

## 3-Terminal Adjustable Positive Voltage Regulator

### TO-92



#### Pin Definition:

1. Adjustable
2. Output
3. Input

### SOP-8



#### Pin Definition:

- |               |           |
|---------------|-----------|
| 1. Input      | 8. N/C    |
| 2. Output     | 7. Output |
| 3. Output     | 6. Output |
| 4. Adjustable | 5. N/C    |

### General Description

The TS317L is adjustable 3-terminal positive voltage regulator capable of supplying in excess of 100mA 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.

Besides replacing fixed regulators, the TS317L 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 TS317L 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 1.25V where most loads draw little current.

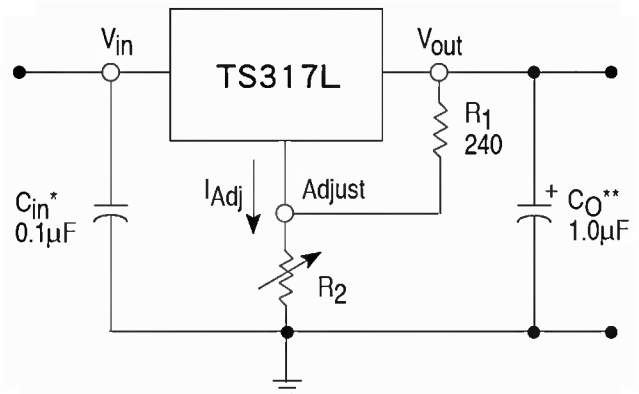
### Features

- Output Voltage Range 1.25 to 37V
- Output current in Excess of 100mA
- 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

### Ordering Information

| Part No.    | Package | Packing            |
|-------------|---------|--------------------|
| TS317LCT B0 | TO-92   | 1Kpcs / Bulk       |
| TS317LCT A3 | TO-92   | 2Kpcs / Ammo       |
| TS317LCS RL | SOP-8   | 2.5Kpcs / 13" Reel |

### Standard Application Circuit



Cin is required if regulator is located an appreciable distance from power supply filter.

Co 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

## 3-Terminal Adjustable Positive Voltage Regulator

### Absolute Maximum Rating (Ta = 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>   | -20~+125         | °C   |
| Storage Temperature Range      | T <sub>STG</sub> | -65~+150         | °C   |

### Electrical Characteristics

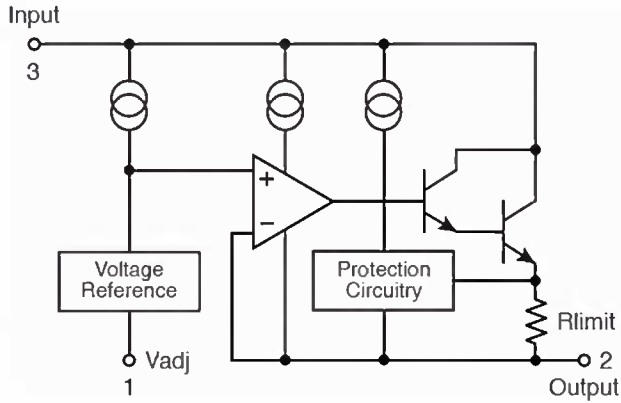
(V<sub>I</sub>-V<sub>O</sub> = 5.0 V, I<sub>o</sub>=40mA; T<sub>J</sub> = T<sub>LOW</sub> to T<sub>HIGH</sub> see [Note 1]; P<sub>max</sub> per [Note 2]; unless otherwise specified.)

