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Performance Comparison of Adaptive Equalizers between Packet and Continuous Data Transmission in Shallow Water

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1. Introduction

The transmitted signals are severely influenced by sea surface and bottom boundaries in swallow water. Very large reflection signals from boundaries cause inter symbol interference (ISI) effect. The channel estimate based equalizer is usually adopted to compensate the reflected signals under the acoustic communication channel. [1)-3)]

In this study, we tried to send data using two methods - packet and continuous data transmission in the swallow water. The purpose was to compare the performance of two methods and reduce the data transmission time. And two complex coefficient equalizers – feed forward equalize (FFE) and decision direct equalizer (DDE) - are also adopted to compensate the channel distortion with least mean square (LMS) algorithm.[4)-5)] The QPSK system[6)] is used for the underwater acoustic communications simulations.

2. Experimental Conditions

Figure 1 shows the configuration of the sea experiment and its sound velocity profile (SVP) in very shallow multipath channel located in the Geoje island, Korea. The specific experimental parameters are given in **Table I**. The ranges between the transmitter and receiver are set to be about 100 and 400 m, and the depth of receiver and transmitter are set to be 7 and 10 m, respectively.

Figure 2(a) and **2(b)** show the channel response for range 100 m and 400 m obtained by transmitted LFM signal for the check the multipath channel of experiment sea area. The direct signal and the third signal (from surface) are remarkable, but the second signal (from bottom) is very weak signal because of the bottom (mud)'s reflection coefficient. Almost energy is concentrated in 10ms by estimation from the accumulated energy.

Figure 3 shows frame structure for packet data transmission. Transmission time of one frame is set to be 1 s. LFM and PN code were used for the purpose of measuring the channel characteristics and symbol time alignment, respectively.

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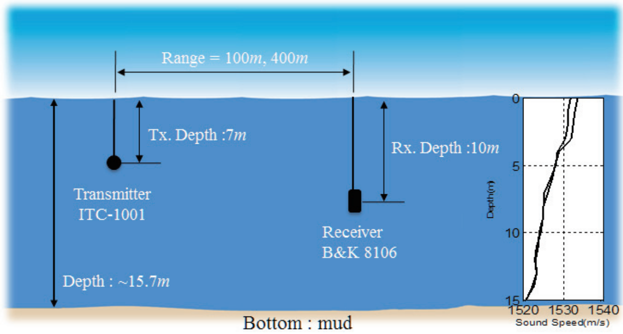


Fig. 1 Experimental configuration and its SVP

Table I. Experimental parameters

Mod/Demodulation	QPSK
Carrier frequency (kHz)	16 kHz
Symbol rates (sps)	100, 400
Data Transmission Type	Packet, Continuous
Tx and Rx range (m)	100, 400
Tx and Rx depth (m)	7, 10
Depth (m)	~15.7
Bottom property	mud
Data (bits)	Image 10,000 bits

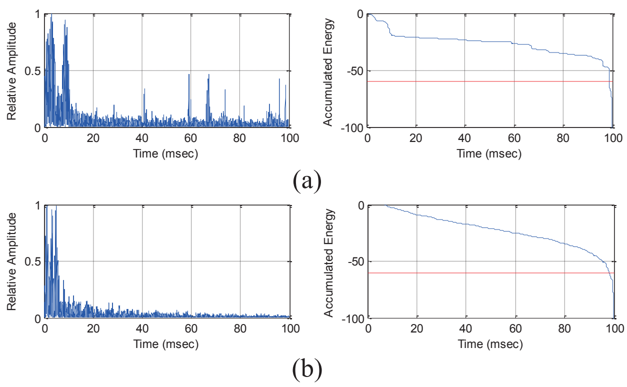


Fig. 2 Channel characteristics and its accumulated energy; (a) 100 m, (b) 400 m

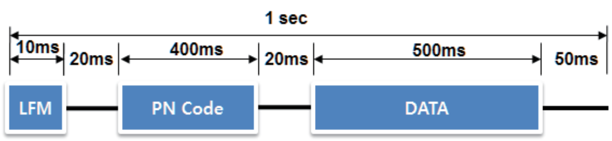
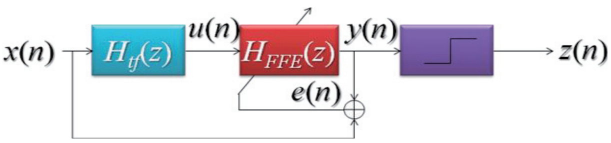


