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Design of a Planar Monopole UWB Antenna Integrated With Band notch Characteristics

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Abstract : *The ultra wide band technology has gained a rapid development in recent years since the FCC (Federal Communication Commission) unlicensed its use in the range 3.1 to 10.6 GHz. Due to its several advantages the UWB technology is very suitable for short range high speed data communication systems. Design of antennas for ultra wide band technology is challenging because of its wide operating range. Planar antennas especially planar monopole antennas are suitable for these systems due to their different advantages. But one of the major problems associated with the ultra wide band is its coexistence with narrow band technologies such as WLAN and WiMAX. Our UWB antenna should be able to avoid the interference between these systems. In this study we present a planar monopole ultra wide band antenna which can notch the wireless LAN (WLAN) which operates in the range 5.15 to 5.85 GHz. The antenna is modeled and simulated in HFSS. AS a reference antenna an existing UWB antenna is also simulated and it was then modified to achieve band notch properties. Simulation results shows that the proposed antenna gives better WLAN band notching characteristics.*

Keywords - *ultra wide band, FCC, WLAN,WiMAX,band notch*

I. Introduction

Antenna is an electrical device that converts electric power to radio waves and vice versa. It is also known as aerial and can be used for both transmission and reception. Antennas are important part of any wireless communication systems as they are called the 'eyes and ears in space'. Therefore the design of antenna is very important topic. In this study we are considering the antennas used in the Ultra Wide Band (UWB) systems.

We need to overcome many challenges in order to implement the ultra wide band technology. Because the ultra wide band systems require an antenna which has an operating band width covering the whole UWB (3.1 to 10.6 GHz) and capable of receiving colligated frequencies. Also the UWB technology modulates nano pulses based waveforms instead of continuous carrier waves. Therefore the design of UWB antenna is different from the ordinary narrow band antennas. High radiation efficiency is required for a UWB antenna for achieving a wider impedance band width. Size of antenna is another important parameter. Because the ultra wide band systems are mainly used to build small low profile ICs that are suitable for portable wireless devices. The size of antenna can be reduced by replacing the 3 dimensional radiators with their planar versions.

Another important issue is the interference between the UWB system and other systems located in the range 3.1 to 10.6 GHz such as IEEE 802.11a WLAN. For the proper functioning of our antenna we need to avoid the interference between our system and the WLAN.

In literature there many methods available for this such as U-shaped slot, inverted C slot, band rejection filter, T-shaped slot etc ([1]-[10]).In this study a planar monopole ultra wide band antenna which can avoid the interference from WLAN is considered.

The paper is organised as follows. Section II describes the methodology, section III represents the experiments and results and section IV gives the conclusion followed by the references.

II. Methodology

We need to design a planar monopole antenna which is integrated with band notch characteristics to avoid interferences from the wireless LAN. The block diagram of our study is given in figure 1.

