By Lew Gordon, K4VX

The K4VX Linear-Loaded Dipole for 7 MHz

Here's a very simple and practical way to make a short but efficient 40-meter dipole.

One of the easiest antennas to build is the half-wavelength dipole fed with coax. Every *ARRL Handbook* since 1930 contains the information required for constructing one. The only limiting aspect to the antenna is the space, or span, required to support it. This becomes a particular concern at the frequencies 7 MHz and below. While in my own personal situation space is not a problem, I decided to design a shortened dipole for use where space *is* limited.

At 7 MHz a standard horizontal dipole requires approximately 66 feet of wire, and with center and end insulators, approaches 68 feet between rope supports. Obviously one must add several more feet to the total span for support. My concept was to design a dipole that is approximately 70% of the length of a standard dipole, yet be very inexpensive and simple to construct. It also had to perform nearly as efficiently as a full-sized antenna. Linear loading seemed to be the simple way to go.

Linear Loading

Linear loading has been around for many years in the design of 80 and 40-meter Yagis. One of the first antennas I can recall was the Hy-Gain 402BA, a 40-meter, 2-element design with 46-foot elements on a 16-foot boom. Other manufacturers copied the concept in their Yagi designs. The shortened dipole presented here is the result of using computer modeling initially to verify the concept, and actual construction to verify the modeling. Not surprisingly theory and reality are very close.

In order to keep the design of this antenna inexpensive I decided that I would try 450-Ω ladder line as the linear-loading mechanism. I pursued two methods of applying the loading:

1. Inserting the loading midway on each side of the span, which requires two additional insulators.
2. Inserting the loading at the center, supported by the antenna wires.

After modeling with *NEC-2*, and later with *NEC-4*, I could see very little difference between these two methods. Since the first method requires two additional insulators, I chose the second method. Both modeling programs provided encouraging results and I decided to construct the antenna.

My initial construction consisted of a 46-foot span of #12 Copperweld fed in the center, and linear loaded with two 12-foot sections of 450-Ω ladder line[1] on

[1]Notes appear on page 42.

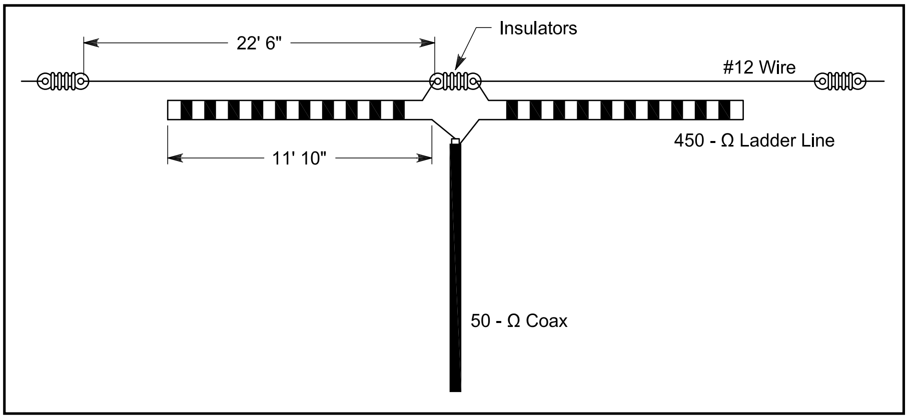

Figure 1—Layout of K4VX linear-loaded dipole. Although the #12 wire is threaded through the 450-Ω window line to support it, this is not shown in this drawing for clarity.

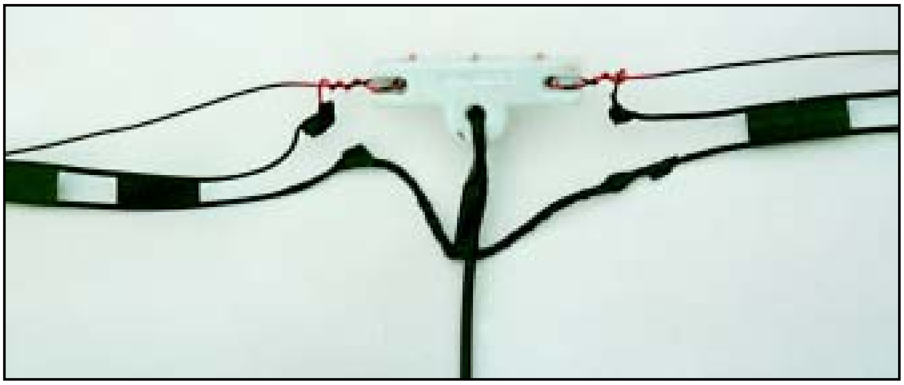

Figure 2—Details of feed point. Note that the feed coax loops through the center insulator for mechanical strain relief.

each side of the center insulator, and shorted at the end away from the center. Where this design differs from previous ones is that in mine the #12 wire is interlaced into the ladder line to provide physical support to the ladder line. See Figure 1, a schematic of the wiring arrangement. Figure 2 is a photo showing details of the feed point, and Figure 3 shows the final method I used for interlacing the #12 wire through the open windows of the ladder line. I'll discuss this in more detail later.

