LM137/LM337-N 3-Terminal Adjustable Negative Regulators

Check for Samples: LM137, LM337-N

FEATURES

- **Output Voltage Adjustable from −1.2V to −37V**
- **1.5A Output Current Specified, −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**

DESCRIPTION

The LM137/LM337-N 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-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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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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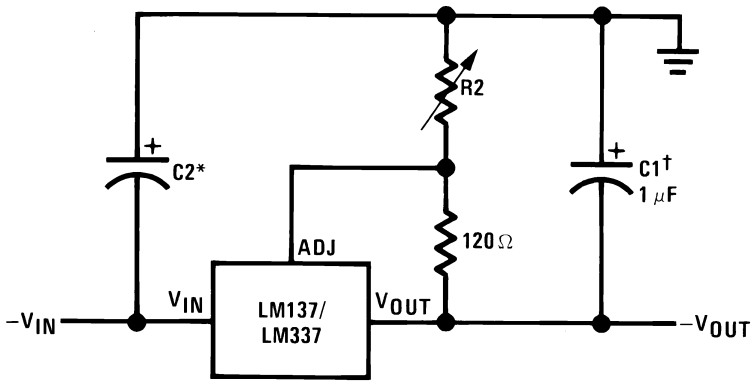
Typical Applications



Full output current not available at high input-output voltages

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

†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

Figure 1. Adjustable Negative Voltage Regulator

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

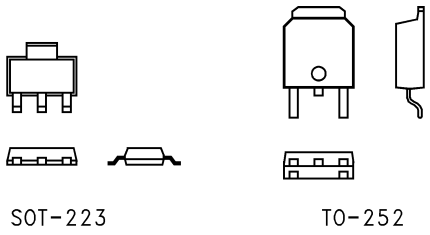


Figure 2. Scale 1:1

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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(1)(2)

Power Dissipation	Internally Limited
Input-Output Voltage Differential	40V
Operating Junction Temperature Range 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_j ≤ +150°C for the LM137, 0°C ≤ T_j ≤ +125°C for the LM337-N; V_{IN} − V_{OUT} = 5V; and I_{OUT} = 0.1A for the TO 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 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 package.

ELECTRICAL CHARACTERISTICS(1)

Parameter	Conditions	LM137			LM337			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	T_j = 25°C, 3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V (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 (3)	−1.225	−1.250	−1.275	−1.213	−1.250	−1.287	V
	3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V, (3) 10 mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}	−1.200	−1.250	−1.300	−1.200	−1.250	−1.300	V
Line Regulation	3V ≤ $\|V_{IN} - V_{OUT}\|$ ≤ 40V, (2)		0.02	0.05		0.02	0.07	%/V
Load Regulation	10 mA ≤ I_{OUT} ≤ I_{MAX}, (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

(1) Unless otherwise specified, these specifications apply −55°C ≤ T_j ≤ +150°C for the LM137, 0°C ≤ T_j ≤ +125°C for the LM337-N; V_{IN} − V_{OUT} = 5V; and I_{OUT} = 0.1A for the TO 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 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 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 ⅛ in. below the base of the TO-3 and TO packages.
(3) Selected devices with tightened tolerance reference voltage available.

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ELECTRICAL CHARACTERISTICS[1] (continued)

Parameter	Conditions	LM137			LM337			Units
		Min	Typ	Max	Min	Typ	Max	
Current Limit	$\|V_{IN} - V_{OUT}\| \le 15V$							
	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
	$\|V_{IN} - V_{OUT}\| = 40V$, $T_j = 25°C$							
	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}	$T_j = 25°C$, 10 Hz ≤ f ≤ 10 kHz		0.003			0.003		%
Ripple Rejection Ratio	$V_{OUT} = -10V$, f = 120 Hz		60			60		dB
	$C_{ADJ} = 10 \mu F$	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	NDT Package		12	15		12	15	°C/W
	K Package		2.3	3		2.3	3	°C/W
	NDE Package					4		°C/W
Thermal Resistance, Junction to Ambient (No Heat Sink)	NDT Package		140			140		°C/W
	K Package		35			35		°C/W
	NDE Package					50		°C/W
	DCY Package					170		°C/W

