Wearable antenna for Body area Network

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요 약 무선 신체 영역 네트워크 (WBAN)는 블루투스 활성화 장치 및 PDA와 같은 작고 가벼운 무선 시스템 의 출현 에 의해 가능하게 되었다. 안테나 는 WBAN 시스템의 필수적인 부분입니다 및 기술적 요구 사항과 물리적 제약 여러 가지 에, 자신의 디자인 및 배치 의 주의 깊은 고려 가 필요하다. 의류 의 일부 는 건강 관리 응용 프로그램에서 추적 및 네비게이션 등의 통신 기능을 제공하기 위해 본 논문 은 착용 할 수 있는 안테나 의 디자인을 제안하고 있다. 착용 할 수 있는 안테나의 기판은 착용 할 수 있도록 하기 위해서 경량, 낮은 유지 보수, 눈에 거슬리지 않는 작은 크기로 만들도록 섬유 재료로 만든다 본 논문은 안테나 디자인 WBAN 요구 사항을 만족 하는지 확인하기 위해 섬유/기판의 유형을 포함하여 착용 할 수 있는 안테나에 대한 다른 매개 변수의 영향을 조사한다. 안테나의특성 및 동작은 무선 표준 기술 및 시스템 요구 사항에 의해 설정된 사양 을 준수 할 필요가 있다. 이것은 다양한 유닛의 송신 및 수신 주파수 대역을 적절하게 선택 될 필요가 있다는 것을 의미한다. 인체에 노출 될 수 있는 힘의 레벨에 제한이 있기 때문에, 안테나 등의 RF 시스템의 구성 요소는 이러한 제한을 충족하도록 설계 되어야한다. 직접 전력 전송 에 영향을 미치는 안테나 이득, 안전 지침 내에 전력 레벨 을 보장 하는 중요한 매개 변수이고 설계에 가장 중요하다. WBAN 안테나 및 장치와 인체 사이의 전자기 상호 작용은 또한 탐색 할 것이다 .

Abstract Wireless Body Area Networks (WBAN) have been made possible by the emergence of small and lightweight wireless systems such as Bluetooth, enabled devices and PDAs. Antennas are an essential part of any WBAN system and due to various technical requirements and physical constraints, careful consideration of their design and deployment is needed. This paper is proposing on the design of wearable antenna as parts of clothing to serve communications functions, such as tracking and navigation in health care applications. The substrates of the wearable antennas will be made from textile materials and since it is wearable, it should have a small size, be light weight, low maintenance, and unobtrusive. This proposed paper will also investigate the influence of different parameters for wearable antenna including types of textile/substrate to ensure that the antenna design satisfies WBAN requirements. The characteristics and behavior of the antenna need to adhere to specifications set by wireless standards and system technology requirements. This means that the transmitting and receiving frequency bands of the various units need to be chosen accordingly. Since there are restrictions on the level of power to which the human body can be exposed to, the antenna as well as other RF system components must be designed to meet these restrictions. Antenna gain, which directly affects power transmitted, is a critical parameter in ensuring power levels fall within the safety guidelines and so will be of primary importance in the design. The electromagnetic interaction between WBAN antennas and devices and the human body will also be explored.

Key Words : WBAN, wearable antenna, wireless systems

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1. Introduction

The concept of a Wireless Body Area Network (WBAN) was initiated for medical purposes in order to keep a continuous record of a patients' health. Wireless body area networks can be used for the long term and continuous monitoring of patients even when they are on move. Sensors are placed around the human body to measure specified parameters and signals in the body, such as blood pressure, heart signals, sugar level, and temperature. The sensor data in most hospitals are usually transferred through wired networks. This requires a number of wires between the sensors and the data acquisition systems, which a inconvenient and hamper patient movement. Nowadays there are many wireless communication solutions available and many of them are intended for short range use and are reasonably power efficient. The BAN (Body Area Network) is a very useful and efficient way of carrying health information[1]. As an extension to sensors, base units can be deployed on or close to the human body to collect information or relay command signals to the various sensors in order to perform a desired operation. Figure 1 presents an illustration of the kind of WBAN applied in healthcare services.

