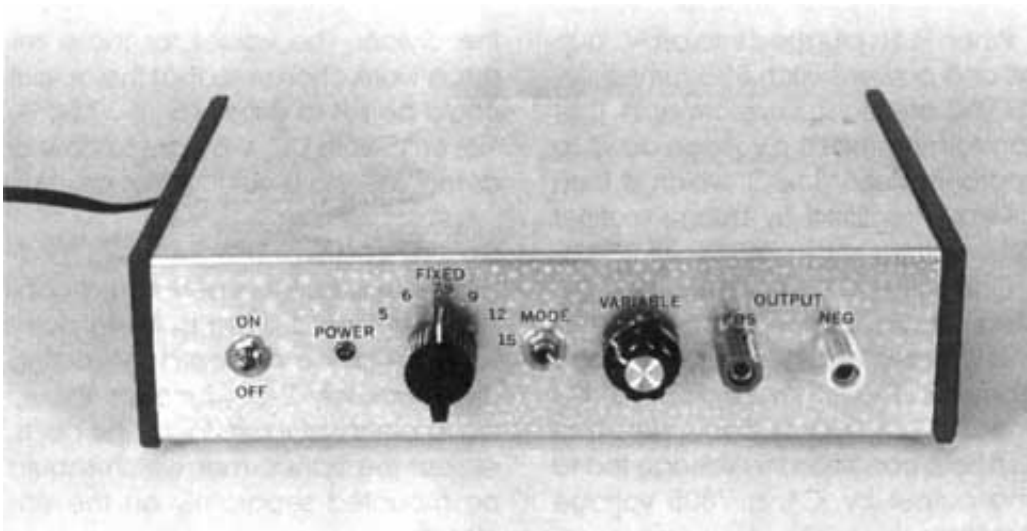


Universal Power Supply

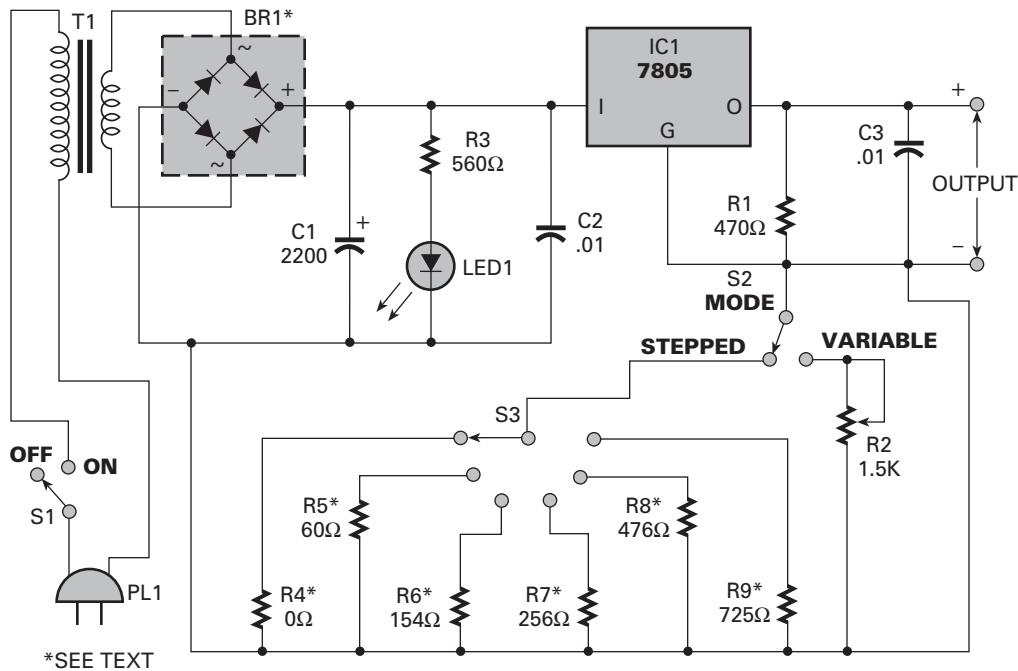


It's an inexpensive and useful addition to any hobbyist's workbench.

