Special software application for antenna modelling in mechanical engineering

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Abstract. The article is devoted to one of the best today computer program for antenna modelling. No special computer simulation skills are required to use this software. In this study, based on foreign and domestic sources, the influence of the MMANA-GAL program on the design of various types of civil antennas is considered. The paper specifically describes this simulation program. The description includes its history of creation, application, comparison with previous programs and algorithms, the interface of the MMANA-GAL itself is also described. It tells about how useful this program is, how it simplifies life and saves time for developers and designers, since the built-in library contains examples of more than two hundred antennas. Standing out advantages are: its free-of-charge basis, and from the operational characteristics - display of 2D and 3D antenna radiation patterns and its frequency response.

1. Introduction
The ability to design antennas using special computer programs provides a person with a huge number of possibilities. Having created a configuration of pipes and wires, one can imagine the approximate characteristics and operation of some antenna structure. Also, with the help of such programs, you can work out and change all the necessary characteristics and design features for the provided requirements. All this helps to avoid problems with the design and operation of the finished product [1].

The first programs for calculating antennas were developed back in the 80s and were rather primitive due to the fact that they could calculate only using specific formulas and only certain types of antennas. When these programs began to use the multidimensional matrix method, with the help of which each antenna element is divided into sections, and at each point the current is already divided into its own and reduced from the other sections. Most modern programs are based on this technique. In the modern world, technologies have stepped far beyond the understanding of a common man in the street, and what seemed impossible before is now available to everyone. Design [2] and further production of parts [3] using solid state printing. This technology makes it possible to manufacture parts with completely different surface roughness index; in some cases, surface smoothing processes [4] allow achieving very high accuracy [5-7].

2. Methodology
MMANA-GAL is a program created for calculating and analysing any antennas represented as a set of wires (figure 1).
The program works on the basis of the MININEC3 method and is its more advanced and updated version for current devices.

![Common interface.](image)

**Figure 1.** Common interface.

This version of the MININEC program has an updated interface that automatically determines the wire connections from the ends of the coordinates at the wires. Also, this program helps to read and interpret an infinite amount of input data. Unfortunately, the ability to interpret geometric data is not available.

MININEC has been expanded to 1600 lines. With a math coprocessor and translator, MININEC3 could solve problems with up to 50 wires and current variables [4].

MMANA has a built-in library containing information on more than 200 antennas. The program itself can be downloaded for free on the Internet, it is still regularly updated and improved, and the library is expanding as the antenna market expands. MMANA “weighs” surprisingly little, about 500 kilobytes, and the requirements for the PC on which it will be used are minimal.

Programs of this type are a kind of laboratories that allow you to calculate all kinds of projects at no cost and get the most accurate data about them. You can also learn using the program, setting all sorts of conditions to the system, while it will simulate the characteristics of the antenna that are suitable for them. Another advantage is the ability to compare antennas [8]. In general, the number of uses of this program tends to infinity.

The program allows you to make simple geometric constructions available to people without special education [9].

3. Discussion

Unfortunately, despite the accuracy of the MMANA calculations, there is still a need to fine-tune the physical antennas based on the results of these very calculations, since the program does not take into account the effect of real external factors, such as the terrain, buildings, and other radio devices.

MMANA-GAL includes features such as:

- creating and editing the antenna description by specifying coordinates or simply using the mouse in the interface;
- consideration of all possible types of antennas;
- calculation of radiation patterns in several planes at all possible angles;
- comparison of models of more than two antennas in real time;
- editing each modelling element individually;
- editing wires;
- calculation of combinations of wires of different diameters;
- creation of multi-storey antenna models from any created by the user;
- antenna optimization due to variable tuning;
- setting the parameters of an antenna optimized by more than 90 percent;
• construction of all kinds of charts;
• automatic calculation of several types of matching devices, which can be included or excluded from the graphs;
• creating tables in MSExcel;
• calculation of individual antenna elements, etc.

In total, the model can have 64 sources, 512 different wiring and 200 loads [10].

The initial table describes the wires. Most antennas are represented by a set of wires, and each line in it is like a description of an individual wire. They are specified by three coordinates 1 (start) and 2 (end), and the section is measured by a radius with dimensions in meters or lambda. Values are also entered not only as numbers, but also using arithmetic formulas, which will be automatically calculated.

The table at the bottom left describes the sources. With the help of special commands, the position of the source is set, and the source itself is set by letters from a to z and numbers.

The term "load" represents some kind of passive circuit. The description of the loads is in the table specially designated for it. Load type is set by analogy with sources. For LC it is described:

• inductor;
• capacitor;
• parallel oscillatory circuit;
• resonant frequency;

Any missing parameters will be automatically calculated [11].

4. Results

MMANA-GAL is not only a convenient tool for designing antennas, but also allows you to optimize various parametric values for them.

Seven “sliders” set the criteria, and the position of each allows you to determine the specific weight of a particular parameter. Thus, the position “indicates that the parameter does not matter, the extreme right, on the contrary, sets the maximum importance”.