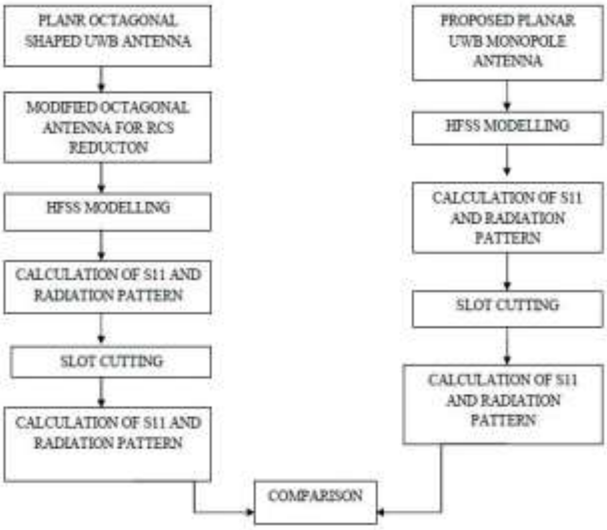


Figure 1. Block diagram of study

We are using slot cutting method for achieving the band notching property for the UWB antenna. Cutting slots within the radiating element sometimes may cause destructive interference for the excited surface currents in the antenna and consequently make it insensitive to certain frequencies which depend on slots dimension and positions. Before considering the proposed antenna with band characteristics we will consider a planar octagonal shaped UWB antenna with reduced RCS proposed in [11]. We first tried to model this antenna in HFSS and then we tried to band notch this antenna using the slot cutting method. This antenna can be taken as a reference antenna. Then we designed and modelled the proposed antenna in HFSS and using slot cutting band notch characteristics are be achieved.

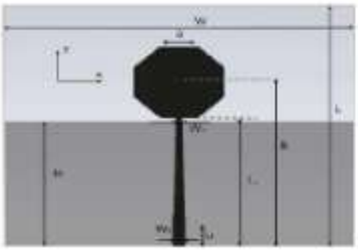
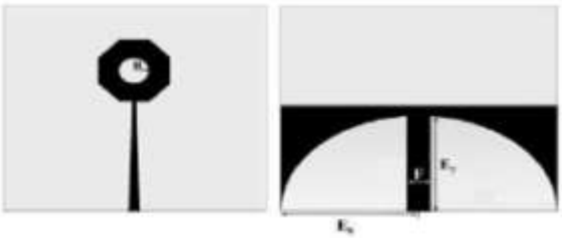



Figure.2 Figure3.
Fig 2.Geometry of octagonal-shaped antenna [11] Fig.3. Top and bottom view of modified octagonal-shaped UWB antenna [11]

The planar octagonal shaped antenna has ArlonDiclad 880 substrate with a relative permittivity of 2.2, a loss tangent of 0.0009, and a thickness of 0.762mm. The octagonal-shaped patch is fed by a tapered structure strip line. The overall dimension of the proposed antenna is 70 x 60 mm. Then, this planar octagonal shaped UWB antenna is modified in order to reduce the RCS. The metal areas which have the minimum current distributions on the surface of the antenna were subtracted (figure 3). Because in [11] RCS reduction is targeted.

2.1 Proposed antenna

The proposed antenna is with FR4 epoxy (fire resistance 4) substrate with relative permittivity 3.9 to 4.9 and a thickness of 1.5 mm. The overall dimension of the antenna is 26.14 x 34.902 mm. The feed width of antenna is 1.791 mm and patch width is 2.178 mm. The geometry is shown in figure 4.

After modelling this antenna using HFSS the return loss plot and the radiation pattern of the antenna will be obtained. After that the antenna will be modified to achieve band notch characteristics using slot cutting method. And then its radiation pattern and return loss plots will be obtained.

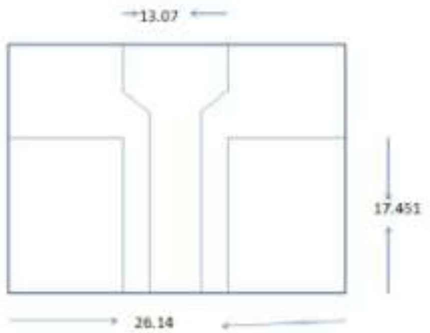


Figure.4 Geometry of proposed antenna

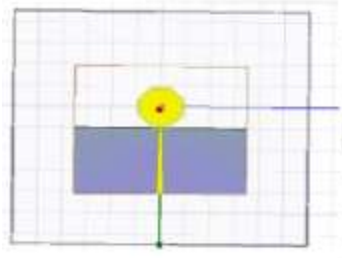
III. Experiments And Results

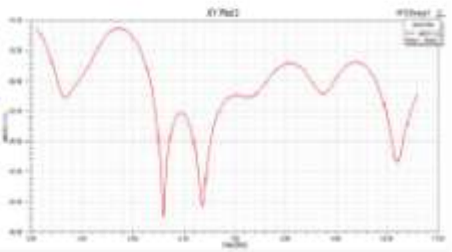
The octagonal antenna, modified octagonal antenna and our proposed antenna were modeled in HFSS. And then their corresponding radiation pattern and simulated reflection coefficient plot were obtained.

