# **LM397**

LM397 Single General Purpose Voltage Comparator



Literature Number: SNOS977C



### 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

### **Features**

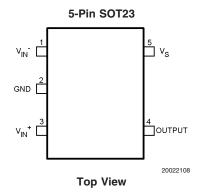
(T<sub>A</sub> = 25°C. Typical values unless otherwise specified).

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

## **Applications**

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

## **Connection Diagram**



# **Typical Circuit**

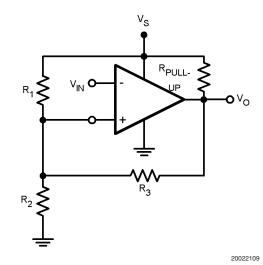


FIGURE 1. Inverting Comparator with Hysteresis

# **Ordering Information**

Package	Part Number	Package Marking	Transport Media	NSC Drawing	
5-Pin SOT-23	LM397MF	C397	1k Units Tape and Reel	MF05A	
	LM397MFX	0397	3k Units Tape and Reel	WIFUSA	

## **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<sub>IN</sub> Differential 30V

Supply Voltages 30V or ±15V Voltage at Input Pins -0.3V to 30V

Storage Temperature Range -65°C to +150°C

Junction Temperature (Note 3) +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

Temperature Range (Note 3) -40°C to +85°C

Package Thermal Resistance (Note 3)

5-Pin SOT23 168°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	Тур	Max	Units
			(Note 5)	(Note 4)	(Note 5)	
Vos	Input Offset Voltage	$V_S = 5V$ to 30V,		2	7	mV
		$V_{O} = 1.4V, V_{CM} = 0V$			10	
Ios	Input Offset Current	$V_{\rm O} = 1.4 V, V_{\rm CM} = 0 V$		1.6	50	nA
					250	
$I_B$	Input Bias Current	$V_{\rm O} = 1.4 V, V_{\rm CM} = 0 V$		10	250	nA
					400	
Is	Supply Current	$R_L = Open, V_S = 5V$		0.25	0.7	mA
		$R_L = Open, V_S = 30V$		0.30	2	ША
Io	Output Sink Current	$V_{IN^{+}} = 1V, V_{IN^{-}} = 0V, V_{O} = 1.5V$	6	13		mA
I <sub>LEAKAGE</sub>	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		μA
V <sub>OL</sub>	Output Voltage Low	$I_{O} = -4\text{mA}, V_{IN^{+}} = 0\text{V}, V_{IN^{-}} = 1\text{V}$		180	400	mV
					700	
V <sub>CM</sub>	Common-Mode Input Voltage	V <sub>S</sub> = 5V to 30V (Note 6)	0		V <sub>S</sub> - 1.5V	V
	Range		0		V <sub>S</sub> - 2V	V
$A_V$	Voltage Gain	$V_S = 15V$ , $V_O = 1.4V$ to 11.4V,		120		V/mV
		$R_L > = 15k\Omega$ connected to $V_S$				
$t_{PHL}$	Propagation Delay	Input Overdrive = 5mV		900		
	(High to Low)	$R_L = 5.1 \text{k}\Omega$ connected to 5V, $C_L = 15 \text{pF}$				ns
		Input Overdrive = 50mV		250		113
		$R_L = 5.1 \text{k}\Omega$ connected to 5V, $C_L = 15 \text{pF}$				
t <sub>PLH</sub>	Propagation Delay	Input Overdrive = 5mV		940		μs
	(Low to High)	$R_L = 5.1 \text{k}\Omega$ connected to 5V, $C_L = 15 \text{pF}$				
		Input Overdrive = 50mV		440		ns
		$R_L = 5.1 \text{k}\Omega$ connected to 5V, $C_L = 15 \text{pF}$				

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.

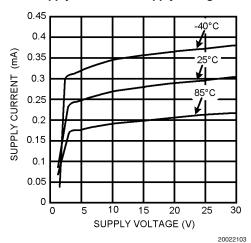
Note 4: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

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

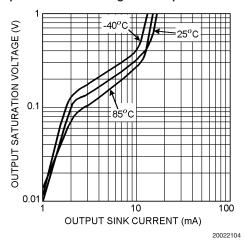
**Note 6:** The input common-mode voltage of either input should not be permitted to go below the negative rail by more than 0.3V. The upper end of the common-mode voltage range is  $V_S - 1.5V$  at  $25^{\circ}C$ .

# Typical Performance Characteristics $T_A = 25$ °C. Unless otherwise specified.

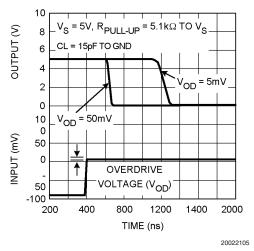
### Supply Current vs. Supply Voltage



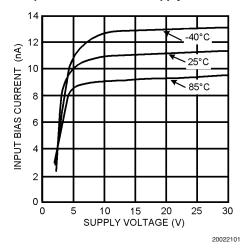
### Output Saturation Voltage vs. Output Sink Current



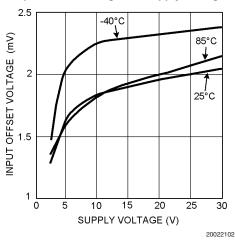
### Response Time for Various Input Overdrives - t<sub>PHL</sub>



