

How to Cite:

Sugapriya, K., & Omkumar, S. (2022). Tuning of dual frequency resonance analysis of circular and rectangular patch UWB antenna used for wireless sensor networks. *International Journal of Health Sciences*, 6(S1), 12858–12867. <https://doi.org/10.53730/ijhs.v6nS1.8207>

Tuning of dual frequency resonance analysis of circular and rectangular patch UWB antenna used for wireless sensor networks

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Abstract---In our modern digital world, communication plays a most important role in research of new designs and novel findings. The proposed analysis is based on Ultra-wide band microstrip patch antenna with two methods of circular and rectangular patch. The design analysis and comparison of various antenna parameters are used for wireless sensor networks. The V-shaped slot is introduced on top of the circular patch and the horizontal T-shaped slot on rectangular patch using jeans substrate material, the design gives good resonance frequency of 9.5GHz and 7.7GHz for wireless communication networks. At resonance the receiver of UWB antenna has a frequency sensing element and the antenna parameters were analyzed using High Frequency Structural Simulator. From the analysis, gain of an antenna, VSWR, return loss as well as radiation pattern, Specific Absorption Rate SAR values are in the acceptable range. The VSWR value of both rectangular and circular patch is 1.05, return loss below -11dB determined in order to avoid surface wave propagation, the specific absorption rate SAR value should be below 2W and gain of each antenna consists of positive value. Hence the antenna meets the requirement suitable for wireless sensor network application.

Keywords---UWB, T-slot, Specific Absorption Rate value and Jean's substrate.

Introduction

Antenna is very effective transducer for wireless signal transmission and receiving function. In wireless communication system antenna plays a vital role with the different designs and novel findings related to communication technology and IoT applications. The microstrip patch antenna is very compact in size, less power, fast data transmission and good radiation pattern can be achieved with the modern printed circuit technology. ultrawide band antenna has a tremendous scope in wireless technology like, frequency sensing, textile, notch band characteristics, WLAN, Wi-Fi, WiMAX, WBAN and Internet of Things.

The spanner shaped rectangular microstrip patch antenna investigated for wireless communication system like mobile and satellite applications [1]. A new switching technique can be analyzed in simple and reconfigurable antenna with the variation of values of lumped parameters for 5G applications [2]. UWB antenna sensor investigated for electromagnetic absorption from the muscle tissue with the radiating near-field condition used for wireless body area network was proposed [3]. antenna with low SAR value was investigated to achieve WBAN technology requirement using the metamaterial and it operates in the ultrawide band region [4]. The antenna investigated for recycling of organic materials like RF-energy harvesting using the nano particles was proposed [5]. The UWB MIMO diversity antenna fabricated and analyzed for the wireless, sensor and mobile applications [6]. Tetra hertz antenna designed for power transmission in WBAN at different modulation techniques [7]. UWB patch antenna investigated for on body measurements was analyzed in free space for WBAN network [8]. Wideband frequency characteristics have been achieved with the antenna substrate consist of epoxy-based composite having the tunable characteristics of the antenna discussed for multiband applications [9]. dual-band resonance investigated in fractal antenna with split-ring resonator for various wireless communications [10]. Dual-band rejection antenna with fork shaped inverted L-stub for UWB application was investigated [11]. T-shaped UWB MIMO antenna investigated to attain enhanced fractal bandwidth using FR4 substrate material [12]. The wearable circular sensor antenna array investigated for WBAN technology, which analyses the communication link between human body and personal devices used for medical applications [13]. Textile antenna for breast tumor detection investigated using the breast tumor phantom model for cancer diagnosis [14]. MIMO antenna designed for radar applications because of reduced surface wave propagation and low dielectric loss [15]. EF shaped microstrip patch antenna using epoxy composite material was investigated for breast cancer detection using microwave imaging system [16]. To enhance the bandwidth of UWB antenna for wireless personal area communication was investigated [17]. Super wide band antenna designed for four different configurations of MIMO used for wide band in wireless communication [18]. Monopole antenna investigated for bandwidth enhancement with suitable gain using the partial ground plane [19]. An integrated antenna based on composite left/right-handed meta material antenna designed for the easy integration of electronic devices [20]. For the antenna realization carbon nanotube was investigated [21]. The milli-meter wave antenna investigated for body-centric networks using the tri-band slotted patch [22]. The two-dimensional network UWB antenna sensor for breast cancer detection was investigated [23]. An algorithm was developed for Multi-path components for

