National Semiconductor

LM137/LM237/LM337 3-Terminal Adjustable Negative Regulators

General Description

The LM137/LM237/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/LM237/LM337 serve a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM137/LM237/LM337 are ideal complements to the LM117/LM217/LM317 adjustable positive regulators.

Features

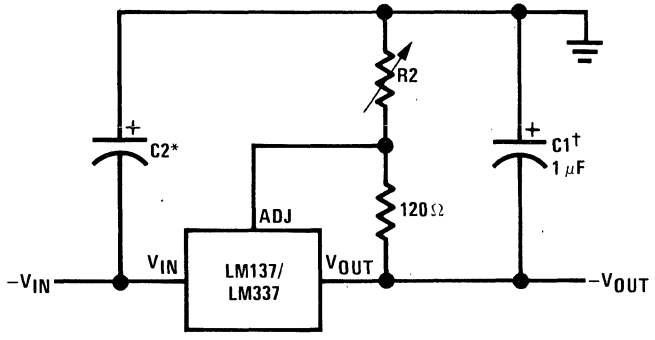
- Output voltage adjustable from −1.2V to −37V
- 1.5A output current guaranteed, −55°C to +150°C
- Line regulation typically 0.01%/V
- Load regulation typically 0.3%
- Excellent thermal regulation, 0.002%/W
- 77 dB ripple rejection
- Excellent rejection of thermal transients
- 50 ppm/°C temperature coefficient
- Temperature-independent current limit
- Internal thermal overload protection
- 100% electrical burn-in
- Standard 3-lead transistor package

LM137 Series Packages and Power Capability

DEVICE	PACKAGE	RATED POWER DISSIPATION	DESIGN LOAD CURRENT
LM137	TO-3	20W	1.5A
LM237 LM337	TO-39	2W	0.5A
LM337T	TO-220	15W	1.5A
LM337M	TO-202	7.5W	0.5A
LM337LZ	TO-92	0.62W	0.1A

Typical Applications

Adjustable Negative Voltage Regulator



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

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

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

Absolute Maximum Ratings

Power Dissipation	Internally limited
Input–Output Voltage Differential	40V
Operating Junction Temperature Range	
LM137	−55°C to +150°C
LM237	−25°C to +150°C
LM337	0°C to +125°C
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

Preconditioning

Burn-In in Thermal Limit — **100% All Devices**

Electrical Characteristics (Note 1)

