Numerically Calculated Transfer Functions for Solving Arbitrary Length Communication Signal Propagation using FDTD method*
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Finite Difference Time Domain (FDTD) simulations at mmWave frequencies for the propagation of a modulated communications waveform between a transmit antenna and receive antenna separated by a distance *D* require high-fidelity grids. At mmWave frequencies, the symbol duration of a modulated communications waveform can require thousands of FDTD time steps as a result of the Courant limit. The computational time of a FDTD simulation of thousands of symbols in a grid of millions of cells is a computationally intensive challenge. To meet this challenge, a Grid Impulse Response (GIR) approach is implemented. Previous similar work by (E. Perrin *et al*, IEEE Transactions on Electromagnetic Compatibility, 52, 173-178, 2010) demonstrates the feasibility of calculating an impulse response in the grid to enhance computational efficiency for low-frequency solutions in a FDTD grid, while another research team (K. Motojima and S. Kozaki, International Journal of Infrared and Millimeter Waves, 22, 923-939, 2001) uses a similar approach to examine frequency selective fading in waveguide structures.

A FDTD GIR is implemented for the calculation of Error Vector Magnitude (EVM) for a M-QAM signal propagating between a transmit half-wave dipole and receive half-wave dipole. The antennas separated by *D* are modeled within the FDTD grid. A delta function at the TX antenna position excites the grid to obtain a broad-band response at the receive antenna (or any grid location) to allow calculation of the GIR. Convolution of the communications waveform with the GIR gives the response at the receive antenna as if the full communications waveform had been simulated. Preliminary results show that an FDTD simulation with a 1000-symbol-duration modulated signal is 140 times slower than using the FDTD GIR. Preliminary results for accuracy using the FDTD GIR show a maximum error percentage (defined as 100 times the maximum of the absolute difference of the two simulation approaches at the receive antenna) of 4.57e-4 percent. Preliminary results for the calculation of EVM using the GIR approach give an EVM of 0.1109 percent. These results are for a 16-QAM modulated waveform at 92.4GHz, with the antenna separated by 0.2m distance (61.6 wavelengths). These results are to be compared with later experimental measurements of mmWave propagation.