Ever wish you could put together a simple reliable useful power supply from junk or surplus parts? Clay Ellis offers you just such a one-evening project!

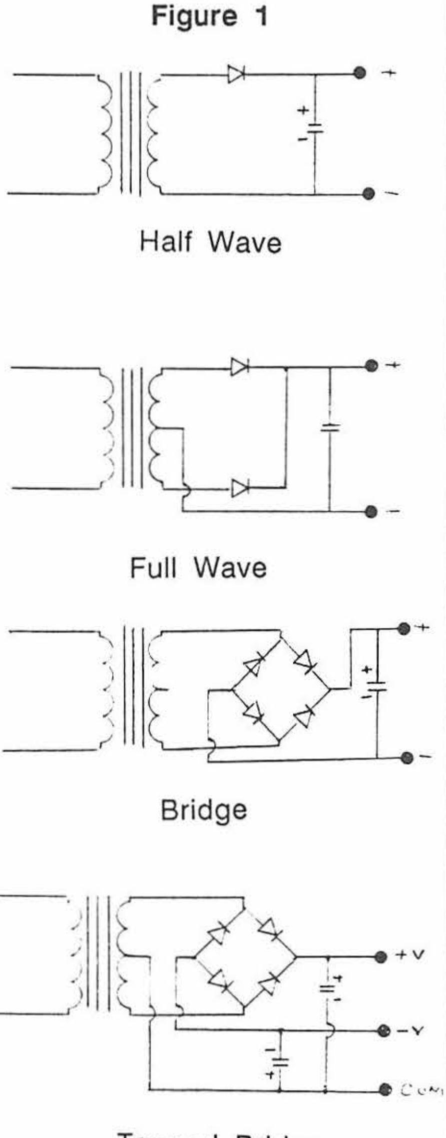
QUICK POWER

by C.W. Ellis

How many times have you looked over the construction plans for a project only to discover that you didn't have the parts for the power supply? Or perhaps you just finished your own breadboard for a new circuit, checked it all out with a bench supply, and now you need to build a supply to finish the design.

What follows here is a quick review of the various common power supply circuits and regulators, along with the information on getting the output you need with the parts on hand. As we go along, I'll try to point out some pitfalls and fine points that can make the difference between power and fire.

Figure 1



Developing the DC

Figure 1 shows the various rectifier circuits most commonly used in low power supplies. The half-wave circuit at the top is the simplest and lowest cost rectifier circuit compared to the remaining three. This circuit's only advantage is that it uses but one diode. Its shortcomings are many; high ripple voltage, large no load to full load variation in output, and inefficient use of the transformer.

It is used to power circuits such as indicator lights, relays and other devices that do not require regulation. The no load output voltage is approximately .7X the transformer output voltage, and rated transformer current can be drawn from the supply.

The second rectifier circuit uses one more diode and requires a center tapped transformer it is called a full wave rectifier. The full wave rectifier uses both halves of the AC cycle and supplies current to the capacitor all the time whereas the half wave rectifier uses only one half of the cycle. The full wave circuit produces lower ripple voltage and efficiency is much improved over the half-wave.

The third circuit is the bridge rectifier. Ripple and efficiency is equal to a full wave circuit. The bridge circuit produces output voltage approximately 1.4X the transformer output and .7X rated transformer current can be drawn.

Rule 1: For a given transformer secondary, (assuming a center tapped transformer) a full-wave circuit gives half the dc output of a bridge circuit.

This means we can vary the dc output of a given circuit by choice of rectifier circuit. Which gives us rule 2.

Rule 2: When buying, salvaging, or winding transformers, those with center tapped windings are more useful as they allow both full-wave and bridge circuit use.

Another use of the bridge circuit is illustrated by the last drawing of figure 1. This circuit produces two outputs, each equal to a full-wave circuit but of opposite polarity. A close look reveals the bridge circuit is made up of two full-wave circuits sharing the same transformer winding, but with the diodes in one circuit reversed to give a negative output.

