International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 4 [April. 2023] PP: 235-244

Design and Development of Small Wearable Antennas for Wireless Body Area Network Applications

Ajeet Pratap Singh
(M.Tech Scholar)
Department of Electronics and Comm.
RITS, Bhopal (M.P.), India

Prof. Sneha Jain
Associate Professor
Department of Electronics and Comm.
RITS, Bhopal (M.P.), India

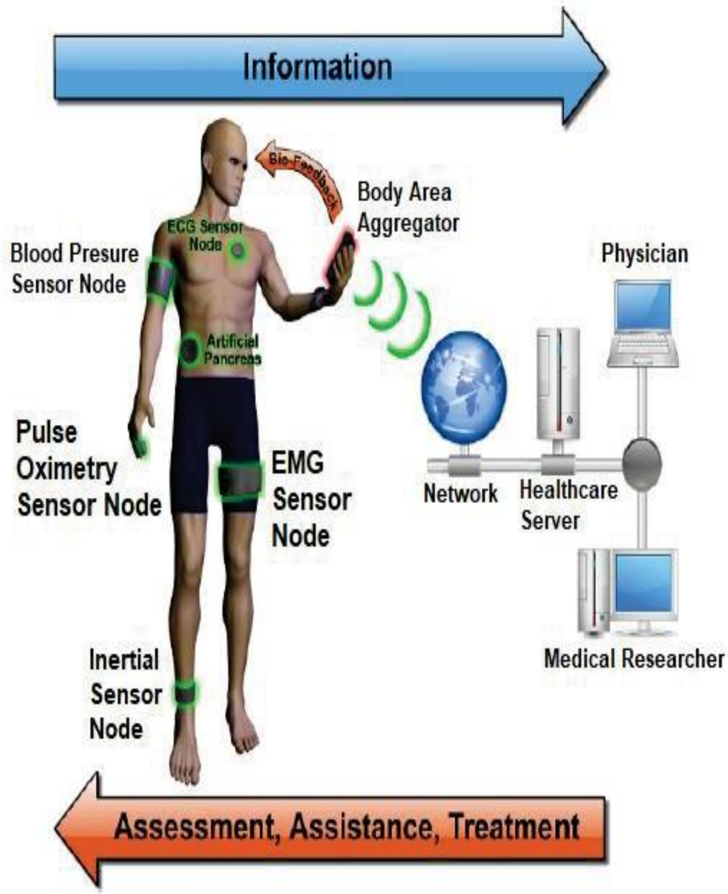
ABSTRACT:
Body-centric wireless communications relate to personal and person-to-person networking which employs several wearable or implantable wireless sensing devices. It comprises of Wireless Body Area Networks (WBANs), Wireless Sensor Networks (WSNs) and Wireless Personal Area Networks (WPANs). Wearable or implantable antennas are the key components of wearable electronic devices for body-centric wireless communications. This thesis primarily focuses over design techniques and prototype development of reliable wearable antennas, specifically for WBAN applications such as defence, sports and healthcare services. The wearable antennas are generally operated in on-body environment which significantly degrades the radiation performance of antenna and causes harmful health related issues for the wearer due to electromagnetic radiations. Among several challenges in the design and development of existing wearable antennas, the key concern is the reduction in the radiation efficiency of the wearable antennas due to its proximity of the lossy human tissues. The antenna radiation raises the temperature of wearer's body and thus limits its maximum transmit power as well. Moreover, the wearability aspects of antennas involve folding or bending of antennas that greatly influences the radiation characteristics of antennas as compared to their radiation performance in flat conditions. The various bending scenarios of wearable antennas also lead to detuning of antenna operating frequency and operational bandwidth variations. Besides aforementioned issues, the wearable devices also require miniaturization of antenna protypes for its conformability and integrability for wearer's clothing.
KEYWORDS *- CST, VSWR, S-Parameter, FR4, Return loss, 3D*

