

## 1.5A Three Terminal Adjustable Voltage Regulator

### Description

The SG117 and SG117A are 3-terminal positive adjustable voltage regulators which offer improved performance over the original 117 design. A major feature of the SG117A is a reference voltage tolerance guaranteed within  $\pm 1\%$ , allowing an overall power supply tolerance to be better than 3% using inexpensive 1% resistors. Line and load regulation performance has been improved as well.

Moreover, the SG117A reference voltage is guaranteed not to exceed 2% when operating over the full load, line and power dissipation conditions. The SG117A adjustable regulators offer an improved solution for all positive voltage regulator requirements with load currents up to 1.5A.

In addition to replacing many fixed regulators, the SG117/A can be used in a variety of other applications due to its 'floating' design as long as the input-to-output differential maximum is not exceeded, such as a current source. A higher voltage version is available the SG117AHV and SG117HV which offers input voltage up to 60V.

### Features

- Adjustable Output Down to 1.25V
- 1% Output Voltage Tolerance
- 0.01%/V Line Regulation
- 0.3% Load Regulation
- Min. 1.5A Output Current
- Typical 80dB Ripple Rejection
- Available in Hermetic TO-257

### High Reliability Features – SG117A/SG117

- Available to MIL-STD-883, ¶1.2.1
- MSC-AMS level "S" Processing Available
- Available to DSCC
  - Standard Microcircuit Drawing (SMD)
- MIL-M-38510/7703405XA SG117AT-JAN
- MIL-M-38510/7703405YA SG117AK-JAN

### Schematic Diagram

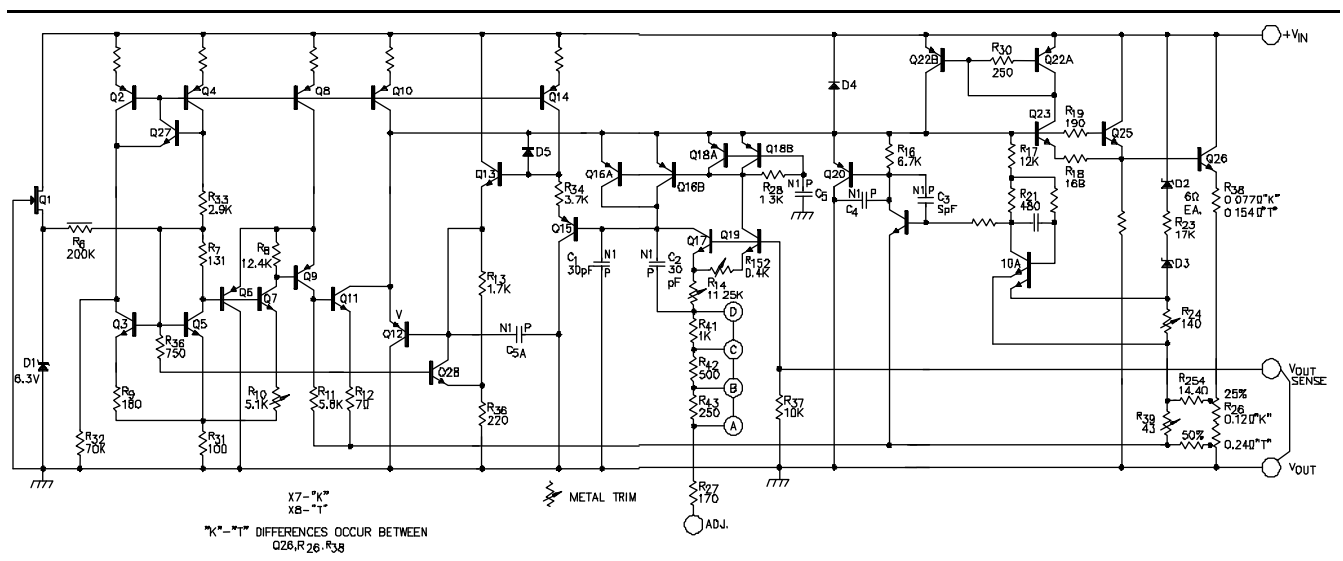
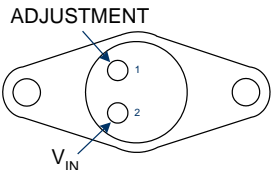
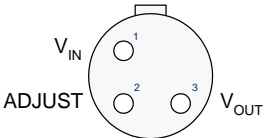
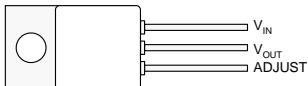
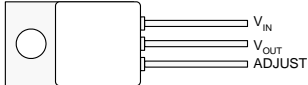


Figure 1 • Block Diagram

## Connection Diagrams and Ordering Information

| Ambient Temperature | Type | Package                           | Part Number   | Packaging Type | Connection Diagram   |
|---------------------|------|-----------------------------------|---------------|----------------|--|
| -55°C to 125°C      | K    | 3-TERMINAL METAL CAN              | SG117AK       | TO-3           |                                   |
|                     |      |                                   | SG117AK-883B  |                |  |
|                     |      |                                   | SG117AK-DESC  |                |  |
|                     |      |                                   | SG117K        |                |  |
|                     |      |                                   | SG117K-883B   |                |  |
|                     |      |                                   | SG117K-DESC   |                |  |
|                     |      |                                   | SG117K-JAN    |                |  |
| -55°C to 125°C      | T    | 3-TERMINAL METAL CAN              | SG117AT       | TO-39          |                                   |
|                     |      |                                   | SG117AT-883B  |                |  |
|                     |      |                                   | SG117AT-DESC  |                |  |
|                     |      |                                   | SG117T        |                |  |
|                     |      |                                   | SG117T-883B   |                |  |
|                     |      |                                   | SG117T-DESC   |                |  |
|                     |      |                                   | SG117T-JAN    |                |  |
| -55°C to 125°C      | IG   | 3-Pin HERMETIC Package (Isolated) | SG117AIG      | TO-257         |  <p>Case is Isolated</p>        |
|                     |      |                                   | SG117AIG-883B |                |  |
|                     |      |                                   | SG117AIG-DESC |                |  |
|                     |      |                                   | SG117IG       |                |  |
|                     |      |                                   | SG117IG-883B  |                |  |
|                     |      |                                   | SG117IG-DESC  |                |  |
| -55°C to 125°C      | G    | 3-Pin HERMETIC Package            | SG117AG       | TO-257         |  <p>Case is V<sub>OUT</sub></p> |
|                     |      |                                   | SG117AG-883B  |                |  |
|                     |      |                                   | SG117AG-DESC  |                |  |
|                     |      |                                   | SG117G        |                |  |
|                     |      |                                   | SG117G-883B   |                |  |
|                     |      |                                   | SG117G-DESC   |                |  |

