

MARS Antennas

What is the Difference?

MARS members want/need:

1. Most MARS communications are within 600 miles or less
2. Most Mars communications needs are omni directional coverage
3. Most MARS frequencies are not harmonically related.
4. channelized frequencies spread over 2 - 30 MHz.

Hams want/need:

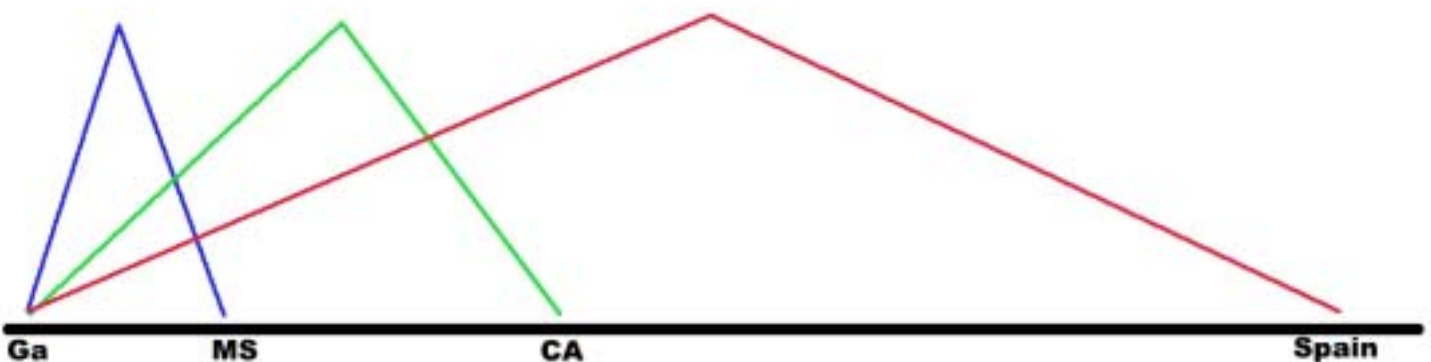
1. Most communications saute after is DX, 3000 mile or more
2. Gain in one direction or another
3. Most Ham frequencies are Harmonically related.
4. Ham frequencies are within a "BAND"

This is what causes the difference in Antenna Design

Mars members needs a NVIS Antenna, What is it?

Ham antennas need to have their take off angle, (the angle in which the wave takes off from the antenna measured at the far field), of 30 degree or less. The lower the take off angle the further the wave travels from the starting point before it is reflected back to earth. This allows communication at 1000 miles or more, DX.

A Mars member needs a high take off angle, 60 to 90 degree. We want the our signal to almost be straight up, so that the reflection will come back down, close to the starting point. (See fig 1)



An antenna that sends most of its radiation straight up is a “Near Vertical Incidence Sky Wave Antenna or NVIS, (also know as a Cloud warmer antenna).

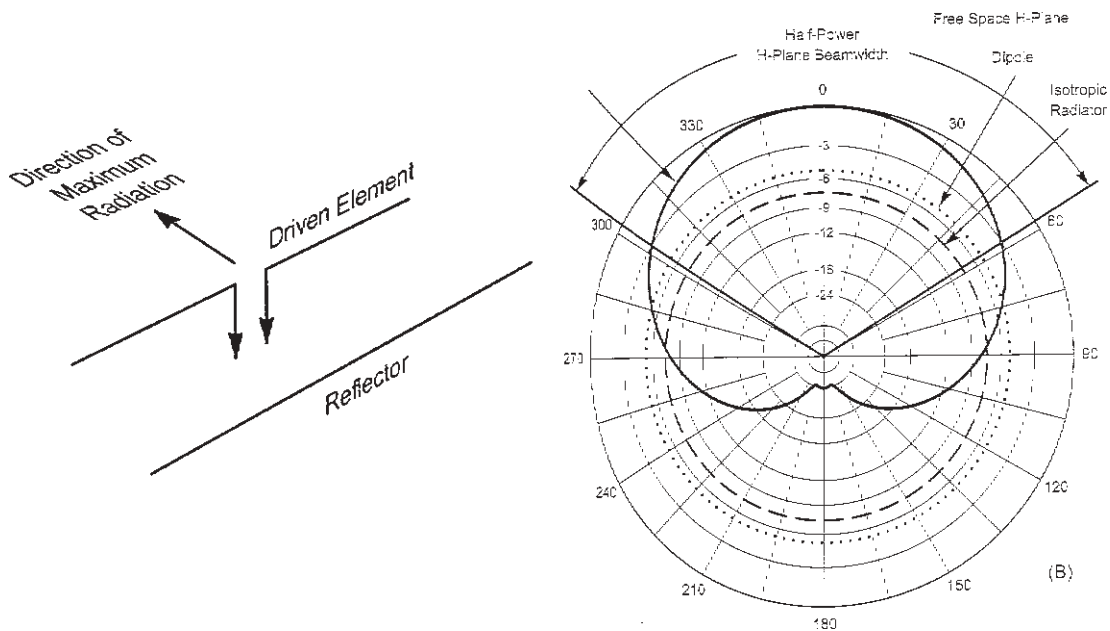
What makes any antenna work as a NVIS antenna?

There are 2 basic answers, (1) the design of the Antenna, and most importantly (2) the height the antennas is above the ground.

1. The design of the antennas: Some antennas in free space radiate broadside to the wire and some endfire from the wire. Dipoles are broadside, Longwires are endfire and loops are broadside, though the hole of the loop.

2. Why is the Height of the antenna so important to the takeoff angle from an antenna?

The earth acts as a reflector for radio waves. If we put a reflector behind an antenna, we cause the back radiation to bounce and go forward. If we do it right this reflective wave will add to the forward wave and add up, giving us gain in that direction. (See fig 2 - 2 Element yagi beam.



So, if we take a Normal dipole, and keep it close to the earth, some of the downward radiation will bounce back up and add to the wave already heading up and add to give us gain and directivity in that direction.

So how high does my dipole need to be for Great NVIS? How high for a great DX antenna.

