Simulation of OFDM MIMO with IDMA for Underwater Acoustic Communication

Salma S. Shahapur, Rajashri Khanai, and D. A. Torse

Abstract This paper describes an underwater acoustic communication with Interleaver Division Multiple Access Orthogonal Frequency Division Multiplexing Multiple Input Multiple Output. IDMA OFDM MIMO is emerging technology in underwater acoustic communication for high data rate. However, underwater channels are prone to errors. To perform the reliable communication in underwater communication we propose the IDMA OFDM MIMO technique. Simulation results are investigated for different coding techniques Turbo/LDPC, various modulation procedures Phase Reversal Keying/Quadrature Point Shift Keying/Quadrature Amplitude Modulation and three interleavers Random/Helical/Matrix. Simulation results reveals that the combination Phase Reversal Keying modulation with Turbo encoding and Random interleaver advances the Bit Error Rate performance.

Keywords BER · Coding · IDMA · Modulation

1 Introduction

In underwater wireless acoustic communication nodes are placed at different depths to achieve certain work like oceanographic information gathering, monitoring the pollution in the water, offshore exploration applications. Autonomous Underwater Vehicles or Unmanned Underwater Vehicles consists of underwater acoustic sensor sand are used for undersea survey of expected resources as well as collecting of precise data required for scientific work. For these requests possible, it is necessary to permit communication between the nodes in the underwater. These Autonomous

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Underwater vehicle or Unmanned Underwater Vehicle must be self-configured and send the collected data to the onshore station. For these applications viable Underwater Acoustic Wireless Networking is the best technology. Underwater communication through Acoustic link consists of adjustable number of sensor nodes sand underwater vehicles that are placed in the water to achieve cooperative monitoring responsibilities over the given zone. To attain the objectives in the underwater communication, underwater sensor nodes and underwater vehicles must be wirelessly connected with acoustic link in the ocean atmosphere. In underwater communication for data collection Acoustic communications is used. For long distance transmission through radio waves signal attenuates [1]. In underwater radio waves can be used at lower frequencies (30–300 Hz) and with this range of frequency large antenna is required, transmission power is high. In underwater optical wave when used to send data they suffer from scattering. Thus, in underwater communication acoustic links are preferred for communications [2]. In traditional method to gather the information in underwater sensor nodes are placed in the water, during the monitoring mission data is recorded in the nodes, and those nodes are collected after few months. This style has the disadvantages:

- As the nodes are collected after few months, online monitoring of data is not conceivable. This is serious in case of observation or in ecological monitoring requests.
- The noted information is not possible to measure till the nodes are collected. That will happen after few months.
- It is not possible to interact among ground controller station and the underwater nodes. Hence it is not possible to reconfigure the arrangement.
- If the node fails or system fails, till the nodes are collected it is not possible to configure the system. This causes the complete failure of the system.
- The amount of data that can be recorded by the sensor nodes are limited because of storage devices.

Hence there is a requirement to deploy the nodes in the water such that they do the real time monitoring of selected areas. In the underwater at different depths nodes are placed, these nodes communicate with each other through acoustic link. Nodes collect information and forward to the base station through acoustic link. Since acoustic communication is affected by multipath, noise due to turbulence, shipping, delay. Bandwidth in underwater is severely limited to 5 kHz as the frequency range is less [3]. The communication range is intensely compact. In our work, we propose Multiple Input Multiple Output scheme combined with Interleaver Division Multiple Access and Orthogonal Frequency Division Multiplexing technique using LDPC and Turbo coding structure combined with interleavers as Random, Matrix and Helical and Binary Phase Shift Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation techniques. Performance parameters Bit Error ratio and Power is compared for different combinations. In segment II the block illustration of planned scheme is shown. In segment III associated determination is presented. In segment IV results are shown.

