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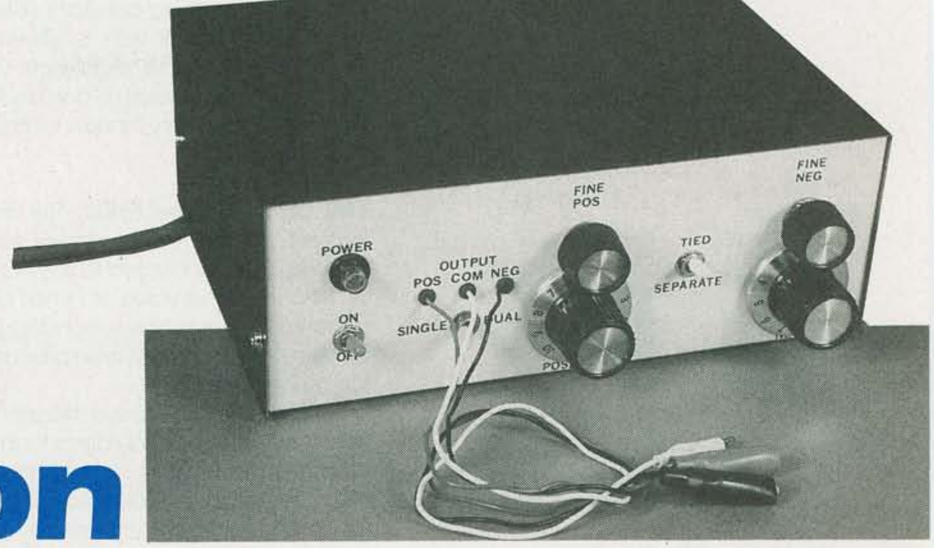
Build a Precision Dual Power Supply

Here's how you can build an inexpensive, adjustable, dual-output power supply that's packed with features—invest a little bit more and you can control the output voltage to the nearest 1/100 of a volt!



The one thing about typical laboratory power supplies is that you can never have too many of them, especially if you do a lot of experimenting. That's because you can't always power everything from one supply, and fixed-output units leave you high and dry when you need a variable voltage source. On top of that, the output of many home-brew variable supplies tend to drift up and down slightly, which is no good at all when you're trying to figure out the optimum reference voltage for some point in a circuit.

With a minimum amount of sweat and wallet shrinkage, we'll show you how to build a power supply with two variable outputs—one positive, and one negative—that might make you shelve the rest. What's more is that, with the addition of two precision potentiometers, at added expense of course, the supply outputs can be set to the nearest rock-steady 1/100-volt.

Adjustable Voltage Regulators. The adjustable voltage regulators readily available today are a veritable boon to any hobbyist building a power supply. Unlike fixed regulators, adjustable units can be programmed to output any voltage within their operating range. (The minimum and maximum of the device varies from model to model and manufacturer to manufacturer.) Furthermore, the devices come in positive and negative "flavors" to suit any reasonable application.

Our power supply uses an LM317 positive adjustable regulator and an LM337 negative adjustable regulator. They can operate from around 1.25 to 33 volts. We buy these versatile little jewels in place of fixed regulators simply because they can provide any voltage required. As long as there are one or two of the units around, there's nothing to slow down building any project that may spring to mind.

Furthermore, as regulators go, they provide excellent ripple rejection. They also have a short-circuit shut-off feature: If you short the regulators' output, it shuts down and automatically turns back on when the short is removed. To add to their value, they are easy to use. In Fig. 1A, a positive adjustable regulator is shown with its two programming resistors in place. A negative adjustable regulator is shown in Fig. 1B. For the sake of discussion, we'll talk about positive regulator's, but keep in mind that the exact same rules apply for negative regulators; the only difference is that the input and output voltages for negative regulators are (you guessed it) negative.

