ANTENNA SEMINAR 2007
SEMINAR NOTES
DOCUMENT #1

OCT 2007 - REVISION 1

WELCOME TO THE THIRD ARMY MARS BROADBAND ANTENNA SEMINAR

PRESENTED BY AAA9EC AND AAA9AT
Oct. 2007

INTRODUCTION: The purpose of this on-the-air seminar is to acquaint MARS members with the techniques and practices that will provide the best possible performance over the entire HF range. In most cases, the designs and techniques are a compromise between performance, available space, and broadband coverage. Except for the mobile and twenty meter vertical, all the antennas and transmission lines described here should be constructed using number 12 or 10 gauge wire and most will require an antenna tuner with balanced output for best results. Some commercial HF antennas promise broadband operation without a tuner. In most cases, these devices have some intentional heat loss and are therefore less efficient than the home made variety. All of these topologies include an antenna matching network. The time honored practice of cutting or pruning the length of HF antennas and/or feedlines to magically affect improved performance is not applicable for true broadband antennas for MARS HF operations.

The first time we conducted this seminar was in the year 2001. It was a very successful effort. In 2005 we attempted to rerun the seminar, but very poor radio propagation conditions forced us to abandon the effort after a few difficult sessions. In an effort to mitigate possible unfavorable propagation conditions that may exist this time, we will attempt to simulcast the net from five locations using five different frequencies. The simulcast stations will be linked together by a telephone conference call. Each simulcast station will use a phone patch to supply the audio signal to their transmitter. This will allow members to transmit and receive on whichever frequency provides the best results for them.

PLEASE NOTE: This seminar is mainly concerned with matching, safety, and broadband (2 MHz to 30 MHz) considerations. We will not address many of the other antenna parameters such as directional characteristics and angle of radiation. All of this material is covered in depth in ARRL publications as well as antenna text books. For most of us with limited space for antennas, the most optimum antenna topology will be what fits in the available space. In general, if space permits, the length of the radiating part of an HF antenna should be about one half wavelength at the lowest operating frequency. Somewhat shorter lengths have been proven to perform quite well.

LIST SEMINAR TOPICS:

1. LONG WIRE
2. SLOPER
3. INVERTED L
4. DIPOLE
5. FOLDED DIPOLE
6. HF MOBILE ANTENNA
7. HORIZONTAL LOOP
8. DELTA LOOP
9. EQUIVALENT CIRCUIT OF ANTENNA INPUT IMPEDANCE
10. GROUND LOSS REDUCTION
11. T AND PI MATCHING NETWORKS
12. SKIN EFFECT
13. CAGE ANTENNAS
14. RF TRANSMISSION LINES
15. LIGHTNING PROTECTION
16. POWER AND TELEPHONE LINE TRANSIENT PROTECTION
17. TWENTY METER PORTABLE ANTENNA
18. NVIS ANTENNAS

PRESENTERS: AAA9EC, AAA9AT PLUS GUEST SPEAKERS
GRAPHICS ARTIST: BILL CASPER / KC8OVZ, FORMER MICHIGAN STATE DIRECTOR AAA5MI

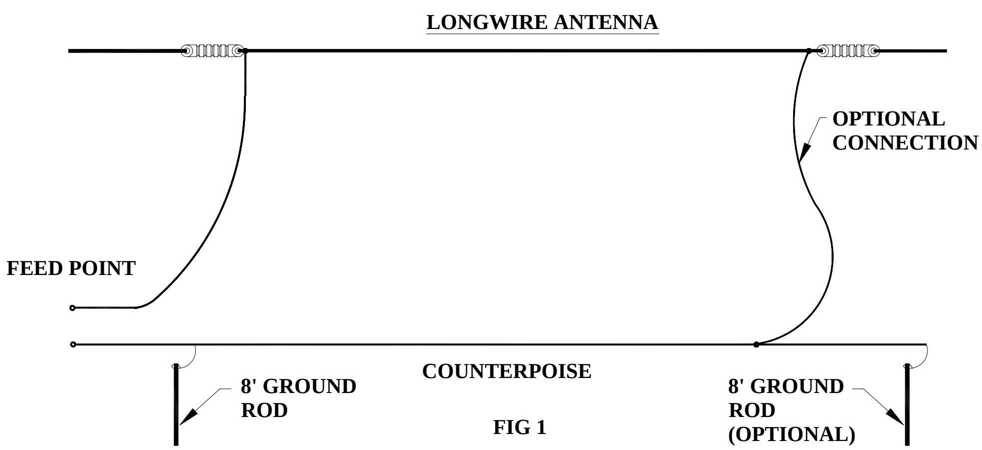


FIG 1

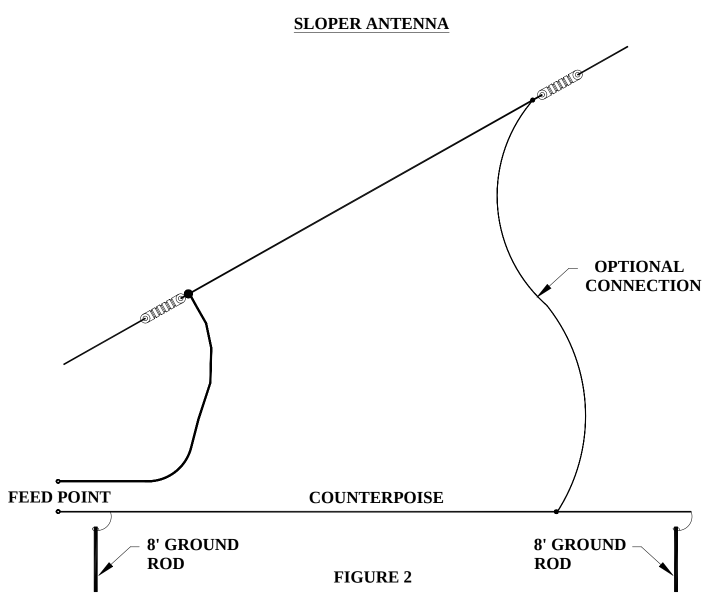


FIGURE 2

INVERTED "L" ANTENNA
(SIMILAR TO LONGWIRE)

