Bi-directional, Zero-Drift Current Sense Amplifiers

CJCA199AX Series Comparators

1 Introduction

The CJCA199AX series of bidirectional zero-drift current sense amplifier can sense drops across shunts at common-mode voltages from -0.3V to 26V, independent of the supply voltage. Unidirectional operation allows the CJCA199AX series to measure currents through a resistive shunt in one direction, while bidirectional operation allows the device to measure currents through a resistive shunt in two directions. The low offset of the zerodrift architecture enables current sensing with maximum drops across the shunt as low as 10mV full-scale.

The CJCA199AX series operates from a single +2.5V to +18V power supply, drawing a maximum of 100μA of supply current. The device is specified from –40°C to +105°C, and offered in SOT-363 and packages.

2 Applications

- Power Management
- Battery Chargers
- Electrical Cigarette
- Smart Phones and Tablets
- Notebook Computers
- Telecom Equipments
- Welding Equipments

3 Features

- Wide common-mode range:
  -0.3V to 26V
- Maximum 180μV Offset voltage (CJCA199A2/A3)
  Enable Shunt Drops of 10mV Full-scale
- Quiescent Current:
  Maximum 100μA
- Accuracy:
  Maximum ±0.5% Gain Error
  Maximum 0.5μV/°C Offset Drift
  Maximum 10ppm/°C Gain Drift
- Choice of Gains:
  CJCA199A1:50V/V
  CJCA199A2:100V/V
  CJCA199A3:200V/V

4 Available Packages

PART NUMBER	PACKAGE
CJCA199A1-R6N	SOT-363
CJCA199A2-R6N	SOT-363
CJCA199A3-R6N	SOT-363

5 Pin Configuration and Marking Information

5.1 Pin Configuration and Function

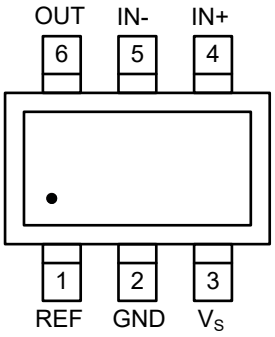
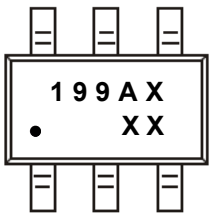


Figure 5-1. CJCA199AX Pin Map

PIN NAME	PIN NO.	I / O	DESCRIPTION
REF	1	-	Reference voltage.
GND	2	-	Negative power supply.
V_S	3	I	Positive power supply. Typically, the voltage is from +2.5V to +18V. A bypass capacitor of 0.1μF as close to the part as possible should be used between power supply pin and ground pin.
IN+	4	I	Non-inverting input of the amplifier.
IN-	5	I	Inverting input of the amplifier.
OUT	6	O	Amplifier output. The voltage range extends to within millivolt of each supply rail.

5.2 Marking Information



SOT-363

"**199AX**": Device number.

"**XX**": Code, indicates weekly record information.

6 Specifications

6.1 Absolute Maximum Ratings

(over operating ambient temperature range, unless otherwise specified)(1)

CHARACTERISTIC	SYMBOL	VALUE	UNIT
Supply voltage	V_S	20	V
Analog Inputs,Differential ($V_{IN+} – V_{IN–}$)	V_{IN+}, V_{IN-}	-26 ~ 26	V
Analog Inputs,Common-Mode	V_{IN+}, V_{IN-}	(GND-0.3) ~ 26	V
REF Input	V_{REF}	(GND-0.3) ~ (V_S+0.3)	V
Output	V_{OUT}	(GND-0.3) ~ (V_S+0.3)	V
Input Current Into All Pins	I_{IN}	5	mA
Maximum junction temperature	$T_{J\ Max}$	150	°C
Storage temperature	T_{stg}	-65 ~ 150	°C
Soldering temperature & time	T_{solder}	260°C, 10s	-

(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.

