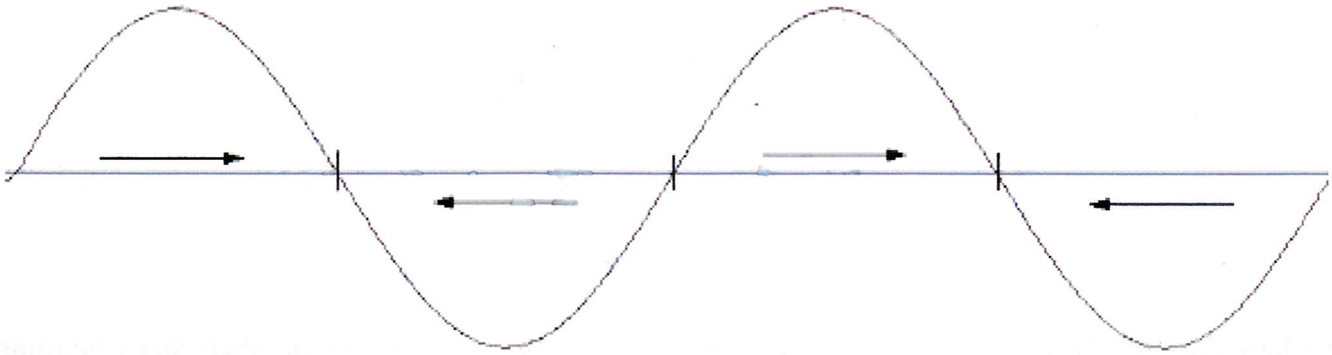
HF Antenna's and MMANA
by
Don Wilks G3VCG

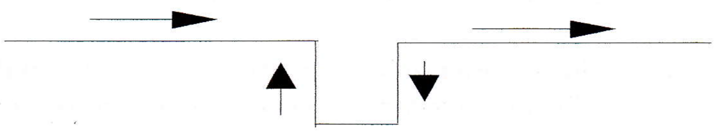
Thanks to Makoto Mori for the excellent MMANA software

**To get a better understanding of HF antenna's there are a few simple rules worth learning.
One of these is to understand that the far end of a wire antenna will always be at high impedance (high voltage) .There are some exceptions, for example if the far end of the antenna was connected to ground for some reason .**



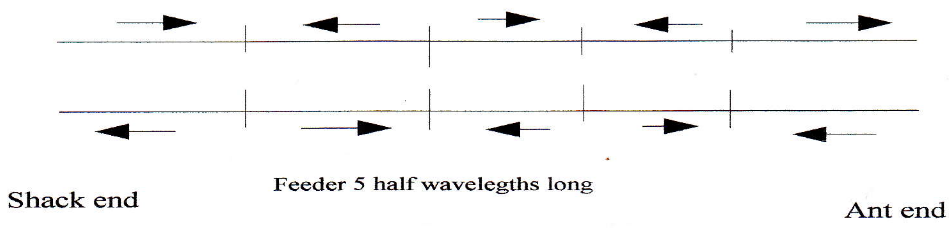
**Another very important thing to understand is that at every half wavelength along the antenna wire, there is a phase change of 180 degs.
The above figure shows a current sine wave along a two wavelength wire.
The right hand end is the far end of the wire and the current there is zero and voltage is high which is why a good insulator is required here. Notice how the sine wave changes phase every 180 degs, the arrows show the phase change in each half wave.
Notice how the arrow heads and tails are arranged, a head must always have a head pointing to it in the next half wave and vice versa for the tails. The curves below the line are 180 degs out of phase with the curves above the line. It is very important to remember this phase change every halfwave along the antenna.**

Three half waves



Centre half wave folded into two quarter wavelengths

By using arrows this way, you can work out the best configuration for your wire antenna. The arrows show the phase change along the three halfwave wire. An antenna like this will radiate ok but will not concentrate the radiated RF in any one direction. To increase the radiation broadside to the antenna wire it would be better to make the antenna into "two halfwaves in phase",easily done by folding the centre ½ wave into a ¼ wave stub.The bottom of the stub (which is really the centre of a ½ wave) is at very low impedance (high current) and therefore a short way up from the bottom you can find a 50 ohm point for coax feed, or the antenna could be fed at one end leaving the stub hanging in the centre.
Alternatively ,open wire feeder could be used instead of the stub, taken right back to the shack to an ATU.
Doing this would give an all band antenna. I.E Doublet.
Lets see what happens along a length of open wire feeder when used this way .

