Quad band microstrip antenna with four notch and rectangular slots

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Abstract

A new quad band microstrip patch antenna is presented in this paper for wireless communication. By introducing slot on patch and ground plane of antenna the bandwidth of antenna enhanced. adjusting the dimension of ground plane and patch, its fractional bandwidth at primary resonance mode can increased sufficiently to achieve desired bandwidth of proposed antenna. In proposed design, it has been found that the feed position of patch have clear impact on bandwidth of antenna. Also rectangular slot on patch will produce quad band. Rectangular slot position of patch over ground plane has clear impact on overall antenna performance. Many antenna structures have been modeled to demonstrate the effects of these parameters on the resulting quad band response. In this paper, a novel compact quad-band microstrip rectangle slot antenna using coaxial-feeding is proposed to support the four wireless communication bands of (2.2-2.46 GHz), (3.88-4.38 GHz), (5.36-5.67 GHz)and (6.32-6.98 GHz).

Keywords : Microstrip antenna, Dielectric Patch antenna, Length; Losses; strip width; strip length.

INTRODUCTION

Ahmed H. Reja [1] proposed Study of Micro Strip Feed Line Patch Antenna experimentally increase the Return Loss -33.60dB at 2.5GHz frequency and VSWR is 1.5 by using CAD for RT DUROID 5880. Santanu Kumar Behera and Y. Choukiker [2] proposed Design and Optimization of Dual Band Micro Strip Antenna using Practical Swarm Optimization maximize the return loss for dual band Frequency at 2.4GHz is -43.9dB and at 3.08GHz is -27.4dB. M. A. S. Alkanhal[3] proposed microstrip antenna by integrating various shapes to get reduced size and maintain performance of antenna for triple band. A A Deshmukh and G Kumar [4] proposed compact L-Shape patch broadband Microstrip antenna experimentally increase bandwidth up to 13.7%. Z M Chen [5] further increase bandwidth of this antenna up to 23.7% -24.43%. K F Lee [6] proposed U Shape slot shorting post small size Microstrip Antenna and increase bandwidth up to 42%. S C Gao [7] used uniplanar photonic band gap structure for enhancing band width and gain. M Khodier [8] New wideband stacked microstrip antennas for enhancing band width. Major issue for micro strip antenna is narrow Bandwidth. Asymmetrical patch on ground plane affect overall performance of antenna. K. Song et. al [10] designed asymmetrical L-shaped patch antenna for UWB application with -10dB return loss and peak gain 2.22 to 6.1 dBi for operating bandwidth 3.01-11.30 GHz frequency.

In this paper we tested our design by using electromagnetic simulator HFSS. Researchers are focusing on how to design microstrip antennas for various bands. Due to its advantages such as low-cost, small size low weight and capability to integrate with Microwave integrated circuits, the microstrip patch antenna is a very good candidate for integrations in applications such as wireless communication systems, mobile phones and laptops. In this paper a single rectangle slot microstrip antenna with four symmetrical strip (Figure 1) is designed and simulated for the frequency range of 1-7 GHz. This antenna presents an extension to the single C-slot antenna presented at LAPC 2009 [8, 9]. The proposed antenna has a gain of 3.8 dBi and presents a size reduction of 11% when compared to a conventional quad band square microstrip patch antenna. Extensive simulation results using Advanced Design Systems by Agilent (uses the MOM method) will be presented.

PROPOSED DESIGN

The results of proposed triple band microstrip patch antenna verified in HFSS Simulator with optimization. The initial antenna is shown in Figure 1. It consists of four rectangle slot with two opposite slot symmetrical to each other at the center of patch. Each end and placed within the patch [7]. The resulting antenna structure has the following parameters; the patch shape length W_p = 36 mm, and its width L_p =36 mm. The size of the ground plane has been found to be of L_{g1} = 32mm and W_{g1} = 32mm. The height of substrate is h= 3.2 mm and dielectric constant $\varepsilon_r = 4.4$. A coaxial attached to the microstrip and has a radious 0.8 and height 2.6mm. The length and width of four rectangle-slot that is S is 15mm and 1.5mm respectively. The four sides of the square patch are replaced with triangular notch, opposite notch are of same angle that is $x_1 = x_2 = 45^o$ and $y_1 = y_2 = 30^o$ [11].