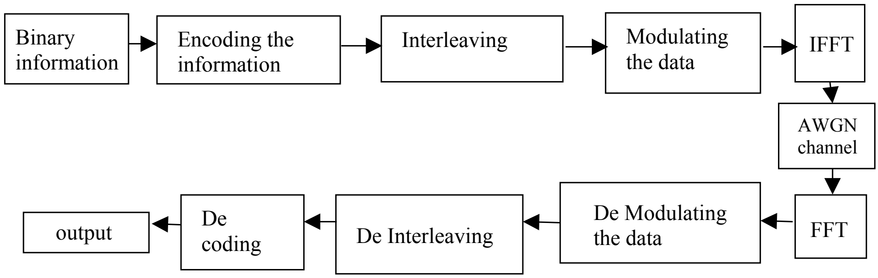

Fig. 1 IDMA OFDM MIMO

2 Block Diagram of IDMA OFDM MIMO

For consistent information broadcast in UWSN, IDMA OFDM MIMO technique as shown in Fig. 1 is executed with numerous coding procedures, dissimilar interleavers and various modulation practices and concert constraints are associated.

3 Related Work

Analytical in Table 1, the literature survey related to the work is presented**.** Using Orthogonal Frequency Division Multiplexing (OFDM) method the bandwidth can be reduced and in comparison, to Frequency Division Multiplexing (FDM), OFDM alleviate the multipath effect [4]. The author has compared for underwater communication the performance parameter such as BER of OFDM and FDM method. Data can be transmitted with more than one antenna and also same data can be received with more than one antenna using Multiple-Input and Multiple-Output (MIMO) arrangement [3]. Communication in underwater using acoustic link, data rate is small and bandwidth is limited [5], using Multiple Input Multiple Output (MIMO) information rate will be increased and bandwidth is controlled. For underwater acoustic communication Multiple access arrangement is used, such that the allocated spectrum and bandwidth can be efficiently used by number of users [6]. IDMA method uses the Inteleaving scheme. In IDMA efficiently data is distributing to the users [7]. The current methods on underwater wireless communication concentrate on only IDMA scheme or only MIMO-OFDM technique [8]. These methods do not resolve the problems of underwater acoustic communication. In terms of bandwidth Frequency

Table 1 Related work

References	Coding technique	Modulation	Interleaver	BER
[8]	Low density parity check	BPSK	Random interleaving	10^{-4}
[1]	Hamming encoder	QAM	Random interleaving	10^{-4}

Division Multiple Access (FDMA) results in inefficient and restrictive performance [9].

4 Methodology Used

In this paper we have used Interleaver Division Multiple Access Orthogonal Frequency Division Multiplexing Multiple Input Multiple Output (IDMA OFDM MIMO) scheme. In IDMA OFDM MIMO technique we checked the different performance parameters Bit Error Ratio (BER), power ingesting. In our work we used LDPC/Turbo coding technique, in the interleaving section we used Random/Helical/Matrix interleavers. In the modulation section Phase Reversal Keying/Quadrature Point Shift Keying/Quadrature Amplitude Modulation procedures is used. Turbo code combined with Random interleaving and Binary PSK variation gives improved BER performance in the underwater Acoustic channel with IDMA OFDM MIMO scheme.

5 Results and Discussion

In the traditional underwater acoustic communication, the noted data cannot be read till the devices are collected that will occur after few calendar months. There is a need for real time underwater communication such that BER should be improved and power consumption should be reduced.

5.1 UWSN with LDPC Coding, Interleaver as Random

Figure 2 shows comparison of Bit Error Rate and Fig. 3 shows the power consumption with LDPC code combined with interleaver as Random and modulation as Phase Reversal Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation. Bit Error Ratio is approximately 10^{-3}, the power measured for BPSK is 33 dB and for QPSK/QAM power consumption is 40 dB for E_b/N_o 14−16 dB. Results are tabulated in Table 2.

5.2 UWSN with LDPC Coding, Matrix Interleaver

Figure 4 shows the assessment of Bit Error Rate and Fig. 5 shows the power consumption with LDPC code combined with interleaver as Matrix and modulation as Phase Reversal Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation.

