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TEXTILE MIMO ANTENNA FOR WIRELESS BODY AREA NETWORKS

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Introduction: MIMO systems [1] have recently proven to be an attractive option for Wireless Body Area Networks, in which body shadowing and user motion lead to multiple rapid changes in the channel characteristics. In this kind of networks, multiple antennas can be used in combination with space-time coding, to save transmit power or to reduce the probability of link failure due to body shadowing [2]

However, the integration of multiple antennas in the personal sphere is not easy, due to the usually limited available space. A possible solution for this scenario is to implement the MIMO system using multimode antennas[3]-[4]. A multimode antenna is an antenna in which several radiating modes [5]-[6] are excited separately on the same antenna structure at the same temporal frequency. This results in multimode diversity, a combination of pattern and polarization diversity to obtain uncorrelated channel impulse responses for MIMO systems.

This paper proposes a multimode MIMO antenna design for Wireless Body Area Network applications operating in the 2.45 GHz Industrial, Scientific and Medical (ISM) band. The antenna consists in a simple metallic circular ring with capacitive loading. Since only a single antenna is used, the space necessary in human body is minimized. The multimode behavior is obtained by using four feeding ports excited with specific phase configurations. The multimode behavior helps to reduce the attenuation and multipath propagation caused by the human body. Moreover, the antenna is implemented on a textile substrate to guarantee its flexibility and conformability, and to favor its integration into clothing.

Textile Substrate Characterization: Several test methods have been used in order to estimate the dielectric constant and loss tangent of the 100% cotton fabric that is used as dielectric substrate for the multimode antenna. The first method that is shown in Fig. 1 is based on the used of a split resonant cavity. This estimation technique is very precise, but only provides results for a single frequency. The second method utilizes the S-parameter measurements of two microstrip transmission lines of different lengths [7]. Knowing the length difference and the S-parameters, the permittivity and loss tangent between 1 and 3 GHz is extracted for the textile substrate. Finally, the third method estimates the permittivity and loss tangent by analyzing the resonances of a printed open stub [8]. A photograph of the measurement board used for the second and third methods can be seen in Fig.2. The layout includes two thin microstrip lines (TMSL) of different lengths, a TRL (Through, Reflect, Line) calibration kit, and a transmission line with an open stub. Results provided by the three methods are in good agreement. In all cases the permittivity obtained for the fabric is close to 1.7, and the loss tangent is approximately 0.06.

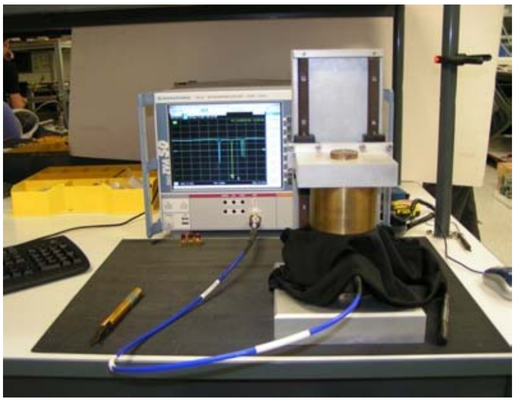

Fig.1: Split cavity used for the estimation of the electric properties of the textile fabric.

Fig.2: Measurement board that includes two thin microstrip lines of different lengths, a TRL calibration kit, and a transmission line with an open stub.

Antenna Structure and Results: Fig. 3 (a) shows the geometry of the proposed antenna that consists in a metallic circular ring with four slots placed at $\phi=\pm45^o$ and $\pm135^o$, that act as capacitive loading. These slots allow the control of the resonances of the orthogonal modes that will provide the desired multimode operation, so all of them would resonate at the same frequency band. In this case, the dimension of the slots has been chosen in order to fix the operation bandwidth of the desired modes close to 2.45 GHz. The multimode operation is accomplished by exciting the antenna with the four L-shaped microstrip lines shown in Fig. 3 (b). As observed, these feeding lines are symmetrically distributed along the structure. An hybrid microstrip network has also been designed in order to obtain the desired phase configurations at the different ports.

The dielectric substrate used for the design is a common 100% cotton fabric. A commercially available electrotextile with a very high conductivity (surface resisitivity <0.1 Ω/sq) has be used for circular ring, feeding lines, and the ground plane.

Fig.4 shows the return loss obtained at each port of the antenna when using the different feeding configurations. Because of the symmetry of the structure, the return loss obtained at every port is exactly the same. Considering a reference value of -6 dB for the return loss, a bandwidth (BW) of 2.4% is obtained for the proposed design.

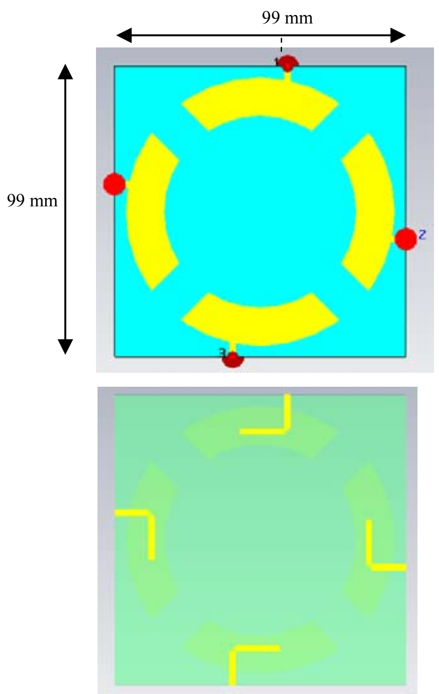

Fig.3: (a) Geometry and dimensions of the proposed antenna. (b) Feeding L-shaped microstrip lines.

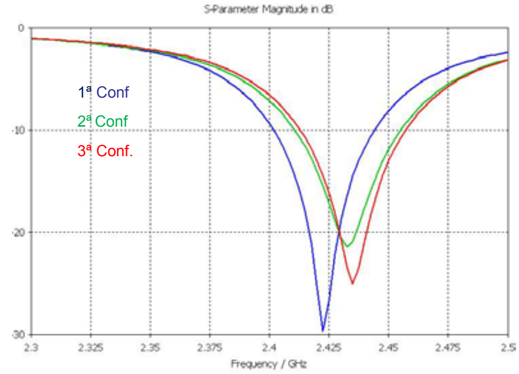

Fig. 4: Return loss obtained at each port for the different feeding configurations.

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