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DESIGN AND SIMULATION OF WEARABLE ANTENNA

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Abstract: Due to the current miniaturization of wireless devices, the use of wearable textile materials as antenna substrates has been an attractive area of research. A crucial ally for remote health monitoring is wireless technology. A wearable antenna is a piece of clothing that is used for tracking and navigation, mobile and wearable computing, and public safety wireless communication applications. It can also be utilized to keep an eye on the healthcare system. The introduction of high-speed smartwatches with integrated Bluetooth antennas, smart glasses with integrated Wi-Fi, GPS, and IR antennas, body-worn action cameras with Bluetooth and Wi-Fi connectivity, and tiny sensor devices in sports shoes with Bluetooth and Wi-Fi connectivity are some of the key developments that have accelerated its growth.

I. INTRODUCTION

Wearable textile-based antennas are one of the captivating areas of research in antennas for body-centric communication. Commonly, wearable antenna requires lightweight, low-cost, almost maintenance-free, and easy installation. Several specialized field segments can use body-centric communication systems, such as medical, firefighters, and military. Besides, wearable antennas also can be applied for patient monitoring, astronauts, and athletes to monitor their heart rate and body temperature. For integration into clothing, antennas are usually required to be small, lightweight, and flexible. They should have stability and exhibit safe person health when placed close to the body. There are several candidate antenna types suitable for wearable antennas, which are PIFAs, microstrip antennas, and planar monopoles. Due to the affordable price and simplicity of manufacturing, microstrip antennas are often utilized, but they may have limited bandwidth and be sensitive to body perturbations. The low dielectric constant of textile materials reduces surface wave losses and enhances impedance bandwidth. Smartwatches with integrated Bluetooth antennas, smart glasses with embedded Wi-Fi, GPS, and IR antennas, body-worn action cameras with built-in Bluetooth and Wi-Fi, and tiny sensor devices in sports shoes with built-in Bluetooth and Wi-Fi that can connect to smartphones are a few examples of consumer-oriented wearable technology that uses wearable antennas.

II. METHODOLOGY

i) Designation of Microstrip patch Antenna:

A patch antenna is an exclusive type of antenna that comprises a ground plane on one side of a dielectric substrate and a radiating patch on the other. The patch can be constructed of any type of conducting material, including copper, silver, or precious metals, and tends to come in the shapes of a square, rectangle, or circle. On the dielectric substrate, the radiating patch and feedlines are usually photoetched.

- Steps in Designing a Patch Antenna:

The following are the steps involved in designing a patch antenna:

1. Determine the desired frequency: The patch antenna size depends on the desired operation frequency.
2. Determine the substrate's material and height: The substrate's loss tangent and dielectric constant will impact the antenna's efficiency. Additionally, the size of the antenna relies on the substrate's conductivity.
3. Compute the patch's dimensions: The antenna's resonance frequency and pattern of radiation will be impacted by the patch's height, width, length, and thickness.
4. Choose the feeding strategy and its position: The feed line can be placed anywhere along the patch, including the patch's center and boundary. The antenna's impedance and radiating pattern will optimize according to the location of the feedline.

ii)Designing a Rectangular Patch Antenna at 2.45 GHz:

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A rectangular patch antenna can be designed to operate at 2.45 GHz, which is a license-free frequency that is used for a variety of applications, such as wireless networking and Bluetooth.

