EVALUATION STUDY OF UNDERWATER LASER COMMUNICATION SYSTEM IN SHATT AL – HILLA – IRAQ

Jassim Mohammed Jassim

Babylon University - College of Science for Women, Iraq

Abstract

In this research, an analytical study of laser communication in water of shatt Al - Hilla using laser source at different wavelengths (407nm, 473nm, 532nm, 632nm and 810nm) transport through samples of water have different turbidity (clear , low turbid and high turbid). Blue laser light was employed as the carrier signal for the reason that it could proceed under water with lowest Absorption coefficient (3.0 cm^{-1}), maximum transmission distance (78m) and Minimum distortion in signal, from the another laser lights.

1. INTRODUCTION

The beam attenuation coefficient, α(λ) is a measure of the light loss from the combined effects of scattering and absorption over a unit length of travel in an attenuating medium. The unit for α(λ)is cm^{-1}. The beam attenuation coefficient, *α(λ)*, is a measure of the decay of the unscattered light and may be described by the Beer–Lambert law as [1].

$$P_r = P_T \exp^{-\alpha R} ------1$$

where, p_r is Initial beam radiant power, p_T is Measured beam radiant power, and R is the water path length An easy way to remember the relationship among these properties is to recall that a(λ) + b(λ) = α(λ). The absorption coefficient, a(λ) is a measure of the conversion of radiant energy to heat and chemical energy[2]. It is numerically equal to the fraction of energy absorbed from a light beam per unit of distance traveled in an absorbing medium, therefore α(λ) can be expressed in terms of the transmittance as[3].

$$\alpha(\lambda) = \frac{1}{R} \ln \frac{1}{T(\lambda)} -----2$$

where T (λ) is the transmitted of under water ,beam is defined by *α(λ)* varies with depth under water temperature due to the non-homogeneous nature of water. Light scattering changes the direction of photon transport, "dispersing" them as they penetrate a sample, without changing their wavelength[4].The scattering coefficient, b(λ), is equal to the fraction of energy dispersed from a light beam per unit of distance traveled in a scattering medium, in cm^{-1}.In distill water, the scattering phenomenon is negligible. Therefore, the attenuation coefficient is equal to the absorption coefficient

(a(λ) = α(λ)).

2. BASICS THEORY

Point to point laser communication can be characterized by equation (3)[5].

$$P_r = P_T \frac{A_{rec}}{(\theta * R)^2} \exp^{(-\alpha R)} -------3$$

Where θ is the beam divergence of laser. The SNR (signal to nose ratio) for PIN photodetector receiver in optical communication is given by [6].

$$SNR = \frac{(RP_r)^2 R_L}{4kT\Delta f} ----4$$

where *K:* Boatman's constant, *T* is the temperature in Kelvin, Δf is the spectral frequency, R_L is the loading resistor and R the spectra responsively of detector. The communication quality of the system is determined by BER (bit error rate) [7].

$$BER = \frac{\exp^{\left(-SNR/2\right)}}{(2\pi SNR)^{0.5}} ----5$$

3. SYSTEM DESCRIPTION

Our optical transceiver system is consisting semiconductor laser diode emitting at 473 nm with drive the semiconductor laser modulation signals, so that issuing a series of laser pulses of light modulation by the sound and photodiode receiver to restored back optical signal to electrical signals. To simulate the underwater communication in the lab, a PVC water cell of the diameter is 3Cm and path length is 100Cm ,the end of this cell is covered by two filter have high transmittance of laser beam is fabricated.. The provision for creating the turbulence is also kept using a electrical water motor, show as in figure (1).

