GM431S

2.5V ADJUSTABLE SHUNT REGULATOR

Description

The GM431S is a three terminal adjustable shunt regulator with a specified thermal stability guaranteed over temperature. The output voltage can be adjusted to any value between 2.5V (V_{REF}) and 36V by using two external resistors. Active output circuitry provides a very sharp turn on characteristic, making the GM431S an excellent replacement for zener diodes in many applications such as on board regulation and adjustable power supplies. The

The GM431S shunt regulator is available with two voltage tolerances 0.5%, and 1.0% over full temperature range and four package options - SOT-23, TO-92, SOT-89 and SO-8.

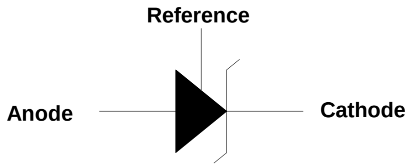
Features

- **Sink Current Capability 1mA to 100mA**
- **Fast Turn On Response**
- **Low output noise**
- **0.5%, or 1% reference voltage tolerance**
- **Temperature range -40°C to + 125°C**
- **Available in most advanced Small SOT23, SOT23, TO92, SOT89 and SO8 packages**

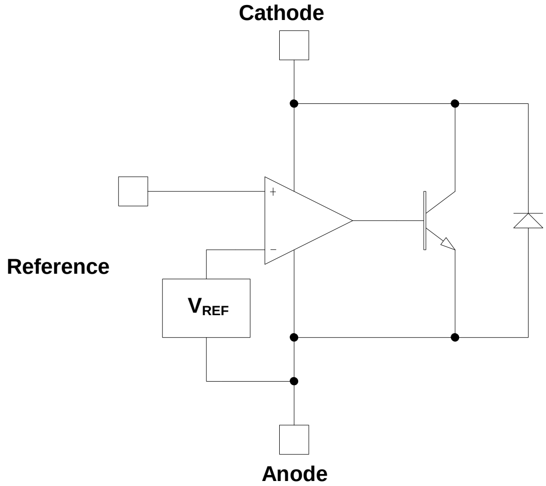
Application

Switching power supplies
Linear regulator
Adjustable supplies
Battery-orperated computers
Computer disk drives
Instrumentation

Logic Symbol



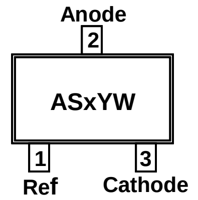
Block Diagram



GM431S V2.01

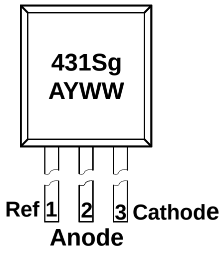
Marking Information and Pin Configurations (Top View)

Small SOT23 and SOT23

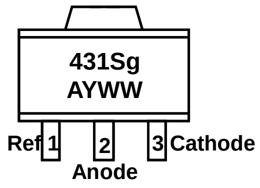


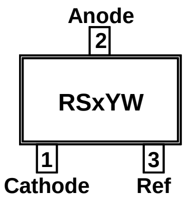
(GM431S)

TO92



SOT89





(GM431SR)

ASx: Marking Code (see table below)

RSx: Marking Code (see table below)

g: Grade Code (A: 0.5%, B: 1.0%)

A: Assembly/Test Site Code

Y: Year

W: Week code

WW: Week

Ordering Information

Ordering Number	Precision	Device Code	Grade	Package	Shipping
GM431SAT92BG	0.5%		A	TO-92	1,000 Units/ESD Bag
GM431SAT92RLG	0.5%		A	TO-92	2,000 Units/Ammo Pack (Tape)
GM431SAST23RG	0.5%	ASA	A	SOT-23	3,000 Units/Tape & Reel
GM431SAST23MRG	0.5%	ASA	A	Small SOT-23	3,000 Units/Tape & Reel
GM431SRAST23RG	0.5%	RSA	A	SOT-23	3,000 Units/Tape & Reel
GM431SAST89RG	0.5%		A	SOT-89	1,000 Units/Tape & Reel
GM431SBT92BG	1.0%		B	TO-92	1,000 Units/ESD Bag
GM431SBT92RLG	1.0%		B	TO-92	2,000 Units/Ammo Pack (Tape)
GM431SBST23RG	1.0%	ASB	B	SOT-23	3,000 Units/Tape & Reel
GM431SBST23MRG	1.0%	ASB	B	Small SOT-23	3,000 Units/Tape & Reel
GM431SRBST23RG	1.0%	RSB	B	SOT-23	3,000 Units/Tape & Reel
GM431BST89RG	1.0%		B	SOT-89	1,000 Units/Tape & Reel

