Question and Answers
by Gene Ferguson, W4FWG

ANTENNAS (OR IS IT ANTENNAE?) AND TRASMISSION LINES

Part I

1. (Q) When using an Antenna Modeling software, a simple dipole cut to length for 3.800 MHz is shown to have an input impedance of 72 ohms and a gain factor given in dB*i*. If installed between two natural supports, (trees) at a height of 30 feet above ground level what would be the characteristic impedance of the transmission line for a proper termination without a tuner or coupler?

(A) This simple dipole should be fed with a 50 ohm feed line. We know that any antenna whose gain is given in dB*i,* is a "Theoretical antenna," high in space with no consideration of the earth's ground. Any additional parameters given will also reflect this theoretical antenna. In real life, when this dipole, or any other antenna, is brought nearer to earth's ground, the impedance decreases. At the reasonable heights we use, the dipole is considered to have an input impedance of 50 ohms and a gain of 1 (or 0 as some would prefer). The simple dipole is the reference for all antenna gains.

2. (Q) If the antenna discussed in question number 1 is installed using a 12 gauge, **bare** wire, what should be the total length we cut this wire?

(A) Using the formula: L = 468/Frequency (MHz), the length is 123.16 feet. We would need to cut the wire about 10 to 12 inches longer than calculated. We then cut this conductor at the center, making two identical lengths. The extra 10 to 12 inches allowed will provide a fold back and twisting for our center and the end insulators.

3. (Q) From question 2, would we need to consider shortening the antenna any further in consideration of the "end effect?"

(A) No, the formula L = 468/F(MHz) takes into consideration, the end effect..

4. (Q) If an **insulated** 12 gage wire is used for the antenna in question 2, what effect would this have?

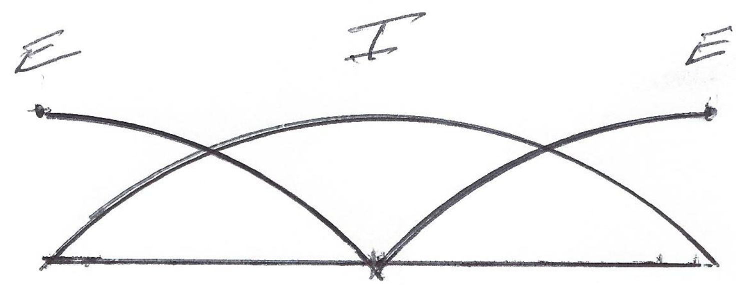
(A) Insulation slows the speed of travel of a signal slightly. A wavelength of an insulated conductor is shorter than if on bare wire, which, in turn is shorter than in free space. The insulated conductor should be a little shorter, usually in the 2 to 5 percentile range. My experience has shown that PVC pipe or tubing will shorten the wavelength by 2 to 4 percent in the VHF/UHF range.

5. (Q). What would be an advantage to using insulated wire for our radiating conductors?

(A) The insulated conductors should last longer, being better protected from the weather. However, for our usage, where "cheap" is our motto and frequent changes are common, why worry?

6. (Q) For a simple dipole, is it absolutely essential that an insulator be inserted in the center of the conductor(s)?

(A) No. In fact, there are two possible advantages for not using an insulator in the center. To understand how we can feed the antenna without insulators, review the following:



The two curved lines shown are the (E) for the voltage field and the (I) for the current field. From Ohm's law, we know that in a DC circuit, R=E / I. In an AC or RF circuit, the "R" is replaced with the symbol "Z", for Impedance. Thus, Z = E / I.

We analyze the E" and "I" lines. The absolute center of the antenna shows the "E" line at zero while the "I" line is at a maximum. If we insert values into our formula, we can see that Z = 0/ (maximum "I" value), so Z = 0, whatever this maximum "I" may be. The absolute center of the antenna has a zero impedance point. At the ends of the conductor, the voltage is at a maximum, while the current is at a minimum. Therefore the ends exhibit maximum impedance (Z = max/zero = max). If the center is "zero" and the ends are "maximum" impedance, at some point between, we are sure to find a point where the impedance is equal to our 50 ohm feed line (or any other feed line impedance). Usually that point is found to be from 1 to 3 inches each side of the center for 50 ohms, near the same spacing that our egg insulator would make. So, if this is a single band antenna, we can attach the two wires of our feed line at these points without cutting the conductor or installing an insulator. An antenna analyzer will assist in determining the correct spacing and attachment points. These points are rather difficult to determine and are extremely critical - hence the popular insulator.

What are the advantages? Without the center insulator, the antenna is lighter, with less strain on the end insulators and supports. It is <u>cheaper</u>. A third advantage may be that of lightening protection. If we ground the outer shield of our feed line and have no insulator in the center, we would be effectively grounding both, the inter and outer conductors of the feed line for surge protection. Not so if we use an insulator. Even with this advantage, we must remember that a direct or nearby lightening strike contains elements of many frequencies and this, or any other arrangement, will not cure all ills.

7. (Q) We always show a dipole mounted horizontally. Can it be mounted it vertically for vertical polarization?

(A) Sure. The height of the supporting device becomes an important factor, however. Too, the mounting support should be non-metallic, if possible, as a metal support tends to cause a "shadowing effect" and may partially blank out transmission or reception path in a small directive area and metal will affect the actual operating frequency (length) of the antenna.

8. (Q) Can we either raise or lower the center of a horizontally mounted dipole relative to the ends to allow the antenna to be used with supports not as tall as required in question number 7?

(A) Yes. It is a common practice to install the "V" which requires two supporting devices with the center or feed line point near the earth ground, or as an "Inverted 'V'", requiring only one support and the feed point high in the air. In both the "V" and the inverted "V", an angle of 45 degrees is ideal and any angle less than 45 degrees is not recommended as there will some cancellation of the signal. Again, non-metallic supports are preferred for either.