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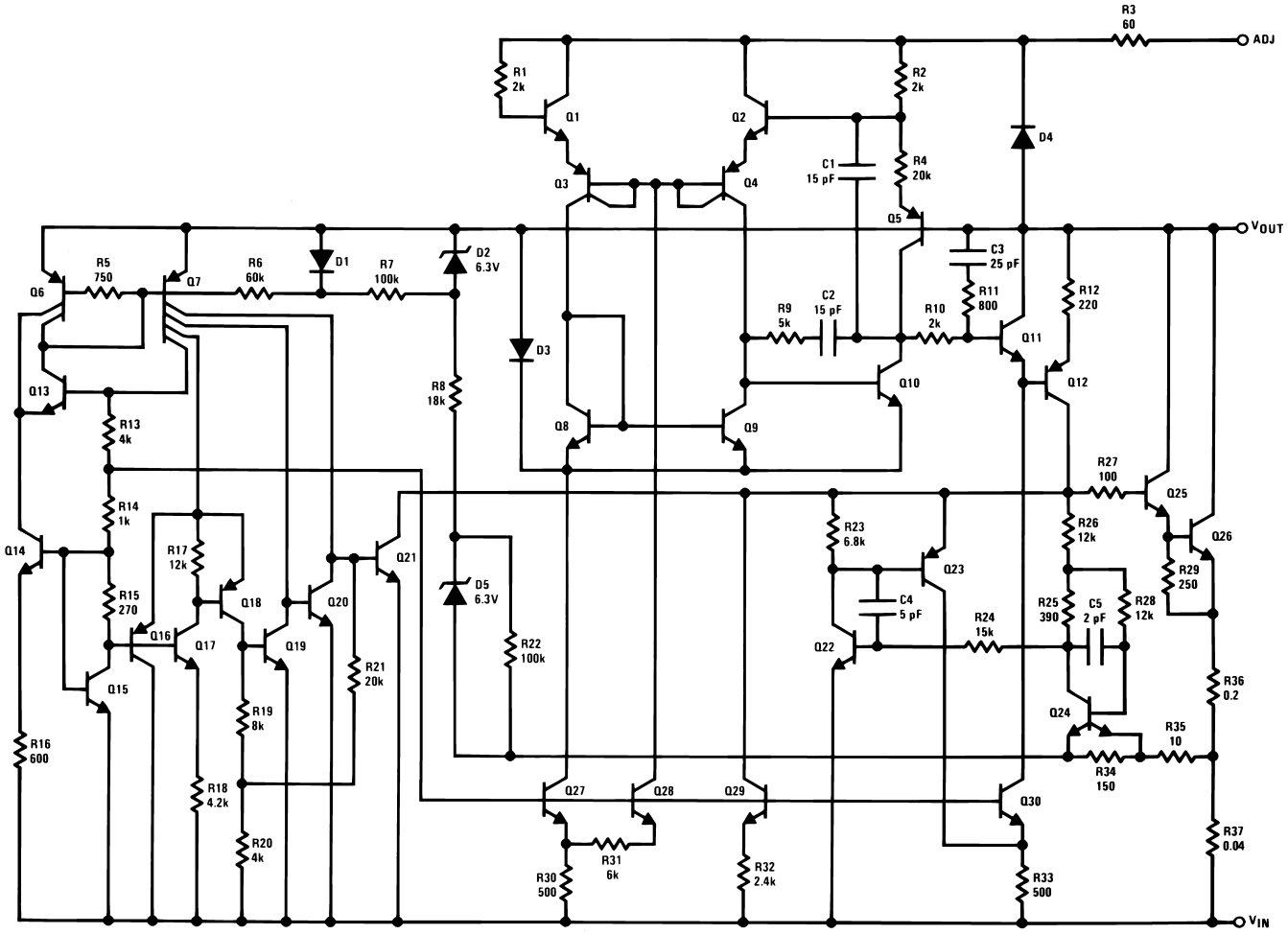
SCHEMATIC DIAGRAM



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.

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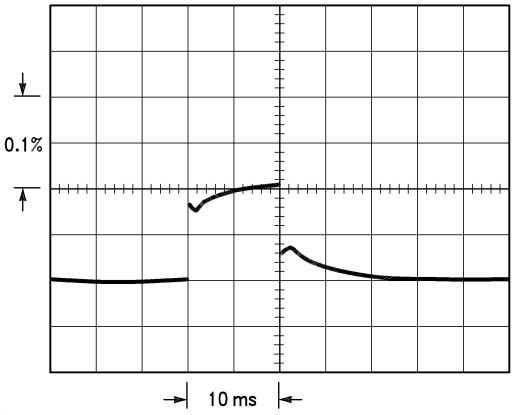
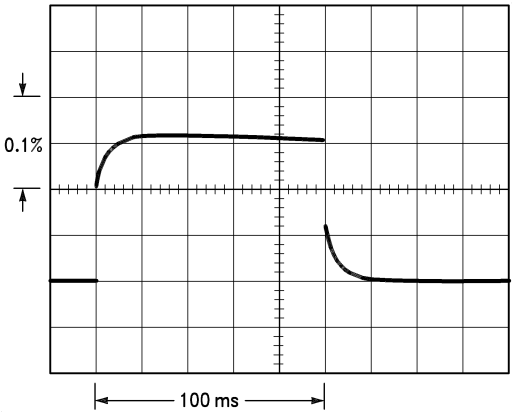


LM137, V_{OUT} = −10V
V_{IN} − V_{OUT} = −40V
I_{IL} = 0A → 0.25A → 0A
Vertical sensitivity, 5 mV/div

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 × 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 → 0.25A → 0A
Horizontal sensitivity, 20 ms/div

Figure 4.

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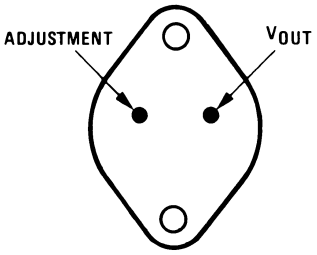
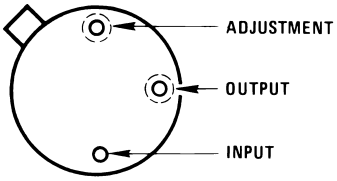
Connection Diagrams



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

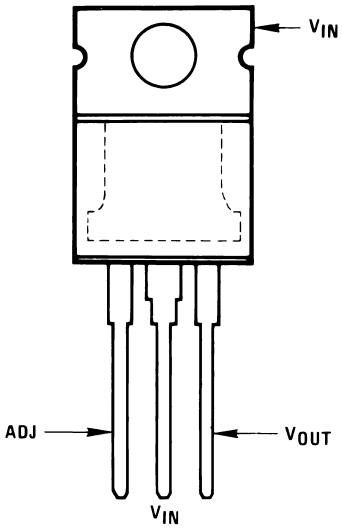


Figure 7. TO-220
Plastic Package
Front View
See Package Number NDE0003B

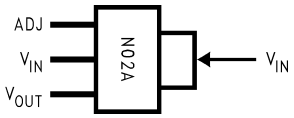


Figure 8. 3-Lead SOT-223
Front View
Package Marked N02A
See Package Number DCY0004A

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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.

