

POWER MANAGEMENT

Description

The SC431L is a three terminal adjustable shunt regulator with thermal stability guaranteed over temperature. The output voltage can be adjusted to any value from 1.24V (V_{REF}) to 20V with two external resistors. The SC431L has a typical dynamic output impedance of 0.05Ω. Active output circuitry provides a very sharp turn on characteristic, making the SC431L an excellent replacement for zener diodes.

The SC431L shunt regulator is available with four voltage tolerances (0.25%, 0.5%, 1.0% and 2.0%), two operating temperature ranges (commercial and industrial) and two package options (SOT-23-3 and SOT-23-5). This allows the designer the opportunity to select the optimum combination of cost and performance for their application.

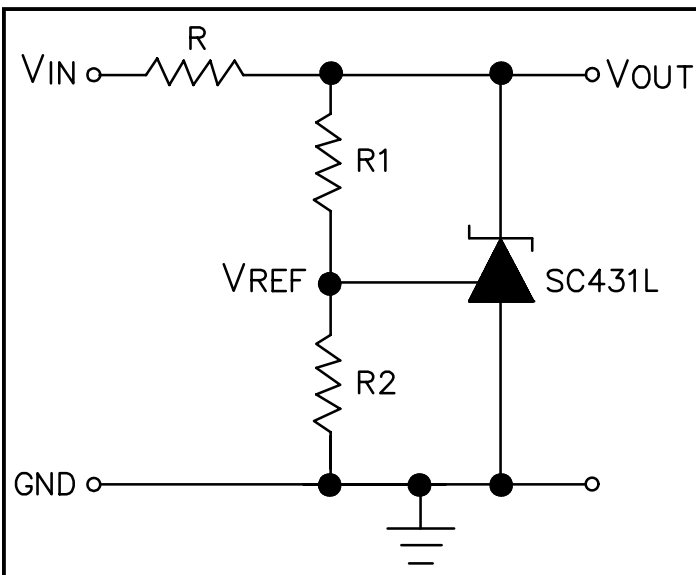
Features

- ◆ Low voltage operation (down to 1.24V)
- ◆ Wide operating current range 100μA to 100mA
- ◆ Low dynamic output impedance 0.05 Ω typ.
- ◆ Trimmed bandgap design ± 0.25%
- ◆ Upgrade for TLV431A
- ◆ SOT-23-3 and SOT-23-5 packages. Also available in Lead-free package, fully WEEE and RoHS compliant

Applications

- ◆ Linear Regulators
- ◆ Adjustable Supplies
- ◆ Switching Power Supplies
- ◆ Battery Operated Computers
- ◆ Instrumentation
- ◆ Computer Disk Drives

Typical Application Circuit⁽¹⁾⁽²⁾



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_z , is greater than the minimum operating current (100μA) at $V_{IN(MIN)}$.

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

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

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

POWER MANAGEMENT
Absolute Maximum Ratings

| Parameter | Symbol | Maximum | Units |
|---|---------------|--------------------------|--------------------|
| Cathode Voltage | V_Z | 20 | V |
| Continuous Cathode Current | I_Z | 100 | mA |
| Reference Input Current | I_{REF} | 3 | mA |
| Power Dissipation at $T_A = 25^\circ\text{C}$ SOT-23-3 SOT-23-5 | P_D | 0.37 0.49 | W |
| Thermal Resistance SOT-23-3 SOT-23-5 | θ_{JA} | 336 256 | $^\circ\text{C/W}$ |
| Operating Ambient Temperature Range SC431LC SC431LI | T_A | 0 to +70 -40 to +85 | $^\circ\text{C}$ |
| Operating Junction Temperature Range SC431LC SC431LI | T_J | 0 to +150 -40 to +150 | $^\circ\text{C}$ |
| Storage Temperature Range | T_{STG} | -65 to +150 | $^\circ\text{C}$ |
| Lead Temperature (Soldering) 10 seconds | T_{LEAD} | 300 | $^\circ\text{C}$ |
| ESD Rating (Human Body Model) | V_{ESD} | 2 | kV |

Electrical Characteristics

Unless specified: $T_A = 25^\circ\text{C}$. Values in **bold** apply over full operating ambient temperature range.

| Parameter | Symbol | Condition | SC431L 0.25% | | | SC431L 0.5% | | | Units |
|---|-------------------------------------|---|-----------------------|----------------|-----------------------|-----------------------|----------------|-----------------------|---------------|
| | | | Min | Typ | Max | Min | Typ | Max | |
| Reference Voltage | V_{REF} | $V_Z = V_{REF}, I_Z = 10\text{mA}^{(1)}$ | 1.237 1.224 | 1.240 | 1.243 1.256 | 1.234 1.222 | 1.240 | 1.246 1.258 | V |
| V_{REF} Temp Deviation | V_{DEV} | $V_Z = V_{REF}, I_Z = 10\text{mA}^{(1)}$ | | 10 | 25 | | 10 | 25 | mV |
| Ratio of Change in V_{REF} to Change in V_Z | $\frac{\Delta V_{REF}}{\Delta V_Z}$ | $I_Z = 10\text{mA}, \Delta V_Z = 16\text{V to } V_{REF}$ | | -1.0 | -2.7 | | -1.0 | -2.7 | mV/V |
| Reference Input Current | I_{REF} | $R1 = 10\text{k}\Omega, R2 = \infty, I_Z = 10\text{mA}^{(2)}$ | | 0.15 | 0.5 | | 0.15 | 0.5 | μA |
| I_{REF} Temperature Deviation | $I_{REF(DEV)}$ | $R1 = 10\text{k}\Omega, R2 = \infty, I_Z = 10\text{mA}^{(2)}$ | | 0.1 | 0.4 | | 0.1 | 0.4 | μA |
| Off-State Cathode Current | $I_{Z(OFF)}$ | $V_{REF} = 0\text{V}, V_Z = 6\text{V}^{(3)}$ $V_{REF} = 0\text{V}, V_Z = 16\text{V}^{(3)}$ | | 0.125 0.135 | 0.150 | | 0.125 0.135 | 0.150 | μA |