## Connection Diagrams and Ordering Information

| Ambient Temperature   | Type | Package        | Part Number  | Packaging Type | Connection Diagram |
|---|------|----------------|--------------|----------------|--------------------|
| -55°C to 125°C  | L    | 20-Pin Ceramic | SG117AL      | CLCC           |                    |
|   |      |                | SG117AL-883B |                |                    |
|   |      |                | SG117AL-DESC |                |                    |
|   |      |                | SG117L       |                |                    |
|   |      |                | SG117L-883B  |                |                    |
|   |      |                | SG117L-DESC  |                |                    |
| <p><i>Notes:</i></p> <ol style="list-style-type: none"> <li>Contact factory for JAN and DESC part availability.</li> <li>All parts are viewed from the top.</li> <li>For devices with multiple inputs and outputs both must be externally connected together at the device terminals.</li> <li>For normal operation, the SENSE pin must be externally connected to the load.</li> <li>These Hermetic Packages use Sn63/Pb37 hot solder dip lead finish, contact factory for availability of RoHS versions.</li> </ol> |      |                |              |                |                    |

## Absolute Maximum Ratings

| Parameter                                | Value              | Units |
|--|--------------------|-------|
| Power Dissipation                        | Internally Limited |       |
| Input to Output Voltage Differential     | 40                 | V     |
| Storage Temperature Range                | -65 to 150         | °C    |
| Maximum Operating Junction Temperature   | 150                | °C    |
| Lead Temperature (Soldering, 10 seconds) | 300                | °C    |

*Notes:*  
Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

## Thermal Data

| Parameter   | Value | Units |
|---|-------|-------|
| <b>K Package: 3 Terminal TO-3 Metal Can</b>           |       |       |
| Thermal Resistance-Junction to Case, $\theta_{JC}$    | 3     | °C/W  |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 35    | °C/W  |
| <b>T Package: 3-Pin TO-39 Metal Can</b>               |       |       |
| Thermal Resistance-Junction to Case, $\theta_{JC}$    | 15    | °C/W  |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 120   | °C/W  |
| <b>IG Package: 3-Pin TO-257 Hermetic (Isolated)</b>   |       |       |
| Thermal Resistance-Junction to Case, $\theta_{JC}$    | 3.5   | °C/W  |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 42    | °C/W  |
| <b>G Package: 3-Pin TO-257 Hermetic</b>               |       |       |
| Thermal Resistance-Junction to Case, $\theta_{JC}$    | 3.5   | °C/W  |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 42    | °C/W  |
| <b>L Package: 20-Pin Ceramic (LCC) Leadless</b>       |       |       |
| Thermal Resistance-Junction to Case, $\theta_{JC}$    | 35    | °C/W  |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 120   | °C/W  |

*Notes:*

- Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JA})$ .
- The above numbers for  $\theta_{JC}$  are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The  $\theta_{JA}$  numbers are meant to be guidelines for the thermal performance of the device/pcboard system. All of the above assume no ambient airflow.

## Recommended Operating Conditions

| Parameter                           | Value                  | Units |
|-------------------------------------|------------------------|-------|
| Input Voltage Range                 | $V_{OUT} + 3.5V$ to 37 | V     |
| Operating Ambient Temperature Range |                        |       |
| SG117A / SG117                      | -55 to 125             | °C    |

*Note:* Range over which the device is functional.

## Electrical Characteristics

Unless otherwise specified, these characteristics apply over the full operating ambient temperature for the SG117A / SG117 with  $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ ,  $V_{\text{IN}} - V_{\text{OUT}} = 5.0\text{V}$  and for  $I_{\text{OUT}} = 500\text{mA}$  (K, G, and IG) and  $I_{\text{OUT}} = 100\text{mA}$  (T, and L packages). Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the T, and L packages, and 20W for the K, G, and IG packages.  $I_{\text{MAX}}$  is 1.5A for the K, G, and IG packages and 500mA for the T, and L packages. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.

| Parameter  | Test Condition   | SG117A |       |       | SG117 |       |      | Units         |    |
|--|--|--------|-------|-------|-------|-------|------|---------------|----|
|  |  | Min    | Typ   | Max   | Min   | Typ   | Max  |               |    |
| <b>Reference Section</b>   |  |        |       |       |       |       |      |               |    |
| Reference Voltage  | $I_{\text{OUT}} = 10\text{mA}$ , $T_A = 25^{\circ}\text{C}$  | 1.238  | 1.250 | 1.262 |       |       |      | V             |    |
|  | $3\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 40\text{V}$ ,<br>$P \leq P_{\text{MAX}}$                     | 1.225  | 1.250 | 1.270 | 1.20  | 1.25  | 1.30 |               |    |
|  | $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$  |        |       |       |       |       |      |               |    |
| <b>Output Section</b>  |  |        |       |       |       |       |      |               |    |
| Line Regulation <sup>1</sup>   | $3\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 40\text{V}$ ,<br>$I_L = 10\text{mA}$                         |        |       |       |       |       |      | %V            |    |
|  | $T_A = 25^{\circ}\text{C}$   |        | 0.005 | 0.01  |       | 0.01  | 0.02 |               |    |
|  | $T_A = T_{\text{MIN}}$ to $T_{\text{MAX}}$   |        | 0.01  | 0.02  |       | 0.02  | 0.05 |               |    |
| Load Regulation <sup>1</sup>   | $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$  |        |       |       |       |       |      | mV            |    |
|  | $V_{\text{OUT}} \leq 5\text{V}$ , $T_A = 25^{\circ}\text{C}$   |        | 5     | 15    |       | 5     | 15   |               |    |
|  | $V_{\text{OUT}} > 5\text{V}$ , $T_A = 25^{\circ}\text{C}$  |        | 0.1   | 0.3   |       | 0.1   | 0.3  |               | %  |
|  | $V_{\text{OUT}} \leq 5\text{V}$  |        | 20    | 50    |       | 20    | 50   |               | mV |
|  | $V_{\text{OUT}} > 5\text{V}$   |        | 0.3   | 1     |       | 0.3   | 1    |               | %  |
| Thermal Regulation <sup>2</sup>  | $T_A = 25^{\circ}\text{C}$ , 20ms pulse  |        | 0.002 | 0.02  |       | 0.03  | 0.07 | %/W           |    |
| Ripple Rejection   | $V_{\text{OUT}} = 10\text{V}$ , $f = 120\text{Hz}$   |        |       |       |       |       |      | dB            |    |
|  | $C_{\text{ADJ}} = 1\mu\text{F}$ , $T_A = 25^{\circ}\text{C}$   |        | 65    |       |       | 65    |      |               |    |
|  | $C_{\text{ADJ}} = 10\mu\text{F}$   | 66     | 80    |       | 66    | 80    |      |               |    |
| Minimum Load Current   | $(V_{\text{IN}} - V_{\text{OUT}}) = 40\text{V}$  |        | 3.5   | 5     |       | 3.5   | 5    | mA            |    |
| Current Limit  | $(V_{\text{IN}} - V_{\text{OUT}}) \leq 15\text{V}$   |        |       |       |       |       |      | A             |    |
|  | K, P, G, IG Packages   | 1.5    | 2.2   |       | 1.5   | 2.2   |      |               |    |
|  | T, L Packages  | 0.5    | 0.8   |       | 0.5   | 0.8   |      |               |    |
|  | $(V_{\text{IN}} - V_{\text{OUT}}) = 40\text{V}$ , $T_J = 25^{\circ}\text{C}$                                       |        |       |       |       |       |      | A             |    |
|  | K, P, G, IG Packages   | 0.3    | 0.4   |       | 0.3   | 0.4   |      |               |    |
|  | T, L Packages  | 0.15   | 0.2   |       | 0.15  | 0.2   |      |               |    |
| Temperature Stability <sup>2</sup>   |  |        | 1     | 2     |       | 1     |      | %             |    |
| Long Term Stability <sup>2</sup>   | $T_A = 125^{\circ}\text{C}$ , 1000 Hours   |        | 0.3   | 1     |       | 0.3   | 1    |               |    |
| RMS Output Noise (% of $V_{\text{OUT}}$ ) <sup>2</sup>   | $T_A = 25^{\circ}\text{C}$ , $10\text{Hz} \leq f \leq 10\text{kHz}$  |        | 0.001 |       |       | 0.001 |      |               |    |
| <b>Adjust Section</b>  |  |        |       |       |       |       |      |               |    |
| Adjust Pin Current   |  |        | 50    | 100   |       | 50    | 100  | $\mu\text{A}$ |    |
| Adjust Pin Current Change  | $10\text{mA} < I_{\text{OUT}} < I_{\text{MAX}}$ ,<br>$2.5\text{V} < (V_{\text{IN}} - V_{\text{OUT}}) < 40\text{V}$ |        | 0.2   | 5     |       | 0.2   | 5    |               |    |
| <sup>1</sup> Regulation is measured at constant junction temperature, using pulse testing with low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.<br><sup>2</sup> These parameters, although guaranteed, are not tested in production. |  |        |       |       |       |       |      |               |    |

## Characteristic Curves

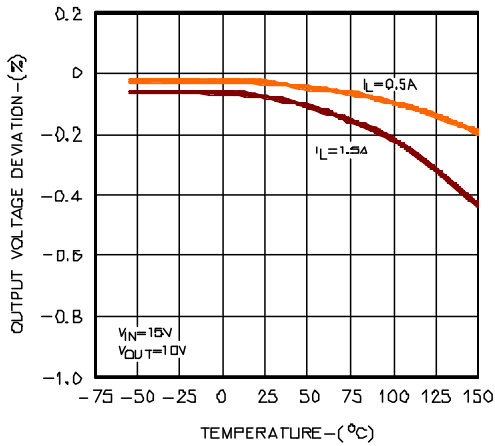


Figure 2 • Output Voltage Deviation vs. Temperature

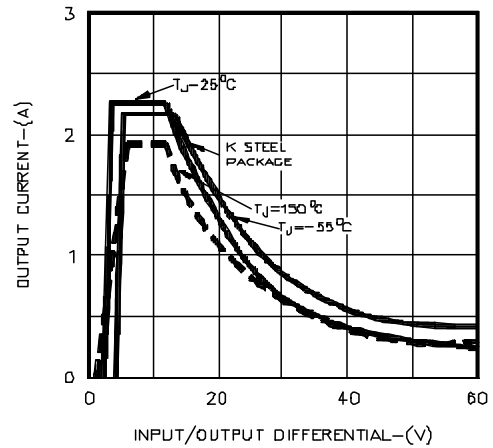


Figure 3 • Output Current vs. Input / Output Differential

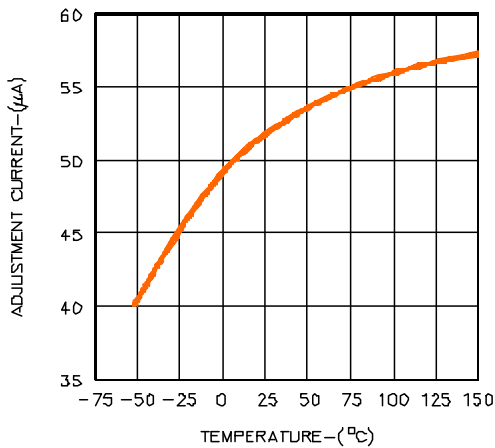


Figure 4 • Adjust Current vs. Temperature

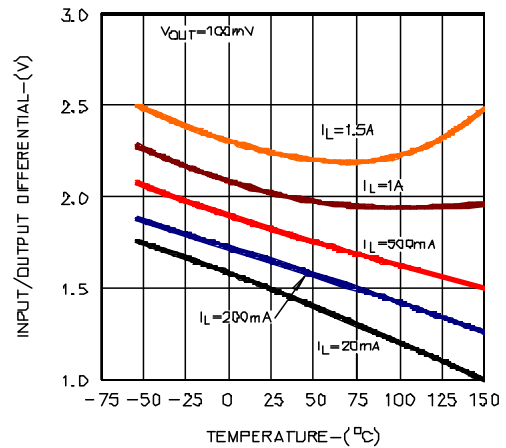


Figure 5 • Input / Output Differential vs. Temperature

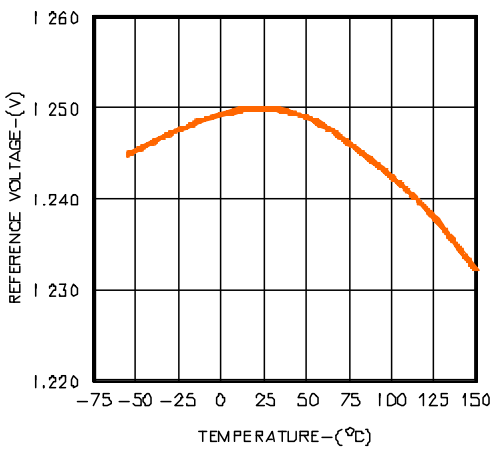


Figure 6 • Reference Voltage vs. Temperature

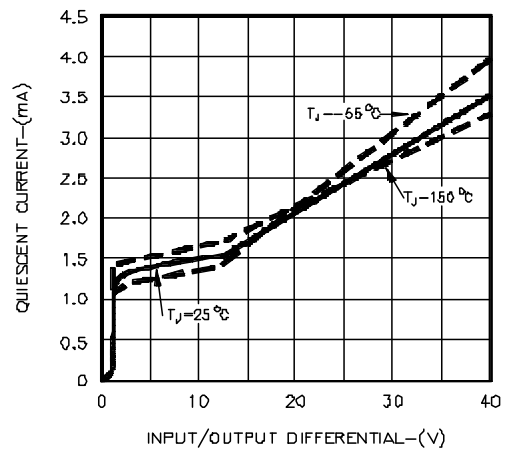
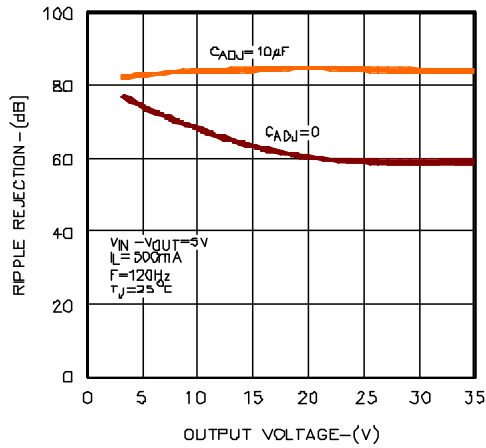
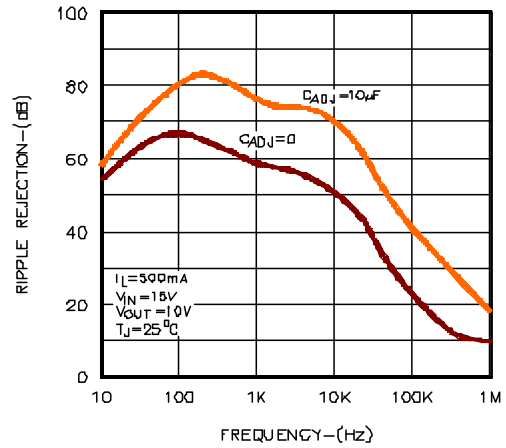


Figure 7 • Quiescent Current vs. Input / Output Differential

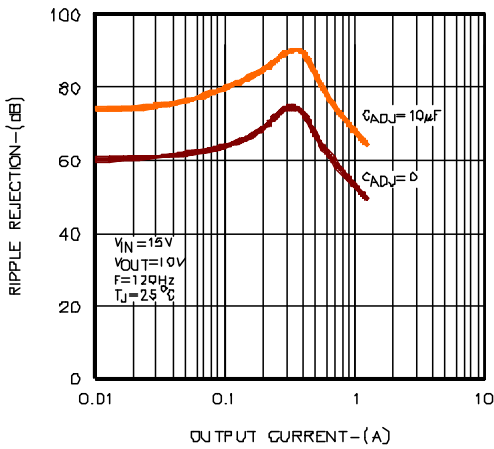
## Characteristic Curves



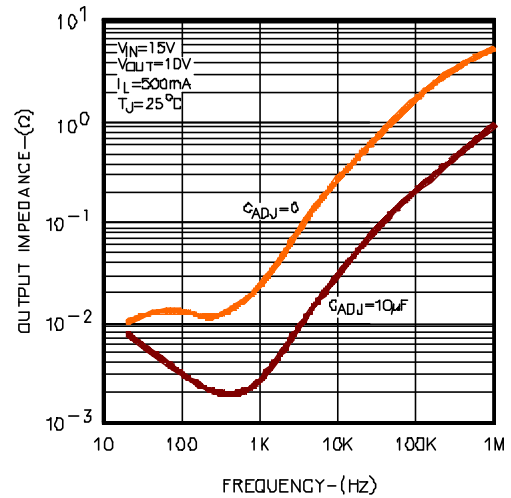
**Figure 8** - Ripple Rejection vs. Output Voltage



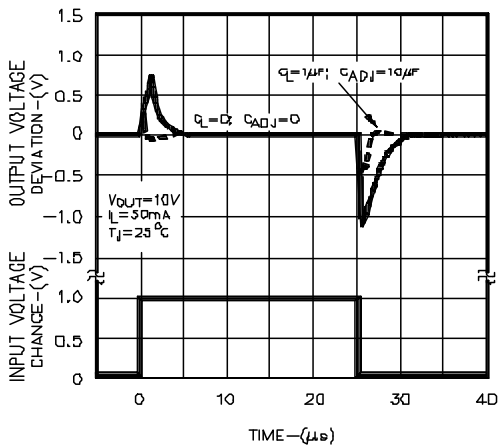
**Figure 9** - Ripple Rejection vs. Frequency



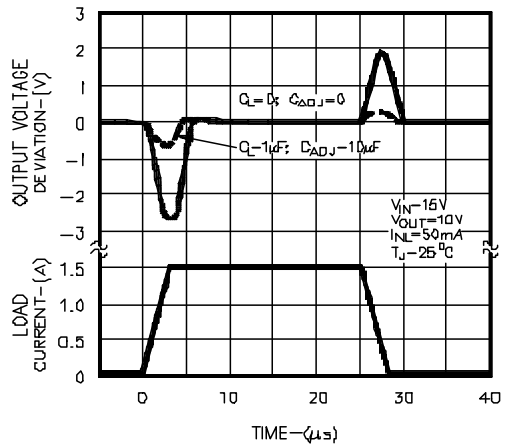
**Figure 10** - Ripple Rejection vs. Output Current



**Figure 11** - Output Impedance vs. Frequency

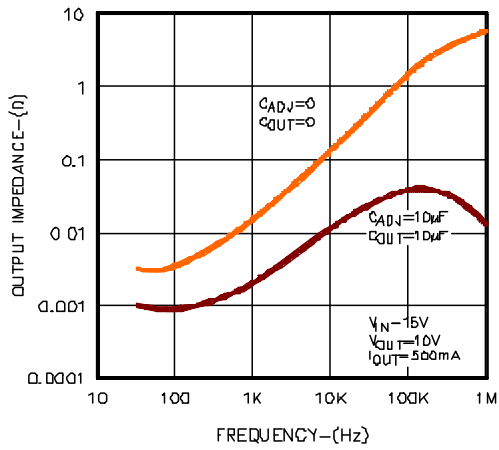


**Figure 12** - Line Transient Response

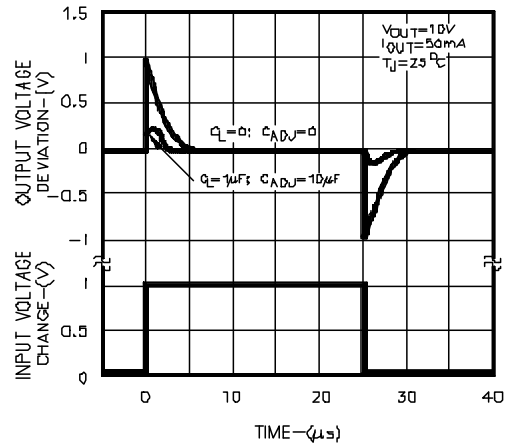


**Figure 13** - Load Transient Response

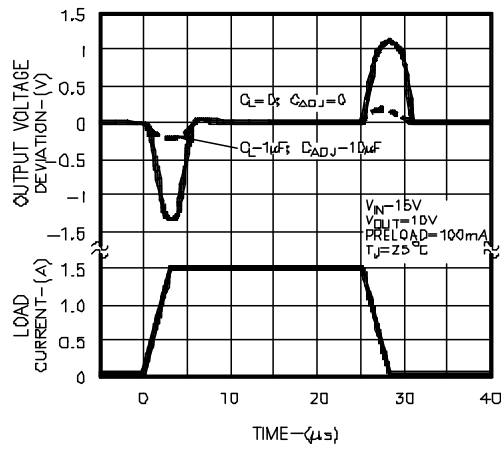
## Characteristic Curves



**Figure 14** - Output Impedance vs. Frequency



**Figure 15** - Line Transient Response



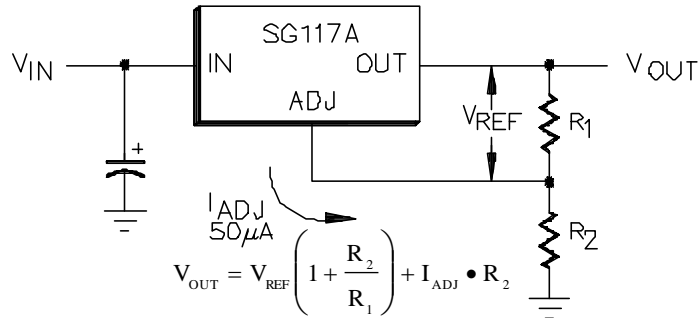
**Figure 16** - Load Transient Response



## Application Information

### General

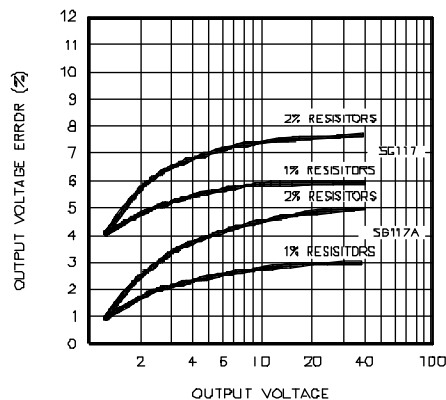
The SG117A develops a 1.25V reference voltage between the output (OUT) and the adjust (ADJ) terminals (see Basic Regulator Circuit). By placing a resistor,  $R_1$  between these two terminals, a constant current is caused to flow through  $R_1$  and down through  $R_2$  to set the overall output voltage. Normally this current is the specified minimum load current of 5mA or 10mA. It is important to maintain this minimum output load current requirement otherwise the device may fail to regulate, and the output voltage may rise.



**Figure 17 - Basic Regulator Circuit**

The  $I_{ADJ}$  current does add an error to the output divider ratio, however because  $I_{ADJ}$  is very small and constant when compared with the current through  $R_1$ , it represents a small error and can often be ignored.

