LM397 Single General-Purpose Voltage Comparator

Description

The LM397 device is a single voltage comparator with an input common mode that includes ground.
The LM397 is designed to operate from a single 5-V to 30-V 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 the space-saving 5-Pin SOT-23 package and is pin-compatible to TL331, a single differential comparator.

Features

- T_A = 25°C. Typical Values Unless Otherwise Specified.
- 5-Pin SOT-23 Package
- Industrial Operating Range −40°C to +85°C
- Single or Dual Power Supplies
- Wide Supply Voltage Range 5 V to 30 V
- Low Supply Current 300 µA
- Low Input Bias Current 7 nA
- Low Input Offset Current ±1 nA
- Low Input Offset Voltage ±2 mV
- Response Time 440 ns (50-mV Overdrive)
- Input Common-Mode Voltage 0 to VS – 1.5 V

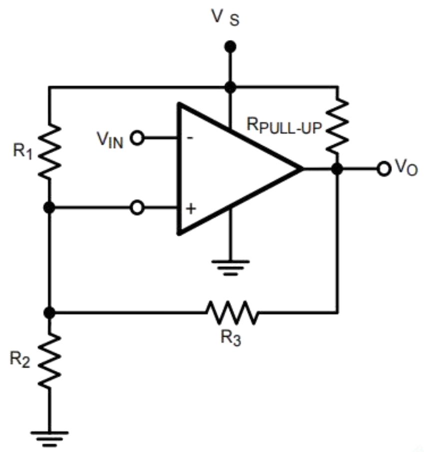
Applications

- A/D Converters
- Pulse, Square-Wave Generators
- Peak Detector
- Industrial Applications

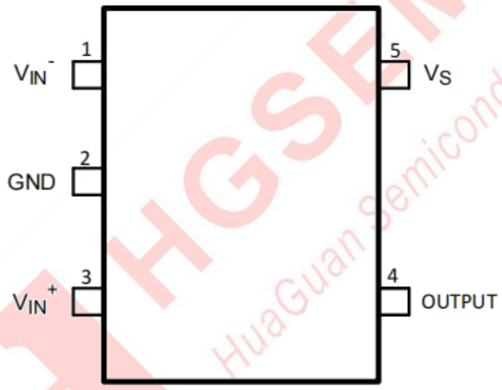
Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
LM397M5/TR	SOT23-5	C397	REEL	3000pcs/Reel

Typical Circuit



Pin Configuration and Functions



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
GND	2	P	Ground
OUTPUT	4	O	Output
V_{IN}+	3	I	Noninverting Input
V_{IN}–	1	I	Inverting Input
V_S	5	P	Supply

Specifications

Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{IN} differential		30	30	V
Supply voltages		±15	30	V
Voltage at input pins		−0.3	30	V
Junction temperature [(2)]			150	°C
Soldering information	Infrared or Convection (20 sec.)		235	°C
	Wave Soldering (10 sec.)		260	°C
Storage Temperature, T_{stg}		−65	150	°C

1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} – T_A)/ R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.

ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)(2)]	±2000	V
		Machine Model[(1)(2)]	±200	

1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
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).

Recommended Operating Conditions

	MIN	MAX	UNIT
Supply voltage, V_S	5	30	V
Temperature [(1)]	−40	85	°C

1) The maximum power dissipation is a function of TJ(MAX), $R_{θJA}$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} – T_A)/ R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.

Thermal Information

THERMAL METRIC(1)		LM397 DBV (SOT-23) 5 PINS	UNIT
RθJA	Junction-to-ambient thermal resistance(2)	186	°C/W
RθJC(top)	Junction-to-case (top) thermal resistance	92.8	°C/W
RθJB	Junction-to-board thermal resistance	38.9	°C/W
ψJT	Junction-to-top characterization parameter	5.6	°C/W

ψJB	Junction-to-board characterization parameter	38.4	°C/W

1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report, SPRA953.
2) The maximum power dissipation is a function of TJ(MAX), RθJA. The maximum allowable power dissipation at any ambient temperature is PD = (TJ(MAX) – TA)/ RθJA . All numbers apply for packages soldered directly onto a PCB.

Electrical Characteristics

Unless otherwise specified, all limits are ensured for TA = 25°C, VS = 5 V, V− = 0 V, VCM = V+/2 = VO.

PARAMETER		TEST CONDITIONS		MIN[1]	TYP[2]	MAX[1]	UNIT
V_{OS}	Input offset voltage	VS = 5 V to 30 V, VO = 1.4 V, VCM = 0 V	TA = 25ºC		2	7	mV
			At the temperature extremes			10	
I_{OS}	Input offset current	VO = 1.4 V, VCM = 0 V	TA = 25ºC		1.6	50	nA
			At the temperature extremes			250	
I_B	Input bias current	VO = 1.4 V, VCM = 0 V	TA = 25ºC		10	250	nA
			At the temperature extremes			400	
I_S	Supply current	RL = open, VS = 5 V			0.25	0.7	mA
		RL = open, VS = 30 V			0.3	2	
I_O	Output sink current	VIN⁺ = 1 V, VIN⁻ = 0 V, VO = 1.5 V		6	13		mA
$I_{LEAKAGE}$	Output leakage current	VIN⁺ = 1 V, VIN⁻ = 0 V, VO = 5 V			0.1		nA
		VIN⁺ = 1 V, VIN⁻ = 0 V, VO = 30 V			1		μA
V_{OL}	Output voltage low	IO = −4 mA, VIN⁺ = 0 V, VIN⁻ = 1 V	TA = 25ºC		180	400	mV
			At the temperature extremes			700	
V_{CM}	Common-mode input voltage range	VS = 5 V to 30 V(3)	TA = 25ºC	0		VS – 1.5	V
			At the temperature extremes	0		VS – 2	
A_V	Voltage gain	VS = 15 V, VO = 1.4 V to 11.4 V, RL > = 15 kΩ connected to VS			120		V/mV
t_{PHL}	Propagation delay (high to low)	Input overdrive = 5 mV RL = 5.1 kΩ connected to 5 V, CL = 15 pF			900		ns
		Input overdrive = 50 mV RL = 5.1 kΩ connected to 5 V, CL = 15 pF			250		
t_{PLH}	Propagation delay (low to high)	Input Overdrive = 5 mV RL = 5.1 kΩ connected to 5 V, CL = 15 pF			940		μs
		Input overdrive = 50 mV RL = 5.1 kΩ connected to 5 V, CL = 15 pF			440		ns

1) All limits are specified by testing or statistical analysis.
2) 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 specified on shipped production material.
3) 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 VS – 1.5 V at 25°C.

Typical Characteristics

T_A = 25°C. Unless otherwise specified.

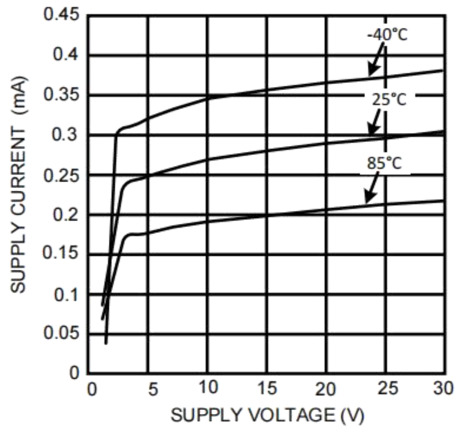


Figure 1. Supply Current vs Supply Voltage

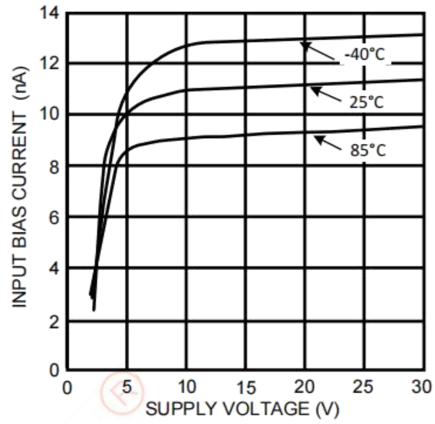


Figure 2. Input Bias Current vs Supply Current

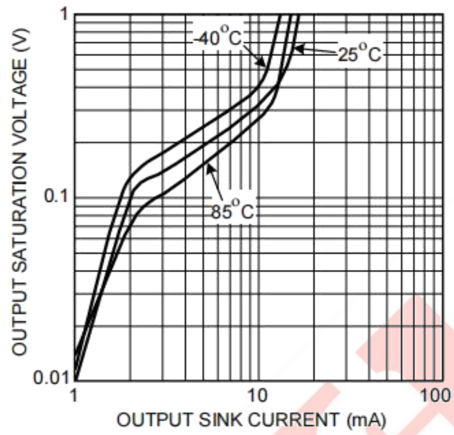


Figure 3. Output Saturation Voltage vs Output Sink Current

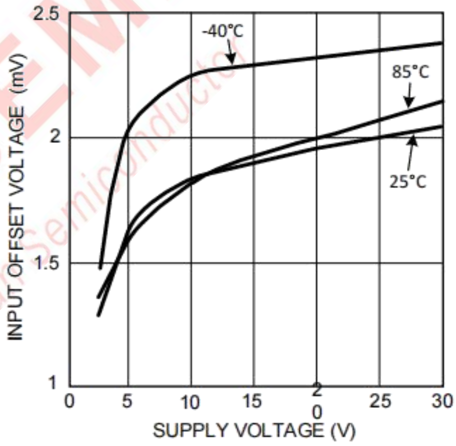


Figure 4. Input Offset Voltage vs Supply Voltage

Detailed Description

Overview

A comparator is often used to convert an analog signal to a digital signal. The comparator compares an input voltage (V_{IN}) at the noninverting pin to the reference voltage (V_{REF}) at the inverting pin. If VIN 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 6.

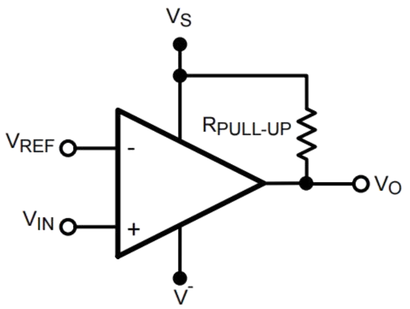


Figure 5. Basic Comparator

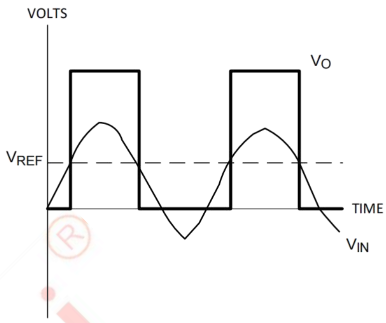
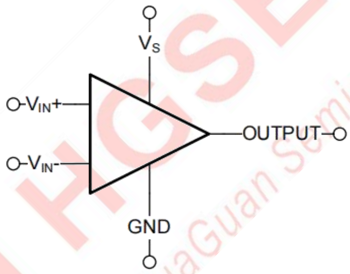


Figure 6. Basic Comparator Output

Functional Block Diagram



Feature Description

Input Stage

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

Output Stage

The LM397 has an open-collector grounded-emitter NPN output transistor for the output stage. This requires an external pullup resistor connected between the positive supply voltage and the output. The external pullup resistor should be high enough resistance so to avoid excessive power dissipation. In addition, the pullup 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 10 mA. When the maximum current limit is reached, the output transistor will saturate and the output will rise rapidly (Figure 7)

Feature Description (continued)

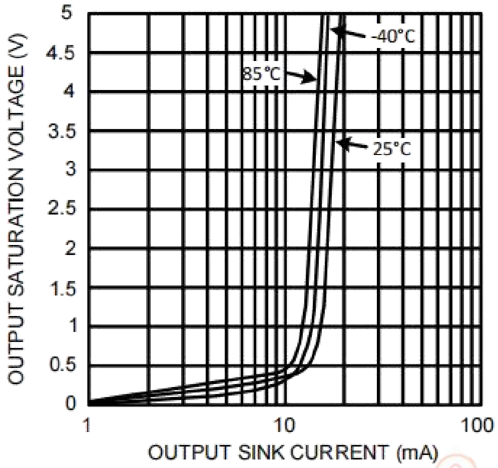


Figure 7. Output Saturation Voltage vs Output Sink Current

Device Functional Modes

Hysteresis

The basic comparator configuration may oscillate or produce a noisy output if the applied differential input is near the input offset voltage of the comparator. 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 (VIN) at the inverting node is less than non-inverting node (VT), the output is high. The equivalent circuit for the three resistor network is R1 in parallel with R3 and in series with R2. The lower threshold voltage VT1 is calculated by Equation 1:

$$V_{T1} = ((V_S R_2) / (((R_1 R_3) / (R_1 + R_3)) + R_2)) \qquad (1)$$

When VIN is greater than VT, the output voltage is low. The equivalent circuit for the three resistor network is R2 in parallel with R3 and in series with R1. The upper threshold voltage VT2 is calculated by Equation 2:

$$V_{T2} = V_S ((R_2 R_3) / (R_2 + R_3)) / (R_1 + ((R_2 R_3) / (R_2 + R_3))) \qquad (2)$$

The hysteresis is defined in Equation 3:

$$\Delta V_{IN} = V_{T1} – V_{T2} \qquad (3)$$

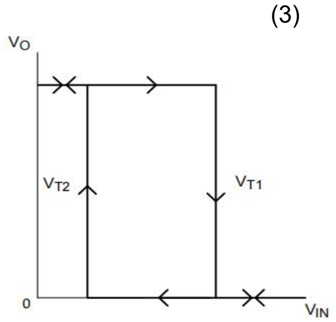


Figure 8. Inverting Configured Comparator - LM397

Application Information

LM397 will typically be used to compare a single signal to a reference or two signals against each other.

