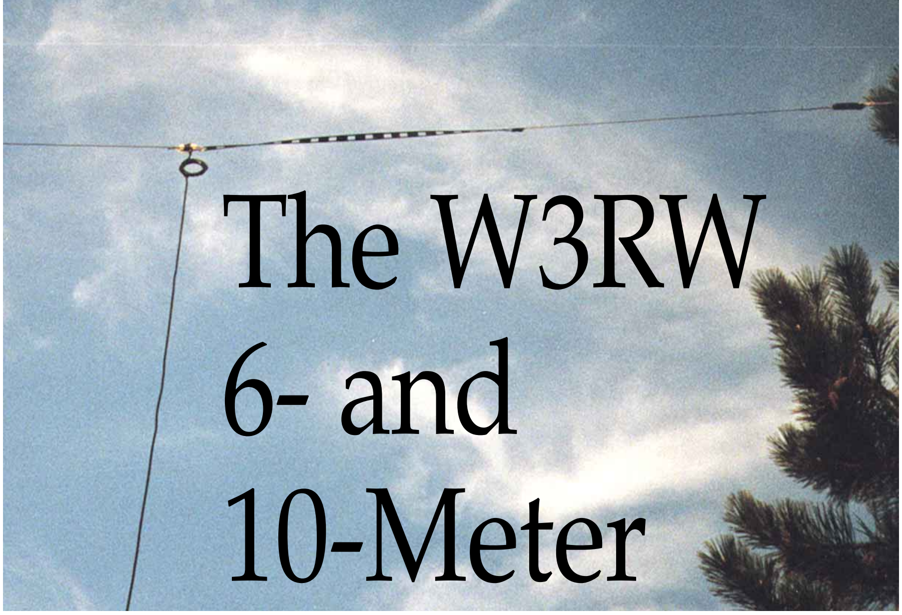
By Bob Witmer, W3RW

Looking for better-than-dipole performance on 6 and 10 meters without investing in a beam and rotator? Here it is! This novel antenna includes a matching section to deliver a near-50-Ω match on both bands.



The W3RW 6- and 10-Meter Long Wire

I received many inquiries about the antennas described in my article, “Wire Gain Antennas for 6 Meters.”[1] My favorite wire antenna—in terms of overall ruggedness, simplicity and pattern coverage—is a 4-λ long wire. In the spring of 1999, with the sunspot cycle improving, I decided I needed an antenna that would also provide some gain over a dipole on 10 meters. With this goal in mind, I investigated how to make a long-wire antenna that works well on 6 *and* 10 meters. Here’s what I found.

Why Use a Long-Wire Antenna?

Wire antennas are among the easiest to install and use (and arguably lowest in cost), but most hams don’t think of using long-wire antennas on VHF. Long-wire antennas *can* be used on VHF—particularly on 6 meters—as easily as on the HF bands. The following paragraphs describe typical long-wire gain and pattern characteristics; feedpoint characteristics are discussed later.

Gain

Antennas more than a couple of wavelengths long at the operating frequency exhibit gain over a dipole. The maximum lobe of an antenna 4λ long has an estimated *gain over a dipole* of approximately 3 dB (3 dBd); see Figure 1. The estimated gain for other multiple-wavelength wire antennas varies. A 3-λ antenna should have a gain of slightly more than 2 dBd; a 5-λ antenna exhibits a gain of about 4 dBd.

Patterns

With the gain increase comes a change in the antenna’s radiation pattern. Along the axis of the wire, there is a narrowing and increase in the amplitude of the gain lobes compared to those of a typical dipole antenna’s broadside pattern. Also, there’s an increase in the number of lobes (and nulls) that provides somewhat omnidirectional coverage. Figure 2 shows some theoretical pattern comparisons.

Dual-Band Long-Wire Design Constraints

By changing which trees I used to support my wire antenna, I had room (just over 105 feet) to put up an antenna longer than the original 77-foot, 4-λ antenna. After playing with the antenna-length formulas, I found that a 3-λ, 10-meter long wire or a 5-λ, 6-meter long wire would fit. Both antennas provide the gain I was looking for—but I didn’t have the room to put up *both*!

