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Portable UWB Based Monopole Antenna for Wearable Applications

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***Abstract:** A planar UWB antenna is intended to deploy for on-body applications. The antenna is typically to manage for free space and placed on a harmonized phantom. The calculations are performed for return loss, radiation pattern and gain. The performance of the UWB antenna ranges from 3-11.2GHz. The main feature of the antenna depicts superior impedance level with good satisfaction on on-body propagation. Here, the observation between the phantom and antenna are carried out which results in input matching of the proposed antenna. The return losses are very slightly affected but the Gain of the antenna is seen decreasing significantly, after placing the antenna on the phantom.*

***Keywords:** Body centric wireless communication, Body area network(BAN),Printed antenna,Ultra wideband (UWB) antenna.*

I. INTRODUCTION

BODY AREA NETWORKS (BAN) is used to establish communication between the wearable and devices which are placed inside the inside the human body. Body centric communication can be either**,** off-body, on-body or in-body. On-body communication is where the different devices located on body, communicate with each other. Body centric communication has lots of application in health care, entertainment, space exploration, identification systems military and smart homes.[2]-[4]. Antenna is a essential part of on-body wireless communication. Different antenna like Printed Circular loop, Printed Monopole, Printed Dipole, inverted L, parasitic L, Wiggle antenna are some of the wearable antennas used for on-body communication. Ultra wideband (UWB) is an interesting technology that is used for on-body communication [5]. The UWB technology is highly promising as it offers a high data rate transmission, low cost and low interfering connected to the narrow band devices.E-Field antenna should improve the quality of the body surface to proceed with the on-body propagation. The three major requirements which are essential for on-body communication are 1) Time domain and Frequency should maintain optimum point [10], 2) Low profile and small size of antenna 3) Good on-body propagation. The compactness of UWB antenna is very significant for wearable applications [6]-[8]. To trim down the height of the radiating structures major efforts must be incorporated. The size of the antenna is considerably reduced to maintain the characteristics of gain, radiation pattern and efficiency. For on-body application the antenna should show suitable on-body propagation. Antenna E-Field designate on the surface of body to get better on the on-body propagation. So, a reduced size UWB antenna with an E-field vertical to the surface of the body is the best condition for on-body propagation [11].In the recent past, the application of electronics in textile and other clothes that are smart in nature are being used in different domains for the enhancement of more comfort and high convenience [16]. The important features namely the less consumption of power, one metallic layer and miniature with both single and double node functions to be given more priority , In addition, UWB antennas along with the CPW – fed has drawn the attention of more researchers in the applications of wireless technologies [17-19]. Federal communications Commission (FCC) has certain standards that use a frequency bandwidth between 3.1 to 10.6 GHz which yields very high speed wireless systems [20]. Handful of researchers have designed many UWB antennas for the purpose of wearing in many applications. For example, the antennas referred in [21] was printed in a planar type of monopole that has 8.6 GHz frequency between 3.4 and 12 GHz by making use of the polyethylene blended terephthalate type of substrate. In another design, the flexible type of UWB is proposed in [22] in a size between of 75 and 18 mm2 to be used as a wearables in some human based band applicationsIn addition [23] refers to an UWB type of antenna that is embroidered in two types namely the conductive and non-conductive materials in addition to a T-slot type of structure and a ground plane that are partial. In yet another proposal as in [24], an CPW-fed monopole antenna is introduced and which is embroidered with the aid of polyesters that are conductive in nature and these are used in the UWB applications with 2.7 GHz-10.62 GHz. In [25], an antenna which is wearable and also compact is introduced with the operating frequency between 3.6 and 15 GHz where the ground plane is restricted and the concept of Defected Ground Structure (DGS) and the path in a circular motion along with the U-Shaped and kind of slot is proposed. In [26], the idea for introducing an micro-strip type of antenna for the medical domain is introduces and which operates in the frequency range of 13.08 GHz and miniature is achieved. In[27],

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A wearable antenna that is more compact is proposed which works on the hexagonal patch and with a blue jeans which is used as a substrate which has the RP ("Relative Permittivity") er = 1.6 for the coverage of the frequency between the bandwidth between 3.7 and 10.7 GHz.

