Influence of seawater depth in hydroacoustic transmission of binary numbers

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Abstract: *The influence of seawater depth in hydroacoustic transmission of binary numbers is experimentally investigated. The binary digits are encoded as sequences of short and long rectangular pulses of a fixed duration. The experiments are carried out in coastal waters of Bulgarian South Black Sea shelf. The transmission of numbers is experimentally compared for three different water depths: 10m, 30m and 60m, at a transmitter-receiver distance of 1500m. Increasing the water depth improved the performance leading to a larger number of correct transmissions. Hydroacoustic transmission in very shallow water is more difficult due to strong interference from reflected signals. In 60m deep water the observed transfer of binary numbers is stable and correct. Certainty of correct transmission increases with increasing water depth in shallow seawater.*
Keywords*: UNDERWATER ACOUSTIC TRANSMISSION, HYDROACOUSTICS*

1. Introduction

The most widely used underwater wireless communication technology is based on acoustic waves [1, 2, 3, 6]. Acoustic waves provide the longest communication range due to the low attenuation of sound in water. Acoustic propagation is characterized by three major factors: attenuation that increases with signal frequency, time-varying multipath propagation, and low speed of sound (1500m/s) [1]. The acoustic channel has strong attenuation with increasing frequency, leading to very limited bandwidth [2]. In a shallow water environment, wave reflections from the surface and the bottom generate multiple arrivals of the same signal [3]. In deep water significant multipath phenomena can be caused by wave refractions due to the spatially varying sound speed. The low speed of sound causes large propagation delays and the delay spread from multiple arrivals is considerable. Underwater acoustic channels are generally recognized as one of the most difficult communication media [1].

In this work, we experimentally compare the operation of a hydroacoustic device in shallow seawater at three different water depths from 10 to 60 meters.

2. Hydroacoustic transmission of binary numbers

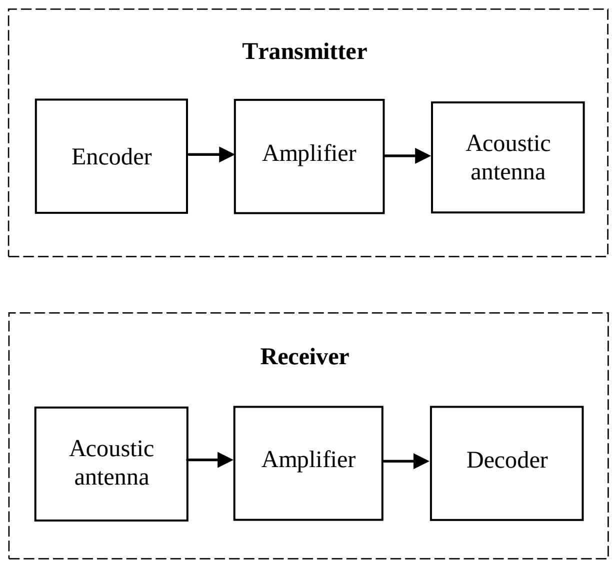
Underwater transmission of binary numbers is carried out using a transmitter/receiver pair, based on hydroacoustic waves. General block diagram of the device is shown in Fig.1a). 9-digit binary numbers from 0 to 511 are transmitted serially. The binary digits are encoded as sequences of short and long rectangular pulses according to Motorola encoding scheme [4]. The timing of the encoding pulses is determined by a clock period of a fixed duration. The waveforms of encoded „one", encoded „zero" and the clock pulses are shown in Fig.1b). In synchronization with the encoding pulses, bursts with two different frequencies in the range of 10-40kHz are fed to a piezoceramic omnidirectional acoustic antenna for signal transmission [5]. The receiving antenna is similar to the one used in the transmitter. The input signal bursts are amplified, demodulated and decoded to numerical form. Reception is considered valid in case of two consecutive identical numbers.

