Design of Micro strip Ultra Wide Band Antenna for Low, Medium, High Pulse Rate Systems

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***Abstract*— An Ultra Wide Band Antenna is printed in a form of rectangular patch. In the given microstrip patch a slight tapering has been done on lower side of patch as well as the ground plane has been truncated at the top. The substrate used has permittivity 4.4 with the dimensions (28X29X1.6). The dimensions are in millimeter. HFSS v11.0 simulation software is used to simulate the design. The paper is presented with the simulation results obtained from this UWB design. An impedance Bandwidth of 13.4 GHz (3.31 GHz -16.71 GHz) is obtained which lies below acceptable parameters (S_{11}<-10 dB).The given antenna exhibits acceptable VSWR values (1.0 – 2.0) and stable E and H radiation pattern. While designing this antenna two methods of achieving wide bandwidth is implemented. Those are frequency independence method and concept of resonant overlapping. The antenna exhibits resonant frequencies at several frequencies. We can use this antenna for transmitting UWB pulses at three different rates (3.3 GHz, 6.9 GHz, and 8.18 GHz). Thus the designed antenna satisfies the requirement for UWB Applications.**

Keywords—, ***FCC, Frequency Independence, Omni-directional, UWB, Return Loss, VSWR.***

I. Introduction

After the satisfactory acceptance of spectrum band between the ranges 3.1 to 10.6 GHz by FCC (Federal Communications Commission), most of educational institutions and development companies and MNCs have commenced their theoretical and practical researches design an antenna which can accommodate more and more efficient working and wide frequency range [1]. There are expectations that this Ultra Wide Band technology will provide higher speed data transmission with almost least power consumption. It can also be predicted that these antennas are applicable for various applications like medically imaging of living things, positioning of radar, in seeing through any objects. Microstrip Patch antennas are low cost, light weight, easily available, reliable, eco-friendly. So it will be an extraordinary design of implementing UWB Antenna on Microstrip patch [3].

Actually all Microstrip patches have demerits of exhibiting narrow impedance bandwidth. Numbers of efforts are being done for enhancing the impedance bandwidth up to optimum level. Many of them include introducing a cleft within the plane of radiating patch antenna. Clefts/ Slots may be of any orientation weather a square-ring or shaped in U format slot [5]. Dor increasing operational bandwidth, methods like stacking the patch which is coupled electromagnetically or using different type of gap coupled feeding techniques [6].

Though multiple antenna designs have been invented (as in the references), the designs are not as up to the mark as they must be. In the recent papers the designed antennas were only able to provide not more than two resonant frequencies. The VSWR was between 1.5 to 2.0 for desired frequency band.. In some papers the antennas fail to accommodate the allotted frequency band by FCC. They only use a part of it.

In the present paper, An antenna is designed on a microstrip patch domain with very simple and compact desgn. Antenna exhibits an impedance bandwidth between 3.31 GHz to 16.71 GHz. The antenna exhibits 5 different resonant frequencies. The VSWR values for operations at different frequencies is almost equal to 1.1.The antenna possesses three different resonant frequencies which can be used respectively for low, medium and high pulse rate based systems. The Gain of antenna varies from 2 dBi to 3.5 dBi. The outline of the given paper is as follows. Section 2 consists of antenna configuration. Section 3 is about the design and analysis of proposed antenna. And lastly section 4 is the conclusion of the proposed paper.

II. Antenna Configuration

The designed structure is placed in x-y plane and the normal to the plane of antenna is *z* axis. The designed antenna is depicted in figure 1, out of which top one resembles the radiating patch whereas bottom one is the Ground Plane [7]. During the designing of Three methods of achieving wide bandwidth is taken into consideration. Out of which two have been implemented i.e. the concept of frequency independence, which states that the impedance and pattern parameters are independent to the frequency changes The second concept is the concept of resonance overlapping, which states that we can add the resonance characteristics of two different geometries by simply combining them. [7].

The antenna consists of a rectangular patch which is cut is cut at trimmed at the bottom is such a way that it appears to be tapered at the center. The top corners are truncated. The antenna consists of four clefts/ slots which are 1.5 mm in length and variable width from 10 to 4 mm. The ground Plane is truncated at the top. The material use for substrate is FR4 substrate, with 4.4 as permittivity. The thickness of substrate is 1.6 mm, where as the thickness of radiator and ground plane is measured to be 0.2.All the given dimensions are in mmThe dimensions of substrate are 28mmX29mmX1.6mm.

