

## Adjustable Precision Shunt Regulator

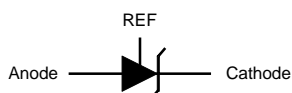
### Features

- Precise Reference Voltage to 2.500V
- Guaranteed 0.5% or 1% Reference Voltage Tolerance
- Sink Current Capability , 1mA to 100mA
- Quick Turn-on
- Adjustable Output Voltage ,  $V_O = V_{REF}$  to 20V
- Low Operational Cathode Current , 250 $\mu$ A Typical
- 0.1 $\Omega$  Typical Output Impedance
- SOT-23 , SOT-89 and TO-92 Packages

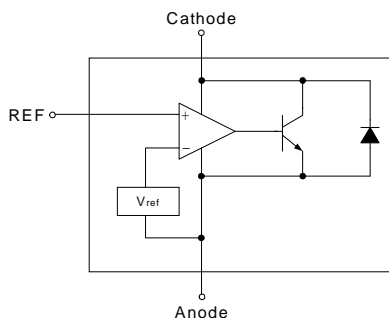
### Applications

- Linear Regulators
- Adjustable Power Supply
- Switching Power Supply

### Symbol

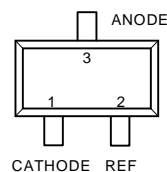


### Functional Diagram

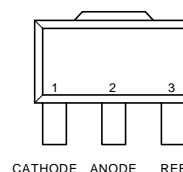


### General Description

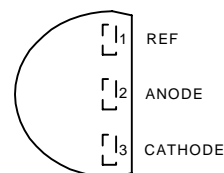
The APL1431 is a 3-terminal adjustable voltage reference with specified thermal stability over applicable commercial temperature ranges. Output voltage may be set to any value between  $V_{ref}$  (2.5 V) and 20 V with two external resistors (see Figure 2). When used with an photocoupler, the APL1431 is an ideal voltage reference in isolated feedback circuits for 2.5V to 12V switching-mode power supplies. This device has a typical output impedance of 0.1 $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making the APL1431 excellent replacements for zener diodes in many applications, including on-board regulation and adjustable power supplies.



SOT-23 (Top View)



SOT-89 (Top View)



TO-92 (Top View)

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

## Ordering and Marking Information

<p>APL1431 <span style="border: 1px solid black; padding: 2px;">□□□-□□□</span></p> <p style="margin-left: 40px;"> <span style="border: 1px solid black; padding: 2px;">□□□</span> → Lead Free Code  <span style="border: 1px solid black; padding: 2px;">□□</span> → Handling Code  <span style="border: 1px solid black; padding: 2px;">□</span> → Temp. Range  <span style="border: 1px solid black; padding: 2px;">□□</span> → Package Code  <span style="border: 1px solid black; padding: 2px;">□</span> → Elec. Grade         </p>	<p><b>Elec. Grade</b>            A : 0.5% Reference Voltage Tolerance            B : 1% Reference Voltage Tolerance</p> <p><b>Package Code</b>            A : SOT-23      D : SOT-89      E : TO-92            Y : Chip Form</p> <p><b>Temp. Range</b>            C : 0 to 70 °C      I : -40 to 85 °C</p> <p><b>Handling Code</b>            PB : Plastic Bag      TB : Tape &amp; Box            TR : Tape &amp; Reel</p> <p><b>Lead Free Code</b>            L : Lead Free Device      Blank : Original Device</p>
<p>APL1431 A : <span style="border: 1px solid black; padding: 2px;">1431</span></p>	<p>APL1431 E : <span style="border: 1px solid black; padding: 2px;">APL 1431 XXXXX</span>      XXXXX - Date Code</p>
<p>APL1431 D : <span style="border: 1px solid black; padding: 2px;">APL1431 XXXXX</span>      XXXXX - Date Code</p>	

## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
$V_{KA}$	Cathode voltage	20	V
$I_K$	Continuous cathode current range	120	mA
$I_{REF}$	Reference current range	3	mA
$\theta_{JA}$	Thermal Resistance from Junction to Ambient in Free Air		°C/W
	SOT-23	416	
	SOT-89	250	
	TO-92	250	
$T_A$	Ambient temperature range	APL1431XXC APL1431XXI	0 to 70 -40 to 85
$T_j$	Junction temperature range	APL1431XXC APL1431XXI	0 to 150 -40 to 150
$T_{STG}$	Storage Temperature Range		-65 to 150
$T_{SOL}$	Lead temperature range, $T_s$ (Soldering, 10sec)		260

