DESIGN OF A CIRCULAR PATCH ANTENNA FOR WIRELESS BODY AREA NETWORK APPLICATION

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Abstract : This paper presents a compacted patch antenna which resonates at 2.27 THz. Rogers RT/duroid 6010 substrate of length 100 µm, width of 100 µm and thickness of 10 µm was utilized to design the antenna. The radius of the circular shape (patch) is 40 µm. The miniaturized compactness of the designed antenna at terahertz frequency is suitable for the application of wireless body area network (WBAN).The antenna was simulated using high frequency structure simulator (HFSS) and its radiation pattern, gain, return loss have been analyzed for communication link quality of the channel. To assess the link quality, signal to noise ratio (SNR) and bit error rate (BER) matrices are being calculated. Path loss, absorption coefficient of human model at terahertz frequency is being determined. The simulation results demonstrate that antenna will offer great link quality at terahertz frequency. The SNR computed for the proposed antenna is high and BER is low.

***Index Terms* - Wireless body area network (WBAN), circular patch antenna, return loss, Signal to noise ratio (SNR), bit error rate (BER).**

I. Introduction

In wireless body area networks (WBANs), radio frequency (RF) technology can altogether help in improving human medicinal services arrangements, illness following methods and other therapeutic purposes. WBANs are required to empower specialists to uninterruptedly quantify the wellbeing status of the patient. Basically, WBANs can convey very solid correspondence between the gadgets and those pieces of the system which are explicitly embedded in the human body for example wearable sensors hub. These wearable sensors hubs comprising of wearable radio wires are deliberately ready to screen patient's ECG, EEG, and pulse and so on [1].The microstrip patch antenna prompts an extremely inventive development in the world of miniaturization [2]. Receiving antennas that are for the most part utilized for WBANs are normally wearable reception devices [3].Now every days, wearable antenna has been assuming a significant job for a brief development in the biomedical applications. Additionally the wearable sensor hubs containing reception devices are being made lighter in weight and conservative in size with the goal that they can be effectively embedded on human body or covered up inside the garments [3, 4]. Wireless body area networks have a tremendous field of use and the antennas in WBAN can be utilized in application like wireless communication, tracking and navigation , mobile computing public safety etc. [5].WBAN antennas are now and then planned to be joined into wearable antennas with the outcome little size, light weight, low profile reception apparatuses are created [6].

Planar receiving antennas are best when contrasted with different reception devices for WBAN because of their position of safety, little size, low weight, and simple manufacture. The planar antenna actualized in a WBAN might be a wide band receiving wire, a tight band reception device, or an implantable or adaptable antenna and so forth. There are not many frequency bands which have been especially assigned for WBAN systems like medical implant communication system band with frequency band of 900 MHz, the industrial scientific medical (ISM) band with the frequency band of 2.4 GHz and 5.80 GHz, and the ultra-wide band with the frequency band extending from 3.00 GHz to 10.00 GHz. Terahertz frequency communication is progressively secure communication for short distance, point-to-point communication that incorporates the WBAN interchanges, and for the transmission interface which request high information rate for example multi-Mb/s to Gb/s. The terahertz frequency communication gives a viable range to free-space transmission. THz area overcomes a huge offer of electromagnetic range situated between the microwave and optical frequencies which is characterized as the band from 0.1 - 10 THz. The inspiration of terahertz band is to build the transmission commitment and information rate. The terahertz frequencies have numerous favorable circumstances, for example, better goals, framework minimization, wide transfer speeds, high directivity, high information rate and so on. In this paper, a circular microstrip antenna has been designed with miniaturized dimension working at frequency 2.27 THz. Microstrip antennas are exceedingly required for WBAN as a result of simple manufacture and conservativeness. The antenna has been intended for 2.27 THz as it can look out of high information rates. Terahertz frequency gives the scaling down of antenna dimensions and in this way it is simpler to be utilized in WBANs. The connection nature of the channel on which proposed antenna emanates has been investigated for wireless body area networks. High packet delivery ratio (PDR), low packets shows great link quality of the imparting channel among transmitter and receiver. Great connection quality might be guaranteed if low bit rate error and high signal to noise ratio is controlled by the communication channel. The antenna designed in this paper, radiates terahertz frequency and therefore, it is utilized for investigation of link quality of WBAN channel. Execution measurements SNR and BER are utilized to assess the connection quality. Further, a correlation has been drawn among various thought about radio wires.