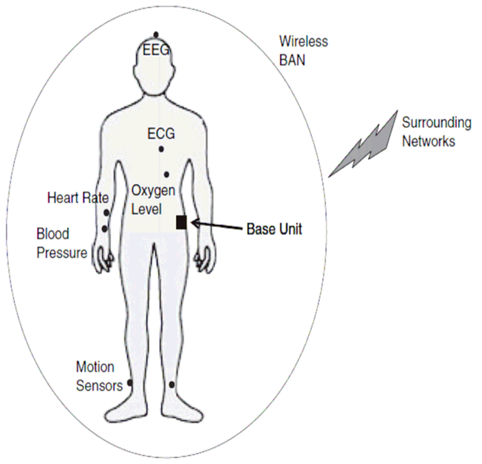

Fig. 1. WBAN Application in healthcare care

WBANs can be applied in many fields, such as: assistance to emergency services such as police, paramedics and fire fighters; military applications including soldier location tracking, image and video transmission and instant decentralized communications; augmented reality to support production and maintenance; access/identification systems by identification of individual peripheral devices; navigation support in the car or while walking and pulse rate monitoring in sports.

The antenna is an essential part of any wireless body-centric network. Its complexity depends on the radio transceiver requirements and also on the propagation characteristics of the surrounding environment. For the conventional long to short wave radio communication, conventional antennas have proven to be more than sufficient to provide the desired performance, whilst minimizing the restraints on cost and production time. On the other hand, for today's and tomorrow's communication devices, the antenna is required to perform more than one task – that is, it needs to operate at different frequencies and use different textiles/substrates to account for the increasing new technologies and services available to the user. Therefore, care is needed in designing antennas for body-worn devices (parts of clothing), which are often hidden and small in size and weight.

Antennas also play a vital role in defining the optimal design of the radio system, since they are used to transmit/receive the signal through free space as electromagnetic waves from/to the specified destination. However, the characteristics and behaviour of the antenna need to adhere to certain specifications set by the wireless standard or system technology requirements. This means that the transmitting and receiving frequency bands of the various units need to be justified accordingly. Another important parameter is the antenna gain that directly affects the power transmitted. Since there are restrictions on the level of power to which the human body can be exposed, the design of the antenna and the other RF components requires careful consideration. The electromagnetic effect of human body also needs to be considered since the body may be located near to radio frequency sources.

The human body has a high dielectric constant with a high loss tangent and low conductivity in the microwave frequency band. Therefore, the gain and radiation efficiency of an antenna can be deteriorated when an antenna is operated on or in the human body[2]. So in designing antennas for wearable and handheld applications, the electromagnetic interaction among the antennas, devices and the human body is an important factor to be considered.

2. Overview and Proposal

Conventional antenna parameters include impedance bandwidth, radiation pattern, directivity, efficiency and gain which are usually applied to fully characterize an antenna. These parameters are usually presented within the classical situation of an antenna placed in free space. However, when the antenna is inside or in close proximity to a lossy medium, such as human tissue, the performance changes significantly and the parameters defining the antenna need to be revisited and redefined.

Recently some antennas, such as dual-band antenna[3], microwave patch antenna[4] and loop antenna[5-6], have been proposed in the application of wireless body area networks. However, on-body channel modelling depends on the type of the antenna used and the on-body location it is placed at[7]. In addition, each antenna behaves differently in different body positions[8]. Transferring high resolution images from digestive organs needs wide bandwidth at high frequency, which makes UWB (Ultra Wideband) very attractive and to be fitted in to the medical device, the antenna needs a very small size, while providing huge bandwidth. The differences on the permittivity and conductivity of the environment where antenna is to be implanted with those of free space, makes antenna performance evaluation very difficult[6]. Therefore numerous challenges need to be overcome.

In this proposed paper, the concentration is focused on wearable antenna, which can become integrated into clothing for communication purposes, such as tracking and navigation for health care applications. Thus, the substrates of the wearable antennas will be made from textile materials. Since the antenna is wearable, it should have a small size, be light weight, low maintenance, and be unobtrusive.

This proposed paper will also investigate the influence of different wearable antenna parameters and different types of textiles/substrates for antenna design to satisfy the demands for WBAN. The characteristics and behaviour of the antenna need to adhere to certain specifications set by the wireless standard or system technology requirements. This means that the transmitting and receiving frequency bands of the various units need to be justified accordingly. Another important parameter is the antenna gain that directly affects the power transmitted. Since there are restrictions on the level of power to which the human body can be exposed, the design of the antenna and the other RF components requires careful consideration. In designing antennas for wearable and handheld applications, the electromagnetic interaction among the antennas/devices and the human body is an important factor to be considered.

