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DESIGN OF AN ASSCHER SHAPED MONOPOLE UWB ANTENNA

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Abstract
This paper proposes a compact planar ultra wideband (UWB) antenna is proposed which is applicable in the field of communication, radar and medical. The proposed antenna has a low profile structure, consisting of a modified radiating patch in Asscher shape with an octagonal slot. The optimized antenna is capable of being operated in frequency range of 2-14GHz band having good omnidirectional radiation pattern and high gain, which almost satisfies the requirements of UWB applications. The antenna system has a compact size of 30×28.5×1.6mm^3. These features make the proposed UWB antenna a good candidate for communication, radar and medical applications.

Keywords:
Antenna, Asscher shape, UWB, Radiation Patch

1. INTRODUCTION

Antennas are the first and the foremost part of the communication system. According to IEEE definition, "an antenna is a means for radiating and receiving radio waves". The rapid evolution in wireless technology the ability to communicate with people has evolved remarkably.

Ultra Wideband (also known as UWB or ultra-band) is a radio technology that can use a very low energy level for short range, high bandwidth communications. The frequency range of UWB is 3.1GHz to 10.6GHz.

UWB short-range wireless communication is different from a traditional carrier wave system. UWB waveforms are short time duration and have some rather unique properties. In spreading signals over very wide bandwidths, the UWB concept is especially attractive since it facilitates optimal sharing of a given bandwidth between different systems and applications. Recent years, rapid developments have been experimented on the technologies using UWB signals. UWB technology offer major enhancements in communications, radar and positioning or ranging.

Nowadays, wireless technology plays a major role in the communication domain. By the usage of the UWB antenna, it ensures the shrinkage in the antenna size and the enhancement of bandwidth. For the design of UWB antenna, the following survey is engrossed.

Pandian and Suriyakala [15] proposed a UWB for cognitive radio. The feeding point is the micro strip line and to this attached the octagon loop structure. This antenna is operating in 32GHz, 55GHz and 70GHz. It covers the ranges at band1: 25GHz-45GHz, band2: 50GHz-60GHz and band3: 60GHz-80GHz. The shape of antenna is highly designed to cover the wide band and provide spectrum reuse compatibility. The reuse of the spectrum is highly intelligent and highly efficiency. This is a UWB tri-band antenna having reflection loss less than -20dB for 32GHz, 55GHz, and 70GHz. The two microstrip rectangular patch antennas crossing each other are responsible for wide band width and low reflection loss. The results confirm good performance of wide tri-band antenna design.

Reddy et al. [11] proposed a spear shaped antenna. This proposed antenna full fills the requirement of low cost, less weight and small size. The design and simulation of proposed CPW fed antenna are carried out with RT duroid substrate and dimensions of antenna substrate is 14mm×18mm. The operating frequency of the proposed antenna is 3.1GHz-10.8GHz. The simple configuration and low profile attributes of the proposed antenna made it easy for fabrication and suitable for the application in the UWB band applications. The proposed antenna can achieve 72% size reduction. By truncating diagonal corners, the polarization is also well implemented in different radical directions.

Lakshmanan and Sukumaran [13] proposed a flexible UWB antenna. This paper introduces a small-sized, low-profile, planar and flexible UWB antenna using natural rubber as the substrate compares the performance with FR4 substrate. The antenna operates from 3.1GHz-10.6GHz, which is a candidate for WBAN operation. The flexible nature of the antenna makes it convenient for the use as a body worn antenna for WBAN. UWB antenna using FR4 substrate was tested using vector network analyser. The simulated results have confirmed UWB characteristics of the antennas with nearly stable omnidirectional radiation properties over the entire frequency band of interest.

Kumar and Surushe [12] proposed an Ultra Wideband (UWB) antenna system for multi-input multi-output (MIMO)/diversity application. The radiating elements are excited by tapered feed for better impedance matching. The antenna system is a microstrip structure with two similar triangular shaped radiating elements and a common ground plane. A T-crossed shaped stub is added in the ground plane to increase the isolation between the two radiators. Radiation pattern gives omnidirectional behaviour in the H-plane and bidirectional behaviour in the E-plane. In the H-plane, the radiation patterns for both the antennas are complimentary to each other.

