36V Low Current Consumption 250mA CMOS Voltage Regulator

■ INTRODUCTION

The SML411 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 SML411 series can deliver 250mA output current and allow an input voltage as high as 36V. The series are very suitable for the battery-powered equipments, such as RF applications and other systems requiring a quiet voltage source.

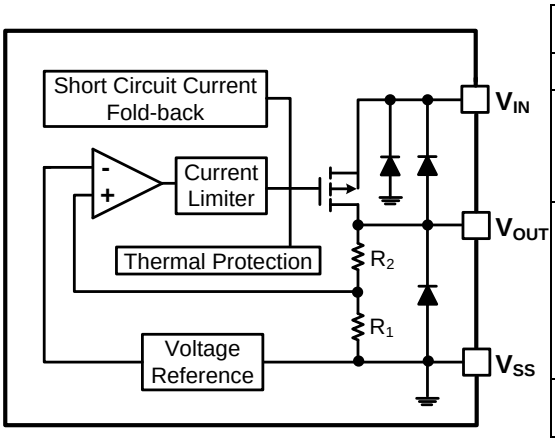
■ FEATURES

- Low Quiescent Current: 2μA
- Operating Voltage Range: 2.5V ~ 36V
- Output Current: 250mA
- Low Dropout Voltage:
  600mV @ 100mA (V_{OUT} = 3.3V)
- Output Voltage: 1.8V ~ 12V
- High Accuracy: ±2% / ±1%(Typ.)
- High Power Supply Rejection Ratio:
  70dB @ 1kHz
- Low Output Noise:
  27 x V_{OUT} μ V_{RMS}(10Hz ~ 100kHz)
- Excellent Line and Load Transient Response
- Built-in Current Limiter, Short-Circuit Protection
- Over-Temperature Protection
- Stable with Ceramic or Tantalum Capacitor

■ 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 Microcontrolle

■ BLOCK DIAGRAM



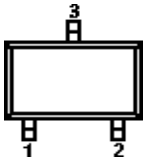
■ ORDER INFORMATION

SML411①②③④⑤⑥

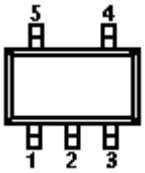
DESIGNATOR	SYMBOL	DESCRIPTION
①	A	Standard
②③④	Integer	Output Voltage e.g.3.3V = ②: 缺省,③: 3,④: 3 e.g.12.0V = ②: 1,③: 2,④: 0
⑤	M/MC/MY	Package: SOT-23-3
	MF/MR	Package: SOT-23-5
	P/PT/PL	Package: SOT-89-3
	T/TA/TB	Package: TO-92
	ES	Package: ESOP8
	G	Package: SOT-223
⑥	-	2% Accuracy
	1	1% Accuracy

■ PIN CONFIGURATION （Top view）

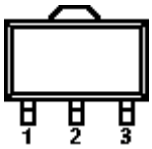
SOT-23-3



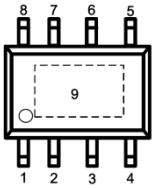
SOT-23-5



SOT-89-3

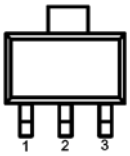


ESOP8



TO-92
(Bottom view)

SOT-223



PIN NUMBER										PIN NAME	FUNCTION
SOT-23-3			SOT-89-3			TO-92			SOT-223		
M	MC	MY	P	PT	PL	T	TA	TB	G		
1	3	3	1	2	2	1	2	2	1	V_{SS}	Ground
2	2	1	3	1	3	3	3	1	3	V_{OUT}	Output
3	1	2	2	3	1	2	1	3	2	V_{IN}	Power input

SOT-23-5

PIN NUMBER		PIN NAME	FUNCTION
MF	MR		
1	2	V_{IN}	Power Input
2	1	V_{SS}	Ground
3/4	4/5	NC	No Connection
5	3	V_{OUT}	Output

ESOP8

PIN NUMBER	PIN NAME	FUNCTION
ES		
1	V_{OUT}	Output
5	V_{SS}	Ground
8	V_{IN}	Power Input
9	—	Thermal PAD
2,3,4,6,7	NC	No Connection

■ ABSOLUTE MAXIMUM RATINGS(1)

(Unless otherwise specified, T_A = 25°C)

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage(2)		V_{IN}	-0.3 ~ 40	V
Output Voltage(2)		V_{OUT}	-0.3 ~ 13	V
Power Dissipation	SOT-23-3/5	P_D	400	mW
	SOT-89-3		600	
	TO-92		500	
	SOT-223		800	
	ESOP8		1500	
Operating free air temperature range		T_A	-40 ~ +85	°C
Operating Junction Temperature Range(3)		T_j	-40 ~ +150	°C
Storage Temperature		T_{stg}	-55 ~ +150	°C
Lead Temperature(Soldering, 10sec)		T_{solder}	260	°C
ESD rating: Human Body Model		HBM	≥ 2	kV
ESD rating: 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 my affect device reliability.