From a 1/8 wave to 3/8 waves for NVIS and 1/2 for DX. If you want a compromise for DX and NVIS, your antenna needs to be 3/4 waves high. (See Fig 3 page 3-18 ARRL Antenna Handbook 20th addition)

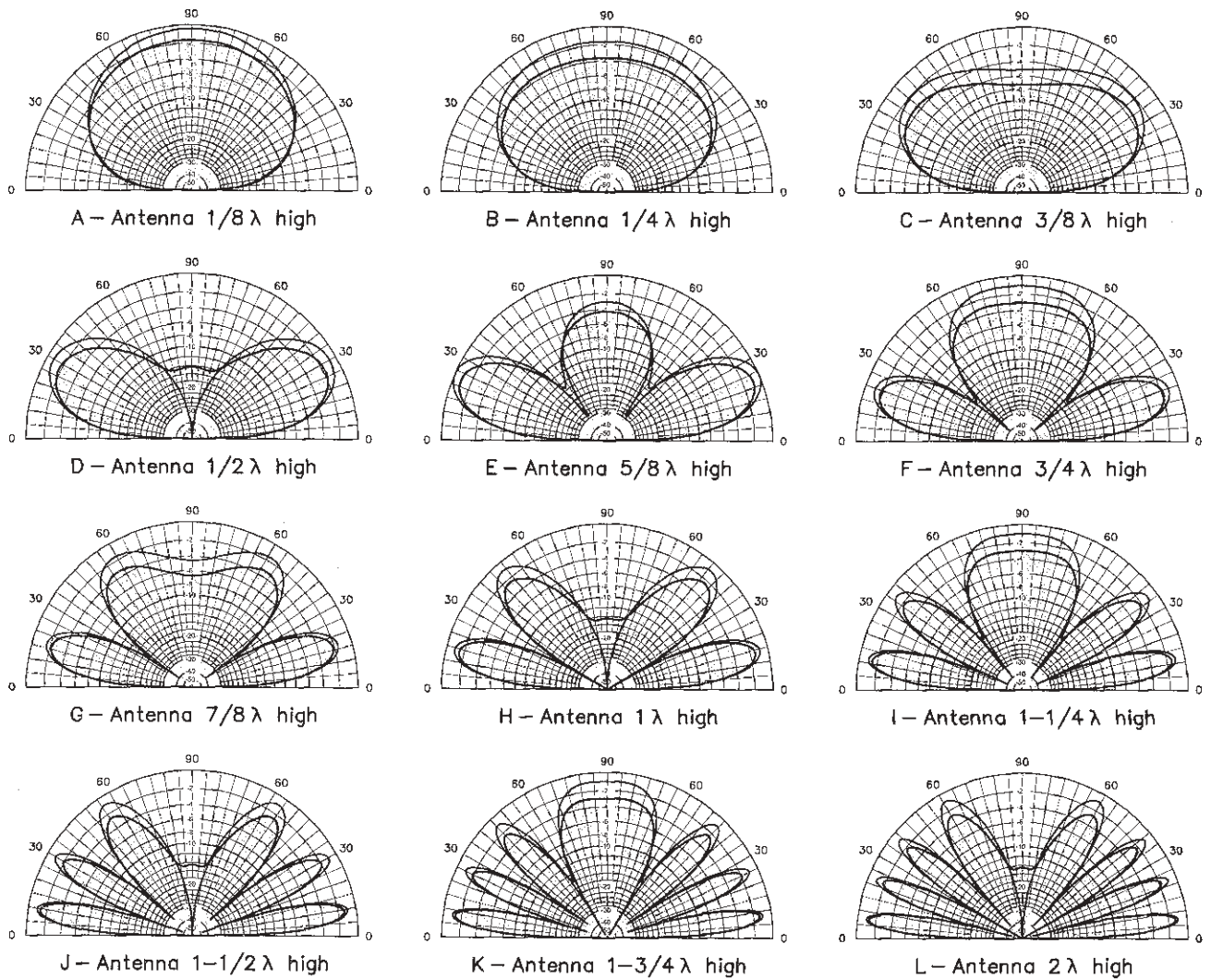


Fig 25—Reflection factors for horizontal dipole antennas at various heights above flat ground. The solid-line curves are the perfect-earth patterns (broadside to the antenna wire); the shaded curves represent the effects of average earth ($k = 13$, $G = 0.005$ S/m) at 14 MHz. Add 7 dB to values shown for absolute gain in dBd referenced to dipole in free space, or 9.15 dB for gain in dBi. For example, peak gain over perfect earth at $\frac{5}{8}\lambda$ height is 7 dBd (or 9.15 dBi) at 25° elevation.

Dipole Heights in feet (all heights are approximate):

Freq MHZ	1/8 wave NVIS	1/4 wave NVIS	3/8 wave NVIS	1/2 wave DX	3/4 wave NVIS & DX
2	63	126	188	251	377
3	42	84	126	168	251
4	31	63	94	126	188
5	25	50	75	101	151
6	21	42	63	84	126
7	18	36	54	72	108
8	16	31	47	63	94
9	14	28	42	56	84
10	13	25	38	50	75
11	11	23	34	46	69
12	10	21	31	42	63
13	10	19	29	39	58
14	9	18	27	36	54
15	8	17	25	34	50
16	8	16	24	31	47
17	7	15	22	30	44
18	7	14	21	28	42
19	7	13	20	26	40
20	6	13	19	25	38
21	6	12	18	24	36
22	6	11	17	23	34
23	5	11	16	22	33
24	5	10	16	21	31
25	5	10	15	20	30
26	5	10	14	19	29
27	5	9	14	19	28
28	4	9	13	18	27
29	4	9	13	17	26
30	4	8	13	17	25

If your wanting DX from your 80 mtr dipole, it needs to be installed at approximately 145 feet up! Most of us don't have an 80 mtr dipole good for dx, it really is a NVIS Antenna. At 40 mtrs, the dipole needs to be mounted at approximately 65 feet high for DX. Changing the Slope of the Dipole or making an inverted "V" will also change the takeoff angle and the radiation pattern of the antenna.

Our Mars dipole for frequencies between 2 and 7 mhz need only be around 47-63 feet high for good NVIS performance. For 8 Mhz to 30 Mhz the Antenna needs to be installed between 13-16 feet high.

As we can see, Our simple dipole can make one of the best "Mars Antennas" . It is simple to build, and can be installed at low heights. I recommend the following heights both for deployments and home use : 2-12 Mhz 30 feet, and 10-30 Mhz 13 feet.

MARS members need Freq agility: We need (1) an antenna that works from 2-30 Mhz or multiple antennas.

