# 36-V Low-Power Comparators

## Features

- Wide Single-Supply Voltage Range or Dual Supplies: +2.5 V to +36 V or ±1.25 V to ±18 V
- Very Low Supply Current: 150 μA/ch
- Low Input Bias Current: 1 nA (Max)
- Low Offset Voltage: ±6.0 mV (Max)
- Input Common-Mode Voltage Range Includes Ground
- Internal Differential Input Voltage Range Equal to The Supply Voltage
- Low Output Saturation
- Operating Temperature Range: −40°C to 125°C
- ESD Rating: 2-kV HBM, 2-kV CDM

## Applications

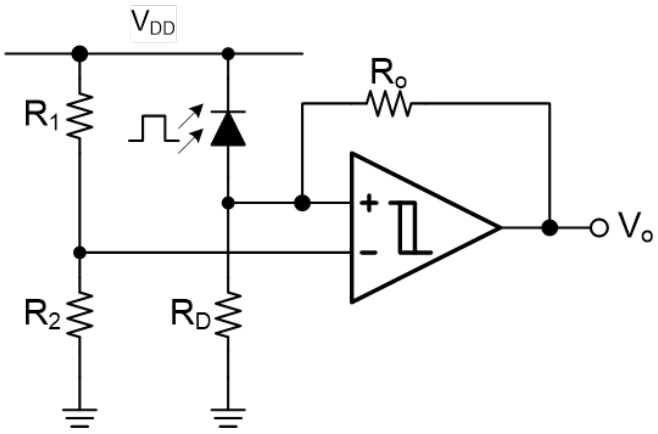
- High-Speed Line or Digital Line Receivers
- High-Speed Sampling Circuits
- Peak and Zero-Crossing Detectors
- Threshold Detectors/Discriminators
- Sensing at Ground or Supply Line

## Description

The devices in this series consist of single/ dual/ quad independent single- or dual-supply voltage comparators on a single monolithic substrate. The common-mode input voltage range includes ground even when operated from a single supply, and the low power supply current drain makes these comparators suitable for battery operation. These types are designed to directly interface with TTL and CMOS. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

All devices are specified for the temperature range from –40°C to 125°C.

## Typical Application Circuit



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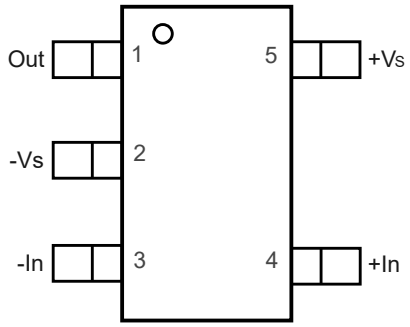
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## Revision History

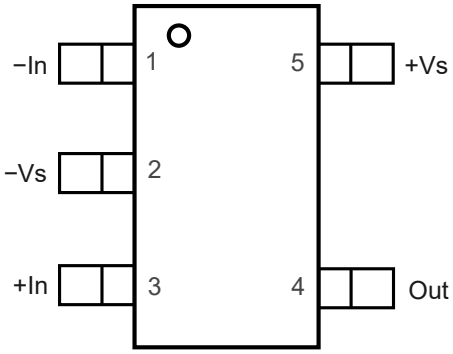
| Date | Revision | Notes |
|---|---|---|
| 2022-05-05 | Rev.A.0 | Updated the document format.<br>Updated the format of Package Outline Dimensions, with no change on the product.<br>Combined LM331A, LM393A, LM339A to one datasheet.<br>Updated the Electrical Characteristics:<br>• $I_B$: added the max value of 1 nA at 25 °C, and 10 nA at −40°C to 125°C;<br>• $I_{OS}$: added the max value of 1 nA at 25 °C, and 10 nA at −40°C to 125°C;<br>• $I_{OS}$: added the typical value of 50 nA at 25 °C. |
| 2023-05-29 | Rev.A.1 | The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged.<br>• Updated the symbol of Figure 3 in Typical Performance Characteristics.<br>• Updated the website address.<br>• Updated Tape and Reel Information.<br>• Updated DFN2X2-8 Package Outline Dimensions. |
| 2024-12-18 | Rev.A.2 | The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged.<br>• Updated to a new datasheet format.<br>• Updated to a new format of Package Outline Dimensions.<br>• Updated the Tape and Reel Information. |
| 2025-01-13 | Rev.A.3 | Corrected the typo of the pin map for the LM331A SOT23-5, and the actual product remains unchanged. |
| 2025-09-12 | Rev.A.4 | Added a new part number: LM393A-SR-C. |
| 2025-11-27 | Rev.A.5 | Added the thermal pad description in the Pin Configuration and Functions. The actual product remains unchanged.<br>Updated the Electrostatic Discharge Protection:<br>• HBM, ANSI/ESDA/JEDEC JS-001: from minimum 4 KV to minimum 2 KV. |