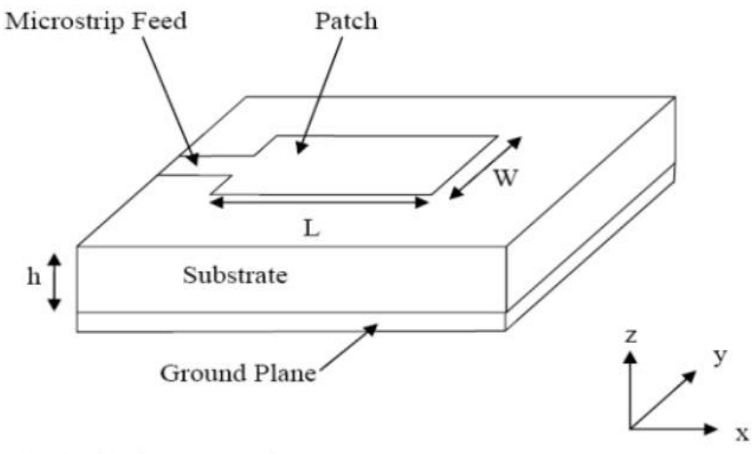

Fig. 1 Block Diagram of Microstrip Patch antenna

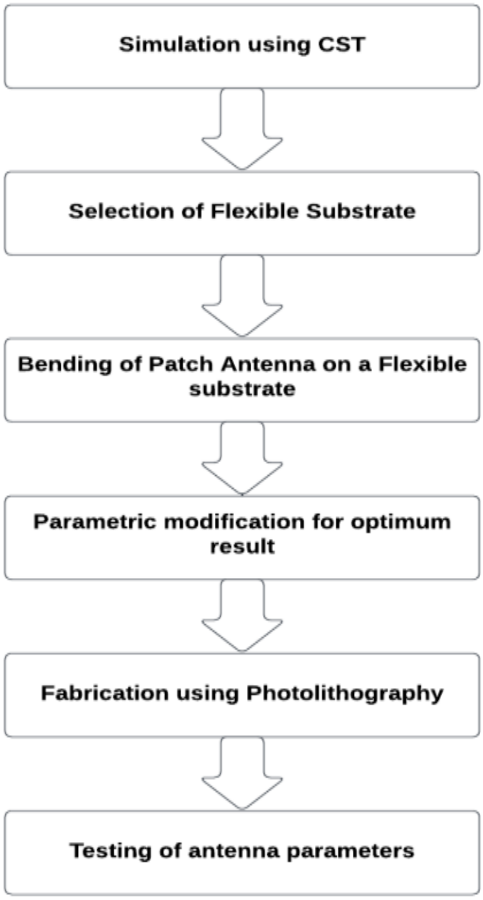

Fig. 2 Process of designing and integration of patch substrate

Software Used:

CST Studio suite

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III. LITERATURE SURVEY

- The publication [1] discusses how wearable textile materials might be used as antenna substrates for tracking, navigation, mobile and wearable computing, and public safety applications. Because they can be constructed using fabric substrate materials that possess a dielectric constant that is relatively low and can increase antenna bandwidth, flexible textile antennas, in particular microstrip patch antennas, are suitable candidates for body-worn applications. Also, HFSS simulation studies on wearable patch antennas were designed and developed for a range of 2.45 GHz. Preliminary results show that flexible, simple, and has a return loss of -32.57 dB at an effective frequency of 2.45 GHz and with an average gain of 7.2 cloth antenna designs.

- The paper [2] examines how the demand for wearable communication tools has increased as a result of the creation of intelligent textile systems that enhance wearer protection. Textile antennas have been produced, but due to the majority of fabrics being fragile, it is challenging for antenna designers to deliver adequate and resilient functioning in the 2.4-2.4835 GHz, industrial-scientific medical bandwidth. Flexible pad foam has been acknowledged as a suitable backing material for antennas in protective clothes due to its homogeneity, stability, thickness, and other features including flame retardancy and water repellency. In this work, the design, fabrication, and performance of the first textile planar antenna constructed on flexible protective foam suitable for firefighter apparel are detailed. The antenna manages to achieve a nearly circular shape even when twisted or compressed.

- The paper [3], a novel method for figuring out the dielectric constant of fabric materials used to make wearable antennas is described. The method is based on the resonance method and uses a microstrip patch as a radiator to precisely calculate the dielectric constant value from the resonant frequency. Six materials linked to fabrics have their dielectric constant values found using this method. Investigated is the operation of wearable antennas in the Bluetooth industrial, scientific, and medical bands. In this study, the performance characteristics of three fabric antennas—including impedance bandwidth, gain, and efficiency were constructed and tested.

- The paper [4] discusses the design and fabrication of a thin wearable antenna using metamaterial (MM) for wireless body area networks (WBAN) applications. The antenna is the most delicate UWB antenna with MM documented in the published material, evaluating just 4.68 mm in thickness. It functions in the (UWB) range of 4.55 to 13 GHz. The antenna was built from fully flexible materials and tested in space after being modeled after a human body. According to simulation results, the position of the MM improved gain, organization, and front-to-back ratio while 98.3% reducing SAR values. Due to its low width, SAR, and ultra-wideband operation, the antenna is thought to be appropriate for WBAN applications.

