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Circular Shape Microstrip Patch Antenna for Body Area Network Application

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ABSTRACT

In wireless communication system antenna plays crucial role. Thus, antenna used every wireless communication system should be low weight, low profile, low cost, smaller in dimension and conformity. A microstrip patch antenna fulfils all these requirements. In this paper a circular shaped microstrip patch antenna for Body Area Network (BAN) application in the 2.45 GHz ISM (Industrial Scientific Medical) band is suggested. To enhance Specific Absorption Rate (SAR). The suggested antenna offers a gain of over 1 dB for the whole 2.45 GHz ISM band application of proposed antenna is in fields of Medical, Military, Sports, Defence etc. Various antenna parameters like return loss, VSWR, directivity, gain etc has been computed and analyzed using HFSS software.

Key words : Circularly polarized antenna, Biomedical application, Body Area Network (BAN), Implantable antenna

1. INTRODUCTION

In wireless communication system, a body area network is referred to as a collection of small, lightweight sensors applied to the body to measure various physical parameters. The network of these sophisticated systems enables the doctors and his specialists to consistently monitor the health of patients and obtain the reaction extremely small microelectronic sensors that are attached to the patient's skin, clothing, or even implanted inside the body. A microstrip patch antenna was created using CST's finite integration technique simulator Microwave Studio [1]. Translates the physical characteristics, including heart rate, oxygen level, and blood pressure (BP) into electrical signals that are linked to the monitoring stations for transmission. These variables are continuously tracked by a remote station and supply the lifesaving information. Medication to the patient via medical professionals or actuators implanted in the body. In these circumstances, wireless communication will be advantageous. Therefore, flexible wearable antenna design is increasingly being used in biomedical research. Commercial wireless communication system requires low profile, light weight and low-cost antenna [2].

Wearable antennas for body area networks can be designed and developed using textile materials, which are often used and are conveniently accessible. Incorporating RF circuits with thin, durable fabric antennas allows for data collection, communication, and sensing in body area networks [1]-[2]. The development of effective antenna systems is the primary emphasis of wireless body area network design. Numerous varieties of textile antennas are produced and successfully utilised to transmit signals between two places on the human body. Body-area networks require antennas that are small in size, light in weight, and flexible enough to be integrated on clothing. The work gives dual-band antenna and it realized by illustrating the miniaturization process and optimizing the slot. The antenna performances such as reflection characteristic and radiation patterns are studied on both in free-space and on-body scenarios [3]. The biological tissues of wearable antennas that are typically placed close to the human body have an impact and cause degradation of antenna functionality. Dielectric characteristics of the human body may vary at millimetre and microwave frequencies, Moreover, the dimension and size of a human body are electrically higher at millimetre frequencies associated with microwaves. Body area networks are made up of several biological sensors that communicate with one another over the air and a central sink that is situated close to the human body. The use of multimodal multiantenna ultrawideband architecture is a possible approach, One antenna is carried by each sensor, and an antenna array is supported by the central sink. This work presents a complete analytical channel model has been developed for the on-body diffracted waves mechanism. It builds on the existing IEEE 802.15.4a standard channel model and offers an innovative space-time correlation model [4]. this work [5] shows a wideband, triple-port, low-profile MIMO antenna with both polarisation and pattern diversities, which can simultaneously enable on-body and off-body communications. The via-loaded circular patch on the bottom creates the vertical polarised pattern, while a closely spaced modified E-shaped stacking patch on the top creates the horizontal polarised pattern.

In particular, splitting the ground planes and adding more slot loadings enhance port isolation. This antenna accomplishes a −10 dB bandwidth of nearly 14%, a mutual coupling of smaller than −15 dB, a radiation efficiency of higher than 93%, and a small ECC below 0.01. A circular shaped ground-fed patch antenna is designed with the operating frequency of 14.6 GHz with -15.68 dB input and 8.14 dB gain. Furthermore, the antenna's construction includes triangle, square, and column shapes in addition to its circular shape [6].

This paper describes design of a circular microstrip patch antenna that operates in S-band frequency range. It has been demonstrated that planned circular microstrip patch antenna generates a steady radiation pattern within frequency range with a bandwidth of about 4% and a flexible 2.4 GHz wireless sensor node with a bespoke single-layer monopole antenna, tuned for on-body operation for wearable applications is also presented [7]-[8]. A 50-ohm microstrip was used to excite a semi-circular slot antenna with a protruding tiny rectangular slot in order to achieve broadband performance. However, most communication applications cannot be covered by impedance bandwidth of these antenna designs. Therefore, it is crucial to further increase these antenna structures' impedance bandwidth in order to make them compatible with contemporary communication systems [9]. For WLAN/WiMAX applications, brand-new small triband planar monopole antenna with two inverted-L slots is proposed.

