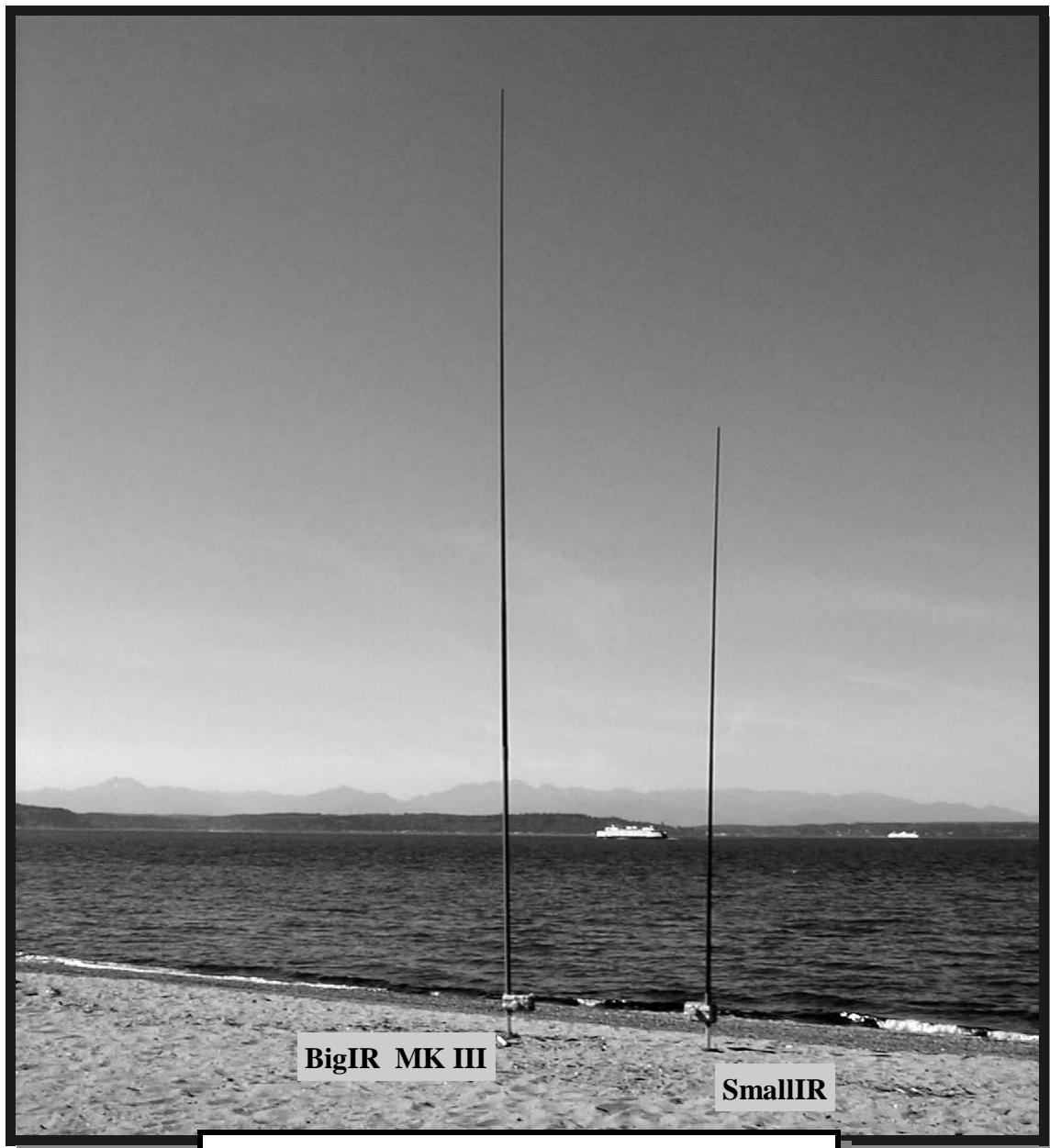


# ***SteppIR*** <sup>TM</sup> ***Antenna Systems***

**Yagi • Dipole • Vertical** (Patented)

## ***SmallIR***

### ***Vertical - Instruction Manual***



**BigIR MK III**

**SmallIR**

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## SteppIR - Why Compromise?

The SteppIR antenna was originally conceived to solve the problem of covering the six ham bands (20m, 17m, 15m, 12m, 10m and 6m) on one tower without the performance sacrifices caused by interaction between all of the required antennas.

Yagis are available that cover 20 meters through 10 meters by using interlaced elements or traps, but do so at the expense of significant performance reduction in gain and front to back ratios. With the addition of the WARC bands on 17m and 12m, the use of interlaced elements and traps has clearly been an exercise in diminishing returns.

Obviously, an antenna that is precisely adjustable in length while in the air would solve the frequency problem, and in addition would have vastly improved performance over existing fixed length yagis. The ability to tune the antenna to a specific frequency, without regard for bandwidth, results in excellent gain and front to back at every frequency.

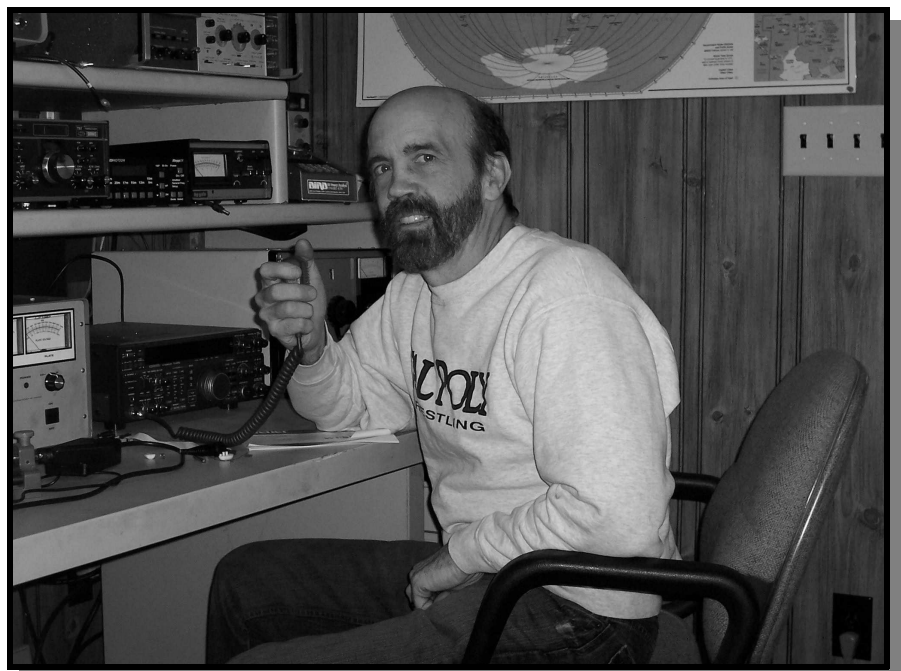
The SteppIR design was made possible by the convergence of determination and high tech materials. The availability of new lightweight glass fiber composites, Teflon blended thermoplastics, high conductivity copper-beryllium and extremely reliable stepper motors has allowed the SteppIR to be a commercially feasible product.

