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DESIGN AND OPTIMIZATION OF COAXIAL-FED CIRCULAR TWO-RESONATOR PATCH ANTENNA FOR 2.4 GHZ FREQUENCY BAND

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ПРОЕКТУВАННЯ ТА ОПТИМІЗАЦІЯ ДВОРЕЗОНАТОРНОЇ КРУГЛОЇ ПАТЧ-АНТЕНИ З КОАКСІАЛЬНИМ ЖИВЛЕННЯМ ДЛЯ ЧАСТОТНОГО ДІАПАЗОНУ 2,4 ГГЦ

Здійснено проектування та оптимізацію дворезонаторної круглої патч-антени з коаксіальним живленням діапазону 2,4 ГГц. У якості діелектричного шару використано повітряний зазор, при цьому для кріплення елементів конструкції використано металеву стійку. Проведено моделювання роботи антени методом скінченних елементів у смузі робочих частот 2,4…2,483 ГГц. В результаті оптимізації антени збільшено смугу її пропускання за рахунок електромагнітного зв’язку між активним та пасивним резонаторами антени. В межах робочої смуги частот КСХ розрахованої антени перебуває в діапазоні 1…1,23.

Development of mobile communication systems and IoT-devices increases the demand for small-size and high-performance microwave antennas. At present, antenna theory is well-studied part of microwave engineering covering a large number of small-size antenna types and design techniques that can be used [1] – [3]. Antenna design is typically an iterative procedure involving numerous simulations to optimize its parameters.

In this paper, a circular coaxial-fed air-dielectric patch antenna for 2.4 GHz band with two patches is designed and simulated using the finite-element method. The antenna to be designed shall operate in 2400…2483 MHz frequency range, and have low directivity as well as small size to be used in mobile ISM band communication systems, such as Wi-Fi. Thus, the operating frequency of the antenna was chosen to be $f_0 = 2442$ MHz, which is the center frequency of the operating band. The design of single resonator air-dielectric patch antennas is considered in [4] – [5]. In the present research, the second parasitic resonator was added to obtain enhanced operating bandwidth. The approach for designing two-resonator patch antennas, which is used in the present research, is considered in [6] – [7].

To enhance the antenna bandwidth, the air was used as a dielectric between the ground plane and the patch. Aluminium was chosen as a material of which conducting parts of the antenna are made. Thus, the parameters of the layers are as follows: dielectric constant $\varepsilon_r = 1$; thickness $h_p = 6$ mm; thickness of the top and bottom aluminium layers $t = 0.5$ mm.

The design of the antenna with the dimensions of the patches is depicted in Fig. 1. The antenna was designed so as to be fed by coaxial line. To perform the matching between the coaxial feeder and the radiating rectangular patch, the end of the coaxial probe should connect to the patch at the point at which its input impedance is equal to the characteristic impedance of the coaxial feeder.

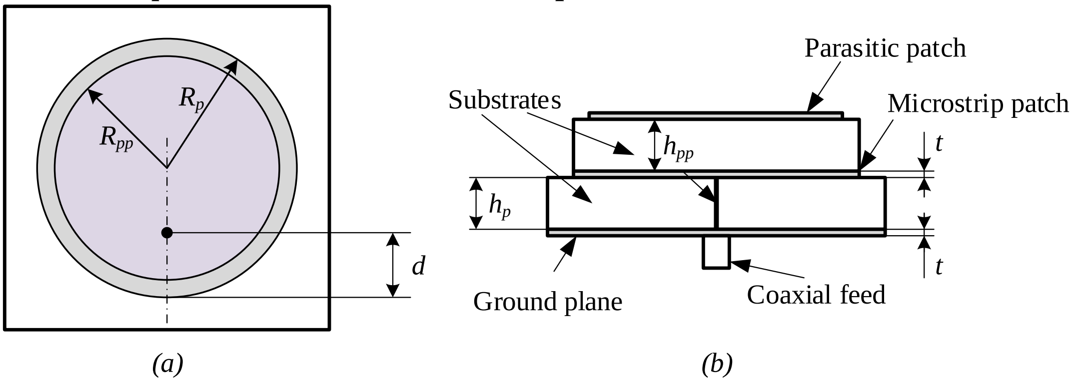


Fig.1. Dimensions of a microstrip patch antenna. (a) Dimensions of the microstrip patch. (b) Dimensions of the substrate and aluminium layers.

The design procedure described in [1] – [3] was used to obtain the initial values of the dimensions of the patch, which are as follows: Radius of the patch R_p = 32 mm; inset distance d = 16.5 mm. As a coaxial feed, the model of SMA connector was used. Thus, the inset distance should correspond to the point at which the input impedance of the patch is equal to Z_0 = 50 Ω.

These values were used for preparing the 3D model of the antenna shown in Fig. 2. A parasitic resonator was added to antenna, and the whole structure was simulated using finite-element numerical method. Single-resonator patch antennas were considered in [4] – [5]. However, they have a resonance-like frequency response. Adding of additional resonator allows to increase antenna bandwidth.

