Features

- SMALL VOLTAGE OFFSET:
  - **TPA2296: ±0.5mV (MAX)**
- WIDE COMMON MODE VOLTAGE:
  - **TPA2296: -0.1V to +70V**
- WIDE CMRR THROUGH COMMON VOLTAGE: **100dB**
- SUPPLY VOLTAGE: **3.0V to +18V**
- ACCURACY and ZERO-DRIFT PERFORMANCE
  - **±0.5% Gain Error (Max, -40°C ~125°C)**
  - **0.6μV/°C Offset Drift (Max, -40°C ~125°C)**
  - **5ppm/°C Gain Drift (Max, -40°C ~125°C)**
- THREE GAIN OPTIONS for VOLTAGE OUTPUT
  - TPA2296T: 20V/V
  - TPA2296F: 50V/V
  - TPA2296H: 100V/V

Description

The TPA2296 family is of high voltage, high side current sense amplifier with voltage output. The TPA2296 can sense drops across shunts at common-mode voltages from –0.1V up to 70 V. The TPA2296 are available with three output voltage scales: 20V/V, 50V/V, 100V/V, with up to 0.5MHz bandwidth.

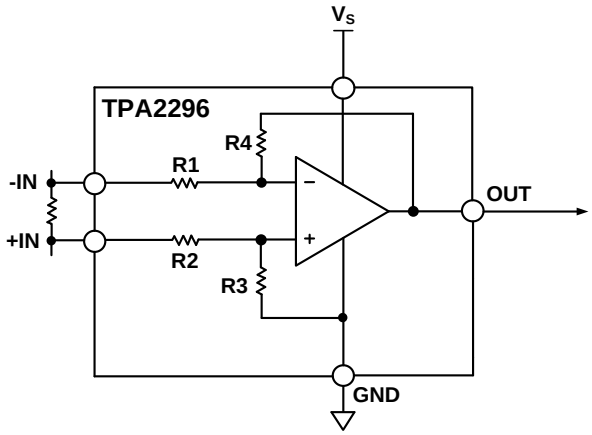
The TPA2296 operates from single 3.0V to 18V supply, offers breakthrough performance throughout the −40°C to +125°C temperature range. It features a zero-drift core, which leads to an offset drift of 0.6μV/°C throughout the operating temperature range and the common-mode voltage range.

The TPA2296 is offered in 6-pin and 5-pin SOT23 package.

Applications

- CURRENT SENSING (High−Side/Low-Side)
- BATTERY CHARGERS & POWER MANAGEMENT
- AUTOMOTIVE & INDUSTRIAL CONTROL
- BASE STATIONS & TELECOM EQUIPMENT

Functional Block Diagram



Pin Configuration

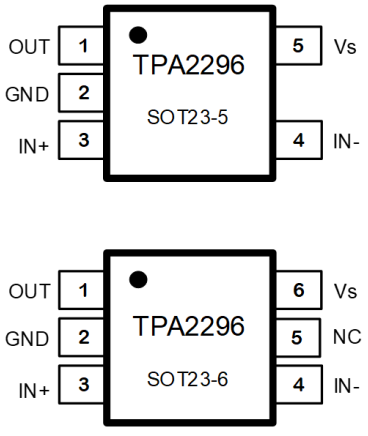


Table of Contents

Revision History

Table 1

Date	Revision	Notes
2019/11/15	Rev.Pre	Initial Version
2020/7/31	Rev.Pre.1	Pre-released datasheet to VIP customer
2020/8/17	Rev.A.0	Released version
2020/10/17	Rev.A.1	Add Vos test condition
2021/10/16	Rev.A.2	Update figure of step response
2022/5/1	Rev.A.3	Update order information and package outline dimensions

Pin Functions and Description

Table 2

PIN No.		PIN NAME	TPA2296 DESCRIPTION
SOT23-5	SOT23-6		
4	4	IN-	Negative Input
2	2	GND	Ground
1	1	OUT	Output
5	6	Vs	Power supply
3	3	IN+	Positive Input.
	5	NC	No Connect

