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Design and Simulation of a Compact UWB Antenna for Wireless Applications

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Abstract: In this paper, a simple compact UWB (ultra wide band) antenna for wireless applications is presented. Modifications on the shape of radiating patch and DGS techniques are used to get ultra wide bandwidth. The proposed is antenna operating for UWB frequency band 3.1-10.6GHz. Bottom side shape of the patch is designed tapered, in order to increase bandwidth. A pair of rectangular slot is created in the ground plane for performance improvement of the antenna. Fed by microstrip line, the proposed antenna is printed on low cost FR-4 epoxy substrate having hight 1.6mm, dielectric constant 4.4, tangent loss 0.002 and dimension 30×24mm². Gain, radiation patterns and efficiency of proposed antenna are also investigated.

Index Terms: DGS (defected ground structure), UWB (ultra wide band), Microstrip line, Tapered.

I. INTRODUCTION

The ultra wide band (UWB) frequency spectrum 3.1-10.6GHz with a emission limit of -41.3dBm/MHz is authorized by Federal Communication Commission FCC (USA) for use of unlicensed commercial applications [1]. For UWB systems the range of operation was found to have some advantages such as low cost, less complexity, low power emission level, high precision ranging, resistant to jamming and multipath for short range high speed wireless communications. For many wireless applications, such as ground penetrating radars and short range wireless local area networks very low spectral power density, high precision ranging, low cost and high data rate are needed. UWB Antennas are key component for UWB system, have recently been extensively investigated by various researchers. Over the recent years, there are various studies have been proposed monopole antennas for various UWB applications [2]-[3].

UWB technology gives the throughput which is need of next generation of converged devices. Also, it support the industry initiatives like the Wi-Media Alliance, which helps ensuring interoperability through multiple protocols which include IEEE 1394, USB, and Universal Plug and Play, making UWB a broad technology solution for creating better WPANs [4]. Various researchers are using some techniques like partial ground or defected ground structure (DGS), increasing the substrate thickness, introducing parasitic stubs, fractal geometry and use of meta-material have been applied by researchers to enhance its bandwidth. Various type of cuts or slots like rectangular and triangular on the patch and ground plane also helps to obtain broad bandwidth [5].

Bandwidth and other performances of UWB antenna are highly susceptible to surface waves which are generated in the dielectric slab due to thickness and large dielectric constant of the dielectric materials. The researcher have investigated EBG structures for improving performances of RF and microwave antennas by suppressing surface waves [6]-[7].

