May 1999

National Semiconductor

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

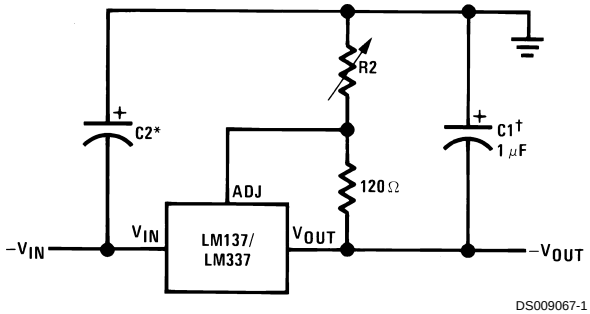
- Output voltage adjustable from −1.2V to −37V
- 1.5A output current guaranteed, −55˚C to +150˚C
- Line regulation typically 0.01%/V
- Load regulation typically 0.3%
- Excellent thermal regulation, 0.002%/W
- 77 dB ripple rejection
- Excellent rejection of thermal transients
- 50 ppm/˚C temperature coefficient
- 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

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

Adjustable Negative Voltage Regulator



DS009067-1

Full output current not available at high input-output voltages

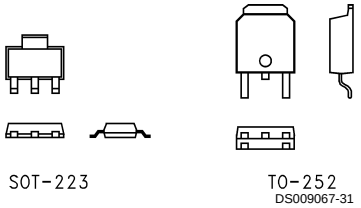
$$-V_{OUT} = -1.25V\left(1 + \frac{R2}{120}\right) + \left(-I_{ADJ} \times R2\right)$$

†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

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



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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
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˚C, 3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V (Note 2) I_L = 10 mA		0.01	0.02		0.01	0.04	%/V
Load Regulation	T_j = 25˚C, 10 mA ≤ I_{OUT} ≤ I_{MAX}		0.3	0.5		0.3	1.0	%
Thermal Regulation	T_j = 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_L ≤ I_{MAX} 3.0V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V, T_A = 25˚C		2	5		2	5	µA
Reference Voltage	T_j = 25˚C (Note 3)	−1.225	−1.250	−1.275	−1.213	−1.250	−1.287	V
	3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V, (Note 3)	−1.200	−1.250	−1.300	−1.200	−1.250	−1.300	V
	10 mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}							
Line Regulation	3V ≤ $\|V_{IN} - V_{OUT}$							
	$_{OUT}$ ≤ I_{MAX}, (Note 2)		0.3	1		0.3	1.5	%
Temperature Stability	T_{MIN} ≤ T_j ≤ T_{MAX}		0.6			0.6		%
Minimum Load Current	$\|V_{IN} - V_{OUT}\|$ ≤ 40V		2.5	5		2.5	10	mA
	$\|V_{IN} - V_{OUT}\|$ ≤ 10V		1.2	3		1.5	6	mA
Current Limit	$\|V_{IN} - V_{OUT}\|$ ≤ 15V							
	K, MP and T Package	1.5	2.2	3.5	1.5	2.2	3.7	A
	H Package	0.5	0.8	1.8	0.5	0.8	1.9	A
	$\|V_{IN} - V_{OUT}\|$ = 40V, T_j = 25˚C							
	K, MP and T Package	0.24	0.4		0.15	0.4		A
	H Package	0.15	0.17		0.10	0.17		A
RMS Output Noise, % of V_{OUT}	T_j = 25˚C, 10 Hz ≤ f ≤ 10 kHz		0.003			0.003		%
Ripple Rejection Ratio	V_{OUT} = −10V, f = 120 Hz		60			60		dB
	C_{ADJ} = 10 µF	66	77		66	77		dB
Long-Term Stability	T_j = 125˚C, 1000 Hours		0.3	1		0.3	1	%
Thermal Resistance, Junction to Case	H Package		12	15		12	15	˚C/W
	K Package		2.3	3		2.3	3	˚C/W
	T Package					4		˚C/W
Thermal Resistance, Junction to Ambient (No Heat Sink)	H Package		140			140		˚C/W
	K Package		35			35		˚C/W
	T Package					50		˚C/W
	MP Package					170		˚C/W

$_j$ ≤ +150˚C for the LM137, 0˚C ≤ T_j ≤ +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.

