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A Brand New Compact CPW Fed Slot Antenna for UWB Applications

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Abstract— **Design and analysis of a brand new coplanar waveguide (CPW) fed ultra wideband (UWB) slot antenna is bestowed during this paper. The proposed antenna is straightforward, compact and low cost. The overall dimension of the antenna is 28×21×1.6 mm3 and fed by 50* coplanar wave guide. The parametric analysis of the antenna is finished by using mom based mostly commercially available electromagnetic solver IE3D. The projected antenna is developed and it's measured come back loss is compared with the simulated result. The measurement is in sensible agreement with the simulation and also the antenna offers glorious performance for UWB range from 3.1 GHz to 1.4 GHz exhibits a -10 dB return loss (VSWR <2) with fractional bandwidth of 114%. The projected antenna provides bidirectional pattern within the E Plane and Omni directional radiation pattern within the H Plane. During this paper the time domain analysis of the antenna is investigated by using the tool IE3D to verify the capability of the projected antenna for the UWB environment.**

Index Terms— **Coplanar Waveguide, Slot antenna, Time domain analysis, Ultra wideband.**

I. Introduction

New generation of wireless systems is to supply high data rate and kind of applications to the mobile user whereas serving a lot of range of users. Once the discharge of radical Wideband (UWB) for unaccredited applications by the independent agency, it receives a lot of attention by the industries and world because of its properties of low power consumption, support of high secured rate and straightforward configuration [1]. With the speedy developments of such wireless systems, plenty of attention is being given for planning the UWB antennas, since they're the key parts to radiate and receive the signals. To design an Antenna to control within the UWB band is quiet difficult one as a result of it's to satisfy the wants like radical wide ohmic resistance information measure, omni directional graphical record, constant gain, high radiation potency, constant cluster delay, Low profile, compact and straightforward producing [2]. Apparently the planar slot antennas with CPW fed possess the higher than same features with straightforward structure, less radiation loss, less dispersion and straightforward integration of monolithic microwave integrated circuits (MMIC) [3]. Hence, the CPW fed planar slot antennas [4] area unit known because the most promising style for broadband wireless applications. In general, the broadband in CPW-fed slot antenna is achieved by standardisation their impedance price. Many ohmic resistance standardisation techniques area unit reported in literature by varied the slot dimensions. For

Example, these has been administrated in varied slot geometries like bow-tie slots, wide rectangular slots [4], circular slot and polygon slot [5]. The ohmic resistance tuning May also performed by victimisation coupling techniques like inductively and capacitively coupled slots [6], dielectric resonator coupling [7] and different techniques like victimization photonic bandgap (PGB) [8]. Although giant ohmic resistance bandwidth may well be obtained by victimisation these techniques, they are quite difficult. In planar slot antennas 2 parameters affect the ohmic resistance information measure of the antenna, the slot dimension and the feed structure. The broader slot provides a lot of information measure and the optimum feed structure provides the nice ohmic resistance matching. A triangular patch is often utilized in microstrip antennas that provides radiation characteristics similar to rectangular patch with smaller space. The proposed antenna during this paper is meant with a compact rectangular slot and a triangular feeding structure at the anterior portion of the feed. The antenna is completely different in structure, little in size and straightforward style because of less range of style parameters compared with the present radical wideband antennas within the literature. The pattern obtained from the simulation is nearly stable across the matching band with a mean gain of four dBi. The simulation software used for this analysis is IE3D. The small print of the proposed style and its experimental result's conferred and discussed within the following sections.

II. Literature Survey

The first antennas were in-built 1888 by German scientist Heinrich Hertz in his pioneering experiments to prove the existence of magnetic attraction waves foreseen by the speculation of James Clerk Maxwell. Hertz placed dipole antennas at the focus of parabolic reflectors for each transmission and receiving. The origin of the word antenna

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relative to wireless equipment is attributed to Italian radio pioneer Guglielmo Marconi. In 1895, whereas testing early radio equipment within the Swiss Alps at Salvan, Schweiz within the mountain peak region, electrical engineer experimented with long wire "aerials". He used a 2.5 meter vertical pole, with a wire hooked up to the highest running right down to the transmitter, as a diverging and receiving aerial part. Compact and Broadband Quasi-Yagi Antenna for X- to Ku-band Applications as well as balun and electrical device for electric resistance matching. In several of the reported style approaches, there have been no express pointers steered for activity electric resistance matching between the cycle line and therefore the input microstrip transmission lines. additionally, within the style of most typically used MS-to-CPS balun structures for the quasi-Yagi antenna steered one hundred eighty degree part distinction on the cycle lines was warranted just for slim information measure close to the middle frequency; i.e., the odd-mode conversion with the part delayed leg was expected to figure just for slim frequency information measure. Also, most of the broadband quasi-Yagi antenna styles were in the main supported come back loss performances. Broad electric resistance information measure, of course, could be a necessary demand for the broadband antennas, however might not be a spare criterion permanently radiation characteristics for whole waveband. A quick history of antenna evolution is as follows

- Yagi-Uda antennas 1920s
- Horn antennas 1939
- Antenna arrays 1940s
- Parabolic reflectors late 1940s and early 1950s
- Patch antennas 1970s
- PIFA 1980s

III. Theoretical Analysis

The theoretical analysis of basic rectangular patch antenna structure, theoretical formulas and calculations required in designing E-shape microstrip patch antenna.

