K4EF LONG WIRE
ANTENNA DESIGNS

Simple antennas provide exceptional performance

By Everett Brown, K4EF, 6710 Highway 329, Crestwood, Kentucky 40014

My interest in long wires was sharpened in the mid-1970s when I acquired my first solid-state transceiver that required no tuneup. It seemed to me that transmitter technology had left antenna development behind. Wouldn't it be a great improvement to have a single high performance all band antenna fed with a single coaxial cable? Think of the convenience! When operating in contests you could switch bands with no time lost. During a QSO, you could check quickly to see if another band was open. You'd be free to operate on any Amateur HF frequency, without the limitations imposed by antenna bandwidths and high SWR. You could explore every nook and cranny of our extensive frequency allocation and find new friends who rarely leave "home" frequencies. I felt long wires offered the best opportunity to achieve that ideal.

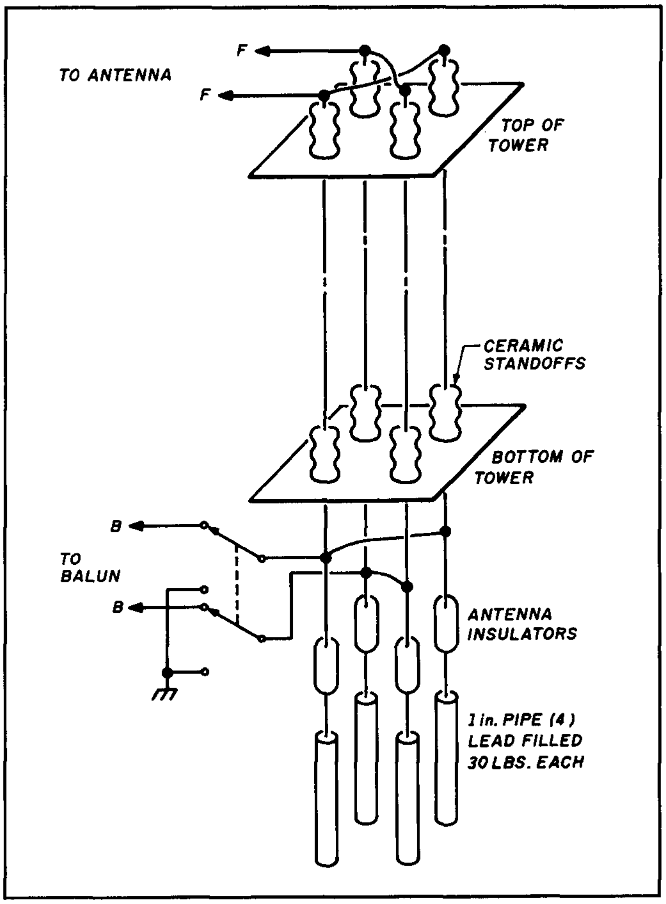
After many months of testing performance on the air and experimenting with numerous configurations, I came to the following conclusions:

- Under skip conditions, V antennas were vastly superior to straight long wires or dipoles. This wasn't due to azimuth gain — they excelled in any direction. Ground wave measurements weren't at all similar to measurements taken during skip contacts.
- A resonant wire, approximately center fed and an odd number of half waves in length, offered a consistent impedance in the vicinity of 200 ohms. If additional wire legs resonant on other frequencies were added, the impedance varied only slightly. If the feedpoint was moved from the center of the element as much as 1/8 wavelength there was surprisingly little shift in impedance.

These findings suggested a whole family of new antenna designs, but I concentrated on my ideal — all bands, one coax. My final design was highly successful and I published it with the associated test and measurement results in the Amateur literature.[1] The final design had one drawback. It occupied about ten acres; not many urban Amateurs could fit it into their backyards. Despite this, I received letters from rural users in many states, and from as far away as VK-land. The Australians were particularly pleased. The antenna performed flawlessly on the commercial frequencies they used in addition to Amateur bands for communications in remote areas.

These antennas are also appealing because they don't require expensive hardware which would oxidize outdoors. I used a single 40-foot wooden mast and aluminum electric fencing wire, which I bought in quarter-mile rolls from commercial suppliers. Trees provided the only other supports.