Date of Submission: 08-04-2023 Date of acceptance: 21-04-2023

I. INTRODUCTION

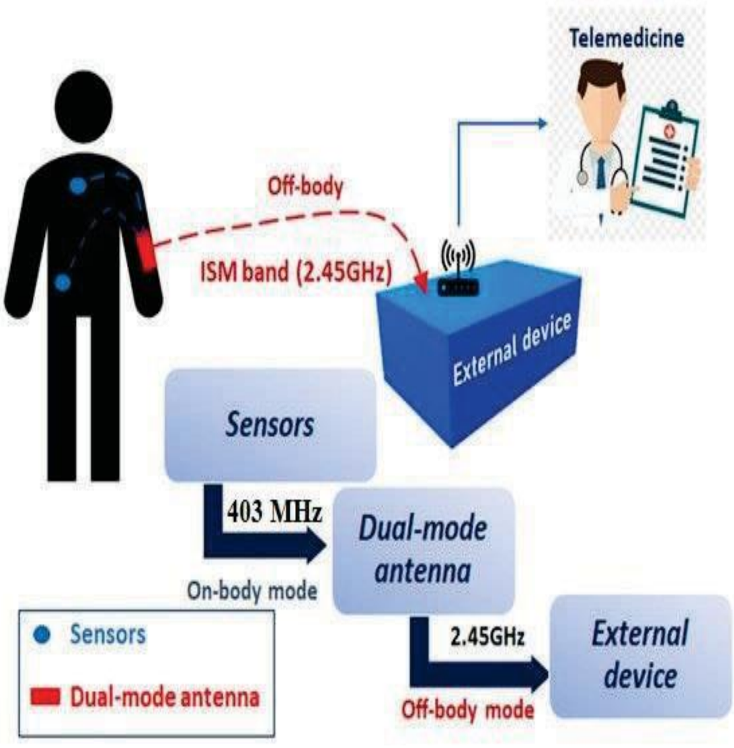
The recent trend in modern communications is emerged to attain maximum level of portability. The portability is almost synonymous to wearability. As the human body is not conducive for propagation of a wireless signal, the radiation efficiency of antennas is diminished due to electromagnetic (EM) absorption in human tissues. The radiation patterns become unstable and distorted. The impedance bandwidth (BW) is changed. The small wearable antennas with good radiation characteristics are desirable for compact implantable and wearable devices.

The recent research is delved into development of novel techniques for designing efficient wearable antennas for Wireless Body Area Network (WBAN) applications [1]. WBAN technology plays an essential rule in most of the modern health monitoring systems as shown in Figure 1.1.



A. WEARABLE ANTENNA

Later improvements and innovative headways in remote correspondence, Micro Electro Mechanical Systems (MEMS) inWearable Antennas are basically any antenna that is explicitly intended to work while being worn. Precedents incorporate smartwatches (which ordinarily have coordinated bluetooth antennas), glasses, (for example, Google Glass which has WIFI and GPS antennas), GoPro activity cameras (which have wifi and bluetooth antennas, and are regularly tied to a client to acquire their recording), and even the Nike+ Sensor (which imparts to a cell phone by means of bluetooth, and is set in a client's shoe). Wearable antennas are ending up progressively normal in buyer hardware, and in that capacity this page is devoted to portraying the novel troubles associated with wearable antenna structurenovation and coordinated circuit

