Portable Trekking Loop Antenna for SOTA
By Robert Capon, W3DX

In August, I wrote an article on adapting existing loop antennas to work with lightweight carbon fiber trekking poles. In this article, I describe a custom-made control box and home-made loop antenna, which you can build for less than $50-75 in parts and adapt to whatever carbon fiber trekking poles you use. A 9-foot loop with LMR400 or LMR240 covers 40-15 meters. For those who need coverage on 40-10, a 6-foot length of LMR400 will do the trick at the expense of some efficiency. One control box works for all three loops, so I've color coded the loops and band markings to simplify operation.

This antenna meets these design goals: multi-band, tree-independent, weight less than 2 pounds, and setup in less than 5 minutes. The final version of the antenna came in at 2 lbs (including the trekking poles), and sets up in 3 minutes (my wife timed me). If you don't count the trekking poles under the theory that you're carrying them anyway, the antenna comes in at 1 lb, 7 ounces. But, OK, let's say you weren't carrying trekking poles and the antenna weighs 2 lbs.

If you substitute LMR240 coax (1/4-inch diameter) for LMR400, the antenna is even lighter: 1 lb, 10 ounces with the trekking poles, and a cool 1 lb, 1 ounce without the trekking poles. And the loop coils up to about 7 inches with the LMR240 as compared to 11 inches with the LMR400 and fits in a freezer bag:

The antenna has done a great job on the air, and was my main antenna for 35 SOTA activations in 2015. After you setup the antenna, you can tune it by peaking the audio in your receiver, so it doesn't require a tuner or antenna analyzer in the field. I put color-coded band-markings on the case to quickly pre-tune the antenna to the desired band, and then peak-up the audio in just a few seconds.

Trekking poles are incredibly versatile. In addition to trekking and supporting your miniature loop antenna, they have lots of other uses: supporting a tent, hanging laundry, fly-fishing (see below), defending yourself against a bear (not recommended), etc. So they're great to have for SOTA expeditions and double as a handy support for the antenna.

Part I: Build the loop and support structure (Part II is the control box). See photos below for details.

Step 1: Find a pair of carbon fiber trekking poles that can be joined handle-to-handle. I searched high and low for a good solution, and found these 3-piece "Yana" trekking from a company named Ruta Locura. The poles weigh just 4.6 ounces each, break down into 3 pieces so they're airline friendly, and have a great way to join together. When you order them, be sure to ask them to include a 5-inch splice tube that can be used to join the trekking poles handle-to-handle:

http://www.rutalocura.com/trekking_poles.html

The Yana is a really cool trekking pole. If you're a fisherman, the web site shows the 1-ounce "Tenkara" fly rod kit to use your trekking pole as an 11-foot fly rod! So you can use the poles to operate your SOTA station, do some fishing in the afternoon, and set up your tent at night. Nice.

Step 2: Build a guy system. I used a lightweight plastic lid from a jar of honey with a hole cut in the center that fits over the trekking pole splice, and three holes to hold lightweight guys. The guys are held by small aluminum stakes. I used bright yellow string, to reduce the risk of hikers tripping over the guy ropes on the trail. The strings are permanently fastened to the lid and the aluminum stakes using a "bowline" knot, again for rapid setup.

Step 3: Purchase or build the large magnetic loop. I've experimented with a lot of coax types for the main loop and prefer LMR-400. LMR-400 is lightweight, but very stiff to hold its shape. I **DO-NOT** recommend LMR-400 ultra-flex or RG-213, they simply won't hold their shape and sag like spaghetti when you try to set it up.

To make the loop you'll need a 9-foot length of LMR-400 terminated with silver male PL-259 connectors on each end. You can build the assembly, or order an inexpensive coax assembly here:

http://www.amateurradiosupplies.com/category-s/152.htm

To use the order form, order LMR-400, quantity 9 (for 9-feet), and select quantity 1 (for 1 pair) of the "Standard x2 PL-259 M Connectors Installed". Note, these are a pair of silver connectors.

