Zero-Drift, Bi-directional Current Sense Amplifier

Features

- Wide common mode voltage: -0.3V~+30V
- Single-Supply Operation from +2.7V ~ +30V
- Rail-to-Rail Input / Output
- Accuracy and Zero-Drift performance
  - ±1% Gain Error（Max over temperature）
  - 0.5μV/℃ Offset Drift (Max)
  - 10ppm/℃ Gain Drift (Max)
- Three gain options for voltage output
  - GS199A:50V/V
  - GS199B:100V/V
  - GS199C:200V/V
- Low Supply Current: 100μA (Typ)
- Operating Temperature: -40°C ~ +125°C
- Embedded RF Anti-EMI Filter
- Small Package:

GS199X Available in SC70-6 and SOT23-6 Packages

General Description

The GS199X series of zero-drift, bi-directional current sense amplifier can sense voltage drops across shunts at common-mode voltages from –0.3V to 30V, independent of the supply voltage. Three fixed gains are available: 50V/V, 100V/V and 200V/V. The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 10mV full-scale. GS199X devices operate from a single +2.7V to 30V power supply, with drawing a typical of 100μA of supply current. All versions are specified from –40°C +125°C, and offered in SC70-6 and SOT23-6 packages

Applications

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- Current sensing (High-Side/Low-Side)
- Battery chargers
- Power management
- Cell phone charger
- Electrical cigarette
- Wireless charger
- Telecom equipment

Pin Configuration

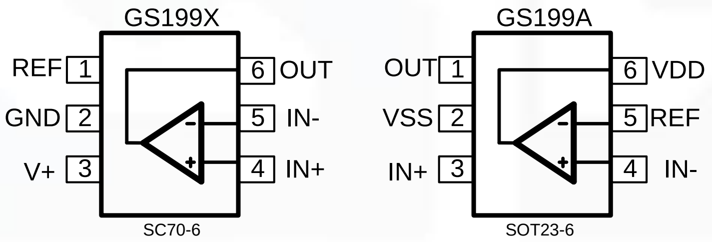


Figure 1. Pin Assignment Diagram

Package/Ordering Information

Model	Channel	Order Number	Package Description	Package Option	Marking Information
GS199A	Single	GS199X-CR	SC70-6	Tape and Reel,3000	199A
GS199B					199B
GS199C					199C
GS199A		GS199A-TR	SOT23-6		GS199A

Absolute Maximum Ratings

Condition	Min	Max
Supply Voltage[Note2]		+39V
Input Voltage	GND-0.3V	+39V
Input Current(+IN,-IN)[Note2]	-5mA	+5mA
Operating Temperature Range	-40°C	+125°C
Maximum Junction Temperature	+150°C	
Storage Temperature Range	-65°C	+150°C
Lead Temperature (soldering, 10sec)	+260°C	
Package Thermal Resistance (T_A=+25℃)		
SC70-6, θ_{JA}	227°C/W	
SOT23-6, θ_{JA}	190°C/W	
ESD Susceptibility		
HBM（ANSI/ESDA/JEDEC JS-001）	±1.5KV	
CDM（ANSI/ESDA/JEDEC JS-002）	±2KV	
Latch up	200mA	

Note 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.

Note 2: The inputs current should be limited to less than 10mA if input voltage exceeds the absolute maximum ratings.

Application schematic

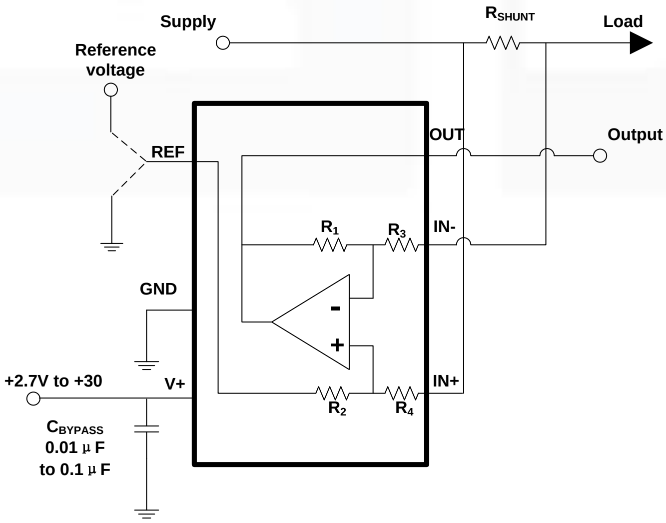


Figure 2. fundamental circuit

Electrical Characteristics

(T_A=25℃ V_{SENSE} = V_{IN+}-V_{IN-},V_S=+5V,V_{IN+}=12V,V_{ERF}=V_S/2, unless otherwise noted.)