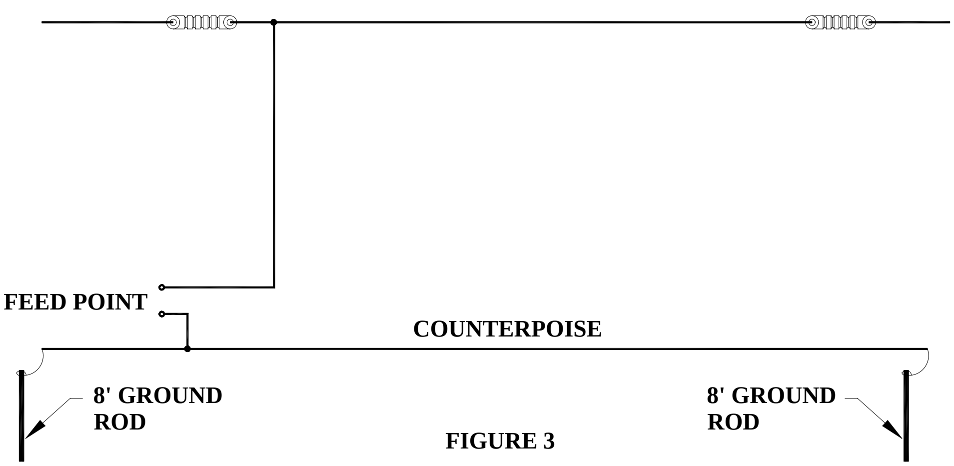


FIGURE 3

DIPOLE ANTENNA

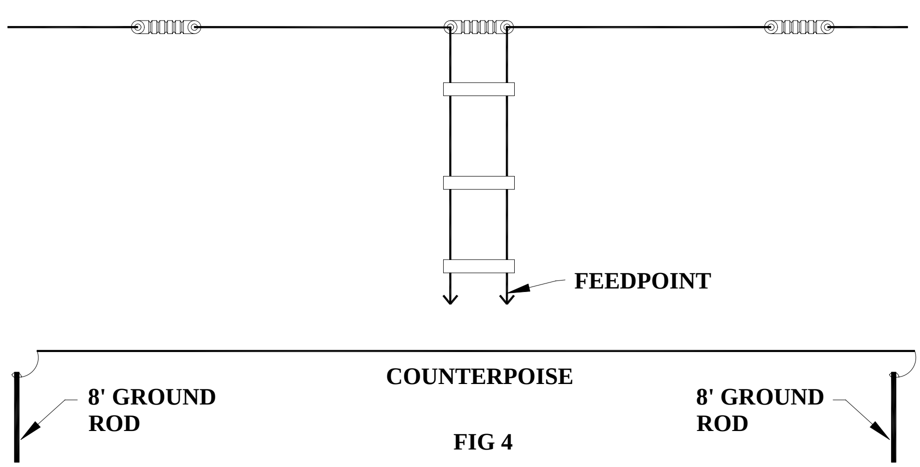


FIG 4

FOLDED DIPOLE ANTENNA

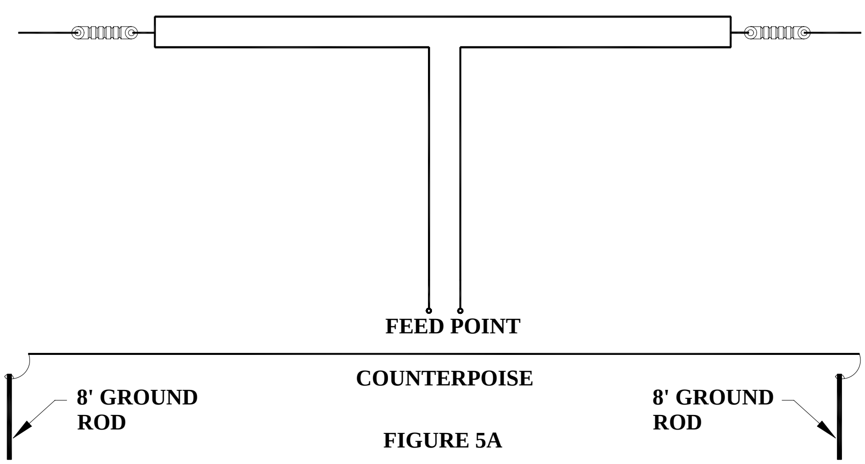


FIGURE 5A

FOLDED DIPOLE ANTENNA

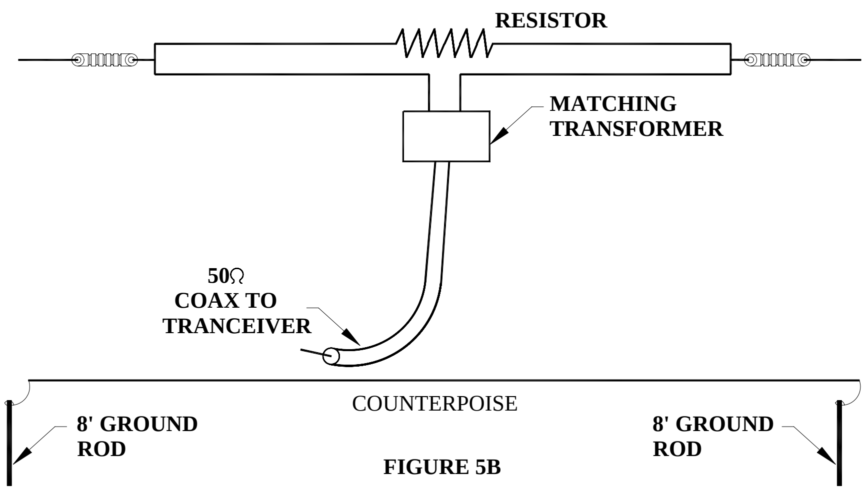


FIGURE 5B

LOADED MOBILE ANTENNAS
VOLTAGE / CURRENT DISTRIBUTION
AND BANDWIDTH

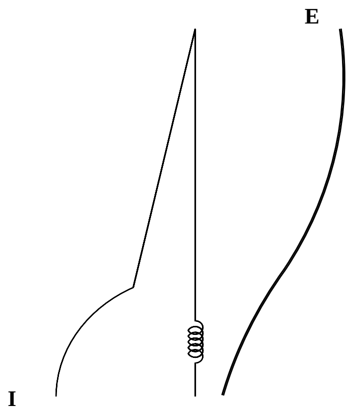


FIGURE 6A

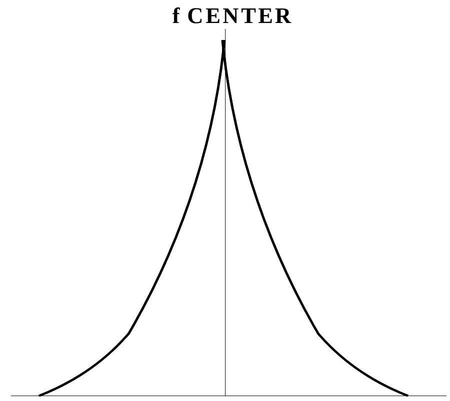


FIGURE 6B

BASE LOADING

LOADED MOBILE ANTENNAS
VOLTAGE / CURRENT DISTRIBUTION
AND BANDWIDTH

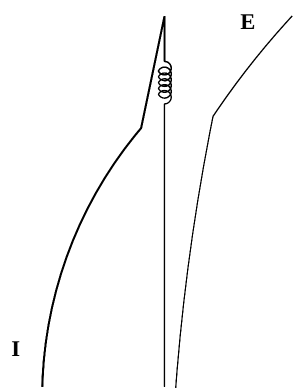


FIGURE 7A

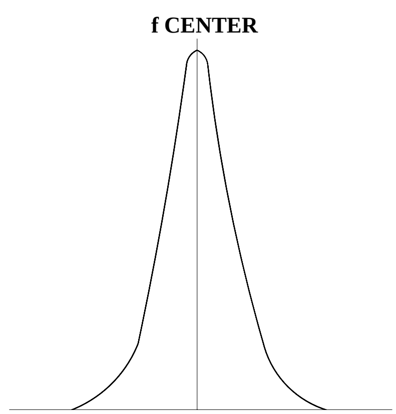


FIGURE 7B

TOP LOADING

RANDOMLY SHAPED LOOP ANTENNAS

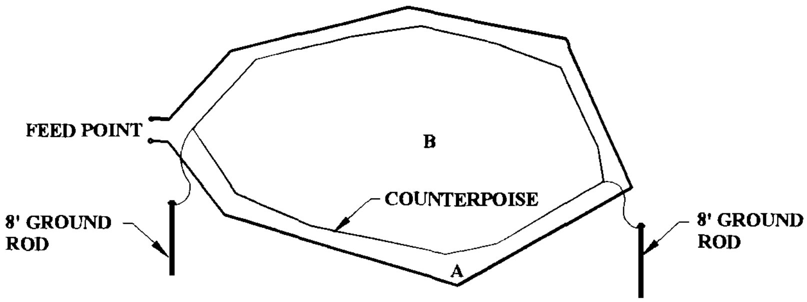


FIGURE 8

CAUTION - FIRE HAZARD - DO NOT INCLUDE YOUR HOME WITHIN THE LOOP!!

MINIMUM TOTAL LENGTH ~ 260 FT.

MAXIMUM TOTAL LENGTH ~ 1000 FT.

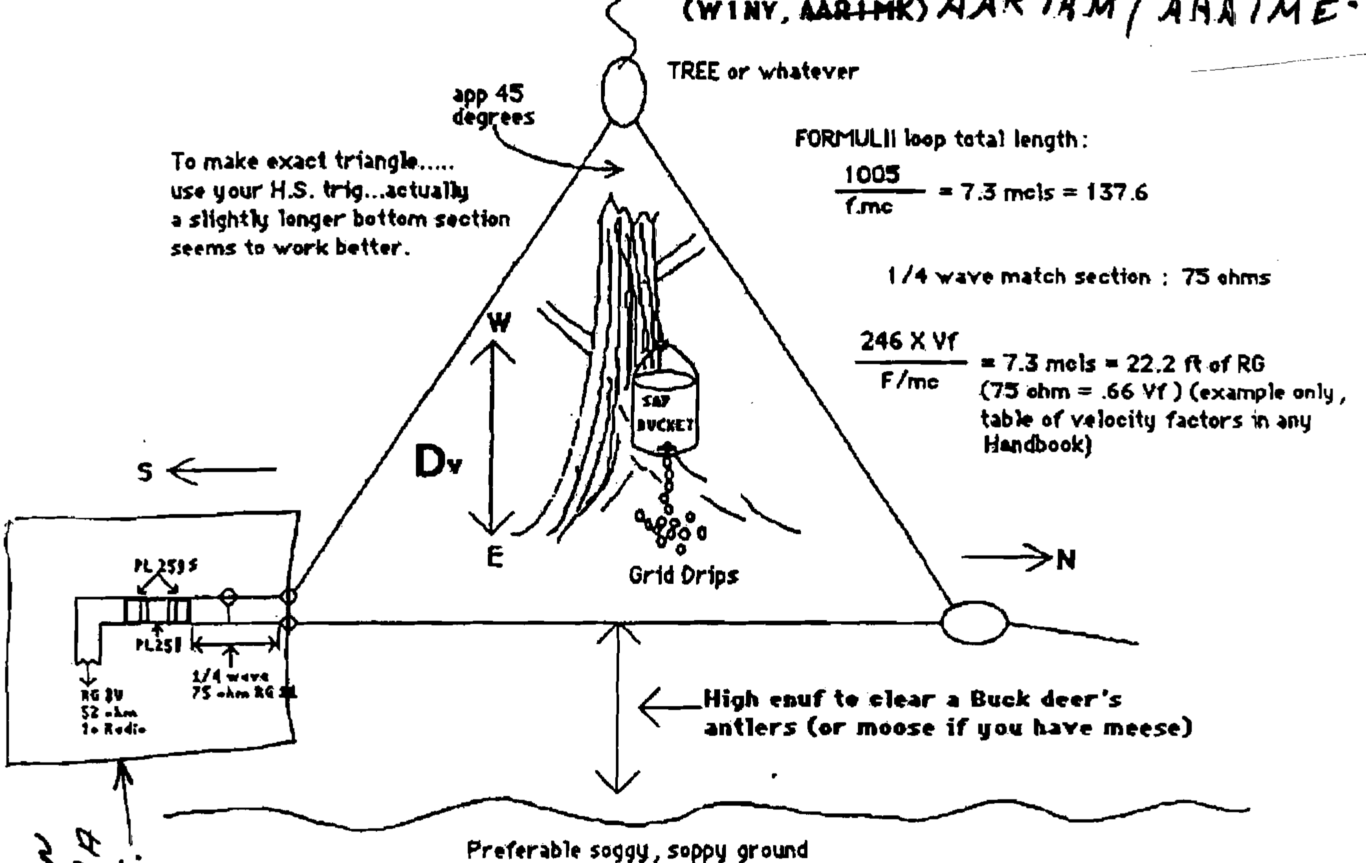
SELECT ATTACHMENT PIONTS FOR MAXIMUM ENCLOSED AREA - NOT MAXIMUM WIRE LENGTH.

A COUNTERPOISE WILL REDUCE GROUND LOSS.

FREQUENCY RANGE 1.8 TO 30 MHZ.

DELTA LOOP Carl Watson's version

(W1NY, ~~AAR1MK~~) AAR1AM / AAR1ME.



FOR BROADBAND OPERATION FEED AS SHOWN IN FIG 17A AND USE AN ANTENNA TUNER. AAR1AM

Directional across plane of the top..........................80 % vertical radiation......................remainder horizontal. Match section should lead directly away from junction for full length before any bends made. Measurement of matching section should include length of PL 259 and fanning of connection to loop, not more than a 6 in. fan-out..preferably approx 4 in. Weather proof all connections! The closer the bottom section is to the ground, (up to 6 ft), the better the vertical component. The best way to get a Delta going right is to put a 2 or 3 turn coil about 1 inch in diameter at the feed point after loop is up... and grid-dip the thing.....you can get it the way you want it that way. (provided the dip meter is fairly accurate). Then short one end of the 1/4 wave matching section, put the same coil at the other end and dip the coax to the same frequency. If you do this a tuner is not needed at all.... you will have almost a perfect match within probably 50 kcs up and down from the center frequency as set. Can also feed it with 300 ohm ladder line and tuner, in place of 75 ohm matching section, to use on other bands.

HORIZONTAL MOUNTING for local (300-400 mile) coverage.
VERTICAL MOUNTING for DX and disturbed atmospheric conditions, OR
TIP IT 45 DEGREES for both coverages.

Computer sketch by AAR1OZ faithfully reproduced from Mr. Watson's (a..hem!) drawing.

FIGURE 9

This always was a band opener on 3,501 AM. You hear the 7.0 Mc/s one, most Friday nites.

