

YW (Yagi for Windows)

Version 2.0, July 26, 2015

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A Personal Note from N6BV

In the summer of 1959 I was first licensed as WH6DKD. Early on, I became greatly interested in HF antennas and in contesting. Over the last thirty years I have been fascinated with computer modeling of antennas, especially after having spent many, many hours wrestling with behemoth Yagi arrays while helping set up contest stations at W6OWQ and at N6RO in the early and mid 1980s, and after setting up and operating with stacked tribanders at my own contest station in New Hampshire during the 1990s.

For the last twenty years or so I have spent an inordinate amount of time “fooling with the computer,” as my wife gently puts it. A number of people assisted at one time or another in these projects, whether they knew about it directly or not. The YW program is built upon the considerable body of work that has been done by other investigators, most of them considerably more capable theoreticians than I am. Notable among these have been Dr. I.L. Morris; Jim Lawson, W2PV; Stan Jaffin, WB3BGU; John Kenney, W1RR; Brian Beezley, K6STI; Wayne Hillenbrand, N2FB; and Dave Leeson, W6NL (ex-W6QHS). There have been others as well. I give thanks to them all.

THE YW PROGRAM

YW is designed to evaluate monoband Yagi antennas. It is fun to use, and it also is accurate when real-world antennas are built from it. YW results compare very closely with Brian Beezley's YO or YA programs and with NEC-based programs, such as EZNEC, NEC-Win Plus or NEC-4. YW is a special-purpose program, designed strictly for monoband Yagis. It has the advantage of running many times more quickly than general-purpose programs such as NEC but it has some attendant limitations.

YW evaluations over ground are done over flat “perfect” ground. Mutual impedances between Yagi elements and the ground are *not* specifically taken into account in YW, so calculations for antennas mounted less than approximately $\lambda/8$ above ground should be taken with a small grain of salt. Antennas mounted in the presence of other nearby antennas or mounted very low to the ground are the specialties of method-of-moment programs like NEC. Despite these caveats, YW will get you very close to a final design — one where you can simply cut the elements and expect that your Yagi will work as advertised.

Version 2.0 of YW includes the ability to do polar plots. Version 2.0 also produces higher resolution charts in the main window than the original version. I use the flexible and very capable TeeChart Pro 5 graphing package in my Windows programs and I highly recommend this software to other programmers. See the Steema Web site for details:

<http://www.steema.com/products/teechart/teechartindex.htm>.

Computer Requirements and Installing YW

The minimum requirements to run *YW* (and its companion programs *TLW*, Transmission Line for Windows, and *HFTA*, HF Terrain Assessment) are a PC running *Windows 95* or later, including *Windows 98*, *Windows XP* and *Windows 7/8*. *YW* runs on *Windows 10* but has not been completely tested. A minimum screen resolution is 800×600 , but 1024×768 is much better. Information about installing *YW*, *TLW*, and *HFTA* is available on *The ARRL Antenna Book's* reference web page, www.arrl.org/arrl-antenna-book-reference.

TAKING YW FOR A TEST DRIVE

From the Desktop Taskbar at the lower left-hand corner of the screen, select **Start**, then **Programs**, followed by clicking on *YW*. You will now see the *YW* icon to the right. You could start *YW* immediately by left-clicking on the *YW* icon if you like. At this point, however, you could also create an shortcut icon on your Desktop in *Windows 98* or higher by right-clicking on the *YW* icon and choosing **Create Shortcut**. This creates a shortcut, which you may select by right-clicking on it, dragging it onto your Desktop and then selecting **Move Here**. If you wish, you can use the same procedure to create a shortcut on your Desktop for the entire Program Group (by default called “Antenna Book Software”) containing all the icons for the Antenna Book programs.

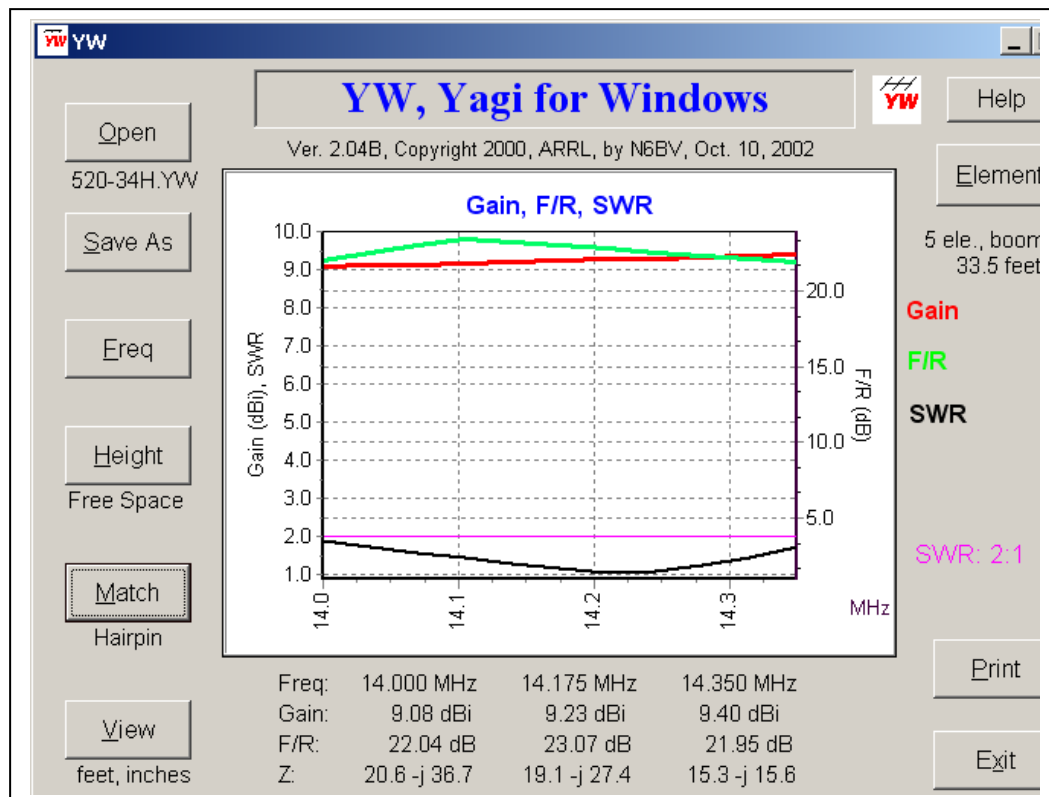


Fig 1—A typical YW main screen.

Tool Tips and Selecting a New Yagi File

Let's assume you have started the program. *YW* starts out with a bold red command: "Open a new file to start." This is asking for the filename of the disk file you wish to analyze.

