Enhanced Bandwidth of UWB Microstrip Antenna using U-slot and Finite Ground Plane

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***Abstract*— Microstrip antennas have many advantages in communication system. It is required in high performance wireless applications. But microstrip antennas do have some considerable drawbacks like narrowband performance due to its resonant nature. Extensive study has been done on microstrip patch antennas in the recent past, it still has many scope for improvement in the near future. To overcome this problem, number of techniques and methods have been suggested and investigated, keeping in mind that the basic advantages of microstrip antenna should not be altered, such as light weight, low profile, simple printed circuit structure and low cost. The area of investigation includes modified geometrical shape of the patch antenna, use of dipole, use of resonators and many other factors or parameters. This paper presents a microstrip antenna loaded with U-slot. Here rectangular patch and partial ground plane is used. Antenna designing is done by HFSS simulation tool. Microstrip feed line is used for feeding (50Ω). Proposed antenna gives impedance bandwidth of 7.85GHz with VSWR<2, operating over frequency range 6.65GHz to 14.5GHz. This antenna is useful for various ultra wideband applications.**

Keywords*— *Narrowband, Partial ground plane, Ultra wideband, Microstrip antenna, HFSS

I. INTRODUCTION

Now a days, due to their several key advantages over conventional wire and metallic antennas, microstrip antennas have been used for many applications, such as Direct Broadcasting Satellite (DBS) systems, mobile communications, Global Positioning System (GPS) and various radar systems. Their advantages include low profile, light weight, low cost, ease of fabrication and integration with RF devices, etc[1][2]. They can also be made conformal to mounting structures . However, when they are applied in the frequency range below 2GHz, the sizes of conventional rectangular microstrip patches seem to be too large, which makes it difficult for them to be installed on televisions, notebook computers or other hand-held terminals, etc. Several techniques have thus been proposed to reduce the sizes of conventional half-wavelength microstrip patch antennas. Material of high dielectric constant has been used. However, this will lead to high cost and high loss. Also, poor efficiency due to surface wave excitation is another drawback of this method. Federal Communication Commission allocated a 7.5GHz bandwidth from 3.1GHz to 10.6GHz for ultra-wideband applications. It is generated by pulses of very short durations generally in picoseconds, therefore it can provide data at very high rate in range of Mbps. Short duration pulses have many advantages like it avoids multi path fading etc. It is used for remote sensing and radars. UWB antennas have high radiation efficiency over ultra wideband from 3.1 to 10.6GHz. The most challenging task is to develop ultra wideband antenna for mobile communication as it requires small area for installation of antenna.

In this paper, a U-shaped microstrip antenna is designed. Slot reduces the overall impedance of antenna. This slot also reduces the copper sheet area which leads to low quality factor and hence bandwidth increases. Because of ease of fabrication, microstrip line is used for feeding. VSWR<2 and S11< -10dB is obtained over the frequency range.

II. THEORETICAL CONSIDERATION

Width of patch of microstrip antenna is simply given as

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

Where,

W= Width of Patch

ε_r = Dielectric constant of the substrate

Actual length of patch of microstrip antenna 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

For the low frequencies, effective dielectric constant is essentially constant. At intermediate frequencies its values begin to monotonically increase and eventually approach the values 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 antenna, radiation occurs due to the fringing effects. Due to fringing effects electrical length of patch is larger than the physical length. This fringing depends on the width of patch and height of substrate [2]. Extended electric length is given by