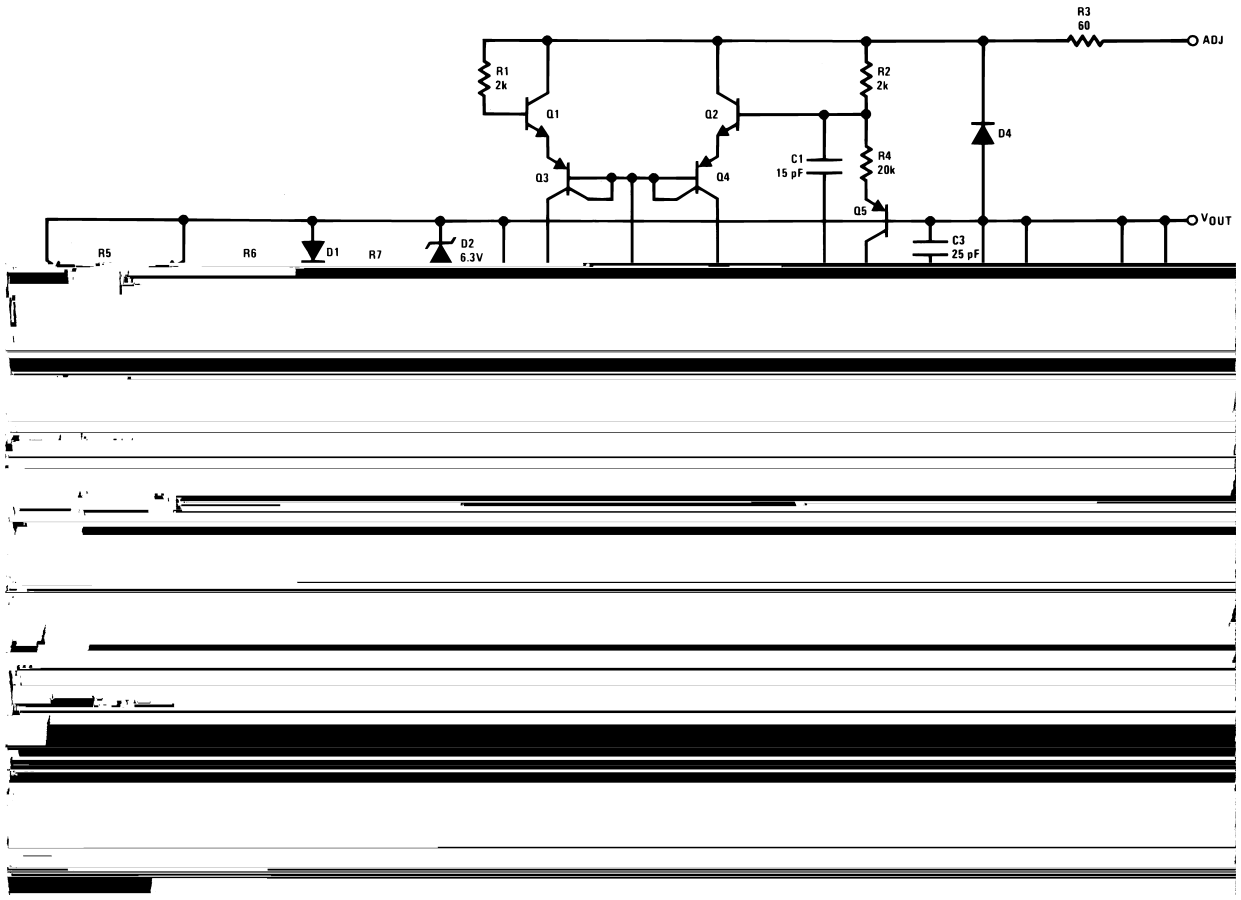
Note 2: Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation. Load regulation is measured on the output pin at a point ⅛" below the base of the TO-3 and TO-39 packages.

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

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

	| ≤ 40V, (Note 2)		0.02	0.05		0.02	0.07	%/V

Schematic Diagram



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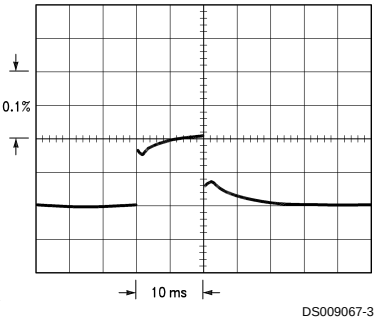
Thermal Regulation

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.



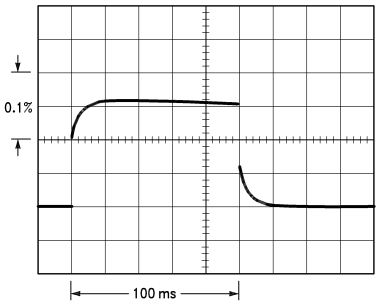
DS009067-3

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

FIGURE 1.

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 x 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).

Thermal Regulation (Continued)



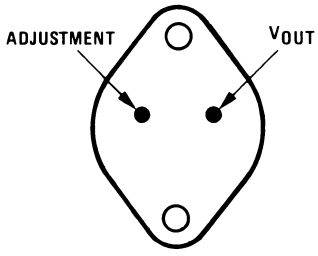
DS009067-4

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

FIGURE 2.

