Handy Dandy Little Circuits

DC Supply

Introduction | Regulators | Other Options

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Introduction

Building a power supply for most electronic projects is not difficult and rather basic in application. The most common and easily available DC supply is the battery. It is ideal for portable systems but, in the long run, constant replacement or recharging can be expensive and time consuming.

For workbench testing and prototypes a power supply unit is more suitable. It should deliver -- under load -- a DC voltage comparable to a battery that is as smooth as possible and with a minimum ripple. All at a reasonable cost. Let's cover the basics without the pains of formulaes but respecting the conventions.

The Transformer

- We select a transformer for (a) Voltage output and (b) Current output required. We must also consider the physical size of the tranformer if we need only a few miliamps of current. Choosing a transformer the size of truck will naturally be much more expensive but will also be bulky, unless of course you want brute force.

- If you need to build a supply for only one system that requires a fixed voltage and current, then choose a transformer that is rated at a voltage slightly above that voltage and rated at approximately 25% above the needed current. If your needs are for a dual polarity supply (+ 0 -) then you will need a center-tapped transformer. The end taps (usually same colour wires) being the total output voltage and the center tap used as the common point or Ground sometimes referred to as zero (0) V.

AC/DC Power Adaptors

- Wall plug-in transformer adapters are a good economical source for transformers. ***Beware***: most are only halfwave rectified but that is no problem if you output into a fullwave bridge. You can find them for little cost at swapmeets, garage sales, surplus stores etc. Some things to look for on the transformer case are voltage, current, and if it's DC or AC, and if it's a positive or negative ground -- usually indicated on the ouside ring of the plug symbol. AC is our first choice.

- When measuring the output voltage with no load applied the voltage will always read as much as 40% higher than its rating. To determine the true voltage and current rating of the unit apply a resistance load at the ouput and measure the voltage.

For example, to find the resistance for a voltage rating of 12VDC @ 300mA. Looking at Ohms Law with , E/I , E=12V, divided by I=.300A = .040k ohms or 40 ohms and the wattage of the resistor should be E X I or 12V X .300A = 3.6Watts. That's the wattage required for a permanent application, but for a fast voltage measurement a one watt resistor could be used.

The Rectifier

- The rectifier diode is simply a one-way conductor. Applied in an AC circuit it will pass only the positive or negative phase of a sine wave. Rectifier diodes are rated for operating voltage and maximum current.

- A rectifier bridge is composed of two or four separate diodes. Its rating is the total of all diode ratings on the bridge. Bridges are useful as they are already internally connected. A full bridge has four connections; two AC inputs and, two rectified voltage outputs marked " + " and " - " .

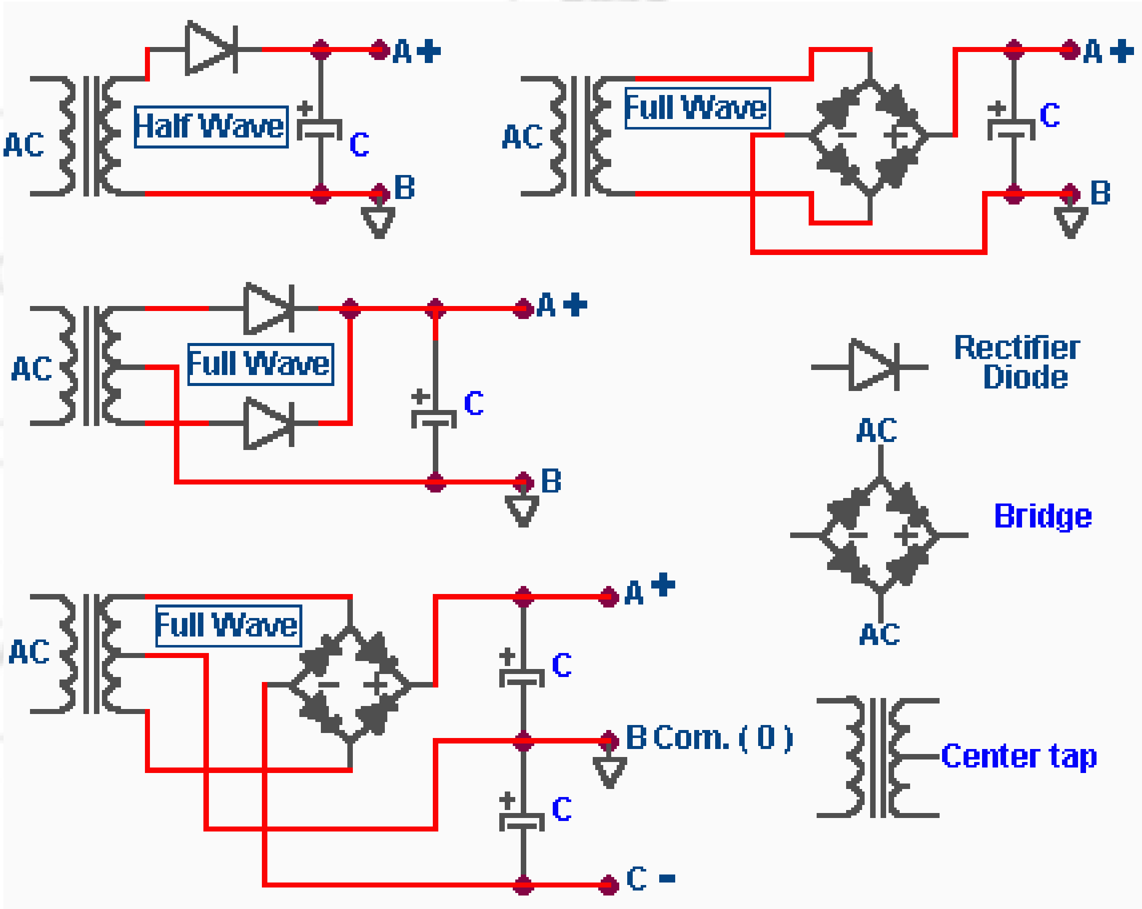
Half wave or Full Wave ?