## Pin Configuration and Functions

LM331A
SOT23-5
Top View




LM331AU
SOT23-5
Top View




LM331AU2
SOT23-5
Top View

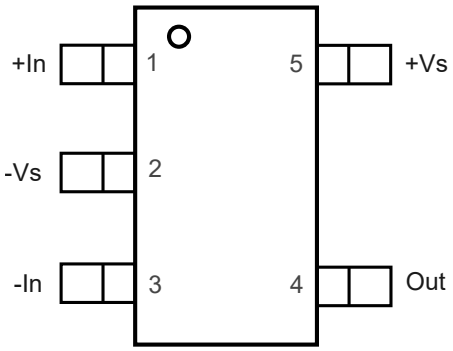



**Table 1. Pin Functions: LM331A/LM331AU/LM331AU2**

| Pin No. | | | Name | I/O | Description |
|---|---|---|---|---|---|
| LM331A | LM331AU | LM331AU2 | | | |
| 3 | 1 | 3 | −In | I | Inverting input |
| 2 | 2 | 2 | $-V_S$ | | Negative power supply |
| 4 | 3 | 1 | +In | I | Non-inverting input |
| 1 | 4 | 4 | Out | O | Output |
| 5 | 5 | 5 | $+V_S$ | | Positive power supply |

LM339A
SOP14/TSSOP14
Top View

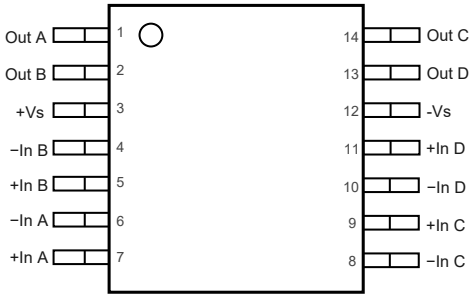
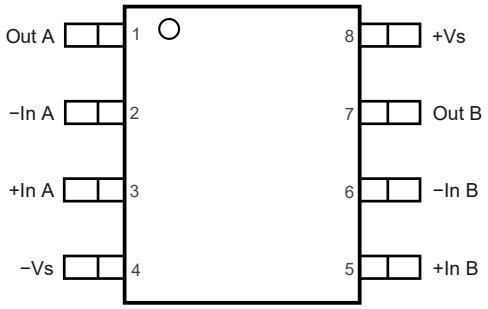



**Table 2. Pin Functions: LM339A**

| Pin No. | Name | I/O | Description |
|---|---|---|---|
| 1 | Out A | O | Output |
| 2 | Out B | O | Output |
| 3 | $+V_S$ | | Positive power supply |
| 4 | −In B | I | Inverting input |
| 5 | +In B | I | Non-inverting input |
| 6 | −In A | I | Inverting input |
| 7 | +In A | I | Non-inverting input |
| 8 | −In C | I | Inverting input |
| 9 | +In C | I | Non-inverting input |
| 10 | −In D | I | Inverting input |
| 11 | +In D | I | Noninverting input |
| 12 | $-V_S$ | | Negative power supply |
| 13 | Out D | O | Output |
| 14 | Out C | O | Output |

LM393A/LM393A-SR-C
SOP8
Top View




LM393A
DFN2X2-8
Top View

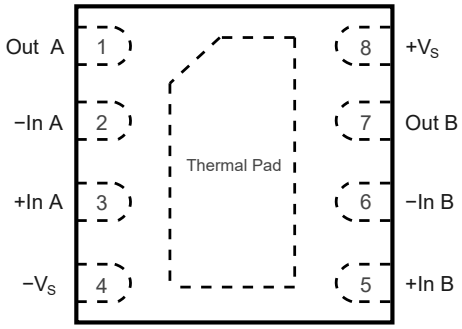



**Table 3. Pin Functions: LM393A**

| Pin No. | | Name | I/O | Description |
|---|---|---|---|---|
| SOP8 | DFN2X2-8 | | | |
| 1 | 1 | Out A | O | Output |
| 2 | 2 | −In A | I | Inverting input |
| 3 | 3 | +In A | I | Non-inverting input |
| 4 | 4 | $-V_S$ | | Negative power supply |
| 5 | 5 | +In B | I | Non-inverting input |
| 6 | 6 | −In B | I | Inverting input |
| 7 | 7 | Out B | O | Output |
| 8 | 8 | $+V_S$ | | Positive power supply |
| | | Thermal Pad | | The thermal pad of the DFN2X2-8 is recommended to be left float or connected to $-V_S$. |

# Specifications

## Absolute Maximum Ratings (1)

| Parameters | | Min | Max | Unit |
|---|---|---|---|---|
| | Supply Voltage: ($+V_S$) − ($-V_S$) | | 42 | V |
| | Voltage on Input and Output Pins | ($-V_S$) − 0.3 | ($+V_S$) + 0.3 | V |
| | Input Current: +IN, –IN (2) | −20 | 20 | mA |
| | Output Current: Out | −20 | 20 | mA |
| | Output Short-Circuit Duration (3) | | Infinite | |
| | Current at Supply Pins | −60 | 60 | mA |
| $T_J$ | Maximum Junction Temperature | | 150 | °C |
| $T_A$ | Operating Temperature Range | −40 | 125 | °C |
| $T_{STG}$ | Storage Temperature Range | −65 | 150 | °C |
| $T_L$ | Lead Temperature (Soldering 10 sec) | | 260 | °C |

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
(2) The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500 mV beyond the power supply, the input current should be limited to less than 10 mA.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

## ESD, Electrostatic Discharge Protection

| Symbol | Parameter | Condition | Minimum Level | Unit |
|---|---|---|---|---|
| HBM | Human Body Model ESD | ANSI/ESDA/JEDEC JS-001 (1) | 2 | kV |
| CDM | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 (2) | 2 | kV |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## Thermal Information

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---|---|---|---|
| SOT23-5 | 250 | 81 | °C/W |
| SOP8 | 158 | 43 | °C/W |
| TSSOP8 | 191 | 44 | °C/W |
| DFN2X2-8 | 100 | 60 | °C/W |
| SOP14 | 97 | 47 | °C/W |
| TSSOP14 | 108 | 43 | °C/W |

