By Michael J. Polia, AB1AW

Shortened End-Fed Half-Wave Antenna for 80 Meters

Construct this easy-to-build shortened version of the classic end-fed half-wave radiator and enjoy one of our best "top bands."

Many of us would like to get on 80 meters, but have been discouraged due to antenna restrictions of one type of another. And, many of us do not have the room for a full size 80 meter half-wave dipole (130 feet). The classic vertical for 80 meters is also not practical due to its height and the extensive ground plane that is required. A shortened dipole may be possible, but even a half-size loaded dipole is about 65 feet and requires support of the feed line.

A random long wire is an alternative. Use of an antenna tuner with a random wire antenna, worked against a good ground or counterpoise, can be effective. To get reasonable efficiency, however, the "random wire" should be at least 1/4 wavelength (about 65 feet for 80 meters) long. Also, if that random wire is cut to a multiple of 1/4 wavelength, the wire impedance, as seen by the tuner, will be low. This necessitates the use of a good ground system to achieve reasonable efficiency.

A special category of wire antenna, used with an antenna tuner, is the end-fed half wave antenna, or EFHWA. This is essentially a half-wave dipole that is fed from one end, rather than from the center. The first advantage of this configuration is that a separate feed line is not required; one end of the wire is simply brought into the station and connected to the antenna tuner. The second advantage is that an EFHWA presents a relatively high impedance to the antenna tuner. This means that an extensive ground system is not required; a connection to a cold water pipe may be sufficient. Figure 1 illustrates the concept of the conventional end-fed antenna with tuner.

Shortening the EFHWA

An EFHWA for 80 meters is still a half-wave in size. We still have the problem of trying to fit it into a small suburban lot or other restricted space. We can, however, apply the theory and techniques of the classic (traditional) shortened dipole to the EFHWA to achieve a shorter antenna.

The theory and techniques for constructing a short dipole are well documented. Loading coils are the standard component added to a dipole in order to decrease its resonant frequency. The classic short dipole consists of a dipole that has two loading coils, one in each leg, as shown in Figure 2. The positions of the loading coils are typically symmetrical and dictate both the bandwidth and the resonant frequency of that antenna. For a given antenna length and coil reactance, the resonant frequency of the antenna decreases as the coils are moved toward the center of the antenna. The bandwidth also decreases as the coils are moved toward the center. If the coils are positioned at the feed point, they can be combined into one coil that has twice the inductance of one of the single coils. *The ARRL Antenna Book* contains detailed information, equations and charts for constructing a shortened dipole, including those needed for determining the values of the coil reactance and positions.[1] Once the coil reactance is determined for the desired antenna length, it is used to calculate the coil inductance for the desired operating frequency. More on this later when we calculate the coil inductance for our

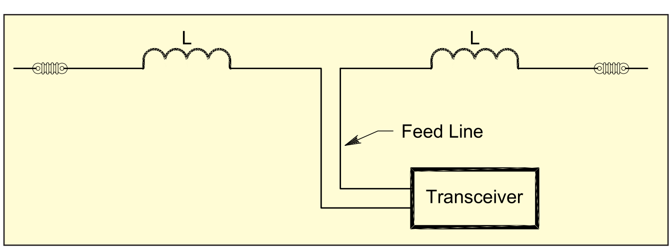

Figure 2—A half-wave dipole shortened with loading coils.

[1] *The ARRL Antenna Book*, 20th edition, pp 6-30 to 6-32. Available from your local dealer or the ARRL Bookstore. Order no. 9043. Telephone toll-free in the US 888-277-5289 or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

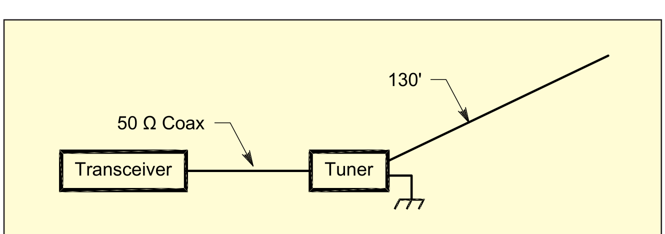

Figure 1—A traditional end-fed half-wave antenna for 80 meters fed with a transmatch or antenna tuner.

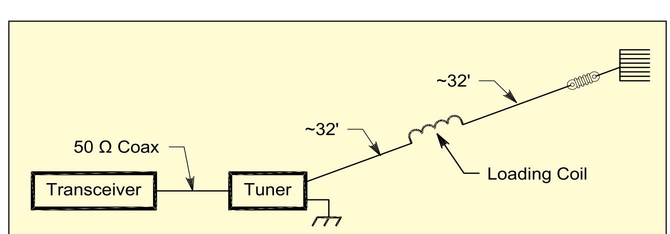

Figure 3—The end-fed half-wave antenna of Figure 1 is now shortened with a single center loading coil.

