July 2004

National Semiconductor

LM117/LM317A/LM317 3-Terminal Adjustable Regulator

General Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

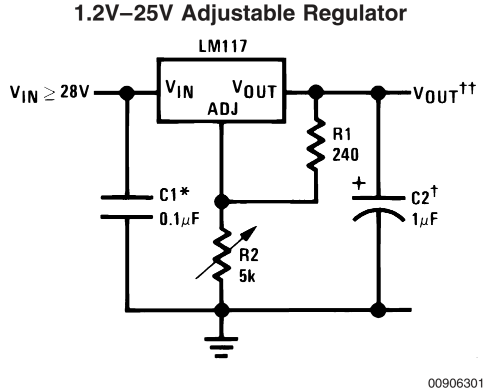
For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet.

Features

- Guaranteed 1% output voltage tolerance (LM317A)
- Guaranteed max. 0.01%/V line regulation (LM317A)
- Guaranteed max. 0.3% load regulation (LM117)
- Guaranteed 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- P^+ Product Enhancement tested
- 80 dB ripple rejection
- Output is short-circuit protected

Typical Applications

1.2V–25V Adjustable Regulator



Full output current not available at high input-output voltages

*Needed if device is more than 6 inches from filter capacitors.

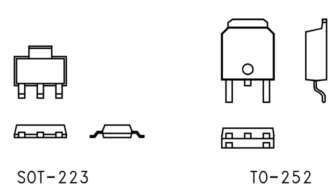
†Optional — improves transient response. Output capacitors in the range of 1µF to 1000µF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

$$^{\dagger\dagger}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}(R_2)$$

LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO-3	1.5A
H	**TO-39**	**0.5A**
T	TO-220	1.5A
E	**LCC**	**0.5A**
S	TO-263	1.5A
EMP	SOT-223	1A
MDT	**TO-252**	**0.5A**

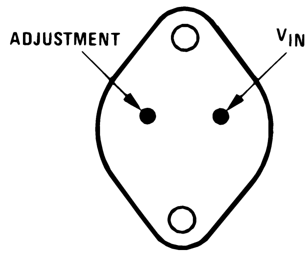
SOT-223 vs. D-Pak (TO-252) Packages



Scale 1:1

Connection Diagrams

(TO-3)
Metal Can Package



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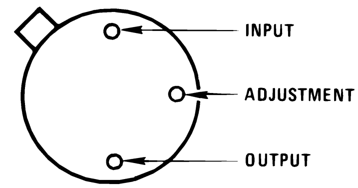
CASE IS OUTPUT

Bottom View
Steel Package
NS Package Number K02A or K02C

(TO-39)
Metal Can Package



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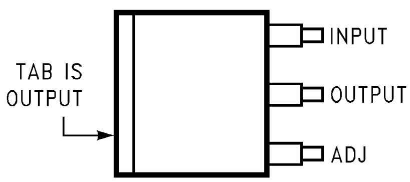
CASE IS OUTPUT

Bottom View
NS Package Number H03A

(TO-263) Surface-Mount Package



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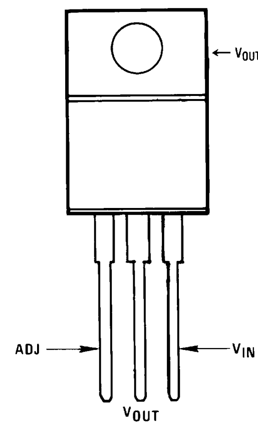
Top View

(TO-220)
Plastic Package



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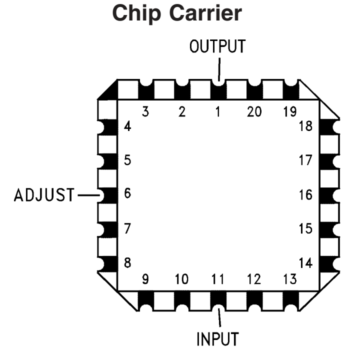
Front View
NS Package Number T03B

00906336

Side View
NS Package Number TS3B

Ceramic Leadless
Chip Carrier



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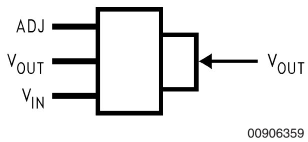
Top View
NS Package Number E20A

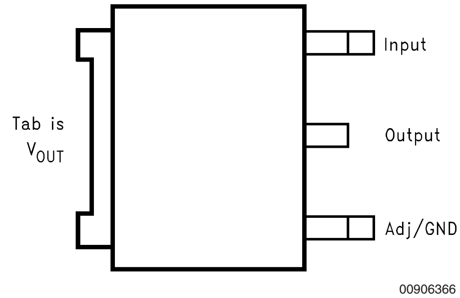
Connection Diagrams (Continued)

4-Lead SOT-223



Front View
NS Package Number MP04A

TO-252 (D-Pak)



Front View
NS Package Number TD03B

Ordering Information

Package	Temperature Range	Part Number	Package Marking	Transport Media	NSC Drawing
Metal Can (TO-3)	$-55^\circ C \le T_J \le +150^\circ C$	LM117K STEEL	LM117K STEEL P+	50 Per Bag	K02A
	$0^\circ C \le T_J \le +125^\circ C$	LM317K STEEL	LM317K STEEL P+	50 Per Bag	
	$-55^\circ C \le T_J \le +150^\circ C$	LM117K/883	LM117K/883	50 Per Bag	K02C
Metal Can (TO-39)	$-55^\circ C \le T_J \le +150^\circ C$	LM117H	LM117H P+	500 Per Box	H03A
	$-55^\circ C \le T_J \le +150^\circ C$	LM117H/883	LM117H/883	20 Per Tray	
	$-40^\circ C \le T_J \le +125^\circ C$	LM317AH	LM317AH P+	500 Per Box	
	$0^\circ C \le T_J \le +125^\circ C$	LM317H	LM317H P+	500 Per Box	
TO-220 3- Lead	$-40^\circ C \le T_J \le +125^\circ C$	LM317AT	LM317AT P+	45 Units/Rail	T03B
	$0^\circ C \le T_J \le +125^\circ C$	LM317T	LM317T P+	45 Units/Rail	
TO-263 3- Lead	$0^\circ C \le T_J \le +125^\circ C$	LM317S	LM317S P+	45 Units/Rail	TS3B
		LM317SX		500 Units Tape and Reel	
LCC	$-55^\circ C \le T_J \le +150^\circ C$	LM117E/883	LM117E/883	50 Units/Rail	E20A
SOT-223 4- Lead	$0^\circ C \le T_J \le +125^\circ C$	LM317EMP	N01A	1k Units Tape and Reel	MP04A
		LM317EMPX		2k Units Tape and Reel	
	$-40^\circ C \le T_J \le +125^\circ C$	LM317AEMP	N07A	1k Units Tape and Reel	
		LM317AEMPX		2k Units Tape and Reel	
D- Pack 3- Lead	$0^\circ C \le T_J \le +125^\circ C$	LM317MDT	LM317MDT	75 Units/Rail	TD03B
		LM317MDTX		2.5k Units Tape and Reel	
	$-40^\circ C \le T_J \le +125^\circ C$	LM317AMDT	LM317AMDT	75 Units/Rail	
		LM317AMDTX		2.5k Units Tape and Reel	

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Dissipation	Internally Limited
Input-Output Voltage Differential	+40V, −0.3V
Storage Temperature	−65˚C to +150˚C
Lead Temperature	
Metal Package (Soldering, 10 seconds)	300˚C
Plastic Package (Soldering, 4 seconds)	260˚C

ESD Tolerance (Note 5) 3 kV

Operating Temperature Range

LM117	$-55^\circ C \le T_J \le +150^\circ C$
LM317A	$-40^\circ C \le T_J \le +125^\circ C$
LM317	$0^\circ C \le T_J \le +125^\circ C$

Preconditioning

Thermal Limit Burn-In All Devices 100%

Electrical Characteristics (Note 3)

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN} - V_{OUT}$ = 5V, and I_{OUT} = 10 mA.

Parameter	Conditions	**LM117** (Note 2)			Units
		Min	Typ	Max	
Reference Voltage					V
	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\ mA \le I_{OUT} \le I_{MAX}$, $P \le P_{MAX}$	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.01	0.02	%/V
			0.02	**0.05**	%/V
Load Regulation	$10\ mA \le I_{OUT} \le I_{MAX}$ (Note 4)		0.1	0.3	%
			0.3	**1**	%
Thermal Regulation	20 ms Pulse		0.03	0.07	%/W
Adjustment Pin Current			**50**	**100**	μA
Adjustment Pin Current Change	$10\ mA \le I_{OUT} \le I_{MAX}$ $3V \le (V_{IN} - V_{OUT}) \le 40V$		**0.2**	**5**	μA
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$		**1**		%
Minimum Load Current	$(V_{IN} - V_{OUT}) = 40V$		**3.5**	**5**	mA
Current Limit	$(V_{IN} - V_{OUT}) \le 15V$				
	K Package	**1.5**	**2.2**	**3.4**	A
	H Package	**0.5**	**0.8**	**1.8**	A
	$(V_{IN} - V_{OUT}) = 40V$				
	K Package	0.3	0.4		A
	H Package	0.15	0.2		A
RMS Output Noise, % of V_{OUT}	$10\ Hz \le f \le 10\ kHz$		0.003		%
Ripple Rejection Ratio	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 0 μF		**65**		dB
	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 10 μF	**66**	**80**		dB
Long-Term Stability	T_J = 125˚C, 1000 hrs		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package		2.3	3	˚C/W
	H Package		12	15	˚C/W
	E Package				˚C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package		35		˚C/W
	H Package		140		˚C/W
	E Package				˚C/W

Electrical Characteristics (Note 3)

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN} - V_{OUT}$ = 5V, and I_{OUT} = 10 mA.

Parameter	Conditions	LM317A			LM317			Units
		Min	Typ	Max	Min	Typ	Max	
Reference Voltage		1.238	1.250	1.262				V
	3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V, 10 mA ≤ I_{OUT} ≤ I_{MAX}, P ≤ P_{MAX}	**1.225**	**1.250**	**1.270**	**1.20**	**1.25**	**1.30**	V
Line Regulation	3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V (Note 4)		0.005	0.01		0.01	0.04	%/V
			0.01	**0.02**		**0.02**	**0.07**	%/V
Load Regulation	10 mA ≤ I_{OUT} ≤ I_{MAX} (Note 4)		0.1	0.5		0.1	0.5	%
			0.3	**1**		**0.3**	**1.5**	%
Thermal Regulation	20 ms Pulse		0.04	0.07		0.04	0.07	%/W
Adjustment Pin Current			**50**	**100**		**50**	**100**	μA
Adjustment Pin Current Change	10 mA ≤ I_{OUT} ≤ I_{MAX} 3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V		**0.2**	**5**		**0.2**	**5**	μA
Temperature Stability	T_{MIN} ≤ T_J ≤ T_{MAX}		**1**			**1**		%
Minimum Load Current	($V_{IN} - V_{OUT}$) = 40V		**3.5**	**10**		**3.5**	**10**	mA
Current Limit	($V_{IN} - V_{OUT}$) ≤ 15V							
	K, T, S Packages	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	A
	H Package	**0.5**	**0.8**	**1.8**	**0.5**	**0.8**	**1.8**	A
	MP Package	**1.5**	**2.2**	**3.4**	**1.5**	**2.2**	**3.4**	A
	($V_{IN} - V_{OUT}$) = 40V							
	K, T, S Packages	0.15	0.4		0.15	0.4		A
	H Package	0.075	0.2		0.075	0.2		A
	MP Package	0.15	0.4		0.15	0.4		A
RMS Output Noise, % of V_{OUT}	10 Hz ≤ f ≤ 10 kHz		0.003			0.003		%
Ripple Rejection Ratio	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 0 μF		**65**			**65**		dB
	V_{OUT} = 10V, f = 120 Hz, C_{ADJ} = 10 μF	**66**	**80**		**66**	**80**		dB
Long-Term Stability	T_J = 125˚C, 1000 hrs		0.3	1		0.3	1	%
Thermal Resistance, Junction-to-Case	K Package					2.3	3	˚C/W
	MDT Package					5		˚C/W
	H Package		12	15		12	15	˚C/W
	T Package		4	5		4		˚C/W
	MP Package		23.5			23.5		˚C/W
Thermal Resistance, Junction-to-Ambient (No Heat Sink)	K Package		35			35		˚C/W
	MDT Package(Note 6)					92		˚C/W
	H Package		140			140		˚C/W
	T Package		50			50		˚C/W
	S Package (Note 6)		50			50		˚C/W

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

Note 2: Refer to RETS117H drawing for the LM117H, or the RETS117K for the LM117K military specifications.

Note 3: Although power dissipation is internally limited, these specifications are applicable for maximum power dissipations of 2W for the TO-39 and SOT-223 and 20W for the TO-3, TO-220, and TO-263. I_{MAX} is 1.5A for the TO-3, TO-220, and TO-263 packages, 0.5A for the TO-39 package and 1A for the SOT-223 Package. All limits (i.e., the numbers in the Min. and Max. columns) are guaranteed to National's AOQL (Average Outgoing Quality Level).

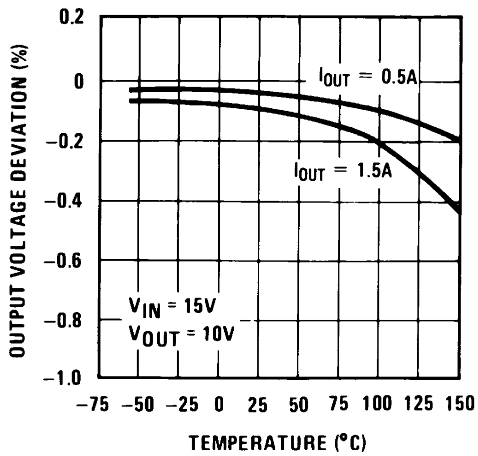
Note 4: Regulation is measured at a constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specifications for thermal regulation.

Note 5: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Note 6: If the TO-263 or TO-252 packages are used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package. Using 0.5 square inches of copper area. θ_{JA} is 50˚C/W; with 1 square inch of copper area, θ_{JA} is 37˚C/W; and with 1.6 or more square inches of copper area, θ_{JA} is 32˚C/W. If the SOT-223 package is used, the thermal resistance can be reduced by increasing the PC board copper area (see applications hints for heatsinking).

Typical Performance Characteristics
Output Capacitor = 0μF unless otherwise noted

Load Regulation



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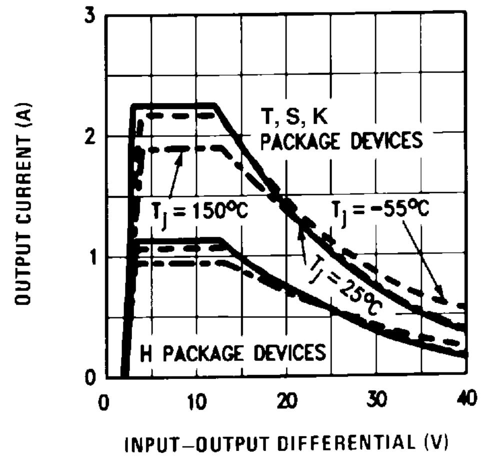
Current Limit



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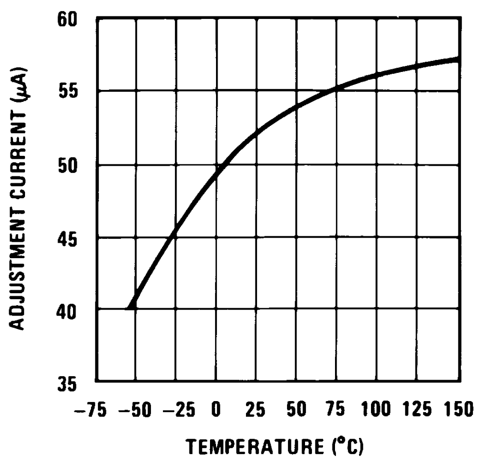
Adjustment Current



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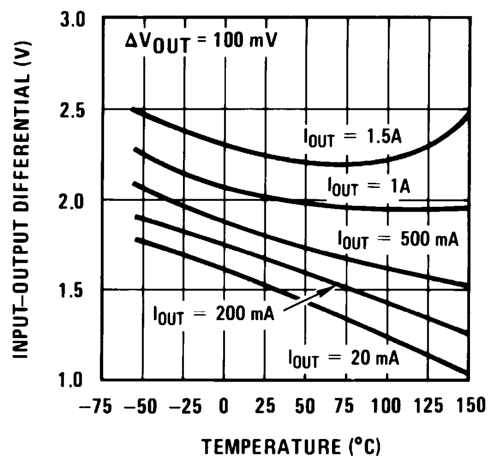
Dropout Voltage



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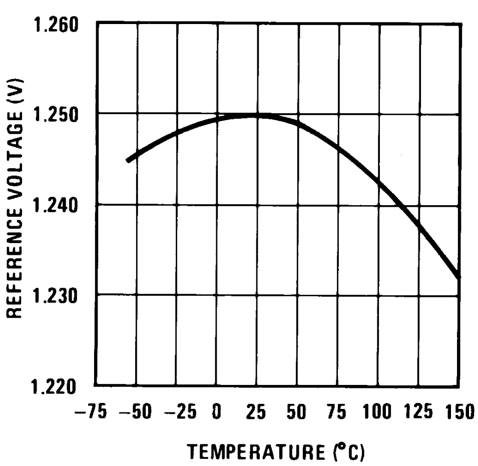
Temperature Stability



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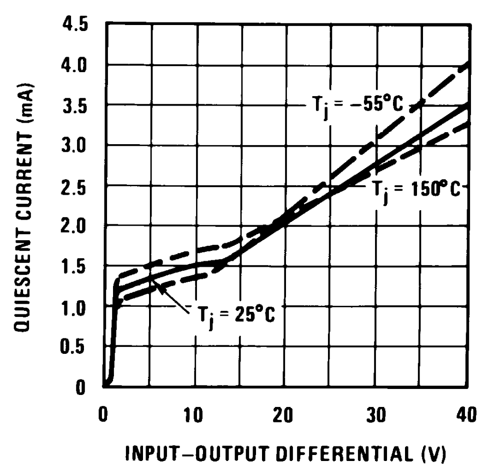
Minimum Operating Current



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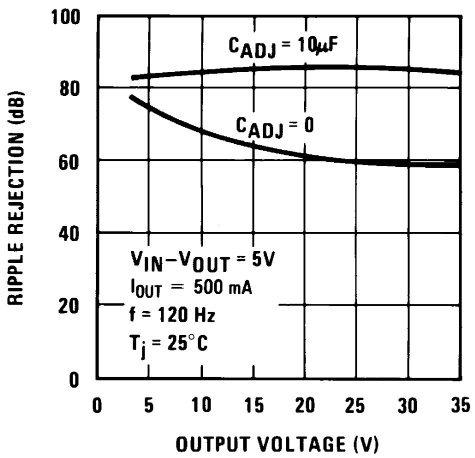
Typical Performance Characteristics Output Capacitor = 0µF unless otherwise noted (Continued)

