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An Inter Looping Wearable Defected Ground Antenna for UWB Biomedical Application

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Abstract: Based on an inter looping array approach with a CSRR design and frequency selective surface, a wearable fabric antenna for UWB applications at 4.2 GHz is shown. The fundamental antenna emits radiation with a circular polarisation, but when used with EBG-DGS, performance and efficiency suffer. Additionally, some harmonic distortion occurs when the antenna is used in close proximity to human tissue, and there is a high specific absorption rate. The antenna uses CSRR with quarter wave transmission to get around this issue, which minimises harmonic distortion, back radiation, and SAR by 100%. Comparing the advanced antenna to the standard antenna, the gain is increased by 5dB, and the radiation efficiency is increased by 83.87 percent. The integrated design has a 1.6 centimetre overall size. The antenna will include materials that human tissue can tolerate, such as cotton and CSRR. Therefore, a well-designed antenna works well for both on- and off-body transmission. We'll build and measure a prototype of the suggested antenna geometry. The findings of the simulation and the measurements have been found to be in excellent agreement.

Keywords— CSRR, SAR, EBG-DGS, UWB, wearable fabric antenna ,Quarter wave transmission.

1. Introduction

Biomedical engineering is one of the technological sectors that is expanding the quickest, with recent successes and even more ambitious goals. In this regard, UWB-supporting healthcare apps may provide significant improvements to patient healthcare, including monitoring of treatments and/or diagnostics. UWB technology has quickly made progress in patient monitoring and medical rehabilitation [1] through [4]. The most important factor in a UWB with a few metre ranges is the design of a particular radiator. For data transfer, attributes including radiation effectiveness, bandwidth, coupling with lossy biological tissues, and use of available space are crucial. Medical professionals must monitor several patients at once when employing UWB, and patients may be watched comfortably from home while going about their everyday lives[20]. The biomedical antennas are used to wirelessly transmit diagnostic data from an electronic device, such as a pacemaker, implanted in or applied to the human body for the purpose of human care and safety. In order to create a bio-communication system between medical equipment and outside instruments for short range biotelemetry applications, antennas may either be implanted into human bodies or simply put over the torso (skin-fat-muscle). Economic considerations are important in addition to the obvious advantages that body implanted technologies provide the healthcare system. Systems for remote monitoring make illness diagnosis easier and benefit the home hospital by shortening hospital stays[6]–[10].

2. ANTENNA DESIGN

The substrate for the antenna is made of fabric cotton and has a permittivity of 1.7 and a thickness of 0.2 mm. Due of its flexibility and low weight, this cloth was chosen. [10]-[12] The software utilised and the design are also included in the design specification, which is made up of the numerous specifications needed to create the proposed antenna.

With the above-mentioned dimensions and the microstrip line feed technology, a triangular-shaped microstrip patch antenna was built [7-8]. High Frequency Structure Simulator (HFSS) software is used to model the arrangement. The inter looping array structure patch antenna schematic is shown below.

Fig. 1. *Ground structure – CSRR*

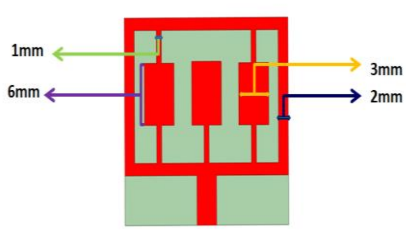

Fig 2 *Schematic of inter looping array structure patch with edge feeding*

3. SIMULATION AND RESULTS

The microstrip patch antenna used in the simulation and result operates at a frequency of 4.25 GHz for UWB applications. Each criteria for the design is shown separately, and the results are provided.

A. Rate versus Return Loss

Return loss in communications refers to the loss of power in the signal that is reflected or returned by a break in an optical fibre or transmission line. This break may be caused by a mismatch with the ending load or a device that has been added to the line. Decibels (dB) are often used to represent it[15]. The return loss of the intended antenna is shown in the image below.

$$\text{Returnloss, RL} = -20 \log_{10} |1/\Gamma|$$

$$\text{Returnloss, RL} = -23.8232$$

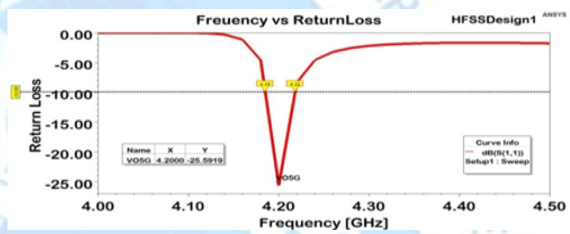

Fig 3. *Return loss of the designed antenna*

B. VSWR

The frequency range over which a microstrip patch antenna is within predetermined bounds matched with the feed line is known as its VSWR or impedance bandwidth. The graph showing the planned antenna's VSWR is shown in figure 5.2.