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

(3) This IC includes over temperature protection that is intended to protect the device during momentary overload. Junction temperature will exceed 125°C when over temperature protection is active. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

■ ELECTRICAL CHARACTERISTICS

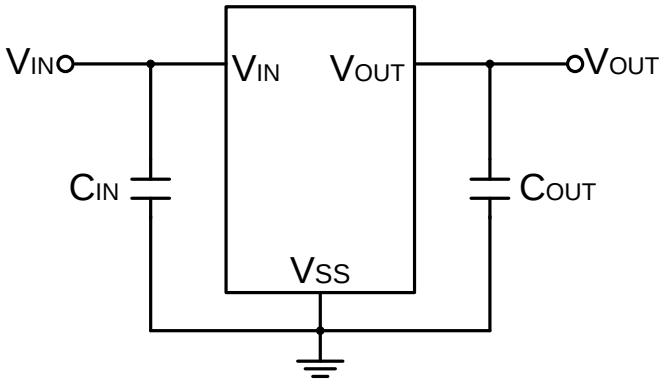
SML411 Series (V_{IN} = V_{OUT} + 2V,C_{IN} = C_{OUT} = 1μF,T_A = 25℃ ,Unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.(4)	MAX.	UNITS
Input Voltage	V_{IN}			2.5	—	36	V
Output Voltage Range	V_{OUT}			1.8	—	12	V
DC Output Accuracy		I_{OUT} = 10mA		-2	—	2	%
				-1	—	1	%
Dropout Voltage	V_{dif}(5)	I_{OUT} = 100mA, V_{OUT} = 3.3V		—	600	—	mV
Supply Current	I_{SS}	I_{OUT} = 0A, 1.8V ≤ V_{OUT} ≤ 5.0V		—	2	5	μA
		I_{OUT} = 0A, 5.0V < V_{OUT} ≤ 12.0V		-	5	10	μA
Line Regulation	$\frac{\Delta V_{OUT}}{V_{OUT} \times \Delta V_{IN}}$	I_{OUT} = 10mA V_{OUT} + 1V ≤ V_{IN} ≤ 36V		—	0.01	0.3	%/V
Load Regulation	ΔV_{OUT}	V_{IN} = V_{OUT} + 2V, 1mA ≤ I_{OUT} ≤ 100mA		—	10	—	mV
Temperature Coefficient	$\frac{\Delta V_{OUT}}{V_{OUT} \times \Delta T_A}$	I_{OUT} = 40mA, -40°C < T_A < 85°C			50		ppm/°C
Output Current Limit	I_{LIM}	V_{OUT} = 0.5 x $V_{OUT(Normal)}$			350		mA
Short Current	I_{SHORT}	V_{OUT} = V_{SS}		—	25	—	mA
Power Supply Rejection Ratio	PSRR	I_{OUT} = 50mA	100Hz		80		dB
			1kHz	—	70	—	
			10kHz	—	60	—	
			100kHz	—	50	—	
Output Noise Voltage	V_{ON}	BW = 10Hz to 100kHz		—	27 x V_{OUT}	—	μ V_{RMS}
Thermal Shutdown Temperature	T_{SD}	I_{LOAD} = 30mA		—	160	—	°C
Thermal Shutdown Hysteresis	ΔT_{SD}	——		—	20	—	°C

(4) Typical numbers are at 25°C and represent the most likely norm.

(5) V_{dif}: The Difference Of Output Voltage And Input Voltage When Input Voltage Is Decreased Gradually Till Output Voltage Equals to 98% Of V_{OUT}(E).

