

## 3-Terminal Adjustable Positive Voltage Regulator

**TO-220**

**TO-263 (D<sup>2</sup>PAK)**

**TO-252 (DPAK)**

**SOT-223**

**Pin Definition:**

1. Adjustable
  2. Output
  3. Input
- Heatsink is connected to Pin 2

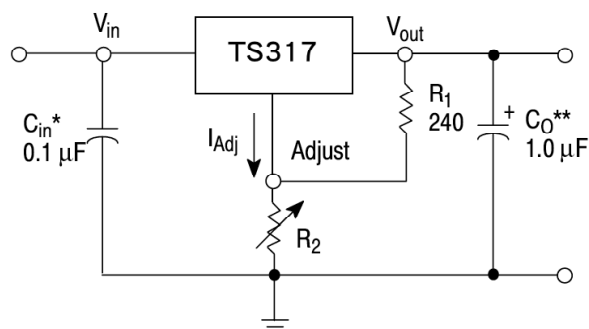
### General Description

The TS317 is adjustable 3-terminal positive voltage regulator capable of supplying in excess of 1.5A over an output voltage range of 1.25 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 Voltage Range 1.25 to 37V
- Output current
  - TO-220/TO-263 up to 1.5A
  - TO-252/SOT-223 up to 500mA
- Eliminates Stocking Many Fixed Voltages
- Internal Thermal Overload Protection
- Current Limit Constant with Temperature
- Output transistor safe-area compensation
- Output voltage offered in 4% tolerance
- Floating Operation for High Voltage Applications

### Standard Application Circuit



C<sub>in</sub> is required if regulator is located an appreciable distance from power supply filter.

C<sub>o</sub> 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<sub>Adj</sub> is controlled to less than 100 μA, the error associated with this term is negligible in most applications

### Ordering Information

Part No.	Package	Packing
TS317CZ C0G	TO-220	50pcs / Tube
TS317CM RNG	TO-263	800pcs / 13" Reel
TS317CP ROG	TO-252	2.5Kpcs / 13" Reel
TS317CW RPG	SOT-223	2.5Kpcs / 13" Reel

**Note:** "G" denotes for Halogen Free

### Absolute Maximum Rating (T<sub>a</sub> = 25°C unless otherwise noted)

Parameter	Symbol	Limit	Unit
Input Voltage	V <sub>IN</sub>	40	V
Power Dissipation	P <sub>D</sub>	Internal Limited	W
Operating Junction Temperature	T <sub>J</sub>	0~+125	°C
Storage Temperature Range	T <sub>STG</sub>	-65~+150	°C

### Thermal Performance

Condition	Package type	Symbol	Typ	Unit
Thermal Resistance Junction to Air	TO-220	$R\theta_{JA}$	50	°C/W
	TO-263		55	
	TO-252		100	
	SOT-223		130	
Thermal Resistance Junction to Case	TO-220	$R\theta_{JC}$	5	°C/W
	TO-263		5	
	TO-252		10	
	SOT-223		15	

### Electrical Characteristics

( $V_I - V_O = 5.0\text{ V}$ ,  $I_O = 500\text{ mA}$  for TO-220/TO-263 packages,  $I_O = 200\text{ mA}$  for TO-252/SOT-223 package)

Parameter	Figure	Symbol	Min.	Typ.	Max.	Unit
Reference voltage, $3\text{ V} \leq V_I - V_O \leq 40\text{ V}$ $10\text{ mA} \leq I_O \leq I_{\text{max}}$ , $P_d \leq P_{\text{max}}$ ,	3	$V_{\text{ref}}$	1.20	1.25	1.30	V
Line regulation (Note 3) $T_a = 25^\circ\text{C}$ , $3\text{ V} \leq V_I - V_O \leq 40\text{ V}$	1	REGline	--	0.01	0.07	%/V
Load regulation $T_a = 25^\circ\text{C}$ , $10\text{ mA} \leq I_O \leq I_{\text{max}}$ (Note 2) $V_O \leq 5.0$ $V_O \geq 5.0$	2	REGload	--	5.0 0.1	25 0.5	mV %V
Thermal regulation, $T_a = 25^\circ\text{C}$ (Note 5), 20mS Pulse		REGtherm	--	0.03	0.07	%Vo/W
Adjustment pin current	3	$I_{\text{adj}}$	--	50	100	$\mu\text{A}$
Adjustment pin current change, $3\text{ V} \leq V_I - V_O \leq 40\text{ V}$ $10\text{ mA} \leq I_O \leq I_{\text{max}}$ , $P_d \leq P_{\text{max}}$ ,	1.2	$\Delta I_{\text{adj}}$	--	0.2	5.0	$\mu\text{A}$
Maximum output current, $V_I - V_O \leq 15\text{ V}$ , $P_d \leq P_{\text{max}}$ TO-220 / TO-263 Package TO-252 / SOT-223 Package	3	$I_{\text{max}}$	1.5 0.5	--	--	A
Temperature stability ( $T_{\text{LOW}} \leq T_j \leq T_{\text{HIGH}}$ )	3	$T_s$	--	1	--	% Vo
Minimum load current to maintain regulation ( $V_I - V_O = 40\text{ V}$ )	3	$I_{\text{Lmin}}$	--	3.5	10	mA
RMS Noise, % of $V_O$ , $T_a = 25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 10\text{ KHz}$		N	--	0.003	--	% Vo
Ripple Rejection, $V_O = 10\text{ V}$ , $f = 120\text{ Hz}$ (Note 3) Without $C_{\text{adj}}$ $C_{\text{adj}} = 10\mu\text{F}$	4	PSRR	-- 66	65 80	--	dB
Long-term stability (Note 4), $T_j = 125^\circ\text{C}$ , 1000hrs	3	S	--	0.3	1.0	%

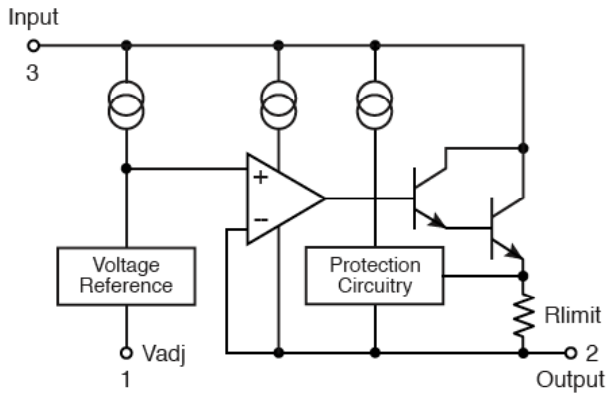
Notes: 1.  $T_{\text{LOW}}$  to  $T_{\text{HIGH}} = 0^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $P_{\text{max}}$  is internally limited

2. 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.

