# BER Performance Evaluation of HF MIMO Spatial Multiplexing Systems

***O.C. Oghre and S. Salous***

School of Engineering and Computing Sciences, University of Durham, Durham, UK.
Email: sana.salous@durham.ac.uk

## Abstract

Over the last decade, the desire for increased data rate and efficient spectrum utilisation in wireless communication systems has evolved the basic single-input single-output (SISO) communication system model into one where multiple antennas are now deployed at both ends of the communication system following the pioneering work of Foschini, Gans and Telatar [1-2]. This system of multiple antennas now commonly referred to as multiple-input multiple-output (MIMO) communication or more generally space-time communication promises an increase in data rate commensurate to the minimum number of antennas deployed at either end of the communication system in multipath rich channel conditions. As a result, a flurry of research efforts has been on to explore the possibility of adopting the MIMO concept into many legacy communication systems. Most of the research has so far focused on the UHF, VHF and SHF bands. In the HF band the presence of different ionization layers in the ionosphere and ground reflections leads to multiple paths connecting the transmitter and the receiver. These multiple paths result in a low data rate which might be alleviated using MIMO technology. However, unlike propagation in the higher frequency bands, the number of multiple paths in the HF band is limited which can lead to a moderate increase in the data rate for MIMO systems. Given the advances recorded in the application of MIMO techniques to other existing communication systems, recently, some effort has been directed at the HF band. However, much of this work has been in experimental measurements [3-5], while others such as [6-7] have focused on establishing the channel capacity increase and de-correlation between transmit and receive antennas, with little effort directed at establishing the potential system performance.

In this paper, we present the bit error rate (BER) performance evaluation of the HF channel based on field measurements conducted on a 255 km radio link between Durham and Leicester, in the UK, using heterogeneous co-located antennas reported in [4-5]. The transmission consisted of continuous wave (CW) transmissions using a nominal frequency of 5.255 MHz, with a 10 Hz separation between transmissions to help distinguish the signals at the receiver. The received data were then filtered to recover the received CW signals. Detailed description of the experimental set up is reported in [5]. Samples of the filtered received CW signals are shown in Fig. 1. The data were further processed to extract the MIMO channel matrices and used to characterize the MIMO channel in our simulator. A spatial multiplexing (SM), MIMO simulator was designed with four different detection schemes. These are linear Zero-Forcing detector, an Ordered Successive Interference Cancellation (OSIC) VBLAST/ZF detector, as well as a sphere decoder (SD), which is essentially a low complexity maximum likelihood (ML) detector. The results for a 2 by 2 MIMO system employing QPSK are displayed in Figure 2 and compared with the SISO curve.

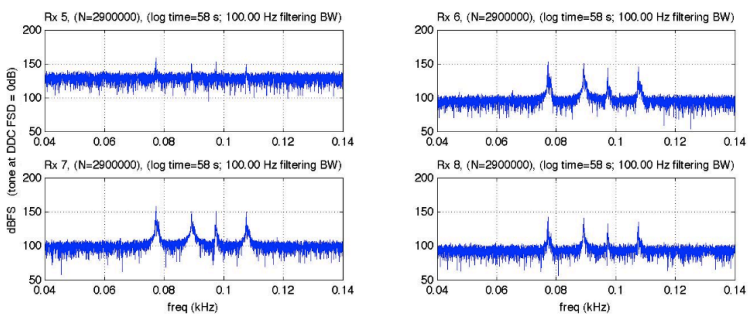


Figure 1 Received HF Measurement results

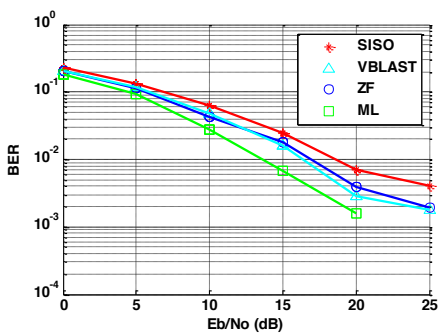


Figure 2 BER Performance for a 2x2 MIMO System

## References


1. G. J. Foschini and M. J. Gans, "On the limits of wireless communications in a fading environment when using multiple antennas," *Wireless Personal Communications,* 1998, pp. 311-335.

2. E. Telatar, "Capacity of Multiantenna Gaussian Channels," *European Transactions on Telecommunications*, November/December1999, pp. 585-595.

3. C. C. Watterson, J. R. Juroshek, and W. D. Bensema, "Experimental confirmation of an HF channel model," *IEEE(R) Trans. Commun. Technology,* December 1970, vol. Com-18, no. 6, pp

4. S. M. Feeney, S. Salous, E. M. Warrington, and S. D. Gunashekar, "HF MIMO measurements using spatial and compact antenna arrays," *URSI General Assembly and Scientific Symposium,* August 2011.

5. S. D. Gunashekar, E. M. Warrington, S. Salous, S. M. Feeney, H. Zhang, L. Bertel, D. Lemur, and M. Oger, "Investigations into the feasibility of MIMO techniques within the HF band: preliminary results," *12th International Ionospheric Symposium,* Virginia, USA, 2008.

6. N. Abbasi, S. D. Gunashekar, E. M. Warrington, S. Salous, S. Feeney, L. Bertel, D. Lemur and M. Oger, "Capacity of HF-MIMO systems," *11th International Conference on Ionospheric Radio Systems and Techniques,* Edinburgh, 2009.

7. S. D. Gunashekar, E. M. Warrington, S. M. Feeney, S. Salous and N. M. Abbasi, "MIMO communications within the HF band using compact antenna arrays, *Journal of Radio Science,* vol. 45, 2010