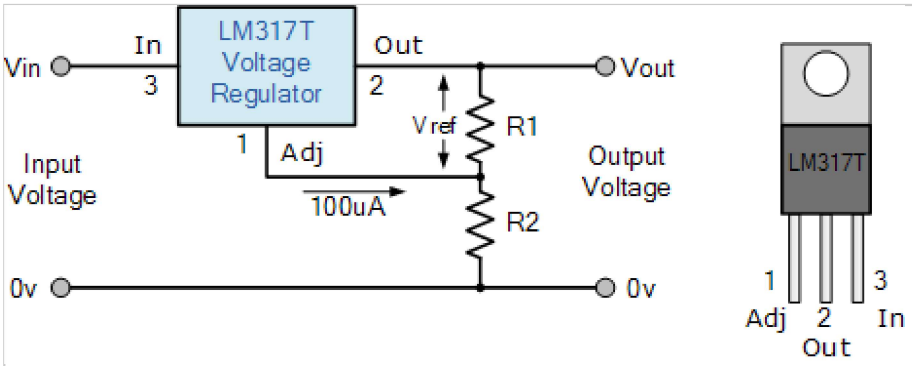


Variable Voltage Power Supply

3-terminal linear fixed voltage regulators are a popular choice for creating either positive or negative voltages

Continuing on from our tutorial about converting an ATX PSU to a bench power supply, one very good addition to this is the LM317T positive voltage regulator which we can use to create a variable voltage power supply.

The LM317T is an adjustable 3-terminal positive voltage regulator capable of supplying different DC voltage outputs other than the fixed voltage power supply of +5 or +12 volts, or as a variable output voltage from a few volts up to some maximum value all with currents of about 1.5 amperes.

With the aid of a small bit of additional circuitry added to the output of the PSU we can have a bench power supply capable of a range of fixed or variable voltages either positive or negative in nature. In fact this is more simple than you may think as the transformer, rectification and smoothing has already been done by the PSU beforehand all we need to do is connect our additional circuit to the +12 volt yellow wire output. But firstly, lets consider a fixed voltage output.

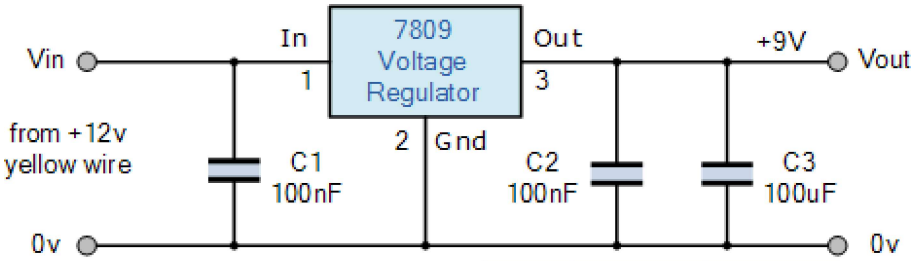
Fixed 9v Power Supply

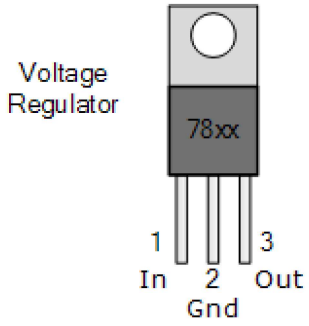
There are a wide variety of 3-terminal voltage regulators available in a standard TO-220 package with the most popular fixed voltage regulator being the 78xx series positive regulators which range from the very common 7805, +5V fixed voltage regulator to the 7824, +24V fixed voltage regulator. There is also a 79xx series of fixed negative voltage regulators which produce a complementary negative voltage from -5 to -24 volts but in this tutorial we will only use the positive **78xx** types.

The fixed 3-terminal regulator is useful in applications were an adjustable output is not required making the output power supply simple, but very flexible as the voltage it outputs is dependant only upon the chosen regulator. They are called 3-terminal voltage regulators because they only have three terminals to connect to and these are the **Input**, **Common** and **Output** respectively.

The input voltage to the regulator will be the +12v yellow wire from the PSU (or separate transformer supply), and is connected between the input and common terminals. The stabilised +9 volts is taken across the output and common as shown.

