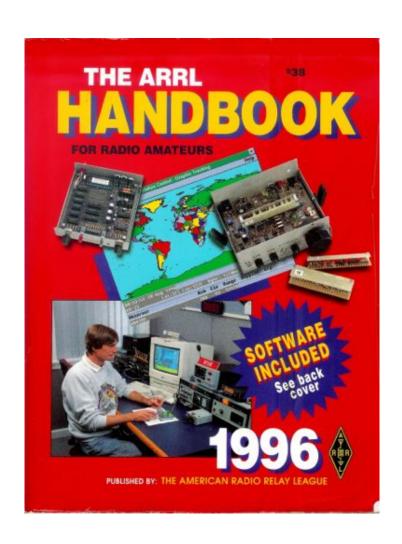
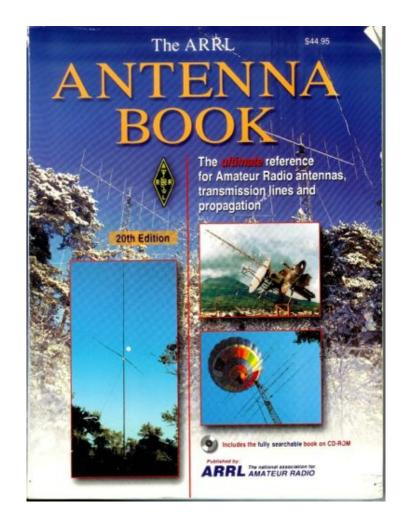
SIMPLE WIRE HF ANTENNA

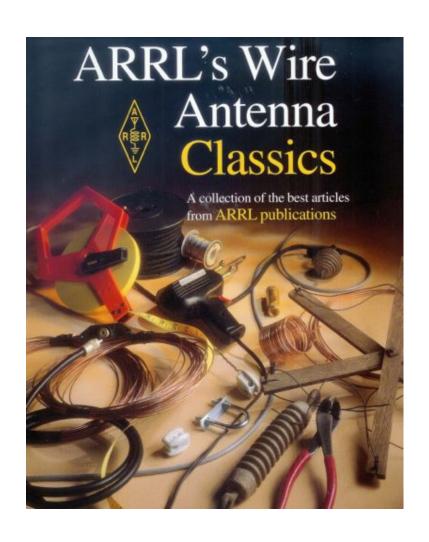
OZAUKEE RADIO CLUB
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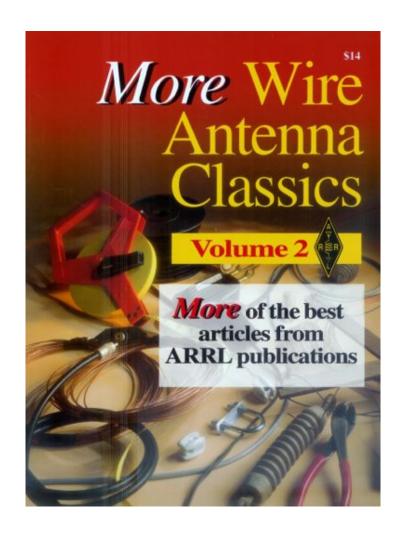
ARRL Essential Publications





ARRL Wire Antenna Publications





HF Wire Antenna

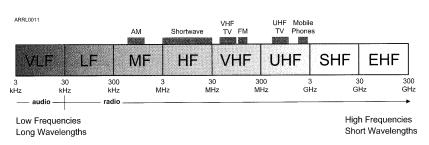
- Polarization
- Impedance
- Long Wire
- Loop
- Windom
- Vertical
- Antenna Tuners

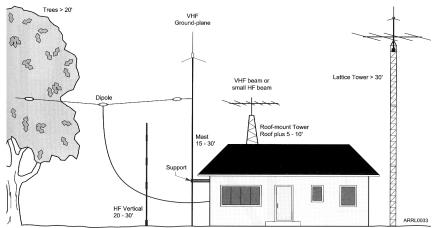
- Dipoles
 - Simple
 - Sloper
 - Inverted "V"
 - Fan
 - Trap
 - Folded
- G5RV
- Zepp
 - End fed
 - Center fed

Simple HF Wire Antenna

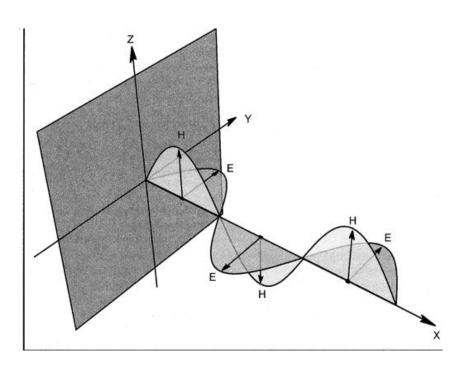
We will explore typical variations of the wire dipole high frequency (HF) antenna

