Experimental Study of the Influence of Dust Particle on Link Range of Free Space Laser Communication System

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ABSTRACT:

The spectrum attenuation of free space optical (FSO) communication systems operating at visible and near infrared (NIR) wavelengths (650nm , 850nm and 1550) under dust was experimentally investigated. Dust are generated and controlled homogeneously along a dedicated atmospheric chamber of (93*63*60)cm dimensions.

Attenuation due to aerosols restricts the distance of FSO communication systems and limits the availability for line-of-sight terrestrial link. This work is focused on the effect of aerosols on the FSO link. The attenuations was studied in the aerosols phenomena for three selected wavelengths (650, 850, and 1550 nm) for transmitting range (1-12) Km.

Keywords:(FSO)communication, dust , attenuation, Kim Model, Visibility.

INTRODUCTION

The atmospheric attenuation of laser power in the atmosphere is described by Beer's Lambert law [1].

$$\tau(R) = \frac{P_r}{P_t} = e^{-\mu R} \qquad (1)$$

where: $\tau(R)$ - transmittance at range R, Pr - laser power at R , Pt - laser power at the source,

R - propagation range , μ - Attenuation or total extinction coefficient (per unit length) .

The attenuation coefficient has contributions from the absorption and scattering of laser photons by different aerosols and gaseous molecule in the atmosphere . The attenuation coefficient is made up of four parts[2] :

$$\mu=\alpha g+\alpha p+{}^{\gamma}g+{}^{\gamma}p \qquad (2)$$

where: αg - molecular absorption coefficient, αp - aerosol absorption coefficient, g^{γ} -molecular or Rayleigh scattering coefficient, and $^{\gamma}p$ - aerosol or Mie scattering coefficient.
The total atmospheric transmittance can be factored as the product of the absorption and scattering transmissivites[3].

$$\tau(R) = \tau(\alpha)\tau(S) \qquad (3)$$

where: $\tau(\alpha)$ - the absorption transmittance, $\tau(S)$- the scattering transmittance

Dust is a solid particle formed by disintegration processes such as crushing, grinding, blasting and drilling. The particles are small replicas of the parent material, and their particle size may range from submicroscopic to microscopic[4].

The attenuation from dust and atmospheric aerosols are resulting from Mie scattering particles, which depend on the volume of the atmospheric aerosols, and the effects of absorption electromagnetic will be relatively small comparing with Mie scattering, therefore, the scattering coefficient can be computed form the visibility distance and wavelength of the incident beam. The range of visibility is related with concentration of dust as[5] :

$$V = 7080C^{-0.8} \qquad (4)$$

Where V - visibility distance , C- concentration of dusts (change with altitude).

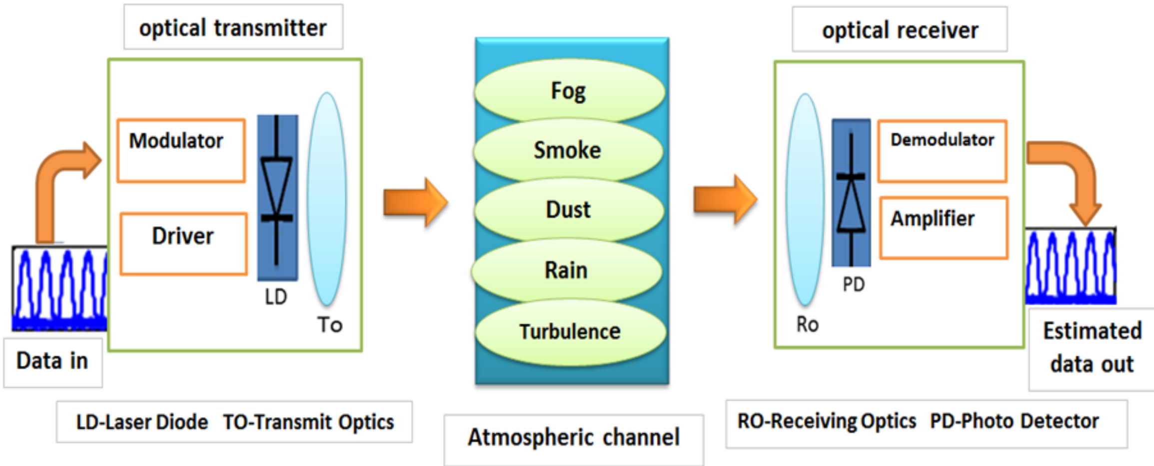
Therefore, there is a direct relation between concentrations of dust and scattering coefficient due to atmospheric
Aerosol[6] :

