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MOTOROLA

LM337M

Three-Terminal Adjustable Output Negative Voltage Regulator

MEDIUM CURRENT THREE–TERMINAL ADJUSTABLE NEGATIVE VOLTAGE REGULATOR

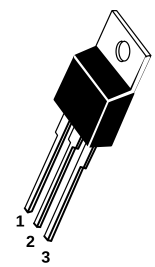
SEMICONDUCTOR TECHNICAL DATA

The LM337M is an adjustable three–terminal negative voltage regulator capable of supplying in excess of 500 mA over an output voltage range of –1.2 V to –37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow–out proof.

The LM337M serves a wide variety of applications including local, on–card regulation. This device can also be used to make a programmable output regulator or by connecting a fixed resistor between the adjustment and output. The LM337M can be used as a precision current regulator.

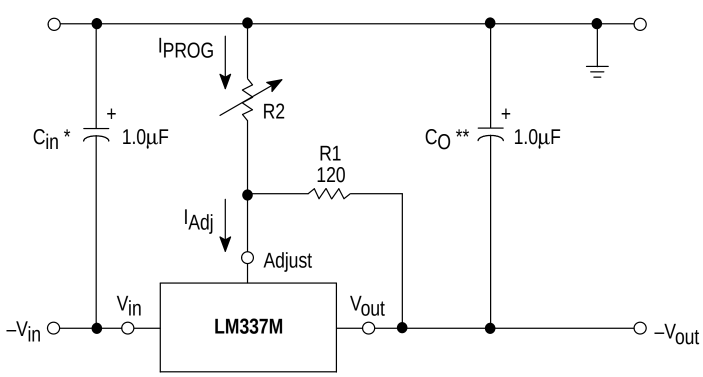
- Output Current in Excess of 500 mA
- Output Adjustable Between –1.2 V and –37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe–Area Compensation
- Floating Operation for High Voltage Applications
- Standard 3–Lead Transistor Packages
- Eliminates Stocking Many Fixed Voltages

T SUFFIX
PLASTIC PACKAGE
CASE 221A



Pin 1. Adjust
2. V_{in}
3. V_{out}

Standard Application



*C_{in} is required if regulator is located more than 4″ from power supply filter. A 1.0 µF solid tantalum or 10 µF aluminum electrolytic is recommended.
**C_O is necessary for stability. A 1.0 µF solid tantalum or 10 µF aluminum electrolytic is recommeded.

$$V_{out} = -1.25\ V\left(1 + \frac{R2}{R1}\right)$$

ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM337MT	T_J = 0° to +125°C	Plastic Power

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input–Output Voltage Differential	$V_I – V_O$	40	Vdc
Power Dissipation	P_D	Internally Limited	W
Operating Junction Temperature Range	T_J	0 to +125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

