PERFORMANCE CHARACTERISTICS ON PATCH ANTENNA WITH SAR REDUCTION USING ARTIFICIAL MAGNETIC CONDUCTOR (AMC) FOR WBAN APPLICATIONS

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Sincerely dedicated to my beloved Mother, father and my Siblings

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ABSTRACT

Great advances have been made in the area of wireless body area networks (WBANs) of improving wireless communication technology since the invention. These advances range in refining, size reduction and shape, gain improvement, more efficiency and combination of the requirements for applications which include health monitoring, military and personal navigation entertainment. Several types of antennas have been developed for WBANs and they have achieved narrow bandwidth, decrease gain, low radiation efficiency, a high specific absorption rate (SAR) value, high front-to-back ratio (FBR) and structural complexity. However, it is necessary to achieve better performance antenna for less impact of frequency detuning, by improving FBR, high radiation efficiency and reduce SAR for WBAN application. Conventional patch antennas are adopted since they can be low weight, low profile and easy to integrate with the device. Having these unique characteristics, patch antenna has shown to have clear advantages for WBAN applications. Since an antenna is placed a close to the human body with its curvatures and complexities, the antenna performance must be taking into account the structural, mismatch, and losses caused by the body, while simultaneously sustaining optimum performance. This work proposes to design, analysis and optimization of low-profile antenna integrated with Artificial Magnetic Conductor (AMC) for WBAN applications. Multilayer model of the adult human body at the frequency band of the proposed antenna is used, which helps to study the effects of the human on the antenna performance. The results showed that the presence of human head affects the antenna performance in terms of radiation pattern, efficiency and S_{11} and SAR values on the body parts. To further improve the performance of the proposed antenna design, several techniques have been developed in reducing SAR value with low complexity using AMC to realize broadside radiation for on /off body communication. AMC structure and miniaturized reflector reduce the back radiation and the impact of frequency detuning due to high losses of human body and the two proposed techniques are mounted on human head phantom. In addition, AMC improved FBR by 15.3 dB with enhanced of gain 7.61 dBi and radiation efficiency more than 88 %. The AMC have achieved 93.7 % reduction of the initial SAR value while metal reflector achieved a reduction of 77.7 %. Then, the antenna is fabricated and measured to validate the concept. Thus, the proposed antenna with AMC structure was designed and fabricated using two different materials for far-field radiation pattern measurements. The measured and simulated results reveals that proposed antenna with AMC array shows good impedance matching and far-field radiation pattern .Therefore, the proposed antenna is a potential candidate for WBAN.

