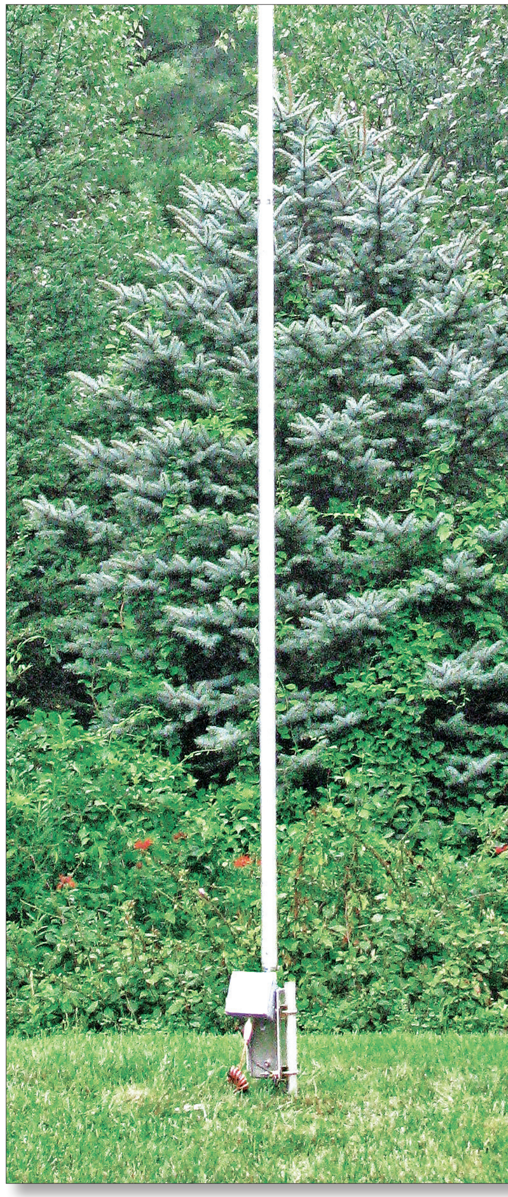
About this Article

This material was included with the downloadable supplemental content accompanying the *ARRL Antenna Book*.

You may print a copy of this material for personal use. Any other use of the information requires permission from the ARRL.

The 3/8-Wavelength Vertical — A Hidden Gem

This vertical antenna design is the third-place winner in the 2018 *QST* Antenna Design Competition.



Joe Reisert, W1JR

As the solar cycle rapidly winds down, the upper HF bands will be less available, but 20 meters will still be plenty active during the day. Many 20-meter operators are always looking for a small or stealthy antenna with good performance, and the ⅜-wavelength vertical antenna is a good candidate to fill that role.

When my son, Jim, AD1C, was first licensed, he built a homebrew receiver and 5 W transmitter for 40 meters. Later, he wanted a simple but efficient antenna. As I looked for a solution, the ⅜-wavelength vertical stood out. It is only about 50 feet in height on 40 meters. Because this vertical has a series impedance of about 200 Ω resistive, plus an inductive reactance of about 300 – 700 Ω, it is easily matched with a 4:1 step-up toroid transformer followed by a series matching capacitor. We strung up an approximately 50-foot wire in a nearby tree and four quarter-wavelength, ground-mounted radials to complete the installation and quickly matched the antenna. It worked quite well in contacting about 50 DXCC entities using Jim's 5 W.

Vertical Antenna Considerations

Ground planes are quite popular (see Figure 1). They are simple to construct and usually don't require matching networks, but do require some tie-down points. Elevated radials, however, can have several problems, including visibility and safety. The ends of the insulated radials are a high voltage point. A quarter-wavelength vertical with many radials on or near ground is also popular. For maximum efficiency, they require a minimum of 16 quarter-wavelength radials.[1] Performance often suffers from ground clutter near the base. The typical *EZNEC* modeled radiation pattern with a takeoff angle of 26° is shown in Figure 2.[2] The current distribution over the monopole is shown in Figure 3. Note that the region of highest current — the place where maximum radiation takes place — is at the bottom of the antenna.

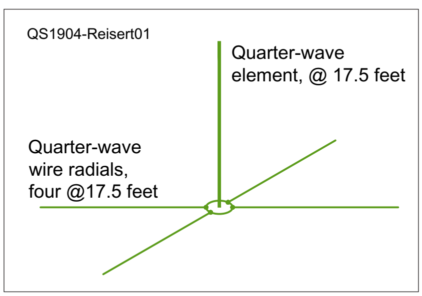


Figure 1 — Dimensions of a quarter-wave, ground-plane vertical antenna for 20 meters. The dimensions are similar for a ground-mounted version, but more radials are required.

