A Shortened Capacitive Loaded 160 Meter Vertical Antenna

Here's another way to get onto 160 from a small space.

Paulo Renato F. Ferreira, PY3PR

As a suburban city lot dweller, I used a 60 foot high inverted L vertical as my DX antenna on the 160 meter band. The horizontal wire component measured about 160 feet long, distributed in a spiral fashion around my small lot. The antenna was not truly a vertical, as part of it was horizontal and thus it radiated a horizontally polarized component. Compromised by the space limitations and by a compromise take-off angle, this antenna configuration did not meet my performance expectations. It did, however, help me realize that I needed a low take-off angle, reasonable gain, adequate bandwidth, simple tuning, low cost and, of course, an antenna that would fit into my lot. A tough task indeed, but I decided to go for it.

Shortened antennas have lower feed point impedance than a ¼ wavelength "full size" monopole. For 160 meters, the inverted L vertical with its top loading capacitive hat is a very simple way to compensate for the shortened vertical length.

An Alternative Solution

I started to consider other forms of antenna loading as I was troubled by the inconvenient horizontal wire length of my inverted L. I wanted to use shorter wire lengths but still keep the antenna resonant and maintain a 50 Ω feed point impedance. That was when I found an interesting *QST* article by AC7A.[1] The author recalled the example of an 80 meter dipole pressed

[1]Notes appear on page 00.

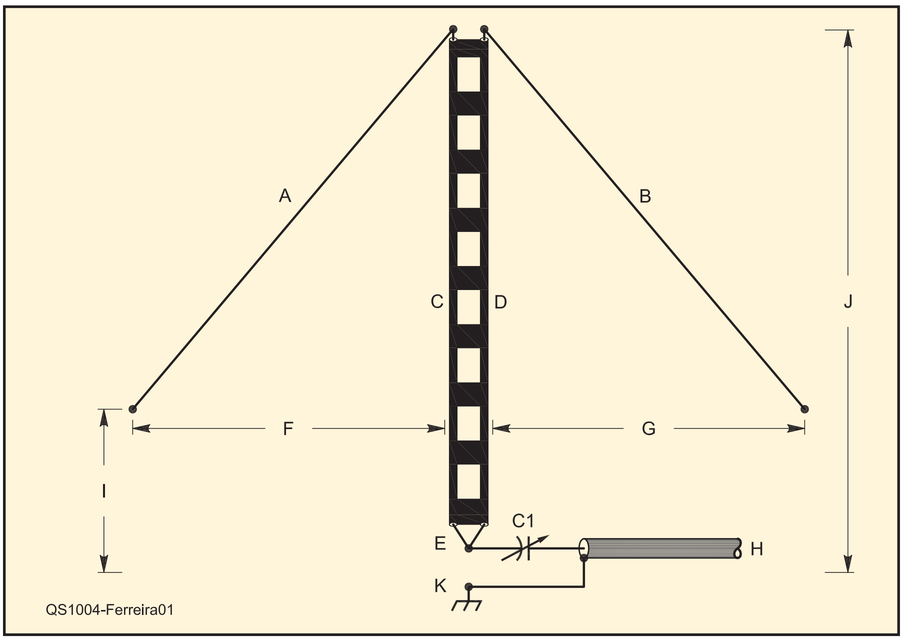

Figure 1 — Diagram and parts list for PY3PR's capacitance loaded 160 meter vertical antenna (not to scale).

C1 — Variable capacitor, 0-1500 pF, 7 kV.
A, B — Sloping segments of 66 foot, 4 inch pieces of #16 AWG enameled copper wire soldered to the top of segments C and D and forming a 45° angle.
C, D — 59 feet of 450 Ω open wire or window line or, alternatively, two parallel lengths of #16 AWG enameled copper wire with a 1 inch separation.
E — 1 inch triangle formed by the bottom ends of the open wire line. Solder them tightly at the vertex and connect to C1.
F, G — Distance between the lower ends of segments A and B from segments C and D, 51 feet.
H — Any length of 50 Ω coaxial cable (RG-213 in this case). The central conductor must be soldered to C1, and the braid to the ground radials.
I — Approximately 16 feet from ground to lower ends of sloping segments A and B.
J — 18.25 m from antenna top to bottom.
K — Ground radials, 60 ¼ λ (the more the better — 32 will form a reasonable ground).

Figure 2 — The completed antenna. In the foreground, from left to right, the ground system, the match box containing the variable capacitor inside and the open wire line tensioned by a nylon rope against a ground stick.

