LM117JAN 3-Terminal Adjustable Regulator

Check for Samples: LM117JAN

FEATURES

- **Specified 0.5A or 1.5A Output Current**
- **Adjustable Output Down to 1.2V**
- **Current Limit Constant with Temperature**
- **80 dB Ripple Rejection**
- **Output is Short-circuit Protected**

DESCRIPTION

The LM117 adjustable 3-terminal positive voltage regulator is capable of supplying either 0.5A or 1.5A over a 1.2V to 37V output range. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators.

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.

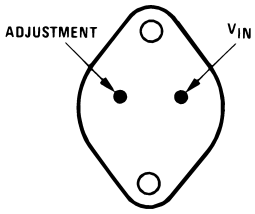
Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection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

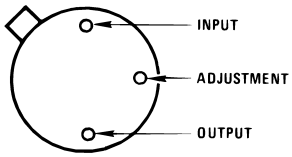
For the negative complement, see LM137 series data sheet.

Connection Diagrams



CASE IS OUTPUT

Figure 1. (TO-3)
Metal Can Package
Bottom View
Steel Package
Package Number K0002C



CASE IS OUTPUT

Figure 2. (TO)
Metal Can Package
Bottom View
Package Number NDT0003A

Table 1. LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO-3	1.5A
NDT	TO	0.5A

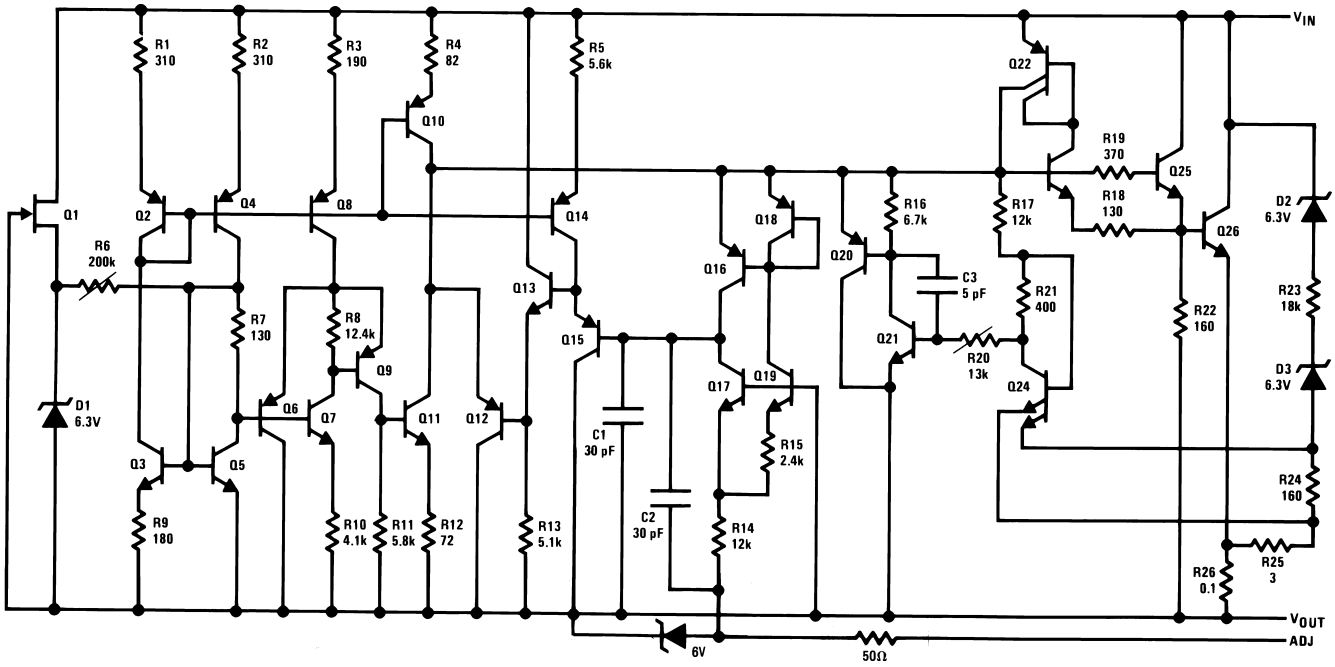
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Schematic Diagram



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings(1)

Power Dissipation (2)		Internally Limited
Input-Output Voltage Differential		+40V, −0.3V
Storage Temperature		$-65°C \le T_A \le +150°C$
Maximum Junction Temperature (T_{Jmax})		+150°C
Lead Temperature Metal Package		300°C
Thermal Resistance		
θ_{JA}	TO–3 Still Air	39°C/W
	TO–3 500LF/Min Air flow	14°C/W
	TO Still Air	186°C/W
	TO 500LF/Min Air flow	64°C/W
θ_{JC}	TO–3	1.9°C/W
	TO Metal Can	21°C/W
ESD Tolerance (3)		3KV

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. "Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO package and 20W for the TO-3 package."

(3) Human body model, 100 pF discharged through a 1.5 kΩ resistor.

Recommended Operating Conditions

Operating Temperature Range	$-55°C \le T_A \le +125°C$
Input Voltage Range	4.25V to 41.25V

Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

Subgroup	Description	Temp °C
1	Static tests at	25
2	Static tests at	125
3	Static tests at	-55
4	Dynamic tests at	25
5	Dynamic tests at	125
6	Dynamic tests at	-55
7	Functional tests at	25
8A	Functional tests at	125
8B	Functional tests at	-55
9	Switching tests at	25
10	Switching tests at	125
11	Switching tests at	-55
12	Settling time at	25
13	Settling time at	125
14	Settling time at	-55

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LM117H JAN Electrical Characteristics DC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 4.25V, I_L = -500mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -50mA		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-9.0	9.0	mV	1
				-23	23	mV	2, 3
V_{RLoad}	Load Regulation	V_I = 6.25V, -500mA ≤ I_L ≤ -5mA		-12	12	mV	1, 2, 3
		V_I = 41.25V, -50mA ≤ I_L ≤ -5mA		-12	12	mV	1, 2, 3
θ_R	Thermal Regulation	V_I = 14.6V, I_L = -500mA		-12	12	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
		V_I = 41.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
ΔI_{Adj} / Line	Adjust Pin Current Change	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-5.0	5.0	µA	1, 2, 3
ΔI_{Adj} / Load	Adjust Pin Current Change	V_I = 6.25V, -500mA ≤ I_L ≤ -5mA		-5.0	5.0	µA	1, 2, 3
I_{OS}	Output Short Circuit Current	V_I = 4.25V		-1.8	-0.5	A	1, 2, 3
		V_I = 40V		-0.5	-0.05	A	1, 2, 3
V_O Recov	Output Voltage Recovery	V_I = 4.25V, R_L = 2.5Ω, C_L = 20µF		1.2	1.3	V	1, 2, 3
		V_I = 40V, R_L = 250Ω		1.2	1.3	V	1, 2, 3
I_Q	Minimum Load Current	V_I = 4.25V, Forced V_O = 1.4V		-3.0	-0.5	mA	1, 2, 3
		V_I = 14.25V, Forced V_O = 1.4V		-3.0	-0.5	mA	1, 2, 3
		V_I = 41.25V, Forced V_O = 1.4V		-5.0	-1.0	mA	1, 2, 3
V_{Start}	Voltage Start-Up	V_I = 4.25V, R_L = 2.5Ω, C_L=20µF, I_L = -500mA		1.2	1.3	V	1, 2, 3
V_O	Output Voltage	V_I = 6.25V, I_L = -5mA	(1)	1.2	1.3	V	2

