

**Features**

- Low-Voltage Operation: Down to 1.24V
- 1% Reference-Voltage Tolerance
- Adjustable Output Voltage,  $V_o = V_{ref}$  to 12V
- Low Operational Cathode Current... $50 \mu A$
- 0.25 $\Omega$  Typical Output Impedance
- SOT-23-3 , SOT-23-5 and TO-92 Packages

**Application**

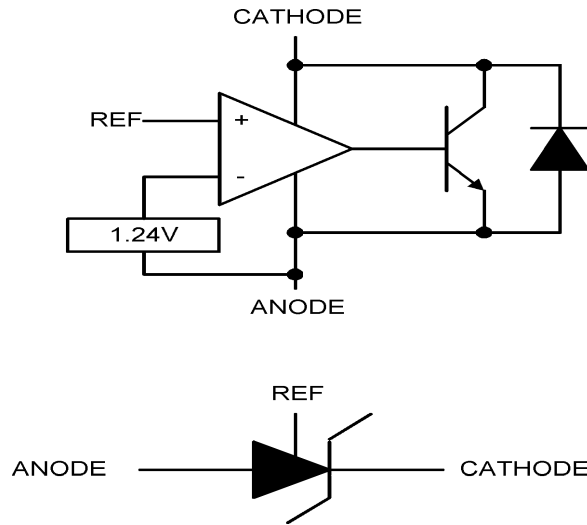
- Linear Regulators
- Voltage Reference for Power Circuit

**Description**

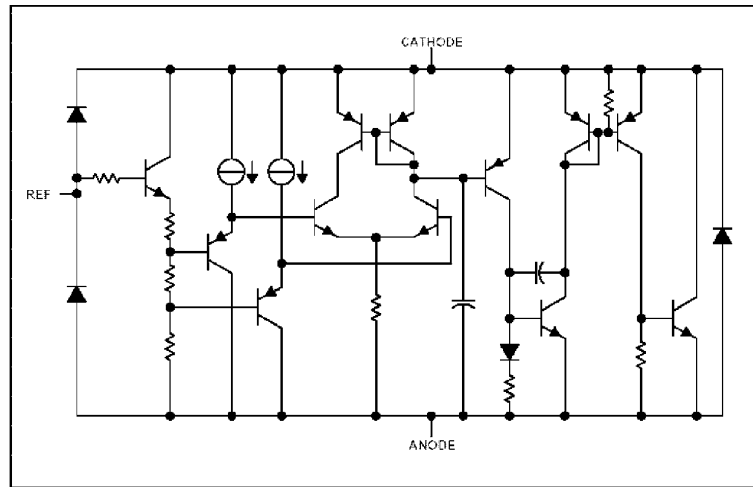
The AT431 is low-voltage three-terminal adjustable voltage reference with specified thermal stability over applicable commercial temperature ranges. Output voltage may be set to any value between  $V_{ref}$  (1.24V) and 12V with two external resistors (see Figure 2).

When used with an optocoupler, the AT431 is ideal voltage reference in isolated feedback circuits for 1.8V to 12 V switching-mode power supplies. This device has typical output impedance of 0.20 $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making the AT431 excellent replacements for low-voltage zener diodes in many applications, including onboard regulation and adjustable power supplies.

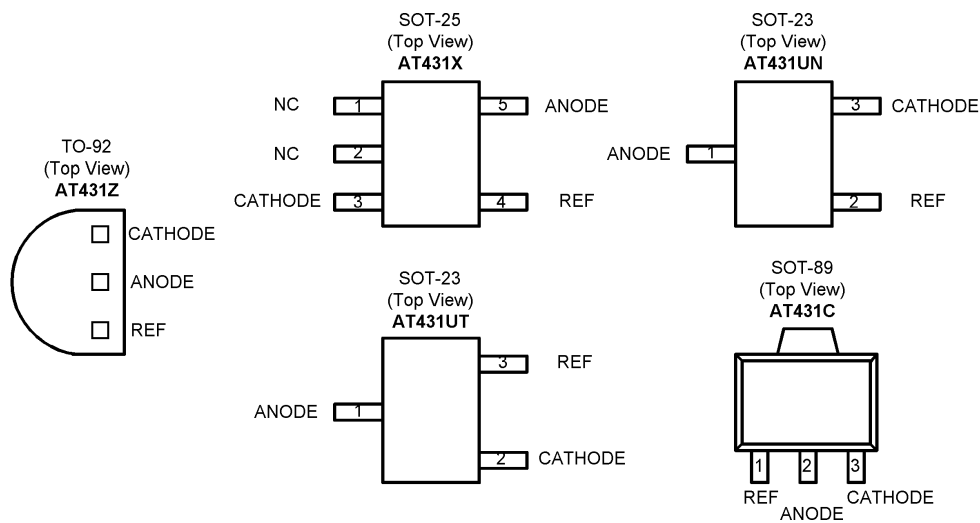
**Block Diagram and Symbol**



**Equivalent Schematic**



**Pin Assignments**



**Ordering Information**

Part number	Package	Marking
AT431Z	TO-92	□□□Z
AT431X	SOT-25	□□□X
AT431UN	SOT-23	□□□N
AT431UT	SOT-23	□□□T
AT431C	SOT-89	□□□C

