

AN-SOF Antenna Simulation

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Keith Rawlings continues with the description of the AN-SOF aerial modelling software package, explains the main functions of this software and offers advice on modelling a simple EWE aerial.

A quick recap: AN-SOF software will run simulations from ELF to microwave frequencies. It is paid-for software, for which there are various options. A trial version is available. This is fully featured and does not expire, but it is limited to 100 segments. This is enough to model a fair number of designs (see below). Like similar packages, AN-SOF comes with some sample designs. Some of these are quite complex, and may not run on the trial version. Full details, including a presentation and a helpful *User Guide*, may be found here:

<https://www.antennasimulator.com>

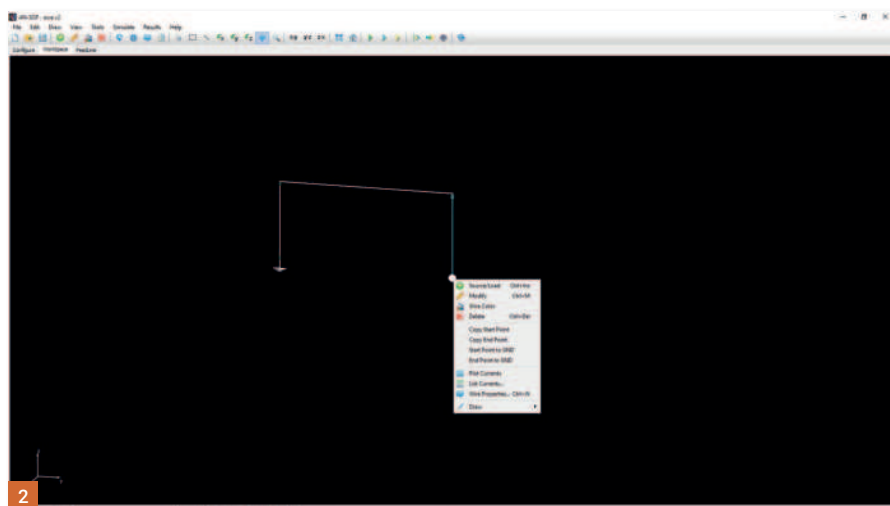
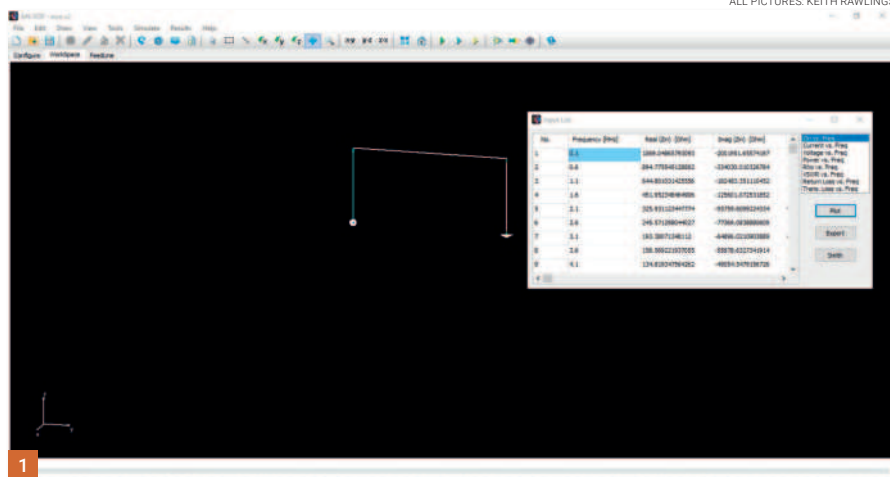
I recommend that readers to download the user manual and explore the website as there is not enough space here to cover but a fraction of the capabilities of this software.

General Overview

Being used to EZNEC, it took me a bit of time to get to know AN-SOF. However, once I got to grips with the way the software works, I found I could build up relatively complex designs relatively quickly. For example, to edit a wire during the design stage, it is only necessary to click on it, and an edit box will come up with the relevant dimensions for that wire. This is easier and quicker, especially with a complex design than searching through a spreadsheet to find it.

Data entry with AN-SOF is different from the spreadsheet-style of some packages. It uses this single window where the coordinates for a single wire are entered or edited. Moreover, on opening, the software the user is presented with is the more familiar Windows presentation of drop-down menus and icons.

Initially, the work area will be blank so the first thing to do is to select the *Preferences* menu to configure such things as the units you want to work with (Hz, kHz, mm, cm, in, ft, and so on).



The modelling can be undertaken in various unit systems (um, cm, mm, m, in, ft) as well as units for inductance (pH, nH, uH, mH, H) and capacitance (pF, nF, uF, mF, F).