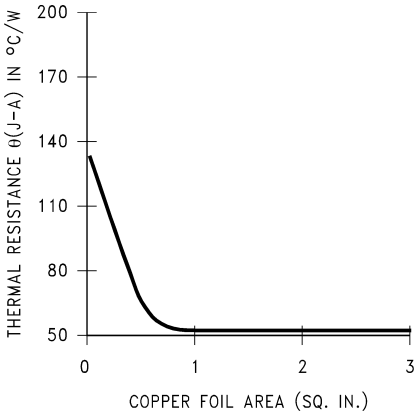

Figure 9. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

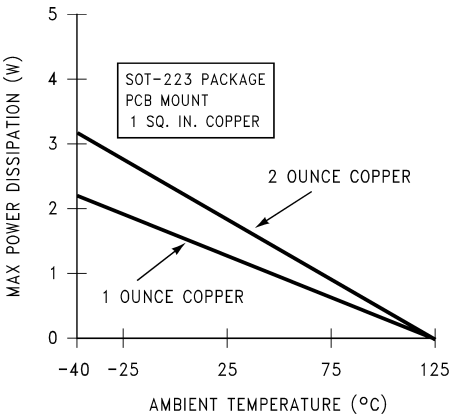

Figure 10. Maximum Power Dissipation vs. T_{AMB} for the SOT-223 Package

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

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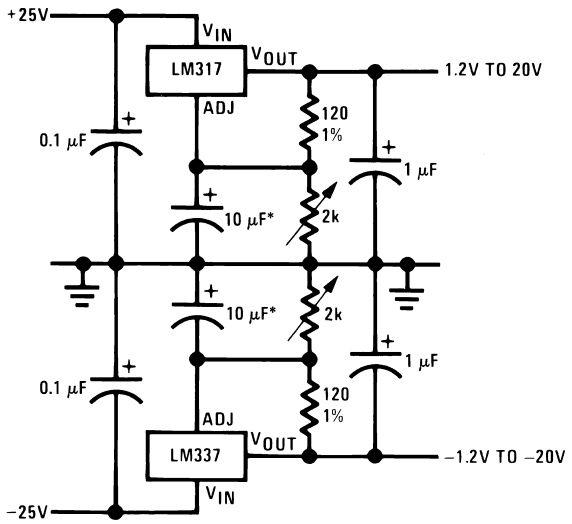
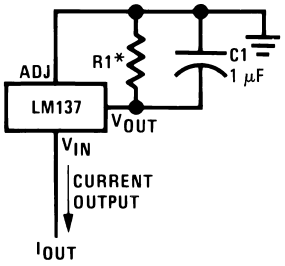
Typical Applications

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

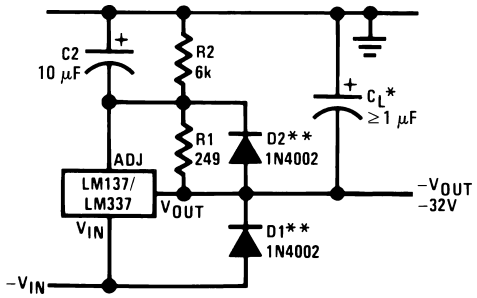
Figure 12. Current Regulator



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

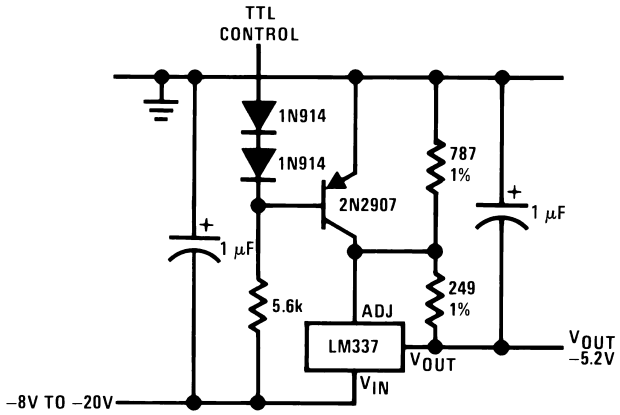
*0.8Ω ≤ R1 ≤ 120Ω

Figure 13. Negative Regulator with Protection Diodes



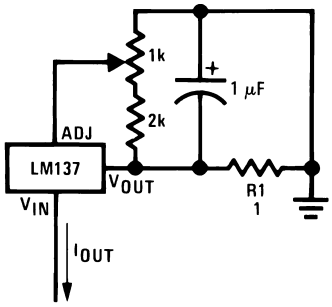
*When C_L is larger than 20 µF, D1 protects the LM137 in case the input supply is shorted
**When C2 is larger than 10 µF and $-V_{OUT}$ is larger than −25V, D2 protects the LM137 in case the output is shorted