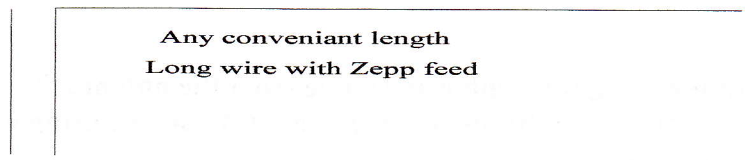


Notice how the currents are 180 degs out of phase with each other in each feedline,therefore providing the currents in the line are balanced there will be very little radiation from the line. Keeping the line away from metal objects usually is all that is needed to keep the line balanced.
If this line which is shown as 5 half wavelengths long were connected to 2 halfwave antenna elements I.E. The doublet, Then at every halfwave from the feedpoint there would be very high voltage.
Now if the line were connected to an ATU it may be found very hard to get the ATU to give a match down to 50 ohms to go to the rig . This would probably only apply to one band because of the high impedance at the shack end with this arrangement.
This is easily solved by adding in an extra length of feedline to bring the impedance at the ATU to a lower value. A length approaching a ¼ wave would be suitable.

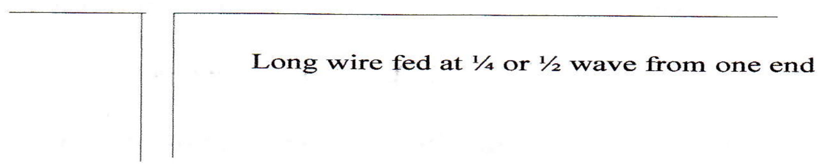
It is interesting to note that whatever impedance the far end of the line is connected to is repeated every ½ wave along the line. Therefore good use can be made of this fact when the feedpoint of the antenna cannot be reached to measure it.
A length of feeder is cut to a multiple of a ½ wavelength, of a suitable length to reach the measuring position ,not forgetting to take the velocity factor into account. This can be open wire or coax and it does not matter what the impedance of this feeder is, providing it is cut accurately for the frequency at which the measurement is going to be made.
This length of feeder is then connected to the antenna to be measured, the antenna pulled up to its operating position and the impedance can be measured at the lower end of the feedline. In other words its like bringing the feedpoint of the antenna into the shack .

It is not always convenient to have an antenna E.G."long wire" coming into the shack. This can cause problems with RF feedback and sometimes a "hot" microphone. Usually this is caused by using a length of wire which happens to be a multiple of a ½ wavelength long and will be high voltage in the shack. One remedy is to make the antenna longer or shorter to bring the length nearer a current point in the shack.
Another way would be to erect the antenna between the most convenient supports and feed it with open wire line ,either at its centre I.E like a doublet which will work all bands and the feedline will be

balanced, or feed with open wire line at one end Zepp fashion.



If the antenna is going to be mainly used on one band it would be better to connect the feeder at a point one ¼ wave or one ½ wave from one end. This would keep the line better balanced.



A horizontal halfwave antenna will radiate mostly broadside to the wire. The pattern is like a fat figure of eight with the nulls at the ends of the wire.
This is not the case for wires of one wavelength or more.
At a length of 1 wave long the fat figure of eight of the dipole starts to break into 4 major lobes, still with the nulls on the ends of the wire. The horizontal angle of the lobes is about 54 degs to the wire.
At 1.5 wavelengths long the major lobes are at about 40 degs to the wire and a minor lobe appears at 90 degs to the wire.
At 2 wavelengths long the major lobes are about 30 degs and another minor lobe appears. The two minor lobes are now about 75 and 85 degs to the wire.
As we go on increasing the number of wavelengths of the antenna, the major lobes get tighter to the direction of the wire and more minor lobes are produced.
This is what is made use of in the Rhombic and V beam antenna's.

