

Adjustable Precision Shunt Regulator

Features

- Precise Reference Voltage to 2.500V
- Guaranteed 0.5%, 1% or 2% 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 μ A Typical
- 0.1 Ω Typical Output Impedance
- SOT-23, SOT-23-5, SOT-89, SO-8, TO-92 and TO-92S Packages
- Lead Free Available (RoHS Compliant)

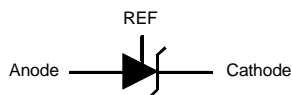
General Description

The APL431 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 APL431 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 Ω . Active output circuitry provides a very sharp turn-on characteristic, making the APL431 excellent replacements for zener diodes in many applications, including on-board regulation and adjustable power supplies.

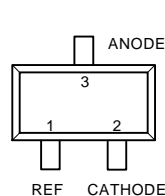
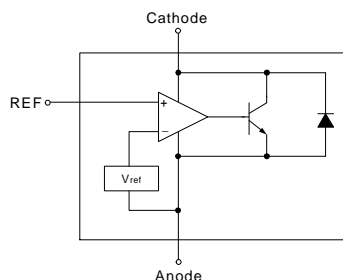
Applications

- Linear Regulators
- Adjustable Power Supply
- Switching Power Supply

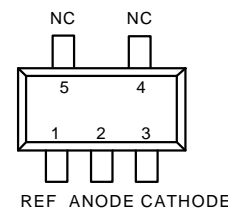
Symbol



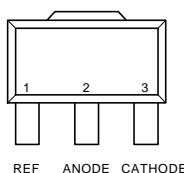
Functional Diagram



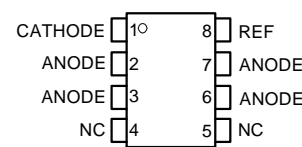
SOT-23 (Top View)



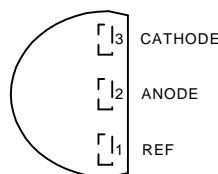
SOT-23-5 (Top View)



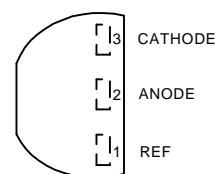
SOT-89 (Top View)



SO-8 (Top View)



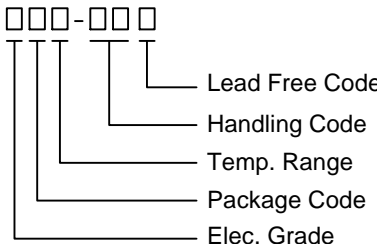
TO-92 (Top View)



TO-92S (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>APL431</p> <p>□□□-□□□</p>  <p>Lead Free Code</p> <p>Handling Code</p> <p>Temp. Range</p> <p>Package Code</p> <p>Elec. Grade</p>	<p>Elec. Grade</p> <p>A : 0.5% Reference Voltage Tolerance</p> <p>B : 1% Reference Voltage Tolerance</p> <p>C : 2% Reference Voltage Tolerance</p> <p>Package Code</p> <p>A : SOT-23 B : SOT-23-5 D : SOT-89</p> <p>E : TO-92 I : TO-92S K : SO-8</p> <p>Y : Chip Form</p> <p>Temp. Range</p> <p>C : 0 to 70 °C I : -40 to 85 °C Q : -40 to 125 °C</p> <p>Handling Code</p> <p>PB : Plastic Bag TB : Tape & Box</p> <p>TR : Tape & Reel</p> <p>Lead Free Code</p> <p>L : Lead Free Device Blank : Original Device</p>
<p>APL431 A/B : 431</p>	<p>APL431 E/I : APL 431 XXXXX XXXXX - Date Code</p>
<p>APL431 D/K : APL431 XXXXX XXXXX - Date Code</p>	

Notes: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte in plate termination finish; which are fully compliant with RoHS and compatible with both SnPb and lead-free soldering operations. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{KA}	Cathode voltage	20	V
I_K	Continuous cathode current range	100	mA
I_{REF}	Reference current range	3	mA
θ_{JA}	Thermal Resistance from Junction to Ambient in Free Air		°C/W
	SOT-23	416	
	SOT-23-5	357	
	SOT-89	250	
	TO-92	250	
	SO-8	210	
T_A	Ambient temperature range		°C
	APL431XXC	0 to 70	
	APL431XXI	-40 to 85	
	APL431XXQ	-40 to 125	
T_j	Junction temperature range		°C
	APL431XXC	0 to 150	
	APL431XXI	-40 to 150	
	APL431XXQ	-40 to 150	
T_{STG}	Storage Temperature Range	-65 to 150	°C
T_{SOL}	Lead temperature range, T_s (Soldering, 10sec)		°C
	Original Device	260	
	Lead Free Device	300	

