MODELING OF ANTENNAS FOR TELEINFORMATION SYSTEM WORKING IN WI-FI STANDARD

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Summary

The article is describing model projects, and simulation analysis of the antennas intended for the cooperation with wireless network cards working in the Wi-Fi standard, reported as applications for acquiring the protection right to the utility models. The projects assumed designing the omnidirectional antenna, and the directional one, providing the maximum possible value of amplifying the signal, at the simultaneous keeping the smallnesses of the size, so that the antennas could work in room conditions. Models, and simulations were performed with the help of a non-commercial program 4nec2, based on the method of moments. Moreover, for an every model, there was drawn up a model of the system fitting the impedance of the antenna to the signal line about the impedance of 50Ω.

Keywords: wireless diagnostic system, directional antenna, omnidirectional antenna, antenna modeling, antenna simulation, microwave.

MODELOWANIE ANTEN DLA BEZPRZEWODOWEGO TELEINFORMATYCZNEGO SYSTEMU DIAGNOSTYCZNEGO

Streszczenie

W pracy zostały przedstawione założenia bezprzewodowego systemu diagnostycznego będącego przedmiotem zgłoszenia patentowego [5]. System ten wykorzystuje w nadajniku metodę rozwijania sygnałów w szereg Fouriera.

Słowa kluczowe: bezprzewodowe systemy diagnostyczne, próbkowanie sygnałów, szeregi Fouriera względem wielomianów ortogonalnych.

INTRODUCTION

In the time of the current development of mobile techniques, and the distinct orientation for the miniaturization, a problem of guaranteeing stable wireless connections for the plug-in devices is becoming substantial. Choosing radio waves as the transmission medium, one should see to the assortment of the appropriate antennas, adapted for the required working conditions, since they have the direct effect to correct action and the productivity of the network.

In the article, projects, and simulation analysis of a directional antenna were described, and omnidirectional, reported as applications for acquiring the protection right to the utility models. These antenns were designed for wireless diagnostic system [5].

1. OMNIDIRECTIONAL ANTENNA

The first of the discussed antennas is the omnidirectional loop antenna, allocated to the work on the frequencies of 2.4 GHz. Figure 1 is showing the visual outline of the project.

The antenna consists of three loops (two vertical, and one horizontal) crossing under the right angle, mutually creating the spherical dipole, and from the plane of mass folded from two wires crossing at right angles. The dipole and the plane of mass are connected non-electrically with themselves, with the help of fittings carried out of the insulator. The soldering point for the so-called hot vein of the signal line, is in the lower part of the dipole, in an intersection of two vertical loops, however the soldering point for the plait is in an intersection of elements constituting the plane of mass.

The technical project assumed carrying out the elements of the antenna including the dimensions described in Table 1.

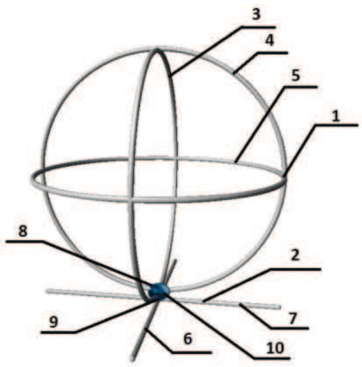

Fig. 1. Model of the omnidirectional loop antenna: 1 - dipole, 2 – plane of mass, 3, 4, 5 – loops creating the dipole, 6, 7 – wires forming the plane of mass, 8 – soldering point of the dipole, 9 – soldering point of the plane of mass, 10 – fittings of the cover

Table 1. Dimensions of individual elements of the omnidirectional antenna

Diameter of elements	1,5 mm
Internal radius of the loop	59,25 mm
Width of the dipole	121,5 mm
Length of elements of the plane of mass	120 mm
Distance of the dipole from the plane of mass	3 mm
Total height of the antenna	126 mm

In purpose of conducting the simulation of the work of the antenna, the geometry of the model was entered into the 4nec2 program. 288 steering cards responsible for handing over basic geometrical parameters of individual elements made the input data.

The simulation has been carried out in two steps:
- simulation of the distant field of the antenna put in free space
- simulations of the distant field of the antenna put at 1 m level above the real surface of the „moderate" type.

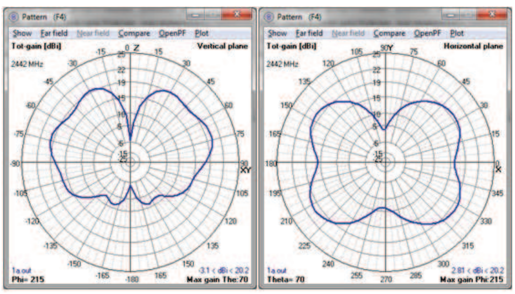

Fig. 2. Characteristics of the vertical (a) and horizontal (b) radiation

Figure 2 is showing the characterization of radiating of the antenna in the process of making a simulation for the model put in free space. Characteristics are clearly showing the omnidirectional character, whereby the horizontal characteristics is matching the theoretical deliberations for the loop about the equal λ,diameter, available in the literature (Szóstka 2006).

