MIMO channel measurements in the HF band

S. Salous[1], *E.M. Warrington[2], S.D. Gunashekar[2], S.M. Feeney[1], H. Zhang[2], N. Abbasi[2], L. Bertel[3], D. Lemur[3], M. Oger[3]*

[1]School of Engineering, University of Durham, Durham DH1 3LE, U.K. (E-mail: sana.salous@durham.ac.uk)
[2]Department of Engineering, University of Leicester, Leicester LE1 7RH, U.K. (E-mail: sdg10@le.ac.uk)
[3]IETR, Université de Rennes 1, UMR CNRS 6164, 35042 Rennes, France (E-mail: louis.bertel@univ-rennes1.fr)

Abstract

Multiple input multiple output (MIMO) systems have been extensively investigated for short range wireless communications in the VHF-SHF frequency bands due to the promise of increased data rate in a limited spectrum. To study their possible application to the HF band (3-30 MHz) a MIMO radio link has been set up over a 255 km path from Durham to Leicester in the UK and a longer radio link from Durham to Rennes-France. Measurements using different antenna configurations and different waveforms have been set up and preliminary results of correlation and capacity are presented in this paper.

Summary

Spatial multiple antenna systems at one of the radio link have long been used to improve the quality of radio communication links. Recently multiple input multiple output (MIMO) systems which employ multiple antennas at both ends have gained significance especially in the UHF band. These systems rely on the de-correlation between the different antenna elements in the presence of multipath to enhance the channel capacity. In the HF band, the de-correlation is achieved by using antenna arrays which, are either separated on the order of a wavelength or using a hybrid set of co-located antennas . So far correlation measurements have been performed for single input multiple output (SIMO) configurations. To investigate the feasibility of MIMO systems in the HF band, an 8 by 8 fully parallel MIMO system is being set up between Durham University and Leicester University in the UK with a longer path between Durham University and Rennes University in France. The measurement system is designed to generate different waveforms using state of the art digital synthesis techniques. This permits both narrowband and wideband measurements to obtain the channel capacity and the multipath structure. The waveform generator designed and implemented employs a direct digital frequency synthesiser (DDFS), which enables the generation of a wide range of waveforms including CW signals with fine tuning, a modulated pseudo random binary sequence and sawtooth and triangular chirp waveforms. Narrowband measurements using simultaneous multiple CW signals separated by 10 Hz have been performed between September and December 2007 using a variety of different antenna array configurations (e.g. homogeneous and heterogeneous spaced arrays) including five vertical monopole antennas arranged in an L-shaped array (length of each arm = 40 m) at the receive end at Leicester with four transmit antennas in Durham for a period of approximately one minute (at 15:43 UT on 17 October 2007). Deep fading was observed on each of the receiving antennas for all four transmissions, indicative of the presence of a number of multipath components. Capacity estimates from the measurements are being computed and these will be presented at the Assembly.

To perform wideband measurements, a digital waveform generator has been designed to control the eight digital synthesisers to generate either PRBS sequences or coherent sawtooth chirp waveforms. Orthogonal waveforms are obtained by staggering the generated signals in time on the order of the expected multipath delay spread, which in HF, is between 10-20 ms. Synchronisation at both ends of the link is achieved using the 1PPS and the 10 MHz reference from GPS. The clock rate of the PRBS sequences is programmable in multiples of 2.5 kHz with a maximum of 20 kHz with either 100 or 200 ms duration with a staggering of either 10 ms or 20 ms. Example of measurements with the wideband signals will also be presented.