

### GENERAL DESCRIPTION

The SGM431V is a low-voltage, three-terminal adjustable shunt regulator, with specified thermal stability over applicable commercial and industrial temperature ranges. The output voltage can be set to any value between  $V_{REF}$  (approximately 1.24V) and 18V, with two external resistors.

The SGM431V has a typical output impedance of 0.1 $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making it an excellent replacement for low-voltage Zener diodes in many applications, such as onboard regulation and adjustable power supplies.

In addition, low output drift versus temperature ensures good stability over the entire temperature range.

The SGM431V is available in a Green SOT-23 package.

### FEATURES

- **Low Voltage Operation: Down to 1.24V**
- **Reference Voltage Tolerance at +25°C:**
  - ◆ **SGM431VA: 1% (A Grade)**
  - ◆ **SGM431VB: 0.5% (B Grade)**
- **Adjustable Output Voltage:  $V_{REF}$  to 18V**
- **Wide Operating Cathode Current Range: 0.1mA to 70mA**
- **Typical Output Impedance: 0.1 $\Omega$**
- **Operating Junction Temperature Range: -40°C to +125°C**
- **Available in a Green SOT-23 Package**

### APPLICATIONS

- Adjustable Voltage and Current Referencing
- Secondary Side Regulation in Flyback SMPSs
- Zener Replacement
- Voltage Monitoring
- Comparator with Integrated Reference

### TYPICAL APPLICATION

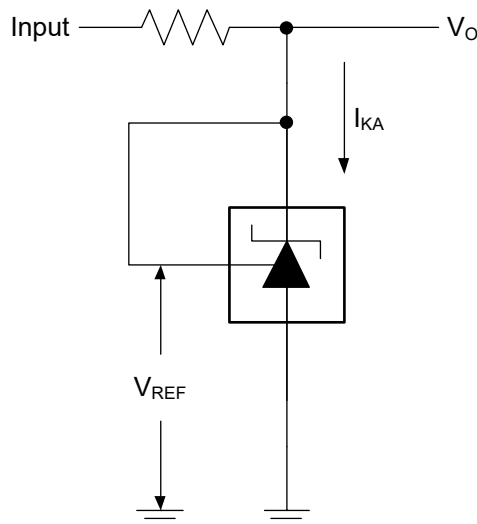


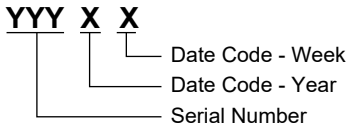
Figure 1. Typical Application Circuit

**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM431VA	SOT-23	-40°C to +125°C	SGM431VAXN3LG/TR	OR9XX	Tape and Reel, 3000
SGM431VB	SOT-23	-40°C to +125°C	SGM431VBXN3LG/TR	R9AXX	Tape and Reel, 3000

**MARKING INFORMATION**

NOTE: XX = Date Code.



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

**ABSOLUTE MAXIMUM RATINGS**

- Cathode Voltage <sup>(1)</sup>, V<sub>KA</sub>..... 20V
- Package Thermal Resistance
- SOT-23,  $\theta_{JA}$ ..... 290°C/W
- Junction Temperature .....+150°C
- Storage Temperature Range.....-65°C to +150°C
- Lead Temperature (Soldering, 10s) .....+260°C
- ESD Susceptibility
- HBM..... 8000V
- CDM ..... 2000V

**RECOMMENDED OPERATING CONDITIONS**

- Cathode Voltage, V<sub>KA</sub> ..... V<sub>REF</sub> to 18V
- Cathode Current, I<sub>KA</sub>.....0.1mA to 70mA
- Operating Junction Temperature Range.....-40°C to +125°C

NOTE:

- All voltage values are with respect to ANODE, unless otherwise noted.

**OVERSTRESS CAUTION**

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

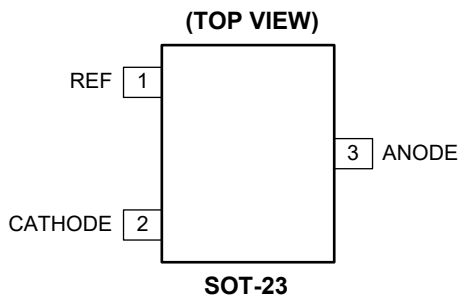
**ESD SENSITIVITY CAUTION**

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

**DISCLAIMER**

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

## PIN CONFIGURATION



## PIN DESCRIPTION

PIN	NAME	TYPE	DESCRIPTION
1	REF	I	Threshold Relative to Common Anode.
2	CATHODE	I/O	Shunt Current/Voltage Input.
3	ANODE	O	Common Pin. Normally connected to ground.

NOTE: I: input, O: output, I/O: input or output.

**ELECTRICAL CHARACTERISTICS**

(Over recommended operating conditions, T<sub>J</sub> = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>SGM431VA</b>							
Reference Voltage	V <sub>REF</sub>	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA	T <sub>J</sub> = +25°C	1.228	1.240	1.252	V
			T <sub>J</sub> = -40°C to +125°C	1.220		1.260	
Deviation of Reference Input Voltage over Full Temperature Range <sup>(1)</sup>	V <sub>I(DEV)</sub>	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA		2	10	mV	
Ratio of Change in Reference Voltage to the Change in Cathode Voltage	ΔV <sub>REF</sub> /ΔV <sub>KA</sub>	I <sub>KA</sub> = 10mA, V <sub>KA</sub> = V <sub>REF</sub> to 18V		-0.1	-0.2	mV/V	
Reference Input Current	I <sub>REF</sub>	I <sub>KA</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = open, see Figure 9		0.06	0.15	μA	
Deviation of Reference Input Current over Full Temperature Range <sup>(1)</sup>	I <sub>I(DEV)</sub>	I <sub>KA</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = open, see Figure 9		0.15	0.5	μA	
Minimum Cathode Current for Regulation	I <sub>MIN</sub>	V <sub>KA</sub> = V <sub>REF</sub>		65	80	μA	
Off-State Cathode Current	I <sub>K(OFF)</sub>	V <sub>KA</sub> = 18V, V <sub>REF</sub> = 0V		0.01	0.1	μA	
Dynamic Impedance <sup>(2)</sup>	Z <sub>KA</sub>	V <sub>KA</sub> = V <sub>REF</sub> , f ≤ 1kHz, I <sub>KA</sub> = 0.1mA to 70mA		0.1	0.3	Ω	
<b>SGM431VB</b>							
Reference Voltage	V <sub>REF</sub>	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA	T <sub>J</sub> = +25°C	1.234	1.240	1.246	V
			T <sub>J</sub> = -40°C to +125°C	1.225		1.255	
Deviation of Reference Input Voltage over Full Temperature Range <sup>(1)</sup>	V <sub>I(DEV)</sub>	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA		2	10	mV	
Ratio of Change in Reference Voltage to the Change in Cathode Voltage	ΔV <sub>REF</sub> /ΔV <sub>KA</sub>	I <sub>KA</sub> = 10mA, V <sub>KA</sub> = V <sub>REF</sub> to 18V		-0.1	-0.2	mV/V	
Reference Input Current	I <sub>REF</sub>	I <sub>KA</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = open, see Figure 9		0.06	0.15	μA	
Deviation of Reference Input Current over Full Temperature Range <sup>(1)</sup>	I <sub>I(DEV)</sub>	I <sub>KA</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = open, see Figure 9		0.15	0.5	μA	
Minimum Cathode Current for Regulation	I <sub>MIN</sub>	V <sub>KA</sub> = V <sub>REF</sub>		65	80	μA	
Off-State Cathode Current	I <sub>K(OFF)</sub>	V <sub>KA</sub> = 18V, V <sub>REF</sub> = 0V		0.01	0.1	μA	
Dynamic Impedance <sup>(2)</sup>	Z <sub>KA</sub>	V <sub>KA</sub> = V <sub>REF</sub> , f ≤ 1kHz, I <sub>KA</sub> = 0.1mA to 70mA		0.1	0.3	Ω	

