International Conference KNOWLEDGE-BASED ORGANIZATION
Vol. XXIV No 3 2018

EXPERIMENTAL MODEL FOR DATA TRANSMISSION IN THE UNDERWATER ENVIRONMENT

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Abstract: *Communications applications in the underwater environment have recently developed a considerable development due to the demand for underwater research with Robot Underwater Vehicle (ROV). The most important aspects addressed by researchers are related to the speed and distance of data transmissions. In most cases, this data signal may be electromagnetic, optical or acoustic.*
The first two cases have limitations on the distance of the communication channel due to signal attenuation. That is why the acoustic field can be considered the favorite in this choice. In this case, the limitations of use are given by the acoustic field propagation, which depends on the temperature, salinity and pressure of the underwater environment and the result is the variation of the propagation speed. The influence of frequency on attenuation and reverberation are important factors limiting the use of the acoustic field. Based on these considerations, the paper presents an experimental transceiver model of data transmission using Frequency Shift Keying **(***FSK***),** *modulation with phase discontinuity for transmitting and receiving commands at the speed of 2kbits / s.*

Keywords: signal, data transmissions, underwater environment, field propagation, Frequency shift keying

1. Introduction

The paper proposes the creation of an underwater data channel with FSK modulation based on a LabView platform, following the following aspects:

a). Randomly choosing a word from a matrix that contains 10 words of four bits.

b). Transmitting the binary word chosen by means of an FSK modulated transmitter that is charged with a piezoceramic acoustic antenna.

c). Reception of the acoustic signal with a piezoceramic reception antenna and an FSK receiver.

d).Validate binary word received. The matrix from which the binary word was randomly chosen for transmission is also stored in the receiver. Validation of the received word leads to the establishment of a correct communication.

2. Acoustic field propagation analysis for optimal choice of symbol duration and two frequencies corresponding to symbols

The underwater communications are influenced by the environment. in which the measure is made much larger than the communications in the atmosphere. In the work are identified the main factors that influence the communications in this environment and the modifications brought in the communication with FSK modulation. The acoustic wave velocity in salty water is 1505m / s, but many equipment performs calculations for the value of 1500m / s. The temperature, the salinity and the pressure in the marine environment to change the speed of sound with depth as [4]:

DOI: 10.1515/kbo-2018-0133

a) a decrease in speed;
b) an increase in speed;
c) a layer of a negative jump;
d) positive jump layer (acoustic channel);
e) isothermal layer at the surface of the sea, at a constant speed.
On the right speed variation schedule acoustic wave propagation direction is represented acoustic beam (perpendicular acoustic wave front) and left speed variation. The sound velocity in water varies with the pressure, salinity and temperature of the water layers. The following chart shows these variations [5].

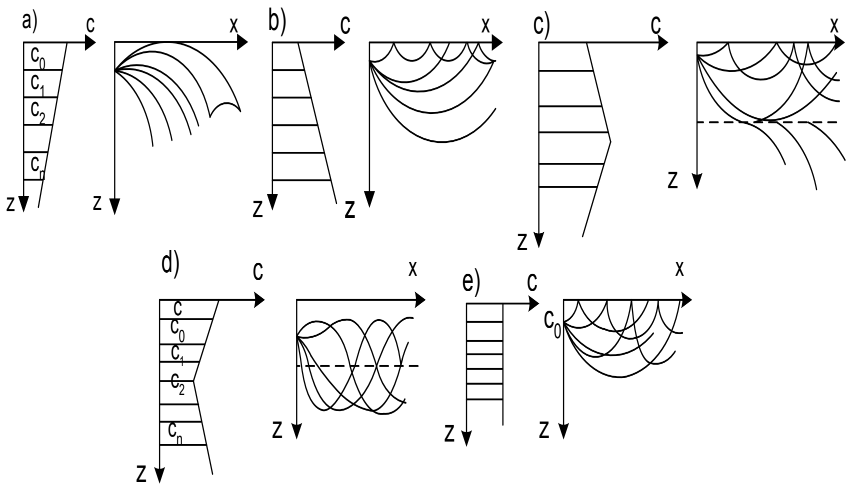

Figure 1: Chart of variation of speed and temperature with depth

The example below is a velocity measure with depth, temperature variation follows the same curve [5]. The variation of the sound velocity in the underwater environment changes the duration of the symbol at the reception and creates the interference of the symbols.