Ripple Rejection



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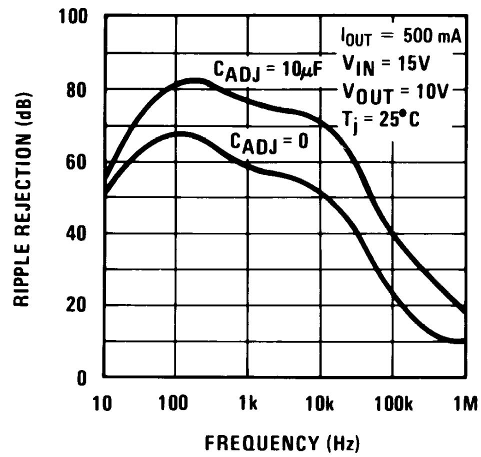
Ripple Rejection



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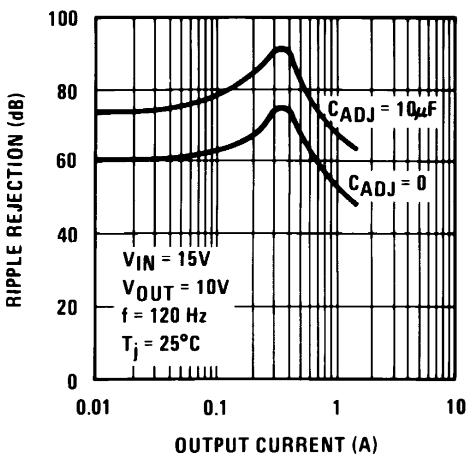
Ripple Rejection



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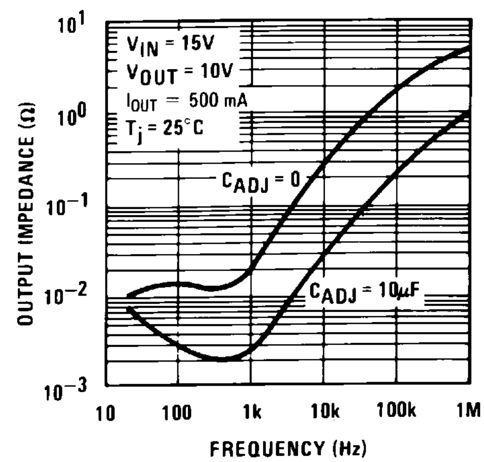
Output Impedance



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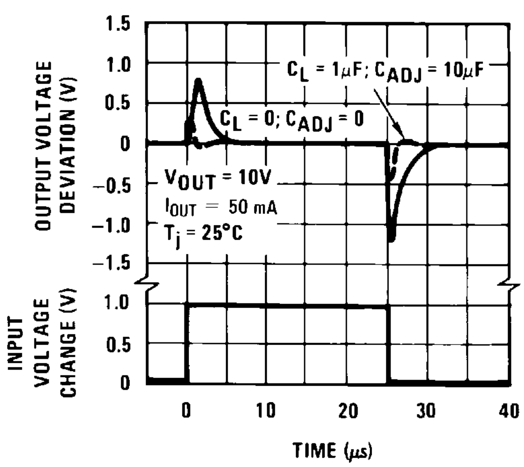
Line Transient Response



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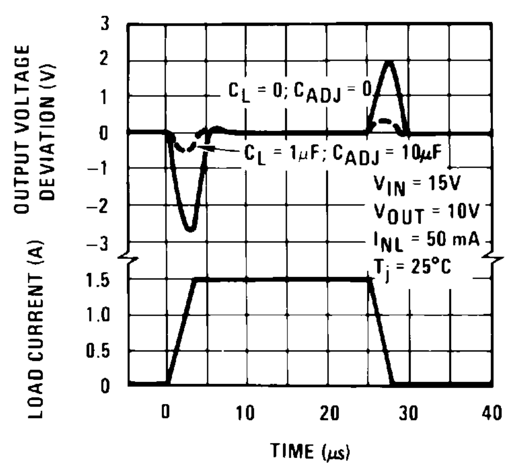
Load Transient Response



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Application Hints

In operation, the LM117 develops a nominal 1.25V reference voltage, V_{REF}, between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

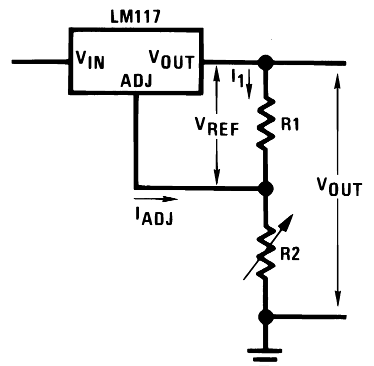


FIGURE 1.

Since the 100μA current from the adjustment terminal represents an error term, the LM117 was designed to minimize I_{ADJ} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

EXTERNAL CAPACITORS

An input bypass capacitor is recommended. A 0.1μF disc or 1μF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the LM117 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10μF bypass capacitor 80dB ripple rejection is obtainable at any output level. Increases over 10μF do not appreciably improve the ripple rejection at frequencies above 120Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use is solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25μF in aluminum electrolytic to equal 1μF solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5MHz. For this reason, 0.01μF disc may seem to work better than a 0.1μF disc as a bypass.

Although the LM117 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500 pF and 5000 pF. A 1μF solid tantalum (or 25μF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10μF will merely improve the loop stability and output impedance.

LOAD REGULATION

The LM117 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal (usually 240Ω) should be tied directly to the output (case) of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05Ω x I_L. If the set resistor is connected near the load the effective line resistance will be 0.05Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 2 shows the effect of resistance between the regulator and 240Ω set resistor.

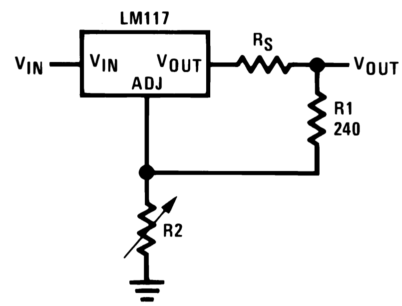


FIGURE 2. Regulator with Line Resistance in Output Lead

With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO-39 package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide remote ground sensing and improve load regulation.

PROTECTION DIODES

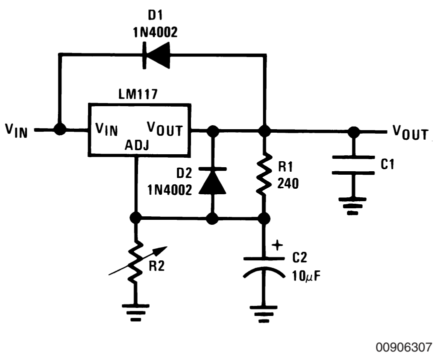
When external capacitors are used with *any* IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN}. In the LM117, this discharge path is through a large junction that is able to sustain 15A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25μF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs

Application Hints (Continued)

when *either* the input or output is shorted. Internal to the LM117 is a 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and 10µF capacitance. *Figure 3* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



$$V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$

D1 protects against C1

D2 protects against C2

FIGURE 3. Regulator with Protection Diodes

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.*

$\theta_{(H-A)}$ is specified numerically by the heatsink manufacturer in the catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

HEATSINKING TO-263, SOT-223 AND TO-252 PACKAGE PARTS

The TO-263 ("S"), SOT-223 ("MP") and TO-252 ("DT") 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 4 shows for the TO-263 the measured values of $\theta_{(J-A)}$ for different copper area sizes using a typical PCB with 1 ounce copper *and no solder mask over the copper area used for heatsinking.*

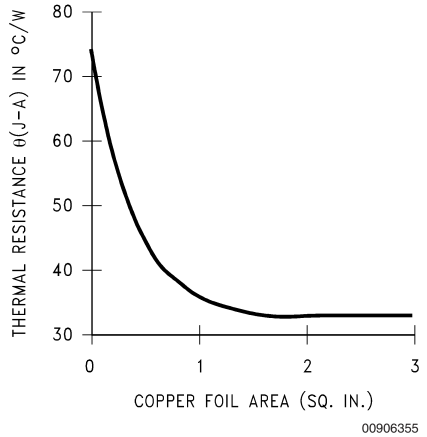


FIGURE 4. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package

As shown in the figure, increasing the copper area beyond 1 square inch produces very little improvement. It should also be observed that the minimum value of $\theta_{(J-A)}$ for the TO-263 package mounted to a PCB is 32˚C/W.

As a design aid, *Figure 5* shows the maximum allowable power dissipation compared to ambient temperature for the TO-263 device (assuming $\theta_{(J-A)}$ is 35˚C/W and the maximum junction temperature is 125˚C).

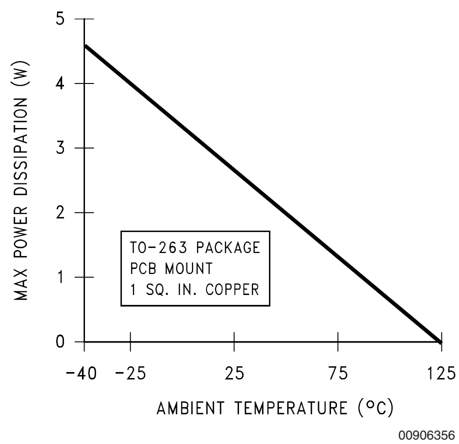


FIGURE 5. Maximum Power Dissipation vs T_{AMB} for the TO-263 Package

Figure 6 and *Figure 7* show the information for the SOT-223 package. *Figure 7* assumes a $\theta_{(J-A)}$ of 74˚C/W for 1 ounce copper and 51˚C/W for 2 ounce copper and a maximum junction temperature of 125˚C.

Application Hints (Continued)

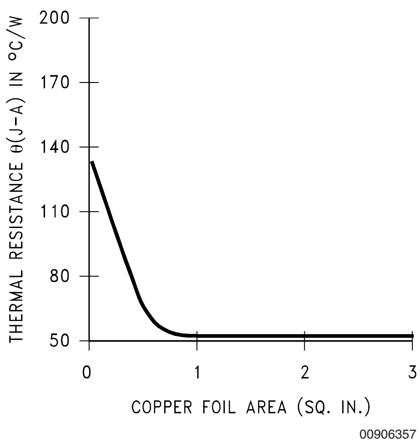


FIGURE 6. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

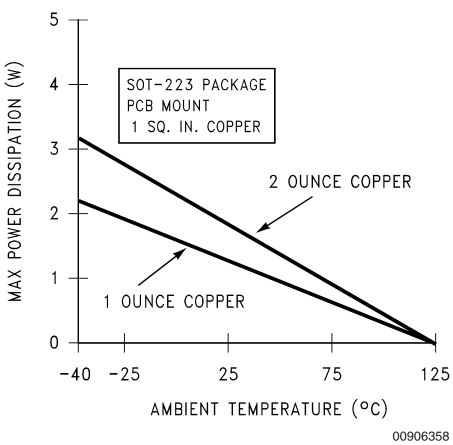


FIGURE 7. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

The LM317 regulators have internal thermal shutdown to protect the device from over-heating. Under all possible operating conditions, the junction temperature of the LM317 must be within the range of 0˚C to 125˚C. A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$$I_{IN} = I_L + I_G$$

$$P_D = (V_{IN} - V_{OUT})\ I_L + V_{IN}I_G$$

Figure 8 shows the voltage and currents which are present in the circuit.

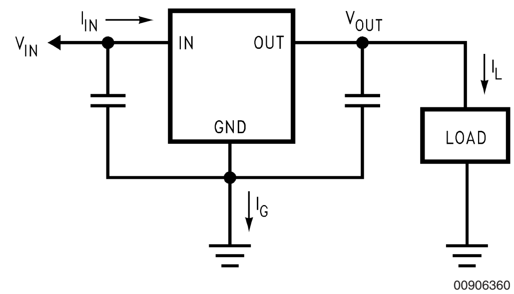


FIGURE 8. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max):

$$T_R(max) = T_J(max) - T_A(max)$$

where T_J(max) is the maximum allowable junction temperature (125˚C), and T_A(max) is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for T_R(max) and P_D, the maximum allowable value for the junction-to-ambient thermal resistance (θ_{JA}) can be calculated:

$$\theta_{JA} = T_R(max)/P_D$$

If the maximum allowable value for θ_{JA} is found to be ≥92˚C/W (Typical Rated Value) for TO-252 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} falls below these limits, a heatsink is required.

As a design aid, *Table 1* shows the value of the θ_{JA} of TO-252 for different heatsink area. The copper patterns that we used to measure these θ_{JA}s are shown at the end of the Application Notes Section. *Figure 9* reflects the same test results as what are in the *Table 1*

Figure 10 shows the maximum allowable power dissipation vs. ambient temperature for the TO-252 device. *Figure 11* shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN1028 for power enhancement techniques to be used with SOT-223 and TO-252 packages.

TABLE 1. θ_{JA} Different Heatsink Area

Layout	Copper Area		Thermal Resistance
	Top Side (in^2)*	Bottom Side (in^2)	(θ_{JA}˚C/W) TO-252
1	0.0123	0	103
2	0.066	0	87
3	0.3	0	60
4	0.53	0	54
5	0.76	0	52
6	1	0	47
7	0	0.2	84
8	0	0.4	70
9	0	0.6	63

Application Hints (Continued)

TABLE 1. θ_{JA} Different Heatsink Area (Continued)

Layout	Copper Area		Thermal Resistance
10	0	0.8	57
11	0	1	57
12	0.066	0.066	89
13	0.175	0.175	72
14	0.284	0.284	61
15	0.392	0.392	55
16	0.5	0.5	53

Note: * Tab of device attached to topside of copper.

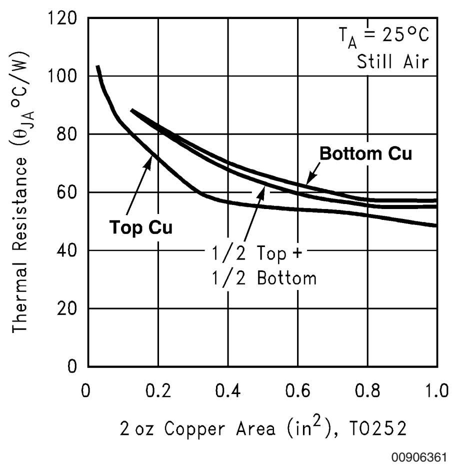


FIGURE 9. θ_{JA} vs 2oz Copper Area for TO-252

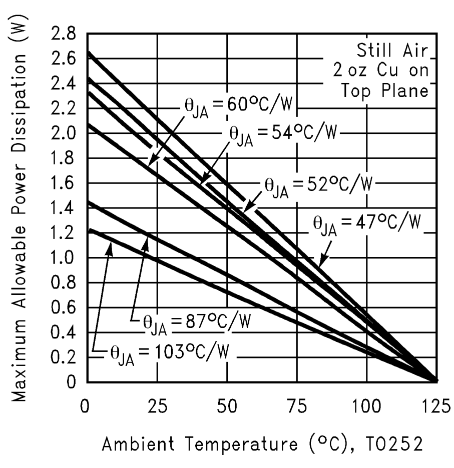


FIGURE 10. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

Application Hints (Continued)

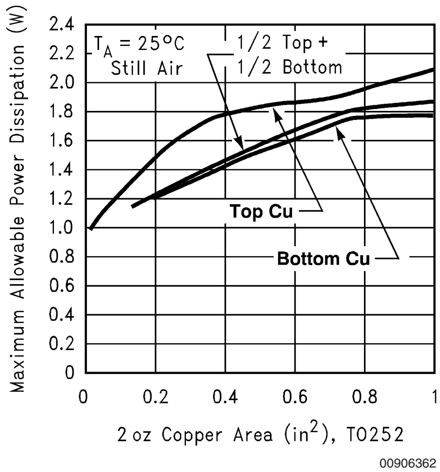


FIGURE 11. Maximum Allowable Power Dissipation vs. 2oz Copper Area for TO-252

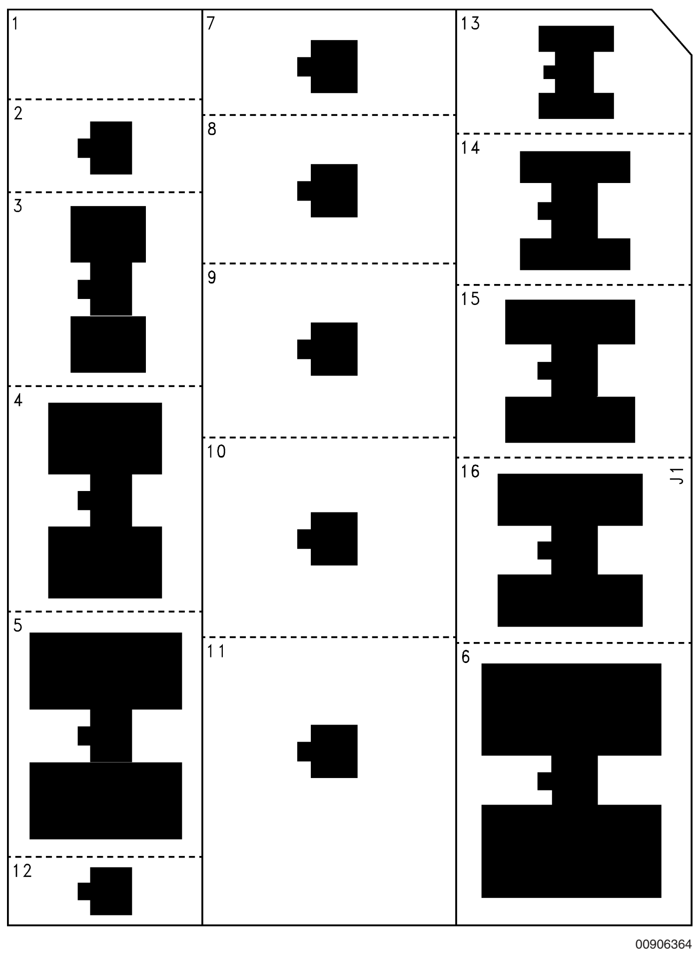


FIGURE 12. Top View of the Thermal Test Pattern in Actual Scale

Application Hints (Continued)

