

## LM397

# Single General Purpose Voltage Comparator

## General Description

The LM397 is a single voltage comparator with an input common mode that includes ground. The LM397 is designed to operate from a single 5V to 30V power supply or a split power supply. Its low supply current is virtually independent of the magnitude of the supply voltage.

The LM397 features an open collector output stage. This allows the connection of an external resistor at the output. The output can directly interface with TTL, CMOS and other logic levels, by tying the resistor to different voltage levels (level translator).

The LM397 is available in space saving 5-Pin SOT23 package and pin compatible to TI's TL331, single differential comparator.

## Features

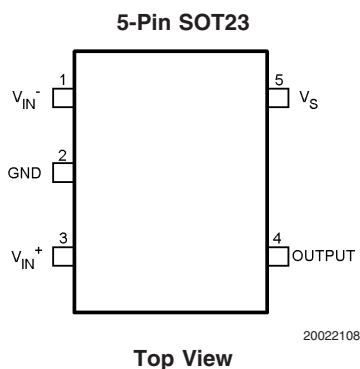
( $T_A = 25^\circ\text{C}$ . Typical values unless otherwise specified).

- 5-Pin SOT23 package
- Industrial operating range  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$
- Single or dual power supplies
- Wide supply voltage range 5V to 30V
- Low supply current  $300\mu\text{A}$
- Low input bias current  $7\text{nA}$
- Low input offset current  $\pm 1\text{nA}$
- Low input offset voltage  $\pm 2\text{mV}$
- Response time 440ns (50mV overdrive)
- Input common mode voltage 0 to  $V_S - 1.5\text{V}$

## Applications

- A/D converters
- Pulse, square wave generators
- Peak detector
- Industrial applications

## Connection Diagram



## Typical Circuit

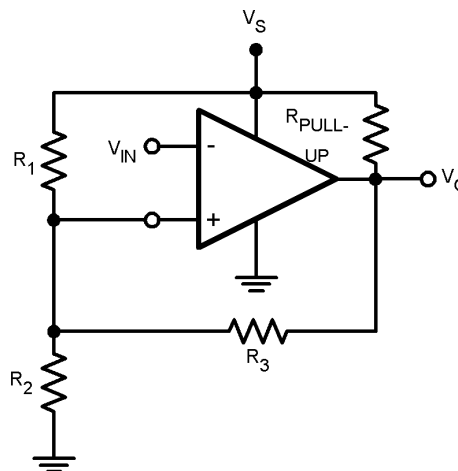


FIGURE 1. Inverting Comparator with Hysteresis

## Ordering Information

| Package      | Part Number | Package Marking | Transport Media        | NSC Drawing |
|--------------|-------------|-----------------|------------------------|-------------|
| 5-Pin SOT-23 | LM397MF     | C397            | 1k Units Tape and Reel | MF05A       |
|              | LM397MFX    |                 | 3k Units Tape and Reel |             |

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

ESD Tolerance (Note 2)

Human Body Model 2KV

Machine Model 200V

$V_{IN}$  Differential 30V

Supply Voltages 30V or  $\pm 15V$

Voltage at Input Pins  $-0.3V$  to 30V

Storage Temperature Range  $-65^{\circ}C$  to  $+150^{\circ}C$

Junction Temperature (Note 3)  $+150^{\circ}C$

Soldering Information

Infrared or Convection (20 sec.)  $235^{\circ}C$

Wave Soldering (10 sec.)  $260^{\circ}C$

**Operating Ratings** (Note 1)

Supply Voltage,  $V_S$  5V to 30V

Temperature Range (Note 3)  $-40^{\circ}C$  to  $+85^{\circ}C$

Package Thermal Resistance (Note 3)

5-Pin SOT23  $168^{\circ}C/W$

**Electrical Characteristics**

Unless otherwise specified, all limits are guaranteed for  $T_A = 25^{\circ}C$ ,  $V_S = 5V$ ,  $V^- = 0V$ ,  $V_{CM} = V^+/2 = V_O$ . **Boldface** limits apply at the temperature extremes.