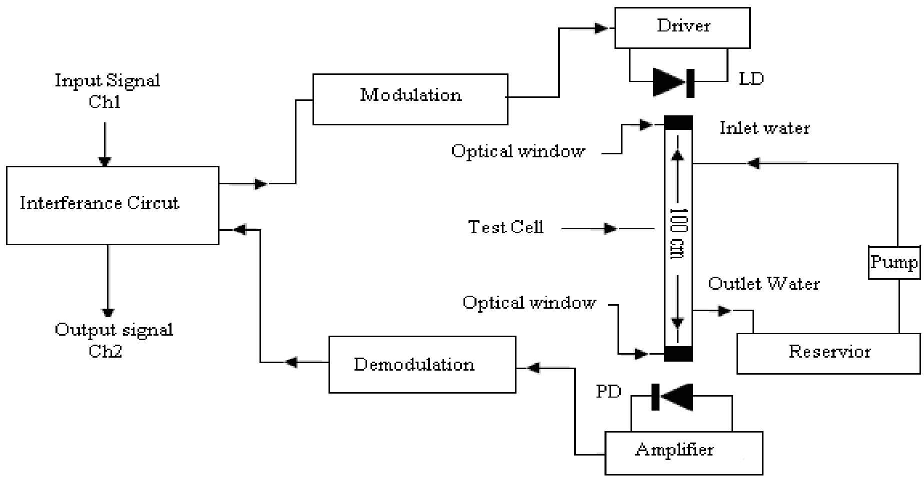


Fig. 1. Schematic diagram of overall system

4. RESULTS AND DESICCATION

4.1. Water Attenuation Measurements

Samples of water shatt Al-Hilla, Iraq placed under laser radiation (fig. 2). In this study diode laser with (407nm, 473 nm, 532 nm, 632 nm and 810 nm) wavelengths were used, with regard to result of this study the amount of light attenuation coefficient for three samples of water shatt Al–Hilla at different wavelengths calculated (Table 1). For the calculating the amount of light attenuation coefficient calculated by the formula.

$$\alpha = -\frac{\ln \frac{I}{I_0}}{X}$$

Where α is the absorption coefficient, X is the length of the cell, I_0 is the diode laser power, and I is the power diode laser power after the cell. It is found that the absorption coefficient varies with turbidity of water and has an value values (3.4×10^{-4} – 4.0×10^{-4} cm^{-1}) especially in blue-green region. So the blue-green laser (the wavelength is about 473 ~ 532*nm*) is typically laser it using in communication under this water. The blue-green laser has the minimum energy fading and can propagate from several tens of meters to in the water. Table (1) so insulator the effective the Contaminates in the water, the absorption coefficient it increased with increased the contaminates and also more effective on the beam propagation.

