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Design and Simulation of Microstrip Patch Antenna for UWB Applications

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Abstract: This paper presents the design of microstrip rectangular patch antenna with center frequency at 3.8 & 5GHz for WiMAX & WLAN application. The antenna with microstrip line feeding technique was designed and simulated using Computer Simulation Tool (CST) Microwave Environment software. The antenna designed on Roger4004substrate with overall size of 30x40 x 1.59 mm3 and dielectric substrate with $\varepsilon_r = 4.4$. This antenna structure isdesigned by using CST Software based on the characteristic impedance for the transmission line model. The performances of designed antenna are compared in terms of parameters like substrate dimension, feed size and ground plane. The antenna performance in terms of its frequency domain and time domain characteristics are investigated.

Keywords: CST Microwave Studio, UWB, WiFi, WiMax, Simulation, Microstrip Line Feed, microstrip Antenna, Omni-directional patterns.

I. INTRODUCTION

Recently, the development of communication technology is highly increased and indicating still continues to grow, not least with a wireless communication system. Not only making advanced technology increases, the wireless communicationsystems such as WiFi (Wireless Fidelity) and WiMAX(Worldwide Interoperability Mobile Access) as well as their services applications are very popular in everyday life with a variety of advantages, such as to provide communication services at anytime and anywhere for the users. Those phenomenon's can be seen by the increasing demand forcellular phone service, wireless internet access, teleconference .These days, there is a very large demand by the end user for integrated wireless digital applications. Antennas whichare used in these applications should be low profile, lightweight, low volume and broad bandwidth [1]. To meet theserequirements, microstrip antenna is preferred. An antenna should be low-profile, comfortable to planar and nonplanar surfaces, simple andinexpensive to manufacture, mechanically robust whenmounted on rigid surfaces [2]. A microstrip patch antenna basically consists of the following sections:

- A radiating patch (perfect electric conductor - PEC)
- Substrate (dielectric material of permittivity ε_r)
- Ground plane (perfect electric conductor - PEC)

The radiating patch is on one side of a dielectric substrate which has a ground plane on the other side.The patch is generally made of conducting material such as copper or gold. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. When the particular patch shape and mode are selected they are very versatile in terms ofresonant frequency, polarization, pattern and impedance.Presently wireless communication isthe fastest growing segment of the communication field. There are many government and commercial applications such as mobile radio, Satellite communication and Wireless communication where weight, size, cost, performance, ease of installation, aerodynamics profile are major constraints. The vision of the wireless communication supporting information exchange between people and devices is the communication frontier of the next few decades. This vision will allow multimedia communication anywhere in the world. In the today's environment, technology demands antennas which can operate on different wireless bands and should have different features like low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. Microstrip single antenna has several advantages, it also hasseveral disadvantages such as low gain, narrow bandwidthwith low efficiency. These disadvantages can be overcomeby constructing many patch antennas in array configuration.In this paper, the design of single microstrip rectangular antennas with microstripline as feeding method is presented. Quarter-wavetransformer is used to match the feeding line to theantennas. The center frequency is determined to operate at 3.8 GHz & 5GHz which is suitable for UWB application. The antenna designed on the substrate type Roger4004 with dielectric constant of 4.4 and thickness of1.6mm. This antenna offers a return loss of -40dB . More significantly, as per the rigoroussimulation study using CST microwave studio, the antenna perform the single patch antenna interms of radiation gain, directivity and bandwidth.

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II. ANTENNA GEOMETRY AND SIMULATION RESULTS

A. Antenna Geometry:

Fig. 1 illustrates the evolution of the proposed Microstrip Antenna on the Roger4004 substrate.

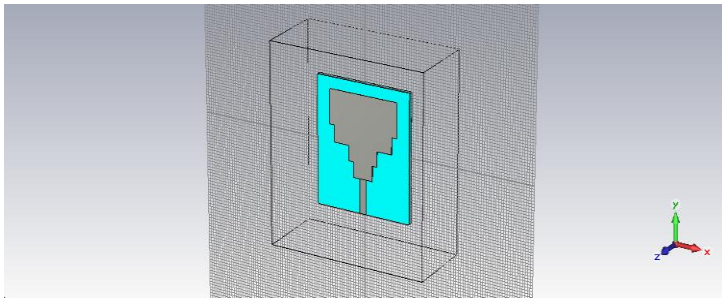
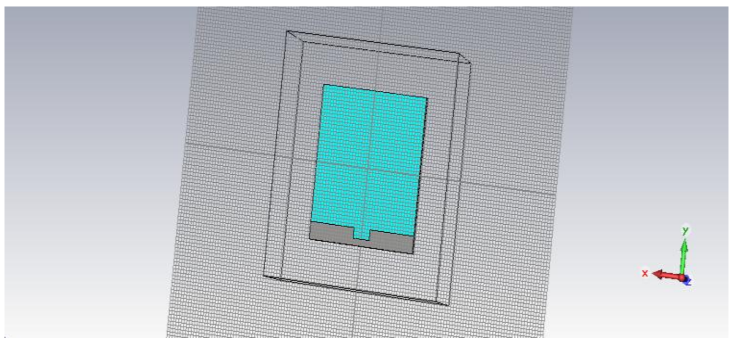


