Newcomers and Elmers Net: HF Antennas on the Cheap!

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Wire antennas represent one of the greatest values in the radio hobby world. For less than the cost of a good meal out on the town you can buy all of the necessary parts for a really good antenna, and have change left over for a fast-food meal to boot!

-- In addition to being efficient and inexpensive, wire antennas have the added bonus of being fun to build and to experiment with, since mistakes are hardly costly and the materials are easy to work with.

HF

- While it may seem hard to believe, HF signals only need thin lengths of wire properly matched to a radio to do their job.
- Common speaker wire that you would normally use with your home stereo is almost perfect for making a basic dipole.
- I actually like speaker wire for one very simple reason: it comes with both wires joined together through its insulating material; you only have to make one cut to get both wires to the proper length when making a center-fed dipole.
- Calculate the length needed for one arm of the dipole, measure and cut the speaker wire to that length, and now both arms of the dipole are exactly the same length!
- As you may remember from your license exam studies, RF current actually travels down the outside of the wire (called the "skin effect"), and in the HF frequency range almost any wire will do.
- I like to avoid really thin wire for permanent installations, but for portable installations thin wire is a great option just for the weight reduction it represents

Dipole

- A *dipole* antenna is made up of 2 poles or lengths of wire, often cut to equal lengths as described above.
- The antenna is considered *resonant* if the total length of the two arms equals ½ wavelength for a given frequency. (This means each arm is ¼ wavelength.)
- The outer ends of each wire are connected to insulators which are in turn tied off to some form of support, usually trees or masts.
- The inner ends of the wires are connected to a feedline in one of several ways, the most simple being ladder-line
- Coax may also be used, but this requires some form of matching since

a dipole is considered a *balanced* line and coax is considered an *unbalanced* line

- These terms have to do with how the RF signal is affected by the feedline. Because the ½ wavelength dipole has two equal lengths, each side has an electrical balance, and this must be matched or transformed to travel along an unbalanced feedline.
- If using coax, one side gets connected to the inner coax conductor and the other side is connected to the outer shield of the coax
- If using ladder line connections are just as easy, and both methods require some form of support for strain relief at the feedpoint

What makes a Wire Dipole so Effective?

- The key to the effectiveness of a wire dipole antenna is that nothing is wasted, given proper construction.
- Electrically nothing is wasted and mechanically nothing is wasted, so the result is a maximum transference of energy where it is intended to go.

Making a Dipole: The Dipole Formula

The common formula for calculating the length of a dipole is:

468 / (f MHz) = dipole length in feet

(e.g. 468/14.275 MHz = 32.8 feet total length (approx. 16.5' per side)

Cut each length a bit long, adding 6 inches or so to each side and then trim or fold back as needed. If you cut the wire too short you will have to add length or start over, so it is always better to leave a margin of error.

Variations on a dipole

- There are numerous variations on a dipole such as an off-center fed (OCF) dipole, a folded dipole, an inverted V, a sloper, and the G5RV antenna
- Some of these can work on multiple bands with an external tuner or one built into a radio
- While SWR is not the only issue for good signals, tuners help match impedance levels to ones acceptable to the modern electronics in rigs
- If you have the room to go up high, say with a tall tree, you can even make a vertical dipole with some interesting radiation properties
- If possible the feedpoint (where the coax meets the antenna) should be approximately ½ wavelength above ground

Loops

- Loop antennas are a great option if you have the room
- A loop is a full-wavelength antenna shaped like a square (quad loop), a rectangle, a triangle (delta), or a circle (hardest to support)

■ My first homemade antenna was a vertical delta loop for 20 meters; approx. 23’ per side with the feedpoint up about 32 feet

■ If you have the room you could string the antenna up horizontally between three or four trees or other supports and feed it anywhere that was convenient and you would have a good antenna with 3db gain

■ Loops are forgiving in that they don’t have to be perfect squares or rectangles or triangles. Get it as close as you can and then don’t worry about it

■ Formula for a loop is 1005/frequency in MHz = length as a starting point; leave a little extra length and fold back or trim as needed

Folded Dipole

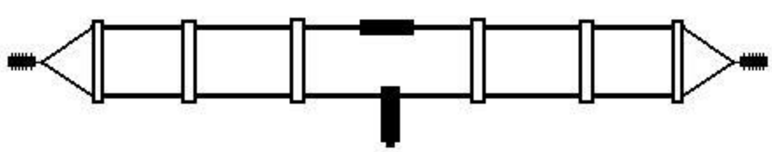
When many people think about a wire antenna they think of a single band antenna cut for a specific frequency.

