Effect of Combination of Hybrid Optical Amplifier and Manchester Encoding in 3 Channel WDM FSO System

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ABSTRACT

In this paper 3 channel WDM FSO system is designed having input as Manchester coded signal, hybrid optical amplifier (EDFA and SOA) and spatial diversity technique. Spatial diversity means MIMO structure i.e. 2 transmitters and 2 receivers. This system is analyzed at 2.5 Gbps data rate for 1550 nm wavelength. The performance of proposed system is measured in terms of Q factor and BER under different atmospheric conditions like haze (attenuation 2.37 dB/Km), light rain (attenuation 3 dB/Km) and medium rain (attenuation 9 dB/Km) for different values of link range. In OptiSystem simulation tool this FSO design is simulated and eye diagrams have been generated to calculate the performance of FSO system in terms of Q factor and BER. These results are also compared with the results mentioned in previous literature.

Keyword: - *Wavelength division multiplexing, FSO, Q-factor, BER, Link Range*

1. INTRODUCTION

Free Space Optical communication is concerned to propagation of modulated visible signals via the atmosphere to achieve broadband and wireless communication effectively. FSO systems can work efficiently for a long distance (in Kms.). FSO can be considered as an alternate to the RF communication. It provides an unregulated spectrum in surplus of terahertz (THz) frequency and very high speed communication, which makes it an attractive medium of fulfilling the continuously increasing demand for high speed broadband network, mostly accessed by last-mile access system and HD television broadcasting purposes. FSO systems depending upon WDM method can provide up to 1 Terabit/s capacity or more. Further benefits consist of smaller and more complex transceivers, decreased installation and development expenses and strength against electromagnetic interference issue. FSO system, equivalent to other communication systems, is primarily made up of three fundamental systems which are: transmitter, communication channel and receiver. Transmitter block has the fundamental task of modulating input signal with laser source to convert it into optical signal for transmitting it via atmosphere to receiver side of FSO communication channel. Transmitter block includes modulator, driver circuit, laser source and transmitter telescope. Modulator modulates the input signal onto the optical carrier signal. On-Off-Keying (OOK) modulation technique is commonly utilized in FSO system. On-Off-Keying modulation technique is very sensitive to fluctuations in amplitude of signal. Atmospheric conditions like clouds, haze and fog significantly degrade performance of FSO system by attenuating the transmitted signal.

The need of advanced bandwidth is growing these days. Very high data rate communication is required that can be presented by FSO and can exchange RF communication in various applications. RF can offer data rate of upto many Mbps, but there is a restriction of spectrum congestion, interference and issues connected to license. FSO is a efficient as well as high bandwidth access technique, which has accepted growing cerebration with modern development of the application

2. FACTORS INFLUENCING FSO SYSTEM

FSO communication systems are influenced by outside interferences from various sources which are as follows:

FSO Attenuation: Absorption and scattering are the two factors contributing to attenuation in FSO channels. Both natural and artificial processes result in an abundance of different gaseous molecules including carbon dioxide (CO_2), ozone (O_3) and water vapour (H_2O) in the atmosphere, which interact with and absorb propagating photons at different wavelengths. Because the rate of absorption is dependent on both the concentration of these gases and wavelength, FSO communications are established at wavelengths around 780 - 1550 nm where absorption is relatively low. Scattering however is an unavoidable source of power loss in the atmosphere. The presence of micro and macro particles in the atmosphere leads to different scattering processes which attenuate the optical power of the propagating signal.

Scintillation: The random fluctuations in signal intensity of an optical beam propagating in the atmosphere which are caused by turbulence are generally referred to as optical scintillation. A common approach used in describing the effect of scintillation along most horizontal paths in the atmosphere is the extended medium model in which the whole range of the signal propagation path is treated as a random medium.

Aperture Averaging: Among the numerous techniques proposed for the mitigation of turbulence effects which include aperture averaging (AA), diversity systems and wave front reconstruction; aperture averaging presents the simplest and most cost effective option applicable to direct detection systems. The basic idea in aperture averaging is to increase the receiving aperture above the cell size of the turbulent eddies responsible for irradiance fluctuations so that such fluctuations are averaged out over a large receiver aperture.

Other Factors: Physical obstacles (such as low flying objects and birds, high rising buildings and mountainous terrains), and external interferences from background ambient signals can be problematic to the propagation of an optical signals in the atmosphere. Additionally, thermal expansion and small movements of buildings caused by high velocity winds, vibrations by heavy machinery and minor earthquakes can increase misalignment and pointing errors above that originally caused by beam wandering. The challenges posed by physical obstacles are mitigated by adequate link path planning during installations, but for FSO links greater than about 100 m range, an automatic pointing, acquisition and tracking (PAT) sub-system is required to mitigate pointing and tracking errors.

3. WAVELENGTH DIVISION MULTIPLEXING (WDM)

In wavelength division multiplexing (WDM), a range of wavelengths within the bands in the International telecommunication union-telecommunication (ITU-T) grid is used and each fixed central wavelength is assigned for the transmission of a specific signal in a common channel. Adequate spacing is provided between the central wavelength assigned for the transmission of each signal and the central wavelength assigned for the transmission of the next adjacent signal, just like the guard band in a TDM/TDMA PON, with wider spacing required for coarse-WDM (CWDM) applications than dense-WDM (DWDM). In a WDM PON, a dedicated central wavelength is used for both the upstream and downstream transmission of signal between the OLT and the ONU.

4. PROPOSED DESIGN

In this paper we have shown performance of 3 channel WDM FSO link for different values of link range under various climate conditions like haze (2.37 dB/Km), light rain (3 dB/Km) and medium rain (9 dB/Km). MIMO technique, Hybrid optical amplifier and Manchester encoding technique are used in WDM FSO system to minimize the effect of turbulence on the performance of the FSO link. All simulations have been performed in OPTISYSTEM simulation tool.

Initially a user defined bit sequence generator having 2.5 Gbps data rate is used to generate user defined bit pattern also called data (110011). One more user defined bit sequence generator having 2.5 Gbps data rate is implemented to generate a clock signal (101010).

Proposed design is shown in Fig 1.