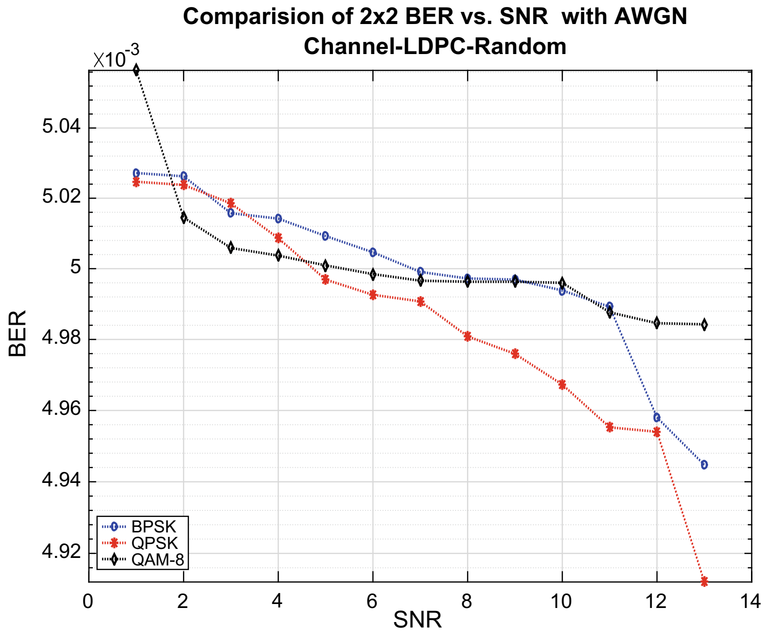

Fig. 2 Bit error rate with LDPC code, random interleaver

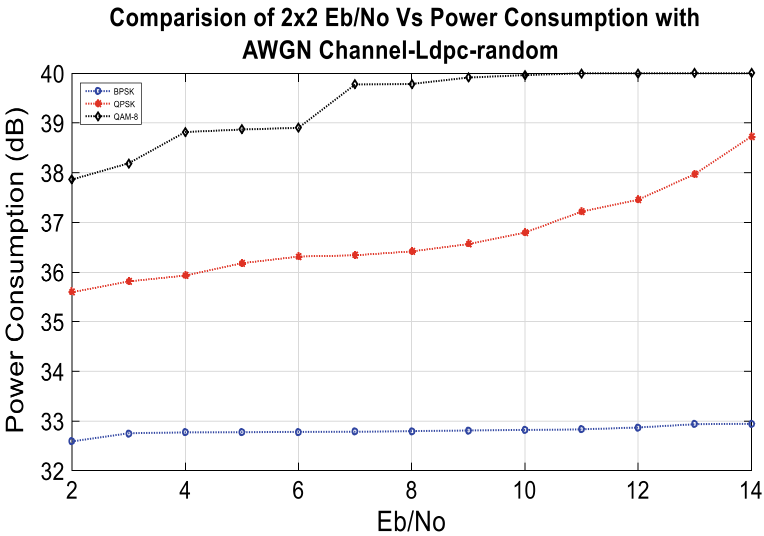

Fig. 3 Power consumption with LDPC code, random interleaver

Table 2 BER and power with LDPC and random interleaver

Modulation method	Coding	Interleavering	Bit error rate	Power in dB
BPSK	Low density parity check	Random interleaver	10^{-3}	39
QPSK	Low density parity check	Random interleaver	10^{-3}	39
QAM	Low density parity check	Random interleaver	10^{-3}	40

