NEC *and* MININEC *Antenna Modeling Programs: A Guide to Further Information*

Thinking about getting some antenna modeling software? First, read this overview of offerings—and pointers to more information.

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Much antenna research and design work is based on systematic antenna modeling in a version of the *Numerical Electromagnetics Code* (*NEC*). The following brief notes are not a review of existing antenna modeling programs, but a basic guide to getting further information on these programs from the software providers.

NEC and *MININEC* are method-of-moments calculation programs for antenna modeling. *NEC-2* and *MININEC* are public-domain programs. *NEC-4* is proprietary. References at the end of this article provide some background information on the history, techniques and limitations of these methods.

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The basic calculating programs are not user-ready. Most individual and small-business users purchase a version of *NEC* or *MININEC* from a vendor who has added input and output interfaces (and often added correction factors) to the basic calculating module(s) to make them user-ready. This guide provides ways to contact commercial sources, starting with the most advanced versions.

NEC-4

The latest version of *NEC* is *NEC-4*, which overcomes most shortcomings of earlier codes. It permits modeling of underground radial systems, elements of varying diameter sections and carefully constructed close-spaced parallel wires, as well as all the modeling capabilities of earlier versions of the code. (Some of these capabilities, however, while superior to those of *NEC-2*, have limitations that are just now becoming well documented.) *NEC-4* is a proprietary code of the Lawrence Livermore National Laboratory, University of California, from whom a user-license must be obtained. Export restrictions apply.

To obtain a user-license, contact Gerald J. Burke, L-156, Lawrence Livermore National Laboratory, PO Box 5504, Livermore, CA 94550; e-mail **burke2@llnl.gov**. The price of the license is $850 ($150 for an approved educational site).

In addition to a license, users must also create or purchase the required interface programming. At present, I

know of only one source of commercial software for *NEC-4*: Roy Lewallen, W7EL. *EZNEC Pro* has an option for *NEC-4* (*EZNEC/4*), if the purchaser has a confirmed license for *NEC-4* ($600). *EZNEC Pro* is also available for *NEC-2* (*EZNEC-M*—$425). Both versions offer the same features, except for the calculating engine options, and can handle more than 3000 segments and 1000 wires—very large antenna models. (See the next section for notes on *NEC-2*.) W7EL also makes available *EZNEC*, a segment-restricted (500) version of *NEC-2* ($89, now in version 2 with enhanced pattern-plot exploration features, SWR plots and other upgrades) and *ELNEC*, a version of *MININEC 3* ($49). All W7EL software packages are written for DOS. They employ similar user interfaces that have earned praise for user friendliness in many circles. Contact Roy Lewallen, W7EL, PO Box 6658, Beaverton, OR 97007; e-mail **w7el@teleport.com**. URL **http://www.teleport.com/~w7el/.**

On the horizon, and possibly available by the time these notes appear in print, is *GNEC*, a Windows-based version of *NEC-4* from Nittany Scientific. A license for *NEC-4* will be required to purchase this program. *GNEC* attempts to implement the full *NEC-4* command set and provides a large array of plotting and other graphical outputs, including rectangular plots of many performance figures and color-coded analytical antenna views. See the entry under *NEC-2* for contact information.

NEC-2

NEC-2 is a highly capable version of the code, which is in the public domain. It is restricted to antenna elements of a single diameter (although some software providers have introduced corrections for linear elements of varying diameters). It cannot handle buried radial systems, although above-ground systems close to the earth can be handled. It is equipped with the Sommerfeld-Norton high-accuracy ground model, for accurate modeling of horizontal wires close to the earth.

