LM337-N 3-Terminal Adjustable Negative Regulators

1 Features

- 1.5-A Output Current
- Line Regulation 0.01%/V (Typical)
- Load Regulation 0.3% (Typical)
- 77-dB Ripple Rejection
- 50 ppm/°C Temperature Coefficient
- Thermal Overload Protection
- Internal Short-Circuit Current Limiting Protections

2 Applications

- Industrial Power Supplies
- Factory Automation Systems
- Building Automation Systems
- PLC Systems
- Instrumentation
- IGBT Drive Negative Gate Supplies
- Networking
- Set-Top Boxes

3 Description

The LM337-N-MIL is an adjustable 3-terminal negative voltage regulator capable of supplying −1.5 A or more currents over an output voltage range of −1.25 V to −37 V. It requires only two external resistors to set the output voltage and one output capacitor for frequency compensation. The circuit design has been optimized for excellent regulation and low thermal transients. Further, the LM337-N-MIL features internal current limiting, thermal shutdown and safe-area compensation, making it virtually blowout-proof against overloads.

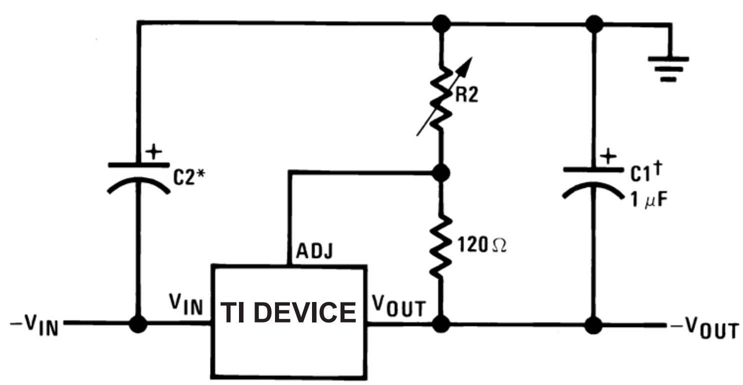
The LM337-N-MIL is an ideal complement to the LM117 and LM317 adjustable positive regulators.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM337-N-MIL	SOT-223 (4)	3.50 mm × 6.50 mm
	TO (3)	8.255 mm × 8.255 mm
	TO-220 (3)	10.16 mm × 14.986 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet. The LF01 is a lead formed (bent) version of the TO-220 package.

Adjustable Negative Voltage Regulator



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

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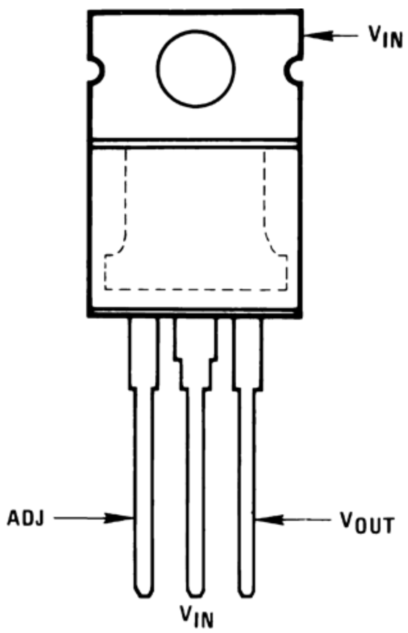
4 Revision History

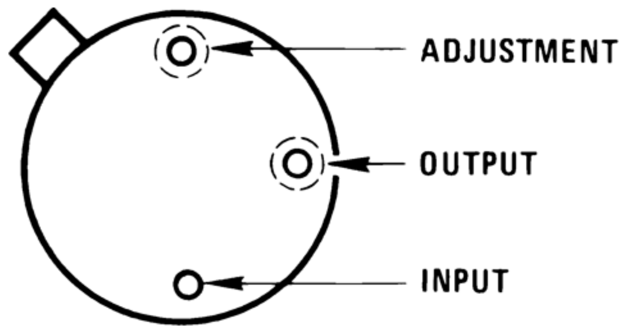
DATE	REVISION	NOTES
June 2017	*	Initial release.

5 Pin Configuration and Functions

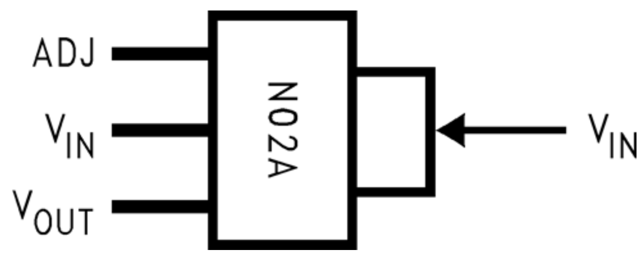
TO-220 Plastic Package
Package Number NDE0003B
Front View



TO Metal Can Package
3-Pin Package Number NDT0003A
Bottom View



SOT-223
3-Lead Package Marked N02A
Front View



Pin Functions

PIN				I/O	DESCRIPTION
NAME	TO-220	TO	SOT-223		
ADJ	1	1	1	—	Adjust pin
V_{IN}	2, TAB	3, CASE	2, 4	I	Input voltage pin for the regulator
V_{OUT}	3	2	3	O	Output voltage pin for the regulator

6 Specifications

6.1 Absolute Maximum Ratings

		MIN	MAX	UNIT
Power dissipation		Internally Limited		
Input-output voltage differential		–0.3	40	V
Operating junction temperature		0	125	°C
Storage temperature, T_{stg}		–65	150	°C

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 [(1)]	±2000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±2000 V may actually have higher performance.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
Operating junction temperature		0	125	°C

6.4 Thermal Information

THERMAL METRIC [(1)]		LM337-N-MIL			UNIT
		NDT (TO)	DCY (SOT-223)	NDE OR NDG (TO-220)	
		3 PINS	3 PINS	3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	140 [(2)]	58.3	22.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	12	36.6	15.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	—	7.2	4.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	—	1.3	2.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	—	7	4.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	1	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.
(2) No heat sink.

