

A 100-watt Compact Z-Match Antenna Tuner

By Phil Salas AD5X

I've been reading about Z-Match antenna tuners for quite awhile now. The nice thing about the Z-Match tuner is that it will match just about anything on all HF bands, and only uses two controls. The folks who use these tuners speak very highly of them, but it always seemed that acquiring the necessary air-wound inductors and variable capacitors was more trouble than it was worth. In addition, air-wound inductors imply large tuners and I'm interested in something that is compact enough for me to easily take along with my portable HF set-up.

Then I picked up an EMTECH ZM-2 QRP Z-Match tuner (www.emtech.steadynet.com). These are sold in kit form. After building it to go along with my portable QRP rig, I became a real believer in Z-Match tuners. Now, my goal was to build a Z-Match tuner that was relatively small and portable, and yet would handle the 100-watt output power of my IC-706MKIIG.

While browsing through the ARRL Antenna Compendium, Volume 5 recently I found an excellent article by Charles Lofgren (W6JJZ) on Z-Match tuners. In that article, the author suggested using a toroid core-based inductor. This would solve my air-core inductor/size problem. Then I found three-section 440-pf/section variable capacitors from Fair Radio Sales (www.fairradio.com). While these variable capacitors are no longer available, an excellent substitute from a commercially available source is now available at a good price (see the Parts List).

Tuner Construction

The final circuit shown in Figure 1 is based on W6JJZ's article. The only real change I made was to go from two switch-selected output links (10-turns and 4-turns) to a single 8-turn output link. I also increased the variable capacitor size to 400-pf. So far, I haven't found anything I can't match from 80-10 meters!

I built my tuner into a 5-1/4"W x 3"H x 5-7/8"D Radio Shack RS270-253 aluminum box as shown in the photos. While Radio Shack no longer carries this enclosure, an excellent substitute is the Eagle instrument case called out in the Parts List. The toroid inductor is supported by its leads, and some hot glue between the inductor and one variable capacitor (C2). I also put a little hot glue between the inductor and side of the box.

The variable capacitors must be insulated from ground, therefore mount both capacitors on a piece of single-sided circuit- or perf-board that is cut just wide enough to fit into the aluminum case. Then mount this capacitor/perf-board assembly in the case with stand-off screws. See Figure 2. I made my own capacitor shaft couplings from a 1/8-NPT brass nipple, available from the plumbing section of most hardware stores. These nipples have a 1/4-inch inside diameter. I cut a 1-inch nipple in half (so as to make two couplers). Then I drilled and tapped holes for two #6 screws in each piece. See Figure 3. For the insulated shafts, I used 1/4" diameter nylon rods available from any True Value hardware store.

Operation

Tuning the Z-Match tuner is very easy. First adjust C2 for maximum receiver noise. Then apply some RF power and adjust C1 and C2 for minimum SWR. If you need more capacitance for matching, you can switch in the extra section of C1, or switch in a fixed mica capacitor across C1. Balanced feedlines terminated in banana plugs can plug right into the SO-239 and adjacent banana jack. For a coax output, an SPST switch grounds one end of the output link as shown in the schematic (Figure 1).

Optical HF SWR Meter for the Z-Match Tuner

While you can use any external SWR meter with the Z-Match tuner including the SWR meter built into most rigs, I built-in an optical SWR meter for convenience. Refer to Figure 4. I found the basic circuit in an old Ham Radio Magazine. The original circuit used meters, but I found that this circuit works great with the high intensity LEDs that are now on the market. I built this on a small piece of perf-board and mounted it in the Z-Match tuner. The perf-board is mounted to the solder lug on the input SO-239. I also added a little hot glue between the perf-board and the back of the chassis. All resistors are ¼-watt. This circuit works well for your typical 100-watt HF transmitter. This is a broadband circuit and it is good through at least 10-meters. With careful lead control, it should work up through 6-meters. The transformer is an FT37-43 ferrite core wound with 10 bifilar turns of #26 enameled wire. The primary is just the RF wire passing through the center of the torroid.