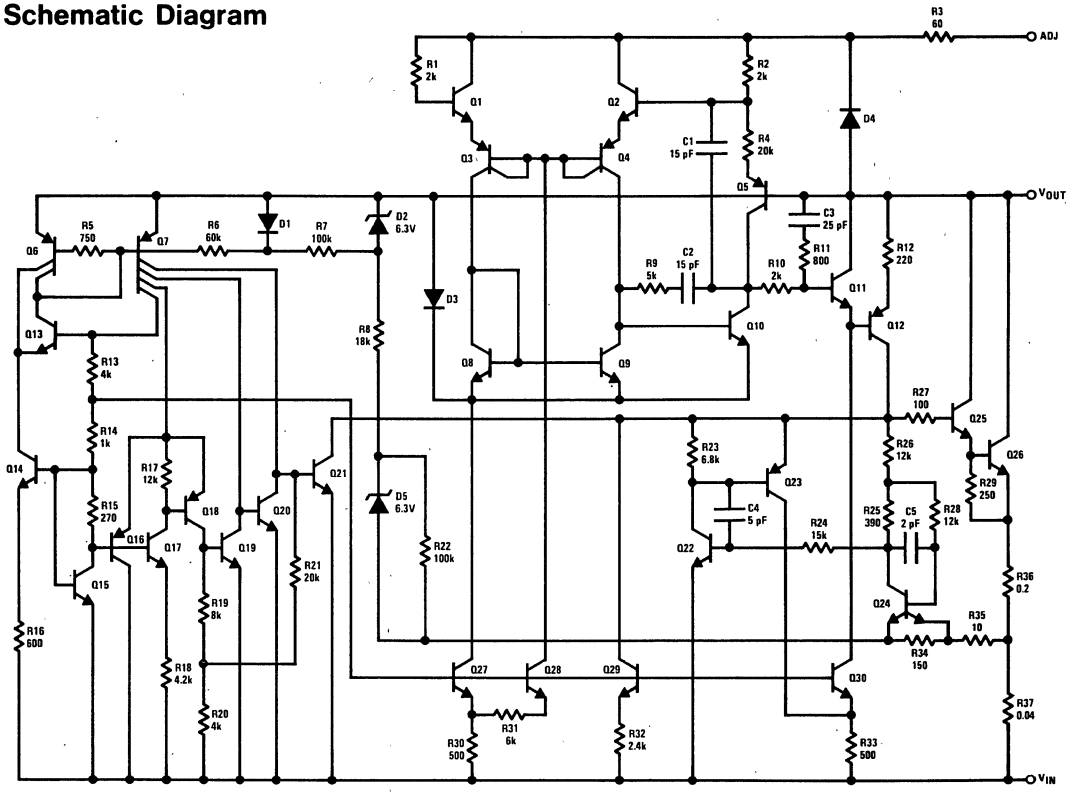
PARAMETER	CONDITIONS	LM137/LM237			LM337			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	$T_A = 25°C$, $3V \le \lvert V_{IN}-V_{OUT}\rvert \le 40V$ (Note 2)		0.01	0.02		0.01	0.04	%/V
Load Regulation	$T_A = 25°C$, $10\ mA \le I_{OUT} \le I_{MAX}$							
	$\lvert V_{OUT}\rvert \le 5V$, (Note 2)		15	25		15	50	mV
	$\lvert V_{OUT}\rvert \ge 5V$, (Note 2)		0.3	0.5		0.3	1.0	%
Thermal Regulation	$T_A = 25°C$, 10 ms Pulse		0.002	0.02		0.003	0.04	%/W
Adjustment Pin Current			65	100		65	100	μA
Adjustment Pin Current Change	$10\ mA \le I_L \le I_{MAX}$ $3.0V \le \lvert V_{IN}-V_{OUT}\rvert \le 40V$, $T_A = 25°C$		2	5		2	5	μA
Reference Voltage	$T_A = 25°C$ (Note 3)	−1.225	−1.250	−1.275	−1.213	−1.250	−1.287	V
	$3 \le \lvert V_{IN}-V_{OUT}\rvert \le 40V$, (Note 3)	−1.200	−1.250	−1.300	−1.200	−1.250	−1.300	V
	$10\ mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$							
Line Regulation	$3V \le \lvert V_{IN}-V_{OUT}\rvert \le 40V$, (Note 2)		0.02	0.05		0.02	0.07	%/V
Load Regulation	$10\ mA \le I_{OUT} \le I_{MAX}$, (Note 2)							
	$\lvert V_{OUT}\rvert \le 5V$		20	50		20	70	mV
	$\lvert V_{OUT}\rvert \ge 5V$		0.3	1		0.3	1.5	%
Temperature Stability	$T_{MIN} \le T_j \le T_{MAX}$		0.6			0.6		%
Minimum Load Current	$\lvert V_{IN}-V_{OUT}\rvert \le 40V$		2.5	5		2.5	10	mA
	$\lvert V_{IN}-V_{OUT}\rvert \le 10V$		1.2	3		1.5	6	mA
Current Limit	$\lvert V_{IN}-V_{OUT}\rvert \le 15V$							
	K and T Package	1.5	2.2		1.5	2.2		A
	H and P Package	0.5	0.8		0.5	0.8		A
	$\lvert V_{IN}-V_{OUT}\rvert = 40V$, $T_j = 25°C$							
	K and T Package	0.24	0.4		0.15	0.4		A
	H and P Package	0.15	0.17		0.10	0.17		A
RMS Output Noise, % of V_{OUT}	$T_A = 25°C$, $10\ Hz \le f \le 10\ kHz$		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	$T_A = 125°C$, 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
	P Package					12		°C/W

Note 1: Unless otherwise specified, these specifications apply $-55°C \le T_j \le +150°C$ for the LM137, $-25°C \le T_j \le +150°C$ for the LM237, $0°C \le T_j \le +125°C$ for the LM337; $V_{IN} - V_{OUT} = 5V$; and $I_{OUT} = 0.1A$ for the TO-39 and TO-202 packages and $I_{OUT} = 0.5A$ for the TO-3 and TO-220 packages. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO-39 and TO-202 and 20W for the TO-3 and TO-220. I_{MAX} is 1.5A for the TO-3 and TO-220 packages, and 0.5A for the TO-202 package 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 1/8" below the base of the TO-3 and TO-39 packages.