\* □□□: Data Code

**Absolute maximum ratings (T<sub>A</sub> = 25°C)**

Parameter	Symbol	Limits	unit
Cathode voltage	V <sub>KA</sub>	12	V
Continuous cathode current range	I <sub>K</sub>	-20~20	mA
Reference Current	I <sub>REF</sub>	-0.05~3	mA
Operating temperature	T <sub>OPR</sub>	-30~+85	°C
Storage temperature	T <sub>STG</sub>	-55~+150	°C
Package thermal impedance θ <sub>JA</sub>	SOT-23-5	347	°C / W
	SOT-23-3		
	TO-92	156	
Power Dissipation	PD	(T <sub>J(max)</sub> -T <sub>A</sub> ) / θ <sub>JA</sub>	

Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**Recommend operating condition**

Parameter	min	Max	unit
Cathode voltage V <sub>KA</sub>	V <sub>ref</sub>	12	V
Continuous cathode current range I <sub>K</sub>	0.05	15	mA
Operating free-air temperature range T <sub>A</sub>	0	70	°C

**Electrical characteristics (unless otherwise noted)**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Reference Voltage	V <sub>ref</sub> (T <sub>A</sub> = 25°C)	1.228	1.24	1.252	V	V <sub>KA</sub> = V <sub>ref</sub>
	V <sub>ref</sub> (T <sub>A</sub> = full range 0~70 °C)	1.221	-	1.259	V	I <sub>K</sub> = 10mA (Figure 1)
V <sub>ref</sub> deviation over full temperature range	V <sub>ref</sub> (dev)	-	4	20	mV	V <sub>KA</sub> = V <sub>ref</sub> I <sub>K</sub> = 10mA (Figure 1)
Ratio of V <sub>ref</sub> change in cathode voltage change	Δ V <sub>ref</sub> / Δ V <sub>KA</sub>	-	-1.5	-2.7	mV/V	V <sub>KA</sub> = V <sub>ref</sub> to 12V I <sub>K</sub> = 10mA (Figure 2)
Reference terminal current	I <sub>ref</sub>	-	0.15	0.5	μA	I <sub>K</sub> = 10mA R1 = 10KΩ (Figure 2)
I <sub>ref</sub> deviation over full temperature range	I <sub>ref</sub> (dev)	-	0.05	0.3	μA	I <sub>K</sub> = 10mA R1 = 10KΩ R2 = open (Figure 2)
Minimum cathode current for regulation	I <sub>K</sub> (min)	-	40	50	μA	V <sub>KA</sub> = V <sub>ref</sub> (Figure 1)
Off-state cathode current	I <sub>K</sub> (off)	-	0.001	0.1	μA	V <sub>KA</sub> = 12V V <sub>ref</sub> = 0V (Figure 3)
Dynamic impedance	Z <sub>KA</sub>	-	0.20	0.4	Ω	V <sub>KA</sub> = V <sub>ref</sub> f ≤ 1KHz I <sub>K</sub> = 0.1mA to 15mA (Figure 1)

\* The dynamic impedance is defined as : |Z<sub>KA</sub>| = Δ V<sub>KA</sub> / Δ I<sub>KA</sub>

