A Triple band Square Ring Patch antenna using Slots and DGS for Cognitive Radio, WLAN and Fixed Satellite applications

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ABSTRACT

This study targets do design a square ring patch antenna of size dimension 30x30x1.6mm3. It produced a triple band of frequencies 4.5GHz, 5.8GHz and 6.8GHz with return loss of -13.81dB, -15.80dB, -11.17dB respectively. With FR4 as dielectric medium having a permittivity of 4.4, a radiation pattern that is stable, gain which is acceptable and impedance matching are noticed at the desired frequencies using the tool HFSS. The intended antenna is compact in nature and offers high gain making it suitable for cognitive radio, wireless local area network and fixed satellite applications.

Key words: Tri band, Slots, Defective ground structure, Cognitive radio, WLAN, Satellite application.

1. INTRODUCTION

Compactness and efficiency have increased as a great need in modern wireless communication. With the advancement of wireless technologies, a greater demand for antennas to attain high performance in an internally constrained space has made tremendous steps to advance the development of antenna designs. Of these, microstrip patch antennas, no doubt, have risen to be some of the focal aspects, considering their possible desirable characteristics: lightweight construction, low profile, and easy integration with other electronic components [20][21]. Recent developments in microstrip patch antenna design are toward primary performance parameters such as bandwidth, gain, and efficiency. The most interesting innovations around this area include the ultra-wideband monopole reconfigurable antennas. The proposed antenna incorporates the U-shaped and cross-shaped slots as filtering components that can efficiently suppress unwanted signals and minimize interferences. Such flexibility is important in the current dynamic wireless environments, where equipment devices have to often shift between various frequency bands and operation modes [14]. Triple-band resonance rectangular patch antenna designed and implemented exhibits excellent performance for wireless LAN and Wi-MAX applications. Nearly omnidirectional radiation pattern is shown by the antenna, a characteristic favorable to persistent signal coverage in all different orientations. The innovative integration of DGS enhances the performance with enhanced bandwidth and decreased impacts of unwanted radiations [15].

Further, fractal geometries, notably the Sierpinski carpet structure, have introduced an avenue for realizing the multiband functionality. The circuits are optimized in terms of size and gain and particularly good for different kinds of industrial and medical applications. The fractal designs exhibit self-similar nature and offer a good antenna performance across different frequency bands with compact size factor [17]. One of the most important innovation of this discipline is ultra-wideband antenna design containing L shaped inverted slots and U shapes slits in its patch. Such construction allows the antenna to achieve tri-band operation and thus addresses a more significant range of frequency requirements while increasing the bandwidth with well-designed use of parasitic elements [18]. A new defected ground plane triple-band proximity-fed array antenna is also developed to enhance the radiation characteristics using David fractal geometry. The design, besides increasing the efficiency of the structure, supports multiple mobile applications, thus showing multiform capabilities in accommodating the needs of modern communication systems [19]. These inventions collectively focus attention on the crucial role that microstrip antennas play in overcoming the traditionally imposed limitations, such as narrow bandwidth and low gain. Overcoming those challenges is what leads them to become much more robust and flexible systems for wireless communications adapted to deal with changing user demands and ever-evolving technologies[8][9].

It is as of now notable that microstrip reception apparatuses have a few weaknesses, for example, having single working recurrence, limited impedance data transfer capacity, and low increase, in which these influence the typical radiation for receiving wires [1][2]. Nonlinear elements present in circuits produce harmonics of the fundamental frequency causing degradation in performance. This can be overcome using various low pass and stop-band filters. Limitation to this method is that it increases the size of the devices [6]. Utilization of Defected Ground Structure (DGS) overcomes system performance degradation issues in microstrip antennas. Integration of DGS inserted into these antennas improves the bandwidth and gain characteristics. Radiation pattern is also enhanced by repressing the higher order harmonics and coupling of adjacent [3][5].
Antennas effectively transmit electromagnetic (EM) energy from transmission line to free

2. ANTENNA CONFIGURATION

space. The need for miniaturization has made compact antennas a crucial prospect in wireless communication and has also increased the interest of research work on compact patch antenna design. The antenna bandwidth is, however, inadequate for wireless communication applications. Employing multiple or parasitic radiation elements enhances the design factors [12][16]. To boost mobility of telecommunication devices, a small and lightweight compact patch antenna is one of the most fitting options. They can be embedded along with other components in a system. Extensive use in communication systems is primarily due to their simplicity of analysis, low cost, less complex feeding mechanism, and improved radiation characteristics [4].

