



Prototype of Slotted Microstrip Patch Antenna for Multiband Application

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Abstract

In this paper a slotted microstrip patch antenna has been designed that works for two frequencies 1.42GHz and 2.65GHz. Since a microstrip patch antenna works only on one resonant frequency so converting that into a multiband patch antenna would enhance the bandwidth and also utilizes the multiple frequencies of operation. This multiband slotted patch antenna is fabricated on FR4 lossy dielectric substrate whose dielectric constant is 4.3 and height is 1.6mm. The length and width of patch are taken as 51.16mm and 39.86mm respectively. we cut out the slots so that the patch antenna works at multiple frequencies. Another advantage of presented design is it reduced the size of antenna actually required for 1.42GHz frequency. Simulation and analysis of slotted patch antenna is done by CST software. Simulation and fabrication results show that the presented antenna design characteristics meet with the standard characteristics of antenna.

Keywords—CSTMW studio software, rectangular slot, inset feed, FR4 lossy material, directivity

1. Introduction

In the field of wireless communication systems, the operation and designing of antennas plays a pivotal role. In RF communication for transmission and reception of RF signal we need antenna. Now a days we are working on several frequency band for different applications [1]. So constructing an antenna which is much conformal to different surfaces and can work in different bands simultaneously is the need for the advancement of this field[2].

Simulation and fabrication of different structures of microstrip patch antenna and has made progress in recent years. Different characteristics of microstrip patch antenna can be improved by changing the structure and dimension of it[3]. Microstrip patch antennas has numerous application field due to certain advantages. It consist light weight, less volume, economic and compatible with integrated circuits so that it can easily install on the rigid surface[4]. Furthermore, they can be easily designed to operate in dual-band, multi-band application, dual or circular polarization.

However, Due to low gain of Patch antennas it is mostly used in ISM band applications. These applications need low power and low profile so we can use patch antenna in indoor and health application[5].

Another problem associated with patch antenna is narrow bandwidth. For increasing the bandwidth many approaches have been utilized such as super substrate, dimensions of antenna, metamaterial, feed network etc [6]. This paper presents a slotted microstrip patch antenna working for two frequencies 1.42GHz and 2.65GHz respectively. This prototype is designed obtain a light weight, compact size, and economical antenna with desirable antenna characteristics. One of the important characteristics of antenna is impedance matching. Mismatching of impedance leads to losses and affects the radiation and directivity of antenna [7].

Generally we analyze impedance matching with the help of Smith Chart. CST MW studio software is used for simulation of proposed antenna. (CST MWS) is the leading edge tool for the fast and accurate 3D simulation of high frequency devices and market leader in Time Domain simulation. It enables the fast and accurate analysis of antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects etc [8].

2. Description of Antenna

A rectangular patch antenna with two rectangular slot is simulated by using CST MW studio software. This antenna is simulated for FR-4 lossy material with dielectric constant 4.4, loss tangent 0.02 and height 1.6mm. After designing a rectangular patch antenna two rectangular slots of 14x2 mm dimensions has been cut at patch antenna. Required Parametric Analysis has given below:

Calculation of Width (W)

$$W = \frac{1}{2f_r \sqrt{\mu_0 \epsilon_0}} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

Effective dielectric constant is calculated from:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(\frac{1}{\sqrt{1 + \frac{12h}{w}}} \right) \quad (2)$$

The actual length of the Patch (L)

$$L = L_{eff} - 2\Delta L \quad (3)$$

where

$$L_{eff} = \frac{C}{2f_r \sqrt{\epsilon_{eff}}} \quad (4)$$

Calculation of Length Extension

$$\frac{\Delta L}{h} = 0.412 \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264\right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8\right)} \quad (5)$$

where,

- ϵ_{reff} = Effective dielectric constant,
- ϵ_r = Dielectric constant of substrate,
- h = Height of dielectric substrate,
- W = Width of the Patch,
- L = Length of the Patch,
- ΔL = Effective Length,
- f_r = Resonating Frequency

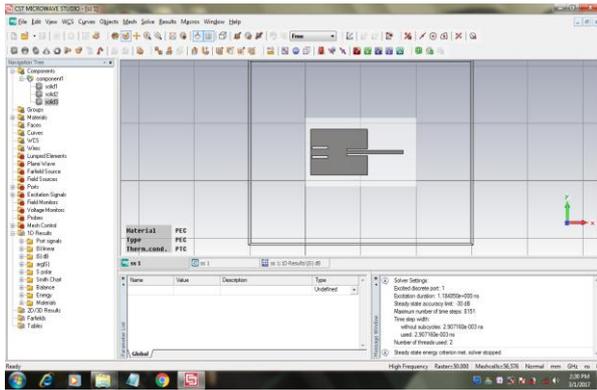


Fig. 1: front view of presented design

The figure 1 shows above represents the structure of slotted Rectangular microstrip Patch whose important specification for designing is mentioned below.