3.  $C_{\text{adj}}$ , when used, is connected between the adjustment pin and ground. 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.

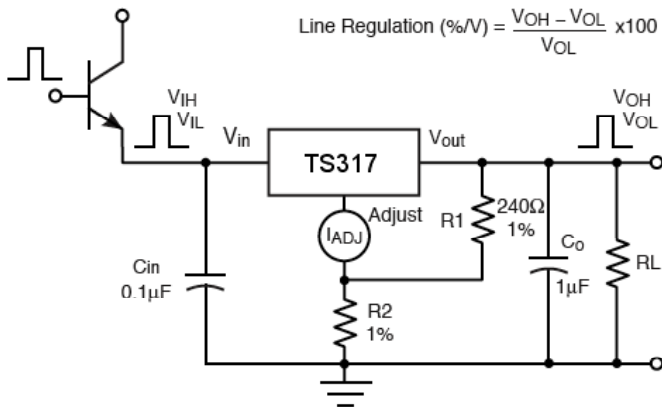
4. Power dissipation within an IC voltage regulator produces a temperature gradient on the die, affecting individual IC components on the die. These effects can be minimized by proper integrated circuit design and layout techniques. Thermal Regulation in the effect of these temperature gradients on the output voltage and is expressed in the percentage of output change per watt of power change in a specified time.

**Functional Block Diagram**



**Test Circuit**

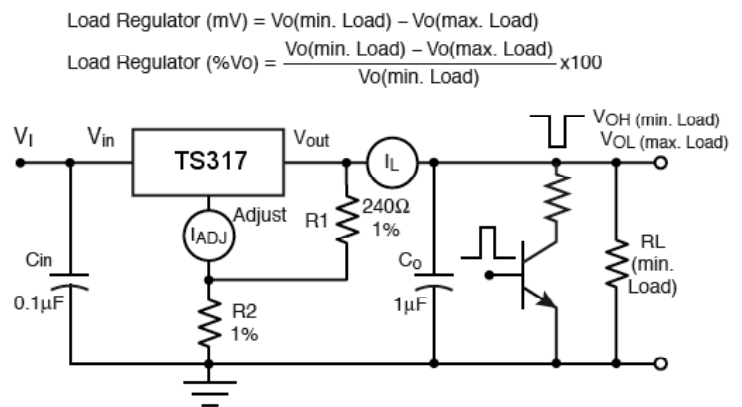
**Figure 1. Line Regulation Test Circuit**



$$\text{Line Regulation (\%V)} = \frac{V_{OH} - V_{OL}}{V_{OL}} \times 100$$

Pulse Testing Required:  
1% Duty Cycle is Suggested

**Figure 2. Load Regulation and  $\Delta I_{adj}/\text{Load}$  Test Circuit**

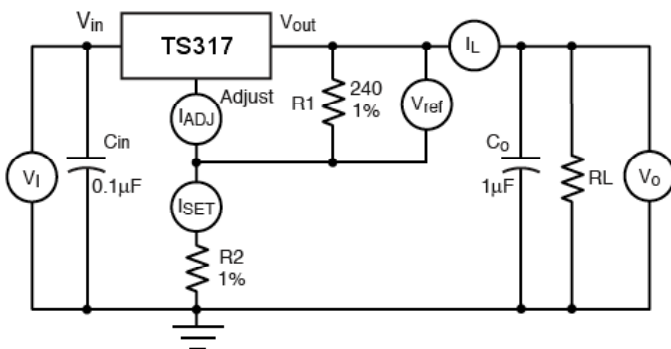


$$\text{Load Regulator (mV)} = V_{o(\text{min. Load})} - V_{o(\text{max. Load})}$$

$$\text{Load Regulator (\%V}_o) = \frac{V_{o(\text{min. Load})} - V_{o(\text{max. Load})}}{V_{o(\text{min. Load})}} \times 100$$