NOTES:

1. The deviation parameters V<sub>I(DEV)</sub> and I<sub>I(DEV)</sub> are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage α<sub>VREF</sub> is defined as:

$$|\alpha_{VREF}| \left( \frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left( \frac{V_{I(DEV)}}{V_{REF \text{ at } 25^{\circ}\text{C}}} \right) \times 10^6}{\Delta T_J}$$

where,

ΔT<sub>J</sub> is the rated operating junction temperature range of the device.

α<sub>VREF</sub> is positive or negative, depending on whether minimum V<sub>REF</sub> or maximum V<sub>REF</sub>, respectively, occurs at the lower temperature.

2. The dynamic impedance is defined as:

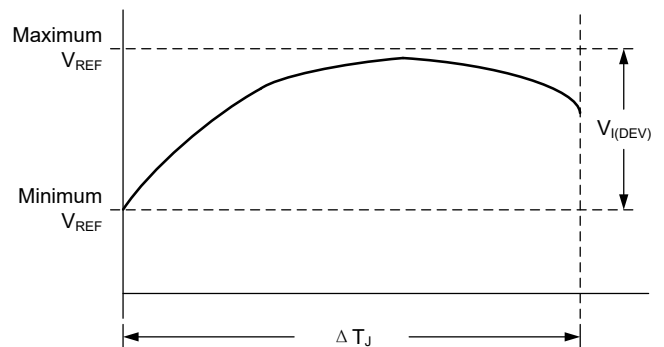
$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

$$|Z| = \frac{\Delta V}{\Delta I}$$

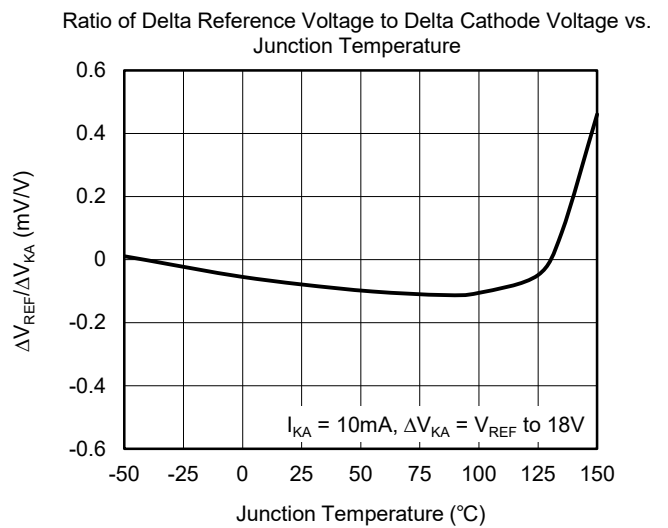
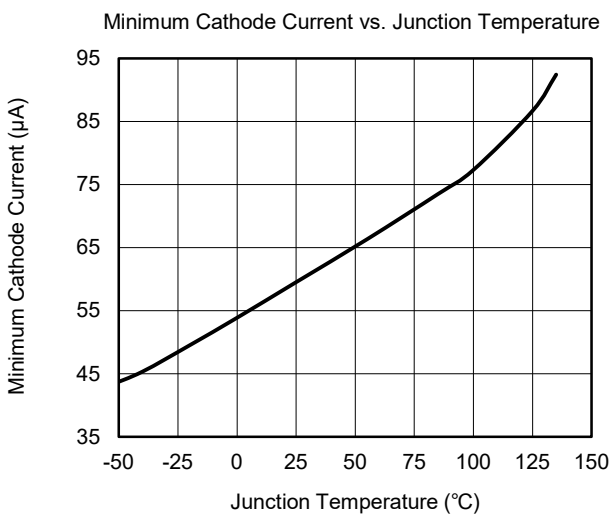
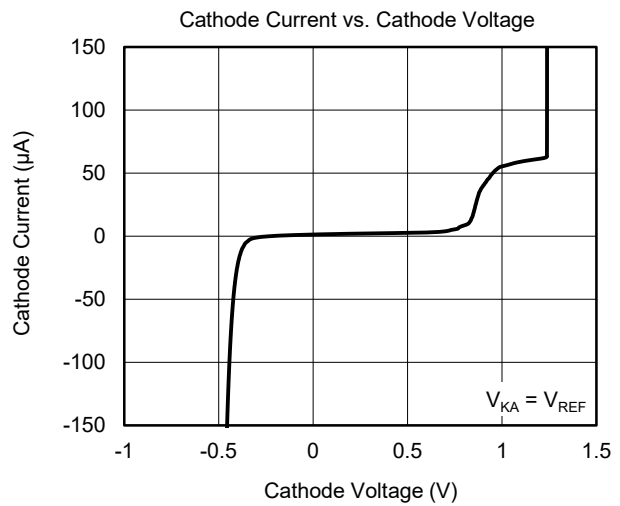
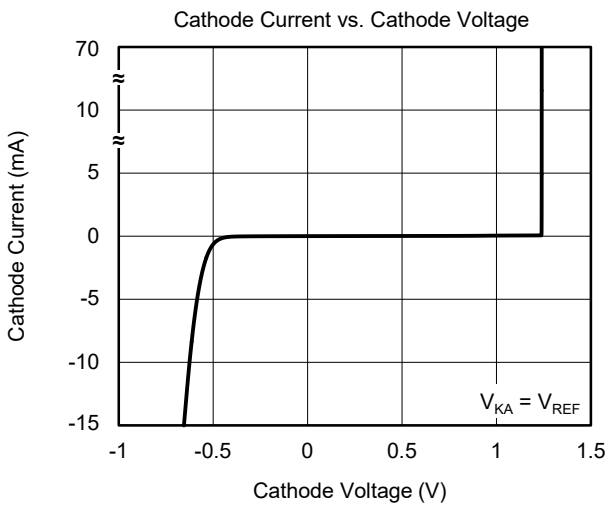
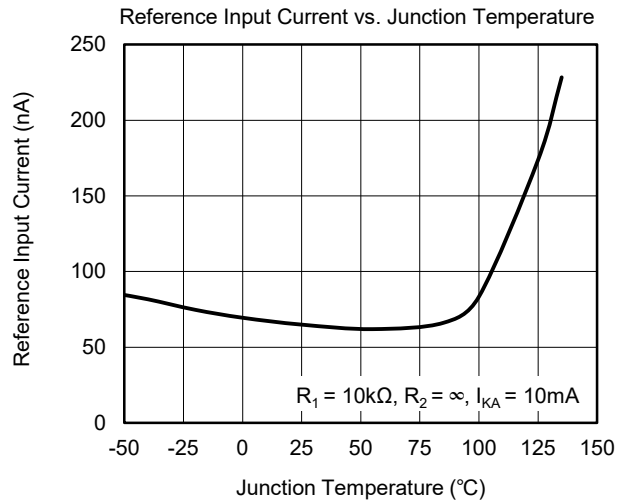
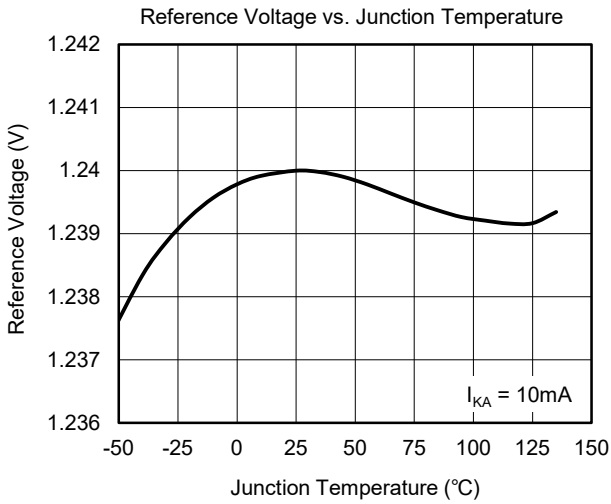
which is approximately equal to