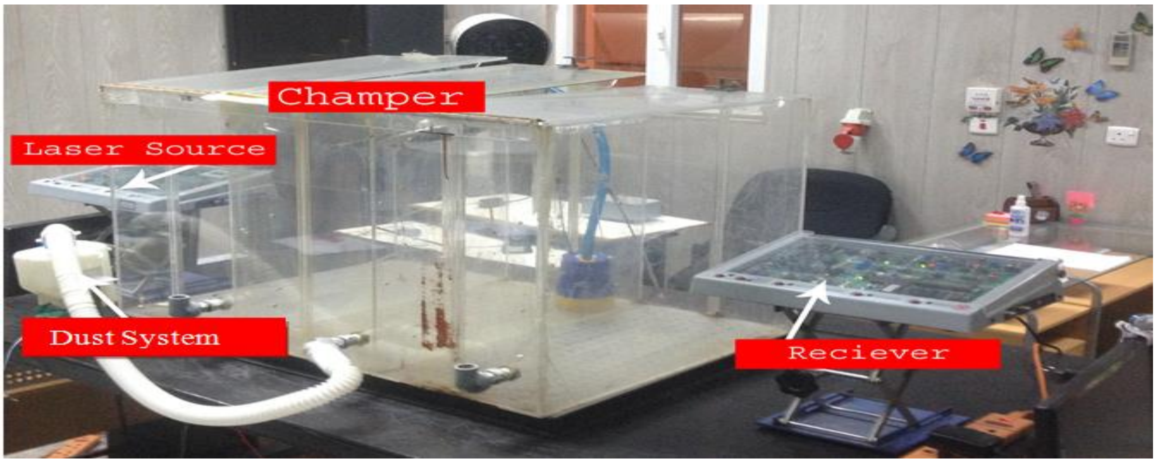
$$\tau_S = \exp\left[\left(\frac{-3.91}{7080\times C^{-0.8}}\right)\left(\frac{\lambda}{0.55}\right)^{-q} \times R\right] \qquad (5)$$

whereτ_τ_S - transmittance resulting from scattering , λ - the wavelength, q - positive constant proposed computed (the size distribution of the scattering particles), R - propagation range
q =1.6 for high visibility (km), q = 1.3 for average visibility (6km < V < 50 km), q = 0.585 V⅓ , = 0.16 V + 0.34 for low visibility (V
6km), q = V - 0.5 for low visibility (0.5 km < V < 1km) , and q = 0 for low visibility (V < 0.5 km) [7].

Results & Discussions.

This design study was based on an advanced computer program allow to carry out the field FSO system description and implementation measurement under of turbulences. The theoretical background of dust attenuations for light based on Mie Scattering can be found using the two most widely used models that we used and implemented which are the Kruse model and the Kim model [8]. At very high attenuations the Kim model is the better model. The effects of dust on Free Space Optics (FSO) communication. growing pollution and dust gales motivated studies, that was the main concern of this study. analysis of the influence of dust on free space optical communication is presented. Dust is a fine powder made up of very small pieces of earth or sand. Dense dust consists of large dust particles that arise from Earth's sphere and whose atmospheric intensification values are high enough to affect FSO communication links. Dust generated storm in the chamber. In order to test visibility data, we made calculations of atmospheric conditions for different dust conditions. As it is related to the optical attenuation, among all the effects, although dust does not affect the intensity of FSO adversely but increasing pollution and dust storms values are high enough to affect FSO communication link.