Pulse Testing Required:  
1% Duty Cycle is Suggested

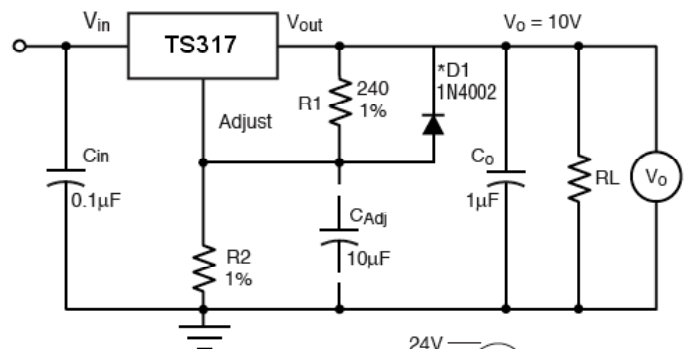
**Figure 3. Standard Test Circuit**



Pulse Testing Required:  
1% Duty Cycle is Suggested

To Calculate R2:  
 $V_o = I_{SET} R_2 + 1.250V$   
Assume  $I_{SET} = 5.25mA$

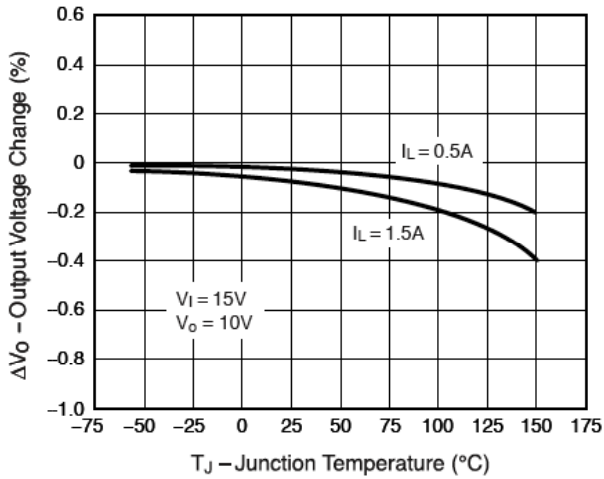
**Figure 4. Ripple Rejection Test Circuit**



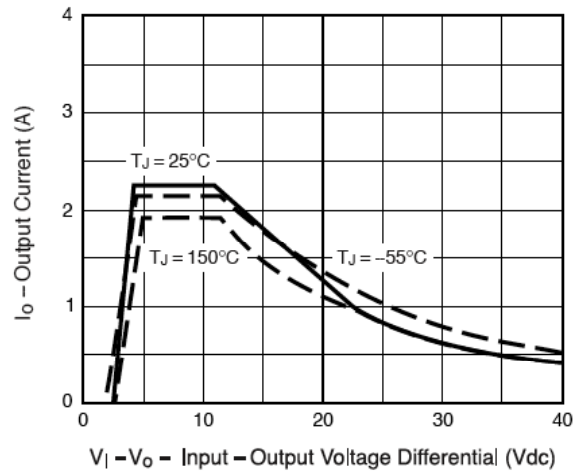
\*D1 Discharges C<sub>ADJ</sub> if Output is Shorted to Ground