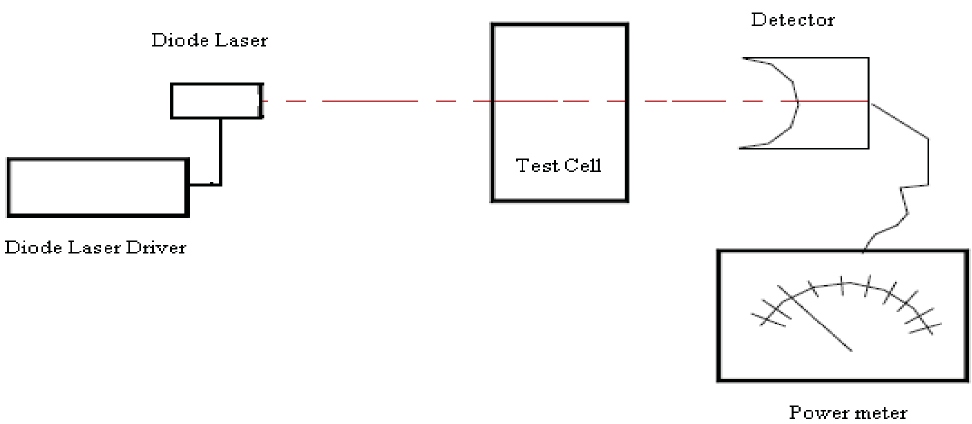


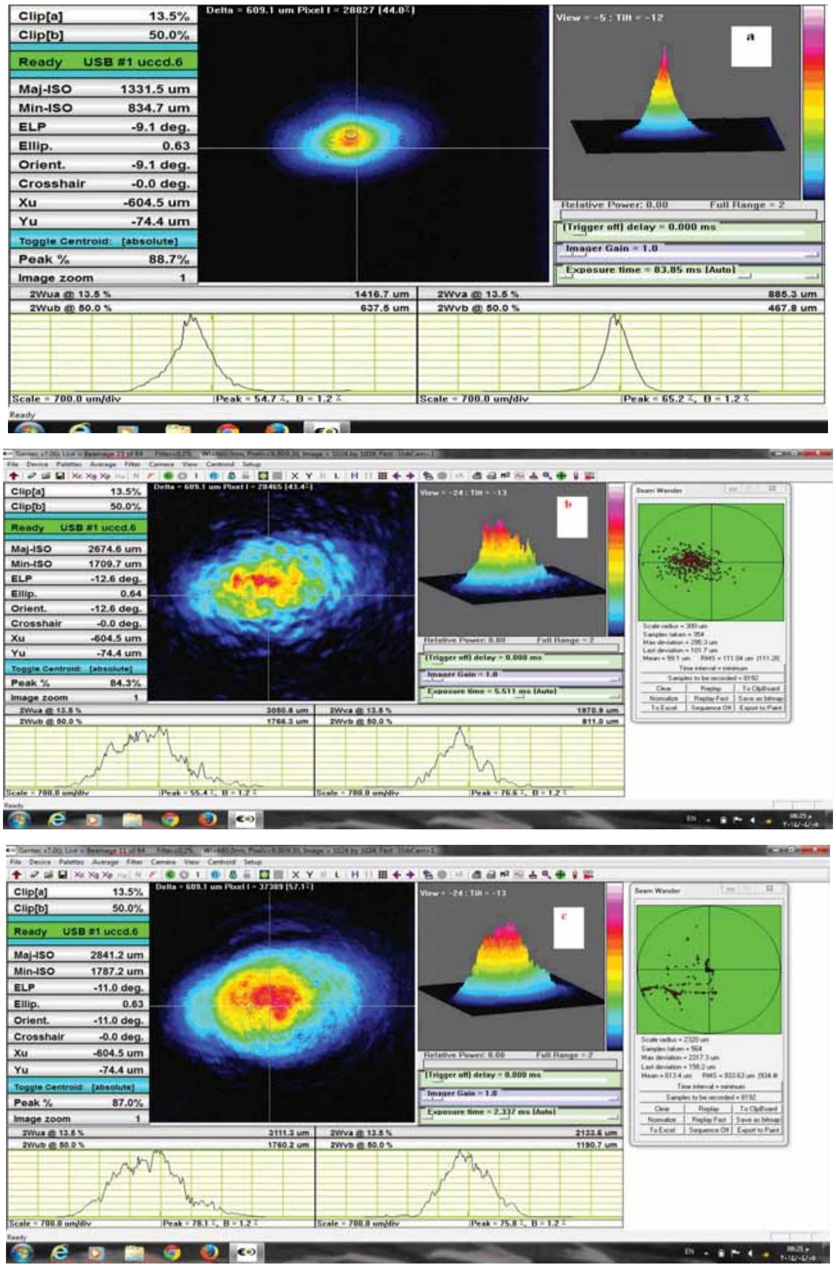
Fig. 2. Schematic set up for measuring absorption coefficient

Table 1. The absorption Coefficient for three types Water in Range (407-810 nm)

Water type	Absorption coefficient (10^{-4}) cm^{-1} λ=407nm	Absorption coefficient (10^{-4}) cm^{-1} λ=473nm	Absorption coefficient (10^{-4}) cm^{-1} λ=532nm	Absorption coefficient (10^{-4}) cm^{-1} λ=632nm	Absorption coefficient (10^{-4}) cm^{-1} λ=808nm
Clear	3.4	3.0	4.09	20.0	100.0
Light Turbid	4.6	3.6	5.4	24.2	108.3
High Turbid	26.0	25	27.8	40.6	165