Configuration and Workspace

Next, you will need to select the *Configure* Tab sheet, to set the parameters to be used during the simulation.

This will consist of setting the frequency (either a single frequency or a swept range with frequency steps), ground type, and settings for Far and Near Field evaluation.

Once everything has been set up, the user selects the *Workspace* tab sheet (Fig. 1).

You can now begin the design. Start by either selecting *Draw* from the drop-down menu, or by right-clicking on the desktop, where you are presented with several options.

If you select *Line*, the 'edit' box will pop up. You can then enter the 'X', 'Y', and 'Z'

dimensions of your design in the two rows of boxes in a point-to-point format. You will then have to enter the *Cross-Section* of your wire, for instance 'circular', 'square', and so on, and also the dimension of the cross-section.

Furthermore, the required number of segments for the simulation and the wire material/resistivity have to be recorded, along with details of the wire coating, if any.

This does sound rather complex but in reality, it is quite easy because the software remembers the last coordinates and other details. You pretty much just enter the dimensions of your design and build it up.

The position of a Source is placed on the design by right-clicking on the wire required and then selecting *Source/Load*. A slider then appears at the bottom of the screen. This is dragged along until the source is in position. The source can be seen *graphically* on the screen as it is dragged along the wire,

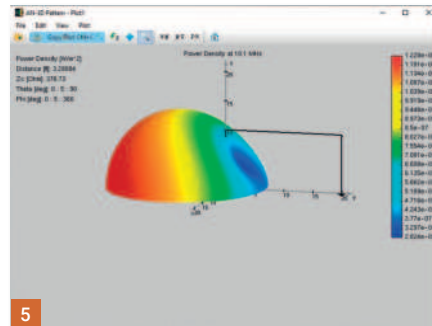
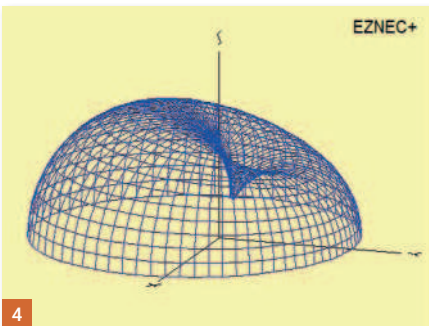
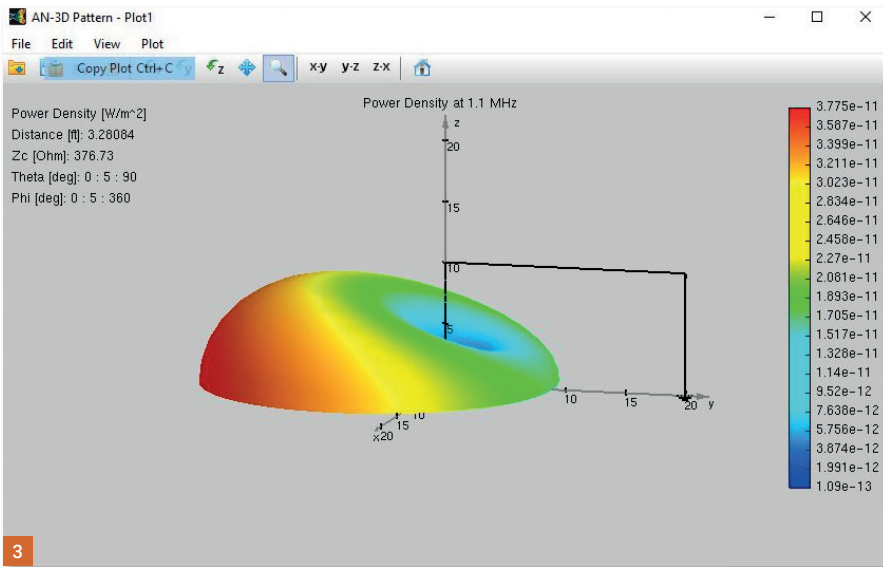


Fig. 1: The AN-SOF Workspace Input List. Fig. 2: AN-SOF Workspace with EWE Design and Modify Box. Fig. 3: Predicted 3D Plot of EWE at 1.1MHz. Fig. 4: Comparison with the predicted plot of Fig. 3, generated in EZNEC. Fig. 5: Predicted EWE at 10.1MHz. Note the change of patterns. Fig. 6: The Configure Tabs sheet in AN-SOF.

and also *textually* on the bottom-right of the display, shown as a percentage of position.

The segment onto which the sources is placed is also shown.

Furthermore, loads can be placed on a design from this selection.

The Simulation Stage

Once a design has been made and the sources placed, the model can be simulated.

You should, however, save it first!

It is now time to run the simulation, by selecting *Simulate Currents, Currents and Near-Field, Currents and Far-Field and Run All*, which does just that – it runs all fields.

