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Simulation and Parametric Analysis of Wideband Antenna for Ultra Wideband Application

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Abstract: This paper proposes a modified wideband corner truncated wideband antenna using semi elliptical ground plane for ultra wideband wireless application.These microstrip patches are excited using microstrip line feeding technique.To improve the gain performance quadrature portion of the circle part is removed both upper and lower edge corners and adding triangular slot is etched the ground plane model using defected ground structure (DGS).Afterthat truncate the diagonal corners for circular polarization and also improve the gain performance.It is designed in variety of shapes in order to obtain enhanced gain,directivity and bandwidth.The resonant frequency is 6.85 GHz and the flame retardant (FR4) substrate is used with dielectric constant 4.3 and thickness about 1.6 mm..During simulation process the gain, s-parameter, radiation pattern, vswr and directivity of proposed wideband antenna has been obtained.The feed network is designed and optimized using Computer Simulation Technology(CST) to cover a frequency range is 3GHz to 12GHz.

Index terms: Microstrip patch antenna · Defected Ground Structure · Microstrip line feed · Circular Polarization

Key words: Circular Polarization · Axial ratio · Microstrip patch Antenna · Microstrip line feed

INTRODUCTION

In present scenario wideband circularly polarized microstrip patch antennas are attracting much attention in wide range of wireless communication systems such as radar,satellite and bio-medical telemetry systems.These applications have become possible due to their many intresting features including compact in size, low profile, light in weight, ease of fabrication and integration with their microwave components.The major drawback of microstrip patch antennas are their very narrow bandwidth so the research has been carried out to enhance the gain and impedance of the patch antennas by keeping the size of the patch antenna as soon as possible.A microstrip patch antenna a is a group of multiple active antennas coupled to a common source or load to produce a directive radiation pattern and gain.The circularly polarized microstrip patch antenna used as effective radiators in many communication systems. These patch antenna has high gain,better efficiency and good radiation pattern.The commercial use of the ultra wide band frequency range is 3GHz to 12GHz.

Generally FR-4 substrate, is widely used to design a wideband antenna.The thick substrate designs described in this paper retain the advantages of simplicity and smaller size [1-3].

For increased bandwidth of a patch antenna a thicker substrate is used and therefore it requires a microstrip line feeding technique.

The single fed type has the simplest structure.It does not require external circuitary to excite circular polarization.The ultra wide band technology are choosen for the purpose of highly secured, low cost and low complexity.It is used in various applications like radar,airbone and military communication.There are various methods are used to improve the gain performance.The antenna was initially developed two orthogonal dipoles with different lengths.Incase of any demand for circular polarization band parasitic elements were employed to produce additional circular polarization so the structure gets complexity.

This planar ultra wide band antenna consists of a rectangular patch etched on flame retardant (FR-4) substrate with 50 ohm feed line.The rectangular patch has

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one round cut at each corner with one slot in the ground plane.This is achieved by adding slots with different shapes in the patch,feed and ground plane or using defected ground structure(DGS).The measurement results agree with a slight shift in the lower and upper and edge frequency[4].

This paper is organized as follows. In section II design equations of the antenna is introduced. In section III detailed analysis of the design model is done and results are observed..Section IV concludes the paper.

Design Parameter: Basic Patch Antenna Design and Geometry: In its most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in figure 1.

The basic design of rectangular microstrip patch antenna is considered here.

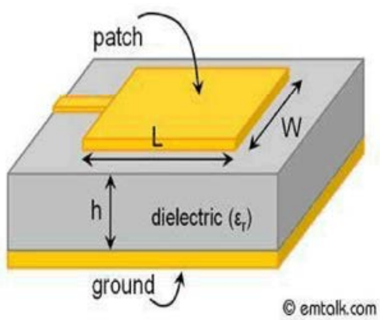

Fig. 1: Basic microstrip patch antenna

Antenna Design: The conventional microstrip antenna design method is used here. Designing the patch antenna is to employ the following equations (1-4):

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

where c-Free space velocity of light,3x10^8
fr-Resonant frequency
εr-Dielectric constant

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-0.5} \tag{2}$$

$$\Delta L = 0.412\frac{h(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)} \tag{3}$$

$$f_r = \frac{c_o}{2L\sqrt{\varepsilon_{reff}}} \tag{4}$$

c_o -speed of the light
fr=resonance frequency

$$BW=2(fh-fl)/(fh+fl) \tag{5}$$

fh-higher cut off frequency
fl-lower cut off frequency

The design of wideband microstrip patch antenna with microstrip line feed has three layers together with the bottom layer incorporating to the ground layer and the substrate layer is the middle layer.This layer consists of FR4 substrate.The top layer is the conducting patch layer.The annealed copper material used as a conducting material.Since a microstrip line feed is in corpotrated a triangular slot is introduced in the partial semi elliptical ground plane.

