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Jameco Part Number 898800

National Semiconductor

June 2006

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.

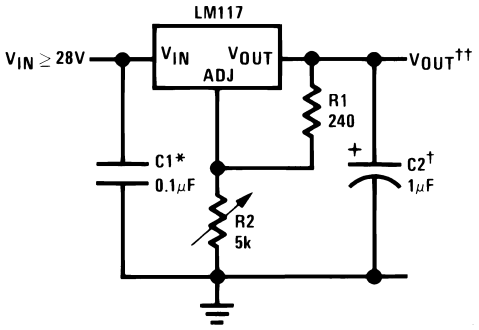
For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet.

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



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Full output current not available at high input-output voltages

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

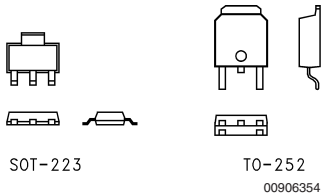
†Optional — improves transient response. Output capacitors in the range of 1μF to 1000μF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

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

LM117/LM317A/LM317 Package Options

Part Number	Suffix	Package	Output Current
LM117, LM317	K	TO-3	1.5A
LM317	T	TO-220	1.5A
LM317	S	TO-263	1.5A
LM317A, LM317	EMP	SOT-223	1.0A
LM117, LM317A, LM317	H	TO-39	0.5A
LM117	E	LCC	0.5A
LM317A, LM317	MDT	TO-252	0.5A

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



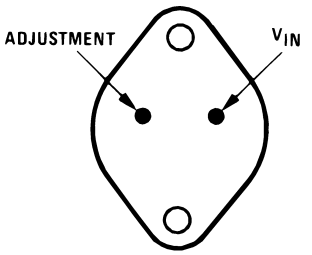
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Scale 1:1

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Connection Diagrams

TO-3 (K)
Metal Can Package

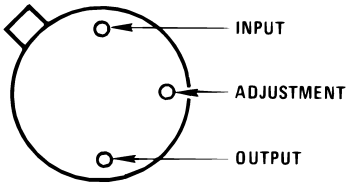


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CASE IS OUTPUT

Bottom View
Steel Package
NS Package Number K02A or K02C

TO-39 (H)
Metal Can Package

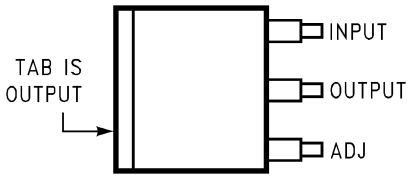


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CASE IS OUTPUT

Bottom View
NS Package Number H03A

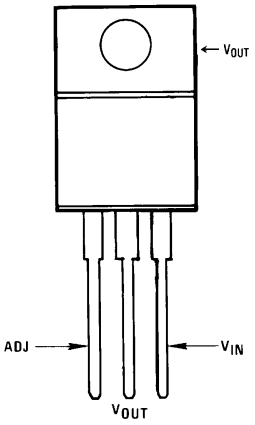
TO-263 (S)
Surface-Mount Package



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Top View

TO-220 (T)
Plastic Package



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Front View
NS Package Number T03B

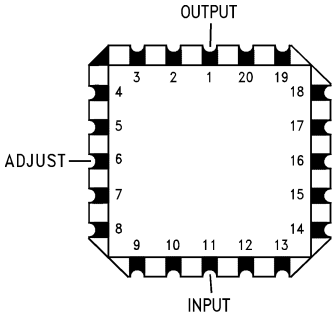
TO-263 (S)
Surface-Mount Package



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Side View
NS Package Number TS3B

Ceramic Leadless
Chip Carrier (E)

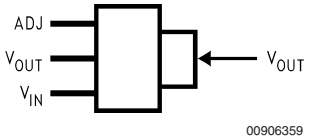


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Top View
NS Package Number E20A

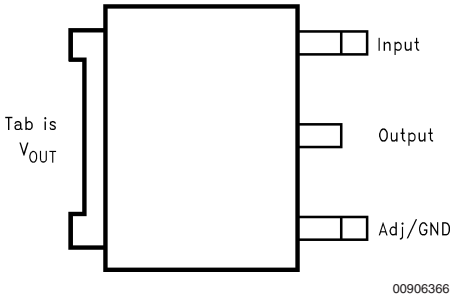
Connection Diagrams (Continued)

4-Lead SOT-223 (EMP)



Front View
NS Package Number MP04A

TO-252 (MDT)



Front View
NS Package Number TD03B

Ordering Information

Package	Temperature Range	Output Current	Order Number	Package Marking	Transport Media	NSC Drawing
TO-3 Metal Can (K)	$-55^{\circ}C \le T_J \le +150^{\circ}C$	1.5A	LM117K STEEL	LM117K STEEL P+	50 Per Bag	K02A
	$0^{\circ}C \le T_J \le +125^{\circ}C$	1.5A	LM317K STEEL	LM317K STEEL P+	50 Per Bag	
	$-55^{\circ}C \le T_J \le +150^{\circ}C$	1.5A	LM117K/883	LM117K/883	50 Per Bag	K02C
TO-220 3- Lead	$-40^{\circ}C \le T_J \le +125^{\circ}C$	1.5A	LM317AT	LM317AT P+	45 Units/Rail	T03B
	$0^{\circ}C \le T_J \le +125^{\circ}C$	1.5A	LM317T	LM317T P+	45 Units/Rail	
TO-263 3- Lead	$0^{\circ}C \le T_J \le +125^{\circ}C$	1.5A	LM317S	LM317S P+	45 Units/Rail	TS3B
			LM317SX		500 Units Tape and Reel	
SOT-223 4- Lead	$0^{\circ}C \le T_J \le +125^{\circ}C$	1.0A	LM317EMP	N01A	1k Units Tape and Reel	MP04A
			LM317EMPX		2k Units Tape and Reel	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	1.0A	LM317AEMP	N07A	1k Units Tape and Reel	
			LM317AEMPX		2k Units Tape and Reel	
TO-39 Metal Can (H)	$-55^{\circ}C \le T_J \le +150^{\circ}C$	0.5A	LM117H	LM117H P+	500 Per Box	H03A
	$-55^{\circ}C \le T_J \le +150^{\circ}C$	0.5A	LM117H/883	LM117H/883	20 Per Tray	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	0.5A	LM317AH	LM317AH P+	500 Per Box	
	$0^{\circ}C \le T_J \le +125^{\circ}C$	0.5A	LM317H	LM317H P+	500 Per Box	
LCC	$-55^{\circ}C \le T_J \le +150^{\circ}C$	0.5A	LM117E/883	LM117E/883	50 Units/Rail	E20A
TO-252 3- Lead D-Pack	$0^{\circ}C \le T_J \le +125^{\circ}C$	0.5A	LM317MDT	LM317MDT	75 Units/Rail	TD03B
			LM317MDTX		2.5k Units Tape and Reel	
	$-40^{\circ}C \le T_J \le +125^{\circ}C$	0.5A	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%

LM117 Electrical Characteristics (Note 3)

Specifications with standard type face are for $T_J = 25^{\circ}C$, 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)			
		Min	Typ	Max	Units
Reference Voltage	$3V \le (V_{IN} - V_{OUT}) \le 40V$, $10\text{ mA} \le I_{OUT} \le I_{MAX}$	**1.20**	**1.25**	**1.30**	V
Line Regulation	$3V \le (V_{IN} - V_{OUT}) \le 40V$ (Note 4)		0.01 **0.02**	0.02 **0.05**	%/V
Load Regulation	$10\text{ mA} \le I_{OUT} \le I_{MAX}$ (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	$10\text{ mA} \le I_{OUT} \le I_{MAX}$ $3V \le (V_{IN} - V_{OUT}) \le 40V$		**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 H, E Package	**1.5** **0.5**	**2.2** **0.8**	**3.4** **1.8**	A
	$(V_{IN} - V_{OUT}) = 40V$ K Package H, E Package	0.3 0.15	0.4 0.20		A
RMS Output Noise, % of V_{OUT}	10 Hz ≤ f ≤ 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	$T_J = 125^{\circ}C$, 1000 hrs		0.3	1	%
Thermal Resistance, θ_{JC} Junction-to-Case	K (TO-3) Package H (TO-39) Package E (LCC) Package		2 21 12		˚C/W
Thermal Resistance, θ_{JA} Junction-to-Ambient (No Heat Sink)	K (TO-3) Package H (TO-39) Package E (LCC) Package		39 186 88		˚C/W

LM317A and LM317 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	-	1.25	-	V
	3V ≤ ($V_{IN} - V_{OUT}$) ≤ 40V, 10 mA ≤ I_{OUT} ≤ I_{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 **0.02**		0.01 **0.02**	0.04 **0.07**	%/V
Load Regulation	10 mA ≤ I_{OUT} ≤ I_{MAX} (Note 4)		0.1 **0.3**	0.5 **1**		0.1 **0.3**	0.5 **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**	A
	EMP Package	**1.0**	**1.5**	**2.6**	**1.0**	**1.5**	**2.6**	
	H, MDT Packages	**0.5**	**0.8**	**1.8**	**0.5**	**0.8**	**1.8**	
	($V_{IN} - V_{OUT}$) = 40V							
	K, T, S Packages	-	-		0.15	0.40		A
	EMP Package	0.112	0.30		0.112	0.30		
	H, MDT Packages	0.075	0.20		0.075	0.20		
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, θ_{JC} Junction-to-Case	K (TO-3) Package		-			2		˚C/W
	T (TO-220) Package		-			4		
	S (TO-263) Package		-			4		
	EMP (SOT-223) Package		23.5			23.5		
	H (TO-39) Package		21			21		
	MDT (TO-252) Package		12			12		
Thermal Resistance, θ_{JA} Junction-to-Ambient (No Heat Sink)	K (TO-3) Package		-			39		˚C/W
	T (TO-220) Package		-			50		
	S (TO-263) Package (Note 6)		-			50		
	EMP (SOT-223) Package (Note 6)		140			140		
	H (TO-39) Package		186			186		
	MDT (TO-252) Package (Note 6)		103			103		

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: I_{MAX} = 1.5A for the K (TO-3), T (TO-220), and S (TO-263) packages. I_{MAX} = 1.0A for the EMP (SOT-223) package. I_{MAX} = 0.5A for the H (TO-39), MDT (TO-252), and E (LCC) packages. Device power dissipation (P_D) is limited by ambient temperature (T_A), device maximum junction temperature (T_J), and package thermal resistance (θ_{JA}). The maximum allowable power dissipation at any temperature is : $P_{D(MAX)} = ((T_{J(MAX)} - T_A)/\theta_{JA})$. All Min. and Max. limits are guaranteed to National's Average Outgoing Quality Level (AOQL).