Fig. 3 Frame structure for packet data transmission

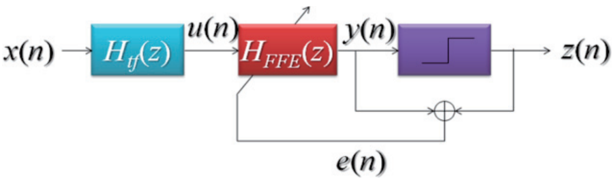
3. Results and conclusions

Figure 4 shows scheme of two complex coefficient equalizers; (a) feed forward equalizer, (b) decision direct equalizer. In FFE and DDE, $x(n)$, $u(n)$, $y(n)$, $z(n)$, and $e(n)$ means original signal to be send, the input in the receiver, filter's output, decision result from $y(n)$, and the error signal between two signals, respectively. $H_{tf}(z)$ means the underwater acoustic communication channel which are given by Fig. 3. Here, the following parameters are used for the LMS adaptive algorithm; the coefficient number of the FFE is given by 6, the step size μ is given by 1.e-5, the coefficient number of the DDE is given by 6, and the step size μ is given by 1e-6. The iterations number for the training in the FFE or DDE is given by 200 to be the same for each result.

The experimental results in packet and continuous data transmission with two different equalizers on QPSK system and the error rate to transmission rate and range are shown for different type equalizers in **Table II** and **Table III** respectively - the result of non equalizer, the result with FFE, and the result with DDE.



(a)



(b)

Fig. 4 Two complex coefficient equalizers; (a) feed forward equalizer, (b) decision direct equalizer

Table II. Performance comparison in packet data transmissions

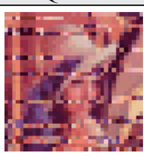
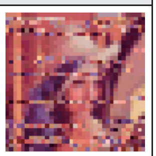
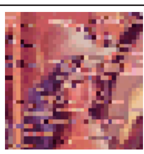
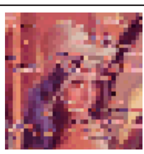
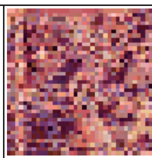
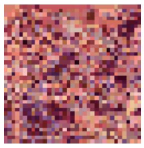
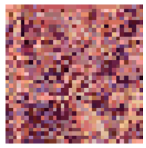
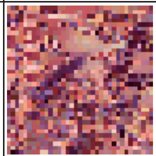
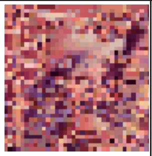
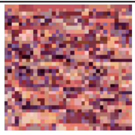
	QPSK	FFE	DDE
400m, 400sps	 0.11571	 0.09888	 0.09143
400m, 100sps	 0.10500	 0.06959	 0.07418
100m, 400sps	 0.22010	 0.23194	 0.23296
100m, 100sps	 0.29112	 0.16153	 0.20398

Table III. Performance comparison in continuous data transmissions

	QPSK	FFE	DDE
400m, 400sps	 0.42347	 0.51908	 0.48459
400m, 100sps	0.46469	0.44878	0.46684
100m, 400sps	0.45122	0.46051	0.46500
100m, 100sps	0.47939	0.48510	0.45878

From the result in **Table II**, performance of FFE and DDE show about 30% improvement than non equalizer on each case. But the result in **Table III** shows not good results. These results come from inaccurate time synchronization between sync signal and data signal. In packet data transmission, each signal has the own sync signal. In continuous data transmission, there is one synchronization signal at start point. As time goes by, the synchronization is out of step, so it needs the synchronization in the middle with continuous data signal

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