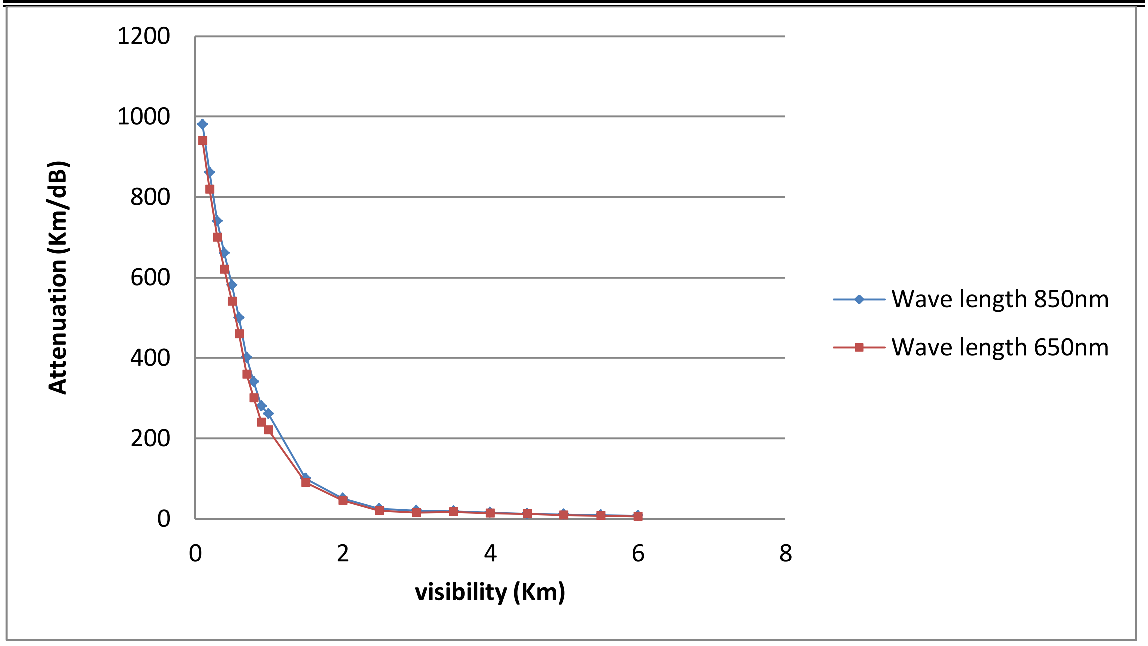


Figure (2): Dust attenuation verses visibility for different wavelengths for lab-controlled FSO link.

the relationship between visibility and attenuation concentration of dust particles is exponentially inverse, while for attention and concentration of dust particles is linearly inverse.