As in [28], the ON jean type of substrate is used for developing an UWB antenna in which the CPW-fed is given. In [29], the UWB antenna with a micro-strip antenna is proposed that can be used in the WBAN (Wire-less Body Area Network) that operates in the frequency range between 4 to 9.5 GHz is proposed. In [30-33] the other type of monopole antennas are presented which used a variety of materials are discussed. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN. The planar type of UWB are introduced in [34] for the application in WBAN that operates with the specification of RT/Duroid's 5880 with an size equaling 86 mm to 72 mm and the substrate is made to get fabricated with the covered frequency between 3.2 GHz to 10.6 GHz. In [35], the effect of the dielectric and electrical properties in a human body that vary between frequencies. Due to these specific properties and the waves that are observed by the body makes the gain of the antenna to be increased when used in the front end of the body [36]. There exists many type of UWBs that uses a variety of slot features. In this research paper, the techniques that are used in [37,38] a more compact and also a wider CPW-fed slot based antenna is discussed that are specifically used for the wearable applications. The proposed structure of antenna design is configured based on the various structure of antenna discussed in the literature survey. This design is carried out using the CADFEKO software.

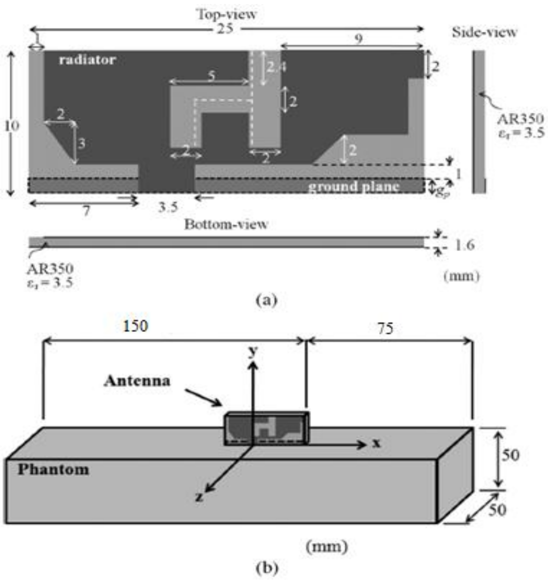

Fig. 1. (a) Proposed structure of antenna, (b) Design of two-thirds muscle-equivalent phantom antenna.

II. EXPERIMENTAL MODEL

A. *Antenna design*

Antenna encompass of Compact Microstrip-fed Printed Monopole antenna with a thickness of 1.6mm AR350 substrate (ε_r=3.5) [1]. The substrate has a dimension 25×10×1.6mm^3 [Fig1(a)].The radiator structure is there on top of the substrate and a ground plane below the substrate. Significantly reducing the size of the wearable antenna simultaneously the radiator and ground plane is reduced and this leads to decrease the entire height of the antenna. The UWB antenna has a vital height around 17 mm which is inappropriate for perpendicular pattern [12]. A radiator structure of dimension 25×10mm is printed on the AR350, the height of the substrate is 1.6mm and relative permittivity of ε_r=3.5.In this the antenna height is reduced by 7mm. For this on the bottom, right and left of the radiator, shapes are cut and the total radiator height is reduced. The ground plane size below the substrate is reduced by 8mm. The ground plane is measured with the size and the radiator is measured with the height are concurrently reduced this helps to increase the total height of the antenna by 10 mm [9]. Thus helps in minimizing the distortions in the antenna performance and also significantly reduces the present path, leading to amplify in the lower band limit. A slot of length 16.4mm is cut on the surface of the reduced radiator structure. The presence of this slot enables slight enlargement in the -10dB return loss bandwidth and covers the full UWB frequency range. The fed type is microstrip fed. A microstrip structure 3.5mm wide is formed on the structure, to fed the antenna. A line fed is provided in this portion.