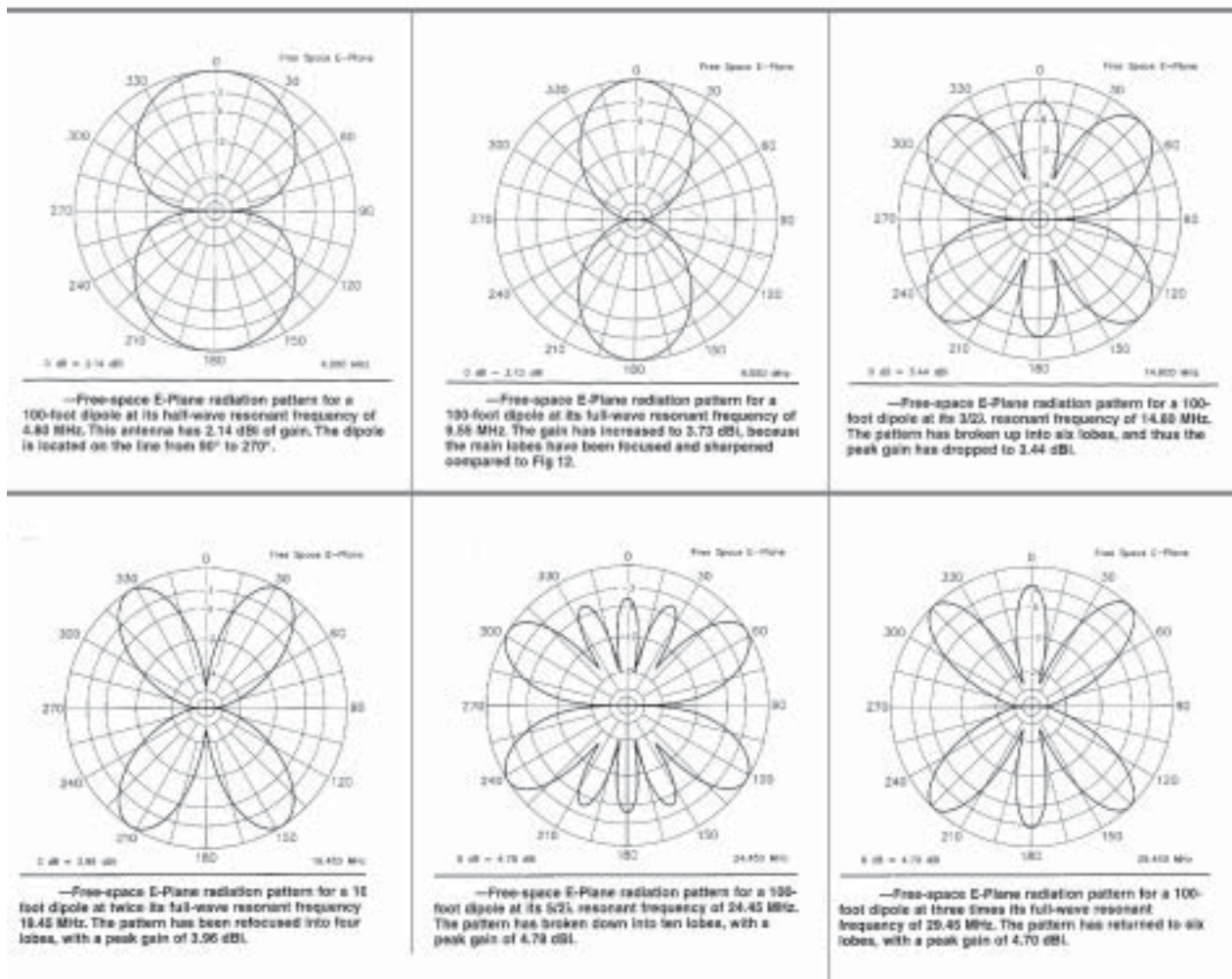
Unlike in the Ham bands, where frequencies have harmonic relationship, the channelized region allocated frequencies most times are not harmonically related to each other. Therefore the effectiveness of an antenna designed to work on more than one frequency thought there harmonic relationship is not possible.

You may ask, "Give me an example of a Ham antenna that works more than on band via Harmonics?" A 40 meter antenna can be used on 15 meters. This is due to the fact that 15 meters is the 3rd harmonic of 40 meters. ($7 \text{ mhz} * 3 = 21 \text{ Mhz}$)

Basic Center Fed Dipole For Mars use:

A Standard dipole may be used on more than 1 frequency. Usually the dipole is cut for a 1/2 wave on the lowest frequency that this antenna will be used. For example, An 80 mtr dipole is approximately 135 feet long. We can feed this antenna on multiple frequencies. Right now we will not consider that the impedance of this antenna changes with the change in Freq. This will be discussed later.

What happens to the angle of radiation from this dipole as the frequency is increased?



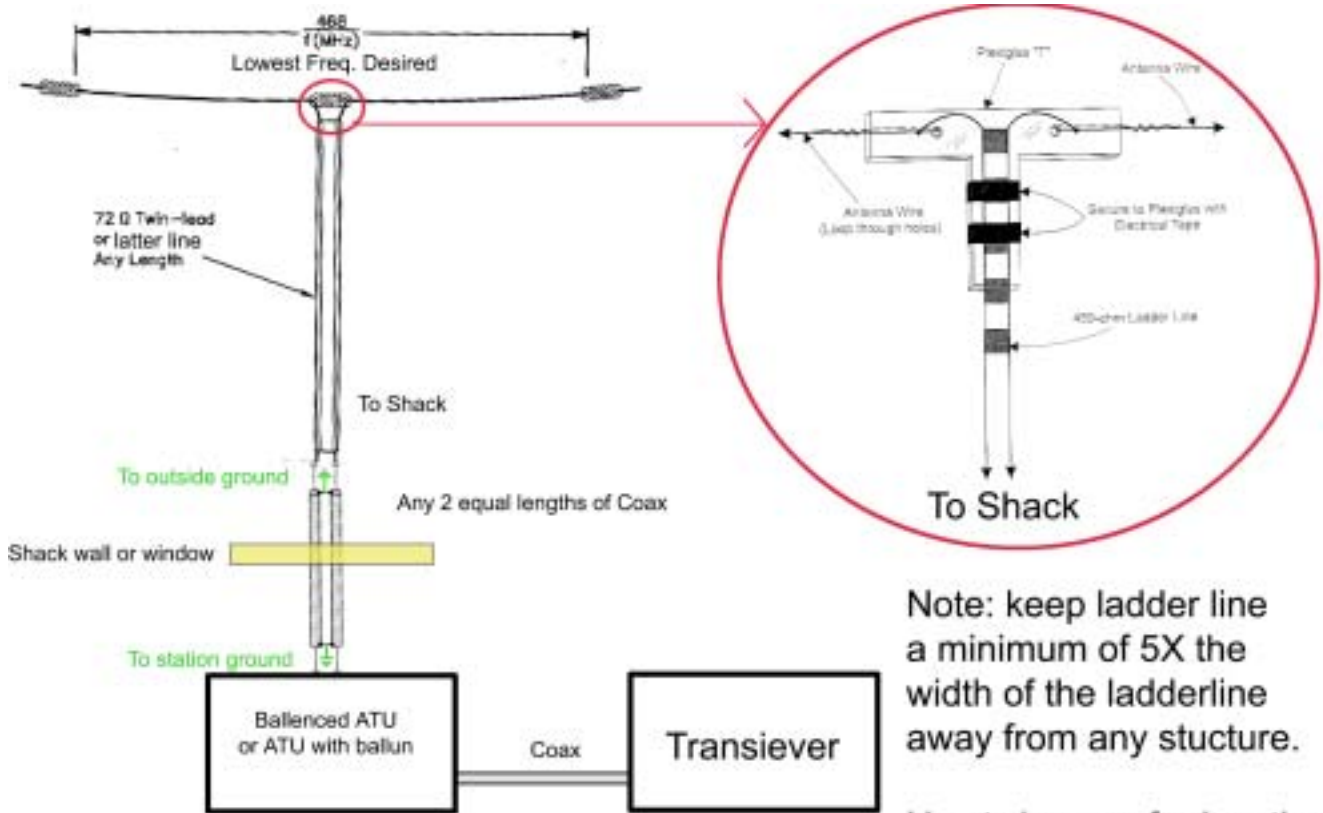
In this example the antenna is 100 foot long, fed in the center, here are the patterns:
 What we see is that as the frequency goes up the radiation becomes more endfire. In other words, the radiation starts following the length of the wire as well as we start getting “Gain” and “Nulls” in our pattern.