| Symbol        | Parameter                          | Conditions                                                                         | Min<br>(Note 5) | Typ<br>(Note 4) | Max<br>(Note 5)                              | Units   |
|---------------|------------------------------------|------------------------------------------------------------------------------------|-----------------|-----------------|----------------------------------------------|---------|
| $V_{OS}$      | Input Offset Voltage               | $V_S = 5V$ to $30V$ ,<br>$V_O = 1.4V$ , $V_{CM} = 0V$                              |                 | 2               | 7<br><b>10</b>                               | mV      |
| $I_{OS}$      | Input Offset Current               | $V_O = 1.4V$ , $V_{CM} = 0V$                                                       |                 | 1.6             | 50<br><b>250</b>                             | nA      |
| $I_B$         | Input Bias Current                 | $V_O = 1.4V$ , $V_{CM} = 0V$                                                       |                 | 10              | 250<br><b>400</b>                            | nA      |
| $I_S$         | Supply Current                     | $R_L = \text{Open}$ , $V_S = 5V$                                                   |                 | 0.25            | 0.7                                          | mA      |
|               |                                    | $R_L = \text{Open}$ , $V_S = 30V$                                                  |                 | 0.30            | 2                                            |         |
| $I_O$         | Output Sink Current                | $V_{IN^+} = 1V$ , $V_{IN^-} = 0V$ , $V_O = 1.5V$                                   | 6               | 13              |                                              | mA      |
| $I_{LEAKAGE}$ | Output Leakage Current             | $V_{IN^+} = 1V$ , $V_{IN^-} = 0V$ , $V_O = 5V$                                     |                 | 0.1             |                                              | nA      |
|               |                                    | $V_{IN^+} = 1V$ , $V_{IN^-} = 0V$ , $V_O = 30V$                                    |                 | 1               |                                              | $\mu A$ |
| $V_{OL}$      | Output Voltage Low                 | $I_O = -4mA$ , $V_{IN^+} = 0V$ , $V_{IN^-} = 1V$                                   |                 | 180             | 400<br><b>700</b>                            | mV      |
| $V_{CM}$      | Common-Mode Input Voltage Range    | $V_S = 5V$ to $30V$ (Note 6)                                                       | 0<br><b>0</b>   |                 | $V_S - 1.5V$<br><b><math>V_S - 2V</math></b> | V       |
| $A_V$         | Voltage Gain                       | $V_S = 15V$ , $V_O = 1.4V$ to $11.4V$ ,<br>$R_L \geq 15k\Omega$ connected to $V_S$ |                 | 120             |                                              | V/mV    |
| $t_{PHL}$     | Propagation Delay<br>(High to Low) | Input Overdrive = 5mV<br>$R_L = 5.1k\Omega$ connected to 5V, $C_L = 15pF$          |                 | 900             |                                              | ns      |
|               |                                    | Input Overdrive = 50mV<br>$R_L = 5.1k\Omega$ connected to 5V, $C_L = 15pF$         |                 | 250             |                                              |         |
| $t_{PLH}$     | Propagation Delay<br>(Low to High) | Input Overdrive = 5mV<br>$R_L = 5.1k\Omega$ connected to 5V, $C_L = 15pF$          |                 | 940             |                                              | $\mu s$ |
|               |                                    | Input Overdrive = 50mV<br>$R_L = 5.1k\Omega$ connected to 5V, $C_L = 15pF$         |                 | 440             |                                              | ns      |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

**Note 2:** Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC)

Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

**Note 3:** The maximum power dissipation is a function of  $T_{J(MAX)}$ ,  $\theta_{JA}$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(MAX)} - T_A) / \theta_{JA}$ . All numbers apply for packages soldered directly onto a PC board.