To calibrate the SWR bridge, connect the output to a good 50-ohm load. Apply RF power on any HF band and adjust the 20-pf variable capacitor until the “REF” LED goes out. The “FWD” LED just gives an indication of transmitter power. You may want to increase the value of the 4.7K-ohm resistor in the “FWD” circuit if the green LED is too bright for you. Or you could even eliminate this LED if desired.

Now to adjust your Z-Match antenna tuner, vary the two capacitors until the “REF” LED is out. Your SWR should be less than about 1.5:1 when this occurs.

A Bar-graph Display for the Optical SWR Meter

If you don't mind supplying DC power to your Z-Match Tuner/SWR meter, you may prefer to use the bargraph display as shown in Figure 5 for displaying the SWR reverse voltage. I modified my Z-Match tuner to use this method for indicating reflected power. I still use only the green LED for forward power indication. The nice thing about using the bargraph display is that it seems to be easier to dip the SWR since this gives you more of an analog meter “feel”.

Conclusion

The Z-Match Tuner is an extremely easy antenna tuner to adjust. In the past, the biggest limitation to a compact 100-watt version was the necessity of using large air-wound inductors, and the ability to find reasonably priced multi-section variable capacitors. The tuner described in this article overcomes these obstacles. The result is a wide-band, easily adjustable tuner that is perfect for either portable or base station operation.

Table 1 – Major Parts List and Sources

Part	Source
T157-6	Amidon Associates (www.amidon-inductive.com)
FT37-43	Amidon Associates (www.amidon-inductive.com)
*400pf 2-section var. caps.	Oren Elliott S2-399x2 (www.orenelliottproducts.com)
LM3914	All Electronics LM3914 (www.allelectronics.com)
Metal Case	Eagle 40UB103 (www.mouser.com 40UB103)
PC or Perf-board	All Electronics PCB-46 or equiv. (www.allelectronics.com)

* If you substitute another variable capacitor, you should use one with at least 350 pf per section, rated at 500 volts rms minimum.