The suggested antenna is more streamlined and has a smaller radiator. In the meantime, the antenna configuration is smaller [10]. This suggested antenna uses two meander lines and a slit line to improve the inductance and capacitance properties for miniaturisation. The manufactured antenna's coverage of 2.45/5.85 GHz WBAN is measured both in open space and on a human body [11]. The circular microstrip antenna of 3D structure (b) Return loss is planned and constructed in this study at a frequency of 1.575GHz (GPS) to reduce patch size of microstrip patch antenna [12]. For CP radiation and UHF RFID portable reader applications, new asymmetric-circular shaped slotted square microstrip patch antennas with slits have been introduced [13]. In study, wearable and non-wearable UWB antenna designs and applications for ON-Body and OFF-Body communication strategies were exhibited and examined. The study also looked at and assessed antenna designs to identify numerous elements, including tiny forms, omnidirectional radiation patterns, bending factors, and substrate kinds, that affect an antenna's efficiency and output [14].

In this antenna, a circle patch produced a broadside radiation pattern, while another circular patch that had been short-circuited produced an omni-azimuthal pattern. About 10 dB served as isolation between ports. Another antenna is a microstrip annular ring-enclosed circular patch antenna [15] that is inductively loaded. There are three 2.4 GHz operating modes available for this antenna. In this letter, they suggest a button antenna for wireless body-area networks that is both wearable and dual-band, dual-mode applications. It covers Industrial, Scientific, and medical bands at 2.45 and 5.8 GHz. The antenna's two working modes are intended to share a single radiator with various functionality for various communication requirements. Due to its omnidirectional radiation pattern and operation between 2.32 and 2.57 GHz, the antenna is suitable for on-body communications. It is a top-loaded monopole antenna with linear polarization [16].

The viability of a high data rate body-implantable antenna and sensor concept has been demonstrated in the research, compatible with the reader's 2.4 GHz power-up signal's low-power energy harvesting. Based on IR-UWB, which operates in the 1.4 to 4.2 GHz frequency range, the implant antenna system connects in both directions to an external reader. It is designed for near-field communications [17]. This study [18] examines the properties of a circular-shaped Microstrip patch antenna with a single band notch for use in applications in Bluetooth (2.4 to 2.485), Wi-Fi (2.4 to 5.8 GHz), Ultra-wideband (UWB) (3.1 to 10.6 GHz) and X-band (8 to 12 GHz) respectively. The antenna has a circular radiation patch that has been modified with circular slots, crescent slots, and L slots. The ground plane of the antenna is defective with two I slots and is truncated at its top corners. this antenna impedance bandwidth is from 2.35 to 12.9 GHz range except the frequencies on single notched bands of 2.9 to 3.8 GHz.

2. CIRCULAR MICROSTRIP PATCH ANTENNA

The patch could be square, rectangular, circular, triangular, or elliptical in shape. Due to its simple shape and easy design, rectangular and circular microstrip resonant patches are typically employed in array setups. Microstrip patch antennas are capable of dual and triple frequencies and support both circular and linear polarization

2.1 Proposed Antenna

The development of circularly polarized antennas with single and multiple feed arrangements. This work proposes the construction of a circular microstrip patch antenna with a single feed and strong pattern symmetry in the E and H plane. Figure 1 shows the proposed Circular shaped Antenna.

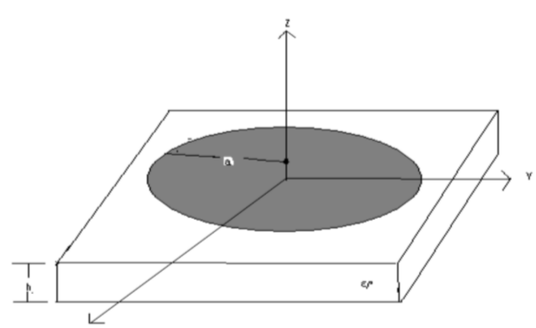

Figure 1: Circular Microstrip Patch Antenna

2.2 Design Parameters of Circular Patch Antenna

Three factors, including substrate's dielectric constant, thickness, and patch size, are used in design of microstrip patch antennas. Depending on operating frequency, dimension, radiation efficiency, return loss, directivity are influenced.

The geometrical dimensions of the patch are less than the electric dimension because of the presence of fringing fields between the ground plane and patch [19].

The following design criteria relate to the proposed circular microstrip patch antenna:

Table 1 - different parameters of the proposed antenna

Parameter	Value
Radius of patch	16.87 mm
Thickness of substrate	3.6 mm
Resonance Frequency	2.45 Ghz
Dielectric Constant	4.4

The above table 1 show the factors of the proposed antenna and dielectric material used for the proposed antenna which has dielectric constant of 4.4 and radius of patch is 16.87mm. The Figure 2 shows the 3D view of circular microstrip patch antenna and Figure 3 show the side view of proposed antenna.

