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Design & Analysis of Square Micro strip Patch Antenna for BW Enhancement using Symmetrical Cuts

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***Abstract*— This paper presents the design of compact rectangular Microstrip patch antenna for wideband applications. The wideband impedance matching and compact size have been obtained by using microstrip feed technique, symmetrical cuts(fractal concept) and ground optimization .The square patch antenna have been designed and fabricated on FR4 substrate (4.4) with configurations of partial ground planes with rectangular slot under the feed line, on the bottom of the substrate. The proposed antenna offers excellent ultra wideband performance ranging from 4.63 GHz to 14.37 GHz. The antenna exhibits bandwidth of 9.73 GHz. The proposed antenna has been simulated using the commercial software based on Finite Element Method and experimentally with respect to design parameters. The experimental radiation pattern of antenna has been observed nearly Omnidirectional. Such type of antenna can be used for wideband communication system.**

Index Terms- Microstrip square patch antenna, Symmetrical cuts, partial ground plane, monopole, wideband Antenna.

I. INTRODUCTION

Nowadays, wireless communication systems are becoming increasingly popular. However, the technologies for wireless communication still need to be improved further to satisfy the higher resolution and data rate requirements. That is why ultra wideband communication systems covering from 3.1 GHz to 10.6 GHz released by the FCC in 2002 [1, 2] are currently under development. UWB also have wide applications in short range and high speed wireless systems, such as ground penetrating radars, medical imaging system, high data rate wireless local area networks (WLAN), communication systems for military and short pulse radars for automotive even or robotics. [3-7]. The design of wideband antenna is very difficult task especially for hand-held terminal since the compromise between size, cost, and simplicity has to be achieved. In UWB communication systems, one of key issues is the design of a compact antenna while providing wideband characteristic over the whole operating band. Broadband planar monopole antennas have received considerable attention owing to their attractive merits, such as wide bandwidth, simple structure, omnidirectional radiation pattern, and ease of construction [6].There are several fractal monopole antenna with different configurations, such as circular, square, star, elliptical, pentagonal, and hexagonal have been proposed for UWB applications [7-14].

A simpler and effective method by optimizing ground plane with cutting a slot on the ground plane under the feed line has been proposed and studied for bandwidth improvement. [5, 15-20]

Thus, a microstrip-fed monopole antenna is suitable candidate for integration with hand-held terminal owing to its attractive features such as low profile, low cost, and light weight [5]. In this letter, we present a novel compact ultra wideband microstrip-fed printed monopole antenna. To achieve the maximum impedance bandwidth, Symmetrical cuts with slot in partial ground plane under the feed line embedded. Simulated and experimental results are presented to demonstrate the performance of a suggested antenna.

In this paper, a new compact square patch antenna with wide band is proposed for wideband applications. The antenna has advantages of compact size, low manufacturing cost, easy fabrication, low profile, and very small ground plane suitable for integration with compact wideband application systems. The performance of the proposed antenna is characterized in term of impedance bandwidth and radiation pattern.

The antenna consists of a square patch, a partial ground plane with slot and microstrip feed line. This antenna is easy to integrate with microwave circuitry for low manufacturing cost. Optimum dimension of the antenna is obtained by simulating the design.

II. ANTENNA DESIGN

Fig. 1 shows the whole geometry with detailed design parameters of the proposed wideband antenna, which is fabricated on a 1.6-mm-thick FR4 substrate with dielectric constant with ε_r= 4.4 and loss tangent tan δ= 0.02. This antenna is fed by a 50 Ω microstrip line with a width of 2.9mm and length 7.2mm. Furthermore, the overall dimensions of the antenna were merely 27.7 (L) *30 (W) mm, and a ground plane was selected with a length of 7.2 mm and a width of 30 mm.

