Wearable Dual Polarized Patch Antenna For WBAN Application

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Abstract- *The fifth generation (5G) multiple-input multiple-output (MIMO) patch antenna made of micro strip is presented in this study as a small, self-complementary design with four ports. The square patch antenna (1010 mm2), which has circular slots and a defective ground structure, operates in the 2.4 GHz range and offers good isolation. In the areas of gain, returning grief, radiation effectiveness, radiation patterning, envelope correlation coefficient (ECC), as well as total active reflecting coefficient (TARC), simulated outcomes for MIMO patch antenna have been examined by HFSS.Due to its simplicity and ease of analysis, a Substrate Integrating Waveguide (SIW) a band pass filter is created using 3D tool software. It is intended to acquire the necessary parameter values from 1.5 GHz through 7.5 GHz. The FR-4 board is utilised with the supplied data, including the substrate's dielectric constant (4.7), the resonant frequency (2.4 GHz), and the height of the substrate (1.6 mm). A periodical metalized via array or slots trench can be used to create a guided-wave structure, which resembles two parallel fences with well-contained EM waves between them.According to a simulation, the filter is intended to transmit data between the specified cut-off frequencies of 1GHz and 6GHz, with a resonant frequency of 2.4GHz. Thus, the suggested filter broadcasts all frequencies above 10 dB, demonstrating its suitability for use in numerous applications such as WLAN, GPS, and radar.*

Keywords- Antenna Design, Micro strip Patch Antenna, Wearable Dual Polarized Patch Antenna, HFSS Software, Fifth Generation, Multiple Input and Multiple Output.

I. INTRODUCTION

Wearable antennas are being used in various body part scenarios, which include around the wrist, on the trunk, and over the head. Wireless Body-Area Networks (WBAN) has attracted a lot of interest in the research community. The Internet of Things (IoT) is becoming more and more prevalent in our daily lives. Researchers have made use of highly adaptable and conductive materials to construct antennas that may be discretely incorporated into everyday clothing in order to achieve ease of use for wearable systems.For wearable applications, the resultant textile antennas often have great mechanical flexibility as well as electrical performance. As an alternative, making antennas out of cloth fasteners like zippers and buttons can help lessen how noticeable the antennas are. The so-called click antennas are objects that can be worn like buttons and act as wireless communication antennas at the same time. As was initially suggested in ground-breaking papers, the construction of the most common button antennas is similar to that of top-hat monopoles [1].

The wearable antennas that operate in multiband with polarisation diversity can achieve several purposes in a single device, such as on- and off-body communications. They are therefore highly welcome in wirelessly body-based network (WBAN) networks due to their benefits of cost effectiveness and space savings.For the wearable antennas in WBAN, there are two methods of wireless data transfer. One is an antenna that has an omnidirectional radiation pattern for on-body propagation links, which can maximise path gain and reduce undesired radiation. Another method is off-body propagation using an antenna having unidirectional radiation which enables the transmission of physiological data to external networks for diagnostic and therapeutic purposes [2].The WBAN (Wireless Body Area Network) has drawn interest from a variety of sectors, including the military, sports, security, and healthcare. The three types of WBAN communication modes—on, off, and in-body modes—are separated based on where the signal nodes are located. The following requirements for WBAN devices must be met: cheap cost, low power consumption, increased bit rate, and the ability to accommodate modifications to the human body.For medicinal implant communications networks, the frequency range designated to WBAN is 400 MHz; for commercial, scientific, as well as medical (ISM) applications, it is 2.4 GHz and 5.8 GHz; and for ultra-wideband services (UWB), it is 3 GHz to 10 GHz. Since the human body actively employs these antennas, researchers have become interested in antennas for WBAN applications. Due to the loss and inconsistent connection of the physical body, antenna efficiency may be affected in comparison to antennas positioned in free space. [3]

Due to the variety of applications it can be used for, such as polarisation reorganisation, noise reduction between communication channels, and antenna integration, the dual-polarized dual-band (DPDB) antenna is desired. Dual-band antenna as well as dual-polarized antenna designs is a broad topic. [4]. The Equivalent Isotropic Radiated Power (EIRP) value for uncontrolled wireless communications over the Ultra-wideband (UWB) range of 3.1 to 10.6 GHz, with an EIRP level of 41.25 dB/MHz, was regularised by the Federal Communications Commission, or FCC, in February 2002. Unlike the frequently used limited-band radio systems that employ continuous waves, this vast bandwidth can be used to send quick pulses. The UWB systems are appropriate for moderate-range the wireless broadband wearable body area network (WBAN) networks, including military, medical, and entertainment applications due to the supported high rate of data and the low power consumption. [5]

The remaining sections of the essay provide details on the following chapters: Chapter I, Introduction; Chapter II, Literature Review; Chapter III, Proposed Methodology; Chapter IV, Results and Discussion; and Chapter V, Conclusion.

