AT431

Adjustable Precision Shunt Regulators

Immense Advance Tech.

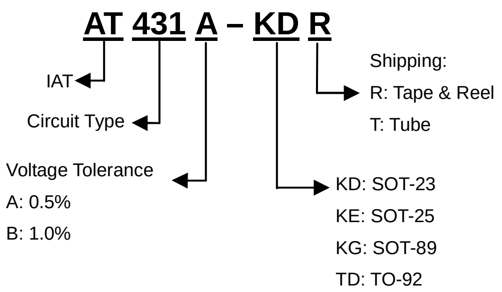
FEATURES

- Programmable Output Voltage to 40V
- Voltage Reference Tolerance 1.0% for B Series and 0.5% for A Series
- Low Dynamic Output Impedance 0.22Ω
- Sink Current Capability of 0.1mA to 100mA
- Equivalent Full-Range Temperature Coefficient of 50ppm/℃
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn on Response
- Available in SOT-23, SOT-25, SOT-89 or TO-92 Packages

APPLICATION

- Low Output Voltage (3.0V to 3.3V) Switching Power Supply Error Amplifier
- Adjustable Voltage or Current Linear and Switch-ing Power Supplies
- Voltage Monitoring
- Current Source and Sink Circuits
- Analog and Digital Circuits Requiring Precision References
- Low Voltage Zener Diode Replacements

ORDER INFORMATION

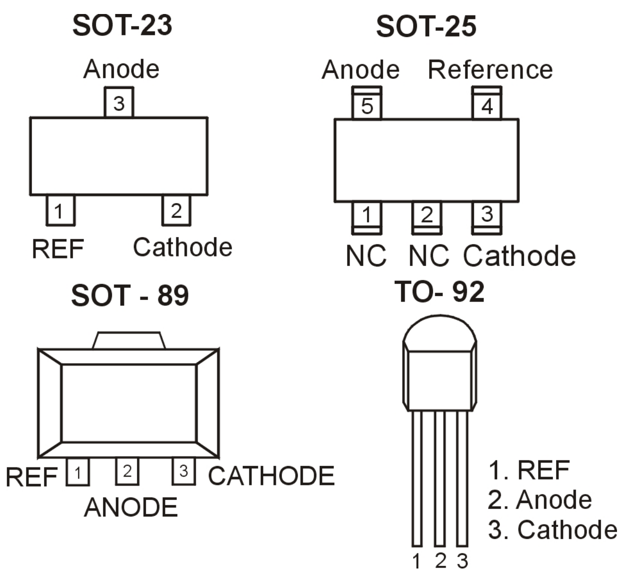


DESCRIPTION

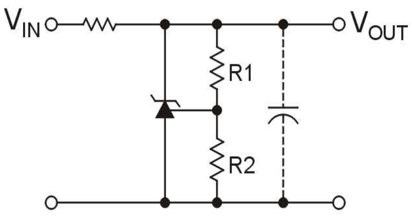
The AT431, A, B is a three-terminal adjust -able regulator series with a guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between vref (approxi- mately 2.5 volts) and 40 volts with two external resistors. These devices have a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.

The AT431, A, B is characterized for operation from 0℃ to +85℃.

PIN CONFIGURATIONS (TOP VIEW)

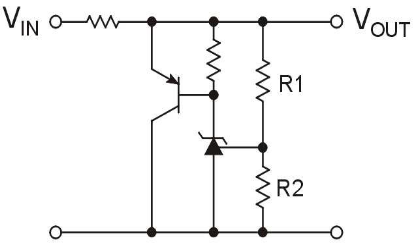


TYPICAL APPLICATION CIRCUITS



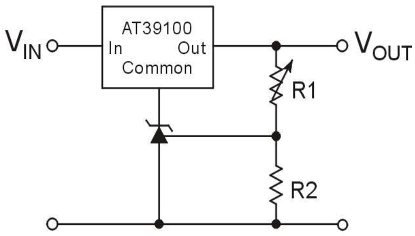
$V_{OUT} = (1+\frac{R1}{R2})\, V_{REF}$

Figure 1. Shunt Regulator



$V_{OUT} = (1+\frac{R1}{R2})\, V_{REF}$

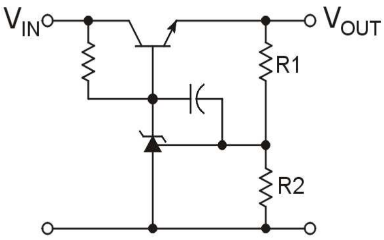
Figure 2. High Current Shunt Regulator



$V_{OUT} = (1+\frac{R1}{R2})\, V_{REF}$

$V_{OUT(MIN)} = V_{REF} + 5.0V$

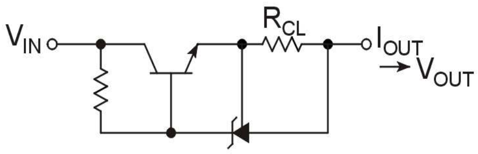
Figure 3. Output Control for a Three Terminal Fixed Regulator