ELECTRICAL CHARACTERISTICS ($|V_I – V_O|$ = 5.0 V, I_O = 0.1; $T_J = T_{low}$ to T_{high} [Note 1], P_{max} per Note 2, unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit
Line Regulation (Note 3) T_A = 25°C, 3.0 V ≤ $\|V_I – V_O\|$ ≤ 40 V	1	Reg_{line}	–	0.01	0.04	%/V
Load Regulation (Note 3) T_A = 25°C, 10 mA ≤ I_O ≤ 0.5 A $\|V_O\|$ ≤ 5.0V $\|V_O\|$ ≥ 5.0V	2	Reg_{load}	 – –	 15 0.3	 15 1.0	 mV %/V_O
Thermal Regulation 10 ms Pulse, T_A = 25°C	–	Reg_{therm}	–	0.03	0.04	% V_O/W
Adjustment Pin Current	3	I_{Adj}	–	65	100	µA
Adjustment Pin Current Change 2.5 V ≤ $\|V_I – V_O\|$ ≤ 40 V, 10 mA ≤ I_L ≤ 0.5 A, P_D ≤ P_{max}, T_A = 25°C	1, 2	ΔI_{Adj}	–	2.0	5.0	µA
Reference Voltage 3.0 V ≤ $\|V_I – V_O\|$ ≤ 40 V, 10 mA ≤ I_O ≤ 0.5 A, P_D ≤ P_{max}, T_A = 25°C T_{low} to T_{high}	3	V_{ref}	 –1.213 –1.20	 –1.250 –1.25	 –1.287 –1.30	V
Line Regulation (Note 3) 3.0 V ≤ $\|V_I – V_O\|$ ≤ 40 V	1	Reg_{line}	–	0.02	0.07	%/V
Load Regulation (Note 3) 10 mA ≤ I_O ≤ 0.5 A $\|V_O\|$ ≤ 5.0 V $\|V_O\|$ ≥ 5.0 V	2	Reg_{load}	 – –	 20 0.3	 70 1.5	 mV %/V_O
Temperature Stability (T_{low} ≤ T_J ≤ T_{high})	3	T_S	–	0.6	–	%/V_O
Minimum Load Current to Maintain Regulation ($\|V_I – V_O\|$ ≤ 10 V) ($\|V_I – V_O\|$ ≤ 40 V)	3	I_{Lmin}	 – –	 1.5 2.5	 6.0 10	mA
Maximum Output Current $\|V_I – V_O\|$ ≤ 15 V, P_D ≤ P_{max} $\|V_I – V_O\|$ ≤ 40 V, P_D ≤ P_{max}, T_J = 25°C	3	I_{max}	 0.5 0.1	 0.9 0.25	 – –	A
RMS Noise, % of V_O T_A = 25°C, 10 Hz ≤ f ≤ 10 kHz	–	N	–	0.003	–	%/V_O
Ripple Rejection, V_O = –10 V, f = 120 Hz (Note 4) Without C_{Adj} C_{Adj} = 10 µF	4	RR	 – 66	 60 77	 – –	dB
Long Term Stability, $T_J = T_{high}$ (Note 5) T_A = 25°C for Endpoint Measurements	3	S	–	0.3	1.0	%/1.0 k Hrs
Thermal Resistance, Junction–to–Case	–	$R_{\Theta JC}$	–	7.0	–	°C/W

NOTES: 1. T_{low} to T_{high} = 0° to +125°C
2. P_{max} = 7.5 W
3 Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
4. C_{Adj}, when used, is connected between the adjustment pin and ground.
5. Since Long Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.