Design of Circular Patch Antenna

The material type utilized for the patch and substrate characterizes the effectiveness and measurement of antenna. A circular patch antenna comprises of a conducting circular shaped patch, put on a Rogers RT/duroid 6010 substrate which acts as a dielectric. Figure1. demonstrates that the substrate is put over the ground plane which is additionally a conducting plane. For excitation, microstrip feed-line is used as current source to the patch. T. In our design, the radius of circle patch is calculated using equation (1).

$$a_e = a\{1 + \left(\frac{2h}{\pi a \epsilon_r}\right)\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\}^{1/2} \quad (1)$$

Where h=Height of the antenna
a= radius of the antenna
ε_r = the dielectric constant of the substrate

As there is just a single parameter (radius) that should be controlled, it turns out to be anything but difficult to design the antenna. Fig. 2, demonstrates the proposed receiving antenna structure, which is wanted to transmit radiations at THZ frequency. The length of the substrate is 100 µm, width is 100 µm and thickness is 10 µm. The substrate utilized for the proposed recieving antenna is RT/Duriod6010 (εr = 10.2). The sweep of fix is 40 µm. The microstrip feed line has length of 10 µm and its width is 10 µm. Fig. 2 demonstrates the schematic diagram of the designed antenna. The intention of utilizing diverse substrate materials is just to break down its impact on the antenna results. ANSYS HFSS software has been utilized for the simulation and analysis of antenna.

II. RESULT ANALYSIS

Fig. 3 demonstrates the S11 parameters versus frequency plot of the proposed antenna. It demonstrates the resonant frequency of 2.27 THz when RT/Duriod6010 is utilized as substrate material. Fig. 4 outlines the E-Plane and H-Plane of radiation pattern of the proposed circular patch antenna. The back lobes in radiation pattern increase the odds of impedance with different devices. Misuse of vitality happens due to back lobes. From the Fig.s 4, 5 demonstrate that back projection radiations of the proposed antenna are particularly less; thusly this receiving antenna is appropriate for the usage in WBANs. Fig. 5 demonstrates the 3D gain plot of the antenna with RT Duroid 6010 substrate. The Fig. additionally portrays the bearing of spread of radiations, which can be believed to be along many directions, which is valuable for the execution of these receiving antennas in WBAN. The gain of this proposed antenna is 6.8 dB, it tends to be seen from the assume that the course of propagation of radiations is along many direction directions. Likewise the directivity for this antenna is observed to be 7.2 dB as appeared in Fig. 6.

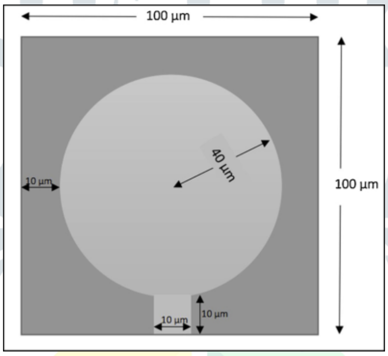

Fig. 1. Schematic diagram of circular shaped patch antenna.