Nittany Scientific produces a *Windows* version of *NEC-2* at two levels: *NECWin Pro*, V 1.1 (NWP; $425) and *NECWin Basic* (NWB; $75: restricted to 500 segments). Both employ a spreadsheet geometry construction page, pull-down boxes for other antenna parameters, and *Windows*-style graphical outputs, including three-dimensional pattern views. In addition, NWP provides direct entry or importation of *NEC* model input "cards" and provides a large assortment of rectangular output graphics, along with other advanced *NEC* capabilities. These include the color-coded analytical antenna views (Necvu 2). Contact Nittany Scientific, 1700 Airline Hwy, Ste 361, Hollister, CA 95023-5621; e-mail **sale@nittany-scientific.com;** URL **http://www.nittany-scientific.com.**

In addition to *EZNEC* and *NECWin*, *NEC-2* is also offered by Brian Beezley, K6STI, in a package called *NEC/Wires* 2.0. This package is part of a suite of programs offered by K6STI, the most well known of which are *AO* and *YO*. Contact information appears in the section on *MININEC*.

MININEC "Professional"

Before recent advances in speed and memory, it was not feasible to run *NEC* on a PC. Rockway and Logan developed *MININEC*, a Basic language adaptation of *NEC* for PCs. More recently, they have advanced the *MININEC* algorithms and code to overcome many of its initial limitations. The "new" *MININEC* can handle sharp angles in antenna geometry directly (without segment length tapering) and antennas close to ground with much better accuracy. However, the *MININEC Professional* code is a proprietary product. EM Scientific offers several levels of *MININEC Professional*, including the basic level *MININEC* for *Windows* (400 wires; $125), *MININEC Professional* (1000 wires; $390), and *MININEC Broadcast Professional* (2000 wires; $790). These are all *Windows* products. Contact EM Scientific, Inc, 2533 N Carson St, Ste 2107, Carson City, NV 89706; e-mail **76111.3171@compuserve.com**. URL **http://www.emsci.com**.

MININEC

The public domain *MININEC* code (version 3.13) is available with several commercial user interfaces, as indicated in these notes. For general antenna analysis that does not press its limitations, *MININEC* is a highly competent code. It handles elements of changing diameter directly and, with segment-length tapering, can accurately model a wide range of antenna geometries. However, horizontal antennas must be at least 0.2 wavelengths above ground for accurate results. Moreover, specification of ground conditions affects only antenna far-field results, not feed point conditions. Antenna size is limited to 256 segments. Despite limitations, *MININEC* has shown results superior even to *NEC-4* on certain types of antenna structures involving close-spaced wires, large sudden changes of element diameter and angular junctions of wires with dissimilar diameters.

Orion of Canada (Madjid Boukri, VE2GMI) offers a *Windows*-based version of *MININEC*, *NEC4WIN*, using a spreadsheet geometry input page, pull-down boxes for other antenna parameters and a pattern-plotting output that includes lobe identification and bandwidth. In addition, the user can vary the height of the antenna without invoking a complete recalculation of the matrix for faster results. The current version is 1.9L ($35). A *Windows 95*-only version with enhanced capabilities may become available soon. Contact Madjid Boukri, VE3GMI, Orion Microsystems, 197 Cr Joncaire, Ile Bizard, Quebec, Canada H9C 2P7; e-mail **mboukri@cam.org**. URL **http://www.cam.org/~mboukri**

Brian Beezley, K6STI, also offers a wide range of *NEC*-related DOS-based software, as well as a Yagi-optimization program and a terrain-analysis program. Perhaps the best known program is *YO*, the Yagi-optimizing program that uses special algorithms calibrated to *NEC-2* (offered as *NEC-Wires*). *AO* (Antenna Optimizer) is a *MININEC*-based program with an optimizing function included. *AO* includes a frequency-correction factor to bring *MININEC* results in line with *NEC* results as antenna frequency increases. The input section of the program includes the ability to use symbolic expressions for antenna dimensions, thus permitting alteration of multiple parts of the structure with a single entry revision. *AO*, *YO* and *NEC/Wires* are each $70 (or any three of the K6STI antenna programs for $120). Contact Brian Beezley, K6STI, 3532 Linda Vista, San Marcos, CA 92069; e-mail **k6sti@n2.net**.