- Fullwave rectification is where both the positive and negative phases of a sine wave are rectified. Halfwave rectification is where only the positive or the negative phase is being rectified. Halfwave rectification is used where the DC voltage need not be smooth and for economy.

The Filtering Capacitor " C "

- The capacitor is used as the primary filtering element of the rectified voltage and as an added bonus serves as a tank to help maintain a constant voltage level as the load demands. For production units the value of " C " is usually calculated by the design engineer to meet the minimum demand and costs necessary for function requirements. I have my own formula *make them as large as you can fit them in* capacitance wise and double the voltage of the rectified output. If the capacitor is too large to fit you may use several smaller ones connected in parallel, the total capacitance will be the sum of each element's capacitance rating.

NOTE: I've found that with a variable supply hooked to a very large capacitor, adjusting the voltage without a load may be slow and lagging. This can be overcome by adding a 1K resistor across the output as a permanent load. This technique is also useful in maintaining good regulation under a light load.



On the next page we review the application of regulators.

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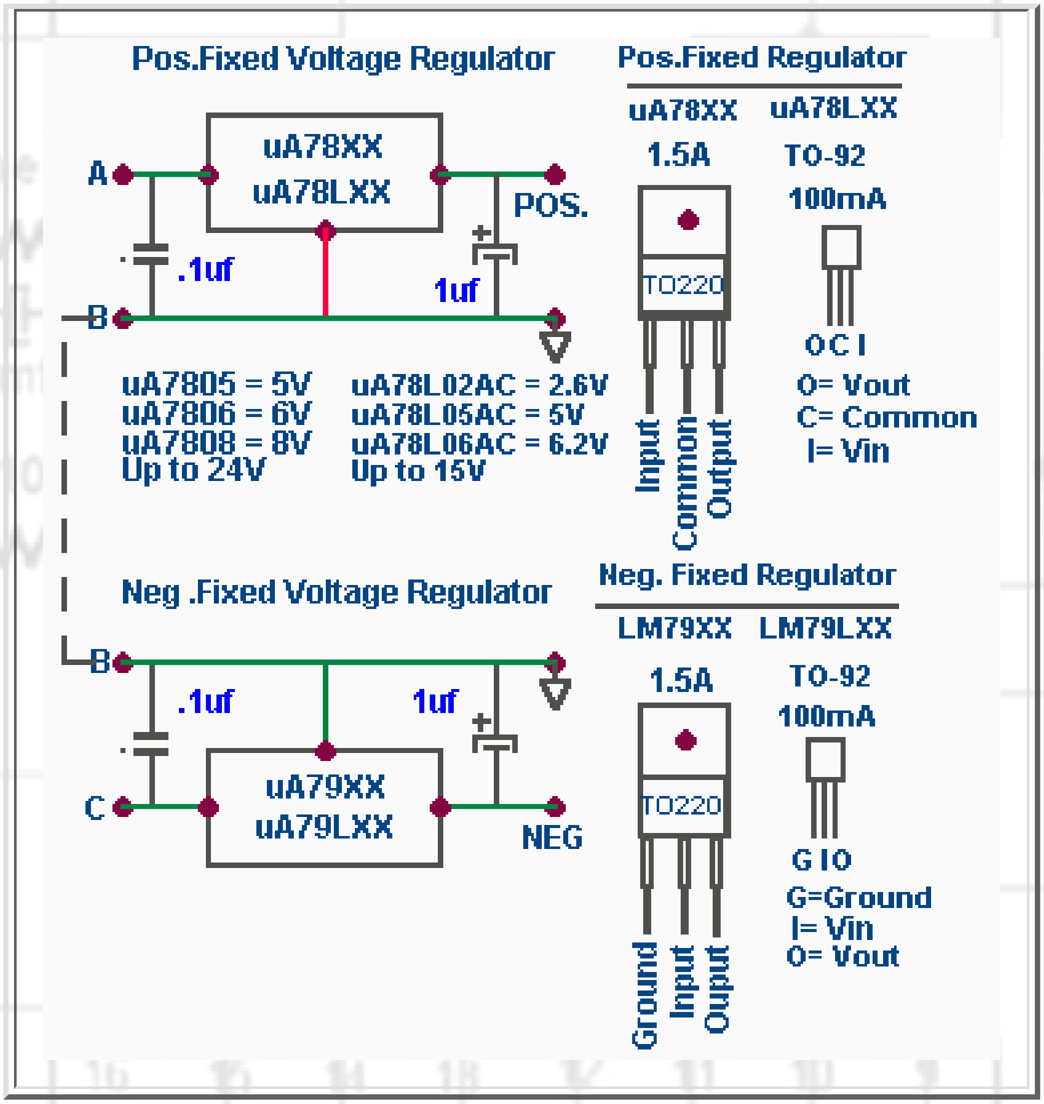
Fixed Regulators