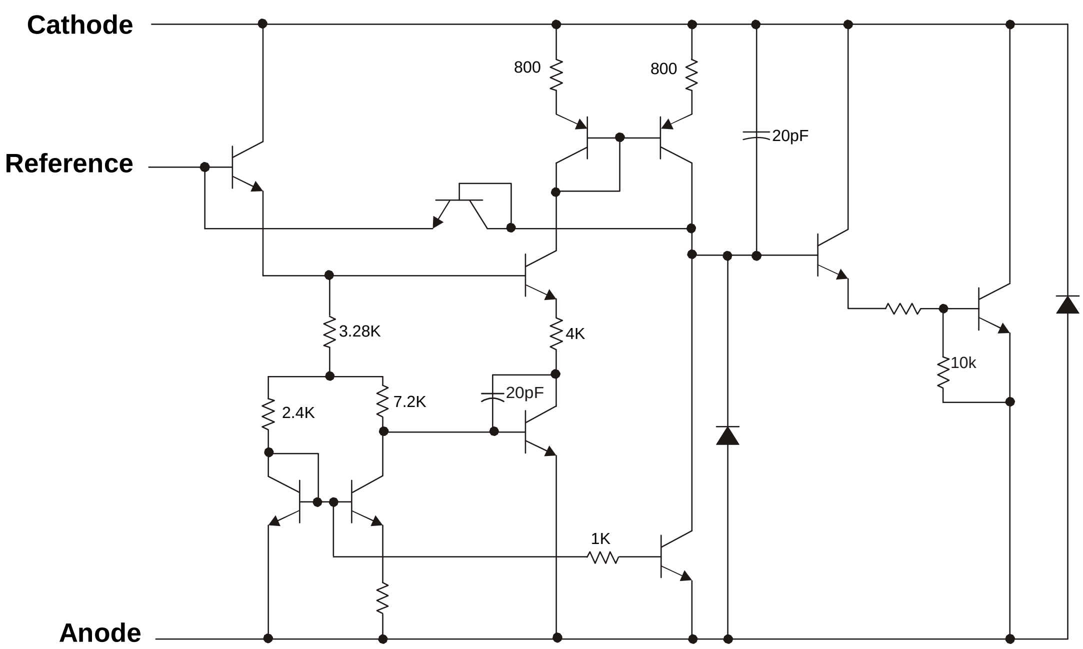
Absolute Maximum Ratings

PARAMETER	SYMBOL	RATINGS	UNITS
Cathode Voltage	V_{KA}	37	V
Continuous Cathode Current Range	I_K	-100 to 150	mA
Reference Input Current Range	I_{REF}	-50µA to 10mA	
Power Dissipation at T_A = 25°C			
SOT-23	P_D	0.23	W
TO-92		0.78	
SOT-89		0.8	
Package Thermal Resistance			
SOT-23	θ_{JA}	336	°C/W
TO-92		132	
SOT-89		132	
Operating Ambient Temperature Range	T_A	-40 - 125	°C
Storage Temperature		- 65 to 150	°C
Lead Temperature (soldering 10 sec.)		260	°C

Recommended Operating Conditions

PARAMETER	SYMBOL	Min	Max	UNITS
Cathode Voltage	V_{KA}	V_{REF}	36	V
Cathode Current	I_K	1	100	mA

