Comparison of attenuation coefficient at different lasers 632, 785nm, 1310nm and 1550nm in Dust for optical wireless

Dr. Mariam M. Abud, Janan A. Akhlati. Asmaa M. Roof.*
Dept. of Physics, College of Education, Al-Mustansiriyaiah University, Baghdad, Iraq.
Email: mariamabud831@gmail.com

Abstract: FSO is the main communication in the world. The air is composed of dust, sand, elemental loading and mineral particulates. The minerals particulates the particulates are majorly of two categories: A. Coarse Particulates (2.5-10 micrometer)
B. Fine Particulates (less than 2.5 micrometer) coarse aerosol particulate is determined by crustal sources like dust.

Methodology used FSO include a laser represent of transmitter through atmosphere to spectrum analyzer (receiver). Transmitter uses many laser sources (632.8, 780, 1310, 1550 nm). Results as shown the transmittance at different lasers and calculated the visibility caused by decreases of total attenuation coefficient with increasing to the light beam propagation. In this paper the visibility measurements for using different laser according laser transmissometer at short distance in the light and heavy dust around this distance between transmitter and receiver, indicate that results are appropriate when choosing a laser window of 632.8 and 1550 nm.

1. Introduction
The free space optical system (FSOS) for optical wireless communication technique of many special advantages, the effect of distance between the transmitter and receiver is necessity for any physical link. Some other advantages of this technology are there is no need to customize the scope of licensed and without any hesitation cost, it is simple for installing and there is no risks of radiation from radio frequency and electromagnetic interference immunity, There appears to be much care ideas about the real possibility of optical laser propagation systems through weather [1,2].
In Free Space Optical (FSO) communication fields, Isaac I. Kim et al. was introduced a study of atmospheric attenuation than 785 or 850 nm light in all weather conditions [3]. During previous studies, such a type of weather problem was presented attenuation when used various laser wavelengths such as 785 nm, 850 nm, and 1550 nm. All attenuated equally by fog. Also this wavelength independence is observed in snow and rain [3, 4]. The important of this studied that the effect of visibility for dust (visibility < 100 m). the processes of laser interaction
with matter (absorption, scattering) and auto-tracking sub-systems include noticeable effects about parameters, to best of our knowledge, almost none of the related researches consider the most effects (together) on FSO link quality [3,4,5,6].

These researchers observed the important range at the 700–10,000 nm wavelengths; there are many atmospheric transmission windows. However, most free space laser systems (FSOS) are designed to work on the windows: 780–850 as well as 1520–1600 nm [7,8].

In this paper, the attenuations in the light and heavy dust were of large field through the direction of laser beams and depending on the atmospheric attenuation coefficient has calculated of the various laser light for heavy dust.

2. Attenuation by Dust

In FSOS, the laser wavelengths beam is selected to operate in the low processes interaction ranges. For this reason, when comparing the laser process especially (absorption) was contributed to the total attenuation coefficient with scattering effect, it was found that absorption becomes very small [9]. Signal scattering occurs because of various kinds of some state weather such as (dust, fog, rain, snow, etc.). [10, 11].

Dust defined as a set of outstanding in the center of Ghazi particles often have the air, or air plankton may be present in the form of airborne dust or spray sparse and smoke, and dust longer of circles effective attenuated all-important in the attenuation of beam of electromagnetic radiation processes. Attenuation due to atmospheric dust or plankton air (aerosol) result from the scattering of the particles may depend on plankton flights [11]. The electromagnetic absorption effect is relatively small compared with the May scattering.

Depending on visibility, dust cases are classified into four classes based on according the World Meteorological Organization (WMO) as shown in the table list (1) [12]. Dust haze (light dust) is the first classify where ample diffusion dust floats up. This event results due to dust which is happened at a considerable distance from the observation location. Light dust is the second kind in which dust particles are blown in the observation location through winds and the visibility reduces to the range (0.2 km) because of strong winds that blow more dust particles, this event is called moderate dust. Lastly, dense dust happens when the visibility becomes (< 0.2 km) when large amount of dust particles are carried up by very strong winds [9, 12].

| Dust Type          | Severe | Dust storm | Blowing dust | Dust haze |
|--------------------|--------|------------|--------------|-----------|
| Description        | Dense  | Moderate   | Light        | Light     |
| V (km)             | <0.2   | 0.2-1      | 1-10         | <10       |

The largest concentration of dust above 1-2 km above the surface of ground is of prime importance.

