



# 60V Low Current Consumption 150mA CMOS Voltage Regulator

## ZS6388 Series

### INTRODUCTION

The ZS6388 series are a group of positive voltage regulators manufactured by CMOS technologies with low power consumption and low dropout voltage, which provide large output currents even when the difference of the input-output voltage is small. The ZS6388 series can deliver 150mA output current and allow an input voltage as high as 60V. The series are very suitable for the battery-powered equipments, such as RF applications and other systems requiring a quiet voltage source.

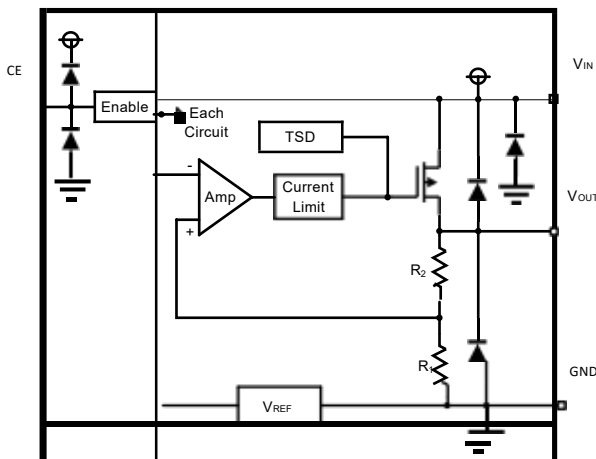
### FEATURES

- ☞ Low Quiescent Current: 3μA
- ☞ Operating Voltage Range: 2.5V~60V
- ☞ Output Current: 150mA
- ☞ Low Dropout Voltage:  
500mV@50mA(V<sub>OUT</sub>=3.3V)
- ☞ Output Voltage: 1.2~ 12.0V
- ☞ High Accuracy: ±2%/±1% (Typ.)
- ☞ High Power Supply Rejection Ratio:  
80dB@1kHz
- ☞ Low Output Noise:  
27xV<sub>OUT</sub> μV<sub>RMS</sub>(10Hz~100kHz)
- ☞ Excellent Line and Load Transient Response
- ☞ Built-in Current Limiter, Short-Circuit Protection
- ☞ Over-Temperature Protection

### APPLICATIONS

- ☞ Cordless Phones
- ☞ Radio control systems
- ☞ Laptop, Palmtops and PDAs
- ☞ Single-lens reflex DSC
- ☞ PC peripherals with memory
- ☞ Wireless Communication Equipments
- ☞ Portable Audio Video Equipments
- ☞ Car Navigation Systems
- ☞ LAN Cards
- ☞ Ultra Low Power Microcontroller

### BLOCK DIAGRAM



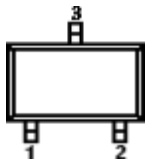
### ORDER INFORMATION

ZS6388①②③④

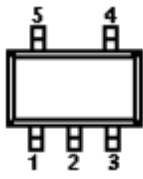
DESIGNATOR	SYMBOL	DESCRIPTION
①	A	Standard
	B	With Shutdown Function
②③	Integer	Output Voltage e.g. 3.3V=②:3, ③:3
		M
④	P	Package: SOT-89-3L/5L
	G	Package: SOT-223

## Pin configuration

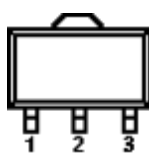
SOT-23-3L



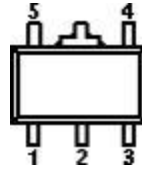
SOT-23-5L



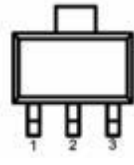
SOT-89-3L



SOT-89-5L



SOT-223



PIN NUMBER			PIN NAME	FUNCTION
SOT-23-3L	SOT-89-3L	SOT223		
<b>M</b>	<b>P</b>	<b>G</b>		
1	1	1	V <sub>SS</sub>	Ground
2	3	3	V <sub>OUT</sub>	Output
3	2	2	V <sub>IN</sub>	Power input

SOT-23-5L

PIN NUMBER	SYMBOL	FUNCTION
1	V <sub>IN</sub>	Power Input Pin
2	V <sub>SS</sub>	Ground
3	CE	Chip Enable Pin
4	NC	No Connection
5	V <sub>OUT</sub>	Output Pin