| Parameter  | Figure | Symbol               | Min. | Typ.  | Max. | Unit               |
|--|--------|----------------------|------|-------|------|--------------------|
| Reference voltage, 3V ≤ V <sub>i</sub> -V <sub>o</sub> ≤ 40V<br>10mA ≤ I <sub>o</sub> ≤ I <sub>max</sub> , P <sub>d</sub> ≤ P <sub>max</sub> ,   | 3      | V <sub>ref</sub>     | 1.20 | 1.25  | 1.30 | V                  |
| Line regulation (Note 3)<br>Ta = 25°C, 3V ≤ V <sub>i</sub> -V <sub>o</sub> ≤ 40V   | 1      | REG <sub>line</sub>  | --   | 0.01  | 0.07 | %/V                |
| Load regulation Ta = 25°C, 10mA ≤ I <sub>o</sub> ≤ I <sub>max</sub> (Note 3)   | 2      | REG <sub>load</sub>  | --   | 5.0   | 25   | mV                 |
|  |        |                      | --   | 0.1   | 0.5  | %V                 |
| Thermal regulation, Ta = 25°C (Note 6), 20mS Pulse   |        | REG <sub>therm</sub> | --   | 0.03  | 0.07 | %V <sub>o</sub> /W |
| Adjustment pin current   | 3      | I <sub>adj</sub>     | --   | 50    | 100  | uA                 |
| Adjustment pin current change, 3V ≤ V <sub>i</sub> - V <sub>o</sub> ≤ 40V<br>10mA ≤ I <sub>o</sub> ≤ I <sub>max</sub> , P <sub>d</sub> ≤ P <sub>max</sub> ,  | 1.2    | ΔI <sub>adj</sub>    | --   | 0.2   | 5.0  | uA                 |
| Maximum output current<br>V <sub>i</sub> - V <sub>o</sub> ≤ 6.25V, P <sub>d</sub> ≤ P <sub>max</sub> (TO-92 package)<br>V <sub>i</sub> - V <sub>o</sub> ≤ 40V, P <sub>d</sub> ≤ P <sub>max</sub> , Ta = 25°C (TO-92 package) | 3      | I <sub>max</sub>     | 100  | 200   | --   | mA                 |
|  |        |                      | --   | 20    | --   |                    |
| Temperature stability (T <sub>LOW</sub> ≤ T <sub>j</sub> ≤ T <sub>HIGH</sub> )   | 3      | T <sub>s</sub>       | --   | 1     | --   | % V <sub>o</sub>   |
| Minimum load current to maintain regulation<br>(V <sub>i</sub> - V <sub>o</sub> = 40 V)  | 3      | I <sub>Lmin</sub>    | --   | 3.5   | 10   | mA                 |
| RMS Noise, % of V <sub>o</sub> , Ta = 25°C, 10Hz ≤ f ≤ 10KHz   |        | N                    | --   | 0.003 | --   | % V <sub>o</sub>   |
| Ripple Rejection, V <sub>o</sub> = 10V, f = 120Hz (Note 4)<br>Without C <sub>adj</sub><br>C <sub>adj</sub> = 10uF  | 4      | PSRR                 | --   | 65    | --   | dB                 |
|  |        |                      | 66   | 80    | --   |                    |
| Long-term stability (Note 5), T <sub>j</sub> = T <sub>HIGH</sub><br>Ta = 25°C for endpoint measurements, 1000hrs   | 3      | S                    | --   | 0.3   | 1.0  | %                  |

#### Notes:

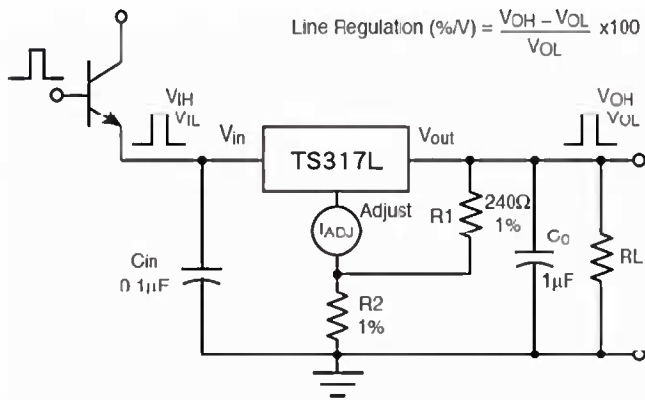
1. T<sub>LOW</sub> to T<sub>HIGH</sub> = -20°C to +125°C
2. P<sub>max</sub> is internally limited
3. Load and line regulation are specified at constant junction temperature. Changes in V<sub>o</sub> due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
4. C<sub>adj</sub>, when used, is connected between the adjustment pin and ground.
5. 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.
6. 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**

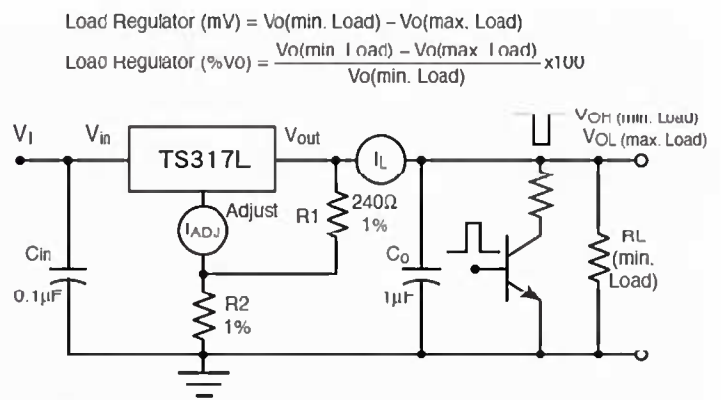
**Figure 1. Line Regulation Test Circuit**



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

Pulse Testing Required:  
1% Duty Cycle is Suggested

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

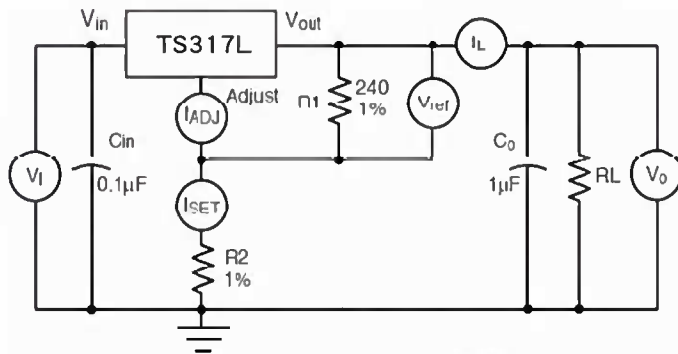


$$\text{Load Regulator (mV)} = V_{o(\text{min. Load})} - V_{o(\text{max. Load})}$$

$$\text{Load Regulator (\%V}_0) = \frac{V_{o(\text{min. Load})} - V_{o(\text{max. Load})}}{V_{o(\text{min. Load})}} \times 100$$

