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A Compact UWB Antenna for IEEE802.11a Standard Communication System

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ABSTRACT

In this proposed paper, a new compact design of microstrip patch Ultra-Wide Band (UWB) antenna is designed for C-wireless communication. The operating frequency for the proposed antenna that work between 4.8 GHz to 10.7 GHz. The proposed microstrip antenna consist of rectangular radiating patch above the FR4 substrate which is having the dielectric constant 4.3 and thickness of 1.6mm and ground plane under the rear end of the substrate. The designed antenna is used in different types of wireless applications due to its light weight, low volume, low cost to fabricate and low profile design. The results of the designed antenna such as radiation pattern, gain and return loss, is simulated by CST Microwave Studio software.

Keywords: Microstrip patch antenna, Ultra-Wide Band (UWB), Gaussian pulse, time domain analysis and return loss.

1. INTRODUCTION

Microstrip patch antennas play an essential role in wireless communication system. The need of Ultra-wide band antenna with broad band frequency span is exponentially increasing in wireless applications. UWB technology plays a superior part in communication system because antenna is the most important component in wireless technology. Nowadays, imaging radar, communications, and other localized applications uses extremely high frequency range UWB technology [1]. In the research of communication system design the broad band antenna design became an attractive and challenging [2]. Normally the UWB system antennas should have sufficiently wide operating bandwidth for impedance matching and high-gain radiation in the particular directions. In recent literature in the design of UWB antenna, is mostly used due to its wide bandwidth, simple structure, light weight and low cost. Many designs of UWB antenna have been proposed [3–9]. On the other hand, some of the antennas involve complex calculation and sophisticated fabrication process. Therefore, we are proposing a simpler method to design the UWB antenna based on microstrip rectangular patch.

2. ANTENNA DESIGN

In this document, the parameters of rectangular patch antenna are calculated based on transmission line modal analysis [2] and the detailed geometry and parameters are shown in Figure 1 and Table 1, respectively. The patch antenna designing involves, the resonant frequency f_r = 7.5GHz and the dielectric substrate FR4 is used. The dielectric constant of the substrate $\blacksquare_r = 4.3$, loss tangent (tan■) of 0.02, and thickness of the substrate h = 1.6mm has been used to design the microstrip patch antenna.

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The microstrip antennas width and length are determined as follows

$$W_{sub} = \frac{c}{2f}\left[\sqrt{\left(\frac{2}{\varepsilon r+1}\right)}\right] \quad (1)$$

Where c is velocity of light in free space.The effective dielectric constant is

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left\{\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}\right\} \quad (2)$$

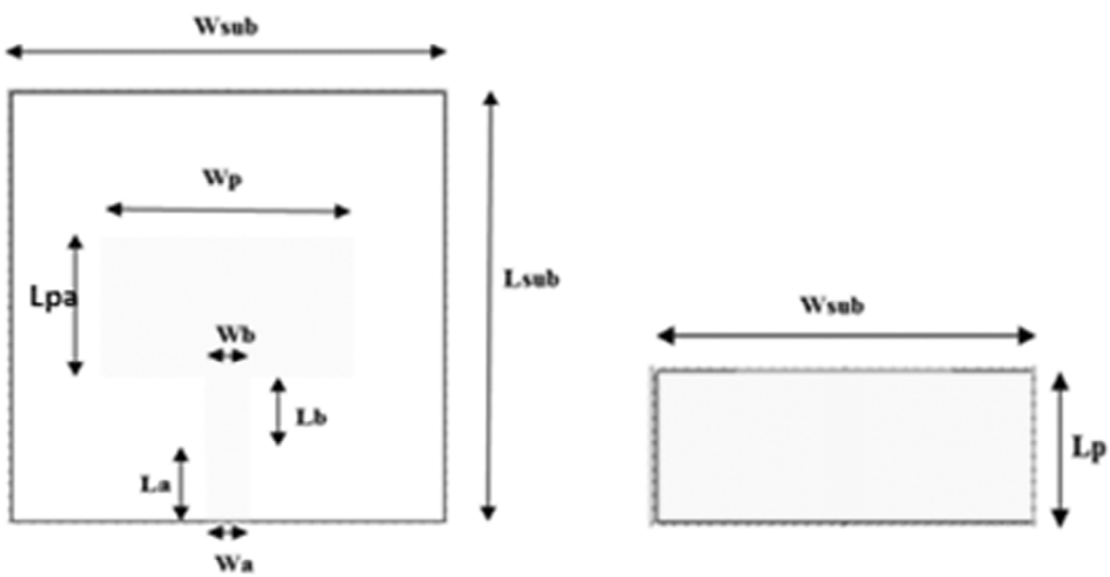
Where, the length of the patch dimension has been extended on each side by a length ΔL. This extended length is a function of the width-to-height ratio (W/h) and effective dielectric constant εreff. The normalized extension of the length is

