



June 2001

# 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 SOT23-5 package and pin compatible to TI's TL331, single differential comparator.

### Features

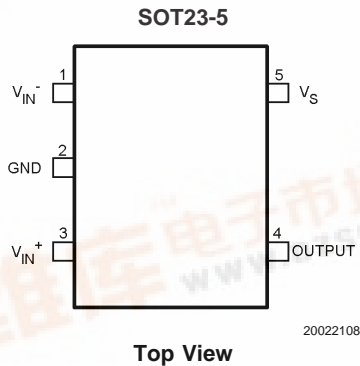
( $T_A = 25^\circ\text{C}$ . Typical values unless otherwise specified).

- SOT23-5 package
- Industrial operating range -40°C to +85°C
- Single or dual power supplies
- Wide supply voltage range 5V to 30V
- Low supply current 300µA
- Low input bias current 7nA
- Low input offset current ±1nA
- Low input offset voltage ±2mV
- Response time 440ns (50mV overdrive)
- Input common mode voltage 0 to  $V_S - 1.5V$

### Applications

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

### Connection Diagram



### Typical Circuit

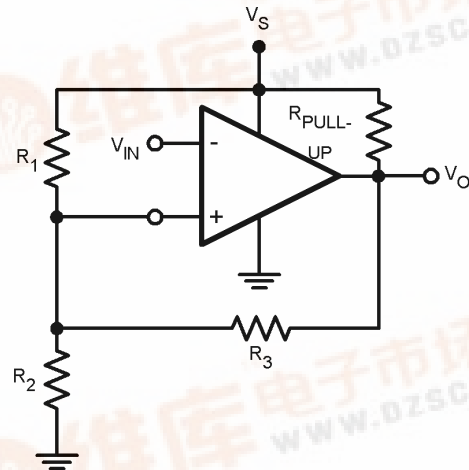


FIGURE 1. Inverting Comparator with Hysteresis

### 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	
Human Body Model	2KV (Note 2)
Machine Model	200V (Note 3)
$V_{IN}$ Differential	30V
Supply Voltages	30V or $\pm 15V$
Voltage at Input Pins	-0.3V to 30V
Storage Temperature Range	-65°C to +150°C

Junction Temperature (Note 4)	+150°C
Soldering Information	
Infrared or Convection (20 sec.)	235°C
Wave Soldering (10 sec.)	260°C

**Operating Ratings** (Note 1)

Supply Voltage, $V_S$	5V to 30V
Junction Temperature Range (Note 4)	-40°C to +85°C
Package Thermal Resistance (Note 4)	
SOT23-5	168°C/W

**Electrical Characteristics**

Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V_S = 5V$ . **Bold-face** limits apply at temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$V_{OS}$	Input Offset Voltage	$V_S = 5V$ to 30V, $V_O = 1.4V$ , $V_{CM} = 0V$		2	7 <b>10</b>	mV
$I_{OS}$	Input Offset Current	$V_O = 1.4V$ , $V_{CM} = 0V$		1.6	50 <b>250</b>	nA
$I_B$	Input Bias Current	$V_O = 1.4V$ , $V_{CM} = 0V$		10	250 <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		$\mu\text{A}$
$V_{OL}$	Output Voltage Low	$I_O = -4\text{mA}$ , $V_{IN^+} = 0V$ , $V_{IN^-} = 1V$		180	400 <b>700</b>	mV
$V_{CM}$	Common-Mode Input Voltage Range	$V_S = 5V$ to 30V (Note 7)	$V_S - 1.5V$ <b><math>V_S - 2V</math></b>		0 <b>0</b>	V

**Electrical Characteristics** Unless otherwise specified, all limits guaranteed for at  $T_J = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ .  
**Boldface** limits apply at temperature extremes. (Continued)