6.2 Recommend Operating Conditions

(over operating ambient temperature range, unless otherwise specified)

PARAMETER	SYMBOL	MIN.	NOM.	MAX.	UNIT
Input voltage	V_S	2.5	-	18	V
Common mode input voltage range	V_{CM}	-0.3	-	26	V
Operating junction temperature	T_J	-40	-	125	°C
Operating ambient temperature	T_A	-40	-	105	°C

6.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge	Human body model(2)	$V_{ESD-HBM}$	4000	V
	Charged device model(3)	$V_{ESD-CDM}$	2000	
	Machine model	V_{ESD-MM}	400	

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

6 Specifications

6.4 Thermal Information

THERMAL METRIC(4)	SYMBOL	CJCJ199AX Series	UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	**SOT-363**	°C/W
		250.00	
Junction-to-case thermal resistance	$R_{\Theta JC}$	**SOT-363**	°C/W
		79.50	
Reference maximum power dissipation for continuous operation	$P_{D\ Ref}$	**SOT-363**	W
		0.40	

(4) T_A = 25°C, measured on evaluation board with 1oz. copper traces of minimum pad size, all device outputs were active.

6 Specifications

6.5 Electrical Characteristics

T_A = +25°C, V_S = 5.0V, V_{IN+} = 12V, V_{SENSE} = V_{IN+} – $V_{IN–}$, and V_{REF} = V_S/2, unless otherwise noted.

Boldface limits apply over the specified temperature range, T_A = −40 to + 105°C.

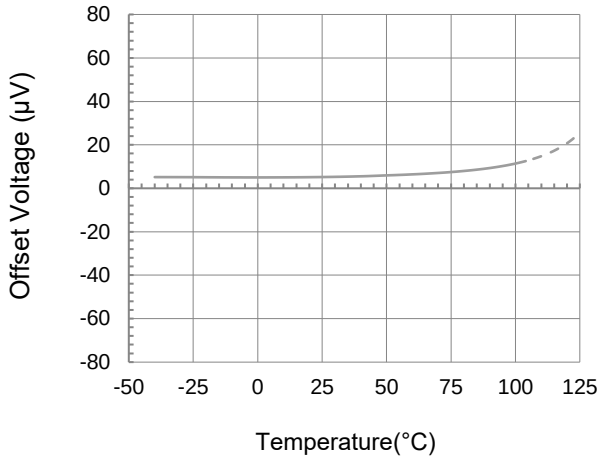
CHARACTERISTIC	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
INPUT							
Input offset voltage	V_{OS}	V_{SENSE} = 0mV	CJCA199A1	-250	+50	300	µV
			CJCA199A2/3	-	±50	±180	µV
Offset voltage drift	$V_{OS\ TC}$	over Temperature		-	0.1	0.5	µV/°C
Input bias current	I_B	V_{SENSE} = 0mV		-	25	-	µA
Input offset current	I_{OS}	V_{SENSE} = 0mV		-	0.02	-	µA
Common mode rejection ratio	CMRR	V_S = 0 to +24V, V_{SENSE} = 0mV, CJCA199A1		91	105	-	dB
		V_S = 0 to +26V, V_{SENSE} = 0mV, CJCA199A2/3		96	110	-	
Input vs power supply	PSR	V_S = +2.5V to +18V, V_{IN+} = +18V, V_{SENSE} = 0mV		-	±0.1	-	µV/V
OUTPUT							
Gain	G	CJCA199A1		-	50	-	V/V
		CJCA199A2		-	100	-	
		CJCA199A3		-	200	-	
Gain error	E_G	V_{SENSE} = -5 mV to 5mV		-	±0.03	±0.5	%
Gain error drift	E_G TC	over Temperature		-	3	10	ppm/°C
Nonlinearity Error		V_{SENSE} = -5 mV to 5mV		-	±0.01	-	%
Maximum Capacitive Load	C_L	No sustained oscillation		-	1	-	nF
Swing to V_S rail	V_{OH}	R_L = 10 k Ω to GND		-	50	200	mV
Swing to V_S GND	V_{OH}	R_L = 10 k Ω to GND		-	5	50	mV
Frequency Response							
Bandwidth	BW	CJCA199A1, C_{LOAD} = 10pF		-	80	-	kHz
		CJCA199A2, C_{LOAD} = 10pF		-	30	-	
		CJCA199A3, C_{LOAD} = 10pF		-	14	-	
Slew rate	SR	-		-	0.65	-	V/µs
POWER SUPPLY							
Quiescent current	I_Q	VSENSE = 0mV		-	70	100	µA
		VSENSE = 0mV, over Temperature		-	-	115	