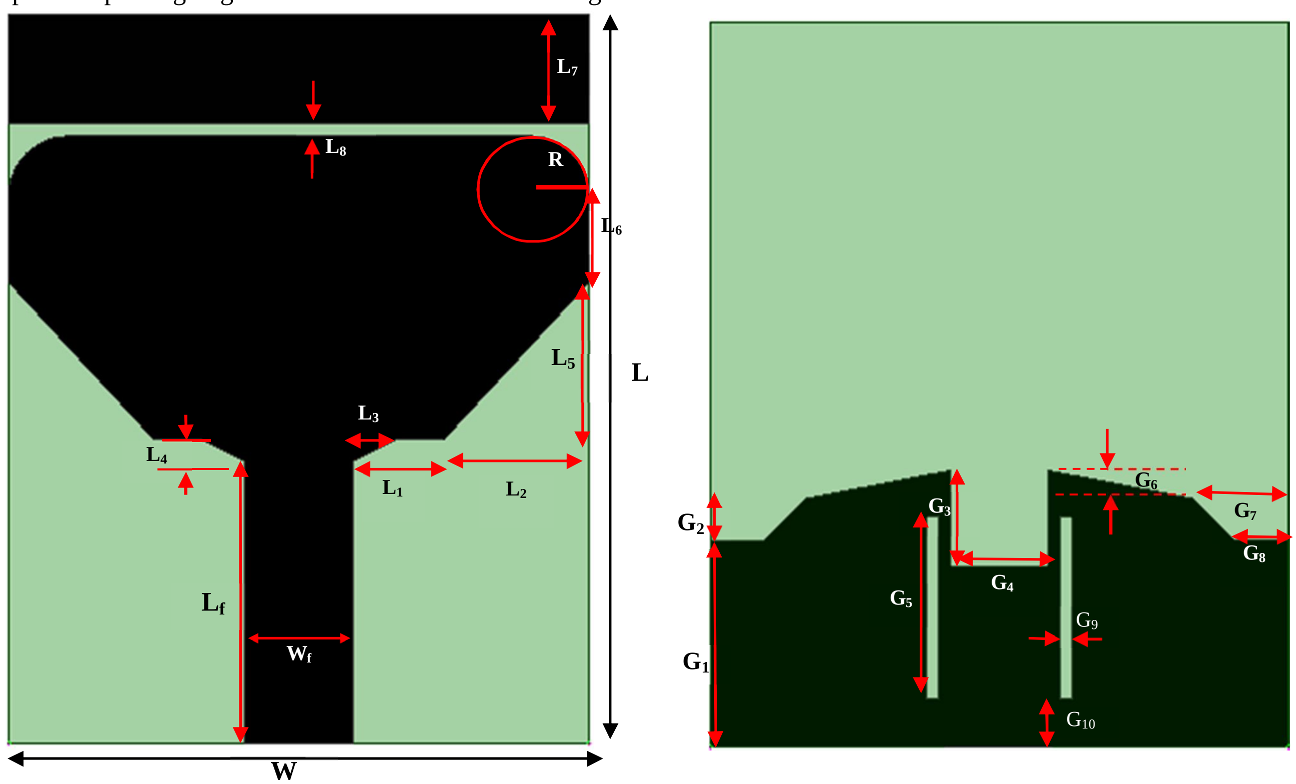
A UWB Omnidirectional antenna using Particle Swarm Optimization (PSO), consists of three identical pairs of printed half-wave dipole radiators. Each pair includes two dipoles which work together to generate a broadband characteristic [8]. A compact ultra wide band antenna good for integrating with the printed circuit board (PCB) is presented. The antenna consists of a folded radiator with bended stubs [9]. A strip-line slot ultra wide band (UWB) antenna is presented [10]. An UWB antenna with a rectangular feeding structure, for a Wireless Body Area Network (WBAN) is proposed [11]. A UWB antenna consists of L-shaped slot (LS) and a narrow slot on the ground plane [12]. UWB monopole antennas with different types of planar, using disc and circular ring are presented [13]. A monopole ultra wide-band (UWB) antenna has hybrid geometry and is consists of using half circular ring and half square ring[14]. A broadband antenna using DGS technique is proposed [5].

In this paper, a compact ultawideband MSA is designed and simulated. Initially transmission line model was used to calculate the dimensions of patch and ground plane, the design frequency used for the TLM is 6.58GHz. The antenna designed using TLM model has very narrow bandwidth. In order to enhance the bandwidth partial ground plane technique has been used, further modifications in the ground plane a rectangular slot is etched on the ground just beneath the feed line and a pair of rectangular slots in the ground plane have been etched.

Further for covering entire UWB range modification on the radiating patch have been done, the bottom part of patch is designed tapered, a stub on top of the patch plane has been integrated which helps for achieving lower frequencies of UWB band by enhancing the current path length. The designing and simulating of the proposed antenna is done using HFSSv15. A series of parametric studies have been done by using HFSS for optimizing the proposed UWB antenna. Simulated results like S 11, VSWR, Gain and efficiency for the proposed UWB antenna are analyzed. Also, there is a comparison between the proposed UWB antenna and previously designed antennas.

II. ANTENNA DESIGN AND GEOMETRY

Figure 1 depicts the geometry of proposed UWB antenna, is fed by microstrip line, the proposed UWB antenna is printed on low cost FR-4 epoxy substrate having thickness of 1.6mm, dielectric constant 4.4, tangent loss 0.002 and dimension 30×24mm^2. This substrate is capable of proving large bandwidth but at the same time gain is limited to few dBi.



(a) (b)

FIGURE 1: (a) top view (b) bottom view of the proposed Antenna

The proposed UWB antenna is designed and optimized by HFSSv15 software, to feed the antenna lumped port has been used, the final values of all the parameters are shown in Table 1.