Order Information

Table 3

Model Name	Order Number	Gain	Package	MSL	Transport Media, Quantity	Package Marking
TPA2296	TPA2296T-S5TR	20	SOT23-5	3	Tape and Reel, 3,000	A6T
	TPA2296F-S5TR Note 1	50	SOT23-5	3	Tape and Reel, 3,000	A6F
	TPA2296H-S5TR-S	100	SOT23-5	3	Tape and Reel, 3,000	A6H
	TPA2296T-S6TR-S Note 1	20	SOT23-6	3	Tape and Reel, 3,000	C6T
	TPA2296F-S6TR-S Note 1	50	SOT23-6	3	Tape and Reel, 3,000	C6F
	TPA2296H-S6TR-S	100	SOT23-6	3	Tape and Reel, 3,000	C6H

Note 1: Future product, contact 3PEAK factory for more information and sample.

Absolute Maximum Ratings Note 2

Supply Voltage ……......40V
Input Common Voltage (Continuous).....-0.3 to 75V
Input Common Voltage (Survival)……..-0.3 to 80V
Input Current: +IN, –IN Note 3.....±10mA
Operating Temperature Range.....–40°C to 125°C
Maximum Working Junction Temperature..... 150°C
Storage Temperature Range..... –65°C to 150°C

Note 2: 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 3: The inputs are protected by ESD protection diodes to power supply.

ESD, Electrostatic Discharge Protection

Table 4

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	1.5	kV

Thermal Resistance

Table 5

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-6	250	81	°C/W
SOT23-5	250	81	°C/W

Electrical Characteristics

The specifications are at T = 25°C, VSENSE = VIN+ – VIN– = 1mV, Vs = 12V, VIN+ = 70V, unless otherwise noted

Table 6

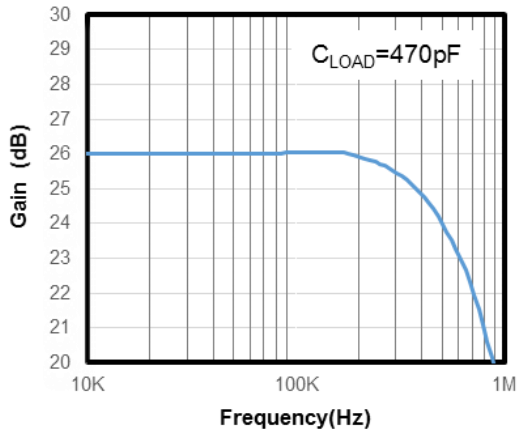
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
INPUT						
V_{OS}	Input Offset Voltage	-40°C to 125°C, VIN- = 0V		±50	±500	μV
V_{OS} TC Note 4	Input Offset Voltage Drift	-40°C to 125°C			0.6	μV/°C
V_{CM}	Common-mode Input Range	-40°C to 125°C	-0.1		70	V
CMRR	Common Mode Rejection Ratio	-40°C to 125°C, -0.3V < V+ < 70V, G=20V/V	90	110		dB
		-40°C to 125°C, -0.3V < V+ < 70V, G=50V/V	95	115		dB
		-40°C to 125°C, -0.3V < V+ < 70V, G=100V/V	100	120		dB
I_B	Input Bias Current	-40°C to 125°C			210	μA
PSRR	Power Supply Rejection Ratio	-40°C to 125°C		110		dB
NOISE RTI Note 5						
e_n	Input Voltage Noise Density	f = 1kHz		55		nV/√Hz
OUTPUT						
G	Gain	TPA2296T, -40°C to 125°C	19.9	20	20.1	V/V
		TPA2296F, -40°C to 125°C	49.75	50	50.25	V/V
		TPA2296H, -40°C to 125°C	99.5	100	100.5	V/V
GE	Gain Error	-40°C to 125°C		±0.1%	±0.5%	
GE TC	Gain Error Vs Temperature	-40°C to 125°C		3	5	ppm/°C
C_{LOAD}	Maxim capacitive load	No oscillation		0.5		nF
V_{OH}	Output Swing from Supply Rail	-40°C to 125°C, Source 1.2mA		0.15	0.310	V
V_{OL}	Output Swing from GND	-40°C to 125°C		0.01	0.02	V
FREQUENCY RESPONSE						
BW	Bandwidth	TPA2296T		400		kHz
		TPA2296F		300		kHz
		TPA2296H		200		kHz
SR	Slew Rate	VSENSE = VIN+ – VIN– = 500mV		20		V/μs
POWER SUPPLY						
Vs	Supply Voltage		3.0		18	V
I_Q	Quiescent Current	-40°C to 125°C		600	1000	μA
TEMPERATURE RANGE						
Specified range			-40		125	°C

