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High Frequency Space Correlation Function in a 2D-Trunk Dominated Forest

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Abstract

With the emergence of 5G wireless communications networks to be deployed in forested areas as shown in Figure 1, there is the need to assess and improve the communication of these systems. One way of improving it is by using MIMO (Multiple Input Multiple Output) antennas to maximize the capacity of the system; the improvements therefore should not come just by meeting the required loss between the transmitter and the receiver, but should come from the possibility of using space diversity antennas at the receiver site. From this point of view, it is important to understand the space correlation function of the propagation channel. The objective of this presentation is to compare the exact solution [1] with the high frequency approximation solution of a stochastic radiowave propagation model useful for assessing the effects of a 2D-trunk dominated forest on the space correlation function of a 5G communication system at the high frequency bands.

Figure 1. Trunk dominated forest

In this study, it is assumed that the transmitter and the receiver are at the same height and that the effects of the ground are not included as shown in Figure 2. Under these assumptions, the waves that travel between the transmitter and the receiver propagate in a plane parallel to the ground, essentially rendering the problem two-dimensional. The forest can now be considered as a slab of randomly distributed parallel resonant cylinders. By using the circular symmetry of the trunk and by assuming that the transmitter and the receiver are in the same transverse plane, the exact 2D-radiative transport equation is solved numerically by the eigenvalue technique and then is compared with the high frequency approximation of the 2D-radiative transport equation. The high frequency approximation of the 2D-radiative transport equation is solved by using physical optics to obtain the 2-D total cross section and the differential scattering cross section of the cylinders used in the 2D-transport equation. Emphasis is placed on obtaining the two-point correlation function at high frequencies. The property of interest is in finding the behavior of the space correlation function, for the exact and the high frequency solutions, as the separation between two diversity antennas increases.

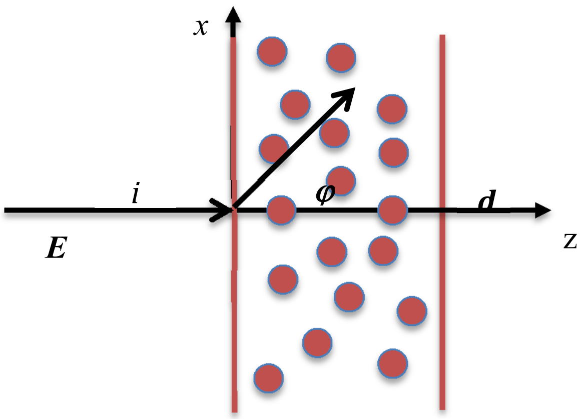

Figure 2. Plane wave normally incident on a 2-D trunk dominated forest.

For the resonant trunk case, solution of the correlation equation by a transform technique does not seem possible; a two-variable perturbation procedure is used instead to derive a generalized transport equation from the correlation equation. The fractional area is the small perturbation parameter used in the above analysis. The derivation of the transport equation from the correlation equation is presented. Several of these exact space correlations functions will be presented at different high frequency bands and compared against the high frequency approximation space correlation functions. Finally, the space correlation function is shown as a function of path length (100 m) as shown in Figure 3. It will be shown that the function shows that the space correlation function decreases as the path length increases. This demonstrates that for a particular high frequency band and space correlation function, there is a limited path length in which the communication system is optimum.

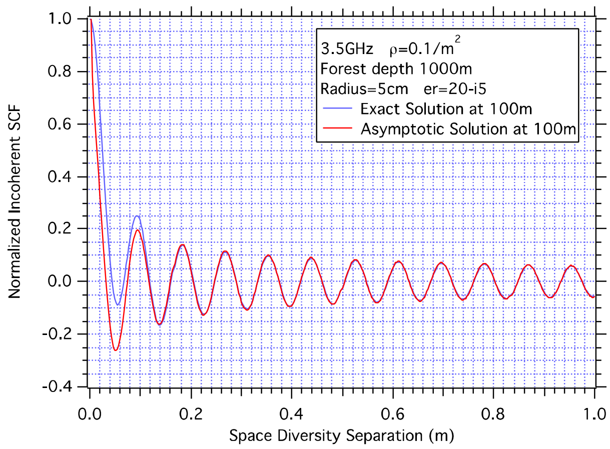

Figure 3. Normalized incoherent 2D- space correlation function vs. space diversity separation at 3.5 GHz with trunk radius of 5cm, 0.1 trunks per m^2, and relative permittivity of the trunks 20-i5.

References

[1] S. A. Torrico, C. Utku, and R. H. Lang, "UHF Propagation Through a Trunk Dominated Forest," DOI: 10.1029/2019RS007038, *Radio Sci.*, Vol. 55, nº 7, July 2020.