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Underwater Image Transmission Performance in Very Shallow Littoral Ocean

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1. Introduction

Underwater acoustic communication system is highly sensitive to channel characteristic which depends on environmental parameters such as background noise, sea surface state, and depth dependent sound speed profile. Special emphasis on the bit error rate (BER) has been given to the effect of time-varying signal fluctuation due to sea surface roughness, which results in severe degradation of system performance by causing time and frequency spread of the transmitted signal. In highly absorptive sea bottom and rough sea surface in deep water, the effect of bottom and sea surface reflection may be ignored by operating the acoustic communication system under vertical channel. Under this channel, the multipath signal from the boundaries is relatively weak to the direct path signal since the subtend angle is high enough to reduce the amplitude of boundary reflected signal.

However, in shallow water or in long range horizontal propagation channel, the boundary reflected multipath signals are high enough to interfere the direct path signal and to induce an inter-symbol interference (ISI).

In this study, image transmission performance of Binary Frequency Shift Keying (BFSK) in very shallow littoral is examined to figure out the range dependent image quality based on BER.

2. Experimental Results and Analysis

The experimental configuration is shown in **Fig. 1**. Depth of water is about 5to 25 m. Bottom sediment is sandy mud or mud depending on experimental site. The source and the receiver is located at depth of 3 and 2.5 m, respectively. CTD is casted to measure water column properties during experiment it gives a uniform vertical sound velocity profile. The effective value of the surface wave height is about 5 to 100 cm.

Before transmitting binary frequency shift keying (BFSK) image signal, linear frequency modulated (LFM) signal is transmitted to measure the channel impulse response and time-align the received signal for demodulation.

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Figures 2 and 3 shows typical band limited impulse response of 5 m water depth showing the time spread of the received signals consisting of direct signal and multipath reflected signals. Impulse response is obtained using linear frequency modulated (LFM) signal.

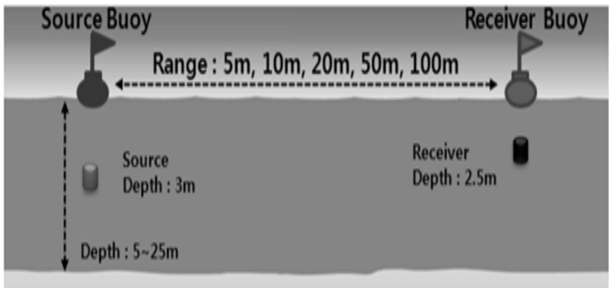

Fig. 1 Experimental configuration.

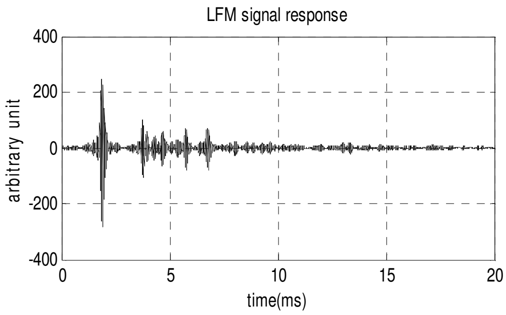

Fig. 2 Band limited impulse response of 5m range.

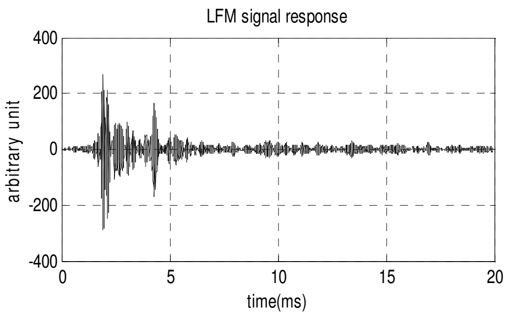

Fig. 3 Band limited impulse response of 50m range.

Figure 4 shows the received images of five different ranges and five transmission bit rates at 5 m water depth. To analyze the effect of signal to noise ratio (SNR), SNR of each range to 5 m range SNR_{ref} is given. The corresponding BERs to transmission rates are given in **Table I**.

