Simulation and Performance Analysis of Free Space Optical System using Bessel Filter under Different Atmospheric Disturbances

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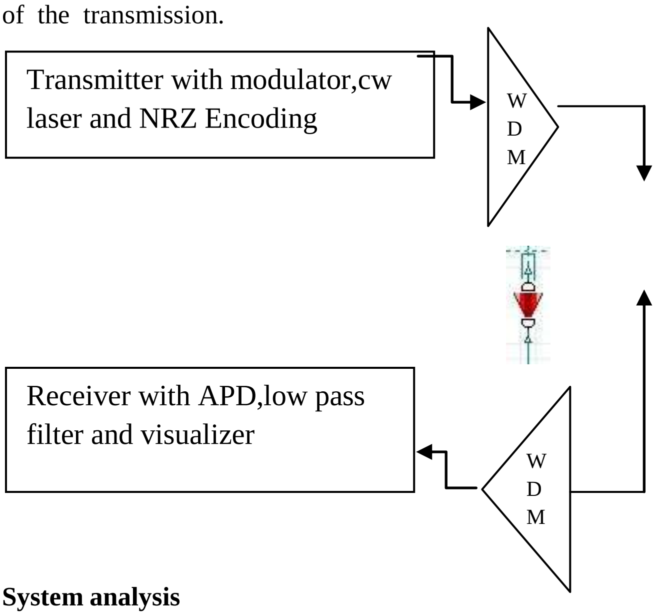
Abstract:- Free space optics is an upcoming field in the communication world. It will provide highest band width, high security, efficient power transmission and less distortion as compared to all other wireless networks, but with all these advantages, free space optics communication is very much affecting with the atmospheric turbulence like haze, rainfall, snow, fall etc. A small amount of dust particle can starch the light beam and provide a high amount of attenuation in the signal. This work tries to reduce the effect of this atmospheric turbulence and make communication as far as possible using optisystem simulator. Signalling rate taken is 2.5GHz, transmitting power is 10 to 30 db and NRZ encoding technique is taken during transmission, transmitter channel is FSO and for reception an avalanche photodiode with Bessel filter is taken .This work also presents the effect of receiving aperture on the signal and shows a communication link more than 180 km in clear weather, 54.5 km in haze with 2.5GHz data rate.

INTRODUCTION

Free space optics(FSO) is a technique in which a optical communication link is established between two different points wirelessly . This method is a wireless technique so it faces difficulties for the duration of communication like **building bend,** as transmitter and receiver is positioned at the building and communication link is line of sight so with building bending the line of sight link goes to interrupt, **Atmospheric turbulence** like fog, haze, rain and dust : as FSO is a optical communication link so communication media is mild and it can travel in a straight line, as any object even a small dust particle is come against the light it will scattered the light due to which the communication link is disturbed or attenuated so during haze, light is attenuated with small dust particles, During rain, light is attenuated with rain drops ,so in these conditions it is very difficult to communicate with FSO. In this work it is shown that with what parameter the communication is possible in this condition. Better conversation gadget needs long distance, minimum scattering, less absorption, minimum misaiming, large laser power & data bits. Device will be cheaper, reliable and easy installable over long distances. To get these and to reduce the effect of these environmental condition, system needs a special quality of FSO link .To do so WDM based FSO link can be used with wide data rate of 2.5 Gbps . A frequency range of 1550 nm with high power laser, a suitable receiver aperture, highly sensitive light detector and better modulation technique is required to improve the device overall performance in terms of excellent of the transmission.



System analysis

The above figure shows basic diagram of WDM primarily based FSO machine, this block diagram indicates three elements which might be

1. Transmitter,
2. Receiver
3. Communication channel(FSO link).

Transmitter:- In transmitter component machine required a CW laser (distinct energy in keeping with surroundings circumstance),Mach-Zehnder modulator for modulation ,Pseudo-Random bit generator for provide and NRZ Pulse Generator for encryption technique. In long distance communique to improve the quality/power of signal system also need an optical amplifier.

Receiver:- In this block to detect the optical signal system used APD Photodiode, low skip Bessel clear out and for measuring output some tools such as Optical Time Domain Visualize and bit error rate visualize are used to visualize the result.

Communication Channel:- In channel, WDM (Multiplexer and De-Multiplexer) method and a FSO direction hyperlink is used.