A. Microstrip Patch Antenna Structure

A microstrip patch antenna (MPA) consists of a conducting patch of any non-planar or planate pure mathematics on one facet of a nonconductor substrate and a ground plane on different facet. It’s a written resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Attributable to its planate configuration and simple integration with microstrip technology, the microstrip patch antenna has been wide used. The oblong and circular patches are the essential and most typically used microstrip antennas.

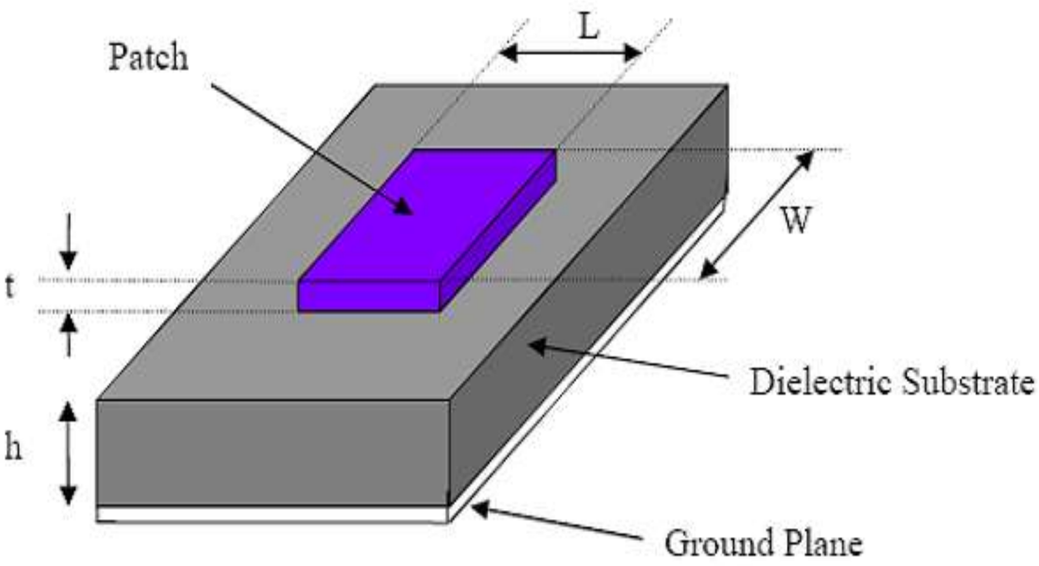

Fig. 3.1: Microstrip Patch Antenna Configuration

The above figure shows a microstrip patch antenna with a nonconductor substrate mounted on a ground plane. The nonconductor substrate is of thickness (h). The patch is mounted on the nonconductor substrate with nonconductor constant or permittivity ($\in_r$). The patch is of length (l), dimension (w) and thickness (t).

In our design we tend to use microstrip printing operation. The microstrip patch with microstrip feed a is as follows

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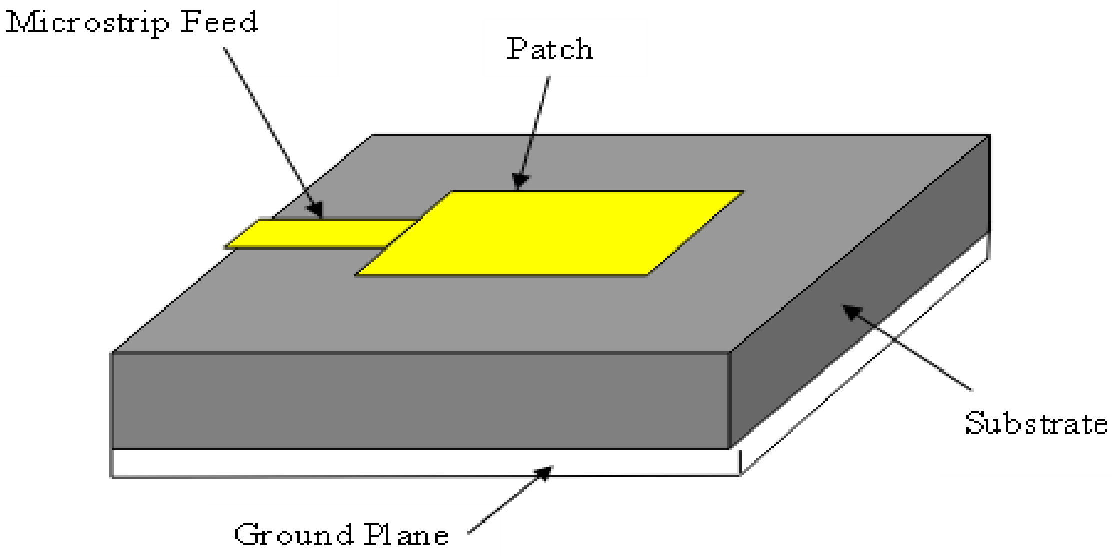

Fig. 3.2: Microstrip Antenna with Microstrip Feed

In the above figure, a conducting strip is connected on to the sting of the microstrip patch. thus it's a microstrip feed. The normally used substrates are FR-4 substrate and RT DUROID 5880 substrates.