FIGURE 1



Detail of the 4-wire 200-ohm feedline and grounding relay.

Antenna feed

Feeding a 200-ohm antenna is simple. It requires a 4:1 balun and 50-ohm coaxial cable. Of course, because commercial baluns usually aren't perfect, a word of caution is in order. I suffered a 3:1 SWR on 10 meters for a year before a nearby lightning strike caused the balun to explode like a hand grenade, littering the yard with plastic fragments. Many of the letters from users of identical antennas had reported unity SWR. That lightning strike was a great help. A new balun cured my SWR problem. After the strike, I took more precautions. These involved moving the balun from the top of the mast to the bottom, and installing a 200-ohm open wire line with a relay which grounded the antenna and disconnected the balun automatically when the transceiver was turned off. The 12 volts DC for the relay was supplied by the transceiver power supply. I recommend you try this procedure if you're in an area that experiences frequent electrical storms. **Figure 1** shows the details. Four no. 10 copper wires are arranged in a square on 2-inch centers and the diagonally opposite wires are joined together at each end of the line. This line has much lower loss than coaxial cable — a worthwhile bonus. I removed the bolts from the ceramic standoffs and fed the wires through the holes, so the insulators acted as guides. The shelves holding the standoffs had 1-inch holes on the wire centers, providing plenty of clearance. I captured the wires above the top insulators with brass washers that I silver soldered to the wire. If this sounds like a lot of work, there's a shortcut. There was 200-ohm twin lead on the surplus market a few years ago, which would work well in this application. However, finding it is difficult.

The Novice license now allows operation on four HF bands. Old-timers, their backyards already bulging with antennas, may not want to add more for WARC bands. It appears there's an urgent need for multiband antennas to gain access to these new bands, without adding significantly to the hardware already in our yards.

I've come up with some antennas which I think get to the heart of this problem. They're all 200-ohm impedance designs which can be fed with 4:1 baluns and 50-ohm coaxial cable. Most can fit into an urban backyard. You'll notice a few monobanders among the designs. They occupy more space than a conventional dipole; so why use them? The answer is performance. They provide more capture area, and a configuration that has proved superior in extensive on-the-air testing.

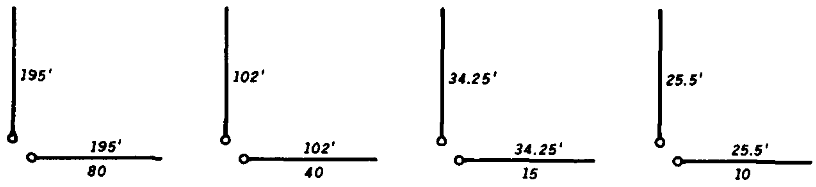
Another feature of these antennas is the 90-degree apex angle, suggesting a V antenna. A V antenna which yields bidirectional gain is fed with the legs *in* phase. These are fed *out* of phase, and this makes them quite different electrically. I couldn't measure any directivity when I used these antennas under skip conditions.

The antenna diagrams in the figures show top views of the antenna wires. Their lengths are identified in feet. The two small circles at the wire ends are the connection points for the 4:1 balun.

Monobanders for the Novice

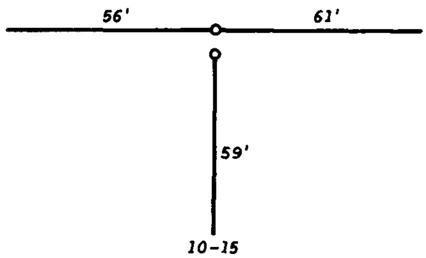
Perhaps you already have several Novice bands covered and wish to add one more. You may want to operate on just one band. In either case, one of the designs in **Figure 2** is for you. These designs require three times the wire of a conventional dipole — and for good reason. The configuration and

