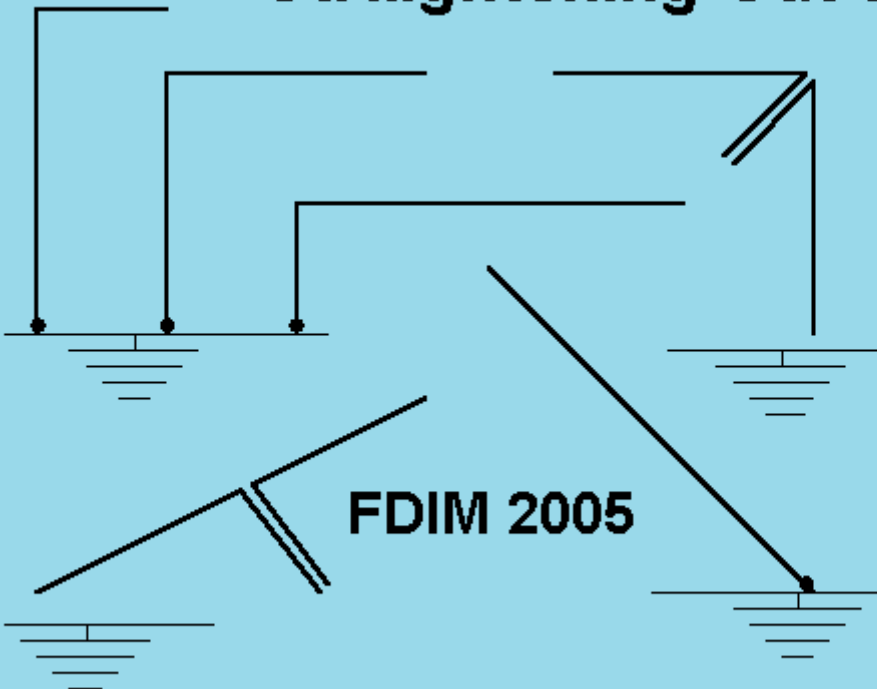


# Straightening Out the IN

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## **Straightening Out the Inverted-L**

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Communications via radio is over a century old. One of the antennas that has been around almost that long is the inverted-L. It has passed through phases of love and hate, honor and denigration, use and disuse. However, it has never been through a phase of understanding. At most, it is just a simple wire whose properties are known only by the testimony (both prosecution and defense) of its successful and unsuccessful users.

I shall now dare a claim. The inverted-L is among the very best inexpensive wire field and small backyard antennas for multi-band general communications work. It is not a rotating or stationary beam. It is not a phased broadside, end-fire, or collinear array. Hence, it will never be the strongest signal in the band (if more than one station is active). However, it will in all of its simplicity put a usable signal in more places on more bands than almost any other contender, both in the field and in the typical small modern backyard.

All that we need to do to lay a foundation for this claim is to understand the inverted-L--both how it works and what to expect from typical installations. In the course of these notes, we shall look at the electrical properties of the inverted-L to understand and befriend it. However, the main body of these notes will be devoted to a tabular and graphical compendium of what inverted-Ls of various forms will produce by way of performance on the HF amateur bands. By picking the material most closely aligned with your installation, you will have a general idea of what to expect from the inverted-L that you build.

Of course, you will build your own. All you need are a length of wire (#12 or #14 copper or copperweld will do nicely), a set of insulators, some transmission lines, and an antenna tuner. If I kit up the wire and insulators and sell them to you for \$45 to \$50, then I have swindled you. And I could not live with myself for the hype it would take to make the kit seem like it will do everything short of slicing bread. Everything else that you need for an effective and safe installation will tend to be site specific, so you will need to visit your hardware depot. Before we close, we shall examine some ideas for making the installation both effective and safe.

### **What is an Inverted-L?**

The simplest answer to this question is electrically wrong. The simplest answer is that an inverted-L is any antenna that looks like an upside-down L. (You may have to walk to the other side of the antenna to make a correct upside-down L.) The answer is defective in two ways. First, there are many antennas that do not look like an upside-down L, but that perform electrically just like an inverted-L. Second, if we could get the antenna high enough, there would be no significant difference in performance from an inverted-L and an erect L. In fact, a few years ago, I suggested the L-antenna as a workable simple solution to needs on 10, 6, and 2 meters to communicate with stations using antennas that are horizontally and that are vertically polarized. Of course, it is easy to raise an antenna 1 to several wavelengths over the ground at these frequencies, but much harder to push an 80-meter wire up that high.

We are not interested in looks, but in performance. If an antenna performs like an inverted-L, then it belongs to the same family of antennas, whatever family name we might concoct. However, we shall have to think in terms of an extended family, since we are speaking of a complex antenna in terms of its frequency coverage. Two inverted-Ls may perform similarly on the lowest band used, but show differences when used at much higher frequencies. Where we feed the antenna and what proportions we use may make a difference in that performance.

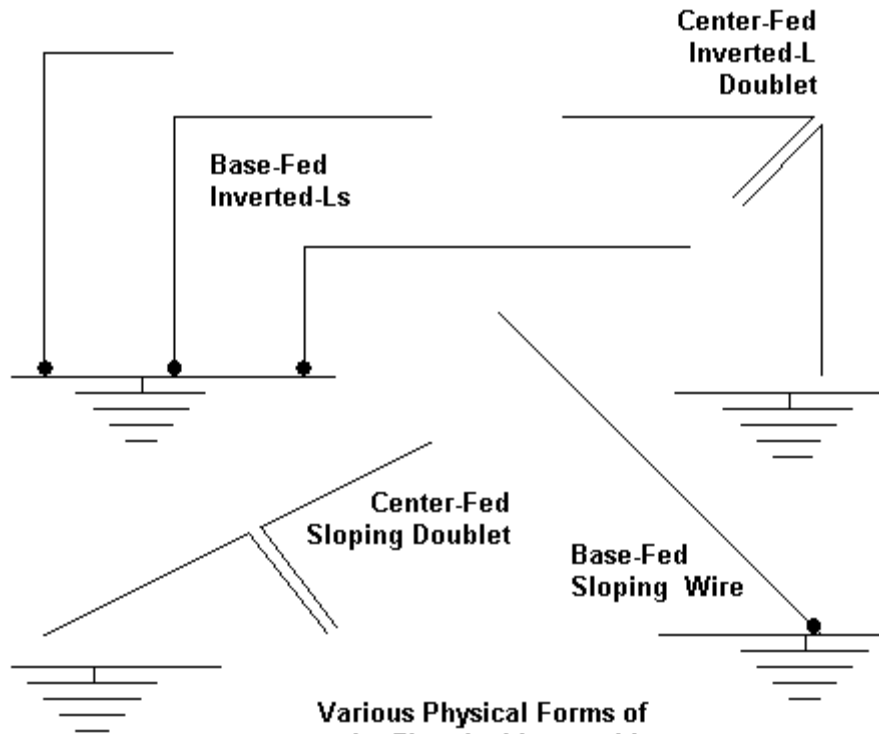


Fig. 1

**Fig. 1** shows some of the members of the family. The upper family branch form distinctly L-shaped antennas. The center-fed doublet type normally uses a center feedpoint relative to the overall wire length. However, the base-fed types may bend over at almost any point along the way. We might even curl the horizontal portion. The DDRR car-rooftop antenna of past years is a variety of inverted-L.

The sloping wires seem a strange addition to the group of inverted-Ls, because they lack a definite bend. However, as a first attempt to imagine why they belong to the family, imagine one of the upper antennas being stretched slowly by the far end of the horizontal wire. The angle would become shallower as we continued pulling the antenna until it formed a straight line. However, in the process, it would not lose the basic electrical properties that made it an inverted-L in the first place.

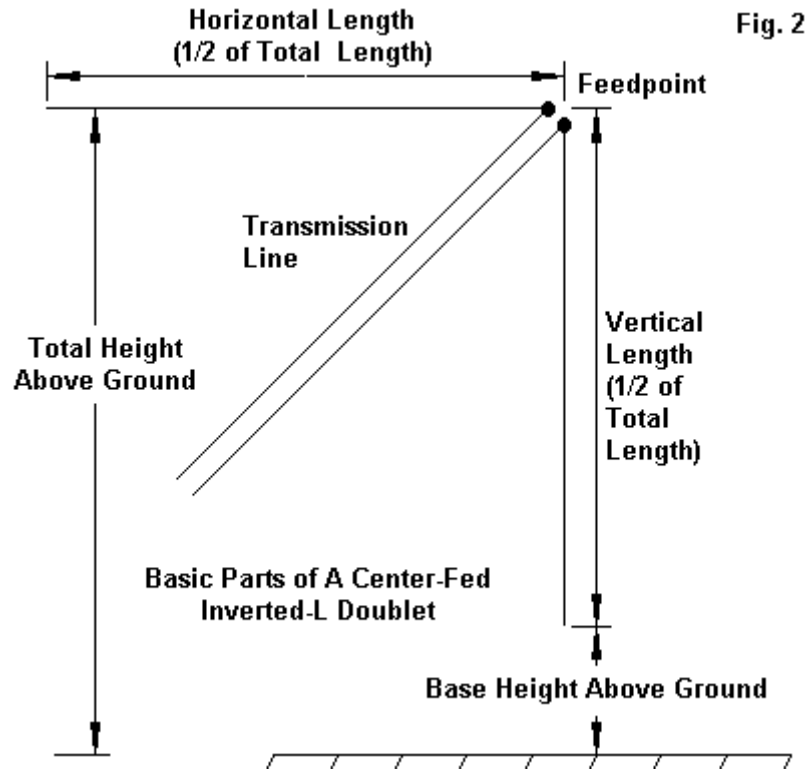
The property that makes the inverted-L what it is as a multi-band antenna is the fact that it has visible or virtual horizontal and vertical parts that give the radiation pattern both vertical and horizontal components. As we change frequency, one or the other component may dominate, but both will be present. Except for wholly negligible remnant components created by ground reflections, a true horizontal dipole has only a horizontal component to its field, while a vertical monopole has only a vertical component to its field. The inverted-L and its cousin, the sloping wire, have both.

You may instantly cry out that the inverted-V also has both components, especially when the sides droop 45 degrees downward from the horizontal line of a standard dipole. You would be correct. In fact, the inverted V (and the erect V) as well as the inverted (and erect) L belong to the same even more extended family. Not a member of this family is the quadrant antenna, one that bends in the middle on a 90-degree angle but remains parallel to the ground. That antenna has only a horizontal component.

In the HF region, where most communications involve ionospheric reactions, the vertical and horizontal components join and skew so that what comes down is randomly polarized. However, that does not make the initial components meaningless. They play an important, if not determinant role in the transmitting and receiving patterns of the antenna. And those patterns make up the core of my starting claim about the utility of the inverted-L for general communications.

## The Center-Fed Inverted-L Doublet

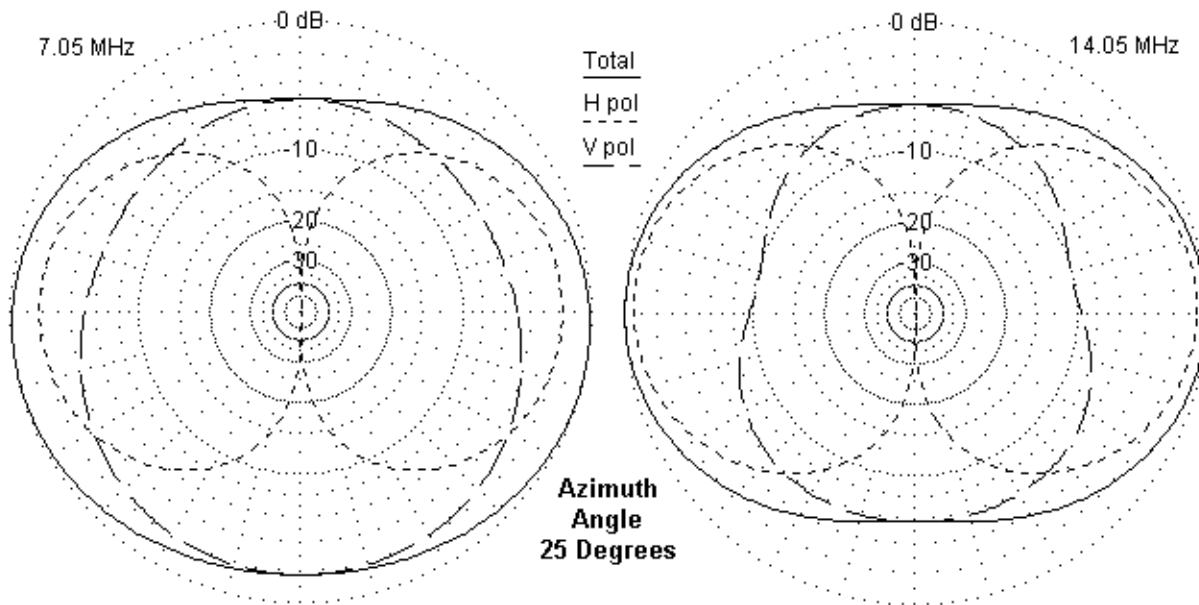
We may feed an inverted L almost anywhere, but the most common places are at the end or the center. To lay out some foundations of inverted-L operation, the center-fed version is a bit more straightforward. **Fig. 2** shows the main parts of the center-fed inverted-L doublet.