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



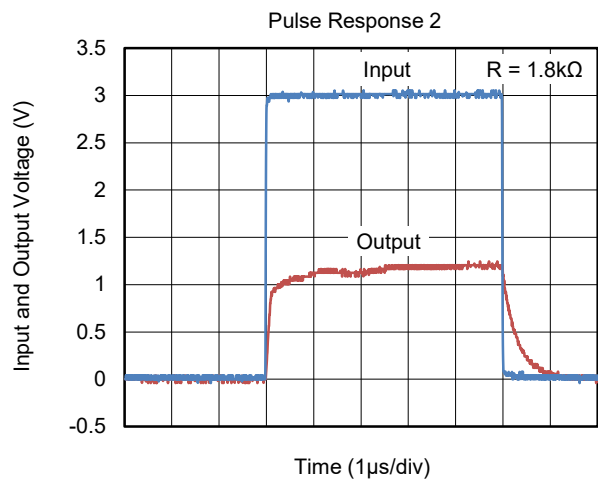
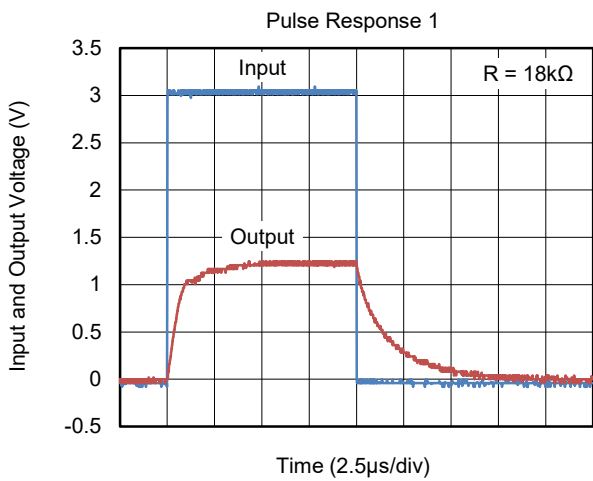
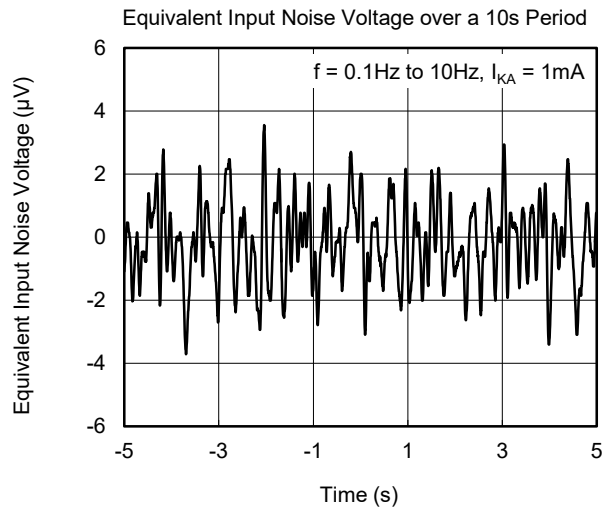
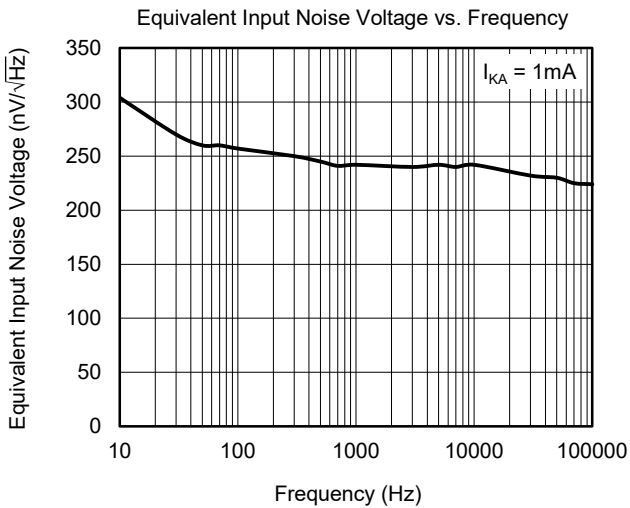
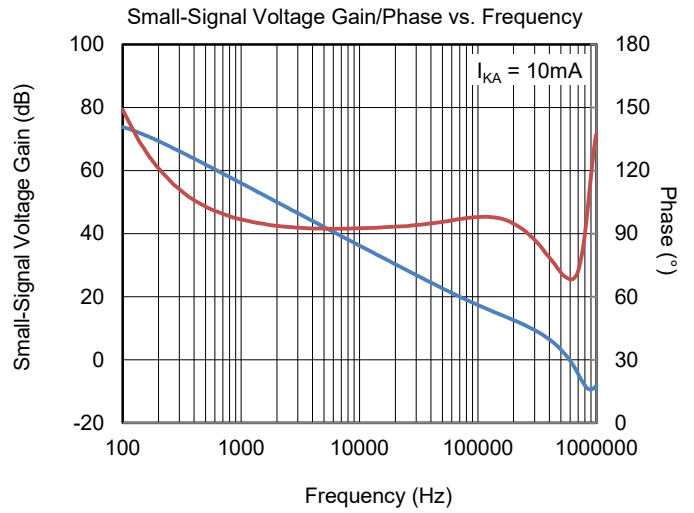
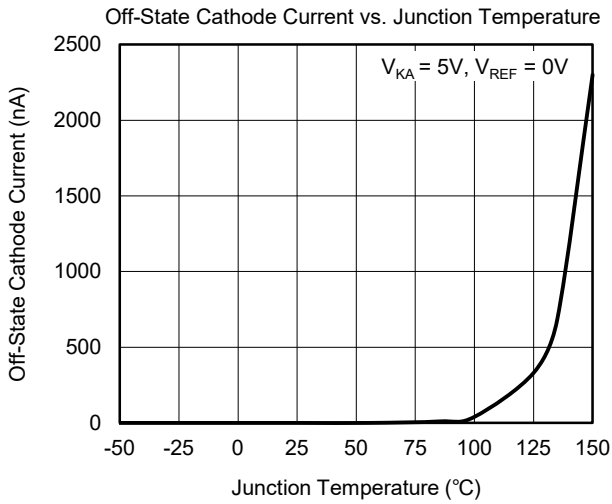
TYPICAL PERFORMANCE CHARACTERISTICS