$V_{OUT} = (1+\frac{R1}{R2})\, V_{REF}$

$V_{OUT(MIN)} = V_{REF} + V_{BE}$

Figure 4. Series Pass Regulator



$I_{OUT} = \frac{V_{REF}}{R_{CL}}$

Figure 5. Constant Current Source

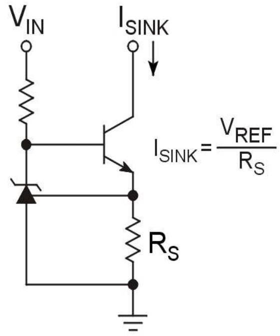
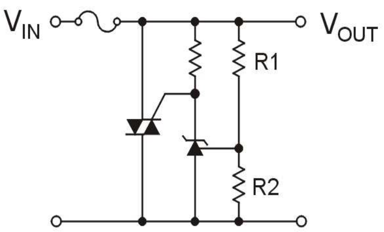
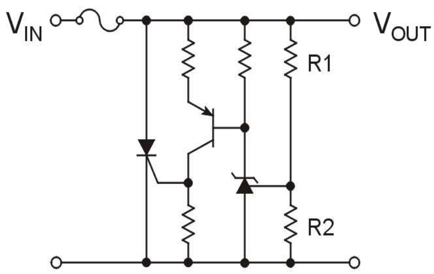


Figure 6. Constant Current Sink



$V_{OUT(TRIP)} = (1+\frac{R1}{R2})V_{REF}$

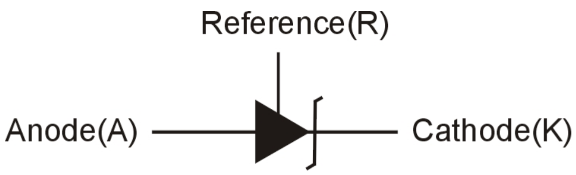
Figure 7. TRIAC Crowbar



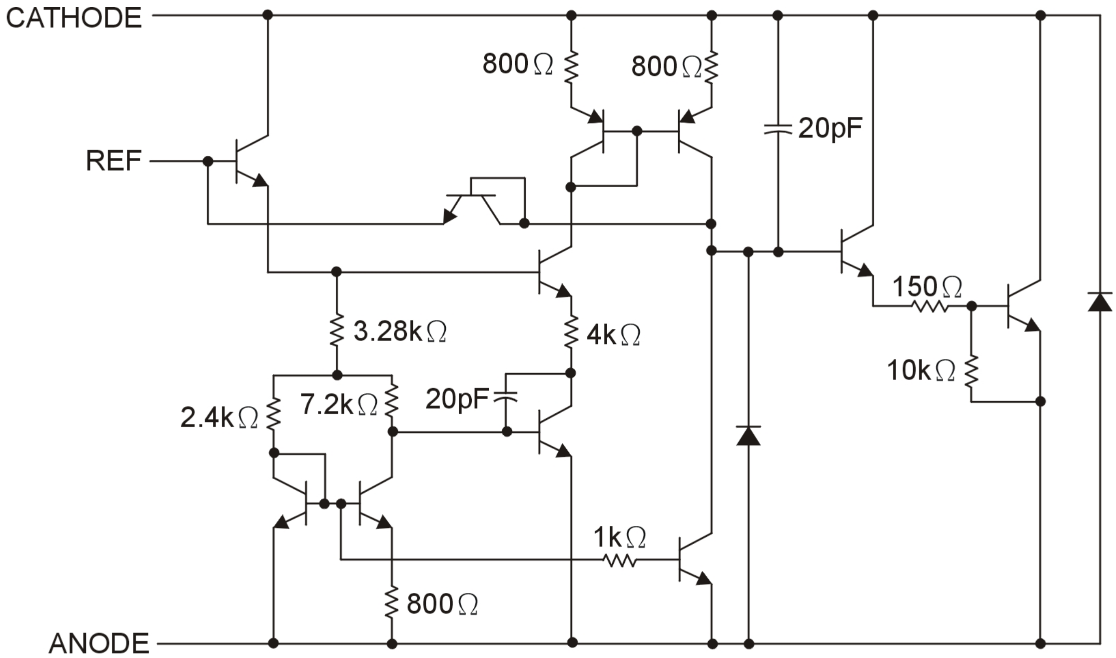
$V_{OUT(TRIP)} = (1+\frac{R1}{R2})\, V_{REF}$