The frequency of operation of the patch antenna of Figure 3.1 is determined by the length L. The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

The above equation shows that the microstrip antenna ought to have a length adequate to one half a wavelength at intervals the nonconductor (substrate) medium. The dimension W of the microstrip antenna controls the input ohmic resistance. Larger widths can also increase the information measure. For a sq. patch antenna fed within the manner higher than, the input ohmic resistance are going to be on the order of three hundred Ohms. By increasing the dimension, the ohmic resistance will be reduced. However, to decrease the input ohmic resistance to fifty Ohms typically needs a really wide patch antenna that takes up plenty of valuable house. The dimension any controls the radiation diagram. The fields of the microstrip antenna ar planned in Figure3.3 for W=L=0.5λ.

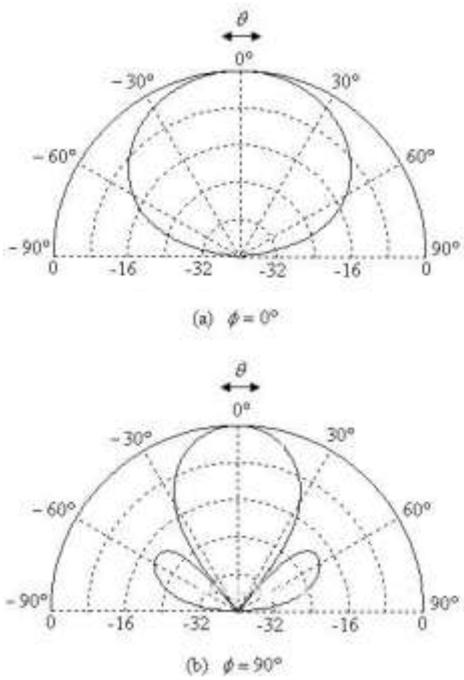

Figure 3.3: Normalized Radiation Pattern for Microstrip (Patch) Antenna

B. Theoretical Values and Calculations

To calculate the dimensions of E-shape microstrip patch antenna, the following theoretical values and formulas are required

1) The width of the patch element (W) is given by

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Where W is the width of patch element

C is the velocity of light= $3x10^8$ m/s

fo is the optimum frequency = 5 GHz

Substituting c = $3x10^8$ m/s, ε r = 2.2, and fo = 5 GHz, then

W =2.3717cm or 933.74 mile.

2) The effective of the dielectric constant (εreff) depending on the same geometry (W, h) but is surrounded by a homogeneous dielectric of effective permittivity εreff, whose value is determined by evaluating the capacitance of the fringing field.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{0.5}$$

Substituting εr = 2.2, W =2.3717cm, and h =0.1575cm, then εreff = 2.1074cm or 829.69mile

3) The effective length (L eff) is given by

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

Substituting, c = $3x10^{8}$ m/s. εreff = 2.0475cm, and fo = 5GHz, then

Leff = 2.0665cm or 813.6 mile

4) The length extension (ΔL) is given by:

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

Substituting εreff = 2.1074cm, W =2.3717cm, and h =0.0787cm, then ΔL= 0.041469cm or 16.3266mile.