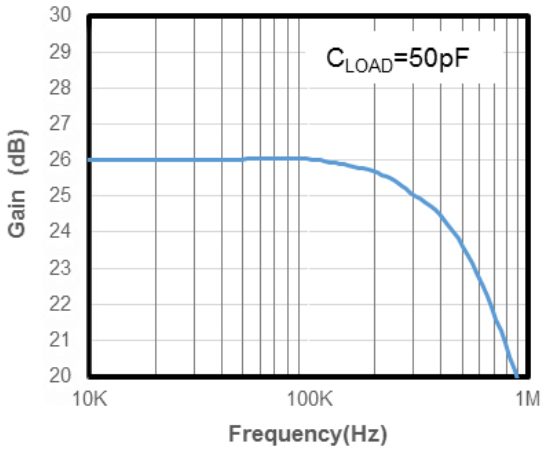
Note 4: Maxim specification is calculated with limited sample quantity in laboratory.

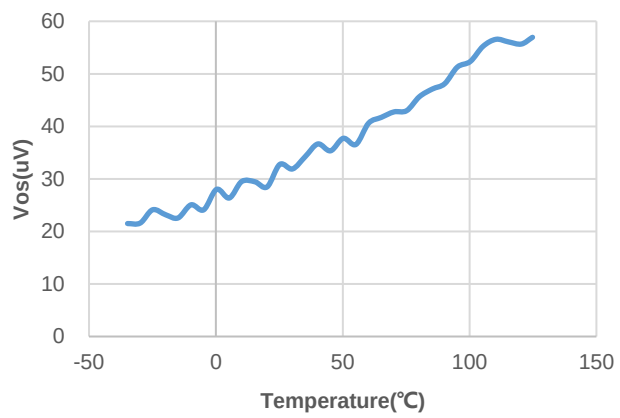
Note 5: RTI = referred to input.

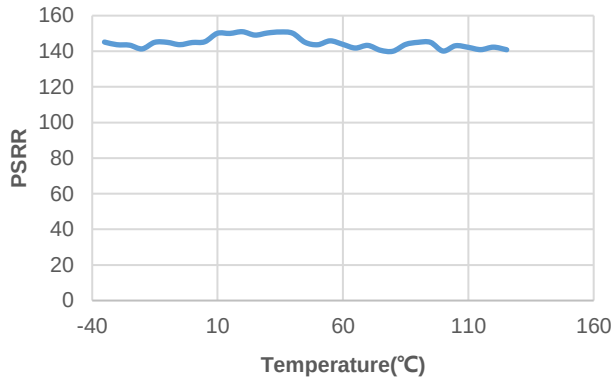
Typical Performance Characteristics

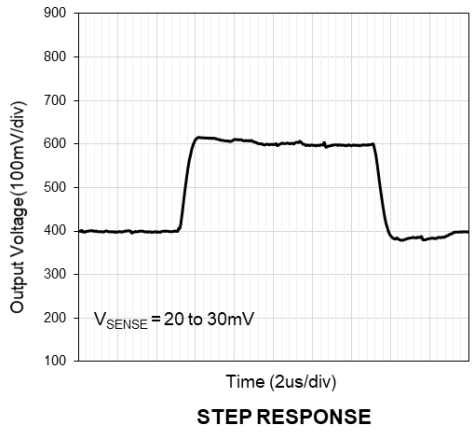
The TPA2296T is used for characteristics at TA = 25°C, VSENSE = VIN+ – VIN– = 1mV, Vs = 12V, VIN+ =24V, unless otherwise noted