We can live with this pattern change, but the major issue is feeding the antenna and minimizing loss in the feed line when we diverge from the normal 1/2 frequency. When the dipole is operating as a half wave antenna, it will have an impedance of approximately 50-75 ohms, but as we move to the dipole acting as a full wave center fed dipole we can have as much as 2000 ohms. This change in impedance is what causes us problems.

Lets first consider feeding this dipole with Coax. RG-213 has a loss of .6 db when perfectly matched, 1:1 swr, but at 20:1 SWR this coax has 3 db loss (half of the power is robbed in heating of the coax) On the other hand, if we feed this same antenna with “Window line/ladderline” the matched loss is less than .1 db and a 20:1 swr brings the loss up to less than .8 dp loss. All of our power reaches the antenna and radiates. We also have no receive loss, unlike our coax example above.

Conclusion:

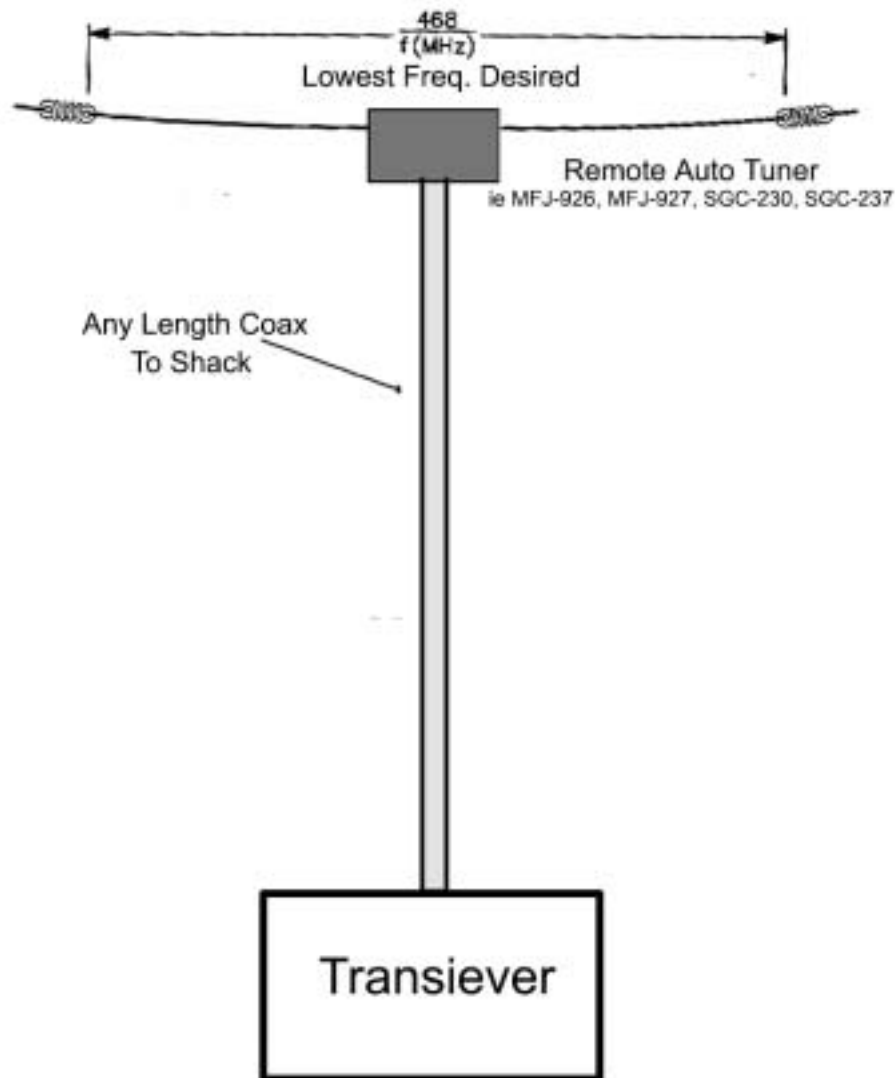
A dipole cut for the lowest freq you will use in MARS and fed with ladder line mounted at a height of 30 feet is an excellent antenna for the Mars members. You will need an ATU to match the impedance at the end of your feedline to the impedance your Transceiver wants to see (50 ohms).



Note: keep ladder line a minimum of 5X the width of the ladderline away from any structure.

Use twin coax for locations where you will be in contact with a structure

Another Dipole using a Auto Tuner mounted at the feed point of dipole.



Any Dipole can have it's legs Sloped (Inverted V) or brought back towards the mounting pole to shorten area needed for full size dipole. Changing these wires from full horizontal to something else results in a lowering of the resonant frequency, a decrease in feed point impedance, slight reduction in efficiency and a narrower bandwidth. We don't get something for nothing, you may have to live with it to get the antenna to fit in your lot.

Adjust the final length of the dipole for lowest SWR on lowest resonant frequency before inserting the ATU or Transmatch.

FEEDING THE ANTENNA

A feed line is designed to bring the power generated by the transmitter to the antenna, then bring the received signals from the antenna to the receiver. It has to do this with the least amount of loss of power and give the best transfer of that power to and from the antenna.

Coax and hardline are known as concentric feed lines and are unbalanced feed lines. It comprises of some form of conducting tube, with a center conducting tube or wire insulated from the tube using some form of dielectric (insulator). The sizes of these wires and tube, the type of dielectric all effects the efficiency, impedance and sizes of the line. The larger in physical size, the lower the losses.

