Long Distance Wideband Propagation Measurements in a Forested Environment

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Recent advancements in physics-based computer models for radio wave propagation in a forested environment, such as those developed at the University of Michigan's Radiation Laboratory, allow for the generation of accurate simulated data, under various scenarios, without the need for an extensive and costly measurements campaign. A more limited measurements campaign is needed however, in order to validate and improve on these physics-based codes. To capture the dispersive effects of the forest environment, including the frequency decorrelation effects of the forest, and to more completely validate the computer models, it is desired to conduct measurements over a broad bandwidth. As the decay rate of the mean field (attenuation constant) through a forest is a function of distance (for example the rate of decay of the mean field at large distances through a forest tends to decrease, as the surviving mean field is dominated by the effects of scattering from the tree structure), it is also desired to conduct the measurements over distances large enough to capture this effect. This however is a difficult task, as the higher system noise in such a wideband configuration reduces receiver sensitivity and does not allow for detection of the weaker signal over large distances.

To overcome the inherent difficulties in operating a wideband system over large propagation distances, a novel measurement system has been developed at the Radiation Laboratory. In this system two HP8753D vector network analyzers (NWA) are employed, one as the system transmitter, one as a low-noise receiver. The NWA provides the level of receiver sensitivity needed (as low as -100 dBm) for the long distances involved. Under normal operation, and NWA is used as a single unit, with all triggering done internally, and with a common LO determining the frequency of the transmitted signal, as well a the center frequency of the narrow-band receiver. When operating two separate units for a common through (S21) measurement, both the LO frequency and the timing of the frequency sweep must be very precisely matched. In order to achieve this level of precision, two synchronized rubidium atomic clocks, which control both the timing of the frequency sweep, as well as provide a stable LO reference for each NWA, are employed.

The discussed system was employed in a measurement campaign conducted at the Lakehurst Navel Air Station, Lakehurst, NJ. The Lakehurst site consists of varying plots of sand pine forests and open areas. Measurements were conducted over a frequency range from 30 MHz to 3 GHz and at distances of over one kilometer, through forest stands of up to 400 m thickness, the limiting factor on distance being available transmitter power. In this paper, data gathered at Lakehurst, in this measurements campaign, will be presented and analyzed, as well as compared to data generated by the physics-based codes discussed earlier. Data presented will include path loss, as well as the frequency decorrelation effects of the forest environment.