We will conduct a simulation study on the structure of Figure 1 by adjusting the dimension of slot S. The resulting dimension of slot after simulation antenna structure is 1.5mm×15mm. Initially we put ground position for entire patch. As we reduce ground material, it is found that return loss is getting reduced from -10dB to -20dB. The ground substrate length on backside of patch is reduced and simulated for different dimension; it is observed that we get second (3.88-4.38 GHz), and third band (5.36-5.56 GHz) with sufficient return loss, the resulting return loss responses obtained by reducing ground plane, we obtain optimized return loss as presented in figure 2. Further we simulated for different dimension of rectangular slot on patch to get optimized result, initial dimension of slot are 15mm × 1mm. We simulated for different value that is from 15mm × 01mm to 15mm ×1.7mm in this case it observed that we get first, second and third band with sufficient return loss, the resulting return loss presented in figure 2. From above result the finalized dimension of ground plane are, dimension of backside and rectangular slot are 32mm×32mm, 15mm×1.5mm respectively.

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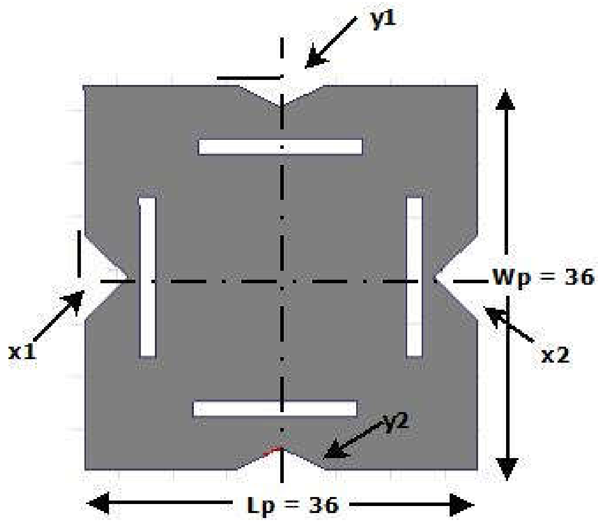

Figure 1. Proposed antenna design

From figure 2 and figure 3, it is observed that, we get minimum return loss that is -20dB, -22dB, -25dB and -31dB at 2.41GHz, 3.9GHz, 5.78GHz and 6.7GHz respectively.