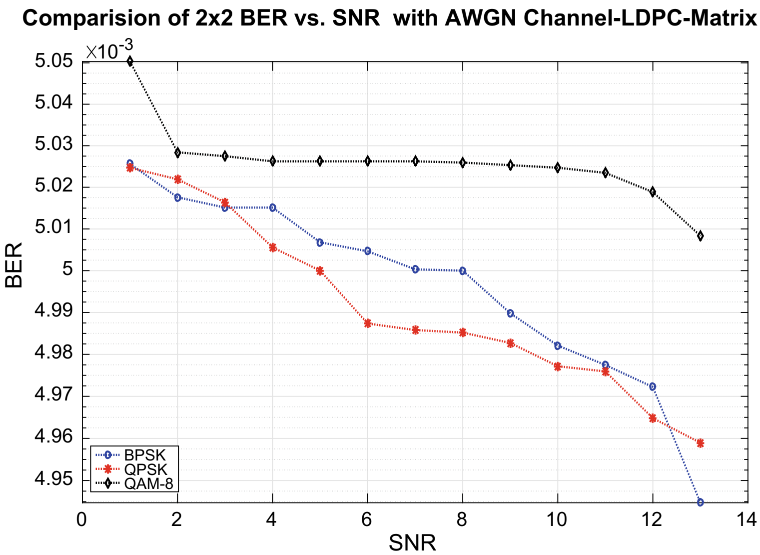

Fig. 4 Bit error rate with LDPC code, matrix interleaver

Results are tabulated in Table 3. Bit Error Rate is approximately 10^{-3}, the power measured for BPSK is 29 dB and for QPSK/QAM power consumption is 39 dB for E_b/N_o 14–16 dB.

5.3 UWSN with LDPC Coding, Helical Interleaver

Figure 6 shows the assessment of Bit Error Rate and Fig. 7 shows the power consumption with LDPC code combined with interleaver as Helical and modulation as Phase Reversal Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation. Results are tabulated in Table 4. Bit Error Rate is approximately 10^{-3}, the power measured for BPSK is 36 dB and for QPSK/QAM power consumption is 40 dB for E_b/N_o 14–16 dB.

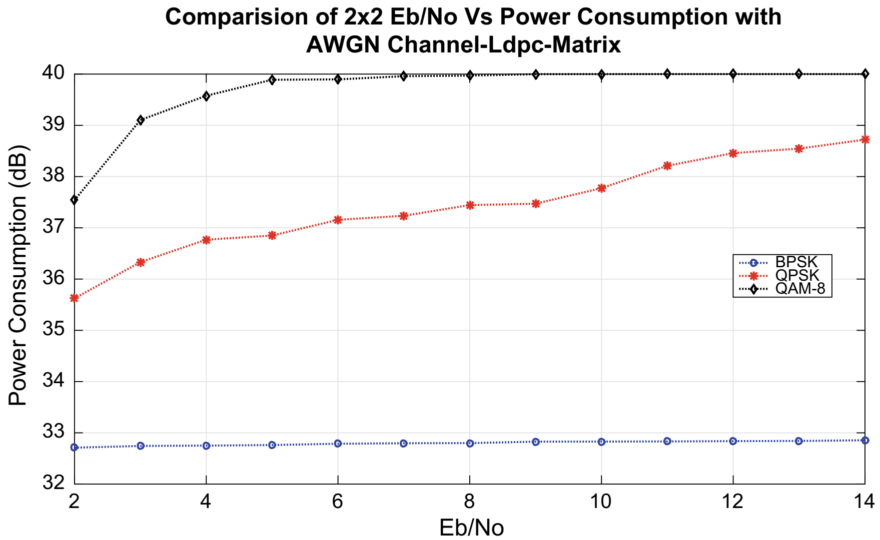

Fig. 5 Power consumption with LDPC code, matrix interleaver

Table 3 BER and power with LDPC and matrix interleaver

Modulation method	Coding	Interleavering	Bit error rate	Power in dB
BPSK	Low density parity check	Matrix interleaver	10^{-3}	33
QPSK	Low density parity check	Matrix interleaver	10^{-3}	38
QAM	Low density parity check	Matrix interleaver	10^{-3}	40

5.4 UWSN with LDPC Coding, Random Interleaver

Figure 8 shows the assessment of Bit Error Rate and Fig. 9 shows the power consumption with Turbo code combined with interleaver as Random and modulation as Phase Reversal Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation. Results are tabulated in Table 5. Bit Error Rate for BPSK is approximately 10^{-6}, for QPSK 10^{-4}, for QAM 10^{-3}. The control measured for BPSK/QPSK/QAM is 36 dB for E_b/N_o 14–16 dB.