Figure 8. SCR Crowbar

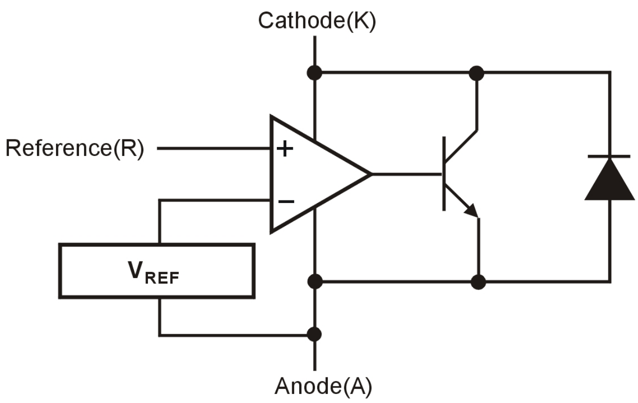
LOGIC SYMBOL



BLOCK DIAGRAM



BLOCK DIAGRAM (POSITIVE LOGIC)



ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter		Symbol	Max Value	Unit
Cathode Voltage (Note 2)		V_{KA}	40	V
Continuous Cathode Current		I_K	-100 to 150	mA
Reference Input Current Range		I_{REF}	-0.05 to 10	mA
Junction Temperature		T_J	150	℃
Lead Temperature(Soldering) 5 Sec.		T_{LEAD}	260	℃
Storage Temperature Range		T_{STG}	-65 to +150	℃
Power Dissipation P_D @ T_A=25℃ (Note 3)	SOT-23	P_D	280	mW
	SOT-25		300	
	SOT-89		640	
	TO-92		625	
Thermal Resistance Junction to Ambient	SOT-23	Θ_{JA}	357	℃ / W
	SOT-25(Note 4)		333	
	SOT-89		156	
	TO-92		160	
Thermal Resistance Junction to Case	SOT-23	Θ_{JC}	106.6	℃ / W
	SOT-25		106.6	
	SOT-89		100	

RECOMMENDED OPERATING CONDITIONS (Note 5)

Parameter	Symbol	Operation Conditions	Unit
Operating Junction Temperature	T_J	0 to 125	℃
Operating Ambient Temperature	T_A	0 to 85	℃
Cathode to Anode Voltage	V_{KA}	V_{REF} to 36	V
Cathode Current	I_K	0.5 to 100	mA

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: Voltage values are with respect to the anode except as noted

Note 3: Thermal Resistance is specified with the component mounted on a low effective thermal conductivity test board in free air at T_A=25℃ .

Note 4: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

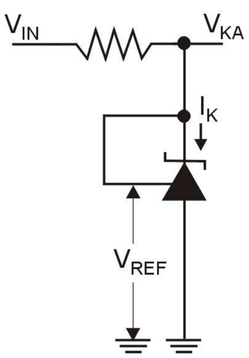
Note 5: The device is not guaranteed to function outside its operating conditions.

ELECTRICAL CHARACTERISTICS

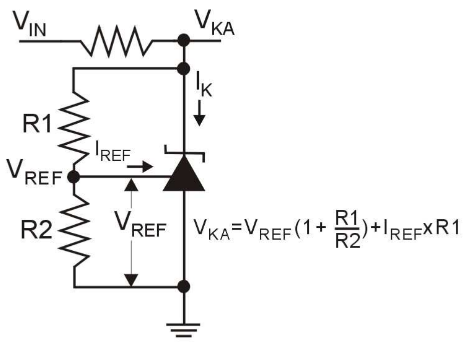
T_A =25℃ unless otherwise noted.