T<sub>J</sub> = +25°C, unless otherwise noted.



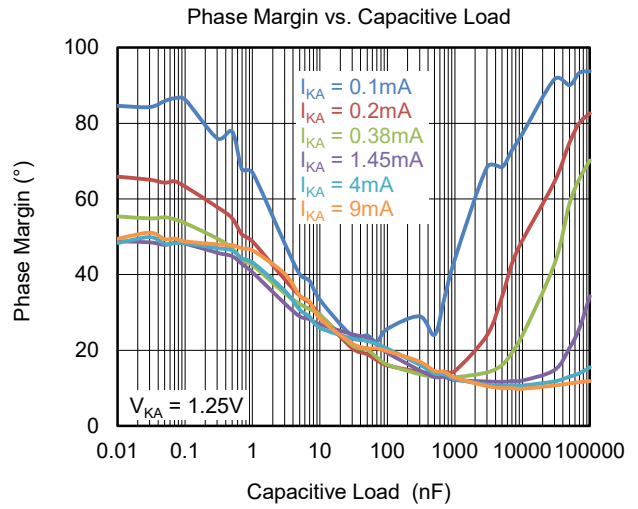
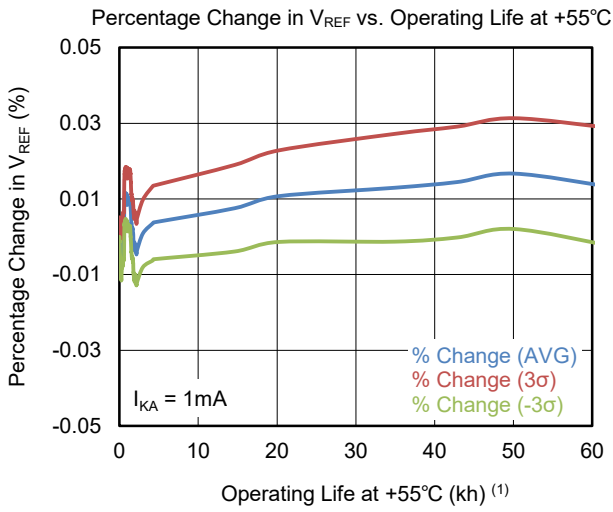
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T<sub>J</sub> = +25°C, unless otherwise noted.

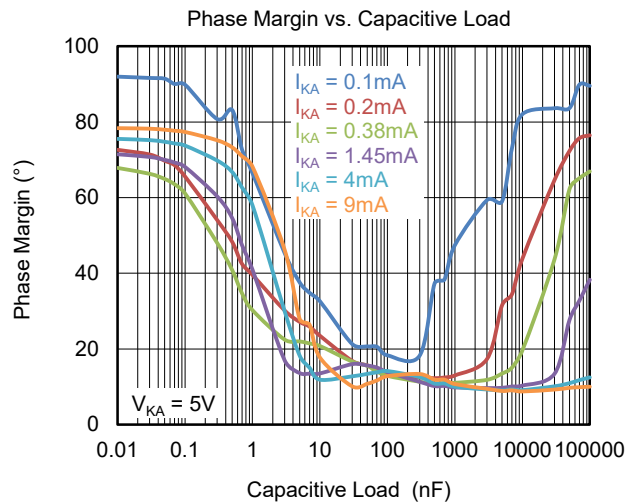
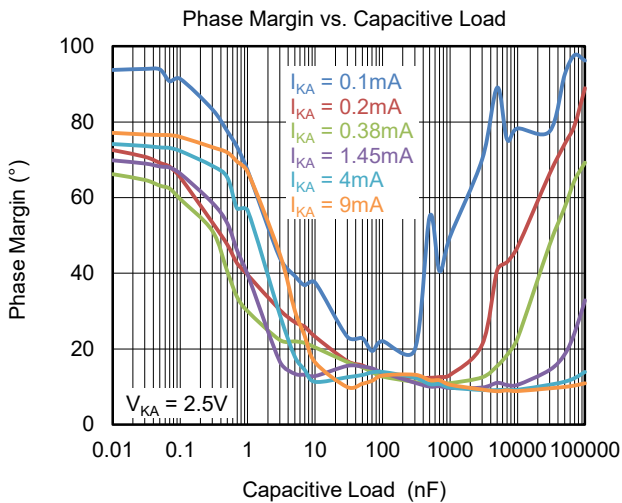


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T<sub>J</sub> = +25°C, unless otherwise noted.



