

## Features

- Precise Reference Voltage to 1.24V
- Guaranteed 0.5% Reference Voltage Tolerance
- Sink Current Capability of 80 $\mu$ A to 100mA
- Quick Turn-on
- Adjustable Output Voltage,  $V_o = V_{REF}$  to 18V
- 0.2 $\Omega$  Typical Output Impedance

## Applications

- Graphic Card
- PC Motherboard
- Voltage Adapter
- Switching Power Supply
- Charger

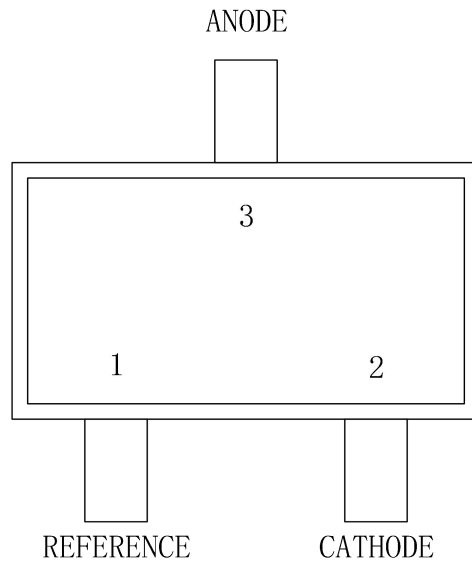
## General Description

The CBM432 is a three-terminal adjustable regulator series with a guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between  $V_{ref}$  (approximately 1.24 voltage) and 18 voltage with two external resistors. These devices have a typical dynamic output impedance of 0.2 $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications. The CBM432 is characterized for operation from -40 $^{\circ}$ C to +125 $^{\circ}$ C.

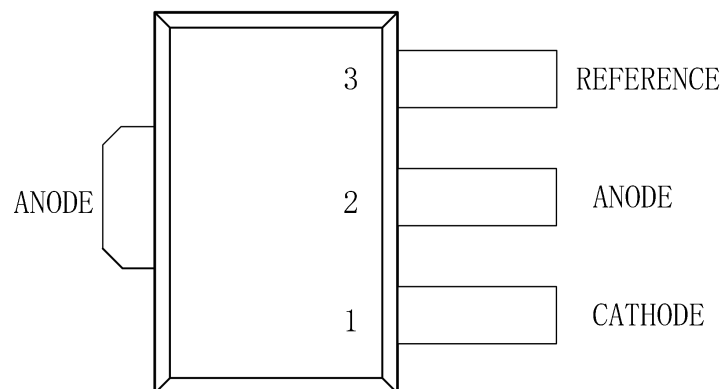
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## Pin Configuration



### SOT23-3



### SOT89-3

Name	SYMBOL(SOT23-3)	SYMBOL(SOT89-3)	TYPE(I/O)	NAME AND FUNCTION
REFERENCE	1	3	I	Threshold relative to common anode
ANODE	3	2	O	Common pin, normally connected to ground
CATHODE	2	1	I/O	Shunt Current/Voltage input

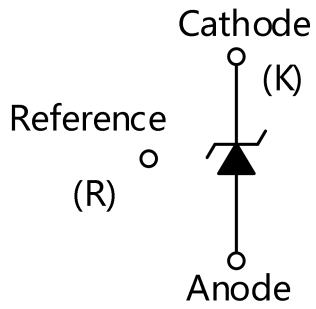
## Absolute Maximum Ratings

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
$T_J$	Junction Temperature Range	-40 to 150	°C
$T_{STG}$	Storage Temperature Range	-60 to 150	°C

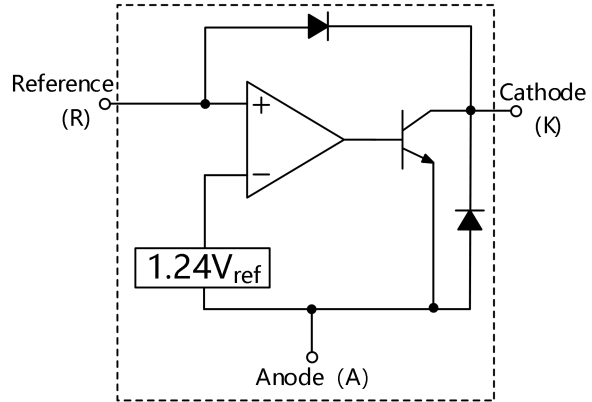
## Thermal information

Symbol	THERMAL METRIC	DBZ (CBM432AST23/CBM432 AST89)	单位
$R_{\theta JA}$	Junction-to-ambient thermal resistance	371.7	C/W
$R_{\theta JC}$	Junction-to-case (top) thermal resistance	145.9	C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	104.7	C/W
$\psi_{JT}$	Junction-to-top characterization parameter	23.9	C/W
$\psi_{JB}$	Junction-to-board characterization parameter	102.9	C/W

