SMART GUARDIAN

Project ID: 19-099

An Ultrasonic Transducer-Based Underwater Data Communication

Final Report

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Bachelor of Science Special (Honors) in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

August 2019

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(Final Report documentation submitted in partial fulfillment of the requirement for the Degree of Bachelor Science Special (honors) In Information Technology)

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ABSTRACT

This thesis is concerning style, simulation associated testing of an underwater modem using transducers. The thesis work combines a theoretical half, whose objective is to grasp the appropriate techniques to modify the characteristics of the targeted channel, simulations and a sensible half relating to the system readying and experimental tests.

The benefits of the web of Things (IoT) to a variety of industries are obvious – primarily the power to remotely monitor machines in the period of time whereas making certain safety and anticipating breakdowns. However, there are technical challenges offered that embrace observance and communication underwater. this can be wherever the underwater internet of Things enters the fray.

A large share of the underwater setting is undiscovered. within the past two decades, there has been a rise within the interest of exploring and observation underwater life among scientists and in trade. Underwater operations square measure very tough because of the dearth of low cost and economical means. Recently, Wireless sensing element Networks are introduced in underwater environment applications. However, underwater communication via acoustic waves is subject to many performance limitations, that makes the relevant analysis problems very completely different from those toward land. during this thesis, we have a tendency to investigate node placement for building an ultrasonic transducer-based Underwater data communication.

This work focusses on the research and development of the underwater acoustic modem for shallow waters and short range communication. The modeled system will with efficiency operate for a depth of 30m, 50m, and 70m for a variety up to 50m. The hardware was developed mistreatment minimum range of parts as a symbol of thought for economical information transmission and reception mistreatment acoustic signals. The hardware was tested to work with efficiency in air, but hardware tests for underwater are usually recommended for future work, which can offer far better performance since acoustics is a lot of appropriate for communication in water than air.

ACKNOWLEDGEMENTS

I would prefer to take chance to precise my feeling to any or all of the those who have helped me and provided their support. I would first prefer to impart my supervisor Dr. Pradeep Abeygunawardhana for providing me with this opportunity. you have got provided me with continual support and knowledge, allowing me the liberty to pursue my analysis in the method I assumed best whereas still being there to supply a smart word of recommendation once needed. I cannot many thanks enough for the support and commitment that you simply have shown to me throughout my studies.

To my parents and sister cannot provide thanks enough. you have got forever instilled in me the will to attempt for achievement in my life and have supported me no matter my decisions. you have got been there through each my successes however additional significantly in my failures with unwavering support and for that I will be able to be everlastingly grateful.

I would like to thank my team colleagues Tharushi Mudalige, Kavisha dineth and Pasan De silva for them help, discussions and comments in each part of my work. It was a great pleasure working with them.

Most importantly, I owe my greatest thanks to my friend Dinusha Amarathunga for the encouragement, and wit made this otherwise insurmountable task seem like something I could actually complete.

I am truly humbled and grateful to have so many extraordinary people in my life

Contents

1. INTRODUCTION

In recent year's communication technologies underwater has become a lively space of analysis because of its vital applications in military, oceanographic knowledge assortment, disaster hindrance, and pollution watching. Communication is a very important method that permits an associate exchange of knowledge transfer between two or a lot of entities or nodes.

Underwater wireless communications gift new and distinct challenges when putting next to wired and wireless communication through the atmosphere, requiring sophisticated communication devices to achieve comparatively low transmission rates, even over short distances. Indeed, the underwater environment possesses a variety of identifying options that make it distinctive and rather completely different from terrestrial radio propagation wherever ancient communication systems are deployed. Underwater, many phenomena may influence communications, like salt concentration, pressure, temperature, amount of light-weight, winds and their effects on waves

However, underwater communication has several challenges that limit the performance of operations. Some of the challenges are:

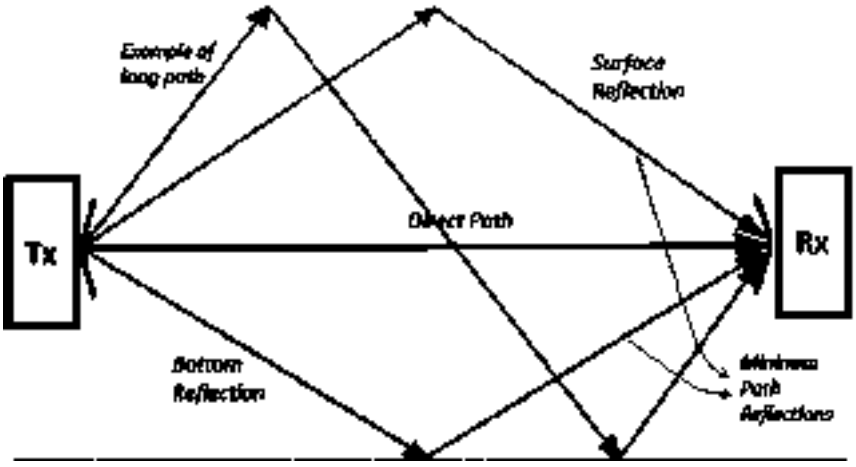
• restricted information measure owing to the low waveband employed in underwater communication channels.

• Underwater channel is extremely prone to path loss thanks to the physical characteristics of the underwater communication channels.

• High propagation delay that's nearly five times on top of the propagation of frequency (RF) terrestrial signals.

• High Bit Error Rate (BER) thanks to high chance of property loss under-water.

- In underwater, there exist multiple methods from the transmitter to receiver, or multipath (See Fig. 1). two elementary mechanisms of multipath formation area unit a reflection at the boundaries.



See Fig. 1

Despite all challenges, wireless communications certainly play a very important role in sensible underwater systems. These challenges are tackled by introducing supersonic transducers nodes that transmit the control information.

There are three main technologies out there for underwater wireless transmissions. One technology is radio-frequency (RF) communication, that options high information throughput short vary and suffers from gentle Doppler effect. Another technology is the optical transmission, ideally in blue-green wavelength, which needs line-of-sight positioning. Another technology, that is that the most used one is acoustic communication. This latter technology is the one that enables the longest vary of communication.

This thesis explores the application of steganography to an Ultrasonic Transducer-Based Underwater Communication such that two nodes could communicate with wearable and floating devices.

The main motive of this document is to acknowledge the behavior and conjointly the implementation of the wearable device with the flood detection and coordination generation. mutually of the most parts of the system the Underwater communication between the wearable and floating devices is of utmost importance in ending the rest of the system functions. Therefore, the respect to each half is completely explained. Special choices to be else and conclusion created at the highest of the literature survey that led to the need of the choices is mentioned. what is more, the technological aspects to be lined and conjointly the deliverables to be distributed at the highest of the implementation square measure given graphically and completely.

1.1 Literature Review

This chapter describes the previous and up to date existing styles of acoustic modems for underwater wireless detector networks and additionally offers a broad understanding associated with this project work supported the literature, conferences papers, books, journals, and publishers. It additionally is a reference supported that the thesis work is allotted. This section describes the whole outline of the communication underwater. Here describe existing systems and therefore the means they move with this part. This the section explains what reasonably neutral use this methodology and therefore the means they operate this methodology.

Referring to this document, developers, and users can merely understand, however, this part goes on. This section describes offered constraints, assumptions and therefore the means this part communicates with various components, etc.

In 2015 a style of Low-Power modem for underwater communication has been developed by Jagdale M.R.1, Puranik V.G [1]. This has been developed primarily by specializing in networks of times rely upon acoustic communication, that poses a number of disputes for reliable information transmission. primarily has many interactive options like to transmitted Signals within the ultrasonic Transmitter and received Signals within the ultrasonic receiver transforms

the mechanism for analog signals into digital signals, code sampling methodology to interpret signals because of the original signals, frequency generators, amplifiers, ultrasonic sensors and lots of methods with sensors are employed in this project.

In 2015 another modem for underwater communication has been made by Slamet Indriyanto, Ian Yosef Matheus Edward [2]. This analysis was supported underwater modem with ultrasonic frequency victimization Frequency Shift Keying (FSK) Modulation. The designed system includes FSK electronic equipment, microcontroller, electronic equipment, and electrical device. Waterproof ultrasonic sensors JSN-SR04T area unit used as transducers for designed modems. a number of the options area unit enclosed in our projected product in addition.