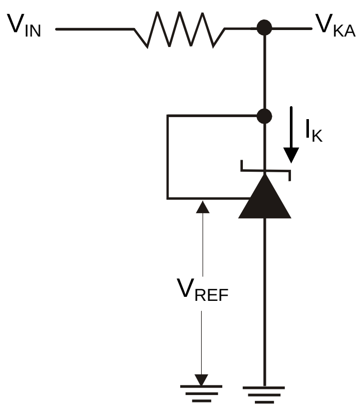
Equivalent Schematics



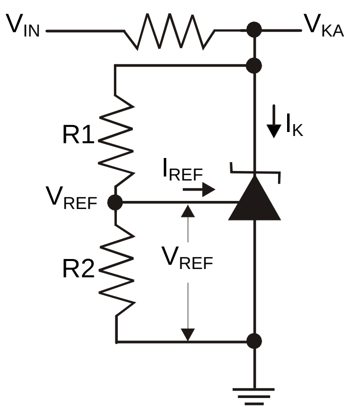
Electrical Characteristics (T_A = 25°C unless otherwise specified)

Parameter		Symbol	Condition		Min	Typ	Max	Unit
Reference Voltage	GM431SA	V_{REF}	$V_{KA} = V_{REF}$, I_K = 10mA, **Test circuit 1**		2487	2500	2513	mV
	GM431SB				2475	2500	2525	
V_{REF} Deviation over Temperature		$V_{REF(DEV)}$	$V_{KA} = V_{REF}$, I_K = 10mA, T_A = 0 to 70°C			8	17	mV
Ratio of change in V_{REF} to change in V_{KA}		$\Delta V_{REF}/\Delta V_{KA}$	I_K = 10mA	ΔV_{KA} = 10V to V_{REF}	-2.7	-1.0		mV/V
				ΔV_{KA} = 36V to 10V	-2	-0.4		
Reference Input Current		I_{REF}	I_K = 10mA, R1 = 10K, R2 = ∞ **Test circuit 2**			0.5	1.2	µA
I_{REF} Deviation over Temperature		$V_{REF(DEV)}$	I_K = 10mA, R1 = 10K, R2 = ∞ T_A =Full range, **Test circuit 2**			0.4	1.2	µA
Minimum Cathode Current		$I_{K(MIN)}$	$V_{KA} = V_{REF}$ **Test circuit 1**			0.4	1.0	mA
Off-state cathode Current		$I_{K(OFF)}$	V_{KA} = 36V, V_{REF} = 0V **Test circuit 3**			0.1	1	µA
Dynamic Impedance		$\lvert Z_{KA}\rvert$	$V_{KA} = V_{REF}$, I_K = 1mA to 10mA, f ≤1kHz, **Test circuit 1**			0.25	0.5	Ω

