# General Purpose, 1.8V, RRI, Open-drain Output Comparators

## General Description

The LM331/393 single-/dual channel comparators with open-drain output offer the ultimate combination of high speed (100 ns propagation delay) and very low power consumption (37 μA), and feature such as rail-torail inputs, low offset voltage (typically 1 mV), large output drive current, and a wide range of supply voltages from 1.8 V to 5.5 V. The devices are very easy to implement in a wide variety of applications where require critical response time, power-sensitive, low voltage, and/or tight board space.

Advantages of the LM331/393 also include the added benefit of internal hysteresis provide noise immunity, preventing output oscillations even with slow-moving input signals. Designed with the most modern techniques, the LM331/393 achieve superior performance over BiCMOS or bipolar versions on the market.

The LM331 (single) is available in SOT23-5 package. The LM393 (dual) is offered in MSOP8/SOP8 package. All devices are rated over -40 °C to +125 °C industrial temperature range.

## Features

- Micro-power Operating Current (37 μA) Preserves Battery Power
- Fast 100 ns Propagation Delay (100 mV Overdrive)
- Single 1.8 V to 5.5 V Supply Voltage Range
  - Can be Powered From the Same 1.8 V / 2.5 V / 3.3 V / 5 V System Rails
- Rail-to-Rail Input
- Open-Drain Output Current Drive: 30 mA Typically at 5V Supply
- Internal Hysteresis for Clean Switching
- Internal RF/EMI Filter
- Operating Temperature Range: -40 °C to +125 °C

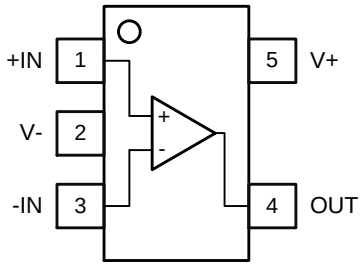
## Applications

- Consumer Accessories
- Portable and Battery-Powered Devices
- Alarms and Monitoring Circuits
- Threshold Detectors and Discriminators
- Logic Level Shifting or Translation
- Zero-Crossing Detectors
- Window Comparators
- IR Receivers
- Line Receivers

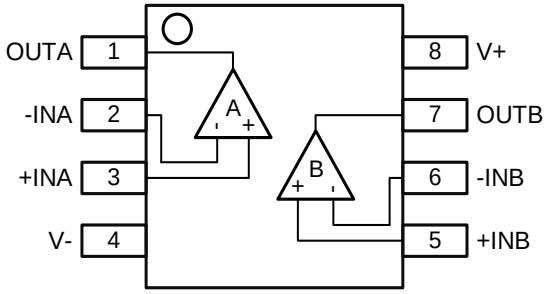
## Device information

| Part No. | Package | Packing Option | MSL |
|---|---|---|---|
| LM331E | SOT23-5 | Tape and Reel , 3K | 3 |
| LM393M | SOP8 | Tape and Reel , 4K | 3 |
| LM393U | MSOP8 | Tape and Reel , 4K | 3 |

## Pin Configurations




LM331E




LM393M/U

## Pin Function

| Symbol | Descriptions |
|---|---|
| -INx | Inverting input |
| +INx | Non-inverting input |
| V+ | Positive supply |
| V- | Negative supply |
| OUTx | Output |

## Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are only stress ratings, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions are not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply Voltage | 0 to 10 | V |
| $V_{IN}$ | Signal input terminals Voltage | (V-)-0.3 to (V+)+0.3 | V |
| $I_{IN}$ | Signal input terminals Current | -10 to +10 | mA |
| $V_{ESD}$ | ESD (Human Body Model) | ±5000 | V |
| | ESD (Component Discharge Model) | ±2000 | V |
| | ESD (Machine Model) | ±250 | V |
| $T_{STG}$ | Storage Temperature Range | -65 to +150 | °C |
| $T_{J(MAX)}$ | Max Junction Temperature Range | +150 | °C |
| $T_A$ | Operating Temperature Range | -40 to +125 | °C |

