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Near Body Zone Characterization

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Abstract

This communication studies the path gain in a new defined Near Body Zone at 4.5 GHz. Measurement are performed around a human subject to collect the received power in three half circular sectors extending from 5 to 35 cm from the body surface. A linear path gain model is derived and discussed.

1. Introduction

Body Area Networks (BAN) raised the interest of radio scientists, due to peculiar issues concerning antennas, propagation and consumption [1]. Thus, new ideas on antenna conception and characterization for BAN have been suggested [2] and channel models have been proposed [3]. Channel studies in the field of BAN mainly concentrate on three scenarios: on-body, when the communicating nodes are at the surface of the body; off-body, when at least one node if far from the body; body-to-body, when the nodes are on the surface of two different human subjects. However, the more and more pervasiveness of wireless devices could lead to the appearance of systems that communicate at short distances to create a Near Body Zone (NBZ). It is thereafter of interest the characterization of this scenario.

In this communication we propose a static characterization of the field radiated by a body mounted antenna around a human subject in three half circular sectors ranging from 5 to 35 cm from the body. A linear path gain model is derived and discussed.

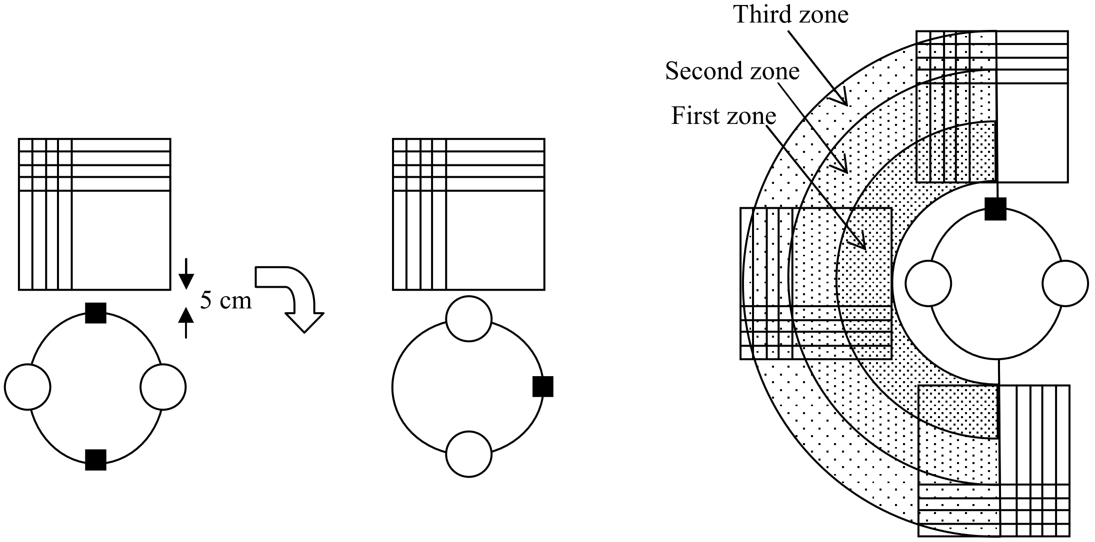
2. Measurement Campaign

We describe the measurement setup. The measurements were conducted on a human subject, whose main physical quantities are summarized in Table 1, in a room of the Université Libre of Bruxelles in the band 4 to 5 GHz. We placed one UWB omnidirectional antenna on the sternum and one identical on the back, at same height, with adhesive paper. Measurement ensured that S11 was below -10 dB for both antennas on the body and that they were adapted in the band of interest. A Vector Network Analyzer (VNA) was calibrated in order to measure the power received by the two on-body mounted antennas from a third one, identical to the others, used as transmitter. The transmitting antenna was fixed to a mechanical positioner in order to obtain 225 measures on a 30x30 cm square grid. We took 1001 measurement points in the band for each spatial point. In order to characterize the Near Body Zone, the center of the grid was placed 20 cm away the surface of the human subject, as schematically depicted in Fig. 1. We took two set of measurements: firstly the human subject was placed in front of the grid, while, in a second time, he was asked to turn clockwise by 90°. In both cases he was standing still.