## Electrical Characteristics $T_A = 25^\circ\text{C}$ ( unless otherwise noted)

Symbol	Parameter	Test Conditions	APL1431			Unit
			Min.	Typ.	Max.	
$V_{REF}$	Reference voltage	$V_{KA}=V_{REF}, I_K=10\text{mA}^{*1}$ APL431A APL431B	2.487 2.475	2.500 2.500	2.513 2.525	V
$\Delta V_{REF}/T$	Reference voltage drift over temp. range	$V_{KA}=V_{REF}, I_K=10\text{mA}$ $T_A = 0 \text{ to } 70^\circ\text{C}^{*1}$ $T_A = -40 \text{ to } 85^\circ\text{C}^{*1}$			20 30	mV
$\Delta V_{REF} / \Delta V_{KA}$	Voltage ratio (open loop gain)	$I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 10V^{*2}$ $I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 20V^{*2}$		-1.5 -1.2	-3 -2.5	mV/V

Electrical Characteristics Cont.  $T_A = 25^\circ\text{C}$  ( unless otherwise noted)

Symbol	Parameter	Test Conditions	APL1431			Unit
			Min.	Typ.	Max.	
$I_{REF}$	Reference current	$I_K=10\text{mA}$ , $R_1=10\text{k}\Omega$ , $R_2=\text{open}^{*2}$		1.0	3	$\mu\text{A}$
$\Delta I_{REF}/T$	Reference current drift	$I_K=10\text{mA}$ , $R_1=10\text{k}\Omega$ , $R_2=\text{open}$ , $T_A = -40$ to $85^\circ\text{C}^{*2}$		0.3	1	$\mu\text{A}$
$I_{K(\text{min})}$	Min. cathode current	$V_{KA}=V_{REF}^{*1}$		0.25	0.5	mA
$I_{K(\text{off})}$	Off-state cathode current	$V_{KA}=20\text{V}$ , $V_{REF}=0\text{V}^{*3}$		0.1	1	$\mu\text{A}$
$ Z_{KA} $	Dynamic impedance	$V_{KA}=V_{REF}$ $I_K=1\text{mA}$ to $100\text{mA}$ , $f \leq 1\text{kHz}^{*1}$		0.1	0.4	$\Omega$
$I_K$	Cathode current	$V_{KA}=V_{REF}+50\text{mV}^{*2}$			100	mA

Notes : \*1 : use Figure 1  
\*2 : use Figure 2  
\*3 : use Figure 3

Test figures

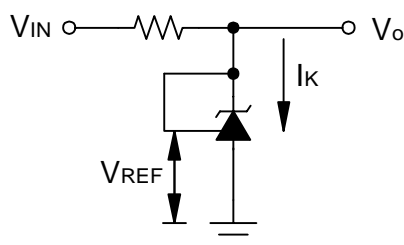


Figure 1. Test Circuit for  $V_{KA}=V_{REF}$ ,  $V_O=V_{KA}=V_{REF}$

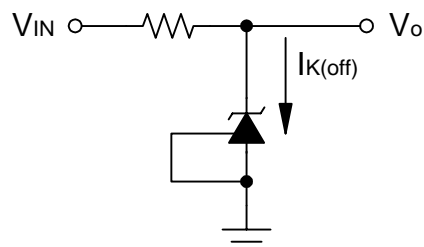


Figure 3. Test Circuit for  $I_{K(\text{off})}$

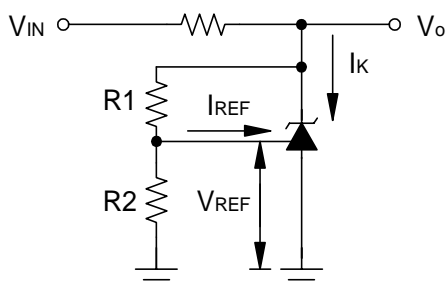
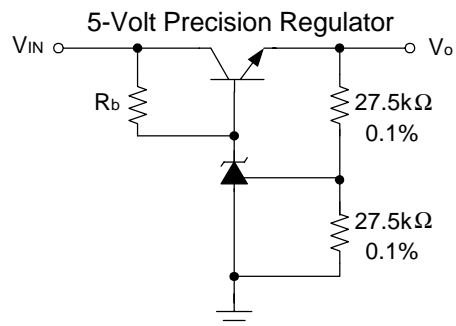


Figure 2. Test Circuit for  $V_{KA} > V_{REF}$ ,  
 $V_O = V_{KA} = V_{REF} \times (1 + R_1/R_2) + I_{REF} \times R_1$

