Variable Power Supply

In our August/September 1985 issue, we had described a simple circuit for a 4.5 V Battery Eliminator. Although very useful for a beginner, a fixed voltage source may cause inconvenience when an experiment you are doing needs certain other value of supply voltage.

A variable voltage power supply circuit is described here. The voltage at the output of this supply can be adjusted smoothly at any desired value between 0 to 15V. The maximum output current is 0.5A. The left half of the circuit shown in figure 1 is similar to the 4.5 V battery eliminator circuit, except for the transformer. The transformer has a secondary voltage of 18 V in this case.

The bridge rectifier B1 is followed by an electrolytic capacitor C1, called the filter capacitor. To understand the function of the filter capacitor, we must once again go back to our notes on alternating currents and voltages.

AC Voltage Sine-Wave

The AC voltage available at the mains socket changes its polarity one hundred times every second. This change does not take place abruptly. The change in voltage level follows a sine wave as illustrated in figure 2. The periodic pattern consists of alternate positive and negative half waves. The sine wave shown in figure 2 is present at the primary input of the transformer. Figure 3 shows the sincewave present at the secondary output of the transformer and the wave form present at the output of the bridge rectifier. The sinewave shown in figure 3 a is proportionately smaller in voltage levels compared to the one shown in figure 2.

The waveform shown in figure 3b is similar to that in figure 3a except for the fact that it consists of all positive half cycles. This inversion of the negative half cycles takes place due to the construction of the bridge rectifier. It allows the positive half wave to pass through to the output directly, but it reverses the polarity of the negative half wave as it passes through the bridge rectifier. The alternating voltage at the input of the bridge is thus converted to a pulsating direct voltage. As this voltage consists of 100 such half waves per second, it is not suitable for an electronic apparatus which requires a steady level of DC voltage. Such a rectified voltage will produce a horrible hum in the loudspeakers if we operate an amplifier from this voltage.

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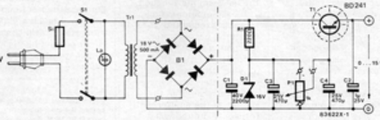

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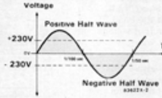

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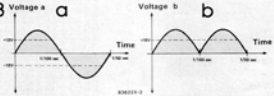

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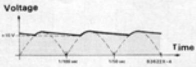

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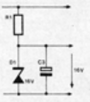


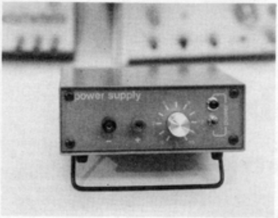
Figure 1 :
Complete circuit diagram of the variable power supply.

Figure 2 :
The sine wave of the alternating voltage.

Figure 3 :
Voltage at the input (a) and output (b) of the bridge rectifier.

Figure 4 :
The voltage across the filter capacitor C1.

Figure 5 :
Reference voltage source using a zener diode



Filter Capacitor

The filter capacitor C1 comes to our help in reducing the voltage variation caused by these half waves. During the very first half wave, the eletrolytic capacitor C1 gets charged to the voltage supplied by the bridge rectifier. When the bridge output starts falling along the sine wave, the capacitor supplies some of its stored charge. Thus the voltage at the output of the bridge does not fall as rapidly as it would have done in absense of the filter capacitor C1. The voltage pattern across the capacitor C1 is shown in figure 4. The small fluctuation that still exists in the output voltage across C1 is called the ripple voltage. Transistor T1 further reduces this ripple voltage.

The part of the circuit that follows C1 is used to obtain variable voltage at the output across capacitor C2. The voltage supplied at the collector of the transistor T1 is always the same as that across the capacitor C1. As we require an adjustable voltage at the emitter, the collector emitter junction must take up the excess voltage. This is achieved by using the property of the base-emitter junction. The base-emitter voltage remains fixed at 0.6 Volts when the base-emitter junction is forced into conduction. Using this physical property of the base-emitter junction we can clearly see that the voltage at the emitter with respect to ground will depend on the base voltage with respect to ground. (see figure 7.) If we can adjust the base voltage, the output voltage at the emitter will automatically change.

This means that we must have an adjustable voltage at the base of transistor T1. To achieve this, a potentiometer P1 is used along with two more filter capacitors C3 and C4. Zener diode D1 provides a stable reference voltage across the potential devider potentiometer P1 (see figure 5 and 6.) A 16V zener is used in this case, so that a stablé 16 V DC is available across the potentiometer P1. The sliding contact of the potentiometer can take voltages from 0 to 16V depending on its position. Now once again refering to the figure 7 we can see that the output voltage Ua will be less than the voltage Ub at the sliding contact of the potentiometer by 0.6V. The relation between the two voltages is as follows :

$$U_a = (U_b - 0.6)\ V$$

The output voltage will thus be adjustable by changing the setting of the potentiometer. This relation also explains why we need a zener voltage of 16 V to achieve a 0 to 15V range at the output. (To be precise, the output will be 0 to 15.4V). When Ub is less than or equal to 0.6V the base-emitter junction will not conduct and the transistor T1 will be cut off. There will be no output voltage available in this case.