- Regulators have been around for some time. No more fussing around with complicated circuits as you can see from the following simple circuit layouts. For the TO220 case you must use a suitable heatsink as quite a bit of heat must be dissipated. On the other hand, the smaller TO92 case is limited to 100mA. The T092 is very handy for onboard applications where voltage regulation is needed to prevent voltage depletion in smaller circuits. In this case an anticipated battery-voltage drop would affect the proper operation of oscillators, references, and other critical requirements.The (TO92) small regulators can also used for and is an ideal choice for an adjustable voltage reference with a ten-turn trim potentiometer.

- For connections reference you may wish to open up a new window.

The following drawing shows how the whole circuit should be assembled. For a dual polarity supply the negative regulator connection to ground (common) is shown with a broken line. Please note the positive end of the capacitor in the negative regulator is tied to ground as positive with respect to the negative output.

If the regulator is to be connected close to the rectifier the .1uf capacitor at the input of the regulator may be omitted. An important point worth mentioning is that the regulator needs a 1.5V headroom to regulate at a specific voltage. For example if we need 12V regulated then the input supply must be at the very least 13.5V. 14V or more would be recommended for good regulation.

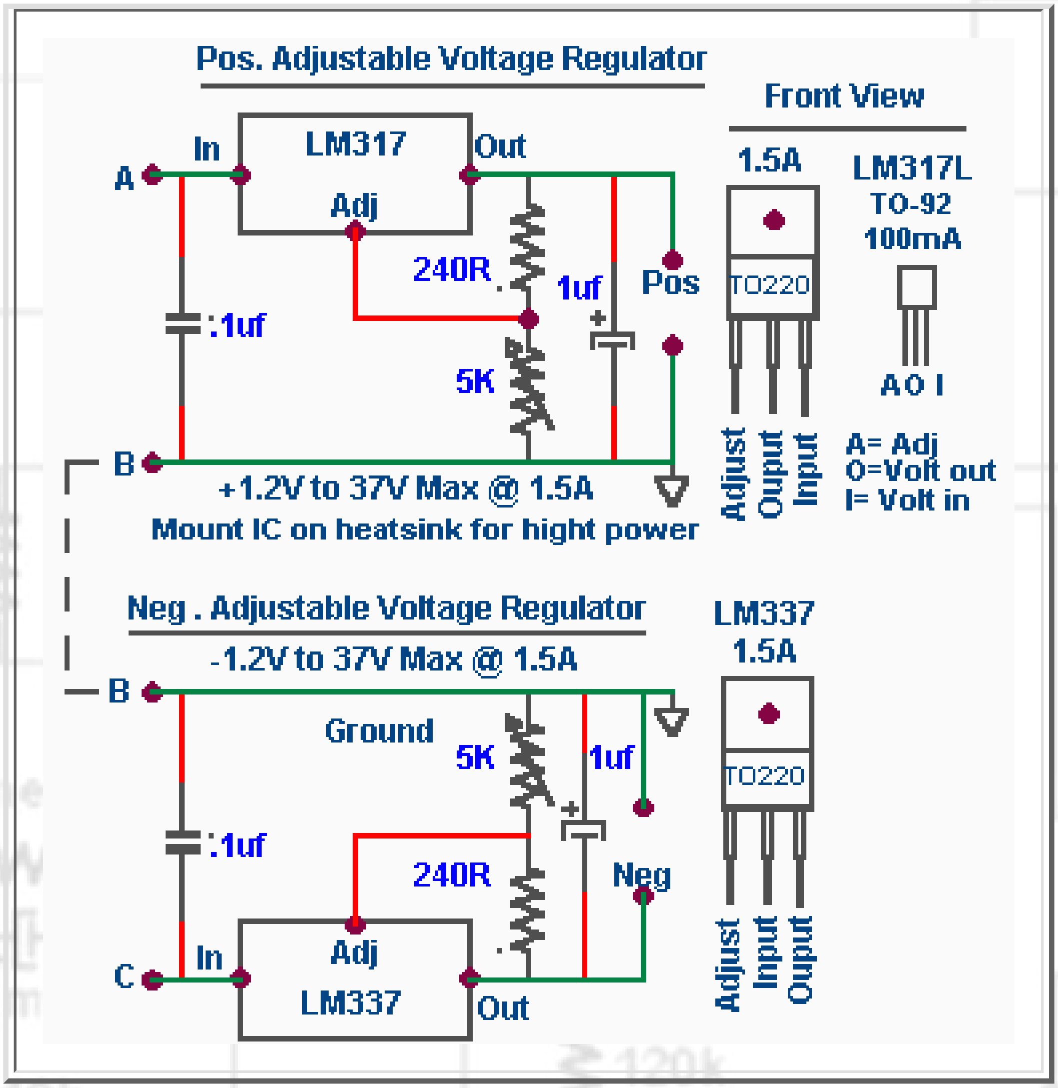


Adjustable Regulators

● Adjustable regulators are physically the same in appearance as fixed regulators. Precautions in their use and application are identical to the fixed regulator.