Resistor R1 is usually chosen to be around 240 ohms to provide optimal performance, but I have often used 220-ohm resistors without the least bit of trouble. While the value of R1 is pretty standard, the value of R2 determines the output voltage of the regulator according to:

$$V_{OUT} = 1.25(1 + R2/R1) + R2 \times I_{adj}$$

where I_{adj} (the adjustment current as it's called) is usually between 40 to 50 μA. That current is so small that you can often disregard it and use this abbreviated equation:

$$V_{OUT} = 1.25(1 + R2/R1)$$

Since you usually know the voltage you want, let's rearrange the equation to find R2 based on V_{OUT}:

$$R2 = R1(V_{OUT}/1.25 - 1)$$

There are just a couple of restrictions you should bear in mind while taking advantage of these devices. First, the supply to the regulator should be filtered to supply at least 3-volts rms more than the desired V_{OUT}. Second, if sub-

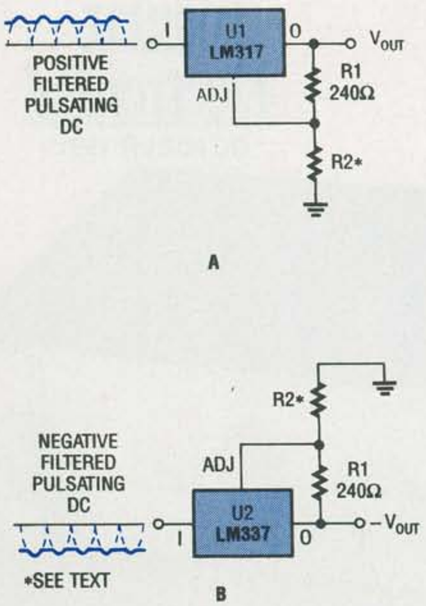


Fig. 1. Adjustable regulators are easy to use. Whether you need a positive (A) or a negative (B) output voltage, you just have to add two resistors and a filtered source of pulsating DC.

PARTS LIST FOR THE LINE TAMER POWER SUPPLY

SEMICONDUCTORS

U1—LM317 positive adjustable-voltage regulator, integrated circuit
U2—LM337 negative adjustable-voltage regulator, integrated circuit
BR1—2-amp 50-PIV, full-wave bridge rectifier

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—33,000-ohm
R2—5000-ohm, dual potentiometer
R3, R5—100-ohm, precision, 10-turn potentiometer
R4, R6—220-ohm
R7—5000-ohm potentiometer

ADDITIONAL PARTS AND MATERIALS

C1, C2—1000-µF, 50-WVDC electrolytic
C3, C4—.02-µF, ceramic disc
F1—4/10-amp fast-blow fuse
NE1—NE-2H neon indicator
PL1—3-terminal molded AC plug with line cord
S1—SPST toggle switch
S2, S3—SPDT toggle switch
T1—25.2-volt, center-tapped, 2-amp power transformer
Perfboard, enclosure, rubber grommets, alligator clips, heat sinks, fuse holder, wire, solder, etc.

stantial current (more than ¼-amp) is to be drawn from the regulator, use a heat sink. You should also use a heat sink if the input voltage is to be more than 6-volts greater than the output voltage.

One last thing to be aware of is the fact that adjustable regulators have different pinouts than constant-voltage models. In a similar vein, positive and negative adjustable regulators don't have the same pinouts as one another. That's enough theory for now, let's get to the real circuit.

The Crux and the Frills. The transformer's primary in the power supply (see Fig. 2) is connected to the AC line via S1 and F1. The value of F1 has been selected to prevent the secondary (yes, we said the secondary) from producing too much current.

If you choose to use a transformer with a different current rating than the 2-amp unit specified in the Parts List, then you will have to compute the value of the fuse to suit your needs. Most transformers are rated by their primary voltage, secondary voltage, and secondary current. You will need to know the maximum current to permit in the primary that will not damage the secondary. Here is a simple equation that you can use to determine that maximum:

$$I_P = I_S(V_S/V_P)$$

where I_P is the primary current, I_S is the secondary current, V_P is the primary voltage, and V_S is the secondary voltage.

You may wish to select a slightly lower fuse capacity for added safety. However, since some of the power produced by the primary is lost in the transformer's iron core, not all of it reaches the secondary. Opinions may vary, but that provides a margin of safety that has proven itself sufficient over the years.

To turn AC into full-wave pulsating DC, most single-sided power supplies have either a center-tapped transformer and two diodes or a regular transformer and a bridge rectifier. Dual supplies usually contain a center-tapped transformer and two bridges. That's the first big difference between our supply and the rest. You'll note that the circuit does have a center-tapped transformer, but only one bridge rectifier. With the mode switch in the "dual" position, that is all the circuitry needs to produce both a positive and a negative voltage simultaneously.