There are other circuit configurations, which we shall touch on later, but for now we can sum up thus: a center tapped transformer can be utilized in any of three ways to vary the dc output voltage according to need.

Regulating the DC

With any power supply ripple will be lowest and voltage highest under a no load condition. As load is increased ripple will increase and voltage decrease (not a good thing for a power supply to do). To eliminate the problem we will use a device called a regulator.

For our purposes we will concentrate on devices called "three terminal regulators". These are integrated circuit devices (IC's) which are quite easy to use. Workhorse of the three terminal regulators is the LM309, a 5 volt 1 amp device. Figure 2 illustrates how most three terminal regulators are wired.

The capacitor on the input of the regulator is normally the same capacitor shown on the output of the rectifier circuits in figure 1, unless the regulator is placed physically some distance away from the rectifier circuit. A second capacitor is placed across the regulator input if this is the case.

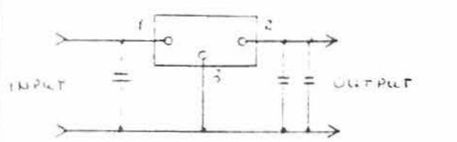
Many circuits use only one capacitor on the regulator output, usually from 10 to 100 mfd., to improve response to changes in load. It is a common practice to parallel this capacitor with a small (.01 mfd.) ceramic capacitor for noise reduction and transient response.

Figure 2, bottom drawing shows the same circuit in a variable supply. The most common regulator IC for this circuit is the LM317. Both ICs process the raw DC with very little ripple and noise.

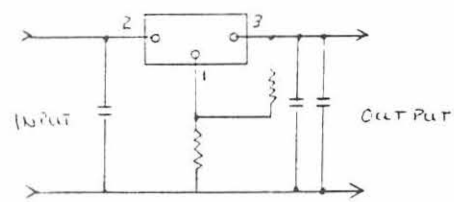
When using regulator ICs bear the following in mind.

1. Use as big a heatsink as practical for the regulator IC.
2. Use thermal conductive "heatsink compound" when mounting regulator ICs.
3. At maximum load, the raw DC input to the regulator must remain at least

Figure 2

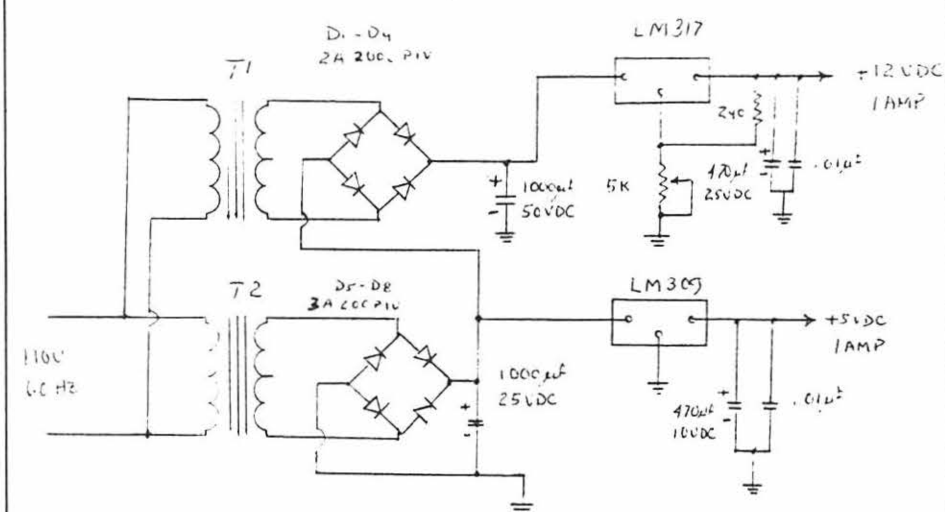


Fixed Output



Variable Output

Figure 3



Stacked Supply

three volts above the rated output voltage.

