

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 SOT-23, and TO-92, SOT-89 and Sop-8 packages

Application

Switching power supplies

Linear regulator

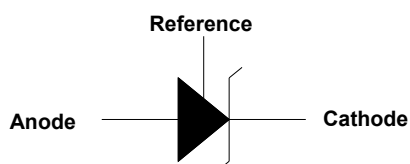
Adjustable supplies

Battery-operated computers

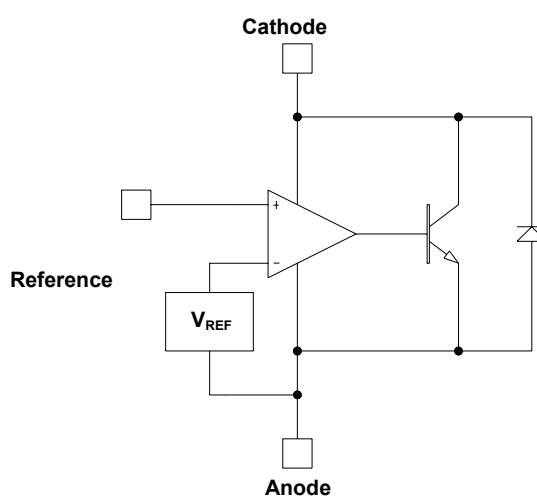
Computer disk drives

Instrumentation

Logic Symbol

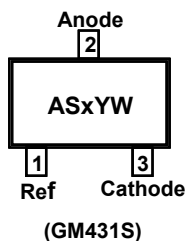


Block Diagram

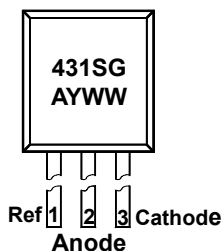


Marking Information and Pin Configurations (Top View)

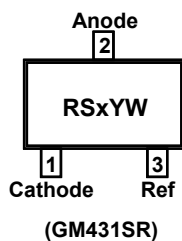
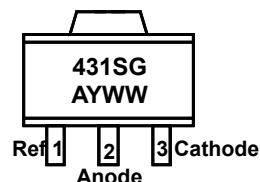
SOT23



TO92



SOT89



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
GM431SAT92B	0.5%		A	TO-92	1,000 Units/ESD Bag
GM431SAT92RL	0.5%		A	TO-92	2,000 Units/Ammo Pack (Tape)
GM431SAST23R	0.5%	ASA		SOT-23	3,000 Units/Tape & Reel
GM431SRAST23R	0.5%	RSA		SOT-23	3,000 Units/Tape & Reel
GM431SAST89R	0.5%		A	SOT-89	1,000 Units/Tape & Reel
GM431SBT92B	1.0%		B	TO-92	1,000 Units/ESD Bag
GM431SBT92RL	1.0%		B	TO-92	2,000 Units/Ammo Pack (Tape)
GM431SBST23R	1.0%	ASB		SOT-23	3,000 Units/Tape & Reel
GM431SRBST23R	1.0%	RSB		SOT-23	3,000 Units/Tape & Reel
GM431BST89R	1.0%		B	SOT-89	1,000 Units/Tape & Reel