POWER MANAGEMENT
Electrical Characteristics (Cont.)

 Unless specified: $T_A = 25^\circ\text{C}$. Values in **bold** apply over full operating ambient temperature range.

| (Continued from page 2) | | | SC431L 0.25% | | | SC431L 0.5% | | | |
|--------------------------------|---------------|---|---------------------|------------|------------|--------------------|------------|------------|---------------|
| Parameter | Symbol | Condition | Min | Typ | Max | Min | Typ | Max | Units |
| Dynamic Output Impedance | r_z | $f < 1\text{kHz}, V_Z = V_{REF}$ $I_Z = 100\mu\text{A to } 100\text{mA}^{(1)}$ | | 0.05 | 0.15 | | 0.05 | 0.15 | Ω |
| Minimum Operating Current | $I_{Z(MIN)}$ | $V_Z = V_{REF}^{(1)}$ | | 20 | 100 | | 20 | 100 | μA |

| | | | SC431L 1% | | | SC431L 2% | | | |
|---|-------------------------------------|---|------------------|------------|--------------|------------------|------------|--------------|---------------|
| Parameter | Symbol | Condition | Min | Typ | Max | Min | Typ | Max | Units |
| Reference Voltage | V_{REF} | $V_Z = V_{REF}, I_Z = 10\text{mA}^{(1)}$ | 1.228 | 1.240 | 1.252 | 1.215 | 1.240 | 1.265 | V |
| | | | 1.215 | | 1.265 | 1.200 | | 1.280 | |
| V_{REF} Temp Deviation | V_{DEV} | $V_Z = V_{REF}, I_Z = 10\text{mA}^{(1)}$ | | 10 | 25 | | 10 | 35 | mV |
| Ratio of Change in V_{REF} to Change in V_Z | $\frac{\Delta V_{REF}}{\Delta V_Z}$ | $I_Z = 10\text{mA}, \Delta V_Z = 16\text{V to } V_{REF}$ | | -1.0 | -2.7 | | -1.0 | -2.7 | mV/V |
| Reference Input Current | I_{REF} | $R1 = 10\text{k}\Omega, R2 = \infty,$ $I_Z = 10\text{mA}^{(2)}$ | | 0.15 | 0.5 | | 0.15 | 0.5 | μA |
| I_{REF} Temperature Deviation | $I_{REF(DEV)}$ | $R1 = 10\text{k}\Omega, R2 = \infty,$ $I_Z = 10\text{mA}^{(2)}$ | | 0.1 | 0.4 | | 0.1 | 0.4 | μA |
| Off-State Cathode Current | $I_{Z(OFF)}$ | $V_{REF} = 0\text{V}, V_Z = 6\text{V}^{(3)}$ $V_{REF} = 0\text{V}, V_Z = 16\text{V}^{(3)}$ | | 0.125 | 0.150 | | 0.125 | 0.150 | μA |
| Dynamic Output Impedance | r_z | $f < 1\text{kHz}, V_Z = V_{REF}$ $I_Z = 100\mu\text{A to } 100\text{mA}^{(1)}$ | | 0.05 | 0.15 | | 0.05 | 0.15 | Ω |
| Minimum Operating Current | $I_{Z(MIN)}$ | $V_Z = V_{REF}^{(1)}$ | | 20 | 100 | | 20 | 100 | μA |

Notes:

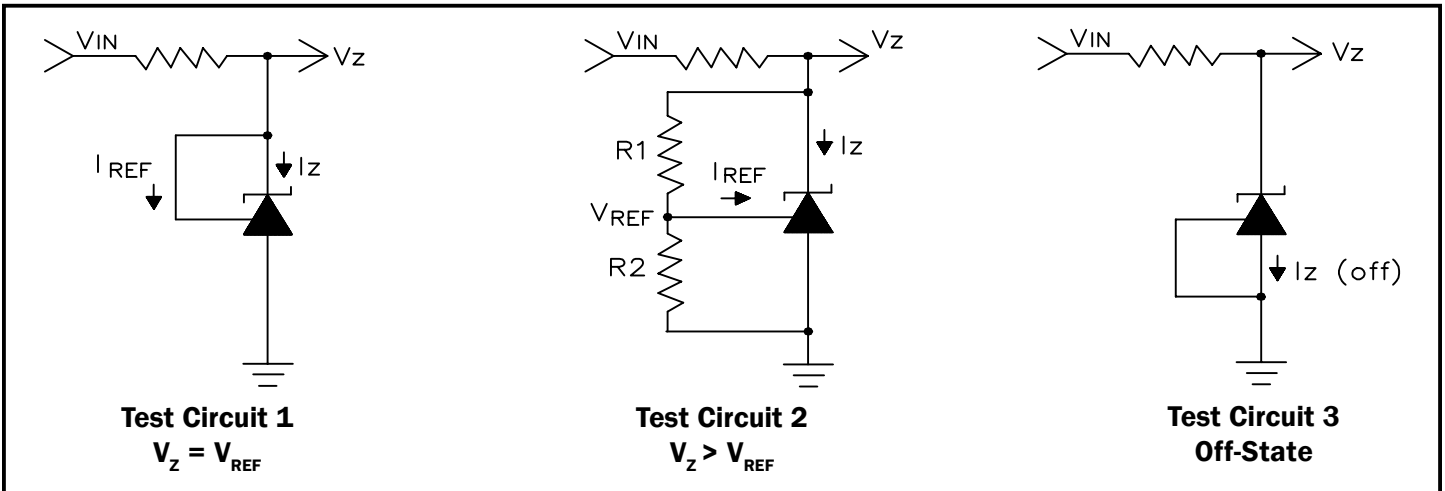
- (1) See Test Circuit 1 on page 4.
- (2) See Test Circuit 2 on page 4.
- (3) See Test Circuit 3 on page 4.

Recommended Operating Conditions

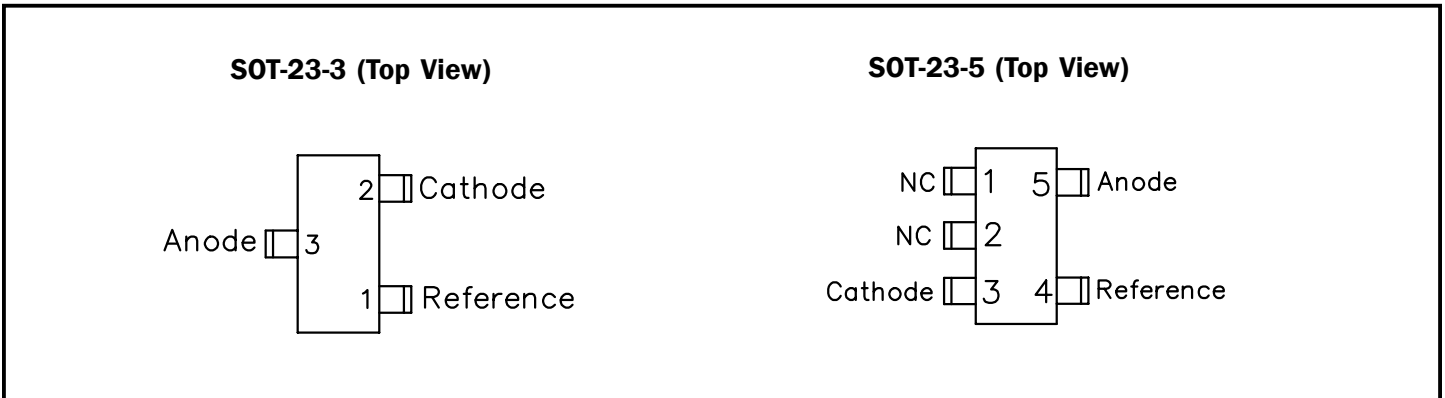
| | Min | Max | Symbol |
|------------------------|-------------------|------------|---------------|
| Cathode Voltage, V_Z | V_{REF} | 16 | V |
| Cathode Current, I_Z | 100 μA | 100 | mA |

