

LM137, 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 LM137 and LM337-N are adjustable 3-terminal negative voltage regulators 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 LM137 and LM337-N feature internal current limiting, thermal shutdown and safe-area compensation, making it virtually blowout-proof against overloads.

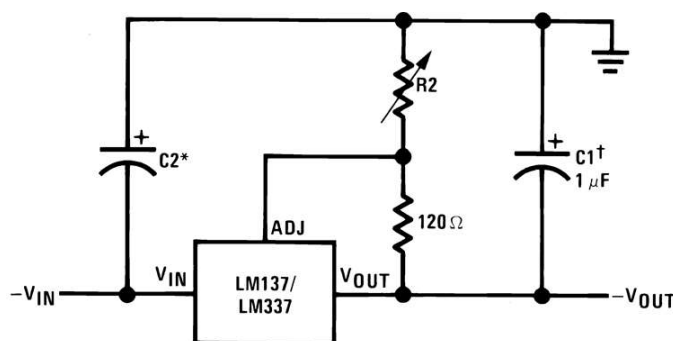
The LM137 and LM337-N are ideal complements to the LM117 and LM317 adjustable positive regulators. The LM137 has a wider operating temperature range than the LM337-N and is also offered in military and space qualified versions.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM137	TO (3)	8.255 mm × 8.255 mm
LM337-N	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

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

†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



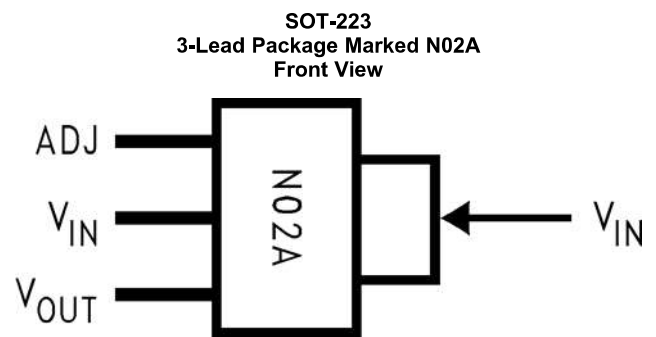
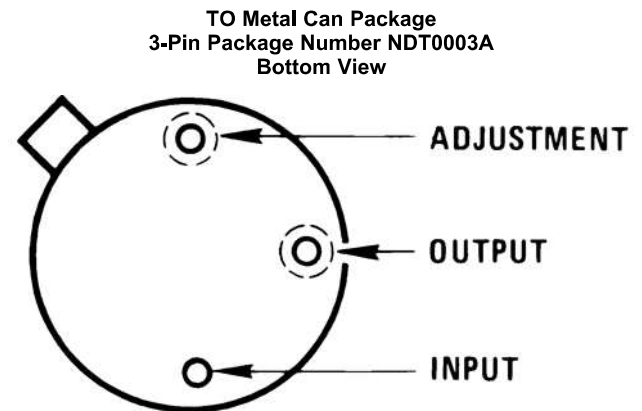
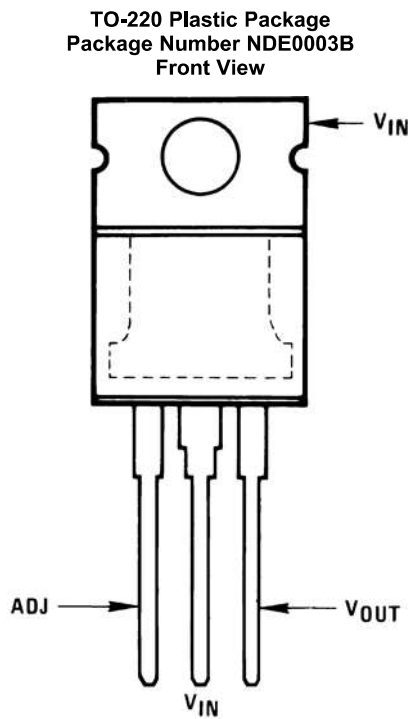
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4 Revision History

Changes from Revision D (April 2013) to Revision E	Page
<ul style="list-style-type: none"> • Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i>, <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section. 1 • Deleted soldering information from <i>Absolute Maximum Ratings</i> 4 	
<hr/>	
Changes from Revision C (April 2013) to Revision D	Page
<ul style="list-style-type: none"> • Changed layout of National Data Sheet to TI format 7 	

5 Pin Configuration and Functions



Pin Functions

NAME	PIN			I/O	DESCRIPTION
	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	LM137	-55	150	°C
	LM337-N	0	125	
	LM337I	-40	125	
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	LM137	-55	150	°C
	LM337-N	0	125	
	LM337I	-40	125	