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

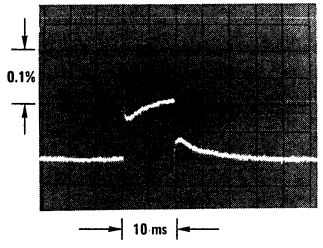
Schematic Diagram



Thermal Regulation

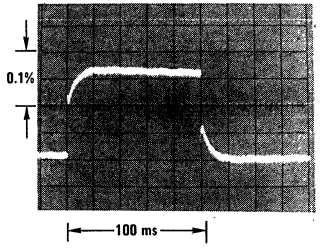
When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large. Thermal regulation is the effect of these temperature gradients on output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

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 as 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).



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

FIGURE 1

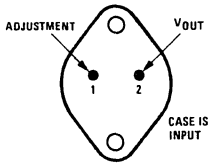


LM137, V_{OUT} = −10V
V_{IN}−V_{OUT} = −40V
I_L = 0A → 0.25A → 0A
Horizontal sensitivity, 20 ms/div

FIGURE 2

Connection Diagrams

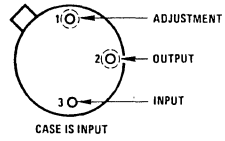
TO-3
Metal Can Package



BOTTOM VIEW

Order Number:
LM137K STEEL
LM237K STEEL
LM337K STEEL
See Package K02A

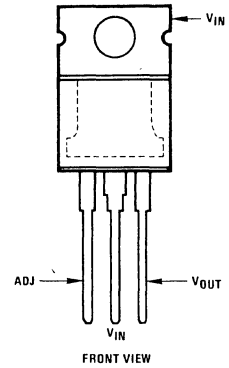
TO-39
Metal Can Package



BOTTOM VIEW

Order Number:
LM137H
LM237H
LM337H
See Package H03B

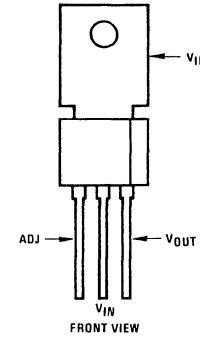
TO-220
Plastic Package



FRONT VIEW

Order Number:
LM337T
See Package T03B

TO-202
Plastic Package



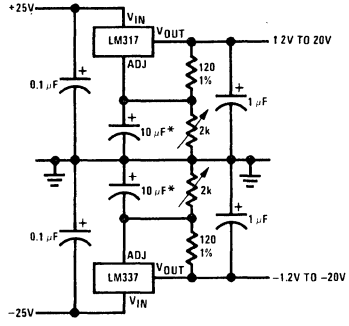
FRONT VIEW

Order Number:
LM337MP
See Package P03A

For Tab Bend TO-202
Order Number:
LM337MP
See Package P03E

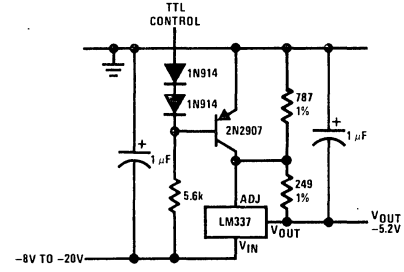
Typical Applications (Continued)

Adjustable Lab Voltage Regulator



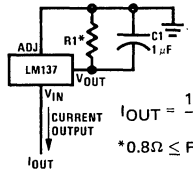
*The 10 μF capacitors are optional to improve ripple rejection

-5.2V Regulator with Electronic Shutdown*



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

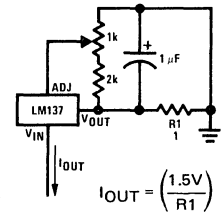
Current Regulator



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

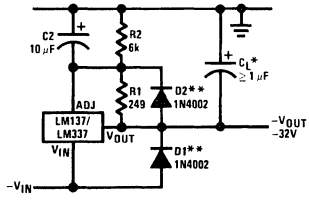
*0.8Ω ≤ R1 ≤ 120Ω

Adjustable Current Regulator



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

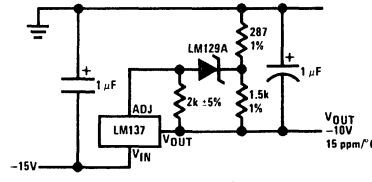
Negative Regulator with Protection Diodes



