Introduction to Antenna Modeling

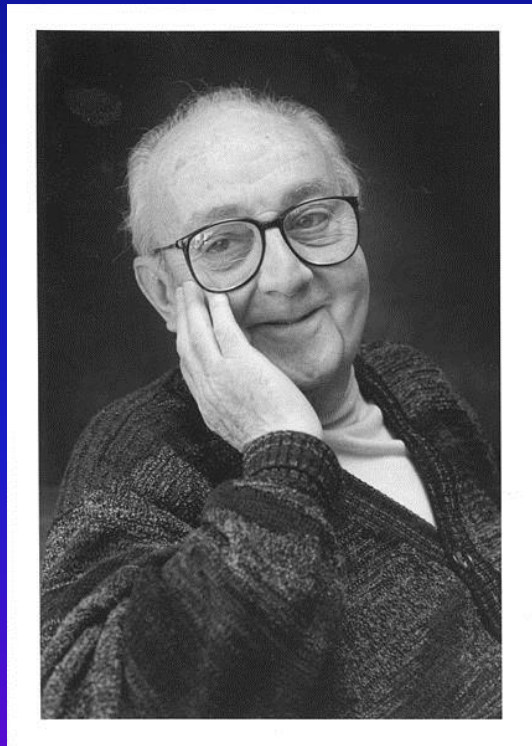**N3AE**

Calvert Amateur Radio Association, Inc

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Some Comments on Modeling

The Prime Directive

"Essentially, all models are wrong, but some are useful"

George Edward Pelham Box
British Mathematician
1919 - 2013

"Since all models are wrong the scientist cannot obtain a "correct" one by excessive elaboration. On the contrary following William of Occam he should seek an economical description of natural phenomena. Just as the ability to devise simple but evocative models is the signature of the great scientist, so overelaboration and over-parameterization is often the mark of mediocrity."

Basis for Antenna Modeling Using Computer Software

"NEC" - Numerical Electromagnetics Code

- Originally written in FORTRAN in the 1970s by Gerald Burke and Andrew Poggio of the Lawrence Livermore National Laboratory

- The code is based on the <u>method of moments</u> solution of the electric field integral equation (EFIE) for thin wires and the magnetic field integral equation (MFIE) for closed, conducting surfaces.

- Breaks antenna conductors into "segments," solves the field equations for each segment and matches boundary conditions with adjacent segments, then combines all the segment fields into a total field.

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NEC for Windows

Most popular and widely used version is EZNEC by Roy Lewallen, W7EL

- **https://www.eznec.com/**

- *Windows XP(SP3)* and later Windows operating systems, 32 or 64 bit*
  - Note: Intel CPU is required on XP and Vista systems but not on Windows 7 and later
- **Three versions ($99 to $675)**
  - EZNEC   NEC-2 engine. 500 max segments
  - EZNEC+   2000 max segments plus other features
  - EZNEC Pro2 Uses improved NEC-2 engine
  - EZNEC Pro4 Uses NEC-4 engine (need NEC-4 license which costs additional $300)

3rd Party EZNEC Support Programs

- **AutoEZ by AC6LA**
  - Automated use of EZNEC
  - http://ac6la.com/autoez.html

- **Basically an Excel shell around EZNEC**

- **AutoEZ allows you to use variables to control diverse aspects of your the model. You can then run multiple EZNEC test cases while AutoEZ automatically changes one or more variables between runs**

EZNEC Ground Models

- **EZNEC has three options to model ground**
  - None: Antenna in free space
  - Perfect: Infinite perfectly conducting plane
  - Real: High-accuracy ground
    - Most accurate but takes computer time
  - MININEC: Compromise between accuracy & speed
    - Assumes perfect ground for calculating currents, but switches to dielectric for far-field pattern calculation – Hence no ground losses
    - Horizontal wires should be at least λ/5 above ground

Books and Links on Antenna Modeling

- **Antenna Modeling Tutorial**

- **An Introduction to Antenna Modeling**

- **Antenna Modeling for Beginners**

- **Basic Antenna Modeling**

- **Antenna Modeling for Radio Amateurs**

Other Modeling Software Packages

- **4NEC2 by *Arie Voors***
  - http://www.qsl.net/4nec2/
  - Free

Tips for Getting Better Accuracy from NEC-2

- **Segment length to wavelength rule**
  - Segment length $< \lambda / 20$
- **Segment length to diameter rule**
  - Segment length $> 2 \times$ diameter
- **Equal segment length rule**
  - All segments in a model have equal length
  - Never connect long segments to short segments
- **Acute angle junction rule**
  - Junction angles or segment lengths large enough that middle 1/3 of joined segments don't interpenetrate
- **Segment alignment rule for parallel wires**
  - Closely spaced parallel and near parallel wires have their segments aligned (paired)
- **Wires near ground**
  - All wires must be least two diameters above ground
  - Wires cannot touch ground

Middle 1/3

Middle 1/3
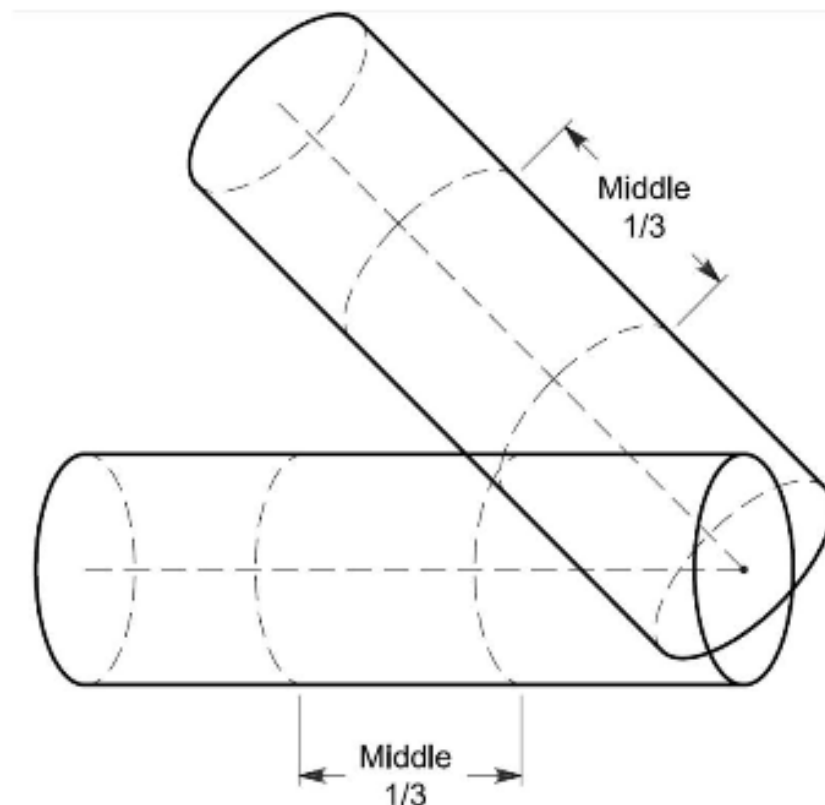
End of Intro

Now we'll open EZNEC V6.0 and run some examples