

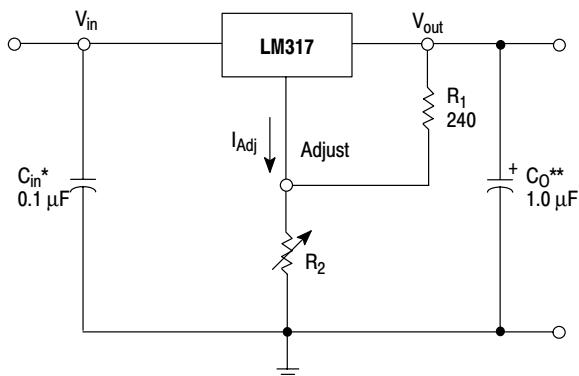
1.5 A Adjustable Output, Positive Voltage Regulator

The LM317 is an 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 requires 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.

The LM317 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317 can be used as a precision current regulator.

- Output Current in Excess of 1.5 A
- 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
- Available in Surface Mount D²PAK, and Standard 3-Lead Transistor Package
- Eliminates Stocking many Fixed Voltages

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.

$$V_{out} = 1.25 V \left(1 + \frac{R_2}{R_1} \right) + I_{Adj} R_2$$

Since I_{Adj} is controlled to less than 100 μA , the error associated with this term is negligible in most applications.

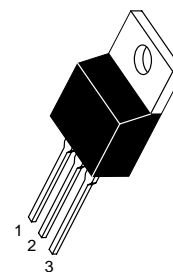
LM317

THREE-TERMINAL ADJUSTABLE POSITIVE VOLTAGE REGULATOR

SEMICONDUCTOR TECHNICAL DATA

T SUFFIX
 PLASTIC PACKAGE
 CASE 221A

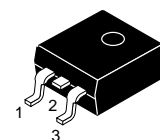
Heatsink surface connected to Pin 2.



Pin 1. Adjust
 2. V_{out}
 3. V_{in}

D2T SUFFIX
 PLASTIC PACKAGE
 CASE 936
 (D²PAK)

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.



ORDERING INFORMATION

| Device | Operating Temperature Range | Package |
|-----------|---|-----------------|
| LM317BD2T | $T_J = -40^\circ \text{ to } +125^\circ \text{C}$ | Surface Mount |
| LM317BT | | Insertion Mount |
| LM317D2T | $T_J = 0^\circ \text{ to } +125^\circ \text{C}$ | Surface Mount |
| LM317T | | Insertion Mount |

LM317

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|--|--|--|
| Input–Output Voltage Differential | $V_I - V_O$ | 40 | Vdc |
| Power Dissipation Case 221A $T_A = +25^\circ\text{C}$ Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case Case 936 (D ² PAK) $T_A = +25^\circ\text{C}$ Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case | P_D θ_{JA} θ_{JC} P_D θ_{JA} θ_{JC} | Internally Limited 65 5.0 Internally Limited 70 5.0 | W $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ W $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ |
| Operating Junction Temperature Range | T_J | –40 to +125 | $^\circ\text{C}$ |
| Storage Temperature Range | T_{stg} | –65 to +150 | $^\circ\text{C}$ |

ELECTRICAL CHARACTERISTICS ($V_I - V_O = 5.0\text{ V}$; $I_O = 0.5\text{ A}$ for D2T and T packages; $T_J = T_{\text{low}}$ to T_{high} [Note 1]; I_{max} and P_{max} [Note 2]; unless otherwise noted.)

| Characteristics | Figure | Symbol | Min | Typ | Max | Unit |
|---|--------|-----------------------------|-------------|------------|-----------|---------------------------|
| Line Regulation (Note 3), $T_A = +25^\circ\text{C}$, $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$ | 1 | Reg_{line} | – | 0.01 | 0.04 | %/V |
| Load Regulation (Note 3), $T_A = +25^\circ\text{C}$, $10\text{ mA} \leq I_O \leq I_{\text{max}}$ $V_O \leq 5.0\text{ V}$ $V_O \geq 5.0\text{ V}$ | 2 | Reg_{load} | – – | 5.0 0.1 | 25 0.5 | mV % V_O |
| Thermal Regulation, $T_A = +25^\circ\text{C}$ (Note 6), 20 ms Pulse | | $\text{Reg}_{\text{therm}}$ | – | 0.03 | 0.07 | % V_O/W |
| Adjustment Pin Current | 3 | I_{Adj} | – | 50 | 100 | μA |
| Adjustment Pin Current Change, $2.5\text{ V} \leq V_I - V_O \leq 40\text{ V}$, $10\text{ mA} \leq I_L \leq I_{\text{max}}$, $P_D \leq P_{\text{max}}$ | 1, 2 | ΔI_{Adj} | – | 0.2 | 5.0 | μA |
| Reference Voltage, $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$, $10\text{ mA} \leq I_O \leq I_{\text{max}}$, $P_D \leq P_{\text{max}}$ | 3 | V_{ref} | 1.2 | 1.25 | 1.3 | V |
| Line Regulation (Note 3), $3.0\text{ V} \leq V_I - V_O \leq 40\text{ V}$ | 1 | Reg_{line} | – | 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 | Reg_{load} | – – | 20 0.3 | 70 1.5 | mV % V_O |
| Temperature Stability ($T_{\text{low}} \leq T_J \leq T_{\text{high}}$) | 3 | T_S | – | 0.7 | – | % V_O |
| Minimum Load Current to Maintain Regulation ($V_I - V_O = 40\text{ V}$) | 3 | I_{Lmin} | – | 3.5 | 10 | mA |
| Maximum Output Current $V_I - V_O \leq 15\text{ V}$, $P_D \leq P_{\text{max}}$, T Package $V_I - V_O = 40\text{ V}$, $P_D \leq P_{\text{max}}$, $T_A = +25^\circ\text{C}$, T Package | 3 | I_{max} | 1.5 0.15 | 2.2 0.4 | – – | A |
| RMS Noise, % of V_O , $T_A = +25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$ | | N | – | 0.003 | – | % V_O |
| Ripple Rejection, $V_O = 10\text{ V}$, $f = 120\text{ Hz}$ (Note 4) Without C_{Adj} $C_{\text{Adj}} = 10\text{ }\mu\text{F}$ | 4 | RR | – 66 | 65 80 | – – | dB |
| Long–Term Stability, $T_J = T_{\text{high}}$ (Note 5), $T_A = +25^\circ\text{C}$ for Endpoint Measurements | 3 | S | – | 0.3 | 1.0 | %/1.0 k Hrs. |
| Thermal Resistance Junction to Case, T Package | | $R_{\theta\text{JC}}$ | – | 5.0 | – | $^\circ\text{C}/\text{W}$ |