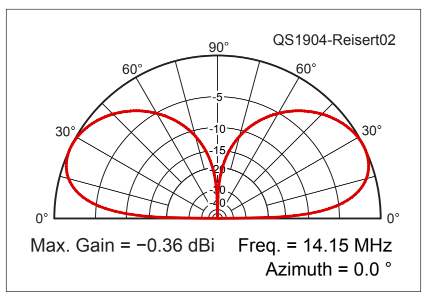


Figure 2 — Elevation pattern of a ground-mounted, quarter-wave antenna for 20 meters.

Table 1
Parts List for 20-Meter, ⅜-Wave Vertical Monopole

60 – 70 feet	#14 AWG PVC insulated wire for radials
1	Plastic electrical box for the matching network (see Figure 10)
2	Capacitors, ceramic disc NPO 20 pFd 1 – 2 kV, as required
1	Ferrite toroid core, T-240-61 2.4-inch OD
4 – 6 feet	#16 AWG PVC insulated twisted-pair wire for the toroid transformer
1	RF coaxial socket to match coax cable
Quantity	**Material (for tubing version only)**
5 – 6	Aluminum tubing 1 – 1.5 inches diameter, 5 – 6 feet long I used a surplus MFJ-1792 vertical antenna
1	Suitable base mount supported by around a 1-inch diameter stake
1	Base insulator
Quantity	**Material (for wire version only)**
2	Antenna insulators
26 feet	#12 AWG copper antenna wire

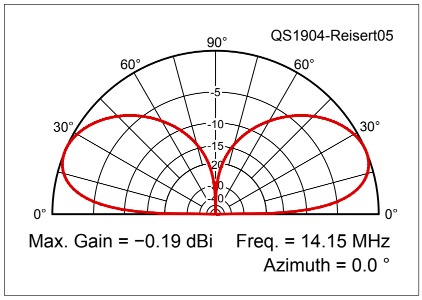


Figure 5 — Elevation pattern of a ground-mounted ⅜-wave antenna for 20 meters.

Meet the ⅜-Wave Vertical

The ⅜-wavelength vertical antenna (see Figure 4) is often an overlooked design. It has several advantages over the common quarter-wave vertical and just adds 50% to the height. Here are some advantages:

- It has a low takeoff angle of radiation at 23°, versus 26° for a ground-mounted, quarter-wave vertical (see Figure 5 and compare to Figure 2). This is a big advantage for working DX.
- It will work well even ground mounted because its maximum radiation point is ⅛ wavelength (about 8.7 feet at 20 meters) above the ground (see Figure 6). This is above the typical clutter present at ground level.
- It is easy to impedance match and, once matched, has a wide bandwidth with low SWR.
- Finally, it has a much higher radiation impedance. Therefore, four quarter-wavelength radials are all that is required for good performance.

Construction

This antenna can be easily constructed using either aluminum tubing or wire. I chose to modify a spare commercial vertical that I already had from a prior project. It had all the aluminum and hardware I needed, plus a good base and base insulator with tilt-over capability. It went together quickly (see Figure 7). Later, a wire equivalent was built at

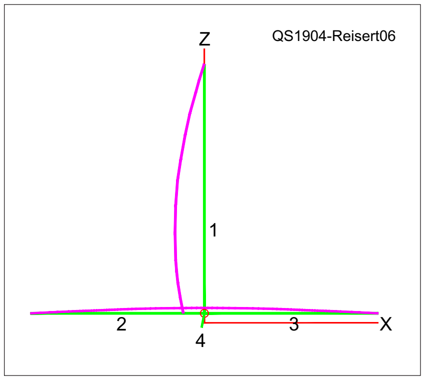


Figure 6 — Current distribution along the ⅜-wave monopole. Note the maximum current, so maximum radiation is ⅛ wavelength up from the base. This is about 8 feet for 20 meters.