A question you may be asking at this point is does the circuit provide full-wave rectification to both the positive and negative regulators of the supply? The answer is yes. To prove it to yourself, follow the current through the bridge when the top terminal of the secondary is positive and the bottom is negative with respect to the center tap. Then follow the current flow when the polar-

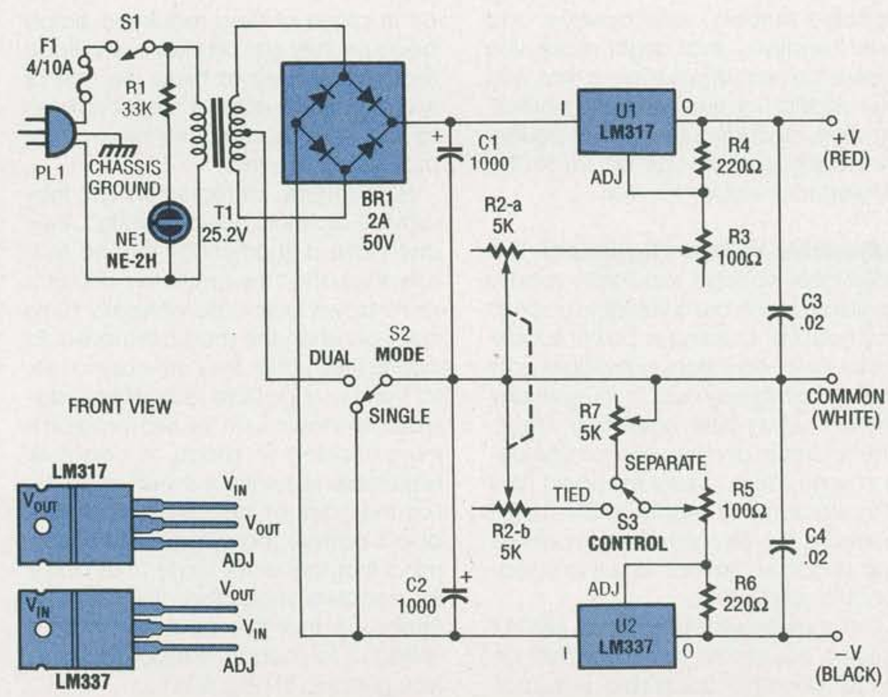


Fig. 2. The adjustable supply uses an unusual combination of bridge rectifier and center-tapped transformer to simultaneously provide positive and negative output voltages.

ity of the secondary reverses. Keep in mind that, no matter what the secondary's polarity is, the center tap is always at zero potential.

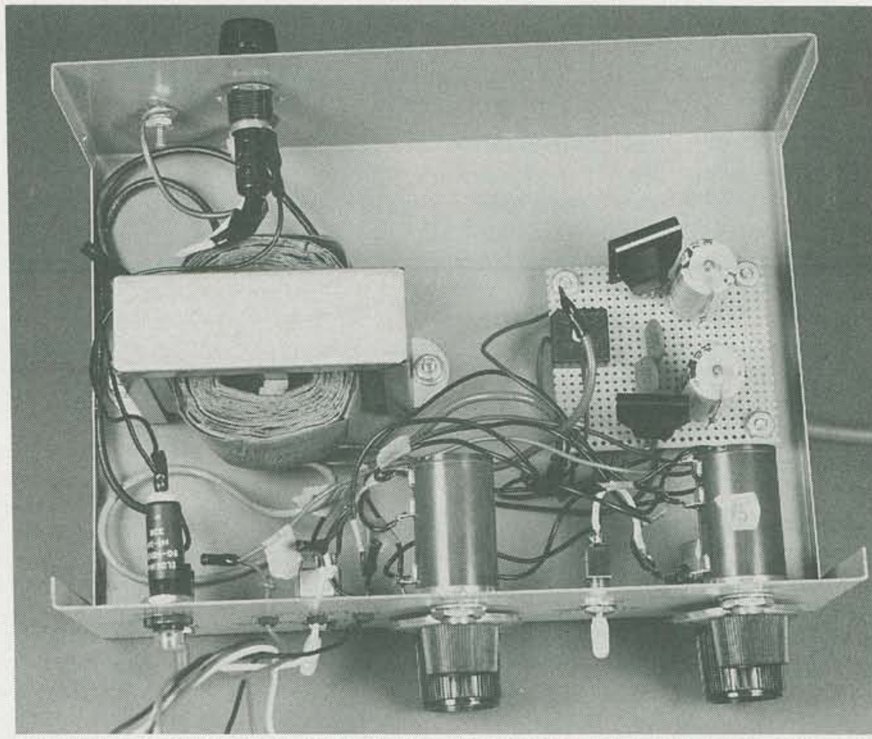
By using this scheme, each regulator receives half of the full secondary voltage in dual mode. When S2 is in the "single" position, the negative supply is shut down and the positive regulator receives the full secondary voltage. That turns the unit into a formidable single-ended power supply capable of driving 1.5-amps at about 17 volts. The voltage output increases to over 30 volts for lighter loads.