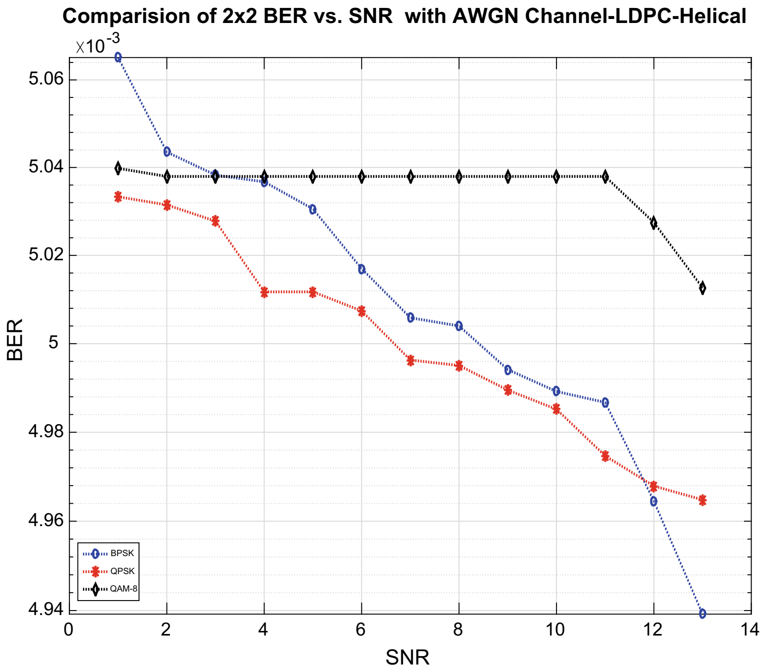

Fig. 6 Bit error rate with LDPC code, helical interleaver

5.5 UWSN with LDPC Coding, Matrix Interleaver

Figure 10 shows the assessment of Bit Error Rate and Fig. 11 shows the power consumption with Turbo code combined with interleaver as Matrix and modulation as Phase Reversal Keying, Quadrature Point Shift Keying, Quadrature Amplitude Modulation. Bit Error Amount is approximately 10^{-3}. The control measured for BPSK/QPSK/QAM is 36 dB for E_b/N_o 14–16 dB. Results are tabulated in Table 6.

5.6 UWSN with LDPC Coding, Helical Interleaver

Figure 12 shows the assessment of Bit Error Rate and Figure 13 shows the control feasting with Turbo encode combined with interleaving as Helical and modulation as Phase Reversal Keying, Quadrature Phase Shift Keying, Quadrature Amplitude Modulation. Bit Error Amount is approximately 10^{-3}. The control measured for BPSK/QPSK/QAM is 30 dB for E_b/N_o 12–14 dB. Results are tabulated in Table 7.