Pulse Testing Required:  
1% Duty Cycle is Suggested

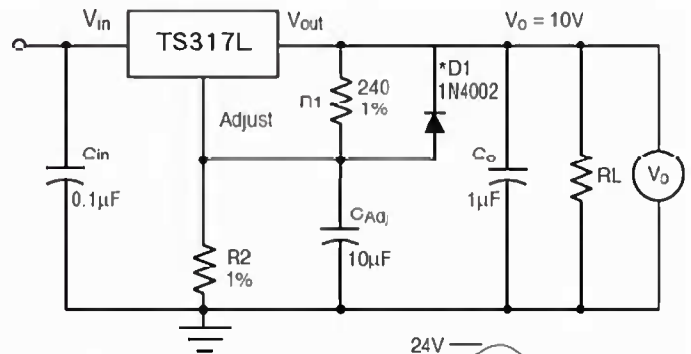
**Figure 3. Standard Test Circuit**



Pulse Testing Required:  
1% Duty Cycle is Suggested

To Calculate R2:  
 $V_0 = I_{SET} R_2 + 1.250V$   
Assume  $I_{SET} = 5.25mA$

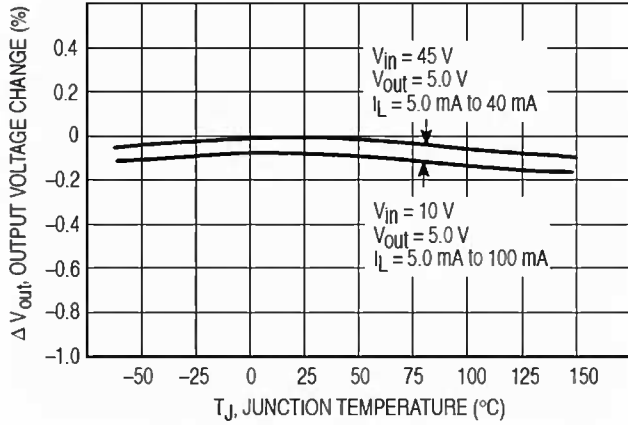
**Figure 4. Ripple Rejection Test Circuit**



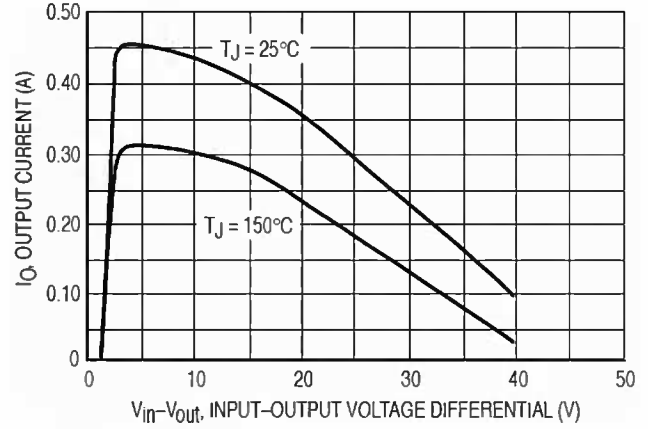
\*D1 Discharges  $C_{ADJ}$  if Output is Shorted to Ground

