{R2(V_{DD})}{[R2 + (R1 \parallel R3)]}$$

where, if R1 = R2 = R3, then:

**EQUATION 4-6:**

$$V_H = \frac{2(V_{DD})}{3}$$

Capacitor C1 will charge up through R4. When the voltage at the comparator’s inverting input is equal to $V_H$, the comparator output will switch. With the output at ground potential, the value at the non-inverting input terminal ($V_L$) is reduced by the hysteresis network to a value given by:

**EQUATION 4-7:**

$$V_L = \frac{V_{DD}}{3}$$

Using the same resistors as before, capacitor C1 must now discharge through R4 toward ground. The output will return to a high state when the voltage across the capacitor has discharged to a value equal to $V_L$. The period of oscillation will be twice the time it takes for the RC circuit to charge up to one half its final value. The period can be calculated from:

**EQUATION 4-8:**

$$\frac{1}{FREQ} = 2(0.694)(R4)(C1)$$

The frequency stability of this circuit should only be a function of the external component tolerances.

Figure 4-5 shows the circuit for a pulse width modulator circuit. It is essentially the same as in Figure 4-4, but with the addition of an input control voltage. When the input control voltage is equal to one-half $V_{DD}$, operation is basically the same as described for the free-running oscillator. If the input control voltage is moved above or below one-half $V_{DD}$, the duty cycle of the output square wave will be altered. This is because the addition of the control voltage at the input has now altered the trip points. The equations for these trip points are shown in Figure 4-5 (see $V_H$ and $V_L$). Pulse width sensitivity to the input voltage variations can be increased by reducing the value of R6 from 10kΩ and conversely, sensitivity will be reduced by increasing the value of R6. The values of R1 and C1 can be varied to produce the desired center frequency.

