

## 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: 8 $\mu$ A (Typ.)
- Operates Down to  $V_{DD} = 1.8V$

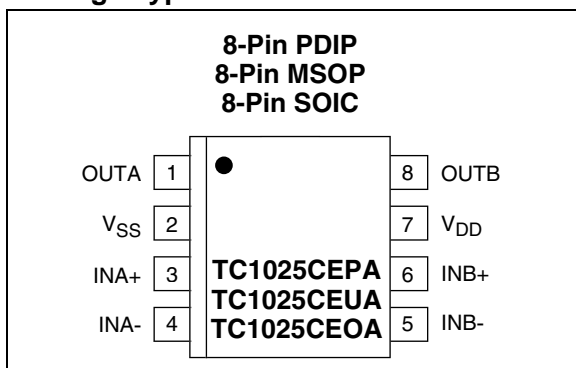
### Applications

- 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

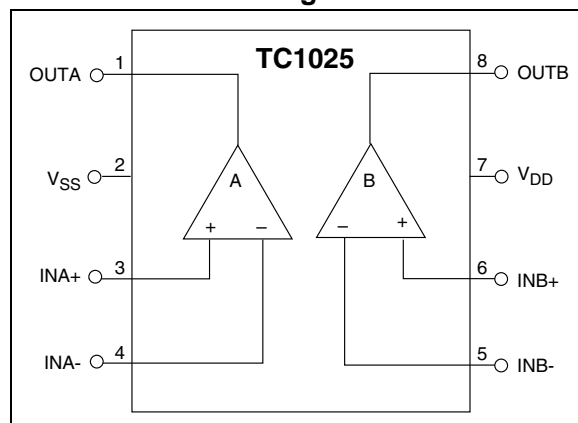
### Package Types



### General Description

The TC1025 is a dual low-power comparator with a typical supply current of 8 $\mu$ A 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



# TC1025

## 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

<b>Electrical Characteristics:</b> Typical values apply at 25°C and $V_{DD} = 3.0V$ . Minimum and maximum values apply for $T_A = -40^\circ$ 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	
<b>Comparator</b>						
$V_{ICMR}$	Common Mode Input Range	$V_{SS} - 0.2$	—	$V_{DD} + 0.2$	V	
$V_{OS}$	Input Offset Voltage	-5 -5	—	+5 +5	mV mV	$V_{DD} = 3V$ , $V_{CM} = 1.5V$ , $T_A = 25^\circ C$
$I_B$	Input Bias Current	-100	—	100	pA	$T_A = 25^\circ C$ , $IN+, IN- = V_{DD}$ to $V_{SS}$
$V_{OH}$	Output High Voltage	$V_{DD} - 0.3$	—	—	V	$R_L = 10k\Omega$ to $V_{SS}$
$V_{OL}$	Output Low Voltage	—	—	0.3	V	$R_L = 10k\Omega$ to $V_{DD}$
CMRR	Common Mode Rejection Ratio	66	—	—	dB	$T_A = 25^\circ C$ , $V_{DD} = 5V$ $V_{CM} = V_{DD}$ to $V_{SS}$
PSRR	Power Supply Rejection Ratio	60	—	—	dB	$T_A = 25^\circ C$ , $V_{CM} = 1.2V$ $V_{DD} = 1.8V$ to 5V
$I_{SRC}$	Output Source Current	1	—	—	mA	$IN+ = V_{DD}$ , $IN- = V_{SS}$ , Output Shorted to $V_{SS}$ $V_{DD} = 1.8V$
$I_{SINK}$	Output Sink Current	2	—	—	mA	$IN+ = V_{SS}$ , $IN- = V_{DD}$ , Output Shorted to $V_{DD}$ $V_{DD} = 1.8V$
$t_{PD1}$	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 <sub>SS</sub>	Negative power supply.
3	INA+	Non inverting input.
4	INA-	Inverting input.
5	INB-	Inverting input.
6	INB+	Non inverting input.
7	V <sub>DD</sub>	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  $R_4$  and  $R_{10}$  and the impedance network composed of  $R_1$ ,  $R_2$  and  $R_3$ . 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  $C_1$  must be small enough to allow CMPTR1 to discharge  $C_1$  to a diode voltage before the feedback signal from CMPTR2 (through  $R_{10}$ ) switches CMPTR1 to its high state and allows  $C_1$  to start an exponential charge through  $R_5$ . Proper circuit action depends upon rapidly discharging  $C_1$  through the voltage set by  $R_6$ ,  $R_9$  and  $D_2$  to a final voltage of a small diode drop. Two propagation delays after the voltage on  $C_1$  drops below the level on the non-inverting input of CMPTR2, the output of CMPTR1 switches to the positive rail and begins to charge  $C_1$  through  $R_5$ . The time delay which sets the output pulse width results from  $C_1$  charging to the reference voltage set by  $R_6$ ,  $R_9$  and  $D_2$ , plus four comparator propagation delays. When the voltage across  $C_1$  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  $R_4$  and  $C_1$ , and the total hysteresis of the loop is set by  $R_1$ ,  $R_2$  and  $R_3$ . 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  $C_1$  is discharged. The voltage at the non-inverting input ( $V_H$ ) is:

### EQUATION 4-5:

$$V_H = \frac{R_2(V_{DD})}{[R_2 + (R_1 \parallel R_3)]}$$

where, if  $R_1 = R_2 = R_3$ , then:

### EQUATION 4-6:

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

Capacitor  $C_1$  will charge up through  $R_4$ . 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  $C_1$  must now discharge through  $R_4$  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:

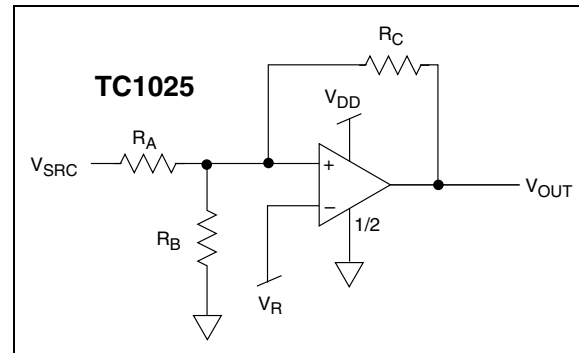
$$\frac{1}{\text{FREQ}} = 2(0.694)(R_4)(C_1)$$

# TC1025

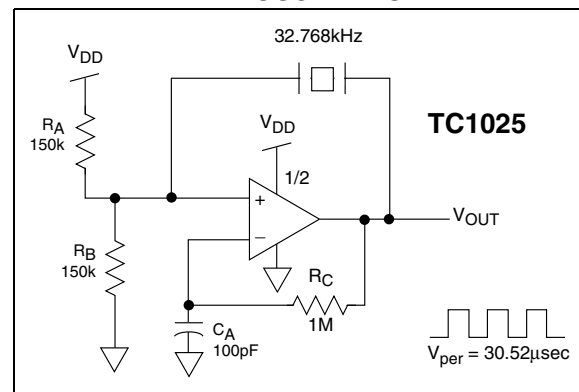
The frequency stability of this circuit should only be a function of the external component tolerances.

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  $R_6$  from  $10k\Omega$  and conversely, sensitivity will be reduced by increasing the value of  $R_6$ . The values of  $R_1$  and  $C_1$  can be varied to produce the desired center frequency.