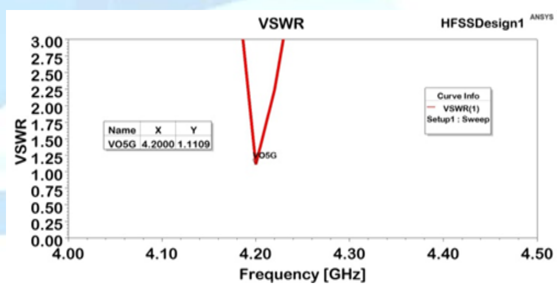

Fig 4. *VSWR of the designed antenna*

VSWR = 1.377 ≈ 1

$$\Gamma = \frac{\text{VSWR}-1}{\text{VSWR}+1}$$

Where Γ = Reflection Coefficient

C. GAIN

Antenna gain is the ability of the antenna to radiate more or less in any direction compared to a theoretical

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antenna. If an antenna could be made as a perfect sphere, it would radiate equally in all directions[17]. The designed antenna will give the gain value of 5 dB in standby the running position.

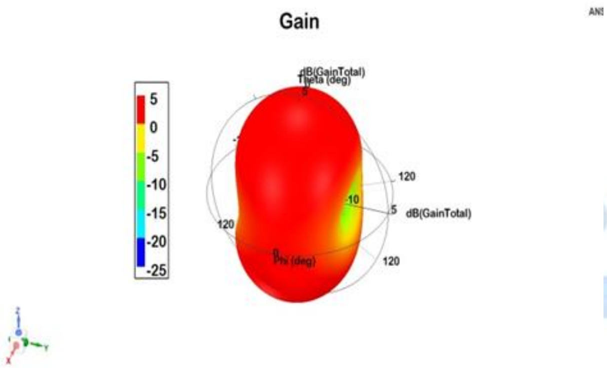

FIG 5. *GAIN OF THE DESIGNED ANTENNA*

D. DIRECTIVITY

Directivity of an antenna is defined as the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The designed antenna stable position and the provide the maximized directivity [19]-[20]. Fig 8. Accepted power of the designed antenna.

E. ACCEPTED POWER

The ability of an antenna to accept power from a source (such as an amplifier) is determined by the input. impedance the antenna presents. For maximum power transfer, the input impedance should exactly match the output impedance of the source.

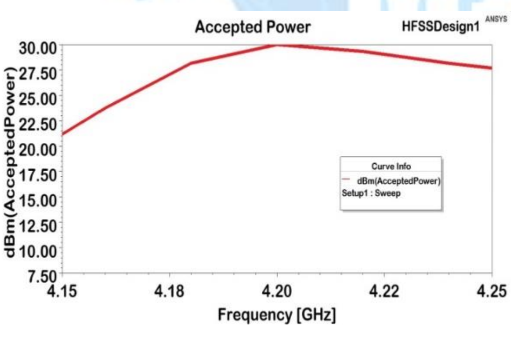

Fig 7. *Accepted power of the designed antenna*

F.RADIATED POWER

Radiated Power (RP) is a measure of how much power is radiated by an antenna when the antenna is connected to an actual radio (or transmitter). RP is an active measurement, in that a powered transmitter is used to transmit through the antenna.

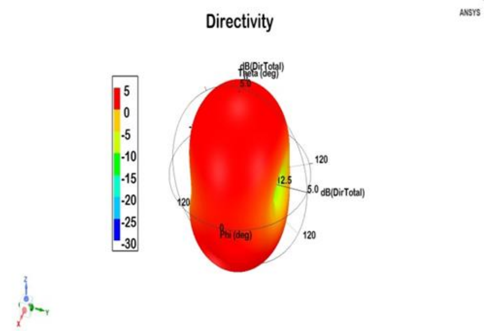

Fig 6. *Directivity of the designed antenna*

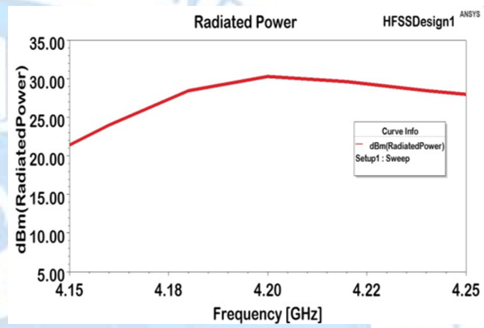

Fig 8. *Accepted power of the designed antenna.*

G. POLARIZATION

The polarization of an antenna is loosely defined as the direction of the electromagnetic fields produced by the antenna as energy radiates away from it. These directional fields determine the direction in which the energy moves away from or is received by an antenna [18].