The legs of the L are equal to each other. Hence, the total height of the horizontal leg must be the length of the vertical leg plus an additional length that I call the base height above ground. For these notes, I shall place the base of each center-fed antenna 10' above average ground for family and visitor safety. Since we shall operate the antenna on many bands, we shall need to use parallel feedline and an antenna tuner (ATU). Ideally, the feed line should depart the antenna at right angles, which would mean directly into or out of the page. However, approximating a 45-degree angle will also work in minimizing unwanted coupling between the wires and the line.

The inverted-L derives its special properties as a general communications antenna from the pattern components of the vertical and horizontal portions of the antenna. **Fig. 3** shows the total pattern and its component parts for two frequencies for a center-fed inverted-L that is cut for 40 meters. On both bands, the horizontal leg of the antenna would point straight up the page. Hence, the vertical component of the pattern leans away from the horizontal leg. The horizontal component in both cases has the figure-8 look that we associate with a horizontal dipole. The vertical component is a distorted circle.

When we operate the 40-meter wire on 20 meters, we notice that the horizontal component becomes more dominant. The total pattern reduces from a circle with a depression into a distinct oval. Nevertheless, the radiation off the ends of antenna remains only 6 dB down from a true circle. It does not have the deep nulls that it might have if we were using a horizontal dipole. As well, the total radiation field is considerably stronger than we might derive from a standard monopole, thanks in part to the highly elevated feedpoint and thanks in part to the contribution of the horizontal component of the pattern. The total pattern on each band will always be a compromise, but a highly usable compromise.



**The Vertical and Horizontal Components of a 69' Total Length Center-Fed Inverted-L Doublet 10'-44.5' Above Average Ground**

**Fig. 3**

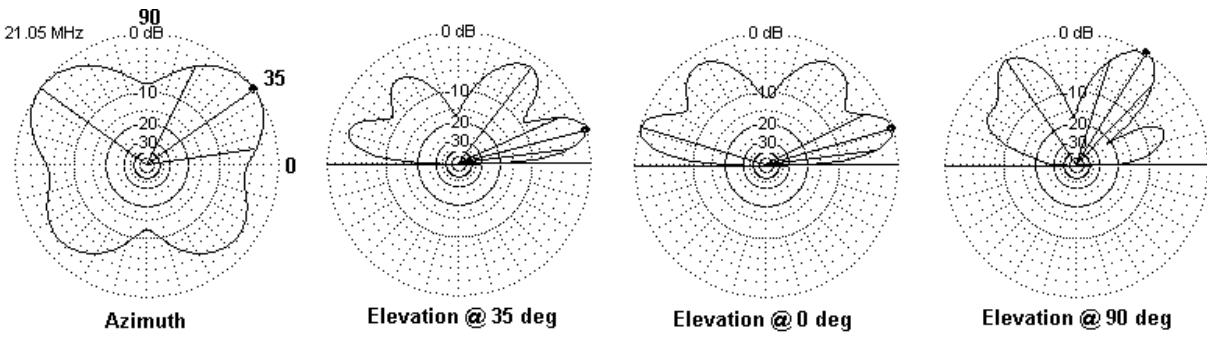
Do not expect such neat patterns for every band. If all of the patterns were neat, I could stop here. However, as we continue upward in frequency, the patterns become more complex, but avoid the large collection of narrow lobes that we associate with long center-fed horizontal doublets. As well, the vertical component, even though weaker at higher frequencies, does fill in the nulls of a typical center-fed horizontal doublet.

To complicate matters a bit further, there are 4 typical lengths for center-fed inverted-Ls: the short 44' version for 40 to 10 meters, the 67-70' version for the same coverage, the short 88' version for 80-10-meter coverage, and the 120-140' longer version for the same set of HF bands. Each version of the antenna deserves its own data so that we do not inadvertently introduce misleading performance ideas. However, the patterns and data that we shall show will presume two things, one important, the other not. The less important fact is that we shall use average ground as the soil beneath the antenna. Since we are not connecting the antenna to the ground, soil quality will not make much of a difference. The more important fact is that we shall presume level ground with no immediate obstructions to alter the patterns. You will have to make adjustments in your thinking about the patterns to account for both terrain tilting and yard clutter.

Every pattern presented--and the tabular data behind it--will use the elevation angle of maximum radiation. The tables will show the azimuth heading of maximum radiation. Along this axis, the table will list the vertical beamwidth. Although not precise, you may estimate that half the beamwidth is above and half below the elevation angle of maximum radiation. This calculation will give you a general idea of the lowest angle for a usable signal from the antenna. The tables will also list the maximum gain in dBi, and from that number, you can estimate the gain at other azimuth angle from the plot. Finally, the tables will list an approximate feedpoint impedance at the antenna terminals. If the antenna has a transmission line between those terminals and the ATU, the value at the ATU will be a function of the line's transformation properties that depend upon the length and characteristic impedance as they interact with the antenna terminal impedance.

Because the inverted-L is non-symmetrical with respect to the earth's surface, some of the values will have limited use. In other words, we should not assume that the elevation pattern is similar all around the azimuth circle. **Fig. 4** shows a typical azimuth pattern for a center-fed inverted-L antenna at 21.05 MHz. Beside it are three elevation patterns. The first one is along the heading for maximum gain on the

azimuth plot, a heading of 35 degrees (and its 180-degree opposite, 215 degrees). The next two plots are at 0 (and 180) degrees, that is, broadside to the horizontal wire and at 90 (and 270) degrees, that is, along the horizontal wire.



Why the Pattern Compendium Is Only a Sampling Fig. 4

Note that all three patterns have very different shapes. In some cases, although not in this one, the vertical beam width may differ along different headings. The elevation angle of maximum radiation certainly is different at 90 degrees. Although the patterns fill the rings, if you relate each one to the azimuth pattern, each has a quite different gain value. How the patterns relate to each other appears in Fig. 5.

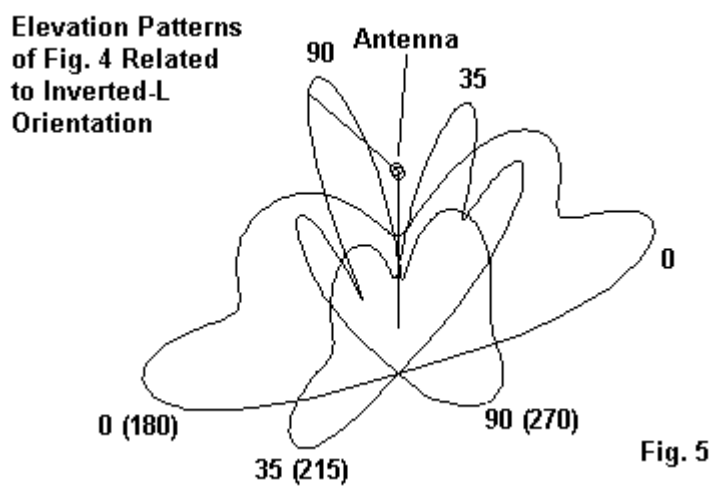


Fig. 5

In general, but perhaps not universally, the lower the gain along a given azimuth heading relative to the maximum gain heading, the more divergent the elevation pattern will be from the maximum gain heading values given in the tables. Despite these limitations, you may use the azimuth patterns and tabulated data in the compendia to follow to get a reasonably good idea of how well each antenna will perform on each band. All sample antennas use AWG #12 copper wire.

1. 44' Center-Fed Inverted-L for 40- to 10-Meter Use

The first version of the antenna (Fig. 6) varies in height from a base at 10' to 32' above ground. Higher mounting will tend to result in slightly more gain and slightly lower elevation angles of maximum gain, especially on the higher amateur bands. The total length of the antenna varies from 1.25 wavelengths at 10 meters to a little over 0.31 wavelength on 40 meters, the lowest frequency of operation (but with possible matching difficulties). Attempts to use the antenna on 60 or 80 meters will result in very low feedpoint resistances, with very high levels of capacitive reactance. Antenna is oriented as in Fig. 5.

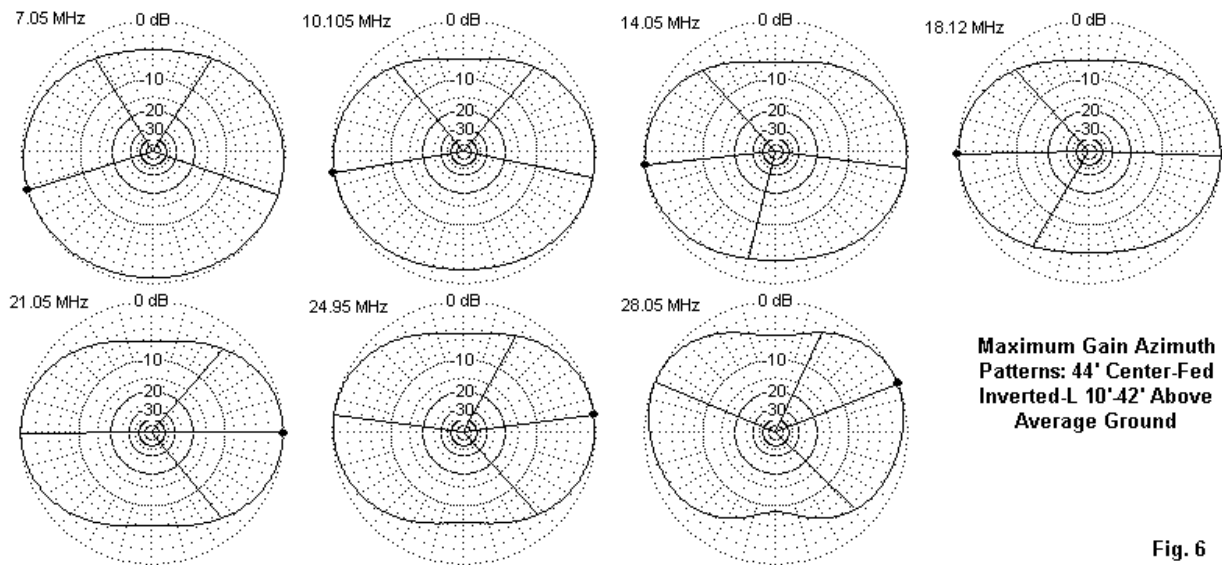


Fig. 6

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
7.05	197	47	148	1.7	17 - j 620
10.105	189	37	152	2.7	41 - j 140
14.05	186	27	40	3.9	110 + j 440
18.12	181	22	28	4.8	570 + j 1600
21.05	0	19	23	4.9	5700 + j 930
24.95	8	17	19	4.1	530 - j 1500
28.05	22	15	17	4.1	200 - j 700

A very wide vertical beamwidth, such as 150 degrees, indicates that the gain does not vary by more than 3 dB across the entire arc of the sky from about 15 degrees above each horizon. Very high values of resistance or reactance may indicate a difficult match unless the feedline length is chosen carefully. A purely horizontal version of this antenna at 42' above ground would have bi-directional patterns broadside to the wire with lobes that become very narrow on the highest bands. The inverted-L version has a lower maximum gain, but better gain in most directions. On the lower bands, the elevation angle of maximum radiation is lower using the inverted-L version.

## 2. 69' Center-Fed Inverted-L for 40- to 10-Meter Use

The 69' inverted-L has a top height of 44.5' with the standard 10' base height. The horizontal leg is 34.5' long. It is also too short for effective use below 40 meters. However, the added overall length begins to show up in the 12- and 10-meter band patterns. See **Fig. 7**. Still, the lobes are fewer and broader than for a 69' horizontal doublet, and the nulls are not so deep. As usual, very high resistance or reactance values may foretell matching difficulties. Lower elevation angles relative to the 44' inverted-L are a function of the added top height of the horizontal wire.