Table 1

Characteristics	Data	Observation
Data rate	2.5 Gbps	Data rate effects BER
Power	10 dbm	Power also effects BER
Link range	181 km	Also effects BER
Receiver Aperture	15 cm	Also effects BER
No. of users	Depend	No. of users versus BER

The other parameter like data rate frequency used and link range are shown in table-1; by means of using fine parameters it's miles possible to make long variety FSO link. The acquired signal fine could be vary a lot depending on the natural environmental effect and design of WDM system.

FSO link parameters, constant value	
Gravitational Constant	980 cm/s^2
Water density	1g/cm^2
Viscosity of air	1.8x10^{-4}(g/cm)
Droplet, a	.001-01cm
Wavelength	1550nm
Q_{scat}	2

Rain Fall Rate	
Type	Cm/s
Light	7.22x10^{-4}
Medium	1.11x10^{-3}
Heavy	2.22x10^{-3}

Table-2

Link margin analysis

The designed receiver must have maximum sensitivity on the given statistics price for the reception of enough electricity of signal,due to the fact received signal comes after FSO link and FSO link have the losses due to media(air) between transmitter and receiver and it is also changing time to time due to different weather situations. So it is required to discover the effect of weather situations consisting of , rain and haze losses on FSO link.

Rain

Rain is the second maximum attenuation element in surroundings after snowfall for light. That's why it affects the FSO hyperlink very much. Rain can reduce the visibility to a whole lot better depth because of light scattered with rain drop. For local rain data mathematic version is derived as given underneath. The arithmetic equation is designed consistent with Beer's law and Stroke's law. Beer's regulation describe the laser electricity attenuation in the surroundings [4, 8]:

It represent that $T(R) = P(R) / P(O) = e^{-\beta R}$ ….1

Here all parameter in this equation are as given under:

R = link range (meters)

Ʈ(R) = transmittance in the variety R (km)

P(R) =laser power in range R

P (O) = laser power at source

B= scattering coefficient (Km^{-1})

The laser mild is very a lot tormented by rain drop, haze, clouds and heavy fog etc. These kind of parameters can scatter the light beam produced through laser, it is not possible to find out the ideal charge of scattering beam, the attenuation coefficient is not dependent on the laser wavelength. Stroke' law can be used to calculate the scattering coefficient of beam due to rain drop or fog. It's miles as given under;

$\beta_{rain\ scat} = \pi a^2 N a Q_{scat}(a/\lambda)$ ………2

listen 'a' represent radius of raindrop (0.001–0.1 cm), 'Na' represent rain drop distribution. 'Q_{scat}' represent scattering performance, λ represent wavelength of the rain drop distribution in this equation, with the aid of using equation (1 and 2) Na can be calculated.

$Na = Za/[4/3(\pi a^3)VA$

Here Za represent the rainfall rate (cm/s), 'a' represent droplet radius and VA represent limit speed precipitation the raindrop Limiting speed is also given by $VA=(2a^2\rho g)/9\eta$

In it ρ represent water density (g/cm2), g represent gravitational constant and η represent air viscosity the constant value of these parameters is given by Table 2 [1]

Attenuation of mild rain is recorded for rain is 6.27 dB/km, for medium rain 9.64 dB/km while for heavy rain 19.28 dB/km at 1550nm wavelength.[1]

Haze

As we see in our environment rainy season or rain time period occurs for few time period but the haze remains for longer time in the surroundings, so affect of haze is more on FSO link as compare to rain, so it's miles very essential to discover impact of haze on FSO hyperlink .The dimension of FSO parameter may be done by measuring the actual $\beta=(3.91/V)(\lambda/550nm)^{-q}$

Visibility in kilometres, λ represent wavelength in nanometres and q represent the size of distribution so the attenuation steady for haze condition is given by 0.23 dB/km at 1550 nm frequency for the visibility range (6 km < V < 50 km) and at heavy haze 2.37db/km at 1550nm for low visibility range (V < 6 km):[1]

FSO parameters optimization

FSO link is dependent on number of parameters like optical amplifier gain, laser power, data bit rate, receiver antenna aperture, frequency used, and type of filter used etc. priority sensible assosiation in line with effect is as given in Fig-2. Through the usage of majority of these parameter the overall performance analyzing is as given in Table-3. This desk of fashioned for 180 km FSO link using beam spreading zero.

machine [6] but this experiment is not efficient every time, so it is required to find out the another method to find forecast the system performance[8].

