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Performance of Block Interleaved Multi Carrier Modulation in Underwater Fading Channel

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1. Introduction

In underwater multipath channel of **Fig. 1**, the performance of the underwater acoustic (UWA) communication is influenced by environmental factors, such as loss, ambient noise, multipath and Doppler effect[3]. The reflection of boundary and medium in UWA multipath channel will affect the amplitude and phase of the transmitted signal[1]. Also, UWA channel shows a frequency selective fading and this induces an inter-symbol interference (ISI) resulting in bit error increase[2].

To cope with ISI in frequency selective multipath fading, such as equalizer and multi carrier modulation (MCM) are developed. Also, A forward error correction (FEC) coding and interleave is adopted to reduce the error by background noise.

In this study, we compare the performance of MCM-Reed-Solomon (RS) code with block interleave (BI) and quadrature phase shift keying (QPSK)-RS in underwater fading channel.

2. Multi Carrier Modulation and Block Interleaving

Figure 2 shows a block diagram of a multi Carrier Modulation (MCM) system. MCM is a method of transmitting data by splitting it into several narrow bandwidths and sending each of these information data over separate carrier signals. The individual carriers have narrow bandwidth, but the composite signal can have broad bandwidth. This method is a method such as Frequency Division Multiplexing (FDM) and Orthogonal Frequency Division Multiplexing (OFDM)[3]. **Fig. 3** shows the band characteristics of the single carrier, FDM and OFDM.

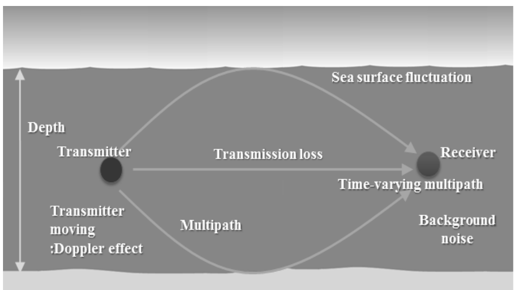

Fig. 1 Underwater fading channel.

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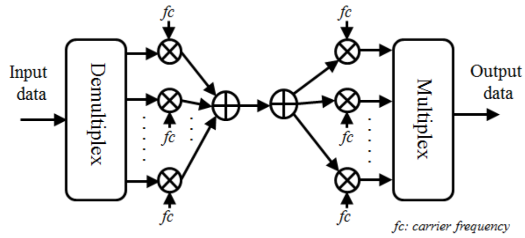

Fig. 2 Block diagram of MCM system.

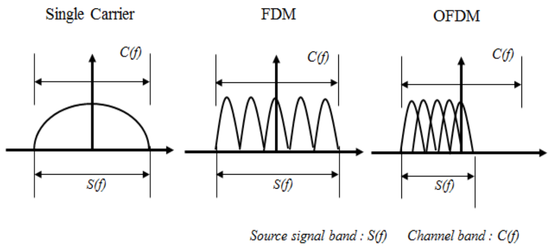

Fig. 3 The characteristics of the single carrier, FDM and OFDM.

Figure 4 shows a 3 X 4 block interleaving. Interleaving is used to obtain time diversity in a digital communication system without adding any overhead. In multi carrier communication systems, interleaving across carriers may be employed to provide frequency diversity, to mitigate frequency selective fading or narrowband interference[4].

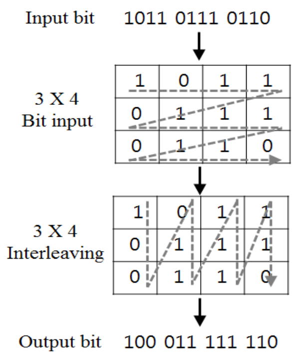

Fig. 4 3 X 4 block interleaving.

3. Experiment and Results

Figure 5 shows Block diagram of UWA communication using block interleaving and MCM. The experimental parameters and configuration are shown in **Fig. 6** and **Table I,** respectively. The source and the receiver are located at depth of 0.3 m and 0.2 m, respectively. **Fig. 7** shows the frequency response of water tank.