4.2. Energy distribution Measurements

In this study used the same Schematic set up for measuring absorption coefficient except replace the power meter by the CCD camera .The important factor in propagation of the Gaussian beam (Fig. 3a) laser diode behavior investigation is received Energy of CCD. Obviously, there were (Fig. 3b, Fig. 3c and Fig. 3d), the energy of laser light has different distribution related to the turbidity of water. Fig. 4 shows the variation of light spot center position in the direction vertical (Yc) and direction horizontal (Xc) to the center of CCD Camera over time. The length of the vertical and horizontal lines indicates the maximum and minimum amplitude of the instantaneous deviation of light spots from the steady position. The position of light spots are the variation between maximum and minimum amplitude because the and flow rate of water.



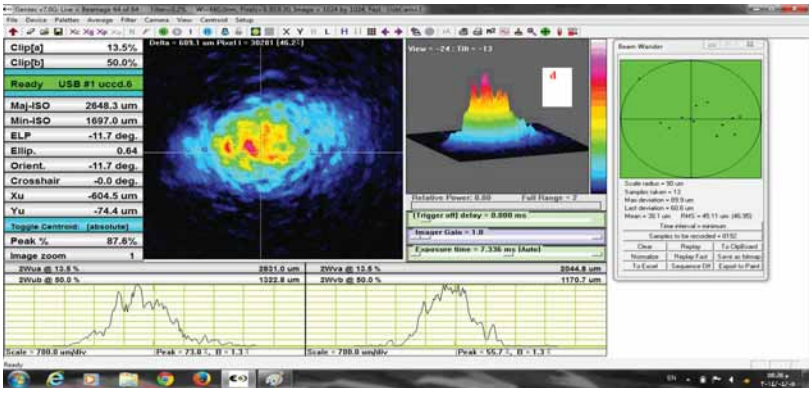


Fig. 3. Energy distribution for laser light (407 nm) through different samples of water at constant flow rate (a- without any effected b- Clear , c-light turbid and d-high turbid)

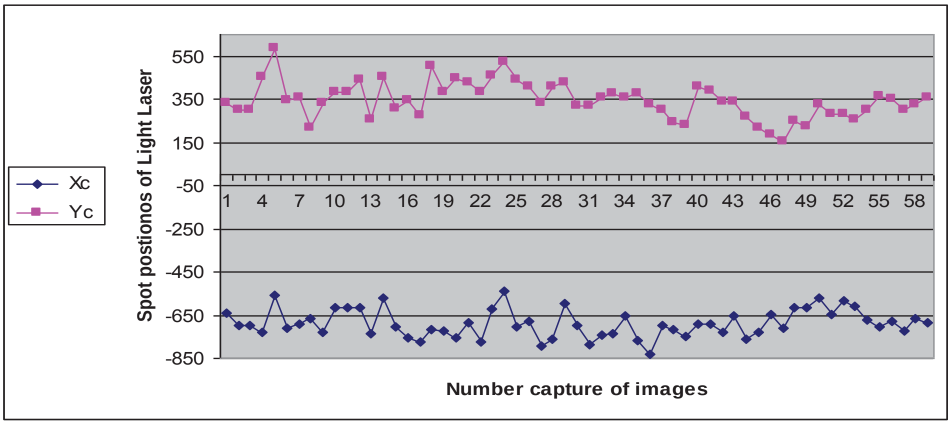


Fig. 4. Variation of Laser light-spot position on receiving CCD Camera

4.3. Long Light-Path Measurements

The relation between transmission distance for clear water and different wavelengths of incident laser light (Fig. 5), the red and infrared light wavelength had a little penetration, so low transmission distance about (2-10 m) and the Blue and Green light wavelength had the most penetration, so high transmission distance about (50-76 m). It's obvious that in Blue light wavelength the transmittance distance change related to the turbidity of water (Fig. 6), at the first sample the transmittance distance about (76 m) and at the last samples the transmittance distance about (10 m).