Connection Diagrams

TO-3
Metal Can Package

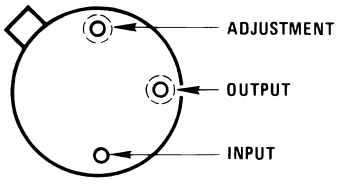


DS009067-5

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

TO-39
Metal Can Package



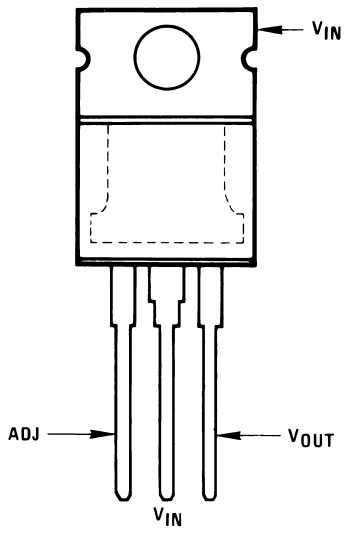
DS009067-6

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

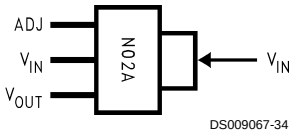
TO-220
Plastic Package



DS009067-7

Front View
Order Number LM337T
See NS Package Number T03B

3-Lead SOT-223



DS009067-34

Front View
Order Number LM337IMP
Package Marked N02ASee NS Package Number MA04A

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.

Application Hints (Continued)

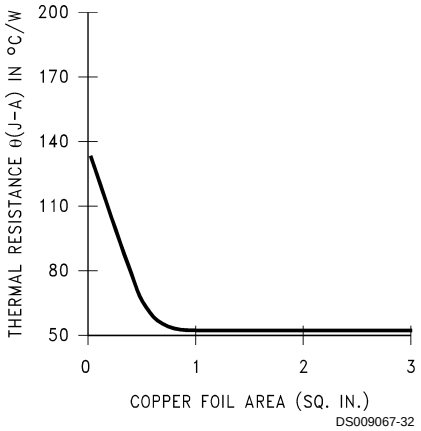


FIGURE 3. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

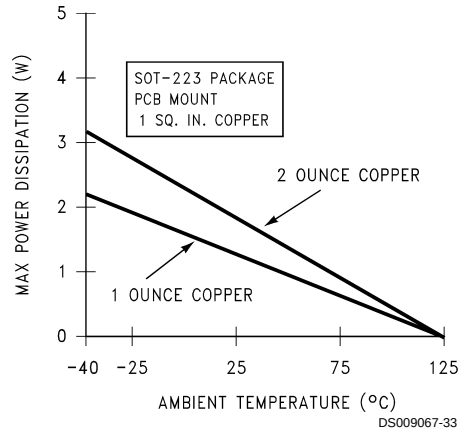
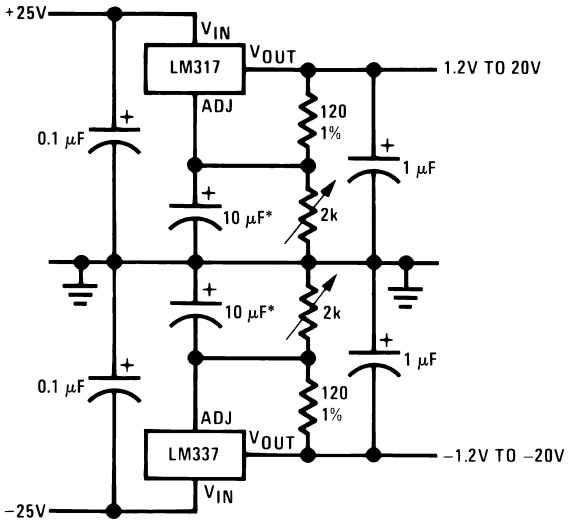


FIGURE 4. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

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

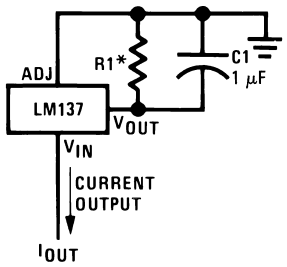
Typical Applications

Adjustable Lab Voltage Regulator



Full output current not available
at high input-output voltages
*The 10 µF capacitors are optional to improve ripple rejection