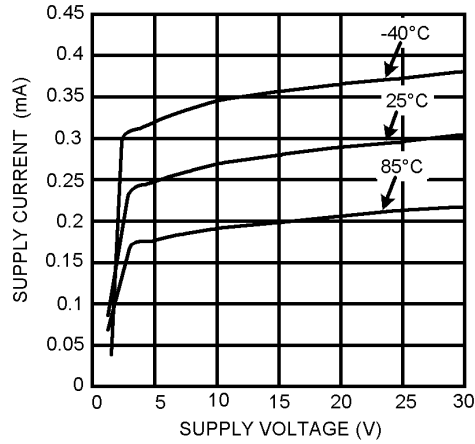
**Note 4:** Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

**Note 5:** All limits are guaranteed by testing or statistical analysis.

**Note 6:** The input common-mode voltage of either input should not be permitted to go below the negative rail by more than 0.3V. The upper end of the common-mode voltage range is  $V_S - 1.5V$  at  $25^{\circ}C$ .

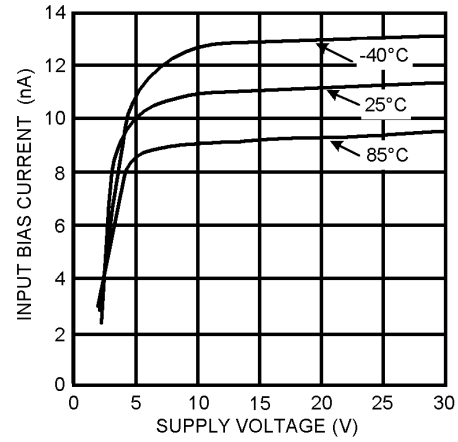
# Typical Performance Characteristics $T_A = 25^\circ\text{C}$ . Unless otherwise specified.

## Supply Current vs. Supply Voltage



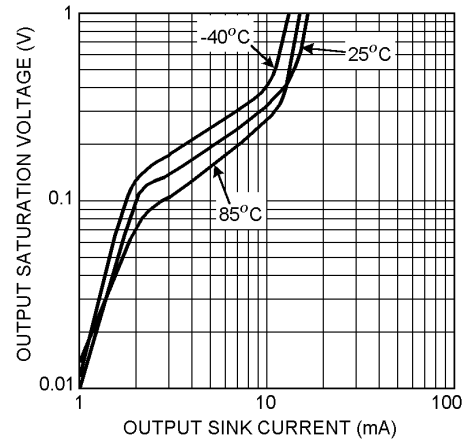
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## Input Bias Current vs. Supply Current



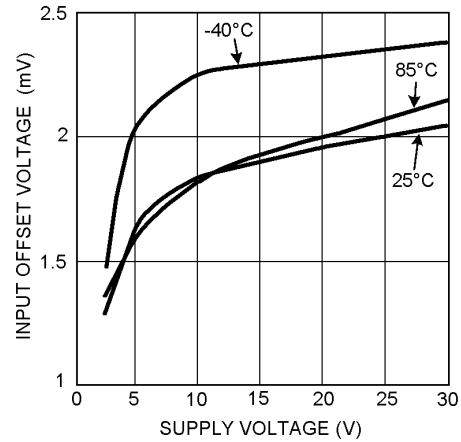
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## Output Saturation Voltage vs. Output Sink Current



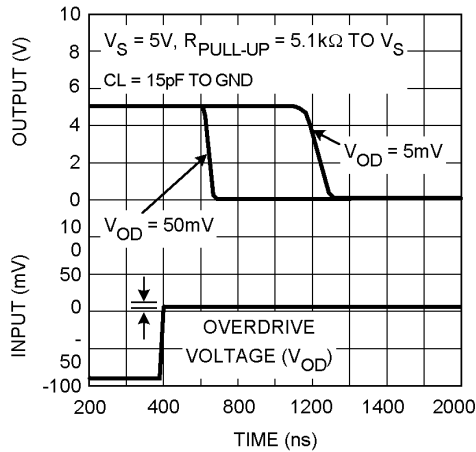
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## Input Offset Voltage vs. Supply Voltage



