

Testbed Implementation of Near-field Magnetic MIMO Communication System using SDR

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Abstract – This article presents a near-field magnetic multi-input multi-output (MIMO) communication system test bed using software defined radio (SDR). We propose a heterogeneous multi-pole loop antenna array for near-field magnetic MIMO system. In this paper, we show improved performance of the proposed near-field magnetic MIMO communication system over a conventional magnetic MIMO system employing a circular loop antenna array via bit error rate (BER) performance evaluation of the near-field magnetic MIMO system testbed.

Index Terms — Near-field communication, magnetic communication, MIMO, SDR, testbed.

1. Introduction

The near-field magnetic communication technologies can provide better performance than conventional radio frequency communication systems in harsh channel environment (water, underground, and biological tissue) due to inherent characteristic of magnetic fields [1]. However, the near-field magnetic technologies are limited to apply in various applications due to a few problems such as the limited channel capacity, the sensitivity to alignment error, and the short communication range [2]. To overcome these limitations, many research groups have tried various approaches [2-6].

In previous work, we proposed a near-field magnetic multi-input multi-output (MIMO) communication system for high data rate transmission using heterogeneous multi-pole loop antenna array with crosstalk cancellation effect [7]. In this work [7], we presented theoretical analysis, 3D numerical simulation, and measurement of the proposed structure, and showed improved channel capacity compared with a conventional near-field magnetic communication single-input single-output (SISO) system.

In this paper, we present an implementation of the near-field magnetic MIMO communication system using a software defined radio (SDR) platform and evaluate its performance. This paper is organized as follows. In Section II, we present the system design of the MIMO system testbed, Section III shows the BER performance evaluation results of the testbed, followed by conclusion in Section IV.

2. Design of the near-field magnetic MIMO system testbed

To realize and measure the near-field magnetic MIMO communication system, a testbed should include four

components: magnetic antenna arrays including a conventional circular loop antenna array and the proposed heterogeneous antenna array, data transmitters and receivers, gigabit Ethernet switch, and host computer. Based on these four components, the architecture of near-field magnetic MIMO communication testbed can be developed as shown in Fig. 1 [8], and Fig. 2 shows the developed testbed. We use universal software radio peripheral (USRP) to implement the transmitters and receivers [8]. In this system, the carrier frequency is 10 MHz with the 400 kHz bandwidth. Each of transmitters and receivers is connected to the antenna, and two transmitters or two receivers are connected to each other by the ‘MIMO cable’ to synchronize their reference clock. The first device of transmitters and receivers are connected to the host computer via gigabit Ethernet switch with network cables, respectively. The host computer with LabVIEW Communications handles entire signal-processing procedures before transmission and after reception. We change the distance between transceiver and receiver from 10 to 140cm.

In the host computer, data bits are randomly generated, and modulated by 4 quadrature amplitude modulation (QAM) as seen in Fig. 3. Before the transmission, the modulated data is divided into two data streams for MIMO transmission, and the two data streams pass through the root-raised-cosine filter for pulse shaping to control inter symbol interference (ISI). Received data streams pass through the matched filter for maximizing the signal to noise ratio (SNR). Prior to integrating the received data streams, they are compensated by synchronization and channel estimation, and the integrated data stream is demodulated to bit data stream. Then, we can obtain the bit error rate (BER) performance of the system by comparing the received data stream and the original data stream as shown in Fig. 3.

