GM431

2.5V ADJUSTABLE SHUNT REGULATOR

Description

The GM431is a three terminal adjustable shunt regulator with thermal stability guaranteed over temperature. The output voltage can be adjusted to any value between 2.5V (V_{REF}) and 18V by using two external resistors. The GM431 has a typical dynamic output impedance of 0.2 . Active output circuitry provides a very unique turn on characteristic, making the GM431an excellent replacement for zener diodes in many applications such as on board regulation and adjustable power supplies. The GM431 is an ideal voltage reference for 3.0 to 3.3V switching power supplies.

The GM431 shunt regulator is available with 3 voltage tolerances 0.5%, 1.0% and 2.0% over full temperature range and four package options (SOT-23, TO-92, SOT-89 and SO-8).

Features

- **Sink Current Capability 1mA to 100mA**
- **Low dynamic out put impedance, 0.2 typ.**
- **Low output noise**
- **0.5%, 1% or 2% reference voltage tolerance**
- **Alternate for TL431, LM431 & AS431**
- **Temperature range -40°C to + 125°C**
- **Available in SOT-23, TO-92, SOT-89 and Sop- 8 packages**

Application

Switching power supplies

Linear regulator

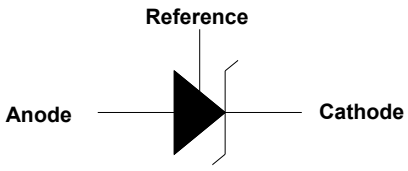
Adjustable supplies

Battery-operated computers

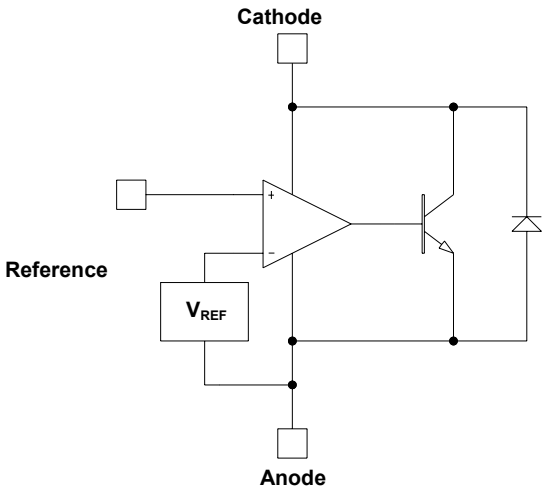
Computer disk drives

Instrumentation

Logic Symbol

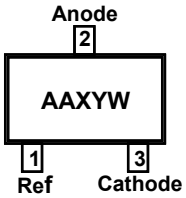


Block Diagram

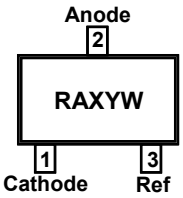


Marking Information and Pin Configurations (Top View)

SOT23

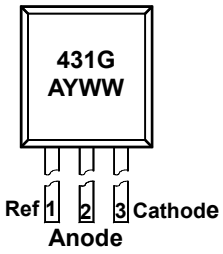


(GM431)

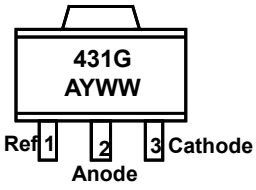


(GM431R)

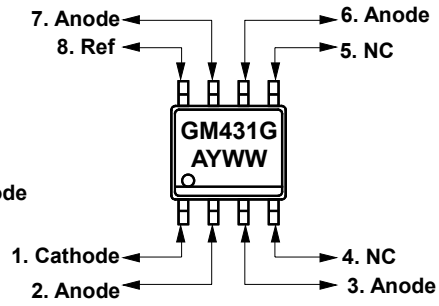
TO92



SOT89



SO8



AAX: Marking Code (see table below)
RAX: Marking Code (see table below)
G: Grade Code (A: 0.5%, B: 1.0%, C: 2.0%)
A: Assembly/Test Site Code
Y: Year
W: Week code
WW: Week

