Diversity Schemes: Alamouti verus MRRC

Sophie Jaro
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***Abstract*—This project recreates the BER performance comparison of coherent BPSK with MRRC and two-branch transmit diversity in Rayleigh fading featured in Siavish Alamouti's 1998 paper. The script models a link with an SNR of up to 50db and can be modified to obtain bit error rates of 10e-6 as in the paper. In this simulation, minimum BER of a 10e-4 was achieved due to simulation time limitations.**

I. Introduction

In Alamouti's paper, it is demonstrated that the Alamouti transmit diversity scheme with two transmit and M receive antennas is equivalent to MRRC with one transmit antenna and 2M receive antennas. That paper and this simulation show that the Alamouti scheme and MRRC schemes achieve comparable bit error rates at the same SNR. More antennas minimized BER more quickly. The plot also illustrates the approximately 3dB offset between MRRC and the new scheme that is caused by dividing the power between transmitters.

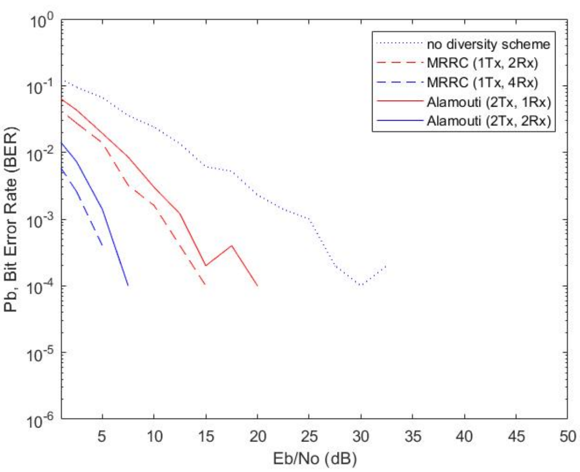

Fig. 1. The BER performance comparison of coherent BPSK with MRRC and two-branch transmit diversity in Rayleigh fading.

II. MRRC Implementation

The MRRC plots were generated according to the scheme described in the Alamouti paper. First, random data was generated, then modulated. It was then multiplied with the filter coefficients and noise was added to obtain the received signal. The combining scheme described in the paper was implemented in the same way. Finally, the output signal of this processing was passed through the maximum likelihood detector, demodulated, and a bit error rate was calculated for the given EbNo value.

A. No diversity

The plot for no transmit or receive diversity was implemented by running the MRRC function for one receiver.

B. 1 Tx and 2 or 4 Rx

The signals and filters were vectorized to make adjusting the number of receive antennas easier.

III. Alamouti Implementation

Similar to the MRRC scheme, the Alamouti scheme followed the encoding and combining scheme outlined in the paper. Signals and filter coefficients were generated, encoded according to the formulas in the paper, combined, then passed through the maximum likelihood detector. Also note that replicating the paper's simulated BER of 10e-6 required simulating at least 10e-6 bits. This took too long.

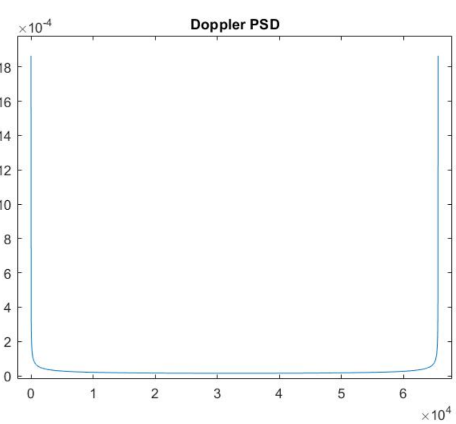

Fig. 2. Doppler Power Spectral Density which will be multiplied with a random distribution of Gaussian variables and passed through the IFFT

IV. Rayleigh Fading Channel

A flat fading channel was used to create this plot. However, a more realistic model would implement the Rayleigh fading channel that was constructed shown in Figure 2. The that generated these coefficients is at the bottom of the main script. Doppler fading was constructed by first selecting the number of bits N, equal to the message bits of the main program. These N must be a multiple of 2. fm was derived from N as N/2. Gaussian random variables on the positive spectrum

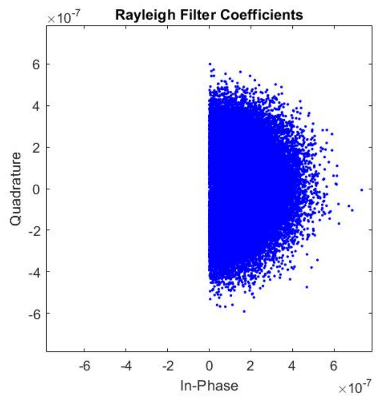

Fig. 3. Scatterplot of Rayleigh Fading Coefficients h

were defined, then the negative side of the spectrum was filled with conjugates. The fading spectrum was constructed from the Doppler shift PSD, with fc set to 0. The fading spectrum and Gaussian random variables were multiplied, then passed through the IFFT. This was repeated twice, with the square root of the sum of the squares of the two results taken as the Rayleigh filter.

The MATLAB script which generated this plot can be found at *https://github.com/sophiejaro/ECE408*.

REFERENCES

[1] S. M. Alamouti, ”A simple transmit diversity technique for wireless communications,” in IEEE Journal on Selected Areas in Communications, vol. 16, no. 8, pp. 1451-1458, Oct. 1998.

[2] Goldsmith, A. (2005). Wireless Communications. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511841224. Page 75.