II. REVIEW OF LITERATURE

Li, H et al., (2022). "All-textile multiband circular patch antenna with a low profile for WBAN applications". wireless connectivity body-area networking (WBAN) applications call for a small, concealed all-textile multiband antenna that can operate across the 2.45/5.8 GHz ISM bands and mobile Wifi IEEE 802.16 2005 (3.3-3.4 GHz), as well as 5G sub-6 NR frequency range n77 (3.85-4.0 GHz). The three modes are tuned to the appropriate operating frequency using an elliptical slot as well as a C-shaped slot. To lessen unwelcome downturn in the 5.8-gigahertz radiation pattern, a rectangular hole is used. The suggested antenna is exceptionally low-profile and ideal for wearable applications because it is made from a conducting fabric layer incorporated onto just one layer of denim. Its overall dimensions are 60 x 60 x 1.17 mm (0.64 g at 2.45 GHz, 0.64 g, 0.0125 g).According to test data, the antenna's reflection coefficient barely affects performance when mounted to and curved around a model of a human arm.

Yang, H et al., (2021). "Design of a conformal array of a broadband circularly polarised all-textile antenna for wearable technology". We examine a wearable conforming antenna array (WCAA) and a broadband circularly polarised (BCP) all-textile antenna for body-centric communications. To begin with, a modified met surface loaded onto a circularly polarised (CP) micro strip antenna patch is intended to produce broad impedance as well as axial ratios (AR) bandwidths. The operating mechanism is understood through the use of characteristic mode analysis, which offers a physical understanding of each mode at multiple frequencies. For off-body communications, an antenna featuring broadside radiation is appropriate. The prototype operating in the 5 GHz (5.15–5.825 GHz) range was made for verification. With a maximum gain of 8.5 dBi, the measured 10 dB resistance as well as three dB AR the bandwidths values 35.1% and 17.5% are attained.

Chen, Y et al., (2022). "Wideband circularly polarised array antenna that can be worn for off-body use". We describe and study a wideband circularly polarised (CP) wearing antenna for 5 GHz wireless body area networks. The resonance can be employed to create unidirectional radiation without improved CP bandwidth since the suggested antenna is supplied by a sequential-phase feed network. A redesigned strip feedline with two pairs from arc-shaped holes carved on the bottom surface is added to lessen the impacts of human loading. Additionally, the flexibility and conformability offered by textiles as a substrate and conductor enable the integration of the antenna with clothing. The prototype was created with the following measurements: 40 mm 40 mm 4 mm (0.73 0 0.73 0 0.07 0). Additionally, it has been demonstrated that the efficiency of the antenna is stable during structure deformation including human body stress.

III. PROPOSED METHODOLOGY

Millimetre wave (mm Wave) frequency bands are being taken into consideration in fifth-generation (5G) communications networks to satisfy the demands for high data rates. A single antennae component isn't going to be able to counter the attenuation at mm Wave because of the substantial path loss and air absorption. The numerous-Input Multiple-Output (MIMO) approach will be employed, in which numerous antenna elements are installed at the wireless system's transmitting and receiving ends. utilising multi-path increases range and dependability without utilising additional capacity at high data rates. As a result, the spectral efficiency is enhanced, and the data rate is raised. The enormous bandwidth, high gain needed to offset atmospheric absorption at the mm Wave band, as well as the tiny dimensions of the structure present numerous design issues for MIMO antennas. A mutually beneficial relationship between the parts of the antenna is another performance-harming element which has to be kept to a minimum.The suggested antenna configuration comprises of five layers of angular slots that are fed using SIW and four funnel-shaped slots. Because SIW is simple to integrate and the antenna may be completely separated from other circuitry on the same substrate, SIW has been selected as the transmission line. Equations for TE10 pattern stimulation at 2.45 GHz are used to determine the SIW's size.

