

# LM137,LM337

*LM137/LM337 3-Terminal Adjustable Negative Regulators*



Literature Number: SNVS778C

# 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

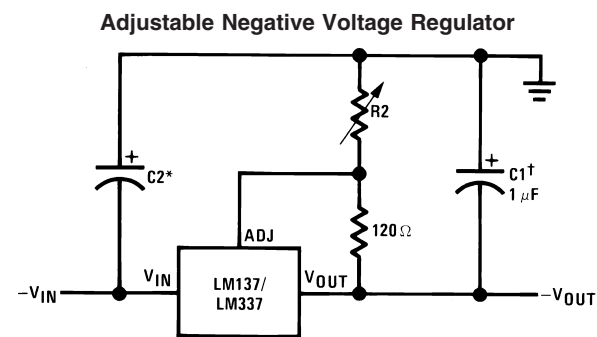
- Output voltage adjustable from  $-1.2V$  to  $-37V$
- $1.5A$  output current guaranteed,  $-55^{\circ}C$  to  $+150^{\circ}C$
- Line regulation typically  $0.01\%/V$
- Load regulation typically  $0.3\%$

- Excellent thermal regulation,  $0.002\%/W$
- $77$  dB ripple rejection
- Excellent rejection of thermal transients
- $50$  ppm/ $^{\circ}C$  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

| Device    | Package      | Rated Power Dissipation | Design Load Current |
|-----------|--------------|-------------------------|---------------------|
| LM137/337 | TO-3 (K)     | 20W                     | 1.5A                |
|           | TO-39 (H)    | 2W                      | 0.5A                |
| LM337     | TO-220 (T)   | 15W                     | 1.5A                |
| LM337     | SOT-223 (MP) | 2W                      | 1A                  |

### Typical Applications



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Full output current not available at high input-output voltages

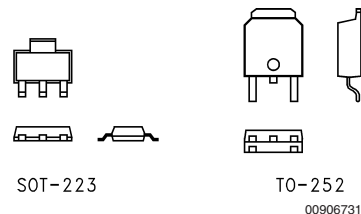
$$-V_{OUT} = -1.25V \left( 1 + \frac{R2}{120} \right) + (-I_{ADJ} \times R2)$$

†C1 =  $1 \mu F$  solid tantalum or  $10 \mu F$  aluminum electrolytic required for stability

\*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)

| Parameter                                              | Conditions                                                                                                                                                                                               | LM137  |        |        | LM337  |        |        | Units              |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------------------|
|                                                        |                                                                                                                                                                                                          | Min    | Typ    | Max    | Min    | Typ    | Max    |                    |
| Line Regulation                                        | $T_j = 25^\circ\text{C}$ , $3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$<br>(Note 2) $I_L = 10\text{ mA}$                                                                            |        | 0.01   | 0.02   |        | 0.01   | 0.04   | %/V                |
| Load Regulation                                        | $T_j = 25^\circ\text{C}$ , $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$                                                                                                                        |        | 0.3    | 0.5    |        | 0.3    | 1.0    | %                  |
| Thermal Regulation                                     | $T_j = 25^\circ\text{C}$ , 10 ms Pulse                                                                                                                                                                   |        | 0.002  | 0.02   |        | 0.003  | 0.04   | %/W                |
| Adjustment Pin Current                                 |                                                                                                                                                                                                          |        | 65     | 100    |        | 65     | 100    | $\mu\text{A}$      |
| Adjustment Pin Current Charge                          | $10\text{ mA} \leq I_L \leq I_{\text{MAX}}$<br>$3.0\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ ,<br>$T_A = 25^\circ\text{C}$                                                         |        | 2      | 5      |        | 2      | 5      | $\mu\text{A}$      |
| Reference Voltage                                      | $T_j = 25^\circ\text{C}$ (Note 3)<br>$3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ , (Note 3)<br>$10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$ , $P \leq P_{\text{MAX}}$    | -1.225 | -1.250 | -1.275 | -1.213 | -1.250 | -1.287 | V                  |
|                                                        |                                                                                                                                                                                                          | -1.200 | -1.250 | -1.300 | -1.200 | -1.250 | -1.300 | V                  |
| Line Regulation                                        | $3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ , (Note 2)                                                                                                                             |        | 0.02   | 0.05   |        | 0.02   | 0.07   | %/V                |
| Load Regulation                                        | $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$ , (Note 2)                                                                                                                                        |        | 0.3    | 1      |        | 0.3    | 1.5    | %                  |
| Temperature Stability                                  | $T_{\text{MIN}} \leq T_j \leq T_{\text{MAX}}$                                                                                                                                                            |        | 0.6    |        |        | 0.6    |        | %                  |
| Minimum Load Current                                   | $ V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$<br>$ V_{\text{IN}} - V_{\text{OUT}}  \leq 10\text{V}$                                                                                                 |        | 2.5    | 5      |        | 2.5    | 10     | mA                 |
|                                                        |                                                                                                                                                                                                          |        | 1.2    | 3      |        | 1.5    | 6      | mA                 |
| Current Limit                                          | $ V_{\text{IN}} - V_{\text{OUT}}  \leq 15\text{V}$<br>K, MP and T Package<br>H Package<br>$ V_{\text{IN}} - V_{\text{OUT}}  = 40\text{V}$ , $T_j = 25^\circ\text{C}$<br>K, MP and T Package<br>H Package | 1.5    | 2.2    | 3.5    | 1.5    | 2.2    | 3.7    | A                  |
|                                                        |                                                                                                                                                                                                          | 0.5    | 0.8    | 1.8    | 0.5    | 0.8    | 1.9    | A                  |
|                                                        |                                                                                                                                                                                                          | 0.24   | 0.4    |        | 0.15   | 0.4    |        | A                  |
|                                                        |                                                                                                                                                                                                          | 0.15   | 0.17   |        | 0.10   | 0.17   |        | A                  |
| RMS Output Noise, % of $V_{\text{OUT}}$                | $T_j = 25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 10\text{ kHz}$                                                                                                                                      |        | 0.003  |        |        | 0.003  |        | %                  |
| Ripple Rejection Ratio                                 | $V_{\text{OUT}} = -10\text{V}$ , $f = 120\text{ Hz}$<br>$C_{\text{ADJ}} = 10\text{ }\mu\text{F}$                                                                                                         |        | 60     |        |        | 60     |        | dB                 |
|                                                        |                                                                                                                                                                                                          | 66     | 77     |        | 66     | 77     |        | dB                 |
| Long-Term Stability                                    | $T_j = 125^\circ\text{C}$ , 1000 Hours                                                                                                                                                                   |        | 0.3    | 1      |        | 0.3    | 1      | %                  |
| Thermal Resistance, Junction to Case                   | H Package                                                                                                                                                                                                |        | 12     | 15     |        | 12     | 15     | $^\circ\text{C/W}$ |
|                                                        | K Package                                                                                                                                                                                                |        | 2.3    | 3      |        | 2.3    | 3      | $^\circ\text{C/W}$ |
|                                                        | T Package                                                                                                                                                                                                |        |        |        |        | 4      |        | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction to Ambient (No Heat Sink) | H Package                                                                                                                                                                                                |        | 140    |        |        | 140    |        | $^\circ\text{C/W}$ |
|                                                        | K Package                                                                                                                                                                                                |        | 35     |        |        | 35     |        | $^\circ\text{C/W}$ |
|                                                        | T Package                                                                                                                                                                                                |        |        |        |        | 50     |        | $^\circ\text{C/W}$ |
|                                                        | MP Package                                                                                                                                                                                               |        |        |        |        | 170    |        | $^\circ\text{C/W}$ |