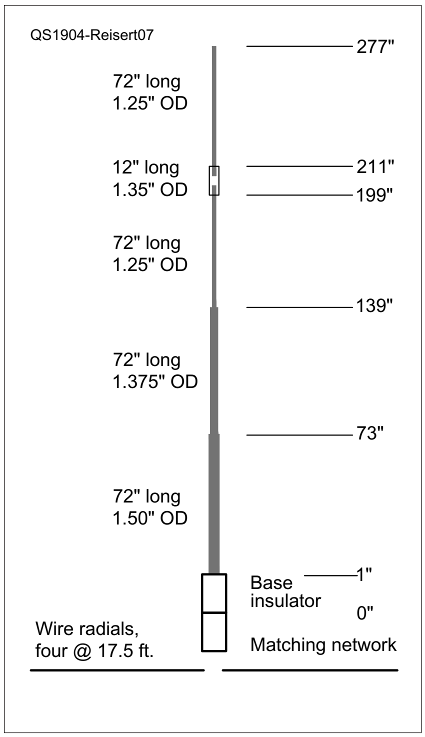


Figure 7 — Tubing construction for a ⅜-wavelength vertical antenna.

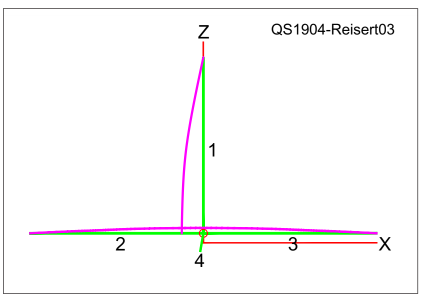


Figure 3 — Current distribution of a quarter-wavelength vertical monopole. Note that for the ground-mounted version, the maximum current and location of the maximum radiation are near the base, where nearby objects can diminish radiation.

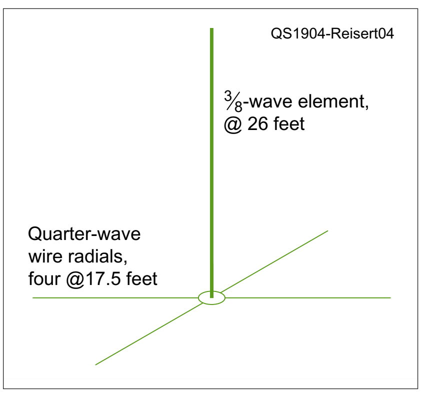


Figure 4 — The ⅜-wave vertical, a practical alternative to the quarter-wave, with some advantages.

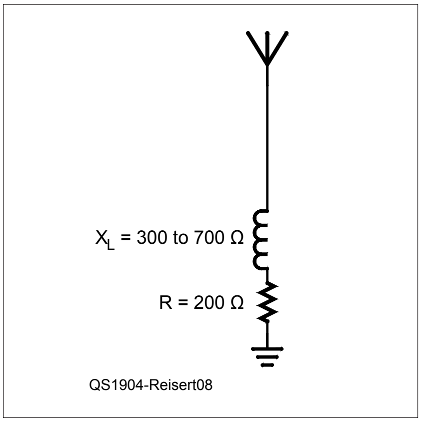


Figure 8 — Typical ⅜-wavelength antenna base feed impedance.

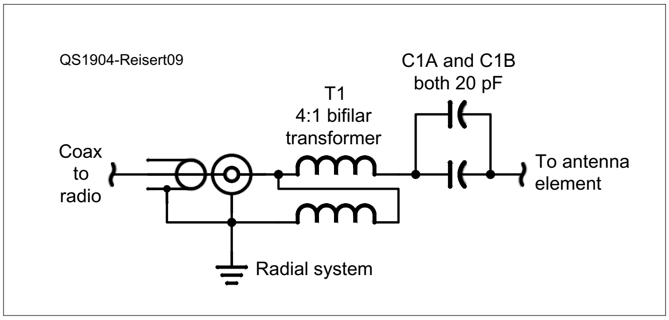


Figure 9 — Impedance-matching network for the ⅜-wavelength vertical. T1 is bifilar twisted pair #16 AWG PVC-covered wire, seven turns on T-240-61 2.4-inch outside diameter toroid. C1A and B are typically 20 pF, 2 kV ceramic disk capacitors. Lower voltage capacitors are useable for low-power operation.

the same location using ordinary seven-conductor #12 AWG copper antenna wire. It requires a top and bottom insulator and some higher structure such as a tree to hold it in place. It had a similar overall length.

