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

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## ПРОЕКТУВАННЯ ТА ОПТИМІЗАЦІЯ ДВОРЕЗОНАТОРНОЇ ДРУКОВАНОЇ КРУГЛОЇ ПАТЧ-АНТЕНИ ІЗ ЗАГЛИБЛЕНИМ ЖИВЛЕННЯМ ДЛЯ ЧАСТОТНОГО ДІАПАЗОНУ 2,4 ГГЦ

Здійснено проектування та оптимізацію дворезонаторної друкованої круглої патч-антени діапазону 2.4 ГГц. Один резонатор є активним та збуджується мікросмужковою лінією, заглибленою в нього. Другий резонатор є пасивним та збуджується за допомогою електромагнітного зв’язку з активним резонатором. Проведено моделювання роботи антени методом скінченних елементів в діапазоні робочих частот 2.4…2.483 ГГц. В результаті оптимізації антени збільшено смугу її пропускання та покращено узгодження у смузі робочих частот. В межах робочої смуги частот КСХ розрахованої антени знаходиться в діапазоні 1…1.2.

Development of mobile communication systems increases the demand for small-size and high-performance microwave antennas. Antenna theory is a well-studied part of microwave engineering, and there are a large number of small-size antenna types and design techniques that can be used for their analysis and fabrication [1] – [3]. Nowadays, antenna design is usually an iterative procedure involving numerous simulations and optimization of its structure. Most frequently used numerical techniques for the full field simulation of antenna structures are the finite-element method (FEM) and the finite-difference time-domain method (FDTD). The comparison of the analytical model and the FEM simulation was done in [4] for a 2.4 GHz single-resonator patch antenna.

In this paper, a microstrip two-resonator circular inset-fed patch antenna for the 2.4 GHz band 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. Single-resonator patch antennas were considered in [4] – [5]. However, they have a resonance-like frequency response resulting in a small bandwidth. In the present research, the second passive patch was added to obtain larger operating bandwidth of the antenna. The approach for designing two-resonator patch antennas, which is used in the present research, is considered in [6] – [7].

As a substrate for the antenna, the RT/Duroid 5880 laminate was used with the following parameters: dielectric constant $\varepsilon_r = 2.2$; thickness $h = 1.575$ mm; thickness of the top and bottom copper layers $t = 0.018$ mm; dissipation is defined by $\tan \delta = 0.0009$.

The design of the antenna showing the dimensions of the patches is depicted in Fig. 1. The antenna was designed so as to be fed by microstrip 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.

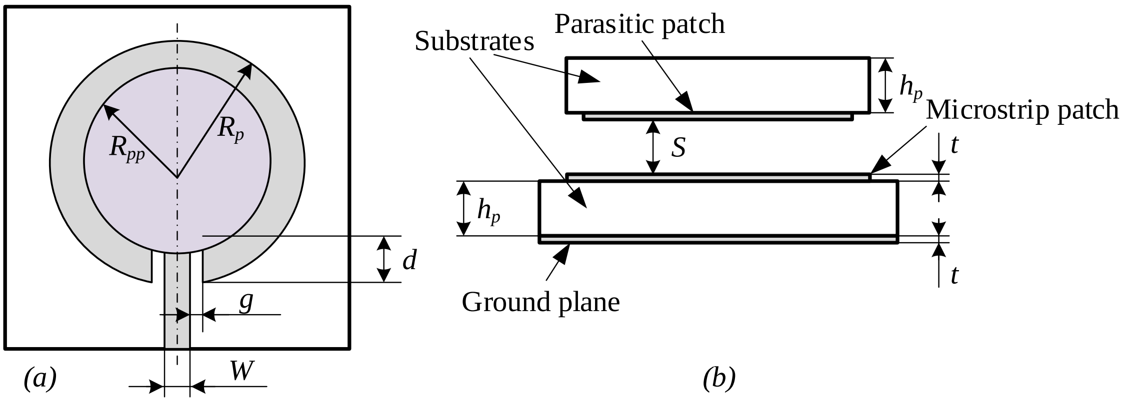



Fig.1. Dimensions of a microstrip patch antenna. (a) Dimensions of the microstrip patches. (b) Dimensions of the substrate and copper layers.