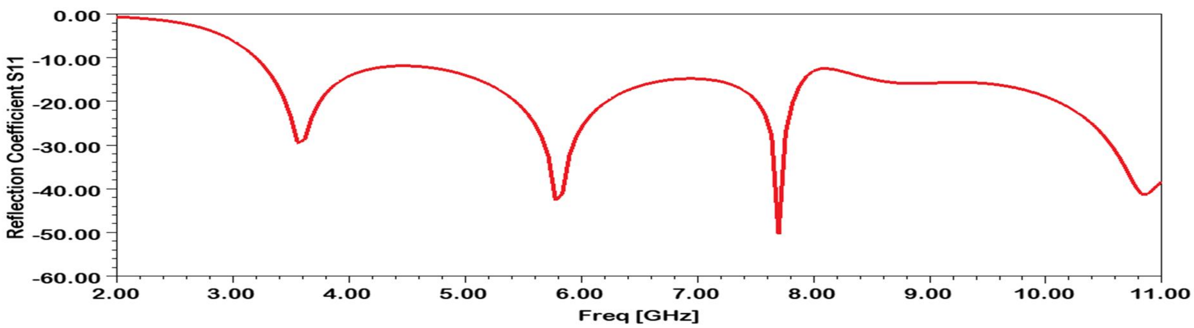
TABLE 1

Optimized parameters and their dimensions

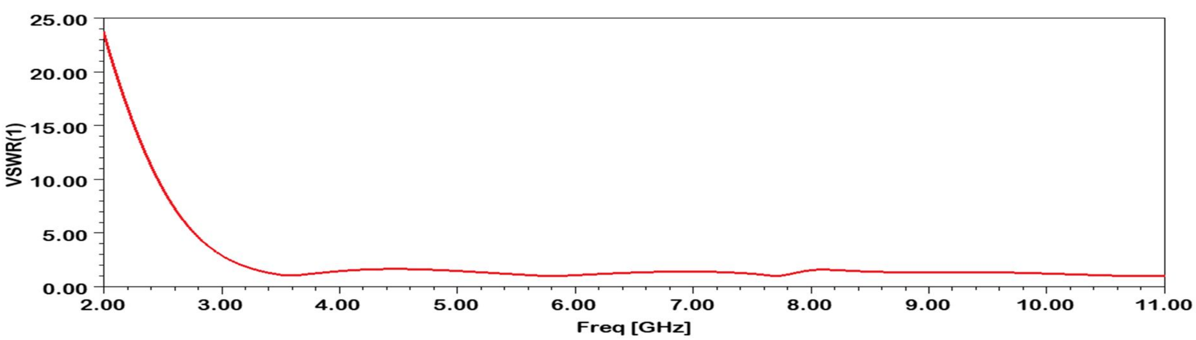
Parameters	L	W	W_f	L_f	R	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	G_1
Dimensions (mm)	30	24	4.5	11.625	2.5	2	6	1.75	2.75	6.5	3.5	4.5	0.5	8.5
Parameters	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}					
Dimensions (mm)	1.77	3.95	4	7.5	1.17	4	2.22	0.5	2					

III. RESULTS AND PERFORMANCE ANALYSIS

Figure 2 depicts the simulated results of proposed antenna, fig.2(a) shows the reflection coefficient(S11) is below -10dB for entire UWB range 3.1-10.6GHz. fig.2(b) shows the VSWRs of the proposed antenna is < 2 over 3–11GHz and fig2(c) shows the peak gain of the proposed antenna is around 4.5dBi for the UWB range. Fig.2(d) shows that the radiation efficiency of proposed antenna is above 90% in the UWB band.



(a)



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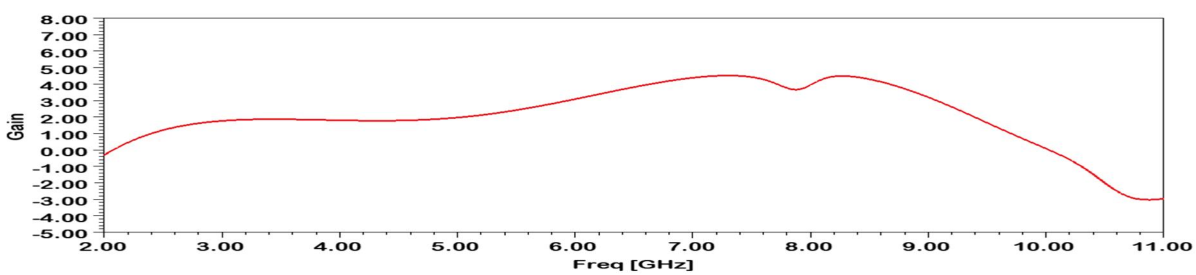
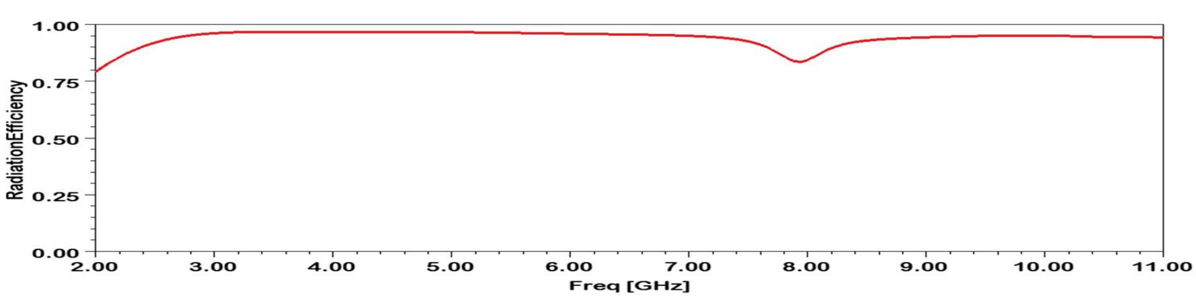