-- They are the most common perhaps, and certainly easy to build. Their main attraction is that they do not require a tuner for good coverage on the desired band.

-- A multi-band antenna almost always requires a tuner to get good coverage of the bands, particularly when covering a wide range of frequencies, such as 10-40 meters or 10-80 meters

-- While a single wire is most common for dipoles, adding another wire or two to a mono-band antenna can widen its bandwidth, and this may be of some use, particularly in the lower frequency bands such as 40 or 80 meters.

-- This “folded dipole” as they are sometimes called works much like a regular dipole, but with higher impedance at the feedpoint, allowing for greater bandwidth.



-- Because the impedance falls off more slowly, the bandwidth matching occurs over a greater distance.

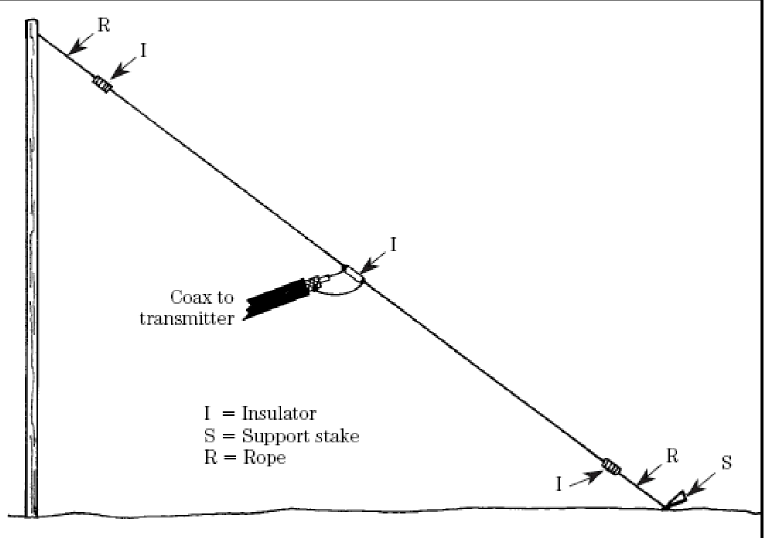
-- The design is a bit like a loop antenna, but the distance between the horizontal wires is only 4-6”, usually set off with plastic spacers.

-- The length is calculated just like a standard dipole, 468/freq. in MHz, multiplied by 2 or 3 depending on the number of “extra” wires you use.

-- If using only two wires you can easily make the antenna with one continuous wire, just making sure the two ends of the wire connect just like a regular dipole.
-- If using three wires, it is easier just to cut three lengths of wire to the desired band length and tie them together at the ends, cutting the lowest wire at the halfway point for connection to the feedline
-- cut the wires longer than required by your calculations and trim back as necessary.
-- As with a dipole, try to run the feedline at right angles to the transmission line for as long as possible.

The impedance is usually about 300 Ohms, and can be fed directly to ladder line, or a 4:1 Balun can be used for coax matching.

Half-Wave Sloper
Slopers (also known as *half-wave slopers*) are a variation of the dipole antenna, and they have both horizontal and vertical polarization characteristics.
-- While a 45° angle is common, they can be anything between 0 and 90 degrees. When they are straight up and down (90°) they are sometimes referred to as a *Halfwave Vertical Dipole* (HVD).



"Slipole" or "sloper."

-- This configuration can be very useful when you have less than the ideal amount of horizontal space for a flat-top antenna, or when you wish to use a single support, such as a tree or mast, for the antenna. -- (If the antenna is going to be used where people are likely to be, make sure the lowest end of the antenna is high enough off the ground to avoid physical contact with the radiator.)