Regardless of whether the unit is operating in dual or single mode, the positive-supply voltage is determined by potentiometers R2-a and R3. They act as coarse and fine voltage-adjustment controls, respectively. Potentiometer R3 is a multi-turn device that allows you to easily set the output voltage to the nearest 1/100th of a volt. The extra precision is great at times when you need a precise reference voltage. If this feature is not important for your applications or seems too expensive to add, you can simply leave out R3.

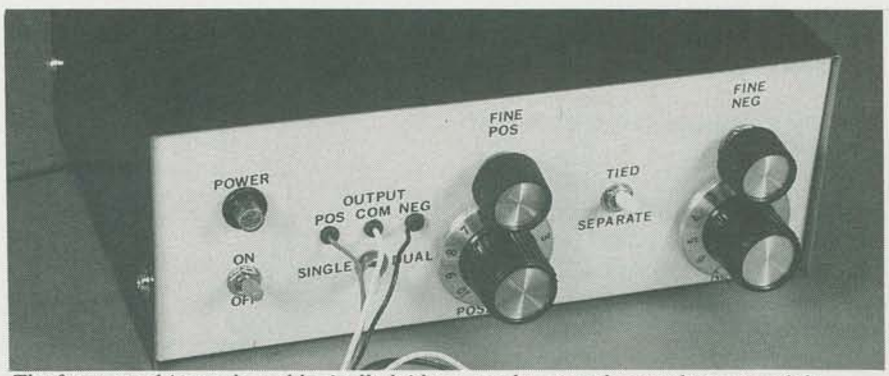
The adjustable negative regulator is controlled in the same way, but S3 lets you choose between two coarse voltage controls: R2-b and R7. Potentiometer R2-b is ganged with R2-a (they form a stereo potentiometer), so if S3 is set to the "tied" position, the positive and negative supplies are adjusted simultaneously. That is useful when you need balanced supplies, such as for op-amps. In that mode, you can use the high-precision potentiometers to precisely adjust the balance. If the high precision feature is too much, you can leave out R5.

With S3 in the separate position, R7 acts as the negative-voltage control and R2 adjusts only the positive supply. This is useful for when the positive and negative voltages are not supposed to match. Of course R5 still acts as a fine-adjustment control.

Capacitors C1 and C2 filter the pulsating DC into a more manageable form for the adjustable regulators. The two capacitors at the outputs (C3 and C4) help eliminate any destructive transients presented to the two power leads.



Here's what the inside of our unit looks like. If you work neatly, you'll end up with a very reliable unit.



The front panel is neatly and logically laid out, so the controls are where you might expect them to be.

Construction. Building the power supply is quite simple because very few components are required. We chose to mount the parts on a piece of perfboard using point-to-point wiring to interconnect the various components. Because all of our controls can be mounted from the inside of the cabinet, we were able to fully assemble the board and all controls before installing them in the cabinet.

The size of the cabinet was chosen mainly for the size of the transformer—the circuit board itself is actually quite small. Also, the multitude of controls requires a lot of space on the front panel. Once you choose a cabinet, don't start drilling holes right away. First you should carefully lay out the drill points according to the controls you use. Also, try to position the controls in somewhat logical locations. You can copy our design if you like.

Although most power supplies have binding-post outputs, you always end up having to connect a lead to them anyway. So for the sake of convenience, we decided to have alligator-clip-equipped leads coming directly out of the cabinet—a red one for the positive output, a white one for the common, and a black one for the negative output. Because of the unique shut-down feature of the voltage regulators, shorting is not a concern with this project.

A neatly drilled cabinet deserves neat labeling. Dry-transfer (rub-on) lettering looks good, and is pretty durable if you burnish it down when finished. Clear lacquer makes it permanent. Four rubber feet complete the job. It's the small details that lead to a good-looking, high-performance, easy-to-use lab supply. And one that will have a home on your workbench for years to come. ■