INPUT IMPEDANCE LOOKING INTO FEEDLINE AT ANTENNA TUNER

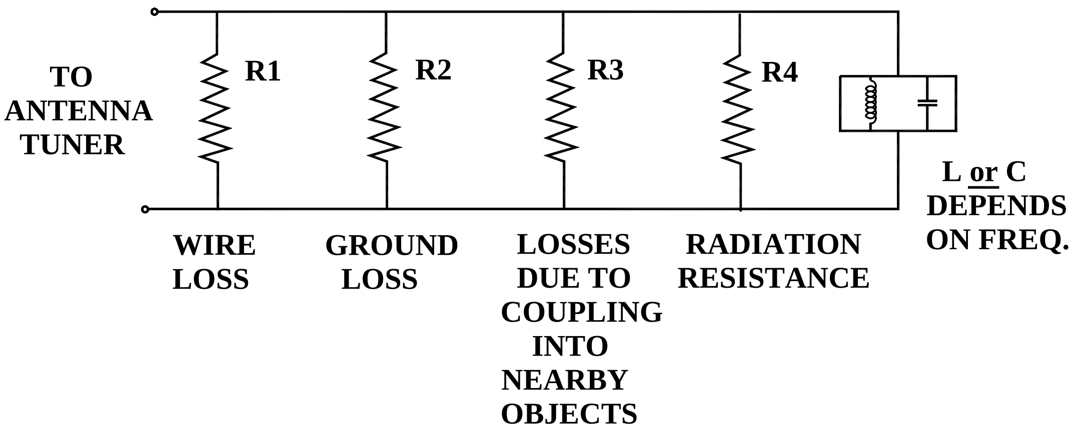


FIG 10

INPUT IMPEDANCE LOOKING INTO FEEDLINE AT ANTENNA TUNER

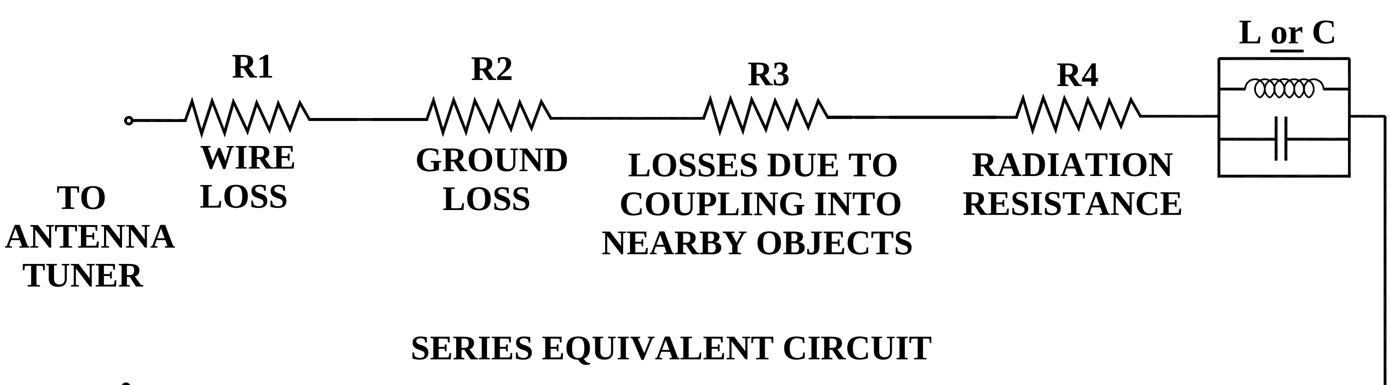


FIG 11

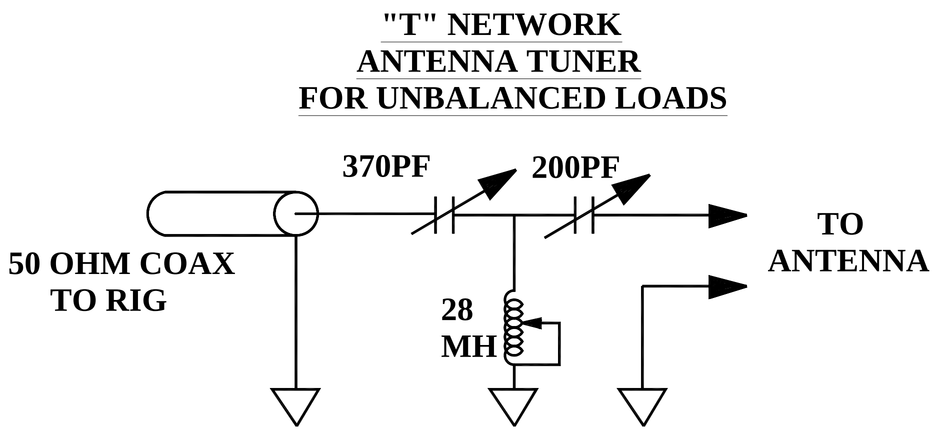


FIG 12A

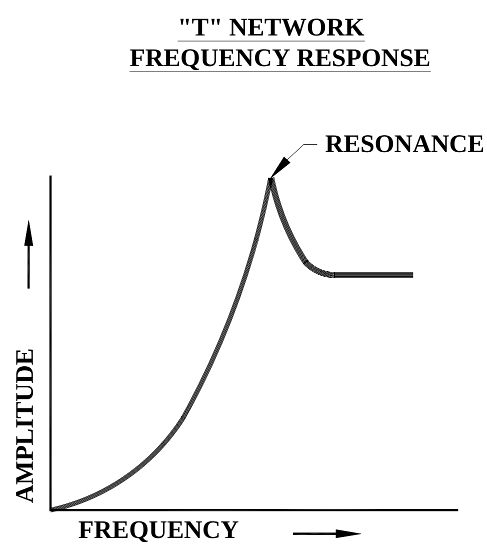


FIG 12B

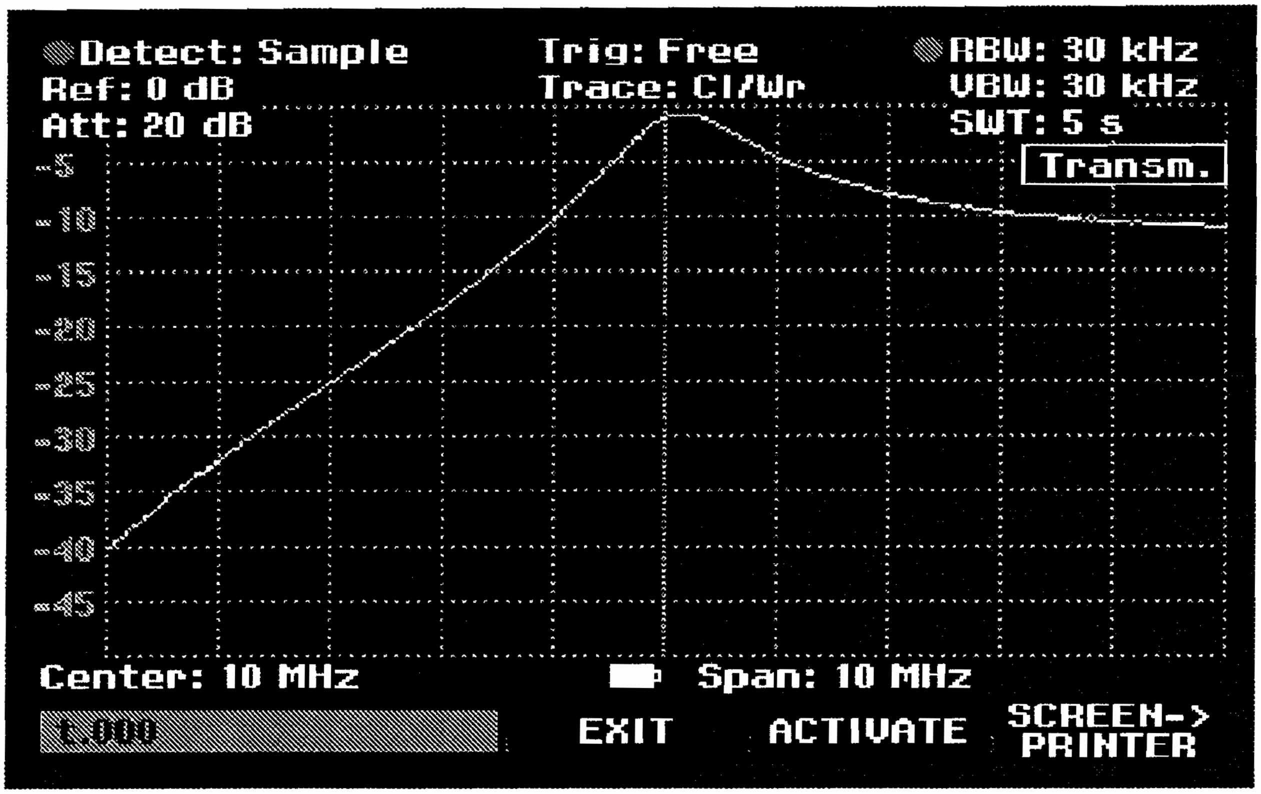


FIGURE 12C

FREQUENCY RESPONSE – GAIN (DB) VS FREQUENCY (MHz)
ANTENNA MATCHING NETWORK (T CONFIGURATION)

