**LM137/LM337**

**3-Terminal Adjustable Negative Regulators**

**General Description**

The LM137/LM337 are adjustable 3-terminal negative voltage regulators capable of supplying in excess of −1.5A over an output voltage range of −1.2V to −37V. These regulators are exceptionally easy to apply, requiring only 2 external resistors to set the output voltage and 1 output capacitor for frequency compensation. The circuit design has been optimized for excellent regulation and low thermal transients. Further, the LM137 series features internal current limiting, thermal shutdown and safe-area compensation, making them virtually blowout-proof against overloads.

The LM137/LM337 serve a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM137/LM337 are ideal complements to the LM117/LM317 adjustable positive regulators.

**Features**

- Output voltage adjustable from −1.2V to −37V
- 1.5A output current guaranteed, −55˚C to +150˚C
- Line regulation typically 0.01%/V
- Load regulation typically 0.3%
- Excellent thermal regulation, 0.002%/W
- 77 dB ripple rejection
- Excellent rejection of thermal transients
- 50 ppm/˚C temperature coefficient
- Temperature-independent current limit
- Internal thermal overload protection
- P+ Product Enhancement tested
- Standard 3-lead transistor package
- Output is short circuit protected

**LM137 Series Packages and Power Capability**

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Rated Power Dissipation</th>
<th>Design Load Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM137/337</td>
<td>TO-3 (K)</td>
<td>20W</td>
<td>1.5A</td>
</tr>
<tr>
<td></td>
<td>TO-39 (H)</td>
<td>2W</td>
<td>0.5A</td>
</tr>
<tr>
<td>LM337</td>
<td>TO-220 (T)</td>
<td>15W</td>
<td>1.5A</td>
</tr>
<tr>
<td></td>
<td>SOT-223 (MP)</td>
<td>2W</td>
<td>1A</td>
</tr>
</tbody>
</table>

**Typical Applications**

Adjustable Negative Voltage Regulator

\[-V_{OUT} = -1.25V \left(1 + \frac{R_2}{120}\right) + \left(-I_{adj} \times R_2\right)\]

\(^1\text{C1 = 1 \mu F solid tantalum or 10 \mu F aluminum electrolytic required for stability}\)

\(^2\text{C2 = 1 \mu F solid tantalum is required only if regulator is more than 4” from power-supply filter capacitor}\)

Output capacitors in the range of 1 \mu F to 1000 \mu F of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

**Comparison between SOT-223 and D-Pak (TO-252) Packages**

Scale 1:1
Absolute Maximum Ratings (Notes 1, 4)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

- Power Dissipation: Internally Limited
- Input-Output Voltage Differential: 40V
- Operating Junction Temperature Range:
  - LM137: −55˚C to +150˚C
  - LM337: 0˚C to +125˚C
  - LM337I: −40˚C to +125˚C