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

Symbol	Parameter	Test Conditions	APL431			Unit	
			Min.	Typ.	Max.		
V_{REF}	Reference voltage	$V_{KA}=V_{REF}, I_K=10\text{mA}^{*1}$	APL431A	2.487	2.500	2.513	V
			APL431B	2.475	2.500	2.525	
			APL431C	2.450	2.500	2.550	
$\Delta V_{REF} / T$	Reference voltage drift over temp. range	$V_{KA}=V_{REF}, I_K=10\text{mA}$ $T_A = 0 \text{ to } 70^\circ\text{C}^{*1}$ $T_A = -40 \text{ to } 85^\circ\text{C}^{*1}$ $T_A = -40 \text{ to } 125^\circ\text{C}^{*1}$			20 30 35	mV	
$\Delta V_{REF} / \Delta V_{KA}$	Voltage ratio (open loop gain)	$I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 10\text{V}^{*2}$		-1.5	-3	mV/V	
		$I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 20\text{V}^{*2}$		-1.2	-2.5		
I_{REF}	Reference current	$I_K=10\text{mA}, R_1=10\text{k}\Omega, R_2=\text{open}^{*2}$		1.0	3	μA	
$\Delta I_{REF}/T$	Reference current drift	$I_K=10\text{mA}, R_1=10\text{k}\Omega, R_2=\text{open}, T_A = -40 \text{ to } 85^\circ\text{C}^{*2}$		0.3	1	μA	
$I_{K(\text{min})}$	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	μA	
$ 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	Ω	
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

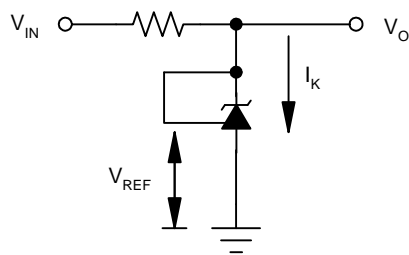


Figure 1. Test Circuit for $V_{KA}=V_{REF}, V_O=V_{KA}=V_{REF}$

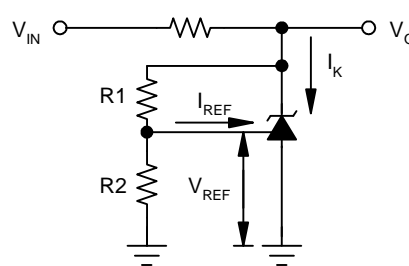


Figure 2. Test Circuit for $V_{KA} > V_{REF}, V_O = V_{KA} = V_{REF} \times (1 + R_1/R_2) + I_{REF} \times R_1$

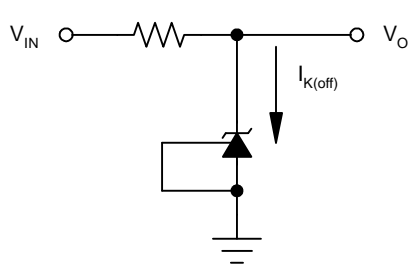
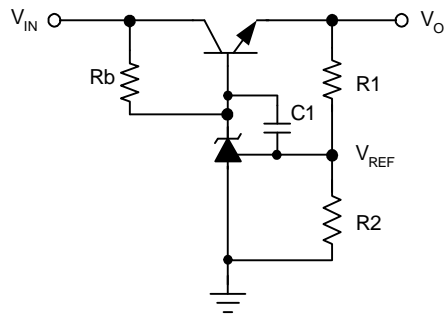


Figure 3. Test Circuit for $I_{K(\text{off})}$

Application schematic

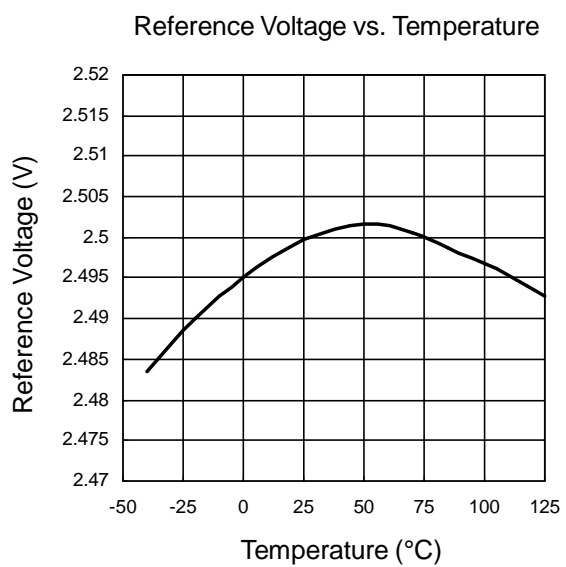
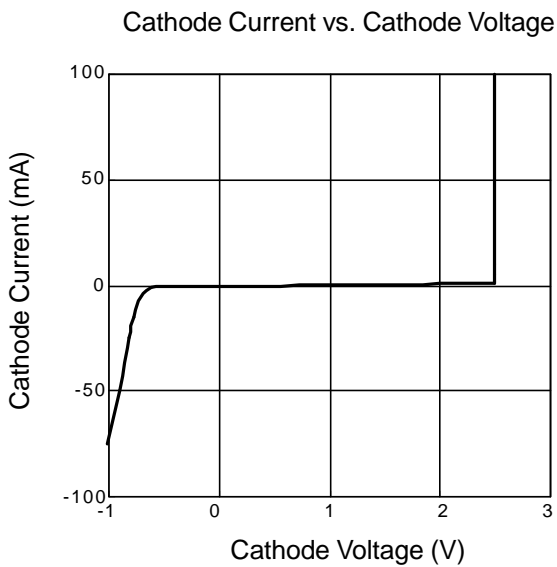
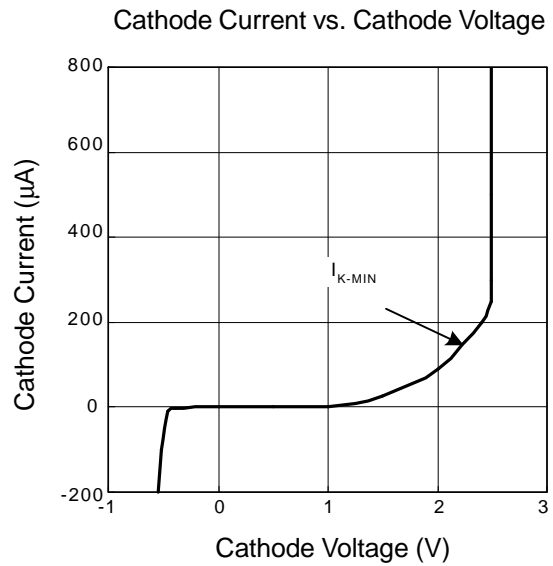
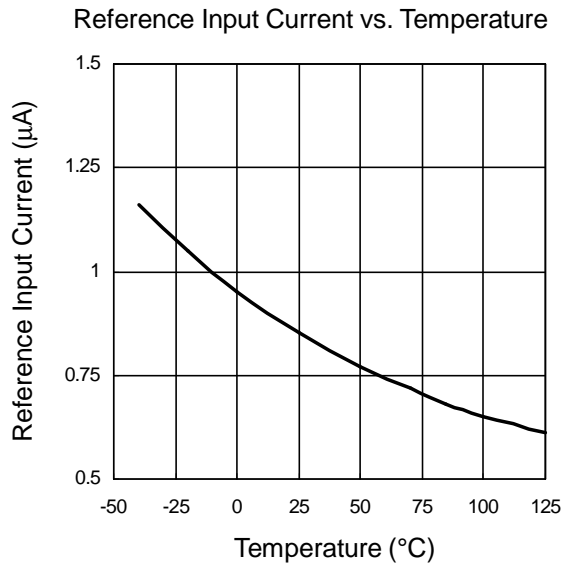
Precision High Current Series Regulator