The current and future SteppIR products should produce the most potent single tower antenna systems ever seen in Amateur Radio! We thank you for using our SteppIR antenna for your ham radio endeavors.

Warm Regards,

*Mike Mertel*

*Michael (Mike) Mertel - K7IR  
President*

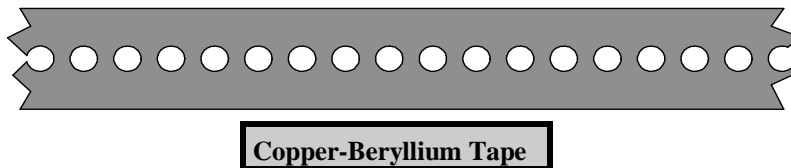


## SteppIR Design

Currently, most multi-band antennas use traps, log cells or interlaced elements as a means to cover several frequency bands. All of these methods have one thing in common—they significantly compromise performance. The SteppIR™ antenna system is our answer to the problem. Resonant antennas must be made a specific length to operate optimally on a given frequency.

So, instead of trying to “trick” the antenna into thinking it is a different length, or simply adding more elements that may destructively interact, why not just change the antenna length? Optimal performance is then possible on all frequencies with a lightweight, compact antenna. Also, since the SteppIR can control the element lengths, a long boom is not needed to achieve near optimum gain and front to back ratios on 20 - 10 meters.

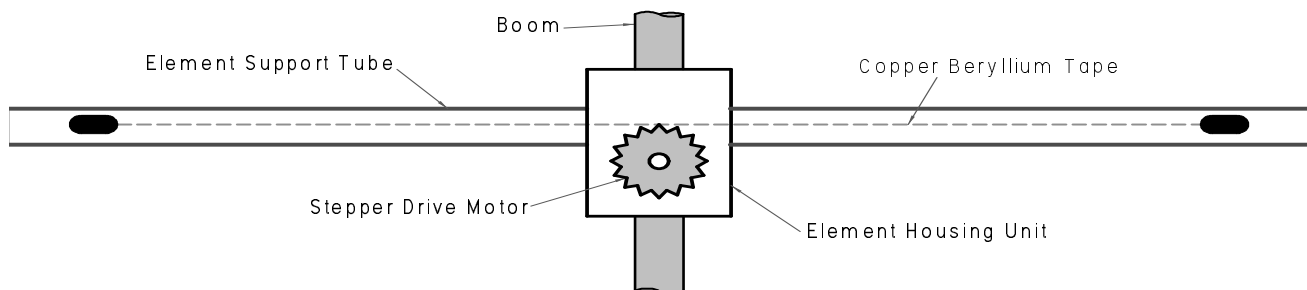
Each antenna element consists of two spools of flat copper-beryllium tape conductor (.54” Wide x .008” Thick) mounted in the element housing unit. The copper-beryllium tape is perforated to allow a stepper motor to drive them simultaneously with sprockets. Stepper motors are well known for their ability to index very accurately, thus giving very precise control of each element length. In addition, the motors are brushless and provide extremely long service life.



The copper-beryllium tape is driven out into a hollow fiberglass elements support tube (see below), forming an element of any desired length up to the limit of each specific antenna model (a vertical uses only one side). The fiberglass elements support tubes (poles) are telescoping, lightweight and very durable. When fully collapsed, each one measures approximately 48” in length. Depending on the model, they may be additional extensions added to increase the overall element length.

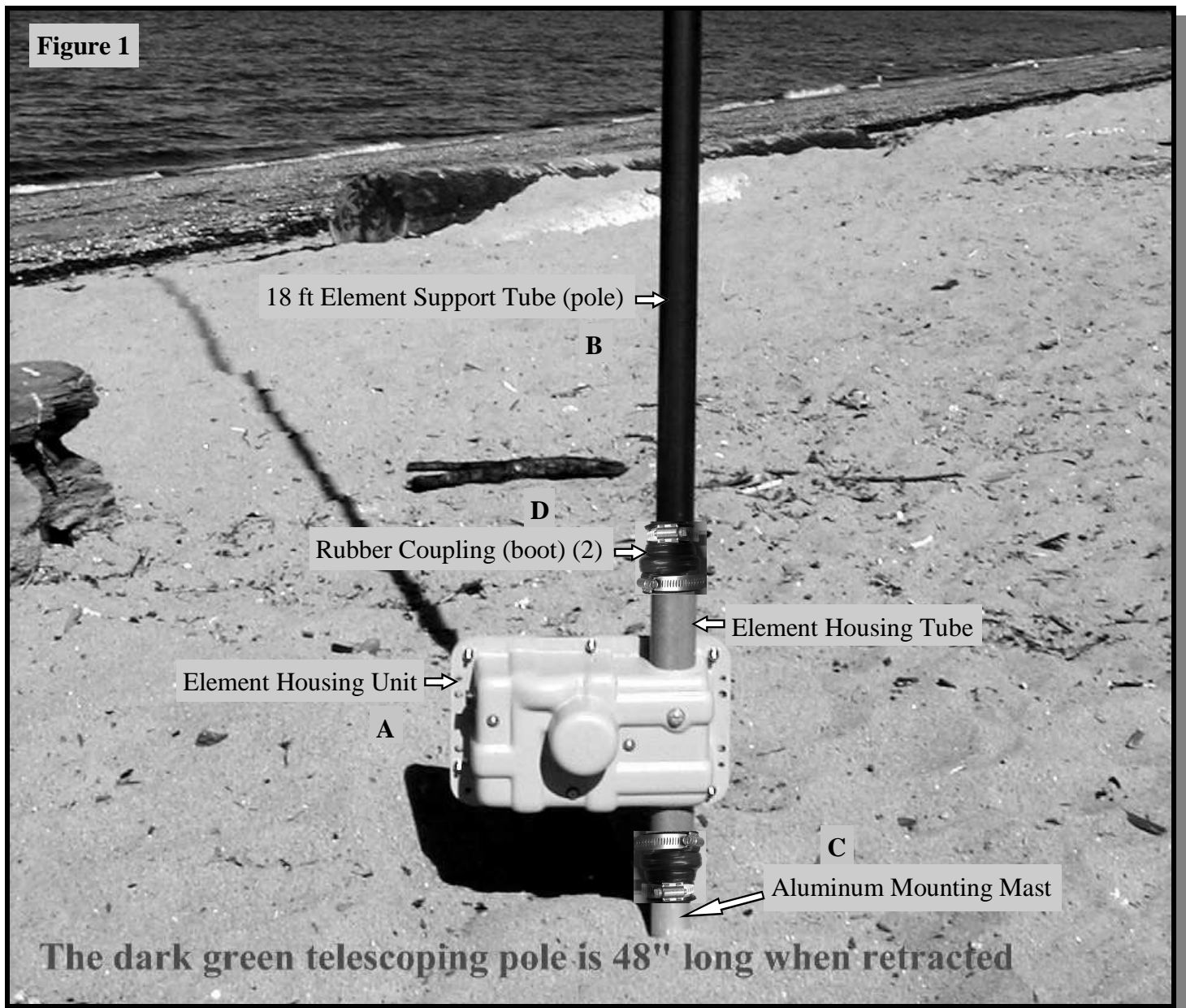
The ability to completely retract the copper-beryllium antenna elements, coupled with the collapsible fiberglass poles makes the entire system easy to disassemble and transport.

