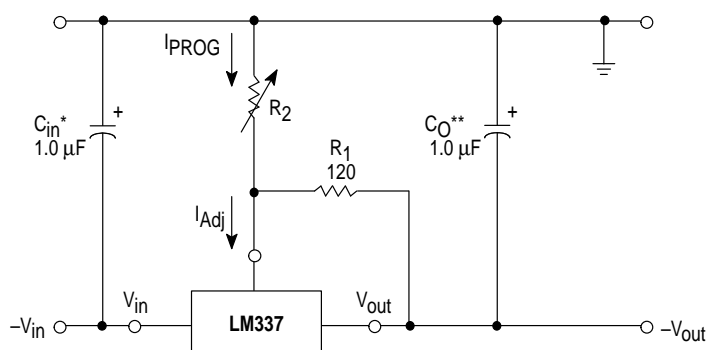**MOTOROLA**

Three-Terminal Adjustable Output Negative Voltage Regulator

The LM337 is an adjustable 3–terminal negative voltage regulator capable of supplying in excess of 1.5 A 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 LM337 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 LM337 can be used as a precision current regulator.

- Output Current in Excess of 1.5 A
- Output Adjustable between −1.2 V and −37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe–Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking many Fixed Voltages
- Available in Surface Mount D^{2}PAK and Standard 3–Lead Transistor Package

LM337

THREE–TERMINAL ADJUSTABLE NEGATIVE VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface connected to Pin 2.

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

D2T SUFFIX
PLASTIC PACKAGE
CASE 936
(D^{2}PAK)

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.

Standard Application

C_{in}* 1.0 μF

I_{PROG}

R_2

R_1 120

I_{Adj}

C_O** 1.0 μF

V_{in}

LM337

V_{out}

−V_{in}

−V_{out}

*C_{in} is required if regulator is located more than 4 inches 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 recommended.

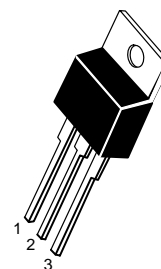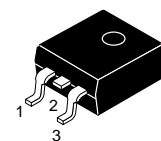$$V_{out} = -1.25 \text{ V} \left(1 + \frac{R_2}{R_1} \right)$$

ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM337BD2T	$T_J = -40°$ to +125°C	Surface Mount
LM337BT		Insertion Mount
LM337D2T	$T_J = 0°$ to +125°C	Surface Mount
LM337T		Insertion Mount

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Rev 1

LM337

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input–Output Voltage Differential	V_I–V_O	40	Vdc

Power Dissipation
Case 221A
   T_A = +25°C
   Thermal Resistance, Junction–to–Ambient
   Thermal Resistance, Junction–to–Case
Case 936 (D^2PAK)
   T_A = +25°C
   Thermal Resistance, Junction–to–Ambient
   Thermal Resistance, Junction–to–Case
	
	P_D
	θ_{JA}
	θ_{JC}
	
	P_D
	θ_{JA}
	θ_{JC}
		
		Internally Limited
		65
		5.0
		
		Internally Limited
		70
		5.0
			
			W
			°C/W
			°C/W
			
			W
			°C/W
			°C/W

Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($|V_I$–$V_O|$ = 5.0 V; I_O = 0.5 A for T package; T_J = T_{low} to T_{high} [Note 1]; I_{max} and P_{max} [Note 2].)

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 ≤ I_{max}
  $|V_O|$ ≤ 5.0 V
  $|V_O|$ ≥ 5.0 V
	2	Reg_{load}	
			
			–
			–
				
				15
				0.3
					
					50
					1.0
						
						mV
						% V_O

Thermal Regulation, T_A = +25°C (Note 6), 10 ms Pulse		Reg_{therm}	–	0.003	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 ≤ I_{max}, P_D ≤ P_{max}, T_A = +25°C	1, 2	ΔI_{Adj}	–	2.0	5.0	µA
Reference Voltage, T_A = +25°C, 3.0 V ≤ $|V_I$–$V_O|$ ≤ 40 V, 10 mA ≤ I_O ≤ I_{max}, P_D ≤ P_{max}, T_J = 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 ≤ I_{max}
  $|V_O|$ ≤ 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}, T Package
  $|V_I$–$V_O|$ ≤ 40 V, P_D ≤ P_{max}, T_J = +25°C, T Package
	3	I_{max}	
			