First, however, move the mouse cursor so that it hovers over the **Open** button. After a short time, a "tool tip" will appear explaining what the program is looking for. In this case the tool tip says "Select existing antenna file." Go ahead and click on the **Open** button, or alternately use the **Alt-N** keyboard combination. The standard Windows "common dialog" appears, from which you choose a file. See **Fig 2**.

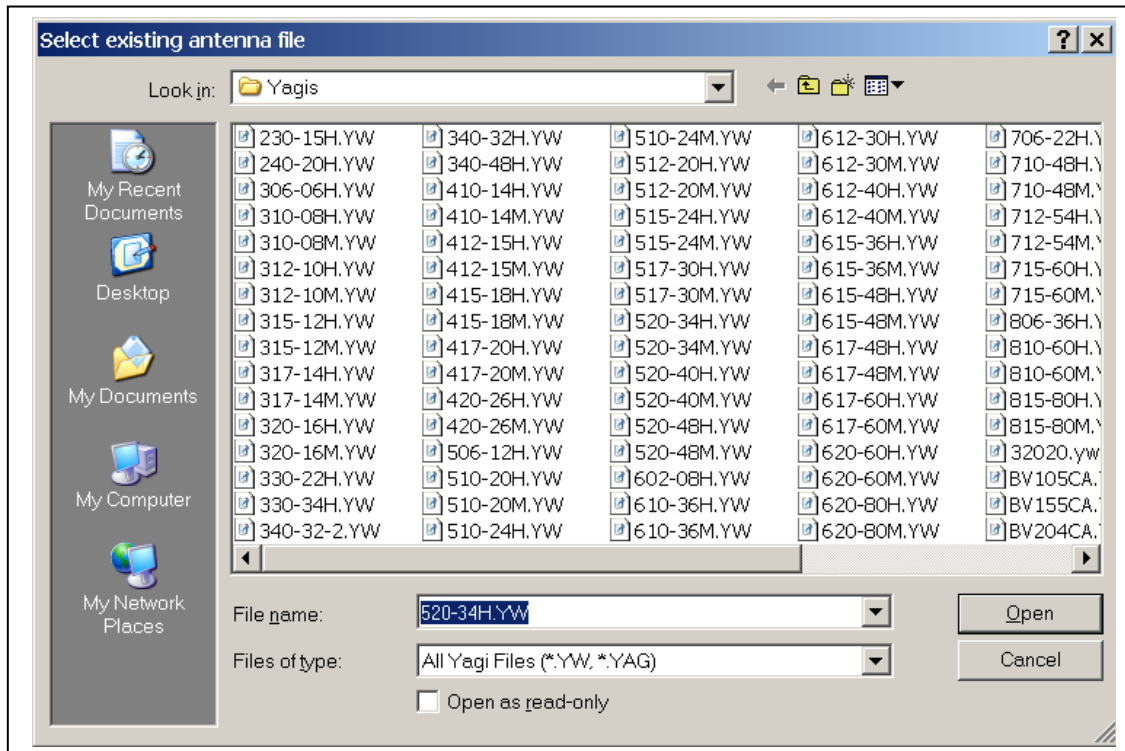


Fig 2—The common dialog window for selecting a Yagi file.

Let's start by opening up the **510-24H.YW** file, which should be located in the default folder, and which is one of the 80+ Yagi designs included with *The ARRL Antenna Book*. As is standard Windows practice, double-click on the filename to open it, or single-click on it and select **Open** in the dialog box. Of course, you could also type in the file name, using either upper- or lower-case letters in the dialog box. After it opens the file, *YW* will convert to upper-case internally and display the file name under the **Open** button to remind you which file you've chosen.

Once *YW* has loaded the data file, it computes the Gain, worst-case F/R and the SWR across the whole frequency band and generates an on-screen graph showing these three parameters. Look at the screen carefully — there is a lot of information presented there.

On the graph, the Gain is shown as a solid red line; F/R as a green line; and the SWR as a black line. Reference lines for the SWR readout are also displayed on the graph, with the 2:1 SWR limit shown as a thin violet line.

You can see that the SWR curve for this antenna is higher than the 2:1 reference line all across the frequency range. Note also that below the graph is a table showing numerical readouts of the gain, F/R (front-to-rear ratio), Z (feed-point impedance) and 50- Ω SWR for three discrete frequencies — the bottom, middle and top of the frequency band. In this case the three frequencies shown are 28.000, 28.400 and 28.800 MHz. The SWR for this design in its native state is 3.37:1 at the bottom, 2.73:1 at the top, and 2.60:1 at the center of the band. You can “interrogate” each curve by moving the mouse cursor on it and reading out the numerical value at each plotted point. Let’s try to match this Yagi better to a 50- Ω coax feed line.

