SHORT Dipoles for 160 Meters

Get on the "top band" with limited real estate—build one of these shortened dipoles. Apply these principles to 80 and 40 meters, too.

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Many hams do not operate 160 meters due to the size of a resonant antenna required for this band. Using the accepted formula of 468/f, the length of a dipole cut for 1.84 MHz would be 254 feet, 4 inches. What we shall endeavor to do here is to design a simple structure that approaches the performance of a full-length dipole, but is less than half that size. For simplicity, most of the antennas (in 7 examples) shown here are 120 feet long and at a height of 60 feet. Shorter and lower dipoles can be designed, but they will have degraded performance (impedance, gain and bandwidth all decreasing).

Arguably, the three most important antenna electrical parameters are impedance, gain, and the SWR bandwidth. If the bandwidth can be wide, then a tuner will not be needed, since today's broadband transceivers will operate directly into 50 Ω. To operate over the full band, however, a tuner will be needed with any of these antennas.

The Full-Length Dipole

The full-length dipole is the standard to compare against. By using *AO* software for the initial modeling and then *NEC Wires* software to take into account the ground effects, the dipole was computed to be 257 feet, 5 inches long.[1] For average soil at 60 feet:

Impedance = $45.8 + j2\ \Omega$ at 1840 kHz.
Gain = +1.27 dBi at 60 feet and +3.15 dBi at 100 feet (at 30° elevation).
2:1 SWR Bandwidth = 65 kHz at 60 feet and 95 kHz at 100 feet.

As expected, higher dipoles have more gain and greater bandwidth. In all of the figures that follow, the numbers (parentheses) represent that antenna point's height above ground. The non-parenthetical numbers represent length.

Example #1

The first approach (Figure 1) is to add coils in both sides of the dipole to reduce its physical length. The design of this type of dipole was covered in a recent *QST* article.[2] The coils were computed to have an inductance of 129.85 µH. The performance was calculated using a coil Q of 500. For average soil at 60 feet:

Impedance = $21.2 + j0\ \Omega$ at 1840 kHz.
Gain = –0.51 dBi at 30° elevation.
2:1 SWR Bandwidth = 10 kHz.

No evaluation was done at 100 feet.

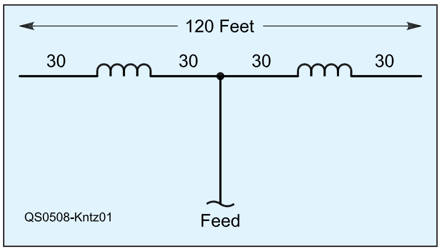

Figure 1—A 160 meter dipole shortened with loading coils. All single-line feeds represent coaxial cable with an insulator at the antenna/feed line junction.

Example #2

Figure 2 shows one of the simplest dipoles of reduced length. The ends of the wire hang straight down and approach (6 feet) the ground. The ends of the wires should be tied down to keep them from flopping around in the wind. The total length of the wire is the same as a full-length dipole.

Impedance = $42.8 + j3\ \Omega$ at 1840 kHz.
Gain = –0.36 dBi at 30° elevation.
2:1 SWR Bandwidth = 65 kHz (same as a full-length dipole).

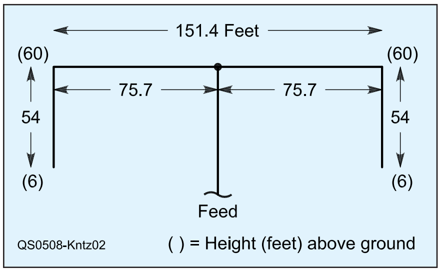

Figure 2—A "hanging ends" shortened dipole. The ends are perpendicular to the antenna main radiator.

Example #3

Another way to gain wire length while keeping the width of the dipole at 120 feet is to bring the drooping wires back toward the center of the antenna and tie them to the ground with small ropes. The impedance can be raised by using "off-center feed," such as feeding at the corner or in the center of one of the sloping wires. Figure 3 shows this example.

Center feed impedance at point (1) = $13 - j0\ \Omega$ at 60 feet.
Corner feed impedance at point (2) = $23 - j0\ \Omega$ at 60 feet.
Sloper center feed impedance at point (3) = $45 + j0\ \Omega$ at 60 feet.
Optimum feed impedance at point (4) = $50.1 + j4\ \Omega$ at 60 feet.

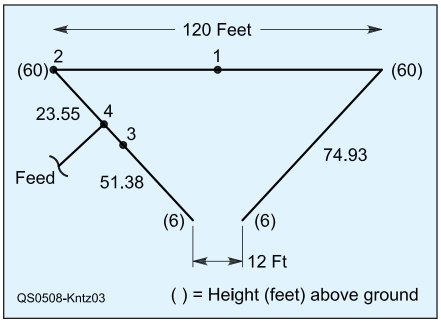

Figure 3—Bringing the wire ends close to the antenna center can increase the antenna's effective length.

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[1] Notes appear on page 34.

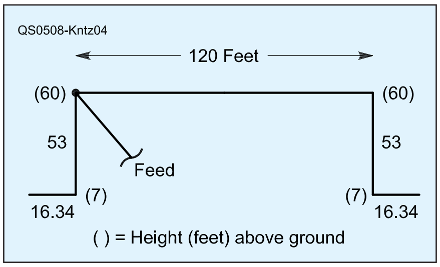

Figure 4—The main radiator is still 120 feet long, but the effective length has been increased with additional horizontal members. The feed point is offset to produce the required match.