			–
			–
				
				1.5
				0.15
					
					2.2
					0.4
						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, T Package		$R_{\theta JC}$	–	4.0	–	°C/W

NOTES: 1. T_{low} to T_{high} = 0° to +125°C, for LM337T, D2T. T_{low} to T_{high} = −40° to +125°C, for LM337BT, BD2T.
    2. I_{max} = 1.5 A, P_{max} = 20 W
    3. Load and line regulation are specified at constant junction temperature. Change in V_O because of heating effects is covered under the Thermal Regulation specification. Pulse testing with a 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.
    6. Power dissipation within an IC voltage regulator produces a temperature gradient on the die, affecting individual IC components on the die. These effects can be minimized by proper integrated circuit design and layout techniques. Thermal Regulation is the effect of these temperature gradients on the output voltage and is expressed in percentage of output change per watt of power change in a specified time.
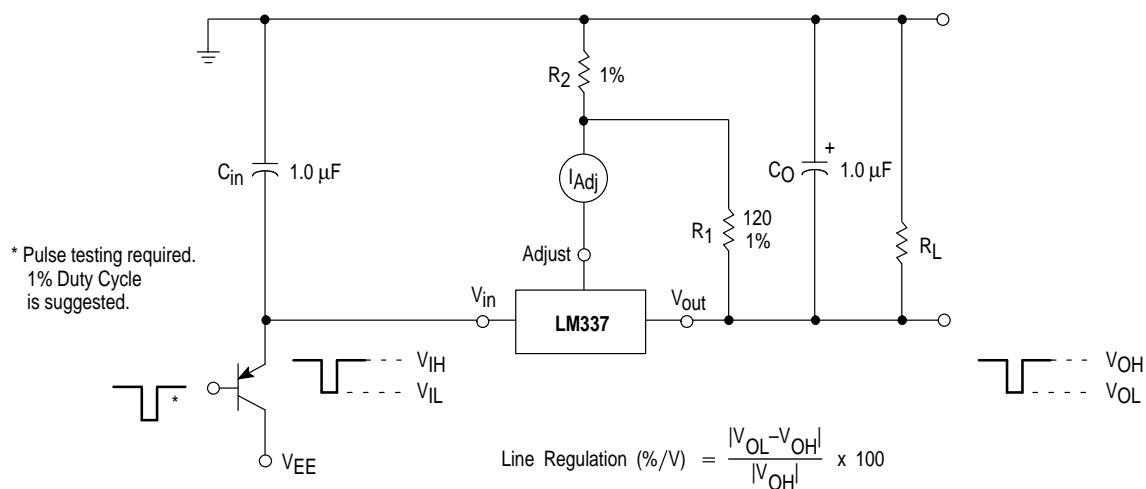
LM337