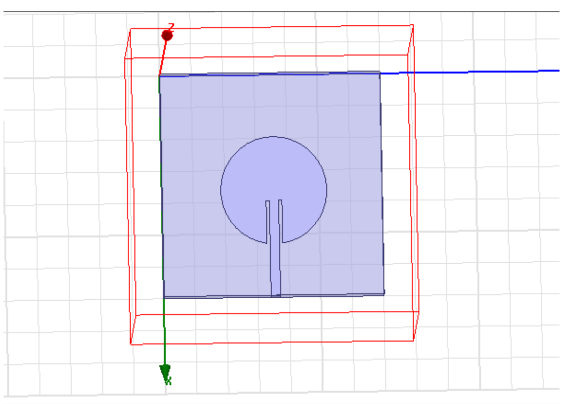

Figure 2: 3D View of circular microstrip patch antenna.

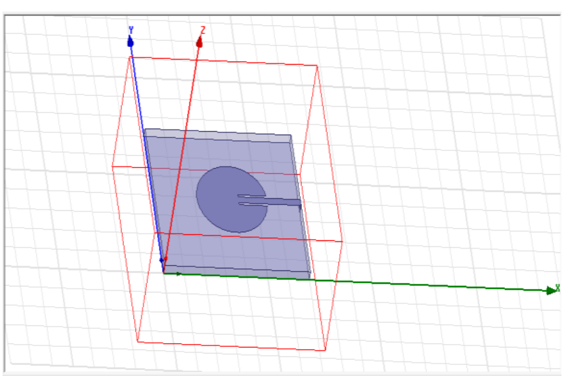

Figure 3: Side view of circular microstrip patch antenna

2.3 Dimensions

The antenna is designed using the material FR4 Epoxy for the substrate whose dimensions are 7.0 mm x 7.0 mm x 3.6 mm. The length and width of the ground plane are equivalent to that of the substrate i.e., 7.0 mm x 7.0 mm. The area of the radiator, that we calculated using the design equation is 9.0 mm^2.

Table 2: Dimensions of Proposed Antenna

Parameters	Dimension
Substrate Length	7.0 mm
Substrate Width	7.0 mm
Substrate Height	3.6 mm
Length of Ground Plane	7.0 mm
Width of Ground Plane	7.0 mm
Area of Radiating Element	9.0 mm^2

3. SIMULATION RESULTS

The proposed antenna configuration has been simulated using software HFSS 15.0. Various antenna parameters are plotted and discussed in following topics. The simulation results are given below with representation of figures. The Figure 4 show the return loss, Figure 5 show Voltage standing wave ratio (VSWR), Figure 6 shows the radiation pattern and Figure 7 show the 3D polar plot.

3.1 Return loss

Return loss, which is expressed as a loss of power in the signal that is returned due to the dislocation of the transfer lines, is measured in decibels. In antennas, lower return loss indicates less energy entering the antenna, while higher return loss indicates more power entering the antenna. An antenna's return loss can be calculated by the following formula,

$$R = 10 \log_{10}\left(\frac{Pi}{Pr}\right)$$

When the written loss is 20 DB, it denotes that there is only 1% of reflection and 99% of the power is entering the antenna. Conversely, when the return loss is 0 DB, it indicates that there is 100% reflection and no power entering the antenna since all of the power is lost.

The figure 4. Shows the return loss of the proposed microstrip patch antenna show in plot of return loss.

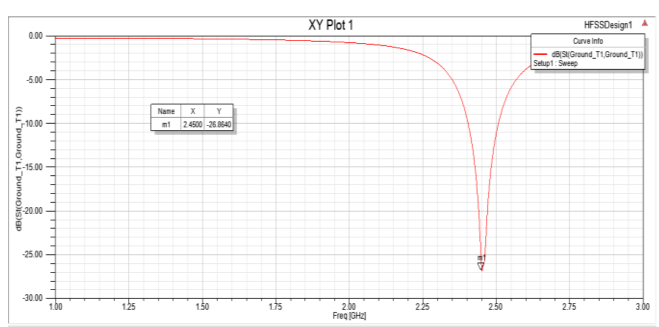

Figure 4: Return loss

.3.2 Voltage Standing Wave Ratio (VSWR)

Voltage Standing Wave Ratio, or VSWR, is a crucial factor to consider when working with antennas. The degree of standing waves on a feeder or transmission line is determined by the VSWR, which measures the power that the load is not accepting. We calculate the VSWR to determine how effectively radio frequency power is transmitted through the feeder and into the load.