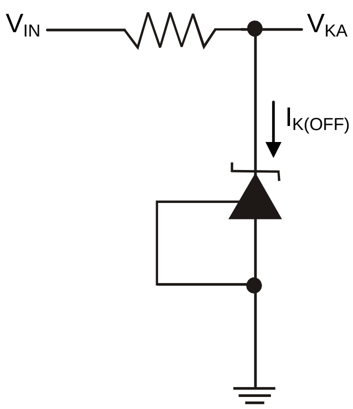
Test Circuits



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



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



Test Circuit 3
Off-State

Typical Characteristics

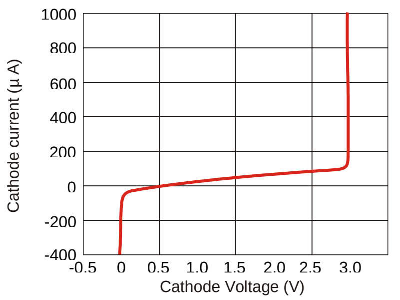


Figure 4. Cathode Current vs. Cathode Voltage

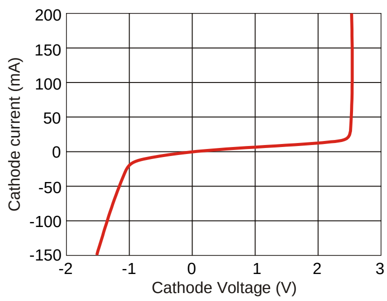


Figure 5. Cathode Current vs. Cathode Voltage

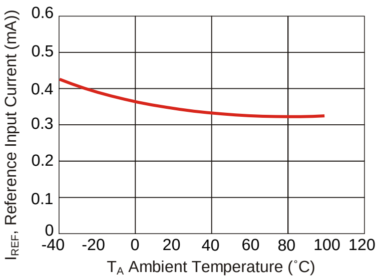


Figure 6. Reference Input Current vs. Ambient Temperature

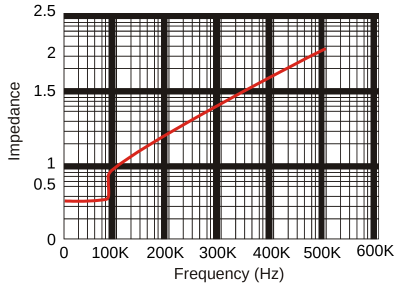


Figure 7. Dynamic Impedance

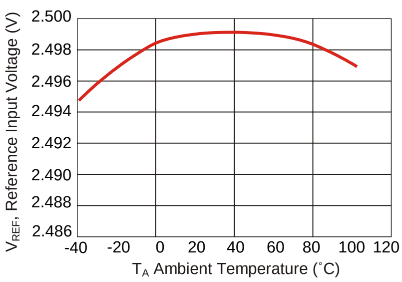


Figure 8. Reference Input Voltage vs. Ambient Temperature

Design Guide for AC-DC SMPS (Switching Mode Power Supply)

Use of Shunt Regulator in Transformer Secondary side control

This example is applicable to both forward transformers and flyback transformers. A Shunt regulator is used on the secondary side as an error amplifier, and feedback to the primary side is provided via a photo-coupler.

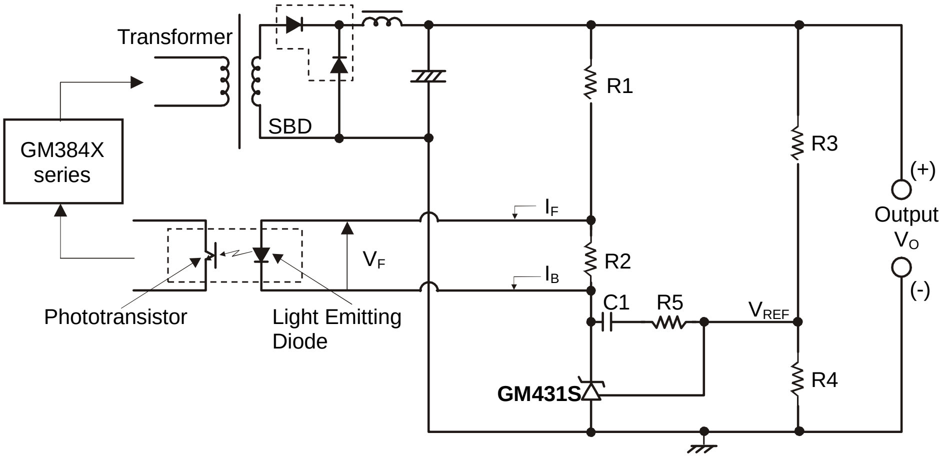


Figure 9. Typical Shunt Regulator/ Error Amplifier

Determination of external constants for the Shunt Regulator

DC Characteristic determination: In the application circuit above, R1 and R2 are protection resistors for the light emitting diode in the photo-coupler, and R2 is a bypass resistor to feed I_K Minimum, and these are determined as shown below. The photo-coupler specification should be obtained separately from the manufacturer. Using the parameters in this circuit, the following formulas are obtained:

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

V_K is the GM431S operating voltage, and is set at around 3V, taking into account a margin for fluctuation. R2 is the current shunt resistance for the 1ight emitting diode, in which a bias current I_B of around 1/5 I_F f1ows.

Next, the output voltage can be determined by R3 and R4, and the following formula is obtained:

$$V_O = V_{REF}\left(\frac{R3 + R4}{R4}\right) \qquad V_{REF} = 2.5V \text{ Typical}$$

The abSo1ute va1ueS of R3 and R4 are determined by the GM431S reference input current I_{REF} and the AC characteristics described in the next Section. The I_{REF} va1ue is around 0.7µA Typ.

AC Characteristic Determination:

This refers to the determination of the gain frequency characteristic of the Shunt regulator as an error amp1ifier. Taking the configuration in Figure 10, the error amp1ifier characteristic is as Shown in Figure 10.