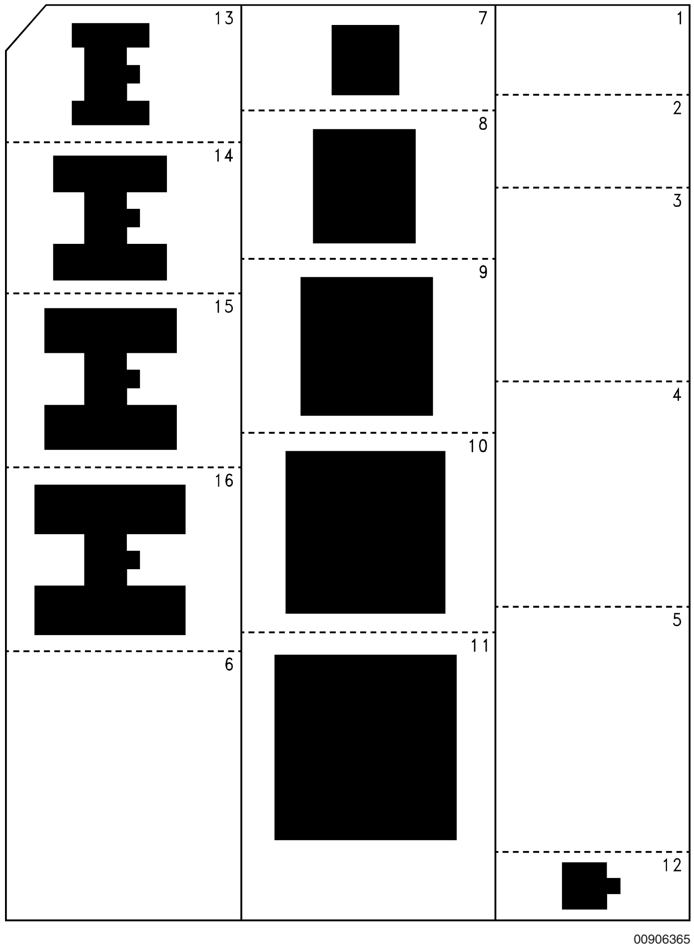
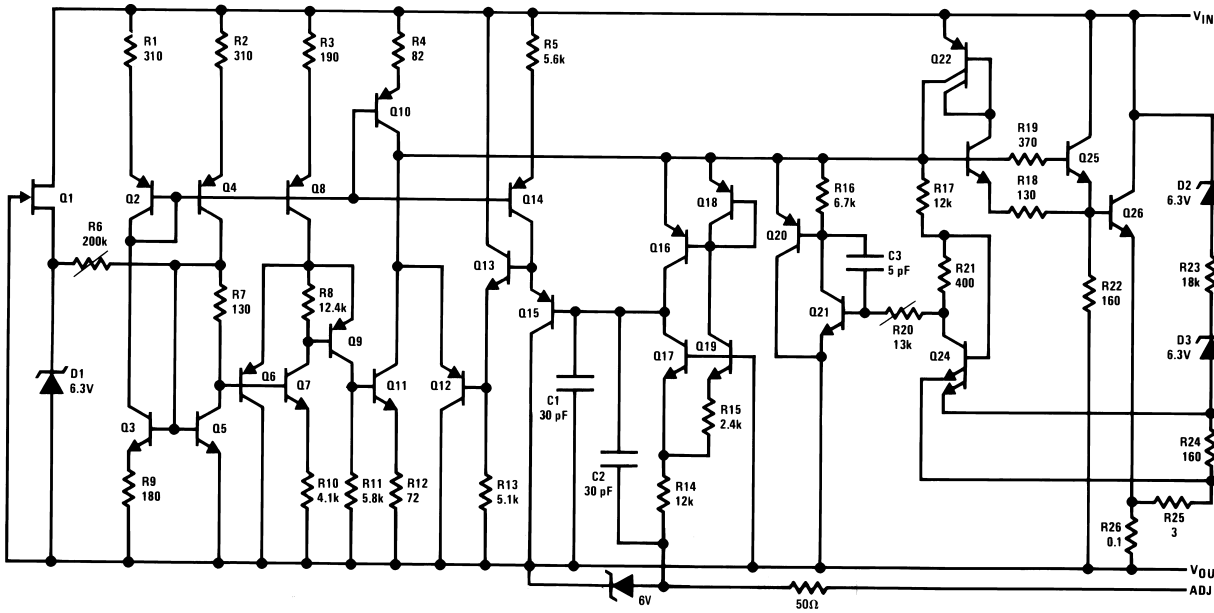


FIGURE 13. Bottom View of the Thermal Test Pattern in Actual Scale

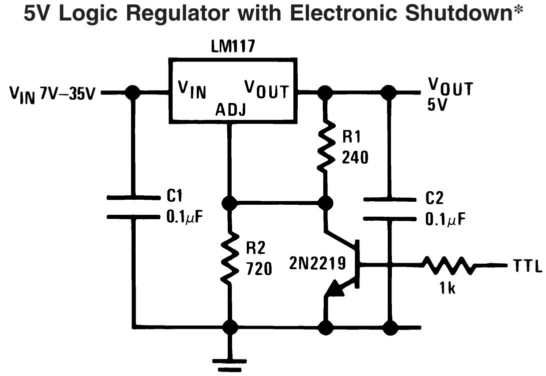
Schematic Diagram



00906308

Typical Applications

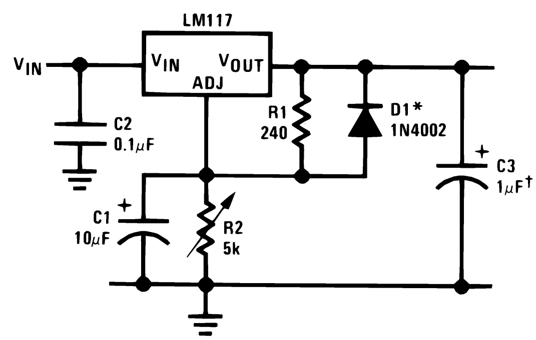
5V Logic Regulator with Electronic Shutdown*



00906303

*Min. output ≅ 1.2V

Adjustable Regulator with Improved Ripple Rejection

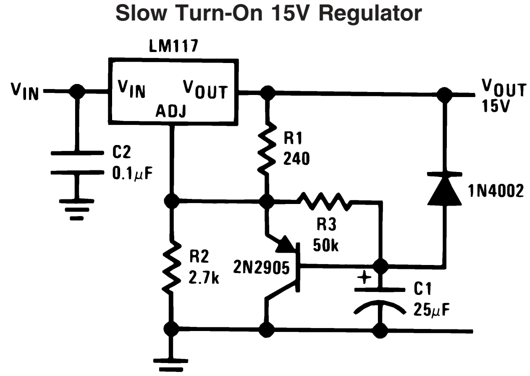


00906310

†Solid tantalum

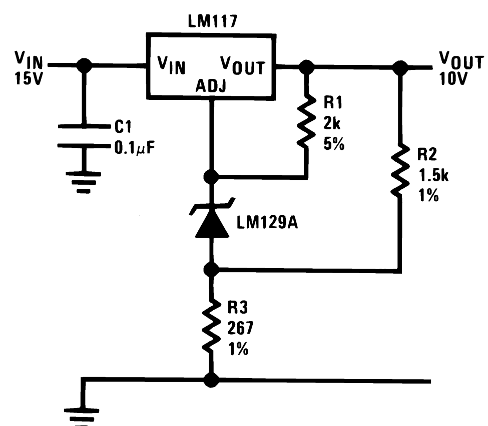
*Discharges C1 if output is shorted to ground

Slow Turn-On 15V Regulator



00906309

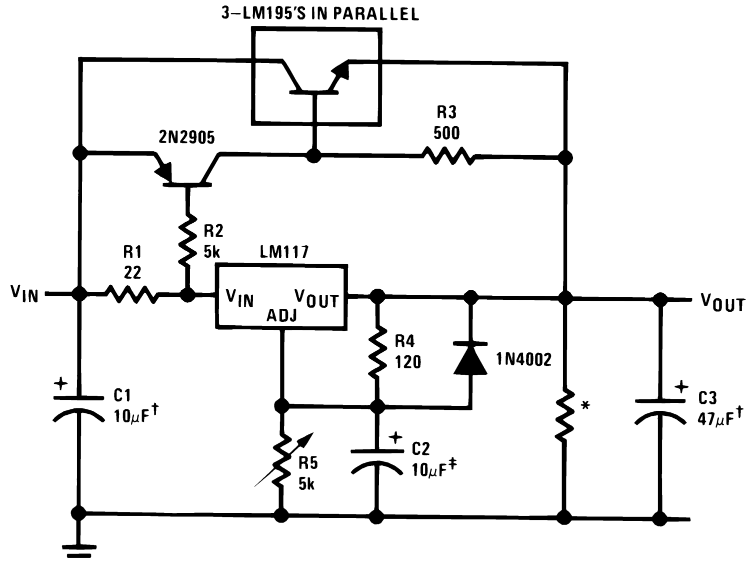
High Stability 10V Regulator



00906311

Typical Applications (Continued)

High Current Adjustable Regulator



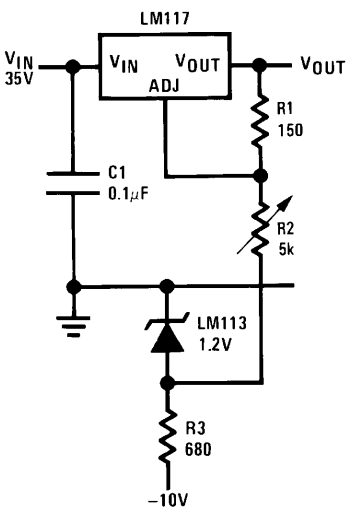
00906312

‡Optional — improves ripple rejection

†Solid tantalum

*Minimum load current = 30 mA

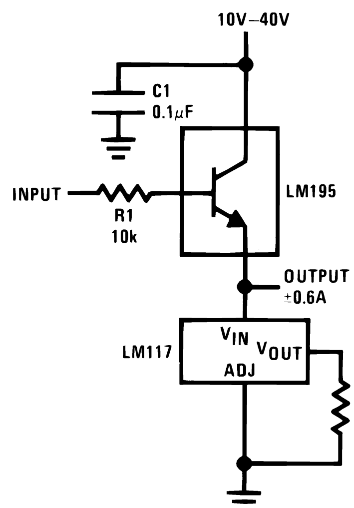
0 to 30V Regulator



00906313

Full output current not available at high input-output voltages

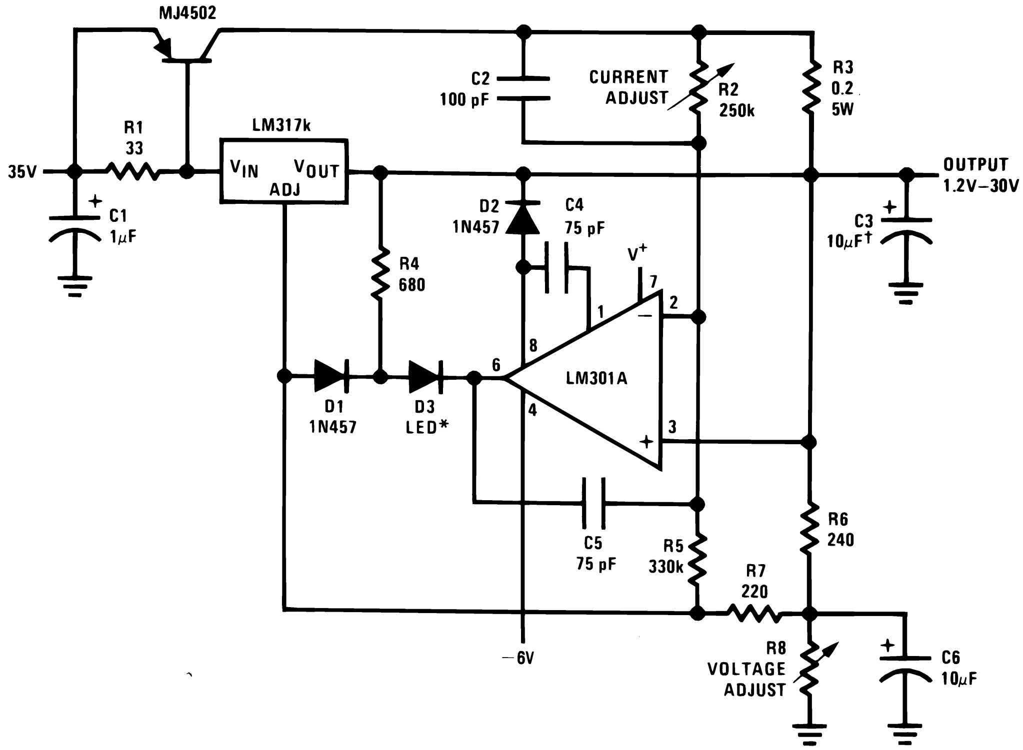
Power Follower



00906314

Typical Applications (Continued)

5A Constant Voltage/Constant Current Regulator

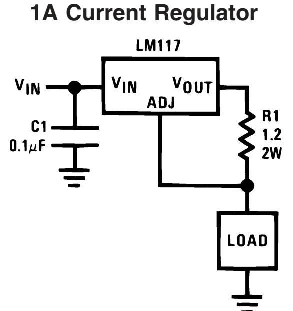


00906315

†Solid tantalum

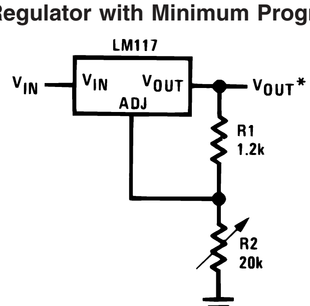
*Lights in constant current mode

1A Current Regulator



00906316

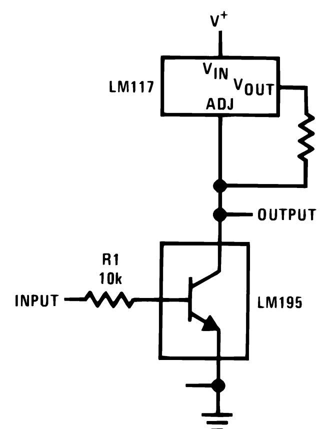
1.2V–20V Regulator with Minimum Program Current



00906317

*Minimum load current ≅ 4 mA

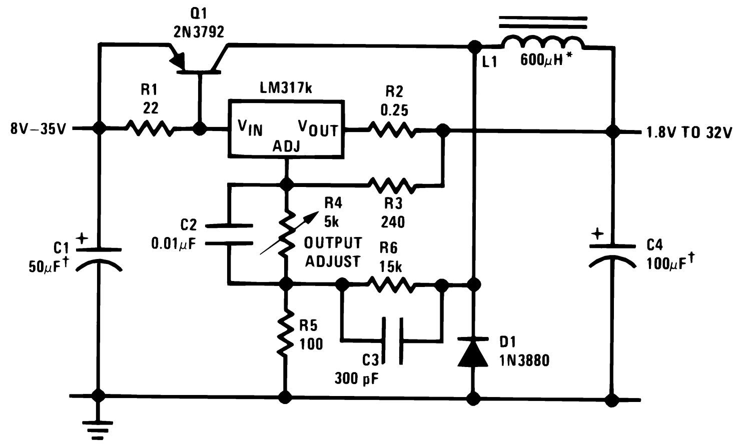
High Gain Amplifier



00906318

Typical Applications (Continued)

Low Cost 3A Switching Regulator

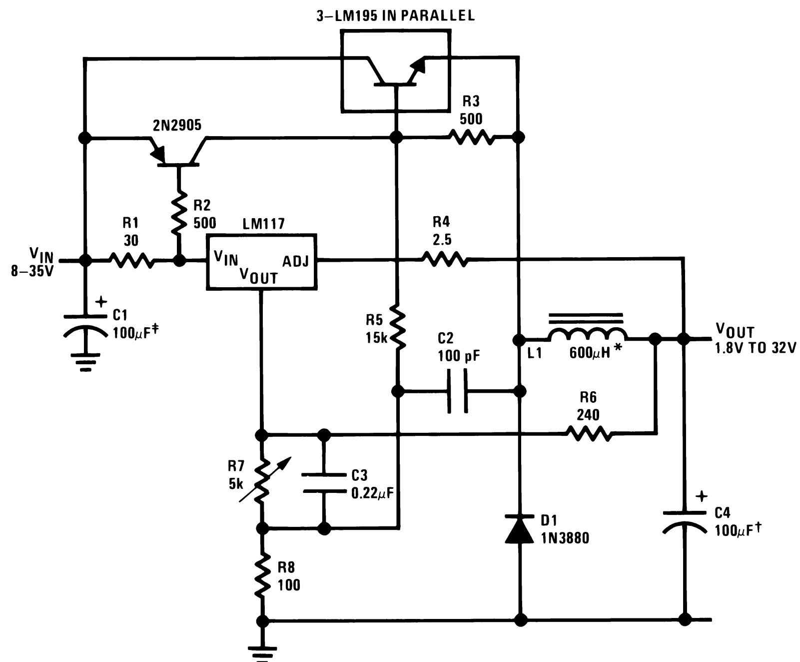


00906319

†Solid tantalum

*Core — Arnold A-254168-2 60 turns

4A Switching Regulator with Overload Protection

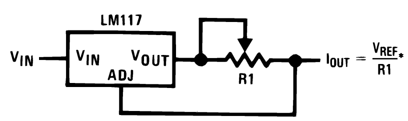


00906320

†Solid tantalum

*Core — Arnold A-254168-2 60 turns

Precision Current Limiter

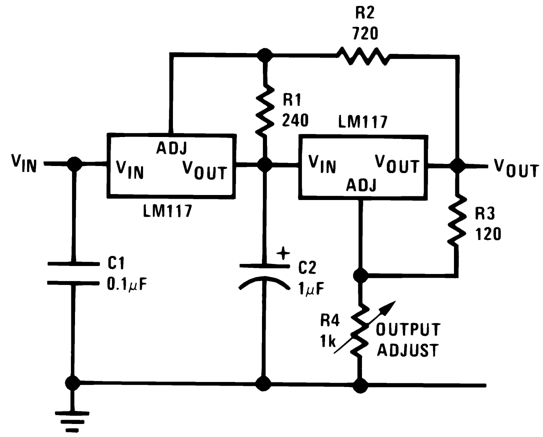


$*0.8\Omega \leq R1 \leq 120\Omega$

00906321

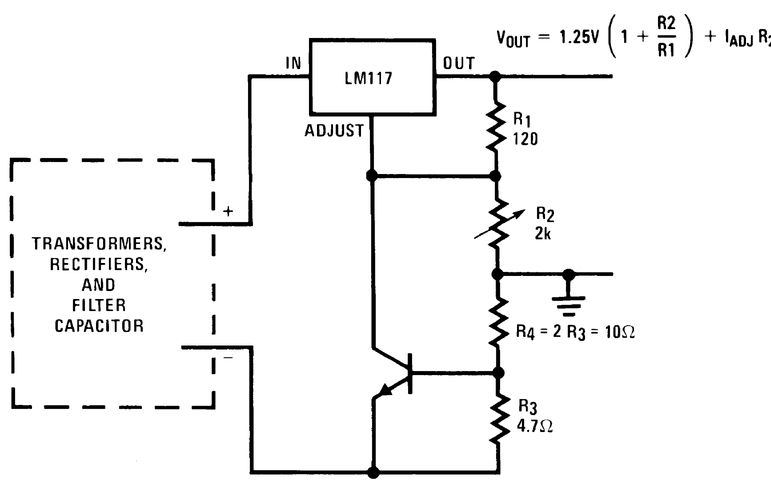
Typical Applications (Continued)

Tracking Preregulator



00906322

Current Limited Voltage Regulator



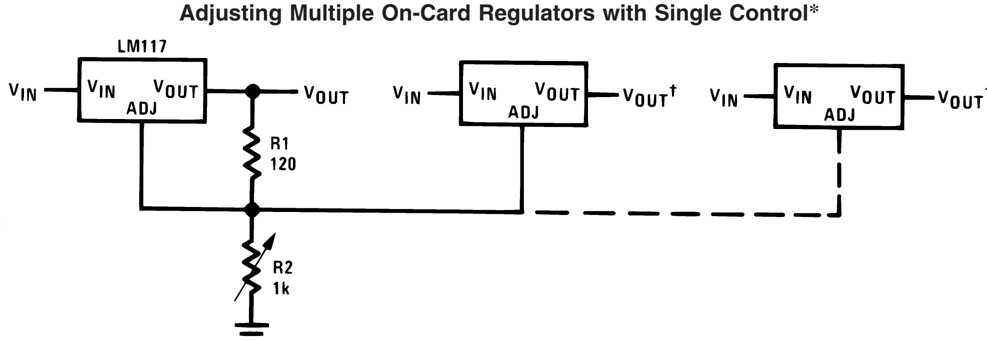
00906323

–Short circuit current is approximately $\frac{600\text{ mV}}{R3}$, or 120 mA

(Compared to LM117's higher current limit)

—At 50 mA output only ¾ volt of drop occurs in R_3 and R_4

Adjusting Multiple On-Card Regulators with Single Control*



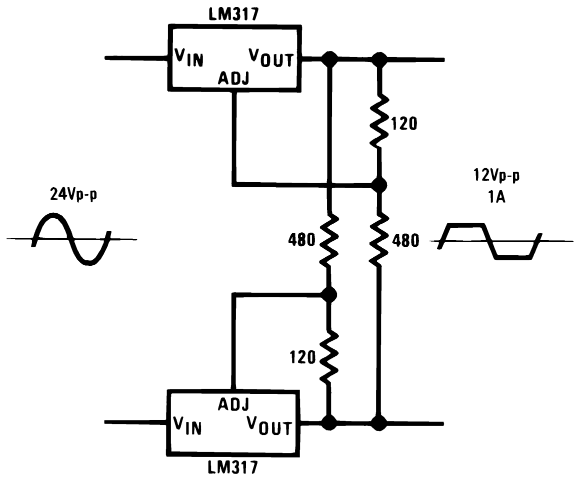
00906324

*All outputs within ±100 mV

†Minimum load—10 mA

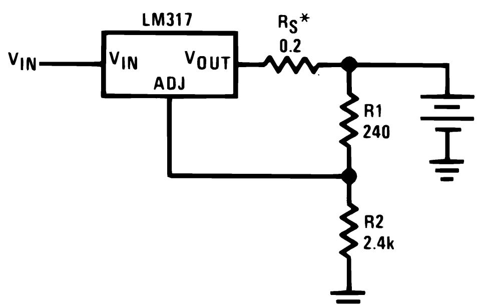
Typical Applications (Continued)

AC Voltage Regulator



00906325

12V Battery Charger

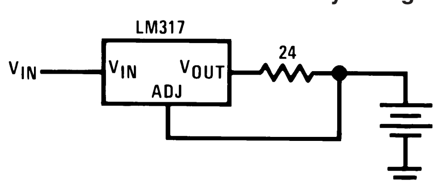


00906326

*R_S—sets output impedance of charger: $Z_{OUT} = R_S \left(1 + \frac{R2}{R1}\right)$

Use of R_S allows low charging rates with fully charged battery.