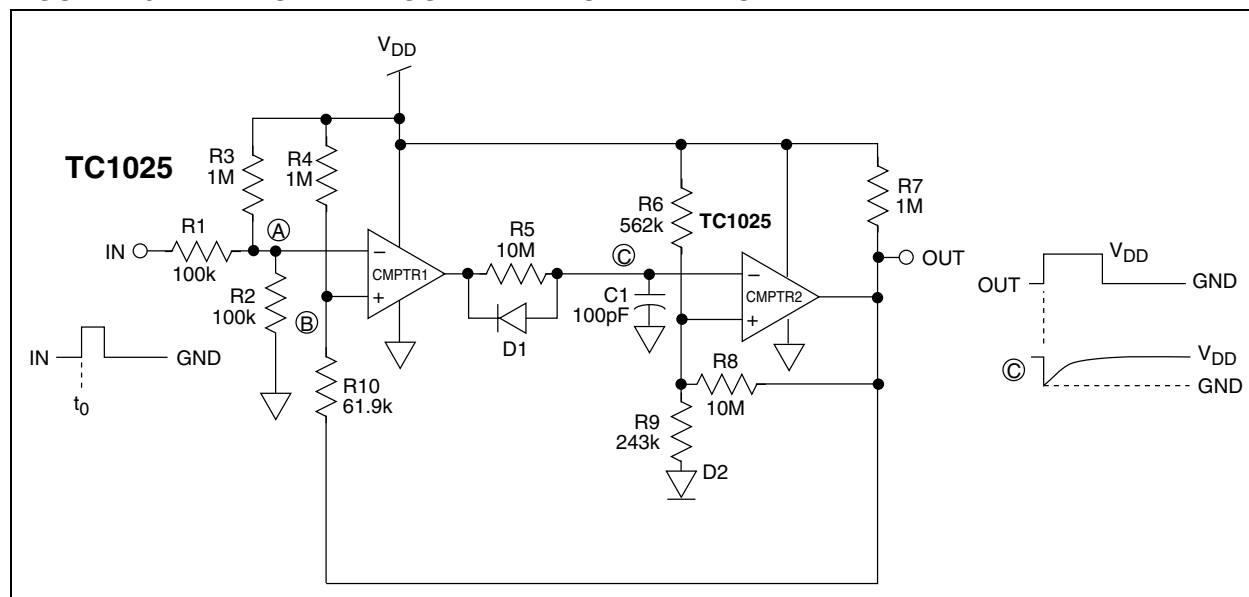
**FIGURE 4-1: COMPARATOR EXTERNAL HYSTERESIS CONFIGURATION**



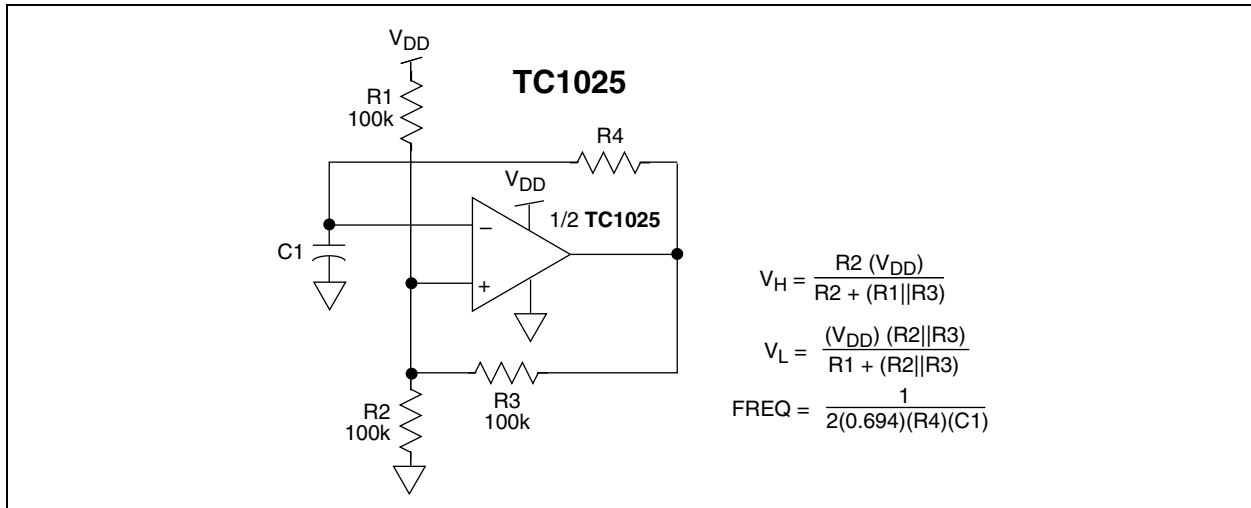
**FIGURE 4-2: 32.768 kHz “TIME OF DAY” CLOCK OSCILLATOR**