(1) Tested @ T_A = 125°C, correlated to T_A = 150°C

LM117H JAN Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_{NO}	Output Noise Voltage	V_I = 6.25V, I_L = -50mA			120	μV_{RMS}	7
ΔV_O / ΔV_I	Line Transient Response	V_I = 6.25V, ΔV_I = 3V, I_L = -10mA			6	mV/V	7
ΔV_O / ΔI_L	Load Transient Response	V_I = 6.25V, ΔI_L = -200mA, I_L = -50mA			0.6	mV/mA	7
ΔV_I / ΔV_O	Ripple Rejection	V_I = 6.25V, I_L = -125mA e_I = $1V_{RMS}$ at f = 2400Hz,		65		dB	4

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LM117H JAN Electrical Characteristics DC Drift Parameters

Deltas performed on JAN S devices at Group B, Subgroup 5, only.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 4.25V, I_L = -500mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -50mA		-0.01	0.01	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-4.0	4.0	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-10	10	µA	1
		V_I = 41.25V, I_L = -5mA		-10	10	µA	1

LM117K JAN Electrical Characteristics DC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 4.25V, I_L = -1.5A		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -5mA		1.2	1.3	V	1, 2, 3
		V_I = 41.25V, I_L = -200mA		1.2	1.3	V	1, 2, 3
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-9.0	9.0	mV	1
				-23	23	mV	2, 3
V_{RLoad}	Load Regulation	V_I = 6.25V, -1.5A ≤ I_L ≤ -5mA		-3.5	3.5	mV	1
				-12	12	mV	2, 3
		V_I = 41.25V, -200mA ≤ I_L ≤ -5mA		-3.5	3.5	mV	1
				-12	12	mV	2, 3
θ_R	Thermal Regulation	V_I = 14.6V, I_L = -1.5A		-12	12	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
		V_I = 41.25V, I_L = -5mA		-100	-15	µA	1, 2, 3
ΔI_{Adj} / Line	Adjust Pin Current Change	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-5.0	5.0	µA	1, 2, 3
ΔI_{Adj} / Load	Adjust Pin Current Change	V_I = 6.25V, -1.5A ≤ I_L ≤ -5mA		-5.0	5.0	µA	1, 2, 3
I_{OS}	Output Short Circuit Current	V_I = 4.25V		-3.5	-1.5	A	1, 2, 3
		V_I = 40V		-1.0	-0.18	A	1, 2, 3
V_O Recov	Output Voltage Recovery	V_I = 4.25V, R_L = 0.833Ω, C_L = 20µF		1.2	1.3	V	1, 2, 3
		V_I = 40V, R_L = 250Ω		1.2	1.3	V	1, 2, 3
I_Q	Minimum Load Current	V_I = 4.25V, Forced V_O = 1.4V		-3.0	-0.2	mA	1, 2, 3
		V_I = 14.25V, Forced V_O = 1.4V		-3.0	-0.2	mA	1, 2, 3
		V_I = 41.25V, Forced V_O = 1.4V		-5.0	-0.2	mA	1, 2, 3
V_{Start}	Voltage Start-Up	V_I = 4.25V, R_L = 0.833Ω, C_L=20µF, I_L = -1.5A		1.2	1.3	V	1, 2, 3
V_O	Output Voltage	V_I = 6.25V, I_L = -5mA	(1)	1.2	1.3	V	2

(1) Tested @ T_A = 125°C, correlated to T_A = 150°C

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LM117K JAN Electrical Characteristics AC Parameters

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_{NO}	Output Noise Voltage	V_I = 6.25V, I_L = -100mA			120	μV_{RMS}	7
$\Delta V_O / \Delta V_I$	Line Transient Response	V_I = 6.25V, ΔV_I = 3V, I_L = -10mA	(1)		18	mV	7
$\Delta V_O / \Delta I_L$	Load Transient Response	V_I = 6.25V, ΔI_L = -400mA, I_L = -100mA	(2)		120	mV	7
$\Delta V_I / \Delta V_O$	Ripple Rejection	V_I = 6.25V, I_L = -500mA e_I = $1V_{RMS}$ at f = 2400Hz,		65		dB	4

(1) SS limit of 6mV/V is equivalent to 18mV
(2) SS limit of 0.3mV/V is equivalent to 120mV

LM117K JAN Electrical Characteristics DC Drift Parameters

Deltas performed on JAN S devices at Group B, Subgroup 5, only.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-group
V_O	Output Voltage	V_I = 4.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 4.25V, I_L = -1.5A		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -5mA		-0.01	0.01	V	1
		V_I = 41.25V, I_L = -200mA		-0.01	0.01	V	1
V_{RLine}	Line Regulation	4.25V ≤ V_I ≤ 41.25V, I_L = -5mA		-4.0	4.0	mV	1
I_{Adj}	Adjust Pin Current	V_I = 4.25V, I_L = -5mA		-10	10	µA	1
		V_I = 41.25V, I_L = -5mA		-10	10	µA	1

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Typical Performance Characteristics

Output Capacitor = 0µF unless otherwise noted

Load Regulation

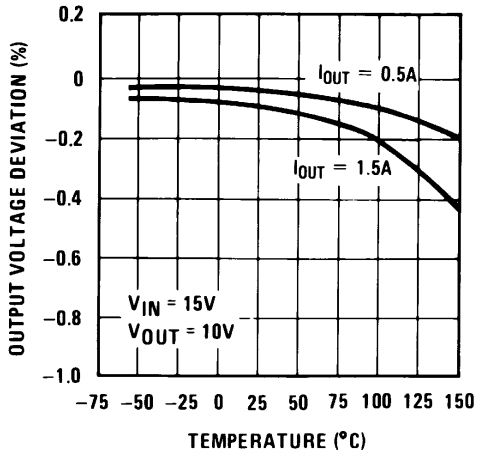


Figure 3.

