Underwater Laser Networking for Military and Defence

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Abstract: *Laser communication under wireless communication domain for transmission of voice. The application purpose of our project is communication, which would be underwater uni-axially transmitted light signal through Laser torch which will act as a carrier between transmitter and receiver. The focus of this project will be Visible Light Communications (VLC)[1]. The project is divided into two main sections transmitter and receiver. The main component in the transmitter is the Laser which can cover distance up to 500m, if any obstruction comes in the path of the beam no sound will be heard at the receiver. The main component in the receiver is the photo-transistor which converts the light energy into electrical energy hence orientation of photo transistor is very important. The light rays from laser must fall on phototransistor. An important feature of laser is privacy. It is virtually impossible for someone to tap into the link. For high security purpose, line-of-sight laser beam is ideal. So, it can be best suited for military applications where security is of utmost concern so that two divers or submarines can communicate with each other. The possible uses that lasers have in underwater environments are growing. Lasers have potential in becoming practical solution to the problem of underwater communication.)*
Keywords: *Laser ,Military, Photodiode ,Visible light communication*

I. Introduction

The focus of this project will be Visible Light Communications (VLC)[1]. Audio signals will be converted into light signals and will be transmitted with Laser torch. The blinking of this Laser torch will not be visible to the human eye as they are blinking at a high frequency. The light from the laser torch will be sent through the water medium carrying the data to the to the receiver. Photodiodes on the receiving side will detect the fluctuation of the Laser torch from the transmitter and will send signals to a two-stage transistor preamplifier and LM386-based audio power amplifier

The first reason to consider is visible light's frequency spectrum bandwidth, which ranges from 430 THz to 750 2 THz. The bandwidth is much larger than the radio frequency bandwidth, which ranges from 3 KHz to 300 GHz. With a larger bandwidth it is possible to accommodate more users and potentially achieve higher transfer rates because each user can be given a larger portion of the bandwidth to transfer information The next major advantage that visible light systems have over other communication systems is its abundance Drawbacks to visible light that could potentially be used as advantages for a visible light communication system. Unlike radio waves, light cannot propagate through walls. Since light cannot propagate out of an enclosed room, the only way to access the information is if the receiver is in the same room; thus, no outside sources will be able to acquire the information

II. Indentations And Equations

The effect of stimulated emission can be amplified to produce a practical source of light, which is coherent and can travel long distances without appreciable spread of the beam width. Such a light source is called LASER, an acronym for Light Amplification by Stimulated Emission of Radiation. The principle behind such amplification is simple. Suppose we start with one photon which strikes an atom in an excited state and releases a photon, we would have two photons and an atom in the ground state. These two photons, in turn, may be incident on two more atoms and give rise to four photons, and so on.

The probability of *stimulated emission* probability from state $E^2 \to E^1$ in terms of *measurable* quantities of the laser media, these being,

1. $A_{2,1}$ is the spontaneous transition rate (the state lifetime).

2. $g_{(v)}$ is the spectral line-shape (including broadening).
3. $I_{(v)}$ is the intensity of light in the medium.
4. v is the frequency of the light.

$$W^{2,1}(v) = \frac{A_{2,1} \, c^2 \, I(v)}{8\pi \, n^2 h \, v^3} g(v)$$

Blackbody radiation: The classical formula for the radiant energy density at a frequency in the energy interval to is obtained by counting the number of modes of the electromagnetic waves in this interval and multiplying it with the average energy per mode kT. The resulting formula is known as Rayleigh- Jeans' Law, which is given by

$$u(\nu)d\nu = \frac{8\pi kT}{c^3}\nu^2 d\nu$$

Stimulated emission the rate equation of population

$$\frac{dN_2}{dt} = B_{12}u(\nu)N_1 - [A_{21} + B_{21}u(\nu)]N_2$$

$$N_1 + N_2 = \text{constant,}$$

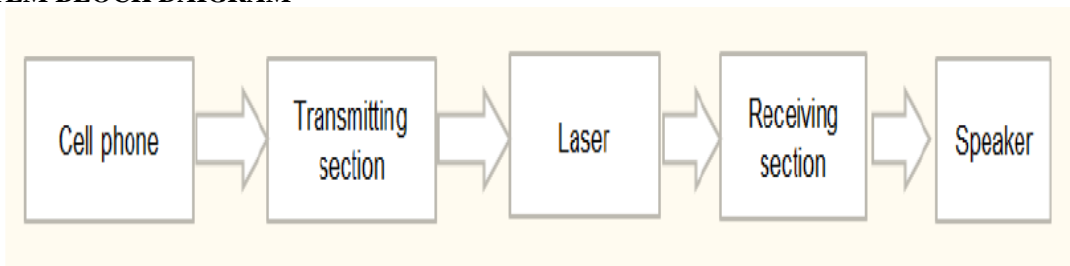$$\frac{\partial N_2}{\partial t} = -\frac{\partial N_1}{\partial t}$$