The Fine particulates were dominated by carbonaceous aerosol (organic matter and elemental carbon). The climate of Lahore is semi-arid. The elemental analysis shows that it contains extremely high concentration of Zn, Cd and several other toxic metals. The elemental concentration in Microgram /cubic meter was found by a group of scientists. Atmosphere attenuation is the process of loss the electromagnetic wave energy when traversing through atmosphere, the attenuation of optical signal decreases with increasing wavelength [13, 14].

2. 1 Beer-Lambert Law
Atmosphere attenuation causes signal distribution in a free space optical link in a little different ways, including dispersing. By law equation below (Willebrand & Ghuman 2001) the atmospheric attenuation is given by [2, 15]:

\[ T_{at} = \exp (-\beta D) \]  

(1)

Where \( \beta \) is the total atmospheric attenuation coefficient contributed by absorption (\( \beta_{abs} \)) and scattering (\( \beta_{scat} \)) and D is represent the distance between the transmitter and receiver [3]. It can be seen that typical terrestrial communication wavelengths like 808 nm, 1064 nm and 1550 nm are material since they place inside the atmospheric transmission window in the absorption spectrum.[15, 16].

2.2. The Visibility measurement

The Visibility (\( V_{ob} \)) is one of the parameters for switching between FSOS and the backup communication system. It can be calculated the optical power of laser is emitted (\( P_0 \)) propagates through the optical atmospheric sample with the path length of D and then the receiver light. The atmosphere visibility can be calculated using \( P_{imp} \) and \( P_0 \) in the experimental prepared as shown in fig(3). The calculate atmospheric transmittance can be obtained as:

\[ T_{at} = \frac{P_{imp}}{P_0} \]  

(2)

The visibility (\( V_{ob} \)) measurement can be calculated from the atmosphere extinction coefficient that can be easily obtained by a laser transmissometer diagram is appeared in the Figure (1).

![Figure 1. Represents Set up of a laser transmissometer](image)

Second processes called the Scattering are two main types:

(1) Rayleigh (molecular) scattering,

(2) Mie (Aerosol) scattering.

An aerosol’s concentration, composition and dimension distribution vary temporally and spatially, so it is difficult to predict attenuation by dust[15].

The atmosphere visibility (\( V_{ob} \)) can be calculated using \( P_{int} \) and \( P_0 \) According to the eq.(2), this term is determined by laser intensity can be calculated as:

\[ V_{ob} = \frac{2.996D}{\ln T_{at}} \]  

(3)

e process scattering affected through account the visibility measurement (\( V_{ob} \)) by eq. (3) [16].

The attenuation coefficient is calculated according to (\( V_{ob} \)) and (\( \lambda_{scat} \)) by the following equation [17]:

\[ \text{Attenuation Coefficient} \]
\[ A_s = \left( \frac{3.91}{V_{ob}} \right) \left( \frac{0.55}{\lambda_{scatt}} \right)^a \] (4)

Where:
\( V_{ob} \): is the visibility measurement.
\( \lambda_{scatt} \): is the wavelength scattering (μm).
\( a \): is the factor has represent the size distribution of the scattering particles.
\( a = 0.585*[(V_{ob})^{1/3}] \) for \( V_{ob} < 6 \) km.

3. Experiment work

The system experimental (FSO) is contained laser lights: 632.8 nm 785nm, is set up according fig(2) by using spectrum analyzer(HR400) to collecting spectra rang and measured maximum intensity and attenuation vs. Different wavelength 1310nm, 1550nm, chamber for study weather conditions and receiver. Laser source transmitted light through the chamber subsequently received the signal by optical power meter at different conditions (light dust, heavy dust) through chamber about 80 cm. The signals output from optical power meter gives the received power for different wavelengths. The setup of laser Transmissiometer as shown in Figure. (2).