Schematic Diagram

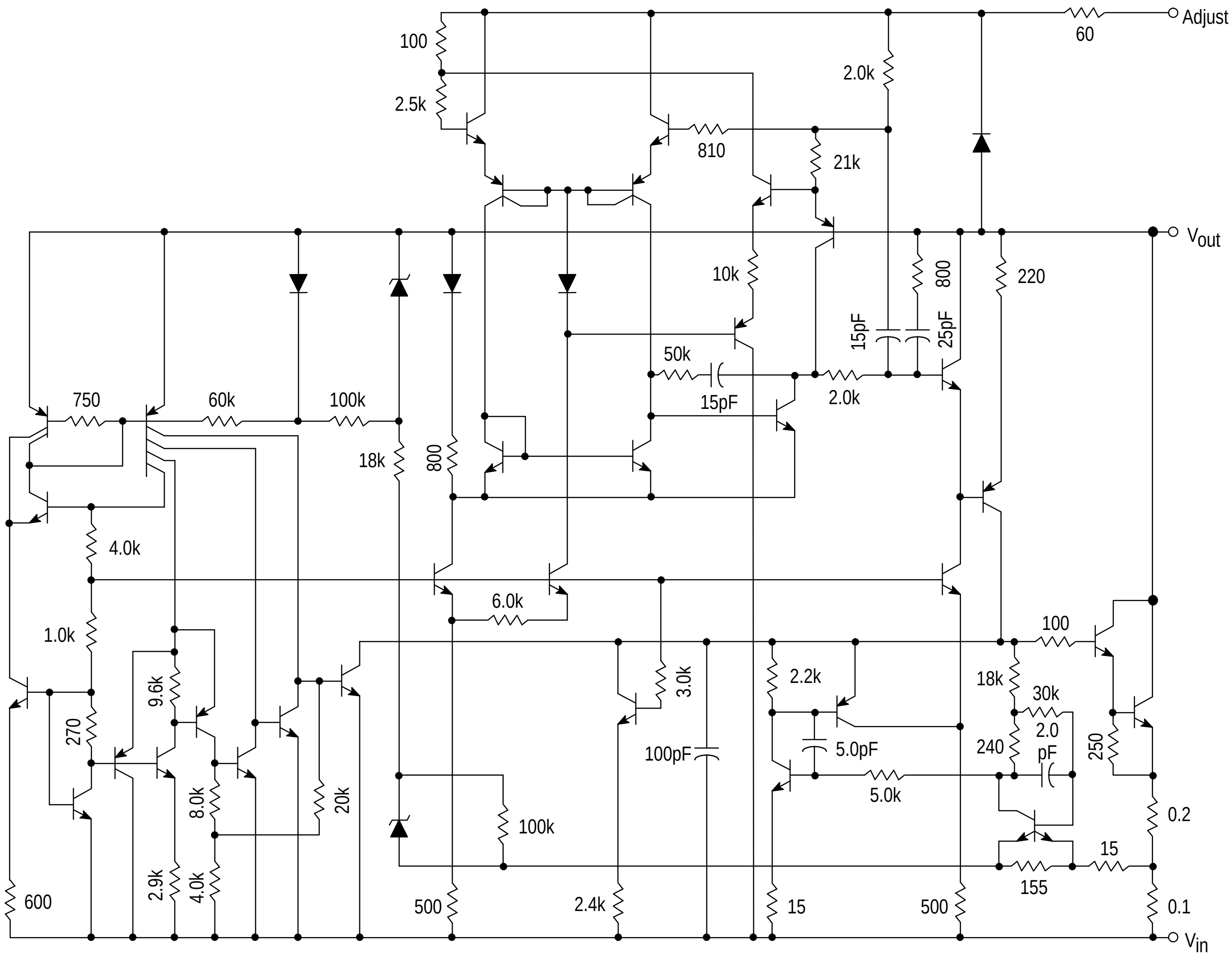


Figure 1. Line Regulation and ΔI_{Adj}/Line Test Circuit

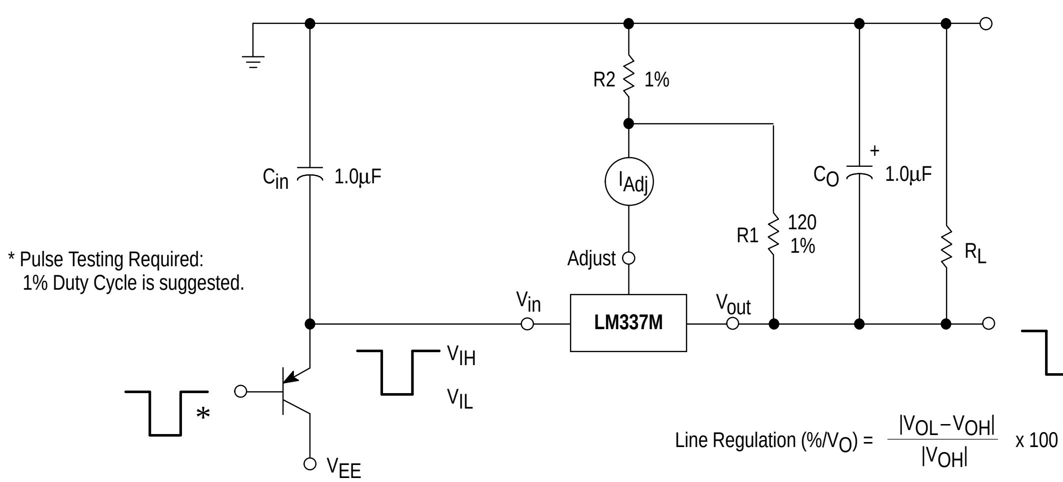
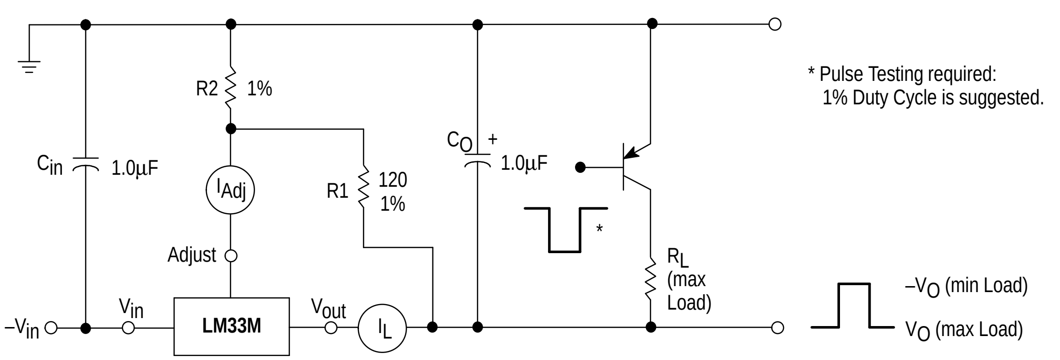