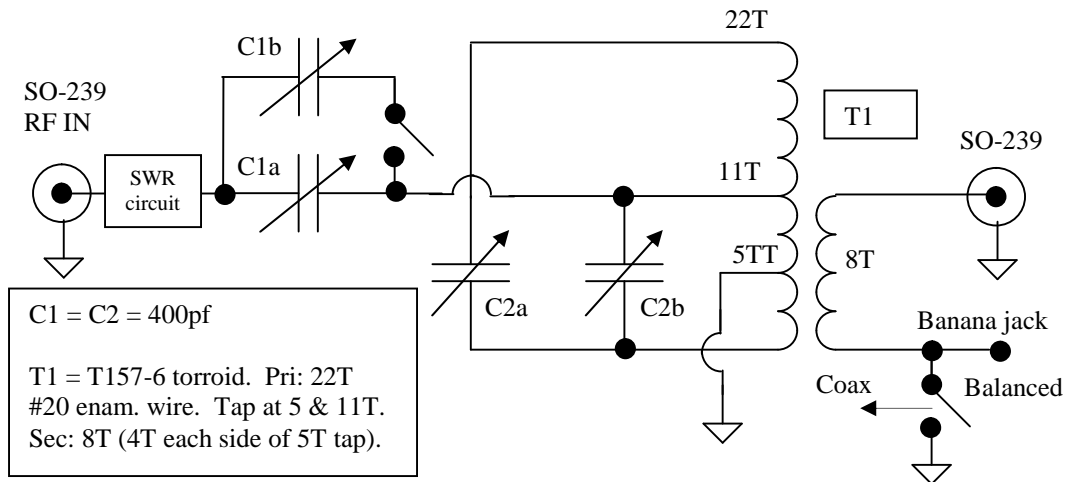


Figure 1: Z-Match Antenna Tuner

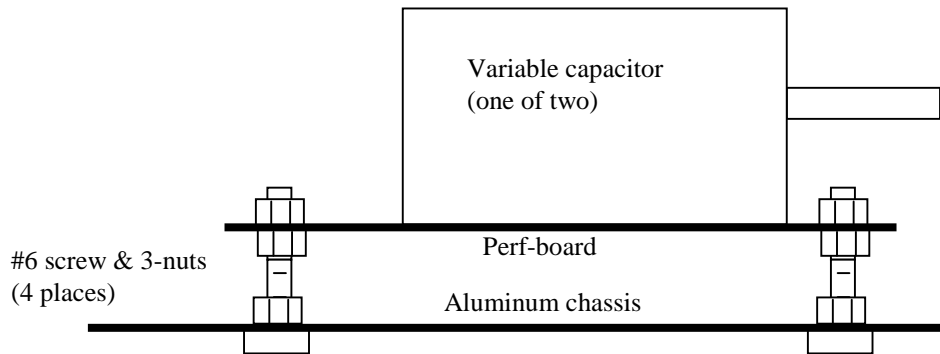


Figure 2: Capacitor Mounting Assembly

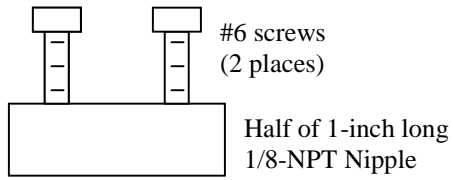


