
Practical Antennas
Chapter 8B
Al VO1NO

Objectives

- To become familiar with:
  - Antenna terminology;
  - Features of common antennas;
  - Antenna radiation patterns;
  - Calculating dimensions of common antennas; and
  - Construction techniques for basic antennas.

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Practical Dipole Antenna

- Impedance approximately **73 ohms.**
- Advantages:
  - Cheap;
  - Easy to build;
  - Rugged; and
  - One feedline can serve several antennas.
- Disadvantages:
  - Narrow bandwith;
  - Requires 2 supports, sometimes 3;
  - Must be fed at center; and
  - One band only.

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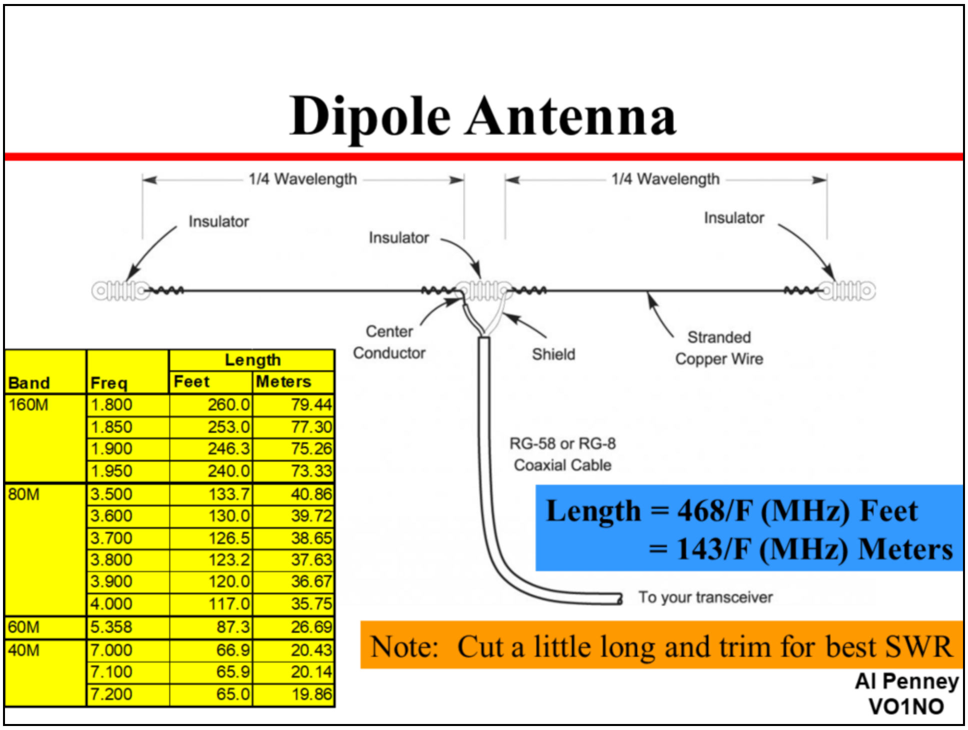
Many hams' first choice of antenna is a half-wave dipole. But don't be misled – just because they are easy to make doesn't mean they don't work well. In fact, a half-wave dipole will often outperform many compromise commercial multiband antennas.

Half-wave dipoles are easy to install and erect and are not nearly as likely as end-fed wires to give rise to EMC/interference problems.

As the name suggests, a dipole has two 'poles' or sections to the radiating element. In its most common form it is a half-wavelength long at the frequency of operation.

The dipole when mounted horizontally radiates most of its power at right angles to the axis of the wire.

In this way it may be possible to angle the antenna to 'fire' in the direction where most contacts are wanted, although the dimensions of your garden are more likely to determine what is possible.



Band	Freq	Length	
		Feet	Meters
160M	1.800	260.0	79.44
	1.850	253.0	77.30
	1.900	246.3	75.26
	1.950	240.0	73.33
80M	3.500	133.7	40.86
	3.600	130.0	39.72
	3.700	126.5	38.65
	3.800	123.2	37.63
	3.900	120.0	36.67
	4.000	117.0	35.75
60M	5.358	87.3	26.69
40M	7.000	66.9	20.43
	7.100	65.9	20.14
	7.200	65.0	19.86

A dipole is quite easy to construct. The length of a half-wave dipole might be thought to be the same as a half-wavelength of the signal in free space, but this is not quite the case. A number of effects, including the velocity factor of the wire, the length / diameter of the wire used for the radiating element and capacitive end effects, mean that the actual length required is a little shorter.

Without the end effect the length of a dipole could be calculated from the formula length (metres) equals 150 / f, where f is the frequency in MHz. With the foreshortening effects the length can be approximated from the formula: Length (metres) = 143 / f (MHz)

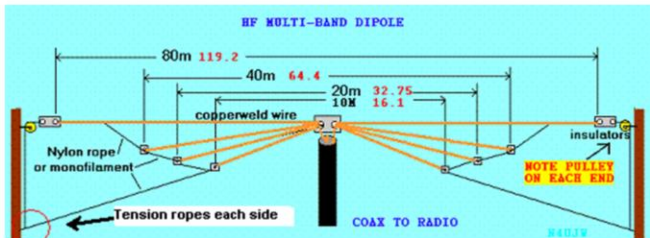
The lengths calculated from this should only be considered as an approximate value – it is best to cut the wire slightly longer than this and then twist the end of the wire back on itself to give the best match.

For a transmitting station one of the easiest ways is to monitor the reflected power on a voltage standing wave ratio, or VSWR, meter.

If operation is tried at different points on the band (taking care not to cause interference) it will be noted that the VSWR is higher at some points than others.

It is also necessary to remember to seal the end of the coax to prevent moisture entering. If moisture does enter, losses rise considerably, rendering the coax useless.

Fan Dipole



Tension rope is not tied to pully rope in picture. It is tied near location of pully rope down on supports within easy reach. It is tied last after final SWR adjustment and the antenna is in it's final position.

Suggested total lengths:
80 meters - 120 feet
40 meters - 65 to 66 feet
20 meters - 34 feet
10 meters - 17 feet
These lengths are not exact. Some tuning may be required. Use the standard formula 468 / freqmhz for total feet for each band (freq) of interest. Adjust each length longer or shorter as needed.

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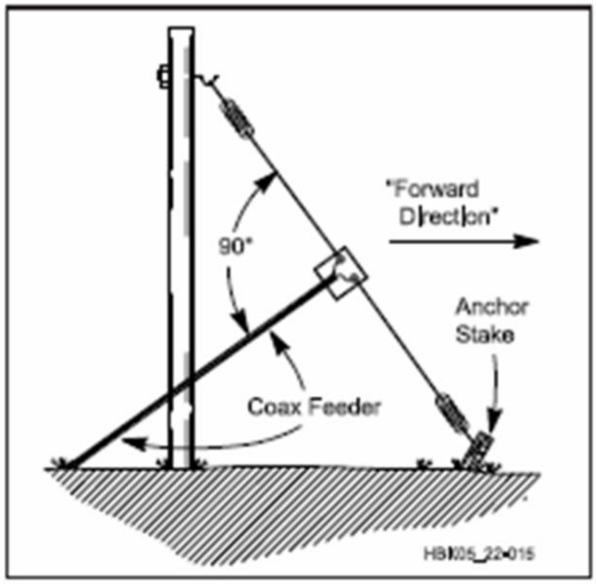
Fan Dipole. Full-Size **Fan dipoles** are multi **dipoles** that are fed with a common feed point. The full-size **dipoles** are spread out like a **fan**, hence the name **Fan Dipole**. A good example of a Full-Size **Fan Dipole** is a full-size 40- and a full-size 80-meter **dipole** on a common feed.

Sloping Dipole



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Dipole Orientation

Dipole antennas need not be installed in a horizontal straight line. They are generally tolerant of bending, sloping or drooping as required by the antenna site. Remember, however, that dipole antennas are RF conductors. For safety's sake, mount all antennas away from conductors (especially power lines), combustibles and well beyond the reach of passersby.

A *sloping dipole* is shown in Fig 20.9. This antenna is often used to favor one direction (the "forward direction" in the figure). With a nonconducting support and poor earth, signals off the back are weaker than those off the front. With a nonconducting mast and good earth, the response is omnidirectional. There is no gain in any direction with a nonconducting mast.

A conductive support such as a tower acts as a parasitic element. So does the coax shield, unless it is routed at 90° from the antenna. The parasitic effects vary with earth quality, support height and other conductors on the support such as a beam at the top. With such variables, performance is very difficult to predict.

Losses increase as the antenna ends approach the support or the ground. To prevent feed-line radiation, route the coax away from the feed-point at 90° from the antenna, and continue on that line as far as possible.

Inverted V Antenna

- Variation of the Dipole.
- Impedance approximately 50 ohms.
- Advantages:
  - Requires only one support; and
  - Provides a better match to **50 ohm coax** cable.
- Disadvantages:
  - Those of a Dipole; and
  - The ends close to the ground present a safety hazard.

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The maximum radiation from a dipole takes place in the centre. Accordingly, this is the most important area of the antenna to keep as high as possible.

Coupled with the fact that in many situations it is only possible to have one high mast or high point on the antenna, this often makes an inverted-V dipole (Fig 5) an ideal choice.

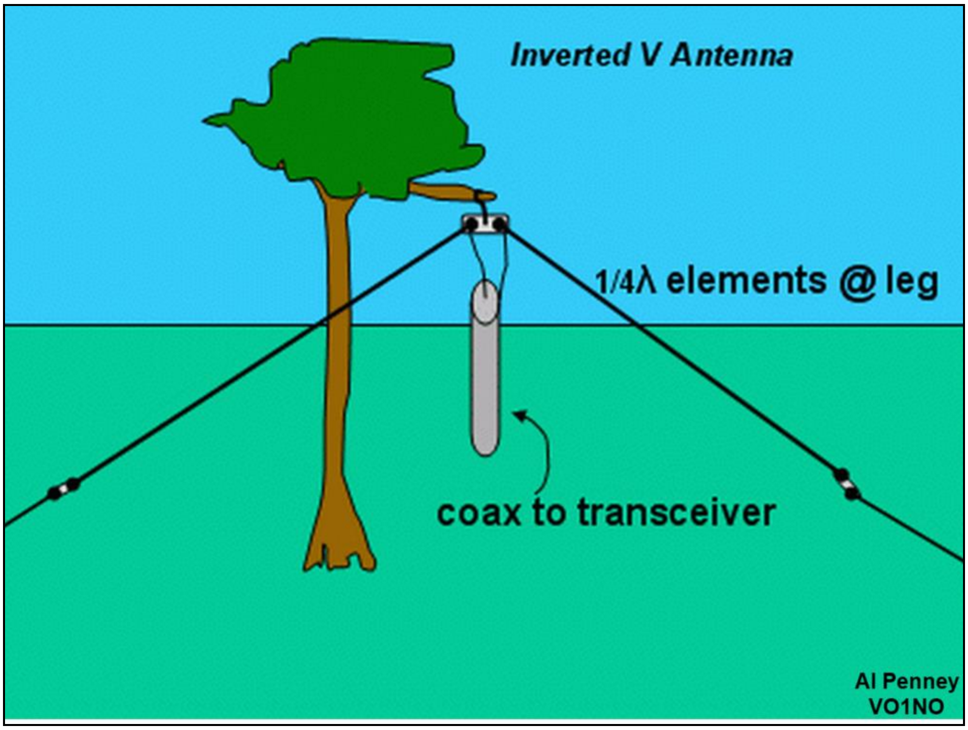
The antenna is basically an ordinary dipole, but rather than keeping it horizontal, a single mast or anchor point is used in the centre and the two halves of the dipole are angled downwards away from the central mast.

Although it does alter the radiation pattern, making it almost omni-directional, its basic operation remains the same. In view of its convenience and operational advantages this type of antenna is widely used and is a favourite with many operators.

The main point to note when erecting a dipole is that the lower ends of the antenna should be kept out of reach of people.

The ends of the antenna will have a high voltage when used for transmitting and the installation should be such that it is not possible to touch them. Also, if the ends come down too low you could get ground losses – keep them at least three metres high if possible.

The securing ropes should also be installed so that people cannot trip or stumble over them. A suitably-located tree or bush may help overcome this problem.


Inverted V Antenna
1/4λ elements @ leg
coax to transceiver
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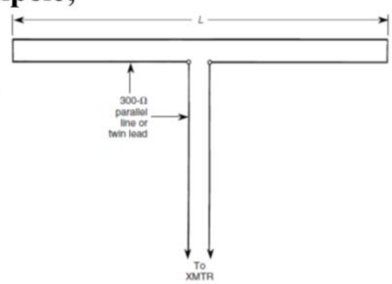
Folded Dipole

- A Full Wave Dipole that is folded back on itself.
- Impedance approximately **300 ohms**.
- Usually used on VHF/UHF.
- Advantages:
  - **Broader bandwith than a dipole;**
- Disadvantages:
  - May require 2 or 3 supports;
  - Must be fed at center; and
  - One band only.



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Folded Dipole

This antenna consists of two or more halfwavelength conductors of identical diameter shorted together at both ends and fed in

the middle of *one* conductor. Except at the ends, the two conductors are held a few inches apart (at HF, at least) by insulated spacers. The two-wire folded dipole is often

made with 300-∧ television antenna twin-lead transmission line. Because the free-space feedpoint impedance is nearly 300 ∧, or four times that of a conventional dipole, the

antenna is a reasonably good match (depending on the height of the antenna above ground) for the same type of twin-lead used as the transmission line. Such a dipole will

exhibit a 50 percent improvement in 2:1 VWSR bandwidth compared to a single-wire dipole. On 80 m, for instance, a folded dipole resonant at 3.750 MHz will cover from 3.6

to 3.9 MHz with an SWR of 2:1 or lower.

Why is the input impedance *four* times the input impedance of a conventional dipole when one of the two wires is fed? Recognize that the folded dipole is a continuous

1-λ loop. At each end of the fed wire, the current does a U-turn and continues into the unfed wire. If this current were of the same phase everywhere, it would thus be flowing

in a spatial direction opposite to the current near the feedpoint. But it's also true that at or near the antenna design frequency the current in the fed half-wave element goes to

zero at each end. Since the current in a wire that is longer than λ/2 reverses direction in adjacent λ/2 sections (i.e., at each current *node*), the current reverses at both ends of the

folded dipole. When viewed from inside the wire (if that were possible), the current flowing in the unfed wire is thus 180 degrees out of phase *electrically* with the drive current,

but its nominal *spatial* direction is the opposite of the current in the driven wire. The two effects (wire path and phase reversal) combine to put the unfed wire's current

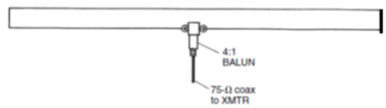
in phase with the drive current, as viewed from outside the wires. The current in the unfed wire is virtually identical in amplitude to that in the fed wire, suffering only a

very slight reduction in amplitude from ohmic and radiation losses.

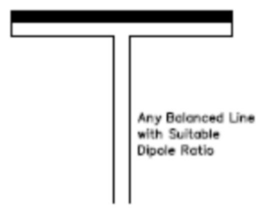
Folded Dipole

Folded Dipole

- Equal diameter conductors give a 4:1 step up impedance transformation (e.g. 75 to 300 ohms)



- Larger unbroken conductors permit higher step up transformations.



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Folded Dipole

The impedance of a ½ wavelength antenna broken at its center is about 70 Ω. If a single conductor of uniform size is folded to make a ½ wavelength dipole, the impedance is stepped up four times. Such a folded dipole can be fed directly with 300-Ω line with no appreciable mismatch. If a 4:1 balun is used, the antenna can be fed with 75-Ω coaxial cable. Higher step-up impedance transformation can be obtained if the unbroken portion is made larger in cross-section than the fed portion,as shown in the figure.

The *impedance step-up ratio* for a two-wire folded dipole is 4:1 if the two conductors are of equal diameter. When they're not, the relationship is more complicated but the

impedance step-up is generally proportional to the ratio of the unfed wire diameter to the fed wire diameter. Thus, a folded dipole can be designed to provide a specific feedpoint

impedance to the transmitter and transmission line, within limits, by making one of the two wires larger than the other.

In many installations, the best feedline for the folded dipole will be 300-ʌ twin-lead or, better yet, open-wire line connected to a balanced wire ATU at the transmitter end.

Trap Dipole

- Traps **isolate** sections of the antenna, permitting multi-band use.
- Advantages:
  - Multi-band operation.
- Disadvantages:
  - Those of a Dipole;
  - Not as efficient as separate dipoles;
  - Weight of the traps makes it difficult to hold up;
  - Pattern can be distorted; and
  - **Can radiate Harmonics (?).**

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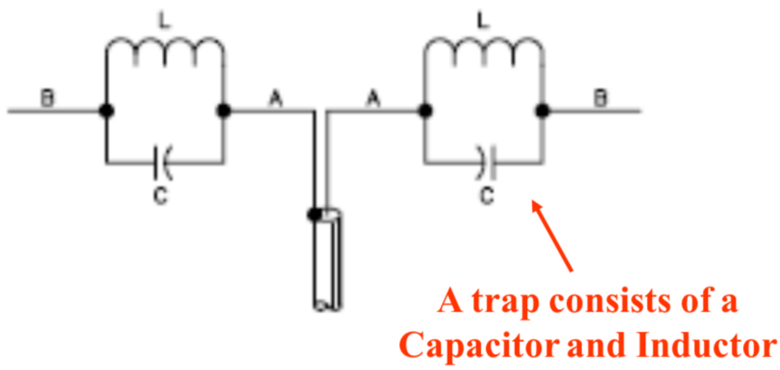
Trap dipoles provide multiband operation from a coax-fed single-wire dipole. A trap is a parallel-resonant circuit that effectively disconnects wire beyond the trap at the resonant frequency. Traps may be constructed from coiled sections of coax or from discrete LC components.

Choose capacitors (Cl in the figure) that are rated for high current and voltage. Mica transmitting capacitors are good. Ceramic transmitting capacitors may work, but their values may change with temperature. Use large wire for the inductors to reduce loss. Any reactance (XL and XC) above 100 W (at f0) will work, but bandwidth increases with reactance (up to several thousand ohms).

Check trap resonance before installation. This can be done with a dip meter and a receiver. To construct a trap antenna, cut a dipole for the highest frequency and connect the pretuned traps to its ends.

It is fairly complicated to calculate the additional wire needed for each band, so just add enough wire to make the antenna 1/2 l and prune it as necessary. Because the inductance in each trap reduces the physical length needed for resonance, the finished antenna will be shorter than a simple 1/2-l dipole.

Trap Dipole



By using tuned circuits of appropriate design strategically placed in a dipole, the antenna can be made to show what is essentially fundamental resonance at a number of different frequencies.

A trap in an antenna system can perform either of two functions, depending on whether or not it is resonant at the operating frequency. A familiar case is where the trap is resonant in an amateur band. For

the moment, let us assume that each parallel L/C combination is resonant in the 7-MHz band. Because of its resonance, the trap presents a high impedance at that point in the antenna

system. The electrical effect at 7 MHz is that the trap behaves as an insulator. It serves to divorce the outside ends, the B sections, from the antenna. The result

is easy to visualize—we have an antenna system that is resonant in the 7-MHz band. Each 33-foot section (labeled A in the drawing) represents 1/4 λ, and

the trap behaves as an insulator. We therefore have a full-size 7-MHz antenna.

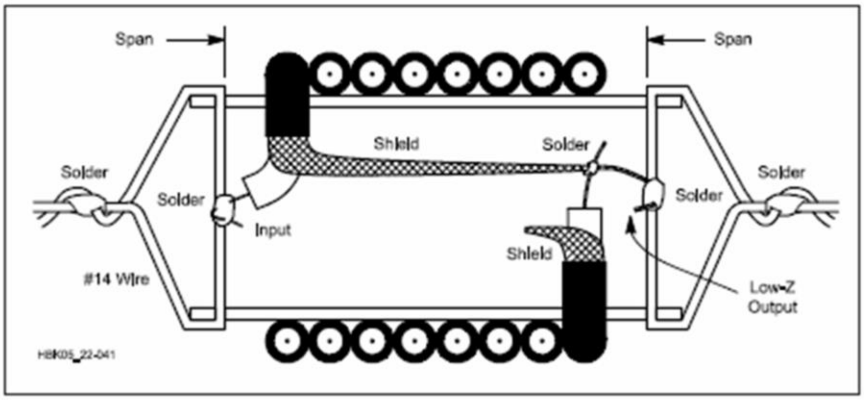
The second function of a trap, obtained when the frequency of operation is *not* the resonant frequency of the trap, is one of electrical loading. If the operating frequency is below that of trap resonance, the trap behaves as an inductor; if above, as a capacitor. Inductive loading will electrically lengthen the antenna, and capacitive loading will electrically shorten the antenna.

Let’s carry our assumption a bit further and try using the antenna we just considered at 3.5 MHz. With the traps resonant in the 7-MHz band, they will behave as inductors when operation takes place at

3.5 MHz, electrically lengthening the antenna. This means that the total length of sections A and B (plus the length of the inductor) may be something less than a physical 1/4 λαμβδα for resonance at 3.5 MHz.

Thus, we have a two-band antenna that is shorter than full size on the lower frequency band. But with the electrical loading provided by the traps, the overall electrical length is 1/2 λαμβδα. The total antenna length needed for resonance in the 3.5-MHz band will depend on the L/C ratio of the trap elements.

Trap Dipole



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A type of trap described by Gary O'Neil, N3GO, in October 1981 *Ham Radio* achieves high impedance with low Q, effectively overcoming the bandwidth problem. The N3GO trap is fabricated from a

single length of coaxial cable. The cable is wound around a form as a single-layer coil, and the shield becomes the trap inductor. The capacitance between the center conductor and shield resonates the

trap. At each end of the coil the center conductor and shield are separated. At the "inside" end of the trap, nearer the antenna feed point, the shield is connected to the outside antenna wire. At the

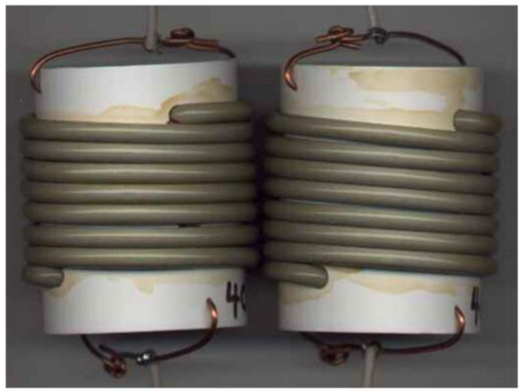
outside end, the center conductor is attached to the outside antenna wire. The center conductor from the inside end is joined to the shield from the outside end to complete the trap. Constructed

in this way, the trap provides high isolation over a greater bandwidth than is possible with conventional traps.

Robert C. Sommer, N4UU, in December 1984 *QST* described how to optimize the N3GO trap. The analysis shows that best results are realized when the trap diameter is from 1 to 2.25 times greater

than the length. Trap diameters toward the higher end of that range are better.

Trap Dipole



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End Fed Long Wire Antenna

- Should be as long (at least ¾ λ) and high as possible.
- Must have a good ground.
- Advantages:
  - Multiband;
  - Can bend to fit as necessary; and
  - Feedpoint is at the end.
- Disadvantages:
  - Requires a matching unit;
  - Pattern difficult to predict;
  - High voltages on the antenna; and
  - **RF present in the shack.**

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The end fed wire antenna simply consists of a length of wire that is as high and reasonably long as possible. The wire is then connected to the transmitting and receiving radio communication station.

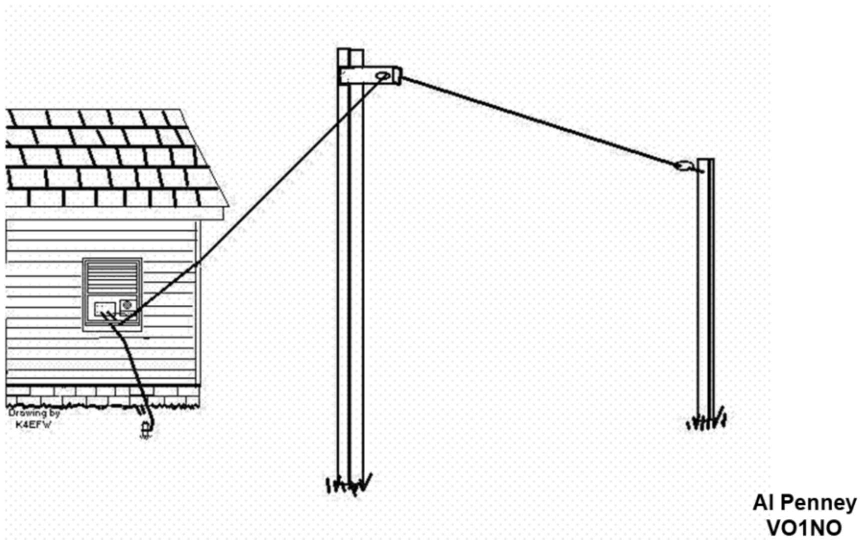
The antenna wire is then typically take out of the radio room, or shack and taken to a horizontal section that runs above obstructions. Once the wire leaves the receiver, transmitter, or antenna tuner, the wire starts to act as an antenna, picking up signals and radiating them.

For best receiving performance and also to ensure that when used with a transmitter, the correct impedance is seen, an antenna tuner or antenna tuning unit, ATU should always be used.

The antenna tuner is placed between the transmitter or receiver and the antenna wire. If a tuner is not used, then the impedance of the antenna will not match that of the receiver or transmitter input and this will result in lower efficiency. Also the transmitter may have trouble matching to this, and this may result in lower power output, or even damage to the transmitter output.

A further requirement is that it is necessary to have a good radio earth - this is not the protective means earth, but an earth connection against which the long wire antenna or end fed wire antenna can work.

End Fed Long Wire Antenna



The wire to the earth connection should be as short as possible, otherwise the inductance etc in the wire will start to place the station at an RF potential above ground.