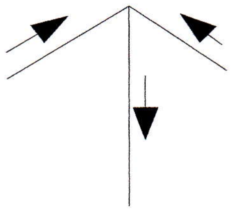
The horizontal patterns from all antenna's are effected by the earth. It would be nice to think that an antenna we put up will produce these patterns and be good for DX in certain directions.
Unfortunately the height of the antenna above the earth makes a big difference to the Vertical angle at which these horizontal patters appear. Instead of going from the antenna and staying horizontal, the effect of the earth is to make the radiation go more vertically .
Lets take an 80m dipole for example. How many of us can erect it ½ wave high !! (40m)

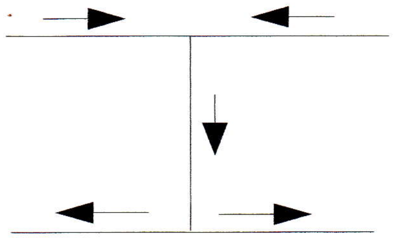
This antenna erected at say 10m will have most of its radiation going straight up to warm the clouds,and very little low angle for DX. Fine for working around Europe, but not so good for DX !
While on the subject of height, the feed impedance at the centre of a dipole changes with height above ground.

What can we do about lowering this high wave angle from the antenna.?
On the lower HF bands 160m 80m the answer is not a lot if you are using a horizontal antenna,other than getting it as high as possible.
However the vertical antenna is probably the best answer and we can take a look at some arrangements that would offer better low angle for DX working.

The wavelengths at these frequencies are very long and not many of us can put up a ¼ wave vertical for 160m which is around 125 feet.
Usually some form loading is used to reduce the height of the vertical, for example ,top loading or bottom loading .

Bottom loading


Top loading


Top and bottom loading

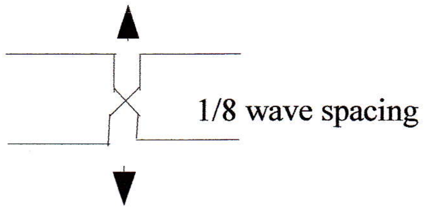
Bottom loading is the least efficient, keeping in mind the length of the wave and that the maximum current will be a ¼ wave from the far end of the antenna you can understand that most of the vertical will be high voltage and the max current will be in the coil.

Top loading is better and for the same length of vertical you can get the max current nearer to the centre of the vertical ,again keeping in mind the length of a halfwave and that the far end(s) will be high voltage. If you remember the way of using the arrows then you can see that the radiation from the two top wires will be out of phase and therefore cancel.

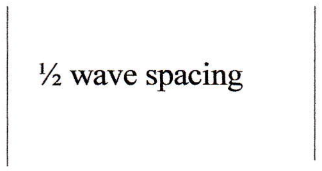
Both of the above antenna's must have a very good earth system to work well. !

The top and bottom loading is probably the best bet with as much vertical as you can get up .
The idea is to make the total length of ½ the top wire, plus the vertical plus ½ the bottom wire, all add up to one ½ wave. E.G for 80m approx sizes would be 10m each side for the top, 20m for the vertical and 10m each side for the bottom .
Using the arrows again, you can see that top and bottom wires cancel out leaving max current in the vertical.
With this top and bottom loaded arrangement no earth is required because it is a "complete" halfwave antenna. It can be fed in the centre of the vertical section or between the bottom of the vertical and the bottom loading wires.
If there is not enough room to run out two top and bottom wires the antenna will still work fairly well with only one wire at the top and bottom although there will probably be some horizontal radiation as well as vertical.
I suggested earlier that the antenna can be fed at the centre. There is no reason why it could not be fed at the end of one of the loading wires. This would only require a parallel tuned circuit with a link winding

for a coax feedline to the shack.
On the higher HF bands beam antenna's are used a great deal. What if you cant put up a beam but want some directivity and gain in some directions !
By combining a couple of wires the correct way we can do this.
The end fire array is positioned horizontally (all wires parallel to the ground) and as high as you can get it. It will give good gain in the direction of the arrows, and



