Elliptical Parasitic Patch Antenna for UWB Applications

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Abstract

In this paper, a compact antenna is designed to operate in the frequency range of 5.1-11 GHz for UWB applications. A Slotted rectangular patch having a parasitic elliptical patch within it, fed asymmetrically using a quarter wave transformer so that the antenna exhibits wideband characteristics. The antenna is designed on an FR4 substrate of thickness of 1.6 mm and ϵ_r of 4.4 while having a partial ground, whose length responsible for the ultra wideband characteristics. The dimensions of the antennas are optimized and parameters like return loss, VSWR and directivity are presented.

Keywords: *Ultra Wide Band, Monopole, Asymmetric feed.*

I. INTRODUCTION

Antennas play an important role in the field of wireless communication without which, the world would have not reached the current age of technology. Modern day wireless systems require light weight, low profile, high gain, simple structure antennas to assure characteristics like mobility, reliability, and high efficiency [1,2]. Since FCC released the 7.5GHz bandwidth (UWB) within the range of 3.1-10.6 GHz with EIRP spectral density of 41.3dBm/MHz for short range applications, UWB technology had received great attention from industry and academia. This bandwidth is license free for low power operations and has numerous applications that require high data rate, imaging radar, remote sensing and localization applications and hence it has lot of potential towards the R&D of UWB technology. In present day scenario, designing an antenna for a portable device that operates at a broad frequency range with stable pattern is not an easy task as several parameters like size; cost and bandwidth should be satisfied. If engineered properly, printed antennas have the capability to satisfy this criteria. Microstrip antennas are relatively easy to construct, light in weight, low cost and can be conformed to any surface if needed. Challenges like increasing the bandwidth, gain and reduction of surface wave losses are some of the areas where more focus is required so that the advantages of the radiators of this class make them popular in various fields of applications.

Wireless communications is continuing to witness tremendous growth and broad implementation in a wide variety of applications. Antennas with broad bandwidth are always in demand as various applications are covered by a single antenna. Planar monopole antennas are used in wireless communication systems over a long period of time due to their simple structures and broad covered band width. Due to light weight and low cost of manufacturing, monopole microstrip patch antennas have become attractive candidates in many application ranging from very high data rate and short range wireless communication systems to modern radar systems [3-6]. The limited bandwidth of the planar conventional micro strip antennas however, needs to be further improved to facilitate applications in ultra wideband (UWB) systems [7-8]. Several techniques like loading the antenna, creating slots of various shapes and modifying the ground plane helps in achieving the UWB characteristics [9,10]

Numerous methods have been adopted by several researchers to achieve ultra wide band characteristics by a microstrip patch antenna. A few of them are listed as follows : A monopole antenna[4] was constructed using half circular and half square rings with a modified ground plane for modern automotive communication that handles high speed data with multimedia content. Here, an extended ground stub is added to enhance the bandwidth and its diversity performance [4]. An eye shaped monopole antenna [5] placed above a flat ground plane fed with a coaxial probe, has a main beam which is fixed over a wide range of frequency with low VSWR [5]. Two dielectric resonators were loaded on a thin monopole [6] and fed using a U-shaped feed line. TSDR and the feed are properly arranged in order to have proper radiation characteristics [6]. Two open L-shaped slot antennas for UWB frequency range are placed perpendicularly to each other to design a MIMO antenna [9]. Here high isolation is obtained by placing the antenna perpendicularly and a narrow slot on the ground plane helps in reducing the mutual coupling between the two antennas [9]. A rectangular patch with the U-shaped open-slot structure operating with multiple resonances is designed with an asymmetrical feed to achieve proper impedance matching within the UWB frequency [10].

In this communication, a newly designed antenna model, a rectangular patch with a slot and an elliptical parasitic element at the centre, asymmetrically fed using a quarter wave transformer is presented. The designed antenna is intended to operate in the UWB frequency range. Here section II presents the design of the antenna, while, simulated results are presented and discussed in section III and Section IV draws the conclusions about this paper.