Figure 3—Final assembly method using interlaced #12 Copperweld wire through holes punched in the windowed ladder line.

I can hear the purists now, "That contraption will never work. The wires are too close." Well, this is the proverbial bumblebee—it doesn't know it can't fly!

Construction

In actual construction I used approximately 54 feet of RG-8X Mini Foam from RadioShack[2] to provide a half-wavelength feed line at 7.025 MHz. Since I assumed I would encounter impedance that was different from 50 Ω, I wanted to make an exact half wavelength that would repeat the value at the center insulator.

I measured the electrical line length using a General Radio 916-A RF bridge, using a Measurements Corporation Model 65-B signal generator as the source, and an IC-740 transceiver as the null detector. For those readers who are not familiar with using a bridge to measure a half wavelength length of coax, the technique is to short one end and look for an impedance at the other end that is zero reactance and a very low resistive value. In this case after some pruning the resultant impedance was $3.1 + j0\ \Omega$.

After the antenna was up in the air, I could then measure the impedance at the feed point and proceed with matching it. As a point of interest, RadioShack states that this coax has a velocity factor of 78%. My measurement was remarkably close, at 77%.

Installation

Once the antenna was constructed, I hoisted it up to about 40 feet. I then used the MFJ-247 bridge to measure SWR. To my shock, the SWR was perfectly flat at 7.025 MHz, the frequency for which I had designed the antenna! Having been a ham for almost 55 years, I can honestly say that the chances of this happening are almost nonexistent. Figure 4 shows the measured SWR for this initial antenna.

Obviously the design center at 7.025 MHz is too low to cover the entire 40-meter band. However, perusal of the data indicates that the 2:1 SWR bandwidth approaches 300 kHz, which is broad enough to cover the entire band with some scaling of the center frequency. In my own case I would probably have left the antenna as is, but since this is an article for the general amateur population, I proceeded to scale the design to 7.125 MHz.

Frequency Scaling

The first thing learned is that a 1.4% (7.125/7.025) proportional change of both wire length and 450-Ω ladder line length will not provide the correct frequency shift. Originally, I shortened each wire tip 4 inches and each linear loading line 2 inches. This moved the resonance to 7.200 MHz, rendering it less than useful at the bottom of the CW band.

Next, I decided to leave the linear loading alone and just lengthen the ends of the #12 wire. After several attempts, resonance is now 7.125 MHz. Figure 5 shows the SWR of the completed antenna. The 2:1 SWR bandwidth is approximately 275 kHz, which covers practically the entire 40-meter band. The measured final dimensions of the antenna are 22.5 feet of #12 Copperweld, and 11 feet 10 inches of ladder line each side of center.

While conducting these tests, I discovered that raising and lowering the antenna alone could shift resonance as much as 20 kHz. This was with no length changes being made. I then decided to secure the #12 Copperweld as closely as possible to the center of the ladder line with electrical tape. It appears that as the secured Copperweld shifted, the coupling between the ladder line and the Copperweld changed—not much, but enough to be detected by the MFJ-247. Electrical tape alone is not the best final solution for this. A better solution is to punch holes in the center of the ladder line insulation and lace the wire through at about 6-inch intervals. This prevents any deviation in the spacing of the conductors. See Figure 3 again.

There are several ways to secure the end of the ladder line to the #12 wire. I chose electrical split-bolt connectors with nylon cord for mechanical strain relief. Care should be taken to insure that the shorted end of the ladder line does not come in

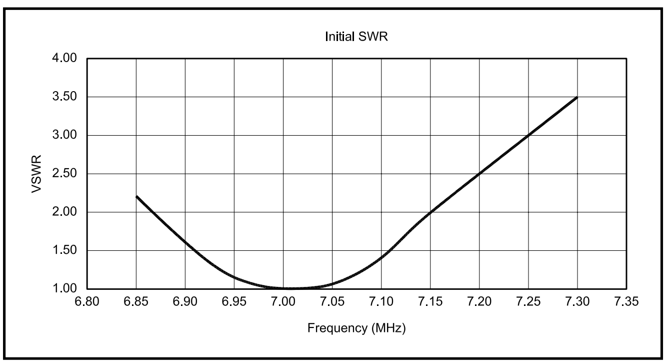

Figure 4—SWR curve for initial model built by K4VX.