-- Assuming you are feeding the sloper in the center, you will want to make sure the feedline does not become part of the radiating element of the antenna since it is near the ground.
-- Two things can help with this: first, make sure you have the feedline at a perpendicular angle to the radiating elements, at least 30-40° or more; second, add a common mode choke at the feedpoint with either ferrite beads or a coaxial loop.
-- Like any antenna the half-wave sloper is a compromise antenna, with its vertical characteristics adding to the noise you are likely to hear. However, its savings in size, use of one tall support, and ease of construction may outweigh its disadvantages, especially in the lower bands.
-- Slopers show a bit of directionality in the direction of the slope, with slight front-to-back signal ratios, and they offer decent low take-off angles for DX work.

Half-Sloper
A popular variation of this antenna is the half-sloper, or ¼ wave sloper.
-- The main advantage of the half-sloper is the reduced height required for the antenna.
-- a standard 160-meter antenna requires quite a bit of height, as does 80 meters. A half-sloper will reduce that amount considerably, but with some reduction in performance.
-- While you always want to put up the best antenna possible, sometimes real-world considerations, such as your neighbor’s property line, can get in the way!
-- A half-sloper may be just the ticket to get you on the air on the bands you want even if the noise level is a bit higher than you might like.

If you can, try to angle the antenna as close to 45° as possible if you are using a tower or other metal support to avoid interference.
-- The half-sloper is usually connected to a metal support, and this metal support becomes the 2nd half of the antenna.
-- The metal support must be grounded, or else you must ground the outer braid of the coax at the base of the support for it to act as a conductor.

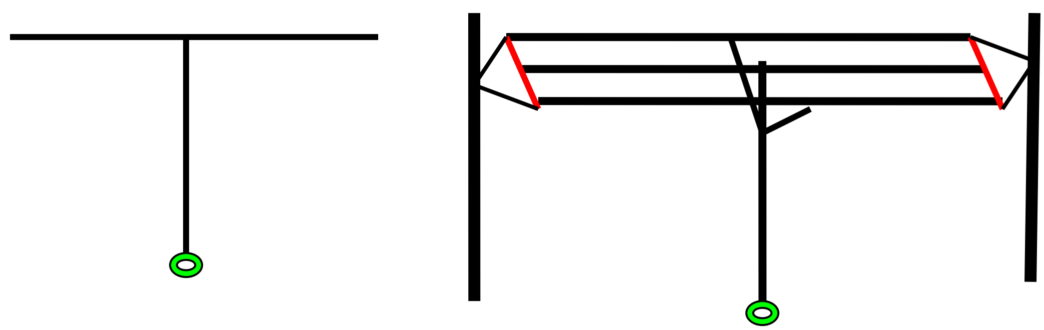
For a half-sloper use the formula: length (L) = 260 / Frequency (MHz), and trim the wire as needed for a good VSWR match.
-- You may have to adjust the feedline attachment point to vary the VSWR if you can’t get it to 2:1 or below by adjusting the angle of the antenna/feedline. Also a tuner may be used at the radio to adjust the impedance if the VSWR is not too high.

Both the ½ and ¼ wavelength sloper can work quite well on the “top” band (160), particularly because of the low take-off angles of the antenna design.

-- As mentioned previously, noise can be a problem, but much of that is determined by your noise surroundings.

The Flat-top or "T" Antenna

This antenna uses one or more horizontal wires held between two masts. A vertical wire is connected to the center of the horizontal wire(s) and runs perpendicular down to the ground, where it is connected to the transmitter or receiver. The T-antenna functions like a monopole antenna with capacitive top-loading:



Left: Single Wire T-Antenna

Right: 3-Wire T-Antenna

Green Circle is the Feedpoint

The vertical height of the antenna is a little less than 1/4λ on higher bands, but is used more often for 80 or 160 meters and at vertical heights as short as 1/10λ. The advantage of multiple horizontal wires is that there is greater capacitance, which in turns requires less inductance at the base of the antenna. This allows for a broader bandwidth and better efficiency than would be possible with only one wire. Beyond several horizontal wires, adding more wires has diminishing returns.