Current Limit

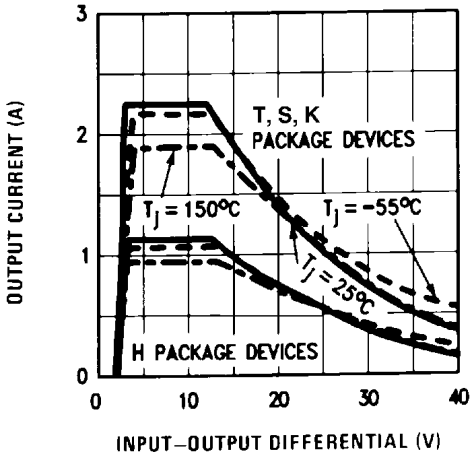


Figure 4.

Adjustment Current

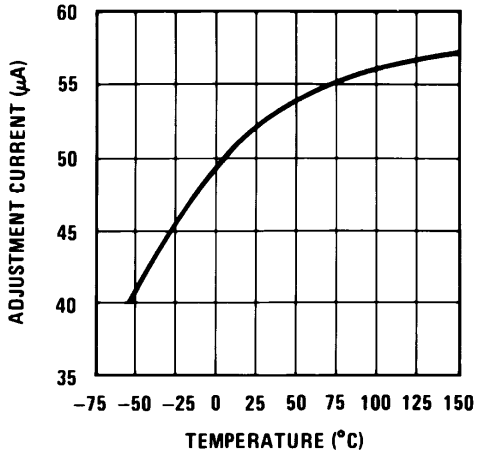


Figure 5.

Dropout Voltage

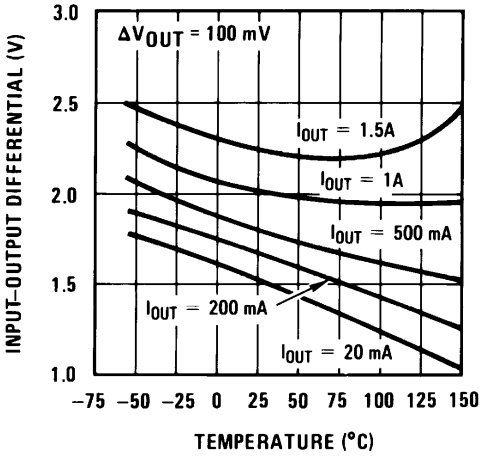


Figure 6.

Temperature Stability

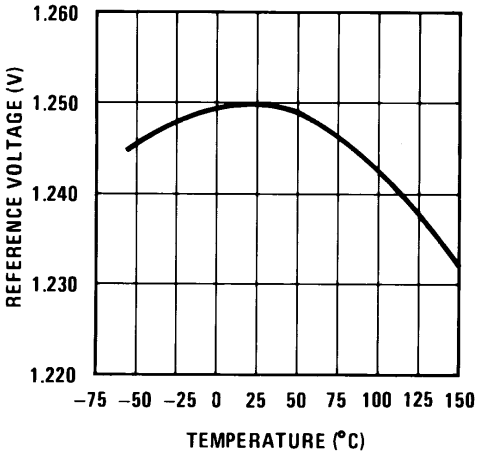


Figure 7.

Minimum Operating Current

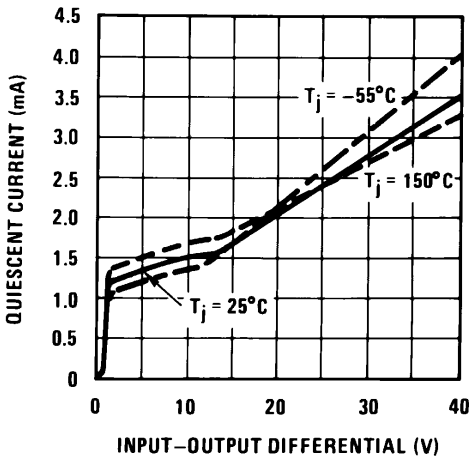


Figure 8.

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Typical Performance Characteristics (continued)

Output Capacitor = 0µF unless otherwise noted

Ripple Rejection

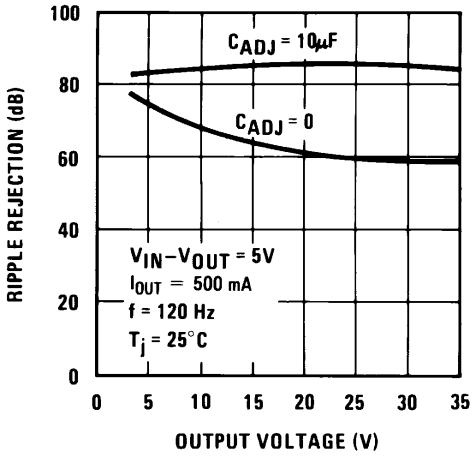


Figure 9.

Ripple Rejection

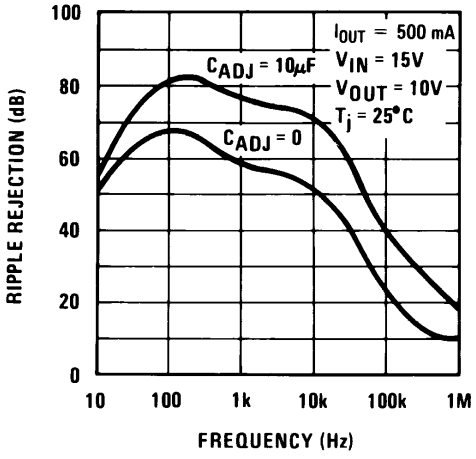


Figure 10.

Ripple Rejection

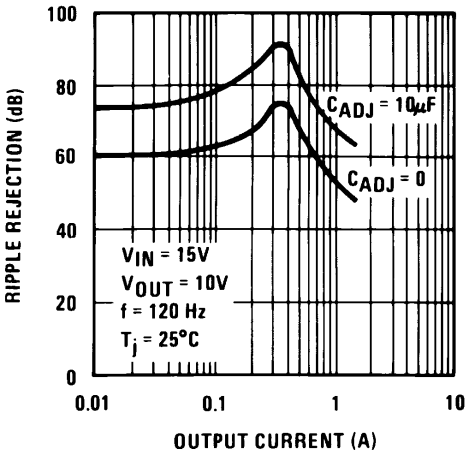


Figure 11.

Output Impedance

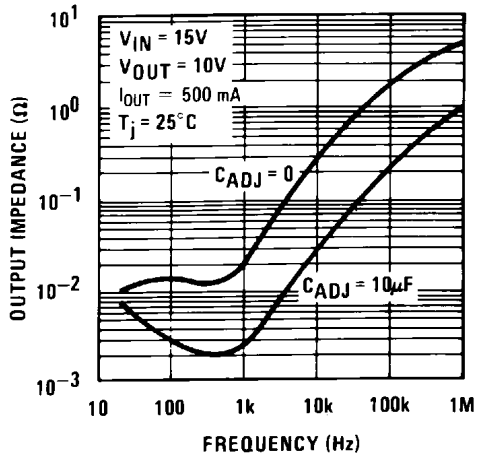


Figure 12.