NOTE: (1) Extrapolated from test data taken at +125°C; the activation energy assumed is 0.7eV



TEST CIRCUITS

Typical Characteristics Measurement Information

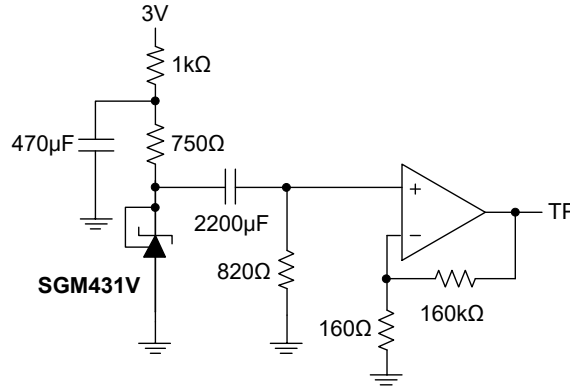


Figure 2. Test Circuit for Equivalent Input Noise Voltage

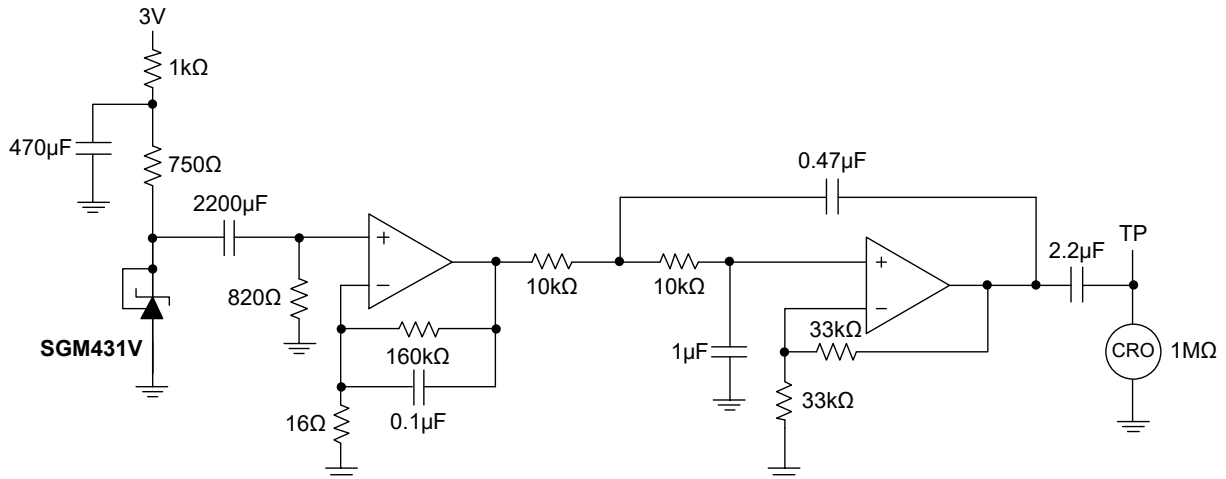


Figure 3. Test Circuit for 0.1Hz to 10Hz Equivalent Noise Voltage

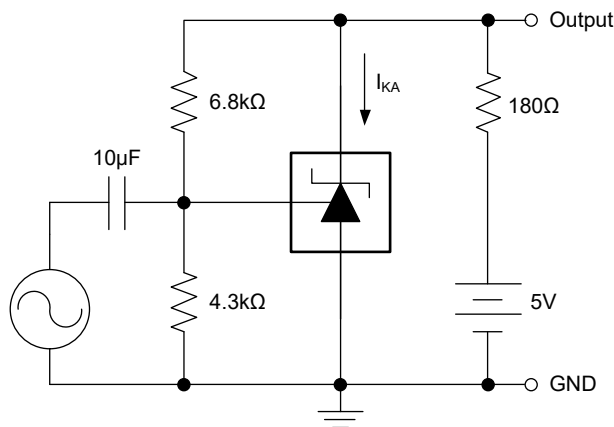


Figure 4. Test Circuit for Voltage Gain and Phase



TEST CIRCUITS (continued)

