Additional data transmission technique based on underwater OFDM communication system for measured pollution data of wastewater

Junghoon Lee[1], Seungho Lee[1], Yongsik Kang[1], Soonho Jung[1], Jungkyu Rho[2], Jintae Kim[3], Jaekwon Shin[3], Minsoo Choi[4], Jaesang Cha[1*]

[1] Dept. of Electronic & IT Media Eng., Seoul National Univ. of Science and Tech., Seoul, Korea
[2] Dept. of Computer Science., Seokyeong Univ., Seoul, Korea.
[3] R&D center of Fivetek Co,. ltd, Sungnam, Korea
[4] Exhibition Division 1, Gwacheon Ntional Science Museum, Kyunggi-Do, Korea

* corresponding author: chajs@seoultech.ac.kr

Abstract. In this paper, additional data transmission scheme using watermarking technique was studied based on underwater acoustic OFDM communication system for reporting pollution data of wastewater. Underwater acoustic signal undergo direct and indirect propagation between sensor (transmitter) and local server(receiver), which cause distortion on received signal. In order to overcome this poor communication condition, OFDM modulation which has long cyclic prefix was selected. And golay code spreaded watermark system was proposed to transmit additional data concurrently with OFDM signal. This proposal was verified via computer simulation.

Keywords: Underwater Channel, OFDM, Golay code, Sensor Communication

1 Introduction

According to increase of concerning about water resource, pollution monitoring system of wastewater gathering sensing data have been studied[1-3]. Pollution measuring sensor is located in underwater and measured data is transmitted into monitoring system via underwater acoustic communication. Because underwater acoustic communication is interfered with multiple path caused by bottom or surface of water, OFDM system has enough long cyclic prefix duration to avoid the influence of multiple path has been studied[4-6]. But additional data's transmission scheme like sensor's status or location was rarely studied yet. So this paper is going to propose concurrent additional data's transmission scheme using golay spreading code based on underwater OFDM sensing data communication.

In chapter 2, OFDM transmission system will be investigated to send underwater sensing data and in chapter 3, additional data transmission scheme using golay code spreaded watermarking system will be investigated and in chapter 4, simulation will

be performed to show the validity of proposed system and in chapter 5, conclusion will be written.

2 The OFDM sensor communication system using underwater channel

Additional data transmission scheme based on underwater OFDM system is as figure 1. Sensor data from transmitter is modulated as OFDM scheme that is, data is sent to S/P block and it is converted as N-parallel symbol. It is finally modulated as orthogonal sub-carrier, 1 OFDM symbol can be expressed as below.

$$s(t) = \mathrm{Re}\left\{ \sum_{i=-\frac{N_s}{2}}^{\frac{N_s}{2}-1} d \quad + N_s / 2 \exp(j2\pi(f_c - \frac{i+0.5}{T})(t-t_s)) \right\}, \; t_s \le t \le t_s + T \tag{1}$$

d_i is conjugated QAM symbol, N_s is the number of sub-carriers, T is symbol duration, f_c is carrier frequency. OFDM undergo underwater acoustic channel and it finally reached at receiver. In order to overcome multiple path interference, cyclic prefix length should be longer than maximum multiple path delay. If not, OFDM signal is polluted by its multiple path signal.

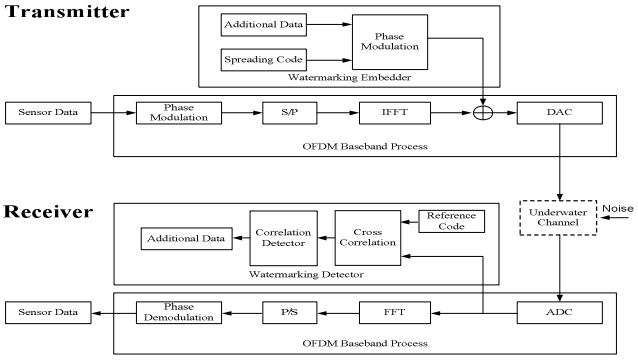

Fig. 1. Block diagram of OFDM communication system and additional data transmission scheme in the underwater channel

3 Additional data transmission method using spreading code

In transmitter sensor data is modulated by OFDM scheme and let's call it as x_k. And let's call additional watermarking data to be sent with OFDM signal as $w_i(k)$.

Then whole sending data, x'_k, can be expressed as equation (4). p is energy level of watermark signal.

$$x'_k = x_k + pw_i(k) \tag{4}$$

Reached signal on receiver can be expressed as equation (5) which means sent data x'_k undergo underwater channel and $n_i(k)$ is noise.

$$r_i(k) = x'_k \otimes e_i + n_i(k) \tag{5}$$

In receiver, watermarked data is demodulated via correlator using golay reference code. If the correlation value is large than the threshold it is regarded as sending data. In case of OFDM signal, it is decoded via reverse way of transmitter. If watermarked data power level is big, the quality of OFDM signal is degraded. If it is very small, OFDM signal is good but watermarked data can't be decoded. So appropriate signal power level must be maintained.

