

## THREE-TERMINAL ADJUSTABLE OUTPUT POSITIVE VOLTAGE REGULATORS

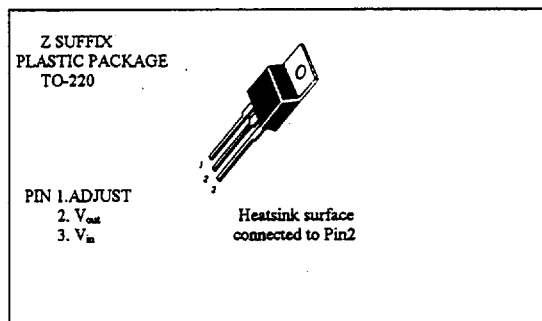
The LM317 is adjustable 3-terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and require only two

external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow-out proof.

### FEATURES

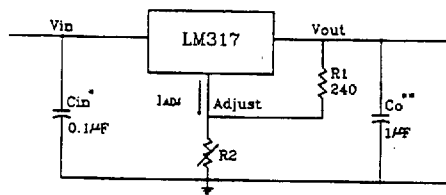
- Output Current in Excess of 1.5 Ampere
- Output Adjustable between 1.2 V and 37 V
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limiting  
Constant with Temperature
- Output Transistor Safe-Area Compensation
- Floating Operation for High Voltage Applications
- Standard 3-lead Transistor Packages
- Eliminates Stocking Many Fixed Voltages

### PIN ARRANGEMENT



### CIRCUIT SCHEMATIC

#### STANDARD APPLICATION



\* =  $C_{in}$  is required if regulator is located an appreciable distance from power supply filter.

\*\* =  $C_o$  is not needed for stability, however it does improve transient response.

$$V_{out} = 1.25 V (1 + R_2 / R_1) + I_{adj} R_2$$

Since  $I_{adj}$  is controlled to less than 100  $\mu A$ , the error associated with this term is negligible in most applications

## ORDERING INFORMATION

Device	Tested Operating Temperature Range	Package
LM317CZ	$T_J = 0^\circ\text{C}$ to $125^\circ\text{C}$	TO-220

## MAXIMUM RATINGS

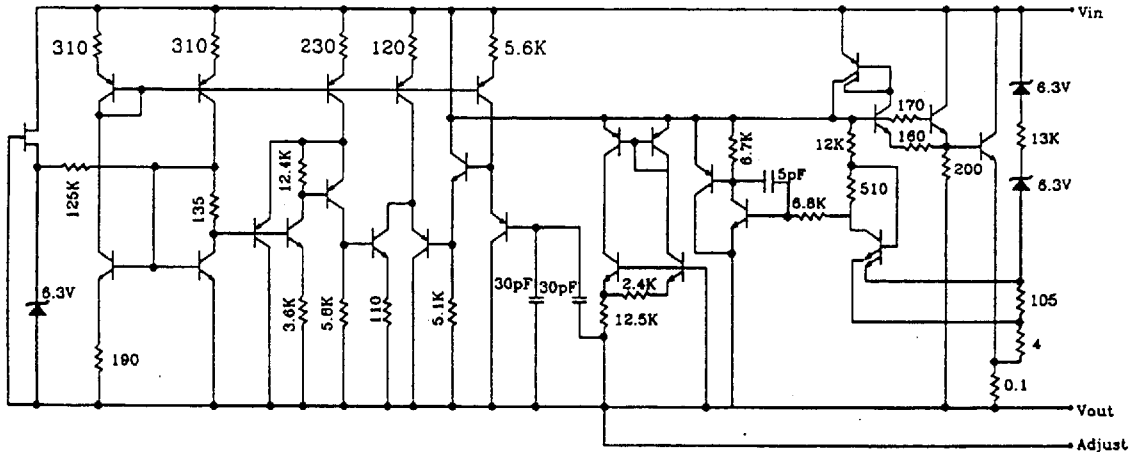
Rating	Symbol	Value	Unit
Input-Output Voltage Differential	$V_I - V_O$	40	Vdc
Power Dissipation	$P_D$	Internally Limited	
Operating Junction Temperature Range	$T_J$	0 to +150	$^\circ\text{C}$
Storage Temperature Range	$T_{\text{stg}}$	-65 to +150	$^\circ\text{C}$

