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Comparative Analysis of FR4 and on a Rectangular Microstrip Patche Antenna

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Abstract: ***Today, in the world of wireless communication, the most widely studied area is wireless technology, and communication schemes are incomplete without the prior knowledge of antenna operation. In the final years of the communication scheme, the necessary condition for improving lightweight, combined and cost effective antennas is to be able to maintain high performance over a wide range of frequencies. This technology trend has been concentrated in the scheme of microstrip patch antennas. Today, microstrip patch antennas are widely used in global microwave access interoperability (WiMAX) and wireless local area network (WLAN) applications. This paper presents a new design of a microstrip patch antenna based on WiMAX and WLAN applications. The proposed antenna design uses different frequency bands and operates within a narrow band of the frequency band. This tuned antenna design provides better performance including return loss, voltage standing wave ratio (VSWR), impedance matching, gain and radiation pattern.***

Keywords: Rectangular Patch Antenna, FR4, Rogers RT/duroid 5870 (tm)

1. Introduction

Today, the world of wireless communications, a small, compatible and inexpensive microstrip patch antenna is needed. The microstrip patch antenna is used to process ultra high frequency signals. The microstrip patch antenna is a broadband narrow beam, which occupies less space. The antenna is placed on an insulating material such as FR4, glass, ceramic, etc., and its dielectric constant is lies between $2.2 \leq \varepsilon\_r \leq 12$. The microstrip antenna is mainly composed of grounding, substrate, and patch and feed line. The base of the antenna is called the ground plane. The substrate is placed over the ground having the same size. The substrate is the middle portion of the antenna having different dielectric constants. The patch in the antenna is made of a conductive material CU (copper) or Au (gold), and it may be any shape of a rectangle, a circle, a triangle and an ellipse or some other common shape.

In the past decade, a large amount of research has been devoted to the bandwidth extension technology of microstrip antennas. One popular approach is to use parasitic patches in another layer (stack geometry) or in the same layer (coplanar geometry). However, the geometry of the stack has the disadvantage of increasing the thickness of the antenna.
In this paper, extensive experimental and simulation results on I and Z-slot patch are presented. Experimental results include cross-polarisation and gain measurements. Also, a Z and I-slot patch antenna with different substrate behaviour is presented and investigated.

2. Related Work

Yadav et al. [2012] designed an E-shaped antenna by changing the position of feed point different parameters of an “E-shape microstrip patch antenna” that has been used for wireless message transmission; s band applications could be optimized. E-shape fractal patch antenna had been engaged to attain size lessening and improve the no. of functioning bands thus used in multiband communication system.

Majidi et al. [2018] presented a quadrilateral microstrip patch antenna with simulation and experimental verification driven at 5.8 GHz. The Sonnet software has been utilized to create the design and determine the Quality of service of antenna. To decrease the complexity of the design as well as the computational load, the antenna and feeding line have been operated independently. Optimization has also been applied to obtain the better efficiency.

Arya et al [2011] presented a DGS in microstrip antenna for dual band which are operating at microwave frequencies. The DGS increase the performance of microstrip antenna. In this research, a stacked patch along with a “skew F-shaped”-DGS have been integrated for getting multiband operation as well as for antenna miniaturization.

Mutiara and Refianti, et al [2011] introduced broadband patch antenna that find application in wireless communication system. The designed antenna comprises a radiating spot on one plane of the dielectric substrate, whereas other plane is grounded. This antenna is used as an antenna in the client computer and is efficient antennas for wireless communications (Wi-Fi).

Bayatmaku et al [2011] investigated E-shaped fractal patch antenna with various iteration fractal antenna. This antenna design made the patch antenna versatile when we talk about resonances and bandwidth –shaped fractal patch had been designed to reduce its size and increase the number of operating bands.

Zulkifli, et al [2010] suggested a multiband antenna array available in dumbbell shape with a defective ground structure. DGS has been introduced into the ground plane to suppress the mutual coupling effect. DGS helps to improve radiation property of the patch antenna array and hence provide an increased gain upto 3 dB.

