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ULTRA-WIDEBAND MICROWAVE PRINTED MICROSTRIP DISC ANTENNA

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НАДШИРОКОСМУГОВА МІКРОХВИЛЬОВА ДРУКОВАНА МІКРОСМУЖКОВА ДИСКОВА АНТЕНА

Здійснено проєктування та оптимізацію несиметричної вібраторної антени із випромінювачем дискового типу, виконаної за друкованою технологією. Живлення антени здійснюється мікросмужковою лінією. Проведено моделювання роботи антени методом скінченних елементів. Шляхом оптимізації конструктивних параметрів антени досягнуто зменшення зворотних втрат у робочій смузі антени. Діапазон частот антени, в межах якого КСХ не перевищує 1.5, складає 2.1…4.7 ГГц. Збільшення робочої смуги антени досягається спеціальною формою випромінювача.

Printed microstrip antennas are widely used in radiocommunication systems due to their small dimensions, low cost and possibility to be integrated at the common PCB with the device. There is a large number of small-size printed antenna types as well as design techniques used for their analysis and fabrication [1] – [3]. The basic radiating structure for this type of antennas is a patch microstrip antenna. However, these antennas are not omnidirectional and typically have gain of 6…9 dB [4 – 5]. To obtain omnidirectional directivity pattern, dipole [6] or monopole antenna [7] printed structures should be used.

In this paper, a microstrip monopole antenna is designed and simulated. The antenna is designed to operate in 2070…4700 MHz frequency band. As a radiating element, a disc topology was used. Such antennas can be considered as a variation of a monopole microstrip antenna, whose radiating element has not a linear, but a specific shape. This approach provides the ability of the antenna to operate in wide frequency band. The antenna, designed in the present work, can be used in mobile ISM band communication systems, such as Wi-Fi, Bluetooth or Zigbee applications. For the simulation and optimization of the antenna, finite-element method (FEM) was used.

As a substrate for the antenna, FR4 laminate was used with the following parameters: dielectric constant $\varepsilon_r = 4.4$; thickness $h = 1.5$ mm; thickness of the top and bottom copper layers $t = 0.018$ mm; dissipation is defined by tan $\delta = 0.02$.

The layout of the antenna is shown in Fig. 1. The antenna was designed so as to be fed by 50 Ω microstrip line or coaxial cable using SMA connector. The antenna of the selected type is ultrawideband and manifests pertinent performance in the 1.1…4.7 GHz frequency range.