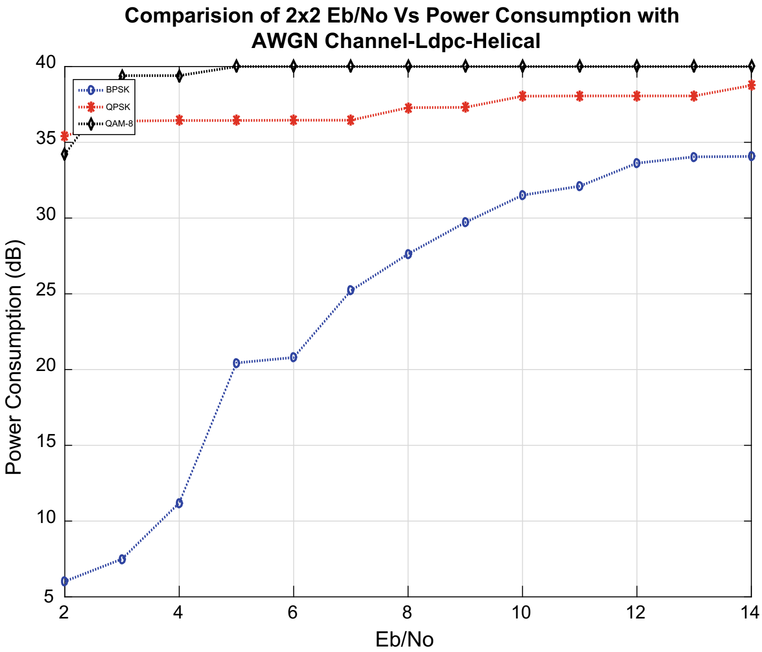

Fig. 7 Power consumption with LDPC code, helical interleaver

Table 4 BER and power with LDPC and helical interleaver

Modulation method	Coding	Interleavering	Bit error rate	Power in dB
BPSK	Low density parity check	Helical interleaver	10^{-3}	36
QPSK	Low density parity check	Helical interleaver	10^{-3}	40
QAM	Low density parity check	Helical interleaver	10^{-3}	40

6 Conclusion

In this paper, to improve the reliability of information send from the underwater to the base station we propose IDMA OFDM MIMO with two channel coding methods, three interleavers, three modulation methods. Simulation is performed in the MATLAB. From simulation results we conclude that BPSK modulation technique with LDPC code and Matrix interleaver have BER of 10^{-3} and energy ingesting is 29 dB at SNR 14-16 dB. Grouping of Binary Phase Shift Keying with Turbo encoding (Random Interleaver) progresses the BER up to 10^{-6}, energy ingesting is 35 dB at 14–16 dB. Simulation result offers trade-off between BER and power consumption.

