Design and optimamization of circular slotted patch antenna

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Abstract - The rise in utilization of Wearable devices in communication applications has been on the rise due to the recent miniaturization of wireless devices! A Wearable antenna is meant to be part of transceiver used for communication purposes. In this project, the design of a slotted circular patch antenna is optimized using optimizers. WBANs got significant attention for various healthcare and biomedical applications due to their potential to monitor physiological parameters remotely. Circular slotted patch antennas represent a promising choice for WBANs due to their compactness, low profile, and ability to operate at desired frequencies. Main aim of paper is on the content optimization of circular slotted patch antennas for WBAN applications. The optimization process involves fine-tuning the geometrical parameters of the circular slotted patch antenna to achieve enhanced performance metrics such as bandwidth, efficiency, and radiation characteristics. Moreover, the content optimization also considers the material properties and fabrication techniques to ensure practical feasibility and cost-effectiveness of the antenna design. The antenna parameters also depended on the substrate.

Index Terms - *Wearable antenna, WBAN, patch antenna, slotted circular patch.*

I. INTRODUCTION

1.1. Patch Antenna

It is made up of a planar metal sheet or "fix" that can be any shape or size, set on top of a larger metal sheet known as a ground plane. Together, the two metal sheets form a thundering Line of transmission microstrip that is about half the wavelength of the radio waves in length. Along the emanating edges, the radiation instrument arises from adjacent areas. A microstrip transmission line's length that is marginally shorter than the half of wavelength at the point recurrence is used to arrange for the radio wire to be audible because the radiation on boundaries leads the wire to act considerably more prominently electrically as opposed to materially measurements! They have been broadly connected in numerous segments due to their preferences of being light weight, little measure, moo profile, moo fetched, having great mechanical quality, a wide recurrence band, tall effectiveness, tall pick up, tall versatility to environment, small radiation harm to the human body, and wide recurrence scope.

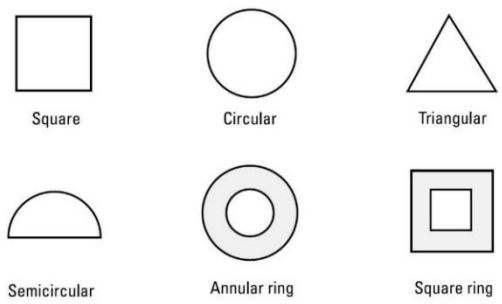


Fig 1. Types of patches

1.2. Wearable Antenna

Wearable antennas, which play a crucial role in encouraging among gadgets in applications such as wellness following and healthcare observing, are imperative parts of wearable innovation. They are outstandingly characterized by being compact, lightweight, and consistently joined into clothing or different extras. In addition, these receiving wires require materials like adaptable substrates and conductive materials to guarantee solidness

and execution in the mid of body developments. The receiving wires ought to have productive radiation characteristics whereas at the same time minimizing any potential obstructions with the human body.

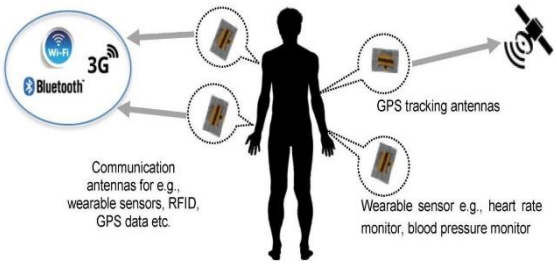


Fig 2. Wearable antenna in WBAN applications

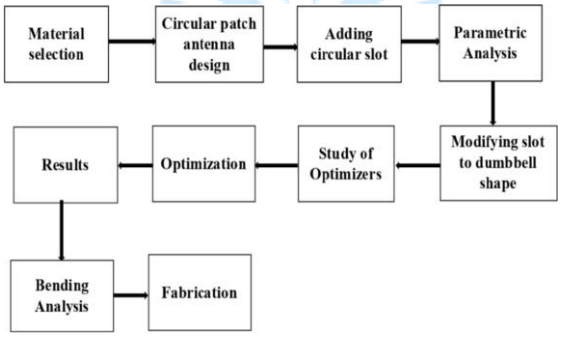
sThis paper's contributions are:

Health care can make advantage of wearable antennas. It has military navigation applications. Posit ion shadowing is another application for it. IoT activities can make use of wearable antennas.