6 Specifications

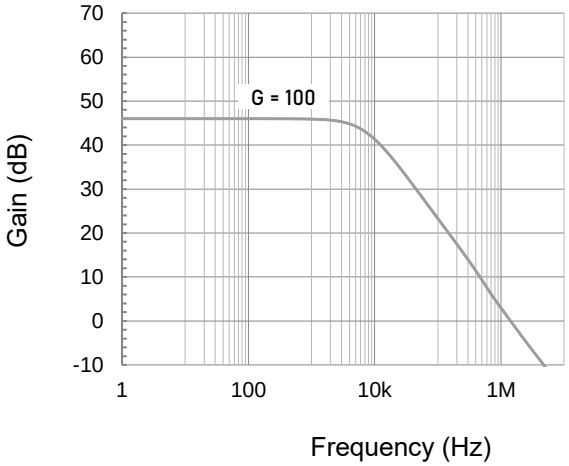
6.6 Typical Characteristics

At T_A = +25°C , V_S = ± 2.5V, V_{CM} = V_S/2, R_L =10kΩ connected to V_S/2, and C_L=15pF, unless otherwise noted.

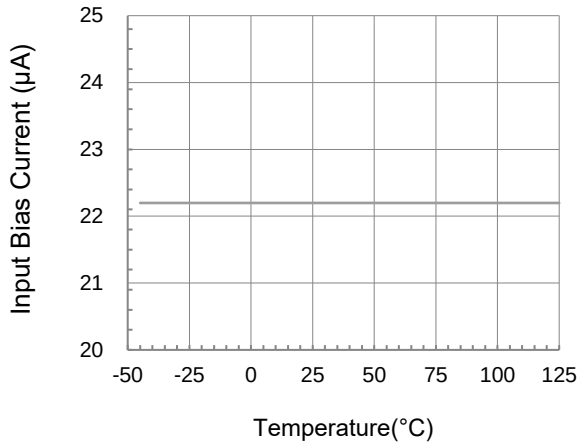
Offset Voltage vs. Temperature



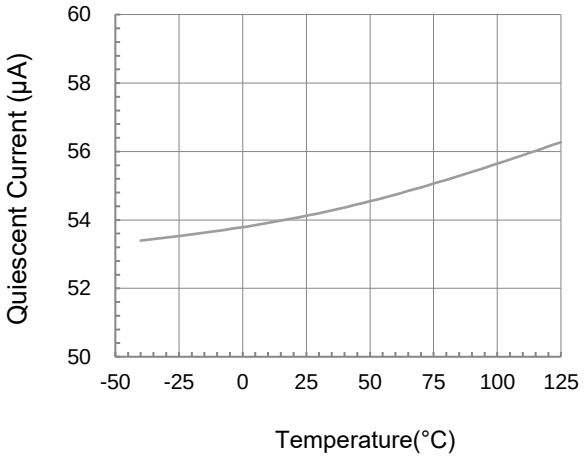
Gain vs. Frequency



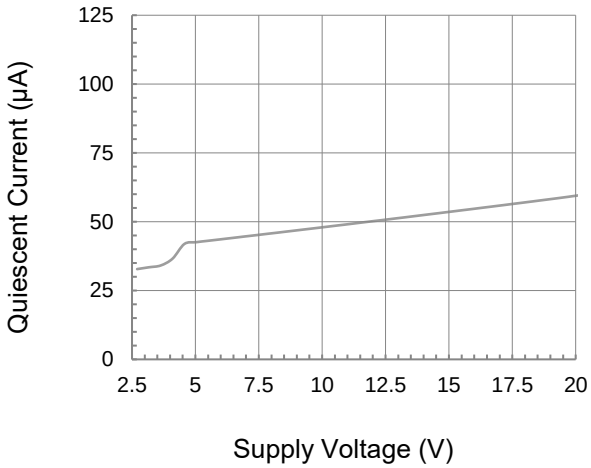
Input Bias Current vs. Temperature