Matching Network and Tuning

The ⅜-wavelength vertical antenna has a series impedance of approximately 200 Ω resistive with a series inductive reactance of 300 to 700 Ω (see Figure 8). Therefore, a 4:1 step-up transformer will match the resistive component, and a series capacitor tunes out the inductive reactance (see Figure 9). Typically, the required series capacitance is approximately 40 to 50 pF at 14 MHz and is not critical. A photo of a typical matching network in a 4 × 4 × 2 inch plastic box from an electrical supplier is shown in Figure 10.

The matching network is easy to use. Figure 11 shows a typical setup using an antenna analyzer to adjust for minimum SWR on the wire version of the antenna. Connect the ground side of the antenna connector to the on-ground radials. Connect the upper terminal to the bottom of the vertical tubing or wire. Next put in the specified capacitors or a ceramic (or equivalent) variable capacitor set to approximately 40 pF. Connect an SWR meter to the base.

Ground Radials

For optimum performance, ground radials are required on most vertical monopoles. They can be made of wire of any gauge or material. I recommend #14 AWG copper wire with a PVC covering because the makeup of the ground material will have little effect on long-term performance. The ⅜-wavelength vertical only requires four quarter-wave radials, which can be installed on the ground. The best length is a quarter-wavelength, or approximately 15 – 17 feet at 20 meters, but length is not critical.[3]

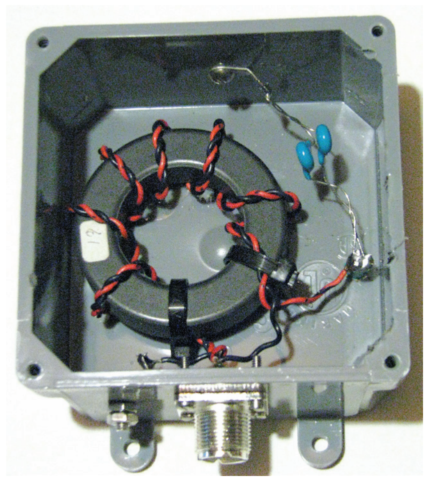


Figure 10 — Construction of impedance-matching network of Figure 9. The enclosure is a plastic electrical box.

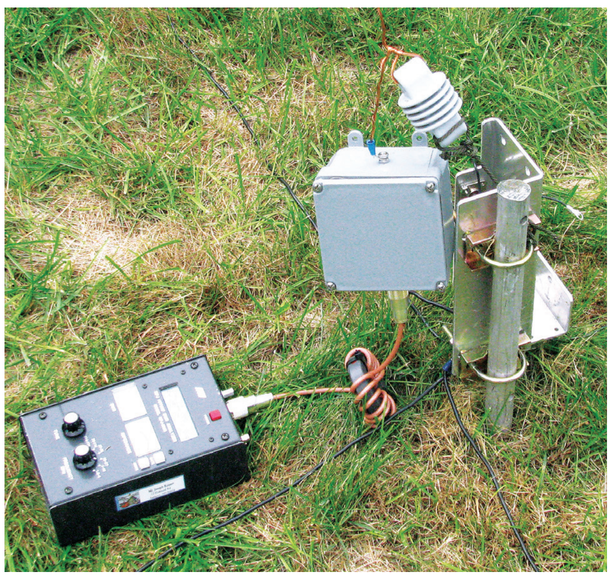


Figure 11 — An antenna analyzer is used in this typical test setup to adjust the matching of the antenna. The wire version is shown.

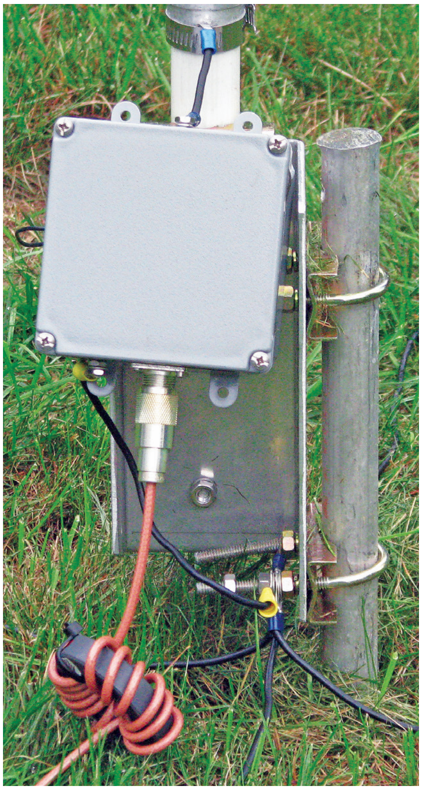


Figure 12 — A ferrite in-line choke is installed on the coax feed line to minimize common-mode current effects.