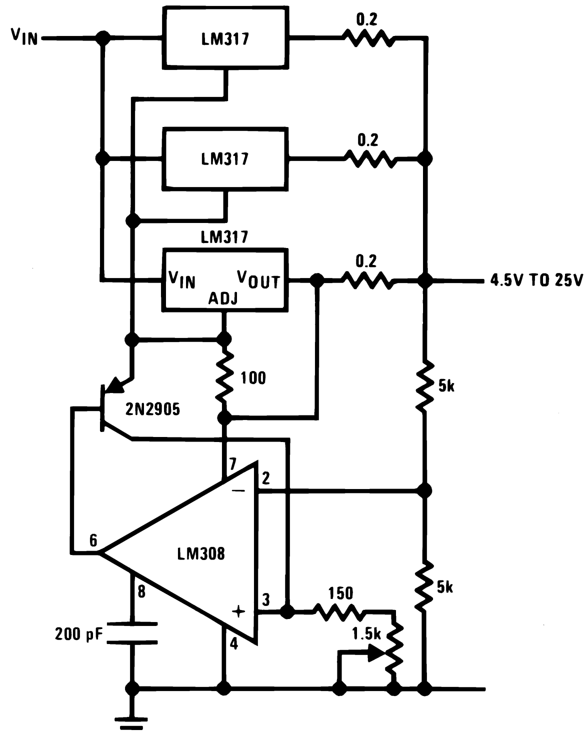
50mA Constant Current Battery Charger



00906327

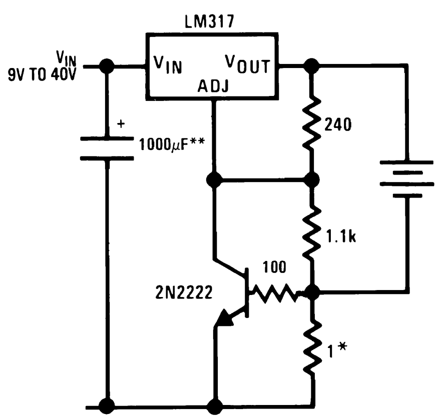
Typical Applications (Continued)

Adjustable 4A Regulator



00906328

Current Limited 6V Charger

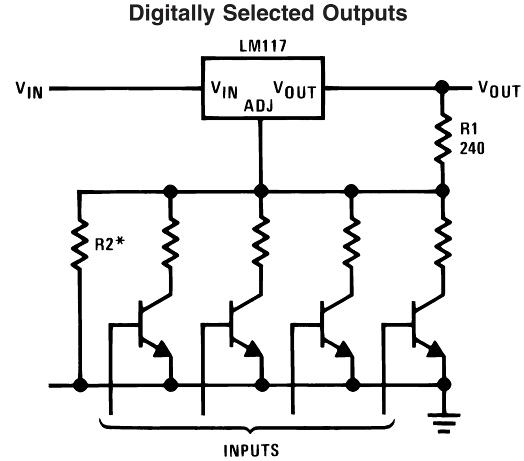


00906329

*Sets peak current (0.6A for 1Ω)

**The 1000μF is recommended to filter out input transients

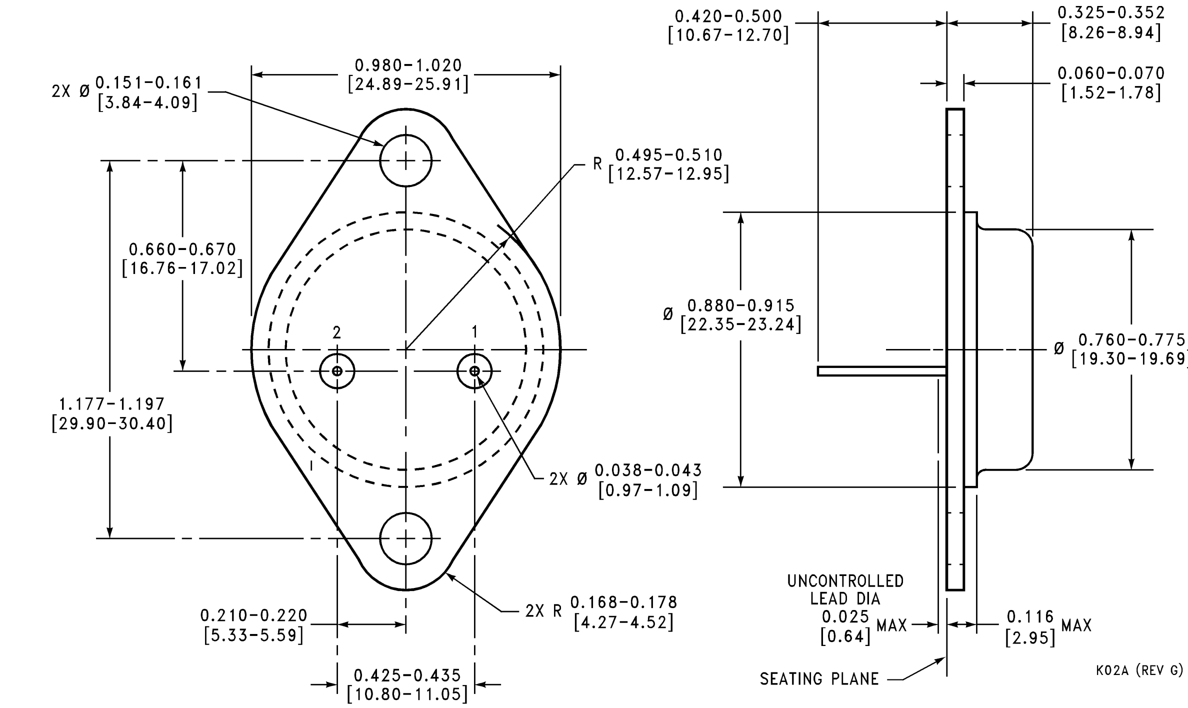
Digitally Selected Outputs



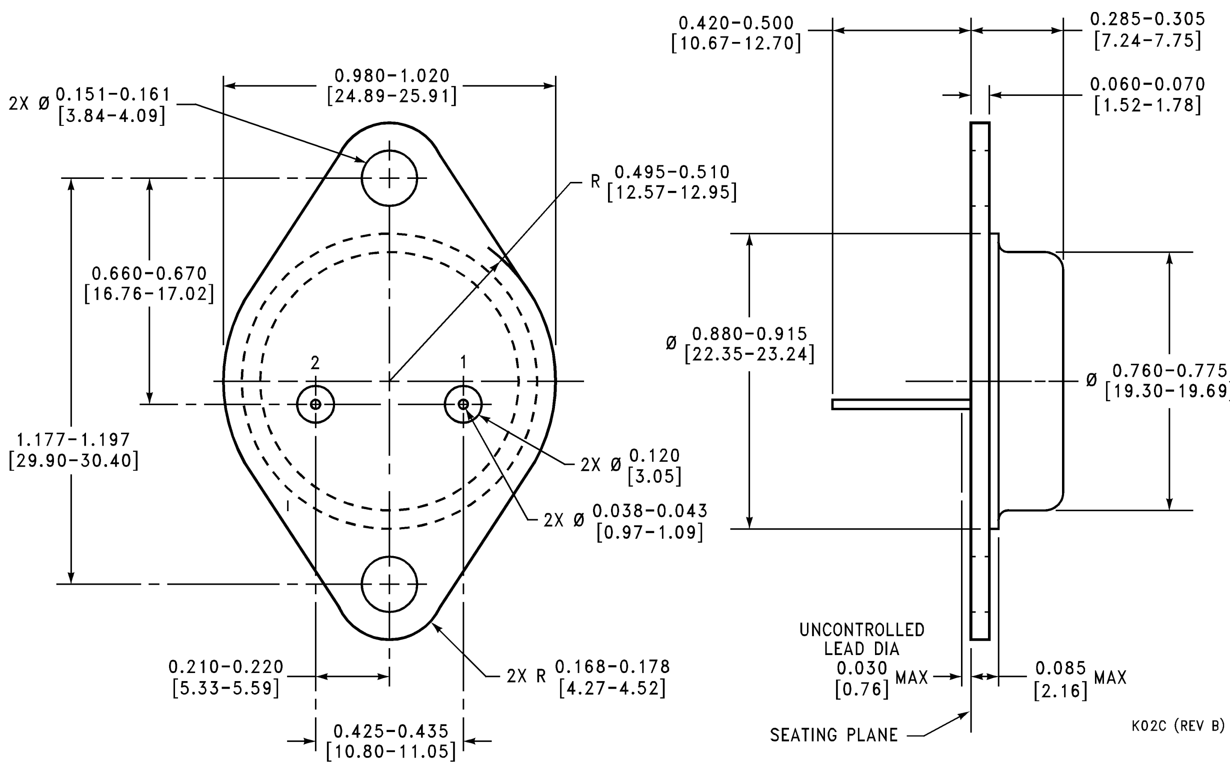
00906302

*Sets maximum V_{OUT}

Physical Dimensions inches (millimeters) unless otherwise noted

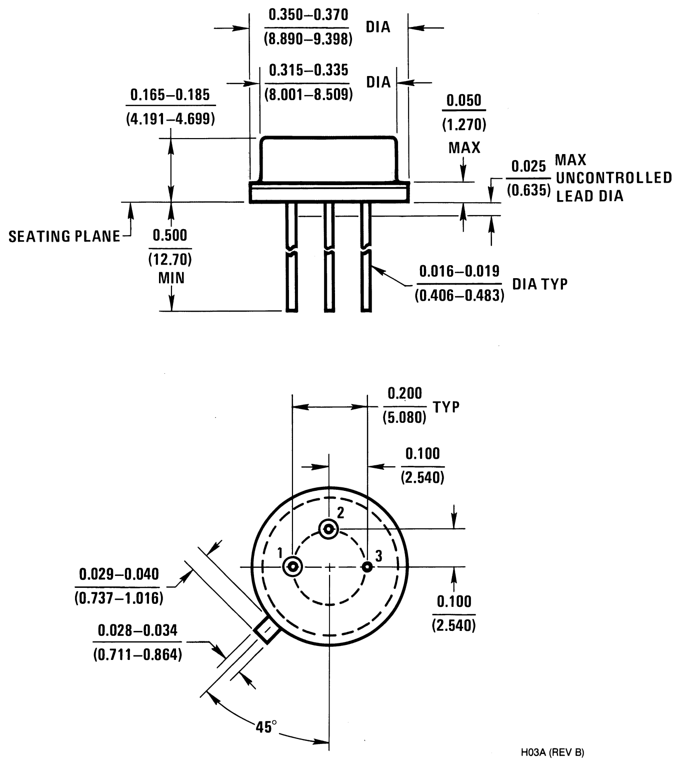


TO-3 Metal Can Package (K)
NS Package Number K02A

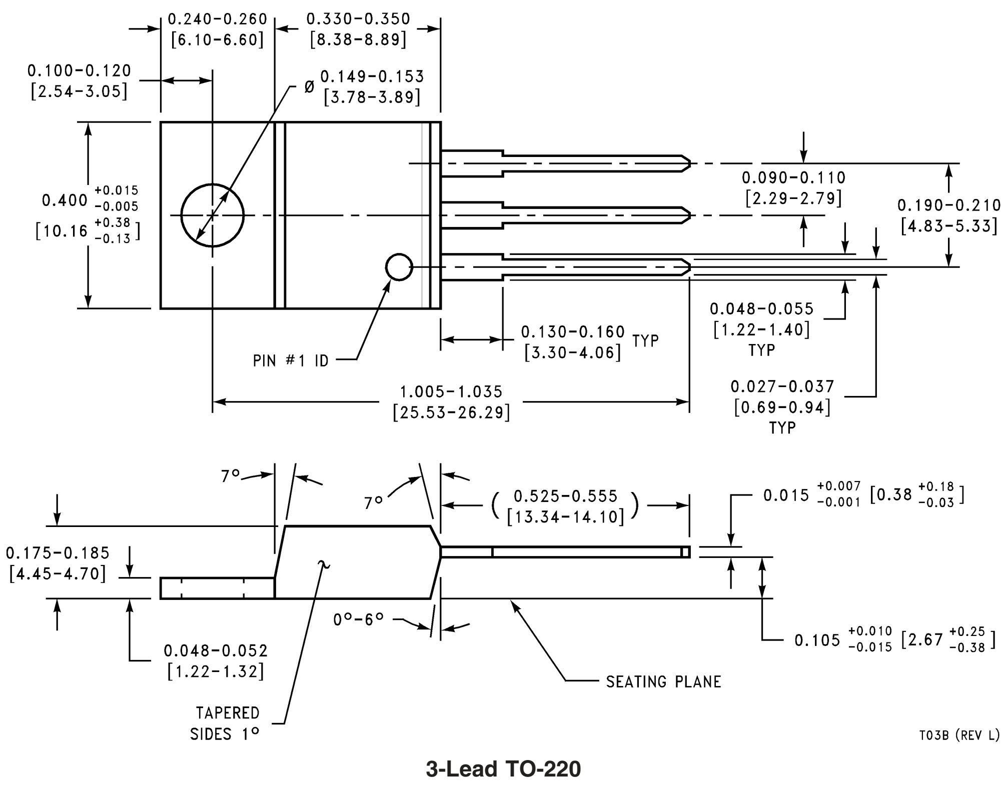


TO-3 Metal Can Package (K)
Mil-Aero Product
NS Package Number K02C

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

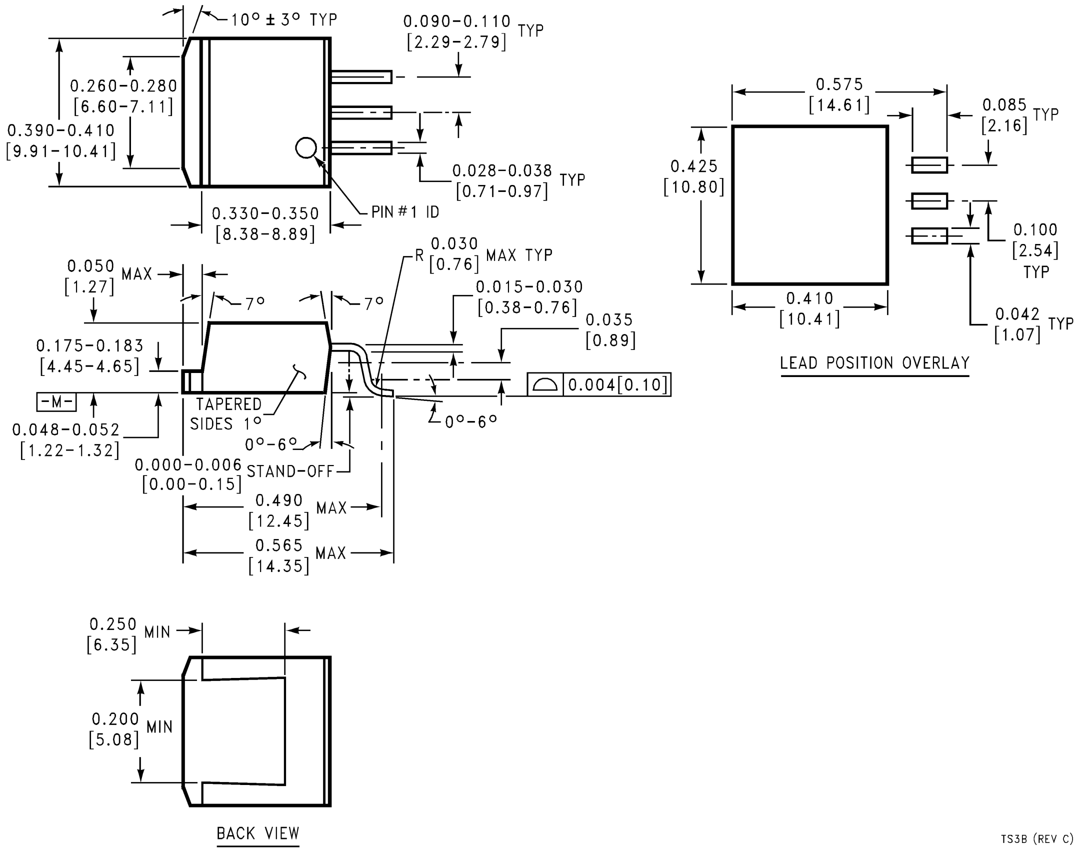


(TO-39) Metal Can Package
NS Package Number H03A



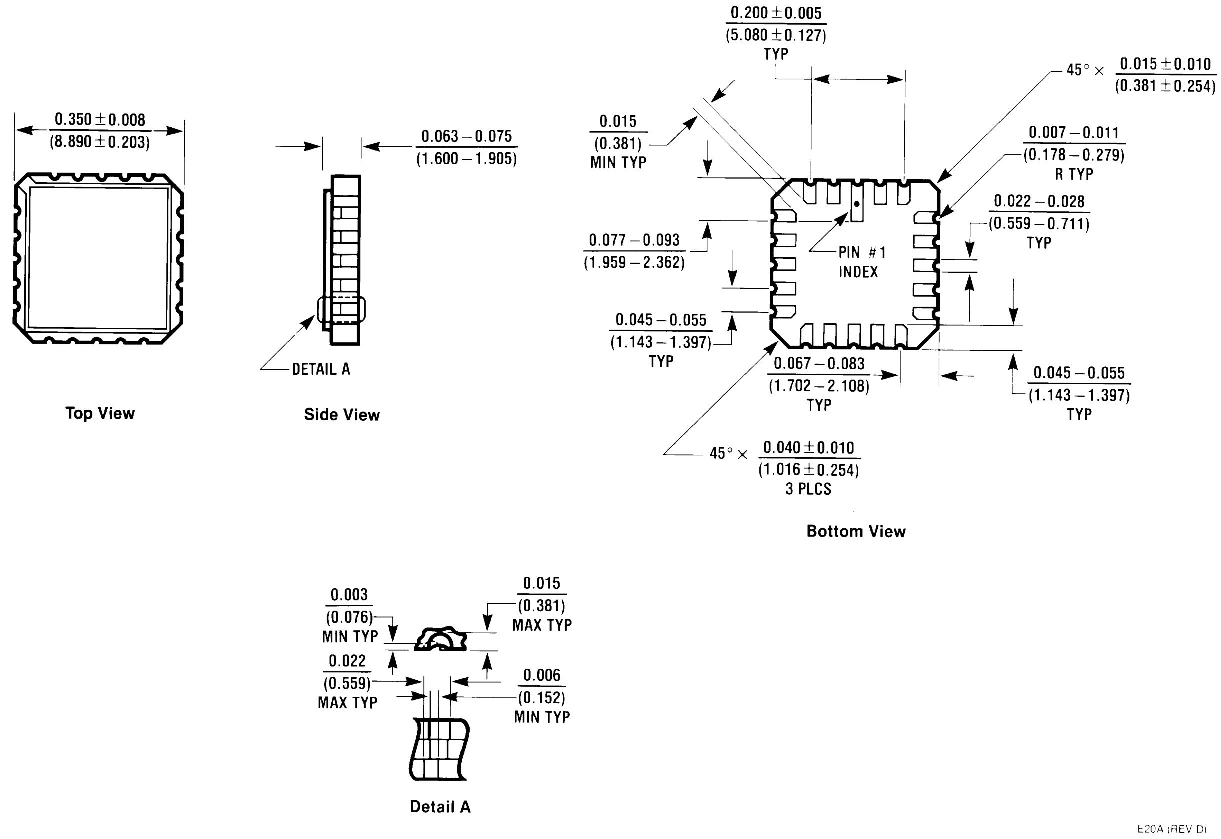
3-Lead TO-220
NS Package Number T03B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