In the purpose of providing computational conditions similar to real conditions of the work of the antenna, a simulation of the model, put at 1 m level above the surface was conducted. Accurate parameters of the chosen base, including the magnetic penetrability, and parameters of the remaining areas were in detail described in the 4nec2 program manual.

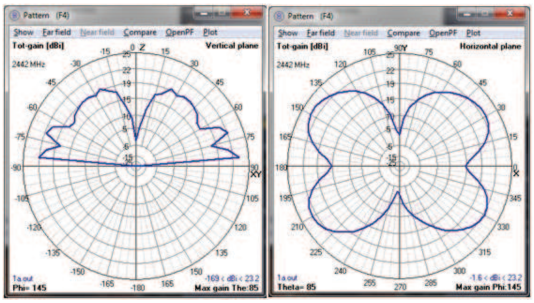

Fig. 3. Characteristics of the radiating of the antenna above the surface: vertical (a) and horizontal (b)

As a result of the change of the area of the antenna, we can observe in Picture 3, changes of the characteristics of the radiation in the vertical plane, caused by reflections of an electromagnetic wave from the ground surface. Horizontal characteristics didn't undergo any considerable changes, however bigger narrowings are noticeable on the edges of the loop.

The input impedance of the simulated antenna equals $Z = 2{,}52 + j24{,}7$. In the purpose of fitting the antenna to the signal line the impedance about 50Ω, one should use the system compensating the existing differences. It was decided to use two parallel connected condensers, described in Figure 4.

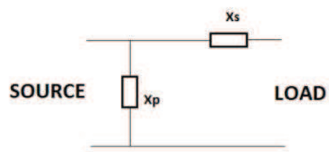

Fig. 4 System fitting the impedance

The used condensers have capacities appropriately:
-Xs=4,75 pF
-Xp=5,65 pF

The output impedance of the antenna after applying the system changed to the level $Z = 49{,}5 + j0{,}13$ and enables safe connecting to the signal line.

The designed antenna enables getting the signal amplified on the level of 23.2 dBi. Figure 5 is showing spatial characteristics of radiating of the designed antenna.

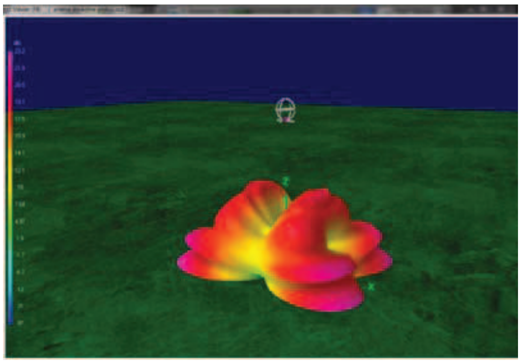

Fig. 5. Spatial characteristics of the omnidirectional antenna

According to the included legend, the maximum strengthening was achieved at the ends of the bottom leaves. As approaching towards the centre of the structure, the strengthening is gradually falling to the level of 10 dBi.

2. DIRECTIONAL ANTENNA

The second amongst the discussed antennas is a directional antenna, intended like the previous one for the work on the frequency of 2.4 GHz. This antenna constitutes the connecting of the loop antenna with the Yagi-Uda type antenna. Individual elements are created from diamond-shaped loops put along the shared axis. The model of the antenna was described in Figure 6.

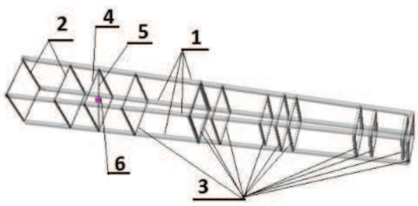

Fig. 6 Model of a directional frame antenna: 1 – casing, 2 – spotlight, 3 – director, 4 – loop dipole, 5 – rectilinear dipole, 6 – power point

It is a 14 element antenna, around which only a dipole constitutes the active element connected directly with the power cord. The dipole consists of two fundamental elements: the loop in the shape of the rhombus, and the rectilinear element going through her middle, connected with the loop in her acute angle. The soldering point of the power cord was put in the half of rectilinear element. Two loops put behind the dipole are acting as the spotlight, however the 11 remaining elements constitute the directors. All the elements are non-electrically connected with themselves through four fittings carried out of the insulator.

The dimensions of individual elements were put together in Table 2 according to the markings put in Figure 7.