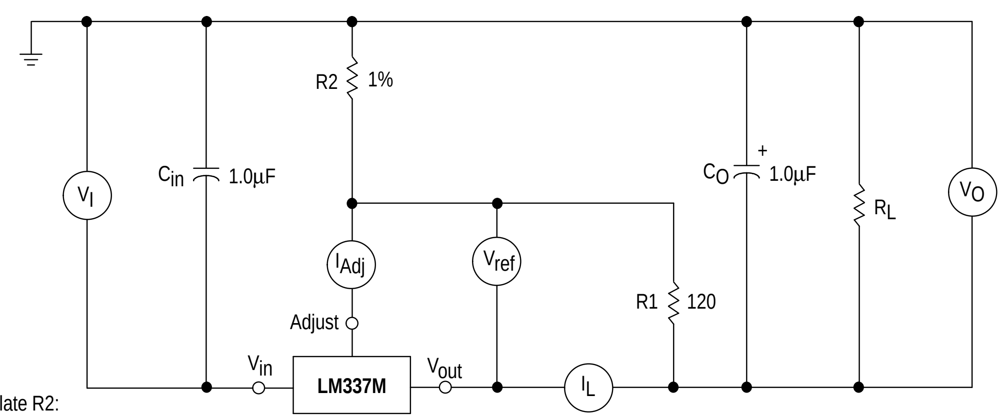
Figure 2. Load Regulation and ΔI_{Adj}/Load Test Circuit



Load Regulation (mV) = V_O (min Load) – V_O (max Load)

$$\text{Load Regulation } (\%/V_O) = \frac{V_O \text{ (min Load)} - V_O \text{(max Load)}}{V_O \text{ (min Load)}} \times 100$$

Figure 3. Standard Test Circuit



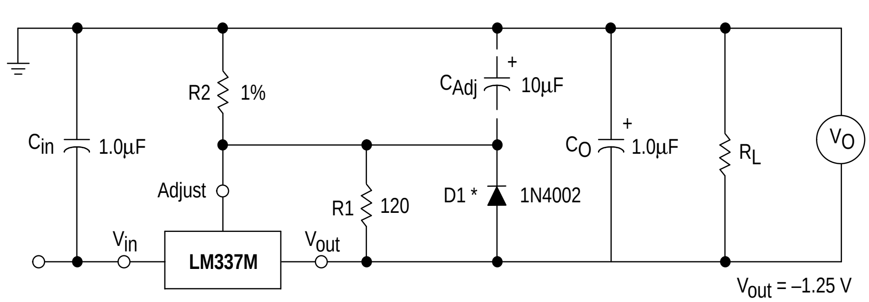
To Calculate R2:

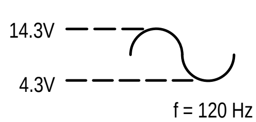
$$R2 = \left(\frac{V_O}{V_{ref}} - 1\right) R_1$$

This assumes I_{Adj} is negligible.

Pulse Testing Required: 1% Duty Cycle is suggested.

Figure 4. Ripple Rejection Test Circuit





*D_1 Discharges C_{Adj} if Output is shorted to Ground.