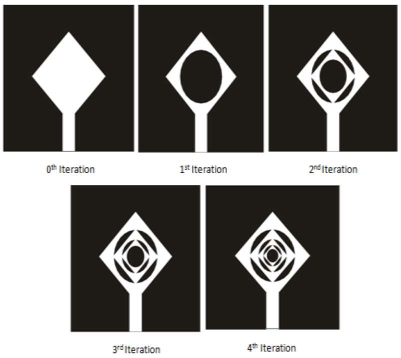
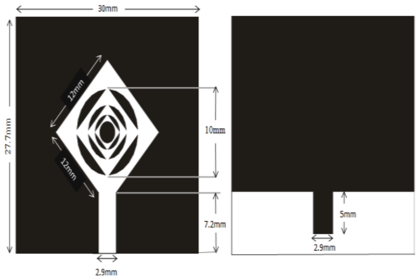


Figure 1: Inscribed Circle Square Patch Antenna With Various Iteration



(a) Front view (b) Back view

Figure 2. Proposed Square Patch Antenna With Dimension

III. ANTENNA SQUARE PATCH GEOMETRY

The iteration wise microstrip square patch antenna was constructed from simple conventional monopole antenna as shown in Figure 1. The solid square monopole antenna has been designed on FR4 substrate ε_r= 4.4, h = 1.6 mm, with width and length are (12*12) mm. This is called the 0^{th} iteration. The 1^{st} iteration of antenna has been constructed by inscribing the circular patch of diameter 10mm inside the square and subtracted it from square. This is called 1^{st} iterative inscribed square circular antenna. The 2^{nd} iteration, 3^{rd} iteration, 4^{th} iteration are constructed by scaling by factor 0.625, 0.4 and 0.25 respectively. The 4^{th} iterative antenna with slit on ground apposite of the feed line has been finalized to design on the same substrate dielectric constant and thickness as conventional microstrip monopole antenna as shown in Figure 2. This antenna has been fed with the microstrip feed line.

The square radiating patch antenna with fractal, feed, a partial ground plane with rectangular slit parameters was optimized to get desired response. Therefore ,the geometric parameters of the proposed structure can be adjusted to tune the return loss and bandwidth over wide range of frequency.

IV. SIMULATED RESULTS

Simulation of both the designs is done over High Frequency Structure Simulator (HFSS) version 13. The simulated results for various parameters like return loss, VSWR, radiation pattern, gain etc., have been obtained from this software.

It is noticed in simulation that the operating bandwidth of the proposed antenna is dependent on iteration number, ground length and length and width of slot. The antenna has been simulated for each iteration. Parameter for maximum bandwidth has been optimized. The fourth iterative proposed antenna with slit in ground has been fabricated called as final antenna. The simulated results of each iteration are shown in Figure 3. It is clear from the Figure 2, as the iterations increase the overall bandwidth increases. The final iterative antenna with slot in ground gives the impedance matching over wide frequency range. Final iteration covers the bandwidth from 4.63GHz to 14.37GHz.

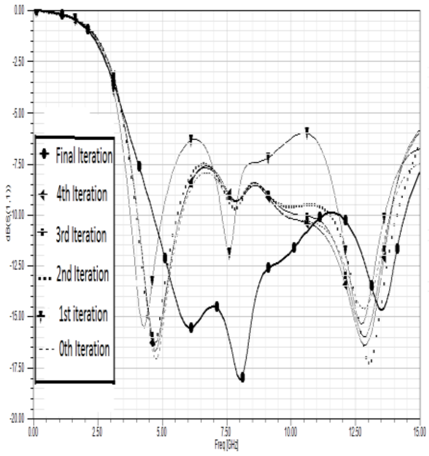


Figure 3. Simulated Result Of Final Iterative Antenna With Respect To Various Iteration.

The proposed monopole antenna has been simulated for various values of ground length. The simulated results have been shown in Figure 4.Ground length is varied by step of 1mm .The shifting in lower resonant frequency is negligible. Ground length at 7.2mm gives good bandwidth.

It is also evidence that this antenna structure does not provide enough impedance matching throughout the band. The impedance matching has been improved by modified the ground and optimizing the dimension of modified ground.