**Note 1:** Unless otherwise specified, these specifications apply  $-55^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$  for the LM137,  $0^\circ\text{C} \leq T_j \leq +125^\circ\text{C}$  for the LM337;  $V_{\text{IN}} - V_{\text{OUT}} = 5\text{V}$ ; and  $I_{\text{OUT}} = 0.1\text{A}$  for the TO-39 package and  $I_{\text{OUT}} = 0.5\text{A}$  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.  $I_{\text{MAX}}$  is 1.5A for the TO-3, SOT-223 and TO-220 packages, and 0.2A for the TO-39 package.

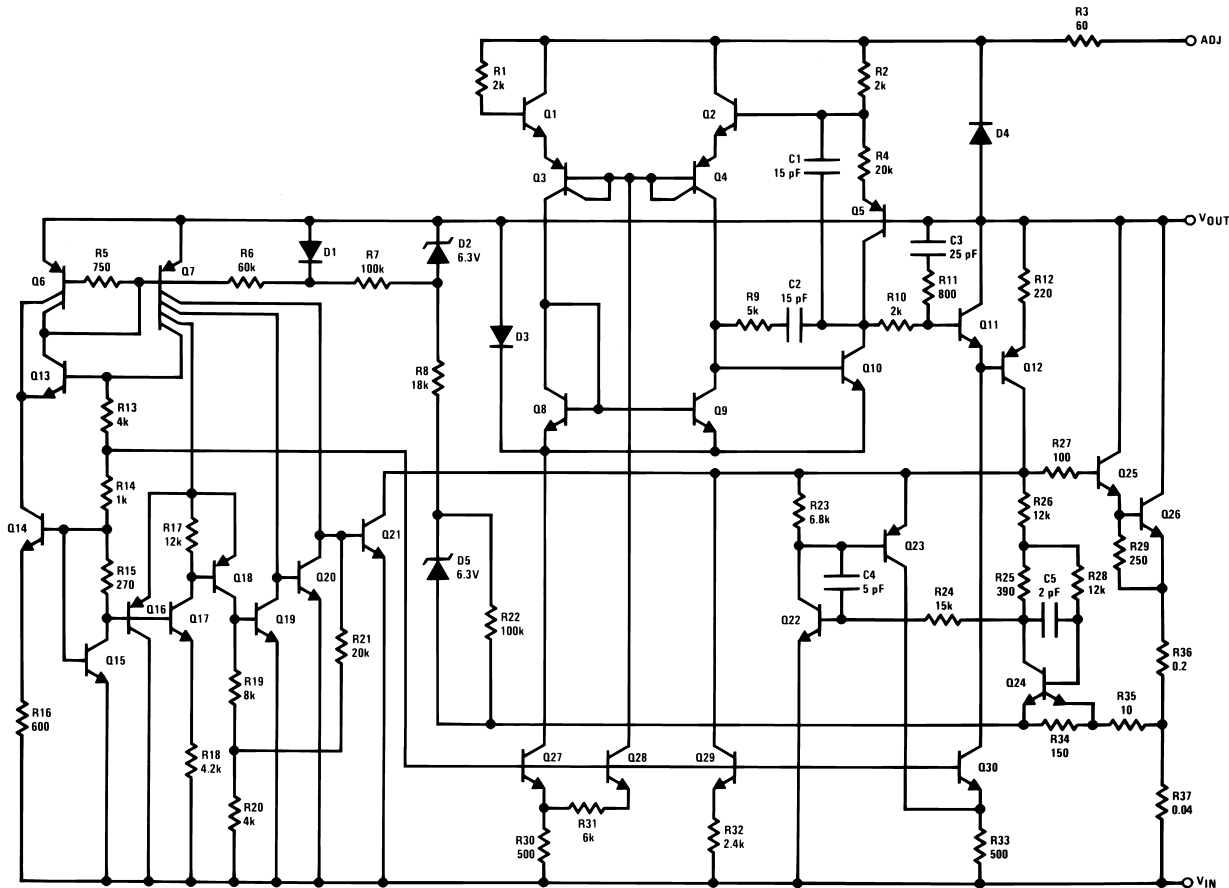
**Note 2:** Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation. Load regulation is measured on the output pin at a point  $\frac{1}{8}$ " below the base of the TO-3 and TO-39 packages.