Step 4: Assemble the small loop feedline assembly. I used a 22-inch length of #12 solid copper wire with a Teflon (or other plastic) coating. To prepare the loop, I stripped ½-inch from each end of the wire. I then formed the wire into a small loop with the stripped end bent on each end. I then took a short length (about 8-feet) of RG-174u lightweight coax and terminated one end with a BNC connector. The other end attaches to the small loop, center conductor to one side, braid to the other. I slipped some heat-shrink tubing over the loop before soldering the coax, then slipped the heat shrink over the solder joint, and shrunk them down to stabilize the connection. A photo shows this detail.

Step 5. Build a bracket to hold the large loop, the small loop, and fasten them to the trekking pole. I experimented with a lot of solutions seeking rapid setup and light weight. I wound up cutting a bracket out of a 3-inch PVC end cap. The bracket has a groove to hold the small loop, and two slots for a nylon tie strap (heavy duty, 175 pound rating). Note the tie strap does double-duty: it holds the loop to the bracket, but you can also leave a length of excess tie strap to provide further support for the small loop. (See photo.)

The groove was cut with a dremel tool using a router bit. The slots were cut with a dremel tool using a cutoff wheel. I use a pair of 1/2 inch nylon straps to fasten the bracket to the trekking pole. The nylon straps are held with a 3/4-inch 6-32 screw, lockwasher and nut. The beauty of this system is that it weighs just 1 ounce and slips over the end of the trekking pole for rapid setup.

The antenna has a permanently integrated assembly of large loop, small loop, feedline and mounting bracket. With the above design, you simply unfurl the assembly, and slip it over the top of the trekking pole.

Part II: Build the 6-Ounce Control Box Assembly

One word of caution: Miniature loop antennas actually have significant voltages in the tuning capacitor, so it's important to electrically isolate the capacitor from the control box. Please follow the instructions below which include using electrical tape and nylon fasteners and parts to accomplish this.

Step 1: Prepare the case. I found a Radio Shack 270-283A case on EBay for a few bucks. You can also find a "Waterproof Project Box 85mm x 58mm x 33mm" if you search EBay. Prepare the case as shown in the photo by drilling holes for the SO-239 female connectors, the shaft of the tuning capacitor, and the four mounting holes to mount the tuning capacitor. Please see photo. "Measure twice, cut once."

Step 2: Mount the female SO-239 connectors. I found silver connectors on EBay for a few dollars. The silver connectors reduce the resistance in the loop and make the loop work more efficiently. I've built several of these control boxes, and it's much easier to install the connectors before you do anything else. I used a socket set to tighten down the SO-239 connectors to the case using the supplied lockwasher. One way to hold the connector in place is to screw a PL-259 male connector on the outside, and then hold it in place with pliers. (If you use pliers on the female threads, you'll damage them.)

Step 3: Prepare the mounting bracket. I use a single 7/16-inch nylon strap to hold the control box to the trekking poles. To hold the nylon strap to the control box, use 6-32 mounting hardware: a 1-inch screw, lockwasher and brass knurled knob. Note the electrical tape on the inside (opposite side) of the aluminum mounting plate to insulate the case from the tuning capacitor.

Step 4: Prepare the tuning capacitor. You can buy a 365 pf, single gang, air variable capacitor with a built-in 8:1 reduction drive shaft from the Crystal Society, available for $20. While you're at it, you can

order the “Connector Assortment” from the Crystal Society for $4. This provides a nice assortment of hardware, solder lugs, and nylon pieces to make a tuning shaft:

http://www.midnightscience.com/catalog5.html

The tuning cap will be mounted to the case with two nylon screws. The Radio Shack case has a little taper, so I used two screws to tilt the tuning capacitor to the case. See the photo below, and turn the tuning capacitor over with the shaft pointing towards you. On the far-right hole, mount a 6-32 nylon screw. Use a dremel tool to cut it down to about ¼-inch so that it doesn’t reach the capacitor blades.

