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Design and Analysis of a Compact UWB Band Notch Antenna for Wireless Communication †

Mohammad Monirujjaman Khan [1,*]

[1] Department of Electrical and Computer Engineering, North South University, Bashundhara, Dhaka-1229, Bangladesh; monirujjaman.khan@northsouth.edu
* Correspondence: monirujjaman.khan@northsouth.edu; Tel.: +8801779006296

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Abstract: Development and investigation of a miniaturized ultra-wideband band notch antenna is demonstrated in this paper. The antenna was modeled and simulated using Computer Simulation Technology (CST)™ Microwave Studio software. The simulated results of this antenna are presented and analyzed. The performance parameters such as return loss, gain, radiation efficiency, radiation patterns are simulation based results provided here. The main objective of this paper was to obtain band notch characteristics at the Wireless Local Area Network (5.15-5.8 GHz) and WiMax (5.25-5.85 GHz) in the UWB frequency ranges of 3.1 to 10.6 GHz in order to avoid interference. Results and analysis show that the antenna meets the objective and shows very good results. It has very compact size as well which is attractive feature of this antenna that will make it suitable for ultra-wideband wireless communication systems.

Keywords: ultra-wideband antenna; band notch; wireless communications; CST; simulation; performance; return loss; gain; radiation efficiency; radiation pattern.

1. Introduction

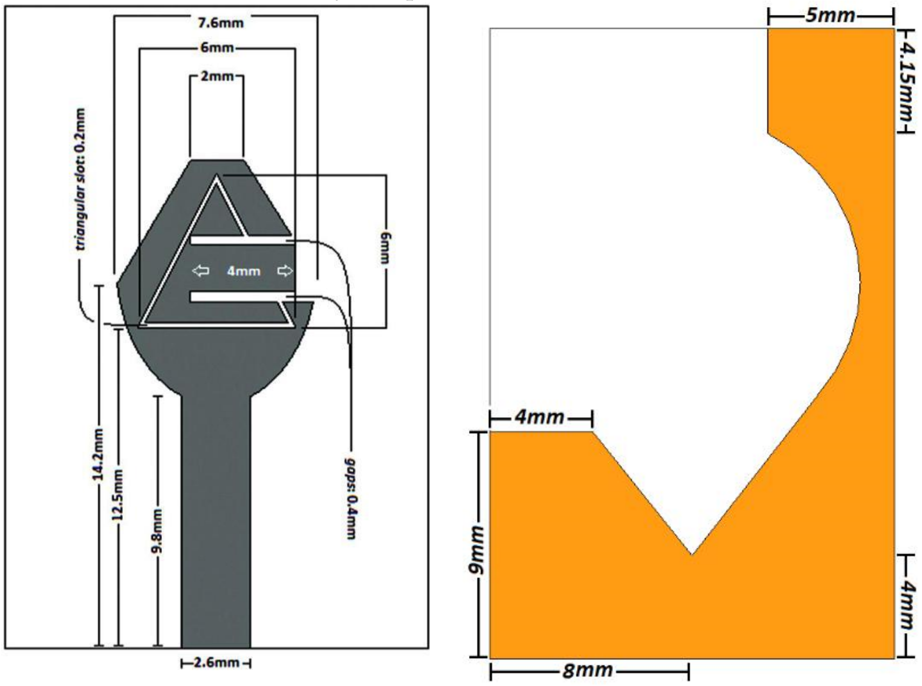
Ultra-wideband (UWB) system is very promising technology for warless communications due its low transmission power, compact size, high data rate and large bandwidth [1]. This technology is an innovative wireless technology which is attracting researchers nowadays. For small period of UWB pulses, it is simple to persuade high data rate with small latency. The promising application of UWB is in sensor network, body area network, wireless positioning system, indoor short range communications, biomedical imaging, and high data rate small range communications [1–5]. Federal Communication Communications FCC declares UWB frequency range is to be from 3.1 GHz to 10.6 GHz at −10 dB return loss [2]. The issue is that in the wide frequency range there are other frequencies for Wireless Local Area Network (5.15–5.8 GHz) and WiMax (5.25–5.85 GHz) which may cause interference. Therefore in order to design interference less and power efficient wireless communications there is a need of band notch ultra-wideband antennas.