II. MICROSTRIP ANTENNA DESIGN

Microstrip patch antennas consist of very thin metallic strips placed on ground plane where the thickness of the metallic strip is restricted by $t \ll \lambda_0$ and the height is restricted by $0.0003\lambda_0 \leq h \leq .05\lambda_0$ [1-2]. The microstrip patch is designed so that its radiation pattern maximum is normal to the patch. For a rectangular patch, the length L of the element is usually $\lambda_0/3 < L < \lambda_0/2$. Depending on the dimension of the radiating patch the operating frequency, bandwidth, gain, radiation efficiency, other related parameters are dependent. For an efficient radiation, the practical width of the patch that leads to good radiation efficiencies can be written as [1, 2]

$$w = \frac{1}{2fr\sqrt{\mu o \varepsilon o}}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{1}$$

Once width (W) is found, we can determine the effective length ΔL using

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.8)} \tag{2}$$

Here the actual length of the patch can be determined by L which is given as

$$L = \frac{1}{2fr\sqrt{\varepsilon_{reff}}\sqrt{\mu o \varepsilon o}} - 2\Delta L \tag{3}$$

Length and width of the ground plane are defined as

$$L_g = L + 6h \tag{4}$$
$$W_g = W + 6h$$

The structure of the designed antenna is shown in fig 1 below. Initially, the conventional patch antenna consisting of a symmetric rectangular patch of length (L_{PH}) and width (W_{PH}) printed on FR4 epoxy substrate with relative permittivity of 4.4, relative permeability of 1, loss tangent of .002 and height of 1.6mm was modelled with the dimensions obtained using the above procedure The overall dimensions of the proposed antenna are 30 x 24.8 x 1.6 mm^3 . A central slot of patch and a floating parasitic patch were created. The antenna is exited by a 50 ohm microstrip line with a quarter wavelength transformer which is located away from the central axis of the patch for better impedance matching. A reduced ground plane is printed on the bottom layer of the substrate. In the antenna, the gap between the patch and the ground plane dimension plays a major role in achieving the large impedance bandwidth below -10db of the return loss.