## Electrical Characteristics

All test conditions: $V_{CC}$ = 5 V, $R_{PU}$ = 10 kΩ, $C_L$ = 15 pF, $T_A$ = 25°C, unless otherwise noted.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | $T_A$ = −40°C to 125°C | | 2.5 | | 36 | V |
| $V_{OS}$ | Input Offset Voltage | $V_{CC}$ = 5 V to 30 V, $V_{CM}$ = 0 V, $V_O$ = 1.4 V, $T_A$ = −40°C to 125°C | | −6 | ±0.6 | 6 | mV |
| $I_B$ | Input Bias Current (1) | $V_{DM}$ = 0 V, $V_{CM}$ = 0 V | | | 0.1 | 1 | nA |
| | | $V_{DM}$ = 0 V, $V_{CM}$ = 0 V, $T_A$ = −40°C to 125°C | | | 1 | 10 | nA |
| $I_{OS}$ | Input Offset Current (1) | $V_{DM}$ = 0 V, $V_{CM}$ = 0 V | | | 0.1 | 1 | nA |
| | | $V_{DM}$ = 0 V, $V_{CM}$ = 0 V, $T_A$ = −40°C to 125°C | | | 1 | 10 | nA |
| $I_{Diff}$ | Input Differential Current | $V_{CC}$ = 36 V, $V_{DM}$ = 36 V | | | 50 | | nA |
| $C_{IN}$ | Input Capacitance | $T_A$ = 25°C | Differential mode | | 2.5 | | pF |
| | | | Common mode | | 5 | | |
| $V_{CM}$ | Common-Mode Input Voltage Range | | | 0 | | $V_{CC}$ − 1.5 | V |
| | | $T_A$ = −40°C to 125°C | | 0 | | $V_{CC}$ − 2 | V |
| $A_{VD}$ | Large-Signal Differential-Voltage Amplification | $V_{CC}$ = 15 V, $V_O$ = 1.4 V to 11.4 V, $R_L$ ≥ 15 kΩ to $V_{CC}$ | | 50 | 400 | | V/mV |
| $I_{OH}$ | High-Level Output Current | $V_{OH}$ = 5 V, $V_{ID}$ = 1 V | | | 25 | 200 | nA |
| | | $V_{CC}$ = 36 V, $V_{OH}$ = 36 V, $V_{ID}$ = 1 V, $T_A$ = −40°C to 125°C | | | | 7 | μA |
| $V_{OL}$ | Low-Level Output Voltage | $I_{OL}$ = 4 mA, $V_{ID}$ = −1 V | | | 250 | 400 | mV |
| | | $I_{OL}$ = 4 mA, $V_{ID}$ = −1 V, $T_A$ = −40°C to 125°C | | | | 500 | mV |
| $I_{OL}$ | Low-Level Output Current | $V_{OL}$ = 1.5 V, $V_{ID}$ = −1 V | | 10 | | | mA |
| $I_Q$ | Quiescent Current per Comparator | $V_{CC}$ = 5 V | | | 150 | 300 | μA |
| | | $V_{CC}$ = 36 V | | | 150 | 300 | μA |
| $t_{RT}$ | Response Time | $R_L$ connected to 5 V through 5.1 kΩ, $C_L$ = 15 pF | 100-mV input step with 5-mV overdrive | | 2 | | μs |
| | | | TTL-level input step | | 0.5 | | |

(1) Provided by bench tests and design simulation.

## Typical Performance Characteristics

All test conditions: $V_S$ = 5 V, $V_{CM}$ = 0 V, $R_L$ = Open, unless otherwise noted.

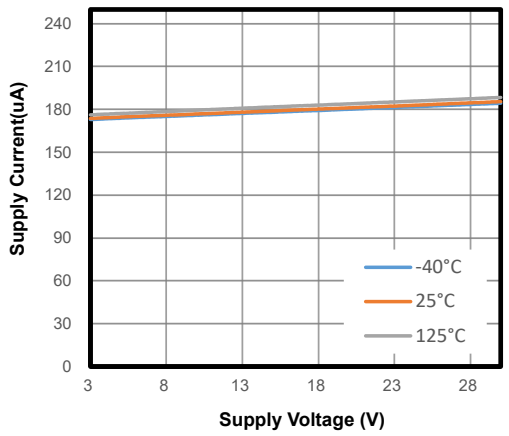



Figure 1. Supply Current vs. Supply Voltage (Dual Channel)