■ TYPICAL APPLICATION CIRCUIT



External Components List

Symbol	Description
C_{IN}	1.0μF or more，10μF is recommended
C_{OUT}	1.0μF or more，10μF is recommended

■ APPLICATION INFORMATION

● Selection of Input/ Output Capacitors

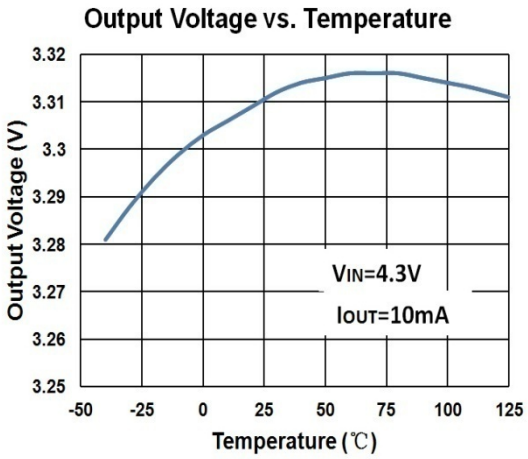
Phase compensation is provided to secure operation even when the load current is varied. For this purpose, use a 1.0μF or more output capacitor (C_{OUT}) with good frequency characteristics and proper ESR (Equivalent Series Resistance). Connect a 1.0μF or more input capacitor (C_{IN}) between the V_{IN} pin and the V_{SS} 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.

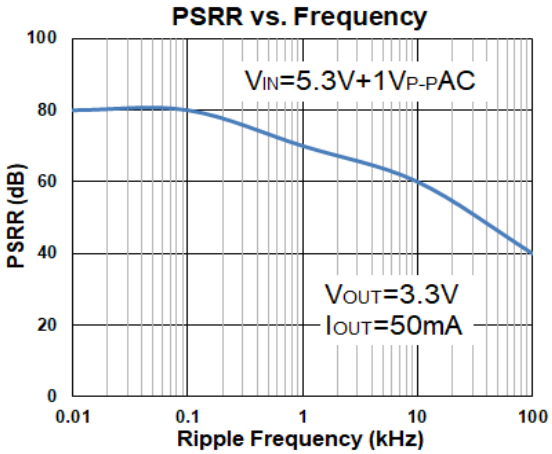
In the design of portable devices the ceramic capacitors are often chosen because of their small size, low equivalent series resistance (ESR) and high RMS current capability. Also, designers have been looking to ceramic capacitors due to shortages of tantalum capacitors.

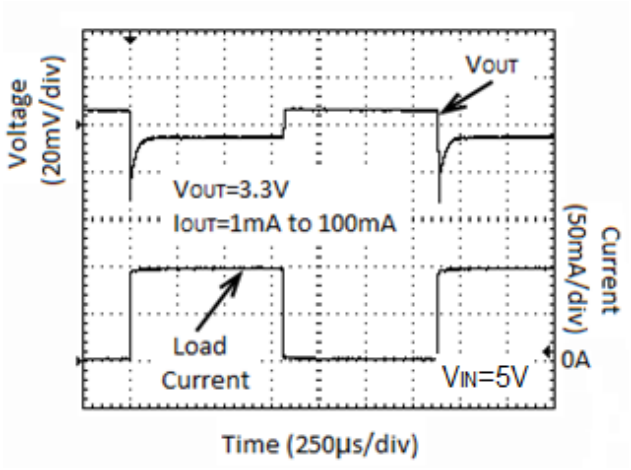
Unfortunately, using ceramic capacitors for input filtering can cause problems. Applying a voltage step to a ceramic capacitor causes a large current surge that stores energy in the inductances of the power leads. A large voltage spike is created when the stored energy is transferred from these inductances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

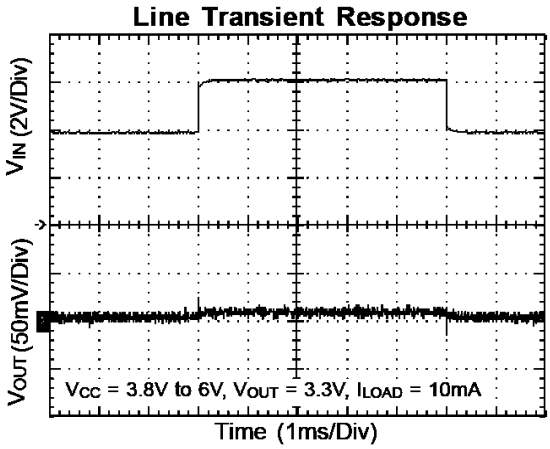
Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors (MLCC). Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, 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.