Transmatch

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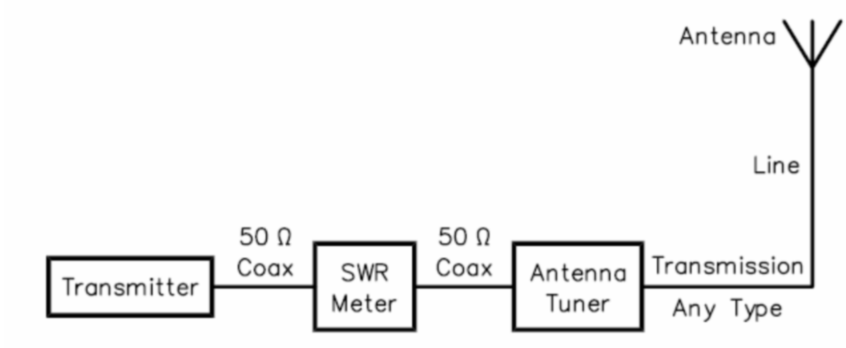
Antenna tuner, **matching network**, **matchbox**, **transmatch**, **antenna tuning unit** (**ATU**), **antenna coupler**, and **feedline coupler** are all equivalent names for a device connected between a radio transmitter and its antenna, to improve power transfer between them by matching the specified load impedance of the radio to the combined input impedance of the feedline and the antenna.

Antenna tuners are particularly important for use with transmitters. Transmitters are typically designed to feed power into a reactance-free, resistive load of a specific value, very often 50 ohms.[1] However the antenna and feedline impedance can vary depending on frequency and other factors. If the impedance seen by the transmitter departs from the design load, circuits in modern transmitters automatically cut back the power output to protect the equipment from the consequences of the impedance mismatch.

In addition to reducing the power radiated by the antenna, the mismatch can distort the signal, and in high power transmitters may overheat the transmitter. Because of this, ATUs are a standard part of almost all radio transmitting systems. They may be a circuit incorporated into the transmitter itself, or a separate piece of equipment connected between the transmitter and the antenna. In transmitting systems with an antenna separated from the transmitter and connected to it by a transmission line (feedline), there may be yet another matching network (or ATU) where the feedline connects to the antenna, to match the transmission line's impedance to the antenna.

Transmitters in cell phones and walkie-talkies have an ATU circuit inside permanently set to work with the installed antenna.[a] In multi-frequency communication stations like amateur radio stations, and high power transmitters like radio broadcasting stations, the ATU is adjustable to accommodate changes in the transmitting system. Matching the transmitter, feedline, antenna, or their environment by adjustment of the ATU is an important procedure done after any change the system, with an instrument called an SWR meter typically used to measure the degree of match or mismatch.

Connecting a Transmatch



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Use in transmitters

Antenna tuners are used almost universally with transmitters. Without an ATU, in addition to reducing the power radiated by the antenna, the reflected current can overheat transformer cores and cause signal distortion. In high-power transmitters it may overheat the transmitter's output amplifier. When reflected power is detected, self-protection circuits in modern transmitters automatically reduce power to safe levels, hence reduce the power of the signal leaving the antenna even further.

Because of this, ATUs are a standard part of almost all radio transmitting systems. They may be a circuit incorporated into the transmitter itself,[a] or a separate piece of equipment connected between the transmitter and the antenna. In transmitting systems with an antenna separated from the transmitter and connected to it by a transmission line (feedline), there may be another matching network (or ATU) at the antenna that matches the transmission line's impedance to the antenna.

High power transmitters like radio broadcasting stations have a matching unit that is adjustable to accommodate changes in the frequency, the transmitter, the antenna, or the antenna's environment. Adjusting the ATU to match the transmitter to the antenna is an important procedure which is done after any work on the transmitter or antenna occurs. The effect of this adjustment is typically measured using an instrument called an SWR meter, which indicates the degree of mismatch between a reference impedance (typically 50 + *j* 0 Ohms) and the complex impedance at the point of insertion of the SWR meter.

What an "antenna tuner" actually tunes

Despite its name, an antenna "tuner" does not actually tune the antenna. It matches the complex impedance of the transmitter to that of the input end of the feedline. The input impedance of the transmission line will be different than the characteristic impedance of the feedline if the impedance of the antenna on the other end of the line does not match the line's characteristic impedance. The consequence of the mismatch is that the line's impedance (voltage to current ratio and phase) will oscillate along the line, or equivalently, raise out-of-phase voltage standing waves and current standing waves along the feedline.

If both the tuner and the feedline were lossless, tuning at the transmitter end would indeed produce a perfect match at every point in the transmitter-feedline-antenna system.[2] However, in practical systems lossy feedlines limit the ability of the antenna tuner to change the antenna's resonant frequency. If the loss of power is low in the line carrying the transmitter's signal to the antenna, a tuner at the transmitter end can produce a worthwhile degree of matching and tuning for the antenna and feedline network as a whole. But with lossy, low-impedance feedlines like the commonly used 50 Ohm coaxial cable, maximum power transfer only occurs if matching is done at the antenna in conjunction with a matched transmitter and feedline, producing a match at both ends of the line.

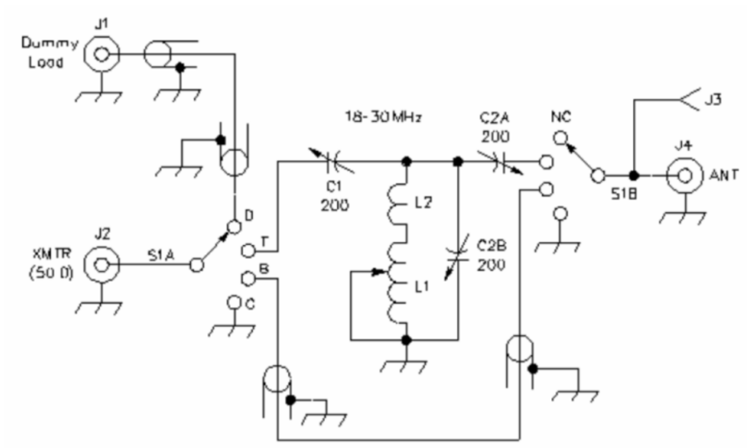
In any case, regardless of its placement, an ATU does not alter the gain, efficiency, or directivity of the antenna, nor does it change the internal complex impedance of the antenna itself.

Efficiency and SWR

If there is still a high standing wave ratio (SWR) in the feedline beyond the ATU, any loss in that part of the feedline is typically increased by the transmitted waves reflecting back and forth between the tuner and the antenna, causing resistive losses in the wires and possibly the insulation of the transmission line. Even with a matching unit at both ends of the feedline – the near ATU matching the transmitter to the feedline and the remote ATU matching the feedline to the antenna – losses in the circuitry of the two ATUs will slightly reduce power delivered to the antenna.

Hence, operating an antenna far from its design frequency and compensating with an ATU between the transmitter and the feedline is not as efficient as using a resonant antenna with a matched-impedance feedline, nor as efficient as a matched feedline from the transmitter to a remote antenna tuner attached directly to the antenna.

Transmatch Schematic Circuit



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This configuration is currently popular because it is capable of matching a large impedance range with capacitors in commonly available sizes. However, it is a high-pass filter and will not attenuate spurious radiation above the cutoff frequency nearly as well as other designs. Due to its low losses and simplicity, many home-built and commercial manually tuned ATUs use this circuit. The tuning coil is also adjustable.

Yagi-Uda Antenna

- Driven Element, Reflector and one or more Directors (AKA **Parasitic Elements**) give gain and directivity.
- Advantages:
  - Effective antenna;
  - Easily rotated;
  - Can be multi-band; and
  - Can be stacked for more gain.
- Disadvantages:
  - Can be expensive;
  - Requires a tower and rotator;
  - Single bearing at a time; and
  - Wind and ice an enemy!

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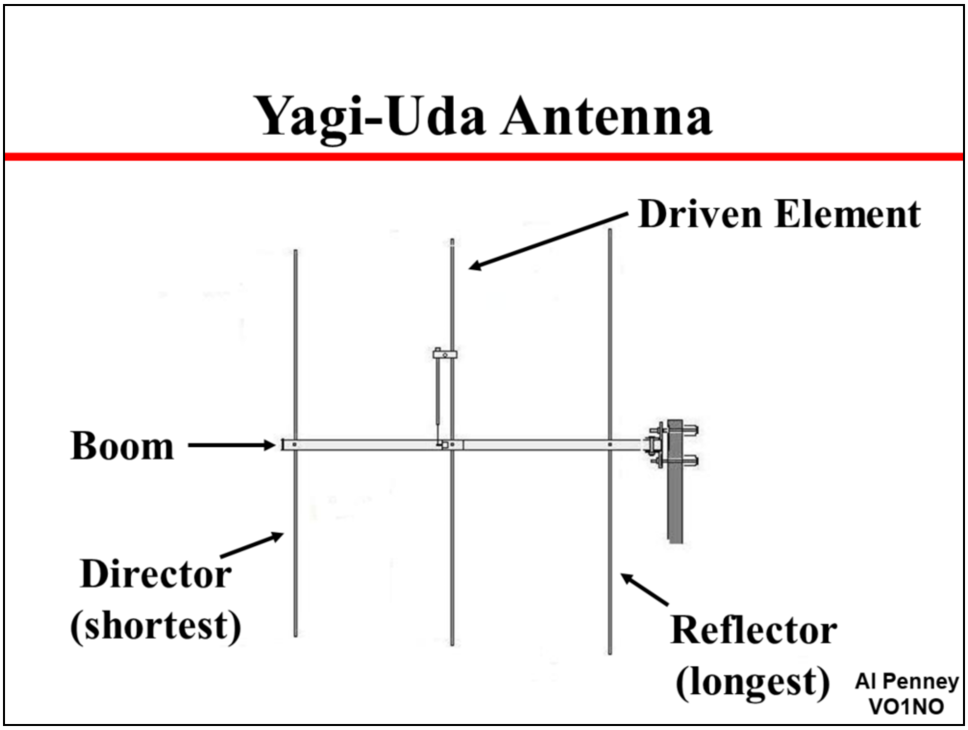
A **Yagi–Uda antenna**, commonly known as a **Yagi antenna**, is a directional antenna consisting of multiple parallel elements in a line, usually half-wave dipoles made of metal rods. Yagi–Uda antennas consist of a single driven element connected to the transmitter or receiver with a transmission line, and additional "parasitic elements" which are not connected to the transmitter or receiver: a so-called *reflector* and one or more *directors*. It was invented in 1926 by Shintaro Uda of Tohoku Imperial University, Japan, and (with a lesser role played by his colleague) Hidetsugu Yagi.

The reflector element is slightly longer than the driven dipole, whereas the directors are a little shorter. The parasitic elements absorb and reradiate the radio waves from the driven element with a different phase, modifying the dipole's radiation pattern. The waves from the multiple elements superpose and interfere to enhance radiation in a single direction, achieving a very substantial increase in the antenna's gain compared to a simple dipole.

Also called a "beam antenna", or "parasitic array", the Yagi is very widely used as a high-gain antenna on the HF, VHF and UHF bands. It has moderate to high gain which depends on the number of elements used, typically limited to about 20 dBi, linear polarization, unidirectional (end-fire) beam pattern with high front-to-back ratio of up to 20 db. and is lightweight, inexpensive and simple to construct. The bandwidth of a Yagi antenna, the frequency range over which it has high gain, is narrow, a few percent of the center frequency, and decreases with increasing gain, so it is often used in fixed-frequency applications. The largest and best-known use is as rooftop terrestrial television antennas, but it is also used for point-to-point fixed communication links, in radar antennas, and for long distance shortwave communication by shortwave broadcasting stations and radio amateurs.



The Yagi–Uda antenna consists of a number of parallel thin rod elements in a line, usually approximately half-wave long, typically supported on a perpendicular crossbar or "boom" along their centers. There is a single driven element driven in the center (consisting of two rods each connected to one side of the transmission line), and a variable number of parasitic elements, a single *reflector* on one side and optionally one or more *directors* on the other side. The parasitic elements are not electrically connected to the transmitter or receiver, and serve as passive radiators, reradiating the radio waves to modify the radiation pattern. Typical spacings between elements vary from about $^1\!/_{10}$ to ¼ of a wavelength, depending on the specific design. The directors are slightly shorter than the driven element, while the reflector(s) are slightly longer. The radiation pattern is unidirectional, with the main lobe along the axis perpendicular to the elements in the plane of the elements, off the end with the directors.

Conveniently, the dipole parasitic elements have a node (point of zero RF voltage) at their centre, so they can be attached to a conductive metal support at that point without need of insulation, without disturbing their electrical operation. They are usually bolted or welded to the antenna's central support boom. The driven element is fed at centre so its two halves must be insulated where the boom supports them.

The gain increases with the number of parasitic elements used. Only one reflector is used since the improvement of gain with additional reflectors is negligible, but Yagis have been built with up to 30–40 directors.[3]

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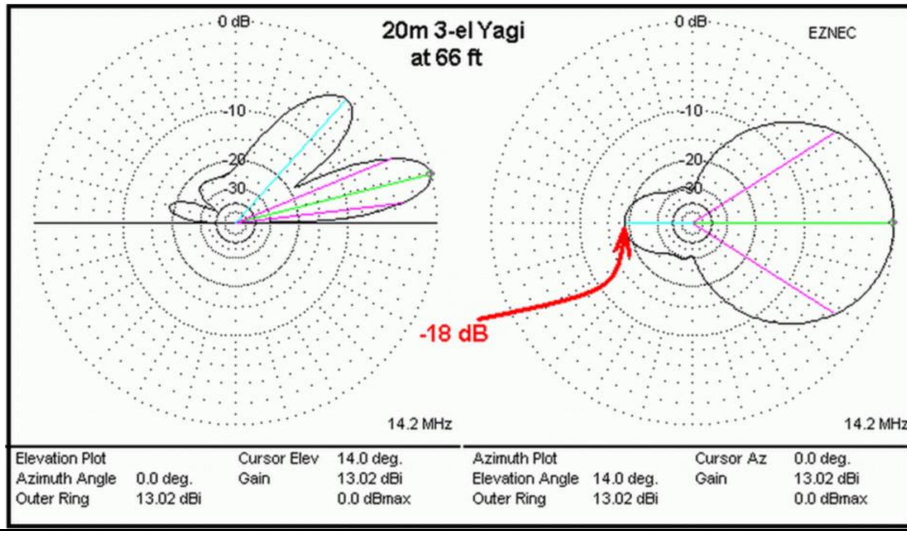
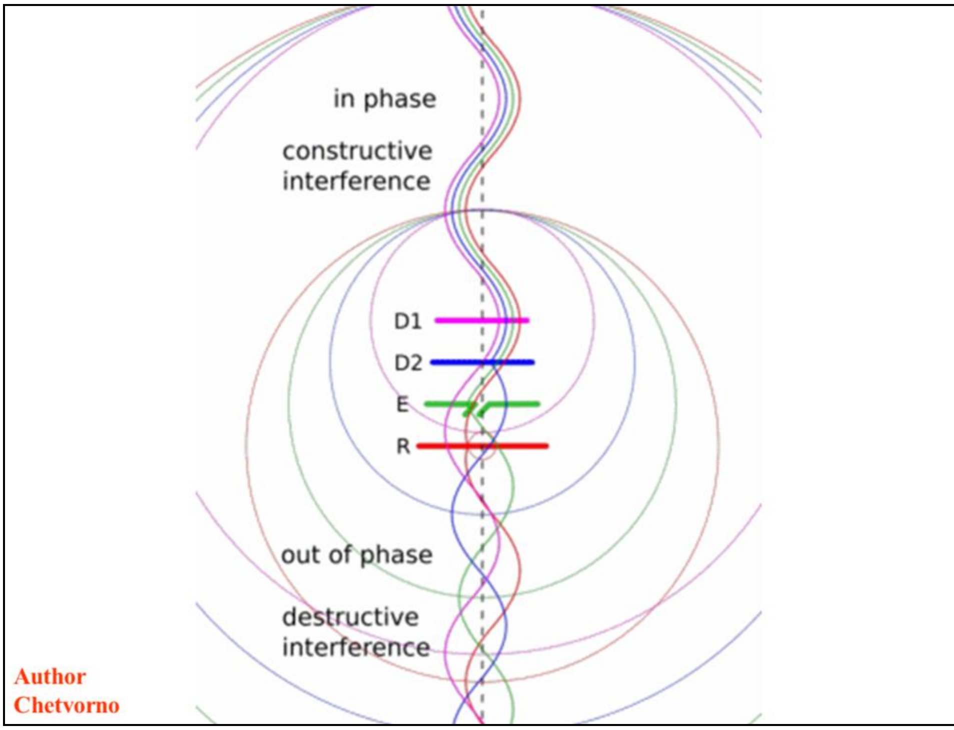
3 Element Yagi-Uda Antenna





Animation showing how a Yagi-Uda antenna works. It consists of 4 half-wave dipole antennas in a line; a driven element *(E)* which is connected to the transmitter and radiates the radio waves, and 3 parasitic elements, two directors *(D1, D2)* and one reflector *(R)* which act as resonators, absorbing and reradiating the waves from the driven element with a different phase. The radio waves from all 4 elements combine and interfere, increasing the power radiated in the desired direction *(up)* and decreasing the power radiated in other directions. The radio waves from each individual element *(wavy moving lines)* are shown in a different color. The waves in the forward direction are in phase, and interfere constructively, adding together to produce a higher signal strength, while the waves in the reverse direction are out of phase, partially canceling each other to produce lower signal strength in that direction.

Wide Element Spacing on Yagi-Uda

- **Spacing** the elements **further apart** (within reason) on a Yagi-Uda antenna gives three advantages:
  - **Greater Gain;**
  - **Less critical tuning; and**
  - **Wider bandwith.**
- Computer programs exist that will **optimize element spacing and lengths** to provide **maximum performance (0.2 wavelength spacing** is close to **optimum** for a **3-element** Yagi-Uda).

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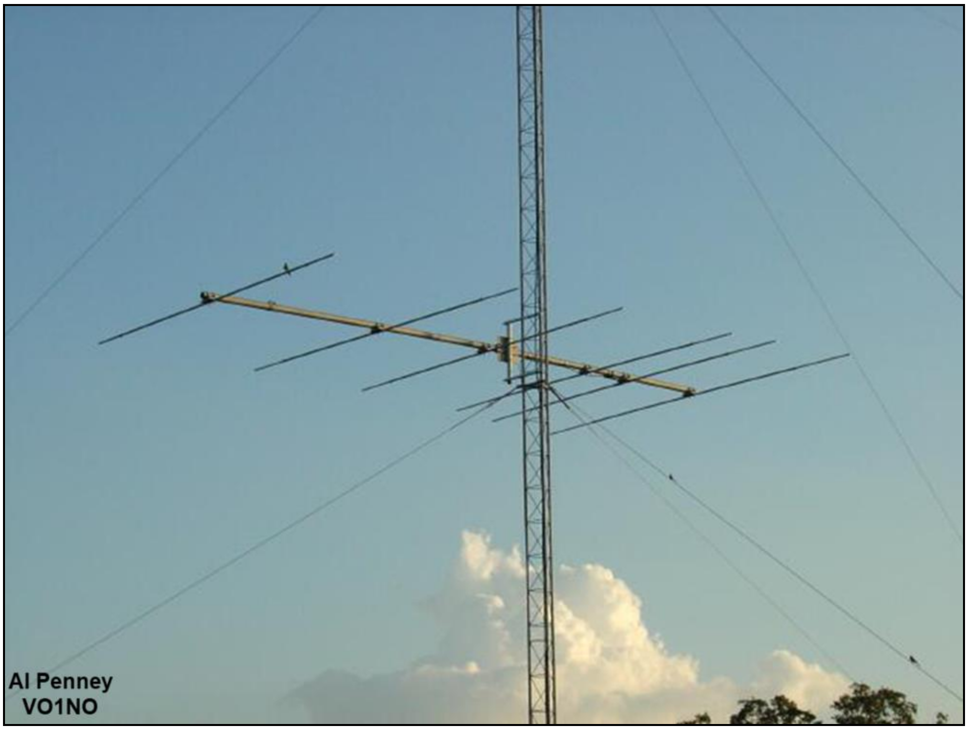
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Trapped Yagi-Uda

- Just as with dipoles, Yagi-Uda antennas can employ traps to enable the antenna to function on several different bands.
- All elements must use traps – the Driven Element, Reflector and Directors.

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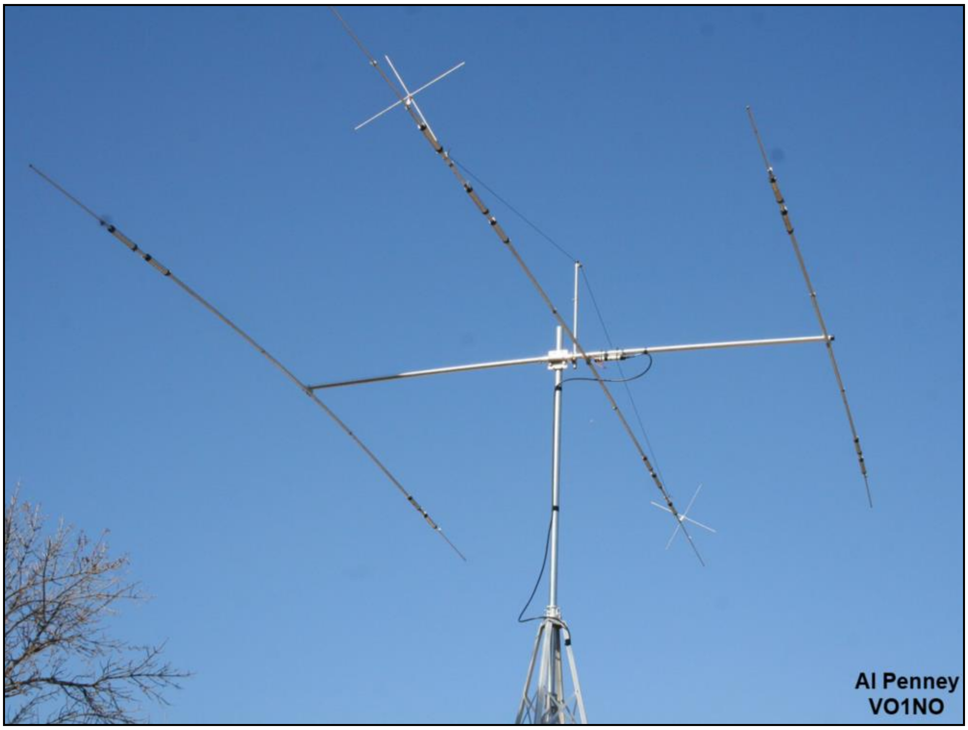
Yagi–Uda antennas used for amateur radio are sometimes designed to operate on multiple bands. These elaborate designs create electrical breaks along each element (both sides) at which point a parallel LC (inductor and capacitor) circuit is inserted. This so-called *trap* has the effect of truncating the element at the higher frequency band, making it approximately a half wavelength in length. At the lower frequency, the entire element (including the remaining inductance due to the trap) is close to half-wave resonance, implementing a *different* Yagi–Uda antenna. Using a second set of traps, a "triband" antenna can be resonant at three different bands. Given the associated costs of erecting an antenna and rotor system above a tower, the combination of antennas for three amateur bands in one unit is a very practical solution. The use of traps is not without disadvantages, however, as they reduce the bandwidth of the antenna on the individual bands and reduce the antenna's electrical efficiency and subject the antenna to additional mechanical considerations (wind loading, water and insect ingress).

Three element Triband antenna (covers 10, 15 and 20 meter bands).



Another triband Yagi (10, 15, 20M), but this one has an extra trap and capacitive loading hats on the driven element to give 40M coverage as a rotatable dipole only – no director or reflector on 40M.

Cubical Quad

- Uses closed loops of approximately **1 wavelength.**
- Driven Element, Reflector and one or more Directors.
- Advantages:
  - Effective, has gain and directivity;
  - Easily rotated;
  - Multiband; and
  - Lighter than a Yagi-Uda.
- Disadvantages:
  - Weaker than a Yagi-Uda, 3D antenna;
  - Requires a tower and rotator;
  - Single bearing only;
  - Wind and Ice!

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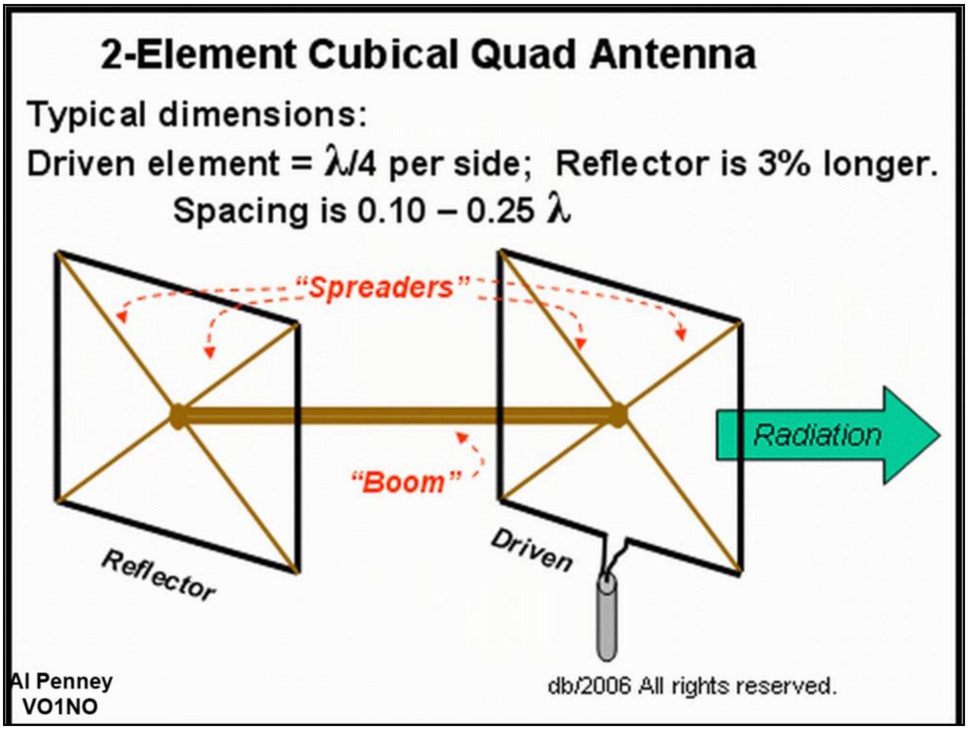
A **quad antenna** is a type of directional wire radio antenna used on the HF and VHF bands. Like a Yagi–Uda antenna ("Yagi"), a quad consists of a driven element and one or more parasitic elements; however in a quad, each of these elements is a loop antenna, which may be square, round, or some other shape. It is used by radio amateurs on the HF and VHF amateur bands.



