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OSDM Based Underwater Acoustic Communication

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ABSTRACT: Underwater acoustic (UWA) communication is an ongoing challenge because of the heavy time spread by multipath and Doppler spreads. In this paper, UWA communication system using orthogonal signal-division multiplexing (OSDM) has been proposed, a scheme that measures the multipath profile without an adaptation or interpolation process, to achieve stable communication in doubly spread channels. The performance of an OFDM scheme in a UWA communication system is already evaluated in simulations. In the present study, the performance of OSDM and existing communication schemes and orthogonal frequency-division multiplexing (OFDM) with respect to communication quality, and calculation complexity. From that OSDM with a multichannel receiver is attractive in terms of communication quality; it achieved a far better bit error rate (BER) performance compared to the other schemes with various input signal-to-noise ratios, although the complexity is less than that achieved with OFDM. Based on these findings, we suggest that OSDM can provide a highly reliable communication environment for UWA communication with multipath and Doppler spread, such as in shallow water.

KEYWORDS:Doppler spread, multipath, underwater acoustic (UWA) communication.

I. INTRODUCTION

Underwater Acoustic (UWA) communication is widely used in many applications and is a particularly critical technology for underwater exploration activities. Systems based on the phase-coherent modulation technique are intensively studied with the goal of increasing the bandwidth efficiency of UWA communication systems. However, several problems present ongoing challenges for UWA communication. UWA channels, especially shallow-water ducts, are characterized by numerous encounters with both the sea surface and seafloor. This multipath environment causes signal fading and inter symbol interference (ISI). The multipath-induced channel spread in time in a horizontal shallow-water duct can cause the ISI to extend to over 100 symbols. Moreover, the existence of the moving sea surface and the communication platform’s movement cause a Doppler shift, and multiple Doppler-scaling paths and time variation of the UWA channel lead to Doppler spread. The ISI and Doppler spread can serve as a barrier to UWA communication, because the effect of ISI and Doppler spread can become several orders of magnitude greater than the one observed in a communication system using radio, considering the sound speed underwater.

I. PROPOSED ALGORITHM

Fig. 1 shows block diagrams of OSDM in the transmitter and the receiver in a baseband system. We consider data vectors of length M, x_{tn} (n=0,1,....,N-1) as the transmission message. Each x_{tn} contains a different message whose elements are modulated symbols [e.g., quadrature phase-shift keying (QPSK)] expressed as complex numbers. The N data vectors x_{tn} are multiplexed into a single data stream of length M N, X, according to

$$X = \sum_{n=0}^{N-1} f_{Nn} \otimes x_{tn} \qquad (1)$$

Where,

$$F_N^{-1} = \begin{pmatrix} f_{N0} \\ f_{N1} \\ \vdots \\ f_{N(N-1)} \end{pmatrix}$$

$$= \frac{1}{\sqrt{N}} \begin{pmatrix} W_N^0 & W_N^0 & \cdots & W_N^0 \\ W_N^0 & W_N^1 & \cdots & W_N^{N-1} \\ \vdots & \vdots & \ddots & \vdots \\ W_N^0 & W_N^{(N-1)} & \cdots & W_N^{(N-1)^2} \end{pmatrix} \quad \mathbf{(2)}$$

$$W_N^k = \exp\left(\frac{2\pi\sqrt{-1}k}{N} \right) \quad \mathbf{(3)}$$

In (1), "$\otimes$" denotes the Kronecker product, and each f_{Nn} corresponds to a row of the inverse discrete Fourier transform matrix F_N^{-1}. Note that corresponds to an interleaved signal in direct-sequence code-division multiple access (DS–CDMA), as well as a signal in OFDM if equals 1. If the maximum channel delay is symbols, the transmission data stream, namely frame X' is obtained by prepending a cyclic prefix in which the last part of X with a length of L is placed at the beginning of X , as follows

$$\bar{X} = (X[MN-L]X[MN-L+1]....X[MN-1]) \quad (4)$$

Note that L corresponds to a correctable channel reverberation time in a discrete model, and $L \leq M$. The transmission data stream is transmitted through the channel. The received data stream from the channel $Y^{0'}$ can be expressed using X' and achannel response of length L ,$\mathbf{h}^0$ as

