International Journal of Engineering Works
Kambohwell Publisher Enterprises
ISSN: 2409-2770
Vol. 5, Issue 5, PP. 111-115, May 2018
www.kwpublisher.com

A Review on Properties Amelioration of Wearable Antennas

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***Abstract*—**The emergence of Body Area Networks (BAN) in recent times has increased the interest of most researchers in the field of wearable antennas. Due to its widespread popularity most of the research has been done to improve the efficiency and flexibility of the wearable antennas for in-body and on-body applications. This work is the review of the recent development in the area of wearable antennas. Further the use of different textile materials has been studied and their performance has been compared with the ordinary used substrate such as FR-4 for wearable antennas. The results show that use of textile materials have not only increased the efficiency but also they are very flexible and make the antenna suitable for in-body and on- body applications such as medical and military. The properties of antennas inside human body, on human body and finally at some distance from the human body have been studied. It has been noted that as the distance between human body and antenna reduces the properties of antenna such as efficiency, directivity and gain degrade more and more. Also the resonant frequency of antenna shifts from its original position which is a very big issue and need to be rectified. For textile materials the shift in resonant frequency is not too much and also the degradation in other properties of antenna such as efficiency, directivity and gain are insignificant.

***Keywords*—** Body Area Network (BAN), Computer Simulation Technology (CST), In-body, On-body,EBG, Textile materials.

I. Introduction

This Antenna is an important part of wireless communication; in fact no wireless communication is possible without an antenna [1]. We have to install antennas at both ends i.e. at transmitter side as well as at receiver side as shown in Fig. 1.Transmitter generates the signal and antenna converts this signal into electromagnetic wave and radiates this Electromagnetic wave into air as mentioned in Fig. 1. The antenna which is installed at receiver side will receive this electromagnetic wave and will feed it to the receiver. So antenna can be defined as A device which is used for transmitting and receiving radio waves [2], [3].The emergence of Body Area Networks (BAN) in recent times has increased the interest of most of the researchers in the field of wearable antennas. Due to its widespread popularity most of the research has been done to improve the efficiency and flexibility of the wearable antennas for in- body and on-body applications. Wearable Antennas are those antennas which operate near the human body, so human body will absorb some of the radiated energy and hence efficiency of antenna will reduce [4]–[7]. The wearable antennas installed on human body may communicate with each other or with an external antenna. This type of network is known as Body Area Network (BAN) [8]. The antennas used in BAN are known as wearable antennas. Fig. 2 shows different examples of wearable antennas.

In-body antennas are those which are inserted inside human body and it is mostly used for medical purpose [9], whereas On-body antennas are those which are installed on the top of human body as shown in Fig. 2. The emergence of BAN shows that in near future almost everyone will be a part of this network, so wearable antenna should be carefully designed in order to achieve all the required properties of antenna even to be in the vicinity of human body or inside the human body. follow.

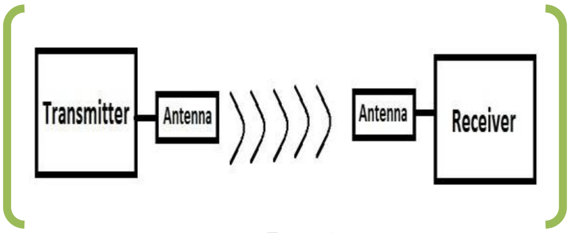


Figure.1

Figure 2.

II. Literature Review

In [10] a monopole antenna is presented which is basically printed on substrate called Neoprene as shown in fig: 3. this antenna is a dual band antenna covering two bands at the same time. The S-Parameter is obtained both in free spaces as well as on T-shirt arm and is shown in Fig. 4. The resonance frequency shifted towards left side after wearing. According to [11] as in case of wearable antenna human body is in near field of antenna so there will be very large absorption by the human body. In [11] writer emphasized to have a reconfigurable pattern for wearable antennas and proposed different wearable antennas as shown in Fig. 5.

