Design of a Simple, Low-Cost, Underwater Acoustic Modem

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Abstract: In our project we are building an underwater acoustic modem with the ultrasonic transducer. Modulation used for modem is ASK and FSK. Message from transmitter can be displayed in visual format. Different simulator tools are used to analyze message. In this paper we compare results with ASK and FSK modem. This paper presents the design considerations, implementation details, and initial experimental results of our modem.

***Key Words*:** Acoustic transducer, ASK modem, FSK modem, FPGA, simulation tools

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I. INTRODUCTION

There is increasing interest in the design and deployment of underwater acoustic communication networks. It is widely recognized that an openarchitecture, low cost underwater acoustic modem is needed to truly enable advanced underwater ecological analyses. Underwater acoustic modems consist of three main (1) an underwater transducer, (2) an analog transceiver (matching pre-amp and amplifier), and (3) a digital platform for control and signal processing. In this paper, we present the design of a short-range underwater acoustic modem starting with the most critical component from a cost perspective .– the transducer.

Sr.No.	Underwater acoustic	Terrestrial radio
1	Low bandwidth (KHz)	High bandwidth (MHz)
2	Long delay	Short delay
3	Distance dependent on bandwidth	Distance independent on bandwidth
4	Few simulation tools available	Several simulation tools available
5	Hard to experiment	Easy to experiment

Table1: Main differences between underwater Acoustic network and terrestrial radio network

Block Diagram FSK Modem:

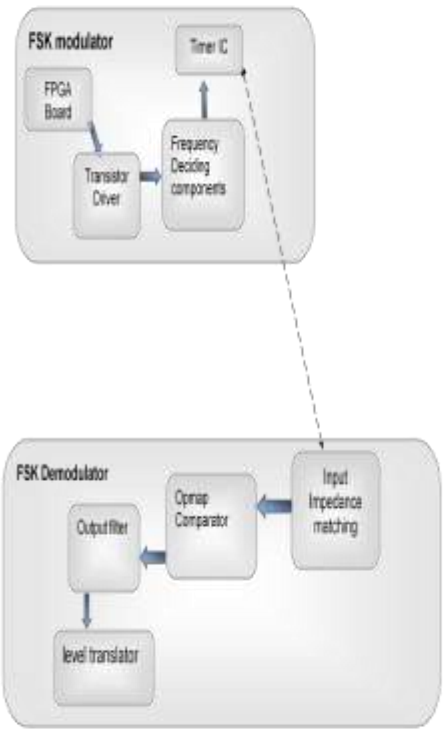

Fig. 1: Major components of an underwater acoustic ASK modem

the properties of the transducer. The 'mark' frequency represents the frequency used to represent a digital '1 ' when converted to baseband and the 'space' frequency represents the frequency used to represent a digital '0' when converted to baseband.

Properties	Assignment
Modulation	FSK
Carrier frequency	1KHz
Mark frequency	1.2KHz
Space frequency	1KHz
Symbol duration	6.6ms
Baseband Frequency	150Hz

Table2: FSK Modem Parameters

Transmitter& Receiver circuit:

Block Diagram ASK Modem:

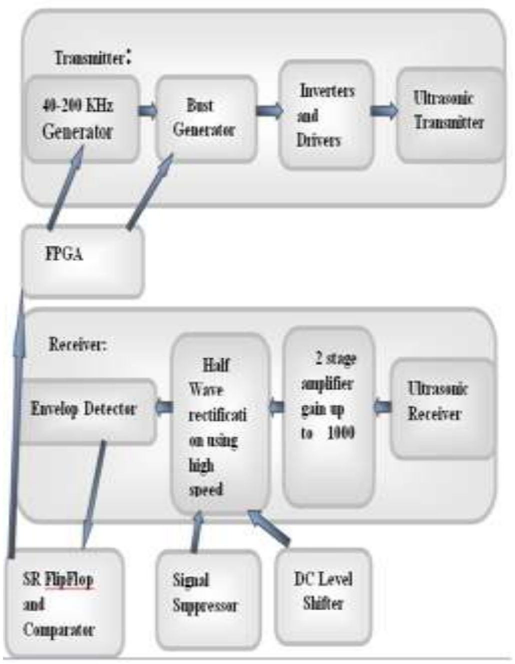

Fig2: Major components of an underwater acoustic ASK modem

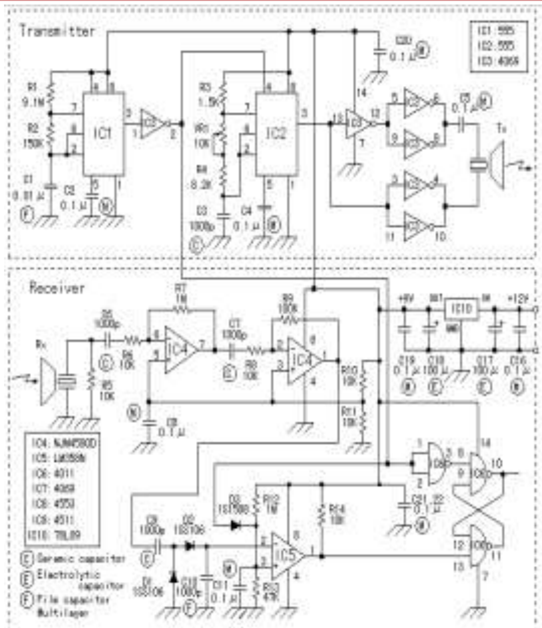

Fig3 : Circuit diagram of ASK Transmitter& Receiver circuit

Ultrasonic oscillator:

IC2 is the circuit to make oscillate the ultrasonic frequency of 40KHz.Oscillatior's operation is same as IC1 and makes oscillate at the frequency of about 40 KHz. wave close to 50%.The frequency of the ultrasonic must be adjusted to the resonant frequency of theultrasonic sensor. Therefore, I am made to be able to adjust the oscillation frequency by making the RB the variable resistor (VR1).The output of IC1 is connected with the reset terminal of IC2 through the inverter. When the reset terminal is the H level, IC2 works in the oscillation. The ultrasonic of 40 KHz is sent out for the 1 millisecond and pauses for the 62 milliseconds.

Ultrasonic sensor drive circuit:

The inverter is used for the drive of the ultrasonic sensor. The two inverters are connected in parallel because of the transmission electric power increase.The phase with the voltage to apply to the positive terminal and the negative terminal of the sensor has been 180 degrees shifted. Because it is cutting the direct current with the capacitor, about twice of voltage of the inverter output are applied to the sensor.

Receiver circuit:

A] **Signal amplification circuit**

The ultrasonic signal which was received with the reception sensor is amplified by 1000 times(60dB) of voltage with the operational amplifier with two stages. It is 100 times at the first stage (40dB) and10 times (20dB) at the next stage. As for the dB (decibel),.Generally, the positive and the negative power supply are used for the operational amplifier. The circuit this time works with the single power supply of +9 V. Therefore, for the positive input of the operational amplifiers, the half of the power supply voltage is applied as the bias voltage and it is made 4.5 V in the central voltage of the amplified alternating current signal. When using the operational amplifier with the negative feedback, the voltage of the positive input terminal and the voltage of the negative input terminal become equal approximately. So, by this voltage, the side of the positive and the side of the negative of the alternating current signal can be equally amplified. When not using this voltage, the distortion causes the alternating current signal. When the alternating current signal is amplified, this way is used when working the operational amplifier for the 2 power supply with the single power supply.

Detection circuit:

The detection is done to detect the received ultrasonic signal. It is the half-wave rectification circuit. The DC voltage according to the level of the detection signal is gotten by the capacitor behind the diode. TheShottky barrier diodes are used because the high frequency characteristic is good.

Signal detector:

This circuit detects the ultrasonic signals which returned from the measurement object. The output of the detection circuit is detected using the comparator. This time in this circuit, the operational amplifier of the single power supply is used. The operational amplifier amplifies and provides output as the difference between the positive input and the negative input.

RESULTS:

1. FSK MODEM :

Sr. No.	Distance between transmitter and receiver in cm	Received signal in peak voltage
1.	2 cm	6.04
2.	5 cm	5.84
3.	15 cm	4.79
4.	20cm	3.97
5.	25cm	3.12

Table3: Observation of distance [between transmitter and receiver] & Received signal in peak voltage [For FSK modem]

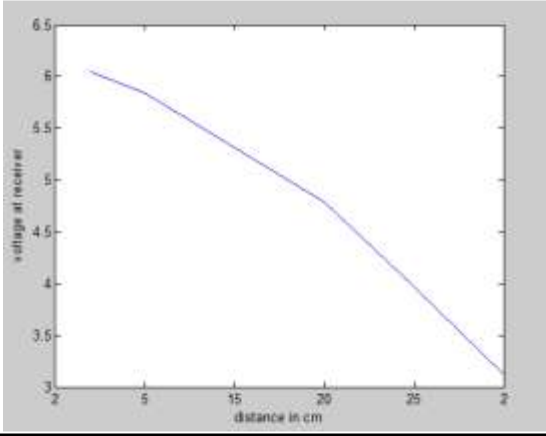

Fig.4 : Experimentally determined voltage response at receiver with respect to distance.