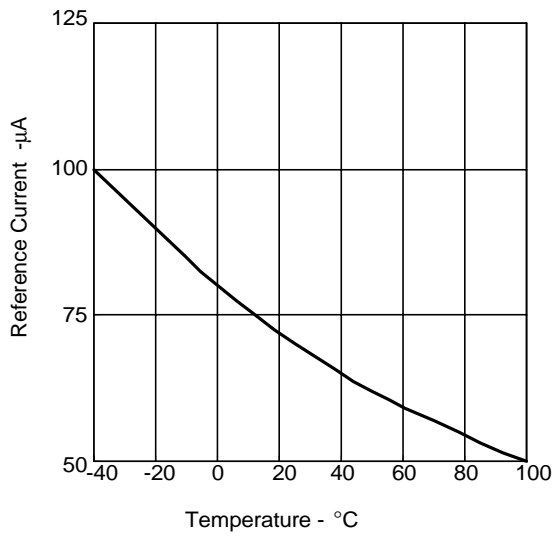
Application schematic



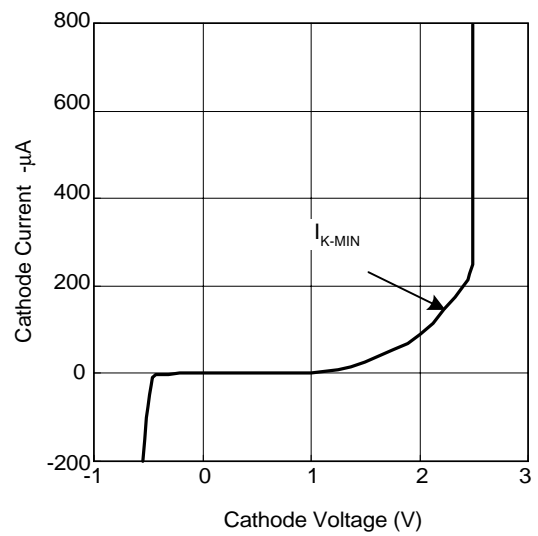
\*  $R_b$  should provide cathode current large than 1mA to maintain APL431 work properly.