## LM317 ELECTRICAL CHARACTERISTICS

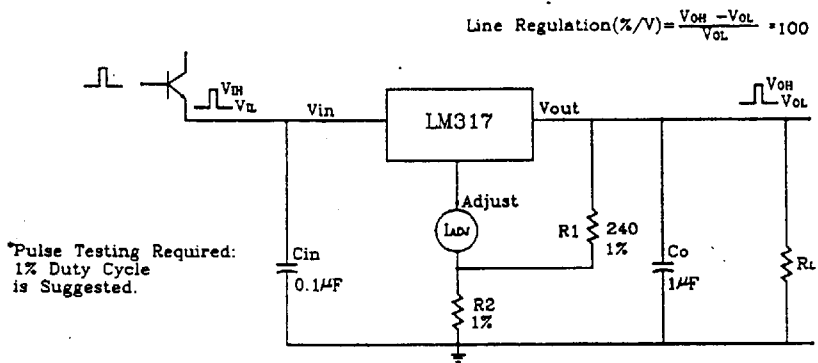
( $V_I - V_O = 5.0\text{ V}$ ;  $I_O = 0.5\text{ A}$  for TO-220 packages;  $T_J = T_{\text{low}}$  to  $T_{\text{high}}$  [see Note 1];  $I_{\text{max}}$  and  $P_{\text{max}}$  per Note 2; unless otherwise specified.)

Characteristic	Figure	Symbol	Min.	Typ.	Max.	Unit
Line Regulation (Note 3) $T_A = 25^\circ\text{C}$ , $3.0\text{ V} \leq V_O \leq 40\text{ V}$	1	REGline	--	0.01	0.04	%V
Load Regulation (Note 3) $T_A = 25^\circ\text{C}$ , $10\text{ mA} \leq I_O \leq I_{\text{max}}$ $V_O \leq 5.0$ $V_O \geq 5.0$	2	REGload	--	5.0	25	mV
			--	0.1	0.5	%V
Thermal Regulation ( $T_A = +25^\circ\text{C}$ ) 20 ms Pulse			--	0.03	0.07	%W
Adjustment Pin Current	3	$I_{\text{Adj}}$	--	50	100	$\mu\text{ A}$
Adjustment Pin Current Change $2.5\text{ V} \leq V_I - V_O \leq 40\text{ V}$ $10\text{ mA} \leq I_I \leq I_{\text{max}}$ , $P_D \leq P_{\text{max}}$	1.2	$\Delta I_{\text{Adj}}$	--	0.2	5.0	$\mu\text{ A}$
Reference Voltage (Note 4) $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$ $10\text{ mA} \leq I_O \leq I_{\text{max}}$ , $P_D \leq P_{\text{max}}$	3	$V_{\text{ref}}$	1.225	1.25	1.275	V
Line Regulation (Note 3) $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$	1	REGline	--	0.02	0.07	%V
Load Regulation (Note 3) $10\text{ mA} \leq I_O \leq I_{\text{max}}$ $V_O \leq 5.0\text{ V}$ $V_O \geq 5.0\text{ V}$	2	REGload	--	20	70	mV
			--	0.3	1.5	%V