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

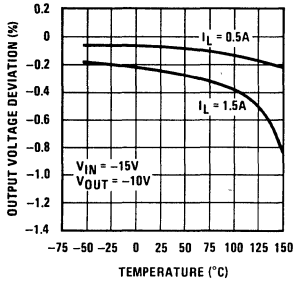
**When C2 is larger than 10 μF and $-V_{OUT}$ is larger than −25V, D2 protects the LM137 in case the output is shorted

High Stability −10V Regulator

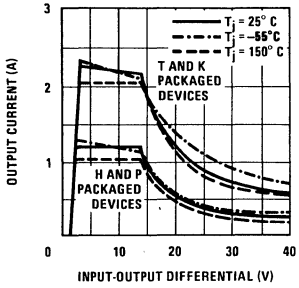


Typical Performance Characteristics (K Steel and T Packages)

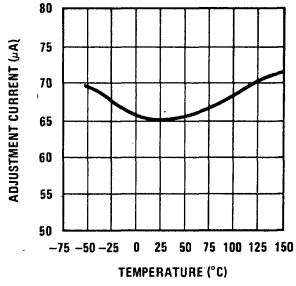
Load Regulation



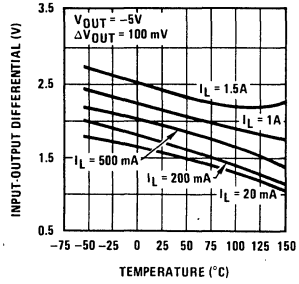
Current Limit



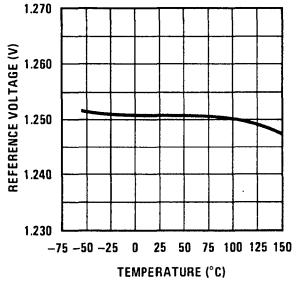
Adjustment Current



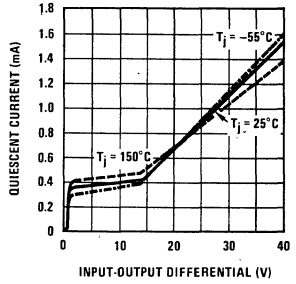
Dropout Voltage



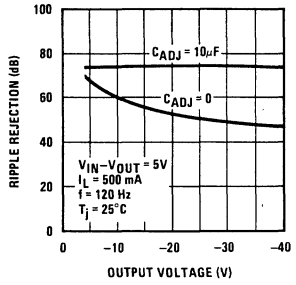
Temperature Stability



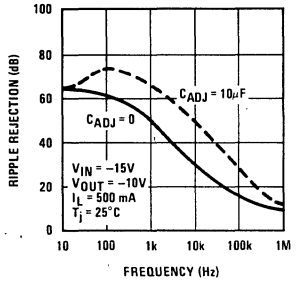
Minimum Operating Current



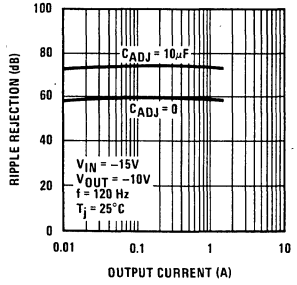
Ripple Rejection



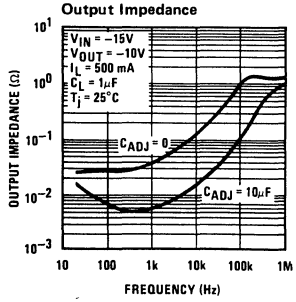
Ripple Rejection



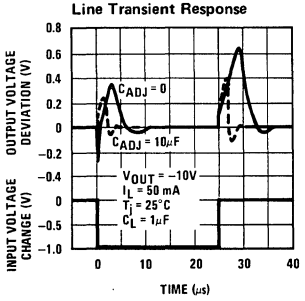
Ripple Rejection



Output Impedance



Line Transient Response



Load Transient Response