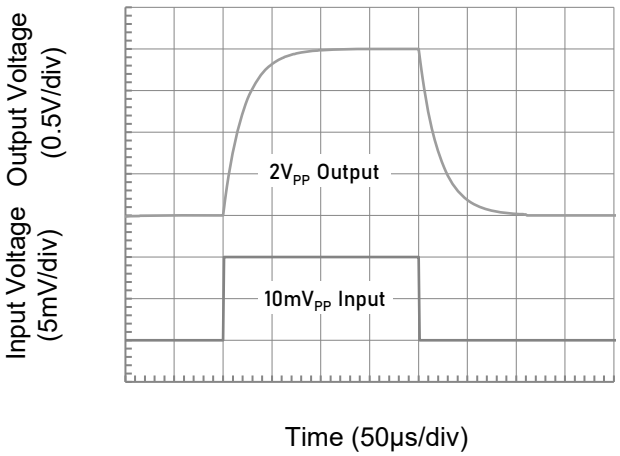
Quiescent Current vs. Temperature



Quiescent Current vs. Supply Voltage



Step Response (10mVPP Input Step)

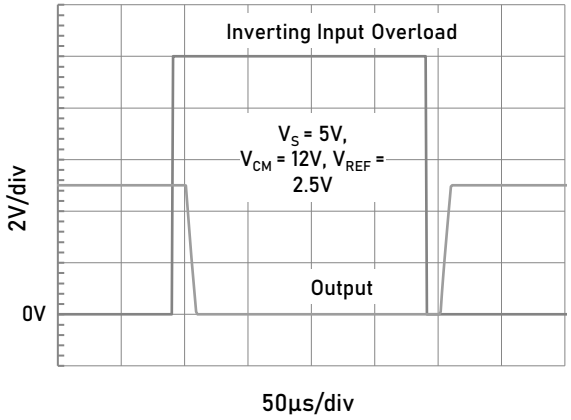


6 Specifications

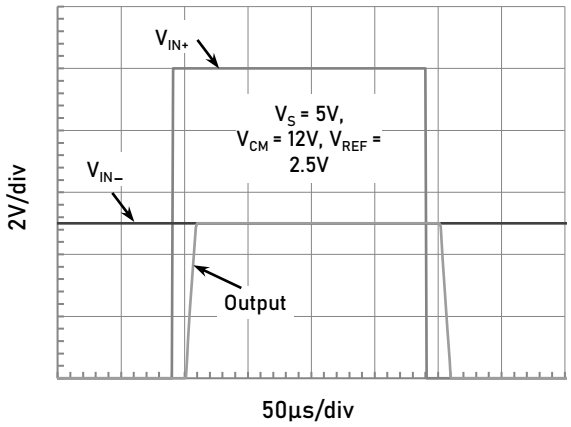
6.6 Typical Characteristics

At T_A = +25°C , V_S = ± 2.5V, V_{CM} = V_S/2, R_L =10kΩ connected to V_S/2, and C_L=15pF, unless otherwise noted.