The antenna is connected to a microprocessor-based controller (via 22 gauge conductor cable) that offers numerous functions including dedicated buttons for each ham band, continuous frequency selection from 40m to 6m (depending on the model). There are also 17 ham and 6 non-ham band memories and you can select a 180° direction reversal\* or bi-directional\* mode and it will adjust in just about 3 seconds (\* yagi only).



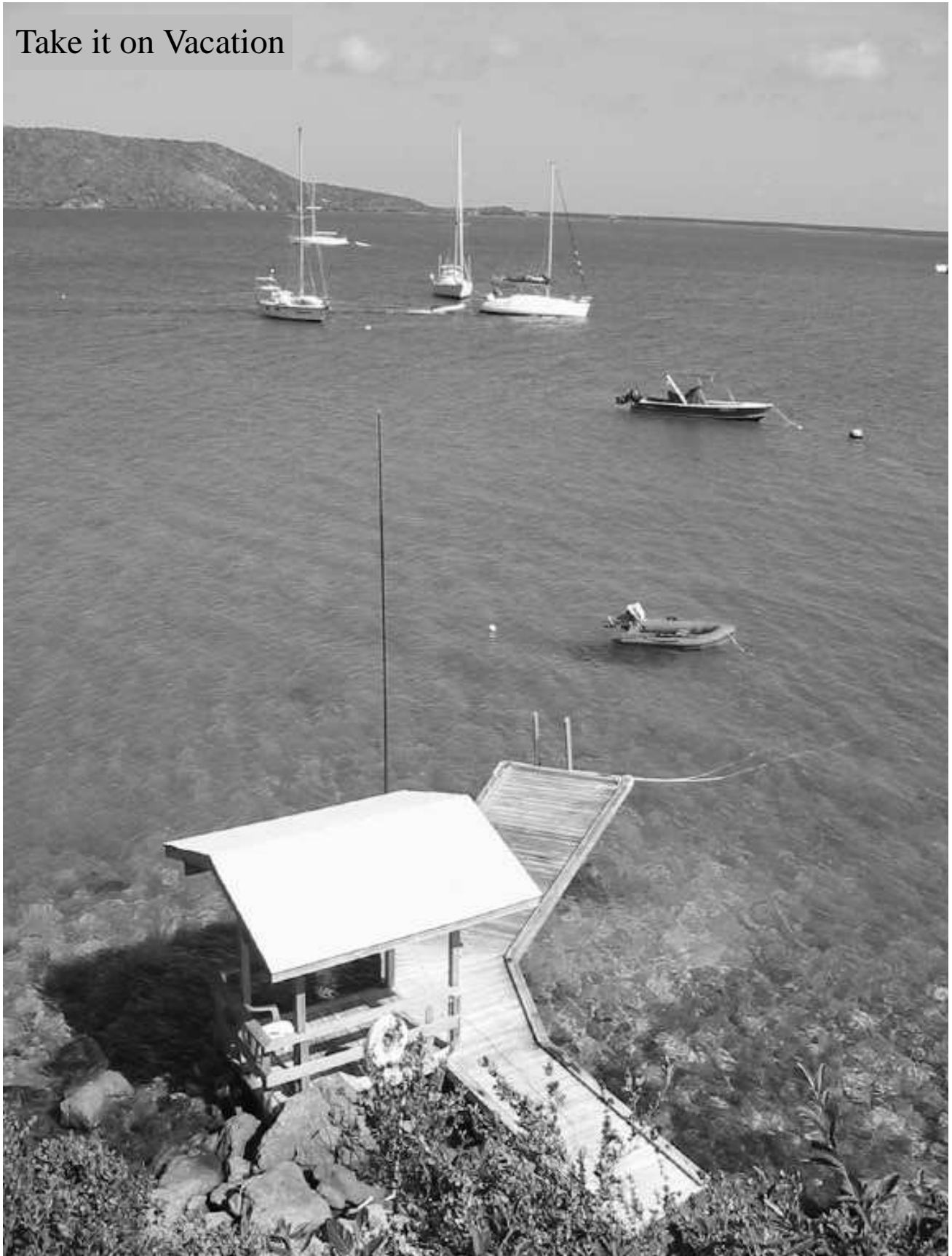
## Installing the SmallIR Vertical

Figure 1



- A: Element Housing Unit (EHU)
- B: 18' Telescoping Fiberglass Pole (EST)
- C: 24" x 1.5" OD Aluminum Mounting Mast
- D: Rubber Coupling (boot) (2)

Take it on Vacation



## Prepare the Telescoping Fiberglass Element Support Tubes

Locate:

- One fiberglass telescoping poles (**Component B, Figure 1**)
- One roll of black electrical tape
- One 10' roll of black silicone self-curing tape
- Your tape measure

**Note:** The stainless steel reinforcing rings on the first two pole sections provide extra strength in potential high wind conditions.

**Warning:** Check all four sections of the pole for packing popcorn or any other foreign object that could interfere with the copper tape movement. Do not remove the black foam plug from the tip of the fourth (small) section. This is a ventilation filter.

Telescope the pole to its full length by pulling each section out **firmly** in a twisting motion until it is extended as far as possible. **Each segment is tapered and should lock securely in place when fully extended.** The pole must be at least 17 feet 8 inches in length as measured from the butt (large) end of the pole to the tip. If the pole comes up a little short (1/2" to 1") try collapsing the pole and starting over, this time aggressively "jerk" each section out instead of twisting. The pole cannot be damaged and you may gain a minimum of 1/2" or more. If you have trouble collapsing the pole try carefully striking one end on a piece of wood or other similar surface placed on the ground.

At the factory when we quality check the poles to verify that they meet minimum length we hold the butt (large) end and whip it like we were casting a fishing pole with considerable force. This procedure can produce a significant difference in the extended length of some poles as a last resort if nothing else works.

**DO BE CAREFUL !!!**

Next wrap each joint on the fiberglass poles with the all weather electrical tape (**Figure 3**). Each joint should have at least the full width of the tape on both sides of the joint. Use common sense on the amount of tape or you will not have enough of the silicon tape used later to cover the electrical tape.

**Exception:** On joints with reinforcing rings, the tape must continue further so it extends at least 3/4" beyond the metal ring and onto the fiberglass pole.



