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Current Trends in Antenna Designing for Body Centric Wireless Communication

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Abstract— This research paper focus on the latest research going on an important research topic of antenna designing for body centric wireless communication. Spotlight is on design specifications of antennas, antenna frequency bands, material used in antenna designing, performance analysis and future design challenges involved in designing of antennas for body centric wireless communication.

Index Terms— Body area networks, On-Body communication, Off-Body communication, Personal area networks, UWB Antennas

1 Introduction

WITH the evolution of wireless communication, particularly in last decade focus is on enhancing and contributing to the life style of human beings, one prong of wireless communication which is contributing in the field of health care, firefighters, support for military personal specially in war zones and other entertainment based personal wireless communication systems is body centric communication which lies under the umbrella of Body Area Network (BAN) and Personal Area Network (PAN) [1]. Body centric communication includes both the on-body and off-body communication. In on-body communication signal is transmitted between two systems implanted over the body while in off-body communication a body mounted system is communicating with some other system which are located in the surroundings like WiFi, GSM or some other system. Body centric communication is a hot topic of research and significant work is done and published related to this topic.

Antenna is a prime component of wireless communication this paper focus on the current trends and approaches proposed by various researchers in designing of antennas for body centric wireless communication and associated parameters like frequency bands, Bandwidth, materials used in antenna fabrication, design approaches and performance.

The parameters that are just mentioned will be discussed in next section in detail.

2 Parameters of Antenna Designing

2.1 Design and Frqequency Band

The basic and common approach in designing antennas for body centric communication is that antennas need to be compact in size. Design basics is further divided into two prongs one being the antenna directly mounted onto the body and second one the antenna is fabricated on some costume like helmet [2] or jacket [3].

Size of antenna is directly dependent on the frequency of the antenna, so size and frequency are interlinked with each other. Currently focus is on three different frequency bands.

- 2.45GHz and 5.8GHz band
- 3.6GHz to 10.6GHz band
- 60GHz band

Many researchers have worked on designing of 2.45GHz and 5.8GHz dual band antennas for body-centric communication, Anupan and Willam [4] designed C-shaped slotted patch antenna for dual band, two frequency bands are achieved resonance of inner and outer patches at two different frequencies. TM10 mode achieved radiation efficiency more than 90% for both the bands.

Another dual band and dual mode antenna operates at 1.9GHz and 2.45GHz by M.Khan, Qammar [5] it's an Omnidirectional and power efficient disk loaded monopole antenna. Radiation efficiency of more than 50% is achieved for both the bands.

3.6GHz to 10.6GHz wide band is an attractive band of research for body-centric communication because Federal Communication Commission (FCC) released this spectrum for Ultra-wide band communication in 2002. Shanshan, Shaoqiu [6] designed a rectangular patch antenna with quasi-trapeziform ground. Antenna simulations were carried out in Ansoft HFSS and CST Microwave Studio environment. Less than -10dB return loss is achieved for entire band.

Hall, Hao and Cotton [7] discussed 60GHz band as a new band for BAN's and established the fact that 57GHz to 64GHz wide spectrum will be the future of body centric communication. Researchers presented 60GHz horn antenna that excites surface waves on ground whose parameters are the same as that of the human body.

The above mentioned three bands do have their pros and corns as you keep on increasing the frequency the penetration depth of electromagnetic signal into the body decreases. Dual band of 2.4GHz and 5.8GHz do face some interference with other technologies operating on these bands like Bluetooth, WLAN and Wimax. At lower frequencies multipath effects are more dominant as compare to those on higher frequencies. In today's world security is consider as a prime concern in designing of wireless communication systems so is the case for

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BAN's and PAN's 60GHz band gives us the leverage of greater security along with high data rates.

2.2 Fabrication Material

The material used in the fabrication of antennas holds a key role. Fabrication material is also directly dependent of thedesign approaches, either the antenna will be designed to directly implant on human body or it is to be placed on to some costume.

Various materials are suggested by the researches T.F. Kennedy and others from NASA [8] used woven conductive material, Nora for designing of e-textile antennas for space applications. Nora is a good choice for designing efficient antennas at wireless communication frequencies another fabric Nomex [8] used having electrical properties same as air and this fact make them good enough to use at high frequencies.

Hall and Hao [1] designed a wearable antenna using fleece fabric and copper foil. Carla and others [9] designed wearable patch textile antenna using a combination of textile materials namely Shieldit, Fleece, Flectron and Felt. Shanshan [6] suggested Felt substrate in designing of antenna. Dielectric constant ε of above mentioned fabric lies in the range of 1.18 to 1.40 and dielectric loss tangent tan δ 0.010 to 0.082 ranges and resistivity 0.03Ω/square to 0.1Ω/square range.

2.3 Design Constraints

Antennas for body centric communication need to be small in size and power efficient. Normal antennas and antennas operating near the human skin are different because body movements, body temperature changes or if skin gets wet it affects the antenna performance. Human tissues dielectric properties do also change with the change in frequencies. Wearable antennas get affected by twisting and flexing. Researchers also focus on maximizing the radiation intensity while trying to reduce losses like dielectric loss, multipath loss.

Integration of designed antennas with other components is also a challenge. Researchers [6] mentioned specific absorption rate (SAR) is an important entity and should be considered when antenna is placed on body. SAR is dependent on three factors firstly; conductivity of the body second is electric field strength of the body and lastly density of the body.

2.4 Performance Analysis

High data rate is a basic design requirement in 4G wireless networks. Ultra-wideband signals have importance in body centric communication so to design an Ultra-wideband system that supports high data rate is one of the objectives. Ultra-wideband utilizes little energy and support high bandwidth short range communication.

Results [5] achieved bandwidth near to that of Ultra-wideband at 5.8GHz exact value mentioned is 400MHz in free space and at 2.45GHz the best bandwidth acquired was 95MHz. In off-body mode results [6] attained with efficiency of 80% and bandwidth as high as 247MHz at 2.45GHz while in on-body mode efficiency decreases to 62% and bandwidth to 70MHz, above mentioned results establishes the fact that in on-body mode performance decreases as compare to on-body mode. Results [10] of coupled patched antenna designed to operate at ISM 2.45GHz band attained bandwidth of 190 MHz while in bent state bandwidth is 145MHz.

Authors [11] designed inverted cone antenna for 3.1GHz to 10.6GHz wide band time domain behavior is analyzed using fidelity analysis and results are highly promising with average fidelity higher than 80%.

Carlos and others [12] designed 60GHz linearly polarized dipole antenna with bandwidth in GHz. Bill and others [13] achieved -10dB impedance bandwidth 44% of the band which almost doubles the requirement of 20% required for broadband communication.

2.5 Future Challenges

Research is going on three frequency bands and two possibilities of implanting antenna onto some costume or placing it on to skin, antenna study and its relative parameters near the human body adds a new research domain in the field of antenna designing and analysis. Antennas need to be robust in terms of matching with other elements and high performance is a prime requirement in the vicinity of body tissues. On the other hand, selection of appropriate e-textile fabric is also a challenge as body centric antennas changes performance even with the change in its wearer.

Structure of the human body is complex, which also varies slightly case to case so propagation calculations around the human body are a difficult task. At high frequencies fading occurs around the human body. Dual mode antenna is also one of the approaches in which antennas can communicate both with the on-body and off-body systems.

3 CONCLUSION

Body Centric Wireless Communication will be the future of wireless communications research is going on many possible wings of BCWC, research approaches in designing and performance of antennas for Body Centric Wireless Networks need to be more specific to cope up with the challenges and to achieve the goals of this 4G standard.

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