Line Transient Response

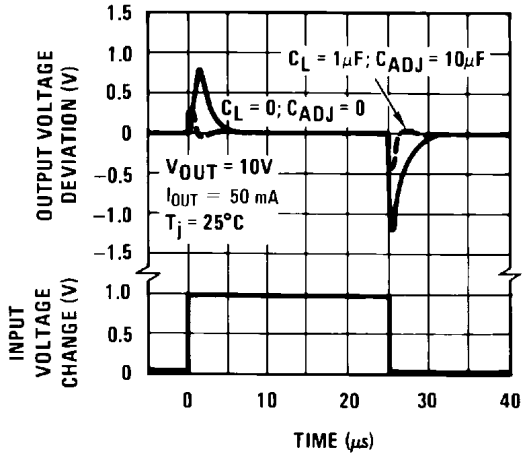


Figure 13.

Load Transient Response

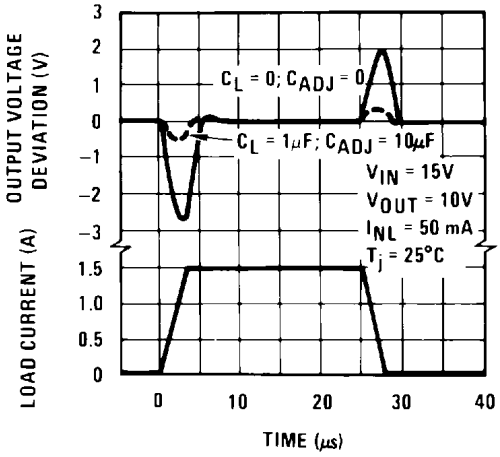


Figure 14.

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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

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

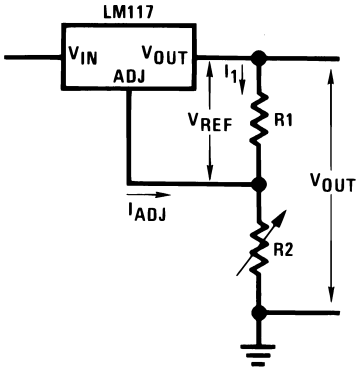


Figure 15.

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 × 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.

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Figure 16 shows the effect of resistance between the regulator and 240Ω set resistor.

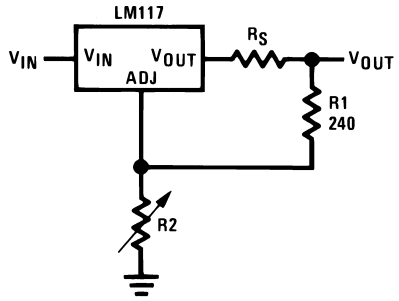


Figure 16. Regulator with Line Resistance in Output Lead

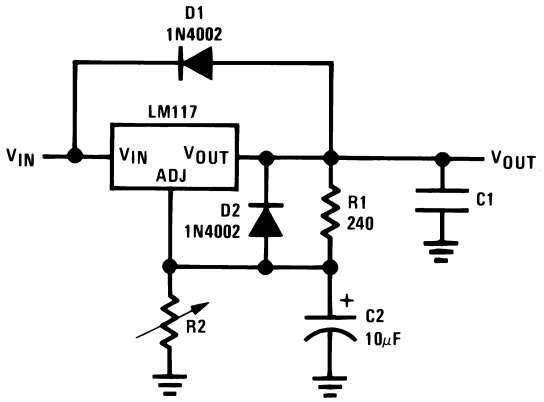
With the TO-3 package, it is easy to minimize the resistance from the case to the set resistor, by using two separate leads to the case. However, with the TO package, care should be taken to minimize the wire length of the output lead. The ground of R2 can be returned near the ground of the load to provide 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 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 17* 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

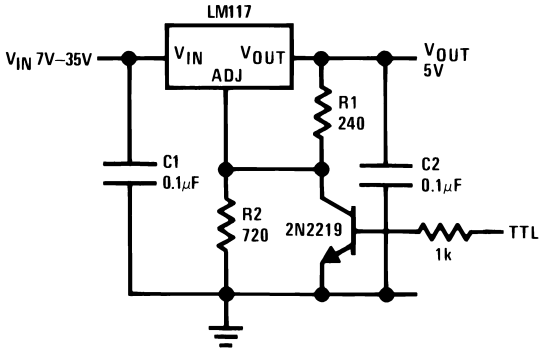
Figure 17. Regulator with Protection Diodes

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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.

Typical Applications



*Min. output ≅ 1.2V

Figure 18. 5V Logic Regulator with Electronic Shutdown*

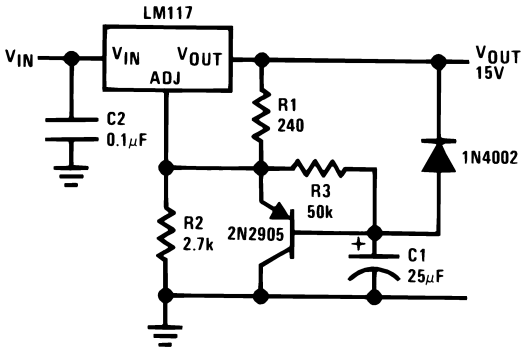
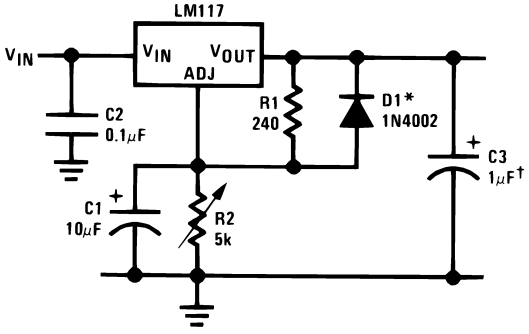