BY MARC SPIWAK

Any project that you ever decide to build is going to need a power supply—any electronic project, that is. So once you have decided on a particular circuit design, the biggest concern is what sort of power supply it needs. Power can come from many sources, including batteries, AC adapters, and bench-top supplies. For that reason, you can never have too many power supplies on the test bench. With

every circuit requiring at least one operating voltage, and some needing more than just one voltage, you can understand the truth of that statement. Batteries are perhaps the easiest form of power to use, but constantly buying batteries can end up sucking your wallet dry after a while. Clearly an AC adapter is a more economical method of delivering power, and perfectly suitable for a project as long



*SEE TEXT

Fig. 1. The Universal Power Supply circuit has an output that can be varied by potentiometer R2 or switched to specific levels by rotary switch S3.

as portability is not a priority. The main problem with AC adapters is that, with the wide range of necessary operating voltages, all those adapters can clutter up the test bench. Also, many inexpensive AC adapters simply can't supply enough current for some circuits. What's really needed is a variable-output, AC-line derived, bench-top power supply. But most hobbyists know that commercial units of that type can get expensive. Why should power supplies cost so much? After all, there's really nothing exotic inside most of them. The internal transformer is usually the most expensive component and that is reasonably priced. So I decided to save some money and build the *Universal Power Supply* described in this article. When planning the project, I decided that its two main duties would be to replace a drawer full of AC adapters, and to also be a useful supply for my test bench. With low cost being a paramount concern, I decided to use as many junk-box components as possible. The only part I purchased was a rotary switch from Radio Shack, and that costs less than two dollars.

Circuit Description

Figure 1 shows the schematic diagram for the Universal Power Supply. The simple circuit outputs a variety of voltages (customized by you), and it can output up

to one ampere of current—that's a lot more than most AC adapters. The supply outputs between 5- and 15-volts DC. When PL1 is plugged into an AC outlet, and power-switch S1 is turned on, 117-volts AC are fed to transformer T1. That transformer steps the voltage down to approximately 18-volts AC, which is then rectified by full-wave, bridge

rectifier BR1. Capacitor C1 smoothes any rippling caused by the rectifier, and stores a charge for the voltage regulator. The other capacitors, C2 and C3, are bypass capacitors that also help condition the voltage fed to and output by IC1, a 7805 voltage regulator. In most circuits containing them, 7805 regulators are used to output a fixed 5 volts. However, in the configuration shown, the regulator's output can be varied between about 5 and 17 volts (although, as mentioned, 15 volts is set as the maximum). Here's how the configuration works: An input voltage higher than 5 volts is applied to the input pin of a 7805 regulator, Pin 2 (G) of the device is normally grounded and it will then regulate the output at pin 3 (O) to 5 volts higher than the potential at pin 2 (normally 0 volts, or ground potential). But if pin 2 is held at some voltage above or below ground, the output voltage will equal the potential at pin 2 plus 5 volts. In this circuit, the voltage at pin 2 of the regulator is maintained by a voltage divider made of R1 and either potentiometer R2 or one resistor selected from R4 through R9. Each of those latter six resistors sets the output to a specific voltage level, while potentiometer R2 allows for a fully variable output. Assume for the moment that switch S2 is set so that potentiometer R2 is part of the voltage

divider, While IC1 tries to maintain exactly 5 volts at its output, the voltage at pin 2 can be varied by changing the resistance of the bottom half of the divider, Therefore, the output voltage is always 5-volts plus the voltage at the divider junction. As IC1's output voltage increases, so does the voltage at the divider junction, which then increases the output voltage, and so on, and so on, until it „runs out% of input voltage. That is how the 7805 regulator is made to have a variable output. When switch S2 is set so that it connects pin 2 of the regulator to rotary switch S3, one of resistors R4 through R9 then becomes the bottom half of the divider. The values for those resistors were chosen so that the output could be set to exactly 5-, 6-, 7.5-, 9-, 12-, or 15-volts DC. We'll get to how to determine those values later on.