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

The actual length of the patch can be determined as

$$L_{sub} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (4)$$

Time domain analysis tools from CST Microwave studio is used for simulating to optimize the design which give broad range of time domain signal which are used in UWB system. The input signal and virtual probe signal of Gaussian pulse are shown in Figure 2 is used for excitation in CST Microwave Studio because Gaussian signal offers a good simulation result in time domain compactness.

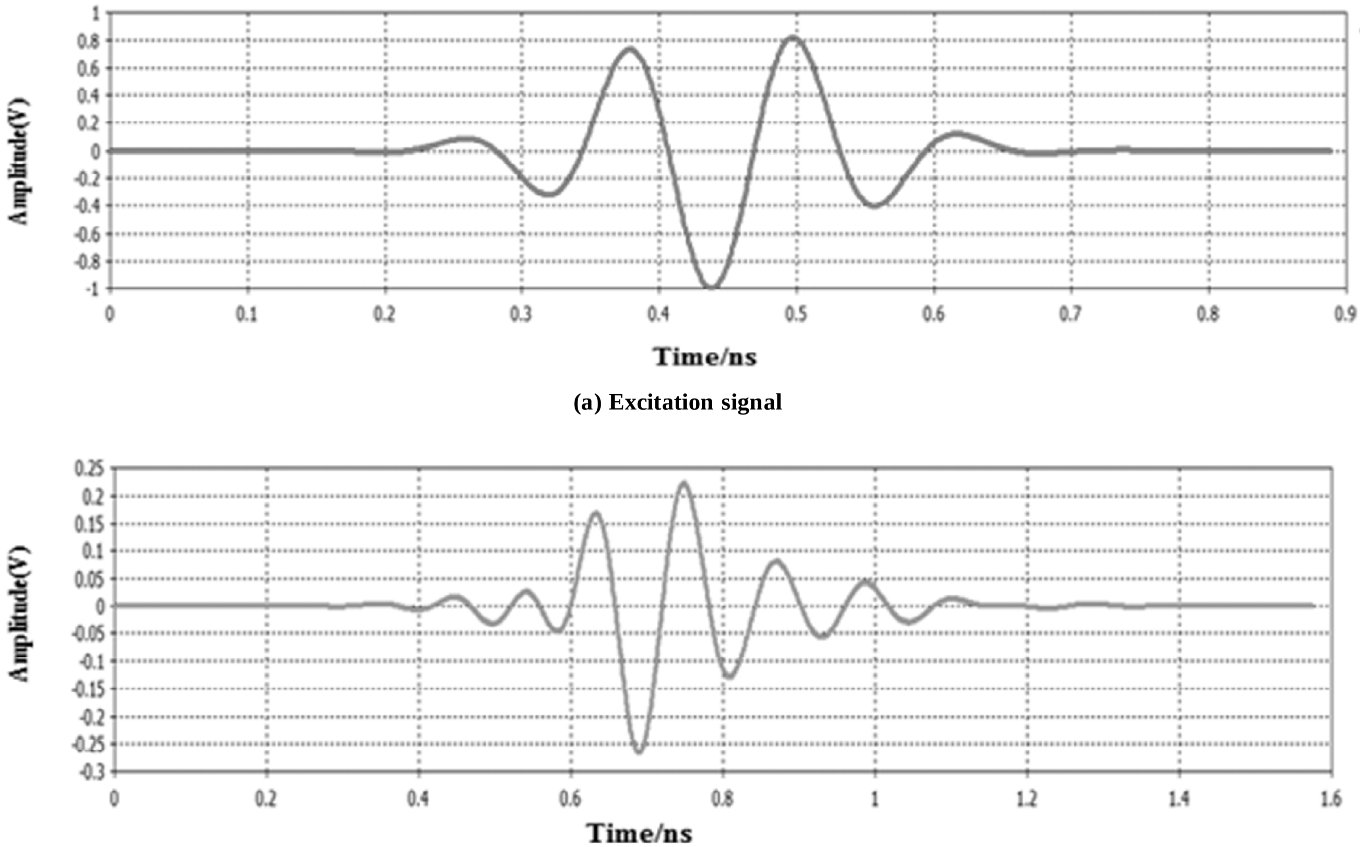


(a) Top view **(b) Bottom view**

Figure 1: The proposed geometry of the UWB patch antenna.