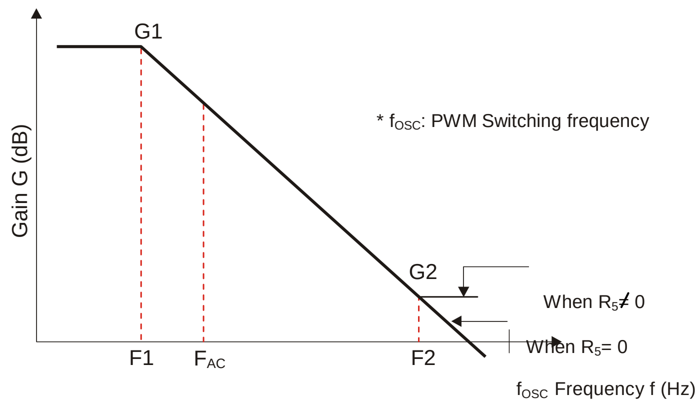


Figure 10. GM431S Error Amplification Characteristic

In Figure 17, the following formulas are obtained:

Gain

$G1 = G0 \cong 50$ dB to 60 dB (determined by shunt regulator)

$$G_2 = \frac{R_5}{R_3}$$

Corner frequencies

$f_1 = 1/(2\quad pC_1G_0R_3)$
$f_2 = 1/(2\quad pC_1R_5)$

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 50 dB.

Practical Example
Consider the example of a photocoupler, with an internal light emitting diode V_F = 1.05 V and I_F = 2.5mA, power supply output vo1tage V2 = 5V, and bias resistance R2 current of approximately 1/5 I_F at 0.5mA. If the Shunt regulator V_K = 3V, the following values are found.

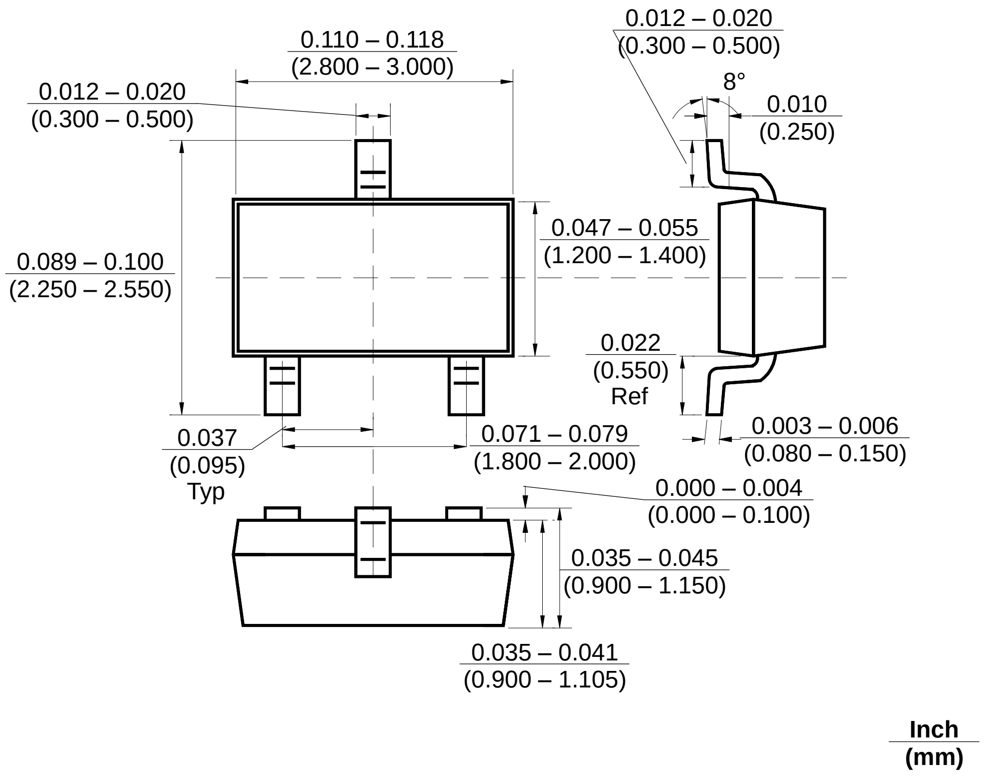
$$R_1 = \frac{5V - 1.05V - 3V}{2.5mA + 0.54mA} = 316\Omega$$

