1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

- **Low-voltage operation, down to 1.24V**
- **0.5%, 1% or 2% reference voltage tolerance**
- **Adjustable output voltage, $V_O = V_{ref}$ to 16V**
- **Wide operating current range, 80μA to 100mA**
- **Low dynamic output impedance, 0.05Ω typical**
- **Wide temperature range, -40º to +85º C**
- **Pin-to-pin replacement for TLV431, SC431L**
- **Available in SOT-23-3, SOT-23-5, SOT-89 TO-92 and SO-8**

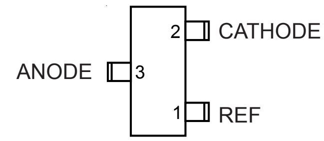
The GM432's are low-voltage three-terminal adjustable precision shunt regulators with specified thermal stability over their full temperature range. Output voltage can be set to any value from V_{ref} (1.24V) to 16V using two external resistors. Their active output circuitry provides a very sharp turn-on characteristIc, making them excellent replacements for zener diodes in many applications such as onboard regulation and adjustable power supplies. At home in a wide range of applications, these versatile darlings are ideal voltage references for 3.0V to 3.3V switching power suppies. With operational cathode current as low as 80μA, batteries keep on going. Whatever your application, the GM432's offer the optimum combination of performance, reliability, and economy.

Applications include:

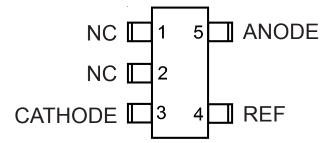
- **Switching power supplies**
- **Linear regulators**
- **Adjustable power supplies**
- **Battery-operated computers, PDA's, portable devices**
- **Monitors, TV's, VCR's, camcorders**
- **Computer disk drives**
- **Instrumentation**

PIN CONFIGURATIONS

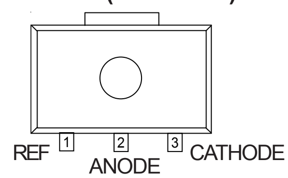
SOT-23-3 (TOP VIEW)



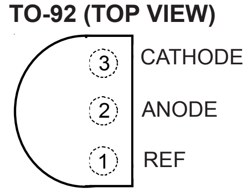
SOT-23-5 (TOP VIEW)



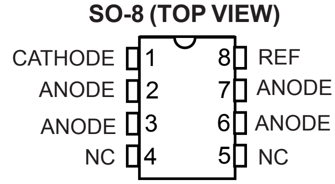
SOT-89 (TOP VIEW)



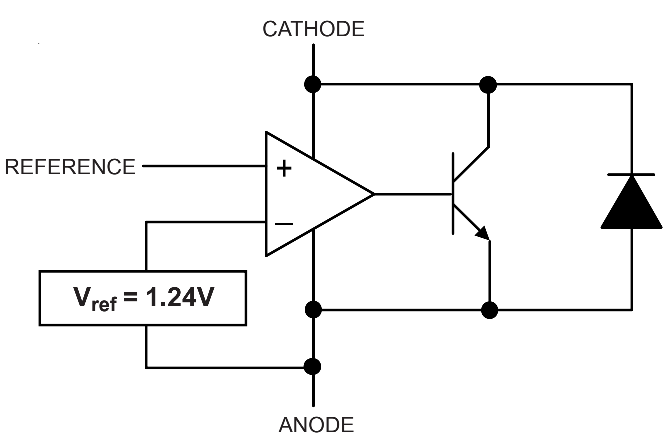
TO-92 (TOP VIEW)



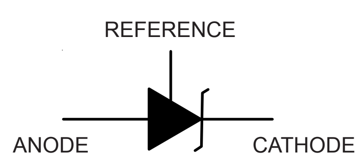
SO-8 (TOP VIEW)



BLOCK DIAGRAM (POSITIVE LOGIC)



LOGIC SYMBOL



ABSOLUTE MAXIMUM RATINGS (over free-air temperature range except as noted)

PARAMETER	SYMBOL	MAXIMUM	UNIT
Cathode Voltage [1]	V_{KA}	20	V
Continuous cathode current	I_K	100	mA
Reference input current	I_{ref}	3	mA
Power dissipation at TA = 25º C SOT-23 SO-8 TO-92	P_D	 0.37 0.49 0.95	W
Package thermal impedance [2, 3] SOT-23-3 SOT-23-5 TO-92 SO-8	θ_{JA}	 336 256 132 97	ºC/W
Operating ambient temperature range	T_A	-40 to +85	ºC
Operating junction temperature range	T_J	-40 to +150	ºC
Lead temperature (soldering) 10 seconds	T_{LEAD}	300	ºC
Storage temperature range	T_{STG}	-65 to + 150	ºC
ESD rating (human body model)	V_{ESD}	2	kV

These are stress ratings only. Functional operation of the device at these or any conditions beyond the "recommended operatiing conditions" is not implied. Exposure to absolute maximum rated conditions may affect device reliability.

