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Microstrip Antenna Design for UWB Applications

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Abstract: This paper presents the design of microstrip circular patch antenna for UWB application. This antenna was designed on Fr4 with overall size of 31.17 x 40 x 0.787 mm^3 and dielectric substrate ε_r = 4.4. This antenna operated at UWB frequency and it designed by using CST Software.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, Simulation, Microstrip line feed, microstrip antenna, Omni-directional patterns.

I. INTRODUCTION

Ultra wideband technology is as a system that occupied over 500Mhz of bandwidth or occupy a fraction bandwidth of 20%or greater Based on the antenna point of view, UWB technology covers today three major types of applications (a) Ground Penetrating Radars (GPR, 1MHz to 10 GHz), (b) Signal intelligence and detection and (c) modern UWB operating in a 3.1 to 10.6 GHz frequency band [1]. A Ultra Wideband technology is defined as a system that occupied over 500MHz of bandwidth or occupy a fractional bandwidth of 20% or greater. Ultra Wideband uses radio modulation technique to achieve a wide bandwidth by transmitting very short pulses (in nanosecond or less) with very low power utilization. This makes Ultra Wide band differs from conventional narrowband systems.Ultra wideband uses radio modulation technique to achieve a wide bandwidth by transmitting very short pulses (in nanosecond or less) with very low power utilization. This makes Ultra Wide band differs from conventional narrowband systems .Microstrip patch antenna is one of the most common antenna used telecommunication due to their low profile structure. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Photo etching and press machining are the lowest cost technologies made Printed antenna technology is suitable for low cost manufacturing in a mass productions. These days, there is a very large demand by the end user for integrated wireless digital applications. Antennas which are used in these applications should be low profile, light weight, low volume and broad bandwidth [1]. To meet these requirements, microstrip antenna is preferred. An antenna should be low-profile, comfortable to planar and non planar surfaces, simple and inexpensive to manufacture, mechanically robust when mounted on rigid surfaces[2]. When the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern and impedance. In this paper, the design of microstrip circular antenna with microstrip line as feeding method is presented. The microstrip antenna designed on the substrate type Fr4 with dielectric

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constant of 4.4 and thickness of 0.787mm. This antenna offers a return loss of -55 dB . More significantly, as per the rigorous simulation study using CST microwave studio, the microstrip patch antenna perform in terms of radiation gain, directivity and bandwidth.

2.ANTENNA GEOMETRY AND SIMULATION RESULTS

A. Antenna Geometry:

Fig. 1 illustrates the evolution of the proposed Microstrip Antenna on the Fr4 substrate.

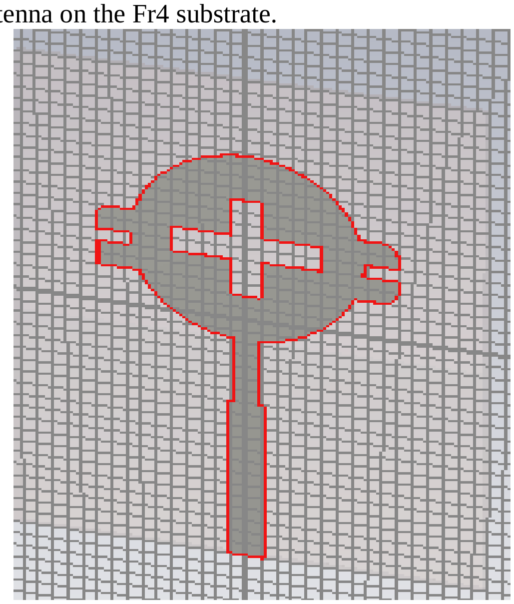

Fig. 1 The proposed Microstrip antenna simulation Model

Table-I Antenna Array Parameter

Sr.No	Description	Value/mm
1	Antenna Length	40mm
2	Antenna width	31.17 mm
3	Width of the ground plane	15.585 mm
5	Substrate thickness h	0.787 mm
6	Feed Size (Width)	2.48mm

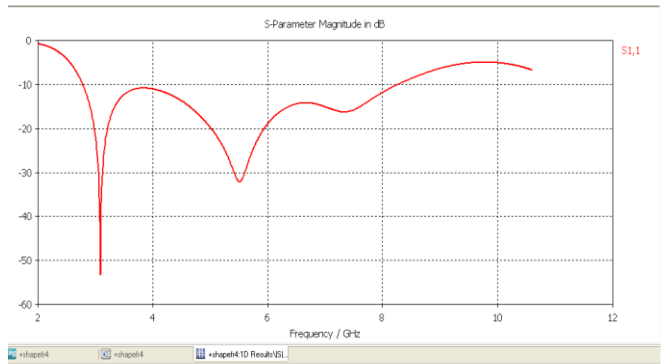

Fig.2.The reflection coefficient (S11, dB) versus frequency (GHz) plot for antenna design.