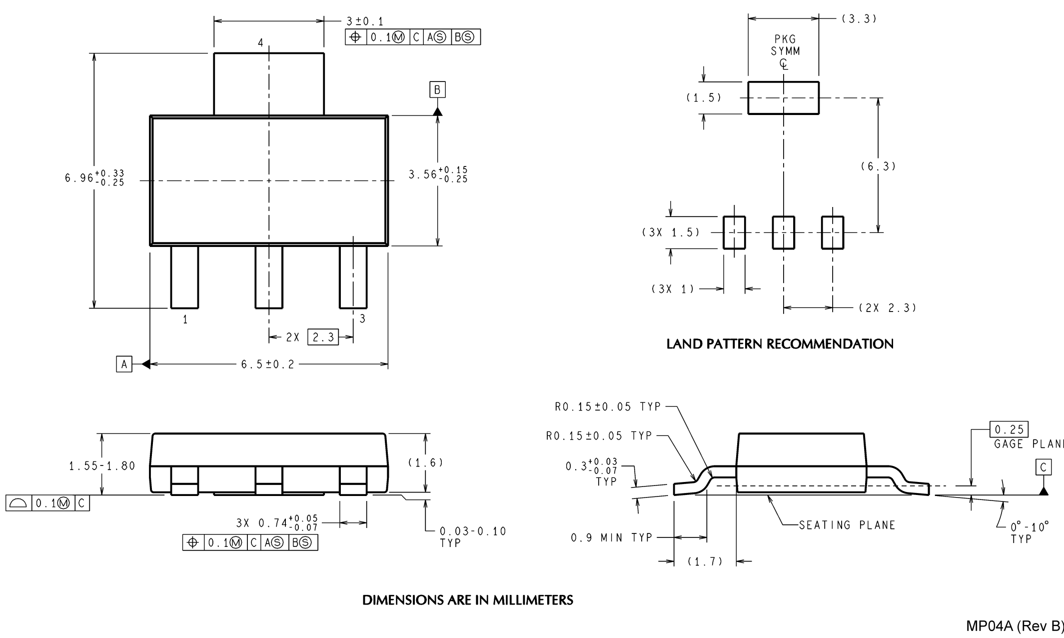


3-Lead TO-263
NS Package Number TS3B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

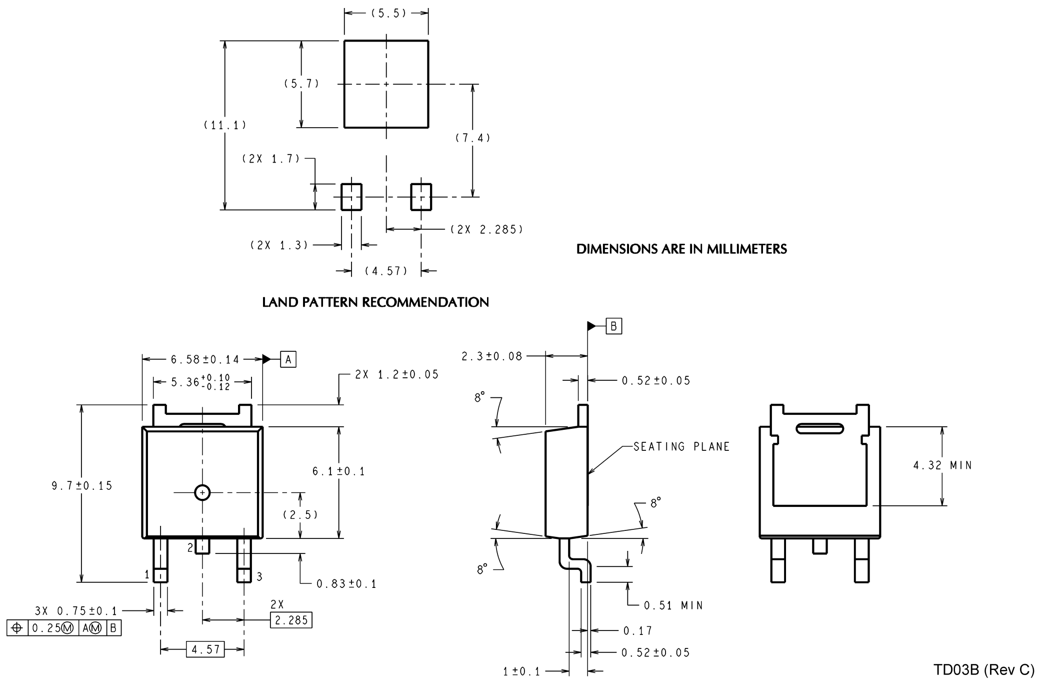


Ceramic Leadless Chip Carrier
NS Package Number E20A



4-Lead SOT-223
NS Package Number MP04A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



3-Lead D-Pack
NS Package Number TD03B

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Tel: 81-3-5639-7560

1.5 A Adjustable Output, Positive Voltage Regulator

LM317

THREE–TERMINAL ADJUSTABLE POSITIVE VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

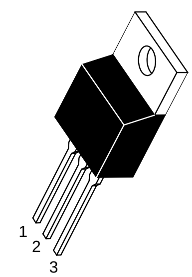
The LM317 is an adjustable 3–terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow–out proof.

The LM317 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 LM317 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
- Available in Surface Mount D^2PAK, and Standard 3–Lead Transistor Package
- Eliminates Stocking many Fixed Voltages

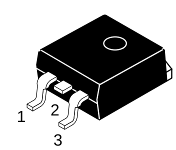
T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface connected to Pin 2.



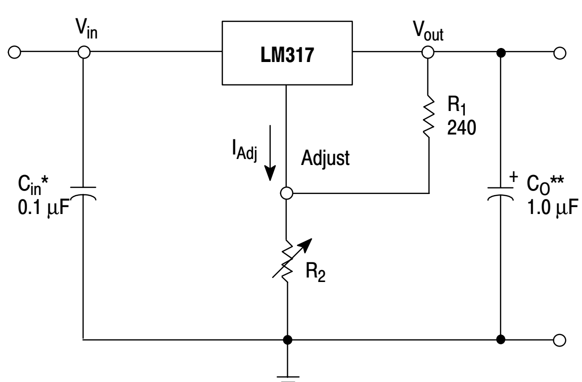
Pin 1. Adjust
2. V_{out}
3. V_{in}

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



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

Standard Application



* C_{in} is required if regulator is located an appreciable distance from power supply filter.
** C_O is not needed for stability, however, it does improve transient response.

$$V_{out} = 1.25\,V\left(1 + \frac{R_2}{R_1}\right) + I_{Adj}\,R_2$$

Since I_{Adj} is controlled to less than 100 µA, the error associated with this term is negligible in most applications.

ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM317BD2T	T_J = –40° to +125°C	Surface Mount
LM317BT		Insertion Mount
LM317D2T	T_J = 0° to +125°C	Surface Mount
LM317T		Insertion Mount

January, 2002 – Rev. 3
Publication Order Number:
LM317/D

MAXIMUM RATINGS

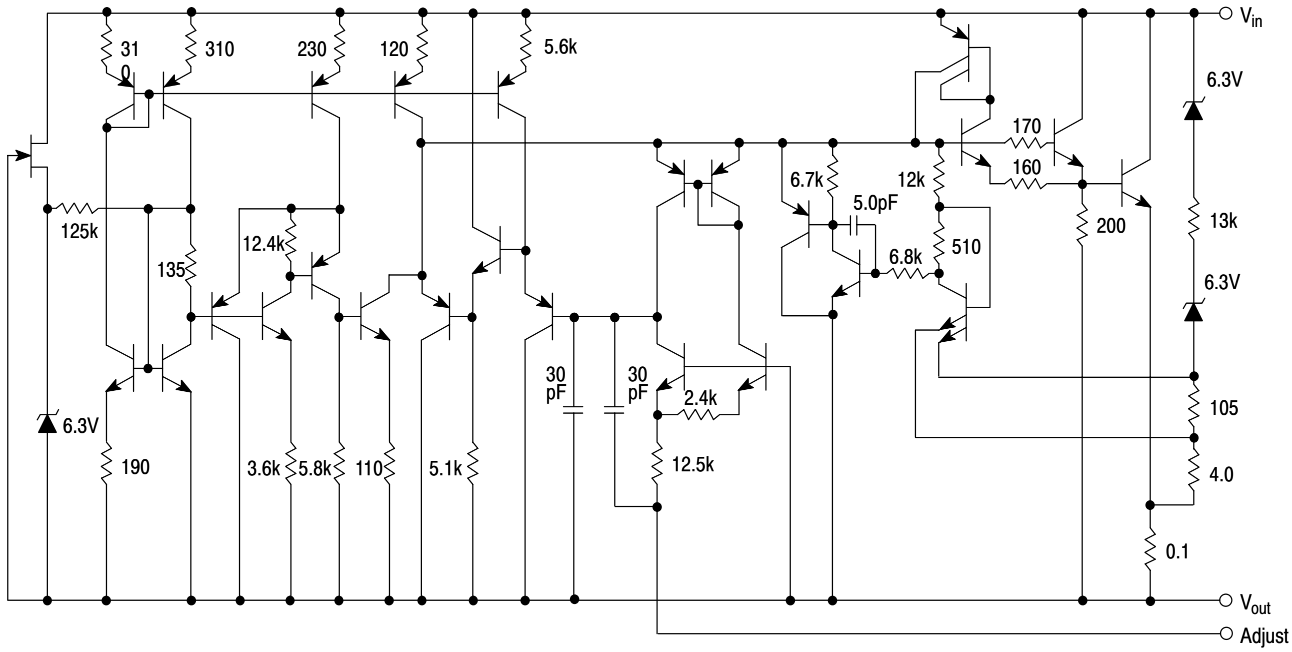
Rating	Symbol	Value	Unit
Input–Output Voltage Differential	V_I–V_O	40	Vdc
Power Dissipation			
Case 221A			
T_A = +25°C	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	θ_{JA}	65	°C/W
Thermal Resistance, Junction–to–Case	θ_{JC}	5.0	°C/W
Case 936 (D^2PAK)			
T_A = +25°C	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	θ_{JA}	70	°C/W
Thermal Resistance, Junction–to–Case	θ_{JC}	5.0	°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 D2T and T packages; T_J = T_{low} to T_{high} [Note 1]; I_{max} and P_{max} [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 ≤ I_{max}	2	Reg_{load}				
V_O ≤ 5.0 V			–	5.0	25	mV
V_O ≥ 5.0 V			–	0.1	0.5	% V_O
Thermal Regulation, T_A = +25°C (Note 6), 20 ms Pulse		Reg_{therm}	–	0.03	0.07	% V_O/W
Adjustment Pin Current	3	I_{Adj}	–	50	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}	1, 2	ΔI_{Adj}	–	0.2	5.0	μA
Reference Voltage, 3.0 V ≤ V_I–V_O ≤ 40 V, 10 mA ≤ I_O ≤ I_{max}, P_D ≤ P_{max}	3	V_{ref}	1.2	1.25	1.3	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}	2	Reg_{load}				
V_O ≤ 5.0 V			–	20	70	mV
V_O ≥ 5.0 V			–	0.3	1.5	% V_O
Temperature Stability (T_{low} ≤ T_J ≤ T_{high})	3	T_S	–	0.7	–	% V_O
Minimum Load Current to Maintain Regulation (V_I–V_O = 40 V)	3	I_{Lmin}	–	3.5	10	mA
Maximum Output Current	3	I_{max}				A
V_I–V_O ≤ 15 V, P_D ≤ $P_{max,}$ T Package			1.5	2.2	–	
V_I–V_O = 40 V, P_D ≤ P_{max}, T_A = +25°C, T Package			0.15	0.4	–	
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)	4	RR				dB
Without C_{Adj}			–	65	–	
C_{Adj} = 10 μF			66	80	–	
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		$R_{\theta JC}$	–	5.0	–	°C/W

NOTES:
1. T_{low} to T_{high} = 0° to +125°C, for LM317T, D2T. T_{low} to T_{high} = –40° to +125°C, for LM317BT, BD2T.
2. I_{max} = 1.5 A, P_{max} = 20 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.
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.

Representative Schematic Diagram



This device contains 29 active transistors.

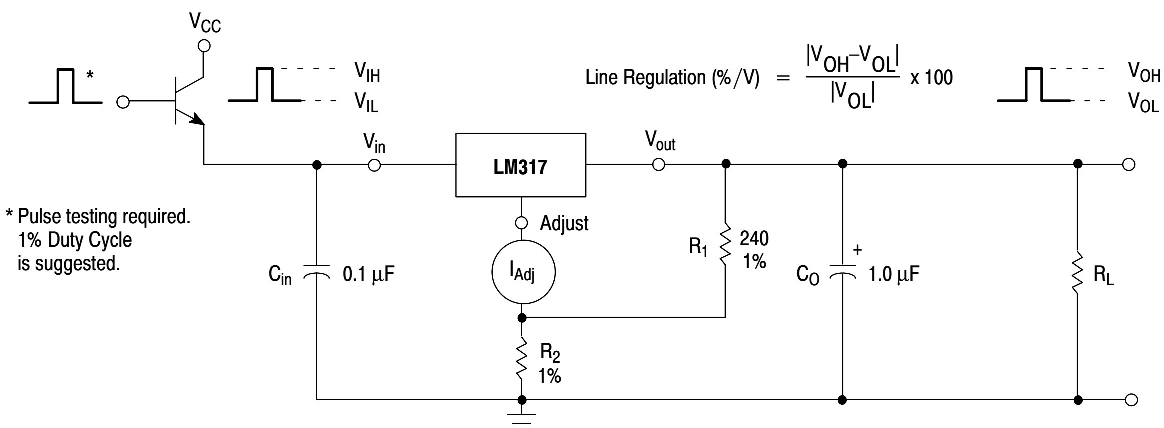
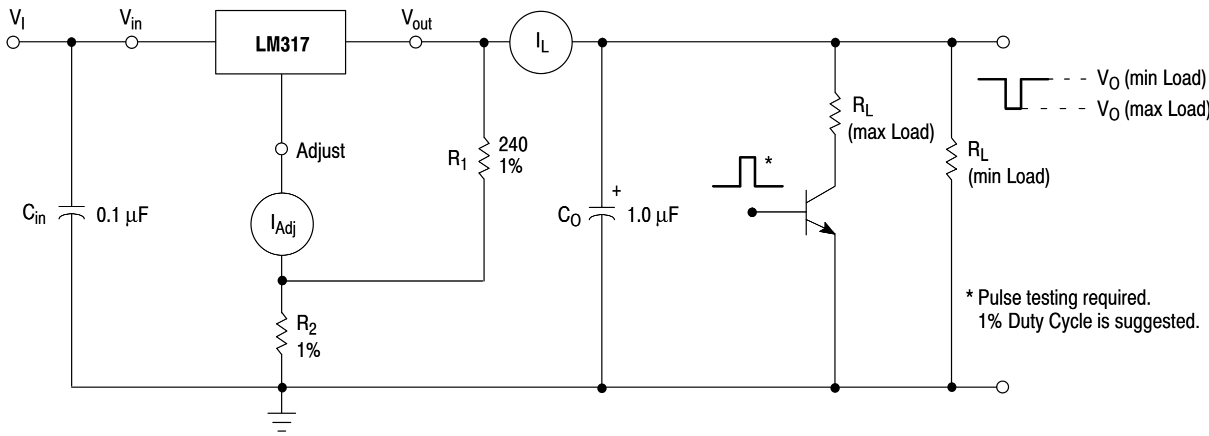


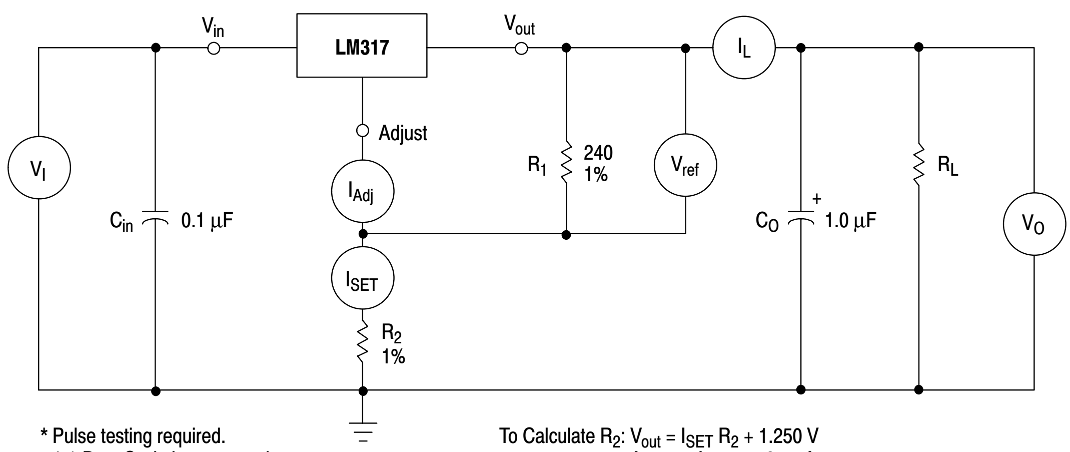
Figure 1. Line Regulation and ΔI_{Adj}/Line Test Circuit