Variable Voltage Power Supply Fixed Regulator Circuit





Type	Min Input Voltage	Output Voltage
7805	7V	+5V
7806	8V	+6V
7808	10V	+8V
7809	11V	+9V
7812	15V	+12V
7815	18V	+15V
7818	22V	+18V
7824	30V	+24V

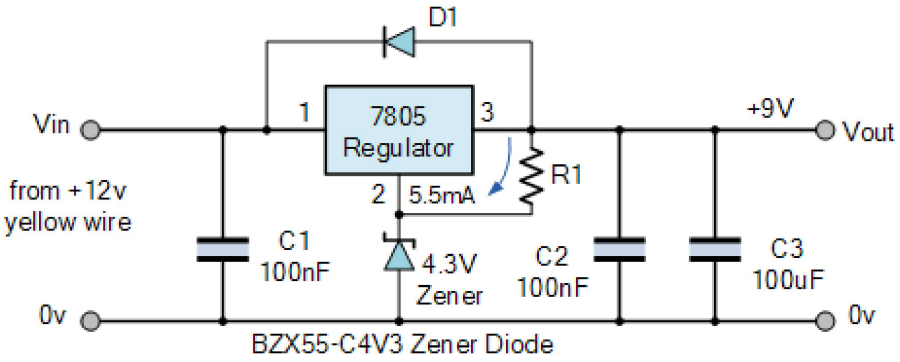
So suppose we want an output voltage of +9 volts from our PSU bench power supply, then all we have to do is connect a +9v voltage regulator to the +12V yellow wire. As the PSU has already done the rectification and smoothing to the +12v output, the only additional components required are a capacitor across the input and another across the output.

These additional capacitors aid in the stability of the regulator and can be anywhere between 100nF and 330nF. The additional 100uF output capacitor helps smooth out the inherent ripple content giving it a good transient response. This large value capacitor placed across the output of a power supply circuit is commonly called a “Smoothing Capacitor”.

These **78xx** series regulators give a maximum output current of about 1.5 amps at fixed stabilised voltages of 5, 6, 8, 9, 12, 15, 18 and 24V respectively. But what if we wanted an output voltage of +9V but only had a 7805, +5V regulator?. The +5V output of the 7805 is referenced to the “ground, Gnd” or “0v” terminal.

If we increased this pin-2 terminal voltage from 0V to 4V then the output would also rise by an additional 4 volts providing there was sufficient input voltage. Then by placing a small 4 volt (nearest preferred value of 4.3V) Zener diode between pin-2 of the regulator and ground, we can make a 7805 5V regulator produce a +9 volts output voltage as shown.

Increasing The Output Voltage



So how does it work. The 4.3V Zener diode requires a reverse bias current of around 5mA to maintain an output with the regulator taking about 0.5mA. This total current of 5.5mA is supplied via resistor “R1” from the output pin-3.

So the value of the resistor required for a 7805 regulator will be R = 5V/5.5mA = 910 Ohm. The feedback diode, D1 connected across the input to output terminals is for protection and prevents the regulator from being reverse biased when the input supply voltage is switched OFF while the output supply remains ON or active for a short period of time due to a large inductive load such as a solenoid or motor.

Then we can use 3-terminal voltage regulators and a suitable Zener diode to produce a variety of fixed output voltages from our previous bench power supply ranging from +5V up to +12V. But we can improve on this design by replacing the fixed voltage regulator with a variable voltage regulator such as the **LM317T**.

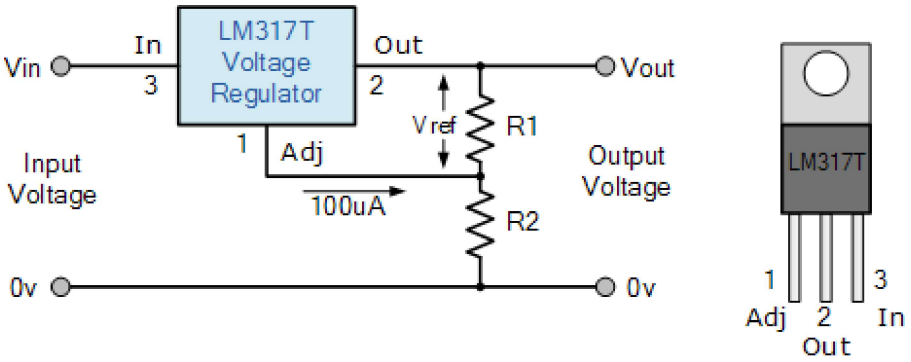
Variable Voltage Power Supply

The LM317T is a fully adjustable 3-terminal positive voltage regulator capable of supplying 1.5 amps with an output voltage ranging from around 1.25 volts to just over 30 volts. By using the ratio of two resistances, one of a fixed value and the other variable (or both fixed), we can set the output voltage to the desired level with a corresponding input voltage being anywhere between 3 and 40 volts.