Typical Application

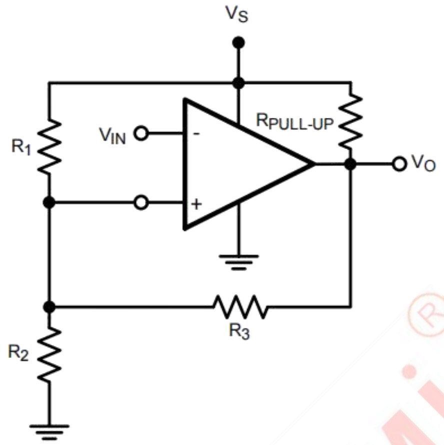


Figure 9. Inverting Comparator With Hysteresis

Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage range	0 V to VS – 1.5 V
Supply voltage	5 V to 30 V
Logic supply voltage(R_{PULLUP} voltage)	5 V to 30 V
Output current (V_{LOGIC}/R_{PULLUP})	1 µA to 20 mA
Input overdrivevoltage	100 mV
Reference voltage	5.5 V

Detailed Design Procedure

When using TL331 in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current

Input Voltage Range

When choosing the input voltage range, the input common mode voltage range (VCM) must be taken in to account. If temperature operation is above or below 25°C the VCM can range from 0 V to VS – 1.5 V. This limits the input voltage range to as high as VS – 1.5 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

Below is a list of input voltage situation and their outcomes:

1. When both IN– and IN+ are both within the common mode range:
   (a) If IN– is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
   (b) If IN– is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
2. When IN– is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
3. When IN+ is higher than common mode and IN– is within common mode, the output is high impedance and the output transistor is not conducting
4. When IN– and IN+ are both higher than common mode, the output is low and the output transistor is sinking current

Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage. To make an accurate comparison; the overdrive voltage should be higher than the input offset voltage. Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive.

Output and Drive Current

Output current is determined by the pullup resistance (R_{PULLUP}) and V_S voltage. The output current will produce a output low voltage (V_{OL}) from the comparator. In which V_{OL} is proportional to the output current. Use Figure 3 to determine V_{OL} based on the output current. The output current can also effect the transient response.

Application Curves

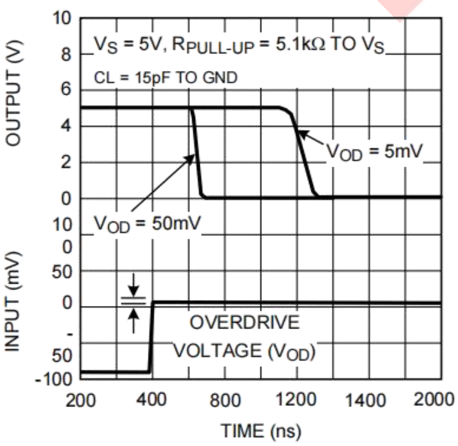


Figure 10.Response Time for Various Input Overdrives-tPHL

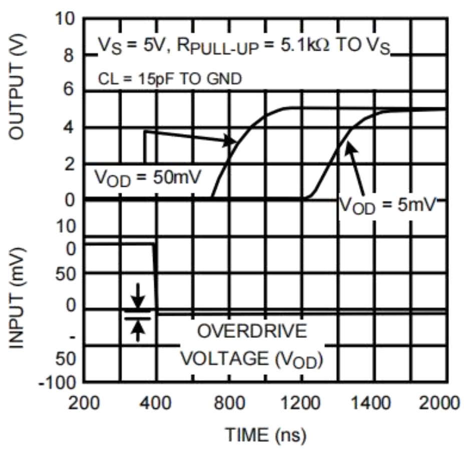
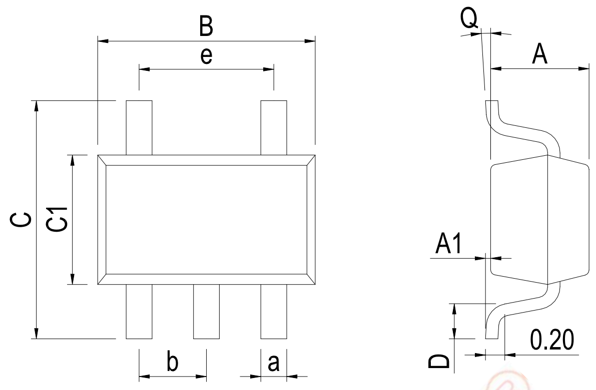


Figure 11. Response Time for Various Input Overdrives-tPLH

Physical Dimensions

SOT23-5



Dimensions In Millimeters(SOT23-5)										
Symbol:	A	A1	B	C	C1	D	Q	a	b	e
Min:	1.05	0.00	2.82	2.65	1.50	0.30	0°	0.30	0.95 BSC	1.90 BSC
Max:	1.15	0.15	3.02	2.95	1.70	0.60	8°	0.40		

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