**FIGURE 4-1: COMPARATOR EXTERNAL HYSTERESIS CONFIGURATION**

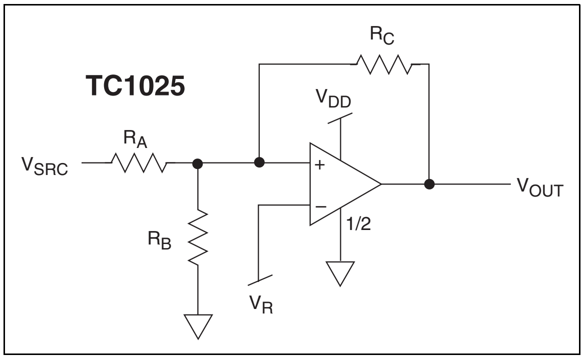


**FIGURE 4-2: 32.768 kHz “TIME OF DAY” CLOCK OSCILLATOR**

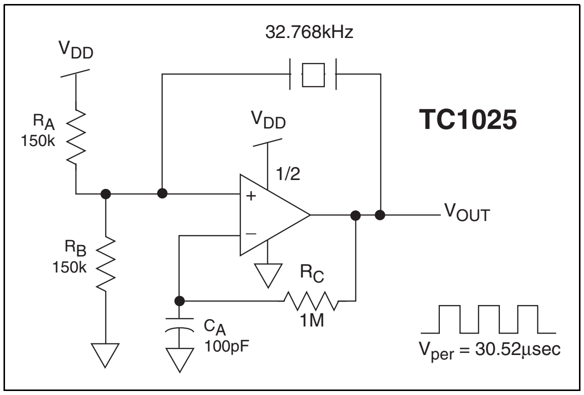


**FIGURE 4-3: NON-RETRIGGERABLE MULTIVIBRATOR**

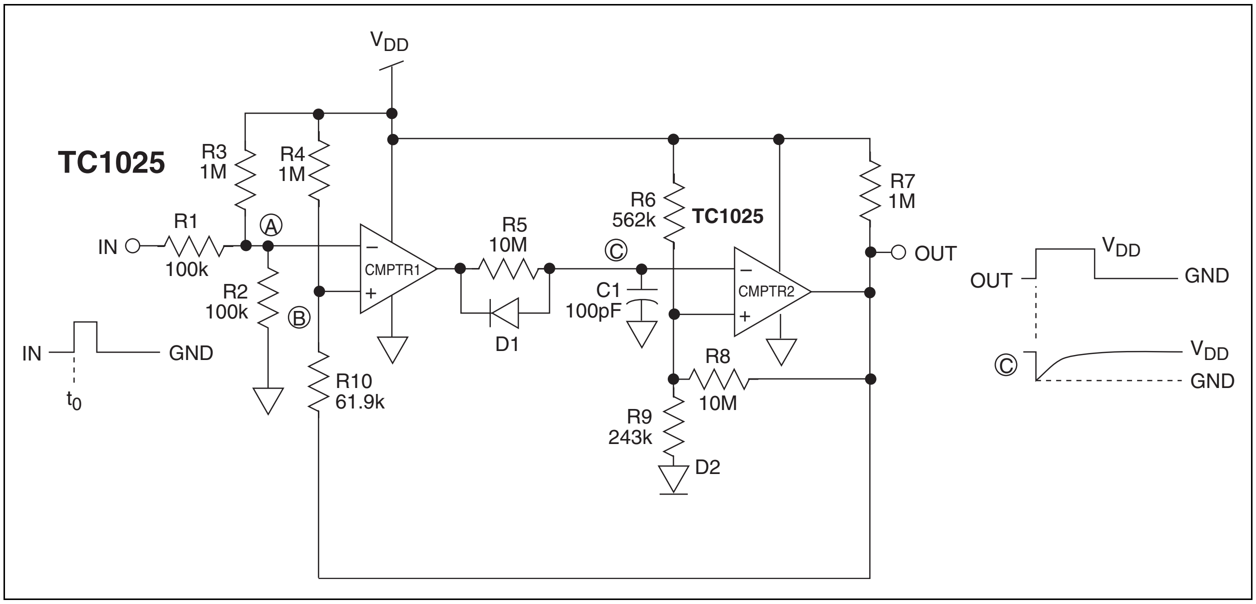
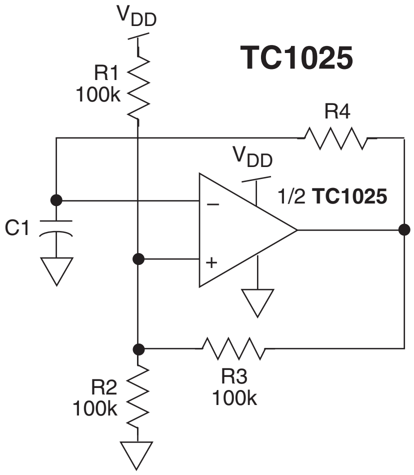