## Recommended Operating Conditions

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply Voltage: (V+) - (V-) | 1.8 to 5.5 | V |
| $T_A$ | Operating Temperature Range | -40 to +125 | °C |

## Thermal Characteristics

| Symbol | Package | Ratings | Value | Unit |
|---|---|---|---|---|
| $R_{\theta JA}$ | SOT23-5 | Thermal Characteristics, Thermal Resistance, Junction-to-Air | 220 | °C/W |
| | MSOP8 | | 180 | °C/W |
| | SOP8 | | 125 | °C/W |

## Electrical Characteristics

$V_S$ = 5.0V, $T_A$ = +25°C, unless otherwise noted.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| $V_{OS}$ | Input offset voltage | $V_{CM}$ = 0V | | ±1 | ±5 | mV |
| $\Delta V_{OS}/\Delta T$ | Input offset voltage vs temperature | $T_A$ = -40°C to +125°C | | ±2 | | µV/°C |
| PSRR | Input offset voltage vs power supply | $V_S$ = 1.8 to 5.5V, $V_{CM}$ < [(V+) - 1V] | 70 | 82 | | dB |
| | | $T_A$ = -40°C to +125°C | 66 | | | |
| Hyst | Input hysteresis | $V_{CM}$ = 0V | | 3 | | mV |
| **INPUT VOLTAGE RANGE** | | | | | | |
| $V_{CM}$ | Common-mode voltage range | $T_A$ = -40°C to +85°C | (V-)-0.1 | | (V+)+0.1 | V |
| | | $T_A$ = -40°C to +125°C | (V-)+0.1 | | (V+)-0.1 | V |
| CMRR | Common-mode rejection ratio | $V_S$ = 5.5V, -0.1V < $V_{CM}$ < 5.5V | 61 | 78 | | dB |
| | | $V_S$ = 5.5V, 0V < $V_{CM}$ < 5.3V, $T_A$ = -40°C to +125°C | 58 | | | |
| | | $V_S$ = 1.8V, -0.1V < $V_{CM}$ < 1.8V | 52 | 77 | | |
| | | $V_S$ = 1.8V, 0V < $V_{CM}$ < 1.6V, $T_A$ = -40°C to +125°C | 50 | | | |
| **INPUT BIAS CURRENT** | | | | | | |
| $I_B$ | Input bias current[(1)] | $V_{CM}$ = ($V_S$)/2 | | 5 | 30 | pA |
| | | $T_A$ = -40°C to +125°C | | | 800 | |
| $I_{OS}$ | Input offset current[(1)] | $V_{CM}$ = ($V_S$)/2 | | 10 | 50 | pA |
| | | $T_A$ = -40°C to +125°C | | | 1000 | |
| **INPUT CAPACITANCE** | | | | | | |
| $C_{ID}$ | Differential | | | 2 | | pF |
| $C_{IC}$ | Common-mode | | | 3.5 | | pF |
| **OUTPUT** | | | | | | |
| $V_{OL}$ | Voltage swing from (V-) | $I_{SINK}$ = 1mA | | 50 | 80 | mV |
| | | $T_A$ = -40°C to +125°C | | | 90 | |
| $I_{SC}$ | Short-circuit current | Sinking | 25 | 30 | | mA |

## Electrical Characteristics (Continued)

$V_S$ = 5.0V, $T_A$ = +25°C, unless otherwise noted.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | |
| $V_S$ | Specified voltage range | | 1.8 | | 5.5 | V |
| $I_Q$ | Quiescent current per comparator | $V_S$ = 1.8V, $V_{CM}$ = 0.5V, $I_O$ = 0 | | 32 | 40 | µA |
| | | $T_A$ = -40°C to +125°C | | | 50 | |
| | | $V_S$ = 5.5V, $V_{CM}$ = 0.5V, $I_O$ = 0 | | 37 | 45 | |
| | | $T_A$ = -40°C to +125°C | | | 60 | |
| **SWITCHING CHARACTERISTICS** | | | | | | |
| $T_{PD}$ | Propagation delay time high-to-low | $V_{OD}$ = 20 mV, $C_L$ = 15 pF | | 240 | | ns |
| | | $V_{OD}$ = 100 mV, $C_L$ = 15 pF | | 100 | | |
| $T_{FALL}$ | Fall time | $V_{OD}$ = 20 mV, $C_L$ = 15 pF | | 20 | | ns |
| | | $V_{OD}$ = 100 mV, $C_L$ = 15 pF | | 10 | | |