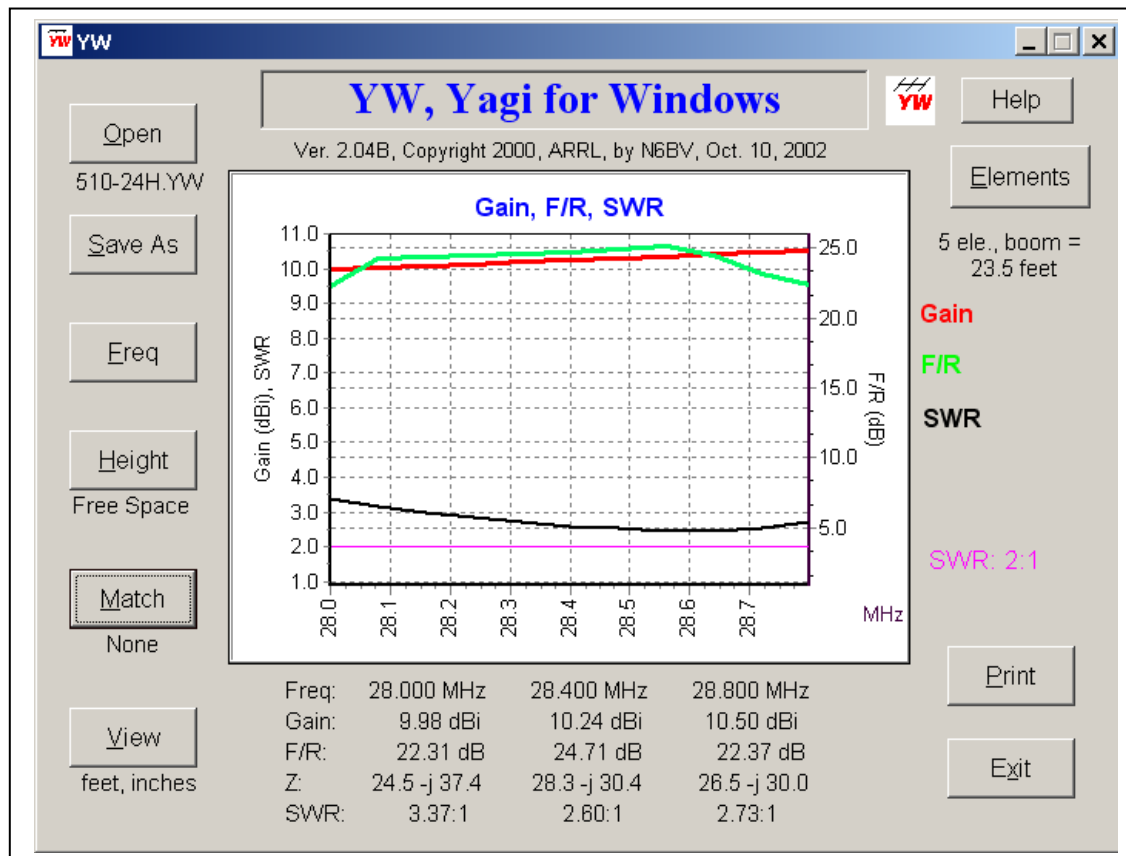


Fig 3—Gain, F/R and SWR curves for 510-24H Yagi over the 28.0-28.8 MHz band.

Matching

Left-click on the **Match** button. A new form pops up, labeled **Matching** at the top left. You have a number of data readouts showing. Look at the data shown for the **Feed-point Z**. At the match frequency (which was automatically selected to be 28.4 MHz, although you can change it), the feed-point impedance is $28.3 - j 30.4$ ohms. The relative levels of the resistance and capacitive reactance give us a good clue here. Since the two are roughly equal in magnitude, this Yagi has been designed for a hairpin match, although a gamma match will work also.

Click on the option button labeled **Hairpin** at the top and some new information pops up at the bottom of the Matching form. The default **Hairpin rod diameter** is 0.25 inches and the

default **Hairpin rod spacing** is 6 inches. These values approximate a Hy-Gain “beta” match, their name for a hairpin matching system. Let’s use the default numbers for now, including the value of 50 ohms for the **Cable Z0 impedance**.

Click on the **Compute Match** button, which has turned yellow to alert you that a computation is needed. Some more new information appears, indicating that the **Hairpin inductance** should be 0.32 μH and the **Hairpin length** is 8.10 inches. You could implement an actual physical hairpin match by putting a 0.32 μH coil across the driver feed-point terminals, or you could install a 1/4-inch diameter rod bent in the shape of a U, 6 inches wide by 8.10 inches long, across the feed-point terminals. Either way would work fine. See **Fig 4**.

Fig 4—Matching screen, where Hairpin has been chosen.

Click on the **OK** button and YW will recompute across the band. Now the SWR curve falls below the 2:1 reference line, with a numerical readout of 1.64:1 at 28.0 MHz, 1.22:1 at 28.4 MHz and 1.23:1 at 28.8 MHz. These values aren’t too bad.

Now go back and try a gamma match. Click again on the **Match** button and then select **Gamma** and **Compute Match**. With the same 1/4-inch OD gamma rod and a spacing of 6” from the driver, YW computes that you need a 15.44-inch long gamma rod, in series with 45.8 pF. Click **OK** and look at the SWR curve again. Note that the SWR at the matching frequency of 28.4 MHz is exactly 1:1. This illustrates one of the advantages of a gamma match — it gives a 1:1 SWR at the design frequency. A gamma match tends to be pretty broadband too. Now the SWR across the band is held lower than 1.31:1, very flat indeed.

Changing the Frequency Limits

Let’s see what happens if we change the frequency range for this 510-24H Yagi. Click on the **Freq.** button and a new form will pop up. Let’s check out the response 400 kHz above and below

the normal frequency limits of 28.0 and 28.8 MHz. The lower-frequency limit might simulate, for example, a situation where some ice accumulates on the elements. So, we type in 27.6 for the **Low Frequency, MHz**, and 29.2 for the **High Frequency, MHz** limits. Note that the form automatically computes the center frequency, which remains at 28.4 MHz for this case.

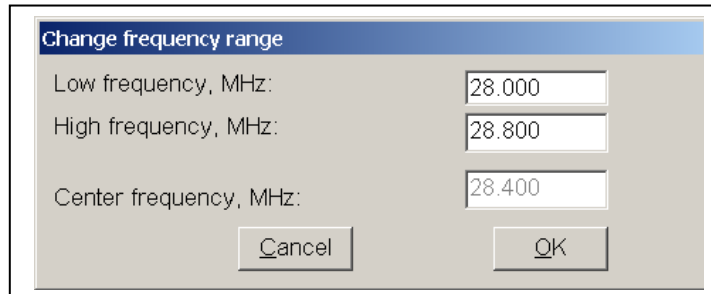
A dialog box titled "Change frequency range" with a blue header. It contains three input fields: "Low frequency, MHz:" with the value "28.000", "High frequency, MHz:" with the value "28.800", and "Center frequency, MHz:" with the value "28.400". At the bottom are "Cancel" and "OK" buttons.

Fig 5—Setting the frequency limits.

Now, the SWR curve at the low end of the range has gone to 2.28, but at the high-frequency end of the range the SWR has risen to 5.84. This Yagi design has been tailored to cover only the low end of the 28.0 to 29.7 MHz amateur band. Note that the F/R curve goes below 20 dB below about 27.9 MHz, while the gain remains reasonably flat both above and below the normal frequency range.

Return to the normal frequency range by selecting **Freq.** and resetting the lower limit to 28.0 MHz and the high limit to 28.8 MHz. By the way, the easiest way to change a number in any of the data input boxes is by double-clicking the number. This highlights it so that you can overwrite the number easily by typing in new numbers.

Changing the Height

Now, click on the **Height** button and after the new form appears type in a value, say, 60 feet. Complete your entry by clicking on the **OK** button.

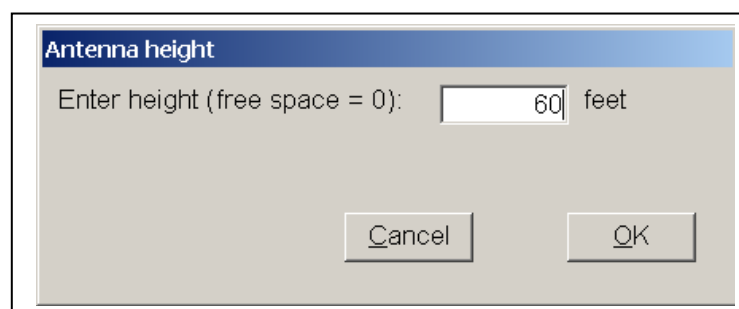
A dialog box titled "Antenna height" with a blue header. It contains a text input field with the label "Enter height (free space = 0):" and the value "60" followed by the unit "feet". At the bottom are "Cancel" and "OK" buttons.