Next, solder a 4-inch length of solid copper hook-up wire to one of the solder lugs on the right side of the tuning capacitor.

Next, solder a 6-inch length of hookup wire to a solder lug. Take a 6-32 screw and cut it down to about 3/16-inch. Then, screw the solder lug in place to the upper left hole (furthest away from you).

Step 5: Next, mount the tuning capacitor inside of the plastic case with nylon, 6-32 screws. Again, you’ll have to cut them down to size so they don’t reach the capacitor tuning blades, about 3/8 to ½-inch in length.

Step 6: Solder the hookup wire to the SO-239 female connectors, soldering to BOTH the ground lug and the center conductor. Then use the screws to close up the box.

Step 7: Build a shaft for the control box. A shaft works MUCH better than a tuning knob because it isolates the capacitance of your hand from the tuning box, and makes tuning more stable.

I used 6-32 set screws and fashioned a tuning shaft with knob. The shaft has a thumbscrew to quickly install the shaft in the field (part of the 3-minute setup process.) I also made a fold-over shaft using a cotter pin (see photo), to have a tuning shaft that’s permanently installed, but folds over for rapid setup.

Step 8: Label the control box. This is optional, but I find it’s very handy to have labels to pre-tune the control box in the field. On the front of the box, I labeled the panel for each band. On the back of the box, I labeled how many extra revolutions of the tuning shaft are required. (Please see labels below: “40, 30 m + 2 turns”. “20, 17, 15 m + 3 turns”). For example, to tune for 20 meters you have to make 3 complete revolutions of the tuning knob, then set the 20 meter position at the 4:00 position on the control box. Thereafter, peak the antenna for maximum received signal.

Be sure to practice setting up and tuning the antenna in your backyard to get the hang of tuning it up before your first SOTA activation.

Part III: Optional LMR240 Coax Loop

I tested my trekking loop antenna with a 9-foot length of LMR240 as the radiator, rather than the same length of LMR400. The LMR240 coaxial cable is ¼-inch in diameter compared to .4 inches for the LMR400. Because skin effect is important for these radiators, one would expect the LMR240 to be less efficient than the LMR400. The question is whether or not it's good enough. The short answer is: yes.

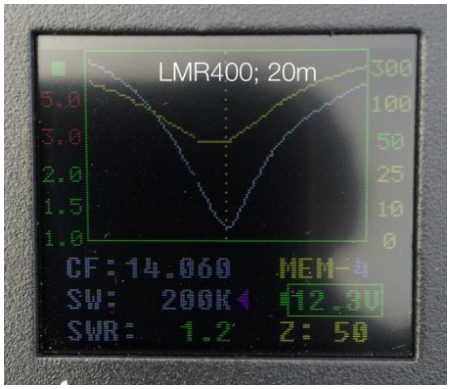
The benefits of the LMR240 are that it's light-weight, and rolls up into a smaller coil: 7-inches in diameter for the LMR240 compared to 11 inches for the LMR400. The LMR240 reduced 6 ounces from the antenna as follows:

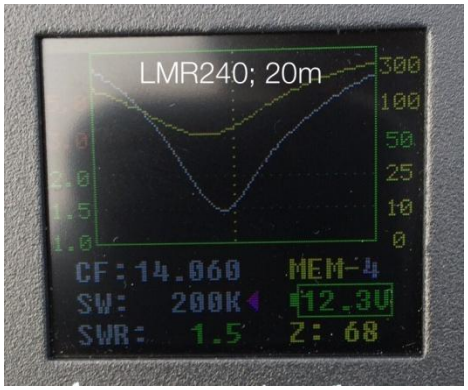
LMR400 Trekking Loop: 2 lbs with trekking poles; 1 lb, 7 ounces without poles
LMR240 Trekking Loop: 1 lb, 10 ounces with trekking poles; 1 lb, 1 ounce without poles