Representative Schematic Diagram
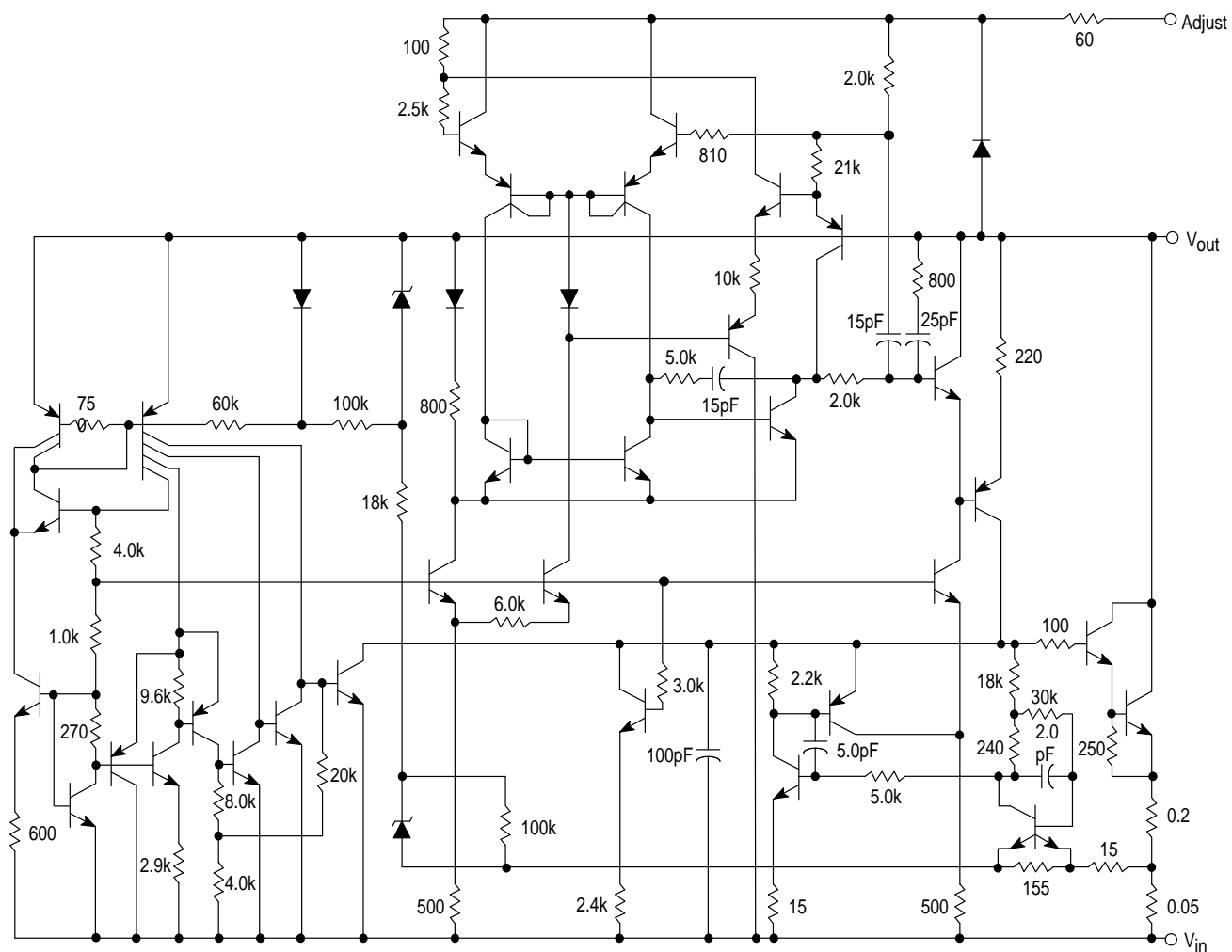
This device contains 39 active transistors.

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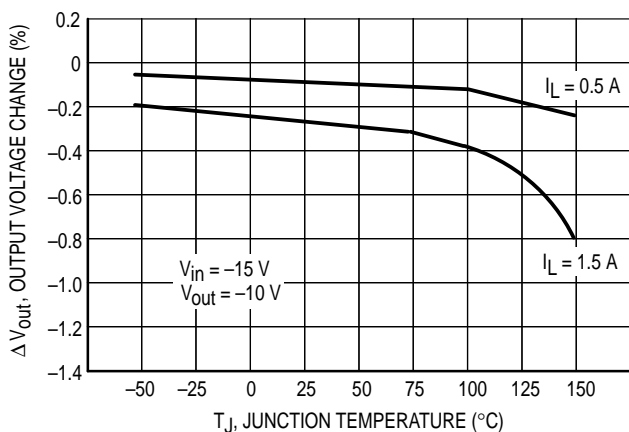

$$\text{Line Regulation (\%/V)} = \frac{|V_{OL} - V_{OH}|}{|V_{OH}|} \times 100$$

* Pulse testing required.
  1% Duty Cycle
  is suggested.

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

* Pulse testing required.
  1% Duty Cycle is suggested.

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

Load Regulation (% V_O) = $\dfrac{V_O \text{ (min Load)} - V_O \text{ (max Load)}}{V_O \text{ (min Load)}}$ x 100

Figure 3. Standard Test Circuit

To Calculate R_2: $R_2 = \left(\dfrac{V_O}{V_{ref}} - 1 \right) R_1$

This assumes I_{Adj} is negligible.

* Pulse testing required.
  1% Duty Cycle is suggested.