5) The actual length (L) of patch is obtained by

$$L = L_{eff} - 2\Delta L$$

The design of E-shape microstrip antenna is as follows

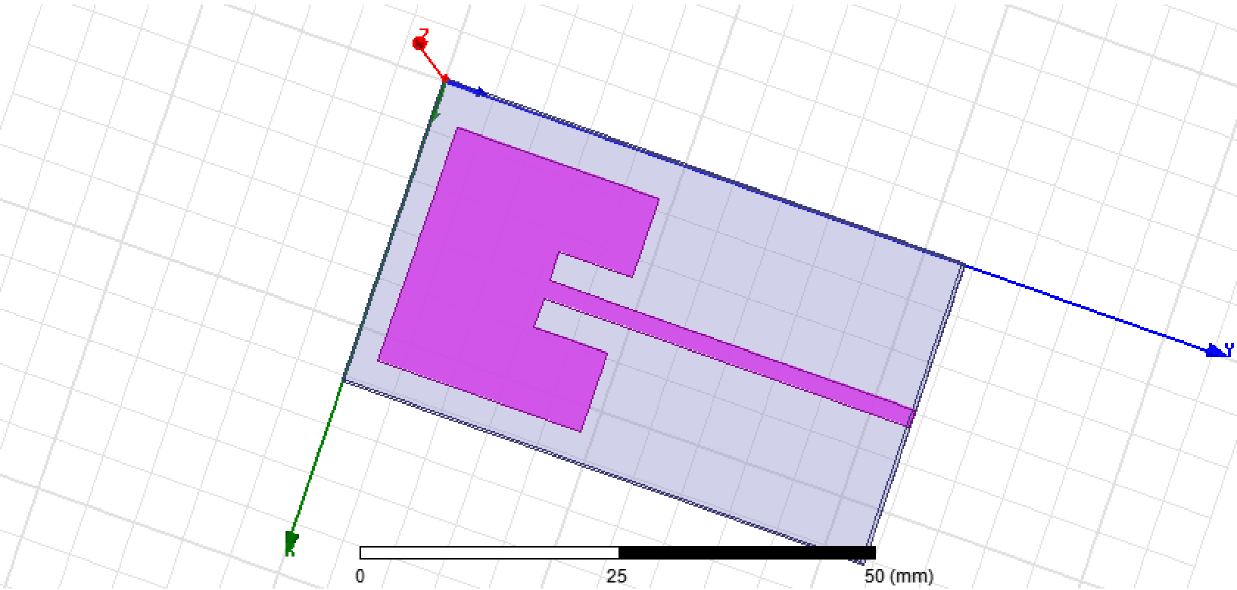

Figure 3.4: Design of E-Shape Microstrip Patch Antenna

In the above design, we use RT-DUROID 5880 substrate as dielectric. In this theme, every node with message searches for potential path nodes to repeat its message. Hence, potential path nodes of a node ar thought of. Using NSS, every node having message selects its path nodes to produce a adequate level of end-to-end latency whereas examining its transmission effort. Here, it derives the CSS live to allow CR-Networks nodes to choose that authorised channels ought to be used. The aim of CSS is to maximise spectrum utilization with minimum interference to primary system. Assume that there are M authorised channels with completely different information measure values and y denotes the information measure of channel c. every CR-Networks node is additionally assumed to sporadically sense a collection of M authorised channels. Mi denotes the set together with Ids of authorised channels that ar sporadically detected by node i. suppose that channel c is sporadically detected by node i in every slot and channel c is idle throughout the quantity x known as channel idle length. Here, it use the merchandise of channel information measure y and also the channel idle length x, tc = xy, as a metric to look at the channel idleness. Moreover, failures within the sensing of primary users ar assumed to cause the collisions among the transmissions of primary users and CR-Networks nodes.

IV. Design Analysis

The design of the structure is based on the theoretical calculations discussed in the previous chapter. The design is done in two simulation softwares namely CST (COMPUTER SIMULATION TECHNOLOGY) and HFSS (HIGH FREQUENCY STRUCTURE SIMULATOR). CST and HFSS are electromagnetic simulators used in the design and analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects.

A. Design Simulator –CST Studio Suite

CST - Computer Simulation Technology AG (CST) is a German computer code company with headquarters in Darmstadt. The most product of CST is CST STUDIO SUITE, which includes varied modules dedicated to specific application areas. There square measure modules

for microwave & RF applications, summarized in CST MICORWAVE STUDIO, low frequency (CST EM STUDIO), PCBs and packages (CST PCB STUDIO), cable harnesses (CST CABLE STUDIO), temperature and mechanical stress (CST MPHYSICS STUDIO) and for the simulation of the interaction of charged particles and magnetism fields (CST PARTICLE STUDIO). All modules square measure integrated with a system AND gate machine (CST style STUDIO).
In our style we tend to use CST MICROWAVE STUDIO (CST MWS). CST MICROWAVE STUDIO® (CST MWS) could be a specialist tool for the 3D EM simulation of high frequency parts. CST MWS' unique performance makes it 1st selection in technology leading R&D departments. CST MWS allows the quick and correct analysis of high frequency (HF) devices like antennas, filters, couplers, placoid and multi-layer structures and SI and EMC effects. Exceptionally user friendly, CST MWS quickly offers associate insight into the EM behavior of high frequency styles.

B. Design Process in CST

For designing the required shape in CST MICROWAVE STUDIO (CST MWS).the following steps are followed.

- ➔ Open CST STUDIO SUITE and then click on CST MICROWAVE STUDIO (CST MWS).
- ➔ As the required design is planar, select planar shape from the basic shapes given.
- ➔ Select brick shape and assign X, Y and Z co-ordinates to it as required per the design. This is the Ground plane. X & Y co-ordinates denote the length and width of the ground plane respectively. Z denotes the thickness. Select the material as PEC (Perfect electric).
- ➔ Then select solid 2 and assign X1, Y1 co-ordinates to it same as that of the ground plane. Z2 is varied .This is the di-electric substrate RT DUROID 5880.The thickness(Z2) of di-electric substrate is varied in our design and simulation results are carried out .
- ➔ Then select solid 3 and co-ordinates to it .This the patch.
- ➔ Select solid and assign X4, Y4 co-ordinates to it. These are the cut width and cut depth of the antenna. Subtract it from solid 3.We get a cut-shape piece (Boolean subtract).
- ➔ Select another solid and assign X5, Y5 co-ordinates. These are the strip patch length and strip patch width respectively. Add it to solid 3 (Boolean add).
- ➔ This completes the design of the structure. Then go to quick start guide and assign frequencies, boundary conditions, wave guide ports etc required as per the design.
- ➔ Start the transient solver and see the simulation results.
- ➔ Return loss (S11) and VSWR are calculated for different substrate thickness (Z2) and simulation results are noted down.

C. Design Simulator –HFSS

HFSS is a commercial finite element method solver for electromagnetic structures from Analysis. The acronym originally stood for high frequency structural simulator. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines, and packaging. It was originally developed by Professor Zoltan Cendes and his students at Carnegie Mellon University.
HFSS is the industry-standard simulation tool for 3D full-wave electromagnetic field simulation. HFSS provides E- and H-fields, currents, S-parameters and near and far radiated field results. Intrinsic to the success of HFSS as an engineering design tool is its automated solution process where users are only required to specify geometry, material properties and the desired output. From here HFSS will automatically generate an appropriate, efficient and accurate mesh for solving the problem.