6.5 Electrical Characteristics

Unless otherwise specified, these specifications apply: 0°C ≤ T_j ≤ 125°C for the LM337-N-MIL; $V_{IN} - V_{OUT}$ = 5 V; and I_{OUT} = 0.1 A for the TO package and I_{OUT} = 0.5 A for the SOT-223 and TO-220 packages. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2 W for the TO and SOT-223, and 20 W for the TO-220. I_{MAX} is 1.5 A for the SOT-223 and TO-220 packages, and 0.2 A for the TO package.

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Line regulation	T_J = 25°C, 3 V ≤ $\lvert V_{IN} - V_{OUT}\rvert$ ≤ 40 V (1) I_L = 10 mA			0.01	0.04	%/V
Load regulation	T_J = 25°C, 10 mA ≤ I_{OUT} ≤ I_{MAX}			0.3%	1%	
Thermal regulation	T_J = 25°C, 10-ms Pulse			0.003	0.04	%/W
Adjustment pin current				65	100	µA
Adjustment pin current charge	10 mA ≤ I_L ≤ I_{MAX} 3 V ≤ $\lvert V_{IN} - V_{OUT}\rvert$ ≤ 40 V, T_A = 25°C			2	5	µA
Reference voltage	3 V ≤ $\lvert V_{IN} - V_{OUT}\rvert$ ≤ 40 V, (2) 10 mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}	T_J = 25°C (2)	−1.213	−1.25	−1.287	V
		−55°C ≤ T_J ≤ 150°C	−1.2	−1.25	−1.3	V
Line regulation	3 V ≤ $\lvert V_{IN} - V_{OUT}\rvert$ ≤ 40 V, (1)			0.02	0.07	%/V
Load regulation	10 mA ≤ I_{OUT} ≤ I_{MAX}, (1)			0.3%	1.5%	
Temperature stability	T_{MIN} ≤ T_j ≤ T_{MAX}			0.6%		
Minimum load current	$\lvert V_{IN} - V_{OUT}\rvert$ ≤ 40 V			2.5	10	mA
	$\lvert V_{IN} - V_{OUT}\rvert$ ≤ 10 V			1.5	6	mA
Current limit	$\lvert V_{IN} - V_{OUT}\rvert$ ≤ 15 V	K, DCY and NDE package	1.5	2.2	3.7	A
		NDT package	0.5	0.8	1.9	A
	$\lvert V_{IN} - V_{OUT}\rvert$ = 40 V, T_J = 25°C	K, DCY and NDE package	0.15	0.4		A
		NDT package	0.1	0.17		A
RMS output noise, % of V_{OUT}	T_j = 25°C, 10 Hz ≤ f ≤ 10 kHz			0.003%		
Ripple rejection ratio	V_{OUT} = −10 V, f = 120 Hz			60		dB
	C_{ADJ} = 10 µF		66	77		dB
Long-term stability	T_J = 125°C, 1000 Hours			0.3%	1%	

(1) 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 in. below the base of the TO packages.
(2) Selected devices with tightened tolerance reference voltage available.

6.6 Typical Characteristics

(NDE Package)