Typical Amateur Radio Transmitting Antenna



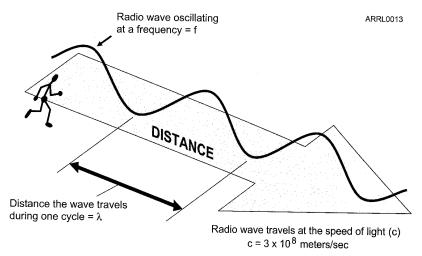


Electromagnetic Wave Polarization



- Electric and magnetic waves are at right angles to each other
- Magnetic wave dissipates within a few wavelengths of antenna
- Electric wave facilitates communications
- Polarization is the orientation of the electric field of the electromagnetic wave
- A horizontally orientated antenna, such as a dipole, emits a horizontally polarized electric wave that is parallel to surface of the earth (like the antenna)
- A vertically orientated antenna, such as a mobile whip, emits a vertically polarized electric wave that is perpendicular to the surface of the earth (like the antenna)

How many meters? (or feet?)



$$\lambda$$
= c/f = 300 / f in MHz

$$\lambda_{\text{meters}} = \frac{299.7925 \times 10^6 \text{ meters/sec}}{\text{f hertz}} = \frac{299.7925}{\text{f MHz}}$$
 (Eq 1)

where λ_{meters} , the Greek letter lambda, is the free-space wavelength in meters.

Expressed in feet, Eq 1 becomes:

$$\lambda_{\text{feet}} = \frac{983.5712}{\text{f MHz}} \approx \frac{983.6}{\text{f MHz}}$$
 (Eq 2)

RF Signal Polarization

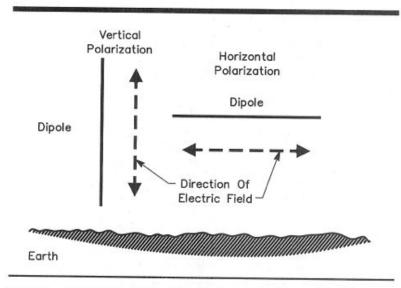


Fig 19—Vertical and horizontal polarization of a dipole above ground. The direction of polarization is the direction of the maximum electric field with respect to the earth.

2-14 Chapter 2

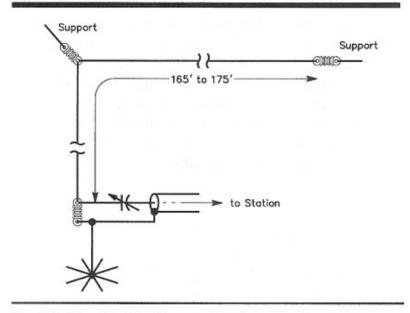
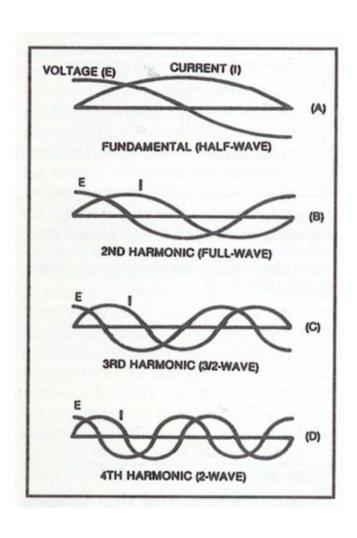


Fig 57—The 1.8-MHz inverted L. Overall wire length is 165 to 175 feet. The variable capacitor has a capacitance range from 100 to 800 pF, at 3 kV or more. Adjust antenna length and variable capacitor for lowest SWR.

6-32 Chapter 6

Antenna Impedance Z = e/i



 Voltage and impedance is high when end fed

 Voltage and impedance is low at center on odd harmonics

 Voltage and impedance is high at center on even harmonics

Random Length Long Wire Antenna

- Random length wire usually one wave length at lowest frequency
- Requires a "tuner" due to wide range of Z
- Unbalanced (single ended) feed
- Typically employs a "pi section" tuner
- RF in the shack
- Ground wire length may figure into antenna length

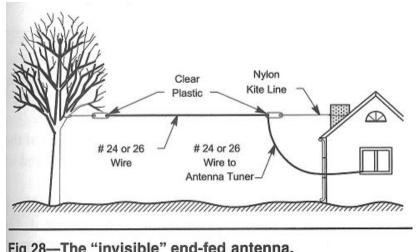
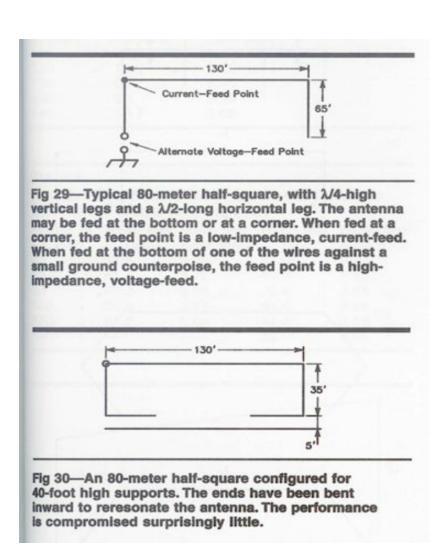


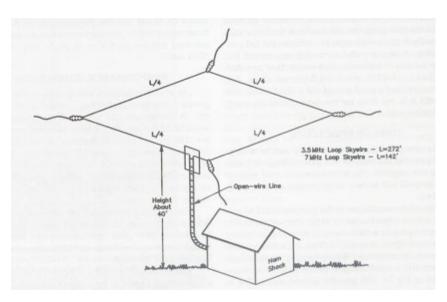
Fig 28-The "invisible" end-fed antenna.