II. LITERATURE SURVEY

Different studies have investigated distinctive optimization methods and plan strategies to improve the execution of these antennas whereas meeting the requirements of WBANs. One common approach within the writing includes utilizing developmental calculations! These optimization calculations effectively investigate the plan space and discover ideal arrangements in terms of transmission capacity, proficiency, and radiation characteristics. For occurrence, in a consider by Smith et al. (2019), GA was being utilized to optimize the measurements of a circular opened fix antenna for WBAN applications. The optimized radio wire plan accomplished a more extensive transmission capacity and progressed radiation productivity compared to ordinary plans, making it appropriate for dependable communication in WBANs. Moreover, analysts have moreover explored the effect of distinctive opening arrangements and courses of action on the antenna's execution. By deliberately putting spaces on the circular patch, it is conceivable to attain upgraded radiation characteristics and diminish common coupling between antennas in WBANs as illustrated by Li al et. (2020)

III. PROPOSAL FOR IMPLEMENTATION



The instructions are followed to achieve the final optimized antenna. Using the CST tool, a basic circular patch antenna was first created. The circular patch was then given a slot to enable the antenna to function at the necessary frequencies.

3.1. Substrate of the antenna

A common substrate in antenna construction, FR-4 provides affordable and adaptable alternatives for a range of uses!!! For antennas that exposed to environmental challenges, FR-4, which made of woven fiberglass cloth impregnated with epoxy resin, offers exceptional mechanical strength and dimensional stability. Its dielectric characteristics, which include a loss tangent and moderate permittivity, help minimize signal attenuation and promote effective signal transmission. Furthermore, FR-4 substrates are simple and easy to work with and widely accessible!!! providing highly efficient manufacturing procedures!!! Although they are widely used, optimization approaches are using frequently to adjust antenna performance on FR-4 substrates, considering variables such substrate thickness, conductor width, and fluctuation in dielectric constant. All things considered; FR-4 substrates

are essential to the creation of high-performance antennas because they provide a compromise between affordability.

3.2. Patch Antenna

Determining the size of the circular patch comes next after choosing the material for the substrate. The main factors affecting the antenna's resonant frequency are the diameter of the patch and the thickness of the substrate. It is essential to identify the feed location and the impedance matching network as the final critical step. The impedance matching network ensures that the antenna and feed line are correctly matched to optimize power transfer and reduce reflections. The feed location is where the coaxial cable connects to the patch. In summary, successfully designing a high-performance antenna system relies on understanding these key phases.

The design equations for circular patch antenna are given as

Circular patch radius is given as

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi\varepsilon_r}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}}}$$

Where

$$F = \frac{9.791 \times 10^9}{f_r\sqrt{\varepsilon_r}}$$

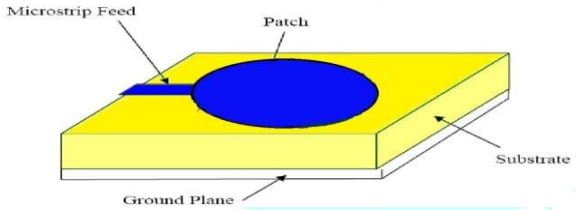


Fig.**3. Patch antenna**

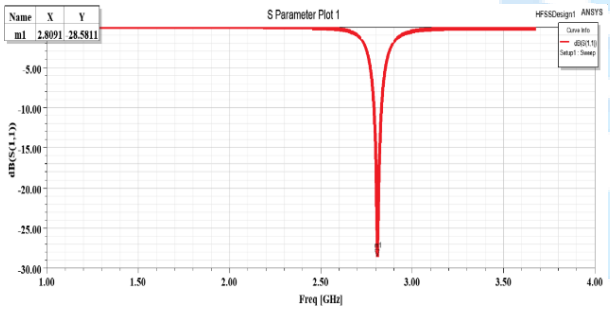


Fig. 4. S11 plot for patch antenna

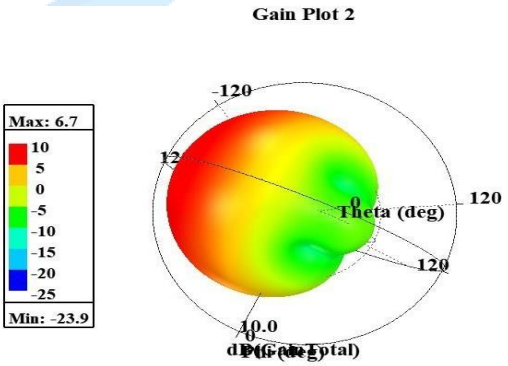


Fig. 5. 3D Polar Plot of patch antenna

3.2. Patch Antenna with Circular slot

In this a slot was added to previous patch antenna and parametric analysis has done to find how S11 and frequency are varied with size of slot and patch. A slot in a patch antenna refers to an aperture or gap in the metallic patch that is used to enhance the antenna's performance. A slot can be used to modify the radiation pattern of a patch antenna. By adjustingthe size, shape, and position of the slot, the antenna can be made to radiate in specific directionsor patterns.

