Heuristic TD-UTD Coefficients for the Transient Analysis of Diffraction by Lossy Conducting Wedges

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Abstract— In this work the time-domain uniform theory of diffraction (TD-UTD) is applied to the characterization of radio channels in urban environments. Early-time approximations are employed to heuristically establish TD-UTD coefficients for the analysis of the diffraction by dispersive obstacle wedges.

I. Introduction

LMDS (Local Multipoint Distribution Services) demand communication signals with large bandwidths. That may require a proper wideband characterization of the radio channel—typically in an urban scenario—prior to the service launch. Such characterizations can be performed by means of time-domain (transient) analyses based on the propagation of short radio pulses from a transmitter (T) to a receiver (R). Here, we employ the time-domain uniform theory of diffraction (TD-UTD) to conduct the analysis, for its computational efficiency and versatility to handle complex environments.

II. TD-UTD for Finite Conductivity Wedges

The TD-UTD coefficients were derived by Rousseau and Pathak for perfectly conducting wedges [1]. The objective of the present work is to extend the TD-UTD to the analysis of lossy obstacles (i.e., obstacles with finite conductivities), in order to provide a more realistic wideband characterization of urban radio channels. For that, we propose the application of the analytic time transform (ATT) to frequency-domain UTD heuristic coefficients [2]-[4]. Such heuristic coefficients involve Fresnel reflection coefficients, functions of the complex permittivity ($\varepsilon_c = \varepsilon - j\sigma/\omega$) of the lossy obstacle. The ω dependence of ε_c and, consequently, of the Fresnel coefficients prevent the attainment of close-form analytical TD-UTD coefficients by the ATT [1]. However, the UTD is an asymptotic formulation, valid in the limit $\omega \to \infty$, which means that the TD-UTD is valid only for early-time wavefronts [1]. So, we propose to treat the complex permittivity in the limit $\omega \to \infty$ (i.e., $\varepsilon_c \approx \varepsilon$, with negligible frequency variation) and, consequently, to assume that the Fresnel reflection coefficients do not vary with ω. If so, the derivation of the TD-UTD heuristic coefficients is quite straightforward [1]. Note that the assumption of a constant ε_c is in agreement with the early-time aspects of the scattering from lossy obstacles, as dispersive effects are negligible in high frequencies [5].

III. Results

In order to investigate the applicability and usefulness of the procedure, the two-dimensional scenario of Fig. 1 was analyzed. The optical paths from T to R (with 5 reflections and 1 diffraction, at most) were obtained by a ray-tracing algorithm based on the image theory. A short pulse is irradiated from an omnidirectional radiator at T. The sides of the square obstacles and the distances between two consecutive obstacles are equal to 25λ, where λ is the wavelength at the central frequency of the pulse spectrum [1]. Figure 2 presents the received signal at R, obtained by the proposed heuristic TD-UTD and by a frequency-domain UTD (FD-UTD) analysis, further converted to the time domain by an inverse discrete Fourier transform (IDFT), for the sake of comparison. Both techniques essentially provide the same results.

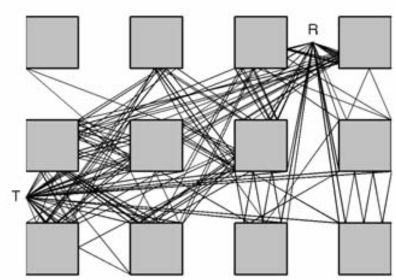

Fig. 1. Two-dimensional scenario of the TD-UTD analysis

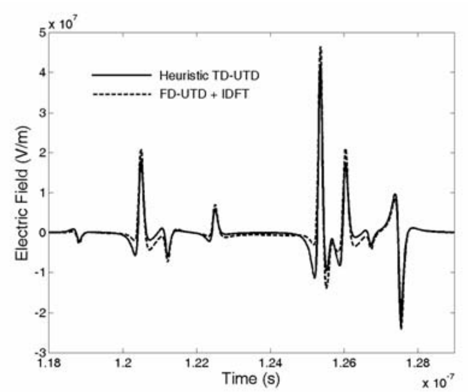

Fig. 2. Electric field amplitude at the receiver

IV. References

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