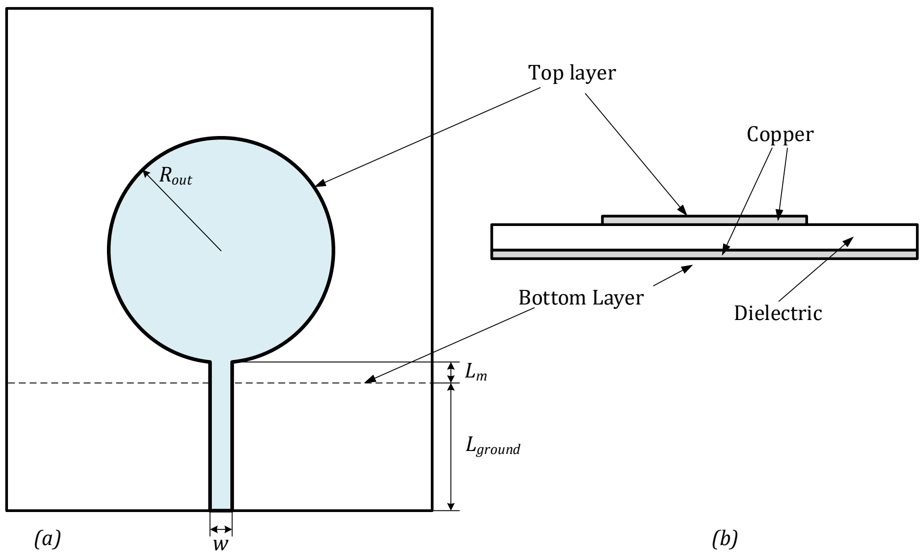
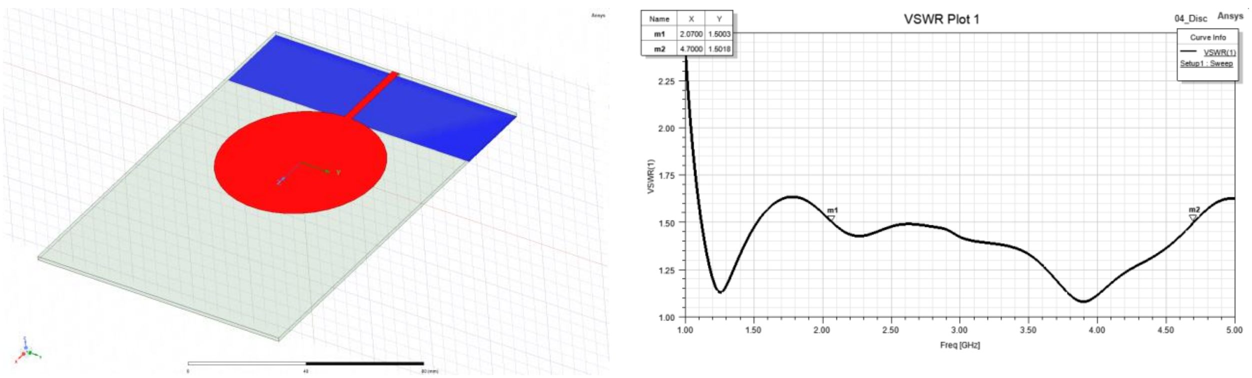


Fig.1. Dimensions of a microstrip monopole antenna.
(a) Antenna dimensions. (b) Side view of the antenna

The theory and design approach for the selected antenna type are considered in [1] – [3]. The design procedure contained the following stages: rough estimation of the geometry parameters according to general principles of the design of monopole antennas; analysis of the impact of L_m parameter on the antenna characteristics; optimization procedure over the two parameters: L_m, R_{out}.

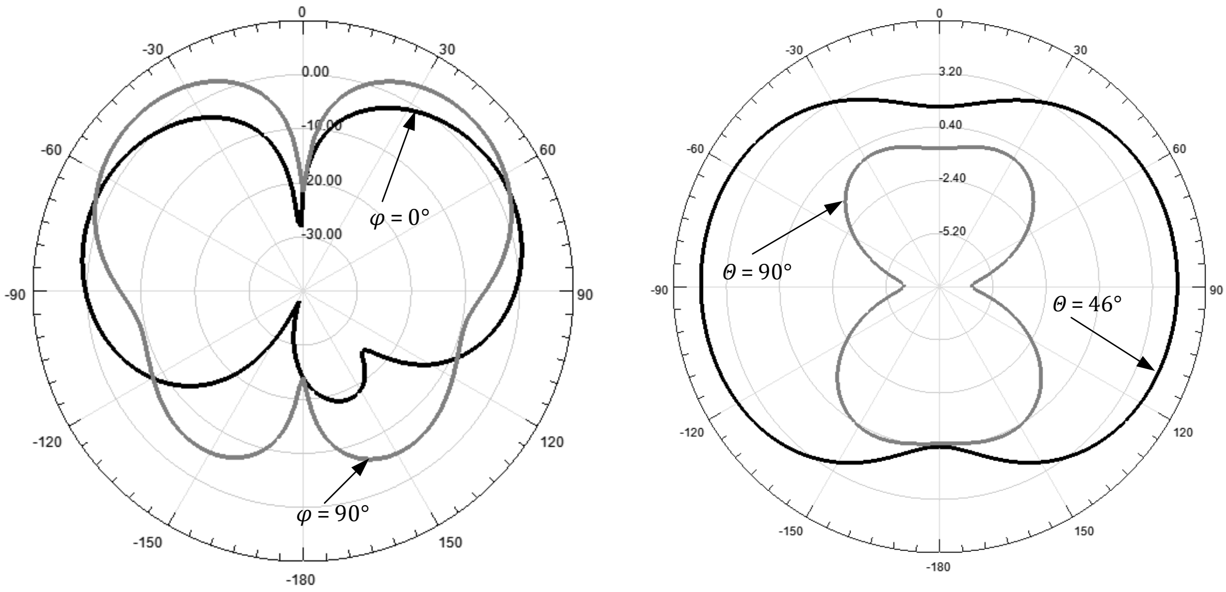
As a result of the optimization process, the following values were obtained for the antenna geometry L_{ground} = 30 mm; L_m = 0.2 mm; w = 2.9 mm; R_{out} = 30 mm. The model of the antenna is shown in Fig. 2 (a), and Fig. 2 (b) shows the VSWR of the antenna. It can be seen that VSWR is lower than 1.5 in the 2.1…4.7 GHz continuous frequency band.