Figure 19. Slow Turn-On 15V Regulator



†Solid tantalum
*Discharges C1 if output is shorted to ground

Figure 20. Adjustable Regulator with Improved Ripple Rejection

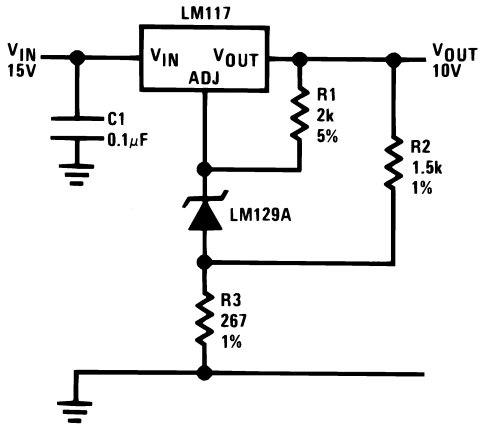
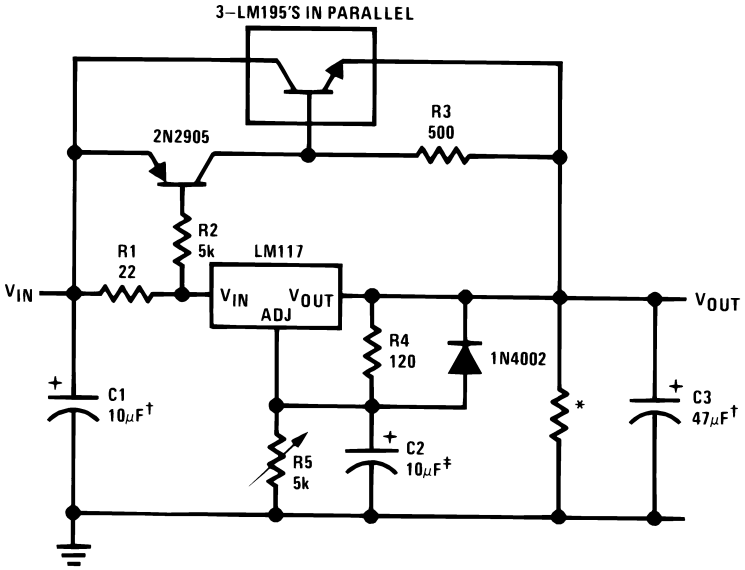


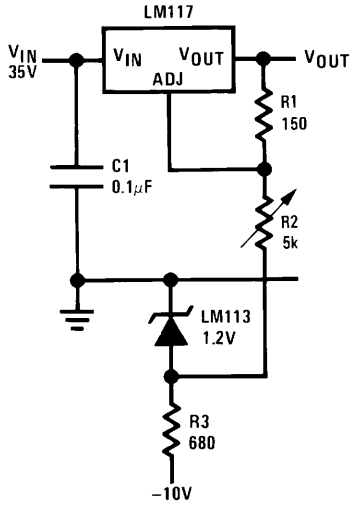
Figure 21. High Stability 10V Regulator



‡Optional—improves ripple rejection
†Solid tantalum
*Minimum load current = 30 mA

Figure 22. High Current Adjustable Regulator

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Full output current not available at high input-output voltages

Figure 23. 0 to 30V Regulator

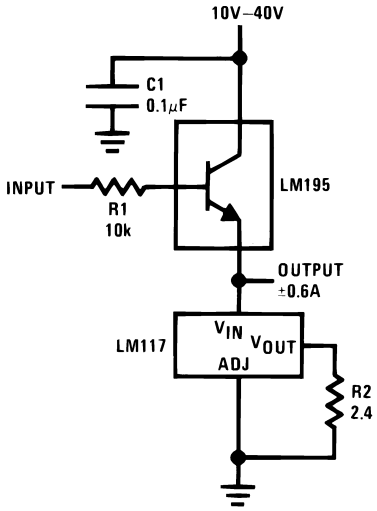
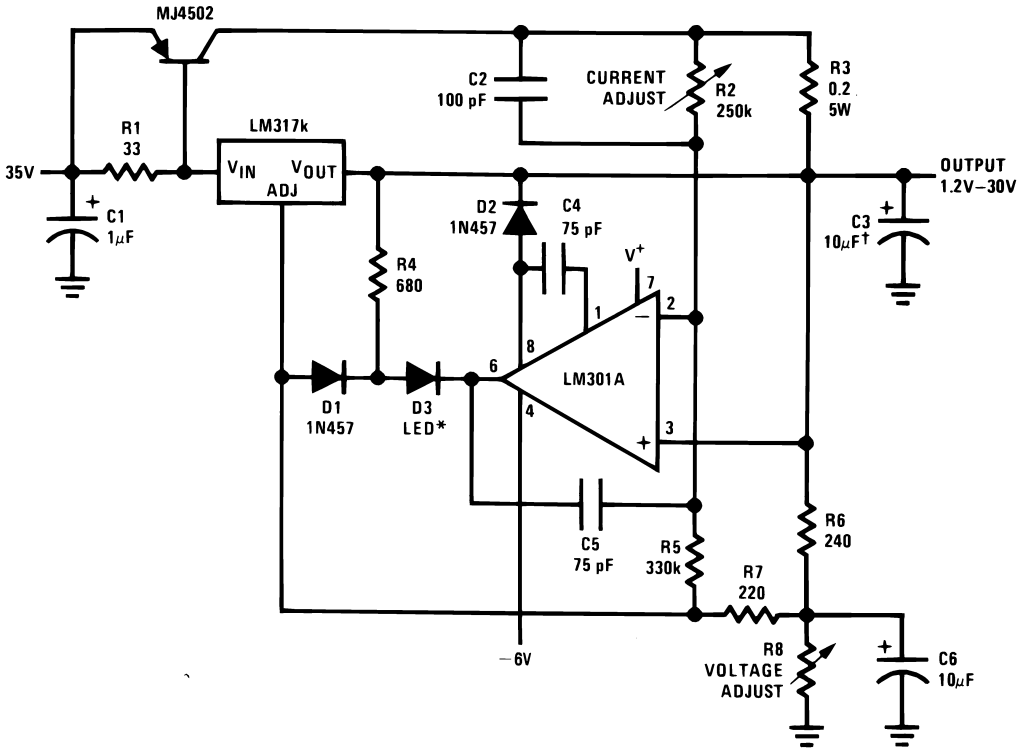


Figure 24. Power Follower



†Solid tantalum
*Lights in constant current mode

Figure 25. 5A Constant Voltage/Constant Current Regulator

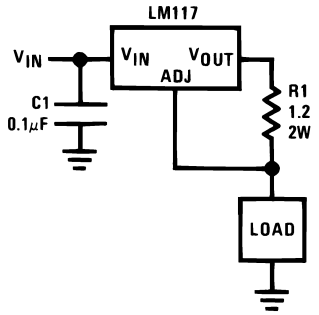
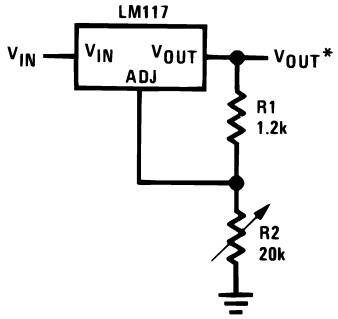


