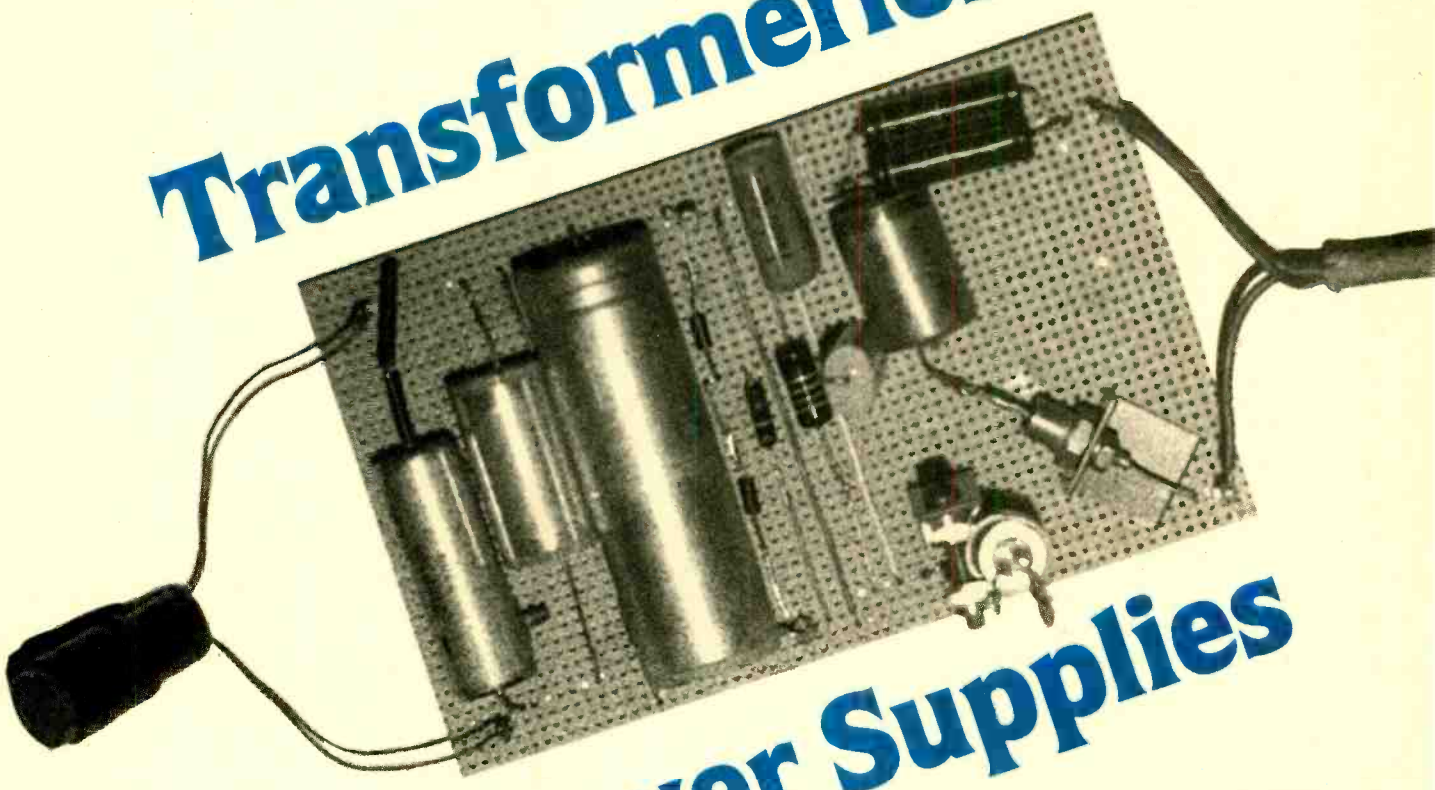
Transformerless DC Power Supplies



BY RALPH HUBSCHER

While the transformer is still a key part of most power-supply designs, it is possible to build a useful power supply without one...and we'll show you how!