POWER MANAGEMENT

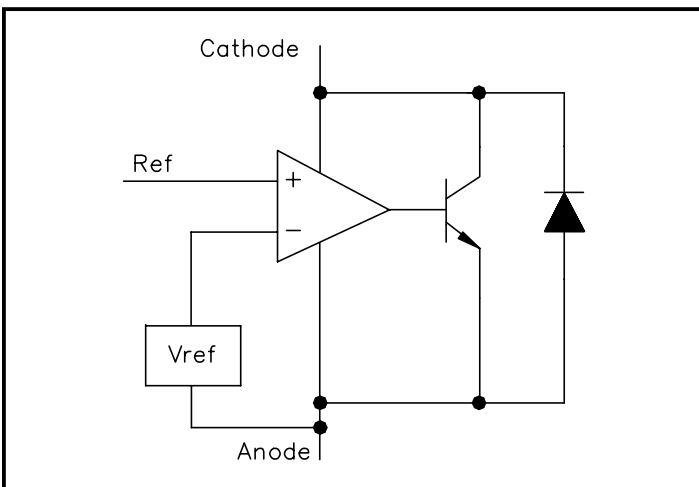
Test Circuits



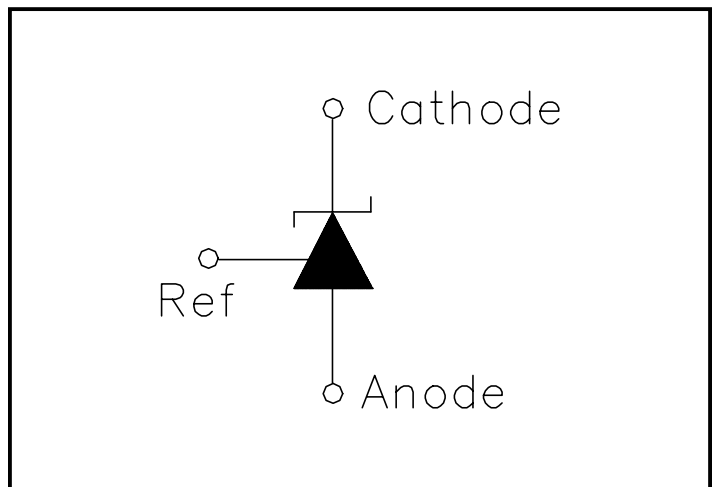
Pin Configurations



Block Diagram



Symbol



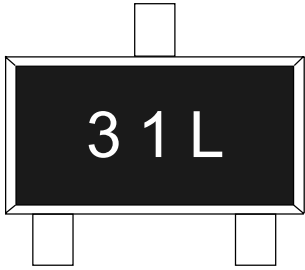
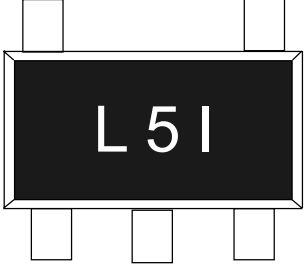
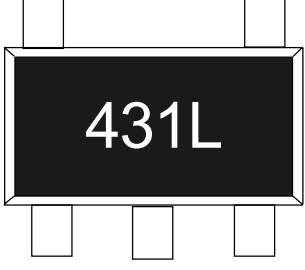
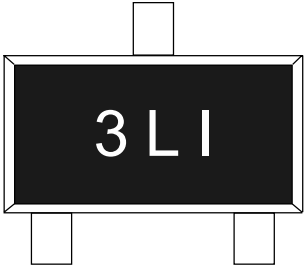
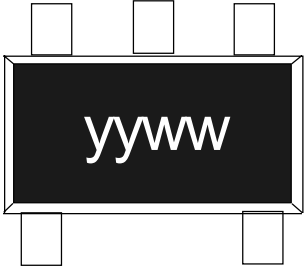
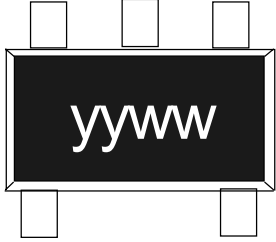
POWER MANAGEMENT
Ordering Information

| Package | T _j (°C) | Tolerance | | | |
|----------------------------|---------------------|------------------|-----------------|-----------------|-----------------|
| | | 0.25% | 0.5% | 1.0% | 2.0% |
| SOT-23-3 ⁽¹⁾⁽²⁾ | 0 to +150 | SC431LCSK-.25TR | SC431LCSK-.5TR | SC431LCSK-1TR | SC431LCSK-2TR |
| | | SC431LCSK-25TRT | SC431LCSK-.5TRT | SC431LCSK-1TRT | SC431LCSK-2TRT |
| | -40 to +150 | SC431LISK-.25TR | SC431LISK-.5TR | SC431LISK-1TR | SC431LISK-2TR |
| | | SC431LISK-.25TRT | SC431LISK-.5TRT | SC431LISK-1TRT | SC431LISK-2TRT |
| SOT-23-5 ⁽¹⁾⁽²⁾ | 0 to +150 | SC431LC5SK.25TR | SC431LC5SK-.5TR | SC431LC5SK-1TR | SC431LC5SK-2TR |
| | | SC431LC5SK25TRT | SC431LC5SK.5TRT | SC431LC5SK-1TRT | SC431LC5SK-2TRT |
| | -40 to +150 | SC431LI5SK.25TR | SC431LI5SK-.5TR | SC431LI5SK-1TR | SC431LI5SK-2TR |
| | | SC431LI5SK25TRT | SC431LI5SK.5TRT | SC431LI5SK-1TRT | SC431LI5SK-2TRT |

Notes:

- (1) Only available in tape and reel packaging. A reel contains 3000 devices.
 (2) "T" at end of part number indicates "lead free". This product is fully WEEE and RoHS compliant.

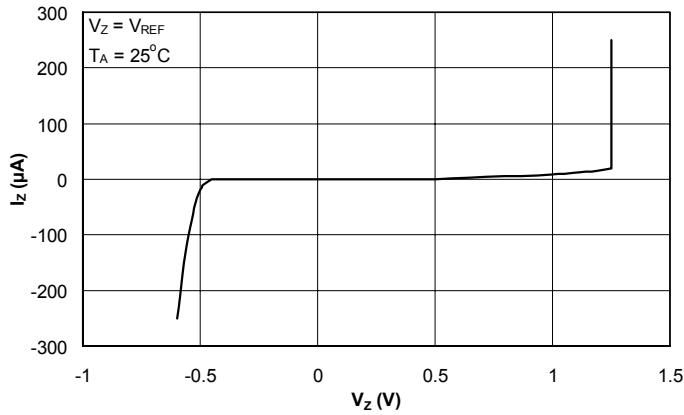
Marking Information

| | | |
|--|--|--|
| <p>SOT-23-3 (Top View only) (0 to +150°C)</p>  | <p>SOT-23-5 (Top View) (-40 to +150°C)</p>  | <p>SOT-23-5 (Top View) (0 to +150°C)</p>  |
| <p>SOT-23-3 (Top View only) (-40 to +150°C)</p>  | <p>SOT-23-5 (Bottom View)</p>  <p>yyww = Datecode, Example: (0115)</p> | <p>SOT-23-5 (Bottom View)</p>  <p>yyww = Datecode, Example: (0015)</p> |