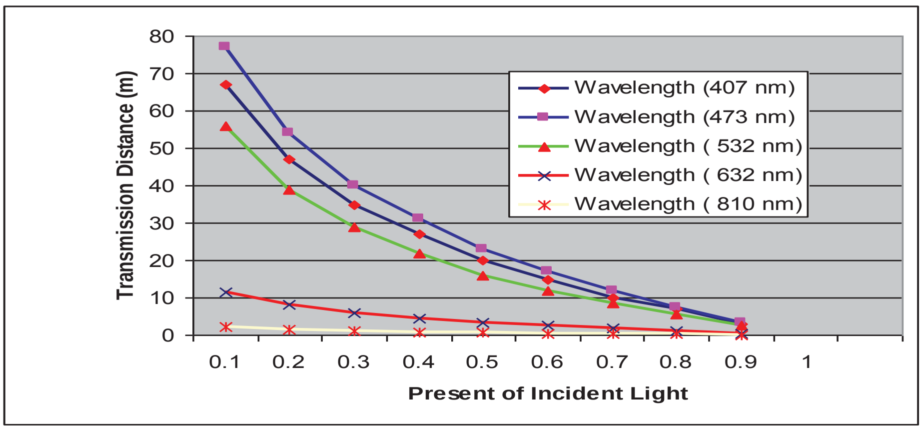


Fig. 5. The transmission Distance for Clear Water at different wavelength of Incident light

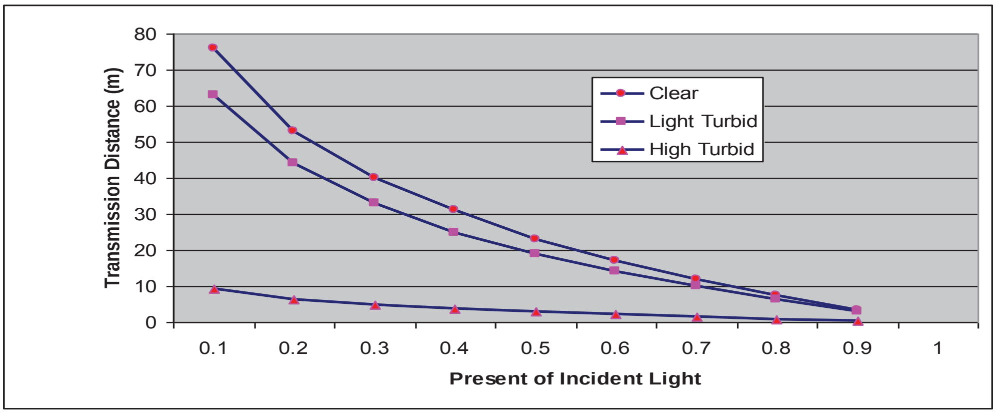
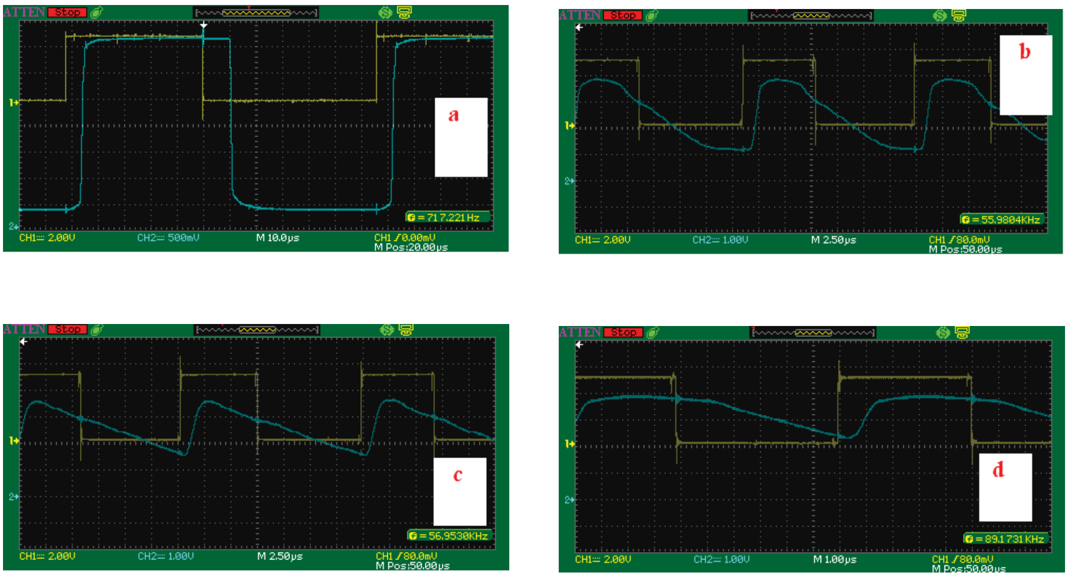


