THE DEVELOPMENT OF A CHANNEL SIMULATOR FOR HF SIGNALS RECEIVED OVER NORTHERLY PATHS

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Channel simulation (for example, the popular model developed by Watterson et al [1]) is frequently employed in system development and testing, however current simulators are aimed at single receiver channels and therefore have limited application when multi-channel receiver systems connected to spaced aperture antenna arrays are employed (e.g. adaptive beam/null steering systems or direction finding systems). In such systems, directional effects are of crucial importance and consequently, there is a need for a channel simulator incorporating directional effects to address this deficiency.

Of particular importance in this paper is the characterisation, in terms appropriate for parametric input to a software based simulator, of the complex behaviour associated with propagation over northerly paths where the signals are reflected within the polar cap, within the auroral oval or from within the mid-latitude trough. Within these regions, the ionosphere is a dynamic propagation medium in which HF radio signals associated with each propagation mode may arrive at the receiver over a range of angles in both azimuth and elevation. Furthermore, ionospheric movements at the reflection points may impose large Doppler spreads and Doppler shifts onto the signals which, together with the occurrence of large delay spreads associated with multipath off-great circle propagation can result in a significant degradation in the performance of digital communication systems.

In order to determine the required characteristics for signals received over northerly paths, measurements of the Doppler, multipath and directional behaviour of HF signals have recently been made over a number of paths: Uppsala, Sweden to Leicester, UK (1500km), Longyearbyen, Svalbard to Kiruna, Sweden (1200km), Kirkenes, Norway to Kiruna, (400km). An example measurement of a 7 MHz channel sounding for the Uppsala – Leicester path is presented in Fig. 1. The received signal exhibits delay and Doppler spreading as well as a spread in direction of arrival. In this instance, the incident energy is clustered around -3Hz, -1 Hz and 2 Hz (Fig.1, right frame), with an azimuth of approximately 46° (corresponding to the great circle direction).

In addition to experimental measurements, a ray-tracing code [2] incorporating a model of the entire polar cap, auroral, and sub-auroral ionosphere has been developed. This enables the delay and directional characteristics to be estimated for any given propagation path and may be used alongside the experimental measurements to determine appropriate input parameters for the channel simulation.

[1] C.C. Watterson, J.R. Juroshek, W.D. Bensema, Experimental confirmation of an HF channel model, *IEEE Transactions on Communication Technology*, COM-18, 792-803, 1970.

[2] N.Y. Zaalov, E.M. Warrington and A.J. Stocker, Simulation of off-great circle HF propagation effects due to the presence of patches and arcs of enhanced electron density within the polar cap ionosphere, *Radio Science*, 38(3), 1052, doi:10.1029/2002RS002798, 2003.

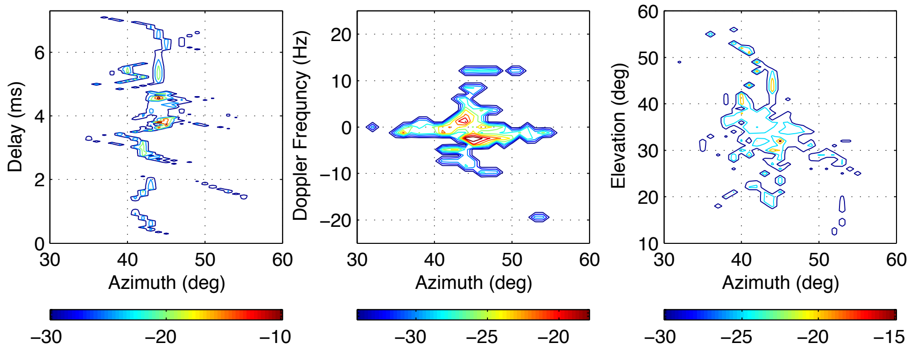

Fig. 1 Measurements of delay, Doppler and elevation spreads with respect to azimuth for a 7 MHz received over the Uppsala – Leicester path. 14:24:54UT on 31 December 2001