



## DESCRIPTION

The AO1369 is ultra-low-power, low-voltage operational amplifier from AiT Semi designed especially for battery-powered applications.

The AO1369 operates on a supply voltage as low as 1.4V and has true rail-to-rail operation that makes it useful for a wide range of applications.

In addition to compact size package and very low quiescent current of 600nA/amplifier at 5V. The AO1369 features 14.5kHz bandwidth, low offset drift ( 2.5 $\mu$ V/ $^{\circ}$ C, max). slew rate of 6V/ms. The AO1369 is designed to provide optimal performance in low voltage and low noise systems.

AO1369 provides rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3mV for AO1369. They are specified over the extended industrial temperature range (-40 $^{\circ}$ C to +125 $^{\circ}$ C). The operating range is from 1.4V to 5.5V.

The AO1369 (single) is available in SOT-25 and SC70-5 packages.

## ORDERING INFORMATION

Package Type	Part Number	
SOT-25 SPQ: 3,000pcs/Reel	E5	AO1369E5R
		AO1369E5VR
SC70-5 SPQ: 3,000pcs/Reel	C5	AO1369C5R
		AO1369C5VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

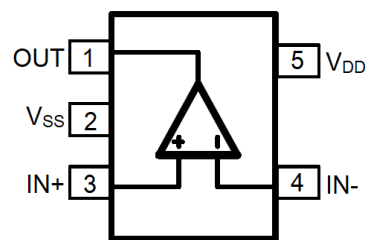
## FEATURES

- Quiescent Current: 600nA per Amplifier (Typ.)
- Low Offset Voltage: 3mV (Max.)
- Low Offset Drift: 2.5 $\mu$ V/ $^{\circ}$ C, max
- Gain-Bandwidth: 14.5kHz (Typ.)
- Single-Supply
- Supply Voltage: 1.4V to 5.5V
- Rail-to-Rail Input / Output
- Low Input Bias Current: 1pA (Typ.)
- Operating Temperature: -40 $^{\circ}$ C ~ +125 $^{\circ}$ C
- Embedded RF Anti-EMI Filter
- Available in SOT-25 and SC70-5 packages

## APPLICATION

- Battery-Powered Instruments
- Portable Devices
- Medical Instruments
- Test Equipment
- Low-Power Sensor Signal Conditioning
- ASIC Input or Output Amplifier
- Sensor Interface
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier

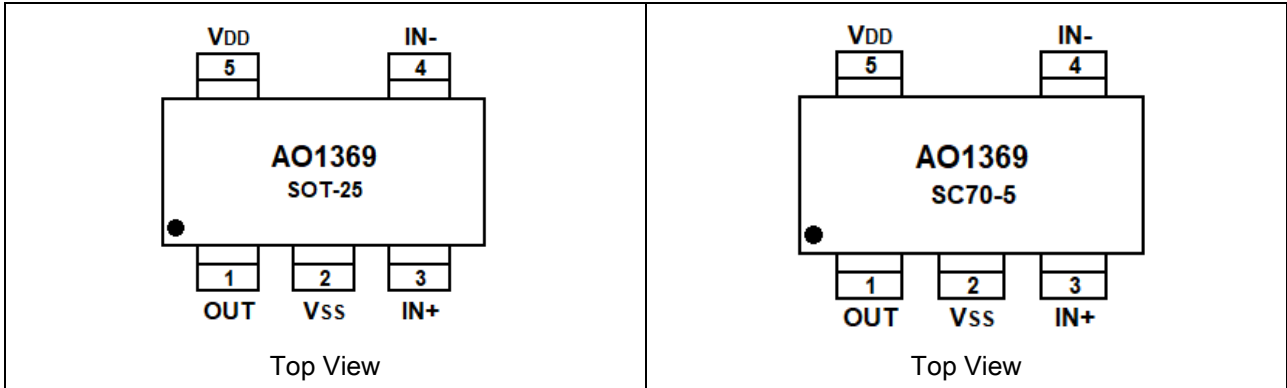
## TYPICAL APPLICATION



SOT-25/SC70-5



**PIN DESCRIPTION**



Pin #		Symbol	Function
SOT-25	SC70-5		
1	1	OUT	Output
2	2	V <sub>SS</sub>	Ground or Negative Power Supply Input
3	3	IN+	Analog Positive Input
4	4	IN-	Analog Inverting Input
5	5	V <sub>DD</sub>	Positive Power Supply Input



## ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage ( $V_{DD}$ to $V_{SS}$ )	-0.5V ~ +7.5V
Analog Input Voltage (IN+ or IN-)	$V_{SS}-0.5V \sim V_{DD}+0.5V$
PDB Input Voltage	$V_{SS}-0.5V \sim +7V$
Operating Temperature Range	-40°C ~ 125°C
Junction Temperature	+160°C
Storage Temperature Range	-55°C ~ 150°C
Lead Temperature (soldering, 10sec)	+260°C
<b>Package Thermal Resistance (<math>T_A=+25^\circ\text{C}</math>)</b>	
$\theta_{JA}$ , SOT-25	190°C/W
$\theta_{JA}$ , SC70-5	333°C/W
<b>ESD Susceptibility</b>	
HBM	6kV
MM	300V

Stress beyond above listed "Absolute Maximum Ratings" may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.



## ELECTRICAL CHARACTERISTICS

At  $V_S = +5V$ ,  $R_L = 1M\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ , unless otherwise noted.

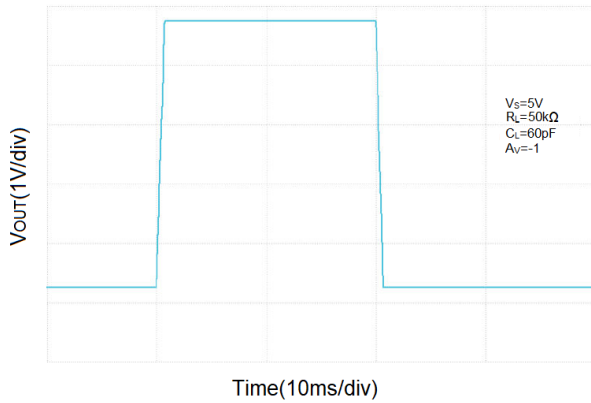
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>INPUT CHARACTERISTICS</b>						
Input Offset Voltage	$V_{OS}$	$V_{CM} = V_S/2$		0.4	3	mV
Input Bias Current	$I_B$		-	1	-	pA
Input Offset Current	$I_{OS}$		-	1	-	pA
Common-Mode Voltage Range	$V_{CM}$	$V_S = 5.5V$	-	-0.1 to +5.6	-	V
Common-Mode Rejection Ratio	CMRR	$V_S = 5V, V_{CM} = -0.1V$ to $2.5V$	66	78	-	dB
		$V_S = 5V, V_{CM} = -0.1V$ to $5.1V$	67	84	-	
Open-Loop Voltage Gain	$A_{OL}$	$V_S=1.4V, R_L = 50k\Omega, V_O = V_S-0.1V$	75	86	-	dB
		$V_S=5V, R_L = 50k\Omega, V_O = V_S-0.1V$	84	93	-	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		-	2.5	-	$\mu V/^\circ C$
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing from Rail	$V_{OH}$	$V_S=1.4V, R_L = 50k\Omega$	1.390	1.395	-	V
	$V_{OL}$		-	4.5	10	mV
	$V_{OH}$	$V_S=5V, R_L = 50k\Omega$	4.990	4.997	-	V
	$V_{OL}$		-	3.5	10	mV
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	-	20	-	mA
	$I_{SINK}$		-	20	-	
<b>POWER SUPPLY</b>						
Operating Voltage Range			-	1.4	-	V
			-	5.5	-	
Power Supply Rejection Ratio	PSRR	$V_S = +1.4V$ to $+5.5V, V_{CM} = +0.5V$	77	80	-	dB
Quiescent Current / Amplifier	$I_Q$		-	600	-	nA
<b>DYNAMIC PERFORMANCE (<math>C_L = 100pF</math>)</b>						
Gain-Bandwidth Product	GBP		-	14.5	-	kHz
Slew Rate	SR	$G = +1, 2V$ Output Step	-	6	-	V/ms



