

Visible Light Communication Technology in Under Water Communication

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Abstract—Light Emitting Diodes (LEDs) and Photo Detectors (PDs) are used to transmit and receive data wirelessly in VLC. While data transmission, weak signal with slower speed limits the usage of traditional methods using radio frequencies in underwater communication. The work explains the communication in under water using Visible Light Communication (VLC). The optical channel is used to facilitate the communication link. The system shows that the Light Fidelity (Li-Fi) technology can be good alternate for Radio Frequency (RF) technology for underwater wireless communication link. The underwater wireless links supports data collection in under water, underwater investigation, underwater environmental monitoring and much more.

Index Terms— VLC, Underwater, LEDs, Visible light, Li-Fi, Acoustic.

I. INTRODUCTION

Pervasive research is going on nowadays about underwater communication. Radio waves, acoustic waves or optical waves supports underwater wireless data communication. The acoustic waves is commonly used for sending long range remote signals in underwater for communication. The acoustic signal travels faster inside water when compared with air. Expansion of bandwidth is difficult in acoustic wave as it suffers from frequency attenuation. Interference and high latency issues prevails in RF communication [1]. The factors that affects the light propagation in underwater are absorption and scattering, and it is dependent on the wavelength λ [2]. Thus the limitation of absorption and scattering prevents the electromagnetic waves to be used in higher range of frequency for underwater communication [3]. The better alternate for wireless communication at short distances is optical communication, which supports high data transfer rate in under water at lower cost [4]. There is increased attention towards optical transmission in underwater as an alternative to acoustic counterpart. Light is used as medium in optical transmission. Illumination and communication can be supported through light

fidelity (Li-Fi) in underwater [5]. Li-Fi needs light source to produce the data as binary 0s and 1s based on the presence and absence of light signal [6]. In underwater, the visible light sources can be used, since the water is transparent to light in the blue and green bands of the optical spectrum [7]. LEDs can be used in underwater communication. LEDs used as modulated source can provide reliable high speed communication system which can be implemented in portable device at a low cost. Thus, in recent advances, LEDs are deployed in underwater wireless optical communication [8].

In this work, section II explains the underwater optical wireless communication model in detail. It briefs out the transmitter and the receiver part with its modulation techniques deployed for data transmission. Section III concludes the work. It explains the impacts of absorption and scattering in different types of water for underwater communication.

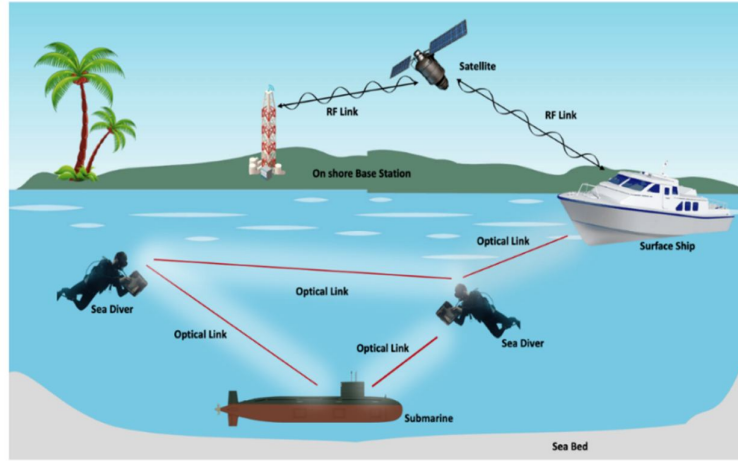


Figure 1. Communication using optical link in underwater

II. UNDER WATER OPTICAL WIRELESS COMMUNICATION MODEL

The electrical signal is converted into optical signal at the transmitter section. The ON-OFF (OOK) keying modulation scheme is the easiest one to be realized in optical communication. The presence of light is recognized as '1' and no light as '0'. The intensity modulated signal is recovered using photo detector at the receiver section. The detected signal is demodulated to get back the data in original form. The high speed data transfer could be attained through Orthogonal Frequency Division Multiplexing (OFDM). The underwater model is shown as figure 2.

Requirement of large antenna and transmitter power along with higher attenuation while using RF signal in underwater communication makes next obvious choice to be chosen. The optical signal provides high data rate in underwater communication. The optical signal exceeds the data rate of Gbps for few meters of distance. The table 1 [9] shows comparison of RF and optical communication performance in underwater communication. The optical link in underwater faces extreme challenges like water absorption or scattering initiated by suspended particles [10].