NOTES:
1. Voltage values are with respect to the anode except as noted.
2. Maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} and T_A. Maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Operation at absolute maximum T_J of 150º C can affect device reliability.
3. Package thermal impedance is calculated per JESD 51.

RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MINIMUM	MAXIMUM	UNIT
Cathode Voltage	V_{KA}	V_{ref}	16	V
Cathode Current	I_K	80μA	100mA	
Operating free-air temperature range	T_A	-40	+85	ºC

ELECTRICAL CHARACTERISTICS (T_A = 25º C unless otherwise noted)

GM432 (0.5%)

PARAMETER		CONDITION	MIN	TYP	MAX	UNIT
Reference Voltage	V_{ref}	$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = 25º C (1)	1.234	1.240	1.246	V
		$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = -40 to +85º C(1)	1.222		1.258	
V_{ref} temp deviation	V_{dev}	$V_{KA} = V_{ref}$, IK = 10 mA (1)		10	25	mV
Ratio of change in V_{ref} to change in V_{KA}	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	I_K = 10mA, ΔV_{KA} = 16V to V_{ref}		1.0	2.7	mV/V
Reference input current	I_{ref}	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2)		0.15	0.5	μA
I_{ref} temp deviation	$I_{ref(dev)}$	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2) **T_A = full range**		0.1	0.4	μA
Minimum operating current	$I_{K(min)}$	$V_{KA} = V_{ref}$ (1)		20	80	μA
Off-state cathode current	$I_{K(off)}$	V_{KA} = 6V, V_{ref} = 0V (3)		0.125	0.150	μA
		V_{KA} = 16V, V_{ref} = 0V (3)		0.135	0.150	
Dynamic impedance	$\| Z_{KA} \|$	f ≤ 1kHz, $V_{KA} = V_{ref}$, IK = 100μA to 100mA (1)		0.05	0.15	Ω

GM432 (1.0%)

PARAMETER		CONDITION	MIN	TYP	MAX	UNIT
Reference Voltage	V_{ref}	$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = 25º C (1)	1.228	1.240	1.252	V
		$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = -40 to +85º C(1)	1.215		1.258	
V_{ref} temp deviation	V_{dev}	$V_{KA} = V_{ref}$, IK = 10 mA (1)		10	25	mV
Ratio of change in V_{ref} to change in V_{KA}	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	I_K = 10mA, ΔV_{KA} = 16V to V_{ref}		1.0	2.7	mV/V
Reference input current	I_{ref}	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2)		0.15	0.5	μA
I_{ref} temp deviation	$I_{ref(dev)}$	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2) **T_A = full range**		0.1	0.4	μA
Minimum operating current	$I_{K(min)}$	$V_{KA} = V_{ref}$ (1)		20	80	μA
Off-state cathode current	$I_{K(off)}$	V_{KA} = 6V, V_{ref} = 0V (3)		0.125	0.150	μA
		V_{KA} = 16V, V_{ref} = 0V (3)		0.135	0.150	
Dynamic impedance	$\| Z_{KA} \|$	f ≤ 1kHz, $V_{KA} = V_{ref}$, IK = 100μA to 100mA (1)		0.05	0.15	Ω

NOTES:
(1) See test circuit 1 on page 4.
(2) See test circuit 2 on page 4.
(3) See test circuit 3 on page 4.

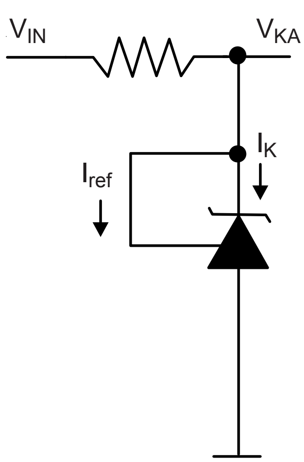
ELECTRICAL CHARACTERISTICS (T_A = 25º C unless otherwise noted)

GM432 (2.0%)