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.

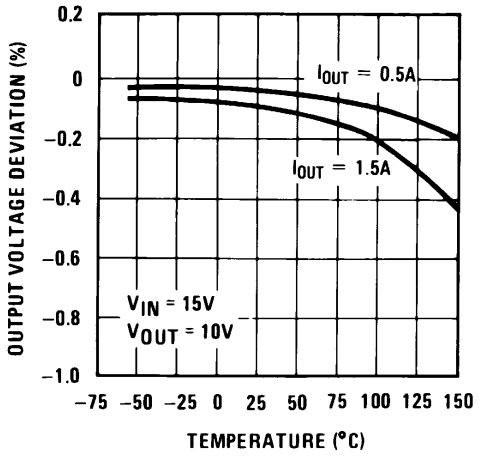
Note 5: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Note 6: When surface mount packages are used (TO-263, SOT-223, TO-252), the junction to ambient thermal resistance can be reduced by increasing the PC board copper area that is thermally connected to the package. See the Applications Hints section for heatsink techniques.

Typical Performance Characteristics

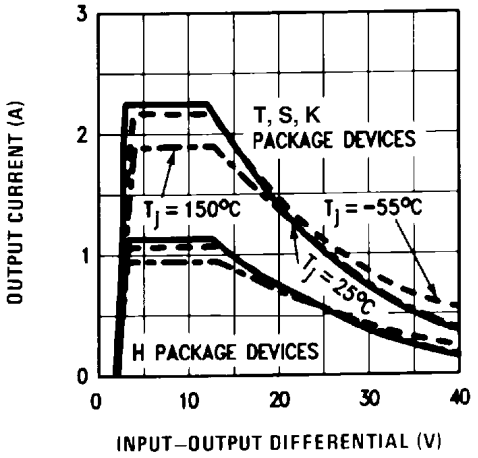
Output Capacitor = 0 µF unless otherwise noted

Load Regulation



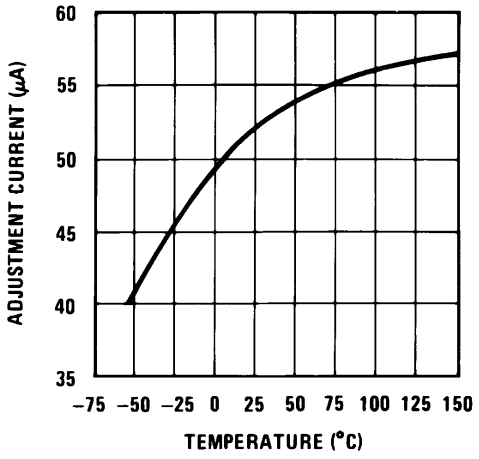
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Current Limit



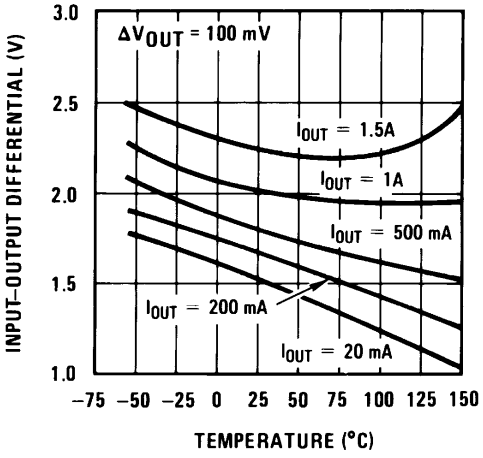
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Adjustment Current



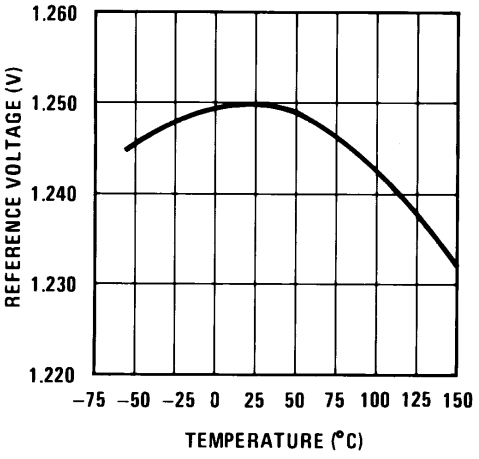
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Dropout Voltage



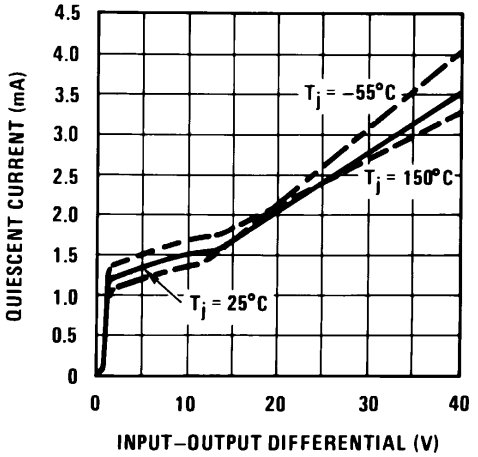
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Temperature Stability



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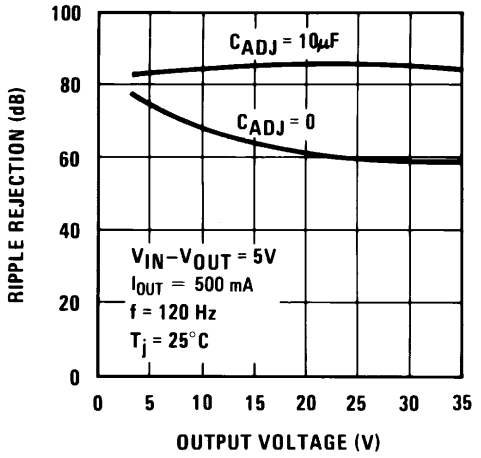
Minimum Operating Current



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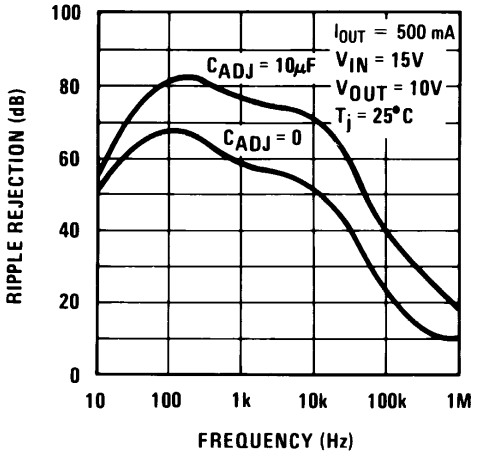
Typical Performance Characteristics Output Capacitor = 0 µF unless otherwise noted (Continued)

Ripple Rejection



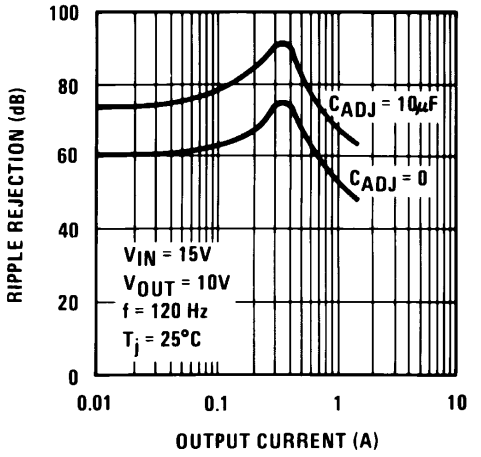
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Ripple Rejection



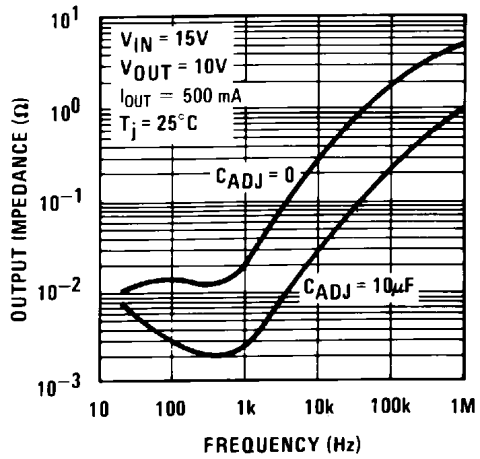
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Ripple Rejection



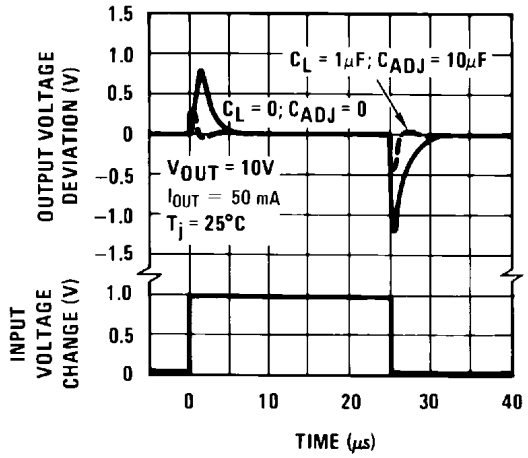
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Output Impedance