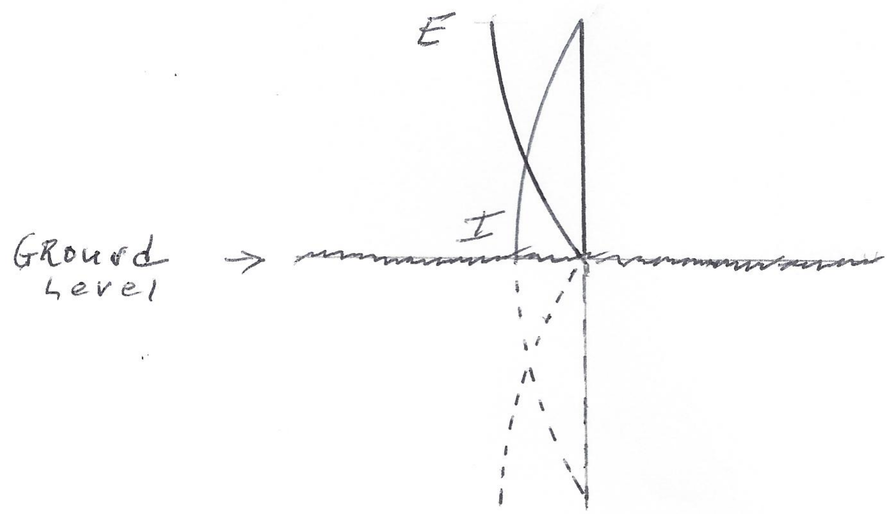
9. (Q) Why would a "V" with two supports ever be used when an inverted "V" requires only one support?

(A) The "V" antenna normally requires a shorter feed line and thus, offers less line loss. Also access to the feed point is easier and shorter.

10. (Q) If we observe the "V" antenna, we have two conductors, coming together and fed near the ground, with the two radiating conductors pointing upward at an angle. Could we eliminate one conductor and have only one vertical conductor, making our antenna only a 1/4 wavelength in length, thereby reducing the need for two supports?

(A) Absolutely, and the reason is:

A review of the dipole as shown with its E and I lines of force rotated vertically, shows the absolute center at zero impedance as when horizontally.. Marconi, during his experiments in the late 1800's until 1904 found that by grounding each of Hertz's two experimental loop antennas (dipoles) at one point, the distances of reception could be extended. He further reasoned that mounting a dipole vertically and allowing the ground itself be one of the elements the Hertz dipole, he could achieve an improved antenna at a lowered height requirement, exactly as our question related. In those early days of radiotelegraphy, long lengths of wire were required as there were no high gain tubes to amplify the received signals and "long waves" were used which would require extremely high supports for a vertically mounted one-half wavelength dipole. Thus was born the 1/4 wavelength Marconi antenna, much shorter. Nearly all broadcast stations utilize this type of antenna, as do many amateurs. Good DX and ground wave coverage has been achieved with verticals.



11. (Q) Are there any special requirements for a vertical antenna?

(A) Yes. A vertical antenna makes use of earth ground as one of its elements. Earth is not always a good conductor and its conductivity may change with climatic conditions. Therefore, all vertical antennas should have conductive radials, called "Ground Plane(s)" installed, starting at the base of the vertical antenna and extending outward for at least 1/4 wavelength. Multiple radials are required, laid out similar to the compass points on a compass. The number of radials may vary with the ground resistance (or conductivity) of the earth at the installation point and with frequency, but good broadcast standards recommend many. If my memory serves me correctly, one author of a broadcast engineer's manual recommended at least 80 to 85 radials. Some stations have more, 120 or more.

12. (Q) Besides lessening the requirement for a tall supporting structure for an antenna, are there any other positive traits of the vertical 1/4 wavelength, as opposed to the 1/2 wave dipole mounted vertically?

(A) Yes. A few come to mind. It may be self-supporting, requires far less real estate, access to the feed point is much easier and mounting a tuning device such as a coupler at the feed point is much easier. The weight and wind resistance of a coupler almost prohibits amateurs from using it high in the air, and the transmission line loss is greatly reduced with a base installed unit. Too, the feed line cable may be directly buried, thereby improving the lightening protection. With a lowered support structure, including self-supporting, the wind resistance will be reduced on the total installation.

13. (Q) Can the 1/4 wavelength vertical be fed at the bottom without an insulator, as discussed in an earlier question relative to a dipole?

(A) Yes, and it is often fed in this manner for "single band" or single frequency applications.

14. (Q) Do all vertical antenna systems require radials?

(A) Yes. Contrary to many advertisements by some manufacturers, all true vertical antennas need radials (including "J" poles). Those particularly in the VHF and higher frequency bands have two distinct needs for radials. One is that ANY true vertical antenna NEEDS a ground plane; a part of the two element dipole. Secondly, that ground plane is usually bent downward at an angle, normally from 30 to 45 degrees, to lower the radiation pattern. Unless the installation is for working aircraft in flight, it is usually designed to communicate ground-to-ground. Therefore, a lowered radiation pattern is needed. We must remember, manufacturers are out to sell antennas, and misleading ads are all too common. Some of the advertised GAIN figures are also preposterous. Too, there are different definitions of the word "Work." While they may "work," not all work to the fullest possible extent. If advertisement will sell them, who needs them to work at maximum efficiently? So, one can't and shouldn't believe all these ads. For VHF or above, only a limited number of radials are needed due to the short range of transmission. Radials for a J-pole should slope downward to only 30 degrees since it is a relatively low beam antenna by design.

(Continued) - Part II will appear soon.