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

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

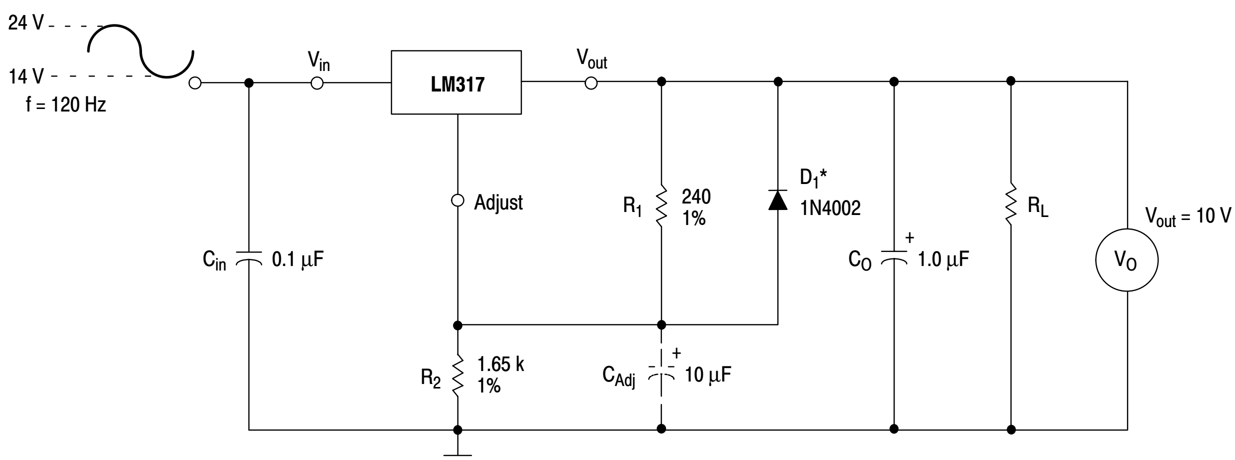
Figure 2. Load Regulation and ΔI_{Adj}/Load Test Circuit



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

To Calculate R_2: $V_{out} = I_{SET} R_2 + 1.250$ V
Assume $I_{SET} = 5.25$ mA

Figure 3. Standard Test Circuit



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

Figure 4. Ripple Rejection Test Circuit

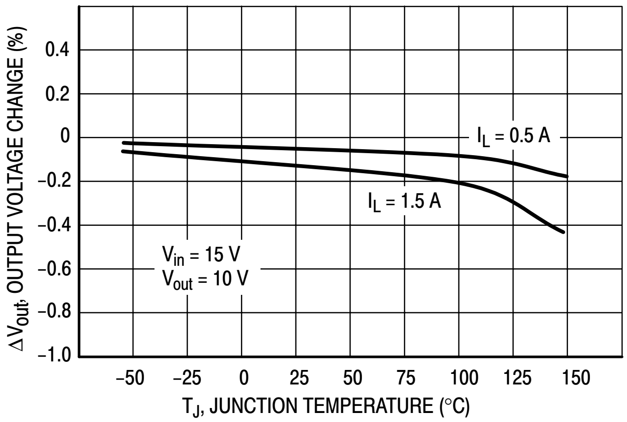


Figure 5. Load Regulation

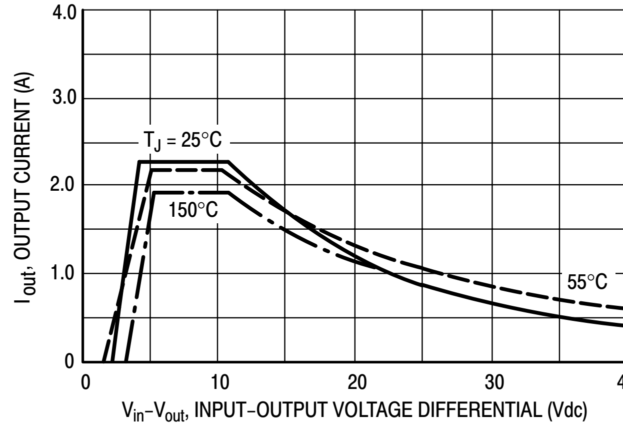


Figure 6. Current Limit

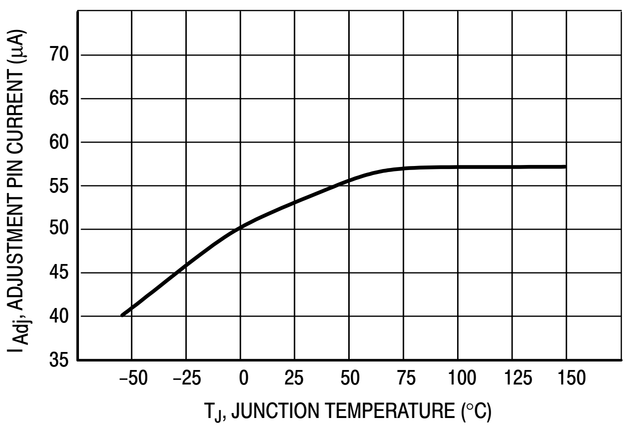


Figure 7. Adjustment Pin Current

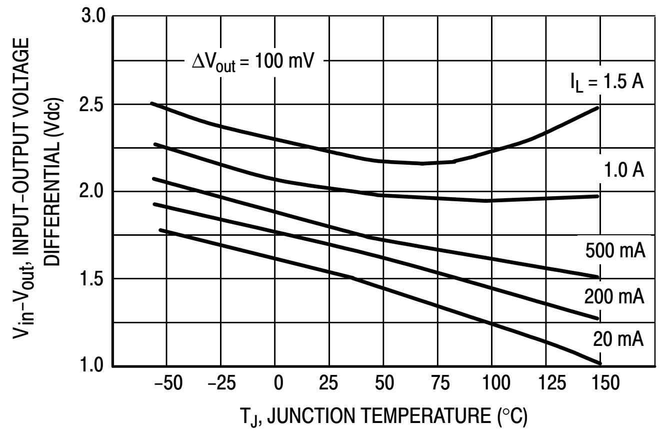


Figure 8. Dropout Voltage

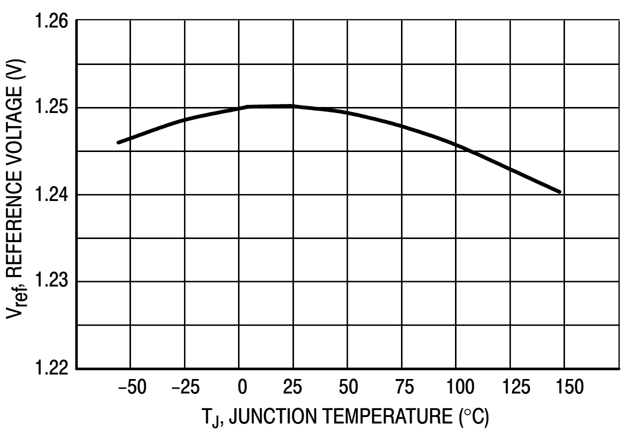


Figure 9. Temperature Stability

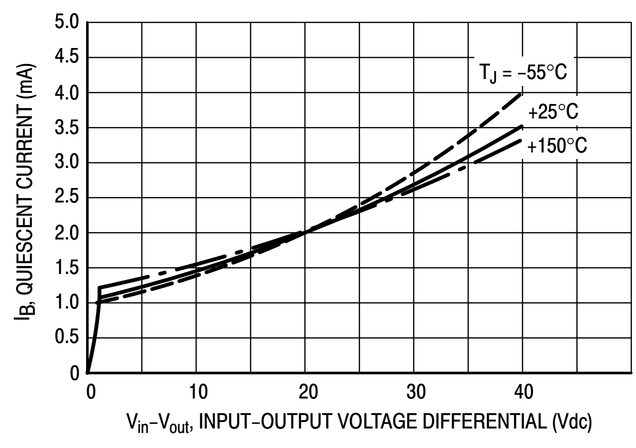


Figure 10. Minimum Operating Current

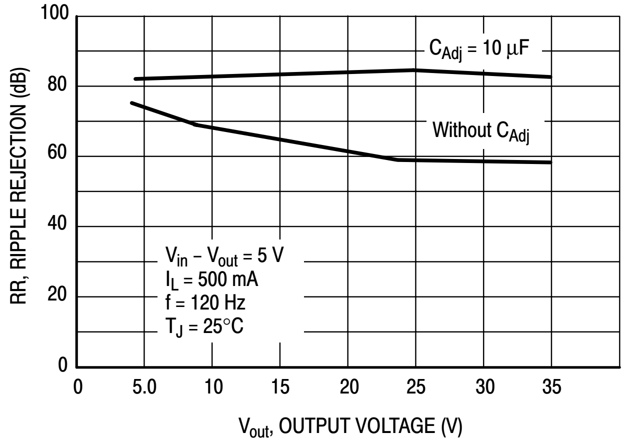


Figure 11. Ripple Rejection versus Output Voltage

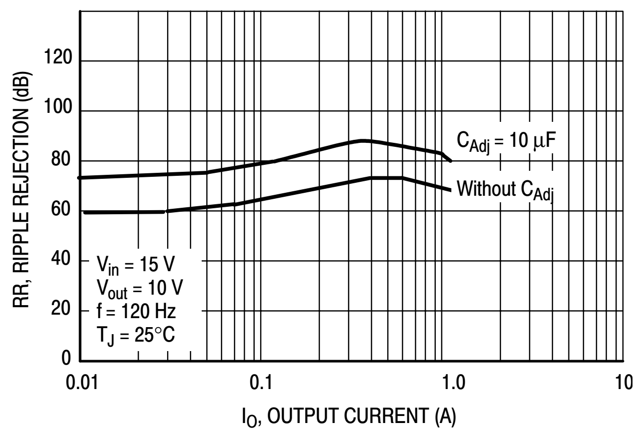


Figure 12. Ripple Rejection versus Output Current

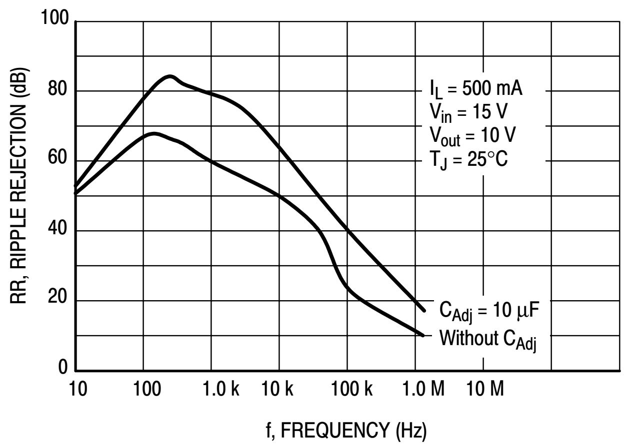


Figure 13. Ripple Rejection versus Frequency

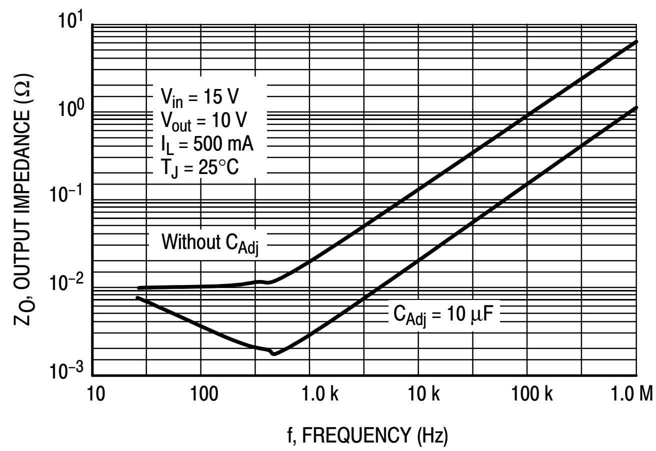


Figure 14. Output Impedance

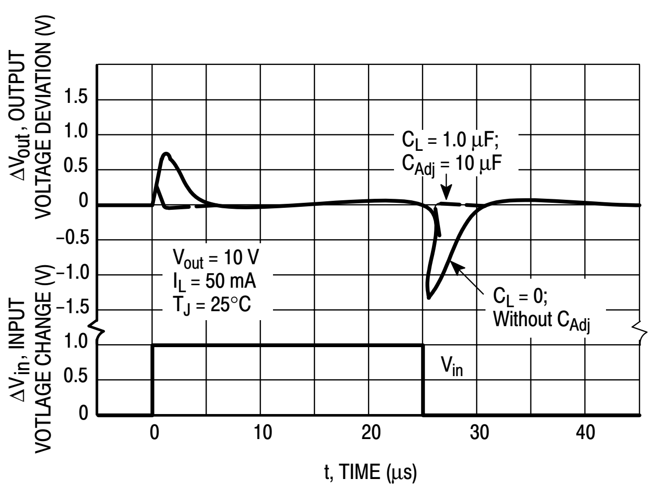


Figure 15. Line Transient Response

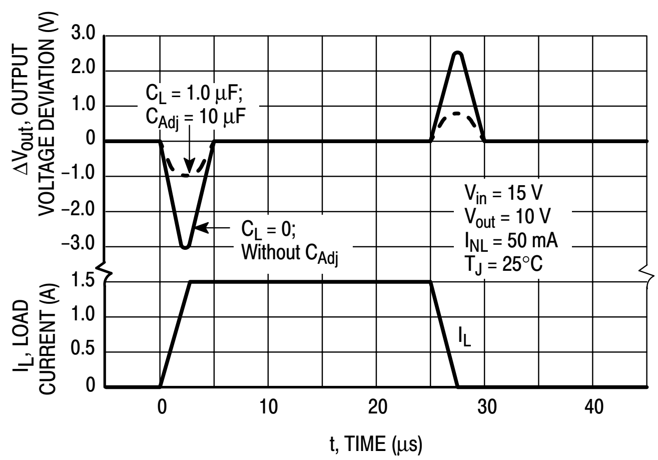


Figure 16. Load Transient Response

APPLICATIONS INFORMATION

Basic Circuit Operation

The LM317 is a 3–terminal floating regulator. In operation, the LM317 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:

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

Since the current from the adjustment terminal (I_{Adj}) represents an error term in the equation, the LM317 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 LM317 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.

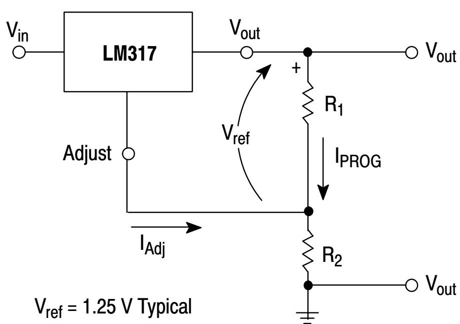


Figure 17. Basic Circuit Configuration

Load Regulation

The LM317 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 0.1 μF disc or 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.

Although the LM317 is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output capacitance (C_O) in the form of a 1.0 μF tantalum or 25 μF aluminum electrolytic capacitor on the output swamps this effect and insures 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 LM317 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.

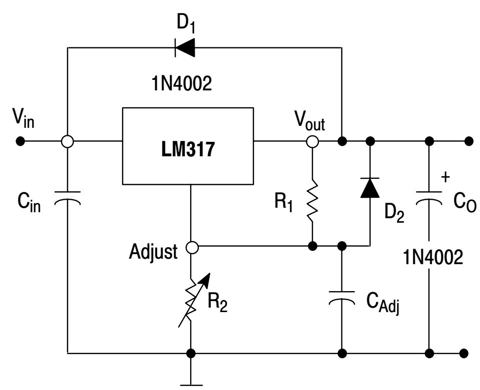


Figure 18. Voltage Regulator with Protection Diodes

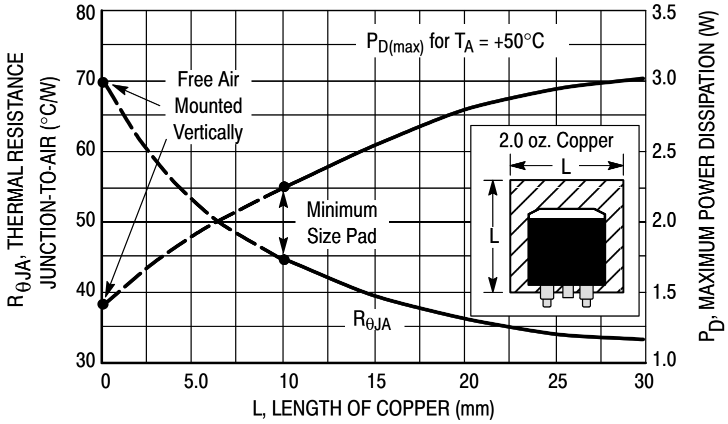


Figure 19. D2PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

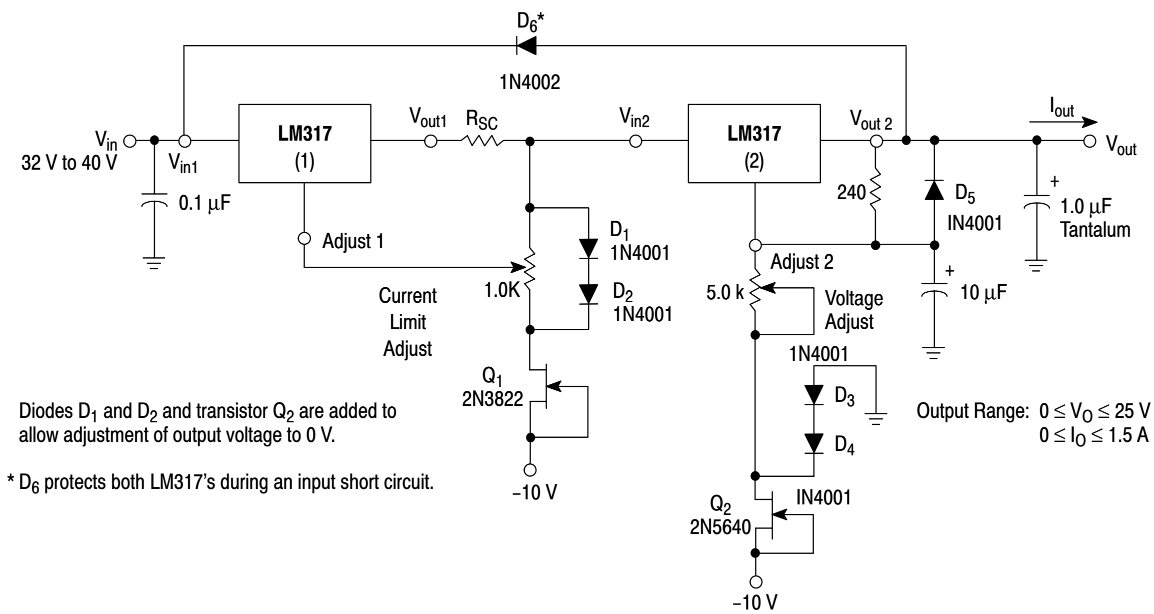


Figure 20. "Laboratory" Power Supply with Adjustable Current Limit and Output Voltage