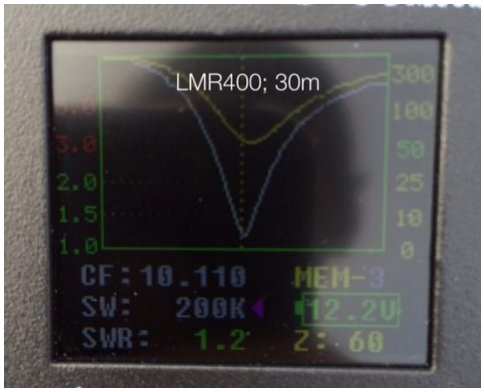
That's right, the entire antenna system weighs 17 ounces, not including the trekking poles and everything fits in a freezer bag. That's pretty good for an antenna that's free-standing (tree independent), covers 40-15 meters, sets up in 5 minutes that you can build for $50.

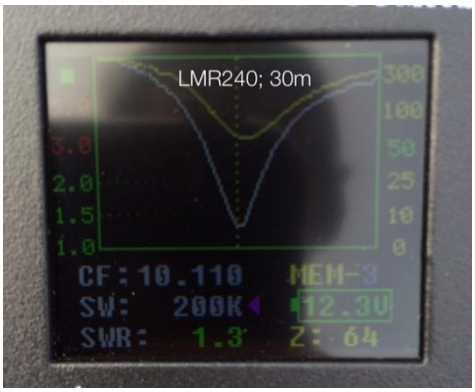
The LMR240 tuned up very easily, and it actually tuned in the same pre-marked spots on my control box as the LMR400. The LMR400 had a slightly better SWR:

LMR400: 1.2:1 on 20 meters, 1.2:1 on 30 meters
LMR240: 1.5:1 on 20 meters, 1.3:1 on 30 meters









On-air performance was very similar. W0MNA in Missouri got on the air and gave me signal reports as follows:

LMR400, 20 meters, 539. LMR240, 20 meters: 529. (1 “S” unit difference).
LMR400, 30 meters: 529. LMR240, 30 meters: 529. (Same).

W0MNA reported the 20 meter performance was actually very close with QSB on the band, and thought the “S” unit might be related to QSB.

LMR240 is a satisfactory radiator for small loop antennas. The LMR240 shaves 6 ounces off of the antenna system, and coils to a very compact 7-inches for a trail-friendly package. The LMR400 remains an excellent solution, and gives slightly better performance than the LMR240 if size and weight are not critical.

Part IV: 6-foot LMR400 loop for coverage on 40-10 meters

The capacitor’s tuning range isn’t quite low enough to tune the 9-foot length of LMR400 on 12 and 10 meters. A simple solution is to shorten the loop to 6-feet, which will cover 40-10 meters. If you do so, there’s no free lunch and the antenna will be less efficient, especially on the low bands.

If you build a 6-foot (circumference) loop, remember that the miniature (inside) coupling loop also has to be reduced in length so the two loops remain proportional. A length of 15-inches of the #12 wire will keep the dimensions of the two loops proportional.

If you decide to build all three loops, you can select the right antenna for your operating plan for the day. And you can color-code the antennas and the band markings with labels:


One control box can provide very good results on 40-10 with 3 different loop designs, and a particular loop can be chosen for a particular operation. Here is a summary of the results, with the calculated efficiency (see below for a link to the loop calculator) provided for 20 meters:

- 9-foot length of LMR400. Covers 40-15. 20 meter efficiency 37%.
- 6-foot length of LMR400. Covers 40-10. 20 meter efficiency 15%.
- 9-foot length of LMR240. Covers 40-15. 20 meter efficiency 26%.

That's an interesting result: the penalty for the lighter coax is smaller than the penalty for the shorter length of the heavier coax.