Since it is shorter than λ/4 the T antenna has a high capacitive reactance. In transmitting antennas, to make the antenna resonant, the capacitance is canceled out by adding an inductive loading coil in series with the base/feedpoint of the antenna. An "L" tuner could be used instead of a coil to cancel out the capacitance, assuming it is a beefy tuner (I would not want to risk an electronic tuner with this setup).

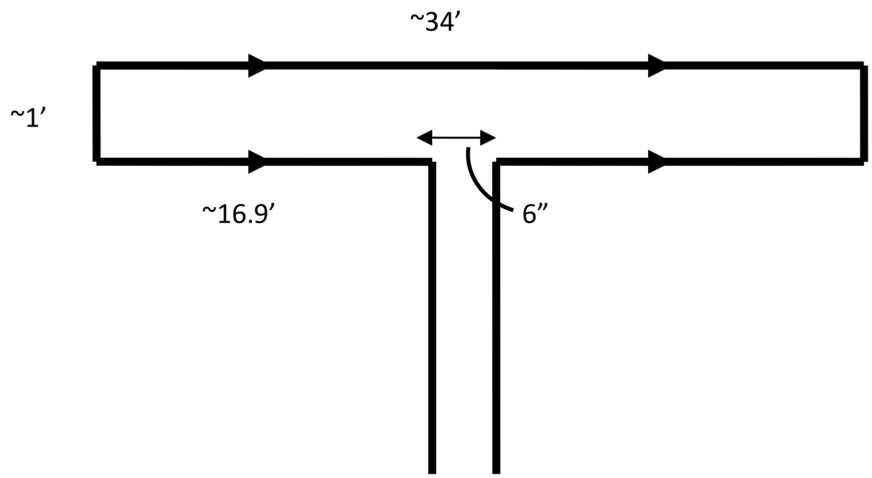
The higher one can suspend the antenna the better the radiation pattern will be, just like a regular vertical monopole. However, because of the capacitance loading of the top wires, there is a greater current along the length of the vertical wire since the current does not go to zero at the top of the wire as in a standard monopole. There is a theoretical four-fold gain because of the capacitance top, but in real terms that number will be reduced somewhat.

It is important to note that the radiation pattern is basically that of a vertical monopole—the horizontal wires do not contribute much of anything to the radiation pattern, except to allow the vertical wire to radiate fully in an omni-directional pattern. This allows for a much shorter vertical to perform better on the lower bands than an equivalent monopole. In space-strapped environs, this could mean the difference between getting on a band or not.

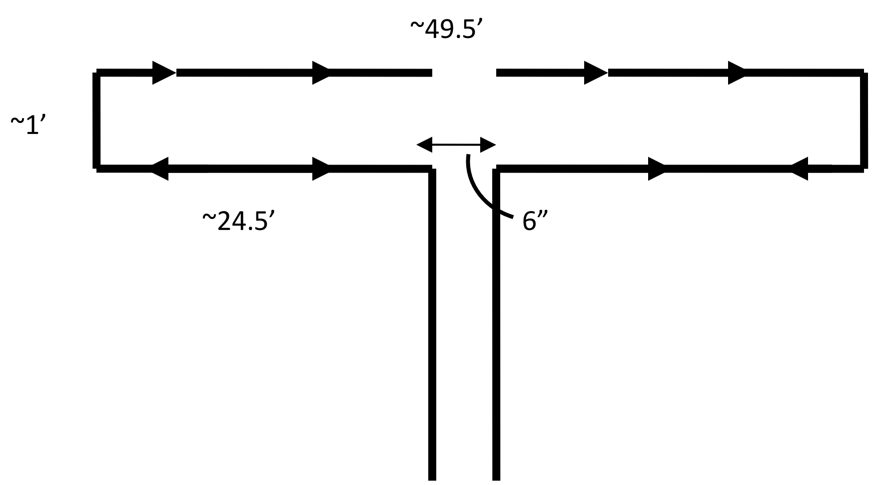
A common variation of this antenna is the umbrella antenna, where the top elements are sloped downward (left). This is often a more practical solution based on logistics, but the sloping portion of the wires will degrade the radiation pattern from the vertical somewhat since the capacitance loading will no longer be perpendicular to the radiation pattern. Depending on the circumstances however, the trade-off may be worth the loss in order to simplify construction.