Storage Temperature:
- −65˚C to +150˚C

Lead Temperature (Soldering, 10 sec.):
- 300˚C

Plastic Package (Soldering, 4 sec.):
- 260˚C

ESD Rating:
- 2k Volts

Electrical Characteristics (Note 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM137</th>
<th>LM337</th>
<th>Units</th>
<th>LM137</th>
<th>LM337</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>Tj = 25˚C, 3V ≤</td>
<td>V_in − V_out</td>
<td>≤ 40V (Note 2) I_L = 10 mA</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>Tj = 25˚C, 10 mA ≤ I_OUT ≤ I_MAX</td>
<td>0.3</td>
<td>0.5</td>
<td>0.3</td>
<td>1.0</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Thermal Regulation</td>
<td>Tj = 25˚C, 10 ms Pulse</td>
<td>0.002</td>
<td>0.02</td>
<td>0.003</td>
<td>0.04</td>
<td>%/W</td>
<td></td>
</tr>
<tr>
<td>Adjustment Pin Current</td>
<td></td>
<td>65</td>
<td>100</td>
<td>65</td>
<td>100</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Adjustment Pin Current Charge</td>
<td>10 mA ≤ I_L ≤ I_MAX, 3.0V ≤</td>
<td>V_in − V_out</td>
<td>≤ 40V, T_A = 25˚C</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Reference Voltage</td>
<td>Tj = 25˚C (Note 3)</td>
<td>3V</td>
<td>40V</td>
<td>0.225</td>
<td>1.250</td>
<td>1.275</td>
<td>−1.213 −1.250 −1.275</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 mA ≤ I_OUT ≤ I_MAX, P ≤ P_MAX</td>
<td>−1.200</td>
<td>−1.250</td>
<td>−1.300</td>
<td>−1.200</td>
<td>−1.250</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>3V ≤</td>
<td>V_in − V_out</td>
<td>≤ 40V, (Note 2)</td>
<td>0.02</td>
<td>0.05</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>10 mA ≤ I_OUT ≤ I_MAX, (Note 2)</td>
<td>0.3</td>
<td>1</td>
<td>0.3</td>
<td>1.5</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Temperature Stability</td>
<td>T_MIN ≤</td>
<td>T_j</td>
<td>≤ T_MAX</td>
<td>0.6</td>
<td>0.6</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Minimum Load Current</td>
<td></td>
<td>V_in − V_OUT</td>
<td>≤ 40V</td>
<td>2.5</td>
<td>5</td>
<td>2.5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V_in − V_OUT</td>
<td>≤ 10V</td>
<td>1.2</td>
<td>3</td>
<td>1.5</td>
<td>6</td>
</tr>
<tr>
<td>Current Limit</td>
<td></td>
<td>V_in − V_OUT</td>
<td>≤ 15V</td>
<td>1.5</td>
<td>2.2</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>K, MP and T Package</td>
<td>0.5</td>
<td>0.8</td>
<td>1.8</td>
<td>0.5</td>
<td>0.8</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>H Package</td>
<td>0.24</td>
<td>0.4</td>
<td>0.15</td>
<td>0.4</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H Package</td>
<td>0.15</td>
<td>0.17</td>
<td>0.10</td>
<td>0.17</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>RMS Output Noise, % of V_OUT</td>
<td>Tj = 25˚C, 10 Hz ≤ f ≤ 10 kHz</td>
<td>0.003</td>
<td>0.003</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ripple Rejection Ratio</td>
<td>V_OUT = −10V, f = 120 Hz</td>
<td>60</td>
<td>60</td>
<td>dBA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C_ADJ = 10 µF</td>
<td>66</td>
<td>77</td>
<td>dBA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term Stability</td>
<td>Tj = 125˚C, 1000 Hours</td>
<td>0.3</td>
<td>1</td>
<td>0.3</td>
<td>1</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance, Junction to</td>
<td>H Package</td>
<td>12</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>°C/W</td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>K Package</td>
<td>2.3</td>
<td>3</td>
<td>2.3</td>
<td>3</td>
<td>°C/W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T Package</td>
<td>140</td>
<td>140</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance, Junction to</td>
<td>H Package</td>
<td>35</td>
<td>35</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient (No Heat Sink)</td>
<td>K Package</td>
<td>50</td>
<td>50</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T Package</td>
<td>170</td>
<td>170</td>
<td>°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Unless otherwise specified, these specifications apply −55˚C ≤ Tj ≤ +150˚C for the LM137; 0˚C ≤ Tj ≤ +125˚C for the LM337; |V_in − V_OUT| = 5V; and I_OUT = 0.1A for the TO-39 package and I_OUT = 0.5A for the TO-3, SOT-223 and TO-220 packages. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO-39 and SOT-223 (see Application Hints), and 20W for the TO-3, and TO-220. I_MAX is 1.5A for the TO-3, SOT-223 and TO-220 packages, and 0.2A for the TO-39 package.

Note 2: 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. Load regulation is measured on the output pin at a point 1/8" below the base of the TO-3 and TO-39 packages.

Note 3: Selected devices with tightened tolerance reference voltage available.
Thermal Regulation

When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large. Thermal regulation is the effect of these temperature gradients on output voltage (in percentage output change) per Watt of power change in a specified time. Thermal regulation error is independent of electrical regulation or temperature coefficient, and occurs within 5 ms to 50 ms after a change in power dissipation. Thermal regulation depends on IC layout as well as electrical design. The thermal regulation of a voltage regulator is defined as the percentage change of $V_{OUT}$, per Watt, within the first 10 ms after a step of power is applied. The LM137’s specification is 0.02%/W, max.

<table>
<thead>
<tr>
<th>$V_{IN} - V_{OUT}$</th>
<th>$I_{IL}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-40V$</td>
<td>0A → 0.25A → 0A</td>
</tr>
</tbody>
</table>

Vertical sensitivity, 5 mV/div
Thermal Regulation (Continued)

In Figure 1, a typical LM137’s output drifts only 3 mV (or 0.03% of $V_{OUT} = -10V$) when a 10W pulse is applied for 10 ms. This performance is thus well inside the specification limit of $0.02%/W \times 10W = 0.2\%$ max. When the 10W pulse is ended, the thermal regulation again shows a 3 mV step at the LM137 chip cools off. Note that the load regulation error of about 8 mV (0.08%) is additional to the thermal regulation error. In Figure 2, when the 10W pulse is applied for 100 ms, the output drifts only slightly beyond the drift in the first 10 ms, and the thermal error stays well within 0.1% (10 mV).

