

A Perl /Tk Package for NEC- Based Antenna Design

*Here is some antenna-modeling software
for Linux/Unix users. You no longer need
Windows to see your antenna pattern.*

By Bill Walker, W5GFE

There are many useful programs available for modeling antenna systems. Among the most popular are those developed by Roy Lewallen, W7EL.¹ Roy's programs are intended for use on machines running Microsoft operating systems.

Other good sources of information include "A Beginner's Guide to Using Computer Antenna Modeling Programs,"² from L. B. Cebik, W4RNL, and "Modeling HF Antennas with MININEC—Guidelines and Tips from a Code User's Notebook,"³ by John Belrose, VE2CV.

¹Notes appear on [page 54](#).

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Enter NEC

If, like me, you're a user of Unix-based operating systems, you may find the program *NEC* more to your interest.⁴ There's very useful downloadable documentation for *NEC* on the Internet.⁵

The *NEC* program is very versatile. It consists of about 9000 lines or so of *FORTRAN* (see [Note 4](#) for a *C* version). To compile the data, you'll need a good *FORTRAN* compiler. If you don't have one, check out the GNU project on the Internet.⁶

NEC is a complex program. It produces output that consists of pages and pages of numbers arranged in seemingly never-ending columns. This may have accounted for its lukewarm acceptance in the amateur community over the years.

In an article published on the Internet,⁷ I described a system of *Tcl/Tk* programs that accepts the voluminous output of *NEC* and produces a series of graphs which are, to me at least, more useful than the numeric output of *NEC*. I find these graphs especially helpful when I'm just fiddling with an antenna.

Although that software proved both useful and popular, it suffered from several problems—including the fact that the *Tcl/Tk* language needs the BLT extension to handle the programs. Also, I must confess that *Tcl/Tk* itself isn't the most comfortable language for me, and I was never satisfied with the "straight line" code produced when writing in *Tcl/Tk*. The current effort, written in *Perl/Tk*, seems more robust and satisfactory.

Perl/Tk is an extension of the enormously popular *Perl* language (see Notes 8 and 9 for authoritative work). Both *Perl* and the *Tk* extension are available for most operating systems in either binary or source form from the Internet (see CPAN at Note 10). I'm using *Perl/Tk* on SCO *Unix* 5.0.4, but many of my students are using it under either *Linux* or *Windows NT*. One intrepid soul is even running it under *Windows 98*!

Modeling antenna patterns with NEC

To model antenna patterns with *NEC*, you must first acquire (or compile) a binary version of the program. Try the Web page in Note 4 for either source code or binary files. While you're at it, you might also try to print the helpful documentation from the source in Note 5.

NEC consists of a single binary file, so installation is easy. Just locate it in a convenient place in your search path. *NEC* does produce some intermediate files, so you need to run *NEC* in a directory where you have write permission. The input to *NEC* consists of a series of lines that describe the geometry of an antenna and the applied excitation.

Informally, each element of an antenna consists of a straight line. Each element is "tagged" with an integer. The two endpoints of each element represented as points with *X*, *Y* and *Z* coordinates. An element is further divided into segments for calculating currents in each segment. It's also possible to specify the radius of wire in the element. The data lines that describe elements are called "GW" lines.

There's usually a GW line for each element of the antenna; however, an antenna such as a discone can be described by rotating several elements if need be, so that isn't always true. Because many who model antennas may wish to use English units and *NEC* requires metric units, it's possible to include a "GS" data line that applies a scaling factor to all elements of an antenna. This allows the designer to work with any convenient unit of measure.

The end of the physical description of the antenna is marked with a "GE 1" data line. Other data lines ("GN" data lines) are used to describe the ground under an antenna, and the frequency ("FR" data lines) and excitation ("EX" data lines) applied to an antenna. Other lines ("LD") can be used to indicate termination impedances.

If you provide a "RP" data line, the program calculates radiation patterns. Different parameters of the RP line ask for E and H fields to be calculated at various angles of azimuth or elevation. The W5GFE antenna package expects you to provide one of two different RP cards to provide correct input to the plotting programs. The "EN" data line indicates the end of the input data. For a complete discussion of all the possible input lines and parameters, see the *NEC* documentation.

Modeling a Rhombic with NEC

I live on about 40 acres of land in southeastern Oklahoma. There's a single diamond-shaped meadow on the property that could accommodate a rhombic antenna that is 120 feet by 240 feet. If I use telephone poles that can place the wires 50 feet in the air, is it worth building that rhombic for 20 meters? Table 1 is a *NEC* data file that describes the situation. The four GW lines describe the rhombic antenna. The rhombic has four elements. The line

GW 1 10 -120.0 0.0 50.0 0.0 60.0 50.0 0.01 describes the first element, which is divided into 10 segments. The coordinates of the endpoints are (-120.0, 0.0, 50.0), as shown in Fig 1. (The 0.01 represents the radius of the wire in the element.)