The FSK will not be with continuity or phase discontinuity will be a time window where the duration ofthe symbol will be equal to or less than the duration of the time window in function the speed of the measured sound for different depths. It is the first proposal to improve FSK communication.

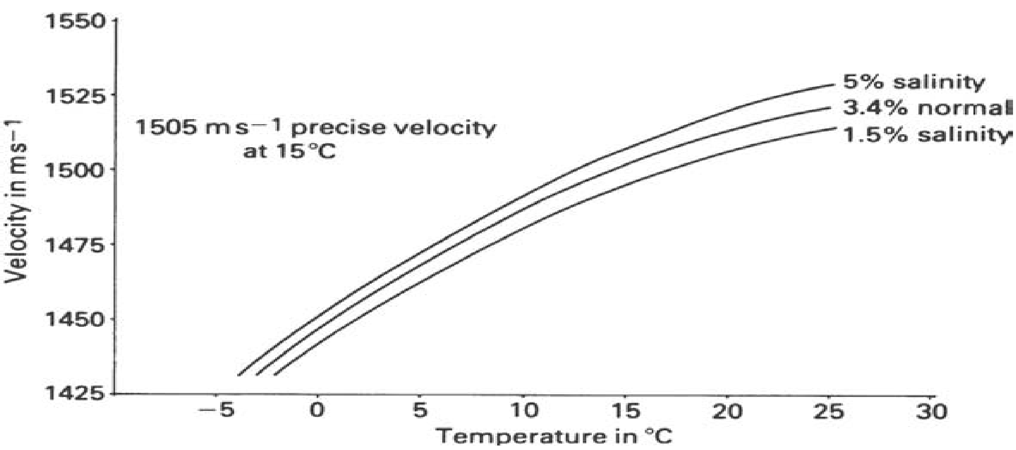

Figure 2: Changing the sound speed with temperature

Attenuation and choice of routing is closely related to the acoustic antenna directivity characteristic, which influences the emission power, the noise signal ratio and the physical dimensions of the acoustic antenna. Frequencies between 15 and 60 KHz are used for long distances with reduced attenuation using transducers magnetostrictive. For small distances piezoceramic transducers are used at frequencies of 200 KHz to 400 KHz and small transducers. Frequent 300KHz at 1MHz are used for measuring velocity at very small distances.

Changing the sound speed in the underwater environment, changing the symbol reception time, and creating symbol interference.

Analyzing this situation results in the choice of symbol duration.

Depending on the sound velocity for different depths, the FSK sequence will not be phase continuity or discontinuity and the duration of the symbol will be less than the duration of the FSK window.

It is the first project to improve FSK communication in the underwater environment. Continue to calculate the delay at 100 m per second at 1537,92 m / s and 1534,46 m / s [3] corresponding to the depths of 50 m and 100 m respectively, for a Δt = 100 \ 1537 , 92-100, 1534, 46 = 0.00014534, approximately 145µs is obtained.

During this time the symbols overlap, the spectra are not distinct, and the result of the spectrum is given by the convolution product of the two spectra.

Our proposal is to measure the velocity of the sound in the underwater environment, for different depths, to calculate the mean velocity and the value δt with a reference of 1505m / s, in which case the FSK window is constant and the duration of the symbol in this window will be reduced by δt

The second analysis refers to the attenuation and selection two frequencies per simbol, which is closely related to the achievement of the acoustic antenna directivity characteristic, which influences the emission power, the noise signal ratio and the physical dimensions of the acoustic antenna. Frequent frequencies between 15 kHz and 60 kHz are used for large distances, with reduced attenuation, using magnetostrictive transducers. For smaller distances, piezoceramic transducers are used at frequencies ranging from 200 KHz to 400KHz and small transducers. The frequencies of 300 KHz at 1MHz are used to measure the speed at very small distances Salinity 3.5% temperature 15 degrees C. [5]

Absorption also depends on the nature of the sea bottom. For example, for a bottom of the slightly muddy mud, the attenuation is around 15 dB and for a bottom of the rocky sea is around 1 dB air for a bottom of the sandy sand around 3 dB. The measurements were made for the frequency of 24 kHz.