Figure 5. Load Regulation

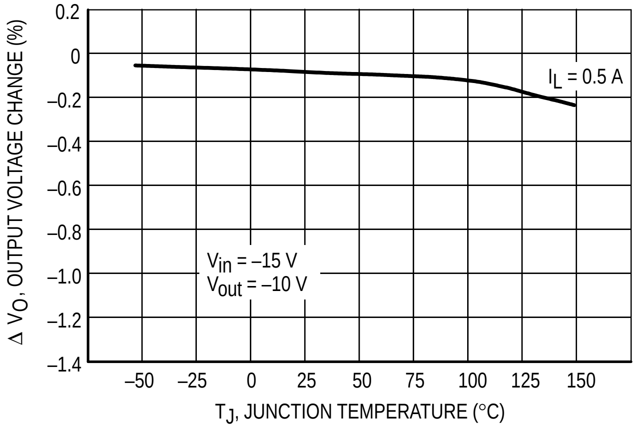


Figure 6. Current Limit

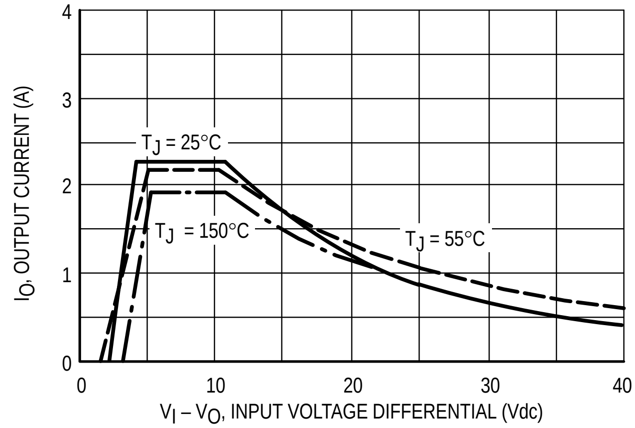


Figure 7. Adjustment Pin Current

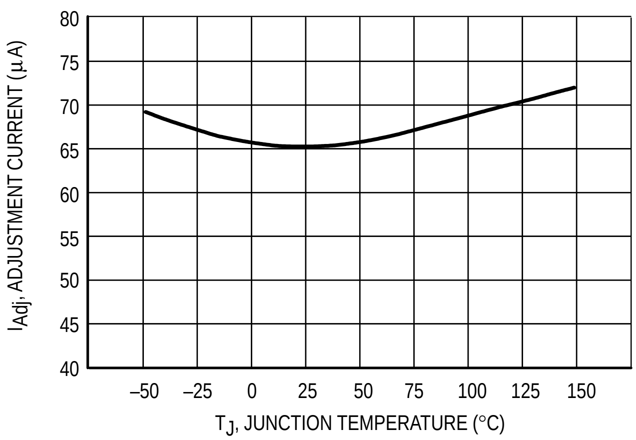


Figure 8. Dropout Voltage

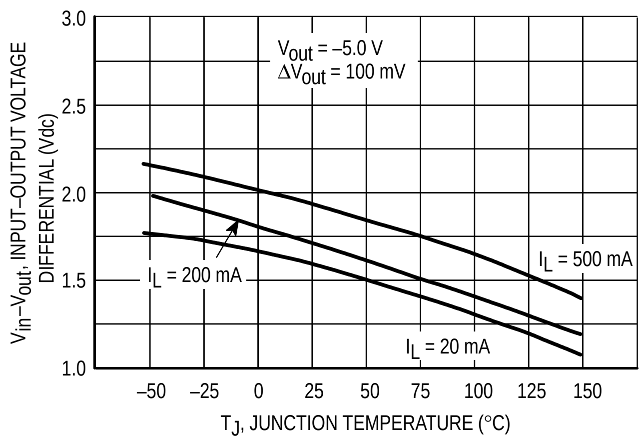


Figure 9. Temperature Stability