Make note of the pin connection differences as shown in the following diagram.

The circuit is not a perfectly adjustable regulator in that the minimum voltage is rectricted to 1.2V and adjustable to a maximum of 37V at its rated load with proper heatsink. The values shown for the resistors are those recommended for proper operation. Resistors 240R should be 1/2 watt resistors.



Dual tracking regulator

- A dual power supply is shown above using two separate 5K potentiometers or a dual 5K potentiometer can be used for a dual tracking power supply. The advantage of using the potentiometers for adjustment is that maximum voltage allowed by the regulators can be used but while using dual potentiometer for a tracking supply , precision may not be accurate. Good tracking voltage can only be obtained if the dual potentiometer is well matched and such a unit can be very expensive.

The circuit below will give you accuracy and precision tracking within a few milivolts but at the sacrifice of voltage limitation as dictated by the op-amp maximum permissible supply voltage which should be no more than plus and minus 15 volts input voltage for a regulated output voltage of 1.250 volts to approximately 13.4 volts at a maximum current of 1.5 amps .

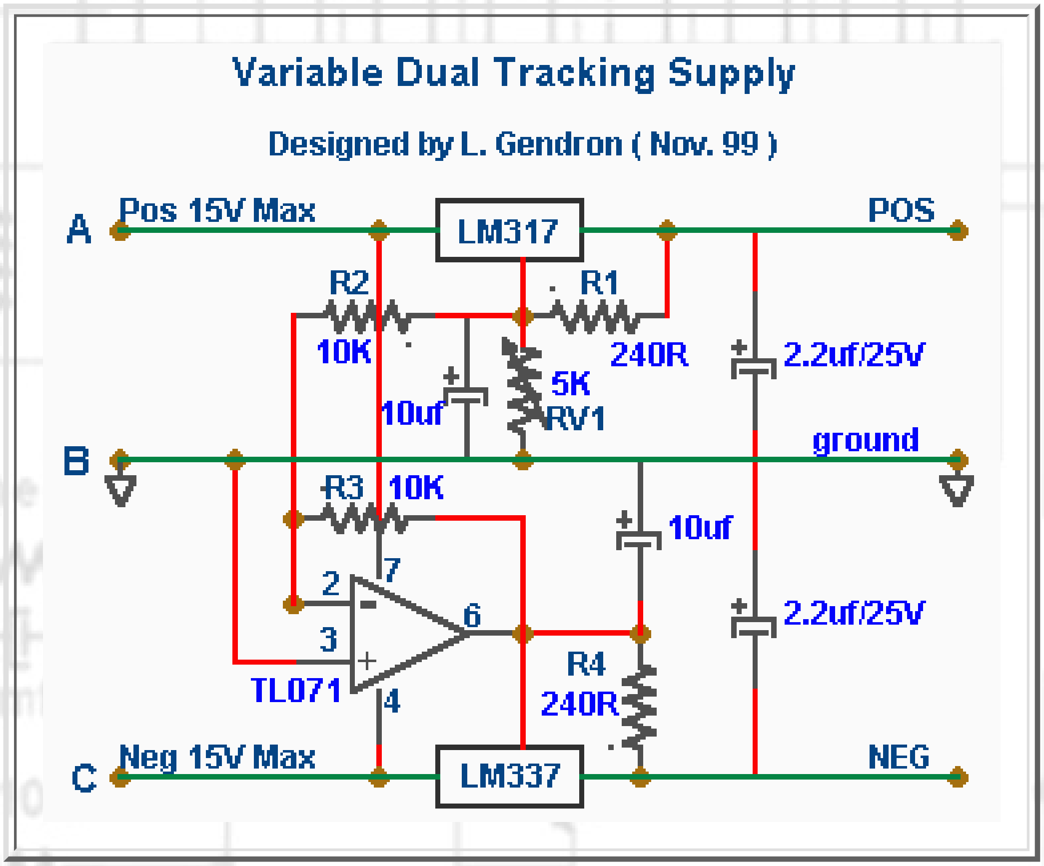
To obtain such precision matched resistors should be used and the op-amp must have a very low offset current , the TL071 a FET type meets this requirement and works very well . You must also insure that the regulators used are of the same manufactured brand.