24V  
14V  
 $t = 120Hz$

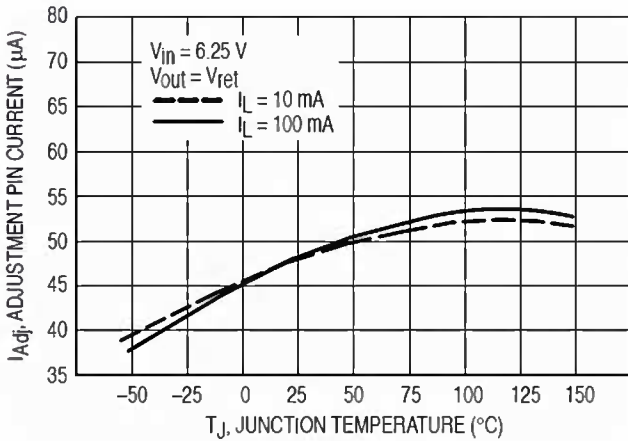
**Electrical Characteristics Curve**



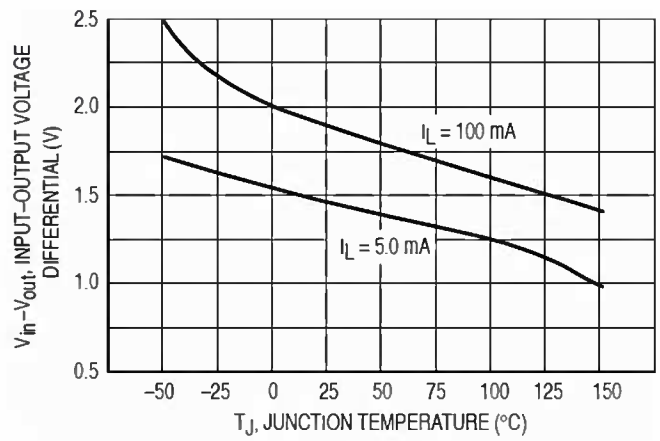
**Figure 5. Load Regulation**



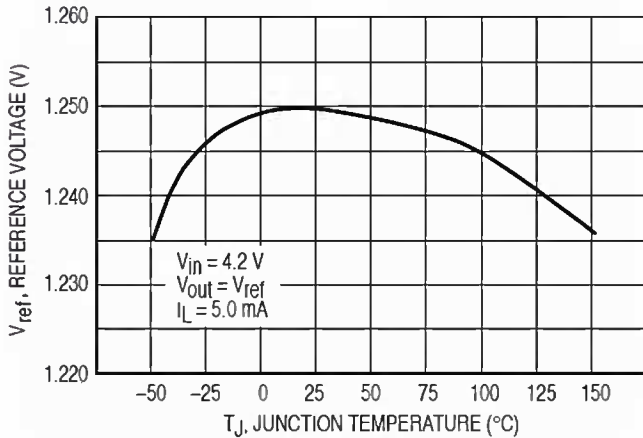
**Figure 6. Current Limit**



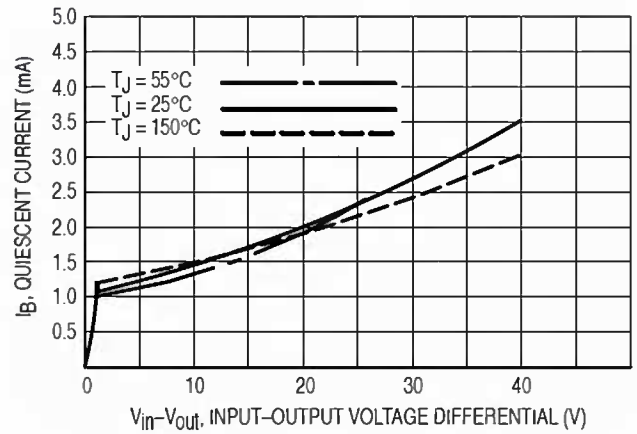
**Figure 7. Adjustment Pin Current**



**Figure 8. Dropout Voltage**



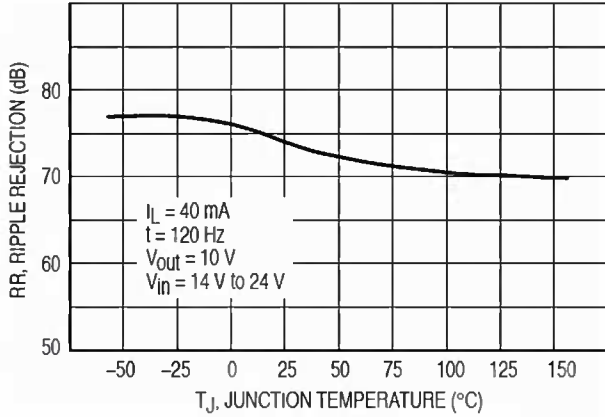
**Figure 9. Temperature Stability**



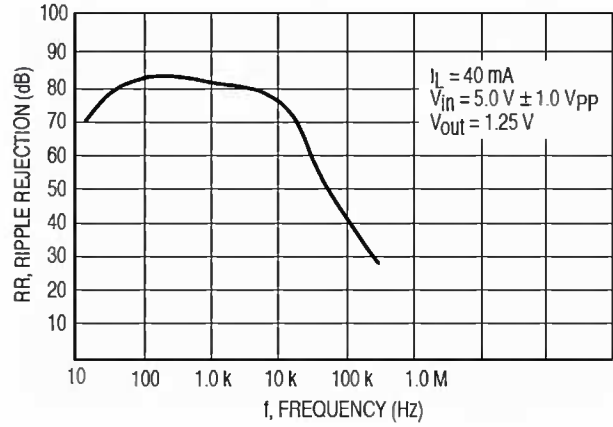
**Figure 10. Minimum Operating Current**