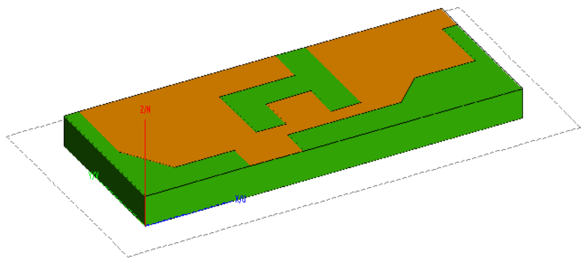

Fig.2 Design of proposed antenna

Table 1. Parameters of the proposed antenna

Substrate	Length	25
	Width	10
	Height	1.6
Radiator	Length	25
	Width	10
Slot	Length	16.4
	Width	2
Ground Plane	Length	25
	Width	1

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B. *Phantom*

The proposed antenna is characterized by placing it on an homogeneous phantom modeling the human arm [Fig 1(b)]. The human arm is designed in a way that has a two-third muscle-equivalent phantom. Antenna is initiated on the top of the phantom with 1mm. which is similar to the situation of placing the antenna on cloths. The shape of the phantom is parallelepipidpic and existing with 225×50×50mm^3 dimensions. A water based semisolid phantom is preferred to be considered as tissue which is corresponding to UWB measurements [13][14]. The phantom has a relative permittivity of 1, and conductivity of 1.73. The complexity of the phantom and also the permittivity and conductivity can be tuned by means of sodium chloride and polyethylene powder. The shape of the phantom preserved with the assistance of Agar. Sodium azides facilitate as a stabilizer and TX-151 progress the phantom stickiness

Fig.3 Design of antenna mounted on phantom

Table2. Parameters of the Phantom

Phantom	Length	225
	Width	50
	Height	50

III. RESULTS AND DISCUSSION

Results denote the calculations made for radiation pattern, return loss and gain

C. *Reflection Coefficient*

The reflection coefficient s_{11} of UWB antenna was signified in Fig 4. Imagine that the antenna present in the free space and mounted on the human arm. These results demonstrate that the s_{11} is somewhat artificial by the occurrence of the phantom and they remain within 3-11.3GHz range. The -10dB return loss envelop to occupy the range of UWB frequency.

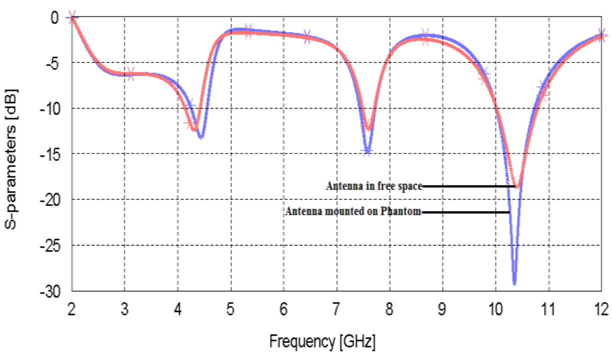


Figure 4 – Frequency Vs S-Parameters

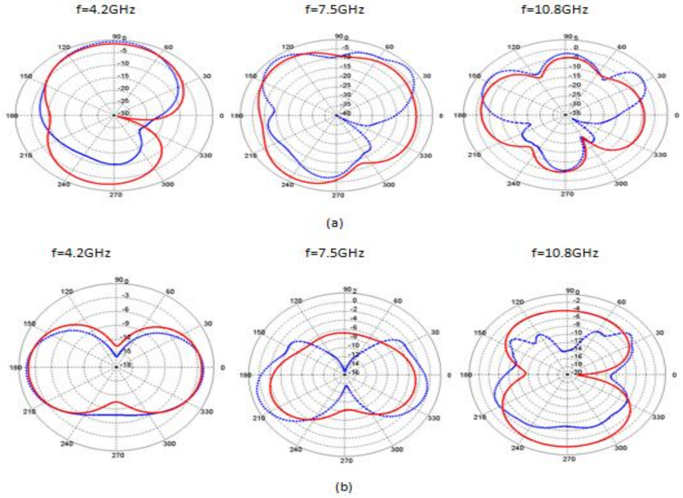


Fig 5 Calculated and simulated radiation pattern

The reflection coefficients are compared among the three slot length with the values of 6.9mm, 11.9mm, and 16.4mm and those are mentioned in Fig 5. The slight enlargement in the -10dB return loss bandwidth can be observed.