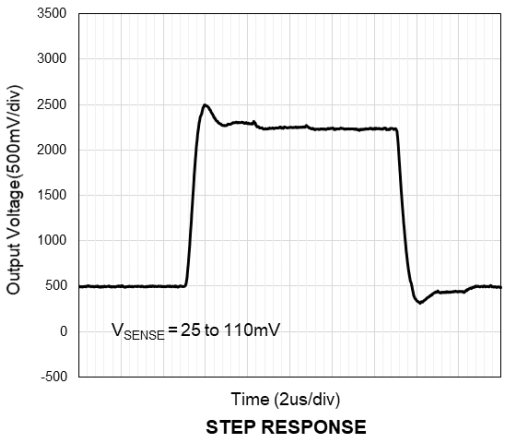


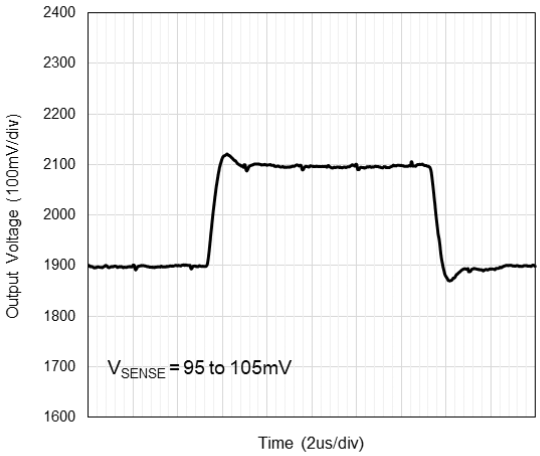




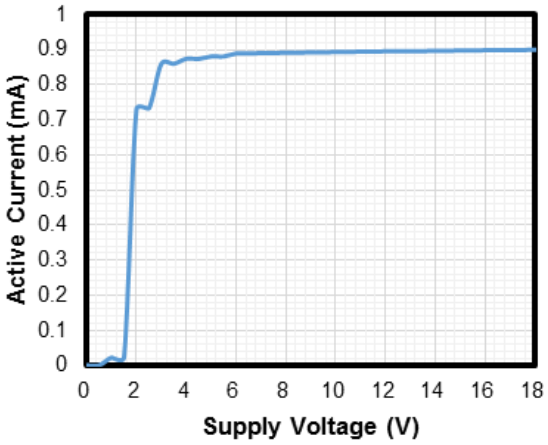








STEP RESPONSE



Applications Information

Selecting Rsense

The zero-drift offset performance of the TPA2296 offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the Rsense. For example, non-zero-drift current sense monitors typically require a full-scale range of 100 mV. The TPA2296 family gives equivalent accuracy at a full-scale range on the order of 10 mV. This accuracy reduces Rsense 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 TPA2296 to accommodate larger Rsense drops on the upper end of the scale.

Recommended Component Values

Ideally, the maximum load current develops the full-scale sense voltage across the current-sense resistor. Choose the gain needed to match the maximum output voltage required for the application:

$$Vout = Vsense \times Av$$

Where Vsense is the full-scale sense voltage, and Av is the gain of the TPA2296.

In applications of monitoring a high current, ensure that Rsense is able to dissipate its own I^2R power loss. If the resistor's power dissipation exceeds the nominal value, its value may drift, or it may fail altogether. The TPA2296 senses a wide variety of currents with different sense-resistor values.