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$A_V$	Voltage Gain	$V_S = 15\text{V}$ , $V_O = 1.4\text{V}$ to $11.4\text{V}$ , $R_L > = 15\text{k}\Omega$ connected to $V_S$		120		V/mV
$t_{PHL}$	Propagation Delay (High to Low)	Input Overdrive = 5mV $R_L = 5.1\text{k}\Omega$ connected to 5V, $C_L = 15\text{pF}$		900		ns
		Input Overdrive = 50mV $R_L = 5.1\text{k}\Omega$ connected to 5V, $C_L = 15\text{pF}$		250		
$t_{PLH}$	Propagation Delay (Low to High)	Input Overdrive = 5mV $R_L = 5.1\text{k}\Omega$ connected to 5V, $C_L = 15\text{pF}$		940		$\mu\text{s}$
		Input Overdrive = 50mV $R_L = 5.1\text{k}\Omega$ connected to 5V, $C_L = 15\text{pF}$		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,  $1.5\text{k}\Omega$  in series with  $100\text{pF}$ .

**Note 3:** Machine model,  $0\Omega$  in series with  $200\text{pF}$ .

**Note 4:** The maximum power dissipation is a function of  $T_{J(\text{MAX})}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(\text{MAX})} - T_A) / \theta_{JA}$ . All numbers apply for packages soldered directly onto a PC board.

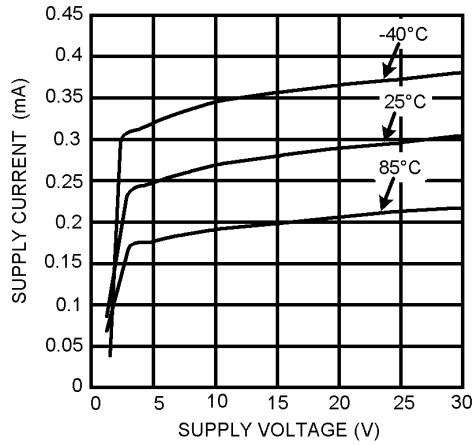
**Note 5:** Typical values represent the most likely parametric norm.

**Note 6:** All limits are guaranteed by testing or statistical analysis.

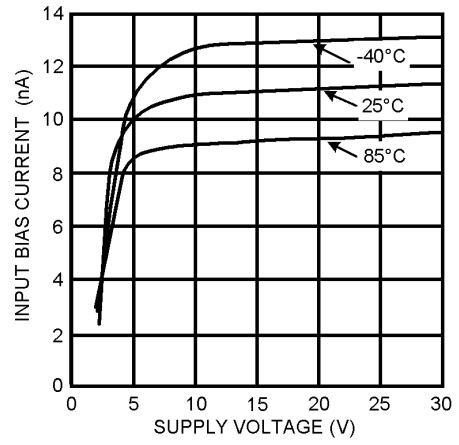
**Note 7:** The input common-mode voltage of either input should not be permitted to go below the negative rail by more than  $0.3\text{V}$ . The upper end of the common-mode voltage range is  $V_S - 1.5\text{V}$  at  $25^\circ\text{C}$ .