FIGURE 2



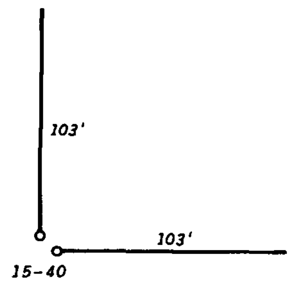
	Length of element		Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
80	3	390	3.72	3.66— 3.77	3.70— 3.75
40	3	204	7.11	7.00— 7.22	7.10— 7.15
15	3	68.5	21.18	20.87—21.50	21.10—21.20
10	3	51	28.46	28.03—28.88	28.10—28.50

FIGURE 3



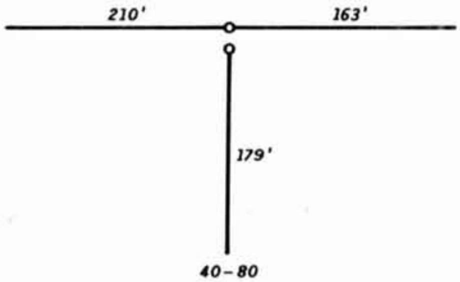
	Length of element		Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
15	5	115	21.18	20.86—21.50	21.10—21.20
10	7	120	28.50	28.07—28.93	28.10—28.50

FIGURE 4



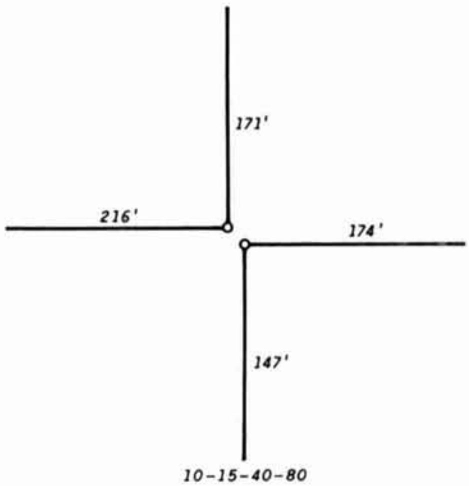
	Length of element		Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
40	3	206	7.05	6.94— 7.15	7.10— 7.15
15	9	206	21.38	21.05—21.70	21.10—21.20

FIGURE 5



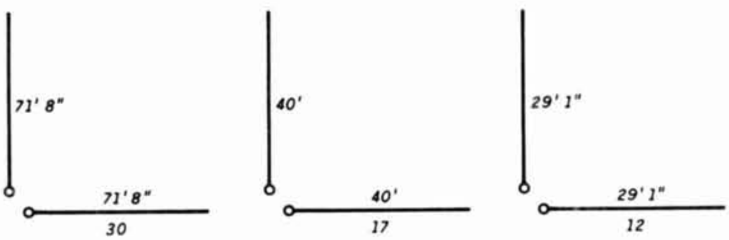
Band	Length of element Half waves	Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
80	3	389	3.73	3.68—3.79	3.70—3.75
40	5	342	7.12	7.01—7.23	7.10—7.15

FIGURE 6



Band	Length of element Half waves	Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
80	3	390	3.72	3.67— 3.78	3.70— 3.75
40	5	345	7.06	6.95— 7.16	7.10— 7.15
15	15	345	21.32	21.00—21.64	21.10—21.20
10	21	363	28.40	27.97—28.82	28.10—28.50

FIGURE 7



Band	Length of element Half waves	Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
30	3	143.3	10.12	9.97—10.27	10.10—10.15
17	3	80	18.14	17.87—18.41	18.06—18.16
12	3	58.2	24.95	24.58—25.32	24.89—24.99

169

170

capture area provide better performance, and they don't have the nulls of a dipole. They are good performers in all directions.

Dual band Novice

This antenna is tailored for the 10 and 15-meter Novice bands (see **Figure 3**). It's compact and will fit into most backyards. Use one band or the other, without any antenna tuning or switching; the SWR remains low. The cost is also low. All you'll need is under 200 feet of inexpensive wire, coaxial cable, and a balun. Total cost, including insulators and rope, can run as little as $50.