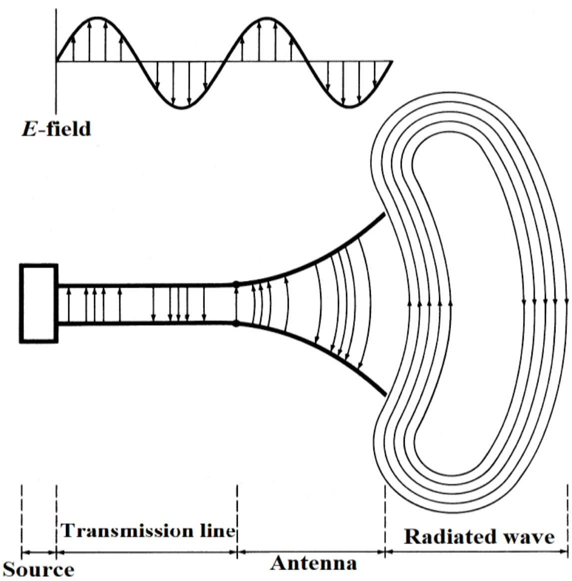


II. LITERATURE SURVEY

In WBAN applications, wearable antenna plays an important role. Wearable antennas are usually based on flexible substrates. A brief description of key antenna performance parameters of wearable antenna and review of the state-of-art related to wearable antennas are discussed in this chapter.

Basics of Antenna

Antenna is a sensing transducer that can radiate and / or receive EM waves. According to IEEE definitions of antennas [27], antenna is defined as "a part of transmitting and receiving system which is designed for radiating or receiving radio waves". In other words, "An antenna is a transition device, or transducer, between a guided wave and free- space, or vice-versa" as shown in Figure 2.1.



shorted top-stacking patches are acquainted with expanding the bandwidth and lessen the profile of the antenna. The tallness of the antenna is $0.05\lambda 0$, where

λ 0 is the free-space wavelength at the most minimal working frequency. The reproduced and estimated results demonstrate that an upgraded impedance bandwidth of about 162% in the scope of 2.5 to 24 GHz (S 11 <; - 10 dB) is accomplished. Furthermore, the impact of the human body to the proposed antenna is negligible. The time-area conduct of the position of the safety UWB antenna is tried, and the outcomes demonstrate a palatable execution in transmitting and getting beat signals.

W. Amer, Gui Yun Tian [2] shows a novel antenna plan for the ultra wideband body territory arrange applications. The plan is made out of two Vivaldi shapes put inverse to one another on a similar substrate, which accomplishes steady impedance coordinating over a wide band and uniform radiation design. To decrease the retrogressive radiation, two kinds of reflector were utilized: level and bended. Results demonstrate that utilizing a bended reflector improves the radiation design on a large portion of the UWB with less impact on the antenna impedance contrasted with the level reflector.

M. Y. ElSalamouny [3] proposes two novel conservative plans of low-profile multi-band microstrip antennas. The first can work in ISM bands (2.4 GHz and 5.8 GHz), which makes it reasonable for Remote Body Zone System (WBAN) medicinal applications. Then again, the second structure executes stacking of antenna to such an extent that the subsequent novel plan works ideally at 3.5GHz and 7.5GHz, which makes it reasonable for Ultra-Wide-Band (UWB) applications. The two antenna plans are minimal in size, that is, the general size of the primary antenna is just 11.54 mm3, while the second is 25.16 mm3. The two antenna structures are reenacted on skin radiation box, so as to permit progressively exact forecast of the antenna execution when utilized in medicinal implantable gadgets. Aside from the minimized size, both antenna structures deliver a base Explicit Assimilation Rate (SAR) which conforms to IEEE standard wellbeing rules, which is essential for shielding patients from electromagnetic harm.

W. Jeong and J. Choi, [4] proposes a position of safety UWB antenna with cone shaped radiation for on-body correspondences is proposed. The antenna has generally speaking elements of 64 mm × 64 mm × 6

mm (0.64 λ 0 × 0.64 λ 0 × 0.06 λ 0 at 3 GHz) in the

Motivation Radio UWB (3.1 GHz - 10.6 GHz) band. The proposed antenna is made out of a mono-cone and a TM41 higher-arrange mode shorted ring patch. The reenacted outcomes demonstrate that the proposed antenna acquires monopole-like radiation exhibitions in the entire working frequency band. The radiation example of the proposed antenna on the apparition is like that in free space so that the on-body WBAN application can be practical.