$$\bar{Y}^0 = h^0 * \bar{X} \quad (5)$$

where "*" denotes a convolution. There is a relationship between the cyclic-prefix-removed sequence $\mathbf{Y}^{0'}$, the channel response $\mathbf{h}^0$, and multiplexed data stream **X**, as

$$Y^0 = X \begin{pmatrix} h^0[-0] & h^0[1] & \cdots & h^0[MN-1] \\ h^0[MN-1] & h^0[0] & \cdots & h^0[MN-2] \\ \vdots & \vdots & \ddots & \vdots \\ h^0[1] & h^0[2] & \cdots & h^0[0] \end{pmatrix} \quad (6)$$

Where,

$$Y^0 = \left(\bar{Y}^0[L] \quad \bar{Y}^0[L+1] \quad \cdots \quad \bar{Y}^0[L+MN-1] \right) \quad (7)$$

The relationship between $\mathbf{Y}^0$and $\mathbf{x}_{tn}$ is expressed by

$$Y^0 D_n = x_{tn} C_n^0 \tag{8}$$

Where,

$$D_n = f_{Nn} \otimes I_M \tag{9}$$

$$C_n^0 = \begin{pmatrix} h^0[0] & h^0[1] & \cdots & h^0[M-1] \\ \overline{W_N^n} h^0[M-1] & h^0[0] & \cdots & h^0[M-2] \\ \vdots & \vdots & \ddots & \vdots \\ \overline{W_N^n} h^0[1] & \overline{W_N^n} h^0[2] & \cdots & h^0[0] \end{pmatrix} \tag{10}$$

And I_M is an -by- identity matrix, f_{Nn}*is a complex conjugate of the transposition of f_{Nn} , W_N^n is a complex conjugate of W_N^n, and h[l] (l=L,L+1,....M-1) is zero. The Kronecker product Dn is prepared in the receiver before communication, and is called the matched filter. We define the matched-filter-operated sequences as y_n^0. If , n=0 the relationship betweenY^0 Dn and x_{t0} becomes

$$Y^0 D_0 = x_{t0} \begin{pmatrix} h^0[0] & h^0[1] & \vdots & h^0[M-1] \\ h^0[M-1] & h^0[0] & \vdots & h^0[M-2] \\ \cdots & \cdots & \ddots & \vdots \\ h^0[1] & h^0[2] & \cdots & h^0[0] \end{pmatrix} \tag{11}$$

If x_{t0} is shared by the transmitter and the receiver, and its periodic autocorrelation function becomes an impulse according to the receiver can obtain the

$$\frac{1}{M} x_{t0} \begin{pmatrix} \overline{x_{t0}}[0] & \overline{x_{t0}}[M-1] & \vdots & \overline{x_{t0}}[1] \\ \overline{x_{t0}}[1] & \overline{x_{t0}}[0] & \vdots & \overline{x_{t0}}[2] \\ \cdots & \cdots & \ddots & \vdots \\ \overline{x_{t0}}[M-1] & \overline{x_{t0}}[M-2] & \cdots & \overline{x_{t0}}[0] \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ \vdots \\ 0 \end{pmatrix} \tag{12}$$

channel response by calculating the periodic cross-correlation function between and as,

$$\frac{1}{M} Y^0 D_0 \begin{pmatrix} \overline{x_{t0}}[0] & \overline{x_{t0}}[M-1] & \cdots & \overline{x_{t0}}[1] \\ \overline{x_{t0}}[1] & \overline{x_{t0}}[0] & \cdots & \overline{x_{t0}}[2] \\ \vdots & \vdots & \ddots & \vdots \\ \overline{x_{t0}}[M-1] & \overline{x_{t0}}[M-2] & \cdots & \overline{x_{t0}}[0] \end{pmatrix} = \begin{pmatrix} h^0[0] & h^0[1] & \cdots & h^0[M-1] \end{pmatrix} \tag{13}$$