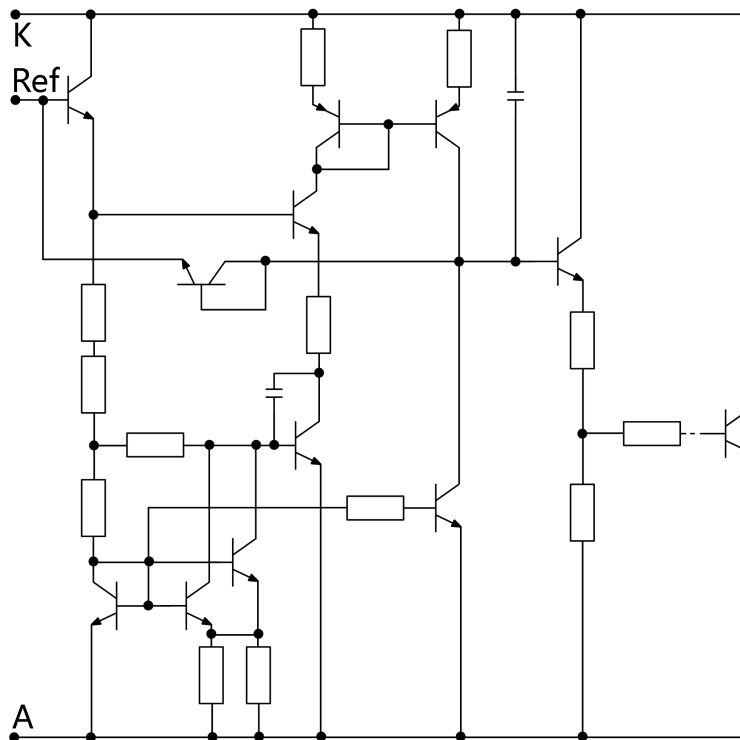
## Symbol



## Functional Block Diagram



## Equivalent Schematic



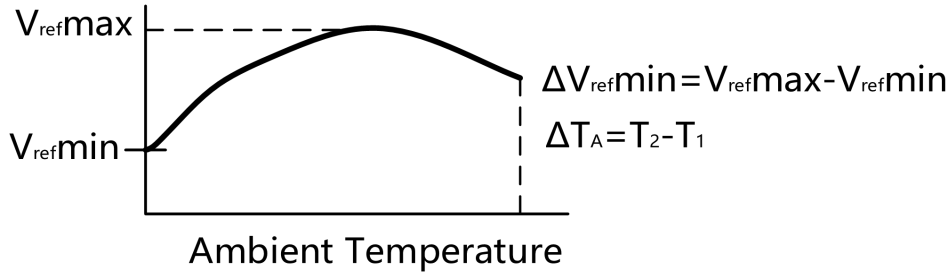
## Electrical Characteristics

( $T_A = 25^\circ\text{C}$ , unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{REF}$	Reference voltage	$V_{KA} = V_{REF}, I_K = 10\text{mA}$ (Fig.1)	1.234	1.240	1.246	V
$V_{DEV}$	$V_{REF}$ Temp Deviation	$T_A = \text{full range}$ (see Note1) $V_{KA} = V_{REF}, I_K = 10\text{mA}$ (Fig.1)		10	25	mV
$\Delta V_{REF} / \Delta V_{KA}$	Ratio of Change in $V_{REF}$ to Change in Cathode Voltage	$I_K = 10\text{mA}, V_{KA} = 18\text{V}$ to $V_{REF}$ (Fig.2)		-1	-2.7	mV/V
$I_{REF}$	Reference Input Current	$I_K = 10\text{mA}, R_1 = 10\text{k}\Omega$ $R_2 = \infty$ (Fig.2)		0.25	0.5	$\mu\text{A}$
$I_{REF (DEV)}$	$I_{REF}$ Temp Deviation	$T_A = \text{full range}$ (see Note1) $R_1 = 10\text{k}\Omega, R_2 = \infty$ $I_K = 10\text{mA}$ (Fig.2)		0.05	0.3	$\mu\text{A}$
$I_K (\text{off})$	Off-state cathode current	$V_{REF} = 0\text{V}$ , (Fig.3) $V_K = 18\text{V}$		0.04	0.5	$\mu\text{A}$
Zka	Dynamic Output Impedance	$V_{ka} = V_{REF}, I_K = 1\text{mA}$ to $100\text{mA}$ $F \leq 1\text{KHz}$ (Fig.1)		0.2	0.4	$\Omega$
$I_{K(MIN)}$	Minimum Operating Current	$V_{ka} = V_{REF}$ (Fig.1)		60	80	$\mu\text{A}$

**Note :**

1. The deviation parameter  $\Delta V_{ref}$  is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies



The average temperature coefficient of the reference input voltage,  $\alpha V_{ref}$  is defined as:

$$V_{ref} \frac{\text{ppm}}{^{\circ}\text{C}} = \frac{\left( \frac{\Delta V_{ref}}{V_{ref}@25^{\circ}\text{C}} \right) \times 10^6}{\Delta V_A} = \frac{\Delta V_{ref} \times 10^6}{\Delta V_A (V_{ref}@25^{\circ}\text{C})}$$

$\alpha V_{ref}$  can be positive or negative depending on whether  $V_{ref\min}$  or  $V_{ref\max}$  occurs at the lower ambient temperature. (Refer to Figure 6.)

Example:  $\Delta V_{ref} = 8.0 \text{ mV}$  and slope is positive,

$$V_{ref}@25^{\circ}\text{C} = 1.24\text{V}, \Delta T_A = 70^{\circ}\text{C} \quad \alpha V_{ref} = \frac{0.008 \times 10^6}{70(1.24)} = 92.2 \text{ ppm}/^{\circ}\text{C}$$

2. The dynamic impedance  $Z_{KA}$  is defined as

$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is programmed with two external resistors,  $R_1$  and  $R_2$ , (refer to Figure 2) the total dynamic impedance of the circuit is defined as:

$$|Z_{KA}'| = |Z_{KA}| \left( 1 + \frac{R_1}{R_2} \right)$$

## Test Circuits

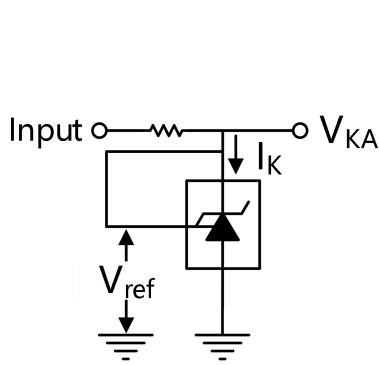


Figure 1. Test Circuit for  $V_{KA} = V_{REF}$

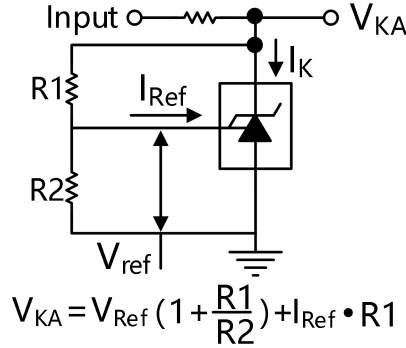


Figure 2. Test Circuit for  $V_{KA} \geq V_{REF}$

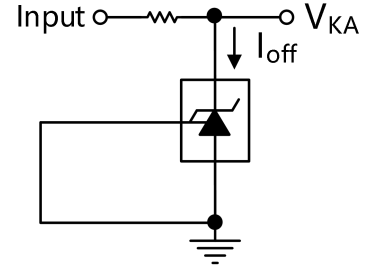


Figure 3. Test Circuit for  $I_{off}$

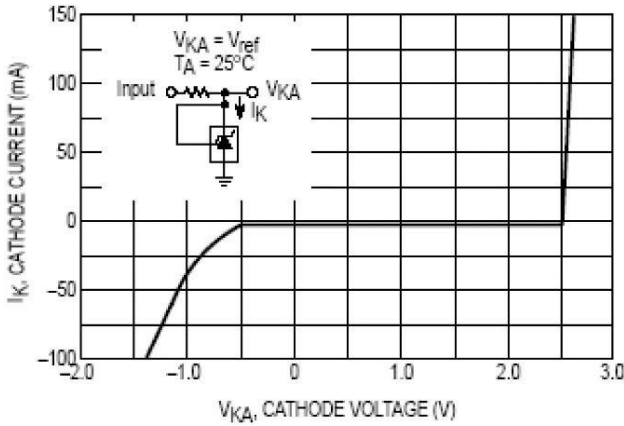


Figure 4. Cathode Current versus Cathode Voltage

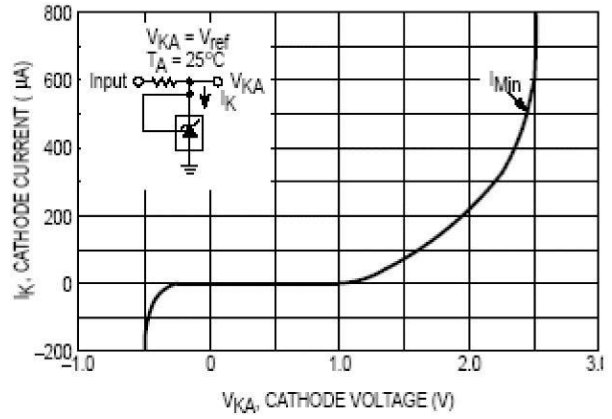


Figure 5. Cathode Current versus Cathode Voltage

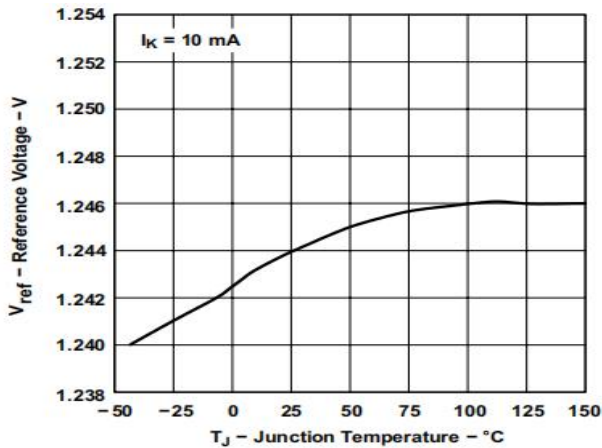


Figure 6. Reference Voltage versus Junction Temperature

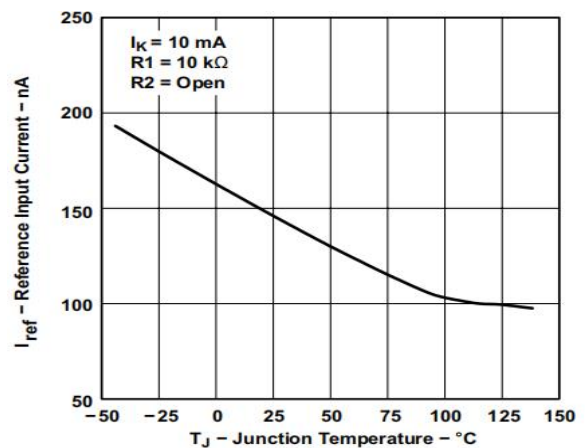


Figure 7. Reference Input Current versus Junction Temperature



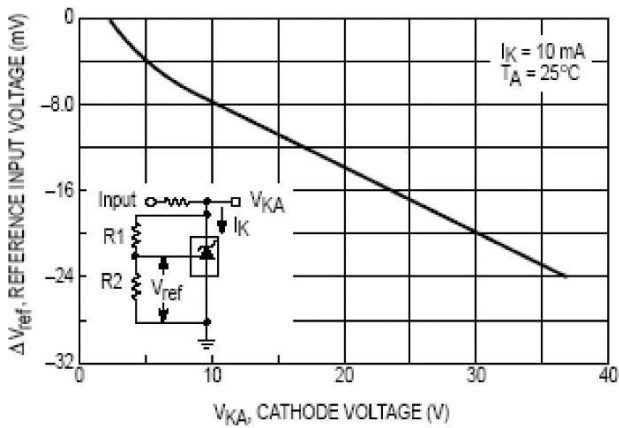


Figure 8. Change in Reference Input Voltage versus Cathode Voltage