A. Zaric, J. R. Costa [5] shows an extremely minimized low-profile (37.6 mm×27 mm×3.1 mm) unidirectional UWB antenna is proposed for remote body territory organize (WBAN) confinement applications by concentrating on its running execution and motivation constancy in time area notwithstanding frequency space attributes. The antenna is insusceptible to coordinate skin contact, and furthermore shows great frequency and time area properties in free space or at any separation to a body: reflection coefficient and radiation design versatility to body impact; level exchange work plentifulness and straight stage over the ideal frequency band from 6 GHz to 9 GHz. Prevalent time area execution is shown in reenactment and estimations with normal drive constancy of 97% in both free space and when put at 0 mm or 3 mm over the body.

A. Zaric, J. R. Costa [6] sows a position of safety unidirectional UWB antenna for WBAN (Remote Body Zone Systems) Motivation Radio (IR) applications is proposed with useful band from 7 GHz to 10.7 GHz. Reproduced reflection coefficient in free space and when 0 mm, 3 mm, or 7 mm over a human body display demonstrate that the body impact is negligible. Time area investigation of heartbeat devotion, of vital significance for IR-UWB, demonstrates normal loyalty of 98% in free space and when 3 mm or 0 mm over the body.

Table 1: Summery of reviews

Author name	**Year of Publication**	**Frequency Range (in GHz)**	**Objective**
B. Sivasha	Dec 2017	2.5 to 24	Low-weight and easy to produce by printed circuit board manufacturing
R. Herzi	Nov 2017	2 to 5	Novel antenna design for ultra wideband body area network applications.
D. Yang	July 2018	2.4 to 5.8	Novel compact designs of low-profile multi-band microstrip antennas
J. Shan	Nov 2017	3.1 to 10.6	Monopole like radiation performances
W. Jeong	Nov 2015	3.1 to 12	Novel folded ultra wideband antenna for Wireless Body Area Network

III. PROBLEM FORMULATION

From the above writing survey, it can reasoned that the primary issue with the Vivaldi microstrip patch antenna is Thin bandwidth, bring down gain (6 dB), extensive ohmic loss in the feed structure of cluster, polarization virtue is hard to accomplish, bring down power taking care of ability and so forth in the light of writing study it can detail an issue of lower bandwidth and low return loss is the fundamental weaknesses. No proficient antenna structure for wearable antenna over body zone organize applications.

IV. PROPOSED DESIGN

In figure 3, demonstrating top perspective of proposed Vivaldi microstrip patch antenna, one side of a dielectric substrate goes about as a transmitting patch and opposite side of substrate goes about as ground plane. Top perspective of a rectangular patch antenna with coaxial feed has. Patch and ground plane together makes bordering fields and this field is in charge of making the radiation from the antenna.

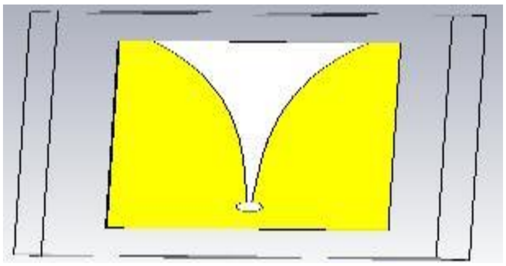


Fig. 3: Top view of proposed Vivaldi antenna

The structure of a vivaldi microstrip antenna which has a wide bandwidth with directional radiation design takes a shot at 3.1 to 10.7 GHz and utilizing less expensive substrate. Substrates utilized for vivaldi microstrip antenna vivaldi is FR4 with a dielectric steady of 4.3 and a thickness of 1.6 mm. In view of the reenactment results we acquired that the antenna configuration has frequency extend 3.1-10.7 GHz for return loss not exactly - 10 dB with a directional radiation design. This antenna gain is 4.8 to 8 dBi with the biggest measurement is 50 mm x 40 mm.

V. SIMULATION RESULT

So as to acknowledge multiband antenna, a wide assortment of antenna types, which utilizes diverse multiband systems, is utilized. The most broadly utilized procedure for acquiring multiband antenna system is the use of different resounding structures. The different full structure strategy is likewise frequently utilized in body zone arrange correspondence systems .

