MININEC Pro

Version 2.1.0 – May 7, 2020

http://www.blackcatsystems.com/software/mininec.html

Introduction

MININEC Pro is an antenna analysis program for Windows and Macintosh computer systems. The antenna geometry is entered as a set of descriptions of the wires that make up the antenna. Then the antenna is analyzed, either for a specific frequency or a range of frequencies. The feedpoint impedance is calculated and displayed, and radiation patterns for the antenna may also be displayed.

An overview of the program

Select File -> New to open a new blank window for analyzing an antenna.

Environment:

Select either Free Space (the antenna is in effect infinitely high above the ground) or Ground, in which case ground effects will be taken into account. The default dielectric constant and conductivity values can be used, unless you know your ground is different. Check Perfect Conductor if your antenna is over a metal plane, such as for a VHF/UHF antenna mounted on a car roof.

Wire:

Each of the wires that make up the antenna are entered here. For each wire there are several values which must be entered. Note that the default units for dimensioned values are meters, although a prefix or suffix can also be used for other units:

Putting a # in front of a number treats it as a wire gauge (AWG).
Putting an f after the number indicates feet, ie: 22.1f
Putting an i indicates inches, ie: 78i
Putting mm indicates millimeters, ie: 250mm

Segments: How many pieces each wire is broken up into during the analysis. More segments usually produce a more accurate result, although there are diminishing returns. You can start with say 10, and then increase the number, noting if/how the calculated results change. If they stop changing, you have likely reached the point of diminishing returns. The more segments, the longer the calculation takes.

Radius: The radius (half diameter) of the wire. This is where the # prefix can be handy.

The two end points of the wire are defined via six values, two sets of three coordinates, one for each end of the wire. X1, Y1, Z1 are the location of the first end, X2, Y2, Z2 the second. The Z axis is height/elevation.

Variables:

Often an antenna design needs to be tweaked. For antennas with multiple wires in particular, the same number needs to be entered into several fields, with all of them changing as the design is modified. Instead of doing this manually, one or more variables can be created. The variable value is defined once, the name of the variable is entered into the wires table as many times as required. Update the variable value and re-calculate the analysis.

Click Add Variable to create a new variable. Edit the name as necessary. Enter the value under Expression. The final calculated value is then displayed.

A note about expressions, this applies to entries in the Wires table as well. In addition to entering in single numbers, mathematical expressions may also be entered. This includes operations such as + - * and / as well as more complicated functions like sin() and cos(). Please see the section about Expressions further in the documentation.

Excitation:

This is the feedpoint of the antenna. The pulse number is the segment where the excitation is located, for a dipole for example it would be the center pulse/segment. The voltage/phase information can usually be left at default values for most antennas with just one excitation.

The frequency for the analysis is also entered, in MHz. The click Calculate. The impedance, current, and power will be calculated. Most likely the impedance is the value of interest.

Load:

Sometimes it is necessary to include a resistance in an antenna model, such as with a rhombic or T2FD. The Load tab can be used to add a resistance (and optional reactance). The pulse number of the segment is specified, along with the resistance and reactance (leave zero if none).

Freq Plot:

This tab allows analysis over a range of frequencies. The resistance and reactance of the feedpoint impedance is calculated for each and plotted on the graph. The SWR is also calculated and plotted on the next tab.

SWR Plot:

The SWR for each frequency analyzed using the previous Freq Plot tab, relative to the entered impedance value.

Plot:

This tab lets you generate azimuth and elevation plots for an analyzed antenna design. Usually you can leave the Far Field set to Total, which uses both the horizontal and vertical fields.

An Azimuth plot is looking down at the antenna, it will show you the pattern in various directions (think if it as north, south, east, and west although the X and Y axes do not necessarily line up that way, unless you specifically enter the antenna wire endpoint coordinates that way)

The Elevation plot shows the radiation intensity at varying elevation angles. This is handy if for example you want to see if an antenna has a significant amount of gain at low elevation angles, which is ideal for DX on HF.

Since we are trying to view a 3 dimensional antenna pattern from the real world in 2 dimensions on the computer screen, it is necessary to also specify what elevation angle should be used for an azimuth plot, or what azimuth direction should be used for an elevation plot. For the azimuth plot, a elevation angle of 0 degrees is straight up, 90 degrees is towards the horizon.

For example, if you have a directional antenna and the maximum azimuth gain is towards 135 degrees, then when viewing an elevation plot, you would likely want to select that as the azimuth angle. It may be necessary to iterate a few times back and forth to determine the peak (highest gain) direction(s) for an antenna design to select the correct values.