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

# Electrical Characteristics (Note 1) (Continued)

Note 4: Refer to RETS137H drawing for LM137H or RETS137K drawing for LM137K military specifications.

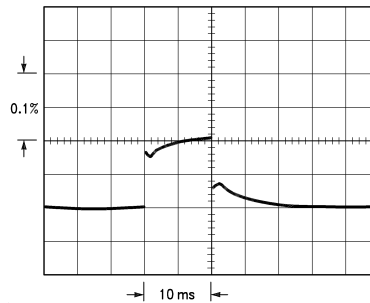
## Schematic Diagram



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## 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.



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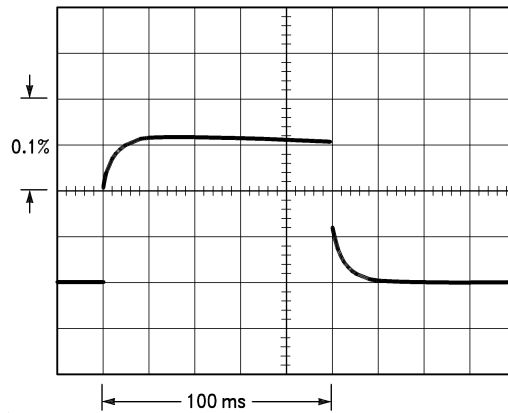
LM137,  $V_{OUT} = -10V$   
 $V_{IN} - V_{OUT} = -40V$   
 $I_L = 0A \rightarrow 0.25A \rightarrow 0A$   
 Vertical sensitivity, 5 mV/div

FIGURE 1.

## 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).

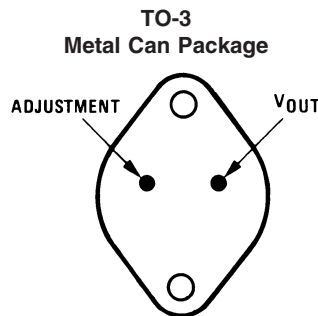


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LM137,  $V_{OUT} = -10V$   
 $V_{IN} - V_{OUT} = -40V$   
 $I_L = 0A \rightarrow 0.25A \rightarrow 0A$   
 Horizontal sensitivity, 20 ms/div

FIGURE 2.

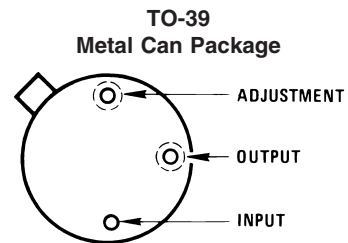
## Connection Diagrams



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Case Is Input

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



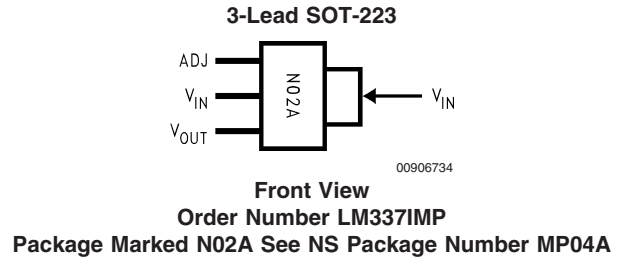
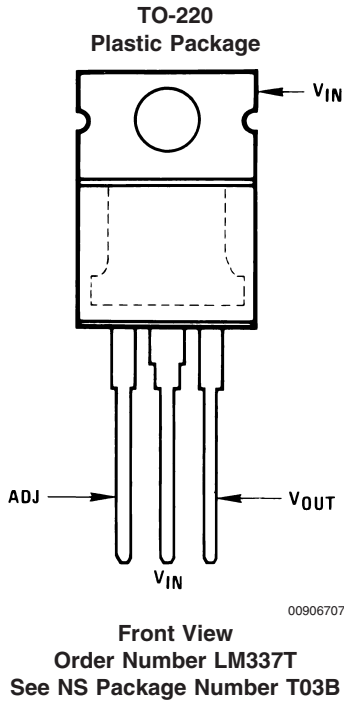
00906706

Case Is Input

**Note 5:** See STD Mil DWG 5962P99517 for Radiation Tolerant Devices

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

Connection Diagrams (Continued)



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.