***Note1***:Guaranteed by design.

## Functional Description

### Operating Voltage

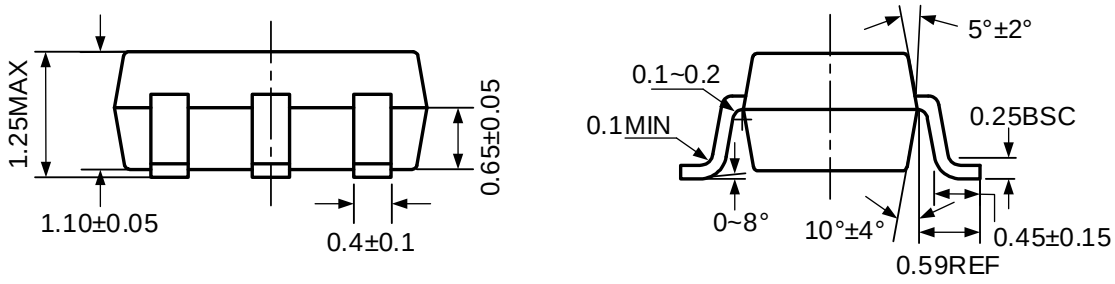
The LM331/393 micro-power comparators of open-drain output are fully specified and ensured for operation from 1.8 V to 5.5 V and offers an excellent speed-to-power combination with a propagation delay of 100ns and a quiescent supply current of 37μA. This combination of fast response time at micropower enables power conscious systems to monitor and respond quickly to fault conditions. In addition, and many specifications apply over the industrial temperature range of -40°C to +125°C.

### Input Voltage

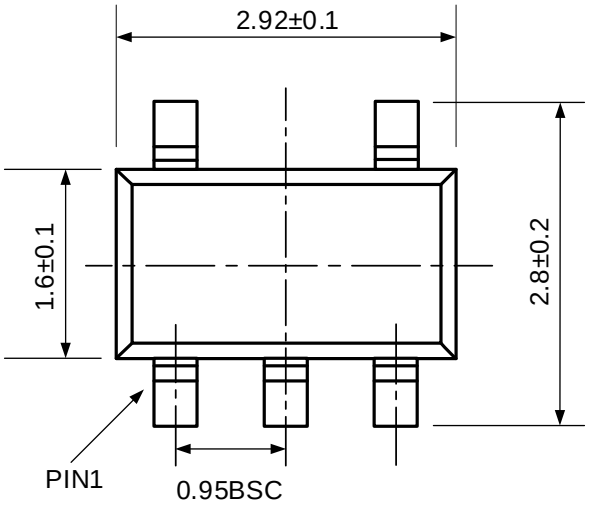
The input common-mode voltage range of the LM331/393 family extends 100mV beyond the supply rails. This performance is achieved with a complementary input stage: an N-channel input differential pair in parallel with a P-channel differential pair. The N-channel pair is active for input voltages close to the positive rail, typically (V+) - 1.4V to the positive supply, whereas the P-channel pair is active for inputs from 100mV below the negative supply to approximately (V+) - 1.4V. There is a small transition region, typically (V+) - 1.2V to (V+) - 1V, in which both pairs are on. This 200mV transition region can vary up to 200mV with process variation. Thus, the transition region (both stages on) can range from (V+) - 1.4V to (V+) - 1.2V on the low end, up to (V+) - 1V to (V+) - 1.8V on the high end. Within this transition region, PSRR, CMRR, offset voltage, offset drift, and THD can be degraded compared to device operation outside this region.