Horizontal end fire array



Vertical broadside array

it can be made from two "dipoles" of any suitable length to fit your garden.
If they are held about 8 to 10 feet apart with a couple of bamboo canes and fed at the centre of the crossover with open wire line it will work very well .
If the feeder is attached to the centre of one dipole instead of the centre crossover, then the max radiation will be in the direction of the "dipole" to which the feeder is connected.

The vertical broadside array is interesting because it can work in two ways.
The two verticals can each be ½ wavelength,fed in the centre or voltage fed at the bottoms with parallel tuned circuits. Exactly equal lengths of feedline must be used to each vertical.
When both verticals are fed in phase they will produce strong radiation broadside from the line of the antenna. I.E. Into and out of the page and at a very low angle because the antenna is vertical.
These two lobes are much narrower than that from a dipole antenna therefore giving quite a good gain.

If we now change the feeder in the shack so that one vertical is fed 180 degs out of phase with the other, the pair of verticals produce a pair of end fire lobes (left and right of the page) which are much fatter and a little lower in gain than the previous arrangement.

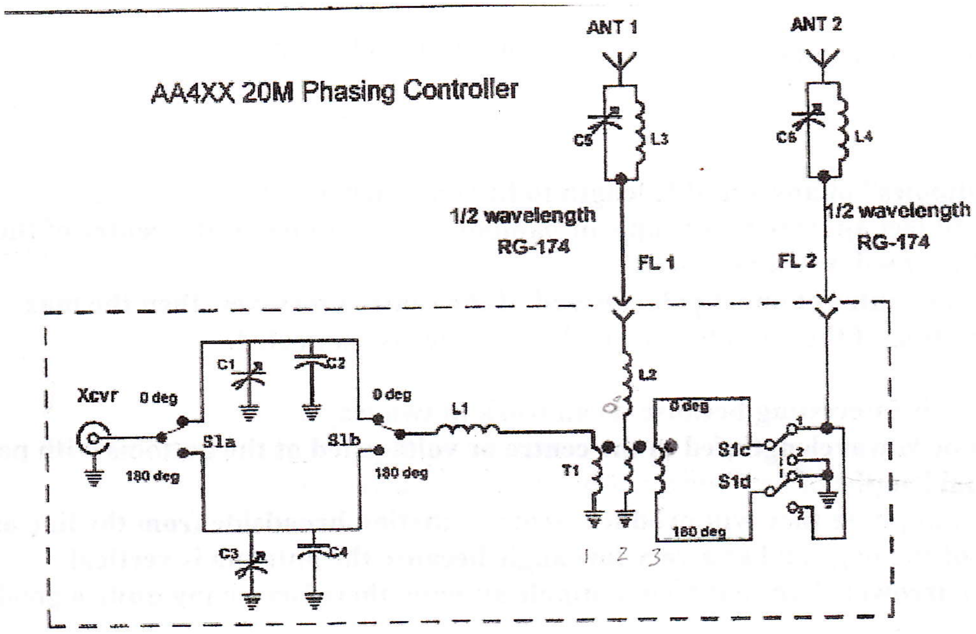
So by using this antenna we can easily switch in the shack from East/West to North/South and to make best use of the higher gain narrower lobes when used in phase (broadside fire) it would probably be best to make the line of the verticals NW/SE . The stronger lobes then going towards the far east and South America. When switched to the out of phase position the lobes would be towards USA and South Africa.

On the next page there is a simple circuit by AA4XX who used this arrangment for portable use.
I have used this with two verticals on 15m and it works very well.
I found it was not necessary to use all the four capacitors and S1a/S1b on the coax feed from the rig, only one was required to bring the SWR down to Zero. There may be a change of SWR when switching the S1c and S1d, if so then try the extra capacitors as shown.