ELNEC is W7EL's DOS-based version of *MININEC*. It uses an interface very similar to those of his programs for *NEC-2* and *NEC-4*. The program contains a parallel-wire correction. See the section on *NEC-4* for contact details.

Other Information Sources

The Applied Computational Electromagnetics Society (ACES) is perhaps the professional focal point of advances in all forms of electromagnetics codes and related mathematical models. It holds an annual meeting on the West Coast in March with a very

full and varied program. Further information can be found at their Web site **http://www.emclab.umr.edu/aces/.**

The Unofficial *NEC* Archives are maintained by Ray Anderson, WB6TPU. Formerly, this collection of *NEC*-related software was available only via FTP. However, the entire contents are now accessible via the Web. They include many source codes for *NEC* and for pre- and post-processing of *NEC*, along with some sample input files. Look for them at **http://www.qsl.net/wb6tpu.**

The Unofficial *NEC* Home Page is supported by Peter D. Richeson, who maintains on-line copies of the *NEC-2* manual (Part III). URL **http://www.dec.tis.net/~richesop/nec/.**

There is also a mailing list for those interested in a forum for questions and information. The address is **nec-list@ee.ubc.ca.**

This listing is necessarily limited, even within the scope of *NEC*-related software and information sources. However, the indicated Web pages lead to other information on details, specifications, related developments and a more complete understanding of the rapidly expanding field of electromagnetic modeling.

In addition to *NEC*-related software, the Web and related FTP sites provide a variety of antenna modeling, optimizing and calculating programs. See, for example, the collection at the following URL **http://www.qsl.net/k7on/shareware/1997**. Most of these programs are either freeware or shareware, and they can ease a large number of antenna design problems—especially if the resulting designs are then further evaluated on one of the *NEC*-based programs.

For Further Reading

NEC-2 and NEC-4: Basic References

J. Burke, A. J. Pogio, *Numerical Electromagnetic Code (NEC) Method of Moments, a User Oriented Code*, Vol 2 (Part III: User's Guide), Tech Doc 116, Naval Systems Center, San Diego, 1982.

Gerald J. Burke, *Numerical Electromagnetic Code—NEC-4: Method of Moments*, (Parts I and II), Lawrence Livermore National Laboratory UCRL-MA-109338, 1992.

MININEC: Basic References

A. J. Julian, J. C. Logan, J. W. Rockway, "*MININEC: a Mini-Numerical Electromagnetic Code*," Tech Doc 516, Naval Systems Center, San Diego, 1982.

J. C. Logan, J. W. Rockway, "*The New MININEC (Version 3): A Mini-Numerical Electromagnetic Code*," Tech Doc 938, Naval Systems Center, San Diego, 1986.

Method of Moments Techniques

John D. Krauss, *Antennas*, 2nd ed. (New York: McGraw-Hill, 1988), pp 384-408.

Antenna Modeling Articles

Roy Lewallen, W7EL, "*MININEC*: The Other Side of the Sword," *QST* (Feb 1991), pp 18-22.

L. B. Cebik, W4RNL, "A Beginner's Guide to Using Computer Antenna Modeling Programs," *ARRL Antenna Compendium*, Vol 3 (1992), pp 148-155.

John S. Belrose, VE2CV, "Modeling HF Antennas with *MININEC*—Guidelines and Tips from a Code-User's Notebook," *ARRL Antenna Compendium*, Vol 3 (1992), pp 155-164.

R. P. Haviland, W4MB, "Programs for Antenna Analysis by the Method of Moments," *ARRL Antenna Compendium*, Vol 4 (1995), pp 69-73.

In addition to these references, the lengthy manuals accompanying such programs as *EL/EZNEC*, *AO/NEC/Wires*, and *NECWin Pro/Basic* can also make significant contributions to your understanding of antenna modeling. A detailed background document on antenna modeling is also available at the EM Scientific (*MININEC* Pro) Web site **http://www.emsci.com**. □□