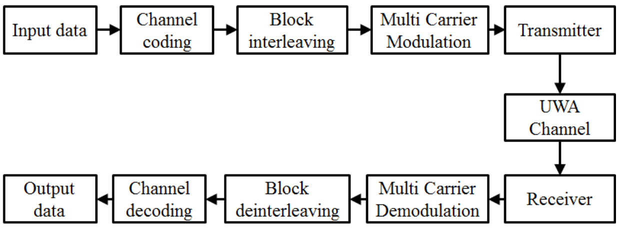

Fig. 5 Block diagram of UWA communication using block interleaving and MCM.

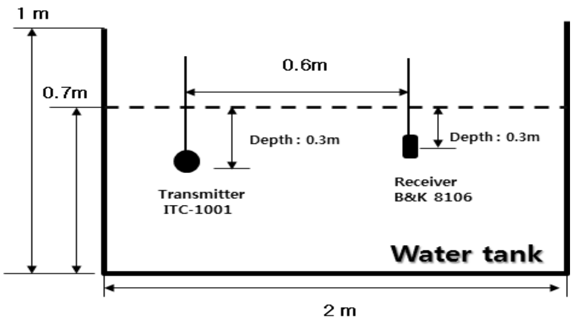

Fig. 6 The experimental configuration.

Table I. The experimental parameters.

Modulation	MCM (QPSK)
Mark Carrier frequency	18 kHz
MCM CH. number	4 CH
Bit rate (sps)	100, 200 symbol per second
Transmission bit	9800 bit
Distance	0.6 m
Transmitter / receiver depth	0.3 m/ 0.3 m
Coding and interleaving	Reed-Solomon code Block interleaving

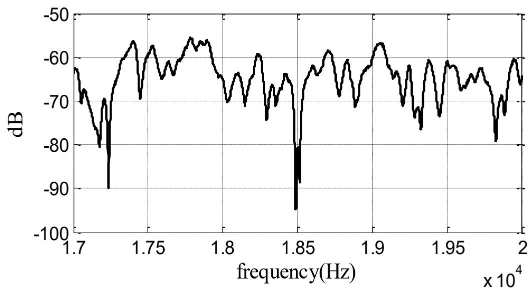

Fig. 7 Frequency response of water tank.

Figure 8 and **Fig 9**. shows the compare the performance of MCM-RS with BI and without BI for 100 sps and 400 sps, respectively. In 100 sps and 400 sps , the performance of MCM-RS with BI is about 1 dB, 3 dB better than that of QPSK-RS, respectively.

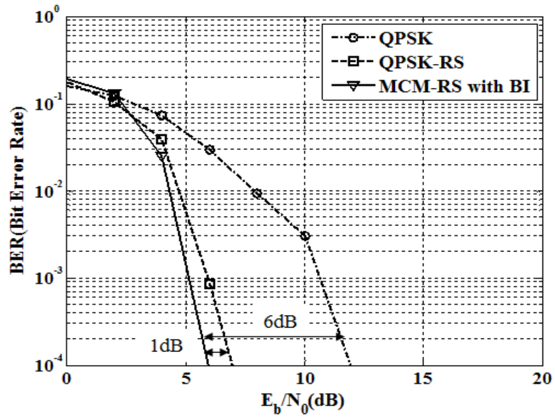

Fig. 8 The performance of MCM-RS with BI and without BI (100 sps).

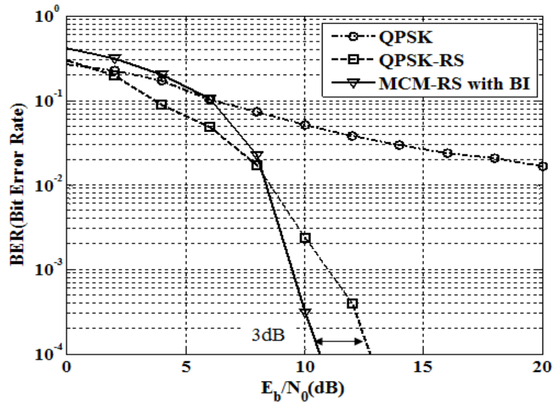

Fig. 9 The performance of MCM-RS with BI and without BI (400 sps).

4. Conclusion

In experimental results, the performance of MCM-RS with BI is 1 dB better than that of QPSK-RS in 100 sps. Also, In the 400 sps, MCM-RS with BI is 3 dB better than that of QPSK-RS. This confirms that MCM-RS with BI is more effective in underwater acoustic fading channel.

Acknowledgment

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