Mathematically, VSWR = |V(max)|/|V(min)|

Figure 5. Also shows the corresponding voltage standing wave ratio for the proposed antenna. Theoretically, the VSWR at resonance should be 1, although a value of 1.9 or better, which corresponds to 10 dB return loss, is acceptable. From figure 5, it can be said that VSWR attains its minimum value at 2.4 GHz.

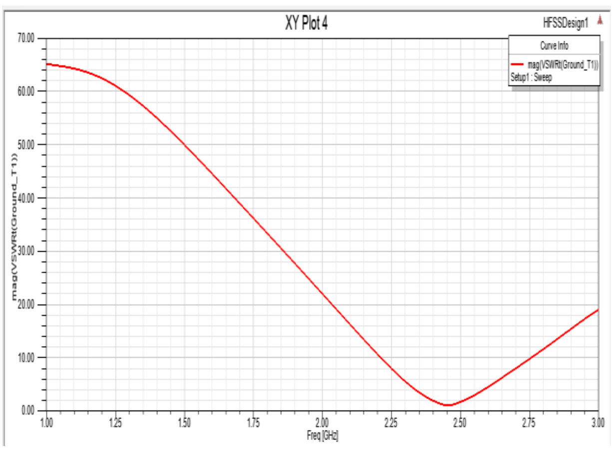

Figure 5: VSWR

3.3 Directivity

The radiation pattern of an antenna is its directional dependency of the strength of the radio waves it emits. Figure 6 displays the proposed antenna configuration's directivity plot (radiation pattern). From Figure 6 the E, H, and D plane designs exhibit excellent pattern symmetry.

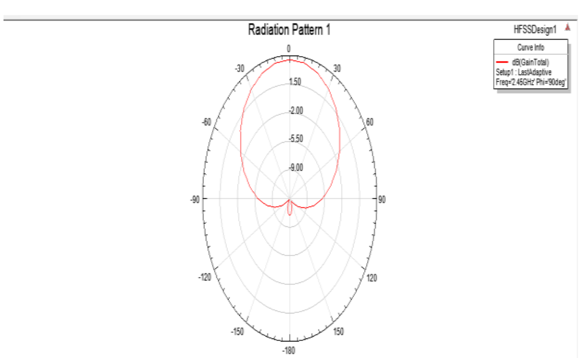

Figure 6: Directivity

Table 3 lists the typical radiation parameter values of proposed Circular Shaped Antenna. The size of the ground plane is responsible for this impact. Therefore, ground plane size can be optimized to obtain the necessary pattern symmetry. This design is most ideal for primary feeds of reflector antennas due to the pattern symfmetry it provides.

Table 3: Typical Radiation Parameter Values of proposed Circular shaped Antenna

Parameter	Value
Resonant Frequency	2.45 GHz
Reflection Coefficient	-8.13 dB
Gain	4.493 dB
Directivity	6.624 dB
Radiation Efficiency	99%
Bandwidth	1.1

3.4 3D Polar Plot

For three-dimensional polar data, Polar plot 3d creates surface, mesh, wireframe, and contour charts. A labelled polar axis can be drawn with a maximum radius following the surface contour or at a set height. On top of the surface, a polar grid can also be created. The Figure 7 Show the corresponding 3D polar plot of the proposed antenna which gives us three-dimensional data of the figure.

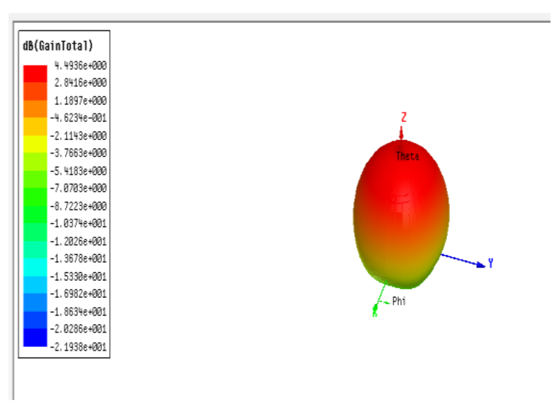

Figure 7: 3D polar plot

4. CONCLUSION

The design of a circular shaped microstrip patch antenna for Body Area Network (BAN) application with the 2.45 GHz ISM (Industrial Scientific Medical) band is presented. It has been shown that the designed circular microstrip patch antenna produces a bandwidth of approximately 1.1% with a stable radiation pattern within the frequency range. The proposed antenna has good return loss performance and efficiency over the frequency range. Gain of the antenna is ~4.493dB. The bandwidth of the antenna can further be improved by optimizing the parameters of the antenna. The simple lumped feeding technique has been used for the micro strip patch antenna design which makes this antenna as a good choice in many communication systems.

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