NOTES: 1. T_{low} to $T_{\text{high}} = 0^\circ$ to $+125^\circ\text{C}$, for LM317T, D2T. T_{low} to $T_{\text{high}} = -40^\circ$ to $+125^\circ\text{C}$, for LM317BT, BD2T.

2. $I_{\text{max}} = 1.5\text{ A}$, $P_{\text{max}} = 20\text{ W}$

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.

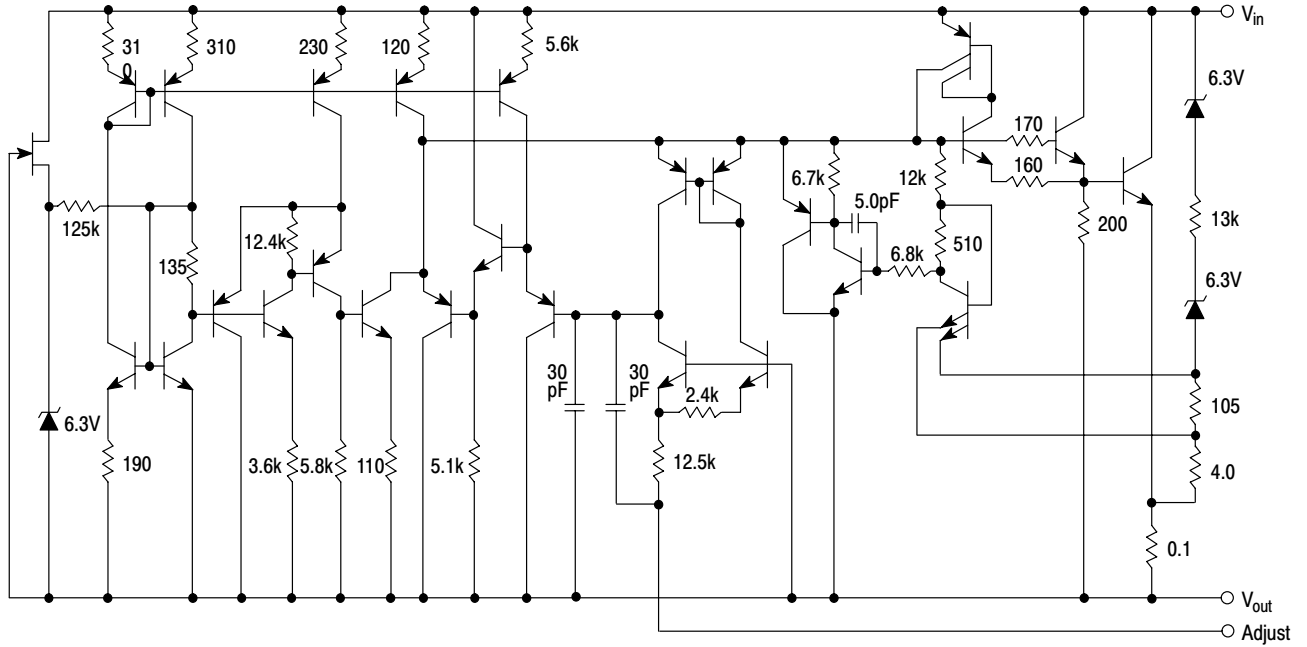
4. C_{Adj} , when used, is connected between the adjustment pin and ground.

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 is the effect of these temperature gradients on the output voltage and is expressed in percentage of output change per watt of power change in a specified time.

LM317

Representative Schematic Diagram



This device contains 29 active transistors.