## SCHEMATIC DIAGRAM



**FIGURE 1- LINE REGULATION AND LINE TEST CIRCUIT**



## ELECTRICAL CHARACTERISTICS

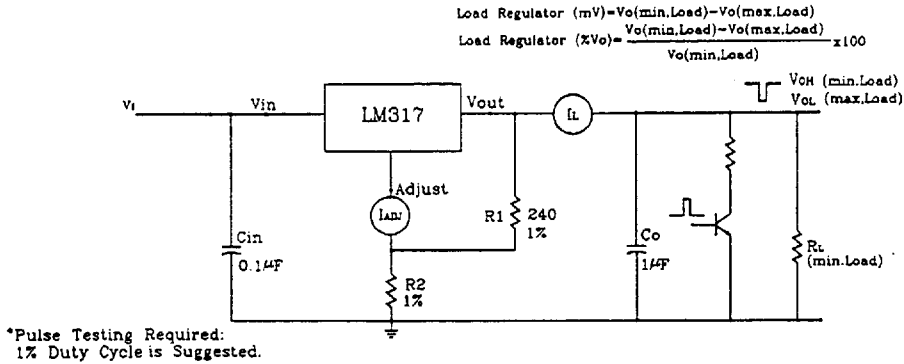
( $V_I - V_O = 5.0$  V;  $I_O = 0.5$  A for TO-220 packages;  $T_J = T_{low}$  to  $T_{high}$  [see Note 1];  $I_{max}$  and  $P_{max}$  per Note 2; unless otherwise specified.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Temperature Stability ( $T_{low} \leq T_J \leq T_{high}$ )	3	$T_S$	--	0.7	--	% V
Minimum Load Current to Maintain Regulation ( $V_I - V_O = 40$ V)	3	$I_{Lmin}$	--	3.5	10	mA
Maximum Output Current $V_I - V_O \leq 15$ V, $P_D \leq P_{max}$ $V_I - V_O = 40$ V, $P_D \leq P_{max}$ , $T_A = 25^\circ\text{C}$	3	$I_{max}$	1.5 0.15	2.2 0.4	-- --	A
RMS Noise, % of $V_O$ $T_A = 25^\circ\text{C}$ , $10$ Hz $\leq f \leq 10$ KHz	--	N	--	0.003	--	% V
Ripple Rejection, $V_O = 10$ V, $f = 120$ Hz (Note 5) Without $C_{Adj}$ $C_{Adj} = 10$ $\mu\text{F}$	4	RR	-- 66	65 80	-- --	dB
Long-Term Stability, $T_J = T_{high}$ (Note 6) $T_A = 25^\circ\text{C}$ for Endpoint Measurements	3	S	--	0.3	1.0	%1.0 K Hrs.
Thermal Resistance Junction to Case	--	$R_{\theta JC}$	--	5.0	--	$^\circ\text{C/W}$

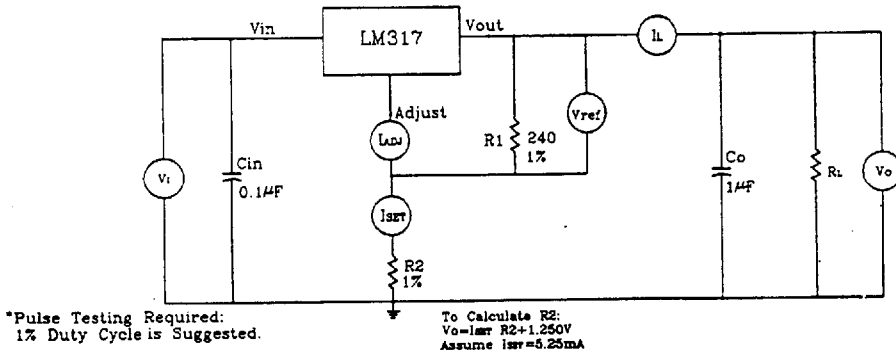
### NOTES:

- (1)  $T_{low} = 0^\circ\text{C}$      $T_{high} = +125^\circ\text{C}$
- (2)  $I_{max} = 1.5$  A  
 $P_{max} = 20$  W
- (3) Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
- (4) Selected devices with tightened tolerance reference voltage available.
- (5)  $C_{Adj}$ , when used, is connected between the adjustment pin and ground.
- (6) Since Long-Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.

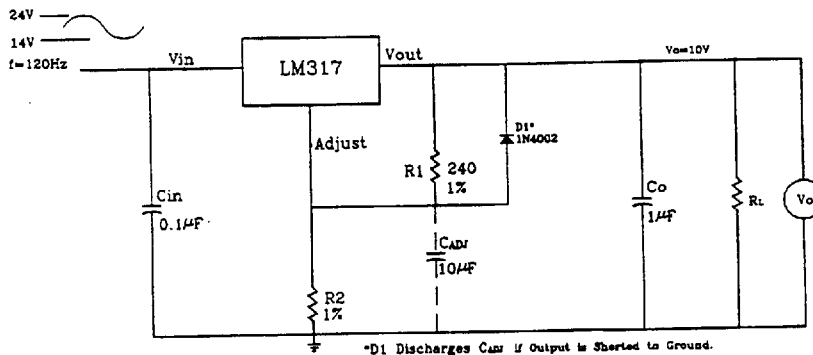
**FIGURE 2 - LOAD REGULATION AND  $\Delta I_{adj}$  / LOAD TEST CIRCUIT**