**3-Terminal Adjustable Positive Voltage Regulator**

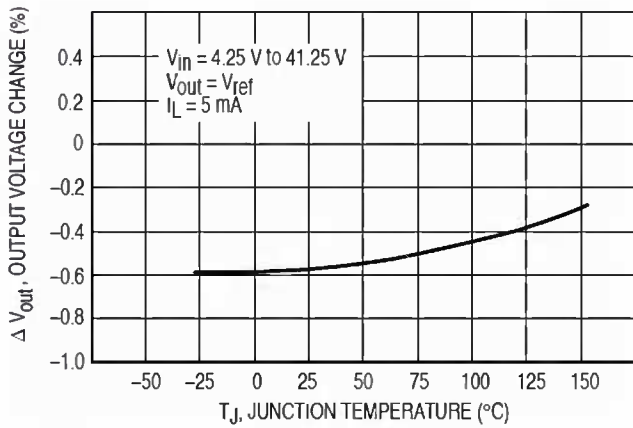
**Electrical Characteristics Curve**



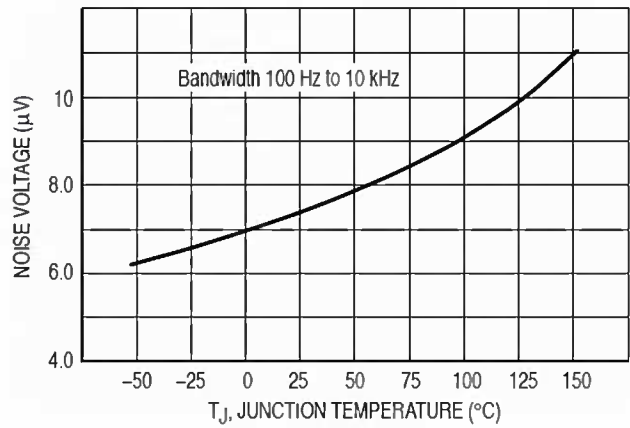
**Figure 11. Ripple Rejection**



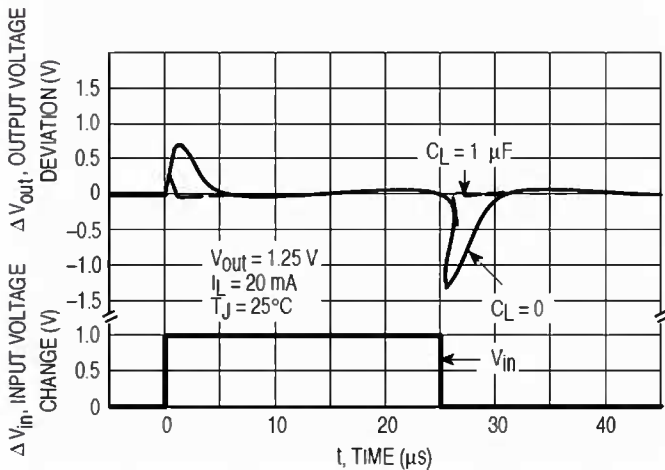
**Figure 12. Ripple Rejection vs. Frequency**



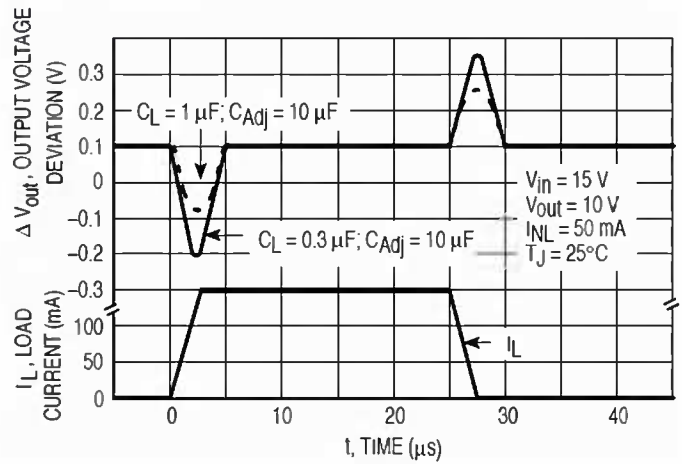
**Figure 13. Line Regulation**



**Figure 14. Output Noise**



**Figure 15. Line Transient Response**



**Figure 16. Load Transient Response**

### Application information

#### Basic Circuit Operation

The TS317L is a 3-terminal floating regulator. In operation, the TS317L 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 TS317L 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 TS317L 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.

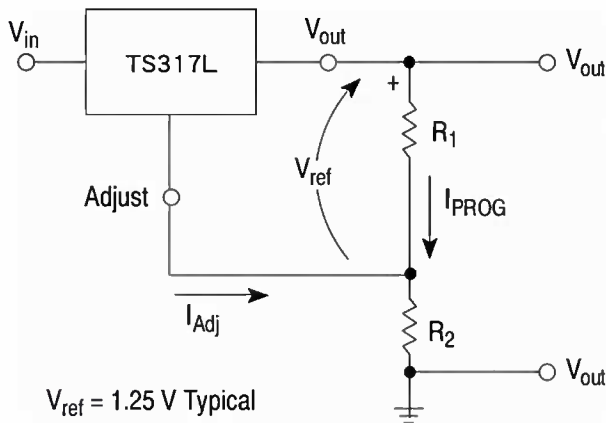


Figure 17. Basic Circuit Configuration

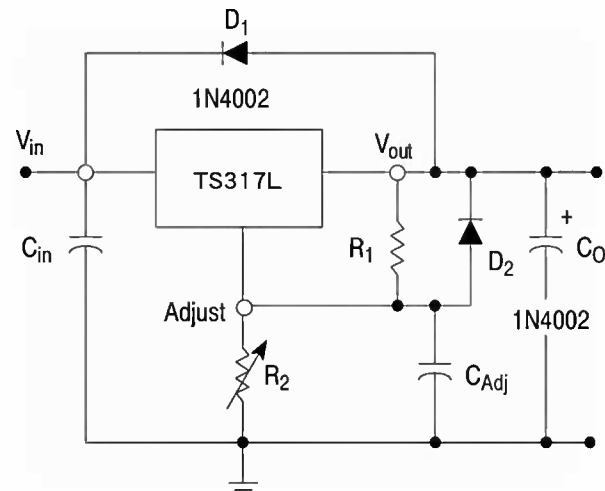


Figure 18. Voltage Regulator with Protection Diode

#### 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 TS317L 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 D1 prevents  $C_o$  from discharging thru the I.C. during an input short circuit. Diode D2 protects against capacitor  $C_{ADJ}$  discharging through the I.C. during an output short circuit. The combination of diodes D1 and D2 prevents  $C_{ADJ}$  from discharging through the I.C. during an input short circuit.