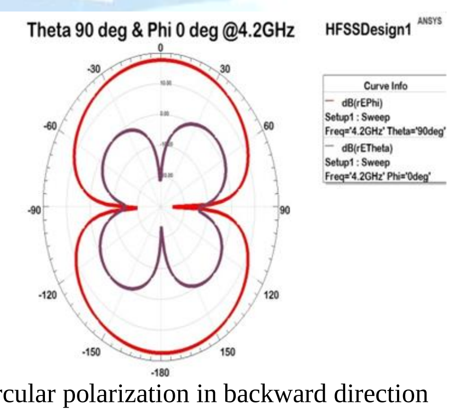

Fig 9. Circular polarization in backward direction

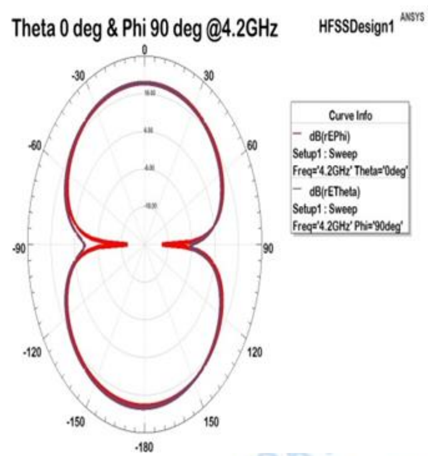

Fig10. *Circular polarization in forward direction*

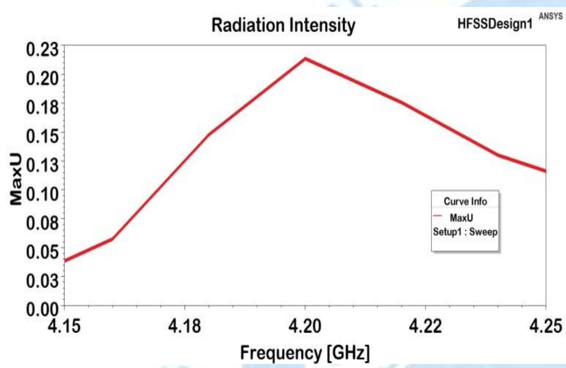

Fig 11. *Radiation intensity of the antenna*

SAR (Surface Absorption Radiation)

H. RADIATION EFFICIENC

The radiation efficiency of an antenna is defined as the ratio of the outward radiated power by the antenna to the input power fed to the excitation port of the antenna represents the radiation efficiency of the proposed microstrip patch antenna.

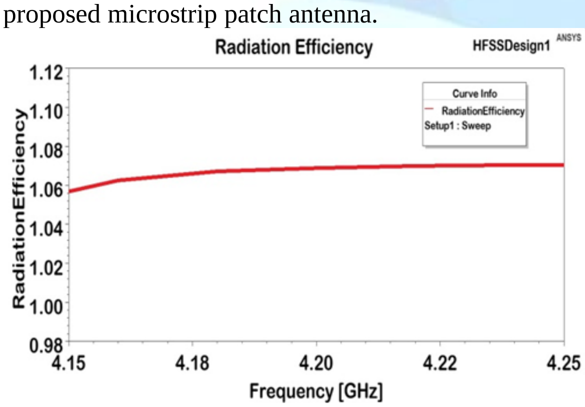

Fig12. *Radiation Efficiency of the antenna*

I.RADIATION INTENSITY

Radiation intensity, or the antenna power pattern, in a given direction is defined as the power radiated from an antenna per unit solid angle. Radiation intensity can be plotted for different directions from the antenna and this gives rise to what is known as a radiation pattern

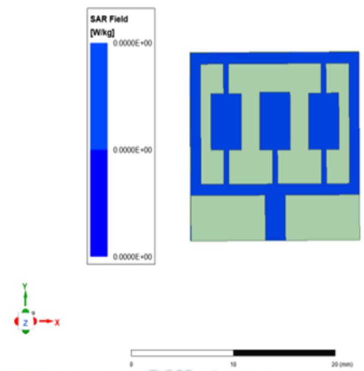

Fig13. *Surface absorption radiation*

4. CONCLUSION

In this research, a small wearable antenna with low harmonic distortion is shown for both on-body and off-body UWB applications at 4.2 GHz. The antenna is created utilising a frequency-selective surface, CSRR design, and inter looping array technology. This antenna is made from a fabric that may be included into our everyday clothing. The results demonstrate how the antenna uses CSRR with quarter wave transmission to reduce harmonic distortion. In addition, the findings show that the antenna has a 5 dBi gain improvement and a 95+% SAR reduction over the antenna alone. To increase the VSWR, return loss, efficiency, and other antenna properties, an antenna is utilized. The described antenna is ideal for wearable UWB applications since it is constructed in a small (1.6 cm) package.

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