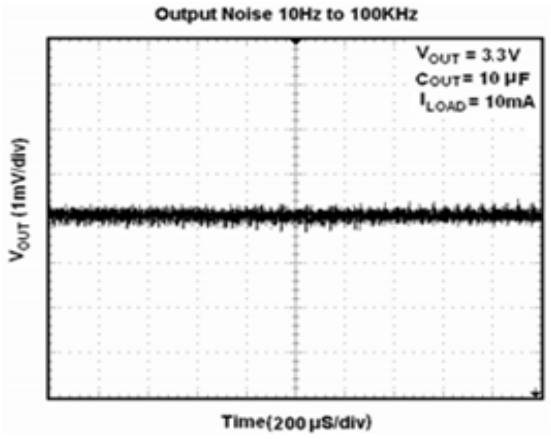
■ TYPICAL PERFORMANCE CHARACTERISTICS

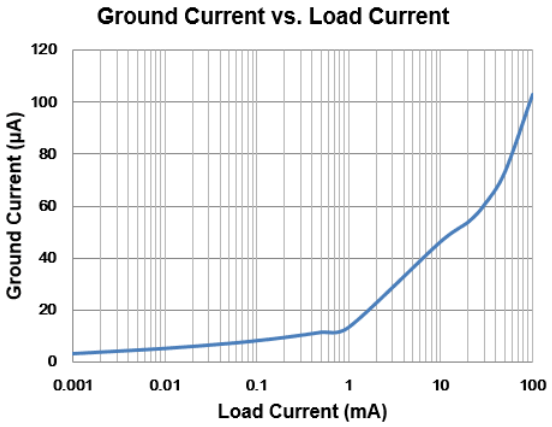






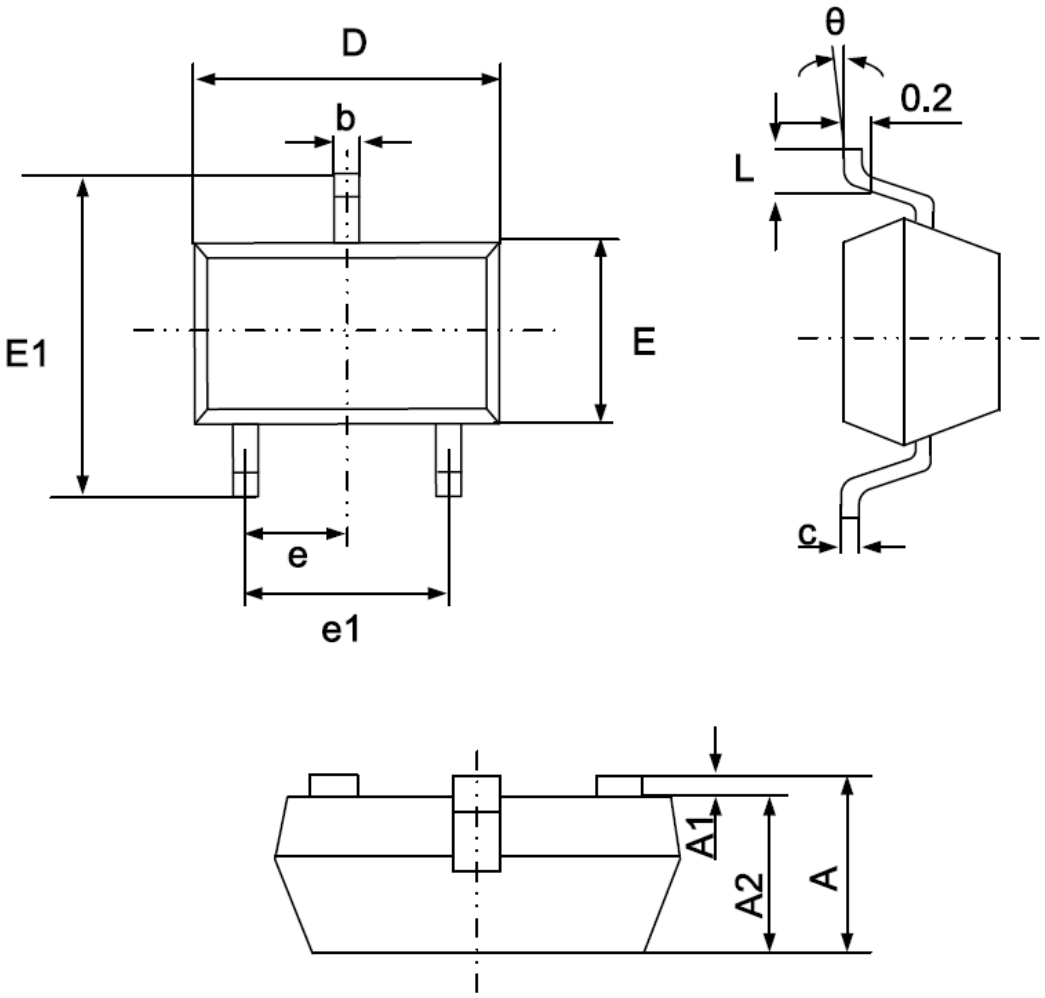






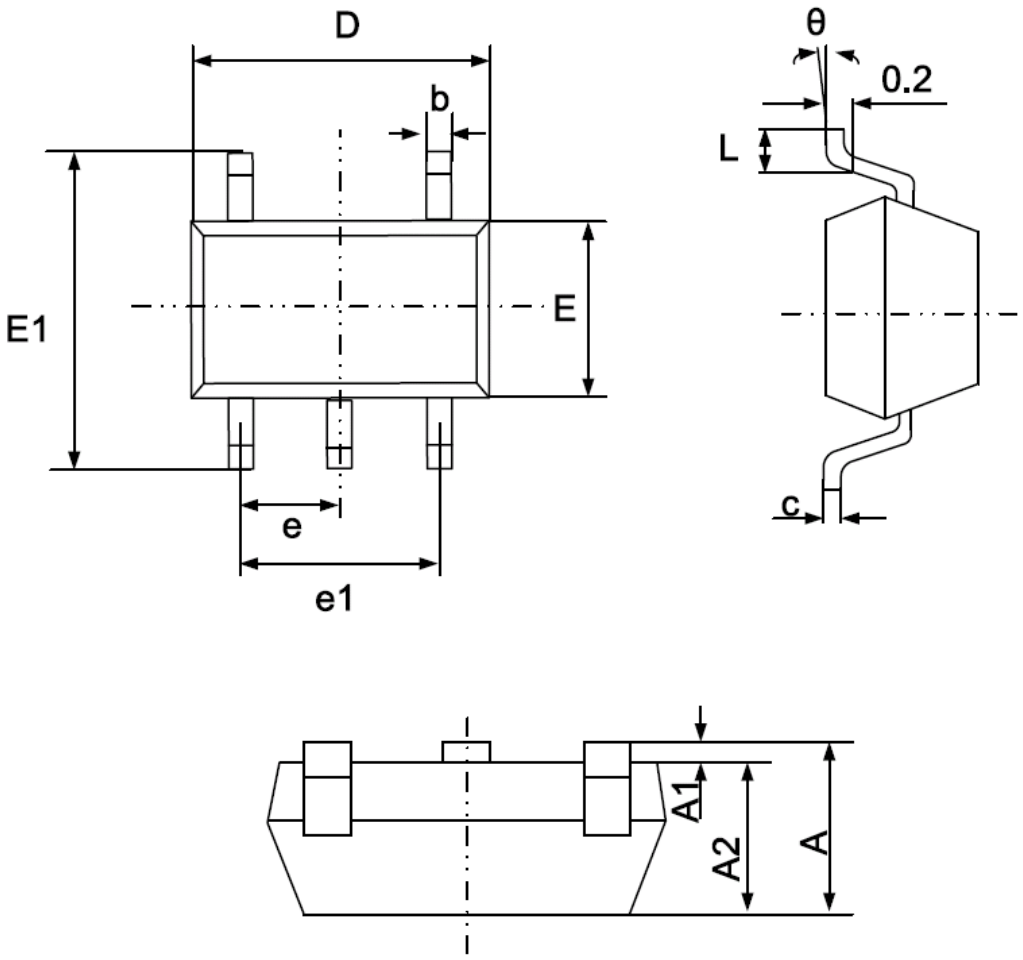
■ PACKAGING INFORMATION

● SOT-23-3 PACKAGE OUTLINE DIMENSIONS