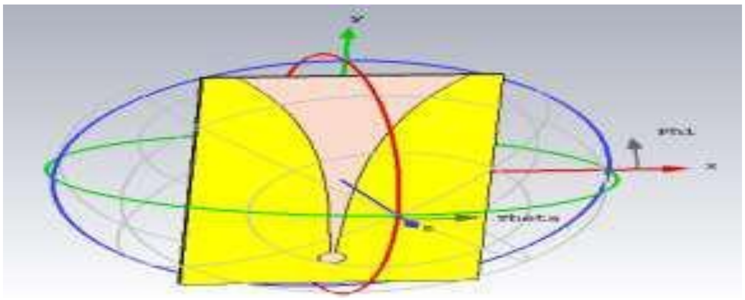


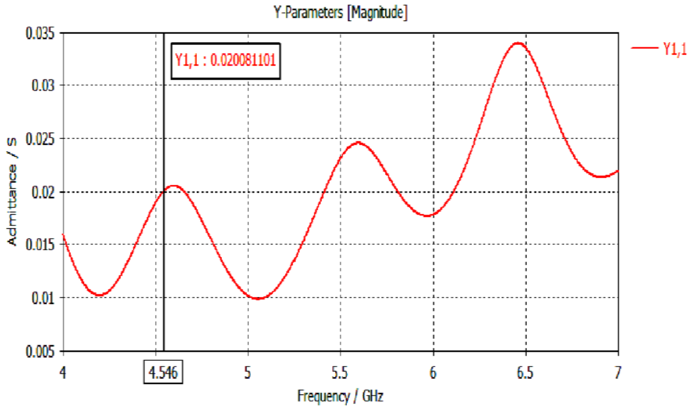
Figure 4, demonstrating reproduced proposed antenna in CST microwave studio, it is a particular device for the quick and precise 3D EM reenactment of high frequency issues. Alongside a wide application run in various field.

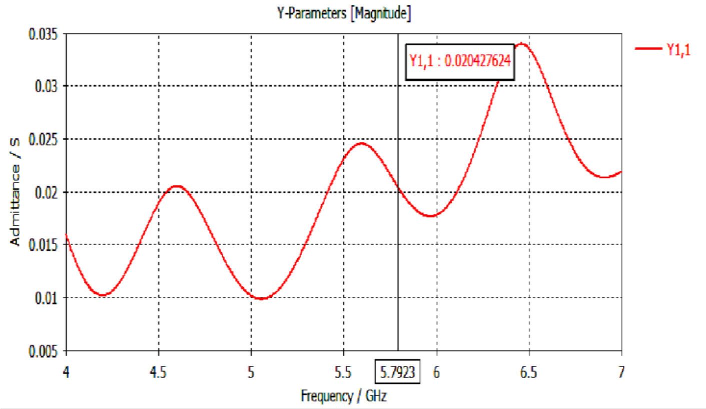
ADMITTANCE AND IMPEDANCE

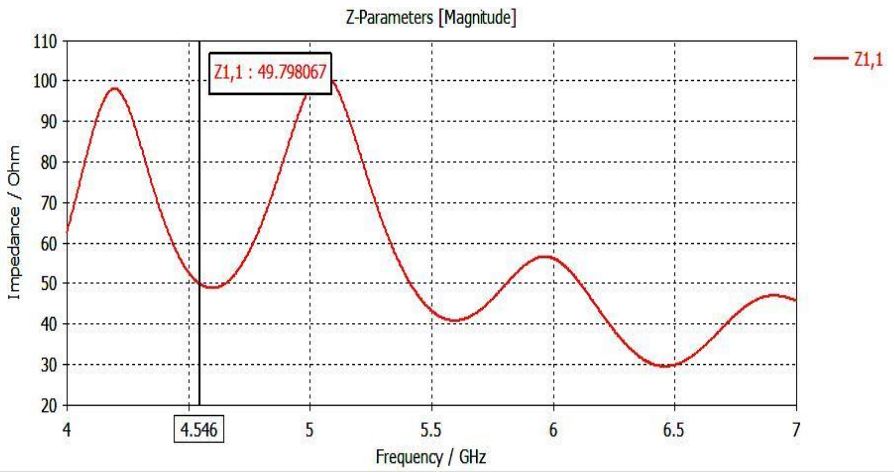
Figure 5.5 and 5.6 appearing of permission and impendence of proposed antenna responsively. A Y-parameter framework depicts the conduct of any direct electrical network that can be viewed as a black box with various ports. Z parameter is utilized to decide the quality factor of an antenna which can give a knowledge about the feasible bandwidth. Z(ant)=R+jX, where R=R(rad)+R(Loss), so ie can anticipated by one way or another the losses and the efficiency.