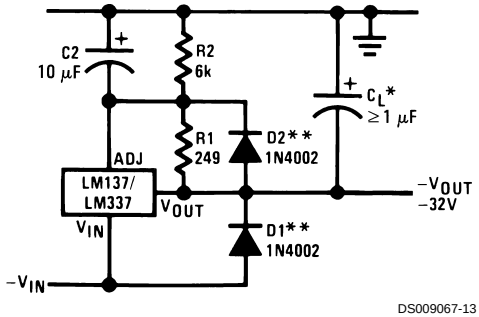
Current Regulator



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

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

Negative Regulator with Protection Diodes

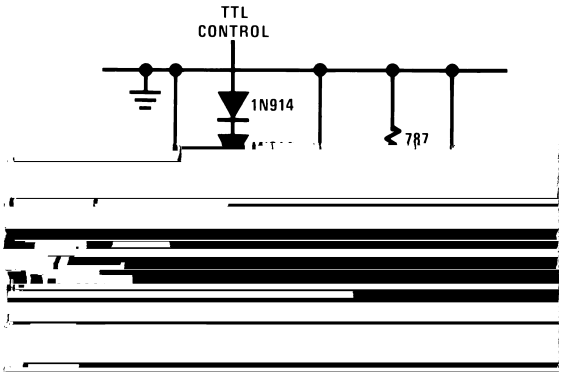


*When C_L is larger than 20 µF, D1 protects the LM137 in case the input supply is shorted

**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 Applications (Continued)

−5.2V Regulator with Electronic Shutdown*



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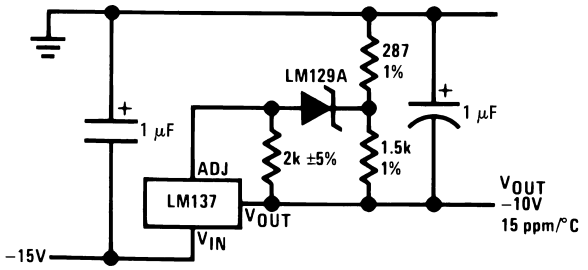
*Minimum output ≃ −1.3V when control input is low

High Stability −10V Regulator



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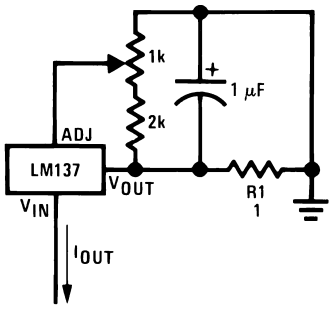
Adjustable Current Regulator



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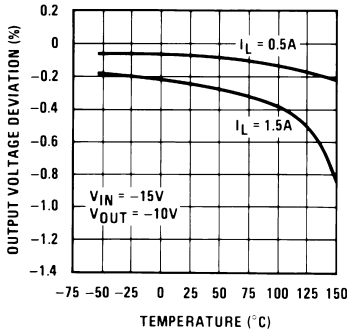
$$I_{OUT} = \left(\frac{1.5V}{R1}\right) \pm 15\% \text{ adjustable}$$

Typical Performance Characteristics (K Steel and T Packages)

Load Regulation



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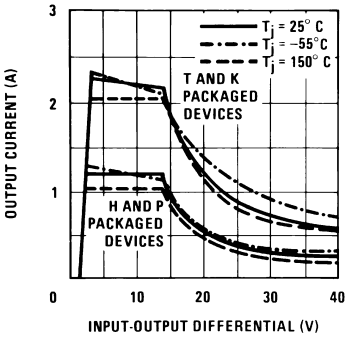
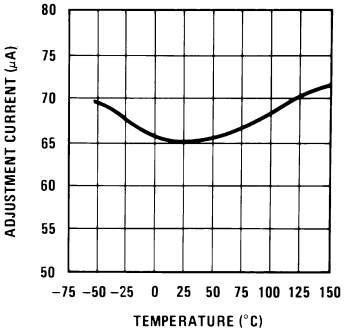
Current Limit



DS009067-17

Adjustment Current



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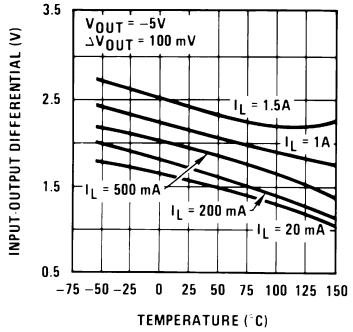
Dropout Voltage



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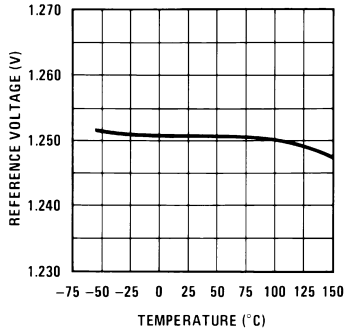
Temperature Stability