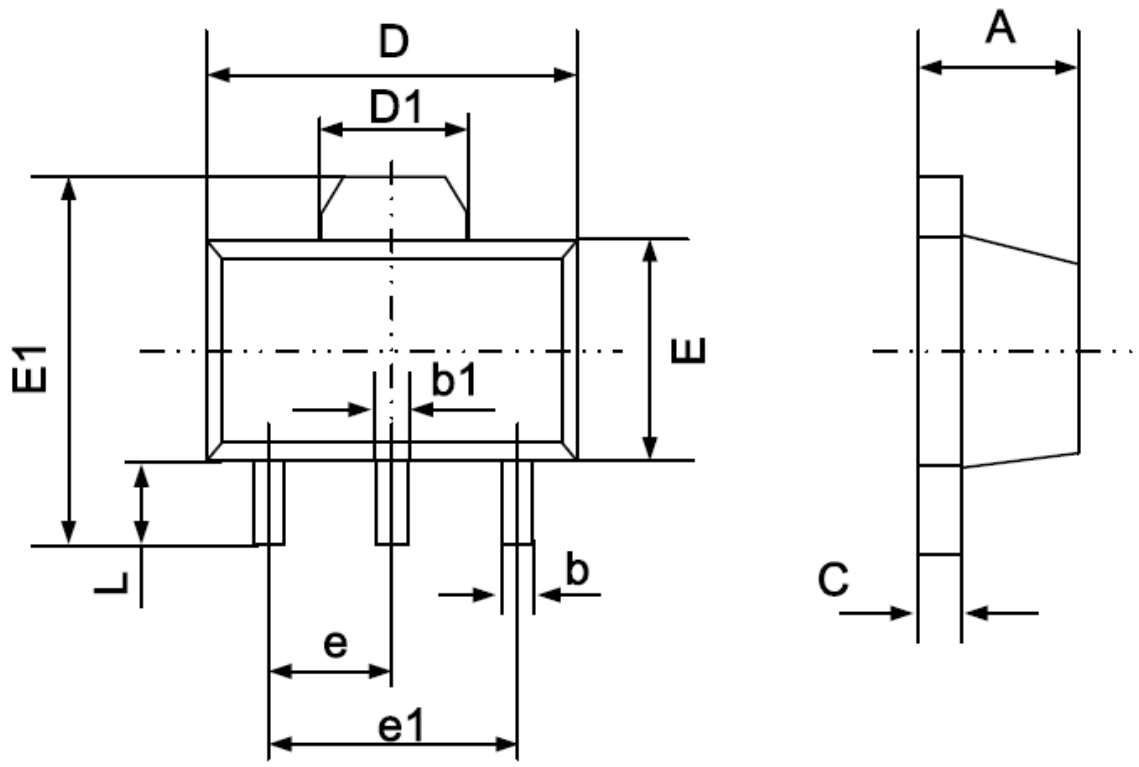
Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.050	1.250
A1	0.000	0.100
A2	1.050	1.150
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
E	1.500	1.700
E1	2.650	2.950
e	0.950(BSC)	
e1	1.800	2.000
L	0.300	0.600
θ	0°	8°

- **SOT-23-5 PACKAGE OUTLINE DIMENSIONS**