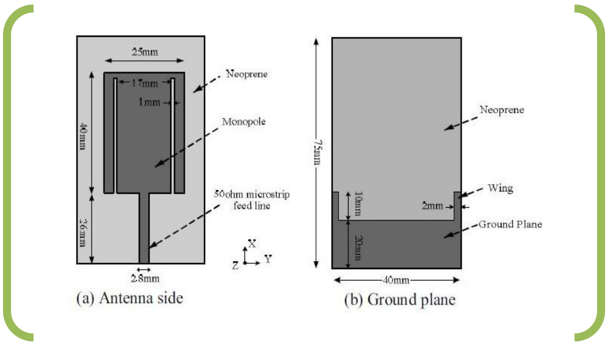
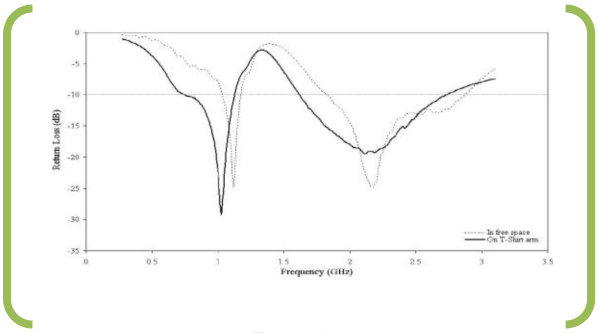


Figure. 3



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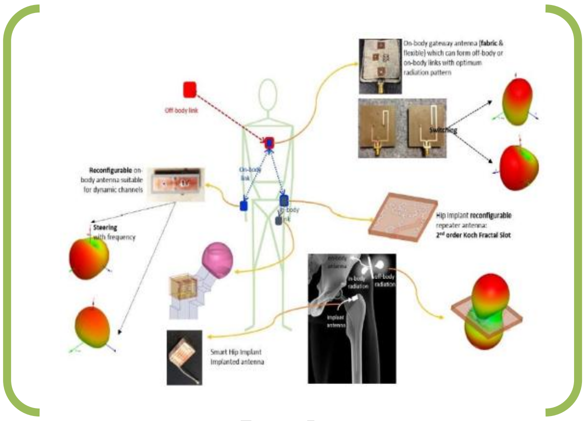
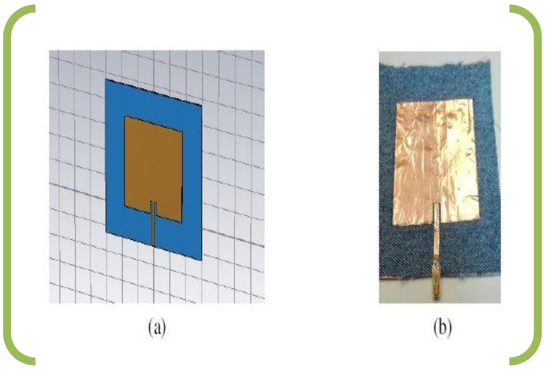


Figure. 5

In [12] a wearable antenna working in Global Positioning System (GPS) band is proposed as shown in Fig. 6. The simulated and measured S-Parameters are shown in Fig. 7. Fig. 8 shows the radiation pattern and S-Parameter result along with human body impact and it is clearly shown that resonant frequency has changed. The above results shows that if we use a frequency reconfigurable antenna carefully designed then after wearing we can make the antenna resonate at its previous frequency. There are a lot of methods to make the frequency of antenna reconfigurable. But the mostly used method is to use switches for connecting and disconnecting different parts of patch and increase or decrease the effective size of antenna [13]–[15].



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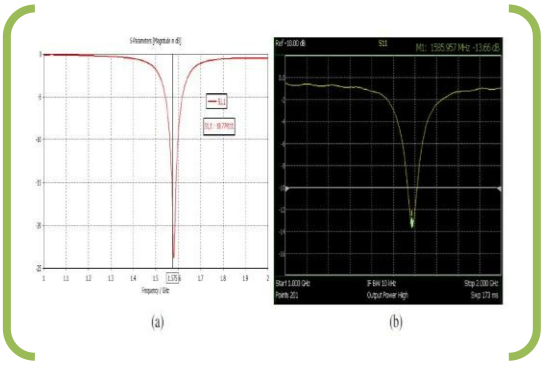

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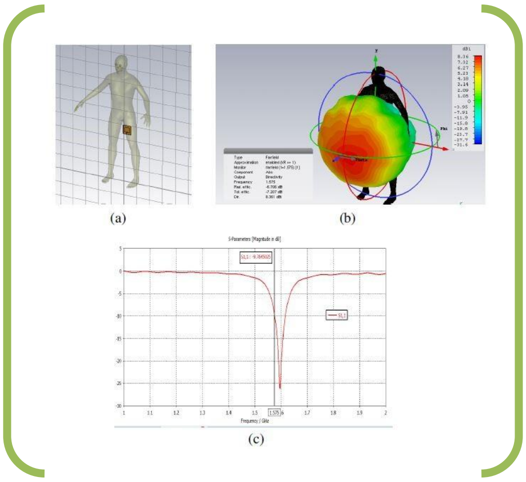