**FIGURE 4-4: SQUARE WAVE GENERATOR**

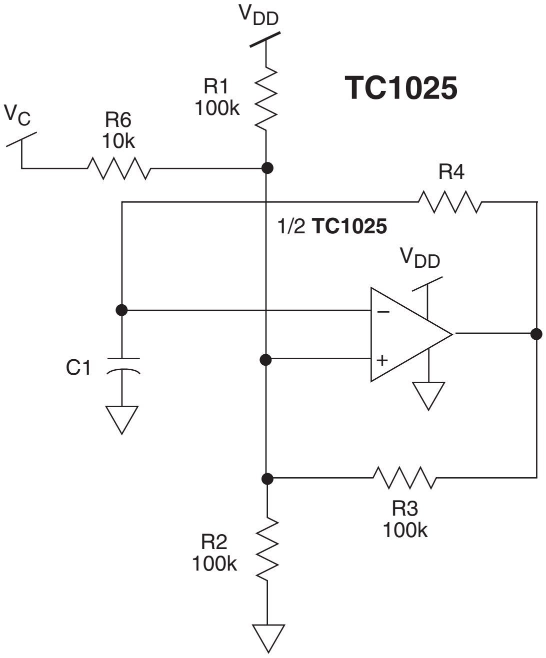


$$V_H = \frac{R2\,(V_{DD})}{R2 + (R1||R3)}$$

$$V_L = \frac{(V_{DD})\,(R2||R3)}{R1 + (R2||R3)}$$

$$FREQ = \frac{1}{2(0.694)(R4)(C1)}$$

**FIGURE 4-5: PULSE WIDTH MODULATOR**



$$V_H = \frac{V_{DD}\,(R_1R_2R_6 + R_2R_3R_6) + V_C\,(R_1R_2R_3)}{R_1R_2R_6 + R_1R_3R_6 + R_2R_3R_6 + R_1R_2R_3}$$

$$V_L = \frac{V_{DD}\,(R_2R_3R_6) + V_C\,(R_1R_2R_3)}{R_1R_2R_6 + R_1R_3R_6 + R_2R_3R_6 + R_1R_2R_3}$$

$$FREQ = \frac{1}{2\,(0.694)\,(R4)\,(C1)}$$

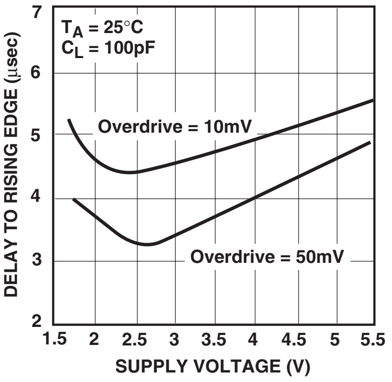
For Square Wave Generation
Select R1 = R2 = R3

$$V_C = \frac{V_{DD}}{2}$$

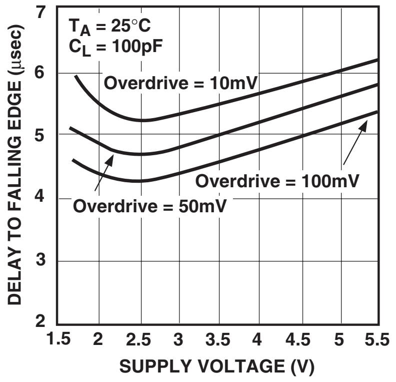
## 5.0 TYPICAL CHARACTERISTICS

**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.

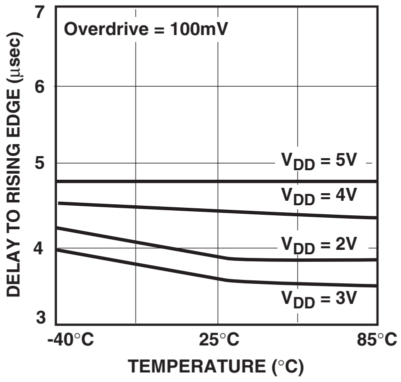
**Comparator Propagation Delay vs. Supply Voltage**



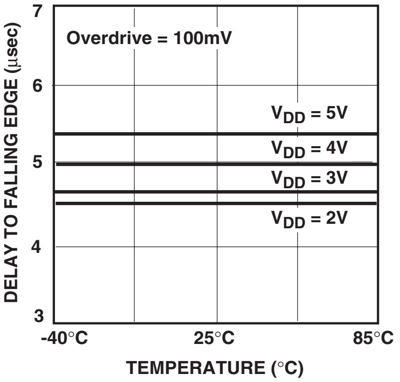
**Comparator Propagation Delay vs. Supply Voltage**



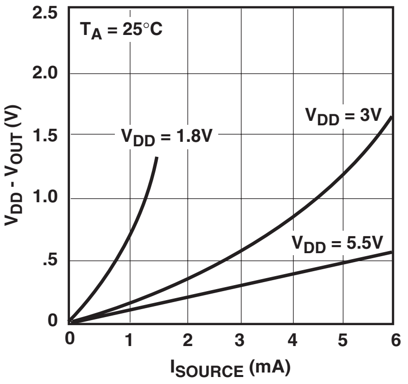
**Comparator Propagation Delay vs. Temperature**



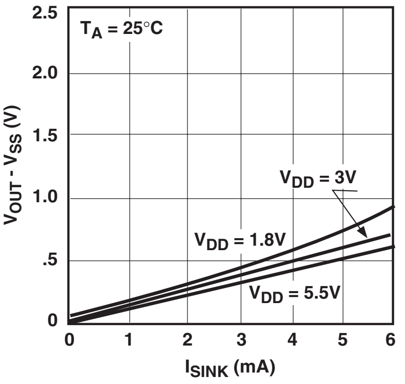
**Comparator Propagation Delay vs. Temperature**



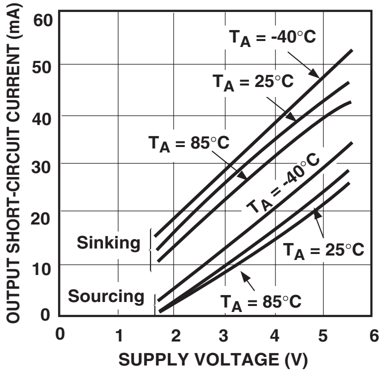
**Comparator Output Swing vs. Output Source Current**