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit	Test Circuit
Reference Input voltage	V_{REF}	0.5%	V_{KA}= V_{REF}, I_K =10mA	2.483	2.495	2.507	V	1
		1.0%		2.470	2.495	2.520		
V_{REF} Temp Deviation	$V_{REF(DEV)}$	V_{KA}= V_{REF}, I_K =10mA, T_A= full range			3	17	mV	1
Ratio of Change in V_{REF} to the Change in V_{KA}	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	I_K =10mA	ΔV_{KA}= 10V to V_{REF}	-0.4	0	2.7	mV/V	2
			ΔV_{KA}= 36V to 10V	-0.4	0	2.0		
Reference Input Current	I_{REF}	I_K =10mA, R1= 10KΩ, R2=∞			1.8	4.0	μA	2
Deviation of Reference Input Current Over Full Temperature Range	$I_{REF(DEV)}$	I_K =10mA, R1= 10KΩ, R2=∞ T_A= full range			0.4	1.2	μA	2
Minimum Operating Current	$I_{K(MIN)}$	V_{KA}= V_{REF}			0.25	0.5	mA	1
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA}= 40V, V_{REF}= 0V			0.17	0.9	μA	3
Dynamic Impedance	$\lvert Z_{KA} \rvert$	f≤1kHz, V_{KA}= V_{REF}, I_K =1mA to 100mA			0.22	0.50	Ω	1