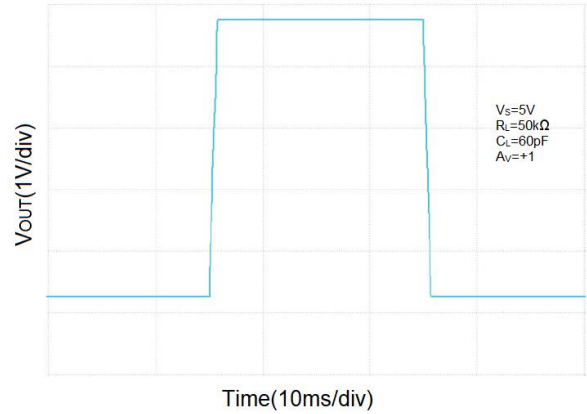
## TYPICAL PERFORMANCE CHARACTERISTICS

At  $T_A=+25^{\circ}\text{C}$ ,  $V_S=+5\text{V}$ , and  $R_L=100\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

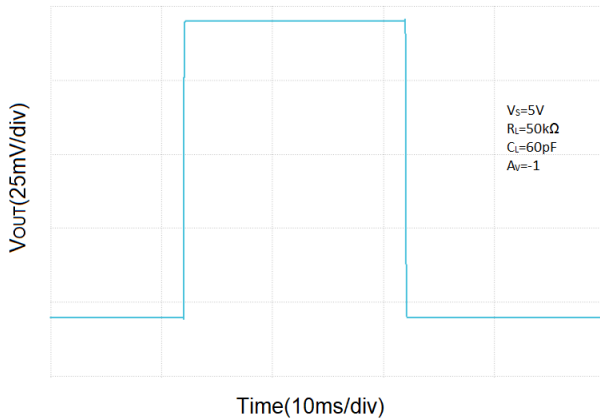
1. Large Signal Inverting Pulse Response



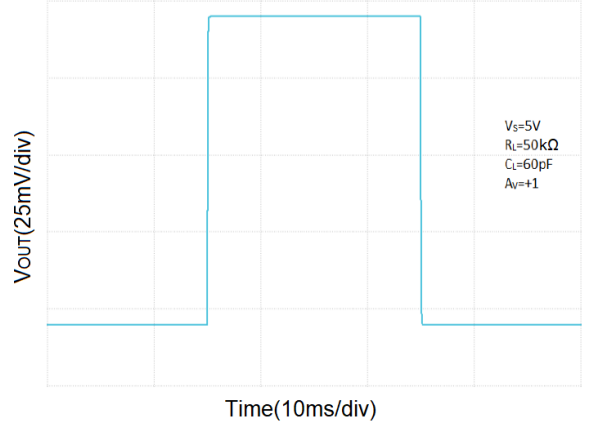
2. Large Signal Non-Inverting Pulse Response



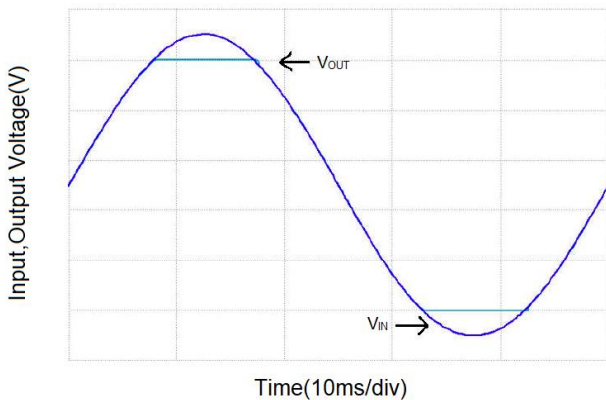
3. Small Signal Inverting Pulse Response



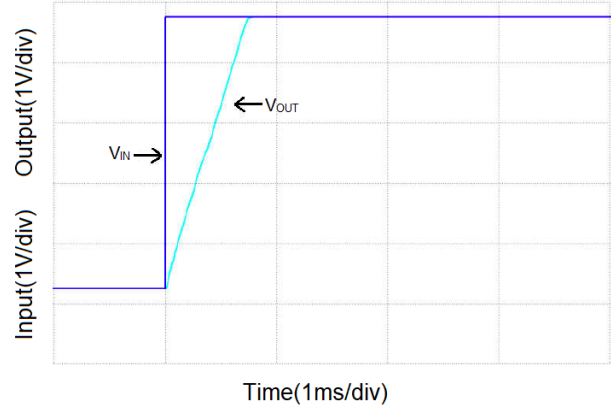
4. Small Signal Non-Inverting Pulse Response



5. No Phase Reversal



6. Output Settling Time





## DETAILED INFORMATION

### Size

AO1369 op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the AO1369 packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

AO1369 operates from a single 1.4V to 5.5V supply or dual  $\pm 0.7V$  to  $\pm 2.75V$  supplies. For best performance, a 0.1 $\mu$ F ceramic capacitor should be placed close to the  $V_{DD}$  pin in single supply operation. For dual supply operation, both  $V_{DD}$  and  $V_{SS}$  supplies should be bypassed to ground with separate 0.1 $\mu$ F ceramic capacitors.