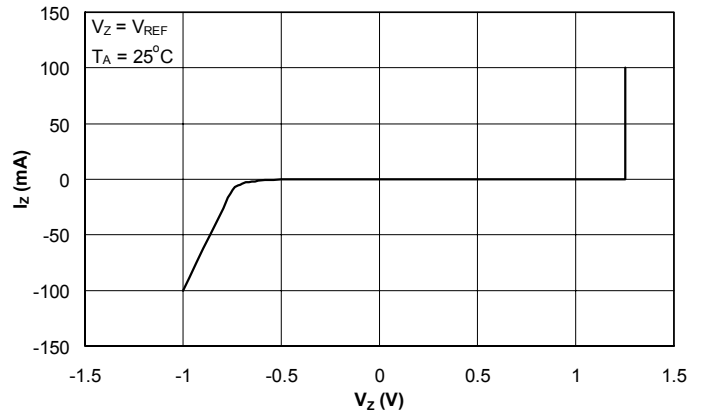
POWER MANAGEMENT

Typical Characteristics

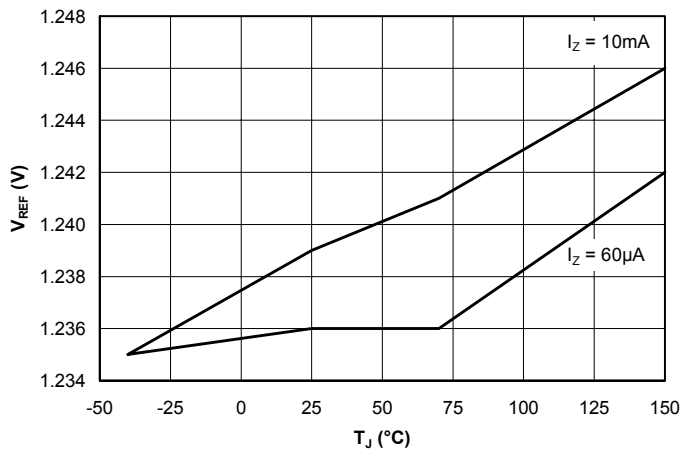
Cathode Current vs. Cathode Voltage



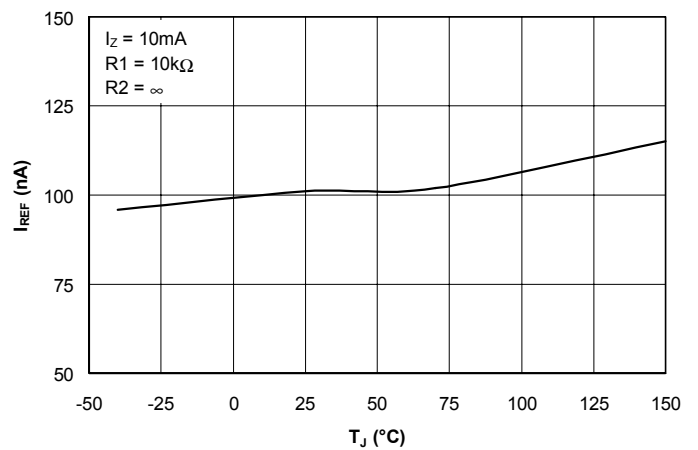
Cathode Current vs. Cathode Voltage



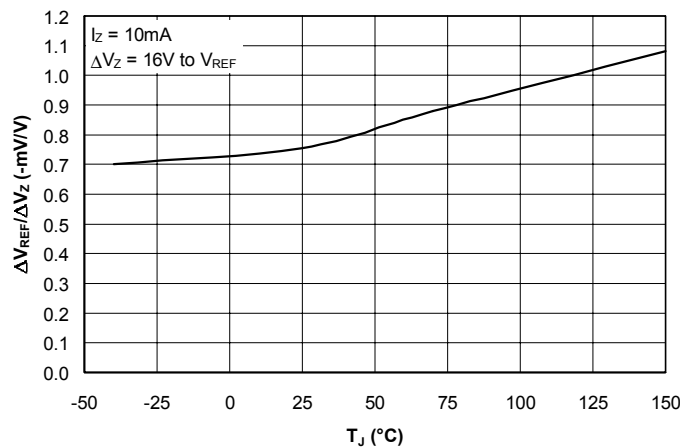
Reference Voltage vs. Junction Temperature



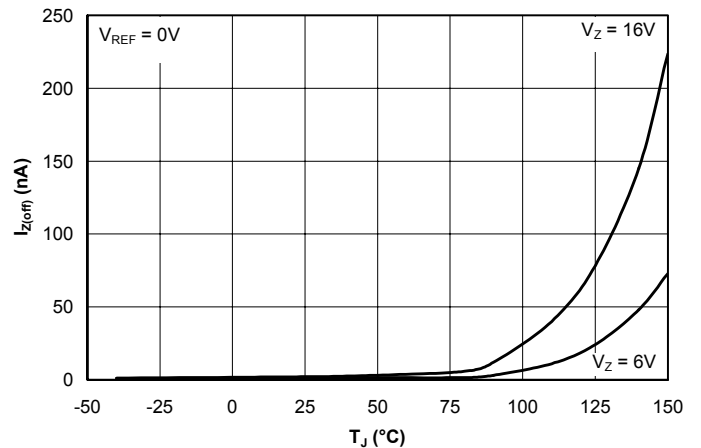
Reference Input Current vs. Junction Temperature



