Simulation of Free-Space Communication using the Orbital Angular Momentum of Radio Waves

Á. Demeter, Cs.Z. Kertész
University Transilvania Braşov, Romania

Abstract

The Orbital Angular Momentum (OAM) property of radio waves can be efficiently used to combine multiple free-space radio-communication channels into a single carrier frequency. This paper presents a study of such a multichannel system using Simulink model of radio-waves with different OAM value combined together. The study focuses on proving that OAM channels remain orthogonal at radio frequencies, and the OAM modulation of FSK, PSK and QAM modulated signals results in bit-error rates close to standard communication channel behaviour in noisy environment.

The Orbital Angular Momentum is part of the total angular momentum of a photon independent of its spin. The phase fronts of electric and magnetic fields depend on this OAM value giving helical polarization to the two field vectors for non-zero OAM states [1]. Different OAM states result in orthogonal polarization values, meaning the OAM state can be used for multiplexing of multiple signals into a single EM field [2,3].

This paper presents the result of Matlab/Simulink simulations of propagation with different OAM state. A helix modulator and demodulator block was designed to simulate the creation of helical phase front intertwining using circular antenna arrays. Test signals modulated with FSK, PSK and QAM modulation were fed into the helix modulator and passed through standard AWGN channel for simulating normal open space communication, as well as through Rician fading blocks to simulate multipath effect as well. Bit error-rate plots for these systems were determined for different OAM states and compared to standard modulated signals passing through the same channels to examine the errors introduced by the helix modulation/demodulation. Also the orthogonality of the system was tested by multiplexing many different OAM state signals into a single communication channel (Fig.1.)

The results are very promising, the bit-error rate of OAM modulated signals are very close to theoretical values, phase changing modulations being a little more sensitive (Fig.2.). The different OAM states proved to be entirely orthogonal, and mixing them presented no negative effects on the single channels. Multi-path effects however showed that the system is very dependent on proper line-of-sight positioning of the transmitter and the receiver.

Fig. 1. Simulink model of the OAM multiplexing of PSK signals

Fig. 2. BER curves of signals passing through OAM modulated channels (left to right: FSK, PSK, QAM, FSK affected by multipath)

References