Specification:

1. Dimension of ground plane = 100x60mm
2. Length of patch = 51.16mm
3. Width of patch = 39.86mm
4. Height of patch = 1.6mm
5. Length of microstrip feed = 51.16mm
6. Width of microstrip feed = 3mm
7. Dimensions of slots = 14x2 mm
8. Resonant frequencies = 1.42GHz , 1.65GHz
9. Dielectric constant $\epsilon_r = 4.4$
10. Loss tangent = 0.02

3. Results and Discussion

The antenna is analyzed and designed by CST-MWS software at the frequency of 2.65GHz. To convert Micro strip Patch Antenna into Multiband Micro strip Patch Antenna we cuts two equal size rectangular shape slots on patch area of antenna with the dimensions 2mmx14mm. Initially our antenna was working only on frequency 2.65GHz but after slot cutting it is working on two resonant frequencies which are 2.65GHz and 1.42GHz.

The return loss of antenna is shown in Figure 2. The return loss at frequency 2.65 GHz is -43 dB and at frequency 1.42 GHz is -22 dB which is below -10 dB that shows that there is good matching at frequency points [9]. At frequency 1.42 GHz, bandwidth is 0.0256 GHz and at frequency 2.65 GHz bandwidth is 0.0383 GHz.

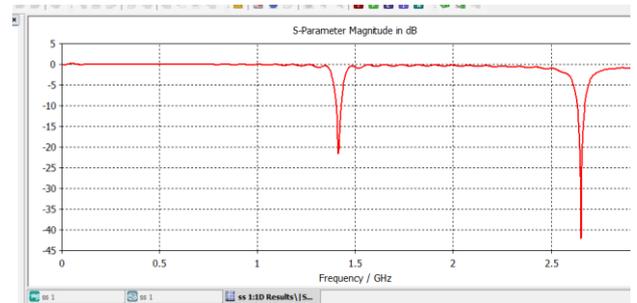


Fig. 2: Simulation result of presented design

Figure 3 shows the smith chart [5] of the microstrip patch antenna. By analysis of Smith chart of presented design it is concluded that impedance of presented design is matched with feed at 1.41GHz as well as 2.65GHz. At 1.41GHz, impedance of antenna is matched with 52.89 ohm which is near to 50Ω although due to little mismatching some error occurred [10]. At 2.65GHz, antenna is perfectly matched with 50Ω.