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

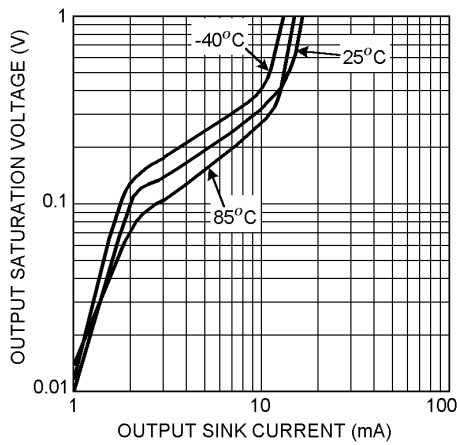
Supply Current vs. Supply Voltage



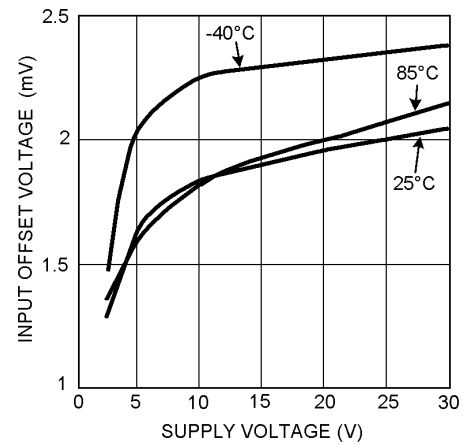
Input Bias Current vs. Supply Current



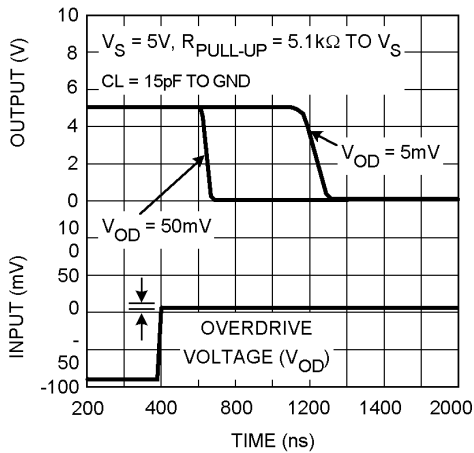
Output Saturation Voltage vs. Output Sink Current



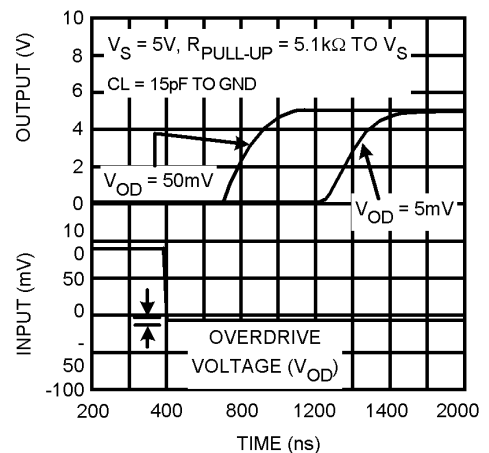
Input Offset Voltage vs. Supply Voltage



Response Time for Various Input Overdrives –  $t_{PHL}$



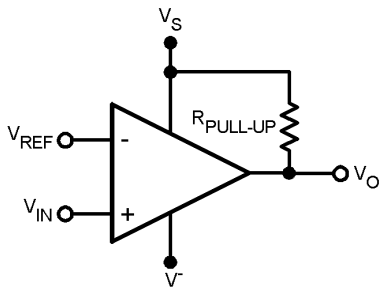
Response Time for Various Input Overdrives –  $t_{PLH}$



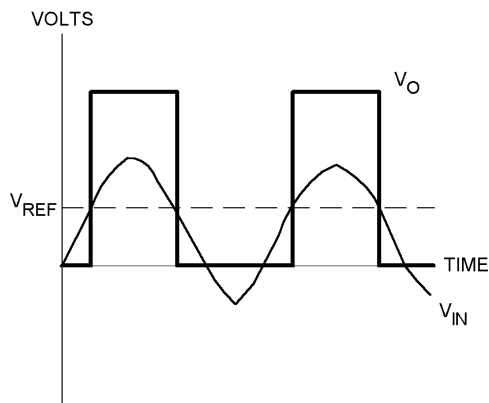
## Application Notes

### 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*.



20022110



20022111

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:

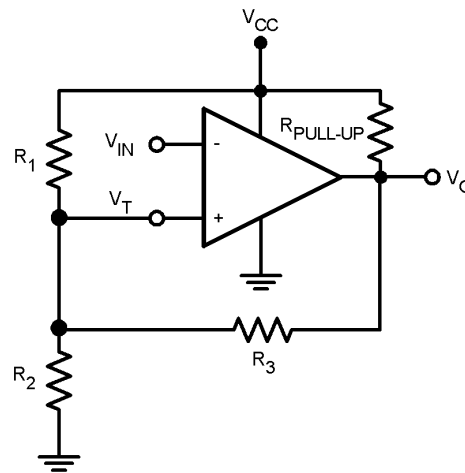
$$V_{T1} = ((V_S R_2) / (((R_1 R_3) / (R_1 + R_3)) + R_2))$$