#### Load Regulation

The TS317L 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

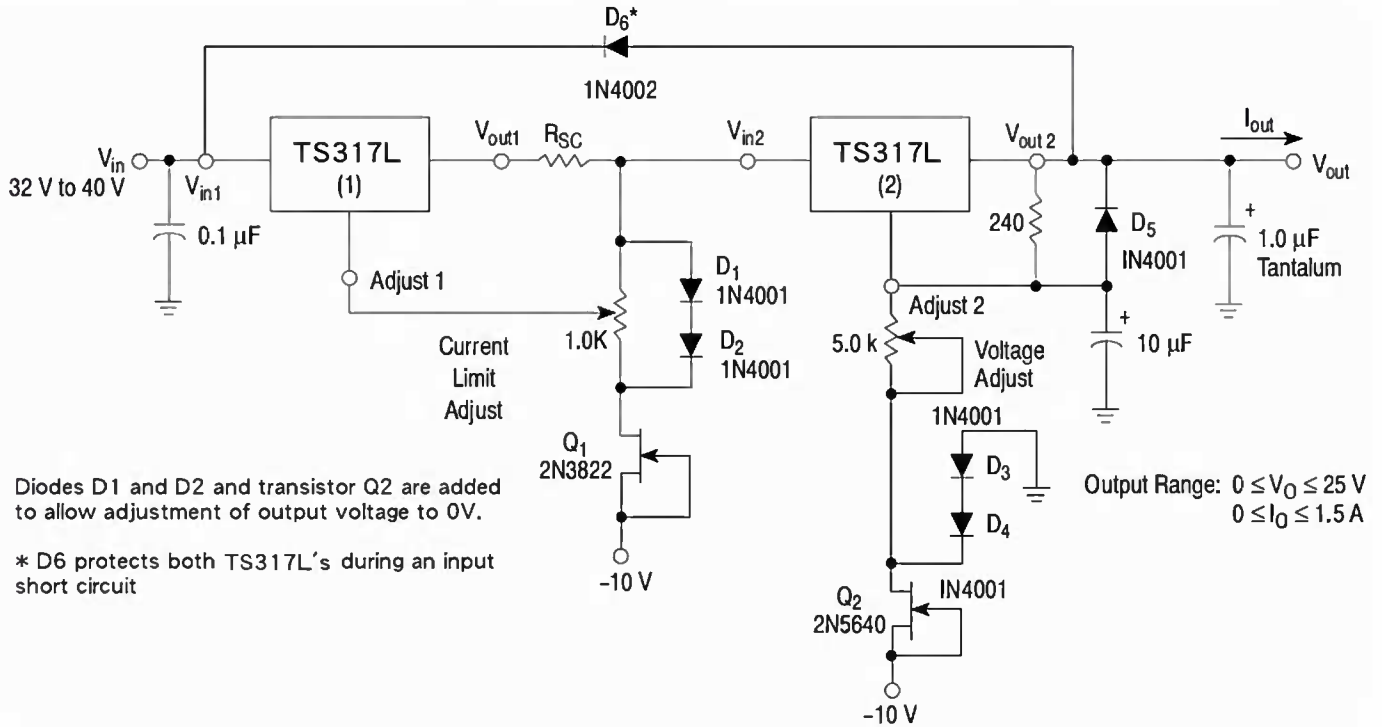
A 0.1 $\mu F$  disc or 1 $\mu F$  tantalum input bypass capacitor ( $C_{in}$ ) is recommended to reduce the sensitivity to input line impedance.

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.

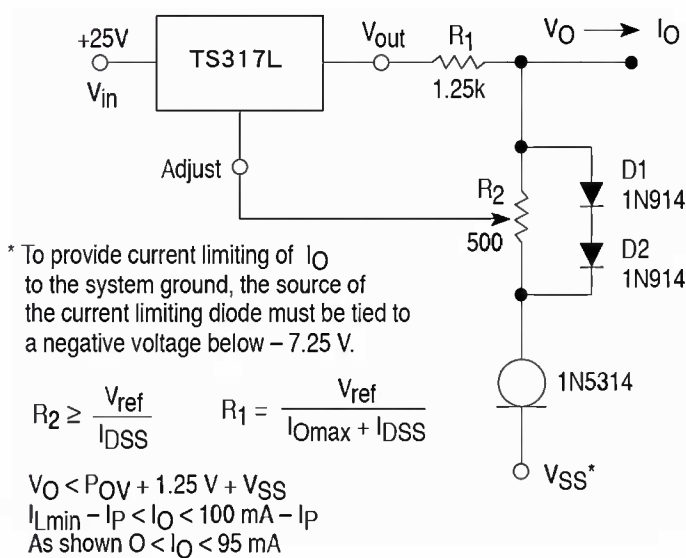
Although the TS317L is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output increased. A 10 $\mu F$  capacitor should improve ripple capacitance ( $C_o$ ) in the form of a 1 $\mu F$  tantalum or 25 $\mu F$  aluminum electrolytic capacitor on the output swamps this effect and insures stability.