3.1The octagonal shaped antenna

Here we consider the modelling of planar octagonal shaped UWB antenna and its parameters. This planar octagonal shaped antenna was proposed in [1]. The main design goal of this octagonal shaped ultra wide band antenna was to achieve radar cross section (RCS) reduction. The already existing Radar cross section reduction methods reduce Radar cross section only in the high frequency region. Radar cross section reduction in low frequency range has been insufficient for the reported studies. So a novel octagonal shaped ultra wide band antenna was proposed in [11] to have a minimum radar cross section.

In the first step an octagonal shaped ultra wide band antenna is modelled in HFSS (High frequency structure simulator) and the model is given in the figure 2. Figure 5 shows the planar octagonal shaped ultra wide band antenna of [11] modelled in HFSS. This antenna has ArlonDiclad 880 substrate, relative permittivity= 2.2, thickness =0.762mm and overall dimension =70 x 60 mm.





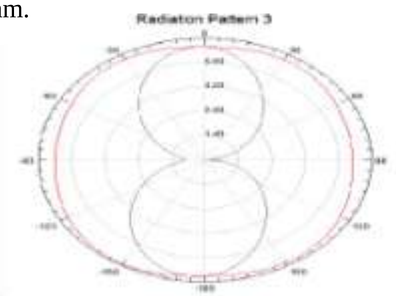


Figure .5 Figure 6 Figure7

Figure .5 HFSS model of octagonal shaped antenna ,Figure. 6 Simulated reflection coefficient result of the planar octagonal shaped UWB antenna , Figure. 7 Radiation pattern of octagonal shaped antenna

HFSS model of octagonal shaped antenna

As a next step we tried to obtain the return loss plot of the modelled octagonal shaped antenna using the HFSS tool. The simulated reflection coefficient plot of the octagonal shaped ultra wide band antenna is given in the figure 6.

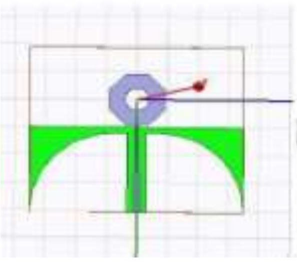
From the above figure we can see that simulated reflection coefficient plot of the planar octagonal shaped ultra wide band antenna is all below -10 dB. Thus the criterion for being ultra wide antenna is satisfied. No parts of the plot are above the -10 dB. From this we can see that the antenna acts as an ultra wide band antenna in the frequency range 3.1 to 10.6 GHz

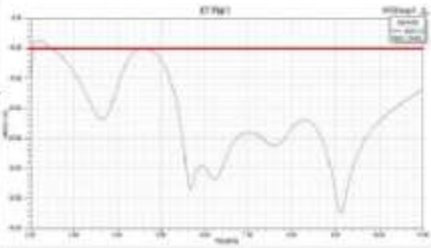
The radiation pattern of the planar octagonal shaped ultra wide band antenna is shown in figure 7. We can see that the radiation pattern is omni directional. And hence it satisfies the criterion for being ultra wide band antenna.

3.2 The modified octagonal shaped antenna

In [11] RCS reduction was the main target. For this purpose they obtained the surface current distributions on the metallic areas of the octagonal antenna. The radiation behaviour of antenna is generally based on the surface current distributions of the metallic areas. Therefore the planar octagonal shaped UWB was modified by removing the metal areas with less surface current distribution on the radiating element for RCS reduction. This modified octagonal shaped antenna is considered here.

