Indoor Wave Propagation Simulations at HF Using Rayleigh-Gans Approximation

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In this paper indoor wave propagation issues at HF band is considered. A salient feature for wave propagation at this band is the fact that the size of objects is smaller or comparable to the wavelength and therefore high frequency methods such as ray-tracing can no longer be applied. On the other hand there are other approximations and simplifying feature exist that can be utilized to achieve accurate models as discussed below.

Analysis of wave propagation in a complex indoor environment composed of many dielectric walls is encountered often for many military and civilian applications such as wireless mobile broadband communications, and inter-floor wave propagation. Thus, it is important to understand the complex indoor propagation mechanisms, including attenuation, scattering, the ground effect, etc., to assess the performance of such radios in an urban or indoor setting. The premise of low frequency radios is in low attenuation and low multi-path fading and their major drawback for mobile applications is in the size of the antenna. With the advent of antenna miniaturization methods techniques this limitation is being removed (Oh, J., J. Choi, F. T. Dagefu, and K. Sarabandi, "Extremely Small Two-Element Monopole Antenna for HF band Applications" IEEE Transactions on Antennas and Propagation, in press 2013) .

Depending on the frequency and the size of the buildings, it is possible to use many full-wave methods such as FDTD at HF bands in order to obtain accurate results. However, these methods quickly lose their advantage for problems with large computational domains and in situations where statistical parameters of wave propagation are to be determined. As mentioned before, high frequency methods are computationally fast, but not appropriate at the desired HF and VHF bands where most interior wall dimensions are small compared to the wavelength. and hence low frequency approximations such as Rayleigh-Gans approximations can be utilized to find the scattered field. In such solutions, the fields inside the walls can easily be calculated using the appropriate polarizability tensor from which the fields in the near-field and far-field regions can easily be computed. Finally, multiple scattering can be analyzed by following an iterative procedure. Initially all the polarization currents for all walls in line-of-sight of the transmitter are computed, then the secondary scattered field is computed for all walls in the line-of-sight of the previous iteration lit walls. This process is continued until a convergence is reached and then fields are computed. In these computations the closed form of the dyadic Green's functions is used to achieve the electric field at desired receiving points.