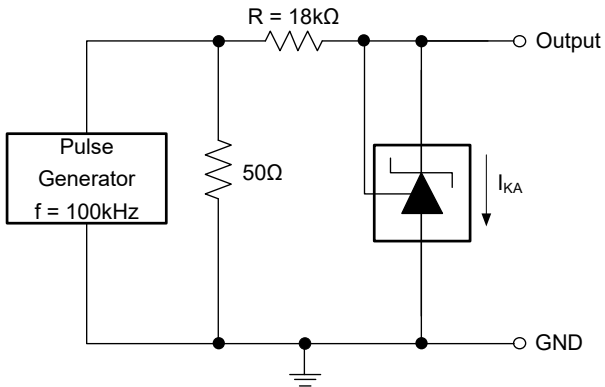


Figure 5. Test Circuit for Pulse Response 1

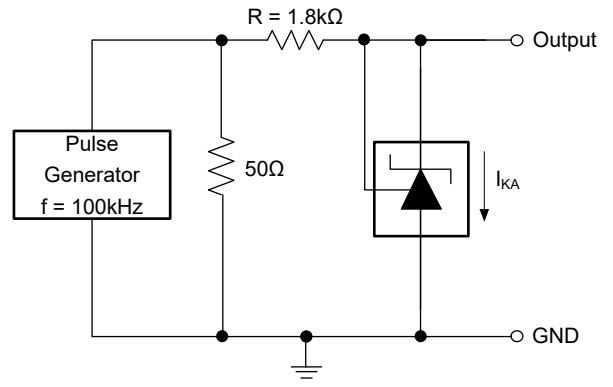


Figure 6. Test Circuit for Pulse Response 2

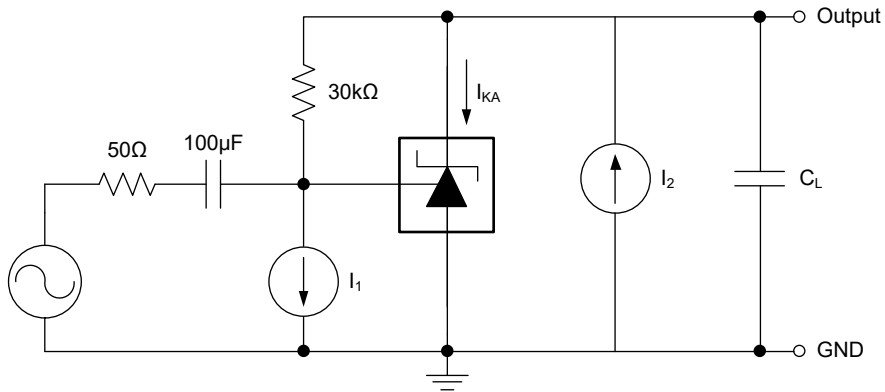


Figure 7. Test Circuit for Phase Margin

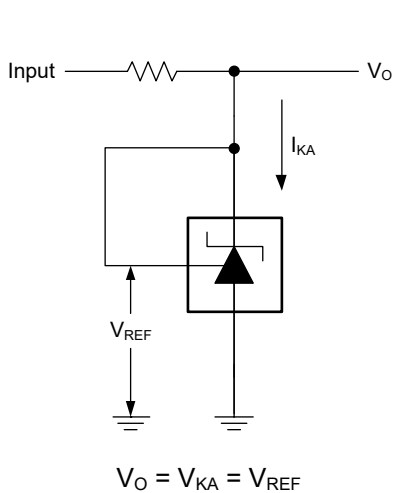


Figure 8. Test Circuit for  $V_{KA} = V_{REF}$

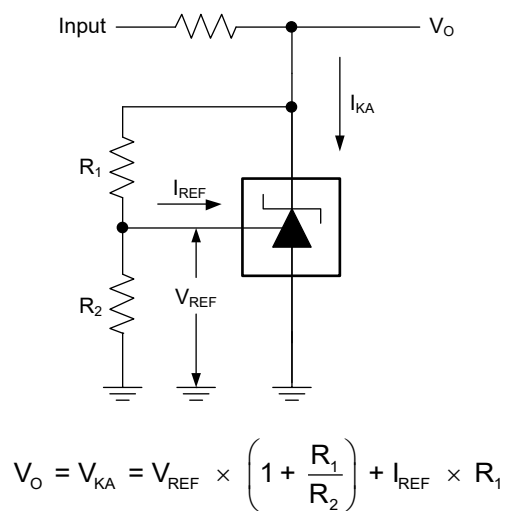


Figure 9. Test Circuit for  $V_{KA} > V_{REF}$

TEST CIRCUITS (continued)

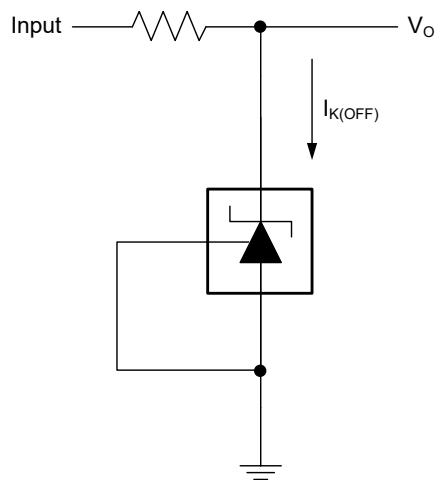


Figure 10. Test Circuit for  $I_{K(OFF)}$

FUNCTIONAL BLOCK DIAGRAM

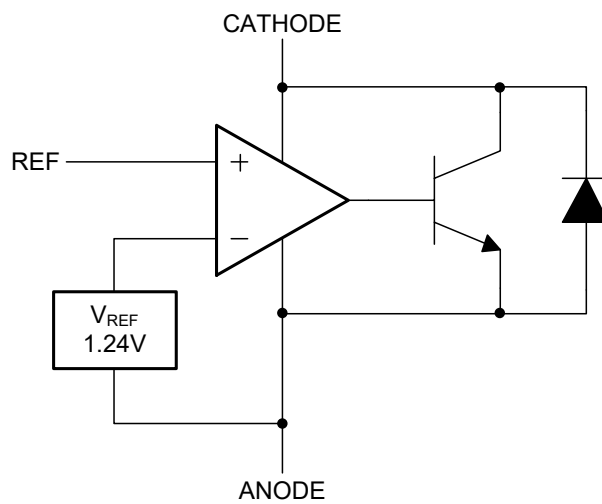


Figure 11. Equivalent Schematic

APPLICATION INFORMATION

Comparator with Integrated Reference (Open Loop)

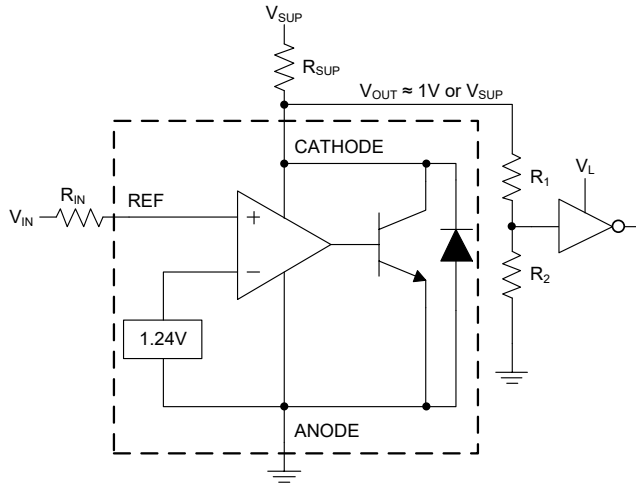


Figure 12. Comparator Application Schematic

Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

Design Parameter	Example Value
Input Voltage Range	0V to 5V
Input Resistance	10kΩ
Supply Voltage	9V
Cathode Current (I <sub>KA</sub> )	500μA
Output Voltage Level	~1V to V <sub>SUP</sub>
Logic Input Thresholds V <sub>IH</sub> /V <sub>IL</sub>	V <sub>L</sub>

In Figure 12, the SGM431V will behave as a comparator, comparing the REF pin voltage to the internal reference voltage. When provided a proper cathode current (I<sub>KA</sub>), the SGM431V will have enough open-loop gain to provide a quick response. With the SGM431V's maximum operating current (I<sub>MIN</sub>) being 80μA, operation below that could result in low gain, leading to a slow response.