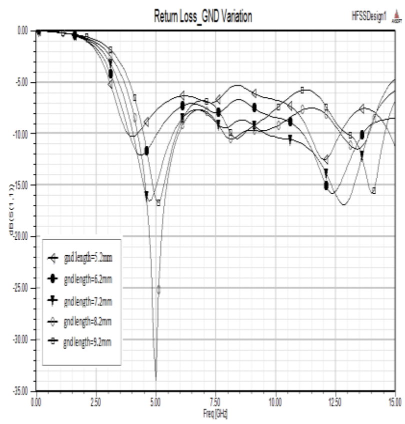


Figure 4. Simulated Results With Various Ground Length

Figure 5. Shows the simulated return loss of the monopole antenna with and without modified ground plane. With modified ground, a drastic improvement in result has been achieved as evidence in Figure 4. Its operating frequency is 4.63GHz to 14.37GHz. The return loss of modified ground has been achieved better than -13dB in the

whole band. Some margin in return loss has been taken because of fabrication constraints and soldering effects. This drastic change in the return loss is because the ground is modified at the position where current density is more. This change in current density due to modified ground brings the change in impedance matching which in turn improves the return loss.

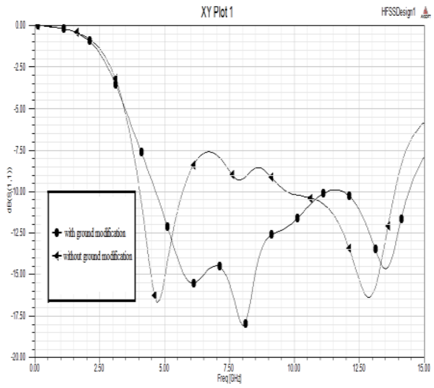


Figure 5. Simulated Result Of Effect Of Slot In Ground.

Figure 6. Show the return loss Vs frequency with respect to variable slot length here slot length is varied by 1mm. Here good overall return loss is obtained at 5mm ground length which is shown in figure.

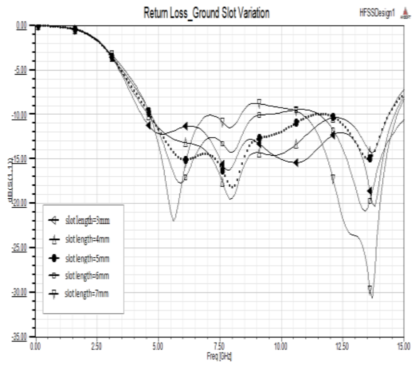


Figure 6. Simulated Results With Various Slot Length Under Feed Line In The Ground

Simulated VSWR (Voltage Standing Wave Ratio) is shown in figure 7. The simulated VSWR defined by VSWR≤ 2 for entire bandwidth from 4.63GHz to 14.37GHz.

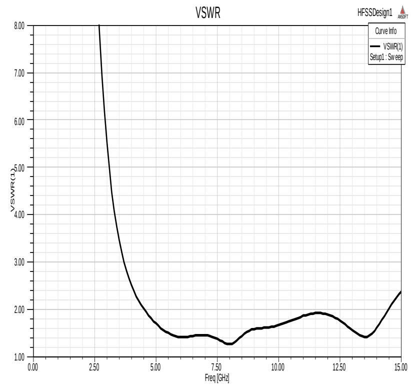


Figure 7. Simulated VSWR For
Final Iteration

Radiation pattern of antenna has been simulated in H and E –plane at selective frequency 5.75 GHz. The simulated radiation patterns for 5.75GHz is shown in Fig.8. It can be seen from the simulated radiation patterns that the nature of radiation patterns in H-plane are nearly Omni-directional and nature in E-plane is dumble shape.