Yang et al. [1] introduced half slot structure and proposed UWB antenna. The overall size of the antenna is 31mm×31mm×1.6mm. The radiating patch is quasi-semi ellipse in shape. This antenna is designed in CST software. The main application of half slot structure is to achieve miniaturization, UWB and good isolation.

Yadav et al. [3] proposed an UWB circular monopole antenna with parasitic resonators. Here the overall size of the antenna is 32mm×24mm. This antenna is made up of two resonators designed for 5.2GHz and 8.2GHz. The upper part is made up of inverted U shaped resonator and the lower part is made up of Iron shaped resonator. This antenna is designed on Rogers 3003 substrate. This antenna is designed using CST software. This antenna is designed with consideration of aspects like UWB, centre frequency of band rejection and bandwidth of the notched band.

Mewara et al. [4] designed a band notched Y shaped planar monopole UWB antenna on CST software. Here U and C shaped slots are introduced in the radiating patch to achieve the notched bands. The overall size of the antenna is 36mm × 38mm × 1.6mm. The notch brands are achieved to eliminate the interference form WiMAX, WLAN, X-band for satellite communication, ITU 8 band and RN band. These individual single notched resonating elements are integrated and thus this quintuple band notched Y shaped UWB antenna.

Jaglan et al. [9] proposed antenna with triple notch characteristics. The proposed antenna has triple notches in the WiMAX band (3.3GHz-3.6GHz), WLAN band (5GHz-6GHz), and X-band satellite communication (7.2GHz-8.4GHz) band. Defected Ground Compact Electromagnetic Band Gap (DG-CEBG) is a design used to accomplish band notches. Defected ground planes are utilised so as to achieve compactness in conventional EBG structures. In these structures, decoupling strips and a slotted ground plane are used to enhance the isolation between two closely spaced UWB monopoles. The individual monopoles are 90^{o} angularly separated with a stepped structure which helps to reduce mutual coupling and also contributes towards impedance matching by increasing the current path length. A triple band rejection UWB MIMO/Diversity antenna with reduced wideband electromagnetic coupling among individual antenna element. The values of ECC are at an acceptable limit that ensures good performance of the proposed antenna. There is a good consistency between measured and simulated results.

Awad and Abdelazeez [10] proposed a both planar UWB antenna and UWB antenna with two rejected bands. The antenna consists of a rectangular patch etched on FR4 substrate with 50Ω feed line. The rectangular patch has one round cut at each corner with one slot in the ground plane. The simulated bandwidth with return loss (RL) ≥ 10dB is 3.42-11.7GHz. The simulated results of the proposed antenna indicate higher gain at the passbands while a sharp drop at the rejected bands. It satisfies the requirement of UWB system and minimize the interferences from WLAN and X-band applications.

Dabas et al. [15] proposed an UWB MIMO antenna using uniplanar EBG structure to introduce multiple stop bands. The EBG cell of size 6.8mm×6.8mm is inserted between the antenna elements. The overall size of the antenna is 27.2mm×46mm×1.6mm. This antenna is designed on the FR 4 substrate. This UWB antenna exhibits four stop bands. This paper aims at designing an UWB antenna which is simulated from 2GHz to 14GHz. It is designed to serve for various applications like communications, radar, medical etc. Measured results are presented to validate the antenna performance.

Kwaha et al. [2] proposed a circular patch antenna. Here a program called FORTRAN was developed to simulate the fundamental parameters of a circular patch antenna. The parameters discussed here are conductance due to radiation, conductance due to conduction, conductance due to dielectric loss, directivity, and input resistance. Gallium Arsenide, Duroid, Indium Phosphide and Silicon were the substrate selected. This paper outlines that resonant frequency increases as the patch radius decreases. This paper involves both manual computation and program computation.

Yekeh and Kohno [7] designed an ultra-wide band antenna. This paper forecasts the differences between the narrow band and ultra wide band antennas. Here L shaped loop antenna is designed. The overall size of the antenna is 24mm×25mm×1mm. For impedance matching tapered transmission line is used. Here FR 4 is used as the dielectric substrate. The simulation results are obtained from the Method of Moments (MoM). The proposed antenna has its excellence for lower band of UWB.

Lim et al. [8] designed a compact ultra wide antenna. Here CST software is used for antenna designing. The antenna is fabricated on FR 4 substrate. Here returns loss improvement is made by the variation in the size of the ground plane. The overall size of the antenna is 34mm×36mm. Here the proposed antenna parameters are calculated using transmission line modal analysis.