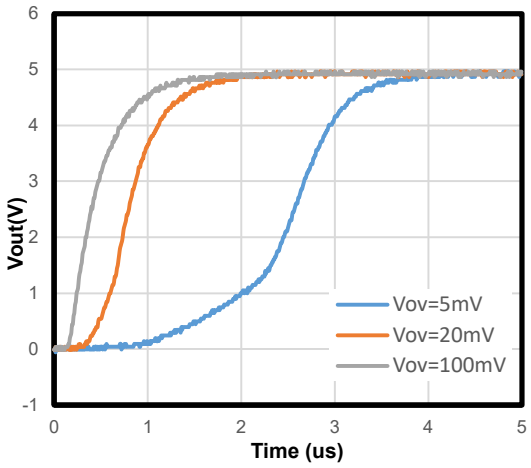



Figure 2. Response Time for Various Input Overdrives: Positive Transition

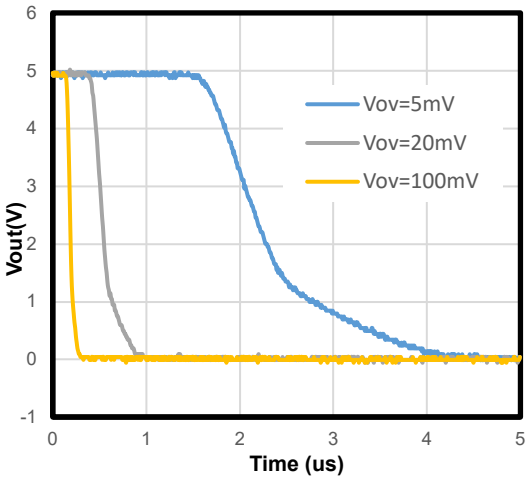



Figure 3. Response Time for Various Input Overdrives: Negative Transition

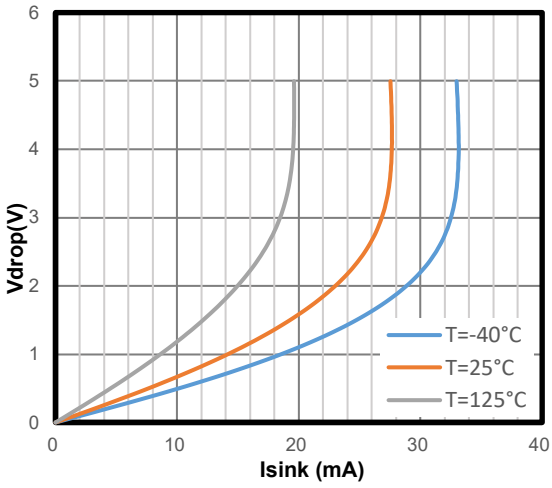



Figure 4. Negative Output Swing vs. Sink Current

# Detailed Description

## Overview

The devices in this series consist of single/ dual/ quad independent single- or dual-supply voltage comparators on a single monolithic substrate. The common-mode input voltage range includes ground even when operated from a single supply, and the low power supply current drain makes these comparators suitable for battery operation. These types are designed to directly interface with TTL and CMOS. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

# Application and Implementation

> Note
>
> Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## Application Information

### Power Supply Layout and Bypass

The power supply pins of the LM331A/393A/339A series should have a local bypass capacitor (i.e., 0.01 μF to 0.1 μF) within 2 mm for high-frequency performance. It can also use a bulk capacitor (i.e., 1 μF or larger) within 100 mm to provide large, slow currents. This bulk capacitor can be shared with other analog parts.

A good ground layout improves performance by decreasing the amount of stray capacitance and noise at the inputs and outputs of the comparator. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components to the comparator pins as close as possible.

### Inputs

The electrostatic discharge (ESD) protection input structure of two back-to-back diodes and 1-kΩ series resistors are used to limit the differential input voltage applied to the precision input of the comparator by clamping input voltages that exceed supply voltages, as shown in Figure 5. Large voltage exceeding the supply voltage should be avoided to prevent damage to the input stage.

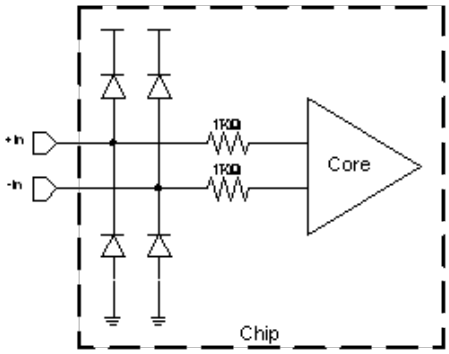



**Figure 5. Equivalent Input Structure**

### Operation Outside of the Common Input Voltage Range

A list of input voltage situation and their outcomes are as follows:

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 MOSFET is sinking current.
   b. If −IN is lower than +IN and the offset voltage, the output is high impedance.
2. When −IN is higher than common mode and +IN is within common mode, the output is low, and the output MOSFET is sinking current.
3. When +IN is higher than common mode and −IN is within common mode, the output is high impedance.
4. When −IN and +IN are both higher than common mode, the output is in uncertain state.

## Typical Application

### IR Receiver

The device is an ideal candidate to be used as an infrared receiver shown in Figure 6. The infrared photo diode creates a current relative to the amount of infrared light present. The current creates a voltage across $R_D$. When this voltage level cross the voltage applied by the voltage divider to the inverting input, the output transitions. Optional $R_O$ provides additional hysteresis for noise immunity.