Table 1
Physical quantities of the body

Parameter	Value
Gender	Male
Height	172 cm
Weight	60 Kg
Torso Perimeter (including arms)	93 cm
Equivalent radius	15 cm

By considering the human body as cylindrical, for the reciprocity principle we can consider our measurement data as the power radiated by the antenna placed on the sternum and received by the antenna moving on three grids located on the front, on the back and on the side of the human subject. We used the collected data to characterize three half circular sectors around the body, as shown in Fig. 1 (b). In the following, we will refer to the sector ranging from 5 to 15 cm from the body surface as the first zone, the sector from 15 to 25 cm from the body surface as the second zone and the sector from 25 to 35 cm as the third zone.



(a) (b)

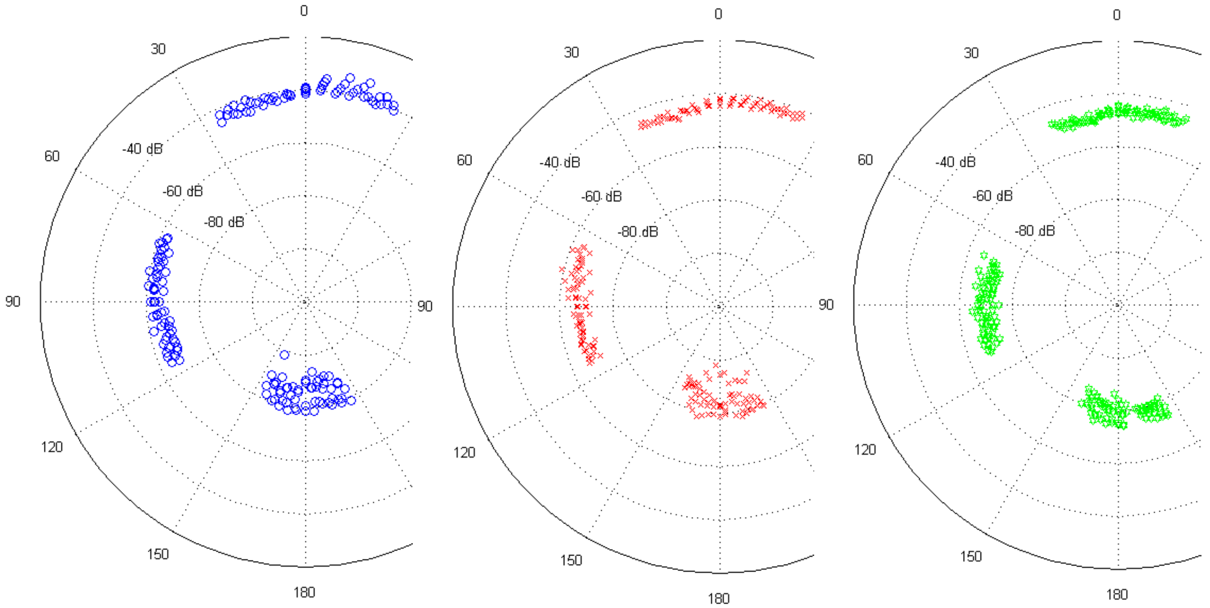
Fig. 1 (a) Schematic representation of the measurement setup: top view. The human subject is represented by a big circle (torso) and two smaller ones (arms). The black squares are the antennas placed on the sternum and on the back, at same height. A transmitting antenna collect a measure on a square grid in front of the torso of the human subject, which turns clockwise by 90 ° for a second set of measures. The measurement set is equivalent to the configuration depicted in (b), where an antenna is located on the body and three grids of measures are collected around the body.

3. Near Body Zone Characterization

We derived the path gain from the available data around the body of the human subject. We considered that the maximum propagation distance between the antennas, without reflections on the environment, is 80 cm. This value is obtained by considering the farthest point on the grid, which is 35 cm from the body, and the antenna located on the back in the first set of measures (see geometry in Fig. 1). Since the electromagnetic arrive at the receiving on the back by diffraction around the body rather than penetration, they have to travel half of the perimeter of the body, which is approximately 47 cm long. Because electromagnetic waves travel at approximately the speed of light in vacuum ($3\cdot10^8$ m/s), we integrated the received power in the range 0-3 ns to obtain the direct path between the antennas without including the energy reflected by walls, floor and ceiling.