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

III. ANTENNA DESIGN

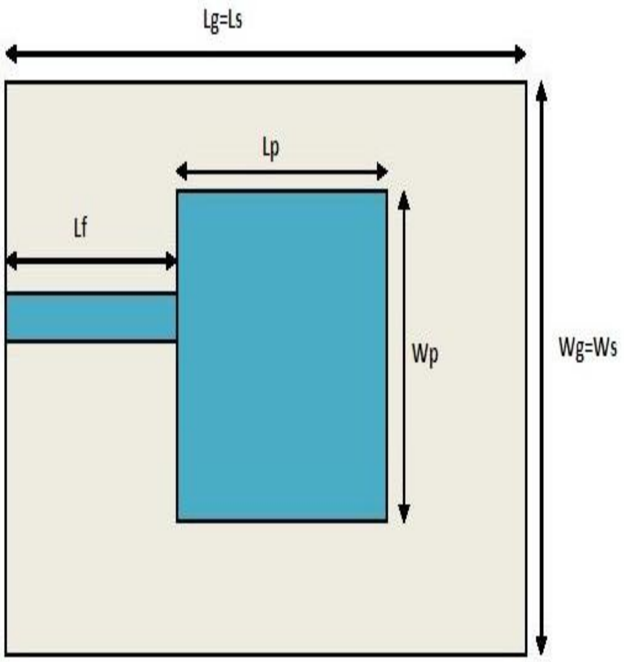

Fig.1 Design of Microstrip Antenna (Antenna 1)

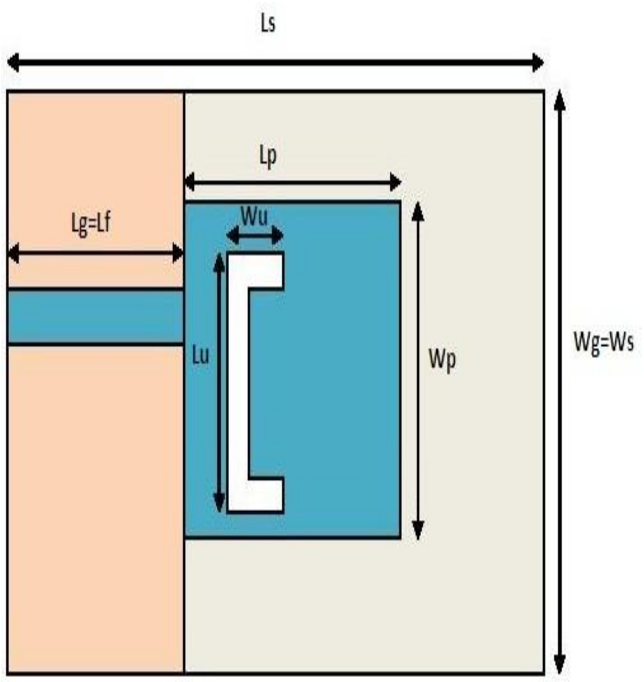

Fig.2 Design of U-slot loaded Microstrip Antenna (Antenna 2)

Figure 1 shows the antenna design of normal microstrip antenna where as figure 2 shows the antenna design of u-slot loaded microstrip antenna.

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

Table 1. Dimensions of Antenna 1

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 2

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= 8 mm
4	U-Slot	L_u= 12 mm W_u= 2mm
5	Feed line	W_f= 3 mm L_f = 8 mm

IV. RESULT AND DISCUSSION

In this paper, antennas are designed by using ANSOFT HFSS (High Frequency Structural Simulator) [4]. Here basically a comparison is done between the normal microstrip antenna operating at ultra wide band frequency and a u-slot loaded microstrip antenna operating at the same frequency with ground plane which is finite. Figure 1 and 2 shows the design of antennas. And table 1 and 2 shows the design specifications of the respective antennas. Here first antenna is the normal microstrip antenna operating at ultra wideband frequency. Figure 3 shows the return loss graph of the first antenna. Here as one can see 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 performace is at 11.6GHz frequency and return loss is -30dB.

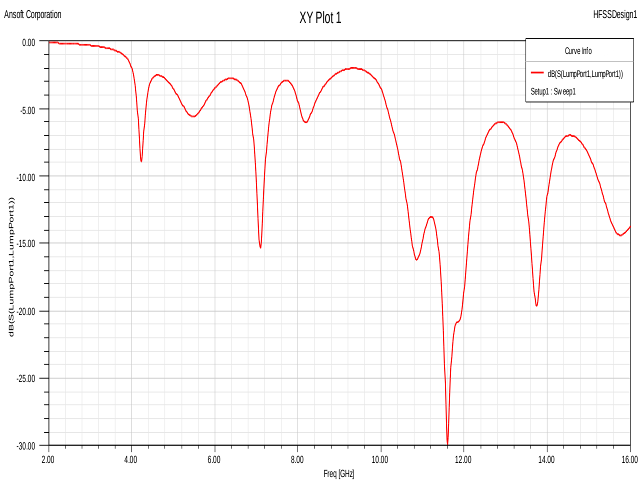

Fig. 3 Return loss graph of MSA (antenna 1)