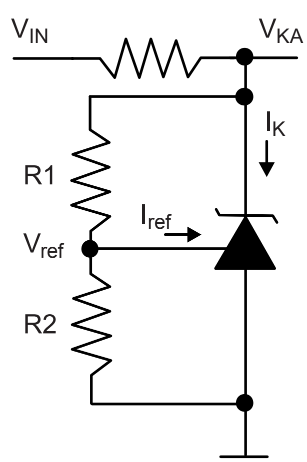
PARAMETER		CONDITION	MIN	TYP	MAX	UNIT
Reference Voltage	V_{ref}	$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = 25º C (1)	1.215	1.240	1.265	V
		$V_{KA} = V_{ref}$, I_K = 10 mA, T_A = -40 to +85º C(1)	1.200		1.280	
V_{ref} temp deviation	V_{dev}	$V_{KA} = V_{ref}$, IK = 10 mA (1)		10	35	mV
Ratio of change in V_{ref} to change in V_{KA}	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	I_K = 10mA, ΔV_{KA} = 16V to V_{ref}		1.0	2.7	mV/V
Reference input current	I_{ref}	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2)		0.15	0.5	μA
I_{ref} temp deviation	$I_{ref(dev)}$	I_K = 10mA, R1 = 10KΩ, R2 = ∞ (2) **T_A = full range**		0.1	0.4	μA
Minimum operating current	$I_{K(min)}$	$V_{KA} = V_{ref}$ (1)		20	80	μA
Off-state cathode current	$I_{K(off)}$	V_{KA} = 6V, V_{ref} = 0V (3)		0.125	0.150	μA
		V_{KA} = 16V, V_{ref} = 0V (3)		0.135	0.150	
Dynamic impedance	$\lvert Z_{KA} \rvert$	f ≤ 1kHz, $V_{KA} = V_{ref}$, IK = 100μA to 100mA (1)		0.05	0.15	Ω

NOTES:
(1) See test circuit 1.
(2) See test circuit 2.
(3) See test circuit 3.

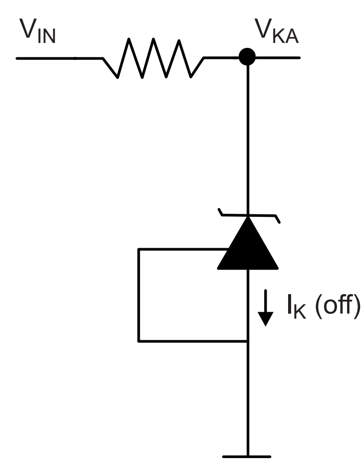
TEST CIRCUITS



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

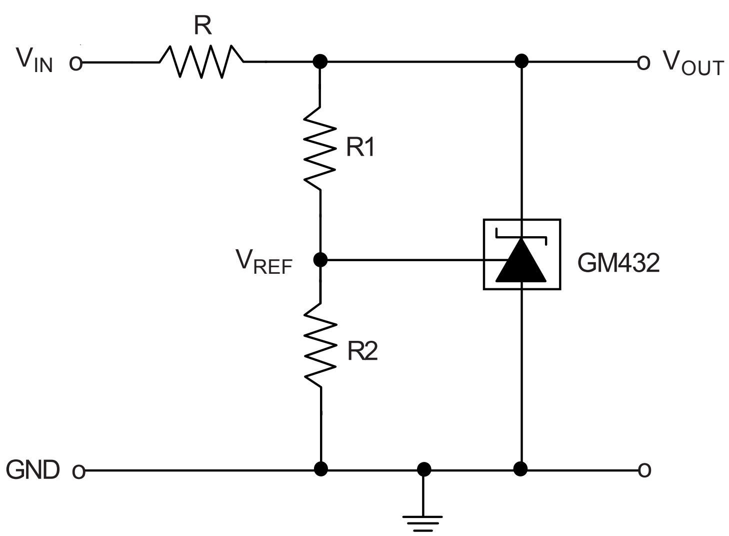


Test Circuit 2
$V_{KA} > V_{ref}$



Test Circuit 3
Off-State

TYPICAL APPLICATION CIRCUIT



Notes:

1) Set V_{OUT} according to the following equation:

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

2) Choose the value for R as follows:

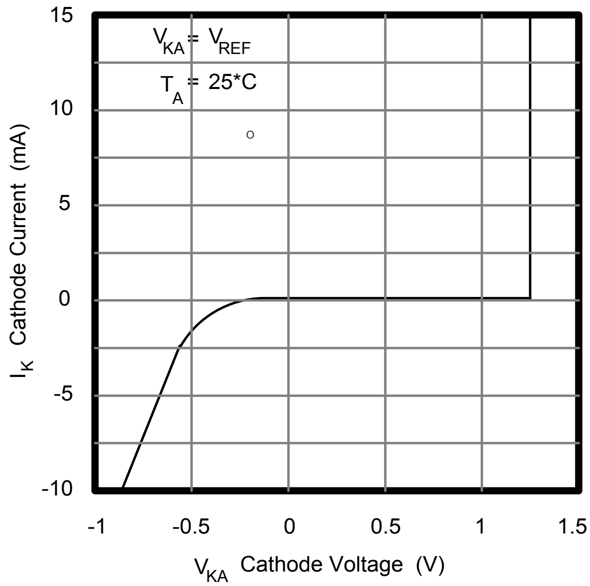
- The maximum limit for R should be such that the cathode current, I_K, is greater than the minimum operating current (80µA) at $V_{IN(MIN)^*}$