The figure makes it easy to determine the other three GW lines. Because the antenna is measured in feet, we use a GS line to scale the entire antenna to metric units. The GE line indicates an end to the antenna geometry, while the GN line describes the ground.

Other lines include the FR line (frequency = 14.0 MHz), two EX lines (the excitation applied to element 1 and element 2) and two LD lines (describe the 600-Ω termination resistors on elements 3 and 4).

The RP Data Line

For purposes of the W5GFE antenna package, it's important to use a special RP data line. The RP line included in Table 1 asks for an elevation profile (angles 0° to 180°) to be computed at a distance of 10 kilometers from the origin. This will instruct *NEC* to provide output the program *Elevation* expects.

When computing azimuth fields, a different RP line is used. If you wish to compute azimuth patterns, use this RP line instead:

```
RP 0 1 361 1001 75.0 0.0 0.0 1.0 10000.0 0.00E+00
```

The RP line isn't used if you simply want to view the antenna. Look at it using either *Wires* or *NECview*.

The Programs

The programs in the W5GFE antenna package include: *Azimuth*, *Elevation*, *Wires* and *NECview*:

Azimuth

The *Azimuth* program expects to use output from *NEC* where the RP data line is of the form:

```
RP 0 1 361 1001 75.0 0.0 1.0 10000.0 0.00E+00
```

Table 1—A NEC data file.

```
CM NEC Input File for W5GFE Rhombic
CE
GW 1 10 -120.0 0.0 50.0 0.0 60.0 50.0 0.01
GW 2 10 -120.0 0.0 50.0 0.0 -60.0 50.0 0.01
GW 3 10 0.0 60.0 50.0 120.0 0.0 50.0 0.01
GW 4 10 0.0 -60.0 50.0 120.0 0.0 50.0 0.01
GS 0 0 0.3048
GE 1
GN 1 0 0 0 0.0 0.0 0.0 0.0 0.0
FR 0 1 0 0 14.0 0.0 0.0 0.0 0.0 0.0
EX 0 1 1 0 1.0 0.0 0.0 0.0 0.0 0.0
EX 0 2 1 0 -1.0 0.0 0.0 0.0 0.0 0.0
LD 0 3 10 10 600.0 0.0 0.0 0.0 0.0 0.0
LD 0 4 10 10 600.0 0.0 0.0 0.0 0.0 0.0
RP 0 180 1 1001 -90.0 0.0 1.0 0.0 10000.0 0.0
EN
```

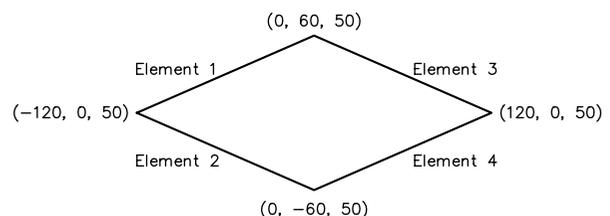


Fig 1—The rhombic antenna.

If the output file from *NEC* were named *rhombic.out*, the command **Azimuth rhombic.out** would produce four windows on the screen. Two of the windows display polar plots of the azimuth pattern, while a third displays a Cartesian plot of the same information. The fourth window provides a “fact box” with useful information about the antenna. An example of the *Azimuth* screen appears in Fig 2.

Elevation

The *Elevation* program expects to use output from *NEC* where the RP data line is of the form:

```
RP 0 180 1 1001 -90.0 0.0 1.0 0.0 10000.0 0.00E+00
```

The command **Elevation rhombic.out** produces four windows similar to those from *Azimuth*, but that contain information about elevation patterns. An example of the *Elevation* screen is shown in Fig 3.

Wires

Unlike *Azimuth* or *Elevation*, *Wires* uses the *NEC* input file, not the file produced as output by *NEC*. *Wires* ignores

all data lines except the GW lines. Therefore, *Wires* isn't useful for antennas created using rotations (such as “GH” or “GR” data lines).

The *Wires* program provides three different views (XY plane, YZ plane and XZ plane) of the same antenna. The corresponding elements of the antenna are colored the same in each view. *Wires* has a file-selection window that lets you pick the antenna description you wish to view.

Wires provides a “static” view of the antenna. Since the arrival of the “active” program, *NECview*, interest in *Wires* seems to have waned considerably.

