

## LM137/LM337-N 3-Terminal Adjustable Negative Regulators

Check for Samples: [LM137](#), [LM337-N](#)

### FEATURES

- Output Voltage Adjustable from  $-1.2\text{V}$  to  $-37\text{V}$
- 1.5A Output Current Specified,  $-55^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$
- 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/ $^{\circ}\text{C}$  Temperature Coefficient
- Temperature-independent Current Limit
- Internal Thermal Overload Protection
- P<sup>+</sup> Product Enhancement Tested
- Standard 3-lead Transistor Package
- Output is Short Circuit Protected

### DESCRIPTION

The LM137/LM337-N are adjustable 3-terminal negative voltage regulators capable of supplying in excess of  $-1.5\text{A}$  over an output voltage range of  $-1.2\text{V}$  to  $-37\text{V}$ . 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-N serve a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM137/LM337-N are ideal complements to the LM117/LM317 adjustable positive regulators.

**Table 1. LM137 Series Packages and Power Capability**

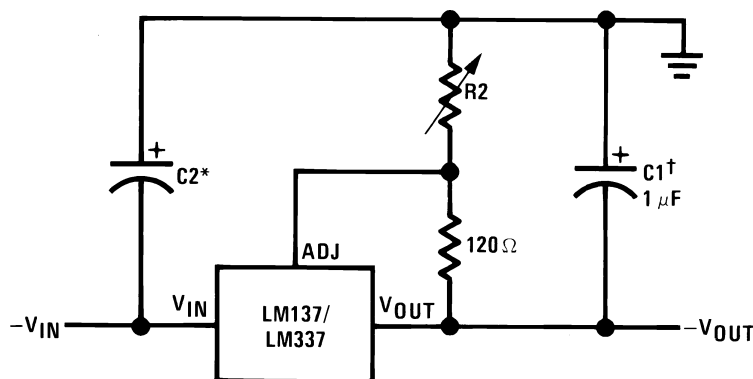
| Device      | Package       | Rated Power Dissipation | Design Load Current |
|-------------|---------------|-------------------------|---------------------|
| LM137/337-N | TO-3 (K)      | 20W                     | 1.5A                |
|             | TO (NDT)      | 2W                      | 0.5A                |
| LM337-N     | TO-220 (NDE)  | 15W                     | 1.5A                |
| LM337-N     | SOT-223 (DCY) | 2W                      | 1A                  |



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## Typical Applications



Full output current not available at high input-output voltages

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

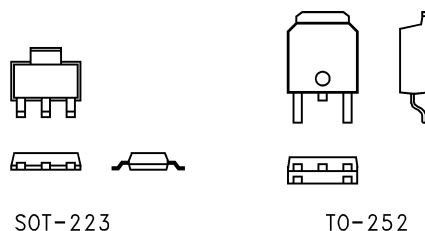
†C1 = 1 μF solid tantalum or 10 μF aluminum electrolytic required for stability

\*C2 = 1 μF solid tantalum is required only if regulator is more than 4" from power-supply filter capacitor

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

**Figure 1. Adjustable Negative Voltage Regulator**

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



**Figure 2. Scale 1:1**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)(2)</sup>

|   |                    |
|---|--------------------|
| Power Dissipation                             | Internally Limited |
| Input-Output Voltage Differential             | 40V                |
| Operating Junction Temperature Range<br>LM137 | –55°C to +150°C    |
| LM337-N                                       | 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           |

- (1) Refer to RETS137H drawing for LM137H or RETS137K drawing for LM137K military specifications.
- (2) Unless otherwise specified, these specifications apply –55°C ≤ T<sub>j</sub> ≤ +150°C for the LM137, 0°C ≤ T<sub>j</sub> ≤ +125°C for the LM337-N; V<sub>IN</sub> – V<sub>OUT</sub> = 5V; and I<sub>OUT</sub> = 0.1A for the TO package and I<sub>OUT</sub> = 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 and SOT-223 (see [APPLICATION HINTS](#)), and 20W for the TO-3, and TO-220. I<sub>MAX</sub> is 1.5A for the TO-3, SOT-223 and TO-220 packages, and 0.2A for the TO package.