4 Simulation and Performance Analysis

Computer simulation was executed to show each signal's BER performance. Because received signal is mainly consist of OFDM signal and watermarked additional signal, this system can be verified if their own signals are alive. Detailed simulation parameters are written in Table 1.

4.1 BER analysis of the number of underwater reflections by the sensor signal based on underwater OFDM

In OFDM system, Cyclic Prefix is selected enough long compared with maximum bounded signal, so we assumed that multiple path signal can be ignored in this simulation. And golay code is used for watermarking spreading code. Figure 2 shows the BER performance of OFDM signal when OFDM signal and watermarking signal is concurrently sent. If the signal ratio of watermarking data and OFDM signal is smaller than -17dB, OFDM BER is converged and it can be thought it is valid.

Table 1. BER Simulation parameters

Parameters	Values
FTT Size	256
Cyclic prefix(CP) ratio	1/4
Number of data subcarriers	64
Spreading Code	Golay(256)
Symbol Number	1000
Amplitude	-40 ~ -15 dB
Eb/No Duration	0 ~ 20dB

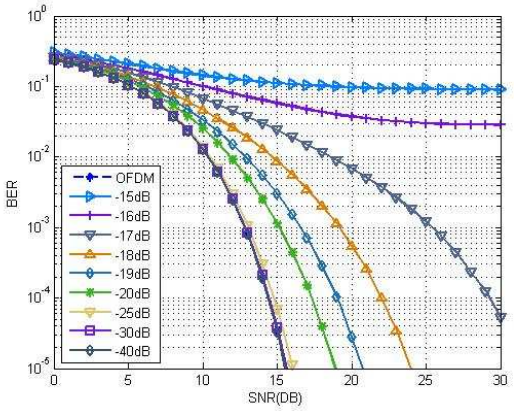

Fig. 2. . BER Performance of OFDM signal among received signal

4.2 BER Performance of watermarking signal among received signal

In case of DER(Detection Error rate) of watermarked signal, if the signal ration of watermarking data and OFDM signal is bigger than -20dB, DER curve meet 10^{-3} level. Considering 4.1 and 4.2 result, useful signal ratio is -18 and -20dB to satisfy both communication's validity.

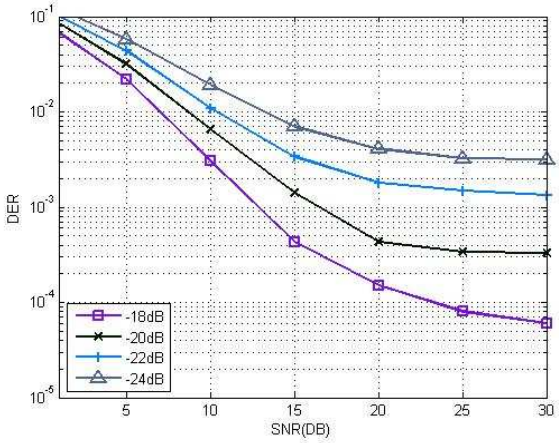

Fig. 3. BER Performance of watermarking signal among received signal

5 Conclusion

In this paper, golay code watermarked additional data transmission scheme was proposed based on underwater OFDM communication system aimed for reporting the pollution degree from sensor to local server. Based on received signal containing OFDM and Spreading signal, this system was simulated and it showed that when the signal ratio of watermarking and OFDM signal is -18 or -20dB, both signal can be transmitted with validity. So this proposed system can be used as a additional data transmission system and this result will be reference afterwards.

Acknowledgment

This subject is supported by Korea Ministry of Environment as “Global Top Project”(Project No.:GT-11-B-02-014-3)

References

1. Yoshida, H, Hyakudome, T., Ishibashi, S., Ochi, H., Asakawa, K., Kasaya, T., Saito, T., Okamoto, S., "Study on land-to-underwater communication", WPMC, 2011 14th International Symposium on, pp. 1-5, (2011)
2. Shuxiang Guo, Zixin Zhao, "Design of a QPSK-CDMA acoustic communication system for multiple underwater vehicles", Mechatronics and Automation, 2009. ICMA 2009., pp. 3568-3572, (2009)
3. Yang Wang, Peng Zeng, Jinchao Xiao, Qiong Zhang, Dewie Li, "Wireless gateway for wastewater treatment", Signal Processing, Communications and Computing (ICSPCC), pp. 1-5, (2011)
4. Jianzhong Huang, Berger, C.R., Shengli Zhou, Jie Huang, "Comparison of basis pursuit algorithms for sparse channel estimation in underwater acoustic OFDM", OCEANS 2010 IEEE - Sydney, pp. 1-6, (2010)
5. Kaizhuo Lei, Zhenhua Yan, Jing Han, Jianguo Huang, "Design and implementation of underwater OFDM acoustic communication transmitter", Audio, Language and Image Processing, 2008. ICALIP 2008., pp. 609-613, (2008)
6. Gomes, Joao, Berger, Christian R., Silva, Antonio, "Demodulation of Underwater OFDM Transmissions by Time Reversal and Basis Pursuit Methods", Wireless Conference 2011 - Sustainable Wireless Technologies (European Wireless), 11th European, pp. 1-9, (2011)