2-Element Cubical Quad Antenna
Typical dimensions:
Driven element = λ/4 per side; Reflector is 3% longer.
Spacing is 0.10 – 0.25 λ
"Spreaders"
"Boom"
Radiation
Reflector
Driven
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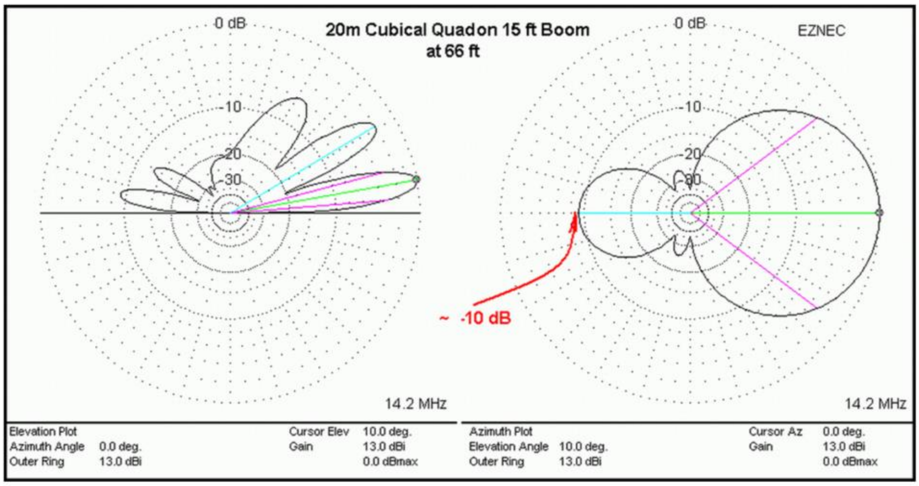
2 Element Cubical Quad

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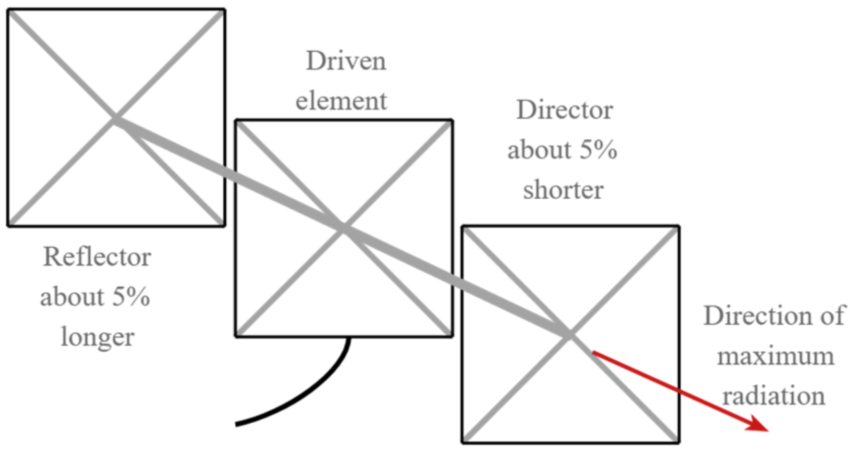
3 Element Cubical Quad



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Cubical Quad Notes

- In general, the performance of a **2-element Cubical Quad** compares to a **3-element Yagi-Uda antenna.**
- **Cubical Quad polarization:**
  - Feedpoint on side **parallel** to ground: **Horizontal**
  - Feedpoint on side **perpendicular** to ground: **Vertical**
- The elements of a Quad can also be **shaped as triangles**, and called a **Delta Quad.**

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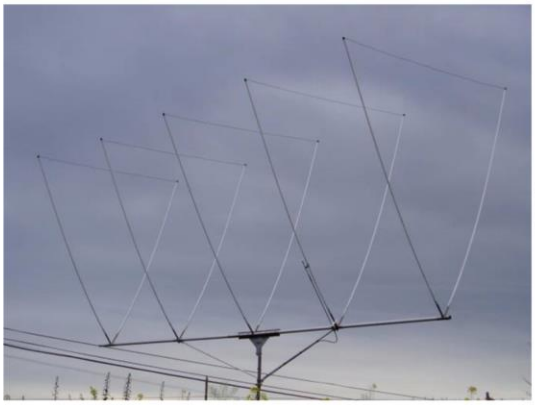
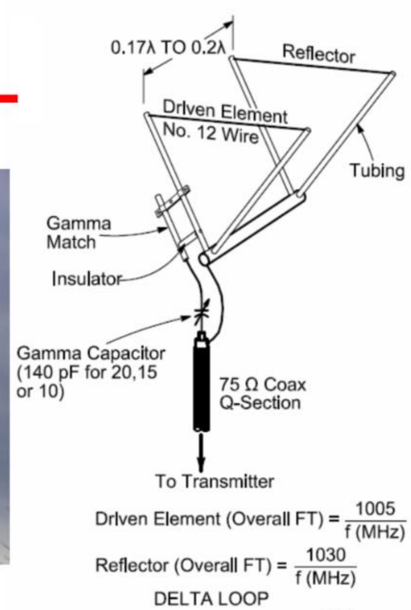
Delta Quad





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Quarter Wave Verticals

- Can be wire, tubular, or tower.
- Some describe them as limited space antennas, BUT you must consider the radial field.
- Offers a low angle of radiation if you can't put a dipole at ½ λ (125 feet on 80M!).

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¼ Wavelength Vertical

- **Omnidirectional.**
- Requires a good ground (radials, groundplane).
- Can use loading coils or capacity hats to reduce height.
- Advantages:
  - Little space (?), easily disguised;
  - Omnidirectional, good groundwave coverage;
  - Low angle of radiation (with a good ground).
- Disadvantages:
  - Omnidirectional;
  - Good ground an absolute must; and
  - Susceptible to man-made noise.

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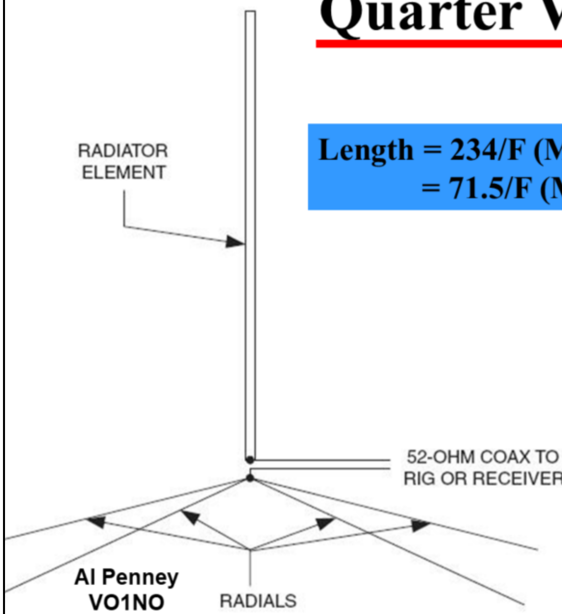
THE VERTICAL MONOPOLE

So far in this discussion on Antenna Fundamentals, we have been using the free-space, center- fed dipole as our main example. Another simple form of antenna derived from a dipole is

called a *monopole*. The name suggests that this is one half of a dipole, and so it is.

Quarter Wave Verticals

Length = 234/F (MHz) Feet
= 71.5/F (MHz) Meters



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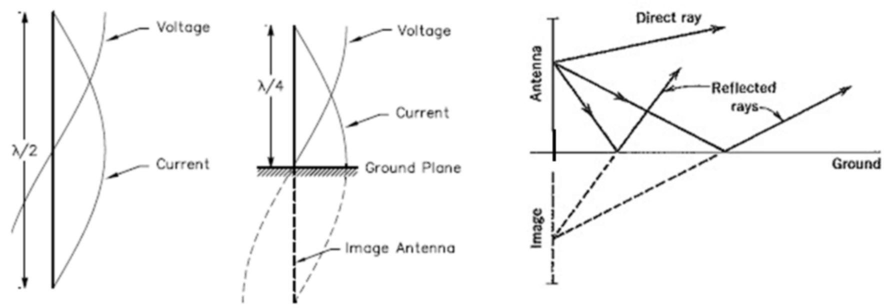
Band	Freq	Height	
		Feet	Meters
160M	1.800	130.0	39.72
	1.850	126.5	38.65
	1.900	123.2	37.60
	1.950	120.0	36.67
80M	3.500	66.9	20.43
	3.600	65.0	19.86
	3.700	63.2	19.32
	3.800	61.6	18.82
	3.900	60.0	18.33
	4.000	58.5	17.88
60M	5.358	43.7	13.34
40M	7.000	33.4	10.21
	7.100	33.0	10.07
	7.200	32.5	9.93

Heights are approximate. Actual height depends on diameter of radiator.

The monopole is always used in conjunction with a *ground plane*, which acts as a sort of electrical mirror. The *image antenna* for the monopole is the dotted line beneath the ground plane. The image forms the “missing second half” of the antenna, transforming a monopole into the functional equivalent of a dipole. From this explanation you can see where the term *image plane* is sometimes

used instead of ground plane.

Image Antenna



NOTE: Effective depth of the antenna ground plane will vary with the soil/season/weather, and could range from several cm to as deep as two meters below the surface.

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The monopole is always used in conjunction with a *ground plane*, which acts as a sort of electrical mirror. See **Fig 20**, where a λ/2 dipole and a λ/4 monopole are

compared. The *image antenna* for the monopole is the dotted line beneath the ground plane. The image forms the "missing second half" of the antenna,

transforming a monopole into the functional equivalent of a dipole. From this explanation you can see where the term *image plane* is sometimes

used instead of ground plane. Although we have been focusing throughout this chapter on antennas in free space, practical monopoles are usually mounted vertically with

respect to the surface of the ground. As such, they are called *vertical monopoles*, or simply *verticals*.

A practical vertical is supplied power by feeding the radiator against a ground system, usually made up of a series of paralleled wires radiating from

and laid out in a circular pattern around the base of the antenna. These wires are termed *radials*.

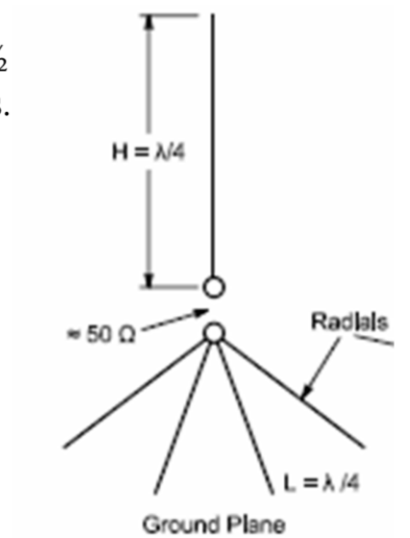
Keep in mind that these discussions of height above earth ground refer to the height of the *electrical* ground, not the sod. Depending upon ground conductivity and groundwater

content, the effective height of earth ground may lie some distance beneath the surface. The actual depth is best found from experimentation and may, unfortunately,

vary with precipitation and with the season—especially if the ground freezes and/or the local water table changes greatly.

¼ Wavelength Vertical

- **Theoretical** impedance is ½ that of a dipole, ie: 36 ohms.
- By **sloping radials** down however, impedance can be brought **closer to 50 ohms**, providing a better match to 50 ohm coax cable.



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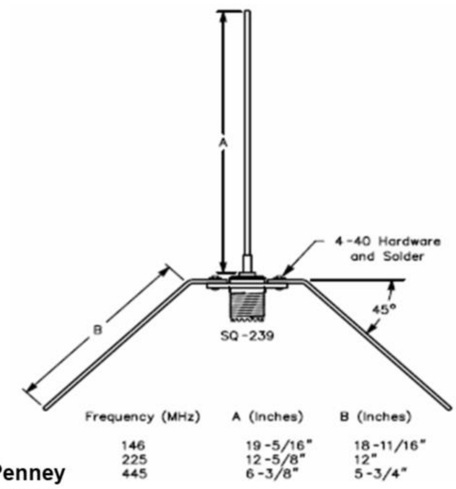
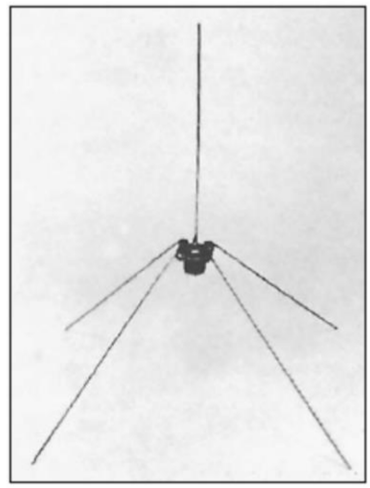
Ground Plane Vertical





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A very simple method of construction, shown in Figs 25 and 26, requires nothing more than an SO- 239 connector and some #4-40 hardware. A small loop

formed at the inside end of each radial is used to attach the radial directly to the mounting holes of the coaxial connector. After the radial is fastened to the

SO-239 with #4-40 hardware, a large soldering iron or propane torch is used to solder the radial and the mounting hardware to the coaxial connector. The radials

are bent to a 45° angle and the vertical portion is soldered to the center pin to complete the antenna. The antenna can be mounted by passing the feed line

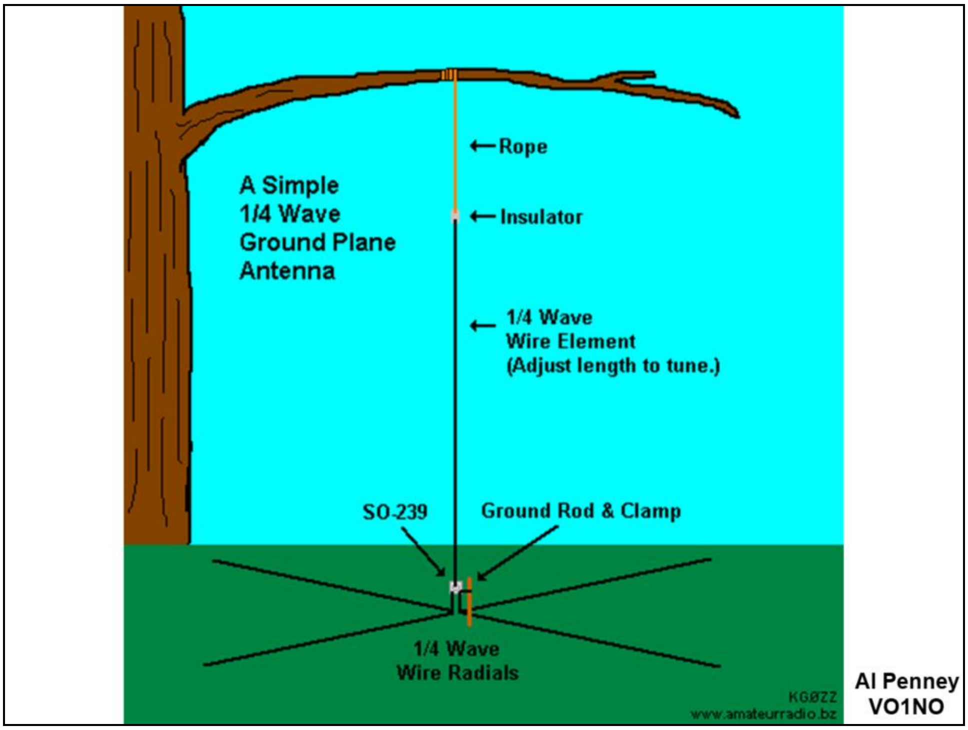
through a mast of 3/4-inch ID plastic or aluminum tubing. A compression hose clamp can be used to securethe PL-259 connector, attached to the feed line, in

the end of the mast.

Homebrew 40M vertical by YF1AR using a wire attached to a fiberglass mast.

Homebrew 40M vertical by VO1FOIX using tent poles.

80M vertical antenna by W8JI, made of Rohn 65 tower sections.



Can make a vertical from wire suspended from a tree. This is easily done for 40M, and may be possible for an 80M antenna.

Number of Radials…

- 30 x ¼ λ ground or buried radials should be plenty.
- 60 x ¼ λ ground or buried radials = point of diminishing return.
- Use at least 8 elevated ¼ λ radials – more is better.
- Given practical considerations, I recommend ground or buried radials instead of elevated.

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16 radials would give acceptable results, but 30 would be better.

Elevated radials can be tricky. While 2 elevated radials can work, it is difficult to obtain equal currents, reducing their effectiveness. People who have studied the issue recommend at least 8 elevated radials to ensure that current imbalances are not a problem. Given the practical difficulties in trying to keep them in the air without strangling someone, I recommend surface or lightly buried radials instead.

Trapped Vertical Antenna

- Just as with dipoles and Yagi-Uda antennas, traps can be added to verticals to give multiband capability.
- This example is a Cushcraft R7 vertical, covering 40m thru to 10M.

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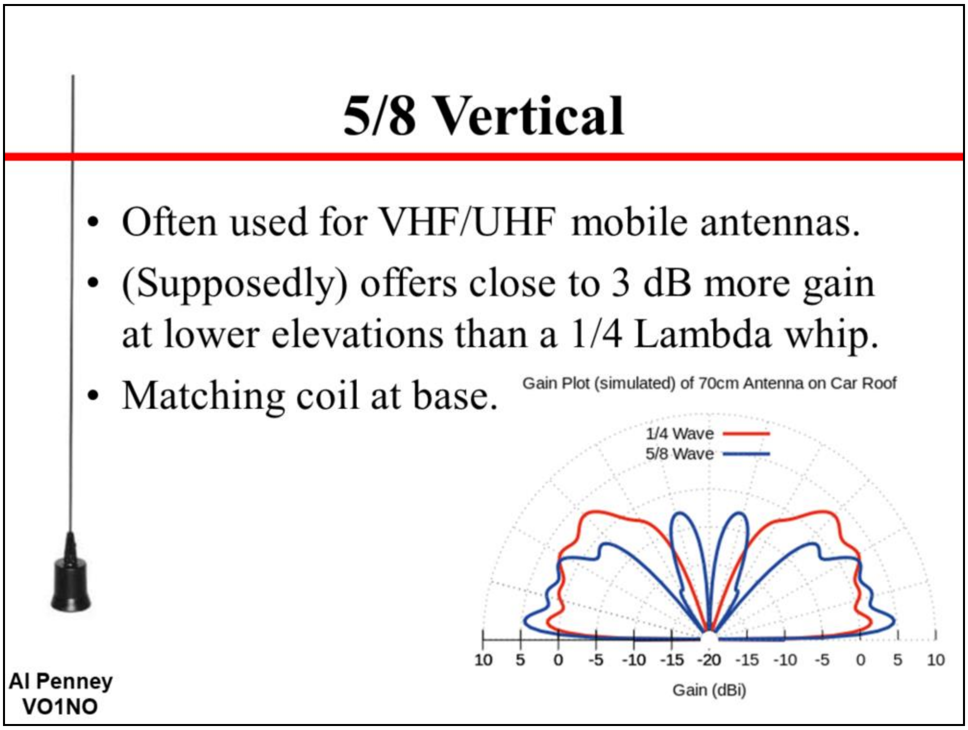

Although the quarter wavelength vertical antenna provides a good level of performance, it is easy obtain some additional gain by extending the radiating element of the vertical antenna to five eighths of a wavelength, $5\lambda/8$.

As a result the five eighths wavelength vertical is used in many instances. Using this antenna, more power is radiated at a low angle of radiation, enabling gain to be obtained in the required plane.

Although the five eighths wavelength vertical antenna can be used in many applications, one particular area where it is used is with mobile radio communications. For many frequencies the additional length is not a problem, and it provides additional gain at little increase in cost.

Five eighths wavelength antenna concept

The concept for the five eighths wavelength vertical antenna starts with the quarter wavelength antenna.

It is found that by extending the length of the vertical element, the amount of power radiated at a low angle is increased. If a half wave dipole is extended in length the radiation at right angles to the antenna starts to increase before finally splitting into several lobes. The maximum level of radiation at right angles to the antenna is achieved when the dipole is about 1.2 times the wavelength.

As a vertical monopole antenna is half the length of a dipole, this equates to about a five eighths wavelength vertical monopole antenna.

5λ/8 vertical antenna gain

When used as a vertical radiator against a ground plane this translates to a length of 5/8 wavelength. It is found that a five eighths wavelength vertical antenna has a gain of close to 4 dBd, i.e. 4 dB gain over a dipole.

To achieve this gain the antenna must be constructed of the right materials so that losses are reduced to the absolute minimum and the overall performance is maintained, otherwise much of the advantage of using the additional length will be lost.

Antenna impedance & matching

For most applications, it is necessary to ensure that the antenna provides a good match to 50Ω coaxial cable.

It is found that a 3/4 wavelength vertical element provides a good match, and therefore one solution for providing a good impedance match for the 5/8 wavelength vertical antenna is to make it appear as a 5/8 radiator but have the electrical length of a 3/4 element. In this way it radiates like a 5λ/8 radiator, but has the impedance of a 3λ/4 antenna.

This is achieved by placing a small loading coil at the base of the antenna to increase its electrical length.

5/8 Vertical Reality (Not for Exam!)

- In reality, the 5/8 pattern is based on an infinitely large ground plane, not a car roof!
- Actual advantage is less than claimed, and due mainly to increased height – easier to "see" distant repeaters.
- In general, try to center your mobile antenna (of any type) on the metal roof to ensure an omnidirectional pattern on the horizon.

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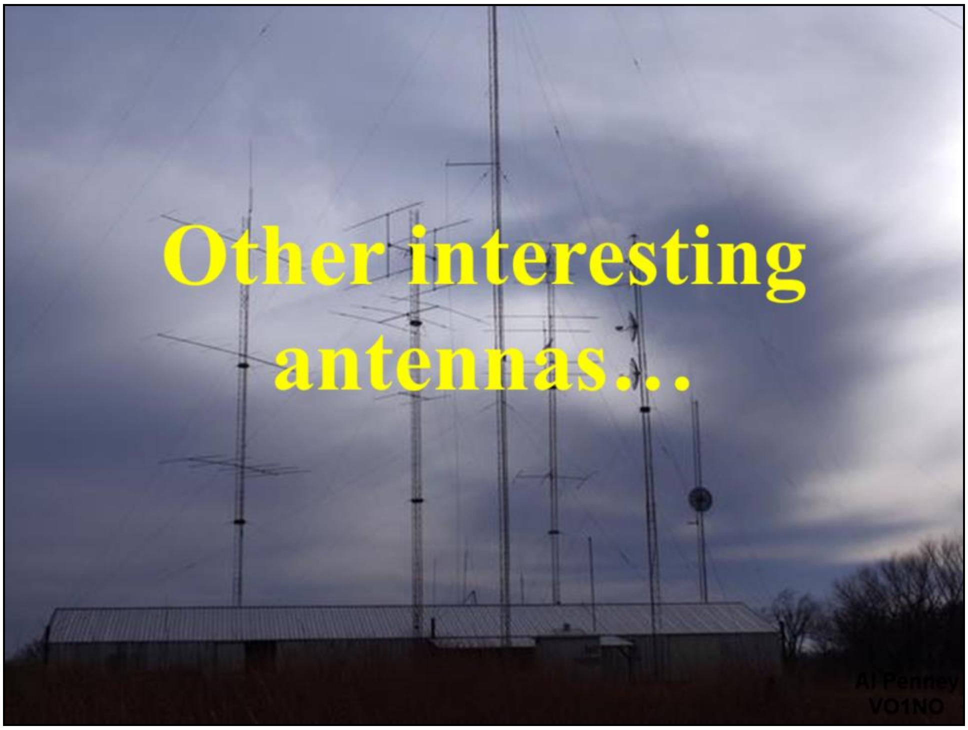
The smaller the roof and/or the less centered the antenna, the less gain advantage for a 5/8th wave. This occurs because 5/8th wave antennas develop gain from ground reflections.

Lower height roofs also have less gain difference, and shape of the roof greatly affects pattern and gain.

The 2.85dB theoretical gain is only for a perfect lossless loading coil antenna over perfect infinite flat ground plane.

In the real world the actual gain difference between a 1/4 wave antenna and a 5/8th wave can be anywhere from no gain or a very slight loss up to a maximum of 2dB gain over a 1/4 wave. The 5/8th wave is never really worse, explaining why people have no problems using them. This is true for any repeater antenna height. The primary advantage of a 5/8th wave in mobile operation is increased antenna height, not from an actual gain increase.

The further from ground, the less advantage a 5/8th wave has.


Other interesting antennas…
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Log Periodic Antennas

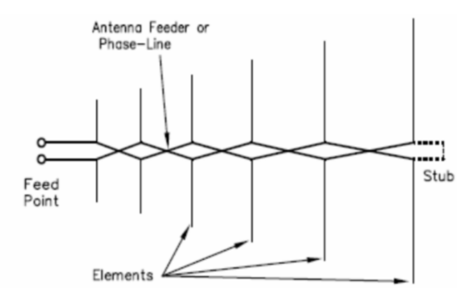

Fig 1—The basic components of a log periodic dipole array (LPDA). The forward direction is to the left in this sketch. Many variations of the basic design are possible.

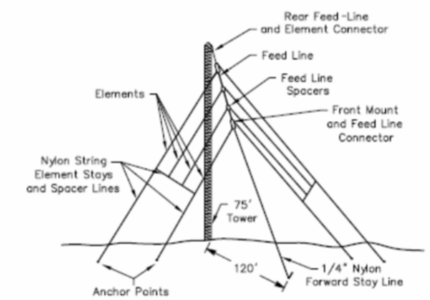

Fig 15—Typical lower-HF wire 4-element log periodic dipole array erected on a tower.