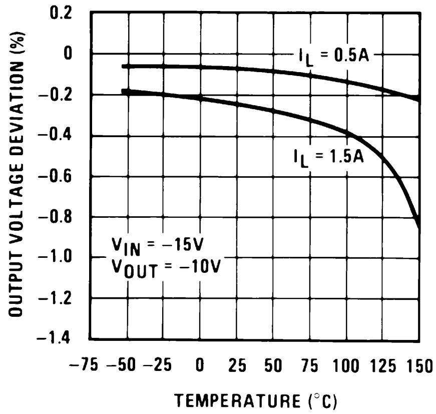


Figure 1. Load Regulation

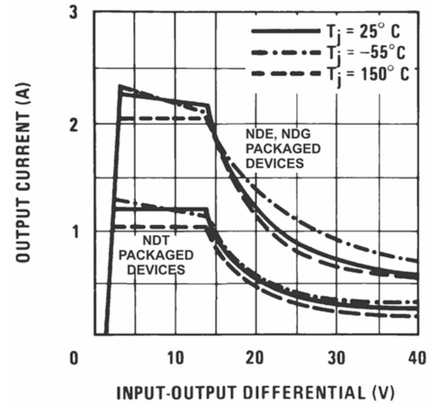


Figure 2. Current Limit

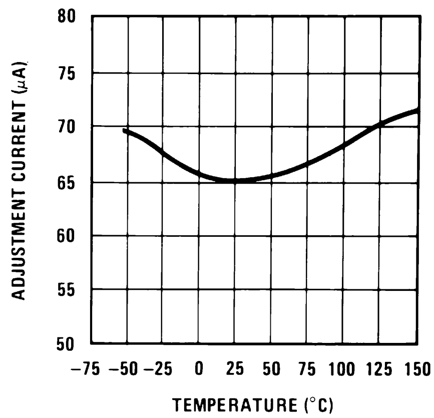


Figure 3. Adjustment Current

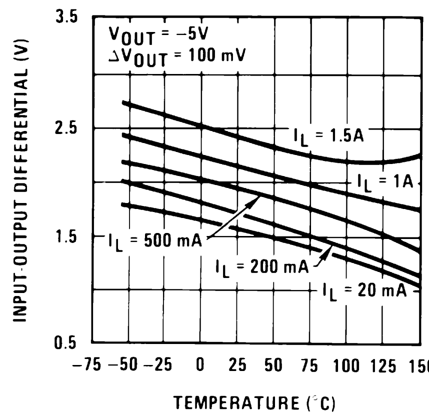


Figure 4. Dropout Voltage

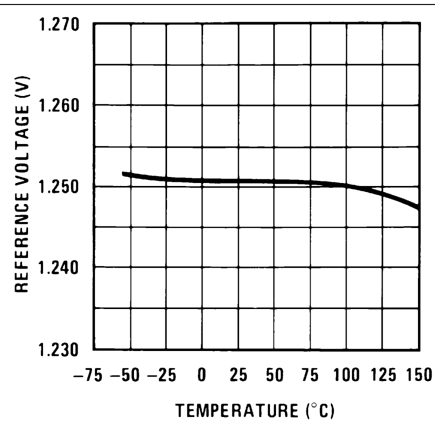


Figure 5. Temperature Stability

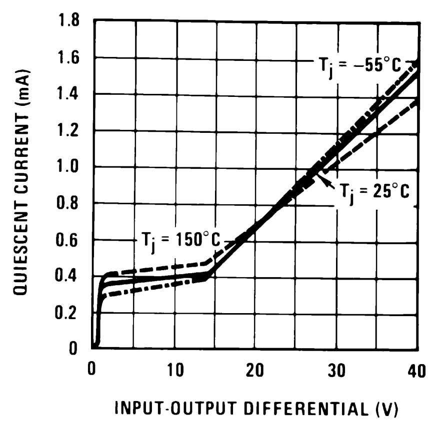


Figure 6. Minimum Operating Current

Typical Characteristics (continued)

(NDE Package)