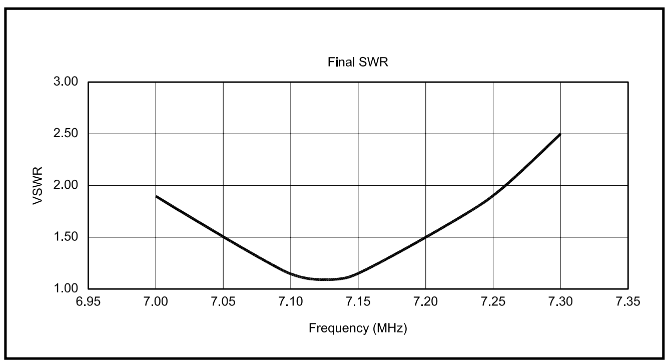

Figure 5—SWR curve for finalized model.

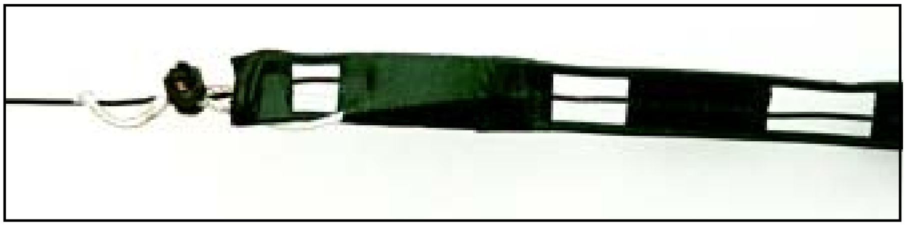

Figure 6— There are several ways to secure the end of the ladder line to the #12 wire. I chose electrical split-bolt connectors with nylon cord for mechanical strain relief. Care should be taken to insure that the shorted end of the ladder line does not come in contact with the wire.

Figure 7— The K4VX 40-meter linear-loaded dipole deployed at 40 feet.

contact with the wire. See Figure 6.

Performance

There appears to be little measurable on-the-air difference between this shortened dipole and a full-sized dipole. Computer modeling indicates less than 1 dB difference also. Figure 7 is a photo of the antenna at 40 feet.

The total cost of this antenna (minus coax) should be less than $25 with all-new materials. The 450-Ω ladder line is available for approximately $0.25/foot and Copperweld #12 wire for less. New insulators should be less than $10, but junk boxes and flea markets can usually suffice.

Conclusion

This design provides a dipole that is 70% of the span of a full-size dipole with little observable difference in performance. On 40 meters this amounts to a reduction of over 20 feet. An 80-meter version requires only a 90-foot span. I can envision an 80-meter 4-square with a 45-foot high linear-loaded vertical element and a single 45-foot linear-loaded radial supported by a 60 to 70-foot tower based upon the ON4UN design.[3]

Another application might be a linear-loaded quarter-wave 160-meter sloper supported from an 80-foot tower. As with most new concepts, experimenters will not necessarily get perfect matches on the first try as I did with this antenna, but for those willing to make adjustments and use some cut-and-try, the rewards will prove worth the effort.

Notes

[1] Available from The WIREMAN, 261 Pittman Rd, Landrum, SC 29356, orders 800-727-WIRE; **cahaba.net/~thewirem/index.shtml**. Part #CQ-552.

[2] RadioShack #278-1313.

[3] *ON4UN's Low-Band DXing* (Newington: ARRL, 1999) p 11-72, Section 5.3.

Photos by the author.

Lew Gordon has been licensed continuously since 1947, and earned his Extra Class license in 1952. He has previously held the calls W9APY, WA4RPK and W4ZCY. He has held K4VX since 1973. Lew's wife holds NSØZ, and his daughter is NØHVY. Lew earned a BS degree in Physics from Purdue University and did graduate work at Georgetown University. Lew is a retired US Government systems engineer. He was elected ARRL Midwest Division Director in 1993 and retired in 2000. An active contester, Lew's main love in Amateur Radio is antenna design and construction. His antenna farm consists of 10 towers ranging from 50 to 170 feet with rotaries on 40, 20, 15 and 10 meters. He has written several human interest articles as well as articles on band-pass filters, antenna designs and other subjects. His freeware program YAGIMAX *is in use all over the world. You can contact the author at PO Box 105, Hannibal, MO 63401;* **k4vx@arrl.net**.

STRAYS

LANDMARKS MAY BE COMING DOWN

◊ Anyone who's driven past the two impressive antenna structures just off I-71 in Oregonia, Ohio (between Wilmington and Rte 73), won't soon forget them. The two 80-foot homemade towers, one of which had a homemade sign with the owner's call sign, are about 150 feet apart—a comforting landmark to travelers to the Dayton Hamvention. The sign has come down, and the towers may soon follow, as Estle Hagemeyer, W8FMV, became a Silent Key last year and his farm is to be sold. *—Charles J. Stinger, W8GFA*

One of the towers, which have stood at the site in Warren County, Ohio, since 1950.