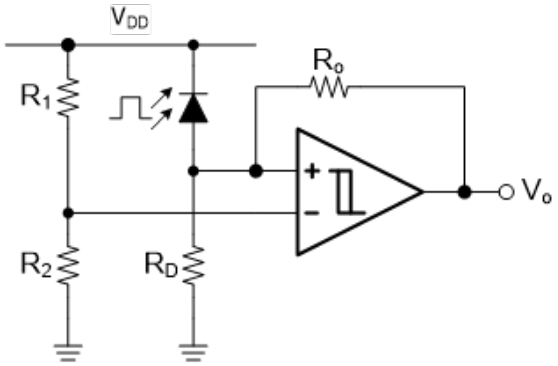
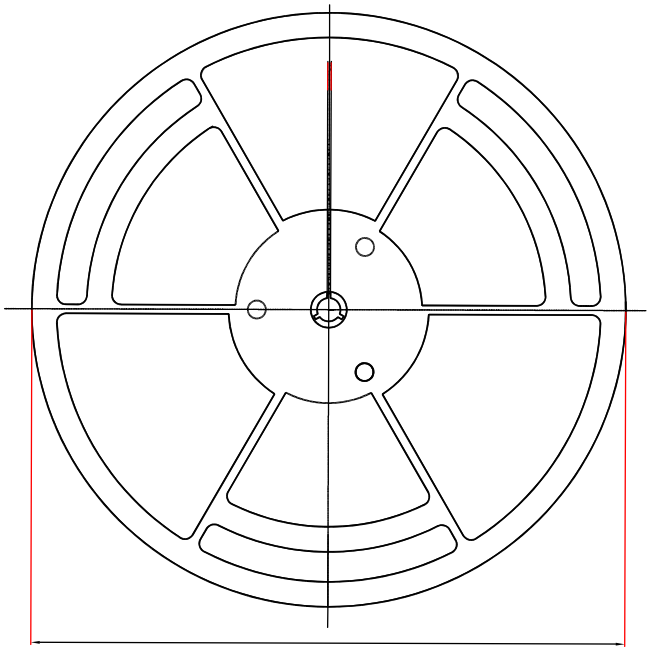
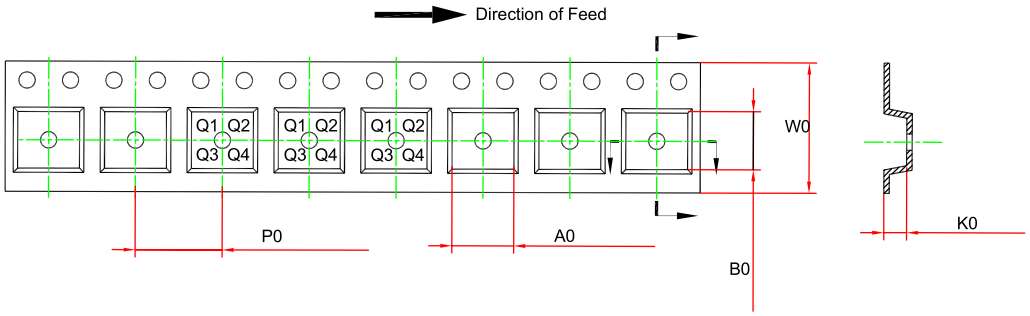



**Figure 6. IR Receiver**

## Tape and Reel Information



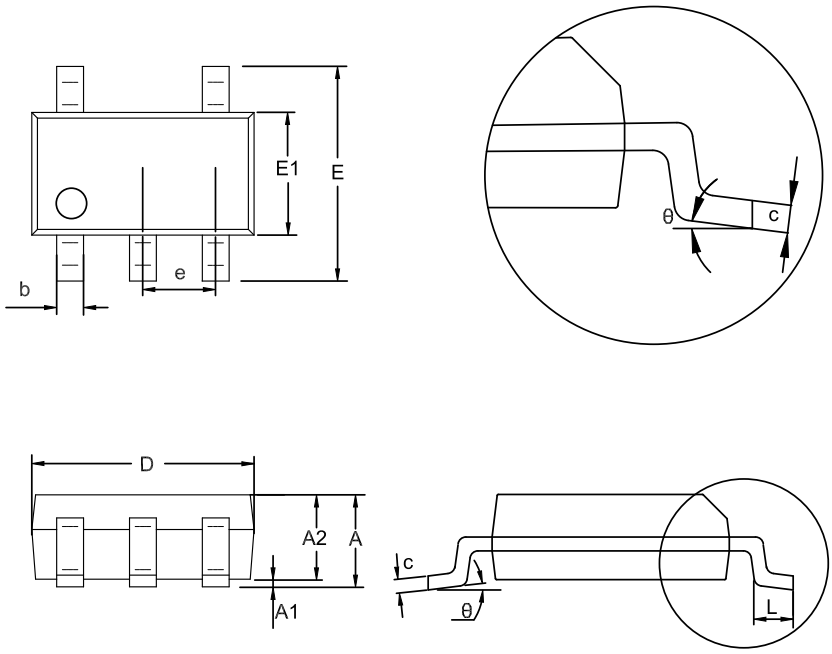

| Order Number | Package | D1 (mm) | W1 (mm) | A0 (mm) (1) | B0 (mm) (1) | K0 (mm) (1) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|
| LM331A-S5TR | SOT23-5 | 179.0 | 13.1 | 3.3 | 3.25 | 1.4 | 4.0 | 8.0 | Q3 |
| LM331AU-S5TR | SOT23-5 | 179.0 | 13.1 | 3.3 | 3.25 | 1.4 | 4.0 | 8.0 | Q3 |
| LM331AU2-S5TR | SOT23-5 | 179.0 | 13.1 | 3.3 | 3.25 | 1.4 | 4.0 | 8.0 | Q3 |
| LM393A-SR | SOP8 | 330.0 | 17.6 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM393A-SR-C | SOP8 | 330.0 | 17.6 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM393A-DFGR | DFN2X2-8 | 180.0 | 12.0 | 2.2 | 2.2 | 1.0 | 4.0 | 8.0 | Q2 |
| LM393A-TSR | TSSOP8 | 330.0 | 17.6 | 6.8 | 3.3 | 1.8 | 8.0 | 12.0 | Q1 |
| LM339A-SR | SOP14 | 330.0 | 22.0 | 6.5 | 9.2 | 2.0 | 8.0 | 16.0 | Q1 |
| LM339A-TR | TSSOP14 | 330.0 | 17.6 | 6.8 | 5.5 | 1.6 | 8.0 | 12.0 | Q1 |

(1) The value is for reference only. Contact the 3PEAK factory for more information.