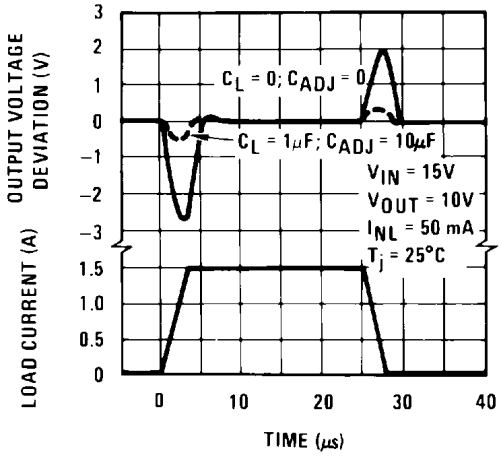
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Line Transient Response



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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

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

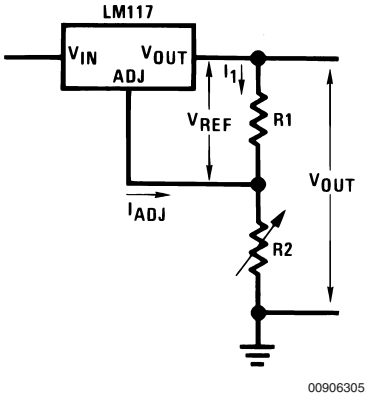


FIGURE 1.

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 10 μF bypass capacitor 80dB ripple rejection is obtainable at any output level. Increases over 10 μF 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 25 μF 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 0.5 MHz. For this reason, 0.01 μF disc may seem to work better than a 0.1 μF 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 1 μF solid tantalum (or 25 μF aluminum electrolytic) on the output swamps this effect and insures stability. Any increase of the load capacitance larger than 10 μF 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.

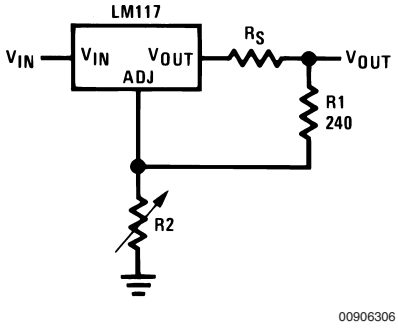


FIGURE 2. Regulator with Line Resistance in Output Lead

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

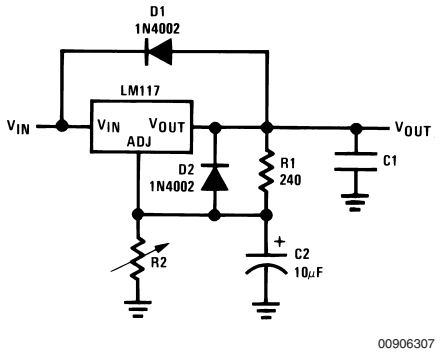
When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator. Most 10 μF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although 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 25 μF 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 the 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 10 µF capacitance. *Figure 3* shows an LM117 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.



$$V_{OUT} = 1.25V \left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2 \quad (2)$$

D1 protects against C1

D2 protects against C2

FIGURE 3. Regulator with Protection Diodes

HEATSINK REQUIREMENTS

The LM317 regulators have internal thermal shutdown to protect the device from over-heating. Under all operating conditions, the junction temperature of the LM317 should not exceed the rated maximum junction temperature (T_J) of 150˚C for the LM117, or 125˚C for the LM317A and LM317. A heatsink may be required depending on the maximum device power dissipation and the maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$$P_D = ((V_{IN} - V_{OUT}) \times I_L) + (V_{IN} \times I_G) \quad (3)$$

Figure 4 shows the voltage and currents which are present in the circuit.

The next parameter which must be calculated is the maximum allowable temperature rise, $T_{R(MAX)}$:

$$T_{R(MAX)} = T_{J(MAX)} - T_{A(MAX)} \quad (4)$$

where $T_{J(MAX)}$ is the maximum allowable junction temperature (150˚C for the LM117, or 125˚C for the LM317A/LM317), 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:

$$\theta_{JA} = (T_{R(MAX)} / P_D) \quad (5)$$

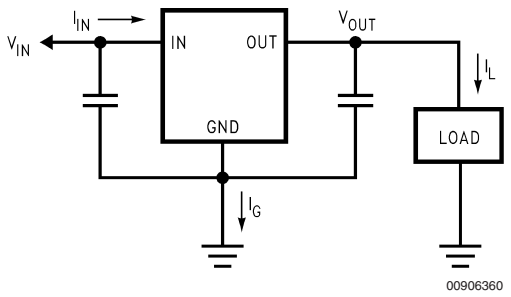


FIGURE 4. Power Dissipation Diagram

If the calculated maximum allowable thermal resistance is higher than the actual package rating, then no additional work is needed. If the calculated maximum allowable thermal resistance is lower than the actual package rating either the power dissipation (P_D) needs to be reduced, the maximum ambient temperature $T_{A(MAX)}$ needs to be reduced, the thermal resistance (θ_{JA}) must be lowered by adding a heatsink, or some combination of these.

If a heatsink is needed, the value can be calculated from the formula:

$$\theta_{HA} \leq (\theta_{JA} - (\theta_{CH} + \theta_{JC})) \quad (6)$$

where (θ_{CH} is the thermal resistance of the contact area between the device case and the heatsink surface, and θ_{JC} is thermal resistance from the junction of the die to surface of the package case.

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.

The $\theta_{(H-A)}$ rating 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 SURFACE MOUNT PACKAGES

The TO-263 (S), SOT-223 (EMP) and TO-252 (MDT) 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.

HEATSINKING THE SOT-223 PACKAGE

Figure 5 and *Figure 6* show the information for the SOT-223 package. *Figure 6* 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. Please see AN-1028 for thermal enhancement techniques to be used with SOT-223 and TO-252 packages.

Application Hints (Continued)

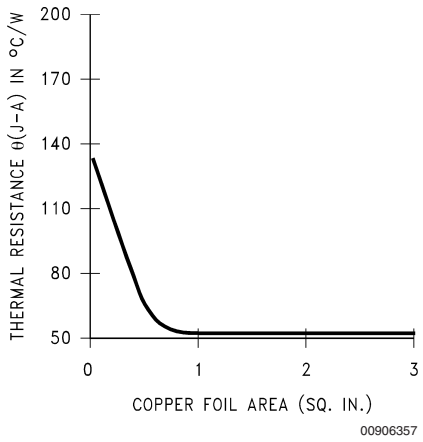


FIGURE 5. $\theta_{(J-A)}$ vs Copper (2 ounce) Area for the SOT-223 Package

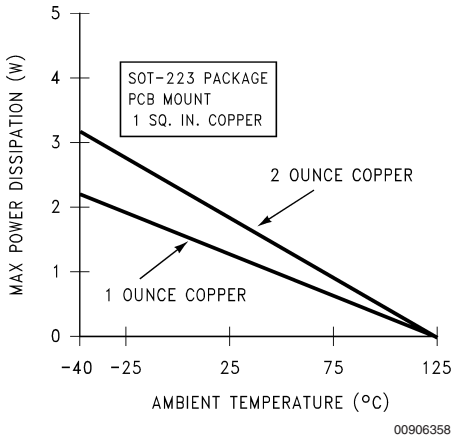


FIGURE 6. Maximum Power Dissipation vs T_{AMB} for the SOT-223 Package

HEATSINKING THE TO-263 PACKAGE

Figure 7 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.

As shown in *Figure 7*, 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.

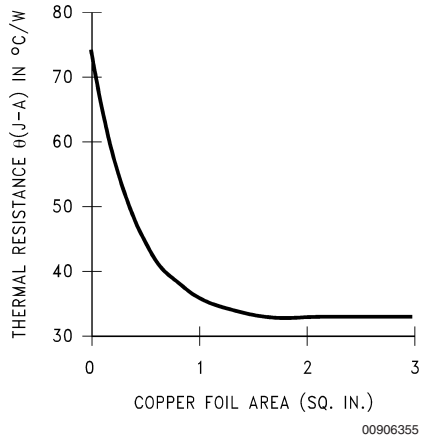


FIGURE 7. $\theta_{(J-A)}$ vs Copper (1 ounce) Area for the TO-263 Package

As a design aid, *Figure 8* 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).

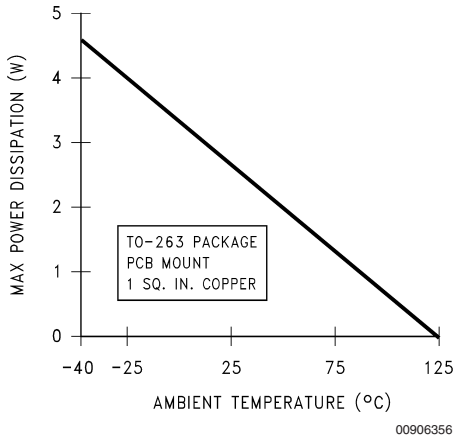


FIGURE 8. Maximum Power Dissipation vs T_{AMB} for the TO-263 Package

HEATSINKING THE TO-252 PACKAGE

If the maximum allowable value for θ_{JA} is found to be ≥103˚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 *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 AN-1028 for thermal enhancement techniques to be used with SOT-223 and TO-252 packages.

Application Hints (Continued)

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	0	47
7	0.066	0.2	84
8	0.066	0.4	70
9	0.066	0.6	63
10	0.066	0.8	57
11	0.066	1.0	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.