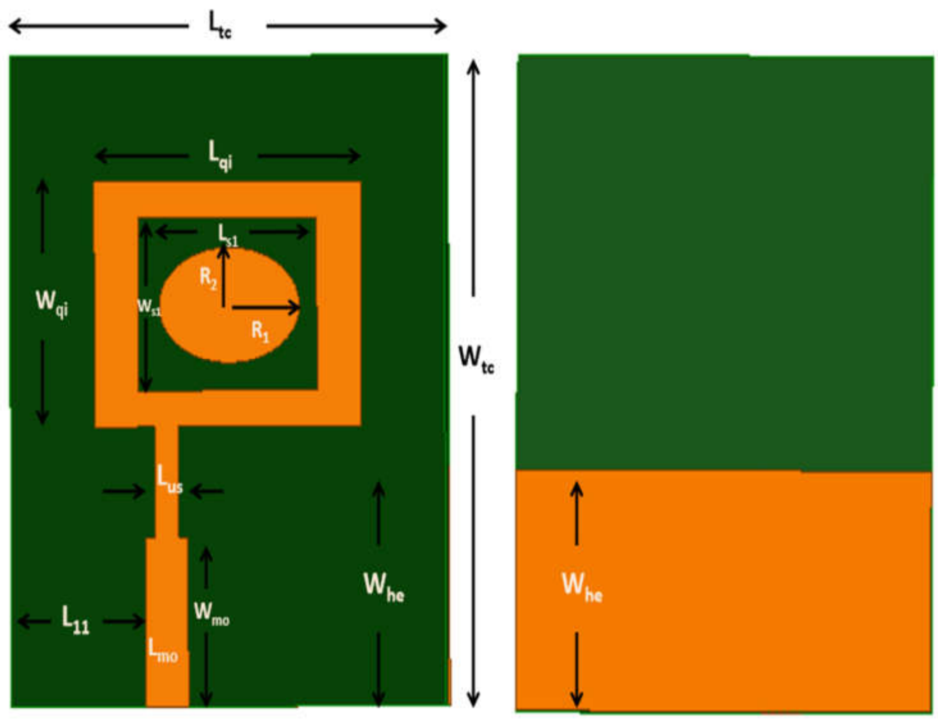

Fig 1: Design of the proposed antenna

The optimized parameters of the antenna are summarized in the following Table as shown

Table 1: Dimensions of parameters of patch antenna

Parameters	Values (cm)
L_{11}	1.45
W_{ge}	8.42
W_{mo}	5.97
W_{qi}	8.64
W_{s1}	6.13
R_1	2.47
W_{tc}	22.95
L_{11}	5.89
L_{no}	1.84
L_{qi}	11.63
L_{s1}	7.8
R_2	6.12
L_{tc}	18.97
L_{us}	1.04

III. SIMULATION & RESULTS

The floating parasitic patch with central slot in the conventional microstrip patch antenna fed asymmetrically with a quarter wavelength transformer for proper impedance matching over the entire UWB frequency was designed and simulated using CST Microwave Studio, a commercial EM simulator which uses finite integral technique.

Figure 2 shows the simulated results of the return loss as a function of frequency. The return loss is below 10dB in operating frequency band of 5.1 GHz to 11 GHz. It is observed from the above result that the antenna has two modes and operates for bandwidth of 80% of the UWB frequency range. Figure 3 shows the simulated results of the VSWR as a function of frequency and it is observed that the value of VSWR is well below 2 for the frequency range 5.1GHz to 11.5GHz. In Figure 4 & 5, the 3D representation of the radiation pattern is given for the antenna designed where the directivity values for f_r=6GHz and 9GHz are 4.1 and 4.6dBi respectively