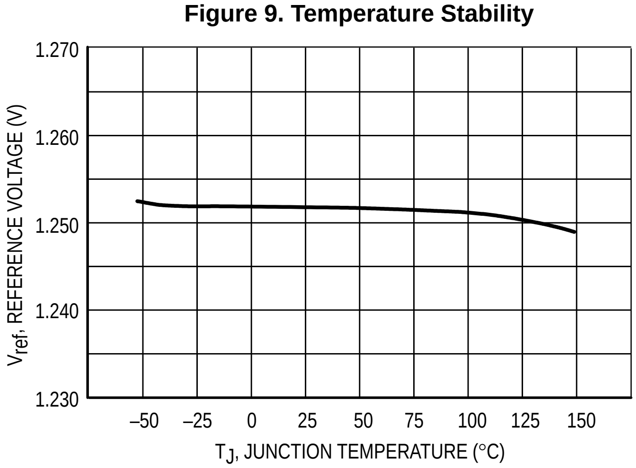


Figure 10. Minimum Operating Current

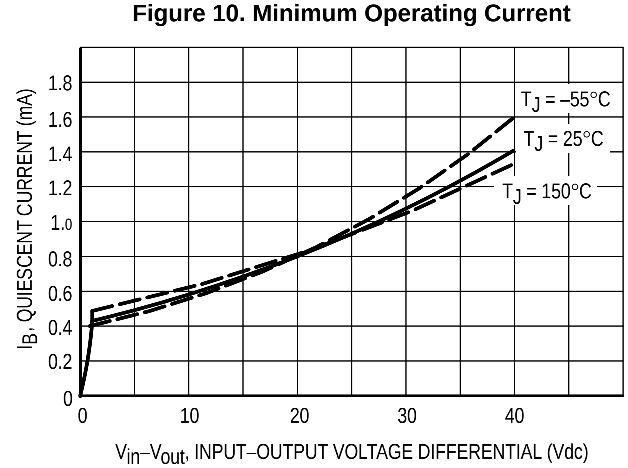


Figure 11. Ripple Rejection versus Output Voltage

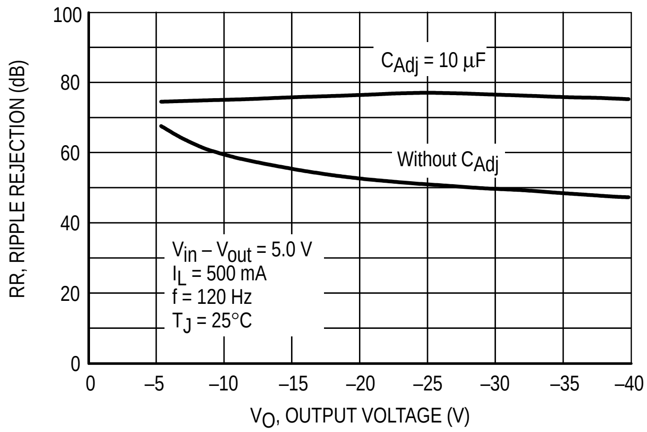


Figure 12. Ripple Rejection versus Output Current