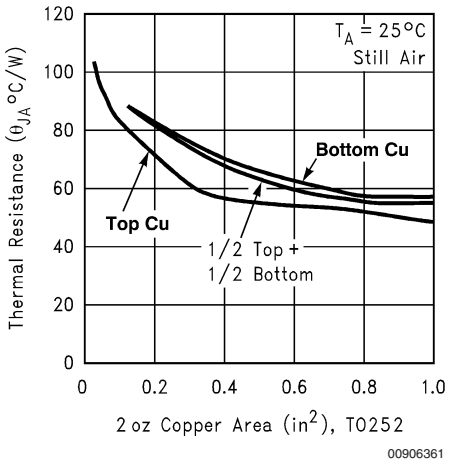


FIGURE 9. θ_{JA} vs 2oz Copper Area for TO-252

Application Hints (Continued)

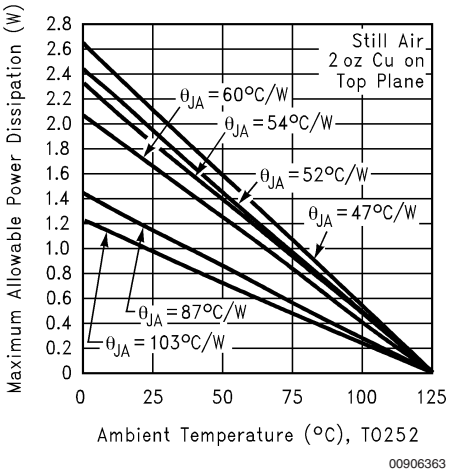


FIGURE 10. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

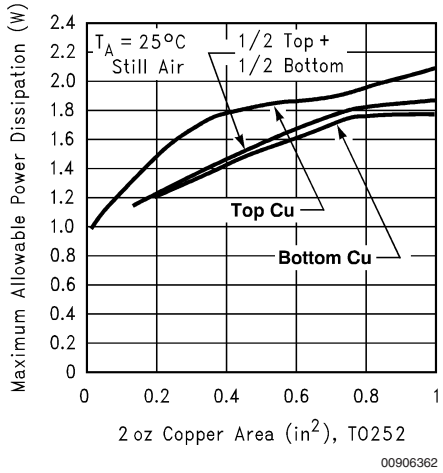


FIGURE 11. Maximum Allowable Power Dissipation vs. 2oz Copper Area for TO-252

Application Hints (Continued)

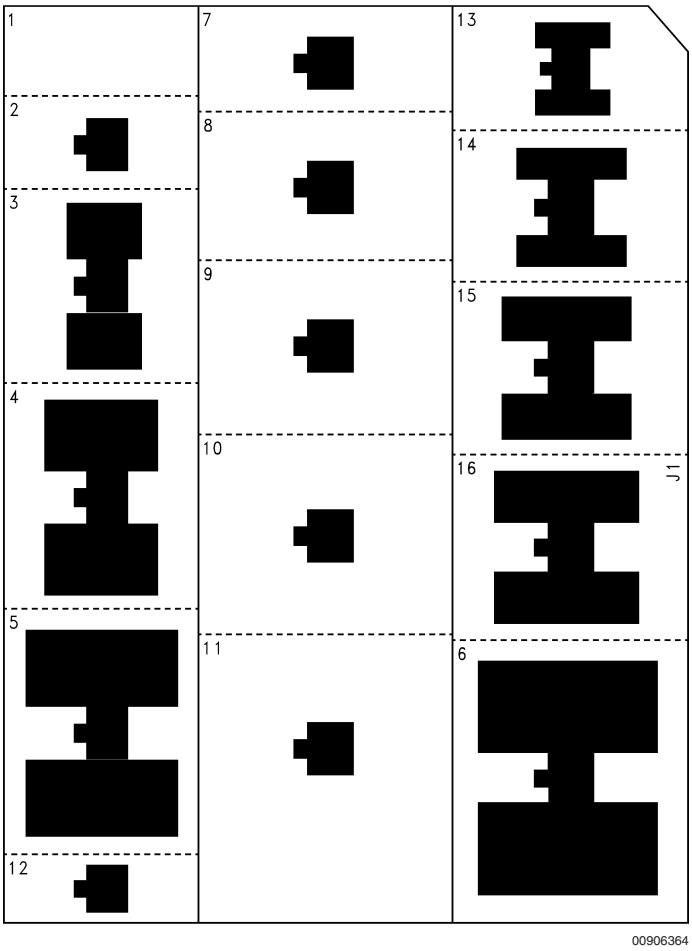


FIGURE 12. Top View of the Thermal Test Pattern in Actual Scale

Application Hints (Continued)

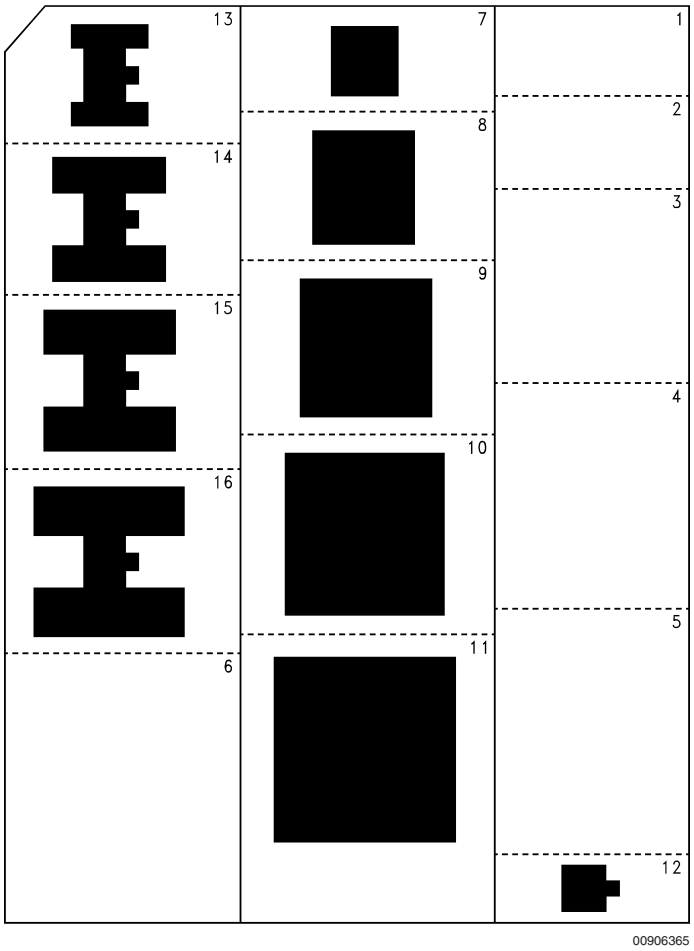
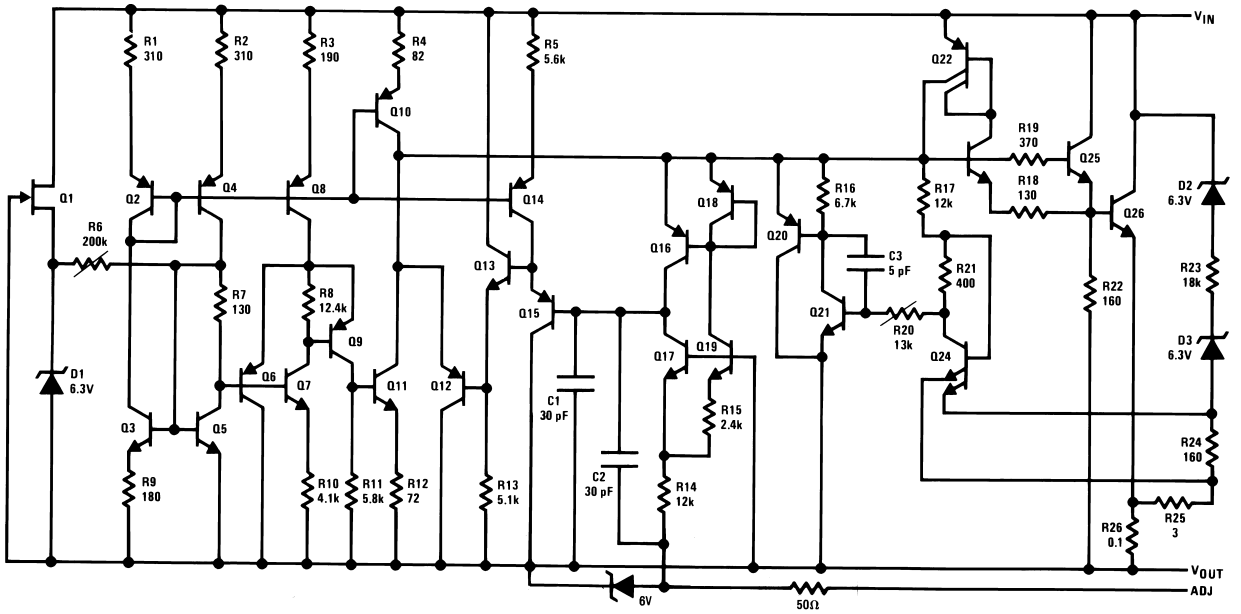