Fig 6—Choosing a new height.

At first glance, nothing much looks like it changed on the main graph. A closer look reveals that the gain figures have increased by almost 6 dB from their free-space values and a new label has appeared to the lower right side of the graph, indicating that the peak elevation angle is 8°. The height above ground has resulted in a gain increase at this elevation angle due to ground-reflection gain. (See Chapter 14 in the *ARRL Antenna Book*.)

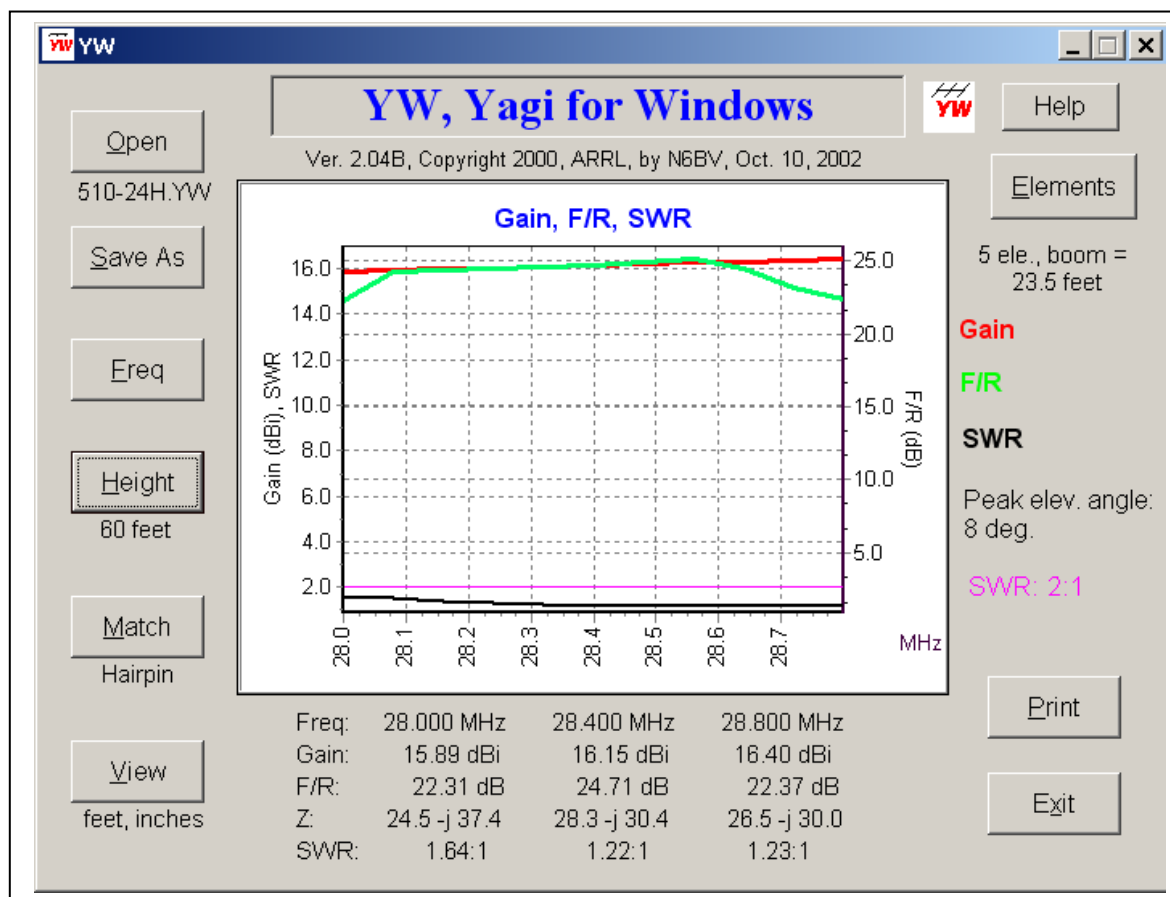


Fig 7—Main window for 510-24H Yagi, 60 feet above flat ground.

If you wish to return to the default of free-space, you would type in a height of 0 feet. This automatically places the antenna in free-space. But before you reset yourself to free space, let's look at the details of the elevation pattern for our chosen height of 60 feet by using YW's plotting capabilities.

Changing the View

Click on the **View** button in the main window and you will be presented with a new form labeled **View, other choices**. The choices are broken down into three categories, separated inside outline frames: **Units**, **Pattern** and **Graph**. See **Fig 8**. We'll discuss the other choices later, but for now select **ARRL polar plot** and click on **OK**.

Fig 9 shows the free-space E-Plane and H-Plane patterns for the 510-24H 10 meter Yagi, mounted 60 feet above flat ground. Note that the responses are labeled "Az" (azimuth) and "El" (elevation), since the Earth is the reference plane. You can see that the 3-dB beamwidth in the Azimuth plane is 58° and only 8° in the Elevation plane.