Inverting Differential Input Overload



Noninverting Differential Input Overload

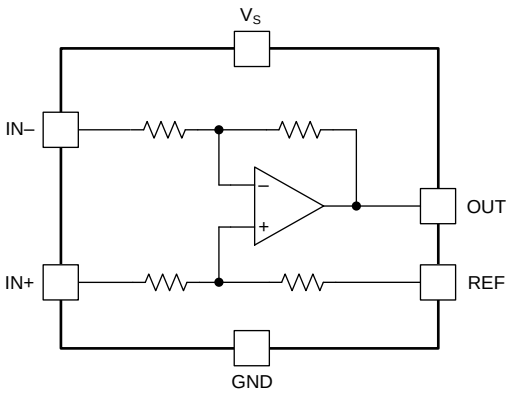


7 Detail Description

7.1 Description

The CJCA199AX series of bidirectional zero-drift current sense amplifier can sense drops across shunts at common-mode voltages from -0.3V to 26V, independent of the supply voltage. Unidirectional operation allows the CJCA199AX series to measure currents through a resistive shunt in one direction, while bidirectional operation allows the device to measure currents through a resistive shunt in two directions. The low offset of the zerodrift architecture enables current sensing with maximum drops across the shunt as low as 10mV full-scale.

7.2 Functonal Block Diagrams



8 Application and Implementation

8.1 Application Information

The CJCA199AX measures the voltage developed across a current-sensing resistor when current passes through it. The ability to drive the reference pin to adjust the functionality of the output signal offers multiple configurations, as discussed throughout this section.

8.2 Typical Application Circuits

Basic Connections

Figure 9-1 shows the basic connections for the CJAC199AX. The input pins, IN+ and IN–, should be connected as closely as possible to the shunt resistor to minimize any resistance in series with the shunt resistance.

Power-supply bypass capacitors are required for stability.Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Connect bypass capacitors close to the device pins.

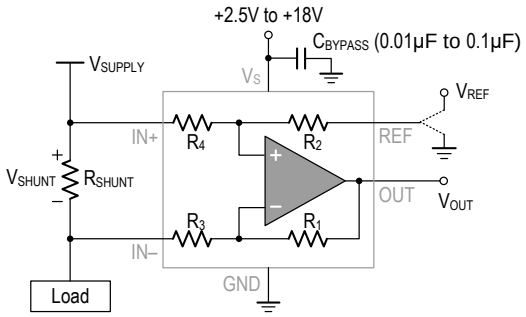


Figure 9-1. Typical Application

Selecting R_S

The zero-drift offset performance of the CJCA199AX offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the shunt. For example, non-zero-drift current sense amplifiers typically require a full-scale range of 100mV.

The CJCA199AX of current sense amplifier gives equivalent accuracy at a full-scale range on the order of 10mV. This accuracy reduces shunt dissipation by an order of magnitude with many additional benefits. Alternatively, there are applications that must measure current over a wide dynamic range that can take advantage of the low offset on the low end of the measurement. Most often, these applications can use the lower gain of 100 to accommodate larger shunt drops on the upper end of the scale.

Unidirectional Operation

Unidirectional operation allows the CJCA199AX to measure currents through a resistive shunt in one direction. The most frequent case of unidirectional operation sets the output at ground by connecting the REF pin to ground. In unidirectional applications where the highest possible accuracy is desirable at very low inputs, bias the REF pin to a convenient value above 50mV to get the device output swing into the linear range for zero inputs.

A less frequent case of unipolar output biasing is to bias the output by connecting the REF pin to the supply; in this case, the quiescent output for zero input is at quiescent supply. This configuration would only respond to negative currents (inverted voltage polarity at the device input).

8 Application and Implementation

8.2 Typical Application Circuits (continued)

Bidirectional Operation

Bidirectional operation allows the CJCA199X to measure currents through a resistive shunt in two directions. In this case, the output can be set anywhere within the limits of what the reference inputs allow (that is, between 0V to V+). Typically, it is set at half-scale for equal range in both directions. In some cases, however, it is set at a voltage other than half-scale when the bidirectional current is nonsymmetrical.