Instructions for obtaining specific criteria are described in a special table of variable parameters. In the “Type” column we can measure the parameter, and the “What” column opens a menu for changing specific parameter values.

The number of rows in the table directly depends on the number of parameters specified by the user. In this table, you should pay extra attention to the parameters. In the presence of a human factor, there is a possibility of an erroneous change in non-existent or mutually exclusive parameters. In this case, optimization may not start.

At first, it is better not to work with a large amount of rows in this table. Optimizing antennas is very difficult and requires a lot of experience and understanding of your actions. Optimization has no concrete result. By changing the characteristics of the antennas, we touch on a large number of local maxima and minima that affect this process. Thus, for the correct operation of this program, direct human intervention is required, the process is not automated.

Since the calculations of the models are quite universal with respect to any location of the wire, they are based solely on generally available formulas (Maxwell’s system of equations).

For numerical methods, more convenience is provided by the transformation of this system into the integral equation of the electric field (EIFE). This is the same system of Maxwell’s equations, transformed into a form that is comfortable for calculations.

This system helps to calculate the intensity of the radiated field in relation to the dependence of the current distribution in the antenna. Distinctive features of EIFE are:
• Ability to solve problems of radiation and scattering in an unlimited area. That is, we get a tool for calculating a radiating antenna.
• This equation is also solved by numerical methods such as the method of moments.

The end result of EIFE’s work is to obtain the distribution of currents in the antenna, for the calculation of which all antenna wires are divided into segments, where the current and induced from each of all other segments are located. [eleven]

If we split the antenna into n segments, then, naturally, in the process of calculating the distribution of currents, a square matrix with side n is obtained. Thus, the time of its calculation and the required memory grow in proportion to the square of the number of segments.

Major modelling errors are combined with antenna segmentation. In each segment, the current is usually linear. If this is not the case, then the final current distribution will not be correct. Therefore, the antenna field will also be incorrect.

A violation of this condition occurs if:

• the length of a segment with a wavelength over 0.1 nm. On such long segments, the linear approximation of the current is different from the true sinusoidal distribution. This error is usually referred to as insufficient segmentation density;
• in the sections of antennas where the current passes through zero, the present position on the sinusoidal distribution within a particular segment may not coincide with that obtained on the basis of a linear approximation of the current in the segment. Thus, at the ends of the antenna and in the so-called voltage antinodes, the size of each segment should be reduced.

MMANA-GAL is not only a convenient tool for designing antennas, but also makes it possible to optimize various parameters and criteria for them.

Seven sliders set the criteria, and the position of each slide allows you to determine the specific weight of a particular parameter. Thus, the leftmost position indicates that the parameter does not matter, the rightmost position, on the contrary, sets the maximum importance.

Instructions for obtaining specific criteria are described in a special table of variable parameters. In the “Type” column we can measure the parameter, and the “What” column opens a menu for changing specific parameter values [7].

The number of rows in the table directly depends on the number of parameters specified by the user. But you should be careful not to change non-existent or mutually exclusive parameters by mistake. Otherwise, optimization will not start.

At first, it is better not to work with a large amount of rows in this table. Optimizing antennas is very difficult and requires a lot of experience and understanding of your actions. Optimization has no concrete result. By changing the characteristics of the antennas, we touch on a large number of local maxima and minima that affect this process. Thus, for the correct operation of this program, direct human intervention is required, the process is not automated.

If there is a specific goal, it is advisable to introduce the use of this program into the training course of students in the specialty [12].

With ample opportunities for prototyping most parts using 3D printing tools, the use of this program and the design of antennas at home is becoming more and more real [13;14].

MMANA, as an antenna simulator, is one of the most convenient and affordable of its kind. It is successfully used in the Windows environment and is extremely simple and straightforward to use. She has a user-friendly interface and a huge selection of tools for fine-tuning and elaboration of particularly complex systems. Thanks to it, the user does not need to spend unnecessary time creating and testing unnecessary structures, which saves both time and money [15;16].

The program is still being updated, the databases are being improved and replenished with all sorts of technologies and new models of antennas, which are being dealt with by its creators and Russian localization enthusiasts who have given a lot of time and effort to it. One of the sources listed in the
bibliography has a complete manual with a detailed description of each parameter and absolutely all the possible MMANA functions [8].

5. Conclusions
In the proposed work, methods of constructing complex connections of antenna software are considered. Having studied the programming methods in the proposed software, the user will be able to analyze, split into sections, select methods for constructing individual hierarchical procedures, and, thus, design and program the entire operation of the antenna.

The main results of the application of the methods are reduced to the expansion of the area of application of the personal software of users through the acquisition of skills in the MMANA-GAL system.

Scientific and methodological novelty lies in the development of a new approach to the creation of complex antennas in the study of the subject “Computer Graphics” and is associated with the development of design thinking in design already at the initial stage of training in technical universities of design specialties.

The proposed method of work was tested in the classroom of the Department of Engineering Graphics [17].

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