The LM317T variable voltage regulator also has built in current limiting and thermal shut down capabilities which makes it short-circuit proof and ideal for any low voltage or home made bench power supply.

The output voltage of the LM317T is determined by ratio of the two feedback resistors R1 and R2 which form a potential divider network across the output terminal as shown below.

LM317T Variable Voltage Regulator



The voltage across the feedback resistor R1 is a constant 1.25V reference voltage, V_{ref} produced between the "output" and "adjustment" terminal. The adjustment terminal current is a constant current of 100uA. Since the reference voltage across resistor R1 is constant, a constant current i will flow through the other resistor R2, resulting in an output voltage of:

$$V_{OUT} = 1.25\left(1+\frac{R_2}{R_1}\right)$$

Then whatever current flows through resistor R1 also flows through resistor R2 (ignoring the very small adjustment terminal current), with the sum of the voltage drops across R1 and R2 being equal to the output voltage, Vout. Obviously the input voltage, Vin must be at least 2.5 volts greater than the required output voltage to power the regulator.

Also, the LM317T has very good load regulation providing that the minimum load current is greater than 10mA. So to maintain a constant reference voltage of 1.25V, the minimum value of feedback resistor R1 needs to be 1.25V/10mA = 120 Ohm and this value can range anywhere from 120 ohms to 1,000 ohms with typical values of R1 being about 220Ω's to 240Ω's for good stability.

If we know the value of the required output voltage, Vout and the feedback resistor R1 is say 240 ohms, then we can calculate the value of resistor R2 from the above equation. For example, our original output voltage of 9V would give a resistive value for R2 of:

$$R1.((Vout/1.25)-1) = 240.((9/1.25)-1) = 1{,}488 \text{ Ohms}$$

or 1,500 Ohms (1k5Ω) to the nearest preferred value.

Of course in practice, resistors R1 and R2 would normally be replaced by a potentiometer so as to produce a variable voltage power supply, or by several switched preset resistances if several fixed output voltages are required.

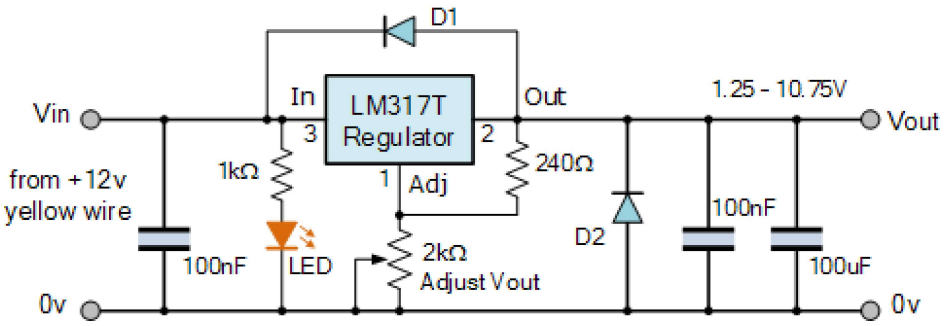
But in order to reduce the math's required in calculating the value of resistor R2 every time we want a particular voltage we can use standard resistance tables as shown below which gives us the regulators output voltage for different ratios of resistors R1 and R2 using E24 resistance values.