Ordering Information

Ordering Number	Precision	Device Code	Grade	Package	Shipping
GM431AT92B	0.5%		A	TO-92	1,000 Units/ESD Bag
GM431AT92RL	0.5%		A	TO-92	2,000 Units/Ammo Pack (Tape)
GM431AST23R	0.5%	AAA		SOT-23	3,000 Units/Tape & Reel
GM431RAST23R	0.5%	RAA		SOT-23	3,000 Units/Tape & Reel
GM431AS8T	0.5%		A	SO-8	100 Units/Tube
GM431AS8R	0.5%		A	SO-8	2,500 Units/Tape & Reel
GM431AST89R	0.5%		A	SOT-89	1,000 Units/Tape & Reel
GM431BT92B	1.0%		B	TO-92	1,000 Units/ESD Bag
GM431BT92RL	1.0%		B	TO-92	2,000 Units/Ammo Pack (Tape)
GM431BST23R	1.0%	AAB		SOT-23	3,000 Units/Tape & Reel
GM431RBST23R	1.0%	RAB		SOT-23	3,000 Units/Tape & Reel
GM431BS8T	1.0%		B	SO-8	100 Units/Tube
GM431BS8R	1.0%		B	SO-8	2,500 Units/Tape & Reel
GM431BST89R	1.0%		B	SOT-89	1,000 Units/Tape & Reel
GM431CT92B	2.0%		A	TO-92	1,000 Units/ESD Bag
GM431CT92RL	2.0%		C	TO-92	2,000 Units/Ammo Pack (Tape)
GM431CST23R	2.0%	AAC		SOT-23	3,000 Units/Tape & Reel
GM431RCST23R	2.0%	RAC		SOT-23	3,000 Units/Tape & Reel
GM431CS8T	2.0%		C	SO-8	100 Units/Tube
GM431CS8R	2.0%		C	SO-8	2,500 Units/Tape & Reel
GM431AST89R	2.0%		C	SOT-89	1,000 Units/Tape & Reel