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A log periodic antenna is a system of driven elements, designed to be operated over a wide range of frequencies. Its advantage is that it exhibits essentially constant characteristics over the frequency

range—the same radiation resistance (and therefore the same SWR), and the same pattern characteristics (approximately the same gain and the same front-to-back ratio). Not all elements in the system are

active on a single frequency of operation; the design of the array is such that the active region shifts among the elements with changes in operating frequency.

Several varieties of log periodic antenna systems exist, such as the zig-zag, planar, trapezoidal, slot, V, and the dipole. The type favored by amateurs is the log-periodic dipole array, often abbreviated

LPDA. The LPDA, shown in **Fig 1**, was invented by D. E. Isbell at the University of Illinois in 1958. Similar to a Yagi antenna in construction and appearance, a log-periodic dipole array may be built as a

rotatable system for all the upper HF bands, such as 18 to 30 MHz. The longest element, at the rear of the array, is a half wavelength at the lower design frequency.

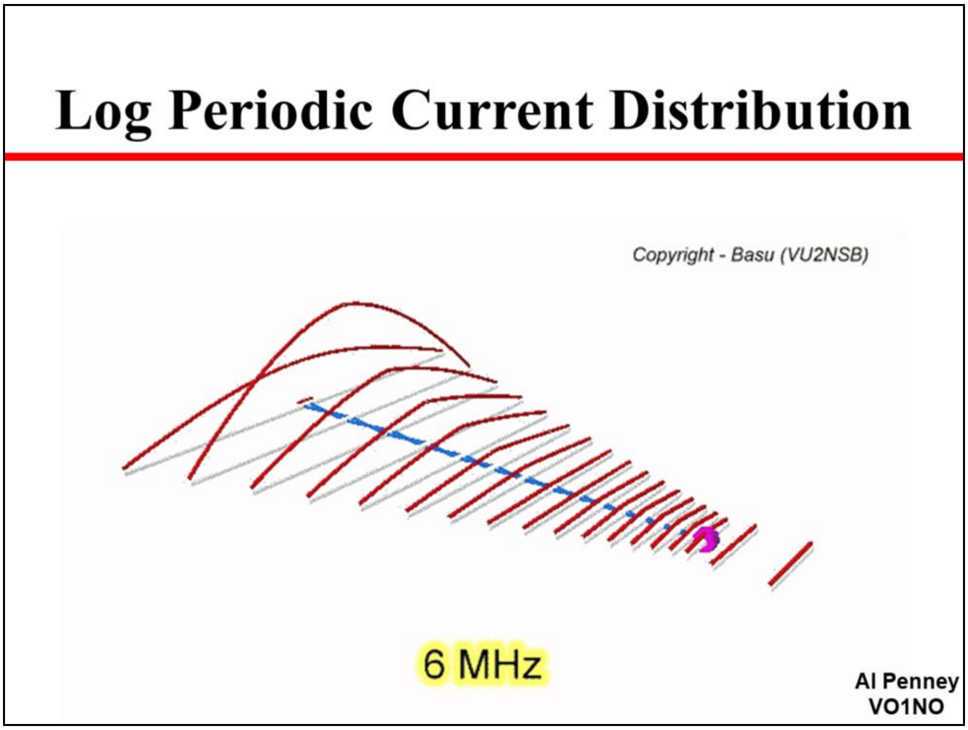
Depending on its design parameters, the LPDA can be operated over a range of frequencies having a ratio of 2:1 or higher. Over this range its electrical characteristics—gain, feed-point impedance, front-to back ratio, and so forth—remain more or less constant.

As may be seen in Fig 1, the log periodic array consists of several dipole elements which are each of different lengths and different relative spacings. A distributive type of feeder system is

used to excite the individual elements. The element lengths and relative spacings, beginning from the feed point for the array, are seen to increase smoothly in dimension, being greater for

each element than for the previous element in the array. It is this feature upon which the design of the LPDA is based, and which permits changes in frequency to be made without greatly affecting the electrical operation. With changes in operating frequency, there is a smooth transition along the array of the elements which comprise the active region.

Feedpoint impedance is approximately 200 ohms, so it can be fed using a 4:1 balun and 50 ohm coax.



Unlike a Yagi where all elements contribute to its forward gain across a narrow band around its design frequency, most of the elements of the LPDA are inactive while only a few elements that are resonant near the frequency of RF excitation are active at any point in time. Usually, 3 elements or perhaps a few more (depending on the design) may be active at a time. As we sweep the excitation frequency across the wide operating bandwidth of the LPDA from low to high, we will notice that the set of elements that become active will shift from the longest element and gradually shift towards smaller length elements till the shortest element finally becomes the one that is active at the highest frequency end of the antenna bandwidth. The transition from one set of the active element to another is usually smooth and seamless.

One may visualize it like a sprint medley relay race where one athlete hands over the baton to the next, while still running, in a smooth manner, without discontinuity or stoppage. In the case of the LPDA, with the change in excitation frequency, the transition from one set of active elements to the next is also discontinuous with a smooth rollover.

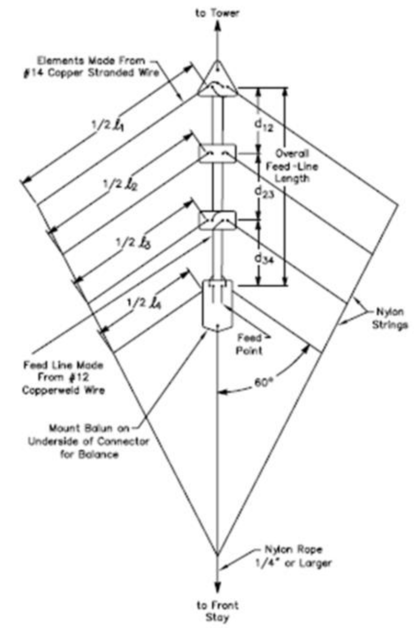


Fig 8—Typical layout for the LPDA. Use a 4:1 balun at the point indicated. See Tables 2 and 3 for dimensions.

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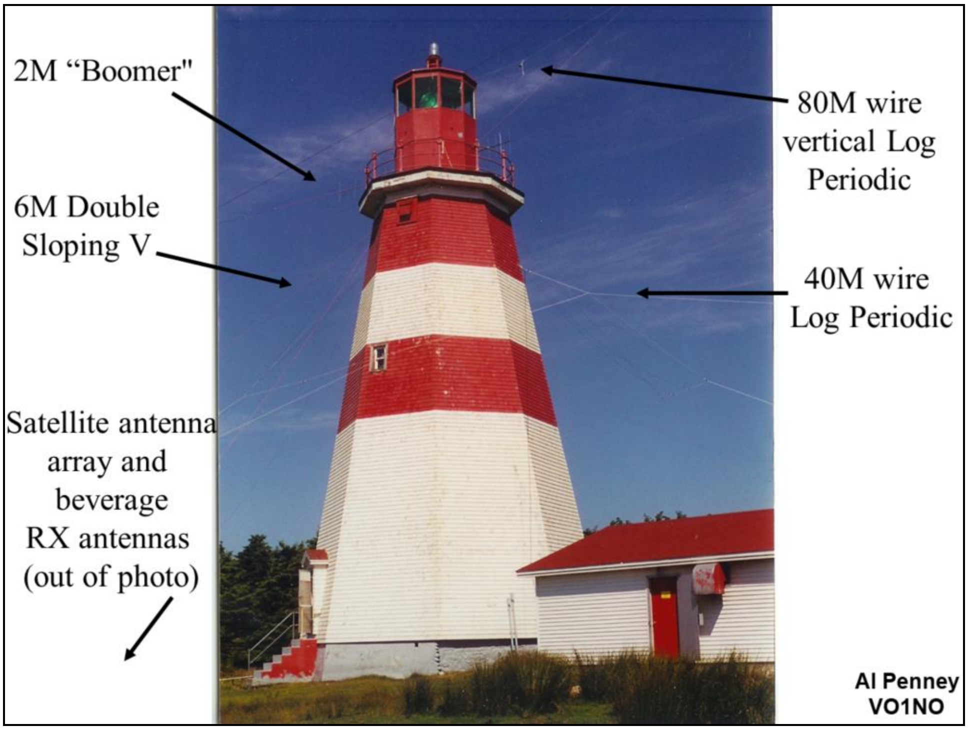
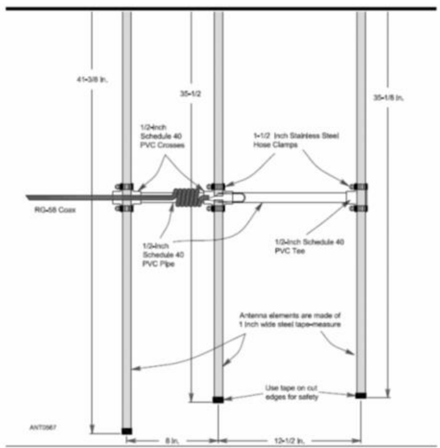
Construction details are in the ARRL Antenna Book.



Two log periodic antennas (and other types) I used on Seal Island for an IOTA expedition.

Tape Measure Yagi



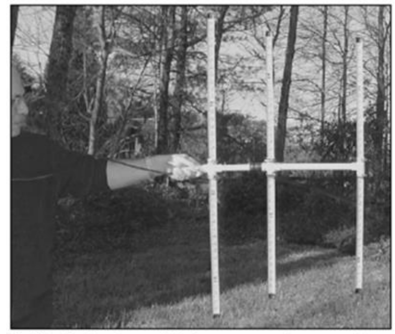


Fig 46—Photo of complete tape-measure beam, ready to hunt foxes!

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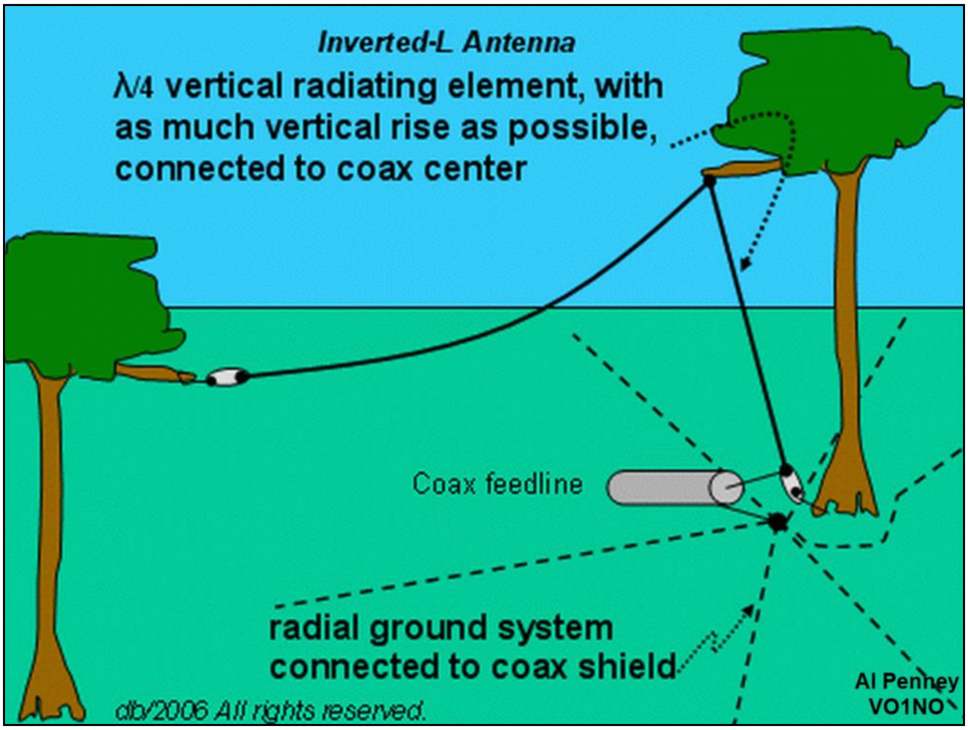
https://www.instructables.com/id/The-Tape-Measure-Antenna/

https://www.youtube.com/watch?v=BmHoQrDfw-0



An "Inverted-L" antenna is basically a wire antenna, typically ¼ to ½ wavelength long on the band it is designed for. The Inverted-L antenna is a common antenna for the 160 meter and 80 meter amateur bands, where typical ¼ wave verticals are impractically tall for most amateurs.

In the Inverted-L configuration, the first portion of the wire rises vertically from the feedpoint, and at some height is bent roughly 90 degrees, and then extends horizontally to the unterminated end. The feedpoint is very close to ground level (typically not more than 3 feet above ground), and the antenna is worked against a Ground consisting of one or more ground-rods, and/or a counterpoise consisting of one or more radial wires – which may be buried, laid directly on the ground, or suspended above the ground at some low height.

Because the input impedance of a typical Inverted-L antenna is low, and the feedpoint is at or very close to ground level, where ground losses are substantial, it is very important to establish a good ground to work the antenna against.

Temporary Inverted L at VO1NO

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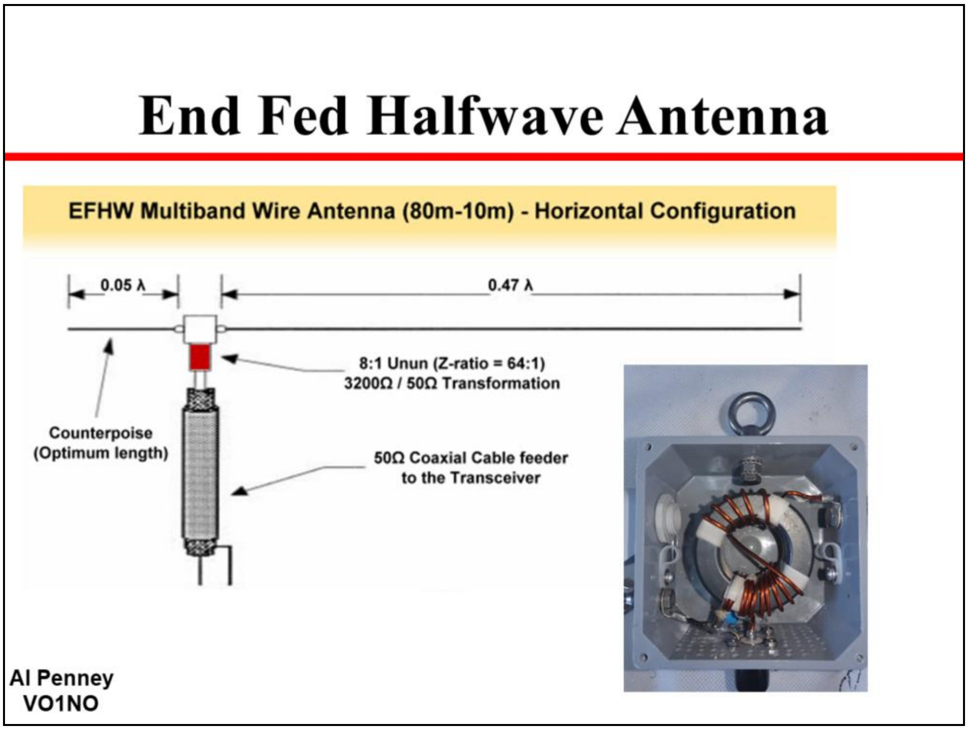
VO1NO

I recently installed a temporary Inverted L for the CQWW 160M SSB Contest. It consists of a piece of wire 130 feet long, with 60 feet hung vertically from the tower, and the rest extending out to a support pole. I used an RF choke at the feedpoint, made by coiling 20 turns of RG-213 around a piece of 4” plastic pipe. I attached radial wires at the base – 10 full size quarter wavelength radials, and about 50 shorter wires. It worked quite well for a simple antenna – I worked stations all over North America and Europe, and as far away as Hawaii and Israel.



The end fed half wave antenna is an attractive option for many radio hams as it is able to provide multiband operation without the use of traps or stubs whilst occupying a minimum amount of space and not presenting a very ugly visual impact.

A broad-band matching network is typically used to transform the high impedance of the EFHW feed point to 50Ω suitable for standard coax cable.

The end fed half wave antenna can be operated with a small counterpoise, and in some instances, no counterpoise is used at all, although this is not necessarily wise. The lower end of the antenna may also be grounded as an alternative to reduce static noise.

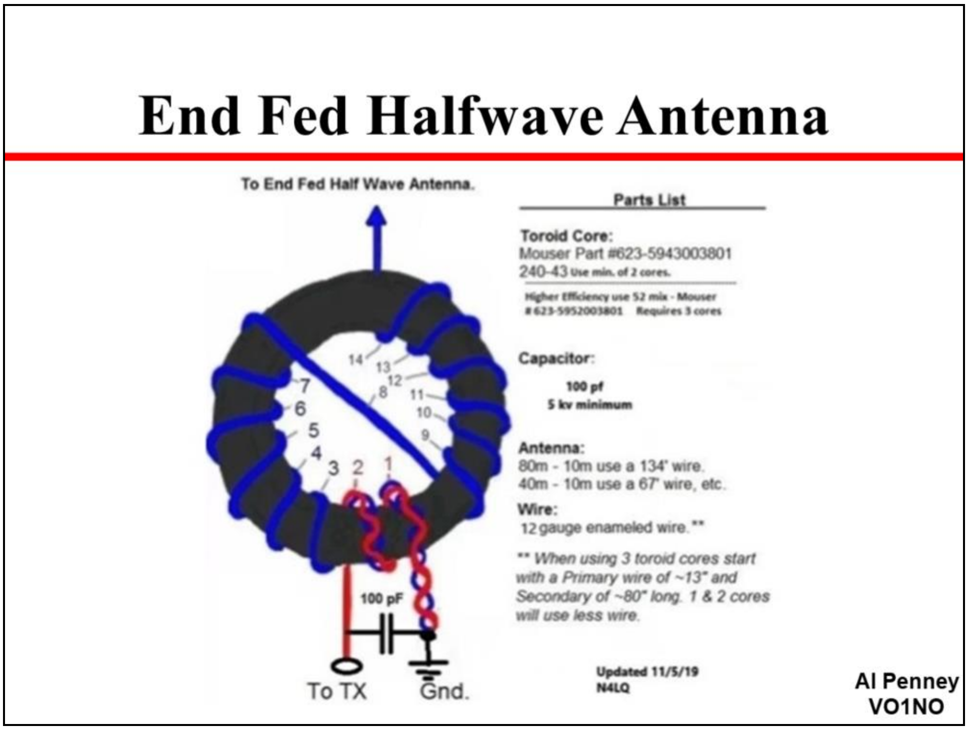
Being a single wire, and end fed it is very easy to set up, often taking only minutes to do and this makes it ideal for ham radio portable operation, as well as for base station usage.

We are all familiar with a centre fed half wave dipole antenna. In free space this presents and impedance of 72Ω to the feeder and this means that it provides a relatively good match to 50Ω coax cable, especially when the proximity pf the ground and other objects will tend to reduce the feed impedance.

When the feeder is connected to the end of a half-wave antenna, the situation is quite different. Here the feed impedance is very much higher, and to enable a good match to be made to 50Ω coax which is normally used a matching device is required, otherwise there will be a discontinuity and power will be reflected.

To provide the match at this point a transformer is normally used and this gives an impedance transformation. Typically the matching transformer transforms the impedance from the value of around 4,000 or 5,000 Ω at the EFHW antenna feed point down to the 50Ω value of the coaxial feeder.

The end fed half wave antenna is also able to provide multi-band operation. It can be used on all odd and even harmonics of the fundamental frequency, presenting the same high impedance at these frequencies.



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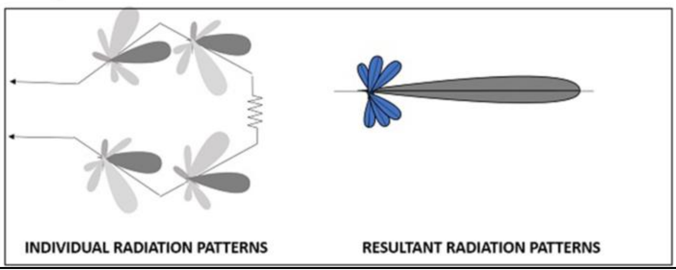
Rhombic Antenna

- Each leg acts as a long wire antenna.
- Forward lobes reinforce, sidelobes cancel.
- Resistor makes it unidirectional.
- Feedpoint is ~600 ohms.



Al Penney
VO1NO

The **Rhombic Antenna** is an equilateral parallelogram shaped antenna. Generally, it has two opposite acute angles. The tilt angle, θ is approximately equal to 90° minus the angle of major lobe. Rhombic antenna works under the principle of travelling wave radiator. It is arranged in the form of a rhombus or diamond shape and suspended horizontally above the surface of the earth.

Frequency Range

The frequency range of operation of a Rhombic antenna is around **3MHz to 300MHz**. This antenna works in **HF** and **VHF** ranges.

Radiation Pattern

The radiation pattern of the rhombic antenna is shown in the following figure. The resultant pattern is the cumulative effect of the radiation at all four legs of the antenna. This pattern is **uni-directional**, while it can be made bi-directional by removing the terminating resistance.

The main disadvantage of rhombic antenna is that the portions of the radiation, which do not combine with the main lobe, result in considerable side lobes having both horizontal and vertical polarization.

Advantages

The following are the advantages of Rhombic antenna −

•Input impedance and radiation pattern are relatively constant
•Multiple rhombic antennas can be connected
•Simple and effective transmission

Disadvantages

The following are the disadvantages of Rhombic antenna −

•Wastage of power in terminating resistor
•Requirement of large space
•Redued transmission efficiency

Applications

The following are the applications of Rhombic antenna −

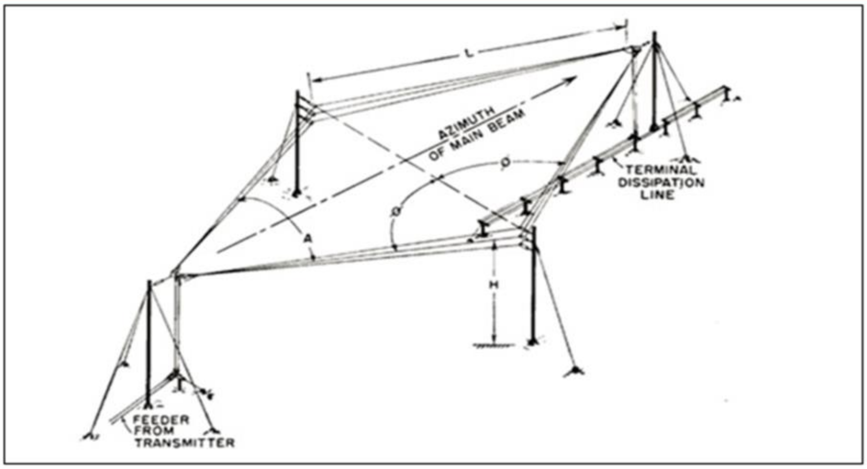
•Used in HF communications
•Used in Long distance sky wave propagations
•Used in point-to-point communications

Conclusion

Rhombic and related V antennas are often described as extremely high gain antennas, but that claim seems to be a little exaggerated or inflated. A 2-wavelength per leg rhombic actually has about the same gain as a single three-element monoband Yagi antenna on the design band. Most of the rhombic's performance limitations come from the high levels of spurious lobes and the very poor efficiency, especially over normal soil. The rhombic has one of the poorest gain-per-acre rankings of any high gain HF antenna array. On the other hand a rhombic antenna does have the very distinct advantage of working over very wide frequency ranges with good SWR and gain, something a basic monoband Yagi can never do. The rhombic is also a simple antenna, requiring only four supports (three supports for the V beam, and one support for inverted V derivatives).

In a large properly designed rhombic, slightly less than half of applied RF power is lost in the termination system. That power is converted to heat. Right away this puts the rhombic at a ~3 dB disadvantage to other more efficient antennas with a similar overall pattern shape or half-power beamwidth. There are ways to use this power but generally very little appears in rhombic resources.

Rhombic Antenna



Al Penney
VO1NO

The terminating resistor must be practically a pure resistance at the operating frequencies; that is, its inductance and capacitance should be negligible. Ordinary wire-wound resistors are not suitable

because they have far too much inductance and distributed capacitance. Small carbon resistors have satisfactory electrical characteristics but will not dissipate more than a few watts and so cannot

be used, except when the transmitter power does not exceed 10 or 20 W or when the antenna is to be used for reception only. The special resistors designed either for use as "dummy" antennas or for

terminating rhombic antennas should be used in other cases. To allow a factor of safety, the total rated power dissipation of the resistor or resistors should be equal to half the power output of the

transmitter.

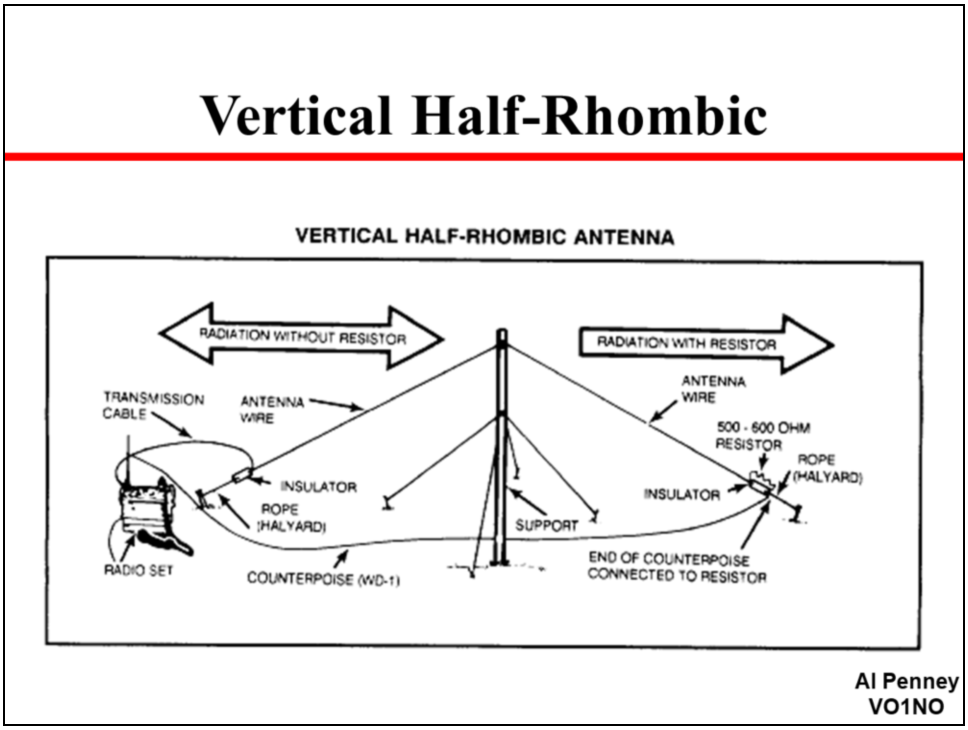
To reduce the effects of stray capacitance it is desirable to use several units, say three, in series even when one alone will safely dissipate the power. The two end units should be identical and each

should have 1/4 to 1/3 the total resistance, with the center unit making up the difference. The units should be installed in a weatherproof housing at the end of the antenna to protect them and to permit mounting without mechanical strain. The connecting leads should be short so that little extraneous inductance is introduced.