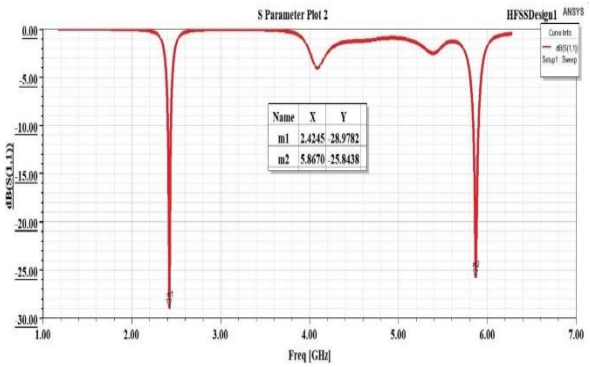


Fig.6. S11 of patch antenna with circular slot

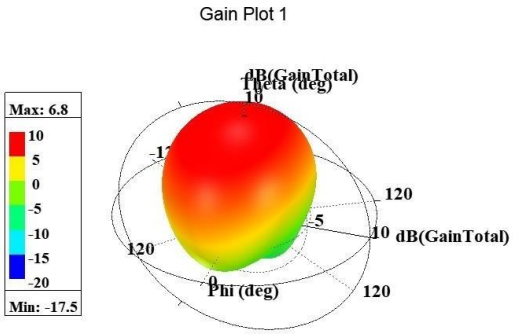
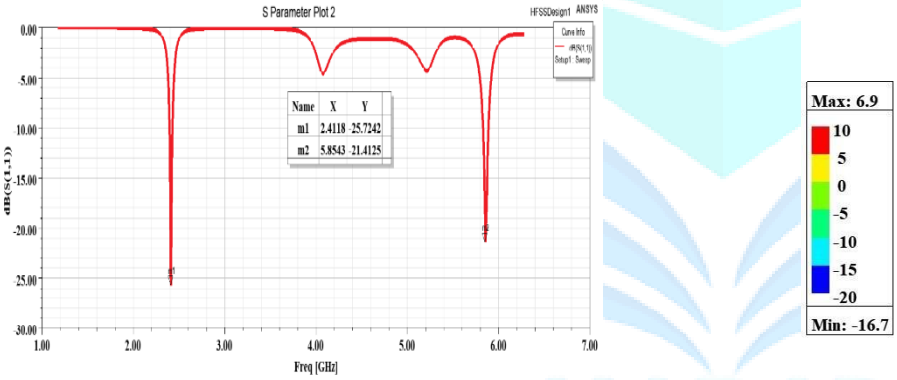


Fig.7. Gain of patch antenna with circular slot

3.3. Patch Antenna with dumbbell shaped slot

After putting the slot a parametric analysis was carried out to study about how the antenna parameters vary with respect to size of patch and slot. The results obtained after the parametric analysis are shown below. After parametric analysis good S11 values were observed when size of patch and slot are 22.8mm and 4.6mm respectively. Hence these resultant dimensions of patch and slot were considered and the remaining process was carried out. It is observed that by increasing the patch the frequency shifts towards left and when patch is decreased the frequency shifts towards right. In the next step two small pieces of patch are added near the slot and the shape of slot is changed to dumbbell shape as shown below.



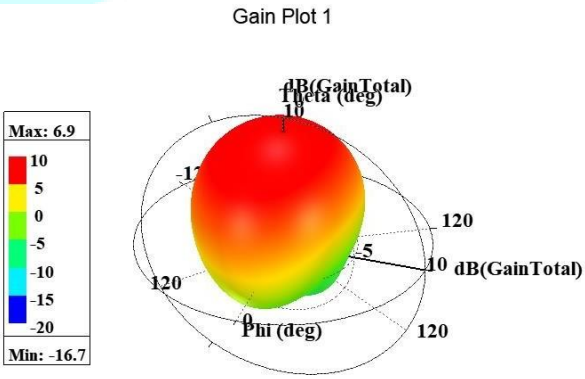
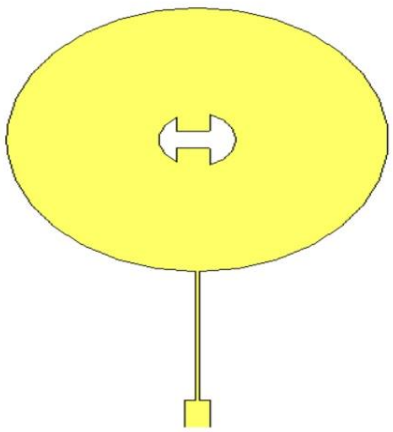


Fig.8. S11 plot of Dumbbell shaped slot patch antenna

Fig.9. Gain plot of Dumbbell shaped slot patch antenna

3.4. Final proposed design



IV.CONCLUSION

This paper discusses about the design and optimization of circular slotted patch antennas represent addition of circular slot to patch antenna and then it converted into dumbbell shaped slot due to change in frequency. It significant advancement in antenna technology, offering enhanced performance, versatility, and cost-effectiveness across various applications in communication systems. These antennas also demonstrate versatility in various applications, ranging from satellite communication to IoT devices. Additionally, their compact size and low profile make them suitable for integration into modern electronic devices. Continued research in this area holds the potential to further refine their design, optimize performance, and broaden their applicability in emerging communication technologies.

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