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
7.05	190	38	151	2.6	56 - j 4
10.105	184	28	39	3.8	220 + j 830
14.05	0	21	25	5.1	4800 - j 2800
18.12	26	18	19	4.1	180 - j 700
21.05	36	16	17	5.1	120 - j 66
24.95	36	13	14	5.9	310 + j 890
28.05	36	11	12	5.7	4900 + j 380

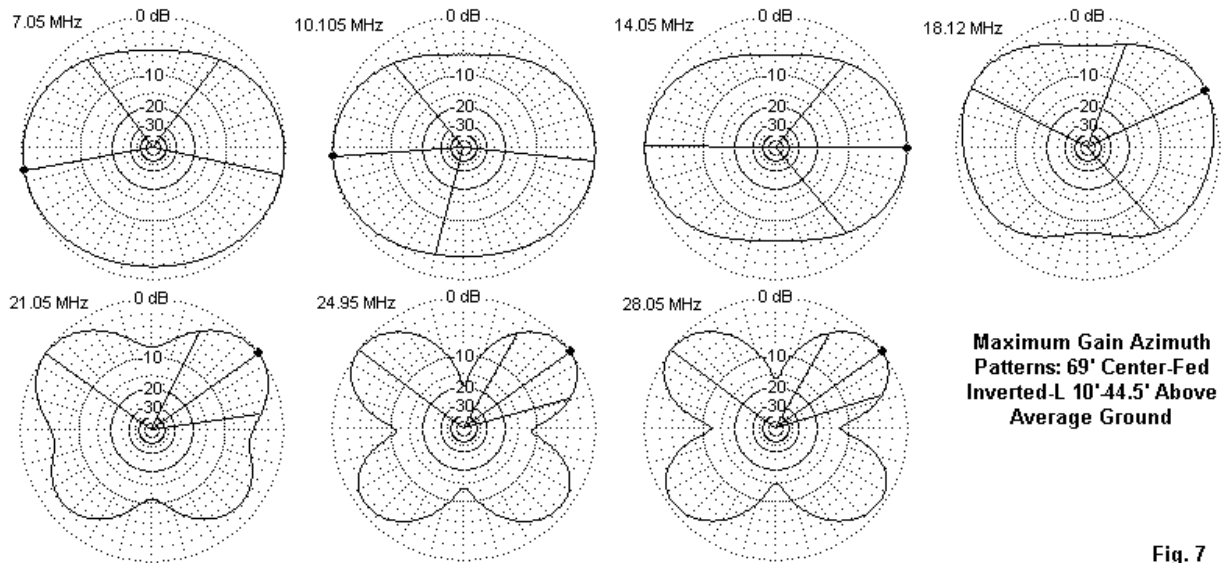


Fig. 7

### 3. 88' Center-Fed Inverted-L for 80- to 10-Meter Use

The 88' center-fed inverted-L is about the shortest recommended length (with marginal matching capabilities) for service down to 80 meters. The patterns omit the 60-meter band, although you can easily infer its shape from the 80- and 40-meter patterns plus the tabular data. By **Fig. 8**, you should be able to see the gradual evolution of the patterns as the antenna grows longer. For example, the 17-meter pattern of **Fig. 7** is similar to the 20-meter pattern for the longer antenna in **Fig. 8**. 10 meters shows the emergence of 2 additional lobes. As well, the tabular data shows slightly higher average gains as the antenna grows both longer and higher above ground. You may wish to imagine in advance the pattern shapes for the 136' center-fed inverted-L, the next antenna in the series, and then check **Fig. 9** to see if you are tracking well. The fact that patterns evolve rather than change suddenly with frequency will let us use fewer pattern samples in later exercises.

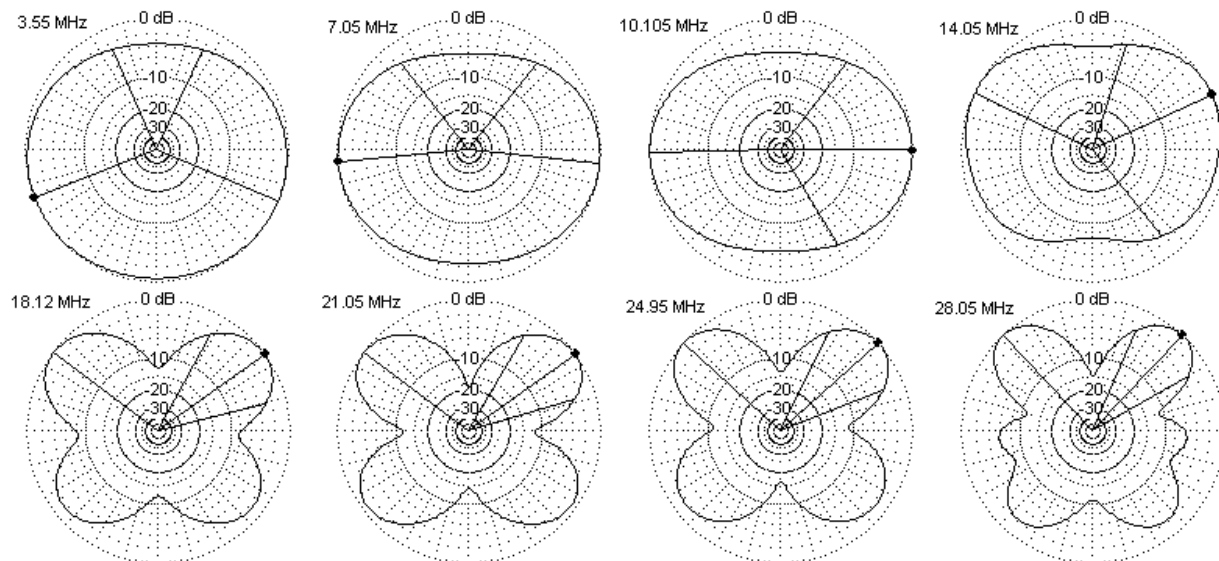


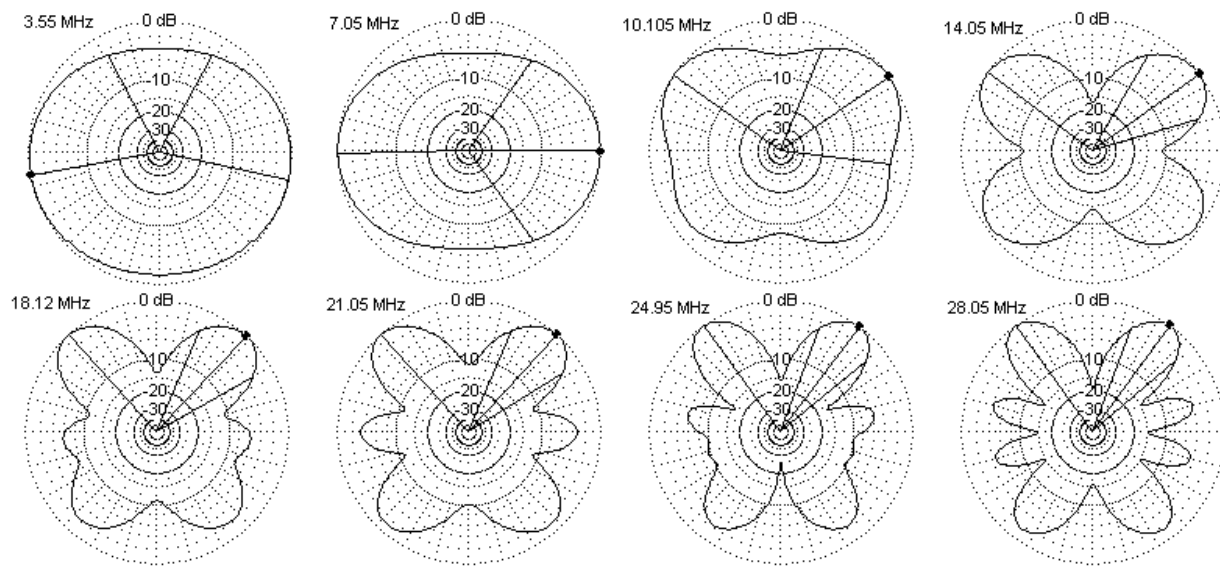
Fig. 8



Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	201	47	148	1.0	20 - j 660
5.368	191	40	150	2.3	55 - j 50
7.05	185	32	52	3.2	130 - j 490
10.105	0	23	30	4.5	3000 + j 3200
14.05	25	19	21	4.0	190 - j 780
18.12	36	15	17	5.6	160 - j 370
21.05	36	12	14	5.8	1600 - j 2200
24.95	42	10	11	5.5	250 - j 810
28.05	47	9	10	6.3	150 + j 45

#### 4. 136' Center-Fed Inverted-L for 80- to 10-Meter Use

The 136' center-fed inverted-L doublet has a 68' top wire and a vertical wire that extends from 10' to 78' above ground. Although this antenna calls for a height that few may reach, it is useful to show the continued evolution of the azimuth patterns. See **Fig. 9**.



**Maximum Gain Azimuth Patterns: 136' Center-Fed Inverted-L  
10'-78' Above Average Ground**

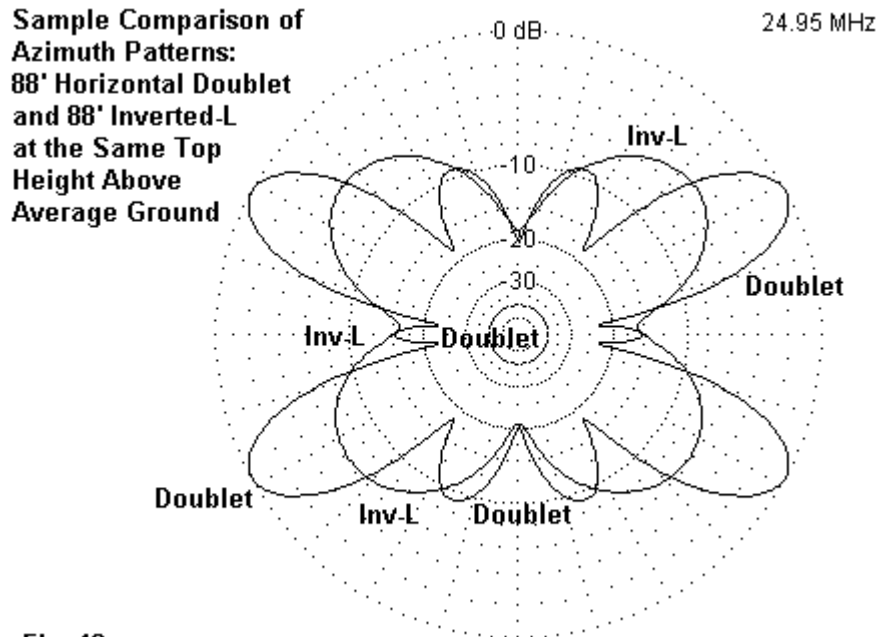
**Fig. 9**

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	190	42	150	2.1	60 - j 10
5.368	184	29	43	3.4	330 + j 1100
7.05	0	24	29	4.8	6300 - j 2000
10.105	34	19	21	4.5	130 - j 320
14.05	36	13	14	5.7	4300 + j 2000
18.12	47	10	11	6.1	150 + j 20
21.05	48	8	9	7.0	2000 + j 2100
24.95	53	7	7	7.4	160 - j 110
28.05	54	6	6	7.6	1100 + j 1600

Although the added height and length of the 136' inverted-L continues to lower the elevation angle and raise the maximum gain, the longest of our doublets raises two question marks. First, note the number of bands on which we have either very high resistance or very high reactance--or both. Second,

note the increasing unevenness of coverage of the azimuth patterns on the upper bands. For some installations (but not for all) where this antenna is feasible, it may not be the best choice. For example, if we can install the 88' version at the 78' top level, we would gain most of the improvement in elevation angle and a bit of the gain, but have fewer matching challenges.

Before we turn to the next antenna, let's make a comparison of azimuth patterns. The sample in **Fig. 10** uses the 88' inverted-L and an 88' doublet, both at the same top height and both on the 12-meter band.



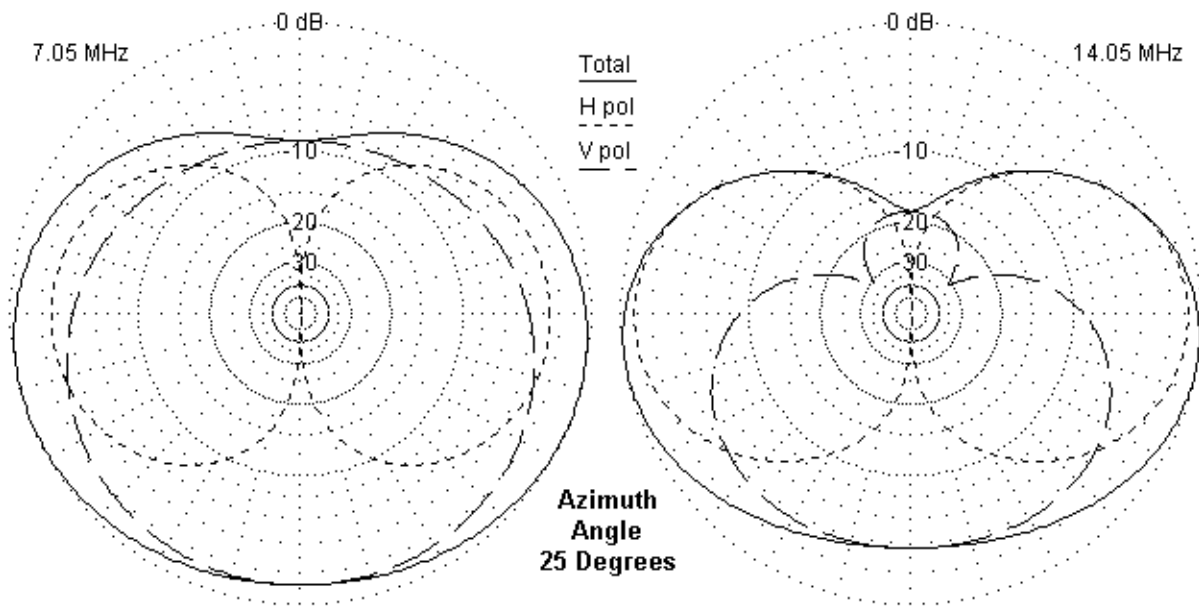
**Fig. 10**

The doublet has 10 lobes on this band, 4 of which are stronger than the inverted-L major lobes. However, for a very large portion of the horizon, the inverted-L shows a higher gain, with more even coverage of the entire horizon. For penetration in specific directions, the doublet may be better, but for general communications with an installation dictated by available supports (trees), the inverted-L is likely to make a very good showing of itself.

### The Center-Fed Sloping Doublet

At the start of this exercise, I noted that a simple center-fed sloping wire shares most of the main characteristics of an inverted-L. The time has arrived to demonstrate that fact. The first step is to note the presence in a sloping wire of both vertical and horizontal pattern components. Our sample antenna will be a 68' AWG #12 wire sloping at a 45-degree angle with its base 10' above ground. Just as the inverted-Ls that we have examined start with their vertical legs in the pattern centers, with the horizontal leg pointed upward on the page, so the sloper will also point upward on the page and in the patterns.