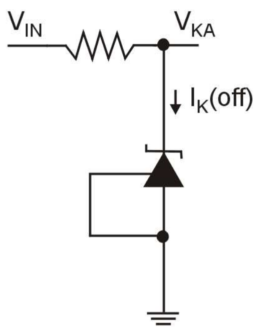
TEST CIRCUIT



Test Circuit 1
$V_{KA} = V_{REF}$



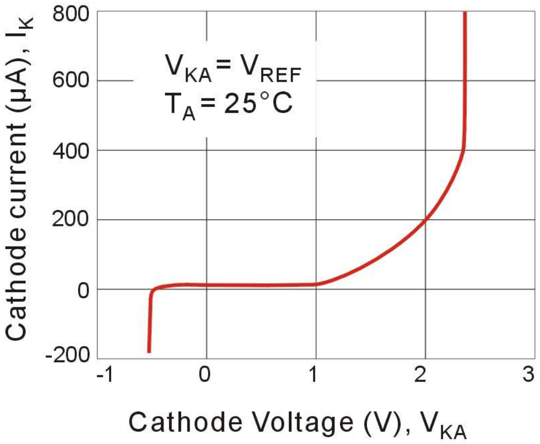
Test Circuit 2
$V_{KA} > V_{REF}$



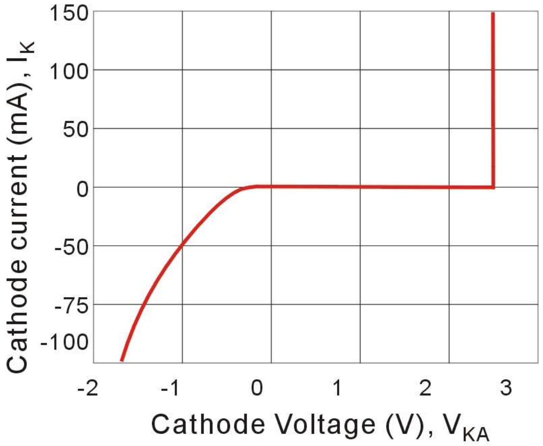
Test Circuit 3
Off-State

TYPICAL OPERATING CHARACTERISTICS

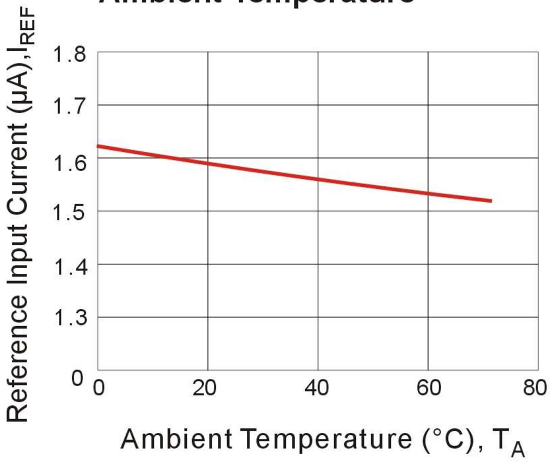
(1) Cathode Current vs. Cathode Voltage



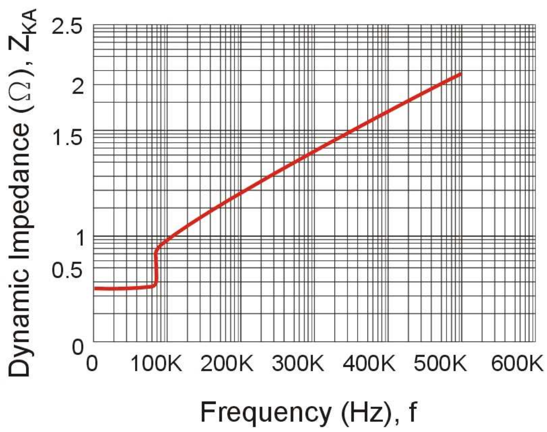
(2) Cathode Current vs. Cathode Voltage



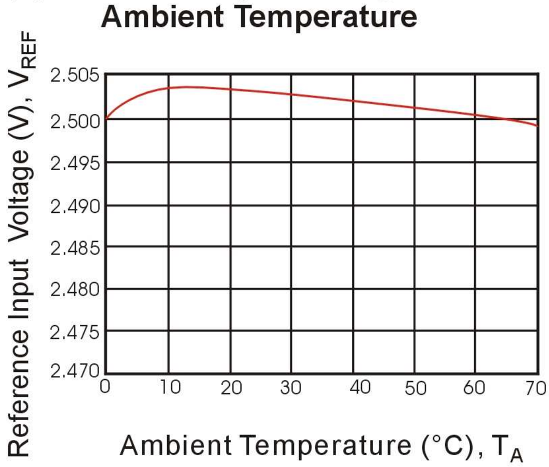
(3) Reference Input Current versus Ambient Temperature



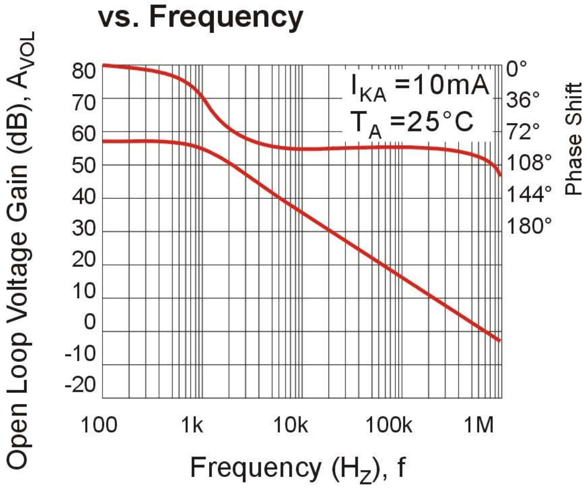
(4) Dynamic Impedance Frequency



(5) Reference Input Voltage versus Ambient Temperature



(6) Open-Loop Voltage Gain vs. Frequency



DESIGN GUIDE FOR AC-DCSMPS (Switching Mode Power Supply)

Use of Shunt Regulator in Transformer Secondary Side Control

This example is applicable to both forward transformers and fly back transformers. A shunt regulator is used on the secondary side as an error amplifier, and feedback to the primary side is provided via a photocoupler.

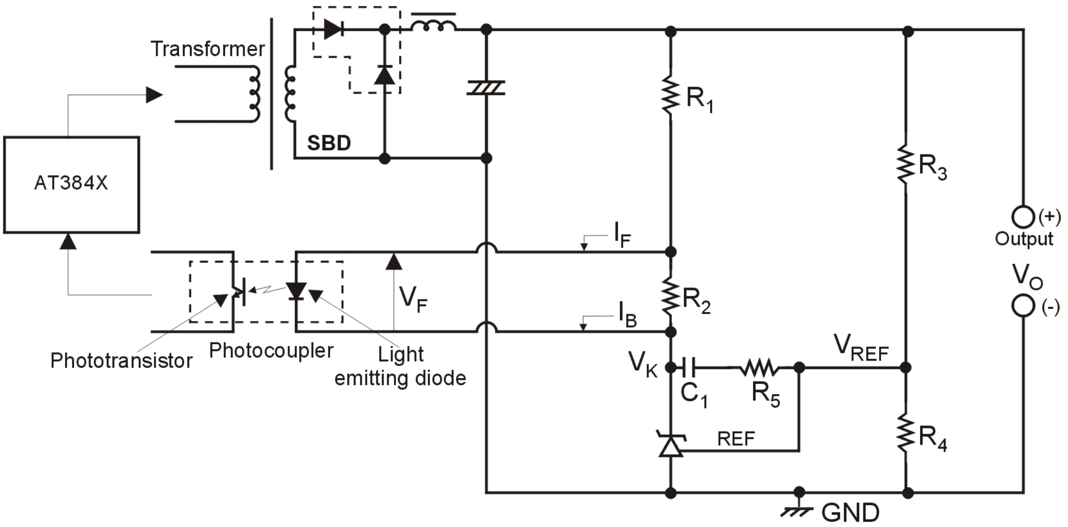


Figure 9. Typical Shunt Regulator/Error Amplifier

Determination of External Constants for the Shunt Regulator

Dc Characteristic Determination:

In figure 9, R_1 and R_2 are protection resistor for the light emitting diode in the photocoupler, and R_2 is a bypass resistor to feed I_K Minimum, and these are determined as shown below. The photocoupler specification should be obtained separately form the manufacturer. Using the parameters in figure 16, the following formulas are obtained:

$$R1 = \frac{V_O - V_F - V_K}{I_F + I_B}, R2 = \frac{V_F}{I_B}$$

V_K is the AT431 operating voltage, and is set at around 3V, taking into account a margin for fluctuation. R_2 is the current shunt resistance for the light emitting diode, in which a bias current I_B of around 1/5 I_F flows.