Note that more complex designs can take some more time to run.

Once the simulation is complete it is time to look at the computed data, and there is plenty of it!

Selecting 'Results' from the drop-down menu, will list some different parameters that have been calculated. Once a parameter has been selected, the user is then often presented with further options to display the information. Selecting the *List Currents* command, by right-clicking on a wire, brings up a pop-up menu which shows the *List Currents* toolbar.

This allows the designer to select an individual wire segment, so that its *current-versus-frequency* may be read. Also, where the selected segment has a source or load, the lists of input impedances, admittances, voltages, power, reflection-coefficient, VSWR, return and transmission losses can be displayed.

A Big Draw: Colour Plots

One of AN-SOF's great features is the graphical demonstration of 3D colour-plots (Fig. 3). These are generated and opened in separate windows. They remain open until closed, so you can have quite a collection of plotted images to compare and save as you run through a design.

Incidentally, these plots stay active even if the AN-SOF software suite has been shut down.

- In *Preferences*, set dimensions as 'feet'.
- In *Configure*, for 'frequency', enter *Sweep*.
- In *Start* enter 0.5 MHz, Step .5MHz, Stop 30MHz.
- For *Ground*, select *Perfect* and you should be able to leave everything else 'as is' for this example.
- Go to *Workspace*, left click and select *Line*.
- In the *popup edit box*, enter: 'From point' X1:0,Y1:0,Z1:0.1 'To point' X2:0,Y2:0,Z2:10
- In *attributes*, enter '33' for Number of Segments, Cross Section as 'Circular' and use 1mm for the cross-section.
- In *Materials*, enter 1.74E-8 for copper.
- Select *Line* once again and enter: X1:0,Y1:0,Z1:10 'to point' X2: -25 ,Y2:0,Z2:10.
- Once again, select *Line* and enter: X1: -25, Y1:0,Z1:10 'to point' X2: -25, Y2:0,Z2:0, remembering to set the attributes as before.
- Right-click on the first wire and select *Source/Load*.
- Click on the *Add Source* circle that appears in the bottom of the window. This selects *Source*.
- In *Impedance* add *Resistance* as 50Ω.
- Leave position at 0% and Click the red 'X'
- Do the same for the third wire; this time select *Load* (this is the little rectangle with 'Z' above it).
- Enter 850 in the 'Ohm' box; drag the slider to around 90%.
- Again click the red 'X'.
- Now *save* the design and then press *F10* to 'Run All'. (see also Figs. 5 and 6).

Table 1: Designing a EWE Aerial with AN-SOF.

As well as graphically, AN-SOF can present its data in textual format too. For example, if a simulation is run from 6-8MHz in 100kHz steps AN-SOF can list the currents at each 100kHz step over the range displaying *Real Part, Imaginary Part, Amplitude* and *Phase*.

Another very useful feature of AN-SOF is the ability to excite a design by utilising an *Incident Field*.

Set (in the *Configure* window) the *Direction of Arrival* of a signal, and its polarization to the model can be specified and modelled. When the *3D View* button is selected, a dialogue box appears into which the axis of the wave can be entered.

This can then be graphically viewed on the screen.

A new feature in AN-SOF V5.01 – and one that I have not yet fully explored – is the embedded transmission line calculator.

Some Points to Consider

AN-SOF has many strengths that make it very versatile but, like other packages, it also places some responsibility on the designer. For example, it is possible to specify different materials within a design.

In AN-SOF, the properties of each wire have to be defined by the user. This is not a problem, as values for resistivity for various materials can be found online and common ones, such as those for *copper* (1.74E-8), 6061-T6 *aluminium* (4E-8), *tin* (1.14E-7) and *zinc* (6E-8), are listed in the manual.

Material cross-sections of *circular*, *square*, *flat*, *elliptical* and *rectangular* may also be selected, along with their respective dimensional sizes.

For wire coating, the user may enter the *relative permittivity*, *relative permeability* and *thickness*.

The latter can be set to '0' when no coating is used.

The same applies to *Ground*. Like other packages, AN-SOF can model in *free space*,

over *perfect ground and real ground*, where parameters are entered by the user.

To simulate things like flat strip lines for modelling planar aerials and PCBs, a *substrate* may be specified.

Please note that, while data for wires is entered or modified via the *Modify* dialogue box, in a *Workspace* window, the settings for *Media* (Ground Type), wire resistance and wire coating ('enabled' or not) is set from the *Configure* window.