Antenna is one of the most important element for any wireless communication system. Therefore the antenna needs to meet the special requirement in terms of impedance bandwidth, return loss, radiation efficiency, gain and radiation pattern. A good antenna design gives relax to system designers. There is tremendous growing research and interest are realized for the design of UWB antennas recently [6–15]. In [6–11] UWB antenna design and radio channel modeling for wireless communication have been presented. Ultra-wideband band north antenna has been presented in open literature in [12–15]. However, different authors have use different techniques for band notch in UWB antennas. There is still no breakthrough for the design of UWB antenna with band notch yet. In [15] the presented band notch antenna is bigger in size. Some band notch antennas in open literatures are found to be bigger in size and some of them have low performances. In order to design compact, light weight, band notch characteristic and efficient system a compact antenna with band notch characteristic and good performance parameters are required.

In this paper a compact novel band notch antenna is designed and simulated. Simulated performance parameters like bandwidth, return loss, gain, efficiency and radiation efficiency have been illustrated and investigated.

2. Antenna Design Using CST Software

The proposed band notch UWB antenna was developed with the help of Computer Simulation Software (CST) microwave studio. In Figure 1 the antenna design is presented. Figure 1a demonstrate the front side and Figure 1b provides the rear side of the antenna. In the backside of the antenna there is not full ground plane. It is noted that ground plane has been cut for getting the desired return loss result. The total length and width of the antenna are 16 mm and 25 mm, respectively. For this design Fr4 substrate has been used with the relative permittivity of 3. The radiation element of the antenna is printed on the substrate as shown in Figure 1. The antenna is excited with waveguide port. A slot was created on the radiating element to get the notch function. The whole height of the antenna is 1.8 mm. The total size of the antenna is very compact.



(**a**) Font view (**b**) Back view

Figure 1. band notch antenna: (**a**) front view, (**b**) back view.

3. Results and Discussions

After modeling the antenna in CST it was simulated. The simulated performance parameters such as return loss, gain, radiation pattern, and radiation efficiency are provided below.

3.1. Simulated Return Loss Response

Figure 2 displays the return loss result of the antenna. From the graph shown in Figure 2, it is noted that the antenna works at ultra-wideband frequency band (3.1 GHz to 10.6 GHz) except there is notch from 5.1 to 5.8 GHz. The main objective of this proposed design was to obtain the band notch characteristics at these frequencies in order to avoid interference with the frequency range from 5.1 to 5.8 GHz. The return loss results meet the expected objective of this paper. However at other frequency in the UWB range the return loss value is below −10 dB which is excellent for power efficient transmission. As we know that return loss −10 dB shows nearly 90% of the power will be transferred.

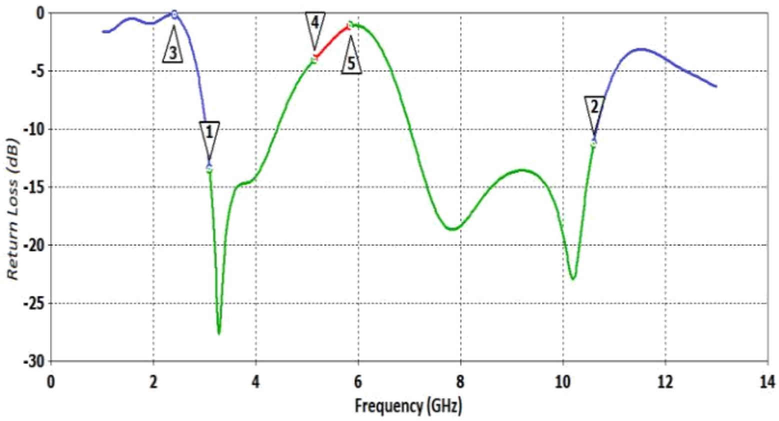


Figure 2. Return loss result of the antenna.