Alternatively, the terminating resistance may be placed at the end of an 800-Ω line connected to the end of the antenna. This will permit placing the resistors and their housing at a point convenient for

adjustment rather than at the top of the pole. Resistance wire may be used for this line, so that a portion of the power will be dissipated before it reaches the resistive termination, thus permitting the use of

lower-wattage lumped resistors. The line length is not critical, since it operates without standing waves.



The slide shows the construction of a vertical half-rhombic antenna. This is essentially one-half of a rhombic antenna split along its major axis and then turned so that its plane is vertical. In this form, the main lobe of radiation is vertically polarized. The system is structurally simple and uses only one supporting pole.

The angle of the wires with respect to ground is a function of the length of the legs. The optimum slope angle is tabulated in Table 3.5. These angles are not the same as one-half of the acute angle of the equivalent horizontal rhombic antenna because, in the latter, the acute angle is adjusted to bring the intersection of the two cones of first maximums a few degrees above the plane of the rhombus, while in this case the angle is that which will maximize the pattern in the plane of the antenna. With this exception, we can say that the vertical pattern for the inverted-V antenna is the same as that of a free-space rhombus in the plane of the rhombus. In the same sense the horizontal-plane pattern for the inverted-V antenna is the same as that in the major axial plane normal to a free-space rhombus.

TABLE 3.5. OPTIMUM SLOPE ANGLES FOR INVERTED-V ANTENNAS

Leg Length Wavelengths	**Slope Angle Degrees**
2	36
3	29
4	24.5
5	22
6	20.5
7	19.5

To feed the inverted V, it is usually preferred to use a balanced feeder, similar to those which would be employed for other balanced antennas, and to make a balanced to unbalanced transformation with the proper impedance ratio to excite the antenna. (In other words, use 450 ohm ladder line and an antenna tuner).

Extended Double Zepp

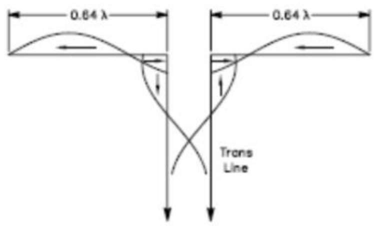


Fig 43—The extended double Zepp. This system gives somewhat more gain than two 1/2-λ collinear elements.

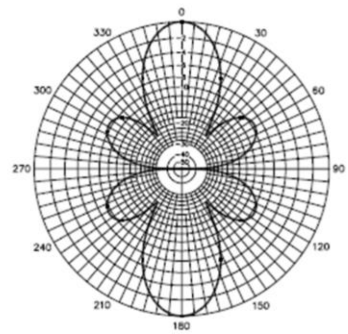


Fig 44—E-plane pattern for the extended double Zepp of Fig 43. This is also the horizontal directional pattern when the elements are horizontal. The axis of the elements lies along the 90°-270° line. The array gain is approximately 3 dBd (5.2 dBi).

Al Penney
VO1NO

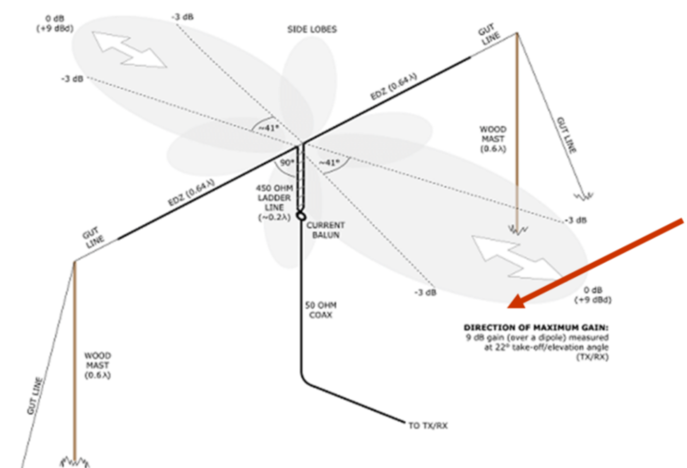
THE EXTENDED DOUBLE ZEPP

An expedient that may be adopted to obtain the higher gain that goes with wider spacing in a simple system of two collinear elements is to make the elements somewhat longer than 1/2 ωλ. As shown in **Fig 43**, this increases the spacing between the two in-phase 1/2-λ sections at the ends of the wires. The section in the center carries a current of opposite phase, but if this section is short the current will be small; it represents only the outer ends of a 1/2-ωλ antenna section. Because of the small current and short length, the radiation from the center is small. The optimum length for each element is 0.64 wλ.

At greater lengths the system tends to act as a long-wire antenna, and the gain decreases. This system is known as the "extended double Zepp." The gain over a 1/2-wλ dipole is approximately 3 dBd,

as compared with approximately 1.6 dBd for two collinear 1/2-wλ dipoles. The directional pattern in the plane containing the axis of the antenna is shown in **Fig 44**. As in the case of all other collinear arrays, the free-space pattern in the plane at right angles to the antenna elements is the same as that of a 1/2-wλ antenna—circular.

Extended Double Zepp



11 m BAND EXTENDED DOUBLE ZEPPELIN (EDZ): RADIATION PATTERN AND MOUNTING DETAILS

Afraid Not!
Gain over a dipole at the same height is about 3 dB!

Al Penney
VO1NO

Some people quote unrealistic gain figures for the Extended Double Zepp, perhaps using antenna modeling software figures of dipoles in free space as the comparison antenna. Remember that a dipole over actual ground can have 6 dB or more gain over a dipole in free space because of reflections off the ground.

The best way to feed the EDZ is with 450 ohm ladder line – it permits it to be used on other bands, though the radiation pattern will not be the same as it is for the band it is designed for. Alternatively, the ladder line section can be (in FEET) 246/F (MHz) long, and connected to 50 ohm coax cable, preferably with an RF choke at the end of the coax. You will have to 'cut-and-try' to get the length correct, so start with the ladder line longer than calculated.

6M Extended Double Zepp, VO1NO

Al Penney
VO1NO

Some people quote unrealistic gain figures for the Extended Double Zepp, perhaps using antenna modeling software figures of dipoles in free space as the comparison antenna. Remember that a dipole over actual ground can have 6 dB or more gain over a dipole in free space because of reflections off the ground.

The best way to feed the EDZ is with 450 ohm ladder line – it permits it to be used on other bands, though the radiation pattern will not be the same as it is for the band it is designed for. Alternatively, the ladder line section can be (in FEET) 246/F (MHz) long, and connected to 50 ohm coax cable, preferably with an RF choke at the end of the coax. You will have to 'cut-and-try' to get the length correct, so start with the ladder line longer than calculated.

Sterba Curtain

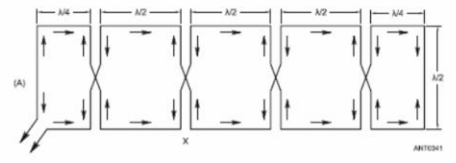
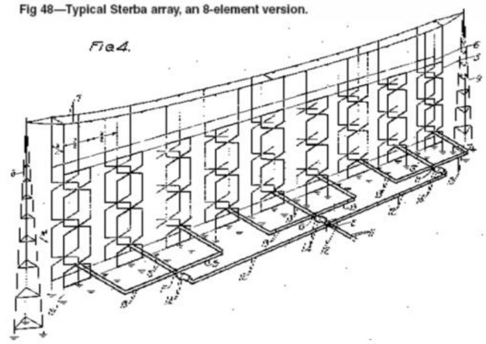


Fig 48—Typical Sterba array, an 8-element version.



Al Penney
VO1NO

The Sterba array, shown at A in **Fig 61**, is a broadside radiator consisting of both collinear and parallel elements with 1/2-λ spacing between the latter. Its distinctive feature is the

method of closing the ends of the system. For direct current and low-frequency ac, the system forms a closed loop, which is advantageous in that heating currents can be sent through the wires to melt the

ice that forms in cold climates. There is comparatively little radiation from the vertical connecting wires at the ends because the currents are relatively small and are flowing in opposite directions with

respect to the center (the voltage loops are marked with dots in this drawing).

The system obviously can be extended as far as desired. The approximate gain is the sum of the gains of one set of collinear elements and one set of broadside elements, counting the two 1/4-λ

sections at the ends as one element. The antenna shown, for example, is about equivalent to one set of four collinear elements and one set of two

parallel broadside elements, so the total gain is approximately 4.3 + 4.0 = 8.3 dBd. Horizontal polarization is the only practicable type at the lower frequencies, and the lower set of

elements should be at least 1/ 2 wλ above ground for best results.

When fed at the point shown, the impedance is of the order of 600 Ω. Alternatively, this point can be closed and the system fed between any two elements, as at X.

In this case a point near the center should be chosen so the power distribution among the elements will be as uniform as possible. The impedance at any such point will be 1 kΩ or less in systems with six or more elements.

Three-bay Sterba Curtain for 6M, Whitehead Island

3 bay Sterba Curtain for 6M on Whitehead Island.

Sterba Curtain

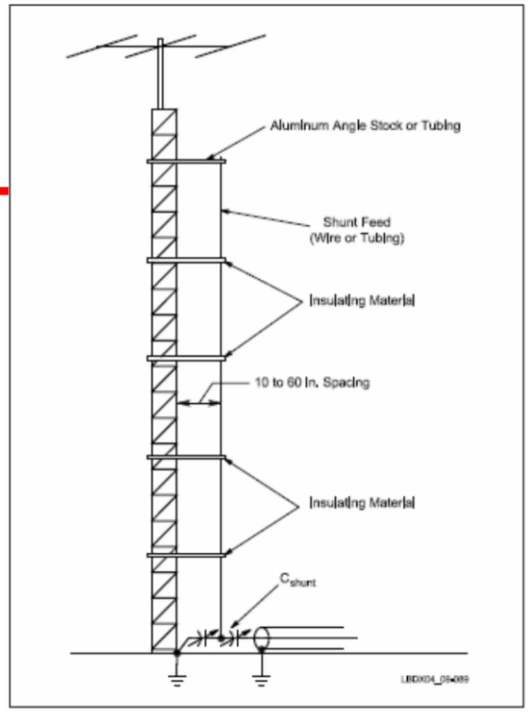
- Three-bay Sterba Curtain for 40M.
- Whitehead Island, in the Bay of Fundy.

Al Penney
VO1NO

Shunt Fed Vertical

- Permits use of a grounded tower as a vertical antenna.
- Yagis make tower appear longer in electrical sense.

Al Penney
VO1NO



A tower can be used as a vertical antenna, provided that a good ground system is available. The shunt-fed tower is at its best on 1.8 MHz, where a full λ/4 vertical antenna is rarely possible. Almost any

tower height can be used. If the beam structure provides some top loading, so much the better, but anything can be made to radiate—if it is fed properly. W5RTQ uses a self-supporting, aluminum, crank-up,

tilt-over tower, with a TH6DXX tribander mounted at 70 feet. Measurements showed that the entire structure has about the same properties as a 125-foot vertical. It thus works quite well as an antenna on

1.8 and 3.5 MHz for DX work requiring low-angle radiation.

Gamma match – one capacitor

Omega Match – two capacitors

Shunt Fed Vertical

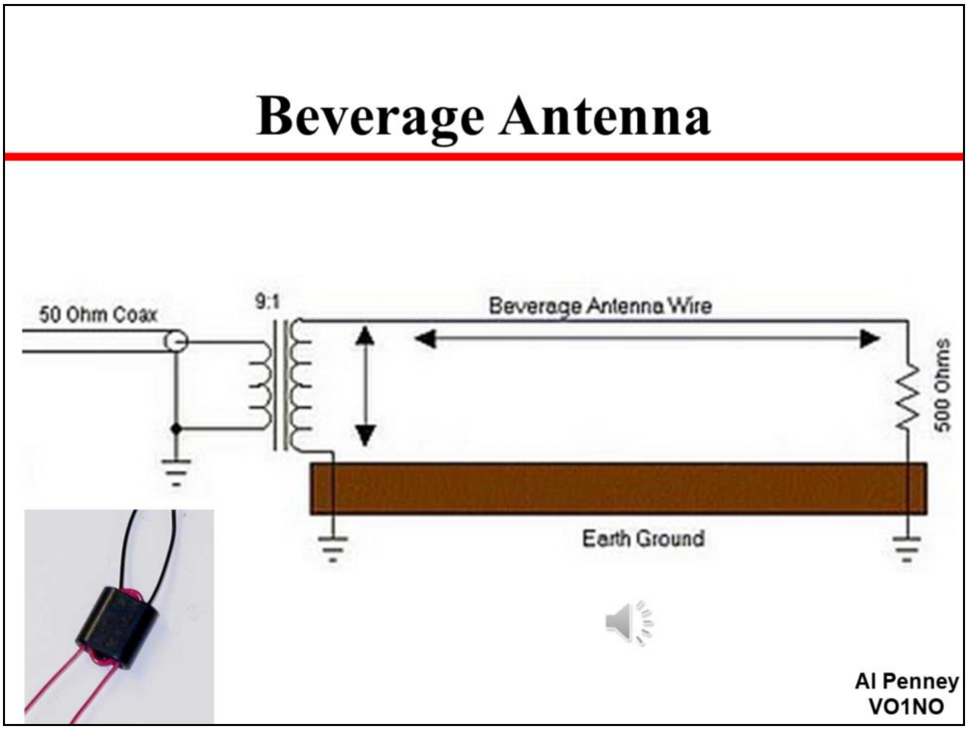
- 40 foot tower loaded for both 160 and 80M on St. Paul Island.

Al Penney
VO1NO

Shunt fed tower for 160 and 80M on St. Paul Island DX’pedition.

Feedpoint for shunt-fed tower. Capacitors in Rubbermaid container.

Feedpoint for shunt fed tower for 160 and 80M on St. Paul Island DX'pedition. Variable capacitors are in the Rubbermaid container.



The **Beverage antenna** or "wave antenna" is a long-wire receiving antenna mainly used in the low frequency and medium frequency radio bands, invented by Harold H. Beverage in 1921. It is used by amateur radio, shortwave listening, and longwave radio DXers and military applications.

A Beverage antenna consists of a horizontal wire from one-half to several wavelengths long (tens to hundreds of meters; yards at HF to several kilometres; miles for longwave) suspended above the ground, with the feedline to the receiver attached to one end, and the other end of the wire terminated through a resistor to ground. The antenna has a unidirectional radiation pattern with the main lobe of the pattern at a shallow angle into the sky off the resistor-terminated end, making it ideal for reception of long distance skywave (skip) transmissions from stations over the horizon which reflect off the ionosphere. However the antenna must be built so the wire points in the direction of the transmitter(s) to be received.

The advantages of the Beverage are excellent directivity, a wider bandwidth than resonant antennas, and a strong ability to receive distant and overseas transmitters. Its disadvantages are its physical size, requiring considerable land area, and inability to rotate to change the direction of reception. Installations often use multiple Beverage antennas to provide wide azimuth coverage.

Feedpoint for the Beverage antenna pointed towards Europe from Bon Portage Island, off the southern tip of NS. It worked great! Signals that were covered in static popped out of the noise when the Beverage antenna was selected for receive. The black box contains relays that select the different antennas.

The matching transformer is mounted in a deodorant container. It is sturdy, it protects the transformer, and it's cheap! Note that one wire goes to the antenna, while the other is attached to the ground rod. The black wire is coax cable that goes to the antenna switchbox, and then back to the radio.

DX'pedition Beverage Antenna

Al Penney
VO1NO

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Beverage Antennas at VO1NO/VE3

- 5 acres near Merrickville
- Dimensions ~ 650 x 320 feet
- 8 directions using end-fire phased Beverages
- Control Box in shack, with 3 switchboxes in field

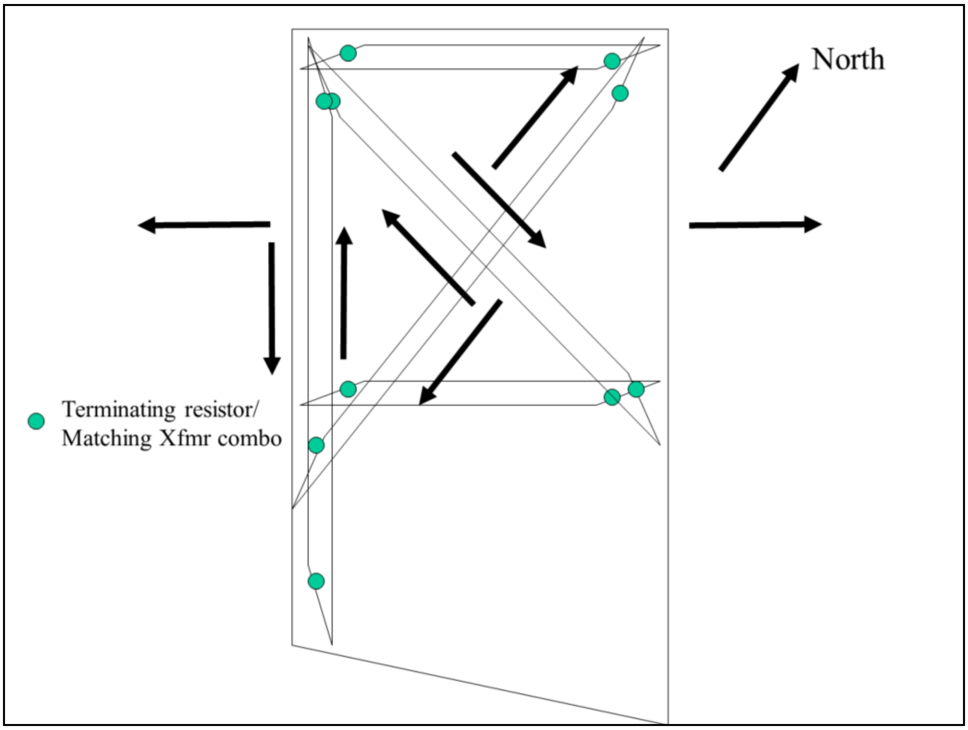
I use 8-foot long 2x2 pieces of lumber, attached to shorter pieces driven into the ground. Supports at the 4 corners are backed up with guy lines. Note the coax coil RF choke. It needs several cores to increase the choking effect.

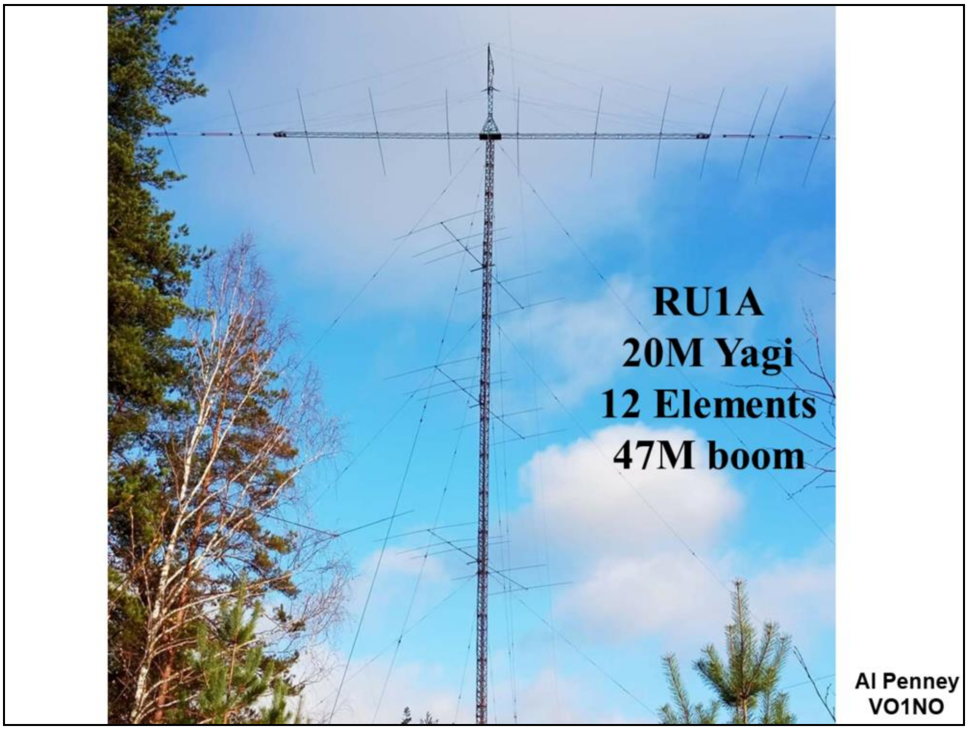
In the shack I have a control box with a knob surrounded by 8 LEDs. As the knob is rotated, a direction is selected, and the corresponding LED is illuminated. I have two coax cables running from the control box to three remote switchboxes in the field (one switchbox feeds into another), and coax running to the receive input on my rig. The switchboxes use relays to switch both the center conductor and braid of the coax to select the proper antenna i.e.: direction. Switching both conductors is important - directivity can be lost if this is not done. As a particular direction is chosen in the shack, the appropriate coax is selected, and the proper control lines energized so as to activate the required relays in the remote switchboxes. Also, 24VDC is applied to the center conductor of the coax that runs to the remote switchbox. More on that in a moment.

I use a Kenwood TS-950SD on HF. It has two RCA plugs on back – RX Ant Out and RX Ant In. Normally they are connected with a jumper, but they can also be used to connect a separate RX antenna. I run a cable from both to the control box. Using the knob in the lower right, I can connect the Beverage antennas, or several other RX antennas, including my K9AY. I can also bypass the RX antennas, feeding the RX Ant Out into the RX Ant In. This makes it easy to use other antennas when I go to higher bands.

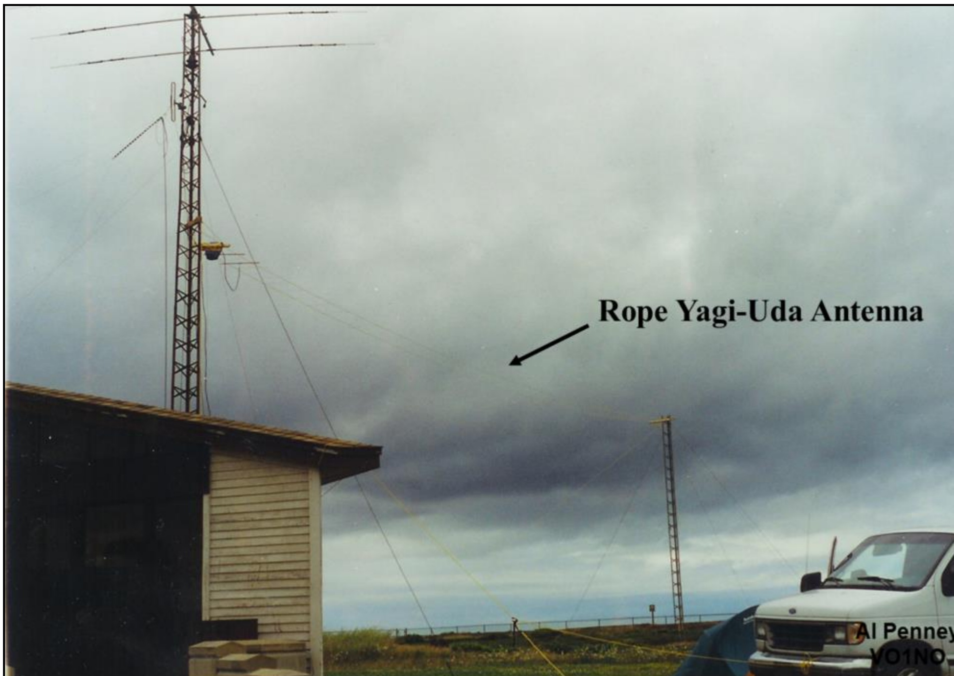
The control box also takes a feed from the PTT line. When I transmit, a relay is keyed to ground the input from the active Beverage. It might not actually be needed, but better safe than sorry! There is also room for a pre-amp if I ever need one.

Why did I use 24VDC? I had lots of 24VDC relays and a 24 VDC power supply. It also suffers from less I2R losses in the control lines and coax center conductor.