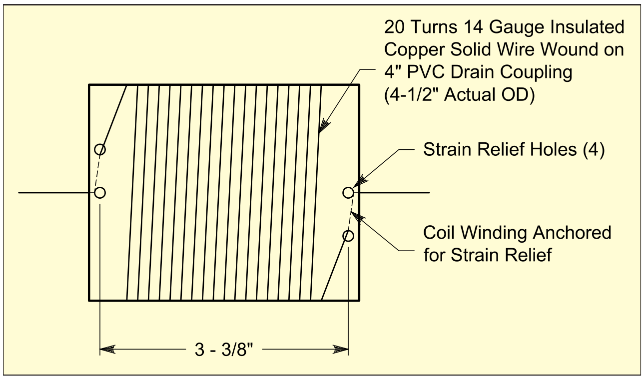

Figure 4—Coil construction for the center loaded antenna. Note the strain relief holes for wire anchor.

shortened EFHWA for 80 meters

The classic shortened dipole is still a dipole, and is traditionally fed like a standard size dipole, using coax or a balanced feed line. Just as a full size half-wave dipole can be end-fed, however, a shortened dipole can also be end-fed. This means that an equivalent end-fed, half-wave resonant 80 meter antenna can be constructed that is considerably shorter than a full size dipole. Such an antenna is constructed with a single loading coil, both for simplicity and to keep the antenna impedance at its ends equivalent to a full size end-fed half-wave dipole.

A dipole antenna, whether full-sized or shortened, can be center-fed, end-fed or fed anywhere in between. There is nothing "magic" about feeding the dipole in the center, except that it allows for an easy match to the standard low impedance (50 Ω) feed line and requires no special matching to your rig's output impedance. Any dipole can be fed off-center with the proper impedance matching between the antenna and feed line.

Off-center fed dipoles are popularly used as multiband antennas. As we move the feed point away from the center, the impedance increases until it reaches a maximum at the end of the wire. Moving the feed point to the end of a half-wave dipole results in a Zepp antenna, typically fed with a high impedance, open-wire, balanced feed line and a transmatch or antenna tuner. Finally, one end of a dipole can be fed directly by an antenna tuner (with no feed line required), resulting in an end-fed half-wave dipole.

Dipoles that are shortened using loading coils still exhibit the same feed point impedances at their centers, as well as at their ends. This means we can shorten an end-fed half-wave dipole using loading coils, in the same manner as a traditional shortened, loaded dipole, and feed it with an antenna tuner just as we would the standard end-fed antenna.

The electrical design of the shortened EFHWA is essentially the same as for a shortened dipole. Either a pair of off-center coils or a single center coil may be used. When a single center coil is used, its reactance is calculated to be twice that of one of the off-center coils. Figure 3 illustrates the concept of a single-coil shortened EFHWA with tuner. Here, the EFHWA is shortened by 50% using a single loading coil in the center, resulting in a 64 foot antenna for 80 meters.

Calculating the Antenna Size

In my implementation of this antenna, I decided to construct a half-size EFHWA for 80 meters. There was nothing magical about this length; it simply allowed the antenna to fit in my backyard. I predominantly operate CW and PSK31 on 80 meters, so I wanted an antenna with an approximate center frequency of 3600 kHz. I started by calculating the length of a standard dipole for 3600 kHz (468/3.6 MHz), or 130 feet for an 80 meter dipole. This was much too long to fit in my backyard. I needed an antenna about half of that length; that is, a total antenna length of 64 feet for operation centered at 3600 kHz. This is about 50% shorter than a full-size half-wave dipole.

The antenna would consist of two 32 foot sections with a single loading coil between the two sections. Using the chart provided in *The ARRL Antenna Book,* 20th edition (Figure 55, page 6-31), I determined that a half-size dipole with two coils located at the center (a *Dimension B, Position of Coil* of zero) required each coil to have a reactance of 500 Ω. This is equivalent to a single center coil that has a reactance (X_L) of 1000 Ω at frequency (f) of 3.6 MHz for an inductance (L) of 44 µH (where $X_L = 2\pi fL$).

To cover the phone portion of the band you will need to shorten the antenna a bit. For a center frequency of 3800 kHz, you'll need an antenna length of (468/3.8 MHz) /2 or about 61.5 feet. Two 31 foot legs will do the trick. The coil inductance drops to about 42 µH. However, this is only a difference of half a turn compared to the 44 µH coil. For practical purposes, the coil can be left at 44 µH.

Constructing the Loading Coil

I constructed the single loading coil using a 4 inch PVC drain pipe coupling and 14 gauge insulated solid copper wire. Both the 14 gauge wire and the PVC pipe coupling should be readily available at your local hardware or plumbing supply store. The outer diameter of the PVC coupling is about 4.5 inches. Twenty turns, close-wound, yield a calculated inductance of about 44 µH. I drilled a couple of holes at each end to act as a strain relief for the coil windings.