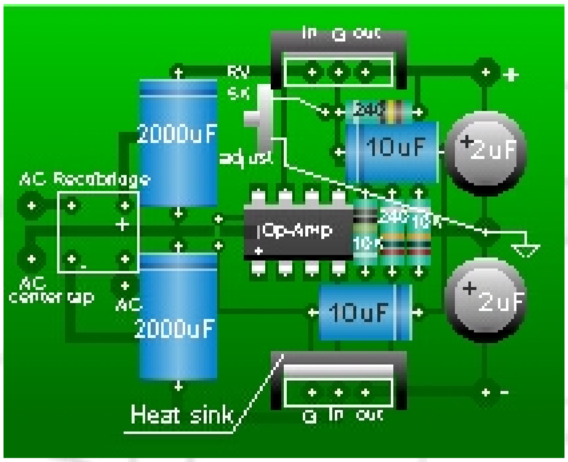
The Circuit

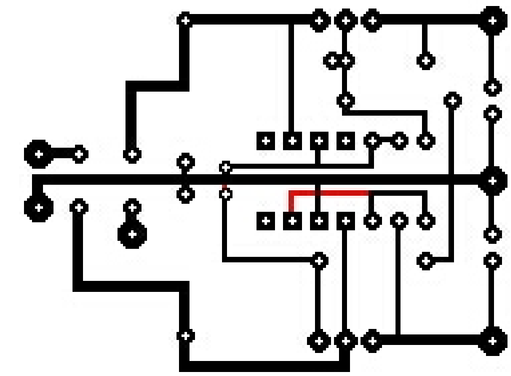
The positive side of the circuit is adjusted with RV1 in the conventional way. From the junction of RV1 and R1 to the LM317 the positive reference voltage is applied to pin 2 input of the op-amp through the 10K resistor and the inverted output reference from pin 6 is applied to the control pin of the LM337. Pin 3 is connected to ground reference zero . If the op-amp used does not have a zero offset current it will be reflected in difference of the inverted reference voltage applied to the negative regulator as compared to the positive reference applied to the positive regulator and the error will be reflected at the negative regulated output.

Other op-amps can be used such as OP-08, TL084, LF356 or similar. Op-amps like the 741 , 301, can also be used but the offset has to be manually adjusted with the use of a 10K miniature potentiometer connected between pins 1 and 5 in the case of the 741 and the negative ouput reference matched to the positive one by adjusting the 10K pot.

Note that the op-amp supply source is taken from the +/- input voltage, this is necessary to obtain the negative voltage reference. The 10uf capacitors are used to increase ripple filtering under heavy load . The 2.2uf capacitors used at the output must be solid tantalum types for best result. Resistors R1,R4 should be 1/2 watt resistors all others can be 1/4 watt .







The total operating current of the circuit is less than 30mA . With proper care of assembly with heatsinks and choice of components, tracking and regulation should be within + or - .5%.

On the next page we'll look at other options.

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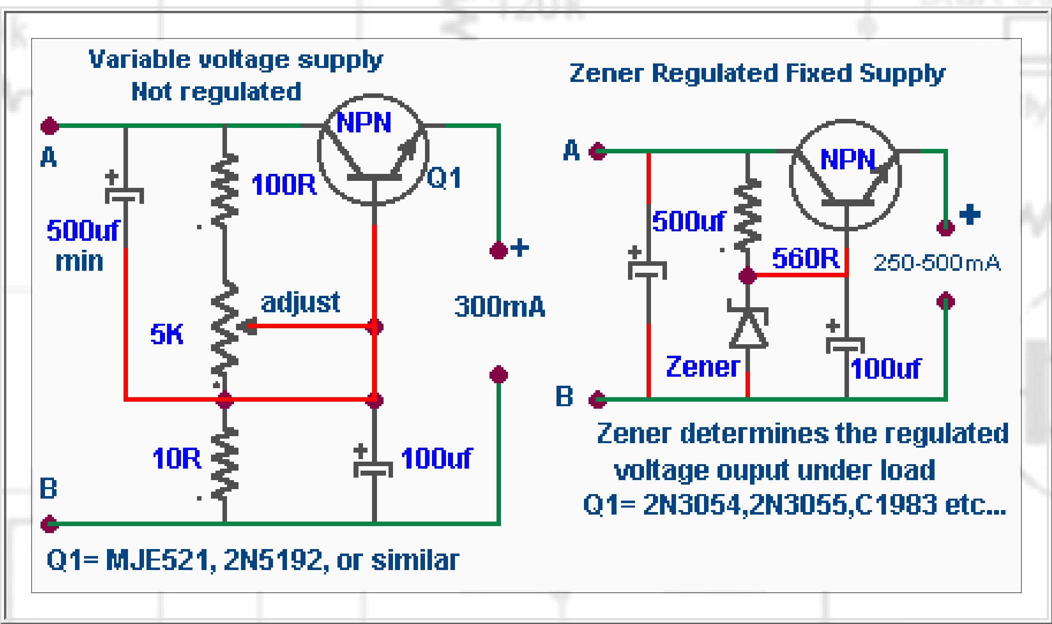
Other Options

