

LM317L 3-Terminal Adjustable Regulator

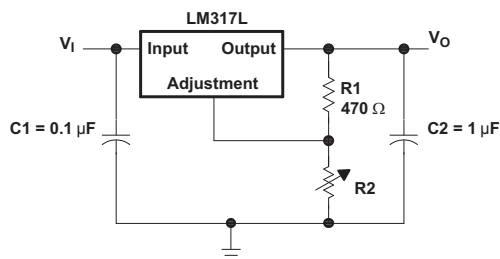
1 Features

- Output Voltage Range Adjustable 1.25 V to 32 V When Used With External Resistor Divider
- Output Current Capability of 100 mA
- Input Regulation Typically 0.01% Per Input-Voltage Change
- Output Regulation Typically 0.5%
- Ripple Rejection Typically 80 dB
- For Higher Output Current Requirements, See [LM317M](#) (500 mA) and [LM317](#) (1.5 A)

2 Applications

- Electronic Points of Sale
- Medical, Health, and Fitness Applications
- Printers
- Appliances and White Goods
- TV Set-Top Boxes

4 Simplified Schematic



3 Description

The LM317L device is an adjustable, 3-terminal, positive-voltage regulator capable of supplying 100 mA over an output-voltage range of 1.25 V to 32 V. It is exceptionally easy to use and requires only two external resistors to set the output voltage.

Device Information

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM317L	SOIC (8)	4.90 mm × 3.91 mm
	TO-92 (3)	4.30 mm × 4.30 mm
	SOT-89 (3)	4.50 mm × 2.50 mm
	TSSOP (8)	3.00 mm × 4.40 mm

LM317L

SLCS144E – JULY 2004 – REVISED OCTOBER 2014

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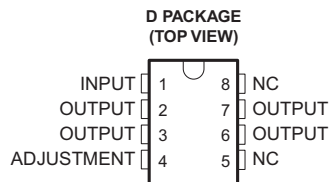
5 Revision History

Changes from Revision D (October 2011) to Revision E

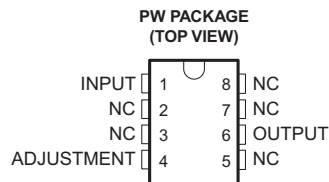
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- Added *Device Information* table, *Pin Functions* table, *Handling Ratings* table, *Thermal Information* table, *Typical Characteristics*, *Detailed Description*, *Application and Implementation*, *Power Supply Recommendations*, *Layout*, *Device and Documentation Support*, and *Mechanical, Packaging, and Orderable Information* sections **1**
- Deleted *Ordering Information* table. **1**

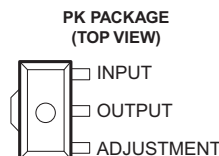
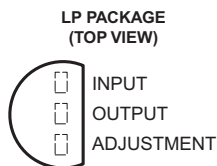
6 Pin Configuration and Functions



NC – No internal connection
OUTPUT terminals are all internally connected.



NC – No internal connection



Pin Functions

NAME	D, PW	LP, PK	TYPE	DESCRIPTION
ADJUSTMENT	4	✓	I	Output feedback voltage
INPUT	1	✓	I	Input supply voltage
NC	5	✓	—	No connect
	8			
OUTPUT	2	✓	O	Regulated output voltage
	3			
	6			
	7			

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

over operating temperature range (unless otherwise noted)

	MIN	MAX	UNIT
$V_I - V_O$ Input-to-output differential voltage		35	V
T_J Operating virtual-junction temperature		150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 Handling Ratings

			MIN	MAX	UNIT
T _{stg}	Storage temperature range		−65	150	°C
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾	0	3000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽²⁾	0	2000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

			MIN	MAX	UNIT
V _O	Output voltage		1.25	32	V
V _I – V _O	Input-to-output voltage differential		2.5	32	V
I _O	Output current		2.5	100	mA
T _J	Operating virtual-junction temperature	LM317LC	0	125	°C
		LM317LI	–40	125	

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾	LM317L				UNIT
	D 8 PINS	LP 3 PINS	PK 3 PINS	PW 8 PINS	
$R\theta_{JA}$ Junction-to-ambient thermal resistance	97.1	139.5	51.5	149.4	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report (SPRA953).

