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Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 419-420
6-8 December, 2010

Sea Surface Fluctuation Effect in Underwater Image Transmission

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1. Introduction

Oceanic environmental parameters such as background noise, sea surface state, and depth dependent sound speed profile affect the underwater acoustic communication bit error rate(BER). Special emphasis on the BER has been given to the effect of time-varying signal fluctuation due to sea surface roughness, which results in severe degradation of the communication system performance by causing time and frequency spread of the transmitted signal. The frequency shift and the average reflection coefficient of a signal scattered by the sea surface is measured as a function of frequency and subtended angle. In the time domain, the received signal suffers fading, such as time-variant fluctuation, in both amplitude and phase owing to interactions with both time-variant sea surface boundary scattering.

In this study, underwater image transmission performance of Binary Frequency Shift Keying (BFSK) for sea surface fluctuation is examined experimentally in water tank.

2. Effect of Sea Surface Fluctuation on the Underwater Communication

The surface fluctuation depends on the Rayleigh parameter, defined as $R = kh\sin\theta$, where k is the wave number, h is the effective value of the surface wave height, and θ is the grazing angle. When $R >> 1$, the surface acts as a scatter, and the scattering path reflected from a surface wavelet will have its own fluctuation frequency, and maximum frequency of which is that of sea surface wave.

For the error free communication, the frequency shift keying(FSK) symbol duration should be longer than the time spread which is inverse of the coherence band width. **Fig. 1** shows time spread of the received signals consisting of direct signal and surface reflected signal. As shown, time spread of each received signal is same but amplitude of each direct signal is different. **Fig. 2** shows BER characteristics of 1kbps When amplitude of the surface reflected signal increases, BER increases.

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This can be also interpreted by effective time spread considering relative strength of surface reflected signal.

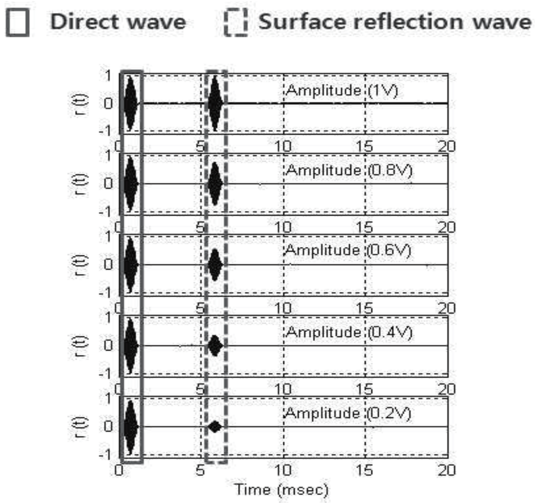

Fig. 1 Received signals with different amplitude of sea surface reflected signals.

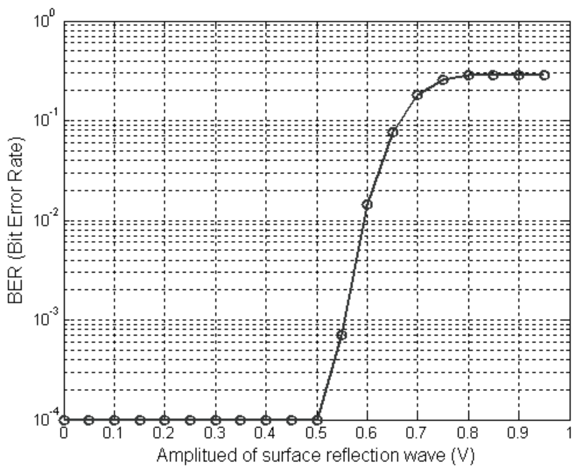

Fig. 2 BER characteristics by amplitude change of sea surface reflected signals.

3. Experiment Result and Discussions

Fig. 3 is experiment configuration for transmission performance of BFSK by surface fluctuation in underwater image transmission. The image is symbol of Pukyong National University (36,764 bits). Transmission rate is 200bps and the total image transmission time is about 184s. The water tank surface was made to fluctuate using plastic sphere to reduce tapping noise. The surface fluctuation frequency and wave height are about 3Hz and 15cm, respectively.

Response characteristics of 20kHz tone burst is shown in **Fig. 4**. Comparing the signal of mirror surface (Fig.4-(a)) and the fluctuated surface(Fig.4-(b)), The reflected signal amplitude of the fluctuated surface is less than that the mirror surface. Rayleigh parameter is about 10.

