SPECTRUM SLICING WDM FOR FSO COMMUNICATION SYSTEM

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Abstract :In developing technologies, broadband applications are in huge demand. In order to fulfill the demands spectrum slicing technique is used. This technique is also used in free space optics in order to increase the data speed and to provide large bandwidth. In this paper spectrum slicing technique is implemented with an array waveguide grating to transmit bit rate of 15Gbps for a distance of 10km in different weather conditions by using modulation formats like MDRZ, DRZ, CSRZ. The proposed model is evaluated using BER and Quality factor.

***IndexTerms* - compressed spectrum return to zero (csrz), duo binary return to zero (drz), Free space optics (fso), modifier duo binary return to zero (mdrz), wavelength division multiplexing (wdm).**

I. INTRODUCTION

In recent years, the FSO communication system has been investigated to provide the benefits of useful properties over optical fiber communication [1]. The FSO communication system having large bandwidth, high capacity, license free operation and operates on very low power as in optical communication [2]. The performance of free space optics (FSO) is affected by the atmospheric conditions such as medium rain, mild rain, fog, haze, high rain, etc.. [3]. WDM is a data transmission technology which is capable to support high data rate and high capacity of the system. In WDM technique, individual wavelength is assign to the each user. The WDM technique required N number of coherent laser source are needed to generate the N frequencies, which increase the cost of the system [4]. The spectrum slicing (SS) technique is a best alternate to the WDM technology, because it has less complexity during the operation, compared to WDM [5]. The Spectrum slicing technique is reported in researchers using super luminescent diodes [6], semiconductor optical amplifier SOA-ASE [7], super continuum spectrum slicing technique [8] . However, these system support number of channels and low data speed, but free space optics can provide large bandwidth and support high speed. The method of spectrum slicing SS-WDM is required for FSO networks. In the past, a lot of research work has been done at different modulation formats. In normal single mode fiber, NRZ and RZ modulation formats are commonly used and the RZ format performs better as compared to NRZ system[9]. In WDM systems, both NRZ and RZ are not suitable. NRZ is more affected by non linearities, RZ is more affected by dispersion [10]. By comparing the performance of RZ and CSRZ, the CSRZ is better than RZ [11]. In this paper, an array waveguide grating spectrum sliced system is demonstrated and the system is analysed for different line coding techniques.

II. SYSTEM DESIGN

The proposed system architecture is four channel spectrum sliced (SS) wavelength division multiplexing system as shown in Fig.1 The continuous wave laser source is sliced into 4- channels such as 193, 193.1, 193.2, 193.3 THz respectively, using an array waveguide grating demux. Array waveguide grating is an optical passive device. It is used to increase the transmission capability of the system. The CW laser source operation frequency started from 193.15THZ. The CW laser having 30 dBm input power. Mach zehnder modulator is used for modulating the optical slices. A pseudo random generator is used to generate a 15Gbps bit stream and the different modulation format is carried out (MDRZ, DRZ, CSRZ) shown in Fig 2, 3, 4. The modulated signal is multiplexed and ready to transmit from the transmitter side into the free space optics towards the receiver. To check the system performance the multiplex signal amplified by EDFA amplifier.

After the amplification the signal is fed to FSO link. The quality of receiving signal depends on the distance between the transmitter and receiver of FSO. To determine the signal quality, the distance of FSO system varies from 1 to 8 km. The signal is demultiplexed and taken at definite ports which are fixed according to the transmittedfrequencies.