Kim & Kruse Model give the mathematical model for it, as given below

where, β represent haze attenuation, V constitute

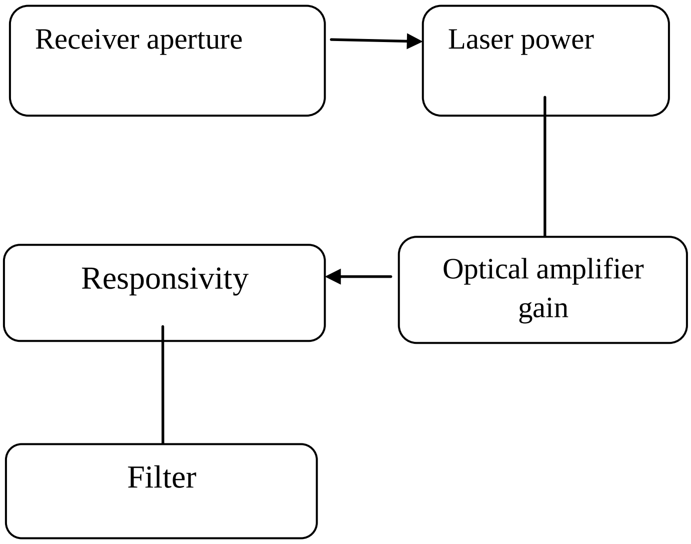


Fig-2: Effect of difference parameters priority wise on receiver

Weather condition	Attenuation(db)	Bit Rate	Laser Power	Responsivity of Rx.	Amplifier Gain	BER(Bessel)
Very clear	0.065	2.5Gbps	10db	1	No	0
Clear	0.233	2.5Gbps	10db	1	No	8.37037e-023
Light haze	0.55	2.5Gbps	10db	10	50db	4.82834e-064
Haze	Special cases					
Rain	Special cases					

