Long-Wire Inverted-V Antennas Sans Tuner

The end of one leg of the 10/15/20-meter inverted V. Band changes are made near ground level, using alligator clips.

BY EDWARD M. NOLL,* W3FQJ

The long-wire inverted V antenna can be fed at the center with a low-impedance coaxial line, and operated as a truly resonant antenna on a number of bands. No form of tuner is required between the antenna and the line. By proper selection of the transmission-line length, one can even dispense with a line tuner at the transmitter. The techniques covered in this article permit the construction of a low-cost and effective multiband antenna, using a single mast or other high support for the apex of the V.

Resonant V

Efficient operation of a long-wire inverted V antenna occurs when it is made a truly resonant antenna on the operating band, and when it displays a resistive low impedance at the center feed point.[1] The resistive low impedance is obtained by making each leg of the V an odd multiple of a quarter wavelength long. This is the basic principle of the center-fed half-wave dipole, which has a quarter-wavelength leg on each side of center. Nearly the same impedance can be obtained by making the leg length $3\lambda/4$, $5\lambda/4$, $7\lambda/4$, etc. Table I lists a series of constants that may be used to determine leg lengths which are an odd quarter-wavelength long, to insure a low resistive impedance at the center feed point.

An attractive feature of a center-fed antenna, in addition to having no reactance if the leg lengths are cut precisely, is that the resistive impedance remains low in ohmic value despite the long length of each leg. The theoretical impedance for the dipole is 72 ohms. The center-point impedance rises slowly with $\lambda/2$ additions to the original dipole leg length, toward 100 ohms for legs a number of odd quarter-wavelengths long. The impedance value depends on the height above ground, and on other factors.

Line Length

The rise of the center impedance value of the long-wire antenna over that of a simple dipole is not great, and the mismatch to 50- or 72-ohm line is not really serious. (Of course, we have assumed that the leg lengths have been controlled precisely so as to minimize the introduction of any reactive component.) If a section of transmission line that is some multiple of a half-wavelength long is chosen, the line will repeat the impedance of the feed point. Therefore, whatever resistance is present at the feed point will be seen by the transmitter.[2] It is significant that the output tuning systems of most transmitters can provide an exact match over a sub-

When multiband inverted V antennas are mentioned, most amateurs immediately think in terms of open-wire feed lines and a transmatch or other tuning methods, because such systems can operate efficiently with a high v.s.w.r. in the line. But multiband antenna systems using coaxial feed lines without tuners are practical, if the s.w.r. in the line is kept low. This article gives data for such systems.

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[1] Covington, "Radiation Resistance of Inverted V Antennas," *QST*, October, 1968.

[2] As the author points out, careful adjustment of the antenna length will provide a fair impedance match to 50- or 75-ohm lines. In such cases, adjustment of the feed-line length usually would not be necessary, because the line s.w.r. is determined solely by the impedance match at the antenna. If a transmitter is rated to handle some specified value of s.w.r., such as 2:1, then it *should* handle any line input impedance that represents a 2:1 s.w.r., whether it be purely resistive, or contain reactance. However, cutting the line to length as described by the author will eliminate any reactance at the input end of the line, and might be required at low frequencies, particularly 1.8 and 3.5 MHz., if the transmitter output tuning network is not flexible enough to compensate for such reactances. — *Editor.*

TABLE I

Leg Lengths in λ	*Leg Lengths in Feet*
1/4	234/*f*
3/4	725/*f*
5/4	1215/*f*
7/4	1710/*f*
9/4	2205/*f*
11/4	2690/*f*
13/4	3185/*f*
15/4	3670/*f*
17/4	4165/*f*
19/4	4655/*f*

Table I. Factors for converting leg lengths in odd quarter wavelengths to feet.

TABLE II

Line Lengths in λ	*Line Lengths in Feet V.F. = 0.66*	*Line Lengths in Feet V.F. = 0.81*
1/2	325/*f*	400/*f*
2/2	650/*f*	800/*f*
3/2	975/*f*	1200/*f*
4/2	1300/*f*	1600/*f*
5/2	1625/*f*	2000/*f*
6/2	1950/*f*	2400/*f*
7/2	2275/*f*	2800/*f*
8/2	2600/*f*	3200/*f*
9/2	2925/*f*	3600/*f*
10/2	3250/*f*	4000/*f*

Table II. Factors for converting line lengths in multiples of a half wavelength to feet, for nominal velocity factors of commonly available coax. In the tables, f equals the operating frequency in MHz.

stantial range of loading resistance (up to 200 ohms is not unusual).