Part V Analytical Resources

As you experiment with loops, it's very helpful to compare the efficiency and capacitances of different designs. This website provides a great tool for doing so.

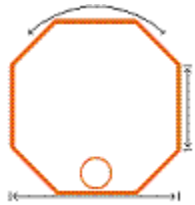
http://www.66pacific.com/calculators/small_tx_loop_calc.aspx

Using 9-feet, .4-inch coax, 5 watts and 14 MHz gives these results:

RESULTS:
Antenna efficiency: 37% (-4.4 dB below 100%)
Antenna bandwidth: 28.6 kHz
Tuning Capacitance: 88 pF

Capacitor voltage: 564 volts RMS
Resonant circulating current: 4.35 A
Radiation resistance: 0.048 ohms
Loss Resistance: 0.084 ohms
Inductance: 1.47 microhenrys
Inductive Reactance: 130 ohms
Quality Factor (Q): 490
Distributed capacity: 7 pF

Antenna "circumference": 9 feet



Side length: 1.13 feet

Antenna diameter: 2.7 feet

Comments:
The specified conductor length of 9 feet is OK.

Conductor length should be between 8.52 and 17.0 feet at the specified frequency of 14 MHz.

For highest efficiency, the conductor length for a small transmitting loop antenna should be greater than 1/8 wavelength (greater than about 8.52 feet at the specified frequency of 14 MHz).

To avoid self-resonance, the conductor length for a small transmitting loop antenna should be less than

1/4 wavelength (less than about 17.0 feet at the specified frequency of 14 MHz).

Input Values:
Length of conductor: 9 feet
Diameter of conductor: .4 inches
Frequency: 14 MHz
Transmitter power: 5 watts

Conclusion:

In conclusion, this is an antenna that you can build for about $50-$75 that weighs less than 2 pounds, is free standing and tree-independent, works on 40-15 meters, that you can set up in 3-5 minutes. Not counting the trekking poles, which I use anyway, the other antenna components weight just 1 lb, 7 ounces, or as little as 1 lb, 1 ounce with the LMR240 option!

For overall performance, I would use the 9-foot length of LMR400. The entire antenna weight is 2 pounds, 1lb, 7 ounces not including the carbon fiber trekking poles.

For operations where weight is very important, you could take the 9-foot length of LMR240. It packs up very small, and would be good for a backpacking operation, or for a plane flight. There's a slight loss of performance, but it's very compact and weighs in at 1 lb, 1 ounce without the trekking poles.

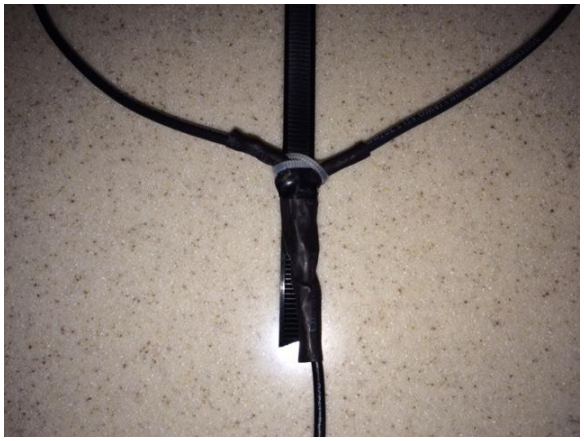
Finally, if you draw the "short straw" and get stuck with 12 and 10 meters for an operation, take the 6-foot length of LMR400. But be prepared to use somebody else's station if you can't make enough contacts on 10 meters at this time of the sunspot cycle.