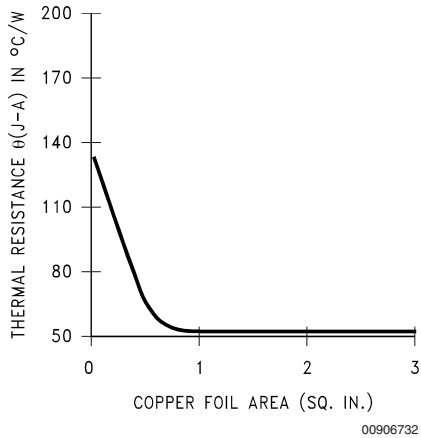


FIGURE 3.  $\theta_{(J-A)}$  vs Copper (2 ounce) Area for the SOT-223 Package

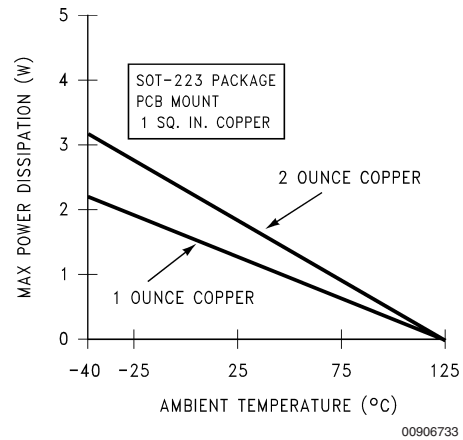
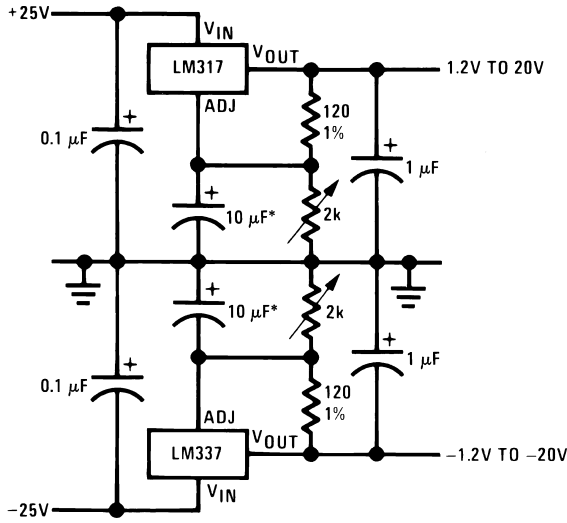


FIGURE 4. Maximum Power Dissipation vs.  $T_{AMB}$  for the SOT-223 Package

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

# Typical Applications

### Adjustable Lab Voltage Regulator

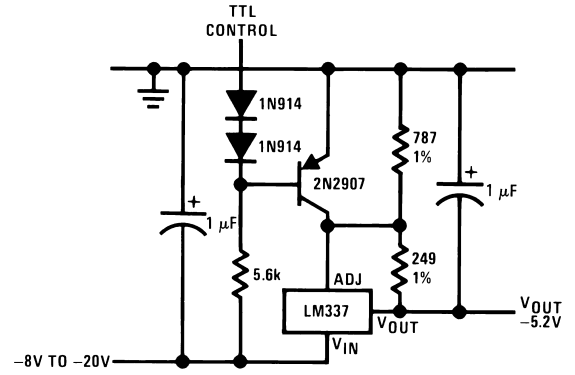


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Full output current not available at high input-output voltages

\*The 10 μF capacitors are optional to improve ripple rejection

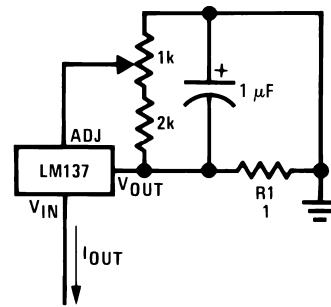
### -5.2V Regulator with Electronic Shutdown\*



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\*Minimum output = -1.3V when control input is low

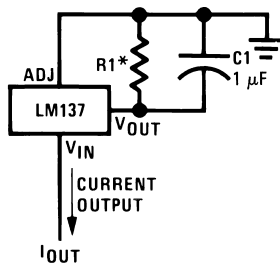
### Adjustable Current Regulator



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$$I_{OUT} = \left( \frac{1.5V}{R1} \right) \pm 15\% \text{ adjustable}$$

### Current Regulator

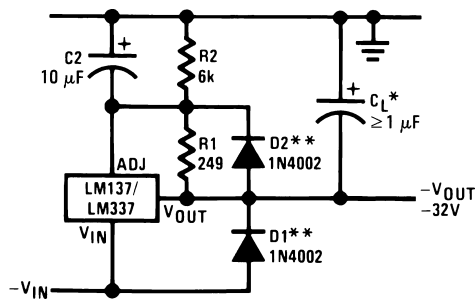


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$$I_{OUT} = \frac{1.250V}{R1}$$

\*0.8Ω ≤ R1 ≤ 120Ω

### Negative Regulator with Protection Diodes

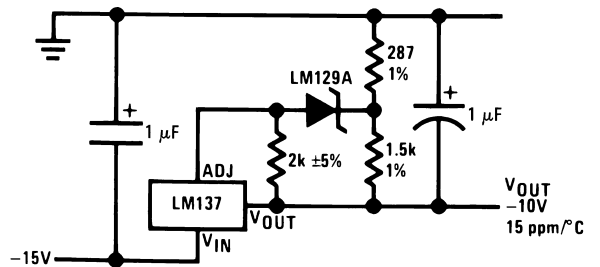


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\*When C<sub>L</sub> is larger than 20 μF, D1 protects the LM137 in case the input supply is shorted

\*\*When C<sub>2</sub> is larger than 10 μF and -V<sub>OUT</sub> is larger than -25V, D2 protects the LM137 in case the output is shorted

