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Performance of time and space diversity technique in underwater acoustic communication

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1. Introduction

In shallow water, a transmitted signal is severely influenced by the sea surface and the sea bottom boundaries[1)]. By the inter-symbol interference (ISI) effect owing to very large reflection signals from these boundaries, the underwater acoustic communication quality degrades[2)]. We evaluated the effect of a time diversity technique using a rake receiver on the QPSK modulation and demodulation system in the shallow water conditions. And we also checked the frequency spectrum according to different depths in receivers for the space diversity.

2. Experimental Conditions

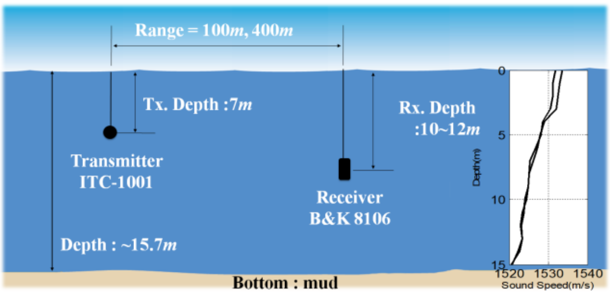


Fig. 1 Schematic diagram of sea experiment configuration

Fig. 1 shows schematic diagram of sea experimental configuration in a shallow multipath channel environment. The experiments were conducted in Geo-je Island, Korea. The experimental parameters are shown in **Table 1**.

Table 1. Experimental parameters

Mod/Demodulation	QPSK
Carrier Frequency (kHz)	16 kHz
Symbol Rates (sps)	200, 400, 800
Data Transmission Type	Packet
Tx and Rx range (m)	100, 400
Tx and Rx depth (m)	7 & 10,11,12
Depth (m)	~15.7
Bottom Property	Mud
Data	Lena Image 10,000 bits

The range between the transmitter (ITC-1001) and receiver (B&K 8106) is set to be 100m and 400m and the depths of transmitter and receiver are set to be 10m, 11m and 12m. The carrier frequency is respectively chosen as 16 kHz. The transmission rates are set to be 200, 400 and 800 sps. The transmitted image is the Lena image consisting of 10,000 bits of data. The channel response assumed had only seven delayed impulse signals for the shallow sea. The impulse responses and frequency spectrum at 100m and at 400m are shown in **Fig. 2** and **Fig. 3**.

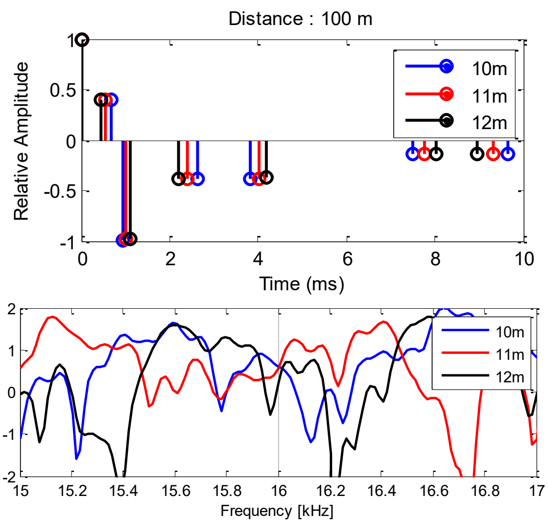


Fig. 2 Impulse response and frequency spectrum at 100m for the shallow water simulation

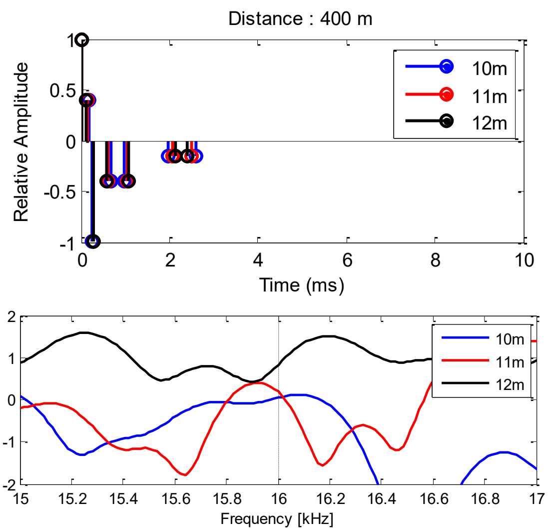


Fig. 3 Impulse response and frequency spectrum at 400m for the shallow water simulation

3. Numerical Simulations

The channel's coherence bandwidth was calculated all simulation situation. They were respectively calculated about 142.4 Hz, 141.6 Hz, 140.3 Hz at 100m and 512 Hz, 510.6 Hz and 506.9 Hz at 400m in shallow water. The results of the experiment are as follows in **Table 2** and **Table 3**.