## ELECTRICAL CHARACTERISTICS<sup>(1)</sup>

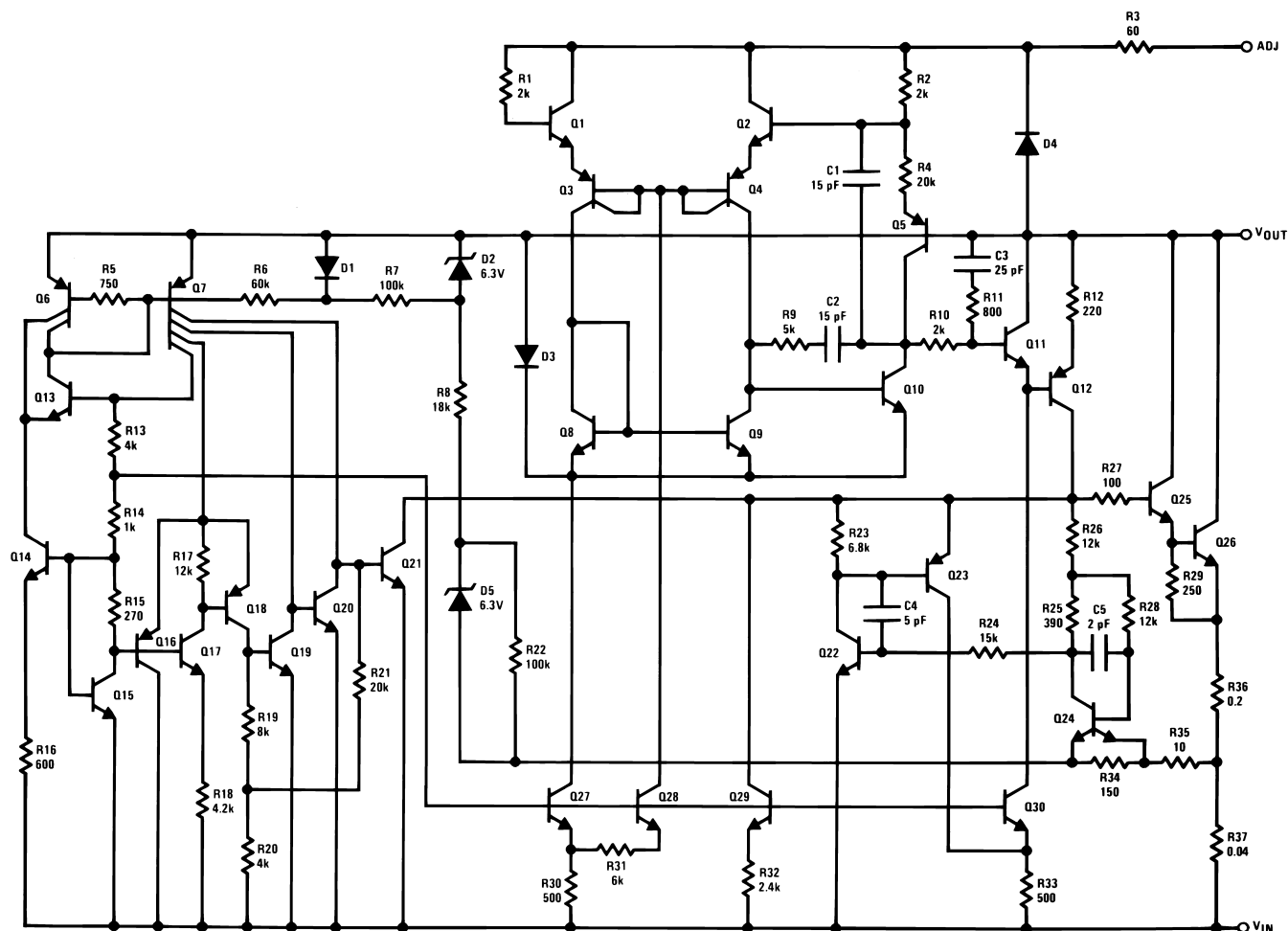
| Parameter                     | Conditions  | LM137  |        |        | LM337  |        |        | Units |
|-------------------------------|---|--------|--------|--------|--------|--------|--------|-------|
|                               |   | Min    | Typ    | Max    | Min    | Typ    | Max    |       |
| Line Regulation               | T <sub>j</sub> = 25°C, 3V ≤  V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 40V<br>(2) I <sub>L</sub> = 10 mA                     |        | 0.01   | 0.02   |        | 0.01   | 0.04   | %/V   |
| Load Regulation               | T <sub>j</sub> = 25°C, 10 mA ≤ I <sub>OUT</sub> ≤ I <sub>MAX</sub>  |        | 0.3    | 0.5    |        | 0.3    | 1.0    | %     |
| Thermal Regulation            | T <sub>j</sub> = 25°C, 10 ms Pulse  |        | 0.002  | 0.02   |        | 0.003  | 0.04   | %/W   |
| Adjustment Pin Current        |   |        | 65     | 100    |        | 65     | 100    | μA    |
| Adjustment Pin Current Charge | 10 mA ≤ I <sub>L</sub> ≤ I <sub>MAX</sub><br>3.0V ≤  V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 40V,<br>T <sub>A</sub> = 25°C |        | 2      | 5      |        | 2      | 5      | μA    |
| Reference Voltage             | T <sub>j</sub> = 25°C <sup>(3)</sup>  | –1.225 | –1.250 | –1.275 | –1.213 | –1.250 | –1.287 | V     |
|                               | 3V ≤  V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 40V, <sup>(3)</sup>  | –1.200 | –1.250 | –1.300 | –1.200 | –1.250 | –1.300 | V     |
|                               | 10 mA ≤ I <sub>OUT</sub> ≤ I <sub>MAX</sub> , P ≤ P <sub>MAX</sub>  |        |        |        |        |        |        |       |
| Line Regulation               | 3V ≤  V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 40V, <sup>(2)</sup>  |        | 0.02   | 0.05   |        | 0.02   | 0.07   | %/V   |
| Load Regulation               | 10 mA ≤ I <sub>OUT</sub> ≤ I <sub>MAX</sub> , <sup>(2)</sup>  |        | 0.3    | 1      |        | 0.3    | 1.5    | %     |
| Temperature Stability         | T <sub>MIN</sub> ≤ T <sub>j</sub> ≤ T <sub>MAX</sub>  |        | 0.6    |        |        | 0.6    |        | %     |
| Minimum Load Current          | V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 40V  |        | 2.5    | 5      |        | 2.5    | 10     | mA    |
|                               | V <sub>IN</sub> – V <sub>OUT</sub>   ≤ 10V  |        | 1.2    | 3      |        | 1.5    | 6      | mA    |

- (1) Unless otherwise specified, these specifications apply –55°C ≤ T<sub>j</sub> ≤ +150°C for the LM137, 0°C ≤ T<sub>j</sub> ≤ +125°C for the LM337-N; V<sub>IN</sub> – V<sub>OUT</sub> = 5V; and I<sub>OUT</sub> = 0.1A for the TO package and I<sub>OUT</sub> = 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 and SOT-223 (see [APPLICATION HINTS](#)), and 20W for the TO-3, and TO-220. I<sub>MAX</sub> is 1.5A for the TO-3, SOT-223 and TO-220 packages, and 0.2A for the TO package.
- (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 in. below the base of the TO-3 and TO packages.
- (3) Selected devices with tightened tolerance reference voltage available.