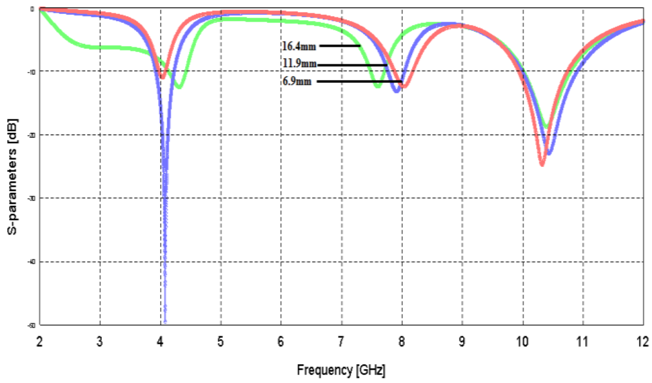
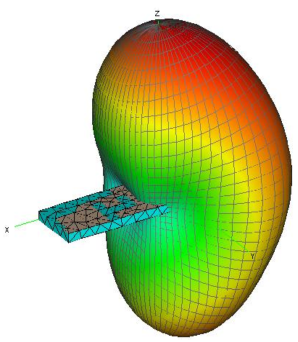


Fig 6 Proposed antenna nearby the free space for various slot shapes The calculated three different values are 6.9mm, 11.9mm, and 16.4mm.

D. *Radiation pattern*

The pattern of radiation in the proposed antenna in free space and after mounting the antenna on a phantom is observer in 3D and in polar plot. The 3D view of the antenna present in the free space and that of the antenna ascend on a phantom is shown in Fig. 6. The figure clearly shows the maximum radiation pattern occures at top position where the red color is seen. More current is distributed there and less backward radiation is obtained. When the antenna is mounted on the phantom, the maximum radiation is at the top portion, where the antenna is mounted



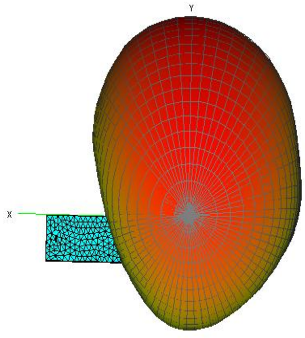


Fig 6. 3D view of (a) antenna in free space and (b) antenna located on phantom.

The polar plot gives the two dimensional view of the radiation pattern. The antenna radiation patterns are calculated at various different frequency points values which are 4.2GHz, 7.5GHz and 10.8GHz mentioned with two configurations such as antenna which is in free space and antenna positioned on a phantom. Radiation pattern is placed within X-Y plane for each frequency and the X-Z plane is calculated and observed.The dotted lines are graph of the antenna mounted on a phantom, and the straight line graph is that of the antenna in free space. When compaing both the antennas phantom perfomance is better which is mentioned in Fig.7.

E. *Gain*

The gain obtained in the free space and after placing the proposed antenna on a human arm muscle-equivalent phantom has been calculated for three different frequencies 4.2GHz, 7.5GHz and 10.8GHz.And it is observed that the gain is seen to reduce after the antenna is mounted on the phantom. It can be observed that gain in the x-z is reduced when the proposed antenna is placed on a phantom due to the absorption. The gain is reduced at the rate of 4.2GHz and the absorption rate is really high at the ratio of 7.5GHz and 10.8GHz present in the x-y plane which results in the reflection caused by the human arm.

		Peak Gain (Free Space)	Peak Gain (on Phantom)
4.2GHz	x-y x-z	2.1 1.6	-0.2 -1.2
7.5GHz	x-y x-z	0.8 3	2.5 1.1
10.8GHz	x-y x-z	1 1.7	2.4 -3.6

Table 3. Peak Antenna's Gain needs to be identified in a free space and from phantom

F. Conclusion

A compact planar UWB monopole modeled for on-body communication systems. The radiator height and the ground plane size has been reduced, thereby reducing the total height of the UWB antenna. This also helps to minimize the distortion in the proposed antenna. Here, the antenna performance was analyzed by keeping it in free space and also after mounting it on a human arm muscle-equivalent phantom. The Reflection Coefficient, Radiation Pattern and Gain was calculated and studied. The Radiation Pattern in 3D and in polar plot is studied. The Reflection Coefficient shows that the return loss lies in the UWB range from 3-11.2GHz. The antenna shows good performance in that range. The Gain present in the X-Y plane and the frequencies are measured with the three different values of 4.2 GHz, 7.5 GHz and 10.8 GHz in X-Z plane are studied and measured

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