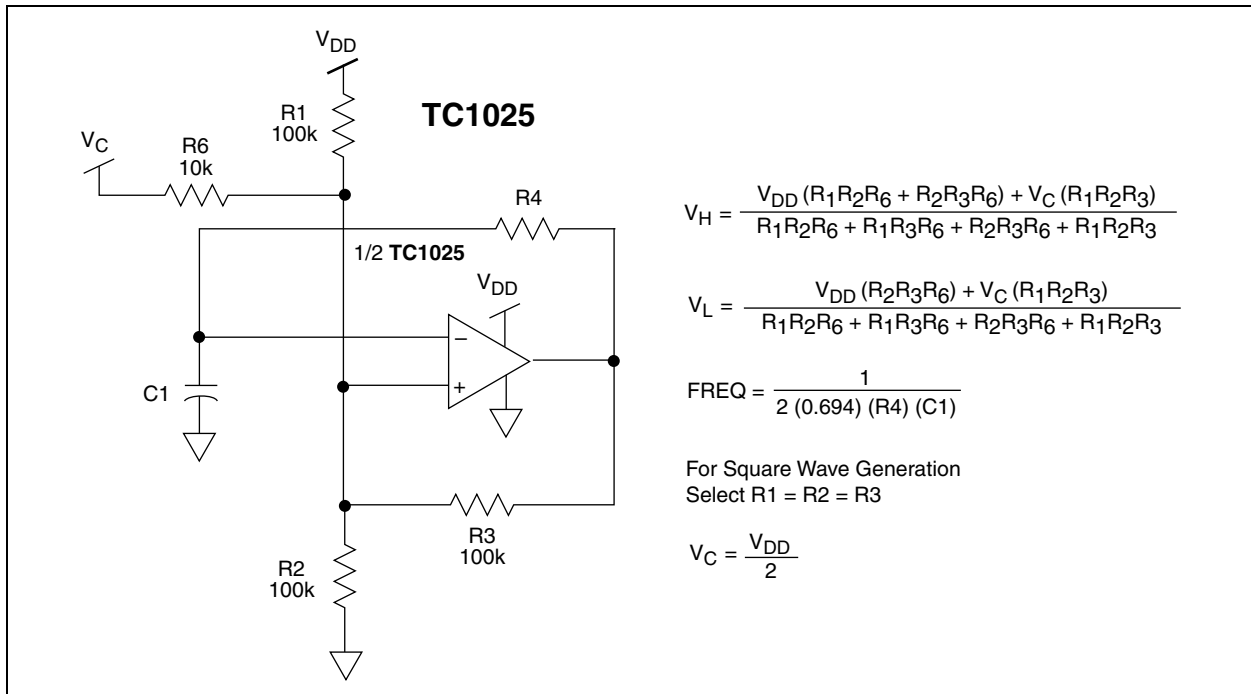
**FIGURE 4-3: NON-RETRIGGERABLE MULTIVIBRATOR**



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



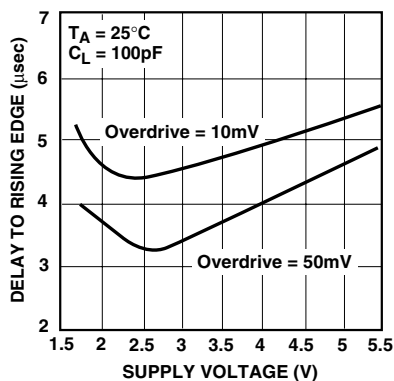
**FIGURE 4-5: PULSE WIDTH MODULATOR**



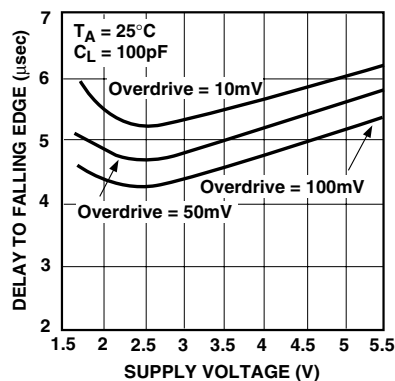
## 5.0 TYPICAL CHARACTERISTICS

**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.

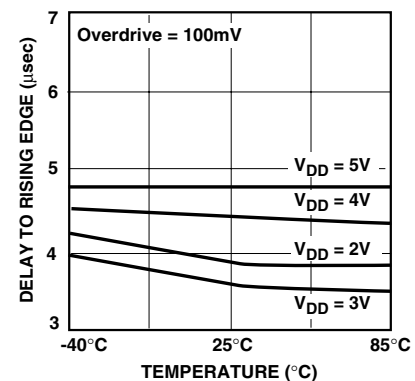
**Comparator Propagation Delay vs. Supply Voltage**