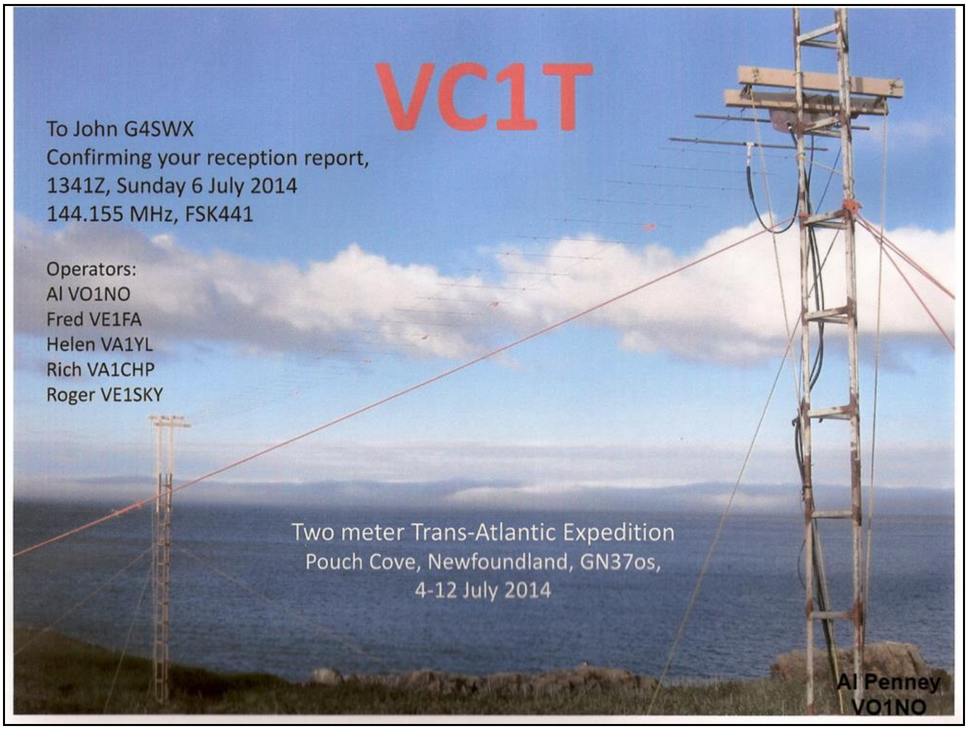

North
Terminating resistor/
Matching Xfmr combo



RU1A (20M 12el Yagi 47m long boom)



2M Trans-Atlantic Attempt, Marconi National Historic Site


VC1T
To John G4SWX
Confirming your reception report,
1341Z, Sunday 6 July 2014
144.155 MHz, FSK441
Operators:
Al VO1NO
Fred VE1FA
Helen VA1YL
Rich VA1CHP
Roger VE1SKY
Two meter Trans-Atlantic Expedition
Pouch Cove, Newfoundland, GN37os,
4-12 July 2014
Al Penney
VO1NO


Questions?

Review Question 1

One solution to multiband operation with a shortened radiator is the “trap dipole” or trap vertical. These “traps” are actually:

- coils wrapped around a ferrite rod
- hollow metal cans
- a coil and capacitor in parallel
- large wire-wound resistors

Review Question 1

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• coils wrapped around a ferrite rod

• hollow metal cans

• a coil and capacitor in parallel

• large wire-wound resistors

< a coil and capacitor in parallel >

Review Question 2

What is a parasitic beam antenna?

• An antenna where some elements obtain their radio energy by induction or radiation from a driven element

• An antenna where the driven element obtains its radio energy by induction or radiation from director elements

• An antenna where all elements are driven by direct connection to the transmission line

• An antenna where wave traps are used to magnetically couple the elements

Review Question 2

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• An antenna where some elements obtain their radio energy by induction or radiation from a driven element

• An antenna where the driven element obtains its radio energy by induction or radiation from director elements

• An antenna where all elements are driven by direct connection to the transmission line

• An antenna where wave traps are used to magnetically couple the elements

< An antenna where some elements obtain their radio energy by induction or radiation from a driven element >

Review Question 3

How can the bandwidth of a parasitic beam antenna be increased?

- Use traps on the elements
- Use tapered-diameter elements
- Use closer element spacing
- Use larger diameter elements

Review Question 3

How can the bandwidth of a parasitic beam antenna be increased?

• Use traps on the elements

• Use tapered-diameter elements

• Use closer element spacing

• Use larger diameter elements

< Use larger diameter elements >

Review Question 4

If a parasitic element slightly longer than a horizontal dipole antenna is placed parallel to the dipole 0.1 wavelength away from it and at the same height, what effect will this have on the antenna's radiation pattern?

- The radiation pattern will not be affected
- A major lobe will develop in the horizontal plane, from the parasitic element, toward the dipole
- A major lobe will develop in the horizontal plane, parallel to the two elements
- A major lobe will develop in the vertical plane, away from the ground

Review Question 4

If a parasitic element slightly longer than a horizontal dipole antenna is placed parallel to the dipole 0.1 wavelength away from it and at the same height, what effect will this have on the antenna's radiation pattern?

• The radiation pattern will not be affected

• A major lobe will develop in the horizontal plane, from the parasitic element, toward the dipole

• A major lobe will develop in the horizontal plane, parallel to the two elements

• A major lobe will develop in the vertical plane, away from the ground

< A major lobe will develop in the horizontal plane, from the parasitic element, toward the dipole >

Review Question 5

Why is a 5/8-wavelength vertical antenna better than a 1/4-wavelength vertical antenna for VHF or UHF mobile operations?

- A 5/8-wavelength antenna is easier to install on a car
- A 5/8-wavelength antenna can handle more power
- A 5/8-wavelength antenna has more gain
- A 5/8-wavelength antenna has less corona loss

Review Question 5

Why is a 5/8-wavelength vertical antenna better than a 1/4-wavelength vertical antenna for VHF or UHF mobile operations?

- A 5/8-wavelength antenna is easier to install on a car
- A 5/8-wavelength antenna can handle more power
- A 5/8-wavelength antenna has more gain
- A 5/8-wavelength antenna has less corona loss

< A 5/8-wavelength antenna has more gain >

Review Question 6

What is an advantage of downward sloping radials on a ground plane antenna?

- It brings the feed point impedance closer to 300 ohms
- It lowers the radiation angle
- It brings the feed point impedance closer to 50 ohms
- It increases the radiation angle

Review Question 6

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< It brings the feed point impedance closer to 50 ohms >

Review Question 7

Which of the following transmission lines will give the best match to the base of a quarter-wave ground-plane antenna?

- 50 ohms coaxial cable
- 300 ohms balanced transmission line
- 75 ohms balanced transmission line
- 300 ohms coaxial cable

Review Question 7

Which of the following transmission lines will give the best match to the base of a quarter-wave ground-plane antenna?

- 50 ohms coaxial cable
- 300 ohms balanced transmission line
- 75 ohms balanced transmission line
- 300 ohms coaxial cable

<50 ohms coaxial cable >

Review Question 8

What is the main reason why so many VHF base and mobile antennas are 5/8 of a wavelength?

- It is easy to match the antenna to the transmitter
- It's a convenient length on VHF
- The angle of radiation is low
- The angle of radiation is high giving excellent local coverage

Review Question 8

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- The angle of radiation is low
- The angle of radiation is high giving excellent local coverage

< The angle of radiation is low >

Review Question 9

Approximately how long is the reflector element of a Yagi antenna for 28.1 MHz?

- 10.67 metres (35 feet)
- 2.66 metres(8.75 feet)
- 5.33 metres (17.5 feet)
- 4.88 metres (16 feet)

Review Question 9

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- 10.67 metres (35 feet)
- 2.66 metres(8.75 feet)
- 5.33 metres (17.5 feet)
- 4.88 metres (16 feet)

< 5.33 metres (17.5 feet) >

Don’t forget that the driven element for a Yagi is most commonly a half-wave dipole.

Review Question 10

What is one effect of increasing the boom length and adding directors to a Yagi antenna?

- Wind load decreases
- Gain increases
- SWR increases
- Weight decreases

Review Question 10

What is one effect of increasing the boom length and adding directors to a Yagi antenna?

- Wind load decreases
- Gain increases
- SWR increases
- Weight decreases

< Gain increases >

Review Question 11

What does “antenna front-to-back ratio” mean in reference to a Yagi antenna?

- The number of directors versus the number of reflectors
- The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction
- The relative position of the driven element with respect to the reflectors and directors
- The power radiated in the major radiation lobe compared to the power radiated 90 degrees away from that direction

Review Question 11

What does “antenna front-to-back ratio” mean in reference to a Yagi antenna?

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• The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction

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• The power radiated in the major radiation lobe compared to the power radiated 90 degrees away from that direction

< The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction >

Review Question 12

The spacing between the elements on a three-element Yagi antenna, representing the best overall choice, is of a wavelength.

- 0.50
- 0.75
- 0.20
- 0.10

Review Question 12

The spacing between the elements on a three-element Yagi antenna, representing the best overall choice, is of a wavelength.

- 0.50
- 0.75
- 0.20
- 0.10

< 0.20 >

Review Question 13

The impedances in ohms at the feed point of the dipole and folded dipole in free space are, respectively:

- 52 and 200
- 73 and 300
- 73 and 150
- 52 and 100

Review Question 13

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- 52 and 200
- 73 and 300
- 73 and 150
- 52 and 100

< 73 and 300 >

Review Question 14

What is a disadvantage of using an antenna equipped with traps?

- It may radiate harmonics more readily
- It is too sharply directional at lower frequencies
- It must be neutralized
- It can only be used for one band

Review Question 14

What is a disadvantage of using an antenna equipped with traps?

- It may radiate harmonics more readily
- It is too sharply directional at lower frequencies
- It must be neutralized
- It can only be used for one band

< It may radiate harmonics more readily >

Review Question 15

What is a cubical quad antenna?

• Four straight, parallel elements in line with each other, each approximately 1/2- electrical wavelength long

• Two or more parallel four-sided wire loops, each approximately one-electrical wavelength long

• A center-fed wire 1/2-electrical wavelength long

• A vertical conductor 1/4-electrical wavelength high, fed at the bottom

Review Question 15

What is a cubical quad antenna?

• Four straight, parallel elements in line with each other, each approximately 1/2- electrical wavelength long

• Two or more parallel four-sided wire loops, each approximately one-electrical wavelength long

• A center-fed wire 1/2-electrical wavelength long

• A vertical conductor 1/4-electrical wavelength high, fed at the bottom

< Two or more parallel four-sided wire loops, each approximately one-electrical wavelength long >

Review Question 16

What is a delta loop antenna?

• An antenna whose elements are each a three-sided loop whose total length is approximately one electrical wavelength

• A large copper ring or wire loop, used in direction finding

• An antenna system made of three vertical antennas, arranged in a triangular shape

• An antenna made from several triangular coils of wire on an insulating form

Review Question 16

What is a delta loop antenna?

• An antenna whose elements are each a three-sided loop whose total length is approximately one electrical wavelength

• A large copper ring or wire loop, used in direction finding

• An antenna system made of three vertical antennas, arranged in a triangular shape

• An antenna made from several triangular coils of wire on an insulating form

< An antenna whose elements are each a three-sided loop whose total length is approximately one electrical wavelength >

Review Question 17

Approximately how long is each leg of a symmetrical delta loop antenna driven element for 28.7 MHz?

- 3.5 metres (11.5 feet)
- 2.67 metres (8.75 feet)
- 7.13 metres (23.4 feet)
- 10.67 metres (35 feet)

Review Question 17

Approximately how long is each leg of a symmetrical delta loop antenna driven element for 28.7 MHz?

- 3.5 metres (11.5 feet)
- 2.67 metres (8.75 feet)
- 7.13 metres (23.4 feet)
- 10.67 metres (35 feet)

< 3.5 metres (11.5 feet) >

Remember that in the delta loop, like the cubical quad, the driven element is one full wavelength long. Each "leg" or side will then be 1/3 wavelength long. Again, IC forgot that the frequency was below 30 MHz. The correct answer is 3.32 m but give IC the answer they want "3.5 metres (11.5 feet)".

Review Question 18

Moving the feed point of a multi-element quad antenna from a side parallel to the ground to a side perpendicular to the ground will have what effect?

• It will change the antenna polarization from vertical to horizontal

• It will significantly decrease the antenna feed point impedance

• It will significantly increase the antenna feed point impedance

• It will change the antenna polarization from horizontal to vertical

Review Question 18

Moving the feed point of a multi-element quad antenna from a side parallel to the ground to a side perpendicular to the ground will have what effect?

• It will change the antenna polarization from vertical to horizontal

• It will significantly decrease the antenna feed point impedance

• It will significantly increase the antenna feed point impedance

• It will change the antenna polarization from horizontal to vertical

< It will change the antenna polarization from horizontal to vertical >

Review Question 19

The cubical “quad” or “quad” antenna consists of two or more square loops of wire. The driven element has an approximate overall length of:

- one wavelength
- three-quarters of a wavelength
- two wavelengths
- one-half wavelength

Review Question 19

The cubical "quad" or "quad" antenna consists of two or more square loops of wire. The driven element has an approximate overall length of:

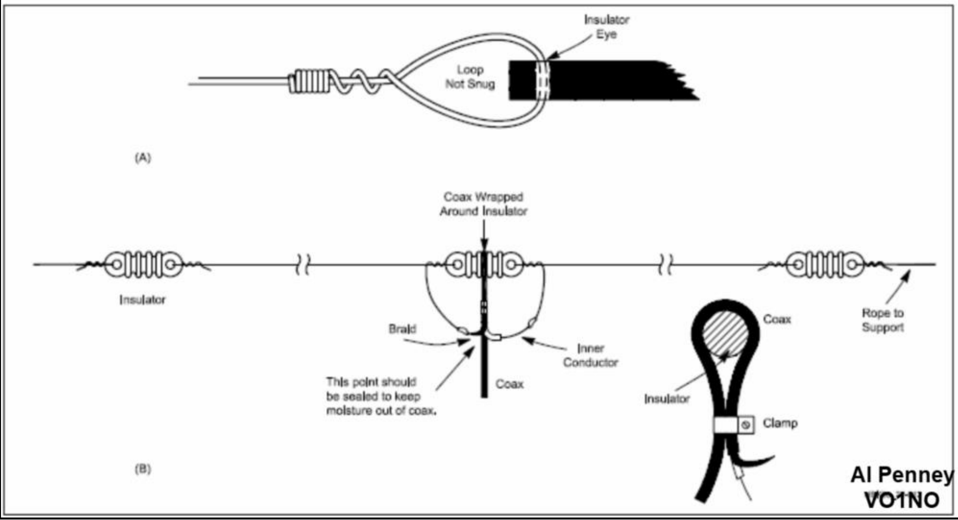
- one wavelength
- three-quarters of a wavelength
- two wavelengths
- one-half wavelength

< one wavelength >


Questions?


Practical Antenna Construction
Al Penney
VO1NO

Dipole Construction



HF dipole construction practical aspects

When constructing an HF dipole for amateur radio applications, or for any application, there are a few precautions that it is wise to follow.

•***Active length of antenna does not include wire looped back for securing:*** When mechanically securing the antenna wire to an insulator or other end point, the best way is often to take the wire through the insulator and wrap and then solder the wire around itself.

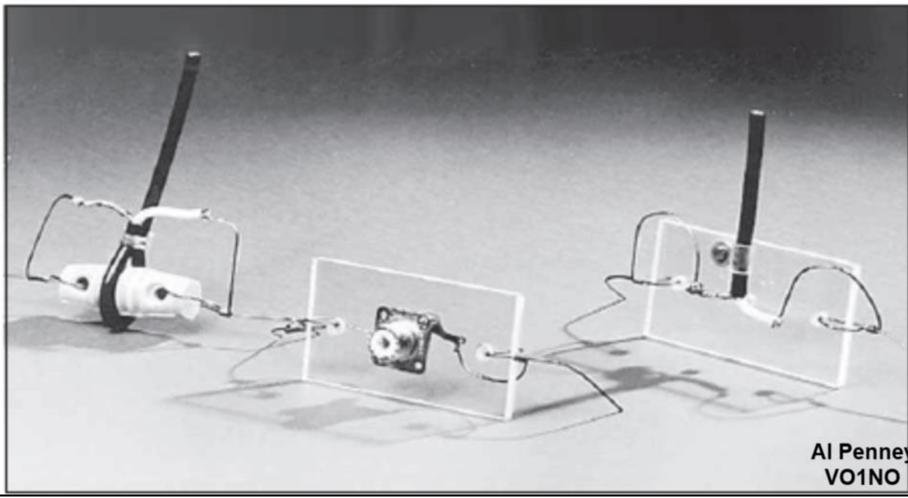
•When measuring the electrical or active length for the antenna, the section that is looped back is not included in the electrical length, and therefore the wire must be cut longer to accommodate this amount. This is in addition to the extra required so that the antenna can be pruned to the right length.

•***As high as possible:*** As with any antenna, it is best to install the HF ham band antenna so that it is as high as possible. This will help ensure that it can provide the best performance. It is surprising the improvement that raising an antenna gives - as it starts to clear the surrounding objects that ask the signal, it will receive and radiate far better.

•***Keep clear of other objects:*** As far as possible the HF ham band dipole antenna should be kept away from objects that could mask the signals being received and transmitted. In a domestic environment, this is not always possible, but a little planning and forethought can make the best of any installation.

•***Seal coax:*** If coaxial cable is to be used, it is essential that the top end is sealed. If not moisture can enter the cable and the loss will increase considerably. Coaxial cable is not cheap, and even a small amount of water ingress can degrade its performance. Even when the cable has dried out, the fact that water has been in there will cause oxidation of the braid screen, etc. and this will increase the loss quite considerably.

Center Insulator Options

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Commercial Center Insulators

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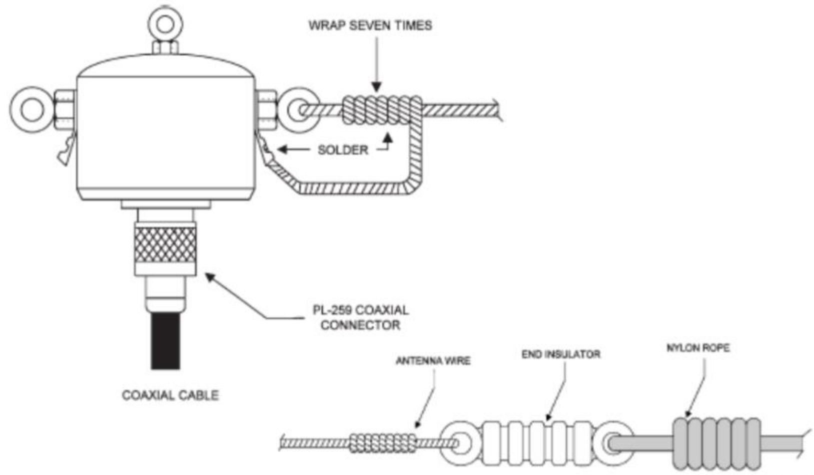
PVC Center Insulator



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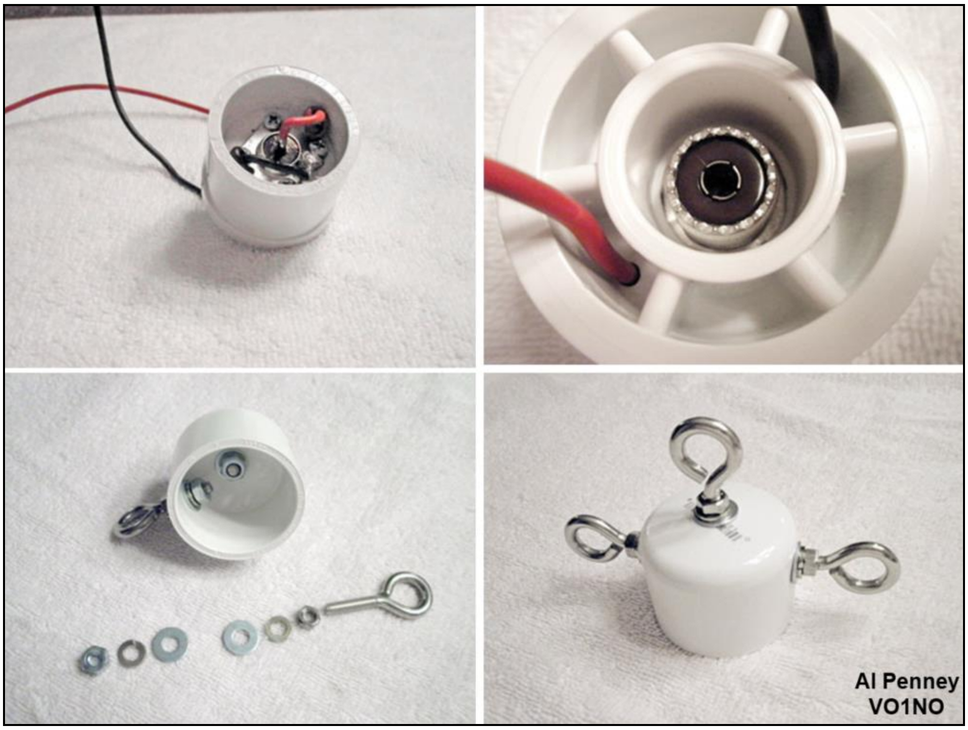


http://www.k4icy.com/dipoleconnector_cylinder.html

This is yet another alternative homebrew center connector for a wire dipole HF antenna. Yes, commercially available versions are cheap and easy, and you can make one out of a scrap piece of Plexiglass (R) but why not make a ***weather-proof*** one out of your scrap junk or cheap material from the home improvement store. This one will fit my requirements for a simple 40m wire dipole or inverted-V and will be compact, waterproof, fairly durable, plus has room for a current BALUN. ***- This will only cost about $12 in materials***!

Parts to be used:

1 - PVC End Cap, 1-1/2"

1 - PVC Reducer, 1-1/2" Pipe Diameter external body to 1/2" adapter

1 - SO-239 UHF Flange Mount Female Socket. Four mount holes in square flange.

1 - Screws, Pan Head Sheet Metal, #6 x 1/2" (or down to 1/4") Stainless if possible.

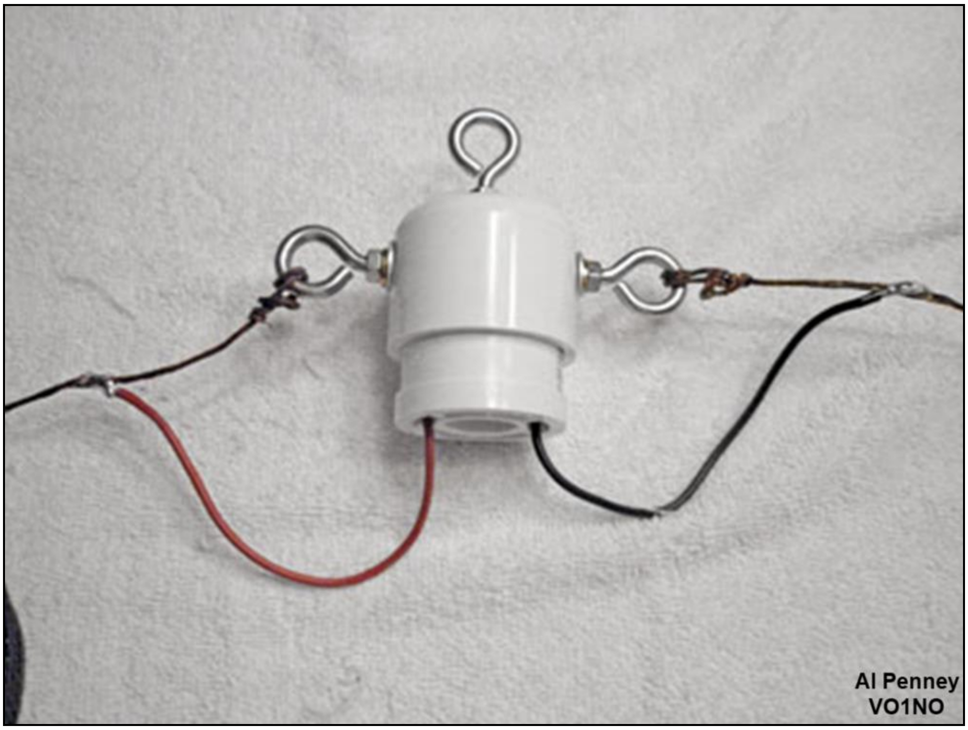
3 - Eye Bolts, Closed Loop, Bolt End 3/16" x 2" plus nylon lock washers or bolts, bolts, x 2 disc washers, lock washers. Course or Fine

threaded, Stainless where available.

10-14 gauge wire for connections.

PVC pipe cleaning fluid and cement.

Silicone long life weather proofing sealant.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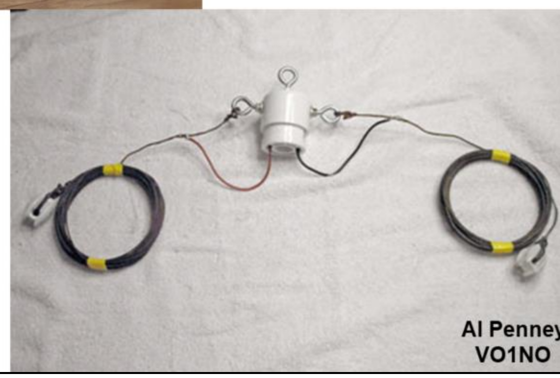
Purchased

Homebrew



Splicing Wire

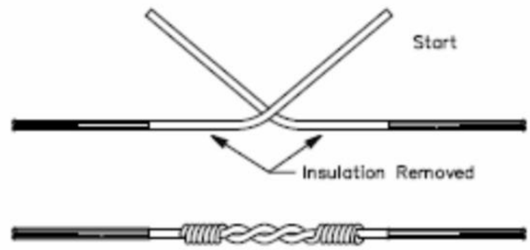


Fig 3—Correct method of splicing antenna wire. Solder should be flowed into the wraps after the connection is completed. After cooling, the joint should be sprayed with acrylic to prevent oxidation and corrosion.