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		LM137	LM337-N		UNIT	
		NDT (TO)	NDT (TO)	DCY (SOT-223)		NDE OR NDG (TO-220)
		3 PINS	3 PINS	3 PINS		3 PINS
$R_{\theta JA}$	Junction-to-ambient thermal resistance	140 ⁽²⁾	140 ⁽²⁾	58.3	22.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	12	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 $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM137, $0^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ for the LM337-N; $V_{\text{IN}} - V_{\text{OUT}} = 5\text{ V}$; and $I_{\text{OUT}} = 0.1\text{ A}$ for the TO package and $I_{\text{OUT}} = 0.5\text{ A}$ 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	LM137			LM337-N			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
Line regulation	$T_J = 25^{\circ}\text{C}$, $3\text{ V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 40\text{ V}^{(1)}$ $I_L = 10\text{ mA}$		0.01	0.02		0.01	0.04	%/V	
Load regulation	$T_J = 25^{\circ}\text{C}$, $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$		0.3%	0.5%		0.3%	1%		
Thermal regulation	$T_J = 25^{\circ}\text{C}$, 10-ms Pulse		0.002	0.02		0.003	0.04	%/W	
Adjustment pin current			65	100		65	100	μA	
Adjustment pin current charge	$10\text{ mA} \leq I_L \leq I_{\text{MAX}}$ $3\text{ V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 40\text{ V}$, $T_A = 25^{\circ}\text{C}$		2	5		2	5	μA	
Reference voltage	$3\text{ V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 40\text{ V}$, ⁽²⁾ $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$, $P \leq P_{\text{MAX}}$	$T_J = 25^{\circ}\text{C}$ ⁽²⁾	-1.225	-1.25	-1.275	-1.213	-1.25	-1.287	V
		$-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$	-1.2	-1.25	-1.3	-1.2	-1.25	-1.3	V
Line regulation	$3\text{ V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 40\text{ V}$, ⁽¹⁾		0.02	0.05		0.02	0.07	%/V	
Load regulation	$10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$, ⁽¹⁾		0.3%	1%		0.3%	1.5%		
Temperature stability	$T_{\text{MIN}} \leq T_J \leq T_{\text{MAX}}$		0.6%			0.6%			
Minimum load current	$ V_{\text{IN}} - V_{\text{OUT}} \leq 40\text{ V}$		2.5	5		2.5	10	mA	
	$ V_{\text{IN}} - V_{\text{OUT}} \leq 10\text{ V}$		1.2	3		1.5	6	mA	
Current limit	$ V_{\text{IN}} - V_{\text{OUT}} \leq 15\text{ V}$	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_{\text{IN}} - V_{\text{OUT}} = 40\text{ V}$, $T_J = 25^{\circ}\text{C}$	K, DCY and NDE package	0.24	0.4		0.15	0.4		A
		NDT package	0.15	0.17		0.1	0.17		A
RMS output noise, % of V_{OUT}	$T_J = 25^{\circ}\text{C}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		0.003%			0.003%			
Ripple rejection ratio	$V_{\text{OUT}} = -10\text{ V}$, $f = 120\text{ Hz}$		60			60		dB	
	$C_{\text{ADJ}} = 10\text{ }\mu\text{F}$		66	77		66	77	dB	
Long-term stability	$T_J = 125^{\circ}\text{C}$, 1000 Hours		0.3%	1%		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 $\frac{1}{8}$ in. below the base of the TO packages.
- (2) Selected devices with tightened tolerance reference voltage available.

6.6 Typical Characteristics

(NDE Package)