Figure 2 shows the antenna with u-slot and finite ground plane. Here patch is 16 mm wide and 12 mm long. Dielectric material is 30 mm wide and 30 mm long and height of the substrate is 1.6 mm. Ground plane is partial providing good impedance match with width 30mm and 8mm length. U-shaped slot is used to decrease the overall antenna impedance. It provides good impedance matching and higher bandwidth. Figure 4 shows the return loss graph of antenna with u-slot and ground plane which is finite one.

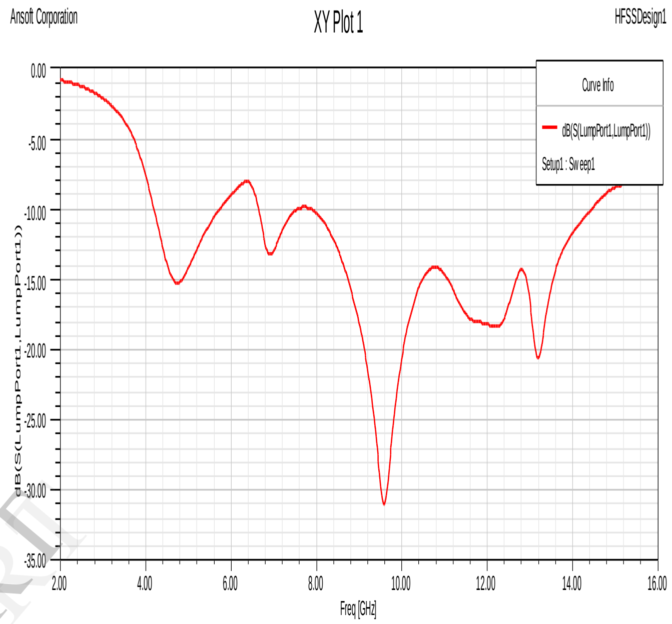

Fig.4 Return loss graph of U-slot antenna (antenna 2)

As it is clear from fig.4 that antenna 2 is consist of two bands, 4.2GHz to 5.7GHz and 6.65GHz to 14.5GHz. the second band is of 7.85GHz bandwidth and maximum return loss is -31.3dB, resonating at 9.6GHz frequency. In comparison to the antenna 1, this antenna provides larger bandwidth capable of handling many wireless applications.

Figure 5 and 6 shows the VSWR graphs for antenna 1 and 2 respectively.

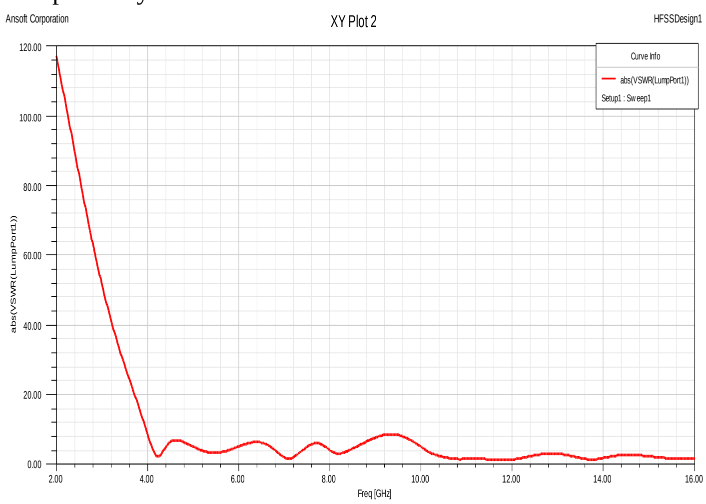

Fig. 5 VSWR graph of MSA (antenna 1)

As it is very clear from the above figure that the level of mismatch of impedance is very high, as VSWR is not less than 2, which is not desirable at all. As the there should be good impedance matching for better performance of antenna.

