Analysis of Security Communication Based on Digital Retrodirective Antenna

Junyeong Bok[1,1], Heung-Gyoon Ryu[1]

[1] Department of Electronics and Engineering, Chungbuk National University
Cheongju, Chungbuk, 361-763, Korea
bjy84@nate.com, ecomm@cbu.ac.kr

Abstract. Fast tracking and security are important factor for data transmission in wireless communication. Retrodirective antenna(RDA) is possible for the high-speed beam tracking without any priori location information. Therefore, RDA system is appropriate technology in wireless mobile communication. Also, it is possible to improve security by making direction toward the source. In this paper, we propose the security communication system based on digital RDA. Simulation results show phase conjugation scheme has better BER performance about 1dB and 3dB at source without signal processing than that of without phase conjugation, when phase delay is 15°and 30°.

Keywords: Retrodirective array, phase conjugation, bandpass sampling, phase detector, phase lock loop.

1 Introduction

There have been increased interest for the security due to development of communication technology. There have been a lot of studied to communication system with improved security. Especially, retrodirective antenna techniques have been attenuated one way for improving security.

Retrodirective antenna techniques can retransmit received signal toward at the source without a priori knowledge of the arrival direction[1]. It is possible to do automatically beam-tracking. Also, retrodirective antenna has merit such as high link gain, easy interference elimination, and high energy efficiency.

Various schemes have been studied to design efficient phase conjugation for implementation of RDA. Among passive retrodirective antenna technology, Corner reflector and Atta Array schemes are well known as analog phase conjugation scheme [2]. The Corner reflector scheme is contributed by placing two intersecting flat reflectors perpendicular to each other. Van Atta Array is a planar or linear array in which the elements with equidistance from the array center are interconnected in pairs with lines of equal length. Another method heterodyne mixing is proposed to design phase conjugation as another schemes[3]. The phase conjugation is achieved by mixing the received signal of know frequency with double frequency of RF

frequency. It is very serious drawback to need double frequency of RF. Passive retrodirective antennas cannot be updated or modify of whole system.

Retrodirective array system using direct down-conversion scheme is proposed for resolving these problem [4]. But, direct down conversion method is sensitivity to DC offset and frequency offset. Recently, retrodirective antenna using under-sampling (bandpass sampling) is studied to solve the problem of direct conversation methods [5-6].

In this paper, we propose security communication system based on digital retrodirective antenna (RDA) and analyze the BER performance of the proposed system.

2 System model

Fig. 1 shows system model using a digital RDA. Here, Antennas at source transmit a Tx.signal to retrodirective antennas and digital RDA sent back to source. The Tx.signal is received with a progressive phase shift across a retrodirective aperture that is an antenna array. The progressive phase shift contains the information of direction of the received beam.

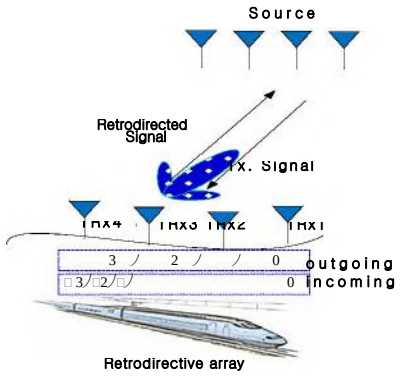

Fig. 1. Retrodirective antenna for fast tracking.

3 Digital Retrodirective Antenna

We analyze the reception performance of the proposed system in AWGN channel. In this paper, we assume that there are two receive elements. Each received signal through elements has different phase delay. This system is doing down-converting using bandpass sampling scheme to IF band and then doing AD converting. Bandpass sampling rate of A/D converter need to satisfy the following condition:

$$f_s \varepsilon 2B . \quad (1)$$

where B is signal bandwidth, f_s is the sampling frequency. Digital phase lock loop (DPLL) is used to estimate phase delay between received signal through adjacent element.

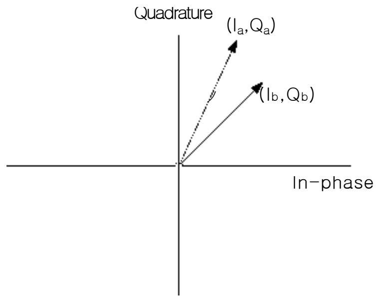

Fig. 2. Phase difference between data (I_a, Q_a) and correct point (I_b, Q_b).

The phase error ϕ between received data (I_a, Q_a) and the correct point (I_b, Q_b) given by

$$e^{j\phi} = e^{j(\theta_a - \theta_b)} = \cos(\theta_a - \theta_b) + j\sin(\theta_a - \theta_b) \quad (2)$$

where amplitude of correct point has $\sqrt{I_b^2 + Q_b^2} = 2$. Equation (2) can be rewritten by

$$\phi \approx \sin\phi = \frac{1}{2(I_a^2 + Q_a^2)}(I_b Q_a \oplus I_a Q_b) \quad (3)$$

The phase difference ϕ can be approximated as

$$\phi = (I_b Q_a \; I_a Q_b) \quad (4)$$

Phase detector can estimate phase delay information between antenna arrays by equation (4).

4 Simulation Results

In this paper, we design the digital RDA system based on bandpass sapling using MATLAB Simulink. The signal of data rate with 25ksym/s is generated and passes through modulated as QPSK signal. Modulated data signal is pass thought up-converter, AWGN channel, and under-sampling processing block. Fig. 3 shows comparison BER performance with and without phase conjugation at the source. Phase conjugation scheme has better BER performance about 1dB and 3dB at source without signal processing than that of without phase conjugation , when phase delay is 15 and 30.

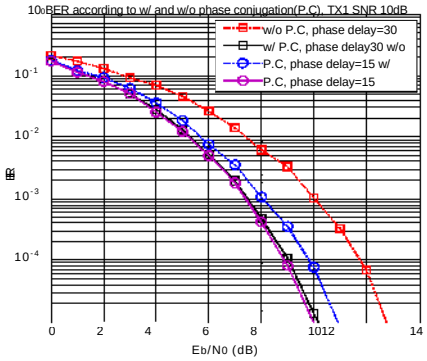

Fig. 3. Comparison of BER performance with and without phase conjugation.

5 Conclusion

In this paper, we propose security communication system based on digital RDA. Digital RDA system does not require the RF analog circuit. Simulation results show correct phase conjugation when the SNR of each source to retrodirective array is 10dB. Phase conjugation scheme has better BER performance about 1dB and 3dB at source without signal processing than that of without phase conjugation when phase delay is 15 and 30. Also phase conjugation technique is able to expect improvement of security due to automatically making beam from source to digital retrodirective antenna.

Acknowledgments. "This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology(No. 2012017339)".

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