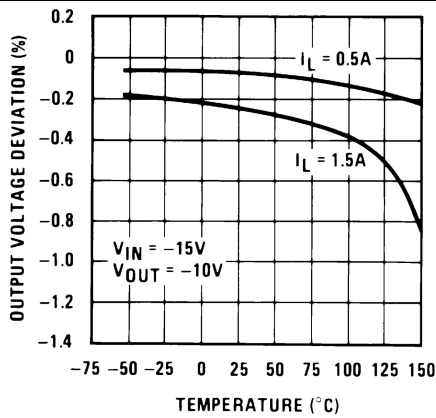


Figure 1. Load Regulation

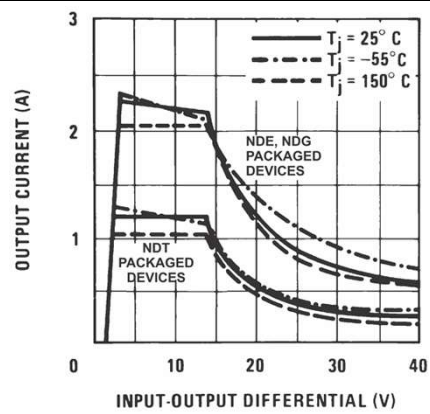


Figure 2. Current Limit

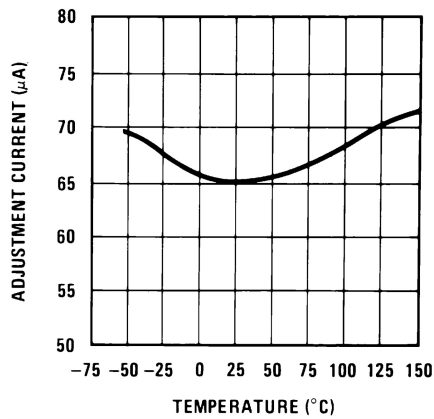


Figure 3. Adjustment Current

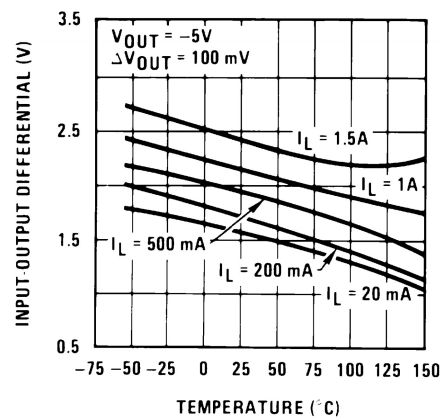


Figure 4. Dropout Voltage

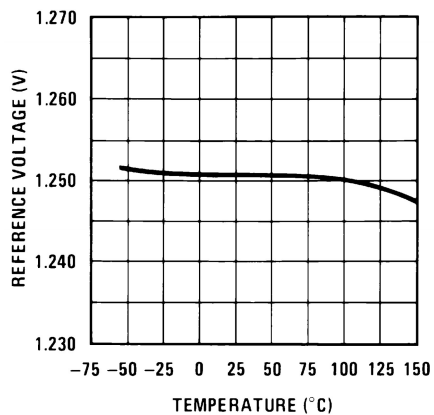


Figure 5. Temperature Stability

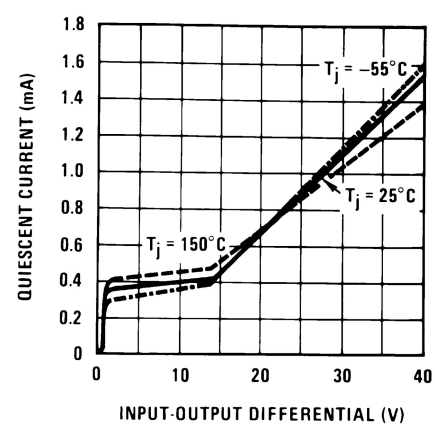


Figure 6. Minimum Operating Current

Typical Characteristics (continued)

(NDE Package)