Parameter	Symbol	Conditions	GS199X			
INPUT CHARACTERISTICS			**TYP**	**MAX**	**MIN**	**UNIT**
Input Offset Voltage	V_{OS}	V_{SENSE} = 0mV	±10	200	-200	μV
Input Bias Current	I_B	V_{SENSE} = 0mV	35			μA
Input Offset Current	I_{OS}		0.4			μA
Common-Mode Voltage Range	V_{CM}	-40℃ to 125℃		30	-0.3	V
Common-Mode Rejection Ratio	CMRR	V_{IN+}=5~26V,V_{SENSE}=0mV,-40℃ to 125℃	120		90	dB
Power Supply Rejection Ratio	PSRR	V_S = +2.7V to 18V, V_{IN+}=+18V, V_{SENSE}=0V	±1			μV/V
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$	V_{SENSE}=0mV,-40℃ to 125℃	0.1	0.5		μV/℃
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail	V_{OH}	R_L = 10kΩ to REF,-40℃ to 125℃	20	50		mV
	V_{OL}	R_L = 10kΩ to REF,-40℃ to 125℃	10	50		mV
Gain	G	GS199A	50			V/V
		GS199B	100			
		GS199C	200			
Gain Error	GE	V_{SENSE}=-5~5mV,-40℃ to 125℃	±0.1%	±1%		
Gain Error Vs Temperature	GE TC	40℃ to 125℃	3	10		ppm
Maxim capacitive load	C_{LOAD}	no sustained oscillation	1			nF
POWER SUPPLY						
Operating Voltage Range	V+			30	2.7	V
Quiescent Current / Amplifier	I_Q		100	190		μA
FREQUENCY RESPONSE						
Bandwidth	BW	CLOAD = 10pF, GS199A	61			KHz
		CLOAD = 10pF, GS199B	27			KHz
		CLOAD = 10pF, GS199C	13			KHz
Slew Rate	SR	G = +1, 2V Output Step	0.3			V/μs
NOISE RTi[Note3]						
Input Voltage Noise Density	e_n	f = 1kHz	30			$nV/\sqrt{Hz}$
TEMPERATURE RANGE						
Operating range				125	-40	℃

Note 3: RTI=referred to input

Typical Performance characteristics

At T_A=+25°C, V_S=5V, V_{IN+}=12V, and V_{REF}=V_S/2, unless otherwise noted.