The ratio of spontaneous emission probability to the stimulated emission probability is

$$\frac{A}{Bu(\nu)} = e^{h\nu/kT} - 1$$

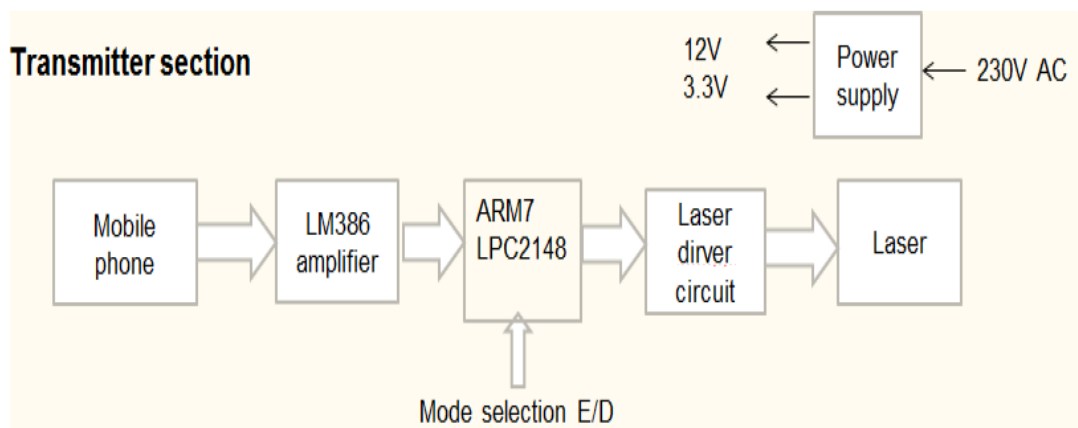## III. Methodology

In this section an overview of the entire system which includes hardware and software is discussed The hardware consist of a transmitter and a receiver part, a laser through which the data will be passed ,a cell phone and a speaker .
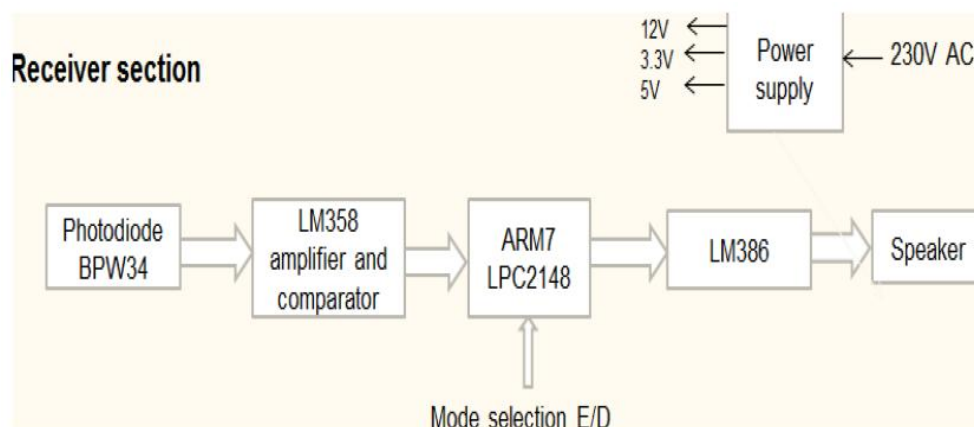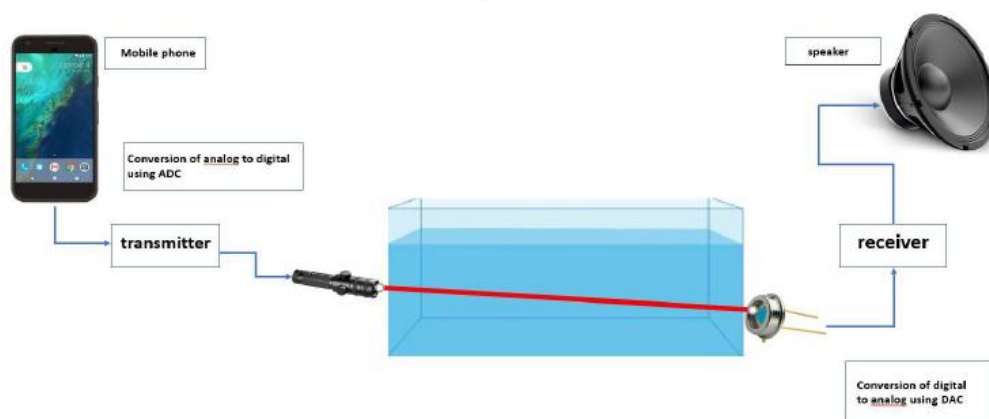
SYSTEM BLOCK DAIGRAM[2]

