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PROPOSITION OF USING LEDS FOR COMMUNICATION IN UNDERWATER USING VISIBLE LIGHT COMMUNICATION TECHNOLOGY

B.Anitha Vijayalakshmi[#1] , A.Aruna[#2], Ms. R.P.keerthi[*3], Ms. S.kumuthabala[*4], Ms. R.vinitha[*5], Ms.A.Kaviya[*6]

[1] Associate Professor, [2]Assistant professor, Department of Electronics & Communication Engineering, Kings Engineering College

[3,4,5,6] UG Students, Department of Electronics & Communication Engineering, Kings Engineering College

***Abstract*- Li-Fi is alike as wireless communication that uses the communication medium as light. Visible light is used to transfer data between the systems instead of radio signals. Li-Fi uses LED light source to transmit the data wirelessly and this method is widely called as visible light communication. Traditional methods using radio frequencies limit the data transmission in underwater in terms of slow speed and weak signals. If underwater communication is applied to deep sea divers it gets even more limited. Traditionally these divers use hand gestures for communication. Existing technology that does allow audio communication underwater for deep sea divers is still limited. This is because of the guttural sound that comes out of the devices or the bulkiness or inconvenience of using the devices. The paper makes to look into method of communication in underwater using visible light.**

Keywords – VLC, Underwater, High speed, Visible light

I. INTRODUCTION:

Nowadays, acoustic technology is mostly used for establishing wireless communication link among divers and ships, or sending long range remote signals. This is because sound waves travel through water faster than in air, receiving very little attenuation. However, due to frequency attenuation characteristic of acoustic waves in water, it is difficult to expand its bandwidth. Therefore acoustic approach cannot achieve high rate, and also portable communication devices are difficult to be designed at a low cost. However, there are demands for high quality, high speed communication links even for distances within few meters. Such demands are there in high quality voice communication between divers, and in data transmission of video streaming and sensing data. Optical communication which can be operated at over hundreds of MHz, can meet these demands. Also, it is known that light in the visible region has the least attenuation in water absorption. A voice communicating system utilizing laser beams had been proposed, however it is rather unrealistic and dangerous to implement a laser in a man-use devices underwater, as the optical axis needs to be fixed all the time. Moreover, laser diodes are an expensive device. Therefore, in this paper we propose a system utilizing a modulated visible light LED for under water communication. LEDs used as modulated source can provide reliable high speed communication system which can be implemented in portable device at a low cost.

Light is a form of radiant energy that comes from the sun. Light energy is also produced when fuels are burned or when electrons pass through the filament in a light bulb. All forms of solar radiation, including visible light, make up what is known as the electromagnetic spectrum, as shown in Figure 1 [1]. This spectrum ranges from radiations with long wavelengths to those with short wavelengths. The wavelength of each type of radiant energy is the length of one complete wave cycle. The frequency of a particular radiation is the number of wavelengths (wave cycles) per second. The higher the frequency of a wavelength, the greater is the energy of that wavelength. Longer wavelengths have lower frequencies

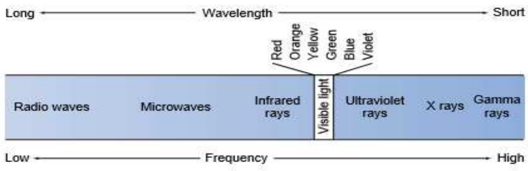

Figure 1: The electromagnetic spectrum

II. FREE SPACE OPTICAL (FSO)

FSO communication is data transmission through light modulation in air without particulates or any other medium. Using the visible light spectrum for FSO Communication is called Visible Light Communication (VLC). VLC has been demonstrated for high speed of data transmission above 1 Gbps. The technique of intensity modulation of light for high data transmission rate has shown great success in recent years with the improvements of LED, Laser, and semiconductor technology. The FSO supports underwater wireless communication applications. Sonar systems can transmit at kilometer range, but only at a few kilobytes per second. This is only enough to send text or audio messages and at slow speeds. The wireless optical communication system, employing infrared light (IR) gets absorbed too easily in underwater and so VLC is a necessary choice. The figure 2 provides the information about absorption coefficient versus wavelength.