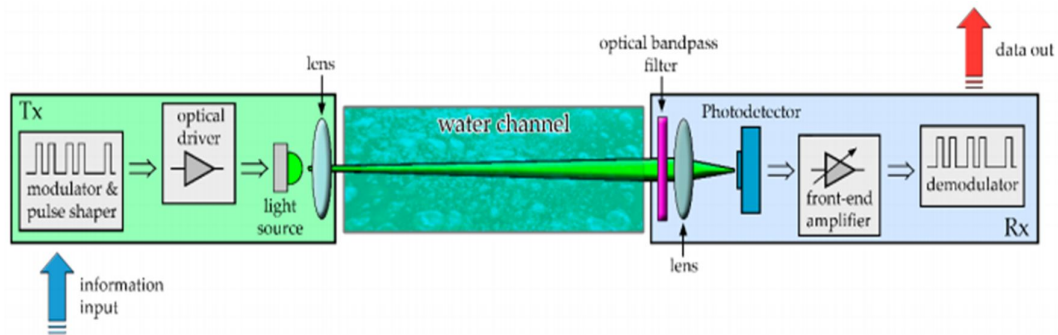


Figure 2: Optical data transmission schematic in underwater

TABLE I. RF AND OPTICAL COMMUNICATION PERFORMANCE COMPARISON IN UNDERWATER COMMUNICATION

Parameter	RF	Optical
Speed	2.3×10^8 m/s	2.3×10^8 m/s
Data rate	Mbps	Gbps
Distance	≤ 10 m	10-150 m
Bandwidth	MHz	150 MHz
Frequency band	30-300 MHz	5×10^{14} Hz

While propagation of optical waves the two crucial effects are absorption and scattering. The geometrical model to realize crucial effects while optical data transmission in underwater is shown in figure 3 [10].

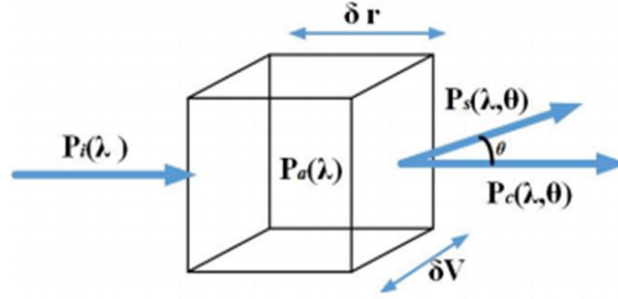


Figure 3: Absorption and Scattering while optical data transmission in underwater

The input beam light strength $P_i(\lambda)$ is related to the absorbed beam $P_a(\lambda)$ and scattered beam $P_s(\lambda)$ by water element [11] as,

$$P_i(\lambda) = P_a(\lambda) + P_s(\lambda) + P_c(\lambda) \quad (1)$$

The unaffected beam is denoted as $P_c(\lambda)$. The overall attenuation in under water coefficient is $c(\lambda)$ [12] and the table 2 [10] shows coefficients values for different types of water. The parameters taken for performance analysis are absorption and scattering.

$$c(\lambda) = a(\lambda) + b(\lambda) \quad (2)$$

TABLE II. COEFFICIENTS VALUES FOR VARIOUS TYPES OF WATER

Type of water for under water communication	$a(\lambda)$	$b(\lambda)$	$c(\lambda)$
Sea water	0.053	0.003	0.056
Clear Ocean water	0.069	0.08	0.15
Coastal Ocean water	0.088	0.216	0.305
Turbid Harbour water	0.295	1.875	2.17

The table III shows the merits and demerits of techniques in underwater communication. Apart from the merits and demerits discussed, the acoustic communication is less favourable for data intensive application [8], whereas underwater optical communication supports high data rate within short distances [10].

TABLE III. COMPARISON OF UNDERWATER TECHNIQUES

Techniques	Acoustic Communication	Underwater optical Communication
Merits	Low attenuation	Less propagation delay, High bandwidth
Demerits	Low bandwidth, High transmission losses, High latency	Requires strong directivity, if not high attenuation

III. CONCLUSION

Underwater communication technology empowers network connection among underwater devices. The motto of this paper is to provide basic study about the underwater communication. VLC technology in under water communication has great potential in terms of data rate, power consumption, attenuation and bandwidth when compared with traditional acoustic communication. The challenges posed by the peculiarities of underwater communication technologies are also discussed. In near future, underwater communication using VLC technology will be the promising one.

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