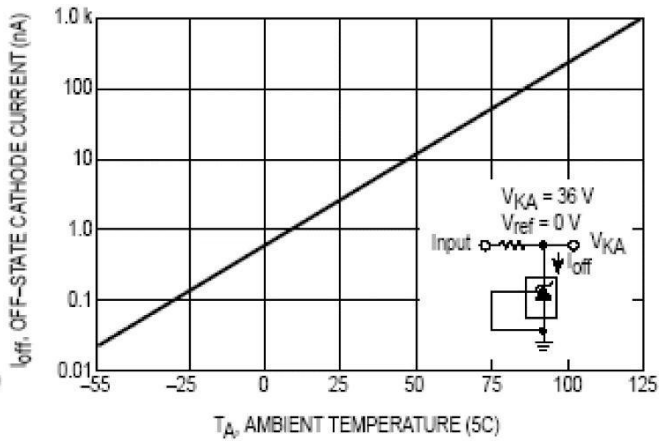


Figure 9. Off-State Cathode Current versus Ambient Temperature

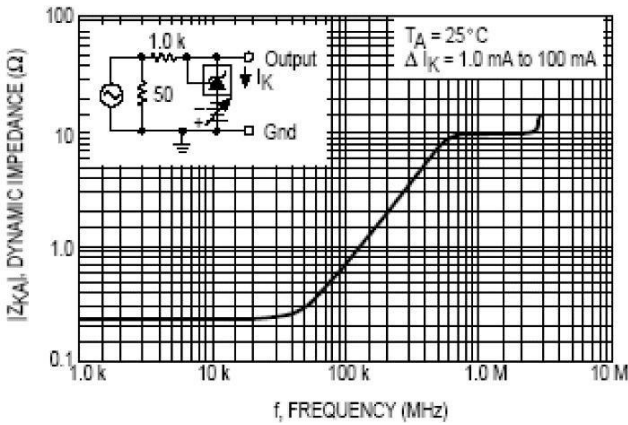


Figure 10. Dynamic Impedance versus Frequency

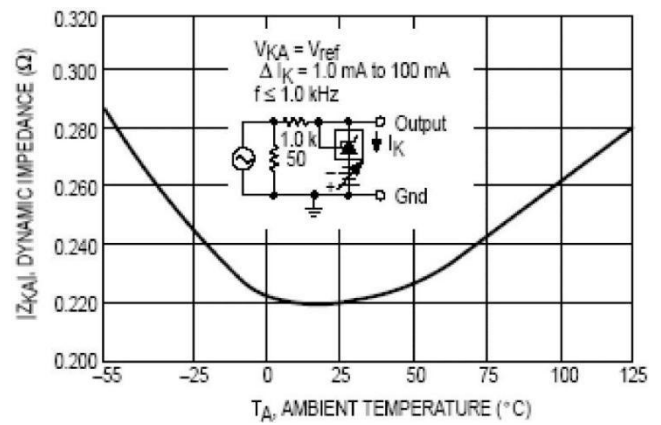


Figure 11. Dynamic Impedance versus Ambient Temperature

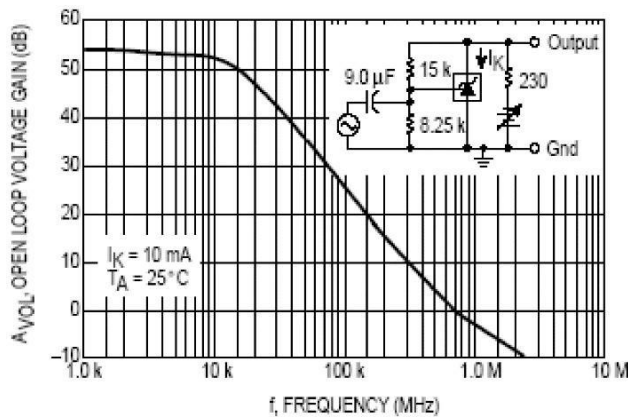


Figure 12. Open-Loop Voltage Gain versus Frequency

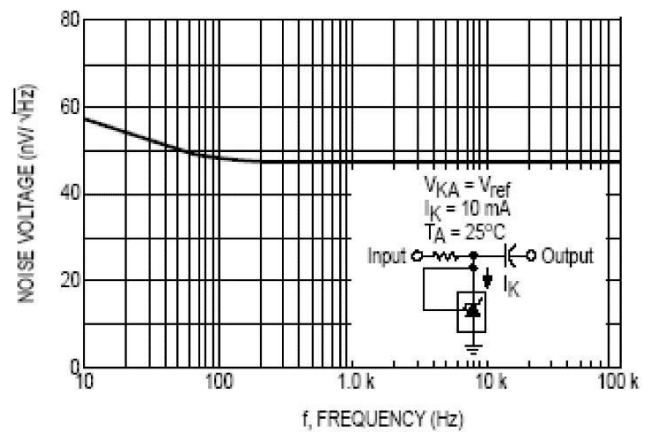


Figure 13. Spectral Noise Density

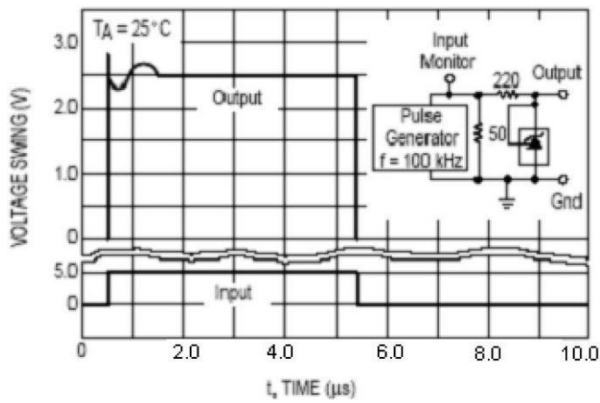


Figure 14. Pulse Response

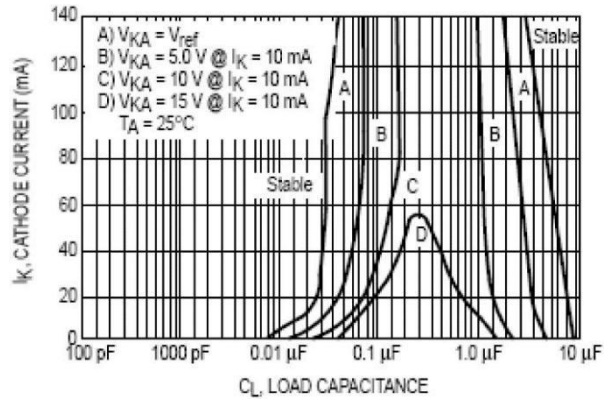


Figure 15. Stability Boundary Conditions

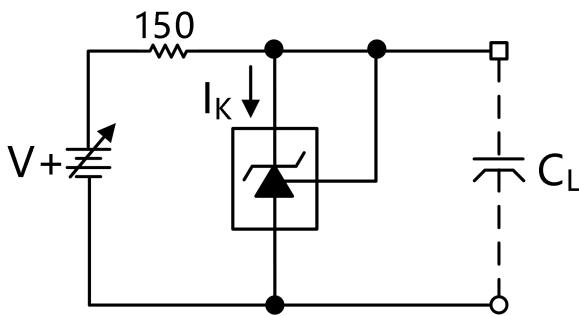


Figure 16. Test Circuit For Curve A of Stability Boundary Conditions

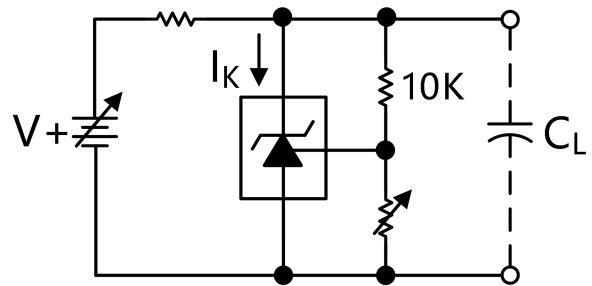