SOT-89-5L

PIN NUMBER		SYMBOL	FUNCTION
1	5	V <sub>OUT</sub>	Output Pin
2	2	V <sub>SS</sub>	Ground
3	4	NC	No Connection
4	3	CE	Chip Enable Pin
5	1	V <sub>IN</sub>	Power Input Pin

### ■ ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

(Unless otherwise specified,  $T_A=25^{\circ}\text{C}$ )

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage <sup>(2)</sup>		$V_{IN}$	-0.3~65	V
Output Voltage <sup>(2)</sup>		$V_{OUT}$	-0.3~15	V
CE Pin Voltage <sup>(2)</sup>		$V_{CE}$	-0.3~ $V_{IN}+0.3$	V
Output Current		$I_{OUT}$	400	mA
Power Dissipation	SOT-23-3L/5L	$P_D$	400	mW
	SOT-89-3L/5L		600	mW
	SOT-223		800	mW
Operating Ambient Temperature Range		$T_A$	-40~+85	$^{\circ}\text{C}$
Operating Junction Temperature Range		$T_j$	-40~+125	$^{\circ}\text{C}$
Storage Temperature		$T_{stg}$	-40~+125	$^{\circ}\text{C}$
Lead Temperature(Soldering, 10 sec)		$T_{solder}$	260	$^{\circ}\text{C}$
ESD rating <sup>(3)</sup>		Human Body Model-(HBM)	2	kV
		Machine Model- (MM)	200	V

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

(2) All voltages are with respect to network ground terminal.

(3) ESD testing is performed according to the respective JEDEC standard. The human body model is a 100 pF capacitor discharged through a 1.5k $\Omega$  resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

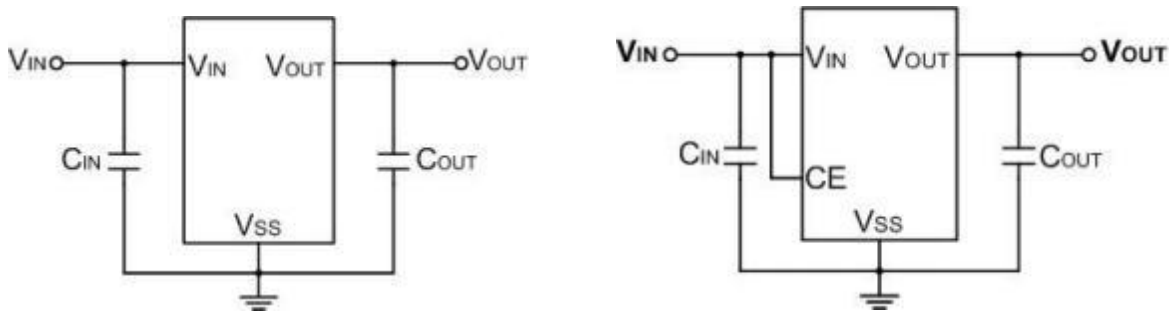
### ■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	MIN.	NOM.	MAX.	UNITS
Supply voltage at $V_{IN}$	2.5		60	V
Operating junction temperature range, $T_j$	-40		125	$^{\circ}\text{C}$
Operating free air temperature range, $T_A$	-40		85	$^{\circ}\text{C}$