Long Wire or Half Square

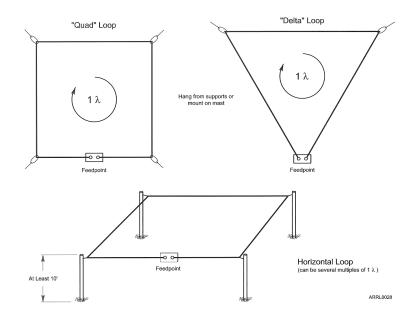


Horizontal Loop

- Need not be a square
- •Works well as multi-band antenna
- Open wire or coax feed line
- Usually cut to one wavelength at lowest frequency



- Balanced load
- May require balun
- •Will require an antenna tuner
- Polarization same as plane of loop



Windom Multi-band Wire Antenna

- Requires a "tuner" due to wide range of Z
- Unbalanced (single ended) load and feed
- Typically employs a "pi section, T section or L section" tuner
- RF in the shack similar to long wire

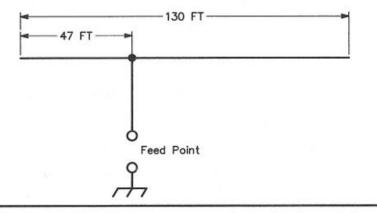
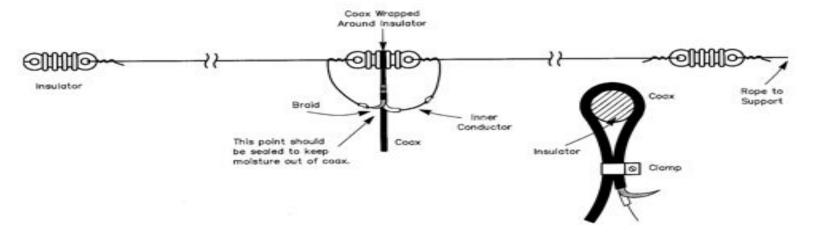


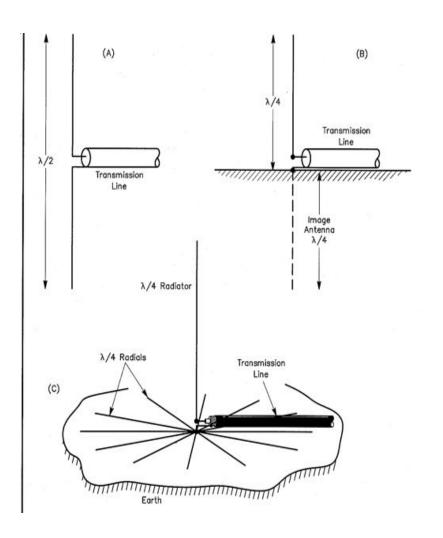
Fig 12—The Windom antenna, cut for a fundamental frequency of 3.75 MHz. The single-wire feeder, connected 14% off center, is brought into the station and the system is fed against ground. The antenna is also effective on its harmonics.

Half-Wavelength Dipole



- Most common HF antenna in amateur radio
- Resonate antenna on the frequency for which it is designed
- L_{feet} = 468/f in MHz

Vertical Wire Antenna



- Actually a vertically orientated resonate 1/2 wave dipole with the earth being the "return" half
- Due to poor ground conductivity a set of 1/4 wavelength long radials may be required
- Emits a low angle vertically polarized electric field
- Used where space is limited and for DX which requires a low angle of radiated signal for longest signal hop
- Perfect ground conditions result in a 36 ohm radiation resistance for a 1/4 wave vertical but in practice it will be 30 to 100 ohms

Multiband Wire Verticals up a Tree

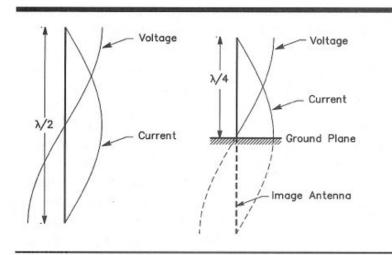


Fig 21—The λ /2 dipole antenna and its λ /4 ground-plane counterpart. The "missing" quarter wavelength is supplied as an image in "perfect" (that is, high-conductivity) ground.