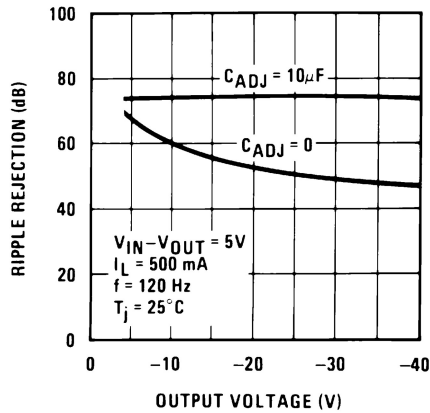


Figure 7. Ripple Rejection

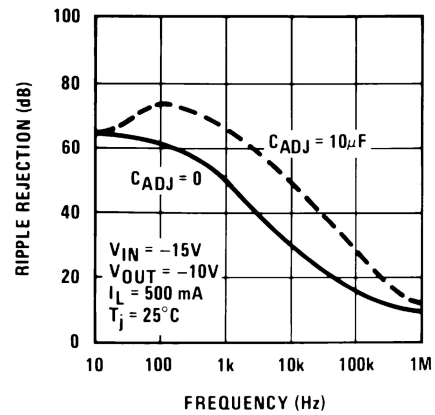


Figure 8. Ripple Rejection

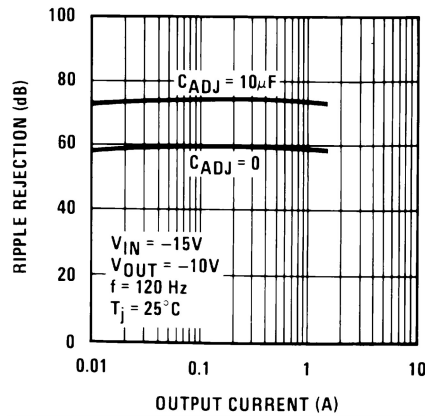


Figure 9. Ripple Rejection

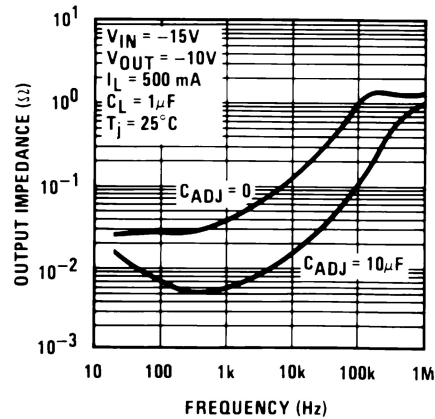


Figure 10. Output Impedance

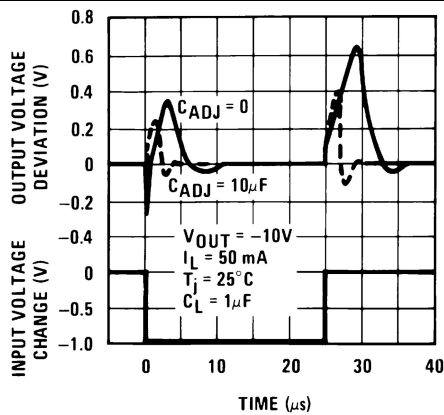


Figure 11. Line Transient Response

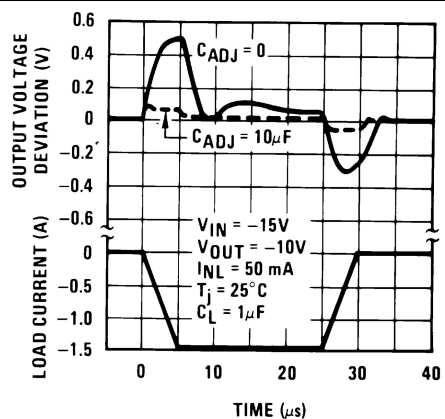


Figure 12. Load Transient Response

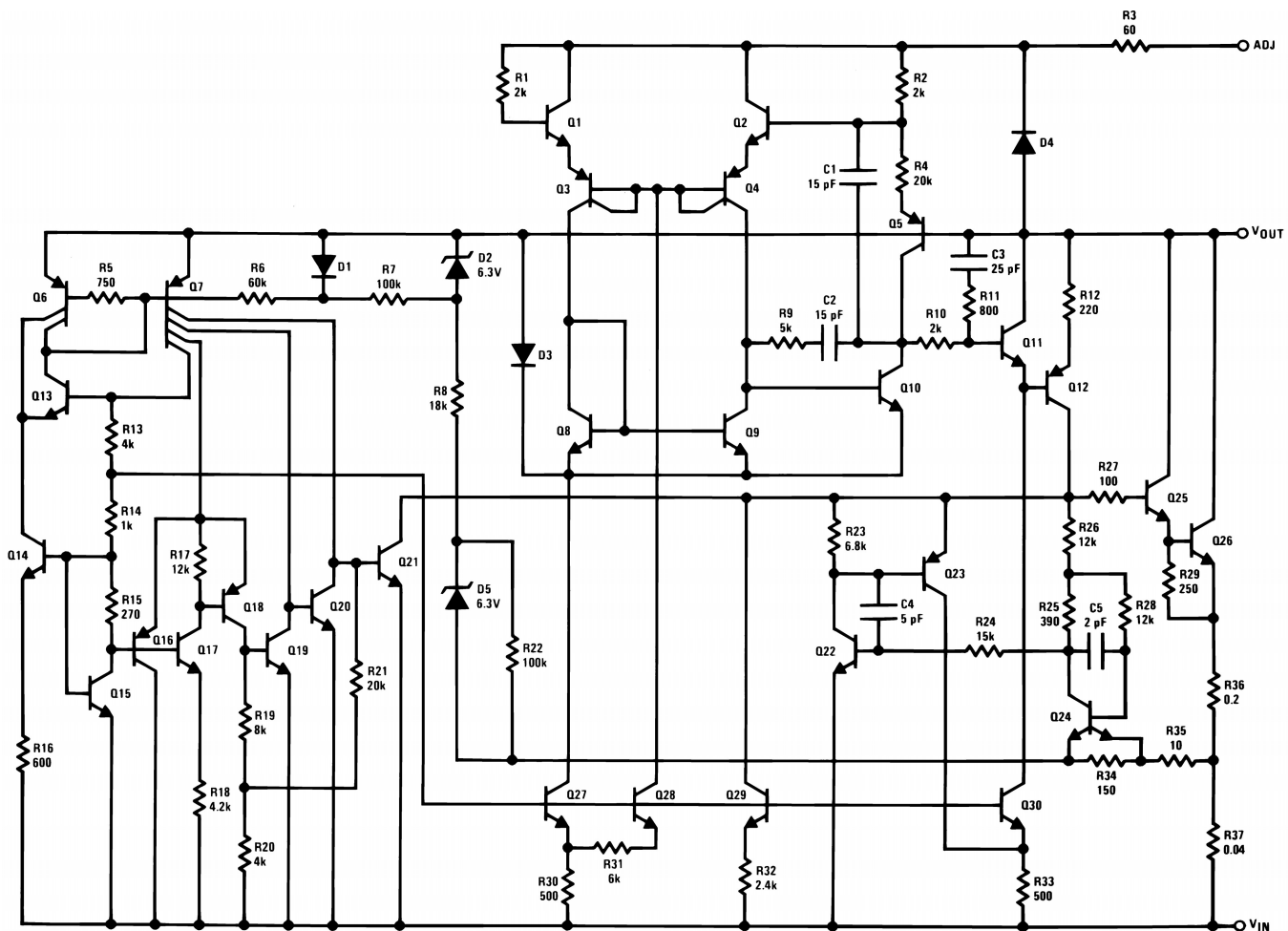
7 Detailed Description

7.1 Overview

In operation, the LM137 and LM337-N 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.

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

7.2 Functional Block Diagram

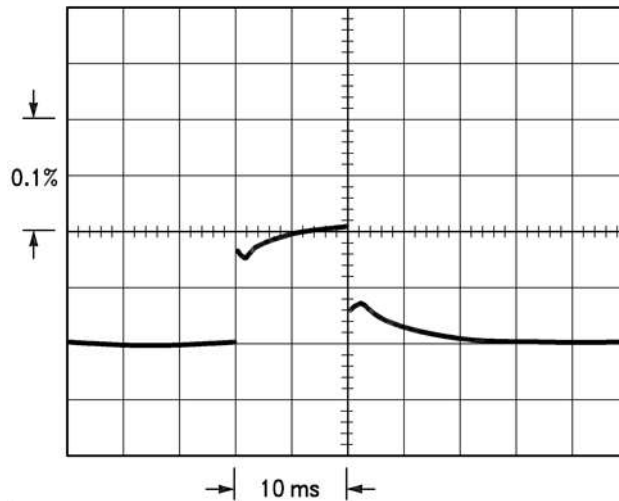


7.3 Feature Description

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. The LM137 device's specification is 0.02%/W, maximum.