So values of admittance and impedance of antenna is-

Y parameter for first band= 0.0200s (siemens), ideal value lies on approx zero therefore is significant archived.
Y parameter for second band= 0.0204s (siemens)

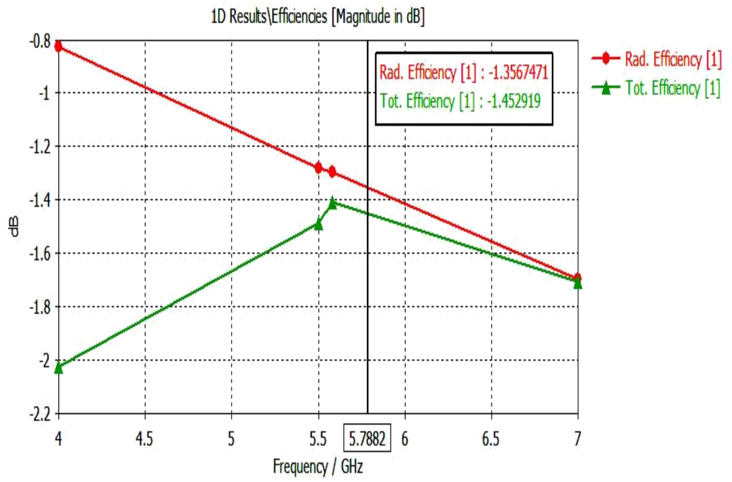


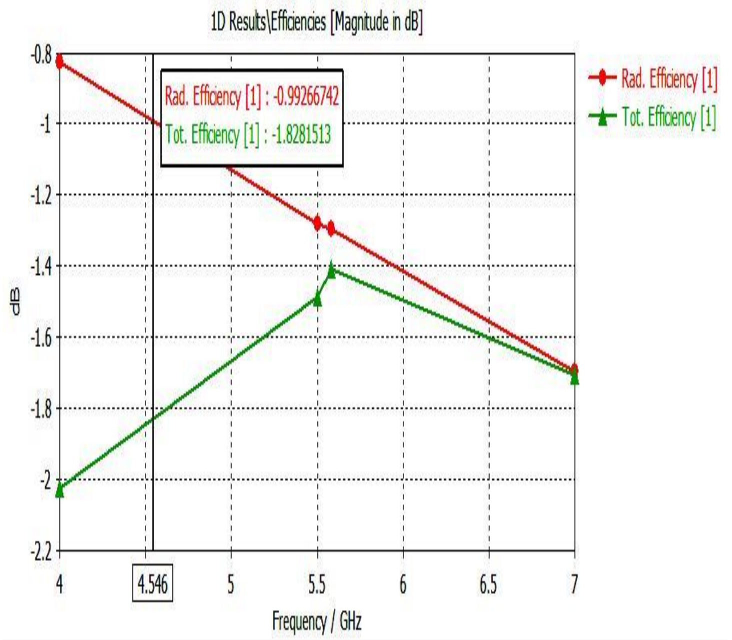




Antenna efficiency

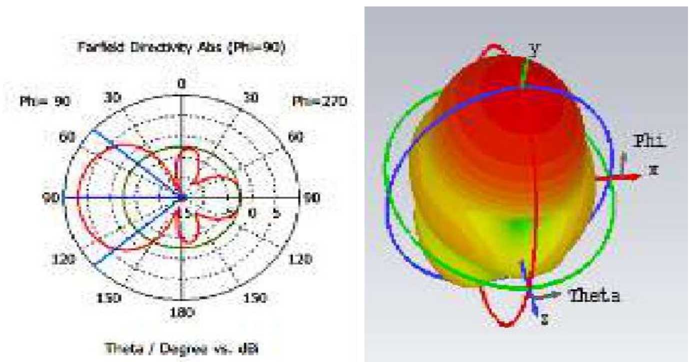
Antenna efficiency is frequently used to mean radiation productivity. With regards to antennas, one frequently just talks about "proficiency." It is a proportion of the electrical effectiveness with which a radio antenna changes over the radio-frequency control acknowledged at its terminals into emanated control. In like manner, in a getting antenna it depicts the extent of the radio wave's capacity caught by the antenna which is really conveyed as an electrical signal. It isn't to be mistaken for opening effectiveness which applies to gap antennas, for example, the illustrative reflecto





RADIATION PATTERN

The far-field pattern of an antenna may be determined experimentally at an antenna range, or alternatively.