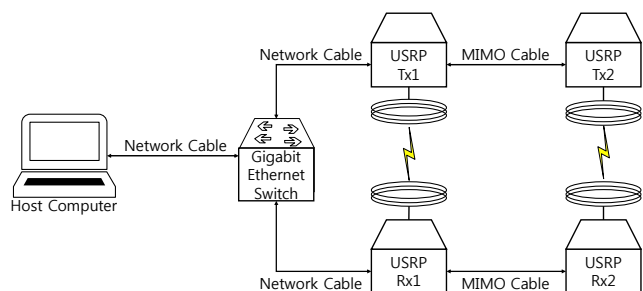


Fig. 1. System architecture of the near-field magnetic MIMO system

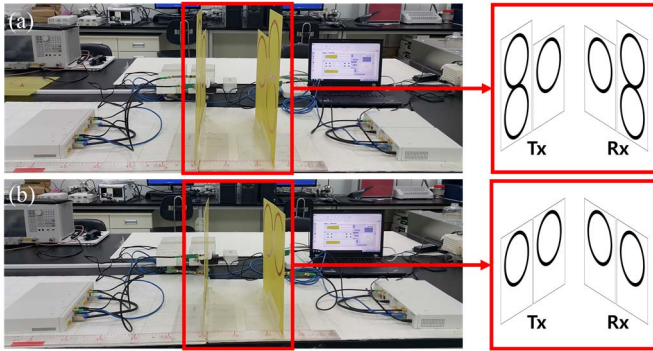


Fig. 2. Near-field magnetic MIMO communication testbed with (a) the proposed heterogeneous multi-pole loop antennas, (b) the conventional circular loop antennas

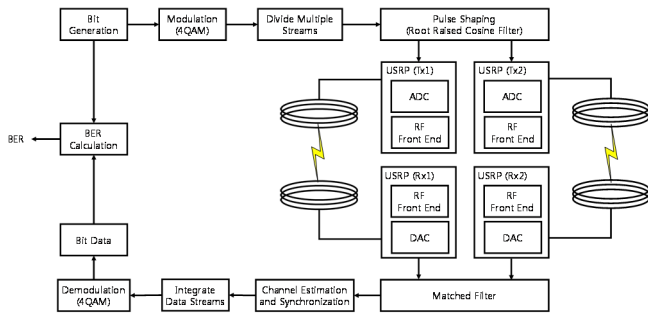


Fig. 3. Transmitter and receiver design

3. BER performance evaluation

Fig. 4 presents the BER performance of near-field magnetic MIMO system with the conventional circular loop antenna array and the proposed heterogeneous multi-pole loop antenna array. Even if a distance between the transmitter and the receiver is small, the conventional system cannot provide low BER since crosstalk signals among the antenna cause interference. On the other hand, the proposed near-field magnetic MIMO system shows much better BER performance even at the large distance due to a crosstalk cancellation effect of the heterogeneous multi-pole loop antenna array as shown in Fig. 4. For a given BER, e.g., 5×10^{-2} , the transmission distance of the proposed scheme is two times larger than that of the conventional scheme.

4. Conclusion

In this paper, we presented the USRP based testbed of near-field magnetic MIMO communication system and tested BER performance. Mainly due to crosstalk cancellation effect, the proposed scheme can provide much better performance than conventional schemes, enabling significantly longer communication distance.

Acknowledgment

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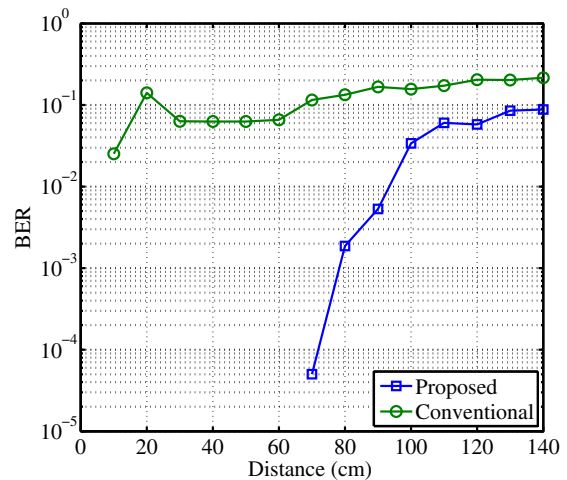


Fig. 4. BER performance of near field magnetic MIMO communication system applying the conventional circular loop antenna and the proposed multi-pole loop antenna array

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