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Design and simulate a rectangular microstrip patch antenna operating at 2.45 GH

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Abstract:
Design and simulation of a 2.45GHz Rectangular Microstrip Patch Antenna (RMPA) are presented in this paper. Duroid (RT\5880), a dielectric material with a dielectric constant of 2.2 and a substrate height of 1.6 mm, was chosen for our design. After the simulation was finished, the results showed a 4.746dBi directivity gain and a (-3dB) half power bandwidth of 91.60 at the E-plane and 114.90 at the H-plane. It was found that the return loss (S11) was -8.38dB. It was found that the voltage standing wave ratio, or VSWR, was 2.23.
Keywords: Rectangular microstrip patch antenna, Duroid (RT\5880), Return loss, directivity, Half Power Bandwidth, Voltage standing wave ratio, CSTSTUDIO SUITE Software.

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تصميم ومحاكاة هوائي التصحيح الشريطي الصغير المستطيل بتردد 2.45 جيجا هرتز

وفاء محمد السعيطي، مهند مفتاح

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الملخص:

تصميم ومحاكاة هوائي التصحيح الشريطي الصغير المستطيل بتردد 2.45 جيجا هرتز (RMPA) في هذا البحث. تم اختيار مادة (RT\5880) Duroid، وهي مادة عازلة ذات ثابت عازل 2.2 وارتفاع الركيزة 1.6 مم، لتصميمنا. بعد الانتهاء من المحاكاة، أظهرت النتائج كسب اتجاهي قدره 4.746 ديسيبل(−dB3) عرض نطاق نصف الطاقة يبلغ 91.60 على المستوى E و114.90 على المستوى H. وقد وجد أن خسارة العودة (S11) كانت −dB8.38. لقد وجد أن نسبة الجهد للموجة الدائمة، أو VSWR، كانت 2.23.

الكلمات المفتاحية: هوائي تصحيح شريطي صغير مستطيل، (RT\5880) Duroid، فقدان الإرجاع، الاتجاهية، عرض النطاق الترددي نصف الطاقة، نسبة موجة الجهد الدائمة، برنامج CSTSTUDIO SUITE.

Introduction

A microstrip patch antenna has its radiating patch and ground plane mounted on opposing sides of a dielectric substrate. One side of the substrate has the radiating patch mounted, and the other side has the ground plane mounted. The patch can be shaped into any shape that can be imagined and is commonly made of conductive materials like copper or gold. Wireless technology's capacity has been growing at an incredibly rapid rate. Using techniques called additive manufacturing, as opposed to subtractive manufacturing, it is now

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feasible to produce complex structures in an economical and efficient manner. Recent work by a group of researchers demonstrated the possibility of creating patch antennas and microstrip transmission lines using conductive and non-conductive filaments [1]. The size and shape of an antenna affects both the frequency range it can receive and the bandwidth it can transmit. Microstrip antennas are usually easy to build, simple, and inexpensive to produce because there are only two sizes available. That's why a good number of people use them [2]. Figure 1 shows the actual physical structure of the microstrip patch antenna. The substrate and metal are arranged in a three-layer stack that makes up the microstrip patch antenna, or MPA. The ground structure, which is the lowest layer, is often made of copper or another well-conductive material [3]. Figure 2 shows the numerous configurations of microstrip patch antennas. It describes the process of evaluating and contrasting that antenna's performance with a patch that is square, dipole, and rectangle, circular, triangular.

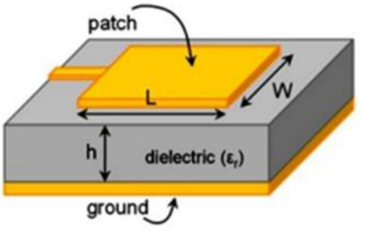

Figure1. Structure of microstrip patch antenna [3]

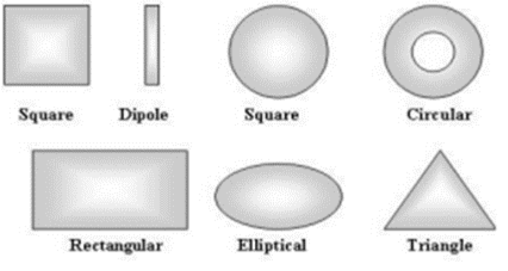

Figure2. Several distinct configurations for microstrip patch antenna [3]

Methodology:

The methodology the four main stages:

- Study on architecture & design equations for rectangular microstrip patch antenna.
- Dimensions of rectangular microstrip patch antenna to be calculated for substrate.
- Simulation of rectangular antenna for substrates.
- Analysis and tabulation of results obtained and comparing VSWR, S11, and radiation pattern with each other.