The main advantage to coax and hardline is the fact it can be laid anywhere, with no ill effects. The disadvantage is that coax and especially hardlines are not cheap. But the main issue with coax and hardline is the internal losses that occur in both a match condition and unmatched condition. All feedlines have a normal resistance to RF energy to one degree or another. With coax, the loss increases when it is not matched to the Antenna.

Twin lead or ladderline are feedlines where the wires are spaced some distance from each other with some form of insulator. The distance and the size of the wire are the main determinations for impedance of ladderline. These feedlines are balanced feedlines.

Ladderline has extremely low losses to RF. Even with extreme SWR mismatch loss they are still quite low. At a 20:1 swr, the loss in most ladderline never reaches more than 1db. This makes ladderline exceptional for Mars All Band Antennas. But there is a big catch, ladderline must be kept balanced, meaning that both wires must remain the same distance away from any structure and ground. Ladderline should be installed so that at least 3x the wire space is the minimum distance that the line needs to be away from any structure or wire. (NOTE: Ladderline CAN NOT be taped to a tower, pole, or building. It must not be laid on the ground!)

To bring ladderline into the shack, you must keep this balance. There are 3 ways to accomplish this task. (1) use coax from the radio to the out of doors and connect a 4:1 balun then connect the ladderline to the balun. (2) use feed through insulators through the wall or window to bring ladderline into shack. and all that is necessary to keep balance and rf radiation to minimum in the shack, (3) As per drawing on page 6, use 2 equal lengths of coax as substitution of ladderline feeding into the shack. This twin coax is a balanced line that can be placed or taped to anything, Use the shortest run of this as possible, because this type of "Balanced Line" has similar feedline losses as coax.

ATU/Transmatch What Are They and where do I use them?

Transmatch is used to transform the impedance seen by the input end of the feed line to the 50 ohms required for the transceiver to work properly and efficiently. It is located either in the Radio or next to the radio in the ham shack.

There are many types and styles of transmatches. Some designed primarily for unbalance to unbalanced conditions. ie; Coax from rig to Coax to Antenna. Some of these include a Balun to convert unbalanced at the Transmatch to a ladder line. These are not as good, where losses are concerned, as a Transmatch designed for unbalance to balanced line.

An example of a Transmatch design for unbalanced to balanced is the MFJ-974HB, MFJ-974B and the MFJ-976, or the old "Johnson Match Box".

All others including all Auto Tuners are designed for unbalanced to unbalanced and use a Balun after the tuner circuit for balanced lines.

A "Antenna Tuning Unit" is a transmatch designed to be installed at the feed point of the antenna.

This is the BEST place for an ATU or Transmatch. We are taking the impedance of the Antenna and transforming it to the COAX feed line. There by the only loss in the line is the matched feedline loss listed in the literature for that coax.

When we have the Transmatch in the ham shack we are tuning the transmission line and the antenna. Any losses in the line will increase do to the impedance mismatch between the antenna and the feed line. A transmatch at the transmitter will not fix this problem and losses, possible large losses, will occur in coaxial feed lines..

Look carefully at the literature for the Tuning unit you wish to purchase. They are rated in Power they can safely handle and the range of impedances the can transform.

IE: MFJ-976 1500 watts, 12-2000 Ohms
MFJ-929 Auto tuner 200 watts, 6-1600 Ohms
LDG KT-100 Auto tuner 125 watts, 4-800 Ohms, w 4:1 balun 6-4000
LDG-11 Pro - Auto tuner 125 watts, 6 - 1000 Ohms
LGG AT-1000 Auto tuner 1000 watts 6-1000 Ohms
Johnson Viking Match Box (unbalanced to Balanced) manual tuner 25 - 3000

If your tuner of interest does not have these specifications, Ask before you buy. You want the highest rating for power and the widest Ohm range you can afford.

A transmatch that can handle a 3:1 swr has a range of 17 to 150 Ohms. Most internal ATU's fall into this range.

G5RV Antenna

This antenna was designed by a ham in England, Louis Varney G5RV, several years ago. This antenna can be used from 3.5 to 30 mhz. See Fig 10 on this page. This is the original design. Many modifications have occurred since it's original conception.

Several designs use a length of ladder line from the feed point of the dipole. At the end of this ladderline some

form of Balun is connected and coax connected to other end.. The coax is then run to the shack. This system is not as effective as many may think. In fact, an analysis of the G5RV feed-point impedance by many hams shows there is no length of balanced line of any characteristic impedance or length that will transform the terminal impedance to the 50 to 75 Ohms on all bands. (low SWR indications with coax feed may indicate excessive losses in the coax line.

It is Recommended, that Mars members wov desire to use a "Dipole" Style antenna, use the 2 basic designs present earlier.

Windom/Carolina Windom/Off Center Fed Dipole (OFC)

Back in the '30 and '40's a "single-feeder Hertz" antenna was presented in the 1929 QST by Loren G Windom W8GZ, see Fig 12.

A Windom antenna is a dipole cut for the lowest freq of interest and fed with a single wire feed line. the feedeer is connected 14% off of center. The idea was that this location on the dipole gave a good impedance match to the impedance of a single wire feed line. The problem with this arrangement is that the feed line is unbalanced and will radiate and bring RF into the shack.

(Note: the impedance of a dipole changes from approximately 50-75 Ohms at it center to approximately 2000 Ohms when fed 1/3 from the end of the dipole to +2000 ohms when fed on the end of the dipole)

Carolina Windom, resolves some of these issues, the feed point was moved sightly to accommodate 300 Ohm ladder line. Edgar Lambert WA4LVB and Joe Wright W4UEB designed a Windom that uses both the horizontal components of the dipole, and the vertical component in the feed line to make an Omni directional dipole that works from 3.5 - 30 mhz (see fig 13 and fig 14 next page.

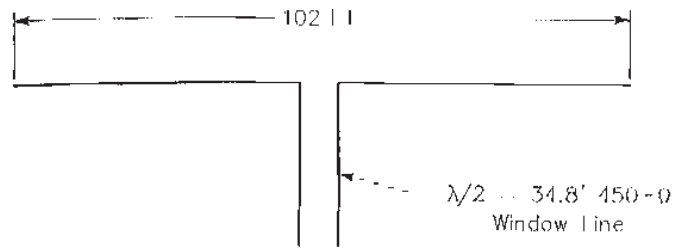


Fig 10—The G5RV multiband antenna covers 3.5 through 30 MHz. Although many amateurs claim it may be fed directly with 50-Ω coax on several amateur bands, Louis Varney, its originator, recommends the use of a matching network on bands other than 14 MHz.