Figure 14. −5.2V Regulator with Electronic Shutdown*



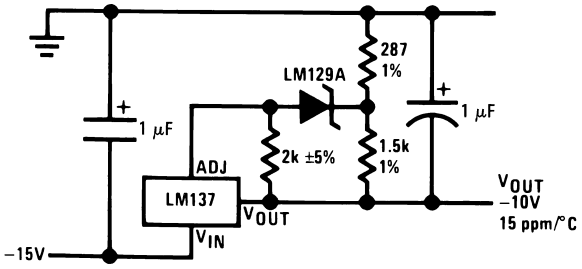
*Minimum output ≈ −1.3V when control input is low

Figure 15. Adjustable Current Regulator



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

Figure 16. High Stability −10V Regulator



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TYPICAL PERFORMANCE CHARACTERISTICS

(K Steel and NDE Packages)

Load Regulation

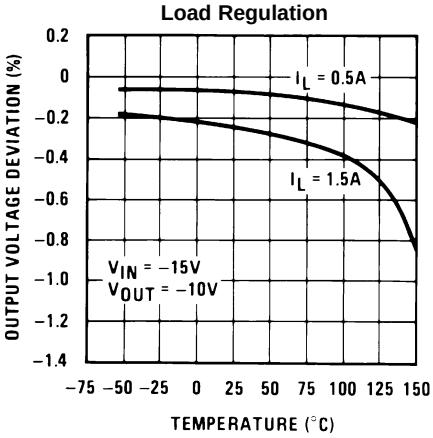

Figure 17.

Current Limit

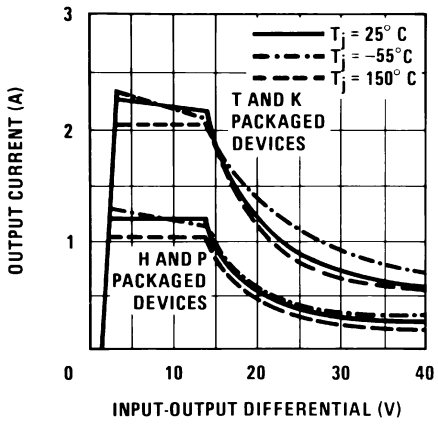

Figure 18.

Adjustment Current

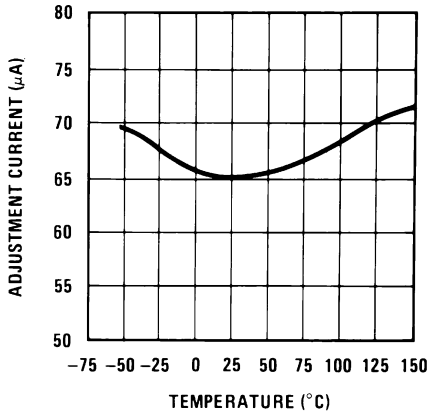

Figure 19.

Dropout Voltage

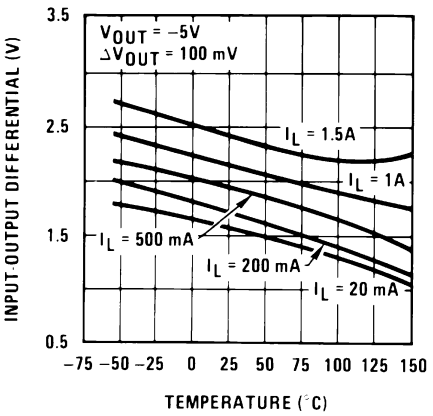

Figure 20.

Temperature Stability

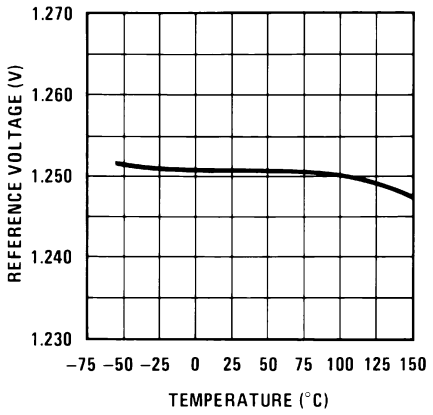

Figure 21.

Minimum Operating Current

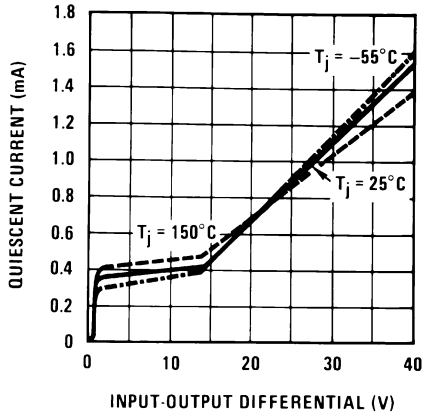

Figure 22.

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TYPICAL PERFORMANCE CHARACTERISTICS (continued)

(K Steel and NDE Packages)

Ripple Rejection

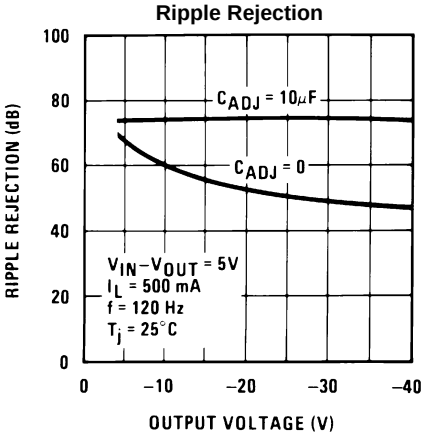

Figure 23.

