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Performance of Convolution and Reed-Solomon Codes in Underwater Acoustic Fading Channel

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1. Introduction

In underwater acoustic channel, the source signal is affected on multipath propagation, long delay spread, limited bandwidth, ambient noise and so on. Therefore, intersymbol interference (ISI) depend on these parameters and performance of underwater acoustic communication systems is declined[1,2].

In this study, we have analyzed performance of convolutional code (CC) and Reed-Solomon (RS) code in underwater acoustic fading channel. Bit error rate (BER) characteristic according to signal to noise ratio (SNR) is examined for quadrature phase shift keying (QPSK) transmission.

2. Underwater acoustic fading channel and channel codes

In underwater acoustic communication, transmitted signals experience delay spread due to multipath. The relationship between the effective delay spread τ_{rms} and the channel's coherence bandwidth B_c is given as[3)]

$$B_c = \frac{1}{5\tau_{rms}} \quad (1)$$

Two kinds of forward error correction (FEC) methods were tested convolutional codes (CC) and Reed-Solomon (RS) codes as **Fig.1** and **Fig. 2**.

Convolutional Codes are generally specified by three parameters (*n, k, m*), where *n* is the number of output bits, *k* represents the number of input bits and *m* corresponds to the number of memory registers. The code rate $R = k/n$ is a measure of the code efficiency[4)].

Reed Solomon codes *(n, k, t)* are cyclic codes, built from *n* symbols with a maximum of $n = q - 1$, where *q* is the number of elements in the Galois field (*GFq*) ($q = 2n$) and *t* is the power correcting code, so the number of control symbols is *2t*. $k = n\text{-}2t$ represents the number of information symbols that can be transmitted[4,5)].

3. Experiment and Results

Figure 3 shows block diagram of underwater acoustic communication system. The experimental configuration and parameters are shown in **Fig. 4** and **Table I**, respectively. The source and the receiver are located at depth of 0.3 m and 0.3 m, respectively. **Figure 5** shows the delay spread in the water tank[6)].

The effective delay spread is calculated about 1.8 ms by equation 1, the corresponding

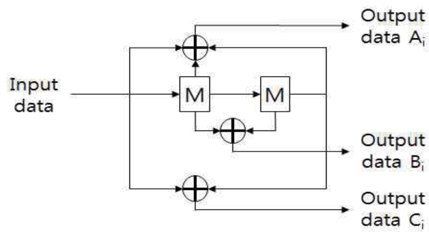

Fig. 1 FEC k=3, rate 1/3 Convolutional encoder

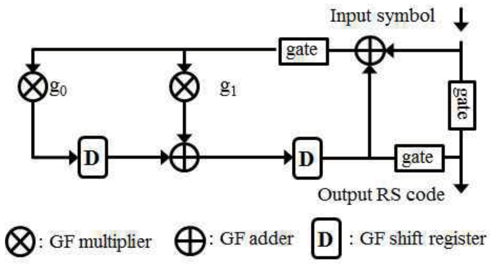

Fig. 2 FEC n=3, k = 1 Reed-Solomon encoder

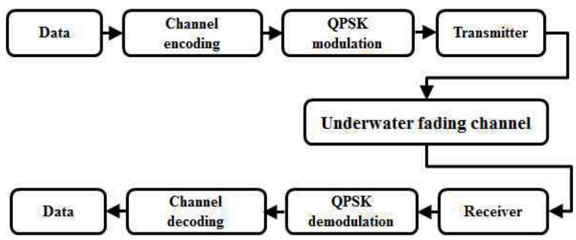

Fig. 3 Block diagram of system

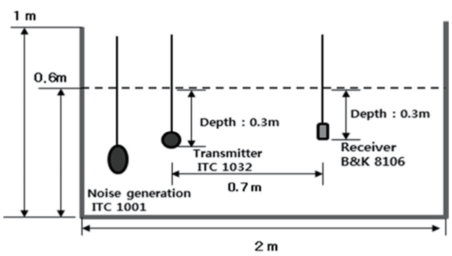

Fig. 4 Experinmental configuration in water tank

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Table I. Experimental parameters.