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:

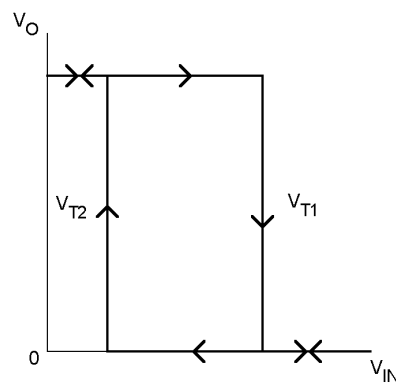
$$V_{T2} = V_S ((R_2 R_3) / (R_2 + R_3)) / (R_1 + ((R_2 R_3) / (R_2 + R_3)))$$

The hysteresis is defined as

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



20022112



20022113

FIGURE 3. Inverting Configured Comparator – LM397

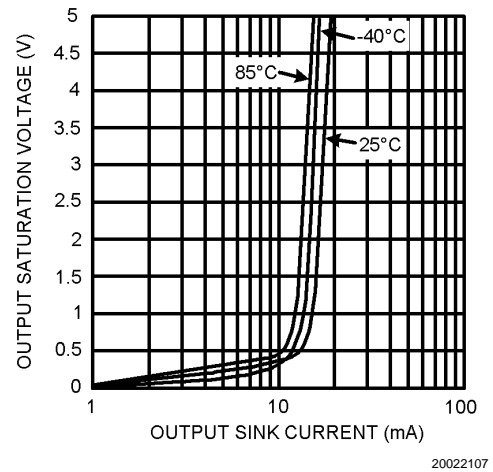
## Application Notes (Continued)

### 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*).



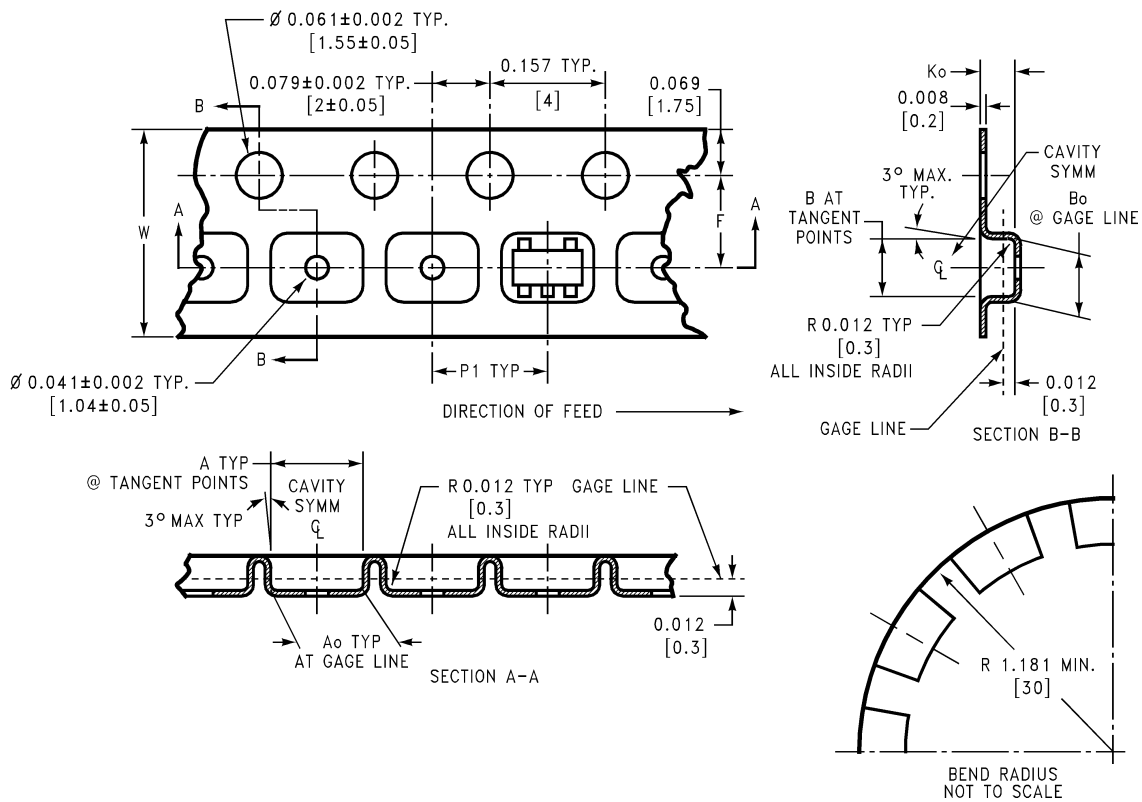
**FIGURE 4. Output Saturation Voltage vs. Output Sink Current**

