ANTENNAS
&
WORKING 160 METERS

By KD8OUT
**Antenna Basics**

**VERTICAL and HORIZONTAL POLARIZATION**

The *Electric field* or E-plane determines the polarization or orientation of the radio wave.

For a vertically-polarized antenna, the E-plane usually coincides with the vertical/elevation plane.

For a horizontally-polarized antenna, the E-plane usually coincides with the horizontal/azimuth plane.

The *Magnetizing field* or H-plane lies at a right angle to the E-plane.

For a vertically polarized antenna, the H-plane usually coincides with the horizontal/azimuth plane.

For a horizontally-polarized antenna, the H-plane usually coincides with the vertical/elevation plane.
**ANTENNA LENGTH**

1 WL (meters) = \( \frac{300}{F_{\text{MHz}}} \) = Lambda (\( \lambda \))

Antenna Length is usually described as wavelength (WL) in meters or degrees:

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Wavelength (Meters)</th>
<th>Wavelength (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>160</td>
<td>510</td>
</tr>
<tr>
<td>3.75</td>
<td>80/75</td>
<td>252</td>
</tr>
<tr>
<td>5.36</td>
<td>60</td>
<td>175</td>
</tr>
<tr>
<td>7.15</td>
<td>40</td>
<td>131</td>
</tr>
<tr>
<td>10.125</td>
<td>30</td>
<td>92.4</td>
</tr>
<tr>
<td>14.175</td>
<td>20</td>
<td>66</td>
</tr>
<tr>
<td>18.1</td>
<td>17</td>
<td>51.2</td>
</tr>
<tr>
<td>21.225</td>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td>24.9</td>
<td>12</td>
<td>37.6</td>
</tr>
<tr>
<td>28.5</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td>52</td>
<td>6</td>
<td>18</td>
</tr>
</tbody>
</table>

\[
\frac{360 \text{ deg}}{\text{deg}} = \frac{\text{Freq Length (ft)}}{\text{ft}}
\]

Example: 50 ft vertical used on 160 m

\[
\frac{360 \text{ deg}}{\text{deg}} = \frac{510 \text{ ft}}{50 \text{ ft}}
\]

\[
360 \times \frac{50}{510} = 34.6 \text{ degrees}
\]
CURRENT DISTRIBUTION
FOR ½ WAVE DIPOLE

(A)

Current Maximum

Feed Point

Voltage Minimum

1/2 wavelength

(B)

\( \lambda/2 \) \( \lambda/2 \) \( \lambda/2 \)
Figure 2.1 — The center-fed dipole antenna. It is assumed that the source of power is directly at the antenna feed point, with no intervening transmission line. Although \( \frac{\lambda}{2} \) is the most common length for amateur dipoles, the length of a dipole antenna can be any fraction of a wavelength.
MONOPOLE/VERTICAL

Figure 3.18 — Example of a radial wire ground system.
CURRENT DISTRIBUTION IN DIPOLE AND MONOPOLE

Figure 2.25 — The $\lambda/2$ dipole antenna and its $\lambda/4$ ground-plane counterpart. The “missing” quarter wavelength is supplied as an image in “perfect” (that is, high-conductivity) ground.
• An antenna’s characteristic impedance is a combination of the +J, -J and R1 + R2 at a driven frequency, based on its length.
• When you operate the antenna at its resonant length, the +J and -J cancel and leave pure resistance (resonance). When you operate outside of the resonant frequency, you have a net +J (long) or -J (short) “reactance” plus the resistance.
We need to review what is meant by “Antenna Impedance”

• Impedance is the AC analog to DC resistance.
• Remember \( E \) (volts) = \( I \) (Amps) \( \times \) \( R \) (Ohms) For DC
• Impedance follows the same math, except we add a “complex” component, reactance.
• \( Z \Omega = R \Omega + j X \Omega \); \( j = \sqrt{-1} \), yes I said -1
  
Z= impedance, R= resistive component, j= the complex operator, X= reactance
\[ X_L = j\omega L \]

\[ X_C = \frac{-j}{\omega C} = \frac{1}{j\omega C} \]
- Radiation resistance for a monopole (vertical) vs the antenna’s “electrical” length in degrees.
- For dipoles, the resistance values double.
- The electrical length can be found by calculating what portion of 90° (monopole) or 180° (dipole) you have based on its percentage of the ideal length. 36.6Ω for monopole or 69.2Ω for dipole.

Figure 2.25 — Radiation resistances (at the current maximum) of monopoles with sinusoidal current distribution. The chart can also be used for dipoles, but all values must be doubled.
160 Meter Antennas

- 1/2 wave dipole (255 ‘@ 1.8 MHZ)
- 1/4 wave vertical (127.5’@ 1.8 mhz)
- 1/4 wave inverted "L" (50’ H x 74’ L @ 1.9 mhz)
- Helically wound vertical
- Loaded vertical or dipoles
  - Capacitive end loading
  - Inductive series loading
- Use a shortened monopole or dipole and have a heavy duty transmatch (tuner).
Fig 2—A \( \frac{1}{2} \lambda \) version of the antenna in Fig 1. This antenna is similar to one used at W4ZCB. L1 may have a relay-selected tap to permit operation on 80 meters as well. L1 and C1 are outside the house at the antenna feed point in a weatherproof box. C1 is motor driven and should have wide spacing or be a vacuum variable capacitor. Illustration B shows a suitable matching network.
KJ4EX 160 meter inverted L antenna.

- 60 feet apx
- 70 ft apx
- 80 - 100 feet RG-213 to LPF in shack, then tuner then radio
- 12 turn Current Choke
- RG-8X on 4 inch PVC form
- 135 feet apx
- North
- 8 foot ground rod
- Single Radial, insulated 14 g housewire, hanging on the ground.

Inverted L at KJ4EX. Supported by TALL Georgia Pines, base at ground level. QRM Noise level significantly lower than the 80/40 doublet, especially when the ground is moist. Will probably use as is for now, and add radials by next 160 season.
160 meter inverted L cut for 1.900 MHz
total wire length 124 feet

Insulators made from 1/2 inch PVC electrical conduit. Each is 8 inches long.

To calculate length of wire needed...

\[
\frac{234}{\text{Freq MHZ}} = \text{Length in feet}
\]
Typical Calculation:

For a target frequency of 1.825 MHz, use 256 feet of #14 gauge 1.6 millimeter diameter wire wrapped around 24.5 feet of a 2.2 inch outside diameter pipe using 19.5 turns-per-foot with an average pitch of 0.62 inches.
Step 7: Capacitance Hat

2 x 3 ft. Brass Rods + Copper Wire
Components of Shortened Vertical

- Capacitance Hat ("Top Hat")
- Loading Coil
- Vertical Radiator (e.g., Aluminum, Copper)
- Ground System
Figure 2.9 — Feed point impedance versus frequency for a theoretical 100-foot long dipole in free space, fed in the center and made of extremely thin 0.001-inch diameter wire. The y-axis is calibrated in positive (inductive) series reactance up from the zero line, and negative (capacitive) series reactance in the downward direction. The range of reactance goes from $-6500 \, \Omega$ to $+6000 \, \Omega$. Note that the x-axis is logarithmic because of the wide range of the real, resistive component of the feed point impedance, from roughly 2 \, \Omega to 10,000 \, \Omega. The numbers placed along the curve show the frequency in MHz.