FL1 and FL2 are shown as ½ wavelengths of feeder, they can be any length but both must be the same. So if you have one vertical near the shack and the other vertical some way away, the coax feeder to the closer vertical can be coiled up .
Also shown are the two parallel tuned circuits which were used to end feed the verticals. The turns given are for 20m and would have to be adjusted for other bands.

T1 is easy to make, three lengths of plastic covered wire about 13 inches long are twisted together and

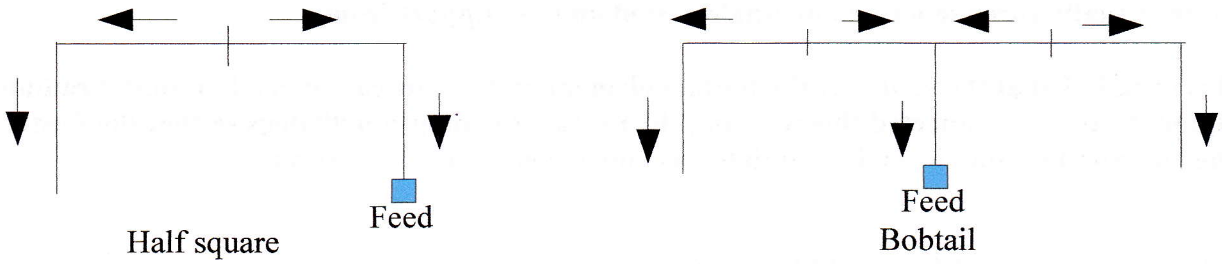
then tape or something is stuck to each wire at both ends and numbered 1 2 3 .At one end only put a spot with each number so you know where the start of the winding is.
This twisted wire is wound over a piece of ferrite rod or onto a torriod, Space the turns so they are not too close together.



C1, C3 5 - 150 pF Variable
C2 100 pF
C4 220 pF
C5, C6 0 - 40 pF Variable
L1, L2 T 37-2 4 T # 28 (0.07 uH)
L3, L4 T 50-2 37 T # 28 (6.8 uH) tapped at 8, 9, 10, 11 T from bottom
T1 FT 50 - 61 3 Trifilar windings, 10 T # 28 twisted together
FL1, FL2 RG - 174 Feedline, 22 ft. 6 in. long
Ant 1, Ant 2 34 ft. 1 in. long # 22 hookup wire
S1 4PDT Rotary Switch or Relay
S2, S3 4 pos. Rotary Sw. to select taps on L3, L4

When using halfwave verticals it is not necessary to have large earth arrangments.
A simple 1 meter square of chicken wire is all that is needed and sometimes not even that.

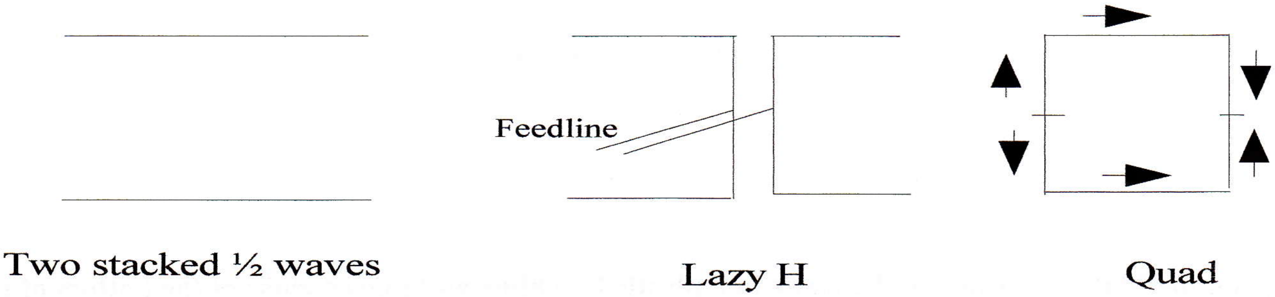
The bobtail and halfsquare are some more examples of vertical antenna arrangments.