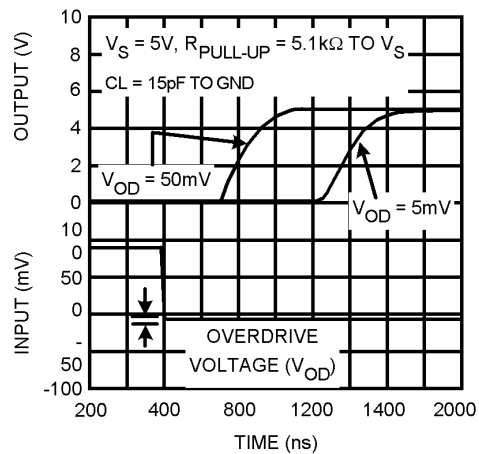
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## Response Time for Various Input Overdrives – $t_{PLH}$



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## Response Time for Various Input Overdrives – $t_{PLH}$



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## Application Notes

### Basic Comparators

A comparator is quite often used to convert an analog signal to a digital signal. The comparator compares an input voltage ( $V_{IN}$ ) at the non-inverting pin to the reference voltage ( $V_{REF}$ ) at the inverting pin. If  $V_{IN}$  is less than  $V_{REF}$ , the output ( $V_O$ ) is low ( $V_{OL}$ ). However, if  $V_{IN}$  is greater than  $V_{REF}$ , the output voltage ( $V_O$ ) is high ( $V_{OH}$ ). Refer to Figure 2.

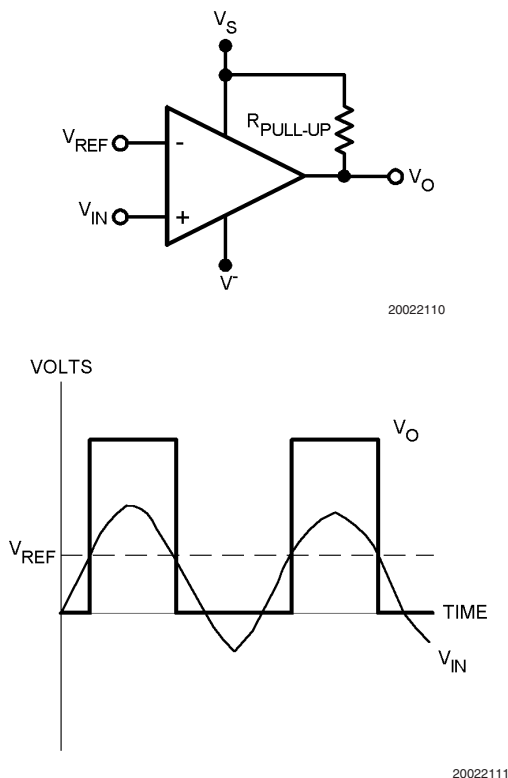


FIGURE 2. Basic Comparator

### Hysteresis

The basic comparator configuration may oscillate or produce a noisy output if the applied differential input is near the comparator's input offset voltage. This tends to occur when the voltage on the input is equal or very close to the other input voltage. Adding hysteresis can prevent this problem. Hysteresis creates two switching thresholds (one for the rising input voltage and the other for the falling input voltage). Hysteresis is the voltage difference between the two switching thresholds. When both inputs are nearly equal, hysteresis causes one input to effectively move quickly pass the other. Thus, effectively moving the input out of region that oscillation may occur.

For an inverting configured comparator, hysteresis can be added with a three resistor network and positive feedback.