Ripple Rejection

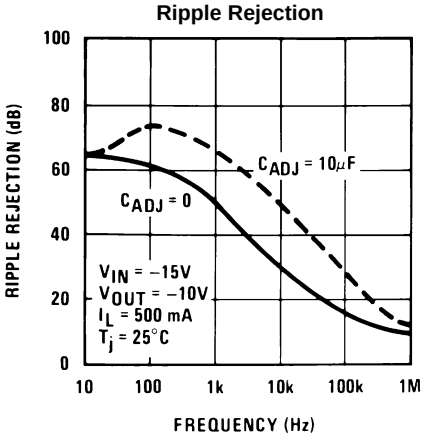

Figure 24.

Ripple Rejection

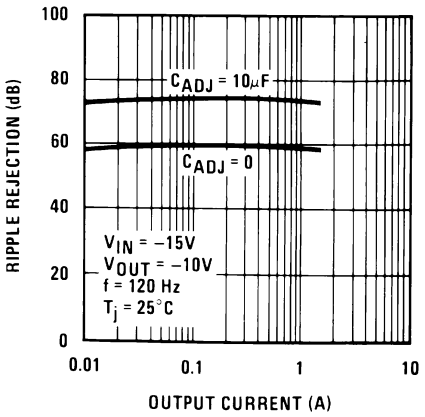

Figure 25.

Output Impedance

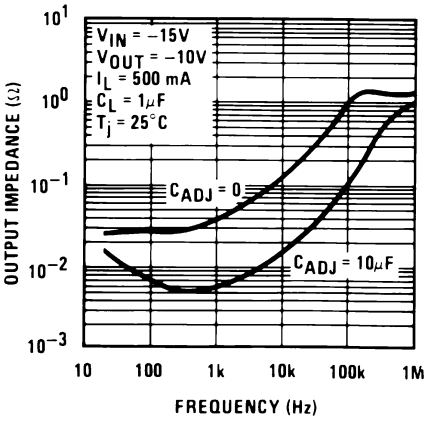

Figure 26.

Line Transient Response

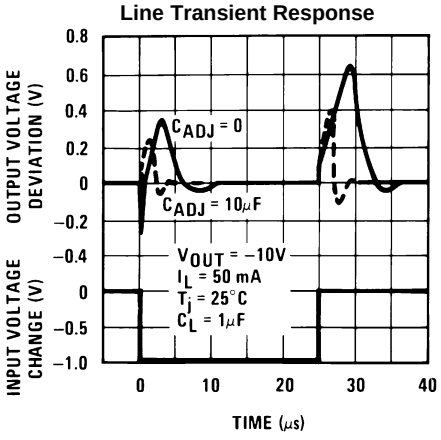

Figure 27.

Load Transient Response

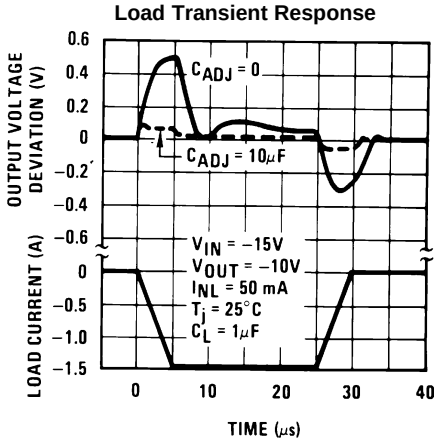

Figure 28.

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REVISION HISTORY

Changes from Revision C (April 2013) to Revision D	Page
• Changed layout of National Data Sheet to TI format	12

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PACKAGING INFORMATION

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

(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.

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)

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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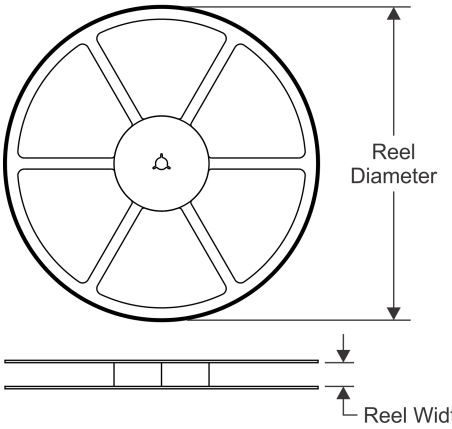
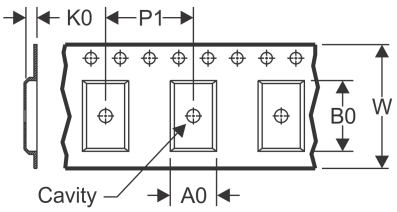
TAPE AND REEL INFORMATION