The analysis work of Akylildiz, Pompili, and Melodia describes the state of art of underwater detector networks beside some analysis challenges for readying of underwater acoustic detector networks (UASN). It describes the various applications of the underwater acoustic detector networks such a number of the main challenges within the style of UWASN's are mentioned like information measure (BW) limitation, high bit error rates followed by shadow zones, limitation in battery power and fouling corrosion. completely different UWASN architectures or topologies like 2D static and 3D underwater detector networks are delineated. This paper conjointly describes a number of the most variations between the territorial detector networks and UWASN's with respect price, deployment, power, and memory. the inside design of associate underwater detector node that consists of a detector, detector interface electronic equipment, microcontroller, power offer, and modem has been delineating well and that they have mentioned the way to create the system waterproof by exploitation PVC housing. Some major challenges are moon-faced by the designers with relevance readying of a coffee price, low scale UWASN's has been listed and briefed. This analysis offers a decent insight associated with many style problems to think about for developing associate modem (Akylildiz, Pompili, and Melodia, 2005).

In the work of Wills, Lolo and Heidemann, the first aim was to style and develop a reasonable} electronic equipment that's affordable for purchase and for readying of the many detector nodes. The target worth of this method is alleged to be 100$ and therefore the electronic equipment is

specially designed for short-range communication of vary 50m-500m. The digital hardware platform used may be a straightforward 8-bit Atmel Atmega 128L microcontrollers and this style makes every of the detector node development price cheaper. The modulation theme used for information transmission here is FSK. A BER of 10-5 was seen once the transmitter and receiver were unbroken getting ready to one another. (Wills, Wei dynasty Ye and Heidemann, 2006).

The information that is gathered through these analysis papers is going to be lead us to a bigger product which is able to have the power to serve human in an additional effective manner.

In the work of Num and Sunshin an, they developed a low power based acoustic modem that basically operates with 3.3V power supply and has a capability of digital data communication. The modulation scheme used in this work is amplitude shift keying (ASK). The system tested to show a data rate of 100 bps, the communication distance of the modem is approximately 3m, however the exact range of the acoustic modem could not be found due to the lack of test facilities. The system has made use of piezo-transducers i.e. Sounder/ projector/speaker at the transmitter and hydrophones at the receiver end, however some problems that needs to be considered for this modem for future work is directional property, reflection and refraction. In addition, this acoustic modem will become the basis for the underwater wireless sensor networks (Num and Sunshin, 2007).

1.2 Research Problem

The primary research problem is find a mechanism for Drowning prevention, along with how well it performs when applied to people.

Secondary research problems include:

- How to Identify the user condition and the depth of the water?
- How to Transmit the data through underwater communication?

- How to locate the floating devices?
- How to identify the flooded area?

When it 'comes to the "An Ultrasonic Transducer-Based Underwater Data Communication" come across with different set of problems.

- Technique of sending and receiving message below water
- How to do the hardware implementation both RX and TX?
- How to find the data is received successfully?
- How to do the error checking?

1.3 Scope

The primary scope of this research is to provide a proof-of-concept for Ultrasonic transducer data communication, and to demonstrate data extraction under simulated underwater acoustic conditions.

At the conclusion of this study, we provide a framework for follow on research and applications. Though valuable the following will not be specifically addressed and are beyond the scope of this thesis:

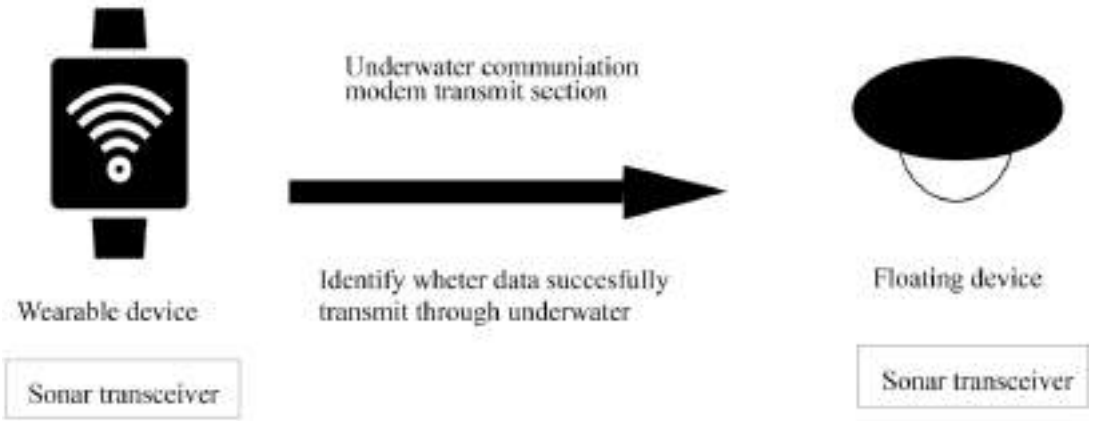
- Receiver and transmitter characteristics, construction, and design.
- Application of different modulation techniques.
- Real-time symbol recovery and receiver synchronization.
- Performance evaluation via at pool testing.
- Compatibility with specific equipment, software, and hardware