2-16 Chapter 2

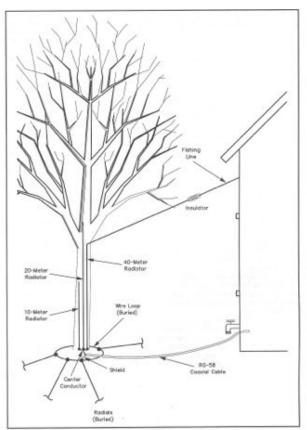


Fig 1—Run the three antenna wires along the trunk and then, if necessary, bend them along the branches. My 40-meter wire is so long that it leaves the tree altogether and attaches to my window frame. Use at least six radials for your ground system, more if you have the space and the patience to place them beneath the soil.

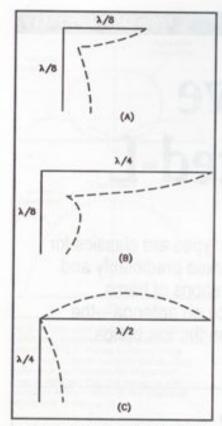


Fig 1-At A, the basic inverted L commonly used on the lower-frequency ham bands. The dotted line represents current distribution. The ½-wavelength inverted L shown at B features a more favorable current distribution. At twice the fundamental (C), the antenna at B acts as a ½-x wire. Note the two current maxima. The antenna behaves like a quarter-wave vertical end-feeding a half-wave dipole.

the pattern more closely resembles the pattern of a dipole at the same height. At twice the antenna's lower operating frequency, this antenna works best for short- and mediumdistance contacts, but I've worked my share of DX with it, too.

Inverted "L" Antenna

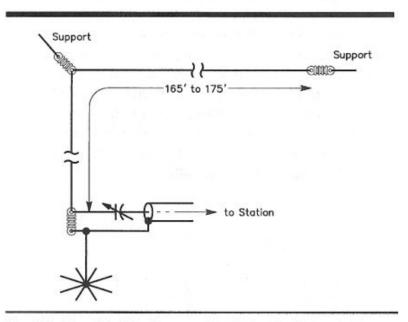
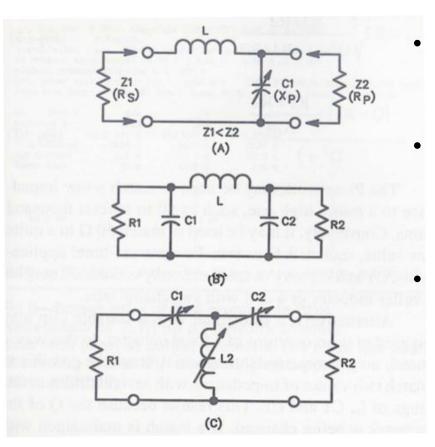


Fig 57—The 1.8-MHz inverted L. Overall wire length is 165 to 175 feet. The variable capacitor has a capacitance range from 100 to 800 pF, at 3 kV or more. Adjust antenna length and variable capacitor for lowest SWR.

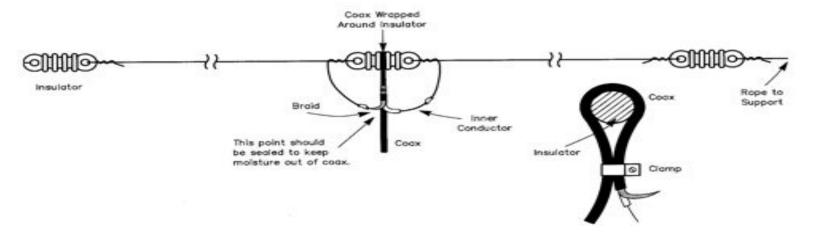
6-32 Chapter 6

Unbalanced (single ended) "L", "Pi" and "T" Section Tuners



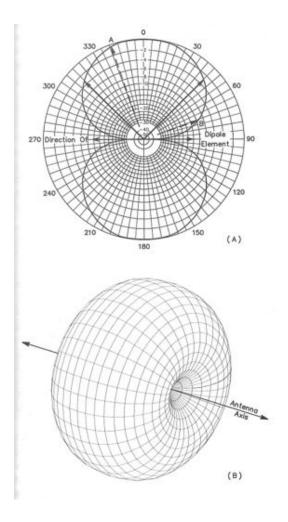
- Unbalanced transmitter output to unbalanced feed line (coax) and antenna
- Transforms the antenna impedance at the feed line output to 50 ohms to match the transmitter 50 ohm output impedance
 - The capacitors and inductor setting must be varied as the operating frequency and resulting antenna impedance vary

Half-Wavelength Dipole



- Resonate antenna on the frequency for which it is designed
- $L_{feet} = 468/f \text{ in MHz}$
- Radiation resistance of 72 ohms when elevated at 0.25 wavelength
- Balanced Load
- Horizontally polarized
- Most common antenna for HF
- Invented by Heinrich Hertz about 1886

Center fed dipole is a simple, effective antenna



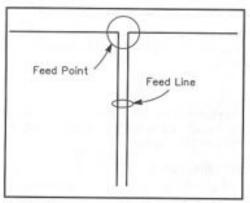


Fig 1—One of the simplest antennas used by hams, the dipole is also one of the most effective, considering the relatively small space it requires. In its simplest form, a dipole is a wire fed at its center.