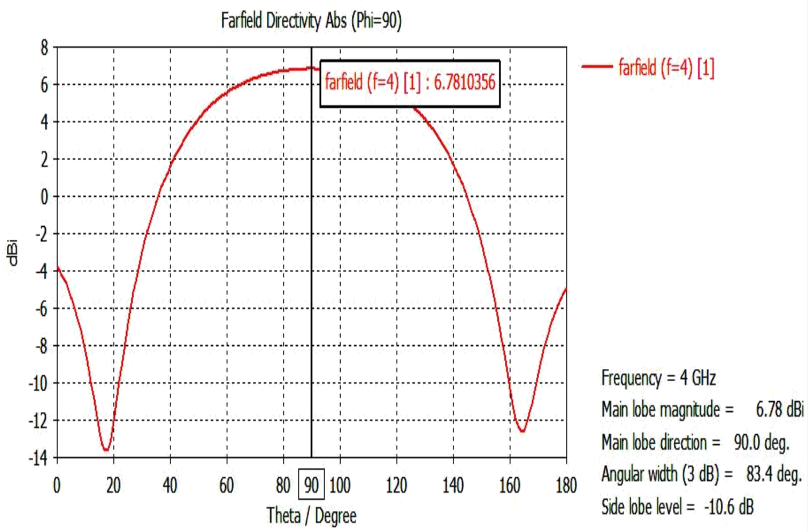


Fig. 8: Radiation pattern

Table II: Result summary of proposed Antenna

S.N.	**Parameter**	**Value (Band-I)**	**Value (Band-II)**
1	S11& Return Loss	-36.37 db	-34.45db
2	Band Width	670.48 MHz	615.55 MHz
3	VSWR	1.030	1.038
4	Resonant Frequency	4.546GHz	5.784GHz
5	Z parameter	49.79 Ohm	48.95Ohm

Table III. Comparison of proposed design result with previous result.

Parameter	**Previous work**	**Proposed Work**
Design shape	Vivaldi	Vivaldi
Bandwidth	180 MHz	670 MHz
	-27.5db	-34.45db
Resonant Frequency	4.35 GHz and 6.59GHz	4.5GHz and 5.7GHz
VSWR	>1	1.009

VI. CONCLUSION

Remote Body Region System (WBAN) is one of created innovation that bolsters telemedical administrations. Up until this point, the antenna's execution is for the most part influenced by a human body when it is connected close to the human body. In the paper, the new sorts of proposed antenna (Vivaldi microstrip patch antenna), which are increasingly fitting for body zone organize applications.