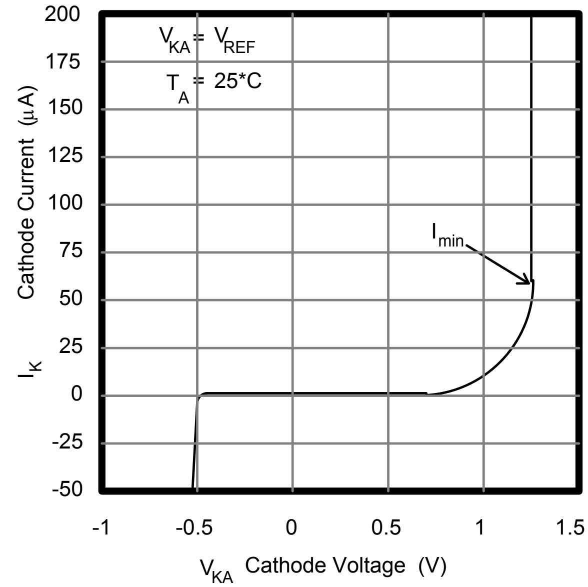
- The minimum limit for R should be such that the cathode current, I_K, does not exceed 100mA under all load conditions, and the instantanenous turn-on value for I_K does not exceed 150 mA. Both of the following conditions must be met:

$$R_{min} \geq \frac{V_{IN(max)}}{150\text{ mA}}$$ (to limit instantaneous turn-on I_K)

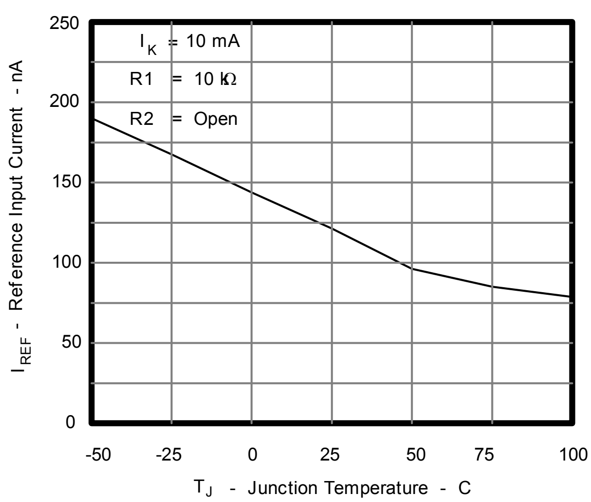
$$R_{min} \geq \frac{V_{IN(max)} - V_{OUT}}{I_{OUT(min)} + 100\text{mA}}$$ (to limit I_K under normal operating conditions)