$$R_2 = \frac{1.05V}{0.54mA} = 2.1k\Omega$$

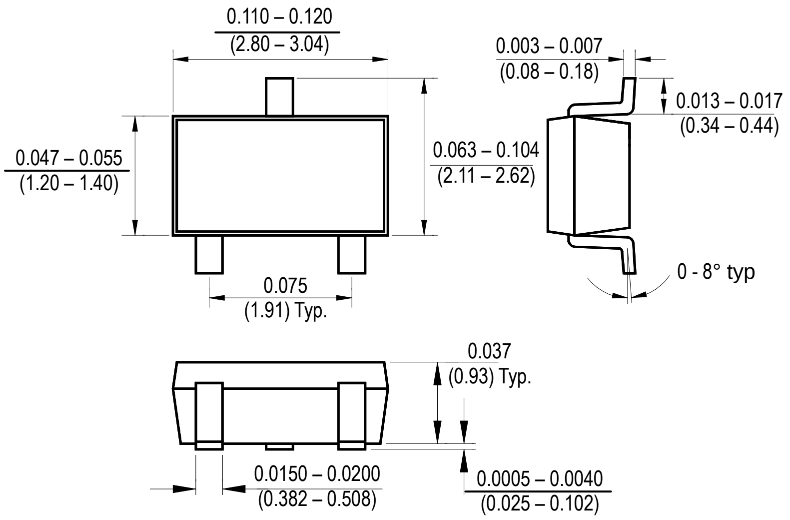
Next, assume that R3 = R4 = 10k. This gives a 5V output. If R5 = 3.3 k, and C1 = 0.022 pF, the following values are found.

G2 = 3.3kΩ / 10kΩ = 0.33 times (-10 dB)
$f_1 = 1 / (2 \times \pi \times 0.022\mu F \times 316 \times 10\ k) = 2.3$ (Hz)
$f_1 = 1 / (2 \times \pi \times 0.022\mu F \times 3.3k) = 2.2$ (kHz) 2

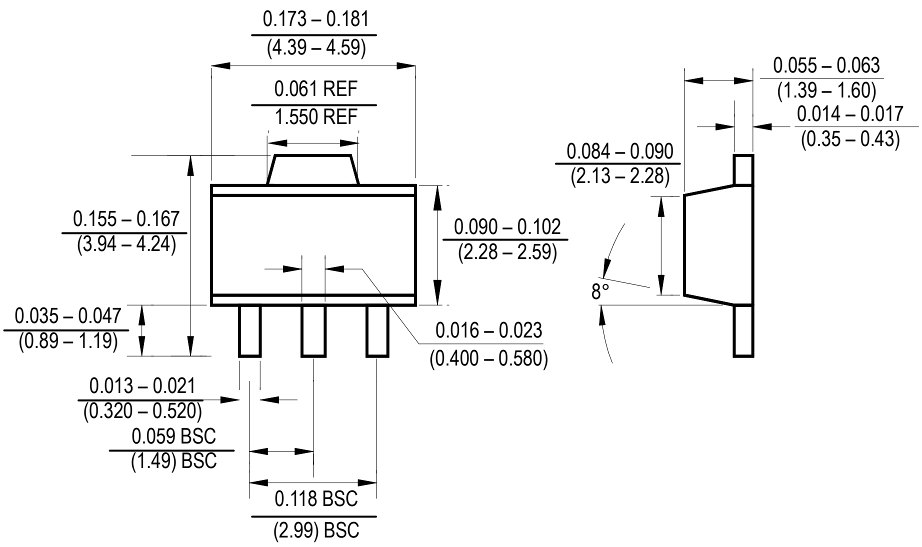
Package Outline Dimensions – Small SOT 23