FIGURE 13. Bottom View of the Thermal Test Pattern in Actual Scale

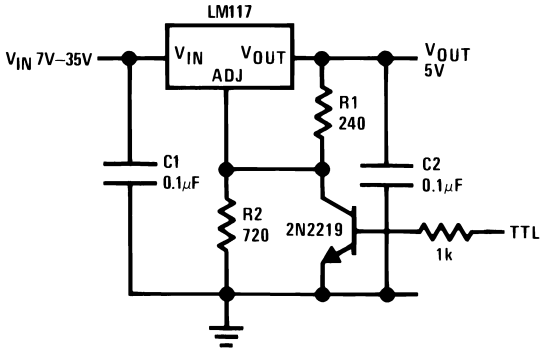
Schematic Diagram



00906308

Typical Applications

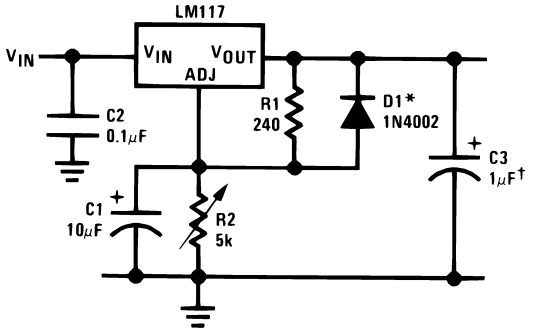
5V Logic Regulator with Electronic Shutdown*



00906303

*Min. output ≅ 1.2V

Adjustable Regulator with Improved Ripple Rejection

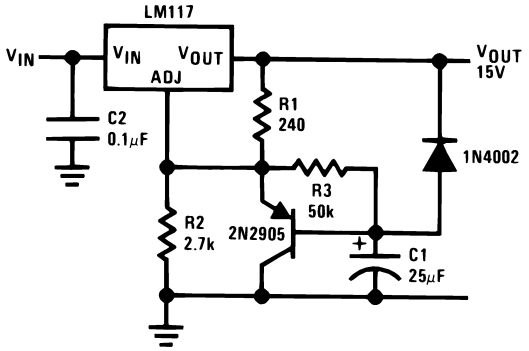


00906310

†Solid tantalum

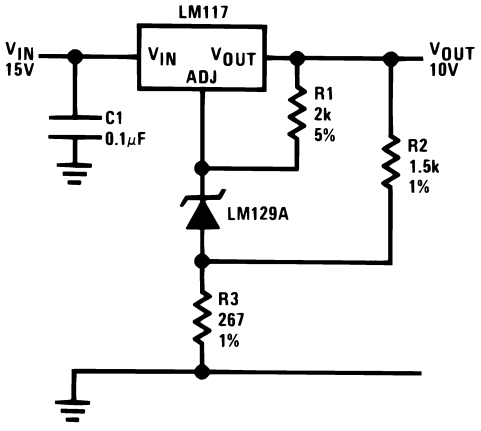
*Discharges C1 if output is shorted to ground

Slow Turn-On 15V Regulator



00906309

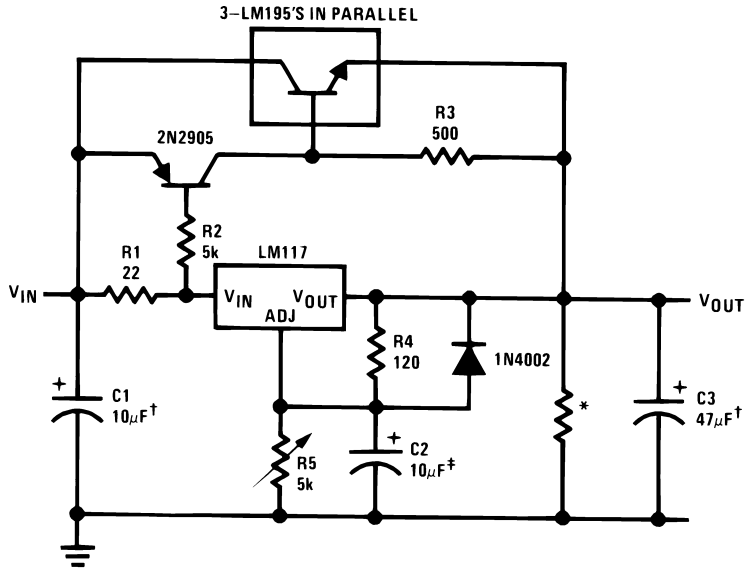
High Stability 10V Regulator



00906311

Typical Applications (Continued)

High Current Adjustable Regulator



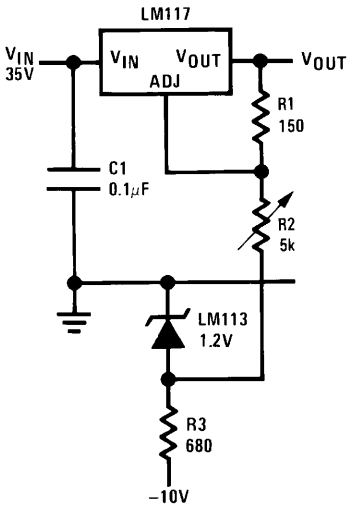
00906312

‡Optional — improves ripple rejection

†Solid tantalum

*Minimum load current = 30 mA

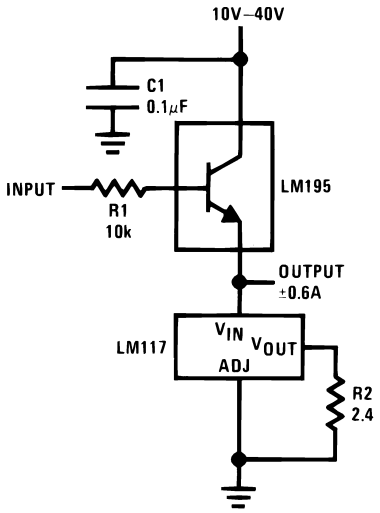
0 to 30V Regulator



00906313

Full output current not available at high input-output voltages

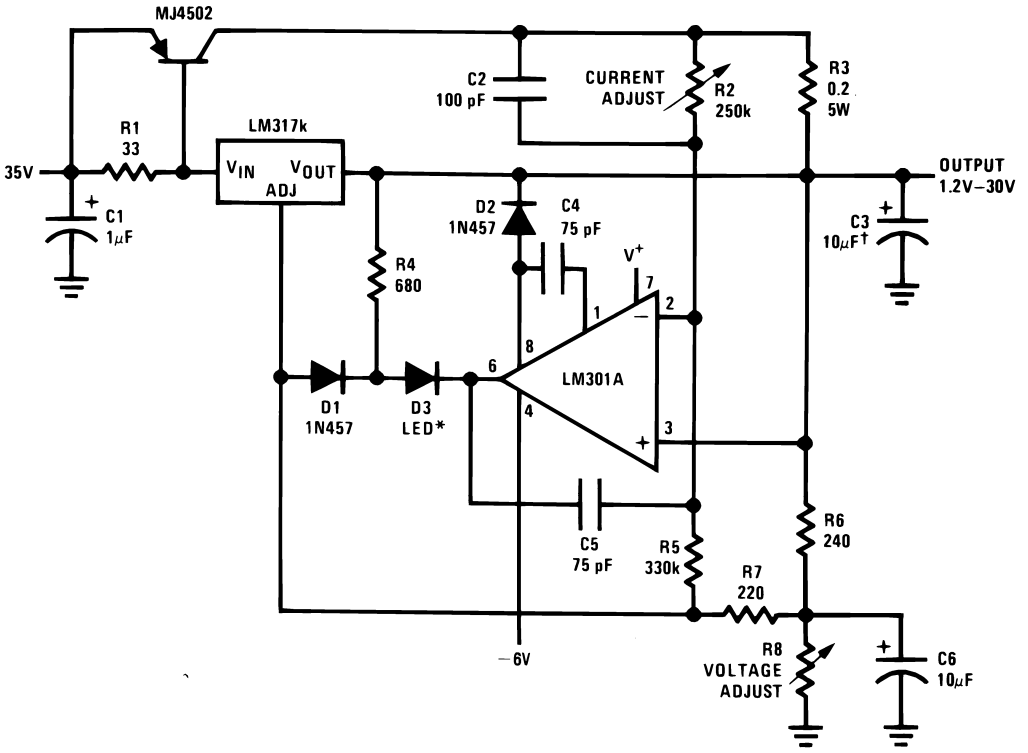
Power Follower



00906314

Typical Applications (Continued)

5A Constant Voltage/Constant Current Regulator

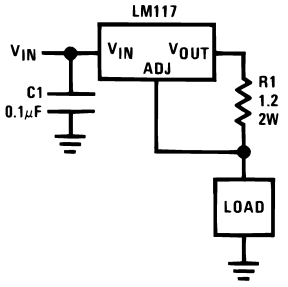


00906315

†Solid tantalum

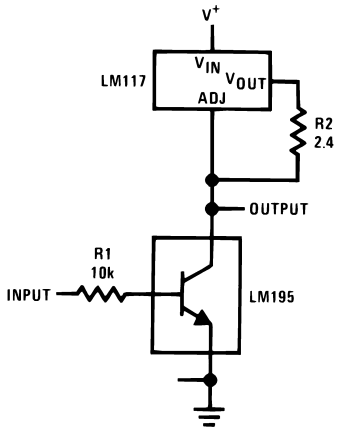
*Lights in constant current mode

1A Current Regulator



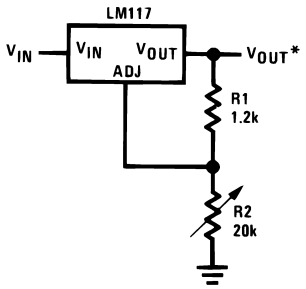
00906316

High Gain Amplifier



00906318

1.2V–20V Regulator with Minimum Program Current

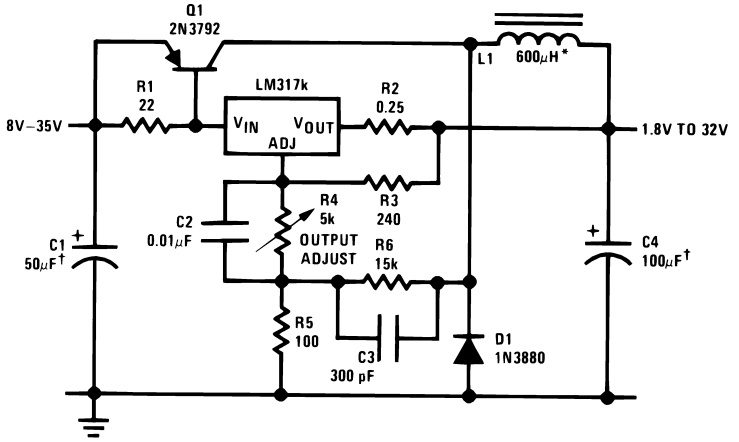


00906317

*Minimum load current ≅ 4 mA

Typical Applications (Continued)