3. Proposed Design

Multiband rectangular patch antenna has been designed with I and Z shapes on the surface of the patch. The schematic structure of the proposed antenna is shown in the figure 1.

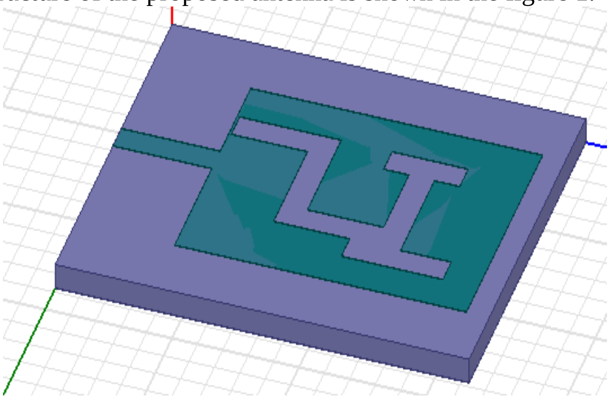

Figure 1: Proposed Antenna Design

Table 1: Dimension of Proposed Antenna Design

Variable	*Value*
Length of ground	32.6mm
Width of ground	27.6mm
Thickness of substrate	0.035mm
Feeding technique used	Microstrip patch antenna
Substrate used	FR4 & Rogers RT/duroid 5870 (tm)

4. Methodology

Different steps are taking place for designing and simulating the rectangular patch antenna that are listed below:

Step 1: To determine the dimension of proposed fractal antenna by selecting the desired operating frequency of the antenna.

Step 2: FR4 and Rogers RT/duroid 5870 (tm) material is used for the substrate of the antenna. Then patch is inserted over it in the triangular form and applied various fractal shapes on the patch.

Step 3: Then microstrip feed line is attached to the patch in order to excite the antenna.

Step4: Boundary condition such as E-filed in applied on the patch surface.

Step5: Air box is inserted on the designed antenna. This air box is used to observe the radiations emitted by the antenna and acts like load.

Step 6: After that the performance parameters like return loss, gain, and VSWR and radiation pattern are measured.

Step 7: Now, the material of the substrate is changed in the proposed work we are using Roger material and also measure the QoS parameters.

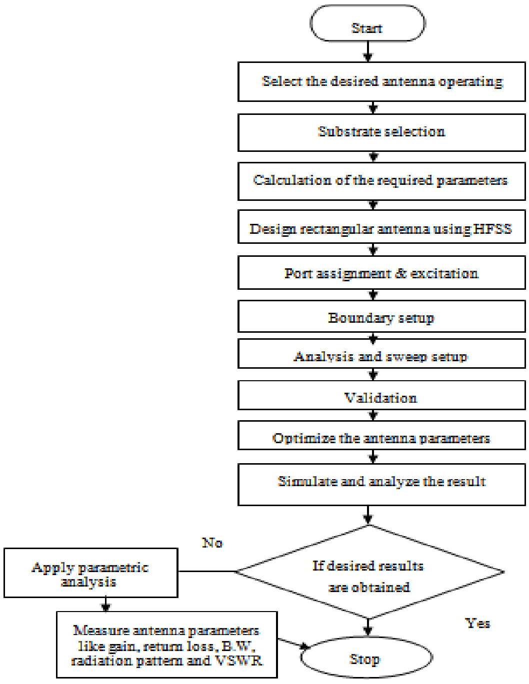

Figure 2: Flow of the proposed work

5. Results and Discussions

The experimental results are performed into two sections with DGS and without DGS. The detail description is provided in the following section.

5.1 Experimental Results without DGS

The experiment is carried out in HFSS simulator with simple I and Z shape patch and using DGS structure. The design is simulated using FR4 and Rogers RT/duroid 5870 (tm) material as a substrate. The results obtained with FR4 and Rogers RT/duroid 5870 (tm) material is shown in Figure 3 and Figure 4 respectively.