NECview

NECview, like *Wires*, provides a picture of an antenna by reading *NEC* input files. Unlike *Wires*, *NECview* provides only a single window. This window has “sliders” that allow the antenna to be rotated continuously so you can view it from different angles. *NECview* is visually stimulating and seems to catch the imagination of users. It's based quite heavily on a program called *xNECview* by P. T. deBoer.¹¹

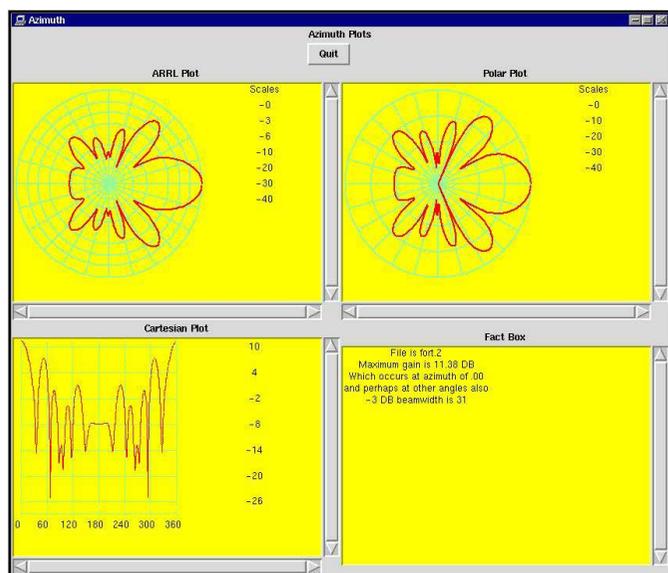


Fig 2—An example of the *Azimuth* screen.

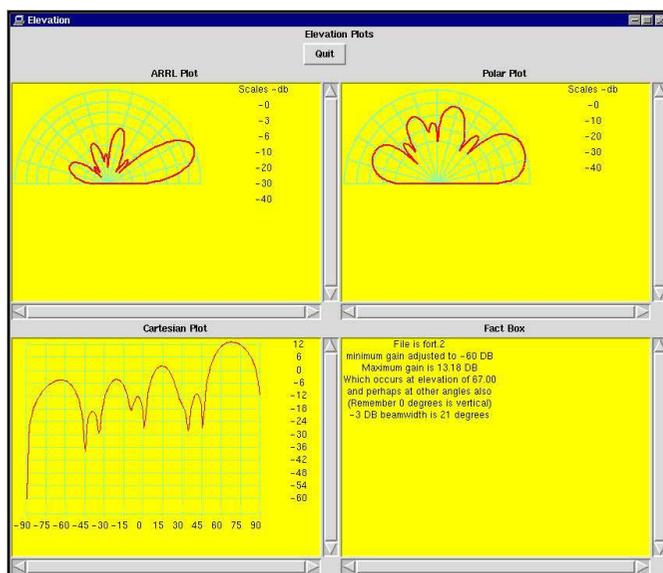


Fig 3—An example of the *Elevation* screen.

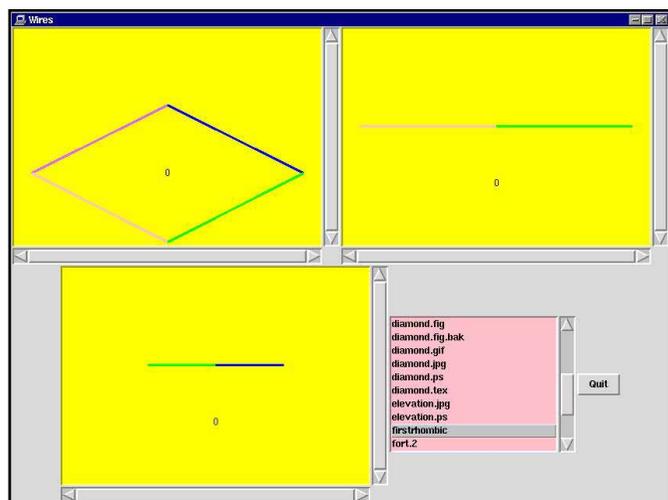


Fig 4—The *Wires* screen

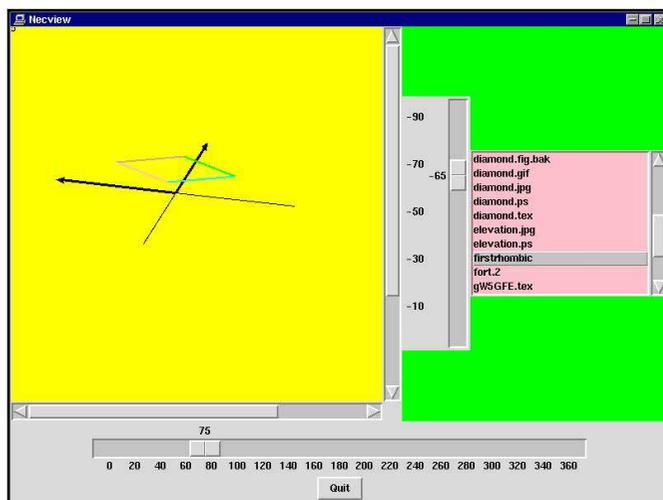


Fig 5—*NECview* in action with the rhombic input file.