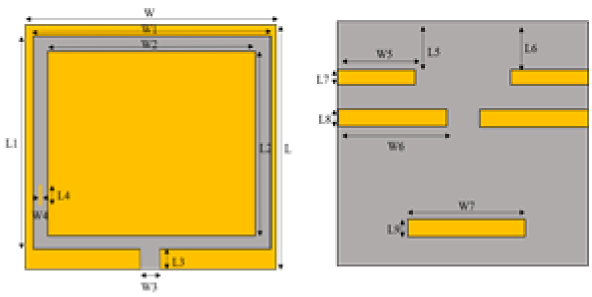

Figure 1. Antenna top view and rear view

Designed antenna arrangement has substrate length(L) = 30mm and width(W) = 30mm. A patch is a square ring structure with L1 = 26mm, W1 = 26mm, L2 = 19mm, W2 = 18.5mm and a feed of L3 = 2mm and W3 = 1mm.The ground plane has slots of dimensions L7= 1.25mm, W5 = 10mm, L8 = 1.5mm, W6 = 13.5mm, L9 = 1.28mm and W7 = 14.8mm where the smaller slots are located at a distance L5 = 9.68mm and L6 = 9.62mm respectively.

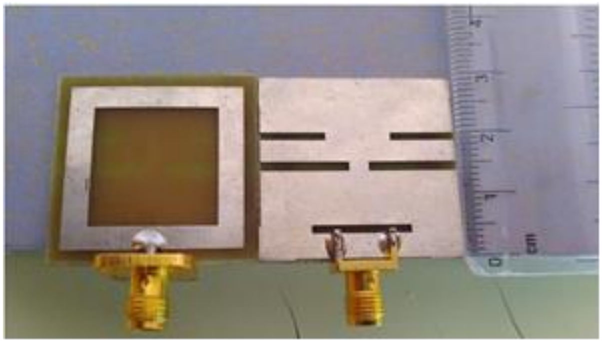

Figure 2. Fabricated antenna

3. RESULTS AND DISCUSSION

3.1 Return loss

The slot in the patch which creates the ring structure improves the return loss. The bandwidth is enhanced and lower frequency harmonics are obtained due to the defected ground created by the insertion of rectangular slots. The larger slots in the ground plane assist in generating the three frequencies making it a multiband antenna.. The VSWR for the obtained frequencies of 4.5GHz, 5.8 GHz and 6.8GHz are 1.51, 1.38 and 1.76, respectively.