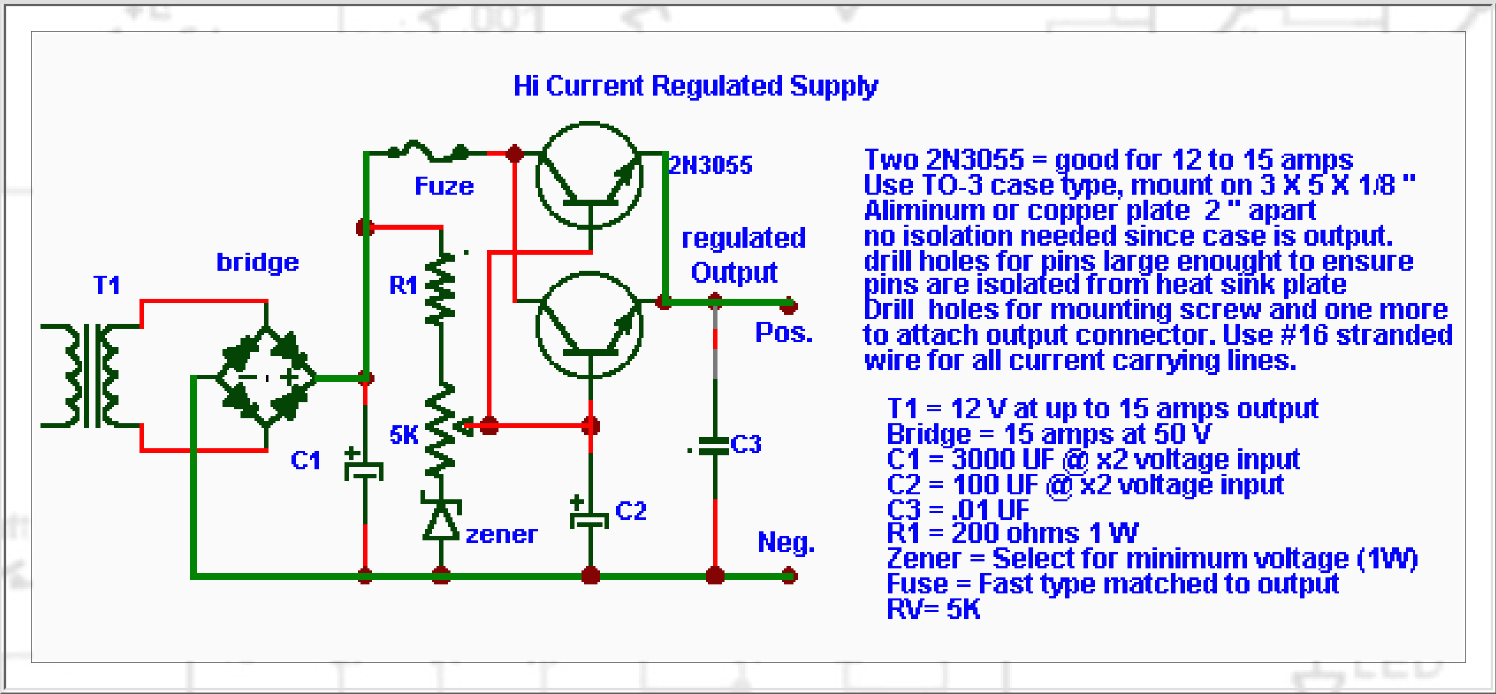
Before the present family of three-pin IC regulators you had a choice of a few regulators on the market which included the notorious LM723 , a versatile but rather unfriendly IC. There are all kinds of applications, some very complicated and others very simple when using the power transistor as a variable resistor controlled by a low power NPN or PNP transistor reference.

- The following two designs are very basic voltage supply controls for a bench supply. The first is a simple variable voltage control that allows you to change voltage from 0V to its maximum. It's easy to build. Choose a power transistor and use a heat sink.

The next circuit is a regulated fixed supply using a zener diode and resistor as the regulating elements connected to the base of the transistor as shown .