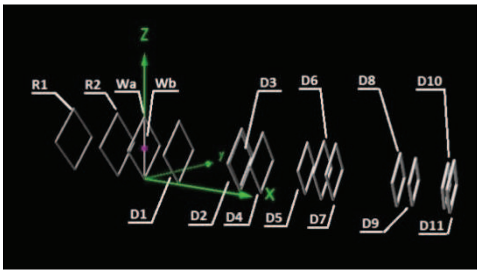

Fig. 7. Marking of elements of the antenna

Table 2
Dimensions of sides of the individual elements, and the rectilinear element

Radius of the elements	0,5 mm
R1	34,8 mm
R2	33,4 mm
Wa / radius of the element	30,2 mm / 1 mm
Wb – total lenght	25 mm
D1	30,6 mm
D2	28,5 mm
D3	25 mm
D4	26,4 mm
D5	20,8 mm
D6	23,6 mm
D7	22,2 mm
D8	19,4 mm
D9	9 mm
D10	8 mm
D11	10 mm

The prepared model consists of 57 steering cards responsible for implementing the geometry of the antenna.

The same as it took place in case of the previous antenna, two simulations of the distant field of the antenna were conducted for the model in free space, and for the one put above plane.

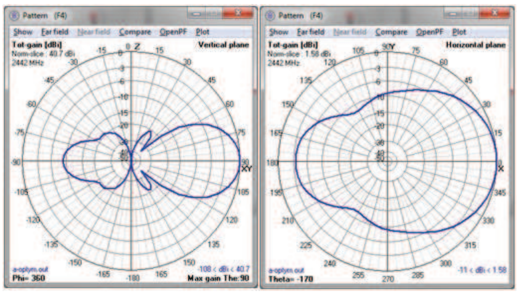

Fig. 8. Characteristics of radiating of the directional antenna: vertical (a), horizontal (b)

Characteristics of radiating of the model put in free space is shown in Picture 9. Easily noticeable is the directionality of the simulated model, however in vertical characteristics, a reactionary bundle, and little side bundles are clearly distinguishing themselves.

Entering the base into the simulation conditions is changing vertical characteristics visible on Figure 9.

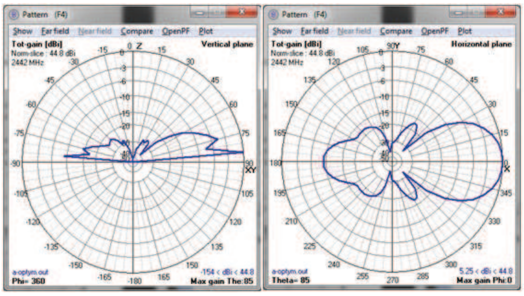

Fig. 9. Characteristics of radiating of the directional antenna above the surface: vertical (a), horizontal (b)

The generated field has a clearly directional character, with a little height in the vertical plane. The antenna isn't strongly directional what shows the wide main bundle visible on Picture 9b. In assumption, it enables covering with the signal a bigger space and facilitating placing the antenna regarding to the remaining antennas.

The initial entrance impedance of the model equals $Z = 1{,}77 + j455$. Using the modified fitting system introduced previously in Picture 4 causes the change of the impedance to the level of $Z = 40{,}3 - j3{,}35$. The modification refers to the change of the value of individual condensers for the following values:

- Xs=0,15 pF
-Xp=6,81 pF

The conducted simulation of the model of the antenna visible on Picture 10, is showing the getting of strengthening of the signal on the level of 43.8 dBi at the total length of 308.5 mm.

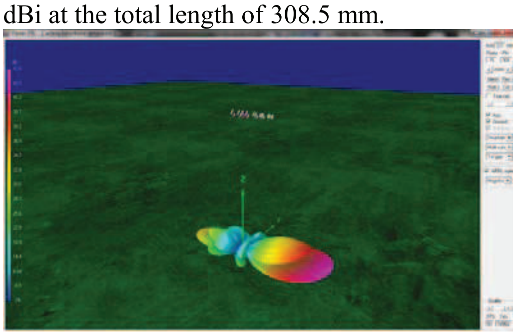

Fig. 10. Spatial characteristics of the directional antenna

3. CONCLUSION

The above article is showing the description of models of indoor antennas intended for the cooperation with devices of the Wi-Fi standard, reported as applications for acquiring the protection rights to the utility models.

In spite of using the specialist software assigned to model antennas, this process is proceeding multiply and still can procure a lot of problems. Unlike classic methods of the design, there is no need for basing on produced prototypes, however the process of optimisation of the acquired parameters itself sometimes requires total rebuilding of the created model. In spite of that, computer assisted designing is reducing the waiting time for the results of the project, and the expenditure associated with possible deviations from the assumed results.

The described models were designed with the thought about the work in room conditions. One of main assumptions was getting the possibly low dimensions, and reaching for the design increasing aesthetics of the lump of the classical antenna. The essential condition for the projects was also getting the biggest possible strengthening of the signal of the antenna, and the easiness of her free distribution with account of the remaining sources of the signal.

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