Table 1 Approximate Lengths of Half-Wave Dipoles for the MF/HF Ham Bands*

Length
16 ft, 6 in.
18 ft, 10 in.
22 ft, 2 in.
25 ft, 10 in.
33 ft, 2 in.
46 ft, 4 in.
65 ft, 11 in.
130 ft
260 ft

^{*}General equation for half-wave dipole length: ℓ = 468 + f, where ℓ is length in feet and f is frequency in megahertz. This equation yields good starting points; you may have to lengthen or trim your antenna to achieve resonance. See the sidebar entitled *Dipole Construction and Adjustment.*

Radiation Pattern Varies With Frequency of Operation & Height

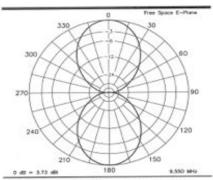


Fig 14—Free-space E-Plane radiation pattern for a 100-foot dipole at its full-wave resonant frequency of 9.55 MHz. The gain has increased to 3.73 dBi, because the main lobes have been focused and sharpened compared to Fig 12.

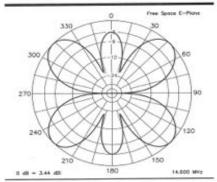


Fig 15—Free-space E-Plane radiation pattern for a 100foot dipole at its 3/23, resonant frequency of 14.50 MHz. The pattern has broken up into six lobes, and thus the peak gain has dropped to 3.44 dBi.

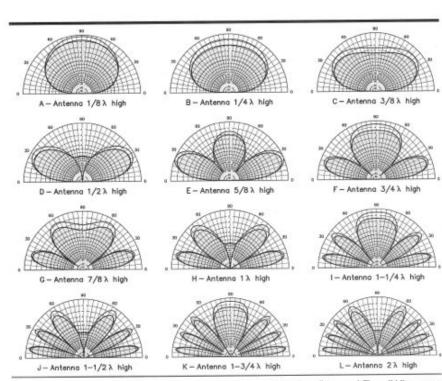


Fig 25—Reflection factors for horizontal dipole antennas at various heights above flat ground. The solid-line curves are the perfect-earth patterns (broadside to the antenna wire); the shaded curves represent the effects of average earth (k = 13, G = 0.005 S/m) at 14 MHz. Add 7 dB to values shown for absolute gain in dBd referenced to dipole in free space, or 9.15 dB for gain in dBi. For example, peak gain over perfect earth at 3/s \(\frac{1}{2}\) height is 7 dBd (or 9.15 dBi) at 25° elevation.

3-18 Chapter 3

Impedance Varies with Height

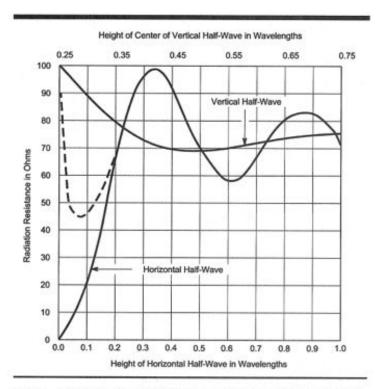


Fig 1—Variation in radiation resistance of vertical and horizontal half-wave antennas at various heights above flat ground. Solid lines are for perfectly conducting ground; the broken line is the radiation resistance of horizontal half-wave antennas at low height over real ground.

Many Other Types of Dipoles

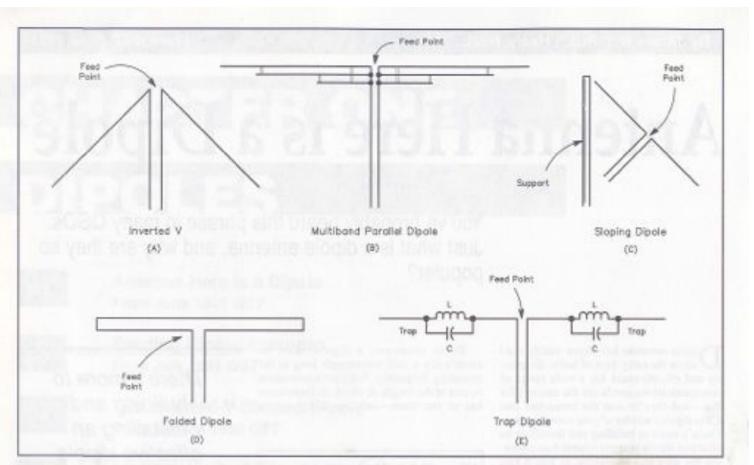


Fig 2—Variations on the dipole are numerous: at A, an inverted V; at B, a multiband parallel dipole; at C, a sloping dipole (sloper); at D, a folded dipole, and at E, a trap dipole. Dipoles of the multiband parallel, trap and folded varieties can be installed in sloping or inverted-V configurations.

