

LM117HV/LM217HV/LM317HV 3-Terminal Adjustable Regulator

General Description

The LM117HV/LM217HV/LM317HV are adjustable 3-terminal positive voltage regulators capable of supplying in excess of 1.5A over a 1.2V to 57V 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 LM117HV is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117HV 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.

Features

- Adjustable output down to 1.2V
- Guaranteed 1.5A output current
- Line regulation typically 0.01%/V
- Load regulation typically 0.1%
- Current limit constant with temperature
- 100% electrical burn-in
- Eliminates the need to stock many voltages
- Standard 3-lead transistor package
- 80 dB ripple rejection

Normally, no capacitors are needed unless the device is situated far 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 rejections ratios which are difficult to achieve with standard 3-terminal regulators.

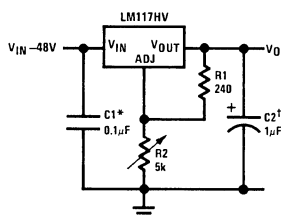
Besides replacing fixed regulators, the LM117HV is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM117HV 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.

The LM117HVK STEEL, LM217HVK STEEL, and LM317HVK STEEL are packaged in standard TO-3 transistor packages while the LM117HVH, LM217HVH and LM317HVH are packaged in a solid Kovar base TO-39 transistor package. The LM117HV is rated for operation from -55°C to $+150^{\circ}\text{C}$, the LM217HV from -25°C to $+150^{\circ}\text{C}$ and the LM317HV from 0°C to $+125^{\circ}\text{C}$.

Typical Applications

1.2V–45V Adjustable Regulator

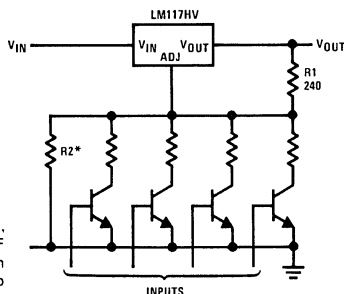


†Optional—improves transient response. Output capacitors in the range of $1\mu\text{F}$ to $1000\mu\text{F}$ of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

*Needed if device is far from filter capacitors.

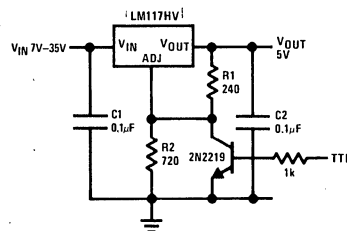
$$\dagger\dagger V_{\text{OUT}} = 1.25V \left(1 + \frac{R_2}{R_1} \right)$$

Digitally Selected Outputs



*Sets maximum V_{OUT}

5V Logic Regulator with Electronic Shutdown*



* Min output $\approx 1.2V$

Absolute Maximum Ratings

Power Dissipation	Internally limited
Input–Output Voltage Differential	60V
Operating Junction Temperature Range	
LM117HV	–55°C to +150°C
LM217HV	–25°C to +150°C
LM317HV	0°C to +125°C
Storage Temperature	–65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

Electrical Characteristics (Note 1)