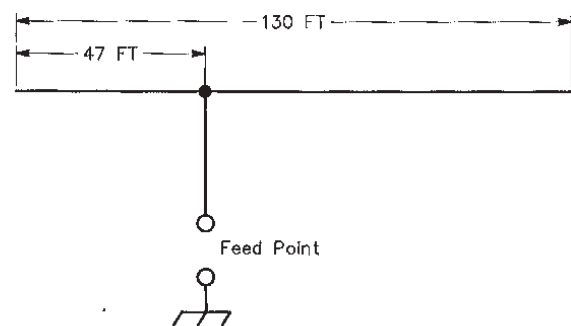


Fig 12—The Windom antenna, cut for a fundamental frequency of 3.75 MHz. The single-wire feeder, connected 14% off center, is brought into the station and the system is fed against ground. The antenna is also effective on its harmonics.

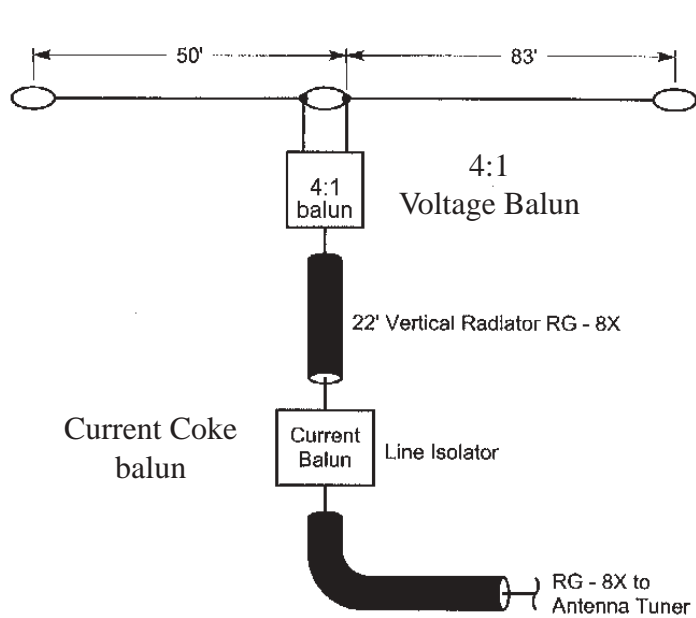


Fig 13—Layout for flattop “Carolina Window” antenna.

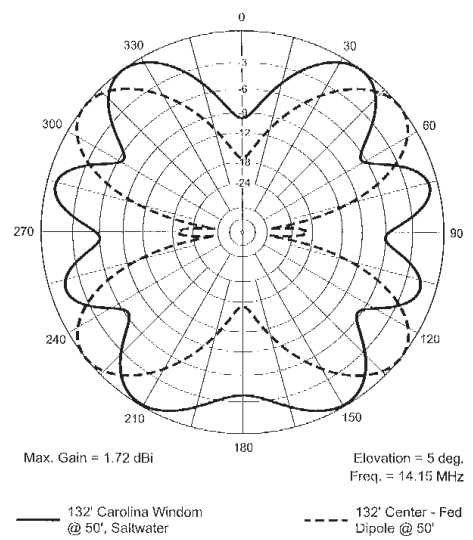


Fig 14—20-meter azimuth patterns for a 132-foot long off-center fed Carolina Window and a 132-foot long center-fed flattop dipole on 20 meters, both at a height of 50 feet above saltwater. The response for the Carolina Window is more omnidirectional because the vertically polarized radiation from the 22-foot long vertical RG-8X coax fills in the deep nulls.

This antenna still requires a transmatch to match the final impedance at the end of the feedline in your ham sack to the 50 Ohm impedance of your transceiver. Most stations have reported that their internal ATU in their radio was able to match on most to the ham bands.

Off-Center-Fed Dipoles (OFC)

As mentioned in the “Note” earlier, it is not necessary to feed a dipole antenna at its center, although doing so will allow it to be operated with a relatively low feed-point impedance on its fundamental and odd harmonics. (past example 7 mhz dipole used on 21 mhz). An OFC dipole fed 1/3 from one end of its length may be used on its fundamental and all even harmonics. (ie 3.5, 7, 14 mhz or 2, 4, 6, 8 etc)

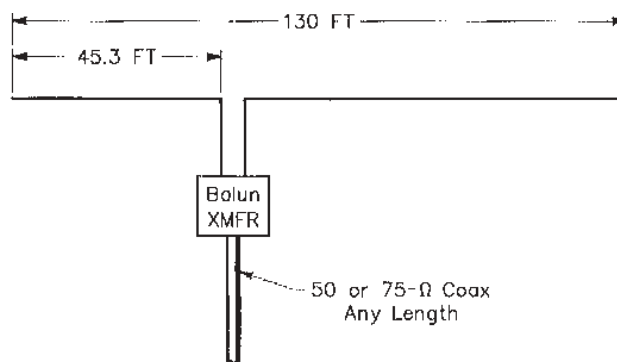


Fig 18—The off-center-fed (OFC) dipole for 3.5, 7 and 14 MHz. A 1:4 or 1:6 step-up current balun is used at the feed point.

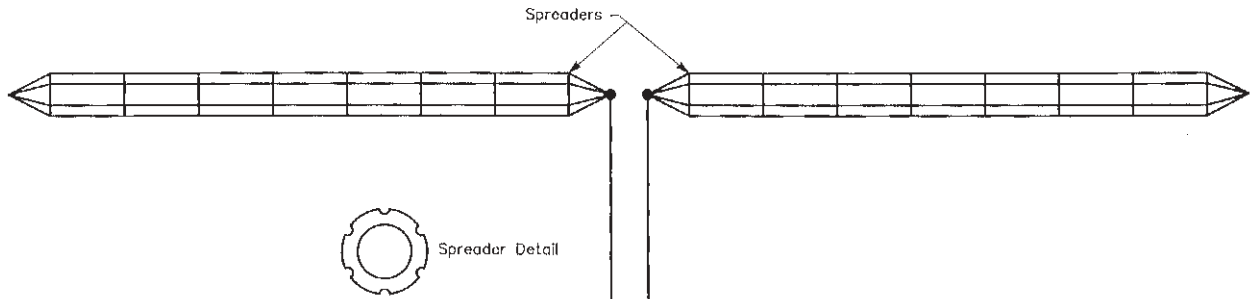
By feeding a dipole at 1/3 from one of its ends with a 4:1 or 6:1 step-up current balun will offer a reasonably good match to 50 or 75 Ohm coax on the fundamental and all even harmonics. Your internal ATU of your radio should be able to match any minor fluctuations.

You must use a Current/choke balun in order to force equal currents to flow on each side of the antenna for proper operation.

Increase the Band Width of Any Antenna with a” Cage”.