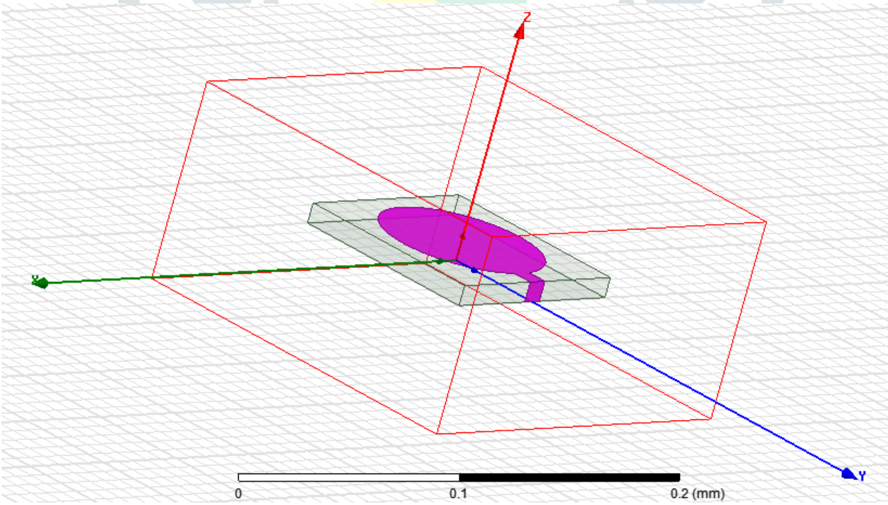

Fig. 2. Design of circular patch antenna using HFSS

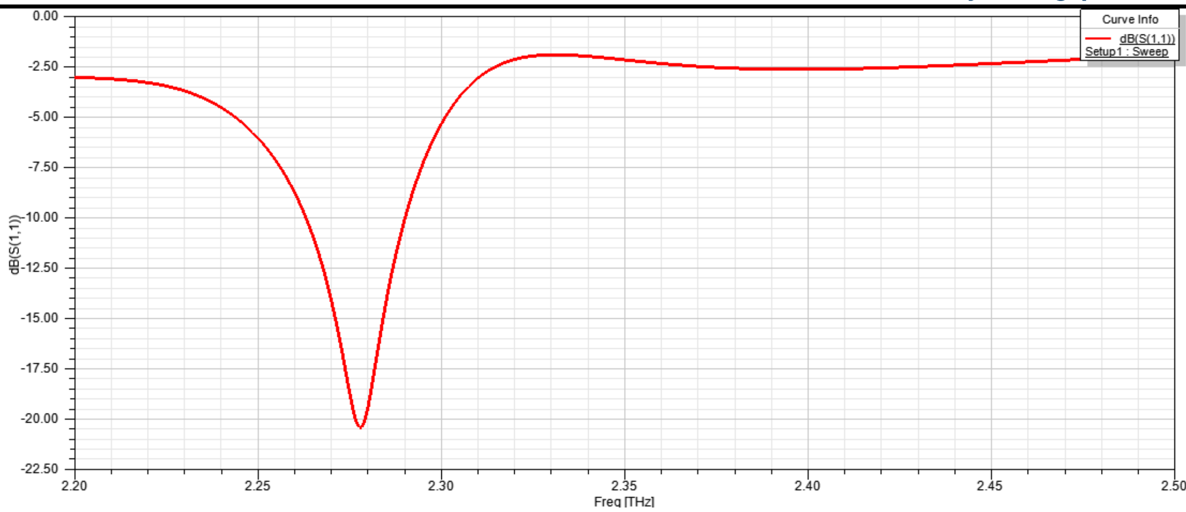

Fig. 3. S_{11} plot of circular patch antenna with resonant frequency at 2.27 THz