Eureka! The Dual-Band Long-Wire Antenna

Like the 4-λ, 6-meter long-wire antenna, I wanted a configuration with its feedpoint at a current loop ($^1/_4$ λ from one end of the antenna) to present a low-impedance to the feed line. This approach essentially separates the antenna into a “long” section and a $^1/_4$-λ section. After examining the individual 3- and 5-λ antenna dimensions using 28.35 MHz and 50.15 MHz as frequencies of operation, it became clear that these antennas have one thing in common: The long sections are almost equal in length. With that in mind, I came up with a dual-band long-wire antenna design (see Figure 3) that uses ladder line as part of the $^1/_4$-λ sections for each band and shares a common long section.

Dual-Band Matching Issues

Figure 1 shows the variation of radiation resistance, as measured at a current loop, with wire antenna length. Using this as a guide, the dual-band long-wire antenna has a theoretical feedpoint impedance of about 125 Ω on 10 meters (3λ) and 140 Ω

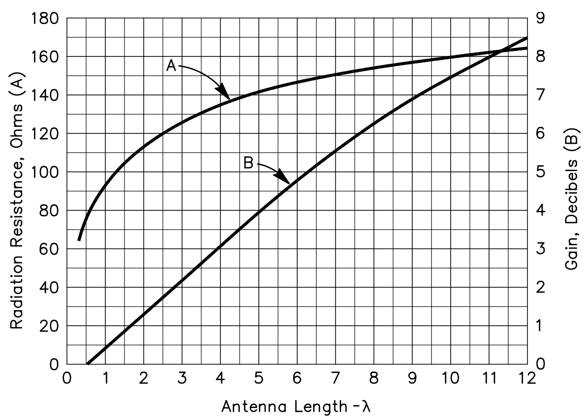


Figure 1—The variation in radiation resistance and power in the major lobe of harmonic (long-wire) antennas. Curve A shows the change in radiation resistance with antenna length, as measured at a current loop, while curve B shows the power gain in the lobes of maximum radiation for long-wire antennas as a ratio to the maximum of a $^1/_2$-λ antenna.

[1]Notes appear on page 48.