Ratio of Delta Reference Voltage to Delta Cathode Voltage vs. Junction Temperature



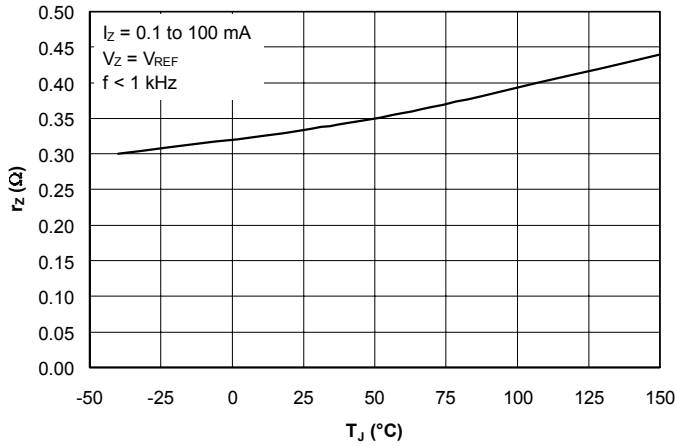
Off-State Cathode Current vs. Junction Temperature



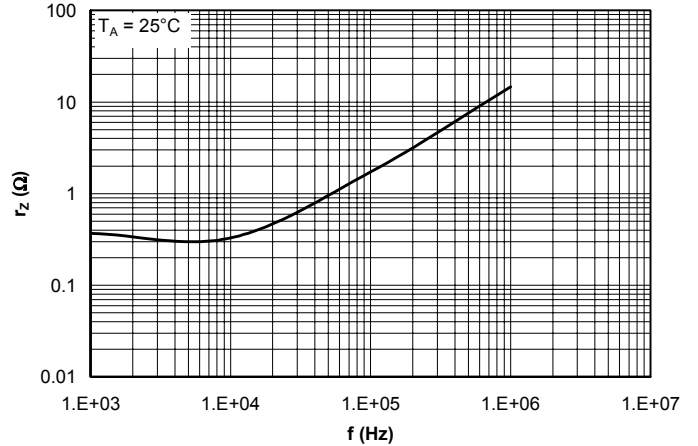
POWER MANAGEMENT

Typical Characteristics (Cont.)

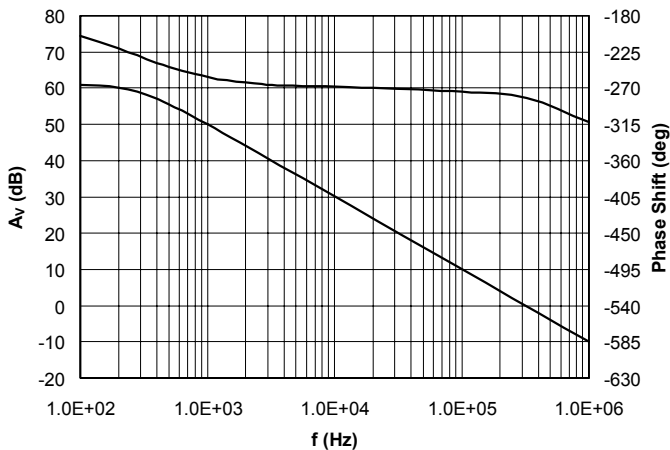
Reference Impedance vs. Junction Temperature