## Typical Characteristics

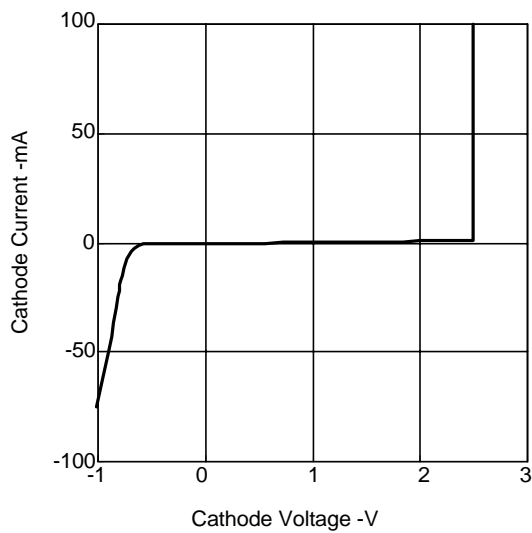
Reference Current vs. Temperature



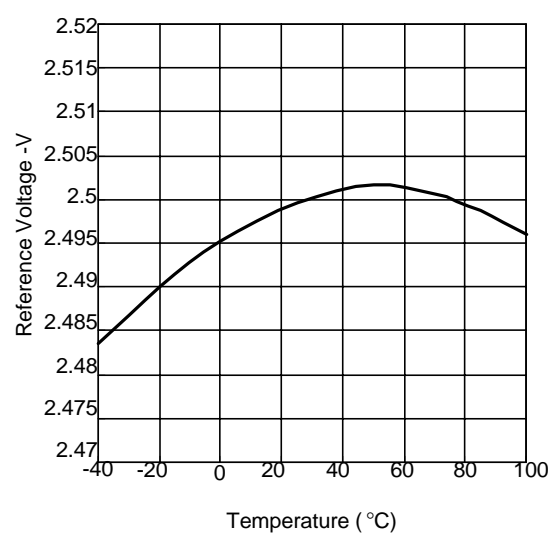
Cathode Current vs. Cathode Voltage



Cathode Current vs. Cathode Voltage

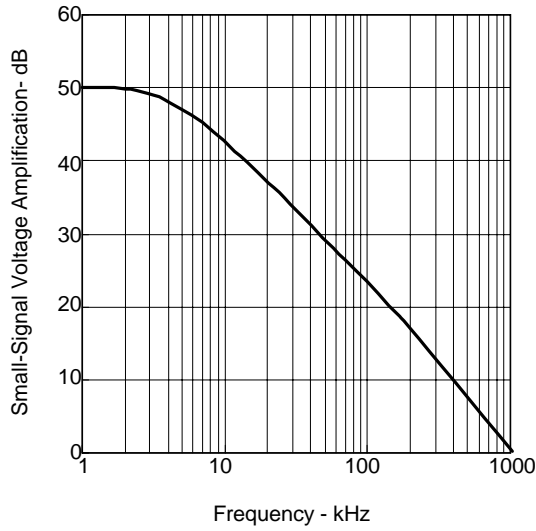


Reference Voltage vs. Temperature

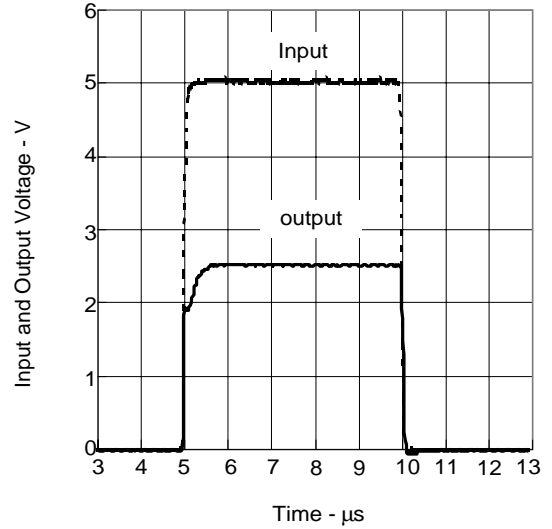


## Typical Characteristics (Cont.)

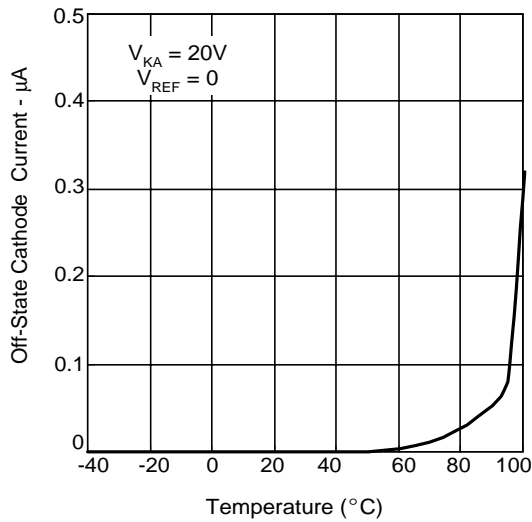
Small-Signal Voltage Amplification vs Frequency



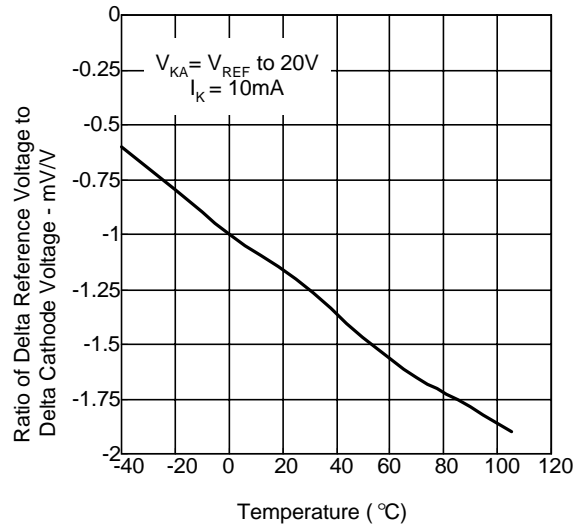
Pulse Response



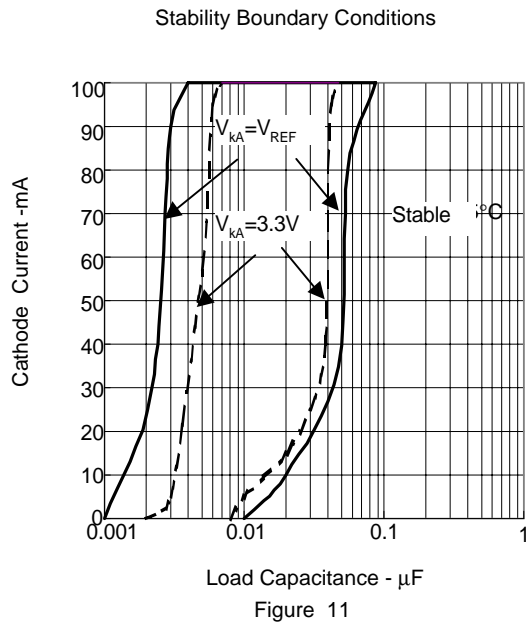
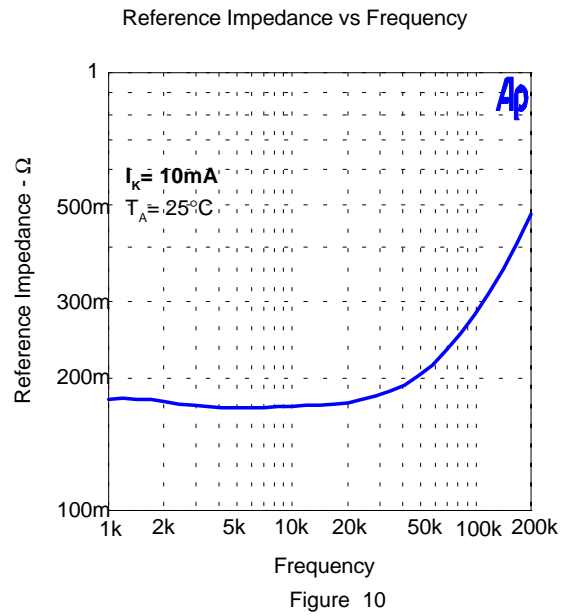
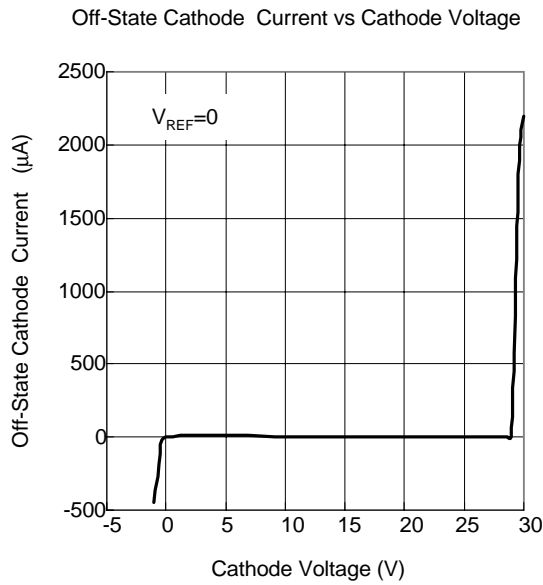
Off-State Cathode Current vs Temperature



Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Temperature

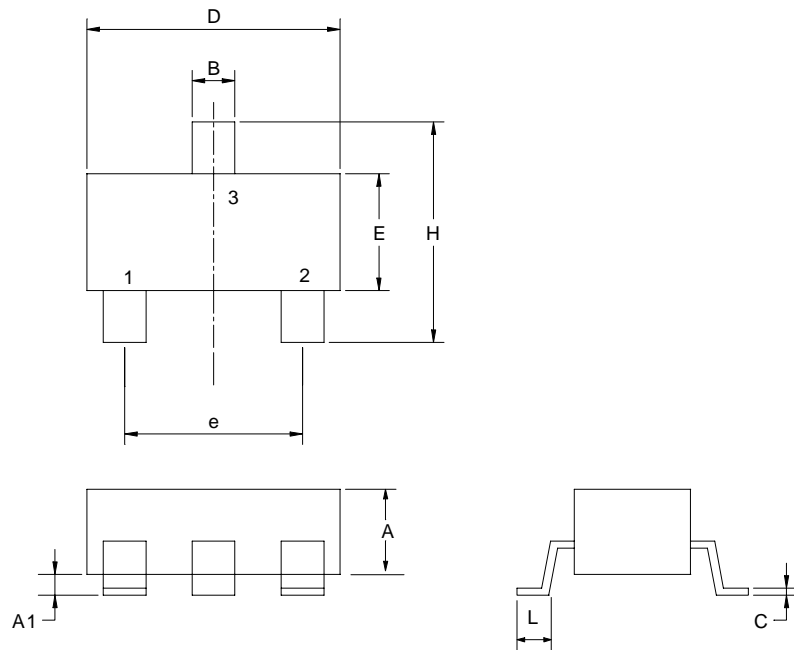


## Typical Characteristics (Cont.)



## Packaging Information

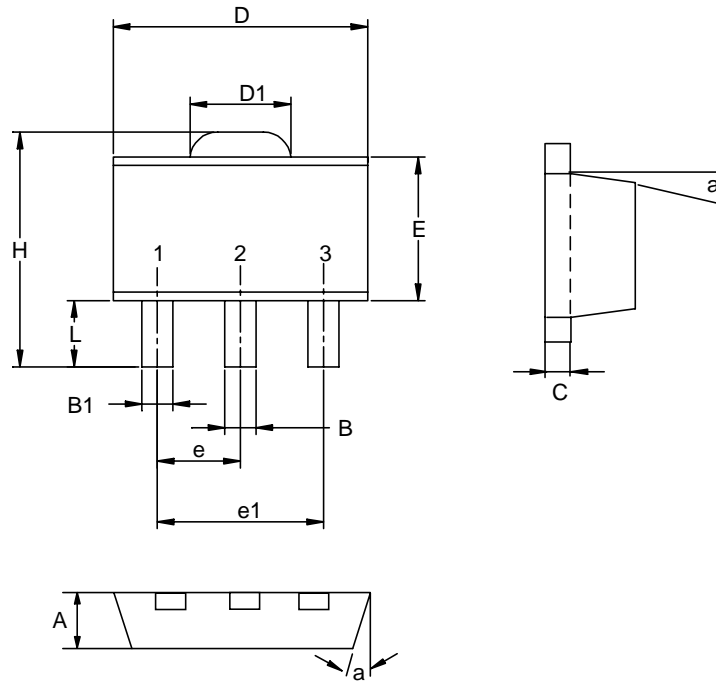
SOT-23



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.00	1.30	0.039	0.051
A1	0.00	0.10	0.000	0.004
B	0.35	0.51	0.014	0.020
C	0.10	0.25	0.004	0.010
D	2.70	3.10	0.106	0.122
E	1.40	1.80	0.055	0.071
e	1.90/2.1 BSC		0.075/0.083 BSC	
H	2.40	3.00	0.094	0.118
L	0.37		0.015	

## Packaging Information

SOT-89

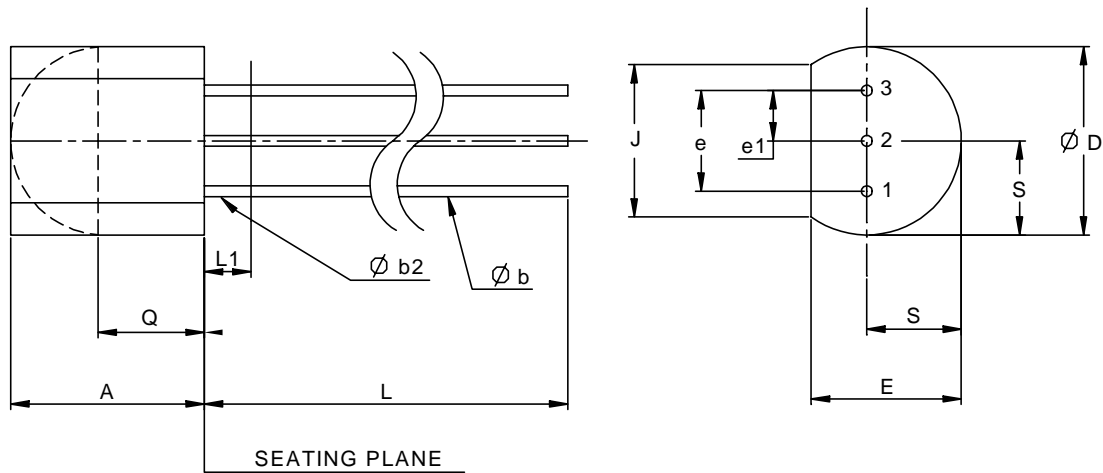


Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.40	1.60	0.055	0.063
B	0.40	0.56	0.016	0.022
B1	0.35	0.48	0.014	0.019
C	0.35	0.44	0.014	0.017
D	4.40	4.60	0.173	0.181
D1	1.35	1.83	0.053	0.072
e	1.50 BSC		0.059 BSC	
e1	3.00 BSC		0.118 BSC	
E	2.29	2.60	0.090	0.102
H	3.75	4.25	0.148	0.167
L	0.80	1.20	0.031	0.047
α		10°		10°