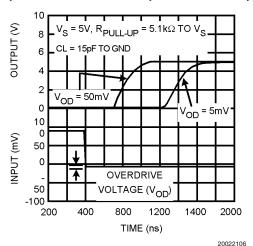
### Input Bias Current vs. Supply Current



Input Offset Voltage vs. Supply Voltage



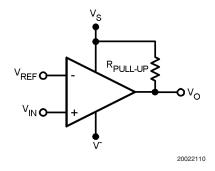
### Response Time for Various Input Overdrives – $t_{\text{PLH}}$



# **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<sub>IN</sub>) at the non-inverting pin to the reference voltage (V<sub>REF</sub>) at the inverting pin. If V<sub>IN</sub> is less than V<sub>REF</sub> the output (V<sub>O</sub>) is low (V<sub>OL</sub>). However, if V<sub>IN</sub> is greater than V<sub>REF</sub>, the output voltage (V<sub>O</sub>) is high (V<sub>OH</sub>). Refer to *Figure 2*.



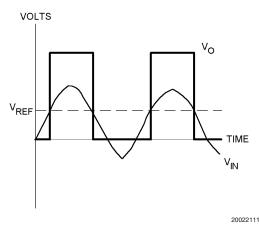


FIGURE 2. Basic Comparator

#### **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:

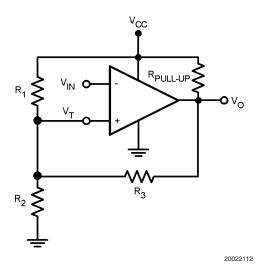
$$V_{T1} = ((V_S R_2) / (((R_1 R_3) / (R_1 + R_3)) + R_2))$$

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

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



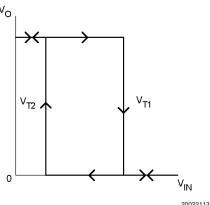


FIGURE 3. Inverting Configured Comparator - LM397

## **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).

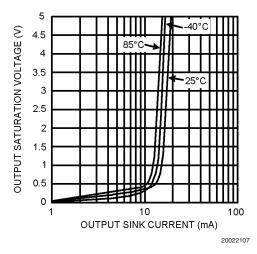


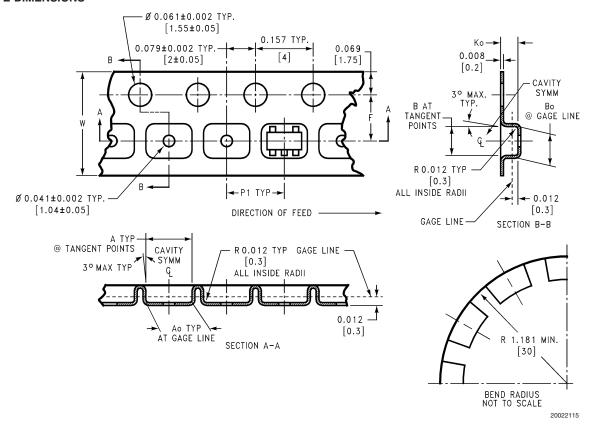
FIGURE 4. Output Saturation Voltage vs. Output Sink Current

# **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	

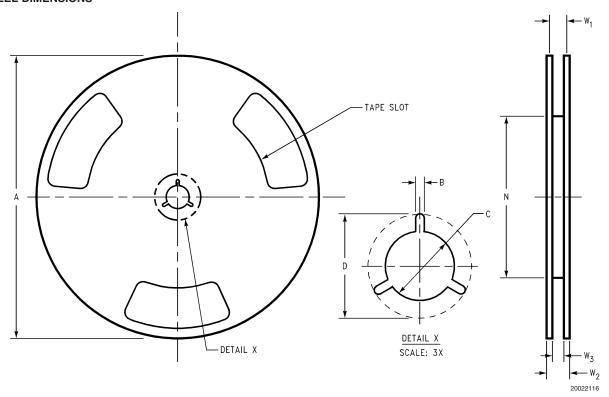
### **TAPE DIMENSIONS**



8mm	0.130	0.124	0.130	0.126	$0.138 \pm 0.002$	$0.055 \pm 0.004$	0.157	0.315 ± 0.012
	(3.3)	(3.15)	(3.3)	(3.2)	$(3.5 \pm 0.05)$	$(1.4 \pm 0.11)$	(4)	$(8 \pm 0.3)$
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)

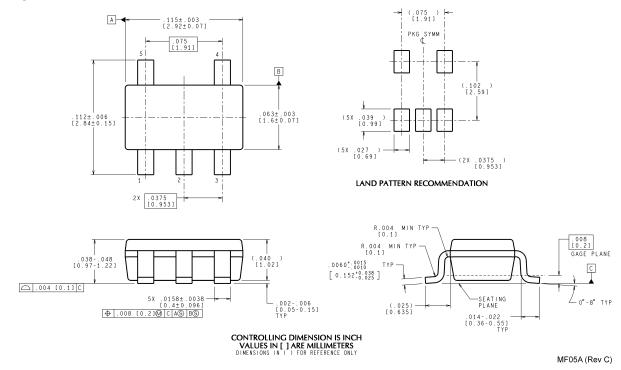
### **REEL DIMENSIONS**



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

7

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



5-Pin SOT23 NS Package Number MF05A

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