Table 1
The parameters for proposed antenna.

Parameter	Size(mm)	Parameter	Size(mm)
h	1.6	Wa	3
Hs	0.035	Wb	3.137
Ht	0.035	Lpa	11
La	11.5	Wp	18
Lb	10.5	Wsub	31
Lp	11	Lsub	34



(a) Excitation signal

(b) Virtual probe signal

Figure 2: Excitation signal and virtual probe signal in time domain

The microstrip patch antenna is excited with frequency range from 4 GHz to 12 GHz is analyzed. The width of the port in the inset feed is six times feed line width and height is four times height of the substrate and it is set from the substrate plane.

3. RESULTS AND DISCUSSION

The results and discussion are explained in detail about parametric study of microstrip patch antenna in time domain analysis. The study of parameters has been conducted to optimize the antenna design. This study is crucial as it does not give accurate measure before antenna fabrication can be done. Figure 3 shows return loss S11 (dB) over function of length ground patch (Lp). It is observed, the antenna is able to operate as a narrowband antenna for Lp of 34 mm. However, when the length ground patch reduces gradually and the good result is obtained at the height of ground plane, Lp of 11mm the return loss of the antenna improves dramatically. The partial ground structure gives better return loss as compared to full ground patch on the bottom because the antenna is transformed from patch-type to monopole-type by the ground plane.

Two steps of feed line are used to improve the overall bandwidth. The first feed line is connected to SMA center pin whose width is 3.137 mm while as an optimization function the second feed line width has been used in this studies. The optimized result of second feed line width is at 2.9mm and it is shown in Figure 4. This technique produces better impedance matching and the bandwidth increases gently. Figure 5 shows the return loss of the optimum design.

Radiation pattern of antenna explains the radiation characteristics on antenna as a function of space coordinate. In case of linearly polarized antenna, performance is often related in terms of the E and H plane field patterns. The E-plane is explained as the plane carrying the electric field vector and the directions of maximum emission of electromagnetic radiation while the H-plane as the plane carrying the magnetic field vector and the direction of maximum emission of electromagnetic radiation. Simulated output of two

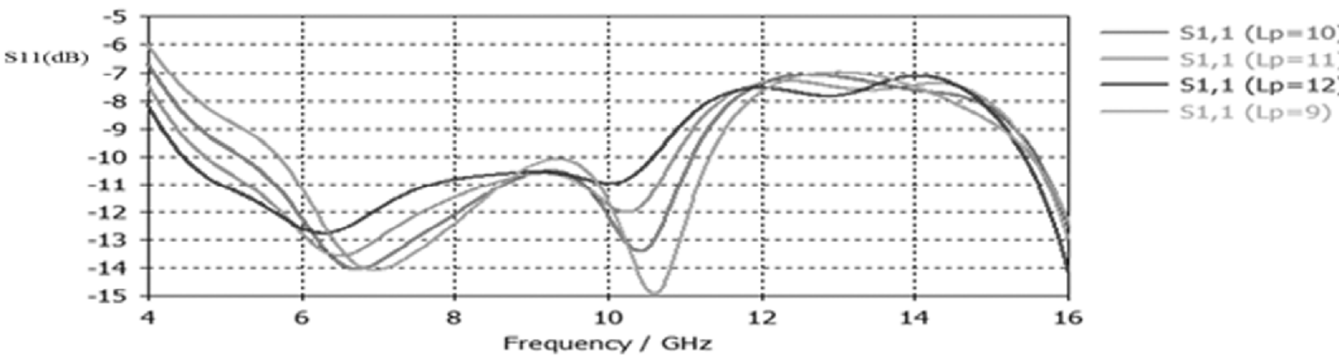


Figure 3: Parametric study of return loss (*S*11) over the lengths of ground layer.