Figure 26. 1A Current Regulator



*Minimum load current ≅ 4 mA

Figure 27. 1.2V–20V Regulator with Minimum Program Current

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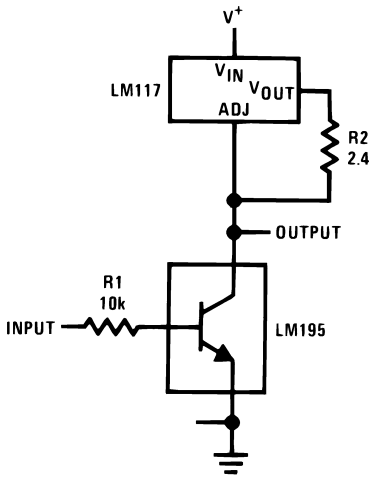
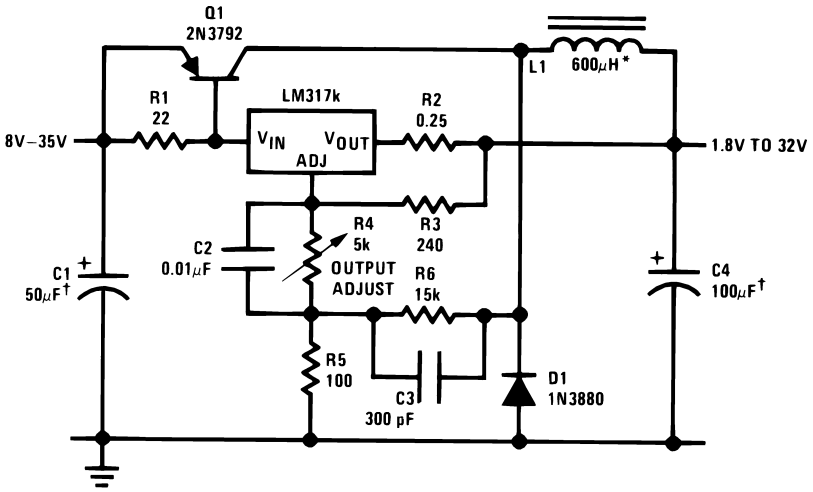
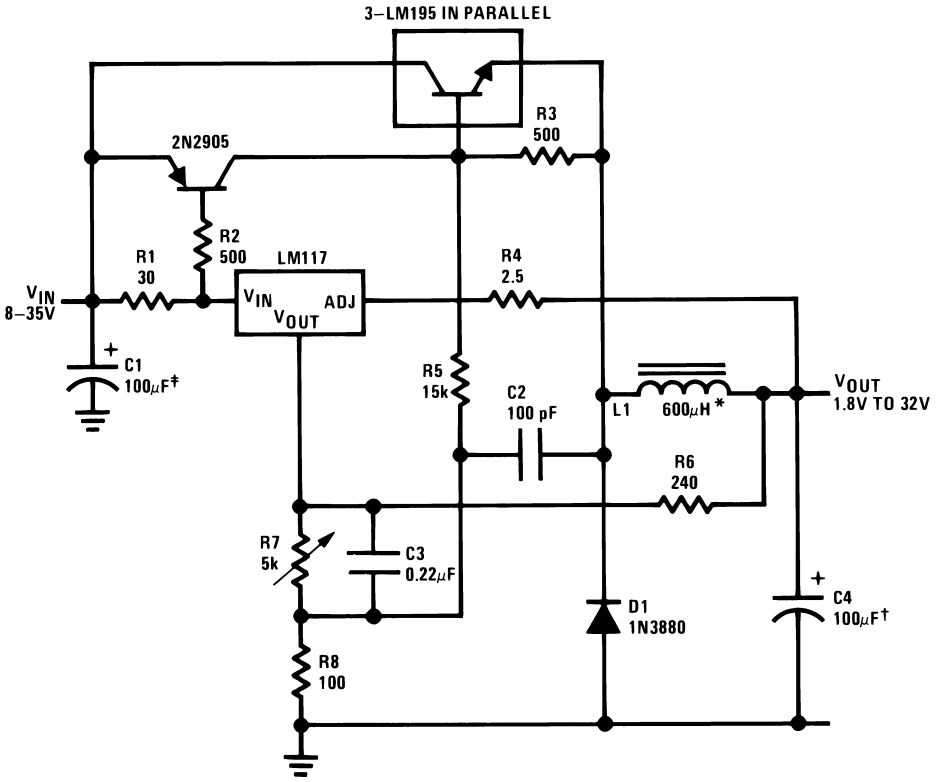


Figure 28. High Gain Amplifier



†Solid tantalum
*Core—Arnold A-254168-2 60 turns

Figure 29. Low Cost 3A Switching Regulator



†Solid tantalum
*Core—Arnold A-254168-2 60 turns

Figure 30. 4A Switching Regulator with Overload Protection

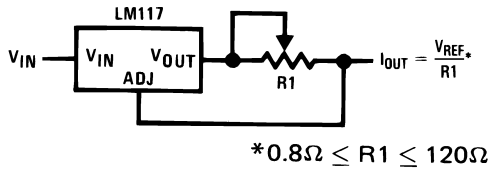


Figure 31. Precision Current Limiter

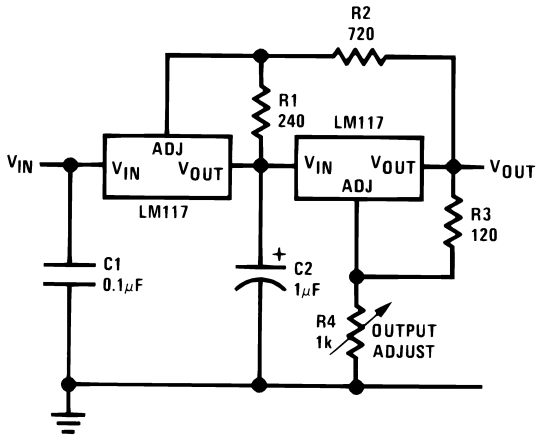
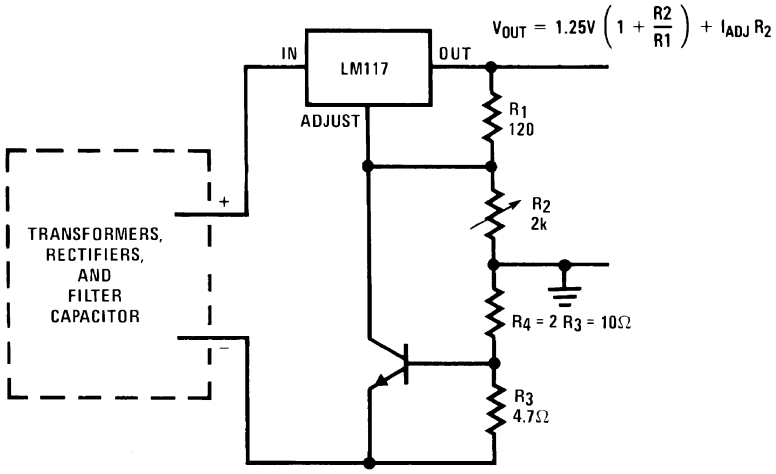


