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Bandwidth Improvement of UWB Microstrip Antenna Using Finite Ground Plane

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ABSTRACT
Microstrip antennas play a vital role in communication system. It is required in high performance wireless applications. But due to its resonant nature microstrip antennas have some considerable drawbacks like narrowband performance. Extensive study has been carried out on microstrip patch antennas in the recent past, but it still have large scope for improvement in the near future. To overcome narrow bandwidth problem, number of methods and techniques have been suggested and investigated, keeping in mind that the basic advantages of microstrip antenna should not be altered such as low profile, light weight, low cost and simple printed circuit structure. The area of investigation includes modification in geometrical shape of the antenna, use of resonators, use of dipole, and many other parameters. This paper presents a comparison between conventional microstrip antenna and microstip antenna with finite ground plane at ultra wideband. HFSS simulation tool is used here for antenna simulation. For feeding purpose microstrip feed line is used (50Ω). Optimized result provides impedance bandwidth of 7.2GHz with VSWR<2, operating frequency range is from 6.5GHz to 13.7GHz. Proposed antenna is useful for many ultra wideband applications.
***Keywords* -** Ultra wideband, Microstrip antenna, Narrowband, HFSS, Partial ground plane.

I. INTRODUCTION

Antennas are one of the most important components of wireless communication system. Because of their great advantages, these antennas are used over conventional or metallic antennas. Antennas are used for transmitting and receiving electromagnetic waves. Out of these antennas, microstrip antennas have been used for many applications, such as mobile communications, Direct Broadcasting Satellite (DBS) systems, various radar systems and Global Positioning System (GPS). Their advantages include light weight, low profile, ease of fabrication, low cost and integration with RF devices, etc[1][2]. However, the sizes of conventional rectangular microstrip antenna seems to be too large when they are applied below 2GHz frequency range, it makes them difficult to be installed on notebook computers, televisions or any other hand-held terminals. Many techniques have been proposed to reduce the sizes of microstrip patch antennas. Material of high dielectric constant has been used. But, this will lead to high loss and high cost. Federal Communication Commission allocated a bandwidth of 7.5GHz, ranging from 3.1GHz to 10.6GHz for ultra-wideband applications. Ultra wideband is generated by pulses of very short durations generally in picoseconds, that's why it can provide data at very high speed in range of Mbps. There are many advantages of short duration pulses like it can avoid multi path fading etc. It can be used for radars and remote sensing. UWB antennas have high order radiation efficiency over ultra wideband from 3.1 to 10.6GHz. In this paper, an ultra wideband microstrip antenna with finite ground plane is designed. Finite ground plane reduces the overall impedance of antenna. This also reduces the copper sheet area which in turn leads to low quality factor and hence antenna bandwidth increases. Microstrip line is used for feeding because of ease of fabrication. VSWR<2 and S11< -10dB is obtained over the frequency range.

II. MATHAMATICAL FORMULATION

Width of microstrip antenna patch is simply given as

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

Where,
W= Width of Patch
ε_r = Substrate material dielectric constant.
Actual length of microstrip antenna patch is given as

$$L_{actual} = L_{eff} - \Delta L \qquad (2)$$

Where,
L_{eff}= Effective length of the patch.
ΔL = Extended electrical length
Effective length of the patch is simply given by

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

Where,

ε_{reff} = Effective dielectric constant

At the low frequencies, effective dielectric constant remains essentially constant. At intermediate frequencies its values starts to monotonically increase and finally approaches the value of dielectric constant of the substrate. Its value is given by,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}} \quad (4)$$

h = thickness of the substrate.

In microstrip patch antenna, radiations occur due to fringing effect. Due to fringing effects electrical length of patch is little bit larger than the physical length. This fringing depends on the width of patch and height of substrate used [2]. Extended electric length is given by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.8)} \quad (5)$$