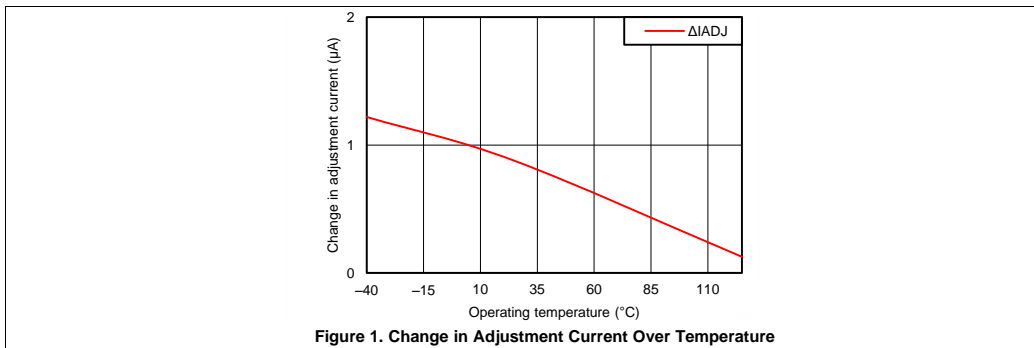
7.5 Electrical Characteristics

over recommended operating virtual-junction temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS ⁽¹⁾		MIN	TYP	MAX	UNIT
Input voltage regulation ⁽²⁾	$V_I - V_O = 5 \text{ V to } 35 \text{ V}$	$T_J = 25^\circ\text{C}$ $I_O = 2.5 \text{ mA to } 100 \text{ mA}$		0.01 0.02	0.02 0.05	%V
Ripple regulation	$V_O = 10 \text{ V},$ $f = 120 \text{ Hz}$			65		dB
	$V_O = 10 \text{ V},$ 10- μF capacitor between ADJUSTMENT and ground		66	80		
Output voltage regulation	$V_I = 5 \text{ V to } 35 \text{ V}, T_J = 25^\circ\text{C},$ $I_O = 2.5 \text{ mA to } 100 \text{ mA},$	$V_O \leq 5 \text{ V}$		25		mV
		$V_O \geq 5 \text{ V}$		5		mV/V
	$V_I = 5 \text{ V to } 35 \text{ V},$ $I_O = 2.5 \text{ mA to } 100 \text{ mA}$	$V_O \leq 5 \text{ V}$ $V_O \geq 5 \text{ V}$		50 10		mV mV/V
Output voltage change with temperature	$T_J = 0^\circ\text{C to } 125^\circ\text{C}$			10		mV/V
Output voltage long-term drift	After 1000 hours at $T_J = 125^\circ\text{C}$ and $V_I - V_O = 35 \text{ V}$			3	10	mV/V
Output noise voltage	$f = 10 \text{ Hz to } 10 \text{ kHz},$ $T_J = 25^\circ\text{C}$			30		$\mu\text{V/V}$
Minimum output current to maintain regulation	$V_I - V_O = 35 \text{ V}$			1.5	2.5	mA
Peak output current	$V_I - V_O \leq 35 \text{ V}$		100	200		mA
ADJUSTMENT current				50	100	μA
Change in ADJUSTMENT current	$V_I - V_O = 2.5 \text{ V to } 35 \text{ V},$ $I_O = 2.5 \text{ mA to } 100 \text{ mA}$			0.2	5	μA
Reference voltage (output to ADJUSTMENT)	$V_I - V_O = 5 \text{ V to } 35 \text{ V},$ $P \leq \text{rated dissipation}$	$I_O = 2.5 \text{ mA to } 100 \text{ mA},$	1.2	1.25	1.3	V

- (1) Unless otherwise noted, these specifications apply for the following test conditions: $V_I - V_O = 5 \text{ V}$ and $I_O = 40 \text{ mA}$. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible. All characteristics are measured with a 0.1- μF capacitor across the input and a 1- μF capacitor across the output.
- (2) Input voltage regulation is expressed here as the percentage change in output voltage per 1-V change at the input.