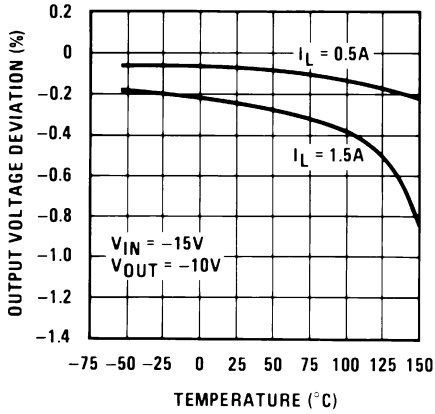
### High Stability -10V Regulator



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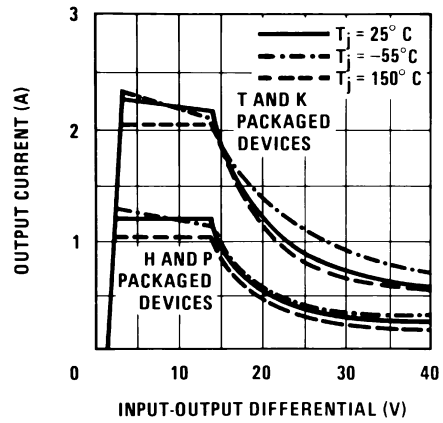
# Typical Performance Characteristics (K Steel and T Packages)

Load Regulation



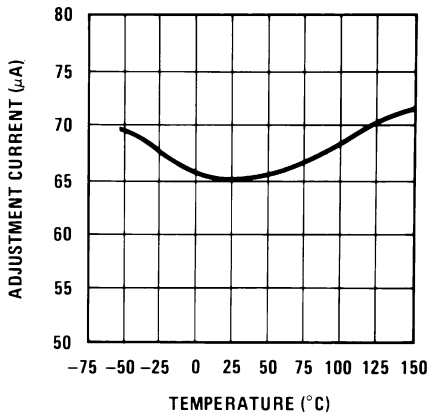
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Current Limit



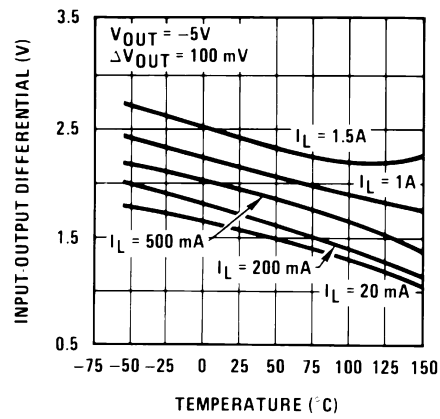
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Adjustment Current



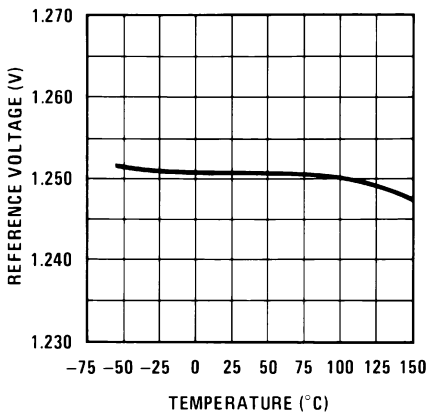
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Dropout Voltage



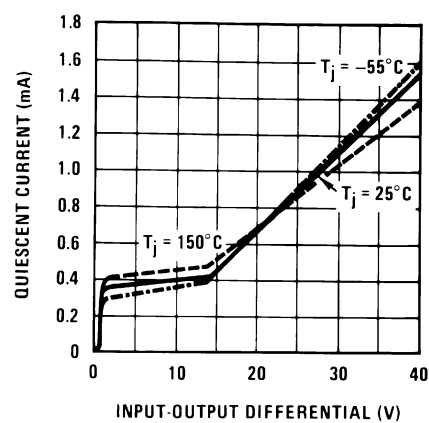
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Temperature Stability



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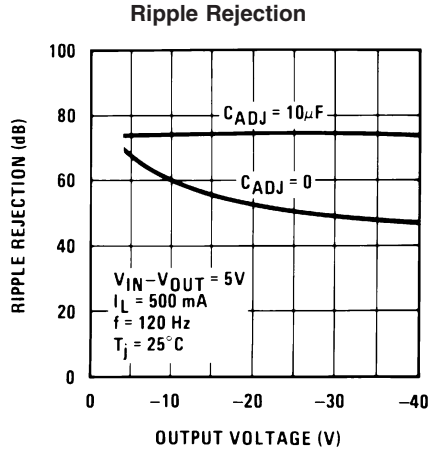
Minimum Operating Current



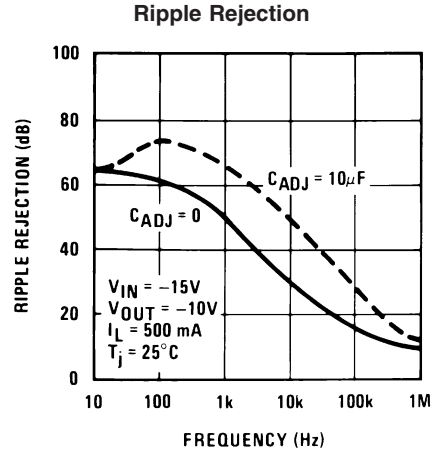
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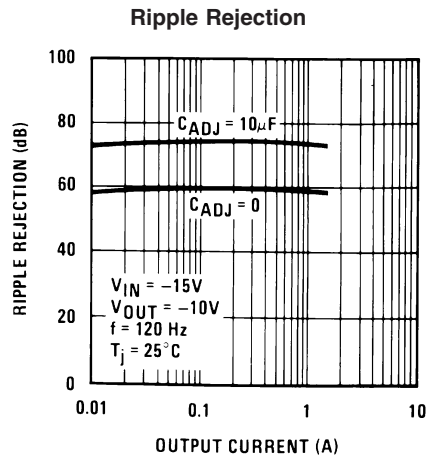
# Typical Performance Characteristics (K Steel and T Packages) (Continued)



