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DESIGN OF ANTENNA IN PROGRAM ENVIRONMENT FEKO

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Abstract: The design and analysis of various types of antennas is necessary to consider the impact of electromagnetic radiation transmitter and receiver module before the antenna is constructed. Electromagnetic radiation of antennas and its impact on the environment is the subject of many studies. The programming environment FEKO (FEldberechnung bei Körpern mit beliebiger Oberflache) is translates as "Calculation of electromagnetic field objects of any shape" already offered by its name the space for the design and analysis of the antennas of any shape. First parts of this article discusses environment FEKO. Another section is devoted to design and analyze a dipole antenna as the primary representative of the antennas in terms of electromagnetic radiation, which was the basis for the simulation.
Keywords: dipole antenna, electromagnetic field, FEKO

INTRODUCTION

The elements whose role is to convert high frequency electrical energy to power the spatial energy electromagnetic waves, or electromagnetic waves, the spatial energy into electric energy of high-frequency current is known as the antenna. Electromagnetic waves are created up of two components. Electromagnetic wave is created from two parts magnetic field intensity and electric field intensity. The electric field is created by difference voltage and their intensity depends on the size of the electric potential. The magnetic field arising from the current flow and the size of this field depends on the current to flow. These fields at high frequencies create the parts of electromagnetic radiation. Electromagnetic radiation has significantly impact on the surrounding environment. Today, we are surrounded by antennas operating at different wavelengths for different systems (ie. Electromagnetic smog) and the need for regulation of radiation is needed more than ever. It is important to ensure health protection against excessive radiation, it is also necessary to prevent the interaction of various emitting devices operating on the same frequency bands (ie. EMC Electromagnetic compatibility), which could significantly affect the transmitting antenna radiating character. FEKO program deals with the design and analysis of these parameters examined. It offers the possibility of examining radiating electromagnetic characteristics of electronic components, reflections of electromagnetic waves from objects [1-4].

PROGRAM ENVIRONMENT FEKO

FEKO software is mainly designed to analyze the problems of the electromagnetic spectrum, which includes EMC, design, analysis of the proposed antennas and their radiation characteristics, also offers an analysis of dispersion. FEKO is based on the solution of Maxwell's integral equations in the frequency domain. This method is called MoM (Method of Moments) [1].

Part of the software package includes several sub-programs that allow you to perform the operation steps from design through configuration to the analysis of antennas.

CADFEKO

CADFEKO allow to design antennas based on the parametric characteristics of antenna. These parameters are: the type of material used, method of power, the choice of the operating frequency, the number of points with regard to which they will apply the examined parameters. At higher frequencies,

which is necessary to choose enough points due to more accurate calculation of the spreading of high-frequency waves. A larger number of selected points ensure accurate results, but the negative effect is in form increasing computing demands. Proposed model requires a complete configuration of all examined parameters. The parameters are defined by using the different variables. Examples of selected variables are shown in Figure 1 in the section entitled as a "structure of model". Change of individual parameters are automatically transferred to the object properties. Files created in this environment are saved with the extension *cfx.