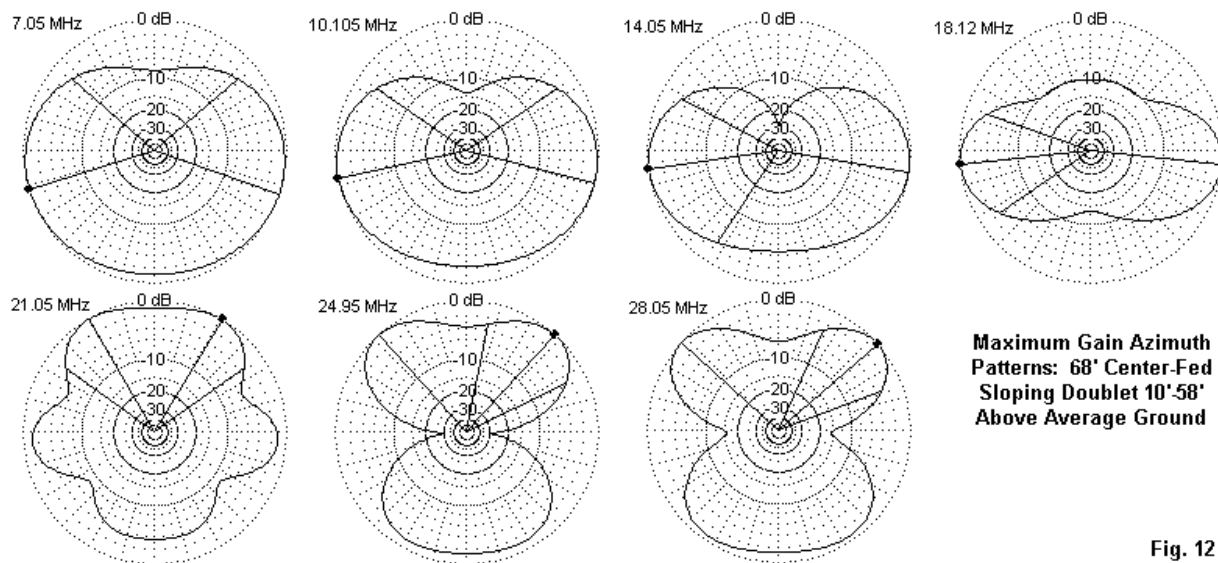
Compare **Fig. 11** with **Fig. 3**. In both cases, we can see for the sample bands the vertical component along with the horizontal component. The total patterns are very similar, but it is clear that the sloping doublet tends to concentrate the vertical component on the antenna end that approaches the ground. This fact does not disable the sloping doublet from operating as a good general communications antenna. However, it does simplify construction somewhat, since we now need only 1 very tall support for the high end of the wire. For a 68' 45-degree sloping doublet, the top point is 58' above ground. If we lower the angle, we lose some of the advantages of the vertical component and raise the elevation angle. Hence, it may be wiser to restrict band coverage and use a shorter wire at a high angle than to use a longer wire at a much lower angle.



**The Vertical and Horizontal Components of a 68' Sloping Doublet 10'-58' Above Average Ground**

**Fig. 11**

The sample sloping center-fed doublet that we shall examine on a band-by-band basis is a 68' long AWG #12 wire extending vertically from 10' to 58' above average ground. The slope is 45 degrees. The inverted-L with which to compare this antenna is the 69' version whose patterns appear in **Fig. 7**. As **Fig. 12** reveals, when we compare the patterns with those of the 69' true inverted-L, we do not achieve the same smooth evolution of patterns. The vertical component of the total pattern is better suppressed in the direction from the low to high end of the wire much more thoroughly than when the wire forms an L. The 20- and 17-meter patterns are elongated broadside to the wire, while the 12- and 10-meter patterns have relatively deep nulls in the broadside directions. See the data table for this antenna to uncover two more ways in which the antenna is not just like an inverted-L. Despite these differences, the antenna still covers a good portion of the horizon on almost all bands with moderate gain.



**Fig. 12**

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
7.05	197	41	152	2.4	85 + j 7
10.105	192	30	59	3.6	330 + j 810
14.05	188	21	33	5.4	4600 - j 1300
18.12	186	16	23	6.2	170 - j 790
21.05	59	12 *	14	3.0	110 - j 80
24.95	49	12 *	14	4.5	480 + j 810
28.05	40	11	17	5.6	3100 + j 590

The starred entries in the elevation angle column represent cases in which the main lobe is straight up, and the indicated angle is for a secondary lobe. The gain difference between lobes is not significant on 12 meters, but is sizable on 15 meters. Most of the other values, including the feedpoint impedances, are quite comparable to those for the corresponding inverted-L.

### Does Ground Quality Make a Difference?

There may be some concern that because the center-fed inverted-L or sloping doublet has one end close to the ground, the ground quality may make a significant difference in performance. As the following short table shows, the difference is only about as much as variation in soil type would make for a horizontal antenna at the same average height in wavelengths above ground. "Cond" means conductivity in S/m and "Perm" means the permittivity or dielectric constant. The listing for each combination of soil quality and frequency shows the maximum gain followed by the elevation angle of maximum radiation.

Frequency MHz	Soil Quality Cond/Perm	Very Good		Average		Poor		Very Poor	
		Gain	Angle	Gain	Angle	Gain	Angle	Gain	Angle
7.05		2.9	39	2.6	38	2.5	37	2.2	36
14.05		5.5	21	5.1	21	5.0	21	4.3	21
21.05		5.5	15	5.1	15	5.0	15	4.4	15
28.05		5.9	11	5.7	11	5.7	11	5.3	11

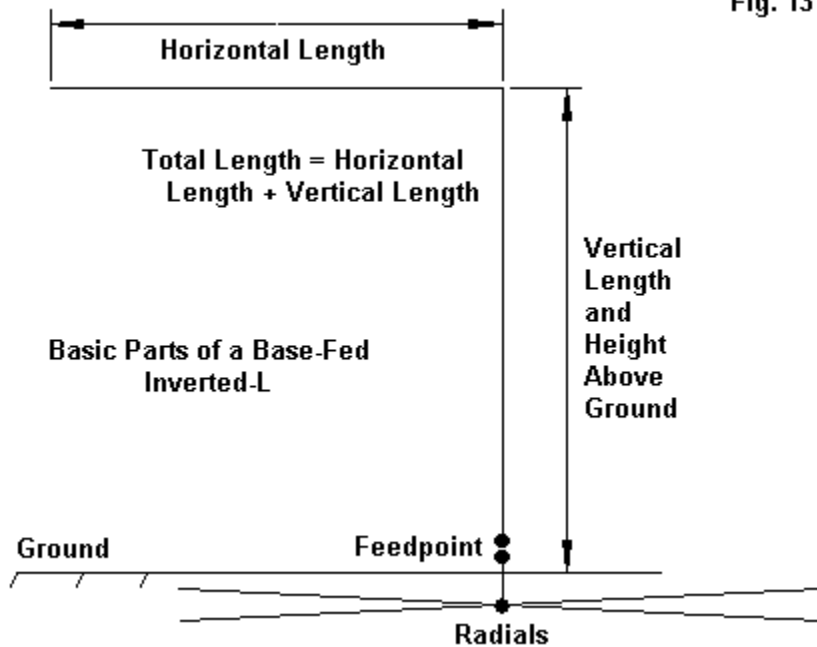
The differentials are small. The variations are functions of the reflection of radiation off the different soil qualities at a distance from the antenna itself. Therefore, a radial system under the antenna or other measures to improve soil quality directly under the antenna will have no significant effect on the radiated signal.

### The Base-Fed Inverted-L

Because it has a physically convenient feedpoint--at ground level--the base-fed inverted-L is considerably more common than the center-fed L. **Fig. 13** outlines the most basic parts of the base-fed inverted-L. Of course, we have the vertical and horizontal sections of wire that together make up the total length. However, since the feedpoint is no longer at the wire's center, we find considerable variation among installations, ranging from those that use more vertical and less horizontal wire to those that do just the opposite. The base-fed version of the antenna differs from the center-fed version also in the fact that its vertical wire must reach the ground, rather than terminating at some safe height above ground. Therefore, for any given antenna total length, the base-fed version will be about 10' lower at its top height.

Because the base-fed inverted-L is fed at its end, it requires a good RF ground when its length is at least ½ wavelength. If used as a ¼-wavelength monopole on its lowest frequency, then it also requires radials to complete the antenna. Ideally, for monopole use, the antenna requires the same ground radial treatment as any other ground-mounted monoband monopole. However, most backyard builders use only as many radials of whatever length they can squeeze into the available space. A scant, small, and short radial system can provide the good RF ground needed by the feedpoint, but it may fall short of an ideal radial system. **Fig. 13** shows only a few radials.

Fig. 13



Until recent years, feeding a base-fed inverted-L was somewhat of a challenge. As a field antenna, the L and its sloping cousin, tended to terminate at the operating table, using a manual ATU. However, we now have access to weather-sealed automatic tuners with remote tuning heads. Hence, we may mount the tuner directly at the feedpoint and use a length of coax rated for ground burial for the run to the operating position. However, the older methods will work perfectly well.

An inverted-L that is near resonance as a monopole on 80 meters is about 69' overall. Because we have so many variations on the basic L to consider, we shall largely focus on this length antenna, with only a few alternatives considered toward the end of this part of our exploration. As always, the wire will be AWG #12. However, before we can examine the antenna on a band-by-band basis, we need to consider some of the alternatives to see how much weight they carry.

### How Many Radials and How Long?

Let's begin with a 69' long inverted-L with 34.5' horizontal and 34.5' vertical. One option available to us is simply to place a ground rod into the soil to use as the remote ATU ground terminal. Although this technique will work to some extent, a system of at least short radials will provide a superior RF ground. For a sample exercise, I created models with radials buried 1' deep, although the exact depth from 6" to 2' is not at all critical. I started with 1 radial, then increased the system size to 4, 16, and 32 radials. All tests initially used average soil with a conductivity of 0.005 S/m and a dielectric constant of 13.

On bands from 40 meters upward, the antenna wire is  $\frac{1}{2}$  wavelength. On 7.05 MHz, I obtained the following results using 15' long radials.

#### Short Radials: 7.05 MHz

No. of Radials	Maximum Gain Angles		Vertical Beam-Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
1	196	47	147	1.8	4200 - j 970
4	196	47	146	1.9	4100 - j 960
16	198	47	146	2.0	4100 - j 980
32	198	48	146	2.0	4100 - j 980

I then increased the length of the radials to 69' each to see if 80-meter monopole-length radials would make a significant difference in 40-meter performance.

Long Radials: 7.05 MHz

No. of Radials	Maximum Gain Angles		Vertical Beam-Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
1	196	47	146	1.8	4100 - j 1000
4	199	46	146	1.9	4000 - j 1000
16	199	47	147	2.1	3900 - j 1100
32	198	46	147	2.3	3900 - j 1200

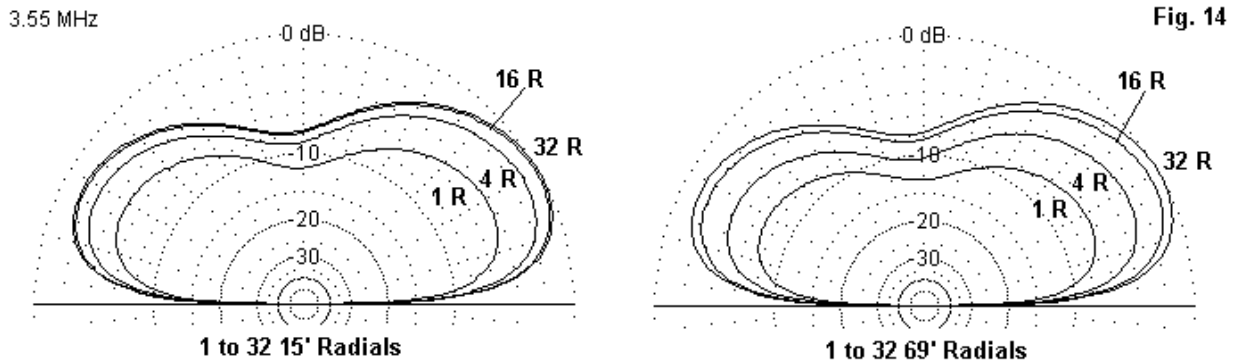
In practical operating terms, the size of the radial field and its length makes very little difference to the antenna's performance when it is at least 1/2 wavelength. However, we cannot make the same claim for the operation of the antenna as an 80-meter 1/4-wavelength monopole. I repeated the same modeling experiment using 3.55 MHz.