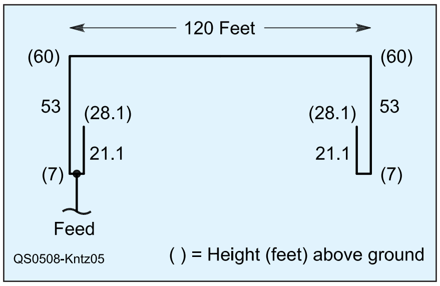

Figure 5—The feed can be closer to the ground with this arrangement.

The antenna has the same performance at each feed point and its parameters are:

Gain = –1.04 dBi at 30° elevation.
2:1 SWR bandwidth = 24 kHz (because of "out of phase" currents in the sloping wires).

Using "off-center feed" gives the same antenna pattern as center feed and can simplify the support of the coax weight and may reduce the length of the coax run. With any of the dipoles presented here, a balun is recommended at the feed point.

Example #4

This dipole is similar to Example #2 except the ends of the wires are bent to run horizontally at the 7-foot height to attain the full wire length required (Figure 4). The feed is in the corner to get a good 50 Ω match. The wire ends could also run toward the center, if desired.

Impedance = 58.9 +j0 Ω at 60 feet.
Gain = –1.56 dBi at 30° elevation.
2:1 SWR Bandwidth = 53 kHz.

This design has good bandwidth and allows for "tweaking" of the tuned frequency from the ground. With clips, the wire ends can be extended to optimize tuning for the CW end of the band.

Example #5

This is similar to the previous antenna except the wire ends are bent back up and run parallel to the vertical wire. Spreaders (using 1/2 inch PVC) are required to hold the wires apart and the ends have to be supported from above by a small rope. Commercial open wire line can be used with some reduction of gain and bandwidth. This will change the length of the wire by a few feet. Figure 5 shows the example.

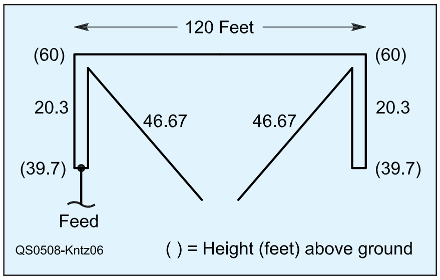

Figure 6—Linear loading is used for lengthening the antenna, while the offset feed provides a good match in this example.

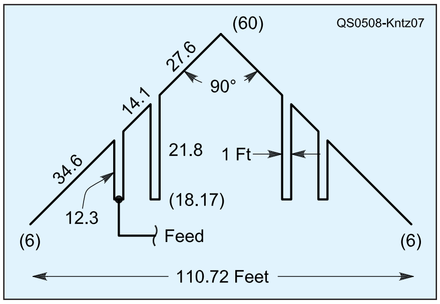

Figure 7—The popular inverted-V can use linear loading to increase its length and an offset feed to provide a match.

Impedance = 54.8 –j4 Ω at 60 feet.
Gain = –1.16 dBi at 30° elevation.
2:1 SWR Bandwidth = 49 kHz.

Example #6

This time, "linear loading" and "off-center feed" are used to provide a perfect 50 Ω match. The feed point is at the bottom of one of the loading stubs, as shown in Figure 6. The length of the stubs sets the impedance, while the sloping wires set the frequency.

Impedance = 49.5 – *j*1.6 Ω at 60 feet.
Gain = +0.71 dBi at 30° elevation.
2:1 SWR Bandwidth = 45 kHz.

Example #7

The inverted V is a favorite of many hams, so a short V was designed for 160 meters. This time, two linear loading stubs are needed on each side, to get down to 1840 kHz. Again, a perfect 50 Ω match can be obtained by adjusting the stub lengths. The center frequency is adjusted at the end of the wire. The antenna is shown in Figure 7.

Impedance = 47.8 – *j*2.0 Ω at 60 feet (45° slope; each wire).
Gain = –4.05 dBi at 30° elevation.
2:1 SWR Bandwidth = 23 kHz.

The low gain and bandwidth are due to the low average height of the inverted V (33 feet).

Conclusion

A word of caution about using "off-center feed": This technique works perfectly on the computer, but in real life the effective height of the antenna is a guess and the ground characteristics are a "wild" guess. These parameters will have major effects on the feed impedance. A better approach to getting a good match in the shack is to use a small L network at the transmitter end to set the match (center feed). By switching between two networks, a separate CW and PHONE match is possible. This would be especially useful on an 80 meter antenna.

The design procedure for the L network is to estimate (or measure) the impedance at the transmitter end of the coax. Then compute the values needed (I used software written by N6BV).[3] If you are going to estimate the impedance, it is helpful make the coax length multiples of a 1/4 wavelength.

I hope this presentation gives you some ideas as to how best fit a 160 meter dipole on your property to enjoy our "top band." You can put these techniques to work with 80 and 40 meter antennas, as well.

Notes

[1] *AO* and *NEC Wires* are antenna programs developed and marketed by Brian Beezley, K6STI. These are no longer available. *EZNEC* by R. Lewallen, W7EL, can now be used to perform this modeling (**www.eznec.com**).

[2] L. Lopes, CT1EOJ, "Designing a Shortened Antenna," *QST*, Oct 2003, pp 28-32.

[3] *Transmission Line for Windows (TLW)* by N6BV as well as *EZNEC ARRL* and other modeling software is included with *The ARRL Antenna Book*, available from your dealer or the ARRL Bookstore. Order no. 9043.

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