**Figure 3**



Figure 5

The new silicone tape is now **BLACK**

Apply one complete wrap of electrical tape around the fiberglass tube as you begin, and then work your way across the joint and back using half overlap wraps, **so that the entire area is seamlessly covered as shown in Figure 3**. Carefully stretch and smooth the tape with your finger as you apply, and especially when you change directions - this will help avoid ripples and have the tape lie as smoothly as possible. At the end of the run, cut the tape with a knife or scissors and press the end onto the pole. Then run your hand over the tape a couple of times to firm up the bonding.

## Recommended Lengths for Silicone Tape Wrapping

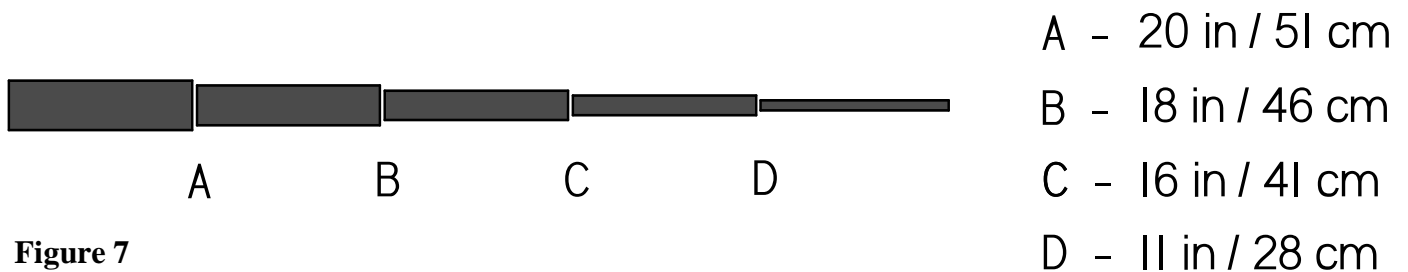


Figure 7

Next, you will weatherproof and UV protect each joint with the black self-curing silicone tape (**Figure 5**). **It is important that you pre-cut the silicone tape to the recommended lengths.** If you do so, you will have more than enough for each joint. Refer to **Figure 7** for proper lengths for each joint.



**IMPORTANT:** Per the manufactures specifications the silicone tape has a shelf life of 12 months before it is used and should be stored in a cool, dry environment.

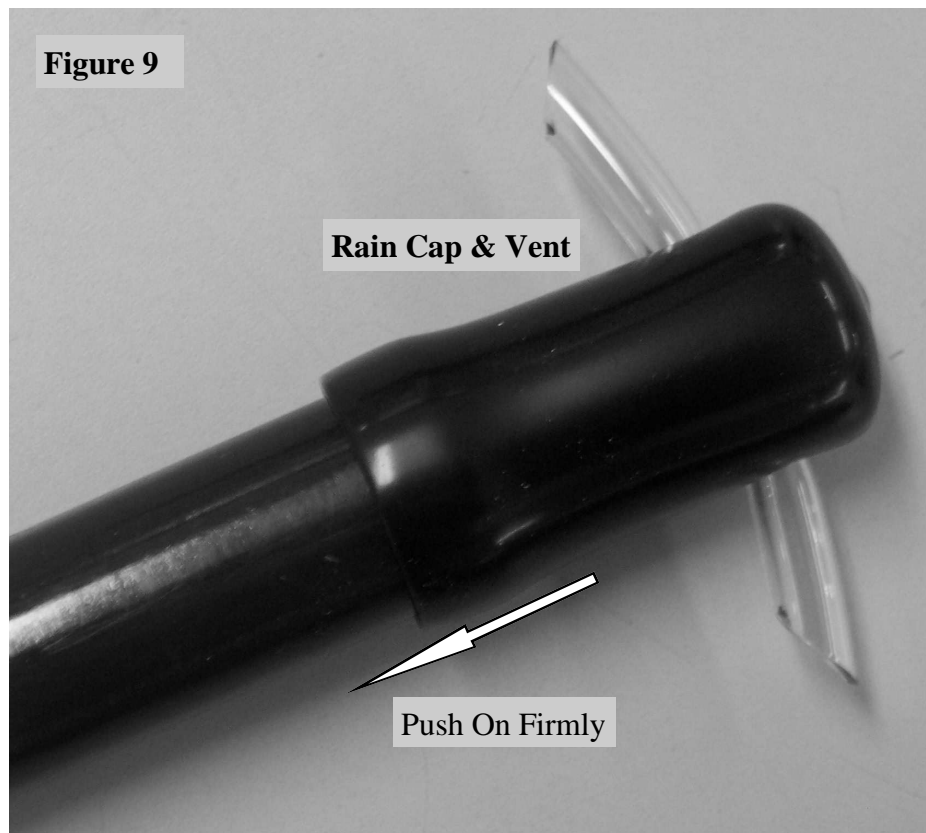
**Silicone tape will only bond to itself.** Be sure to remove the entire connector protector residue from your hands before handling silicone tape, as that residue will cause the silicone wrap not to adhere to itself in places. Take care to keep the silicone wrap free of dirt or debris. Also, this tape **MUST** be cut. Do not tear it. Wash your hands before completing the following steps.

**You will need to stretch the silicone tape approximately 100 % its original length as you wrap the joints. This will activate its ability to bond to itself forming a secure water proof seal.**

Position the black silicone wrap about 1/2" to the right of the black electrical tape and wrap one layer completely around the pole so the tape fully overlaps itself. Then slowly wrap the silicone tape to the left using half overlap wraps, extending about 1/2" beyond the black tape. When you reach the end, wrap one layer completely around the pole so the tape fully overlaps itself just as you did at the beginning of the wrap. If you are stretching the tape correctly you will get about two layers of tape at each joint. As before, carefully stretch and lay the tape down as smooth as possible.

## **Installation of the Rain Cap**

On the tip of the pole you will install a black cap (**Figure 9**) with a piece of tubing passing through it. The purpose of this vent cap is to keep the rain out, yet still allow air flow through the foam plug into the telescoping pole.