**FIGURE 2.**

LM137, $V_{OUT} = -10V$
$V_{IN} - V_{OUT} = -40V$
$I_L = 0A \rightarrow 0.25A \rightarrow 0A$
Horizontal sensitivity, 20 ms/div

Connection Diagrams

TO-3
Metal Can Package

TO-39
Metal Can Package

Case is Input

Order Number LM137K/883
LM137KPQML and LM137KPQMLV(Note 5)
See NS Package Number K02C
Order Number LM337K STEEL
See NS Package Number K02A

Order Number LM137H, LM137H/883 or LM337H
LM137HPQML and LM137HPQMLV(Note 5)
See NS Package Number H03A

*Note 5: See STD MIL DWG 5962P99517 for Radiation Tolerant Devices*
Application Hints

When a value for $\theta_{(H-A)}$ is found using the equation shown, a heatsink must be selected that has a value that is less than or equal to this number.

HEATSINKING SOT-223 PACKAGE PARTS

The SOT-223 ("MP") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

Figures 3, 4 show the information for the SOT-223 package. Figure 4 assumes a $\theta_{(J-A)}$ of 75°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C.

Please see AN1028 for power enhancement techniques to be used with the SOT-223 package.
Typical Applications

Adjustable Lab Voltage Regulator

Full output current not available at high input-output voltages

*The 10 µF capacitors are optional to improve ripple rejection

Current Regulator

\[ i_{\text{out}} = \frac{1.250V}{R_1} \]
*0.8Ω ≤ R1 ≤ 120Ω

Negative Regulator with Protection Diodes

*When C2 is larger than 20 µF, D1 protects the LM137 in case the input supply is shorted

**When C2 is larger than 10 µF and –V_{OUT} is larger than –25V, D2 protects the LM137 in case the output is shorted
Typical Performance Characteristics (K Steel and T Packages)

Load Regulation

Current Limit

Adjustment Current

Dropout Voltage

Temperature Stability

Minimum Operating Current
Typical Performance Characteristics (K Steel and T Packages) (Continued)

Ripple Rejection

- **Ripple Rejection (K Steel)**
  - $C_{\text{adj}} = 10 \mu\text{F}$
  - $C_{\text{adj}} = 0$

- **Ripple Rejection (T Packages)**
  - $V_{\text{IN}} - V_{\text{OUT}} = 5\text{V}$
  - $I_L = 500\text{ mA}$
  - $f = 120\text{ Hz}$
  - $T_J = 25\text{°C}$

Output Impedance

- **Output Impedance (K Steel)**
  - $C_{\text{adj}} = 10 \mu\text{F}$
  - $C_{\text{adj}} = 0$

- **Output Impedance (T Packages)**
  - $V_{\text{IN}} = -15\text{V}$
  - $V_{\text{OUT}} = -10\text{V}$
  - $I_L = 500\text{ mA}$
  - $C_L = 1\mu\text{F}$
  - $T_J = 25\text{°C}$

Line Transient Response

- **Line Transient Response (K Steel)**
  - $C_{\text{adj}} = 10 \mu\text{F}$
  - $C_{\text{adj}} = 0$

- **Line Transient Response (T Packages)**
  - $V_{\text{OUT}} = -10\text{V}$
  - $I_L = 50\text{ mA}$
  - $T_J = 25\text{°C}$
  - $C_L = 1\mu\text{F}$

Load Transient Response

- **Load Transient Response (K Steel)**
  - $C_{\text{adj}} = 10 \mu\text{F}$
  - $C_{\text{adj}} = 0$

- **Load Transient Response (T Packages)**
  - $V_{\text{IN}} = -15\text{V}$
  - $V_{\text{OUT}} = -10\text{V}$
  - $I_L = 50\text{ mA}$
  - $T_J = 25\text{°C}$
  - $C_L = 1\mu\text{F}$
Physical Dimensions  inches (millimeters)  
unless otherwise noted

Metal Can Package (H)  
Order Number LM137H, LM137H/883 or LM337H  
NS Package Number H03A
Physical Dimensions  inches (millimeters) unless otherwise noted  (Continued)

Metal Can Package (K)
Order Number LM337K STEEL
NS Package Number K02A

Mil-Aero Metal Can Package (K)
Order Number LM137K/883
NS Package Number K02C
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

3-Lead SOT-23 Package
Order Number LM337IMP
NS Package Number MP04A

DIMENSIONS ARE IN MILLIMETERS

MP04A (Rev B)
Physical Dimensions  inches (millimeters) unless otherwise noted (Continued)

TO-220 Plastic Package (T)
Order Number LM337T
NS Package Number T03B

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.
For the most current product information visit us at www.national.com.

LIFE SUPPORT POLICY
NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:
1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or
   (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE
National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no “Banned Substances” as defined in CSP-9-111S2.
This datasheet has been download from:

www.datasheetcatalog.com

Datasheets for electronics components.