Inverted "V" Dipole

Relative to Horizontal Dipole

- 1. Single support
- 2. Slightly less gain
- 3. Slightly less directionality
- 4. Slightly longer for freq.
- 5. Slightly lower feed point Z
- 6. SWR varies with apex angle

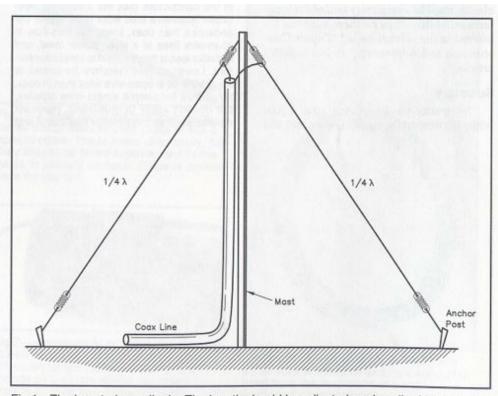
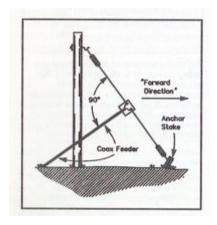
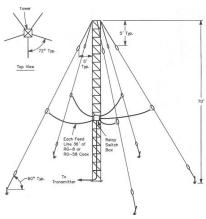


Fig 1—The inverted-vee dipole. The length should be adjusted as described in the text.

Half Wavelength Sloper Dipoles





- Favors signals off the front of antenna
- No gain over dipole
- Metal support acts as a parasitic element and impacts gain and pattern

Off Center Fed Dipole

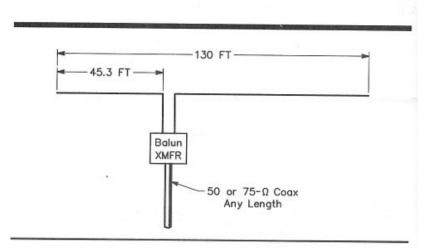
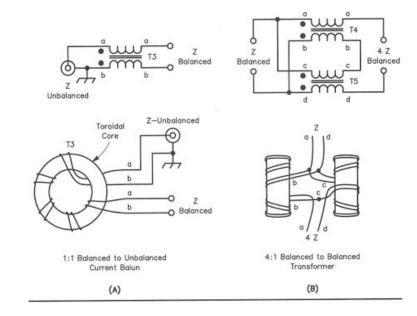


Fig 18—The off-center-fed (OCF) dipole for 3.5, 7 and 14 MHz. A 1:4 or 1:6 step-up current balun is used at the feed point.



Multiband Dipoles

Fan Dipole for several bands

- •Each dipole is a resonate circuit tuned to the band of interest.
- The non-resonate dipoles reject unrelated power

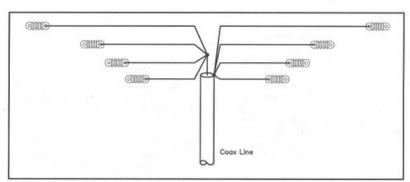
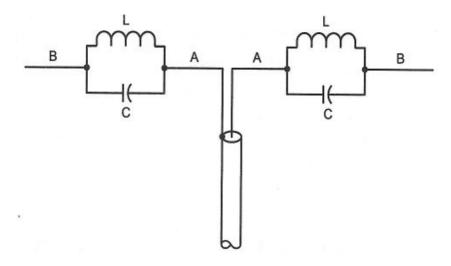


Fig. 1—Sketch showing the arrangement of parallel half-wave antennas in the coax-fed multiband antenna system.

Trap Dipole for 40/80 meters

The LC circuit presents a high impedance at 40 meters and low impedance at 80 meters



Using Current Chokes

Transmitter current travels on center conductor and inside of the shield of co-axial cable feed line – shield current feeds antenna leg and outside of shield – RF current on outside of shield radiates like a vertical antenna and also travels back into the shack – current choke balun at

feed point "chokes" the RF current on outside of co-axial feed line

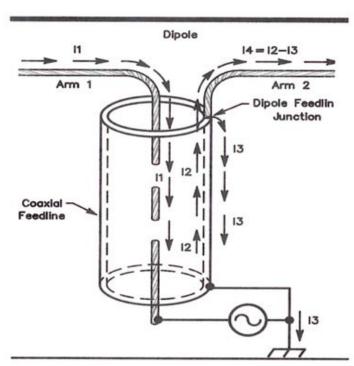


Fig 24—Drawing showing various current paths at feed point of a balanced dipole fed with unbalanced coaxial cable. The diameter of the coax is exaggerated to show currents clearly.



Fig 1—A bead balun made from several ferrite beads stacked on a piece of RG-8 coaxial cable. These cores chip easily, so they should be taped together and to the cable to prevent damage. (Tape is omitted here for clarity.)