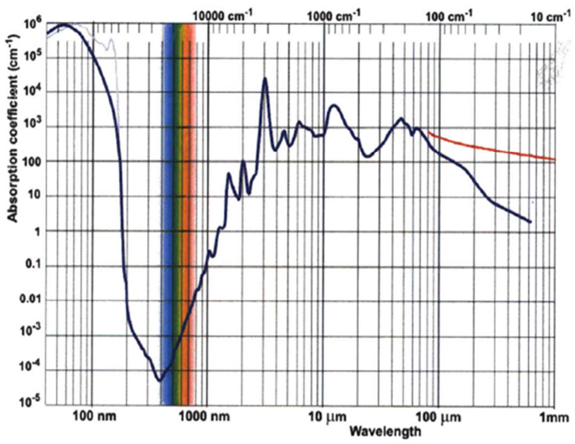

Figure 2: Light absorptions for various wavelengths

III. OPTICAL SOURCES

Lasers are unidirectional and can transmit at far ranges. Even in wireless systems, many lasers are employed in the development of satellite communications. Lasers offer high data transmission rates (usually in the Gbps range) over ultra long distances. Lasers are typically high powered and require large systems in order to transmit over long distances. Depending on the system, lasers require cooling systems, which adds on to the circuit complexity [2]. For underwater applications, the high-powered nature of lasers allows for longer distances, which is a problem with underwater optical communication (UWOC). The problem with the unidirectionality is with the immense scattering and refraction occurring with light underwater. Laser light is much easier to miss the receiver and organic or inorganic objects in the water also can easily block it. Laser systems are also more expensive and take up more space. In general, lasers are more practical for larger applications such as air to sea communication.

Due to the increase in better semiconductor technology, LEDs have become a very viable transmitter in VLC. LEDs are low cost and do not need large systems to operate. LED systems can be very small and implemented in flashlights and headwear for underwater use. LEDs are low power and can operate on batteries. Heat sinks for the LEDs may be necessary, but usually do not take up as much space as a cooling system. Scattering and line of sight for transmission is still a problem, but with large viewing angles LEDs are less susceptible than lasers. LEDs do not transmit very far unless a lens focuses the light, but then the LED become unidirectional [3]. Another way to compensate for the transmission range is to create an array of LEDs and illuminate a large area. LEDs are easier to implement in smaller applications and have been of interest in diving.

IV. WIRELESS UNDERWATER TECHNOLOGIES

The acoustic waves are used as primary carrier for under water wireless communication due to their relatively less absorption and long coverage distance. The first underwater audio communication was developed in United States using single sideband (SSB) suppressed carrier amplitude modulation at carrier frequencies between 8 and 15 kHz using simple voice band and pulse shaping filters. The below table [4] gives the comparison of different wireless underwater technologies

Table 1: Comparison of different wireless underwater technologies

Parameter	Acoustic	RF	Optical
Attenuation	Distance and frequency dependent (0.1-4 db/km)	Frequency and conductivity dependent (3.5-5 db/m)	0.39 db/m(ocean) 11 db/m (turbid)
Data rate	~kbps	~Mbps	~Gbps

Latency	High	Moderate	Low
Distance	Up to kms	Up to ~10 meters	~10-100 meters
Bandwidth	Distance dependent	~MHz	10-150MHz
Transmission power	Tens of watts(typical value)	Few mW to hundred of watts(distance dependent)	Few watts
Antenna size	0.1m	0.5m	0.1m
Performance parameters	Temperature, salinity and pressure	Conductivity and permittivity	Absorption, turbidity/scattering, organic matter

The use of RF waves in underwater wireless communication has been explored for further improvement in data rates as it provides higher bandwidth and faster velocity in underwater environment. The RF frequencies in MHz range are capable of propagating in sea water up to distance of 100 m by using dipole radiation with high transmission powers in the order of 100 W. However, it requires sophisticated antennas design and high transmission power. For RF system design which involves a communication link between under water and terrestrial transceiver, any frequency range from MHz to GHz works effectively. Other design configuration involves direct RF communication link between two transceivers submerged underwater or one set inside the water and other set in the air. The RF frequencies for underwater communication suffer from the high losses due to conductivity of sea water. This increases the absorption loss at high frequencies in sea water as shown in Figure. 4.