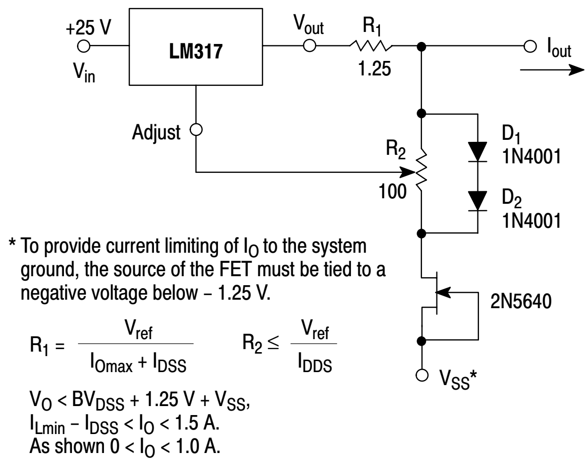


Figure 21. Adjustable Current Limiter

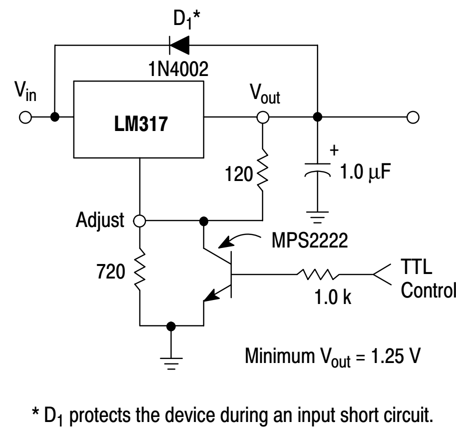


Figure 22. 5.0 V Electronic Shutdown Regulator

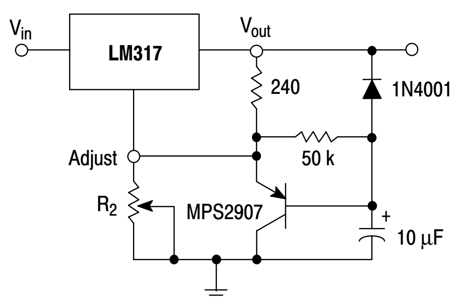


Figure 23. Slow Turn–On Regulator

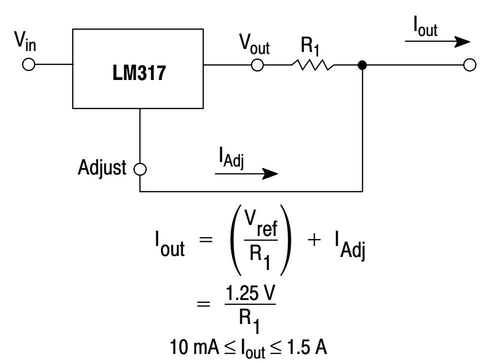
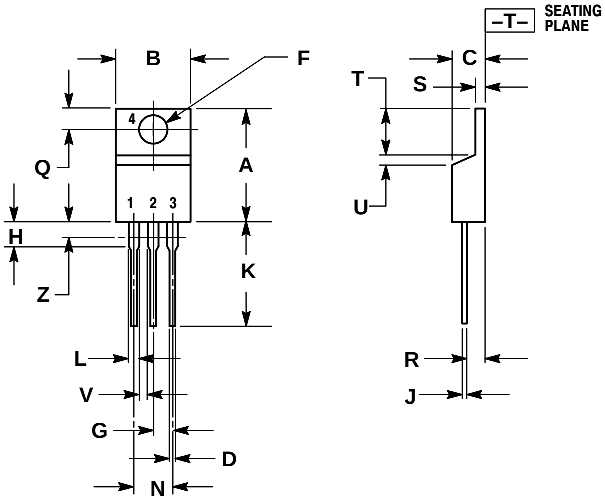


Figure 24. Current Regulator

PACKAGE DIMENSIONS

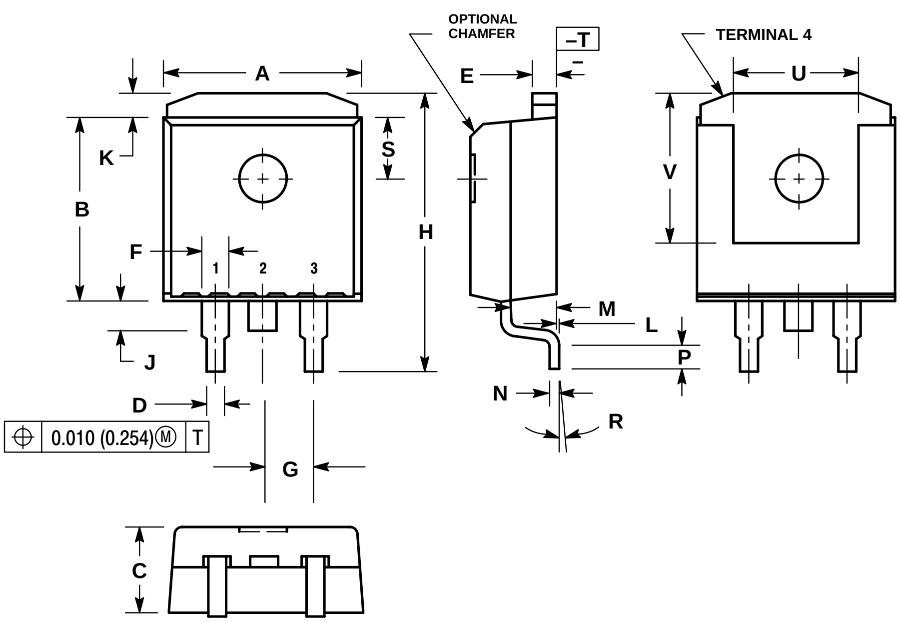
T SUFFIX
PLASTIC PACKAGE
CASE 221A–09
ISSUE AA



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

D2T SUFFIX
PLASTIC PACKAGE
CASE 936–03
(D^2PAK)
ISSUE B



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.

	INCHES		MILLIMETERS	
DIM	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	

Notes

PUBLICATION ORDERING INFORMATION

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For additional information, please contact your local Sales Representative.

LM317(LM317AT-ND), стабилизатор с регулируемым выходным напряжением в цепи положительного полюса (расположение выводов смотрите на рисунке) - PT# 92448-ND

D1 - 1N4002, 1 А, 200 В, (соблюдайте полярность при установке) - PT# 1N4002GICT-ND

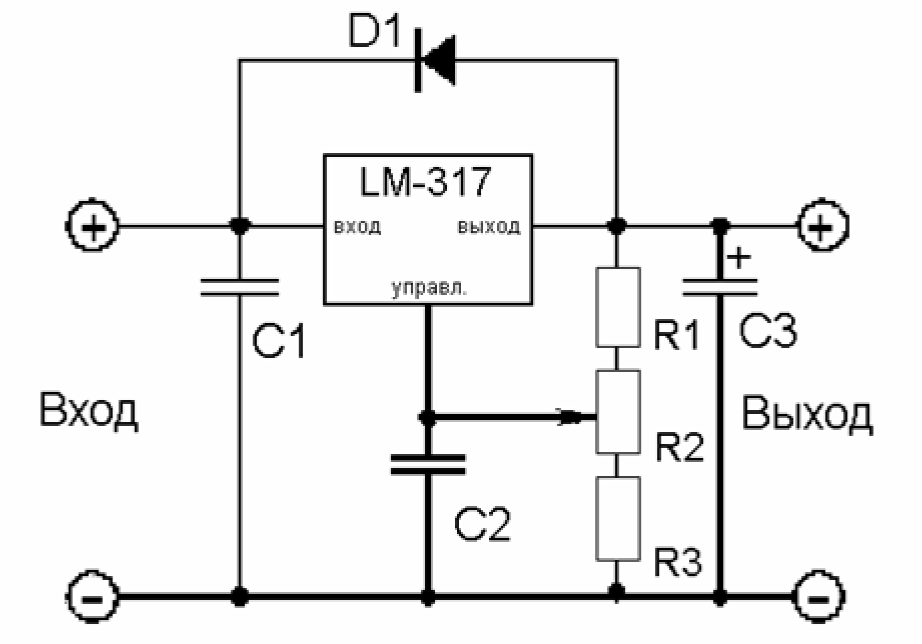
R1, R3 – Точные значения сопротивлений могут быть получены расчётным путём. Для большей стабильности использованы прецизионные проволочные резисторы. Если точность и стабильность получаемого напряжения Вас удовлетворяют, можно использовать резисторы других типов. - PT# SC1A(номинал)-ND или SC3D(номинал)-ND.

R2 - подстроечный резистор, например, типа Bourns 3059P, номинал зависит от диапазона перестройки и величины выходного напряжения Vo (см. расчёт). - PT# 3059P(номинал)-ND. Примечание: в качестве переменного резистора можно применить и недорогие их типы с небольшой потерей в стабильности и удобстве настройки.

C1 – 0,1 мкФ, 50 В минимально, монолитный керамический - PT# P4887-ND
C2 - 220 пФ, 50 В минимально, монолитный керамический - PT# P4804-ND
C3 - 2,2 мкФ, 50 В оксидный (соблюдайте полярность при установке) - PT# P6790-ND

Стеклотекстолитовая плата с отверстиями (PerfBoard) – может быть приобретена в Digi-Key. Manufacturers: Vector Co. или Keystone. Размер платы 4.5 x 6.5 дюймов (можно разместить 3 и более стабилизаторов) - PT# V1043.

Радиатор: хорошим источником радиаторов является “сдохший” компьютерный монитор. Digi-Key также поставляет литые радиаторы Aavid. Размер радиаторов зависит от нагрева ИС, тока нагрузки и температуры внутри корпуса БП с ИС. У тех же производителей можно “разжиться” теплопроводной пастой.



Order this document by LM337/D

MOTOROLA

LM337

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.

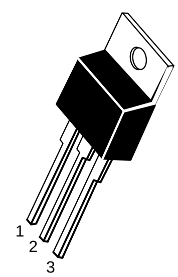
- Output Current in Excess of 1.5 A
- Output Adjustable between –1.2 V and –37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe–Area Compensation
- Floating Operation for High Voltage Applications
- Eliminates Stocking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

THREE–TERMINAL ADJUSTABLE NEGATIVE VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

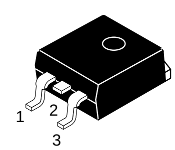
T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface connected to Pin 2.



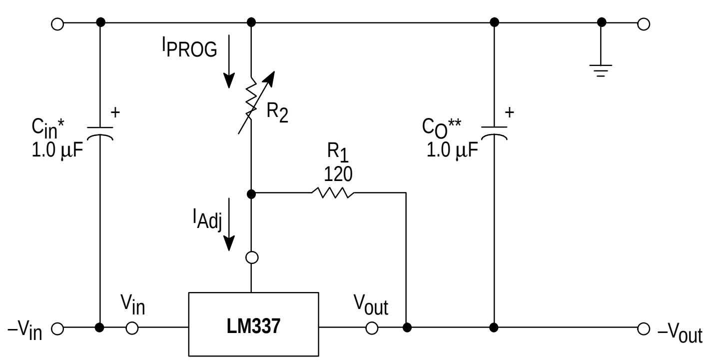
Pin 1. Adjust
2. V_{in}
3. V_{out}

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



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

Standard Application



*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 recommeded.

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

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

MAXIMUM RATINGS

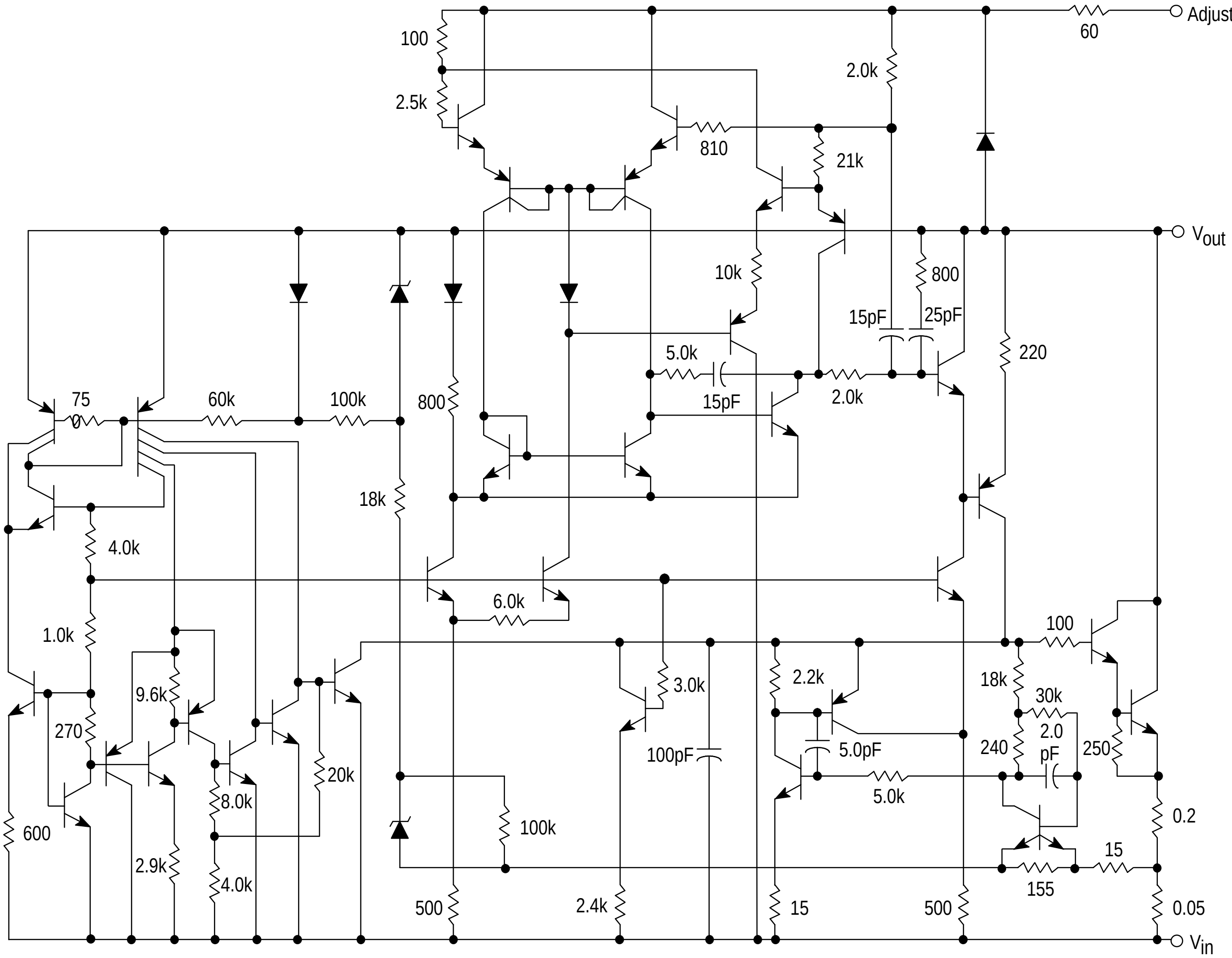
Rating	Symbol	Value	Unit
Input–Output Voltage Differential	$V_I–V_O$	40	Vdc
Power Dissipation Case 221A T_A = +25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case Case 936 (D^2PAK) T_A = +25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case	 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.

Representative Schematic Diagram



This device contains 39 active transistors.

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

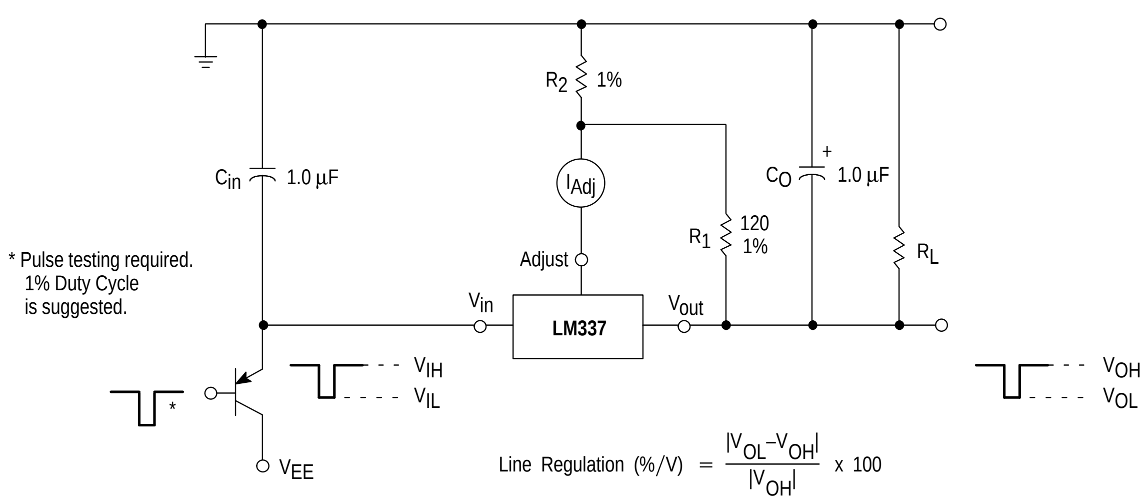
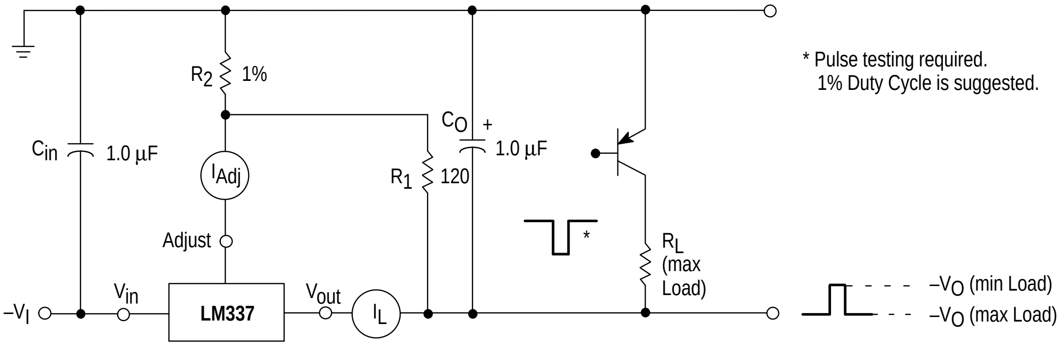


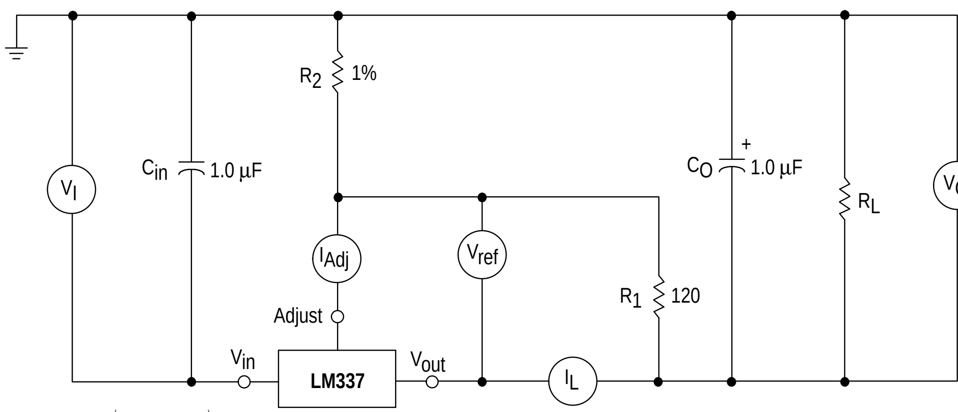
Figure 2. Load Regulation and ΔI_{Adj}/Load Test Circuit