The Halfsquare works in a similar way to the two verticals shown earlier as a broadside array.
Each vertical is approx a ¼ wavelength and the horizontal top is ½ wavelength.
The antenna is fed at the bottom of one of the verticals via a parallel tuned circuit.
From the unfed end it is a ½ wave to the centre of the horizontal wire ,then the phase changes in the next halfwave to the feedpoint.
Note how the two verticals are in phase and the currents in the horizontal section are out of phase and will cancel.

The Bobtail works in the same way, but now there are three verticals therefore more gain.
Compared to delta loops and other similar antenna's the Bobtail has the highest gain.
Of course if room was available the Bobtail antenna could be made with more vertical elements giving even higher gain and narrower beam.

Lets look at other ways in which we can lower the angle of radiation from the antenna.
If another ½ wave element is added below a dipole for example, the effect of the ground is lessened and the wave angle is lowered.

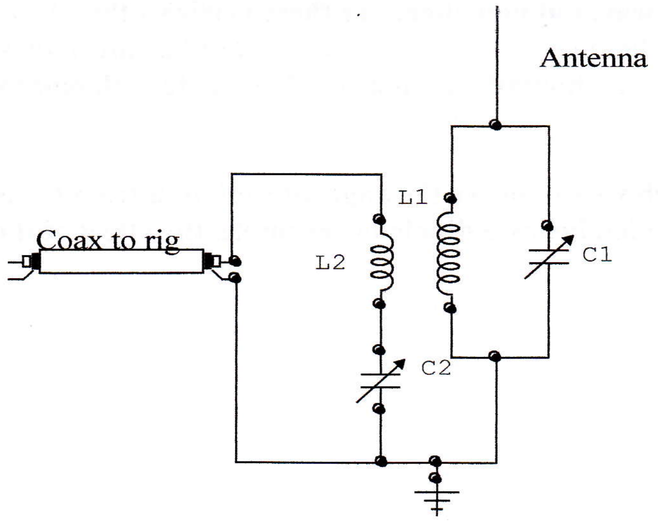


Maximum gain is achieved when the "stacking" distance is around a ½ wavelength .
The top and bottom elements of the Lazy H can be made any convenient length as long as everything is kept symmetrical from the feedpoint. It is usually fed with open wire line .
If you make the top and bottom 33 to 40 feet and the spacing 16 to 25 feet, it will work very well from 20m to 10m. The larger dimensions giving increased gain. The higher you can get the bottom element off the ground the better it will work.

The Quad is simply two stacked dipoles folded and joined at their ends. This gives less gain than the previous example but is more convenient because of its size. This is also a broadside fire antenna and a combination of broadside and end fire is made use of in the quad beam antenna by putting another set of elements behind the driven ones, either tuned as a reflector or director.
It will only work on the frequency for which the dipoles are cut, which is why when you see a multiband quad there are usually three seperate antenna's nested on one support frame.

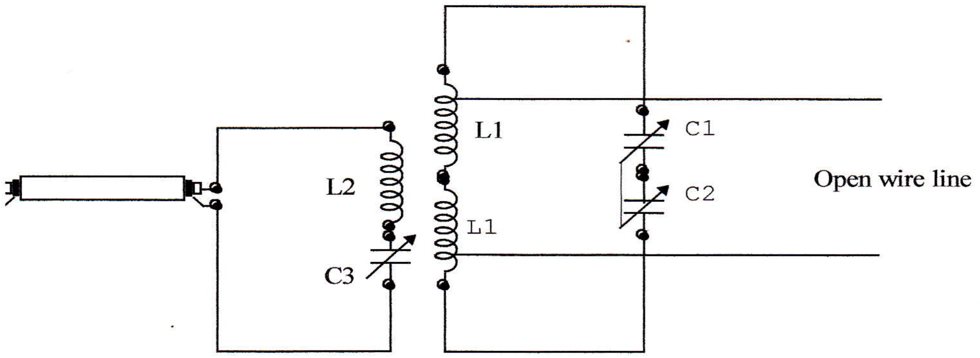
The Quad is usually fed at the centre of the bottom element and in this case it is a horizontal radiator. If you imagine the feeder connected this way and then rotate the diagram 90 degs so that the feeder is on one side the antenna becomes a vertical radiator as you can see with the arrows.