Cathode Current vs. Cathode Voltage

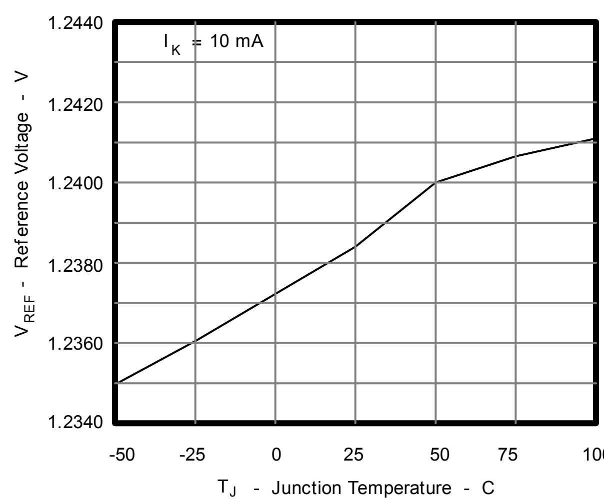




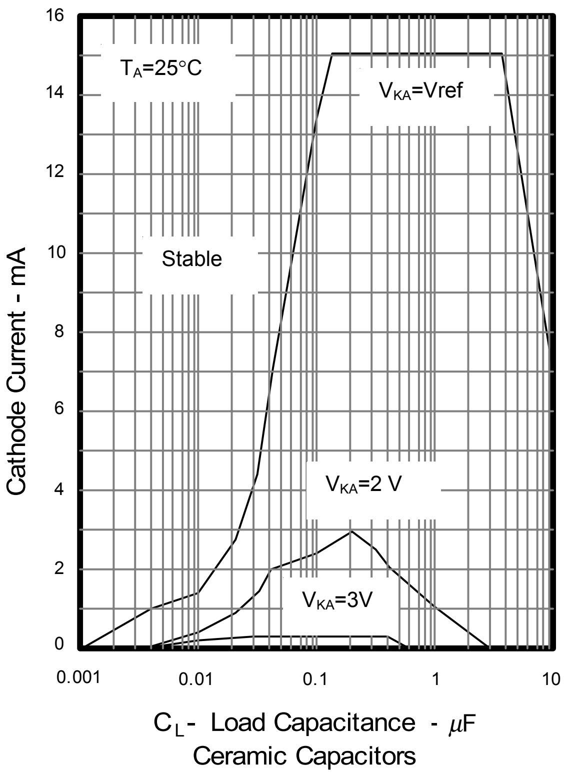
Ref. Voltage vs. Junction Temperature



Ref. Input Current vs. Junction Temperature



STABILITY BOUNDARY CONDITIONS

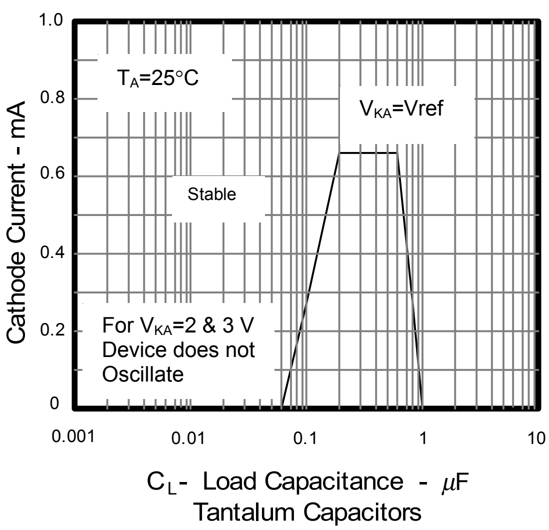


A Note About Stability

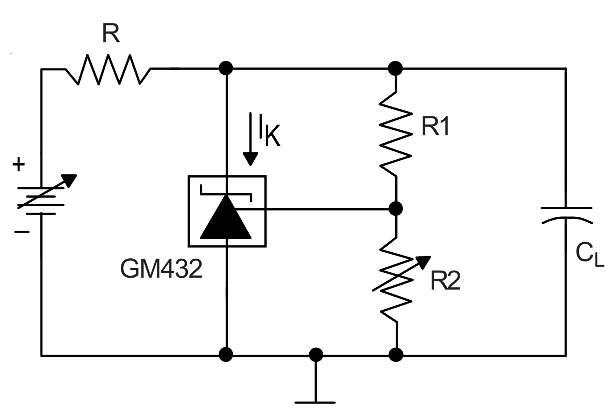
When using the GM432 as a shunt regulator, you can optimize stability by setting C_L either (1) no load capacitance across the GM432, decouple at the load; or (2) large capacitance across the GM432, optional decoupling at the load.

The GM432 can become unstable with capacitances of approximately 10nF to 1µF when cathode currents are less than 3mA or so, with instability increasing as cathode current is reduced. So, while the GM432 is happily stable at, for example, cathode current of 10mA with a 0.1µF capacitor across it, it can oscillate transiently as the cathode current rises through the region of instability. To avoid this problem completely, simply eliminate the capacitor or select a very low or very high (e.g. 10µF) capacitor C_L.

Since you will probably want local decoupling at the load, the best idea is to use no capacitance across the device. Just the resistance and capacitance of the PCB traces and vias will prevent local load decoupling from causing transient oscillation during start-up. If you place the GM432 right next to the load, with the load decoupling capacitor directly across it, you must use a capacitor of $\leq$nF or $\geq 10\mu$F.