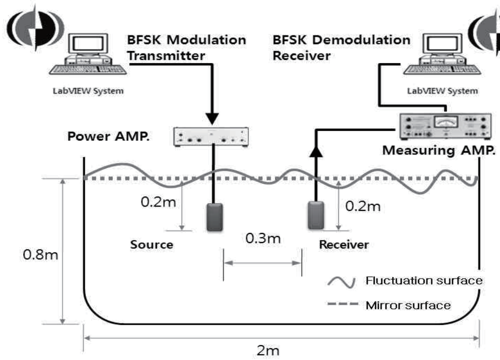

Fig. 3 Water tank experiment configuration.

Fig. 5 shows the received images of the mirror surface and fluctuation surface cases. The BER of the fluctuated surface is less than that of the mirror surface. **Fig. 6** is BER characteristics of mirror surface and fluctuation surface by SNR.

In conclusion, the surface fluctuation causes the scattering on the incident signal and the amplitude of surface reflected signal decreases compared to that of the mirror surface. Therefore the effective time spread decreases and the BER of the communication decreases. The results of this study will also be analyzed statistically using Rayleigh and Rice fading models for surface fluctuation.

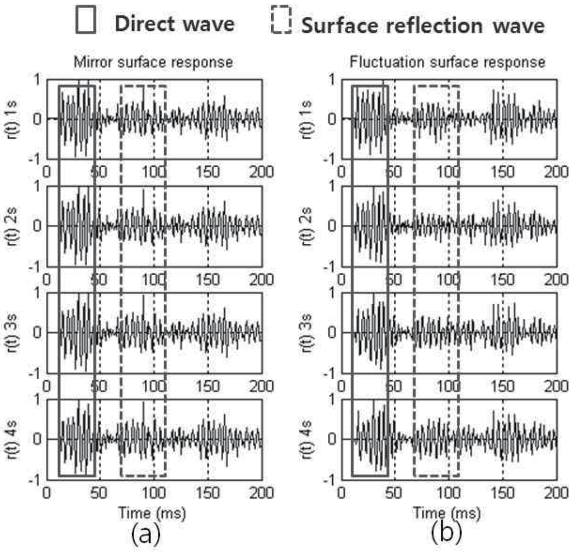

Fig. 4 Response characteristics of water tank: (a) mirror surface, (b) fluctuated surface.

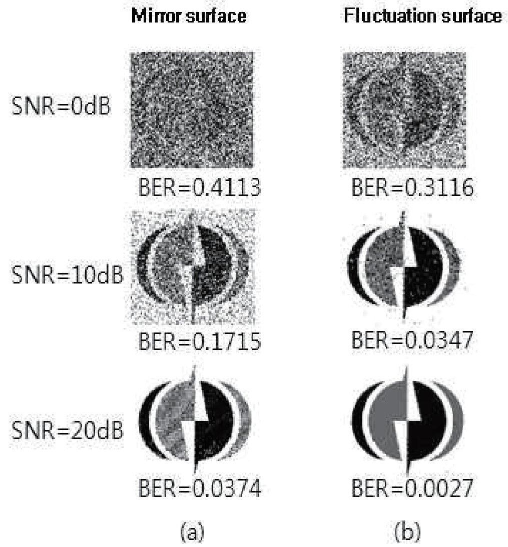

Fig. 5 Received image with respected to the surface fluctuation state and SNR: (a) mirror surface, (b) fluctuated surface.

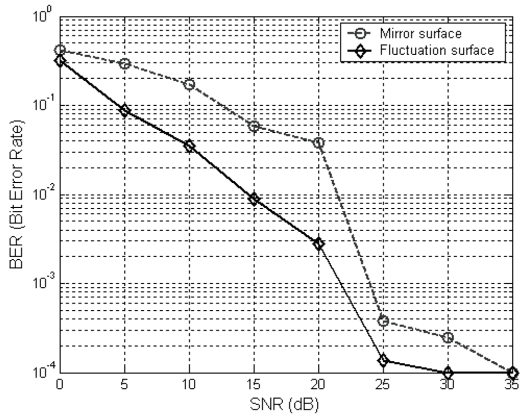

Fig. 6 BER characteristics by SNR in underwater image transmission.

Acknowledgment

This work is the result of the "Human Resource Development Center for Economic Region Leading Industry" Project, supported by the Ministry of Education, Science & Technology(MEST) and the National Research Foundation of Korea(NRF).

References

1. Stojanovic, M., Preisig, J.: IEEE C. Magazine. 47 (2009) P. 84 – 89.
2. J. G. Proakis: *Digital Communications* (McGraw - Hill , New York, 2001) 4th ed., p. 177.
3. W.B.Yang, and T.C.Yang: J. Acoust. Soc. Am. 120(2006). 2615.
4. J. Park, J. R. Yoon, and J. Park: Jpn. J. Appl. Phys. **48** (2009) 07GL03.
5. J. Park, K. Park, and J. R. Yoon: Jpn. J. Appl. Phys. 49 (2010) 07HG10.