Chapter 7
Reconfigurable Low-Profile Antenna-Based Metamaterial for On/Off Body Communications

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ABSTRACT

This chapter proposes a novel method to reduce the specific absorption rate (SAR) of a compact CPW antenna. A combination of three efficient techniques is employed to develop a dual-band bowtie metamaterial antenna with safer SARs. Following this approach, the authors have designed a low-profile antenna with a footprint of only $0.074\lambda_0^2$ and low backward radiation. The simulated results confirm the antenna's suitability for wireless body area network devices operating in the Unlicensed National Information Infrastructure (U-NII) at 5.33 GHz and 18.17 GHz frequency bands for military radar applications. The authors have developed two oppositely faced B-shaped resonators to form the bowtie-shaped DNG unit cell. A compact size and dual-band operation were attained by loading the bowtie-shaped into the CPW antenna. The antenna's conception used the available package CST software, printed on Rogers RT5880, and the CPW-fed monopole mechanism for the excitation.

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INTRODUCTION

The rise of modern telecommunication technologies for near-body communications applications like health care (Lee et al., 2015), defense (Hu et al., 2015), sports (Hall & Hao, 2012), and personal security (Koo et al., 2015) requires the design of a new category of antennas that do not cause any health risks, at the same time, offers a high degree of comfort, mentioning flexible and miniature (Alemaryeen & Noghanian, 2017; Mantash et al., 2016; Yan & Vandenbosch, 2016) Antennas are an imperative element of those systems, which compose the communication support between a device on the user and the off-body equipment. Consequently, the correct design of WBAN antennas is crucial, not only due to the ongoing growth in traffic demands but also because of the intense influence of the electromagnetic properties of the human body on the performance of these antennas.

The body-worn antenna robustness is inversely proportional to the amount of power absorbed by the human body per unit mass(Erkan & Gamze, 2018). The degree of isolation from the human body is defined by the Specific Absorption Rate (SAR), which controls the coupling between the antenna and the dissipative biological tissue and maintains it under the level set by the standards. In this regard, two intentional norms are presented for the safety limits measured in W/kg, the American National Standard Institute (ANSI) and the European International Commission of Non-Ionizing Radiation Protection (ICNIRP). The values of 1.6 W/kg and 2 W/kg averaged over 1g and 10g of tissue are defined as the maximum acceptable limit of the specific absorption rate (SAR).

The antenna designers recounter a compromise between the antenna robustness, which requires a large ground plan, and the user's comfortability requires a small footprint (Hall et al., 2007; Nepa & Rogier, 2015). Further, reducing the electrical size of the antenna results in a decrease in efficiency and bandwidth. The suggested solution to overcome the narrow bandwidth is manufacturing a miniature frequency reconfigurable antenna when the communication standard allows it. As a result, instantly limited bandwidth will be possible.

Traditionally, wireless systems are designed for a predefined application. The increase in the need for telecommunications means involves the creation of new frequency standards (3G, 4G, Wifi, Etc.) and poses increasingly significant constraints on telecommunication systems. Indeed, conventional miniature antennas cannot meet these new requirements because they operate on predefined narrow bands, and their design subjects them to solid physical limits (narrow bands, efficiency, Etc.). Emerging wireless communications applications require advanced antenna systems that can meet the needs of frequency diversification, efficiency, small footprint and power consumption. For this, the reconfigurable antenna can be the solution to meet the new standards.

Reconfigurable antennas were introduced for the first time by 1998 to expand the functional possibilities of common antennas by changing their configurations according to demand. The antenna reconfigurability is achieved by an intentional redistribution of the currents or, equivalently, the electromagnetic fields of the effective aperture of the antenna. As a result, reversible changes in antenna impedance or radiation properties. The reconfigurable approach offers significant advantages of compactness and flexibility. Also, when considering the interference levels at the receiver, they are the best option since only one band is in use at any given time.

A reconfigurable antenna is said to be ideal if it is capable of immediately varying all its characteristics over an extensive range. In this chapter, the authors are interested in the frequency reconfiguration of miniature antennas by paying particular attention to the evolution of the adaptation and the radiation efficiency over the entire frequency tuning range.