D. Design Process in HFSS

1) Open HFSS software.
2) Select insert HFSS design and draw rectangle1 .This is ground plane. All x,y and z dimensions are kept in mil.
3) Then draw box1 which is dielectric with thickness .Assign x,y and z co-ordinates.
4) Then draw rectangle2 which is patch. Assign x,y and z co-ordinates.
5) Then draw rectangle3 with different centre and subtract it from rectangle 2. Assign x,y and z co-ordinates.
6) Draw rectangle4 and assign x,y and z co-ordinates. This gives the strip path length and strip path width.
7) Then draw box2 which is the radiation box. Select wave guide port and give excitation.
8) Start the solver and see the simulation results. The substrate thickness is varied and simulations are carried out for different substrate thickness

V. Results

5.1 Structure in CST/HFSS:

The Figure 5.1 shows the structure in CST/HFSS,

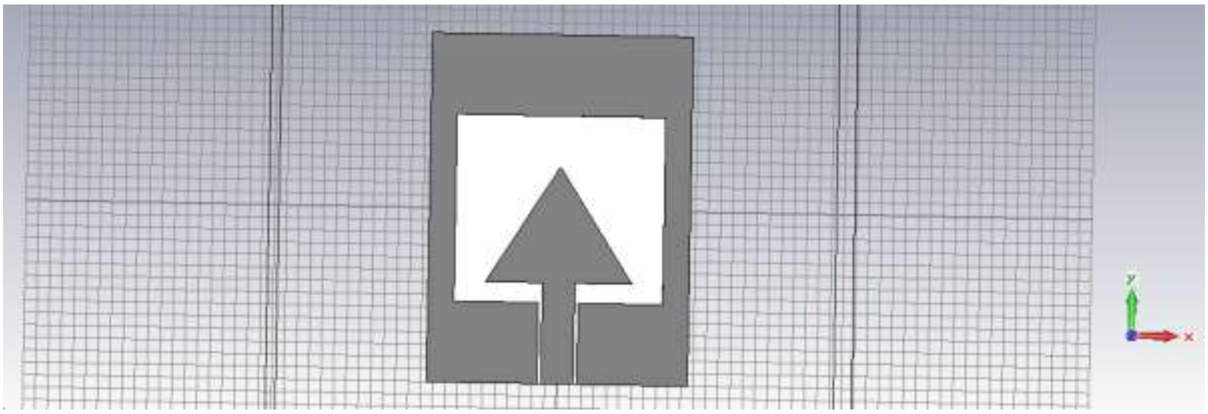

Fig 5.1 Structure in CST/HFSS

5.2 Results in CST/HFSS

The results in CST/HFSS shown in the Fig. 5.2 S-Parameters, S11 for optimum Parameters, S11for L1=13mm, S11 for L1=14mm, S11 for L1=16mm, S11 for L1=17mm, S11 for W1=15mm S11 for W1=16mm S11 for W1=17.6mm S11 for W1=18.4 mm, Radiation Pattern shown in the Fig. 5.3.