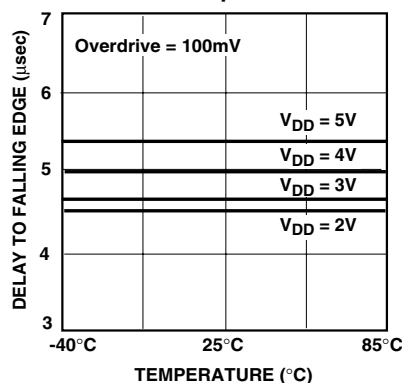
**Comparator Propagation Delay vs. Supply Voltage**



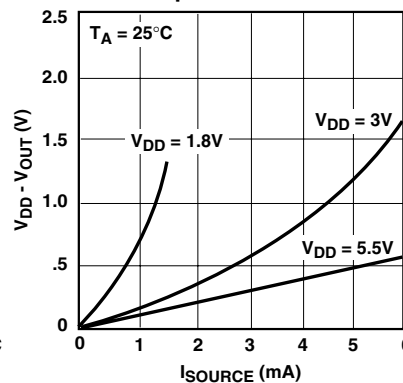
**Comparator Propagation Delay vs. Temperature**



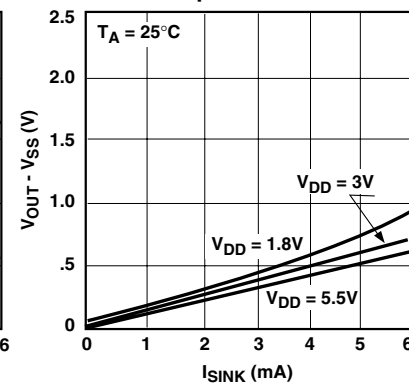
**Comparator Propagation Delay vs. Temperature**



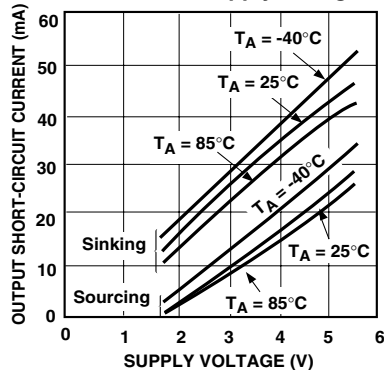
**Comparator Output Swing vs. Output Source Current**



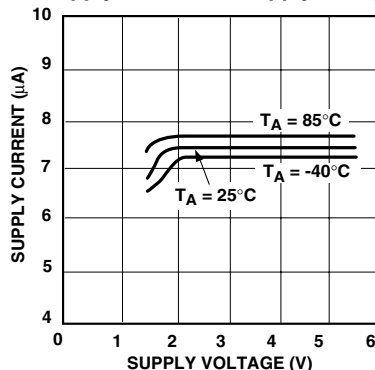
**Comparator Output Swing vs. Output Sink Current**



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



**Supply Current vs. Supply Voltage**





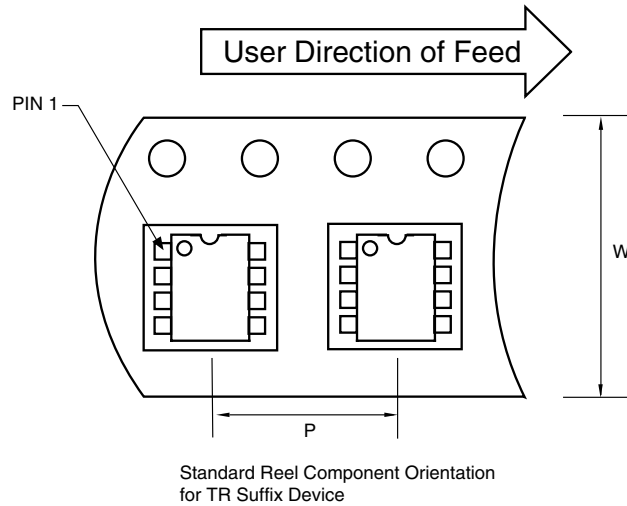
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

Package marking data not available at this time.