When input voltage ( $V_{IN}$ ) at the inverting node is less than non-inverting node ( $V_T$ ), the output is high. The equivalent circuit for the three resistor network is  $R_1$  in parallel with  $R_3$  and in series with  $R_2$ . The lower threshold voltage  $V_{T1}$  is calculated by:

$$V_{T1} = ((V_S R_2) / (((R_1 R_3) / (R_1 + R_3)) + R_2))$$

When  $V_{IN}$  is greater than  $V_T$ , the output voltage is low. The equivalent circuit for the three resistor network is  $R_2$  in parallel with  $R_3$  and in series with  $R_1$ . The upper threshold voltage  $V_{T2}$  is calculated by:

$$V_{T2} = V_S ((R_2 R_3) / (R_2 + R_3)) / (R_1 + ((R_2 R_3) / (R_2 + R_3)))$$

The hysteresis is defined as

$$\Delta V_{IN} = V_{T1} - V_{T2}$$

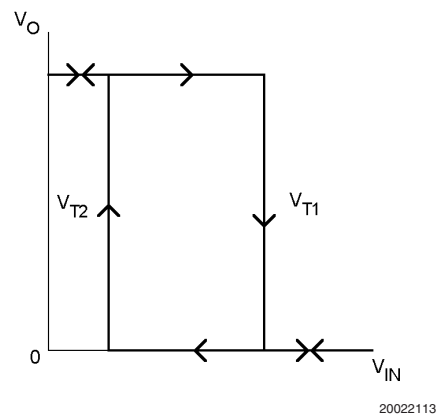
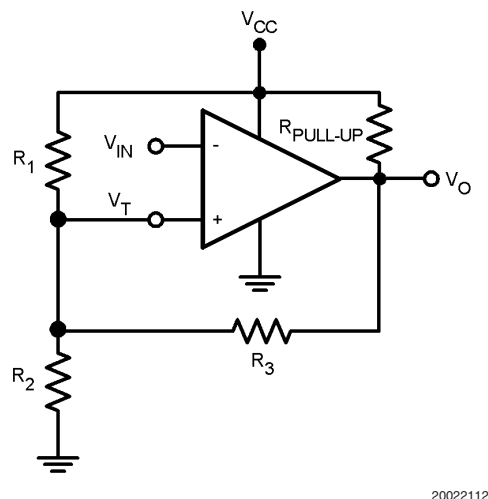


FIGURE 3. Inverting Configured Comparator – LM397

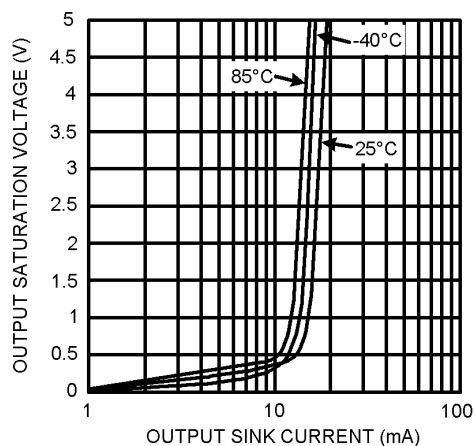
## Application Notes (Continued)

### Input Stage

The LM397 has a bipolar input stage. The input common mode voltage range is from 0 to ( $V_S - 1.5V$ ).

### Output Stage

The LM397 has an open collector grounded-emitter NPN output transistor for the output stage. This requires an external pull-up resistor connected between the positive supply voltage and the output. The external pull-up resistor should be high enough resistance so to avoid excessive power dissipation. In addition, the pull-up resistor should be low enough resistance to enable the comparator to switch with the load circuitry connected. Because it is an open collector output stage, several comparator outputs can be connected together to create an OR'ing function output. With an open collector, the output can be used as a simple SPST switch to ground. The amount of current which the output can sink is approximately 10mA. When the maximum current limit is reached, the output transistor will saturate and the output will rise rapidly (*Figure 4*).