5.2.1 S-Parameters:

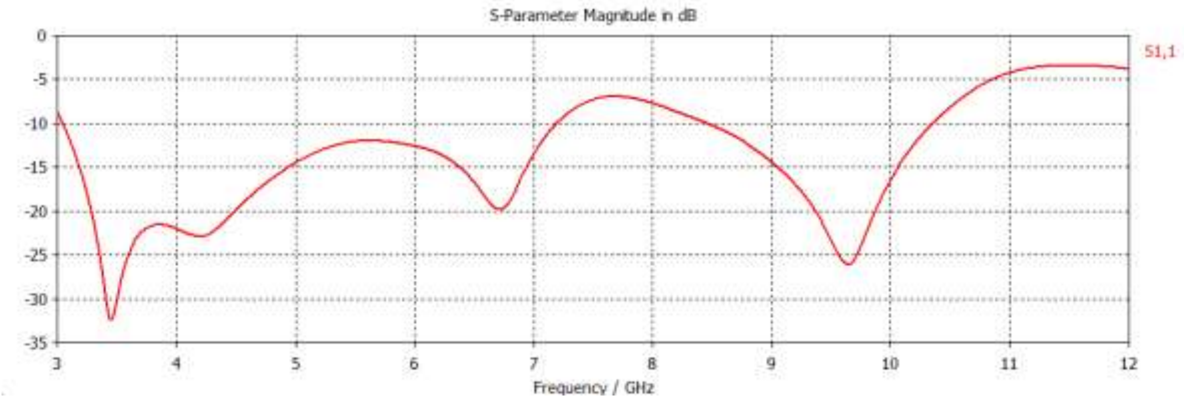

Fig 5.2(a) S11 for optimum Parameters

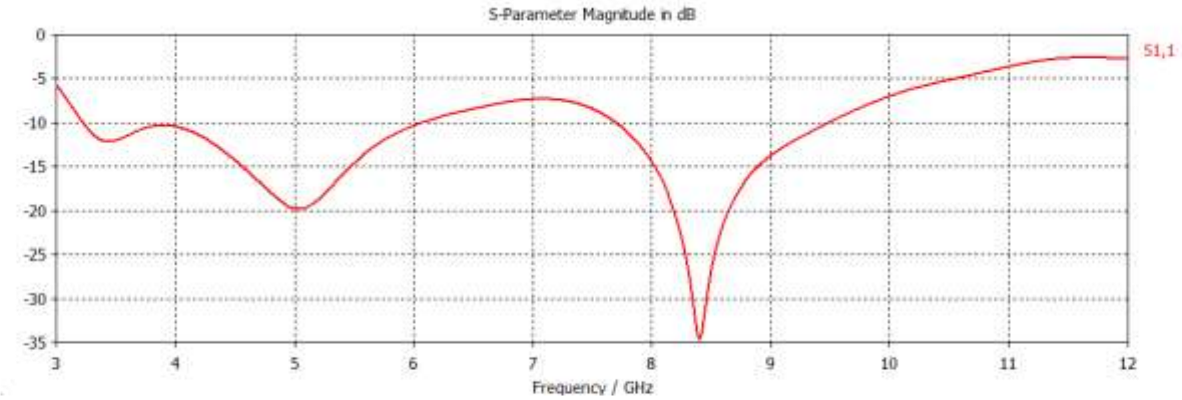

Fig 5.2(b) S11forL1=13mm

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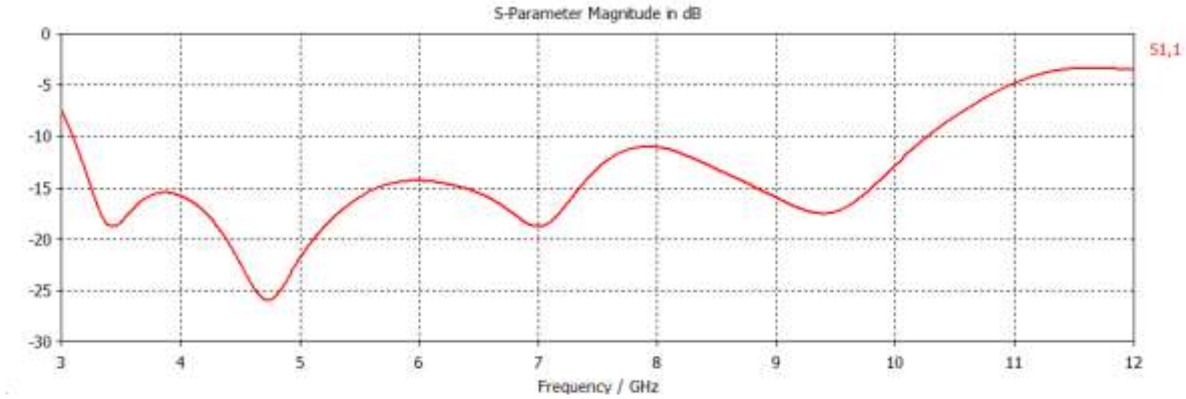