24V  
14V  
f = 120Hz

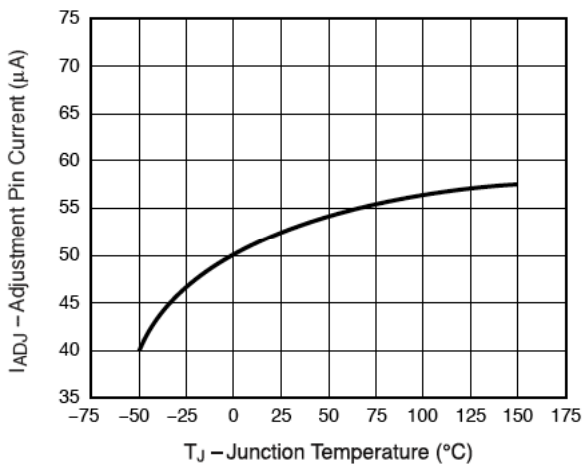
**Electrical Characteristics Curve**



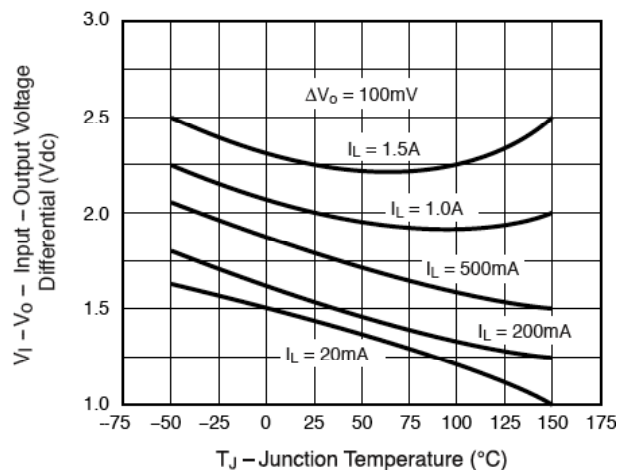
**Figure 5. Load Regulation**



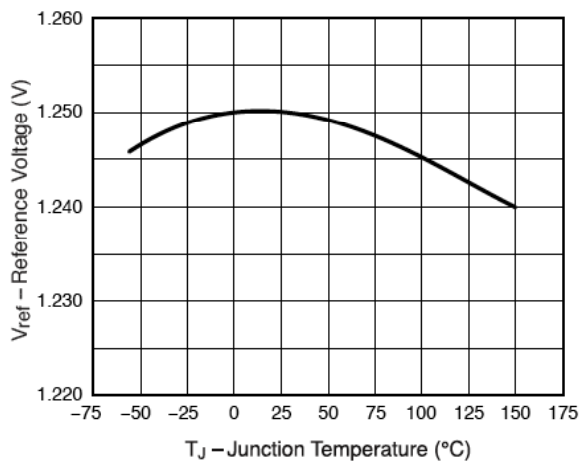
**Figure 6. Current Limit**



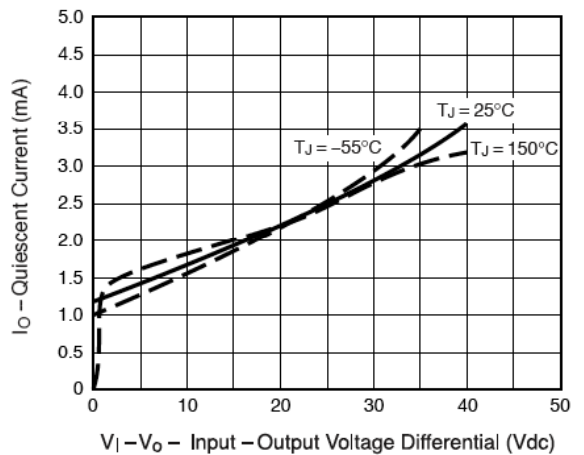
**Figure 7. Adjustment Pin Current**



**Figure 8. Dropout Voltage**

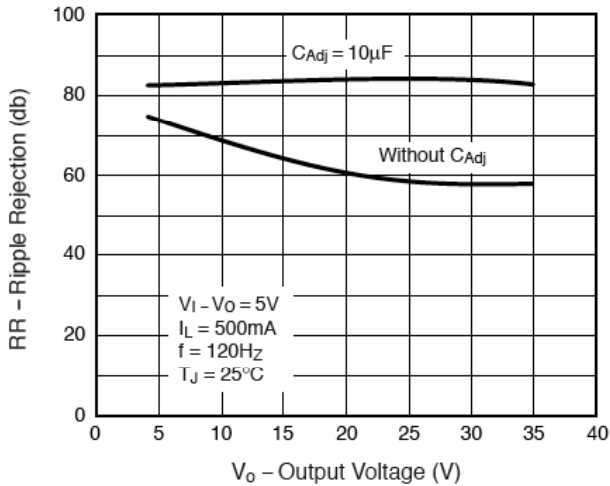


**Figure 9. Temperature Stability**

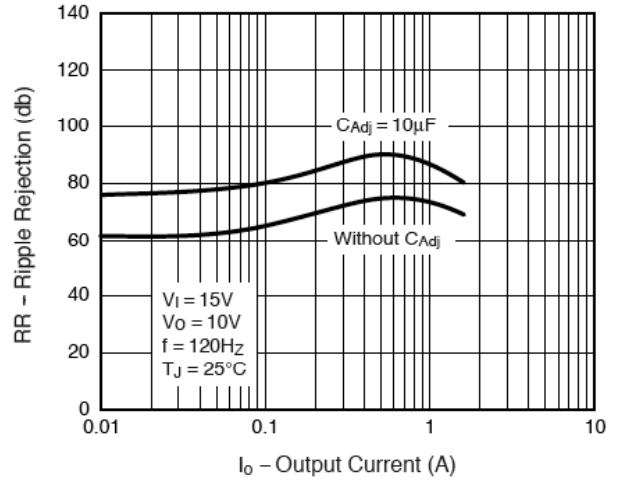


**Figure 10. Minimum Operating Current**

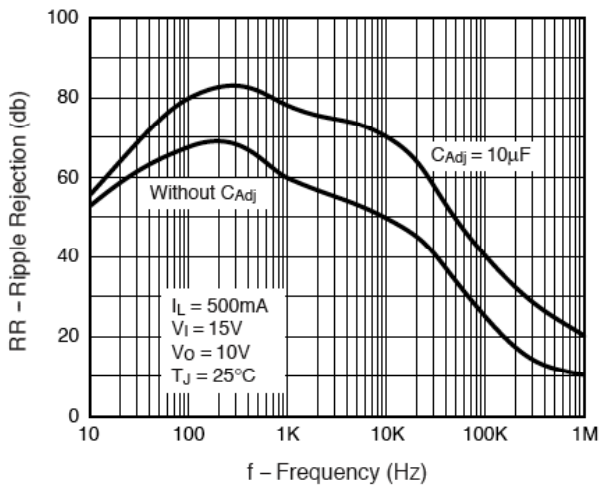
**Electrical Characteristics Curve**



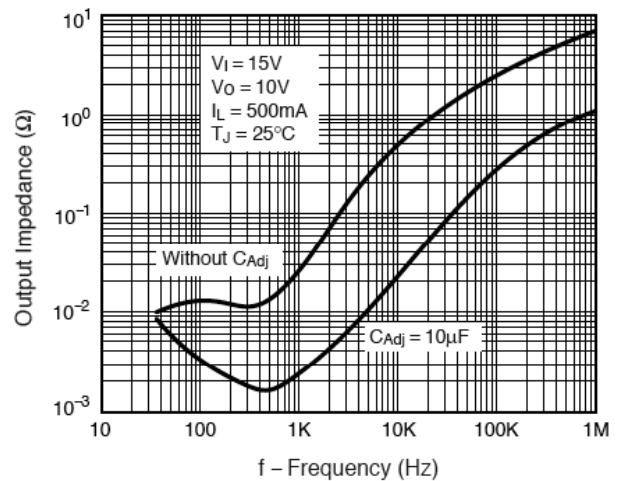
**Figure 11. Ripple Rejection vs. Output Voltage**



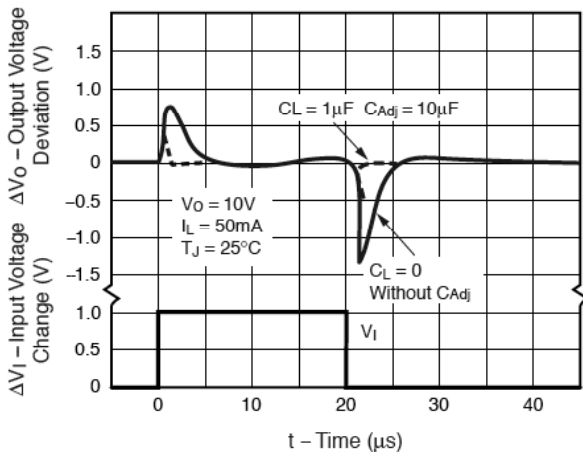
**Figure 12. Ripple Rejection vs. Output Current**



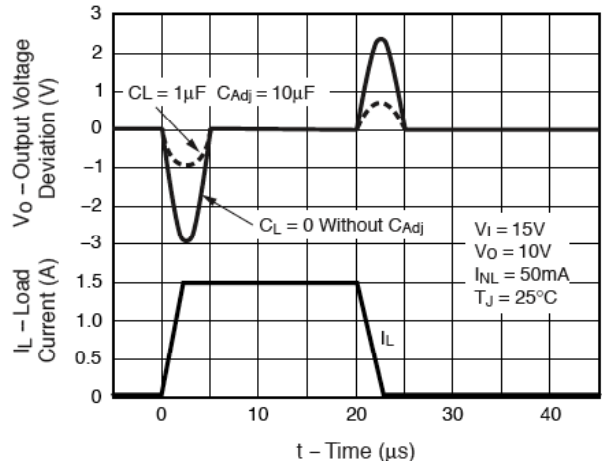
**Figure 13. Ripple Rejection vs. Frequency**



**Figure 14. Output Impedance**



**Figure 15. Line Transient Response**



**Figure 16. Load Transient Response**

### Application information

#### Basic Circuit Operation

The TS317 is a 3-terminal floating regulator. In operation, the TS317 develops and maintains a nominal 1.25V 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:

$$V_{out} = V_{ref} ( 1 + R_2 / R_1 ) + I_{adj} * R_2$$

Since the current from the adjustment terminal ( $I_{adj}$ ) represents an error term in the equation, the TS317 was designed to control  $I_{adj}$  to less than 100uA 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 TS317 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.

