About this Article

This material was included with the downloadable supplemental content accompanying the *ARRL Antenna Book*.

You may print a copy of this material for personal use. Any other use of the information requires permission from the ARRL.

Copyright/Reprint Notice

In general, all ARRL content is copyrighted. ARRL articles, pages, or documents – printed and online – are not in the public domain. Therefore, they may not be freely distributed or copied. Additionally, no part of this document may be copied, sold to third parties, or otherwise commercially exploited without the explicit prior written consent of the ARRL. You cannot post this document to a website or otherwise distribute it to other through any electronic medium.

For permission to quote or reprint material from ARRL, send a request including the issue date, a description of the material requested, and a description of where you intend to use the reprinted material to the ARRL Editorial and Production staff at: **permission@arrl.org**.

By Phil Salas, AD5X

A Compact 100-W Z-Match Antenna Tuner

The nice thing about the Z-Match tuner is that it will match just about anything on the HF bands and it uses only two controls. Here's a 100 W version using toroid inductors.

After reading about Z-Match antenna tuners for quite a while, I eventually capitulated and bought an Emtech ZM-2 QRP Z-Match tuner kit.[1] After building it to go along with my Yaesu FT-817, I became a real believer in the Z-Match design. The folks who use these tuners speak very highly of them, but it had always appeared to me that acquiring the necessary air-wound inductors and variable capacitors for a higher power (100 W) version was more trouble than it was worth. In addition, air-wound inductors implied larger enclosures and I was interested in a tuner that was compact enough for me to easily take along with my portable HF setup that used an ICOM IC-706.

I later discovered an excellent article on Z-Match tuners by Charles Lofgren, W6JJZ.[2] In that article, the author suggested using a toroidal core inductor. This idea effectively solved the inductor size problem for me. I then found that 440 pF (per section) variable capacitors were available from Fair Radio Sales.[3] Similar capacitors are available from other sources, although it might take a bit of hunting. All of my excuses for not building a 100 W version of the Z-Match had vanished!

Construction

The final circuit shown in Figure 1 is based on W6JJZ's article, with the output transformer changed to a single 8-turn output link. Also, 440 pF per section variable capacitors were used for C1 and C2. So far, I haven't found anything I can't match and that's from 80 through10 meters!

I built the tuner in a 5¼×3×5 inch (HWD) aluminum box. Toroid L1 is supported by its own leads, as shown in Figure 2. Some hot glue is used between this inductor and the frame of C2, one of the variable capacitors. I also put a little hot

[1]Notes appear on page 30.

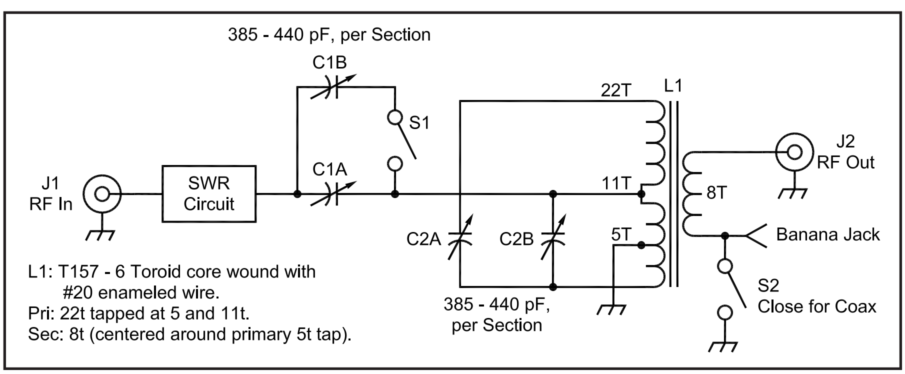

Figure 1—Schematic of the 100-W Z-Match tuner. AA = Amidon Associates (www.amidon-inductive.com); RS = RadioShack (www.radioshack.com); FRS = Fair Radio Sales (www.fairradio.com).