Figure 1. Description of the graphical user interface CADFEKO

EDITFEKO

Software environment EDITFEKO is based on scripting language, and its role corresponding to the role of software CADFEKO. Model designed in an environment CADFEKO is expressed in an environment EDITFEKO script that defines all the parameters of the module and the required simulation parameters. Changing parameters of the code will take effect immediate change in the model parameters created in the environment CADFEKO. When creating a model in the design environment automatically creating a set of representative models in EDITFEKO. Files created with EDITFEKO have the extension *.pre. In Fig. 2 is show the working environment software EDITFEKO.
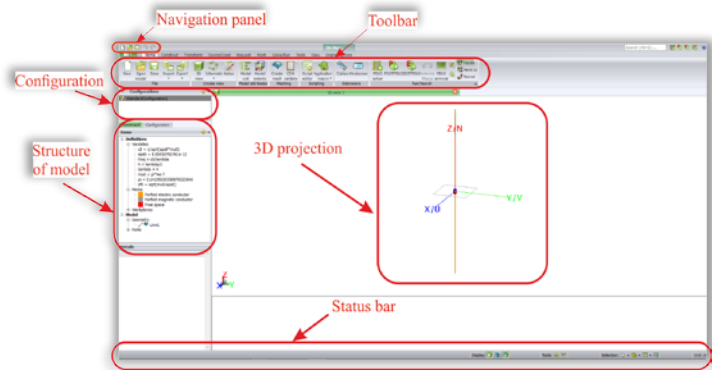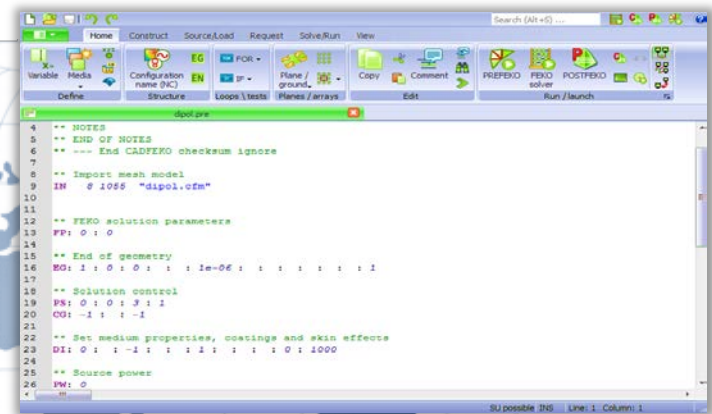

Figure 2. The working environment software EDITFEKO

POSTFEKO

Software environment program POSTFEKO allows the analysis of the results obtained from the simulation model that is stored in binary file (*.bof). From a binary file is loaded resulting values obtained by simulation, which are then viewed by a selected display format for example Cartesian, polar and Smith chart.
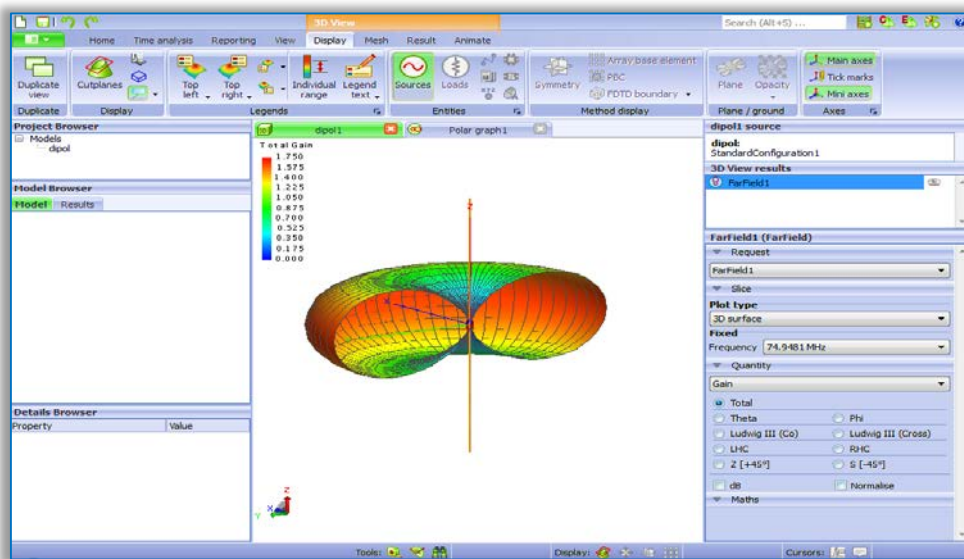

Figure 3. The working environment software POSTFEKO

In POSTFEKO is possible analyze the resulting characteristics through 2D and 3D models. Tools to facilitate the analysis of the resulting characteristics of the program POSTFEKO are located in the menu

toolbar. There is also the possibility of using different types of units and different scales. Using the decibel scale is possible seen characteristics of decreased performance by 3dB [2-5].

In Fig. 3 shows the working environment software POSTFEKO. This figure shows an example of electromagnetic radiation dipole antenna, which design and analysis will be discussed in the next section of this article.

