



## HYBRID FSO/FO LINK SIMULATION FOR DIFFERENT WEATHER CONDITIONS

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**Abstract:** Optical wireless is the alternative approach to complete the deployment of optical cable networks in case of failure in implementation. In optical wave the attenuation due to atmospheric turbulence conditions causes a performance degradation of a free space optical (FSO) system. Thus, it will lead to the deterioration of the signal power in the optical cable. To overcome these challenges, multi-channel FSO transmitter and erbium doped fiber in optical link was adopted with high transmission power. A hybrid FSO/fiber optic (FSO/FO) link is simulated and investigated under different weather conditions including fog, dust and obtained better Q-factor and minimum BER which is desired for better communication.

**Index Terms** - Atmospheric Attenuation, Fiber Optic Communication, Hybrid FSO/Fiber Optic System, Multi-Channel FSO.

### I. INTRODUCTION

WOC communication is considered as the next frontier for high-speed broadband connection due to its unique features: Extremely high bandwidth, Ease of deployment, Tariff-free bandwidth allocation, Low power (~ 1/2 of radio frequency (RF) systems), Less mass (~ 1/2 of RF systems), Small size (~ 1/10 the diameter of RF antenna), and Improved channel security. It has emerged a good commercial alternative to existing radio-frequency communication as it supports larger data rates and provides high gain due to its narrow beam divergence. It is capable of transmitting data up to 10 Gbps and voice and video communication through the atmosphere/free space. WOC have two broad categories, namely, indoor and outdoor wireless optical communications. Indoor WOC is classified into four generic system configurations, i.e., directed line-of sight (LOS), non-directed LOS, diffused, and quasi diffused. Outdoor wireless optical communication is also termed as free-space optical (FSO) communication. Free Space Optical (FSO) communication or Optical wireless communication (OWC) has emerged as a viable technology for next generation broadband wireless applications in different areas of the long and short haul communications space from links of inter satellite to links of inter building. In applying wireless infrared communication, non-directed links, which do not require precise alignment between transmitter and receiver, are desirable. They can be categorized as either line-of sight (LOS) or diffuse links. LOS links require an unobstructed path for reliable communication, whereas diffuse links rely on multiple optical paths from surface reflections. On the other hand, FSO communication usually involves directed LOS and point-to point laser links from transmitter to receiver through the atmosphere. FSO communication over few kilometer distances has been demonstrated at multi Gbps data rates. FSO technology offers the potential of broadband communication capacity using unlicensed optical wavelengths. However, in-homogeneities in the temperature and pressure of the atmosphere lead to refractive index variations along the transmission path. These refractive index variations lead to spatial and temporal variations in the optical intensity incident on a receiver, resulted in the fading. In FSO communication, faded links caused by such atmospheric effect can cause performance degradation manifested by increased bit error rate (BER) and transmission delays.

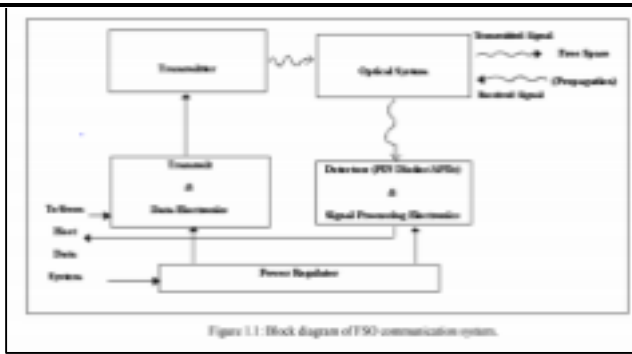


Figure 1.1 Block diagram of FSO communication system.

**Hybrid FSO:**

A hybrid configuration was proposed to satisfy these demands. There are two types of hybrid communication systems, namely, FSO/RF and FSO/FO. The hybrid FSO/RF system needs to pre-transformation of the optical signal to electrical (O/E) and E/O then transmitting/receiving which limits the system performance especially the bandwidth and implementation. Thus, all optical hybrid links are recently used to overcome these limitations in hybrid communication systems. In these improving systems, the optical signal is directly transmitted/inserting from the optical fiber to free space and from free space to optical fiber without any optoelectronics conversion. The hybrid FSO/FO link represents an alternative solution in situations where the fiber-based communications infrastructures are widely destroyed due to disasters. Therefore, offering efficient communications link for both the emergency and medical services. In addition, the using of FSO link at each ends of the FO link, solve both of the first mile and last mile troubles of the optical communication systems.