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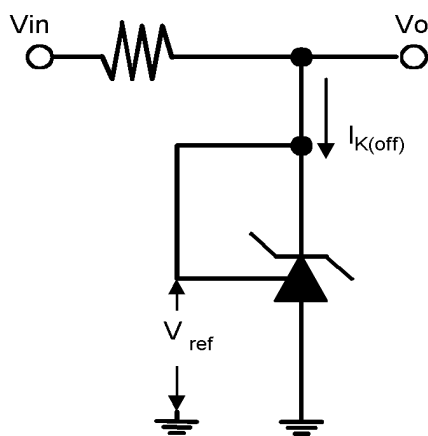
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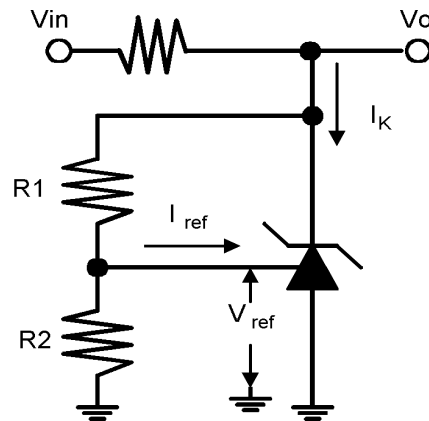
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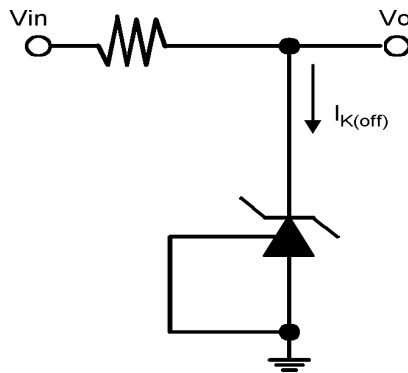
**Parameter Measurement Information**



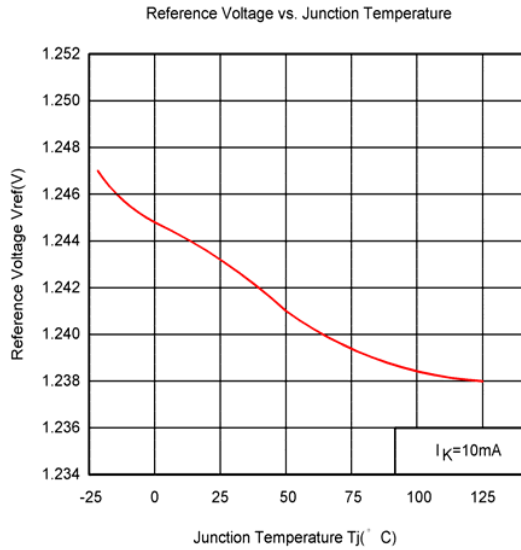
**Figure 1. Test Circuit for  $V_{KA} = V_{ref}$**   
 $V_O = V_{KA} = V_{ref}$



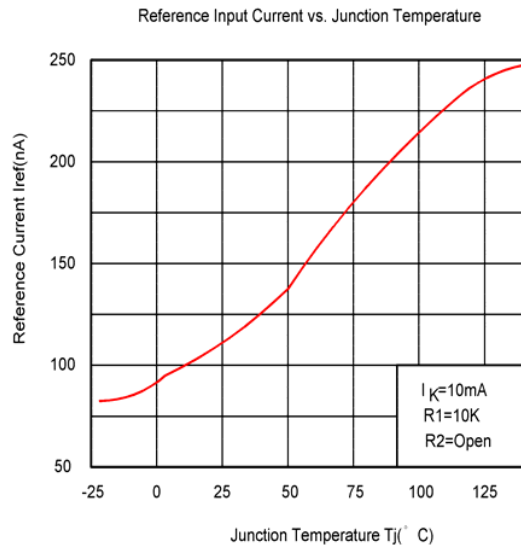
**Figure 2. Test Circuit for  $V_{KA} > V_{ref}$**   
 $V_O = V_{KA} = V_{ref} * (1 + R1/R2) + I_{ref} * R1$



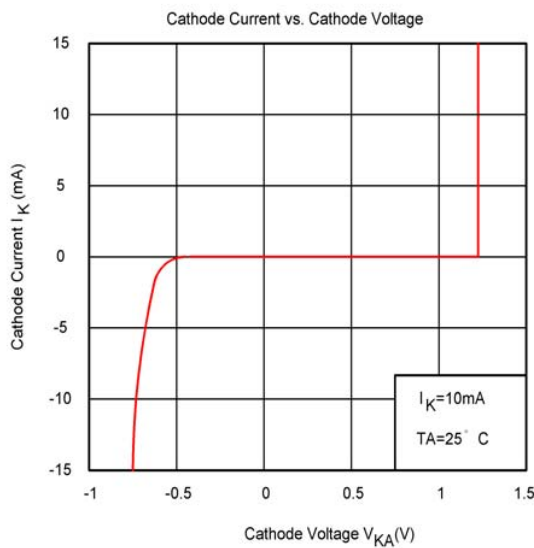
**Figure 3. Test Circuit for  $I_{K(off)}$**