4. Raw DC input greater than the 3 volt + rated output only contributes heat and does nothing for regulation.

Actual supplies

Figure 3 shows a dual power supply capable of putting out five and twelve volts, it also illustrates the concept of stacked supplies. The raw DC for the LM317 is stacked on the raw DC that feeds the LM309.

This is a legal design and works as follows: Transformer T2 is chosen with an 8 volt ac output; which gives about 11 volts of dc to feed the LM309. T1 is identical to T2, and the rectifier output is again 11 volts dc. However, the minus or return side is connected to the + 11 volts of T2's bridge, and adds to it to give 22 volts at the input of the LM317.

Stacking voltages are useful in situations such as when a 16 volt transformer for the LM317 can not be found. In like manner, the ground terminal on a three terminal regulator can be returned to a dc voltage instead of ground to achieve a higher output voltage. When an IC regulator is stacked on another dc voltage, that voltage should be a regulated voltage, not a raw dc rectifier voltage.

Rule 3: When stacking voltages, remember that the bottom voltage in the stack must handle not only the current for its load, but the current for the load of the supply above it.

TRANSFORMER SELECTION			
DC OUT	RECTIFIER	TRANS VOLTS	TRANS AMPS
.7X TR	FULL	DC/.7	1.3 X DC
1.4 X TR	BRIDGE	DC/1.4	1.8 X DC

REGULATOR SELECTION				
VOLTS REQD.	RAW DC INPUT	DC AMPS REQD.	+REGULATOR	-REGULATOR
5	+8-15	1	LM309	
5	+8-15	1.5	LM340-5	LM320-5
12	16-30	1.5	LM340-12	LM320-12
15	19-35	1.5	LM340-15	LM320-15
5	9-15	3	LM323	LM345
2-30	5-35	1.5	LM317	LM337
2-30	5-35	3	LM350	
2-30	5-35	5	LM338	

What this means in terms of Figure 3 is that the transformer T2 and its bridge circuit must be capable of 2 amps, as it will supply 1 amp for the LM309 and 1 amp for the LM317. If regulator ICs are stacked, the bottom regulator will also have to supply current for its load and current for the regulator above it.

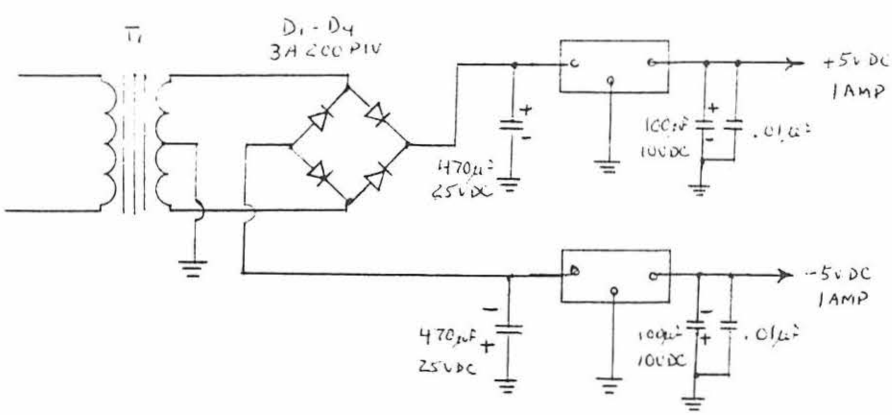
Transformer currents

Now that we know how to develop the voltage desired, we must figure the current ratings of the components. *Most* construction projects power needs can be handled by a supply of 1 to 5 amp capacity. At the end of the article is a chart describing various regulators for building fixed and variable supplies in the 1 to 5 amp range. See above chart for how you can determine the size of the transformer for a given current.

Hints and kinks

If your power supply doesn't regulate at high loads check to the input of the regulator to be certain the input voltage is a minimum of 3 volts above the rated output. If it lacks only a volt or so, try adding a 200mfd. capacitor to the regulator input. This will some-

Figure 4



Dual Supply

times raise the input voltage enough to get by at maximum load. Don't get carried away adding capacitance tho-- see next hint.