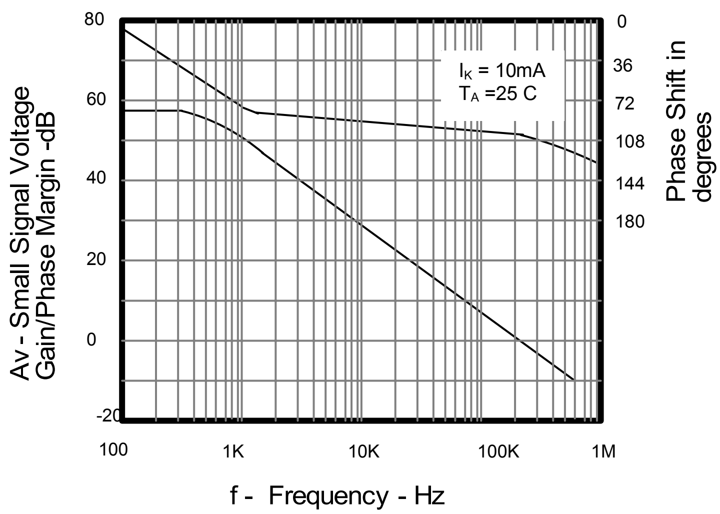


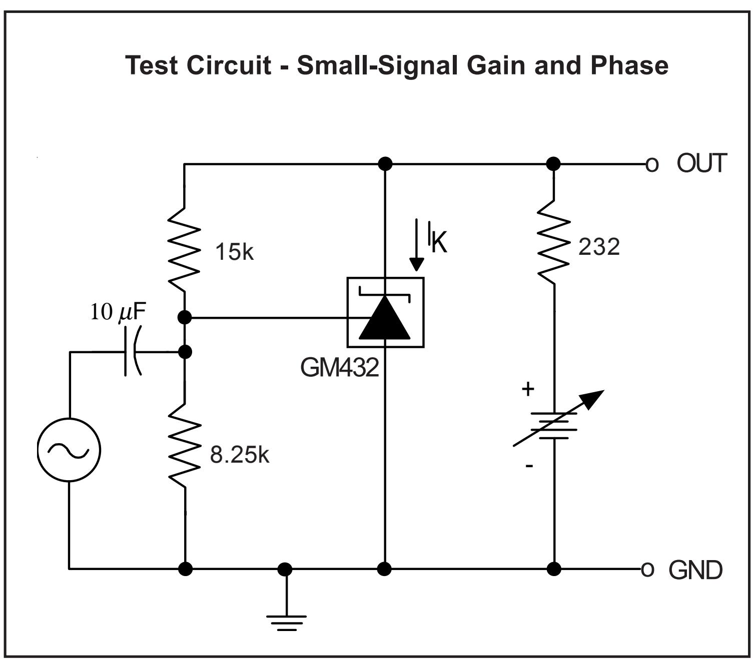
Test Circuit - Stability



* Stability boundary condition test shows that tantalum capacitors are recommended to minimize the conditions that may cause the device to oscillate.

Small Signal Voltage Gain/Phase Margin vs. Frequency





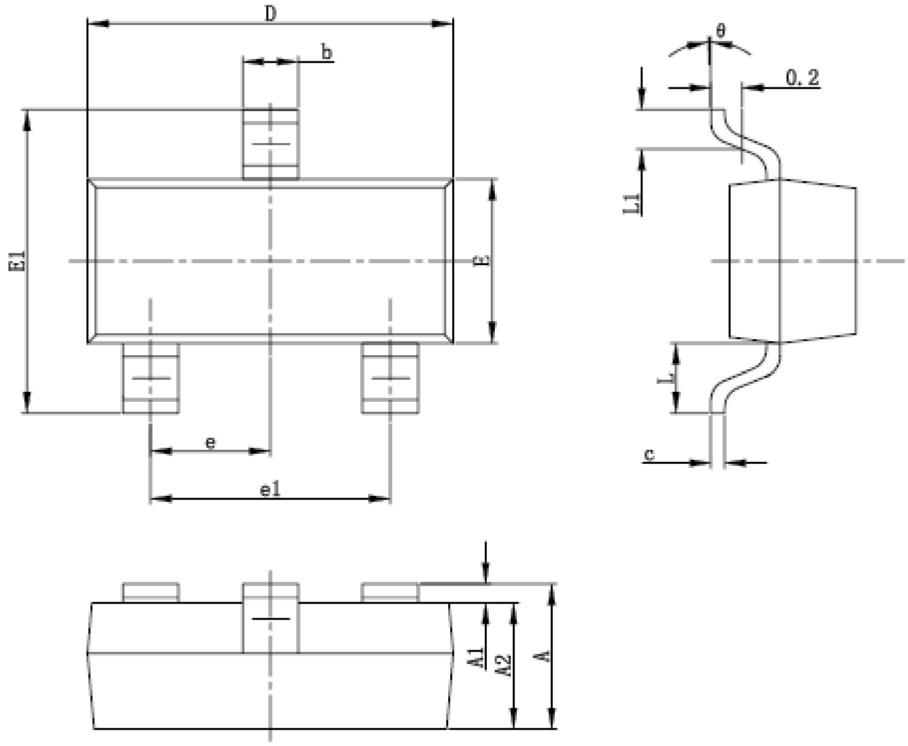
ORDERING INFORMATION

PACKAGE	T_A (ºC)	T_J (ºC)	Tolerance		
			0.5%	1.0%	2.0%
SOT- 23 (1)	-40 to +85	-40 to +150	GM432A-ST23	GM432B-ST23	GM432C-ST23
SOT- 25 (1)	-40 to +85	-40 to +150	GM432A-ST25	GM432B-ST25	GM432C-ST25
SO-8 (2)	-40 to +85	-40 to +150	GM432A-S8	GM432B-S8	GM432C-S8
TO- 92 (3)	-40 to +85	-40 to +150	GM432A-TO92	GM432B-TO92	GM432C-TO92
SOT-89	-40 to +85	-40 to +150	GM432A-ST89	GM432B-ST89	GM432C-ST89

NOTES:

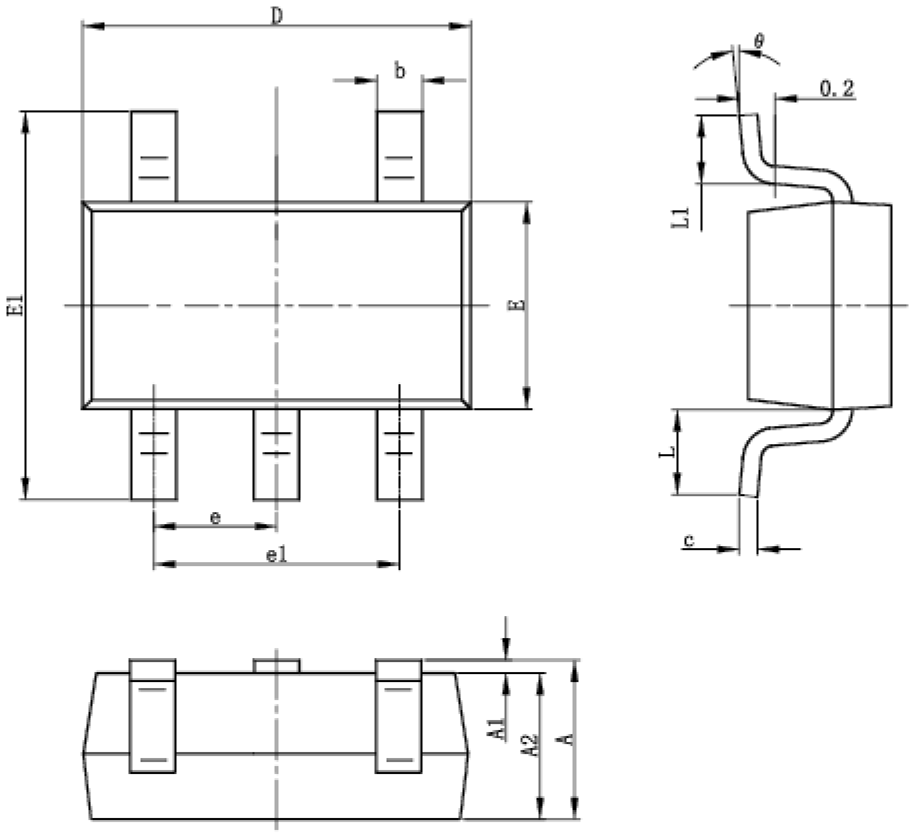
(1) Shipped in tape and reel, 3000 units per reel.
(2) Shipped in tape and reel, 2500 units per reel.
(3) Available in bulk pack 1000 units per bag (no suffix), tape and reel (3000 units per reel, suffix-R) and ammo pack (2000 units, suffix-A)

SOT-23-3 PACKAGE OUTLINE DIMENSIONS



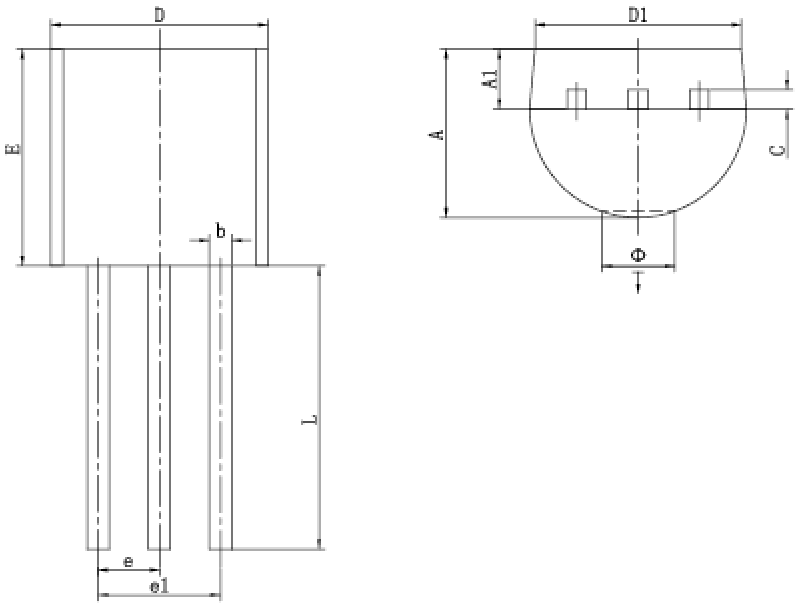
SYMBOL	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.300	0.500	0.012	0.020
c	0.080	0.150	0.003	0.006
D	2.800	3.000	0.110	0.118
E	1.200	1.400	0.047	0.055
E1	2.250	2.550	0.089	0.100
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.550TYP		0.022TYP	
L1	0.300	0.500	0.012	0.020
θ	0°	8°	0°	10°