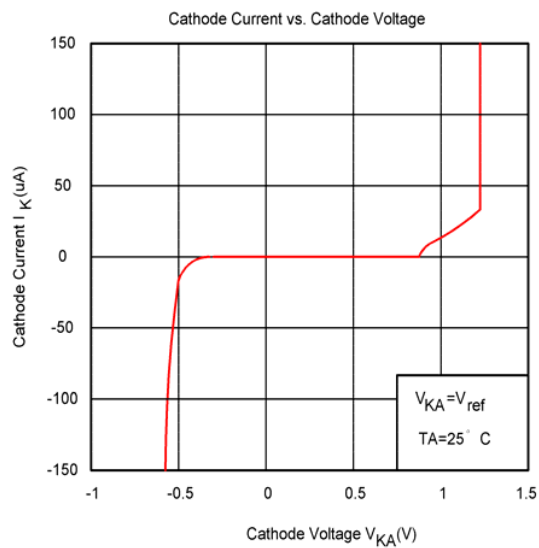
**Figure 4.**



**Figure 5.**



**Figure 6.**



**Figure 7.**

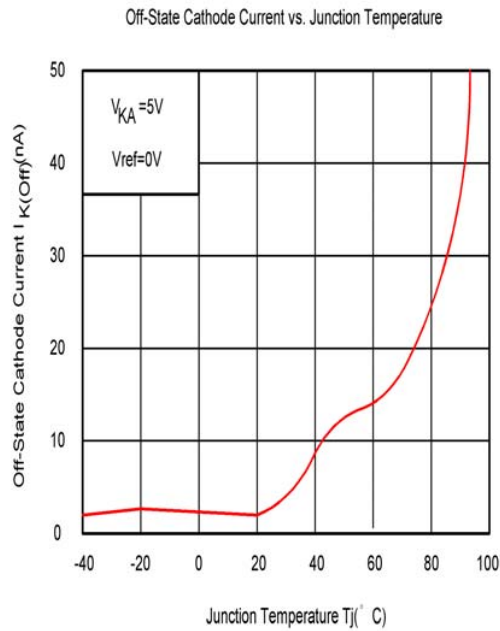


Figure 8.

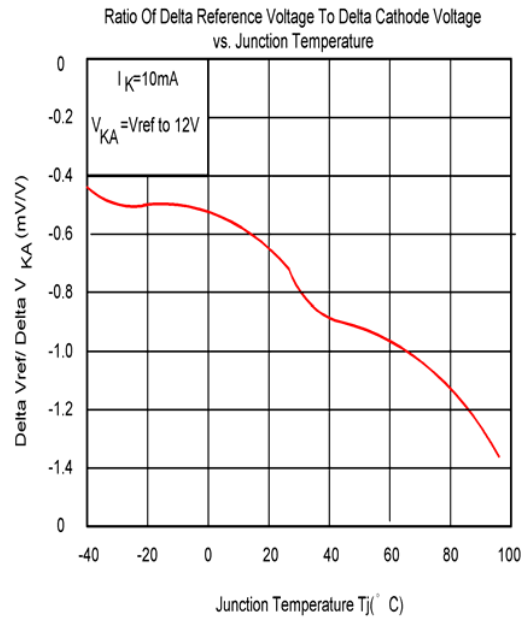


Figure 9.