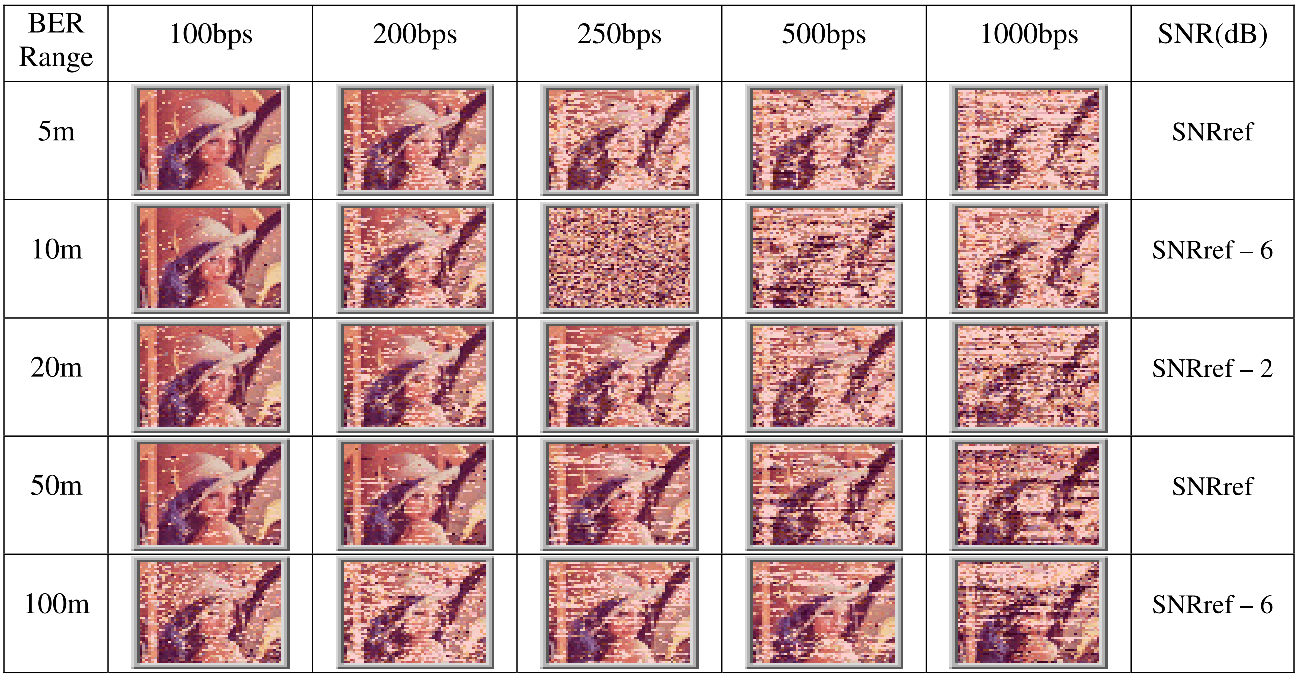

Fig. 4 Received images with respect to the range, bit rate and SNR.

Table I. BER with respect to the range, bit rate and SNR

Bit rate / distance	100bps	200bps	250bps	500bps	1000bps
5m	0.021	0.099	0.313	0.245	0.282
10m	0.025	0.158	0.500	0.367	0.258
20m	0.057	0.107	0.167	0.264	0.422
50m	0.034	0.050	0.104	0.200	0.313
100m	0.114	0.176	0.118	0.120	0.209

As shown in **Fig. 4** and **Table I**, BERs depend on range, transmission bit rate and SNR. In the same SNR of 5 and 50 m, and 10 and 100 m, image quality and BER are better in longer range except 100bps. Image quality and BER of 10 m range is the worst in overall. This explains that there is transition range between short range and long range.

3. Conclusions

In this study, underwater image transmission performance of BFSK in very shallow littoral zone is examined and analyzed to figure out the range dependent image quality based on BER and SNR. It is found that there is the worst performance which is in between short range and long range in underwater acoustic communication.

Multipath reflection effect in very shallow littoral may explain this result and the related analysis is ongoing considering impulse response related to sea surface state, bottom sediment property, water depth and sound velocity profile.

Acknowledgment

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