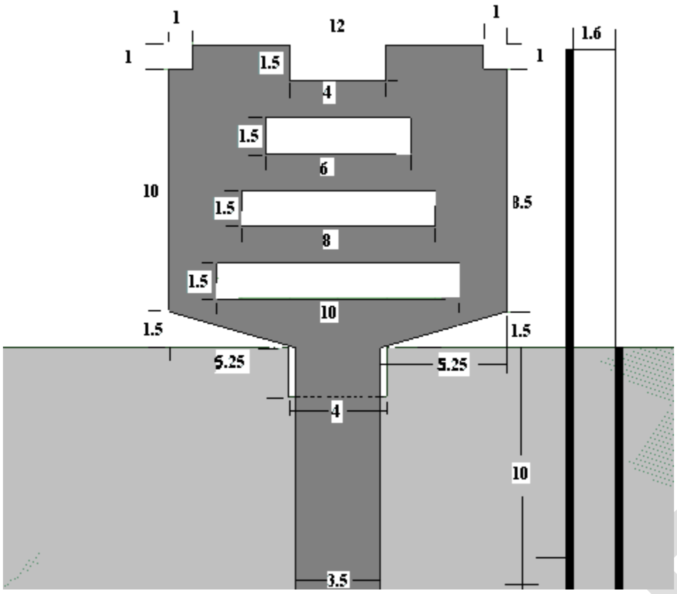

Fig. 1 Geometry of proposed Microstrip antenna.

III. ANTENNA DESIGN AND ANALYSIS

Antenna designing process is done in simulation software named as HFSS vs 11.0.We are able to get almost all the parameters of any antenna.

A. Design formulae

$$W = \frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}} = \frac{\upsilon_0}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \quad \dots (1)$$

$$\epsilon_{\text{reff}} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \quad \dots (2)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{\text{reff}}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{\text{reff}}-0.258)\left(\frac{W}{h}+0.8\right)} \quad \dots (3)$$

$$L = \frac{1}{2f_r\sqrt{\epsilon_{\text{reff}}}\sqrt{\mu_0\epsilon_0}} - 2\Delta L \quad \dots (4)$$

B. Design steps

1. The first and the foremost step is design of width W for given rectangular patch antenna of length 'L' and width 'W' for FR4 substrate(ε = 4.4) of thickness 'h'=1.6mm and frequency *f*r= 6.5GHz.(1)
2. Using this W we will find out effective permittivity ε_{reff}
3. Now find out ΔL using equation (3).
4. Finally we find L from equation (4)[10].

In this way the given design is achieved for solution frequency of 6.5 GHz [10]. From [2], a wider bandwidth can be achieved by inserting a slot on the radiating region of the given patch antenna and introducing a slant at the periphery edge of the radiating patch. The resonating frequencies are obtained due to the changes in the width of slot [8].

The relation between slot width $W_s$and resonant frequencies are given in table 1. The relations are easily found by substituting values of $W_s$in equation (1).

TABLE I

W_s (mm)	**Theoretical *Resonant frequency***	**Practical *Reonant frequency***
14	6.66 GHz	6.9 GHz
10	9.2 GHz	8.5 GHz
8	11.42 GHz	11.12 GHz
6	15.19 GHz	15.15 GHz

The designed structure for antenna is shown in figure 3. The analysis of UWB antenna is discussed in following points.

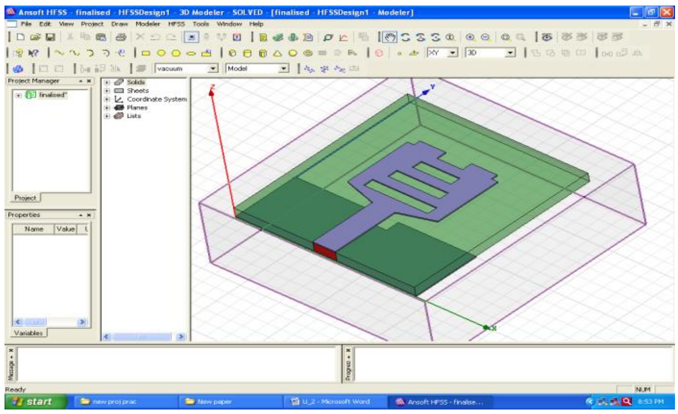

Fig. 2 Prototype of proposed antenna designed in HFSS v11.0

C. Return Loss

The Return Loss plot is shown in figure 4.The figure shows that the antenna exhibits optimum at 6 different resonant frequencies. The resonant frequencies are 4.5 GHz, 6.9 GHz, 8.5 GHz, 11.12 GHz, 13.9 GHz and 15.15 GHz. But we are expecting three different frequencies for low, medium and high bands (channels) of UWB spectrum. The resonant frequency at 8.5 GHz is narrow than 500 MHz so it cannot fit for UWB unit under rules [2]. We can use this band for some other purpose.