(c)



(d)

Figure 2: (a) reflection coefficient(S11), (b) VSWRs of the proposed antenna, (c) shows the peak gain of the proposed antenna (d) Radiation efficiency of proposed antenna

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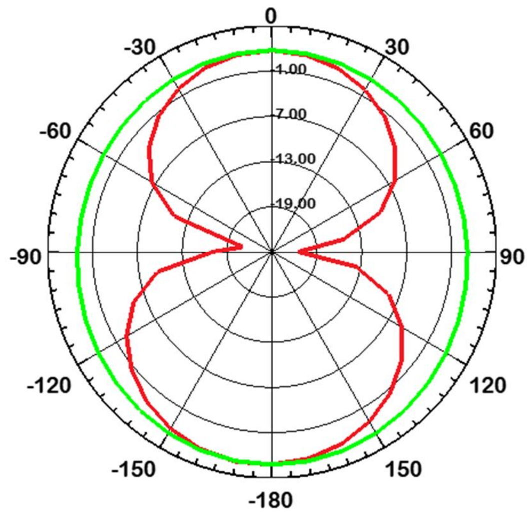
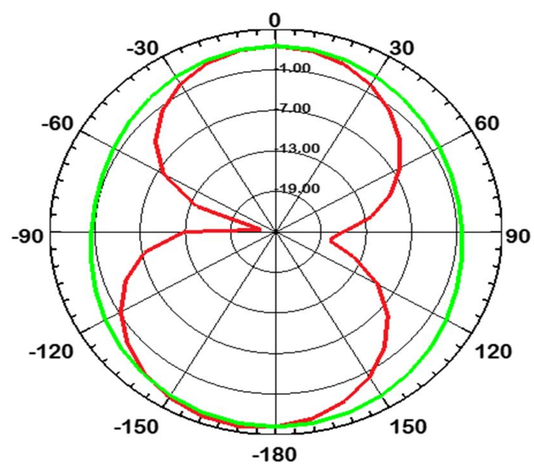
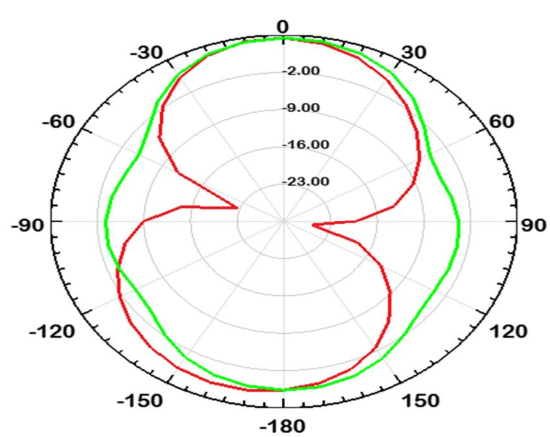
The proposed antenna exhibit stable radiation patterns and retains almost omni-directionality for the lower frequencies of UWB range, as the frequency get increases the pattern is no more omni-directional.. The simulated radiation patterns (**E**-plane and **H**-plane) for proposed UWB antenna at different frequencies i.e. 4.3, 5.6 and 8.3GHz are shown in figure 3. The red plot shows E-plane and the green plot shows H-plane.