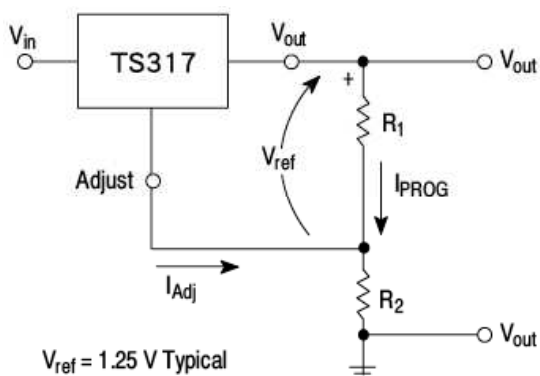


Figure 17. Basic Circuit Configuration

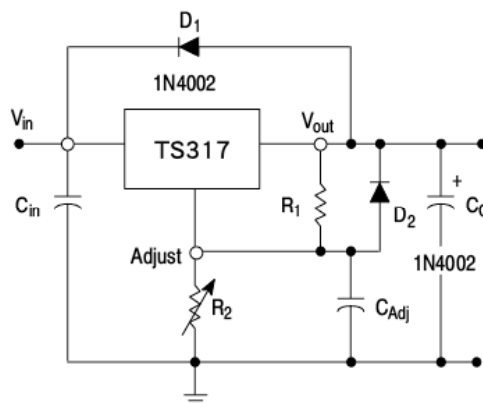


Figure 18. Voltage Regulator with Protection Diode

#### Protection Diode

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 TS317 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.

#### Load Regulation

The TS317 is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor ( $R_1$ ) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of  $R_2$  can be returned near the load ground to provide remote ground sensing and improve load regulation.

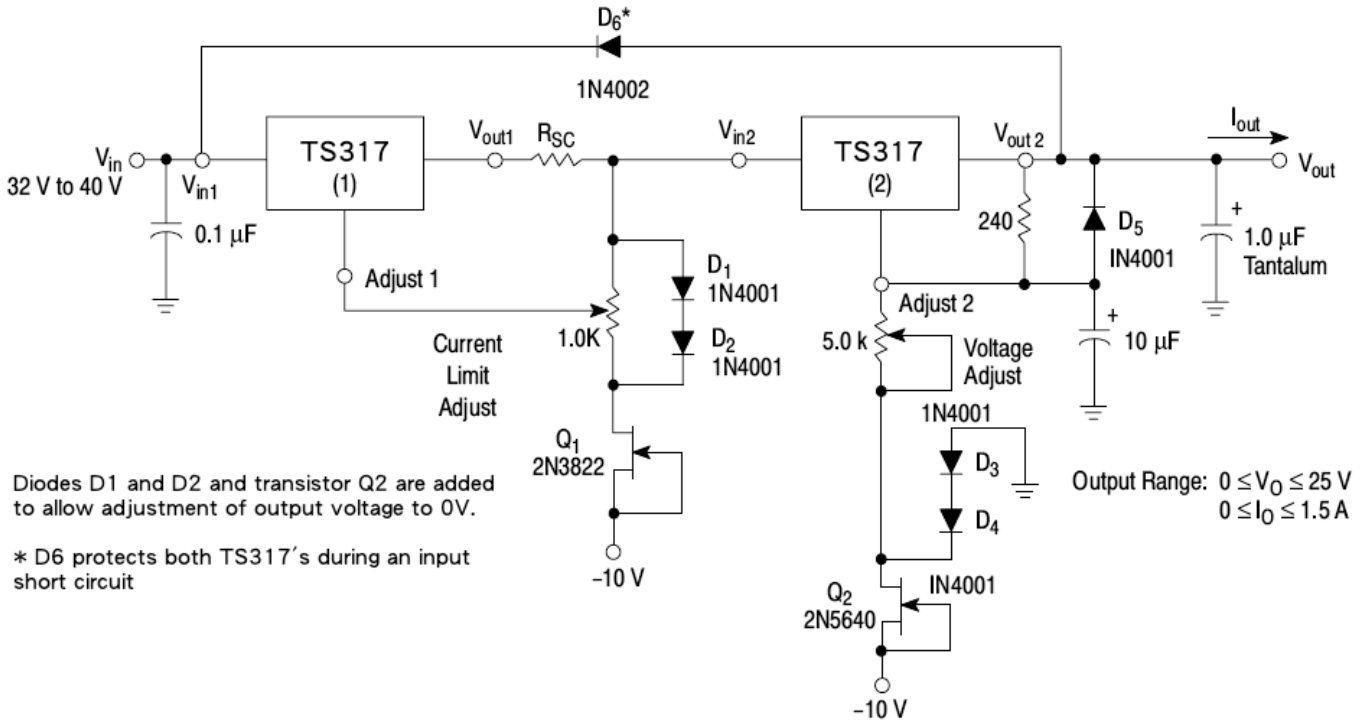
#### External Capacitor

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.