C1, C2—385-440 pF 2-sec variable capacitor (FRS APS-440 or equivalent).
C3—2-20 pF variable capacitor (RS 900-5850).
C4—100 pF capacitor (RS 272-123).
C5-8—0.01 µF capacitor (RS 272-131).
C9—4.7 µF capacitor (RS 272-1012 or 272-1024).
D1—Red LED, high-intensity (RS 276-307).
D2—Green LED, high-intensity (RS 276-304).
D3, D4—1N4148 (RS 276-1122).
L1—T157-6 toroid (AA).
L2—FT37-43 toroid (AA).
R1—150 Ω, ¼ W.
R2—3.3 kΩ, ¼ W.
R3—2 kΩ, ¼ W.
R4—4.7 kΩ, ¼ W.
R5—100 kΩ, ¼ W.
R6—2.2 kΩ, ¼ W.
R7—1.5 kΩ, ¼ W.
S1, S2—SPDT mini-toggle switch (RS 275-634).
U1—Display driver IC, LM3914 (RS 900-6840).
U2—10-LED bar graph display (RS 276-081).
Misc
J1, J2—SO-239 connectors (RS 287-201).
Enclosure (RS 270-253).
Perforated board (RS 276-1394).
#20 solid enameled wire.
#26 solid enameled wire.

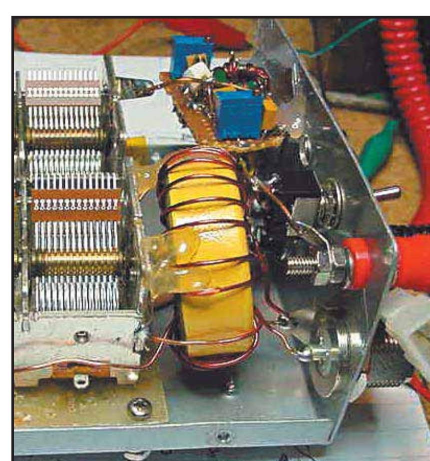

Figure 2—L1 is mounted with hot glue to the bracket of C2, but also supported by its leads.

glue between the inductor and the side of the enclosure.

Because both variable capacitors must be insulated from ground, including their shafts, I mounted both on a piece of perforated board that was cut to fit the aluminum case. The assembly is mounted in the case with stand-off screws, as shown in Figure 3. I made my own capacitor shaft couplings from a 1/8-NPT brass nipple, available in the plumbing section of most hardware stores. These nipples have a ¼-inch inside diameter. Cut a 1-inch long nipple in half to make two couplers. Drill and tap holes for two #6 set screws in each coupling. The completed shaft coupling is shown in Figure 3. For the insulated shafts, I used ¼ inch diameter nylon rods, which are also available from most hardware stores.

Operation

Tuning the Z-Match tuner is very easy. First, adjust the resonating capacitor 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, use S1 to switch in extra sections for C1. Balanced feed lines, which are terminated in banana plugs, plug into the center pin of the output SO-239 and the adjacent banana jack. To feed coax, ground one end of the output link with switch S2.

Optical HF SWR Meter

You can use an external SWR meter with the Z-Match tuner, but I built a convenient optical (LED) SWR meter into the same case. It works well with the newer high intensity LEDs that are currently available. The schematic is shown in Figure 4A. I built the circuit on a small piece of perforated board and mounted it into the Z-Match tuner enclosure. This can be seen in Figure 5. I also added a bit of hot glue between the perforated board assembly and the back of the chassis.

This broadband circuit works well at the 100 W level through at least the 10 meter amateur band. With short leads, it should work well 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 single wire passing through the center of the toroid. To calibrate the SWR bridge, connect the output to a resistive 50 Ω load. Apply RF power on any HF band and adjust the 20 pF variable capacitor until the REFL LED goes out.