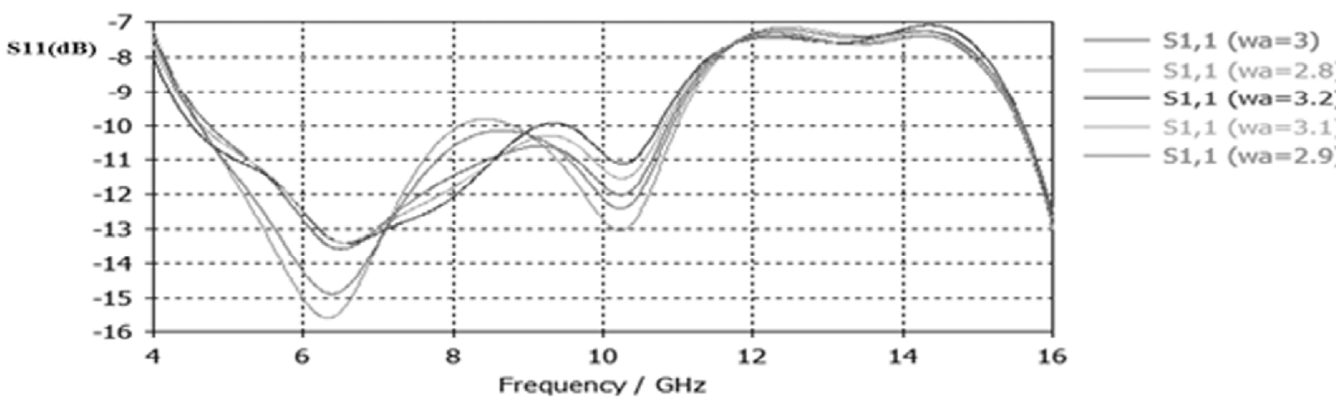


Figure 4: Parametric study of return loss (S11) over the width of second feed line.

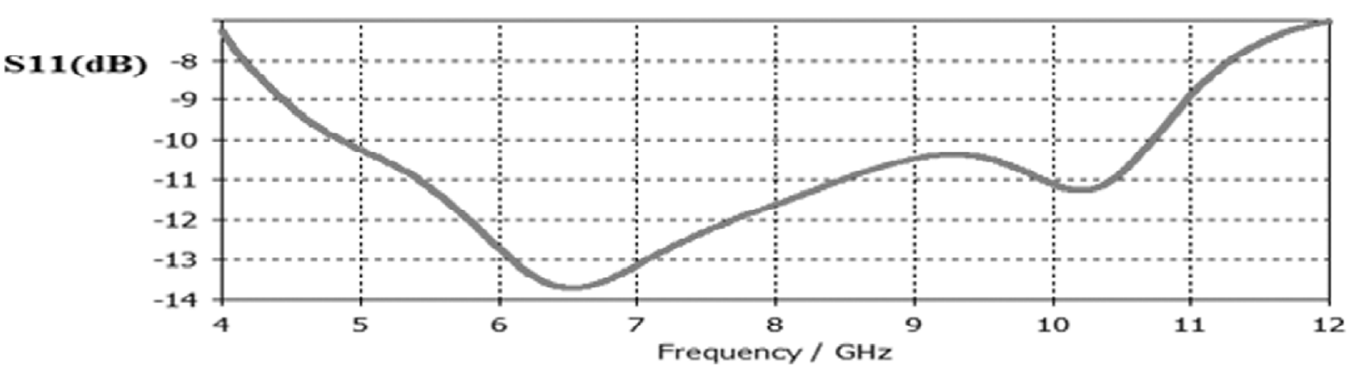


Figure 5: Return loss of the optimized proposed antenna.