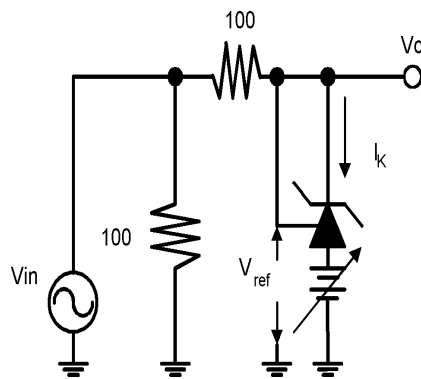
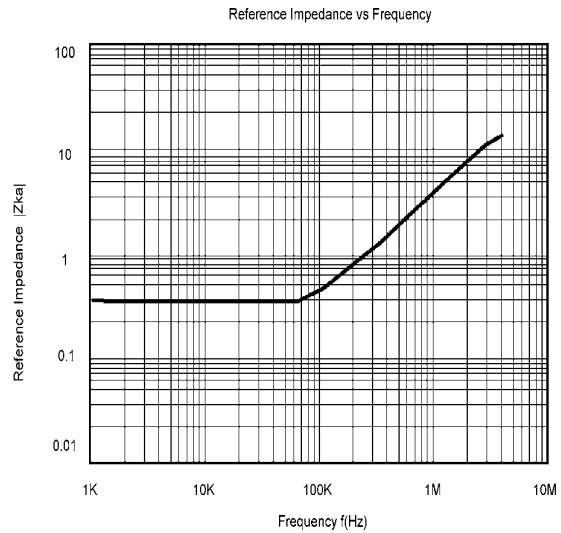
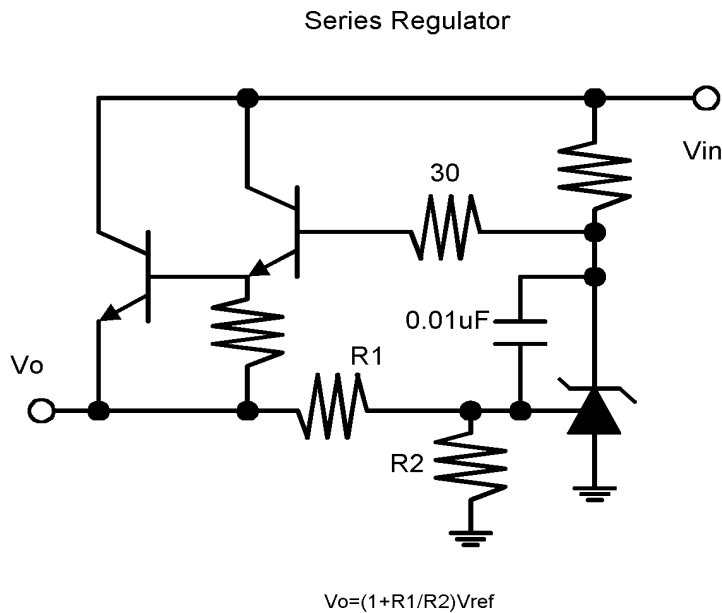
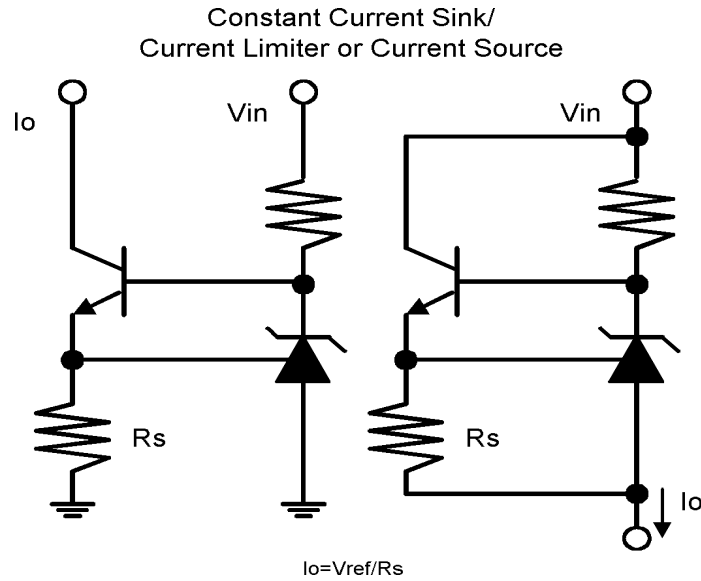


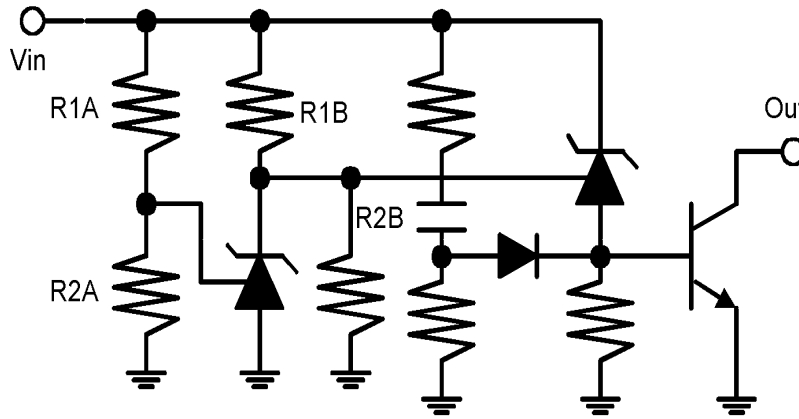
Figure 10.