III. ANTENNA DESIGN

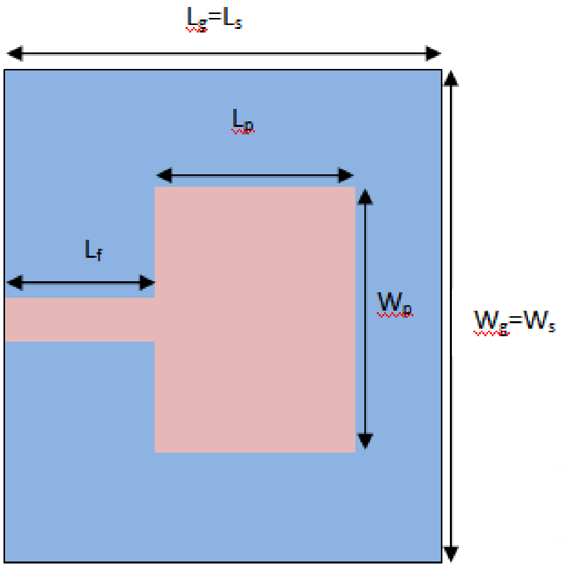

Figure 1: Design of Conventional Microstrip Antenna

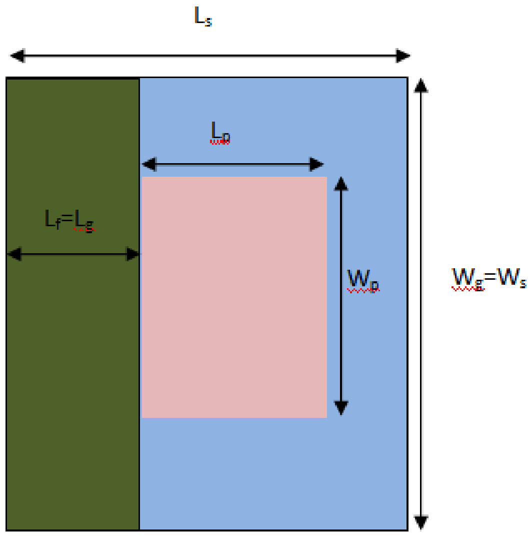

Figure 2: Design of Proposed Microstrip Antenna

Figure 1 shows the antenna design of conventional microstrip antenna where as figure 2 shows the antenna design of microstrip antenna with finite ground plane.

Table 1and 2 shows the dimension of various parameters of antennas.

Table 1: Dimensions of Conventional Antenna

S.No	Parameters	Dimensions
1	Substrate	W_s=30 mm L_s=30 mm H_s= 1.6mm
2	Rectangular patch	L_p= 12 mm W_p= 16mm
3	Ground Plane	W_g= 30mm L_g= 30 mm
4	Feed line	W_f= 3 mm L_f = 8 mm

Table 2: Dimensions of Antenna with Finite ground Plane

S.No	Parameters	Dimensions
1	Substrate	W_s=30 mm L_s=30 mm H_s= 1.6mm
2	Rectangular patch	L_p= 12 mm W_p= 16mm
3	Ground Plane	W_g= 30mm L_g= varying
4	Feed line	W_f= 3 mm L_f= 8 mm

IV. RESULT AND DISCUSSION

In this paper, ANSOFT HFSS (High Frequency Structural Simulator) is used for antenna designing. Here basically a comparison is done between the conventional microstrip antenna operating at ultra wide band frequency and a microstrip antenna with finite ground plane, operating at the same frequency. Figure 1 and 2 shows the design of respective antennas and table 1 and 2 shows the design specifications of the respective antennas. Figure 3 shows the return loss graph of the conventional antenna. Here it can be seen that it consists of three bands (6.98-7.21GHz, 10.5-12.28GHz, and 13.4-14.02GHz). Also it is very clear from the graph that the antenna's best performance is at 11.6GHz frequency and return loss is -30dB.

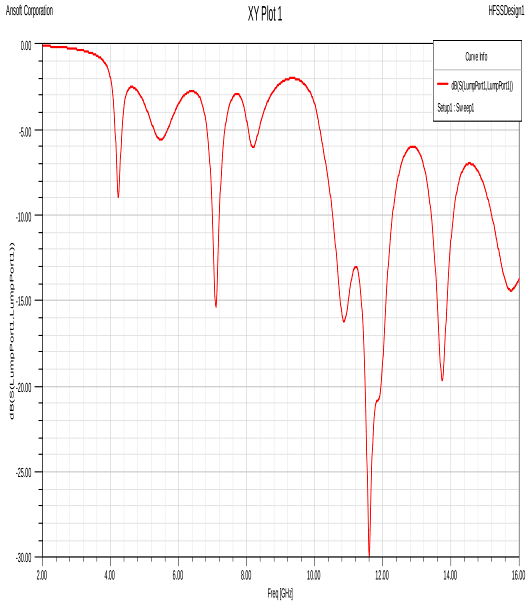

Figure 3: Return loss graph of conventional microstrip antenna

Figure 2 shows the antenna with finite ground plane. Here patch width is 16 mm and length is 12 mm. Dielectric material is 30 mm wide and 30 mm long and height of the substrate is 1.6 mm. Ground plane is finite, which provides good impedance match with width 30mm and varying length. Figure 4 shows the return loss graph of antenna with finite ground plane. Here ground plane is varied from 7mm to 9mm. At different length of ground plane (7mm, 7.4mm, 7.8mm, 8mm, 8.4mm, 8.8mm and 9mm) effect on bandwidth of antenna is observed. Table 3 demonstrates different frequency ranges at different ground plane length.