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

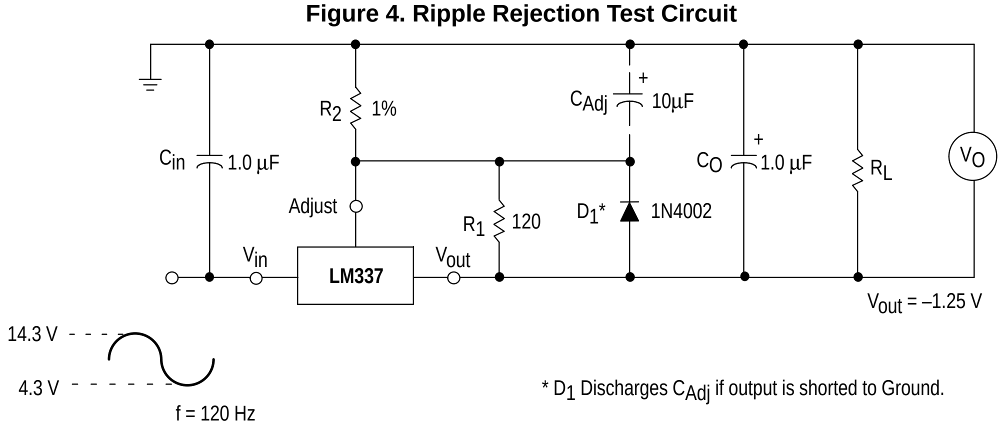


To Calculate R_2: $R_2 = \left(\frac{V_O}{V_{ref}} - 1\right) R_1$

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

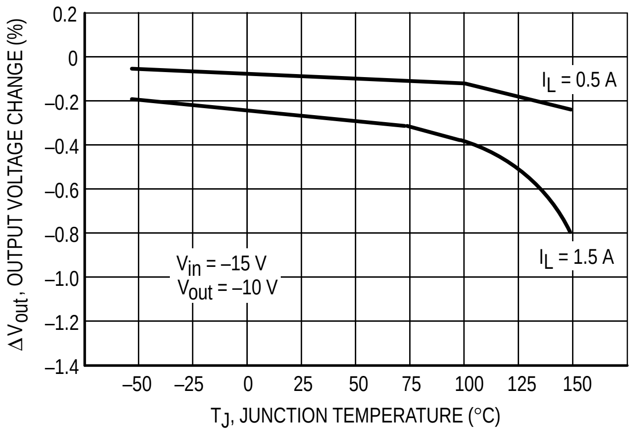


Figure 6. Current Limit

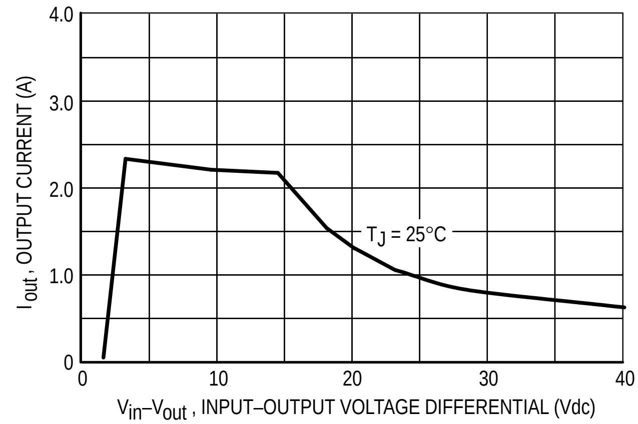


Figure 7. Adjustment Pin Current

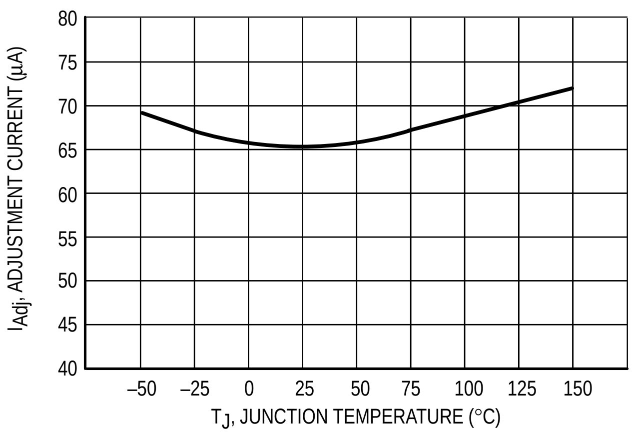


Figure 8. Dropout Voltage

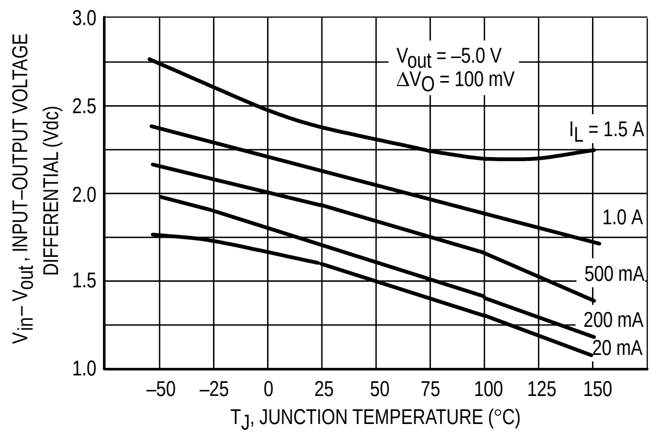


Figure 9. Temperature Stability

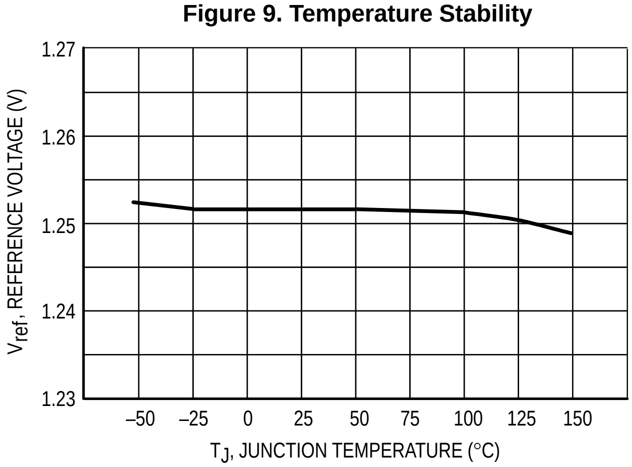


Figure 10. Minimum Operating Current

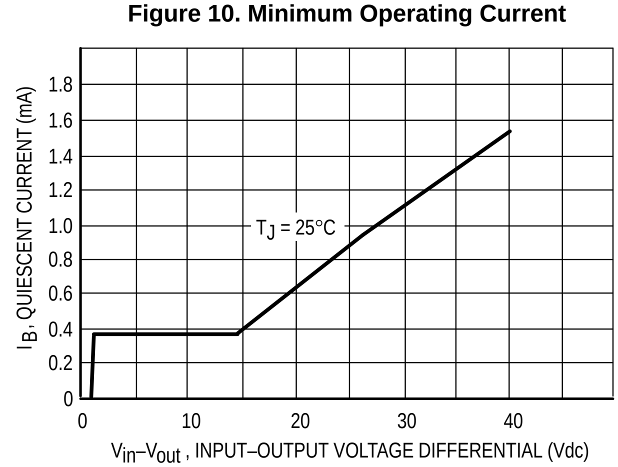


Figure 11. Ripple Rejection versus Output Voltage

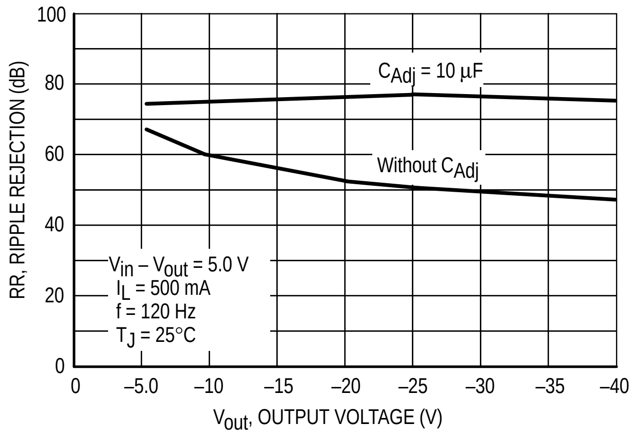


Figure 12. Ripple Rejection versus Output Current

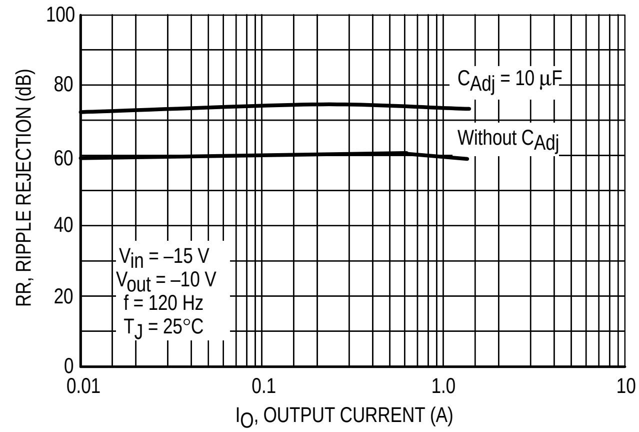


Figure 13. Ripple Rejection versus Frequency

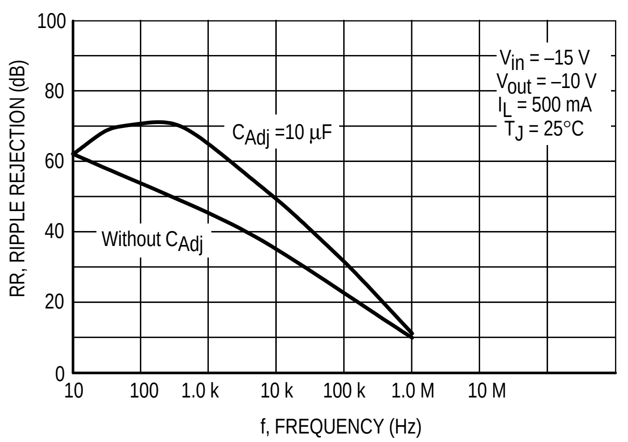


Figure 14. Output Impedance

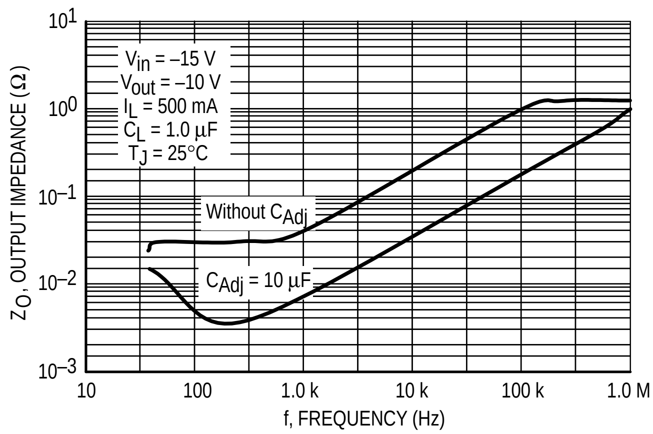


Figure 15. Line Transient Response

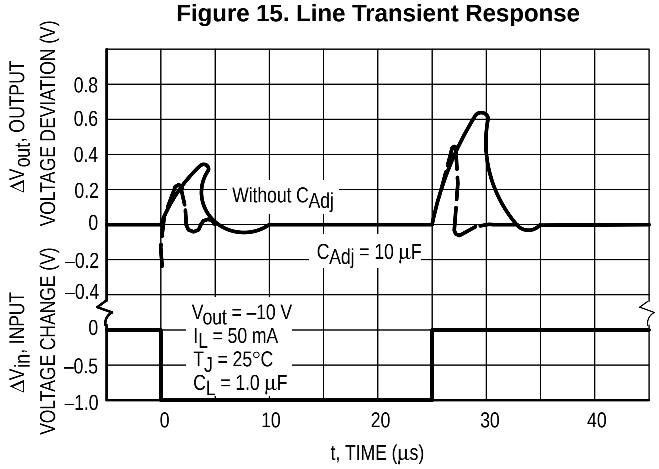
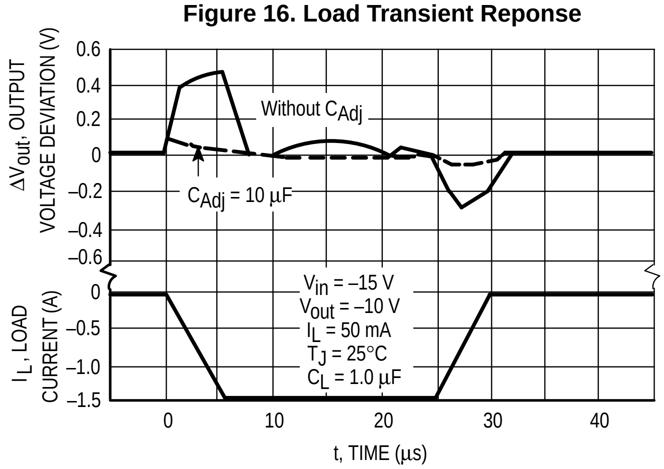


Figure 16. Load Transient Reponse



APPLICATIONS INFORMATION

Basic Circuit Operation

The 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.

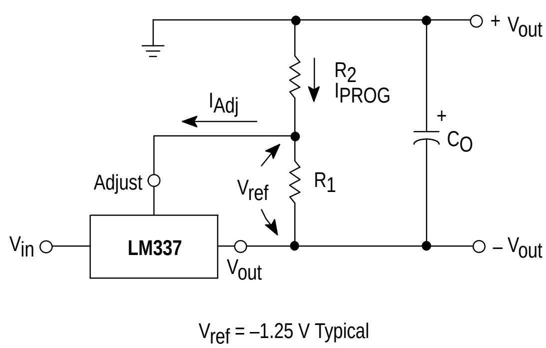
The regulated output voltage is given by:

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

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



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

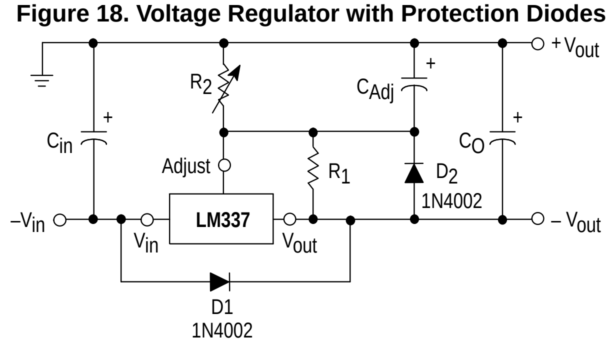
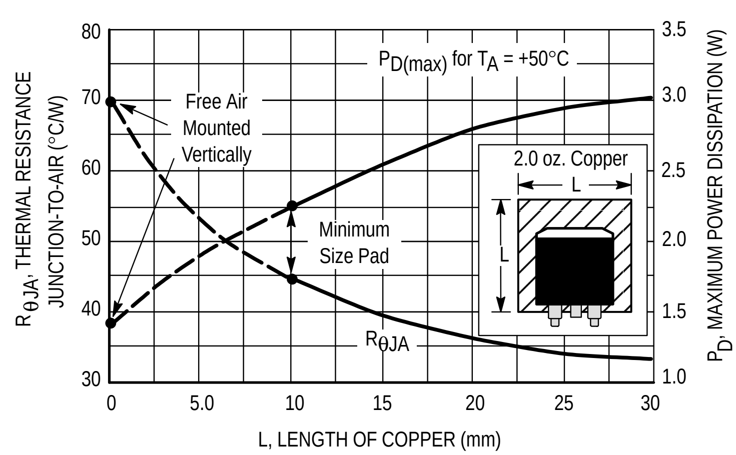
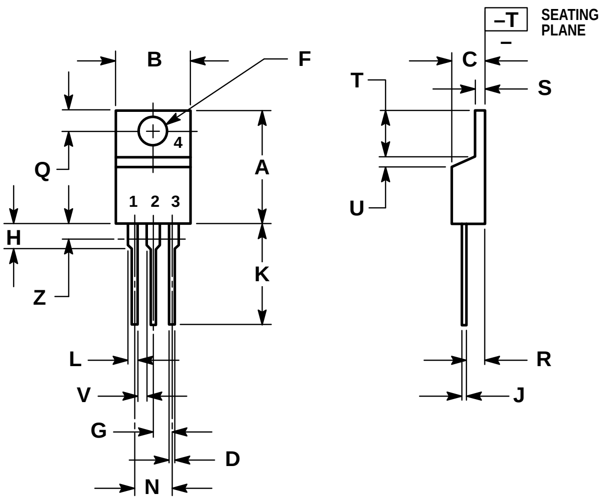


Figure 19. D2PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length



OUTLINE DIMENSIONS

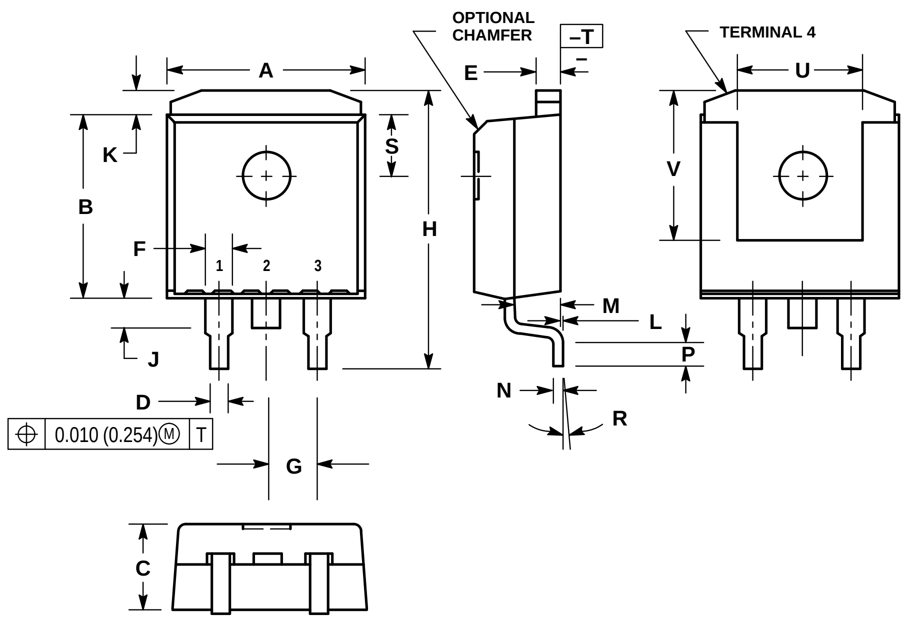
T SUFFIX
PLASTIC PACKAGE
CASE 221A–06
ISSUE Y



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
(D^2PAK)
ISSUE B



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	

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