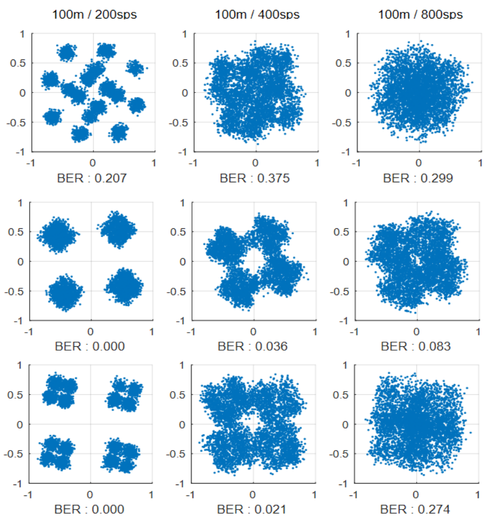
Table 2. Simulation result at 100m

		100m		
		200 sps	400 sps	800 sps
10m	Non	0.207	0.375	0.299
	With corr.	0.000	0.035	0.083
11m	Non	0.000	0.021	0.274
	With corr.	0.000	0.000	0.071
12m	Non	0.000	0.000	0.104
	With corr.	0.000	0.001	0.101
10+11+12m	Non	0.000	0.001	0.037
	With corr.	0.003	0.053	0.118
Coherence BW [Hz]		142.4	141.6	140.3

Table 3. Simulation result at 400m

		400m		
		200 sps	400 sps	800 sps
10m	Non	0.000	0.000	0.016
	With corr.	0.000	0.000	0.006
11m	Non	0.000	0.000	0.031
	With corr.	0.000	0.013	0.053
12m	Non	0.000	0.000	0.000
	With corr.	0.000	0.000	0.000
10+11+12m	Non	0.000	0.000	0.001
	With corr.	0.000	0.000	0.000
Coherence BW [Hz]		512.0	510.6	506.9

We demonstrate constellations on the communication system at 100m which is shown in **Fig. 4**. (top: without correlator, bottom: with correlator)



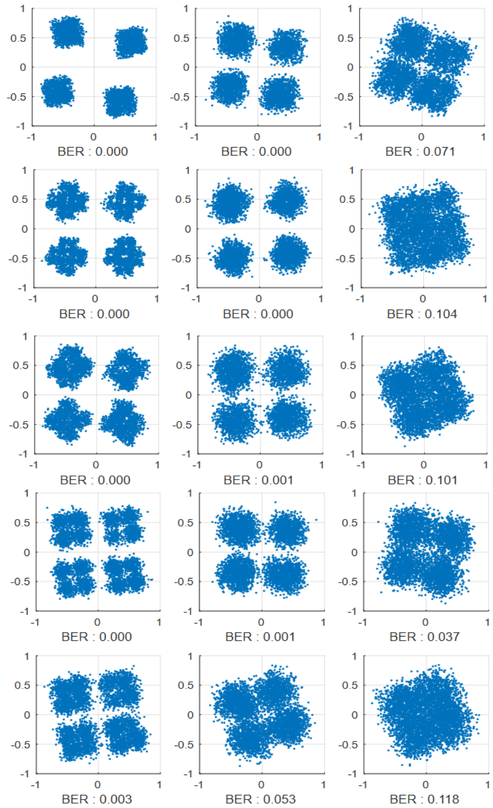


Fig. 4 Results of phase compensation at 100m

4. Conclusions

We introduced the approach with the rake receiver to improve the performance on the underwater acoustic communication system. And, in order to perform space diversity, QPSK communication simulation was carried out with three receiving sensors at a depth of 10m, 11m and 12m. The coherence bandwidth of each sensor becomes narrow as the depth increases. However, coherence bandwidth and BER are not significantly related to each other. Also, analysis of the frequency spectrum shows that the effect of fading is greater than the coherence bandwidth. It can be confirmed that it is possible to apply it to selective space diversity.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2017R1D1A3B03036098).

References

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