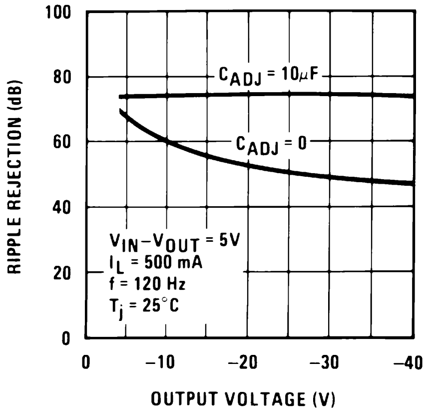


Figure 7. Ripple Rejection

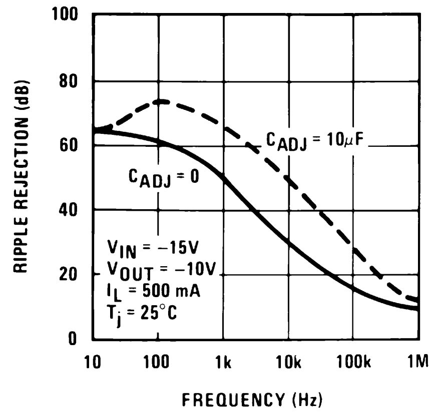


Figure 8. Ripple Rejection

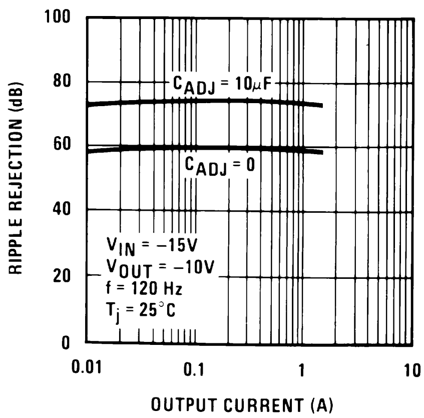


Figure 9. Ripple Rejection

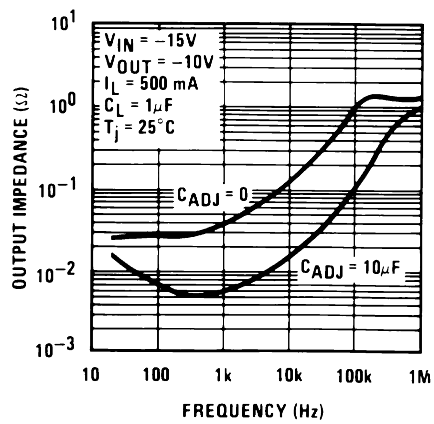


Figure 10. Output Impedance

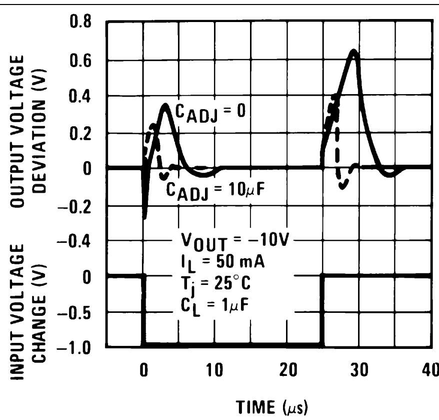


Figure 11. Line Transient Response

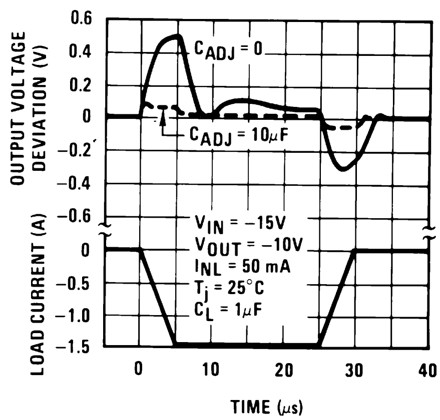


Figure 12. Load Transient Response

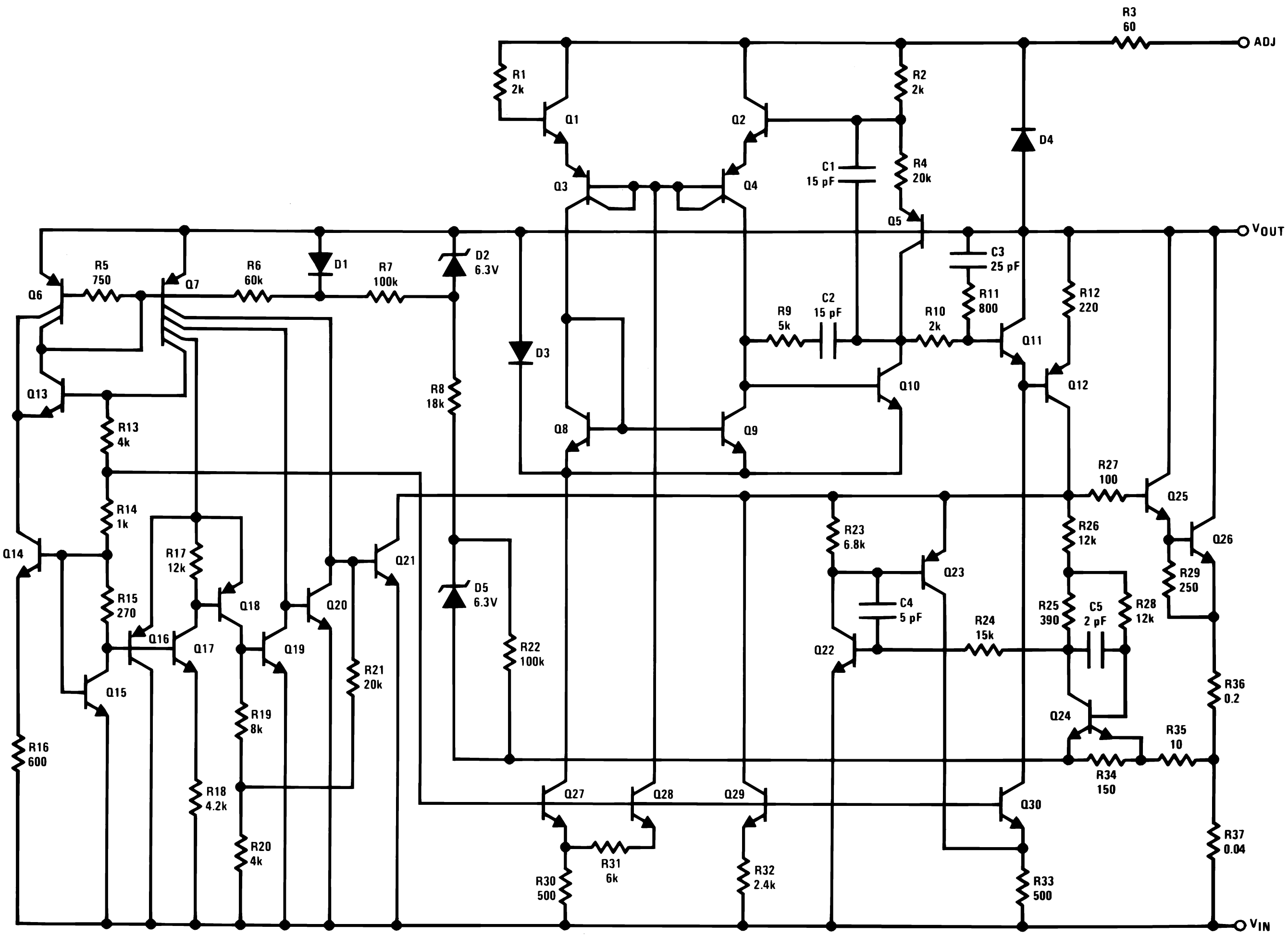
7 Detailed Description

7.1 Overview

In operation, the LM337-N-MIL develops a nominal −1.25-V reference voltage between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 (120 Ω for example) and, because the voltage is constant, a constant current then flows through the output set resistor R2, giving an output voltage calculated by Equation 1.

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

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 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 because 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.

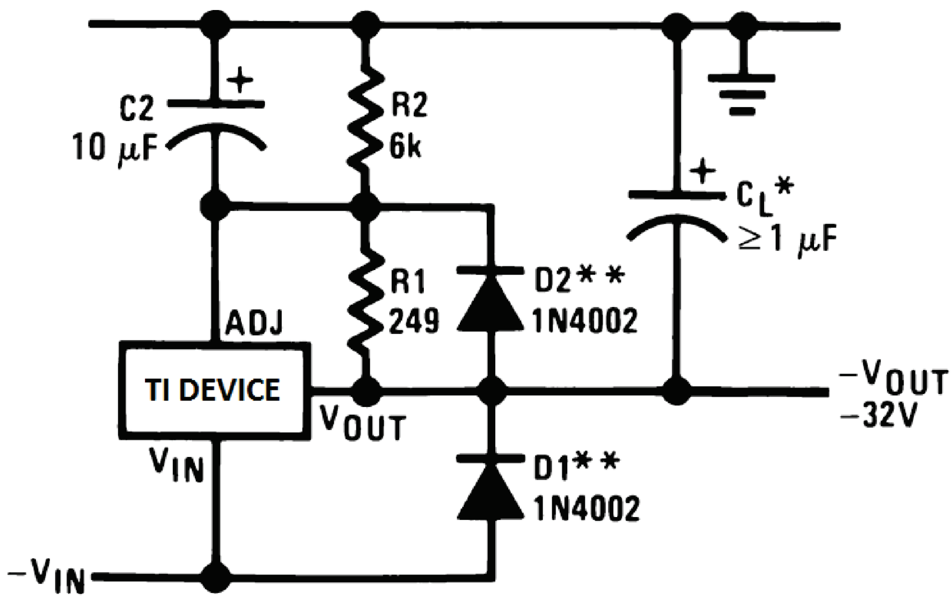
7.4 Device Functional Modes

7.4.1 Protection Diodes

When external capacitors are used with any IC regulator, it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10-µF capacitors have low enough internal series resistance to deliver 20-A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a negative output regulator and the input is shorted, the output capacitor pulls current out of the output of the regulator. The current depends on the value of the capacitor, the output voltage of the regulator, and the rate at which V_{IN} is shorted to ground.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when either the input, or the output, is shorted. Figure 13 shows the placement of the protection diodes.