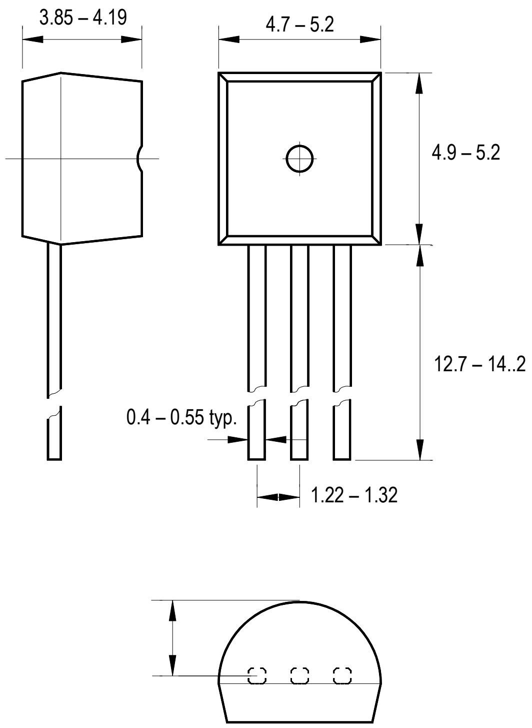
Package Outline Dimensions – SOT 23



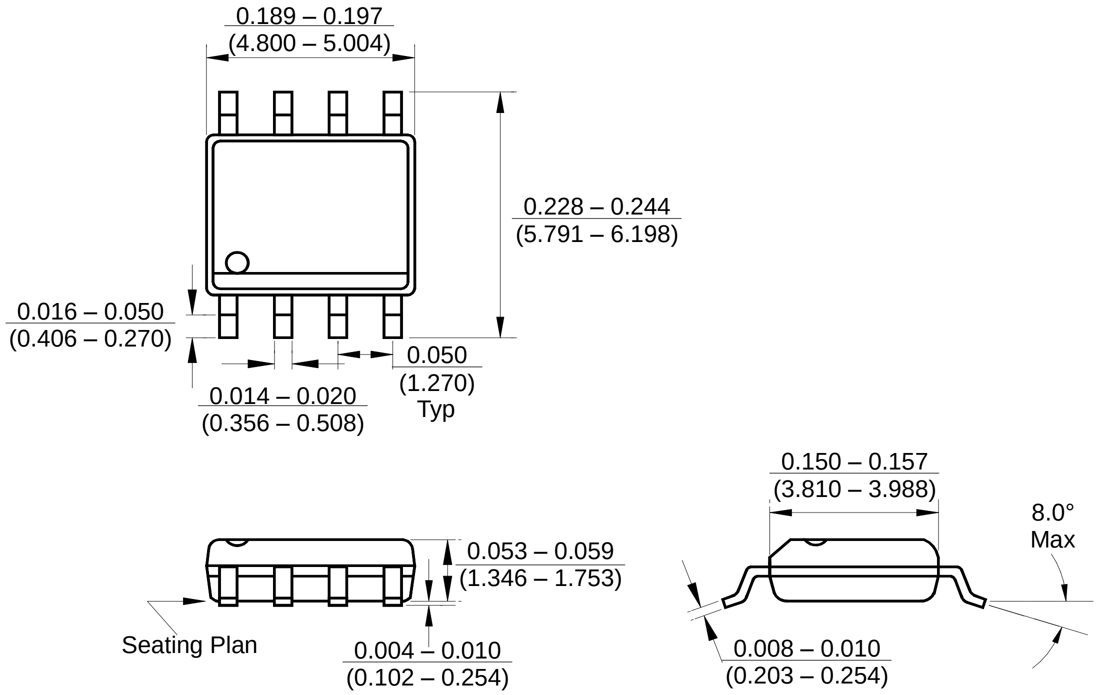
Package Outline Dimensions – SOT 89



Package Outline Dimensions – TO 92



Package Outline Dimensions – SO 8



Ordering Number

GM	431S	A	ST23	R	G
APM Gamma Micro	Circuit Type	Output Accuracy	Package Type	Shipping Type	G:Green
		A: 0.5% B: 1.0%	T92: TO92 ST23:SOT23 ST23M: Small SOT23 ST89: SOT89 S8: SO8	B: Bag RL: Ammo Pack (Tape) T: Tube R: Tape & Reel	

GM	431SR	A	ST23	R	G
APM Gamma Micro	Circuit Type	Output Accuracy	Package Type	Shipping Type	G:Green
		A: 0.5% B: 1.0%	T92: TO92 ST23:SOT23 ST23M: Small SOT23 ST89: SOT89 S8: SO8	B: Bag RL: Ammo Pack (Tape) T: Tube R: Tape & Reel	

Note:

Pb-free products:

- RoHS compliant and compatible with the current require-ments of IPC/JEDEC J-STD-020.
- Suitable for use in Pb-free soldering processes with 100% matte tin (Sn) plating.

Green products:

- Lead-free (RoHS compliant)
- Halogen free(Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight)