SILICON GENERAL

LINEAR INTEGRATED CIRCUITS

# SG137A/SG237A/SG337A
# SG137/SG237/SG337

# 1.5 AMP NEGATIVE ADJUSTABLE REGULATOR

## DESCRIPTION

The SG137A family of negative adjustable regulators will deliver up to 1.5A output current over an output voltage range of -1.2V to -37V. Silicon General has made significant improvements in these regulators compared to previous devices, such as better line and load regulation, and a maximum output voltage error of 1%. The SG137 family uses the same chip design and guarantees maximum output voltage error of ±2%.

Every effort has been made to make these devices easy to use and difficult to damage. Internal current and power limiting coupled with true thermal limiting prevents device damage due to overloads or shorts even if the regulator is not fastened to a heat sink.

The SG137A/137 family of products are ideal complements to the SG117A/117 adjustable positive regulators.

## FEATURES

- **1 % output voltage tolerance**
- **0.01%/V line regulation**
- **0.5% load regulation**
- **0.02%/W thermal regulation**
- **Available in hermetic TO-220**

## HIGH RELIABILITY FEATURES -SG137A/SG137

- **Available to MIL-STD-883 and DESC SMD**
- **Scheduled for MIL-M38510 QPL listing**
- **SG level "S" processing available**

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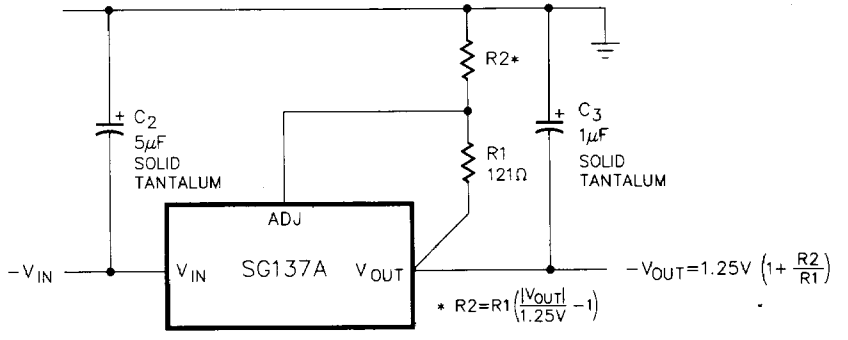
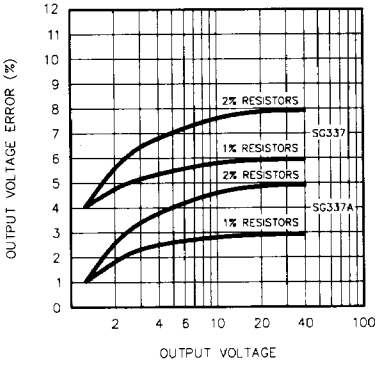
## BLOCK DIAGRAM




April 1990

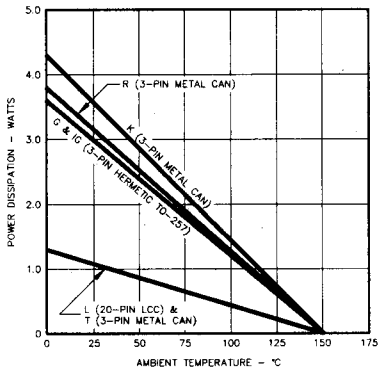
## ABSOLUTE MAXIMUM RATINGS (Note 1)

Power Dissipation ..... Internally Limited
Input to Output Voltage Differential ..... 40V
Storage Temperature Range ..... -65°C to 150°C

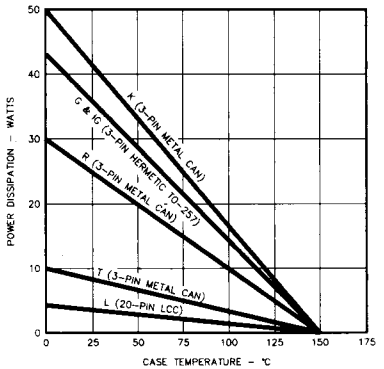
Operating Junction Temperature
Hermetic (K, R, T, L, G, IG-Packages) ..... 150°C
Lead Temperature (Soldering, 10 Seconds) ..... 300°C

Note 1. Exceeding these ratings could cause damage to the device.

THERMAL DERATING CURVES




MAXIMUM POWER DISSIPATION vs AMBIENT TEMPERATURE




MAXIMUM POWER DISSIPATION vs CASE TEMPERATURE

## RECOMMENDED OPERATING CONDITIONS (Note 2 & 3)

Input Voltage Range ..... $-(V_{OUT} + 3.5V)$ to -36V

Operating Junction Temperature Range
SG137A/SG137 ..... -55°C to 150°C
SG237A/SG237 ..... -25°C to 150°C
SG337A/SG337 ..... 0°C to 125°C

Note 2. Range over which the device is functional.
Note 3. These ratings are applicable for junction temperatures of less than 135°C.

## ELECTRICAL SPECIFICATIONS

(Unless otherwise specified, these specifications apply over full operating ambient temperatures for SG137A/SG137 with $-55°C \le T_A \le 150°C$, SG237A/SG237 with $-25°C \le T_A \le 150°C$, SG337A/SG337 with $0°C \le T_A \le 125°C$, $|V_{IN} - V_{OUT}| = 5.0V$, and for $I_{OUT} = 500mA$ (K, R, G, and IG power packages) and $I_{OUT} = 100mA$ (T, F, and L packages). Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the T, F and L packages, and 20W for the K, R, G, and IG packages. $I_{MAX}$ is 1.5A for the K, R, G, and IG packages and 0.5A for the T, F and L packages. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

| Parameter | Test Conditions | SG137A/SG237A | | | SG137/SG237 | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| **Reference Voltage** | **$I_{OUT} = 10mA$, $T_A = 25°C$** | **-1.238** | **-1.250** | **-1.262** | **-1.225** | **-1.250** | **-1.275** | **V** |
| | $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 40V$, $10mA \le I_{OUT} \le I_{MAX}$ | -1.220 | -1.250 | -1.280 | -1.200 | -1.250 | -1.300 | V |
| **Line Regulation (Note 4)** | **$3V \le \lvert V_{IN} - V_{OUT} \rvert \le 40V$, $I_{OUT} \le I_{MAX}$** | | | | | | | |
| | $T_A = 25°C$ | | 0.005 | 0.01 | | 0.01 | 0.02 | %/V |
| **Load Regulation (Note 4)** | **$10mA \le I_{OUT} \le I_{MAX}$** | | | | | | | |
| | $\lvert V_{OUT} \rvert \le 5V$, $T_A = 25°C$ | | 5 | 25 | | 15 | 25 | mV |
| | **$\lvert V_{OUT} \rvert \ge 5V$, $T_A = 25°C$** | | **0.1** | **0.5** | | **0.3** | **0.5** | **%** |
| | $\lvert V_{OUT} \rvert \le 5V$ | | 10 | 50 | | 20 | 50 | mV |
| | **$\lvert V_{OUT} \rvert \ge 5V$** | | **0.2** | **1.0** | | **0.3** | **1.0** | **%** |
| Thermal Regulation (Note 5) | $T_A = 25°C$, 10ms pulse | | 0.002 | 0.02 | | 0.002 | 0.02 | %/W |
| **Ripple Rejection** | **$V_{OUT} = -10V$, f =120Hz** | | | | | | | |
| | $C_{ADJ} = 0$, $T_A = 25°C$ | 60 | 66 | | | 60 | | dB |
| | **$C_{ADJ} = 10\mu F$** | **70** | **80** | | **66** | **77** | | **dB** |
| Adjust Pin Current | $T_A = 25°C$ | | 65 | 100 | | 65 | 100 | µA |
| **Adjust Pin Current Change** | **$3V \le \lvert V_{IN} - V_{OUT} \rvert \le 40V$** | | **1.0** | **5** | | **2** | **5** | **µA** |
| | $10mA \le I_{OUT} \le I_{MAX}$ | | 0.2 | 2 | | 0.5 | 5 | µA |

**ELECTRICAL SPECIFICATIONS** (continued)

| Parameter | Test Conditions | SG137A/SG237A | | | SG137/SG237 | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| **Minimum Load Current** | **$\|V_{IN} - V_{OUT}\| \le 40V$** | | **2.5** | **5.0** | | **2.5** | **5.0** | **mA** |
| | $\|V_{IN} - V_{OUT}\| \le 10V$ | | 1.2 | 3 | | 1.2 | 3.0 | mA |
| **Current Limit** | **$\|V_{IN} - V_{OUT}\| \le 15V$** | | | | | | | |
| | K, P, R, G, IG Packages | 1.5 | 2.2 | 3.2 | 1.5 | 2.2 | | A |
| | **T, L, Packages** | **0.5** | **0.8** | **1.5** | **0.5** | **0.8** | | **A** |
| | $\|V_{IN} - V_{OUT}\| \le 40V$, $T_J = 25°C$ | | | | | | | |
| | **K, P, R, G, IG Packages** | **0.24** | **0.4** | **1.0** | **0.24** | **0.4** | | **A** |
| | T, L, Packages | 0.15 | 0.25 | 0.5 | 0.15 | 0.25 | | A |
| **Temperature Stability (Note 5)** | | | **0.6** | **1.5** | | **0.6** | | **%** |
| Long Term Stability (Note 5) | $T_A = 125°C$, 1000 Hours | | 0.3 | 1.0 | | 0.3 | 1.0 | % |
| **RMS Output Noise (% of $V_{OUT}$)** | **$T_A = 25°C$, 10Hz ≤ f ≤ 10 KHz (Note 5)** | | **0.003** | | | **0.003** | | **%** |

| Parameter | Test Conditions | SG337A | | | SG337 | | | Units |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| **Reference Voltage** | **$I_{OUT} = 10mA$, $T_A = 25°C$** | **-1.238** | **-1.250** | **-1.262** | **-1.213** | **-1.250** | **-1.287** | **V** |
| | $3V \le \|V_{IN} - V_{OUT}\| \le 40V$, $10mA \le I_{OUT} \le I_{MAX}$ | -1.220 | -1.250 | -1.280 | -1.200 | -1.250 | -1.300 | V |
| **Line Regulation (Note 4)** | **$3V \le \|V_{IN} - V_{OUT}\| \le 40V$, $I_{OUT} \le I_{MAX}$** | | | | | | | |
| | $T_A = 25°C$ | | 0.005 | 0.01 | | 0.01 | 0.04 | %/V |
| **Load Regulation (Note 4)** | **$10mA \le I_{OUT} \le I_{MAX}$** | | | | | | | |
| | $\|V_{OUT}\| \le 5V$, $T_A = 25°C$ | | 5 | 25 | | 15 | 50 | mV |
| | **$\|V_{OUT}\| \ge 5V$, $T_A = 25°C$** | | **0.1** | **0.5** | | **0.3** | **1.0** | **%** |
| | $\|V_{OUT}\| \le 5V$ | | 10 | 50 | | 20 | 70 | mV |
| | **$\|V_{OUT}\| \ge 5V$** | | **0.2** | **1.0** | | **0.3** | **1.5** | **%** |
| Thermal Regulation (Note 5) | $T_A = 25°C$, 10ms pulse | | 0.002 | 0.02 | | 0.003 | 0.04 | %/W |
| **Ripple Rejection** | **$V_{OUT} = -10V$, f =120Hz** | | | | | | | |
| | $C_{ADJ} = 0$, $T_A = 25°C$ | 60 | 66 | | | 60 | | dB |
| | **$C_{ADJ} = 10\mu F$** | **70** | **80** | | **66** | **77** | | **dB** |
| Adjust Pin Current | $T_A = 25°C$ | | 65 | 100 | | 65 | 100 | µA |
| **Adjust Pin Current Change** | **$3V \le \|V_{IN} - V_{OUT}\| \le 40V$** | | **1.0** | **5** | | **2** | **5** | **µA** |
| | $10mA \le I_{OUT} \le I_{MAX}$ | | 0.2 | 2 | | 0.5 | 5 | µA |
| **Minimum Load Current** | **$\|V_{IN} - V_{OUT}\| \le 40V$** | | **2.5** | **5** | | **2.5** | **10** | **mA** |
| | $\|V_{IN} - V_{OUT}\| \le 10V$ | | 1.2 | 3 | | 1 | 6 | mA |
| **Current Limit** | **$\|V_{IN} - V_{OUT}\| \le 15V$** | | | | | | | |
| | K, P, R, G, IG-Packages | 1.5 | 2.2 | 3.5 | 1.5 | 2.2 | | A |
| | **T, L-Packages** | **0.5** | **0.8** | **1.5** | **0.5** | **0.8** | | **A** |
| | $\|V_{IN} - V_{OUT}\| \le 40V$, $T_J = 25°C$ | | | | | | | |
| | **K, P, R, G, IG- Packages** | **0.24** | **0.5** | **1.0** | **0.15** | **0.4** | | **A** |
| | T, L-Packages | 0.15 | 0.25 | 0.5 | 0.10 | 0.17 | | A |
| **Temperature Stability (Note 5)** | | | **0.6** | **1.5** | | **0.6** | | **%** |
| Long Term Stability (Note 5) | $T_A = 125°C$, 1000hr | | 0.3 | 1.0 | | 0.3 | 1.0 | % |
| **RMS Output Noise (% of $V_{OUT}$)** | **$T_A = 25°C$, 10Hz ≤ f ≤ 10KHz (Note 5)** | | **0.003** | | | **0.003** | | **%** |