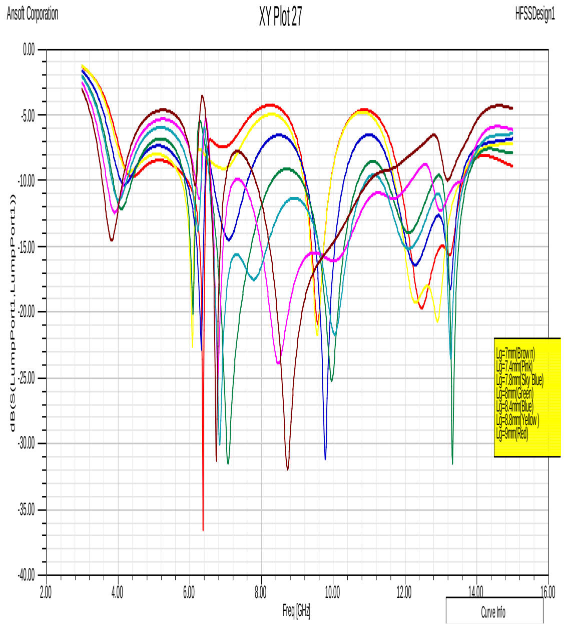

Figure 4: Return loss graph of antenna at different ground plane length

Table 3: Bandwidth at Different Length of Ground Plane

Length of Ground Plane (mm)	Frequency Range (GHz)	Bandwidth (GHz)	Fractional Bandwidth (%)	
7	7.8 – 11.01	3.21	44.58	
7.4	6.5 – 12.22	5.72	79.44	
7.8	6.5 – 13.6	7.1	98.6	
8	6.5 – 13.7	7.2	100	
8.4	9.2 – 10.33	1.13	15.69	
8.8	9.17 – 9.94	0.77	10.69	
9	9.22 – 9.92	0.7	9.72	

From the figure 4 and table 3 it is clear that as the length is increased from 7mm to 8mm the bandwidth increases but as the length increased beyond 8mm then the bandwidth starts decreasing in huge amount. So the optimum bandwidth is achieved when length of ground plane is 8mm (Green colour curve) i.e. 7.2 GHz.

V. CONCLUSION

From the above result and discussion, it can be concluded that microstrip antenna with finite ground plane provides better performance in terms of bandwidth when compared with the conventional one. Conventional microstrip antenna provides three smaller bands, while the proposed antenna with finite ground plane provides band of larger bandwidth. Length of ground plane varied from 7mm to 9mm and it was found that at 8mm the bandwidth is maximum (7.2GHz). The proposed design of the antenna can be used for a variety of UWB applications like wireless connectivity between UWB-enabled devices, high speed data transfers, many medical and defence applications.

REFERENCES

[1] Bahl I. J. & Bhartia P, *Microstrip Antennas* (Artech House, New Delhi), 1980.

[2] Balanis C.A., *Antenna Theory, Analysis and Design*,(John Wiley, New York),1982.

[3] FCC 1st Report and Order on Ultra Wideband Technology, Feb.2002.

[4] Ansoft HFSS, Pittsburg PA 15219,USA.

[5] Mohamed A. Hassanien and Ehab K.I. Hamad, "Compact Rectangular U-Shaped Slot Microstrip Patch Antenna for UWB Applications*",2010 Middle East Conference on Antenna and Propagation,* Cairo, Egypt.

[6] J.A. Ansari, Anurag Mishra, Ashish Singh, ,"Analysis of Ultra-Wideband Patch Antenna for S,C & X Band Applications", *International Conference on computer & Communication Technology*(ICCCT)-2011

[7] Guillanton, E., Dauvignac, J. Y., Pichot, C., & Cashman, J. (1998). A new design tapered slot antenna for ultrawideband applications. *Microwave and Optical Technology Letters, 19(4)*, 286-289.

[8] Qu, S. W., Ruan, C., & Wang, B. Z. "Bandwidth enhancement of wide-slot antenna fed by CPW and microstrip line", *IEEE Antennas and Wireless Propagation Letters, 5(1)*, 15-17 (2006).

[9] P.K.Singhal, Piyush Moghe; Design of a single layer E-shaped micro strip patch antenna; 0-7803-9433-X/05/2005 IEEE.

[10] David M Pozar; *Micro strip antennas*; 0018-9219/1992 IEEE

[11] Latif, S. I., Shafai, L., & Sharma, S. K. "Bandwidth enhancement and size reduction of microstrip slot antenna", *IEEE Transactions on Antennas and Propagation, 53(3)*, 994-1003 (2005).

[12] Anand Sharma and Rajesh Kumar Vishwakarma, "Microstrip Antenna With Swastik Slot For UWB Applications"*2014 IEEE Students' Conference on Electrical, Electronics and Computer Science*

[13] Keshav Mishra, Mehajabeen Fatima, "Analysis of Double U-slot Loaded Patch Antenna for UWB Applications", *International Journal of Engineering Research and Technology Vol. 3* Issue 5, May-2014

[14] Qu, S. W., Ruan, C., & Wang, B. Z. "Bandwidthenhancement of wide-slot antenna fed by CPW and microstrip line", *IEEE Antennas and Wireless Propagation Letters, 5(1)*, 15-17 (2006).

[15] S.H.S. Esfahlani, A. Tavakoli, P.Dehkhoda; A compact single layer dual band micro strip antenna for satellite application; *IEEE Antenna and Wireless Propagation Lettes VOL.10*,2011

[16] Keshav Mishra, Mehajabeen Fatima, "Enhanced Bandwidth of UWB Microstrip Antenna using U-slot and Finite Ground Plane", *International Journal of Engineering Research and Technology Vol. 3* Issue 6, June-2014.