A twofold band, the rectangular microstrip patch antenna is planned and recreated utilizing CST reenactment programming. The reproduction results are displayed and talked about. Structure of proposed antenna is straightforward and conservative in size of approx 40×40 ×1.6 〖mm〗^3. the smaller size of planned antenna makes it simple to be fused in little gadgets. Results demonstrate that the frequency bandwidth covers WBAN (4-7) GHz, at focus frequencies 4.915 GHz and 6.018GHz individually for VSWR under 2, and S11 not exactly - 10 dB. The last outcomes fulfill every one of the parameters of a proficient antenna. The structured antenna works proficiently under all conditions with low return loss and appropriate impedance matching.

REFERENCES

[1]. D. Yang, J. Hu and S. Liu, "A Low Profile UWB Antenna for WBAN Applications", IEEE Access, Vol. 6, pp. 25214-25219, 2018.

[2]. W. Amer, Gui Yun Tian and C. Tsimenidis, "A novel, low-profile, directional UWB antenna for WBAN", Loughborough Antennas and Propagation Conference (LAPC), Loughborough, pp. 708-710, 2014

[3]. M. Y. ElSalamouny and R. M. Shubair, "Novel design of compact low-profile multi-band microstrip antennas for medical applications", Loughborough Antennas & Propagation Conference (LAPC), Loughborough, pp. 1-4, 2015

[4]. W. Jeong and J. Choi, "A low profile IR-UWB antenna with conical radiation pattern for on-body communications", IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, Vancouver, BC, pp. 2023-2024, 2015

[5]. **A**. Zaric, J. R. Costa and C. A. Fernandes, "Design and Ranging Performance of a Low-profile UWB Antenna for WBAN Localization Applications", IEEE Transactions on Antennas and Propagation, Vol. 62(12), pp. 6420-6427, 2014.

[6]. A. Zaric, J. R. Costa and C. A. Fernandes, "Low profile UWB antenna for Wireless Body Area Networks", 8th European Conference on Antennas and Propagation (EuCAP 2014), The Hague, 2014

[7]. K. Yekeh Yazdandoost, "UWB loop antenna for in-body Wireless Body Area Network" 7th European Conference on Antennas and Propagation (EuCAP), Gothenburg, pp. 1138-1141, 2013

[8]. C. Kang, S. Wu and J. Tarng, "A Novel Folded UWB Antenna for Wireless Body Area Network", IEEE Transactions on Antennas and Propagation, Vol. 60(2), pp. 1139-1142, 2012.

[9]. Q. Wang, R. Hahnel, H. Zhang and D. Plettemeier, "On-body directional antenna design for in-body UWB wireless communication", 6th European Conference on Antennas and Propagation (EUCAP), Prague, pp. 1011-1015, 2012

[10]. J. Shan, A. Xu and J. Lin, "A parametric study of microstrip-fed Vivaldi antenna", 3rd IEEE International Conference on Computer and Communications (ICCC), Chengdu, pp. 1099-1103, 2017

[11]. R. Herzi, M. Bouslama, L. Osman and A. Gharsallah, "Design of a compact antipodal Vivaldi antenna with band- rejected characteristic", Mediterranean Microwave Symposium (MMS), Marseille, pp. 1-4, 2017

[12]. Y. Dong, J. Choi and T. Itoh, "Vivaldi Antenna With Pattern Diversity for 0.7 to 2.7 GHz Cellular Band Applications", IEEE Antennas and Wireless Propagation Letters, Vol. 17(2), pp. 247-250, 2018.

[13]. B. Sivashanmugavalli and B. Vijayalakshmi, "Performance measures of Vivaldi antenna with parasitic elements", International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), Chennai, pp. 25-28, 2017

[14]. E. N. F. S. E. Embong, K. N. A. Rani and H. A. Rahim, "The wearable textile-based microstrip patch antenna preliminary design and development", IEEE 3rd International Conference on Engineering Technologies and Social Sciences (ICETSS), Bangkok, pp. 1-5, 2017

[15]. S. Ha and C. W. Jung, "Reconfigurable Beam Steering Using a Microstrip Patch Antenna With a U-Slot for Wearable Fabric Applications", IEEE Antennas and Wireless Propagation Letters, Vol. 10, pp. 1228-1231, 2011.