### Low Supply Current

The low supply current (typical 600nA per channel) of AO1369 will help to maximize battery life. They are ideal for battery powered systems.

### Operating Voltage

AO1369 operates under wide input supply voltage (1.4V to 5.5V). In addition, all temperature specifications apply from  $-40^{\circ}C$  to  $+125^{\circ}C$ . Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

### Rail-to-Rail Input

The input common-mode range of AO1369 extends 100mV beyond the supply rails ( $V_{SS}-0.1V$  to  $V_{DD}+0.1V$ ). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

### Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of AO1369 can typically swing to less than 50mV from supply rail in light resistive loads ( $>50k\Omega$ ).



### Capacitive Load Tolerance

The AO1369 is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain.

Figure 1 shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

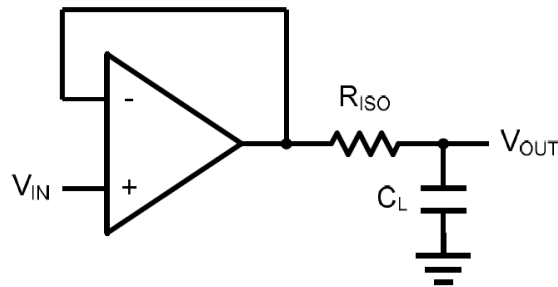


Figure 1. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. However, if there is a resistive load  $R_L$  in parallel with the capacitive load, a voltage divider (proportional to  $R_{ISO}/R_L$ ) is formed, this will result in a gain error.

The circuit in Figure 2 is an improvement to the one in Figure 1.  $R_F$  provides the DC accuracy by feed-forward the  $V_{IN}$  to  $R_L$ .  $C_F$  and  $R_{ISO}$  serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of  $C_F$ . This in turn will slow down the pulse response.

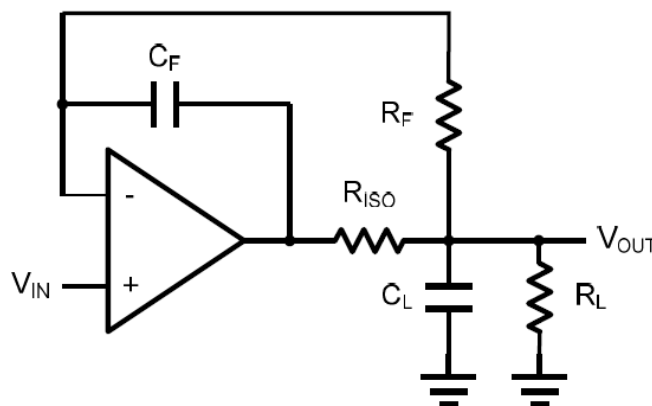


Figure 2. Indirectly Driving a Capacitive Load with DC Accuracy



## Typical Application Circuits

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 3 shown the differential amplifier using AO1369.

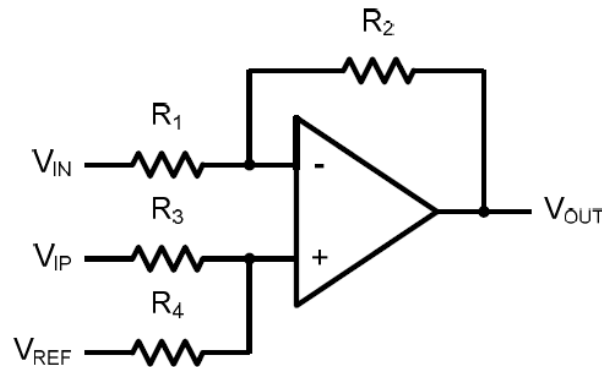


Figure 3. Differential Amplifier

$$V_{OUT} = \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} V_{REF}$$

If the resistor ratios are equal (i.e.  $R_1=R_3$  and  $R_2=R_4$ ), then

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

### Low Pass Active Filter

The low pass active filter is shown in Figure 4. The DC gain is defined by  $-R_2/R_1$ . The filter has a -20dB/decade roll-off after its corner frequency  $f_c=1/(2\pi R_3 C_1)$ .

