Antennas for SOTA

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INTRODUCTION

SOTA peaks came “on-line” during the summer of 2011, and that’s when I did my first activation. I elected to use a 20 meter dipole because I had one on hand. It used an RG58 feedline. I used cords wrapped around full water bottles to toss over branches to support the ends.

I stripped cord off the water bottle and it lay carelessly on the ground. My toss might have been fine, but the line on the ground caught on some twigs which dragged the throw to one side, it missed the branch entirely, and sailed over the edge of a cliff! After about 20 minutes I had climbed back up the cliff with the errant water bottle, finally ready for another try while resolving never to be throwing water bottles again.

The antenna for my second SOTA activation would need to cope with a peak above tree line. I brought a somewhat stout fishing pole and the same 20 meter dipole. I theorized that the legs of the dipole and the third leg of the RG58 feedline could form a three-way guying system for the top of the pole. Think again.

The dipole with feedline completely overpowered the fishing pole doubling it over. The more the legs were pulled, the more the pole doubled over and threatened to break. There was nothing stable about this approach.

It was after those two experiences that I thought of using an end-fed antenna where a feedline need not be supported at all. The end-fed ought to be some iteration of a halfwave because that can place the low current point near the ground to minimize ground losses without the need for a counterpoise. The wire itself can serve as the feedline in this case. That eliminates feedline losses, as well as time (weight) involved in coiling or uncoiling the line.

The wire might be deployed as a slant-wire from the top of the pole to the ground where it can easily be fed. Better, though, is to deploy the wire as an inverted-L feeding it at the base of the pole. This is because the length of wire being supported in the air by the lightweight pole will be about 20 feet shorter than a slant-wire approach. Then too, the vertical leg of the wire, with the most current at the top, provides low loss and low angle radiation for DX.

MATCHING

A resonant endfed halfwave wire will present a very high impedance which typical ATU’s can not match. Here are ways to accomplish matching it.

A 9:1 balun will convert the approximately 3,000 ohm impedance to something around 300 ohms which an ATU will handle. Keep the coax between the balun and the radio as short as possible to minimize feedline losses. Examples of a 9:1 balun can be found elsewhere on the web.

An impedance transformer of one of the two shown here can be used. For QRP power levels it is possible to build them so small that they can fit into a dental floss case. See figures #2 and #3.

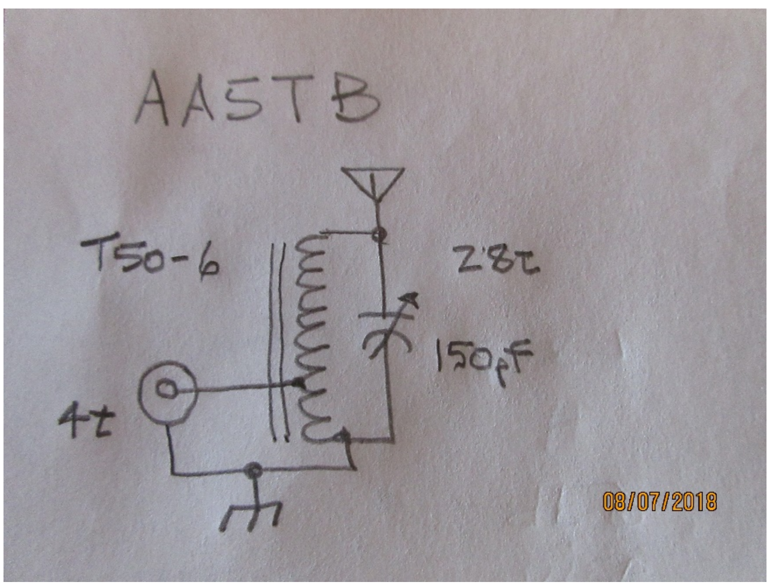
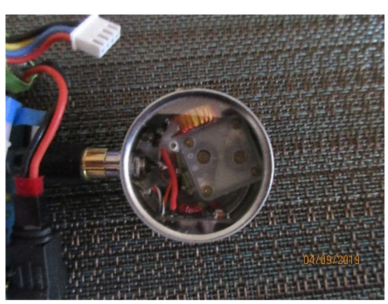


Figure # 1 a tunable high impedance matching unit



Tuned device shown with the tinySWR indicator by DK2IT. It can be tuned accurately enough just by optimizing band noise. It is shown plugging directly into an MTR type transceiver using no feedline.