1.4 Research Objective

The long term goal of the research is to develop a 'An Ultrasonic Transducer-Based Underwater Data Communication' The objective of the current study is to provide a comprehensive review of literatures and industry practices in relation to constraint analysis and outline a conceptual framework.

Particularly, the study has the following sub-objectives:

- To conduct literature review on acoustic signals, existing underwater acoustic modems, underwater channel characteristics, modulation schemes, and error detection, correction schemes.
- To model the underwater Ultrasonic Transducer (TX & RX) and analyzing the device performance.
- To design, model and simulate the underwater device using appropriate simulation tool for the desired specifications.
- To realize the designed system in hardware for accurate data communication
- To test and analyze the performance of the developed system

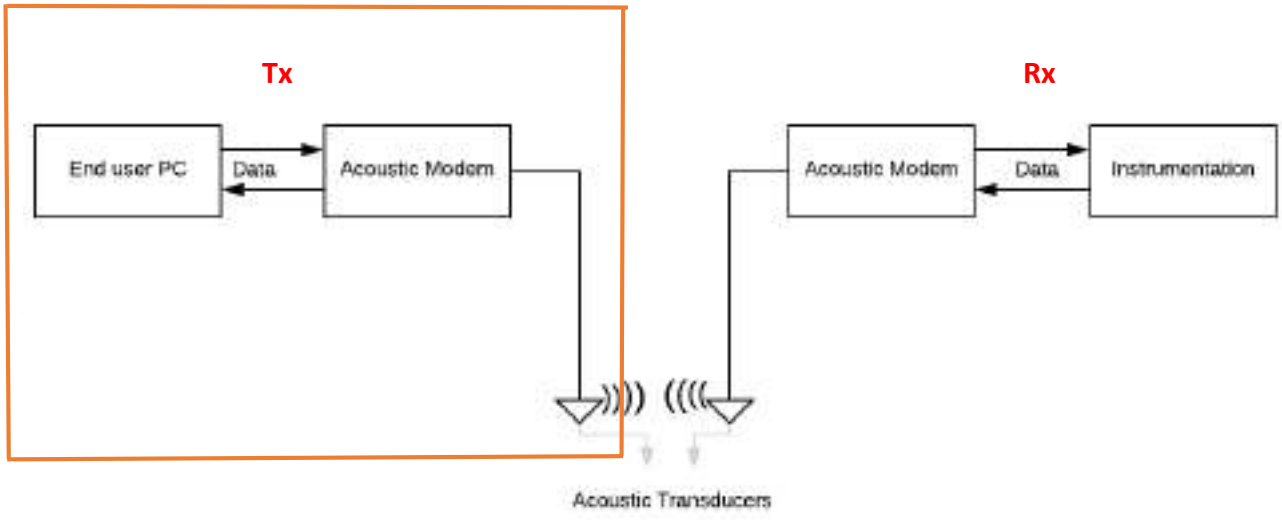


2. METHODOLOGY

2.1 Methodology

Underwater communication is a way of sending and receiving message below water. There are several ways of employing such communication where the most common is using transducers. For a booming establishment of an acoustic communication link below given environmental conditions, the physical line should be taken into consideration. Acoustic waves that result from variations of pressure in an exceedingly medium are widely used as a physical layer in Underwater acoustic communications.

The system which consists of two Acoustic modems (Tx & Rx) and communicate through these two modems. The system has the capability of getting connected to remote floating devices and getting signal who wear the wearable device via the physical board. The floating devices will be providing the correct signal message to the server with and interface to engage in the app.



High level Architectural Design

2.2 Testing & Implementation

2.2.1 Implementation

Following are the Hardware used for Acoustic Underwater Communication System In between wearable and floating devices. Parts list:

1) Ultrasonic transducer TX and RX (disordered from a HC-SR04 module)

2) LM386 to amplify the received signal

3) LM393 for comparing the signal once amplified

4) Two Arduino Uno

5) 10K pot for the tuning

6) LED

7) 220 Ohms' resistor

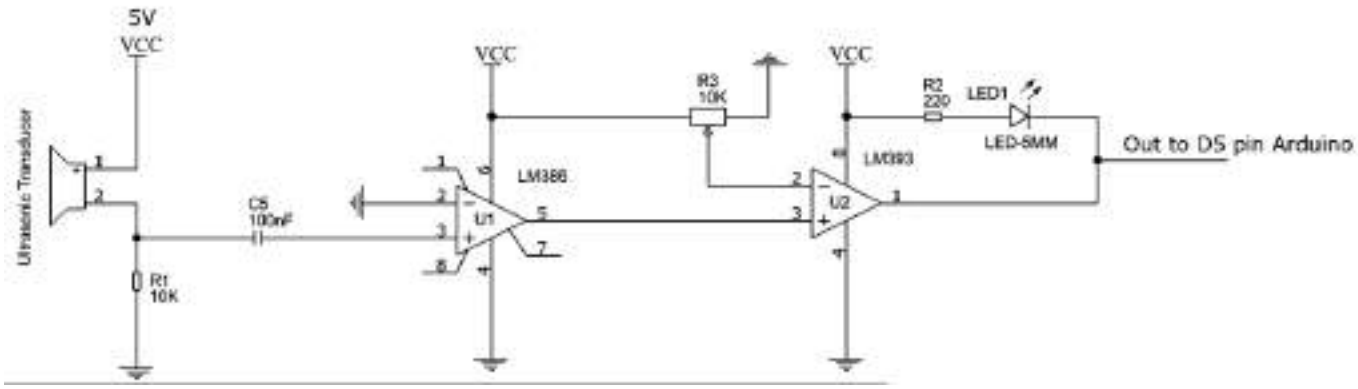
8) 100nF cap

9) 10K resistor

Ultrasonic Data Transmitter & Receiver

For the transmitter, the ultrasonic transducer is simply tied to one of the digital pins on the Arduino. The receiver is a bit more complex, requiring a LM386 amplifier and LM393 comparator to create a clean signal for the second Arduino to read.

Circuit of Ultrasonic Data Receiver



TX Source code

```
void setup()
{
    Serial.begin(115200);
    pinMode(3,OUTPUT);
}

void send(String msg)
{
   byte ch;
   unsigned int pos = 0;
   unsigned int sz = msg.length();
   while(pos<sz)
   {
      ch = msg.charAt(pos);
      Serial.print((char)ch);
      tone(3,40000);
      delay(10);
      noTone(3);
      for(int i=0;i<8;i++)
      {
         boolean b;
         b = bitRead(ch,7-i);
         if(b)
         {
            tone(3,40000);
            delay(2);
         }
         else
         {
            tone(3,40000);
            delay(4);
         }
         noTone(3);
         delay(11);
      }
      pos++;
   }
```

RX Source Code

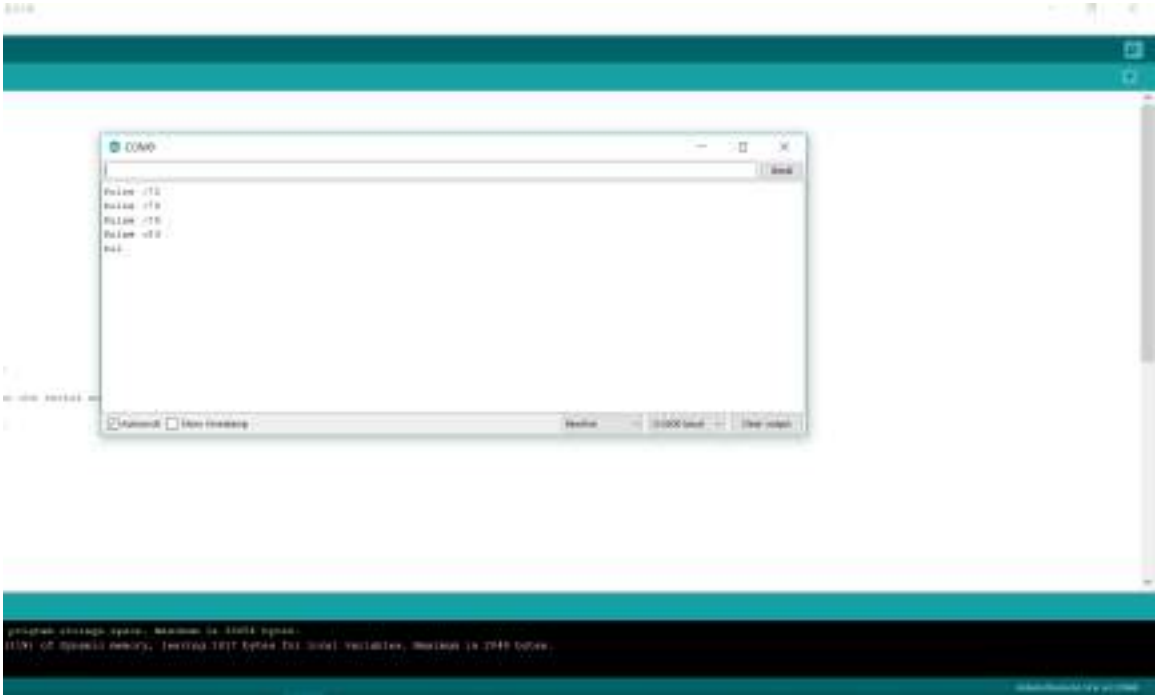
```
int pos = 0;
unsigned char CH = 0;
unsigned int bits1 = 0;
boolean capture = false;

void setup()
{
   Serial.begin(115200);
   pinMode(5,INPUT_PULLUP);
}

void loop()
{
   if(digitalRead(5))
   {
      bits1 = 0;
      unsigned long delta7 = millis();
      while(millis()-delta7 <= 10) if(digitalRead(5))
       bits1 ++;
      //Serial.println(bits1);
      if(capture)
      {
         boolean b = 0;
         if(bits1 > 290 && bits1 < 600) b = 0;
         if(bits1 > 20 && bits1 < 290) b = 1;
         if(b) bitSet(CH,7-pos); else bitClear
         (CH,7-pos);
         //Serial.print(b);
         pos++;
         if(pos == 8)
         {
            Serial.print((char)CH);
            pos = 0;
            capture = false;
         }
      }
      if(bits1 > 600)
      {
         capture = true;
         pos = 0;
      }
   }
}
```

Looking through the source code for the transmitter and receiver, it's concerning as basic because it gets. The transmitter Arduino breaks down a given string into individual characters, then any converts the ASCII to eight binary bits.

These bits are sent out as tones and are picked au fait the receiving finish. Once the receiver has collected a good chunk of tones, it works through them and turns the binary values back to ASCII characters that get drop over serial. It's slow, however, it's straightforward.

3. RESULTS & DISCUSSION

3.1 Results



Powered by a combine of Arduinos and using transducers salvaged from the extraordinarily standard HC-SR04 module, during this example, I'm sending strings of text from one node to a different.

For this take a look at, I needed to envision however a simple transducer would behave with a flame present. This primarily shows the heart beat rate that received from the transmitter.

TX and RX transducers disordered from an HC-SR04 module along with a pair of Unos to transmit text short distances. An LM386 amplifier and LM393 comparator are also used for the receiver. While the transmission can easily be interrupted by putting a hand between the TX and RX.

3.2 Discussion

The results to this point demonstrated that it absolutely was feasible to transmit string information using an ultrasonic transducer modulation scheme over short-range, using capacitive ultrasonic transducers with a restricted bandwidth of only 40kHz with wireless ultrasonic synchronization.

4. CONCLUSION

The novelty of this study was in its use of ultrasonic for wireless communication for our product. The experimental results for the ultrasonic 40khz modulation data communication area unit provided. The experiment was got wind of in both water and air.

This study is predicated on an analysis of the feasibleness of using ultrasonic underwater communication. It is troublesome to discover the signal from the receiver. To discover the signal, we tend to study the ultrasound, frequency selection, investigated transducers and their properties for analysis and designed the experiment. in a very future study, we are going to conceive to use robust modulation, and enhance a lot of frequency and accuracy.

5. REFERENCES

[1] http://dl.ifip.org/db/conf/euc/eucw2007/NamA07.pdf

[2] Design of a Low-Cost, Underwater Acoustic Modem for Short-Range Sensor Networks: http://cseweb.ucsd.edu/~kastner/papers/oceans10-low_cost_modem.pdf

[3] Design of a Low-Cost Underwater Acoustic Modem:

https://www.researchgate.net/publication/220413512_Design_of_a_Low-Cost_Underwater_Acoustic_Modem