7.6 Typical Characteristics



8 Detailed Description

8.1 Overview

The LM317L device is a 100-mA linear regulator with high voltage tolerance up to 35 V. The device has a feedback voltage that is relative to the output instead of ground. This ungrounded design allows the LM317L device to have superior line and load regulation. This design also allows the LM317L device to be used as a current source or current sink using a single resistor. Any output voltage from 1.25 to 32 V can be obtained by using two resistors. The bias current of the device, up to 2.5 mA, flows to the output; this current must be used by the load or the feedback resistors. The power dissipation is the product of pass-element voltage and current, which is calculated as shown in Equation 1.

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} \quad (1)$$

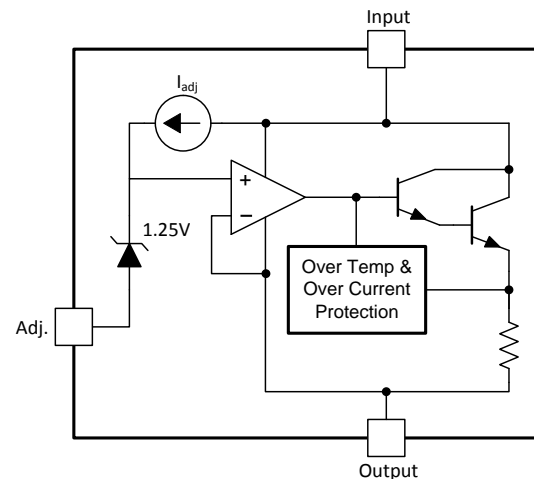
The application heat sink must be able to absorb the power calculated in Equation 1.

In addition to higher performance than fixed regulators, this regulator offers full overload protection, available only in integrated circuits. Included on the chip are current-limiting and thermal-overload protection. All overload-protection circuitry remains fully functional even when ADJUSTMENT is disconnected. 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. ADJUSTMENT can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard three-terminal regulators.

In addition to replacing fixed regulators, the LM317L regulator 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. Its primary application is that of a programmable output regulator, but by connecting a fixed resistor between ADJUSTMENT and OUTPUT, this device can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping ADJUSTMENT to ground, programming the output to 1.25 V, where most loads draw little current.

The LM317LC device is characterized for operation over the virtual junction temperature range of 0°C to 125°C . The LM317LI device is characterized for operation over the virtual junction temperature range of -40°C to 125°C .

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 NPN Darlington Output Drive

NPN Darlington output topology provides naturally low output impedance and an output capacitor is optional. To support maximum current and lowest temperature, 2.5-V headroom is recommended ($V_I - V_O$).

8.3.2 Overload Block

Over-current and over-temperature shutdown protects the device against overload or damage from operating in excessive heat.

8.3.3 Programmable Feedback

Op amp with 1.25-V offset input at the ADJUST pin provides easy output voltage or current (not both) programming. For current regulation applications, a single resistor whose resistance value is $1.25 \text{ V} / I_{OUT}$ and power rating is greater than $(1.25 \text{ V})^2 / R$ should be used. For voltage regulation applications, two resistors set the output voltage. See [Typical Application](#) for a schematic and the resistor formula.

8.4 Device Functional Modes

8.4.1 Normal operation

The device OUTPUT pin will source current necessary to make OUTPUT pin 1.25 V greater than ADJUST terminal to provide output regulation.

8.4.2 Operation With Low Input Voltage

The device requires up to 2.5-V headroom ($V_I - V_O$) to operate in regulation. With less headroom, the device may drop out and OUTPUT voltage will be INPUT voltage minus drop out voltage.

8.4.3 Operation at Light Loads

The device passes its bias current to the OUTPUT pin. The load or feedback must consume this minimum current for regulation or the output may be too high.

8.4.4 Operation In Self Protection

When an overload occurs the device will shut down Darlington NPN output stage or reduce the output current to prevent device damage. The device will automatically reset from the overload. The output may be reduced or alternate between on and off until the overload is removed.

9 Application and Implementation

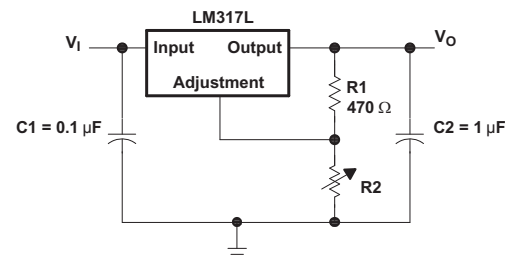
NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The two output resistors are the only components required to adjust V_{OUT} .