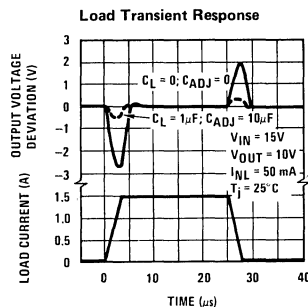
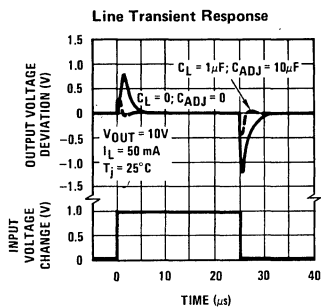
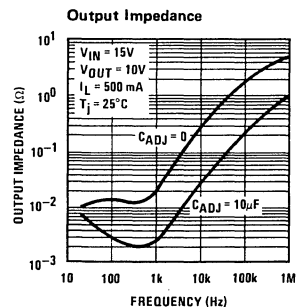
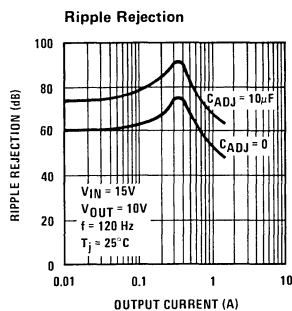
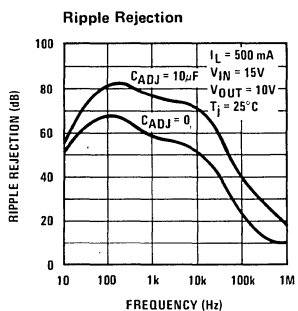
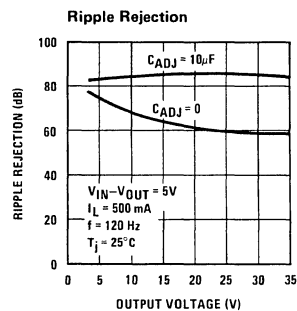
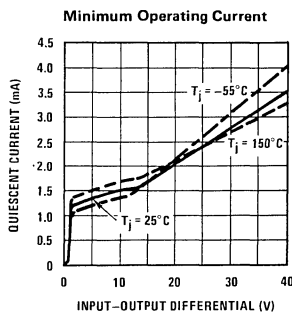
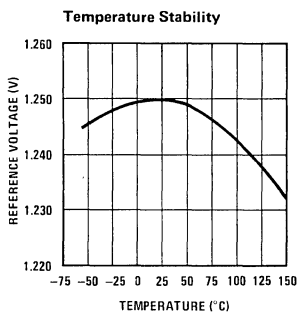
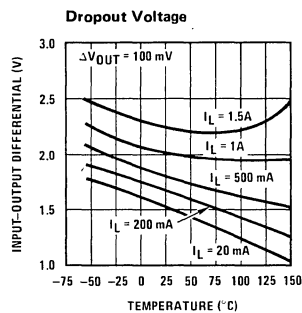
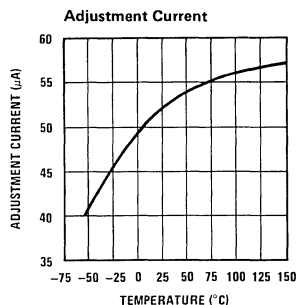
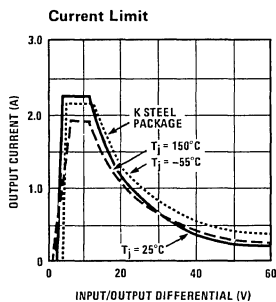
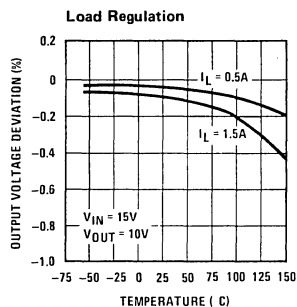
PARAMETER	CONDITIONS	LM117HV/LM217HV			LM317HV			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	$T_A = 25^\circ\text{C}$, $3\text{V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 60\text{V}$ (Note 2)		0.01	0.02		0.01	0.04	%/V
Load Regulation	$T_A = 25^\circ\text{C}$, $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$							
	$V_{\text{OUT}} \leq 5\text{V}$, (Note 2)		5	15		5	25	mV
	$V_{\text{OUT}} \geq 5\text{V}$, (Note 2)		0.1	0.3		0.1	0.5	%
Thermal Regulation	$T_A = 25^\circ\text{C}$, 20ms Pulse		0.03	0.07		0.04	0.07	%/W
Adjustment Pin Current			50	100		50	100	μA
Adjustment Pin Current Change			0.2	5		0.2	5	μA
Reference Voltage	$10\text{mA} \leq I_L \leq I_{\text{MAX}}$ $3.0\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 60\text{V}$							
	$3 \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 60\text{V}$, (Note 3) $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$, $P \leq P_{\text{MAX}}$	1.20	1.25	1.30	1.20	1.25	1.30	V
Line Regulation	$3\text{V} \leq V_{\text{IN}} - V_{\text{OUT}} \leq 60\text{V}$, (Note 2)		0.02	0.05		0.02	0.07	%/V
Load Regulation	$10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$, (Note 2)							
	$V_{\text{OUT}} \leq 5\text{V}$		20	50		20	70	mV
	$V_{\text{OUT}} \geq 5\text{V}$		0.3	1		0.3	1.5	%
Temperature Stability	$T_{\text{MIN}} \leq T_j \leq T_{\text{MAX}}$		1			1		%
Minimum Load Current	$V_{\text{IN}} - V_{\text{OUT}} = 60\text{V}$		3.5	7		3.5	12	mA
Current Limit	$V_{\text{IN}} - V_{\text{OUT}} \leq 15\text{V}$							
	K Package	1.5	2.2		1.5	2.2		A
	H Package	0.5	0.8		0.5	0.8		A
	$V_{\text{IN}} - V_{\text{OUT}} = 60\text{V}$							
	K Package		0.1			0.1		A
	H Package		0.03			0.03		A
RMS Output Noise, % of V_{OUT}	$T_A = 25^\circ\text{C}$, $10\text{Hz} \leq f \leq 10\text{kHz}$		0.003			0.003		%
Ripple Rejection Ratio	$V_{\text{OUT}} = 10\text{V}$, $f = 120\text{Hz}$		65			65		dB
	$C_{\text{ADJ}} = 10\mu\text{F}$	66	80		66	80		dB
Long-Term Stability	$T_A = 125^\circ\text{C}$		0.3	1		0.3	1	%
Thermal Resistance, Junction to Case	H Package		12	15		12	15	$^\circ\text{C/W}$
	K Package		2.3	3		2.3	3	$^\circ\text{C/W}$