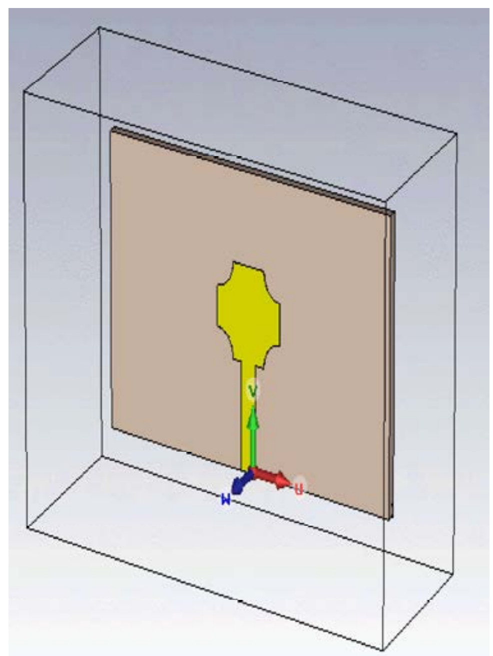

Fig. 2: Perpective view of wideband antenna

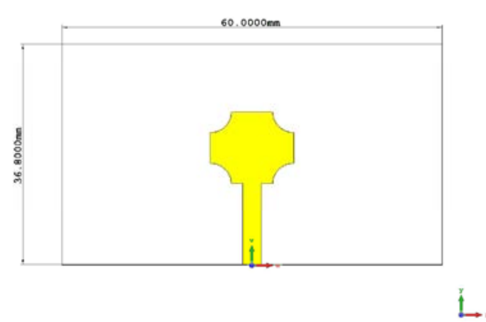

Fig. 3: Topview of the wideband antenna design

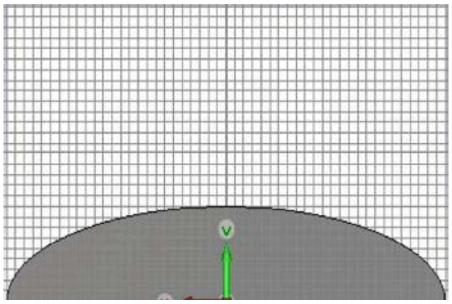

Fig. 4: Bottom view of the wideband antenna

The figure 3 shows that the quarter circle part is removed from the four corners.To enhance the gain performance using semi elliptical ground in the bottom plane..The copper material used a conducting material and it thickness which is used to this material is 35micron.The radius of the edge corner is 3mm.The same FR4 substrate is used.

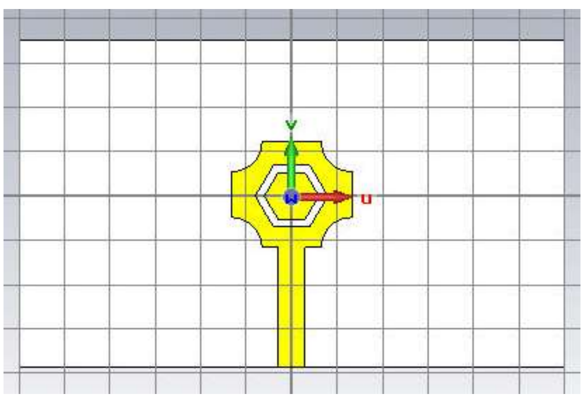

Fig. 5: Hexagonal slot of proposed wideband antenna.

Simulation Results

A Return Loss Plot of Wideband Antenna: Return loss is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line.The return loss is used in modern practise because it has better resolution for small values of reflected wave.The observed return loss is -24dB,-15dB and -14dB respectively at the two frequencies respectively as shown in the figure.6 shows the behavior of the S_{11} parameter or the input reflection coefficient over a range of frequencies.