Note 4. Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.

Note 5. These parameters, although guaranteed, are not tested in production.

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## CHARACTERISTIC CURVES

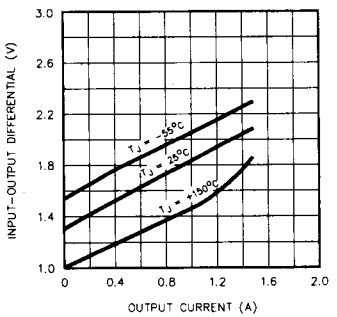



FIGURE 1.
INPUT/OUTPUT DIFFERENTIAL
VS. OUTPUT CURRENT

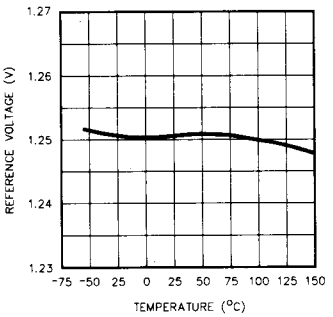



FIGURE 2.
REFERENCE VOLTAGE VS. TEMPERATURE

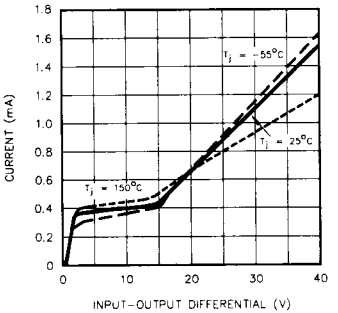



FIGURE 3.
CURRENT VS. INPUT/OUTPUT DIFFERENTIAL

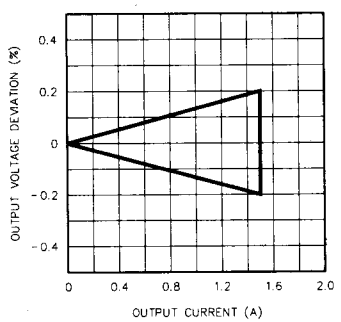



FIGURE 4. *
OUTPUT VOLTAGE DEVIATION
VS. OUTPUT CURRENT

* The SG137A has load regulation compensation which makes the typical unit read close to zero. This band represents the typical production spread.

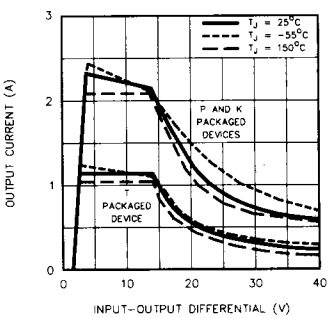



FIGURE 5.
INPUT/OUTPUT DIFFERENTIAL
VS. OUTPUT CURRENT

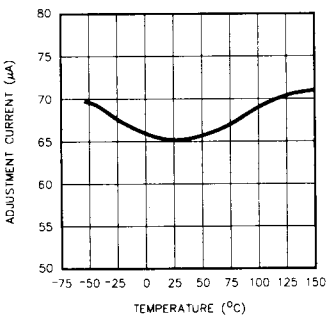



FIGURE 6.
ADJUSTMENT CURRENT VS. TEMPERATURE

## APPLICATION INFORMATION

### OUTPUT VOLTAGE

The output voltage is determined by two external resistors, $R_1$ & $R_2$(see Figure 7).