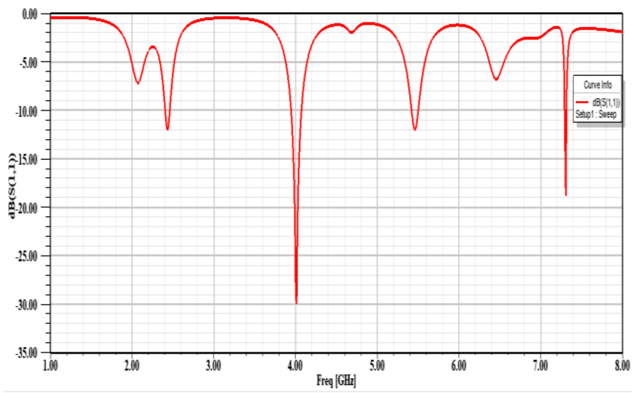

Figure 3: Return loss using FR4

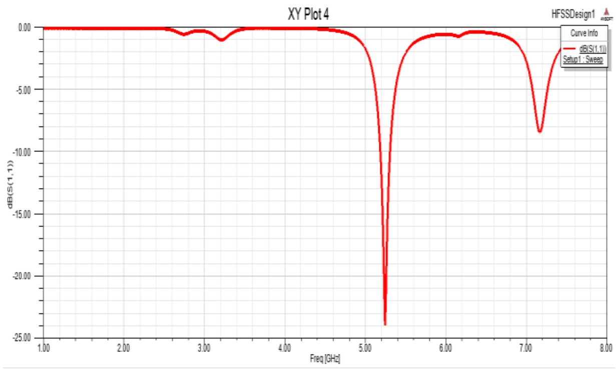

Figure 4: Return loss using Rogers RT/duroid 5870 (tm)

It is used to measure the mismatching of the feed line and patch. It is measured in dB. It is also known as reflection coefficient. From Figure 3 and Figure 4 it has been observed that four number of bands obtained using FR4 substrate while using Rogers RT/duroid 5870 (tm) antenna resonates at single frequency (5.23 GHz).

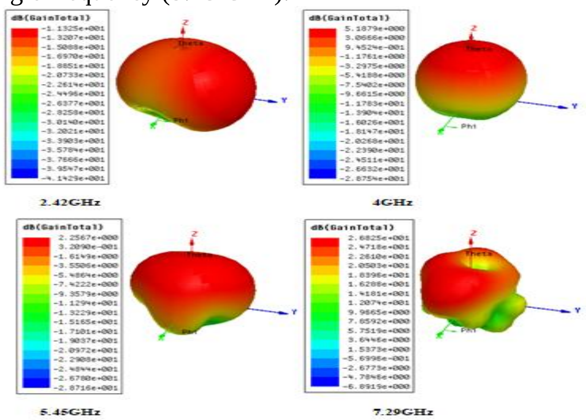

Figure 5: Gain using FR4 Substrate

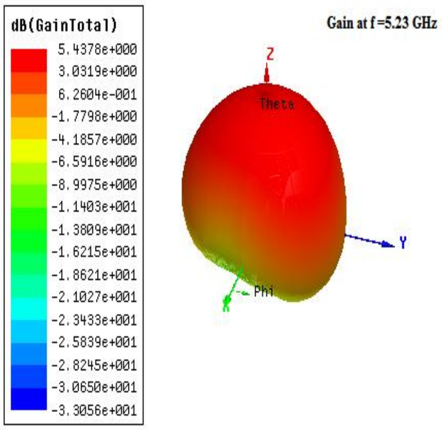

Figure 6: Gain using Rogers RT/duroid 5870 (tm)

Gain is defined as the intensity of radiated waves in a specified direction to the radiation intensity that is radiated by the antenna which accepted all input power. Gain comparison for FR4 substrate and Rogers RT/duroid 5870 (tm) has been depicted in Figure 5 and Figure 6 respectively. From the figure it has been analyzed that the gain measured using Rogers RT/duroid 5870 (tm) is high compared to FR4 substrate.