The transformer has been with us for quite a while, and has lent itself nicely to several applications. For instance, it is handy for raising or lowering AC voltages, and has been used widely for adjusting impedances or separating individual stages in multistage systems.

It's hard to imagine that the transformer will ever become obsolete. But haven't you wondered whether such a heavy, cumbersome piece of equipment might not be some day replaced by something more modern (or, at least smaller)? Any transformer replacement is not likely to be a tiny chip because when sizable currents flow, heat must be dissipated (often sizable amounts of heat), so surface and bulk become mandatory.

But if it is a power supply that you seek, certainly one can be built without a transformer—hence the basis of this article; the *Transformerless Power Supply*. **It should be mentioned, however, that such a power supply poses a greater shock hazard than do those that incorporate a transformer into their designs, since the circuit operates at line (117-volts AC) potential. As such, a great deal of caution should be observed when building and using such a supply.**

About the Circuit. Figure 1 is a schematic diagram of the Transformerless Power Supply. Switch S1 places one of a bank of non-polarized electrolytic "scoop" capacitors (C2–C7) across the AC line, allowing it to charge. (I call them scoop capacitors because they sort of scoop the AC to the SCR.) The SCR (SCR1) is configured so that it only fires (conducts) during positive excursions of the AC waveform. When the SCR fires, it acts as a conventional diode, allowing the charge from the scoop capacitor to flow through it to the output filter capacitor (C9) and out to the load.

As you can see, the whole thing is really quite simple. The balance of the circuitry serves support functions such as ensuring that the SCR fires only during the positive half-cycles of the AC waveform. The Zener diode (D1) is placed in the circuit to regulate the voltage available at the output. Resistor R1 essentially acts as a "slo-blo" fuse, with some "olefactory and visual indicators." That is, if excessive current flows, the resistor will become discolored and begin to smell even before it goes up in smoke. That will give you plenty of time to pull the plug. Capacitor C1 acts as an AC resistor.

The voltage and current available at the output is determined by the value of the scoop capacitor selected and the size of the load. If you check Table 1, you'll see that voltages of 3.2 to 43.5 volts DC were measured with a 100-ohm, 20-watt load connected across the output of the circuit. Currents ranged from 31 to 322 mA.

www.americanradiohistory.com

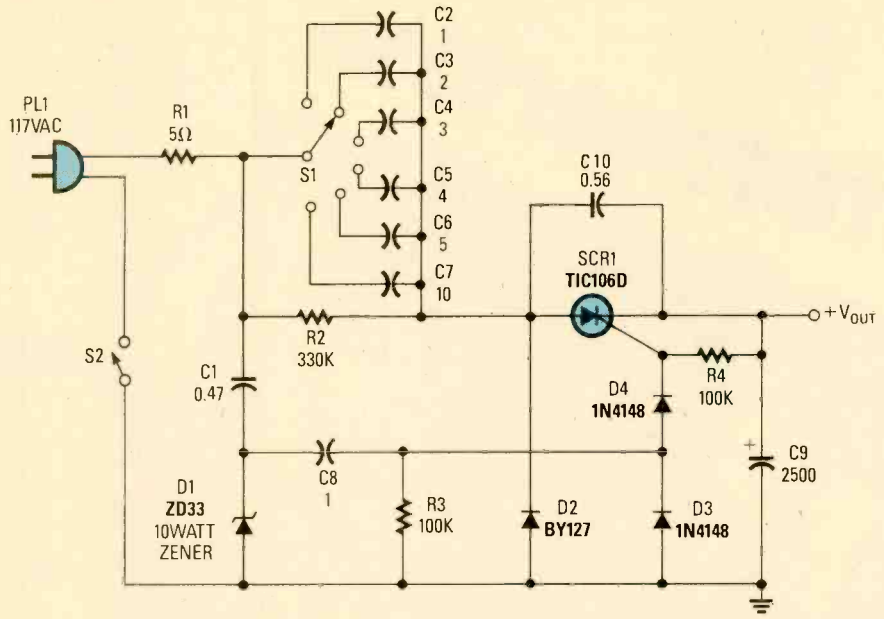


Fig. 1. The Transformerless Power Supply is made up of relatively few, readily available components. The output voltage level (and the amount of available current, see Table 1) can be varied by rotating switch S1.

TABLE 1—OUTPUT CURRENT/VOLTAGE AT SPECIFIED LOADS

Capacitance (μF)	Load					
	100 Ohms		200 Ohms		1000 Ohms	
	V_{OUT} (V)	Current (mA)	V_{OUT} (V)	Current (mA)	V_{OUT} (V)	Current (mA)
1	3.2	31	6.0	29	25	24
2	6.4	61	11.2	54	41	41
3	9.0	87	16.1	78	52	52
4	11.8	113	20.7	100	61	61
5	15.5	147	24.7	120	67	67
6	17.8	169	28.8	140	68	68
7	18.5	176	31.9	155	69.4	68
8	20.3	195	36.8	173	70	71
9	22.8	220	41.0	193	70	71
10	24.9	238	42.0	204	71	71
11	27.1	259	44.9	219	—	—
14	33.0	317	52.7	257	—	—
20	43.5	422	65.8	322	—	—

If you want to supply a specific DC voltage or current to meet the requirements of a specific piece of equipment, check the device's resistance. Connect an equivalent resistor across the output of the Transformerless Power Supply. Also connect a voltmeter to the output and switch through the scoop capacitors until you get the voltage needed. It is possible to raise voltage and/or current further by going to an even larger scoop capacitor. However oil-capacitors beyond 10-μF 200-volts AC are large. Zener diodes and SCR's also need larger heat sinks when pushed into the 20-watt region. The power supply described herein is not exactly small to begin with and it should not be expanded into a range where it becomes obvious that it will take up more space than the transformer/rectifier power supply that it is to replace.

PARTS LIST FOR THE TRANSFORMERLESS POWER SUPPLY

SEMICONDUCTORS

SCR1—TIC106D or similar, 8-amp, 400-PIV, silicon-controlled rectifier
D1—ZD33, ECG5142 or similar, 33-volt, 10-watt Zener diode
D2—BY127 or similar, 3-amp, 1000-PIV silicon rectifier diode
D3, D4—1N4148 or 1N914, small signal, silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless noted)

R1—5-ohm, 10-watt
R2—330,000-ohm
R3, R4—100,000-ohm

CAPACITORS

C1—0.47-μF, 200-WVDC, ceramic-disc
C2—1-μF, 200-WVDC, non-polarized electrolytic
C3—2-μF, 200-WVDC, non-polarized electrolytic
C4—3-μF, 200-WVDC, non-polarized electrolytic
C5—4-μF, 200-WVDC, non-polarized electrolytic
C6—5-μF, 200-WVDC, non-polarized electrolytic
C7—10-μF, 200-WVDC, non-polarized electrolytic
C8—1-μF, 50-WVDC, non-polarized electrolytic
C9—2500-μF, 70-WVDC, electrolytic
C10—0.56-μF, 400-WVDC, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

S1—SP5T rotary switch
S2—SPST toggle switch
PL1—117-volt AC molded power plug with line cord
Perfboard materials, enclosure, wire, solder, hardware, etc.

Note that the switched scoop capacitors (C2–C7) must be non-polarized types, meaning that they can be foil capacitors or oil-filled capacitors. They cannot be standard electrolytics because such capacitors would heat up and may explode. AC motor-starting capacitors will do the job. In place of the specified SCR (a TIC106D 5-amp 400-PIV unit) equivalent SCR's, such as the T6N400 (AEG) or others, can be used. They must be mounted on heat sinks.

The Zener diode regulates the voltage supplied to C9. For test purposes and for applications requiring only a few milliamperes, a ZPD30 (30-volt Zener) or a combination of two ZPD15

(Continued on page 104)

www.americanradiohistory.com