



A short antenna optimization tutorial using MMANA-GAL, Part 4

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■ Home

■ MMANA
Quick Start

■ Optimization
part1

■ Optimization
part2

■ Optimization
part3

■ Optimization
part4

We are now ready to look into the way MMANA-GAL specifies the use of tapered tubing as in a typical yagi element. One of the advantages of using the MiniNec engine in MMANA-GAL is the ease with which tapering elements can be accommodated. Discontinuous changes in element radius are allowed, providing that the details of the calculation are adjusted accordingly. MMANA-GAL takes care of this for us. This process is more complicated in programs like EZNEC, since step discontinuities in radius are not allowed.

The way in which MMANA-GAL specifies that a wire in the Geometry table is to be tapered is by entering a negative integer in the R(mm) column. This negative radius is used as a pointer to a corresponding line in the "Taper wire set" table. Thus if all the wires in the antenna are tapered the same, then all the elements would have -1.0 as the radius. If there is another set of elements with a different taper, then they could have -2.0 as the radius. Many different taper sets can be used, but in practice for HF monoband yagis, usually only one set is needed.

Here is the table which specifies the tapering schedual, via Edit -> Taper wire set

No.	R	Type	L1(m)	R1(mm)	L2(m)	R2(mm)	L3(m)	R3(mm)	L4(m)	R4(mm)
1	-1.0	<>	1.8	15.0	1.8	12.5	99999.9	10.0		

The first column in this table, **R** refers to the value used in the R(mm) column in the Geometry table. Here the value is -1.

Next is the **Type** column. Highlight this cell by using the arrow keys, and then hit enter. You are given four choices, however it is only really necessary to use the first two for typical HF antennas (the other two would be for more advanced users):

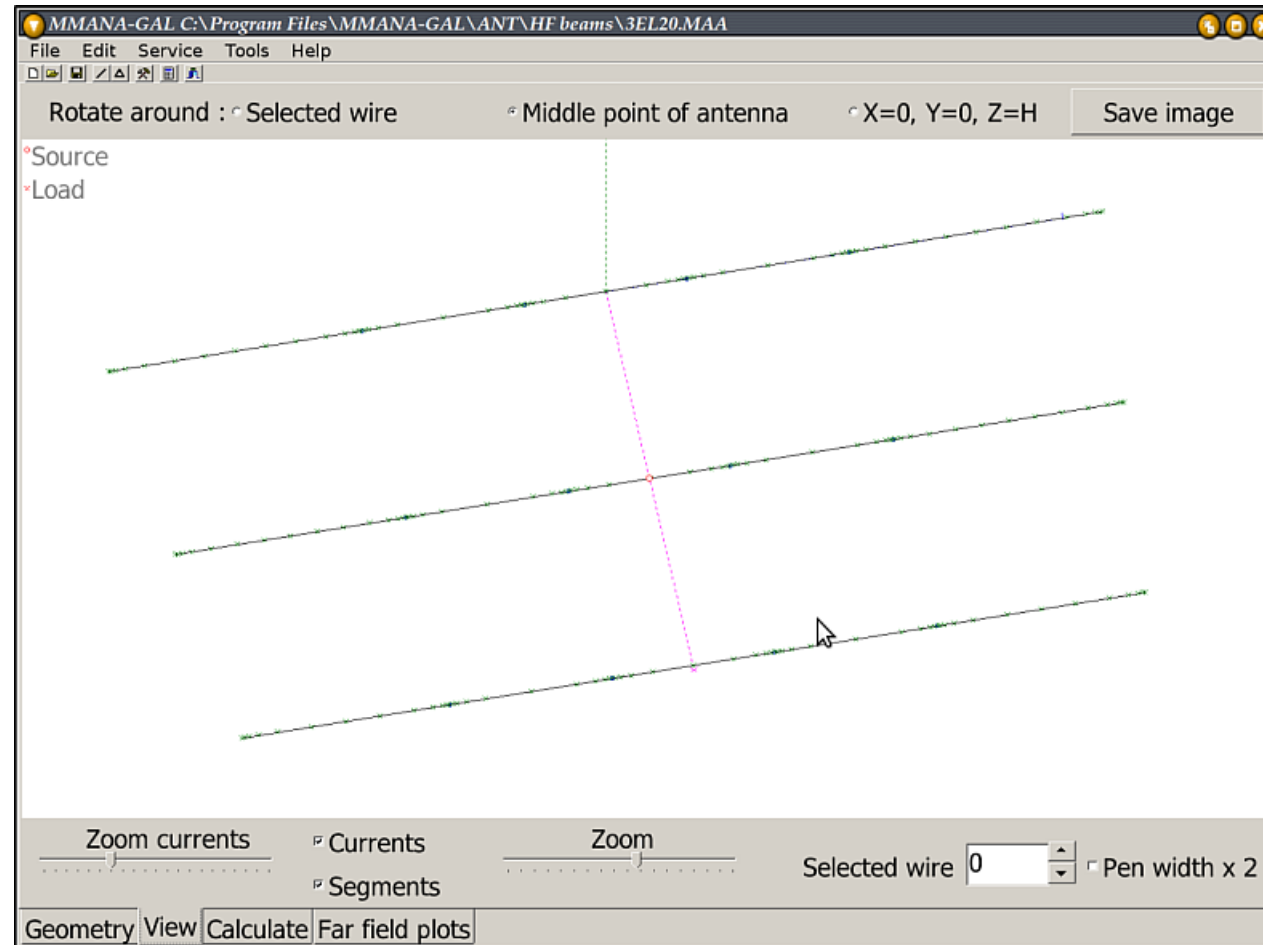
- The symbol < > means that the tapering is applied symmetrically to both ends of the wire, starting at the center, as in a typical yagi element. The program will automatically generate the proper segmentation (an internal mathematical consideration) to give a high accuracy result.
- The symbol -> indicates that the tapering is applied from the starting point of the wire to the end point. This would be the type to use in designing a vertical antenna. In that case the starting point would be at ground level.

