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Wideband Channel Measurements for Polarised Indoor Off-Body Communications

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Abstract

This paper presents the initial results of wideband channel measurements for polarised off-body communications at 5.8 GHz in an indoor environment. Channel Impulse Response measurements were performed simultaneously for two orthogonal polarisations of a wearable antenna (several placements) and repeated for vertical and horizontal orientations of the off-body one. Four types of scenarios were considered in order to investigate the influence of user dynamics, presence of people in the environment, and body-shadowing effects from the user or other persons obstructing Line-of-Sight in between transmitter and receiver. Initial results are presented.

1 Introduction

Body Area Networks (BAN) are foreseen to revolutionise and to fundamentally change the human-computer interaction we know today [1]. Some of the most promising applications exploit the communication between an on-body BAN and the surrounding infrastructure or another nearby BAN. Therefore, off-body and body-to-body communications are gaining considerable attention [2]. The performance of BAN systems highly relies on the quality of the communication channel, hence, its optimisation depends on the proper understanding of the underlying phenomena and on the availability of appropriate channel models, which account for the specific aspects of body-centric communications [3]. Having various application in mind, such as video streaming, the wideband channels, required to support high data rate demands, one needs attention and focused channel modelling efforts.

This paper presents initial results of a measurement campaign performed with the goal to investigate the influence of signal polarisation, user dynamics, and presence of people in the environment, on the characteristics of wideband off-body channels in indoor environments. A series of Channel Impulse Response (CIR) measurements were performed for both static and dynamic users, considering different off-body antenna placements.

2 Measurements Description

Measurements were performed in an office meeting room ($7\times5\times3$ m^3). The off-body antenna(s), representing an Access Point (AP), was attached to the wall on one side of the room, while the user and other people occupied the scenario area. The measurements were performed with a 4-port Vector Network Analyser (VNA) Agilent E5071C, which was used to capture CIRs for a 500 MHz wide channel at 5.8 GHz. Three VNA ports were used: one acting as transmitter (Tx), and two as receiver (Rx). The Tx pulse width was 3.9 ns, while CIRs were recorded over a 100 ns delay window, with a resolution of 0.25 ns. In total 401 sample points were obtained for each CIR. The Tx power was 10 dBm, yielding 4 dBm at the Tx antenna port, as 6 dB attenuation was introduced by the cable. Two different antenna sets were used in the measurements: Set 1 consisted of a coplanar-fed Ultra-wideband (UWB) monopole antenna at the off-body side, and a dual-polarised on-body UWB one, composed of two ring monopoles on a common substrate plate, separated by 29.5 mm; in Set 2, UWB monopole from the previous set was used as the wearable Tx antenna, while two orthogonal dual-band dipoles (vertical (V) and horizontal (H)) were used for simultaneous dual-polarised reception at the off-body side. The connections in between the VNA and the antennas were realised using 10 m long flexible coaxial cables. A detailed description of the used equipment and the main measurement parameters is available in [4].

In order to investigate the influence of different wearable antenna placements, the following were considered: front side of the torso (To_F), left side of the head (He_L), left lower arm (AL_L), and left lower leg (LL_L). In order to investigate the influence of user dynamics on the channel characteristics, three parallel paths were considered, separated by 1 m, each 6.5 m long. The measurements were performed with the user standing at uniformly spaced positions, every 0.5 m along the path, and walking at a constant velocity (≈1.3 m/s). For both the static and dynamic cases, measurements were performed with the user facing towards and away from the AP.

The second set of measurements aimed to investigate how the presence of people in the environment affects off-body channel characteristics. With the previous scenario serving as a reference, the measurements were additionally performed with 6 additional people in the room, being static, i.e. preserving fixed posture and position, quasi-dynamic, i.e. changing postures at fixed positions, and dynamic, i.e. moving across the room. Each of the scenarios were repeated for the user standing still and walking towards and away from the AP.

The third set was exclusively performed in order to investigate the body-shadowing effect. In order to analyse this effect in more detail, the measurements were performed for two types of body-shadowing scenarios, with the shadowing caused by either the user, i.e. self-shadowing, or another person, i.e. third-person shadowing.