Matlab code

Dist = [2 5 15 20 25];

Voltage = [6.04 5.84 4.79 3.97 3.12];

Plot (dist,voltage)

Set (gca, 'xticklabel',{dist})

Xlabel ('distance in cm'); label ('voltage at receiver')

sdf

2. ASK & FSK MODEM:

Sr no.	Distance between transmitter and receiver in cm	Received signal in peak voltage
1	2cm	9.60
2	5cm	9.20
3	15cm	8.80
4	20cm	8.40
5	25cm	8.00

Table4: Observation of distance [between transmitter and receiver] & Received signal in peak voltage [For ASK modem]

Sr no.	Distance between transmitter and receiver in cm	Received signal in peak voltage
1	2cm	7.80
2	5cm	7.60
3	15cm	7.40
4	20cm	7.20
5	25cm	7.00

Table5: Observation of distance [between transmitter and receiver] & Received signal in peak voltage [For FSK modem]

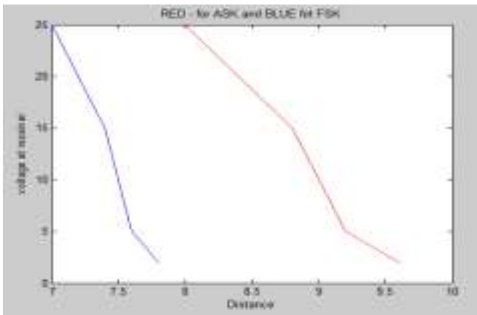

Fig. 5: Experimentally determined voltage response at receiver with respect to distance.

Waveforms:

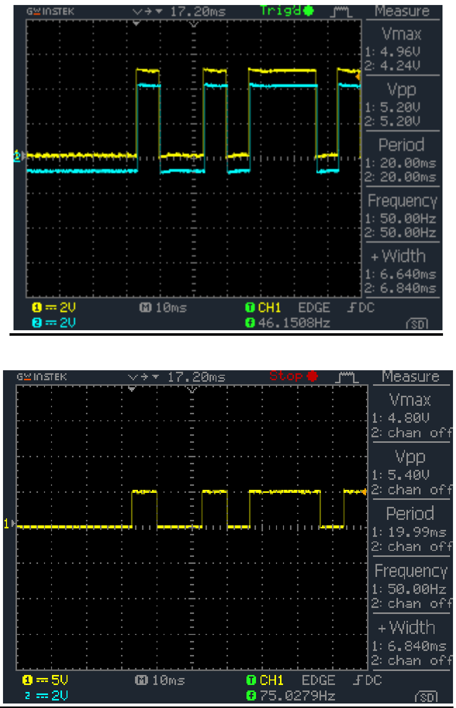

Fig. 6: Snapshot of waveforms of ASK modem (50 Hz).

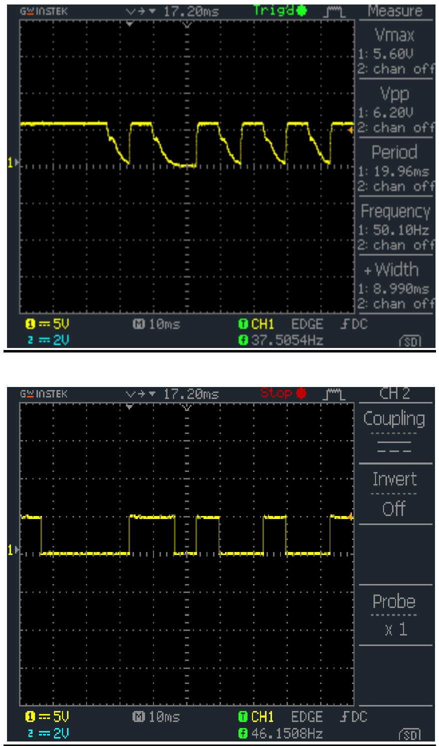

Fig. 7: Snapshot of waveform of ASK modem (50.10 Hz)

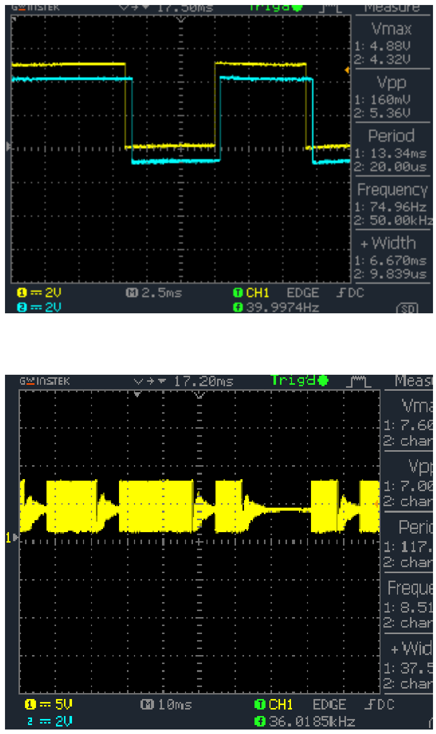

Fig. 8 : Snapshot of wave forms of ASK modem.

ISSN: 2321-8169
5624 - 5628

CONCLUSION :

Modulation Type	FSK	ASK
Carrier Frequency (KHz)	1KHz	40KHz
Mark Frequency (KHz)	1.2KHz	NA
Space frequency (KHz)	1KHz	NA
Symbol duration (ms)	6.6ms	1.04ms
Baseband frequency Hz	150Hz	960 Hz

Table 6 : Comparison between ASK & FSK modulation technique.

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