ABSTRAK

Kemajuan besar telah dicapai dalam bidang rangkaian kawasan badan tanpa wayar (WBANs) untuk meningkatkan lagi teknologi komunikasi tanpa wayar sejak penciptaannya. Kemajuan ini merangkumi penambahbaikan dari segi pengurangan saiz dan bentuk, peningkatan gandaan, lebin cekap, dan gabungan semua keperluan bagi pelbagai aplikasi termasuk pemantauan kesihatan, tentera dan hiburan navigasi peribadi. Beberapa jenis antena telah dibangunkan untuk WBAN dan telah mencapai lebar jalur yang sempit, penurunan gandaan, kecekapan radiasi yang rendah, nilai kadar penyerapan tertentu (SAR) yang tinggi, nisbah-depan-belakang (FBR) yang tinggi dan pengurangan kerumitan struktur. Walau bagaimanapun, adalah penting bagi mencapai prestasi antena yang lebih baik untuk mengurangkan kesan nyahtala frekuensi, dengan meningkatkan nisbah FBR, meningkatkan kecekapan radiasi serta mengurangkan bacaan SAR yang sesuai untuk aplikasi WBAN. Antena tampalan konvensional diadaptasikan kerana ia bersifat ringan, berprofil rendah dan ianya mudah untuk diintegrasikan dengan peranti. Dengan memiliki ciri-ciri yang unik ini, antena tampalan telah menunjukkan kelebihan yang jelas untuk aplikasi WBAN. Oleh kerana antena sentiasa berhampiran dengan tubuh manusia dan berbentuk lekuk dan rumit, prestasi antena mesti diambil kira berdasarkan kepada struktur, ketidakserasian dan kehilangan yang disebabkan oleh tubuh manusia dalam masa yang sama mengekalkan prestasi yang optimum. Kajian ini memberi tumpuan kepada reka bentuk, analisa dan pengoptimuman antena berprofil rendah yang disambungkan dengan aplikasi Konduktor Magnetik Buatan (AMC) untuk WBAN yang dicadangkan. Model simulasi pelbagai lapisan kepala manusia dewasa pada jalur frekuensi dan antena digunakan, bagi membantu pengkajian tentang kesan manusia terhadap prestasi antena. Hasil kajian yang diperolehi menunjukkan kehadiran kepala manusia berhampiran antena memberi kesan terhadap prestasi antena tersebut terutamanya pada corak radiasi, kecekapan dan S_{11}, ia juga memberi kesan terhadap bacaan SAR dan pengedaran gelombang pada bahagian badan. Untuk mempertingkatkan lagi prestasi rekabentuk antenna, beberapa teknik telah dilaksanakan dalam mengurangkan bacaan SAR dengan kerumitan yang rendah menggunakan AMC untuk merealisasikan radiasi sisi lebar bagi buka/tutup komunikasi pada badan. Struktur AMC dan reflektor mini mengurangkan radiasi belakang dan impak frekuensi nyahtala disebabkan kehilangan oleh tubuh manusia yang tinggi, dan kedua-dua teknik yang dicadangkan telah dipasang kepada model kepala manusia. Tambahan pula, AMC meningkatkan bacaan FBR sebanyak 15.3 dB dengan peningkatan gandaan sebanyak 7.61 dBi dan kecekapan radiasi lebih daripada 88 %. AMC telah mencapai pengurangan nilai SAR awal sebanyak 93.7 % manakala reflektor logam mencapai 77.7 % pengurangan nilai SAR awal. Untuk mengesahkan konsep yang dicadangkan, antena menggunakan struktur AMC telah direka dan difabrikasi dengan dua bahan yang berbeza untuk pengukuran corak sinaran medan jauh. Hasil simulasi dan pengukuran antena menggunakan tatasusun AMC array menurnjukkan padanan yang baik dan corak sinaran medan jauh. Oleh itu, antena ini merupakan calon yang berpotensi untuk WBAN.

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LIST OF SYMBOLS AND ABBREVIATIONS

λo	-	Wavelength of radio waves
$\mathcal{E}r$	-	Dielectric constant
$\mathcal{E}reff$	-	Effective dielectric constant
c	-	Speed of light
Zo	-	Characteristic impedance
Tx	-	Antenna transmission
Rx	-	Antenna receiving
fc	-	Resonance frequency
dB	-	Decibel
GHz	-	Gigahertz
BW	-	Bandwidth
$S11$	-	Reflection coefficient
SMA	-	Surface Mount Adapter
DGS	-	Defected Ground Structure
EBG	-	Electromagnetic Band Gap
S-Parameter	-	Scattering Parameter
CST	-	Computer Simulation Technology
MWS	-	Microwave Studio Environment
PCB	-	Printed Circuit Board
VSWR	-	Voltage Standing Wave Ratio
RF	-	Radio Frequency
WPAN	-	Wireless Personal Area Network
SAR	-	Specific Absorption Rate
FCC	-	Federal Communication Commission
(ICNIRP)	-	International Commission on Non-Ionizing Radiation Protection
EMC	-	Electromagnetic Compatibility Center

ISM	-	Industrial, scientific, and medical radio band
IEEE	-	Institute of Electrical and Electronics Engineers
MRI	-	Magnetic Resonance Imaging
FBR	-	Front-to-Back Ratio
CSF	-	Cerebrospinal Fluid
VNA	-	Vector Network analyzer
SAM	-	Specific Anthropomorphic Mannequin
WBAN	-	Wireless Body Area Network
FDTD	-	Finite-Difference Time-Domain
BCCs	-	Body Coupling Communications.
ERC	-	European Radio Communications Commissions
UBW	-	Ultra-Wideband
MIMO	-	Multiple-Input-Multiple-Output
EM	-	Electromagnetic

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Antenna is a significant element for transmitting and receiving signals from the environment and air, as a medium in the radio frequency (RF) system. Without proper antenna design, signals generated by the RF system will not be transmitted and the signal is will not be detected in the receiver. Therefore, antennas have been developed into different categories or shapes and implanted commonly in everyday application, such as personal communication, home electronics, warfare electronics and transportation.