Figure 17. Test Circuit For Curves B, C, And D of Stability Boundary Conditions

## Typical Applications

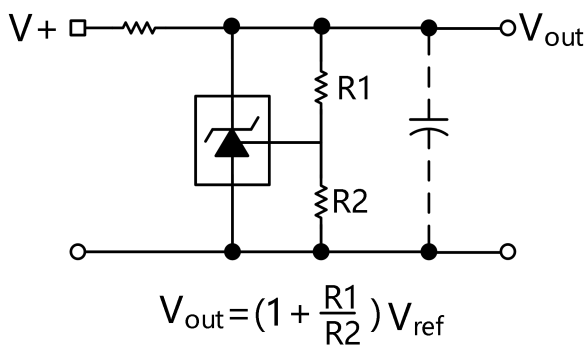


Figure 18. Shunt Regulator

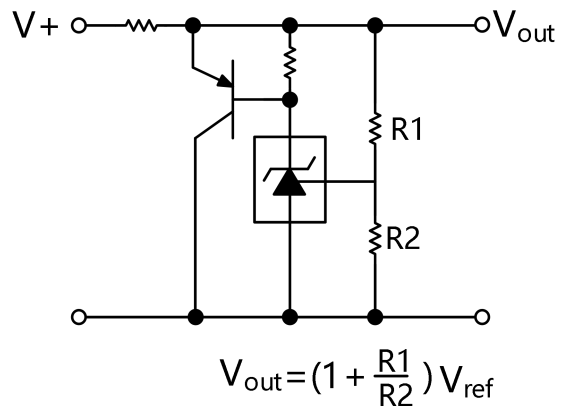


Figure 19. High Current Shunt Regulator

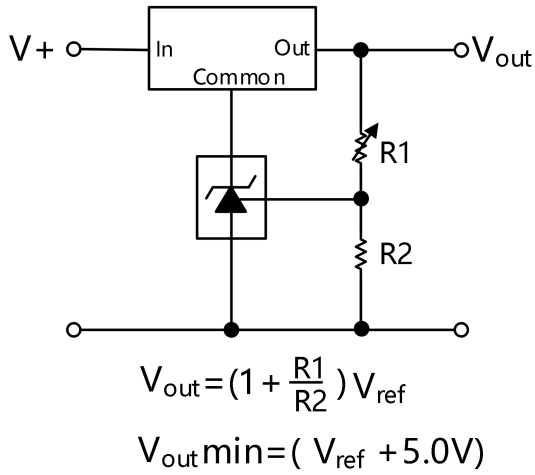


Figure 20. Output Control for a Three-Terminal Fixed Regulator

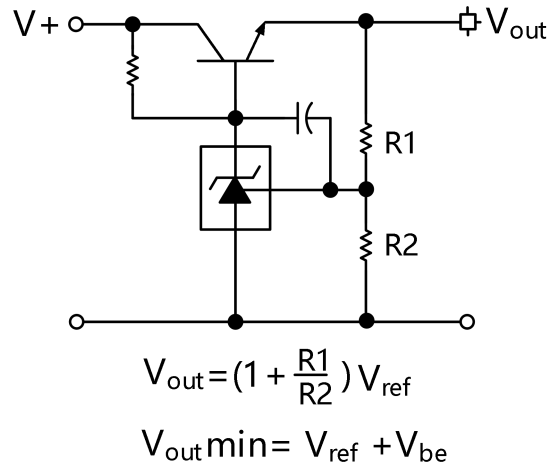


Figure 21. Series Pass Regulator

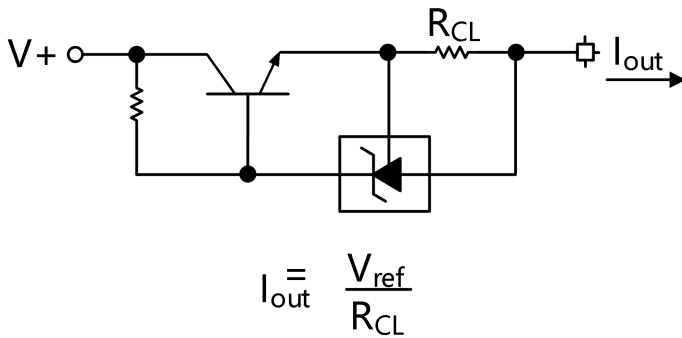
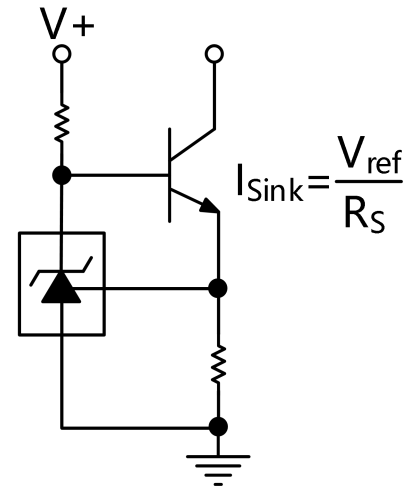


Figure 22. Constant Current Source Figure



23. Constant Current Sink

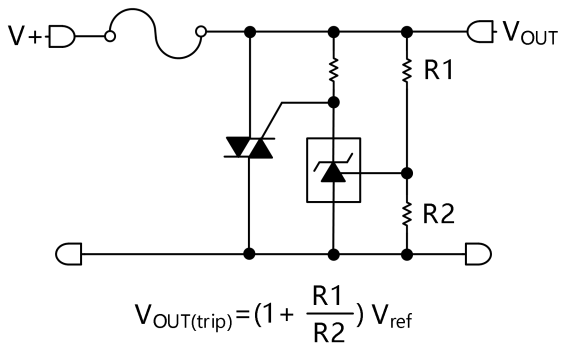


Figure 24. TRIAC Crowbar

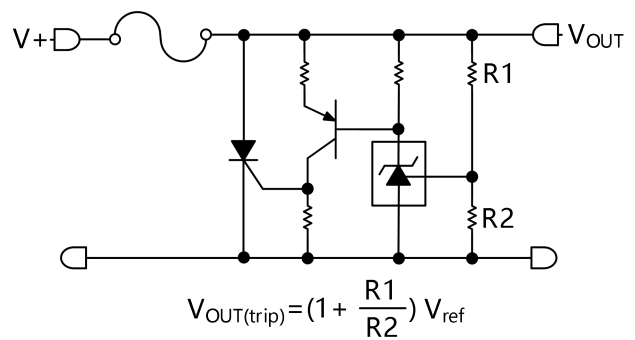
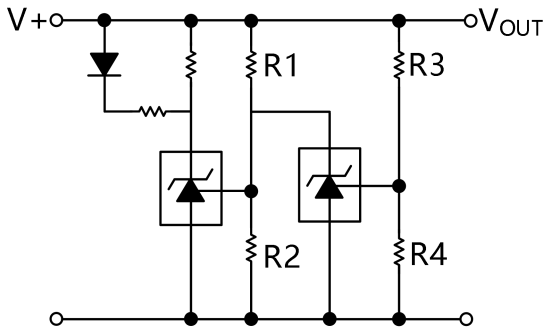


Figure 25. SRC Crowbar



LED Indicator is 'on' when V+ is between the upper and lower limits.