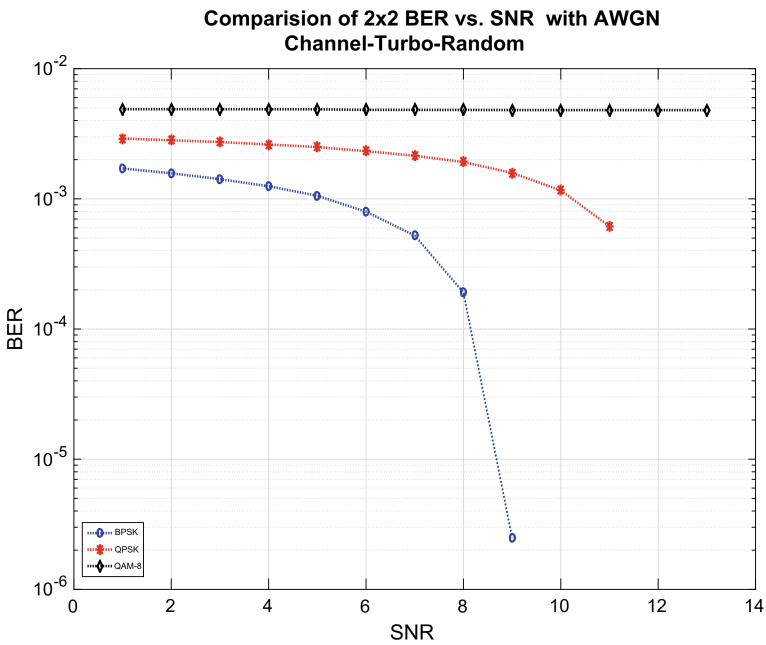

Fig. 8 Bit error rate with Turbo code, random interleaver

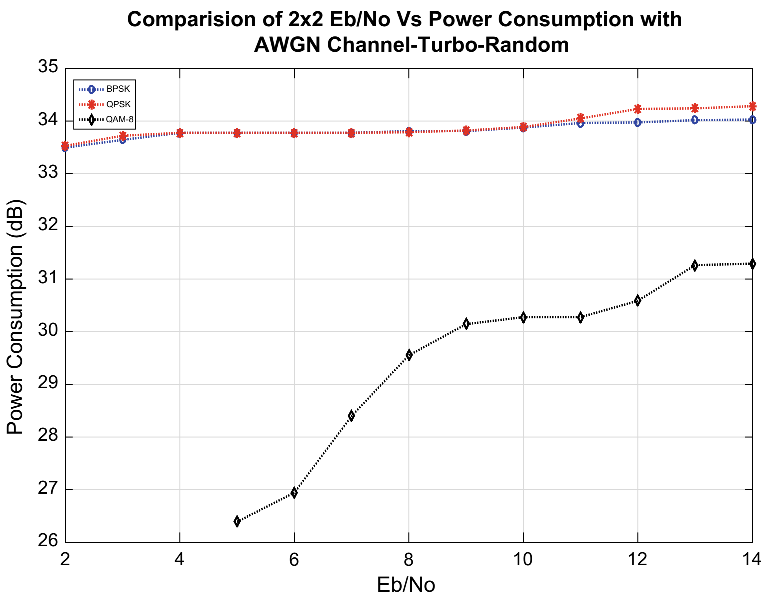

Fig. 9 Power consumption with Turbo code, random nterleaver

Table 5 BER and power with Turbo and random interleaver

Modulation method	Coding	Interleavering	Bit error rate	Power in dB
BPSK	Turbo code	Random interleaver	10^{-6}	35
QPSK	Turbo code	Random interleaver	10^{-3}	35
QAM	Turbo code	Random interleaver	10^{-3}	32

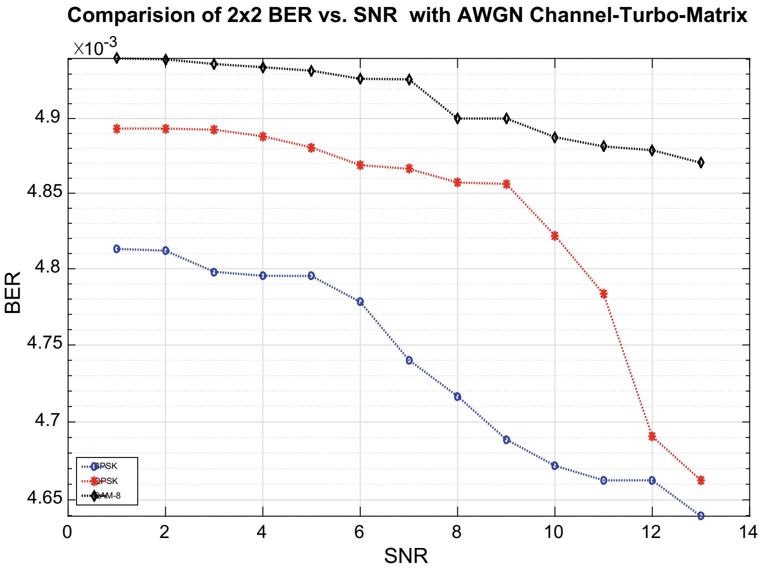

Fig. 10 Bit error rate with Turbo code, matrix interleaver

In the future work the above results can be combined with MAC layer as cross layer approach.

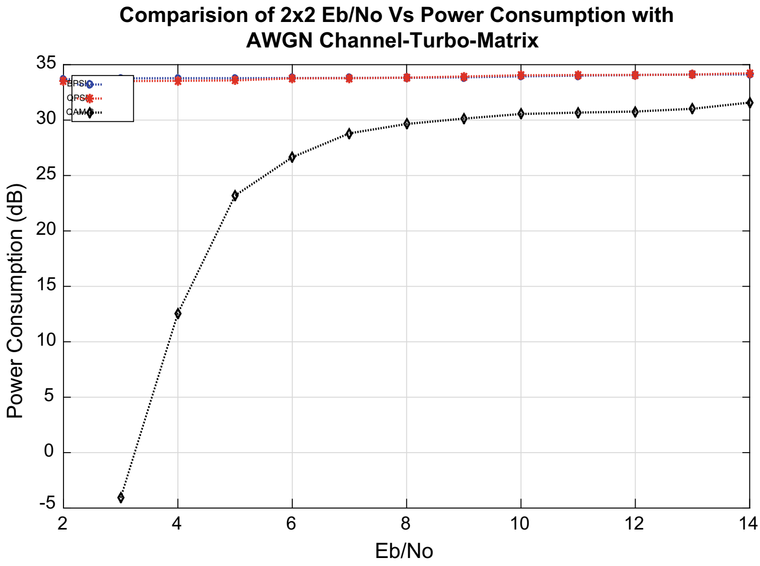

Fig. 11 Power consumption with Turbo code, matrix interleaver

Table 6 BER and power with Turbo and matrix interleaver

Modulation method	Coding	interleavering	Bit Error Rate	Power in dB
BPSK	Turbo coding	Matrix interleaver	10^{-3}	34
QPSK	Turbo coding	Matrix interleaver	10^{-3}	34
QAM	Turbo coding	Matrix interleaver	10^{-3}	32