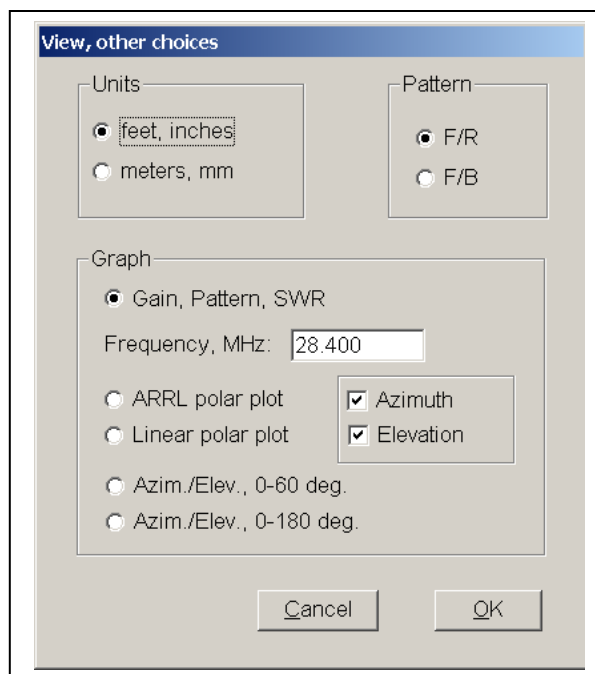


Fig 8—View window

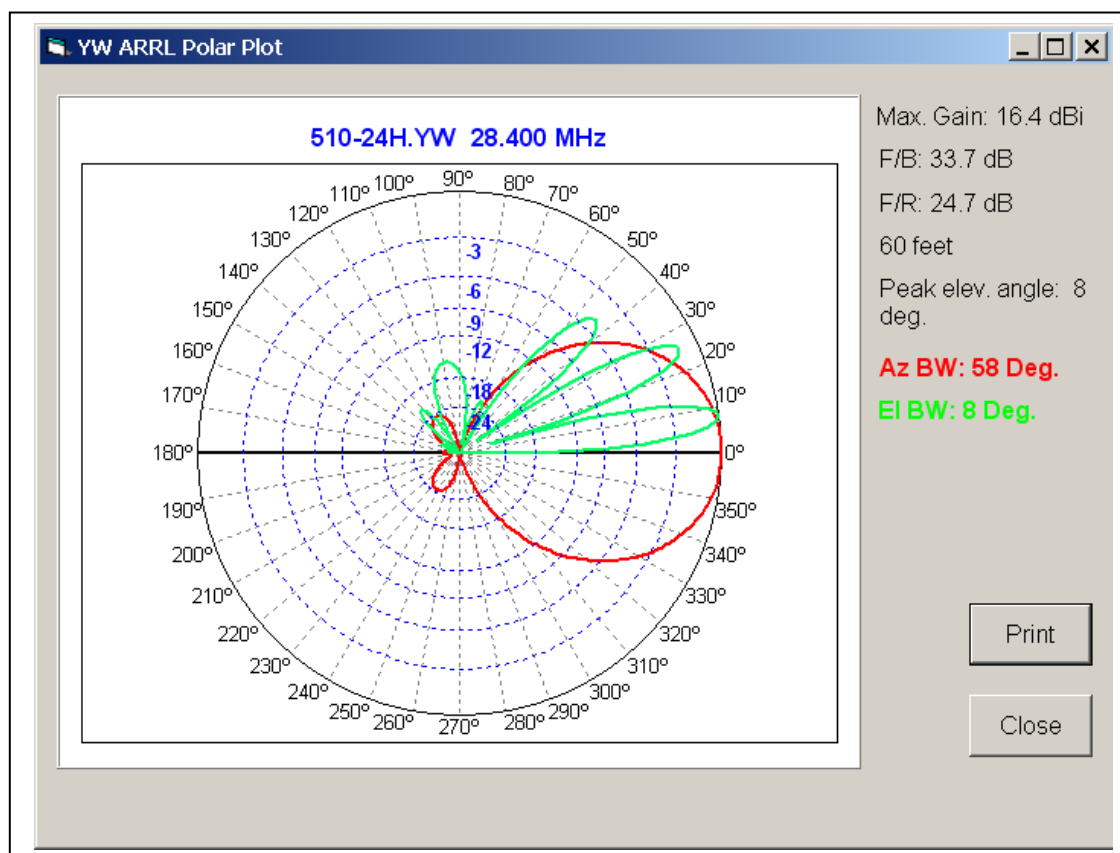


Fig 9—ARRL polar plot for 510-24H 10 meter Yagi, mounted 60 feet above flat ground.

The azimuth and elevation plots may be combined together on one chart, with the azimuth in red and the elevation in green. For Yagis with narrow azimuth and elevation beamwidths the combined display can become a little overwhelming. On the **View** screen, you may choose to see either the azimuth (E-plane) or the elevation (H-plane) response by itself.

You may zoom in on the graph to show low-level details in the ARRL plot. Hold down the right-mouse button while moving the mouse to zoom in and out. The first unmarked blue calibration circle beneath the -24 dB circle is -40 dB. Zooming in further will reveal a second blue calibration circle for -50 dB.

Close the **ARRL polar plot** window and open the **View** window again by clicking on that button in the main window. Click on the **Linear polar plot** option box and then click on **OK** to view the resulting graph. These response shapes are different from those in Fig 7. The ARRL plot is calibrated to show less detail in the rear quadrant, while emphasizing the response at the nose, compared to a scale calibrated in linear dB.

Now, go back to the main window, click on **View** and then select **Azim./Elev., 0-180 deg.** in the **Graph** frame, followed by **OK**. YW generates a rectangular graph showing the azimuth- and elevation-plane patterns for this 60-foot high antenna at 28.4 MHz. See **Fig 10**. The azimuth and elevation patterns are shown over the full range—from straight ahead at 0° elevation, sweeping overhead all the way back to directly behind the antenna for the elevation pattern. Change the frequency if you wish on the **View, other choices** form to check out the frequency dependence of the Yagi.

The first elevation lobe peaks at 8° degrees, and subsequent lobes occur at roughly 25° , 44° and 66° . There are also nulls, occurring about 16° , 35° and 60° elevation. You can run the mouse cursor over individual points to read out the response level on each curve. Note that only one-half of the total response is shown in order to give maximum resolution on the graph. The other side of the graph mirrors these response curves through the Y-axis.

Now, click on **Azim./Elev., 0-60 deg.** in the **Graph** window, followed by **OK**. YW generates a new rectangular graph showing even more resolution of the azimuth- and elevation-plane patterns, this time over a range from 0° to 60° . Again, this is one-half the overall response, which again is mirrored through Y-axis.

Now click on the **Height** button and set the height back to 0 feet, meaning that the antenna is in free space. Now, click **View** and select **ARRL polar plot**. Note that the labels have changed to show E- and H-plane patterns, since the antenna is in free space. The -3 dB free-space H-plane response is now 74° wide.

Changing to F/B rather than F/R

Now, let's change the graph display to show F/B (front-to-back ratio) rather than the default F/R (worst-case front-to-rear ratio). See *The ARRL Antenna Book* for definitions. Click on the **View** button and then select **F/B** in the Patterns outline box. Now click on **OK** and look at the resulting Gain, F/B, SWR graph. The peak F/B response has gone from the 25 dB region to a maximum of just over 40 dB at about 28.3 MHz. That certainly looks impressive!