Construction

The author's prototype was built on perforated construction board using point-to-point wiring. A piece of board measuring approximately 2 by 4 inches should leave plenty of room for all the parts, except the transformer, which should be mounted separately on the enclosure. To determine where you will position the circuit board in your project enclosure, begin by mounting transformer T1, which is a ordinary 120- to 12- volts AC, 1-ampere, 60-Hertz model. Connect a power cord and plug to the transformer. Then wire switch S1 into the circuit. Next, begin mounting the on-board components, starting with the bridge rectifier. You can use a regular bridge rectifier or four discrete diodes as

mentioned in the Parts List. Next, install capacitor C1, the 2200- μ F unit. Because C1,s purpose is to smooth the DC voltage ripples from the bridge rectifier, any large-value (1000- μ F or higher) electrolytic capacitor can be used. Go on to install capacitors C2 and C3, resistors R1 and R3, and LED1. Continue with assembly by mounting the voltage regulator. Connect a heatsink to the regulator to prevent it from overheating when it is outputting more than just a few-hundred milliamps, If you are using a metal case, a wall of the case can serve as a heatsink for the regulator if you mount the regulator on the edge of the board and mount the board up against the wall of the case after assembly is complete. Connect potentiometer R2 and switch S2 off-board. The output voltage from the circuit should be connected to a pair of binding posts. You can use leads or banana plugs to connect the Power Supply to other circuits, or you can build a custom cable that will be described later on. Before you can install fixed-resistors R4-R9, you will have to determine what values will work best for your circuit. Because of component tolerances and other factors, the values will probably be different than the ones in the prototype, even if you use similar parts. Set S2 to VARIABLE, Plug the circuit in, and turn on S1. Connect a DMM to the binding posts, and adjust R2 to make sure that the output voltage varies. Next, determine what fixed voltages you would like your power supply to output, and then write them down (you might want to use the ones mentioned earlier). Adjust R2 to get the first voltage on your list at your output terminals. Then switch

Table 1

Desired Output	Measured R2 Resistance	Fixed Resistor Used
5 volts	0 ohms	wire jumper
6 volts	60 ohms	56 + 4.7 ohms
7.5 volts	154 ohms	150 + 3.9 ohms
9 volts	256 ohms	220 + 18 + 18 ohms
12 volts	476 ohms	470+ 5.6 ohms
15 volts	725 ohms	680+ 47 ohms

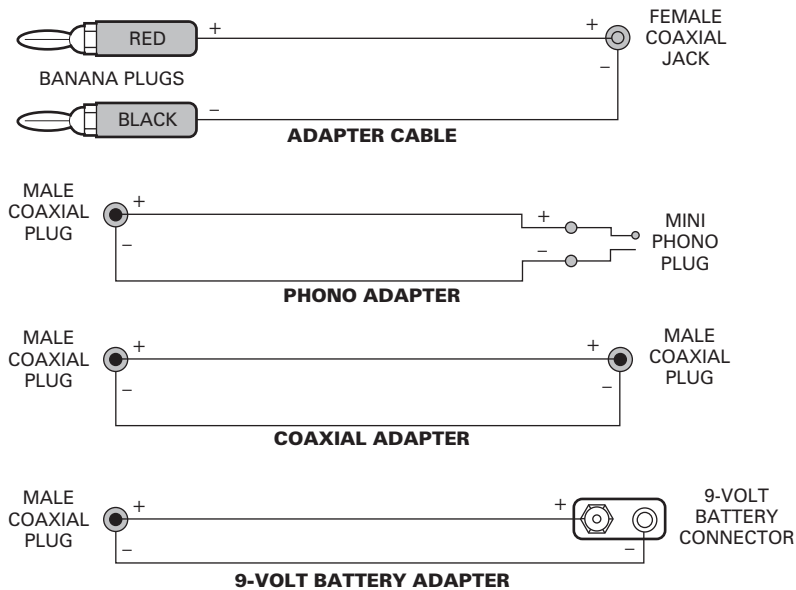
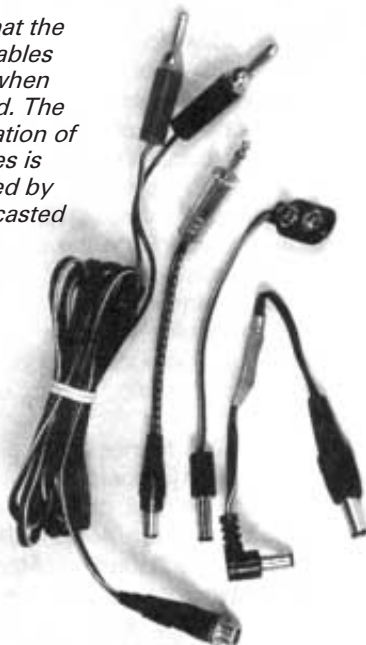


Fig. 2. Assembling these adapter cables makes it easy to connect the power supply to a variety of appliances.