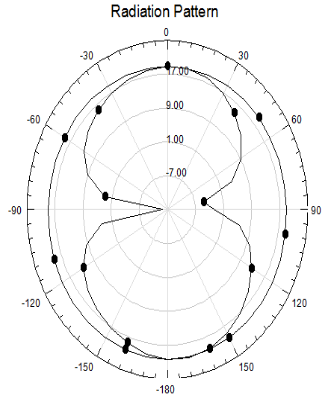


Figure 8.Radiation Pattern At Frequency 5.75ghz

Figure.9. Shows the plot of frequency Vs radiation efficiency (%).Designed antenna is near about 90% efficient over all the frequency range.

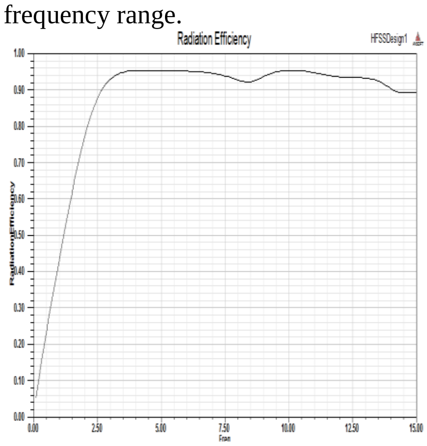


Figure 9.Radiation Efficiency (%).

V. EXPERIMENTAL RESULTS

The proposed antenna fabricated with optimized parameter. The photograph of the proposed fractal antenna is shown in Figure 10. The measured results of proposed fractal antenna shown in Figure 10. The antennas have been tested using vector network analyzer R&S ZVA 40. The experimental results of proposed fractal antenna on the Vector Network Analyzer exhibits the excellent ultra wide impedance bandwidth from 5.125 GHz to beyond 13.5GHz.The measured return loss versus frequency of this fractal antenna has been shown in Figure 11. and measured VSWR Shown in Figure 12.

(a)Front view (b)Back view

Figure 10. Fabricated Antenna

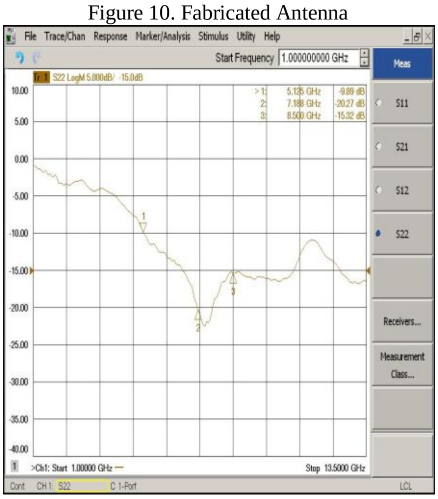


Figure 11. Experimental Return Loss Versus Frequency

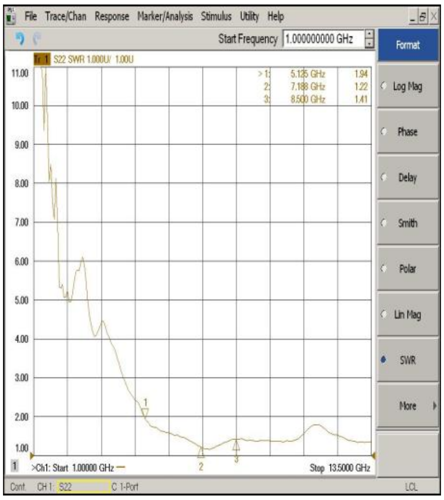


Figure 12. Experimental VSWR

VI. CONCLUSIONS

The proposed monopole antenna has a wide operating frequency band of 5.125 GHz to beyond 13.5GHz and (VSWR < 2). It is observed that the radiation patterns of antenna in H-plane is Omni-directional and E plane is dipole-like radiation pattern over the entire operating band width. The proposed antenna design is compact, low profile, low cost easy to manufacture and integrate with RF devices and offers very large impedance bandwidth required for next generation application. The use of microstrip feed line makes the design easy and more suitable for impedance matching and fabrication. Parametric studies are also presented to show the effects of different parameters on the antenna design. The measurement results have shown a good agreement with the simulation ones. Such type of antenna can be useful for UWB systems well as suitable for various military and commercial wideband applications.

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