9.2 Typical Application



9.2.1 Design Requirements

1. Use of an input bypass capacitor is recommended if regulator is far from the filter capacitors.
2. For this design example, use the parameters listed in [Table 1](#).
3. Use of an output capacitor improves transient response, but is optional.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage range	(Output Voltage + 2.5 V) to 32 V
Output voltage	$V_{REF} \times (1 + R_2 / R_1) + I_{ADJ} \times R_2$

9.2.2 Detailed Design Procedure

9.2.2.1 Input Capacitor

An input capacitor is not required, but it is recommended, particularly if the regulator is not in close proximity to the power-supply filter capacitors. A 0.1-μF ceramic or 1-μF tantalum provides sufficient bypassing for most applications, especially when adjustment and output capacitors are used.

9.2.2.2 Output Capacitor

An output capacitor improves transient response, but it not needed for stability.

9.2.2.3 Feedback Resistors

The feedback resistor set the output voltage using [Equation 2](#).

$$V_{REF} \times (1 + R_2 / R_1) + I_{ADJ} \times R_2 \quad (2)$$

9.2.2.4 Adjustment Terminal Capacitor

The optional adjustment pin capacitor will improve ripple rejection by preventing the amplification of the ripple. When capacitor is used and $V_{OUT} > 6\text{ V}$, a protection diode from adjust to output is recommended.

9.2.2.5 Design Options and Parameters

Common Linear Regulator designs are concerned with the following parameters:

- Input voltage range
- Input capacitor range
- Output voltage
- Output current rating
- Output capacitor range
- Input short protection
- Stability
- Ripple rejection

9.2.2.6 Output Voltage

V_O is calculated as shown in Equation 3.

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_2}{R_1}\right) + (I_{ADJ} \times R_2) \quad (3)$$

Because I_{ADJ} typically is 50 μA , it is negligible in most applications.

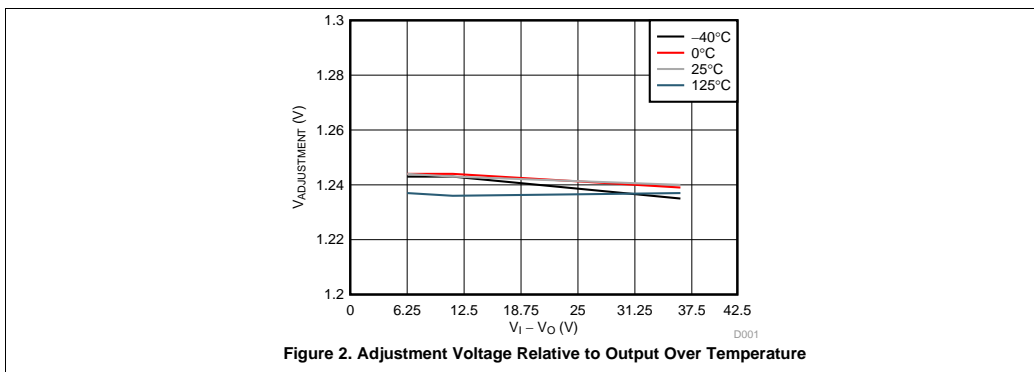
9.2.2.7 Ripple Rejection

C_{ADJ} is used to improve ripple rejection; it prevents amplification of the ripple as the output voltage is adjusted higher. If C_{ADJ} is used, it is best to include protection diodes.

9.2.2.8 Input Short Protection

If the input is shorted to ground during a fault condition, protection diodes provide measures to prevent the possibility of external capacitors discharging through low-impedance paths in the IC. By providing low-impedance discharge paths for C_O and C_{ADJ} , respectively, D1 and D2 prevent the capacitors from discharging into the output of the regulator.

9.2.3 Application Curves



9.3 General Configurations

9.3.1 Regulator Circuit With Improved Ripple Rejection

C_2 helps to stabilize the voltage at the adjustment pin, which will help reject noise. Diode D1 exists to discharge C_2 in case the output is shorted to ground.