Figure 4 illustrates the coil construction. I used PVC pipe cement to cement the coil windings into place. The coil is placed between the two 32 foot legs of the antenna. Be sure to anchor it firmly. I made the legs of the antenna from an old short-wave antenna kit from RadioShack. I used the bare, stranded copper wire from that kit for the "far" leg, and the insulated lead-in for the "near" leg that entered the shack. Of course, any solid or stranded copper or copper-clad wire can be used.

Constructing the Tuner

Although nearly any tuner can be used to drive an end-fed antenna, a simple tuner consisting of a single coil and a variable capacitor is sufficient. Figure 5 shows the simple tuner I used. My tuner consists of a PVC pipe coil form for the inductor and a variable capacitor stolen from an old AM tube radio (this has a C

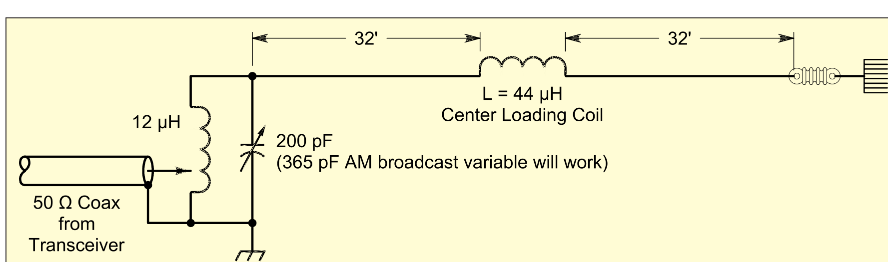

Figure 5—Although any single-wire tuner can be used, here is a simple tuner for the shortened end-fed wire antenna. The capacitor can be an AM broadcast band variable having a total C of about 365 pF.

of about 365 pF). If you don't have a suitable variable capacitor in your junk box, you can purchase one from a variety of electronic parts dealers. If you keep the transmit power under 10 W, you can even use the miniature tuning capacitor from an old portable AM radio. The coil is wound on a 5 inch length of $1^{1}/_{2}$ inch PVC pipe. The actual outer diameter of such a pipe is about 1.9 inches.

I used 18 gauge solid, bare copper wire to wind the coil. The wire should be readily available at your local hardware store. I found that Ace Hardware sells 25 foot rolls of 18 gauge solid, bare copper wire…perfect for winding coils. I wound 27 turns at 6 turns per inch, to cover $4^{1}/_{2}$ inches of the pipe. This results in a calculated coil inductance of about 12 µH. I chose this inductance because it resonates with a variable capacitor that adjusts within a range of 100 pF to 200 pF. This combination covers the entire 80 meter band.

I cemented the coil windings with hot glue to maintain even spacing between the windings (6 turns per inch). Using bare copper wire, I am able to place the coil tap at the proper point using a small alligator clip. I found that placing the tap at about 3 turns from the ground end yielded an SWR of less than 1.5:1 at 3600 kHz (with proper adjustment of the capacitor). This tap position will vary by a turn or so depending on your operating frequency and antenna installation position. Although I'm not sure of the power handling capability of this tuner, it is certainly sufficient for QRP operation. I find that I get about a 30 kHz bandwidth with a 2:1 SWR without the need to readjust the tuner setting.

Putting It Together

The antenna can be mounted in a variety of positions and does not have to be installed as a straight line radiator. As with conventional dipoles, you can install this shortened EFHWA as a sloper, an inverted V or an inverted L. The beauty of this is that you don't need to worry about the separate feed line to its center, as with a conventional dipole. I actually have the first 32 feet of the antenna running out my window, up the side of the house to the top of my brick chimney. At that point I have the coil tethered to the top of the chimney, and the second half of the antenna stretched horizontally across my yard to a tree. I brought the feed point into the shack through a window, simply closing the window down on the wire to keep it in place. Connect the feed point to the end of the tuner coil, adjust the coil tap and variable capacitor for best SWR and you are on the air! I've not tried using this antenna on other bands, but a conventional EFHWA can be made to operate on its even harmonics, so I suspect this shortened version can do the same, allowing operation on 40, 20 and 10 meters.

Michael Polia, AB1AW, was first licensed as WB1EET at age 14 in 1976. He received his Advanced class license while still in high school and earned the Amateur Extra class ticket in 2001. Mike has a BSEE from Northeastern University and an MS in Computer Science from Boston University. He has worked in various fields, including design and development of audio and radio/satellite equipment, medical and semiconductor instrumentation, and networking. Mike is currently a principal software engineer at Nortel Networks. Active on PSK31 and CW, he's interested in digital communications techniques and low power (QRP) operation. You can contact him at **ab1aw@yahoo.com**.

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