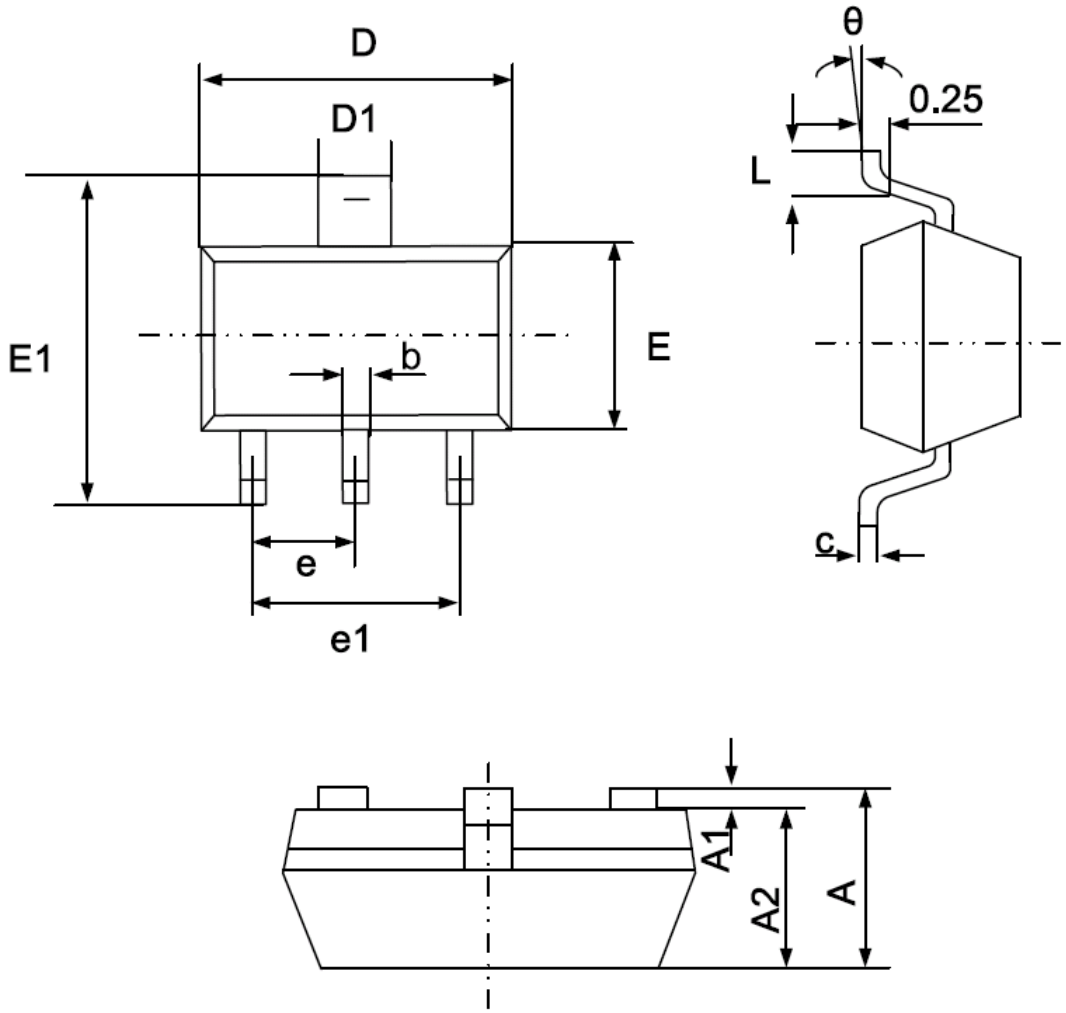
Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.050	1.250
A1	0.000	0.100
A2	1.050	1.150
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
E	1.500	1.700
E1	2.650	2.950
e	0.950(BSC)	
e1	1.800	2.000
L	0.300	0.600
θ	0°	8°