Feature Description (continued)



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

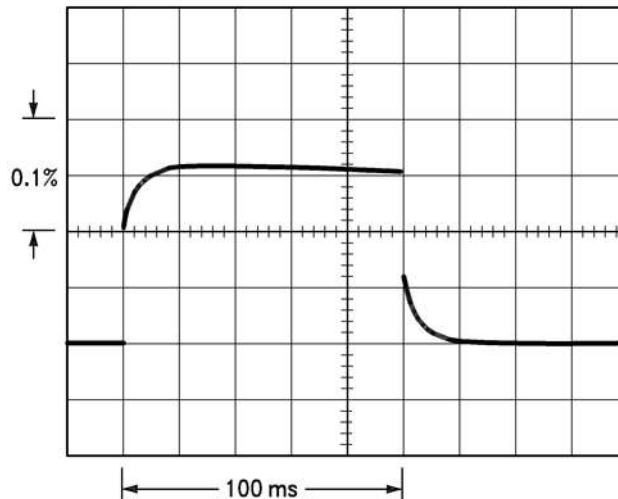
Figure 13. Output Drift (10W Pulse for 10ms)

In Figure 13, a typical LM137 device's output drifts only 3 mV (or 0.03% of $V_{OUT} = -10\text{ V}$) when a 10-W pulse is applied for 10 ms. This performance is thus well inside the specification limit of $0.02\%/W \times 10\text{ W} = 0.2\%$ maximum. When the 10-W pulse is ended, the thermal regulation again shows a 3-mV step at the LM137 chip cools off.

NOTE

The load regulation error of about 8 mV (0.08%) is additional to the thermal regulation error.

In Figure 14, when the 10-W 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).

Feature Description (continued)


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

Figure 14. Output Drift (10-W Pulse for 100 ms)

7.4 Device Functional Modes

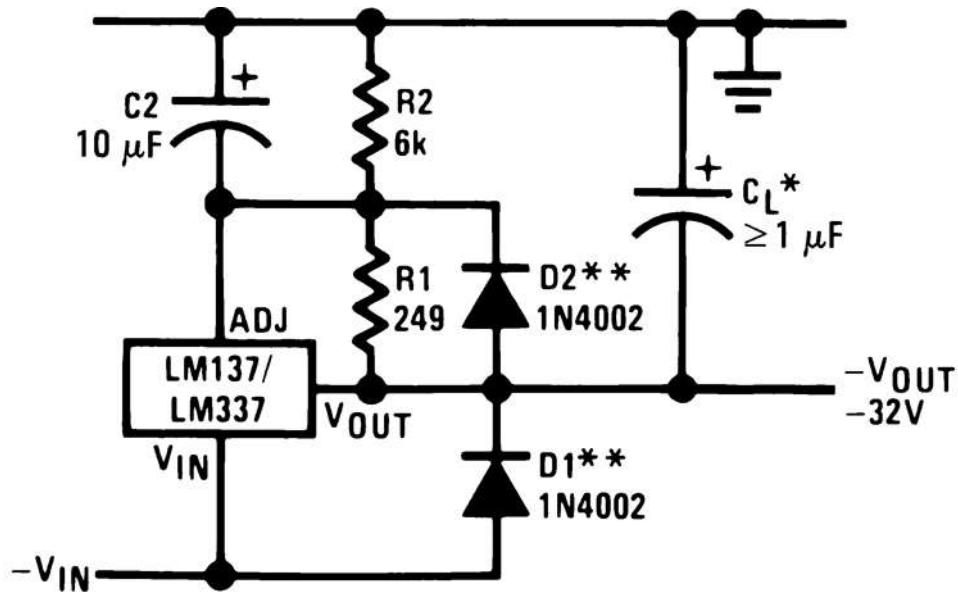
7.4.1 Protection Diodes

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 15](#) shows the placement of the protection diodes.

Device Functional Modes (continued)



*When C_L is larger than $20\ \mu\text{F}$, D1 protects the LM137 in case the input supply is shorted

**When C2 is larger than $10\ \mu\text{F}$ and $-V_{OUT}$ is larger than -25V , D2 protects the LM137 in case the output is shorted

Figure 15. 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.

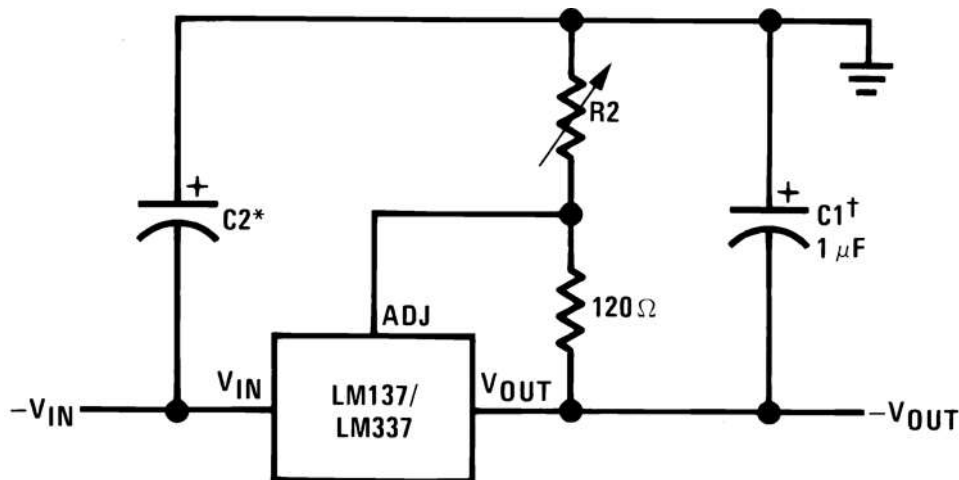
8.1 Application Information

The LM137 and LM337-N are versatile, high performance, negative output linear regulators 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 device's functionality 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 LM137 and LM337-N 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 16](#).