Output:

The calculated coordinates and currents for each pulse/segment in an antenna design is displayed here, mostly for diagnostic purposes.

Debug:

The raw MININEC output text is displayed here, again mostly for diagnostic purposes.

A Quick Tutorial To Get Started

As an example, let's analyze the standard half wave dipole antenna. Our antenna will be designed for 7.15 MHz in the 40 meter ham radio band.

The dipole is analyzed as a single wire, 20.4 meters long, with a feedpoint in the center.

We'll first analyze the antenna in free space (not taking into account the ground). Go to the Environment tab, and make sure Free Space is checked. The other parameters can be ignored for now.

Next select the Wires tab, and go to the bottom, where we enter in our single wire. We must first decide how many pulses the wire should be divided into, we'll choose 10 for now. The larger the number of pulses, the more accurate (in general) the results. But this is a good starting point. So enter in 10. Next enter 20.4 into the Length input. We can ignore the Position input, that is used to more easily enter in information for antenna with several wires, such as when analyzing a yagi. Enter in a radius of 0.001 (1 mm) and select m (meters) from the popup menu, as all of our values have been entered in meters. Click on the Add button. An entry has been added to the list of wires.

Next we want to set the height of the wire. Click on the 0 value under Z1 (the height of the starting end of the wire), and change it to 8 (for 8 meters, or about 25 feet). Do likewise for the 0 under Z2 (the height of the second end of the wire).

Next we need to enter in an excitation, this is where power is applied to the antenna (ie: where the transmission line to the radio is connected). Click on the Excitation tab, and then the Add button. There are three values we need to deal with here, the Pulse number, the Voltage, and the Phase:

Each wire is divided into pulses, as explained above. In our case, we divided it into 10 pulses. The dipole is center fed, so we need to apply our excitation to the center pulse in the wire, number 5. This happens to be the default value for an excitation, so we don't need to change it. If you wanted to change the value, you would click on the value twice to turn it into an edit field, and type in the new value. Likewise, we can use the default voltage and phase values, which represent the magnitude and phase of the applied RF.

Next we need to set the frequency to 7.15 MHz. After doing this, click on the Calculate button. The Feedpoint impedance is calculated, about 70 ohms resistive and -2 ohms reactive in our case - our antenna not exactly resonant at 7.15 MHz, but is very close.

Next we'd like to take a look at the radiation pattern for the antenna. Click on the Plot tab.

We'll use the default values of Total (vertical and horizontal radiation) and do an Azimuth plot at an elevation of 90 degrees, that is looking at the radiation towards the horizon (0 degrees orientation is straight up, 90 degrees is towards the horizon with MININEC). Click on the Plot button, and you get the standard figure eight type pattern that you expect. Our results seem to agree well with theory!

Next we can look at an Elevation plot, that is, how the radiation field varies with the takeoff angle. Change the Type to Elevation, and keep the angle at 90, we want to look at the pattern at one of the main lobes. Click plot. We see a perfect circle, which makes sense since we're ignoring the ground. The dipole radiates equally well at all elevations.

Next we want to see the effects of ground. Go back to the Environment tab, and change from Free Space to Ground. For simplicity we will assume a perfect conductor, so click that box as well. Go back to the Excitation tab, and click Calculate to run the analysis again. Notice that the impedance has changed, due to the effects of ground. Note: If you get invalid results, go back and make sure you correctly entered all the information, including the height of the antenna. It is very easy to accidentally leave it as zero, which will work with an antenna in free space, but not one over a ground!

Go back to the Plot tab, and without changing anything, click on the Plot button. Now we see that there is no radiation directed downwards (due to the ground) and the peak radiation is straight up, again as expected from theory.

Change to type back to Azimuth, and change the angle from 90 degrees to something slightly smaller (since in theory there is zero radiation exactly towards the horizon). We'll try 80 degrees. We have our figure eight again, but not quite as sharp as the free space example.

Next let's see what happens when we use the antenna at the third harmonic, as a 3/2 wave dipole on 15 meters. Change the frequency to 21.2 MHz and click on Calculate. The feedpoint impedance goes up, as expected. If we calculate the plot at 80 degrees altitude, we see the additional lobes, as expected for a 3/2 wavelength dipole. Changing to an Elevation plot at 0 degrees shows us that there is a narrow lobe directed upwards, and two other lobes at an elevation of about 30 degrees. We can go back and look at a plot for 30 degrees, and see a clover shaped radiation pattern.