Short Radials: 3.55 MHz

No. of Radials	Maximum Gain Angles		Vertical Beam-Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
1	270	28	53	-5.6	94 + j 25
4	270	28	54	-2.5	50 + j 11
16	270	29	54	-1.5	40 + j 7
32	270	29	54	-1.3	38 + j 5

Long Radials: 3.55 MHz

No. of Radials	Maximum Gain Angles		Vertical Beam-Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
1	270	28	54	-6.2	112 + j 40
4	270	28	54	-2.5	51 + j 23
16	270	28	54	-0.4	32 + j 15
32	270	28	54	+0.3	28 + j 12



**Maximum Gain Elevation Patterns: 69' Base-Fed Inverted-L With Different Size Radial Sets**

**Fig. 14** shows the elevation patterns for 3.55 MHz using the short radials on the left and the long radials on the right. The 4-radial patterns are of equal strength. Obviously, using the longer radials and more of them provides a significant improvement in 80-meter gain--almost 2 dB for the 32-radial system. Hence, the advice is this: install as many radials as possible--even up to 64 1/4-wavelength radials--if circumstances permit. However, most backyard inverted-L users are likely to have room only for a smaller set of shorter radials--and their lengths and paths may vary according to what is already in the yard. Note that there is little difference between the 16- and 32-radial systems when using 15' radials--

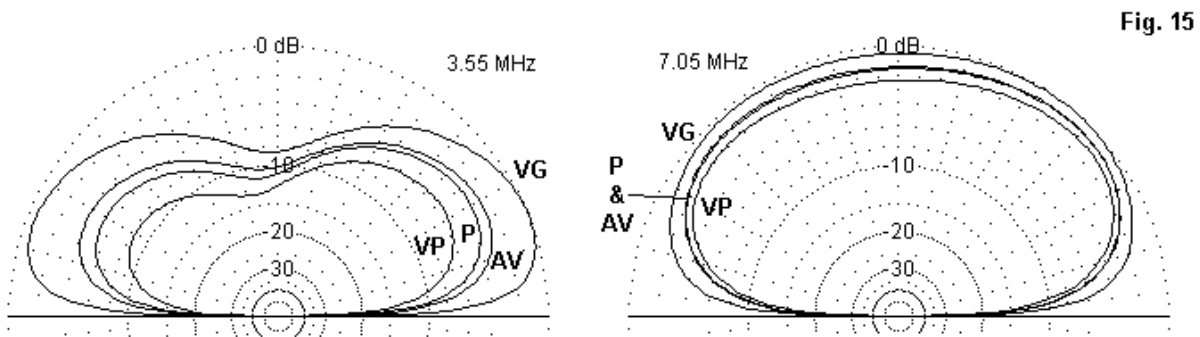
enough for a good RF ground and little more. Therefore, for the remainder of our sampling work, we shall adopt that system as the standard. However, if you plan to use the inverted-L as a monopole on the lowest band, strive for the largest, most complete, and most symmetrical system of radials that you can manage.

### Does Soil Type Make a Difference to the Base-Fed Inverted-L?

The answer to our next question is simple: yes and no. Which answer you choose depends on the band of concern. For the lowest or monopole band, the soil quality makes a considerable difference. However, for bands on which the antenna is at least ½ wavelength, Soil quality makes only a small difference. The following table compares 3.55-MHz and 7.05-MHz model reports for the soils we previously classified as Very Good, Average, Poor, and Very Poor under the center-fed version of the antenna. The listing for each combination of soil quality and frequency shows the maximum gain followed by the elevation angle of maximum radiation.

Frequency MHz	Soil Quality Cond/Perm	Very Good		Average		Poor		Very Poor	
3.55	0.0303/20	1.1	21	-1.5	29	-2.2	31	-4.3	34
7.05	0.001/5	2.6	47	2.0	47	2.0	47	1.5	44

**Fig. 15** graphically portrays the differences for each band in terms of elevation patterns along the axis of maximum gain. Clearly, soil quality makes a considerable difference to the performance of the 80-m monopole, even with the short radials used in the test. The range of gain values is nearly 5.5 dB across the soil types. On 40 meters, the range of gain differences is just over 1 dB, not dissimilar to the differences we might see with a horizontal antenna at the same top heights at the base-fed inverted-L. However, remember that the models use the same soil type both just below the antenna and at the distances responsible for ground reflections. So treating the local soil will have only a limited effect on improving antenna performance.



**Maximum Gain Elevation Patterns: 69' Base-Fed Inverted-L With 16 Short Radials Over Very Poor, Poor, Average, and Very Good Soil**

### Does the Ratio of Vertical Wire to Horizontal Wire Make a Difference in Performance?

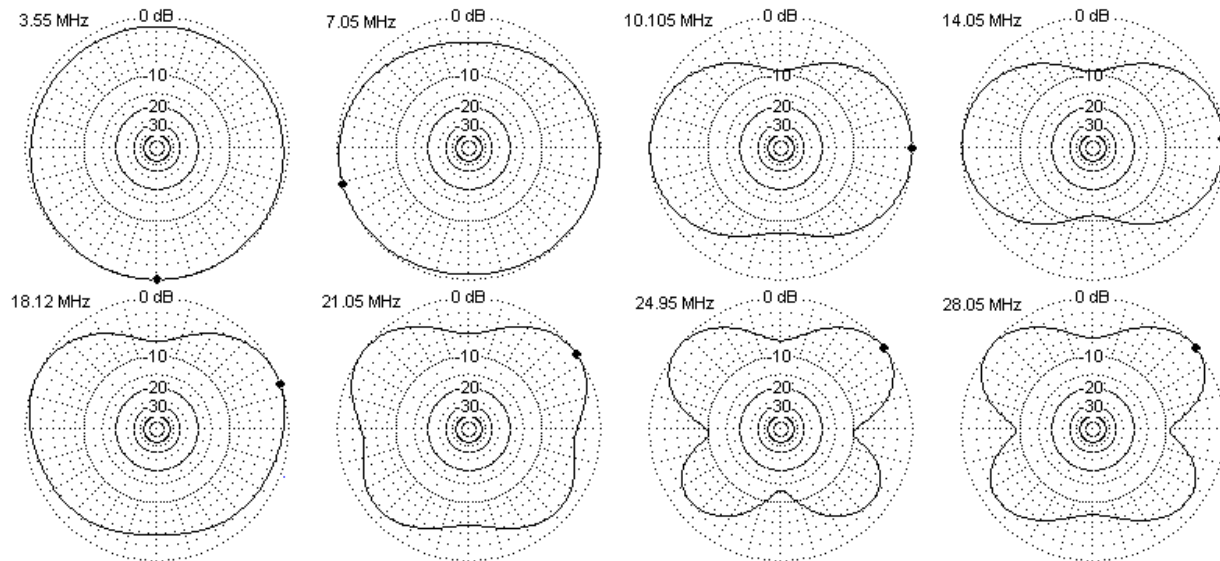
Base-fed inverted-Ls of any selected total length tend to vary in proportions according to how many convenient supports may be available. It is not possible to explore every possible variation, and even if it were possible, we could not include every yard or field clutter scenario. However, we can sample at least three variations on the 69' L. The basic version places 50% of the wire horizontally and 50% vertically. Next comes a short version, with 33% of the wire vertical and 67% horizontal. Finally, we can reverse the proportions, with 67% of the wire vertical and the remaining 33% horizontal. The most general conclusion that will aid you in keeping the tables that follow straight is that the low elevation angles at lower frequencies result from the vertical portion of the antenna. The higher the frequency that we reach before

encountering a jump in the elevation angle, the more of the antenna that is vertical. In all cases, we shall use the set of 16 15' radials.

1. *The 69' Base-Fed Inverted-L for 80- to 10-Meter Use, with 50% Vertical and 50% Horizontal*

As the following table shows, the antenna functions essentially as a monopole on 80 and 60 meters. Above that frequency, operation becomes much more like an end-fed horizontal wire with a minimum length of 1/2 wavelength. See **Fig. 16** for sample patterns (with 60 meters omitted to save space). As a reminder, the vertical part of the antenna is at the pattern center, and the horizontal part extends vertically, that is, up the page.

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	270	29	54	-1.5	40 + j 7
5.368	257	32	78	-0.2	160 + j 580
7.05	198	47 <sup>^</sup>	146	2.0	4100 - j 980
10.105	0	40	64	5.6	75 - j 130
14.05	4	27	35	5.3	1500 + j 470
18.12	20	24	38	4.5	130 + j 80
21.05	34	21	28	4.6	1100 + j 620
24.95	38	16	20	5.8	160 + j 40
28.05	38	15 <sup>*</sup>	51	5.0	770 + j 360



**Maximum Gain Azimuth Patterns: 69' Base-Fed Inverted-L With 16 Short Radials  
34.5' Vertical by 34.5' Horizontal, Over Average Ground**

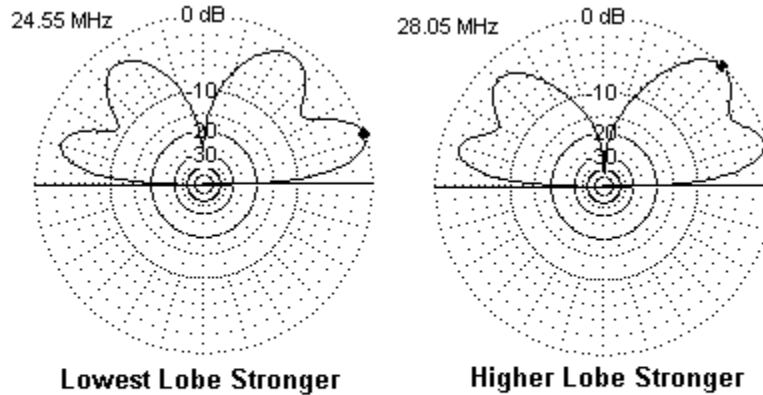
**Fig. 16**

The symmetrical division of the 69' base-fed inverted-L gives it performance values similar to those of the center-fed inverted-L of the same general length. The base-fed model has higher elevation angles in the upper HF region because it is lower overall compared to the center-fed version, with its 10' base height. However, the shapes of the patterns are quite similar to those of the center-fed model. Even when the pattern begins to form multiple lobes, they are broad, and the nulls are not fatally deep. In exchange for small deficits relative to the center-fed inverted-L, we gain operation on 80 and 60 meters.

The starred elevation angle entry indicates that the table uses a lower lobe when maximum gain belongs to a higher angle lobe. However, on 10 meters, the difference in strength between the two lobes is very small. See **Fig. 17** for a comparison between a "normal" upper HF elevation pattern and the worst



case, which occurs on 10 meters. Starred entries generally were unnecessary with the center-fed inverted-L because its greater overall height tended to ensure that the lowest elevation lobe was the strongest. However, such entries will be common in our survey of base-fed inverted Ls. The "A" indicates the band where the elevation angle increases rather than decreases.

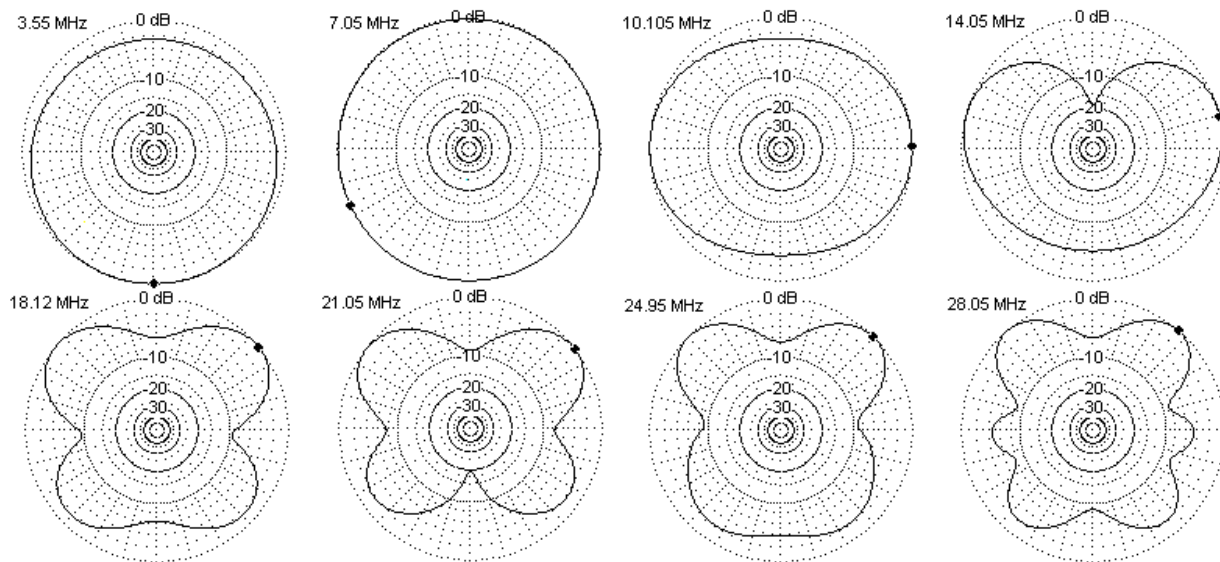


**12- and 10-Meter Elevation Patterns  
69' Base-Fed Inverted-L, Equal Legs**

**Fig. 17**

*1. The 69' Base-Fed Inverted-L for 80- to 10-Meter Use, with 33% Vertical and 67% Horizontal*

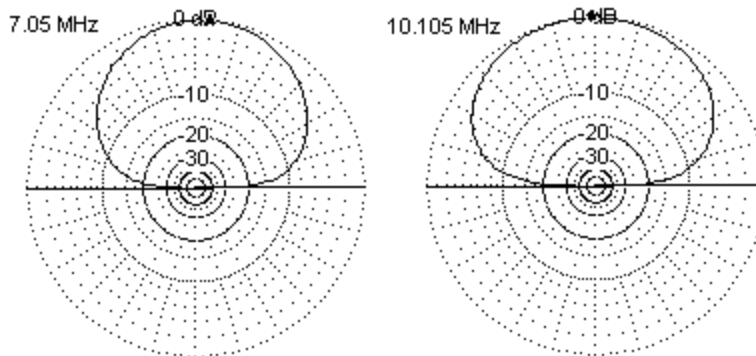
The "short" version of the 69' base-fed inverted-L uses a 23' vertical wire and a 46' horizontal wire. Hence, we should expect some performance differences from the version just sampled. A lower overall antenna height (23') will produce higher elevation angles when the horizontal component becomes the dominant contributor to the total pattern. Even the feedpoint impedances will differ, but not so far from the initial values that we cannot recognize the relationships. **Fig. 18** supplies the patterns to go with the tabular data.