**3-Terminal Adjustable Positive Voltage Regulator**

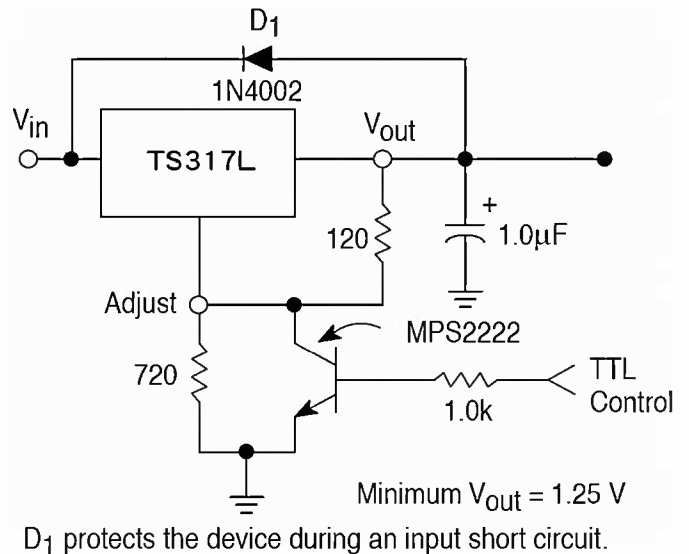
**Application information (Continue)**



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



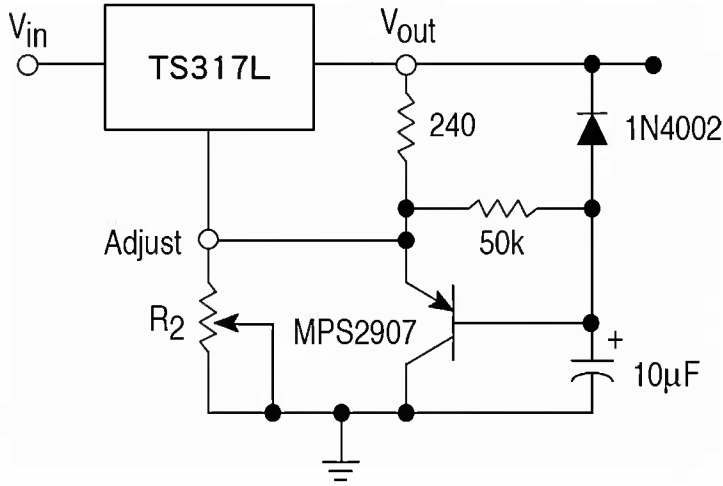
**Figure 20. Adjustable Current Limiter**



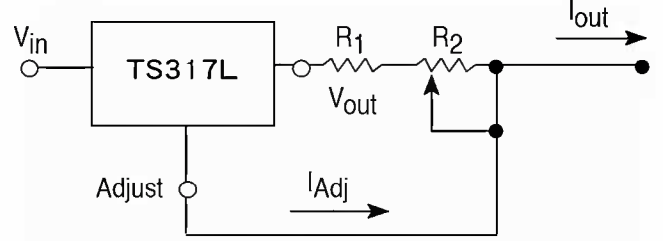
**Figure 21. 5V Electronic Shutdown Regulator**

**3-Terminal Adjustable Positive Voltage Regulator**

**Application information (Continue)**



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



$$I_{outmax} = \left( \frac{V_{ref}}{R_1} \right) + I_{Adj} \cong \frac{1.25 V}{R_1}$$

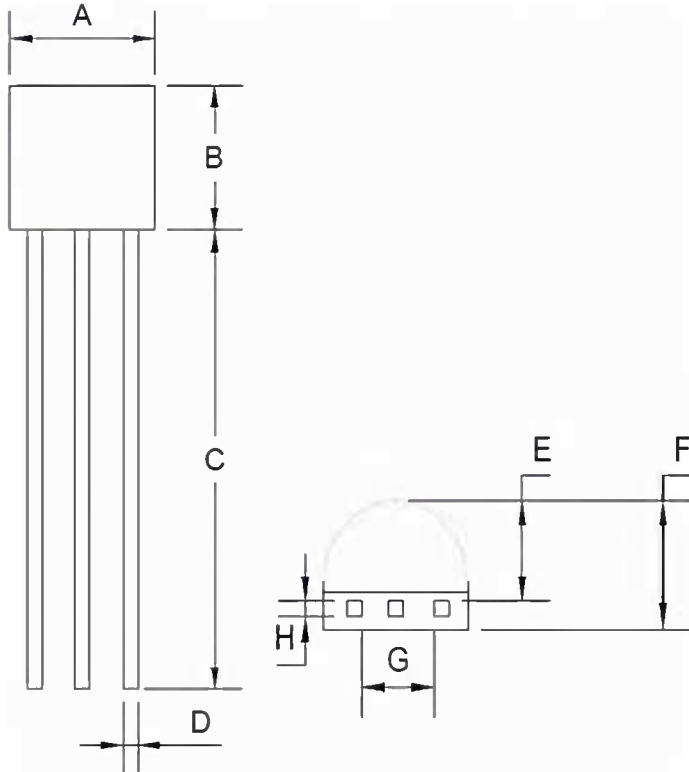
$$I_{outmax} = \left( \frac{V_{ref}}{R_1 + R_2} \right) + I_{Adj} \cong \frac{1.25 V}{R_1 + R_2}$$