DESIGN OF DIPOLE ANTENNA IN PROGRAM ENVIRONMENT FEKO

Elementary electric dipole is one of the easiest antennas, and its can be created through unfurled a length λ/4 of no-load electrical conductor. If the electrical conductor is supplied with a time-varying signal, then are formed standing waves, which terminates at the end of a current node of the electrical conductor. Elementary radiator is part of the electrical conductor, which is in the elementary section of the same current distribution at all times, resulting in radiation. The point of this section is design a half wave dipole. Defined variables represent physical properties of the proposed dipole.

The length of dipole is defined by relation:

$$h = \frac{\lambda}{2},$$

(1)

where λ represent wavelength. The frequency at which the dipole antenna will operate is determined by the relation (2), which has the following form:

$$f = \frac{c_0}{\lambda},$$

(2)

while c_0 represent speed of light (c_0=3*10^8ms^-1). For half wave dipole λ is represented by a 4 meters which is the ratio of the speed of wave propagation per one period [4-7].

Construction 3D model of antenna

Environment CADFEKO used UVN coordinate system that is an alternative for XYZ space, which correspond with U = X, V = Y, N = Z. The construction of all objects based on the assumption that all the points defining the shape of the object are assigned coordi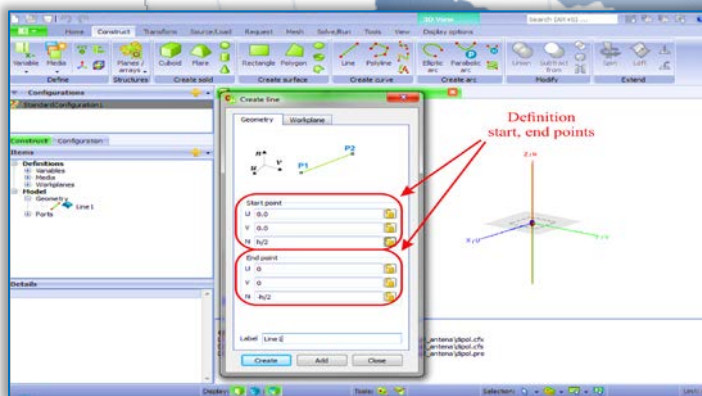nates in space UVN respectively XYZ. Configuring the coordinates of the points are immediately reflected in the 3D view of the proposed model.

In Figure 4 is show an example configuration parameters for a simple dipole model. For this type of antenna it is sufficient to define only the start and end point of the electrical conductor. Electrical conductor represent dipole antenna. For a comprehensive definition of the model, it is necessary to define further the values of variables, which are then incorporated into the calculation. Among the additional parameters included: wavelength, speed of light, permittivity environment permeability and other special parameters. Through auxiliary variables can be simplified while the definition to clarify the determination of the main variables. Variables can be defined through the relations that include already known variables. Then through the function evaluate calculated values assigned to each variable. The main advantage of the parametric definition of the variables through relations is change

Figure 4. Example of definition coordinates for antenna in environment CADFEKO

	Name	Expression	Comment	Value
1	c0	1/sqrt(eps0*mu0)	Speed of light in free space in m/sec	299792458.000176
2	eps0	8.85418781761e-12	Permittivity of free space in F/m	8.85418781761e-12
3	freq	c0/lambda	frequency	74948114.500044
4	h	lambda/2	dlzka_dipolu	2
5	lambda	4	wavelenght	4
6	mu0	pi*4e-7	Permeability of free space in H/m	1.25663706143592e-06
7	pi	3.14159265358979323846	Ratio of a circle's circumference to its diameter	3.14159265358979
8	zf0	sqrt(mu0/eps0)	Characteristic impedance of free space in Ohm	376.730313461992

Figure 5. Variables defined for dipole antenna

at the moment in the value of the variable in the event of a change in the value of any basic parameter. View the table of defined variables is shown in Figure 5. The more complex the type and design of the antenna will be more difficult (time consuming and computationally) processing and simulation character of electromagnetic radiation. This is caused by numbers of variables.

CONFIGURATION

After definition the variables you can go to the next point configuration. Configure other parameters necessary for simulation are: port settings, resource load model. Through port we can understand the point through which one can express the model in place where it enters and exits electricity. Types of supported ports are wire port, edge port, microstrip port, waveguide port, FEM line port and FEM modal port. For each type of antenna it is suitable for a different type of power port. For the selected port is chosen power supply, which must have defined parameters: amplitude, frequency, power supply and others. In case of a dipole antenna is selected wire port. Wire port is designed for antenna type with zero emission surfaces. It is therefore especially suited for structures made of wire respectively curvilinear elements.