positioning in wireless communication[24].Ultra-wide band beam forming was investigated for wireless sensor networks[25]. The base station indoor environment analysis made using L-shaped configuration with the variation of channel parameters [26]. The antenna designed and investigated for the visceral and subcutaneous fat layer analysis also the signal propagation through the tissues[27].In an large indoor environment the narrow band and wide band measurement analysis investigated for sensors in communication[28].Two dielectric substrate material techniques developed for the sensor node application[29].The antenna investigated for intra-body signal transmission analysis with the variation of channel impulse responses for medical applications[30].Algebraic space-time code developed for multi-band orthogonal frequency division multiplexing UWB system[31]. Microwave broad band spectroscopy system in the range of UWB was analyzed [32]. Impulse radio UWB sensor analysis investigated using CMOS process [33]. Frequency selective surfaces calculated using the genetic algorithm was investigated [34]. An antenna investigated for the determination of unwanted cells in the human tissue [35]. From the various literature survey UWB radiator sensor used for wireless communication network for the easy identification of spectrum as well as fast data transmission of signals. The novelty of proposed work is to get two different frequencies of resonance for rectangular as well as circular patch to achieve the effective spectrum sensing property in communication.

1. Antenna design measurements

The antenna design parameters we have to select with suitable properties for appropriate application. Microstrip patch antenna consists of ground plane, substrate, patch and feed line impedance, in this paper the rectangular and circular patch antenna design was proposed. Ground plane of a proposed design is partial ground plane, substrate material was chosen as jeans used for sensing the frequency spectrum in which the antenna uses in military and ISM band applications. The antenna consists of circular patch with V-shaped slot on the top of the patch, small diamond shape slot in the middle of patch and rectangular patch with horizontal T-shaped slot is introduced. In this proposed design the 50Ω impedance applied for the input excitation of microstrip line. The length L and width W of a rectangular patch and diameter of circular patch antenna can be calculated using the formula, the patch length can now be calculated as

$$L = \frac{1}{2f_r \sqrt{\epsilon_{reff}} \sqrt{\mu_0 \epsilon_0}} - 2 \Delta L$$

Calculation of the effective dielectric constant and the patch width is calculated using the

formula given below,

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2}$$

$$W = \frac{1}{2f_r \sqrt{\mu_0 \epsilon_0} \sqrt{\epsilon_r + 1}} = \frac{v_0}{2f_r \sqrt{\epsilon_r + 1}}$$

The patch length L and width W calculated using the formula, slot length and width was chosen according to the radiation of the patch antenna. The microstrip line feeding can be used for the input feeding technique, circular patch diameter

is 30mm and the dimensions of both the patch antenna was shown in the table 1, given below.

Table 1
Antenna dimensions

Sl.No	Antenna design parameter	Rectangular patch Measurements	Circular patch Measurements
1	Patch Length L	25mm	60mm
2	Patch width W	25mm	60mm
3	Circular patch diameter	-	30mm
4	Middle slot	9mmx8mm	6mm
5	Top slot	-	10.4mm
6	Feed length and width	10mm and 3.5mm	29mm and 3.2mm
7	Jean's substrate material	Dielectric constant=1.7	Dielectric constant=1.7