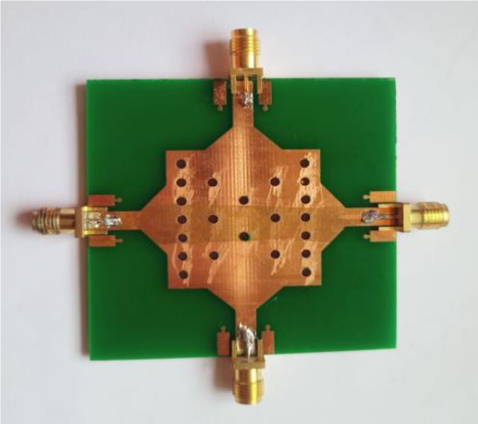


Figure 1 Proposed Method

SIW Design Equations:

The dimension "b" is not significant in SIW filters for TE10 modes because it has no impact on the waveguide's cut-off frequency. As a result, the substrate's thickness has no bearing on anything other than the loss of dielectric (thicker = less loss).

Application: ADS2009

Platform: FR4

Dielectric strength: 2.4 GHz is the operating frequency

Impedance:50 input impedance

Thickness: 1.58 mm.

The following formula determines the cut-off frequency of an arbitrary mode for a rectangular waveguide:

$$f_c = \frac{c}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

Where:

C - The speed of light
M, n - the mode numbers
A, b - the waveguide's dimensions
We are able to submit the layout equations for SIW after determining the dimension "a" for the DFW.

$$a_s = a_d - \frac{d^2}{0.95p}$$

For TE_{10} mode, the much-simplified version of this is:

$$f_c = \frac{c}{2a}$$

The following mathematical formula can be used to determine the effective width and length.

$$W_{eff} = W_{SIW} - \frac{D^2}{0.95\ p}$$

$$L_{eff} = L_{SIW} - \frac{D^2}{0.95\ p}$$

S. No	Parameter	Values
1	Distance between the parallel via-holes(a_s)	5.6mm
2	Breath of the waveguide (a_d)	4.1965mm
3	Width of the waveguide(w)	14mm
4	Length of the waveguide(l)	18mm

Table 1: SIW Design Values

Significant Parameters:

The Substrate Parameters are displayed in Table 2.

S.NO	PARAMETER	Value with units
1	Permittivity (ε_r)	4.600
2	Permeability (μ_r)	1.000
3	Height (H)	1.58 mm
4	Hu	3.9e + 34 mm
5	Thickness (T)	1.000 mm
6	Dielectric loss	1.000

The Components Parameter is displayed in Table 3.

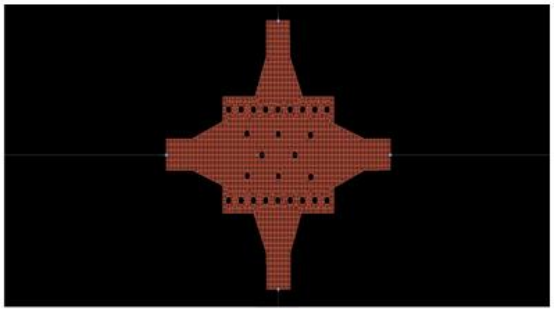
S.NO	PARAMETERS	VALUE
1	Frequency	2.4 GHz

Physical parameters are provided in Table 4

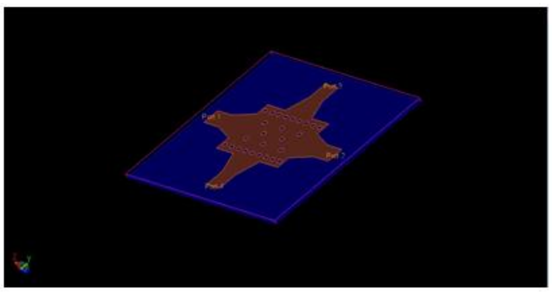
S. NO	PARAMETERS	VALUES
1	Width	2.366430 mm
2	Length	17.271500 mm

IV. RESULTS AND DISCUSSION

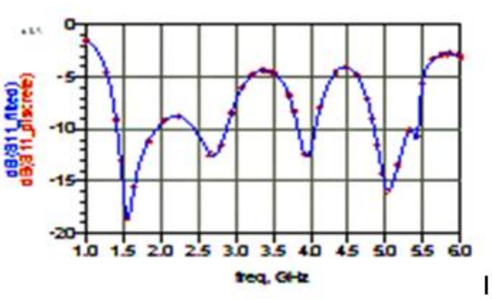
Our project's primary goal is to use ADS and HFSS Software to design a wearable dual polarised antenna patch for WBAN applications. Having a layout window open. Establish the necessary substrate's form. Enter the substrate's dimensions using the insert command or by dragging on the design window.The filter's proposed design and simulation results are displayed below.



Using AD2009, design a 4 x 4 substrates integrated waveguide filter.