Note 1: Unless otherwise specified, these specifications apply $-55^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$ for the LM117HV, $-25^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$ for the LM217HV and $0^\circ\text{C} \leq T_j \leq +125^\circ\text{C}$ for the LM317HV; $V_{\text{IN}} - V_{\text{OUT}} = 5\text{V}$ and $I_{\text{OUT}} = 0.1\text{A}$ for the TO-39 package and $I_{\text{OUT}} = 0.5\text{A}$ for the TO-3 package. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO-39 and 20W for the TO-3. I_{MAX} is 1.5A for the TO-3 and 0.5A for the TO-39 package.

Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Note 3: Selected devices with tightened tolerance reference voltage available.

Typical Performance Characteristics (K and T Packages)



Application Hints

In operation, the LM117HV develops a nominal 1.25V reference voltage, V_{REF} , between the output and adjustment terminal. The reference voltage is impressed across program resistor R_1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R_2 , giving an output voltage of

$$V_{OUT} = V_{REF} \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ} R_2$$

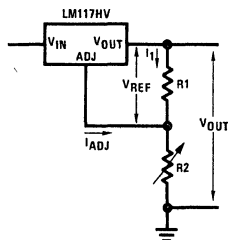


FIGURE 1.

Since the 100 μ A current from the adjustment terminal represents an error term, the LM117HV 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 0.1 μ F disc or 1 μ F 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 LM117HV to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 μ F bypass capacitor 80 dB ripple rejection is obtainable at any output level. Increases over 10 μ F do not appreciably improve the ripple rejection at frequencies above 120 Hz. 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 are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 μ F in aluminum electrolytic to equal 1 μ F 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 μ F disc may seem to work better than a 0.1 μ F disc as a bypass.

Although the LM117HV 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 μ F solid tantalum (or 25 μ F aluminum electrolytic) on the output swamps this effect and insures stability.

Load Regulation

The LM117HV 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 240 Ω) should be tied directly to the output 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 0.05 Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05 Ω \times I_L . If the set resistor is connected near the load the effective line resistance will be 0.05 Ω (1 + R_2/R_1) or in this case, 11.5 times worse.

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

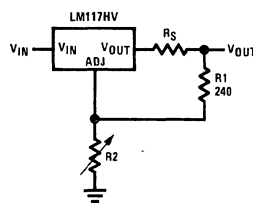


FIGURE 2. Regulator with Line Resistance in Output Lead

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-5 package, care should be taken to minimize the wire length of the output lead. The ground of R_2 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 μ F 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

Application Hints (cont'd.)

current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN} . In the LM117HV, 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 $25\mu\text{F}$ 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 LM117HV is a 50Ω resistor which limits the peak discharge current. No protection is needed for output voltages of 25V or less and $10\mu\text{F}$ capacitance. *Figure 3* shows an LM117HV with protection diodes included for use with outputs greater than 25V and high values of output capacitance.