Zin=50 ohms
Zout= 50 ohms

TEST EQUIPMENT:
RHODE AND SCHWARZ
SPECTRUM ANALYZER WITH
TRACKING GENERATOR

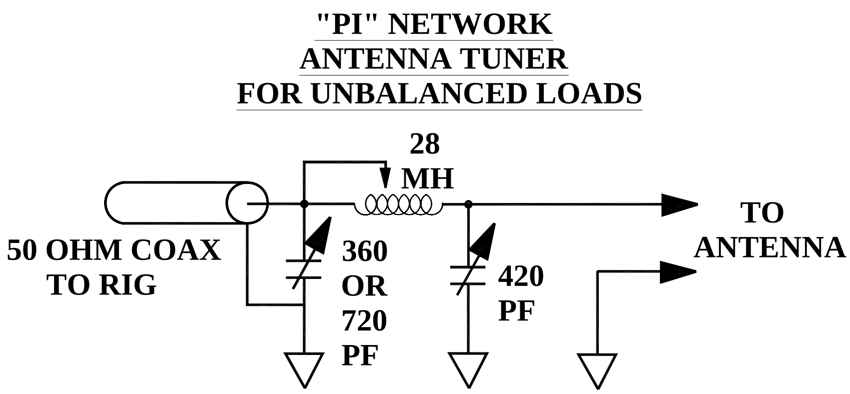


FIG 13A

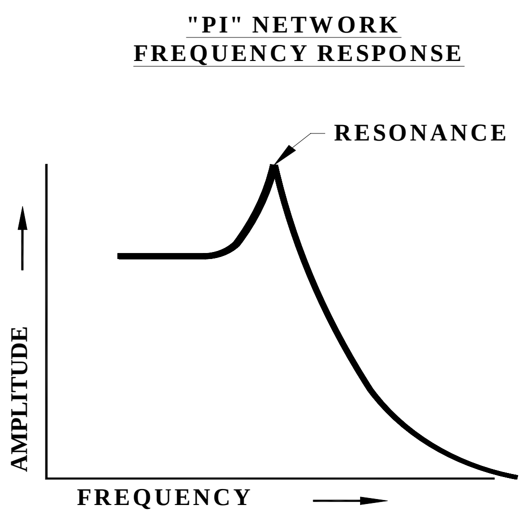


FIG 13B

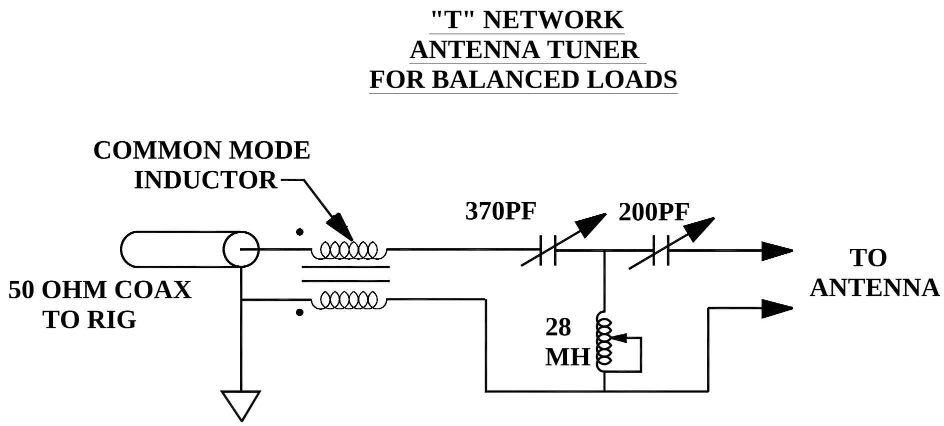


FIG 14A

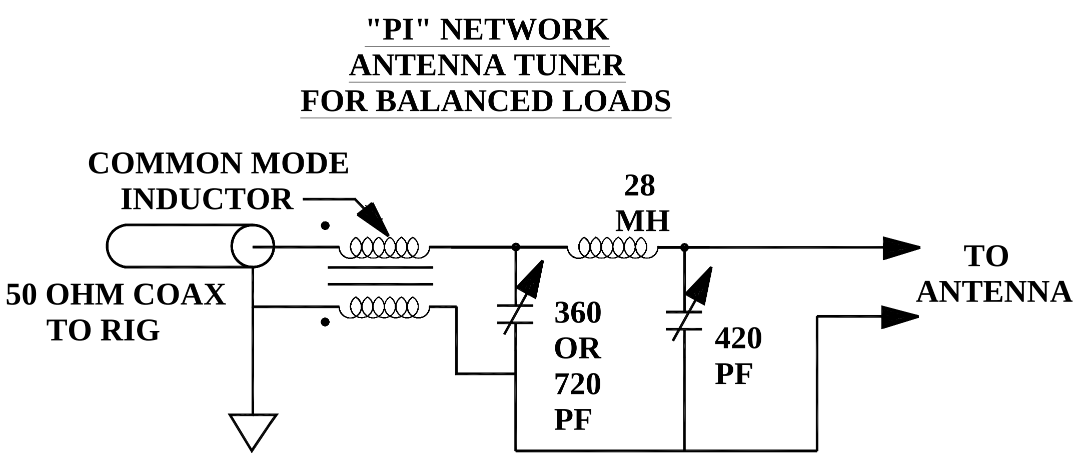
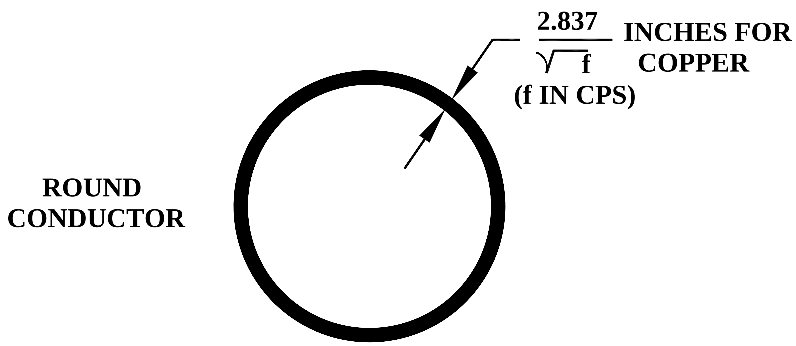


FIG 14B

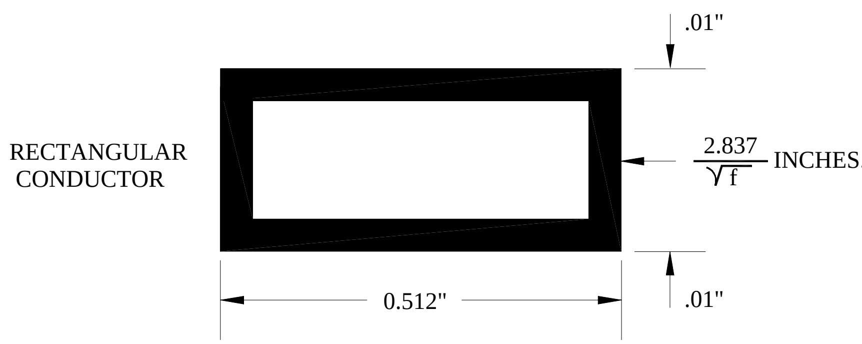
SKIN EFFECT



FREQ.	PENETRATION	R_{AC} / R_{DC} FOR #12 WIRE
2 MC	.001688"	12
4 MC	.001419"	14
6 MC	.001158"	18
7 MC	.001072"	19
30 MC	.000518"	39
60CPS	.366"	1.0

FIG 15A

SKIN EFFECT

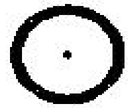


AT 7MC $R_{AC}/R_{DC} = 4.7$

FIGURE 15B

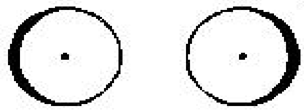
SKIN EFFECT

FIG. 15C



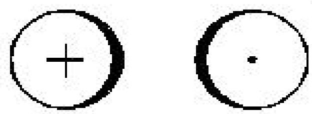
SINGLE WIRE IN FREE SPACE
CARRYING AN AC CURRENT

FIG. 15D



TWO WIRES, IN CLOSE PROXIMITY,
CARRYING CURRENT IN
IN THE SAME DIRECTION.

FIG. 15E

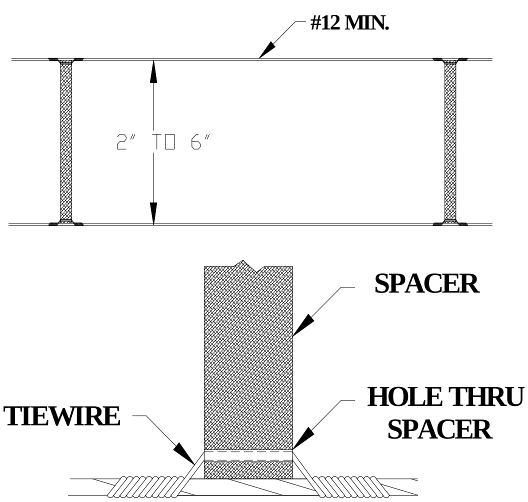


TWO WIRES, IN CLOSE PROXIMITY,
CARRYING CURRENT IN
THE OPPOSITE DIRECTION.

FIG. 15F

TWO WIRES, SPACED ABOUT
20 WIRE DIAMETERS APART
CARRYING R.F. CURRENT

TRANSMISSION LINES



TYPICAL CONSTRUCTION OF OPEN-WIRE LINES. THE LINE CONDUCTOR FITS IN A GROVE IN THE END OF THE SPACER AND IS HELD IN PLACE BY A TIEWIRE ANCHORED IN A HOLE NEAR THE GROOVE.

REPRINTED WITH PERMISION - ARRL 1959 HANDBOOK

FIGURE 16

NEVER RUN OPEN WIRE LINE IN YOUR HOME!!

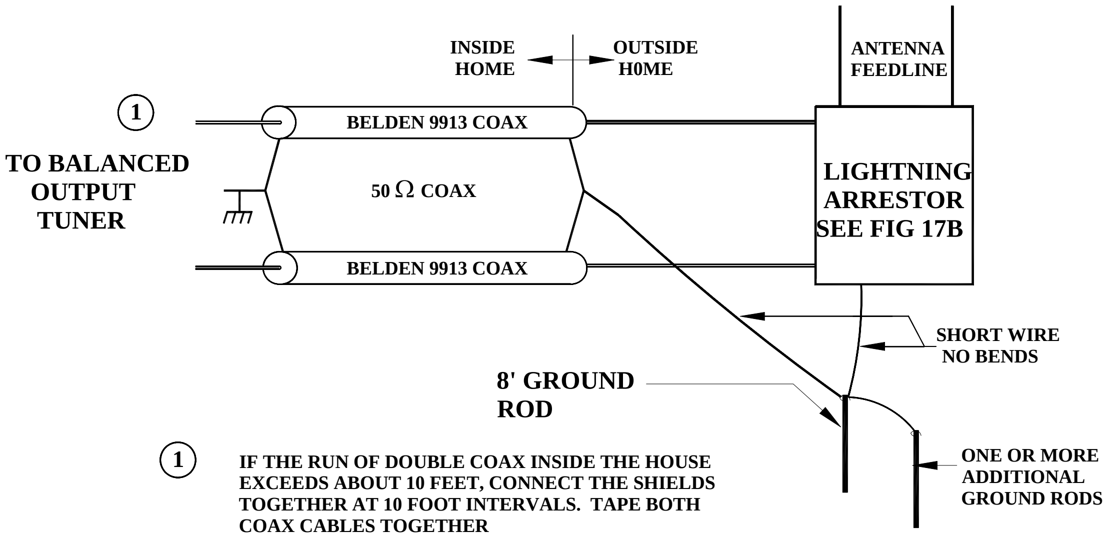
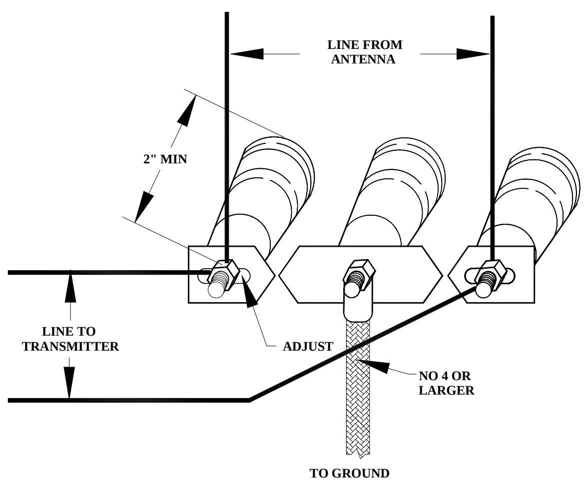


FIGURE 17A

LIGHTNING ARRESTER FOR OPEN WIRE LINES



USED WITH PERMISION - ARRL 1959 HANDBOOK

FIG 17B

This is a simple lightning arrestor made from three stand-off insulators and sections of 1/16" min. thick brass stock. It should be installed in the open-wire line at the point where it is nearest the ground rod outside the house. The lead between the lightning arrestor and ground should be as short as possible and free of all bends.