## Package Dimension

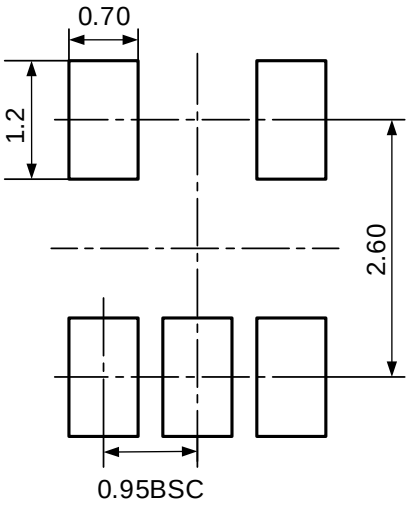
SOT23-5




SIDE VIEW



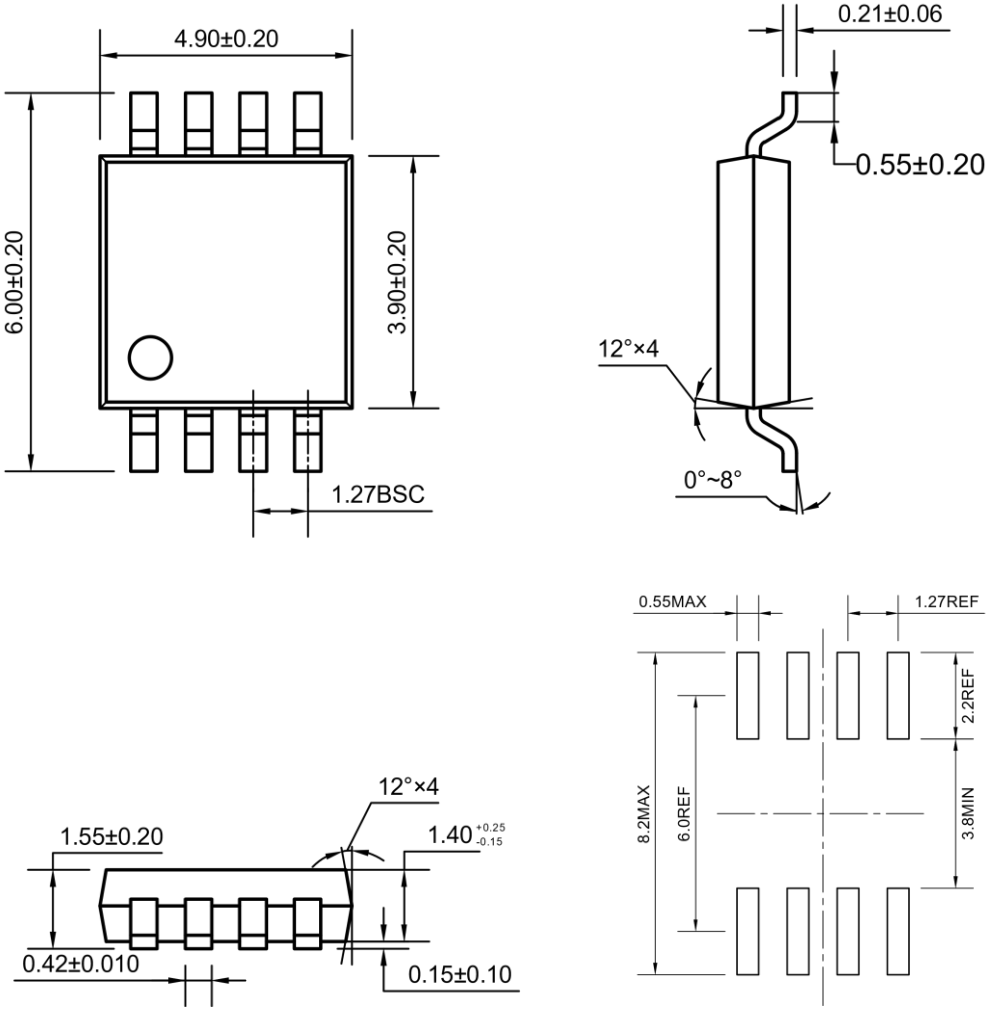

TOP VIEW




**Recommended Land Pattern**

Unit: mm

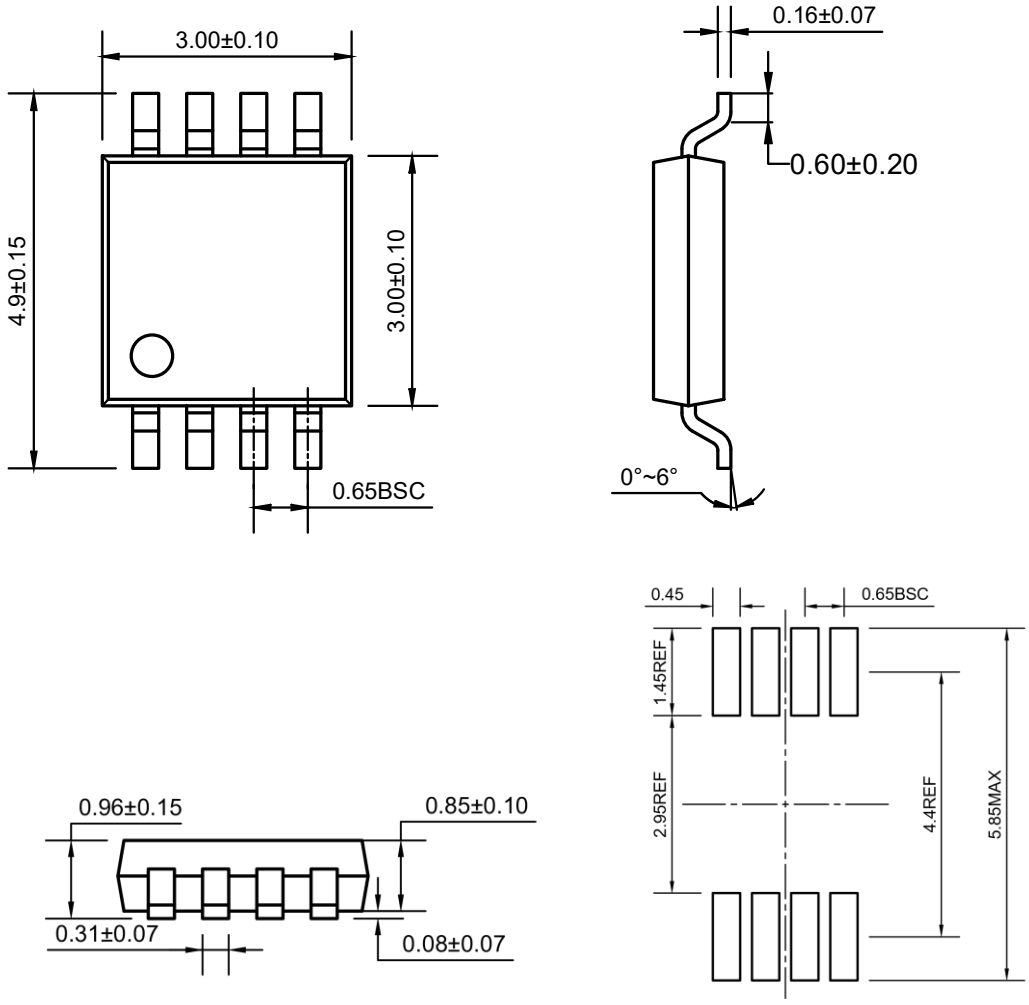
SOP8




**Recommended Land Pattern**

Unit: mm

MSOP8




**Recommended Land Pattern**

Unit: mm

## Revision History and Checking Table

| Version | Date | Revision Item | Modifier | Function & Spec Checking | Package & Tape Checking |
|---|---|---|---|---|---|
| 1.0 | 2024-2-23 | Original Version | Jiangqp | Shibo | Liujy |
| | | | | | |
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