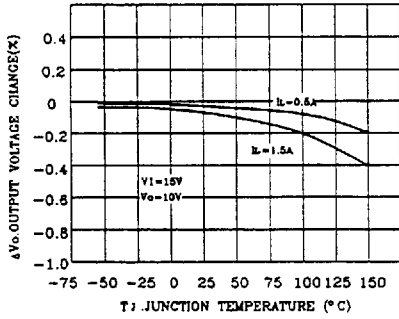
**FIGURE 3 - STANDARD TEST CIRCUIT**



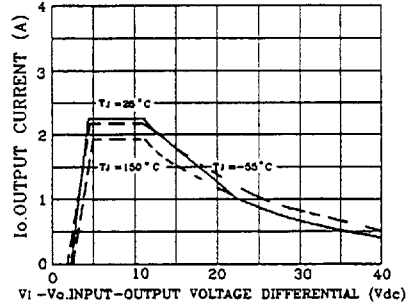
**FIGURE 4 - RIPPLE REJECTION TEST CIRCUIT**



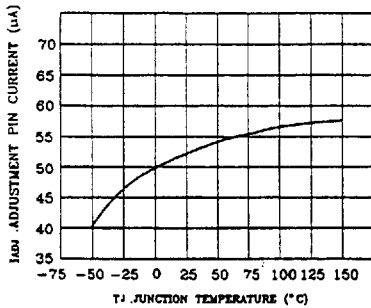
**FIGURE 5-LOAD REGULATION**



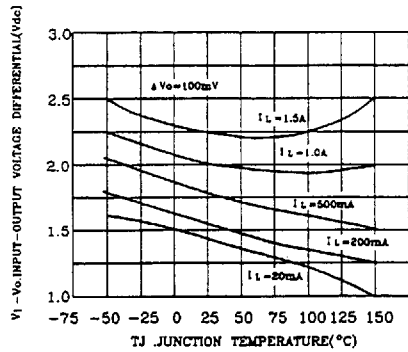
**FIGURE 6-CURRENT LIMIT**



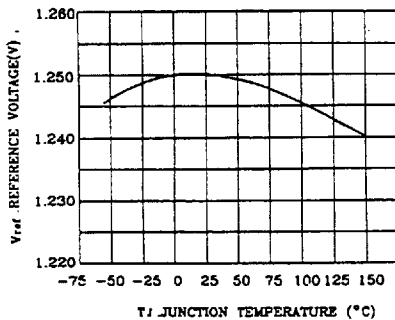
**FIGURE 7-ADJUSTMENT PIN CURRENT**



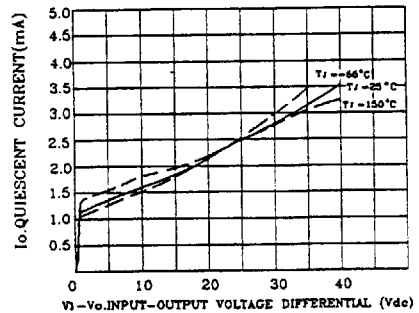
**FIGURE 8-DROPOUT VOLTAGE**



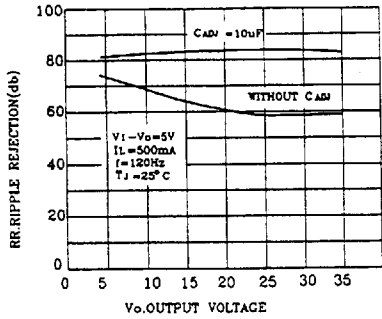
**FIGURE 9-TEMPERATURE STABILITY**



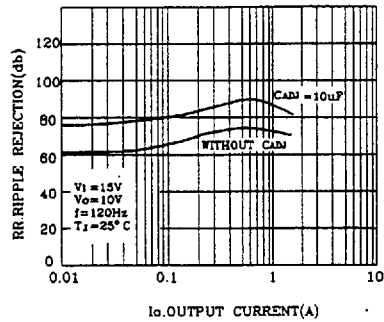
**FIGURE 10-MINIMUM OPERATING CURRENT**



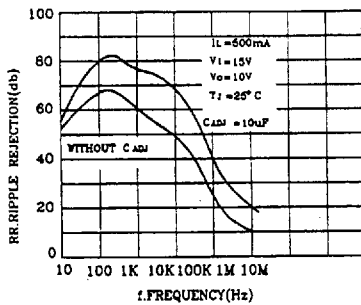
**FIGURE 11-RIPPLE REJECTION versus  
OUTPUT VOLTAGE**