*When C_L is larger than 20 µF, D1 protects the LM1337-N-MIL in case the input supply is shorted
**When C2 is larger than 10 µF and $-V_{OUT}$ is larger than −25V, D2 protects the LM1337-N-MIL in case the output is shorted

Figure 13. Regulator With Protection Diodes

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

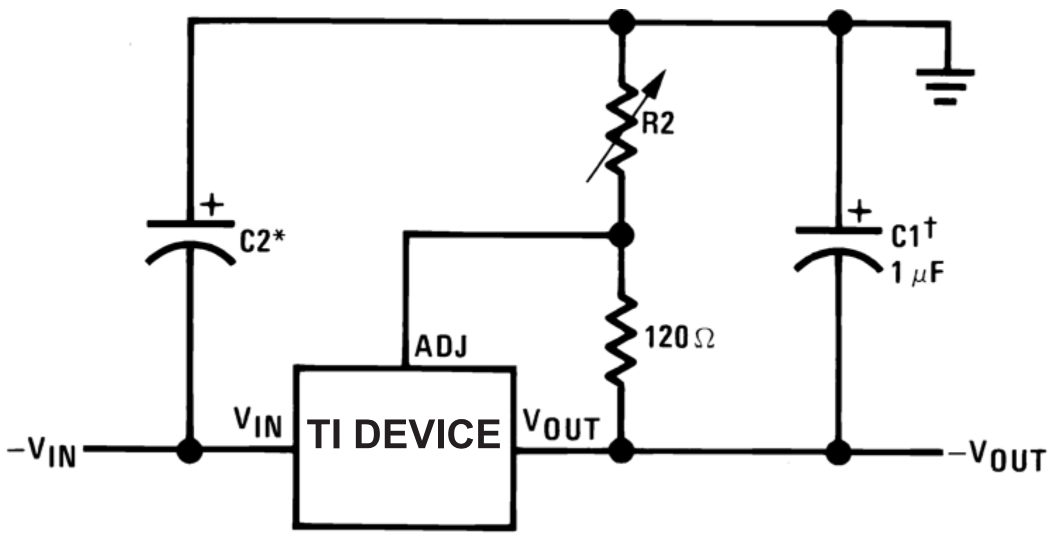
8.1 Application Information

The LM337-N-MIL is a versatile, high performance, negative output linear regulator with high accuracy and a wide temperature range. An output capacitor can be added to further improve transient response, and the ADJ pin can be bypassed to achieve very high ripple-rejection ratios. The functionality of the device can be utilized in many different applications that require negative voltage supplies, such as bipolar amplifiers, operational amplifiers, and constant current regulators.

8.2 Typical Applications

8.2.1 Adjustable Negative Voltage Regulator

The LM337-N-MIL can be used as a simple, negative output regulator to enable a variety of output voltages needed for demanding applications. By using an adjustable R2 resistor, a variety of negative output voltages can be made possible as shown in Figure 14.



Full output current not available at high input-output voltages
†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 inches 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 14. Adjustable Negative Voltage Regulator

$$-V_{OUT} = -1.25V\left(1+\frac{R2}{120}\right)+\left(-I_{ADJ}\times R2\right) \quad (2)$$

8.2.1.1 Design Requirements

The device component count is very minimal, employing two resistors as part of a voltage divider circuit and an output capacitor for load regulation. An input capacitor is needed if the device is more than 4 inches from the filter capacitors.

Typical Applications (continued)

8.2.1.2 Detailed Design Procedure

The output voltage is set based on the selection of the two resistors, R1 and R2, as shown in Figure 14.

8.2.1.3 Application Curve

As shown in Figure 15, the maximum output current capability is limited by the input-output voltage differential, package type, and junction temperature.