Packaging Information

TO-92

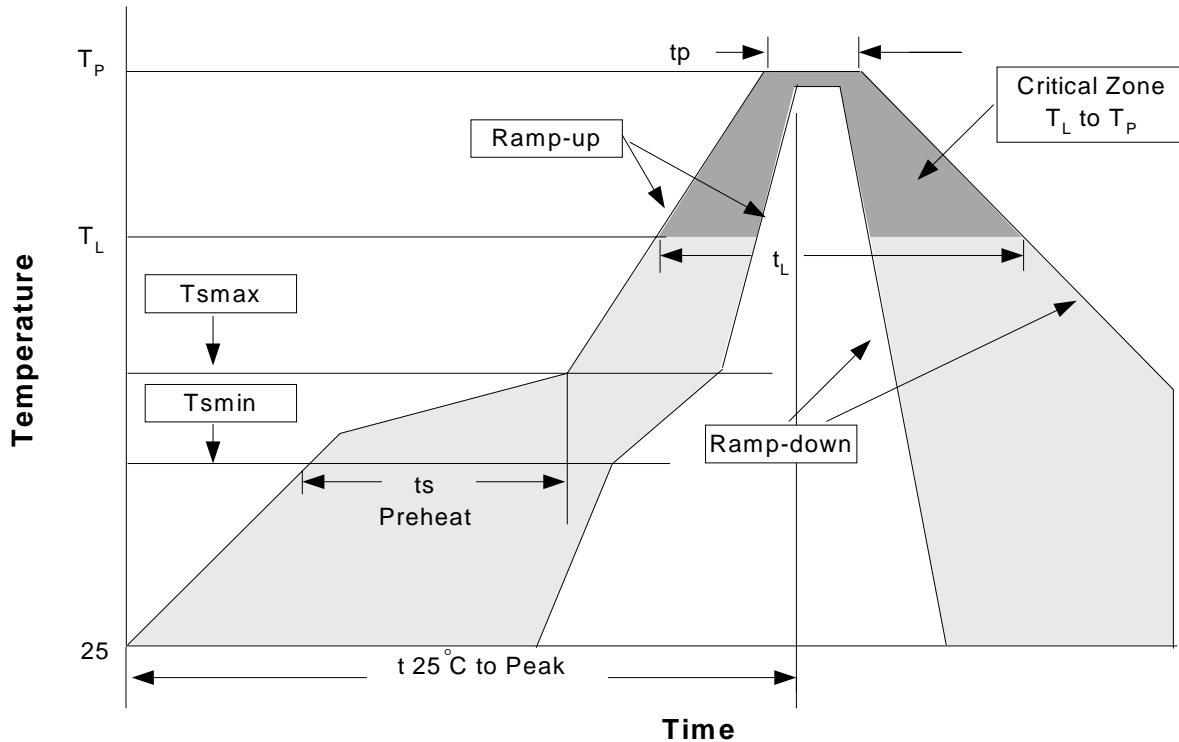


Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	4.318	5.334	0.170	0.210
φ b	0.406	0.559	0.016	0.022
φ b2	0.406	0.559	0.016	0.022
φ D	4.445	5.207	0.175	0.205
E	3.175	4.191	0.125	0.165
e	2.413	2.667	0.095	0.105
e1	1.143	1.397	0.045	0.055
J	3.429		0.135	
L	12.70		0.500	
L1		1.27		0.050
Q	2.921		0.115	
S	2.032	2.667	0.080	0.105

## Physical Specifications

Terminal Material	Solder-Plated Copper (Solder Material : 90/10 or 63/37 SnPb), 100%Sn
Lead Solderability	Meets EIA Specification RSI86-91, ANSI/J-STD-002 Category 3.

### Reflow Condition (IR/Convection or VPR Reflow)



### Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate ( $T_L$ to $T_P$ )	3°C/second max.	3°C/second max.
Preheat		
- Temperature Min ( $T_{smin}$ )	100°C	150°C
- Temperature Max ( $T_{smax}$ )	150°C	200°C
- Time (min to max) ( $t_s$ )	60-120 seconds	60-180 seconds
Time maintained above:		
- Temperature ( $T_L$ )	183°C	217°C
- Time ( $t_L$ )	60-150 seconds	60-150 seconds
Peak/Classification Temperature ( $T_p$ )	See table 1	See table 2
Time within 5°C of actual Peak Temperature ( $t_p$ )	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Notes: All temperatures refer to topside of the package .Measured on the body surface.

## Classification Reflow Profiles(Cont.)

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> ≥350
<2.5 mm	240 +0/-5°C	225 +0/-5°C
≥2.5 mm	225 +0/-5°C	225 +0/-5°C

Table 2. Pb-free Process – Package Classification Reflow Temperatures

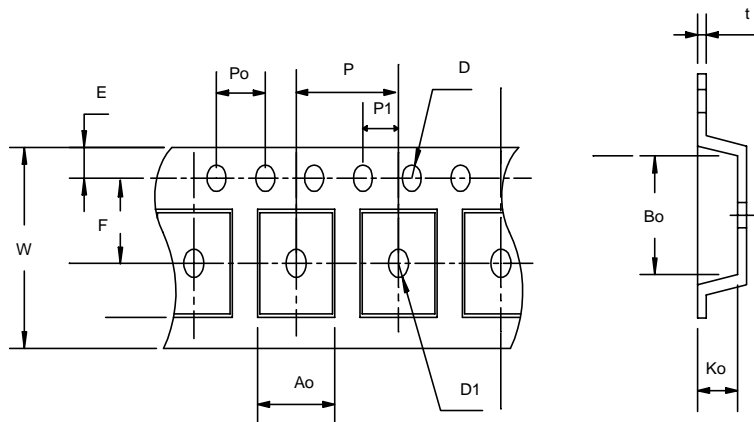
Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350-2000	Volume mm <sup>3</sup> >2000
<1.6 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6 mm – 2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≥2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*