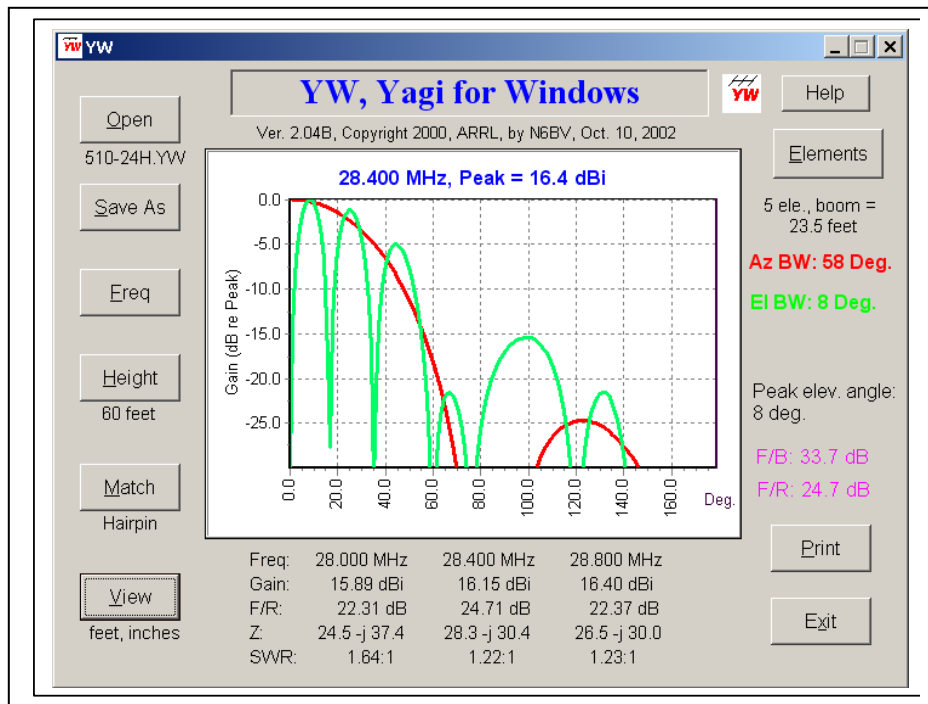


Fig 10—Rectangular graph over 0-180° for an antenna height of 60 feet. The responses shown are one-half the overall responses, which are mirrored in the Y-Axis.

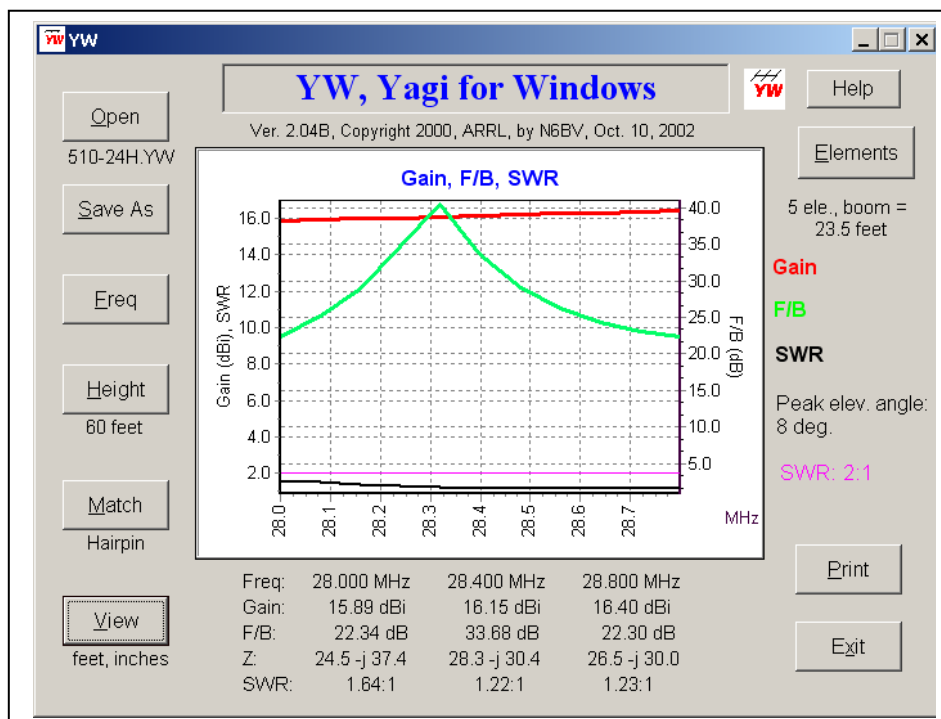


Fig 11—The result of selecting a readout of F/B rather than F/R.

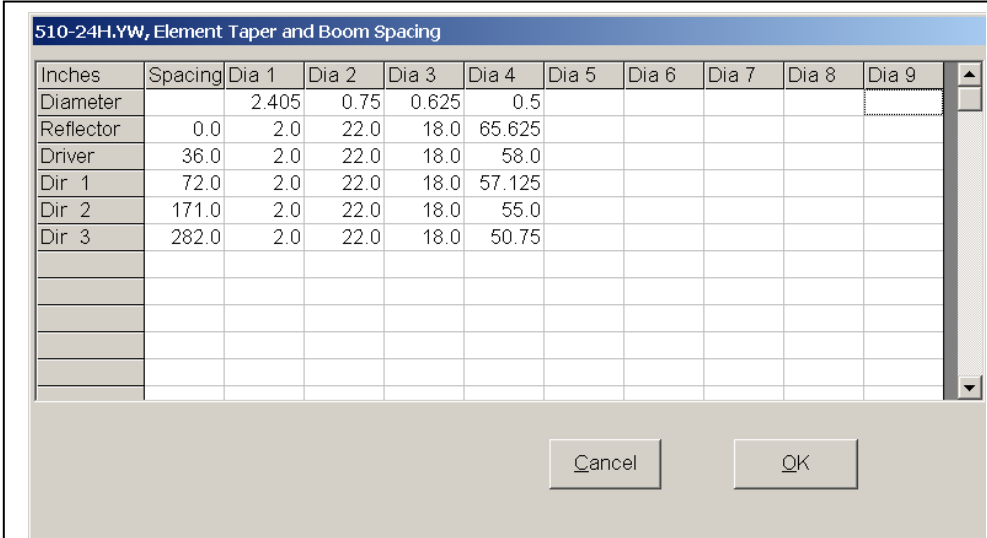
Click **View** again, type in a new frequency of 28.3 MHz, and select **ARRL polar plot** followed by **OK**. Now you can see that the worst-case lobe at about 120° is still only about 25 dB down at 28.3 MHz. This is less impressive than a F/B of 40 dB, but it is a more realistic assessment of a Yagi’s rearward pattern — after all, interference doesn’t come only from directly off the back of the antenna; interference can come from almost any direction. Now you can see why the F/R (worst-case front-to-rear ratio) is chosen as the default for YW.

Changing the Dimension Units

Click the **View** button once again. Select **meters, mm** option in the **Units** frame. You will note that the choice in the **Graph** outline box reverts automatically back to the default **Gain, Pattern, SWR** option. Click on the **OK** button to return to the main screen. Now, the label under the **View** button has changed to “meters, mm.” If you have previously entered a height of 100 feet, the value will change to 30.5 meters, as shown in the label under the **Height** button.