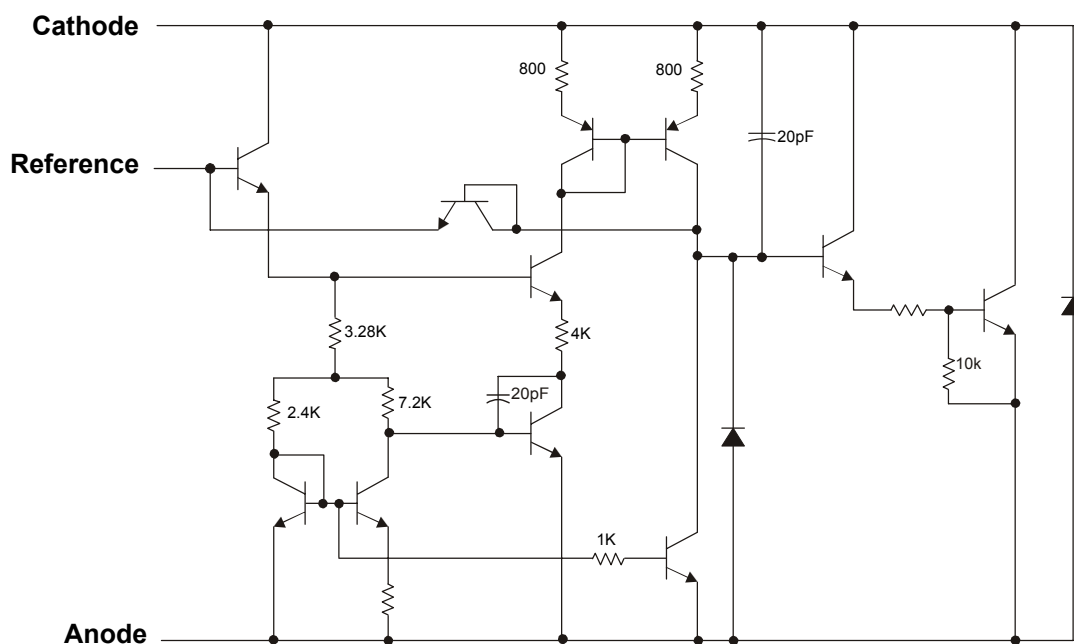
Absolute Maximum Ratings

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

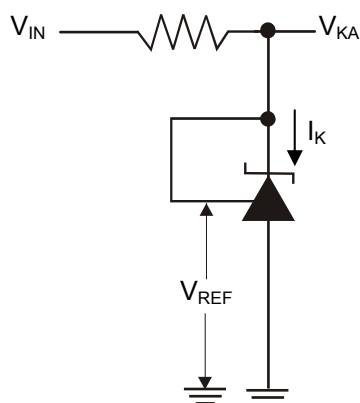
Equivalent Schematics



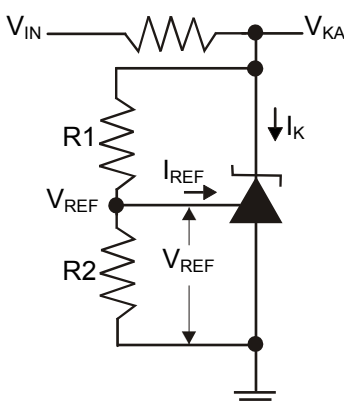
Electrical Characteristics ($T_A = 25^\circ\text{C}$ unless otherwise specified)