Slow or inaccurate responses can also occur when the REF pin is not provided enough overdrive voltage. This is the amount of voltage that is higher than the internal reference. The internal reference voltage will be approximate 1.24V, the more overdrive voltage provided, the faster the SGM431V will respond. For fast response, setting the trip point to > 10% of the internal V<sub>REF</sub> should suffice.

For minimal voltage drop or difference from V<sub>IN</sub> to the REF pin, it is recommended to use an input resistor < 10kΩ to provide I<sub>REF</sub>. The logic output must be readable by the receiving logic device. This is accomplished by knowing the input high and low level threshold voltage levels, typically denoted by V<sub>IH</sub> and V<sub>IL</sub>. In Figure 13 and Figure 14, the SGM431V's output low level voltage in open-loop/comparator mode is around 1V, which is typically sufficient for 3.3V supplied logic. However, it would not work for 2.5V or 1.8V supplied logic. In order to accommodate this, a resistive divider can be tied to the output to attenuate the output voltage to a voltage legible to the receiving low voltage logic device.

The SGM431V's output high voltage is equal to V<sub>SUP</sub> due to the SGM431V being open-collector. If V<sub>SUP</sub> is much higher than the receiving logic's maximum input voltage tolerance, the output must be attenuated to accommodate the outgoing logic's reliability. When using a resistive divider on the output, be sure to make the sum of the resistive divider (R<sub>1</sub> and R<sub>2</sub> in Figure 12) is much greater than R<sub>SUP</sub> in order to not interfere with the SGM431V's ability to pull close to V<sub>SUP</sub> when turning off.

The SGM431V requires an input resistance in this application in order to source the reference current (I<sub>REF</sub>) needed from this device to be in the proper operating regions while turning on. The actual voltage seen at the REF pin will be V<sub>REF</sub> = V<sub>IN</sub> - I<sub>REF</sub> × R<sub>IN</sub>. Since I<sub>REF</sub> can be as high as 0.15μA it is recommended to use a resistance small enough that will mitigate the error that I<sub>REF</sub> creates from V<sub>IN</sub>.

APPLICATION INFORMATION (continued)

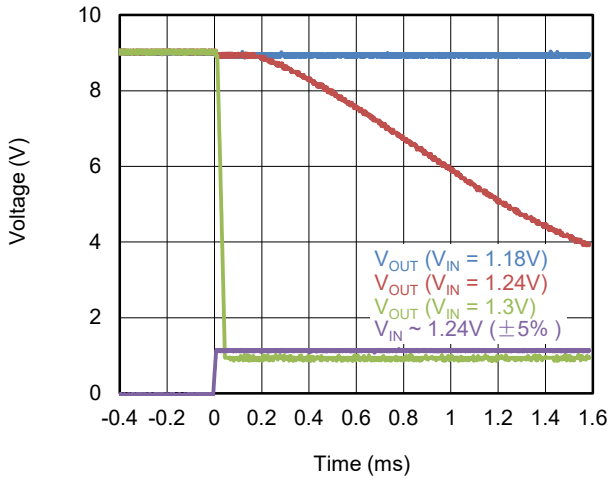


Figure 13. Output Response with Small Overdrive Voltages

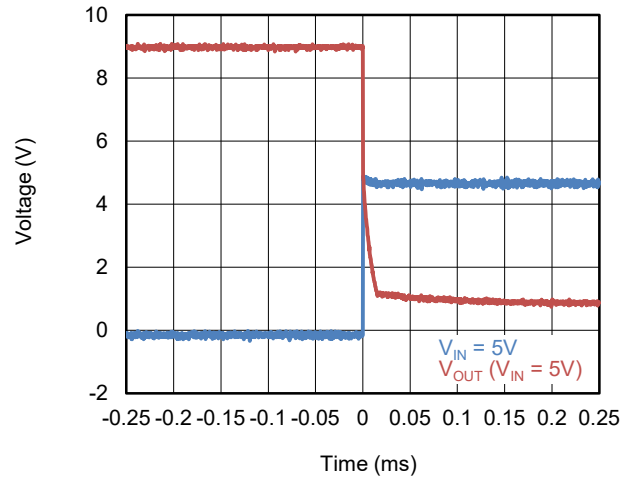


Figure 14. Output Response with Large Overdrive Voltage

Shunt Regulator/Reference

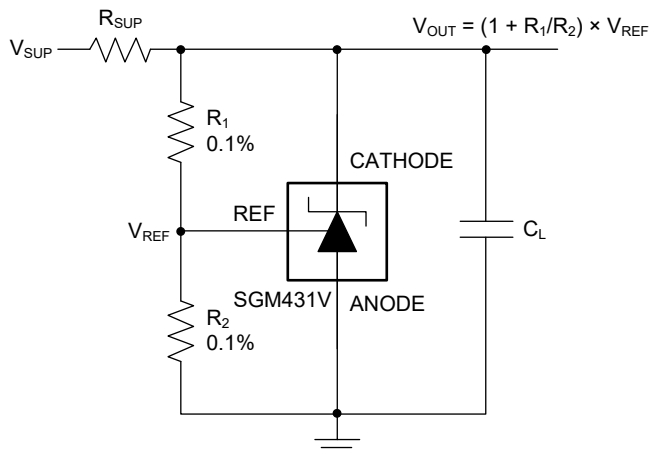


Figure 15. Shunt Regulator Schematic

Design Requirements

For this design example, use the parameters listed in Table 2 as the input parameters.