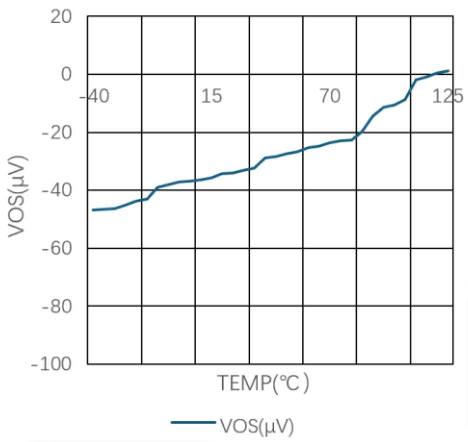


Figure3. Voltage Offset vs Temperature

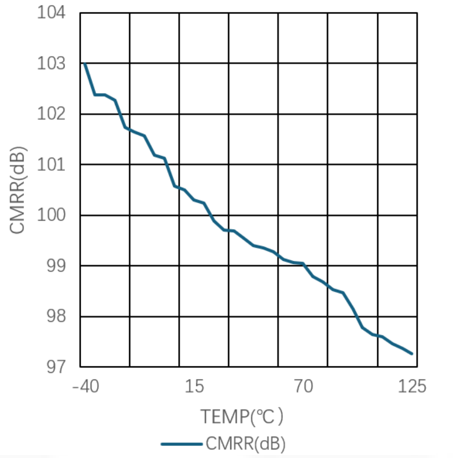


Figure4. CMRR vs. Temperature

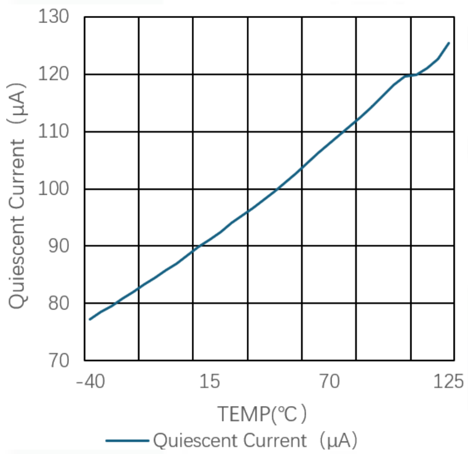


Figure5. Quiescent Current vs Temperature

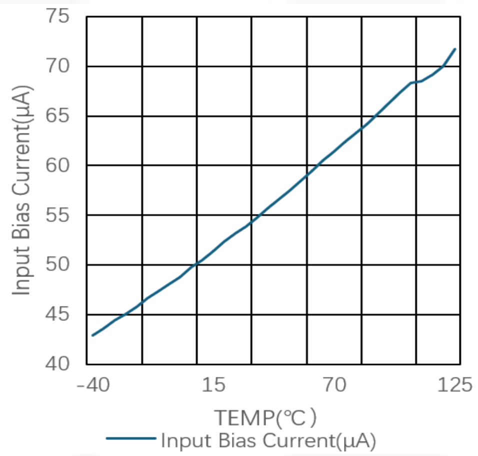


Figure6. Input Bias Current vs Temperature

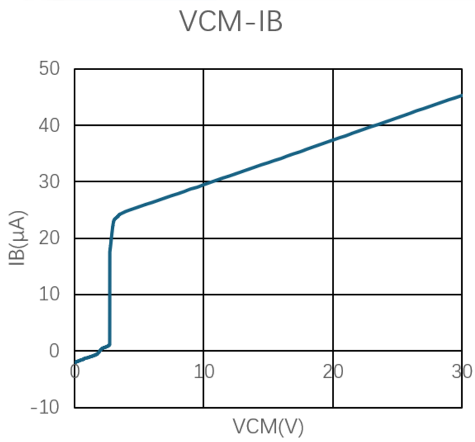


Figure7. Input Bias Current vs Common-Mode Voltage

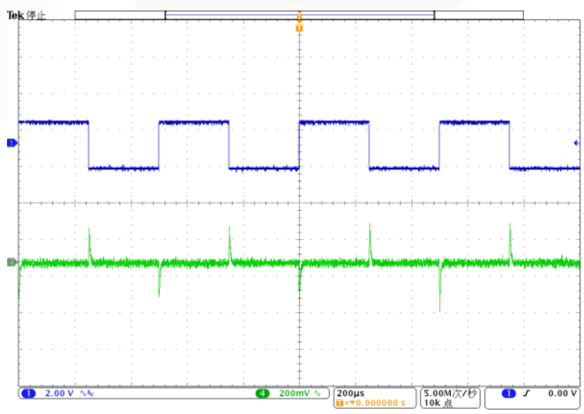


Figure8. Common-Mode Voltage Transient Response

Typical Performance characteristics

At T_A=+25ºC, V_S=+5V, V_{IN+}=12V, and V_{REF}=V_S/2, unless otherwise noted.

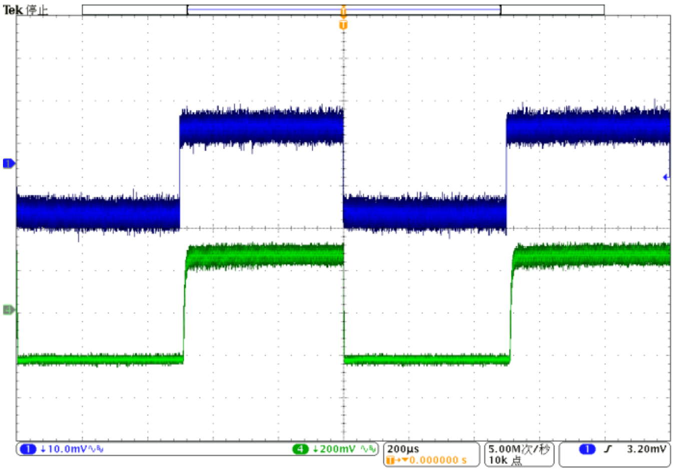


Figure9.Step response (20-mVpp Input Step)