## Package Outline Dimensions

### SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



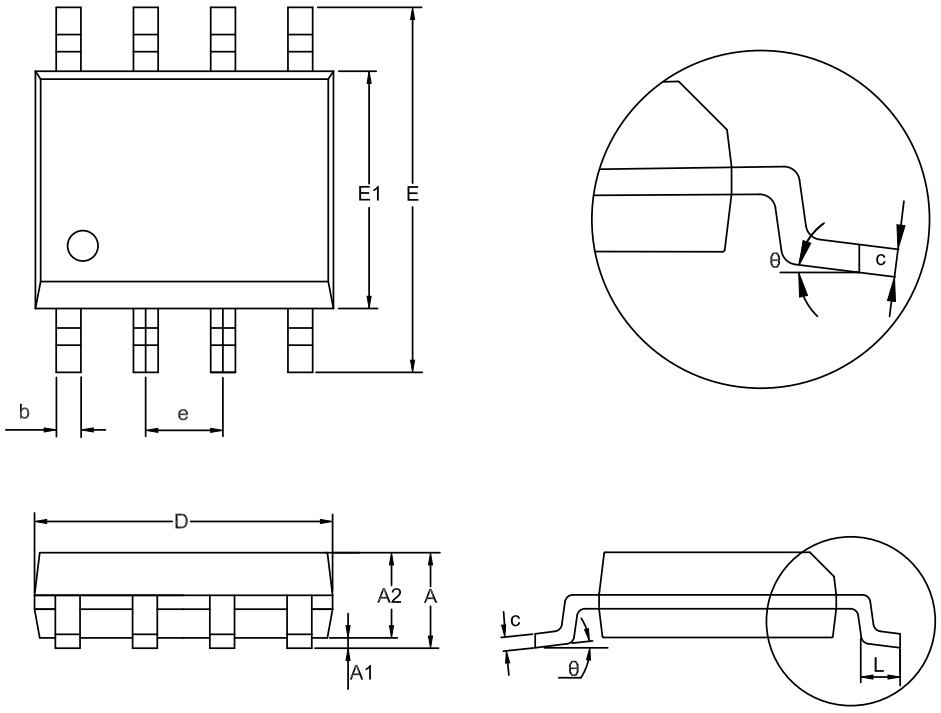

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| A2 | 1.000 | 1.200 | 0.039 | 0.047 |
| b | 0.280 | 0.500 | 0.011 | 0.020 |
| c | 0.100 | 0.230 | 0.004 | 0.009 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 2.600 | 3.000 | 0.102 | 0.118 |
| E1 | 1.500 | 1.720 | 0.059 | 0.068 |
| e | 0.950 BSC | | 0.037 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## SOP8

Package Outline Dimensions SO1(SOP-8-A)



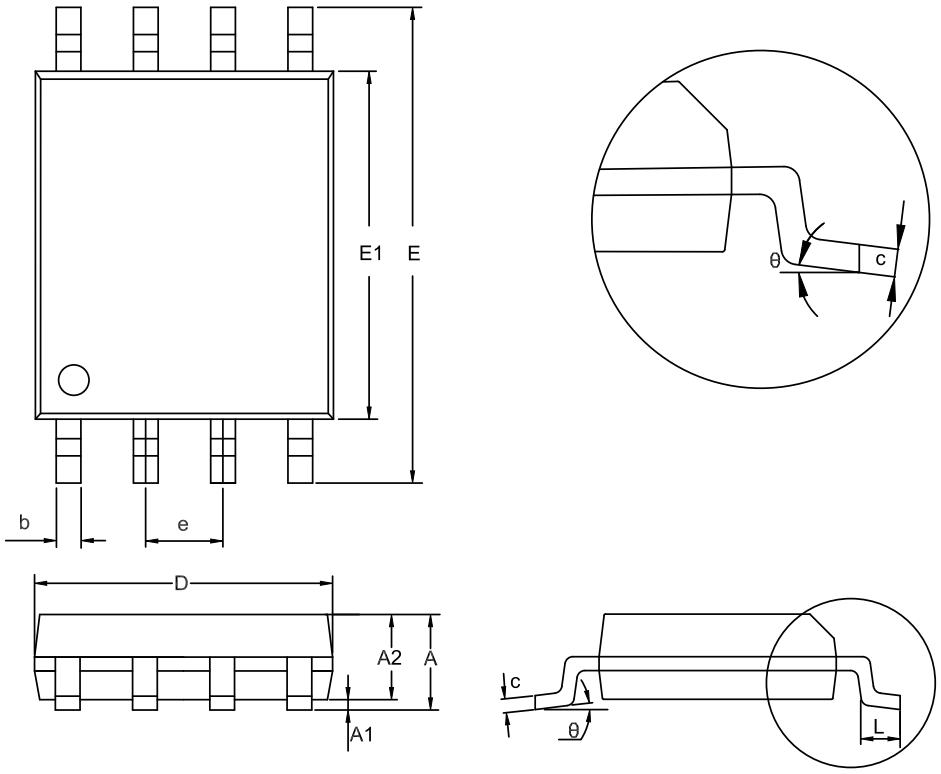

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.250 | 0.002 | 0.010 |
| A2 | 1.250 | 1.550 | 0.049 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.201 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| L | 0.400 | 1.000 | 0.016 | 0.039 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## TSSOP8

Package Outline Dimensions TS1(TSSOP-8-A)