The design procedure described in [1] and [4] was used to obtain the initial values of the dimensions of the patch, which are as follows: radius of the patch $R_p = 24.6$ mm; inset distance $d = 18$ mm; notch width $g = 0.28$ mm. The width of the feeding line strip was chosen to be $W = 4.9$ mm in order to perform the characteristic impedance of the line to be $Z_0 = 50\ \Omega$.

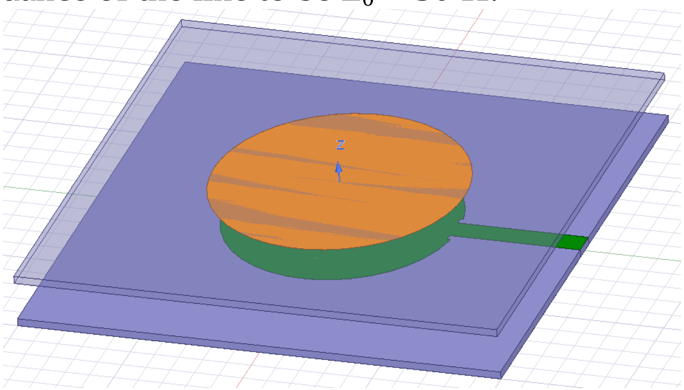
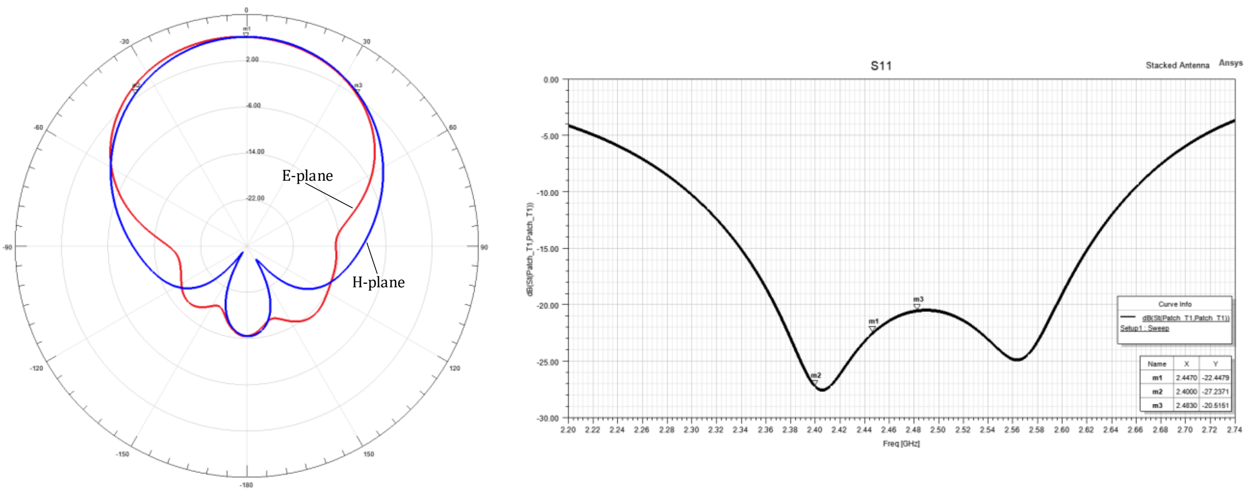


Fig.2. Model of the antenna.

As a result of the optimization procedure, the following dimensions were obtained for the antenna: $R_p = 24$ mm; $R_{pp} = 26$ mm; $d = 1$ mm; $S = 8$ mm; $g = 1.5$ mm. In Fig.3, the simulated results for the directivity diagram and the frequency responses of the antenna are shown. As it could be seen, the return loss is $RL = |S_{11}| \approx -27.2$ dB at the operating band's left bound ($f_L = 2.4$ GHz), and $RL = |S_{11}| \approx -20.5$ dB at the band's right bound ($f_R = 2.483$ GHz), and

$RL = |S_{11}| \approx$ -22.4 dB at the center frequency $f_0$ = 2.442 GHz. The gain of the antenna is $G$ = 6.1 dB. The polarization of the antenna is linear.




(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 an additional parasitic rectangular patch resonator positioned next to the active resonator lead to the relatively high bandwidth of the antenna comparing with the one studied in [4]. VSWR value is less than 1.2 within the operating bandwidth 2.4…2.483 GHz.

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