Figure 2 : Set up experimental to determine the attenuation

4. The Results and Discussion

The Free space optics systems (FSOS) included 1): transmitter, 2) Free space transmitted channel, 3) receiver. We noted, atmospheric windows (1310, 1550)nm in the far IR wavelength range. this research uses dust is included a very small pieces .it is formed from the dust of atmosphere of Baghdad. The laser beam emitted as an optical source He-Ne laser 633 nm was collected in the receiver (spectrum analyzer) .the relation of the intensity vs. wavelength in FSO Techniques Figure 3 and attenuation of intensity through light dust and heavy dust c. By using the Beer- Lambert’s law as indicated in Eq. 1 and used of information from the relation between intensity (counts) and wavelength as shown in Figure 3 and 4.. Figure 4 as shown the relation between intensity and wavelength of diode laser 785 nm in FSOS (a) with light dust (b) and heavy dust to obtain the atmospheric transmittance results.
Figure 3. Explain the relation between intensity and wavelength at 632.8nm: a. In FSO, b. with light dust, c. with heavy dust.

It is noted that the intensity was deceased with light dust at transmitter source using diode laser 785 nm. So the intensity was suffered more decreases at heavy dust than light dust Figure (4).

Figure 4. represent the intensity to the wavelength 785 nm according to: a. FSO, b. light dust, c. heavy dust.

Then, we is measured the visibility \( V_{ob} \) for different laser of transmissiometer, according eq. (3). Also, the laser is transmitted of the signal is highly affected by scattering at uses sources (1310-1550) nm. Attenuation is principle the result of scattering by light and heavy dust. Finally, step the visibility at different lasers after calculated the transmittance caused by total attenuation coefficient are illustrative shown as in the table (2)

Table 2. Total atmospheric attenuation coefficient parameter for different lasers of light and heavy dust.

| Lasers wavelength (nm) | The visibility(km) | Atmospheric attenuation coefficient (mm\(^{-1}\)) |
|------------------------|--------------------|-----------------------------------------------|
|                        | Light dust         | Heavy dust                                    | Light dust       | Heavy dust       |
| 633                    | 6.1868             | 4.824089                                      | 0.5435           | 0.8105           |
| 785                    | 0.23032            | 0.09262                                       | 0.047            | 0.0844           |
| 1310                   | 0.2206998          | 0.4254322                                     | 0.00824          | 0.002            |
| 1550                   | 3.72405            | 0.08                                           | 0.08x10\(^{-3}\) | 0.03588          |
Attenuations coefficient (AS) of the light in light and heavy dust are of great interest in the different laser light propagation. The results presented in Fig. 5 show the relationship between attenuation coefficient (As) and different wavelengths is decreased with increasing wavelength (λs). We proved that the attenuation coefficient (As) is obtained received power at the wavelength of 1550 nm appear the best region to work in (FSOS) as compared to the other lasers in spite of heavy dust.

![Graph showing attenuation coefficient vs. wavelength](image)

**Figure 5.** Shows the attenuation coefficient vs. different lasers wavelength nm

### 5. Conclusion

In this paper the total attenuation coefficient (As) are calculated for different sources laser distributions light and heavy dust, which is decreasing with the increase beam light concluded some observations can be explained to the power of each scattering order relative to the total received power become interest in the heavy dust. The collisions of a laser beams with dust particles may be significant for the large density of the dust in Baghdad atmosphere. When is used various lasers within the infrared region with the increase of wavelength leads to decreasing atmosphere attenuation coefficient. total scatterings are considered, the relative to the visibility (Va) results are important to the visibility measurements for using different laser according laser transmissometer in the light and heavy dust which obtain some properties on the design of the optical wireless systems communication such as of the laser transmissometer around the distance between transmitter and receiver at < (1 m).

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