Figure. 8

In [16] a planner inverted F antenna is proposed whose structure is like an inverted F as its name shows. They have extended the patch due to which return loss is reduced and efficiency has improved. Fig. 9 shows the S-Parameter for 3mm extension in patch. In [17] an E-shaped antenna is proposed as shown and they have used both transmission line feeding as well as coaxial feeding. Three different textile materials have been used as substrate for the antenna. The S-Parameter graphs has shown in Fig. 10. Different measured parameters and their comparison are shown in Table 1. The [18] refer to a wearable antenna for the smart clothing applications which is far better than other conventional antenna in term of radiation efficiency [19]. The failure of radio link occurs due to closeness of human body is problem and is specially addressed by [18]. A conventional fleece fabric is used as substrate of patch antenna whose dielectric constant can be found by the method of cavity perturbation while for the improvement of flexibility the knitted copper is used to design ground plane radiating element as well which improved the bandwidth also. A wearable antenna also contributes in Health Gear Systems doing real time monitoring, collecting data and analyzing the system [20]. Fig. 11 shows the block diagram of health gear system.

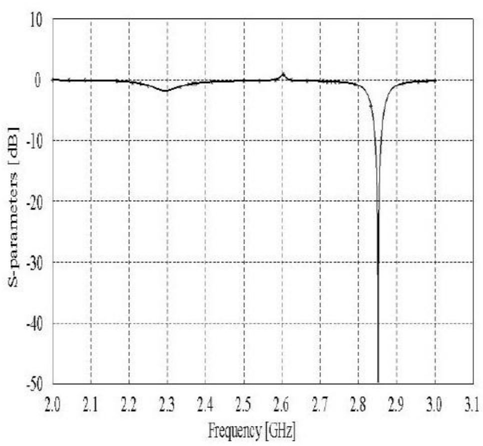

Figure. 9

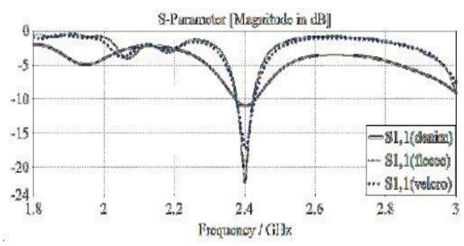

Figure. 10

Textile materials	Band width (MHz)	Directivity (dBi)	Radiation efficiency (dB)	Gain (dBi)	Impedance bandwidth (%)
Fleece	45.6	8.4	-0.811	7.59	19
Denim	38.6	7.44	-5.74	1.66	25
Velcro	52.1	7.95	-1.39	6.56	22
Fleece (Coaxial probe feed)	84.64	9.12	-0.1375	8.98	36

Table.1

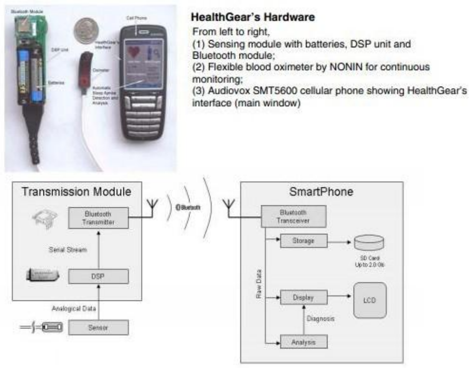

Figure. 11

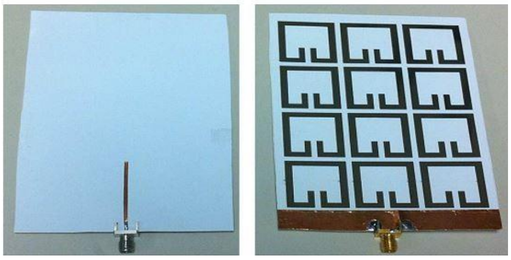

Figure. 12

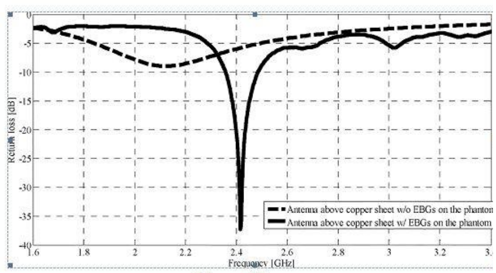

Figure. 13

ISSN: 2409-2770

When the service starts, the client is physiological sensing modules connected to the Media Access Control (MAC) address of the cell phone, number of clients can be accepted by mobile phone from different sensing modules. Its result shows that the health gear system is 100% comfortable and pleasurable in [21] a specific combination of wearable antenna and Electromagnetic Band Gap (EBG) structure is integrated to overcome the losses due to human body. System efficiency has improved by utilization of wearable monopole antenna at Industrial, Scientific & Medical Radio (ISM) band with EBG structure. The closeness to human body reduces the gain of antenna which almost leads to failure of link. The body absorb electromagnetic radiations which also causes some biological effects [22]– [25]. So, all such problems have been avoided by using a specific combination of antenna and EBG structure for safe environment. The Fig 12 and 13 shows the design and result of S-Plot respectively.