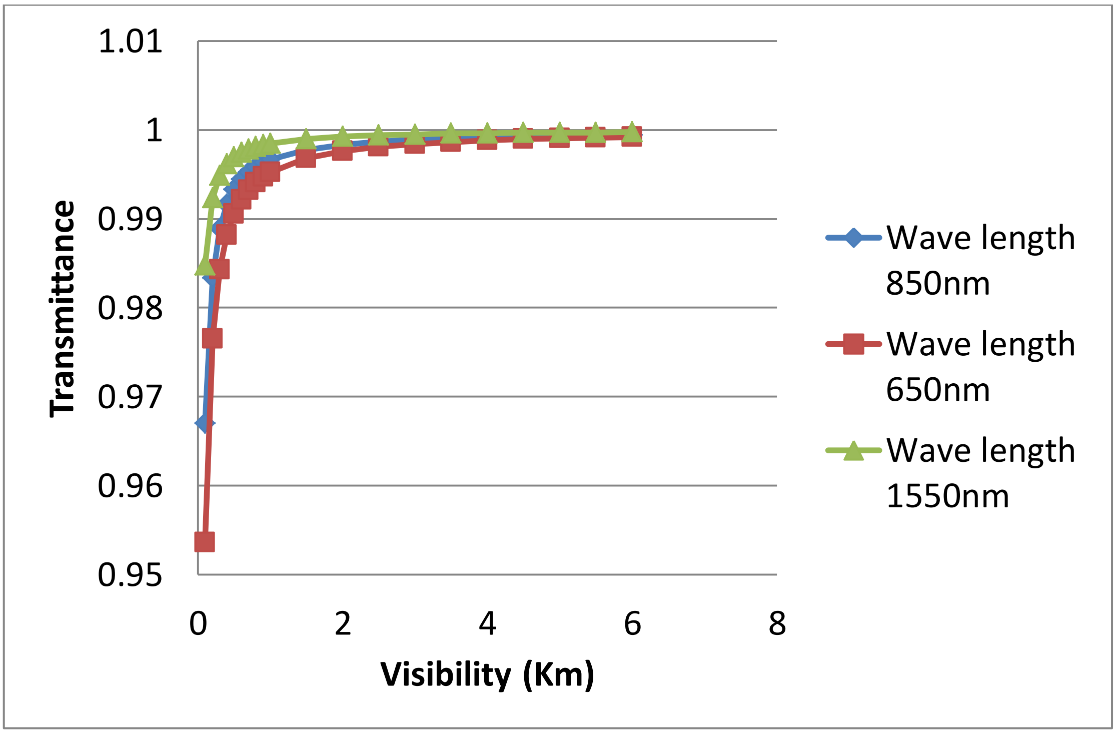


Figure 3. Atmospheric transmittance of wavelength (650, 850, and 1550) nm dependent on visibility distance.