You can increase the band width of any antenna (dipoles, verticals, loops, etc.) by increasing the diameter of the wire used in creating the antenna.

A well know example of this is known as a “Caged Dipole.” A standard dipole with 12 gage wire will have a band width of about 100 kc, a cage ant 6” dia. will have about 287 kc band width.



Construction of a cage dipole, which has some resemblance to a round birdcage. The spreaders need not be of conductive material, and should be lightweight. Between adjacent conductors, the spacing should be 0.02λ or less. The number of spreaders and their spacing should be sufficient to maintain a relatively constant separation of the radiator wires.

Increase the Band Width by Using a Resistive Load. (B&W Dipole, T2FD, 1/2 Rombics.,RLM)

We can increase the bandwidth of an antenna, if we radiate and burn up any energy that arrives at the antenna from the transmitter. There can be no SWR, if all the energy is dissipated in the antenna, and the impedance of the antenna and the feed line is matched at the feed-point.

A well know antenna of this design is built by B&W. It is a folded dipole with a non-inductive resistor in upper center fold, and a balun at the feed point. This design is also know as a T2FD antenna.

These antennas will usually be about 3 to 9 db down from a standard dipole, but where you need to rapidly move from one frequency to another without the use of an ATU or Transmatch, such as MARS HF use of the WINLINK system, it is an excellent antenna.

The non-inductive resistor in the antenna must be of sufficient size to dissipate at least half of the transmitted power. And the balun such that it transforms the antenna impedance to 50 Ohms.

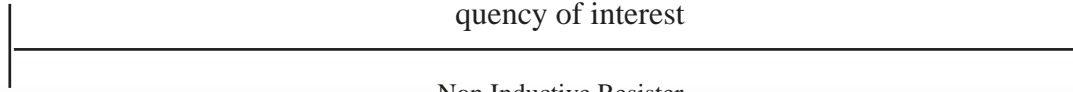
The Actual length of the antenna, is not so important, but the longer the better. If possible, have the length equal to a Halfwave dipole at the lowest frequency desired. This will give you maximum radiation efficiency.

Common Loads and baluns are: 450 Ohms, 9:1; 600 Ohms, 12:1 balun, 800 Ohms, 16:1 balun. Buxcomm.com is currently selling both loads and baluns for these antenna styles.

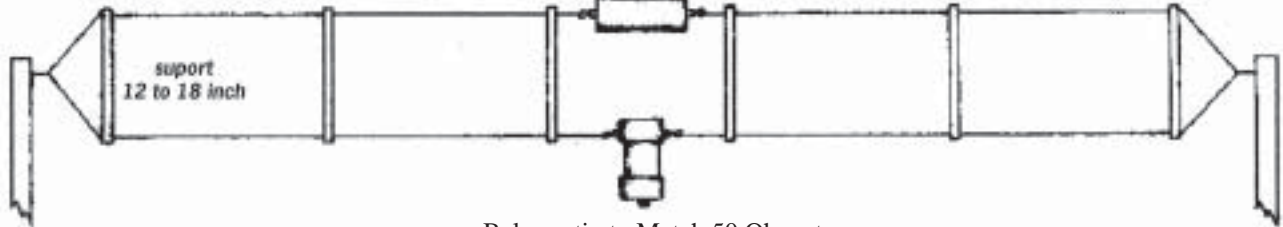
The following page are two antenna designs using a resistive Load