One must consider the velocity factor of the line when cutting it to length. Table II provides a list of constants that can be employed in selecting an optimum length of line. It assumes a velocity factor of 0.66 for conventional coaxial lines and 0.81 for the foam types.

A Practical Single-Band Antenna

A long-wire inverted V antenna can be simple, as shown in Fig. 1. Assume 15-meter operation is desired with resonance at 21.3 MHz. If the pole height is to be 40 feet and the mounting space is limited, a leg length of five quarter-wavelengths would be suitable. In this case the leg length becomes:

$$\textit{Leg length} = \frac{1215}{21.3} = 57.1 \textit{ feet.}$$

This corresponds to an antenna with an overall electrical length of 2½ wavelengths.

Since the ends of the antenna are brought down near ground level, the exact dimension is somewhat shorter than the above calculated value. The two ends can be trimmed conveniently, using an s.w.r. meter or an antenna noise bridge.

The transmission line can be an integral number of half-wavelengths long. For a velocity factor of 0.66, a half-wavelength line has a physical length of:

$$\textit{Half wavelength} = \frac{492 \times 0.66}{21.3} = 15.25 \textit{ feet.}$$

The line can either be this length, or any whole multiple of this length. If you estimate that the line length must be somewhat over 100 feet, a precise cut can be made to 106 feet 9 inches. Refer to Table II and the constant for seven half-wavelengths:

$$\textit{Line length} = \frac{2275}{21.3} = 106.75 \textit{ feet.}$$

See Fig. 1B.

Leg Length Changes

One of the attractive features of the inverted V construction is that the ends of the legs are near the ground, and changes can be made conveniently. For example, it is possible to cut the above antenna to near the high end of the 15-meter band as follows:

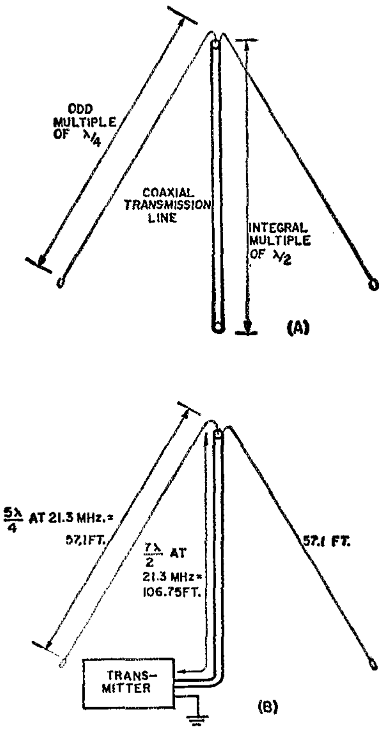
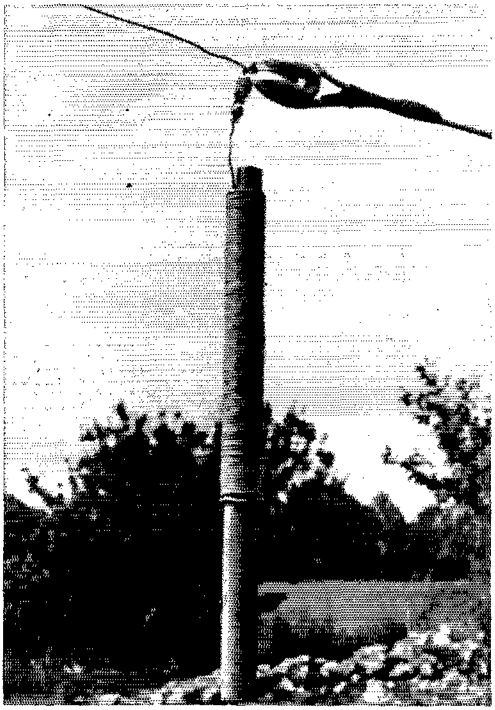


Fig. 1—Dimensions for resonant and matched long-wire inverted V antennas. General dimensions are shown at A, while B shows lengths for 15-meter operation.



A clip-on loading coil for end-loading of the antenna. See text for coil data.

$$Leg\ length = \frac{1215}{21.45} = 56.7\ feet.$$

By making alligator clips or other connectors and two or three pairs of very short segments of antenna wire available, the antenna can be resonated to any precise frequency in the band by clipping additional lengths onto the ends of the antenna, as shown in Fig. 2. Lengths of one foot can change the resonant frequency from one end of the band to the other. The calculated length at 21.1 MHz. is 57.6 feet, as compared to 56.7 feet at 21.45 MHz.

