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Compact Elliptical Multiband Slotted Patch Antenna with Defective Ground Structure

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***Abstract*— A compact antenna consisting of Elliptical patch, a slotting line and Coaxial feed line is proposed in this work. This design is made up of a square patch along with the capability of covering multiple bands in 1-15GHz range. The simulation results of square patch with slotted line arrangement with different slot size and with the modification in slot geometry of these different arrangements are presented in this paper. The slotted square patch antenna designed with RT-Duroid substrate (ε_r=2.22, h=0.37mm). Simulation results of return loss and polar radiation pattern are analysed in this paper.**

***Keywords*—Microstrip antenna, Return loss, Bandwidth, VSWR, Reflection Coefficient.**

I. Introduction

In this era of communication is dominantly of the broad-and multi-band nature. Antenna designers are therefore enforced to design antennas matched to the operation in multi-bands. Considering mobile communication, the designed antennas have to be compact. And that is why the planar technology is so popular. New development in wireless communication and radar systems has presented new challenges to design and produce high-quality miniature components with multi-band performance. Immense growth in wireless communication system demands more complex and sophisticated systems along with more operating bands. In mobile communication systems many different frequency bands are needed such as global system for mobile communication (GSM800/900), digital communication system (DCS), personal communication system (PCS), universal mobile telecommunication system (UMTS) and the industrial scientific and medical (ISM) band [1-2].

In recent years, many authors have dedicated their investigations to create new designs or variations in the original antenna that to some extent; produce either wider bandwidths or multiple-frequency operation in a single element. Many techniques of are implemented to achieve multi frequency operations.

Multi-band microstrip antenna was realized by cutting a quarter wavelength or half wavelength slots inside the patch[2] operation also the stacked structure was utilized for multiband structure [3] again by applying fractal shape technique into antenna geometrics, multiband antenna can be constructed [4]–[8]. By using multilayer stacked patch [9] and single layer microstrip antenna [10] has been paid to little attention for achieving dual-band. In [11] dual frequency is achieved by cutting a square slot in the middle of a rectangular patch where they achieved both compactness and dual frequency operation. Dual frequency with tuneable frequency ratio can be attained by loading a pair of narrow slots parallel and close to the radiating edges of a bow tie patch [12]. Pre factual geometry and two short circuits in patch are used to achieve compact dual-band circular polarization antenna [13].

The aim of this article is to design multiband Elliptical patch antenna for wireless communication systems and study the different techniques to improve number of bands in 1 to 15 GHz range. Primarily simple Elliptical patch was designed with the required frequency range of 1-15 GHz range, which was a dual band antenna with the frequency bands with central frequencies of 8.64 GHz and 10.81 GHz respectively with fine radiation intensity at both of the frequencies. Further the slotting technique was studied for the purpose of increasing number of bands.

To increase the number of bands in the same design on the RT-Duroid substrate (ε_r = 2.22, h= 37 mm), slotting technique was studied and implemented along with the defective ground plane structure. Both the applied techniques increases the electrical length of the antenna and hence lowers the resonance frequency this reduction in the resonance frequency, allows more number of operation band to be accommodate in the given range. With the inclusion of this technique he structure was made triple band. The simulation results at different stages are discussed and analysed.

II. Antenna Design

The proposed antenna has a simple square patch using an Coaxial feed; the patch antenna is designed using the basic concepts of the microstrip technology.

A. Basic theory

Microstrip patch antennas consist of a metallic patch of metal that is on the top of a grounded dielectric substrate of thickness *h*, with relative permittivity ε_r as shown in Fig. 1.