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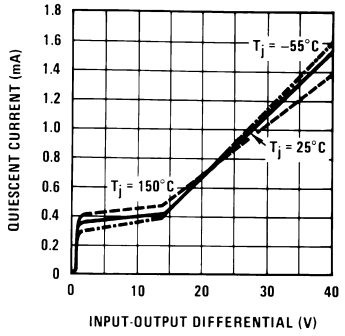
Minimum Operating Current



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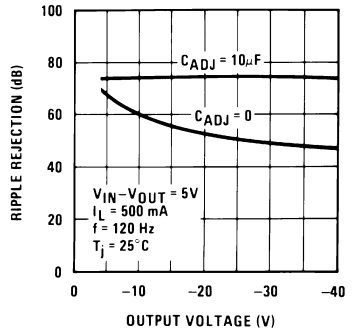
Ripple Rejection



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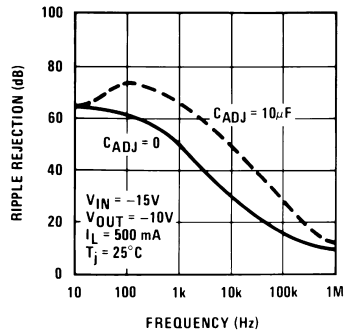
Ripple Rejection



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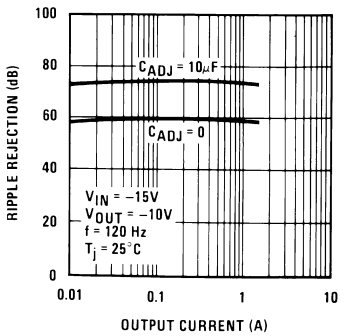
Ripple Rejection



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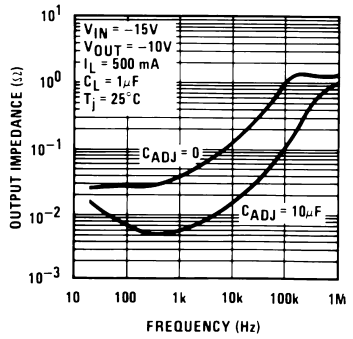
Output Impedance



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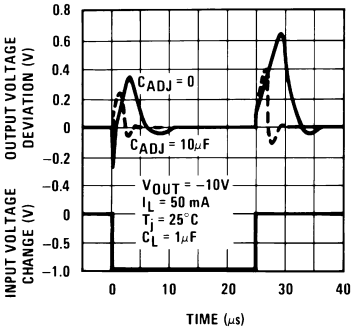
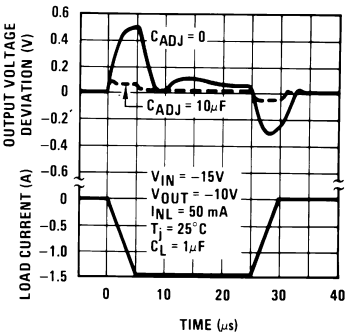
Line Transient Response