### 6.2 Taping Form

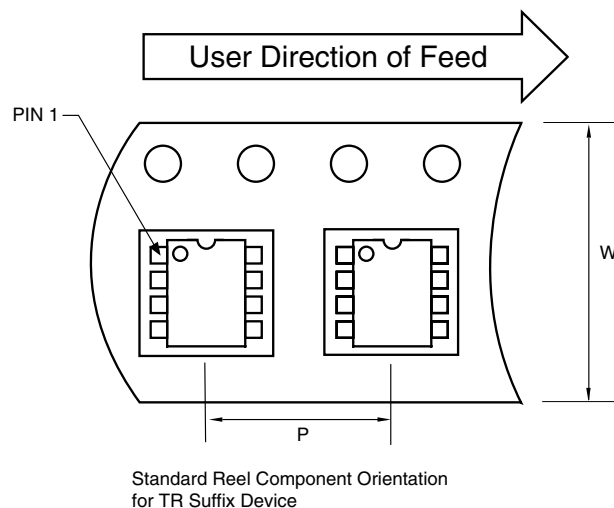
#### Component Taping Orientation for 8-Pin MSOP Devices



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

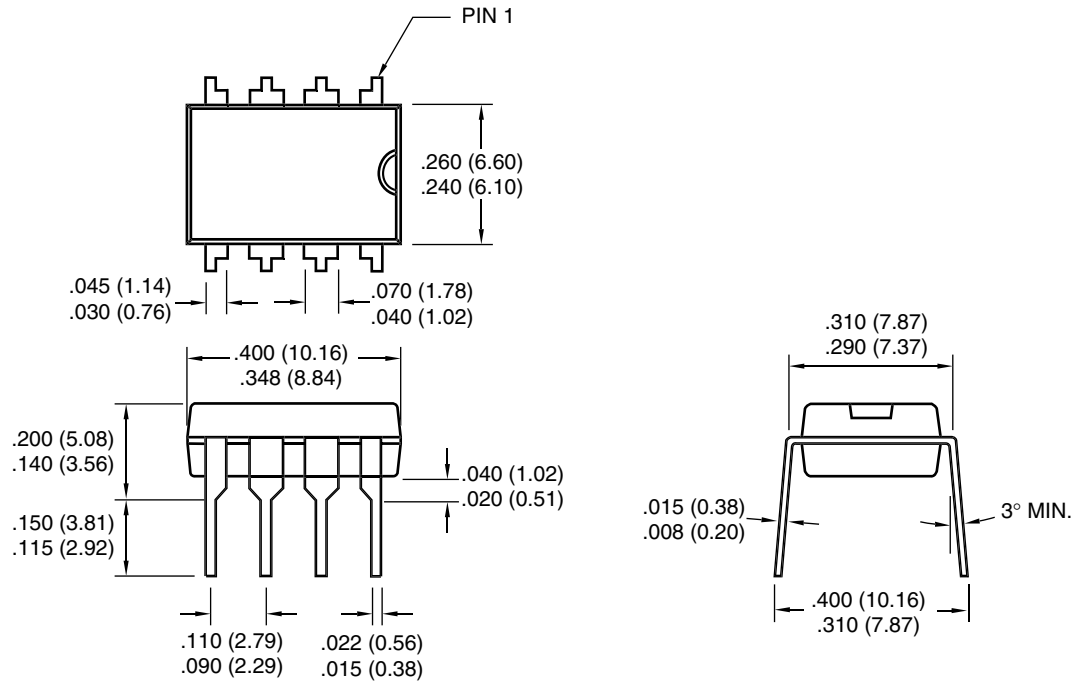


Carrier Tape, Number of Components Per Reel and Reel Size

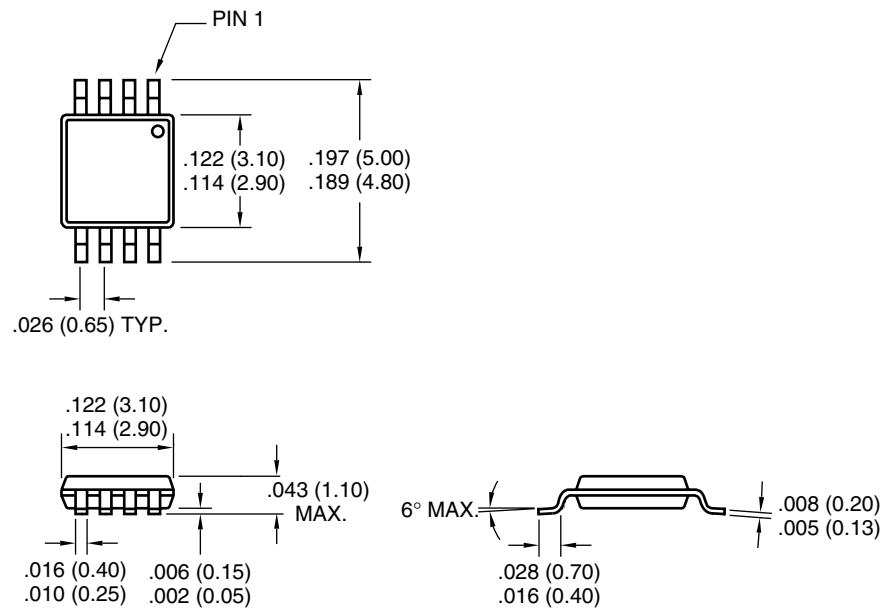
Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