The quiescent output voltage is set by applying voltage to the reference input. Under zero differential input conditions the output assumes the same voltage that is applied to the reference input.

Input Filtering

An obvious and straightforward filtering location is at the device output. However, this location negates the advantage of the low output impedance of the internal buffer. The only other filtering option is at the device input pins. This location, though, does require consideration of the 30% tolerance of the internal resistances. Figure 9-2 shows a filter placed at the inputs pins.

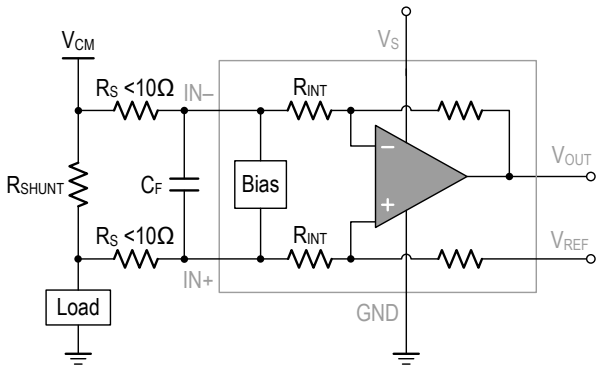


Figure 9-2. Filter at Input Pins

The addition of external series resistance, however, creates an additional error in the measurement so the value of these series resistors must be kept to 10 Ω (or less if possible) to reduce any affect to accuracy. The internal bias network shown in Figure 9-2 present at the input pins creates a mismatch in input bias currents when a differential voltage is applied between the input pins. If additional external series filter resistors are added to the circuit, the mismatch in bias currents results in a mismatch of voltage drops across the filter resistors. This mismatch creates a differential error voltage that subtracts from the voltage developed at the shunt resistor. This error results in a voltage at the device input pins that is different than the voltage developed across the shunt resistor. Without the additional series resistance, the mismatch in input bias currents has little effect on device operation. The amount of error these external filter resistor add to the measurement can be calculated using Equation 2 where the gain error factor is calculated using Equation 1.

The amount of variance in the differential voltage present at the device input relative to the voltage developed at the shunt resistor is based both on the external series resistance value as well as the internal input resistors, R3 and R4 (or RINT as shown in Figure 9-2). The reduction of the shunt voltage reaching the device input pins appears as a gain error when comparing the output voltage relative to the voltage across the shunt resistor. A factor can be calculated to determine the amount of gain error that is introduced by the addition of external series resistance. The equation used to calculate the expected deviation from the shunt voltage to what is seen at the device input pins is given in Equation 1:

8 Application and Implementation

8.2 Typical Application Circuits (continued)

Input Filtering (continued)

$$Gain\ Error\ Factor = \frac{R_{INT}}{1250 \times R_S + 1250 \times R_{INT} + R_S \times R_{INT}}$$

where:

• R_{INT} is the internal input resistor (R_3 and R_4).

• R_S is the external series resistance.

The gain error that can be expected from the addition of the external series resistors can then be calculated based on Equation 2:

$$\text{Gain Error}(\%) = 100 - (100 \times \text{Gain Error Factor})$$

For CJCA199AX, a series resistance of 10Ω results in a gain error factor of 0.991. The corresponding gain error is then calculated using Equation 2, resulting in a gain error of approximately 0.89% solely because of the external 10Ω series resistors.

8.3 Power Supply Recommendations

The input circuitry of the CJCA199AX can accurately measure beyond its power-supply voltage, V_S. For example, the V_S power supply can be 5V, whereas the load power-supply voltage can be as high as +18V. However, the output voltage range of the OUT terminal is limited by the voltages on the power-supply pin. Note also that the CJCA199AX can withstand the full –0.3V to +26V range in the input pins, regardless of whether the device has power applied or not.

9 Notes and Revision History

9.1 Associated Product Family and Others

To view other products of the same type or IC products of other types, click the official website of SZCJ -- https: ***www.***szcjsemi.com for more details.