B Voltage Stanging Wave Ratio: The figure 7 represents the voltage standing wave ratio(VSWR) at the frequency range is 2GHz to 12GHz and it represents the 2-dimensional graphical representation. In general if the

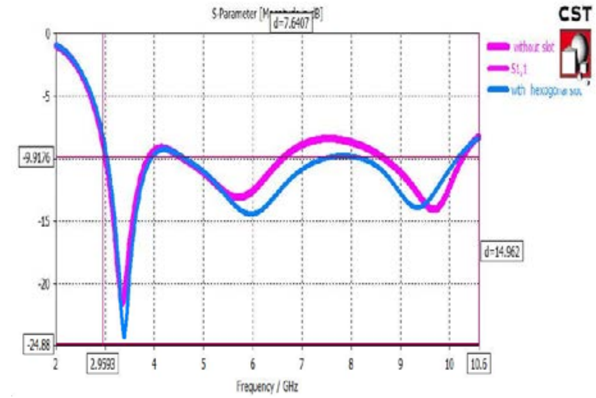

Fig. 6: Return loss plot of wideband antenna design

voltage standing wave ratio range is 1 to 2 the antenna match is considered very good and little would be gained by impedance matching.The vswr plot is a measure that conveys how well the systemis matches and how much of energy is getting into the antenna.The voltage standing wave ratio range(VSWR) when it is observed to be low also conveys that it is good for amplifier load effects.

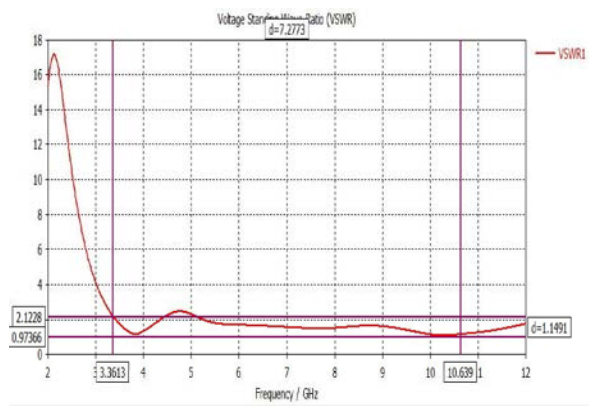

Fig. 7: vswr plot of proposed wideband antenna design

C E-Field Pattern of Wideband Antenna Design: The electric field or "E" plane determines the polarization or orientation of the radio wave. For a vertically polarized antenna, the E-plane usually coincides with the vertical/elevation plane. For a horizontally polarized antenna, the E-Plane usually coincides with the horizontal/azimuth plane. E- plane and H-plane should be 90 degrees apart.The figure 9,10 and 11 shows the E-field pattern of wideband antenna at 5.7GHz,7GHz and 7.40GHz.

D H-Field Pattern of Wideband Antenna Design: The magnatizing field or "H" plane lies at a right angle to the "E" plane. For a vertically polarized antenna,

Table 1: Parameter Measurements

FREQUENCY(GHz)	5.7	6.1	7.1	7.4	8	8.2	9.4	9.6	10.4	10.7	11.9
GAIN(dB)	3.36	3.23	3.43	3.71	4.76	5.07	5.84	5.77	4.89	5.72	5.79
DIRECTIVITY(dBi)	4.48	4.2	4.6	5.00	5.45	5.78	7.09	7.07	6.14	6.54	7.0
AXIAL RATIO(dB)	2.75	3	2.8	2.5	2.95	2.98	2.43	2.67	2.96	2.98	2.69

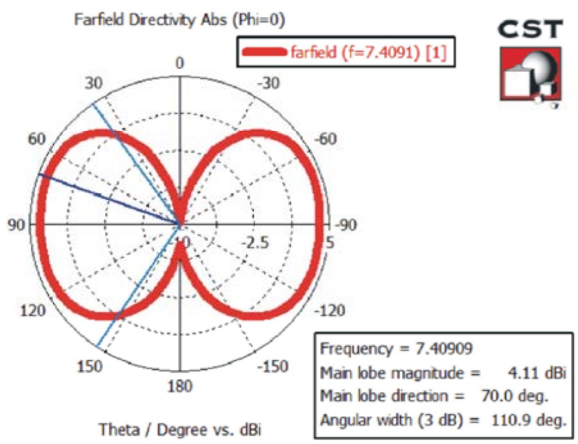

Fig. 9: E-field pattern at 7.0GHz.