REEL DIMENSIONS

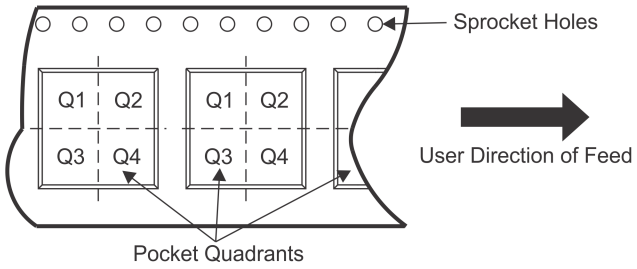


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

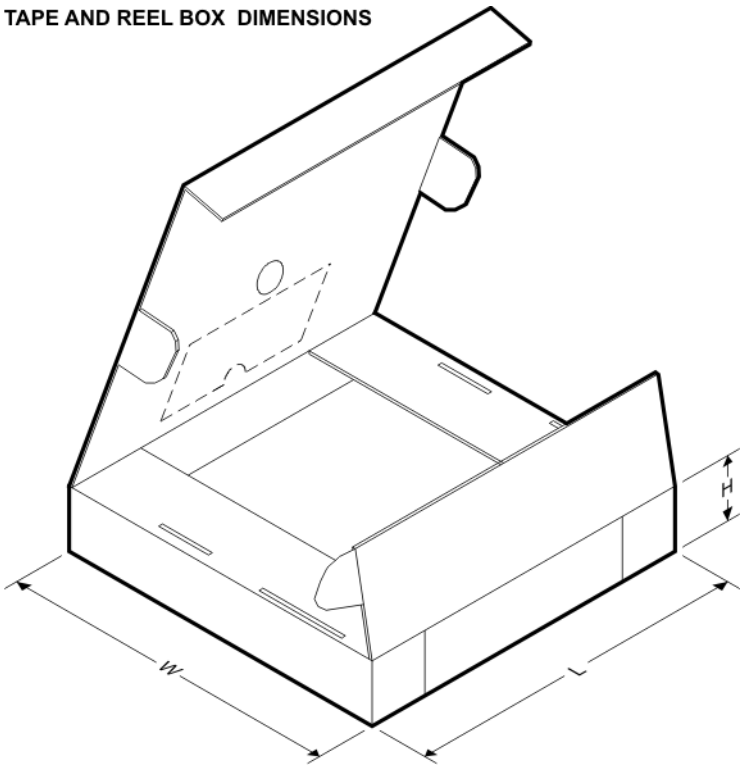
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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

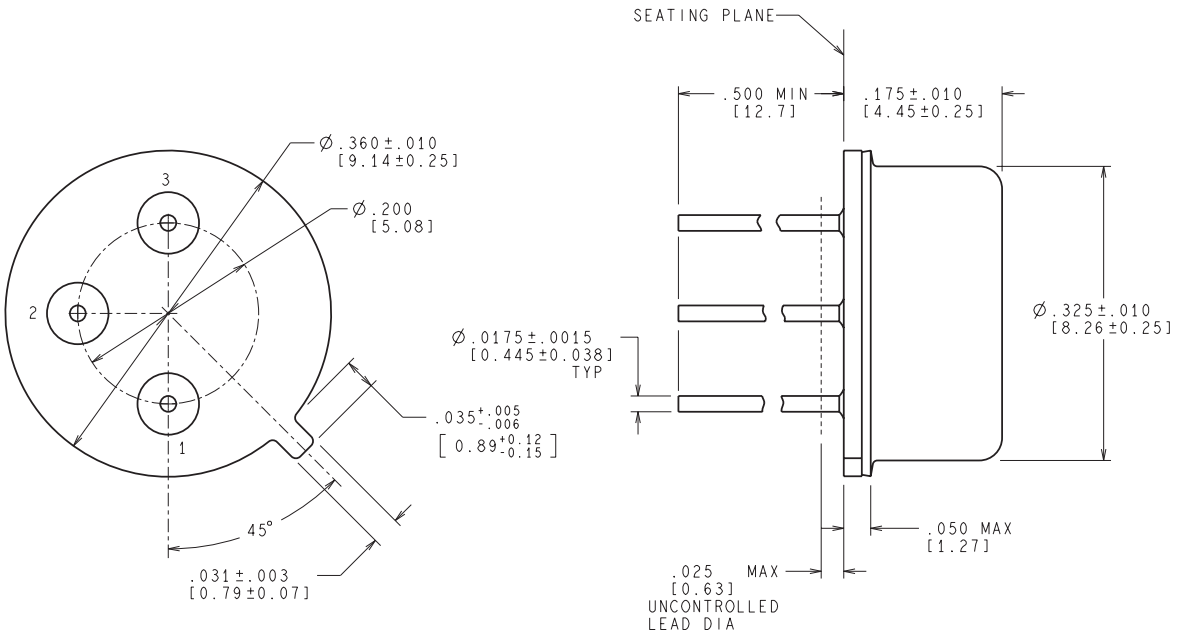
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM337IMP	SOT-223	DCY	4	1000	367.0	367.0	35.0
LM337IMP/NOPB	SOT-223	DCY	4	1000	367.0	367.0	35.0
LM337IMPX	SOT-223	DCY	4	2000	367.0	367.0	35.0
LM337IMPX/NOPB	SOT-223	DCY	4	2000	367.0	367.0	35.0