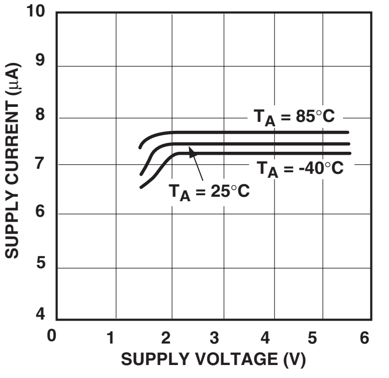
**Comparator Output Swing vs. Output Sink Current**



**Comparator Output Short-Circuit Current vs. Supply Voltage**



**Supply Current vs. Supply Voltage**



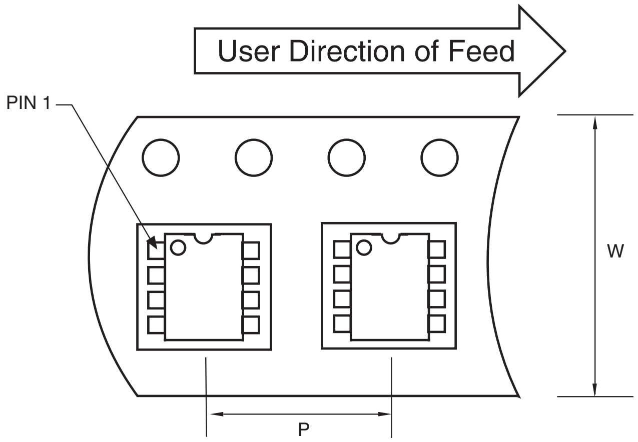
## 6.0 PACKAGING INFORMATION

### 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**

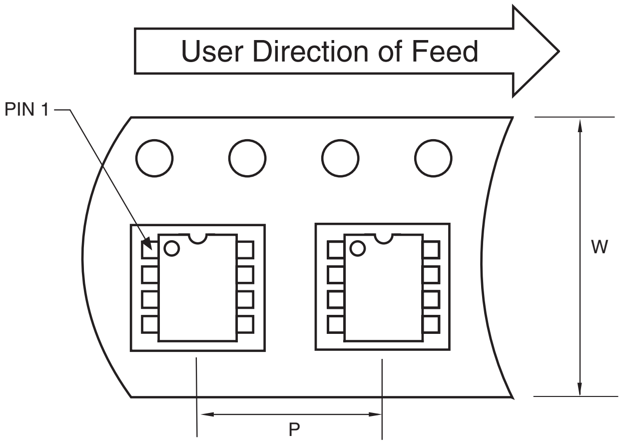


Standard Reel Component Orientation
for TR Suffix Device

**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**



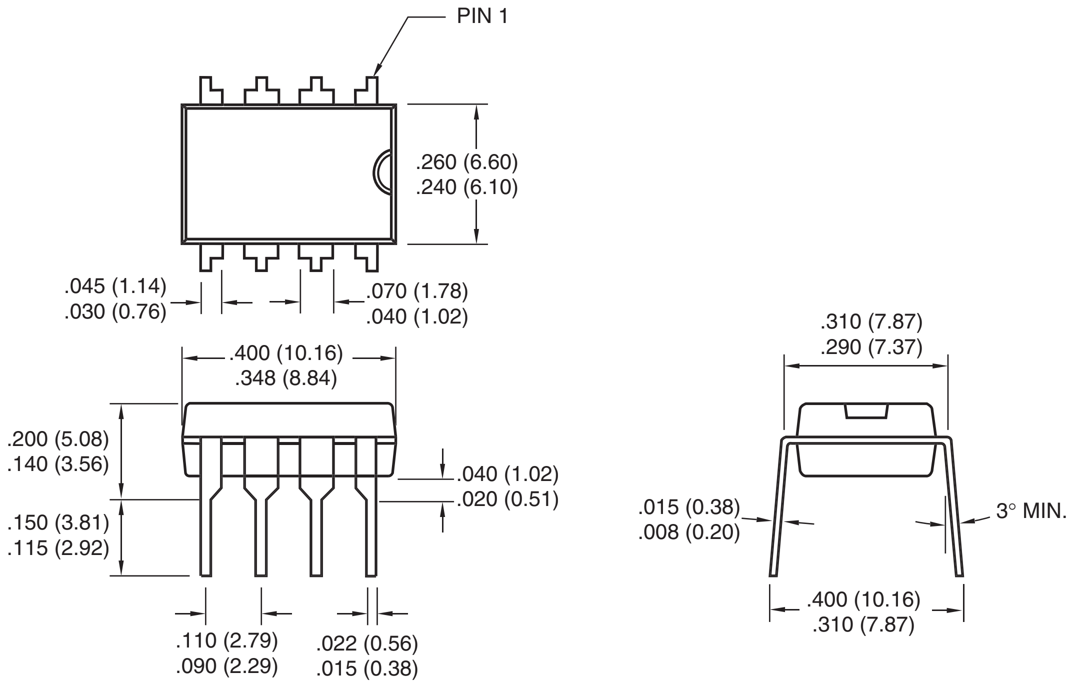
Standard Reel Component Orientation
for TR Suffix Device