Deng et al. [5] designed an open slotted antenna for ultra wide band application. The antenna structure consists of a radiating patch and an L shaped slot etched in the ground plane to enhance the bandwidth. Here the antenna is fabricated on the FR 4 substrate. The antenna is optimized using HFSS software. This antenna is designed to cover WLAN and UWB applications. Here bandwidth is extended by optimising the feed position.

Singhal [6] designed UWB antenna with dual notched bands. The antenna consists of modified ground plane and a square shaped radiating patch. T shaped stub is introduced in the radiating patch and U shaped parasitic strips beside the feed line for the WiMAX and WLAN application. Main feature of the antenna is the high rejection bands. Rogers4003 substrate is used here. The antenna has wide bandwidth ranging from 2.8GHz to 11GHz.

Ali [16] designed a UWB antenna for wireless communications. It is a miniaturized antenna with truncated ground plane. The antenna is etched on the etched on the Taconic RF-30 (tm) substrate. The dimension of the antenna is 50mm×50mm. The antenna is simulated on the Ansoft High Frequency Structure Simulator (HFSS) software. Another advantage of this antenna is it has reduced size and lighter weight.

2. ANTENNA DESIGN

An Asscher-shaped UWB monopole antenna is designed with the following specifications. An Asscher-shaped Monopole antenna is designed which envelopes for various fields like communication bands, radar fields, and medical purpose. The proposed antenna is insculped on FR-4 substrate with relative permittivity ε_r = 4.4, thickness h = 1.6mm. FR-4 is a composite material composed of woven fiberglass cloth with epoxy resin binder that is flame resistant. This substrate is used to interface the electromagnetic field from patch to the ground. The complete layout is as shown in the Fig.1 in which there are two parts one is the radiating and the other is the ground plane structure. Two ports are placed port 1 in the radiating patch and port 2 in the ground plane. The antenna is simulated on ADS (Advanced Design System) software with 2016.01 Version. Microstrip line feeding is used here in which a conducting strip is connected directly to the edge of the microstrip patch. Here the width of the conducting strip is smaller than the patch. In this type of feeding the feed radiation increases as the thickness of the dielectric substrate increases. It also leads to the undesired cross polarised radiation. Here the proposed antenna is well in agreement with the simulated results.

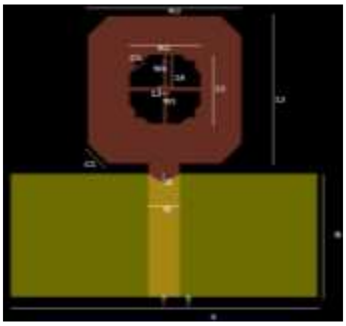

Fig.1. Layout of UWB antenna

3. DESIGN PARAMETERS

Usually narrow band antennas are replaced by single UWB antenna which covers the whole frequency band of interest. The parameters used for the design of an UWB antenna is given in the Table.1. The antenna with the below defined parameters is designed and simulated in the ADS software.

Table.1. Design Parameters

Length and Width	**Units in mm**
W_0	0.4
W_1	0.8
W_2	7
W_3	15
L_0	3.1
L_1	0.8
L_2	7
L_3	15
W	3
H	0.75
C_1	0.141
C_2	1.131
A	30
B	12.5

where A and B indicates the length and height of the ground plane respectively, W indicates the width of the feed line, H indicates the height to which the ground plane is defected, W_3 and L_3 are the width and the length of the outer Asscher shaped in the radiating patch respectively, W_2 and L_2 indicates the width and length of the inner Asscher shape in the radiating patch respectively, C_1 and C_2 are the slots made in the inner and outer radiating patch to get Asscher shape, W_0 and L_0 indicates the length and width of the rectangular conductors, respectively.W_1 and L_1 indicates the width and length of the second Asscher shape which is placed at the center of the octagonal slot.

4. DESIGN CONFIGURATION

The radiating patch consists of Asscher shaped UWB antenna with four iterations. Here, brown colour indicates the radiating patch structure and Green colour indicates the ground plane.

Iteration 1: In the first step a rectangular patch with a defected ground structure is designed as depicted below in Fig.2. The design is simulated from 2GHz to 14GHz.