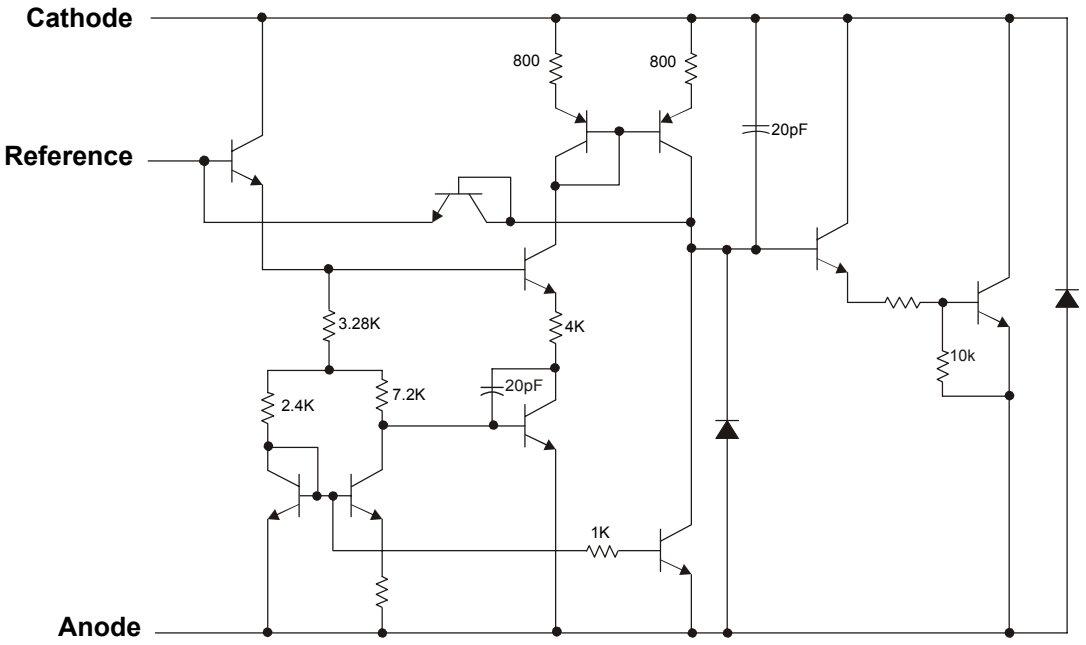
Absolute Maximum Ratings

PARAMETER	SYMBOL	RATINGS	UNITS
Cathode Voltage	V_{KA}	20	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	
SO-8		0.6	
Package Thermal Resistance			
SOT-23	θ_{JA}	336	°C/W
TO-92		132	
SOT-89		132	
SO-8		163	
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}	18	V
Cathode Current	I_K	10	100	mA

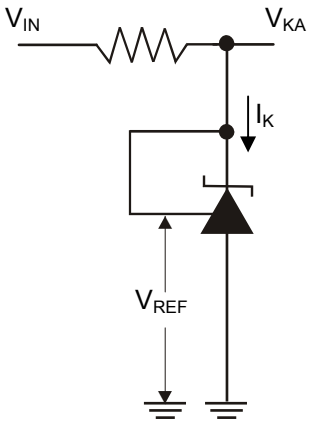
Equivalent Schematics



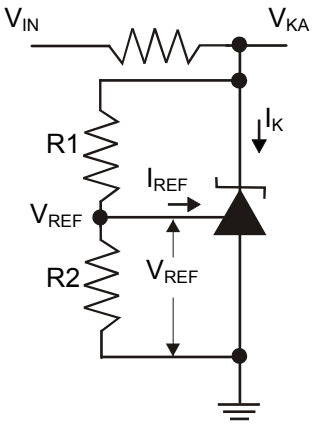
Electrical Characteristics (T_A = 25°C unless otherwise specified)

Parameter		Symbol	Condition		Min	Typ	Max	Unit
Reference Voltage	GM431A	V_{REF}	V_{KA} = V_{REF}, I_K = 10mA, Test circuit 1		2.488	2.500	2.513	mV
	GM431B				2.475	2.500	2.525	
	GM431C				2.450	2.500	2.550	
V_{REF} Deviation over Temperature		$V_{REF(DEV)}$	V_{KA} = V_{REF}, I_K = 10mA, Full Range Test circuit 1			4	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		µA
				ΔV_{KA} = 18V to 10V	-2	-0.4		
Reference Input Current		I_{REF}	I_K = 10mA, R1 = 10K, R2 = ∞ Test circuit 2			1.3	4	µA
I_{REF} Deviation over Temperature		$V_{REF(DEV)}$	I_K = 10mA, R1 = 10K, R2 = ∞ 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} = 18V, V_{REF} = 0V Test circuit 3			0.1	1	µA
Dynamic Impedance		$\|Z_{KA}\|$	V_{KA} = V_{REF}, I_K = 1mA to 10mA, f ≤1kHz, Test circuit 1			0.2	0.5	Ω