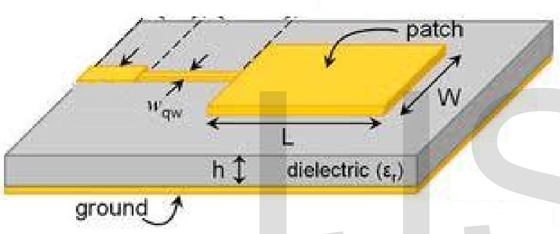
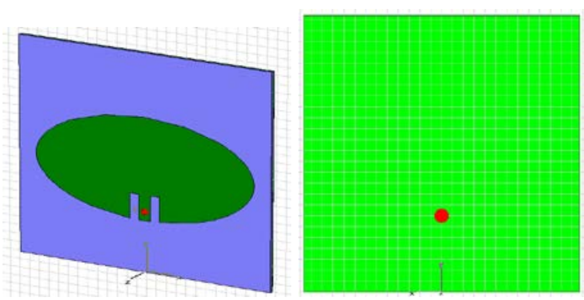


Fig. 1 Geometry of microstrip patch antenna

The metallic patch may be of various shapes, with rectangular and circular being the most common; the geometry of a Rectangular Microstrip Patch Antenna (RMPA) is shown in Figure 1. The patch of length 'L', width 'W' and thickness 't' is printed on RT- Duroid (ε_r = 2.22) substrate.

B. Proposed Design

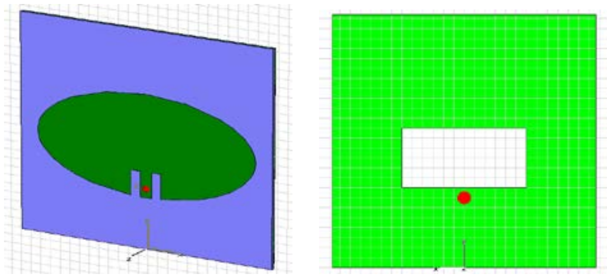
The proposed antenna is composed of a PEC (Perfect Electric Conductor) ground plane, substrate which is RT-Duroid (ε_r = 2.22, h = 0.37 mm) above which a square patch is printed with Coaxial feed line.



(a) (b)

Fig. 2 Top (a) and bottom (b) view of Elliptical patch antenna

The dimensions of the patch are calculated using the standard design equations [14] and optimized to a value of largest side of the octagon is 13 mm , the substrates have dimension 25.4 x 25.4 mm^2, length of the Coaxial feed line is optimized to 10.2 mm with a calculated width of 1.2 mm.



(a) (b)

Fig. 3 Design of microstrip slotted antenna (a) top view with defective ground plane (b) bottom view with defective ground plane

The patch used to make the above structure of dual band antenna to a triple band antenna slotting was done in the patch and a GDS structure was used. A high permittivity substrate will make the metal patch look electrically larger by changing the wave propagation speed; another method used in tuning a microstrip antenna is loading the patch with slots. There are two helpful models that can be used to explain change in resonant frequency as the ground plane used here is defective ground structure (DGS) with dimensions 25.4 x 13 mm^2. Partial ground or defective ground structure is used here, in such a technique named *defected ground structure* (DGS), the ground plane metal of a microstrip (or stripline, or coplanar waveguide) circuit is intentionally modified to enhance performance [15]. The DGS helps in shifting the resonant frequency to get desired frequency [16], by combining with a defective ground plane, the bandwidth is augmented and the resonant frequency is lowered simultaneously [17]. DGS helps in convergence of field in a relatively small region shifting the high frequencies at lower dimensions, ultimately playing a significant role in size reduction.

III. Simulation Results and Analysis

Initial simulations were carried out for the proposed design (Fig. 2) with the optimized dimensions. The initial simulation results of Return loss (S_{11} in dB) were obtained

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for the optimized design; we can observe from the result that there are two frequency bands on the X-band range for which the S11 is observed less than -10 dB. Initial results are quite sufficient to prove the design satisfactory for the purpose.

