Antenna and Electromagnetic Modeling Software

By Steve Stearns, K6OIK

Originally developed at Lawrence Livermore National Laboratory (LLNL) in the 1970s, the program *Numerical Electromagnetics Code* or *NEC* is publicly available for general use and is available for personal computers running Windows, Linux, and macOS. The public version is *NEC-2* (**www.nec2.org**). An updated version, *NEC-4*, is only available as a compiled binary program under license agreement with LLNL and is best-known to amateurs in the *EZNEC-Pro* software. More information about *NEC* is available from **en.wikipedia.org/wiki/Numerical_Electromagnetics_Code**.

The *NEC* program family (*NEC, NEC-BSC, NEC-2, NEC-3, NEC-4*) and the alternative implementation *MININEC* are examples of "thin wire" codes, which are limited to modeling antennas made of wires, rods, and tubes, with materials limited to non-magnetic metals.

Other programs have appeared since *NEC* was developed. For example, a series of programs started from B.D. Popovic's modeling program *WireZeus*, including *AWAS, WIPL, WIPL-D,* and *HOBBIES*. *WireZeus* and *AWAS* are thin-wire programs. *WIPL* and *WIPL-D* are professional modeling programs. *HOBBIES* was released in 2012 and is the newest member of the family. Most of these programs are characterized as electromagnetic "solvers" or simulators that use advanced numerical algorithms to handle general geometries and arbitrary materials.

Programs such as *WIPL-D*, *FEKO*, and *HOBBIES* have, in addition to a thin-wire code, the ability to model surfaces. Just as a thin-wire code divides a wire into segments, a surface code divides a surface into elementary patches by using a process called *meshing*. Surface meshing allows one to model irregularly shaped antennas on irregularly shaped platforms such as automobiles, airplanes, ships, and even irregular terrain. Consequently, models can include structural features such as buildings, trees, hills, and valleys, which a thin-wire code cannot model.

Figure 8.A shows a mesh model of a car's surface modeled as metal skin over ground. A 2-meter whip is mounted on the car's roof. The surface has been meshed into small triangular patches by the modeling program *FEKO*. A source placed at the base of the whip feeds it against the roof. *FEKO* computes RF current in each triangular patch. **Figure 8.B** shows the computed currents. Magnitude is shown as shades of grey and current direction is depicted by small arrows. Note how current concentrates around the edges of the windows. (See KI6BDR's October 2016 *QST* article for more about this type of modeling.)

HOBBIES is an acronym for "Higher Order Basis Based Integral Equation Solver." It runs on an ordinary Windows PC, is feature rich, and is affordable for amateurs. However, it does require learning modern CAD geometry modeling and uses *GiD* version 10 for specifying model geometries.