NDT0003A

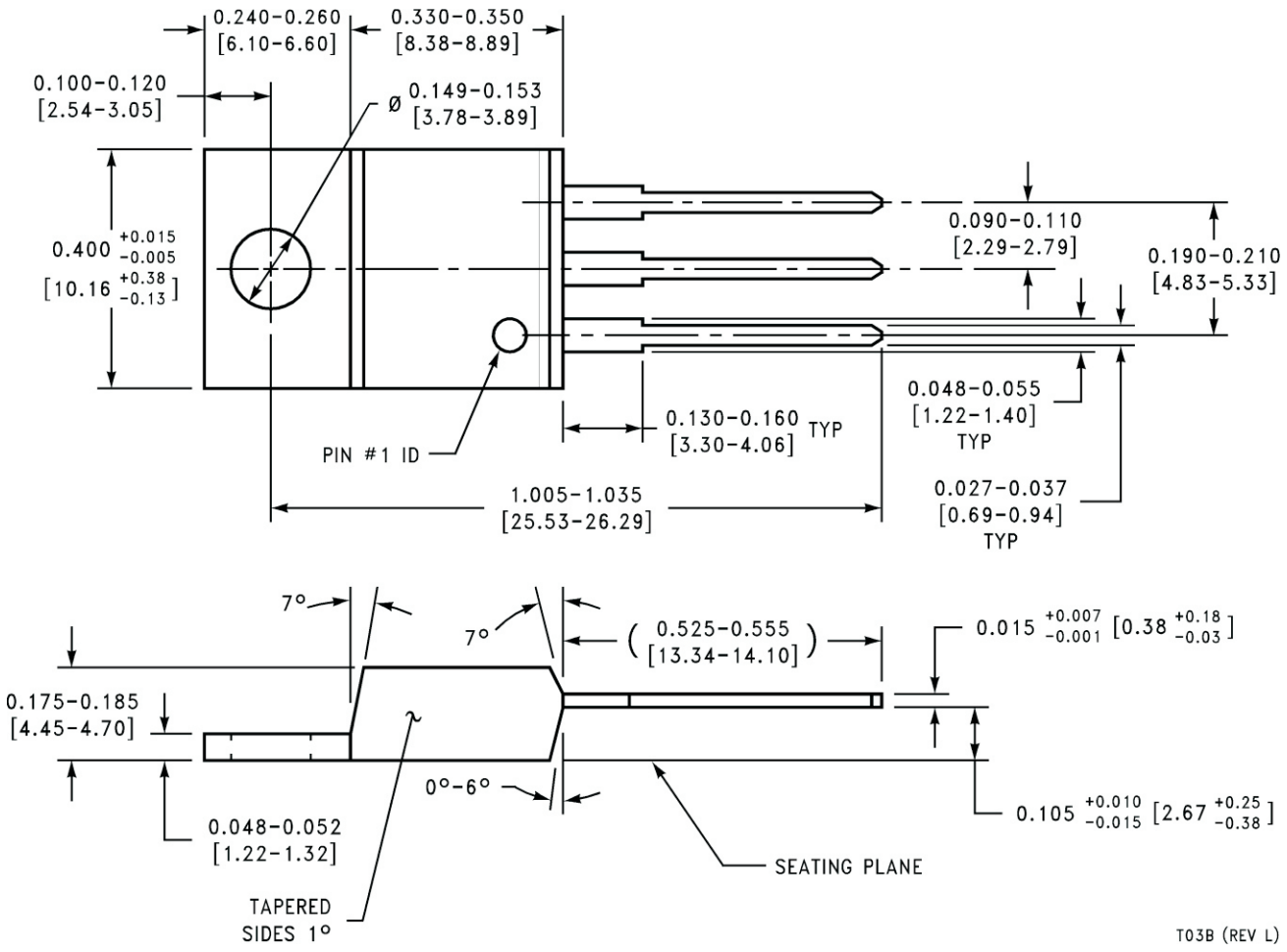


CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

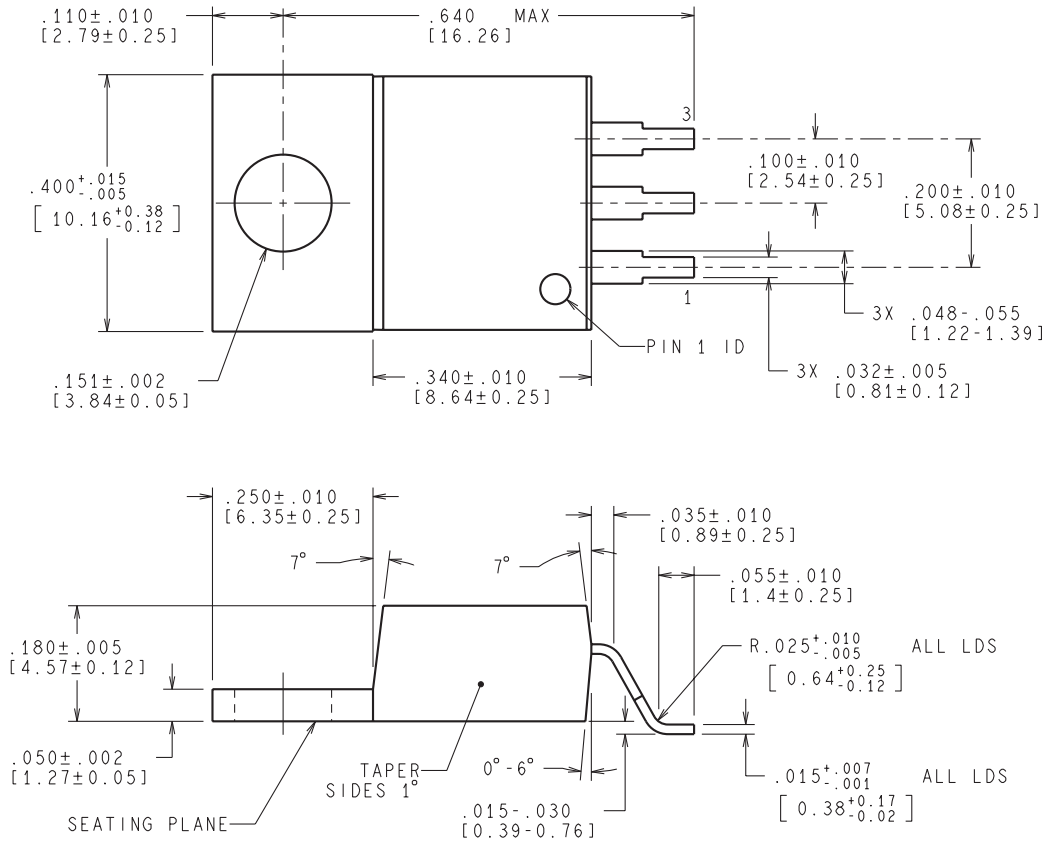
MIL-PRF-38535
CONFIGURATION CONTROL

H03A (Rev D)