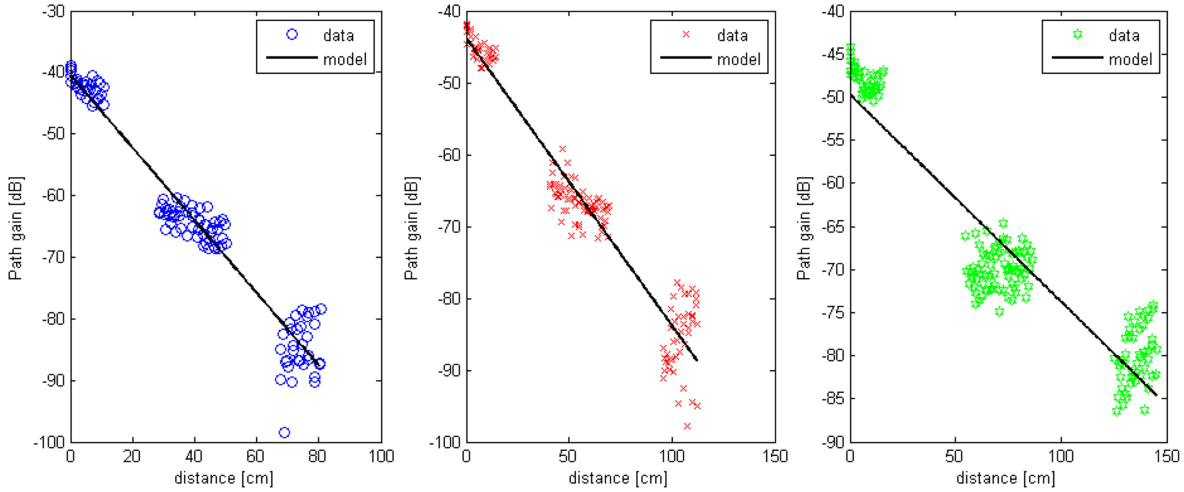
We collected the measures in the three circular sectors defined in the previous section. In Fig. 2 we report the results in polar coordinates for the three zones. It is clear that the path gain decreases as moving from the front to the back of the body. Moreover, on the front and on the side of the body, path gain decreases from zone one to zone three, while in the back the measured field is greater for zone three than for the other two. This is due to the fact that on the back, the “deep shadow region” is more pronounced close to the surface of the body [4].

The path gain has been calculated as function of the distance around the body for the three zones. Distance has been obtained by multiplying the azimuthal angle by the radius of each circular zone calculated from the center of the body (thus 25, 35 and 45 cm respectively). In Fig. 3 the path gain of the three zones is shown. A linear interpolation has been performed in order to derive a model for the path gain, whose parameters are summarized in Table 2. The path gain slope decreases from the first to the third zone, as shadowing by the human body is more pronounced close to its surface.



(a) (b) (c)

FIG. 2 Measurement results at 4.5 GHz for the first (a), second (b) and third (c) half circular zones around a human subject in polar coordinates system.



(a) (b) (c)

FIG. 3 Path gain at 4.5 GHz for the first (a), second (b) and third (c) zones around a human subject.

Table 2
Parameters of the linear path gain model

y = a*x + b	**Distance around perimeter**
First zone	a = -0.59 ; b = -40.5
Second zone	a = -0.40 ; b = -43.8
Third zone	a = -0.24 ; b = -49.8

4. Conclusions

In this communication we presented the results of a measurement campaign conducted to characterize a new defined Near Body Zone. Three half circular sectors ranging from 5 to 35 cm from the surface of a human subject have been investigated and a linear path gain model has been derived. It has been shown that path gain slope decreases from the sector that is closer to the body to the farther, since human shadowing is more pronounced in its closeness.

6. Acknowledgments

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