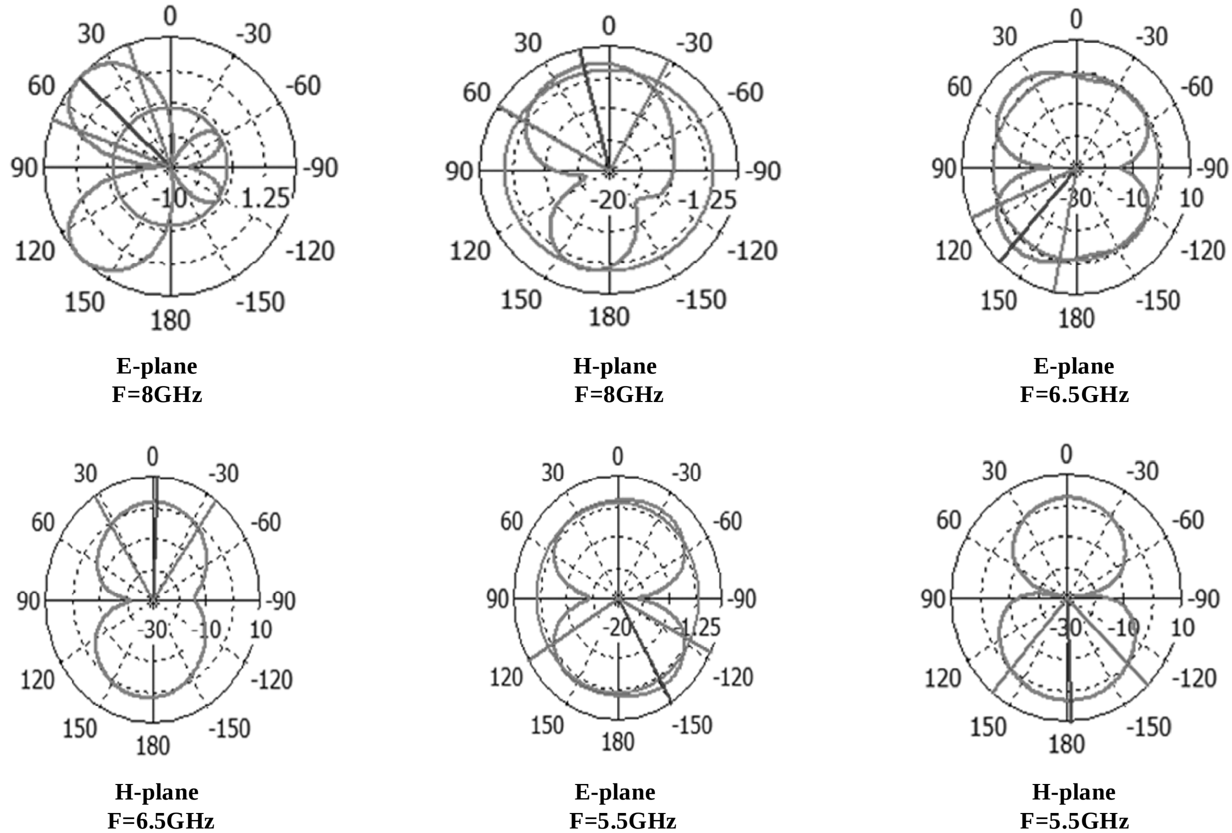


Figure 6: Radiation Pattern of UWB antenna.

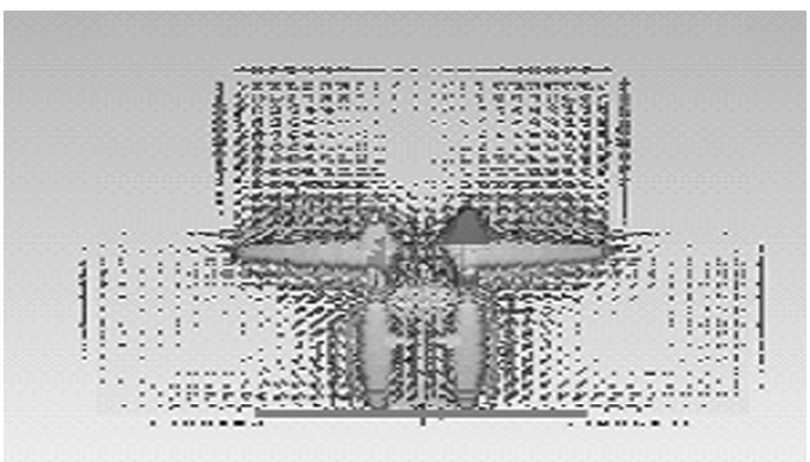


Figure 7: Surface current distributions

dimensional E and H-plane field pattern at three different frequencies 8GHz, 6.5GHz and 5.5GHz are shown in Figure 6.

The surface current distribution of microstrip patch antenna is shown in figure 7. The maximum current 43.6A/m is resulted in the point at which end of the feed line joined to the patch.

4. CONCLUSION

The proposed UWB antenna which can support to produce large bandwidth simulated by a time domain Gaussian pulse. By varying the length of the ground plane, improvement in return loss has been demonstrated.

Further enhancement of the antenna performance in term of bandwidth has been revealed by stepped impedance matching procedure. A further enhancement of the proposed antenna will be done in future by introducing slot in the ground plane.

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