The proximity of human body, the overall efficiency of wearable antenna is affected i.e. power absorption, radiation distortion, change in input impedance of antenna and also the operating frequency [26], [27]. As it operates in ISM band which is directly fed by the antenna through via without having extra connecting circuitry. One of the major problems in wearable antenna is parasitic coupling which causes instabilities in circuit [28]. To overcome the effect of parasitic coupling a specific type of flexible form material is used to design an antenna with combination of Low Noise Amplifier (LNA) substrate. The effect of proximity of human body is reduced by this design. But the other aspects are also influenced their effect on the performance of wearable antenna. Such as input match performance and peak Specific Absorption Rate (SAR) value at ISM band [29]. A model to overcome the above mentioned problem a special Wireless Local Area Network (WLAN) textile wearable antenna has been designed using Finite Difference Time Domain (FDTD) method which has developed in University of California, Los Angeles (UCLA). A simple fleece fabric is used as a substrate whose dielectric constant is 1.1 at ISM band. Fabric of 8mm of thickness is used which is optimum for input-match for ISM range. In this design the knitted copper is used to design the patch and ground plane of antenna. A series of simulations have been observed and showed that impedance matching and radiation is almost unaffected by the human body. It has been derived that Printed Circuit Board (PCB) antenna can easily replace the textile antenna [29].

The [30] addressed the problem of patch antenna with low conductivity materials. The revolution of electronics and communication devices made it possible that our near future will have almost wearable devices fabricated in clothing. Wearable antenna is one of the major parts of it. As the conductivity of these material is not enough to treat as perfectly conducting materials and the aim of this research is to design such a compatible wearable antenna with low conductivity material. An antenna with such properties has been designed for all conductors being made of copper with specific dimensions. With the number of simulations the properties of wearable antenna found accordingly. That shows the performance of patch antenna with non-metallic conductors and also defined the limit least conductivity of practical microstrip patch antenna to implement. The geometry is given in Fig. 14. Its compatibility with low conductive materials made it versatile in nature. Wearable antenna can also be used in multi- band mode [31]. Along with single band uses it has wide use in dual frequency band also which allowing network connection [32], [33]. Here a novel dual band antenna integrated with EBG structure which can be fabricated within clothing. This combination avoids the backward radiations to the maximum level as possible. The ground plane and patch of antenna is made of specific material conducting fabric Zelt.

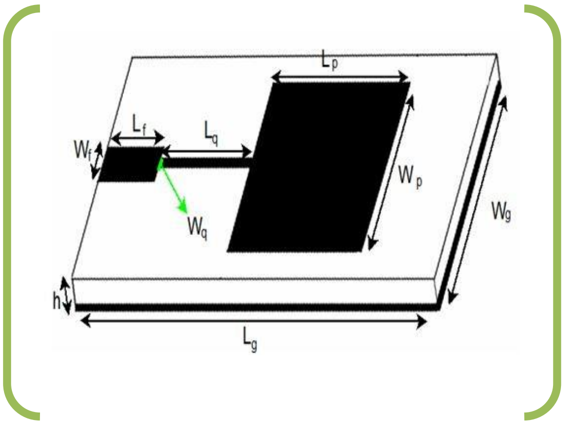

Figure. 14

III. CONCULSION AND FUTURE WORK

Recent research presented in these paper shows that textile materials are preferred for wearable antennas as far as efficiency and flexibility is concerned. Also in broad, microstrip patch antennas are suitable for wearing as they have a ground plan appearing in between the patch and human body. So in case of microstrip patch antennas absorption by the human body will be relatively low as compare to other types of antennas. Some more work is still needed in order to increase the range of these antennas applications to improve some parameters which are the major issues concern with wearable antenna. The most common issues the absorptions of radiation by human body due to the proximity of body so the SAR value should be reduce as much as possible and the other issue with such antenna is power consumption. So for better performance these issues should be resolve.

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ISSN: 2409-2770