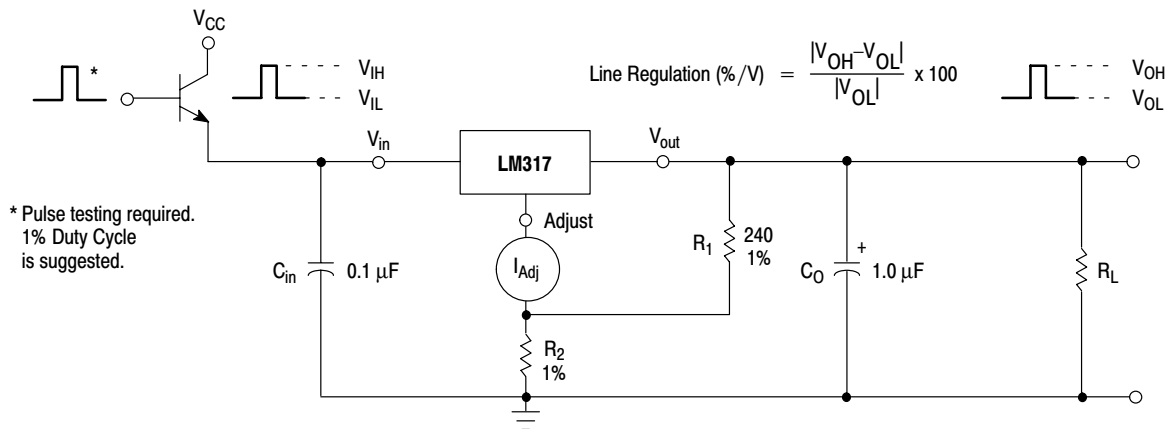
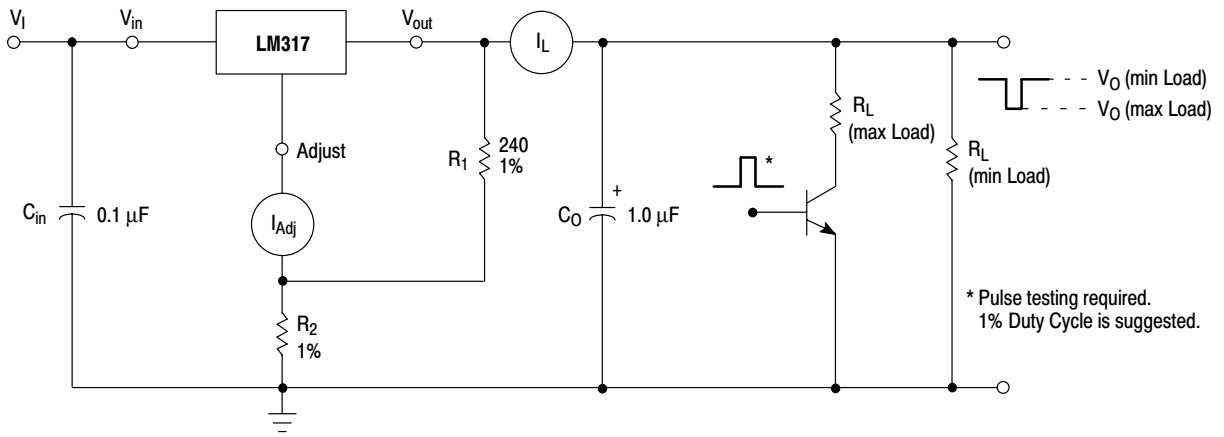


Figure 1. Line Regulation and $\Delta I_{Adj}/\text{Line}$ Test Circuit

LM317



Load Regulation (mV) = V_O (min Load) - V_O (max Load)

Load Regulation (% V_O) = $\frac{V_O$ (min Load) - V_O (max Load)}{V_O (min Load)} x 100