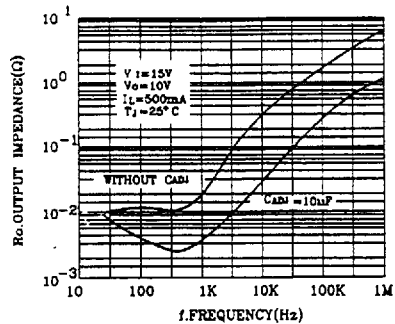
**FIGURE 12-RIPPLE REJECTION versus  
OUTPUT CURRENT**



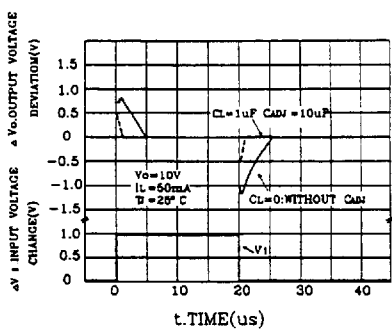
**FIGURE 13-RIPPLE REJECTION versus  
FREQUENCY**



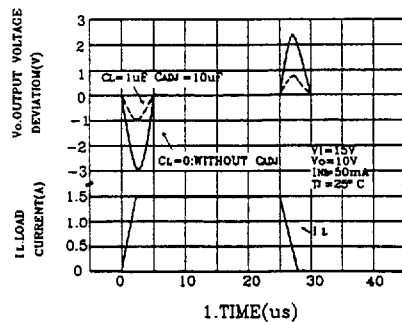
**FIGURE 14-OUTPUT IMPEDANCE**



**FIGURE 15-TEMPERATURE STABILITY**



**FIGURE 16-LOAD TRANSIENT RESPONSE**



## APPLICATIONS INFORMATION

### BASIC CIRCUIT OPERATION

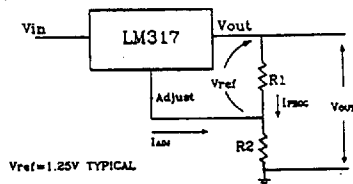
The LM317 is a 3-terminal floating regulator. In operation, the LM317 develops and maintains a nominal 1.25 volt reference ( $V_{ref}$ ) between its output and adjustment terminals. This reference voltage is converted to a programming current ( $I_{PROG}$ ) by  $R_1$  (see Figure 17), and this constant current flows through  $R_2$  to ground. The regulated output voltage is given by:

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

Since the current from the adjustment terminal ( $I_{adj}$ ) represents an error term in the equation, the LM317 was designed to control  $I_{adj}$  to less than 100  $\mu A$  and keep it constant. To do this, all quiescent operating current is returned to the output terminal. This imposes the requirement for a minimum load current. If the load current is less than this minimum, the output voltage will rise.

Since the LM317 is a floating regulator, it is only the voltage differential across the circuit which is important to performance, and operation at high voltages with respect to ground is possible.

**FIGURE 17 - BASIC CIRCUIT CONFIGURATION**



### EXTERNAL CAPACITORS

A 0.1 $\mu F$  disc or 1 $\mu F$  tantalum input bypass capacitor ( $C_{in}$ ) is recommended to reduce the sensitivity to input line impedance.

The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor ( $C_{ADJ}$ ) prevents ripple from being amplified as the output voltage is rejected about 15dB at 120 Hz in a 10 volt application.

increased. A 10 $\mu F$  capacitor should improve ripple

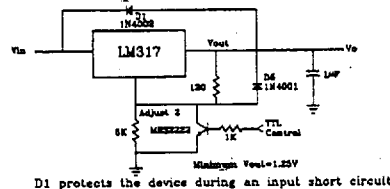
Although the LM317 is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output capacitance ( $C_O$ ) in the form of a 1  $\mu F$  tantalum or 25  $\mu F$  aluminum electrolytic capacitor on the output swamps this effect and insures stability.

### PROTECTION DIODES

When external capacitors are used with any I.C. regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator.