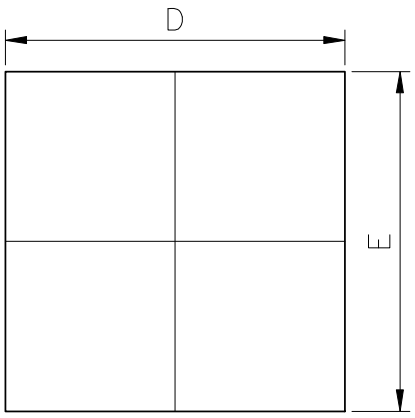

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.900 | 1.200 | 0.035 | 0.047 |
| A1 | 0.050 | 0.150 | 0.002 | 0.006 |
| A2 | 0.800 | 1.050 | 0.031 | 0.041 |
| b | 0.190 | 0.300 | 0.007 | 0.012 |
| c | 0.090 | 0.200 | 0.004 | 0.008 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| E | 6.200 | 6.600 | 0.244 | 0.260 |
| E1 | 4.300 | 4.500 | 0.169 | 0.177 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.450 | 0.750 | 0.018 | 0.030 |
| θ | 0 | 8° | 0 | 8° |

NOTES

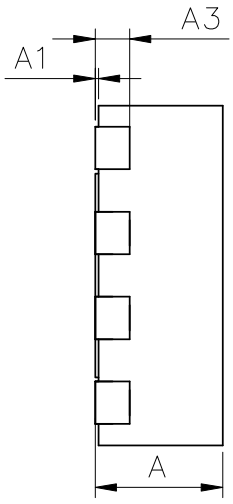
1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

**DFN2X2-8**

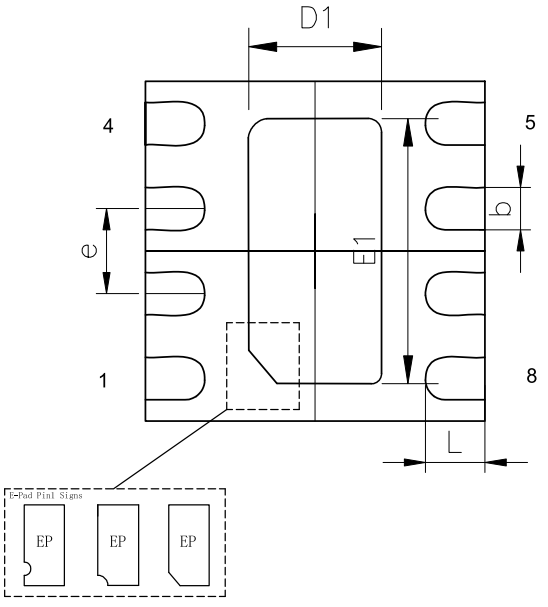
## Package Outline Dimensions DFG(DFN2X2-8-E)




Top View




Side View




Bottom View

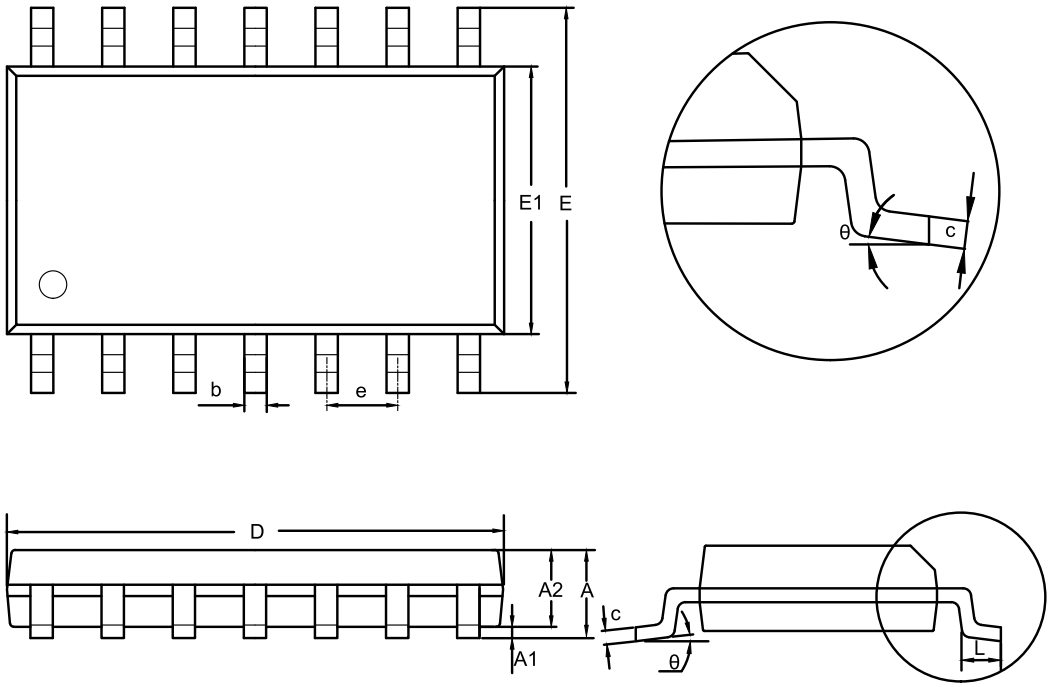
NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.
3. The many types of E-pad Pin1 signs may appear in the product.

