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Examination on Remote Control of CMOS sensor using ultrasonic communication in the shallow sea

浅海域における超音波通信を用いたCMOS カメラの遠隔操作に関する検討

Yoshikazu Koike[1], Hiroaki Arai[1], Takahiro Yomoda[1], Takayoshi Sekiguchi[1] and Harumasa Hojoh[2] ([1]Shibaura Inst. of Tech., [2]Tokyo Univ. of Marine Sci. and Tech.)
小池義和 [1‡]，新井宏章 [1]，四方田孝廣 [1]，関口貴善 [1]，北條晴正 [2]（[1] 芝浦工大, [2] 東京海洋大）

1. Introduction

Recently, underwater communication by ultrasonic becomes important for the purpose of the effective utilization of the sea environment. [1-3] Image communications already have been achieved in order to maintain the cable on the sea bed. In the report, the communication environment is deep sea in the depth of over 100m. Such a se environment is more stable than the shallow sea. Authors already reported the image transfer in the shallow sea in the depth of around 10m by ultrasonic.[4] In such a shallow sea, the multi-path fading is very server problem. And, hence, it is difficult to reduce bit error rate (BER). In this report, the CMOS image sensor in the shallow is controlled and the image is transferred by ultrasonic communication. The experiment result using the drip-proof ultrasonic sensor has been reported. [5] However, the transfer is slow at the speed of 100bps. The transmitter and receiver are achieved by Digital signal processor (DSP). The modulation is Minimum Shift Keying (MSK). The BER is investigated, varying the communication distance. Finally, the color image of 4800 pixels is transferred.

2. Configurations of transmitter and receiver

Figure 1 shows the configuration and the dimensions of the employed transducers. The shape of transmitter and receiver are cylindrical. The dimensions are 10mm in height, 24mm in outer diameter and 22mm in inner diameter. Poly-urethane is molded around the cylindrical PZT element for water proof. In most of the reports, the QPSK modulation is used to achieve a high-speed data transfer. In our system, the MSK modulation is employed for the advantage of multipath fading. The modulator and the demodulator are realized by the DSK board (TMS320C6416, Texas Instruments Incorporated.). The DSK output is through out the mixer where the local oscillator is 17.89kHz. For the demodulation, the output signal of receiver is also through out the mixer. Figure 3 shows the block diagrams of the demodulator. The communication experiment was carried out at Toyosu canal. Both transmitter and receiver are immersed at 1m in depth. The distance between the transmitter and the receiver is 0.15m, 3m or 10m.

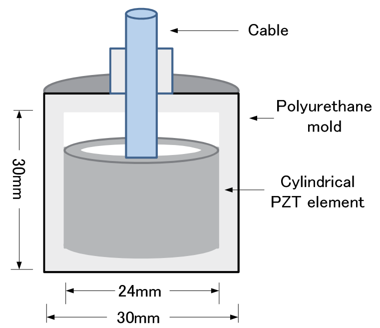

Fig.1 Dimensions and shape of transducer.

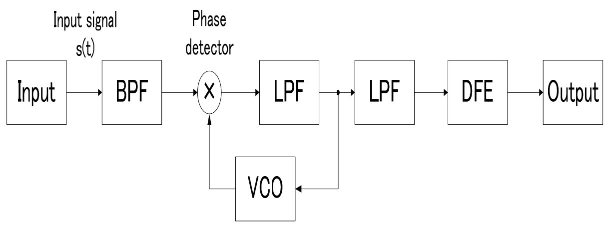

Fig.2 Block diagram of delay detection.

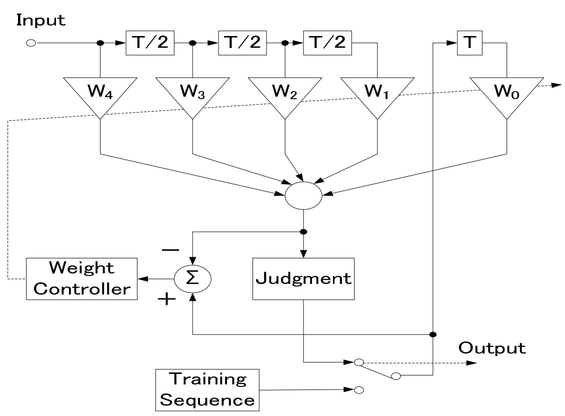

Fig.3 Block diagram of DFE.