Now let's see how the feedpoint impedance varies over all of HF. Go to the FreqPlot tab. Enter starting and ending frequencies of 2 and 30 MHz. If you have a fast computer, or want to wait a while, enter in a step of 0.1 MHz. Then click on Plot. The yellow line represents resistance, the blue line represents reactance.

Other features and Useful information

Sometimes it is necessary to include a resistance in an antenna model, such as with a rhombic or T2FD. The Load tab can be used to add a resistance (and optional reactance). The pulse number of the segment is specified, along with the resistance and reactance (leave zero if none).

After an analysis is run, the Output tab has a table showing all of the pulses in the design. For each pulse, the coordinates (X,Y,Z) are given, along with the wire radius, connection information, as well as the real and imaginary current, as well as the magnitude and phase of the current.

In addition to a perfect conductor, more realistic grounds can be used. Uncheck the Perfect Conductor checkbox, and enter in values for the dielectric constant (13 is a typical value, it could be lower such as 5 for very poor ground, and 20 for good ground) and conductivity (which can range from 0.001 for poor ground to 0.03 for good ground, 0.005 is an average value).

You can enter in dimensions in a variety of units. By default, all numbers are treated as meters. You can put a suffix after a number to specify another unit: putting a f indicates feet, i indicates inches, and mm indicates millimeters. Putting a # in front of a number treats it as a wire gauge (AWG).

Expressions:

Mathematical expressions may be be entered into wires and variables fields. This includes operations such as + - * and / as well as more complicated functions like tan(), sin() and cos(). These can be an extremely powerful tool for defining the geometry of an antenna and then easily modifying it by changing just a few, or one, variable. As an example, I will describe how I modeled my 500 ft beverage antenna.

The antenna is 500 ft long and oriented towards 60 degrees, 7 ft high and terminated into a 300 ohm impedance to ground.

I defined two variables, angle and length.

angle is defined as 60*3.14159/180   That is, 60 degrees, converted to radians, since trig functions (sin, cos, etc) use radians as their unit.

length is defined as 500f since the antenna is 500 ft long.

height is defined as 7f

Here’s what the Variables tab looks like:

Environment | Wire | Variables | Excitation | Load | FreqPlot | SWR Plot | Plot | Output | Debug

Variable	Expression	Final Value
angle	60*3.14159/180	1.047197
length	500f	153.8462
height	7f	2.153846

The Final Value fields show the actual variable values, note for dimensions/coordinates they are in meters. Next here are the two wires, the beverage itself, and the termination to ground at the far end.

Environment | Wire | Variables | Excitation | Load | FreqPlot | SWR Plot | Plot | Output | Debug

Segments	Radius	X1	Y1	Z1	X2	Y2	Z2
100	0.001	0	0	height	length*cos(angle)	length*sin(angle)	height
10	0.001	length*cos(angle)	length*sin(angle)	height	length*cos(angle)	length*sin(angle)	0

The excitation:

Environment | Wire | Variables | Excitation | Load | FreqPlot | SWR Plot | Plot | Output | Debug

Pulse	Voltage	Phase	Impedance	Current	Power
1	100	0	320.4983-2028.421J	0.0075998+0.0480986J	0.3799886

And the 300 ohm termination resistor.

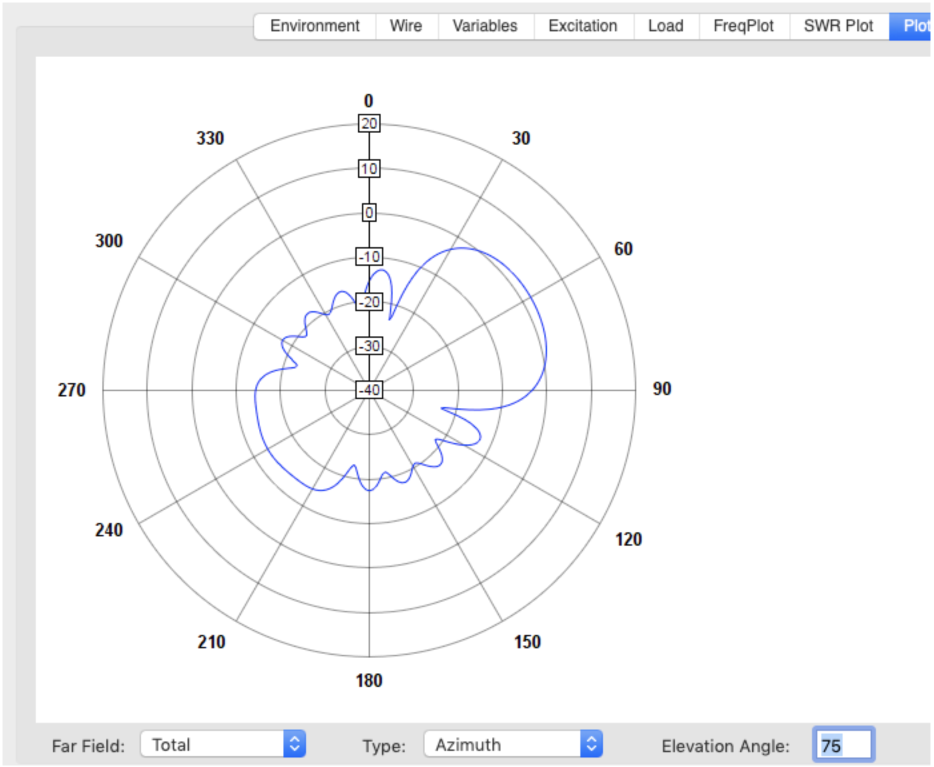
Environment | Wire | Variables | Excitation | Load | FreqPlot | SWR Plot | Plot | Output | Debug