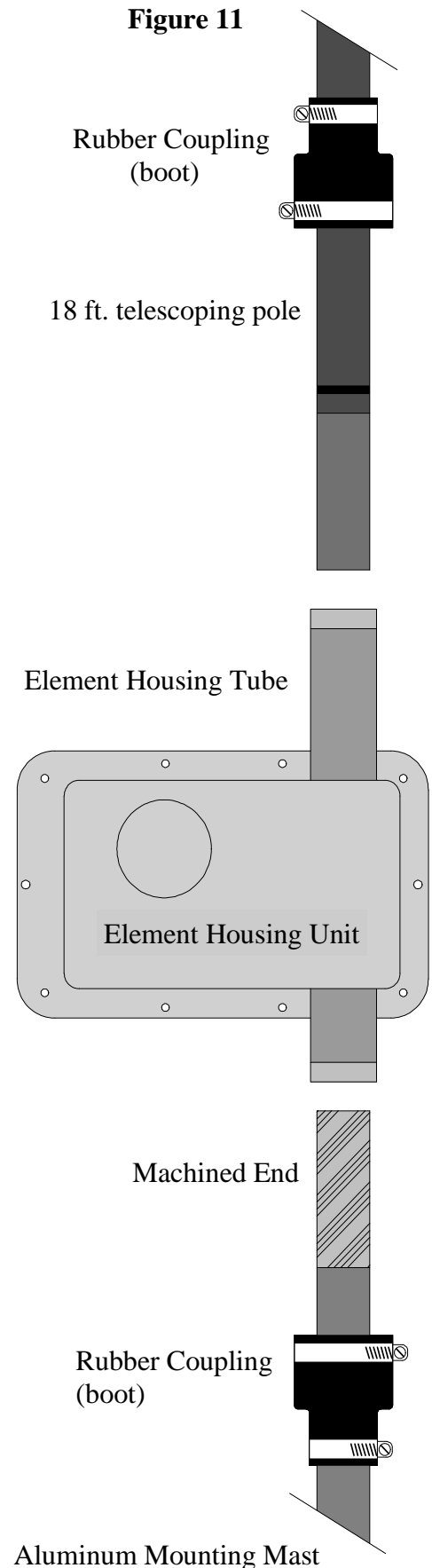
## Assemble the Antenna:

- You can lay the element housing unit on the ground flat on it's side or install it on its mounting mast before installing the 18 ft. telescoping pole.
- For ground mounting you will want to ensure that the mounting pole (included) does not shift or settle over time, using concrete to secure it in the ground is a way to eliminate the potential for this problem. Position the mounting pole (machined end up) so that the bottom of the element housing is 6 inches above the ground (**Figure 15**). After the mounting post is in place and level, you are ready to erect your SteppIR Vertical!
- A rubber boot must be installed (small end first) on the 1-1/2" mast (ground or elevated mount) before mounting the element housing unit on the mast (**Figure 11**). After the EHU is mounted on the mast push the rubber boot up onto the EHT firmly until it bottoms out against the edge of the EHT and tighten the two clamps. This boot will prevent the antenna from turning on the mast.
- Install a rubber boot on to the 18 ft. telescoping (**Figure 11**) pole before you insert it into the element housing tube. The small end of the boot goes on the pole first about 8" up from the butt.

Note: The telescoping pole can be mounted to the element housing unit first if you choose and the fully assembled antenna can then be mounted on the mast (**Figure 17**).

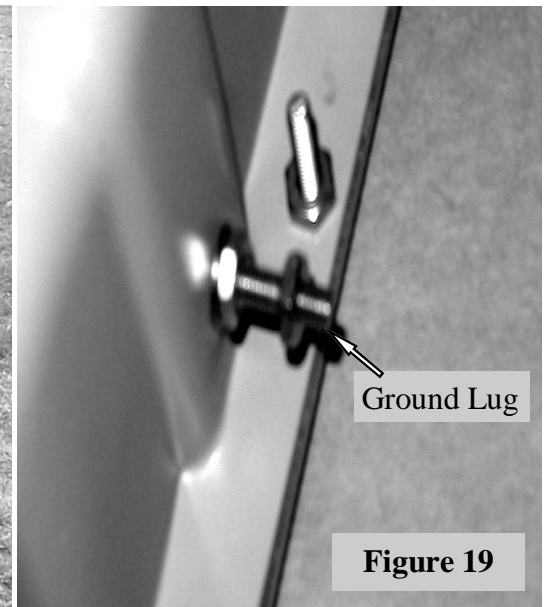
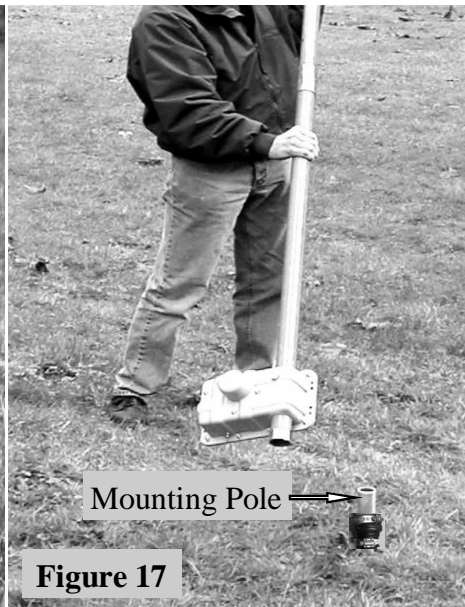
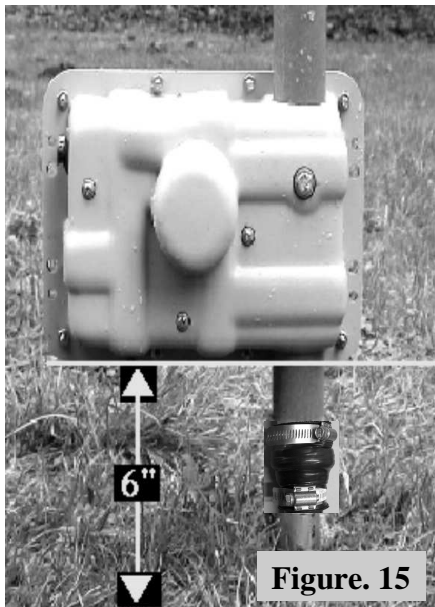
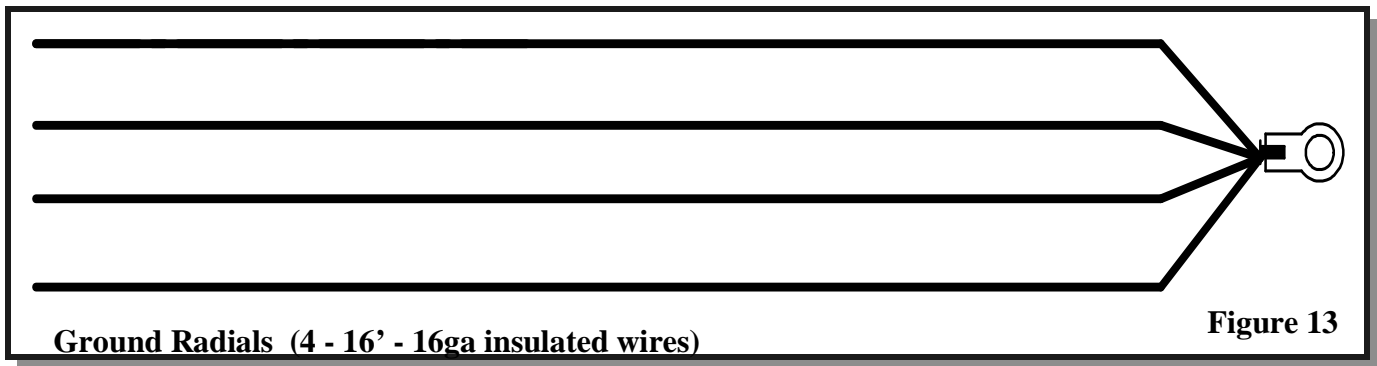
- Slide the butt (large) end of the telescoping fiberglass pole into the element housing tube (EHT) until it is firmly bottomed. Push the rubber boot down firmly onto the element housing tube until it bottoms out and tighten the two clamps. This boot will prevent water from getting into the element housing unit (EHU).