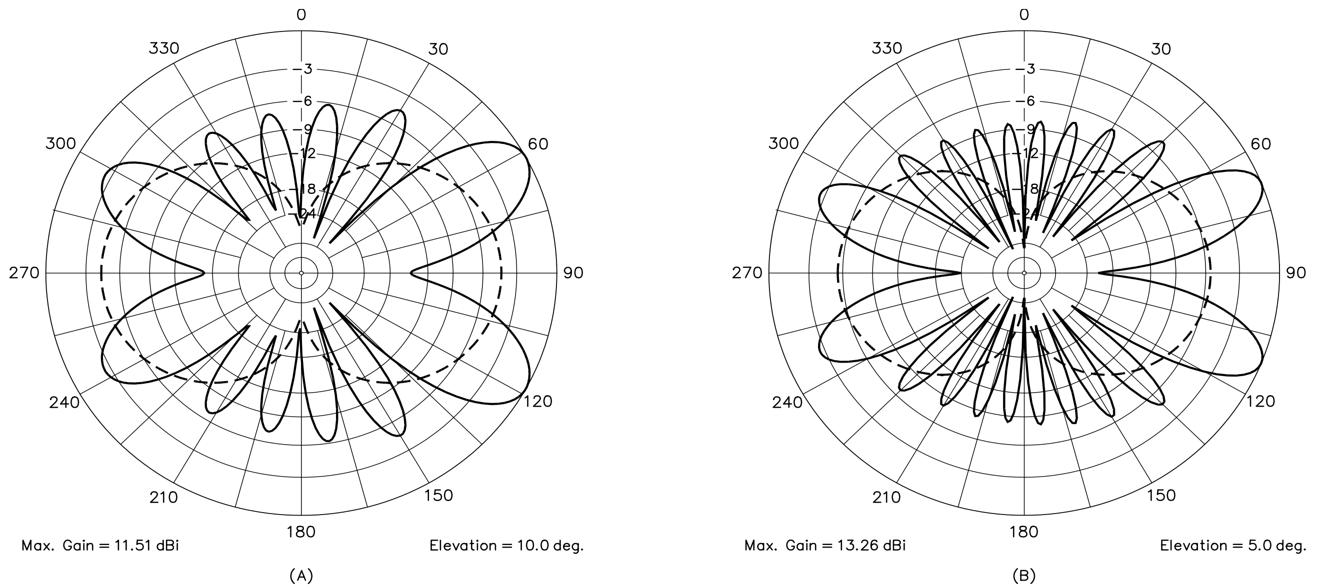


Figure 2—Predicted horizontal radiation patterns of a long-wire antenna as a function of length. At A, pattern of a 50-foot-high 3-λ long-wire antenna (solid lines) compared to that of a dipole (dashed lines). At B, pattern of a 50-foot-high 5-λ long-wire antenna (solid lines) compared to that of a dipole (dashed lines). ***Tnx Dean Straw, N6BV***

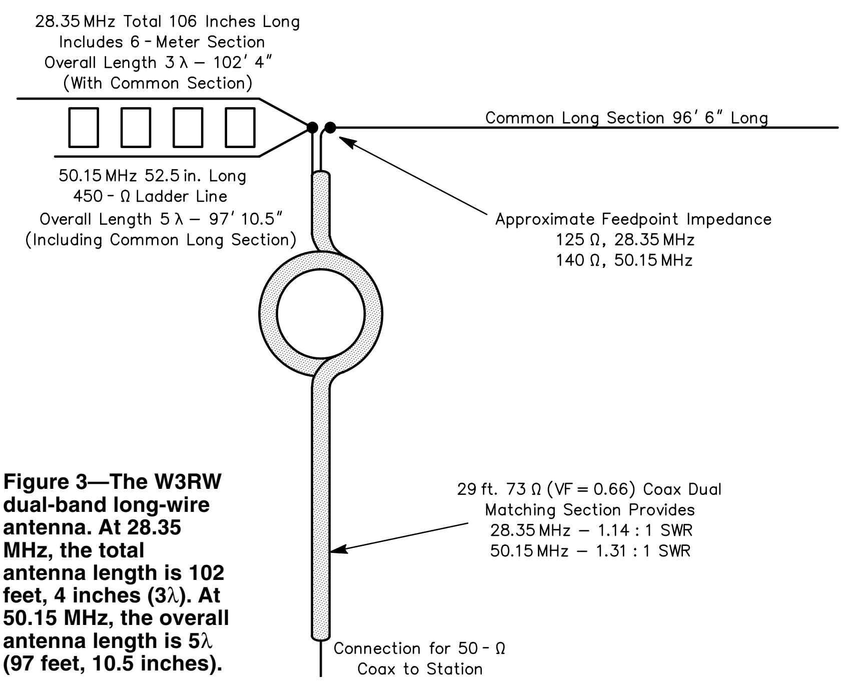


Figure 3—The W3RW dual-band long-wire antenna. At 28.35 MHz, the total antenna length is 102 feet, 4 inches (3λ). At 50.15 MHz, the overall antenna length is 5λ (97 feet, 10.5 inches).

on 6 meters (5λ). Either feedpoint impedance lends itself to using a 1/4-λ 75-Ω coax matching section to match a 50-Ω coax feed line, but the typical 1/4-λ coax matching section on 10 meters doesn't work on 6 meters and vice-versa. A wideband 4:1 balun could be used for matching, but the resulting impedance transfer would probably not be as close to 50 Ω as the 1/4-λ matching technique provides. Also, most 4:1 baluns are relatively heavy, adding to antenna sag. Wideband 4:1 baluns are also expensive compared to the cost of 20 to 30 feet of coax. So, I decided to evaluate other approaches.

Eureka Again! The Dual-Band Coax Matching Section

I thought of the dual-band matching solution when I decided to experiment by adding a number of 1/2-λ coax sections after the 6- and 10-meter 1/4-λ sections. Comparisons showed that there is a combination of 1/4-λ and 1/2-λ transmission-line sections that results in total coax lengths for *each* band that are almost the same. (See Figure 4 and the sidebar "Characteristics of Half-Wavelength Transmission Lines.")

The total lengths of the two coax sections are close enough that the combination match works for the frequency pair of 28.35 and 50.15 MHz, although frequencies of 50 and 29.9 MHz provide an optimum calculated dual match. With the combination of the dual-band matching section and the dual-band long wire, an overall good match to 50-Ω line is obtained over the low-frequency ends of 6 and 10 meters.

