A Homemade High-Power Tuning Capacitor

Transmitting types of variable capacitors are expensive and hard to find! Why not build your own?

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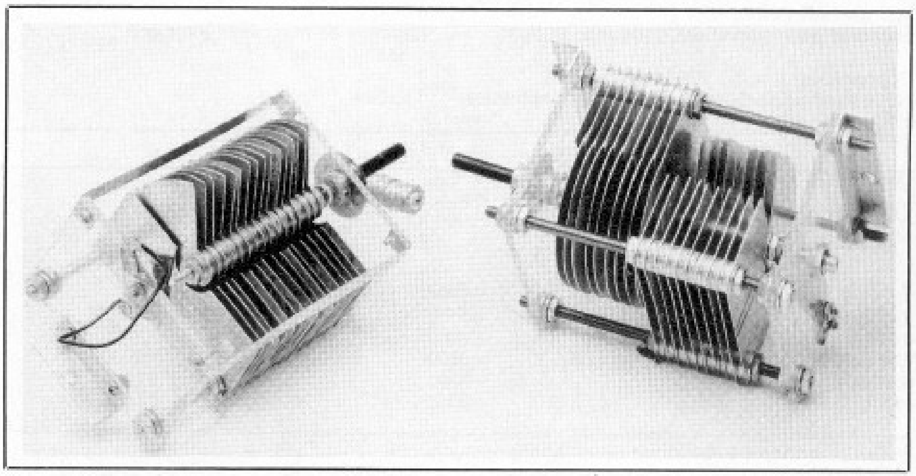

Do you have lots of spare time and good mechanical skills? If so, this project is for you! No longer do you have to pay premium prices for a high-power variable capacitor. One look at the parts list (Table 1) should pique your interest; all the parts should be available from your hardware store and/or junkbox.

First, the mathematics. Before building the capacitor, the number of rotor and stator plates must be calculated. The formula for capacitance between two parallel plates is

$$C = \frac{0.224AK}{d} \quad \text{(Eq. 1)}$$

where

C is the capacitance in picofarads (pF)
A is the plate area in square inches
d is the plate separation in inches
K is the dielectric constant (air = 1)

Table 2 shows typical plate spacing for various peak voltages. I chose a plate spacing of 0.075 inch for my first capacitor — enough to withstand 3000-V peak.[1] Since there is a chance of bending plates, a stack of five no. 8 washers (0.042 inches thick) provide approximately 0.0975-inch spacing between rotor and stator plates, allowing a slight margin for bending. This arrangement is shown in Fig. 1.

To calculate the capacitance per rotor plate, first find the total area of the rotor plate, which includes both sides of the

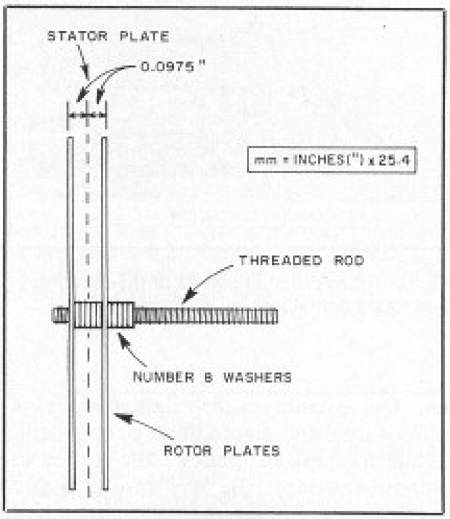

Fig. 1 — No. 8 washers are used to space the rotor and stator plates. See text for details.

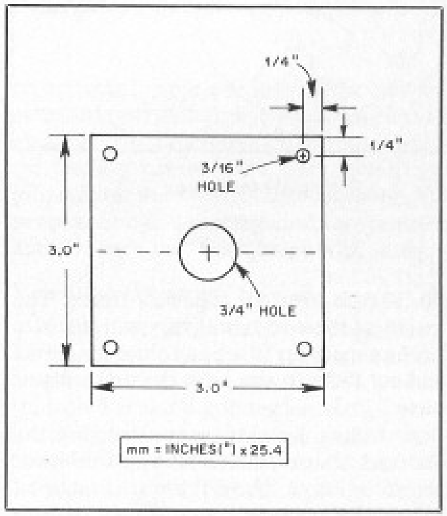

Fig. 2 — Template for the stator, and end-plate jig.

plate minus the center notches (which provide clearance for the rotor shaft) in the stator plates.

$$A = \pi R^2 \text{ (total plate)} - \pi r^2 \text{ (notch)} \quad \text{(Eq. 2)}$$

where

A is the total area
R is the radius of the total plate
r is the radius of the notch

Substituting the values for my capacitor:

$$A = \pi(1.4375)^2 - \pi(0.375)^2 = 6.05 \text{ square inches} \quad \text{(Eq. 3)}$$

Using Eq. 1, the capacitance per rotor plate can now be calculated:

$$C = \frac{(0.224) \times (6.05) \times 1}{0.0975} = 13.9 \text{ pF} \quad \text{(Eq. 4)}$$

The maximum capacitance of one section of a capacitor (two stator plates plus one rotor plate) is equal to the capacitance of this section at full mesh plus the minimum capacitance, which is about 10% of the maximum. Therefore, each section will have a capacitance of 1.1 × C, or 15.3 pF, in my capacitor.

Construction

Two 3 × 3 × 1/4-inch Plexiglas® plates are used as end supports, and

[1] mm = in. × 25.4.

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Table 1

Parts List for the Homemade Capacitor

Description	*Quantity*
Plexiglas sheet plastic 3 × 3 × 1/4 inch	2
Threaded no. 10 brass rod	5
No. 10 hexnuts	Box of 100 (more than enough; common-size package)
No. 10 brass hexnut	1
Half-hard aluminum sheet, 0.020 inch thick	Depends on number of rotor and stator plates
Copper strip, 1 × 3 × 0.07 inches	1
No. 8 washers, 0.450-inch dia. by 0.042 inch thick	1 lb box

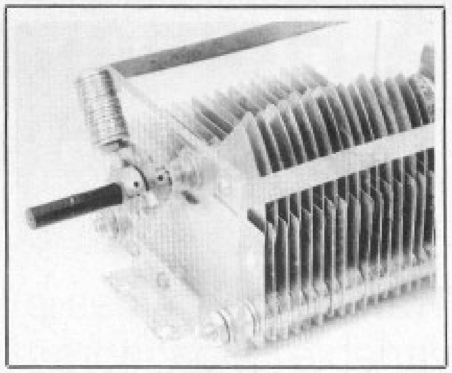

Fig. 5 — Rotor balancing modification. Use enough washers to just balance the capacitor.

Table 2

Typical Capacitor Plate Spacings

Spacing Inches (mm)	*Peak Voltage*	*Spacing Inches (mm)*	*Peak Voltage*	*Spacing Inches (mm)*	*Peak Voltage*
0.015 (0.4)	1000	0.07 (1.8)	3000	0.175 (4.4)	7000
0.02 (0.5)	1200	0.08 (2.8)	3500	0.25 (6.3)	9000
0.03 (0.8)	1500	0.125 (3.0)	4500	0.35 (8.9)	11,000
0.05 (1.3)	2000	0.15 (3.8)	6000	0.5 (12.7)	13,000

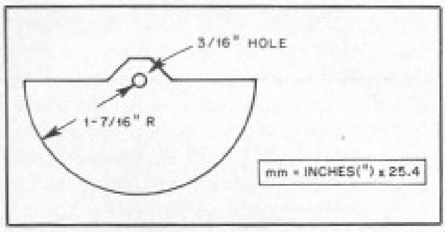

Fig. 3 — Rotor-plate template.

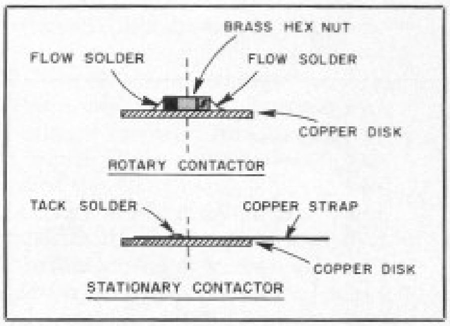

Fig. 4 — Construction details of the stationary and rotary contactors.

no. 10 rods form the capacitor frame. The length of these rods will vary with the size of the capacitor; it is best to use long rods and cut them to size once the unit is completed.

A drilling jig aids in constructing the end and stator plates. The jig outline is shown in Fig. 2. Use a fairly stiff material for the jig, such as phenolic or 0.04-inch aluminum sheet stock. Drill the end plates while using the jig and place a screw in each drilled hole to ensure proper alignment. Cut out and drill the 3-inch aluminum sheets, again while using the jig. These plates will be cut in two to form the stator plates. Once the sheets have been cut and drilled, enlarge the center hole to 3/4 inch (the best method is to use a chassis punch) and cut each sheet in half. The resultant half-moon shape in each stator plate provides clearance for the rotor shaft.

Each rotor plate is made from the same aluminum sheet, using Fig. 3 as a guide. Note that the rotor radius is 1-7/16 inches instead of 1-1/2 inches. This provides clearance for the frame rods. Once the rotor plates have been cut, you can use a file to smooth and round them. One filing method I tried was to stack all the plates on a rod and fan them out to form a circle. The assembly is then tightened with a pair of nuts and placed in an electric drill. While spinning the plates a file is used to smooth the edges. Be *very* careful if you try this method; be sure the drill is secured firmly.

Two contactors are needed to provide an electrical connection for the rotor assembly. These contactors are made from 3/4-inch-diameter copper, brass or silver (best) disks, copper strap and a brass nut. Construction details of the stationary and rotary contactors are shown in Fig. 4.

The rotor shaft is made from a brass no. 10 threaded rod (length depending on the design capacitance) and two 1-1/2 inch lengths of 1/4-inch aluminum shaft material. Drill one end of each aluminum shaft to a depth of 1/2 inch and tap them with a 10-32 *bottoming* tap.

Assembly

Assemble the rotor first. Select one of the no. 10 threaded rods as a rotor shaft, screw one of the threaded aluminum shafts over the end of this rod, then secure it with a drop of glue. Next, slide two washers over the rod and follow with a nut. Tighten the nut slightly; the washers are used as end-play bearings. Slide on another flat washer, followed by a rotor plate, more washers (number depending on chosen spacing) and another rotor plate. Repeat this process until all the plates are in place. Slide one more washer next to the last plate and secure with a nut. Screw on another nut, leaving a 1/16-inch space from the last nut; this nut will serve as a locking device for the contactor assembly. Screw on the rotary contactor so that the flat surface is facing away from the rotor plates. Now, screw on the stationary contactor so that the flat surfaces mate with each other. Finally, screw on the other threaded aluminum shaft. This completes the rotor assembly.

Next, mount the potentiometer bearings to the plastic end plates and install two frame rods in the lower corners of one end plate. Use nuts and washers on both sides of the plate. Install the stator plates on these two parallel rods, using the same procedure as for the rotor plates.

After all the stator plates are mounted, slip the coil spring on the rotor shaft and attach the rear end plate. The end-to-end spacing should be enough to allow some play in the rotor, but the spring should provide a fair amount of tension. Finally, attach the two top frame rods. This completes the assembly of the capacitor.

Alignment

It will take a few minutes of adjusting to ensure free rotation of the capacitor. Some of the plates may have to be bent; it is hard not to bend them when assembling the unit. After building several capacitors, I found they needed a little counterbalancing. This was accomplished with a collar on the rotor shaft that has a 1-1/4 inch set screw. This modification is shown in Fig. 5.

Although this project is time consuming, it surely is cost effective. If you use reasonable care when drilling, cutting and bending, you will have a capacitor of which you can be proud. QST