**ELECTRICAL CHARACTERISTICS<sup>(1)</sup> (continued)**

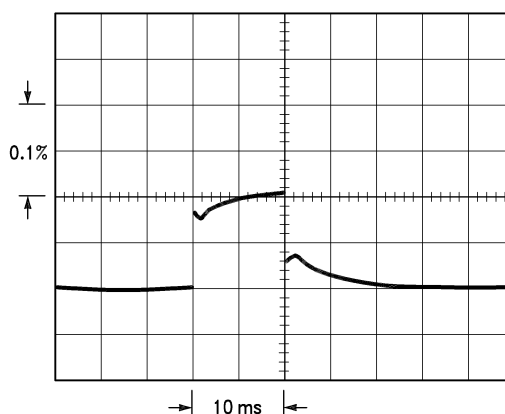
| Parameter  | Conditions   | LM137 |       |     | LM337 |       |     | Units        |
|--|--|-------|-------|-----|-------|-------|-----|--------------|
|  |  | Min   | Typ   | Max | Min   | Typ   | Max |              |
| Current Limit  | $ V_{IN} - V_{OUT}  \leq 15V$                              |       |       |     |       |       |     |              |
|  | K, DCY and NDE Package                                     | 1.5   | 2.2   | 3.5 | 1.5   | 2.2   | 3.7 | A            |
|  | NDT Package  | 0.5   | 0.8   | 1.8 | 0.5   | 0.8   | 1.9 | A            |
|  | $ V_{IN} - V_{OUT}  = 40V, T_j = 25^\circ C$               |       |       |     |       |       |     |              |
|  | K, DCY and NDE Package                                     | 0.24  | 0.4   |     | 0.15  | 0.4   |     | A            |
|  | NDT Package  | 0.15  | 0.17  |     | 0.10  | 0.17  |     | A            |
| RMS Output Noise, % of $V_{OUT}$                       | $T_j = 25^\circ C, 10\text{ Hz} \leq f \leq 10\text{ kHz}$ |       | 0.003 |     |       | 0.003 |     | %            |
| Ripple Rejection Ratio                                 | $V_{OUT} = -10V, f = 120\text{ Hz}$                        |       | 60    |     |       | 60    |     | dB           |
|  | $C_{ADJ} = 10\text{ }\mu F$                                | 66    | 77    |     | 66    | 77    |     | dB           |
| Long-Term Stability                                    | $T_j = 125^\circ C, 1000\text{ Hours}$                     |       | 0.3   | 1   |       | 0.3   | 1   | %            |
| Thermal Resistance, Junction to Case                   | NDT Package  |       | 12    | 15  |       | 12    | 15  | $^\circ C/W$ |
|  | K Package  |       | 2.3   | 3   |       | 2.3   | 3   | $^\circ C/W$ |
|  | NDE Package  |       |       |     |       | 4     |     | $^\circ C/W$ |
| Thermal Resistance, Junction to Ambient (No Heat Sink) | NDT Package  |       | 140   |     |       | 140   |     | $^\circ C/W$ |
|  | K Package  |       | 35    |     |       | 35    |     | $^\circ C/W$ |
|  | NDE Package  |       |       |     |       | 50    |     | $^\circ C/W$ |
|  | DCY Package  |       |       |     |       | 170   |     | $^\circ C/W$ |

## SCHEMATIC DIAGRAM



## Thermal Regulation

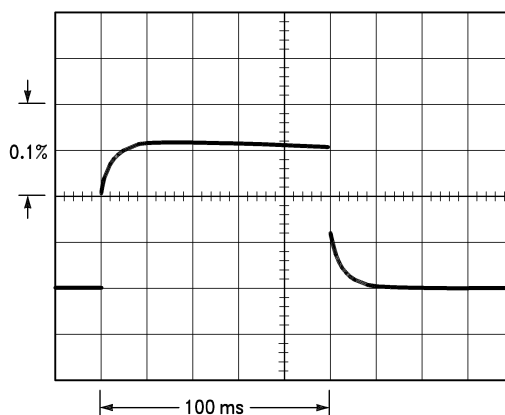
When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large. Thermal regulation is the effect of these temperature gradients on output 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.



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

**Figure 3.**

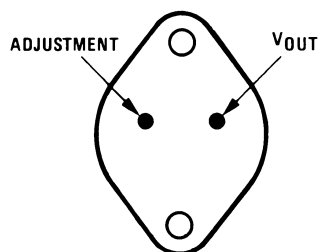
In [Figure 3](#), a typical LM137's output drifts only 3 mV (or 0.03% of  $V_{OUT} = -10V$ ) when a 10W pulse is applied for 10 ms. This performance is thus well inside the specification limit of  $0.02\%/W \times 10W = 0.2\%$  max. When the 10W pulse is ended, the thermal regulation again shows a 3 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 4](#), 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).