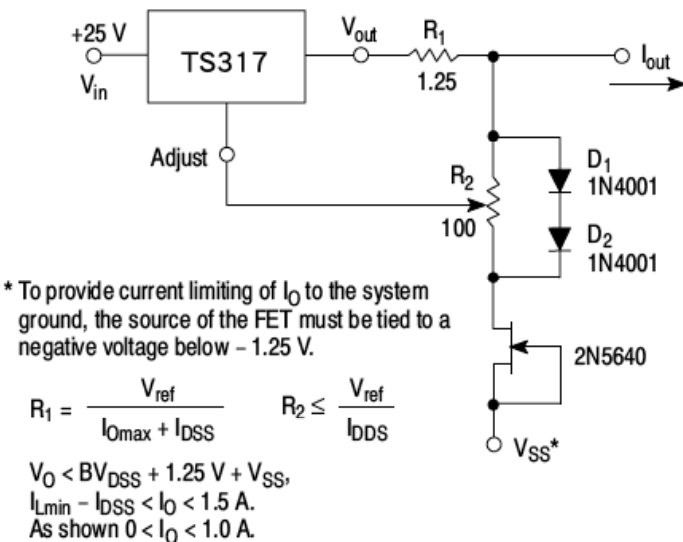
The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor ( $C_{adj}$ ) prevents ripple from being amplified as the output voltage is rejection about 15dB at 120 Hz in a 10V application.

Although the TS317 is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output increased. A 10 $\mu F$  capacitor should improve ripple 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.