Fig. 6. The transmission distance varies with incident Blue Laser light (473 nm) for three samples of water

4.4. Distortion in optical signal measurements

Fig. 7 (a ,b, c, and d) show the transmitted signal (Ch1) and received signal (Ch2) through the water shatt Al –Hilla at different turbidity and flow rate. Observably that the broadening and attenuation on the input pulse (squire wave), it take different shapes dependent on the flow rate of water and different amplitude values dependent on the turbidity of water. Both broadening and attenuation case limitation on the optical transmission bandwidth and transmission distance.



5. CONSOLATIONS

1. The laser beams with different wavelengths experience different transmission distance .the wavelength has strong influence on transmission distance in water.

2. Any increase in turbid of water causes a decrease in the amount of water transmission which leads to decrease in intensity peak and received power values.

3. Laser light-spot position it variation over the time with turbidity and flow rate of water

4. The turbidity and flow rate of water case distortion on optical sign

References

[1] B. woodward, 2008, "Underwater speech communications with a modulated laser", Appl. Phys. B 91, 189–194.

[2] W. Scott Pegau, Deric Gray, and J. Ronald V. Zaneveld, 1977, "Absorption and attenuation of visible and near-infrared light in water: dependence on temperature and salinity" APPLIED OPTICS, Vol. 36, No. 24.

[3] F. D. Kashani (C.A.), M. Reza Hedayati Rad and E. Kazemian , 2013 " Analyzing the Propagation Behavior of a Gaussian Laser Beam through Seawater and Comparing with Atmosphere" Iranian Journal of Electrical & Electronic Engineering, Vol. 9, No. 4.

[4] Ziad T. Al Dahan 1, Samar Y. Al Dabagh 2 and Asmahan Assad, 2013, "Design and Implementation of Under Water Optical Communication System" International Journal of Application or Innovation in Engineering & Management (IJAIEM)" Volume 2, Issue 6.

[5] Vikrant, Anjesh Kumar, Dr. R.S. Jha, 2012, "Comparison of Underwater Laser Communication System with Underwater Acoustic Sensor Network" International Journal of Scientific & Engineering Research, Volume 3, Issue 10.

[6] Mohammed F. Mohammed, Dina J. Matti, 2011, Analytical Study of Water Purity Using Low Power He:Ne Laser" Nahrain University, College of Engineering Journal (NUCEJ) Vol.14 No.1.

[7] M. Torabi Azad, H. Hosseini, M. R. Afzali and Moz. Emtyazjoo, 2011, "Physics of Light in the North Coasts of Persian Gulf (Bushehr province) during Winter Season" J. Phys. Educ. Vol. 5, No. 3.