CURRENT VS TIME PROFILE OF LIGHTNING STRIKE

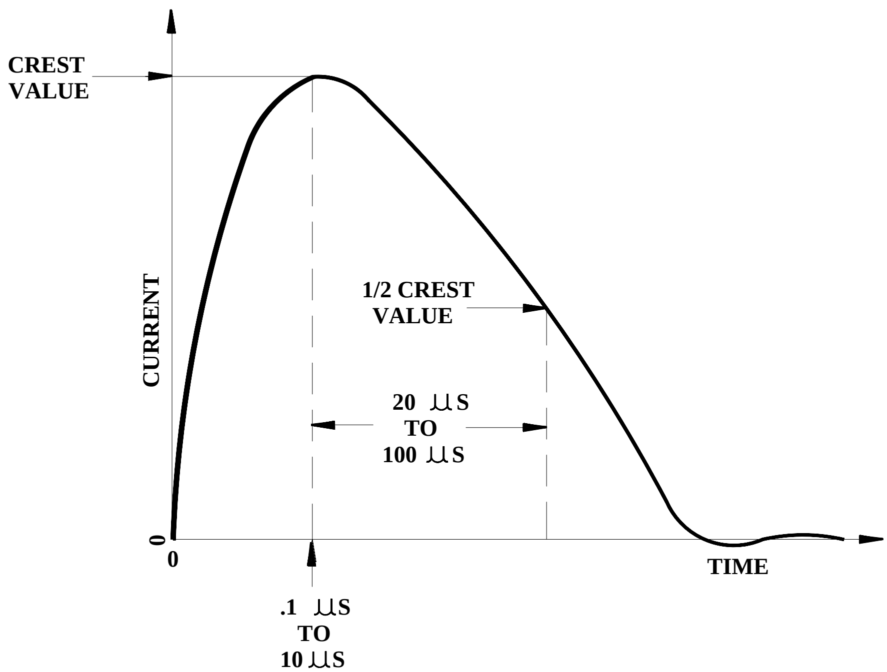


FIG 18

VOLTAGE - TIME PROFILE OF A TYPICAL LIGHTNING INDUCED POWER LINE TRANSIENT

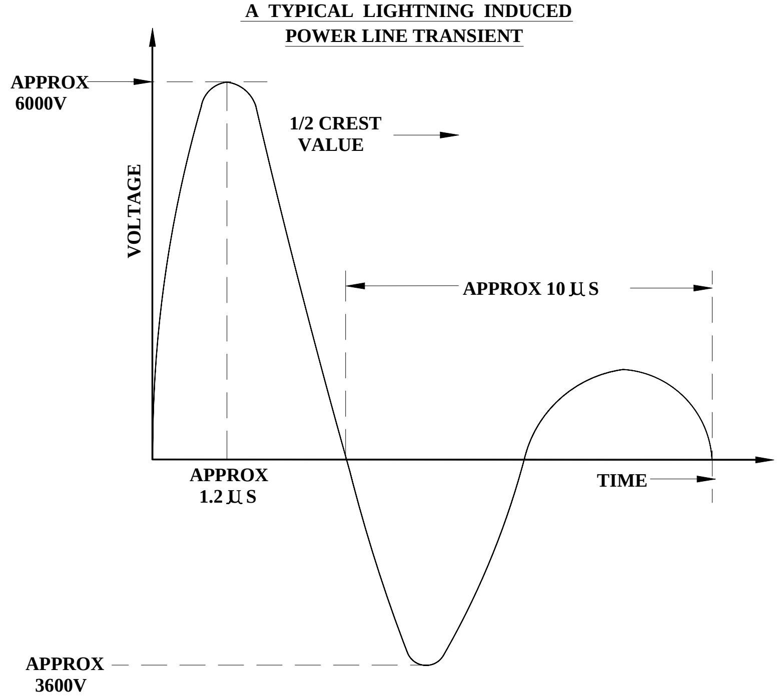


FIG 19

HOW NOT TO WIRE A RADIO STATION

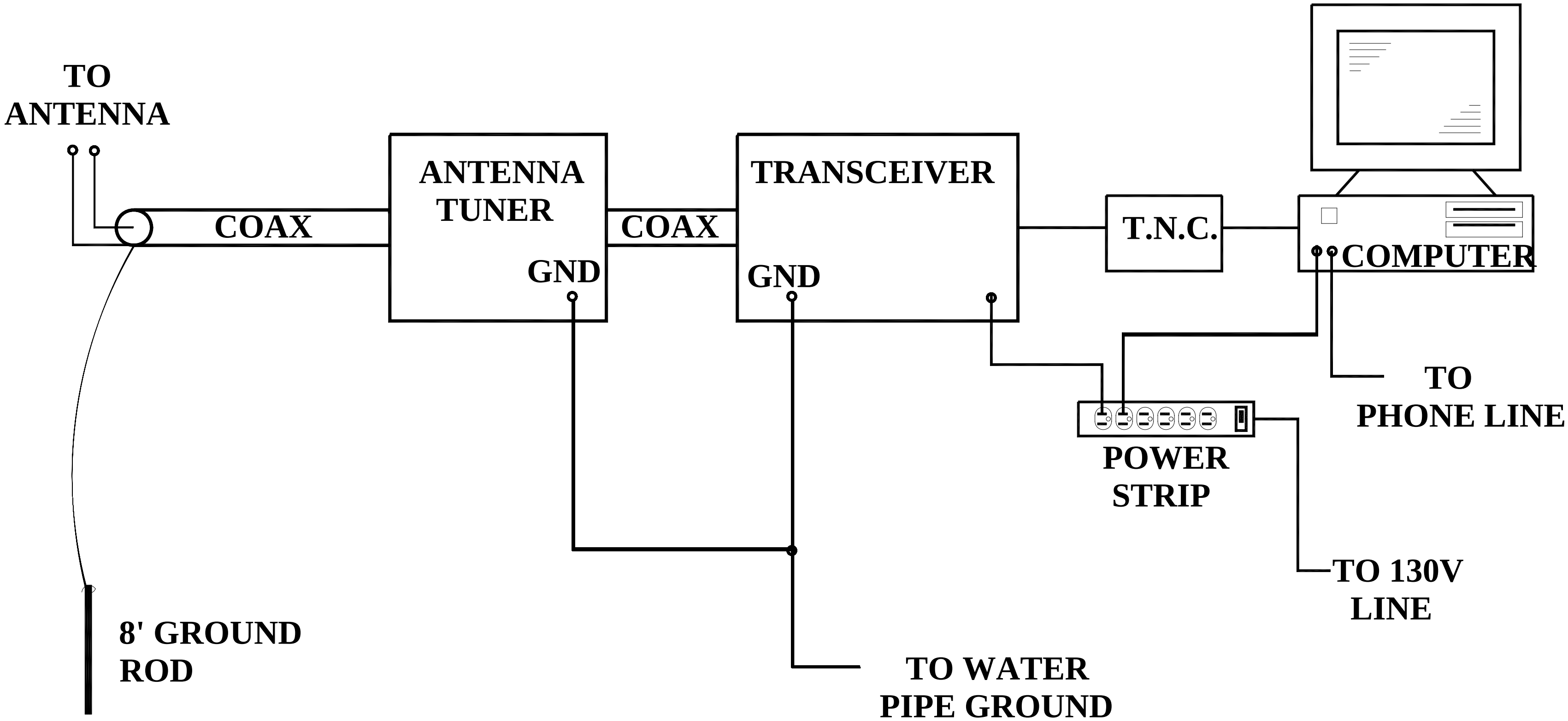
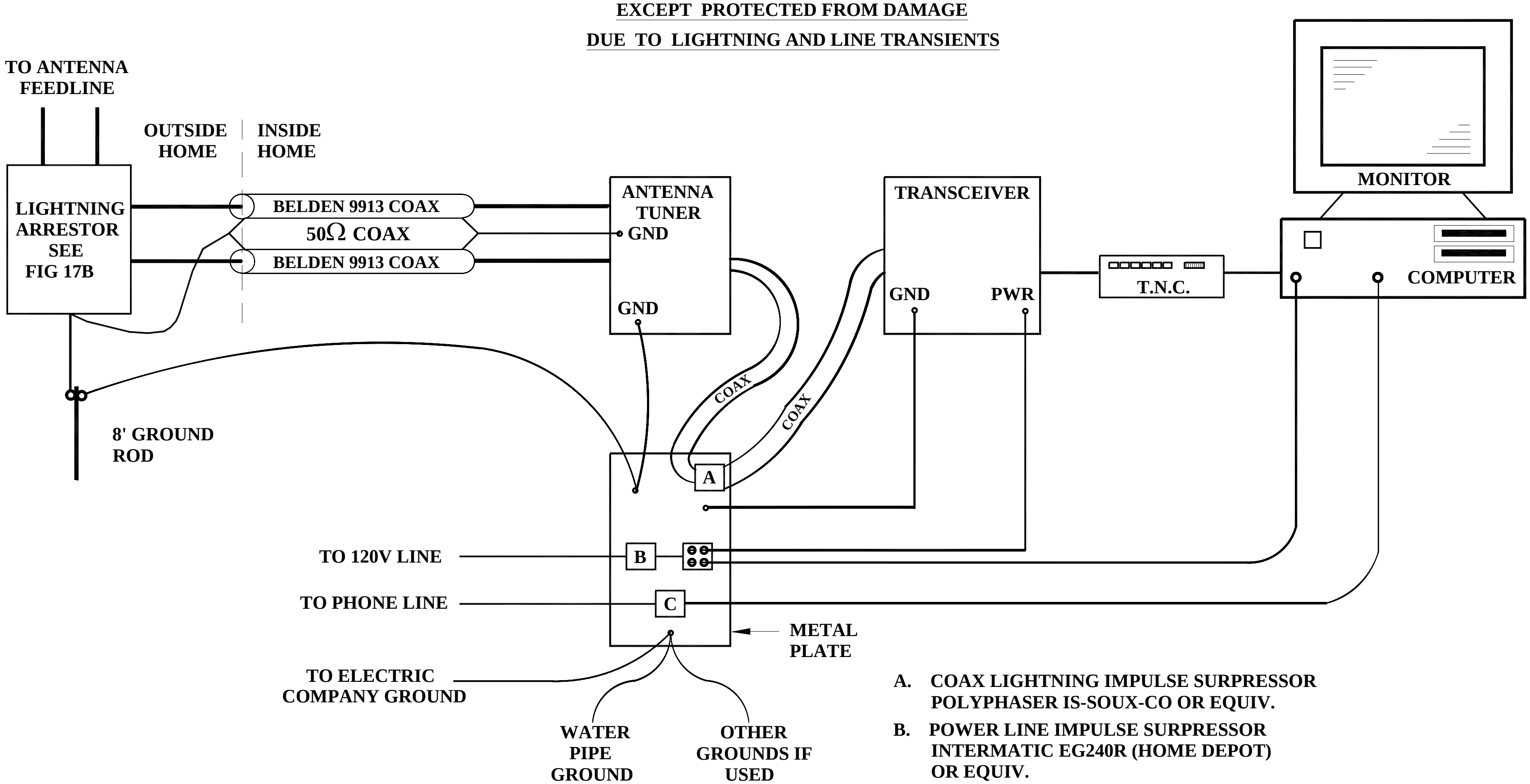


FIG 20

SAME STATION AS FIGURE 20
EXCEPT PROTECTED FROM DAMAGE
DUE TO LIGHTNING AND LINE TRANSIENTS



A. COAX LIGHTNING IMPULSE SURPRESSOR POLYPHASER IS-SOUX-CO OR EQUIV.

B. POWER LINE IMPULSE SURPRESSOR INTERMATIC EG240R (HOME DEPOT) OR EQUIV.

C. TELEPHONE LINE IMPULSE SURPRESSOR POLYPHASER IS-SPTL OR RADIO SHACK 43-111 OR EQUIV.

FIG 21

QUARTER WAVELENGTH VERTICAL ANTENNA

Designed by Pat Lane AAA9EC

September 2005

This article describes the 14 MHz antenna used by WGU-231 for the 2005 Armed Forces Day crossband contacts.

The antenna was designed with the following criteria in mind:

1. It must fit into the trunk of my car.
2. It must be able to be assembled in the field by one person.
3. It must require a minimum of tools for assembly.
4. The performance should be equal to or better than most commercially manufactured products.
5. The cost must not be prohibitive.
6. All parts must be available locally.
7. It must be easily adjusted and cover a wide frequency range.

Item one was met by using a tubing cutter to keep all lengths under 55 inches.

Items two and three were met by using lightweight materials and assembly with only a screwdriver.

Item four was met by using copper tubing as the radiating element with solid connections between the sections.

Items five and six were met by all parts being available either in my junk box or at a hardware store such as Home Depot or Lowe's.

Item seven is a byproduct of the design.