Figure 4. Ripple Rejection Test Circuit

$V_{out} = -1.25$ V

14.3 V
4.3 V
f = 120 Hz

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

Figure 5. Load Regulation

Figure 6. Current Limit
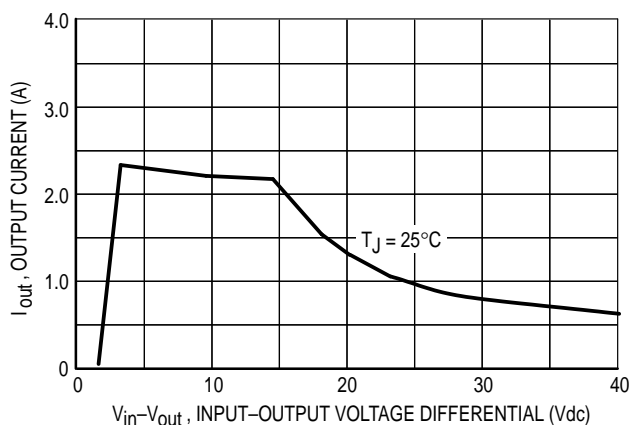
Figure 7. Adjustment Pin Current
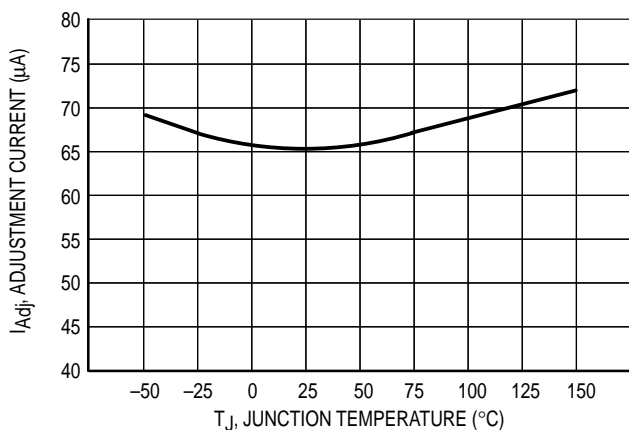
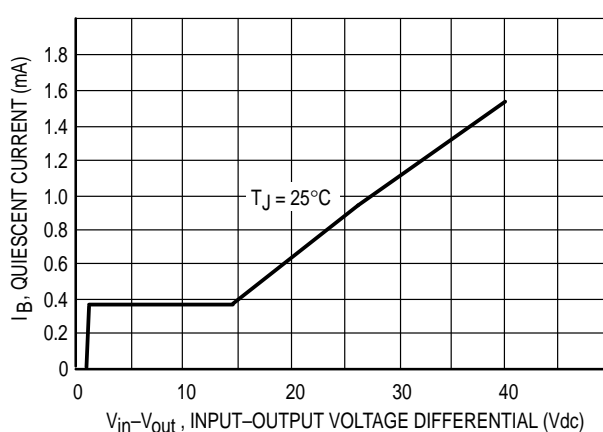## Figure 8. Dropout Voltage
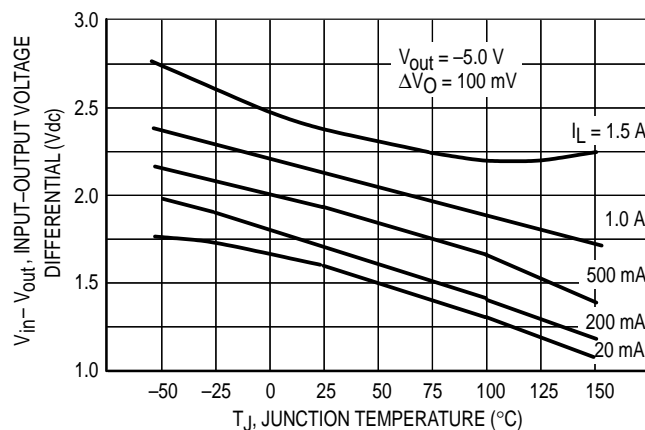
Figure 9. Temperature Stability
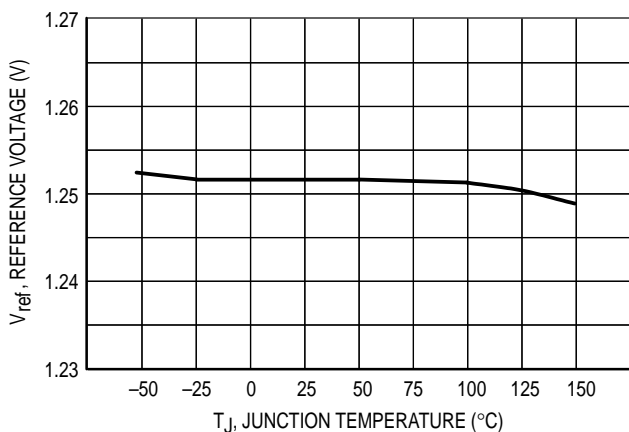
Figure 10. Minimum Operating Current