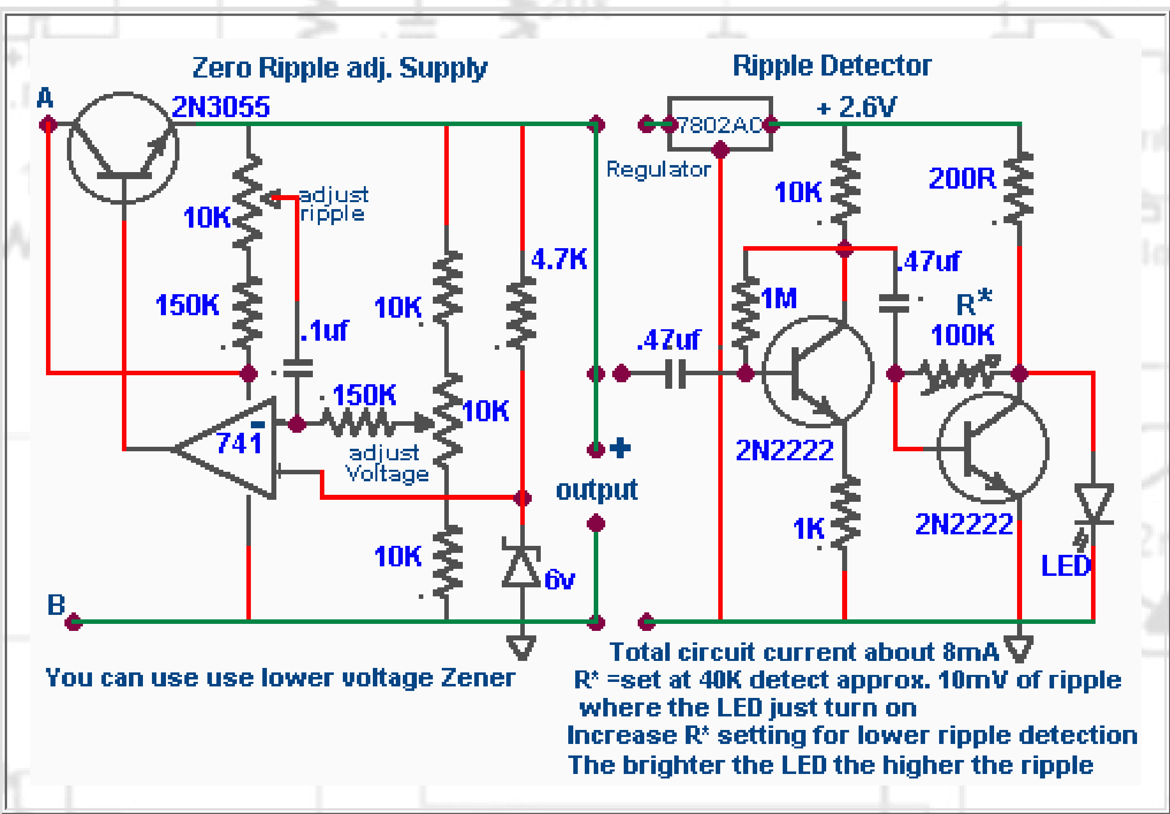


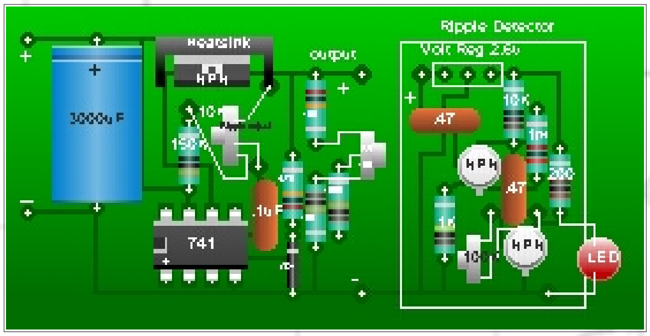
- The circuit shown below is a combination of an adjustable resistance with a Zener diode which will enable adjustment of a regulated voltage , note that you will not be able to lower the voltage below the zener's voltage value. This type of regulation will allow you to use higher current output than a single regulator IC as described previously which is limited to 1.5A. For still higher current output an additional identical transistor can be connected in parallel.

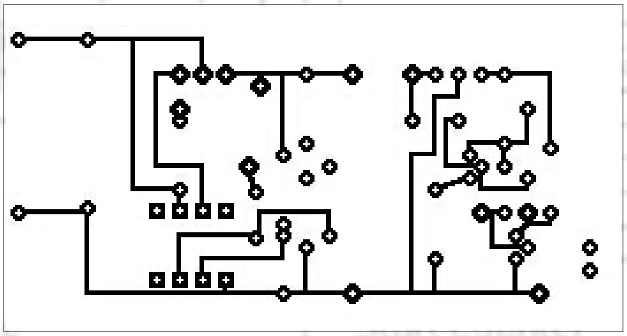


The next circuit is an adjustable regulated supply circuit which incorporates a control to reduce the ripple to a minimum. It is important to remember that the ***input voltage may not be more than the IC recommended maximum voltage .***

Normally, to adjust the ripple it would be necessary to be able to monitor it with an oscilloscope. But if you don't have a scope then you might want to check out a small circuit I've designed that will monitor the ripple voltage continuously. And then it's a simple matter to add another control on the cabinet so that while observing the LED when the supply is under load, adjustments can be made to control ripple. The ripple detector voltage supply is regulated at 2.6V and will remain stable at all voltage levels above 4V of the transistor ouput.