Figure 6 shows the VSWR graph for U-slot antenna (antenna 2).

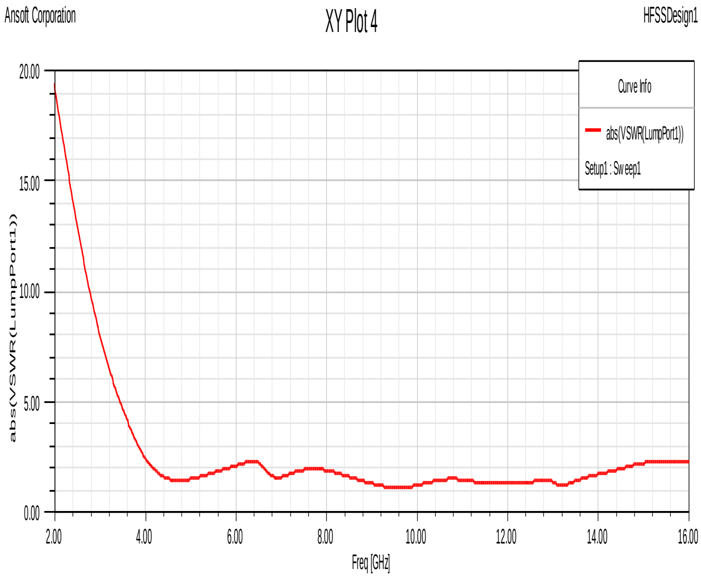

Fig. 6 VSWR graph for U-slot antenna (antenna 2)

It is very clear from the graph that VSWR is less than 2 for the bands that are generated for antenna 2. VSWR<2 is acceptable for good impedance matching and for good antenna performance.

Figure 7 and 8 shows the 3D radiation pattern of antenna 1 and 2 respectively.

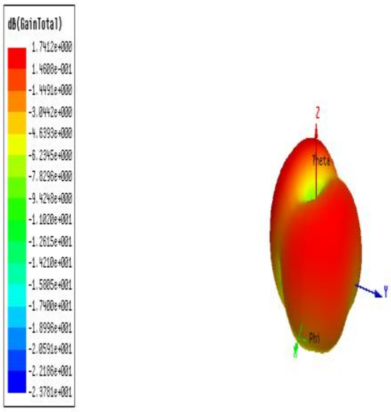

Fig.7 3D radiation pattern of antenna 1

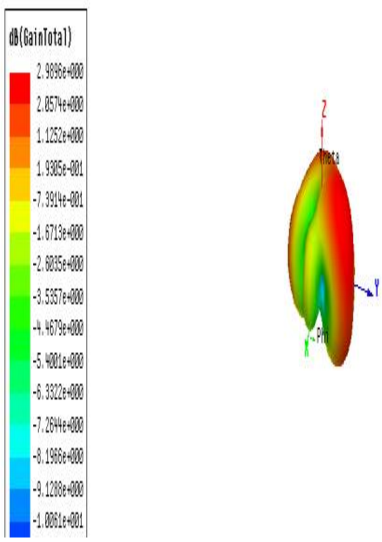

Fig. 8 3D radiation pattern of antenna 2

V. CONCLUSION

It is observed that antenna 2 which consist of u-slot provides larger bandwidth (7.85GHz) in comparison to antenna 1. Also the VSWR of antenna 2 is less than 2 which makes it acceptable for wireless communication. The proposed design of the antenna can be used for a variety of UWB applications including high speed data transfers, wireless connectivity between UWB-enabled devices and many medical and defence applications.

ACKNOWLEDGMENT

Authors would like to thank Mr. Anand Sharma (Jaypee University of Engineering and Technology, Guna,India) for his kind guidance and support and special thanks to Mr. Prashant Kumar (Pondicherry University) for his support and valuable suggestions.

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