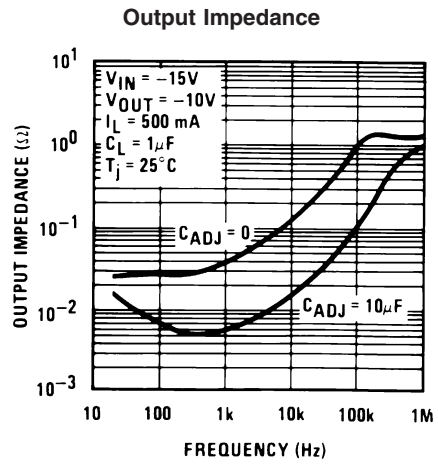
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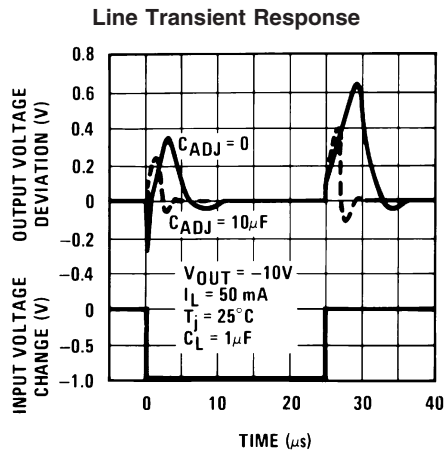
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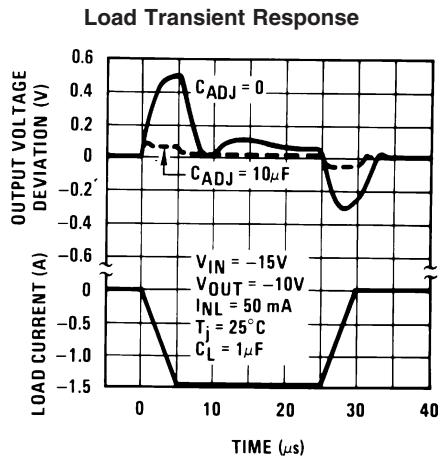
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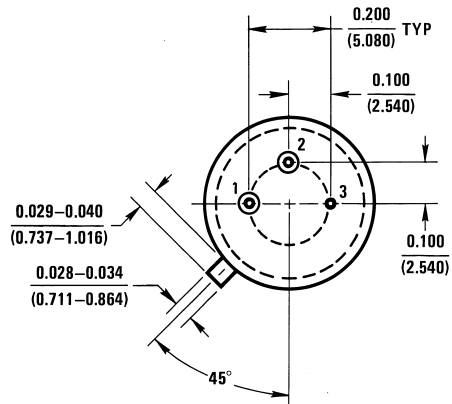
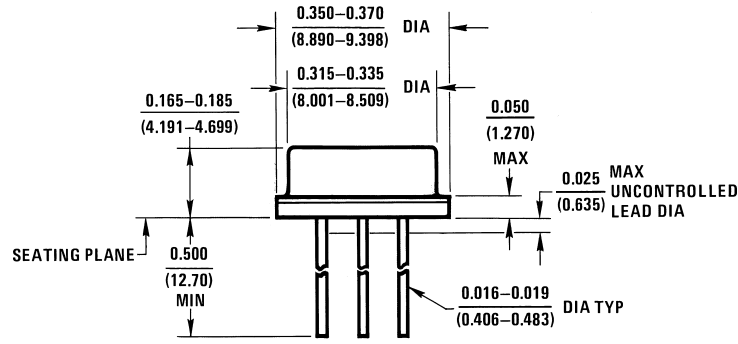
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**Physical Dimensions** inches (millimeters)