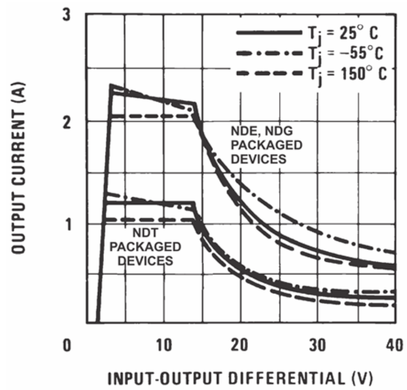
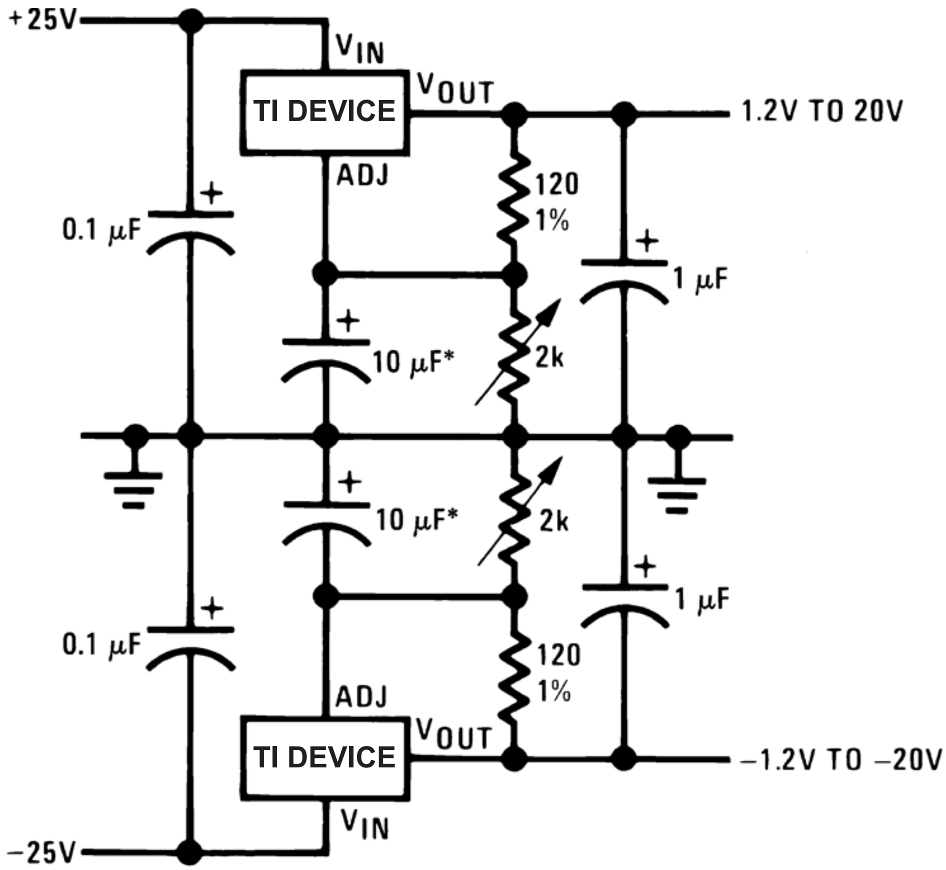


Figure 15. Current Limit

8.2.2 Adjustable Lab Voltage Regulator

The LM337-N-MIL can be combined with a positive regulator such as the LM317-N to provide both a positive and negative voltage rail. This can be useful in applications that use bi-directional amplifiers and dual-supply operational amplifiers.

Typical Applications (continued)

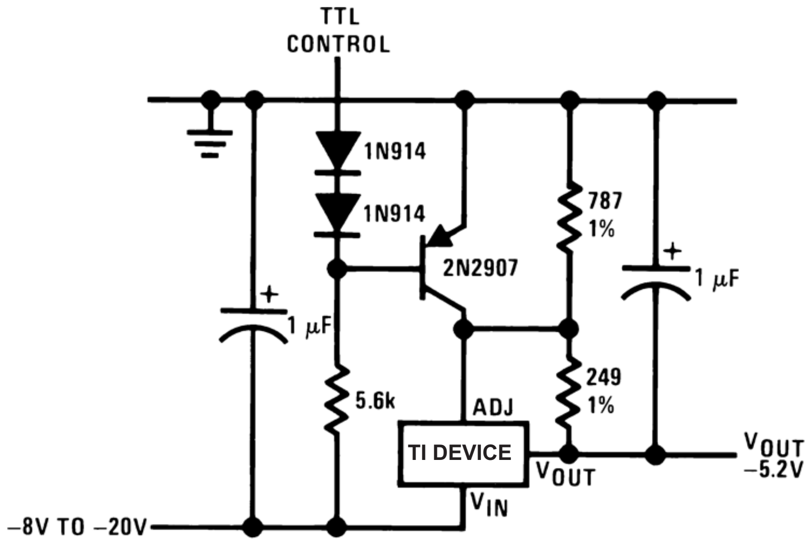


Full output current not available at high input-output voltages
*The 10 μF capacitors are optional to improve ripple rejection

8.2.3 −5.2-V Regulator with Electronic Shutdown

The LM337-N-MIL can be used with a PNP transistor to provide shutdown control from a TTL control signal. The PNP can short or open the ADJ pin to GND. When ADJ is shorted to GND by the PNP, the output is −1.3 V. When ADJ is disconnected from GND by the PNP, then the LM337-N-MIL outputs the programmed output of −5.2 V.

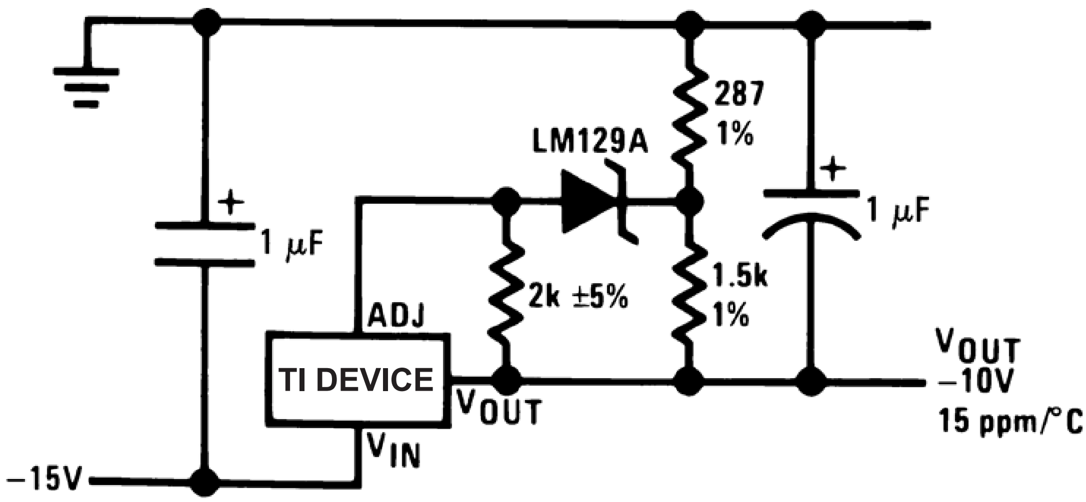
Typical Applications (continued)



Minimum output ≃ −1.3 V when control input is low

8.2.4 High Stability −10-V Regulator

Using a high stability shunt voltage reference in the feedback path, such as the LM329, provides damping necessary for a stable, low noise output.