As we can see from figure 8 a strip line width of 6 mm is left on the ground is left on the ground layer to feed the radiator element. An elliptical geometry is subtracted from the ground layer. Also a circular part with radius 4 mm is subtracted from the radiator element.





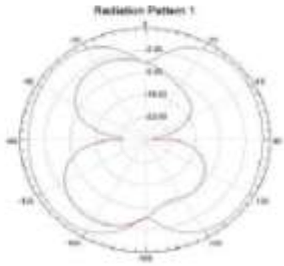


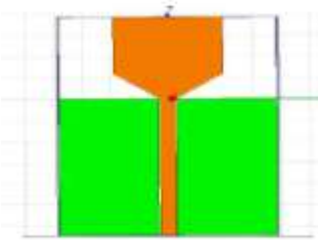
Figure 8 Figure 9 Figure 10

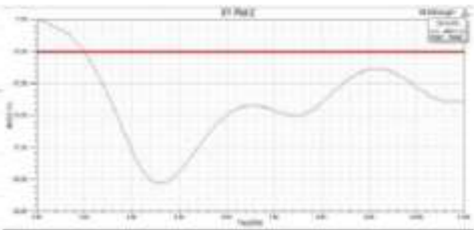
Figure. 8 HFSS model of modified octagonal antenna ,Figure.9 simulated reflection coefficient result of modified octagonal antenna ,Figure.10. Radiation pattern of modified octagonal antenna

The radiation pattern of the modified planar octagonal shaped ultra wide band antenna is shown in figure 10. We can see that the radiation pattern is omni directional. And hence it satisfies the criterion for being ultra wide band antenna.

Proposed planar monopole UWB antenna

HFSS model of proposed antenna without slot is given in the following figure.





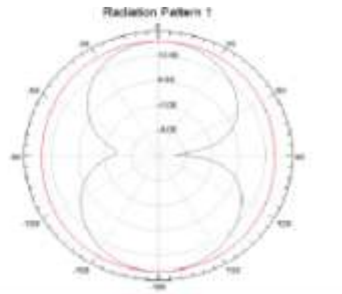


Figure11 Figure 12 Figure 13

Figure 11 HFSS model of proposed antenna without slot ,Figure 12 Simulated reflection coefficient result of the planar octagonal shaped UWB antenna ,Figure 13. Radiation pattern of proposed antenna

We can see that the simulated reflection coefficient plot of the modified planar octagonal shaped ultra wide band antenna is all below -10 dB. Thus the criterion for being ultra wide antenna is satisfied.

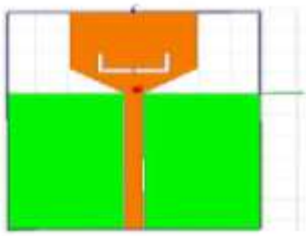
The radiation pattern of the proposed planar monopole ultra wide band antenna is shown in figure 13. We can see that the radiation pattern is omni directional. And hence it satisfies the criterion for being ultra wide band antenna.

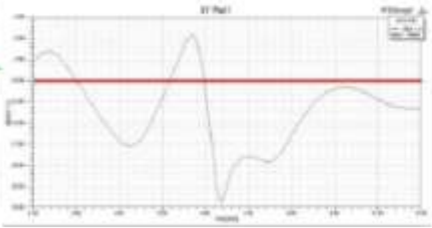
The notched band frequency is controllable by adjusting the length of the slot. The band rejected frequency can be assumed as

$$fnotch = c/2Lslot\sqrt{Eff} \quad (1)$$

Where *Lslot* is the length of the slot; *Eeff* is the effective dielectric constant; *c* is the speed of light.

We can use this equation to predict the notch frequency of the antenna. The band notched frequency can be adjusted by varying the lengths of the slots. However, the widths of the slot also affect the notched bandwidth. We need rejection of WLAN band (from 5.15 to 5.825 GHz). So we make a U shaped slot for band rejection on our proposed planar monopole UWB antenna which is as shown in figure 14. The dimension of the slot depends on the centre frequency of the notch band.