If the fuse in the primary (you did include one, didn't you?) tends to blow on turn on, the input capacitance to the regulator may be too big. Try a slo-blow fuse. Do not exceed three times the transformer volt/amp rating with a standard fuse, or 1.5 times the volt/amp rating with a slo-blow.

If the regulator runs hot at rated load, increase the heatsink size, or reduce the input voltage to the regulator but not below 3 volts greater than the rated output. Sometimes both may be required.

For convenience, use diode bridge packages instead of individual diodes. Diode current ratings should be three or more times the regulator current rating. Diode voltage ratings should be 200 PIV or more for any supply in the 2 to 30 volt range.

Use Tantalum capacitors where long life is important, or where low ripple and noise are desired.

Zener circuits

Quick power would not be complete without the mention of Zener regulator circuits. Figure 5 illustrates simple zener circuits for both positive and negative voltages.

Zeners shine in places where a voltage different that the main supply voltage are needed at low currents. Perhaps a bias voltage is required, or one TTL chip must be added to a circuit and +5 volts is not available. In such cases a zener circuit takes little space and is easy to design.

The zener itself is selected to give the desired voltage, and a dropping resistor is used to limit current. Simple Ohms law calculations supply the resistor size There are two voltages involved, and one current. Vbulk is the supply voltage which will supply the zener and will always be higher than Vzener, which is the output voltage. There is a minimum zener current, which is the zener current at full output load, and maximum zener current which occurs at no load conditions.

The calculations are as follows:

1) Subtract the zener (output) voltage from the bulk voltage. This is the voltage across the resistor.
2) Determine maximum current the load will draw.
3) Add 20% to this current. This is maximum zener current.
4) Multiply maximum zener current by rated zener voltage. This is the size of the zener in watts. Use the next higher zener size if it falls between standard sizes.
5) Determine resistor value by dividing the resistor voltage from step 1 by the zener current of step 2.
6) Determine resistor wattage by multiplying resistor voltage from step by zener current of step 3. Use next higher standard value.

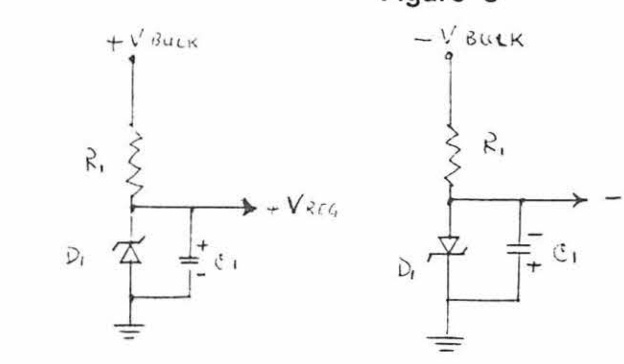
For example: We have a 12 volt supply in an instrument to which we want to add a circuit requiring 8 volts at 30 milliamps (.030 amps).

1) 12v - 8v = 4 volts, the resistor voltage.
2) Already stated - .030 amps load.
3) 120% of .030 = .036 amps, max load.
4) 8v x .036 amps = .288 watts or 288 milliwatts. A 500 milliwatt zener is needed.
5) 4 volts divided by .036 amps = 111 ohms. A standard 110 ohm resistor will work fine.
6) 4 volts X .036 amp = .144 watt, use a 1/4 watt resistor.

Wire the resistor and zener as shown in figure 5, and bypass it with a 1 mfd. capacitor, and you have an 8 volt regulated supply at 30 milliamp capacity for your added circuit. Zeners come in many sizes and wattages, from 1/4 watt to 50 watts, and from 2 volts through several hundred volts. Regulation is almost as good as the IC regulators in many cases, and cost and complexity is much less.

Should you have any questions concerning this article, I will endeavor to answer them directly provided your letter is accompanied by an SASE -- More power to you! mt

Figure 5



Zener Regulators