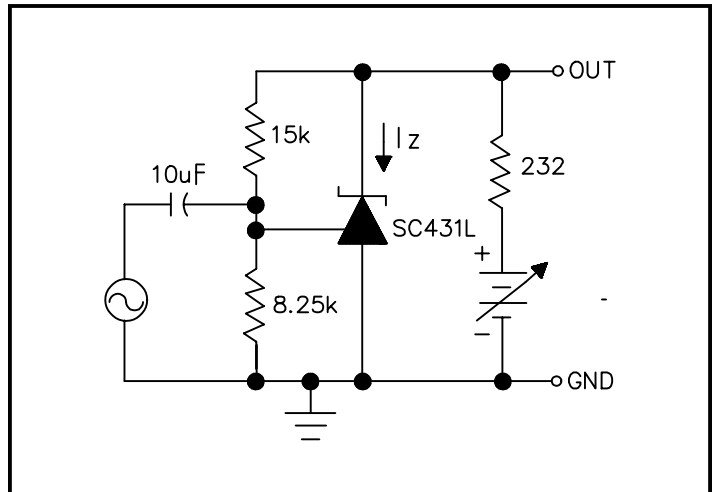
Reference Impedance vs. Frequency



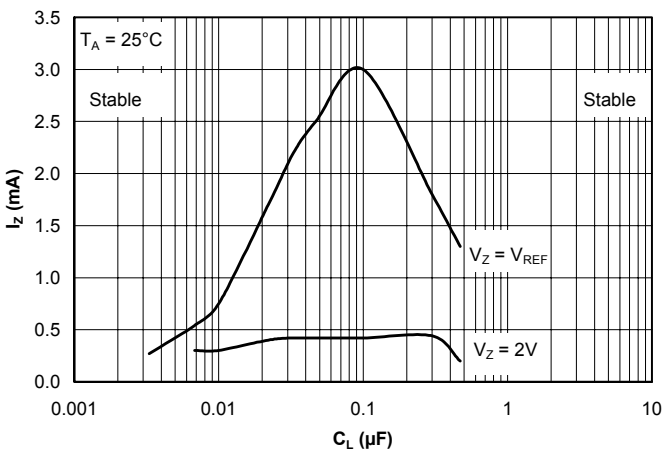
Small-Signal Gain and Phase Shift vs. Frequency



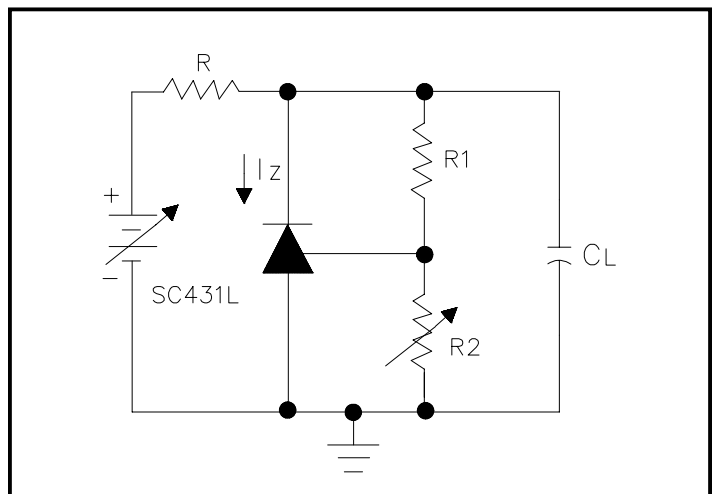
Test Circuit - Small-Signal Gain and Phase



Stability Boundary Condition For Shunt Regulation vs. Cathode Current and Load Capacitance



Test Circuit - Stability



POWER MANAGEMENT**Applications Information - Stability****Selection of load capacitance when using SC431L as a shunt regulator**

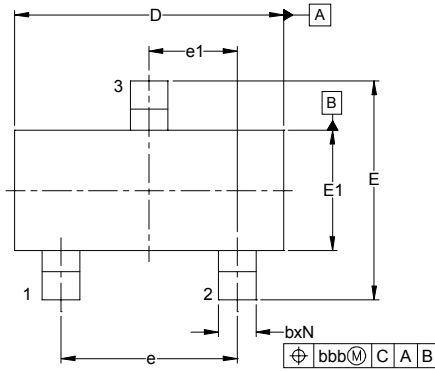
When the SC431L is used as a shunt regulator, two options for selection of C_L (see diagram on page 7) are recommended for optimal stability:

- 1) No load capacitance across the device, decouple at the load.
- 2) Large capacitance across the device, optional decoupling at the load.

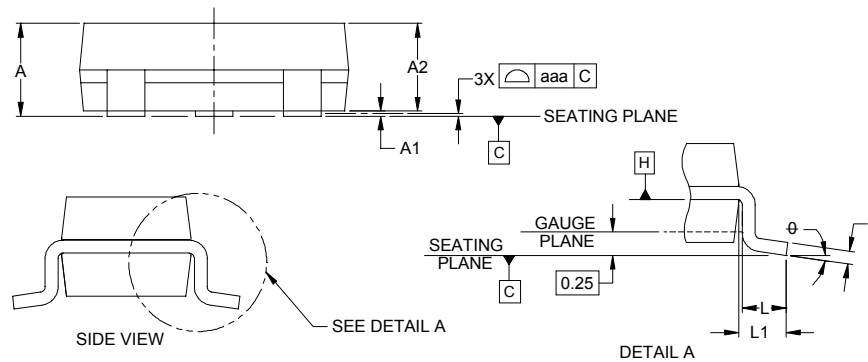
The reason for this is that SC431L exhibits instability with capacitances in the range of 10nF to 1 μ F (approx.) at light cathode currents (up to 3mA typical). The device is less stable the lower the cathode voltage has been set for. Therefore while the device will be perfectly stable operating at a cathode current of (say) 10mA with a 0.1 μ F capacitor across it, it will oscillate transiently during start-up as the cathode current passes through the instability region. Selecting a very low (or preferably, no) capacitance, or alternatively a high capacitance (such as 10 μ F) will avoid this issue altogether. Since the user will probably wish to have local decoupling at the load anyway, the most cost effective method is to use no capacitance at all directly across the device. PCB trace/via resistance and inductance prevent the local load decoupling from causing the oscillation during the transient start-up phase. Note: if the SC431L is located right at the load, so the load decoupling capacitor is directly across it, then this capacitor will have to be ≤ 1 nF or $\geq 10\mu$ F.