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 16. Adjustable Negative Voltage Regulator

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

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.

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 16](#).

Typical Applications (continued)

8.2.1.3 Application Curve

As shown in Figure 17, the maximum output current capability is limited by the input-output voltage differential, package type, and junction temperature.

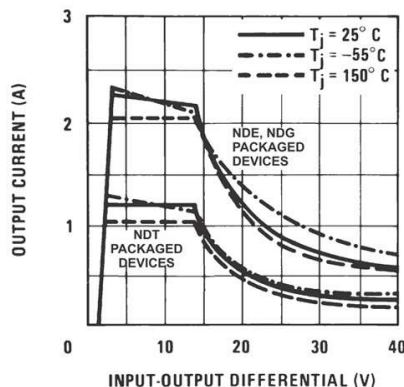
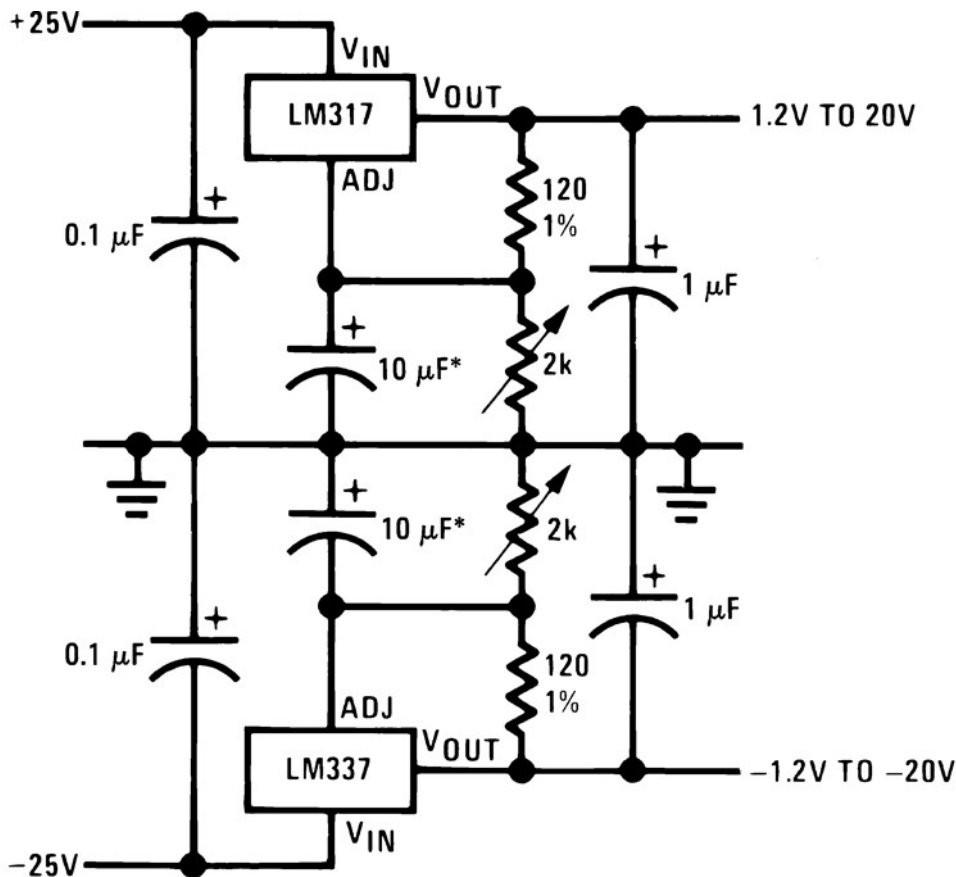


Figure 17. Current Limit

8.2.2 Adjustable Lab Voltage Regulator

The LM337-N 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.



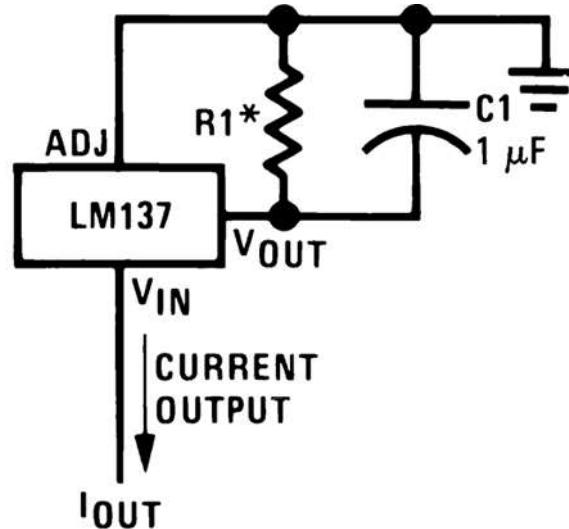
Full output current not available at high input-output voltages

*The 10 μF capacitors are optional to improve ripple rejection

Typical Applications (continued)

8.2.3 Current Regulator

A simple, fixed current regulator can be made by placing a resistor between the V_{OUT} and ADJ pins of the LM137. By regulating a constant 1.25 V between these two terminals, a constant current can be delivered.



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

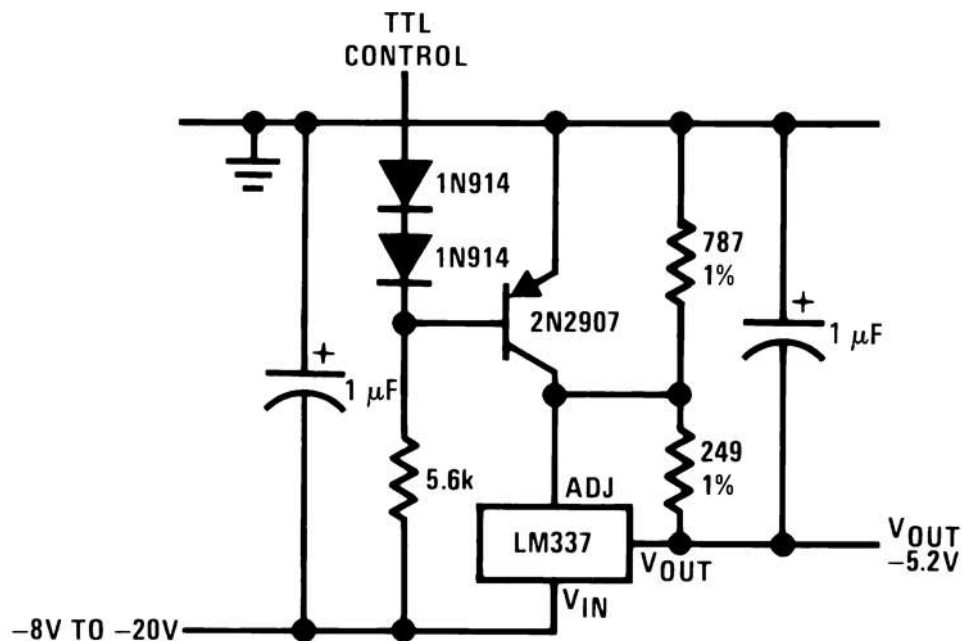
$$*0.8 \Omega \leq R1 \leq 120 \Omega$$

(3)

(4)

8.2.4 -5.2-V Regulator with Electronic Shutdown

The LM337-N 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 -1.3V. When ADJ is disconnected from GND by the PNP, then the LM337-N outputs the programmed output of -5.2 V.

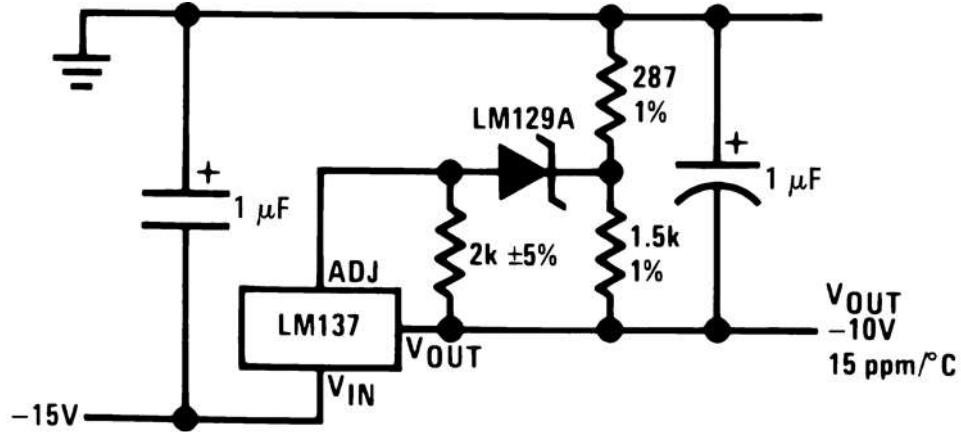


Minimum output ≈ -1.3 V when control input is low

Typical Applications (continued)

8.2.5 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 LM137 and LM337-N must be kept at a voltage level such that its 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 LM137 and LM337-N 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