Fig. 1 The proposed Microstrip antenna array
(a) Simulation Model



(b) Ground Structure of Antenna

Table-I Antenna Array Parameter

Sr.No	Description	Value/mm
1	Antenna Length	30 mm
2	Antenna width	40 mm
3	Width of the ground plane	5mm
4	Feed Size (Width)	3 mm

B.Impedance Bandwidth

Fig.2 shows the simulated return losses (S parameter) of the antenna has a multi-band characteristic in the UWB spectrum. Three resonant frequencies locate at about 3.8GHz and 5GHz with the return losses reach -30dB, and -40dB respectively. The ground plane size selection is also based on the study presented in [3], [4] on the microstrip slot antennas.

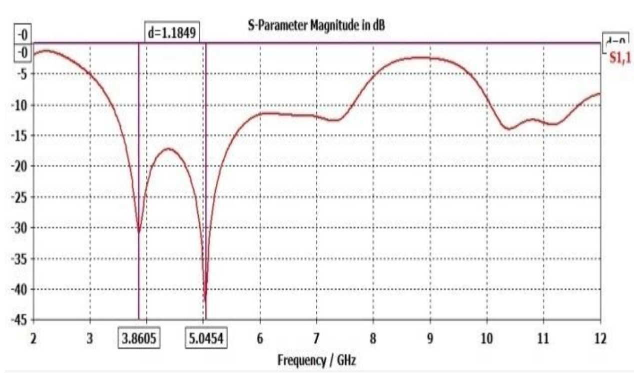


Fig.2.The reflection coefficient (S11, dB) versus frequency (GHz) plot for antenna design.

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III. SMITH CHART PLOT

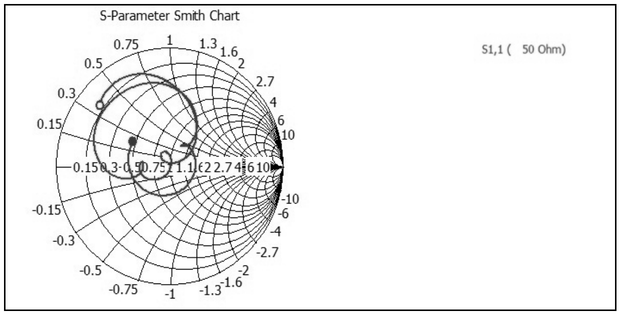

Figure 3:-Smith chart plot (microstrip linefeed) for simulated antenna design

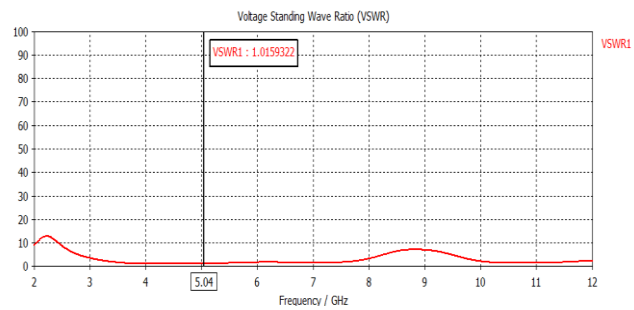

Figure.4 VSWR Plot

IV. EFFECT OF PARAMETER VARIATION ON ANTENNA PERFORMANCE

Substrate permittivity (ε_r) Variation :In this case there is comparisons of return loss with the variation in the permittivity of the materials. On decreasing the dielectric constant of substrate , the bandwidth increases as shown in figure below:

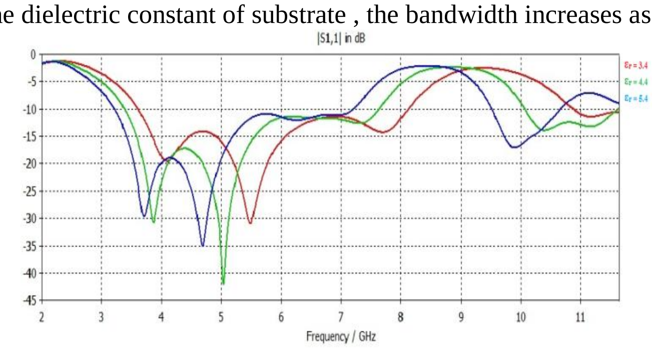

Figure 4 – Effect of substrate permittivity (ε_r) on antenna performance characteristics

Effect of ground size width: On increasing the ground size width, the return loss between the resonant frequencies increases but at a specific value of ground width there is a impedance matching at this value min. return loss is achieved and the proposed antenna provides the effective result.