Currently, *NECview* only supports the GW and the GR data lines. Fig 4 is a screen shot of *NECview* in action with the rhombic as an input file.

Availability

The entire W5GFE antenna package is available via anonymous FTP.¹²

Conclusion

In an article long ago,¹³ I explored some propagation effects at VHF. How I wish I'd had modeling software such as *NEC* then!

If you like to fiddle with antennas, the *NEC* modeling software combined with the W5GFE antenna tool kit will provide many enjoyable hours at the computer and inspire more than a few hours on a ladder. It is no longer *NEC*essary to "fly by the seat of your pants" when designing antennas. Enjoy!

Notes

¹R. Lewallen, W7EL, W7EL Software, PO Box 6658, Beaverton, OR 97007.

²L. B. Cebik, W4RNL, "A Beginner's Guide to Using Computer Antenna Modeling Programs," *The ARRL Antenna Compendium*, Vol 3.

³J. Belrose, VE2CV, "Modeling HF Antennas with MININEC—Guidelines and Tips from a Code User's Notebook," *The ARRL Antenna Compendium*, Vol 3.

⁴A really useful and rich reference for *NEC* documentation, code and utilities is at www.qsl.net/wb6tpu/.

⁵*NEC* documentation is downloadable from members.home.net/nec2/.

⁶The EGCS group merged with the GNU C project located at gcc.gnu.org/. Look for their C and Fortran compilers at [ftp://ftp.freesoftware.com/pub/sourceware/gcc/releases/index.html](http://ftp.freesoftware.com/pub/sourceware/gcc/releases/index.html).

⁷Bill Walker, "Jiffy" Visualization Software for *NEC*-based Antenna Design can be downloaded as W5GFE.tar.gz from www.qsl.net/wb6tpu/swindex.html.

⁸L. Wall, T. Christiansen and R. Schwartz, *Programming in Perl*, Second Edition (Cambridge, Massachusetts: O'Reilly & Associates, Inc; www.oreilly.com; 1996).

⁹N. Walsh, *Learning Perl/Tk*, (O'Reilly & Associates, 1999).

¹⁰The Comprehensive Perl Archive Network (CPAN) home page is at www.cpan.org/.

¹¹P. T. deBoer, pa3fwm@amsat.org, ptdeboer@cs.utwente.nl.

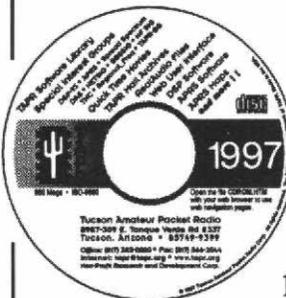
¹²The entire software package is available as W5GFE2.tar.gz at www.qsl.net/wb6tpu/swindex.html.

¹³Bill Walker, "Predicting Radio Horizons at VHF," *QST*, June 1978, pp 28-29.

Bill Walker holds an Extra-class license. He received his "ticket" in 1961 at the age of 14 and has held the same call throughout his ham life. He also holds BS, MS and PhD degrees in mathematics and is currently Professor and Chairman of Computer Science at East Central University in Ada, Oklahoma, where he lives with his wife Anita and their son Dalton. Anita also holds the PhD degree in mathematics and she is Professor of Mathematics at the same institution. Professor Walker has authored three textbooks on computing and writes a regular column ("Pow-wow Circle") for Whispering Wind magazine, a publication which is devoted to Native American crafts and culture. Dr. Walker and his family are active participants at powwows throughout Oklahoma. He has written articles that have appeared in QST and 73. □□



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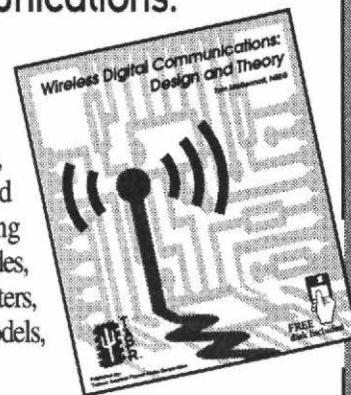


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