2-Wire Half-Wave Antenna

In keeping with the “simple is better” theme, I am also intrigued by the 2-wire half-wave antenna. I first saw this antenna (and its alternate) from an article by John Kraus, W8JK, from around 1940. This antenna is interesting to me because it is designed with ladder-line in mind. This is as we know one of the best ways to feed an antenna. The design lends itself well to using either 300- or 450-Ω wire, which also means the antenna is extremely economical. This version has dimensions for 20 meters:



A variant of this which more closely matches the 450-Ω ladder line is the three-quarter wave 2-wire antenna:



The main advantage of these antennas besides the feedpoint impedance is that they will have a wider bandwidth than their single-wire cousins, with the three-quarter-wave antenna being slightly more directional.

Flat-top vs. Inverted V

Whenever there are a group of old-timers around talking about antennas there are sure to be debates over the simplest of matters. One of those debates will likely be the merits of using an Inverted V configuration for convenience versus using a flat-top design for dipoles and the like. The arguments usually focus on the current feedpoint height and the drop-off of current at the ends of a half-wave antenna. There are merits to both sides.

On the one hand it is certainly true that the high current point of a centerfed dipole will be at the high point, and assuming the apex angle between the two legs of the antenna is greater than 90°, the interaction between the radiation patterns of the two halves will not be overly significant.

On the other hand, a flat-top design will show more gain at all frequencies, assuming average ground, but especially on higher frequencies. Since most of us have to get more than one band out of an antenna, this can become an important issue when dealing with a typical multi-band wire antenna.
The radiation patterns reveal another aspect of these two antennas, namely that the inverted V in both 20 and 80 meters works better for local communications, while the flat-top works best for DX communication.

OCF – Off-Center Fed Dipoles

Another antenna of some good controversy is the Off-Center Fed Dipole, a variation of a standard dipole which can be completely horizontal or slope downward on either end or both. Part of the reason there is such debate about these antennas is that like so many antennas, the foundation for the arguments are anecdotal. "I worked 27 countries in 15 minutes after putting up my OCF antenna!" "Those antennas are nothing but (cloud or ground) warmers—they are deaf as a post!"
In reality, OCF antennas can work really well if they are understood, and if the "KISS" principle is remembered: Keep it simple, silly! An OCF is an unbalanced antenna. A center-fed dipole is a balanced antenna, all things being equal; by feeding the antenna at a point other than the exact center, the antenna becomes unbalanced. This is not a bad thing—just something to be remembered.

A tuner should be used, especially when using the antenna for multiple bands. For our purposes here I will presume the use of our old friend, the 135' dipole, and this time at height of 40 feet. Ladder line is preferred, but coax may be used instead, with reduced performance. The patterns here for 20 meters are reasonable as they are for 80 meters. This can be a great solution for when there simply is not room for a standard dipole.

Many designs use a split of approximately 80′/55′, but this is not critical, as long as the long side does not begin to resemble an end-fed antenna. The whole point of an OCF antenna is for convenience for getting into the shack. If space is not an issue, a standard center-fed dipole should be used as it will give the best overall performance.
If using a multiband design, keep in mind there are multiple changes which will occur as the feedpoint is moved in or out. If a computer modeling station is available, I would definitely make use of it to see the effects of changing the wire lengths around on as many bands as the antenna will be used.
If this is not possible, I would recommend cutting the antenna larger than the longest anticipated length, and then folding the wire ends back to check different short/long end combinations. An antenna analyzer would be most useful here since the antenna will be covering a number of non-resonant bands.
In addition to length, antenna height will have a big influence on impedance matching with OCF antennas. They can be sloped if needed, but this will make significant changes to the radiation patterns, particularly if the short end is the one sloped

OCF antennas have been used for a long time, and for good reason: they work. Are they better than a standard center-fed dipole? No. But there are some situations where they will work better simple because they will fit where needed.

Simple antennas translate to economical antennas, and there are no more economical antennas than wire antennas. They have fascinated us for years, and they will continue to fascinate us for years to come, as each radio generation "discovers" their excellent radiation properties.
So buy a spool of wire, grab a handful of insulators, get some weatherproof rope, and have some fun this summer!