## Electrical Characteristics

( $V_{CE}=V_{IN}=V_{OUT}+2V$ ,  $C_{IN}=C_{OUT}=1\mu F$ ,  $T_A=25^\circ C$ , unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	
Input Voltage	$V_{IN}$		2.5	–	60	V	
Output Voltage Range	$V_{OUT}$		1.2	–	12	V	
DC Output Accuracy		$I_{OUT}=1mA$	-2	–	2	%	
			-1	–	1	%	
Dropout Voltage	$V_{dif}$	$I_{OUT}=50mA, V_{OUT}=3.3V$	–	500	–	mV	
Supply Current	$I_{SS}$	$I_{OUT}=0A$	$V_{OUT}\leq 5.0V$	–	3	6	$\mu A$
			$V_{OUT}> 5.0V$		5	10	$\mu A$
Standby Current	$I_{STBY}$	$CE = V_{SS}$		0.1	0.5	$\mu A$	
Line Regulation	$\frac{\Delta V_{OUT}}{V_{OUT} \Delta V_{IN}}$	$I_{OUT}=10mA$ $V_{OUT}+1V \leq V_{IN} \leq 18V$	–	0.01	0.3	%/V	
Load Regulation	$\Delta V_{OUT}$	$V_{IN}=V_{OUT}+1V$ , $1mA \leq I_{OUT} \leq 100mA$	–	10	–	mV	
Temperature Coefficient	$\frac{\Delta V_{OUT}}{V_{OUT} \Delta T_A}$	$I_{OUT}=10mA$ , $-40^\circ C < T_A < 125^\circ C$		50		ppm	
Output Current Limit	$I_{LIM}$	$V_{OUT}=0.5 \times V_{OUT(Normal)}$ , $V_{IN}=5V$	150	250		mA	
Short Current	$I_{SHORT}$	$V_{OUT}=V_{SS}$	–	20	–	mA	
Power Supply Rejection Ratio	PSRR	$I_{OUT}=50mA$	100Hz		75		dB
			1kHz	–	80	–	
			10kHz	–	60	–	
			100kHz	–	45	–	
Output Noise Voltage	$V_{ON}$	BW=10Hz to 100kHz	–	$27 \times V_{OUT}$	–	$\mu V_{RMS}$	
Thermal Shutdown Temperature	$T_{SD}$	—	–	170	–	$^\circ C$	
Thermal Shutdown Hysteresis	$\Delta T_{SD}$	—	–	20	–	$^\circ C$	
CE "High" Voltage	$V_{CE} "H"$		1.5		$V_{IN}$	V	
CE "Low" Voltage	$V_{CE} "L"$				0.3	V	



**External Components List**

Symbol	Description
C <sub>IN</sub>	1.0μF or more
C <sub>OUT</sub>	1.0μF or more , 10μF is recommended

**APPLICATION INFORMATION**

**Selection of Input/ Output Capacitors**

Phase compensation is provided to secure operation even when the load current is varied. For this purpose, use a 1.0μF or more output capacitor (C<sub>OUT</sub>) with good frequency characteristics and proper ESR (Equivalent Series Resistance). Connect a 1.0μF or more input capacitor (C<sub>IN</sub>) between the V<sub>IN</sub> pin and the V<sub>SS</sub> pin as close as possible to the pins.

The value of the output overshoot or undershoot transient response varies depending on the value of the output capacitor.

When selecting the output capacitor, perform sufficient evaluation, including evaluation of temperature characteristics, on the actual device.

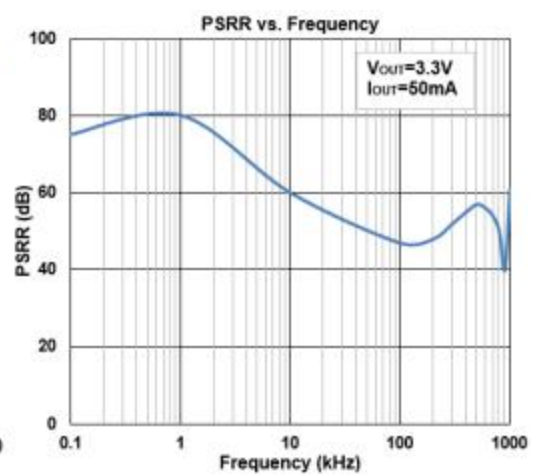
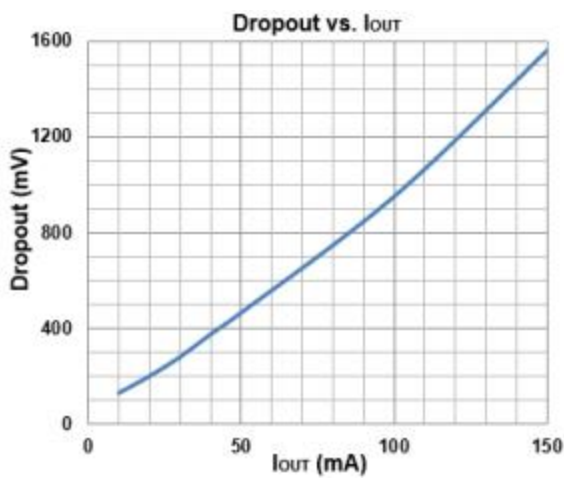
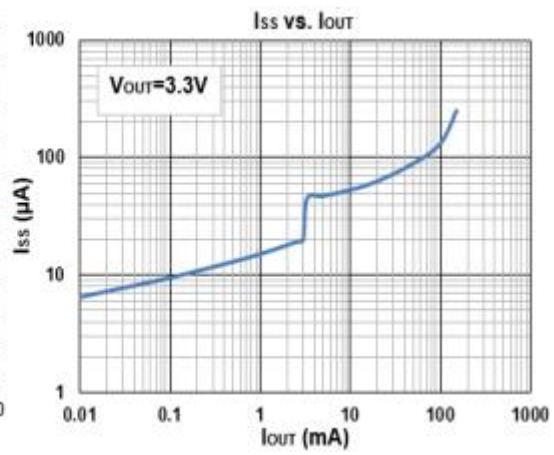
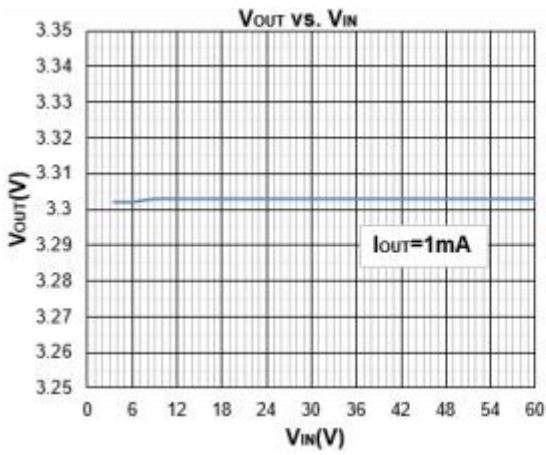
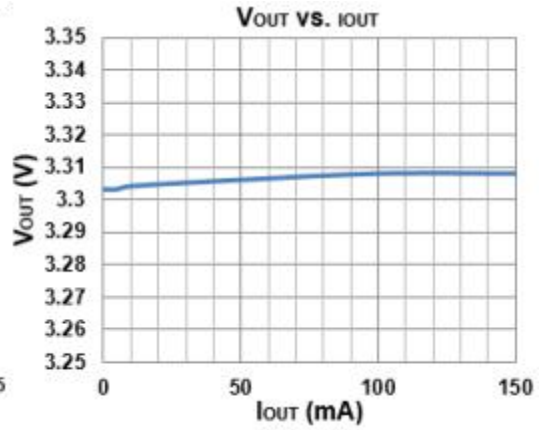
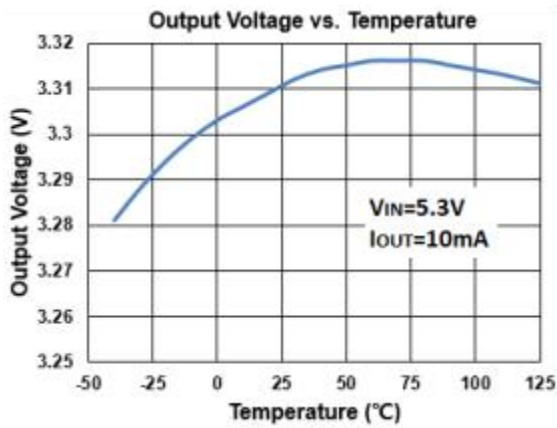
In the design of portable devices the ceramic capacitors are often chosen because of their small size, low equivalent series resistance (ESR) and high RMS current capability. Also, designers have been looking to ceramic capacitors due to shortages of tantalum capacitors.

Unfortunately, using ceramic capacitors for input filtering can cause problems. Applying a voltage step to a ceramic capacitor causes a large current surge that stores energy in the inductances of the power leads. A large voltage spike is created when the stored energy is transferred from these inductances into the ceramic capacitor. These voltage spikes can easily be twice the amplitude of the input voltage step.

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors (MLCC). Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the LDO input to a live power source. Adding a 3Ω resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients.

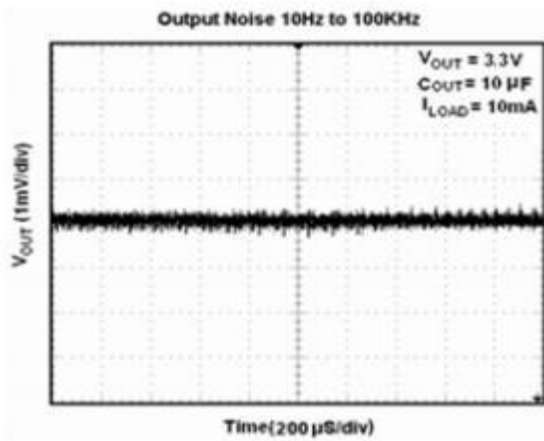
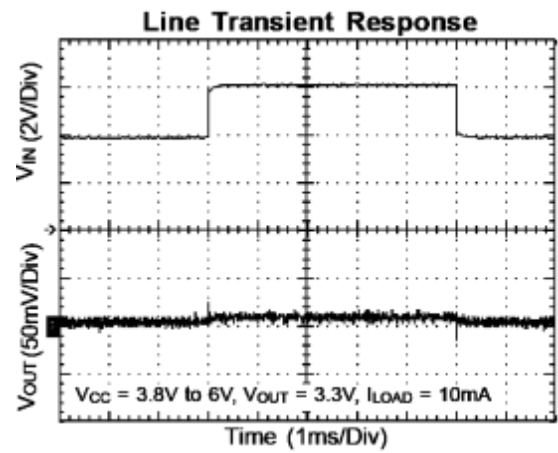
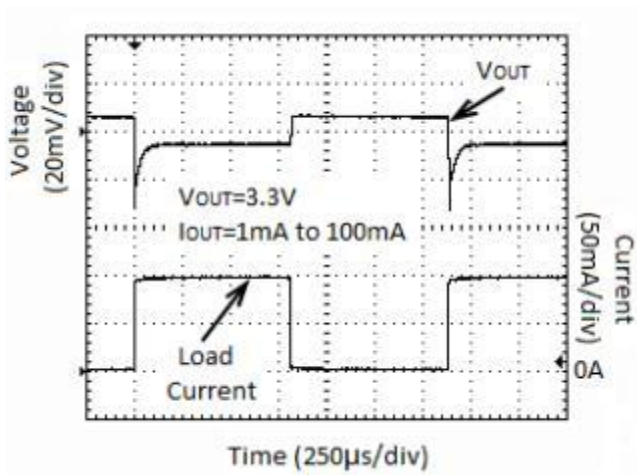
## Typical Characteristics

( $V_{CE}=V_{IN}=V_{OUT}+2V$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=10\mu F$ ,  $T_A=25^\circ C$ , unless otherwise specified)

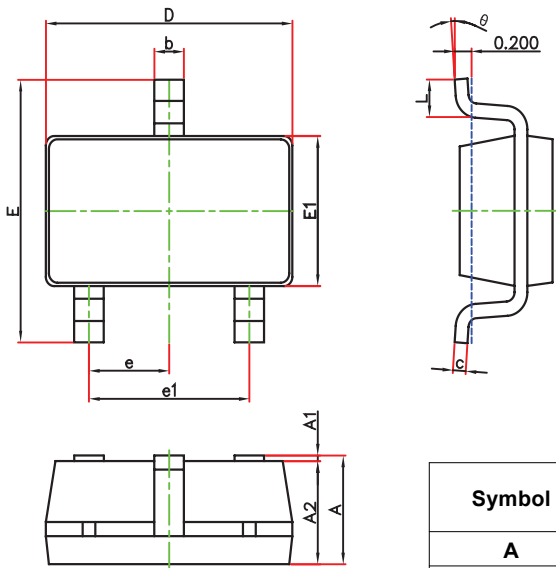


## Typical Characteristics

( $V_{CE}=V_{IN}=V_{OUT}+2V$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=10\mu F$ ,  $T_A=25^\circ C$ , unless otherwise specified)

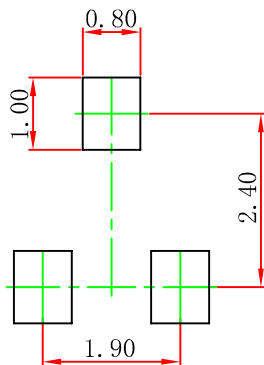


## SOT-23-3L Package Outline Dimensions



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	2.650	2.950	0.104	0.116
E1	1.500	1.700	0.059	0.067
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