Table-3: Optimization for the link of 180km

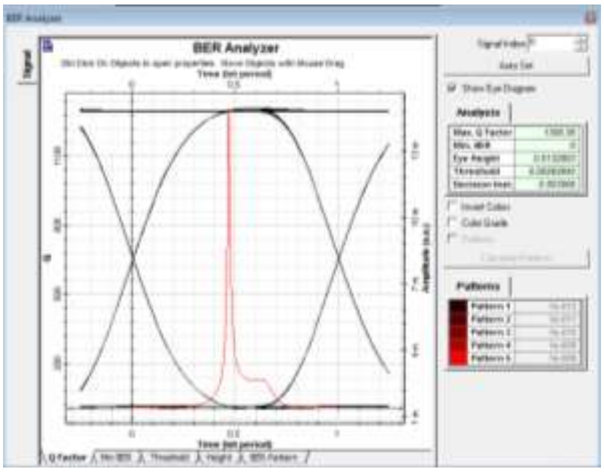


Fig-3:-Very Clear weather after 180 Km

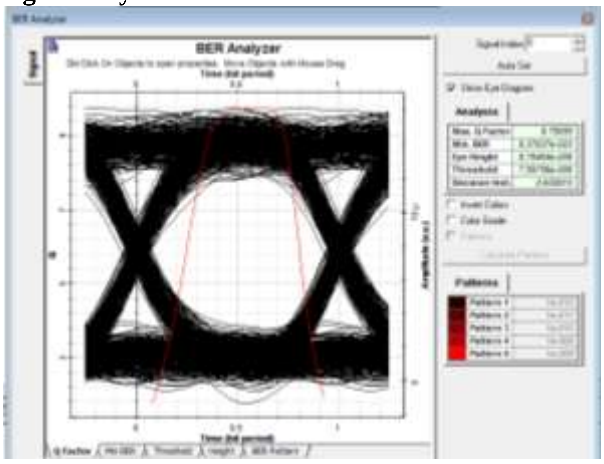


Fig-4:-Clear weather afer 180 km

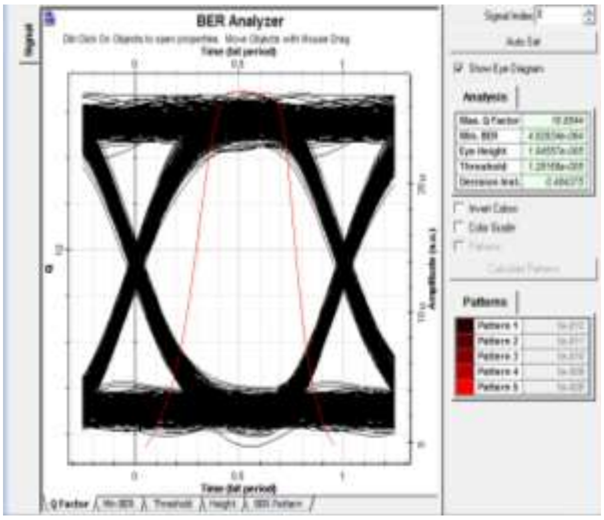


Fig-5: At light haze after 180 KM using Bessel filter

In haze and rain, visibility is become less so light is scattered more or attenuation is accelerated greater.On this circumstance it is not feasible for the laser beam to pass this effect to the 180 km but this condition occures rarely. In routine days clear weather is present or some time light haze is there so in all these condition it is possible to make the WDM based FSO link to pass 2.5 Gbps bit rate as shown in the table 3 or fig.no.4,5,6 in these tables one more thing is clear that if we are using Bessel filter, it gives the better BER result so use of Bessel filter in WDM based totally FSO machine provide bettereffects . In case of heavy haze or rain we should make some improvement in our gadget because rain is the biggest problem in free space optics communication. So this system have to boom the energy of the laser to 30 db, boom the gain of the amplifier as much as 50 db, receiver aperture to 30 cm and Responsivity of the APD photo diode to 10 in all cases we are using beam spreading 0 .table-4 and fig.6, 7, 8, 9can constitute the distinctive parameter end result.

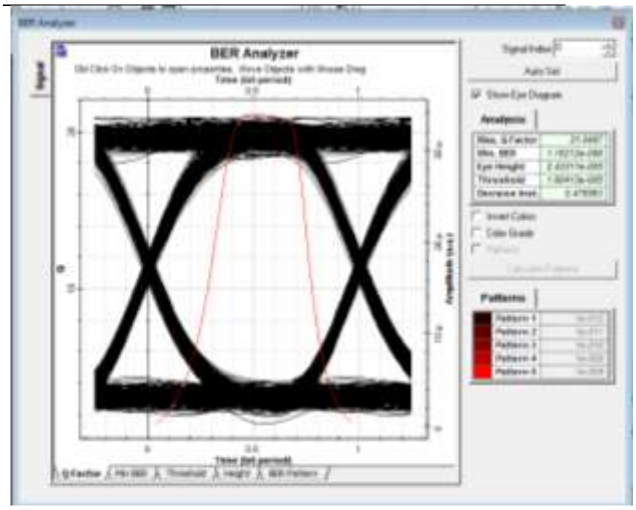


Fig-6:At heavy haze after 54 km at 2.5 Gbps using Bessel

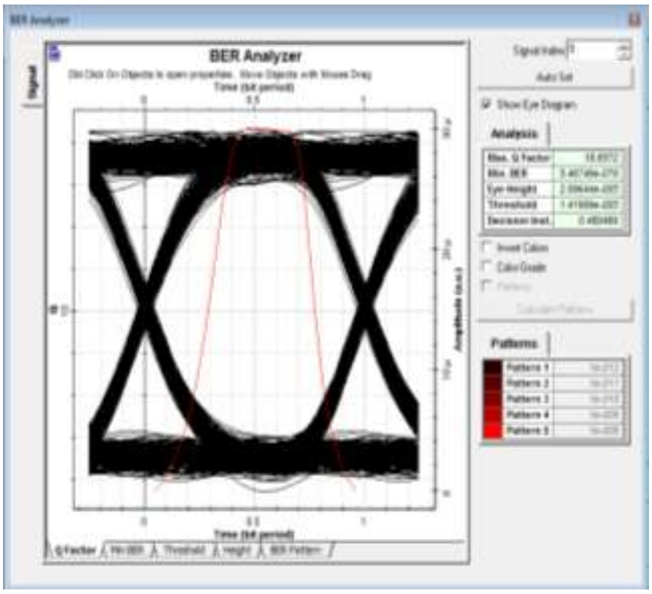


Fig-7:At light rain at 2.5 Gbps at using Bessel filter after 20.5 Km

Weather condition	Attenuation(db)	Bit Rate	laser power	Amplifier Gain	BER(Bessel)	Link rang(km)
Heavy haze	2.37db	2.5Gbps	30db	50db	1.16212e-098	54 km
Light rain	6.27db	2.5Gbps	30db	50db	5.46749e-078	20.5km
Medium rain	9.64db	2.5Gbps	30db	50db	1.86875e-059	13.4 km
Heavy Rain	19.28db	2.5Gbps	30db	50db	1.40093e-008	6.95 km