Fig 5.2(c) S11 for L1=14mm

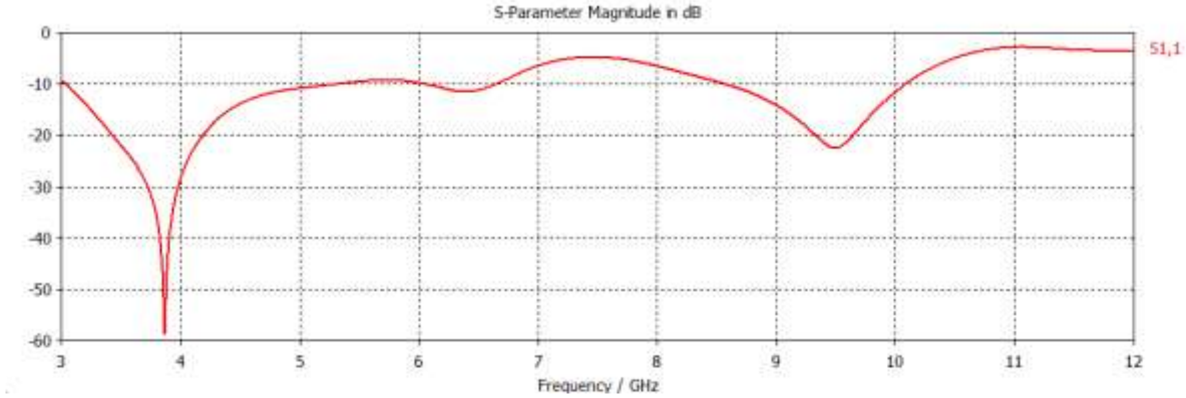

Fig 5.2(d) S11 for L1=16mm

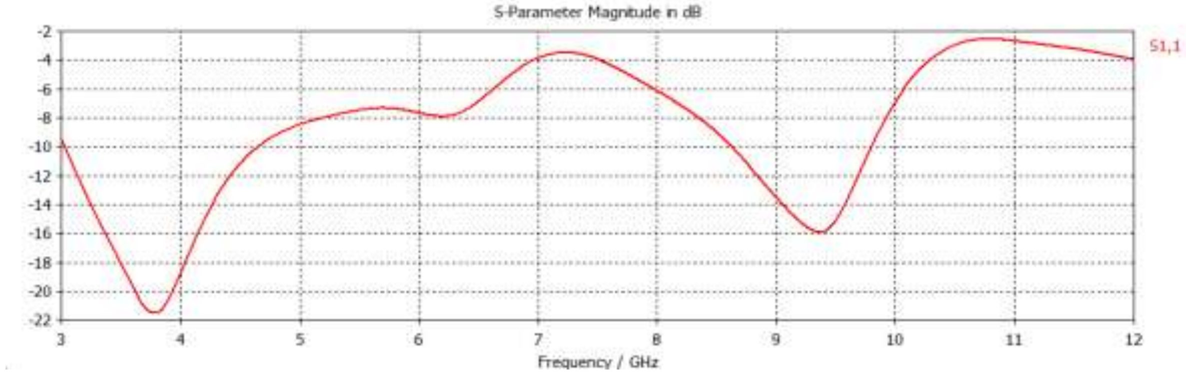

Fig 5.2(e) S11 for L1=17mm

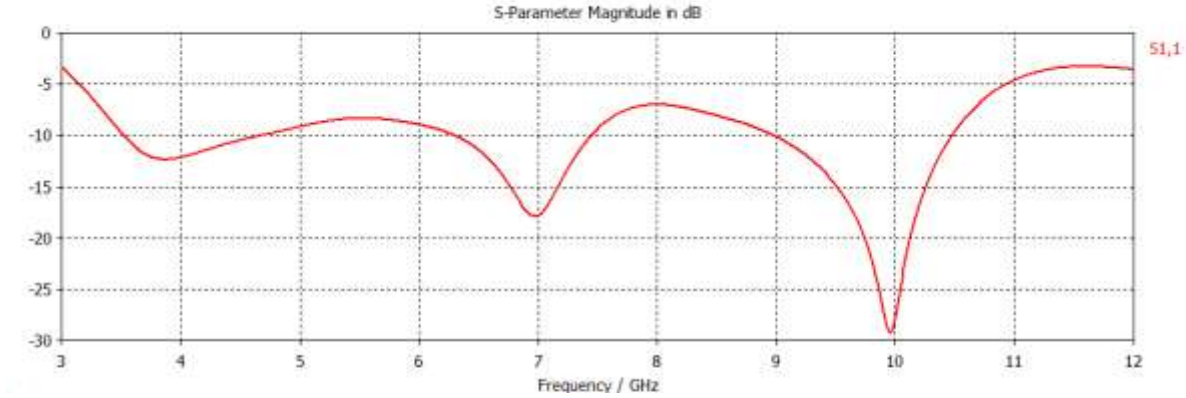

Fig 5.2(f) S11 for W1=15mm

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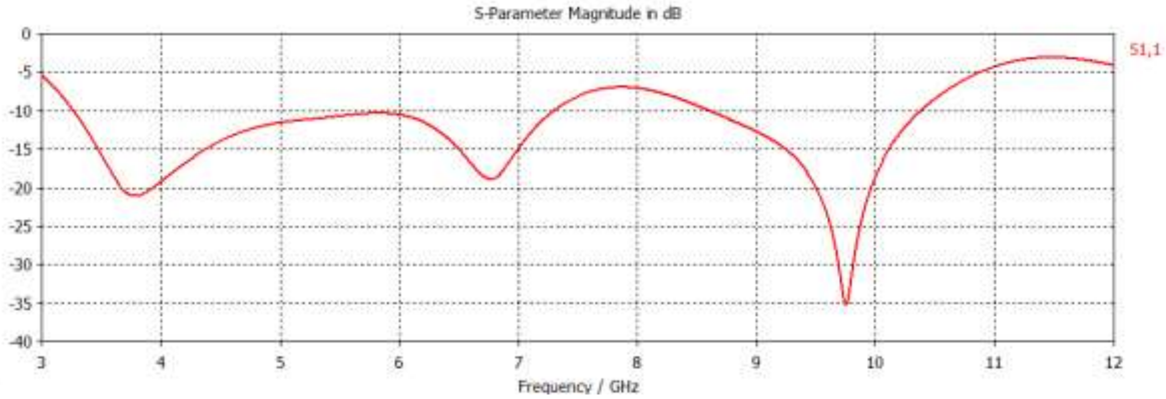