Multiband Operation

One of the unique advantages of end-tuning the long-wire inverted V is that rather limited adjustments in length permit the antenna to be operated as a truly resonant antenna on more than one band. Let us plan an antenna for 10/15/20-meter sideband operation. We can select preferred center points at 14.3, 21.3, and 28.6 MHz. By referring to Table I, we can come up with an inverted V that operates as a $3\lambda/2$ antenna on 20, a $5\lambda/2$ antenna on 15, and a $7\lambda/2$ antenna on 10. The required leg lengths are:

$$(20)\ Leg\ length = \frac{725}{14.3} = 50.7\ feet.$$

$$(15)\ Leg\ length = \frac{1215}{21.3} = 57.1\ feet.$$

$$(10)\ Leg\ length = \frac{1710}{28.6} = 59.8\ feet.$$

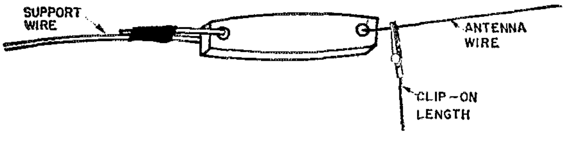


Fig. 2—Short lengths of wire may be clipped to the leg ends to decrease the resonant frequency of the antenna. A one-foot length of wire can shift the resonant frequency from the high to the low end of an amateur band.

Note that the difference spread is about nine feet. Appropriate sections of line for attachment to the antenna ends can permit multiband operation.

Such an antenna was actually constructed, and resonances at the desired frequencies were obtained with the dimensions given in Fig. 3. The end of each leg includes three insulators and appropriate wire sections. Alligator clips are used to jumper across the first two insulators to permit operation on the 10-meter band. Opening the clip connection at the insulator nearest the center feed point permits 20-meter operation. With the clip closed at the first insulator and open at the second, it is possible to obtain 15-meter resonance. With both clip connections closed for 10-meter operation, we also have a bonus in the form of 75-meter sideband operation, where the antenna performs as a simple inverted V dipole.

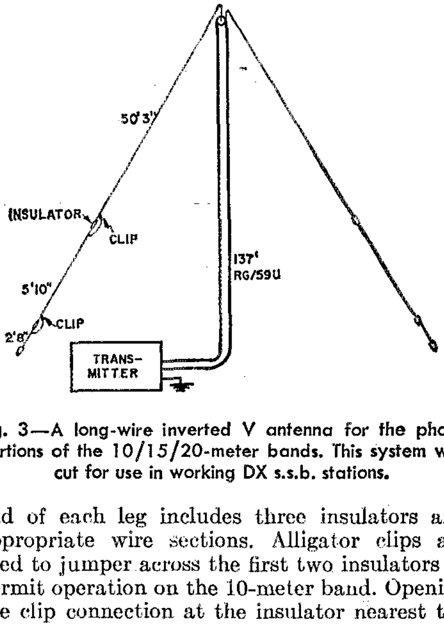


Fig. 3—A long-wire inverted V antenna for the phone portions of the 10/15/20-meter bands. This system was cut for use in working DX s.s.b. stations.

Of course, with the proper optimizing of frequencies and lengths, reasonable operation can be obtained over each of the three bands, 20, 15, and 10 meters. An alternate plan is to cut the leg lengths for the high end of each band and use small clip-on sections to tune to any frequency range on any band, as shown in Fig. 2.

How does one choose a length of transmission line that is able to accommodate more than one band? Here again it is possible to come up with values that provide integral half-wavelengths on the various frequencies, and, at the same time,

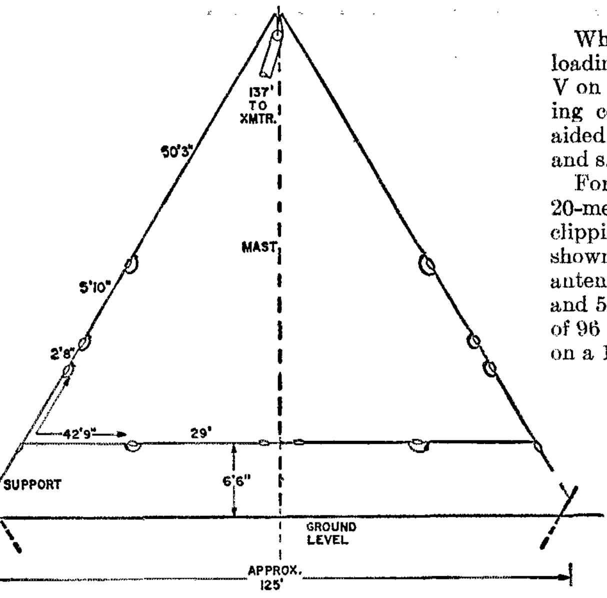


Fig. 4—Inverted dipole and long-wire inverted V assembly for 6 through 160 meters. This is an inexpensive but efficient multiband antenna system.