FEKO uses to calculate electromagnetic radiation model, the distribution of the surrounding area into smaller parts that are under calculation basis and final processing are combined to form a complete electromagnetic radiation characteristics. The method calculation of elementary triangles is for each case specifically defined. Each antenna has a different shape which is also affects the radiation characteristics. Defining these parameters for the simulation it is performed by the MESH network, which consists of elementary triangles. The general rule is that the more complicated type of antenna thus denser concentration must be elementary triangles, which is reflected in a higher performance calculation and simulation process. In the "Global mesh size" you can choose from several predefined profiles. Predefined profiles can calculate the number, length of the edges of elementary triangles automatically. Through predefined profiles you can choose one of the following options: Fine, Standard and Coarse. For specific requirements for the simulation it is possible to choose custom configuration, through which specify the parameters of the element. The parameters that can be configured have to include: edge length of the triangle and in case where are the curve objects have to include: Wire segment length, segment of the wire radius. The configuration parameter is reflected on the character of the resulting simulation, with the smaller dimensions of the rectangle, and the concentration of the more dense the resulting values are more accurate, but at the cost of longer and more demanding calculation.

CONFIGURATION PARAMETERS FOR THE CALCULATION OF RADIATION DISTRIBUTION

Configuration parameters for calculating the radiation pattern for the electromagnetic field is generated by adding the element "Far Fields". FEKO program can work with the two types of fields designed for the simulation of electromagnetic fields as: near field and far fields. In case of dipole antennas were chosen fields "Far Fields". Type computing field is represented by a sphere formed from the elementary portion (points) of which it will measure the intensity of the electromagnetic field and radiation pattern. The configuration for the far field for dipole antenna is shown in Figure 6.
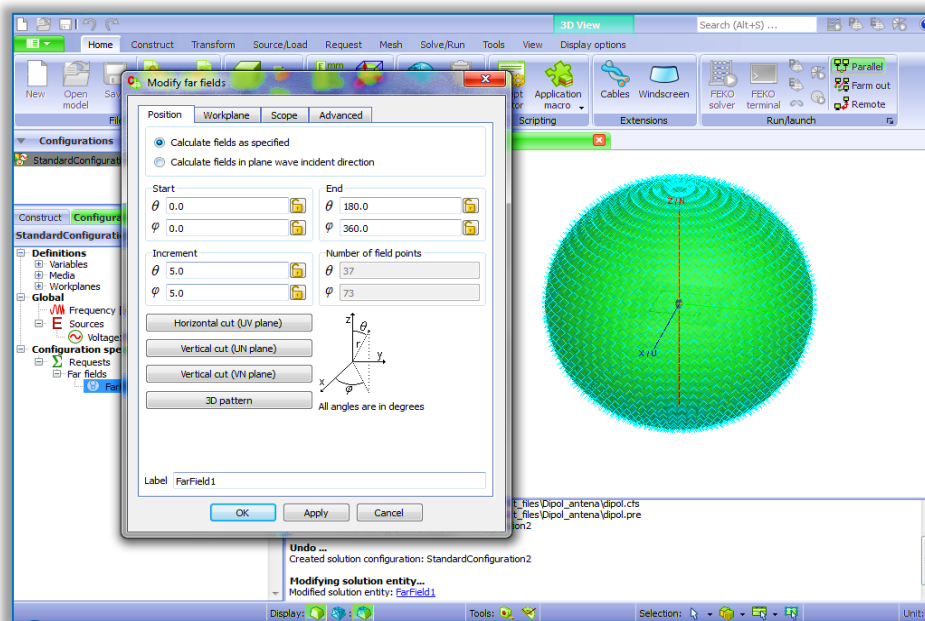

Figure 6. Example of configuration "far fields" for calculation electromagnetic radiation

In Figure 6 is possible seen the configuration of the starting and ending points of the object (in this case a sphere) with respect to which the calculation of the electromagnetic field occur. Through vertical and

horizontal angles φ, θ is defined by the content of the surface of the sphere. The distance between the points constituting an object representing remote fields is called the increment. The number of points in the horizontal and vertical directions is calculated automatically by the parameter for the horizontal, and the vertical angle increment. To create a 3D model around the model points are spread out evenly across the surface of a sphere apart 5° in both directions (φ, θ). However, the size values determining the distance between the triangles can be changed individually, as required for the specific type of the proposed antenna.