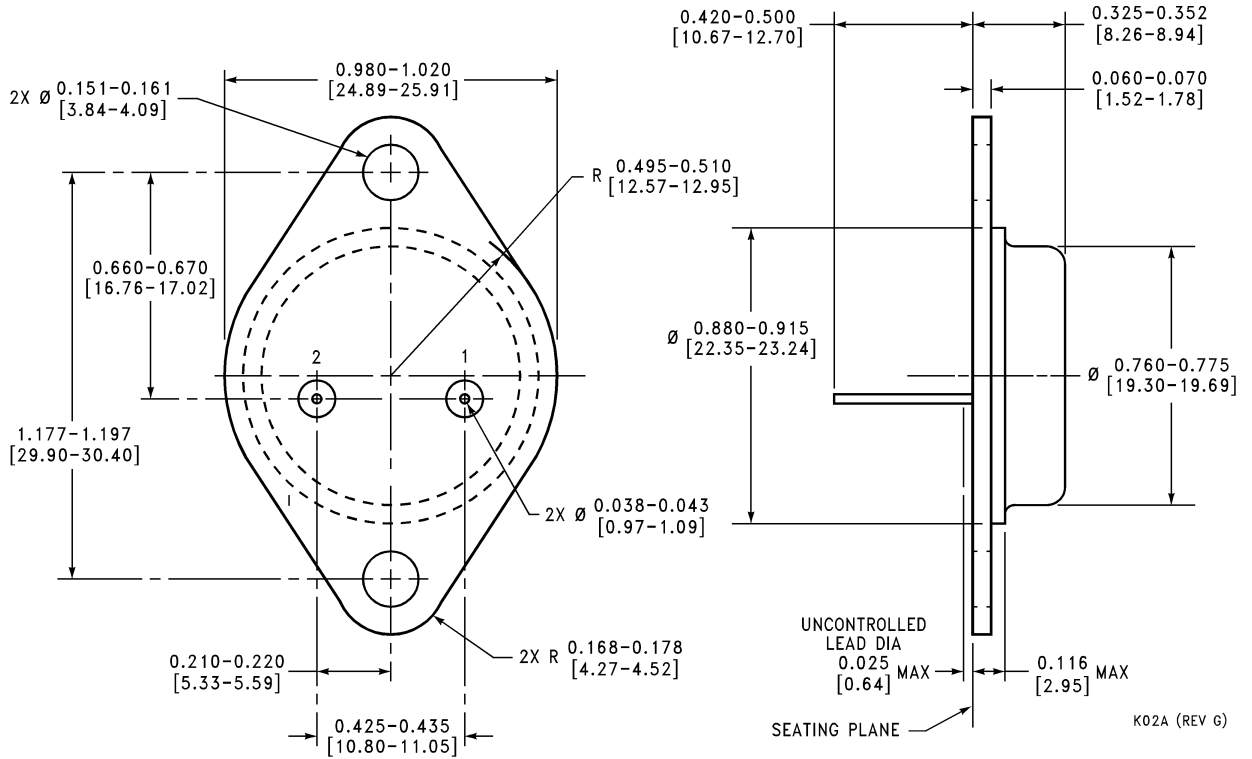
unless otherwise noted



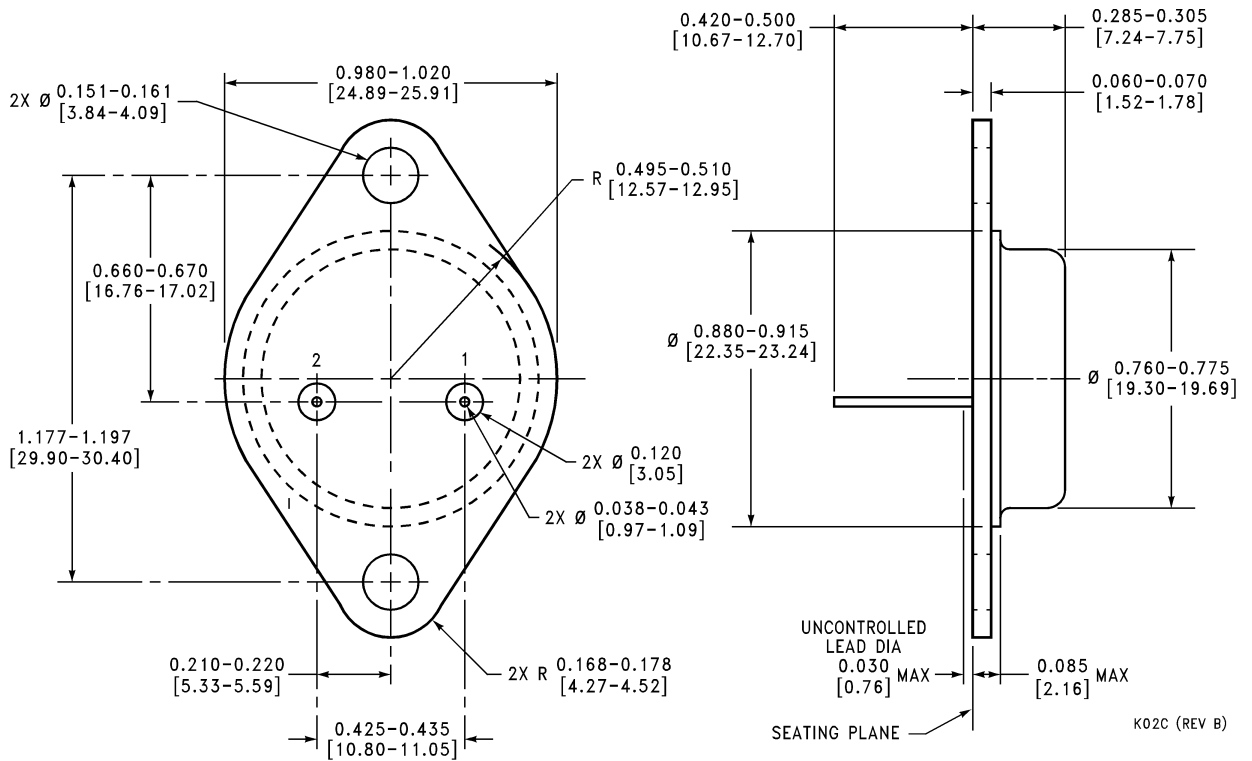
H03A (REV B)

**Metal Can Package (H)**  
**Order Number LM137H, LM137H/883 or LM337H**  
**NS Package Number H03A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)