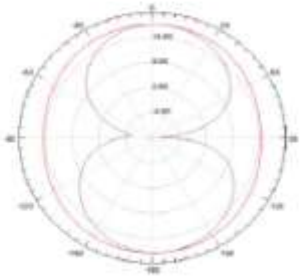


Figure 14 Figure 15 Figure 16

Figure 14 HFSS model of proposed antenna with slot ,Figure 15 Simulated reflection coefficient result of the proposed UWB antenna with band notching ,Figure 16. Radiation pattern of proposed antenna with band notching

The simulated reflection coefficient result of our proposed antenna with WLAN band notching is shown in figure 15.In the figure on right side the return loss plot is above -10 dB in the range 5.2 to 5.9 GHz. Therefore we can see that the WLAN frequency band is notched. And thus a planar monopole ultra wide band antenna with WLAN band notching is obtained.

The radiation pattern of the proposed planar monopole ultra wide band antenna with WLAN band notch is shown in figure 16. We can see that the radiation pattern is omni directional. And hence it satisfies the criterion for being ultra wide band antenna.We then tried to obtain WLAN band notching for the modified octagonal shaped UWB antenna using slot cutting. For this an inverted U shaped slot was cut on the radiating element of the antenna. HFSS model of this antenna is given in figure 17.

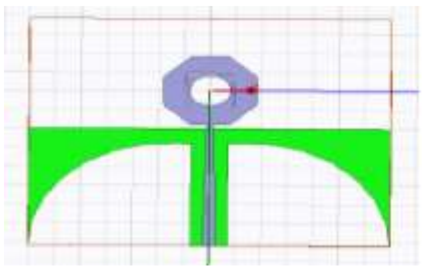


Figure 17

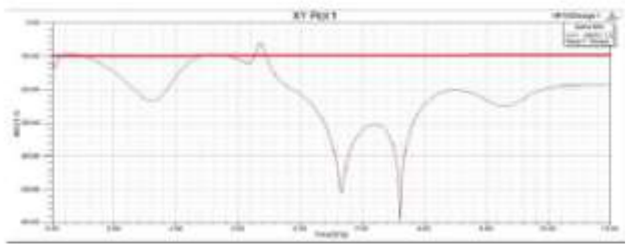


Figure 18

Figure 17 HFSS model of slotted octagonal shaped antenna ,Figure 18 Simulated reflection coefficient result of the slotted octagonal shaped antenna

Simulated reflection coefficient plot is given below. From figure 18 we can see that the s11 plot is above the -10 dB line in the range 5.3-5.5 GHz. So there is band notching in the range 5.3 to 5.5 GHz. That means only the lower WLAN band is notched. The whole WLAN cannot be notched.

IV. Conclusion

A planar monopole ultra wide band antenna integrated with band notch characteristics was designed. The band notch characteristics were achieved by using slot cutting method. The proposed antenna was modelled in HFSS before cutting the slot. The radiation pattern and reflection coefficient plots were obtained for the same. Then after introducing the U shaped slot the radiation pattern and reflection coefficient plots were again obtained using the HFSS tools.

As a reference antenna an already existing antenna (a planar octagonal shaped UWB antenna with reduced radar cross section [11]) was also considered. This antenna was also modelled in HFSS. And the radiation pattern and reflection coefficient plots were obtained for the same. After this an inverted U shaped slot was introduced in the radiating element of the antenna in order to achieve the band notch characteristics. Again we obtained the radiation pattern and the simulated reflection coefficient of the antenna. On comparing both the antennas we can see that the octagonal shaped antenna has only 5.3-5.5 GHz notch band which does not include the whole WLAN frequency band. But our proposed antenna eliminates the complete WLAN band as it has notch band from 5.-5.9 GHz. So our proposed antenna gives a better band notch performance.

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