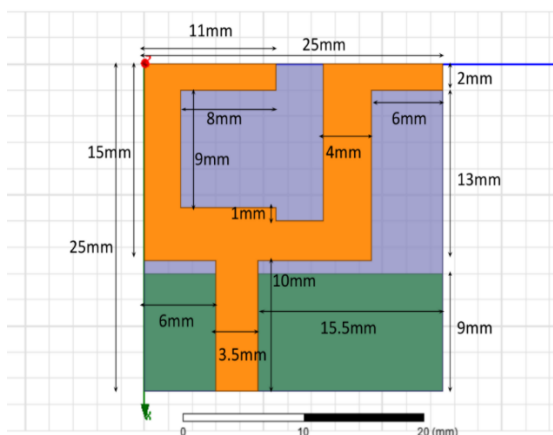


Fig.1 Rectangular patch

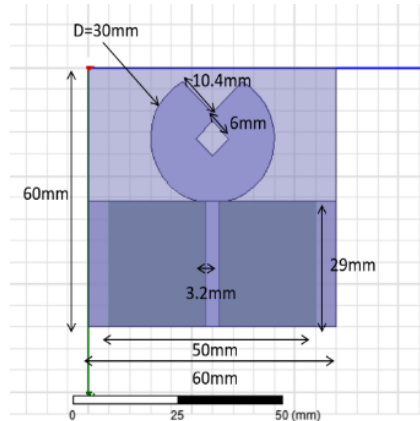


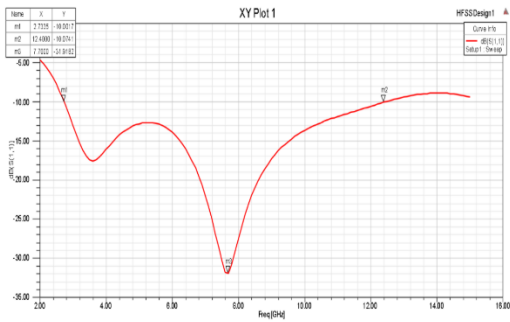
Fig.2 circular patch

The ultrawide band microstrip patch antenna designed using the measurements given in the table 1, rectangular patch antenna with horizontal T-shaped slot design measurements shown in the fig 1, the 10mmx 3.5mm microstrip line feeding technique used for excitation and the slot can be created to give better resonance at 7.7GHz. The circular patch with diamond shaped slot in middle and V-shaped slot in the top of the patch created was shown in fig 2, to get the good resonance at 9.5GHz frequency. Effective dielectric constant 1.7 can be taken for both circular and rectangular UWB antenna. The designed antenna can be simulated and parameters analyzed using high frequency structural simulator HFSS software.

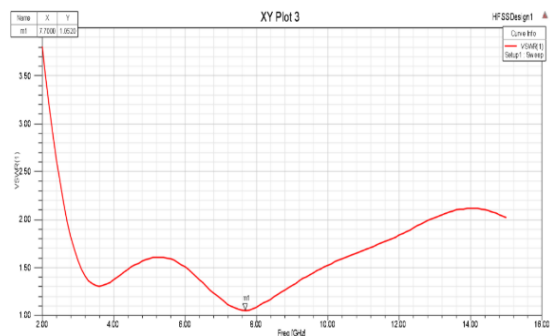
2. Parametric analysis

The rectangular patch and circular patch ultrawide band antenna designed, simulated and analyzed. From the design analysis, the antenna voltage standing wave ratio VSWR, return loss, specific absorption rate SAR value and gain value should be measured using the simulation. The jeans substrate material was chosen for the proposed method to get the good wireless sensing characteristic in textile applications.

The Rectangular patch ultrawide band antenna designed according to the length and width given in the table 1, a horizontal T-shaped 9mmx8mm slot was created in the rectangular patch. The antenna resonates at a frequency of 7.7GHz and the s-parameter plot is determined to get return loss vs frequency and the plot is shown in fig 3. The voltage standing wave ratio of 1.05, the frequency vs VSWR is given in fig 4. The SAR specific absorption rate value of the designed antenna is below 2 watts and 3db gain should be measured using simulation was shown in fig 3,4. The rectangular ultrawide band microstrip antenna parameters are measured for suitable wireless sensing application.



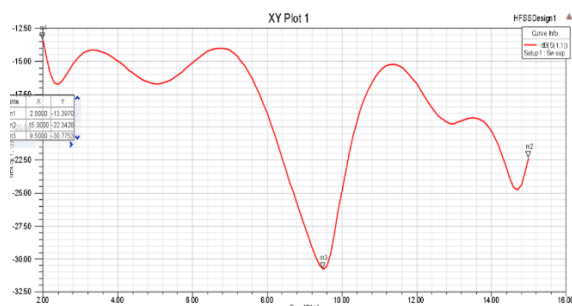
Parameter	Value
Resonant frequency	7.7GHZ
Bandwidth	2.7-12.4GHZ