9 Power Supply Recommendations

The input supply to the LM337-N must be kept at a voltage level such that the maximum input to output differential voltage rating is not exceeded. The minimum dropout voltage must also be met with extra headroom when possible to keep the LM337-N-MIL in regulation. TI recommends an input capacitor, especially when the input pin is placed more than 4 inches away from the power-supply filter capacitor.

10 Layout

10.1 Layout Guidelines

Some layout guidelines must be followed to ensure proper regulation of the output voltage with minimum noise. Traces carrying the load current must be wide to reduce the amount of parasitic trace inductance and the feedback loop from V_{OUT} to ADJ must be kept as short as possible. To improve PSRR, a bypass capacitor can be placed at the ADJ pin and must be placed as close as possible to the IC. In cases when V_{IN} shorts to ground, an external diode must be placed from V_{IN} to V_{OUT} to divert the surge current into the output capacitor and protect the IC. Similarly, in cases when a large bypass capacitor is placed at the ADJ pin and V_{OUT} shorts to ground, an external diode must be placed from V_{OUT} to ADJ to provide a path for the bypass capacitor to discharge. These diodes must be placed close to the corresponding IC pins to increase their effectiveness.

10.2 Layout Example

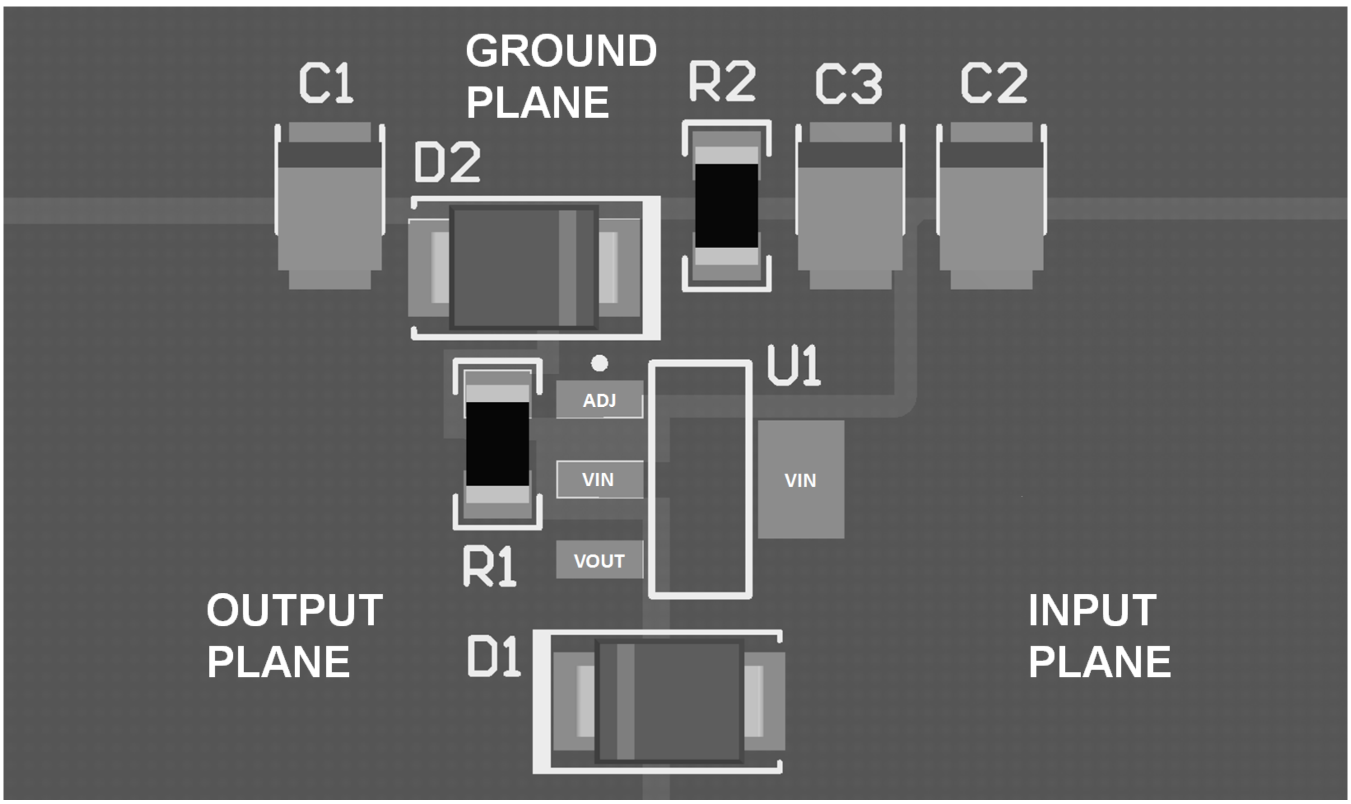


Figure 16. Layout Example (SOT-223)

10.3 Thermal Considerations

10.3.1 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 17 and Figure 18 show the information for the SOT-223 package. Figure 18 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.