Bandwidth enhancement is achieved by tapering the radiator at the bottom edge (slanting towards the feed line). Because of this technique there is a discontinuity in the microstrip line [2]. This results in the second resonating frequency at 6.9 GHz [6].

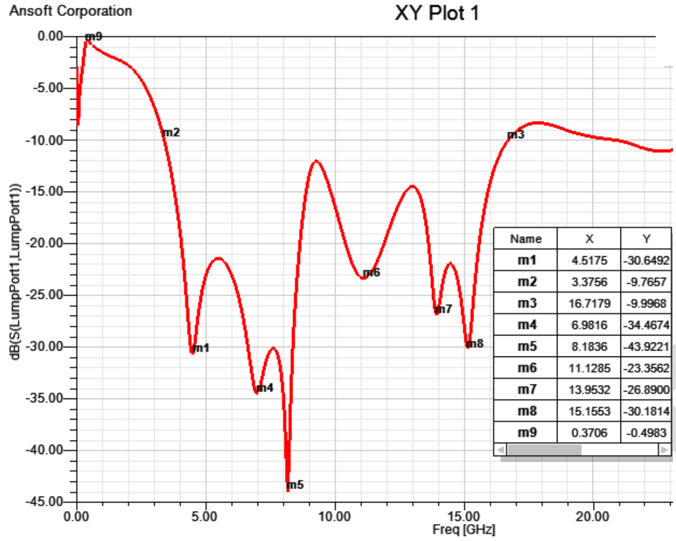

Fig. 3 Return loss

D. Radiation Pattern

Nearly an Omni directional 3 D radiation pattern is exhibited by proposed antenna. The VSWR value for all the resonant frequencies lies between 1 and 1.15.Which means that the reflected power is less than 5 % of the transmitted power.

Figure 4 shows 3-Dimensional radiation pattern. Figure 5 shows the VSWR plot

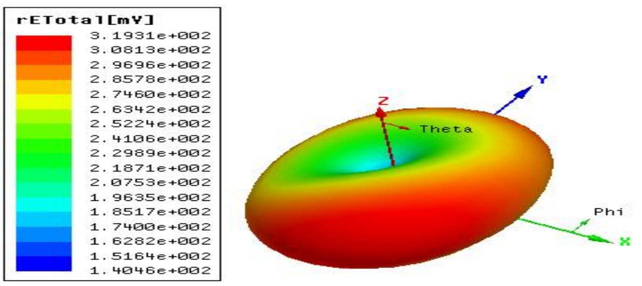

Fig. 4.Radiation Pattern.

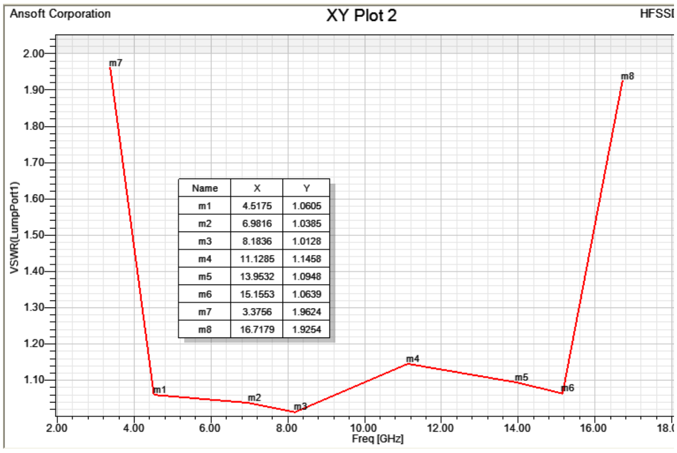

Fig. 5 VSWR plots.

E. Group Delay

Group delay is one of the most important parameters to find out the performance characteristics of UWB technology. The Group delay is nothing but the shortest pulse width that transmitted by that particular antenna with minimal distortion. The group delay is below 0.3 ns for the given proposed structure. The group delay is depicted in figure 6.