The proposed rectangular microstrip patch antenna is designed using CST Studio Suite 2019 software. Once the design is complete, the antenna can be simulated in the software to estimate its real world performance. For antenna design, it is assumed that the dielectric constant of the substrate (εr), the resonant frequency (2.45GHz), and the height of the substrate h (in mm) are known. Then a set of simplified equations of cavity model is used for calculating design parameters of rectangular microstrip patch antenna.

Antenna design:

For this investigation, the equations shown further down the page are utilized to determine the values of the parameters. In the microstrip format, it is measured across the whole width of the patch antenna as shown in (1): [5]

$$w = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

The effective potential divided by the dielectric constant as shown in (2):

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \quad (2)$$

Lengthened measurement as shown in (3)

$$L_{eff} = \frac{V_0}{2f_r\sqrt{\varepsilon_{reff}}} \quad (3)$$

By applying the following equation, will be able to eliminate the fringe effect and determine the length of the patch as shown in (4).

$$\Delta \text{L}=0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)} \quad (4)$$

$$L = L_{eff} - 2\Delta \text{L} \quad (5)$$

Simulation Results:

Using the CST Studio Suite 2019 software, the simulation results of RMPA are displayed in figures 3through 7.This displays several antenna properties such as return loss (S11), VSWR, gain, directivity, radiation pattern. In order to evaluate and examine the antenna performance of the suggested antenna design utilizing these antenna parameters, a summary of the results of the simulated antenna designs for the designed rectangular patch antenna are provided and described below.

-Return loss:

The S-parameters model the input-output interactions that exist between ports or terminals. The reflection coefficient, which is often referred to as the $S11$ coefficient, is a measurement that determines how much power an antenna reflects [6] At 2.45 GHz, this antenna's peak S-parameter is -8.38dB.Figure 3 shows the characteristics of the return loss.

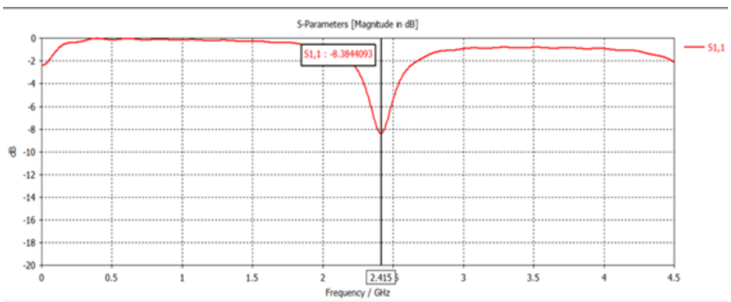

Figure 3. A graph showing return loss versus frequency is presented below

-Voltage standing wave ratio:

The power reflected by an aerial is denoted by the VSWR, which stands for the VSWR. The antenna's performance improves as the VSWR value goes down [7]. Figure 4 shows the value of VSWR plotted against frequency. It shows that 2.45 GHz is when the value of 2.23 is obtained.

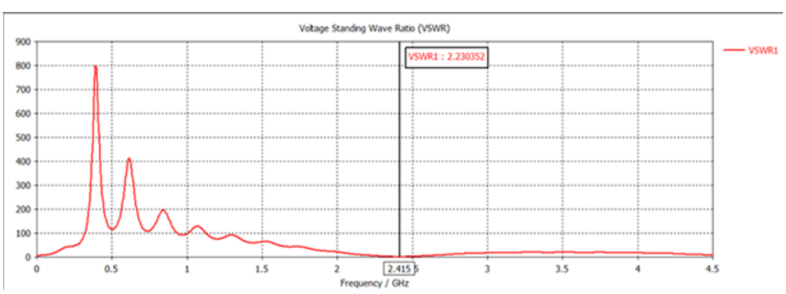

Figure 4. Frequency vs VSWR graphical representation

-Gain and Directivity:

The gain of an antenna is the measure of the antenna efficiency. It describes how far signals can travel through space, while the directivity of an antenna measures the ability of the antenna to radiate energy in a particular direction [5]. The higher the gain, the farther signals will travel [8].Figure 5 displays the 3D polar plot of the simulated antenna design. Figure 6 displays the antenna's directivity gain at 2.45 GHz, which is 4.746 dBi.