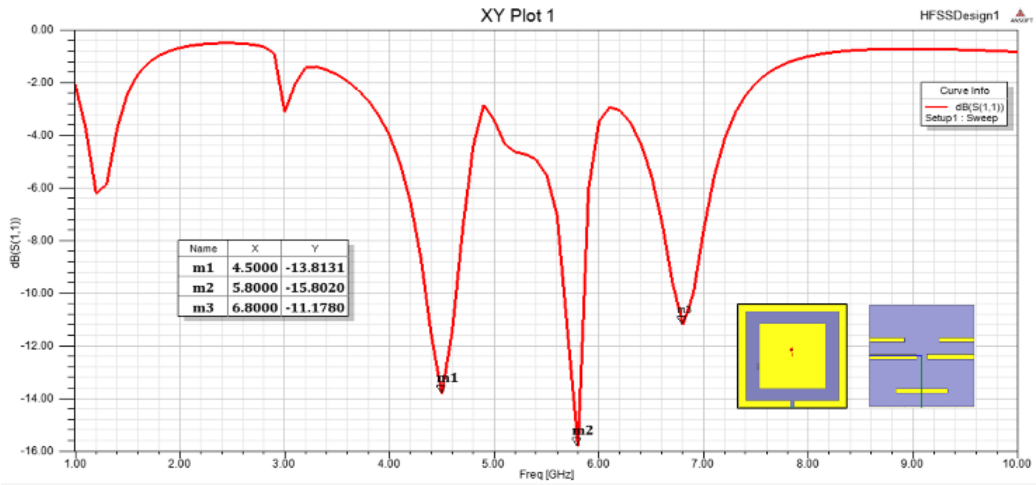

Figure 3. Return loss

3.2 Gain

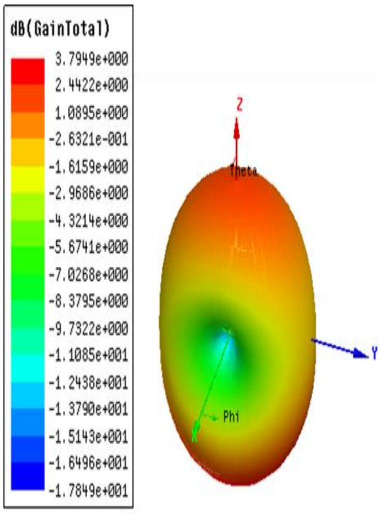

Figure 4a. At 4.5GHz

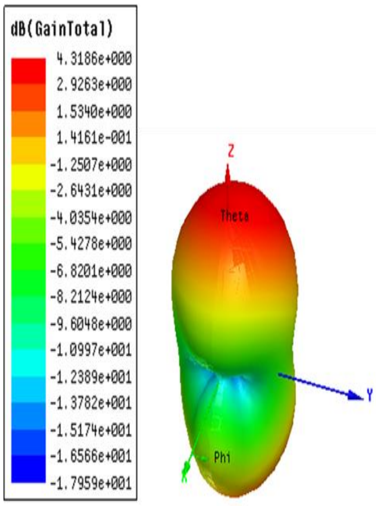

Figure 4b. At 5.8GHz

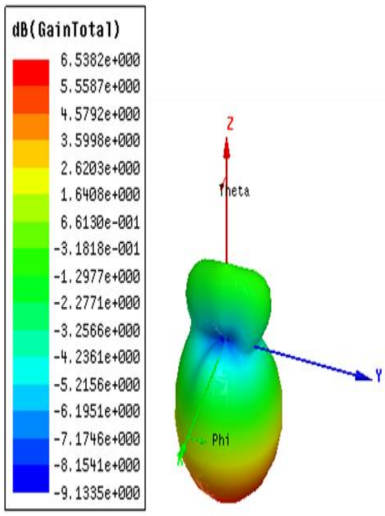

Figure 4c. At 6.8GHz

The gain obtained at 4.5GHz, 5.8GHz and 6.8GHz are 3.79dB, 4.31dB and 6.53dB respectively.

3.3 Radiation Pattern

3.3.1 E-plane radiation:

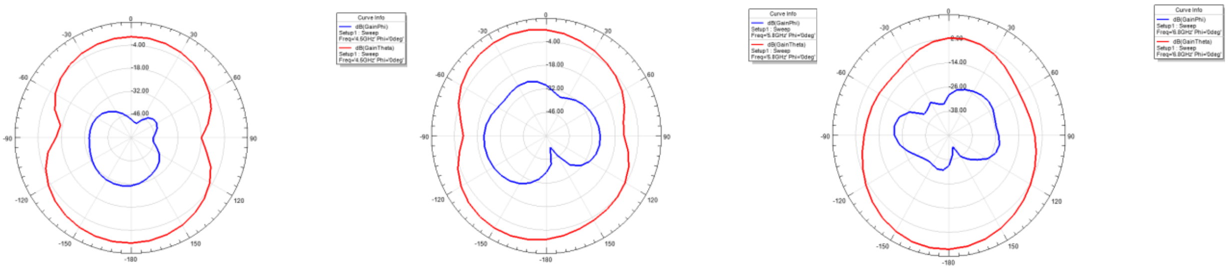

Figure 5a. At 4.5 GHz, 5.8GHz and 6.8GHz

3.3.2 H Plane Radiation

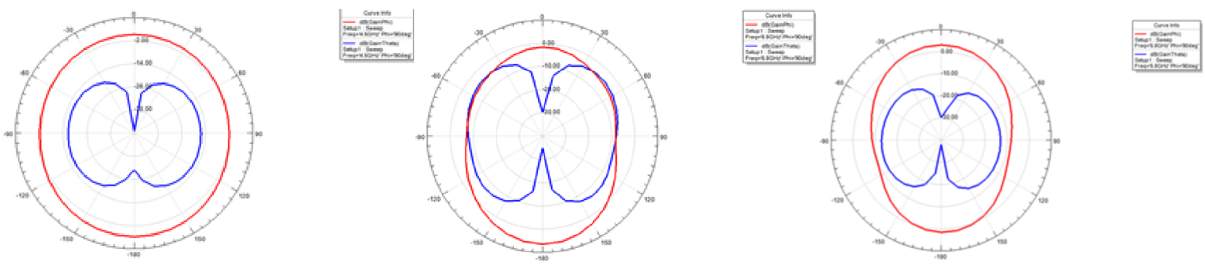

Figure 5b. At 4.5 GHz, 5.8GHz and 6.8GHz

In both figures 5a and 5b, blue color pattern indicate cross-polarization and red color pattern indicate co-polarization at the designed operating frequencies.