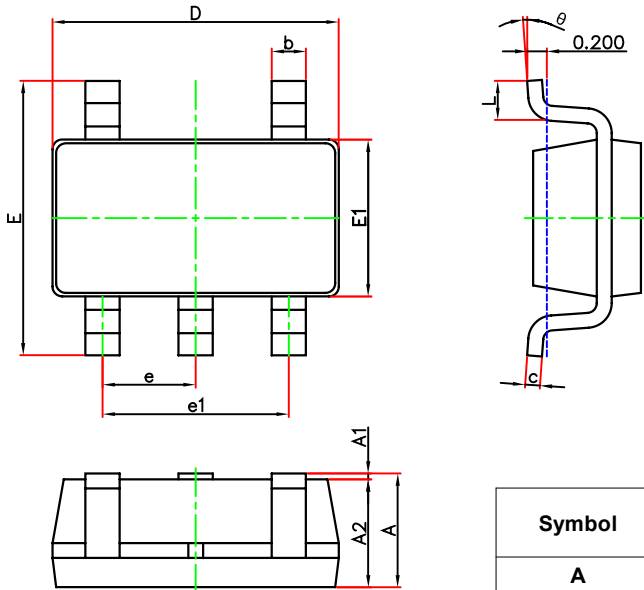
## SOT-23-3L Suggested pad Layout



- Note:
1. Controlling dimension: in millimeters.
  2. General tolerance:  $\pm 0.05\text{mm}$ .
  3. The pad layout is for reference purposes only.

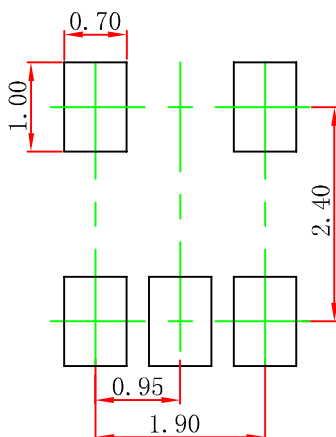


## SOT-23-5L Package Outline Dimensions



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	2.650	2.950	0.104	0.116
E1	1.500	1.700	0.059	0.067
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
theta	0°	8°	0°	8°

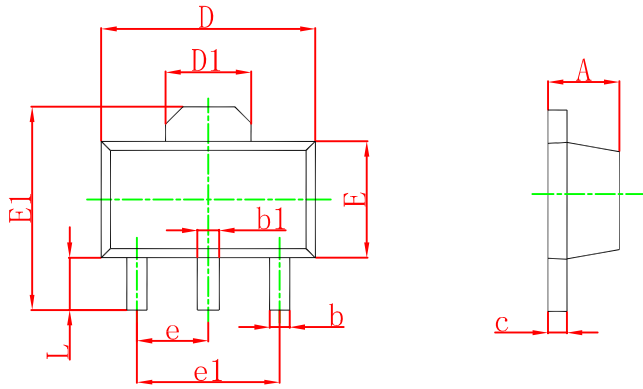
## SOT-23-5L Suggested Pad Layout



**Note:**

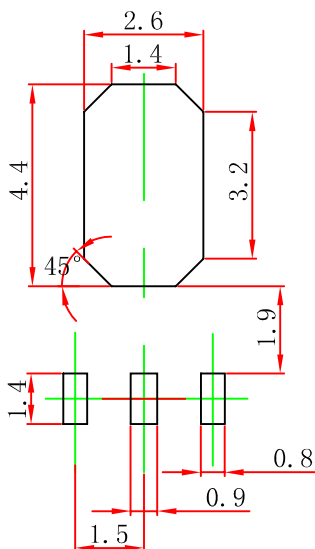
1. Controlling dimension; in millimeters.
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## SOT-89-3L Package Outline Dimensions



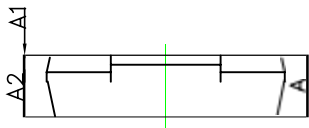
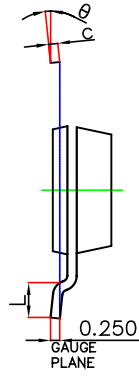
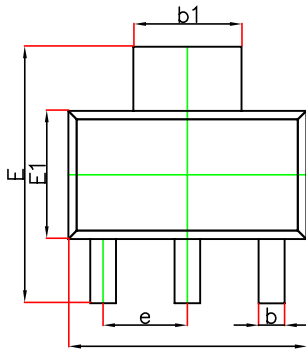
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.197
b1	0.400	0.580	0.016	0.023
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.550 REF		0.061 REF	
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500 TYP		0.060 TYP	
e1	3.000 TYP		0.118 TYP	
L	0.900	1.200	0.035	0.047