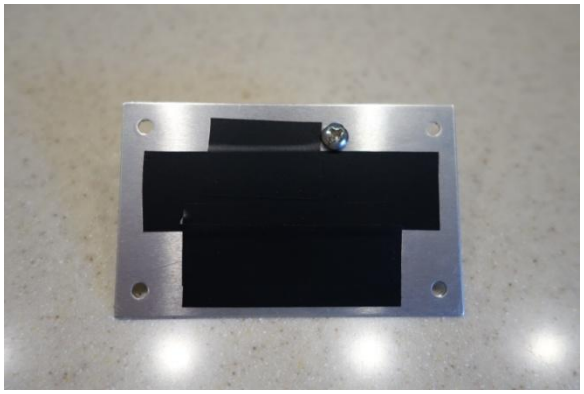
I've used the antenna on most of my 35 SOTA activations in 2015, and it's never failed to achieve a good activation using only an Elecraft KX1 running 3 watts.

73,

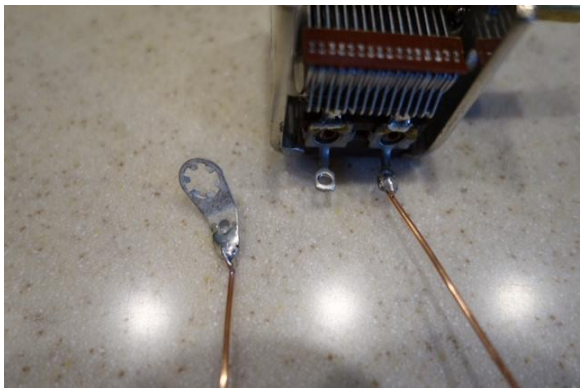
W3DX

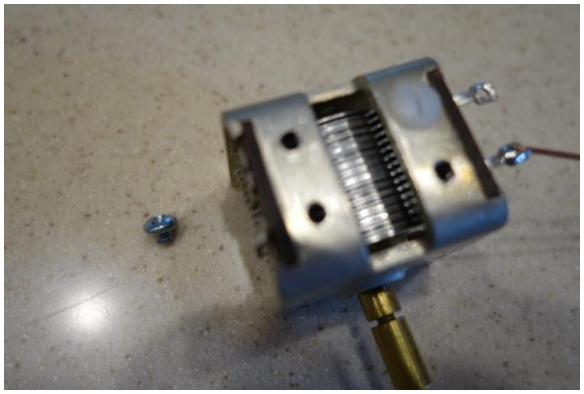
Part 1: Antenna Photos

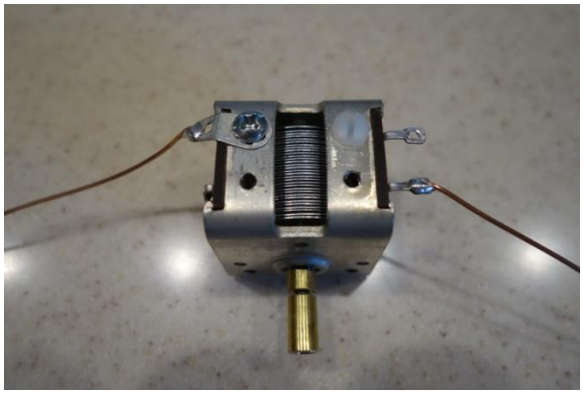


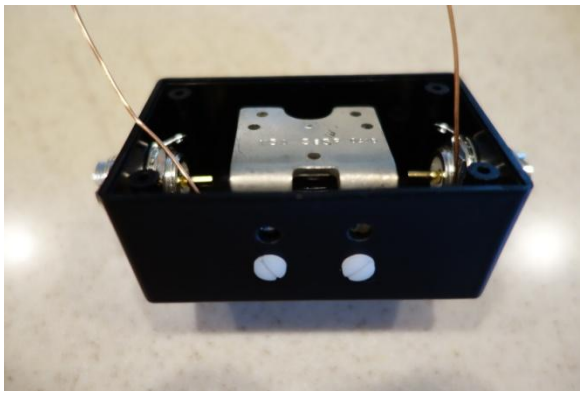


Part 2 Control Box Photos:









Fold-Over Tuning Shaft Option: