

VLC for Underwater Operations

Li-Fi Solution for Underwater Short Range Communication

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Abstract:—With the growing utilization of the ocean, communication under water is need in various types of underwater activities, such as ocean sciences, salvage operations, oil and gas exploartions, marine archeology, law enforcement and military activities. Strong signal absorption by water makes RF use is practically impossible under the water. Acoustic navigation and positioning which is the currently used technology which uses the low bandwidth acoustic waves which disturb the marine li. so this paper presents to you how Li-Fi technology can be well suited and advantageous for the short range underwater communication (navigation and positioning)

Keywords: Li-Fi, VLC, LED, UVLC

I. INTRODUCTION

The term Light Fidelity (Li-Fi) technology was first introduced by professor Herald Hass who demonstrated it by transmitting both audio and video data over visible light over a short distance in TED talk. The technology basically requires a light source and transducer which can convert light energy into electrical signals (ex: solar panel, photodiode). whatever the type of data, it is converted into binary 0s and 1s which corresponds to the light source being on and off, and this action of the light source is detected by the highly sensitive receiver which converts the light source into electric signals which there on can be processed to retrieve the data. Submarines play an important and vital role in the country's defense. It is basically a piece of equipment that does things like intelligence gathering and lot many defensive roles. For such an important piece of equipment of our defense, navigation under water has been little tough, since the radio wave do not reach far underwater they are basically useless for the submarines, apart from this, acoustic wave which are used by these submarines also disturbs the aquatic life. Not only submarines various other underwater operations like oil gas explorations, salvage operations etc. require underwater navigations and positioning of which navigation in submarines was just to get an idea why navigation underwater is important.

The current use of acoustic navigation and positioning involves the use of sonar which produce sound waves averaging 200db. Which travels miles of distances underwater still maintain an intensity of 140db. which no doubt is too much for many marine lives. Evidences also show that many whales travel hundreds of miles rapidly changing depth causing bleeding of their ears and eyes, and almost killing them. Many reports say that single testing would cause killing of thousands

of mammals and injuries & many other symptoms like temporary deafness.

So, there is a need of a technology which can help communicate under water without harming or disturbing the marine life

This paper presents to you a promising technology which can be of real use and can serve as a proper and better replacement for the current underwater communication systems. Since the system proposed uses light waves of which no harmful effects are known up to the date like that caused by the continuous exposure to the RF waves and acoustic waves.

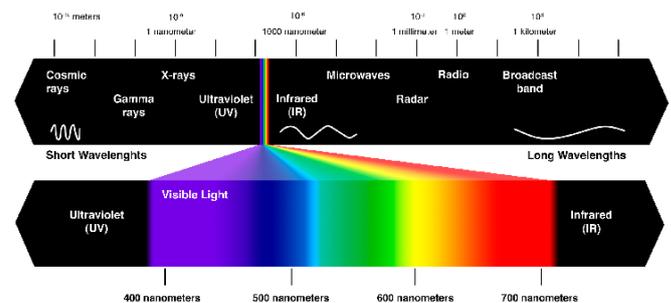


Figure 1: spectrum of light

Visible light which falls between 400nm and 700nm can be used for communication. The two main properties of visible light which makes it best for the communication is the speed of light and reach of it. Then to add on visible light provides greater bandwidth almost 1000 times than RF waves. Therefore, greater speeds are achievable using Li-Fi. Researchers at oxford have achieved speeds of 224GB/s.

II. LITERATURE REVIEW

Currently there is lot of research happening around the world in the development of Light-Emitting Diode (LED). These systems have comparatively lower power consumption and longer life time than fluorescent lamps. Following are the examples of similar work using the advantages of LED.

A.H Elgala et al [1] differentiate between radio and Visible Light Communication (VLC) and in his paper he has declared that optical wireless communication has long history. He also says the deployment of solid state lighting is driving the visible light technology. Figures obtained from his paper shows that

data densities of 0.41 bits/s/Hz/m² are possible and are being achieved.

The various modulation techniques analyzed in this paper have its unique feature and disadvantages as well. B.W.O. Popoola et al [2] states in the paper that some are simply implementable and bandwidth efficient like On-Off Keying (OOK). He explains that the other techniques like Pulse Interval Modulation (PIM) is great for inherent synchronization, whereas the Pulse Position Modulation (PPM) provides the greater power efficiency in Line Of Sight communication (LOS) but the performance decreases in depressed communication channel. There have been lots of modulation techniques thoroughly studied, analyzed and explained in this paper.

C.HU Guo-yong†1 et al [3] proposes the use of visible red light to be used as signal source in Free-Space Optical(FSO) communication.in this paper using the data for transmission of 650nm laser in atmospheric channel the performance of laser communication link is evaluated. The paper states that the system can achieve a max range of 300m at 100 Mbps. experimental data given in this paper shows data rate of 10Mbps with distance covering 300m.

D. Akassh et al [4] proposes the use of VLC to use internet. He states that the VLC connected network can easily pave a way for wire-free comfortable future, these kind of technology can be very useful in development of personal wireless networks, mobile services and underwater communication. In this paper the applications of VLC for internet has been shown to explain the concept of VLC. This paper also stresses upon the low power consumption of this technology because of the use of Light Emitting Diodes (LED). This paper also explains the structure required to build such a system in real time. The cost effectiveness of the solution is one of the greatest advantages of the technology in implementing it.

III. RELATED WORK

A. I-MAJUN an underwater communication device:

In 2013 a company named ‘MARINE COMMS RYUKYU’ a leading in Underwater Visible Light Communication (UVLC) technology lunched a new diving device which can help the diver communicate with his co diver at maximum distance of 30 m inside water at depth of 30m.this device is a 2-channel device, battery powered which can last for up to 240minutes of communication.

IV. COMPARISON WITH EXISTING SYSTEMS

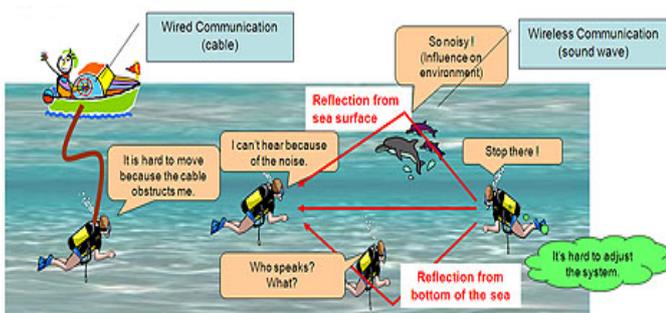


Figure 2: Disadvantages

A. Disadvantages of cable or wired communication underwater

- Mobility is limited.
- Marine life may be disturbed [10].

B. Disadvantages of sound wave for underwater communication

- There might be some confusion in deciding from which side the sound is coming, as there is very less difference of time that the sound takes to reach the two ears, because sound travels at around 1500m/s underwater.
- Reflection of sound in shoal and pool [10].

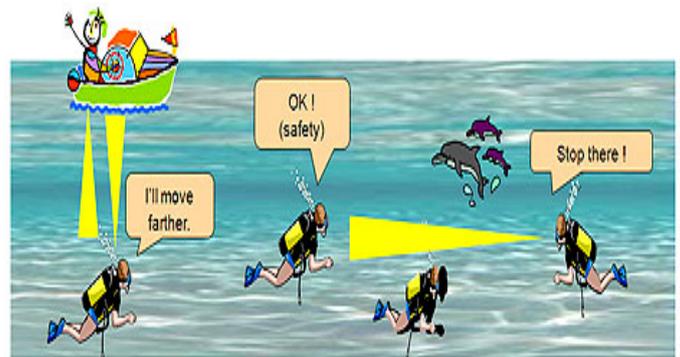


Figure 3: advantages of using VLC

C. Advantages of the solution proposed in this paper Underwater Visible Light Communication

- Greater mobility
- Adjustment is easy and no diffusion of light underwater unlike sound.
- Voice sourcing can be checked visually [10].

D. Advantage of Subaquatic Visible Light Communications

- *Advantages over supersonic wave communication:*
Power consumption is low and the voice can be received very easily, the power backup is good over ultrasonic device.
- *Advantage over sound wave communication (underwater speaker):*
It makes it easy to talk to many people simultaneously by turning the light source to that person without causing any problem whereas in sound wave communication this narrow scope is not possible while talking to many people. [10].