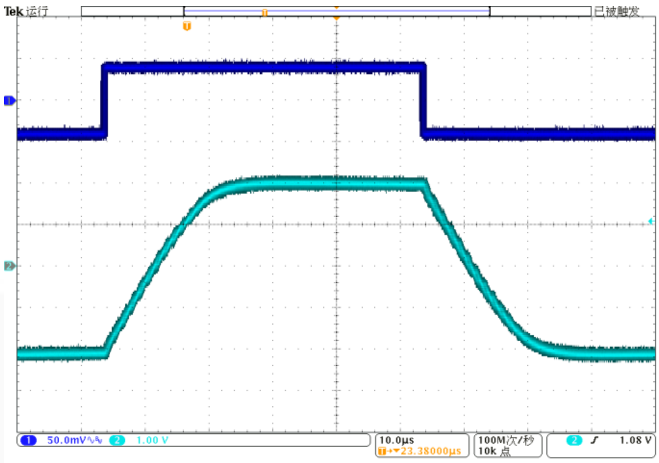


Figure10.Step response (80-mVpp Input Step)

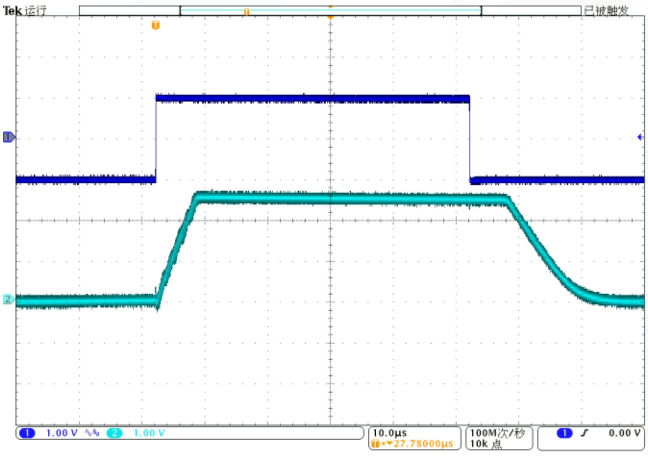


Figure11.Noninverting Differential Input Overload

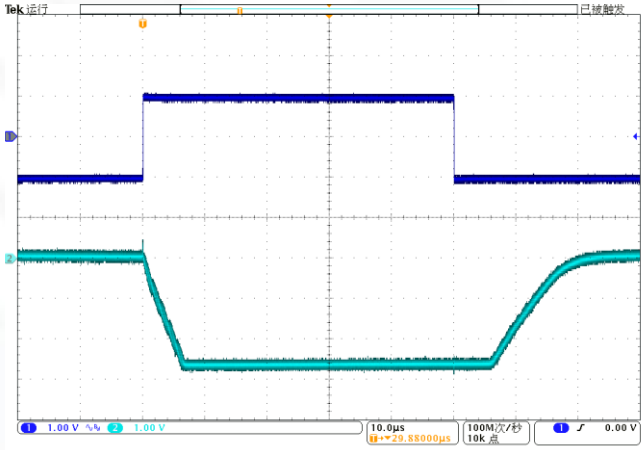


Figure12.Inverting Differential Input Overload

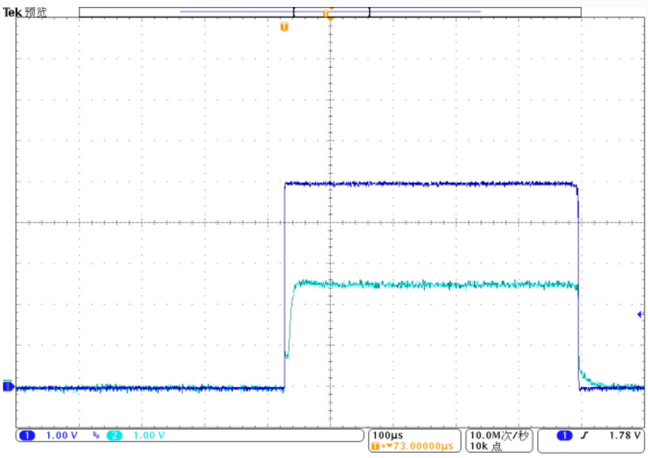


Figure13.Start-up Response

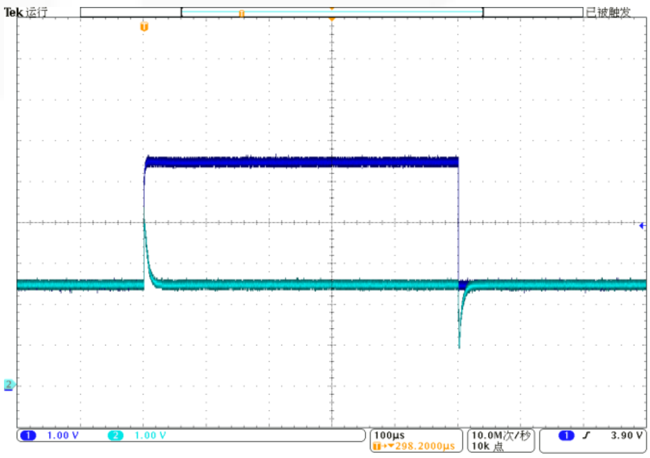


Figure14.Brownout Recovery

Typical Performance characteristics

At T_A=+25ºC, V_S=+5V, V_{IN+}=12V, and V_{REF}=V_S/2, unless otherwise noted.

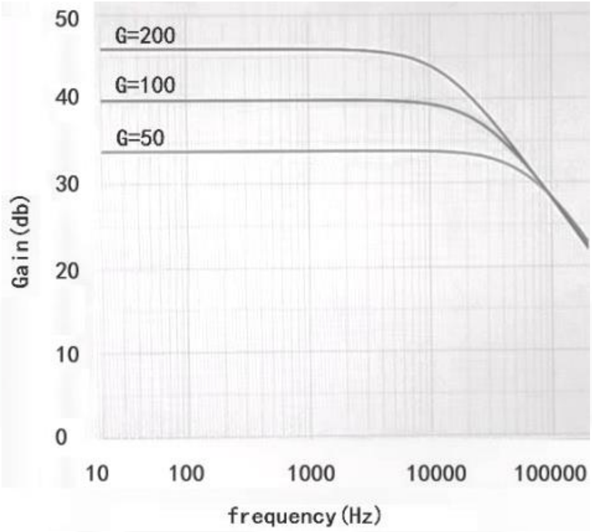
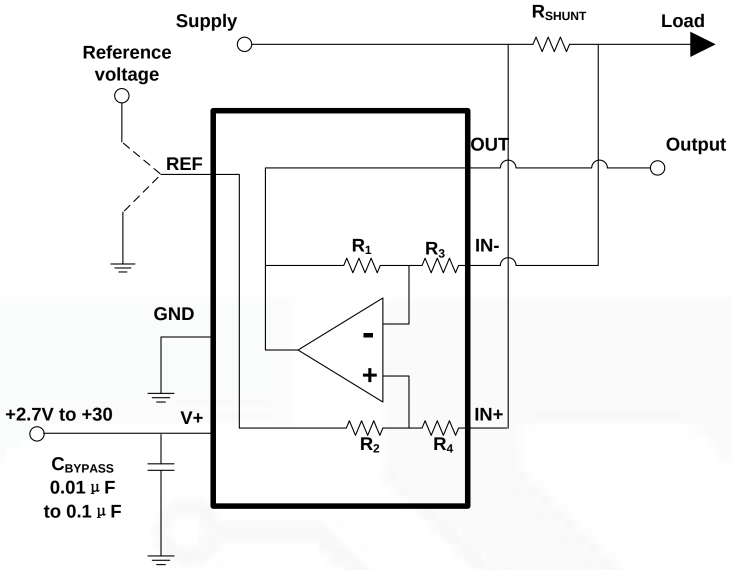


Figure15. Gain vs Frequency

Application Information

Application schematic



Above figure shows the basic connections of the GS199X. 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 resistor.

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.

Selecting R_{SHUNT}

The zero-drift offset performance of the GS199X offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the shunt. For example, nonzero-drift current shunt monitors typically require a full-scale range of 100 mV.

The GS199X family gives equivalent accuracy at a full-scale range on the order of 10 mV. 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 gains of the GS199X to accommodate larger shunt drops on the upper end of the scale. For instance, an GS199A operating on a 3.3-V supply could easily handle a full-scale shunt drop of 60 mV, with only 200uV of offset.

REF Input Impedance Effects

As with any difference amplifier, the GS199X family common-mode rejection ratio is affected by any impedance present at the REF input. This concern is not a problem when the REF pin is connected directly to most references or power supplies. When using resistive dividers from the power supply or a reference voltage, the REF pin should be buffered by an op amp.