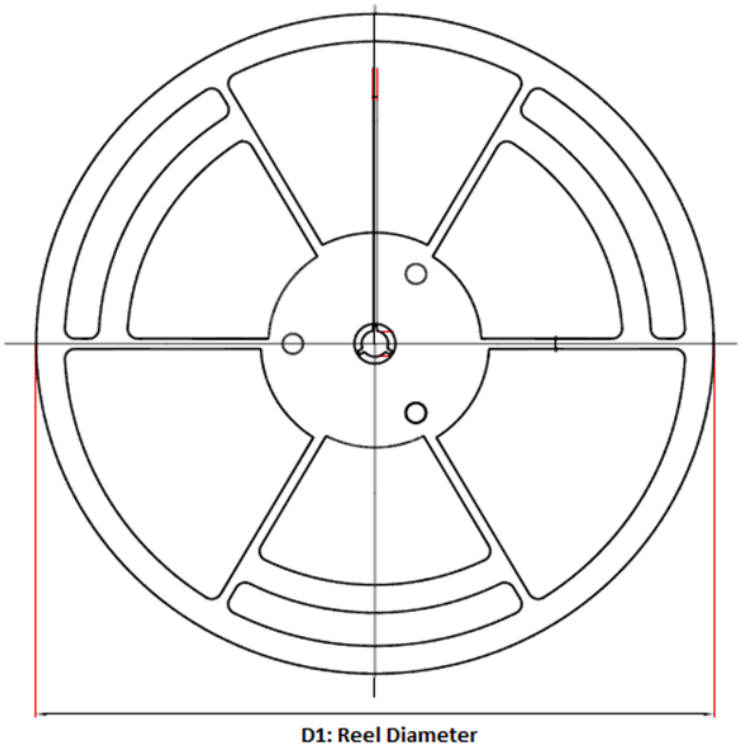
Power Supply Recommendation

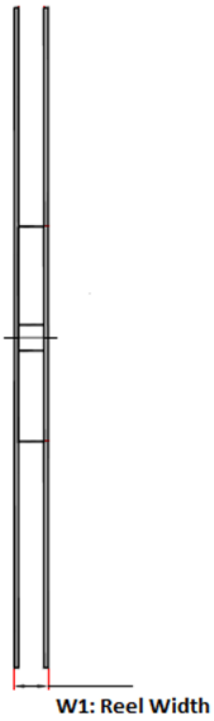
The input circuitry of the TPA2296 can accurately measure beyond its power-supply voltage, Vs. For example, the Vs power supply can be 5V, whereas the load power-supply voltage can be as high as 70V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin.

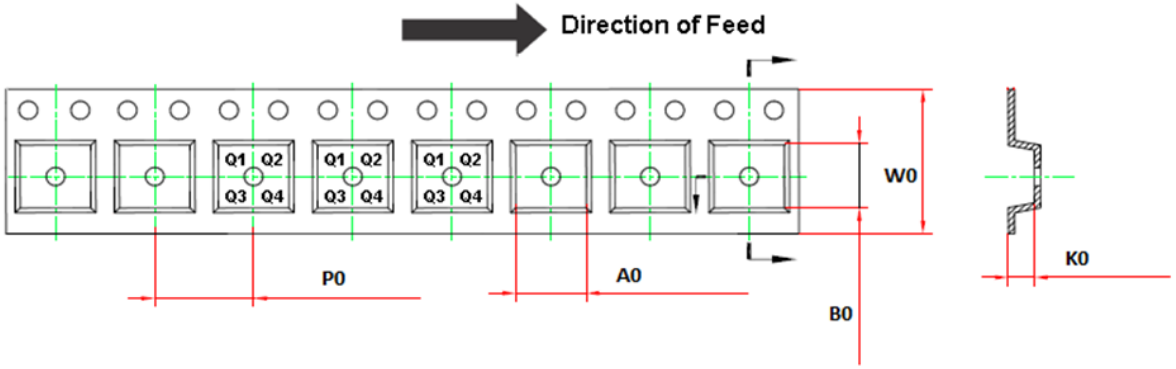
Layout: Kelvin connection

A typical routing of Kelvin-sensed traces to the inputs of the TPA2296 is needed in PCB Layout. The Kelvin-sense traces should be as close as possible to the current-sense resistor's solder contact pads. Any additional high-current carrying impedance can cause significant measurement errors because the current resistor has a very low value.