Ratio of Resistances R1 to R2

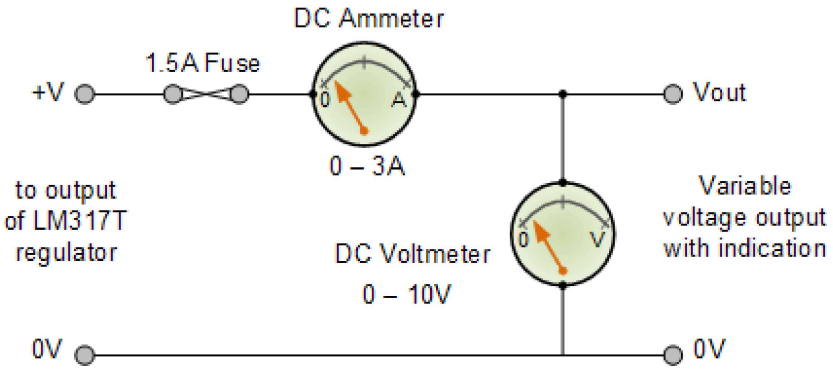
R2 Value	Resistor R1 Value								
	150	180	220	240	270	330	370	390	470
100	2.08	1.94	1.82	1.77	1.71	1.63	1.59	1.57	1.52
120	2.25	2.08	1.93	1.88	1.81	1.70	1.66	1.63	1.57
150	2.50	2.29	2.10	2.03	1.94	1.82	1.76	1.73	1.65
180	2.75	2.50	2.27	2.19	2.08	1.93	1.86	1.83	1.73
220	3.08	2.78	2.50	2.40	2.27	2.08	1.99	1.96	1.84
240	3.25	2.92	2.61	2.50	2.36	2.16	2.06	2.02	1.89
270	3.50	3.13	2.78	2.66	2.50	2.27	2.16	2.12	1.97
330	4.00	3.54	3.13	2.97	2.78	2.50	2.36	2.31	2.13
370	4.33	3.82	3.35	3.18	2.96	2.65	2.50	2.44	2.23
390	4.50	3.96	3.47	3.28	3.06	2.73	2.57	2.50	2.29
470	5.17	4.51	3.92	3.70	3.43	3.03	2.84	2.76	2.50
560	5.92	5.14	4.43	4.17	3.84	3.37	3.14	3.04	2.74
680	6.92	5.97	5.11	4.79	4.40	3.83	3.55	3.43	3.06
820	8.08	6.94	5.91	5.52	5.05	4.36	4.02	3.88	3.43
1000	9.58	8.19	6.93	6.46	5.88	5.04	4.63	4.46	3.91
1200	11.25	9.58	8.07	7.50	6.81	5.80	5.30	5.10	4.44
1500	13.75	11.67	9.77	9.06	8.19	6.93	6.32	6.06	5.24

By changing resistor R2 for a 2k ohm potentiometer we can control the output voltage range of our PSU bench power supply from about 1.25 volts to a maximum output voltage of 10.75 (12-1.25) volts. Then our final modified variable power supply circuit is shown below.

Variable Voltage Power Supply Circuit



We can improve our basic voltage regulator circuit a little more by connecting an Ammeter and a Voltmeter to the output terminals. These instruments will give a visual indication of both the current and voltage output from the variable voltage regulator. A fast-acting fuse can also be incorporated if desired in the design to provide additional short circuit protection as shown.



Disadvantages of the LM317T

One of the main disadvantages of using the LM317T as part of a variable voltage power supply circuit to regulate a voltage is that as much as 2.5 volts is dropped or lost as heat across the regulator. So for example, if the required output voltage is to

be +9 volts, then the input voltage will need to be as much as 12 volts or more if the output voltage is to remain stable under maximum load conditions. This voltage drop across the regulator is called “dropout”. Also due to this dropout voltage some form of heatsinking is required to keep the regulator cool.

Fortunately low dropout variable voltage regulators are available such as the National Semiconductor “LM2941T” Low Dropout variable voltage regulator which has a low dropout voltage of just 0.9 volts at maximum load. This low dropout comes at a cost as this device is only capable of delivering 1.0 amp with a variable voltage output from 5 to 20 volts. However, we can use this device to give an output voltage of about 11.1V, just a little lower than the input voltage.

So to summarise, our bench power supply that we made from an old PC power supply unit in a previous tutorial can be converted to provide a variable voltage power supply by using a LM317T to regulate the voltage. By connecting the input of this device across the +12V yellow output wire of the PSU we can have both fixed +5V, +12V and a variable output voltage ranging from about 2 to 10 volts at a maximum output current of 1.5A.