Pulse	Resistance	Reactance
105	300	0

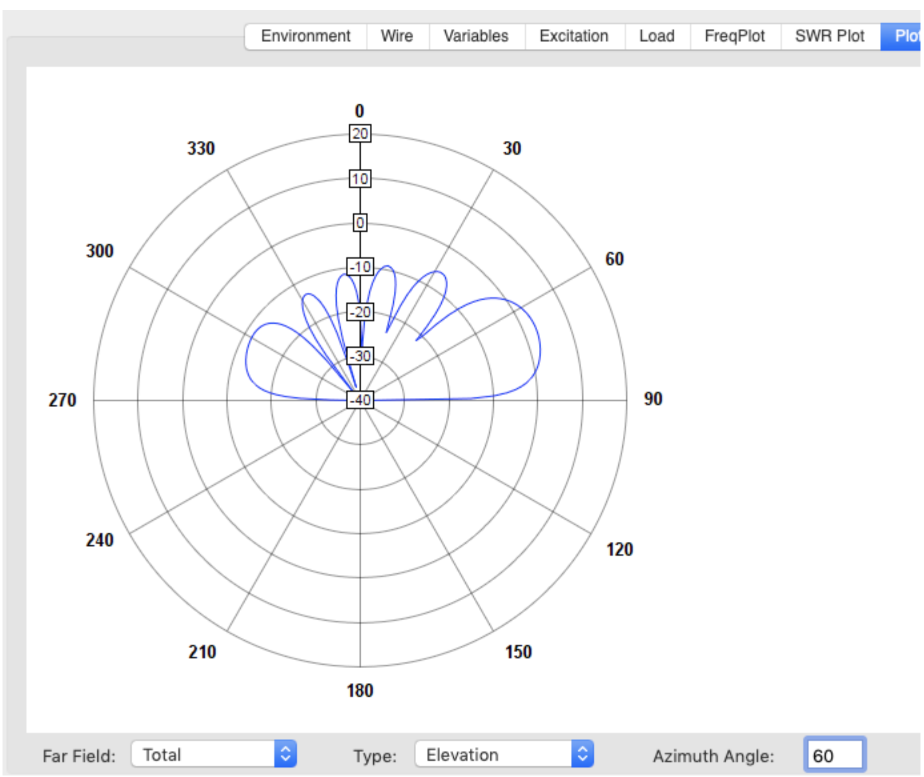
By placing the 300 ohm load at pulse 105, it is located in the middle of the wire going from the far end of the beverage to ground.

By defining variables for the angle, length, and height, it becomes easy to rotate the antenna, or otherwise modify it, without changing lots of fields, and possibly making errors.

First, here is the azimuth plot, with an elevation angle of 75 degrees, which is the peak elevation radiation angle, that is 75 degrees from vertical, or at a 15 degree angle from ground. Not bad for DX.



Next here is the elevation plot, at an azimuth of 60 degrees:



MININEC Pro Version History

2.1.0b1 May 7, 2020
Added variables and expressions.
Added buttons to copy graphs and plots to the clipboard.

2.0.0b1 April 10, 2020
First 64 bit build for macOS.

1.4.0 September 1, 2015
Added sample files within the app.
Can drag and drop antenna files onto the app to load them.
Bug fixes.

1.3.0 January 29, 2014
Several bug fixes.

1.2.0 November 15, 2012
Added sanity checking to input values.

1.0.1 December 22, 2008
Corrected a small error when converting values in files from inches.

1.0.0 December 4, 2008
Initial Release.

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