Figure 18 shows the LM317 with the recommended protection diodes for output voltages in excess of 25 V or high capacitance values ( $C_O > 25 \mu F$ ,  $C_{ADJ} > 10 \mu F$ ). Diode  $D_1$  prevents  $C_O$  from discharging thru the I.C. during an input short circuit. Diode  $D_2$  protects against capacitor  $C_{ADJ}$  discharging through the I.C. during an output short circuit. The combination of diodes  $D_1$  and  $D_2$  prevents  $C_{ADJ}$  from discharging through the I.C. during an input short circuit.

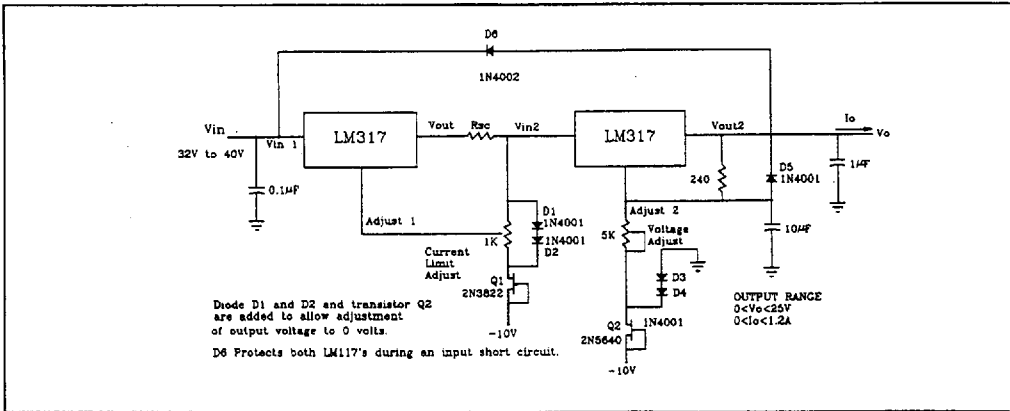
**FIGURE 18 - VOLTAGE REGULATOR WITH PROTECTION DIODES**



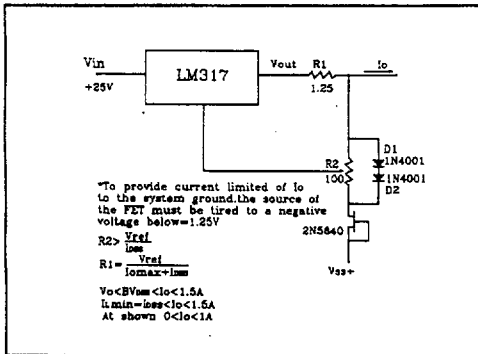
The LM317 is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor ( $R_1$ ) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of  $R_2$  can be returned near the load ground to provide remote ground sensing and improve load regulation.



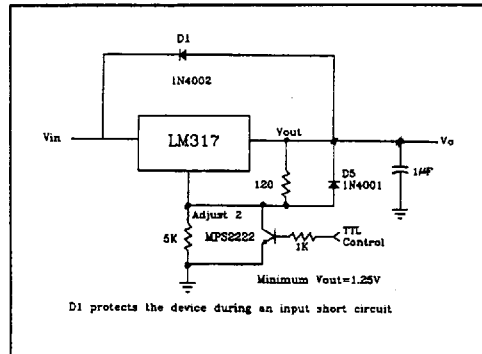
**FIGURE 19-"LABORATORY"POWER SUPPLY WITH ADJUSTABLE CURRENT LIMIT AND OUTPUT VOLTAGE**



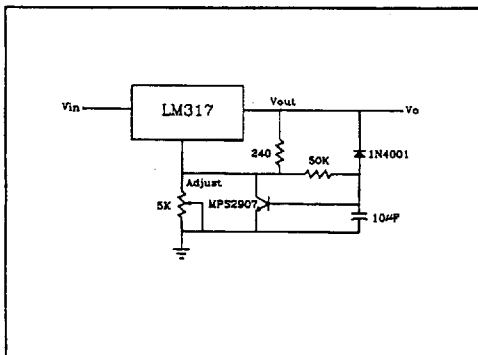
**FIGURE 20-ADJUSTABLE CURRENT LIMITER**



**FIGURE 21-5V ELECTRONIC SHUT DOWN REGULATOR**



**FIGURE 22-SLOW TURN-ON REGULATOR**



**FIGURE 23-CURRENT REGULATOR**