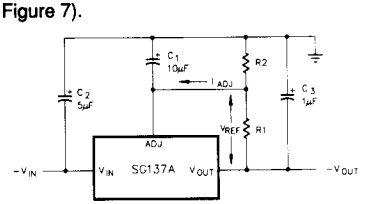



FIGURE 7

The exact formula for the output voltage is:

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

Where: $V_{REF}$ =Reference Voltage, $I_{ADJ}$ = Adjustment Pin Current. In most applications, the second term is small enough to be ignored, typically about 0.5% of $V_{OUT}$. In more critical applications, the exact formula should be used, with $I_{ADJ}$ equal to 65µA. Solving for $R_2$ yields:

$$R_2 = \frac{V_{OUT} - V_{REF}}{\frac{V_{REF}}{R_1} + I_{ADJ}}$$

Smaller values of $R_1$ and $R_2$ will reduce the influence of $I_{ADJ}$ on the output voltage, but the no-load current drain on the regulator will be increased. Typical values for $R_1$ are between 100Ω and 300Ω, giving 12.5 mA and 4.2mA no-load current respectively. There is an additional consideration in selecting $R_1$ the minimum load current specification of the regulator. The operating current of the

## APPLICATION INFORMATION (continued)

SG137A flows from input to output. If this current is not absorbed by the load, the output of the regulator will rise above the regulated value. The current drawn by $R_1$ and $R_2$ is normally high enough to absorb the current, but care must be taken in no–load situations where $R_1$ and $R_2$ have high values. The maximum value for the operating current, which must be absorbed, is 5mA for the SG137A, If input-output voltage differential is less than 10V, the operating current that must be absorbed drops to 3mA.

EXAMPLES:

1. A precision 10V regulator to supply up to 1Amp load current.

   a. Select $R_1 = 100\Omega$ to minimize effect of $I_{ADJ}$

   b. Calculate $R_2 = \frac{V_{OUT} - V_{REF}}{(V_{REF}/R_1) + I_{ADJ}} = \frac{10V - 1.25V}{(1.25V/100\Omega) + 65\mu A} = 704\Omega$

2. A 15V regulator to run off batteries and supply 50mA.
   $V_{IN}$ MAX = 25V

   a. To minimize battery drain, select $R_1$ as high as possible

   $$R_1 = \frac{1.25V}{3mA} = 417\Omega, \text{ use } 404\Omega, 1\%$$

## TYPICAL APPLICATIONS

The output stability, load regulation, line regulation, thermal regulation, temperature drift, long term drift, and noise, can be improved by a factor of 6.6 over the standard regulator configuration. This assumes a zener whose drift and noise is considerably better than the regulator itself. The LM329B has 20PPM/°C maximum drift and about 10 times lower noise than the regulator.

In the application shown Figure 8, regulators #2 to #N will track regulator #1 to within ±24mV initially, and to ±60mV over all load, line, and temperature conditions. If any regulator output is shorted to ground, all other outputs will drop to -2V. Load regulation of regulators #2 to #N will be improved by $V_{OUT}/1.25V$ compared to a standard regulator, so regulator #1 should be the one which has the lowest load current.