$$5.0 \text{ mA} < I_{out} < 100 \text{ mA}$$

**Figure 23. Current Regulator**

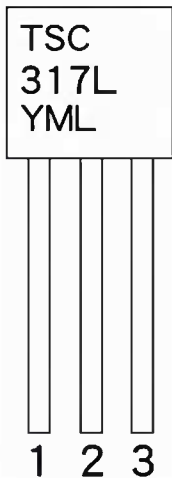


**TO-92 Mechanical Drawing**



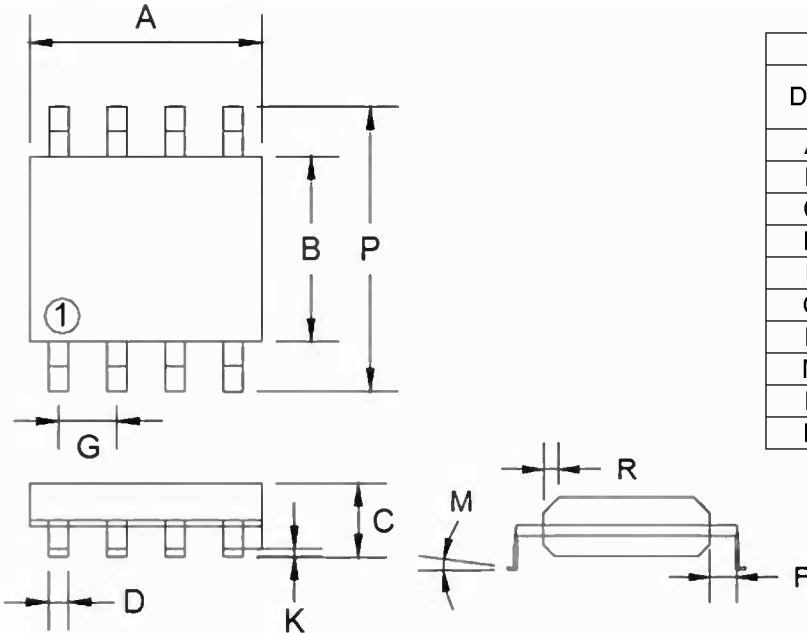
| TO-92 DIMENSION |             |      |            |       |
|-----------------|-------------|------|------------|-------|
| DIM             | MILLIMETERS |      | INCHES     |       |
|                 | MIN         | MAX  | MIN        | MAX   |
| A               | 4.30        | 4.70 | 0.169      | 0.185 |
| B               | 4.30        | 4.70 | 0.169      | 0.185 |
| C               | 14.30(typ)  |      | 0.563(typ) |       |
| D               | 0.43        | 0.49 | 0.017      | 0.019 |
| E               | 2.19        | 2.81 | 0.086      | 0.111 |
| F               | 3.30        | 3.70 | 0.130      | 0.146 |
| G               | 2.42        | 2.66 | 0.095      | 0.105 |
| H               | 0.37        | 0.43 | 0.015      | 0.017 |

**Marking Diagram**



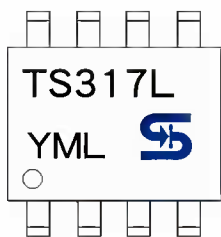
- Y** = Year Code
- M** = Month Code  
(A=Jan, B=Feb, C=Mar, D=Apl, E=May, F=Jun, G=Jul, H=Aug, I=Sep, J=Oct, K=Nov, L=Dec)
- L** = Lot Code

**SOP-8 Mechanical Drawing**



| DIM | MILLIMETERS |      | INCHES  |       |
|-----|-------------|------|---------|-------|
|     | MIN         | MAX  | MIN     | MAX.  |
| A   | 4.80        | 5.00 | 0.189   | 0.196 |
| B   | 3.80        | 4.00 | 0.150   | 0.157 |
| C   | 1.35        | 1.75 | 0.054   | 0.068 |
| D   | 0.35        | 0.49 | 0.014   | 0.019 |
| F   | 0.40        | 1.25 | 0.016   | 0.049 |
| G   | 1.27BSC     |      | 0.05BSC |       |
| K   | 0.10        | 0.25 | 0.004   | 0.009 |
| M   | 0°          | 7°   | 0°      | 7°    |
| P   | 5.80        | 6.20 | 0.229   | 0.244 |
| R   | 0.25        | 0.50 | 0.010   | 0.019 |

**Marking Diagram**



- Y** = Year Code
- M** = Month Code  
(A=Jan, B=Feb, C=Mar, D=Apl, E=May, F=Jun, G=Jul, H=Aug, I=Sep, J=Oct, K=Nov, L=Dec)
- L** = Lot Code

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