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

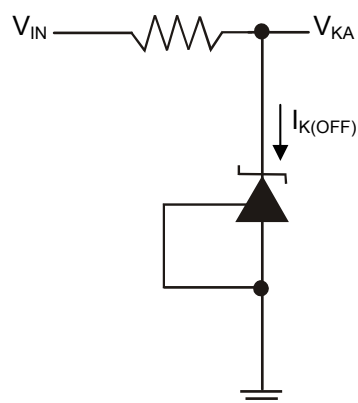
Test Circuits



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



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



Test Circuit 3
Off-State

Typical Characteristics

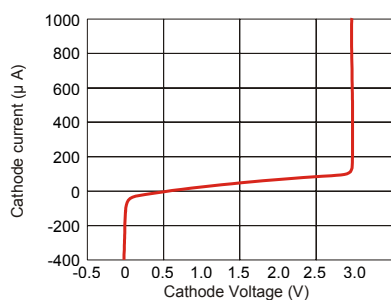


Figure 4. Cathode Current vs. Cathode Voltage

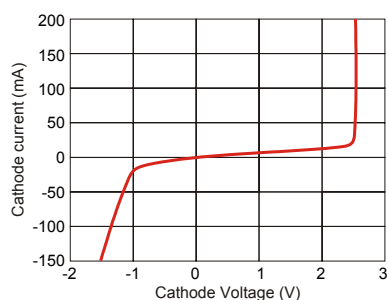


Figure 5. Cathode Current vs. Cathode Voltage

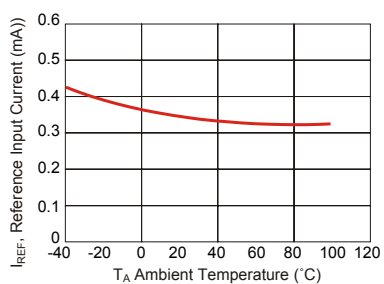


Figure 6. Reference Input Current vs. Ambient Temperature

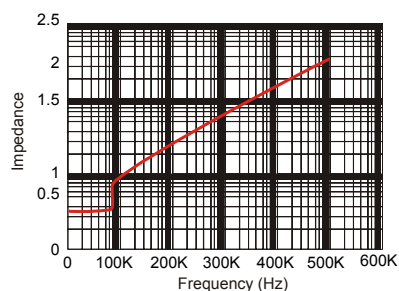


Figure 7. Dynamic Impedance

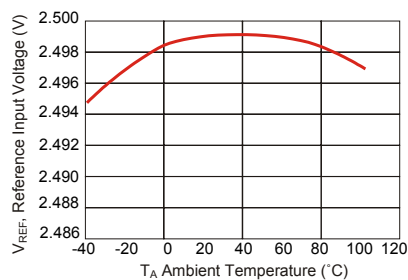


Figure 8. Reference Input Voltage vs. Ambient Temperature

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.

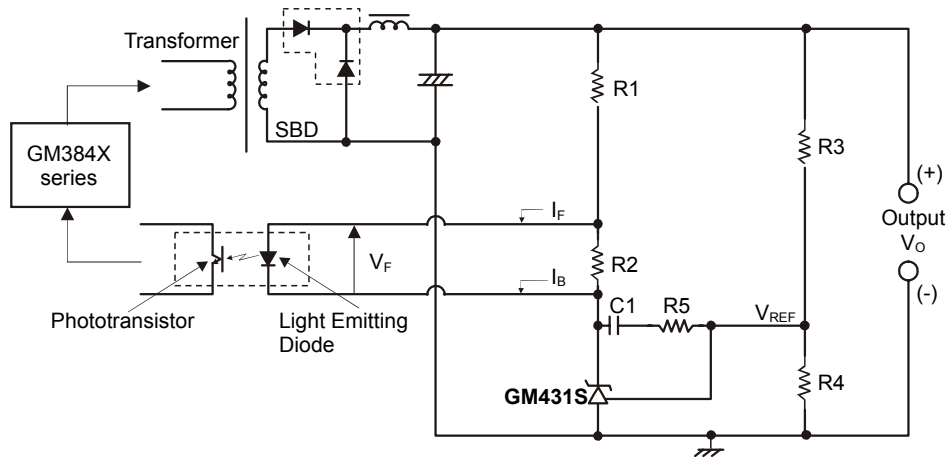


Figure 9. Typical Shunt Regulator/ Error Amplifier

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:

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

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 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 R3 and R4, and the following formula is obtained:

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

The absolute values 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} value 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 amplifier. Taking the configuration in Figure 10, the error amplifier characteristic is as Shown in Figure 10.

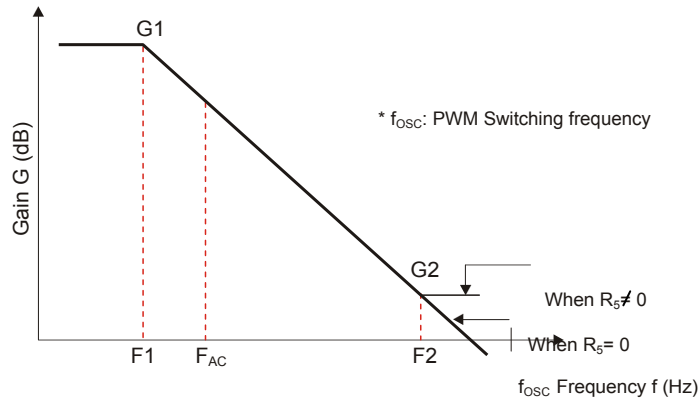


Figure 10. GM431S Error Amplification Characteristic

In Figure 17, the following formulas are obtained:

Gain

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

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

Corner frequencies

$$f_1 = 1/(2\pi C_1 G_0 R_3)$$

$$f_2 = 1/(2\pi C_1 R_5)$$

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 50 dB.