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.500 | 0.600 | 0.020 | 0.024 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| b | 0.150 | 0.300 | 0.006 | 0.012 |
| A3 | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 1.900 | 2.100 | 0.075 | 0.083 |
| D1 | 0.800 | 1.000 | 0.031 | 0.039 |
| E | 1.900 | 2.100 | 0.075 | 0.083 |
| E1 | 1.600 | 1.800 | 0.063 | 0.071 |
| e | 0.500 BSC | | 0.020BSC | |
| L | 0.224 | 0.376 | 0.009 | 0.015 |

**SOP14**

## Package Outline Dimensions SO2(SOP-14-A)



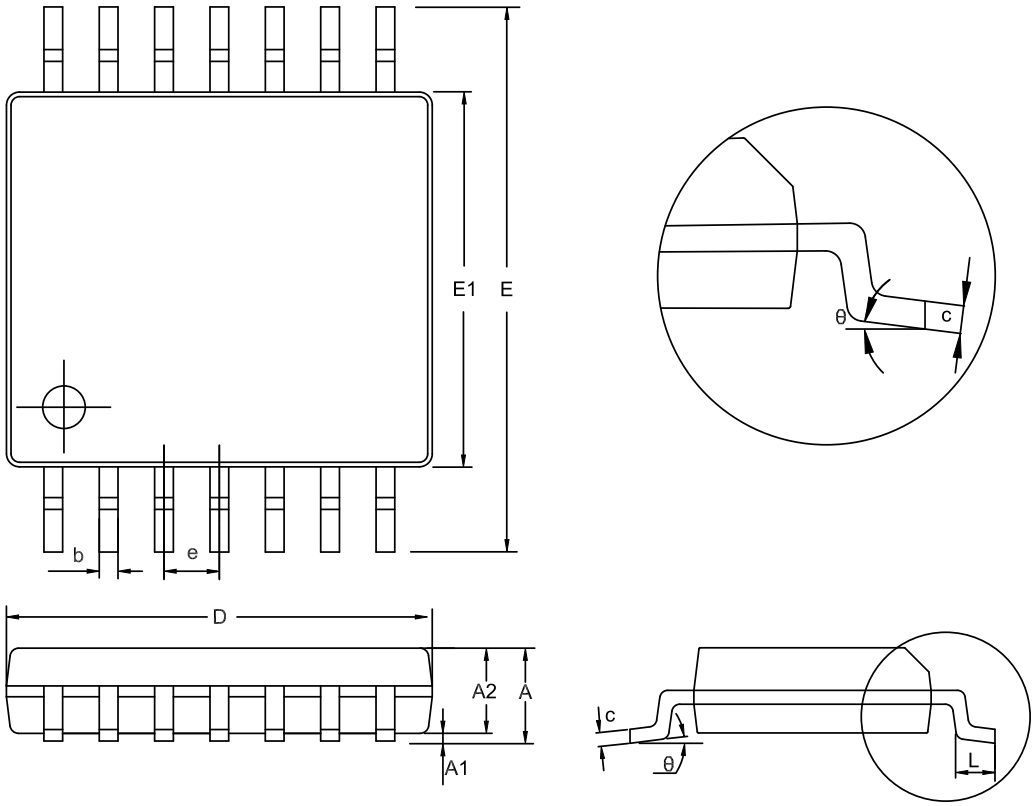

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.250 | 0.002 | 0.010 |
| A2 | 1.250 | 1.650 | 0.049 | 0.065 |
| b | 0.310 | 0.510 | 0.012 | 0.020 |
| c | 0.100 | 0.250 | 0.004 | 0.010 |
| D | 8.450 | 8.850 | 0.333 | 0.348 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

**TSSOP14**

Package Outline Dimensions TS2(TSSOP-14-A)




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.900 | 1.200 | 0.035 | 0.047 |
| A1 | 0.050 | 0.150 | 0.002 | 0.006 |
| A2 | 0.800 | 1.050 | 0.031 | 0.041 |
| b | 0.190 | 0.300 | 0.007 | 0.012 |
| c | 0.090 | 0.200 | 0.004 | 0.008 |
| D | 4.900 | 5.100 | 0.193 | 0.201 |
| E | 6.200 | 6.600 | 0.244 | 0.260 |
| E1 | 4.300 | 4.500 | 0.169 | 0.177 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.450 | 0.750 | 0.018 | 0.030 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## Order Information

| Order Number | Operating Temperature Range | Package | Marking Information | MSL | Transport Media, Quantity | Eco Plan |
|---|---|---|---|---|---|---|
| LM331A-S5TR | −40 to 125°C | SOT23-5 | 31A | 3 | Tape and Reel, 3000 | Green |
| LM331AU-S5TR | −40 to 125°C | SOT23-5 | CA4 | 3 | Tape and Reel, 3000 | Green |
| LM331AU2-S5TR | −40 to 125°C | SOT23-5 | 31V | 3 | Tape and Reel, 3000 | Green |
| LM393A-SR | −40 to 125°C | SOP8 | 393A | 3 | Tape and Reel, 4000 | Green |
| LM393A-SR-C | −40 to 125°C | SOP8 | 393A | 3 | Tape and Reel, 4000 | Green |
| LM393A-DFGR | −40 to 125°C | DFN2X2-8 | 93A | 3 | Tape and Reel, 3000 | Green |
| LM393A-TSR | −40 to 125°C | TSSOP8 | 393A | 3 | Tape and Reel, 3000 | Green |
| LM339A-SR | −40 to 125°C | SOP14 | LM339 | 3 | Tape and Reel, 2500 | Green |
| LM339A-TR | −40 to 125°C | TSSOP14 | LM339 | 3 | Tape and Reel, 3000 | Green |

**Green**: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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