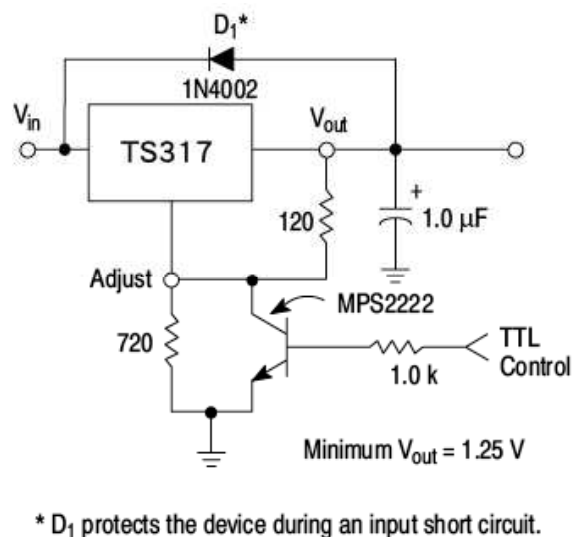
**Application information (Continue)**



**Figure 19. "LABORATORY" power supply with adjustable current limit and output voltage**

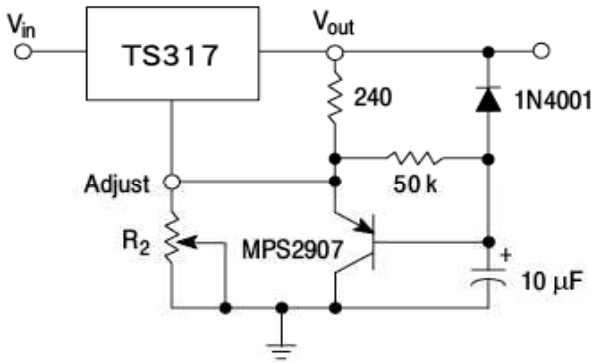


**Figure 20. Adjustable Current Limiter**

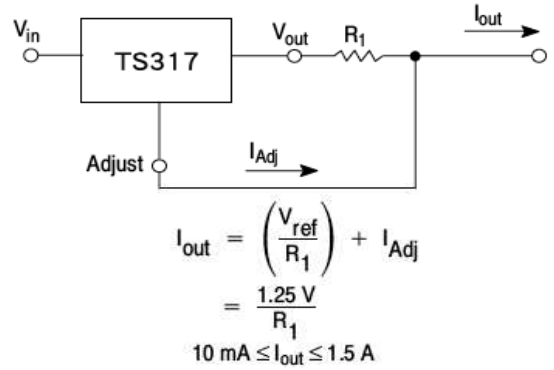


**Figure 21. 5V Electronic Shutdown Regulator**

**Application information (Continue)**



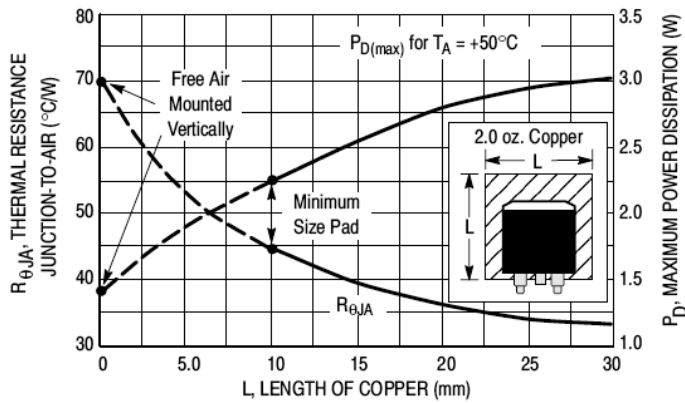
**Figure 22. Slow Turn-on Regulator**



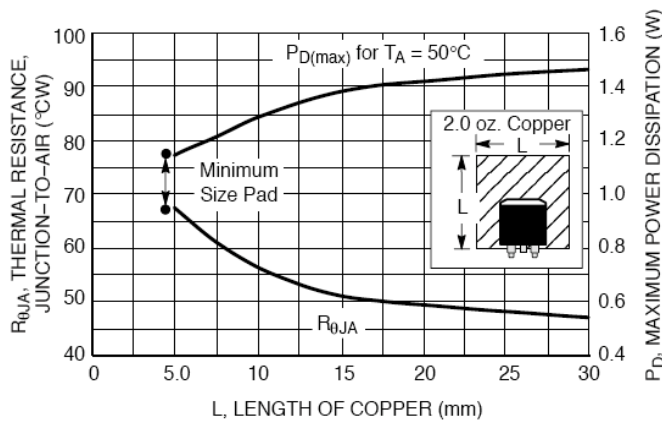
**Figure 23. Current Regulator**



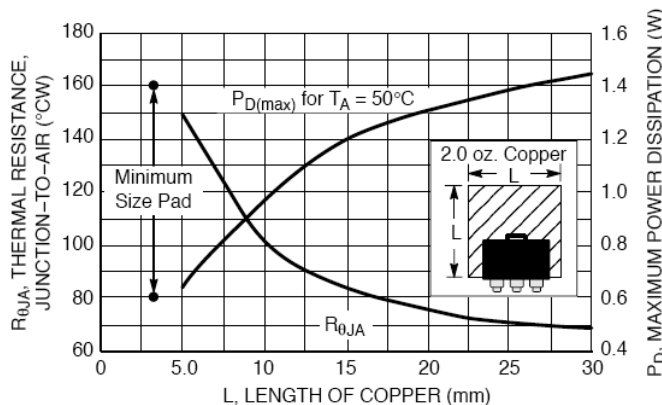
**Application Information**



**Figure 24. D²PAK Thermal Resistance and Maximum Power Dissipation vs. P.C.B Copper Length**

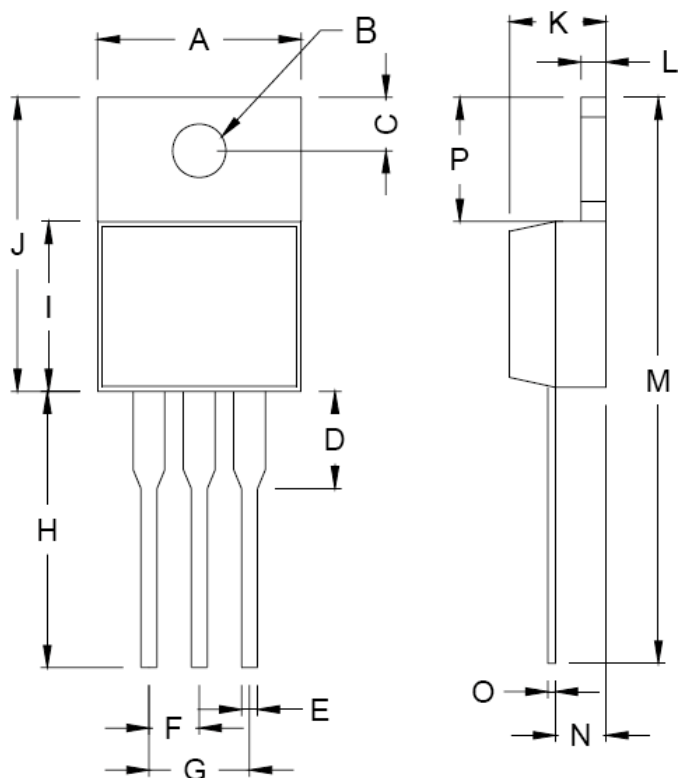


**Figure 25. DPAK Thermal Resistance and Maximum Power Dissipation vs. P.C.B Copper Length**



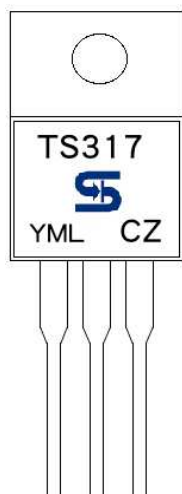
**Figure 26. SOT-223 Thermal Resistance and Maximum Power Dissipation vs. P.C.B Copper Length**

### TO-220 Mechanical Drawing



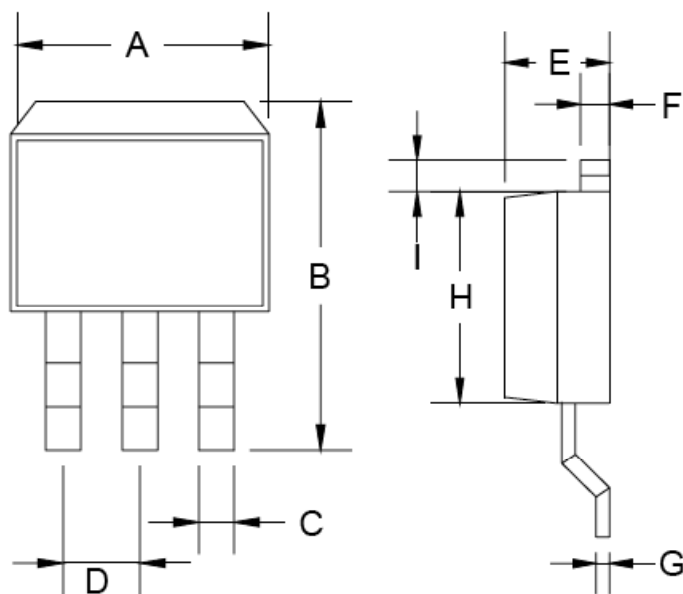
DIM	TO-220 DIMENSION			
	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.000	10.500	0.394	0.413
B	3.740	3.910	0.147	0.154
C	2.440	2.940	0.096	0.116
D	-	6.350	-	0.250
E	0.381	1.106	0.015	0.040
F	2.345	2.715	0.092	0.058
G	4.690	5.430	0.092	0.107
H	12.700	14.732	0.500	0.581
I	8.382	9.017	0.330	0.355
J	14.224	16.510	0.560	0.650
K	3.556	4.826	0.140	0.190
L	0.508	1.397	0.020	0.055
M	27.700	29.620	1.060	1.230
N	2.032	2.921	0.080	0.115
O	0.255	0.610	0.010	0.024
P	5.842	6.858	0.230	0.270

### Marking Diagram



- Y** = Year Code
- M** = Month Code for Halogen Free Product
  - O** =Jan    **P** =Feb    **Q** =Mar    **R** =Apr
  - S** =May    **T** =Jun    **U** =Jul    **V** =Aug
  - W** =Sep    **X** =Oct    **Y** =Nov    **Z** =Dec
- L** = Lot Code
- CZ** = Package Code for TO-220