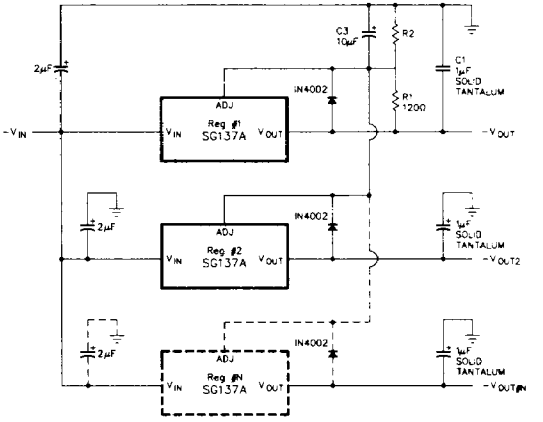



FIGURE 8 - MULTIPLE TRACKING REGULATORS

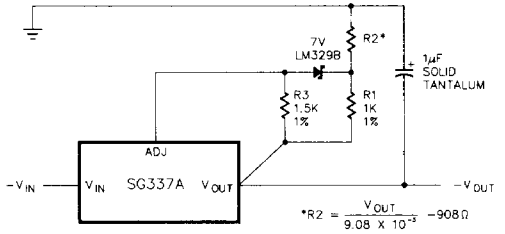



FIGURE 9 - HIGH STABILITY REGULATOR

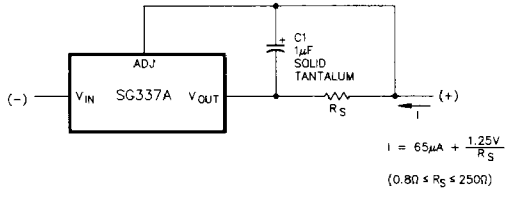



FIGURE 10 - CURRENT REGULATOR

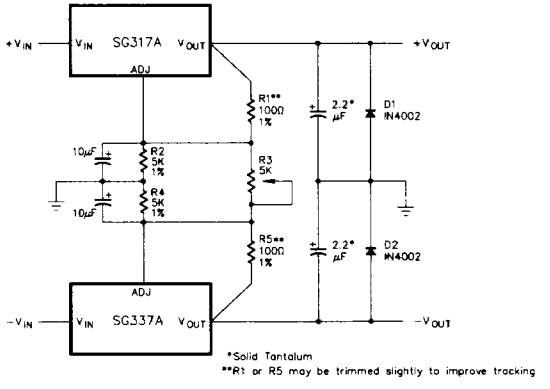
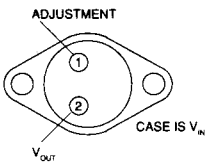
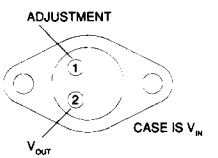
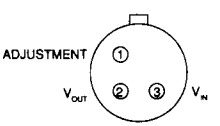
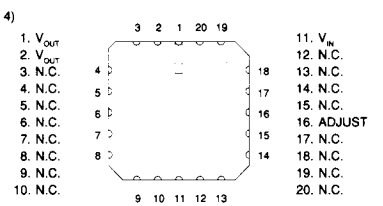



FIGURE 11 - DUAL TRACKING SUPPLY ±1.25V to ±20V

## CONNECTION DIAGRAMS & ORDERING INFORMATION (See Notes Below)

| Package | Part No. | Ambient Temperature Range | Connection Diagram |
|---|---|---|---|
| 3-TERMINAL TO-3<br>METAL CAN<br>K-PACKAGE | SG137AK/883B<br>SG137AK<br>SG237AK<br>SG337AK<br>SG137K/883B<br>SG137K<br>SG237K<br>SG337K | -55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70C<br>-55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70°C |  |
| 3-TERMINAL TO-66<br>METAL CAN<br>R-PACKAGE | SG137AR/883B<br>SG137AR<br>SG237AR<br>SG337AR<br>SG137R/883B<br>SG137R<br>SG237R<br>SG337R | -55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70°C<br>-55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70°C |  |
| 3-PIN TO-39 METAL CAN<br>T-PACKAGE | SG137AT/883B<br>SG137AT<br>SG237AT<br>SG337AT<br>SG137T/883B<br>SG137T<br>SG237T<br>SG337T | -55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70°C<br>-55°C to 125°C<br>-55°C to 125°C<br>-25°C to 85°C<br>0°C to 70°C |  |
| 3-PIN HERMETIC TO-257<br>G-PACKAGE (Non-Isolated)<br><br>3-PIN HERMETIC TO-257<br>IG-PACKAGE (Isolated) | SG137AG/883B<br>SG137AG<br>SG137G/883B<br>SG137G<br><br>SG137AIG/883B<br>SG137AIG<br>SG137IG/883B<br>SG137IG | -55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C<br><br>-55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C | |
| 20-PIN CERAMIC (LCC)<br>LEADLESS CHIP CARRIER<br>L- PACKAGE | SG137AL/883B<br>SG137AL<br>SG137L/883B<br>SG137L | -55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C<br>-55°C to 125°C | (Note 4)<br>  |

Note 1. Contact factory for JAN and DESC product availability.
2. All parts are viewed from the top.
3. Product is also available in flatpack. Consult factory for price and delivery.
4. Both outputs must be externally connected together at the device terminals.