9.2 Notes

Electrostatic Discharge Caution



This IC may be damaged by ESD. Relevant personnel shall comply with correct installation and use specifications to avoid ESD damage to the IC. If appropriate measures are not taken to prevent ESD damage, the hazards caused by ESD include but are not limited to degradation of integrated circuit performance or complete damage of integrated circuit. For some precision integrated circuits, a very small parameter change may cause the whole device to be inconsistent with its published specifications.

9.3 Revision History

December 2025: released CJCA199AX Series rev - 1.0.

10 Orderable, Mechanical, and Packaging Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.

Orderable Information

MODEL	DEVICE	PACKAGE	OP TEMP	ECO PLAN	MSL	PACKING OPTION	SORT
CJCA199A1	CJCA199A1-R6N	SOT-363	-40 ~ 105°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJCA199A2	CJCA199A2-R6N	SOT-363	-40 ~ 105°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
CJCA199A3	CJCA199A2-R6N	SOT-363	-40 ~ 105°C	RoHS & Green	Level 3 168 HR	Tape and Reel 3000 Units / Reel	Active
Others	-	-	-	-	-	-	Customized

Note:

ECO PLAN: For the RoHS and Green certification standards of this product, please refer to the official report provided by SZCJ

MSL: Moisture Sensitivity Level. Determined according to JEDEC industry standard classification.

SORT: Specifically defined as follows:

Active: Recommended for new products;

Customized: Products manufactured to meet the specific needs of customers;

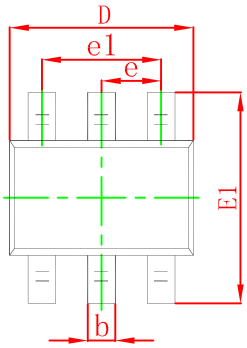
Preview: The device has been released and has not been fully mass produced. The sample may or may not be available;

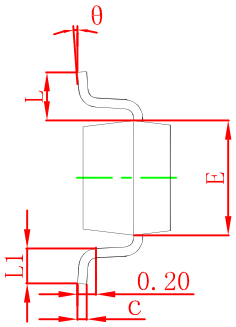
NoRD: It is not recommended to use the device for new design. The device is only produced for the needs of existing customers; Obsolete: The device has been discontinued.

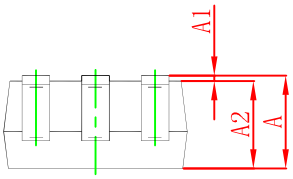
Mechanical Information

SOT-363 Mechanical Information

SOT-363 Outline Dimensions

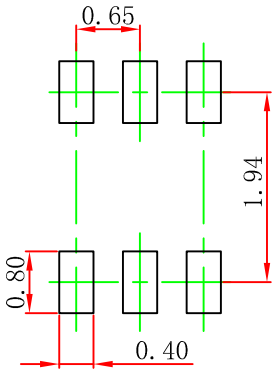






Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.100	0.150	0.004	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.400	0.085	0.094
e	0.650 TYP		0.026 TYP	
e1	1.200	1.400	0.047	0.055
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

SOT-363 Suggested Pad Layout

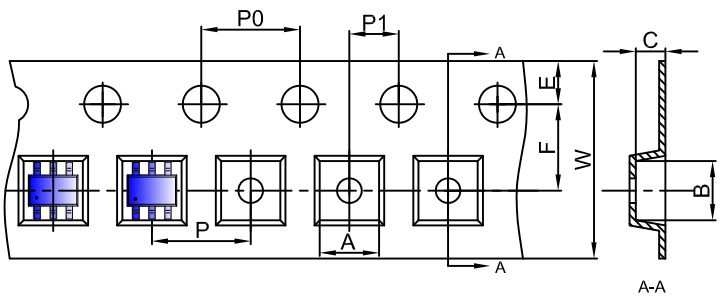


Note:
1.Controlling dimension:in millimeters.
2.General tolerance:± 0.05mm.
3.The pad layout is for reference purposes only.