3.4 Measured Result

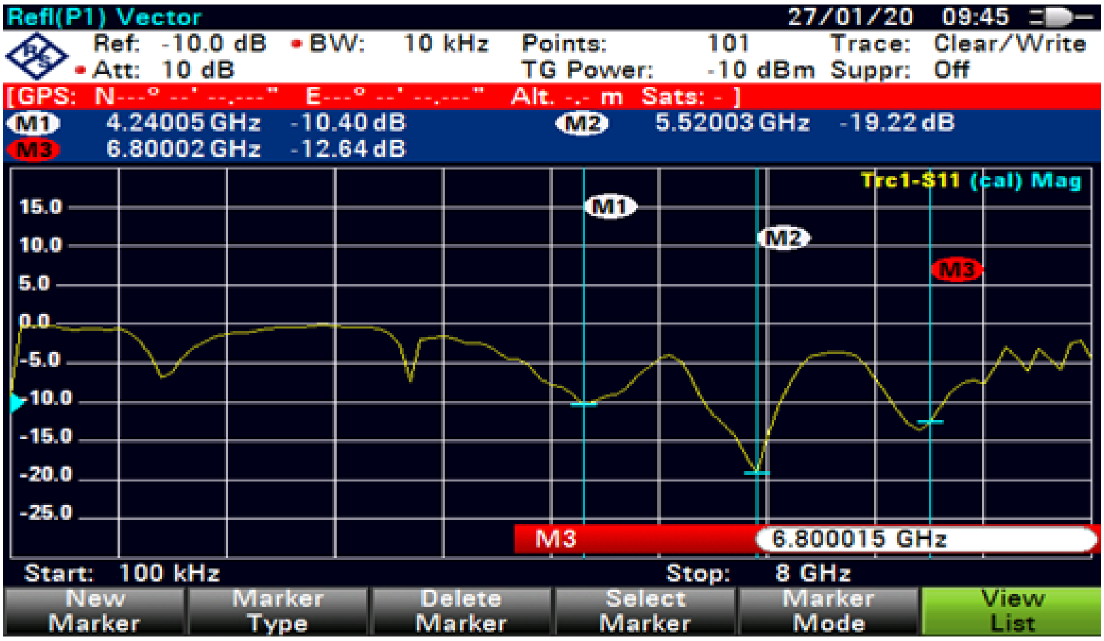

Figure 6. Experimental result using ZVH8 Vector network analyzer

3.5 Measured and simulated results comparison

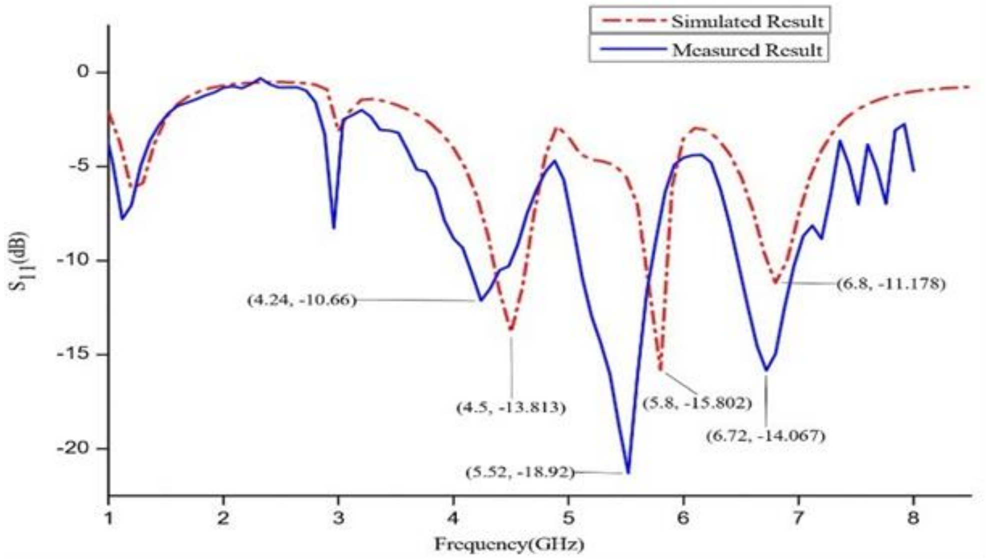

Figure 7. Comparison at operating frequencies

Table1. Parameter comparison table of simulated and measured design

Parameters	Simulated			Measured		
Frequency (GHz)	4.5	5.8	6.8	4.24	5.52	6.72
S_{11} (dB)	-13.8131	-15.80	-11.17	-10.66	-18.92	-14.067
VSWR	1.5121	1.387	1.7629	1.91	1.25	1.5

Table2. Comparison of gain with designs in the literature

Ref. no.	Total size (mm^3)	Working bands (GHz)	Gain (dB)
[14]	34.9x31.3x1.6	2.65 3.43	-2.5, 5.0
[15]	34x30x1.6	2.4 3.5	2.01 2.99
[18]	22.7x22.7x1.6	3.7 6.7 9.5	2.8 2.95 3.2
[20]	54x54x1.6	6.5 11.34	2.5 5.79
[21]	30x20x1.6	2.4 5.8	2.5 4.0
Proposed antenna	30x30x1.6	4.5 5.8 6.8	3.96 4.41 6.48

4. CONCLUSION

A tri band compact antenna is outlined in the present study using FR4 Epoxy Surface as well as gain and bandwidth improving methods such as slots and defected ground structure. The desired high gain is obtained for the frequencies 4.5GHz, 5.8GHz and 6.8GHz to be used for cognitive radio, WLAN and fixed satellite applications respectively.

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