Next, the output voltage can be determined by R_3 and R_4, and the following formula is obtained:

$$V_{OUT} = \frac{R3 + R4}{R4} \times V_{REF}, V_{REF} = 2.5V \text{ Typ.}$$

The absolute values of R_3 and R_4 are determined by the AT431 reference input current I_{REF} and the AC characteristics described in the next section. The I_{REF} value is around 1.8μA Typ.

AC Characteristic Determination:

This refers to the determination of the gain frequency characteristic of the shunt regulator as an error amplifier. Taking the configuration in figure 9, the error amplifier characteristic is as shown in figure 10.

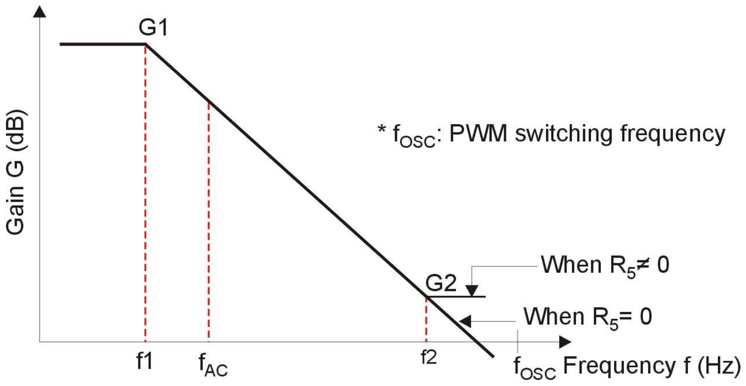


Figure 10. Error Amplification Characteristic

In Figure 10, the following formulas are obtained:

Gain

$$G_1 = G_0 \approx 50 \text{ dB to } 60 \text{ dB (determined by shunt regulator)}$$

$$G2 = \frac{R_5}{R_3}$$

Corner frequencies

f_1=1/(2p C1 G_0 R_3)

f_2=1/(2p C1 R_5)

G_0 is the shunt regulator open-loop gain; this is given by the reciprocal of the reference voltage fluctuation $\Delta V_{REF}/\Delta V_{KA}$, and is approximately 50dB.

Practical Example

Consider the example of a photo-coupler, with an internal light emitting diode V_F = 1.05V and I_F = 2.5mA, power supply output voltage V_2 = 5V, and bias resistance R_2 current of approximately 1/5 I_F at 0.5mA. If the shunt regulator V_K = 3V, the following values are found.

$$R1 = \frac{5V - 1.05V - 3V}{2.5mA + 0.54mA} = 316\Omega$$

$$R2 = \frac{1.05V}{0.54mA} = 2.1k\Omega$$

Next, assume that R_3= R_4=10kΩ. This gives a 5V output. If R_5 = 3.3 kΩ and C_1=0.022μF, the following values are found.

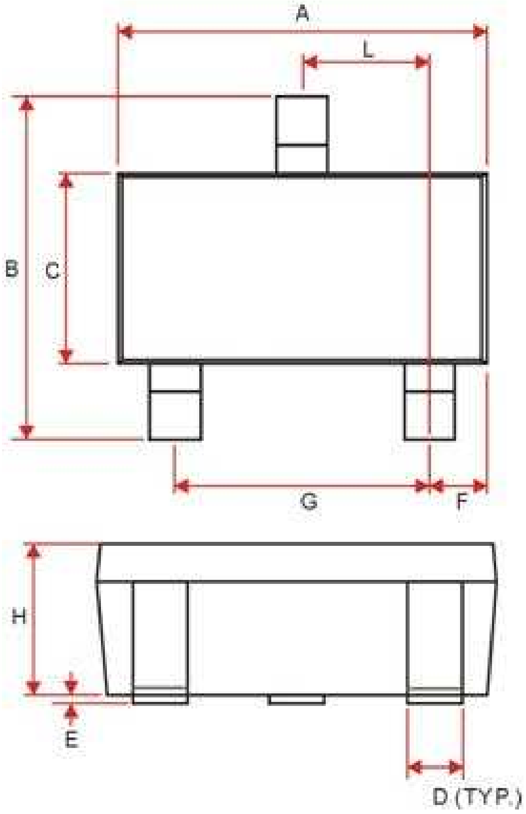
G_2 = 3.3kΩ / 10kΩ = 0.33 times (-10dB)

