Modelling and Comparison of the Propagation of 433 MHz, 868 MHz, 2.4 GHz and 5.0 GHz Electromagnetic Waves within a Simulation Construction

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The propagation of 433 MHz, 868 MHz, 2.4 GHz and 5.0 GHz electromagnetic waves within a simulation construction was modelled by using a computer tool. The main aim was to model how the thickness of the wall and the wall material affect the attenuation of the electromagnetic waves. Research on electromagnetic wave propagation within a building has been going on at Tampere University of Techonology recently. (P. Ali-Rantala *et al.*: Indoor Propagation Comparison between 2.45 GHz and 433 MHz Transmissions, 2002, IEEE AP-S Interational Symposium) The research has considered modelling and measuring the wave attenuation in a building.

The wall materials used in the simulations were concrete and wood. The simulated thicknesses of both materials were 0.15 m, 0.2 m, 0.25 m, 0.3 m and 0.4 m. The electromagnetic properties that have the largest affect on the attenuation are conductivity σ, dielectric constant ε_r. (D. M. Pozar, Microwave Engineering, 22-27 and 38-46, 1990) These parameters were used in the simulations when modelling the propagation. For concrete $\varepsilon_r = 4$ and $\sigma = 0.05$ S/m. However, moisture content affects the electromagnetic properties of wood. Therefore wood was simulated by using different parameters. For example parameters $\varepsilon_r = 4.2$ and $\sigma = 1.0*10^{-5}$ S/m model the average wooden material and were therefore selected for further discussion. (Forest Products Laboratory, Wood handbook – wood as an engineering material, Chapter 3, 1999)

The length of the construction used in the simulations was 20 m, the width was 15 m and the height was 2.5 m. The construction was divided into seven rooms that were 2 – 4 m wide. The width varied between 2 and 4 meters so that the construction had similarities with real buildings (Figure 1). An omnidirectional antenna was used as a 1 mW power transmitter and it was placed in the middle of the centermost room of the construction and its height was 1 m. The gain of the antenna was about 2 dB.

It is seen from the simulation results that the attenuation properties of concrete depend not only on thickness of the wall but also on the system frequency because concrete consists of both conducting and insulating parts. It is also seen that the attenuation properties of wood depend only on system frequency because wood can be considered an insulator due to its low conductivity.

From the concrete simulation results it can be seen that for example at 868 MHz frequency when the thickness of the wall is 0.25 m in every wall and room the attenuation increases of about 15 dB (from – 20 dB to – 85 dB) (Figure 2). However, from the simulation results of the wooden wall it can be seen that at 868 MHz frequency when the thickness is 0.25 m the attenuation is about – 40 dB all over the construction.

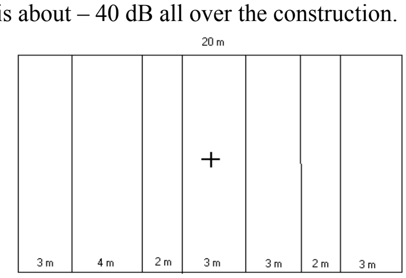

Figure 1. The simulation construction

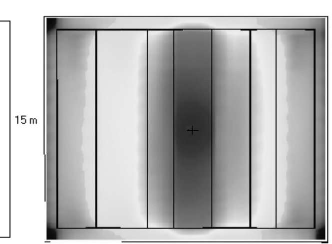

Figure 2. A simulated picture of the wave attenuation in the 0.25 m thick concrete wall at 868 MHz