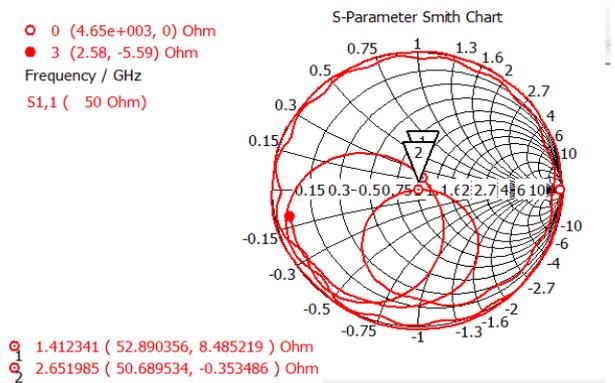


Fig. 3: Analysis of impedance matching of presented design

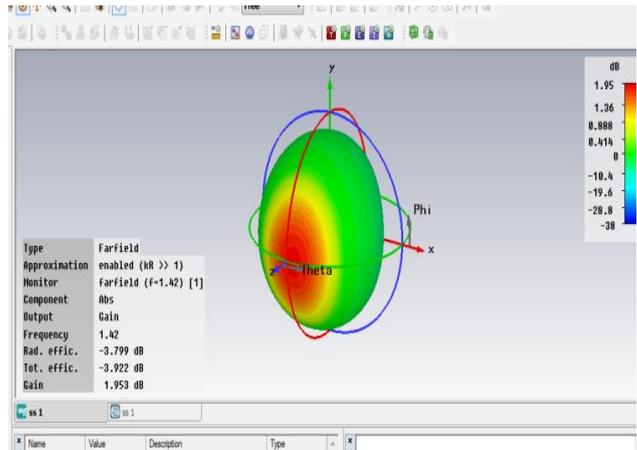


Fig. 4: Gain of presented design at 1.42GHz

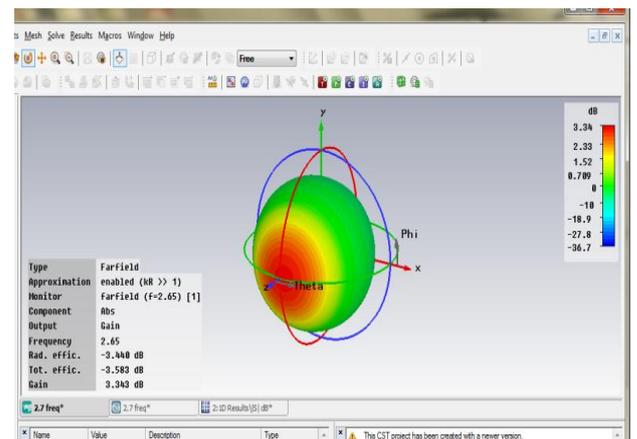


Fig. 5: Gain of presented design at 2.65GHz

Figure 4 shows the gain of proposed slotted antenna at frequency 1.42 GHz which is 1.953 dB. Figure 5 shows the gain of proposed slotted antenna at frequency 2.65 GHz which is 3.343 dB[11]. Figure 6 shows the directivity of proposed design at frequency 1.42 GHz. At 1.42 GHz directivity and bandwidth are 5.052 dB and 0.0256 GHz respectively. At frequency 2.65 GHz, directivity and bandwidth are 5.753 dB and 0.0383 GHz respectively[12].

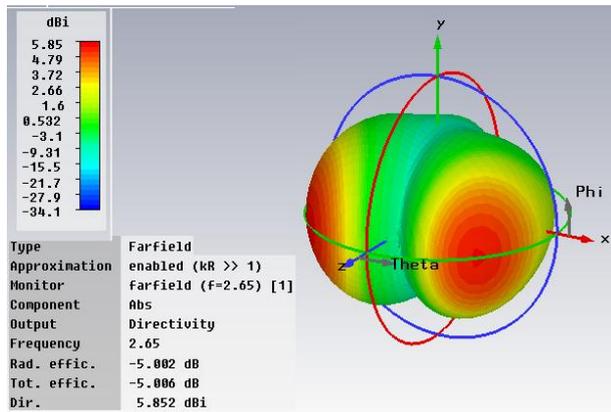


Fig. 6: Directivity at 2.65GHz

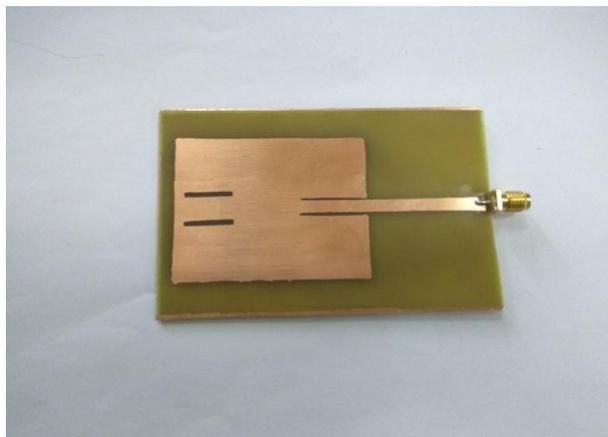


Fig. 7: Antenna Hardware

Hardware of proposed antenna is shown in Figure 7 . The return loss of fabricated antenna at frequency 1.42GHz is -18.6dB and at frequency 2.65GHz is -26.9dB.

Comparison between Fabricated Antenna Results and Software Simulation Results

Frequencies	Fabricated Antenna (Return Loss)	Software Design (Return Loss)
2.65 GHz	-26.9 Db	-43 dB
1.45 GHz	-18.6 dB	-22 dB

4. Conclusion

Proposed prototype of slotted rectangular microstrip patch antenna has been simulated and fabricated for two frequencies 1.42GHz and 2.65GHz respectively. The return loss at frequency 2.65 GHz is -43 dB and at frequency 1.42 GHz is -22 dB which is below -10 dB hence impedance of antenna is matched and return loss is very low . At frequency 1.42 GHz, directivity and bandwidth are 5.052 dB and 0.0256 GHz respectively and at frequency 2.65 GHz, directivity and bandwidth are 5.753 dB and 0.0383 GHz respectively. Gain is 1.953 dB at frequency 1.42 GHz and 3.343 dB at frequency 2.65 GHz. Fabrication result of presented design are also satisfying required characteristics of antenna.

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