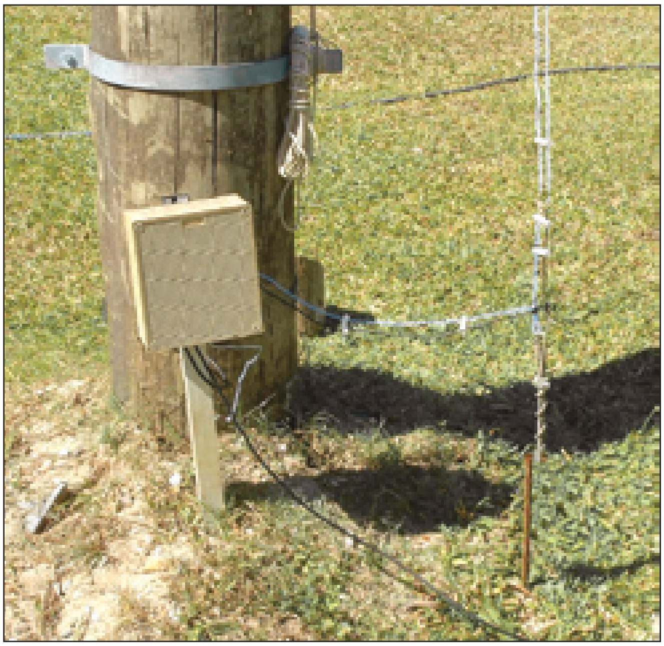

Figure 3 — Front view of antenna showing the details.

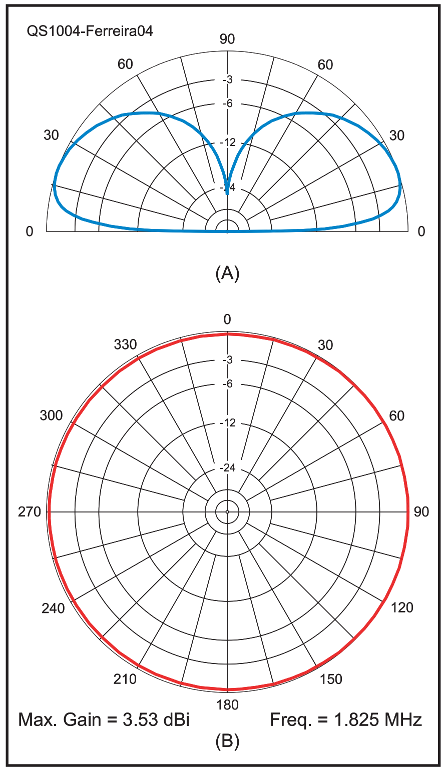

Figure 4 — *MMANA-GAL v. 2.03* (real ground) azimuth (A) and elevation angle (B) plots centered at 1.825 MHz. Notice the omnidirectional pattern and the low take-off angle.

into service as a vertical on 160 meters by shorting the feed line conductors together at the transmitter and working the vertical against ground. The feed line becomes a vertical radiator and the horizontal dipole wires become a capacitive top hat. Because the dipole wires are physically 180° apart, the horizontal component of the radiation cancels in the direction perpendicular to the dipole axis, and is small elsewhere.

Following the idea, I tried some variations resulting in the design shown in Figure 1. It consists of two close vertical wires as two opposed inverted L shaped antennas connected and fed from a common point at the bottom. *MMANA-GAL* software verified the arrangement shown in Figure 1 with a resonance at 1.825 MHz.[2] The resultant antenna was mounted on top of a wooden utility pole, under a two element 40 meter Yagi (see Figures 2 and 3). It consisted of the two 59 foot vertical wires of open wire line with a 1 inch separation lying parallel to the pole and soldered at the bottom. At the top of the line, I soldered a 66 foot, 4 inch wire to each side of the ladder line. For convenience, I sloped the far ends of these wires to within 16 feet of the ground. This sloping shape did not affect the results noticeably.

Tuning was obtained through a 0-1500 pF, 7 kV, variable capacitor (C1) connected in series between bottom of the ladder line and the center conductor of a length of RG-213 coaxial cable. The coaxial braid was connected to 60 quarter wave long buried radials. *The ARRL Antenna Book* recommends 40 or more on ground or buried radials, each 0.2 wavelengths or longer for efficient short vertical antennas.[3] [Recent studies have confirmed that four elevated, insulated and resonant radials can be as efficient, but they can pose problems in a multiuse space.[4] — *Ed.*]

The results obtained from *MMANA GAL* modeling were very positive for DX purposes (see Figure 4). The antenna showed an omnidirectional radiation pattern and a take-off angle of 19.6°.