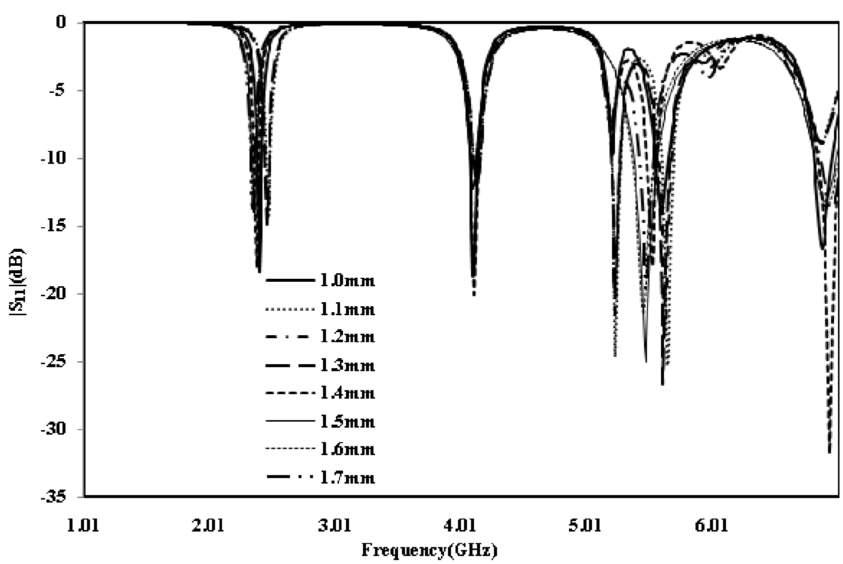

Fig 2: Return loss of antenna for variation in slot

Results of the variation of the size of the ground plane, as Figure 1 implies, that the tripple band response deteriorates for ground plane width other than the reference value.
However, quad-band responses are obtained with increased or decreased higher resonating bands. The effect of the width of ground has been demonstrated in Figure 2, and Figure 3.

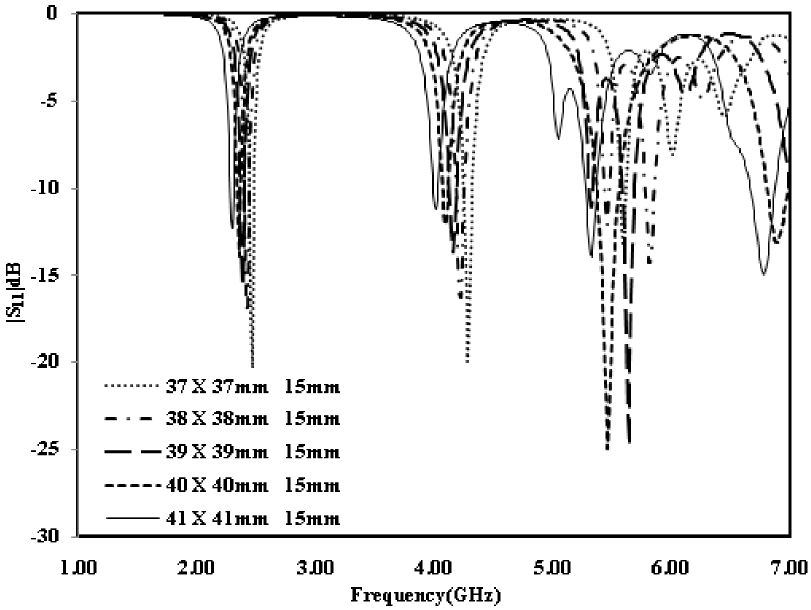

Fig 3: Return loss of antenna for variation in ground plane

For larger values of the width of ground, the antenna offers a one-band resonant behavior, and the quad-band resonance occurs as the width is made smaller and approaches that of the reference antenna.