**II. THEORETICAL FRAMEWORK**

In this context, bidirectional FSO system was used to link low altitude platforms in disaster areas with optical cables to connect the affected area to the rest of the world. The performance of these platforms in various weather environments was investigated and demonstrated. In addition, a 10 GB/s hybrid FO/FSO link was proposed as part of a telecommunication system for application in emergency cases such as bridges damage. Moreover, a hybrid FSO/FO link was proposed utilizing super channel

system which has the advantage of eliminating the use of distinct laser for each sub-carrier like in conventional WDM systems. The process of combining these two technologies (FSO and FO) requires taking into consideration the attenuation that occurs in the transmitted/received signal from/to optical cable via FSO. Environmental disturbances such as rain, dust and others are affected in characteristics of the bidirectional FSO transmission channel. That’s leading to degradation in quality factor and reduces the link availability.

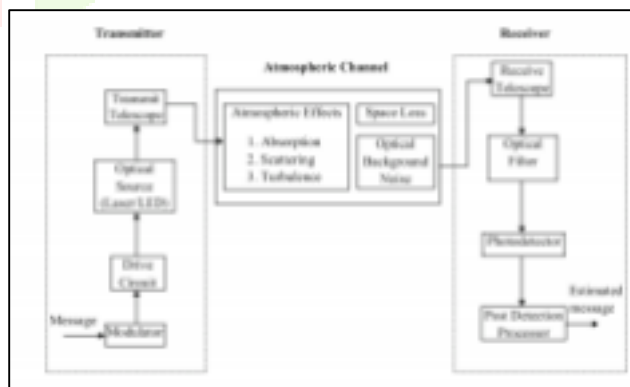


Fig 1.2 Block Diagram Of FSO Communication Link

The basic block diagram of an FSO link comprises of three basic subsystems, viz., transmitter, channel, and receiver.

**Transmitter:** Its primary function is to modulate the message signal onto the optical carrier which is then propagated through the atmosphere to the receiver. The essential components of the transmitter are (a) the modulator, (b) the driver circuit for the optical source to stabilize the optical radiations against temperature fluctuations, and (c) the collimator or the telescope that collects, collimates, and

directs the optical radiations toward the receiver. The most widely used modulation is the intensity modulation (IM) in which the source data is modulated on the irradiance/intensity of the optical carrier. This can be achieved by varying the driving current of the optical source

directly with the message signal to be transmitted or by using an external modulator.

**Channel:** Since the FSO communication channel has the atmosphere as its propagating medium, it is influenced by unpredictable environmental factors like cloud, snow, fog, rain, etc. These factors do not have fixed characteristics and cause attenuation and deterioration of the received signal. The channel is one of the limiting factors in the performance of FSO system.

**Receiver:** Its primary function is to recover the transmitted data from the incident optical radiation. It consists of a receiver telescope, optical filter, photo detector, and demodulator. The receiver telescope collects and focuses the incoming optical radiation onto the photo detector. The optical filter reduces the level of background radiation and directs the signal on the photo detector that converts the incident optical signal into an electrical signal.

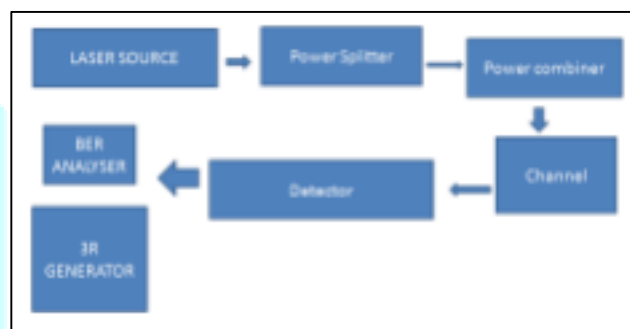


Fig 1.3 Block diagram of Hybrid FSO/FO Communication Systems

The simulation models are consisting of transmitter, medium and the receiver end. The FSO transmission part includes a non return-to-zero pulse generator, pseudo random bit generator, continuous wave laser diodes is the carrier source for wavelength 1550nm in addition to a Mach-Zehnder modulator. The receiving sides an avalanche photo diode and a low-pass Gaussian filter are used. NRZ pulse modulator converts this stream of 0's and 1's in the form of electric pulses having NRZ format. These electrical pulses from the output of NRZ pulse modulator are fed to the input of Mach Zehnder modulator which modulates information signal with a continuous wave laser. An APD photodiode can also be used in place of PIN photodiode for better performance. The output

of PIN photodiode is fed to low pass Gaussian filter which removes all the high-frequency noise present in the received signal. At last signal is analyzed using BER analyzer.