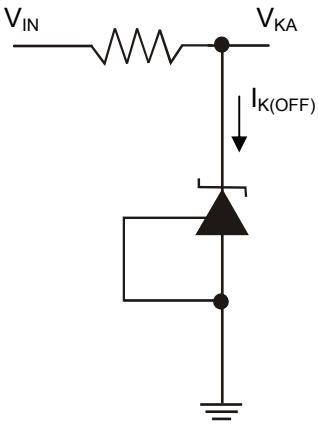
Test Circuits



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



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



Test Circuit 3
Off-State

Typical Characteristics

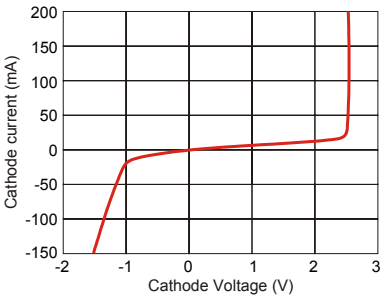


Figure 5. Cathode Current vs. Cathode Voltage

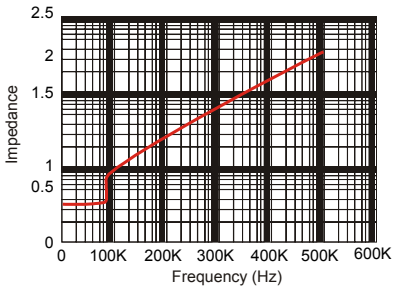


Figure 7. Dynamic Impedance

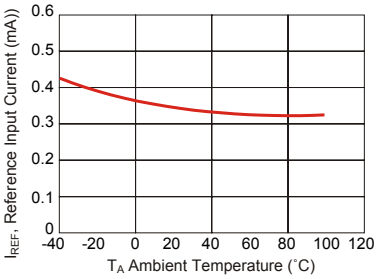


Figure 6. Reference Input Current vs. Ambient Temperature

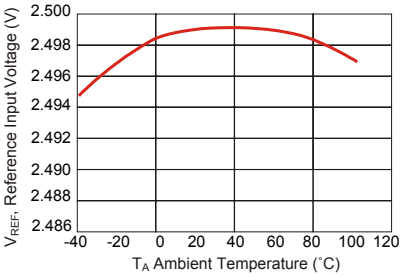


Figure 8. Reference Input Voltage vs. Ambient Temperature

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.

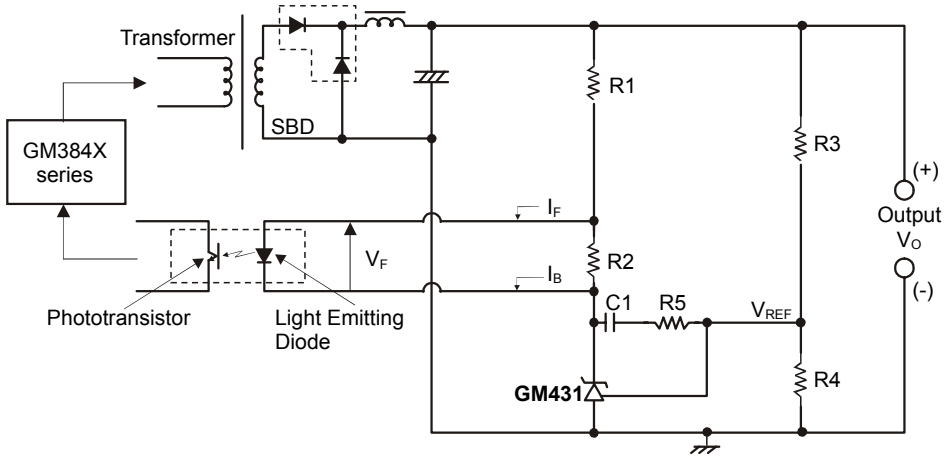


Figure 9. Typical Shunt Regulator/ Error Amplifier

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 GM431 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 GM431 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.

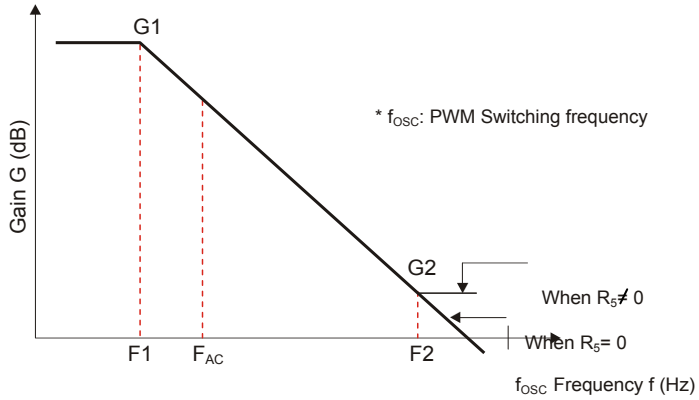


Figure 10. GM431 Error Amplification Characteristic

In Figure 17, the following formulas are obtained:

Gain

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

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

Corner frequencies

$$\mathbf{f_1 = 1/(2pC_1G_0R_3)}$$
$$\mathbf{f_2 = 1/(2pC_1R_5)}$$

G_0 iS the Shunt regulator open-loop gain; this is given by the reciprocal of the reference voltage fluctuation:

$\mathbf{\Delta V_{REF}/\Delta V_{KA}}$**, 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.

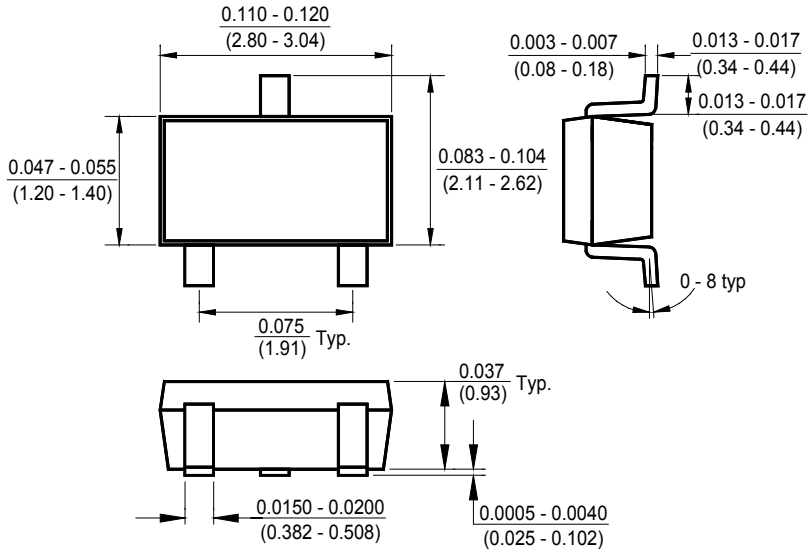
$$\mathbf{R_1 = \frac{5V - 1.05V - 3V}{2.5mA + 0.54mA} = 316\Omega}$$

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

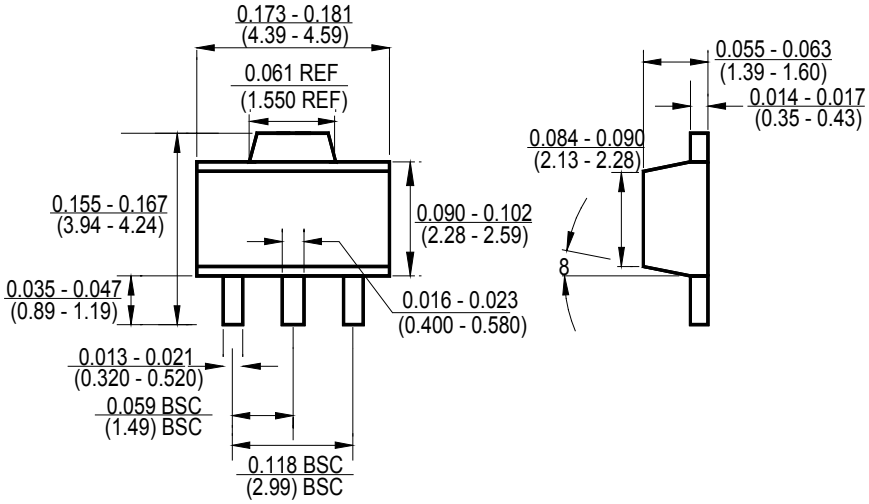
Next, assume that R3 = R4 = 10k. This gives a 5V output. If R5 = 3.3 k, and C1 = 0.022 pF, the following values are found.