DS009067-26

Load Transient Response



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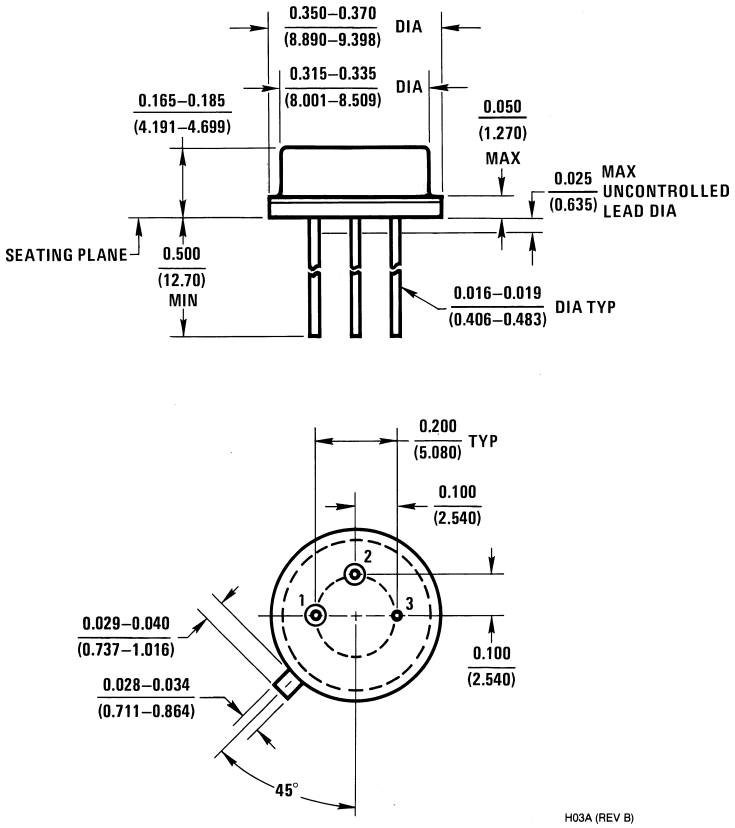
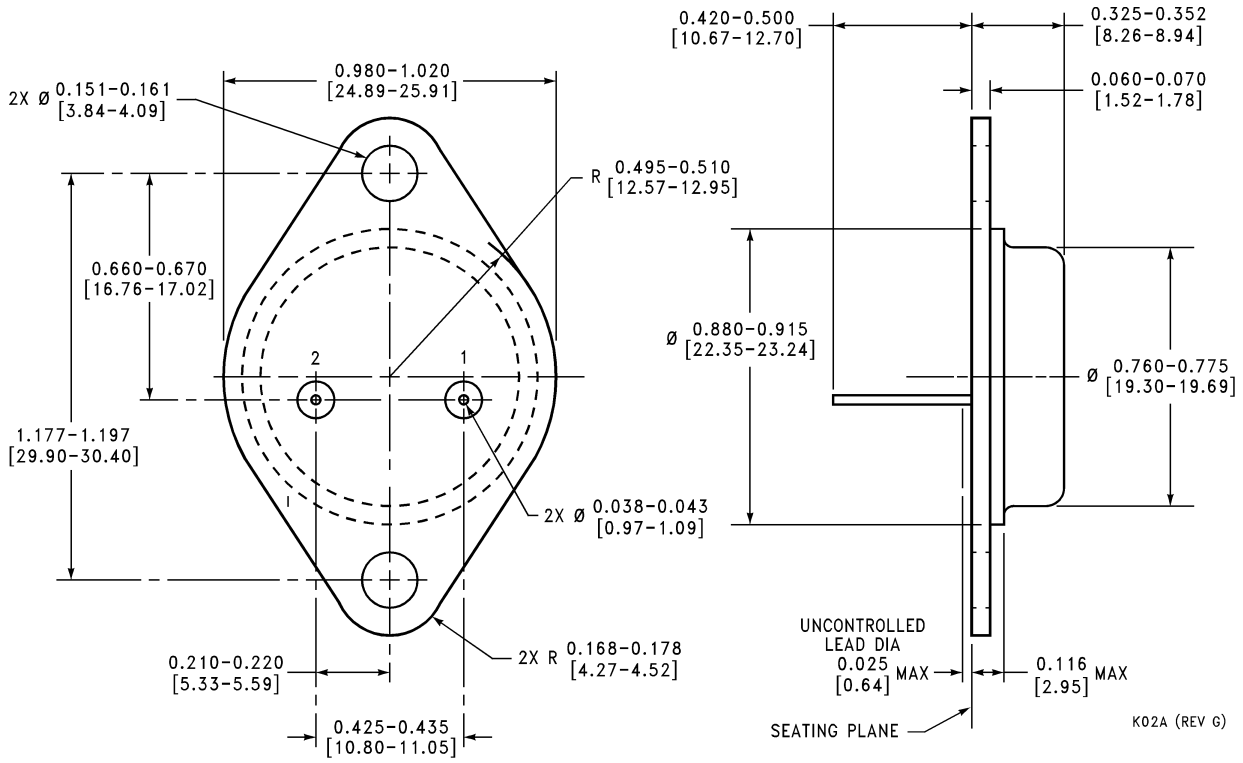
Physical Dimensions inches (millimeters) unless otherwise noted

