Influence of the clock of the encoding pulses in hydroacoustic transmission of binary numbers

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Abstract: *Hydroacoustic waves are used to experimentally transmit binary numbers underwater. The numbers are first encoded into pulse sequences, according to the encoding scheme: two consecutive short pulses for a digit zero and two consecutive long pulses for a digit one. A clock period determines the timing of the encoding pulses. The influence of the clock period duration on the number of correctly transmitted binary numbers is tested in 30m deep coastal seawater, at a 1500m distance. The performance is compared at three different periods of the clock: 10ms, 20ms and 40ms. Increasing the clock period of the encoding pulses leads to an increase in the number of correct transmissions. At the longest tested clock period of 40ms all the transmissions of binary numbers are successful. Certainty of correct transmission increases at the longer clock periods of the encoding pulses due to attenuated interference from reflected signals.*
Keywords*: UNDERWATER ACOUSTIC TRANSMISSION, HYDROACOUSTICS*

1. Introduction

Acoustic communication is the most widely used technology for underwater wireless data transmission [1, 2, 7]. Acoustic waves are used as the primary carrier for underwater wireless communication systems due to the relatively low absorption in underwater environments [1]. The channel attenuation is frequency - dependent. Acoustic propagation is best supported at low frequencies, and the bandwidth available for communication is extremely limited [3]. The speed of sound underwater is low – approximately 1500 m/s. The acoustic system is affected by multipath signal propagation due to reflection and refraction. The channel delay spread can be very large (tens of milliseconds, for example), which results in severe intersymbol interference. In addition, the communication channel is affected by ambient noise and has variable characteristics. Effective modulation and demodulation techniques are required to overcome these problems.

Our object is to evaluate the influence of the clock period, used to encode binary numbers into rectangular pulses, on the number of successful acoustic transmissions in seawater.

2. Experimental device

Hydroacoustic waves are used to experimentally transmit binary numbers underwater. The experimental device is a pair of transmitter and receiver, shown in Fig.1. In the transmitter, a number between 0 and 511 is converted to binary and padded with leading zeros to form a 9-digit binary number. Remote transmission is accomplished by encoding the numbers into pulse sequences, formation of pulse bursts with two frequencies between 10 and 40kHz, synchronously with the encoding pulses, and an acoustic antenna [4]. The Motorola protocol, used in MC145026 integrated circuit [5, 6], is selected for encoding of the binary digits. It is developed especially for event transmission and gives very high reliability. As shown in the waveforms in Fig.2, "0" is encoded as two consecutive short pulses and "1" - as two consecutive long pulses. A clock period determines the timing of the encoding pulses. The duration of one digit is 8 periods of the selected clock, and the duration of the short and long pulses is 1 and 7 half-periods of the clock, respectively. Every 9-digit sequence is followed by a pause. The implementation of the protocol on a microcontroller allows the clock period duration to be selected between different values. In the receiver, the input acoustic signal is received through a piezoceramic antenna, amplified and decoded. Two sequential identical numbers are required for a valid reception.

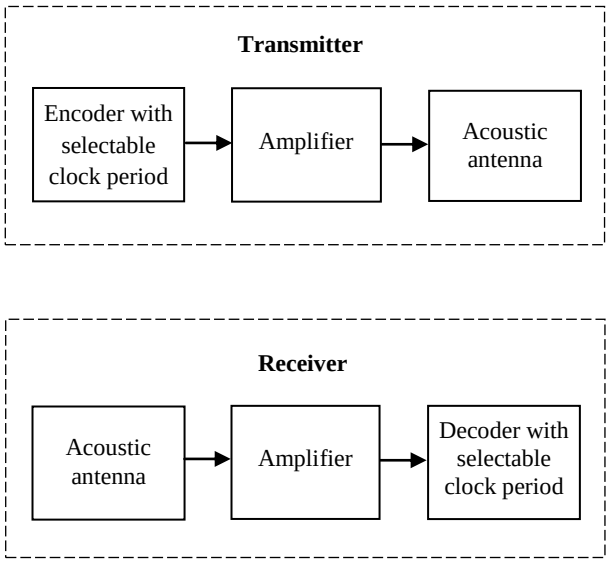

Fig.1. *Experimental device for hydroacoustic transmission*

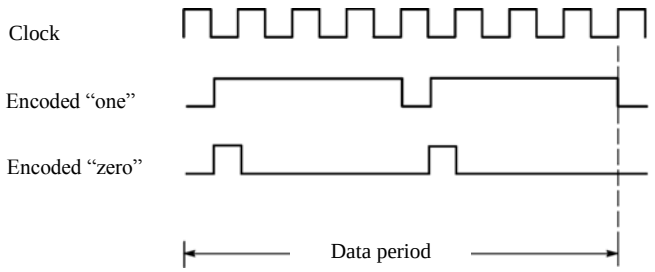

Fig.2. *Encoding waveforms*

3. Experimental results

Binary numbers are experimentally transmitted underwater using acoustic waves. The digits are first encoded into pulse sequences. The timing parameters of the encoding pulses are determined by a clock period. The influence of the clock period duration on the number of correctly transmitted binary numbers is tested in seawater in the southern Bulgarian Black Sea region. The experiments are conducted in shallow waters with a depth of 30m. The bottom is sandy with small stones. The transmitting and receiving antennas are located at about 1500m distance from each other, at several different locations.

Table 1. *Experimental results*

Clock period, ms	10	20	40
Correct transmissions, number	34	45	50
Failed transmissions, number	16	5	-
False transmissions, number	-	-	-

The performance is compared at three different periods of the clock: 10ms, 20ms and 40ms. 50 numbers in the range from 0 to 511 (converted to binary) are transmitted for each of the clock periods. The numbers of correct transmissions, failed transmissions and false transmissions are presented in Table 1. Fig.3 shows a graph of the number of correct transmissions versus the clock period. The experimental results show that increasing the duration of the clock period of the encoding pulses leads to an increase in the number of correct transmissions. At the longest tested clock period of 40ms all the transmissions of binary numbers are successful due to attenuated interference from reflected signals. The two shorter clock periods of 20ms and 10ms resulted in 45 correct transmissions vs. 5 failed ones and 34 correct transmissions vs. 16 failed ones, respectively. The encoding into pulse sequences successfully prevented false transmissions, but it is at the expense of significantly increased transmission time.

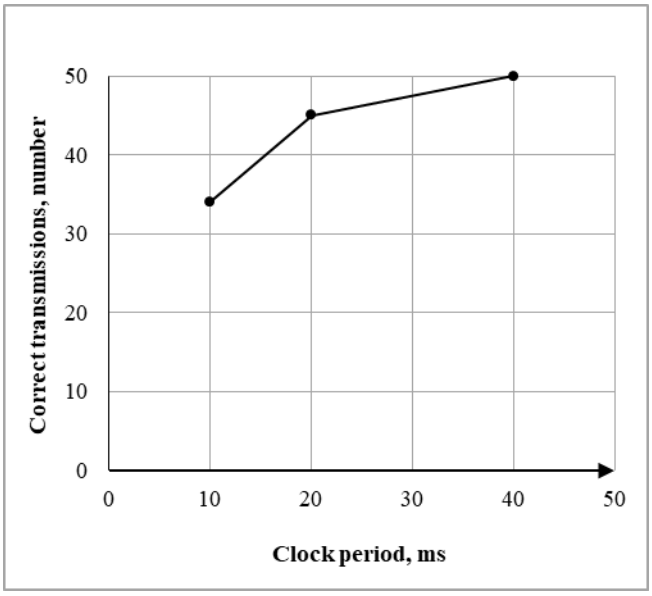

Fig.3. *Number of correct transmissions versus the clock period of the encoding pulses in 30m deep seawater*

4. Conclusion

Hydroacoustic waves are used to experimentally transmit binary numbers underwater. The numbers are encoded into pulse sequences, the timing of which is determined by a clock period. The influence of the clock period duration on the number of correctly transmitted binary numbers is tested in 30m deep coastal seawater, at a 1500m distance. The performance was compared at three different periods of the clock: 10ms, 20ms and 40ms. The experimental results show that increasing the clock period of the encoding pulses leads to an increase in the number of correct transmissions. At the longest tested clock period of 40ms all the transmissions of binary numbers are successful. The encoding into pulse sequences prevents false transmissions, but it is at the expense of increased transmission time. Certainty of correct transmission increases at the longer clock periods of the encoding pulses due to attenuated interference from reflected signals.

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