Low Cost 3A Switching Regulator

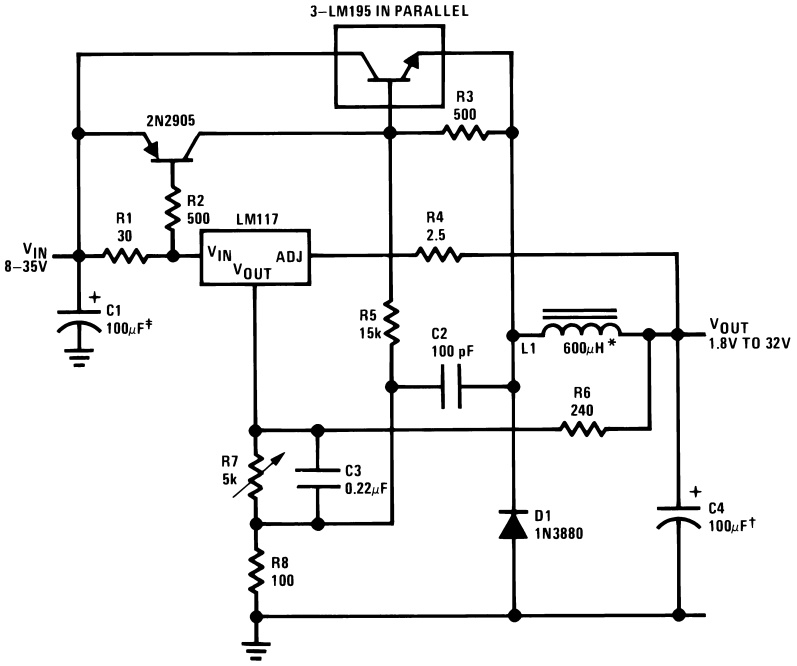


00906319

†Solid tantalum

*Core — Arnold A-254168-2 60 turns

4A Switching Regulator with Overload Protection

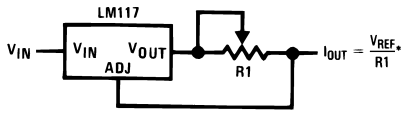


00906320

†Solid tantalum

*Core — Arnold A-254168-2 60 turns

Precision Current Limiter

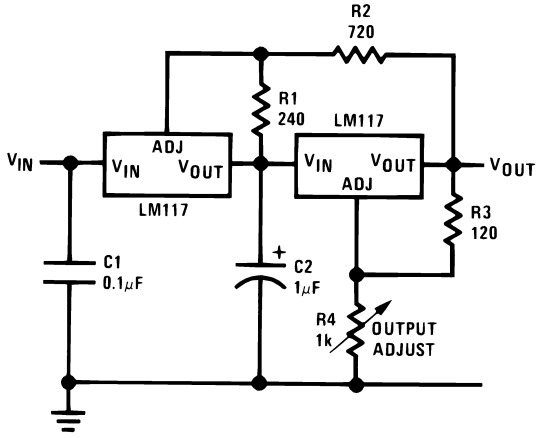


*0.8Ω ≤ R1 ≤ 120Ω

00906321

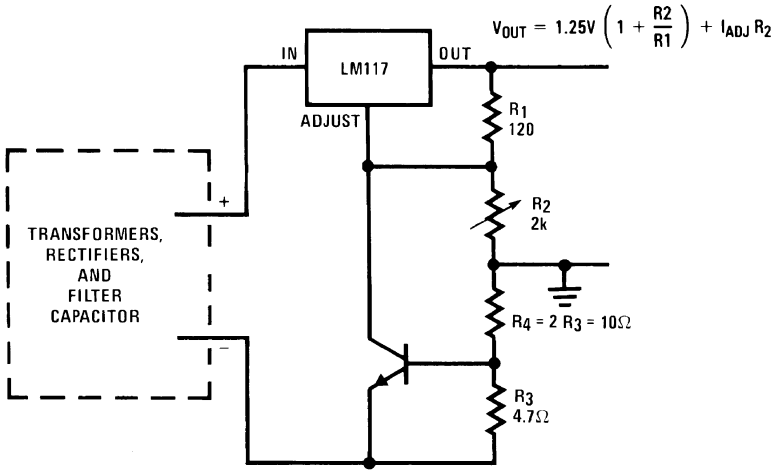
Typical Applications (Continued)

Tracking Preregulator



00906322

Current Limited Voltage Regulator



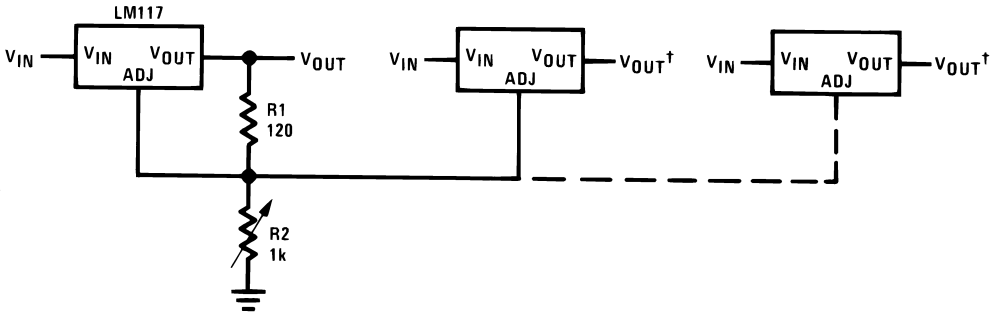
00906323

—Short circuit current is approximately $\frac{600\ mV}{R3}$, 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*



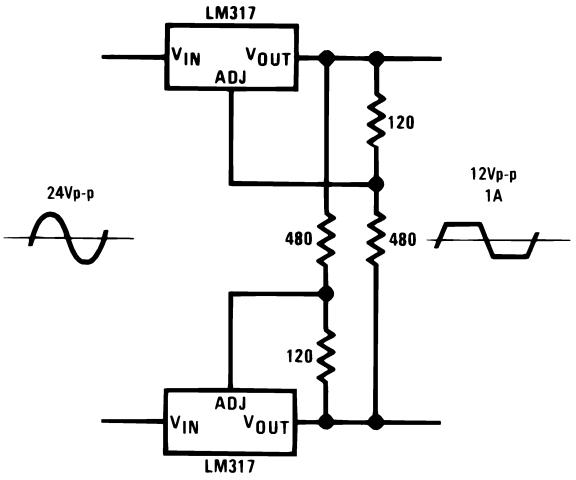
00906324

*All outputs within ±100 mV

†Minimum load—10 mA

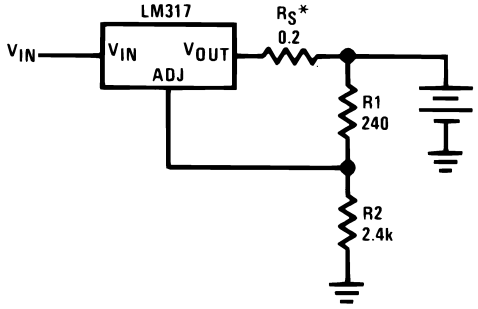
Typical Applications (Continued)

AC Voltage Regulator



00906325

12V Battery Charger

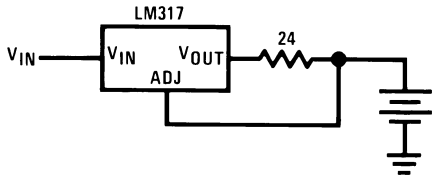


00906326

*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.

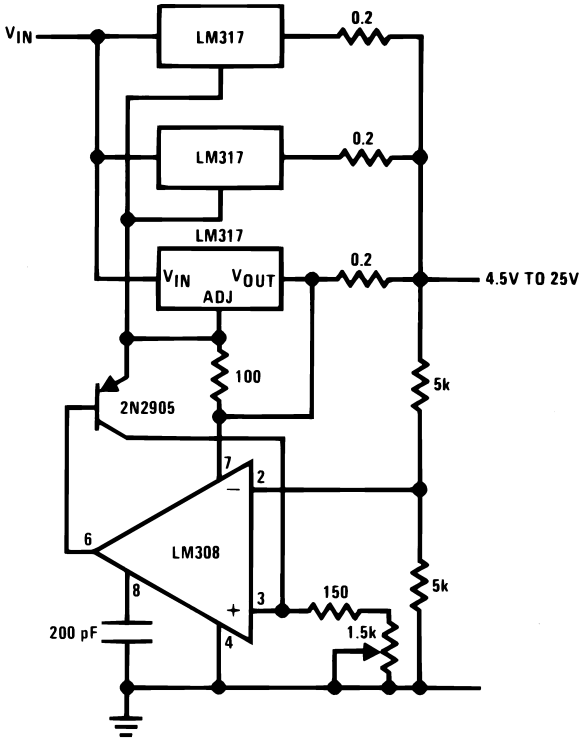
50mA Constant Current Battery Charger



00906327

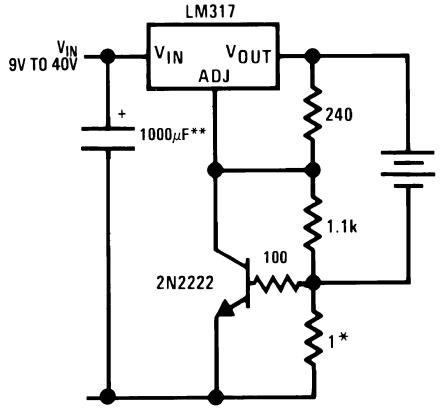
Typical Applications (Continued)