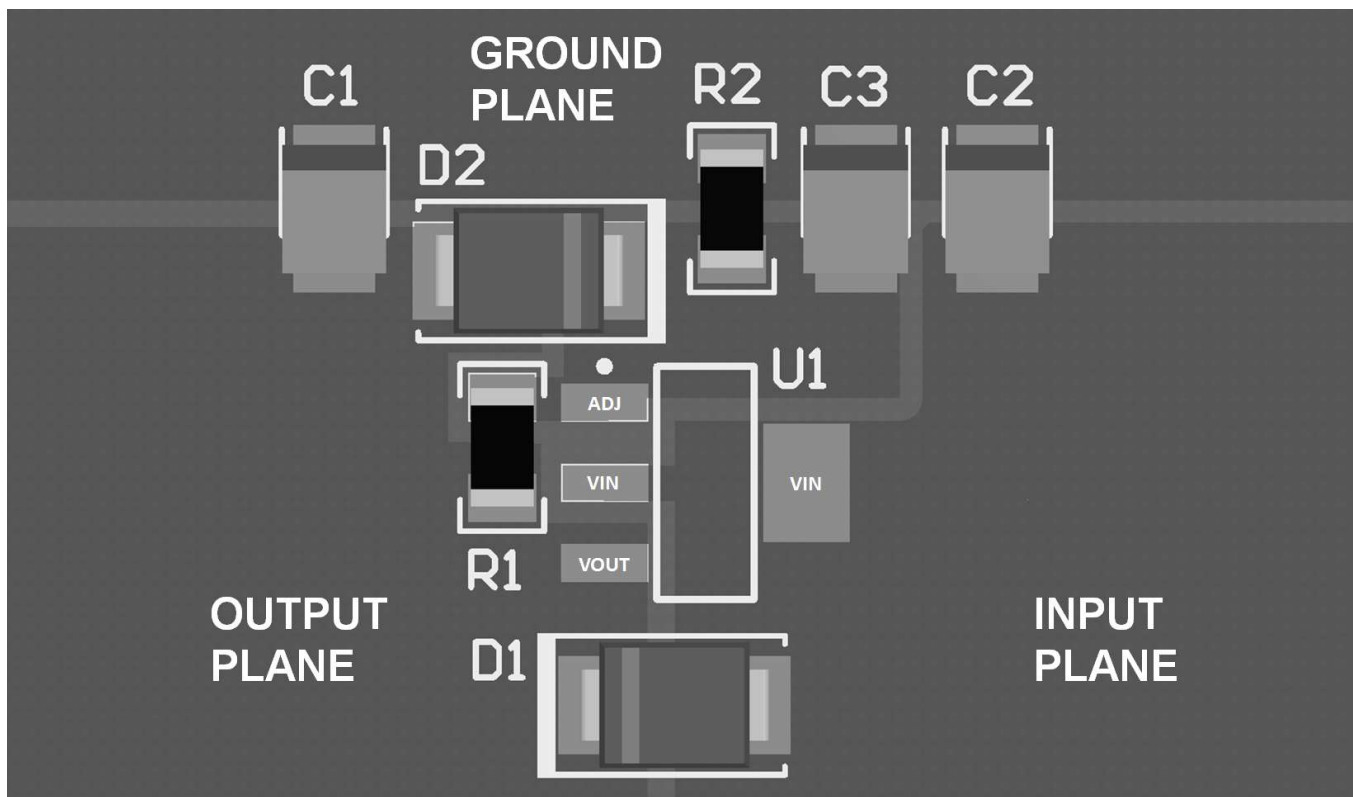


Figure 18. Layout Example (SOT-223)

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 19 and Figure 20 show the information for the SOT-223 package. Figure 20 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.

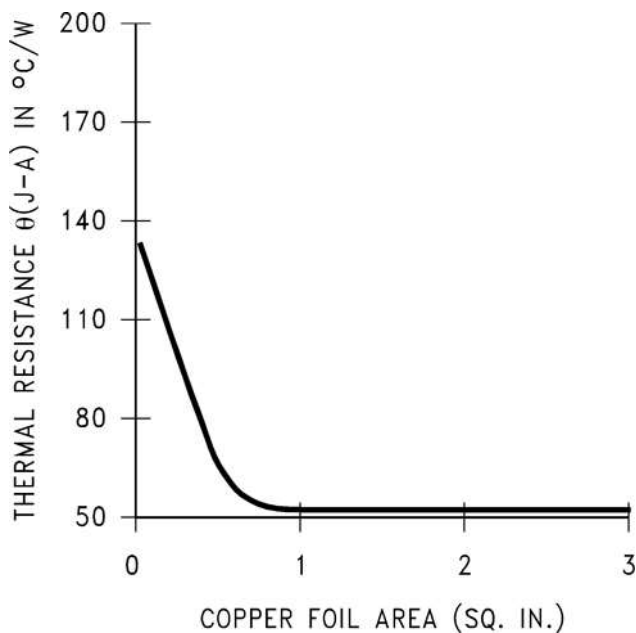


Figure 19. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

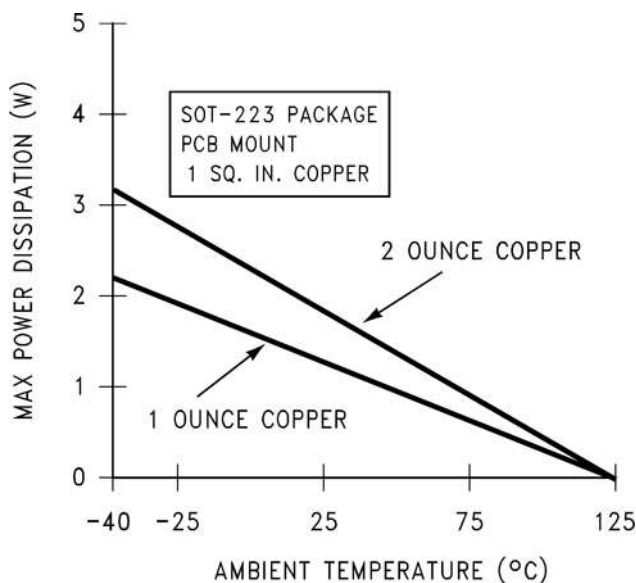


Figure 20. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

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 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LM137	Click here	Click here	Click here	Click here	Click here
LM337-N	Click here	Click here	Click here	Click here	Click here

11.3 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.

11.4 Trademarks

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

11.5 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.

11.6 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.