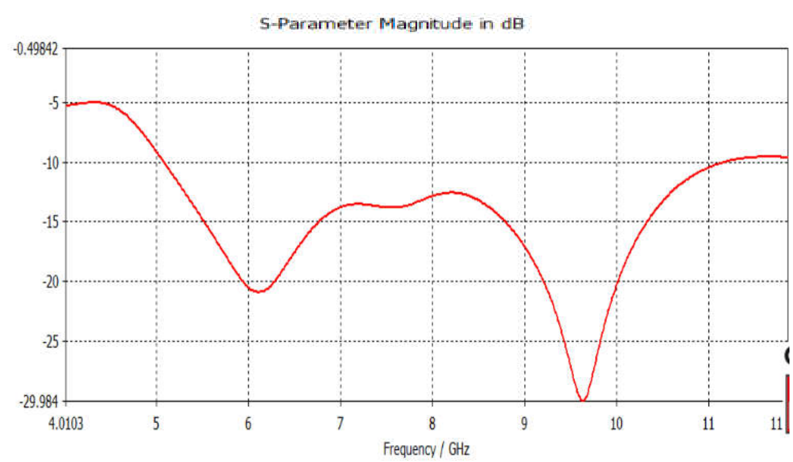

Fig 2: Simulated Return Loss of the proposed element

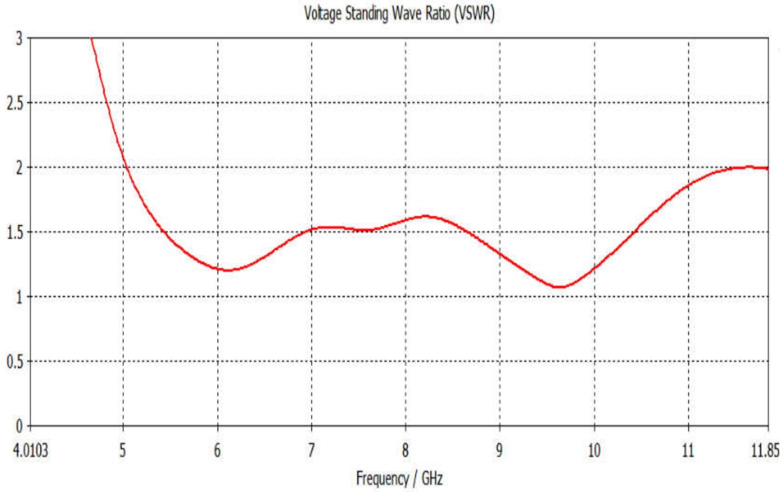

Fig 3: VSWR of the proposed element

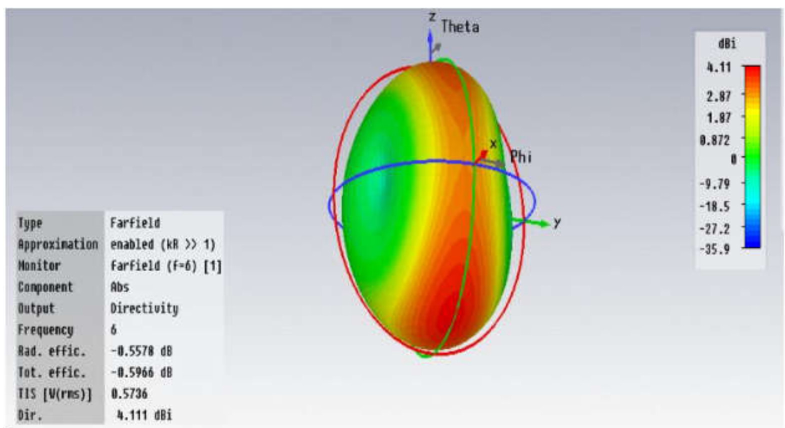

Fig 4 : 3D- Radiation Pattern at f_r = 6 GHz

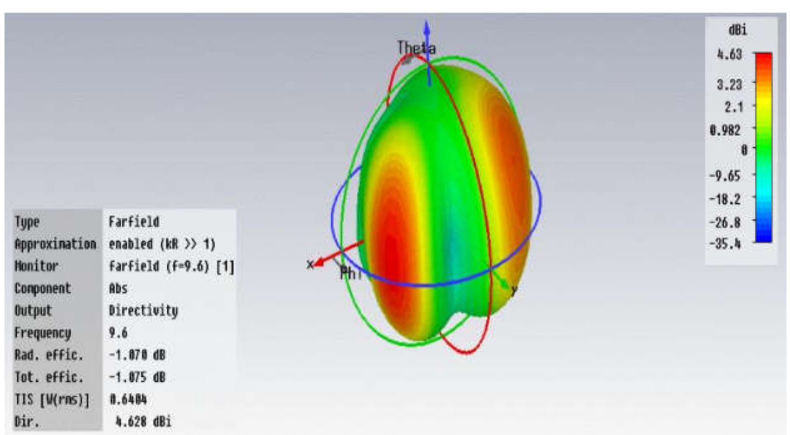

Fig 5 : 3D- Radiation Pattern at f_r = 9.6 GHz

IV. CONCLUSION

Development of technology and ever growing need for better inter- operability has resulted in multifunctional systems becoming the need of the hour. An UWB antenna having a slotted rectangular patch and a parasitic elliptical patch within it at the centre, had been successfully designed and simulated. In this design, the dimensions of the elliptical parasitic patch had been optimized such that broader bandwidth is achieved. The performance of antenna given in terms of impedance bandwidth is 80% when considered below 10dB. This covers the upper UWB frequency range where the VSWR is less than 2 with in this region. The performance of the antenna in terms of directivity of the designed antenna is nearly equal to 4.5 dBi on an average over the entire unlicensed UWB frequency.

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