TAPE AND REEL INFORMATION





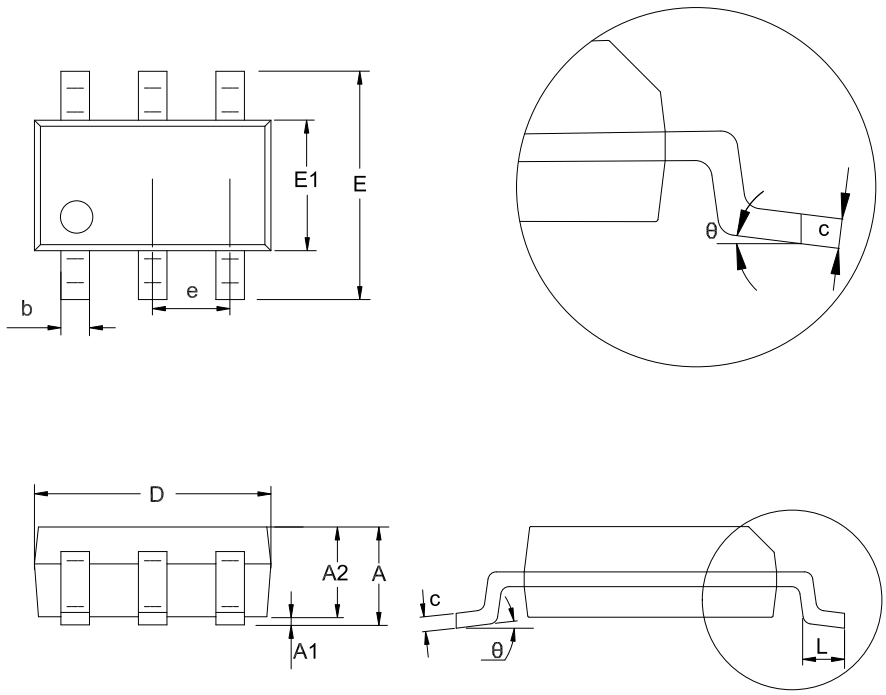


Order Number	Package	D1	W1	A0	B0	K0	P0	W0	Pin1 Quadrant
TPA2296T-S5TR	5-Pin SOT23	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA2296F-S5TR	5-Pin SOT23	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA2296H-S5TR-S	5-Pin SOT23	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA2296T-S6TR-S	6-Pin SOT23	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TPA2296F-S6TR-S	6-Pin SOT23	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TPA2296H-S6TR-S	6-Pin SOT23	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3

Package Outline Dimensions

SOT23-6L

Package Outline Dimensions S6T(SOT23-6-A)



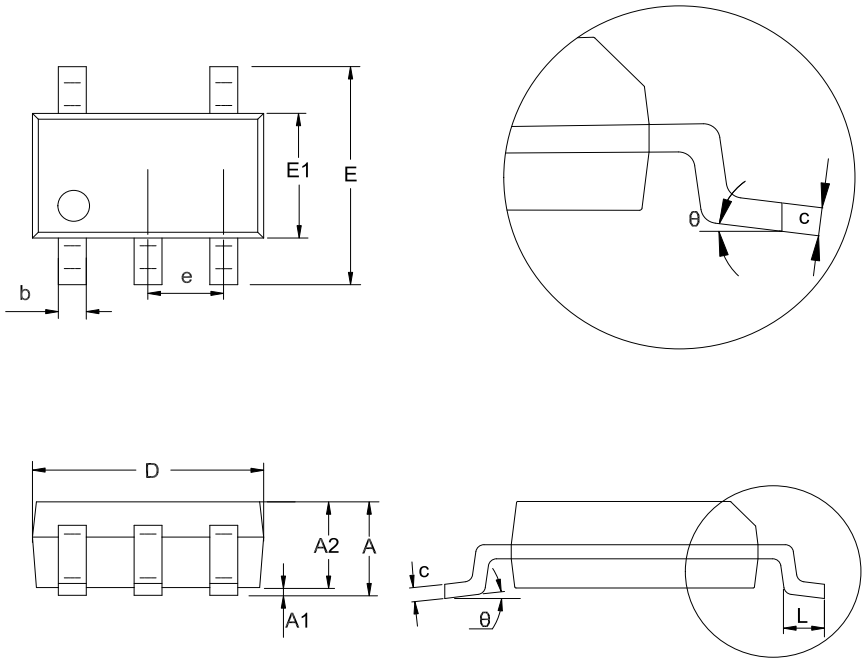
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOT23-5L

Package Outline Dimensions S5T(SOT23-5-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.