Using the Elements Button

Now, let’s examine detailed dimensions of the Yagi itself. Click on the **Elements** button. A spreadsheet-like presentation of the taper schedule and element placement along the boom comes on-screen. If you have left the units in mm, the upper left-hand label will show “mm.”



Inches	Spacing	Dia 1	Dia 2	Dia 3	Dia 4	Dia 5	Dia 6	Dia 7	Dia 8	Dia 9
Diameter		2.405	0.75	0.625	0.5					
Reflector	0.0	2.0	22.0	18.0	65.625					
Driver	36.0	2.0	22.0	18.0	58.0					
Dir 1	72.0	2.0	22.0	18.0	57.125					
Dir 2	171.0	2.0	22.0	18.0	55.0					
Dir 3	282.0	2.0	22.0	18.0	50.75					

Fig 12—Elements window for 510-24H Yagi.

If you like, you can escape from the spreadsheet presentation by clicking the **Cancel** button. You can then select **View** and then **feet, inches** followed by **OK**. Now when you bring up the spreadsheet using the **Elements** button, you’ll see the dimensions in inches. Incidentally, when YW exits back to the Windows Desktop, it writes the unit of measurement you have chosen to a disk file called YW.DEF, so that it will come up with these units the next time it is booted up.

Examine the spreadsheet carefully. You’ll see that the taper schedule of telescoping aluminum tubing for this 510-24H Yagi design ranges from 2.405, 0.75, 0.625 and 0.5 inches. The dimensions shown are on one side of the boom only. The other side is symmetrical. Now,

where did that oddball first diameter of 2.405 inches come from? It represents a compensation factor to emulate the effect of the bracket mounting each element to the boom.

As explained in Chapter 11 of the *ARRL Antenna Book*, this 10 meter design uses a flat piece of metal as a bracket, with two U-bolts to hold the element to the plate and two more U-bolts to hold the plate to the boom. The plate is 4×4 inches by $\frac{1}{4}$ -inches thick. The length of the 0.75-inch OD second segment is shortened by 2 inches in this model, at 22 inches, rather than its actual physical length of 24 inches in order to model the bracket.

Now, experiment a bit at changing the length of an element to see what happens to the frequency response. Let's try changing the length of the reflector tip from 65.625 inches to, say, 70 inches. Click on the spreadsheet cell representing the end tip of the reflector. A new form pops opens, indicating by its label that you have indeed chosen the reflector to work on. It also tells you that the original dimension of the reflector tip is 65.625 inches. This gives you a frame of reference if you do multiple modifications to an element in successive passes.

Now type the number 70 in the *New dimension* input box and click on **OK**. Click on the **OK** button on the spreadsheet form. Now the F/R pattern has changed, falling lower than 20 dB for the higher frequencies in the 28.0 to 28.8 MHz range. Click **Elements** again and return the reflector tip to its original dimensions if you want to reassure yourself that the response will indeed return to normal.

Printing Out a Graph or Screen

If you wish to print out a particular graph, simply select **Print** while that graph or screen window is on-screen. YW automatically prints with a white background to save on ink or toner in your printer. Note that if you try to print a full-screen graphic, parts of it may be cut off towards the edges of the print. Resize the graphic to print it fully on your particular printer. You may also use the [**Print Screen**] key to capture an image to the Windows Clipboard, or you may use the key combination [**Alt**][**Print Screen**] to capture the active window to the Windows Clipboard. I do this when I want to manipulate a screen image or import a screen image to another application. For example, I've been doing this to capture the Figures in this document.

Saving a Design to Another Disk File

If you change an existing design to optimize particular performance parameters, or if you wish to document the hairpin or gamma matching parameters, you can do so by clicking on the **Save As** button. This will present you with a standard common-dialog format for saving a file. The matching network parameters are recorded at the end of the element schedule in the new disk file, which you can examine using any word processor.

The Use of dBi for Gain

The gains given in YW are referenced to dBi (meaning "isotropic") in free space. The vertical takeoff angle is at zero degrees, the free-space value. For the patterns calculated over flat, perfect ground, the vertical elevation takeoff angles vary with height over ground, as pointed out previously.

YW makes some simplifying assumptions when doing vertical elevation patterns over perfect ground. Specifically, mutual impedances to the ground plane are ignored. For real-world

antennas higher than about an eighth-wavelength over ground this assumption is reasonable. For 40 meter beams less than perhaps 30 feet over ground you should use a program like *NEC* or *EZNEC* if you want to see exact values for the feed-point impedance.

What About Using a 200:50 Ω Balun?

Some designs have matching systems that employ a 200:50- Ω balun at the feed point. For example, load in the **506-12H.YW** file, which describes the 5-element 6 meter Yagi in Chapter 18 of *The ARRL Antenna Book*. This design uses a coaxial 200:50- Ω balun and a hairpin match at the driver. Click on the **Match** button and note in the feed-point impedance readout that the ratio of the capacitive reactance to the resistive portion of the impedance (that is, the Q of the series circuit) is about 3:1. This gives a very important clue about how this Yagi was designed — the length of the driver has purposely been shortened to yield this value of Q so that the transformation to the parallel-equivalent circuit results in 200 Ω .

Now, type the number 200 in the **Cable Z0 impedance** data box. Click the **Hairpin** option, the **Compute Match** button and then the **OK** button. The SWR over the frequency range will be nice and low, as it was designed to be. See the section in Chapter 26 of *The ARRL Antenna Book* about hairpin matches for more insights into the design process.

YW Data Files

YW uses data from ASCII disk files that have been created off-line. There are over 80 optimized Yagi design files supplied with YW so you'll have some excellent models to work with for the various amateur bands. Here are some tips on generating your own Yagi files.

You could generate a completely new disk file for YW or you could edit an existing one with an ASCII (text) word processor and then save it under a different file name. Be careful — many word processors store data in their own peculiar formats. Anything other than ordinary ASCII text will not work in a predictable fashion in YW.

Remember that some word processors will allow you to save a file as a text file, but they will stubbornly append the “.txt” filename extension to the file, no matter what you name it. Microsoft *Word* is one example. You must “rename” the file to get rid of the spurious extension before YW can recognize the file. A typical YW disk file looks like this:

204BA.YW, Hy-Gain 204BA tuned for high phone.

14.000 14.174 14.350 MHz

4 elements, inches

	1.250	1.125	0.875	0.625	0.438
0.000	44.500	46.000	50.500	24.000	50.000
122.875	35.000	46.000	50.500	24.000	50.000
211.625	21.000	46.000	50.500	24.000	51.000
307.250	16.750	46.000	50.500	24.000	49.000

The first line is the label for the file. It's a good practice to include the disk file name as the first item on the line, together with a brief description of the design. YW uses only the first 50 characters on the line, so you may find that verbose descriptions are truncated when displayed by

YW, particularly if a design is modified and saved to a different file name. This won't hurt anything, but it may make things a bit cryptic later on.