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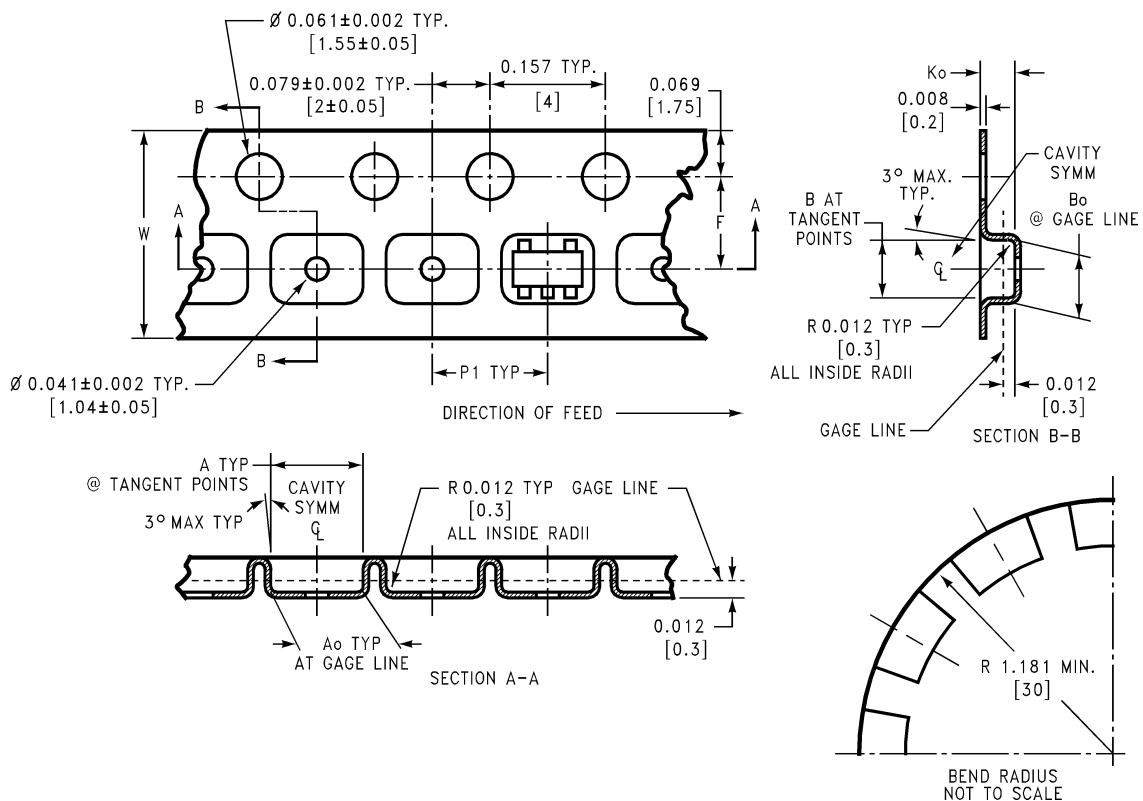
**FIGURE 4. Output Saturation Voltage vs. Output Sink Current**

# SOT23-5 Tape and Reel Specification

## Tape Format

| Tape Section       | # Cavities | Cavity Status | Cover Tape Status |
|--------------------|------------|---------------|-------------------|
| Leader (Start End) | 0 (min)    | Empty         | Sealed            |
|                    | 75 (min)   | Empty         | Sealed            |
| Carrier            | 3000       | Filled        | Sealed            |
|                    | 1000       | Filled        | Sealed            |
| Trailer (Hub End)  | 125 (min)  | Empty         | Sealed            |
|                    | 0 (min)    | Empty         | Sealed            |