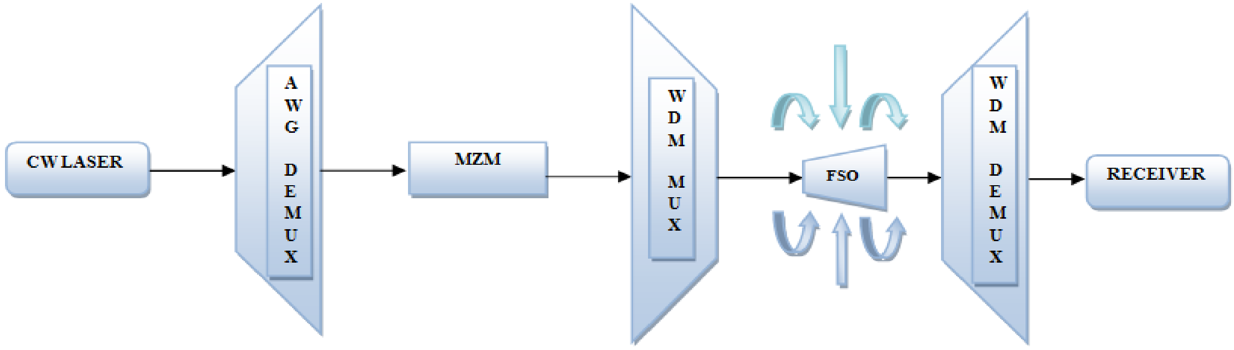

Fig.1 Structure of four channel AWG-SS-WDM FSO communication system.

At the receiver side the photodiode detects the light and convert it into electric form. In this PIN photodiode with 10 nA and responsibility is 1 A/W is used and low pass bessel filters which are used after the PINs to remove the undesired signal. A 3R regenerator placed after LPF for reshaping and re-amplification followed by BER analyser. system parameters are shown in table 1 which are used in simulations.

Table 1 system specification of proposed system

Parameters	**Values**
PRBS bit rate (Gbps)	15
Weather conditions investigated	Clear weather, medium rain, haze , fog
Wavelength	1552 nm
No of channels	4
Channel spacing	100
Line coding	MDRZ, DRZ, CSRZ
Link length	More than 8 km
Diameter of transmitting antenna (in cm)	5
Diameter of receiving antenna (in cm)	5
Beam divergence (mrad)	1

To analyse the effects of these environmental disturbances. Attenuations are in the context of turbulence given in table 2.

Table 2 Atmospheric weather conditions along with value of attenuation

S.no	Atmospheric weather conditions	Value of attenuation (db/km)
1	Clear weather	0.11
2	Haze	4
3	Medium rain	9.64
4	Fog	22

III. GENERATION OF VARIOUS TYPES OF MODULATION FORMAT

In Fig.2 the modifier duo binary return to zero format is generated by first creating an NRZ duo binary signal using delay and substract circuit that drives the first mach zehnder modulator, and then concatenating with a next mach zehnder modulator, its driven by electrical signal (sine generator).

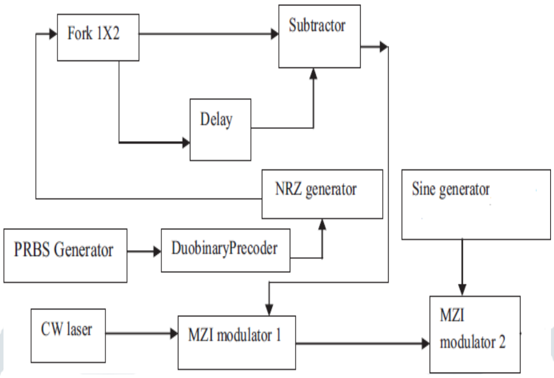

Fig.2 Schematic diagram of MDRZ modulation format.

In Fig.3 the duo binary format is generated by creating an non return to zero duo binary signal using a precoder and pulse generator that drives the first mach zhender modulator and then concatenating with a next modulator (MZM), its driven by electrical signal (sine generator).

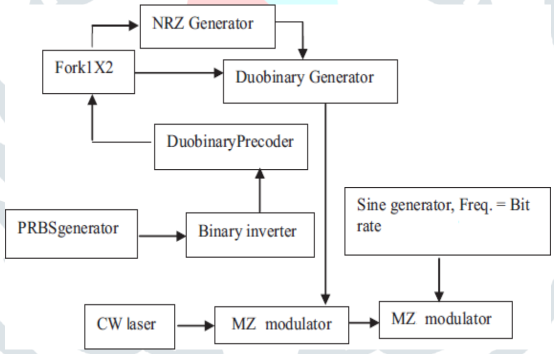

Fig.3 Schematic diagram of DRZ modulation format.