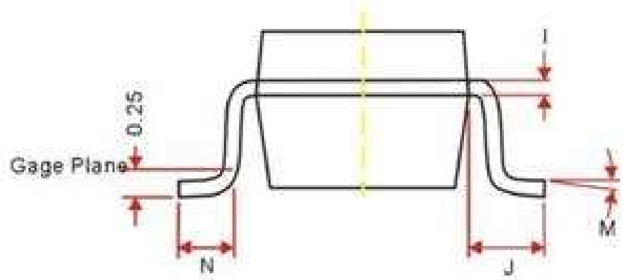
f1 =1 / (2 x π x 0.022μF x 316 x 10kΩ) = 2.3(Hz)

f2 =1 / (2 x π x 0.022μF x 3.3kΩ) = 2.2(kHz)

PACKAGE OUTLINE DIMENSIONS

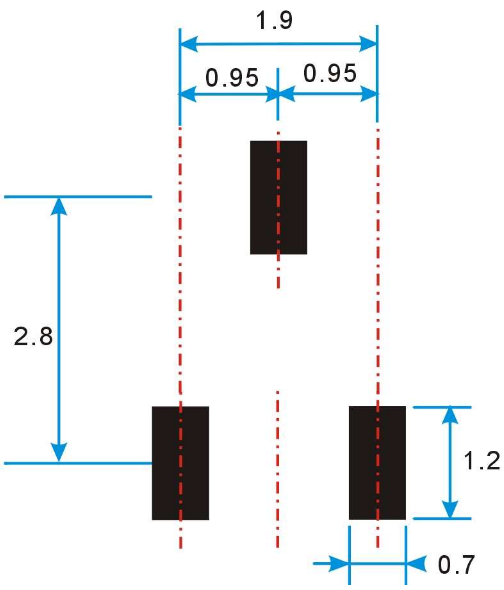
SOT-23 PACKAGE OUTLINE





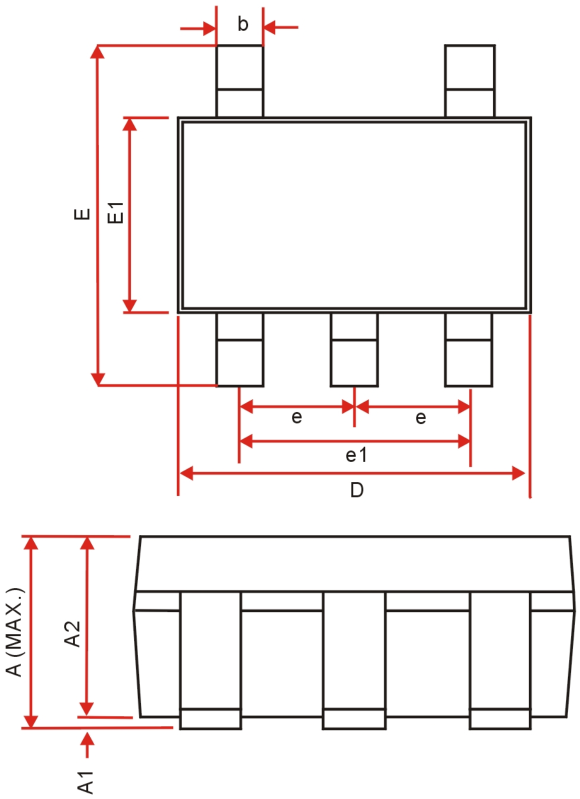
Symbol	Dimensions In Millimeters	
	Min.	Max.
A	2.80	3.10
B	2.20	2.95
C	1.20	1.70
D	0.30	0.50
E	0	0.15
F	0.45	0.55
N	0.30	0.60
G	1.80	2.0
H	0.90	1.15
I	0.10	0.20
J	0.60REF.	
L	0.95REF.	
M	0°	10°

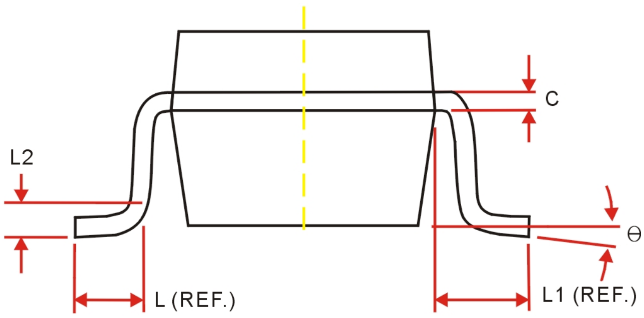
SOT-23 PACKAGE FOOTPRINT (mm)