To prevent radiation from the feed line, it is recommended that a ferrite inline choke (see Figure 12) be installed on the feed line. A 2.4-inch outside diameter ferrite toroid with type 61 ferrite and 10 – 12 turns of RG-303 PTFE coax, W1JR style, makes a good choke.[4] You should now be ready to test.

First, measure the SWR. The upper tubing or wire height can be lengthened or shortened a few inches if required to minimize SWR in the 20-meter band. Next, if a variable capacitor is used, adjust it for best SWR. Continue back and forth until the desired SWR is obtained. Typical SWR results are shown in Figure 13. Then replace the variable capacitor (if used) with fixed capacitors as shown in Figure 9. Because current and voltage are high at this point, two parallel high-voltage ceramic-disk capacitors are recommended.

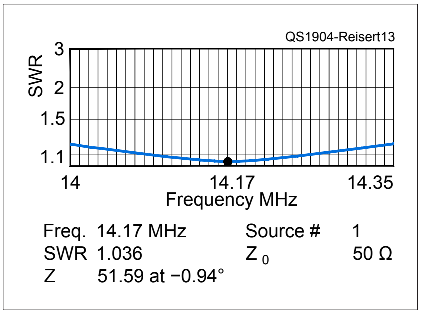


Figure 13 — Typical SWR curve for a 20-meter ⅜-wavelength vertical antenna, tubing or wire, after the matching network is adjusted. Note the bandwidth is comfortably wide.

Performance Results

With this antenna, I quickly qualified for Worked All Continents on 20 meters, running only 100 W. I was able to break through the TX5T Austral Islands pileup in short order to complete the objective.

This antenna can easily be scaled to other amateur bands using the ⅜-wavelength principles. In less than 1 hour, I added two more tubing sections on the top of the 20-meter antenna to a total of approximately 33 feet of tubing. I lengthened the radials to a quarter wavelength, retuned the series capacitor (approximately 52 pF) for minimum SWR and was operational on 30 meters. Immediately, I contacted an African station while running 100 W. However, this modification is tall enough that I recommend a few insulated guy wires.

Notes

[1]R. Severns, N6LF, "Radial System Design and Efficiency in HF Verticals," **www.antennasbyn6lf.com.**

[2]Several versions of *EZNEC* antenna modeling software are available from developer Roy Lewallen, W7EL, at **www.eznec.com**.

[3]See Note 1.

[4]J. Reisert, W1JR, "Simple and Efficient Broadband Balun," *Ham Radio Magazine*, Sep. 1978, pp. 12 – 15.

Joe Reisert, W1JR, is an ARRL Life Member and Amateur Extra-class licensee. Joe was first licensed in 1951 as WN2HQL, one of the first holders of the new Novice-class license.

He received his AAS degree in electronic technology from the State University of New York at Farmingdale, Long Island, in 1956. Over the years, he has been employed by Sperry, IBM, Lockheed Missiles and Space, Fairchild Microwave, The MITRE Corp., Wang Labs, and Cushcraft. In 1992, he formed Antennaco, Inc. and designed and manufactured commercial antennas for VHF, UHF, and microwave communications.

His Amateur Radio interests are primarily DX from HF through microwave. He was a pioneer on Earth-Moon-Earth communications, especially on 70 centimeters. He holds DXCC 392/340, DX Challenge 3160, 13BWAS, 11BDXCC, and IOTA 1100. In 2014, he was inducted into the CQ DX Hall of Fame.

Joe was at one time on the ARRL DX Advisory Committee and was also the Chairman of the VHF/UHF Advisory Committee that developed the present VHF/UHF Band Plans. He has published over 150 technical papers and given over 125 invited talks on various Amateur Radio subjects. You can reach Joe at **w1jr@arrl.net**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

Feedback

- In the article "A Force-Sensing CW Paddle" by Art Heft, K8CIT, in the February 2019 issue of *QST*, Pins 2 and 3 of U1A and Pins 5 and 6 of U1B should be swapped.

- In the article "An Arduino-Powered RF Detector" by Teri Bloom, AC5YL, in the March 2019 issue of *QST*, there are two errors in the schematic diagram shown in Figure 3. The Arduino Nano pin labeled "RAW" should have been labeled "VIN." The cathode of diode D1 should be connected to the Vin pin, not the 5.5 V pin.