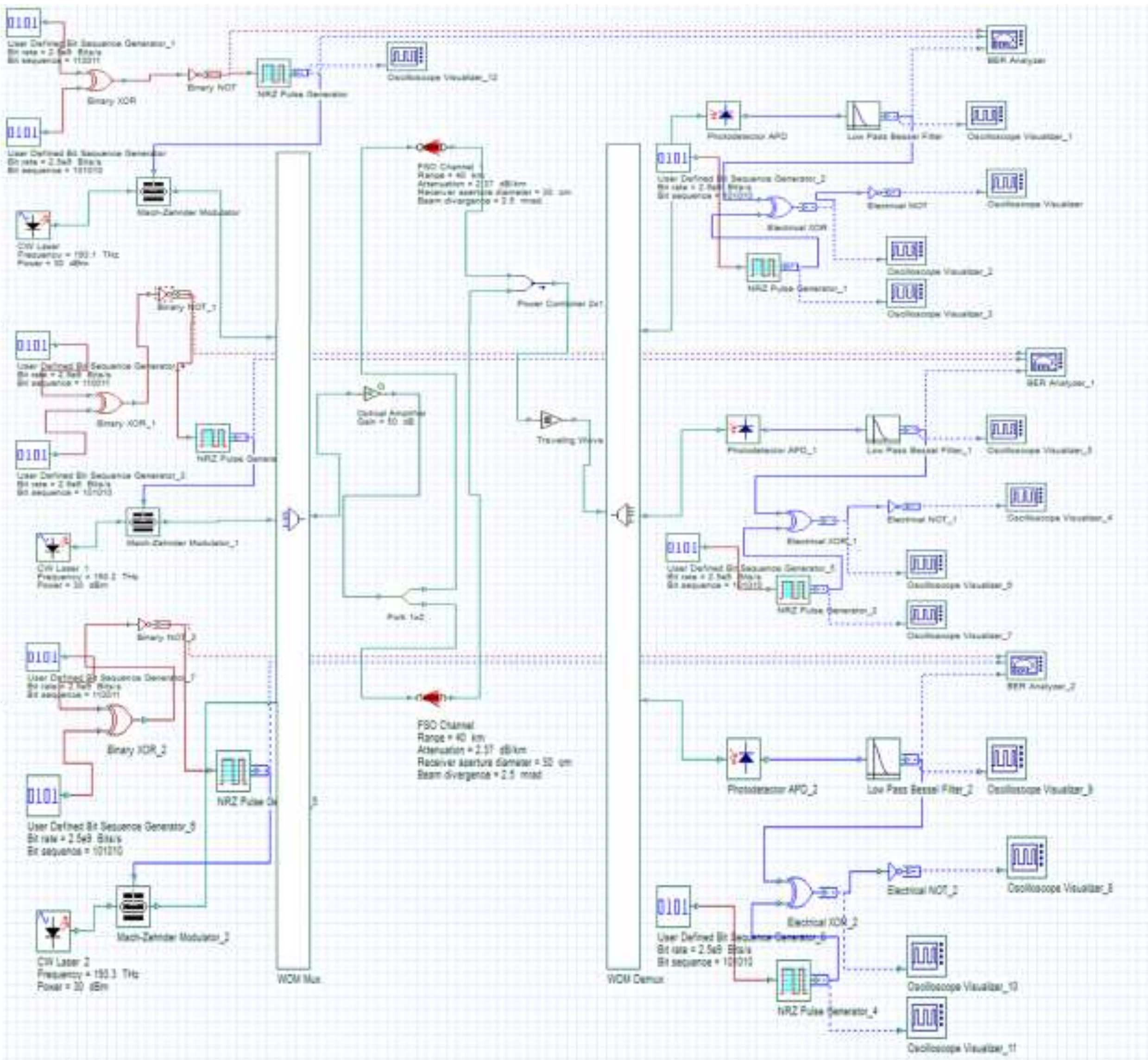

Fig 1 3 channel WDM FSO system

Then data and clock signals are passed through binary XOR component to produce binary output. Now this output is passed through binary NOT gate to produce binary value of Manchester signal. This Manchester signal is then converted into electrical signal through NRZ pulse generator. Then this NRZ pulse is modulated with CW laser source by MZM (Mach-Zehnder modulator). This modulator converts the pulse into optical signal. Optical signal is then amplified through EDFA. Then signal is passed to fork which makes the copy of signal to transmit the same signal in 2 FSO channels. This part of system completes the transmitter section of FSO system. Now at receiver end optical signal is received, combined using power combiner and amplified through travelling wave SOA. Received optical signal is passed through Avalanche photodetector and gets converted into electrical signal. Now the electrical signal is passed through low pass Bessel filter to eliminate unwanted high frequency noise signals. Here we obtain our Manchester encoded signal. This signal is transmitted to BER analyzer to calculate properties Q-factor, eye height

5. FSO ANALYSIS FOR DIFFERENT LINK RANGE

Proposed 3 channel WDM FSO system is simulated to determine the Q-factor and BER when bit rate is constant at different atmospheric conditions and different link range of communication. Simulation results of this analysis are shown below: Bit rate = 2.5 Gbps,

1. For haze climate, Attenuation = 2.37 dB/Km
2. For light rain climate, Attenuation = 3 dB/Km
3. For medium rain climate, Attenuation = 9 dB/Km

Table 1 Simulation results for constant bit rate at haze climate

Bit rate = 2.5 Gbps, Attenuation = 2.37 dB/Km		
Link Range (Km)	**Q-factor**	**BER**
25	6.71	8.407e-12
30	22.28	3.166e-110
35	30.41	1.408e-203
40	14.74	1.004e-49
45	13.35	3.49e-41
50	10.24	5.75e-25

Table 2 Simulation results for constant bit rate at light rain climate

Bit rate = 2.5 Gbps, Attenuation = 3 dB/Km		
Link Range (Km)	**Q-factor**	**BER**
22	11.11	4.850e-29
25	25.89	3.862e-148
28	30.79	9.720e-209
31	16.89	1.366e-64
34	13.81	5.784e-44
37	13.21	2.143e-40

Table 3 Simulation results for constant bit rate at medium rain climate

Bit rate = 2.5 Gbps, Attenuation = 9 dB/Km		
Link Range (Km)	Q-factor	BER
7.5	6.09	5.344e-10
8.5	12.61	9.357e-37
9.5	26.49	5.425e-155
10.5	27.52	3.144e-167
11.5	15.57	3.520e-55
12.5	13.62	8.785e-43

6. COMPARISON OF OUR RESULT

Our simulation results are shown below for link range variation under different atmospheric conditions.

Table 4 Comparison table for different climate conditions

(a) Haze climate

Attenuation = 2.37 dB/Km, Range = 40 Km		
Parameters	Proposed Work	Ref [7]
Q-factor	14.74	16.28
BER	1.004e-49	3.043e-60

(b) Light rain climate

Attenuation = 3 dB/Km, Range = 31 Km		
Parameters	Proposed Work	Ref [7]
Q-factor	16.89	9.27
BER	1.366e-64	4.317e-21

(c) Medium rain climate

Attenuation = 9 dB/Km, Range = 11.5 Km		
Parameters	**Proposed Work**	**Ref [7]**
Q-factor	15.57	11.86
BER	3.520e-55	4.510e-33

6. CONCLUSIONS

In this thesis 3 channel WDM FSO system is designed having input as Manchester coded signal, hybrid optical amplifier (EDFA and SOA) and spatial diversity technique. Spatial diversity means MIMO structure i.e. 2 transmitters and 2 receivers. This system is analyzed at 2.5 Gbps data rate for 1550 nm wavelength. The performance of proposed system is measured in terms of Q factor and BER under different atmospheric conditions like haze (attenuation 2.37 dB/Km), light rain (attenuation 3 dB/Km) and medium rain (attenuation 9 dB/Km) for different link range and bit rate. In OptiSystem simulation tool this FSO design is simulated.

In previous work at 1550 nm wavelength, Q factor for haze (40 Km range), light rain (31 Km range) and medium rain (11.5 km) is 16.28, 9.27 and 11.86 respectively whereas our results are 14.74, 16.89 and 15.57 which is better than previous results. BER for haze (40 Km range), light rain (31 Km range) and medium rain (11.5 km) is 3.043e-60, 4.317e-21 and 4.510e-33 respectively whereas our results are 1.004e-49, 1.366e-64 and 3.520e-55 which is better than previous results.

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