A Wearable Health-Monitoring System for Medical Emergency Alerts Based on Textile Radiators and Indoor Radar supporting Fall-Detection, Localization and Telemetry

Ping Jack Soh, *Student Member, IEEE*, and Guy A. E. Vandenbosch, *Fellow, IEEE.*

***Abstract*—The main objective of this fellowship is to design, develop and integrate a simple, low-cost, unobtrusive health monitoring system consisting of transceivers, sensors and textile antennas for the purpose of fall-detection, target localization and telemetry. Besides that, this system also co-operates with an indoor a non-contact indoor radar operates between 6 and 7 GHz, with a maximum EIRP of -41.3 dBm/MHz. For this purpose, a unidirectional antenna system with low mutual coupling has also been developed.**

***Index Terms*—Wearable antennas, radars, health monitoring.**

I. INTRODUCTION

FALLS are the leading cause of injury-related visits to emergency departments, and even the primary reason of accidental deaths for home-bound and semi-mobile seniors over 65 years [1]. Men and women from this target age group who experience this and remain on the floor for more than an hour are most likely to suffer from various medical complications, with half of them dying within the next six months. Thus it is imperative that cost-effective and consistent medical monitoring for such a group is provided to enable an immediate dispatching of medical assistance, both indoors and outdoors.

An effective alternative would be to directly link this alert to emergency response services through wearable systems such as those reviewed in [2]. These systems are realized by integrating a variety of sensors onto a vest (Electrocardiography (ECG), respiration, temperature and fall sensors), besides featuring telemetry mechanisms to channel information back to health-monitoring personnel through the use of existing wireless infrastructures and protocols, e.g. GSM, Bluetooth, WLAN, WPAN, WBAN. To provide a consistent balance between privacy and monitoring effectiveness, the use of a remote fall-detection radar installed indoors, coupled with a worn system for outdoors, is considered most ideal. For both purposes, the use of low-profile, conformal radiators in such body-worn systems is crucial in guaranteeing user's comfort,

without limiting their regular movements. Textile antenna systems are regarded as one of the most realistic candidates in achieving these requirements, offering sufficient flexibility, conformality and ergonomicity [4-5]. Moreover, this flexible system also offers seniors additional fall localization when worn indoors.

The authors are with the ESAT-TELEMIC Research Division, KU Leuven, 3001 Leuven, Belgium. (e-mail: pingjack.soh@kuleuven.be, guy.vandenbosch@kuleuven.be).

II. RESULTS AND DISCUSSION

A. Radar Antenna and System

To realize antennas for the indoor radar system, a set of well-directed, compact and unidirectional radiators is required. This commonly involves the use of wideband planar monopole structures, which can only exhibit wide bandwidth using a partial ground plane at its reverse. This results in bi-directional broadside radiation, which is undesired. Reducing back-radiation using a full ground plane results in impedance bandwidth degradation. Moreover, in a typical radar system, an antenna element will be used for transmitting, and another for receipt. To achieve compactness, these two antennas will need to be spaced as closely as possible, which will consequently give rise to high mutual coupling. When uncontrolled, the relatively higher transmitted power will 'overflow' to the adjacent receiving antenna, overwhelming the information-containing, low-powered receive signals, which must be extracted and processed to determine the targets' condition.

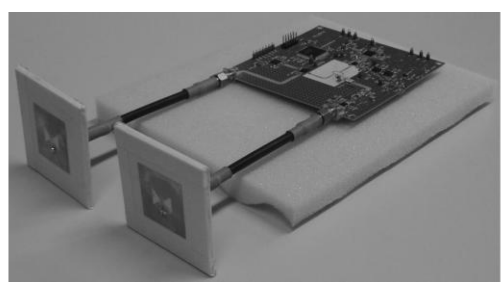


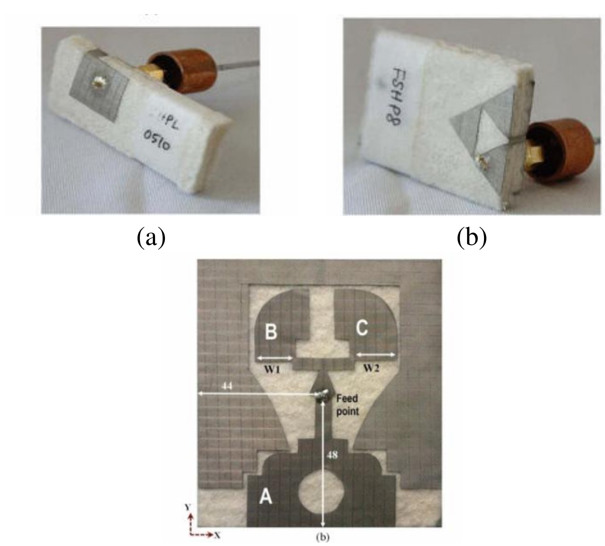
Fig. 1. Developed antenna integrated from the indoor radar system [6].

In this research, existing bowtie-based antenna have been improved in terms of back radiation suppression and miniaturization. This has been achieved via the integration of an artificial magnetic conductor (AMC), which functions as a perfect magnetic conductor (PMC) within the radar operating frequency range [6]. This structure, shown in Fig. 1, enables the PMC, which functions as a ground plane and reflector, to be placed closer to the radiating element, hence effective miniaturization and back radiation suppression. This is done without compromising the antenna matching and radiation patterns, as it maintained a large bandwidth and high front-to-back ratio.

B. Wearable Antennas and System

On the other hand, for the wearable antenna system, the existence of large back radiation is expected to degrade its immunity against absorption by the human body when worn. This will then result in bandwidth and reflection performance changes, besides significant efficiency and gain reductions [7-8]. Moreover, due to the intended placement of contact sensors on the reverse side of the antenna system (i.e. directly on the body), excessive back radiation will cause interference to sensors' operation in the antenna's vicinity.

To mitigate this, efforts have been concentrated on suppressing the back radiation of the wearable antenna, while keeping it in a flexible form factor, as shown in Fig. 2. This is found to be effective by implementing it in the form of a composite right/left handed (CRLH) concept [9].



(a) (b)

(c)

Fig. 2. Textile-based antennas designed in this work (a) planar inverted-F antenna (PIFA) [4], (b) fractal PIFA [3], and (c) microstrip-based UWB antenna [10].

Besides improving the existing narrowband wearable antenna, this research has also concentrated in exploring the possibility of utilizing the Wireless Body Area Network Ultra-Wideband (WBAN-UWB) frequency band for vital sign/health monitoring in a worn form. To minimize coupling to the body, the antenna was designed based on the narrowband microstrip antenna, which features a full ground plane, before being integrated with seven broadbanding techniques and optimized [10]. This has resulted in a robust antenna when evaluated on- and off-body in both time- and frequency-domains [11]. Besides this, a comprehensive validation of the safety level of the textile antennas have been performed by characterizing their specific absorption rate (SAR) in various frequency bands [12-13].

III. Impact Statement

I am truly honored to have my research recognized by the IEEE MTT-S via this fellowship. It has provided me with the opportunity to attend IMS 2013 in Seattle. The additional financial support from this fellowship also allowed me to expand my research scope and resulted in several additional collaborations and publications.

IV. Career Plans

The recognition from this fellowship has increased my interest and confidence in pursuing deeper research work in antennas for health monitoring applications. Upon completion of my PhD study, I plan to pursue a career in research as a Postdoctoral Researcher prior to joining a university as an Assistant Professor.

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