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

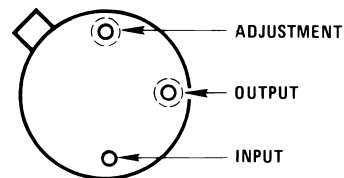
**Figure 4.**

## Connection Diagrams



Case is Input

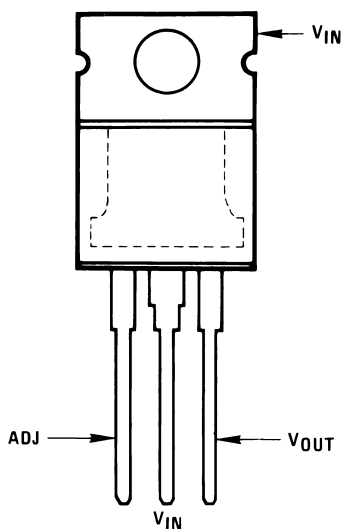
**Figure 5. TO-3  
Metal Can Package  
Bottom View**  
See Package Number K0002C  
See Package Number NDS0002A



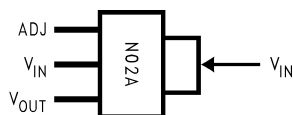
Case Is Input

See STD Mil DWG 5962P99517 for  
Radiation Tolerant Devices

**Figure 6. TO  
Metal Can Package  
Bottom View**  
See Package Number NDT0003A



**Figure 7. TO-220  
Plastic Package  
Front View**  
See Package Number NDE0003B



**Figure 8. 3-Lead SOT-223  
Front View**  
Package Marked N02A  
See Package Number DCY0004A

## 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 ("DCY") 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.

Figure 9 and Figure 10 show the information for the SOT-223 package. Figure 10 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.

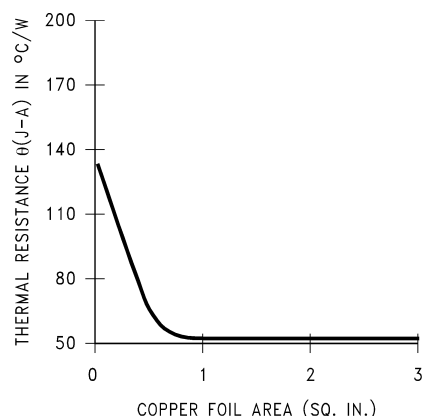


Figure 9.  $\theta_{(J-A)}$  vs Copper (2 ounce) Area for the SOT-223 Package

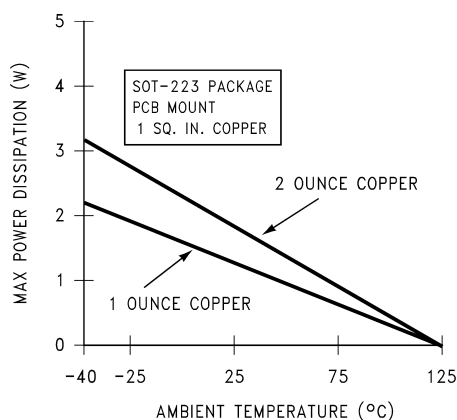
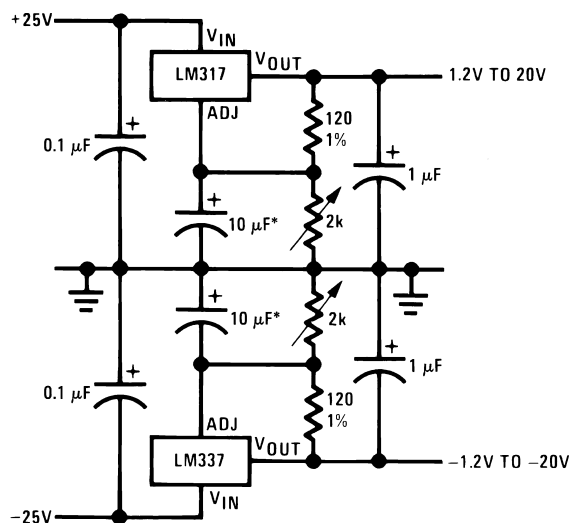


Figure 10. Maximum Power Dissipation vs.  $T_{AMB}$  for the SOT-223 Package

Please see AN-1028 (literature number [SNVA036](#)) for power enhancement techniques to be used with the SOT-223 package.

## Typical Applications

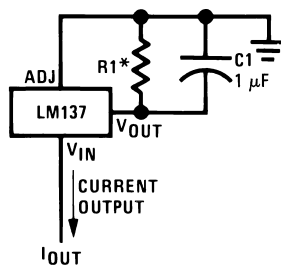
**Figure 11. Adjustable Lab Voltage Regulator**



Full output current not available  
at high input-output voltages

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

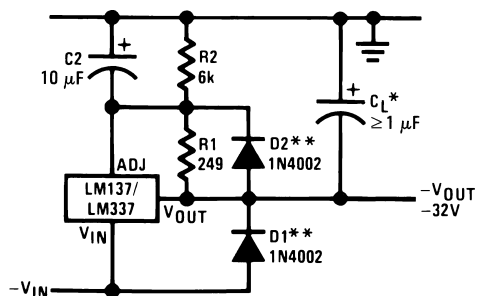
**Figure 12. Current Regulator**



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

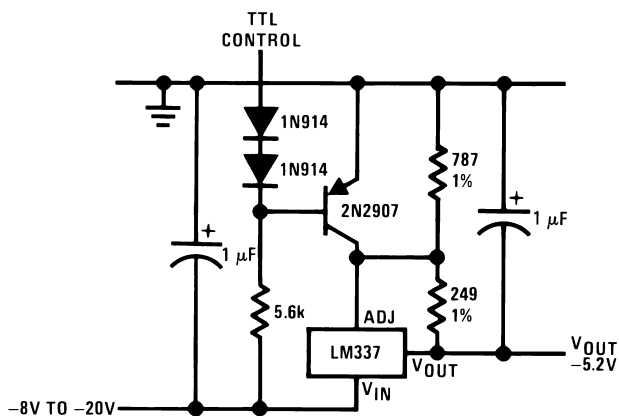
\*0.8Ω ≤ R1 ≤ 120Ω

**Figure 13. Negative Regulator with Protection Diodes**

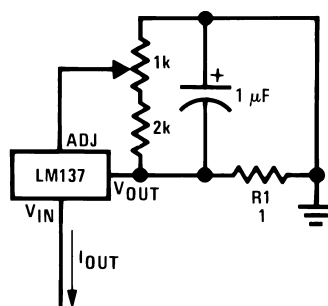


\*When C<sub>L</sub> is larger than 20 μF, D1 protects the LM137 in case the input supply is shorted