Power Supply Recommendation

The input circuitry of the GS199X can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power-supply voltage can be as high as 30 V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Note also that the GS199X can withstand the full input signal range up to 36 V at the input pins, regardless of whether the device has power applied or not.

Proper Board Layout

To ensure optimum performance at the PCB level, care must be taken in the design of the board layout. To avoid leakage currents, the surface of the board should be kept clean and free of moisture. Coating the surface creates a barrier to moisture accumulation and helps reduce parasitic resistance on the board.

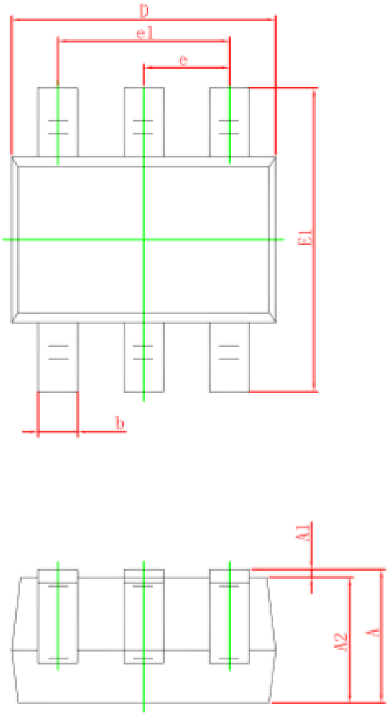
Keeping supply traces short and properly bypassing the power supplies minimizes power supply disturbances due to output current variation, such as when driving an ac signal into a heavy load. Bypass capacitors should be connected as closely as possible to the device supply pins. Stray capacitances are a concern at the outputs and the inputs of the amplifier. It is recommended that signal traces be kept at least 5mm from supply lines to minimize coupling.

A variation in temperature across the PCB can cause a mismatch in the See beck voltages at solder joints and other points where dissimilar metals are in contact, resulting in thermal voltage errors. To minimize these thermocouple effects, orient resistors so heat sources warm both ends equally. Input signal paths should contain matching numbers and types of components, where possible to match the number and type of thermocouple junctions. For example, dummy components such as zero value resistors can be used to match real resistors in the opposite input path. Matching components should be located in close proximity and should be oriented in the same manner. Ensure leads are of equal length so that thermal conduction is in equilibrium. Keep heat sources on the PCB as far away from amplifier input circuitry as is practical.

The use of a ground plane is highly recommended. A ground plane reduces EMI noise and also helps to maintain a constant temperature across the circuit board.

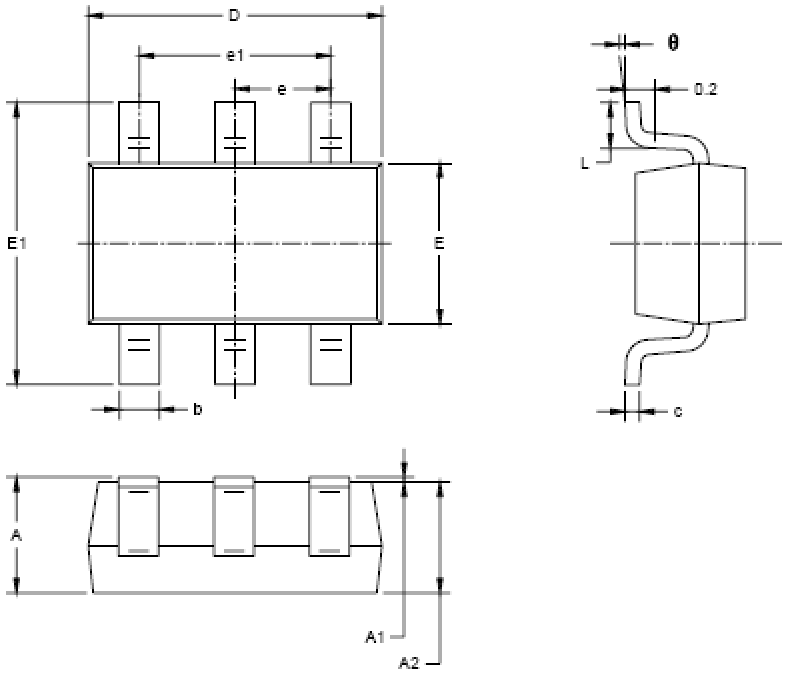
Package Information

SC70-6



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	0.110	0.175	0.004	0.007
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
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°

SOT23-6



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°