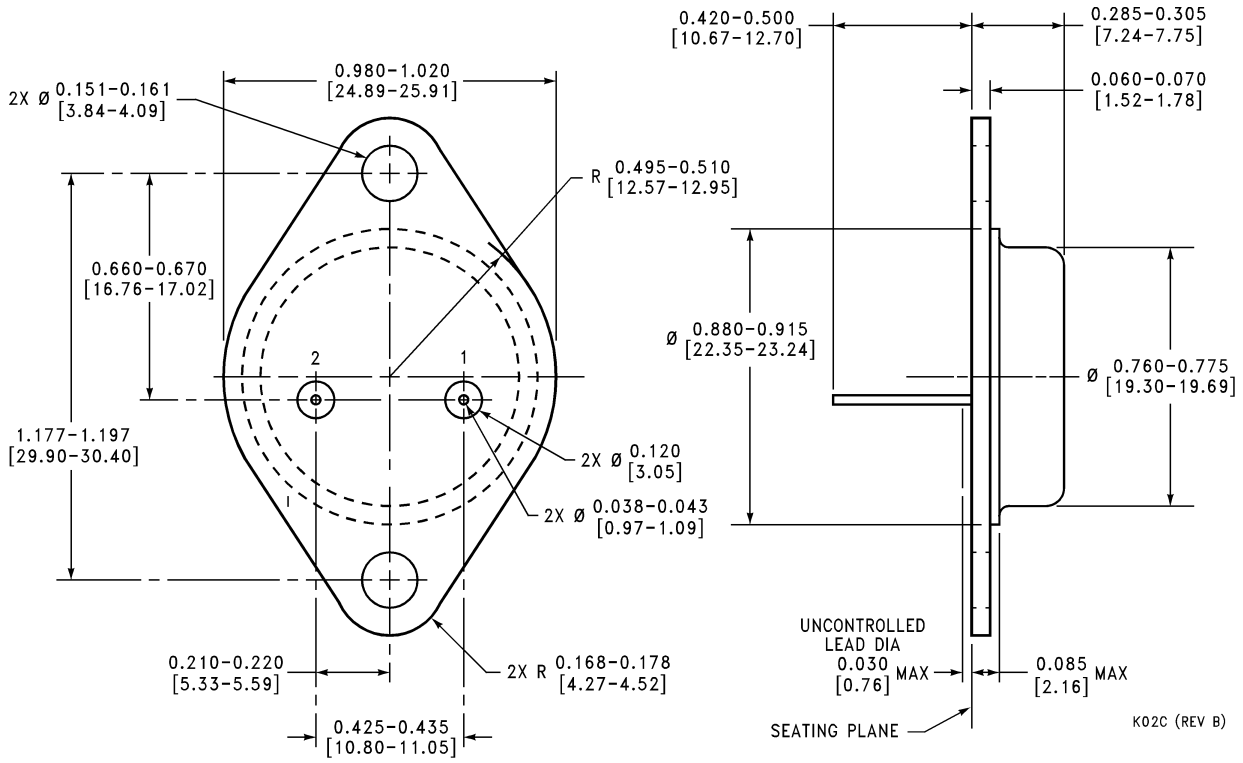


Metal Can Package (H)
Order Number LM137H, LM137H/883 or LM337H
NS Package Number H03A