**Figure 11**



## Mounting the Antenna (ground)

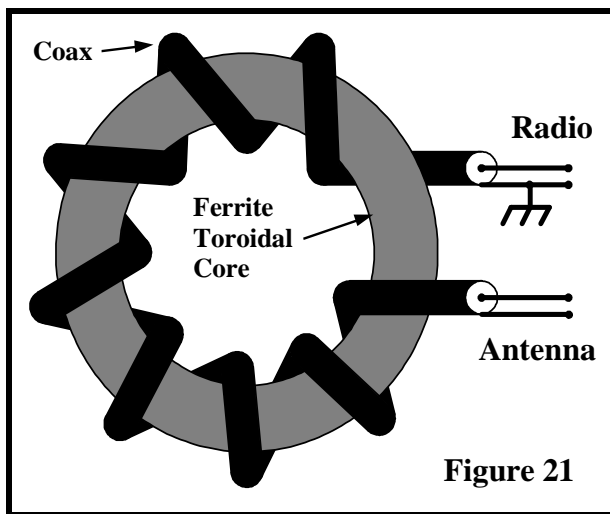
Now you are ready to connect the radials! We recommend using a lug connector at the end of your radials, and then tightening the lug onto the connector post shown in **Figure 19**. If you purchase optional radial kits (**Figure 13**), you will notice there are 4 wires per set, all soldered and crimped to a lug connector.



## Optional (1-1) External Balun

**Note:** If you have purchased the optional balun now is a good time to install it.

A balun is an electrical circuit used to help resolve the inherent problem of feeding an antenna with an electrically unbalanced (coax) feed line. It is intended to present an infinite impedance to any RF current that might otherwise flow on the outer conductor (shield) of the coax producing radiation from the line. This current, if high enough, can cause heat buildup and potential damage to the radio as well as a distorted radiation pattern.



### Why is it Optional ?:

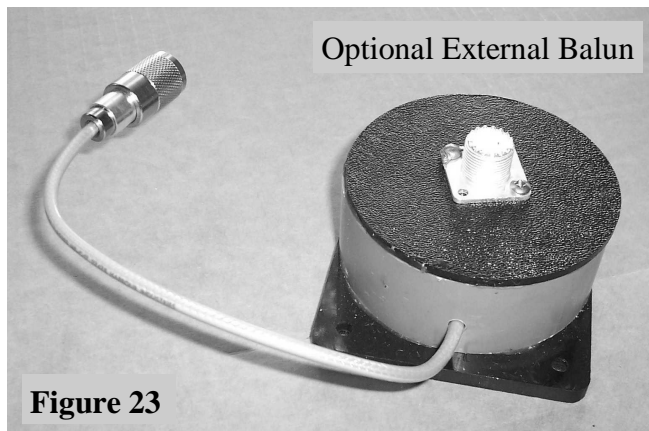
In the normal configuration, ground mounted with 12 or more radials, the ground will bleed/drain the unwanted RF signal from the coax shield.

### When Should You Use A Balun ?:

- When elevating the base of a vertical antenna above the ground
- When only a few radials are used
- When the coax run is shorter than the radials
- When the ground condition is poor
- Unusual SWR readings on one band

### Balun Installation

To install the balun (**Figure 23**) we suggest that you mount it as shown in **Figure 25**. There are two holes in the base of the balun that will line up with two screws in the end of the element housing unit next to the SO-239 connector. Remove these two screws and reinstall them through the balun then connect the PL-259 as shown in **Figure 25**. Your feed line will then plug into the SO-239 in the center of the balun.



## ***Radial Systems for Elevated and Ground mounted Vertical Antennas***

All vertical monopoles need some form of counterpoise in which antenna image currents flow to work efficiently. This counterpoise usually consists of a system of radial wires placed either on the ground or elevated above ground.

This is not an in depth publication but simply a general guide on installing and using the SteppIR verticals. There is much more information available in various publications if you need it. The ARRL Antenna Handbook is a good source for additional information.

By following a few simple guidelines, you can obtain excellent performance from vertical antennas mounted on the ground or elevated above the ground. There are a number of verticals available that say “no radials required”, but they do have “radials”, in the form of a shortened, tuned counterpoise system. As you might expect, you pay a price for such a small counterpoise system - less efficiency.

As you will see in the following pages, you can get fairly high efficiency with a relatively modest radial system that will far outperform small counterpoise systems. It should be noted that counterpoise systems are only good for curing near field losses caused by losses from the earth, which is a poor conductor of RF, even with good soil. There is nothing you can do about far field losses that reduce the signal strength and low angle radiation, except get to some saltwater. We briefly discuss salt water locations later on in this article.

### ***Ground Mount or Elevate?***

#### **Ground Mounting:**

##### **PROS**

- The radials can be any length and they work on all frequencies
- Easy to mount
- Easy access
- Lower visual profile
- Eight to twelve 0.1 wavelength radials gives 60% - 65% efficiency (one set of 8 - 12 radials cut to 0.1 wavelength at lowest frequency)

##### **CONS**

- Takes 120 radials to equal an elevated vertical with 2 resonant radials (90% efficient)
- Surrounding objects can reduce signal strength

## Elevated Mounting:

### PROS

- + 90% efficient with two .25 wavelength radials
- Antenna is generally more “in the clear”, so surrounding objects don’t cause as much attenuation
- A peaked metal roof will make a very good all-frequency radial system

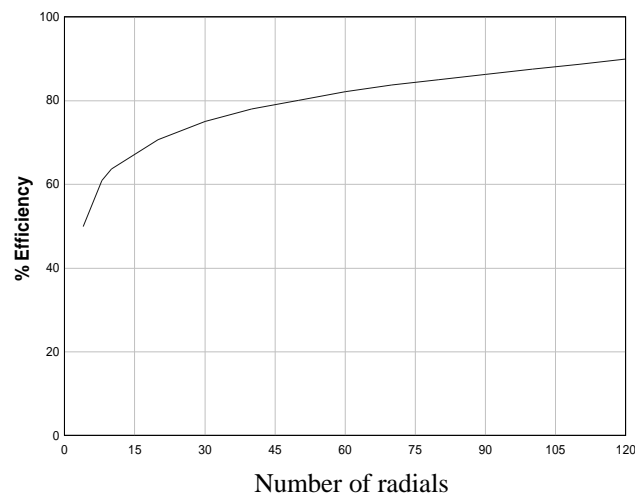
### CONS

- Requires two .25 wavelength radials for each band of operation (radials interact, so spacing will affect length)
- Mounting is generally more involved
- Visually higher profile
- Must be mounted high enough that people won’t walk into it
- Needs to be about .2 wavelengths high to get an ideal 50 ohm match
- Radials need at least a 20° slope to get a good match
- Involves adjusting and fine tuning the radial lengths