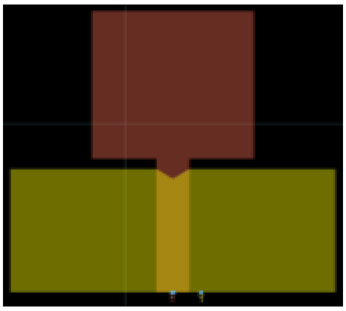

Fig.2. Layout of first Iteration

Iteration 2: An octagonal shaped slot of the above mentioned dimension is introduced in the Asscher shaped rectangular patch along with the defected ground as depicted in Fig.3. It is simulated from 2GHz to 14GHz.

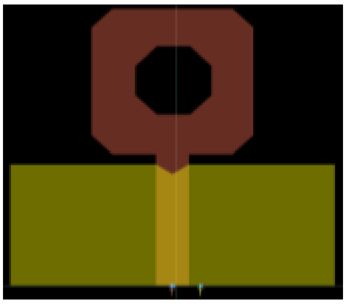

Fig.3. Layout of second iteration

Iteration 3: In the third step triangular slots are introduced in the outer rim of the octagonal slot as depicted in the Fig.4. This third iteration is simulated from 2GHz to 14GHz.

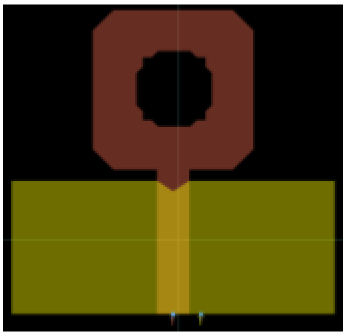

Fig.4. Layout of Iteration 3

Iteration 4: This is the final step of the UWB design in which an Asscher shaped is merged with plus type conductor at the centre as depicted in Fig.5. The design is simulated from 2GHz to 14GHz.

Fig.5. Layout of Iteration 4

5. SIMULATION RESULTS

The proposed antenna is simulated from 2GHz to 14GHz. The return loss of antenna at first iteration is depicted below in Fig.6. In the first iteration due to the rectangular patch with the defected ground the return loss is moderately achieved. The return loss of the antenna is m_1 = -16.02dB at 5.6GHz.

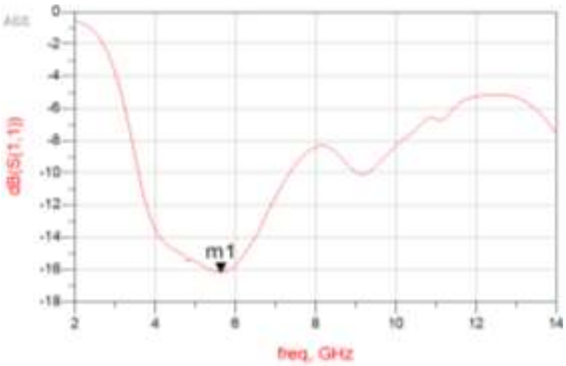

Fig.6. Result of Iteration 1

The simulated results of the second iteration antenna is depicted below in Fig.7. As a result of octagonal slot etched in the radiating patch the simulated result of the antenna almost covers the UWB band. The bandwidth of the antenna is 7GHz. The return loss of the antenna is m_3 = -18.2dB at 6.6GHz and m_4 = -16.5dB at 9.2GHz.

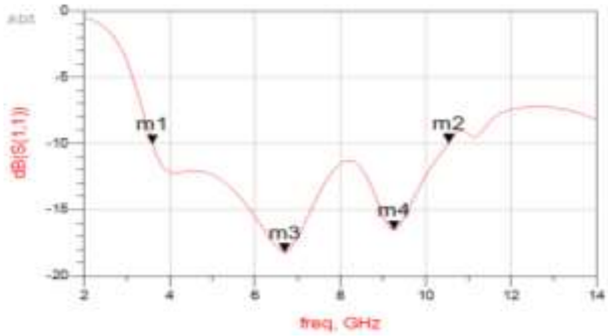

Fig.7. Result of Iteration 2

The simulated result of the third iteration antenna is depicted below in Fig.8. There is no change in the return loss and bandwidth by the introduction of triangular slots in addition to the octagonal slot. In this iteration a bandwidth of 7GHz is achieved. The return loss of the antenna is m_3 = -18.189dB at 6.6GHz and m_4 = -16.517dB at 9.2GHz. The bandwidth and the return loss is the same as achieved in the previous iteration.