Adjustable 4A Regulator



00906328

Current Limited 6V Charger

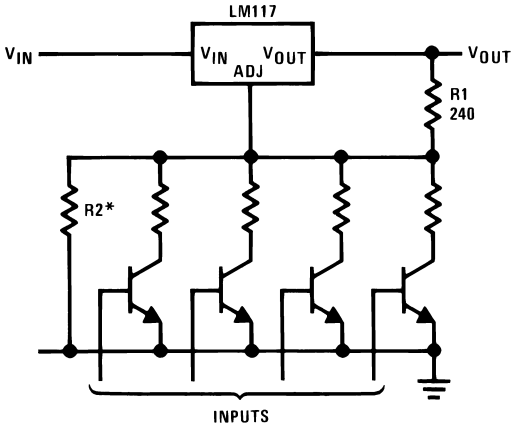


00906329

*Sets peak current (0.6A for 1Ω)

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

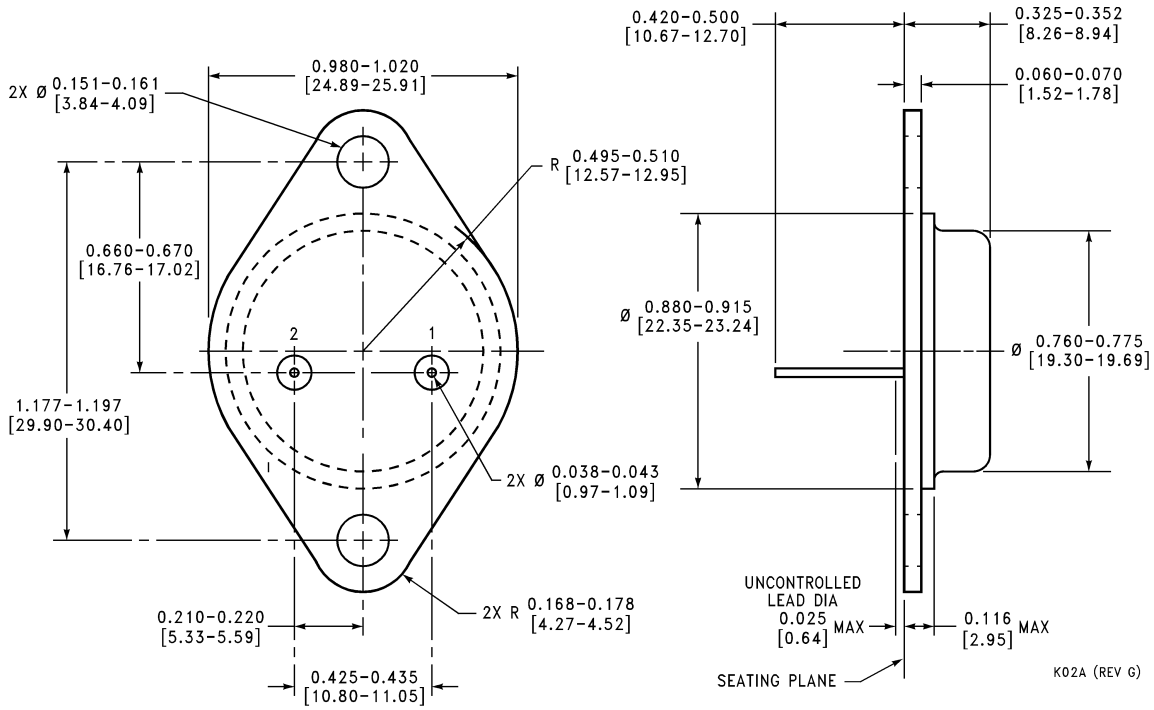
Digitally Selected Outputs



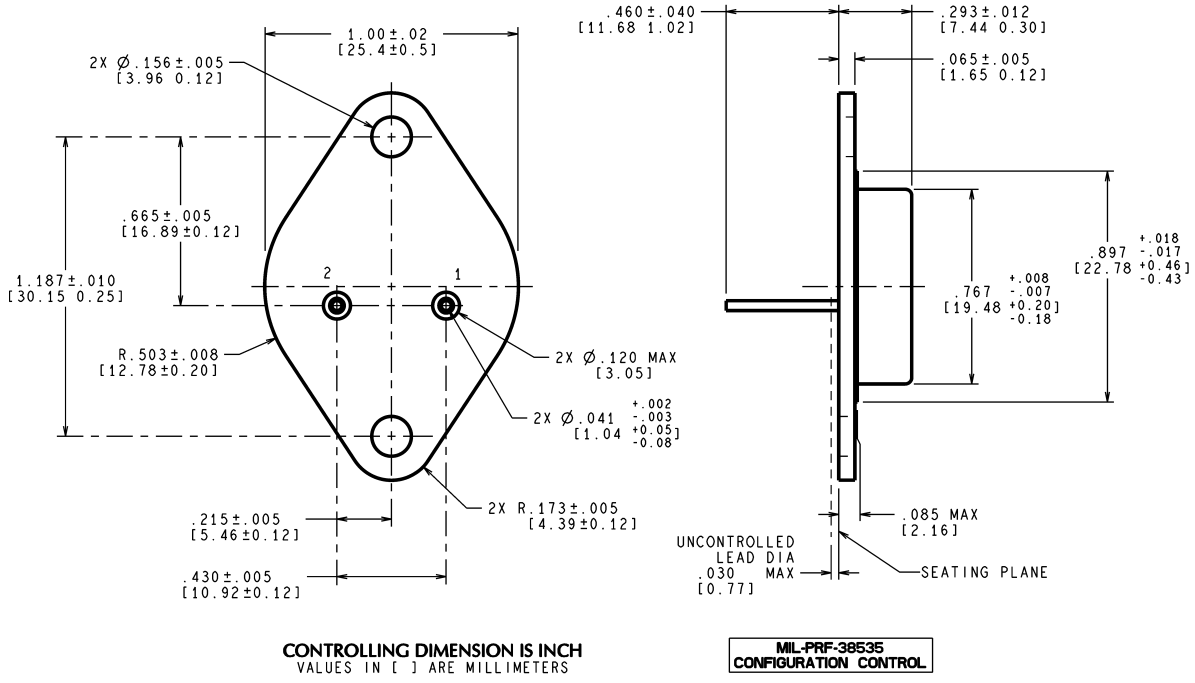
00906302

*Sets maximum V_{OUT}

Physical Dimensions inches (millimeters) unless otherwise noted

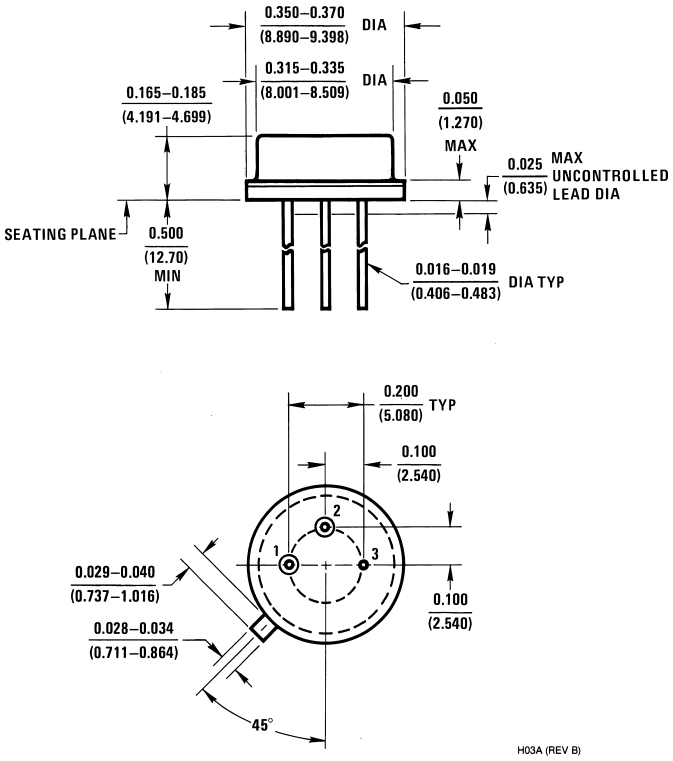


TO-3 Metal Can Package (K)
NS Package Number K02A

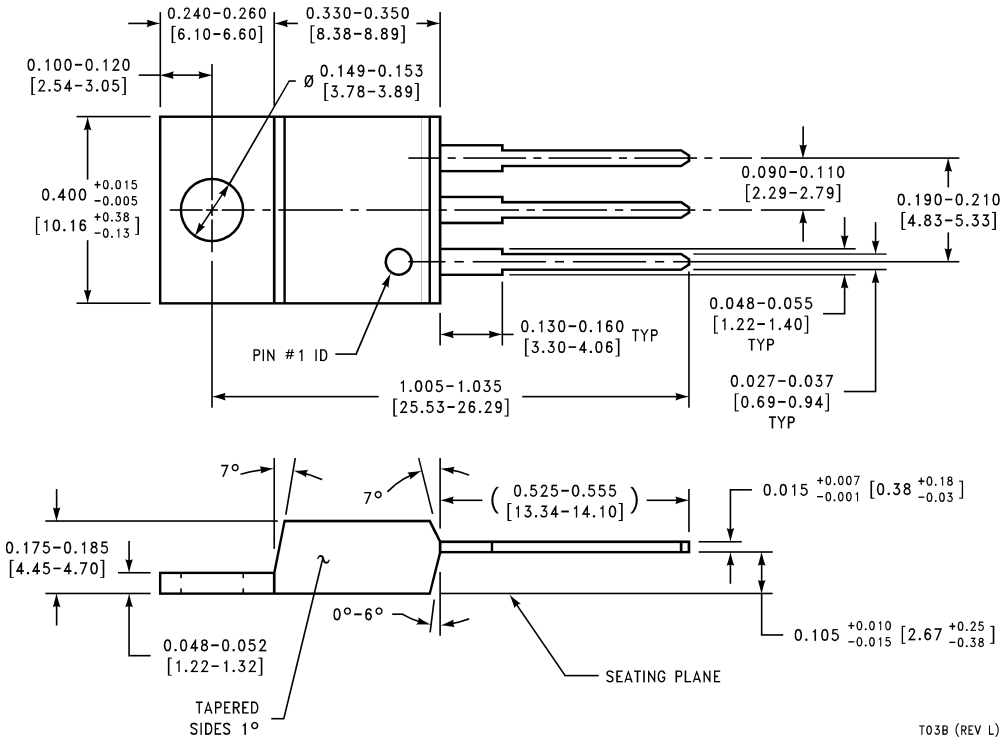


TO-3 Metal Can Package (K)
Mil-Aero Product
NS Package Number K02C

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

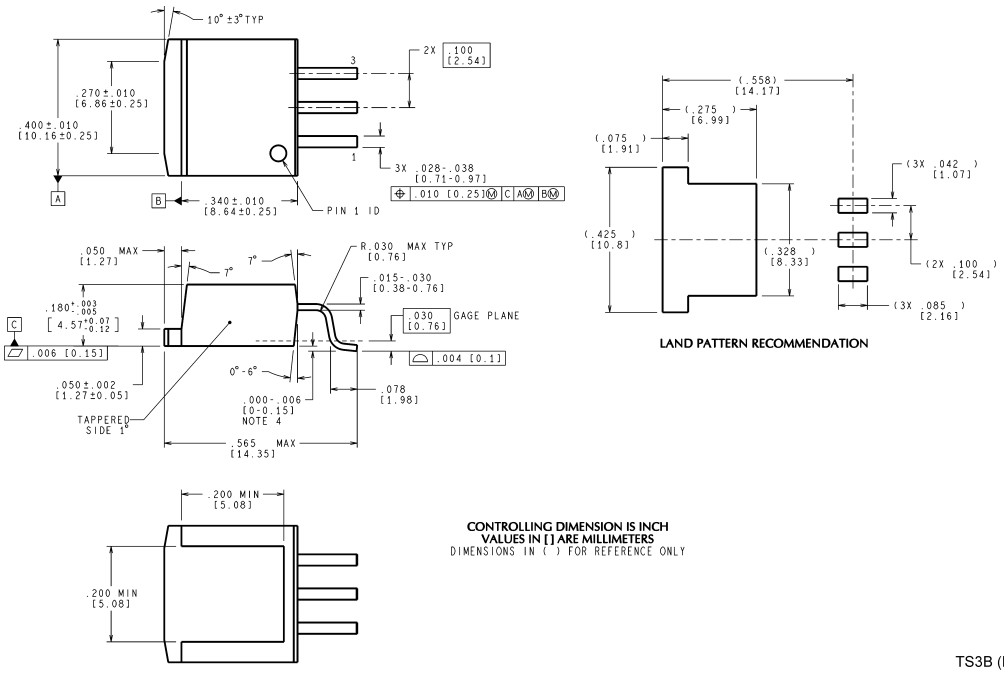