3 Initial Measurements Results

While a considerably large measurement data set was collected during the campaign, only a few samples from the initial processing phase are presented in this paper. As a first example, Fig. 1 shows a set of the average Rx power traces vs. delay for the case with the V-polarised He_L antenna and the user standing facing the AP at different distances. The figure shows the change in the Rx power distribution over delays at different positions, where the trend is the most evident for the LoS component. Its power is observed to decrease while delay increases with distance. The average Rx power values shown in Fig. 1 are obtained by averaging over successive 50 CIR traces recorded at each distance.

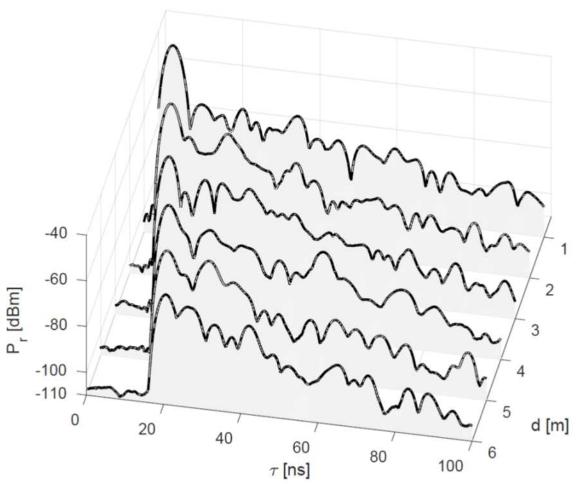

Figure 1. Rx power vs. delay and distance: He_L, static user facing towards the AP (vertical off-body antenna).

With the 3 m distance case chosen arbitrarily, Fig. 2 shows the Rx power vs. delay for both polarisations of the on-body Rx antenna. The solid line in the figure corresponds to the average Rx power, while the variations around this mean during the observation period are shown in grey. As one can observe, the co-oriented Rx antenna typically received more power than the cross-oriented one. A strong direct path component is apparent in both polarisations, being stronger in the co-polarised antenna case rather than in the cross-oriented one. A somewhat similar power distribution pattern is observed for the following multipath components, however, some late specular components after 70 ns were received only by the co-oriented Rx antenna.

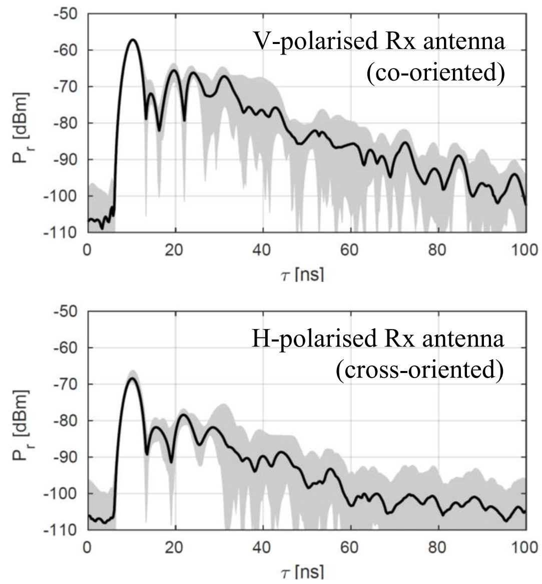

Figure 2. Rx power vs. delay: He_L, static user facing the AP at 3 m distance (vertical off-body antenna).

4 Conclusions

This paper presents a measurement campaign, whose goal was to investigate several important effects in the wideband off-body channel, namely, the influence of user dynamics, people present in the environment, and body-shadowing from the user or other persons obstructing the LoS in between Tx and Rx. A few sample results of the preliminary processing of measurements are presented. For the static user case, results show the important impact of the Rx antenna polarisation, where the power received by the cross-oriented antenna is considerably lower than that from the co-oriented one; the lower number of significant MPCs being received in the latter case. Future work will include detailed processing of the measurement data, for the purpose of channel characterisation and development of the models for the investigated phenomena.

5 References

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