NDE0003B


0.240-0.260
[6.10-6.60]
0.330-0.350
[8.38-8.89]
0.100-0.120
[2.54-3.05]
Ø 0.149-0.153
[3.78-3.89]
0.400 +0.015 -0.005
[10.16 +0.38 -0.13]
0.090-0.110
[2.29-2.79]
0.190-0.210
[4.83-5.33]
0.048-0.055
[1.22-1.40]
TYP
0.130-0.160 TYP
[3.30-4.06]
PIN #1 ID
1.005-1.035
[25.53-26.29]
0.027-0.037
[0.69-0.94]
TYP
7°
7°
(0.525-0.555
[13.34-14.10])
0.015 +0.007 -0.001 [0.38 +0.18 -0.03]
0.175-0.185
[4.45-4.70]
0°-6°
0.105 +0.010 -0.015 [2.67 +0.25 -0.38]
0.048-0.052
[1.22-1.32]
SEATING PLANE
TAPERED
SIDES 1°
T03B (REV L)

NDG0003F

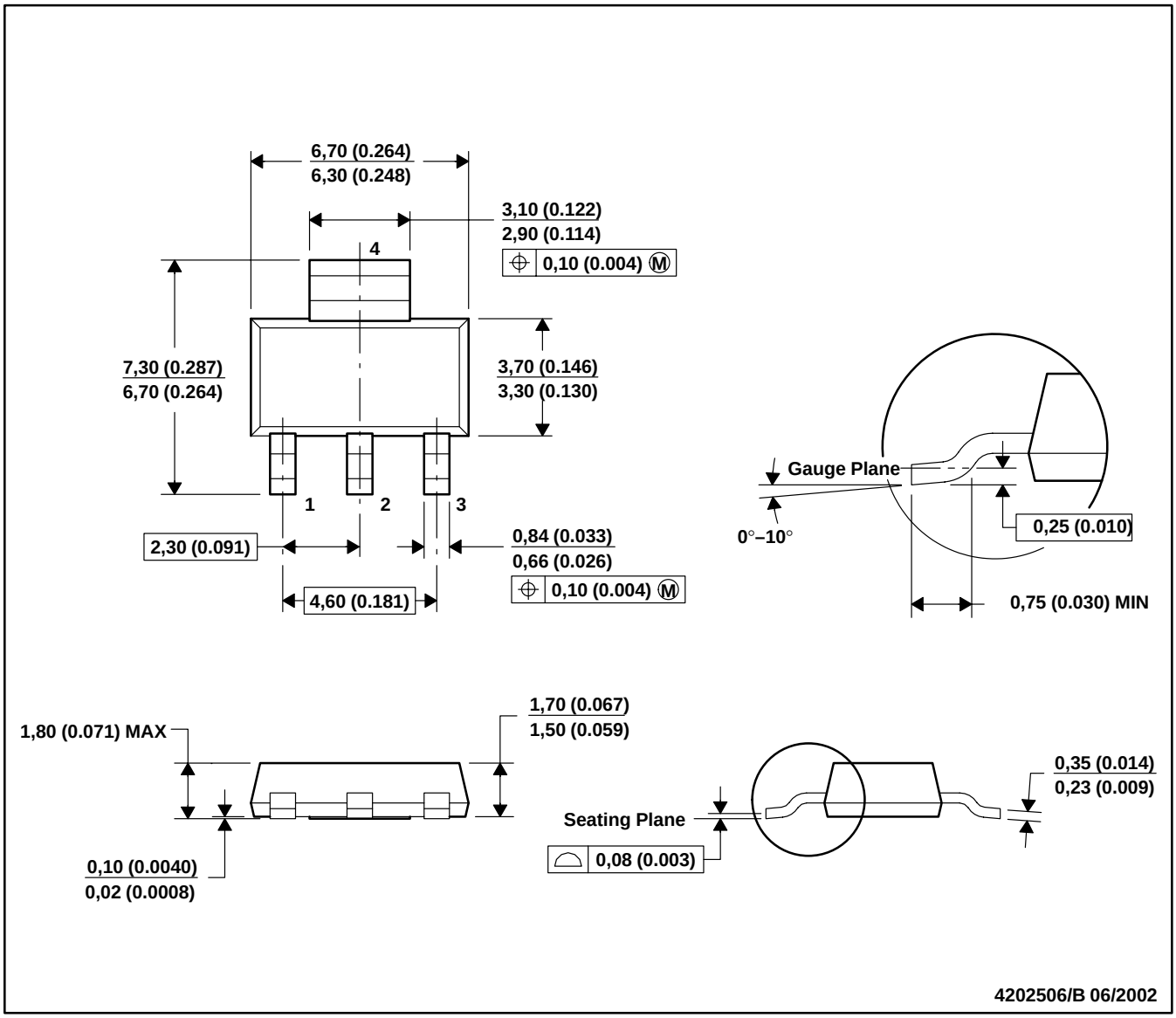


CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

T03F (Rev B)

MPDS094A – APRIL 2001 – REVISED JUNE 2002

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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