Frequency	VSWR
7.7GHZ	1.05

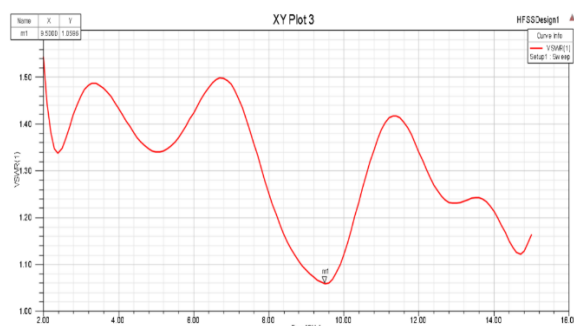
Fig.3 Rectangular patch S-parameter plot Fig.4 Rectangular patch VSWR at 9.5GHz

Circular patch antenna with small diamond shaped slot can be introduced in the middle of the patch and V-shaped slot created on the top of the patch according to the dimension given in the table 1. To enhance the performance of resonance frequency and sensing characteristics the diamond shaped slot created in the middle of patch also the partial ground plane was introduced in the design. The antenna simulated using the HFSS and parameters are measured like VSWR, S-parameter, SAR value and gain. The frequency vs return loss and frequency vs VSWR plot was shown in the fig 5,6.



Parameter	Value
Resonant frequency	9.5GHZ
Bandwidth	2-15GHZ

Fig.5 circular patch S-parameter plot



Frequency	VSWR
9.5GHZ	1.05

Fig.6 circular patch VSWR

The specific absorption rate of the proposed design can be analyzed using the human phantom model. It consists of few layers like muscle consideration measurement was 10mm, 1mm air, 2mm skin and 4mm fat is represented in fig 7. By considering this measurement the design is simulated to get SAR value and it has shown the result of below 2watts. In the proposed design various antenna parametric analysis encounters the requirement of wireless sensing in communication.

Result Analysis and Discussion

Wireless communication technology growing very fast in digital environment, while designing an antenna, the suitable application is the novel findings in results of simulation and experimental investigation. The ultrawide band antenna needed for high-speed communication in short range applications and the UWB operating frequency range is 3.1GHz to 10.6GHz, which is most suitable for wireless sensor networks. For the cognitive radio networks the frequency spectrum analysis can be done during primary and secondary users, so the two different resonance frequency values are obtained using the jeans substrate material. In order to get the desired frequency for particular spectrum in radio signal transmission.



Fig.7 Human phantom model

The dual frequency tuning process can be made using the varactor diode in accordance with the corresponding patch. The UWB radiator, sense the frequency of 9.5GHz or 7.7GHz for radio spectrum during signal transmission. The rectangular patch antenna has the resonance frequency of 7.7GHz and circular patch antenna has a resonance frequency of 9.5GHz determined during experimental and simulation method. In order to meet the sensor requirement, the VSWR value should be 1.05, bandwidth 2-15GHz as well as to avoid inconvenience of the users gain and SAR values were measured. The measured result shows that, both the values are in acceptable range and the radiation pattern of the antenna was measured using anechoic chamber to get the accurate radiation of an antenna during the ultrawide band frequency range, which shows the good radiation results. The textile antenna used in a challenging industrial environment for sensing and monitoring process in medical field. According to the simulation and experimental measurements, the proposed antenna exhibits two frequencies to achieve good sensing characteristics and good SAR value to avoid health grievance. Hence the proposed UWB design is suitable for wireless sensor networks.

Conclusion

Wireless communication technology is a very fast data transmission in indoor and outdoor communication in sensor and other networks. In the proposed design the circular and rectangular microstrip patch antenna analysis done with the jean's substrate material using the HFSS software. According to the simulated results of rectangular and circular patch of the resonance frequency 7.7GHz and 9.5GHz, SAR values and gain of an antenna shows good agreement with wireless frequency sensing for wider communication. Dual frequency spectrum sensing uses the same substrate material. Also, the radiation of the antenna gives a better radiation pattern, in which the antenna radiation will be effective for cognitive spectrum analysis and sensing in wireless communication. Hence the proposed design was suitable for wireless communication networks.

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