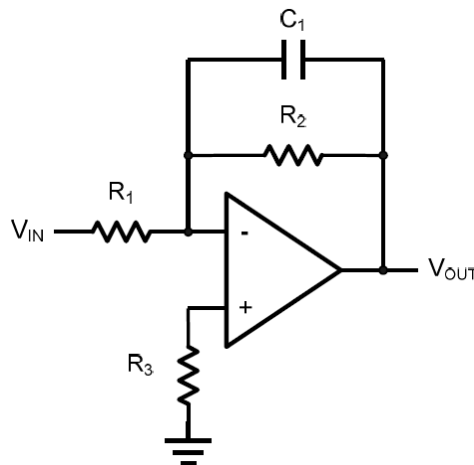


Figure 4. Low Pass Active Filter





### Instrumentation Amplifier

The triple AO1369 can be used to build a three-op-amp instrumentation amplifier as shown in Figure 5. The amplifier in Figure 5 is a high input impedance differential amplifier with gain of  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.

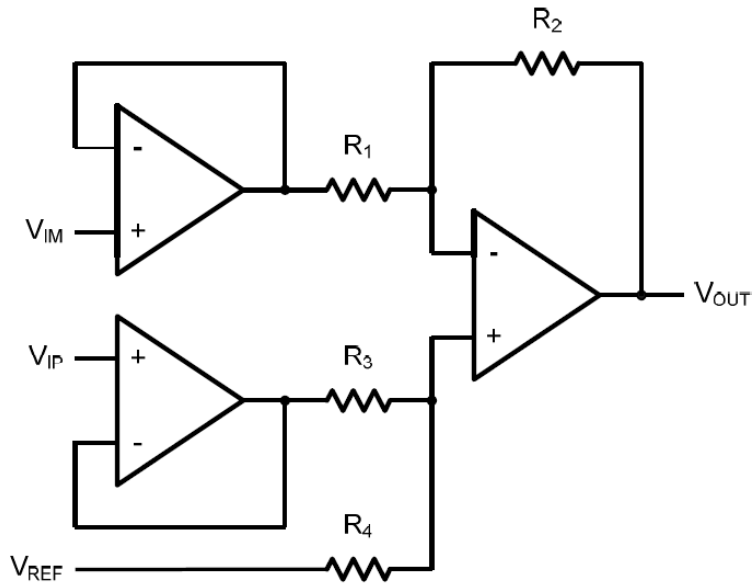
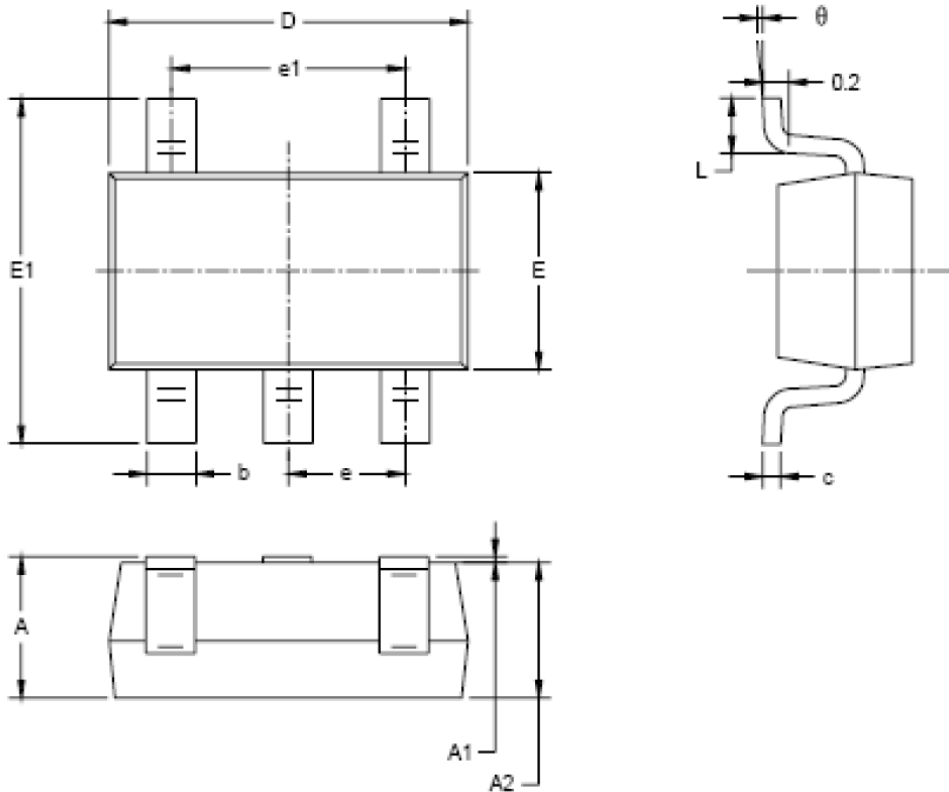