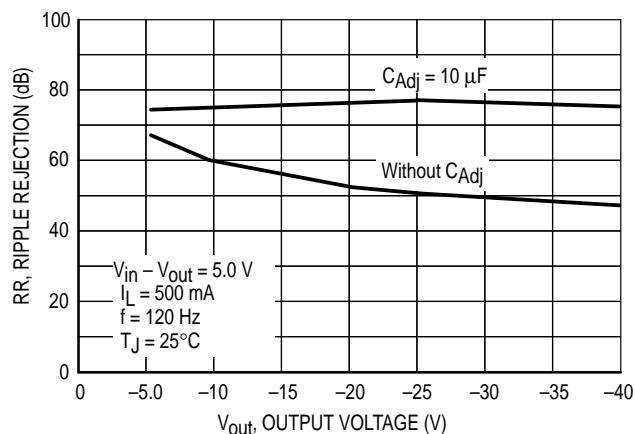**Figure 11. Ripple Rejection versus Output Voltage**
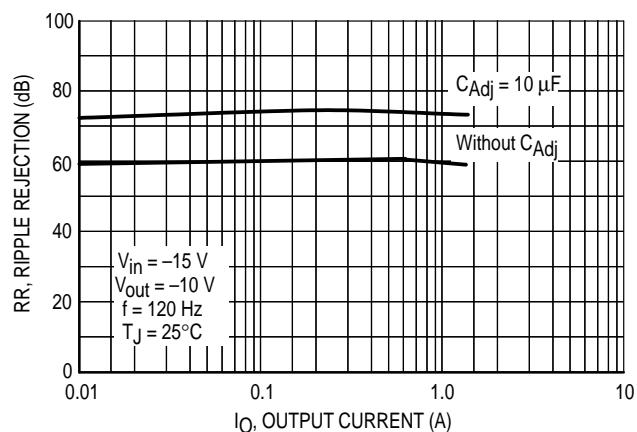

Figure 12. Ripple Rejection versus Output Current
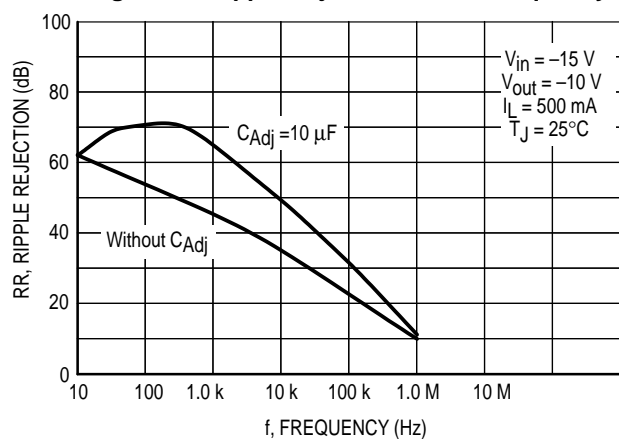