**Maximum Gain Azimuth Patterns: 69' Base-Fed Inverted-L With 16 Short Radials  
23' Vertical by 46' Horizontal, Over Average Ground**

**Fig. 18**

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	270	33	72	-2.1	31 + j 7
5.368	237	64^	129	-0.5	130 + j 590
7.05	210	84++	110	4.4	3800 - j 1900
10.105	1	61+	133	5.2	95 - j 95
14.05	15	35	71	3.5	2000 + j 450
18.12	39	32	42	5.6	130 + j 70
21.05	37	26	35	5.8	980 + j 450
24.95	45	25	34	6.1	140 + j 45
8.05	49	22	27	6.4	800 + j 570



**Very High Angle 40- and 30-Meter Elevation Patterns  
69' Base-Fed Inverted-L, Short Vertical Leg**

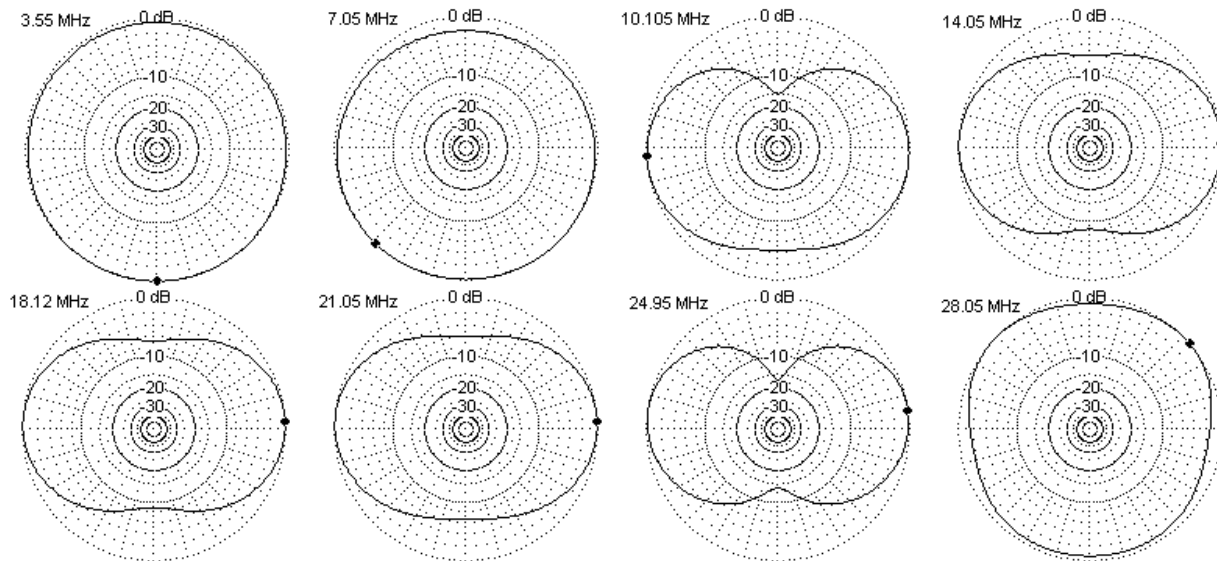
**Fig. 19**

The short version of the 69' inverted-L has no stronger upper lobes per se, but the overall decrease in height yields some entries marked with a plus sign. Note the very high angles for 60 through 30 meters, and see **Fig. 19**. These angles are generally well above normal skip angles, especially on 40 meters. At 7.05 MHz, the signal strength at normal skip angles for that band is considerably lower than indicated by the maximum gain value. Also note that by the 60-meter band, the antenna has lost the low elevation angle advantage to compensate for a lower maximum gain value. Even on the upper HF bands, the elevation angle of maximum radiation is 7-8 degrees higher than it is with the evenly divided version of the inverted-L. The longer horizontal length shows up in the fact that on 10 meters, we find the emergence of 2 more lobes to the overall azimuth pattern structure. Although this version of the antenna is perfectly usable, it approaches perfection far less closely than the basic antenna with equal vertical and horizontal legs.

*1. The 69' Base-Fed Inverted-L for 80- to 10-Meter Use, with 67% Vertical and 33% Horizontal*

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	270	26	47	-1.4	49 + j 10
5.368	270	25	46	-0.4	200 + j 570
7.05	227	24	45	0.5	3600 - j 660
10.105	184	32^	45	4.5	40 - j 120
14.05	2	27	27	4.5	2000 + j 660
18.12	3	17	20	5.0	140 + j 70
21.05	3	15*	52	4.1	1000 + j 420
24.95	8	12*	15	3.8	160 + j 50
28.05	40	39+	24	5.2	860 + j 480

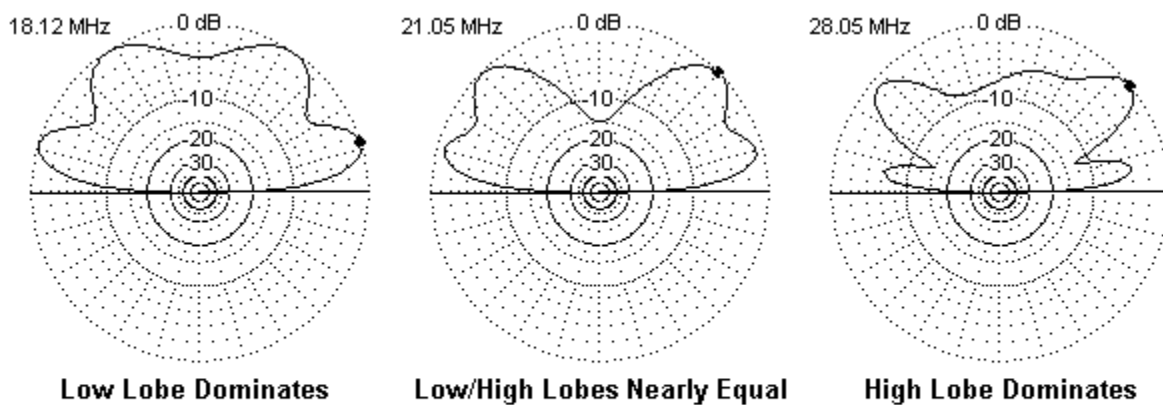
The final version of the 69' base-fed inverted-L reverses the vertical and horizontal proportions. It is 46' tall by 23' horizontally. **Fig. 20** presents the azimuth patterns that coincide with the data in the table.



**Maximum Gain Azimuth Patterns: 69' Base-Fed Inverted-L With 16 Short Radials  
46' Vertical by 23' Horizontal, Over Average Ground**

**Fig. 20**

The tall version of the 69' inverted-L retains its vertical component domination through 40 meters. However, on 15 and 12 meters, the lowest elevation lobe is not the strongest, although it is not far behind the higher-angle main lobe. See **Fig. 21** for a picture of how the elevation pattern evolves with increasing frequency. On 10 meters, the lowest lobe is somewhat diminutive, making the high angle (39-degree) lobe the major lobe worth notice. The 10-meter pattern in **Fig. 20** may be somewhat misleading: although coverage is wide, it is at an angle well above most signals on the band.



**Evolution of Elevation Patterns  
69' Base-Fed Inverted-L, Long Vertical Leg**

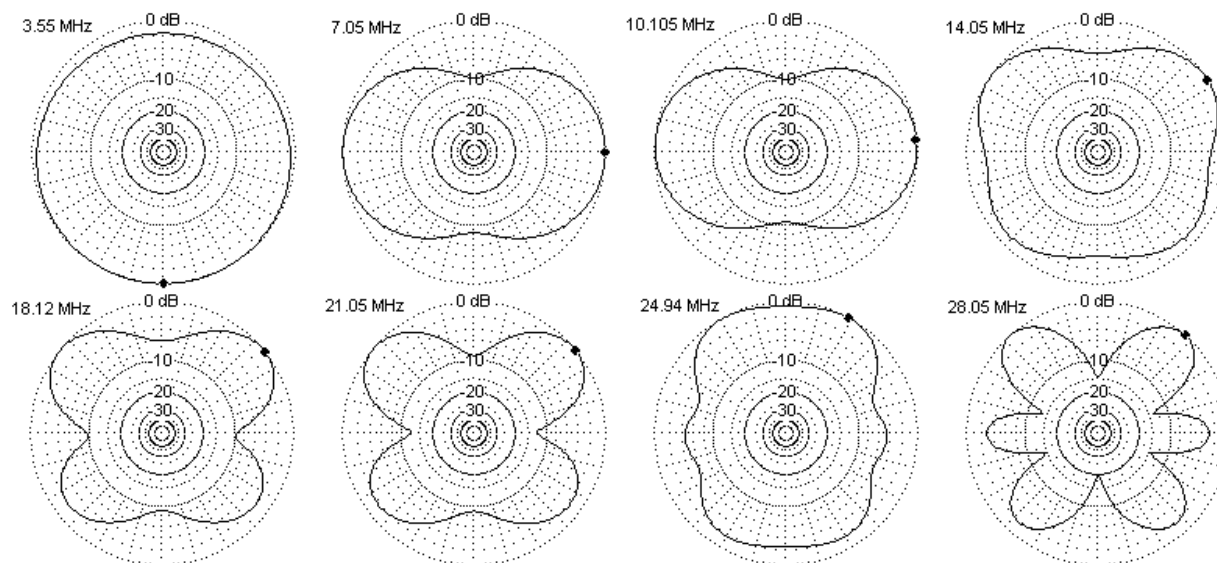
**Fig. 21**

Of the three variations on the 69' inverted-L, the first version, with balance between the horizontal and vertical legs, offers the best combination of patterns and elevation angles. The others are usable, but tend to have 2 or more bands with lesser performance.

## A 100' Base-Fed Inverted-L for 80- to 10-Meter Use, with 50' Vertical and 50' Horizontal

A second typical length for a base-fed inverted-L is about 100'. Although it is equally subject to variations in proportions, we shall examine only the version using equal lengths for the vertical and horizontal lengths. From that data, you can easily infer the likely performance variations for other ratios of vertical to horizontal legs. With a greater top height (50' rather than 34.5'), we might expect slightly higher gain values and slightly lower elevation angles than for the corresponding 69' model. However, inverted-L antennas are in fact fairly complex in the interactions between vertical and horizontal components of the total pattern. So the antenna may offer a few surprises. See Fig. 22 for a selection of representative azimuth patterns for the 100' inverted-L.

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	270	30	70	-0.3	130 + j 490
5.368	189	49 <sup>^</sup>	141	3.6	430 - j 1400
7.05	0	38	60	5.6	76 - j 120
10.105	5	26	33	5.6	1300 - j 830
14.05	33	23	31	4.4	570 + j 680
18.12	38	16*	20	5.1	270 + j 250
21.05	39	14*	18	6.0	260 - j 270
24.95	61	37+	19	7.5	960 - j 360
28.05	48	10	10	5.3	320 + j 290



Maximum Gain Azimuth Patterns: 100' Base-Fed Inverted-L With 16 Short Radials  
50' Vertical by 50' Horizontal, Over Average Ground

Fig. 22

The 100' inverted-L offers fairly easy matching on all bands, with the possible exceptions of 60 and 30 meters. However, the spectrum from 17 through 12 meters is subject to wasting energy at very high angles relative to the normal skip angles on those bands. On 17 and 15 meters, the lower lobe is nearly as strong as the higher main lobe, but on 12 meters, the high angle lobe dominates. Hence, the high gain for 12 meters may be more illusory than real in practical operation. On 10 meters, we find 6 well-developed lobes and nulls. For general HF communications, the 100' length may not be as satisfactory as the 69' version of the antenna. Greater length of an antenna does not always mean that it is a better antenna for a particular situation or task. Nor does it always mean better gain, if we think about general communications and the need for some gain all across the horizon.

## Is There A Perfect But Realistic Inverted-L Length?

The practical inverted-L builder has two considerations to balance in answering the lead question. Let's consider versions of the antenna between 69' and 100' on the premise that one of those considerations--pattern properties--is satisfactory at both ends of the progression. Since patterns evolve, you can infer the small changes in pattern shape with each step by reviewing the patterns for the 69' base-fed inverted-L and those for the 100' version. As well, we shall restrict ourselves to antennas in which 50% of the wire is horizontal and 50% is vertical. Again, you can review the variations presented for the 69' inverted-L to infer both pattern changes and impedance changes as we alter the ratio of vertical to horizontal sections.

The consideration that may override perfection of pattern is the impedance at the antenna feedpoint. We shall use the 16-short-radial antenna model as a basis for seeing if there is a probable ideal length in a 50-50 inverted L by looking at the impedance on all HF bands from 80 through 10 meters. The table of impedances provides approximate values and does not take into consideration variations created by the actual radial system available or by the effects of nearby objects. However, the data may be useful for initial planning, assuming that available supports will cooperate. Each data entry lists the resistance plus or minus the reactance in abbreviated form. All modeled values are rounded to 2 significant digits.