V. SYSTEM DESIGN

The proposed system requires a transmitter which picks up audio, a receiver which decodes the received signal. Basically, these two parts of the setup has many subcomponents which are as follows:

A. A fast switching light source:

The base of the li-fi system is the light source which can switch at greater speed so that it can be synchronized with the audio signals that are picked up in a transmitter circuit.

With the fast growth in led technology, increased use of it and its fast switching speed makes it ideal for the li-fi communication. So li-fi system would have a led as the light source which turns on and off with the change in the input audio signals. For experimenting a power led of 1 watt and torch led as a light source.

The important point to note is LED's consume very little amount of power which make li-fi technology efficient.



Figure 4: torch LED and power LED

B. Power amplifier:

An RF power amplifier is needed in the system to amplify the signals either coming from the 3.5mm audio jack or an electret mic into the li-fi transmitter.so that the waves trigger the led driver.

C. Led driver:

The signals coming from the RF power amplifier can drive the led if the voltage and the current are just enough. But for a light source of greater wattage the system should include a led driver.

D. Photo detector:

The light from the li-fi transmitter must be detected and received by the li-fi receiver so the system requires a light detector. Many types of light detector can be used for a li-fi system, this system uses a solar panel as photo detector, which directly converts light source into electric form so no complex circuit is required for the conversion as in the case of photo detector like a light dependent resistor. The solar panel to be used must be of 4 volt or greater so that if you are not using a preamplifier speaker like your mobile earphones, then it can drive them.



Figure 5: solar panel with 3.5mm female audio jack

E. Decoder:

A decoder in the above system proposed is an electric circuit which basically converts light into an equivalent electric form which can reproduce the actual audio which was transmitted by the li-fi transmitter.in case of audio communication over li-fi like the proposed system the decoder circuit may or may not be present. For example, in this system the decoder circuit is absent since the system uses a solar panel as the photo detector which directly converts it to electric equivalent of the incoming light

F. Preamplified speakers:

To be able to listen the audio at louder volume, one would require a pre-amplified speaker which has its own power source so that the signals coming in from the audio jack can be amplified to achieve louder audio. But one can use tiny mobile phone ear plugs, the audio is just fine with them. It has been experimented with both

VI. BLOCK DIAGRAM

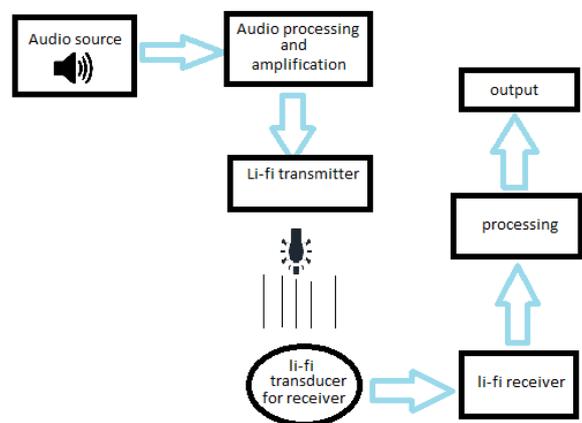
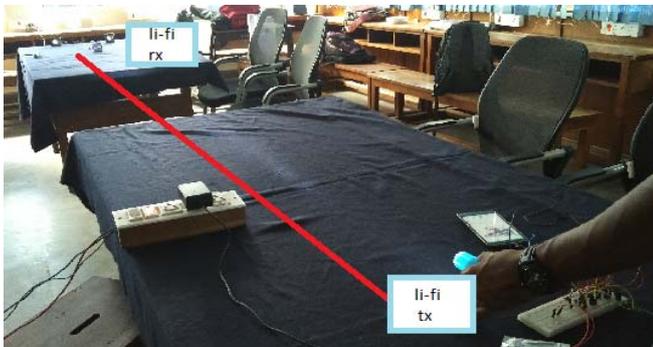


Figure 6: typical li-fi audio transmission

VII. EXPERIMENT AND OBSERVATIONS

In this paper the concern is about underwater communication so two experiments were performed, one with air as the medium and other with the setup inside the water

Setup-1. The first experiment where transmitted audio which is played on a mobile phone to li-fi transmitter connected to a speaker placed at a distance. Then once the song starts playing on the mobile phone connected to the li-fi transmitter, the signals starts coming out of the mobile phone into the RF amplifier of the li-fi circuit. Thereon the LED source starts blinking accordingly which is not observable to the human eye (but the blinking can be observed when the frequency of the audio signal is quite low). This light source is made to fall on the solar panel of li-fi receiver. This fluctuation in the light source is detected by the solar panel, which is converted into electric signals this signal is then sent on to pre-amplified speakers to hear the audio. So when the light is made to fall on the solar panel the audio can be heard on the speakers. Blocking of light source with opaque objects resulted in stopping of the audio as it blocked the transmission. But however, when blocked with white paper and few other semi-transparent objects the audio was hearable but at a lower volume which proved the lower intensity light signals also can fetch data with a little more amplification at the receiver end, this experiment was done in two parts one with a power LED as a light source and other with a torch as the light source, it was observed the range was limited to the type of the light source. So here in this experiment with the torch as the light source greater range was achieved of about 7 meter which is closer to the range of Bluetooth.



In the figure 7, yellow colored waveform is the input to the led coming from the RF amplifier to drive the LED. It can be observed from the waveform that the voltage going into the LED is varying which is the result of the input audio file being played, so the led would turn on and off accordingly.

The green waveform in the following figure, is the output of the solar panel, it is observed that the waveform of it is inverted from that of LED's input.

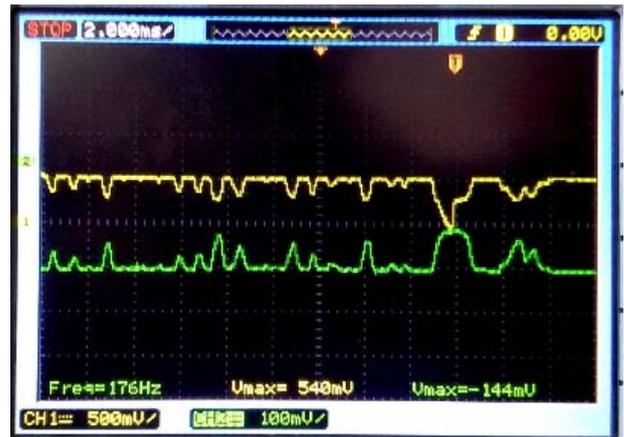


Figure 7: led input waveform and solar panel output waveform

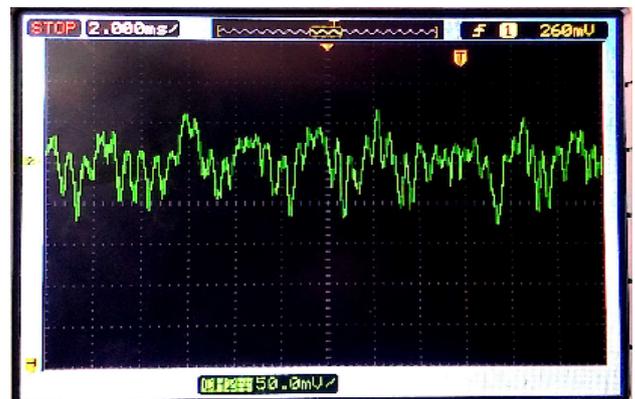


Figure 8: input to the RF amplifier

In the figure 8 is the waveform of the audio that is being played on the mobile phone, so from the figure it can be observed that the voltage of the signal is not enough to drive a LED, so this signal is sent to the RF amplifier.

Setup-2. In the second experiment had water in a beaker in between the li-fi transmitter and li-fi receiver to simulate underwater communications. It was observed that volume of the audio fell by very small amounts from that of air being the medium. This was due to the absorption of light by water and little bit of scattering by the walls of the beaker. But the audio was clear and fine



Figure 9: experimenting with water as medium

VIII. CONCLUSION

Li-Fi and LED are the emerging technologies in which huge development and progress would take place and cheaper and better underwater communication solutions using li-fi can be developed. It is an approach that will make our lives more technology driven soon. This technology is not just limited to

underwater communication; it has wide variety of applications. By using this technology, greener, safer and cleaner future is possible.

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