3.2. Simulated Radiation Efficnecy and Gain

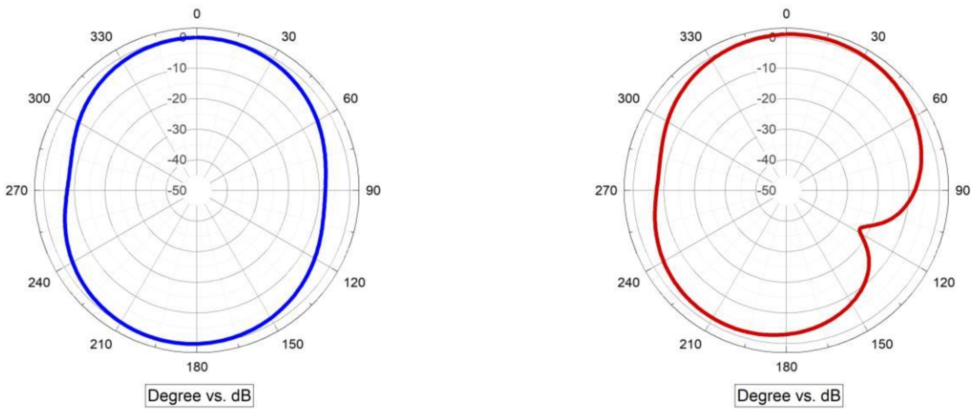
The gain and radiation efficiency of this antenna are listed in Table 1. The gain and radiation efficiency are extracted from the far field simulated results at the frequencies of 3.5 GHz, 5.7 GHz (band notch), 8 GHz and 10 GHz. From the table it is noticed that the antenna demonstrates higher gain at 3.5 GHz, 8 GHz, and 10 GHz as compared with the 5.7 GHz. At 5.7 GHz the gain is lower due to notch at this frequency and this is expected. For the case of radiation efficiency same trend is noticed. There is very low efficiency 38% at the 5.7 GHz whereas other bands they show very good radiation efficiency.

Table 1. Values of gain and radiation efficiency at various frequencies.

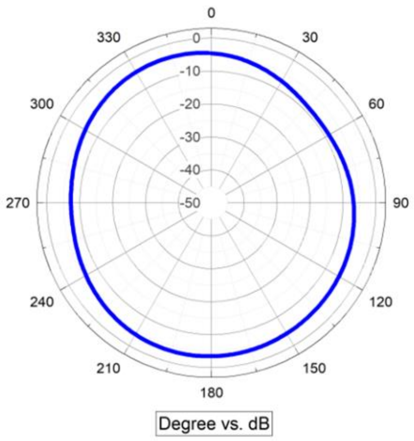
Frequency (GHz)	3.5 GHz	5.7 GHz	8 GHz	10 GHz
Gain (dBi)	1.65	0.72	2.40	2.35
Radiation Efficiency (%)	85.08	38.00	74.00	79.00

3.3. Simulated Radiation Patterns

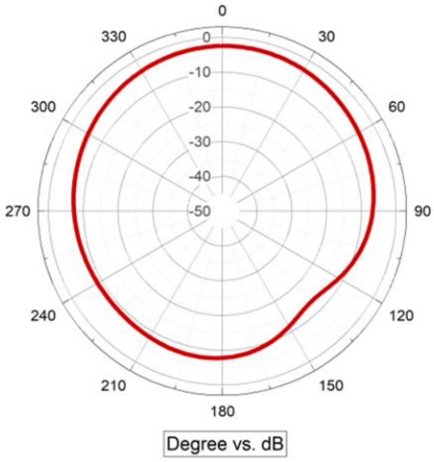
Simulated radiation patterns of the antenna are extracted from the far field at specific frequency. The radiation pattern is extracted from the 3D radiation of the antenna. Figures 3a–f shows the simulated radiation patterns of the antenna at various frequencies. The radiation patterns have been plotted as plane wise like elevation and azimuth planes. At 3.5 GHz the radiation pattern at XY plane looks omnidirectional and at XZ plane it looks there is a null at the 120° angle. Both planes radiation patterns look similar at 5.7 GHz. At higher frequencies such as 8 GHz and 10 GHz the radiation patterns look little distorted at certain angle.