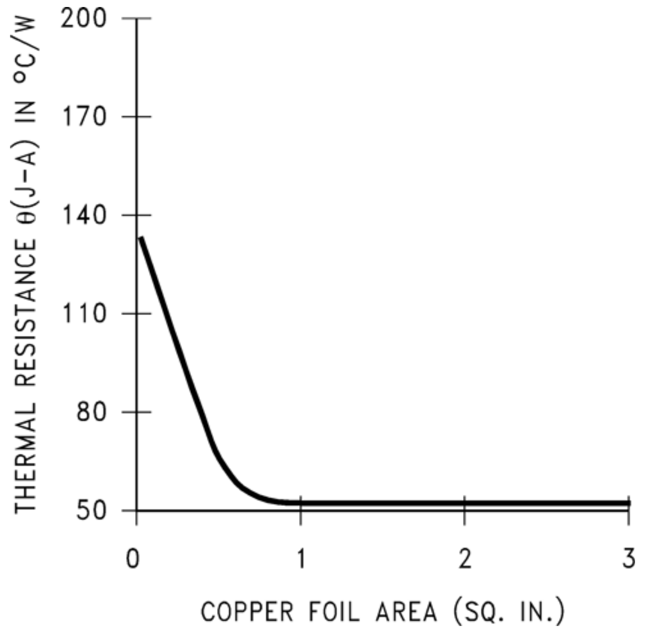


Figure 17. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

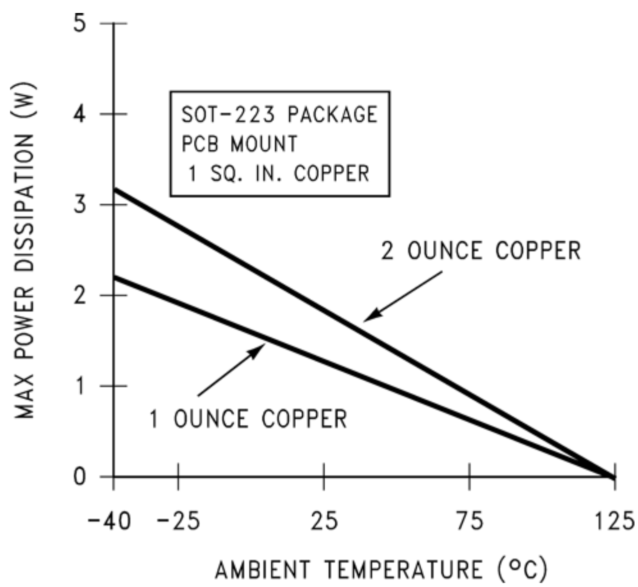


Figure 18. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

See AN-1028, SNVA036, for power enhancement techniques to be used with the SOT-223 package.

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

AN-1028, SNVA036

11.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution

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.

11.5 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM337H	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	0 to 0	(LM337H, LM337H)
LM337H/NOPB	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	0 to 0	(LM337H, LM337H)

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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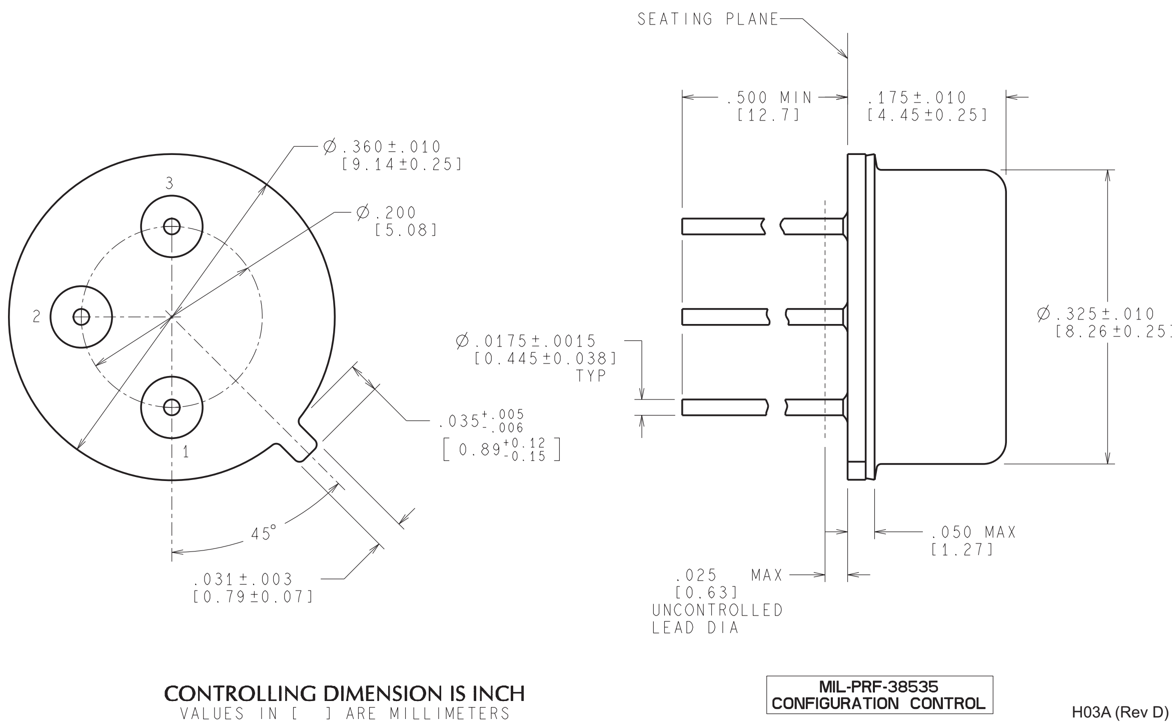
NDT0003A


SEATING PLANE
.500 MIN
[12.7]
.175±.010
[4.45±0.25]
Ø.360±.010
[9.14±0.25]
Ø.200
[5.08]
3
2
1
Ø.0175±.0015
[0.445±0.038]
TYP
.035+.005 -.006
[0.89+0.12 -0.15]
Ø.325±.010
[8.26±0.25]
45°
.031±.003
[0.79±0.07]
.050 MAX
[1.27]
.025 MAX
[0.63]
UNCONTROLLED
LEAD DIA
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
MIL-PRF-38535
CONFIGURATION CONTROL
H03A (Rev D)