Perhaps a few words on the ATU would be in order.
An ATU does NOT tune the antenna. It does not matter what you do at the shack end of a feeder, you cannot alter the antenna itself or the feedpoint impedance at the antenna terminals.
The name Antenna Tuning Unit is very misleading.
The name Antenna Matching Unit is more correct because that is exactly what it does, it matches or transforms the impedance at the line terminals down to a value to suit the rig.
Consider the Bobtail antenna shown earlier. The bottom of the centre vertical is very high impedance so the way to match coax to it would be to use a simple Antenna Matching Unit consisting of a parallel tuned circuit with a link winding for the coax.



This simple Matching Unit can be made in a plastic lunchbox and placed right at the bottom of the vertical, fixed to a short wooden post if needed.
The earth can be a ground rod or about 1 square meter of chicken wire.
The top of the tuned circuit is very high impedance, so is suitable to connect straight onto the vertical.
An SWR bridge can be used temporarilly between the coax and the matching unit and adjustment of C1 and C2 should give 1:1 swr.
This same circuit could also be used for the Pair of phased verticals or the Halfsquare antenna.
L2 is three or four turns wound over the bottom end of L1.

The Balanced matching unit below is suitable for open wire line.
The coil L2 is wound over the centre of L1 . The two capacitors are ganged together and do not need to be earthed.
The centre of L1 can also be left floating or can be earthed through an RF choke to get rid of static charges on the antenna.
An SWR bridge in the coax line to the rig is all that is needed to adjust the unit and by adjusting C1/C2 C3 and the tap positions of the line on L1 a good match will be found.
L1 and C1/C2 must resonate at the freq in use.
For high impedance on this end of the line, the tapping points will be found near the ends of L1.
For lower impedance the line will need to be tapped nearer the centre of L1.



Here is the address for downloading the MMANA software.

http://www.qsl.net/mmhamsoft/

THE EXPANDED LAZY H ANTENNA

Before covering the details of the Expanded Lazy H antenna, some information of the ZEPP antenna is needed.
The original Zepp antenna was a simple half wave of wire fed with open wire line, one side of the line connected and the other side of the line open circuit. this method of feeding does not give a very good balanced line.
Enter the DOUBLE ZEPP.
Two halfwave wires fed with open wire line.

THE EXTENDED DOUBLE ZEPP

By increasing the length of each halfwave wire by adding 1/8 wavelength (making each wire 5/8 wavelength), extra gain is obtained because the seperation of the two halfwaves gives some co-linear gain. It must be fed with open wire line to be able to use it on other bands.
This antenna will work very well with a 4:1 frequency ratio I.E if cut for 28 mhz it will work down to 7 mhz.
The nice thing about this antenna is that at all frequencies BELOW the design frequency (4:1) it will always radiate two major lobes. Above the design frequency the lobes will start to break up into multiple lobes.

THE EXPANDED LAZY H

By using the above information we can get even more gain by stacking two of these Extended double Zepp’s making sure that all the (now 4) 5/8 wavelength wires are in phase.
This is easily done by using a section of open wire line as a phasing line between the centre of the top and bottom of the two Extended double zepps. The main open wire feedline going to the exact centre of the phasing line, and back to the shack to a matching unit.
The measurements for a 10 Meter Lazy H are 44ft for the top and bottom, the phasing line 22ft, connected between the centre of the top and bottom elements.
DO NOT BE MIS-LED BY SOME INFO ON THE WEB showing the phase line with a 180 deg twist and the feeder connected to the bottom element, this will give an antenna that only works on one band.