SOT-23-5 PACKAGE OUTLINE DIMENSIONS



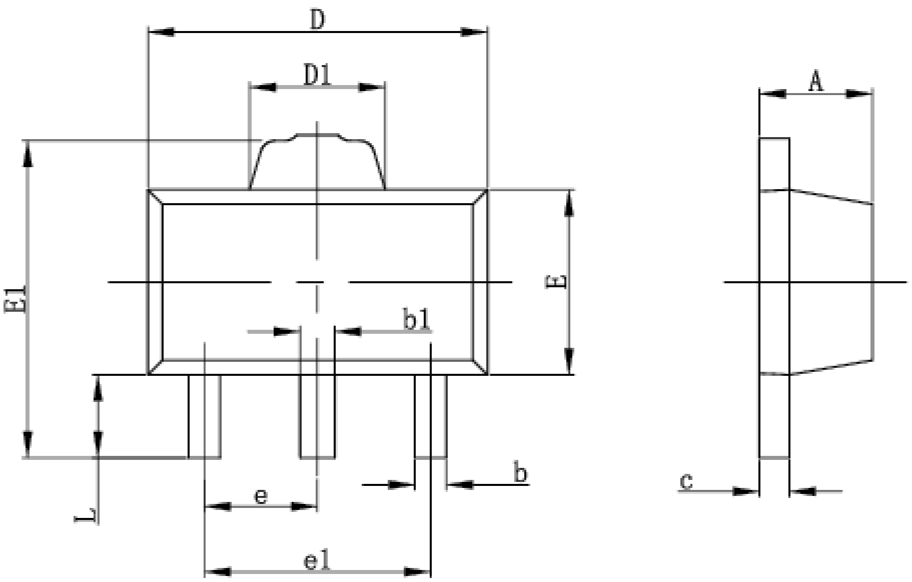
SYMBOL	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP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

■ TO-92 PACKAGE OUTLINE DIMENSIONS



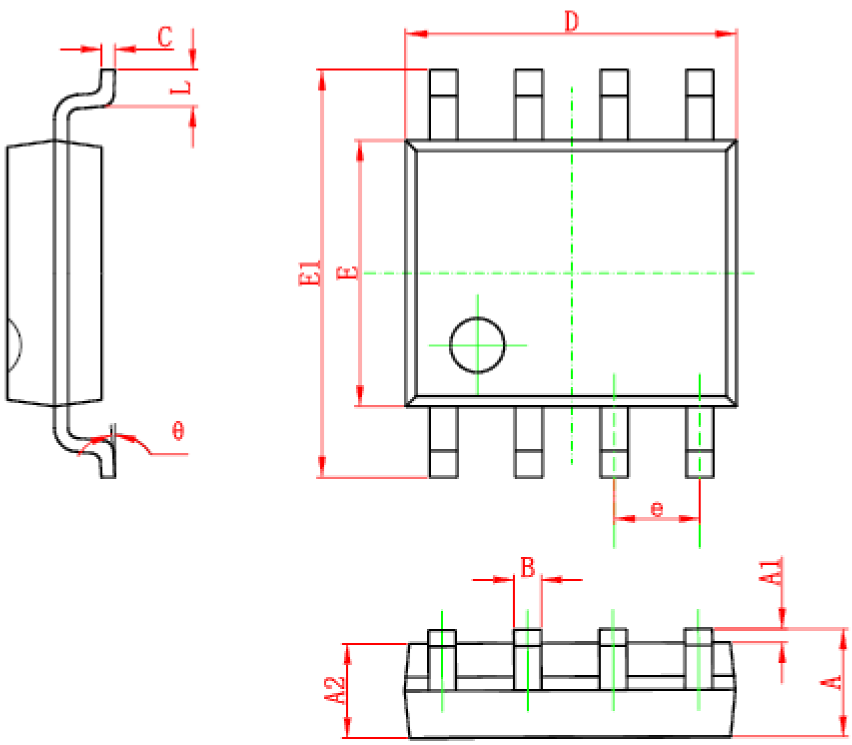
SYMBOL	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	3.300	3.700	0.130	0.146
A1	1.100	1.400	0.043	0.055
b	0.380	0.550	0.015	0.022
c	0.360	0.510	0.014	0.020
D	4.400	4.700	0.173	0.185
D1	3.430	-	0.135	-
E	4.300	4.700	0.169	0.185
e	1.270TYP		0.050TYP	
e1	2.440	2.640	0.096	0.104
L	14.100	14.500	0.555	0.571
Φ	-	1.600	-	0.063
↧	0.000	0.380	0.000	0.015

SOT-89-3L PACKAGE OUTLINE DIMENSIONS



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	0.014	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	1.500TYP		0.060TYP	
e1	2.900	3.100	0.114	0.122
L	0.900	1.100	0.035	0.043

SOP-8 PACKAGE OUTLINE DIMENSIONS



SYMBOL	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.45	1.75	0.057	0.069
A1	0.1	0.25	0.004	0.01
A2	1.35	1.55	0.053	0.061
B	0.306	0.506	0.012	0.02
C	0.153	0.253	0.006	0.01
D	4.81	5.01	0.189	1.197
E	3.84	4.04	0.151	0.159
E1	5.84	6.24	0.23	0.246
e	1.27		0.05	
L	0.45	1	0.018	0.039
θ	0°	8°	0°	8°