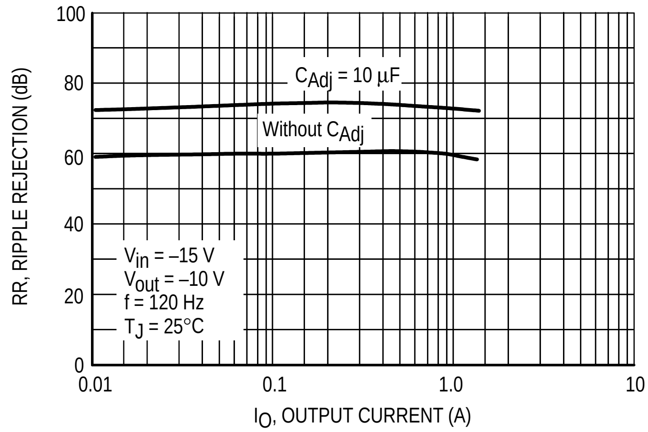


Figure 13. Ripple Rejection versus Frequency

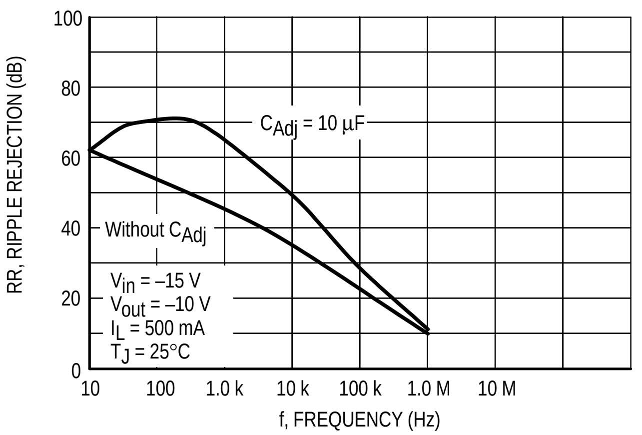


Figure 14. Output Impedance

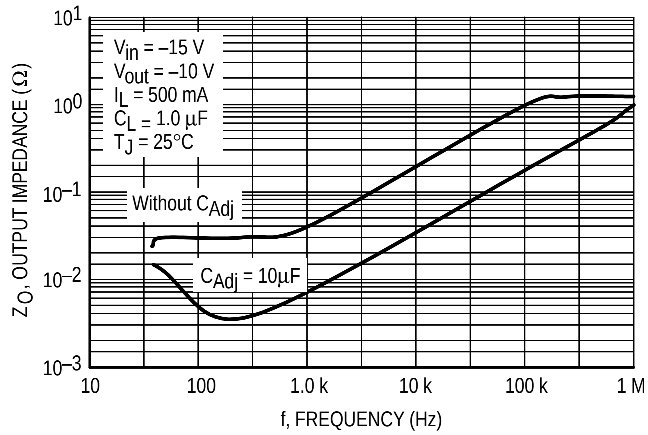


Figure 15. Line Transient Response

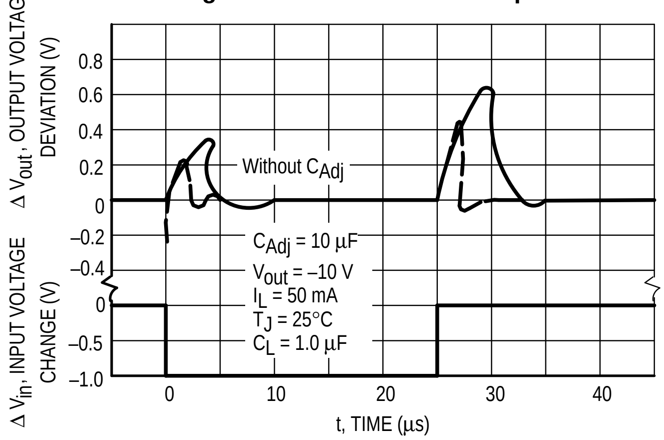
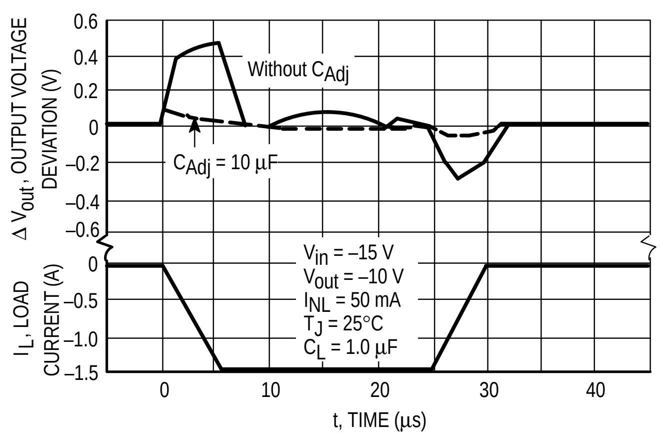