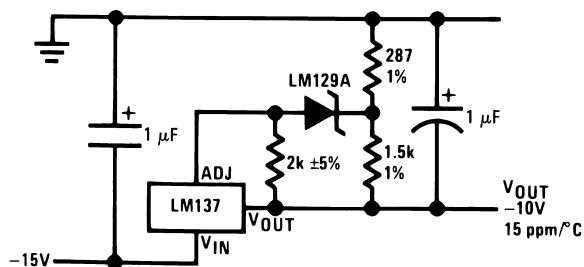
\*\*When C2 is larger than 10 μF and -V<sub>OUT</sub> is larger than -25V, D2 protects the LM137 in case the output is shorted

**Figure 14. –5.2V Regulator with Electronic Shutdown\***

\*Minimum output  $\approx -1.3\text{V}$  when control input is low

**Figure 15. Adjustable Current Regulator**

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

**Figure 16. High Stability –10V Regulator**

## TYPICAL PERFORMANCE CHARACTERISTICS

(K Steel and NDE Packages)

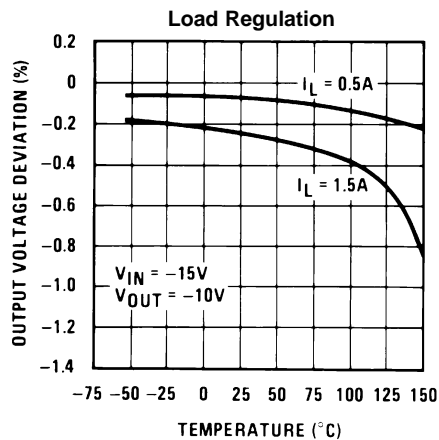


Figure 17.

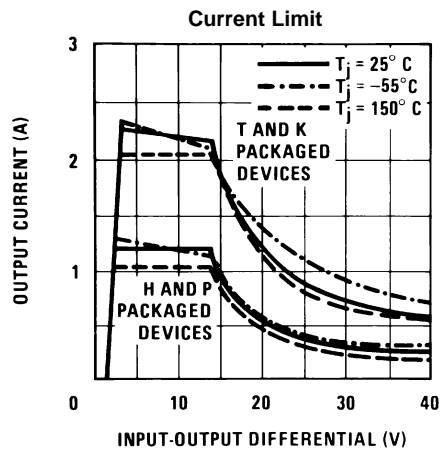


Figure 18.

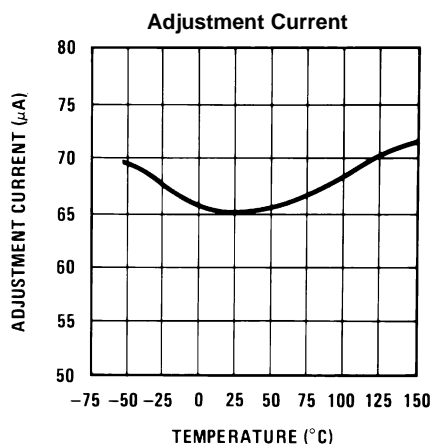


Figure 19.

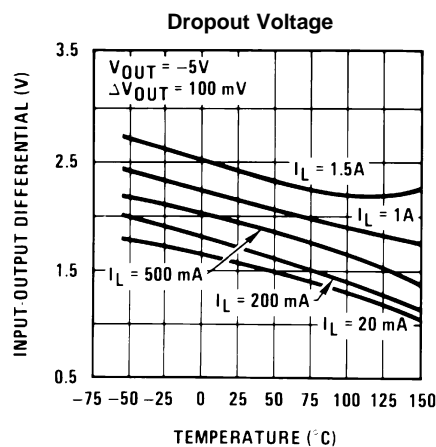


Figure 20.

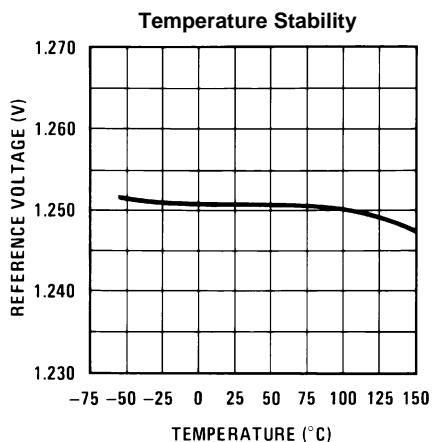


Figure 21.

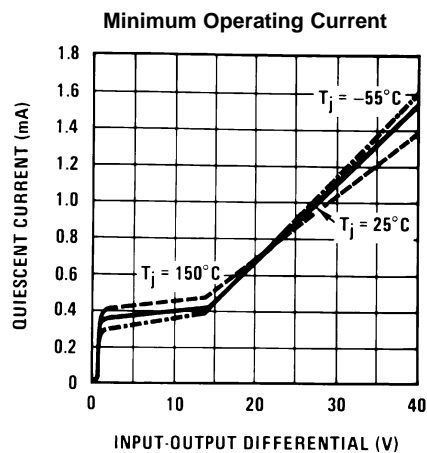


Figure 22.

**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

(K Steel and NDE Packages)

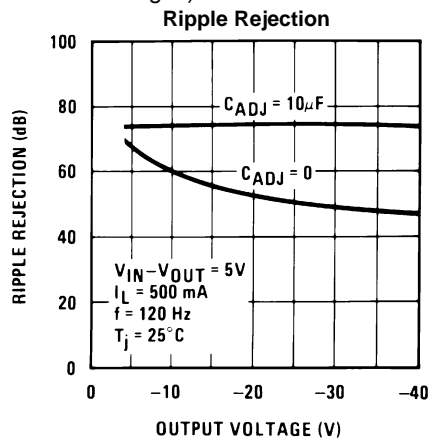


Figure 23.