## Ground Mounting:

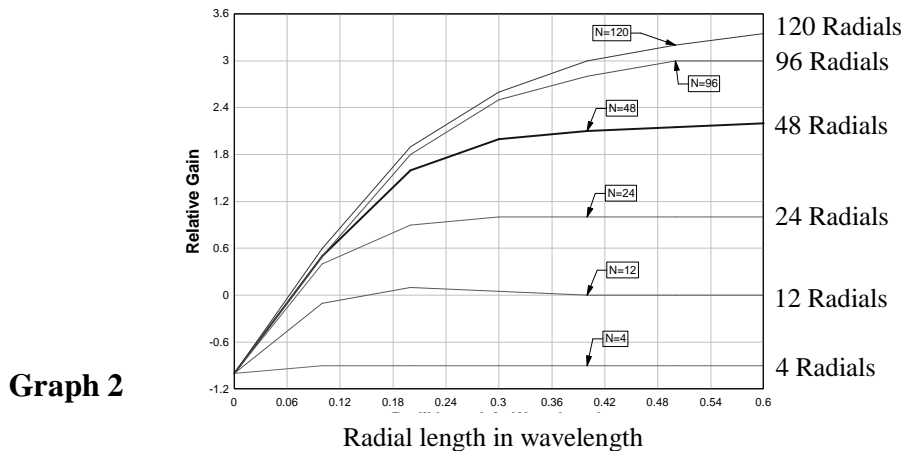
If you chose to ground mount the vertical, pick a spot that will allow you the best chance of spreading your radials evenly around the antenna, and away from trees and other objects if possible. Mount the antenna within one foot of ground if possible, the closer to ground the better. Next, you will need to determine how much effort and wire you are willing to invest in this installation. The tradeoffs are as follows:

1. More radials equals higher efficiency (see **Graph 1**)
2. More short radials are generally better than a few long ones
3. If only a few radials are going to be used, they need not be very long
4. If you have very good earth (very few of us actually do), you can obtain good performance with very few radials.



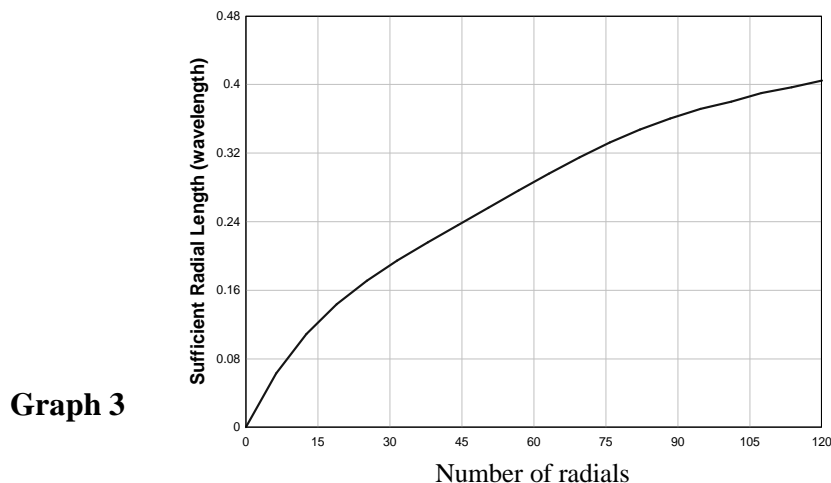
**Graph 1**

Four radials are what we consider to be the absolute minimum in average soil. How much you have to gain with a good radial system depends on how good your earth is. Most of us have poor earth conditions, so the radial system is important. The worse the earth is, the more can be gained with radials. **Graph 2** shows a graph produced by Brian Edward (N2MF) that illustrates the relative signal gain you get with the radials and varying length over poor earth. With better earth, the gain difference between 4 radials and 120 radials will be about 2.5 dB, as opposed to 4 dB with poor earth.



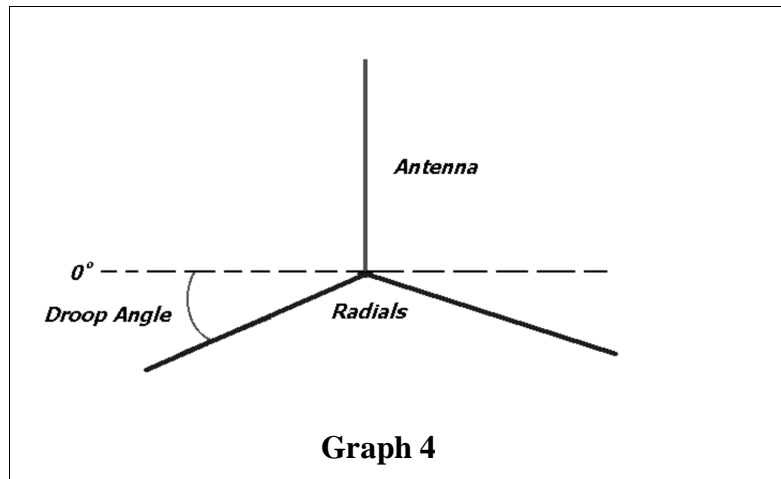
If you are restricted to .1 wavelength radials there is not much advantage to using more than about 24 radials. You can see from **Graph 3** that if more radials are used there is a huge advantage to making them longer.

If you cannot lay the radials out in a symmetrical radial pattern, don't worry too much - it will distort your omni-directional pattern slightly but won't reduce your efficiency very much. Lay the radials out in the best manner possible given your situation. There are various ways to accomplish laying a radial system, including turning corners, etc. Good results are limited only to your creative energy and determination! Be aware that very high voltages can exist at the ends of radials, so be certain that no one can come into contact with them. It is a good idea to use insulated wire to protect from corrosion, and don't bury the radials any deeper than necessary, one to three inches is sufficient.



## Elevated Mounting:

You can elevate a vertical just a few feet from the ground (4 feet for 20m, 8 feet for 40m) and get fairly good performance with just 2 radials (elevated as well) per band of operation. The problem is you won't have a very good match to 50 ohms, and the close proximity of the earth will degrade the signal - especially if it is poor earth. For ideal matching, we recommend .2 wavelength (about 15 feet on 20m and 30 feet on 40m) at the lowest planned frequency of operation. As the height decreases below .2 wavelength, the ground losses start to increase, unless you have very good ground. When a vertical is raised off the ground the impedance drops fairly rapidly from 36 ohms (Over perfect ground or with many radials it will be close to 36 ohms, over real ground it is generally 40– 60 ohms) to about 22 ohms when .3 wavelength is reached. This would make a pretty poor match to 50 ohms, so a couple of tricks are in order. Once you elevate a vertical, two radials are all you really need. It is important that you try to keep a 180° angle between the two (opposed, directly in line) for the best pattern. Spread the radials out as far as possible to reduce interaction, if they are less than a foot apart it can be difficult to get a good match on all bands. To facilitate a match to 50 ohms you can angle the radials downward, this raises the impedance of the antenna as you increase the angle downward. **Graph 4** shows the approximate relationship of radial angle to impedance:



Radial Droop Angle		Antenna Impedance
0°	=	22 Ohms
10°	=	28 ohms
20°	=	35 ohms
30°	=	47 ohms
40°	=	53 ohms
50°	=	55 ohms
Note: above 50° results in diminishing returns		



Can't get enough droop angle to achieve a good match? Simply adjust the antenna element slightly longer than the factory 1/4 wavelength (up to 20% longer) settings and the impedance will rise. This will cause the radials to be too long, so they may need to be pruned a bit. Be aware that increasing the antenna 2% to 3% longer may require radials to be 5% to 7% shorter. Once you have a good match, replace the factory default values by saving the new antenna (to do this you will use the "create, modify" feature in the setup mode).

