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Analysis of Electric Field Strength for Planning Indoor 5.8 GHz Wireless Networks

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***Abstract*— Understanding radio channel path characteristics is a very important factor for ensuring quality of service and high data rates for indoor wireless communication systems. Obstacles such as human occupants, doors, walls, windows, etc. all have a significant impact on received signals strengths and will contribute to fading, multipath and shadowing effects. This paper studies the effects of changes within a building, such as opening and closing doors, and the movement and number of human occupants, on indoor signal propagation at 5.8 GHz. The effects of different obstacles inside the rooms are compared and highlight which has the most significant effect on the received electric field strength.**

***Keywords*— electromagnetic field strength, indoor radio propagation, energy efficient buildings, shadowing.**

I. Introduction

There is growing interest in developing techniques to predict and control radio propagation within buildings. Understanding radio channel path characteristics is a very important factor for ensuring quality of service and high data rates for indoor wireless communication systems [1] and developing new methods for providing wireless security [2]. Obstacles such as human occupants, doors, walls, windows, etc. all have a significant impact on received signal strengths and will contribute to fading, multipath and shadowing effects. As new materials are used to develop more energy efficient buildings new challenges for smart metering and mobile cellular applications are faced. In this paper the effects of changes within a building, such as opening and closing doors, and the movement and number of human occupants, on indoor signal propagation at 5.8 GHz are studied. The distribution of Electric Field strength within the building has been calculated using the FEKO simulation suite [3]. The effects of different obstacles inside the rooms are compared and highlight which have the most significant effect on the received electric field strength. This work builds on the studies performed for the suitability of 2.4GHz Zigbee based smart metering systems [4] [5].

The remainder of this work describes the simulation scenarios, analysis of the results and discussions and conclusions.

II. Design and Simulation

A. Experimental configuration

This simulation study considers a typical Victorian terrace house of three levels which are commonly found in the UK. The house includes a basement, ground floor and first floor. The first floor consists of two bedrooms while the ground floor includes a front room which is accessed directly from the front of the building and a kitchen at the rear. The kitchen is 3.5 m wide and 3.2 m long, while the front room is 3.5 m wide and 3.8 m long. The house geometry, material properties and scenario layout have been described in [6].

Geometrical Optics (GO) numerical analysis techniques were used which is suitable for solving large model and inhomogeneous structures [7]. Angular resolutions of θ=0.08° and ϕ= 0.03° have been carefully selected for this simulation while the maximum number of ray interactions used was 2. Thin Dielectric Sheet (TDS) is used to model the walls and rooms of the building. In such cases, the walls are modelled with one surface and the real thickness defined in a layered structure. Simulations were performed using a 5.8 GHz have-wavelength dipole antenna to generate the E-fields. The dipole antenna has a length of 23.26 mm and a wire segment radius of 0.5 mm. It was positioned in the kitchen 1.2 m above the ground, 0.3 m from middle wall and 0.4 m from external wall. Analysis was performed for different occupancy scenarios as described in the following section. The dielectric properties of the human body at 5.8 GHz have been chosen as described in [8], where the whole body relative permittivity was ε_r=48.2 and conductivity σ=6 S/m.

III. Simulation Results

The results presented consider the E-field amplitude distributions calculated for the ground floor of the Victorian house at 5.8GHz. Results were sampled in a plane 1.2m above the ground, at the same height as the source antenna. 840 samples of the E-field amplitude were obtained from the simulations in both the kitchen and front room. As described in [9] and [10], amplitude probability and the cumulative probability distributions of the E-field distribution have been used for analysis purposes.

Fig. 1 shows the results of E-field amplitude distribution and cumulative probability distribution for scenarios A, B, I and J, respectively within the kitchen and front room. The x-axis and y-axis represent the distribution of field levels and the probability percentage of the appearance of each field level, respectively. The results demonstrate that there is no noticeable difference in the E-field distribution in the kitchen for all four scenarios, whereas the average E-field distribution increases in the front room when the kitchen is occupied. The closed door has a great effect on the transmitted signal which results in signal degradation. The presence of the human in the kitchen also attenuated the signal levels in the front room. In the case of open door scenarios, it is clear that the presence of the human reduces the average value of the transmitted signal from -15 dBV/m to -18 dBV/m which correspond to 16.6% compared to when there was no human in the kitchen.

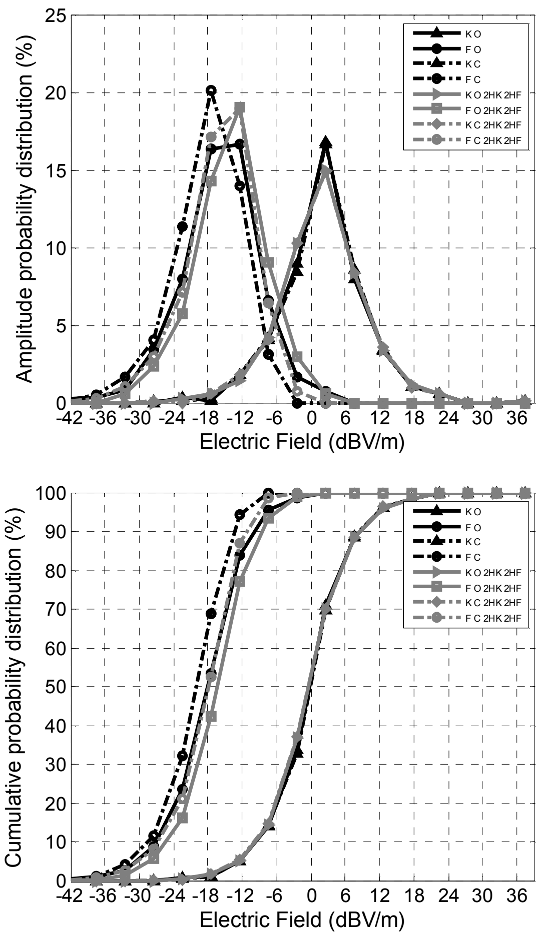

Fig. 1. E-field amplitude and cumulative probability distribution for scenarios A, B, I & J (key: K = kitchen, F = front room, O = open door, C = closed door, 2HK = two occupants in the kitchen and 2HF= two occupants in the front room).

IV. CONCLUSIONS

As understanding radio channel path characteristics is an important factor for ensuring quality of service and high data rates for indoor wireless communication systems, this paper investigates the changes in the electric field strength within the ground floor of a Victorian house at 5.8GHz. Different scenarios are considered for changing the building's occupancy level in addition to the status of opening and closing doors. The effects of different obstacles inside the rooms are compared and highlight which has the most significant effect on the received electric field strength. Results show that opening or closing doors between rooms can locally change the E-Field by approximately 9dBV/m. Furthermore, human occupants can have an effect which varies from 3 to 9dBV/m. Finally, it is shown that the human body causes attenuation due to a shadowing effect, mainly over a short range near to human body. Future work will include the investigation of other commonly used frequencies for smart wireless communications such as 868MHz and 433 MHz.

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