Practical Example

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

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

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

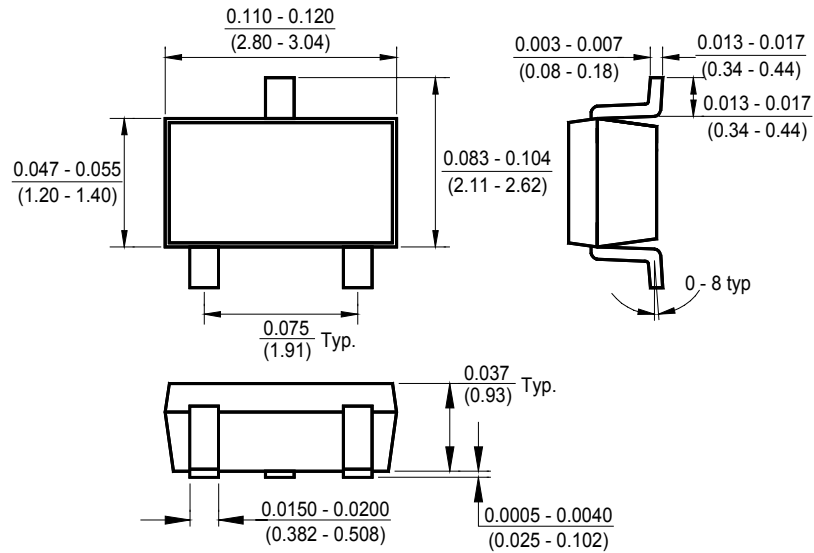
Next, assume that $R_3 = R_4 = 10 \text{ k}$. This gives a 5 V output. If $R_5 = 3.3 \text{ k}$, and $C_1 = 0.022 \text{ pF}$, the following values are found.

$$G_2 = 3.3 \text{ k}\Omega / 10 \text{ k}\Omega = 0.33 \text{ times } (-10 \text{ dB})$$

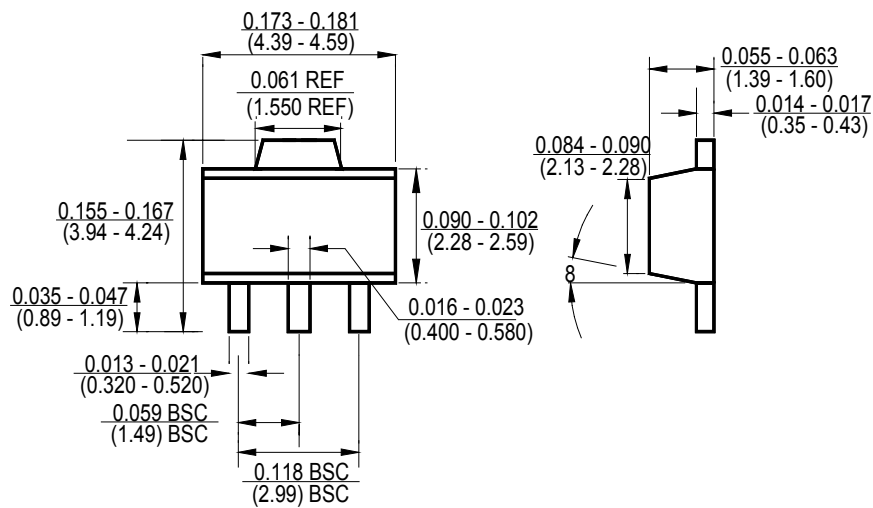
$$f_1 = 1 / (2 \times \pi \times 0.022 \mu\text{F} \times 316 \times 10 \text{ k}) = 2.3 \text{ (Hz)}$$

$$f_2 = 1 / (2 \times \pi \times 0.022 \mu\text{F} \times 3.3 \text{ k}) = 2.2 \text{ (kHz)}$$

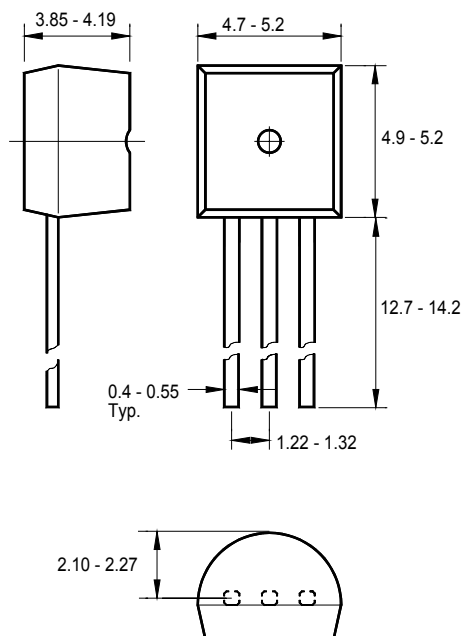
Package Outline Dimensions – SOT 23



Package Outline Dimensions – SOT 89



Package Outline Dimensions – TO 92



Dimensions are in millimeters

Ordering Number

GM 431S 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 431SR 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