3. Experimental results

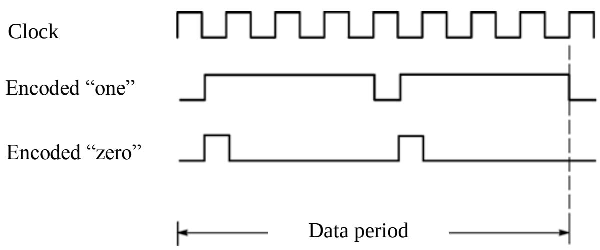
The influence of seawater depth in hydroacoustic transmission of binary numbers is experimentally investigated. The binary digits are encoded as sequences of pulses using a clock period equal to 20ms. Hence, the duration of each binary digit is 160ms. The experiments are carried out in coastal waters of Bulgarian South Black Sea shelf. Underwater acoustic transmission of binary numbers is compared for three different water depths:

- 10m - the transmitter and receiver are located inside a bay;

- 30m - the transmitter and receiver are outside a bay, on the border of the bay and open sea;



a)



b)

Fig.1. *Hydroacoustic transmission of binary numbers:*
a) general block diagram of the device;
b) encoding of the binary digits.

- 60m - the transmitter and receiver are outside bays, at a distance from the shore of not less than 3500m.

The distance between the transmitting and receiving antennas is maintained at about 1500m. The immersion depth of the antennas is about 5m. At each given depth of seawater, 50 binary numbers are transmitted. The correct transmissions, failed transmissions and false transmissions of binary numbers are reported. The results are presented in Table 1. Fig.2 graphically shows the number of correct transmissions versus the seawater depth.

Table 1. *Experimental results*

Seawater depth, m	10	30	60
Correct transmissions, number	38	47	50
Failed transmissions, number	12	3	-
False transmissions, number	-	-	-

Overall, increasing the water depth improves the performance leading to a larger number of correct transmissions. In 60m deep water the observed transfer of binary numbers is stable and correct and all of the 50 transmissions are successful. At a depth of 30m there are 47 correct transmissions against 3 failed transmissions and at a depth of 10m – 38 correct transmissions against 12 failed ones. Hydroacoustic transmission in very shallow water is more difficult due to strong interference from reflected signals. No false transmissions are found during the experiments.

4. Conclusion

The influence of seawater depth in hydroacoustic transmission of binary numbers is experimentally investigated. The binary numbers are encoded as sequences of rectangular pulses using a fixed clock period of 20ms. Experiments are carried out in coastal waters of Bulgarian South Black Sea shelf for three different water depths: 10m, 30m and 60m, at a transmitter-receiver distance of 1500m. Increasing the water depth improves the performance leading to a larger number of correct transmissions. No false transmissions are found. Hydroacoustic transmission in 60m deep water is stable and correct. In very shallow water the transfer is more difficult due to strong interference from reflected signals. Certainty of correct transmission increases with increasing water depth in shallow seawater.

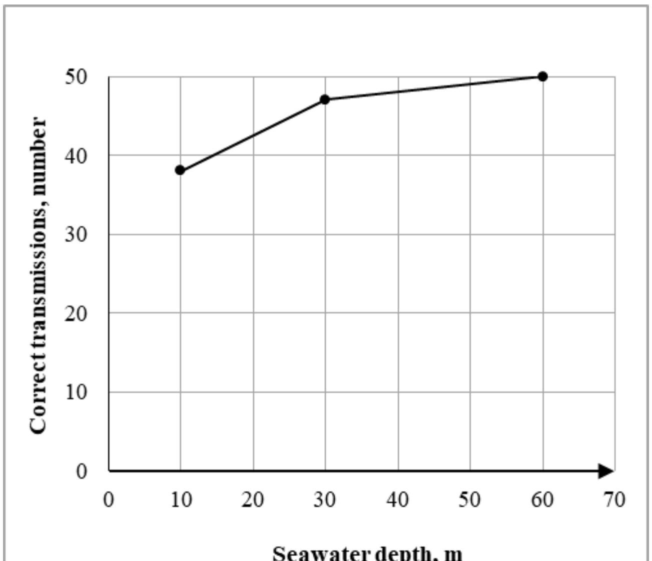


Fig.2. *Number of correct transmissions versus seawater depth*

Acknowledgement

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