Figure 2. Load Regulation and ΔI_{Adj} /Load Test Circuit

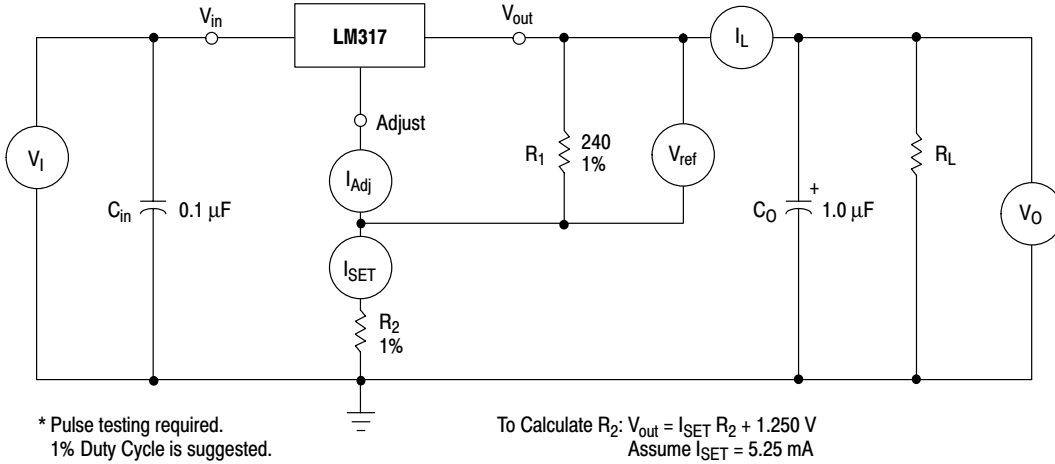


Figure 3. Standard Test Circuit

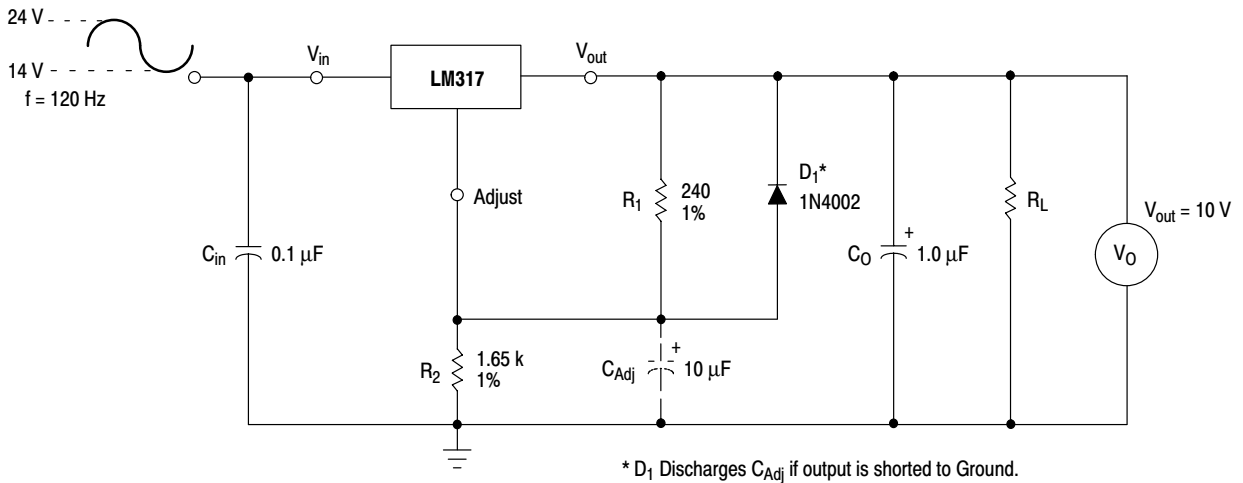


Figure 4. Ripple Rejection Test Circuit

LM317

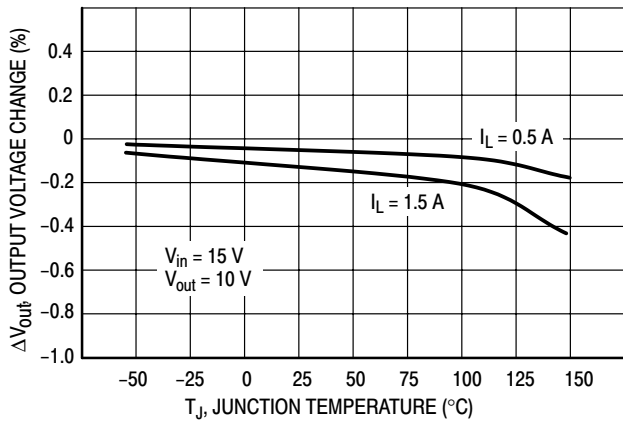


Figure 5. Load Regulation

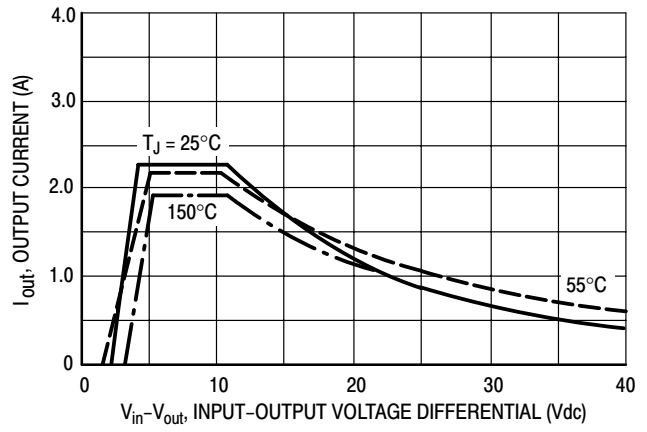


Figure 6. Current Limit

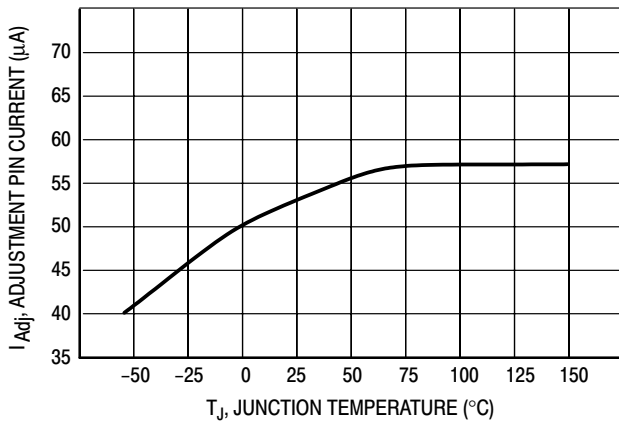


Figure 7. Adjustment Pin Current

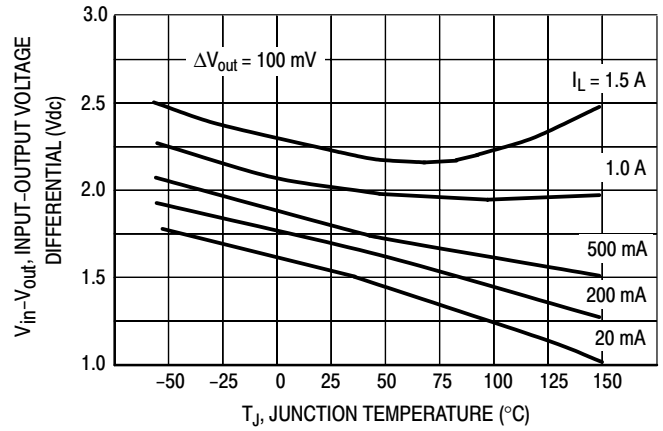


Figure 8. Dropout Voltage

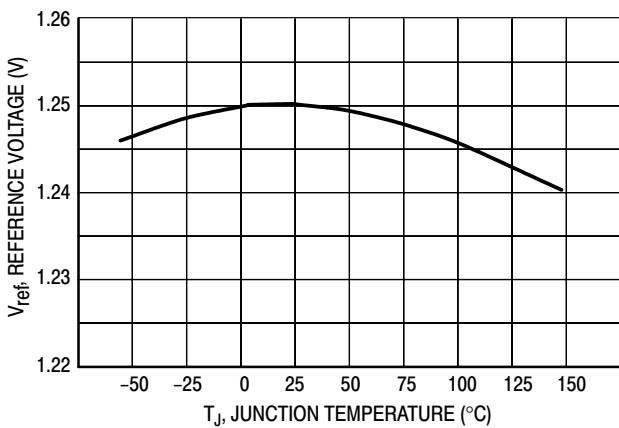


Figure 9. Temperature Stability

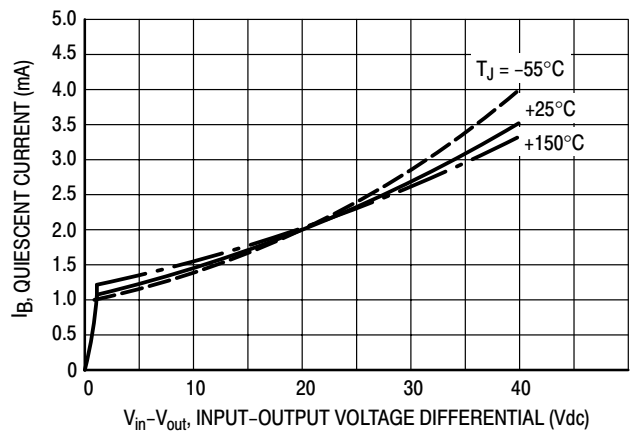


Figure 10. Minimum Operating Current

LM317

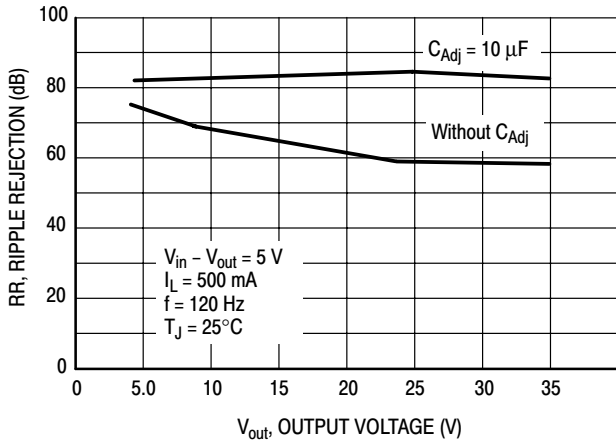


Figure 11. Ripple Rejection versus Output Voltage