**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 |

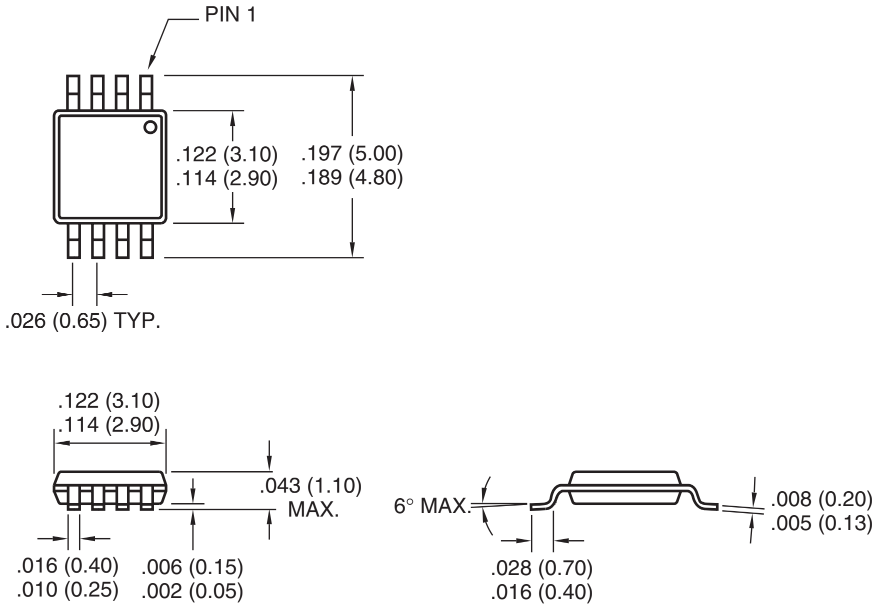
## 6.3 Package Dimensions

### 8-Pin Plastic DIP



**Dimensions: inches (mm)**

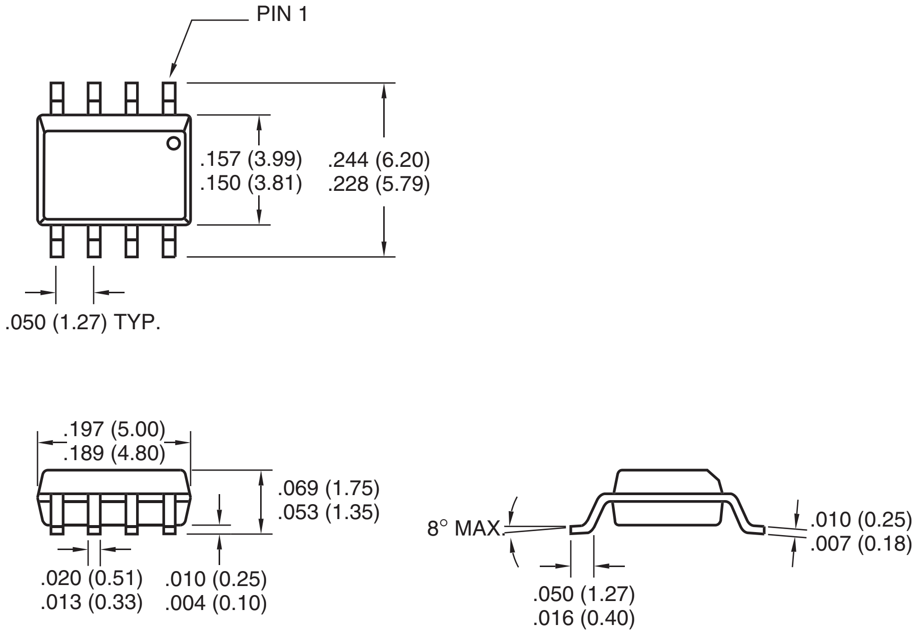
### 8-Pin MSOP



**Dimensions: inches (mm)**

## 6.3 Package Dimensions (Continued)

### 8-Pin SOIC



**Dimensions: inches (mm)**

**NOTES:**

## 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**
Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

NOTES:

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE**.** Microchip disclaims all liability arising from this information and its use. Use of Microchip's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

**Trademarks**

The Microchip name and logo, the Microchip logo, Accuron, dsPIC, KEELOQ, microID, MPLAB, PIC, PICmicro, PICSTART, PRO MATE, PowerSmart, rfPIC, and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AmpLab, FilterLab, Migratable Memory, MXDEV, MXLAB, PICMASTER, SEEVAL, SmartSensor and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, dsPICDEM, dsPICDEM.net, dsPICworks, ECAN, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, Linear Active Thermistor, MPASM, MPLIB, MPLINK, MPSIM, PICkit, PICDEM, PICDEM.net, PICLAB, PICtail, PowerCal, PowerInfo, PowerMate, PowerTool, rfLAB, rfPICDEM, Select Mode, Smart Serial, SmartTel, Total Endurance and WiperLock are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2005, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

♻ Printed on recycled paper.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

*Microchip received ISO/TS-16949:2002 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona and Mountain View, California in October 2003. The Company's quality system processes and procedures are for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

# WORLDWIDE SALES AND SERVICE

## AMERICAS

**Corporate Office**
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

**Atlanta**
Alpharetta, GA
Tel: 770-640-0034
Fax: 770-640-0307

**Boston**
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

**Chicago**
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

**Dallas**
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

**Detroit**
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

**Kokomo**
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

**Los Angeles**
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

**San Jose**
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

