LM397 Single General Purpose Voltage Comparator

Check for Samples: LM397

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 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

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 SOT-23 package and pin compatible to TI's TL331, single differential comparator.

Connection Diagram

Top View

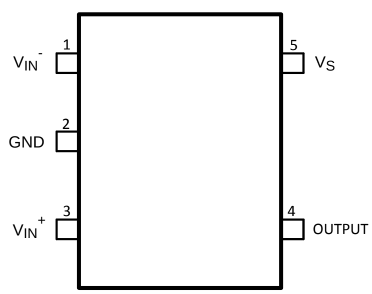

Figure 1. 5-Pin SOT-23 Package
See Package Number DBV0005A

Typical Circuit

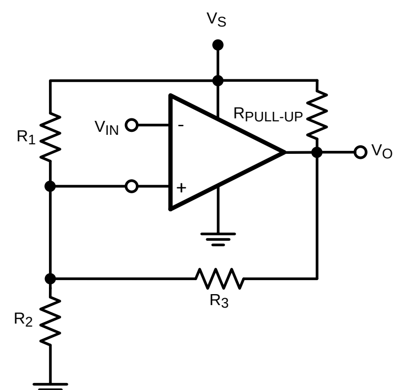

Figure 2. Inverting Comparator with Hysteresis

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[1][2]

ESD Tolerance[3]	Human Body Model	2KV
	Machine Model	200V
V_{IN} 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[4]		+150°C
Soldering Information	Infrared or Convection (20 sec.)	235°C
	Wave Soldering (10 sec.)	260°C

(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 ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) 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).
(4) The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{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.

Operating Ratings[1]

Supply Voltage, V_S		5V to 30V
Temperature Range[2]		−40°C to +85°C
Package Thermal Resistance[2]	5-Pin SOT-23	168°C/W

(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 ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
(2) The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{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.

Electrical Characteristics

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

Parameter		Test Conditions	Min (1)	Typ (2)	Max (1)	Units
V_{OS}	Input Offset Voltage	V_S = 5V to 30V, V_O = 1.4V, V_{CM} = 0V		2	7 **10**	mV
I_{OS}	Input Offset Current	V_O = 1.4V, V_{CM} = 0V		1.6	50 **250**	nA
I_B	Input Bias Current	V_O = 1.4V, V_{CM} = 0V		10	250 **400**	nA
I_S	Supply Current	R_L = Open, V_S = 5V		0.25	0.7	mA
		R_L = 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		µA
V_{OL}	Output Voltage Low	I_O = −4mA, V_{IN}^+ = 0V,V_{IN}^- = 1V		180	400 **700**	mV
V_{CM}	Common-Mode Input Voltage Range	V_S = 5V to 30V (3)	0 **0**		V_S - 1.5V **V_S - 2V**	V
A_V	Voltage Gain	V_S = 15V, V_O = 1.4V to 11.4V, R_L > = 15kΩ connected to V_S		120		V/mV
t_{PHL}	Propagation Delay (High to Low)	Input Overdrive = 5mV R_L = 5.1kΩ connected to 5V, C_L = 15pF		900		ns
		Input Overdrive = 50mV R_L = 5.1kΩ connected to 5V, C_L = 15pF		250		
t_{PLH}	Propagation Delay (Low to High)	Input Overdrive = 5mV R_L = 5.1kΩ connected to 5V, C_L = 15pF		940		µs
		Input Overdrive = 50mV R_L = 5.1kΩ connected to 5V, C_L = 15pF		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 V_S - 1.5V at 25°C.

Typical Performance Characteristics

T_A = 25°C. Unless otherwise specified.

Supply Current vs. Supply Voltage

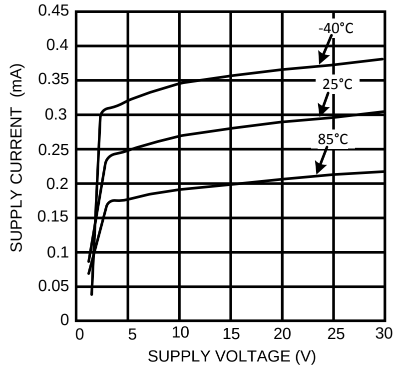

Figure 3.