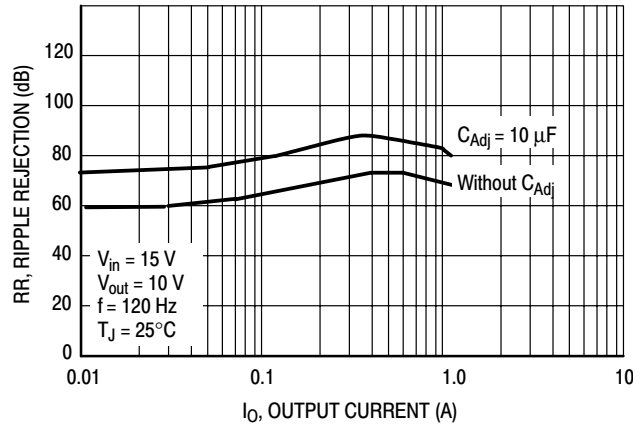


Figure 12. Ripple Rejection versus Output Current

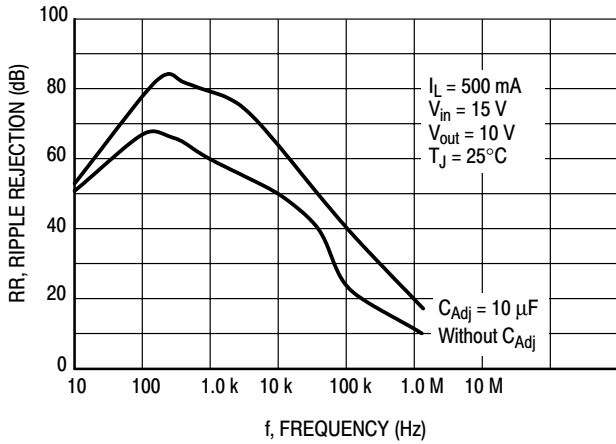


Figure 13. Ripple Rejection versus Frequency

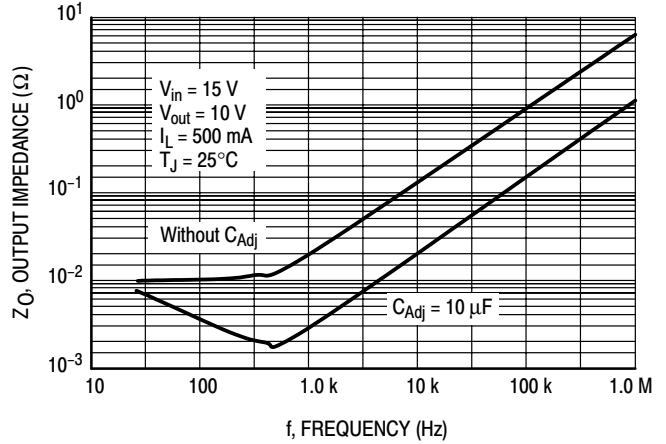


Figure 14. Output Impedance

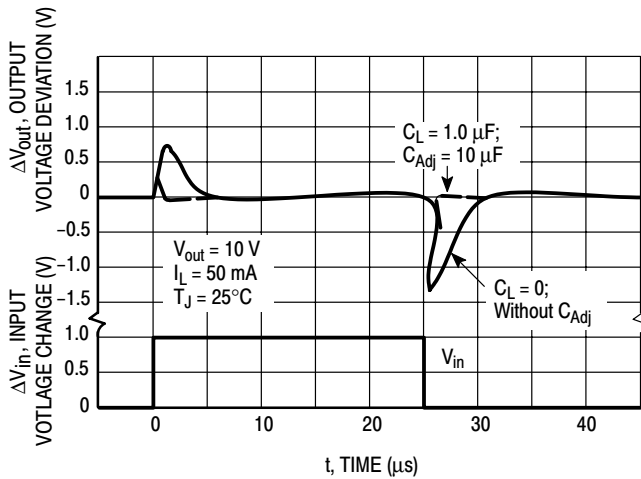


Figure 15. Line Transient Response

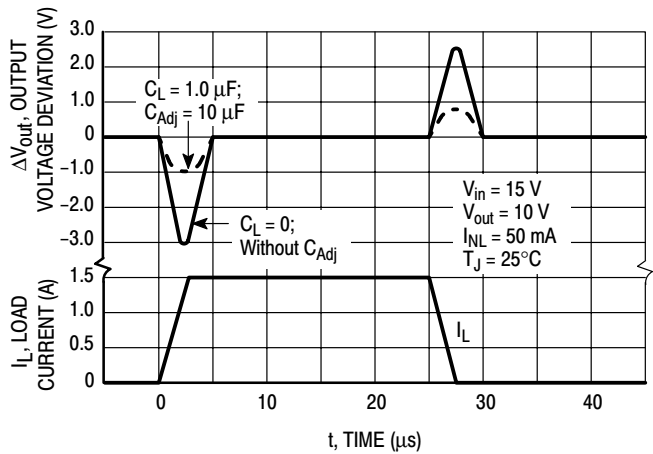


Figure 16. Load Transient Response

APPLICATIONS INFORMATION

Basic Circuit Operation

The LM317 is a 3-terminal floating regulator. In operation, the LM317 develops and maintains a nominal 1.25 V 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 μA 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.

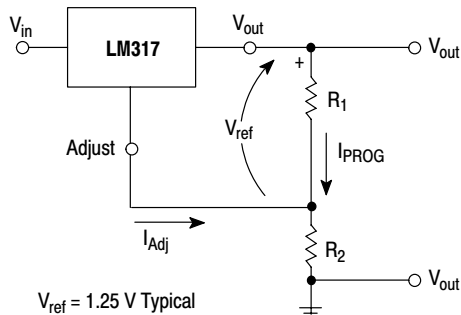


Figure 17. Basic Circuit Configuration

Load Regulation

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.

External Capacitors

A 0.1 μF disc or 1.0 μF 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 increased. A 10 μF capacitor should improve ripple rejection about 15 dB at 120 Hz in a 10 V application.

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 1.0 μF tantalum or 25 μF aluminum electrolytic capacitor on the output swamps this effect and insures stability.

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.

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 IC during an input short circuit. Diode D_2 protects against capacitor C_{Adj} discharging through the IC during an output short circuit. The combination of diodes D_1 and D_2 prevents C_{Adj} from discharging through the IC during an input short circuit.