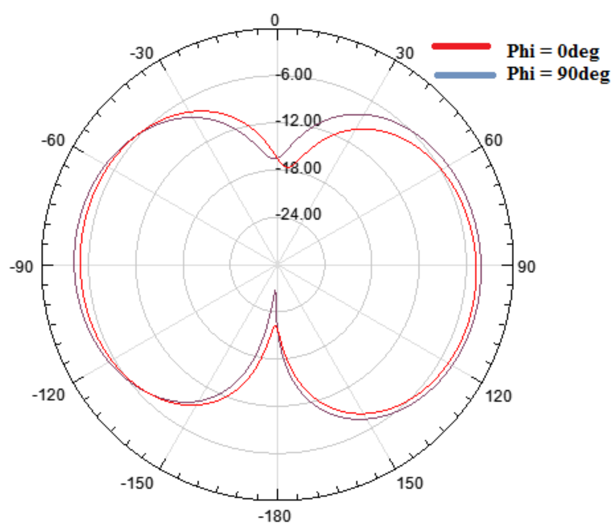

Fig. 4 Radiation pattern at 2.41GHz

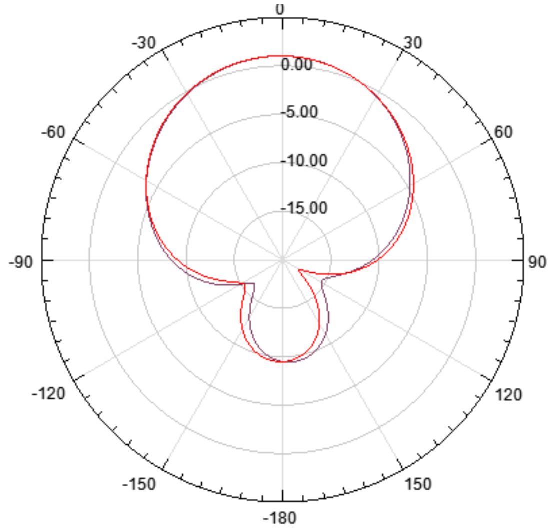

Fig. 5 Radiation pattern at 3.9GHz

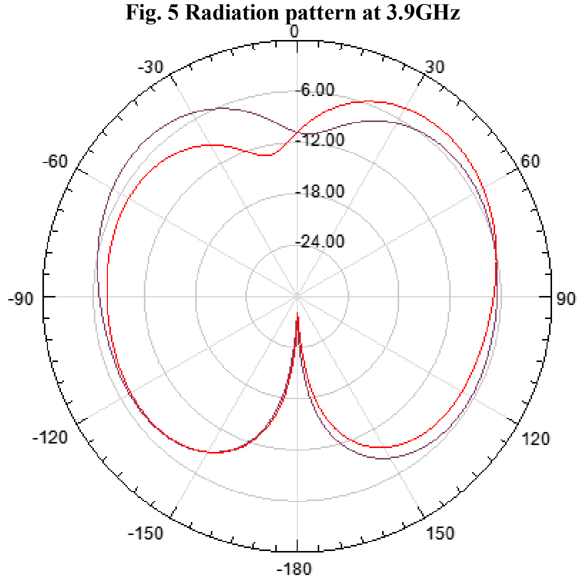

Fig. 6 Radiation pattern at 5.78GHz

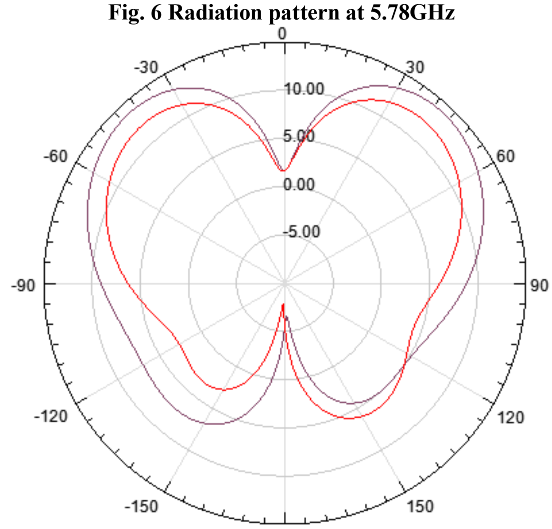

Fig. 7 Radiation pattern at 6.7GHz

Figure (4)-(7) depicts the radiation pattern for quad band that is at 2.41GHz, 3.9GHz, 5.78GHz and 6.7GHz frequency since return loss at this frequency is -20dB, -22dB, -25dB and -31dB respectively.

CONCLUSION

The design optimization of a Four slot patch antenna has been presented and discussed. It has been shown that with correct selection of slot dimensions on patch and shape of ground plane, a quad band frequency response can be achieved. With this antenna, we get much improved bandwidth this design is obtained method, as a candidate for use quad band that is (2.2-2.46 GHz), (3.88-4.38 GHz), (5.36-5.67 GHz)and (6.32-6.98 GHz). The antenna has been modeled and its performance has been analyzed using a HFSS simulator. The proposed antenna has been found to possess a miniaturized size and a width making it suitable for compact size quad band applications. The simulated results of HFSS at 2.41 GHz is Return loss = -20dB, at 3.9GHz Return loss = -22 dB, at 5.78 GHz Return loss = -25 and at 6.7GHz Return loss = -30. VSWR at 2.41 GHz is 1.5, Gain = 1.8dBi at 2.4 GHz Efficiency= 90%..

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