Modulation	QPSK
Depth (m)	0.6
Symbol per rate (sps)	100
Distance(m)	0.7
Tx and Rx depth(m)	0.3 and 0.3
Transmission data	Image(50x50) 8bit (60,000bit)
Channel Coding	Convolutional Code Reed-Solomon Code
Code rate	1/3

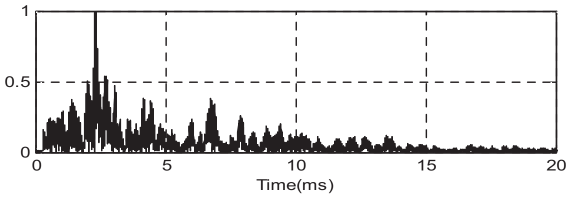


Fig. 5 Channel response of water tank

coherence bandwidth is about 110 Hz. Therefore, the signal that can be transmitted without error is at a rate of less than 110 sps under high signal to noise ratio. Noise generator emits pseudo noise (PN) signal modulated by carrier. After channel encoding, bit length must be same to compare their performances. So as shown the **Fig. 1** and **Fig. 2**, code rate and constraint length of CC is 1/3 and 3. Code word length and data word length of RS is 3 and 1, respectively.

Table II. Experimental results

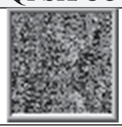
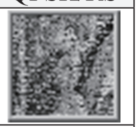
		QPSK	QPSK/CC	QPSK/RS
0 dB	Image			
	BER	0.29895	0.33075	0.1922
4 dB	Image			
	BER	0.0884	0.0165	0.05435
8 dB	Image			
	BER	0.01485	0	0.0012
12 dB	Image			
	BER	0.00035	0	0
16 dB	Image			
	BER	0	0	0

Table II shows received images and BER to E_b/N_o for QPSK, QPSK/CC and QPSK/RS. In image transmission performance to E_b/N_o, QPSK/CC depicts better performance than QPSK/RS. It is also found that channel encoding gain of QPSK/CC is about 7 dB in underwater acoustic fading channel but that of QPSK/RS is about 5 dB as shown in **Fig. 6**.

Figure 6 shows BER to E_b/N_o for each experiment. As shown in the **Table II** and **Fig. 6**, generally to use FEC is better than not used code about 5 to 7 dB. Also QPSK/CC is shown improved performance than QPSK/RS about 2 dB.

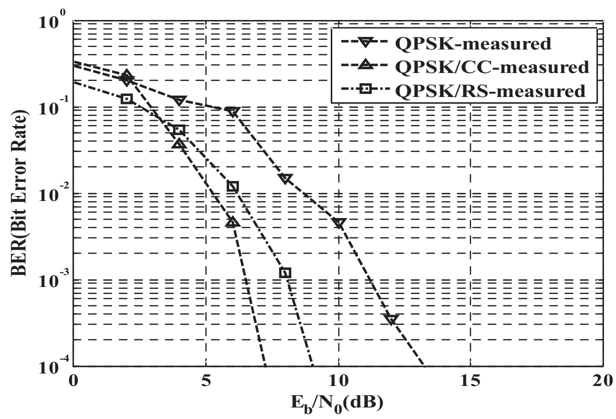


Fig. 6 BER to E_b/N_o for each encoding scheme

4. Conclusions

In this study, performances of QPSK/CC and QPSK/RS are examined BER to E_b/N_o in underwater fading channel. Channel encoding gain of QPSK/CC and QPSK/RS are about 7 dB and 5 dB, respectively. Therefore, we confirmed performance improvement by using channel coding method in underwater acoustic fading channel.

Acknowledgment

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References

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