CONSTRUCTION

Cut an approximately 21-inch piece of inch and a half PVC pipe for the base insulator. The length and diameter are not critical. Use what you have available.

Purchase two ten-foot lengths of half inch copper pipe and one ten foot length of three quarter inch copper pipe. Cut one piece of half inch pipe and the three quarter inch pipe into two 55-inch lengths each. Be sure and adjust the size according to what will fit in the trunk of your car.

Purchase a three quarter inch to half inch reducing coupling and four half inch couplings.

Purchase six hose clamps that will clamp tightly around the half couplings.

Purchase two hose clamps that will clamp tightly around the three quarter inch couplings and pipe.

PLEASE INSERT THIS SHEET AFTER PAGE 18

Add one 3/4-inch coupling to the parts list in order to couple the two cut pieces of 3/4-inch copper pipe.

NOTE: Since the article was written, some hardware stores such as Home Depot are now stocking copper pipe couplings with built-in solder. Do not use these couplings as they have a ridge on the outside that interferes with tightening the hose clamp over the slotted end of the coupling.

Purchase four hose clamps that will clamp tightly around the ground rod and the three quarter inch pipe to secure both to the PVC base insulator.

Purchase a half inch copper end cap.

Cut a four-foot length of copper pipe or use a four-foot copper clad ground rod to drive into the ground for support as shown in photo 6.

Solder a three quarter to half inch reducer to one end of a length of three quarter inch pipe as shown in figure 2.

Use a cutting wheel on a Dremel tool or a hacksaw to cut three or four slots into the half inch adapter. (photo 2)

Use a rat tail file to remove the internal stops in the adapter so the half inch pipe will telescope into the three quarter inch pipe.

Solder couplings to one end of the other three quarter inch pipe and to one end of the half inch pipes. Slot the open end of the couplings as above. (photo 3)

Although it doesn’t improve performance, looks are enhanced by soldering an end cap to a short piece of half inch pipe and placing it on the very top of the antenna.

Hose clamps are used to attach the insulator to the ground rod and the driven element. Use two clamps on each end. Hose clamps also are used to secure the pipe connections with the slotted couplings (photo 2), and to attach the feed to the antenna. (photo 4)

The radials are a quarter wavelength long (about 16 feet) made of number 10 solid electrical wire, and soldered to a small piece of copper strap at one end. The strap is secured to the center of a UHF barrel connector with a hose clamp as shown in photos 1 and 4. Two number 14 solid wires are connected to a PL-259 connector that attaches to one end of the barrel connector. Waterproof the PL-259 by filling it with RTV sealant. The pigtails should be less than 6 inches long and are secured to the ground rod and to the driven element with hose clamps. Your feed line connects to the other end of the barrel connector shown in photo 4.

Stretch the radials along the ground every 90 degrees from the antenna base.

Adjust the driven element by telescoping the half inch pipe into the three quarter inch pipe for lowest reflected power and tighten the hose clamp. (photo 2)

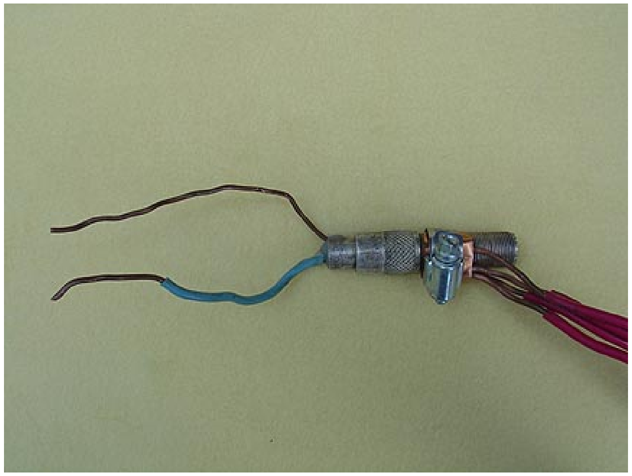


Photo 1


Photo 2


Photo 3


Photo 4


Photo 5


Photo6

LIGHTNING AVOIDANCE AND STATIC ELECTRICITY DAMAGE PROTECTION FOR YOUR VHF AND UHF EQUIPMENT

By Ed Butorajac, AAR4AJ / KM4QQ

During the antenna seminar that has been in progress from the end of October 2001, through mid March 2002, many antennas, grounding systems, lightning avoidance techniques and other related subjects have been presented. One subject has not been discussed: Lightning avoidance for VHF and UHF equipment. This is important because most, if not all of us have some equipment fitting this description in our stations. This could be a path for lightning energy to enter our stations and destroy not only the VHF/UHF equipment, but other radio, computer and other auxiliary equipment. Many of us rely on our VHF/UHF FM equipment to provide a point of entry into the MARS Message System. While this is not a part of our wideband HF effort, it is, in many cases, a vital part of our MARS station. Loss of this facility, at a minimum would be inconvenient and expensive to replace or repair.

There are many lightning arrestors on the market for RF feedline use at a variety of prices. Most if not all of them have one drawback. When they have done their job they permanently short. Some will only short after handling a certain level of energy. When this happens, the station is out of commission because the antenna is effectively shorted and not useable. Another problem that can happen is the transmitter can be damaged by transmitting into that short if the radio has either no VSWR monitoring capability that can reduce the output to a safe level, or the protection circuit malfunctions. This is more likely to happen at a remote repeater site because nobody would be there to realize the problem. While a voice repeater going off the air is immediately noticed, a digital node or repeater might be a different story!

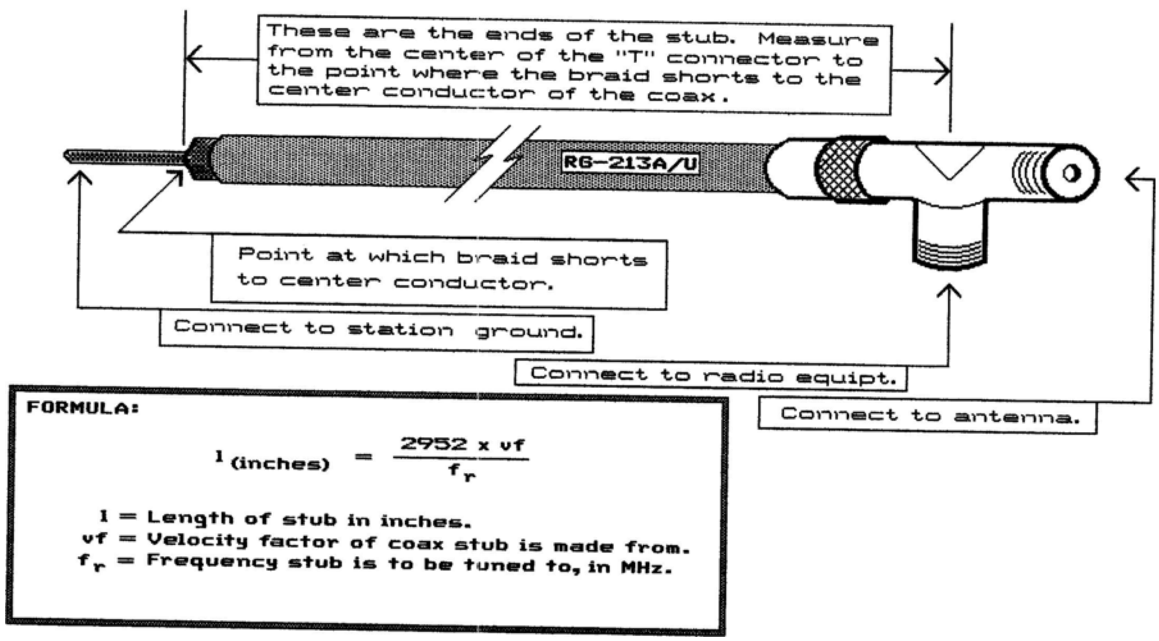
There are some who say the device I am about to present does not work as well as the suppressors their company sells. I can only say this: I have been associated with several installations that use the device described here in use, and there has not been one piece of radio equipment damaged by lightning of which I am aware. I am the repairman that is responsible for these radios and would know. More than 275 transceivers or transmitter/receiver combination sets for which I do maintenance and repair have been in use (some since 1987) continuously, and while have had other failures, none has come from lightning strikes. We are in an area known to be a lightning intensive area. Antennas have been hit and in several cases were blown clear off the buildings they were attached to. No radio damage was incurred. Yes, we had to change antennas and install new coaxial cable, but when the radios were connected, they worked. If everything is bought new to make this little device, even at some of the higher-priced electronics chain stores, it should cost no more than ten or twelve Dollars to construct.

The device I am presenting here is the quarter-wave shorted stub. I will discuss how it is connected in the antenna system, how it is made, the calculations for determining the length of the stub, how to measure the stub’s length and how to ground it, among other topics. This device can be mounted inside the station or outside the station building. It is a very flexible device as far as where it is installed. The closer it is to the radio, the less chance there is of any strike between it and the protected equipment. As I said, replacement is very cheap compared to the equipment being protected.

First it needs to be said that we are dealing with a device that is going to totally ground your antenna system to which it is connected. Not only will this device eliminate damage to your equipment, it will also free you from the necessity of continuously disconnecting your equipment from the antenna each time you leave your equipment. Many ground plane antennas have a vertical radiating element that is isolated from ground. This is an invitation for static or lightning damage to occur.

The characteristics of the quarter-wave shorted stub are very interesting. At the frequency to which it is tuned (or cut), it has an infinitely high impedance. As you apply signals which are further removed from the design frequency, the shorted stub will shunt more and more of the signal to ground. Therefore, it is also a filter for strong signals that may be plaguing your station. A good example is a strong FM broadcast or television transmitting station in proximity to your location. There is no reason to fear, the stub is sufficiently broad to cover the entire two-meter band, for example. In practice, there is a bandwidth of about 5 MHz before any noticeable attenuation occurs. If one wants to increase the slope of the skirts on the bandwidth pattern, several stubs could be used in parallel. This would not increase the lightning protection characteristics, but would act as a more selective filter device. Because this places your entire antenna at ground potential, it will do one other thing for you. On FM normally, static is not much of a problem. On SSB, AM or CW (which some of us use on VHF and UHF) it is of concern. When using these modes, if your antenna was not totally grounded before, and the stub is connected, you should notice a 6 to 9 dB reduction in static from storm activity, etc.

QUARTER-WAVE SHORTING STUB



Take a look at the drawing of the stub. Notice this drawing shows several interesting things.

1. The length of the stub is measured from the center of the "T" connector to the point at which the coax braid is shorted to the center conductor of the coax. This is important! If measuring is done in any other manner, it will be found the stub will not have the desired tuning range.

2. Each port of the "T" connector has a specific connection specified. This is very important for proper operation and the most effective ground path for a lightning or static charge to follow. (Remember, lightning does not like sharp curves and turns!)

a. The stub is connected to one of the two straight-through ports.

b. The antenna cable is connected to the other straight-through port.

c. The 90-degree port is connected to the radio equipment

3. The “T” connector used (or pictured) here is a three-female type connector. This is only because that is what I normally use. Other types can be used, such as one with a male connector on the 90-degree port. If BNC connectors are to be used in your system, use a BNC “T” connector. Type-N or any other type connector configuration can be used as well. The principles will still remain the same, and all measurements, etc. will not change. Or at least not the method of making measurements and the way the device is constructed.