## TAPE DIMENSIONS

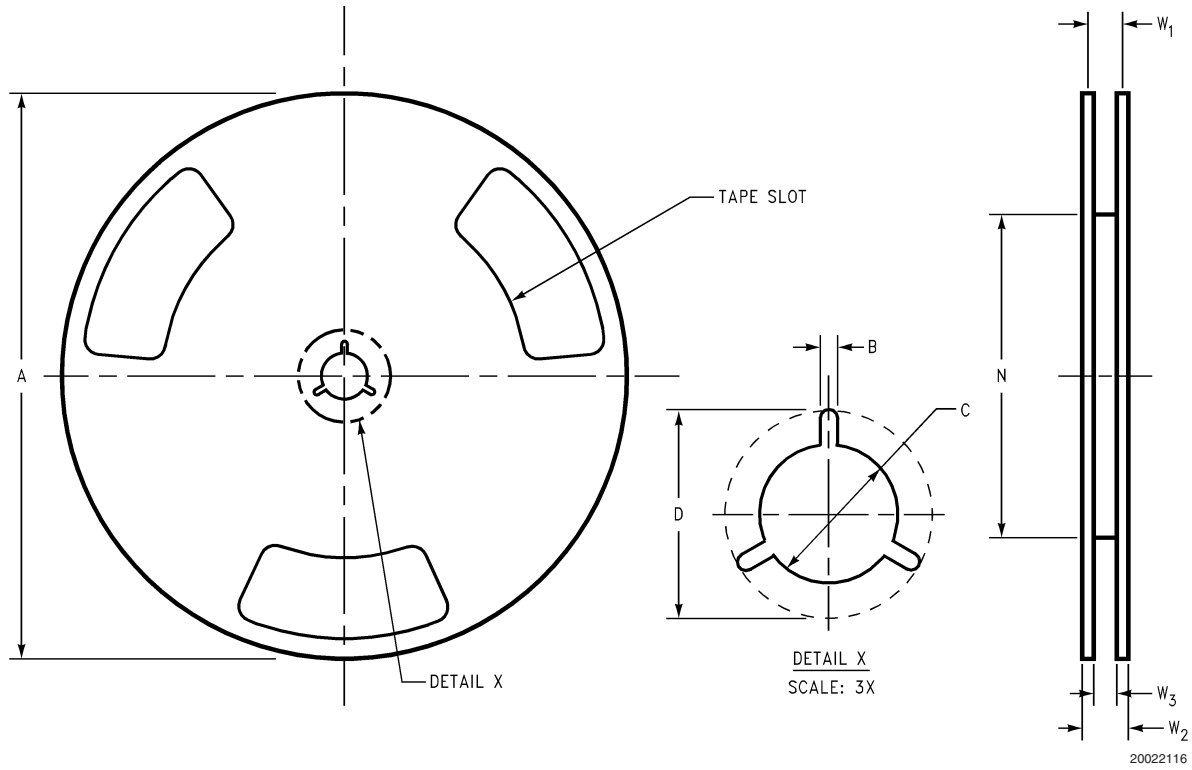


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|           |                |                 |                |                |                                       |                                       |              |                                    |
|-----------|----------------|-----------------|----------------|----------------|---------------------------------------|---------------------------------------|--------------|------------------------------------|
| 8mm       | 0.130<br>(3.3) | 0.124<br>(3.15) | 0.130<br>(3.3) | 0.126<br>(3.2) | $0.138 \pm 0.002$<br>(3.5 $\pm$ 0.05) | $0.055 \pm 0.004$<br>(1.4 $\pm$ 0.11) | 0.157<br>(4) | $0.315 \pm 0.012$<br>(8 $\pm$ 0.3) |
| Tape Size | DIM A          | DIM Ao          | DIM B          | DIM Bo         | DIM F                                 | DIM Ko                                | DIM P1       | DIM W                              |

# SOT23-5 Tape and Reel Specification (Continued)

## REEL DIMENSIONS



|           |                |               |                |                |                |                                           |                |                                      |
|-----------|----------------|---------------|----------------|----------------|----------------|-------------------------------------------|----------------|--------------------------------------|
| 8mm       | 7.00<br>330.00 | 0.059<br>1.50 | 0.512<br>13.00 | 0.795<br>20.20 | 2.165<br>55.00 | 0.331 + 0.059/-0.000<br>8.40 + 1.50/-0.00 | 0.567<br>14.40 | W1 + 0.078/-0.039<br>W1 + 2.00/-1.00 |
| Tape Size | A              | B             | C              | D              | N              | W1                                        | W2             | W3                                   |

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