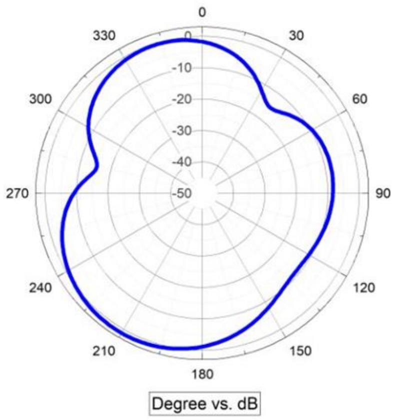
(**a**) XY Plane at 3.5 GHz (**b**) XZ Plane at 3.5 GHz



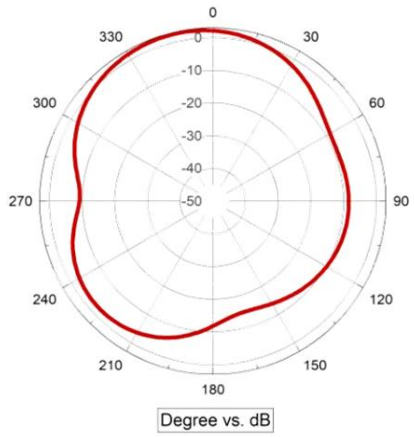
(**c**) XY Plane at 5.7 GHz



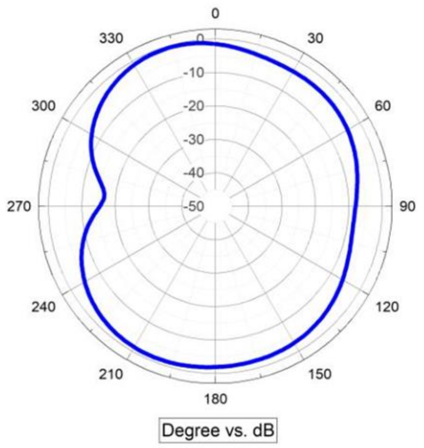
(**d**) XZ Plane at 5.7 GHz



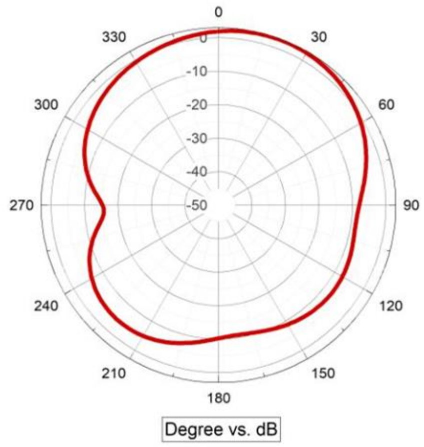
(**e**) XY Plane at 8 GHz



(**f**) XZ Plane at 8 GHz



(**g**) XY Plane at 10 GHz



(**h**) XZ Plane at 10 GHz

Figure 3. Simulated radiation patterns of the antennas at various frequencies.

3.4. Future Work

This antenna will be fabricated and the performance will be measured and compared with the simulation results. CST software is very user friendly and it has been noticed for other articles cases [7–10] that the simulated results are comparable to the measured results. Parametric study of this antenna will be carried out and it will be designed also on the textile substrate to see the usability of this antenna for wearable applications. The on-body results of this textile antenna will be investigated. This future work is going on and due to lack of space here we have not demonstrated them. However, in future we will submit the extended version of this paper in a MDPI journal for review.

4. Conclusion

Software designed and simulation based performance of a compact novel UWB band notch antennas are provided. The antenna works in the FCC defined UWB frequency ranges 3.1 GHz to 10.6 GHz perfectly with the band notch characteristic 5.1 to 5.8 GHz with a view to avoid interference and power efficient wireless communications. At 5.7 GHz the antenna demonstrated very bad results due to notch feature and that was the objective of this paper. However, except the band notch frequency this antenna shows very good results. At 3.5 GHz, 6 GHz, 8 GHz, and 10 GHz the antenna shows very good efficiency and gain values. Due to compact and novel size, and very good results, band notch characteristic this antenna will be a suitable candidate for wireless communications.

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Conflicts of Interest: The authors declare no conflict of interest.

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