# 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

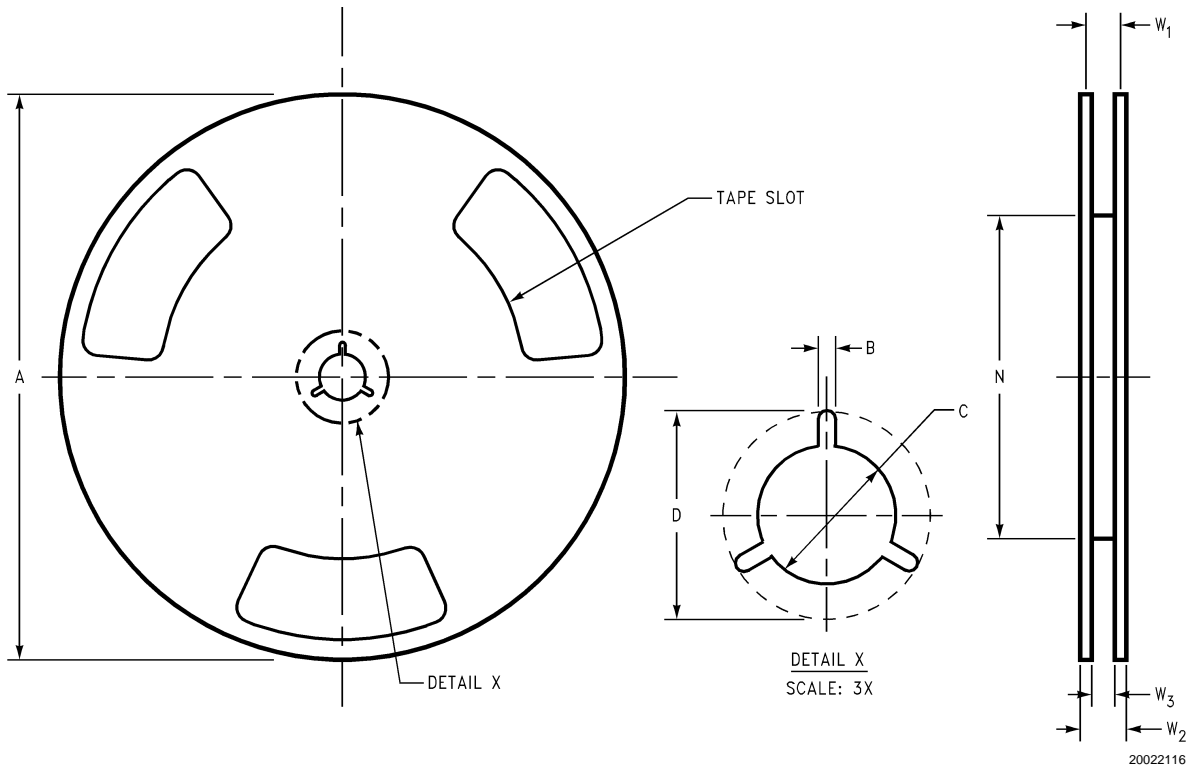


20022115

8mm	0.130 (3.3)	0.124 (3.15)	0.130 (3.3)	0.126 (3.2)	$0.138 \pm 0.002$ ( $3.5 \pm 0.05$ )	$0.055 \pm 0.004$ ( $1.4 \pm 0.11$ )	0.157 (4)	$0.315 \pm 0.012$ ( $8 \pm 0.3$ )
Tape Size	DIM A	DIM A <sub>0</sub>	DIM B	DIM B <sub>0</sub>	DIM F	DIM K <sub>0</sub>	DIM P1	DIM W

# SOT23-5 Tape and Reel Specification (Continued)

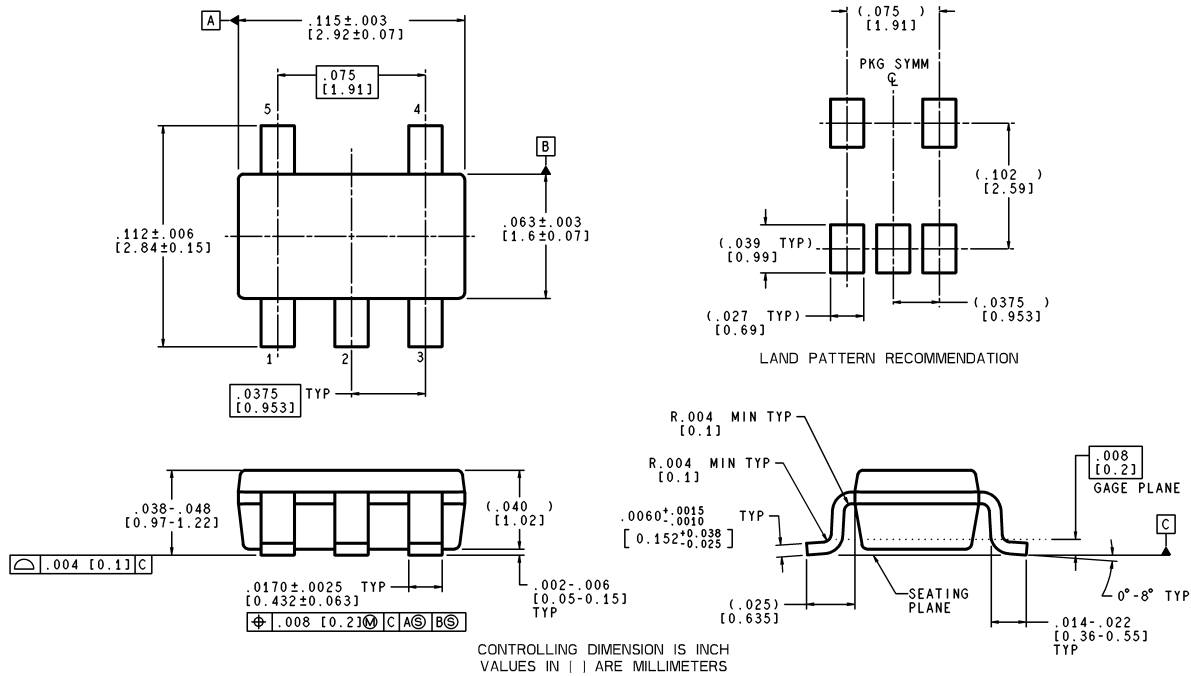
## REEL DIMENSIONS



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



**Physical Dimensions** inches (millimeters) unless otherwise noted



**5-Pin SOT23**  
**NS Package Number MF05A**

MF05A (Rev A)

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

**National Semiconductor Corporation**  
Americas  
Email: support@nsc.com

**National Semiconductor Europe**  
Fax: +49 (0) 180-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 69 9508 6208  
English Tel: +44 (0) 870 24 0 2171  
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor Asia Pacific Customer Response Group**  
Tel: 65-2544466  
Fax: 65-2504466  
Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507

www.national.com