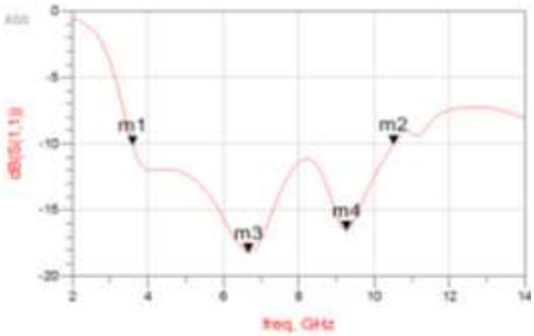

Fig.8. Result of Iteration 3

The simulated result of the fourth iteration antenna is depicted below in Fig.9. Bandwidth is increased in this iteration due to the introduction of the plus shaped rectangular bars. In this iteration a bandwidth of 7.2GHz is achieved and the return loss of m_3 = -21.112dB at 6.6GHz is also improved when compared to the above iterations.

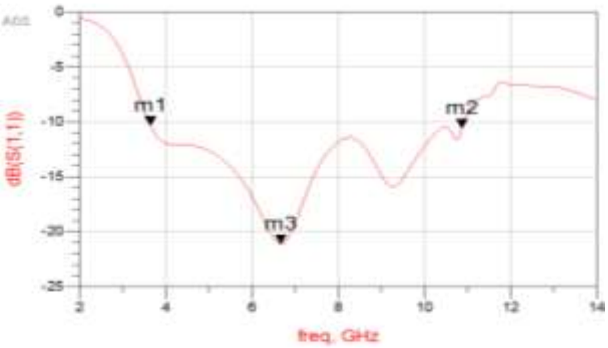

Fig.9. Result of Iteration 4

6. ANALYSIS

The radiation pattern indicates the directional dependence and also the variation of the strength of the radio waves from the antenna. The E-field, H-field for the UWB antenna iteration is depicted below in Fig.10(a) and Fig.10(b) respectively. From the graphs it is clear that the radiation is well obtained. Here the radiation pattern has widened major lobe supporting the requirement of UWB. It serves well for the communication, radar and medical applications.

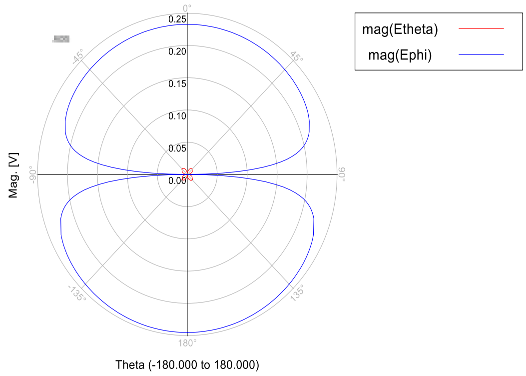

Fig.10(a). Electric Farfield Pattern of UWB Antenna

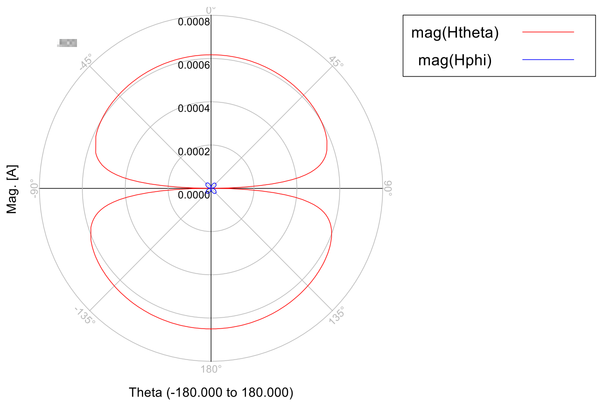

Fig.10(b). Magnetic Farfield Pattern of UWB Antenna

The frequency vs. directivity and frequency vs. gain graph of UWB antenna is depicted below in the Fig.10(c) and Fig.10(d), respectively. Directivity refers to the major lobe of radiation. As we see in the below graph the directivity of the proposed UWB antenna keeps on increasing as the frequency increases. The directivity starts at 2.5GHz and goes above 7 at 14GHz.