SIMULATION SETUP

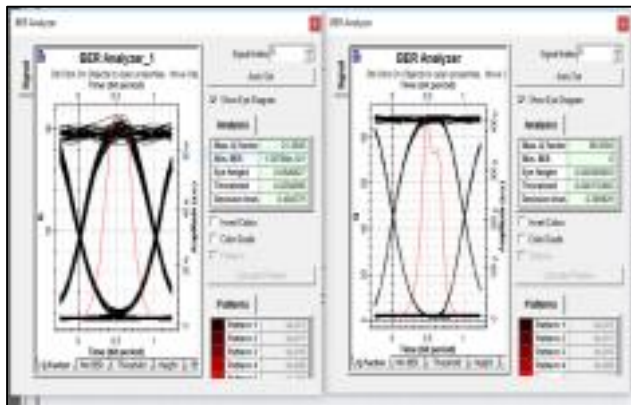


Fig 1.4 Simulation diagram for Hybrid FSO/FO Communication System using single channel under heavy fog condition

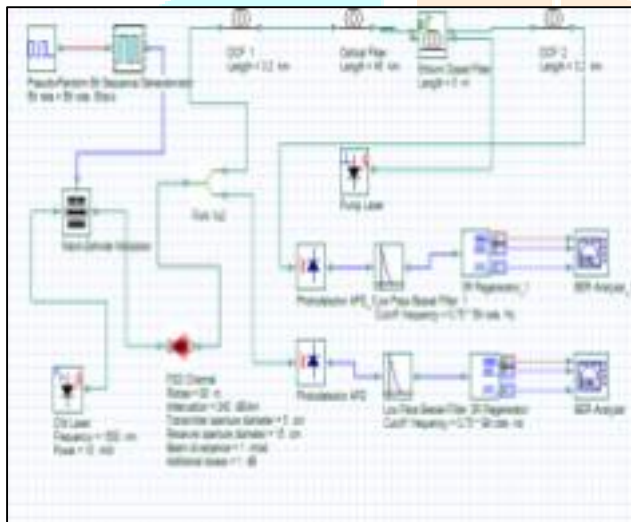


Fig 1.5 Simulation diagram for Hybrid FSO/FO Communication System using single channel under heavy dust condition

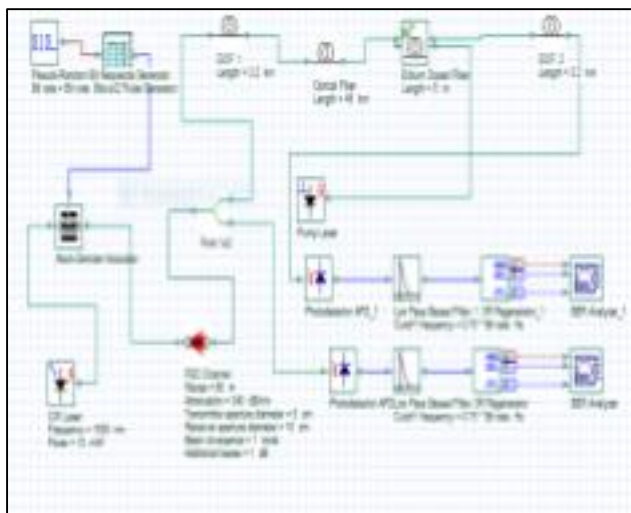
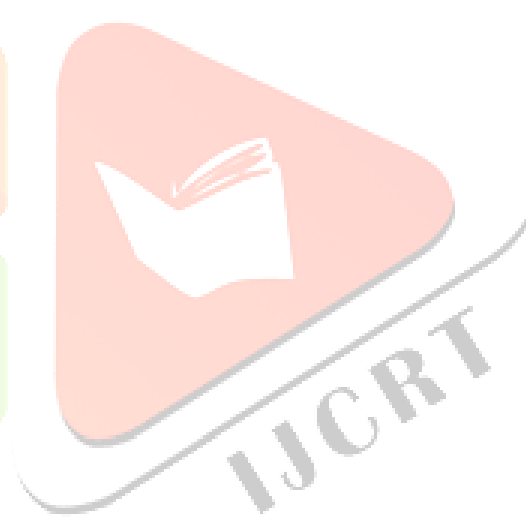


Fig 1.6 Hybrid FSO/FO system under heavy fog condition



#### IV. RESULTS AND DISCUSSION

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**Table 1.1 Result Analysis for Heavy fog Condition**

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**Table 1.2 single channel FSO**

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**Table 1.3 Result Analysis for Heavy dust Condition**

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**Table 1.4 single channel FSO**

#### V. CONCLUSION

A new approach for hybrid FSO/FO link simulation under various weather conditions has been presented having a feature of high Q-factor and BER is very close to zero. IN FUTURE WORK, THIS WORK IS PLANNED TO EXTEND BY USING MULTICHANNEL IN HYBRID FSO/FO COMMUNICATION SYSTEM UNDER DIFFERENT WEATHER CONDITIONS.

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