The significance of antennas in wireless associations cannot be neglected and this is obvious in every portable device without a link association. Even though the trend in communication is moving towards wireless, there are users who care about their health, since there are some potential health effects coming from the electromagnetic field radiated by the antenna inside wireless device.

This chapter provides the motivation of the thesis and background of the research work carried out throughout this thesis. Problem statement is defined according to the conventional systems used to verify the purpose of this study. Later, the objectives of the study were discussed to solve the problem. The scope of the research ensures that work and steps are described in detail to achieve the stated objectives. The flow of the thesis is indicated at the end of the section containing a brief introduction to each section of the thesis.

1.2 Background and Motivation

Over the last decade, great research efforts have been made to characterize exposure to radio frequency (RF) below 10 GHz for bands where most radio communications resources operate. The exposure limits proposed by the International Commission on International Protection Indicators (ICNIRP) should not exceed 2 W/kg over 10 g tissue. On the other hand, most studies described the close interactions between biological tissues and antennas that focus on frequency below 3 GHz but were limited to body area network application.

Wireless body area network (WBAN) has attracted greater attention to providing the necessary communication needed for applications such as network applications, health monitoring, military and personal navigation entertainment [1-5]. However, the design of the WBAN antenna faces the biggest challenge in using the particles needed to fully understand the characteristics of the antenna and the loss of propagation in the existence of the human body [6]. For this reason, the importance of a high-efficiency antenna during body proximity becomes a necessity. In particular, the proximity of the body minimizes the efficiency of the antenna and maximizes radiation pattern irregularities and impedance detuning. Additionally, the impact of WBAN radiation on the human body is characterized by a specific absorption rate (SAR), which must be considered to avoid any effect on the human body and the value must be a minimum [7]. Figure 1.1 indicates the general structure of WBAN system.

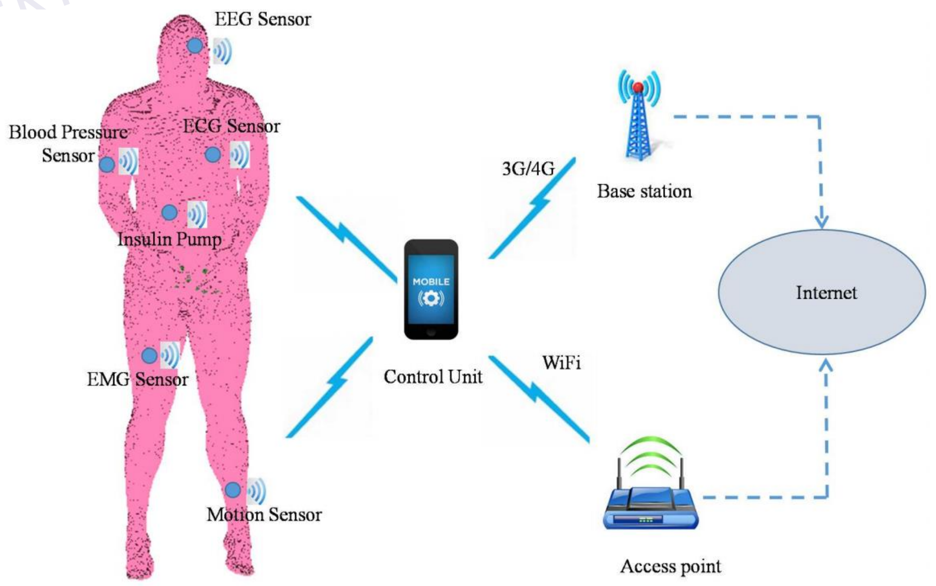

Figure 1.1: General structure of WBAN system [8]

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