POWER MANAGEMENT

Outline Drawing - SOT-23-3

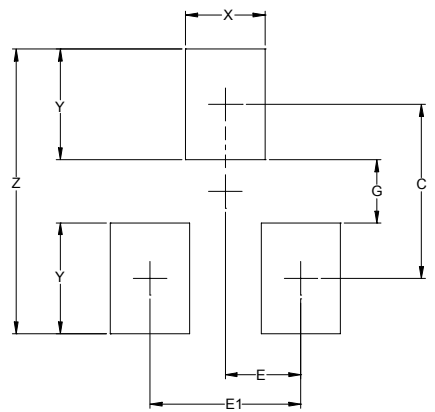


| DIM | INCHES | | | MILLIMETERS | | |
|----------|---------------|------|------|-------------|------|------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | .035 | - | .044 | 0.89 | - | 1.12 |
| A1 | .000 | - | .004 | 0.01 | - | 0.10 |
| A2 | .035 | .037 | .040 | 0.88 | 0.95 | 1.02 |
| b | .012 | - | .020 | 0.30 | - | 0.51 |
| c | .003 | - | .007 | 0.08 | - | 0.18 |
| D | .110 | .114 | .120 | 2.80 | 2.90 | 3.04 |
| E | .082 | .093 | .104 | 2.10 | 2.37 | 2.64 |
| E1 | .047 | .051 | .055 | 1.20 | 1.30 | 1.40 |
| e | .075 1.90 BSC | | | | | |
| e1 | .037 0.95 BSC | | | | | |
| L | .015 | .020 | .024 | 0.40 | 0.50 | 0.60 |
| L1 | .022 (0.55) | | | | | |
| N | 3 | | | | | |
| θ | 0° | - | 8° | 0° | - | 8° |
| aaa | .004 0.10 | | | | | |
| bbb | .008 0.20 | | | | | |



- NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
 2. DATUMS **-A-** AND **-B-** TO BE DETERMINED AT DATUM PLANE **-H-**
 3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

Land Pattern - SOT-23-3



| DIM | DIMENSIONS | |
|-----|------------|-------------|
| | INCHES | MILLIMETERS |
| C | (.087) | (2.20) |
| E | .037 | 0.95 |
| E1 | .075 | 1.90 |
| G | .031 | 0.80 |
| X | .039 | 1.00 |
| Y | .055 | 1.40 |
| Z | .141 | 3.60 |

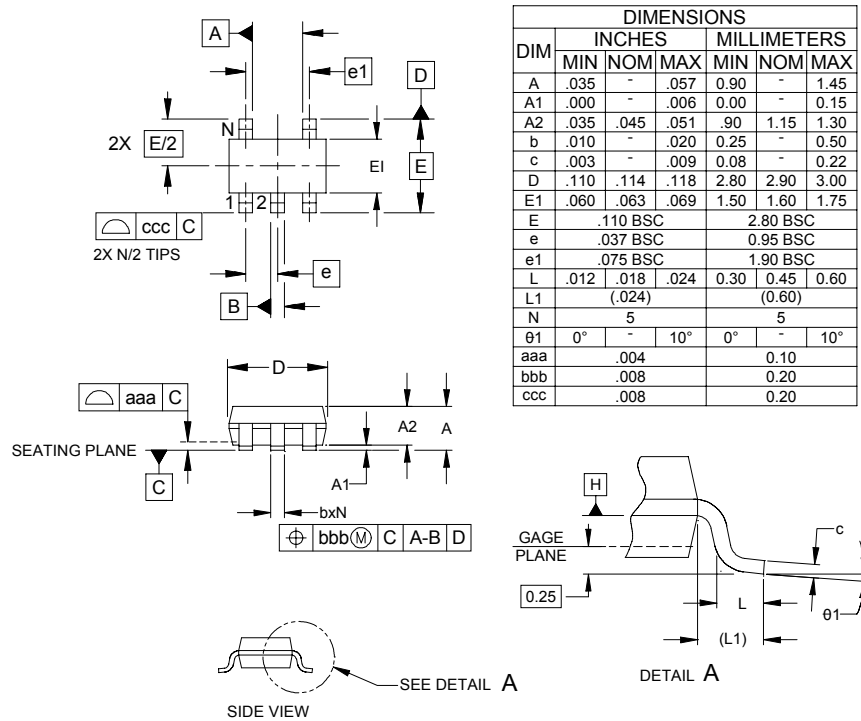
- NOTES:
1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
 2. REFERENCE IPC-SM-782A.

Note:

(1) Grid placement courtyard is 8 x 8 elements (4mm x 4mm) in accordance with the international grid detailed in IEC Publication 97.

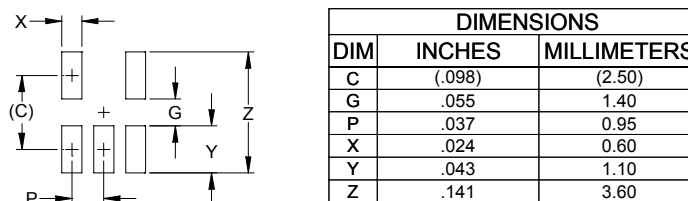
POWER MANAGEMENT

Outline Drawing - SOT-23-5



- NOTES:
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
 2. DATUMS **-A-** AND **-B-** TO BE DETERMINED AT DATUM PLANE **-H-**
 3. DIMENSIONS "E1" AND "D" DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

Land Pattern - SOT-23-5



- NOTES:
1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.

Contact Information

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Authorized Distributor

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