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

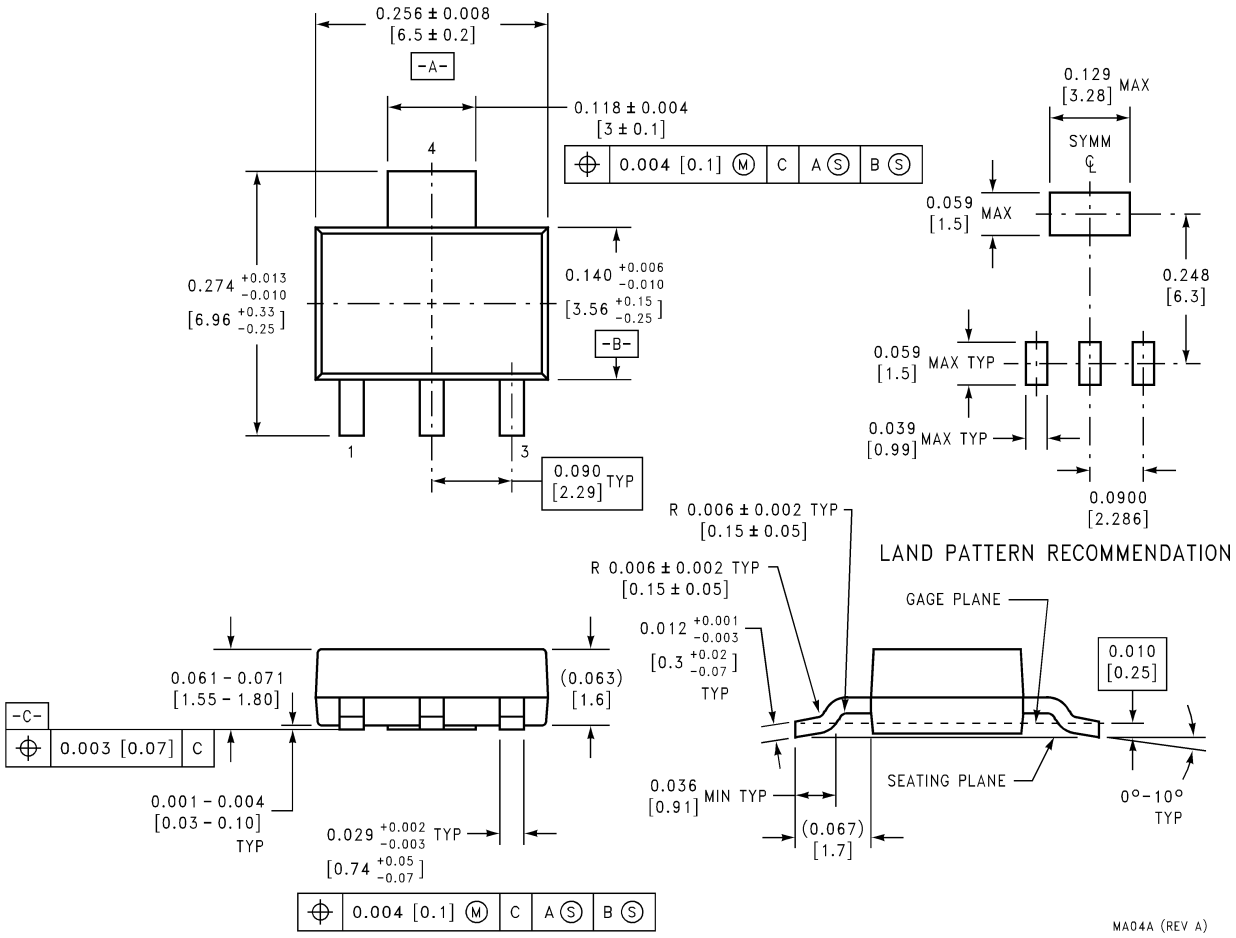


Metal Can Package (K)
Order Number LM337K STEEL
NS Package Number K02A



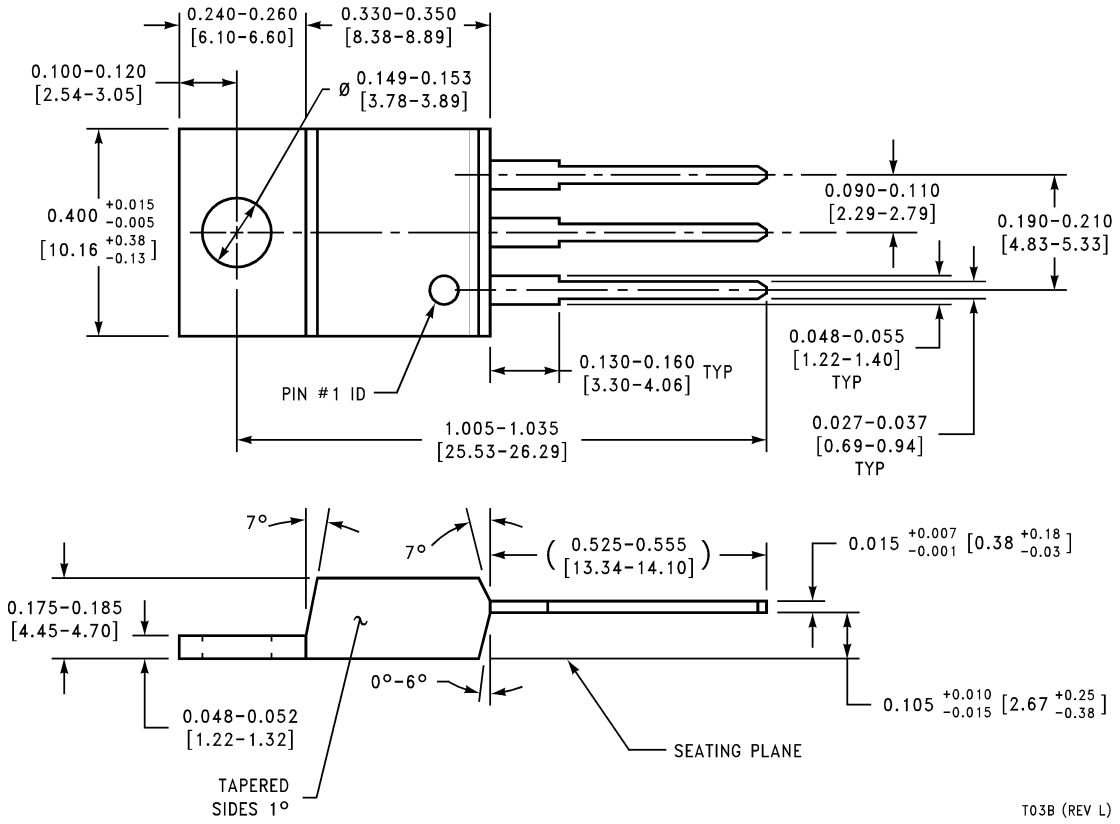
Mil-Aero Metal Can Package (K)
Order Number LM137K/883
NS Package Number K02C

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



3-Lead SOT-223 Package
Order Number LM337IMP
NS Package Number M04A

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



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

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.

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