Packaging Information

SOT-363 Tape and Reel Information

SOT-363 Embossed Carrier Tape

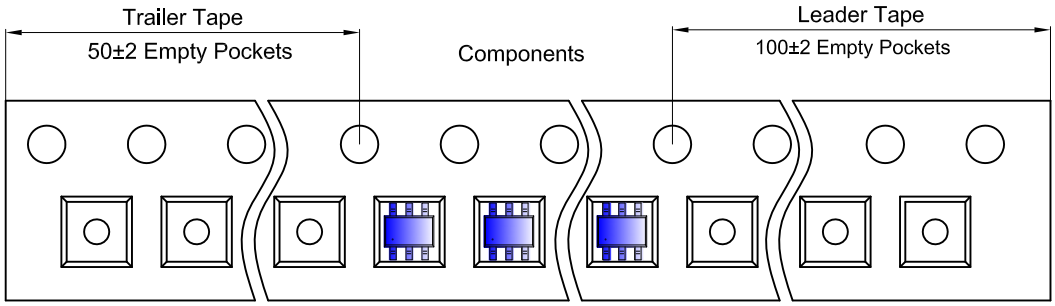


Packaging Description:

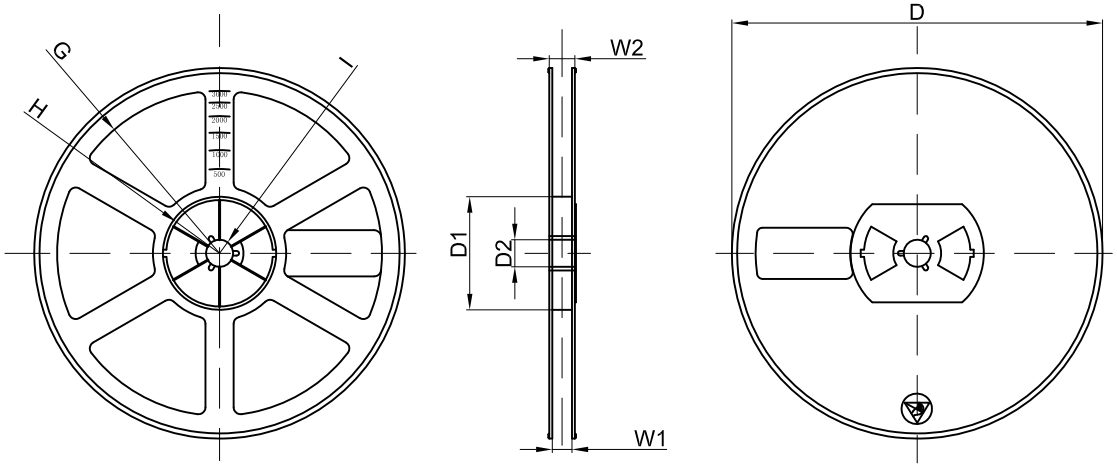
SOT-363 parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 3,000 units per 7" or 17.8cm diameter reel. The reels are clear in color and is made of polystyrene plastic (anti-static coated).

Dimensions are in millimeter										
Pkg type	A	B	C	d	E	F	P0	P	P1	W
SOT-363	2.25	2.55	1.20	Ø1.50	1.75	3.50	4.00	4.00	2.00	8.00

SOT-363 Tape Leader and Trailer



SOT-363 Reel



Dimensions are in millimeter								
Reel Option	D	D1	D2	G	H	I	W1	W2
7"Dia	Ø178.00	54.40	13.00	R78.00	R25.60	R6.50	9.50	12.30

REEL	Reel Size	Box	Box Size(mm)	Carton	Carton Size(mm)	G.W.(kg)
3000 pcs	7 inch	45,000 pcs	203×203×195	180,000 pcs	438×438×220	

DISCLAIMER

IMPORTANT NOTICE, PLEASE READ CAREFULLY

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