On-The-Air Performance: Does it Work?

The system appears to work well—just like individual 6- and 10-meter long wires! With the long-wire antenna's maximum-strength lobes favoring the North/South directions, I use a two-element 6-meter quad in the attic to provide extra gain to the West. Although there are directions in which the quad *is* significantly better than the dual-band long wire, I've found that the long wire can hear everything the quad can hear—*including some signals the quad doesn't*.

My first QSO with the antenna came just after I finished making some adjustments. With my IC-706 connected directly to the end of the coax matching section, I answered a station in upstate New York calling CQ on 50.125 MHz. He came right back to me and we exchanged good signal reports (he was off the slightly weaker major lobe's end of the antenna.) After that, I switched to 10 meters and proceeded to work quite a few South and Central American stations in the main line of the antenna's stronger gain lobes. With the help of a small antenna tuner, I stretched the antenna's 10-meter bandwidth to cover the repeater segment and proceeded

Characteristics of Half-Wavelength Transmission Lines

A key factor in the dual-band matching solution is the 1/2-λ characteristic of transmission lines. Any impedance presented at one end of a 1/2-λ of coax—with coax of *any impedance* (that's the important part)—that same impedance is seen at the opposite end of the cable. For example, if you connect a 1/2-λ (or any multiple of 1/2-λ) of 75-Ω coax to a 50-Ω load, a 50-Ω impedance is seen at the other end—*even though the characteristic impedance of the coax in between is 75 Ω*. (All wavelength references are to *electrical* lengths of coax; this takes into account the velocity factor of the cable.)

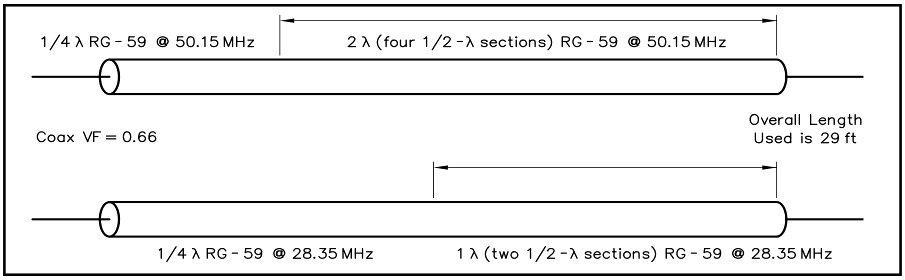


Figure 4—The W3RW dual-band matching section. Lengths shown here are for coax with a velocity factor of 0.66. The upper cable leg consists of a 50.15-MHz 1/4-λ section of RG-59 coax in series with a 50.15-MHz 2-λ (four 1/2λ-lines in series) section of RG-59 coax. The lower leg is a 28.35-MHz 1/4-λ of RG-59 coax in series with a 28.35-MHz 1-λ section (two 1/2λ-lines in series) of RG-59.

to work several additional stations.

As I write this, the September VHF contest and Hurricane Floyd's visit occurred about two months ago. I didn't actively participate in the contest, but I did use it to further check the antenna's 6-meter performance. With a transmitter RF output of 100 W, I found I could work everything I heard, including several sporadic-E contacts late one Sunday, but I did have to use a 400-W amplifier to make an Auroral contact. Ten-meter performance has been great! I've had no trouble working most DX I can hear from all over, including 7X, 9K, JA, ZS, ZL—and even a DS—with just 100 W output.

Construction Tips

Figure 3 shows the antenna details (not to scale). Cut the wire sections of the antenna a little long and wrap the far ends of the extra wire lengths back onto the main wire. This way, if you need to lengthen the antenna, you just unwrap the extra wire; you don't have to worry about adding more wire. If the antenna is too long, simply wrap more wire back onto the main run to reduce the antenna's overall length.

I started out with a little more than 5 feet of 450-Ω #14 stranded copper-clad ladder line for the 1/4-λ antenna section, allowing for connection to the center insulator and the 10-meter wire extension. As shown in Figure 3, one conductor of the 450-Ω line (the upper one) is used on 10 meters. The shorter conductor (lower one) is used on 6 meters. Make the cut for the 6-meter section so that it is *inside* one of the solid-dielectric sections of the line. Cutting the ladder line this way helps maintain the overall physical strength of the 6-meter section. (By the way, the dual-band long wire survived Hurricane Floyd's visit!)