Table 2. Design Parameters

Design Parameter	Example Value
Reference Initial Accuracy	1.0%
Supply Voltage	6V
Cathode Current ( $I_{KA}$ )	500 $\mu$ A
Output Voltage Level	1.24V to 6V
Load Capacitance	4.7 $\mu$ F
Feedback Resistor Values and Accuracy ( $R_1$ and $R_2$ )	10k $\Omega$

Detailed Design Procedure

When using SGM431V as a shunt regulator, determine the following:

- ◆ Input Voltage Range
- ◆ Temperature Range
- ◆ Total Accuracy
- ◆ Cathode Current
- ◆ Reference Initial Accuracy
- ◆ Output Capacitance

Programming Output/Cathode Voltage

In order to program the cathode voltage to a regulated voltage a resistive divider must be shunted between the CATHODE and ANODE pins with the mid-point tied to the REF pin. This can be seen in Figure 15, with  $R_1$  and  $R_2$  being the resistive divider. The cathode/output voltage in the shunt regulator configuration can be approximated by the equation shown in Figure 15. The cathode voltage can be more accurately determined by taking into account the reference input current:

$$V_{OUT} = V_{REF} \times \left( 1 + \frac{R_1}{R_2} \right) + I_{REF} \times R_1$$

In order for this equation to be valid, the SGM431V must be fully biased so that it has enough open-loop gain to mitigate any gain error. This can be done by meeting the  $I_{MIN}$  specification denoted in Electrical Characteristics.

APPLICATION INFORMATION (continued)

**Total Accuracy**

When programming the output above unity gain ( $V_{KA} = V_{REF}$ ), the SGM431V is susceptible to other errors that may effect the overall accuracy beyond  $V_{REF}$ . These errors include:

- ♦  $R_1$  and  $R_2$  accuracies
- ♦  $V_{I(DEV)}$ : change in reference voltage over temperature
- ♦  $\Delta V_{REF}/\Delta V_{KA}$ : change in reference voltage to the change in cathode voltage
- ♦  $|Z_{KA}|$ : dynamic impedance, causing a change in cathode voltage with cathode current

Worst case cathode voltage can be determined by taking all of the variables into account.

**Stability**

For a traditional 431 device, the reference output stability is affected by output decoupling capacitor which must be selected in a limited range in order to keep 431 device stable in applications. However, the SGM431V is different from the others, the SGM431V uses a special design to greatly improve output stability when it drives capacitive load. The output of the SGM431V is stable in a wider range of capacitive load. If the SGM431V is used as a linear regulator, a bigger decoupling capacitor can be used to improve regulator's load transient or reduce the noise of power supply. If the SGM431V is used to replace the others, the SGM431V will be stable and there is no need to change the output decoupling capacitor in the original design.

**Start-Up Time**

As shown in Figure 16, the SGM431V has a fast response suitable for many clamp applications.

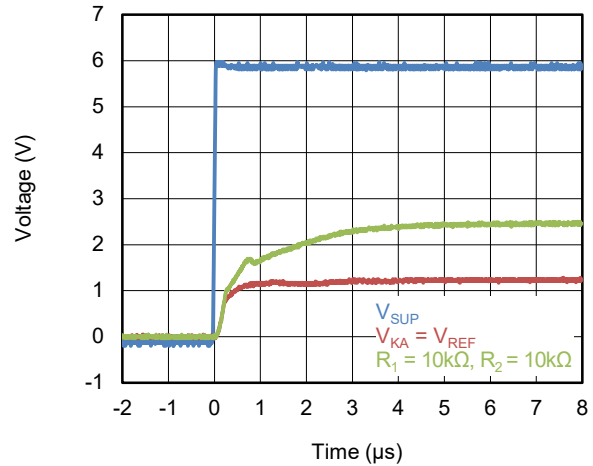


Figure 16. SGM431V Start-Up Response

**Power Supply Recommendations**

When using the SGM431V as a linear regulator to supply a load, designers will typically use a bypass capacitor on the CATHODE pin. When doing this, the SGM431V remains stable.

In order to not exceed the maximum cathode current, be sure that the supply voltage is current limited. Also, be sure to limit the current being driven into the REF pin, as not to exceed its absolute maximum rating.

For applications shunting high currents, pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have the proper current density.

**Layout**

Decoupling capacitors should be placed as close to the device as possible. Use appropriate widths for traces when shunting high currents to avoid excessive voltage drops.

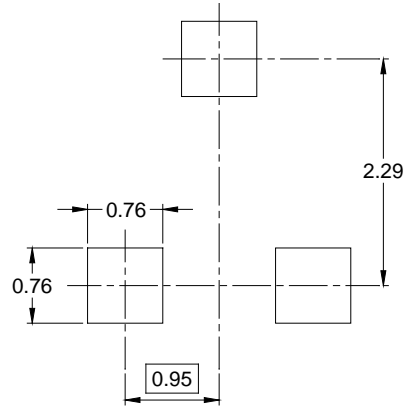
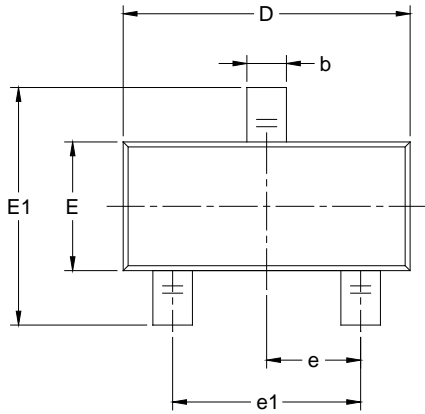
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

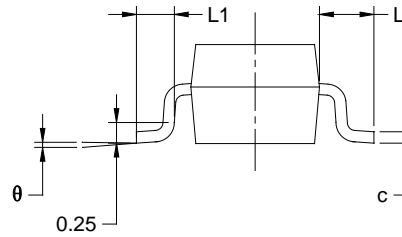
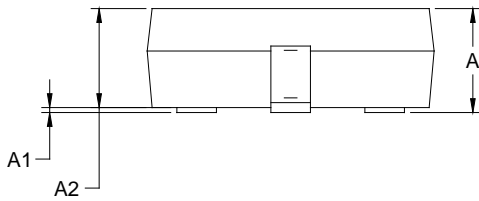
Changes from Original (DECEMBER 2020) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SOT-23



RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.89	1.12	0.035	0.044
A1	0.01	0.10	0.000	0.004
A2	0.88	1.02	0.035	0.040
b	0.30	0.50	0.012	0.020
c	0.08	0.20	0.003	0.008
D	2.80	3.04	0.110	0.120
E	1.20	1.40	0.047	0.055
E1	2.10	2.64	0.083	0.104
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.54 REF		0.021 REF	
L1	0.40	0.60	0.016	0.024
θ	0°	8°	0°	8°

# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23	7"	9.5	3.15	2.77	1.22	4.0	4.0	2.0	8.0	Q3

DD0001

# PACKAGE INFORMATION

## CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18

DD0002