**Application Circuit**

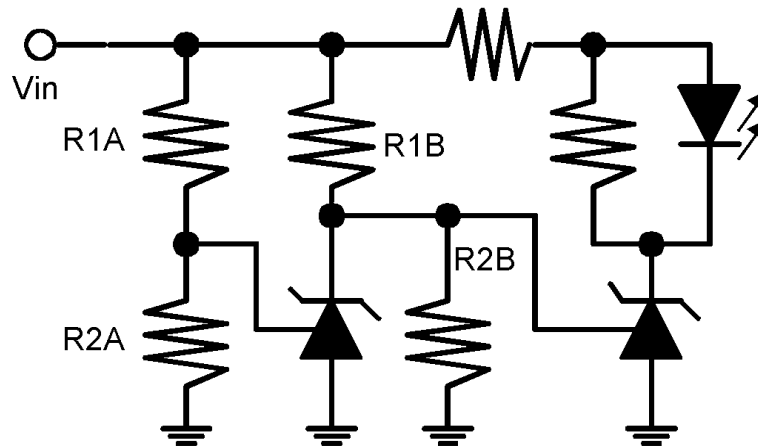


Over Voltage/Under Voltage Protection Circuit



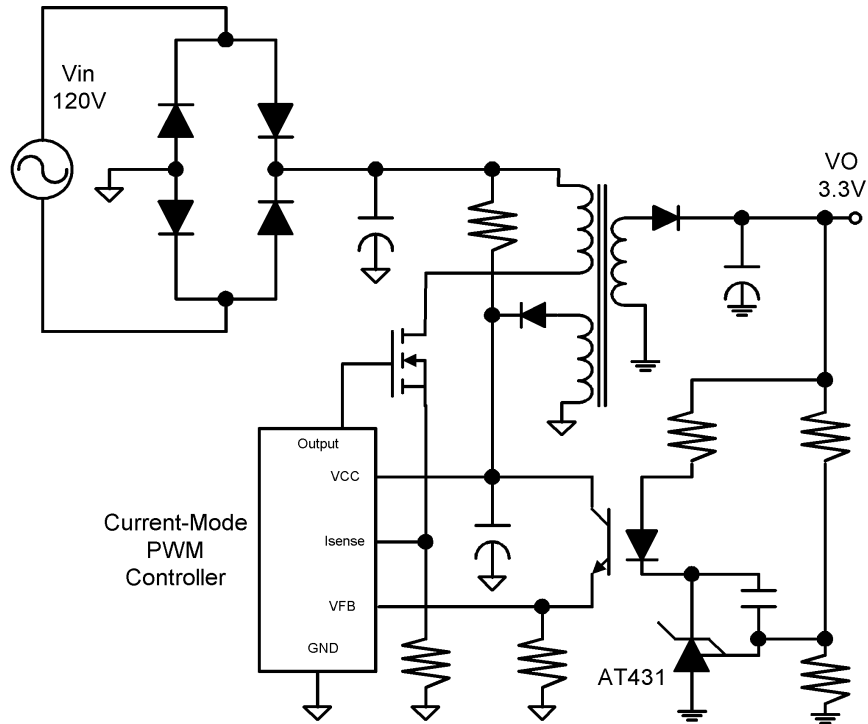
Low Limit =  $(1 + R1B/R2B)V_{ref} + V_{be}$   
 High Limit =  $(1 + R1A/R2A)V_{ref}$   
 Out ON When Low Limit <  $V_{in}$  < High Limit

Voltage Monitor Circuit



Low Limit =  $(1 + R1B/R2B)V_{ref}$   
 High Limit =  $(1 + R1A/R2A)V_{ref}$   
 LED ON When Low Limit <  $V_{in}$  < High Limit