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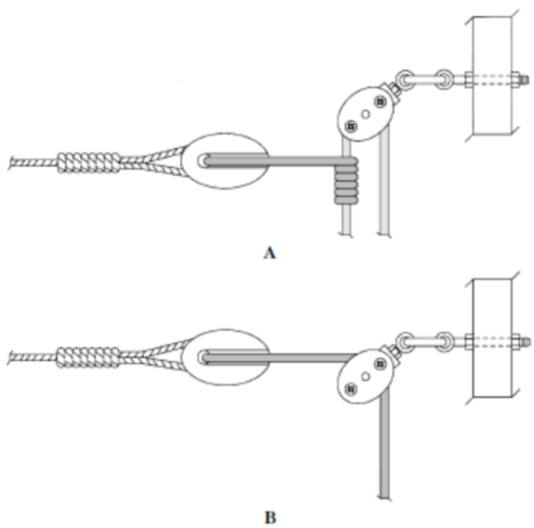
End Supports



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End Supports

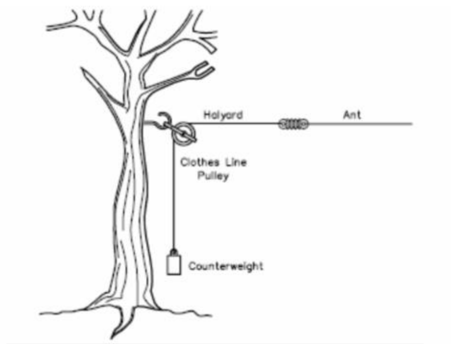
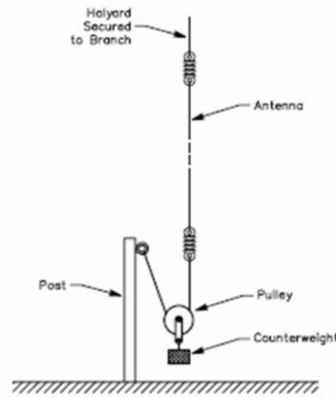


Fig 1—A method of counter weighting to minimize antenna movement and avoid its breaking from tree movement in the wind. The antenna may be lowered without climbing the tree by removing the counter-weight and tying additional rope at the bottom end of the halyard. Excess rope may be left at the counter-weight for this purpose, as the knot at the lower end of the halyard will not pass through the pulley.



g 5—Counterweight for a vertical antenna suspended om an overhanging tree branch.

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Passing a Line Thru Trees

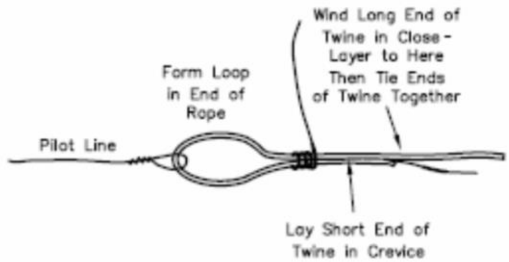

Fig 2—In connecting the halyard to the pilot line, a large knot that might snag in the crotch of a tree should be avoided, as shown.

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Homebrew Mast

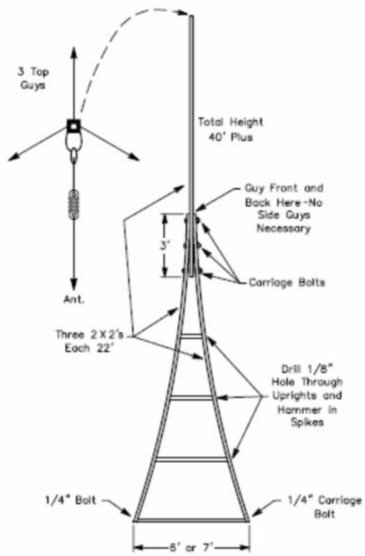

Fig 7—The A-frame mast is lightweight and easily constructed and erected.

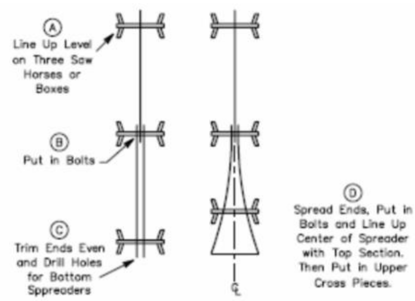

Fig 8—Method of assembling the A-frame mast on sawhorses.

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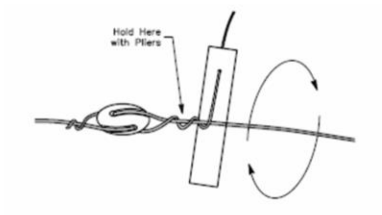

Fig 9—Simple lever for twisting solid guy wires when attaching strain insulators.

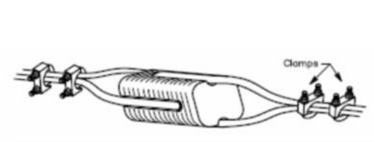

Fig 10—Stranded guy wire should be attached to strain insulators by means of standard cable clamps made to fit the size of wire used.

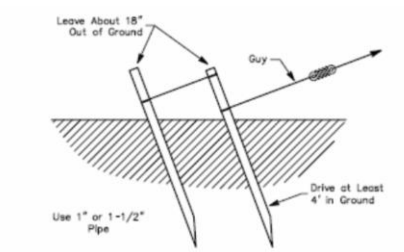

Fig 11—Driven guy anchors. One pipe is usually sufficient for a small mast. For added strength, a second pipe may be added, as shown.

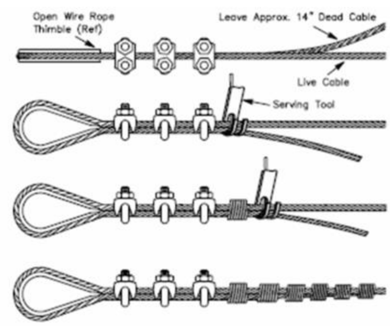

Fig 25—Traditional method for securing the end of a guy wire.

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Gin Pole

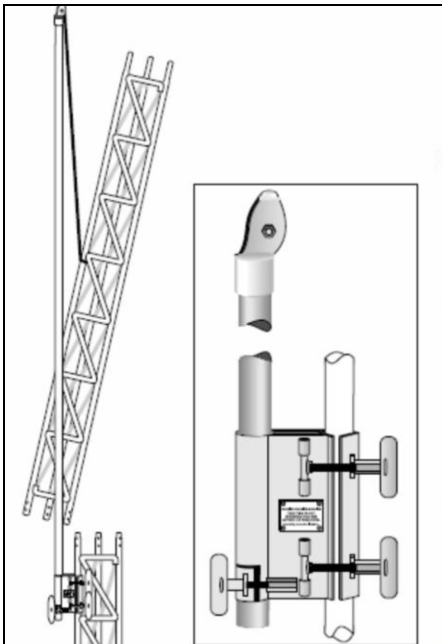

Fig 21—Drawing of Rohn "Erection Fixture" EF2545, also known commonly as a "gin pole."

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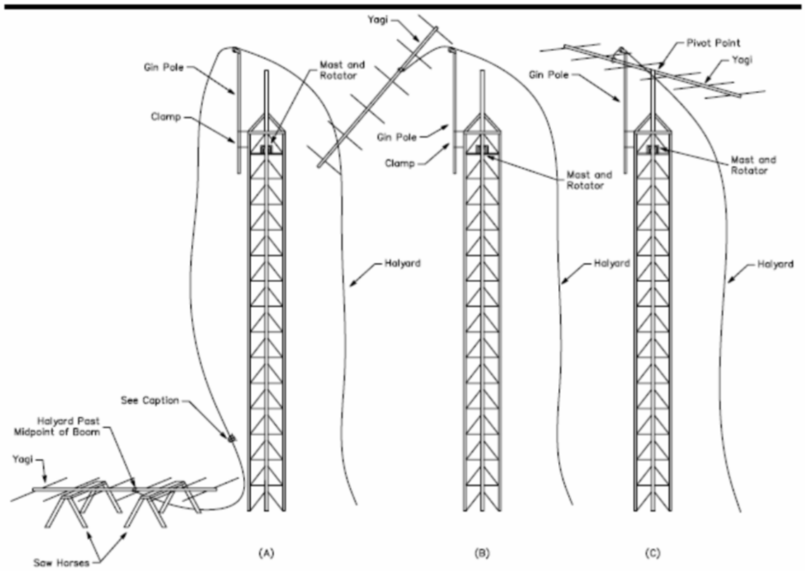

Fig 33—Raising a Yagi antenna alongside the tower. At A the Yagi is placed in a clear area, with the boom pointing toward the tower. The halyard is passed under the elements, then is secured to the boom beyond the midpoint. B shows the antenna approaching the top of the mast. The person on the tower guides it after the lifting rope has been untied from the front of the antenna. At C the antenna is pulled into a horizontal position by the ground crew. The tower worker inserts the pivot bolt and secures it. Note: A short piece of rope is tied around the halyard and the boom at the front of the antenna to stabilize the beam as it is being raised. The tower worker removes it when the boom reaches him at the top of the tower.

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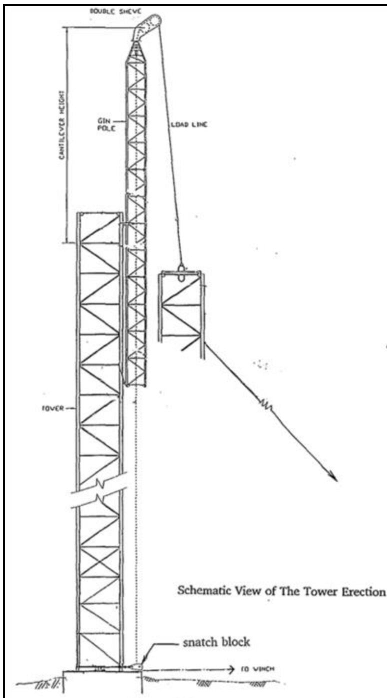
Snatch Block



Schematic View of The Tower Erection

Figure 1.5

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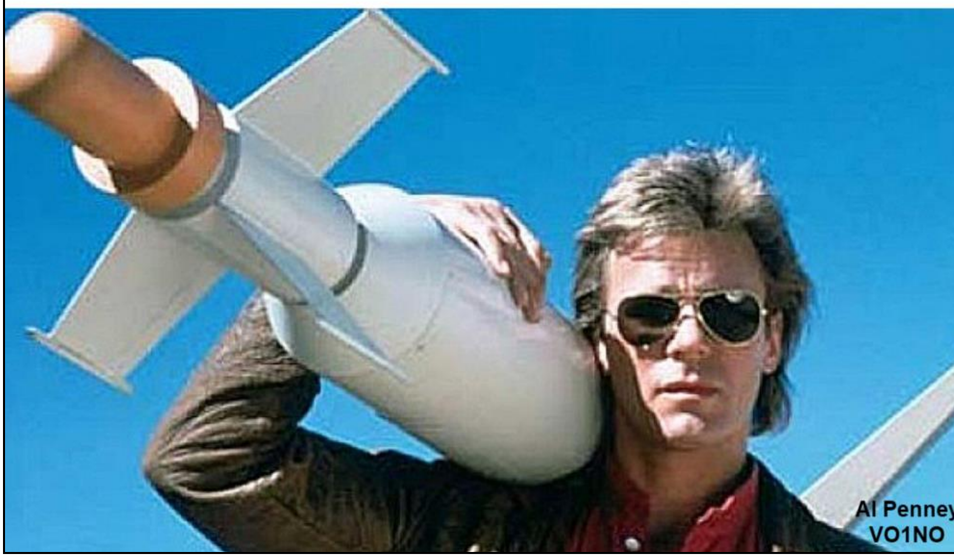
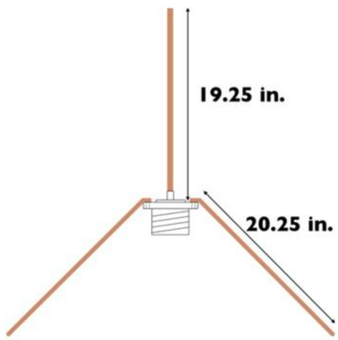
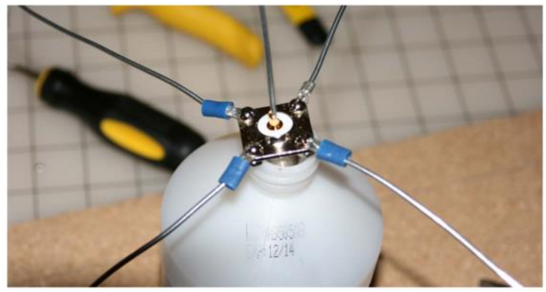
Field Expedient Antennas
DELTA GEAR
INSULATOR
INSULATOR
ANTENNA WIRE
ANTENNA WIRE
INSULATORS
GROUND STAKE
GROUND STAKE
Al Penney
VO1NO

or
"How to Macgyver an Antenna"!



2M ¼ λ Vertical





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VHF/UHF Vertical with BNC

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Use Coax as a Support

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Above: I needed a quickie quarter-wave ground plane antenna cut for the UHF bands but made with available parts laying around. An SO-239 chassis connector with coat hanger radiating element and ground radials soldered as shown. The RG-8/U 50 ohm coax connects to it via an PL-259 connector, a vent pipe and some tape makes it happen. I can receive UHF SATCOM signals with this, especially the ones lower on my horizon. Gain is good if you can get it, simple can work. Nothing original here.

For small **quarter wave** VHF/UHF ground plane antennas, working in centimeters is convenient:

L=7120/F

Vertical element approximate **L**ength (in centimeters) = 7120/**F**(mc).
(Or L=2808/F when working in inches)
Make the radials about 5% longer, sloping downward about 45 degrees makes the feedpoint pretty close to 50 ohms.

Coat hanger wire works well in a pinch, it it usually lacquer or paint coated so it will not rust in the near-term. Another good material is TIG welding rod. “Harbor Fright” sells 3/32″ TIG rods, type ER4043. About $1.00 each, they fit inside the female contact of an SO-239 coax connector. They work well. Below are some 1/8″ TIG rods for a bigger connector diameter installation.

Wire Ground Plane Antenna

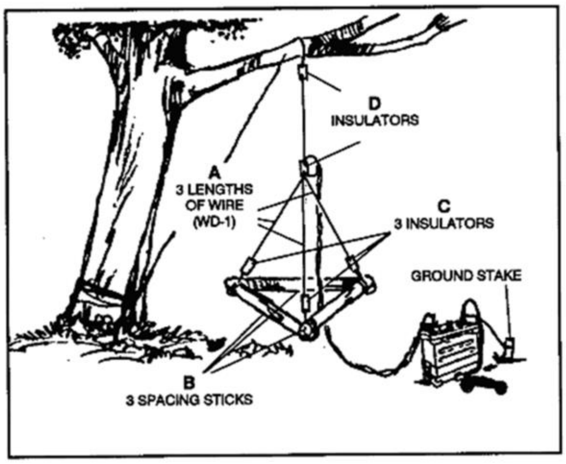
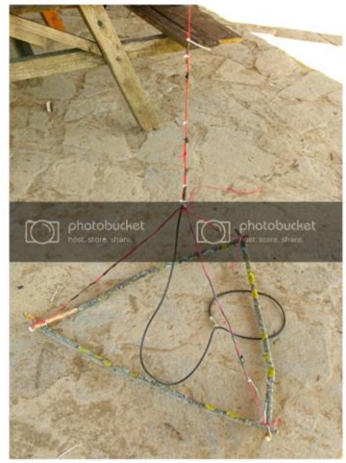


Figure 7-13. Expedient 292-type antenna.



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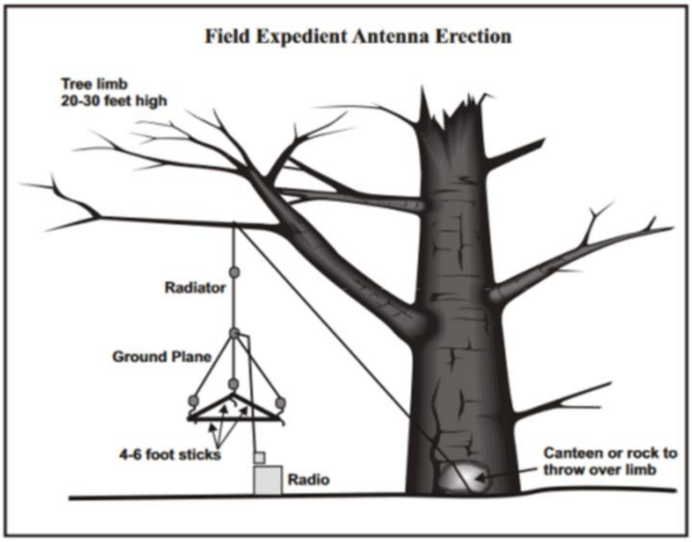
Wire Ground Plane Antenna



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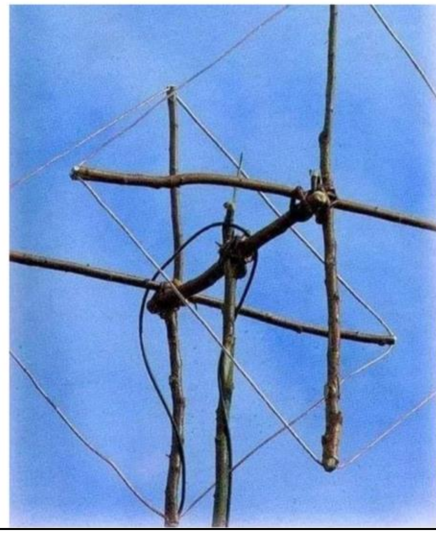
Field Expedient Cubical Quad



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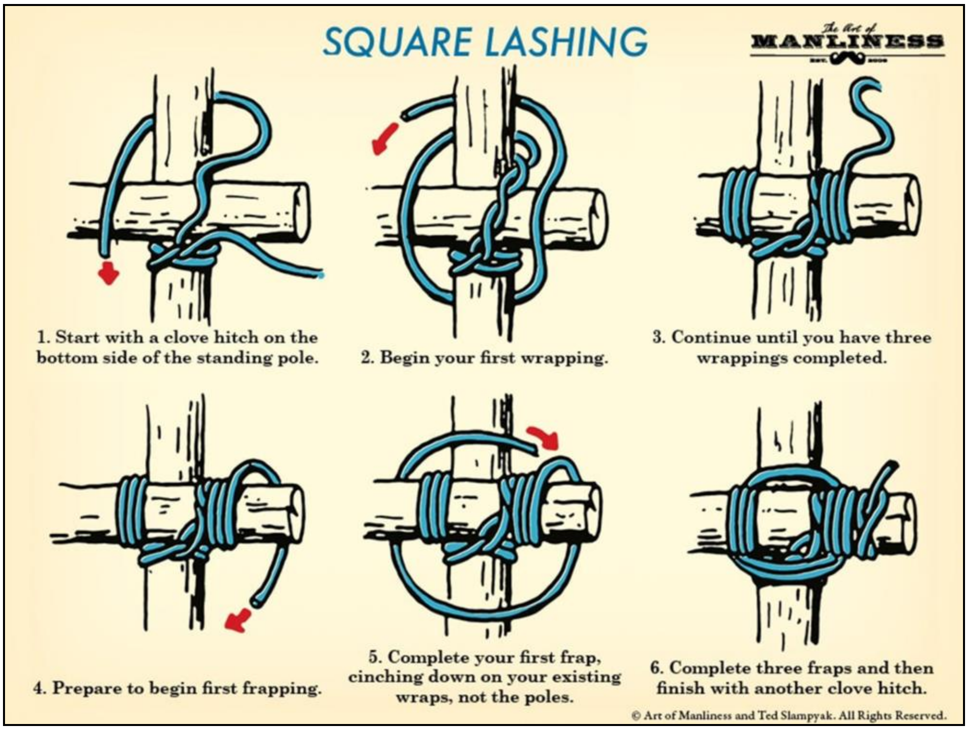
SQUARE LASHING
The Art of MANLINESS
1. Start with a clove hitch on the bottom side of the standing pole.
2. Begin your first wrapping.
3. Continue until you have three wrappings completed.
4. Prepare to begin first frapping.
5. Complete your first frap, cinching down on your existing wraps, not the poles.
6. Complete three fraps and then finish with another clove hitch.
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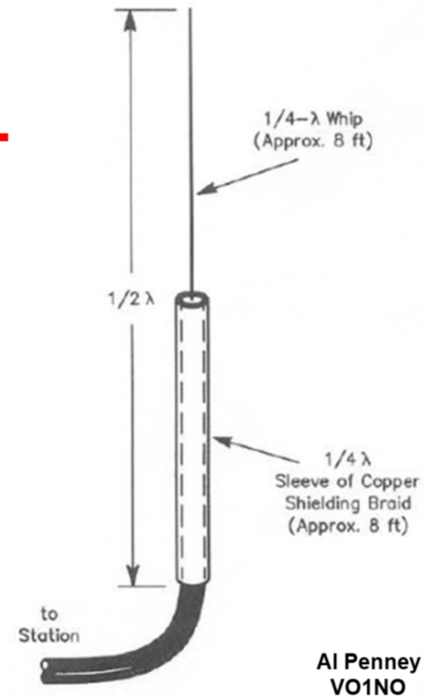
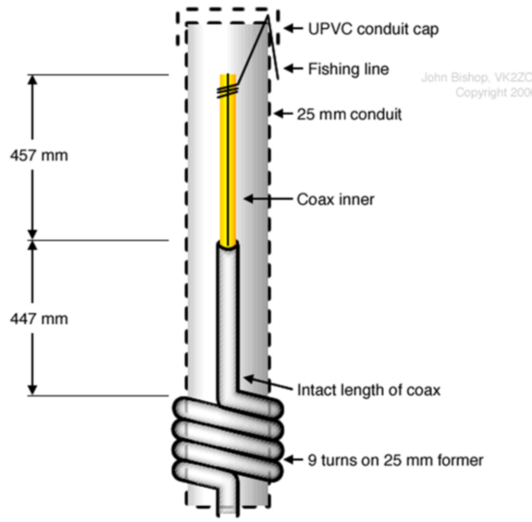
Sleeve Dipole

- Strip 1/4 λ outer insulation off end of coax. Do not cut braid!
- Loosen braid and fold back over coax.
- Consider an RF choke in coax immediately below the braid sleeve.



Even Easier Vertical Dipole!



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General Purpose Center Insulator

Here's another dipole center insulator built with scrap plastic and connectors: Connect the coax connector center pin to one screw terminal, the other goes to the chassis connector "ground". Cheap, simple, lightweight, obvious.

Another Center Insulator

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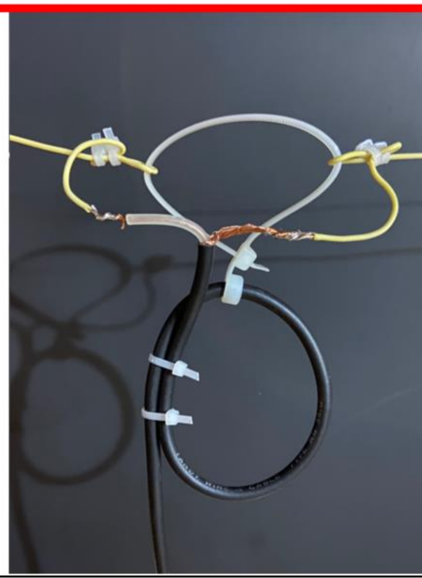
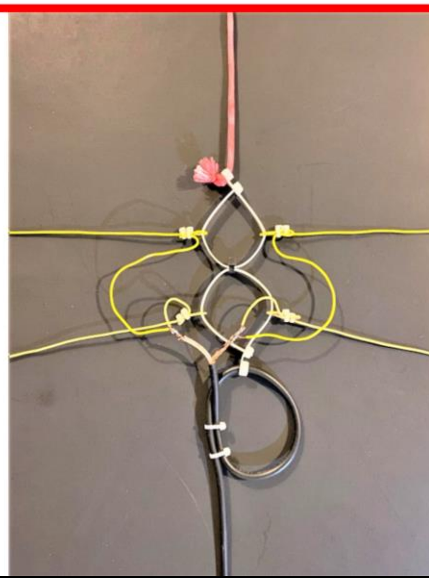
Above: Another off-the-shelf expedient, a Pomona 1296 shown here, or the preferred Pomona 1452 (female) BNC/Banana terminal adapter. The female Pomona 1452 (NSN 6625-00-102-5652) is preferred for a dipole fed by RG-58/U coax with an existing BNC male connector already attached. Otherwise you will need a “BNC double barrel” adapter as shown above.

This can work well and is simple and small. However the coaxial cable can pull out of the BNC cable connector if the feedline is too long/heavy. The feedline may need some strain relief at the connector for long runs back to the radio.

Zip Tie Center Insulator



Zip Tie Center Insulator



Multi-band dipole

Antenna Wire

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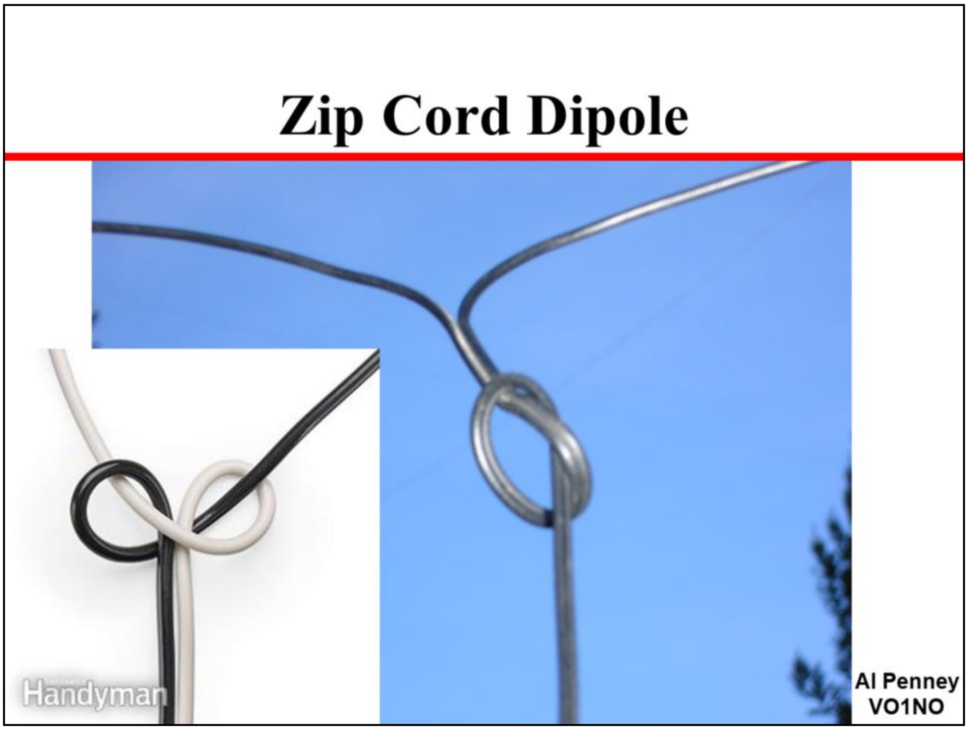
In an emergency, any wire of sufficient length can be used for an antenna; for example, barbed wire, electrical wire, fence wire, and metal-cored clothesline. Communication has been successful using metal house gutters and even metal bed springs. A radio operator's mission is not completed until communication is established.