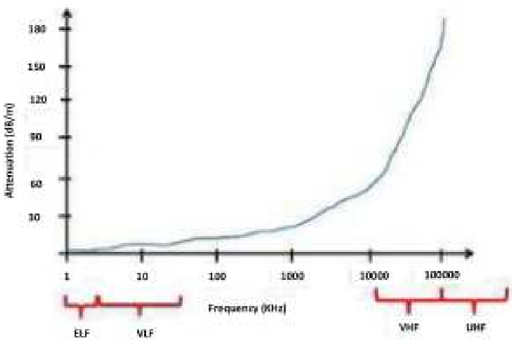

Figure 3: RF attenuation in sea water

As RF signals require huge antenna size, large transmitter power in fresh water and suffers from high attenuation in sea water, the next obvious choice for underwater communication to support high data rate is using optical signal. UOWC is capable of exceeding Gbps at a distance of few hundreds of meters due to high frequency of optical carrier. Although optical signals in underwater environment face several extreme challenges due to water absorption or scattering caused by suspended particles or due to strong disturbance caused by the Sun, there are still many evidences for broadband optical link underwater over moderate ranges.

V. PROPOSED BLOCK DIAGRAM

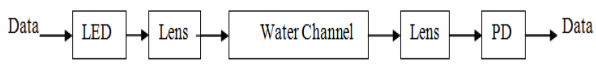

Fig. 4 Block diagram

The system is LOS (Line of Sight) model having a LED as the transmitter and a PD (Photo Detector) as the receiver. Each equipped with a lens. We assume the noise as AWGN (Additive White Gaussian Noise). In optical channels, the quality of transmission is typically dominated by shot noise. When little or no ambient light is present, the dominant noise source is receiver pre-amplifier noise, which is also signal-independent and Gaussian. Accordingly, the wireless optical channel model is expressed as follows;

$$Y(t)=R\ X(t)*h(t)+N(t)$$

Where Y(t) represents the received signal current at certain times t. R represents the receiver's optical-electrical efficiency. X(t) represents the transmitted optical pulse. The h(t) denotes the impulse response. N(t) denotes the AWGN and the symbol * means convolution. The average transmitted optical power P is the performance of each LED and it differs when the turbidity varies.

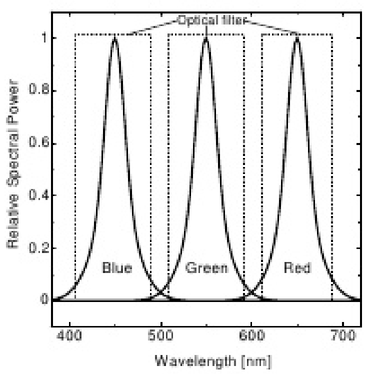

Fig.5 Relative spectral distribution of LED

For high turbidity, Blue LED out performs Red LED. However, for longer distance, as water absorption becomes dominant, Red LED has the worst performance.

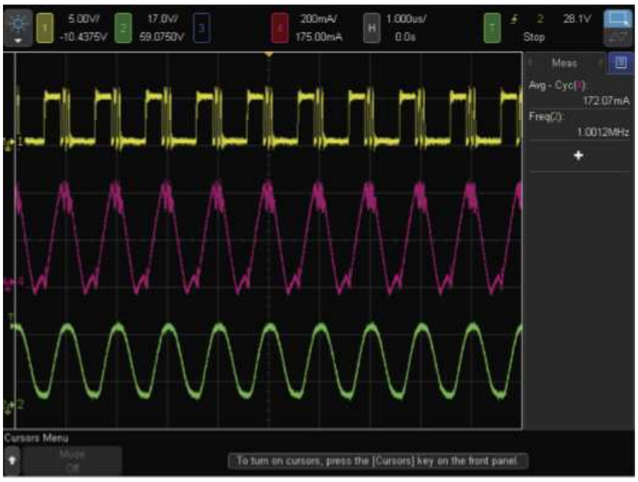

Fig.6 LED current and photo detector current

VI. CONCLUSION

In this paper, we discussed the fundamental analysis about the underwater communication using VLC technology. LED enabled VLC technology can be used in under water communication. By using LASER as the light source, the distance between transmitter and receiver can be increased. The proposed system using VLC technology is safe and getting expected results. By using different wavelength LEDs, it is found that, directive LEDs give better and fast results as they are subjected to less beam spread. It is important to have the transmitter and receiver to be in line of sight failing which the system fails to deliver any result.

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