are very near to each other. We can use the constants of Table II to locate these possibilities. Let us assume again that the total line length must be something in excess of 100 feet. Calculations then produce values of:

$$(20)\ \mathit{Line\ length} = \frac{1950}{14.3} = 136.3\ \mathit{feet.}$$

$$(15)\ \mathit{Line\ length} = \frac{2925}{21.3} = 137.3\ \mathit{feet.}$$

$$(10)\ \mathit{Line\ length} = \frac{3900}{28.6} = 136.4\ \mathit{feet.}^{3}$$

Cutting the transmission line to 137 feet provides a good impedance transfer on all three bands. Of course, if you do wish precise matching of your transmitter, a simple line tuner at the transmitter end of the line is all that is needed. (The method described here for coaxial lines, with the use of the appropriate velocity factor, can also be used for the pruning of open-wire feed lines in multiband systems if the line tuner has limited matching capabilities, or if a tuner is omitted.)

Elaborate line tuners can accommodate a wide range of reflected values from an antenna system. This does not always mean that the most favorable line conditions exist with coaxial feed lines, though, where high s.w.r. values increase the losses in the line. In fact, even when using an elaborate line tuner, the resonant tuning of the antenna itself and the matching to obtain the favorable s.w.r. on the coax line will encourage a better overall efficiency.

Loading Coils

When pinched for space, it is possible to use loading coils to resonate the long-wire inverted V on more than one band. Construction of loading coils is a cut-and-try proposition, and is aided with the use of an antenna noise bridge and s.w.r. meter.

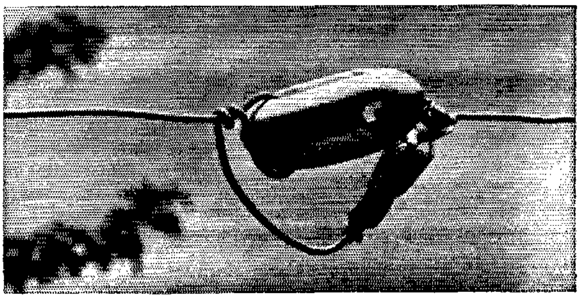
For example, it is possible to tune the basic 20-meter antenna of Fig. 3 to 15 meters by clipping a loading coil onto each leg end, as shown in one of the photographs. Again, the antenna operates as a 3λ/2 antenna on 20 meters and 5λ/2 on 15 meters. The loading coil consists of 96 turns of No. 18 insulated wire, close-wound on a 1-foot length of ¾-inch wooden dowel.

Inverted V for 6 — 160 Meters

Additional bands can be added to the basic construction of Fig. 3 by increasing or adding leg lengths. Top-band 160-meter operation is feasible without requiring any additional space, by folding the legs back toward the mast as shown in Fig. 4. This return span to the mast can be made at a height of about 6½ feet above ground, to keep all band-changing positions for additional bands within easy reach.

Adding a length of some 40 feet provides an overall leg length of about 101 feet, the dimension for obtaining 3λ/4 operation on 40 meters. This length also has a λ/4 multiple in the 6-meter band. A further addition of some 20 feet provides proper loading for 160-meter operation as a dipole.

All-band operation from 6 to 160 meters is possible with a *single* 35- to 45-foot mast in a space under 125 feet. Only one transmission line is needed, and *no* antenna tuner. The antenna operates as an inverted-V dipole on 80 meters, a modified inverted-V dipole on 160 meters, and as a long-wire inverted V on the remainder of the bands. It is indeed a very inexpensive antenna and yet gives good performance as a multiband type. It is one you can construct yourself. Be careful in cutting the lengths and be patient in tuning these lengths on each band. Start on 20 meters (shortest span) and continue through 160 meters (longest span).



A jumpered insulator for increasing the antenna's leg length. The clip is permanently mounted on the short section of wire that is used to extend the antenna length.

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[3] This conversion factor is not included in Table II. For numbers of half wavelengths greater than shown, the table progresses in multiples of the values given, so that 3900/*f* applies to twelve half wavelengths.