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- 3. Convert ATX PSU to Bench Supply
- 4. Variable Voltage Power Supply
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- *Jim Burns*

  Excellent information !
  Can I drive multiple LM317 regulators from one DC power source if that DC power source can supply the current with a safety margin? Is any isolation needed between the LM317 inputs?
  Thank You !
  Jim

  Posted on September 26th 2022 | 12:51 am

Reply

- *Wayne Storr*

  Yes you can drive two or more regulators from the same DC power source. There is no particular isolation needed between their inputs.

  Posted on September 26th 2022 | 9:20 am
  Reply

- *James*

  Why does my pot burn up and my lm 317 short out over and over again. Please reply.

  Posted on June 27th 2022 | 7:45 pm
  Reply

  - *Wayne Storr*

    Overcurrent condition, incorrectly connected

    Posted on June 28th 2022 | 6:30 am
    Reply

- *Gary Plasschaert*

  I am looking for circuit for an adjustable AC of about 13 volts at 20 amps. How would I construct the circuit? Thank you

  Posted on May 06th 2022 | 8:00 pm
  Reply

- *User*

  Why do you even need linear voltage regulator, why not just a resistor, in this case the potentiometer?

  Posted on May 06th 2022 | 6:33 pm
  Reply

- *Paul mabeti*

  Please i what to learn about electricity

  Posted on February 06th 2022 | 5:20 pm
  Reply

- *Anirvan Kule*

  How to calculate the heatsink size (length and width) of lm317 according to voltage drop and load current ?

  Posted on February 06th 2022 | 8:06 am
  Reply

- *Michael webster*

  Very interested in teaching my electrical class about soldering, and building power supplies, both constant and variable voltages, from an old ATX supply. And learning safe guarding of persons and equipment.
  All the Best,
  Michael

  Posted on January 02nd 2022 | 4:07 am
  Reply

- *ATS Generators*

  Really helpful blog about Variable Voltage Power Supply.

  Posted on October 16th 2021 | 6:17 am
  Reply

- *Samuel Rasmooh*

  Very educative

  Posted on June 22nd 2021 | 8:07 am

Reply

- *Ogastus*

  If you are looking for a High Current Power Supply circuit made with LM317 read this blog:

  Posted on June 08th 2021 | 8:44 pm
  Reply
- *Fashion2021*

  Thanks

  Posted on May 08th 2021 | 5:00 am
  Reply
- *YAHAYA NAFIU*

  Very nice to me and thanks for your help

  Posted on May 01st 2021 | 12:54 pm
  Reply
- *Janjan dumancas*

  Lerning electronics

  Posted on April 11th 2021 | 8:21 am
  Reply
- *Tom Jackson*

  Hi Everyone, I'm a student of Electronics and collecting information about voltage regulators. Before landing here I came across this article https://www.derf.com/an-overview-on-voltage-regulators/ but didn't understand much as they provided very basic information. Can anyone here provide me any reference where I can learn and read more about voltage regulators.

  Posted on January 21st 2021 | 1:42 am
  Reply
- *D.K Lourembam*

  I assemble one variable voltage regulator of LM317. I supplied 35 d.c. voltage at the input terminal of LM317. After some second R1 (220 Ohms) and R2(10K) are burnt out. Please give the suggestion.

  Posted on November 08th 2020 | 12:43 pm
  Reply
- *Kimberly Carreon*

  Good Day Ma'am/Sir, May I ask about why my variable 12-0-12 V power supply, when turned on, directly proceeds to 30 V? Thank you and God bless

  Posted on October 30th 2020 | 3:31 pm
  Reply
- *Naffas*

  How can I get exactly 12 volts, from a auto mobile which the current variable from 12 v to 14.5 v

  Posted on October 29th 2020 | 1:15 pm
  Reply
    - More
- *Gurmit Singh*

  Proview 14 " monitor led blinking and sound of relay Tripp.

  Posted on September 18th 2020 | 3:34 pm
  Reply
- *Gopalalan Kothile Vala*

  how to add current variability from 0-3 Ampere

Posted on August 22nd 2020 | 7:17 am
Reply

- *YB*

  I am looking for a programmable (vis Arduino) power supply for 0-19V, 2A. Any idea?

  Posted on August 10th 2020 | 7:22 am
  Reply