Construction Details

While building this antenna, keep in mind that the dimensions shown in Figure 1 may need to be trimmed depending on the wire diameter, the sloping wire lengths, the vertical wire separation and length, the angle between the vertical and sloping wires and the value of C1. I highly recommend you have an antenna analyzer at hand, so you may watch the feed point impedance as you pull it all together to facilitate matching. As a general rule, if the real part of the impedance is lower than the desired 50 Ω, you should increase both sloping wire lengths symmetrically. If the real part is higher than 50 Ω, make it go the other direction by carefully trimming no more than 2 inches per pass.

Modifying the wire lengths will also result in a change in reactance. You should be able to adjust the reactance to 0 Ω at your favorite frequency within the range of C1. In my case, I got a match with C1 set to about 1000 pF.[5]

Install C1 in an insulated plastic box near the bottom of the antenna. Alternatively, once you find the needed value, measure it with your antenna analyzer and replace it with a fixed 7 kV mica capacitor.

On the Air with the Vertical

Both theoretical (see Figure 5) and practical results achieved with this small antenna validated my initial expectations, particularly for DX purposes. Low take-off angle is a necessary condition for DX performance and I was gratified by its predicted 19.6° elevation angle and a gain, similar to a full size ¼ wave monopole. The 2:1 SWR bandwidth of 26.2 kHz was also convenient. I tried full legal power, and observed neither cable warming nor SWR variation in the RG-213 coaxial cable. The total cost was under $80, because I had already the variable capacitor and the support. Finally, the antenna fit entirely into my lot. As a top band vertical, this antenna has a typical noisy reception pattern and thus makes an efficient antenna

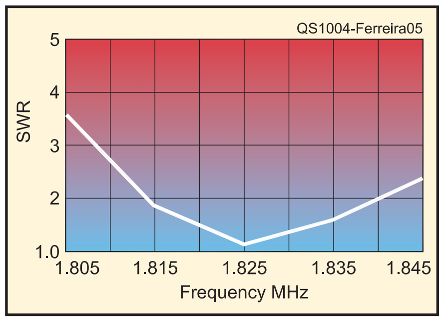

Figure 5 — Plot of SWR versus frequency. Bandwidth is 26.2 kHz at SWR<2.0:1.

system if combined with a low noise antenna such as a K9AY loop for reception.[6]

In Conclusion

Saving precious physical space, while still offering good DX performance, are the main benefits of this shortened top band antenna. It is a compromise solution, however, and certainly does not equal the performance of a full quarter wave monopole. Nonetheless, it has provided me lots of excitement.

I wish to thank Paul Toledo, PY3DX, Antonio de Padua Vargas Alves, PY3IOD, Rafael Haag, PY3FF, and Odi da Silva Melo, PY3BC, for their contributions to this project.

Notes

[1]T. Kuehl, AC7A, "Build Efficient, Short Vertical Antennas," *QST*, Mar 1998, pp 39-44.

[2]*MMANA-GAL* V 2.03 is an antenna analysis tool based on the method of moments as introduced in *MININEC* V 3 and featuring multiple on-screen language support. The *BASIC* source code of the computation engine is published as a PDS in *MININEC*. All versions of the program, as of V 2.03 and higher, use the *MININEC-3* engine modified by Alexandre Schewelew, DL1PBD, and are written in *Borland C++* V 4.0. *MMANA-GAL* is available without cost to hams at **mmhamsoft.amateur-radio.ca/pages/mmana-gal.php**.

[3]R. D. Straw, Editor, *The ARRL Antenna Book,* 21st Edition, p 6-36. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 9876. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop**; **pubsales@arrl.org**.

[4]R. Severns, N6LF, "An Experimental Look at Ground Systems for HF Verticals," *QST,* Mar 2009, pp 30-33.

[5]Some antenna analyzers do not show the sign of the reactance. If so, it can usually be determined by increasing or decreasing the frequency slightly. If the reactance goes up with increasing frequency, the reactance is inductive. Make sure you don't change frequency so much that the reactance goes through 0. Alternately, just adjust the value of C1 value, or the wire length, to obtain the lowest reactance reading possible.

[6]G. Breed, K9AY, "The K9AY Terminated Loop — A Compact, Directional Receiving Antenna," *QST*, Sep 1997, pp 43-46.

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