Input Bias Current vs. Supply Current

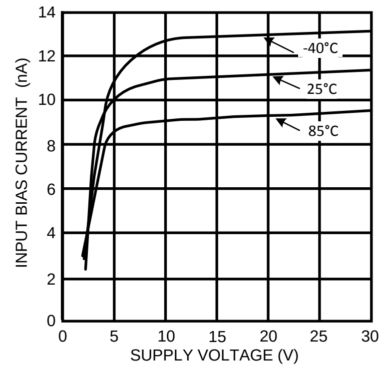

Figure 4.

Output Saturation Voltage vs. Output Sink Current

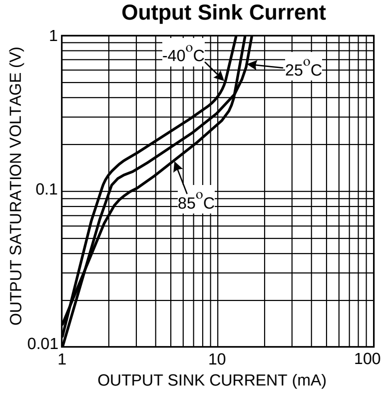

Figure 5.

Input Offset Voltage vs. Supply Voltage

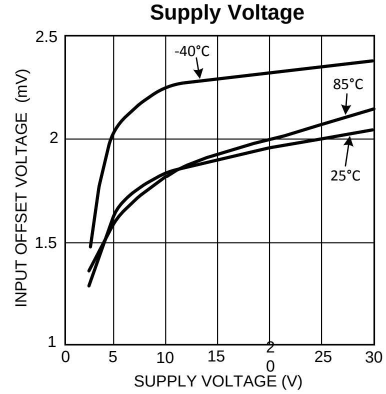

Figure 6.

Response Time for Various Input Overdrives – t_{PHL}

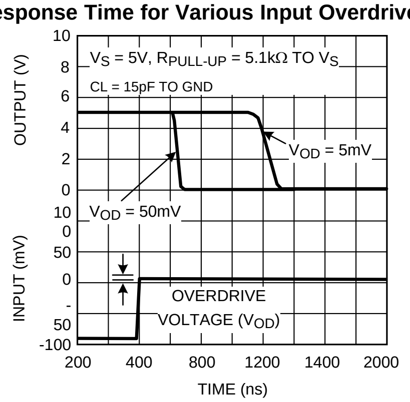

Figure 7.

Response Time for Various Input Overdrives – t_{PLH}

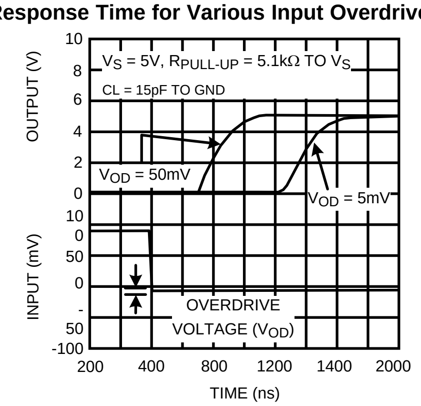

Figure 8.

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 9.

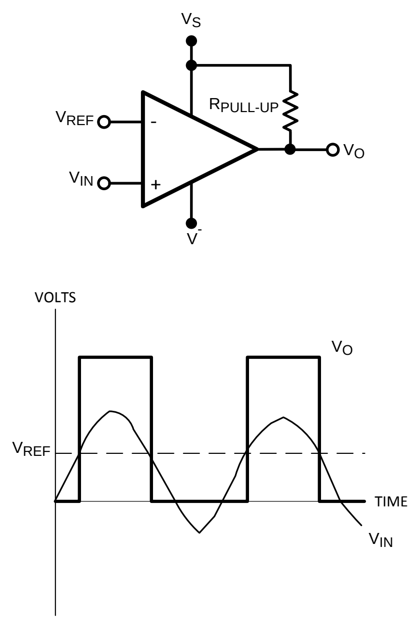

Figure 9. Basic Comparator

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:

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

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:

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

The hysteresis is defined as

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

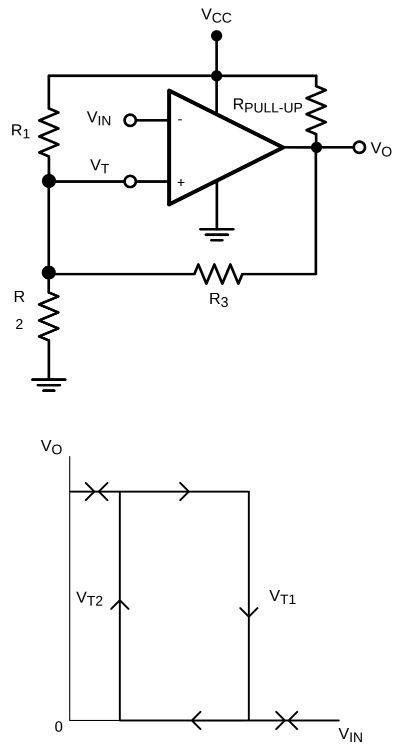

Figure 10. Inverting Configured Comparator - LM397

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 11).