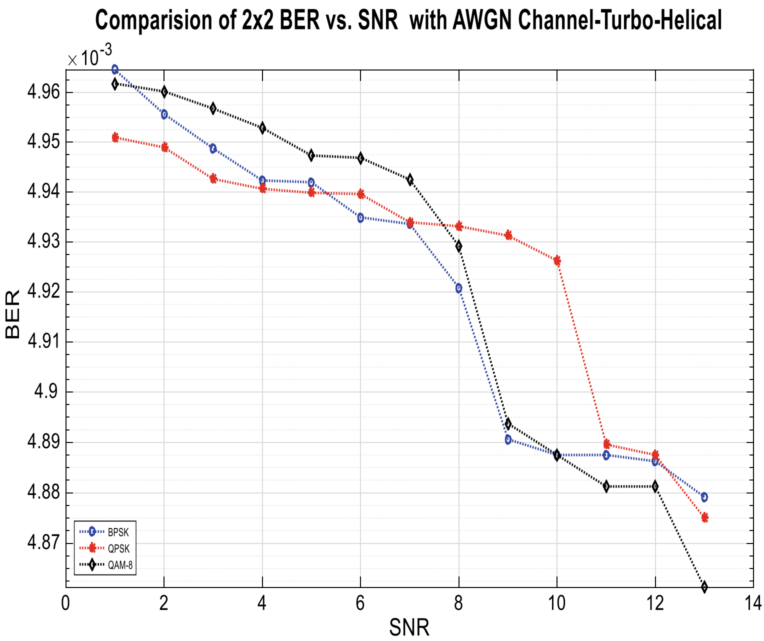

Fig. 12 Bit error rate with Turbo code, helical interleaver

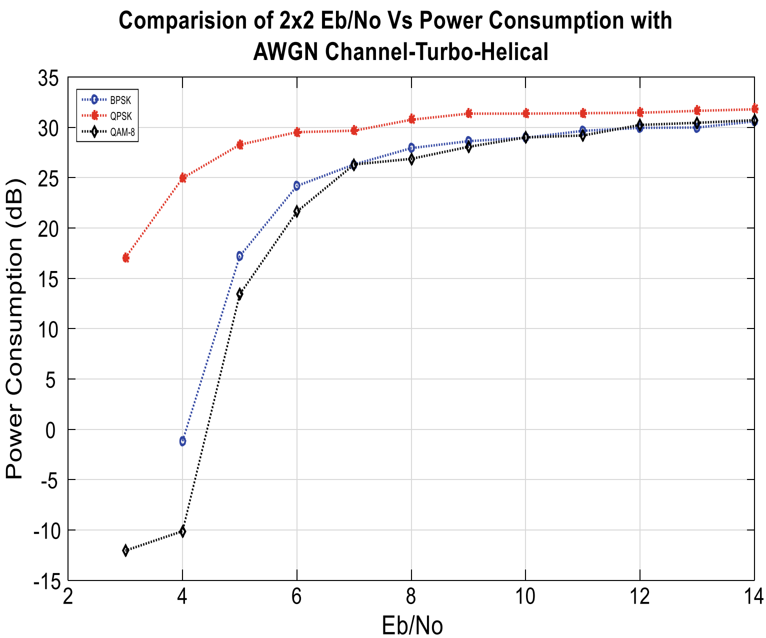

Fig. 13 Power consumption with Turbo code, helical interleaver

Table 7 BER and power with Turbo and Helical interleaver

Modulation method	Coding	Interleavering	Bit error rate	Power in dB
BPSK	Turbo coding	Helical interleaver	10^{-3}	32
QPSK	Turbo coding	Helical Interleaver	10^{-3}	31
QAM	Turbo coding	Helical interleaver	10^{-3}	31

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