(a) (b)

Fig.2. (a) Model of the antenna. (b) Return loss of the antenna.

The antenna with a disc shape of monopole has semi-omnidirectional directivity pattern. The maximum radiation is observed not in the azimuthal plane, but is inclined for about 45 degrees. In Fig. 3, the radiation pattern of the antenna is presented. The maximum gain is 4.6 dBi and observed within the cone of the highest directivity at $\Theta = 46°$. The distortion of the radiation pattern is caused by the dielectric layer of PCB and the disc shape of the radiating element.



(a) (b)

Fig.3. Directivity pattern of the antenna. (a) E-plane. (b) H-plane.

The antenna designed in the present research is small-sized and easily fabricated. VSWR value is less than 1.5 within the operating bandwidth 2.1…4.7 GHz. The antenna gain in the maximum of the main lobe is 4.6 dBi. The main lobe is inclined for about 45° relative to the azimuthal plane, which makes this solution well-suited for being mounted at considerable height for providing wide coverage areas.

References

1. Balanis C. A. Antenna theory: analysis and design. – John wiley & sons, 2016.
2. Garg R. et al. Microstrip antenna design handbook. – Artech house, 2001.
3. James J. R., Hall P. S., Wood C. Microstrip antenna: theory and design. – Iet, 1986.
4. Trubarov I.V. Design and Optimization of Two-Resonator Inset-Fed Printed Circular Patch Antenna for 2.4 GHz Frequency Band // XVI International Scientific Conference "Modern Challenges in Telecommunications" MCT-2022. Conference proceedings. Kyiv. Igor Sikorsky Kyiv Polytechnic Institute, 2022 – pp. 66 – 68. – ISSN(print)2663-502X
5. Trubarov I.V. Design and Optimization of Coaxial-Fed Circular Two-Resonator Patch Antenna for 2.4 GHz Frequency Band // XVI International Scientific Conference "Modern Challenges in Telecommunications" MCT-2022. Conference proceedings. Kyiv. Igor Sikorsky Kyiv Polytechnic Institute, 2022 – pp. 69 – 71. – ISSN(print)2663-502X.
6. Trubarov I.V. Printed Dipole Antenna for 2.4 GHz Frequency Band // XVII International Scientific Conference "Modern Challenges in Telecommunications" MCT-2023. Conference proceedings. Kyiv. Igor Sikorsky Kyiv Polytechnic Institute, 2023 – pp. 96 – 98. – ISSN(print)2663-502X.
7. Trubarov I.V. Microstrip Ring Antenna for 2.4 GHz Frequency Band // XVII International Scientific Conference "Modern Challenges in Telecommunications" MCT-2023. Conference proceedings. Kyiv. Igor Sikorsky Kyiv Polytechnic Institute, 2023 – pp. 99 – 101. – ISSN(print)2663-502X.