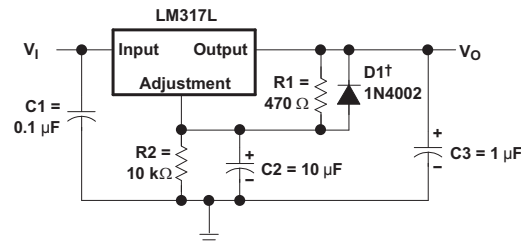


Figure 3. Regulator Circuit With Improved Ripple Rejection

9.3.2 0-V to 30-V Regulator Circuit

In the 0-V to 30-V regulator circuit application, the output voltage is determined by Equation 4.

$$V_{OUT} = V_{REF} \left(1 + \frac{R_2 + R_3}{R_1}\right) - 10\text{ V} \quad (4)$$

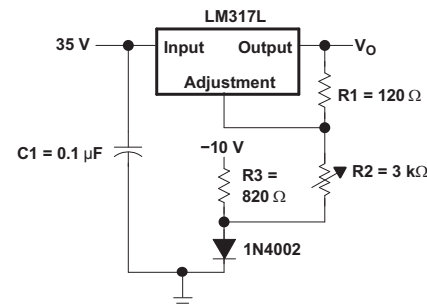


Figure 4. 0-V to 30-V Regulator Circuit

9.3.3 Precision Current-Limiter Circuit

This application will limit the output current to the I_{LIMIT} shown in Figure 5.

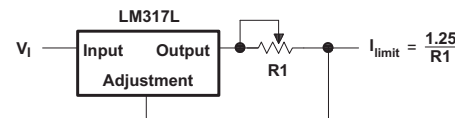


Figure 5. Precision Current-Limiter Circuit

General Configurations (continued)

9.3.4 Tracking Preregulator Circuit

The tracking preregulator circuit application keeps a constant voltage across the second LM317L in the circuit.

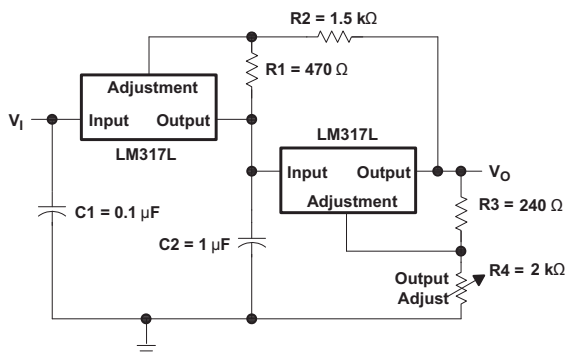


Figure 6. Tracking Preregulator Circuit

9.3.5 Slow-Turn On 15-V Regulator Circuit

The capacitor C1, in combination with the PNP transistor, helps the circuit to slowly start supplying voltage. In the beginning, the capacitor is not charged. Therefore, output voltage will start at 1.9 V, as determined by Equation 5. As the capacitor voltage rises, V_{OUT} will rise at the same rate. When the output voltage reaches the value determined by R1 and R2, the PNP will be turned off.

$$V_{C1} + V_{BE} + 1.25 \text{ V} = 0 \text{ V} + 0.65 \text{ V} + 1.25 \text{ V} = 1.9 \text{ V} \quad (5)$$

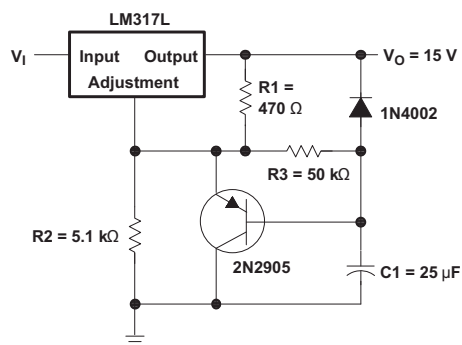


Figure 7. Slow-Turn On 15-V Regulator Circuit

General Configurations (continued)

9.3.6 50-mA Constant-Current Battery-Charger Circuit

The current-limit operation mode can be used to trickle charge a battery at a fixed current as determined by Equation 6. V_I should be greater than V_{BAT} + 3.75 V.