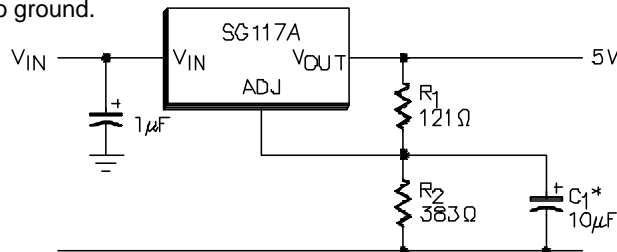
It is easily seen from the above equation, that even if the resistors were of exact value, the accuracy of the output is limited by the accuracy of  $V_{REF}$ . With a guaranteed 1% reference, a 5V power supply design, using  $\pm 2\%$  resistors, would have a worst case manufacturing tolerance of  $\pm 4\%$ . If 1% resistors were used, the tolerance would drop to  $\pm 2.5\%$ . A plot of the worst case output voltage tolerance as a function of resistor tolerance is shown below.



**Figure 18 - Voltage Tolerance vs. Resistor Tolerance**

### Bypass Capacitors

Input bypassing using a 0.1  $\mu\text{F}$  ceramic or 1 $\mu\text{F}$  solid tantalum is recommended, and especially when any input filter capacitors are more than 5 inches from the device. A 0.1 $\mu\text{F}$  bypass capacitor on the ADJ pin is required if the load current varies by more than 1A/ $\mu\text{sec}$ . Improved ripple rejection (80dB) can be accomplished by adding a 10 $\mu\text{F}$  capacitor from the ADJ pin to ground.



\* $C_1$  Improves Ripple Rejection.  $X_C$  should be small compared to  $R_2$ .

**Figure 19 - Improving Ripple Rejection**

While the SG117 is stable with no output capacitor, for improved AC transient response and to prevent the possibility of oscillation due to an unknown reactive load, a 1µF capacitor is also recommended at the output. Because of their low impedance at high frequencies, the best type of capacitor to use is solid tantalum; ceramic capacitors may also be used. When bypass capacitors are used, it may be necessary to provide external protection diodes to prevent this external large capacitance from discharging through internal low current paths, which may damage the device. Although the duration of any surge current is short, there may be sufficient energy to damage the regulator. This is particularly true of the large capacitance on the ADJ pin when output voltages are higher than 25V. Such a capacitor could discharge into the ADJ pin when either the input or output is shorted. See figure below.

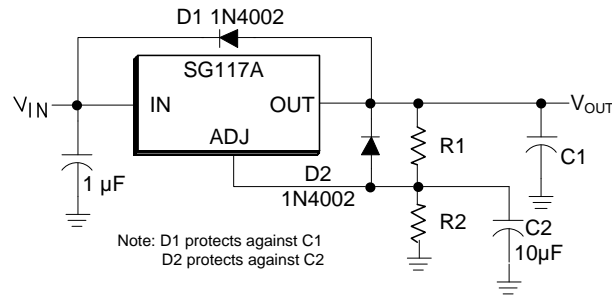


Figure 20 · Use of Protection Diodes

**Load Regulation**

Because the SG117A is a three-terminal device, it is not possible to provide true remote load sensing. Load regulation will be limited by the resistance of the wire connecting the regulator to the load. From the data sheet specification, regulation is measured at the bottom of the package. Negative side sensing is a true Kelvin connection, with the bottom of the output divider returned to the negative side of the load. Although it may not be immediately obvious, best load regulation is obtained when the top of the divider is connected directly to the case, not to the load. This is illustrated in (Connections for Best Load Regulation). If \$R\_1\$ were connected to the load, the effective resistance between the regulator and the load would be:

$$R_p \cdot \left( \frac{R_2 + R_1}{R_1} \right), R_p = \text{Parasitic Line Resistance}$$

Connected as shown, \$R\_p\$ is not multiplied by the divider ratio. \$R\_p\$ is about 0.004Ω per foot using 16 gauge wire. This translates to 4mV/ft. at 1A load current, so it is important to keep the positive lead between regulator and load as short as possible.

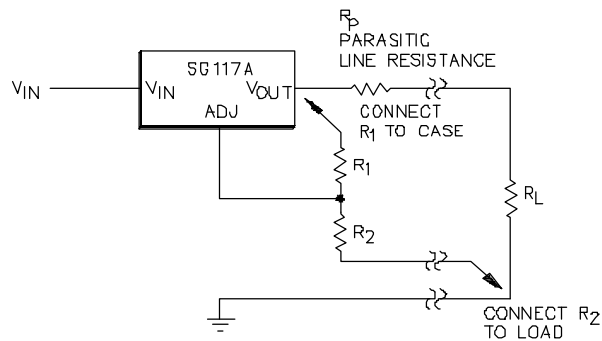
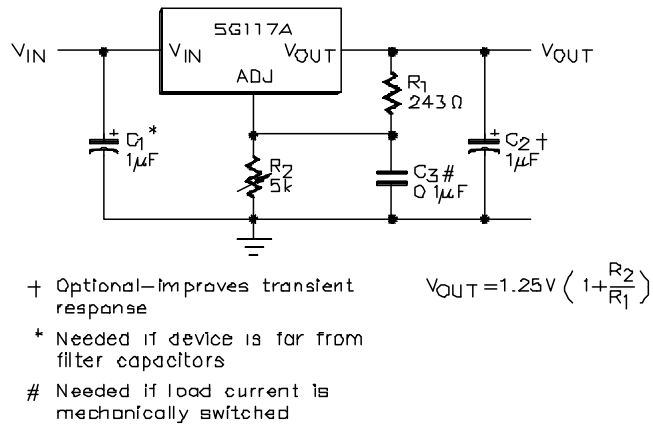


Figure 21 · Connections for Best Load Regulation

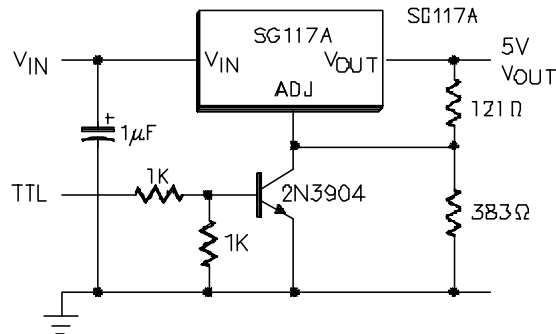
### Current Limit

As outlined in the Electrical Characteristics the current limit will activate whenever the output current exceeds the specified levels. It is also important to bear in mind that the regulator includes a foldback-current characteristic that limits the current at higher  $V_{IN}$  to  $V_{OUT}$  differential voltages. This power limiting characteristic will prevent the regulator from providing full output current depending on the  $V_{IN}$  to  $V_{OUT}$  differential. Also if during a short circuit situation the regulator was presented with a voltage that exceeds the Absolute Maximum Rating of 40V (e.g.  $V_{IN} > 40V$ ,  $V_{OUT} = 0V$ ) the device may fail, or be permanently damaged.