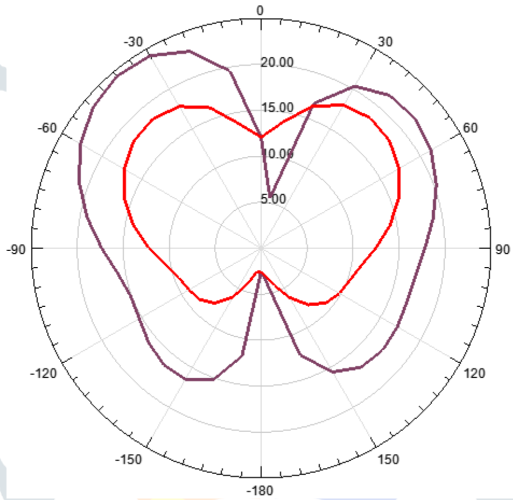

Fig. 4. Radiation pattern of circular patch antenna at 2.27 THz

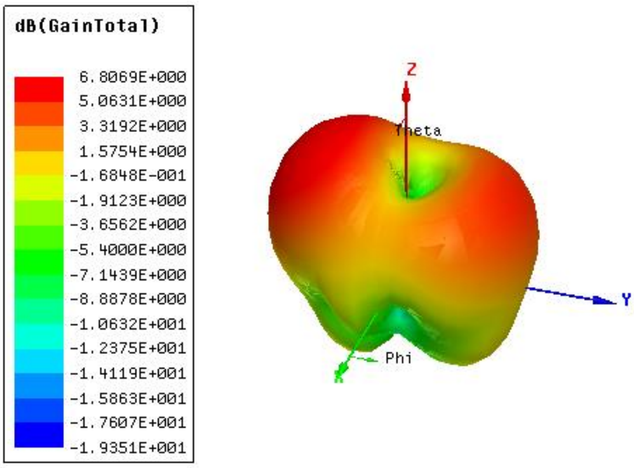

Fig. 5. 3D plot for gain

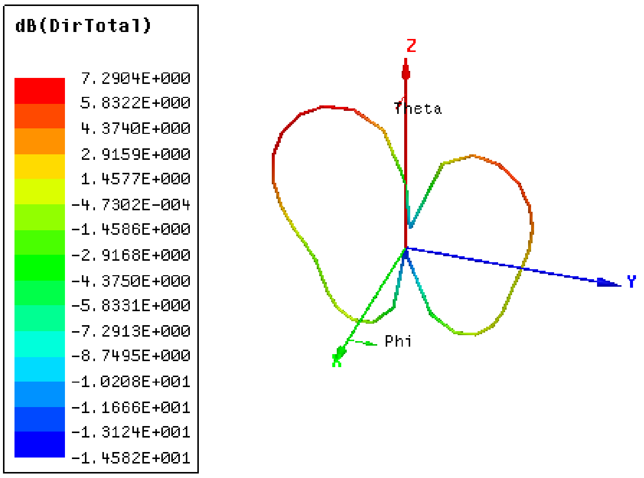

Fig. 6. 3D polar plot for directivity

III. WBAN RESULTS

Antenna is a significant and fundamental piece of sensor hub which is the core of WBAN. This conservative antenna designed in this paper transmits terahertz frequency. A standout amongst the most appealing fields of utilizations these days is WBAN. Like every other segment of body area arranges, antennas do a significant job. The receiving antenna designed in this paper is minimal (length of the substrate is 100 µm, width is 100 µm and thickness is 10µm).While the transmission between source hub and goal hub in WBANs, the link quality between them should be high. Link quality of the radiated signal is significant parameter for correspondence. High SNR and low BER guarantee better connection quality. Along these lines in this segment of the paper, the SNR and BER of the proposed antenna has been analyzed and contrasted and different antenna. The equation for SNR has been evaluated using equation (3.1).

$$SNR = (\frac{(E_{on}R_b - P_{total})G_tG_r}{PLM_l N_f (1+\alpha)N_b} \qquad (3.1)$$

Further, BER is calculated using equation (3.2)

$$BER = (\frac{1}{SNR})^k \qquad (3.2)$$

In the above equation, k is the particular subcarrier index. PL is the path loss between source and destination and d is the distance between source and destination. P_{total} indicates the total transmitted power and its value is 200 nW. R_b demonstrates the bit rate, which is taken to be 1Mbps in this specific case. N_f is the noise Fig. which is taken to be taken to be equivalent to 10 dB and M_l is equivalent to 40dB. Specific subcarrier index (k) has a value equivalent to 2.From equation (3.1) and equation (3.2), it is clear that BER and SNR depend greatly on the path loss. In order to evaluate path loss absorption coefficient of simplified human model within WBAN operating at terahertz frequency, following equation (3.3) and equation (3.4) are used.

$$PL[dB] = PL_{Spread} + PL_{Absorption} \qquad (3.3)$$

Where PL_{Spread} specifies the path loss which may occur due to the spreading and propagation of the wave in the medium and $PL_{Absorption}$ specifies the path loss caused by the absorption in the medium.

PL_{Spread} is defined in dB as:

$$PL_{Spread} = -10\log_{10}(\frac{\lambda_g}{4\pi d})^2 \qquad (3.4)$$

Where d symbolizes the total path length and λ_g denotes the wavelength of the medium. Basically this wavelength itself is a ratio given as $\lambda_g = \frac{\lambda_0}{n}$ where n is the refractive index of the material. $PL_{Absorption}$ is defined as equation (3.5).

$$PL_{Absorption} = -10\log_{10} e^{-\alpha d} \qquad (3.5)$$

Where α is the absorption coefficient and here $\alpha = \frac{4\pi k}{\lambda_0}$, where k= extinction coefficient which basically defines the attenuation of an electromagnetic wave as per unit distance. The SNR and BER calculated for the proposed antenna is 41 dB and 4.3 e^{-36} respectively. These values indicate that the proposed antenna offers highest SNR and low BER as compared to previous antenna designs.

IV. Conclusion

The proposed circular patch antenna is minimal and resonants at 2.27 THz. The return loss at resonant frequency is -20.39 dB which reasonable for good antenna design . In this paper a high gain antenna has been designed which is usable at terahertz and gain accomplished is 6.8 dB with directivity 7.2 dB. Designed antenna is scaled down in size and subsequently appropriate for its execution in WBAN. The proposed antenna is broke down for its link quality by estimating BER and SNR of the receiver antenna. The result interprets that the link quality offered by the proposed compact antenna at terahertz frequency is great, consequently it will be appropriate for WBAN.

References

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