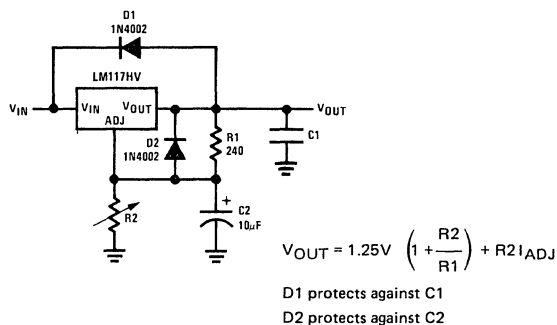
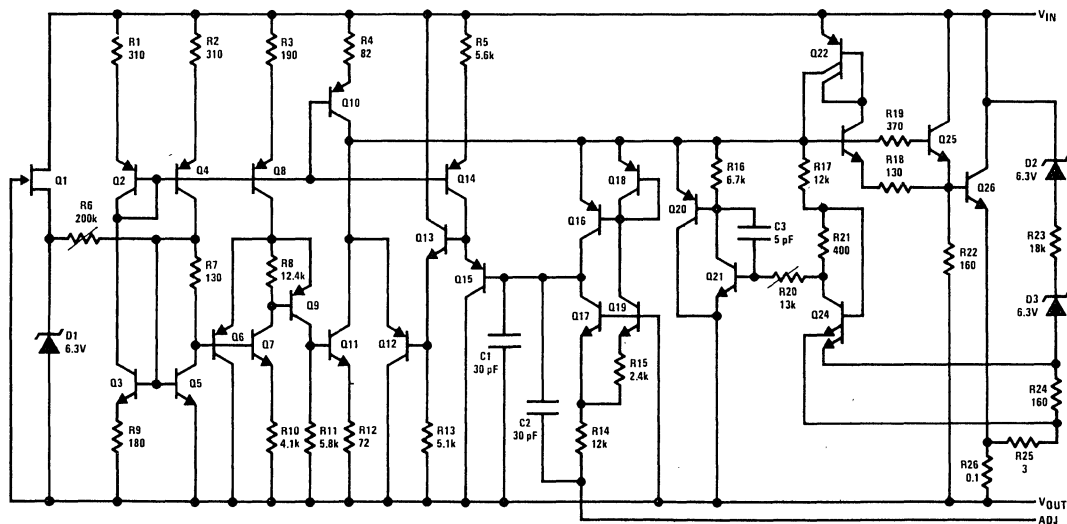


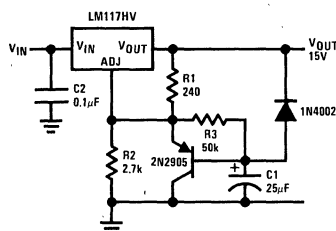
FIGURE 3. Regulator with Protection Diodes

Schematic Diagram

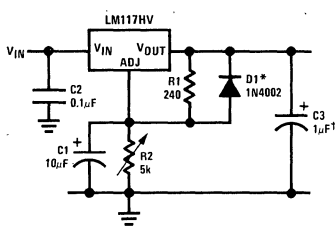


Typical Applications (cont'd.)

Slow Turn-On 15V Regulator



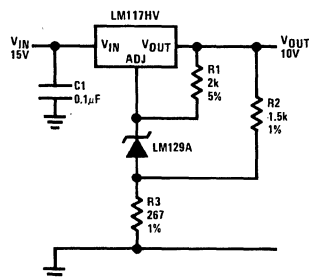
Adjustable Regulator with Improved Ripple Rejection