In Fig.4 the compressed spectrum return to zero format that will introduce a π phase shift between any two adjacent bits and the spectrum will be modified such that the central peak at the carrier frequency is suppressed.

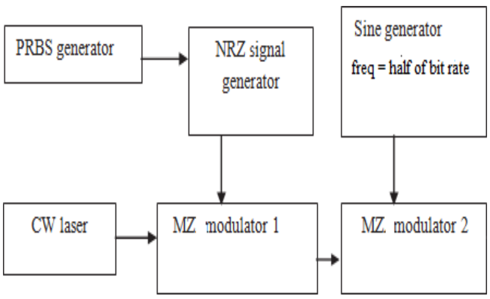

Fig.4 Schematic diagram of CSRZ modulation format.

IV. RESULTS AND DISCUSSION

To evaluate the signal quality of reception under different atmospheric weather conditions. The link length of FSO communication is varied from 1 to 8 km. It is observed that the maximum prolonged distance is observed in clear weather condition and minimum distance observed in fog. Fig.5 depicts that to increasing the distance, the quality of the received signal decreases. Different modulation formats are investigated over free space optical communication (FSO) system and Q factor is observed for these modulation formats.

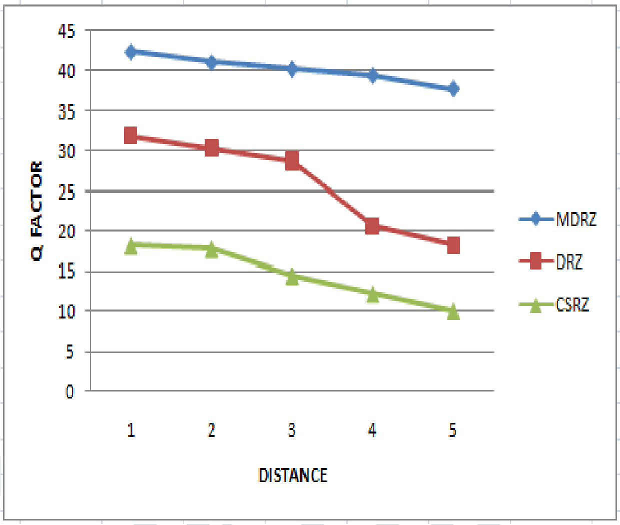

Fig.5 Graphical representation of different modulation formats.

It is perceived that the effect of modulations on Q factor is significant. The MDRZ modulation format provides better results compared to other modulation format in term of quality factor. It is evident that the quality factor of MDRZ is best due to dispersion tolerance and constant power. In Fig.6 revealed that the eye diagram of various weather conditions for SS-WDM FSO communication system. It is cleared from the eye diagram that the maximum eye opening is obtained in case of clear weather condition which only provide the idea of good quality of the received signal and recognizing the effect of distortion. To demonstrate the system performance different atmospheric factors are considered such as transmitter/receiver aperture size, beam divergence, distance between transmitter and receiver, and modulation formats. A spectrum sliced (SS) WDM technique is used to determine the signal quality of the received signal by varying the free space optic link length from 1 to 8 km.