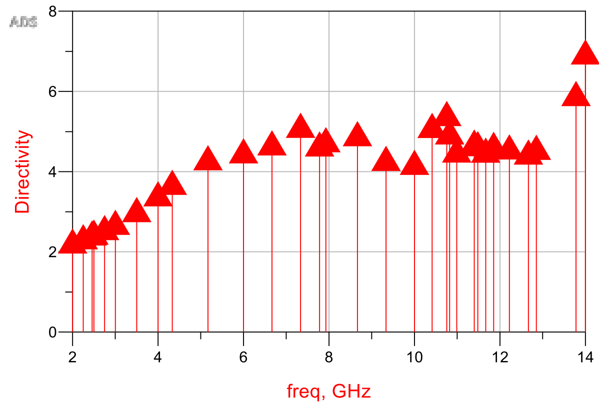

Fig.10(c). Frequency vs. Directivity of UWB Antenna

Gain of the antenna refers to the amount of power radiated in major lobe direction. From the below graph maximum gain is achieved at most of the frequencies except at some frequencies.

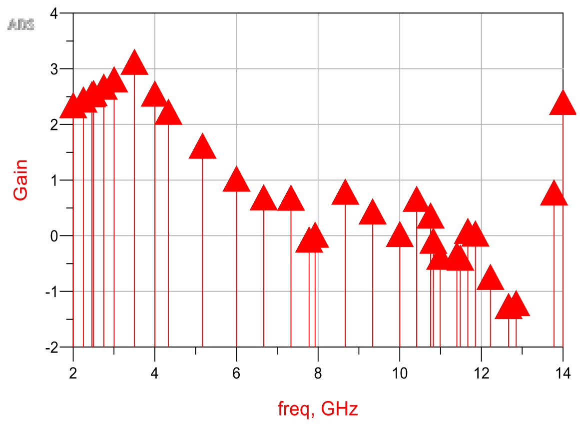

Fig.10(d). Frequency vs. Gain of UWB Antenna

Thus from the graphs the Directivity and Gain are well obtained for the designed UWB Monopole Antenna.

The proposed antenna is fabricated and measured by Agilent network analyzer. The fabricated antenna and the results of the designed UWB antenna are depicted below in the Fig.10(e) and Fig.10(f) respectively. Then the S parameters are plotted. Fig.10(e) indicates the front side (radiating patch) and Fig.10(f) indicates the defected ground plane (back side) of the proposed UWB antenna. Here SMI connector is used in the feed line for hardware measurement.

Fig.10(e). Radiating patch

Fig.10(f). Ground plane

The comparison of simulated and measured results are depicted below in the Fig.10(g). Due to changes in the factors like permittivity, thickness of the substrate, fabrication intensity, soldering, SMI connections and measuring environment the measured and simulated results vary slightly.

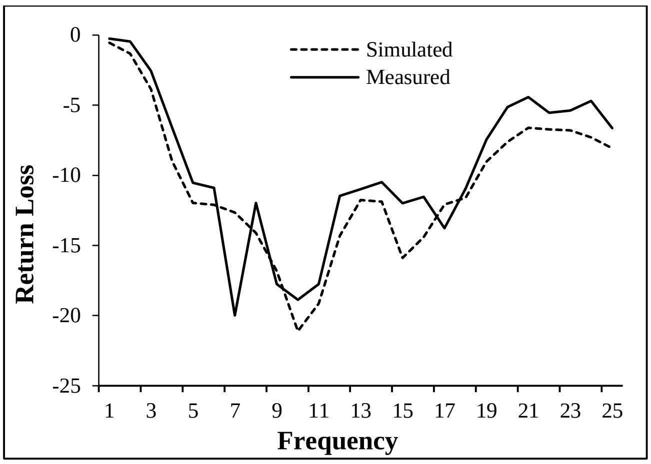

Fig.10(g). Comparison of Return loss (in dB) between simulated and measured results

Thus from the graph it is clear that the measured result is in accordance with the simulated result.

7. CONCLUSION

The proposed Asscher shaped monopole UWB antenna resonates from 3.6GHz to 10.8GHz, so it can be used for various fields like communication, radar and medical. It has additional features like low cost, low profile, easily mounted and fabricated. The antenna is simulated from 2-14GHz. The Asscher shaped monopole UWB antenna has better improvement in gain, directivity, bandwidth, and radiation efficiency. The measured result well matches with the simulated result thus enhancing the performance of the antenna.