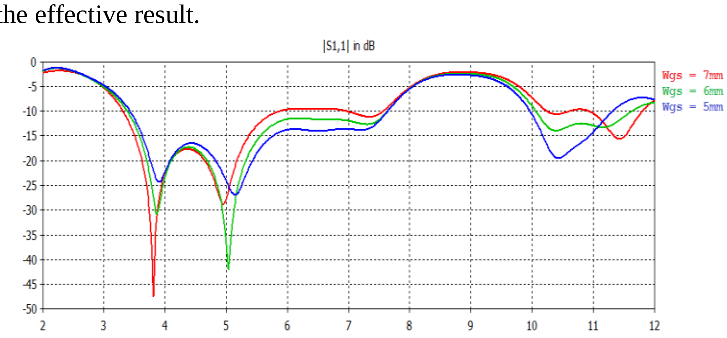

Figure 5: Effect of ground size variation on the antenna performance

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Feed width (Wf) Variation : On increasing the feed width (Wf), the bandwidth increases and return loss decreases as shown in figure below:

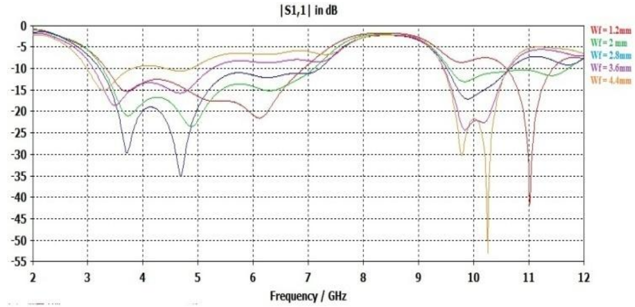
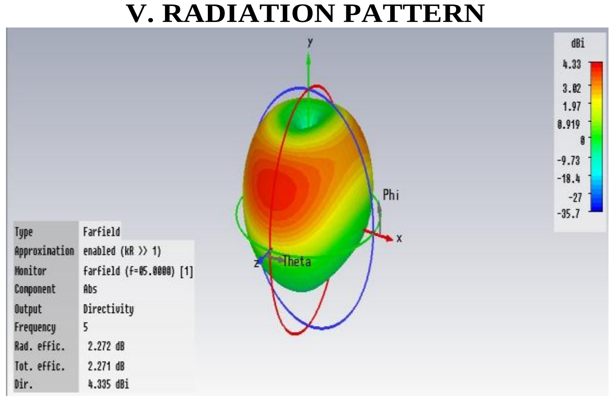
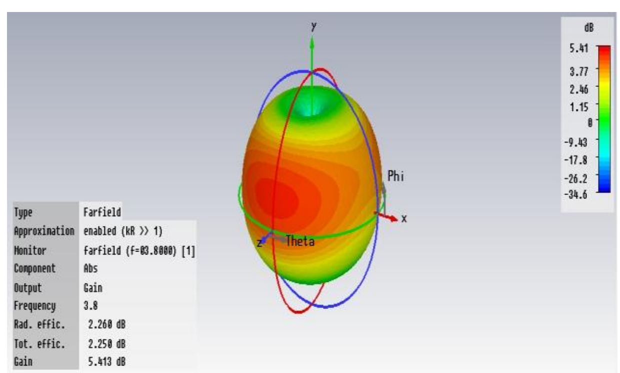


Figure 6 – Effect of feed width (ε_r) on antenna performance characteristics

V. RADIATION PATTERN





VI. CONCLUSION

A microstrip rectangular patch antenna that feed by microstrip line has been designed, simulated and compared with the single rectangle antenna. The performance was measured and it shows that the array antenna outperform the single antenna in terms of directivity, bandwidth and gain. The final antenna design was than fabricated and the performance was than compared with the simulated antenna. Overall, the performance of the antenna meets the desired requirement in terms of return loss and VSWR. The simulation return loss is equal to -30 dB & -40 dB at the freq. of 3.8 GHz & 5GHz respectively. Adding to this, the performance ofthe microstripantenna strongly depends on several factors such as feeding technique, type of substrate, the thickness and dielectric constant of substrate respectively Although there were some side lobes for the radiation pattern of microstrip antenna due to the use of array structure, however in general the performance of array antenna has accomplished the specifications required byUWB application.The feed size of antenna is inversely proportional to the port impedance. The dimension of the microstrip antenna also has an impact on the antenna performance because the current is mainly distributed along the edge on the radiator. In a broad sense, the ground plane of the antenna design perform operation as an impedance matching circuit, and it tunes the input impedance and hence changes the operating bandwidth with variation of antenna feed size[10].

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