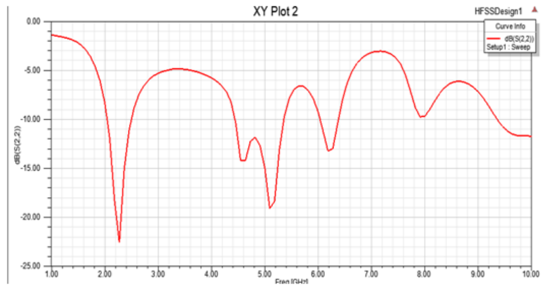
The SIW filter's design



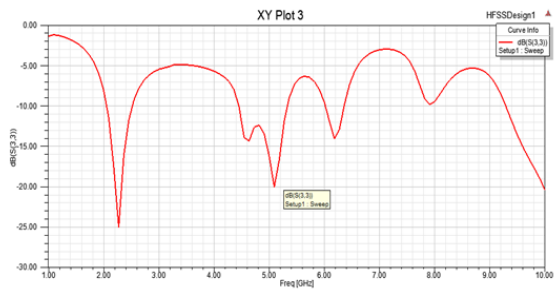
S-parameter-Stimulated output of input impedance measurement at port 1

Some peak frequencies that can be employed in a variety of applications are displayed in the graph above. They are listed below.

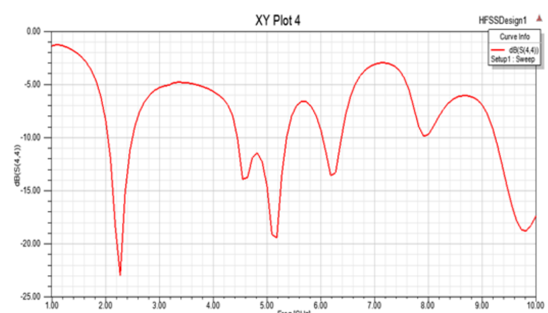
Label	Frequency in GHz	Equivalent dB value	Application
m_1	1.556	18.5	GPS
m_2	2.680	12.541	Radar Application
m_3	3.980	12.541	WiMAX
m_4	5.028	15.930	WLAN
m_5	5.3	10.70	WLAN



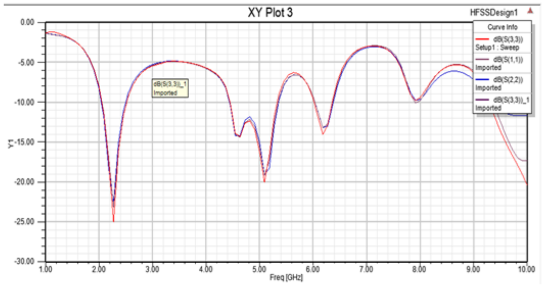
s-parameter-stimulated output of input impedance measurement at port 2



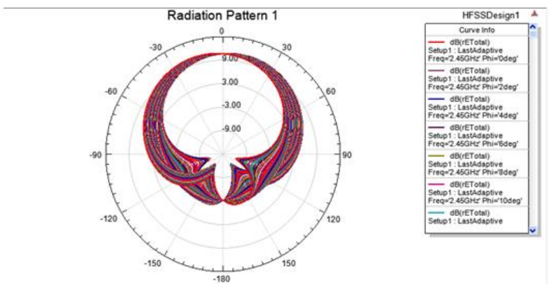
The impedance of the input at port 3 stimulated result using s-parameter



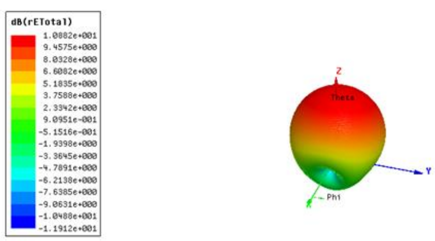
The impedance of the input at port 4 stimulated result using s-parameter



Forward voltage gain stimulation outcome with port 1 and input port as well as port 2 as via port



Consequence of radiation stimulation



Gain-stimulating effects

V. CONCLUSION

Since the filter is intended to transmit within the specified cut-off frequency of 1GHz to 6GHz, having a resonant frequency of 2.4GHz, we can infer this from the simulation results. The suggested filter transmits all frequencies above 10 dB, demonstrating its suitability for use in a variety of applications including WLAN, radar, GPS, and WiMAX. The intended RWG filter rejects unwanted frequencies in the band range between 1GHz and 6GHz. The developed filter is utilised at frequencies above, where smaller designs with a higher Q value are possible. The created model will be used in a real-time setting in the future. Wireless transceivers will be able to use the suggested filter.

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