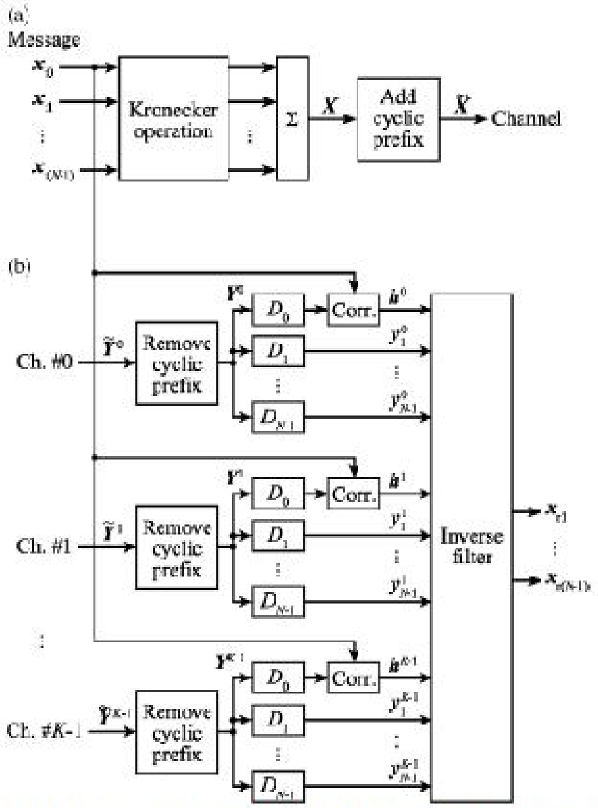


Fig. 1. Block diagram of OSDM in (a) the transmitter and (b) the receiver. eq.(3)

Using the channel response obtained from the pilot signal x_{t0} , the receiver can calculate the matrix Cn^0. We can then obtain the received message x_{tn} by solving,

$$x_{tn} = Y^0 D_n \left(C_n^0\right)^{-1} \qquad (14)$$

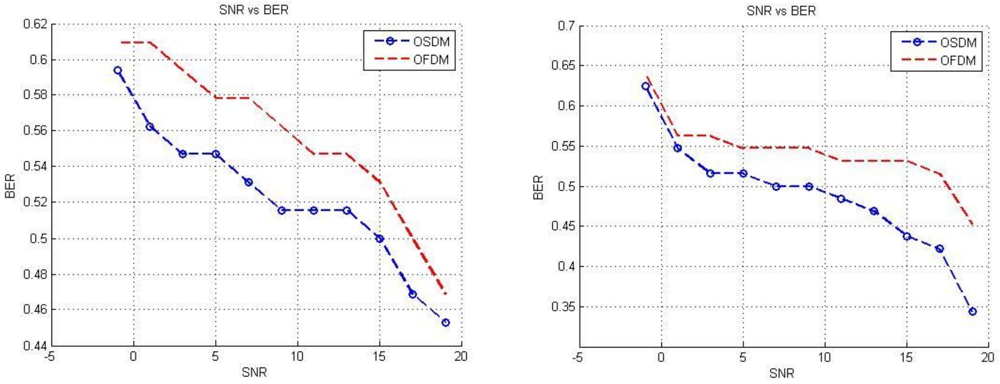
In the following,

$$x_{t0}[m] = \exp\left(\frac{2\pi\sqrt{-1}m^2}{M}\right), m = 0,1,....,M-1 \qquad (15)$$