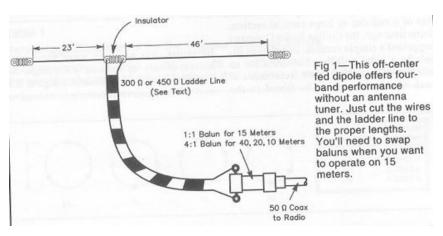


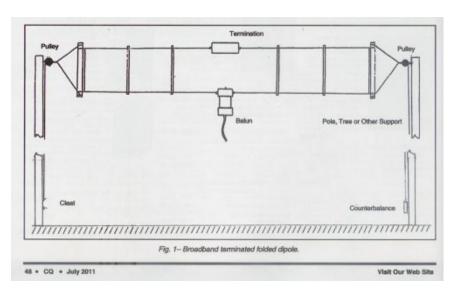
Fig 2—A coaxial-choke balun, wound from RG-58 on a piece of ABS plumbing pipe, effectively stops the flow of RF on the outside of the coax shield, but doesn't impede current flow inside the cable.



Fig 3—A coaxial-cable choke balun with an air core is effective and light enough to hang from the feed point of a wellsupported dipole antenna.

Using Z Matching and Current Baluns





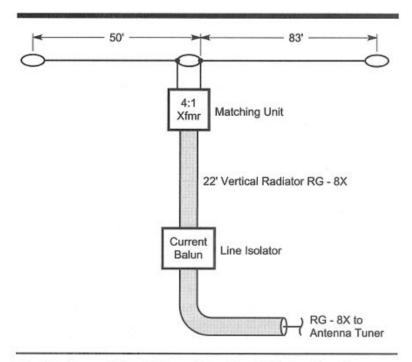
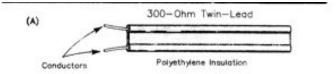
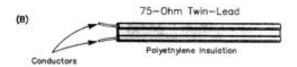
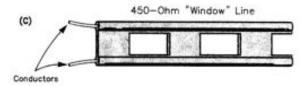


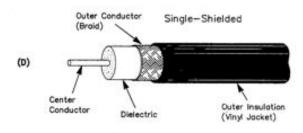
Fig 13-Layout for flattop "Carolina Windom" antenna.

7-8 Chapter 7

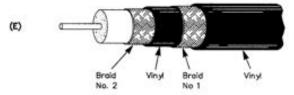








Double-Shielded



Feed lines

- Conducts transmitted power from transmitter to antenna
- Parallel conductor and coaxial cable
- Air insulated conductors have less loss per foot
- As signal frequency increases the signal loss per foot increases

Open Wire (Ladder Line) Feeders

- Ladder line provides a balanced feed to a balanced load (antenna)
- 2. Net zero feed line radiation
- 3. Allows multiband operation
- 4. Tolerates high SWR and voltage
- 5. Very low transmission line loss
- 6. Requires a "balanced to unbalanced" tuner

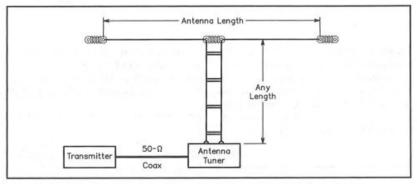
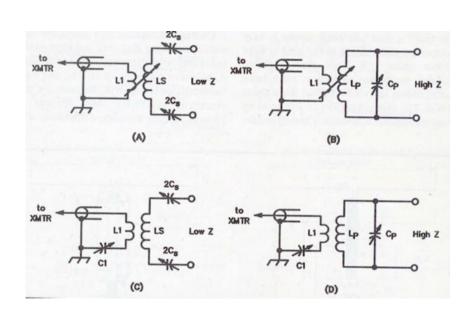


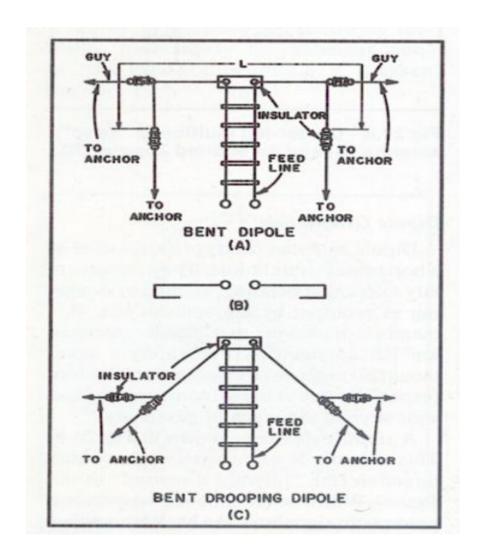
Fig A-A center-fed antenna system for multiband use.