Figure 4 shows an antenna for 15 and 40-meter coverage that uses a little more wire for about the same cost as the preceding design. It's simple to install, and has just two legs. The antenna is resonated in both bands by 206 feet of wire. One antenna does double duty and, like all of these designs, it provides low SWR and excellent performance. If you can't fit the wires onto your property with the 90-degree apex angle, you can make it a straight, center-fed long wire. The SWR will continue to be low; however, the antenna becomes directional and performance suffers on some headings. But this may be your best compromise.

Unfortunately, there isn't a wire length of reasonable dimensions which will resonate on both 80 and 40. The solution is to revert to the three-leg design in **Figure 5**, which provides a different length for each band. The two resonances fall almost in the center of the Novice segments and this, together with the large area of the array, makes it a very efficient performer. It's ironic that resonances also fall in the 15 and 10-meter bands, but the feedpoint is far removed from the current loops resulting in high SWR on these bands.

All band Novice

The antenna in **Figure 6** gives access to all four Novice HF bands. And, when you upgrade to General, it stands ready to serve in other segments. Though I haven't shown it here, the 363-foot element resonates at the high end of 80. This opens 3.9 to 4 MHz up to SSB. In addition, the 345-foot length resonates at the top of the 10-meter band, allowing SSB operation above 29 MHz. This antenna is large, but don't let that deter you. If you have friendly neighbors, you may be able to run unobtrusive wires through the trees over their properties. I did this for a number of years using inexpensive electric fencing wire.

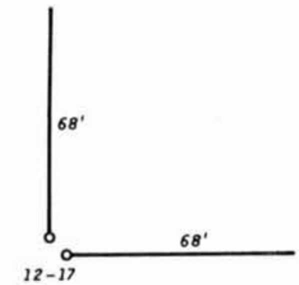
WARC monobanders

The monobanders in **Figure 7** are for the ham who wants to add a WARC band. If you cut the wire lengths carefully to the measurements shown, and your antenna is reasonably in the clear, the resonance will fall almost dead center in the band. This will give you a low SWR from band edge to band edge. These element lengths give no resonances on other HF Amateur bands, and shouldn't interfere with existing antennas.

Dual band WARC

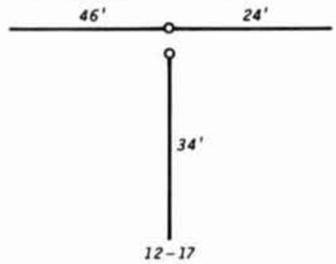
Are you a General who hasn't tried 12 or 17? Here are two antennas which give you both 12 and 17. They are compact and can be erected in the average backyard. I've given two alternatives in **Figures 8A** and **B**. Choose the one which best suits your layout. If you have a tower available, use it as the main support with the legs coming down like an inverted V. A flat top, however, is preferable. None of the element lengths

FIGURE 8A



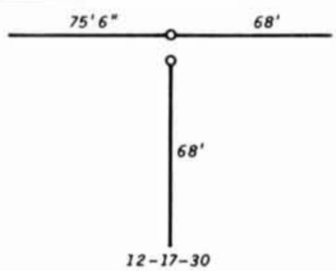
Length of element			Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
17	5	136	17.90	17.63—18.18	18.06—18.16
12	7	136	25.14	24.76—25.52	24.89—24.99

FIGURE 8B



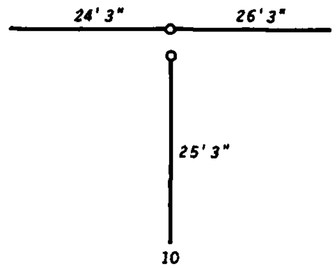
Length of element			Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
17	3	80	18.14	17.87—18.41	18.06—18.16
12	3	58	25.02	24.65—25.40	24.89—24.99

FIGURE 9



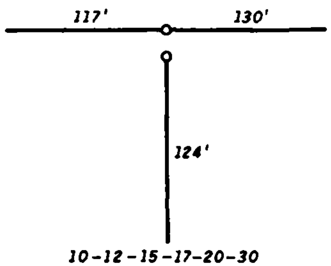
Length of element			Resonant	Bandwidth	Amateur
Band	Half waves	Feet	frequency MHz	2:1 SWR points MHz	band MHz
30	3	143.5	10.11	9.96—10.27	10.10—10.15
17	5	136	17.90	17.63—18.18	18.06—18.16
12	7	136	25.14	24.76—25.52	24.89—24.99