3. Methodology and Feasibility Analysis

Wearable antennas are required to be insensitive to the proximity to the body and to have a radiation pattern that minimizes the link loss among wearable antennas and communication units in the WBAN. Microstrip patch antennas are chosen as an example of a low-profile wearable antenna. A typical microstrip patch antenna consists of three layers, a ground plane, substrate and conductor patch. This antenna is planar

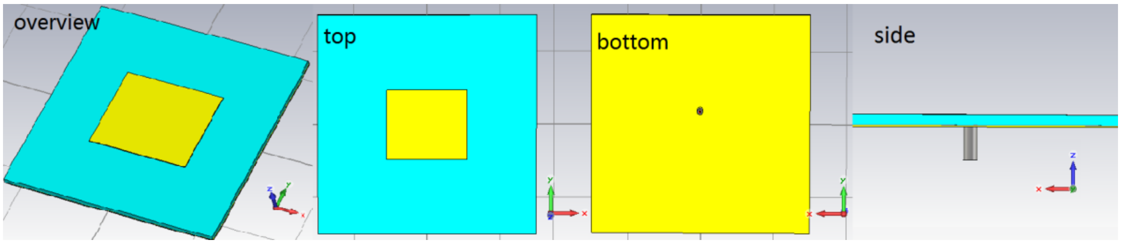

Fig. 2. the design of the patch antenna under investigation that operates at 2.45 GHz.

and potentially conformal to the human body. It has minimal sensitivity to body proximity, presumably due to the effects of the ground plane. It is necessary to mention that this antenna is presented as reference design that could be modified and further miniaturized to suit wearable technologies requirements.

Microstrip patch antennas radiate close to their resonance frequency and the radiators main dimension is usually a half-guided wavelength at the operating frequency. Rectangular patches represent the simplest and most widely used configuration of the microstrip printed antenna. Figure 6.6 shows the design of a patch antenna under investigation that operates at 2.45 GHz. Antenna modelling is performed using the finite integral technique (FIT) utilized within Computer Simulation Technology (CST) Microwave Studio®.

Figure 2 shows the design of the patch antenna under investigation that operates at 2.45 GHz.

The on-body antenna performance is numerically (in addition to experimentally) investigated by applying a one-layer human tissue slab model (muscle with $\epsilon_r = 53$ and conductivity = 1.7 S/m at 2.4GHz, dimensions 120×120×40mm). The detuning experienced when placed on the body is not significant due to the ground plane size.

However, for smaller antennas and ground planes the detuning will be more significant and apparent. The radiation performance of the antenna when placed on the chest was experimentally measured and compared to the pattern obtained in free space and also to simulated patterns obtained by numerical modelling techniques.

4. Conclusions

Wireless body area networks have been made possible by the emergence of small and lightweight wireless systems such as Bluetooth, enabled devices and PDAs. Antennas are an essential part of any WBAN system and, due to varying requirements and constraints, careful consideration of their design and deployment is needed.

This project will investigate wireless body area networks and their progression from WLAN and WPAN to satisfy the demand for more personal systems. As an inseparable part of the whole communication system, specifically in WBAN, the influence of different antenna parameters and types on the radio propagation channel is of great significance, especially when designing antennas for wearable personal technologies.

The antenna performance evaluation and radio propagation characterization provides indications of potential developments in designing optimum performance sensors. Improvements are necessary in antenna design, matching circuitry and also sensor layout for better coverage area and also to achieve the maximum range with respect to the transceiver module.

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References

[1] P.A. Yadav, "Wireless Communication in Biomedical Sensors," Advanced Computing & Communication Technologies (ACCT), pp.513-516, 2012.

[2] K. Kwon and J. Choi. "Antennas for Wireless Body Area Network," Antennas and Propagation (EuCAP), pp.375-379, 2013

[3] K. Kwon, J. Tak and J. Choi, "Design of a dual-band antenna for wearable wireless body area network repeater systems," Antennas and Propagation (EuCAP), 2013 7th European Conference on, pp.418-421, 2013

[4] A. Michalopoulou, A.A. Alexandridis, K. Peppas, et al., "On-body channel statistical analysis based on measurements in an indoor environment at 2.45 GHz," IET Microwaves, Antennas & Propagation,vol.6, no.6, pp.636-645, Apr. 2012

[5] T. Tuovinen, K.Y. Yazdandoost, J. Iinatti, "Ultra Wideband loop antenna for on-body communication in Wireless Body Area Network," Antennas and Propagation (EUCAP), 2012 6th European Conference on, pp.1349-1352, 2012

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

[7] A. Michalopoulou, A.A. Alexandridis, K. Peppas, et al., "Statistical Analysis for On-Body Spatial Diversity Communications at 2.45 GHz," IEEE Trans. Antennas Propag. vol.60, no.8, Aug. 2012, pp.4014-4019, 2012.

[8] A. Michalopoulou, T. Zervos, K. Peppas et al. "The influence of the wearable antenna type on the on-body channel modeling at 2.45 GHz." Antennas and Propagation (EuCAP), 2013 7th European Conference on, pp.3044-3047, 2013

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