Freq. MHz	Total Length of the Inverted-L, With Half Vertical and Half Horizontal						
	69'	75'	80'	85'	90'	95'	100'
3.55	40+7	49+82	58+150	70+220	85+300	110+390	130+490
5.368	160+580	290+880	590+1300*	1700+2K*	4400-610*	1300-2K*	430-1400*
7.05	4100-980*	590-1500*	210-900	110-580	82-380	73-240	76-120
10.105	75-125	97+57	140+220	240+410	520+660	1400+650*	1300-830*
14.05	1500+470*	520-740	170-350	110-92	130+120	220+350	370+680
18.12	130+80	290+430	1200+630*	610-740	170-270	160+17	270+250
21.05	1140+620*	310-500	150-77	230+190	560+390	900-270	260-270
24.95	160+39	430+370	920-200	230-200	190+140	490+440	960-360
28.05	770+360	280-230	200+150	550+470	660-460	180-40	320+290

To use this initial guidance chart, evaluate two factors in addition to the maximum size of inverted-L that you can install. First, what length provides the most easily matched impedances on the bands that you wish to work--using long-range thinking rather than just short term habits. The chart stars entries in which either the resistance or the reactance exceeds 1,000 Ohms, and those bands might be difficult to match well. The goal is to select an antenna length that minimizes starred entries next to bands you may wish to use. Compare the 75' and 85' versions of the antenna. Both star only one entry, but the 75' antenna shows a high impedance on one of the most popular general communications bands.

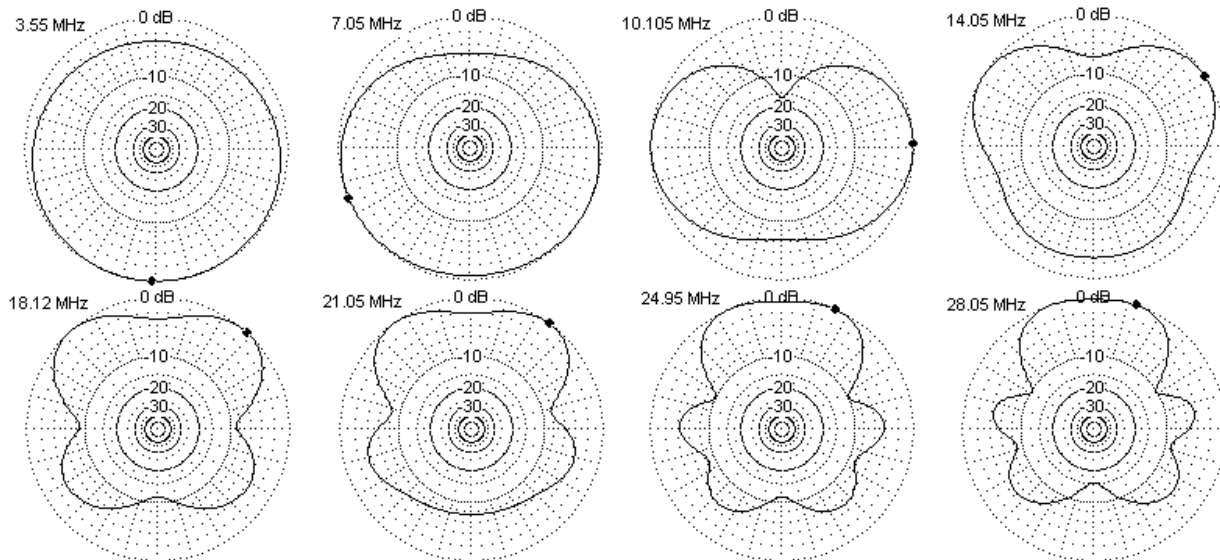
Second, consider the matching range of your tuner. Most automatic tuners placed at the antenna feedpoint have somewhat restricted ranges of reactance compensation, but resistance matching may also be somewhat more limited than for other antenna tuner types. If we eliminate 60 meters, then the 85' and 90' versions of the antenna may provide a satisfactory match on all of the other HF bands. If the tuner will handle 60 meters and its reduced power levels with under 2:1 SWR at the rig end of the line, then we can use that band also. However, remember that your backyard may have enough clutter to alter the listed values significantly. As well, changing the ratio of vertical to horizontal sections of the wire may also change the impedance at the feedpoint.

Nevertheless, the chart gives you some idea of what to expect. The modeled ideal length range of about 85' to 90' is not usually recommended, most likely because few folks have surveyed what inverted-L length means to the matching problem. Now that you have some initial guidance, as limited as it might be, you can also use the chart as a suggestive start in knowing whether to lengthen or shorten an installation that presents a matching problem on one or more desired bands. Shortening is usually no problem. If you have to add a few feet of wire, do not be afraid to let it hang down so long as no one can touch it.

## The Base-Fed Sloping Wire

We covered the center-fed sloping doublet earlier because, like the inverted-L doublet, it included both vertical and horizontal components in the formation of its total patterns on each band. A sloping base-fed wire shares that property with base-fed inverted-Ls, so we should briefly check out its potential performance. Let's use a 69' wire sloping at an angle of 45 degrees. In all patterns, the wire will extend from the pattern upward on the diagrams, just like the horizontal leg of the inverted Ls. The top height of the AWG #12 wire will be at 48.8' above ground. **Fig. 23** shows the patterns that go with the tabular data.

Frequency MHz	Maximum Gain Angles		Vertical Beam- Width (deg)	Gain dBi	Impedance R+/-jX Ohms
	Azimuth (deg)	Elevation (deg)			
3.55	270	30	63	-1.4	46 + j 18
5.368	226	35	108	-0.0	230 + j 630
7.05	203	46 <sup>^</sup>	150	1.4	2100 - j 1500
10.105	2	40	65	2.9	70 - j 80
14.05	32	23	116	2.5	2200 - j 620
18.12	47	19	109	2.9	110 + j 130
21.05	53	16	61	3.3	1800 + j 190
24.95	66	14 <sup>*</sup>	25	3.7	110 + j 100
28.05	71	12 <sup>*</sup>	25	3.9	1400 + j 520



**Maximum Gain Azimuth Patterns: 69' Base-Fed Sloping Wire With 16 Short Radials  
45-Degree Slope, Top Height 48.8' Over Average Ground**

**Fig. 23**

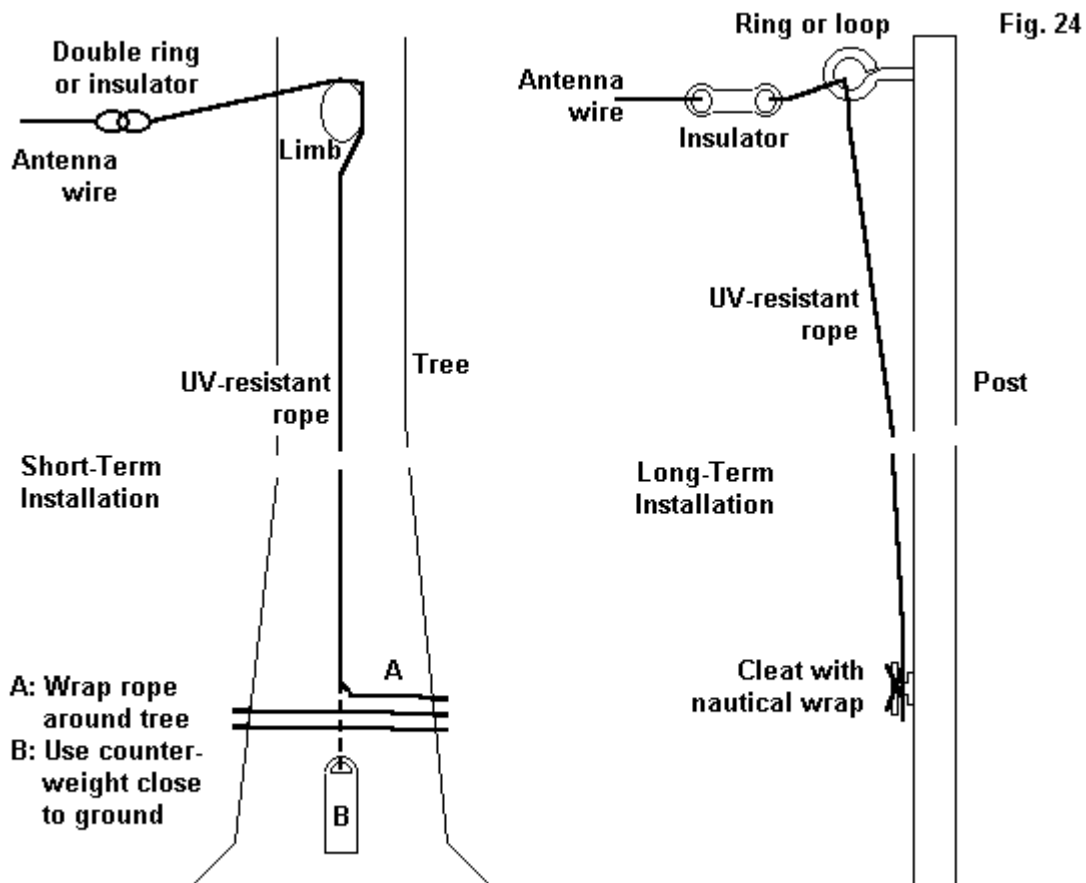
The sloping wire is similar in performance to, but not just like, the corresponding inverted-L. On the lowest 2 bands, performance is as good as, if not a tiny bit better than, the L. However, all of the gain values from 40 meters through 10 meters are lower than the L values by a noticeable amount, that is, by 2 dB or more. Most of the gain reduction stems from the very wide vertical beamwidths. Even though the elevation angle of maximum gain is low, the gain remains considerable even at high angles well above normal skip angles on each band. On 12 and 10 meters, there is a high-angle lobe that is stronger than the low-angle lobe listed.

As a consequence, a true inverted-L is more likely to give satisfactory performance than the sloping wire. However, where there is only 1 high support, the sloping wire will provide communications across most of the horizon. As well, for emergency communications work in the HF region, the sloping base-fed wire is a proven performer, and one that you can easily replace should it break due to weather conditions.

## Some Notes on Building an Inverted-L

The performance of an inverted-L or its sloping cousin will depend as much upon using sound mechanical and electrical installation techniques as upon the wire itself. Therefore, in our effort to straighten out the inverted-L, we should close with a potpourri of building ideas. Not all of them will apply to a given backyard or field situation, but the general principles involved will trigger more specific ideas for actual antenna sites.

Let's begin at the far end of the antenna, the elevated wire end that is common to both an inverted-L and a sloping wire. **Fig. 24** encapsulates a number of sound practices for both temporary and permanent installations.



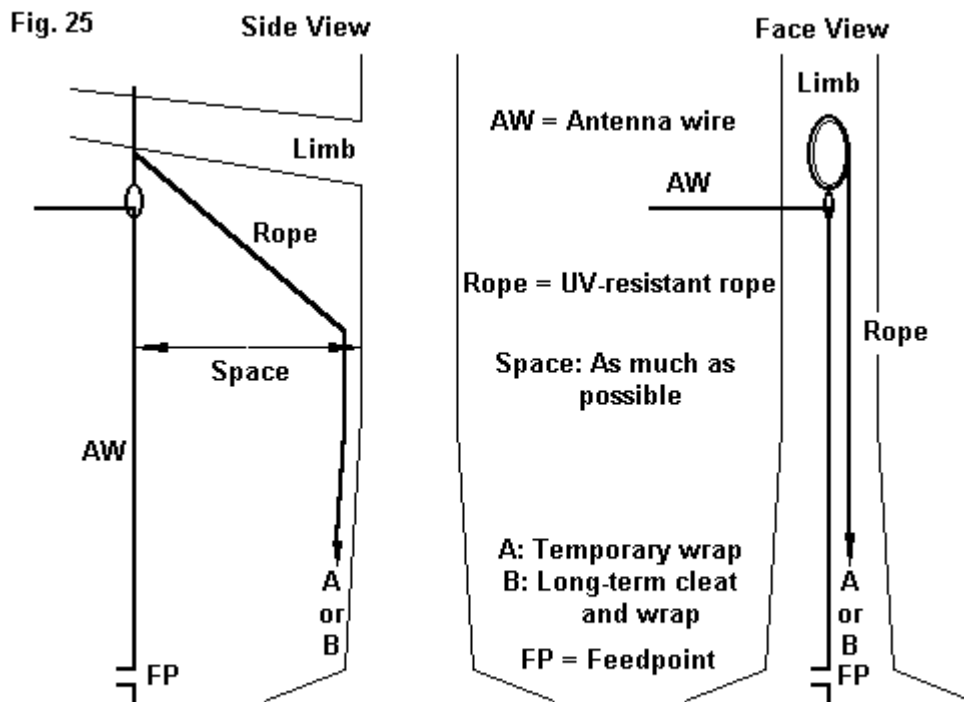
**Some Ideas for the Far End of the Inverted-L**

In the field, throwing a rope over a high and handy limb is a time-proven method of securing a wire end. The rope should be both UV and abrasion resistant, or else it requires replacement after every few field exercises. Since these antennas are useful for HF emergency communications, it never pays to use cheap materials that fail in the midst of public service activity. Of course, with this end of the antenna and all other parts, inspection before taking to the field is not merely recommended; it is mandatory.

