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

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

Здійснено проектування та оптимізацію дворезонаторної друкованої 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…1.7.

Development of mobile communication systems increases the demand for small-size and high-performance microwave antennas. Theory of antenna design is 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 design 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 rectangular inset-fed patch antenna for the 2.4 GHz band is designed and simulated using the finite-element method. Single-resonator patch antennas were considered in [5], [6]. However, they have a resonance-like frequency response. Adding of additional resonator allows to increase antenna bandwidth.

The antenna to be designed should operate in the frequency range 2400…2483 MHz, which is one of ISM bands. Thus, the operating frequency of the antenna was chosen to be f_0 = 2442 MHz, which is the central frequency of the operating band.

To enhance the antenna bandwidth, an additional parasitic patch was added to the antenna design. 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 topology of the antenna with the dimensions of the patch 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.

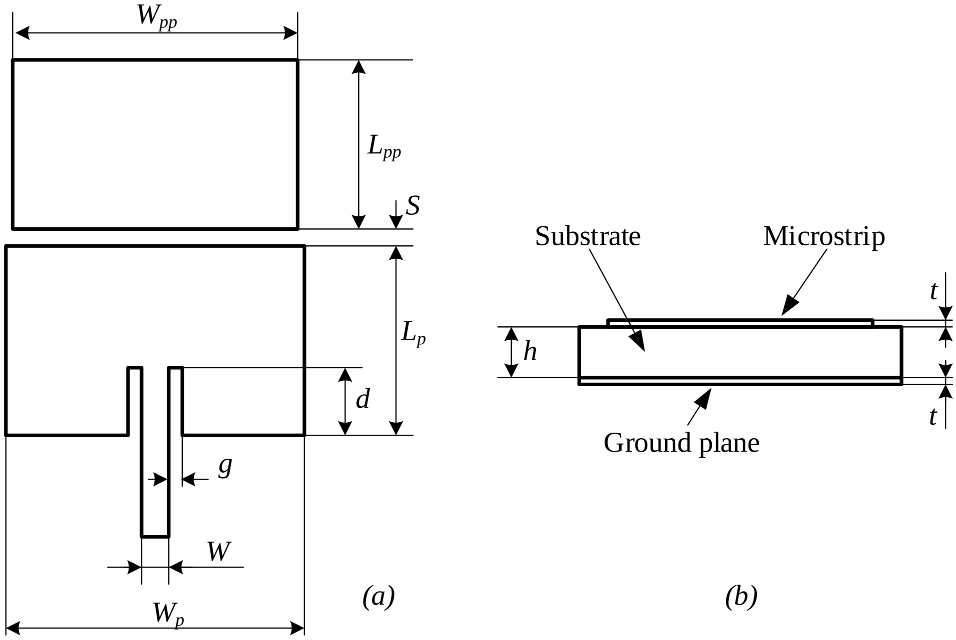


Fig.1. Dimensions of a microstrip patch antenna.
(a) Dimensions of the microstrip patches. (b) Dimensions of the substrate and copper layers.

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: width of the patch $W_p = 48.56$ mm; length of the patch $L_p = 40.64$ mm; inset distance $d = 14.25$ 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 $Z_0 = 50\ \Omega$.

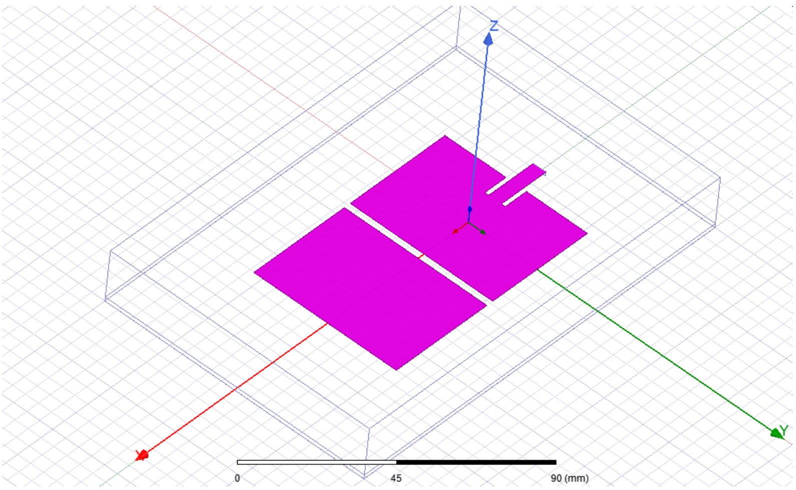
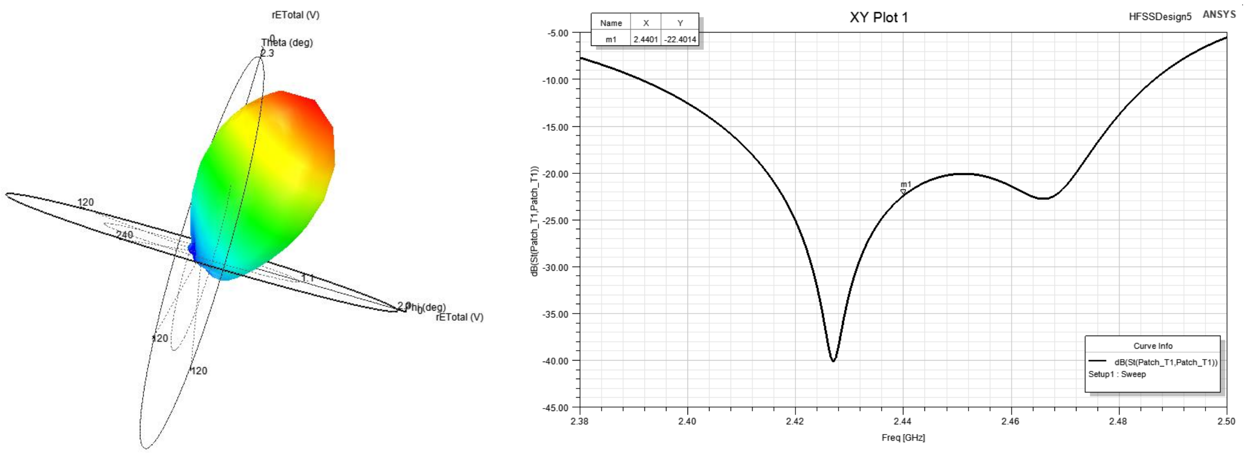


Fig.2. Model of the antenna

After the optimization procedure the following dimensions were chosen for the antenna: $W_p = W_{pp} = 55$ mm; $L_p = 40.3$ mm; $d = 9$ mm; $S = 2.5$ mm;

L_{pp} = 38.5 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 $RL = |S_{11}| \approx$ -12 dB at the edges of the operating bandwidth, i.e. at the frequencies f_L = 2.4 GHz and f_R = 2.483 GHz, and $RL = |S_{11}| \approx$ -22 dB at the centre frequency f_0 = 2.442 GHz. The gain of the antenna is G = 8.6 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]. The bandwidth at the level of RL = -12 dB is Δf = 83 MHz, i.e. VSWR within the required bandwidth is in the range 1…1.7.

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