Construction Details

The circuit described above can be constructed as per the component layout shown in figure 8. Follow the usual sequence for soldering various components. First the jumper wires, then resistors, condensors and semiconductors. Except for resistors, other components in this circuit are polarised. They must be mounted with the correct polarity to avoid any undesired damage.

The plus pole of the Zener diode coincides with the ring printed on the body.

Since the transistor conducts the entire load current through its collector-emitter it will become hot during operation. A cooling fin or heat sink must be provided for the transistor T1 for proper heat dissipation. the heat sink can be fixed on to the transistor body with a nut and screw. As the heat sink is not very

Figure 6 :
Potentiometer P1 used as a potential divider to obtain voltages from 0 to 16 V.

Figure 7 :
How the transistor T1 functions.

Figure 8 :
Component layout of the variable voltage power supply.

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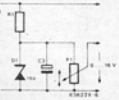

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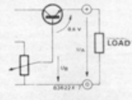

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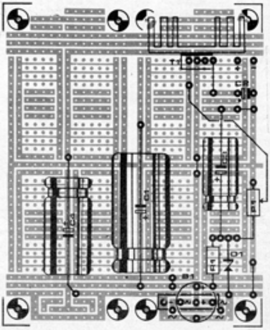


Table 1

Voltage across:	Value:	Gives information on :
Transformer primary	230V AC	socket, plug, cable, fuse, and transformer.
Transformer secondary	18V AC (Approx.)	Transformer.
C1	25V DC (Approx)	B1, C1.
D1	16V DC	R1, D1, P1, C3
C4	0 to 16V DC (Depending on potentiometer setting).	P1, C4, T1
Output	0 to 15 V DC (Depending on potentiometer setting).	T1, C2

heavy, it can by supported directly by the soldered transistor itself. Note that the heat sink fixed onto the transistor is connected to the collector of the transistor and should not be grounded.

Wiring diagram for other components like potentiometer, sockets, transformer, switch, fuse and indicator lamp can be seen in figure 1. While assembling the power supply in its casing, the rules to be observed with equipment connected to AC mains voltage must be strictly followed. These rules have been earlier discussed on page 7.66 of the July 1985 issue of Elektor India.

Figure 9 shows the completed assembly of the power supply. A mains input socket with a built-in fuse holder is used in the prototype as shown in figure 10.

After the assembly is complete, you can give your power supply the 'Smoke Test', before fixing the top cover of the casing. Connect the mains cord and switch on the power. If nothing smokes, burns, cracks, gives foul smell or gives any disaster signals, the first test is passed !

For the second test, connect a multimeter at the output and check if the potentiometr is able to adjust the output voltage between 0 to 15V. If everything is in order, the casing can be closed. If the circuit does not work properly, check all the voltages given in table 1 to locate the faulty components or wrong connections. If the measured voltage for any component deviates considerably from the specified value, check more carefully in that area for wrong connections

If all connections are correct, that particular component may be defective.

While purchasing the components, care must be taken to obtain the correct ratings as given in the component list. Power ratings of D1 and P1 must be properly confirmed, as well as the voltage ratings for the capacitors. If a 16V zener is not available, select another standard value which is the nearest. This will affect the output voltage range.

Calibration

If you decide to use a voltmeter and an ammeter with your power supply, calibration of the potentiometer dial is not necessary. However, if you construct the low cost version without the voltmeter and ammeter, you will have to calibrale the potentiometer dial using a good multimeter connected across the output.

The potentiometer dial can be calibrated in 1V or 1.5V steps as desired.

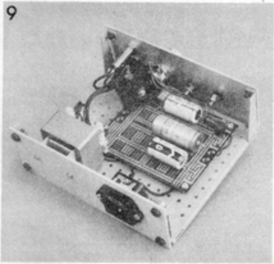
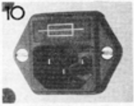


Table 1 : Checklist of test voltages.

Figure 9 : Construction of the power supply

Figure 10 : Mains socket with built-in fuse holder.

Figure 11 : Voltmeter, ammeter connections detail.



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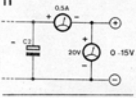

Components

R1 = 220 Ω ½W

P1 = 1K Linear Pot. ½ w

C1 = 2200 µF/40V (Electrolytic)

C2 = 1 µF/25V (Tantalum)

C3, C4 = 470 µF/25V (Electrolytic)

B1 = Rectifier bridge (500 mA or 1A)

D1 = 16V/1W Zener diode

T1 = BD 241 (with suitable heatsink)

Tr1 = 18V/500 mA Transformer.

La = Indicator lamp (230V)

S1 = Double pole mains switch.

Si = 200 mA Slow Blow Fuse.

Other parts.

1 Suitable casing

2 Mains Cord

1 Mains Cord

1 Mains socket with fuse holder

1 Suitable PCB

1 Knob for potentiometer (preferably with dial)

2 Banana sockets (Red & Black)

6 Soldering lugs.

1 Voltmeter (0 to 20V) - Optional

1 Ammeter (0 to 500 mA) - Optional

(See figure 11 for connections of Voltmeter and ammeter)