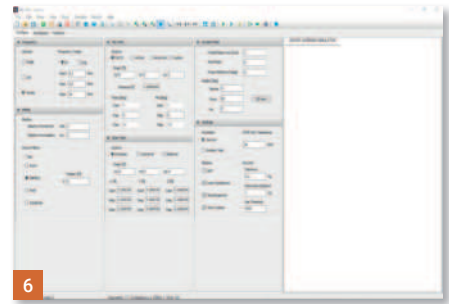
For more complex designs the software has built-in routines to calculate, *arcs*, *circles*, *helixes*, *spirals*, *plates*, *patches*, *discs*, *cones*, *cylinders*, *spheres*, *parabolas* and other varieties.

A Practical EWE Design

A simple aerial to practice a model of with this program is the popular 'EWE' aerial:

<https://tinyurl.com/y2qn2xqy>

Here, I will use a design for 10ft in height and 25ft long (Fig. 2). This model should run under the *Demo* version. Table 1 shows the



steps to follow.

There will be a lot of data available but for now go to *Results*, *Plot Far-Field Pattern, 3D Plot* (or select this from the toolbar) and then select what frequency you want the 3D Plot for. At a frequency of 1MHz, you should see something like Fig. 3. Compare this with an EZNEC plot (Figs. 4-6).

Have fun and play with different frequencies and views and try some simple designs of your own.

Table 2 contains a glossary of some of the key terms used in this article.

Admittance: Is the 'Dual' (or Reciprocal) of 'Impedance'; in electronic terms, it is a measurement of how easily a circuit or device will allow a current to flow. The term is attributed to Oliver Heaviside.

Amplitude: In terms of aerial design can be taken as the strength of the wave.

Capacitance: Ability of a component or circuit to collect and store energy as an electrical charge.

Current(s): Flow of electric charge through a material.

Current-v.-Frequency: Flow of electric charge at a particular frequency.

Excite a Design: A design in AN-SOF can be simulated with power being applied at the source on the design itself, or by simulating a passing wave from a remote source.

Flat Strip Lines: A *strip-line* circuit can be a *flat strip* of metal, sandwiched between two parallel ground planes, such as a PCB.

Free Space: In modelling terms, this means there is no ground to affect the design.

Imaginary Part: See 'Real Part'.

Impedance: Has various uses. Can be said as the effective resistance of an electric circuit alternating current caused by the combined effects of ohmic resistance and reactance. Can be taken as the resistance to an electrical signal in an antenna. The impedance of the aerial, the transmission line and the equipment should match, otherwise, losses occur.

Incident Wave: Or 'forward wave', is a wave moving from the transmitter.

Inductance: The ability of an inductor to store energy in the form of a magnetic field created by the flow of electrical current.

Load: In aerial simulation is the positioning of a component that places an electrical load on the design, such as an inductor, capacitor or resistor.

Perfect Ground: In modelling terms is perfectly conducting, with no loss, and it is perfectly flat.

Phase: Can relate to several things, for example, in AN-SOF, 'phase' can be an expression of the relative displacement between waves having the same frequency.

Planar Aerials: Usually a two-dimensional aerial whose elements are all in one plane, i.e. side-by-side.

Power: AN-SOF can calculate estimated radiated power at a selected part of a design based on the input level entered by the designer.

Real Ground: Used for simulating real-world earth ground where ground media has to be specified.

Real Part: The real part of the impedance is called 'resistance', where the imaginary part is called 'reactance'.

Reflection coefficient: See: VSWR.

Relative permeability: In AN-SOF, it is used as the magnetic permeability of the coating material relative to the permeability of vacuum when declaring a wire coating.

Relative Permittivity: In AN-SOF, this is used as the permittivity or dielectric constant of the coating material relative to the permittivity of vacuum when declaring a wire coating.

Resistivity: Is the electrical resistance of a conductor's cross-sectional area and unit length. High resistivity indicates a poor conductor.

Return/Transmission Losses: Relationship between the reflection coefficient and the standing wave ratio (cf. VSWR).

Segment: In modelling, wires are broken into segments for calculation.

Source: In modelling, a source is placed at the point where the feeder or feeders are connected.

Substrate: Used in AN-SOF when modelling the ground plane for microstrip aerials and printed circuit boards.

Transmission Line Calculator Facility: In AN-SOF, this is used for the calculation of transmission line parameters.

Voltages: Here: Levels of calculated voltages at a point on a design.

VSWR: VSWR stands for *Voltage Standing Wave Ratio* or *Standing Wave Ratio (SWR)*; a function of the reflection coefficient, describing the power reflected from the antenna.

Wire: In modelling terms, an element-part of an design. It could be a literal wire or of larger: section, such as an aluminium tube.

More information on these terms and values can be found here:

<https://tinyurl.com/y5qogppx>

<https://tinyurl.com/y7xnmwmap>

<https://www.antennasimulator.com>

<https://www.antennasimulator.com/Feedline>

Table 2: Glossary