## 6.3 Package Dimensions

### 8-Pin Plastic DIP

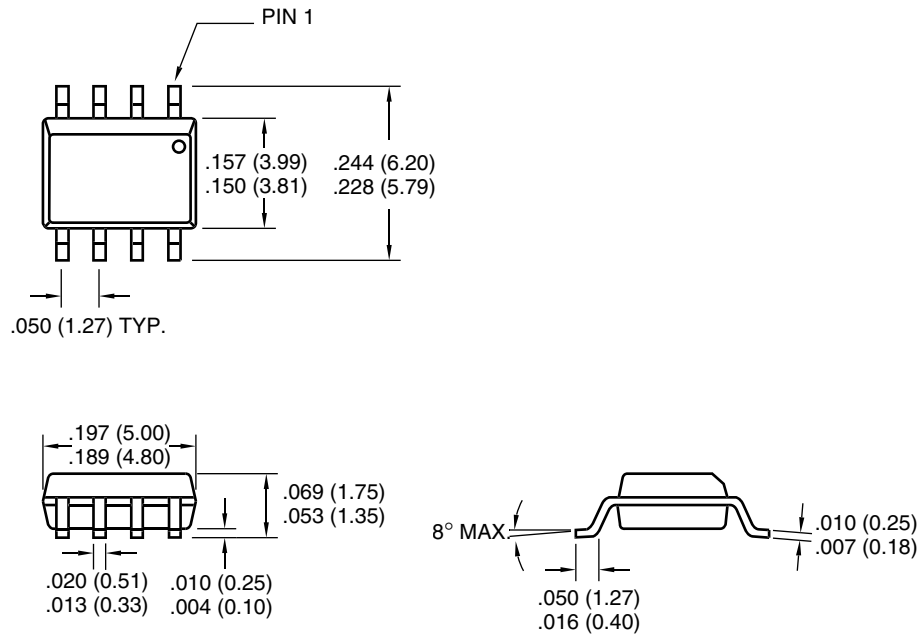


### 8-Pin MSOP



## 6.3 Package Dimensions (Continued)

### 8-Pin SOIC



Dimensions: inches (mm)

NOTES:

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# TC1025

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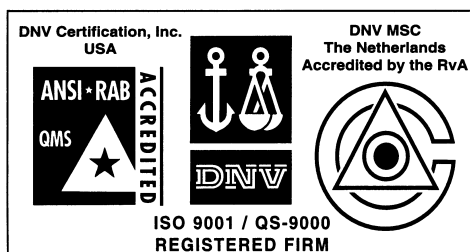
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