The next columns consist of pairs of lengths in meters **L(m)**, and radii in millimeters **R(mm)** which describe the actual tubing sizes used. In the case shown, the center section of tubing has a length of 1.8m, and a radius of 15.0mm. This section then telescopes onto the next smaller size tubing, with a length of 1.8m exposed, and a radius of 12.5mm. Note in this case that there will be two sections of this size, one on each end of the center section. The final sections, the end tips, have a radius of 10.0mm, but the length shown, "99999.9" is not to be taken literally. The width of the element is still defined by the Geometry table, so MMANA-GAL will automatically adjust the length of the outer sections of tubing so that the overall element length will equal this definition. The 99999.9 label tells the program to use only enough of the end tubing to equal this length. In addition, while optimization is in process, only the end sections of the element are varied. The inner sections stay constant at the lengths defined in the table.

For a vertical antenna, the tapering works in the same way, but only one section of tubing is used for each radius defined. Previously the center section was used only once, and the rest were used twice.

It is necessary to remember that while tubing is specified by its diameter, in MMANA-GAL only the radius is used so one must divide the tubing size by 2. Also, only the exposed sections of tubing are considered. Tubing overlap, which is necessary for structural purposes, does not enter into the electrical properties of the antenna.

With this information, it is now possible to change the design of our initial 3 element yagi to use tapered elements. Change all the values in the R(mm) column to -1. Then fill in some values for tubing which would be available to you for the Taper wire set, or use the values shown above. Reoptimize the antenna and note how the element lengths have all changed. Extreme tapering of an element usually requires that its overall length must be increased to maintain the same resonant frequency. The sections of the Taper wire set are shown in the View tab below, and it is a good idea to look there to verify that the various lengths have been entered properly:



This view has the Segments box checked. Segments are the smallest units by which the overall antenna is divided. Too few segments, and accuracy is poor, too many and computation time goes higher. Here one can see the small X marks that denote the segments. Note that they are smallest near any discontinuity, such as telescoped tubing, at a sharp turn, or at element end. The ends of the various tubing sections are denoted with a small square, and coincide with smaller segmentation. As an experiment, edit the Taper wire set so

that L1(m) is now 3.0, and see how the View window changes.

At VHF frequencies, it is sometimes necessary to adjust for the influence of the element to boom mounting hardware. This is a somewhat experimental area. One method to accommodate the mounting hardware is to use a very short, large diameter section as the middle section of the taper wire set. In other words, the boom + hardware region is approximated by a short, fat cylinder. The exact dimensions will take some trial and error, but a place to start would be set the width equal to that of the element clamp, and the radius somewhat less than that of the boom, but greater than the radius of next length of actual tubing.

The information presented so far is sufficient to enable the creation of very accurate designs. Some adjustments are usually required when a model is constructed in the real world, due to unknown effects of local ground and near by metallic objects, but the dimensions will be very close indeed. I hope you are encouraged to experiment.

Please send corrections and clarifications. The [MMANA-GAL group on Yahoo](#) is a great place to ask questions, and I often look there as well.

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