\*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

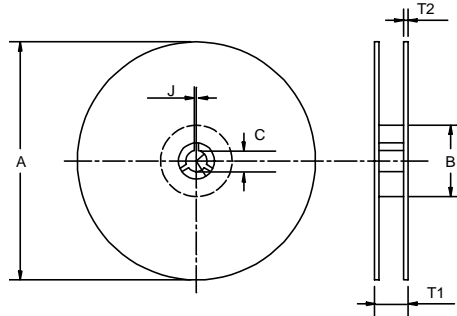
## Reliability Test Program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C, 5 SEC
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @ 125°C
PCT	JESD-22-B,A102	168 Hrs, 100%RH, 121°C
TST	MIL-STD-883D-1011.9	-65°C~150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms, 1 <sub>tr</sub> > 100mA

## Carrier Tape & Reel Dimensions

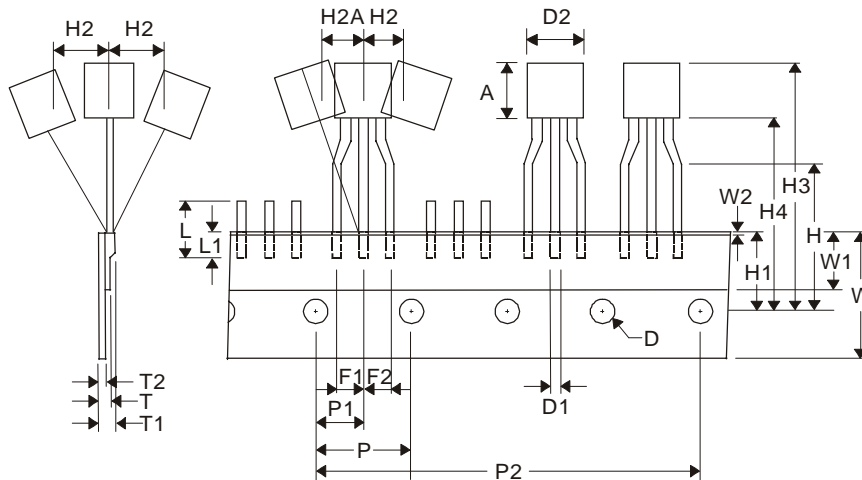


Carrier Tape & Reel Dimensions(Cont.)



Application	A	B	C	J	T1	T2	W	P	E
SOT-23	178±1	60 ± 1.0	12.0	2.5 ± 0.15	9.0 ± 0.5	1.4	8.0+0.3 -0.3	4.0	1.75
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	3.5 ± 0.05	1.5 +0.1	φ 0.1MIN	4.0	2.0 ± 0.05	3.1	3.0	1.3	0.2±0.03
Application	A	B	C	J	T1	T2	W	P	E
SOT-89	178 ± 1	70 ± 2	13.5 ± 0.15	3 ± 0.15	14 ± 2	1.3 ± 0.3	12+0.3 12-0.1	8 ± 0.1	1.75 ± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	5.5 ± 0.05	1.5 ± 0.1	1.5 ± 0.1	4.0 ± 0.1	2.0 ± 0.1	4.8 ± 0.1	4.5 ± 0.1	1.80 ± 0.1	0.3 ± 0.013

(mm)



## Carrier Tape & Reel Dimensions(Cont.)

Application	A	D	D1	D2	F1,F2	H	H1	H2	H2A
TO-92	3.18~12	4.0±0.2	0.36~0.53	9.0 MAX	2.5+0.2 -0.1	16±0.5	9±0.5	0.5 MAX	0.5 MAX
	H3	H4	L	L1	P	P1	P2	T	T1
	27.0 MAX	20.0 MAX	11.0 MAX	2.5 MIN	12.7±0.2	6.35±0.4	50.8±0.5	0.55 MAX	1.42 MAX
	T2	W	W1	W2					
	0.36~0.68	17.5~19	5.0~7.0	0.5 MAX					

(mm)

## Cover Tape Dimensions

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOT- 23	8	5.3	3000
SOT- 89	12	9.3	1000
TO-92	17.5~19	5.0~7.0	2000

## Customer Service

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