Underwater acoustic communication

Wireless underwater communications can be established by transmission of acoustic waves. The underwater acoustic communication channels, however, have limited bandwidth, and often cause signal dispersion in time and frequency . Despite these limitations, underwater acoustic communications are a rapidly growing field of research and engineering.
Acoustic waves can travel over longer distance.There are several ways of employing such communication but the most common is by using hydrophones Underwater communication is difficult due to factors such as multi-path propagation, time variations of the channel, small available bandwidth and strong signal attenuation especially over long ranges. Compared to terrestrial communication, underwater communication has low data rates because it uses acoustic waves instead of electromagnetic waves.

Systems Based on Noncoherent Modulation:

Noncoherent detection of FSK signals has been used for channels exhibiting rapid phase variation, such as the shallow water long-range and medium-range channels. To overcome the ISI, the existing noncoherent systems employ signal design with guard times, which are inserted between successive pulses to ensure that all the reverberation will vanish before each subsequent pulse is to be received. The insertion of idle periods of time obviously results in a reduction of the available data throughput. In addition, because fading is correlated among frequencies separated by less than the coherence bandwidth (the inverse of the multipath spread), it is desired that only those frequency channels that are separated by more than the coherence bandwidth be used at the same time. This requirement further reduces the system efficiency unless some form of coding is employed so that the adjacent, simultaneously transmitted frequencies belong to different codewords.

Systems Based on Coherent and Differentially Coherent Modulation:

To increase bandwidth and efficiency PSK and QAM techniques are used.Depending on the method for carrier synchronization, phase-coherent systems fall into two categories: differentially coherent and purely phase coherent. The advantage of using differentially encoded PSK (DPSK) with differentially coherent detection is the simple carrier recovery it allows.

Multicarrier Systems:

Multicarrier modulation is a technique used to combat the frequency selectivity of the channel. This technique in the form of orthogonal frequency division multiplexing.The appeal of OFDM lies in the computational efficiency of FFT-based processing, and in the fact that it easily scales to different bandwidths. Unlike with single-carrier systems, where the equalizer length has to be adjusted in accordance with the bandwidth B because it determines the symbol duration and

hence the extent of ISI, with OFDM it simply suffices to increase/decrease the number of carriers K, that is, the size of the FFT, while keeping the same carrier separation f = B/K.

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High-Speed Underwater Acoustic Communication Based on OFDM

OFDM is an attractive technique beginning used in UWA communication with three obvious advantages: good performance against multipath interference, ability to combat the frequency selective fading and the high frequency band efficiency.

Characteristics of underwater acoustic channel:

Bandwidth:

The parameters of The frequency bandwidth of an UWA communication system is determined by frequency dependent transmission loss, ambient noise and range. Usually, the bandwidth of this system ranging about 10 km is only few khz.

Multipath:

Within the limited bandwidth, the signal is subject to multipath propagation through underwater channel. Multipath propagation causes ISI which restricts the data throughputs and degrades the system performance.

Doppler:

There are two aspects to cause the Doppler. The first one is the motion of sea surfaces and currents. Thus, the UWA channel is a double spread channel. The second one is the relative motion between transmitter and receiver. Normally, Doppler shift is much larger than Doppler spread and has to be compensated in the receiver, especially for OFDM system, which very sensitive to frequency offset.

(https://sci-hub.do/https://ieeexplore.ieee.org/abstract/document/1618121/)