PACKAGE OUTLINE DIMENSIONS

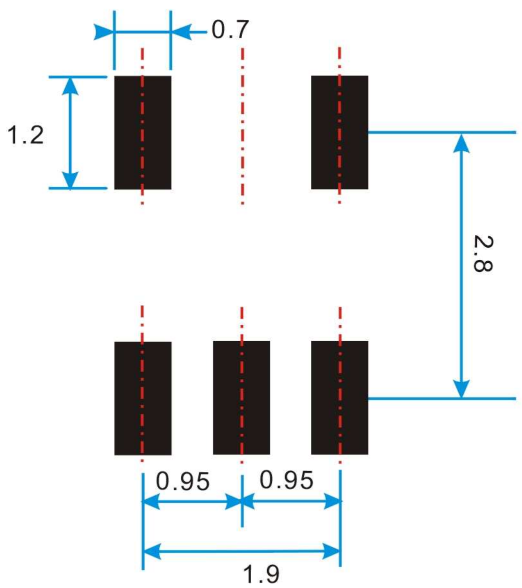
SOT-25 PACKAGE OUTLINE DIMENSIONS





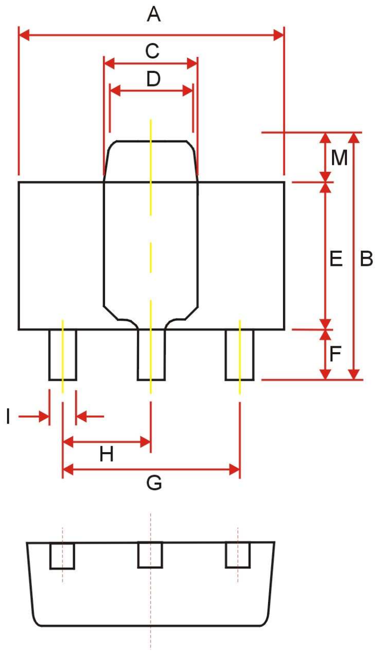
Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.45 MAX.	
A1	0	0.15
A2	0.90	1.30
C	0.08	0.22
D	2.90 BSC.	
E	2.80 BSC.	
E1	1.60 BSC.	
L	0.30	0.60
L1	0.60BSC.	
L2	0.25BSC.	
θ	0°	10°
b	0.30	0.50
e	0.95BSC.	
e1	1.90BSC.	

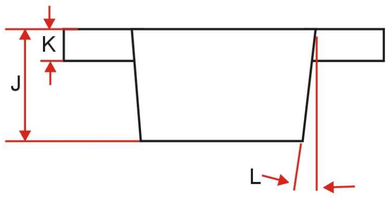
SOT-25 PACKAGE FOOTPRINT (mm)



PACKAGE OUTLINE DIMENSIONS

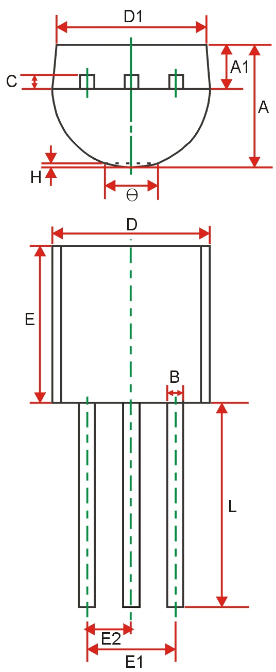
SOT-89 PACKAGE OUTLINE DIMENSIONS





REF.	Dimensions In Millimeters	
	Min.	Max.
A	4.40	4.60
B	3.94	4.25
C	1.50	1.70
D	1.30	1.50
E	2.29	2.60
F	0.89	1.20
G	3.00 REF.	
H	1.50 REF.	
I	0.40	0.56
J	1.40	1.60
K	0.35	0.44
L	5°TYP.	
M	0.70 REF.	

TO-92 PACKAGE OUTLINE DIMENSIONS



REF.	Dimensions In Millimeters	
	Min.	Max.
A	3.30	3.70
A1	1.10	1.40
B	0.38	0.55
C	0.36	0.51
D	4.40	4.70
D1	3.43	-
E	4.30	4.70
E1	2.44	2.64
E2	1.27 REF.	
L	14.1	14.5
θ	-	1.60
H	0.00	0.38

Note :

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