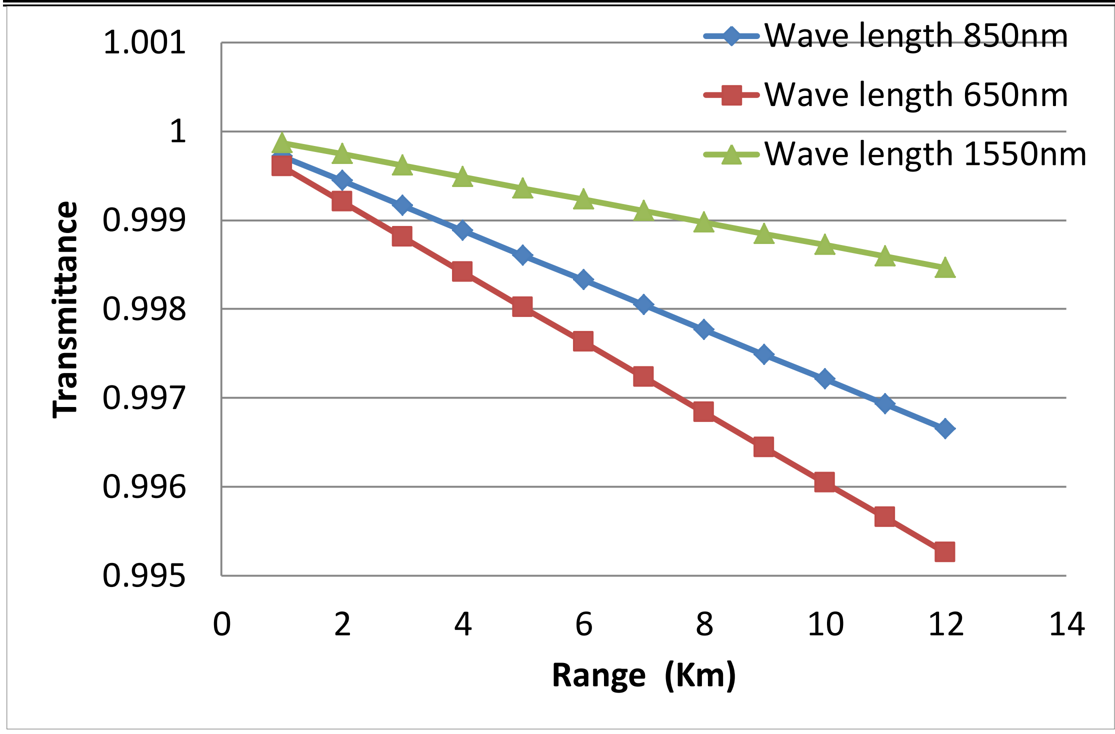


Figure 4. Variations of transmittance as a function of dust concentration, for the three wavelengths, for path length.

Figure (5) shows variation of the visibility distance as a function of the concentration of dust is calculated from equation (5).

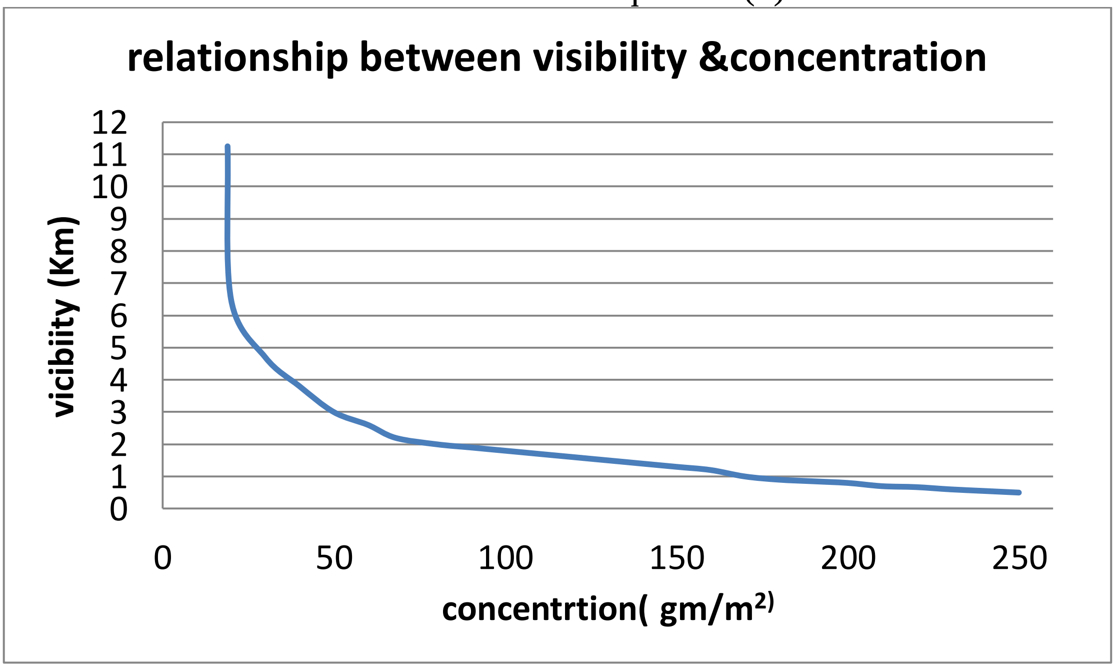


Figure (5): Variations of Visibility Range as Functions of Dust Concentration

CONCLUSIONS

Laser beam of wavelength (1550 nm) is more suitable to overcome some of the atmospheric effects has more than wavelengths of (650 nm, and 850 nm) as used in laser communication.

The experimental result clearly demonstrates the dependency of the wavelength on the resultant dust attenuation even if V is below 0.5 km. the visibility distance decreases because the concentrations of particles in the size are increased, which reduces the visibility distance

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