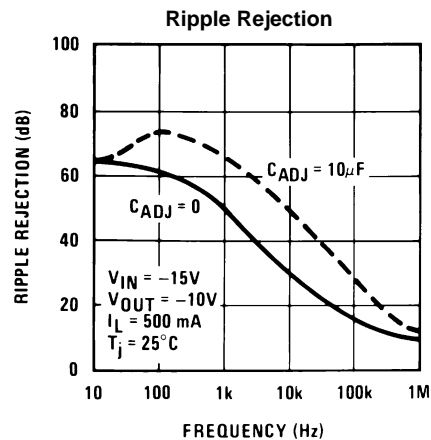


Figure 24.

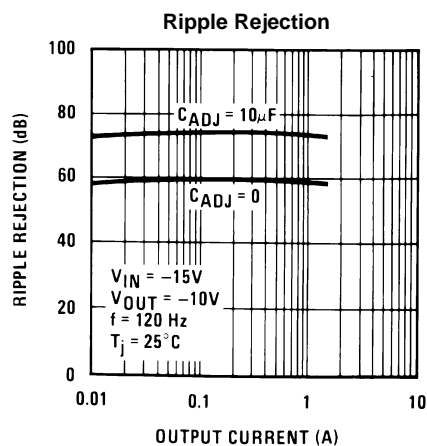


Figure 25.

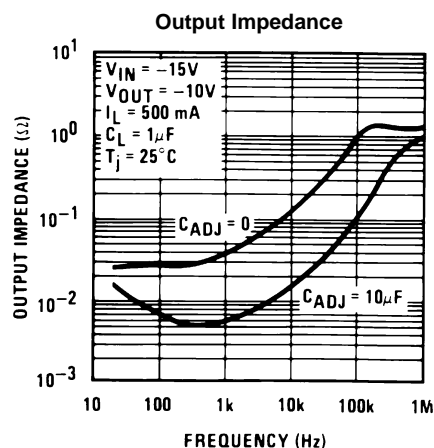


Figure 26.

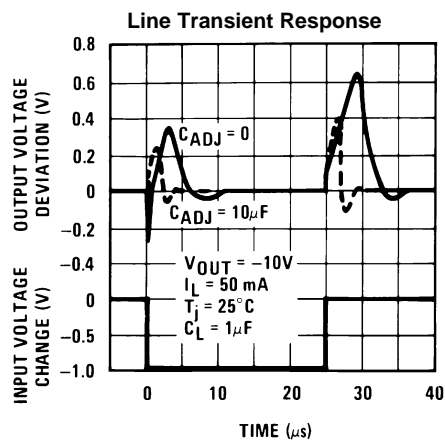


Figure 27.