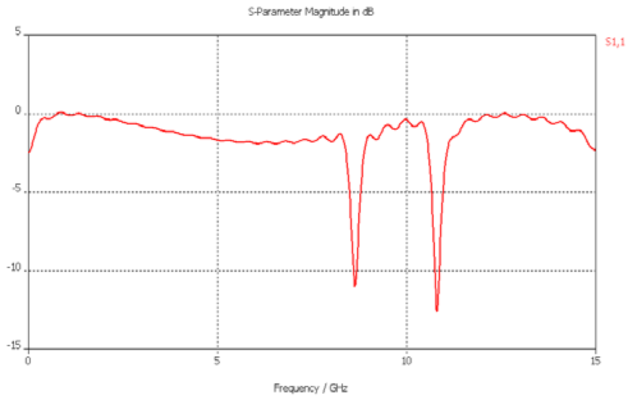

Fig. 4 S_{11} parameter of the proposed dual band design

From return loss results in Figure 3.5 it can be observed that the value of return loss is -13 dB for the second resonance frequency of 10.81 GHz while the first value of return loss comes out to be -11 dB for resonance frequency of 8.64 GHz.

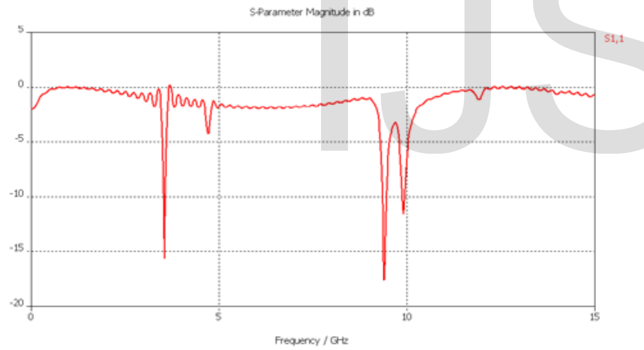

Fig. 5 S_{11} parameter of the proposed triple band design

From the simulation result in Figure 5 it can be observed that the value of return loss is -15.6 dB for the first resonance frequency of 3.6 GHz, while the second value of return loss comes out to be -17.57 dB for resonance frequency of 9.3 GHz, the third resonance frequency of 10 GHz is observed with a return loss of -12dB. Value of return loss is well below -10 dB for all the resonance frequencies which is a good result with communication antenna perspective.

Value of return loss is well below -10dB for both the antennas at all the resonance frequencies which is a good result with communication antenna perspective. A return loss below -10 dB is acceptable for the communication system antennas as it means a radiation of 90% of the incident power.

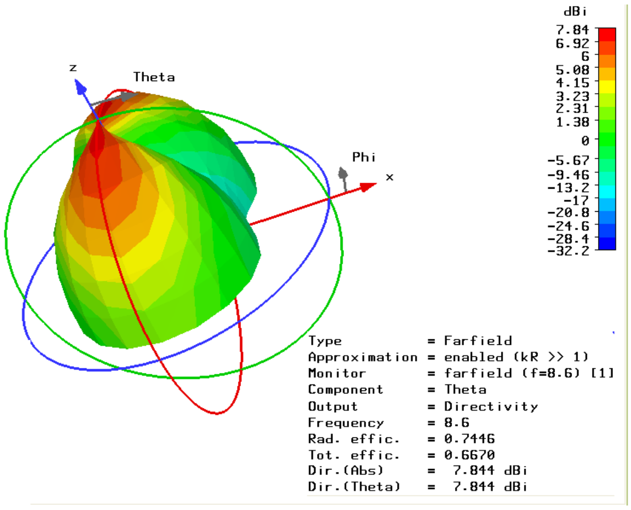

Fig. 6 Fare Field of proposed dual band antenna at 8.64 GHz

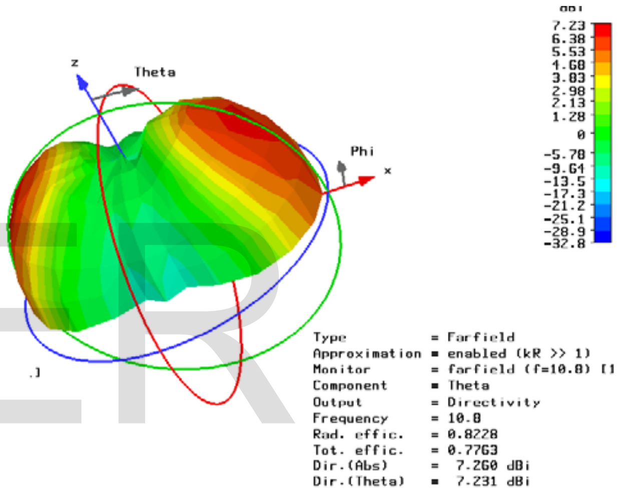

Fig. 7 Fare Field of proposed dual band antenna at 10.81 GHz

The respective radiation patterns for the central frequencies of the two bands i.e. at 10 GHz and 11.6 GHz are shown in Fig. 6 and Fig. 7 and it can be observe from the radiation patterns that the far-field pattern is invariant of the frequency for the dual band antenna.