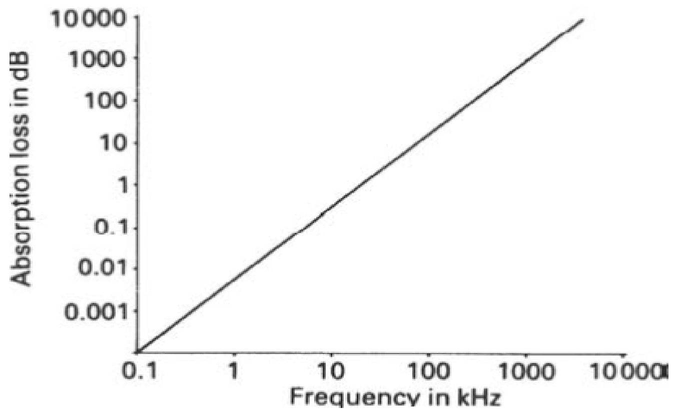

Figure 3: Variation the absorption loss with frequency

Absorption also depends on the nature of the bottom of the sea, for example in the case of a bottom of the mild slightly muddy attenuation of about 15 dB, for a bottom of the rocky sea is about 1 db and for a sandy one around 3 dB. Measurements were made for the 24 KHz Frequency

The conditions required for the communication channel analyzed were: the depth of about 200 meters, the distance of the channel about 2 miles, and the type of the bottom of the sea can be any.

Under these conditions frequencies greater than 50 KHz can be used.

Among the advantages of this method can be enumerated: the small dimensions of the acoustic antennas, the increase of the noise signal ratio by reducing the reverberation level and the small angles of opening of the directivity function, thus increased noise protection. For additional protection, when interfacing the frequency symbols, choose the relation f, 2f, so that the spectral convolution product in the overlay area is canceled

3. Modulation of FSK

The transmitted data sequence, with a probability of equal symbols, can be written:

$s(\mathrm{t}) = \sum_n d_n p(t - nT)$ (1)

$d_n = \{d_1, d_2, \dots \dots \dots d_n\}$ (2)

$p(t - nT)$ = a periodic function of rectangular pulses with T period

For FSK modulation s (t) is the sum of the second component as follows:

$s(t) = cos\omega_1(t) \sum_n d_n p(t - nT) +$ $cos\omega 0(t)ndnpt{-}nT$ (3)

Where w1 = 2πf1 is the carrier frequency for symbol 1 and w0 = 2πf0 the carrier for the symbol 0.

$\mathrm{F}[s(t)] = F[cos\omega_1(t) \sum d_n p(t - nT)] +$ $F[cos\omega_0(t) \sum d_n p(t - nT)]$ (4)

But knowing that,

$F(f \cdot g) = F(f) \cdot F(g)$ (5)

The probability of occurrence of the symbols 0,1 is equal, so the sum is a series of rectangular impulses so that we can use the discrete form of the convolution product and will result for positive frequencies:

$\pi\delta(\omega - \omega_0) \cdot \frac{sin\pi t}{\pi t}$ and

$\pi\delta(\omega - \omega_1) \cdot \frac{sin\pi t}{\pi t}$ (6)

But for a symbol there is only a spectrum physically. The received signal is:

$r(t) = \lambda(t - nT)s(t) + n(t)$ (7)

where h (t-nT) is the transfer function of the receptor and the propagation medium