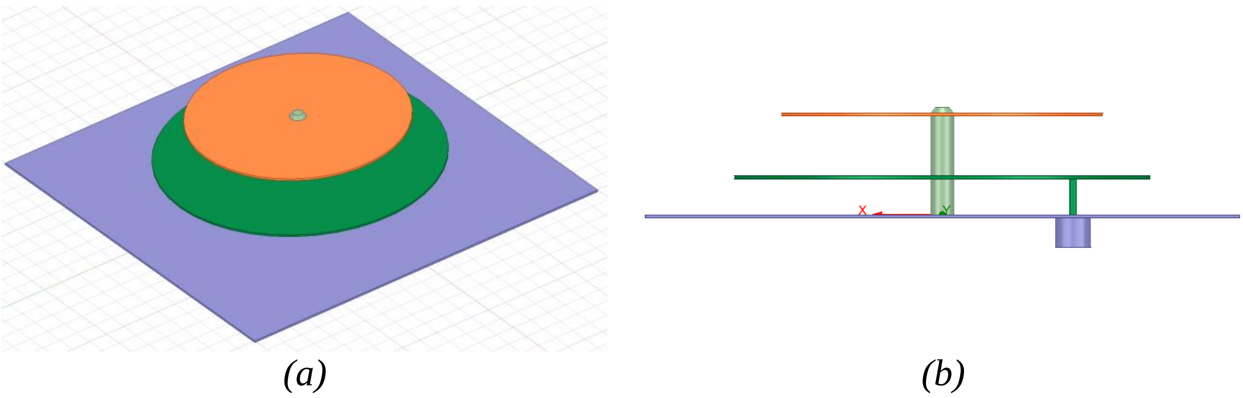
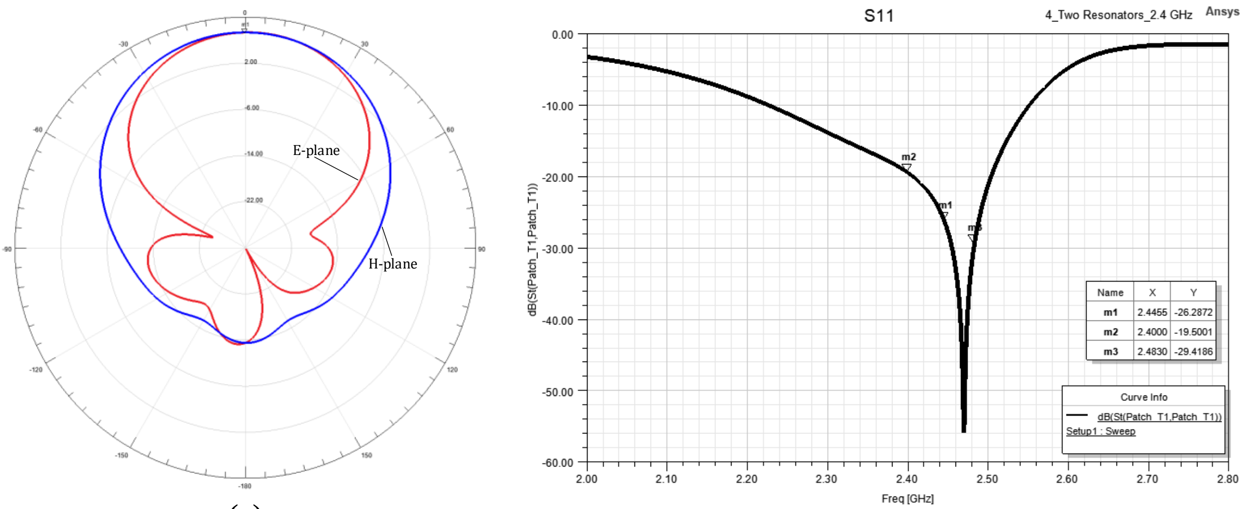


Fig.2. Model of the antenna. (a) Upper view. (b) Side view.

As the result of the optimization procedure, the following dimensions were obtained for the antenna: R_p = 35 mm; R_{pp} = 27 mm; d = 13 mm. In Fig.3, the simulated results for the directivity diagram and the frequency response of the antenna are shown. As it could be seen, the return loss is $RL = |S_{11}| \approx$ -19.5 dB at the band's left bound (f_L = 2.4 GHz), and $RL = |S_{11}| \approx$ -29.4 dB at the band's right bound (f_R = 2.483 GHz), and $RL = |S_{11}| \approx$ -26.3 dB at the center frequency

f_0 = 2.442 GHz. The gain of the antenna is G = 7.3 dB. The polarization of the antenna is linear with ***E*** vector oriented in XZ-plane, as shown in Fig. 2.



(a)

(b)

Fig.3. Characteristics of the antenna. (a) Directivity. (b) Return loss.

The antenna designed in the present research is small-sized and easily fabricated. Adding a parasitic resonator as small value of dielectric constant $\varepsilon = 1$ lead to the relatively large bandwidth of the antenna comparing with the one studied in [5]. VSWR value is less than 1.23 within the operating bandwidth 2.4…2.483 GHz.

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