**Toronto**
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

## ASIA/PACIFIC

**Australia - Sydney**
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

**China - Beijing**
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

**China - Chengdu**
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

**China - Fuzhou**
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

**China - Hong Kong SAR**
Tel: 852-2401-1200
Fax: 852-2401-3431

**China - Qingdao**
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

**China - Shanghai**
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

**China - Shenyang**
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

**China - Shenzhen**
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

**China - Shunde**
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

**China - Wuhan**
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

**China - Xian**
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

## ASIA/PACIFIC

**India - Bangalore**
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

**India - New Delhi**
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

**India - Pune**
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

**Japan - Yokohama**
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

**Korea - Gumi**
Tel: 82-54-473-4301
Fax: 82-54-473-4302

**Korea - Seoul**
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

**Malaysia - Penang**
Tel: 60-4-646-8870
Fax: 60-4-646-5086

**Philippines - Manila**
Tel: 63-2-634-9065
Fax: 63-2-634-9069

**Singapore**
Tel: 65-6334-8870
Fax: 65-6334-8850

**Taiwan - Hsin Chu**
Tel: 886-3-572-9526
Fax: 886-3-572-6459

**Taiwan - Kaohsiung**
Tel: 886-7-536-4818
Fax: 886-7-536-4803

**Taiwan - Taipei**
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

**Thailand - Bangkok**
Tel: 66-2-694-1351
Fax: 66-2-694-1350

## EUROPE

**Austria - Wels**
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

**Denmark - Copenhagen**
Tel: 45-4450-2828
Fax: 45-4485-2829

**France - Paris**
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

**Germany - Munich**
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

**Italy - Milan**
Tel: 39-0331-742611
Fax: 39-0331-466781

**Netherlands - Drunen**
Tel: 31-416-690399
Fax: 31-416-690340

**Spain - Madrid**
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

**UK - Wokingham**
Tel: 44-118-921-5869
Fax: 44-118-921-5820

10/31/05