4. Conclusions

We calculate the 100 meters delay of the second wave at 1537.92m / s and 1534.46m / s corresponding to the 50m respectively 100m depths. dt = 100 \ 1537,92-100 \ 1534,46 = 0.00014534 about145μs. During this time the symbols overlap, the spectra are not distinct and the resulting spectrum is given by the convolution of the two spectra. measuring the velocity of the sound in the underwater environment for different depths, calculate the mean velocity and the value δt with the reference of 1505m / s. The FSK window is constant, but the duration of the symbol in this window will be reduced by δt. FSK transceiver is built on a LabView platform and NI USB 6008 acquisition (receiver, transmitter) plates. The boards only support 10 kS\s, a parameter that limits the frequencies f0 and f1 to 5kHz. Figure 6 is the Front Panel for the transmitter. There were chosen f0 = 300Hz and f1 = 200Hz, NI USB 6008 can only work at 10kS \ s. In the work it was considered the use of a NI acquisition board at 10mS \ s. The binary word was transmitted by 4 bits (1100) 2 At the reception in figure 4 it is observed that the same binary word was received. The word was randomly chosen from a ten-array matrix and can be developed anyway. In the case of the project, the same matrix is stored at the reception and we compare the received word with the memorized ones and it is decided to execute the commands if

there is a coincidence. In Figure 5 the Front Panel is presented to the decision block.
In figures 6, 7, 8 and 9 are shown the transmitter, the block diagram of the FSK receiver and decision scheme, the Random word block selection scheme and FSK transmitter and the workstation that were made simulations and measurements.

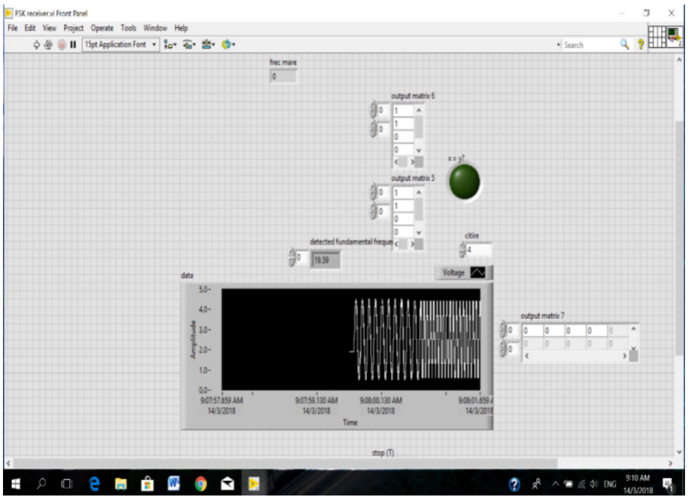

Figure 4:Receiver

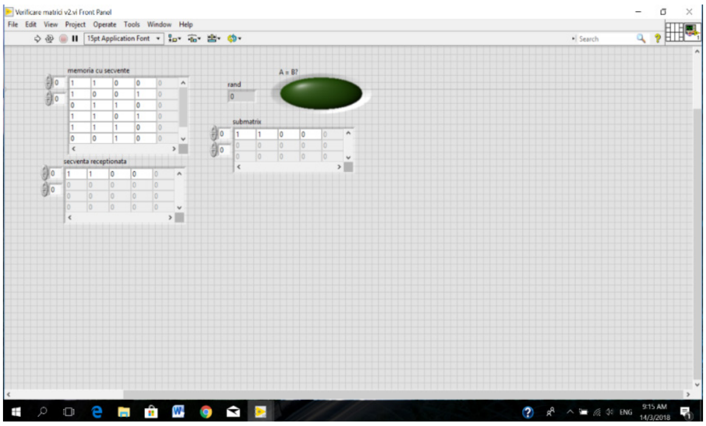

Figure 5. The 4-bit binary word decision mode received correctly.