Figure 3: Shaft coupling assembly

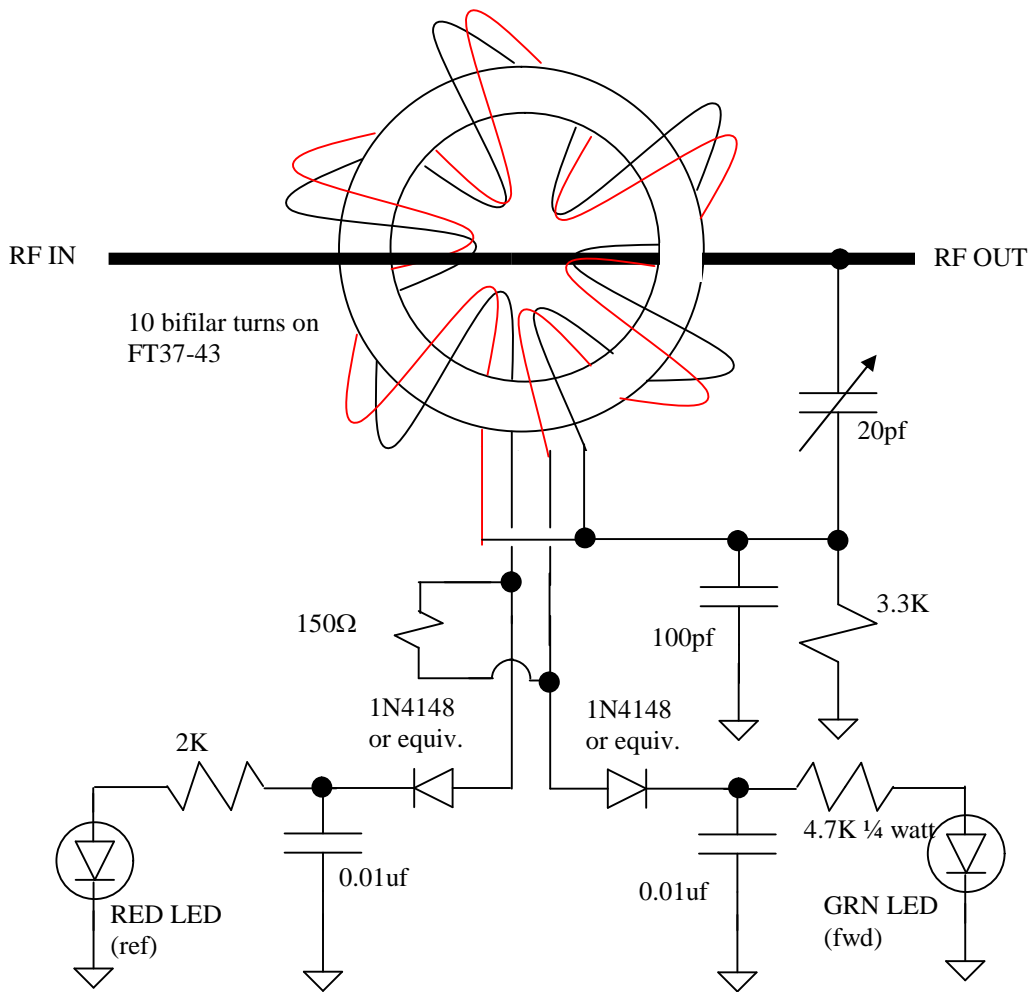


Figure 4: Optical SWR Meter

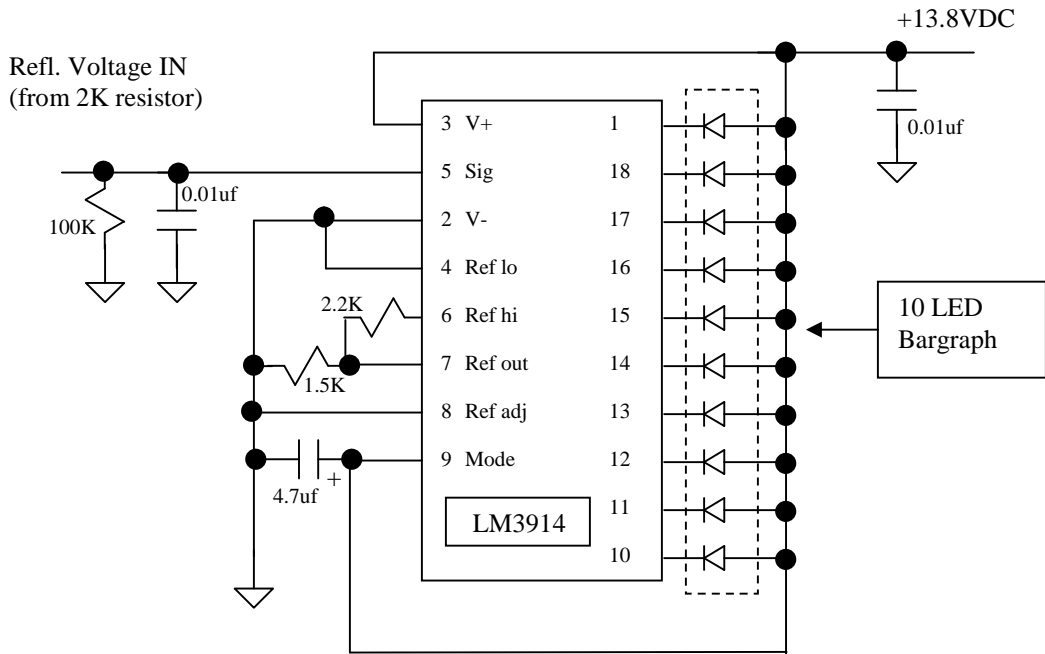
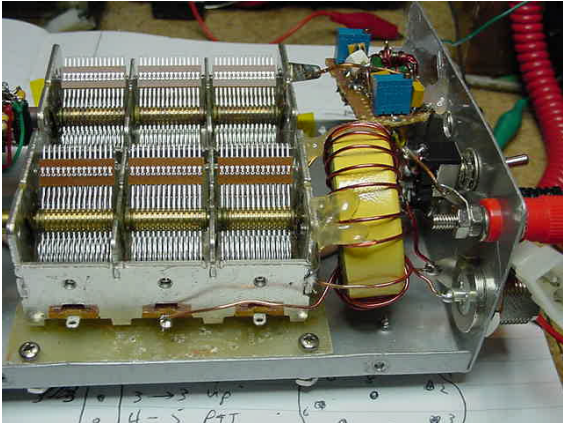
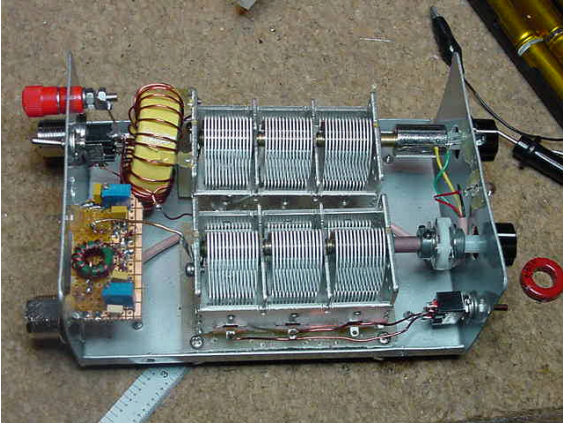