ANTENNA ANALYSIS IN ENVIRONMENT POSTFEKO

Before you can run the analysis, it is necessary to compile the configuration via FEKO solver, and in the process takes place validate the parameters. This check is essential for the calculation, in order to avoid the case where the antenna is fed improperly positioned ports. Inappropriate locations, choose the type of power port will cause distortion of the output values respectively in general does not allow running the simulation because the chosen port type may not be suitable for the type of antenna approach.
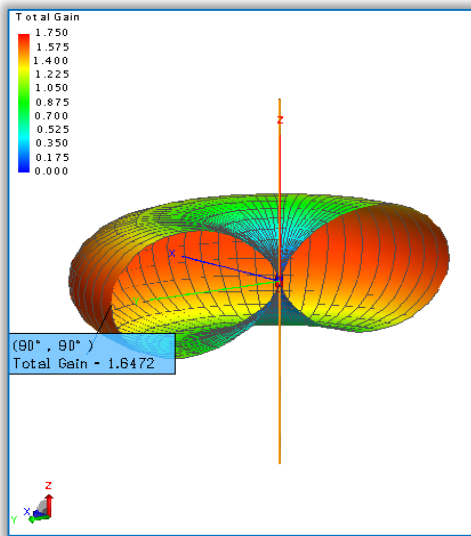

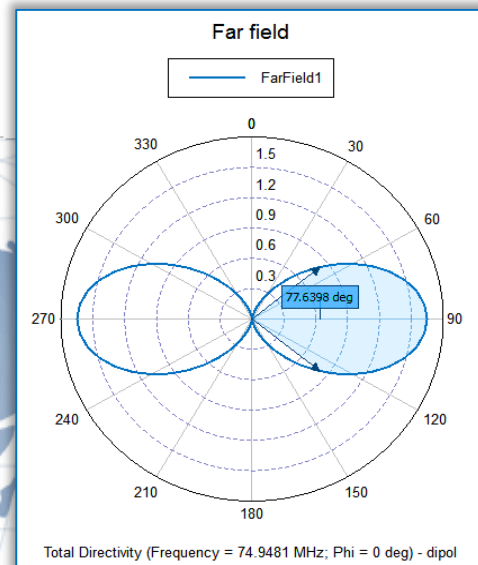Figure 7. Radiation characteristic of simulated dipole antenna

Figure 8. Results of simulation shown in Polar diagram

For the analysis of the radiation characteristics it was chosen Cartesian plain, where is highlighted in antenna gain through red colour. This distribution of radiation dipole antenna is shown in Figure 7. In Figure 8 is possible to seen a polar diagram that takes into account emissions in depending of angles θ and φ. The program POSTFEKO allows in dealing with complex simulations creates animations of simulation. For example, emitted by the antenna in the simulation of transmission or switching electromagnetic waves through selected environment.

CONCLUSION

FEKO software environment is complex in terms of design and simulation of antennas, their location in space and analysis of radiation characteristics. In the first part were described parts of the program suite. CADFEKO features of the program were explained in a practical demonstration of creating a dipole antenna, which served as the basis for demonstrations. In the description of the program suite POSTFEKO were explained using tools to analyze electromagnetic radiation.

The results analyzed in the program POSTFEKO the dipole antenna as shown in Figure 7 and Figure 8 represents the emission characteristics of Cartesian plain and polar diagram. Dipole antenna is horizontally omnidirectional distribution of radiation and maximum radiant power is expressed as 1.6474 and 2.1149 dB in decibel scale. Angle determining the loss of power by 3dB in the positive, negative direction is expressed 77.6398 °. When evaluating using the polar diagram the value is $\varphi = 0$. As can be possible seen from the simulation results, the type used dipole antenna has no side lobes. This is ensured by the customized wavelength.

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