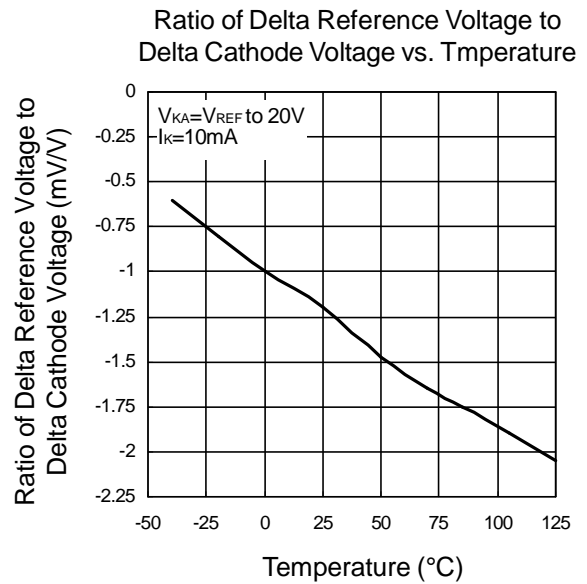
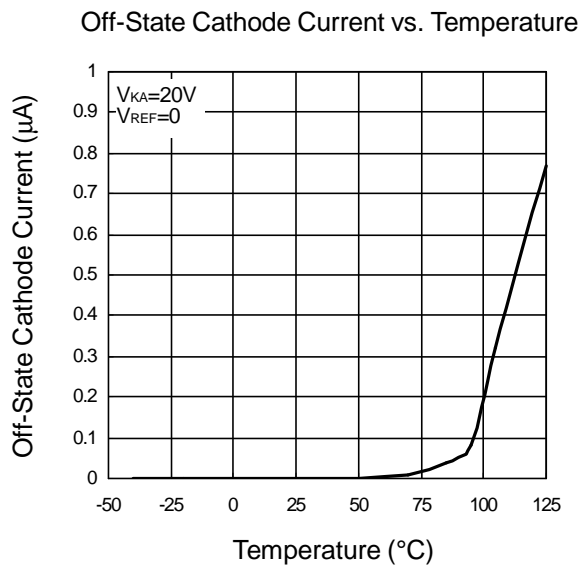
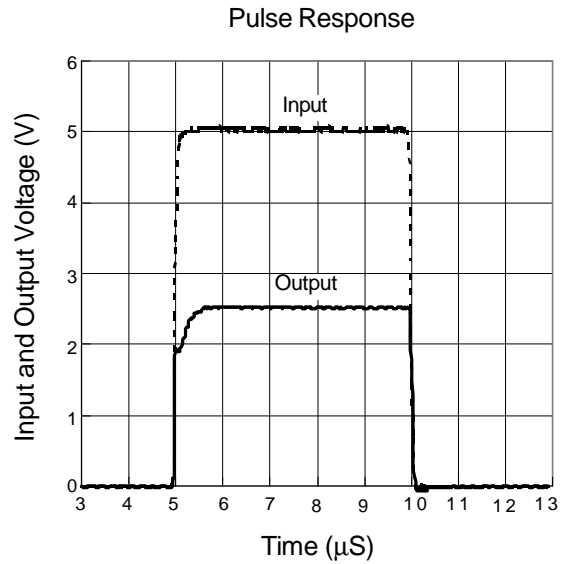
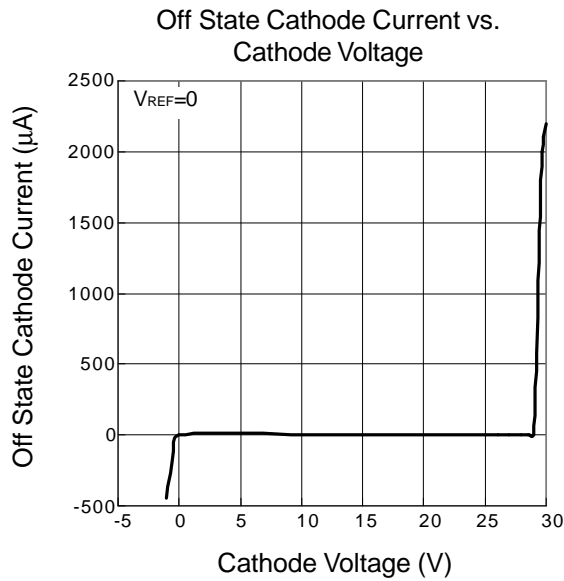
R_b should provide cathode current $\geq 1\text{mA}$ to maintain APL431 work properly.