Fig 5.2(g) S11 for W1=16mm

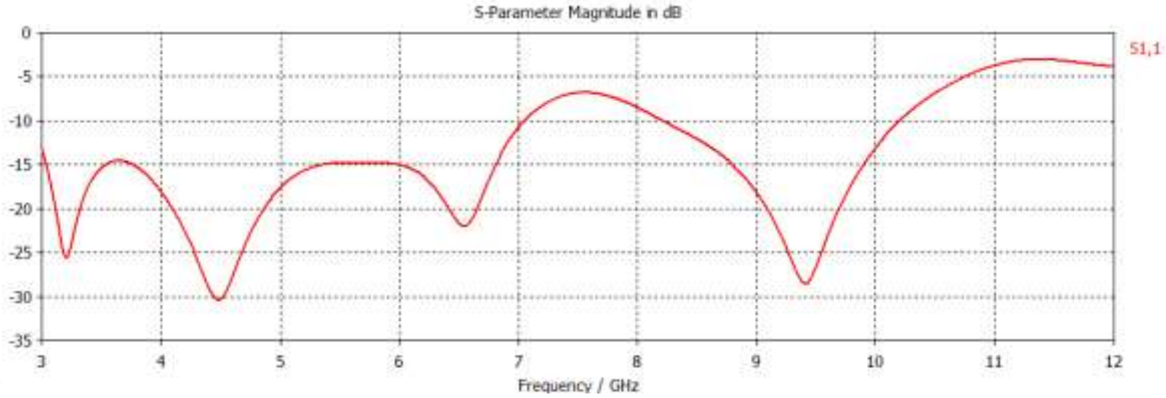

Fig 5.2(h) S11 for W1=17.6mm

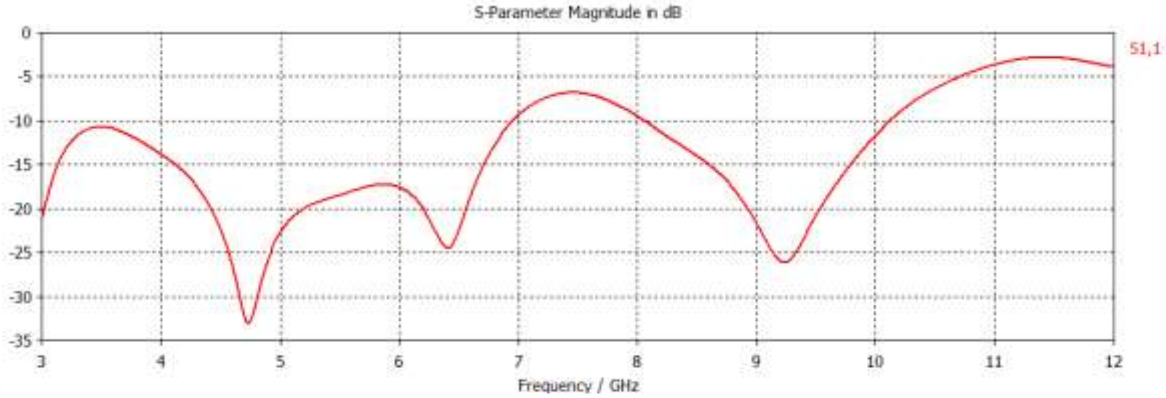

Fig 5.2(i) S11 for W1=18.4 mm

5.2.2 Radiation Pattern:

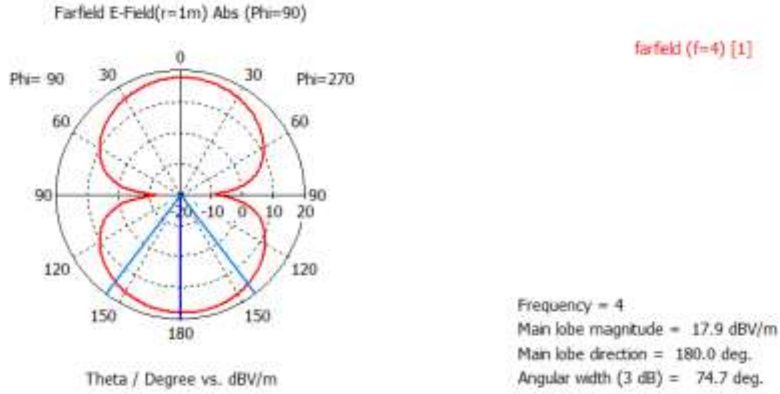

Fig 5.3(a) At 4 GHz and at phi=90deg

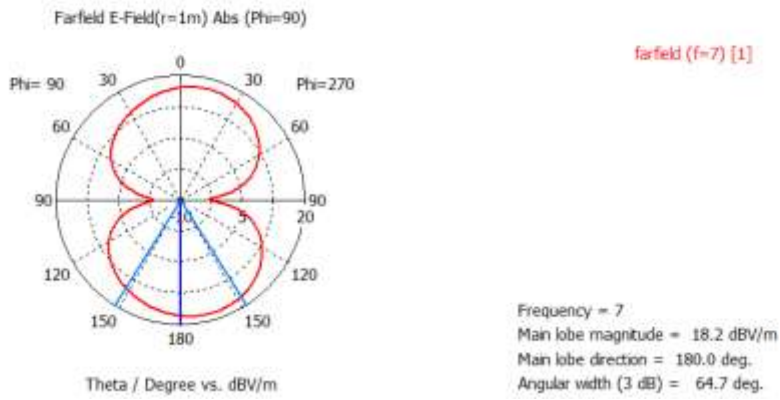

Fig 5.3(b) At 4 GHz and at phi=90deg

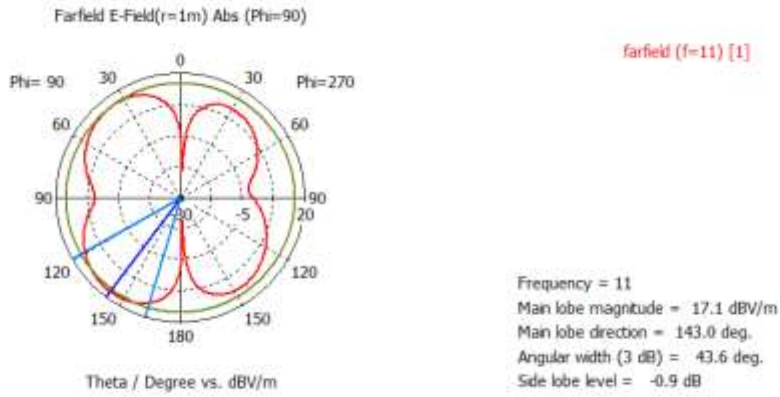

Fig 5.3(c) At 4 GHz and at phi=90deg

6 CONCLUSION

In this paper, a simple antenna structure has been proposed with minimal antenna size and better impedance matching. The triangular like tuning stub is introduced at the anterior portion of the feed to enhance the coupling between the slot and feed. With the above structural features the overall dimension of the proposed antenna configuration comes around 28×21×1.6 mm3. It is observed that 114% of bandwidth with better size reduction over the frequency range of 3.1 GHz to 11.4 GHz. The computed time domain analysis of the designed antenna ensures the capability of the antenna working in the UWB environment. Hence, this type of antenna is suitable for UWB indoor applications.

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