$$I_{CHG} = 1.25 \text{ V} \div 24 \Omega \quad (6)$$

$$(1.25 \text{ V} [V_{REF}] + 2.5 \text{ V} [\text{headroom}]) \quad (7)$$

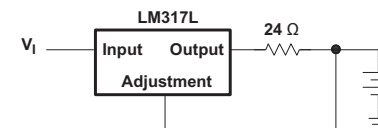


Figure 8. 50-mA Constant-Current Battery-Charger Circuit

9.3.7 Current-Limited 6-V Charger

As the charge current increases, the voltage at the bottom resistor increases until the NPN starts sinking current from the adjustment pin. The voltage at the adjustment pin will drop, and consequently the output voltage will decrease until the NPN stops conducting.

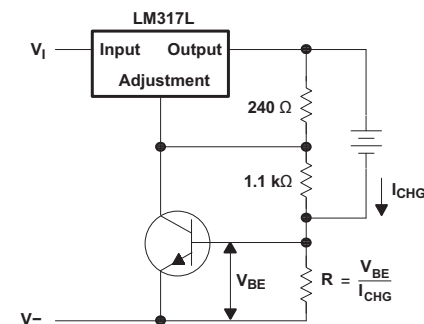


Figure 9. Current-Limited 6-V Charger

General Configurations (continued)

9.3.8 High-Current Adjustable Regulator

This application allows higher currents at V_{OUT} than the LM317L device can provide, while still keeping the output voltage at levels determined by the adjustment-pin resistor divider of the LM317L.

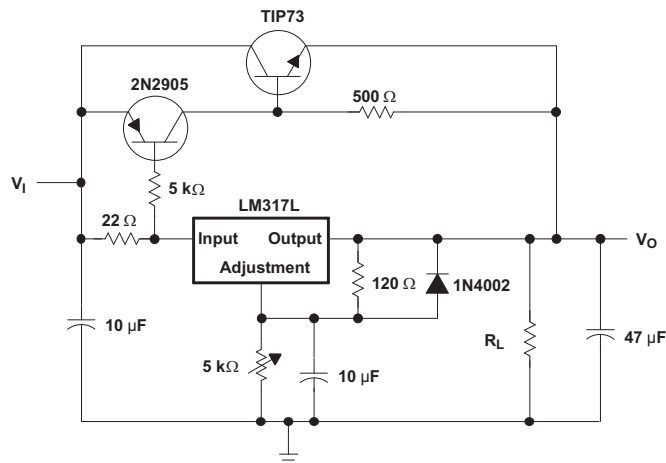


Figure 10. High-Current Adjustable Regulator

10 Power Supply Recommendations

The LM317L device is designed to operate from an input voltage supply range between 2.5 V to 32 V greater than the output voltage. If the device is more than six inches from the input filter capacitors, an input bypass capacitor, 0.1 μF or greater, of any type is needed for stability.

11 Layout

11.1 Layout Guidelines

- It is recommended that the input pin be bypassed to ground with a bypass-capacitor.
- The optimum placement is closest to the VIN of the device and GND of the system. Care must be taken to minimize the loop area formed by the bypass-capacitor connection, the VIN pin, and the GND pin of the system.
- For operation at full-rated load, it is recommended to use wide trace lengths to eliminate IR drop and heat dissipation.

11.2 Layout Example

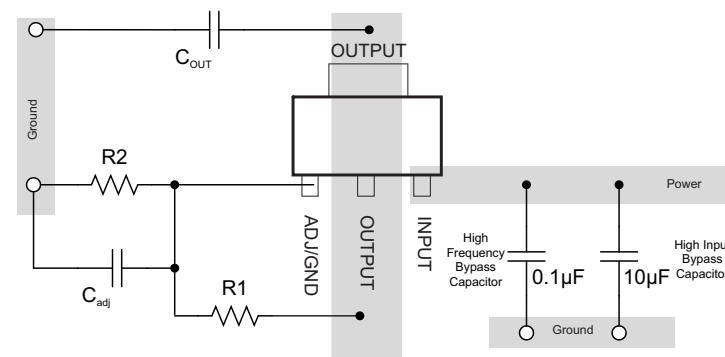


Figure 11. Layout Diagram