Above: On the go? Only have some WD-1A/TT infantry field commo wire, speaker wire or Zip cord for your dipole? What could be simpler? Just unzip the leg lengths you want, tie an overhand knot to keep the feed line portion from further unzipping, hang it up.
No center insulator available or needed for low power operation? The wire insulation itself does the job.

Assuming the feed point looks like, say, 72 ohms and you are feeding it from a 20 watt transmitter, the voltage here between the legs = 38 volts RMS. No problem for this insulation. At 100 watts it is only 85 volts, again no problem. WD-1A/TT wire insulation is rated at 1000 volts RMS (MIL-DTL-49104C) per conductor, so you are not going to arc it over when operating the antenna at its resonant frequency. You can also use lamp "zip cord", speaker wire, demo wire etc.

Or rig it vertically for VHF ops with other vertically polarized VHF stations in your Net. In either case, run the feed line away from the antenna at 90 degrees for at least a quarter wave if you can (for a more "textbook" omnidirectional radiation pattern).

Field Expedient Insulators

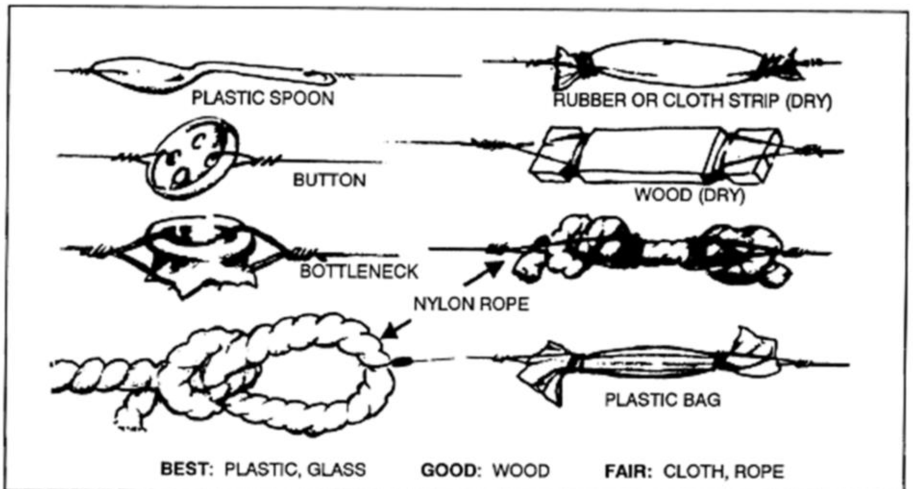


Figure D-15. Expedient insulators.

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Field Expedient Insulators

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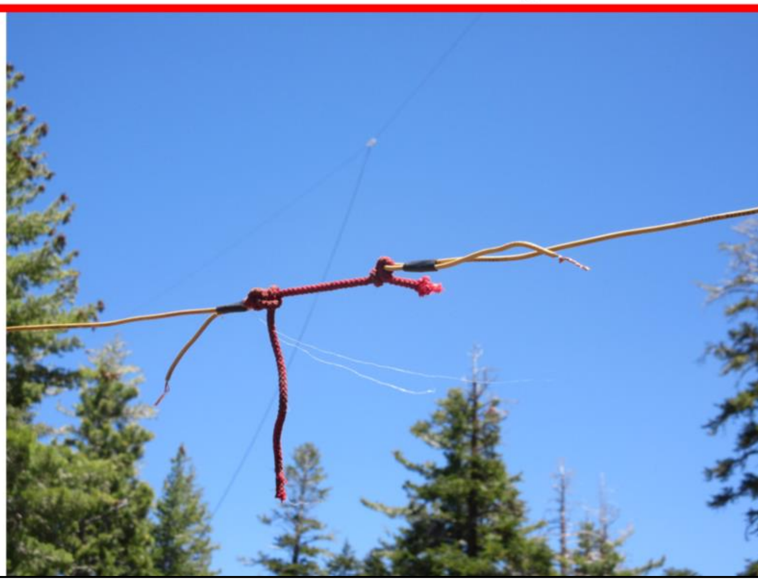
Dipole or other wire-end expedient insulators? Because the highest voltages on a wire antenna are at the far end(s). Insulators? You've read the manual; Below:

For HF wire antennas, plastic spoons from C-Rats or MRE's can work if they are all you have. They are not very strong but they illustrate the concept of field-expediency. Better to just cut the "handle" off and use only that part, see below. Best to melt the holes, say with a hot nail rather than trying to puncture them with a knife, the thin plastic splits easily. You get the idea, this is all common-sense stuff.

As a practical matter, end insulators like these are really not even needed for a low powered HF field set. A 20 watt transmitter will not arc over at the antenna end or de-tune even if you are just using dry 550 cord holding up bare antenna wire. Or even just the insulation of field commo wire or similar. You don't really need much insulation for the antenna to work at low power levels from say a PRC-104, 150 or even a PRC-47. It's just good engineering practice and appropriate to highlight in a Field Manual used for training.

Multi-Band Dipoles



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Another field expedient below: We were operating an 80 meter dipole in the boonies but needed to make comms on 60 meters. No problem. Cut the dipole legs for the 60 meter (or other higher) freq and reattach the remaining wire via an expedient insulator to isolate the remaining length. One for each of the 2 dipole legs. You can "re-jump" these insulators by twisting the wires together to go back to 80 meters.

Another Insulator!

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A good field expedient antenna must first start with a good antenna design. Or at least you should be willing to accept (**and understand the reasons for**) potentially marginal performance. The expedient part is based upon availability of materials but you have to start with a good design.

The standard DIY reference for military and civilian antennas is the ARRL Antenna Book (Reference 45). Full of tried and proven antennas for a range of frequencies of interest from LF, HF, VHF, UHF and beyond. The designs are based upon solid engineering but backed up by solid measurements and practical, proven performance in a real environment.

The US Marine Corps Antenna Handbook is also excellent and practical. (Reference 88)

Start there if you are new to this stuff! Read them a few hundred times. Learn, Practice, Evaluate, Experiment, Communicate!

Run what you brung. Improvise, adapt, overcome.

Another Use For Water Bottles

Speaking of water bottles, see that innocuous water bottle up on the roof? Look closely at the center ridge tile – see the wire? I used the plastic bottle (with a little water in it) to sling and insulate one end of a dipole antenna up on the roof of the NCO Club at Camp San Luis Obispo, CA. On 7050 KC I used it to work station K6KPH over 200 miles north of here with a GRC-109 running 10 watts on this end. No one the wiser. The ubiquitous plastic water bottle makes a handy antenna insulator or lanyard heaving weight with the addition of a little sand or water.

Vertical Antenna

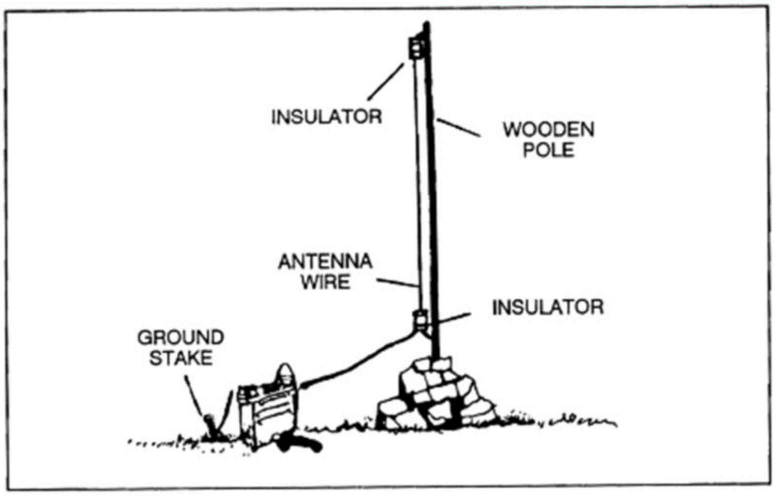

Figure D-14. Using field wire as an emergency whip.

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Broken Whip?

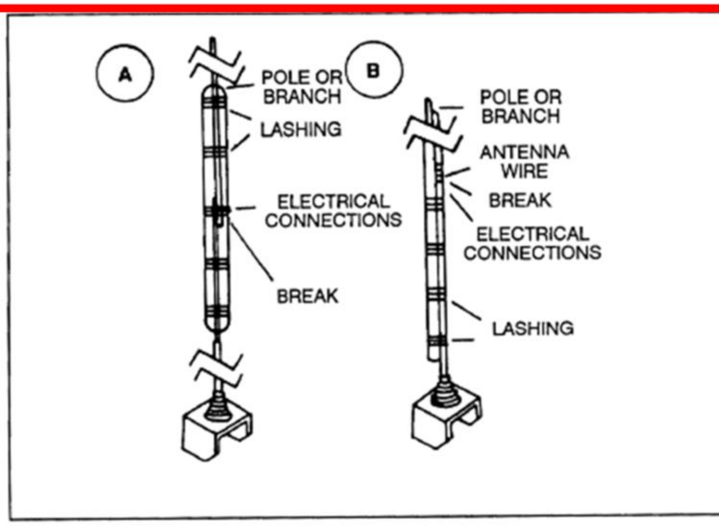

Figure D-13. Using broken sections for emergency repair.

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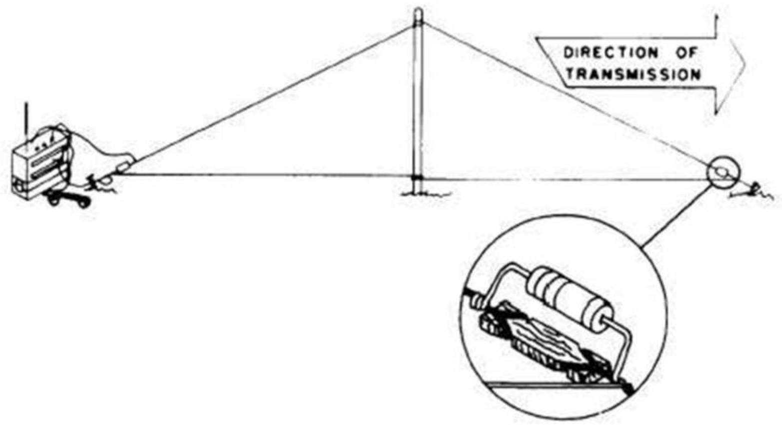
VHF Vertical Half Rhombic



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To build a unidirectional vertical half-rhombic antenna, terminate the far end with a resistance to ground. See below. (Without the resistor the antenna is bidirectional.)

The termination resistor value should nominally be around 600 ohms connected from the far end of the single wire, to ground. Connect the "ground end" of the resistor to either a ground stake, a counterpoise wire as shown, or both. ARRL Antenna Book (Reference 45), Field Radio Techniques, FM24-18. (Reference 87), USMC Antenna Handbook, (Reference 88).

Field Expedient Resistor

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Don’t have a 600* ohm non-inductive resistor? Just the basic stuff you might have at a field site? Improvise, adapt, overcome.

Here’s how you can make a termination resistor with these “field expedient” parts:

A 500mL bottle of water, a pinch of salt from your MRE, 2 feet of WD-1A/TT field phone wire and a ground stake (screw terminal optional). The salted water is conductive and dissipates RF power as a resistor.

Split the conductors apart, strip off about 6 inches of insulation from each wire, immerse them in the salted water. Keep the bare wires as far apart as you can; don’t let them touch each other.

Field Expedient Resistor

Connect one resistor wire to the far end of the antenna wire, the other resistor wire to the ground stake. This makes it electrically in parallel with the insulator.

The de-painted aluminum stake anchors the antenna end/insulator (MRE spoon in this example) via a short cord and the stake also serves as the ground point. Pour the remainder of the salt (or more if you have some) in a little hole, fill with water, keep it wet, done.

For a more efficient or more permanent system you could connect a few ground radials to the stake and/or run a ground wire from the stake, under the antenna, back to the transmitter chassis ground terminal per the above sketch.

As installed at the end of a vertical half-rhombic, (or as it might be at each leg of a VEE beam array.)

The termination resistor should be able to dissipate about one-half of the transmitter rated output power. (The other half is radiated.) This water bottle resistor should easily handle a 10-20 watt CW set or a 100 watt low duty-cycle SSB transmitter. Ideal for a vertical half-rhombic used with a tactical VHF FM radio.

For those with an Engineering inclination, take advantage of the very high

Specific Heat of water. Dissipating 12 watts of continuous RF power will raise the temperature of 500 mL of water from 20 degrees C to 40 degrees C (68 to 104 degrees F) in 1 hour. (Assumes insulated bottle, it's not). Scale accordingly. You're good-to-go.

Of course the above example is not well engineered or tested on a network analyzer or an instrumented antenna test range. (However, end-terminated vertical half-rhombic antennas are well engineered, tested and proven.) *This is a field expedient.*

Second-order effects? Yes. Geometry is somewhat random, the DC resistance (VOM) will be different than the AC/RF resistance, there will be some reactance, the end-impedance of a practical wire antenna is probably not 600 ohms, the wires will eventually corrode, bottled water has random minerals in it, water will slowly evaporate etc.

But with very basic items you may have available in the field, it will work. It will get you some forward gain and some rejection of back-azimuth signals. (Like jamming, enemy SIGINT, co-channel interference deconfliction etc.). You get the idea.

Field Expedient Resistor

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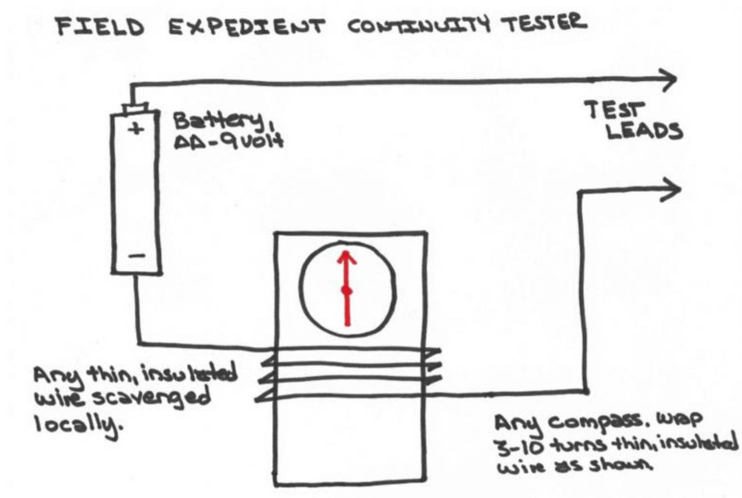
In this example, it took just a half-pinch of salt in 500 mL of water, “shaken, not stirred” to get near 600 ohms. If you have one, you can test the resistance with a VOM, that’s somewhat legit. Season to taste. It does not have to be very precise. (Add a little more salt if you need it to be 300 ohms.) Close enough for a ship this size.

No Coax? No Problem!

Above: You brought your complete field antenna kit but you just arrived at these coord's – and your comm window starts in 8 minutes. No time to rig a coax-fed dipole. So rig a Hasty Dipole; just the two dipole legs connected directly to the radio Antenna and Ground terminals, no transmission line. With resonant quarter wave length wires off into the trees, it tunes to full power with this 10 watt TRC-77 at a lakeside surveillance site. Here after working a mobile outside Glacier National Park in Montana on CW, 450 + miles away on 7050 kc, mid-day. It works great. Quick and easy.

Continuity Checker



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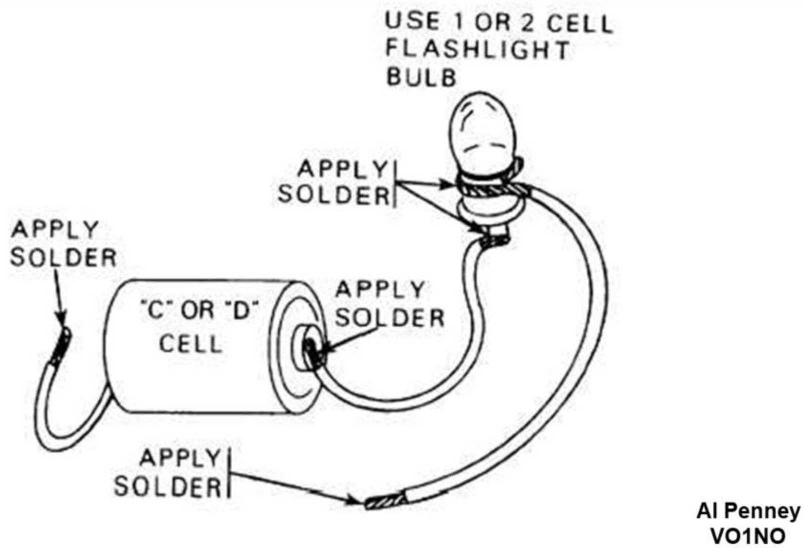
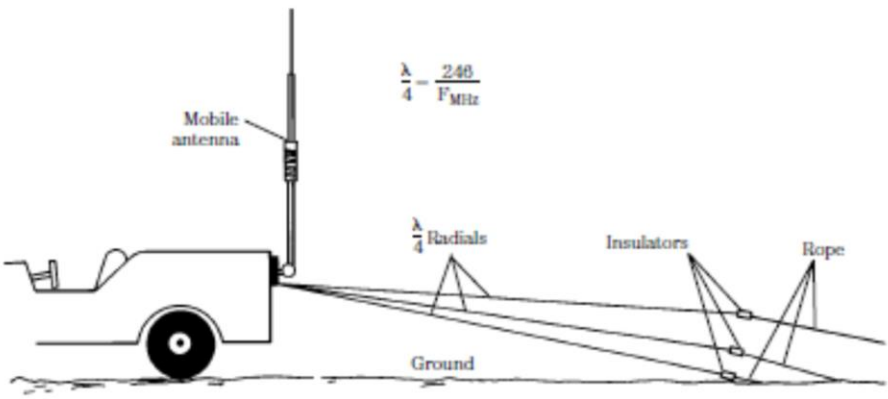
Continuity Checker



A continuity checker can be made from a flashlight bulb, flashlight battery, and three pieces of wire.
When the free ends of the wires are touched to a circuit where continuity (or a short) exists, the bulb will glow. If a two-cell flashlight bulb is used with only one battery, the bulb will glow with one-half its normal brilliance.

Improved Mobile Whip



25-5B Multiple radials are even better.

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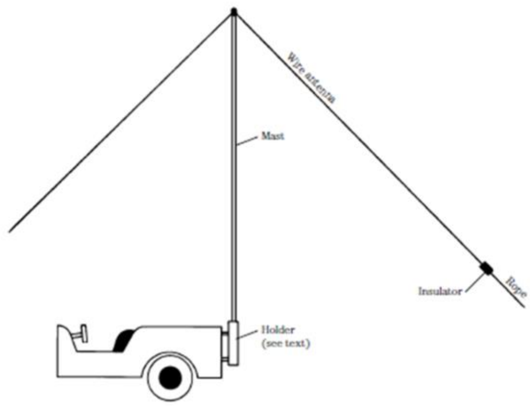
Towing Hitch



25-7 Portable inverted-vee antenna.

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Questions?
DELTA GEAR
INSULATOR
INSULATOR
ANTENNA WIRE
ANTENNA WIRE
INSULATORS
GROUND STAKE
GROUND STAKE
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DX'pedition to Pouch Cove NL to try to get across the Atlantic on the 2M band.

Assembling the long boom 2M antenna used for the backup system.

The backup 2M antenna pointed towards Europe.

Fred VE1FA assembling the receive preamplifier and associated relays at the rope yagi's feedpoint.

Raising the 30 meter long rope yagi.

Notice how long the rope yagi is!

Antenna: Yagi, with 43-horizontal elements: 1 reflector, 1 driven, 41 directors, suspended and aligned on 2 strands of Kevlar cord 60 cm apart.

Length = 30 meters (Reflector to Director #41)
Height = 6 to 8.5 meters above ground (ground slopes toward ocean).
Uses taller, non-metallic front support. Antenna is horizontal.
Azimuth (bearing) = 62° (centered on Ireland!)

Feedpoint Z = 50 Ω, ferrite 5-choke balun
SWR =1.15
Forward gain = **23.9 dBd**
F:B ratio = 32dB
F:S ratio >25 dB (270°)

Main lobe takeoff angle = 4.5°,
Beam (main lobe)width = 15.6° at -3dBpoints
Beam vertical thickness = 4.7° at -3dB points

Driven with 750W, the ERP in the center of the major lobe will be about **150 kW** assuming element geometry is reasonably accurate.

Here are the technical details of the antenna. To avoid any interaction with the antenna, the top of the forward support tower will be non-metallic. We have calculated that the minus 3 dB horizontal beamwidth will be 15.6 degrees, while the vertical beamwidth will be 4.7 degrees. The main lobe takeoff angle will be 4.5 degrees.

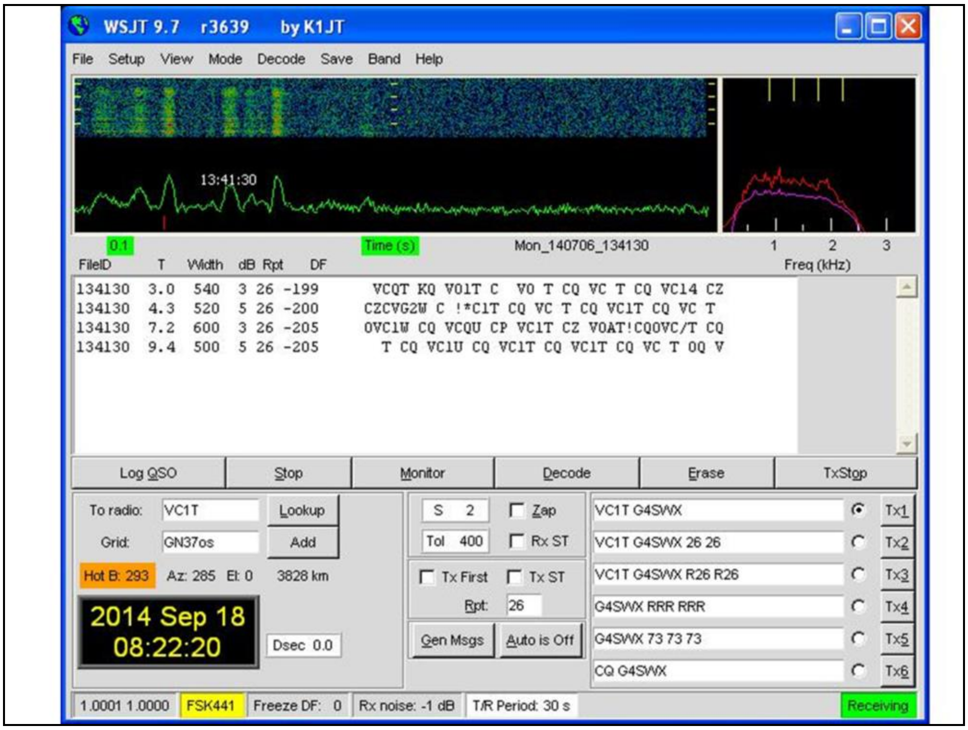
The calculated gain of the antenna is 23.9 dB over a dipole. When driven with 750 watts, the maximum output permitted under Canadian regulations, the center of the main lobe will have an effective radiated power of 150 kilowatts.

Our calculations indicate that within reasonable limits, increasing the height of the antenna would have little impact on the gain or takeoff angle of the main lobe.

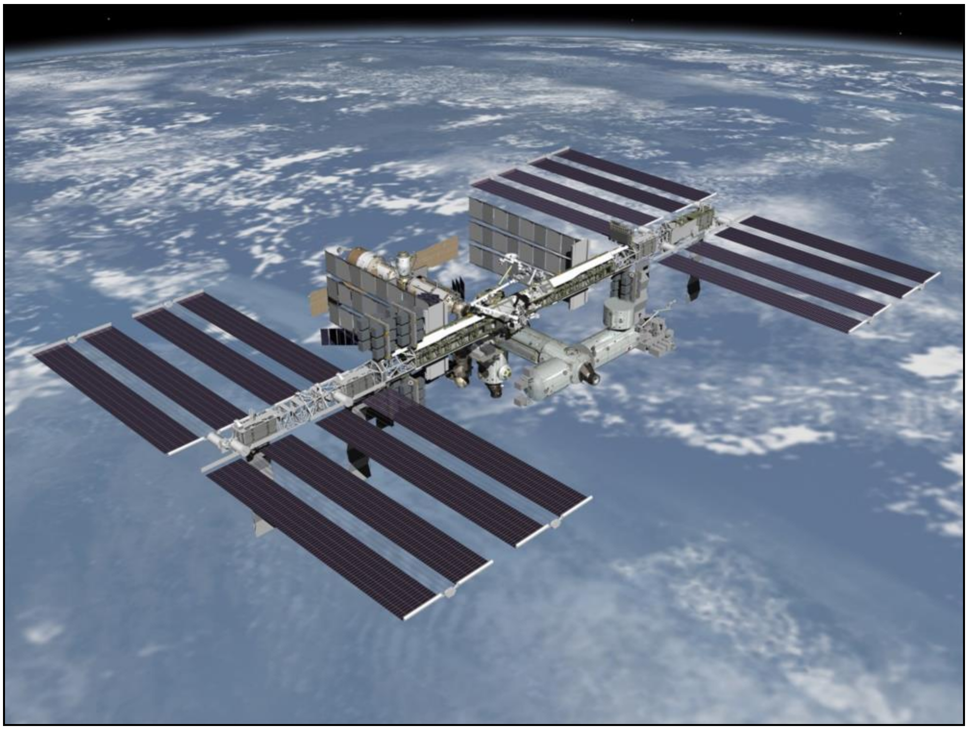
Enjoying Indonesian food for supper!

We conducted a moonbounce (EME) QSO with G4SWX to confirm that the backup station was working well.

The Larcan amplifier.



Our transmission was copied by G4SWX in England!



But, unfortunately, it was reflected off the ISS, and so was not a terrestrial propagation mode.

There is always a pot of gold at the base of an antenna!