You may secure the lower end of the rope by several wraps round the tree or with a weight. If you use a counter-weight, be certain that it is low to the ground for safety. With a long-term (sometimes miscalled a permanent) installation, a boat or pick-up truck cleat is a superior way to lock down the extension tope to the wire and the insulator. In long-term installations, an insulator usually provides smoother surfaces around which to wrap the wire on one side and the rope on the other, thereby reducing

the chance of cutting the rope with the wire as the two bounce in the breezes. Use a nautical wrap around the cleat for a no-knot, secure, termination.

The near end of an inverted-L presents the builder with the greatest challenges. **Fig. 25** shows some ways to achieve a satisfactory installation of the vertical wire. First and foremost on the list of necessities is to set the vertical wire as far from any vertical support or other object as possible. Tree trunks and house sides will change conductivity with the weather and the season, and houses have all manner of hidden metal in their walls. The sketch shows the vertical wire spaced many feet from a tree trunk. Increase that spacing if you use a tower or a house as the support. If the vertical portion of the antenna does little other than to irradiate a tree trunk or house wiring, the antenna performance will range from poor to pathetic.



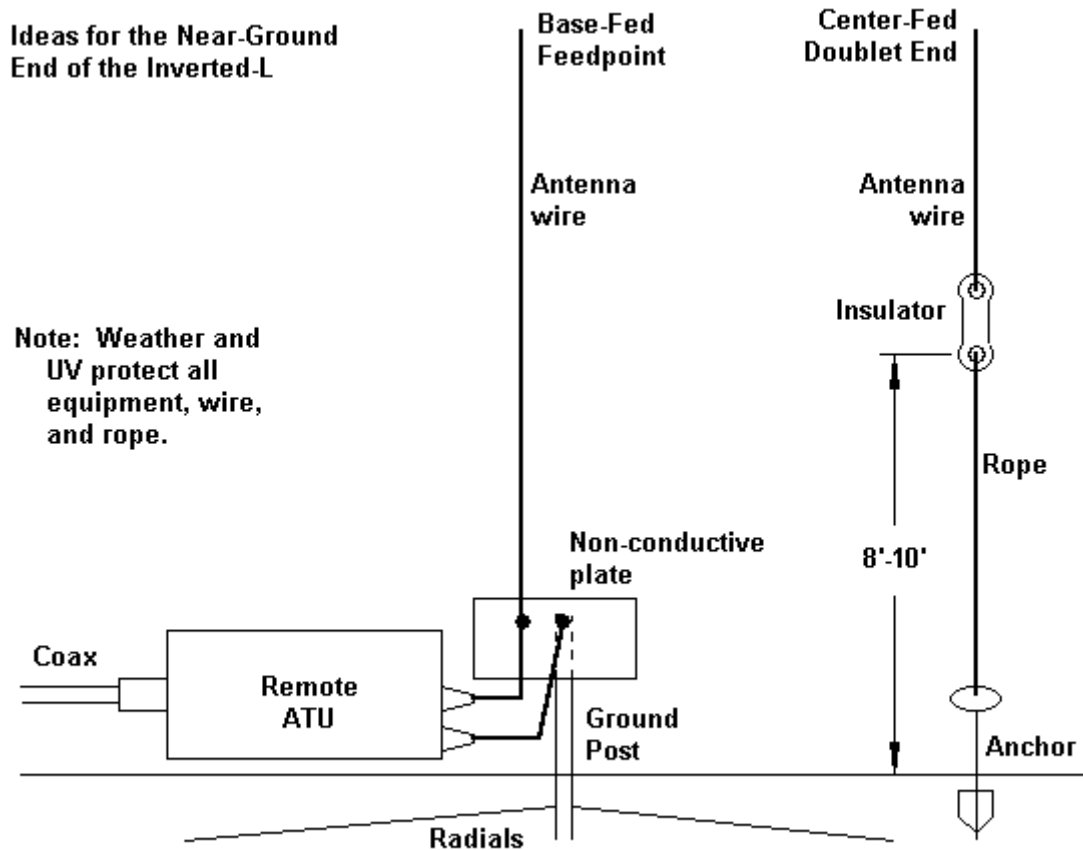
**Some Ideas for the Near End of the Inverted-L**

At the upper end, the antenna wire will make a right-angle turn. Support it with a non-conductive ring. Do not use a metal ring, and do not drape the wire directly over a limb or other support. Trees and other wood supports are not true insulators. At best, they are semi-conductors capable of dissipating a good bit of power over their surfaces. Even in the 1920s, amateurs used wood insulators only after soaking them in boiling paraffin. Since that practice is not applicable to a limb that is still on the tree, some variant of the rope and ring system is necessary for proper support of the L. At the base, you may use either the field or long-term techniques of **Fig. 24** to secure the rope.

For a center-fed inverted-L doublet, replace the suspended ring with an insulator or a commercial doublet centerpiece designed for use with parallel feedline (either ladder line or vinyl-covered transmission line). Use care to design the center support of the junction of transmission line and antenna wire for the type of support that you will use. A tree limb will require a flexible support. However, if you use a tall wooden post or similar structure, then you may wish to devise a more rigid extension to the doublet center insulator to reduce movement. Parallel feedlines show their greatest weakness where they emerge from the junction fixture. 24-hour a day wind movement will gradually flex the wires to the breaking point.



**Fig. 25** does not show any particular means of mechanically terminating the lower end of a sloping or vertical wire. The base-fed and center-fed terminations require different treatments. **Fig. 26** is only a starter set of ideas, designed to show what is necessary by way of installation, but not necessarily what specific hardware you will need. What both systems have in common is the need to pin down the end of the vertical assembly without creating so much tension that the system breaks in the middle or at the far end.



**Fig. 26**

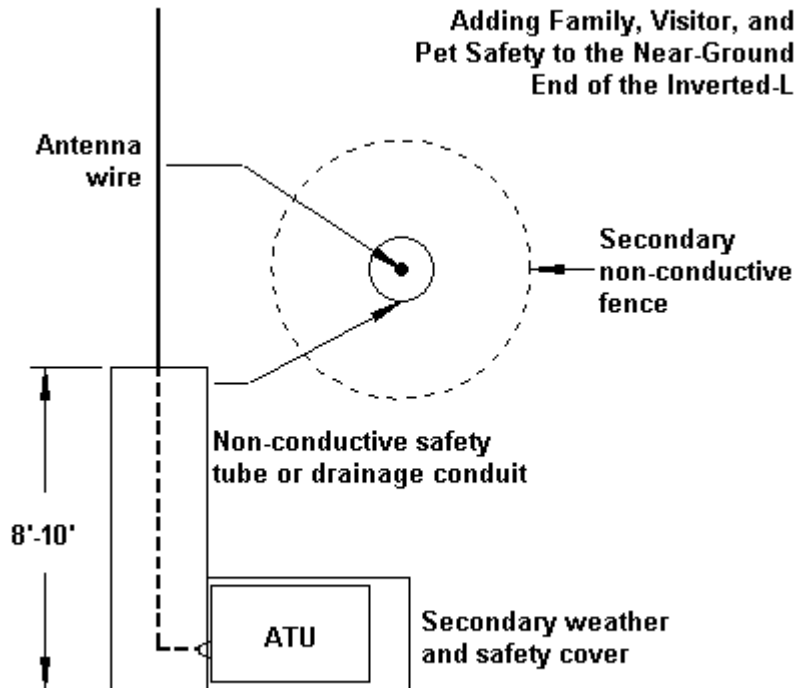
With the base-fed inverted-L, the wire descends all of the way to near-ground level. Even in a field operation, do not connect it directly to an ATU terminal. The diagram shows a non-conductive plate with terminals. On one side, the terminal connects to a ground stake or rod, and to that rod, we connect the radials. The other terminal secures the antenna wire. Then, leads from the ATU connect with no stress to the plate terminals. In permanent installations, waterproof all connections. In fact, consider adding a secondary weatherproof housing to the commercial remote antenna tuner as an added layer of protection. Do not place the ATU directly on the ground. In fact, keep it above the level of water that even the worst yard flooding might produce.

The center-fed doublet requires an extension rope (and insulator) between the wire and a ground anchor. Unless the installation is very heavy or undergoes extreme stresses, a guy-wire screw anchor is usually not necessary. There are pet chain anchors that will secure AWG #12 wire and rope ends quite well. However, be certain that the device is non-rusting.

The diagram lists a height of 8' to 10' as the distance between the ground and the element end. A better way to determine the minimum height above ground for the antenna wire end is to consider the

highest level a family member or visitor (or pet) might jump (with arms extended) and then add 2' to that level. The goal is to ensure that no one can reach the wire under any normal circumstance. Doublet wire ends can carry considerable voltage, even at low power levels. Safety is the first concern in all antenna installations.

The base-fed inverted-L is not amenable to the safety height that we can build into the center-fed inverted-L. Therefore, we must take other steps to keep family members, pets, and visitors from accidental contact with antenna wires and terminals. **Fig. 27** shows essentially a 2-tier safety arrangement for the casual backyard installation.



**Fig. 27**

The first line of safety defense consists of a non-conductive tube placed over the wire and extending high enough that no one can jump and touch the wire emerging from it. For HF, rigid PVC drainage pipe is usable by cutting a slot along the ATU side to pass the leads from the tuner. The plate and the ground rod go inside the tube. Less rigid but equally usable are sections of ABS or similar drainage pipes designed to carry downspout water away from a house. By lightly sanding the surface of either type of protective pipe, you may prime and paint the pipe to a yard-compatible color, so long as you use a paint with no metallic content. Note that this first line of defense also contains a safety cover for the ATU to prevent unwanted contact. This same cover may also act as the recommended secondary weatherproof shield for the unit.

The second line of defense consists of a non-conductive fence, such as a set of PVC or similar pickets. This fence adds a radius of a few feet from the central tube and tuner (if the antenna is base-fed). Adding a flowerbed inside the fence but away from the antenna itself further discourages the inquisitive from entering the area just to see what the end of an antenna really feels like. Similar techniques have long been used around the bases of towers to discourage potential climbers.

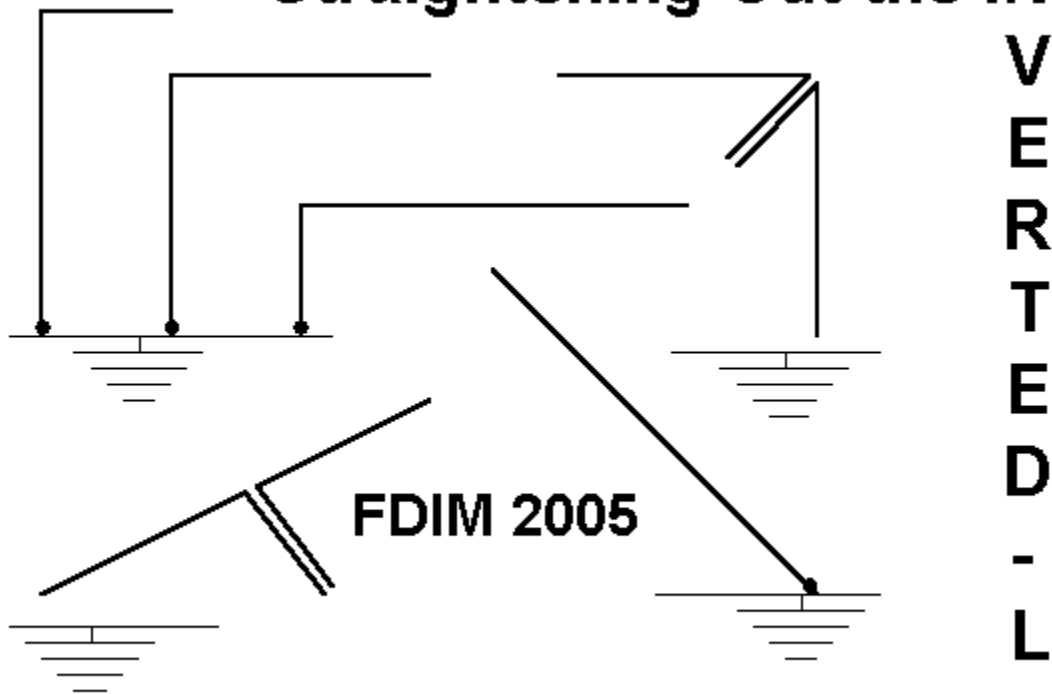
In the field, you are unlikely to use any of these safety measures. However, do not presume that everyone at the site will be on the watch for your antenna wires. Add flags to all wires, and if they slope,

add several to make the angle obvious. Use construction perimeter flags to mark the route of any cable. And never set any wire in a position that it might catch a passerby just under the chin.

These precautions take some of the excitement out of antennas. But all antennas must have a mixture of excitement and responsibility, with a heavy dose of the latter.

In the end, either the center-fed or the base-fed inverted-L has a number of properties that make it a good candidate for the amateur seeking multi-band general communications in as many directions as possible. The vertical and horizontal components combine to produce moderate gain in most directions. The lobes tend to be fewer and broader--and the nulls shallower--than they are when using a horizontal doublet. The antennas are not perfect. But they are cheap and relatively easy to build from locally available parts. If they do not merit first place among your antennas, they make very good back up antennas for the main system. However, for many field operations and small backyards, they may be the best choice for a simple, multi-band wire antenna.

## Straightening Out the IN



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