FIGURE 10



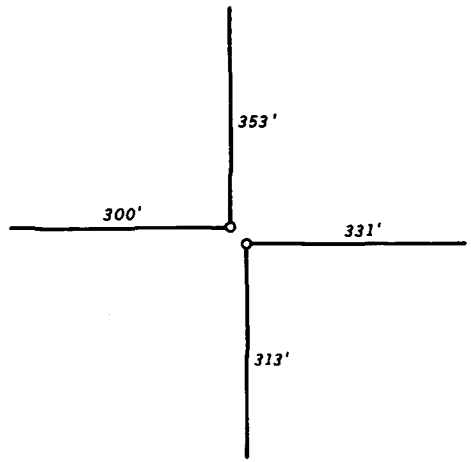
Band	Length of element: Half waves	Length of element: Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
10	3	51.5	28.18	27.76—29.76	28.00—29.70
		49.5	29.32		

FIGURE 11



Band	Length of element: Half waves	Length of element: Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
30	5	241	10.10	9.95—10.26	10.10—10.15
20	7	241	14.19	13.98—14.40	14.00—14.35
17	9	241	18.27	18.00—18.54	18.06—18.16
15	11	254	21.21	20.89—21.53	21.00—21.45
12	13	254	25.08	24.71—25.46	24.89—24.99
10	15	254	28.95	28.52—29.30	28.00—29.70

FIGURE 12



Band	Length of element: Half waves	Length of element: Feet	Resonant frequency MHz	Bandwidth 2:1 SWR points MHz	Amateur band MHz
80	5	613	3.97	3.50— 4.03	3.50 4.00
	5	631	3.86		
	5	666	3.66		
	5	684	3.56		
40	9	613	7.18	6.80— 7.30	7.00— 7.30
	9	631	6.98		
30	13	631	10.00	9.95— 10.25	10.10—10.15
20	19	666	14.00	13.79—14.35	14.00—14.35
17	23	613	18.42	17.62—18.70	18.06 18.16
	23	631	17.89		
12	31	613	24.84	24.46 25.21	24.89—24.99
10	35	613	28.05	27.63—29.24	28.00—29.70
	37	631	28.81		
	39	666	28.77		
	39	684	28.02		

on the three-leg design resonate on or near other Amateur bands, so it shouldn't pose a problem for your Yagis or other antennas. The three-leg design also provides a somewhat lower SWR. On the other hand, the two-leg design will resonate on 40, 20, and 10 meters, and should be kept clear of other antennas on those bands.

Triband WARC

Here's your chance to put up one antenna with capabilities on all WARC bands! (See **Figure 9**.) While these designs will function satisfactorily when installed as inverted Vs, it's preferable to make them flat tops. Unlike a dipole, which has a single current loop at the center, these antennas have at least three current loops (including one in the center). The current loops provide maximum radiation.

Broadband 10-meter monobander for general coverage

Because this band is so much wider, it poses problems of band coverage with narrowband antennas. The design shown in **Figure 10** will cover the entire band. Don't use a coaxial balun; it will limit your bandwidth. If you wind your own, use the Amidon iron powder kit with eight bifilar turns instead of the usual ten. On this HF band, worry about coaxial cable losses. RG-58, with a run of 100 feet and transceiver output of 100 watts, will deliver only 56 watts to the antenna. By comparison, Belden 9913 or equivalent will deliver 85 watts to the antenna in similar circumstances on 10 meters.

Six band general coverage

The simple antenna in **Figure 11** will deliver six of the nine HF bands! It provides the traditional DX bands, plus all WARC frequencies. The resonances fall within all the bands but 17 and 12, where they are slightly on the high side. However, the antenna bandwidth amply covers these two WARC bands with an SWR of less than 2:1. A commercial balun will handle this design; but if you use a kit and wind your own, I suggest once again that you use eight turns instead of the usual ten. The fewer turns will slightly lower SWR on 10 and 12 meters.