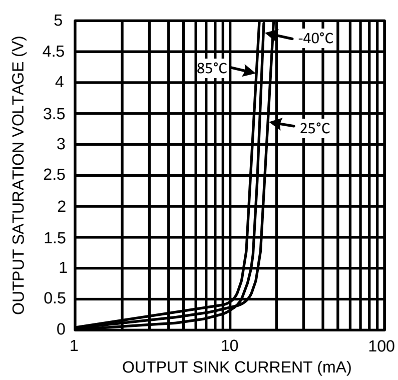

Figure 11. Output Saturation Voltage vs. Output Sink Current

REVISION HISTORY

Changes from Revision C (March 2013) to Revision D	Page
• Changed layout of National Data Sheet to TI format	6

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM397MF	NRND	SOT-23	DBV	5	1000	TBD	Call TI	Call TI	-40 to 85	C397	
LM397MF/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	C397	Samples
LM397MFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	C397	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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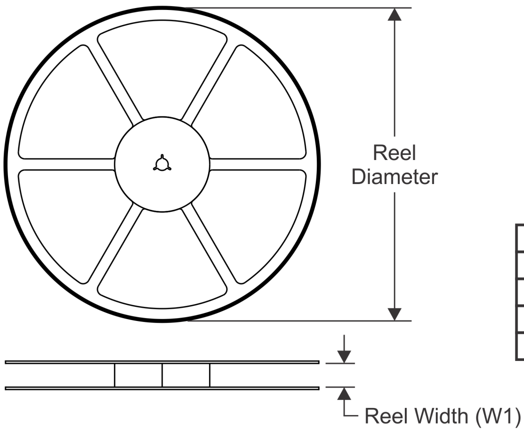
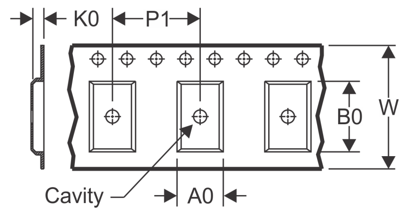
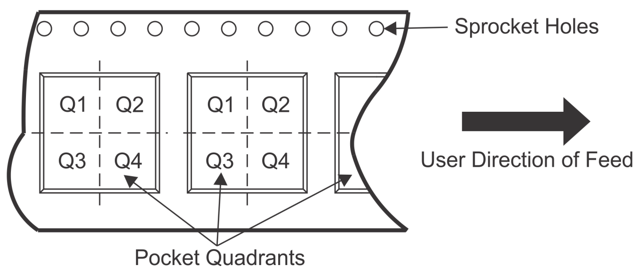
TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

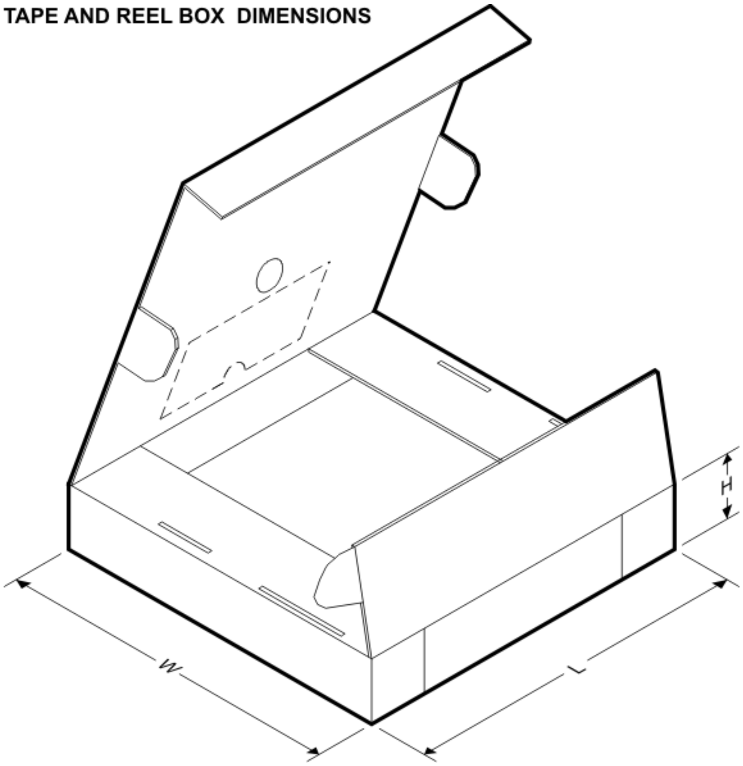
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM397MF	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM397MF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM397MFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

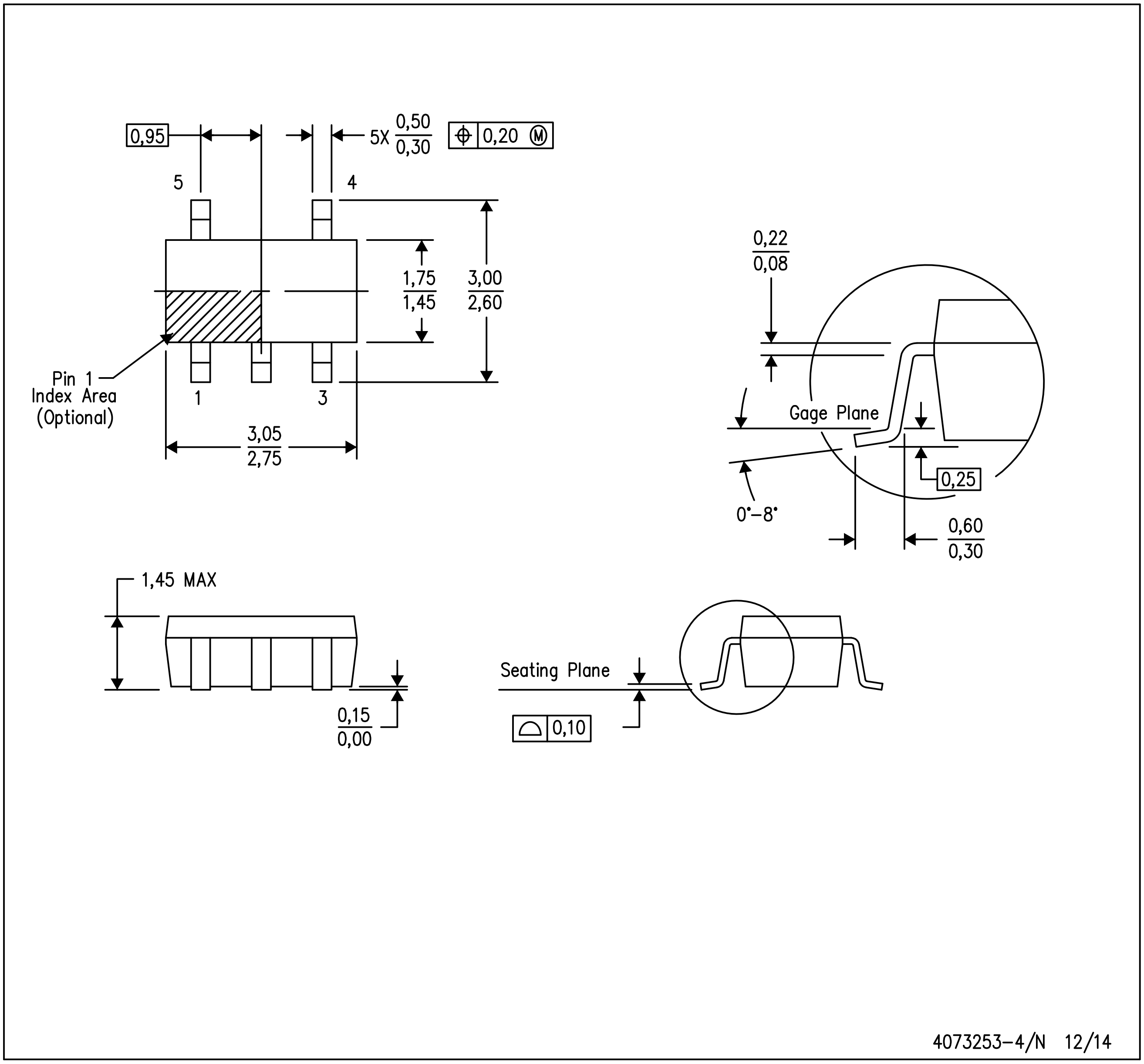
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

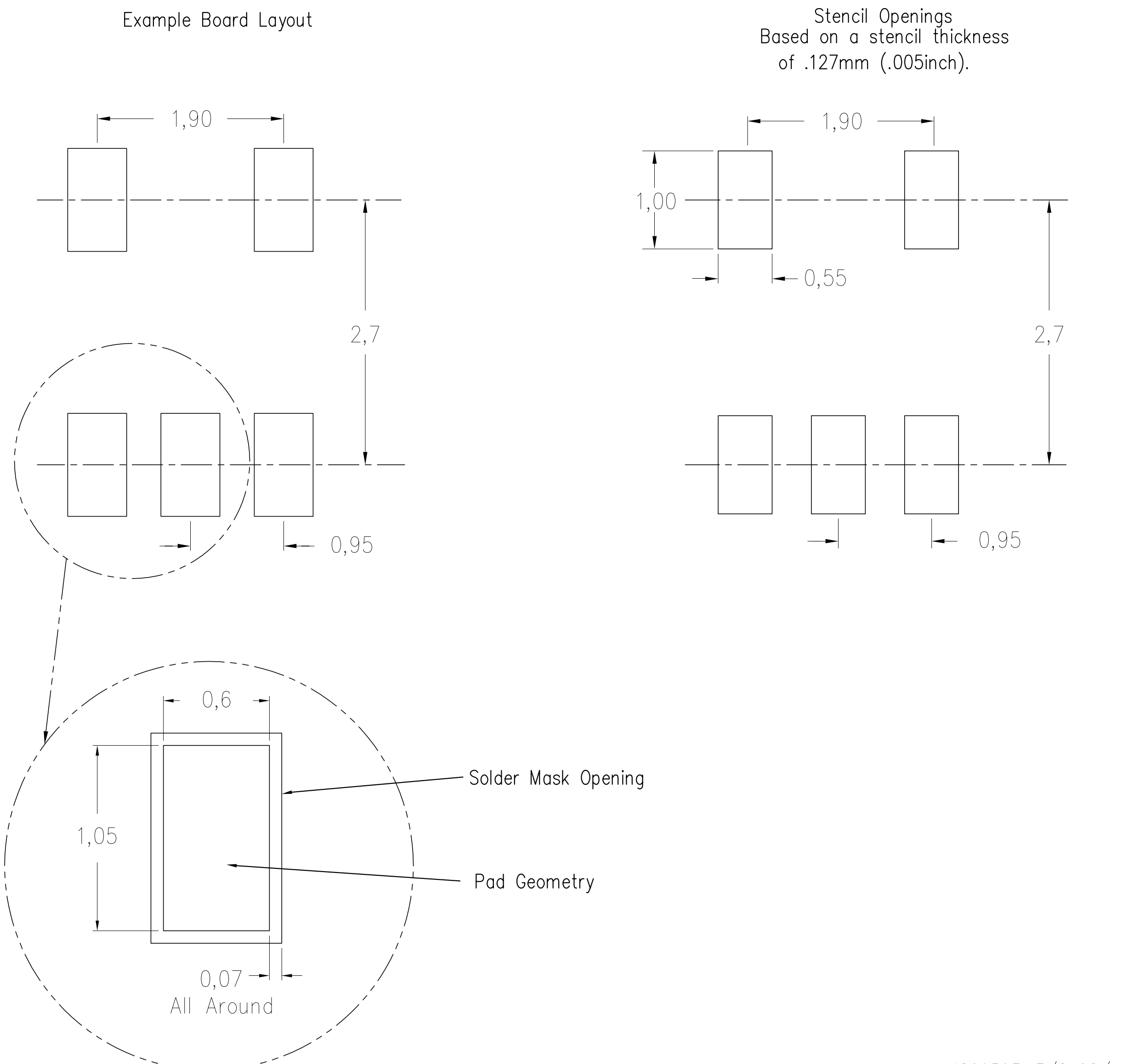
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM397MF	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM397MF/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM397MFX/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0

DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5) PLASTIC SMALL OUTLINE



4209593-3/C 08/11

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC-7351 is recommended for alternate designs.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.