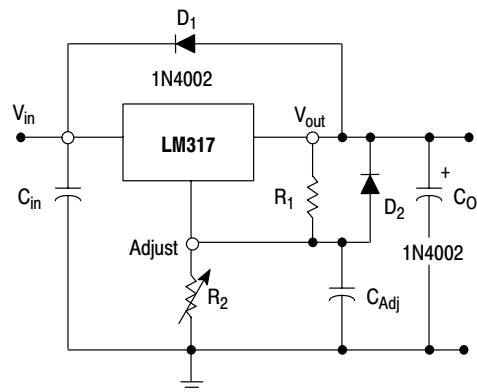


Figure 18. Voltage Regulator with Protection Diodes

LM317

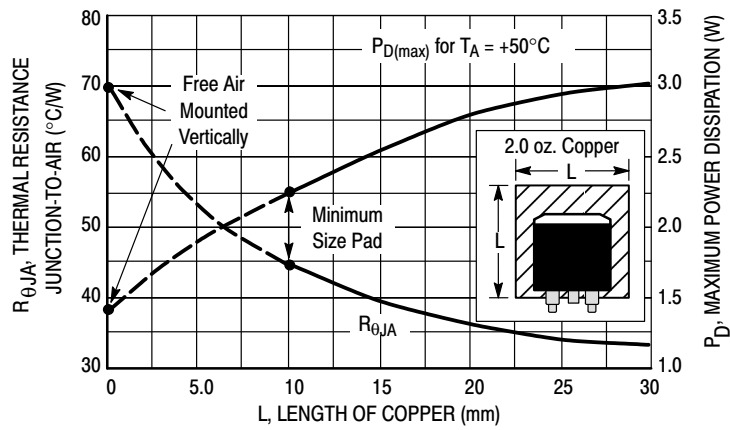
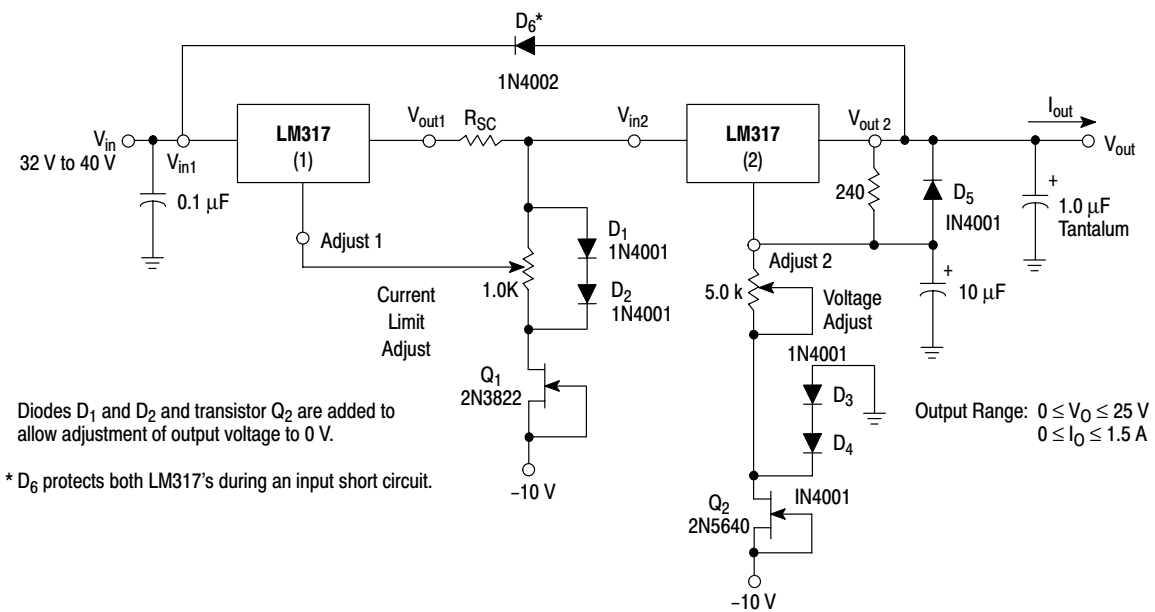


Figure 19. D²PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length



Diodes D_1 and D_2 and transistor Q_2 are added to allow adjustment of output voltage to 0 V.

* D_6 protects both LM317's during an input short circuit.

Figure 20. "Laboratory" Power Supply with Adjustable Current Limit and Output Voltage