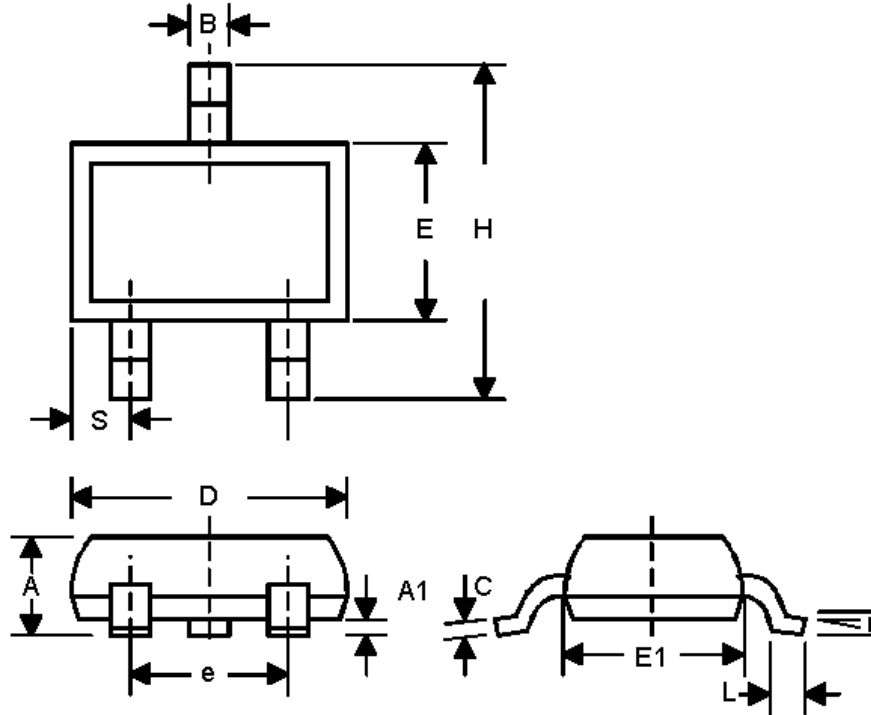




Above shows the AT431 used in a 3.3V isolated flyback supply. Output voltage  $V_o$  can be as low as reference voltage  $V_{ref}$  ( $1.24V \pm 1\%$ ). The output of the regulator, plus the forward voltage drop of the optocoupler LED ( $1.24 + 1.4 = 2.64V$ ), determine the minimum voltage that can be regulated in an isolated supply configuration. Regulated voltage as low as 2.7V is possible using the circuit.

**Package Information**

**SOT-23**



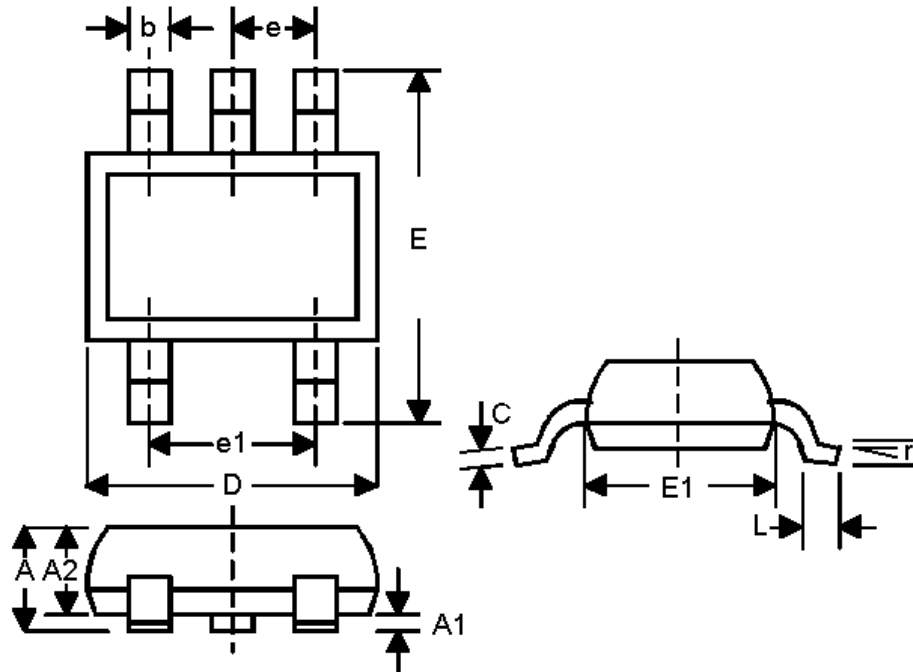
SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.787	1.194	0.031	0.047
A1	0.025	0.127	0.001	0.005
B	0.356	0.559	0.014	0.022
C	0.086	0.152	0.0034	0.006
D	2.667	3.048	0.105	0.120
E	1.194	1.397	0.047	0.055
E1	1.778	2.032	0.070	0.080
H	2.083	2.489	0.082	0.098
L	0.102	0.305	0.004	0.012
S	0.432	0.559	0.017	0.022
R	0°	8°	0°	8°

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SOT-25



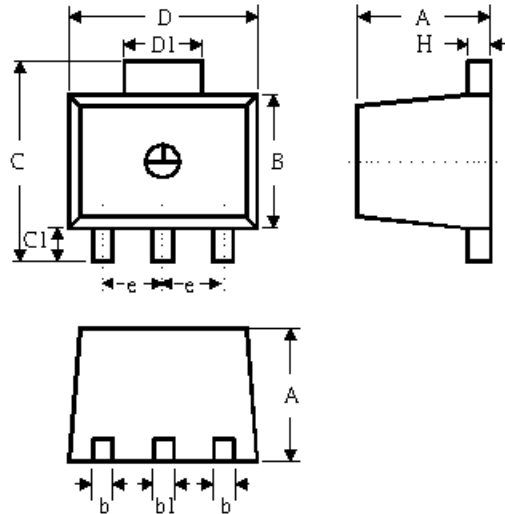
SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.035	0.057	0.90	1.45
A1	0.000	0.006	0.00	0.15
A2	0.035	0.051	0.90	1.30
b	0.010	0.020	0.25	0.50
C	0.003	0.008	0.08	0.20
D	0.110	0.122	2.80	3.10
E	0.102	0.118	2.60	3.00
E1	0.059	0.069	1.50	1.75
L	0.014	0.022	0.35	0.55
e	0.037ref		0.95ref	
E1	0.075ref		1.90ref	
r	0 <sup>0</sup>	10 <sup>0</sup>	0 <sup>0</sup>	10 <sup>0</sup>

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SOT-89



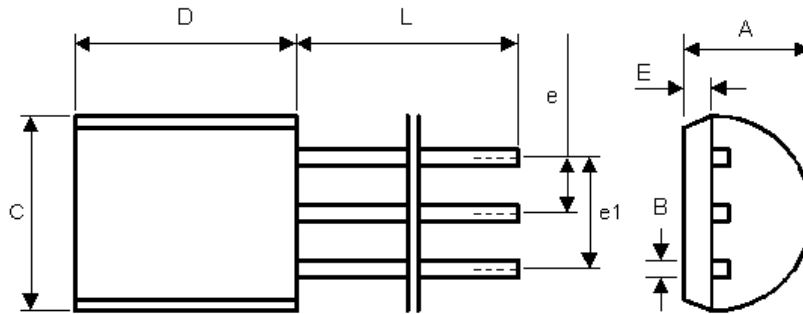
SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.397	1.600	0.055	0.063
B	0.356	0.483	0.014	0.019
B	2.388	2.591	0.094	0.102
b1	0.406	0.533	0.016	0.021
C	--	4.242	--	0.167
C1	0.787	1.194	0.031	0.047
D	4.394	4.597	0.173	0.181
D1	1.397	1.753	0.055	0.069
E	1.448	1.549	0.057	0.061
H	0.381	0.432	0.015	0.017

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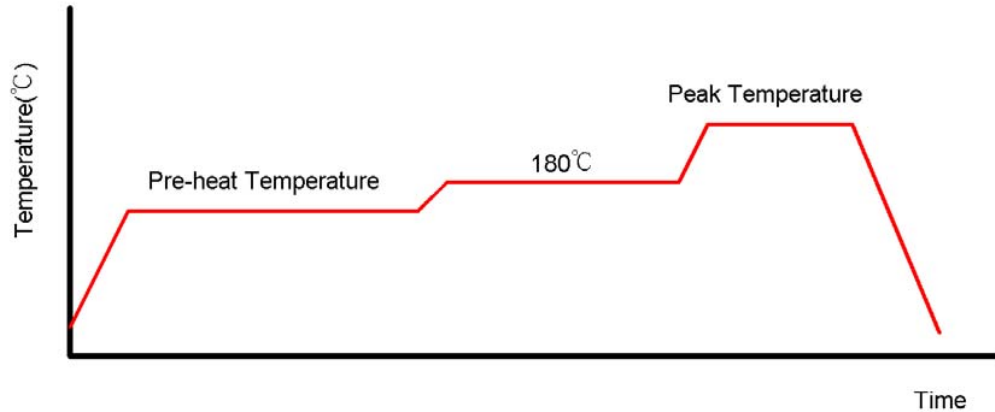
TO-92



SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.4	3.8	0.134	0.150
B	0.3	0.5	0.012	0.020
C	4.4	4.8	0.173	0.189
D	4.4	4.8	0.173	0.189
E	0.9	1.5	0.035	0.059
e	1.17	1.37	0.046	0.054
e1	2.39	2.69	0.094	0.106
L	12	16	0.472	0.630

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

Reference JEDEC Standard J-STD-020A



**Classification Reflow Profiles**

	Convection or IR/Convection	VPR
Average Heating Rate(180°C to peak)	5°C/second max.	10°C/second max.
Preheat Temperature(125±20°C)	120 seconds max.	
Temperature maintained above 180°C	10~150 seconds	
Time within 5°C of actual Peak Temperature	10~20 seconds	60 seconds
Peak Temperature Range(Note 1)	219~225°C or 235~240°C	219~225°C or 235~240°C
Cooling Rate	6°C /second max.	10°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	

\*1 The maximum peak temperatures for IR and VP reflow are depending on package dimensions.

**Package Reflow Conditions**

Pkg. Thickness ≥2.5mm and all bags	Pkg. Thickness <2.5mm and Pkg. Volume ≥350 mm <sup>3</sup>	Pkg. Thickness <2.5mm and Pkg. Volume <350 mm <sup>3</sup>
Convection 219~225°C		Convection 235~240°C
VPR 219~225°C		VPR 235~240°C
IR/Convection 219~225°C		IR/Convection 235~240°C

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