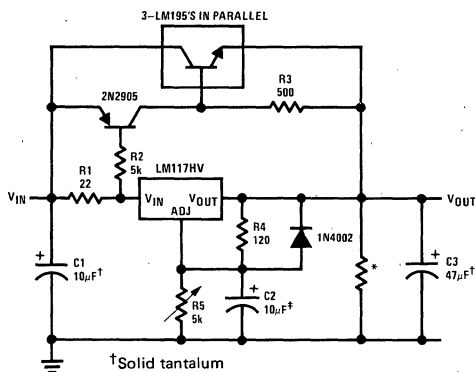
†Solid tantalum

*Discharges C1 if output is shorted to ground

High Stability 10V Regulator



High Current Adjustable Regulator

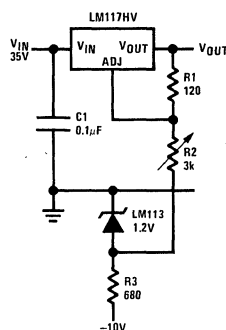


†Solid tantalum

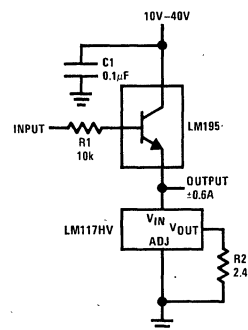
*Minimum load current = 30 mA

‡Optional—improves ripple rejection

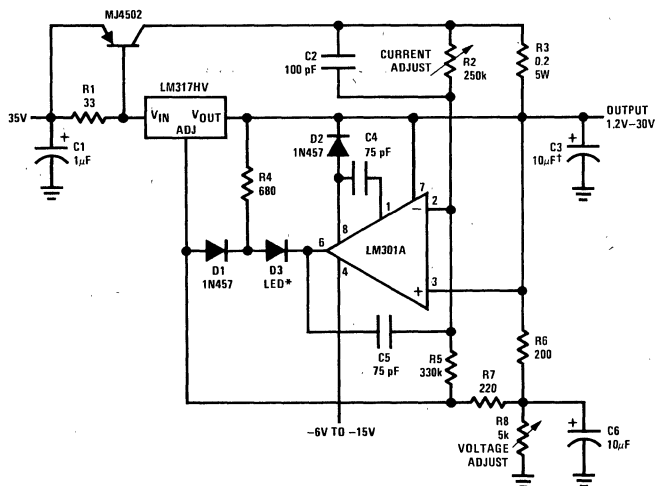
0 to 30V Regulator



Power Follower



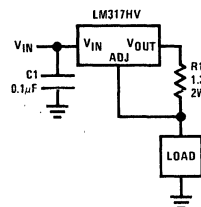
5A Constant Voltage/Constant Current Regulator



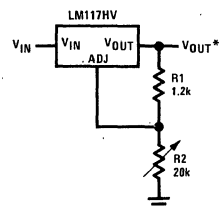
†Solid tantalum

*Lights in constant current mode

1A Current Regulator



1.2V-20V Regulator with Minimum Program Current



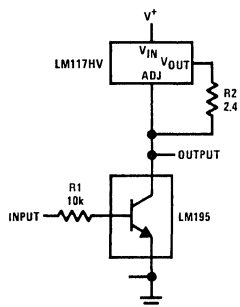
*Minimum load current ≈ 4 mA

Typical Applications (cont'd.)

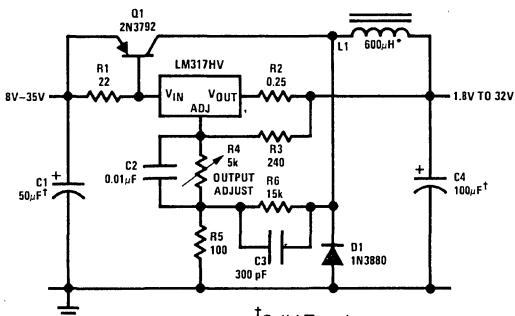
LM117HV/
LM217HV/LM317HV

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High Gain Amplifier



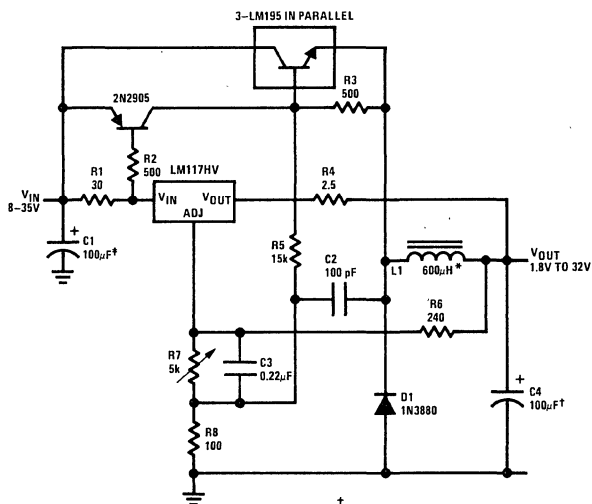
Low Cost 3A Switching Regulator



†Solid Tantalum

*Core—Arnold A-254168-2 60 turns

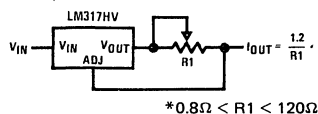
4A Switching Regulator with Overload Protection