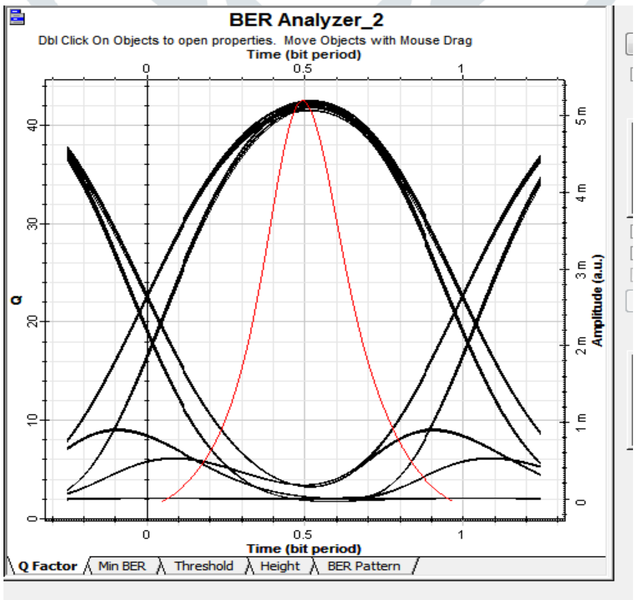

Fig 6 (a) Clear weather

Fig 6 (a) shows the clear weather condition for SS-WDM – FSO communication system. It is cleared from the eye diagram that the maximum eye opening is obtained in case of clear weather condition.

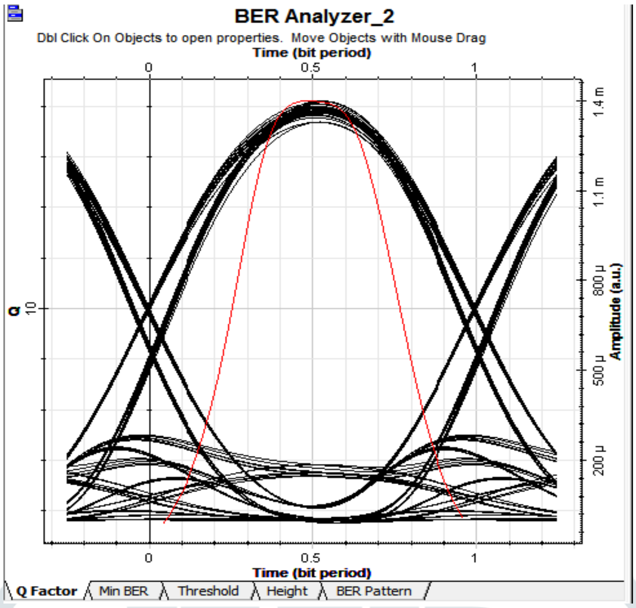

Fig 6 (b) Haze condition

Fig 6 (b) shows the haze condition for SS-WDM –FSO communication system. From the figure it is verified that the eye opening of clear weather condition is larger than the haze condition which results in reduction in Q factor.

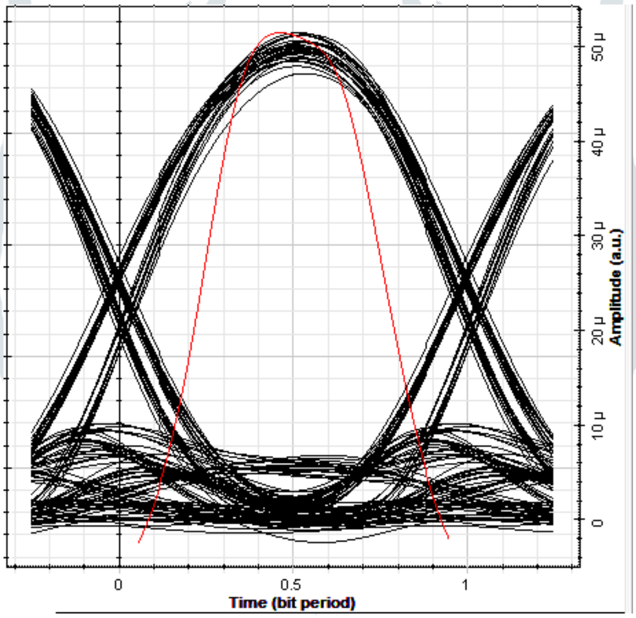

Fig 6 (c) Medium rain condition

Fig 6 (c) shows the medium rain condition for SS-WDM – FSO communication system. It is cleared from the eye opening of medium rain condition, quality factor is less compared to the eye opening of haze condition.