‡ koikey@sic.shibaura-it.ac.jp

In order to reduce multipath fading, the DEF is employed. Figure 3 shows the block diagram of DFE (decision feed back equalizer). The renewal of the coefficient of the adaptive filter is calculated by LMS (least mean square method) algorithm.

3. The evaluation result of BER

BER was evaluated, varying the distance between the transmitter and the receiver. Figure 6 shows the BER as the function of the feed forward (FF) tap and the feed back (FB) one. The number of the transmitted signal is 984 bit. The number of training bits is 500. The evaluation of BER is employed by 484 bits. In 3m of the distance, the BER is almost 0 when the FB tap number is over 22. For 10m of the distance, the BER increases over 30, conversely. As LMS is calculated in the fixed floating point, the influence of rounding error will be appeared over 30. Figure 5 shows the variation of BER against the distance. BER is less than 0.01 with DFE although BER is over 0.1 without DFE. In our proposed communication system, the DEF works well to reduce BER. The CMOS sensor image was also transferred. The distance between the transmitter and the receiver is 10m. The image is bitmap, 80 ×60 pixels and 24bit color. The total bit number is 115.2k. 500 bit is added as the training bits at the head of the transferred data. The number of FF and FB tap is 5 and 22. The transferred result is shown in Fig.6. Figure 6(a) is an original image and Fig.6(b) is a transferred image. It took almost 20seconds to transfer whole image while the transfer rate is 8kbps. In 1m of the depth, the communication environment is varied continuously. Such a server environment, BER is achieved 0.02 with DFE. Although some error bits are appeared in Fig.6(b), the original image can be found. Our future plan is to increase the transfer speed and is also to realize the sensor network system using the communication system.

References

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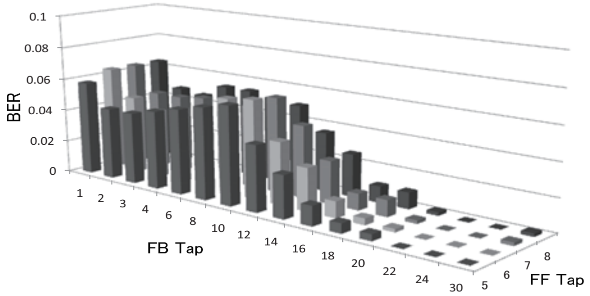
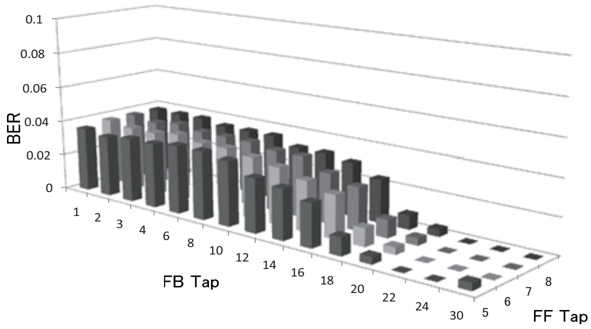


(a) 3m of the distance



(b) 10m of the distance

Fig.4 BER using synchronized detection against tap number.

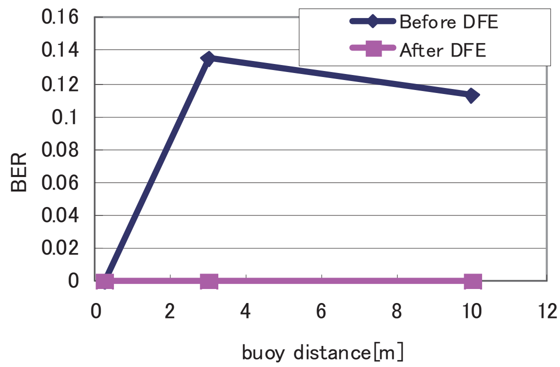
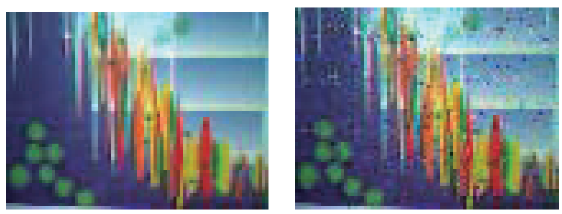


Fig.5 BER against buoy distance using synchronized detection



(a) (b)

Fig.6 Results of image transfer; (a) original image, (b) transferred image.