$$\text{Lower Limit} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$$\text{Upper Limit} = \left(1 + \frac{R3}{R4}\right) V_{ref}$$

Figure 26. Voltage Monitor

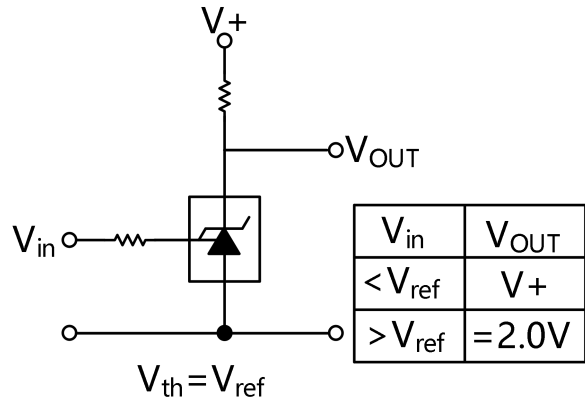


Figure 27. Single-Supply Comparator with Temperature-Compensated Threshold

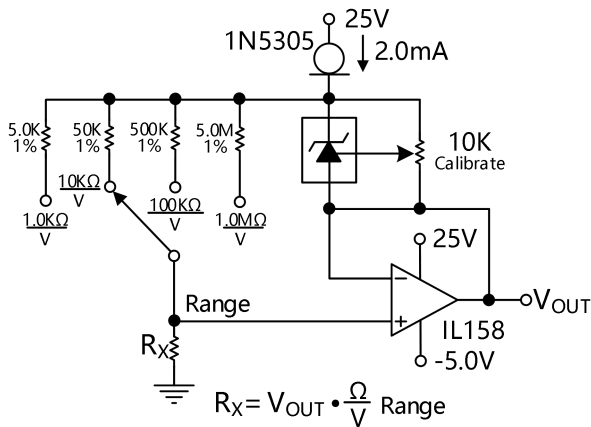


Figure 28. Linear Ohmmeter

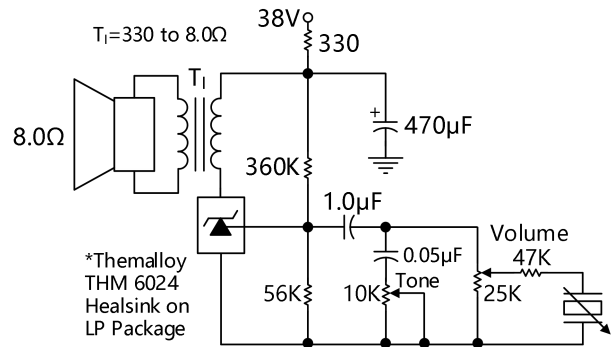


Figure 29. Simple 400 mW Phono Amplifier

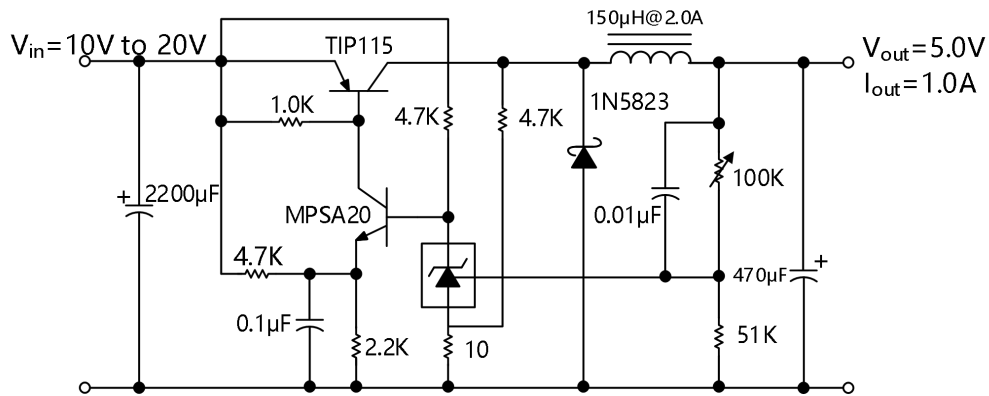


Figure 30. High Efficiency Step-Down Switching Converter

Test	Conditions	Results
Line Regulation	$V_{IN}=10V$ to $20V$ , $I_o=1.0A$	53mV (1.1%)
Load Regulation	$V_{IN}=15V$ , $I_o=0A$ to $1.0A$	25mV (0.5%)
Output Ripple	$V_{IN}=10V$ , $I_o=1.0A$	50mVpp P.A.R.D
Output Ripple	$V_{IN}=20V$ , $I_o=1.0A$	100mVpp P.A.R.D
Efficiency	$V_{IN}=15V$ , $I_o=1.0A$	82%

## Applications Information

The CBM432 is a programmable precision reference which is used in a variety of ways. It serves as a reference voltage in circuits where a non-standard reference voltage is needed. Other uses include feedback control for driving an optocoupler in power supplies, voltage monitor, constant current source, constant current sink and series pass regulator. In each of these applications, it is critical to maintain stability of the device at various operating currents and load capacitances. In some cases the circuit designer can estimate the stabilization capacitance from the stability boundary conditions curve provided in Figure 15. However, these typical curves only provide stability information at specific cathode voltages and at a specific load condition.

Additional information is needed to determine the capacitance needed to optimize phase margin or allow for process variation. A simplified model of the CBM432 is shown in Figure 31. When tested for stability boundaries, the load resistance is 150 Ω. The model reference input consists of an input transistor and a dc emitter resistance connected to the device anode. A dependent current source,  $G_m$ , develops a current whose amplitude is determined by the difference between the 1.78 V internal reference voltage source and the input transistor emitter voltage. A portion of  $G_m$  flows through compensation capacitance,  $C_{P2}$ . The voltage across  $C_{P2}$  drives the output dependent current source,  $G_o$ , which is connected across the device cathode and anode.

Model component values are:

$$V_{ref} = 1.78 \text{ V}$$

$$G_m = 0.3 + 2.7 \exp(-I_C/26 \text{ mA})$$

where  $I_C$  is the device cathode current and  $G_m$  is in mhos

$$G_o = 1.25 (V_{cP2}) \mu\text{mhos.}$$

Resistor and capacitor typical values are shown on the model. Process tolerances are  $\pm 20\%$  for resistors,  $\pm 10\%$  for capacitors, and  $\pm 40\%$  for transconductances.