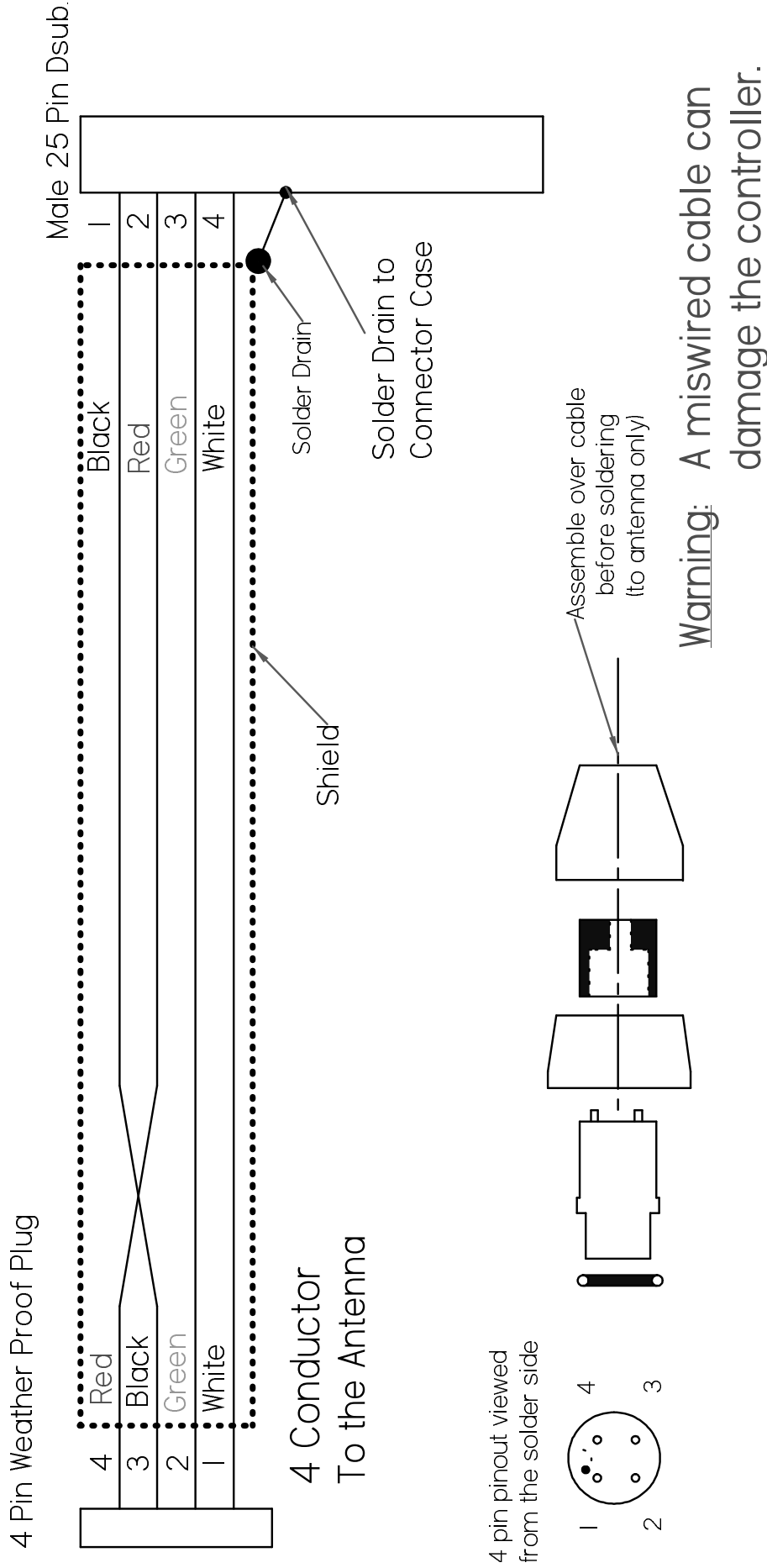
When the vertical is elevated you can get away with just one resonant radial, however, the pattern won't be omni-directional. You will have -12 dB to 15 dB null in one direction

## Using a Vertical in on or Near Salt Water:

If you are lucky enough to have a dock over salt water, a vertical can offer unparalleled performance for low angle DX. Simply mount the vertical to the dock and attach two radials per band of operation. They can be stapled right to the dock if it is non-metallic. Mounting the vertical in ground flooded by salt water a couple of times per day can be equally effective. Proximity to the ocean improves the far field loss of a vertical and allows very low angle radiation - get as close to the water as possible to enhance performance.

Due to the fact that RF does not penetrate more than 2 inches into the water, direct coupling (a wire in the water) is difficult. Objects like metal floats or boats, providing they are large enough, can make good grounds in salt water. If you are using a metal boat or large metal object, corrosion is no longer a problem because the large surface capacitively couples to the water. When using a small metal float (3 ft x 3 ft is just enough to "connect" to salt water), you want to be certain that the metal does not corrode over time. For long term immersion, Monel is a good (but fairly expensive ) choice.





## 4 Conductor Cable (Small IR)



### **Limited Warranty**

These products have a limited warranty against manufacturer's defects in materials or construction for two (2) years from date of sale. Do not modify this product or change physical construction without the written permission of SteppIR Antennas Inc. This limited warranty is automatically void if the following occurs: improper installation, unauthorized modifications, physical abuse or damage from severe weather, beyond the manufacturer's control. Manufacturer's responsibility is strictly limited to repair, or replacement of defective components. The shipping instructions will be issued to the buyer for defective components, and shipping charges will be paid for by the buyer to the manufacturer. The manufacturer assumes no further liability.

# *Thank you for choosing SteppIR!!*



# ***SteppIR*** <sup>TM</sup> ***Antenna Systems***

Yagi • Dipole • Vertical

[www.steppir.com](http://www.steppir.com)

SteppIR Antenna Information Web Sites (as of 4/09/07)

<http://steppir.com/>

<http://groups.yahoo.com/group/steppir/>