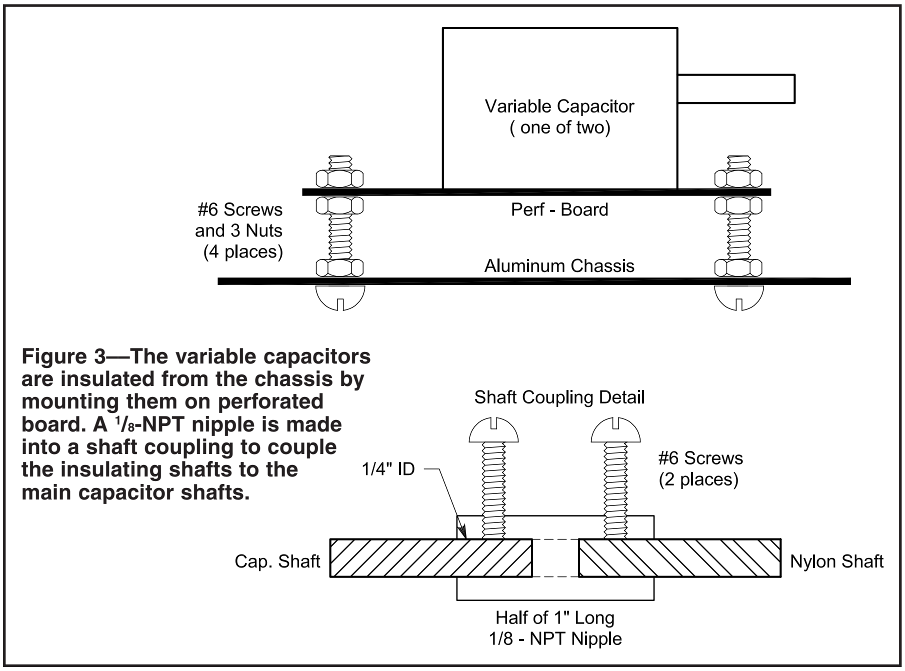

Figure 3—The variable capacitors are insulated from the chassis by mounting them on perforated board. A 1/8-NPT nipple is made into a shaft coupling to couple the insulating shafts to the main capacitor shafts.

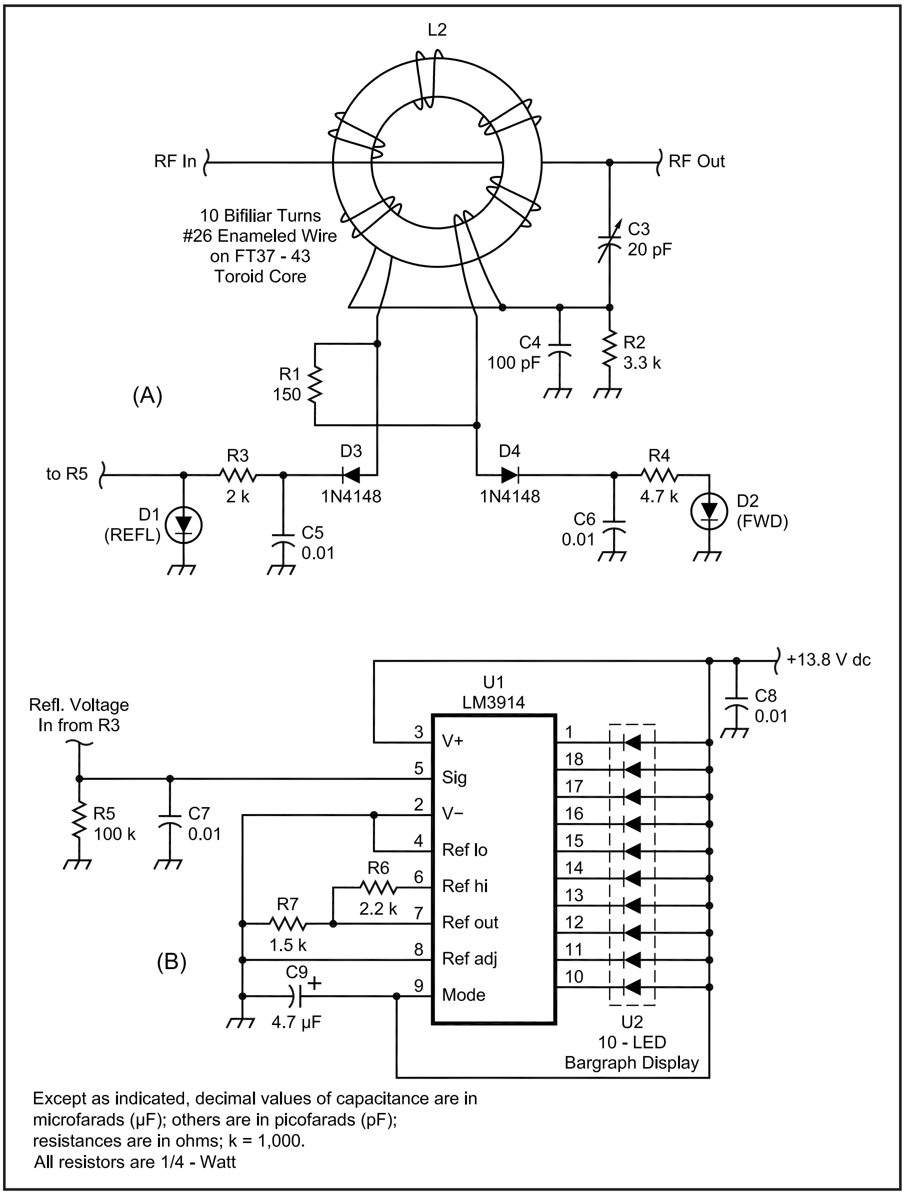

Figure 4—Optical SWR meter schematic with the bar graph display modification (see text). The basic LED version is shown in A and the bar graph addition in B.