Eight band general coverage

This is the "Monster." It covers about ten acres (see **Figure 12**). Since the publication of the details of this design[1] it has been used in many states and DX locations. Nearly all users reported SWR readings on each band similar to those I had experienced.

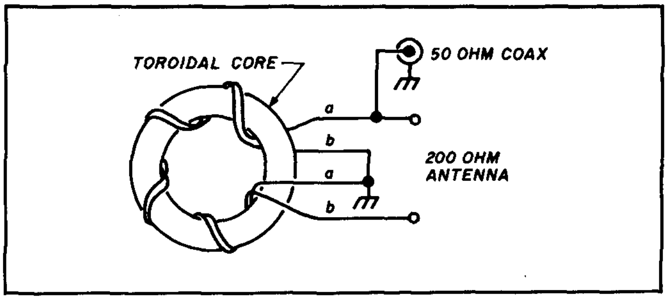
All of the preceding antennas require a 4:1 balun to give a good match with RG-58 or RG-8 type 50-ohm coaxial cable. I have provided several options.

Toroid balun

There are a number of commercial baluns available from Amateur equipment distributors. Be sure you get a 4:1, not a 1:1 (see **Figure 13**). If you'd like to wind your own, you can order a kit from Amidon Associates or Radiokit.* They come with instructions suggesting they be packaged in PVC pipe. I recommend you wrap the core with Scotch® no. 27 glass electrical cloth tape. You can get epoxy potting material from your local electrical supply house and completely encapsulate the unit. The final professional touch for the ultimate in reliability is to do the potting in a high school or college science lab, and immediately place it in a vacuum jar. This removes all bubbles or moisture.

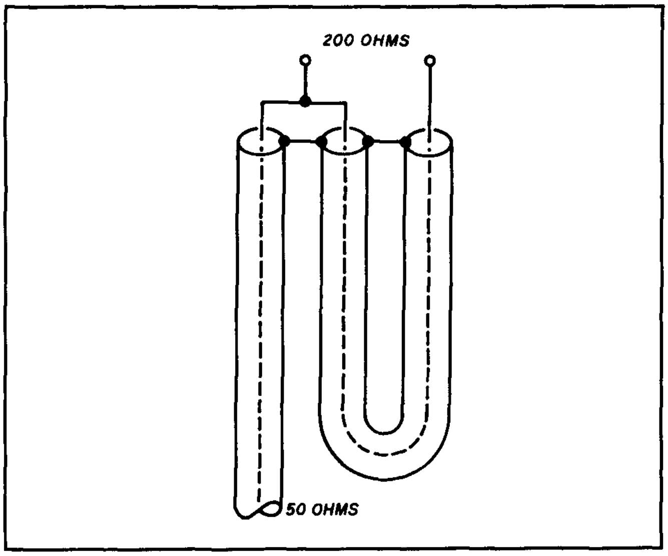
*Amidon Associates, 12033 Otsego Street, North Hollywood, California 91607.
Radiokit, Box 973, Pelham, New Hampshire 03076. (603) 633-2235

FIGURE 13



Detail for winding a 4:1 balun.

FIGURE 14



Detail for making coaxial balun.

Coaxial balun

You can make your balun of coaxial cable for **some** of the monoband antenna designs I've described. Details are shown in **Figure 14**. The U section may be coiled and secured with tape; its length is as follows:

Coaxial cable length U section

Band	Solid	Foam
80 Novice	87'2"	104'4"
40	45'7"	54'7"
30	32'1"	38'5"
17	17'10"	21'6"
15	15'4"	18'5"
12	13'	15'7"
10 Novice	11'5"	13'8"

Conclusion

I hope you'll give one of these long wire antenna designs a try. Pick a band (or bands) that your existing antenna system doesn't cover, and put one to the test. I'll look for you on the air!

REFERENCES

1. E.S. Brown, K4EF, "Antenna Design Using the Long Wire Principle, *Ham Radio*, May 1977, page 10