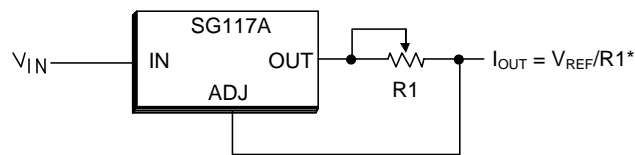
### Typical Applications



**Figure 22** - 1.2V – 25V Adjustable Regulator



**Figure 23** - 5V Regulator with Shut Down



\*  $0.8\Omega \leq R1 \leq 120\Omega$

**Figure 24** -

**Figure 25** - Programmable Current Limiter

## PACKAGE OUTLINE DIMENSIONS

Controlling dimensions are in inches, metric equivalents are shown for general information.

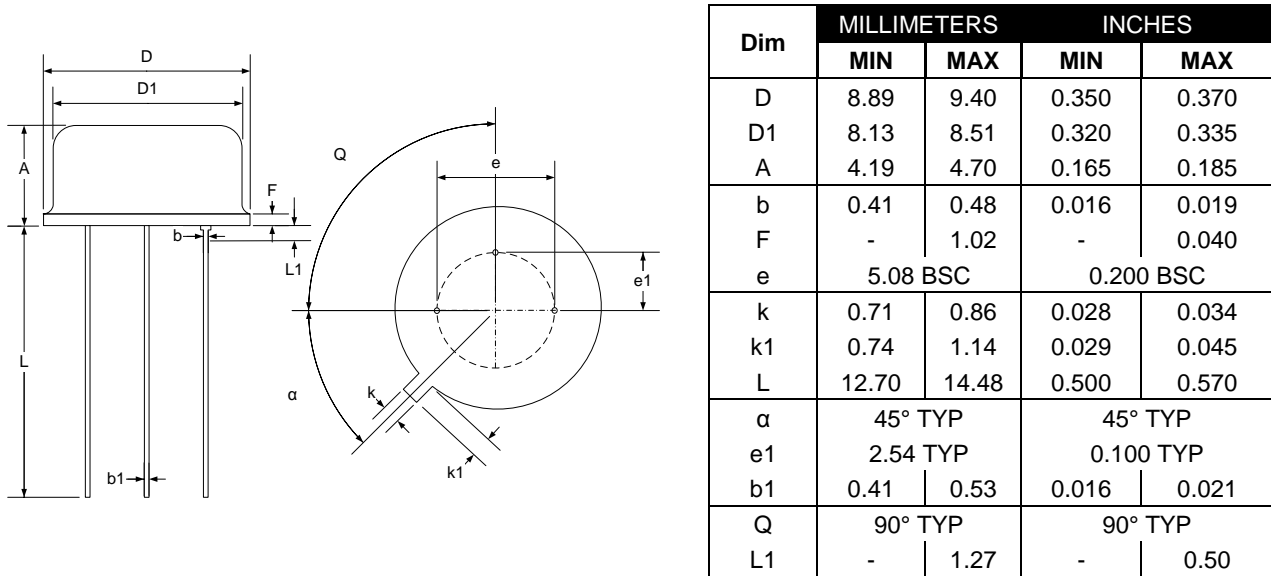
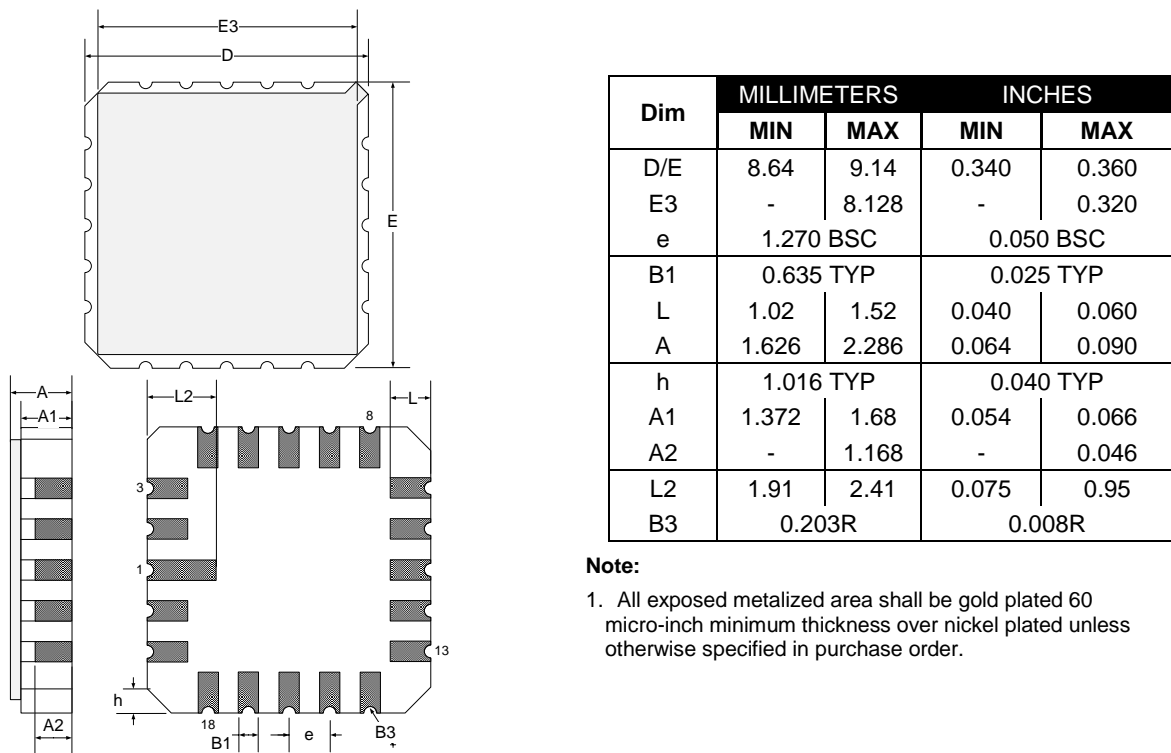