- **SOT-89-3 PACKAGE OUTLINE DIMENSIONS**



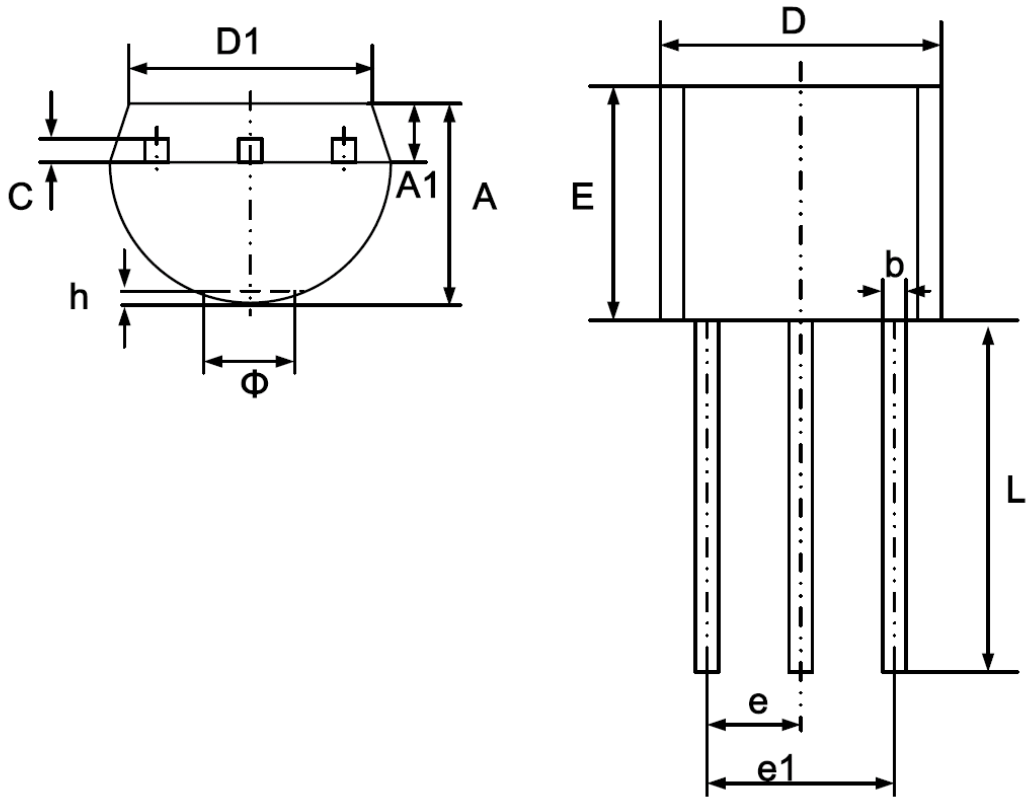
Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.400	1.600
b	0.320	0.520
b1	0.400	0.580
c	0.350	0.440
D	4.400	4.600
D1	1.550 REF	
E	2.300	2.600
E1	3.940	4.250
e	1.500 TYP	
e1	3.000 TYP	
L	0.900	1.200