REFERENCES

[1] Bing Yang, Minzhe Chen and Lingyun Li, "Design of a Four-Element WLAN/LTE/UWB MIMO Antenna using Half-Slot Structure", *AEU-International Journal of Electronics and Communication*, Vol. 93, pp. 354-359, 2018.

[2] B.J. Kwaha, O.N. Inyang and P.Amalu, "The Circular Microstrip Patch Antenna-Design and Implementation", *International Journal of Research and Reviews in Applied Sciences*, Vol. 8, No. 8, pp. 88-95, 2011.

[3] Dinesh Yadav, Mahesh P. Abegaonkar, Shiban K. Koul, Vivekanand Tiwari and Deepak Bhatnagar, "A Compact Dual Band-Notched UWB Circular Monopole Antenna with Parasitic Resonators", *AEU-International Journal of Electronics and Communication*, Vol. 84, pp. 313-320, 2018.

[4] Hari Shankar Mewara, Jitendra Kumar Deegwal and Mahendra Mohan Sharma, "A Slot Resonators based Quintuple Band-Notched Y-Shaped Planar Monopole Ultra-Wideband Antenna", *AEU-International Journal of Electronics and Communication*, Vol. 83, pp. 470-478, 2018.

[5] Jing-Ya Deng, Tian-Qi Fan, Yan Zhang, Xiang Wen, Guo-Qiang Liu and Li-Xin Guo, "An Open Slot Antenna with Bandwidth Extension for WLAN/UWB Applications", *International Journal of Antennas and Propagatio*n, Vol. 2015, pp. 1-7, 2015.

[6] Kajal Ankur Singhal, "Design and Simulation of Circular Rectangular Microstrip Patch Antenna for Wireless Applications", *Engineering and Technology Journal*, Vol. 3, No. 1, pp. 361-365, 2018.

[7] K. Yekeh Yazdandoost and R. Kohno, "Design and Analysis of Ultra WideBand Antenna", *IEEE Communication Magazine*, Vol. 42, No. 10, pp. 1-4, 2004.

[8] K.S. Lim, M. Nagalingam and C.P. Tan, "Design and Construction of Microstrip UWB Antenna with the Time Domain Analysis", *Progress in Electromagnetics Research M*, Vol. 3, pp. 153-164, 2008.

[9] Naveen Jaglan, Samir D. Gupta, Binod K. Kanaujia, Shweta Srivastava and Ekta Thakur, "Triple Band Notched DG-CEBG Structure Based UWB MIMO/Diversity Antenna", *Progress in Electromagnetics Research C*, Vol. 80, pp. 21-37, 2018.

[10] Noor M. Awad and Mohamed K. Abdelazeez, "Multislot Microstrip Antenna for UWB Applications", *Journal of King Saud University - Engineering Sciences*, Vol. 30, No. 1, pp. 38-45, 2018.

[11] N. Sudhakar Reddy, K. Siddappa Naidu and S. Ashok Kumar, "Performance and Design of Spear Shaped Antenna for UWB Band Applications", *Alexandria Engineering Journal*, Vol. 57, No. 2, pp. 719-722, 2016.

[12] Raj Kumar and Gopal Surushe, "Design of Microstrip-Fed Printed UWB Diversity Antenna with Tee Crossed Shaped Structure", *International journal On Engineering Science and Technology*, Vol. 19, No. 2, pp. 946-955, 2016.

[13] Reshma Lakshmanan and Shinoj K. Sukumaran, "Flexible Ultra Wide Band Antenna for WBAN Application", *Proceedings of International Conference on Emerging Trends in Engineering, Science and* Technology, pp. 880-887, 2016.

[14] S. Siva Sundara Pandian and C.D. Suriyakala, "A New UWB Tri-Band Antenna for Cognitive Radio", *Proceedings of International Conference on Communication, Computing and Security*, pp. 747-753, 2012.

[15] Tanvi Dabas, Deepak Gangwar, Binod Kumar Kanaujia and A.K. Gautam, "Mutual Coupling Reduction between Elements of UWB MIMO Antenna using Small Size Uniplanar EBG Exhibiting Multiple Stop Bands", *AEU-International Journal of Electronics and Communication*, Vol. 93, pp. 32-38, 2018.

[16] Zuhura Juma Ali, "A Printed Microstrip Patch Antenna Design for Ultra Wideband Application", *International Journal of Science and Research*, Vol. 3, No. 4, pp. 422-424, 2014.