T2FD/B&W Folded Dipole

($468/f$ Mhz) for lowest frequency of interest



Non Inductive Resister
1/2 Power rating of Transmitter

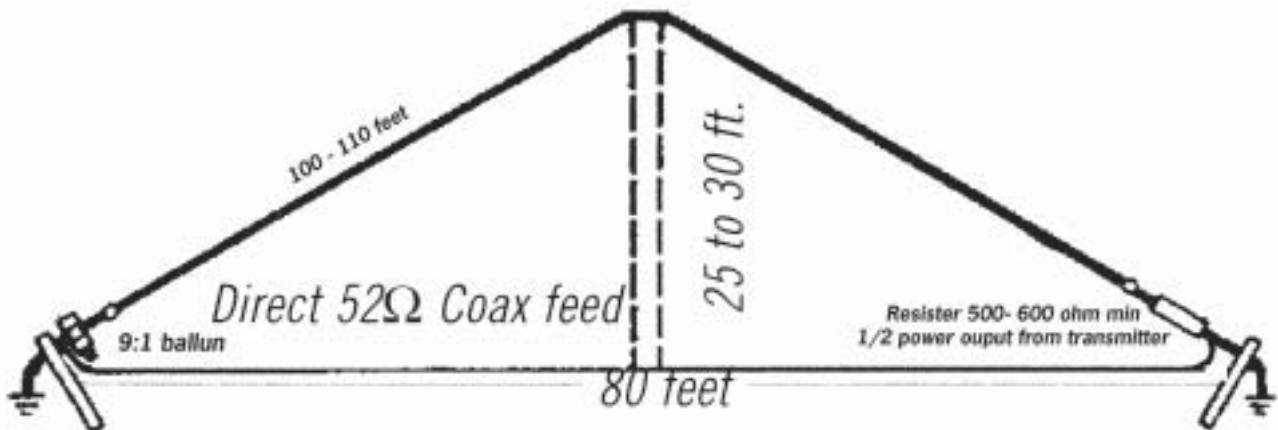


Balun ratio to Match 50 Ohms to Antenna Impedance

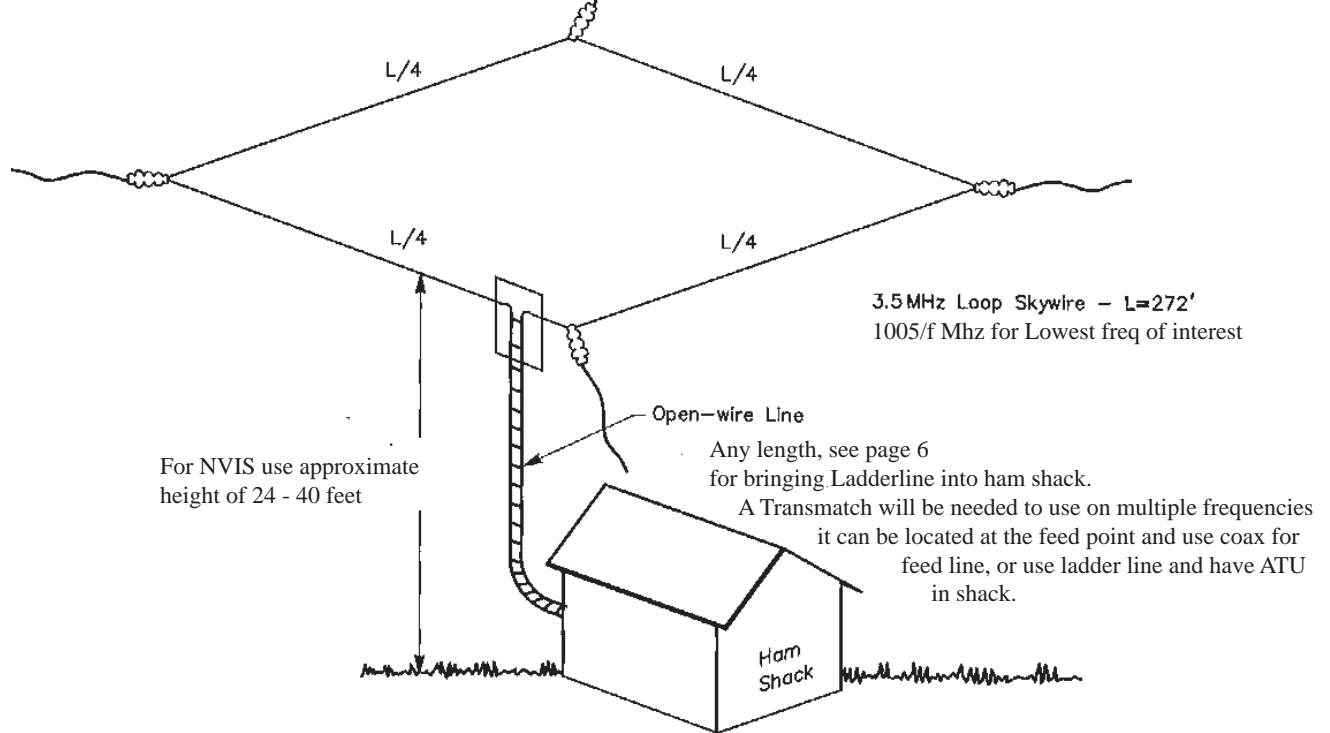
Balun	Resister
9:1	450 - 600
12:1	550 - 650
16:1	700 - 800

1/2 Rombic /B&W “V”

“Best for deployment, voice and digital, Very easy to set up”
requires only one support



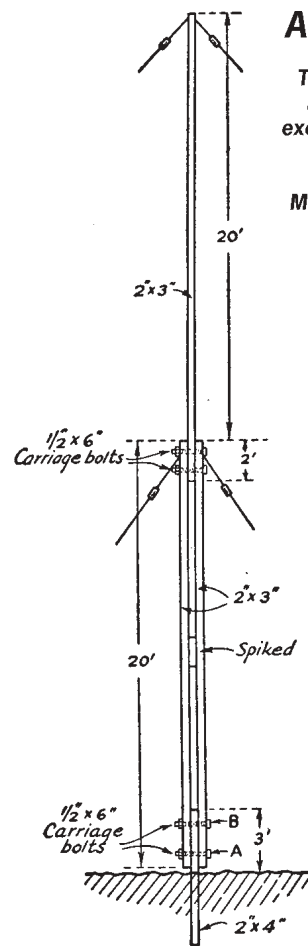
Horizontal Full Wave Loop "A Great MARS Antenna"



A horizontal loop is a great for MARS use. It can be used efficiently on all frequencies, has low noise pickup, and sends all or most of the radiation straight up. The ground acts as a reflector. You may increase the effectiveness of the ground reflection by installing a closed loop 1/8 wave under the loop, or a few inches under the ground.

A Transmatch is needed in order to use on more than one frequency band. A remote ATU can be located at the feed point and coax use for feed line. Otherwise, use ladderline and bring it into the shack as described on page 6 in the way as the all band dipole described.

The loop requires a minimum of 4 supports, They can be trees, poles, masts. The following is an easy and cheep support mast for such an antenna. I used 2x4s, total height approximately 25 feet, and I don't use guys. It is totally self supporting.



Antenna Farm Mast

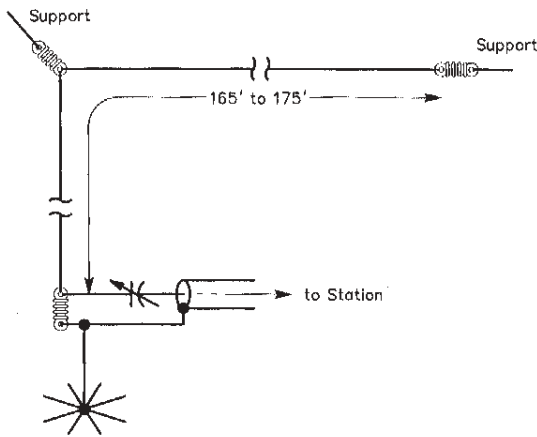
This is the mast system in use at KETGZ/AAV4WR ant farm except I used 14 foot 2X4s and a metal post set in concrete

Mast is 24' tall and has no guys

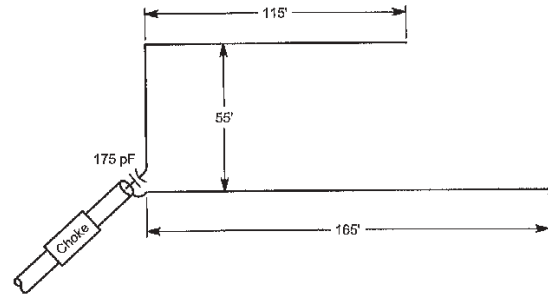
Fig. 14-49—A simple and sturdy mast for heights in the vicinity of 40 feet, pivoted at the base for easy erection. The height can be extended to 50 feet or more by using 2 X 4s instead of 2 X 3s.

Inverted 'L'

“Another Great MARS Deployment Antenna”



The 1.8-MHz inverted L. Overall wire length is 165 to 175 feet. The variable capacitor has a capacitance range from 100 to 800 pF, at 3 kV or more. Adjust antenna length and variable capacitor for lowest SWR. Or use a manual or auto antenna tuner at feed point.



A single elevated radial can be used for the inverted-L. This changes the directivity slightly. Here, we are adding a ground wire to improve efficiency. A Transmatch can also be used at the feed point for use on multi - frequency agility.

This is a simple and easy to construct antenna that requires only two supports. Though the graphic depicts a certain length of wire to use, this antenna will work as long as the total length of wire is a minimum of a 1/4 to 3/8 wave at the lowest frequency of interest. When installing antenna, the height is to some degree more important than the top length, For best use on MAR frequencies use a wire length of about 125 to 170 feet. The better the ground system the more efficient the antenna. A Good Ground is very important to it's performance.

The required capacitor will change with length of the antenna and frequency in use. In stead of using a capacitor,, a transmatch or Auto antenna tuner should be used by MARS members to allow agility in frequency coverage.