whose periodic cross-correlation function becomes an impulse, as x_{t0}

II. SIMULATION RESULTS

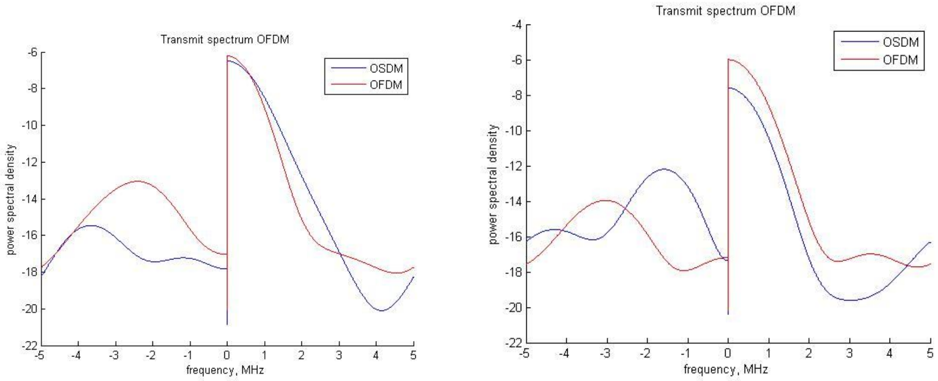
We compared the results of OSDM with OFDM with respect to bit error rate, signal-to-noise ratio and power spectral density which are shown below,



(a)

(b)

Fig (a) & (b) shows the relation between BER and SNR.



(c)

(d)

Fig (c) & (d) shows the power spectral density.

From the fig (c) & (d) we can conclude that OSDM consumes less power than OFDM. Since it will requires less amount of power for both transmitting and receiving the signals.

From fig (a) & (b), when the SNR increases, BER reduces and the BER of ODSM is less than the OFDM. Since OSDM will provide a better error free communication the OFDM. It shows that OSDM provides quality of communication than the existing system. To summarize, multichannel OSDM is well suited as a UWA communication scheme, in which the effects of a Doppler spread are severe. Therefore, we expect that OSDM will enable UWA communication at practical data rates and levels of complexity in shallow water.

IV. CONCLUSION AND FUTURE WORK

We reported the performance comparison of the OSDM scheme and existing schemes in doubly spread channels. we compared the performance of these schemes with respect to communication quality, data rate, frame length, and calculation complexity. We found that OSDM with multichannel receiver is attractive in terms of communication quality; it achieved far better BER performance compared to the other schemes in both static and dynamic channels, although its complexity is less than that of OFDM. We expect that OSDM can become a viable alternative offering a highly reliable communication environment for UWA communication with multipath and Doppler spread (such as shallow water) with practical complexity

REFERENCES

1. M. Stojanovic, “Recent advances in high-speed underwater acoustic communications,” *IEEE J. Ocean. Eng.*, vol. 21, no. 2, pp. 125–136, Apr. 1996.
2. P. C. Etter, *Underwater Acoustic Modeling and Simulation*, 3rd ed. Abingdon, Oxfordshire, U.K.: Spon Press, 2003, p. 94.
3. R. S. H. Istepanian and M. Stojanovic, *Underwater Acoustic Digital Signal Processing and Communication Systems*. Dordrecht, The Netherlands: Kluwer, 2002, pp. 3–7.
4. H.Ochi, T. Tsuchiya, Y.Amitani,M. Suzuki, and S.Negishi, “Study on color video pictures transmission by digital acoustic signal,” in *Proc. Conf. Pacific Ocean Environ. Probing*, 1992, pp. 132–137.
5. M. Suzuki, T. Sasaki, and T. Tsuchiya, “Digital acoustic image transmission system for deep-sea research submersible,” in *Proc. OCEANS Conf.*, 1992, pp. 567–570.
6. M. Stojanovic, J. Catipovic, and J. Proakis, “Phase coherent digital communications for underwater acoustic channels,” *IEEE J. Ocean. Eng.*, vol. 19, no. 1, pp. 100–111, Jan. 1994.
7. M. Stojanovic, J. A. Catipovic, and J. G. Proakis, “Adaptive multichannel combining and equalization for underwater acoustic communications,” *J. Acoust. Soc. Amer.*, vol. 94, pp. 1621–1631, 1993.
8. P. S. D. Tarbit, G. Howe, O. Hinton, A. Adams, and B. Sharif, “Development of a real-time adaptive equalizer for a high-rate underwater acoustic data communication link,” in *Proc.OCEANS Conf.*, 1994, vol. 1, pp. I307–I3