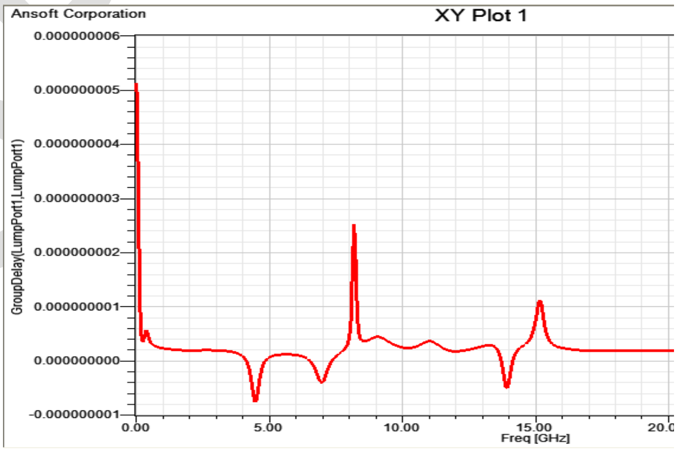

Fig.6 Group delay

F. Applications;

Low pulsed rate (3-5 giga-pulses per second) UWB Antennas can be used to communicate between PC peripherals, as well as it can be used for indoor short range applications due to its low emission levels.

Medium rate (5-7 giga-pulses per second) applications include usage in radio frequency sensitive environments like hospitals because of it precise handling capabilities.

Higher rate (7-10 giga-pulses per second) contribute wall through imaging, radar positioning, target reorganization and automatic target tracking.

CONCLUSION

The designed microstrip patch Ultra Wide Band Antenna satisfies the requirement if UB technology (between 3.31-16.71 GHz). The antenna exhibits acceptable VSWR and return loss properties. The 3D radiation pattern of antenna is nearly Omni-directional. Antenna provides acceptable group delay between 0.1 to 0.3 ns with gain is about 2 dBi Thus the given designed antenna satisfies to be applicable for UWB technology.

FUTURE SCOPE:

Till now no antenna has acquired 14 resonating bands of UWB system. Using one or two band is sufficient; this may get saturated, so one has to come up with the design which accommodates all 14 communication bands of UWB technology. One can use inter office communications with the use of solar energy during day time. This is what called as energy harvesting.

REFERENCES

[1] BaskaranKasi, Lee Chia Ping, Chandan Kumar Chakrabarty, “A Compact Microstrip antenna for Ultra wide band Application,” *European Journal of Scientific Research*, ISSN 1450-216X Vol.67 No.1 (2011), pp. 45-51

[2] K.C. Gupta, R. Garg, I. Bahl and P. Bhartia, “*Microstrip Lines and Slotlines*,” Artech House, 2nd Ed, 1996.

[3] Y. Zehforoosh, C. Ghobadi and J. Nourinia, “Antenna design for Ultra Wideband Application Using a New Multilayer Structure,” *Progress in Electromagnetics Research Symposium*, Beijing, 26–30 March 2007.

[4] S. Sadat, M. Fardis, F. Geran, and G. Dadashzadeh, "A compact microstrip square-ring slot antenna for UWB applications,"*Progress In Electromagnetics Research*, Vol. 67, 173–179, 2007.

[5] K. F. Lee, K. M. Luk, K. F. Tong, S. M. Shum, T. Huyn and R. Q. Lee, “Experimental and Simulation Studies of the Coaxially Fed U–slot Rectangular Patch” *IEEE Proceedings of Microwave Antenna Propagation*, Vol. 144, No. 5, October 1997, pp. 354–358.

[6] FCC report and order for part 15 acceptance of ultra wideband UWB) systems from 3.1– 10.6 GHz, Washington, DC, 2002.

[7] Werner Wiesbeck,GrzegorzAdamiuk, Christian Sturm, “Basic Properties and Design Principles of UWB antennas,” *Microwave and Optical Technology Letters*, Vol. 29, No.2, April 20 2001, pp. 95–97.

[8] Ramesh Garg,PrakashBhartia,InderBhal,ApisakIttipiboon “Microstrip Antenna Design handbook,” *ISBN-0890065136*, pp. 253-268.

[9] Hans Gregory Schantz , “ A BRIEF HISTORY OF UWB ANTENNAS ” ,Next-RF, Inc. 4811Cove Creek Drive Brownsboro, AL 35741

[10] C.A.Balanis, “Antenna Theory,” *Jhon Wiley and Sons*, pp. 811-835.