### TO-263 Mechanical Drawing



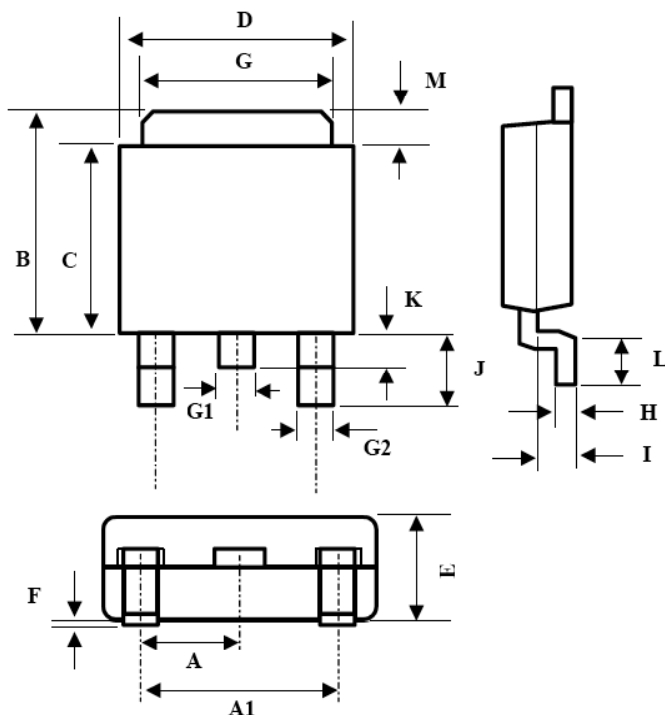
TO-263 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.000	10.500	0.394	0.413
B	14.605	15.875	0.575	0.625
C	0.508	0.991	0.020	0.039
D	2.420	2.660	0.095	0.105
E	4.064	4.830	0.160	0.190
F	1.118	1.400	0.045	0.055
G	0.450	0.730	0.018	0.029
H	8.280	8.800	0.325	0.346
I	1.140	1.400	0.044	0.055
J	1.480	1.520	0.058	0.060

### Marking Diagram



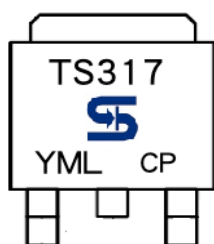
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- L** = Lot Code
- CM** = Package Code for TO-263

### TO-252 Mechanical Drawing



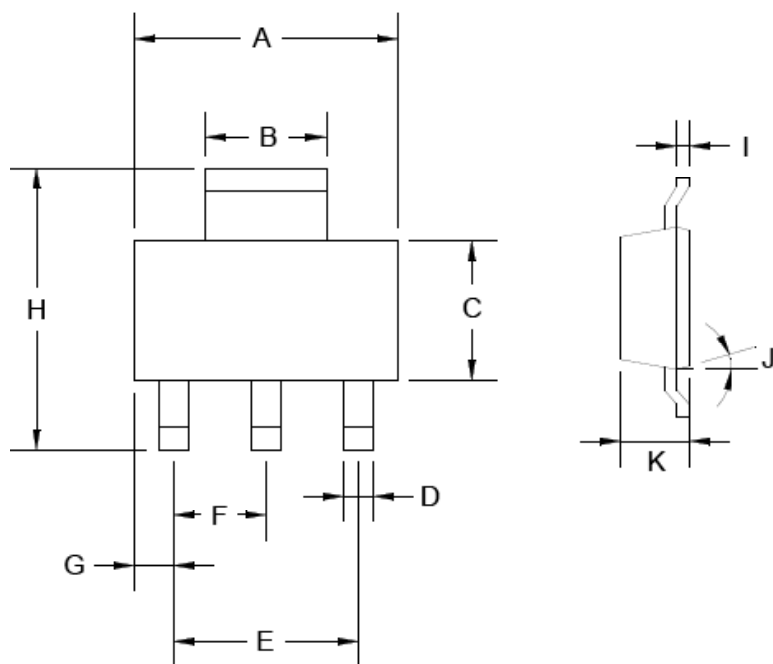
TO-252 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.3BSC		0.09BSC	
A1	4.6BSC		0.18BSC	
B	6.80	7.20	0.268	0.283
C	5.40	5.60	0.213	0.220
D	6.40	6.65	0.252	0.262
E	2.20	2.40	0.087	0.094
F	0.00	0.20	0.000	0.008
G	5.20	5.40	0.205	0.213
G1	0.75	0.85	0.030	0.033
G2	0.55	0.65	0.022	0.026
H	0.35	0.65	0.014	0.026
I	0.90	1.50	0.035	0.059
J	2.20	2.80	0.087	0.110
K	0.50	1.10	0.020	0.043
L	0.90	1.50	0.035	0.059
M	1.30	1.70	0.051	0.67

### Marking Diagram



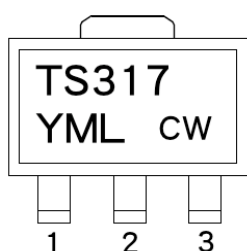
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  - W =Sep    X =Oct    Y =Nov    Z =Dec
- L = Lot Code
- CP = Package Code for TO-252

### SOT-223 Mechanical Drawing



SOT-223 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.350	6.850	0.250	0.270
B	2.900	3.100	0.114	0.122
C	3.300	3.750	0.129	0.148
D	0.660	0.840	0.025	0.033
E	4.550	4.650	0.179	0.183
F	2.250	2.350	0.088	0.093
G	0.850	1.050	0.033	0.041
H	6.700	7.300	0.263	0.287
I	0.230	0.355	0.009	0.014
J	10°	16°	10°	16°
K	1.550	1.800	0.061	0.071

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- CW** = Package Code for TO-223

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