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 3.1GHz and 5.5 GHz with the return losses reach -55dB and -30dB respectively. The ground plane size selection is also based on the study presented in [3], [4] on the microstrip slot antennas.

3. Smith Chart Plot

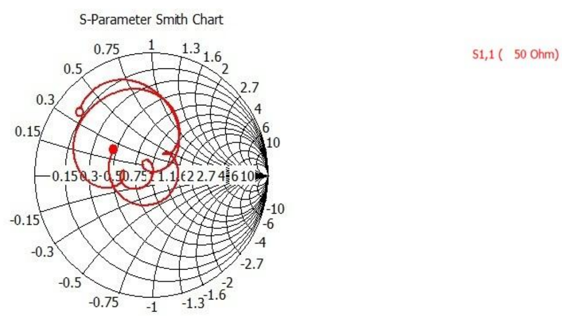

Figure 3:-Smith chart plot (microstrip line feed) for simulated antenna

4. Effect of Parameter variation on Antenna Performance*:*

Substrate material Variation: In this case there are comparisons of return loss with the variation in the materials of substrate. In this investigation of effect generally Roger 3006, Roger 6006 & Fr4 are considered. From the result it is to be observed that Fr4 provides the min. return loss as compared to the Roger 3006 and Roger6006. So Fr4 is considered as a suitable material for the proposed antenna design. With the use of Fr4 as a substrate material the bandwidth increases as shown in figure below:

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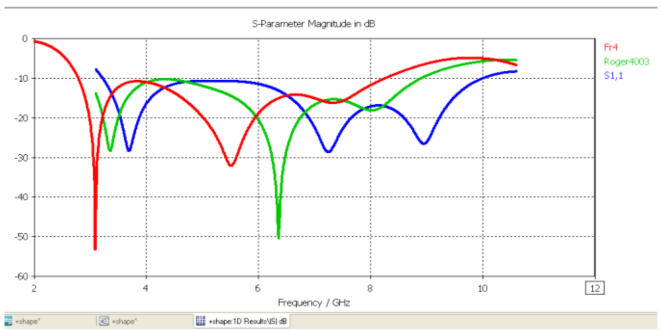


Figure 4: Effect of substrate material on the antenna performance

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[5] as shown in figure below:

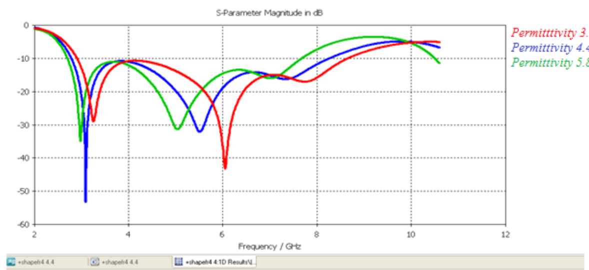


Figure 5 – Effect of substrate permittivity (ε_r) on antenna performance characteristics

Effect of ground size width: On increasing the ground size width, the return loss between the resonant frequencies increases[6] 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.

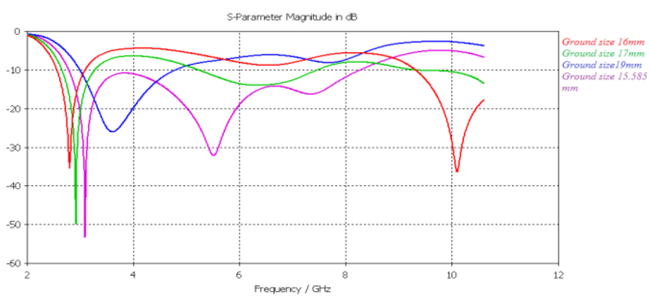


Figure 6: Effect of ground size variation on the antenna performance

Feed width (Wf) Variation : On increasing the feed width (Wf), the bandwidth increases[7] and return loss decreases as shown in figure below:

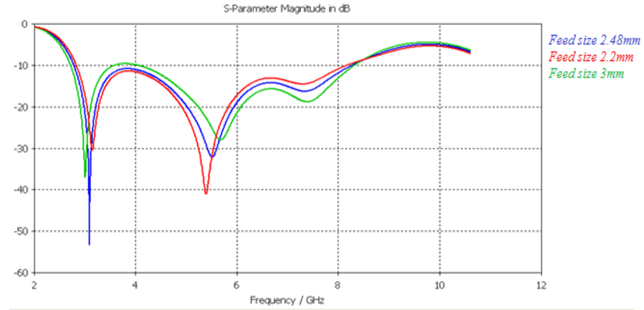


Figure 7 – Effect of feed width (ε_r) on antenna performance characteristics

Slot effect: At some specific value there is impedence matching and at this value min. Return loss is achieved as shown in figure below:

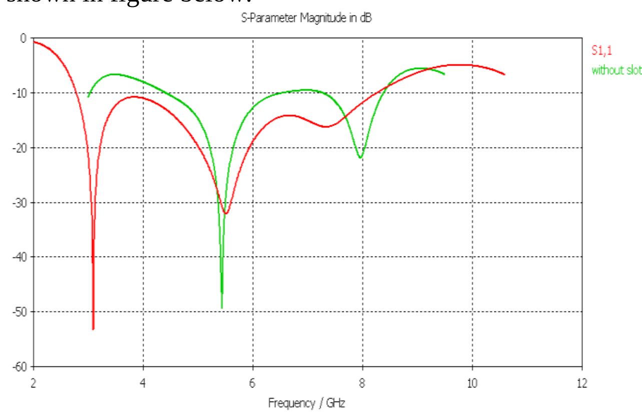
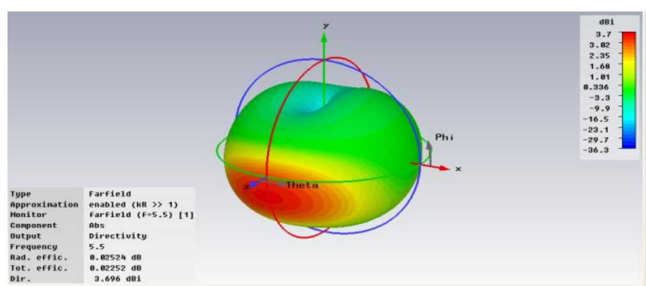


Figure 8 – Effect of slot on radiator on antenna performance characteristics

5. Radiation Pattern



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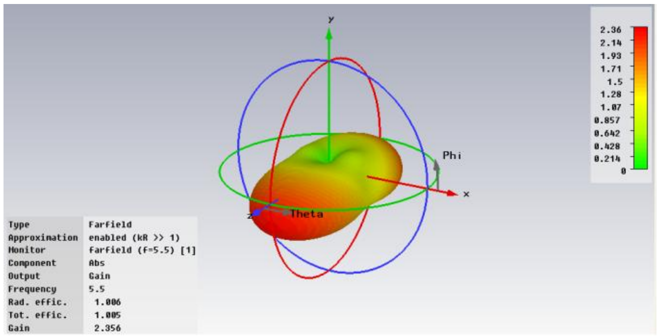

Figure 6.12 & 6.13 – Radiation pattern 3D plot (showing directivity & gain) at resonant frequency

6. CONCLUSION

In this paper, a circular patch antenna with slot on the radiator is designed and simulated. It operates in the frequency range of 2.7 GHz to 8.2GHz. The slot on the radiator is used to reduce antenna size [8] and decrease the resonant frequency to lower frequencies. The antenna has suitable size and omni-directional radiation pattern which allow us to use it for UWB applications. Overall, the performance of the antenna meets the desired requirement in terms of return loss and VSWR. The simulation return loss is equal to -55 dB & -30 dB at the freq. of 3.1 GHz & 5.5 GHz respectively. Adding to this, the performance of the microstrip antenna strongly depends on several factors such as feeding technique, type of substrate, the thickness and dielectric constant of substrate respectively. 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[9]. 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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