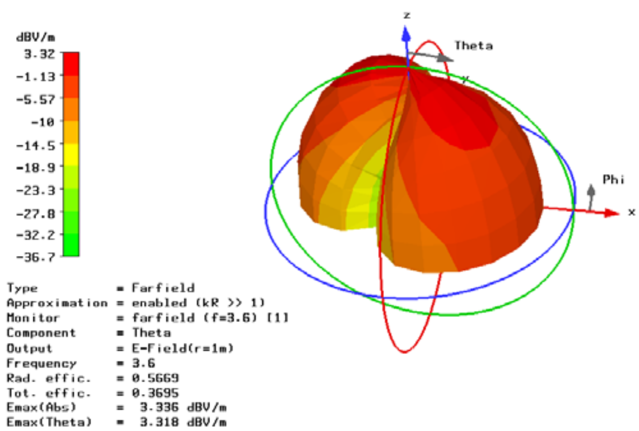

Fig. 8 Fare Field E- Field of proposed triple band antenna at 3.6 GHz

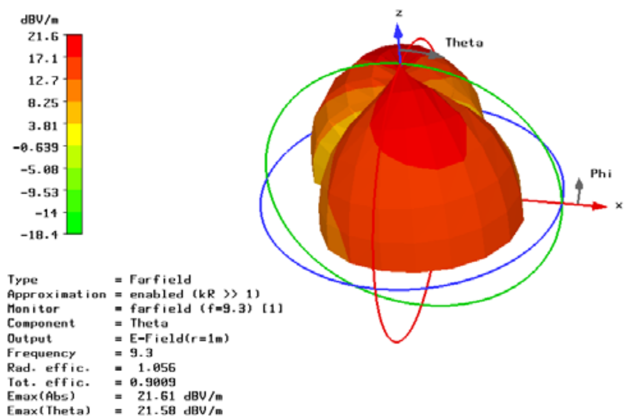

Fig. 9 Fare Field E- Field of proposed tripal band antenna at 9.3 GHz

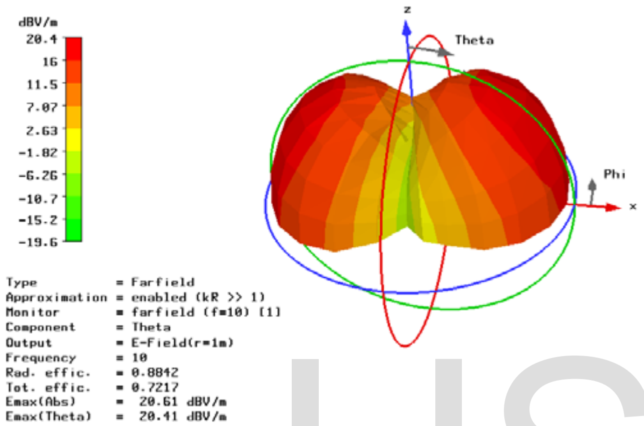

Fig. 10 Fare Field E- Field of proposed triple band antenna at 11.8 GHz

Similar to results of dual band antenna the far field radiation patterns of the triple band antenna here also the direction of radiation is invariant of frequency fig.8-10.

IV. Conclusions

Design, simulation and comparative analysis of slotted microstrip Elliptical patch antenna using defective ground structure presented in this paper come out to be very efficient and utilizable antenna. Initial results draw an interest for study of slotted structure an important technology in designing of compact multiband patch antenna. Slotting and Defective ground structure has a utility in designing the compact antennas; it needs some research and focus to emerge as a milestone in compact antenna technology.

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