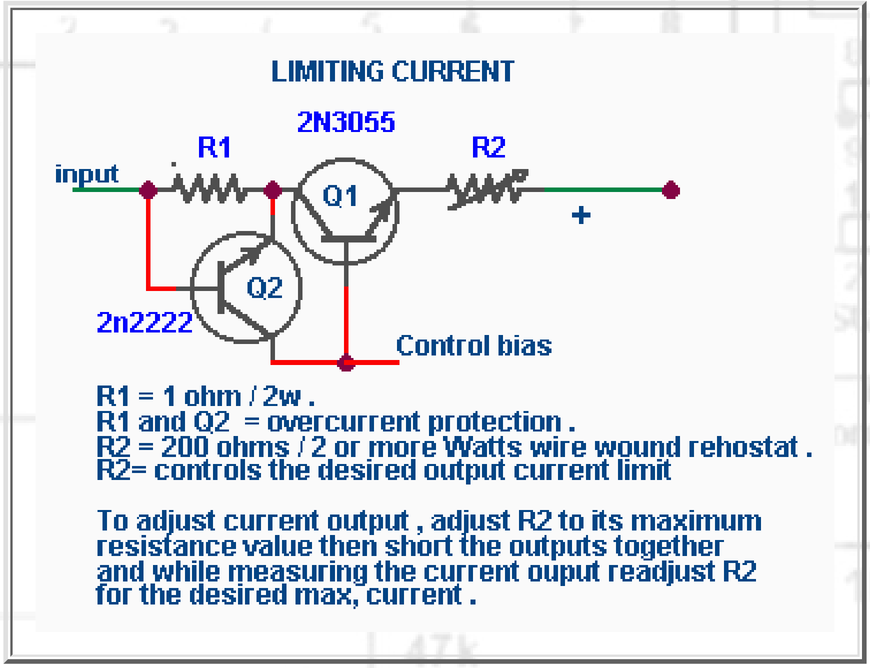


Controlling Current

The simplest way of controlling current is to insert a high wattage resistance in series with the output transistor. A variable rehostat (R2) is very handy for adjusting the maximum current delivered to a circuit. It can be used to check for shorts and excessive current caused by errors or malfuntions as well as prevent damage to the circuit being tested. In the trade it's called a "Smoke Test".

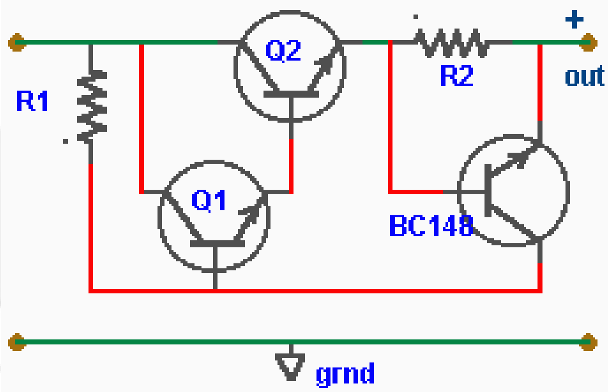
In case of accidental shorting of the ouputs an overcurrent protection provided by R1 and Q2, as shown in the circuit, can be used . Since R1 is in series with the Q1, the voltage across it is proportional to the output current. This voltage is used to drive Q2 so that the larger the output current becomes, the more Q2 turns on. When Q2 comes on the base drive is reduced or removed from Q1 regulation, limiting the output current. For more current output R1 can be reduced . By experimenting with your supply output current you can adjust the resistance value of R1 to achieve your requirements.

The advantage of adding R2 makes the supply more versatile as it can also be used for battery charging. This is done by setting both voltage and current levels required for a particular battery charging rate so that by monitoring the current you can see the state of the battery's condition. As the battery charges the current demand decreases to zero showing that the battery is fully charged.



There are other ways to protect your power supply ? The next two circuits are electronic fuses or rather current fold back circuits which when connected in series with your power supply will shut down your supply system when any excessive current or short circuit is detected.

Electronic Fuse

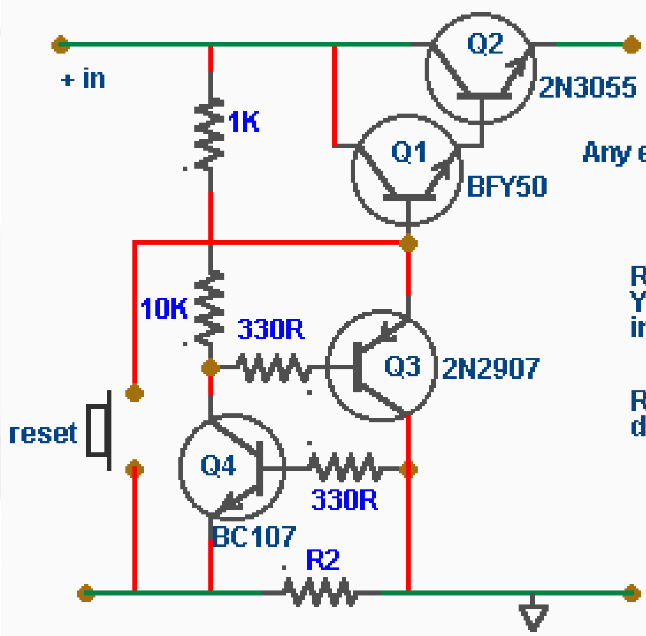


I max	R1	R2	Q1	Q2
5.0A	100R	0.1R	BFY50	2N3055
0.5A	1K	1.0R	BC107	BFY50
0.1A	4.7k	3.7R	BC107	BFY50

The above are suitable for voltage up tp 45 volts.

To reset shuft off and remove load or short

A better Electronic Fuse



Any equivalent transistors can be used.

R2 = Current sensing resistance
You can use the same values listed
in the other circuit for Max current

Reset = When reset is on it removes
drives from Q3,Q4 and reduce voltage to zero

When you have completed your power supply and everything appears to be functioning properly you most likely would like to monitor your voltage and current and possibly add the current limiting rehostat R2 control. Before choosing an enclosure to install your circuit you should get acquainted with the section on **Metering a Power Supply**.

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