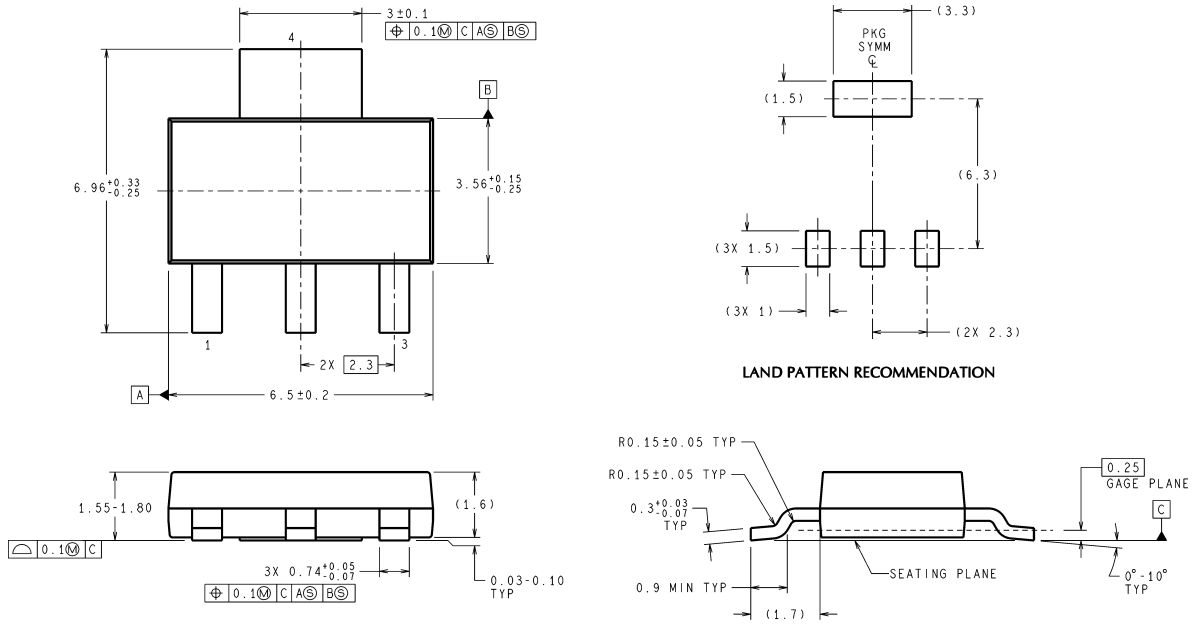


**Metal Can Package (K)**  
**Order Number LM337K STEEL**  
**NS Package Number K02A**



**Mil-Aero Metal Can Package (K)**  
**Order Number LM137K/883**  
**NS Package Number K02C**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)

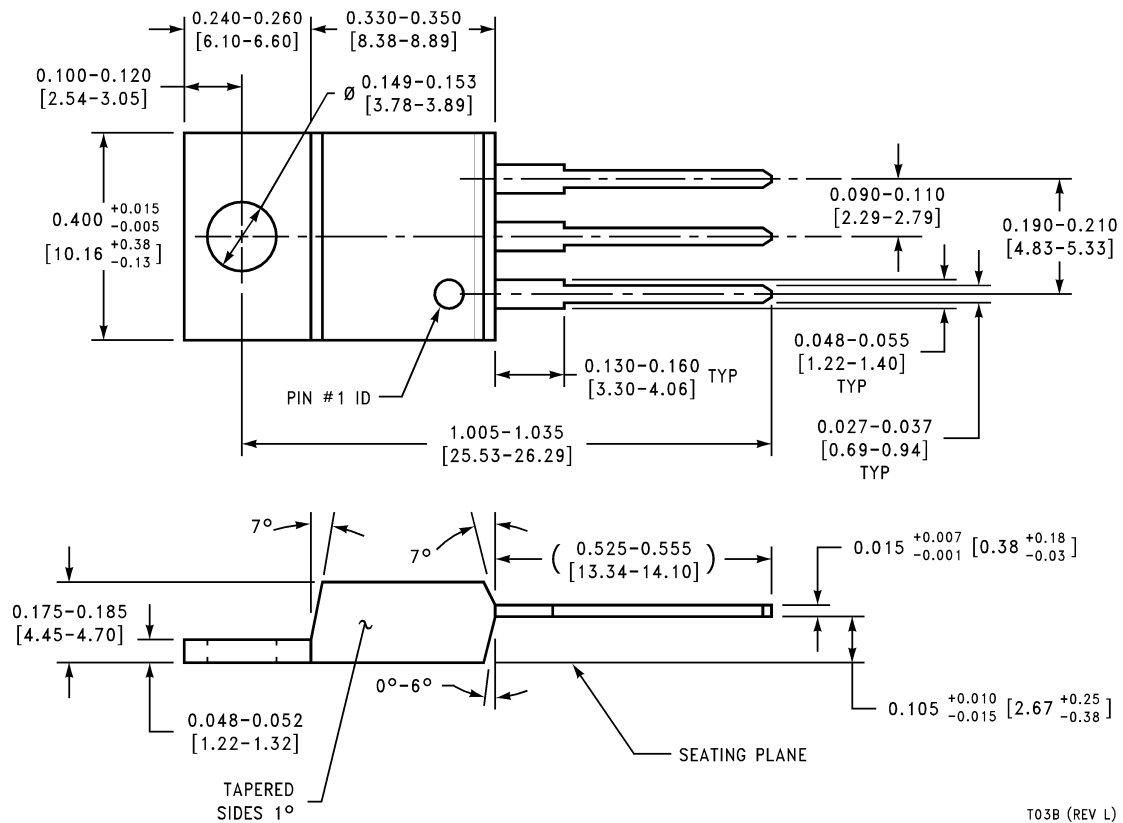


DIMENSIONS ARE IN MILLIMETERS

MP04A (Rev B)

**3-Lead SOT-223 Package  
Order Number LM337IMP  
NS Package Number MP04A**

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



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

T03B (REV L)

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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.

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**National Semiconductor**  
**Europe Customer Support Center**  
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 Email: [europe.support@nsc.com](mailto:europe.support@nsc.com)  
 Deutsch Tel: +49 (0) 69 9508 6208  
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**National Semiconductor**  
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