An examination of the device model reveals the location of circuit poles and zeroes:

$$P1 = \frac{1}{2_\pi R_{GM} C_{P1}} = \frac{1}{2_\pi * 1.0M * 20pF} = 7.96\text{kHz}$$

$$P2 = \frac{1}{2_\pi R_{P2} C_{P2}} = \frac{1}{2_\pi * 1.0M * 0.265pF} = 60\text{kHz}$$

$$Z1 = \frac{1}{2_\pi R_{Z1} C_{P1}} = \frac{1}{2_\pi * 15.9K * 20pF} = 500\text{kHz}$$

In addition, there is an external circuit pole defined by the load:

$$P_L = \frac{1}{2\pi R_L C_L}$$

Also, the transfer dc voltage gain of the CBM432 is:

$$G = G_M R_{GM} G_O R_L$$

**Example 1:**

$I_C=10\text{mA}$ ,  $R_L=230\Omega$ ,  $C_L=0$ , Define the transfer gain. The DC gain is:

$$G = G_M R_{GM} G_O R_L = (2.138)(1.0\text{M})(1.25\mu)(230) = 615 = 56\text{dB}$$

$$\text{Loop gain} = G \frac{8.25\text{k}}{8.25\text{k} + 15\text{k}} = 218 = 47\text{dB}$$

The resulting transfer function Bode plot is shown in Figure 32. The asymptotic plot may be expressed as the following equation:

$$A_V = 615 \frac{\left(\frac{1 + jf}{500\text{kHz}}\right)}{\left(\frac{1 + jf}{8.0\text{kHz}}\right)\left(\frac{1 + jf}{60\text{kHz}}\right)}$$

The Bode plot shows a unity gain crossover frequency of approximately 600 kHz. The phase margin, calculated from the equation, would be 55.9 degrees. This model matches the Open-Loop Bode Plot of Figure 12. The total loop would have a unity gain frequency of about 300 kHz with a phase margin of about 44 degrees.

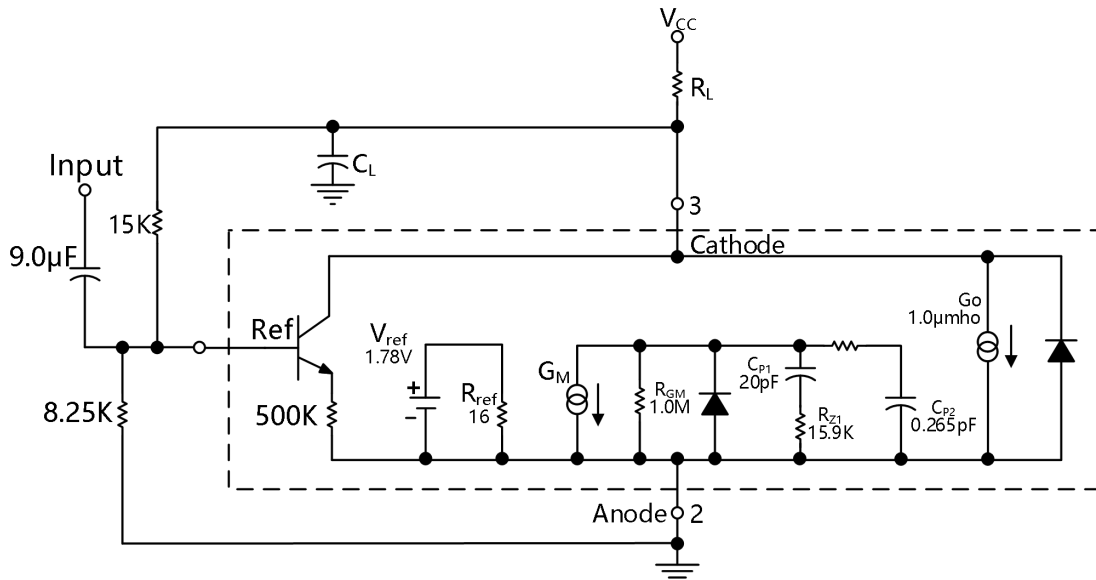


Figure 31. Simplified CBM432 Device Model

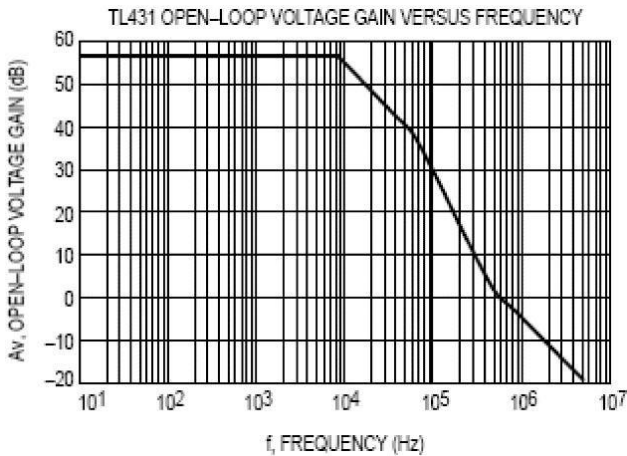


Figure 32. Example 1 Circuit Open Loop Gain Plot

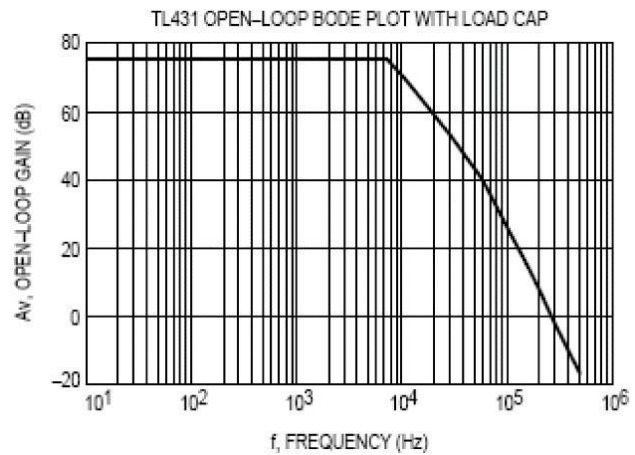


Figure 33. Example 2 Circuit Open Loop Gain Plot

### Example 2.

$I_C = 7.5\text{mA}$ ,  $R_L = 2.2\text{k}\Omega$ ,  $C_L = 0.01\ \mu\text{F}$ .