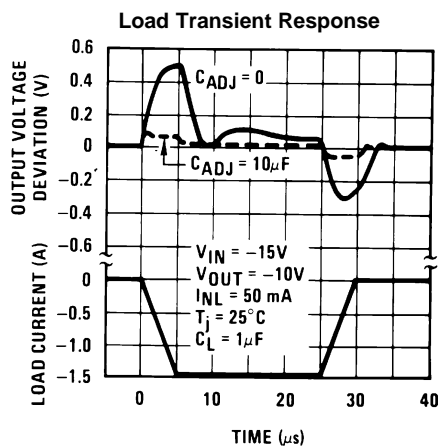


Figure 28.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|-------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| LM137H           | ACTIVE        | TO           | NDT                | 3    | 500         | Green (RoHS<br>& no Sb/Br) | POST-PLATE       | Level-1-NA-UNLIM     | -55 to 150   | LM137HP+                 | <a href="#">Samples</a> |
| LM137H/NOPB      | ACTIVE        | TO           | NDT                | 3    | 500         | Green (RoHS<br>& no Sb/Br) | POST-PLATE       | Level-1-NA-UNLIM     | -55 to 150   | LM137HP+                 | <a href="#">Samples</a> |
| LM337H           | ACTIVE        | TO           | NDT                | 3    | 500         | Green (RoHS<br>& no Sb/Br) | POST-PLATE       | Level-1-NA-UNLIM     | -40 to 125   | LM337H                   | <a href="#">Samples</a> |
| LM337H/NOPB      | ACTIVE        | TO           | NDT                | 3    | 500         | Green (RoHS<br>& no Sb/Br) | POST-PLATE       | Level-1-NA-UNLIM     | -40 to 125   | LM337H                   | <a href="#">Samples</a> |
| LM337IMP         | ACTIVE        | SOT-223      | DCY                | 4    | 1000        | TBD                        | Call TI          | Call TI              | -40 to 125   | N02A                     | <a href="#">Samples</a> |
| LM337IMP/NOPB    | ACTIVE        | SOT-223      | DCY                | 4    | 1000        | Green (RoHS<br>& no Sb/Br) | CU SN            | Level-1-260C-UNLIM   | -40 to 125   | N02A                     | <a href="#">Samples</a> |
| LM337IMPX        | ACTIVE        | SOT-223      | DCY                | 4    | 2000        | TBD                        | Call TI          | Call TI              | -40 to 125   | N02A                     | <a href="#">Samples</a> |
| LM337IMPX/NOPB   | ACTIVE        | SOT-223      | DCY                | 4    | 2000        | Green (RoHS<br>& no Sb/Br) | CU SN            | Level-1-260C-UNLIM   | -40 to 125   | N02A                     | <a href="#">Samples</a> |
| LM337T           | ACTIVE        | TO-220       | NDE                | 3    | 45          | TBD                        | Call TI          | Call TI              | -40 to 125   | LM337T P+                | <a href="#">Samples</a> |
| LM337T/LF01      | ACTIVE        | TO-220       | NDG                | 3    | 45          | Pb-Free (RoHS<br>Exempt)   | CU SN            | Level-3-245C-168 HR  |              | LM337T P+                | <a href="#">Samples</a> |
| LM337T/NOPB      | ACTIVE        | TO-220       | NDE                | 3    | 45          | Pb-Free (RoHS<br>Exempt)   | CU SN            | Level-1-NA-UNLIM     | -40 to 125   | LM337T P+                | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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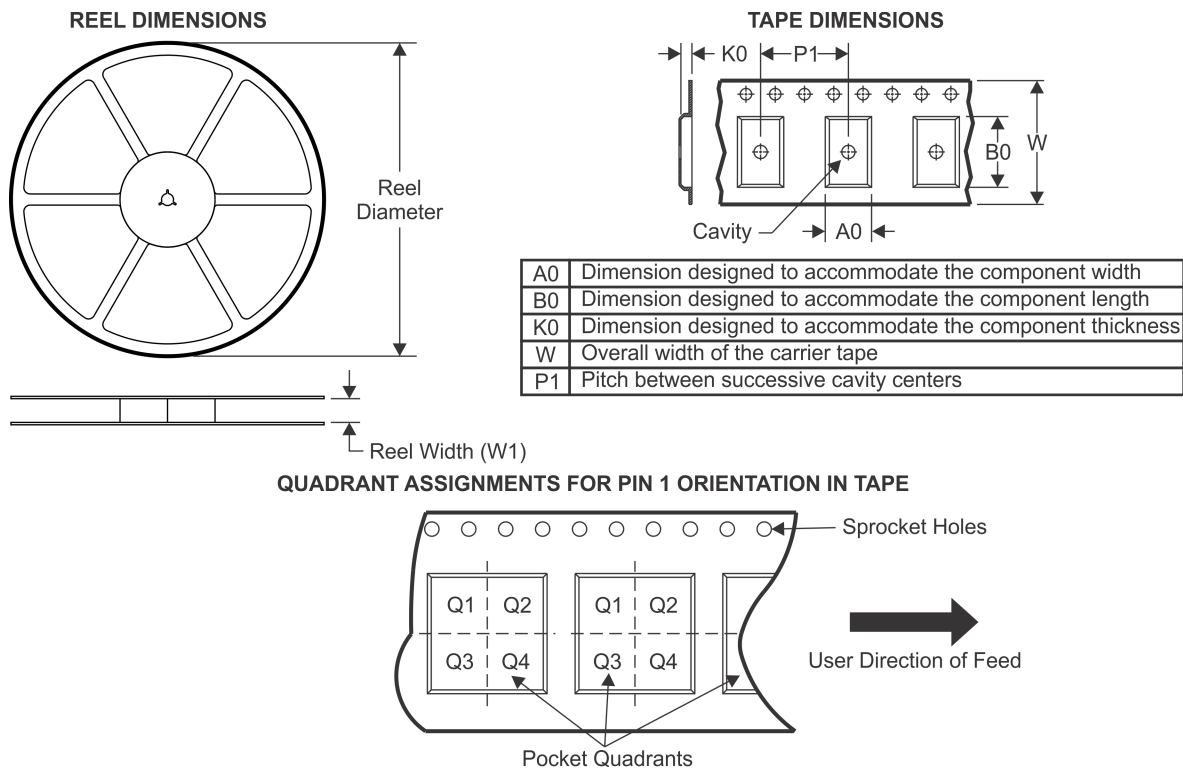
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> Only one of markings shown within the brackets will appear on the physical device.

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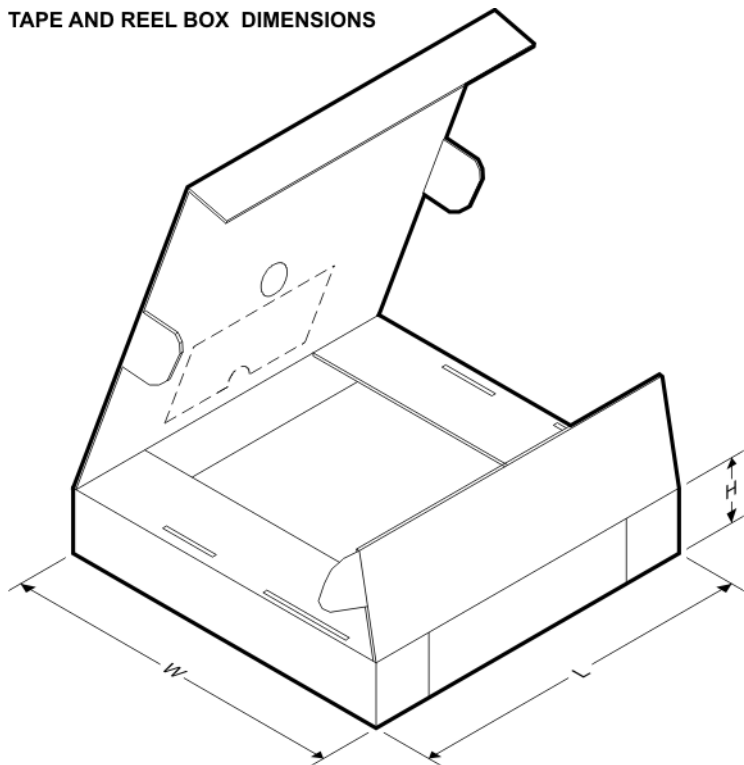
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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM337IMP       | SOT-223      | DCY             | 4    | 1000 | 330.0              | 16.4               | 7.0     | 7.5     | 2.2     | 12.0    | 16.0   | Q3            |
| LM337IMP/NOPB  | SOT-223      | DCY             | 4    | 1000 | 330.0              | 16.4               | 7.0     | 7.5     | 2.2     | 12.0    | 16.0   | Q3            |
| LM337IMPX      | SOT-223      | DCY             | 4    | 2000 | 330.0              | 16.4               | 7.0     | 7.5     | 2.2     | 12.0    | 16.0   | Q3            |
| LM337IMPX/NOPB | SOT-223      | DCY             | 4    | 2000 | 330.0              | 16.4               | 7.0     | 7.5     | 2.2     | 12.0    | 16.0   | Q3            |