Figure 26 • T 3-Pin Metal Can TO-39 Package Dimensions

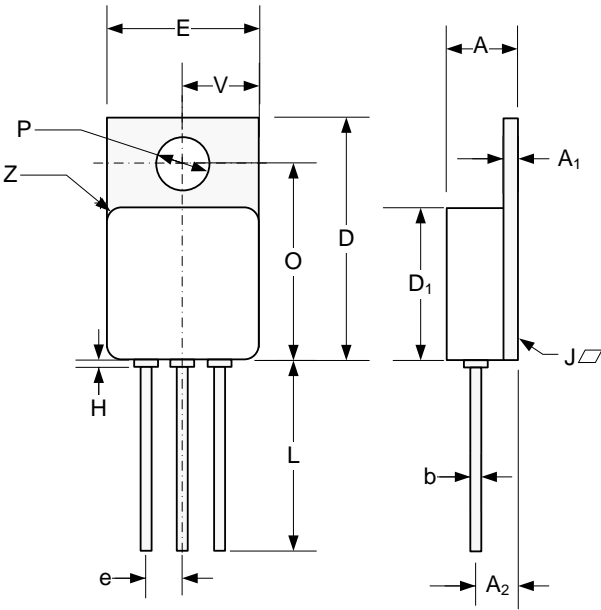


**Note:**

1. All exposed metalized area shall be gold plated 60 micro-inch minimum thickness over nickel plated unless otherwise specified in purchase order.

Figure 27 • L 20-Pin Ceramic Leadless Chip Carrier (LCC) Package Dimensions

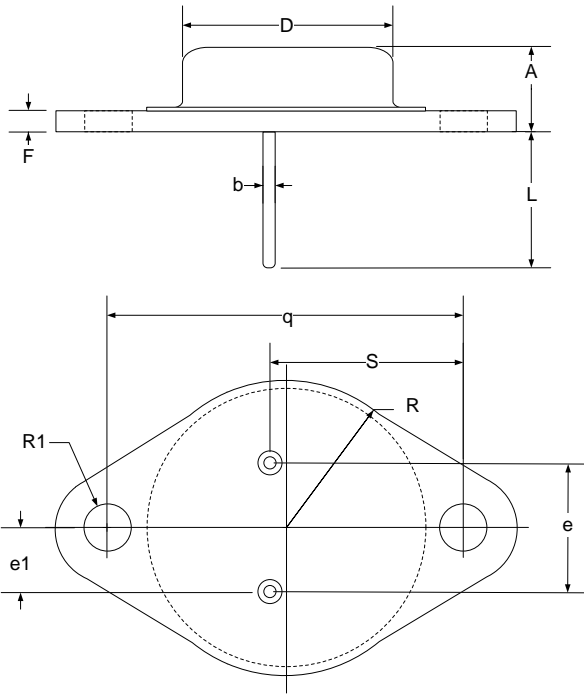
# PACKAGE OUTLINE DIMENSIONS



| Dim              | MILLIMETERS |       | INCHES    |       |
|------------------|-------------|-------|-----------|-------|
|                  | MIN         | MAX   | MIN       | MAX   |
| A                | 4.70        | 5.21  | 0.185     | 0.205 |
| A <sub>1</sub>   | 0.89        | 1.14  | 0.035     | 0.045 |
| A <sub>2</sub>   | 2.92        | 3.18  | 0.115     | 0.125 |
| b                | 0.71        | .081  | 0.027     | 0.032 |
| D                | 16.38       | 16.76 | 0.645     | 0.660 |
| D <sub>1</sub> * | 10.41       | 10.92 | 0.410     | 0.430 |
| e                | 2.54 BSC    |       | 0.100 BSC |       |
| E*               | 10.41       | 10.67 | 0.410     | 0.420 |
| H                |             | 0.50  |           | 0.020 |
| L                | 12.70       |       | 0.500     |       |
| O                | 13.39       | 13.64 | 0.527     | 0.537 |
| P                | 3.56        | 3.81  | 0.140     | 0.150 |
| J                |             | 0.10  |           | 0.004 |
| V                | 5.13        | 5.38  | 0.202     | 0.212 |
| Z                | 1.40 TYP    |       | 0.055 TYP |       |

\*Excludes Weld Fillet Around Lid.

**Figure 28 • G/IG 3-Pin Hermetic TO-257 Package Dimensions**



| Dim | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 6.86        | 7.62  | 0.270  | 0.300 |
| q   | 29.90       | 30.40 | 1.177  | 1.197 |
| b   | 0.97        | 1.09  | 0.038  | 0.043 |
| D   | 19.43       | 19.68 | 0.765  | 0.775 |
| S   | 16.64       | 17.14 | 0.655  | 0.675 |
| e   | 10.67       | 11.18 | 0.420  | 0.440 |
| E1  | 5.21        | 5.72  | 0.205  | 0.225 |
| F   | 1.52        | 2.03  | 0.060  | 0.080 |
| R1  | 3.84        | 4.09  | 0.151  | 0.161 |
| L   | 10.79       | 12.19 | 0.425  | 0.480 |
| R   | 12.57       | 13.34 | 0.495  | 0.525 |

**Figure 29 • K 3-Pin TO-3 Package Dimensions**



**Microsemi Corporate Headquarters**  
One Enterprise, Aliso Viejo,  
CA 92656 USA

**Within the USA:** +1 (800) 713-4113  
**Outside the USA:** +1 (949) 380-6100  
**Sales:** +1 (949) 380-6136  
**Fax:** +1 (949) 215-4996

**E-mail:** [sales.support@microsemi.com](mailto:sales.support@microsemi.com)

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