Figure 16. Load Transient Reponse



APPLICATIONS INFORMATION

Basic Circuit Operation

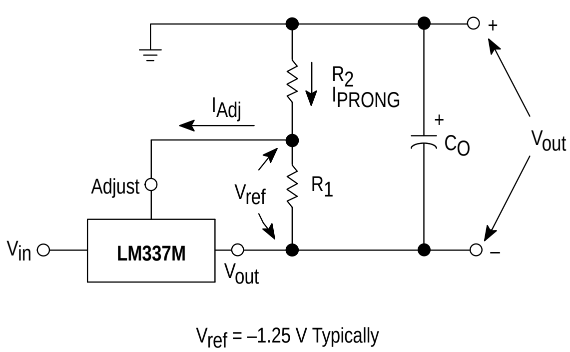
The LM337M is a three–terminal floating regulator. In operation, the LM337M develops and maintains a nominal –1.25 V reference (V_{ref}) between its output and adjustment terminals. This reference voltage is converted to a programming current (I_{PROG}) by R_1 (see Figure 17), and this constant current flows through R_2 to ground. The regulated output voltage is given by:

$$V_{out} = V_{ref}\,(1 + \frac{R_2}{R_1}) + I_{Adj}\,R_2$$

Since the current into the adjustment terminal (I_{Adj}) represents an error term in the equation, the LM337M was designed to control I_{Adj} to less than 100 µA and keep it constant. To do this, all quiescent operating current is returned to the output terminal. This imposes the requirement for a minimum load current. If the load current is less than this minimum, the output voltage will rise.

Since the LM337M is a floating regulator, it is only the voltage differential across the circuit which is important to performance, and operation at high voltages with respect to ground is possible.

Figure 17. Basic Circuit Configuration



Load Regulation

The LM337M is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor (R_1) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of R_2 can be returned near the load ground to provide remote ground sensing and improve load regulation.

External Capacitors

A 1.0 µF tantalum input bypass capacitor (C_{in}) is recommended to reduce the sensitivity to input line impedance.

The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor (C_{Adj}) prevents ripple from being amplified as the output voltage is increased. A 10 µF capacitor should improve ripple rejection about 15 dB at 120 Hz in a 10 V application.

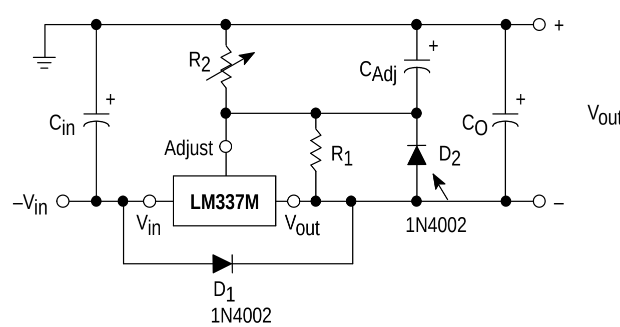
An output capacitance (C_O) in the form of a 1.0 µF tantalum or 10 µF aluminum electrolytic capacitor is required for stability.

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.

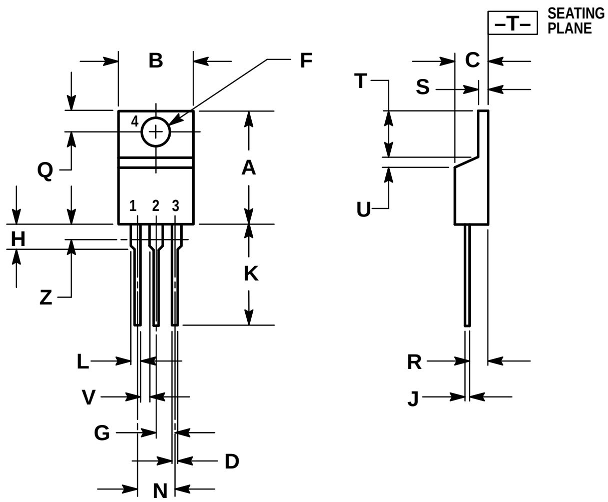
Figure 18 shows the LM337M with the recommended protection diodes for output voltages in excess of –25 V or high capacitance values (C_O > 25 µF, C_{Adj} > 10 µF). Diode D_1 prevents C_O from discharging thru the IC during an input short circuit. Diode D_2 protects against capacitor C_{Adj} discharging through the IC during an output short circuit. The combination of diodes D_1 and D_2 prevents C_{Adj} from discharging through the IC during an input short circuit.

Figure 18. Voltage Regulator with Protection Diodes



OUTLINE DIMENSIONS

T SUFFIX
PLASTIC PACKAGE
CASE 221A–06
ISSUE Y



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	—	1.15	—
Z	—	0.080	—	2.04

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