The second line shows three frequencies, followed by a frequency unit of measurement. The left-hand frequency (14.000) is the low end of a band; the right-hand frequency (14.350) is the high end of the band. The center entry is the middle between the low and high frequencies; that is, the half the sum of the low and high frequencies.

YW assumes that the three frequencies listed are in Megahertz (MHz), unless a unit modifier is included: Hz, kHz, MHz or GHz. This modifier may be entered in upper- or lower-case characters, but must be spelled exactly.

The third line shows the number of elements, separated by a comma, and followed by the unit of measurement. The unit of measurement may be designated as: inches, feet, meters, centimeters, millimeters, or wavelengths, in upper- or lower-case characters. The spelling however must be exactly as shown. YW will internally convert the unit of measurement to inches, but will only display output in inches or mm, as selected by the operator.

Note that if you wish to add or subtract an element from a particular design, you'll have to do so by exiting YW and then editing the file with an ASCII (text) word processor. It's best to copy the original file to a new filename, and then edit that file. Alternatively, you can **Save to** another filename, then exit YW and edit the new file using an ASCII (text) word processor. The rest of the file consists of a tabular arrangement of element diameters versus corresponding element lengths for each element. The listing must start with the reflector and proceed outwards along the boom in order; that is, reflector, followed by the driven element (abbreviated as "driver" in YW), first director, second director, etc. The YW format is quite flexible in that data blocks on a line may be separated by Tabs, spaces or by commas.

For reasons of readability and aesthetics you might want to line up the decimal points in neat columns. The fourth line in the example above shows the taper schedule for the element diameters, listed from left to right, in sequence from the boom outwards. The maximum number of tapered element diameters possible in YW is nine. YW will accept designs up to 40 elements. Note that the computation time goes up dramatically with increasing number of elements. You might want to bring up the file K1FO4071.YW, which is a K1FO-designed 40-element 70-cm antenna. It is a wonderful design, and it takes a long time to compute, especially if your computer is getting a little long in the tooth.

The fifth through eight lines in the example above show the element lengths *on one side of the boom*, corresponding to each diameter in the taper schedule. YW assumes that the other half of each element is symmetrical on the other side of the boom. The first entry on each of the element length lines is the spacing along the boom, starting with 0.000 inches spacing for the reflector, and accumulating for each element. In the 204BA example shown above, the fourth element (the second director) is 307.25" away from the reflector, while the length of the 0.438" OD element tip is 49.000" long.

In order for YW to figure out when a new diameter schedule is specified, rather than a length, a line specifying a new taper diameter schedule must start in either of two manners:

- (1) with a Tab, or at least eight spaces, or (2) with the word "Spacing"

An illustrative example of the second file form for the Hy-Gain 204BA for *spacing* between elements (rather than the cumulative dimension along the boom from the reflector onward) is shown below:

204BA_1.YW, Hy-Gain 204BA tuned for high phone.

14.000 14.174 14.350 MHz

4 elements, inches

Spacing	1.250	1.125	0.875	0.625	0.438
0.000	44.500	46.000	50.500	24.000	50.000
122.875	35.000	46.000	50.500	24.000	50.000
88.750	21.000	46.000	50.500	24.000	51.000
95.625	16.750	46.000	50.500	24.000	49.000

Note that this particular data file does not include the effect of the “taper swaging” used by Hy-Gain in their designs. For example the overall length of the 1.25” OD first part of the tapered element is 44.5” long, but about 6” of that length is taken up by the gradual squeezing down from 1.25” to 1.125” OD at the end of each segment.

Taper-swaging has a very minor effect on the frequency response of the antennas, but some users actually include a separate taper of 1.186” (the geometric mean of 1.25” and 1.125”) with a length of 6” in their files.

The next file shown below illustrates the flexibility of the YW file format in that the second element in the N2FB design (the driven element) consists of a single taper of 1” OD tubing. Obviously this is not too practical for construction, but it is theoretically possible, and YW will obligingly analyze it.

N2FB620.YW, 6-el 20m, NCJ Jan 1986

14.000 14.174 14.350 MHz

6 elements, inches

	1.250	1.125	1.000
0.000	18.000	54.000	138.970
86.380	0.000	0.000	196.578
164.090	18.000	54.000	126.470
321.590	18.000	54.000	121.950
464.450	18.000	54.000	121.900
643.990	18.000	54.000	113.520

The data file above uses 0.000” lengths for the non-existent 1.25” and 1.125” taper lengths for the driven element, but it could also be represented by the following file format.

N2FB6201.YW, 6-el 20m, NCJ Jan 1986

14.000 14.174 14.350 MHz

6 elements, inches

	1.250	1.125	1.000
0.000	18.000	54.000	138.970
	1.000		
86.380	196.578		
	1.250	1.125	1.000
164.090	18.000	54.000	126.470
321.590	18.000	54.000	121.950
464.450	18.000	54.000	121.900
643.990	18.000	54.000	113.520

In this representation the new taper schedule for the monotaper driven-element (1.000" OD) starts with a number of blank spaces. When the taper schedule is changed (back to the original), another line for the 1.250", 1.125", and 1.000" line-up is used to separate the spacing and lengths for the last four elements. Unless the taper schedule changes, the diameter line last specified will hold through the rest of the file.

The English words used to describe these formats are more torturous and harder to read (and write) than simple inspection of the data files by the reader. The human brain is a marvelous thing, especially compared to a computer, which takes things excruciatingly literally!

There are other variations allowed for in the file format, including modifying the unit of measurement on-the-fly. In the example shown below the element spacing along the boom is shown in feet (using both the single apostrophe and the ft abbreviation) rather than in inches, and just for fun the length of each element tip is shown in millimeters, for all but director two, which is specified in wavelengths at the geometric mean frequency of 14.174 MHz.

204BA_2.YW, Hy-Gain 204BA tuned for high phone.

14.000 14.174 14.350 MHz

4 elements, inches

	1.250	1.125	0.875	0.625	0.438
0.000	44.500	46.000	50.500	24.000	1270.0mm
10.240'	35.000	46.000	50.500	24.000	1270.0mm
17.635ft	21.000	46.000	50.500	24.000	1295.4mm
25.604'	16.750	46.000	50.500	24.000	0.05884w

The rule is that a units modifier must immediately follow the numeric data (no spaces allowed), and must use only the following units:

in " ft ' mm cm m w

standing respectively for inches, inches, feet, feet, millimeters, centimeters, meters and wavelengths (at center frequency). The units modifier will hold only for the numeric data it immediately follows.