Figure 13. Ripple Rejection versus Frequency

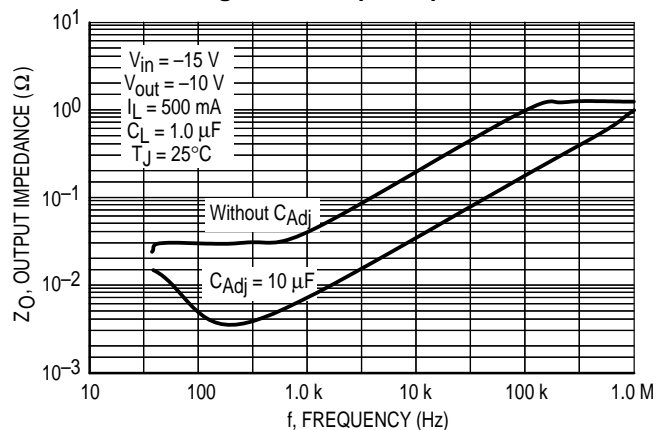**Figure 14. Output Impedance**

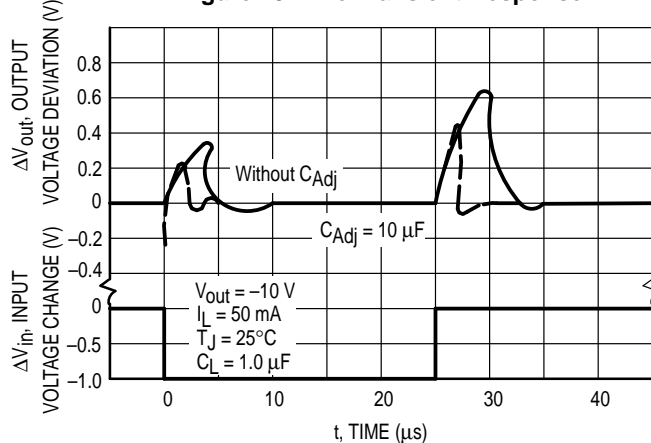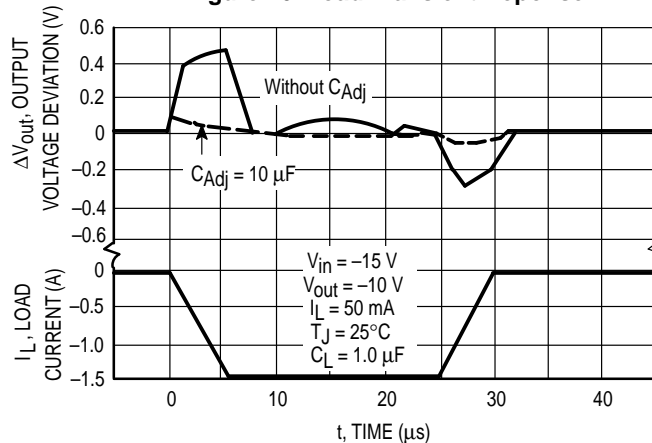**Figure 15. Line Transient Response**

Figure 16. Load Transient Reponse

LM337
APPLICATIONS INFORMATION

Basic Circuit Operation

The LM337 is a 3–terminal floating regulator. In operation, the LM337 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 from ground.

The regulated output voltage is given by:

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

Since the current into the adjustment terminal (I_{Adj}) represents an error term in the equation, the LM337 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 LM337 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

$V_{ref} = -1.25$ V Typical
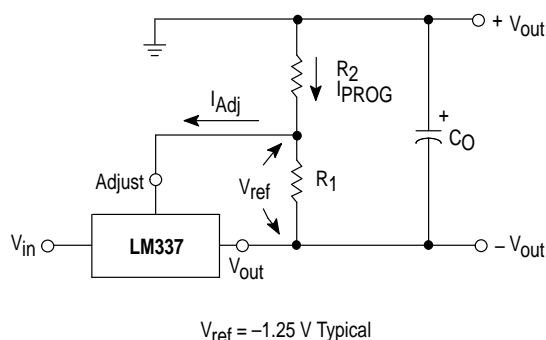
Load Regulation

The LM337 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 LM337 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 the discharging through the IC during an input short circuit.