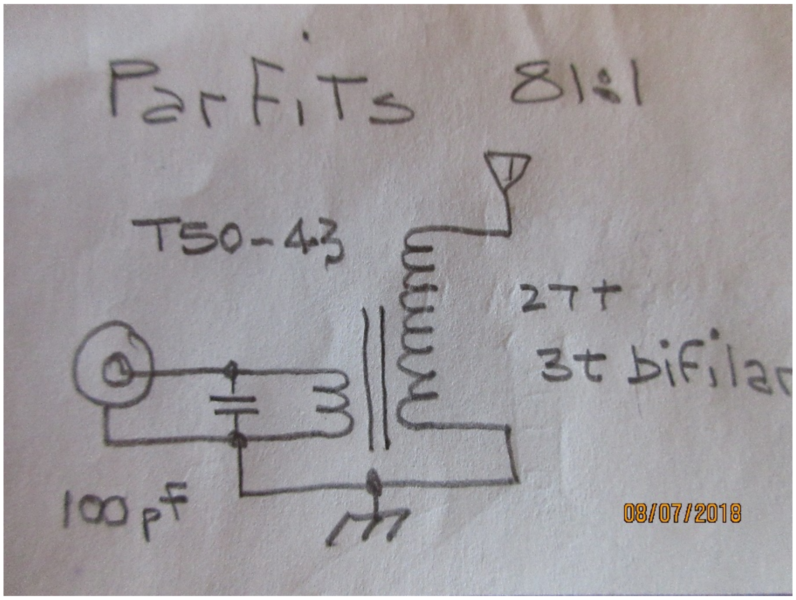


Figure #2 a 7-21 mhz broadband matching unit

Housed in a way where there is no feedline at all.

A simple 15/20/40 end-fed Antenna with GAIN

An endfed wire approximately 68 feet in length is resonant on 40 meters. Any of the above matching approaches may be used. This same wire is two halfwaves on 20 meters and presents a close enough match for an ATU. The reason it isn't a perfect match is that there are only two ends for the "end effect" which causes resonance to be shorter.

A perfect resonance for 20 meters can be achieved by dropping a short (about 24 inches) wire stub (B in figure #4) in the middle of the wire. On 40 meters it will be ignored, but on 20 meters the path will be followed because the length is resonant.

Want a BEAM on 20 meters? Here is your chance 😉 It all depends upon the shape that the wire is deployed.

Deploy the wire in the shape shown in the diagram below. It is now two top loaded halfwave verticals in phase yielding a low angle (think DX) bi-directional signal broadside to the inverted-U, with current high (no need for radials) low ground loss radiation.

In the field, use the pole to drag one end of the wire over a branch and along until approximately 17 feet of wire is hanging down. Locate the pole (or another branch over which the wire might be draped) such that the upside down U is broadside in the preferred direction.

This antenna will also present a close match on 15 meters where it is three halfwaves. An ATU should be used. The verticals will also be adding with broadside gain, and the horizontal component will also be cancelling.

Figure #3 shows this antenna with current distribution on 20 meters.