S2 to STEPPED (which is an open setting, as its not connected to anything yet), and measure the exact resistance of the potentiometer using a DMM. Be careful not to disturb the setting. Write down the value of the resistance that gives you the desired output voltage, turn S2 back to VARIABLE again, and perform the same procedures for each output voltage you want. The next step is to piece together the exact resistance value for each output from individual resistors. In most cases you should be able to get the exact value you need by connecting only two resistors in series and only one, if you're lucky. Table 1 shows the potentiometer values that

Here's what the adapter cables look like when completed. The final limitation of total cables is determined by your forecasted needs.



were measured for the prototype's output voltages, and the fixed resistors that had to be connected in series to equal those values. Once you have determined what resistors will be used, you can add them and rotary-switch S3 to the circuit. That switch in the author's prototype is a 2-pole, 6-position switch (Radio Shack 275-1386), of which only one pole (section) is used, providing six fixed settings. After you're done wiring the resistors, use a DMM to make sure each setting is correct. Carefully lay out and drill holes for the LED, switches, binding posts, and potentiometer in the case you are using. If you are using a metal case, the binding posts must be insulated from it (binding posts come with special plastic spacers (shoulder washers) that, with the correct hole size drilled in the front panel, will keep the center conductor away from the panel. Once all the panel components are mounted, make sure to clearly label the panel so you can identify voltage settings.

Convenience Cable

Because one of the intended uses for this power supply is as an AC-adapter replacement, you might want to build a custom cable to do the job. Figure 2 contains the wiring connections of the custom cable. Begin by soldering a pair of banana plugs, red (positive) and black (negative), to the leads at one end of a two conductor wire. At the other end, attach a female coaxial jack, with the center conductor being positive. Next make adapters for various jacks into which you might want to plug the supply (Fig. 2 shows a few examples). All the adapters have a male coaxial plug on one end for connecting to the female plug on the end of the banana cable, and some type of plug on the other end. For example, one adapter has a male coaxial plug, another a mini-phonon plug, and another a 9-volt battery connector. That way, anything that has a coaxial power jack, a mini-plug jack, or uses a 9-volt battery, can be powered quickly and conveniently.



PARTS LIST FOR THE UNIVERSAL POWER SUPPLY

SEMICONDUCTORS

IC1—LM7805 5-volt regulator, integrated circuit
LED1—Light-emitting diode, any color
BR1—50-volt, 1-A, bridge rectifier, or four 1N4001 diodes (see text)

RESISTORS

(All fixed resistors are 1/4-watt, 5% units, unless noted)

R1—470-ohm
R2—1500-ohm, panel-mount potentiometer
R3—560-ohm
R4—0-ohm (approximate value; see text and Table 1)
R5—60-ohm (approximate value; see text and Table 1)
R6—154-ohm (approximate value; see text and Table 1)
R7—256-ohm (approximate value; see text and Table 1)
R8—476-ohm (approximate value; see text and Table 1)
R9—725-ohm (approximate value; see text and Table 1)

ADDITIONAL PARTS AND MATERIALS

C1—2200- μ F, 50-WVDC, electrolytic capacitor
C2, C3—0.01- μ F, ceramic-disc capacitor
PL1, PL2—2-conductor, AC plug
S1, S2—SPDT toggle switch
S3—6-position, rotary switch (RadioShack 275-1386, or equivalent)
T1—120-to-12-volt AC transformer (see text)
Perforated construction board, project case, heat sink, 2 insulated binding posts, coaxial jack, 4 coaxial plugs, miniphono plug, 9-volt battery connector, banana plugs, power cord, grommet, wire, solder, hardware, etc.

Copyright © 1997, POPtronix Inc.

All rights reserved.

As a service to readers, POPtronix, Inc. publishes available plans or information relating to newsworthy products, techniques and scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, we disclaim any responsibility for the safe and proper functioning of reader-built projects based upon or from plans or information published online.

Since some of the equipment and circuitry described in POPtronix, Inc. Project Articles may relate to or be covered by U.S. patents, we disclaim any liability for the infringement of such patents by the making, using, or selling of any such equipment or circuitry, and suggest that anyone interested in such projects consult a patent attorney.