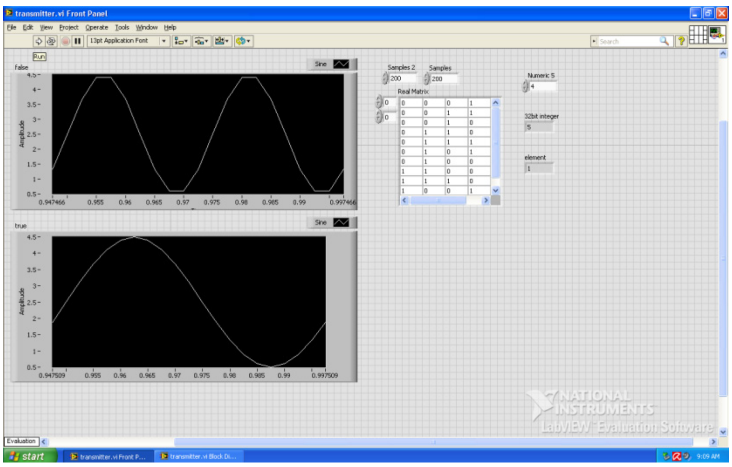

Figure 6: Transmitter

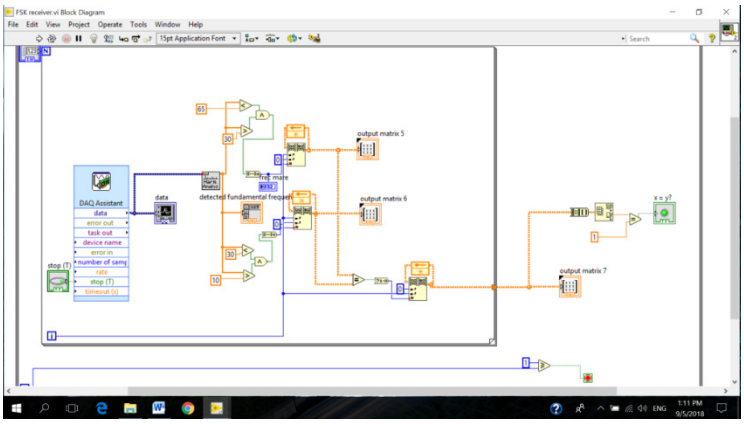

Figure 7: Block diagram of the FSK receiver and decision scheme

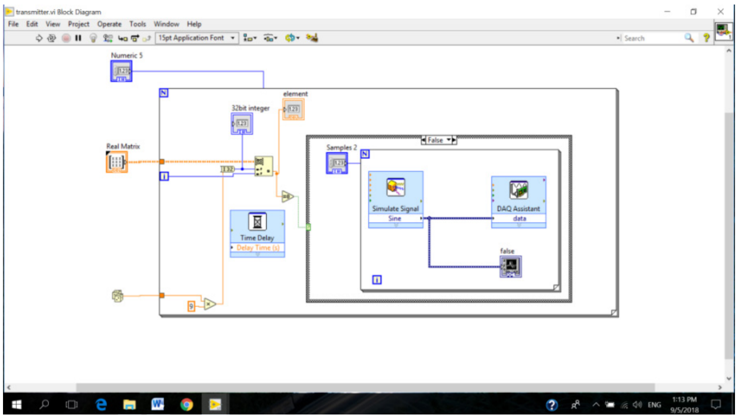

Figure 8: Random word block selection scheme and FSK transmitter

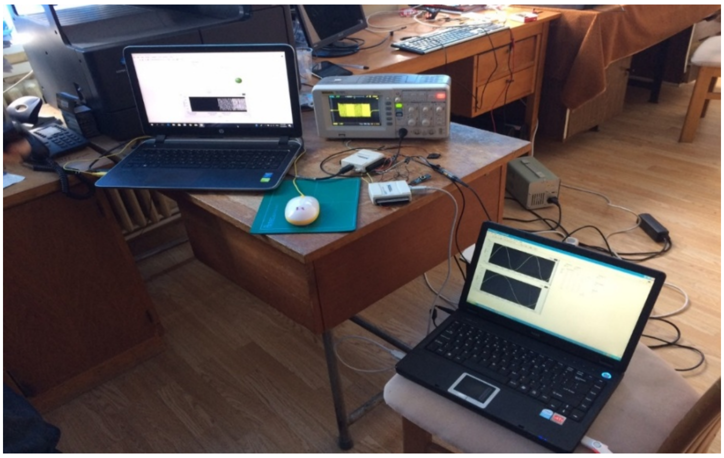

Figure 9: Workstation

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