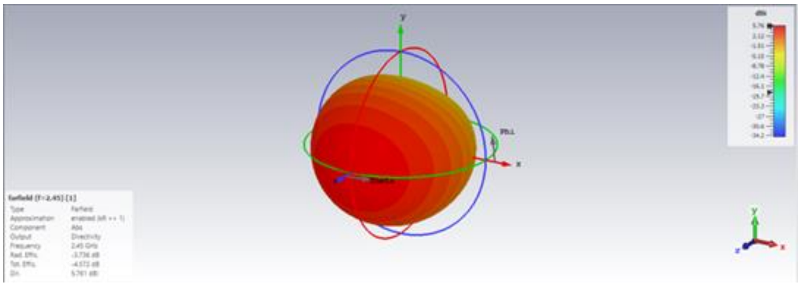

Figure 5. 3D radiation pattern of the proposed antenna

-Radiation Pattern:

The radiation pattern of an antenna describes the shape and direction of the beam of electromagnetic wave from the antenna. The measured far-field radiation patterns of designed RPMA are shown in Figure. 6 shown the E-plane and figure 8 H-plane radiation pattern of the designed RPMA polar plot. The radiation pattern of the proposed antenna is omnidirectional with minimum side lobe. Half power bandwidth (-3dB) of 91.60at E-plane and 114.90 at H-plane.

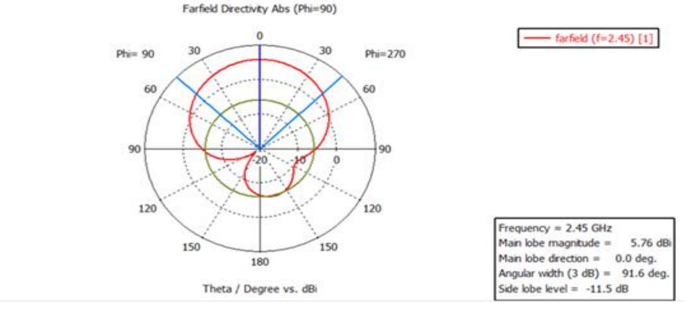

Figure 6. Simulated Radiation pattern at 2.45 GHz (E – plane)

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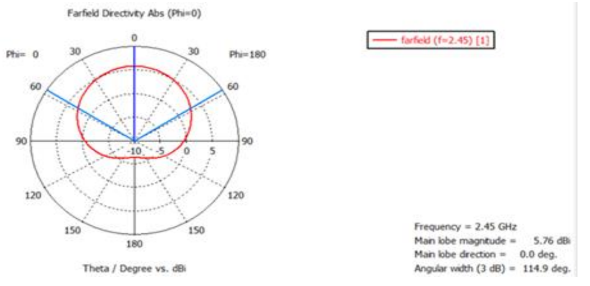

Figure 7 Simulated Radiation pattern at 2.45 GHz (H – plane)

Table .1 shows the simulation results of a rectangular Microstrip antenna Rogers RT 5880 (lossy) fr=2.45G9Hz□r = 2.2 h =1.6mm

Parameters	S11 (dB)	VSWR	Rin	D (dB)	G (dB)	Q	Tolefficien (dB)
Program computation	-8.38	2.23	252.2	5.761	4.746	82	-4.572

Conclusion:

The paper's goal was to simulate a rectangular microstrip patch antenna for the Roger RT5880 at 2.45GHz central frequency using CST software. The S11-8.38 has half power bandwidth (-3dB) of 91.60 at the E-plane and 114.90 at the H-plane, VSWR2.23, Directivity5.761 dBi, gain 4.746 dBi. Better results from this design and modeling could make them a viable option for wireless applications down the road. Additionally, the simulation values and the latter design should be compared.

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