Figure 5. Instrument Amplifier



**PACKAGE INFORMATION**

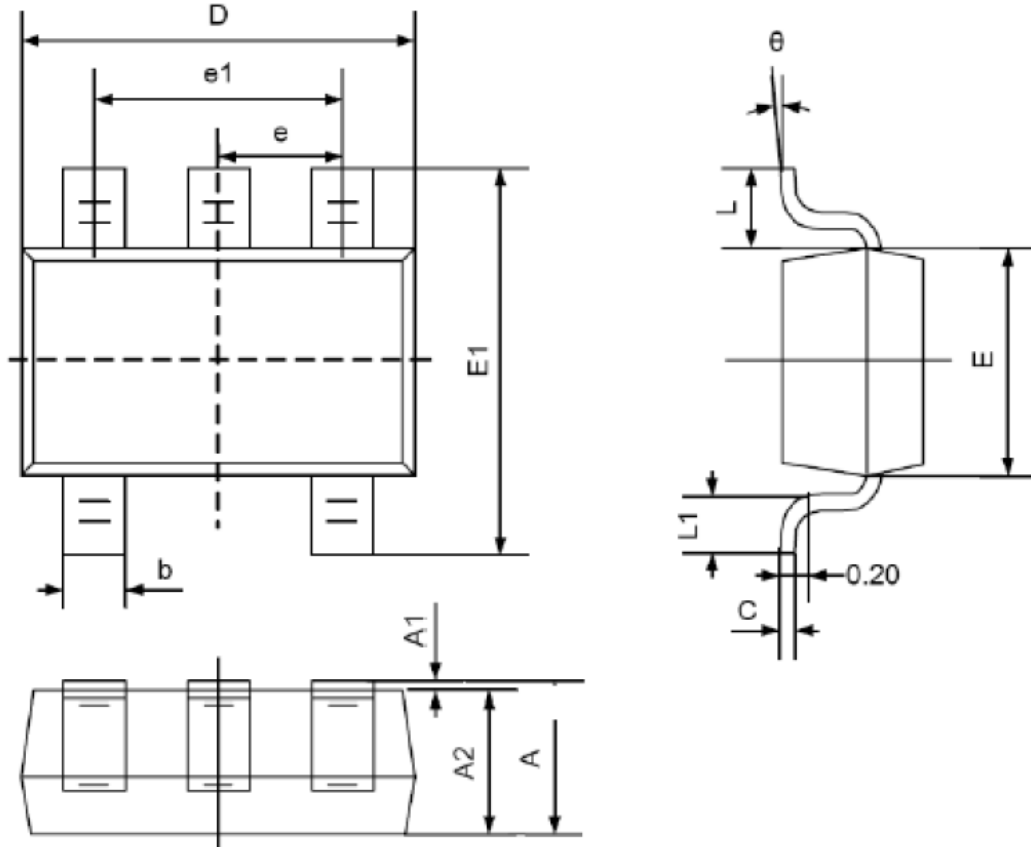
Dimension in SOT-25 (Unit: mm)



Symbol	Millimeters		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°



Dimension in SC70-5 (Unit: mm)



Symbol	Millimeters		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	0.080	0.150	0.003	0.006
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
theta	0°	8°	0°	8°



## IMPORTANT NOTICE

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