Weatherproof the antenna by sealing the coax-to-wire connections, the connection between the matching-section coax and the 50-Ω feed line, and the connections at the ends of the matching section. Use a low-loss 50-Ω cable between the matching section and your shack.

To properly cut the matching line, you *must know* the velocity factor of the 75-Ω coax! The matching section I use is made of 0.66 velocity factor RG-59 coax, but cables with other velocity factors can be used as well. (When selecting the matching-section coax, remember that the center conductor in *foam-dielectric* coax has a tendency to migrate, potentially resulting in a short to the shield if the coax provides some structural support or is coiled.) I took the precaution of verifying the coax velocity factor by cutting an approximate 1/4-λ section and checking its length and frequency characteristics using a dip meter. Larger-diameter 75-Ω coax (such as RG-11) can be used if you want lower loss, but the cable is heavier than RG-59, and will likely increase the antenna sag. Interestingly, the data tables for coaxial cable show that the loss of many RG-59 coax types is similar to, or slightly *lower* than, RG-8X coax types at 50 MHz.

Adjustment

To tune the antenna, first adjust the lengths of the 1/4-λ sections, then adjust the long-wire sections to minimize the SWR on both bands. Then check the 1/4-λ-section lengths again. It takes no more than a couple of iterations to achieve the lowest SWR on both bands. The exact length of the dual-band coax matching section doesn't appear to be critical. I cut the matching section a little longer than 29 feet (using 0.66 velocity-factor coax) to provide the extra length needed for the connections to the wire and ladder-line sections and for the end coax connector. The resulting match was close enough to not require adjustment.

Coaxial Choke Balun

To isolate the feed line from the radiating currents of the antenna, I use a choke balun consisting of four feet of the matching-section coax wrapped in four turns just below the antenna feedpoint. This approach may not be as effective as using a traditional balun, but it seems to work; and considering the unbalanced antenna configuration, it may work almost as well. I have had no complaints about RF in the shack or house on either band. I derived this approach from the information in Table 19.4 on page 19.16 of *The 2000 ARRL Handbook for Radio Amateurs*.[2]

Summary

The W3RW 6- and 10-meter long-wire antenna is a resonant multiwavelength antenna that provides gain over a dipole on 6 and 10 meters and integrates a unique coax-cable matching section to provide a close match to 50 Ω on both bands. This is a predominantly horizontally polarized antenna optimized for the SSB portions of the 6- and 10-meter bands. Considering its simplicity and low cost, you ought to give it a try!

Notes

[1]J. Robert Witmer, W3RW, "Wire Gain Antennas for 6 Meters," *QST*, Feb 1997, pp 66-67.

[2]ARRL publications are available from your local dealer, or directly from ARRL. See the ARRL Bookcase elsewhere in this issue, or check out the ARRL web site at: **http://www.arrl.org/catalog/**.

[3]Please contact me for price and availability of a partial kit consisting of the dual-band matching-section coax, the 1/4-λ open-wire section and additional assembly information. Bob Witmer, W3RW, 146 Forest Trail Dr, Lansdale, PA 19446-6415; **w3rw@arrl.net**.

References

The ARRL Antenna Book (Newington: ARRL, 15th ed., 1988)

Edward M. Noll, W3FQJ, "A Multiband Long-wire Antenna," *ham radio*, Nov 1969, pp 28-31

ARRL's Wire Antenna Classics, (Newington: ARRL, 1999)

John D. Heys, G3BDQ, ed., "Practical Wire Antennas," (Potters Bar, England: RSGB, 1989)

Bob Witmer, W3RW, was first licensed in 1962 as K3VAX; he got his Extra class license in 1967. His Amateur Radio interests include equipment and antennas, 6- and 10-meter operating and HF DXing. Bob is a program manager for BAE Systems of Lansdale, Pennsylvania, with responsibility for a variety of electronic warfare programs. Bob has written several articles for QST. You can contact Bob at 146 Forest Trail Dr, Lansdale, PA 19446-6415; **w3rw@arrl.net**.

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