Cathode tied to reference input pin. An examination of the data sheet stability boundary curve (Figure 15) shows that this value of load capacitance and cathode current is on the boundary. Define the transfer gain. The DC gain is:

$$G = G_M R_{GM} G_0 R_L = (2.323)(1.0\text{ M})(1.25\ \mu)(2200) = 6389 = 76\text{dB}$$

The resulting open loop Bode plot is shown in Figure 33. The asymptotic plot may be expressed as the following equation:

$$A_V = 615 \frac{(1 + jf / 500\text{kHz})}{(1 + jf / 8.0\text{kHz})(1 + jf / 60\text{kHz})(1 + jf / 7.2\text{kHz})}$$

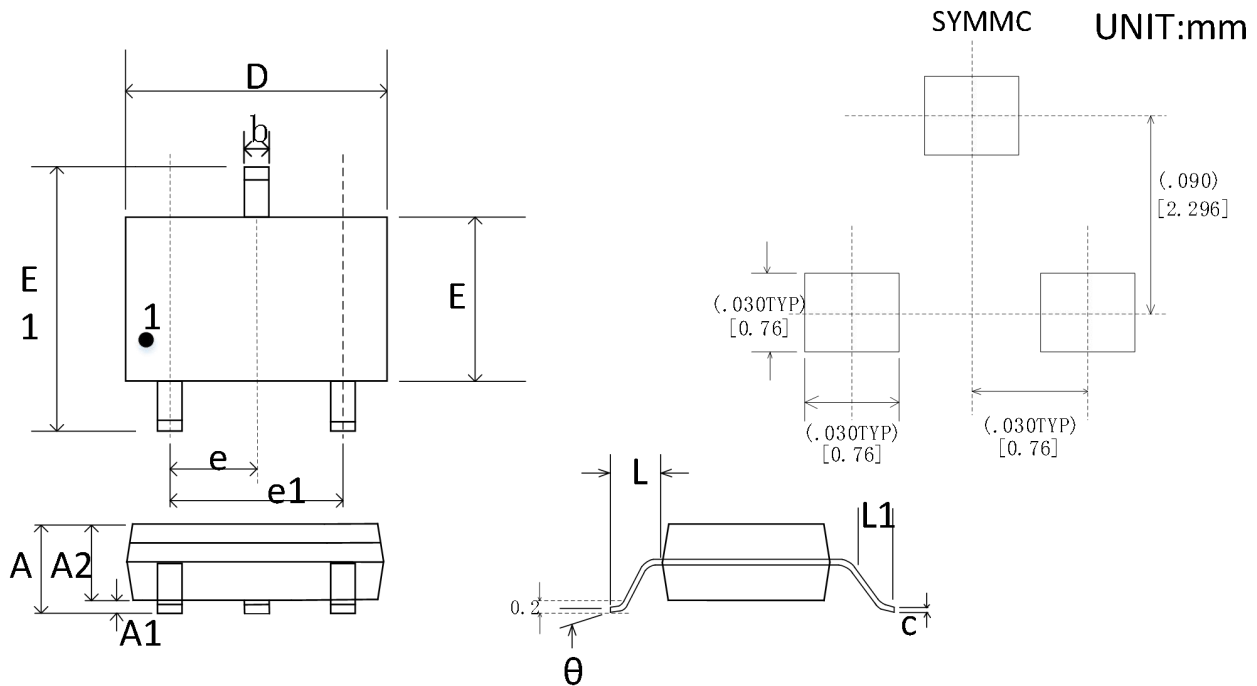
Note that the transfer function now has an extra pole formed by the load capacitance and load resistance. Note that the crossover frequency in this case is about 250 kHz, having a phase margin of about  $-46$  degrees. Therefore, instability of this circuit is likely.

With three poles, this system is unstable. The only hope for stabilizing this circuit is to add a zero. However, that can only be done by adding a series resistance to the output capacitance, which will reduce its effectiveness as a noise filter. Therefore, practically, in reference voltage applications, the best solution appears to be to use a smaller value of capacitance in low noise applications or a very large value to provide noise filtering and a dominant pole rolloff of the system.



## Package Information

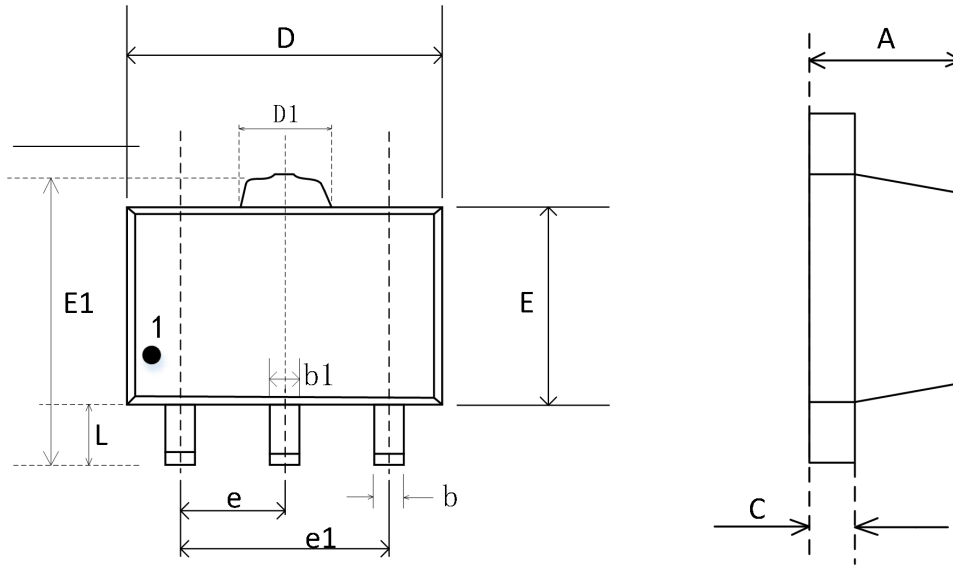
### SOT23-3



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 TYP		0.037 TYP	
e1	1.800	2.000	0.071	0.079
L	0.700 REF		0.028 REF	
L1	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°

## SOT89-3

UNIT:mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.360	0.560	0.014	0.022
c	0.350	0.440	0.016	0.017
D	4.400	4.600	0.173	0.181
D1	1.400	1.800	0.055	0.071
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500 TYP		0.060 TYP	
e1	2.900	3.100	0.114	0.122
L	0.900	1.100	0.035	0.043

## Package/Ordering Information

ORDERING NUMBER	TEMPRANGE	PACKAGE	PAKEAGE MARKING	TRANSPOT MEDIA,QUANTILY
CBM432AST23	-40°C~125°C	SOT23-3	432	Reel, 3000
CBM432AST89	-40°C~125°C	SOT89-3	432	Reel, 3000