Figure 32. Tracking Preregulator

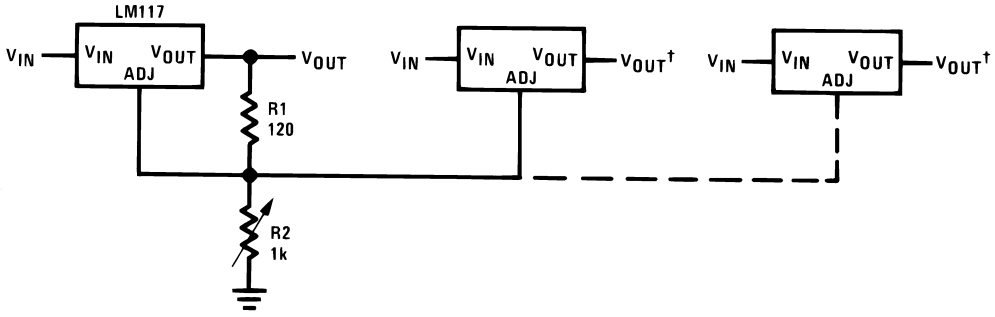
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– Short circuit current is approximately $\frac{600\ mV}{R3}$, or 120 mA

(Compared to LM117's higher current limit)
—At 50 mA output only ¾ volt of drop occurs in R_3 and R_4

Figure 33. Current Limited Voltage Regulator



*All outputs within ±100 mV
†Minimum load—10 mA

Figure 34. Adjusting Multiple On-Card Regulators with Single Control*

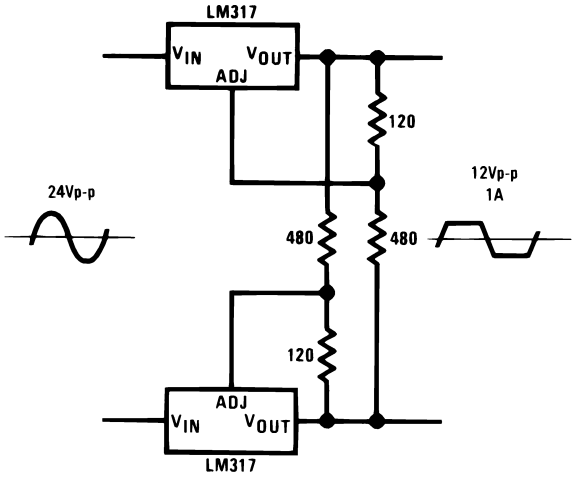
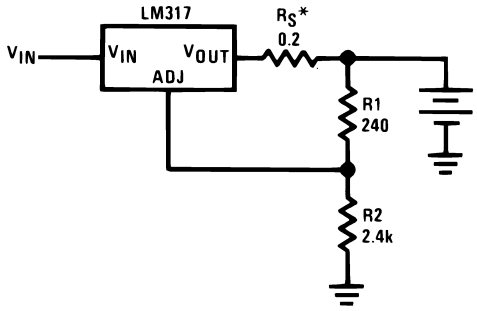


Figure 35. AC Voltage Regulator



*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.

Figure 36. 12V Battery Charger

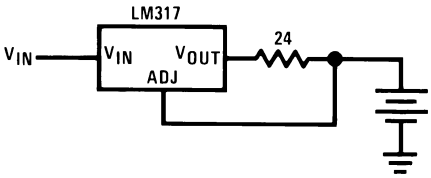


Figure 37. 50mA Constant Current Battery Charger

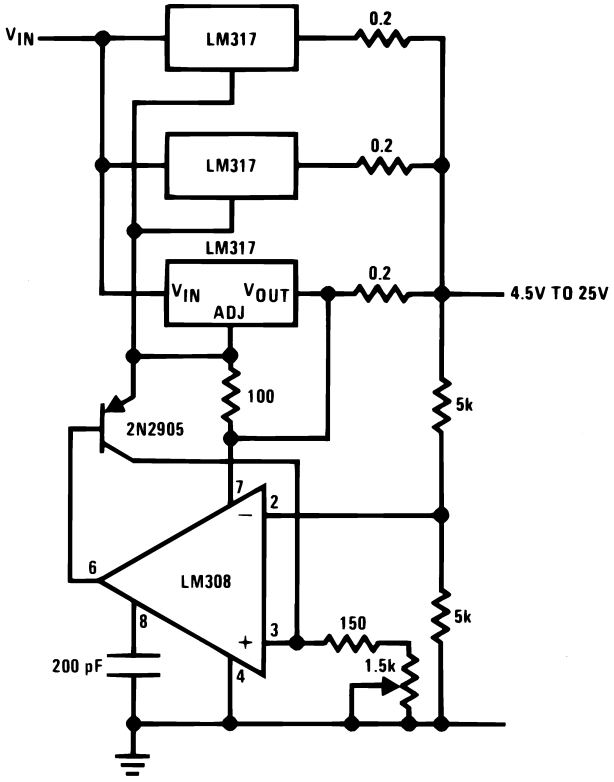
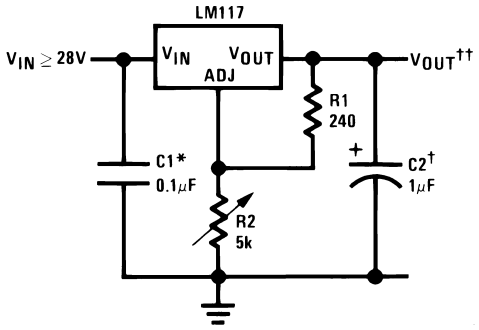


Figure 38. Adjustable 4A Regulator

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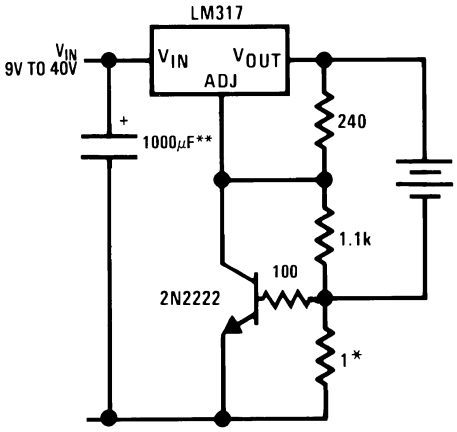
Full output current not available at high input-output voltages

*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.