Notice again; the diagram shows the “Best protection” method for connection of the three devices. The antenna and stub are connected to the two straight-through ports because it is the most direct route for static discharge. Of course, the radio equipment will connect to the 90-degree port.

The formula for calculation of the stub length is shown in the box at the lower left of the diagram. The figure “2952” is a constant that allows calculation of the length of the stub in inches, rather than feet. This is done for the convenience of measuring accuracy.

In the numerator of the formula, the term “vf” is used. This is the velocity factor of the coax cable used to make the stub. I recommend using a cable with a velocity factor of 0.66. Practically any coaxial cable with polyethylene dielectric is in this category. For a 50-Ohm coaxial system in general, or for the construction of the stub, use RG-58 ( ), 213 (A), 214*, or 223*. These are good cables of modern design and are the industry standards for power levels used by amateurs and MARS members. RG-8 is an old design cable that is no longer accepted by the MIL-STD. There are manufacturers still making it, however. The big problem is that RG-8/U has specifications that call for a “contaminating” type outer jacket. What this means is that there is a chemical reaction between the chemicals in the outer jacket, and the inner dielectric. The inner dielectric undergoes a chemical change due to this contamination, becoming conductive. The longer this goes on, the lower the resistance becomes. After a period of time (3 – 5 years after manufacture) depending on it’s installation conditions, it becomes such a poor conductor of RF it makes a better dummy load than a transmission line. For this reason, it may cost a few cents more, but RG-213 or RG-213A are a far better buy. RG-213 is the standard cable that has replaced RG-8 (A) in the military these days. (The cable types with an * after them are double-shielded types.)

Foam-type cables have a different set of problems that should exclude them from use in amateur and MARS antenna systems.

1. They have a much lower dielectric strength and handle much lower power levels than their polypropylene counterpart cables. These cables do not handle high VSWR as well because they have a lower dielectric strength. In fact, many sources do not even rate the dielectric strength of RG-8X foam dielectric cable because it is so variable from manufacturer to manufacturer. In some cases, it has been found to be as low as 250 Vrms, and even lower!

2. They are prone to having the center conductor migrate from the center of the cable towards the shield in bends. This causes impedance bumps and increases losses as well as further reduces the dielectric ‘s ability to handle high voltages, especially under the stress of an antenna that has a high VSWR.

3. Foam dielectric can be damaged by the heat used in soldering connectors onto the cables. The use of crimp-on style connectors is not desirable in construction of good quality antenna components that have to handle high currents. The unsoldered connections tend to corrode and present a high resistance to current flow (compared to a soldered connection.) There is also the chance that these connections can become diodic and contribute to causing unwanted sidebands and phantom signals that can cause interference to amateur, MARS and other services stations.

CONSTRUCTION:

STEP 1. Select the type of cable, connectors and “T” connector to be used. Make sure these are all compatible with the rest of the antenna system and station equipment.

STEP 2. Install the coax connector on one end of the coaxial cable you will use for the stub. Properly solder the connector to the cable and do any assembly of connector parts to finish the installation.

STEP 3. Perform the calculations to determine the length of the stub. Use the formula found in the diagram. Do not forget to multiply the constant by the velocity factor of the cable used.

STEP 4. Install the cable and connector you just put together in step 2 to one of the straight-through ports on the “T” connector.

STEP 5. Measure from the center of the “T” connector, down the stub’s length and mark the point at which the short needs to be made. (Review the drawing to make sure you are measuring from the proper point on the “T” connector.) Now, mark a second point 2 inches or a bit more below where you made the first mark (designating where the short will be placed). Cut the cable off at this point. This will be the end of the cable, and this extra part will be attached to ground or to a ground cable going to the ground.

STEP 6. Remove the outer jacket of the coax about ¼ inch above the first mark you made on the cable. Keep this piece of outer jacket, because you will need it as a reference to locate the point for making the short.

STEP 7. Fold the shield back over the outer jacket of the cable, exposing the center dielectric. This is done by placing your fingers on the end of the braid and pushing it back away from the end of the cable. It should start folding back over the outer jacket. Continue to push until it is completely inside-out over the jacket.

STEP 8. Using the piece of outer jacket you cut off in step 6, measure and mark the point for the braid to short to the center conductor. Now, from about 1/32 of an inch above that point, remove the center insulation, exposing the center conductor.

STEP 9. Reverse the process done in step 7 above. Fold the braid back over the center conductor. Pull it tight, and at the end of the center dielectric, form the shield down to make connection as close to the end of the insulation as possible. Refer to the drawing. Now compress the shield along the center conductor, and twist a bit to make sure it makes good contact.

STEP 10. Using a soldering iron or gun set at approximately 750 degrees F. solder the brain and center conductor. Completely fill the braid with solder until it is completely saturated. All exposed braid should be soldered all the way back to the end of the outer jacket. Insure this is a good solder connection made with good 60/40 rosin core electronics type solder. **DO NOT USE ACID CORE SOLDER UNDER ANY CIRCUMSTANCES.**

STEP 11. Connect your shorting stub as described above. Sit back and enjoy the peace of mind knowing you have just eliminated lightning damage from entering your station through your VHF/UHF antenna.

LIMITATIONS:

1. If you use this stub on a 2-band antenna system, it has disabled the band for which the stub is **NOT** cut. For example a 144 / 440 antenna becomes a 144 MHz antenna if the 2-meter stub is used. It would be possible to damage a radio by trying to use an antenna so connected on the 440 MHz band.

2. This particular device is only practical for use at VHF frequencies and above. At HF frequencies, the delay times would be excessive to provide effective lightning suppression. The size of the assembly would be a problem also. There were many fine methods of lightning avoidance and static suppression presented during the seminar, and are covered elsewhere in these end notes.

3. Remember, all or your antennas must be properly protected to effectively protect your entire station from lightning damage to the maximum extent possible. These stubs on your VHF and UHF antennas will take care of the problems in the 30 MHz and up range. Use of the other techniques given during the antenna seminar will protect your HF antenna arrays.

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By Robert Hollister, N7INK

A Portable NVIS Antenna

As the Amateur Radio Emergency Service (ARES) District Emergency Coordinator (DEC) and Radio Amateur Civil Emergency Service (RACES) officer for Cochise County, Arizona, I am always looking for simple solutions to complex problems. The problem in this case was to provide easy-to-use antennas for our county Emergency Response Vehicle (ERV) (Figure 1). Our ARES/RACES unit operates the ERV communications unit for the county sheriff's department in support of the Emergency Services Office, Search and Rescue Team and other emergency missions. Located in the southeast corner of Arizona, Cochise County consists of high desert, higher mountains and deep canyons. This presents a difficult environment to maintain reliable radio communications. Although the Amateur Radio clubs and the sheriff's department have a good network of VHF/UHF repeaters, there are many areas where repeaters or cell phones just do not provide the coverage we need to maintain contact with the sheriff's dispatch center in Bisbee.

A Solution

I recently read a Web article published by WØIPL that described the use of mobile monoband whip antennas in a near vertical incidence systems (NVIS) configuration (**www.w0ipl.com/ECom/NVIS/nvis.htm**). I decided, therefore, to experiment with this NVIS technique and build a portable kit for use with our ICOM IC-706 installed in the ERV.

The first step was to develop a shopping list (Table 1) and purchase the necessary items I thought I would need to make it work. At a recent hamfest, I purchased two monoband mobile whip antennas for each of the two bands I wanted to operate, and a dipole adapter that I had seen at the Dayton Hamvention.[1] I then broke out my trusty MFJ antenna analyzer to help with the trimming and SWR measurements.

First, I set up antenna number 1 (75 meters) on my Outpost tripod to start the tuning process.[2] The target was a 5 MHz frequency that I wanted to use to connect with the Fort Huachuca Military Affiliate Radio Service (MARS) station digital bulletin board. Many of our ARES/RACE members are also active in the Army MARS program and we have a TNC in our ERV for both HF and VHF digital communications. I knew that the normal range of the mobile whip antenna covered the 75 meter portion of the band effectively, but that it would require a much shorter stinger than the 48 inch standard length to reach the target 5 MHz frequency.

Figure 1—The Cochise County, Arizona emergency response vehicle (ERV).

[1]Notes appear on page 00.

Construction

Rather than trimming the stainless steel stinger that came with the antenna in steps, I started with a piece of wire coat hanger cut to 24 inches that fit into the collar on the top of the bottom section of the antenna. I scraped the varnish off the wire on the piece to be inserted in the collar for a good electrical connection (Figure 2). If you have ever tried to cut stainless stingers before, you will understand quickly why using the softer coat hanger wire is the preferred method. On the first test, the antenna was resonant at about 6.250 MHz. This told me that I was still much too long. I cut the wire stinger in half with my wire cutters to about a 12 inch stinger and tried again. I was now in the ballpark and only 500 Hz away. I continued cutting at half-inch intervals and tested the results.

I was soon at my desired resonant frequency. The stinger was now extended only 6 inches above the bottom section of the antenna. The antenna instruction sheet suggested that not more than 4 inches be inserted into the bottom section. The

Table 1
NVIS Antenna Parts

75 meter mobile monoband antenna	2 each = $30
Extra 48" stingers	2 each = $18
40 meter mobile monoband antenna	2 each = $30
Dipole adapter	1 each = $15
Stainless radiator clamps, 2"	2 each = $1
5 foot fiberglass pole, surplus	2 each = $15
RORO ("big foot") mount	1 each = $90
10" section, 3/8" aluminum stock	1 each from junk box
10" section, 2" aluminum stock	1 each from junk box
	Total = $199

Figure 2—A coat hanger is used as a prototype "stinger" during testing and requires that the paint be scraped off its end. It is shown next to a new stainless steel tip. The dipole adapter is shown at the top.

total length of the now resonant stinger was 10 inches. I used this trimmed piece of wire as a template and laid it next to the original stainless stinger. After carefully marking the new length and allowing for adequate length to extend into the top of the lower section, I cut the stainless stinger to length with my hacksaw. After smoothing and rounding the cut end of the stainless steel whip with a diamond file, I rechecked the resonant frequency. It was right on. I took the new short stainless stinger and, using the same measurement as the first one, checked it with the second 75 meter antenna bottom section for resonance. It was close, but required a slight amount of adjustment to be brought to frequency. The second stinger was quickly cut and ready for testing (Figure 3).

NVIS Height

Since the dipole adapter I purchased did not come with any instruction sheet, I needed to figure out how to get the antenna to a suitable height above ground. I already had something we call our roll-on/roll-off (RORO) or “big foot” to use as an antenna support base plate (Figure 4).[3] The NVIS literature and field testing suggests that the optimum height above ground is not an exact science but that it should be approximately 10-12 feet high to reliably cover a range from 0 to 300 miles. Height above ground and the conductivity of the soil below the antenna will affect the optimum range and the resonant frequency. Minor adjustments to stinger lengths may be required at different locations, depending on ground conductivity. A height of 10 to12 feet above ground also ensures that it is high enough so that most pedestrians and NBA basketball players are not likely to run into the ends.