G2 = 3.3kΩ / 10kΩ = 0.33 times (-10 dB)
f_1 = 1 / (2 × π × 0.022μF × 316 × 10 k) = 2.3 (Hz)
f_1 = 1 / (2 × π × 0.022μF × 3.3k) = 2.2 (kHz) 2

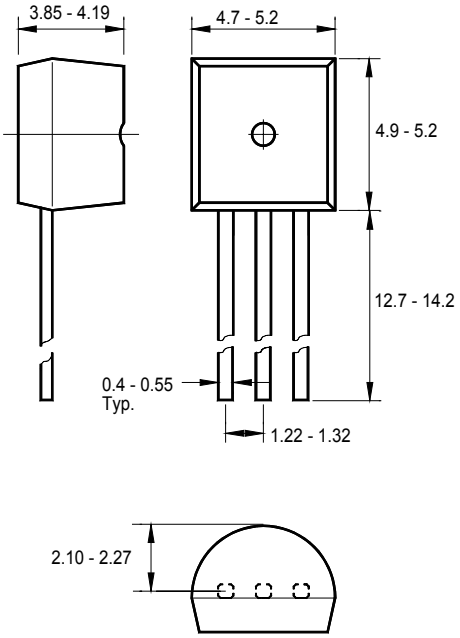
Package Outline Dimensions – SOT 23



Package Outline Dimensions – SOT 89

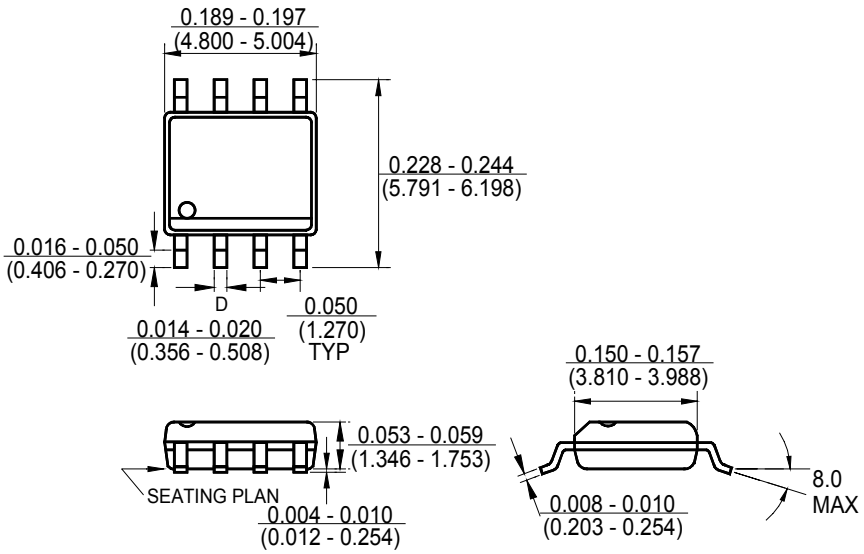


Package Outline Dimensions – TO 92



Dimensions are in millimeters

Package Outline Dimensions – SO 8



Ordering Number

GM	431	A	T92	R
APM Gamma Micro	Circuit Type	Output Accuracy	Package Type	Shipping Type
		A: 0.5% B: 1.0% C: 2.0%	T92: TO-92 ST23:SOT-23 ST89: SOT-89 S8: SO-8	B: Bag RL: Ammo Pack (Tape) T: Tube R: Tape & Reel

Ordering Number

GM	431R	A	ST23	R
APM Gamma Micro	Circuit Type	Output Accuracy	Package Type	Shipping Type
		A: 0.5% B: 1.0% C: 2.0%	ST23:SOT-23	R: Tape & Reel