For the series regulator applications, add a compensation capacitor C₁ between CATHODE and REF is strongly recommended to improve the stability of output voltage .

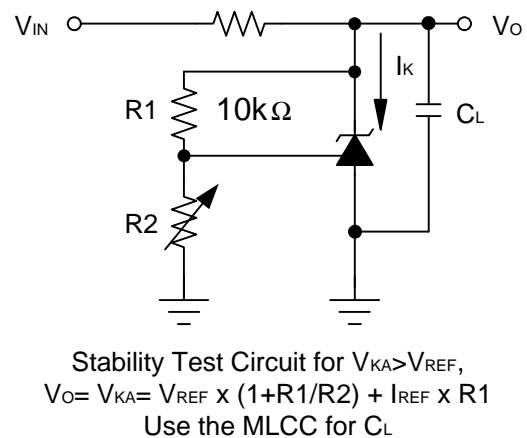
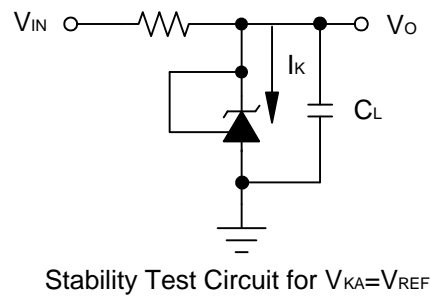
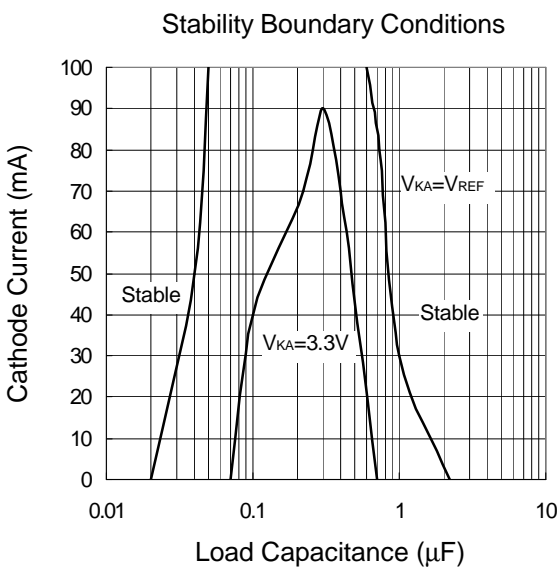
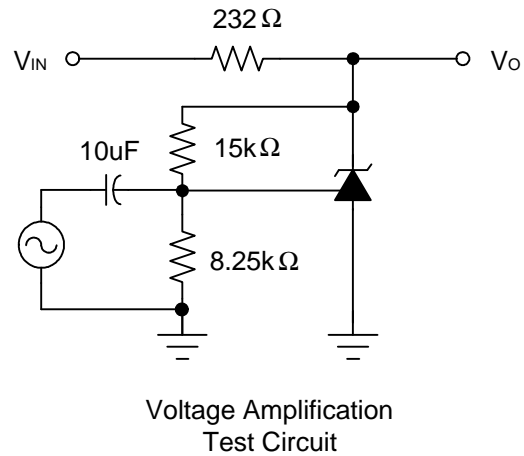
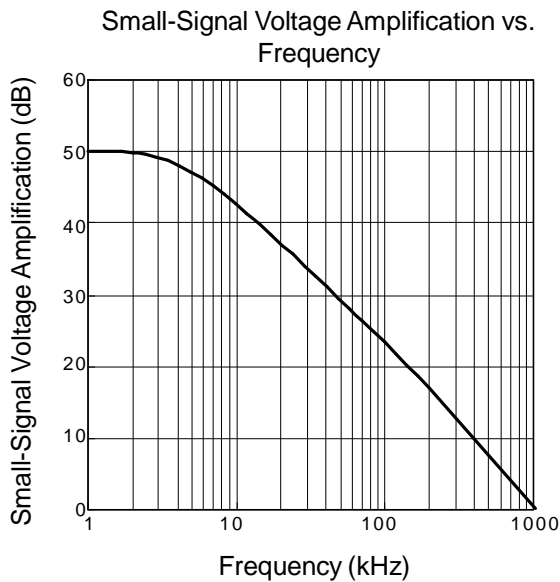
Typical Characteristics



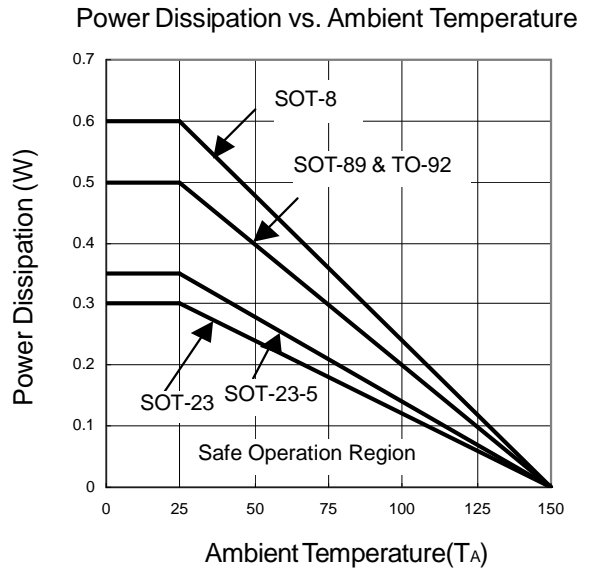
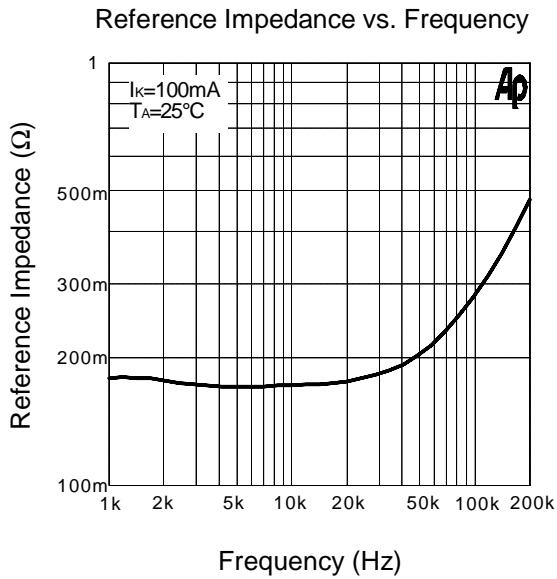
Typical Characteristics (Cont.)



Typical Characteristics (Cont.)

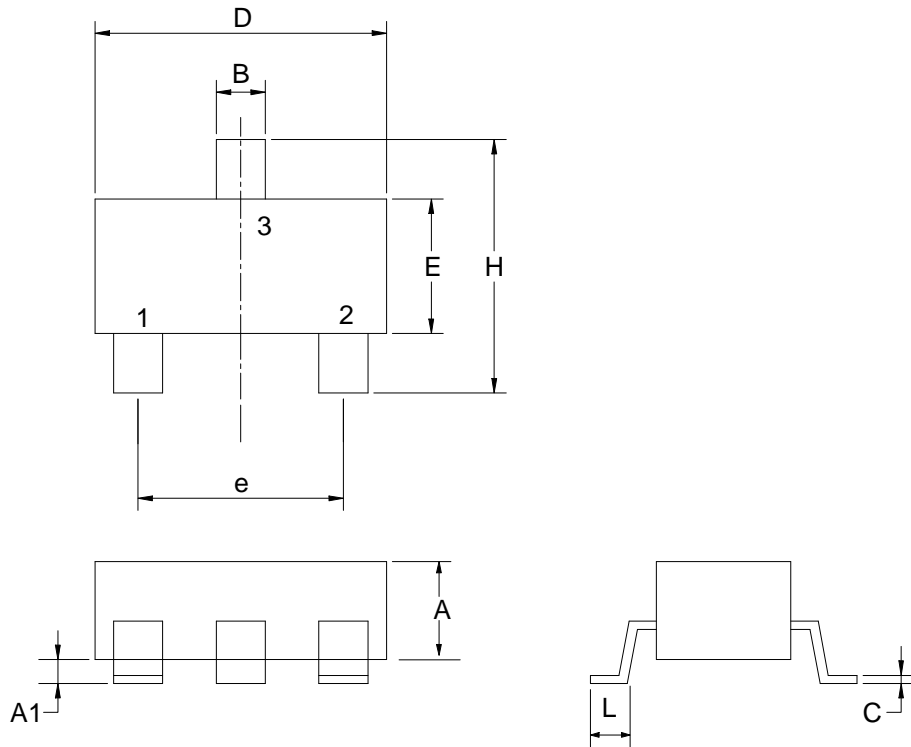


Typical Characteristics (Cont.)



Package Information

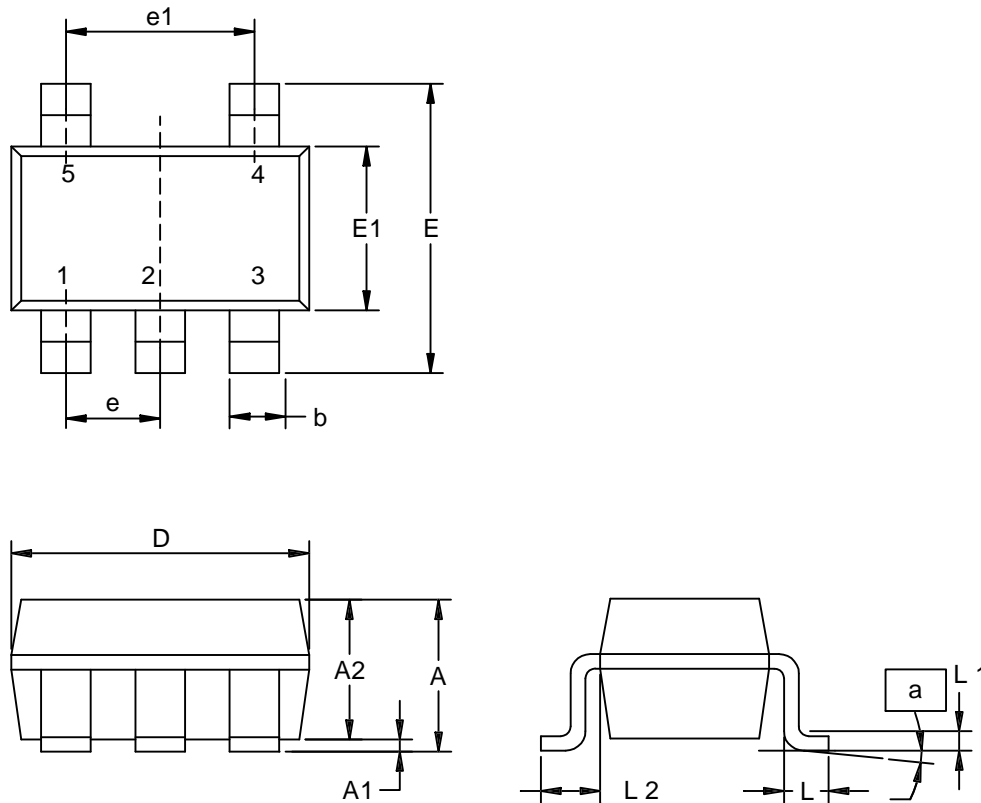
SOT-23



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	

Package Information

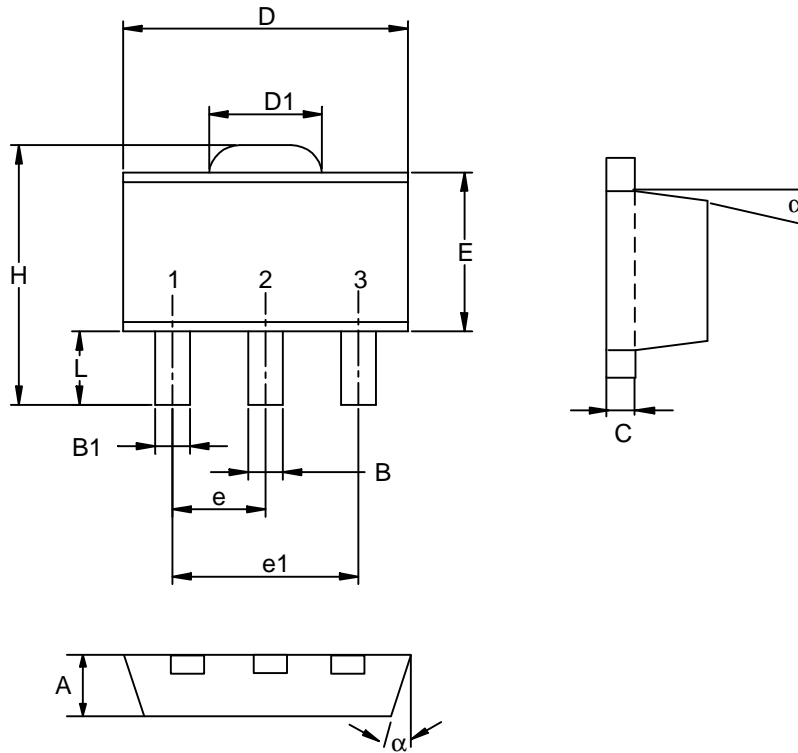
SOT-23-5



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.95	1.45	0.037	0.057
A1	0.05	0.15	0.002	0.006
A2	0.90	1.30	0.035	0.051
b	0.35	0.55	0.0138	0.0217
D	2.8	3.00	0.110	0.118
E	2.6	3.00	0.102	0.118
E1	1.5	1.70	0.059	0.067
e	0.95		0.037	
e1	1.90		0.075	
L	0.35	0.55	0.014	0.022
L1	0.20 BSC		0.008 BSC	
L2	0.5	0.7	0.020	0.028
a	0°	10°	0°	10°

Package Information

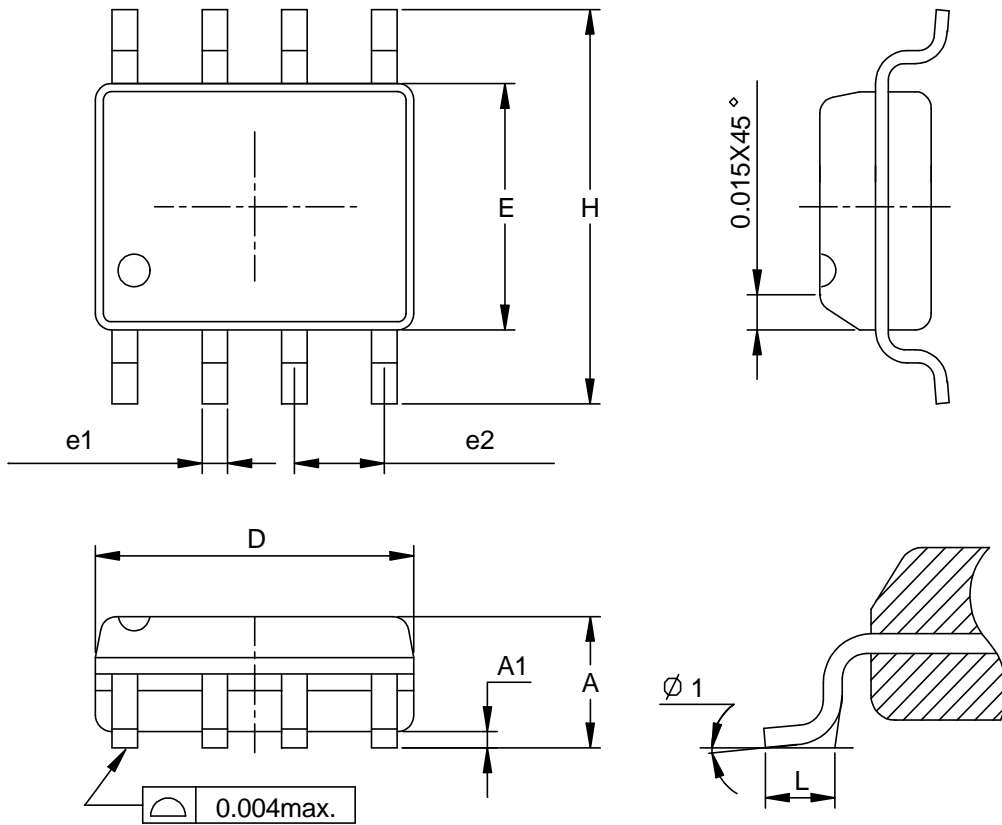
SOT-89 (Reference EIAJ ED-7500A Registration SC-62)



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°

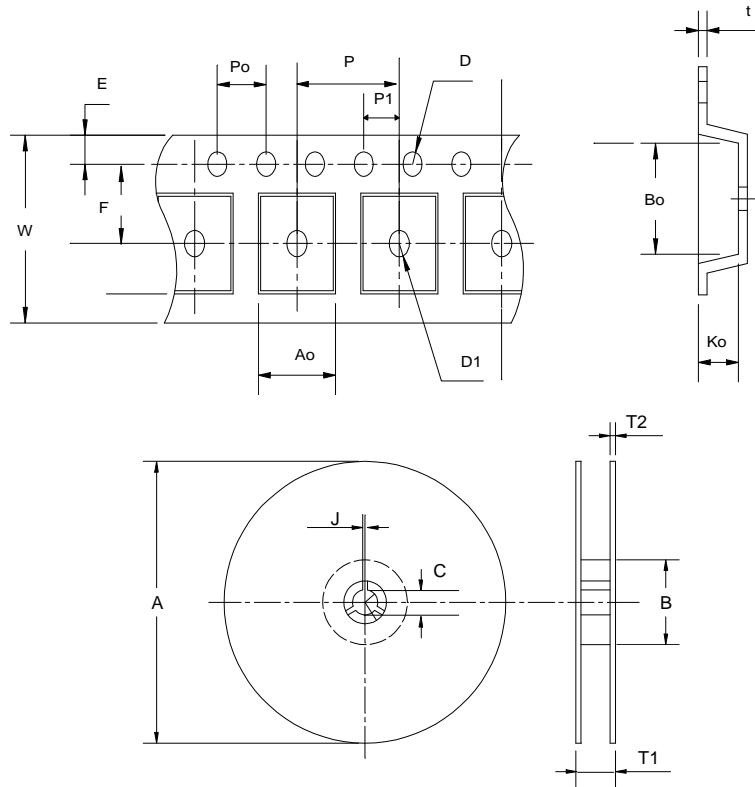
Packaging Information

SO-8



Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
D	4.80	5.00	0.189	0.197
E	3.80	4.00	0.150	0.157
H	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
e1	0.33	0.51	0.013	0.020
e2	1.27BSC		0.50BSC	
$\phi 1$	0°	8°	0°	8°

Carrier Tape & Reel Dimensions



Application	A	B	C	J	T1	T2	W	P	E
SO-8	330 ± 1	62 +1.5	12.75+ 0.15	2 ± 0.5	12.4 ± 0.2	2 ± 0.2	12 ± 0.3	8 ± 0.1	1.75 ± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	5.5 ± 1	1.55 +0.1	1.55+ 0.25	4.0 ± 0.1	2.0 ± 0.1	6.4 ± 0.1	5.2 ± 0.1	2.1 ± 0.1	0.3 ± 0.013
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	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-23-5	178 ± 1	72 ± 1.0	13.0 + 0.2	2.5 ± 0.15	8.4 ± 2	1.5 ± 0.3	8.0 ± 0.3	4 ± 0.1	1.75 ± 0.1
	F	D	D1	Po	P1	Ao	Bo	Ko	t
	3.5 ± 0.05	1.5 ± 0.1	1.5 ± 0.1	4.0 ± 0.1	2.0 ± 0.1	3.15 ± 0.1	3.2 ± 0.1	1.4 ± 0.1	0.2 ± 0.033
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

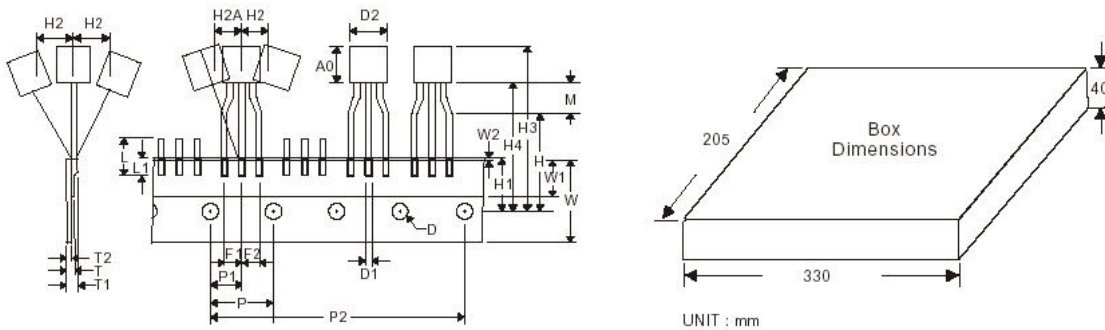
(mm)

Carrier Tape Dimensions (Cont.)

Application	A0	D	D1	D2	F1=F2	F1-F2	M	H	H1
TO-92	3.18~12	4.0±0.2	0.36~0.53	9.0 MAX	2.5+0.2 -0.1	±0.3	2.5±0.5	16±0.5	9±0.5
	H2	H2A	H3	H4	H5=H0+M	L	L1	P	P1
	0.5 MAX	0.5 MAX	27.0 MAX	20.0 MAX	18.5±0.5	11.0 MAX	2.5 MIN	12.7±0.3	6.35±0.4
	P2	T	T1	T2	W	W1	W2	W	W1
	50.8±0.5	0.55 MAX	1.42 MAX	0.36~0.68	18.0±0.2	6.0±0.2	≤1	18.0±0.2	6.0±0.2

(mm)

Carrier Tape & Box Dimensions



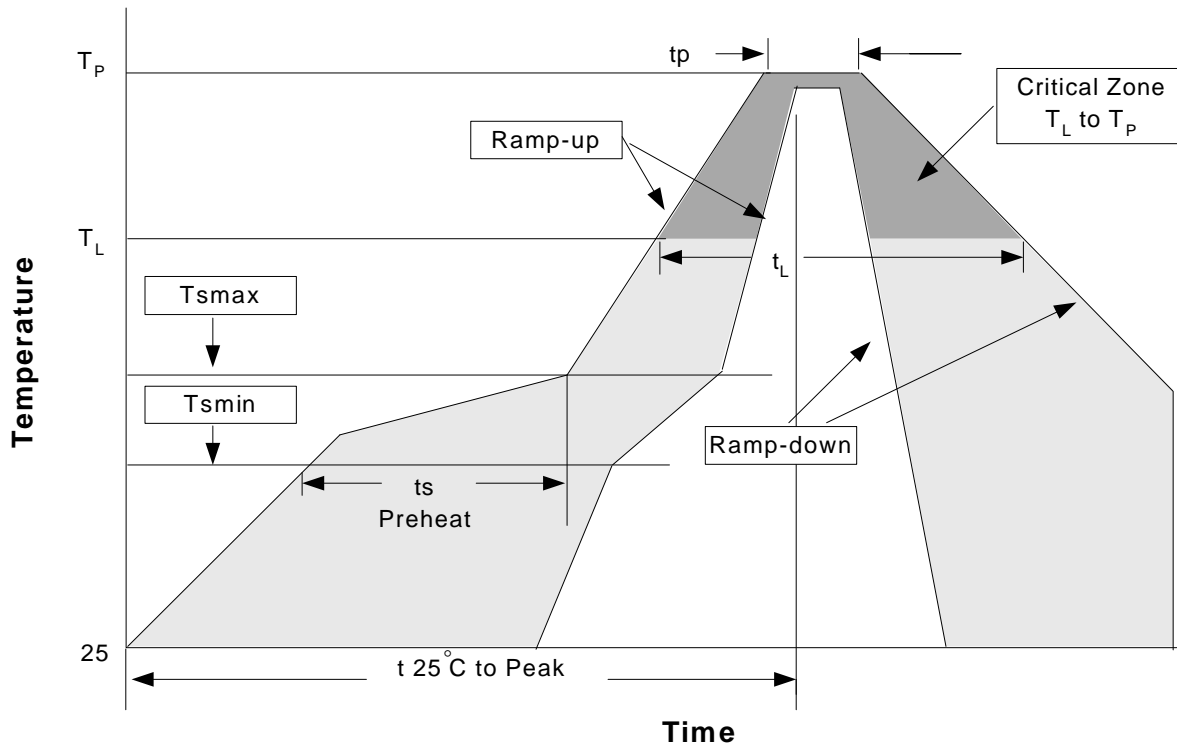
Cover Tape Dimensions

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOP- 8	12	9.3	2500
SOT- 23	8	5.3	3000
SOT- 23-5	8	5.3	3000
SOT- 89	12	9.3	1000
TO-92	17.5~19	5.0~7.0	2000

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 ³ <350	Volume mm ³ ≥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 ³ <350	Volume mm ³ 350-2000	Volume mm ³ >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 _{tr} > 100mA

Customer Service

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