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

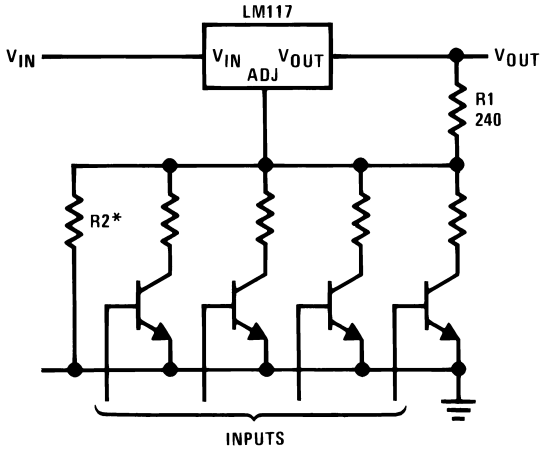
Figure 39. 1.2V–25V Adjustable Regulator



*Sets peak current (0.6A for 1Ω)

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

Figure 40. Current Limited 6V Charger



*Sets maximum V_{OUT}

Figure 41. Digitally Selected Outputs

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Revision History

Date Released	Revision	Section	Originator	Changes
03/14/06	A	New Release to corporate format	L. Lytle	2 MDS data sheets were consolidated into one corporate data sheet format. MJLM117–K Rev 0C1 and MJLM117–H Rev 1A1 will be archived.
03/20/2013	A	All Sections		Changed layout of National Data Sheet to TI format

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
JL117BXA	Active	Production	TO (NDT) | 3	20 | TRAY NON-STD	No	Call TI	Level-1-NA-UNLIM	-55 to 125	JL117BXA JM38510/11703BXA Q ACO JM38510/11703BXA Q >T
JM38510/11703BXA	Active	Production	TO (NDT) | 3	20 | TRAY NON-STD	No	Call TI	Level-1-NA-UNLIM	-55 to 125	JL117BXA JM38510/11703BXA Q ACO JM38510/11703BXA Q >T
M38510/11703BXA	Active	Production	TO (NDT) | 3	20 | TRAY NON-STD	No	Call TI	Level-1-NA-UNLIM	-55 to 125	JL117BXA JM38510/11703BXA Q ACO JM38510/11703BXA Q >T

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

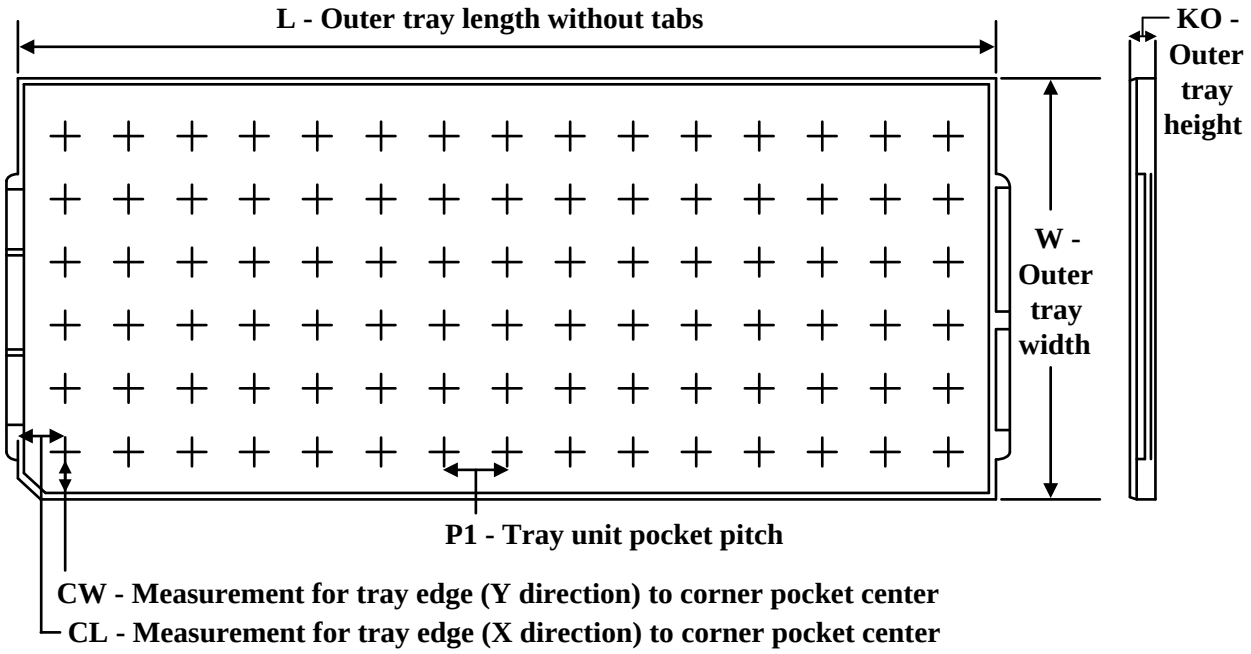
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TRAY

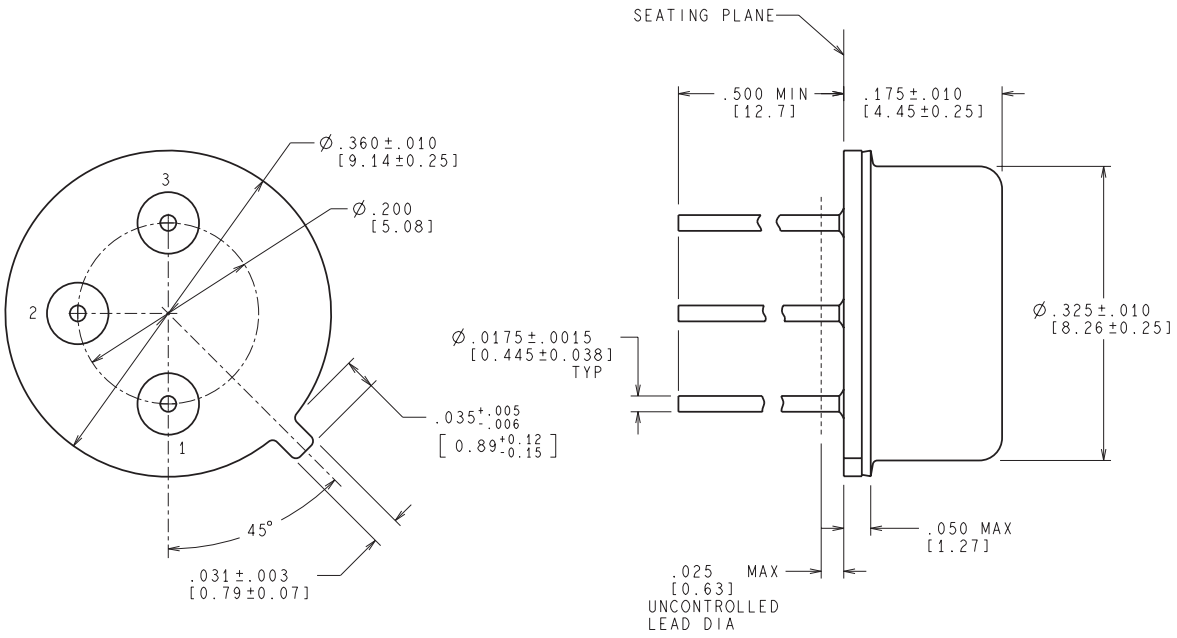


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
JL117BXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
JM38510/11703BXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54
M38510/11703BXA	NDT	TO-CAN	3	20	2 X 10	150	126.49	61.98	8890	11.18	12.95	18.54

NDT0003A



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H03A (Rev D)

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