Figure 18. Voltage Regulator with Protection Diodes

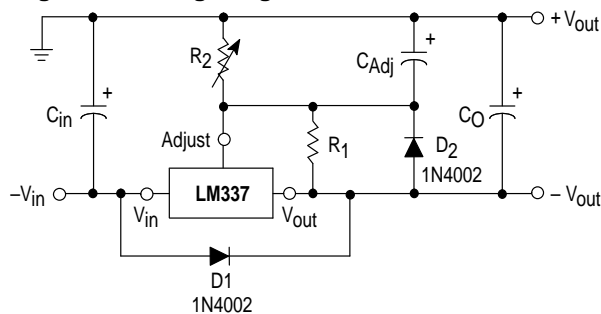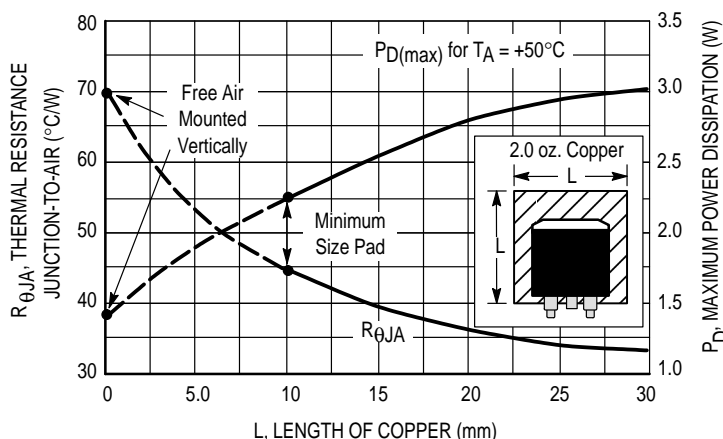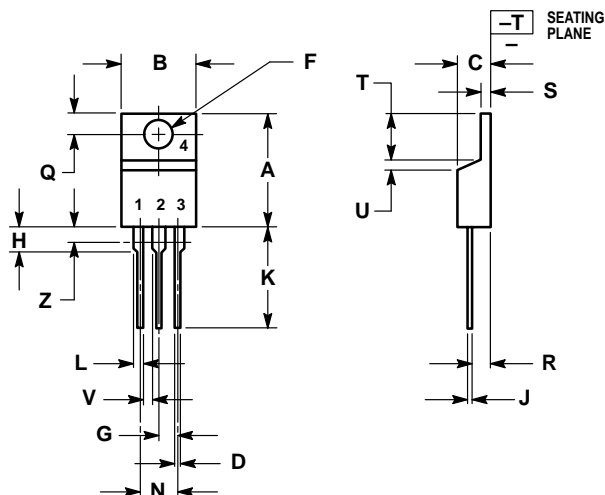#### Figure 19. D²PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

OUTLINE DIMENSIONS

T SUFFIX
PLASTIC PACKAGE
CASE 221A–06
ISSUE Y

SEATING PLANE

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

DIM	INCHES		MILLIMETERS	
	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

D2T SUFFIX
PLASTIC PACKAGE
CASE 936–03
(D²PAK)
ISSUE B

OPTIONAL CHAMFER

TERMINAL 4

⊕ | 0.010 (0.254) Ⓜ | T
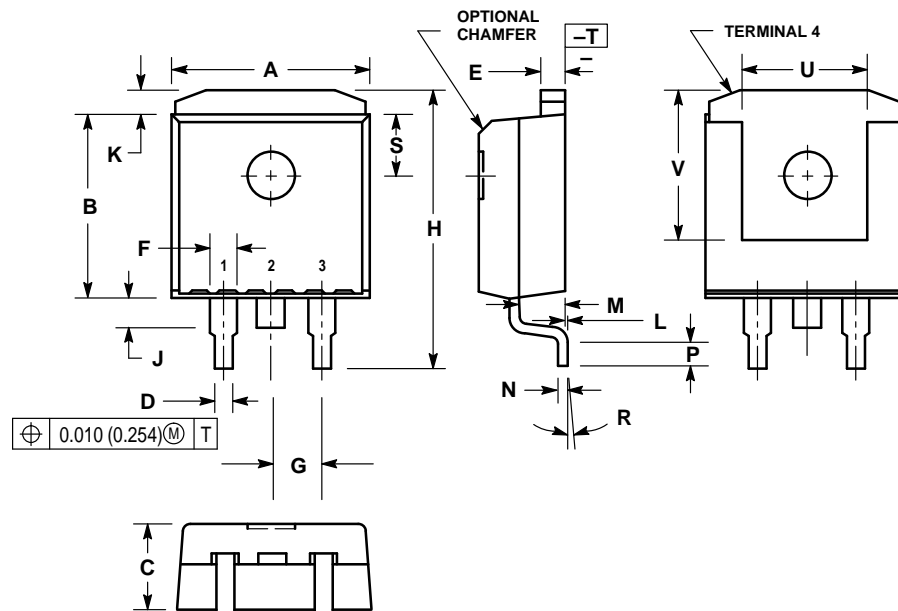
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
F	0.051 REF		1.295 REF	
G	0.100 BSC		2.540 BSC	
H	0.539	0.579	13.691	14.707
J	0.125 MAX		3.175 MAX	
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5° REF		5° REF	
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	