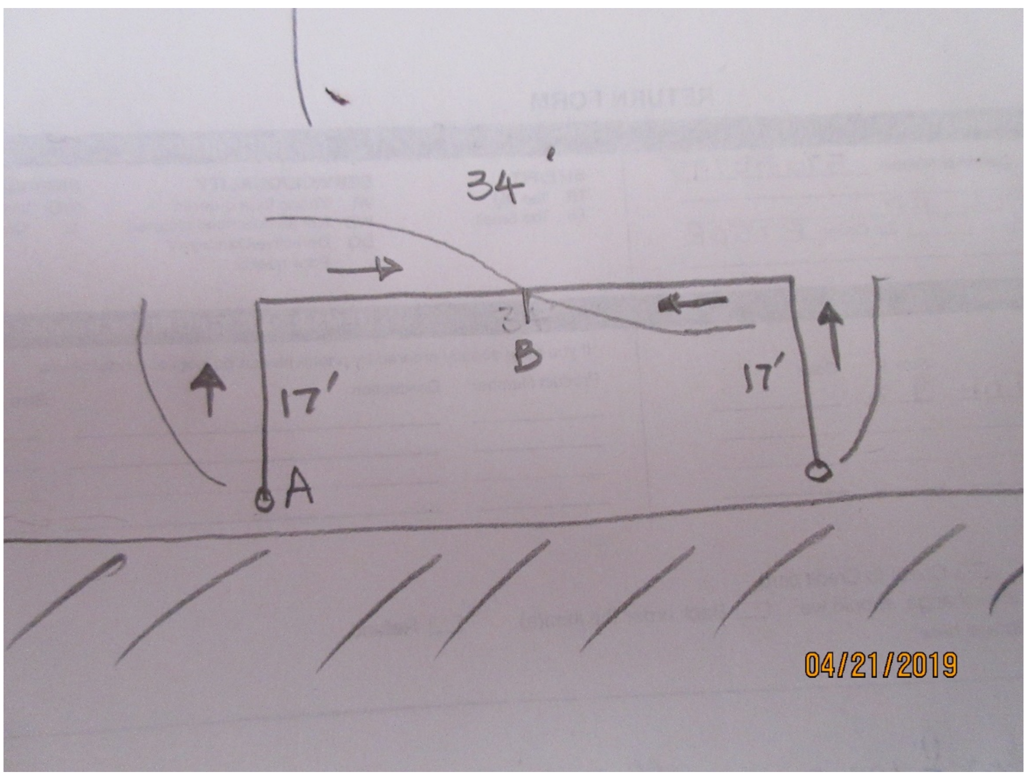


Figure #3 Inverted-U antenna with low angle broadside bi-directional gain

If using it with an ATU such as found in the Elecraft KX2, this antenna will easily tune on 10, 15, 20, 30, and even 60 meters while offering its especially low angle and directional qualities on 15 and 20 meters when deployed as an inverted-U.

In Search of a multi-band wire SOTA Antenna

RANDOM WIRE:

If an ATU is available, such as in the small Elecraft rigs like the KX2 and the KX3, the simplest approach is a “random” length wire that is matched using it. No special skills or knowledge is needed to make one.

A good length for 10 through 40 meters is about 43 feet. This may plug directly into the radio, no coaxial feedline needed. Build some sort of adapter to plug into the RF jack on the radio. The ATU can deal with presented impedances.

A counterpoise will be required. You may need to experiment with the length, and the length may need to be different for different bands. Try 18 feet as a starting point.

Understand that this counterpoise will have RF present, and it is equivalent to laying part of your antenna on the ground.

Figure # 4 … on left, an 81:1 impedance matching device built into a dental floss case for direct attachment to a BNC jack. On right, an adaptor for direct connection of a random wire to a radio with a built-in ATU.

EFHW with links:

An endfed halfwave is a resonant antenna. It is especially appealing for SOTA because the lightweight pole does not need to be able to carry the weight of a feedline. It can be used with no feedline, or a short one which begins at the base of the pole.

A counterpoise may not be needed because at QRP power levels typically used for SOTA, the radio, the headphone cable, the paddle cable, and the operator's body seem to suffice.

Approximately 67 foot wire will be resonant on 40 meters. Add the tuning stub as described earlier, and you have automatic band changing for 20 and 40 meters. But what if you would like 17 and 30 meters?

The easiest way to accomplish this is to create "links" in the wire at halfwave points for each band. You can find 2mm diameter banana plugs on ebay and elsewhere to do this.

Instead of links, it may be easier to use SPST switches. Quite small ones can be obtained.

The only downside of either of these approaches, is that changing bands may require putting the radio down and lowering the antenna wire, to operate the switches. Automatic band switching can be accomplished using traps instead of switches. Just know that building tiny traps that actually work is not easy.

TRAPS:

A trap is a tuned circuit, an inductance and a capacitance in parallel, that presents a high impedance (resistance) at its resonant frequency. Placed at the end of a halfwave length wire, it can act just like an insulator. If the signal is not resonant, then the trap acts like an inductance and will pass through the trap to the wire beyond.

Traps have been given a "bad rap." They are said to be "lossy." It isn't so. A properly made trap introduces less than a half DB of loss. A trapped dipole has two of them which together are still less than a DB, the smallest amount of loss that can be discerned. An EFHW will have only one trap (per band).

The wire length for the halfwave of lower frequencies beyond the trap will be shortened from what might otherwise be expected because of the inductance of the trap. Provided this shortening effect doesn't reduce the wirelength more than about 30%, the loss from this shortening will be imperceptible. The shortening of the overall wire length may be desirable when on a small rugged mountain peak, or when trying to support the wire with a flimsy fishing pole!