LM317

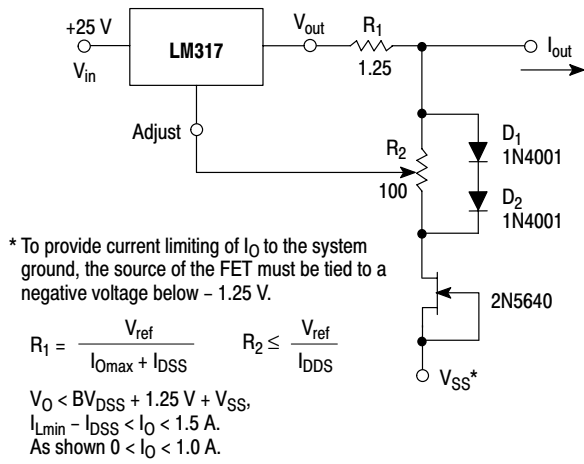


Figure 21. Adjustable Current Limiter

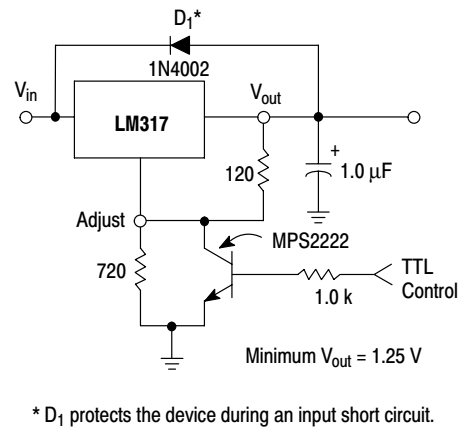


Figure 22. 5.0 V Electronic Shutdown Regulator

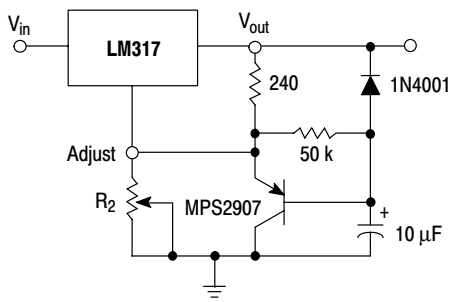


Figure 23. Slow Turn-On Regulator

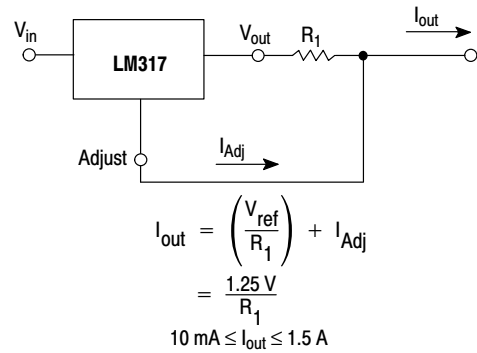
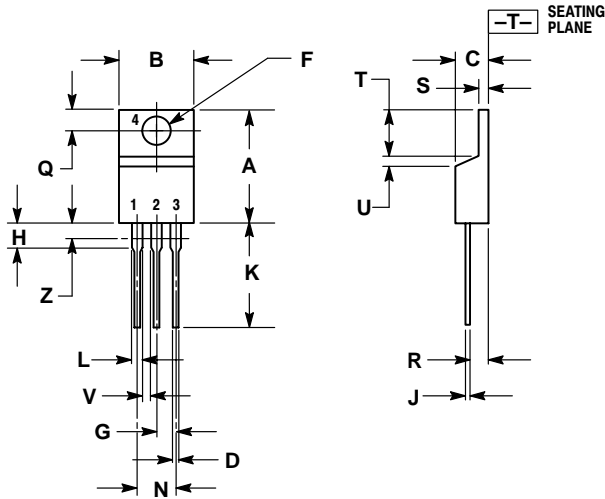


Figure 24. Current Regulator

LM317

PACKAGE DIMENSIONS

T SUFFIX PLASTIC PACKAGE CASE 221A-09 ISSUE AA

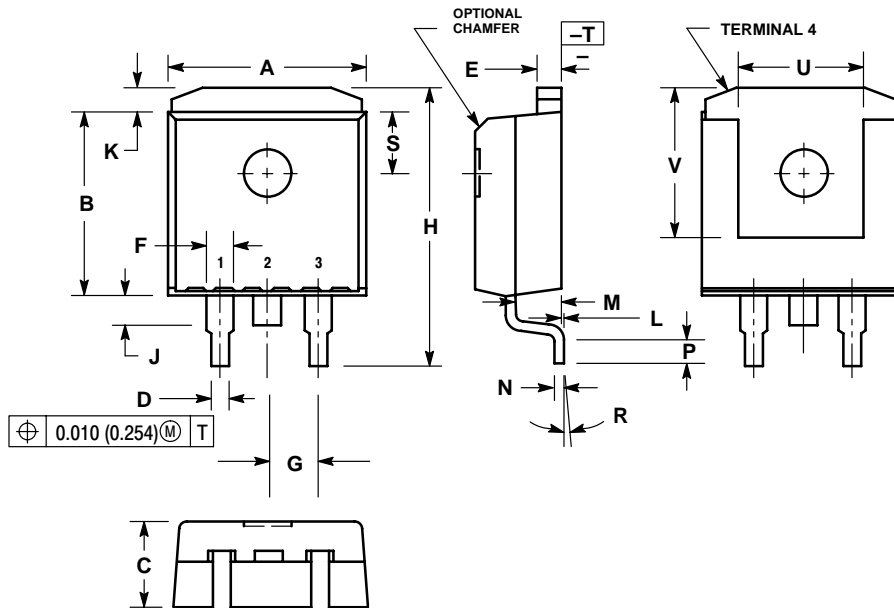


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

| DIM | INCHES | | MILLIMETERS | |
|-----|--------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.570 | 0.620 | 14.48 | 15.75 |
| B | 0.380 | 0.405 | 9.66 | 10.28 |
| C | 0.160 | 0.190 | 4.07 | 4.82 |
| D | 0.025 | 0.035 | 0.64 | 0.88 |
| F | 0.142 | 0.147 | 3.61 | 3.73 |
| G | 0.095 | 0.105 | 2.42 | 2.66 |
| H | 0.110 | 0.155 | 2.80 | 3.93 |
| J | 0.018 | 0.025 | 0.46 | 0.64 |
| K | 0.500 | 0.562 | 12.70 | 14.27 |
| L | 0.045 | 0.060 | 1.15 | 1.52 |
| N | 0.190 | 0.210 | 4.83 | 5.33 |
| Q | 0.100 | 0.120 | 2.54 | 3.04 |
| R | 0.080 | 0.110 | 2.04 | 2.79 |
| S | 0.045 | 0.055 | 1.15 | 1.39 |
| T | 0.235 | 0.255 | 5.97 | 6.47 |
| U | 0.000 | 0.050 | 0.00 | 1.27 |
| V | 0.045 | --- | 1.15 | --- |
| Z | --- | 0.080 | --- | 2.04 |

D2T SUFFIX PLASTIC PACKAGE CASE 936-03 (D²PAK) ISSUE B



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|--------|
| | MIN | MAX | MIN | MAX |
| A | 0.386 | 0.403 | 9.804 | 10.236 |
| B | 0.356 | 0.368 | 9.042 | 9.347 |
| C | 0.170 | 0.180 | 4.318 | 4.572 |
| D | 0.026 | 0.036 | 0.660 | 0.914 |
| E | 0.045 | 0.055 | 1.143 | 1.397 |
| F | 0.051 REF | --- | 1.295 REF | --- |
| G | 0.100 BSC | --- | 2.540 BSC | --- |
| H | 0.539 | 0.579 | 13.691 | 14.707 |
| J | 0.125 MAX | --- | 3.175 MAX | --- |
| K | 0.050 REF | --- | 1.270 REF | --- |
| L | 0.000 | 0.010 | 0.000 | 0.254 |
| M | 0.088 | 0.102 | 2.235 | 2.591 |
| N | 0.018 | 0.026 | 0.457 | 0.660 |
| P | 0.058 | 0.078 | 1.473 | 1.981 |
| R | 5° REF | --- | 5° REF | --- |
| S | 0.116 REF | --- | 2.946 REF | --- |
| U | 0.200 MIN | --- | 5.080 MIN | --- |
| V | 0.250 MIN | --- | 6.350 MIN | --- |

Notes

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