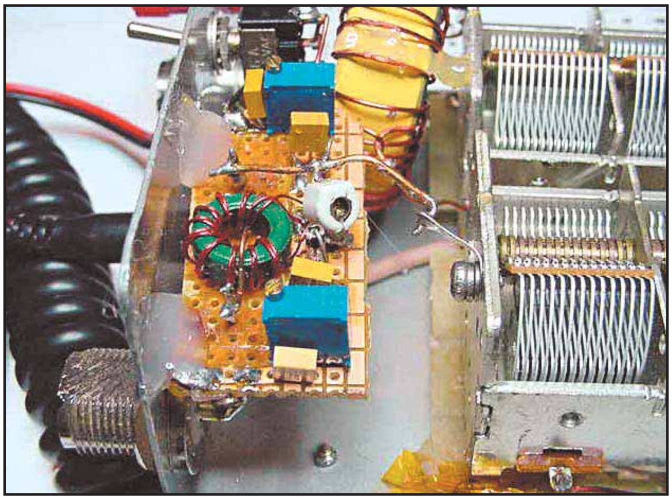

Figure 5—The SWR Meter circuit is soldered directly to the RF Input connector and attached to the back panel with hot glue.

Figure 6—The bar graph display of reflected power makes tuning easier and more intuitive.

Figure 7—The completed Z-Match Tuner and IC-706 make a nice portable HF package.

Adjust the Z-Match tuner for minimum brightness of the REFL LED. When this occurs, the SWR will be something less than 1.5:1. The brightness of the FWD LED is an indication of transmitter forward power output. If the green LED is too bright, increase the value of the current limit resistor in the FWD circuit. If desired, you can eliminate this LED completely and use only the REFL LED.

If you can supply dc power to your Z-Match Tuner and SWR meter, you may want to add a bar graph display for the SWR reflected power. This is shown, schematically, in Figure 4B and physically, in Figure 6. It uses an LM3914 LED display driver to drive a bar graph display and takes its input from the reflected voltage output of the SWR sampler. If you do use the bar graph display, you can remove LED 1 and connect pin 5 of the LM3914 input to the output of R3. The nice thing about the bar graph display is that it seems easier to null the reflected power, as this display brings the operator closer to the intuitive "feel" of a classic analog meter pointer, but it does require an external dc voltage.

Conclusion

The completed Z-Match tuner on top of the IC-706 is shown in Figure 7. It is very easy to adjust. The biggest obstacles to construction of a compact 100 W version, the necessity of using large air-wound inductors and finding cost-effective multi-section air-variable capacitors, were overcome. The result is an inexpensive, wide-band, easily adjustable tuner for portable or base station operation.

Notes

[1] Emtech, 1127 Poindexter Ave W, Bremerton, WA 98312, tel 360-405-6805; **www. emtech. steadynet.com**.

[2] C. Lofgren, W6JJZ, "An Improved Single-Coil Z-Match," *The ARRL Antenna Compendium, Vol 5*, p 194.

[3] Fair Radio Sales, 2395 St Johns Rd, Lima, OH 45802, tel 419-227-6573; **www.fairradio. com**. Similar capacitors in this range are available from other sources.

Phil Salas, AD5X, has been a ham for 38 years. He is an ARRL Life Member, and is currently the Director of Hardware Engineering at Celion Networks in Richardson, Texas. You can reach the author at **ad5x@arrl.net**.

NEW PRODUCTS

WINCAP WIZARD 3 PROPAGATION PREDICTION SOFTWARE

◊ Kangaroo Tabor Software has released *WinCAP Wizard 3*, a specialized "third generation" front end for the powerful *VOACAP* propagation prediction engine. The software provides simultaneous HF propagation predictions from 18 DX locations around the world and is exceptional at HF propagation prediction and link analysis. By comparing real-time received signals with predicted values, users can learn about the intricacies of worldwide HF propagation as they calculate the best times to make contact with hams in various parts of the world.

Price: $65. Download a free trial version at **www. taborsoft.com/wwizard3**. For more information, contact Kangaroo Tabor Software at 1203 County Rd 5, Farwell, TX 79325-9430, fax 806-225-4006, **www.taborsoft.com**.