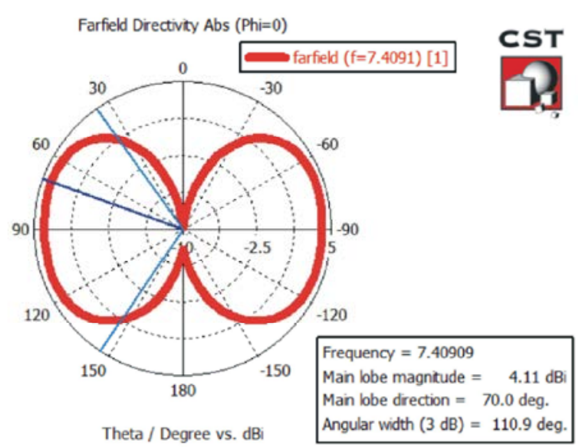

Fig. 10: E-field pattern at 7.4GHz,

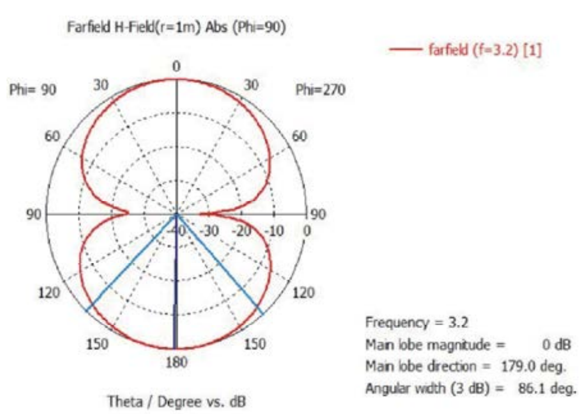

Fig. 11: E-field pattern at 8.66GHz,

the H-plane usually coincides with the horizontal/ azimuth plane. For a horizontally polarized antenna, the H-plane usually coincides with the vertical/elevation plane.The Figure 5.19 and 5.20 shows the H-field pattern of wideband antenna at 3.2GHz and 8.66GHz respectively.

E Directivity: This is an important measure because most emissions are intended to go in a particular direction or atleast in a particular plane(horizontal or vertical) emissions in other directions or planes are wasteful(or worse).Here the directivty is observed to be around 6.85db for the frequency 8.66GHz.The figure 12,13 and shows the directivity radiation plot of 7.4GHz,8.4GHz and 10.6GHz.The table 1 shows the parameter results of wideband antenna.

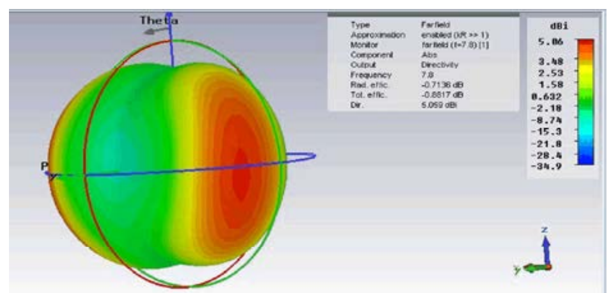

Fig. 12: Directivity pattern at 7.4GHz

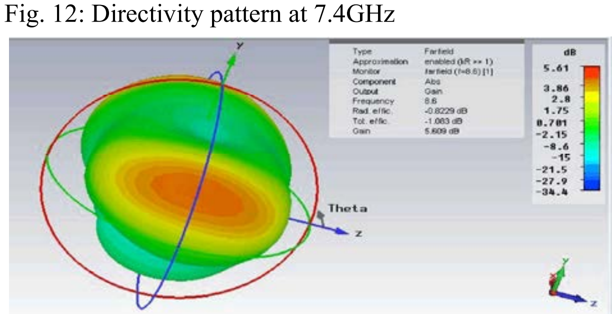

Fig. 13: Gain plot of wideband antenna at 8.6 GHz

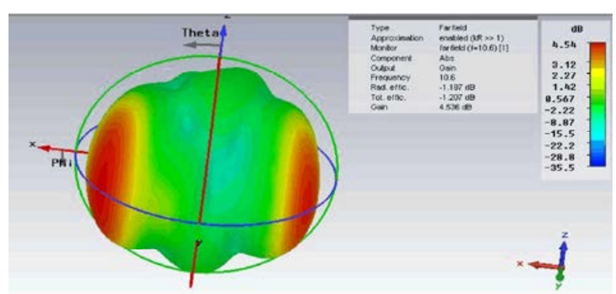

Fig. 14: Gain plot of wideband antenna at 10.6 GHz

IV Fabrication and Testing Results:

A Fabricated Wideband Antenna: The proposed wideband patch antenna design is fabricated and the design optimizations are carried out to further enhance the performance parameters of the project and tested.The measured resullts are then compared with the simulation results.The figure 15 and 16 shows the topview and bottom view of the fabricated antenna.

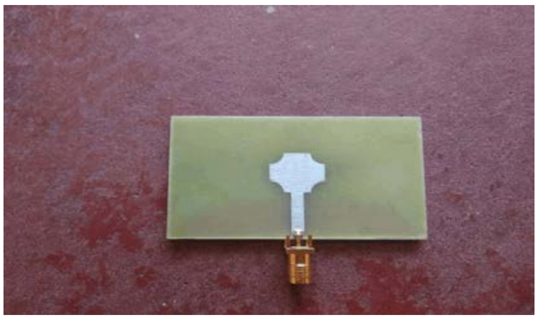

Fig. 15: Structure of the proposed wideband antenna design

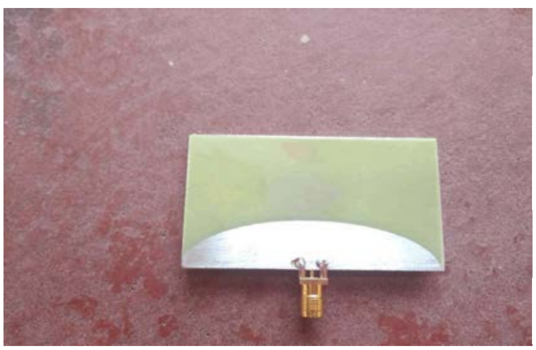

Fig. 16: Bottom view of the proposed wideband antenna design

Fig. 17: Measurement return loss plot of proposed wideband antenna design

B Voltage Standing Wave Ratio: The figure 18 shows the measured voltage standing wave ratio is found to be 1.6,1.05 and 1.30 for the 3.0GHz,5.4GHz and 7.2GHz respectively.

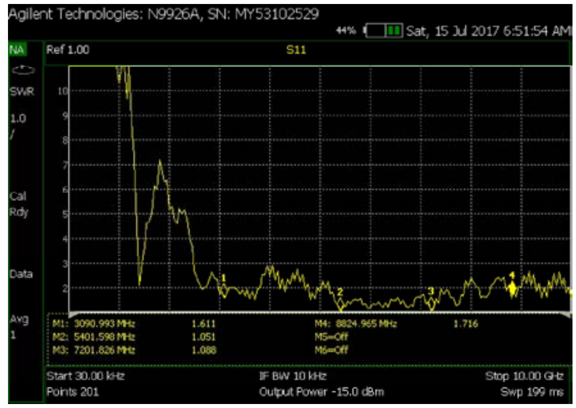

Fig. 18: Voltage standing wave ratio plot

CONCLUSION

In this project a wide band antenna is proposed incorporated into a single patch and single feed mechanism.The proposed wideband antenna design is fabricated and the design optimizations are carried out to further enhance the performance parameters of the project and tested.The measured results are then compared with the simulation results.The proposed patch yield desirable results throughout the operating frequency range.When comparing to the microstrip antenna which gives wide bandwidth and the wide band antenna provides improved bandwidth and Axial ratio. Above the antenna was found to produce a gain of around 7.84 dBi and the maximum directivity value 6.99dBi.The proposed antenna is designed for wideband at the frequency range is 3GHz to 12GHz performs well in ultra wideband wireless application.

Future Work: The substrate thickness has to be increased in order to obtain high gain and improved bandwidth. But increasing the substrate thickness produces surface wave loss and extraneous radiations.So to reduce the substrate thickness.In future adding additional array structure to improve the bandwidth. So the length and the breadth of the patch can be further adjusted to reduce the resonant frequency of operation to this range.

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