Unbalanced to Balanced Antenna Tuner

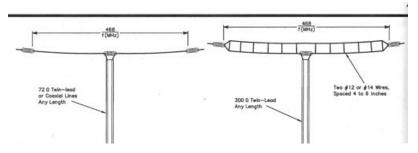


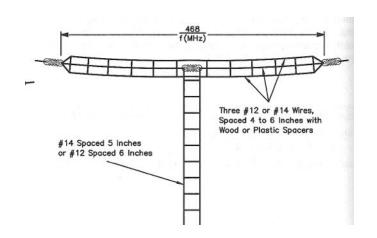
Short Resonate Dipoles

- 1. Entire length of dipole does not have to be co-linear
- 2. Bent ends may change resonate frequency slightly
- 3. Bent ends will change radiation pattern
- 4. Use of open wire feeder and tuner may allow multi-band operation



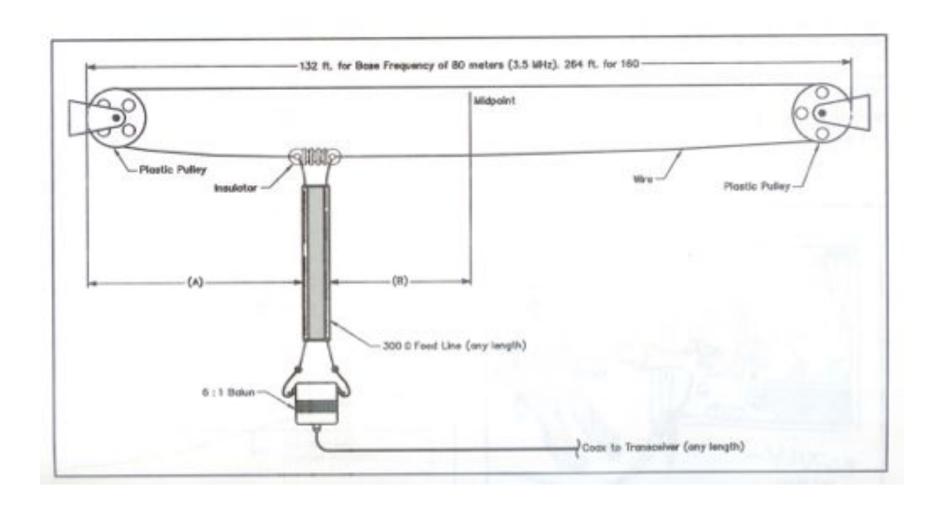
Dipoles vs. Folded Dipoles





- All have same radiation pattern
- Dipole Z = 72 ohms
- Folded Dipole Z = 300 ohms
- 3 wire Dipole Z = 450 to 600 ohms
- Multi-wire dipoles may require a balun and will require a tuner
- Multi-wire dipoles have wider frequency range with lower SWR

"Clothesline Folded Dipole"



G5RV Multiband Wire Antenna

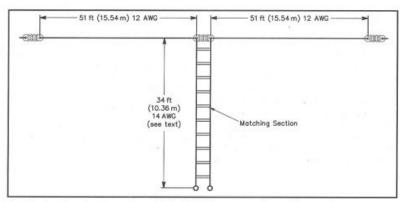
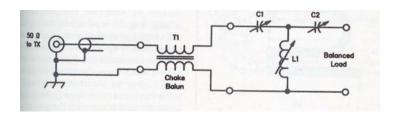
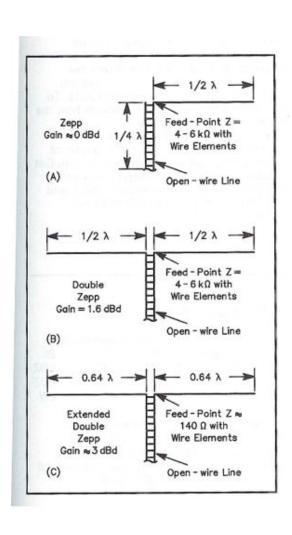


Fig. 9-Construction dimensions of the G5RV antenna and matching section.



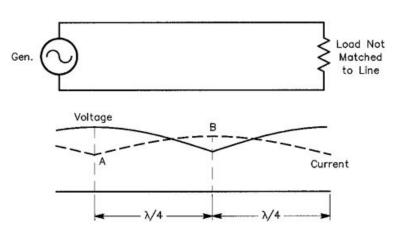
- 3.5 to 28 MHz
- 102 ft. center fed dipole with 34 ft open wire feeders
- Open wire feeders act as a matching section
- Requires use of tuner with balanced output

Zepp (Zeppelin) Wire Antenna



- Multi-band antenna
- Use length for lowest desired frequency
- More wire more gain
- May require a balun
- Will require an antenna tuner

SWR





- Note that as the transmitted signal deviates from the antenna design frequency the antenna reactance and SWR increases
- Increasing SWR results in increasing losses in feed line
- Modern transceivers will reduce power when SWR is greater than 3
- SWR = E_{max} / E_{min}
- The forward and reverse power/voltage can be measured using a directional coupler

HF Wire Antenna

- Polarization
- Impedance
- Long Wire
- Loop
- Windom
- Vertical
- Antenna Tuners

- Dipoles
 - Simple
 - Sloper
 - Inverted "V"
 - Fan
 - Trap
 - Folded
- G5RV
- Zepp
 - End fed
 - Center fed

ARRL Wire Antenna Publications