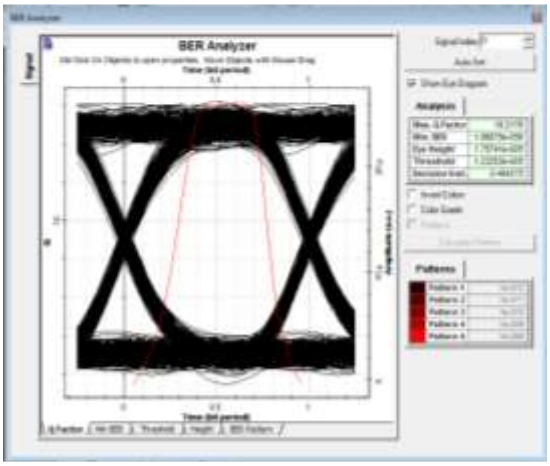


Fig-8:At medium rain at 2.5 Gbps at using Bessel filter after 13.4 Km

In this table as we see that in heavy haze it is possible to communicate up to 54 kilo meter with a excellent BER of 1.16212e-098 usage of 2.5 Gbps facts price with wave length of 1550nm shown in fig.5 and is possible to increase the communication length up to 59 km with efficient data rate but in rain the communication is decrees to 20.5 kilo meter with BER 5.46749e-078 On 1550nm wavelength or 2.5Gbps bit rate fig.6 and 7 constitute .it is greater decreases up to 6.95 kilo meter in heavy rain effect shown in fig 8 and 9 we can also improve these result by using number of amplifier in transmitter and receiver or increasing the receiver aperture and laser strength. All the above result additionally display the opportunity of WDM based FSO communication in all the environment condition.

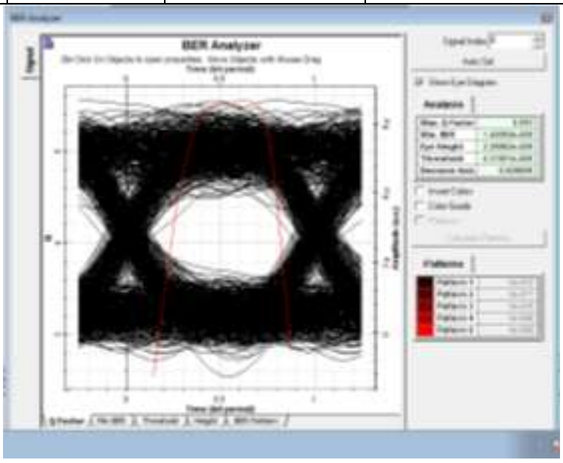


Fig-9:At heavy rain at 2.5 Gbps at using Bessel filter after 6.95 Km

Conclusion

In this paper simulation modeling of WDM FSO system is investigated and observed correctly verbal exchange between transmitter and receiver. In this paper it's far finding out that in clear weather condition communication link of 180 km with 2.5 Gbps data rate has been successfully transmitted through WDM FSO system. The simulation results indicate the tradeoff between simulation parameters (link range, receiver aperture and input power). For example, at 2.5Gbps under clear weather, the BER value of 8.37037e-023 is achieved for 180 km, while at 30 db laser power 30 cm aperture the BER value of 1.815230-021 is achieved for 300 km transmission distance. The impact of clear out utilized in receiver and environmental effect on FSO link has been presented experimentally (using OptiSystem version 10.0) and illustrates that Bessel filter out having higher bring about 2.5 Gbps bit rate in all condition like in rain, heavy haze and clear weather. In FSO link environmental parameter like longer links, heavy haze, light rain, medium rain and heavy rain generate highest attenuation so due to it to tackle this attenuation short link range can be used to optimize the FSO system.

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