As I owned a number of 5 foot military surplus aluminum and fiberglass antenna mast sections, I decided to use two of the fiberglass sections as the main antenna support.[4] These are the same type we use to hold up our spare dual band (144/440) antenna when we need additional range over the vehicle-mounted antenna. I then had to decide how to easily and quickly attach the adapter to these mast sections. A short piece of a scrapped aluminum mast section cut to 10 inches, two each 2 inch stainless hose clamps, and another 10 inch piece cut from some 1/2 inch aluminum tubing fit the bill. This allows a quick slip-on fit over the top of the fiberglass mast section (see Figure 3).

The next step was to attach the two modified mobile antennas and coax to the dipole adapter. I slipped the adapter over the top of one of the fiberglass masts, inserted it into the “big foot” and reattached the coax to my analyzer. It was too much to hope that it would still be exactly on frequency and, unfortunately, I was correct. There was enough interaction with the added metal of the adapter to require some additional tuning. Fortunately, it was minor and only required shortening both of the elements approximately another 3/4 inch to bring it back to my desired frequency. The next step: On-the-air testing.

Testing

With the two fiberglass mast sections inserted into the “big foot” base, the completed horizontal dipole was now approximately 11 feet in the air (Figure 5). Hooking up the radio, the computer and the TNC (terminal node controller), my first attempt to connect to the Fort Huachuca MARS BBS (bulletin

Figure 3—A top view of the assembled dipole adapter used to mount and secure both antennas, which are shown below it.

Figure 4—The RORO (“big foot”) mount. This was custom-built for the author by a welding shop (see text).

Figure 5—The completed antenna in use in the Chiricahua mountains of Arizona.

board system) using PACTOR (a digital communications protocol)was a success. Solid S9 copy was obtained with approximately 40 W output. I quickly prepared a sample message to send, reconnected to the BBS, uploaded the message and disconnected. Again success! Before disassembly to move to the next frequency of interest, each stinger and bottom antenna section were color coded with a band of red and white paint to ensure the correct stinger could easily be reassembled with the correct bottom section.

I had purchased a second set of stingers (of normal 48 inch length) for the 75 meter antennas and a pair of 40 meter antennas at the time I made the original purchase. Setting up for the other two primary frequencies I wanted to use was straightforward and required no trimming. Using two standard-size 48 inch whips and collets, these two stingers were adjusted for the Arizona RACES frequency of 3.990 MHz on the Outpost tripod. These are adjusted for our Arizona state RACES net on 3.990 MHz, and the third set is set for our alternate frequency of 7.248 MHz. There was adequate flexibility using the standard stingers to adjust to the state MARS nets just outside the amateur band with no additional trimming required.

The state RACES net has stations representing most state counties and reaches all corners of the state. I am located in the southeast corner with the furthest station about 250 miles away. Again, attaching the antennas to the dipole adapter required some minor shortening to achieve resonance (1.2:1). During a Sunday morning RACES net, I conducted on-the-air A/B testing. I compared the NVIS configuration to a Hustler vertical (previously used for portable operation), attached to the Outpost tripod. The NVIS configuration demonstrated an approximate 1-2 S unit improvement for most signals compared to the vertical.

Switching to 40 meters, and using the same procedure with two 40 meter antennas on the Sunday morning Arizona MARS net, showed a similar improvement. Most signals showed a 1-2 S unit improvement in signal strength using the NVIS dipole compared to the vertical. The biggest audible improvement was noticed in interference/noise levels. Some stations were totally lost in the noise on the vertical and came back to Q5 on the NVIS dipole. This net included stations in Arizona and southern California. Similar distances to those of the Arizona RACES net were covered. At that time of day (one hour later than the RACES net), the 40 meter coverage was generally better on all stations.

Conclusion

Two weeks later, I was able to run a few more tests from a remote location in the Chiricahua Mountains. Over the Labor Day weekend, the Cochise Amateur Radio Association conducts a special event operation from the ghost town of Paradise. This provided the most realistic test yet, as we deployed the ERV and operated portable in the mountains, much like a normal search mission. I tested all configurations on both voice and digital frequencies. The antenna was quick to set up and provided reliable communication to the stations I needed to contact. The complete antenna kit requires less than 5 minutes to assemble and erect. This antenna has proven to be a reliable addition to our emergency communications needs and it meets all of my expectations.

Notes

[1]The antennas are available from the Lakeview Company (**www.hamstick.com/9106.htm**) and WBØW (**wb0w.com**) as well as other sources. The dipole adapter is available from a number of sources, including: Atoc Technologies (Iron Horse) (**www.atoctechnologies.com/**) and Quicksilver Radio Products (**www.qsradio.com/products.htm**).

[2]**www.alphadeltacom.com/pg6.htm**.

[3]The RORO mount was built to specification by a local welder for $75. A drawing can be provided for others who are interested in having one fabricated. I have seen similar designs available at several hamfests.

[4]The mast sections came from The Mast Company (K4TMC), PO Box 1932, Raleigh, NC 27602; **www.tmastco.com/**. Henry offers a variety of military surplus mast sections in aluminum or fiberglass. I prefer the lighter fiberglass but I have used both with equal success.

Photos by the author.

Robert Hollister, N7INK, was first licensed as N2BCY in 1978, while serving with the US Army in Germany. He's also held the calls DA2HO and GM5ELQ. Bob retired from the Army in 1986 as a communications intercept technician. He has a BA from The State University of New York and an MS in Applied Management from Lesley College, Cambridge, Massachusetts. Bob also has an Amateur Extra class license and is a life member of the ARRL. He can be contacted at 5457 S San Juan Ave, Sierra Vista, AZ 85650, or at **n7ink@arrl.net**.

RORO Dimensions

Bill of Materials

1 ea – 1 ¾ or 2" Inside Diameter x 18" Tube for mast sections is dependent on the size mast.

I use Mast sections that have an outside diameter of 1 ½"

Optimum tubing is between 1 ¾" – 2"

2 ea – ½ " x 19 support rods

6 ea – 3/8 eye bolts with weldable (black iron) nuts

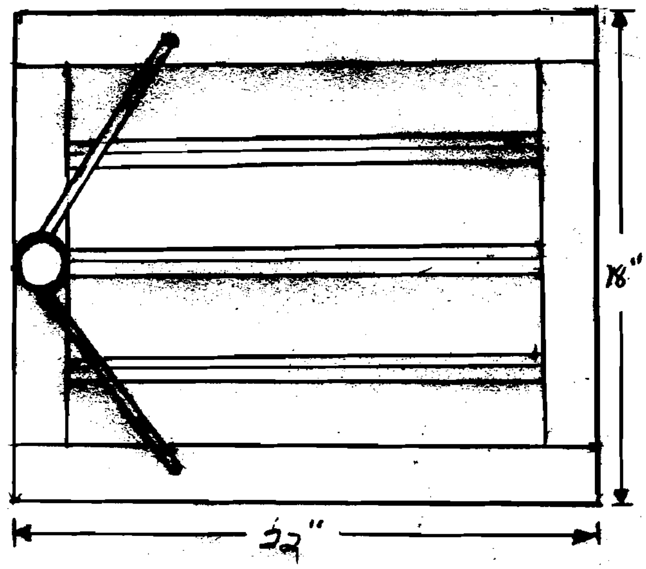
3 ea – 1 ½" x 17 ¾" Angle Iron

2 ea – 1" x 2" x 22" channel iron

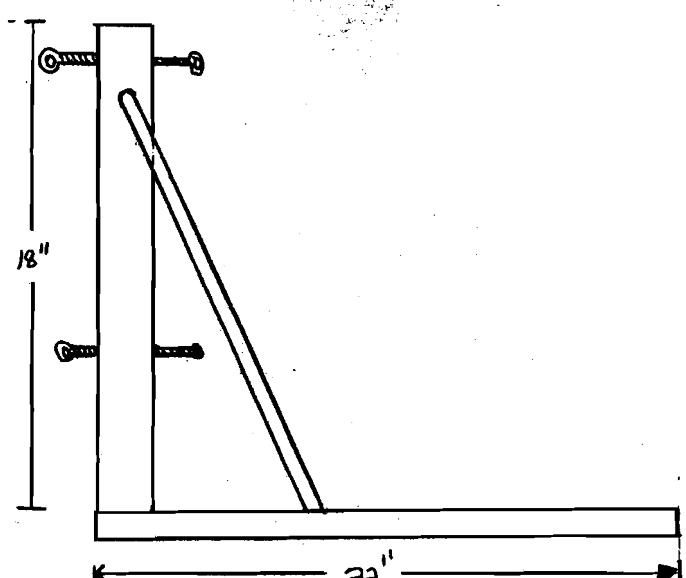
2 ea – 1" x 2" x 13 ¾" channel iron

Exterior dimension of the roll on-roll off base is approx 22"x18"
Channel iron sections welded into a rectangle with channel facing down
3 pieces of angle iron are welded corner pointing up inside the rectangle to form a grid
Spacing of ridges from inside of rectangle is at 3", 7" and 11".

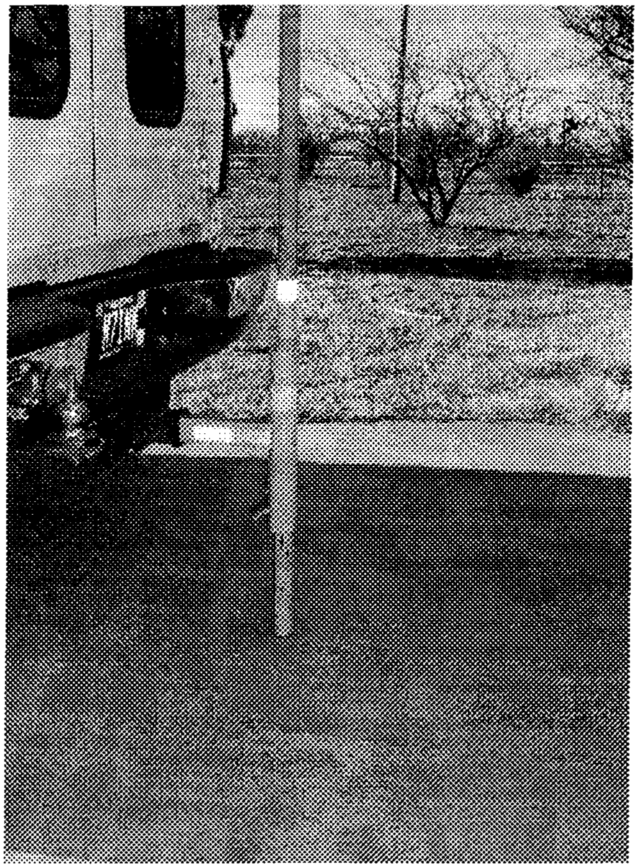
The tube is welded to the base centered on a short side.
The two rods are welded at an angle out to the long side for support/strength.
Three hole are drilled equidistant around the tube large enough to allow the eye bolts to pass through. The top bolts are about an inch from the top of the tube and the three of the nuts are welded over the hole but centered to allow the bolts to pass through to the center of the tube. The bottom three are about 6 " from the bottom. The eyebolts allow you to tighten down onto the mast section once it has dropped into place.



TOP VIEW



SIDE VIEW



Alternative Mast Mount attached to vehicle trailer hitch
Cost at local welder was $50. Used a standard hitch square tube and a two-inch inside diameter piece of tube. Screws to tighten down on mast were similar to the RORO above.