## SOT-89-3L Suggested Pad Layout



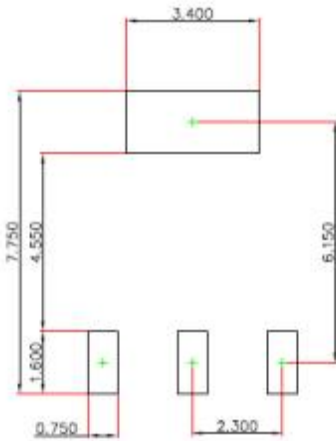
Note:  
 1. Controlling dimension: in millimeters.  
 2. General tolerance:  $\pm 0.05\text{mm}$ .  
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## SOT-223 Package Outline Dimensions



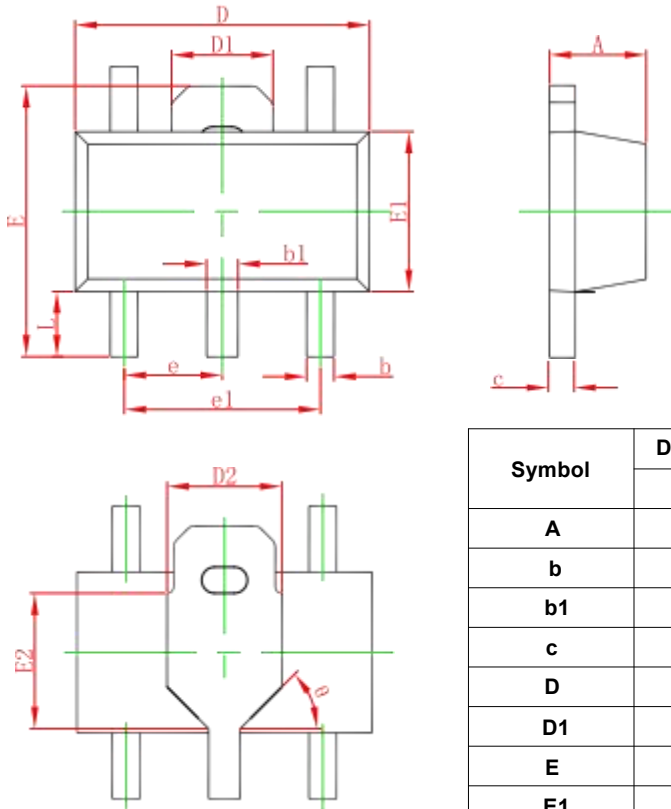
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	—	1.800	—	0.071
A1	0.020	0.100	0.001	0.004
A2	1.500	1.700	0.059	0.067
b	0.660	0.840	0.026	0.033
$b_1$	2.900	3.100	0.114	0.122
c	0.230	0.350	0.009	0.014
D	6.300	6.700	0.248	0.264
E	6.700	7.300	0.264	0.287
E1	3.300	3.700	0.130	0.146
e	2.300(BSC)		0.091(BSC)	
L	0.750	—	0.030	—
$\theta$	0°	10°	0°	10°

## SOT-223 Suggested Pad Layout



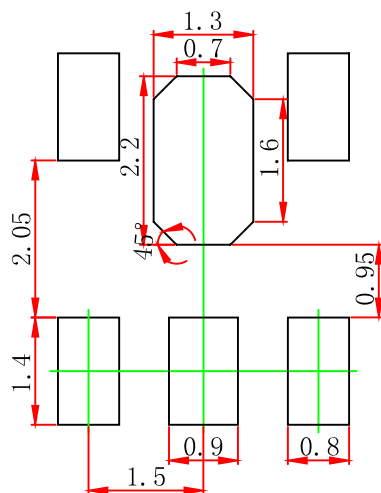
- Note:
1. Controlling dimension: in millimeters.
  2. General tolerance:  $\pm 0.05$ mm.
  3. The pad layout is for reference purposes only.

## SOT-89-5L Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.360	0.560	0.014	0.022
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.400	1.800	0.055	0.071
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500TYP		0.060TYP	
e1	2.900	3.100	0.114	0.122
L	0.900	1.100	0.035	0.043

## SOT-89-5L Suggested Pad Layout



**Note:**

1. Controlling dimension: In millimeters.
2. General tolerance:  $\pm 0.05\text{mm}$ .
3. The pad layout is for reference purposes only.

# DISCLAIMER

## **IMPORTANT NOTICE, PLEASE READ CAREFULLY**

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