Making traps:

You MUST tune the traps. A formula will yield only an approximate result. Actual capacitor values vary, in the case of toroids, the cores vary, the winder varies in style, all mean you can not just use a certain core, a certain capacitor value, wind a specific number of turns, and expect the trap to be resonant at the planned frequency. It won't happen. If you are not familiar with measuring the frequency of a tuned circuit using oscilloscope or noise bridge, this is probably not a good project for you. Use a SPST switch as previously described.

The best traps are made using air as the insulator for the inductor. My first attempt at a QRP trap was made using ¾ inch diameter Airdux mini-ductor and a 500 volt NPO mica capacitor. Unfortunately, this inductor hasn't been available for a long time and not easily found.

Figure # 5… miniature trap made with an airdux coil

This trap works extremely well. With two of them, this antenna operates on 20, 30, and 40 meters with automatic band switching. It is fed using either of aforementioned high impedance matching transformers.

A similar inductor can be made by winding #28 wire on a small diameter non-conducting tube. The best material to use for the tube a teflon. Tiny SMD capacitors can be used. Use at least 500 volt ones described as NPO (temperature stabilized). The trap shown in figure # 6 is wound using #28 wire on a ½ inch diameter Teflon tube. Inside the tube is a length of circuitboard on which the SMD capacitor is mounted.

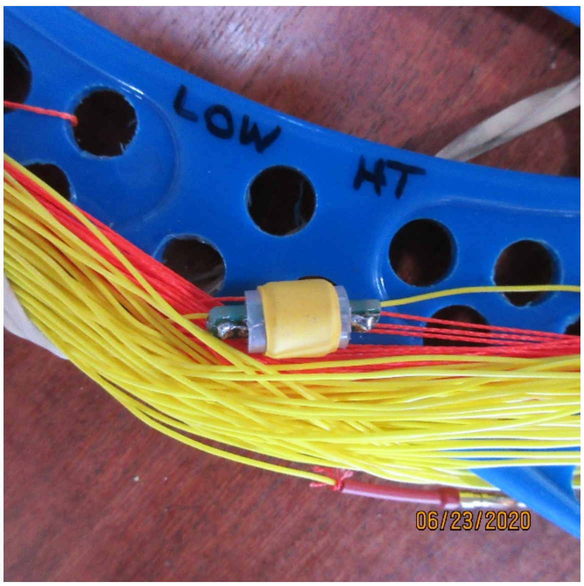


Figure # 6 homemade Teflon core trap

A tuned circuit like these shown can be made with a wide range of values. The smaller the capacitance, the larger, heavier, and greater wind resistance of the inductor. The smaller the capacitance, the higher impedance resistance that will be achieved. The resistance must be high enough to actually stop the RF from continuing into the next length of wire. A good target minimum is 1,000 ohms. Large commercial traps use very small capacitance and achieve impedances of 75,000 ohms and more!

While the two trap constructs shown above work well, inductances are relatively small, such that the overall length of the wire is shortened only a little bit. The 20/30/40 trapped wire 100 pF SMD caps and the Teflon tube inductors turned out to be about 57 feet long instead of the normal 67 feet long of a 40 meter halfwave.

To shorten the wire even more to make deployment on some peaks easier, and to make the antenna supportable by a lighter fishing pole, try using an inductor with a toroid core. In this frequency range, use a T50-6 yellow core.

The wire length before the first trap in the wire should be very close to the same length it would be if instead of a trap there was an insulator. In the case of a 20/30/40 (two) trapped EFHW wire, that first length should be very close to 32-6. If resonance occurs at a significantly shorter length the trap is not fulling stopping the RF. If adjusting the lengths of wires past the first wire length, changes the resonance of that first length, this, too, is symptomatic that the trap is not working well as an insulator.

There are (at least) two ways a trap might fail. The first is it may not be tuned to the right frequency. Extremely high impedance commercial traps may be tuned to a frequency quite a bit lower than the frequency of use, but these tiny traps don't achieve such high impedance and really need to be tuned close, about 100 khz below the intended frequency of use, or even closer.

The second way the toroidal inductor trap may fail is that it isn't producing a high enough impedance to stop the RF from going past it into the rest of the wire, even if it is tuned correctly.