The transmitter board consist of a mobile phone, a amplifier LM386, an ARM7 LPC2148 which will be programmed for serial data communication at the receiver side then there is a laser driver circuit which will help to operate a laser. The audio input is given to the mobile phone and then this analog input is given to the LM386 amplifier where it will be amplified and given to then ARM7 where the analog input is converted to digital input and passed to the laser driver circuit to the laser and through the water.

This laser light falls on the photodiode then to the LM358 where the input from the photo diode is amplified and compared to the set values then passed to the ARM7 on the receiver side where it is decrypted and converted to analog voice signal then passed through a LM386 amplifier and heard on the speaker. The input power supply for the LM386 is 12v , for the ARM7 is 3.3v ,for the LM358 has a supply voltage of 5v.

IV. Proposed System

The transmitter and the receiver consisting of the ARM7 IC will be kept on either sides of the water tank the data i.e the voice recording from the mobile phone will be played this data will be amplified by the LM386 and passed through the arm. The conversion of the data from analog to digital will take place and through the laser the data will be passed. This laser light will go through the water and fall on the photodiode. Then the data obtained from the photo diode will be amplified and compared to the set values with the help of the LM358 amplifier and comparator IC. Then the signal will will be converted from digital to analog by the ARM IC and amplified again by the LM386 and heard at the speaker.

V. Future Scope

Additional functions that would enhance the project but are not mandatory goals of this design include sending video, sending data at a distance greater than one meter, and transmitting data at a minimum of 1 Gbps. Other features include using different colored Lasers simultaneously to increase data transfer rate and/or allow simultaneous use by multiple users. The reasons for not including these features include time constraints, budget concerns, as well as stability issues .When trying to transmit at higher frequencies, stability becomes more on an issue as parts become less ideal. Also, in order to transmit at a higher frequency, the quality of our design parts would have to increase which would cost more money and consume more time.

VI. Conclusion

The underwater laser communication system is capable of transmitting audio through laser and at the receiver, user can actually receive the transmitted voice on the speaker. The demand for secure communication for military applications underwater between different submarines is increasing and many nations are looking forward to implement the laser communication system which would provide them the absolute security which the RF fails to provide.

VII. Result

Software:
The coding part has been done using embedded C. The input to the laser is given by a mobile phone .Basically an audio (digital signal) is passed through the laser which is then converted in analog signal as it passes through the arm processor. This signal is then sensed by the photo diode which is then again passed through arm processor on the receiver side to convert the digital signal into analog such that the audio signal can be played through the speaker.
Hardware:
Arm Processor: LPC2148
Amplifiers: LM386(Transmitter Side as well as Receiver side), LM358(Reciever Side)
Photodiode: BPW34
Power supply: ARM: 3.3V, LM386 and LM358: 5V.

References

Journal Papers:
[1].   D. C. O'Brien, L. Zeng, H. Le-Minh, G. Faulkner, J. W. Walewski and S. Randel, "Visible light communications: Challenges and possibilities," Personal, Indoor and Mobile Radio Communications, 2008. PIMRC 2008. IEEE 19th International Symposium on, Cannes, 2008, pp.1-5. doi: 10.1109/PIMRC.2008.4699964
[2].   Kilfoyle, D.B.; Baggeroer, A.B. "The state of the art in underwater acoustic telemetry",Oceanic Engineering, IEEE Journal of, On page(s): 4 - 27 Volume: 25, Issue: 1, Jan. 2000
[3].   Joseph C. Palais (1988) , Fiber Optic Communications second Edition, Second edition. Prentice Hall.
[4].   T. Komine and M. Nakagawa, ―Integrated System of White LED Visible-Light Communication and Power-Line Communication‖, Proceedings of IEEE Transactions on Consumer Electronics, Feb. 2003, Vol. 49, pp. 71-79.
[5].   Maurice Gibson, ―ELECTRO-MAGNETIC SPECTRUM‖, IEEE Students' Quarterly Journal. March 1934, Vol. 4, pp. 140-145.