Modern programs for computational electromagnetics do a better job of telling us what is going on with antennas and structures. Such programs not only allow more complex models, but their graphical output can improve our understanding of electromagnetic physics, fields, and wave propagation. An expanded discussion of modeling software and automated shell programs such as *AutoEZ* is available on the *Antenna Book* web page: **www.arrl.org/arrl-antenna-book-reference**. See K6OIK's 2017 Pacificon presentation on antenna modeling, "Antenna Modeling for Radio Amateurs," at **www.fars.k6ya.org/docs/k6oik**.
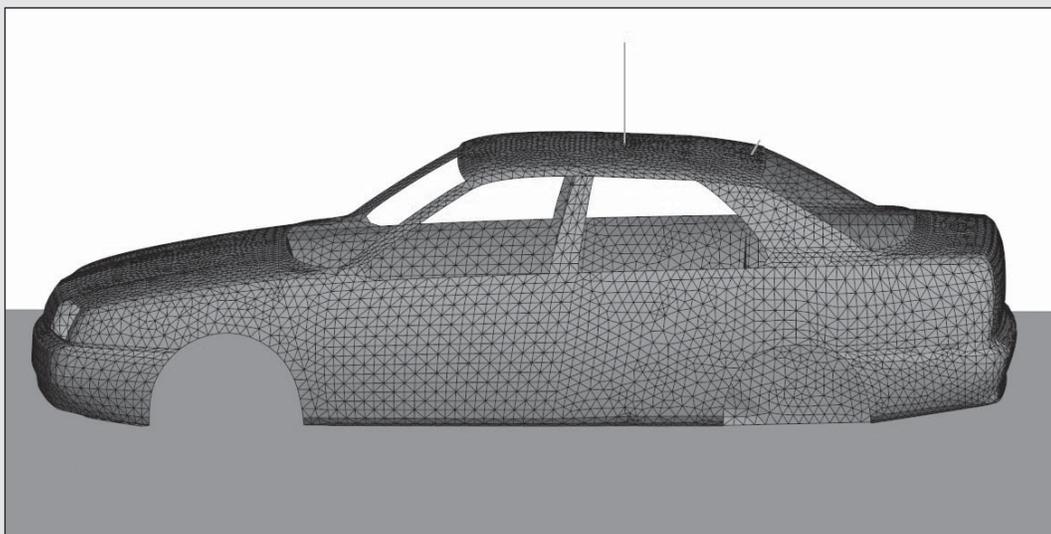
Figure A — *FEKO* model of a 2 meter whip on the roof of a car.
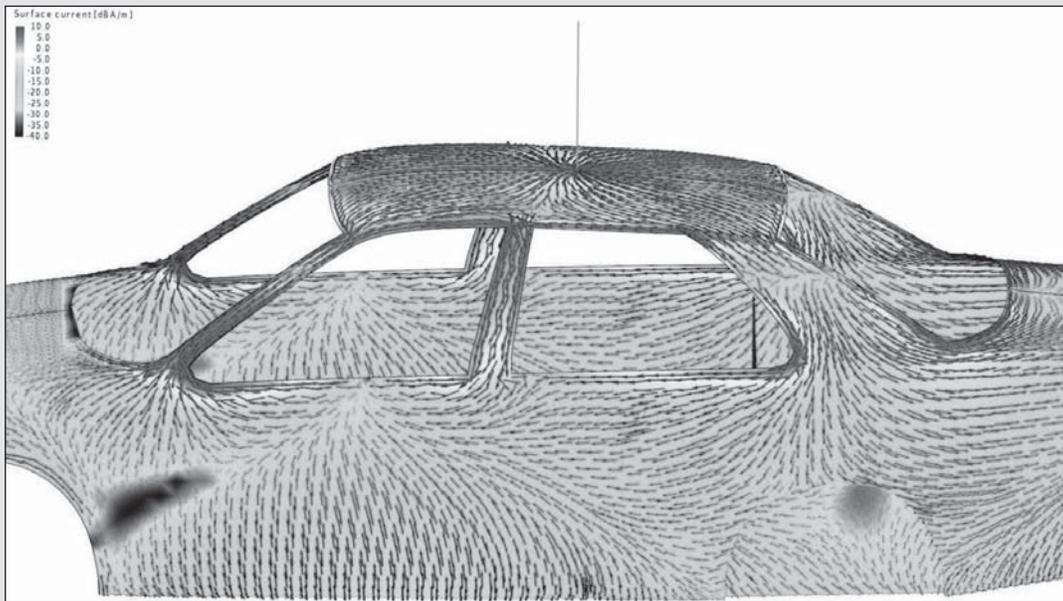
Figure B — Skin currents in car are concentrated around the windows.

Table 8.A
Antenna and Electromagnetic Modeling Software

Program	Website	Notes
4NEC2	**www.qsl.net/4nec2**	
EZNEC, EZNEC-Pro	**www.eznec.com**	
AutoEZ	**www.ac6la.com/autoez.html**	Automated shell for *EZNEC*, based on *Excel*
YW — Yagi for Windows	**www.arrl.org/arrl-antenna-book-reference**	
YagiCAD	**www.yagicad.com/yagicad/YagiCAD.htm**	Calculator for VHF/UHF Yagi design
Yagi Calculator	**www.vk5dj.com/yagi.html**	Calculator for DL6WU long-Yagi VHF/UHF design
CocoaNEC	**www.w7ay.net/site/Applications/cocoaNEC/**	macOS version of *NEC*
MMANA-GAL, MMANA-GAL PRO	**gal-ana.de**	
NEC2GO	**www.nec2go.com/**	Simplified user interface
NEC 4.2	**ipo.llnl.gov/technologies/nec**	
NEC archives by WB6TPU	**www.qsl.net/wb6tpu** **Nec-archives.pa3kj.com**	Unofficial archives

Electromagnetic solver/modeling/simulation

HOBBIES	**www.em-hobbies.com/**	
WIPL, WIPL-D	**wipl-d.com/**	
FEKO	**altairhyperworks.com/product/FEKO**	

See also **en.wikipedia.org/wiki/Comparison_of_EM_simulation_software**