TO-39 Metal Can Package (H)
NS Package Number H03A



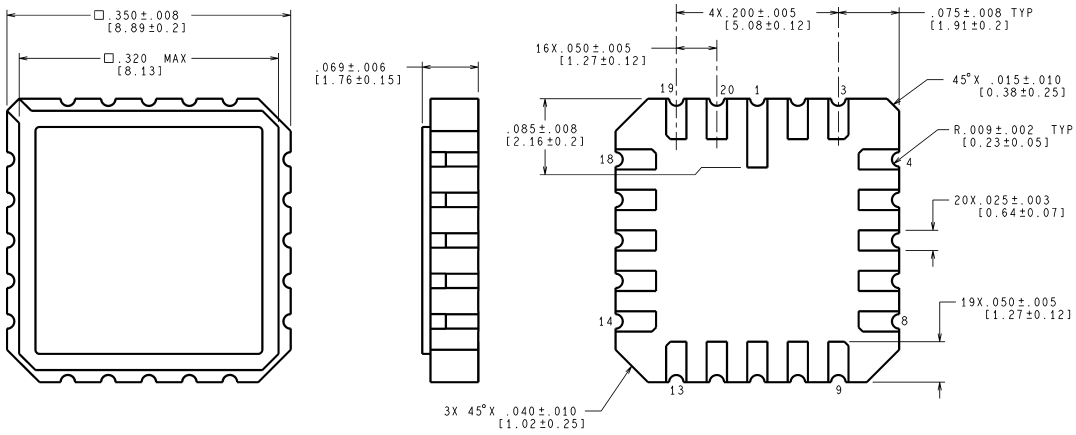
3-Lead TO-220 (T)
NS Package Number T03B

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



TS3B (Rev F)

3-Lead TO-263 (S)
NS Package Number TS3B

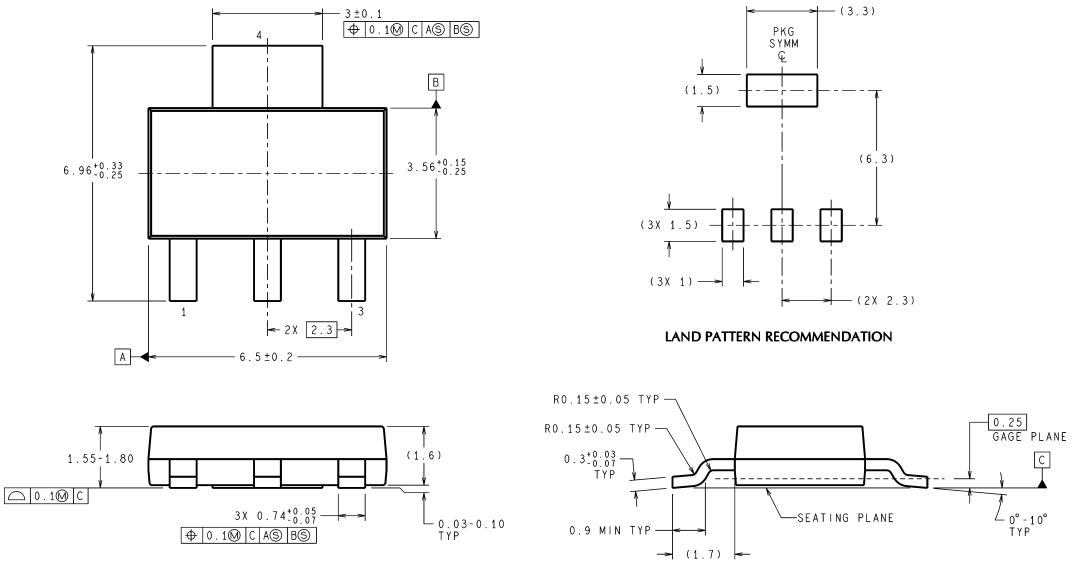


CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

E20A (Rev F)

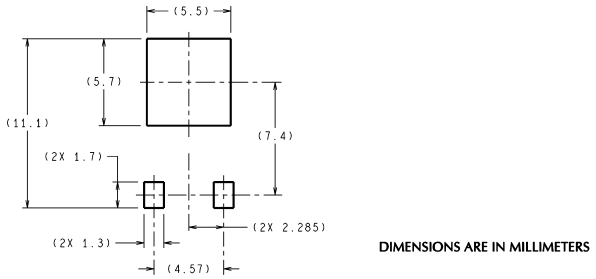
Ceramic Leadless Chip Carrier (E)
NS Package Number E20A

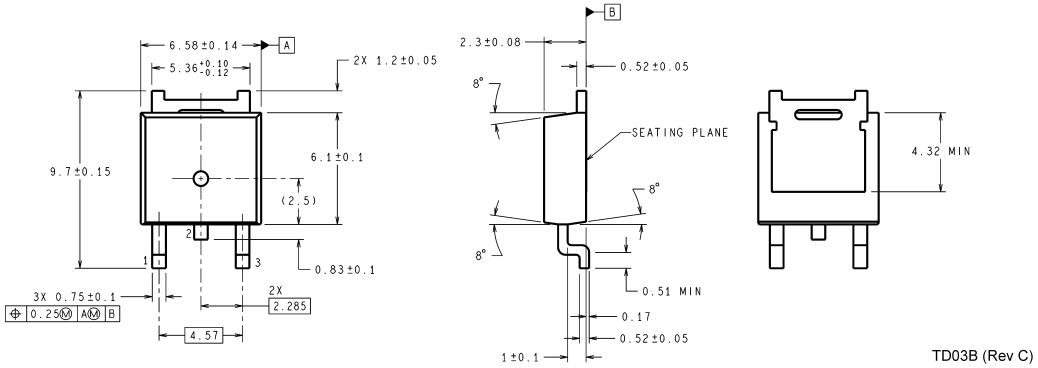
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



MP04A (Rev B)

4-Lead SOT-223 (EMP)
NS Package Number MP04A





TD03B (Rev C)

3-Lead D-Pack (MDT)
NS Package Number TD03B

Notes

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