- In paper [5], a layered human body model is used to provide the efficiency analysis of an Ultra- Wideband (UWB) fabric antenna for Wireless Body Area Network (WBAN) applications. The antenna is attached to a human body model made of skin, fat, and muscle. The antenna is made of Dacron fabric and has a bandwidth of 11.4 GHz (2.4–14 GHz). The proposed antenna presents a challenge for UWB applications on the human body due to its favorable return loss, VSWR, and SAR (specific absorption rate) characteristics, according to the results. The results of the simulation and the antenna's specs are shown using CST Microwave Studio.

- The review paper [6] discussed how wearable fabrics are increasingly being used in antenna technology for tracking and navigation, mobile computing, and public safety. The review emphasizes the necessity for additional factors, such as material selection and analysis for specific absorption rates (SAR), to be taken into account when building wearable antennas. Concluding, wearable antennas are a promising technology with significant potential for the development of wireless communication.

- In the publication [7], a unique wearable dipole antenna with a 325 MHz resonance frequency is presented. Its substrate is a textile fabric. 3D electromagnetic models and measurements are used to confirm the design. The results demonstrate S11 18 dB, a gain of 1.5 dB, 49% efficiency, and a 20 MHz bandwidth at a resonance frequency. The impact of bending on the performance of the antenna is also investigated, indicating that when the radius of bending is adjusted from 32.5 to 3 cm, the resonance frequency shifts by 10 MHz with a sensitivity of 0.285 MHz/cm.

- The paper [8] briefs about the design and application of a compact, programmable rectangular notch WLAN. The antenna's UWB characteristics are provided by truncating the lower ends of the rectangular microstrip patch, and its notch features are provided by electromagnetic bandgap (EBG) structures. The EBG factors can be changed to alter the wireless local area network band's notch, which provides good selectivity. The recommended antenna has an overall portable size of 16 25 1.52 mm3 and covers the spectrum of UWB from 3.1 to 12.5GHz. The conclusions of the modeling and the measurements show good agreement.

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● The paper [9] examines the numerous wearable antenna designs and their uses in a variety of fields, including the Internet of Things, wearable electronics, medical applications, UWB, telecommunications, and in the field of defence. Wearable antennas are designed using a variety of textile materials, including cotton, foam, polyester, nylon, silk, and Kevlar fabric. Bandwidth, return loss, bending performance, radiation characteristics, and gain are among the performance factors to be taken into consideration when building antennas. Textile antennas, which are lightweight, comfortable to wear, and easily incorporated into garments, have become a crucial component of modern wireless communication.

● In the paper [10], a belt antenna with an EBG ground plane made of textile. To provide a communication channel with other electronic devices, and sensors for monitoring people's movements, an antenna is fabricated in a smart belt system. For BLE communications, it uses the ISM band at 2.45 GHz. Through the integration of the ground plane, the antenna achieves an ideal realized gain of 7.94 dBi and a minimum SAR of 0.04 W/kg at 0.5 W input power. In order to investigate the fundamental idea and enhance the functionality of the antenna, characteristic mode analysis (CMA) was used in the design process.

IV. SUMMARY

The papers reviewed address a range of wearable antenna design and application topics. They look at various substrates, antenna kinds, and wearable device applications. The research focuses on improving antenna performance, addressing complications with on-body communication, and taking into factors like SAR, fabric material dielectric characteristics, and integration into clothes and safety gear.

The results of this study emphasize the significance of creating flexible, low-profile antennas that can provide dependable wireless communication in difficult circumstances. The articles provide information and suggestions for better wireless connectivity in wearable applications, which advances the field of wearable antenna technology.

V. CONCLUSION

Overall, the papers provide a comprehensive description of the design and implementation of the wearable patch antenna. They have shown creative methods for circumventing the difficulties of embedding antennas into clothing and accessories, enabling wearable electronics to communicate and sense without interruption.

These developments have opened the door for the creation of wearable technology that is more efficient and user-friendly.

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