5.2 Experimental Results with DGS

A slot integrated in the ground plane of the patch antenna is referred to as a defective ground structure (DGS). DGS is used as an emerging technology to improve various parameters of patch antenna, namely narrow bandwidth, cross polarization, low gain, and many more. This section describes the introduction and evolution of DGS using different materials patch surface.

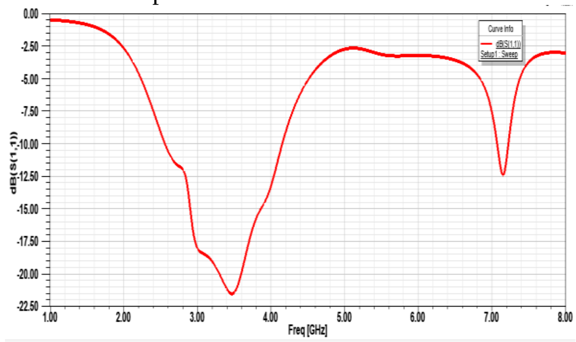

Figure 7: Return loss with DGS (FR4)

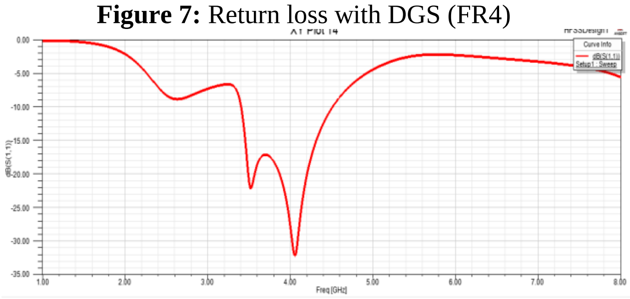

Figure 8: Return Loss with DGS (Rogers RT/duroid 5870 (tm)

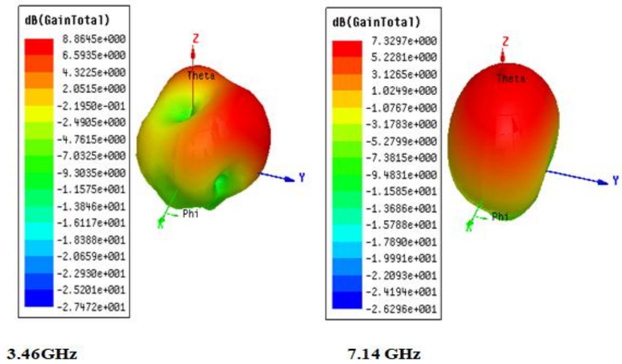

Figure 9: Gain with DGS (FR4)

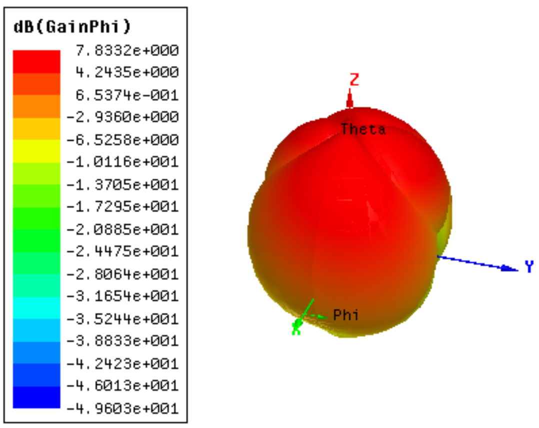

Figure 10: 4.04 GHz ((Rogers RT/duroid 5870 (tm))

6. Conclusion

The theoretical and simulation of a rectangular microstrip patch antenna with DGS ground operating in WIMax and WLAN application has been designed successfully using HFSS simulator. A novel rectangular patch antenna is designed which is resonated at 3.46 GHz, 7.14 GHz and 4.04 GHz. The gain and return loss has been examined using FR4 and Rogers RT/duroid 5870 (tm) substrate. From the results it has been examined that the results with FR4 substrate are better compared to Rogers RT/duroid 5870 (tm) material.

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