†Solid Tantalum

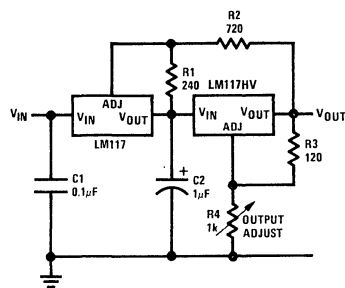
*Core Arnold A-254168-2 60 turns

Precision Current Limiter

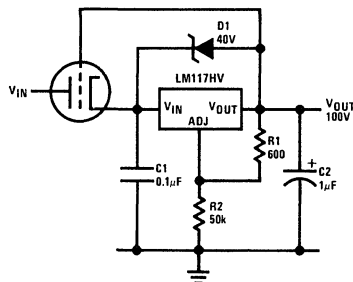


*0.8Ω ≤ R1 ≤ 120Ω

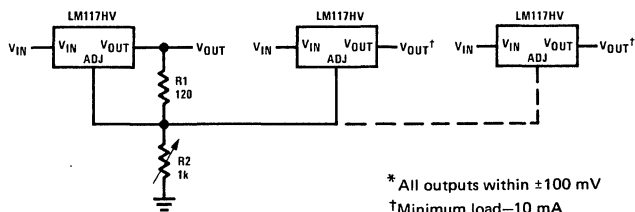
Tracking Preregulator



High Voltage Regulator



Adjusting Multiple On-Card Regulators with Single Control*

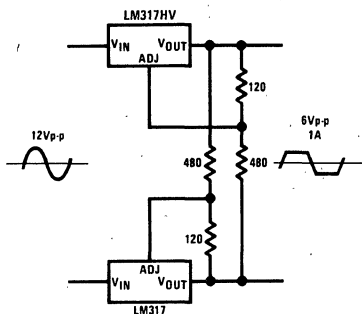


*All outputs within ±100 mV

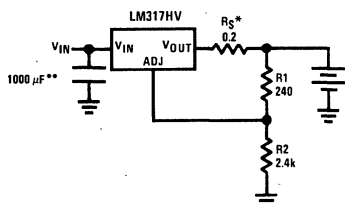
†Minimum load—10 mA

Typical Applications (cont'd.)

AC Voltage Regulator



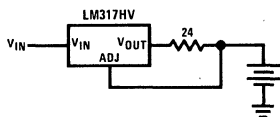
12V Battery Charger



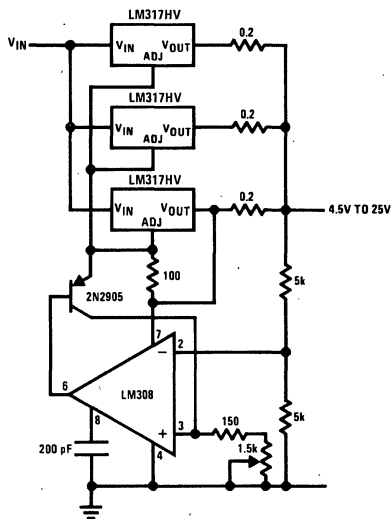
* R_S —sets output impedance of charger $Z_{OUT} = R_S \left(1 + \frac{R_2}{R_1}\right)$
Use of R_S allows low charging rates with fully charged battery.

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

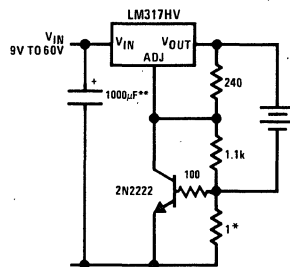
50 mA Constant Current Battery Charger



Adjustable 4A Regulator



Current Limited 6V Charger

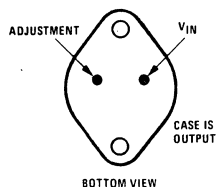


*Sets peak current (0.6A for 1Ω)

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

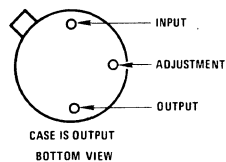
Connection Diagrams

(TO-3 Steel)
Metal Can Package



Order Number LM117HVK STEEL,
LM217HVK STEEL, or
LM317HVK STEEL
See Package KO2A

(TO-39)
Metal Can Package



Order Number LM117HVH,
LM217HVH, or LM317HVH
See Package H03A