See TOROIDS.INFO to make calculations of tuned circuits using different toroids. For example, select T37-6. Then insert 14 mhz, 68 pF for the capacitor, and click, calculate. This yields the (approximate) number turns of wire, 25, and it also says 167 ohms. This is only a 3:1 SWR. The desired impedance value should be at least 500 ohms, and would be better if over 1,000 ohms! To achieve that, one would need to use a capacitor around 12 pF, and that would require around 60 turns of wire on the core, which is probably impossible to do.

So, look to use a larger core on which more turns can be wound. Try a T50-6 core. About 42 turns of #28 wire can be wound on this larger core. That can be paired with a 15pF capacitor to get resonance at 14 mhz. This produces about 750 ohms resistive impedance, a 15:1 SWR. Using this combination resulted in the 20 meter wire being only a few inches shorter than predicted by formula, and adjusting wire lengths beyond the trap caused no interaction.

For the 30 meter trap, try using a 33 pF capacitor and about the same number of windings. This only produces about 500 ohms, or an SWR of 10:1, but trimming of the 40M wire after the trap had almost no impact upon the 30M resonance.

The above two traps introduced enough inductance that the overall wire length for this 20/30/40 EFHW wire is about 43 feet in total length. A circuit board for a trap designed by Rex, KE6MT, can be obtained from OSH PARK here: https://oshpark.com/shared_projects/nrjciEFR It has pads for the capacitor, the inductor and the antenna wire.

10/12/15/17/20/30/40/60 meters with just 3 traps!

Accomplishing all these frequencies with one simple light weight antenna assumes a radio that can operate on all these frequencies. The simplest approach is still a random wire with a counterpoise as previously described.

The difference offered by the three trapped wire is that because it is an end-fed halfwave (on all but 60 meters), it can be matched with a high impedance transformer (as previously described) on 17 through 40 meters, no ATU required.

Start with the 20/30/40 meter two trapped wire that is just 43 feet long previously described. Add a trap for 17 meters.

The difficulty here is that if a toroid is used for the inductor, 10 pf (or less) may be necessary to produce a high enough impedance in the trap to prevent RF from going past it resulting in difficulty tuning wire lengths because of interaction of the segments. This requires about 40 turns on the core and will substantially shorten the wire length to where it will become an inefficient radiator at the lower frequencies.

Instead of a toroid inductor for the trap, use an air core trap. Try 50 pF for the capacitor. On a ½ inch diameter form something like 15 to 18 turns of # 28 will yield a trap resonant on 18 Mhz. This results in a much higher impedance that will stop interaction from the wires beyond, and accomplishes the task while reducing the overall wire length by only a few inches.

The trap can be inserted into the previous 20/30/40 trapped wire at almost exactly the formula (465/ F Mhz, 25' 6"). The remaining length of wire up to the 20 meter trap will need to be readjusted only a few inches as it will be shortened by the inductance of the trap.

The antenna should be fed through an impedance transformer such as either of those previously described.

10 meters: the wire is close to being 4 halfwaves. It is electrically a little long because there are only two ends for end effect shortening. The ATU can handle it.

12 meters: the wire length is almost exactly 4 halfwaves long. The ATU makes short work of it.

15 meters: the wire length is almost exactly three halfwaves long. The ATU handles it.

17 meters: the wire length is seen as an EFHW due to the 17M trap. If the wire length is carefully adjusted and fed through the impedance transformer, the ATU is not required.

20 meters: the wire length is seen as an EFHW due to the 20M trap. If the wire length is carefully adjusted and fed through the impedance transformer, the ATU is not required.

30 meters: the wire length is seen as an EFHW due to the 30M trap. If the wire length is carefully adjusted and fed through the impedance transformer, the ATU is not required.

40 meters: the entire wire length is seen as an EFHW. If the wire length is carefully adjusted and fed through the impedance transformer, the ATU is not required.

60 meters: Substitute the adaptor for direct connection to the radio instead of one of the high impedance transformers. If the radio is sitting on a table, then add a counterpoise of about 21 feet in length. This creates a resonant antenna that is being fed at about the 400 ohm impedance point which the ATU in the radio will easily tune. If you are HOLDING the radio during the activation, you may be a sufficient capacitive coupling to the ground to not need a counterpoise.

Figure # 7 … 10 through 60 meters with just three traps. Wire is # 26 teflon. Shown with high impedance tuning device built into a dental floss case and which can match the antenna 17-40 meters.