Figure 5: SWR Bargraph Modification



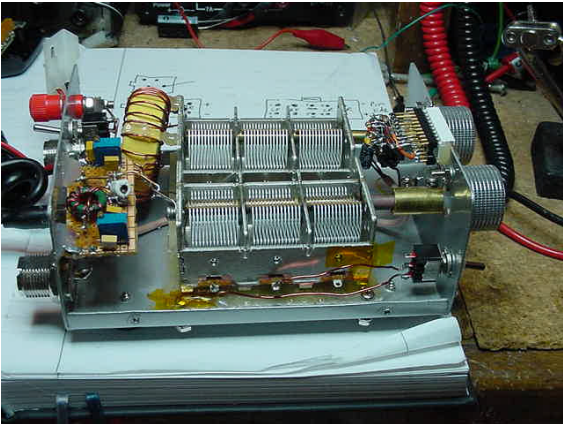
Coil Detail



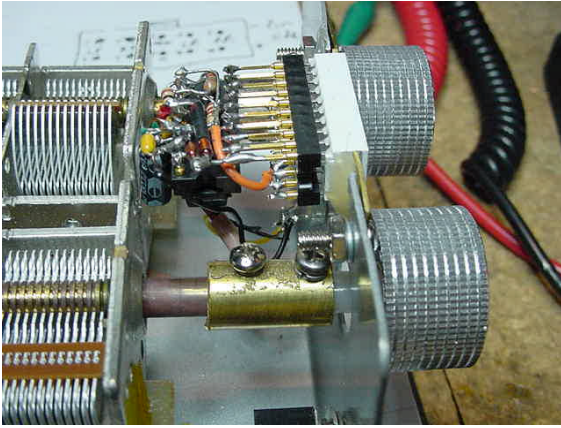
LED Tuner inside with SWR board



LED Tuner front panel



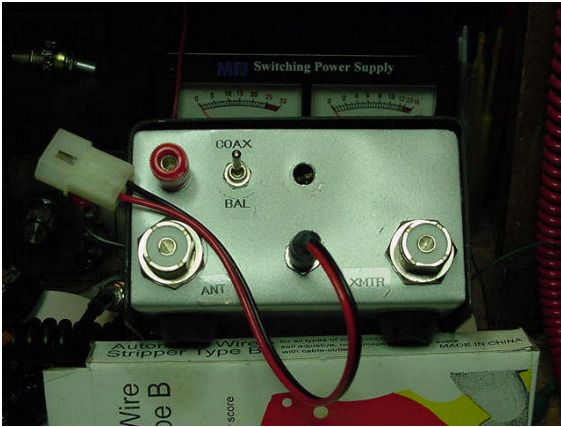
Bargraph Tuner inside



Bargraph Tuner inside close-up



Bargraph Tuner front panel



Tuner backside with power for bargraph