(a)



(b)



(c)

Figure 3: (a) E-plane & H plane at 4.3GHz, (b) E-plane & H- plane at 5.6 GHz and (c) E-plane & H- plane at 8.3 GHz

IV. CONCLUSIONS

A compact microstrip line-fed planar UWB antenna has been proposed and analyzed. The antenna employ a pair of slot in ground plane with partial ground plane and has an overall dimension of 30mm×24mm. Rectangular Stub makes bandwidth large and improve performance of the antenna. Gain of the proposed antenna was 4.5dBi with better radiation efficiency. The characteristics of low profile, light weight, small size, satisfactory gain make the proposed antenna suitable for personal wireless applications and UWB applications.

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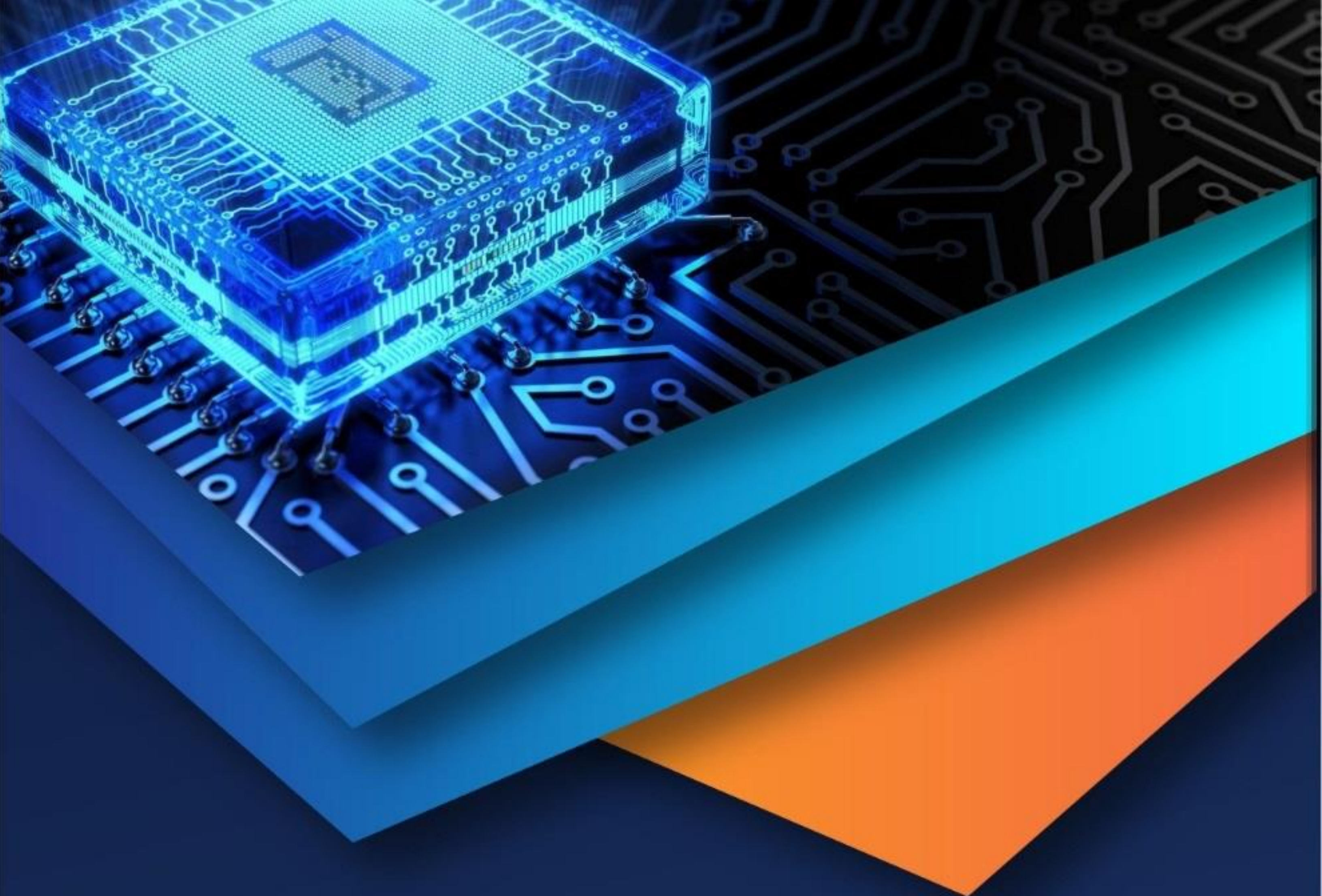

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