## TAPE AND REEL BOX DIMENSIONS



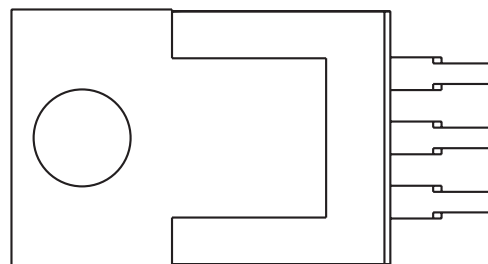
\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM337IMP       | SOT-223      | DCY             | 4    | 1000 | 349.0       | 337.0      | 45.0        |
| LM337IMP/NOPB  | SOT-223      | DCY             | 4    | 1000 | 349.0       | 337.0      | 45.0        |
| LM337IMPX      | SOT-223      | DCY             | 4    | 2000 | 354.0       | 340.0      | 35.0        |
| LM337IMPX/NOPB | SOT-223      | DCY             | 4    | 2000 | 354.0       | 340.0      | 35.0        |



H03A (Rev D)

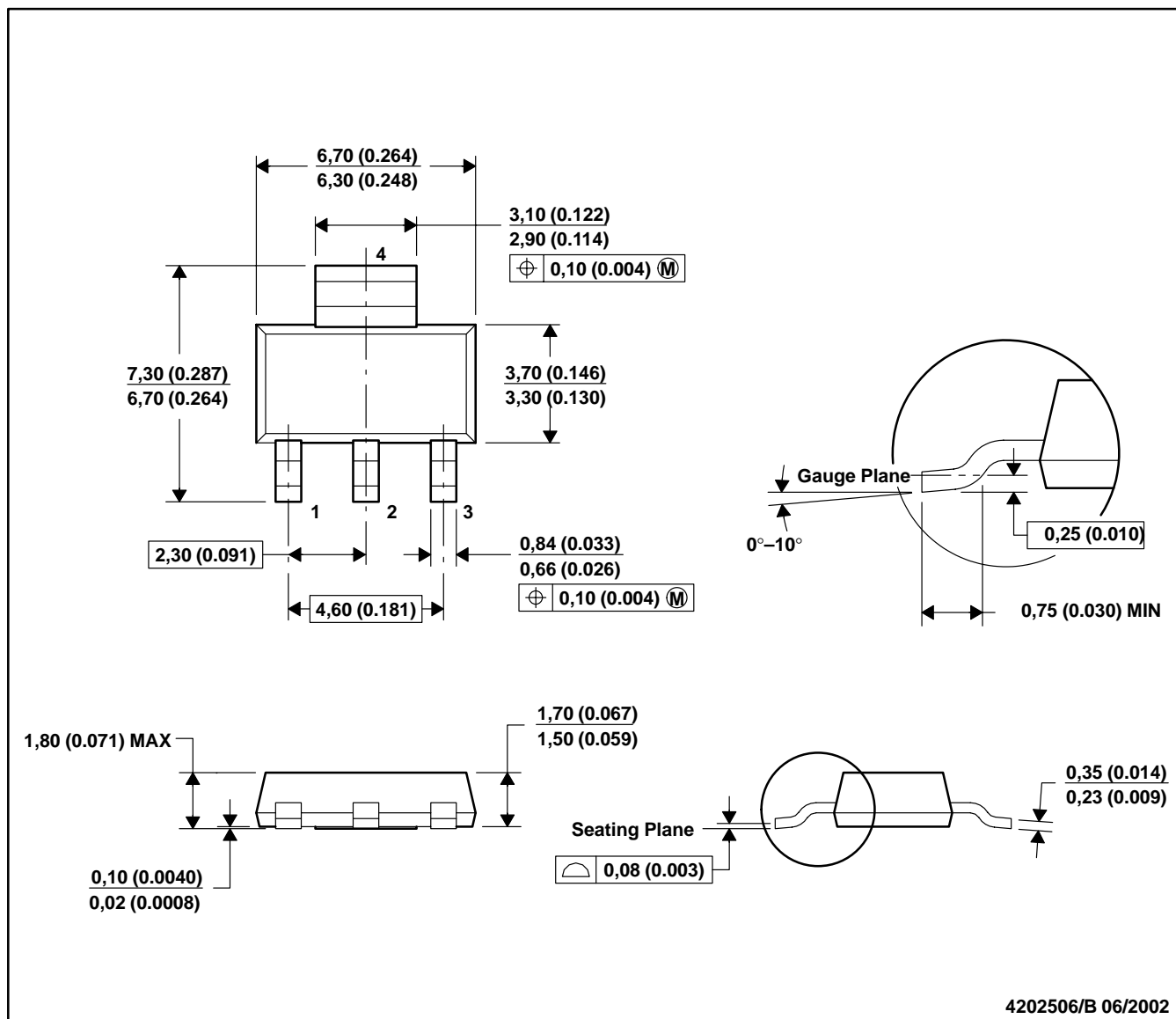




T03F (Rev B)

DCY (R-PDSO-G4)

PLASTIC SMALL-OUTLINE



- NOTES: A. All linear dimensions are in millimeters (inches).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion.  
 D. Falls within JEDEC TO-261 Variation AA.

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