- **SOT-223 PACKAGE OUTLINE DIMENSIONS**



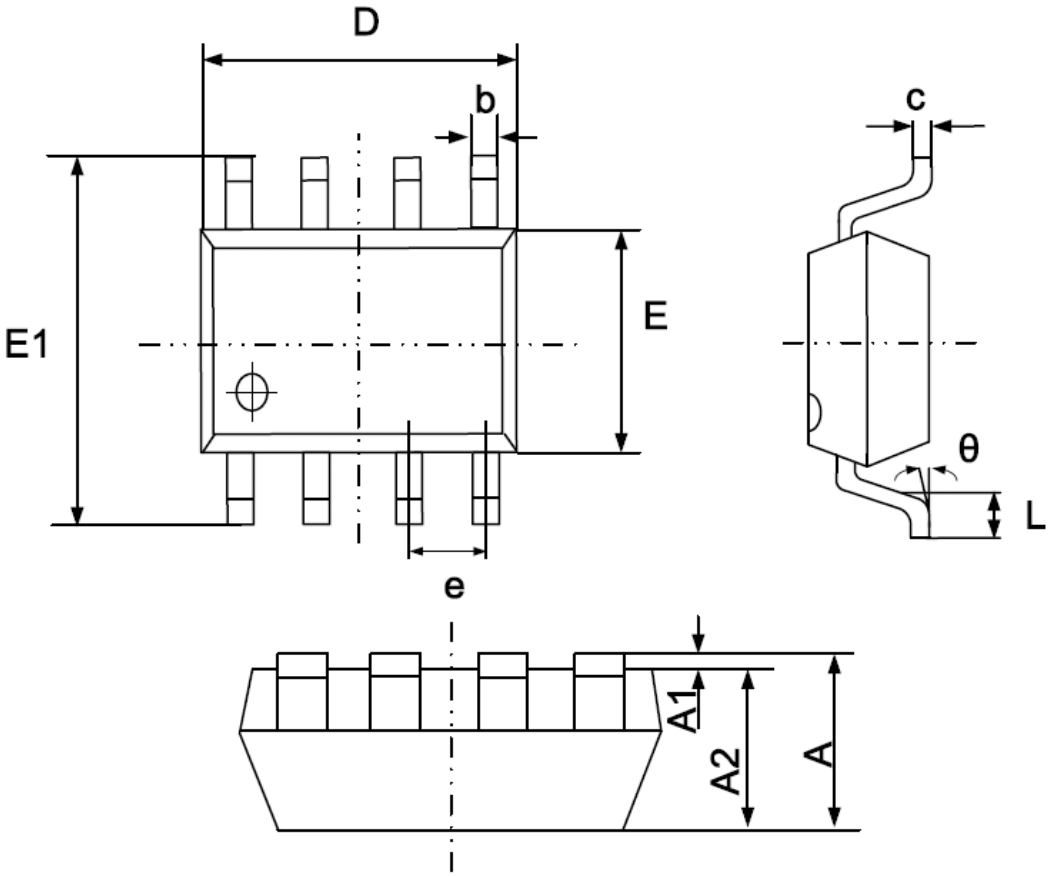
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.520	1.800	0.060	0.071
A1	0.000	0.100	0.000	0.004
A2	1.500	1.700	0.059	0.067
b	0.660	0.820	0.026	0.032
c	0.250	0.350	0.010	0.014
D	6.200	6.400	0.244	0.252
D1	2.900	3.100	0.114	0.122
E	3.300	3.700	0.130	0.146
E1	6.830	7.070	0.269	0.278
e	2.300 (BSC)		0.091 (BSC)	
e1	4.500	4.700	0.177	0.185
L	0.900	1.150	0.035	0.045
θ	0°	10°	0°	10°

- **TO-92 PACKAGE OUTLINE DIMENSIONS**



Symbol	Dimensions In Millimeters	
	Min.	Max.
A	3.300	3.800
A1	1.100	1.400
b	0.380	0.600
c	0.300	0.500
D	4.400	4.800
D1	3.430	
E	4.300	4.700
e	1.270 TYP	
e1	2.440	2.640
L	13. 00	15.00
Φ		1.600
h	0.000	0.380

- **ESOP8 PACKAGE OUTLINE DIMENSIONS**



Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.350	1.750
A1	0.100	0.250
A2	1.350	1.550
b	0.330	0.510
c	0.170	0. 250
D	4.700	5.100
D1	3.100	3.500
E	3.800	4.000
E1	5.800	6.200
E2	2.200	2.600
e	1.270(BSC)	
L	0.400	1.270
θ	0°	8°