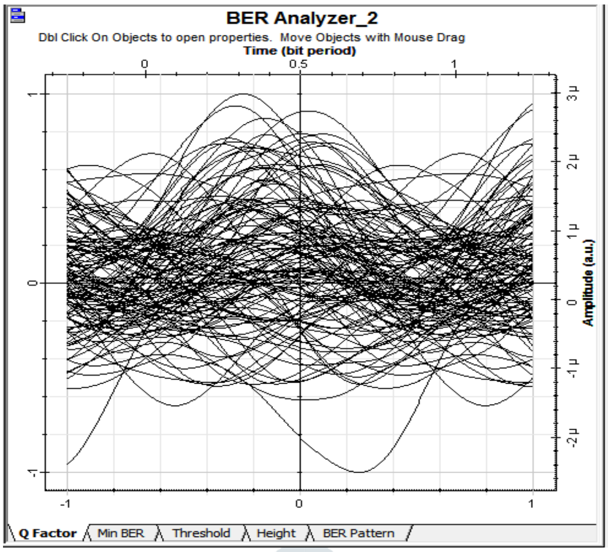

Fig 6 (d) fog condition

Fig 6 (d) shows the fog condition for SS-WDM –FSO communication system.

The comparison between MDRZ, DRZ and CSRZ modulation formats is shown in Table 3, 4, 5.

Table 3 The values of quality factor for mdrz at different link length

Distance (km)	Clear weather (0.1db/ km)	Haze (4 db/km)	Medium rain (9.64 db/km)	Fog (22 db/km)
1	42.54	18.66	18.21	0
2	41.13	16.45	13.14	0
3	40.28	10.40	0	0
4	39.45	8.76	0	0
5	37.76	0	0	0

Table 4 The values of quality factor for drz at different link length.

Distance (km)	Clear weather (0.1db/ km)	Haze (4 db/km)	Medium rain (9.64 db/km)	Fog (22 db/km)
1	31.89	17.54	15.49	0
2	30.42	10.05	0	0
3	28.73	7.07	0	0
4	20.68	0	0	0
5	18.31	0	0	0

Table 5 The values of quality factor for csrz at different link length.

Distance (km)	Clear weather (0.1db/ km)	Haze (4 db/km)	Medium rain (9.64 db/km)	Fog (22 db/km)
1	18.24	16.48	14.78	0
2	17.79	9.78	0	0
3	14.48	0	0	0
4	12.18	0	0	0
5	9.98	0	0	0

On comparing three modulation formats such as a modifier duo binary return to zero, compressed spectrum return to zero, duo binary return to zero, (MDRZ,CSRZ,DRZ). modifier duo binary return to zero (MDRZ) performs better than other modulation formats.

V. CONCLUSION

In this paper an AWG SS-WDM-FSO communication system is investigated. Analysis has been carried out in different weather conditions such as clear weather, haze, medium rain and fog conditions. The system is capable to transmit the data rate up to 15 Gbps for 10 km. For clear weather condition maximum link length is observed and minimum link length is observed in case of fog condition. The investigation has been carried out for the purpose to check the system performance by varying different modulation formats. So by varying such parameters, we observed that the SS WDM technique provides the best performance in case of MDRZ modulation formats.

VI. ACKNOWLEDGMENT

The work presented in the manuscript has been carried out by software OPTISYSTEM and free trial version available at www.optiwave.com.The authors like to thank our Head of the department who supported to carried out this work.

REFERENCES

[1] He, J., Norwood, R. A., Pearce, M. B., Djordjevic, I. B., et al. (2014). A survey on recent advances in optical communications.
Computers & Electrical Engineering, 40, 216–240
[2] Kazaura, K., Omae, K., Suzuki, T., et al. (2006). Experimental demonstration of next-generation FSO communication system. Optics East. Int'1. Society of Photo Optical Instrumentation Engineers (SPIE), 6390, 63900–63912.
[3] Chaudhary, S., Amphawan, A., & Nisar, K. (2014). Realization of free space optics with OFDM under atmospheric turbulence. Optik - International Journal for Light and Electron Optics, 125, 5196–5198.
[4] Ciaramella, E., Arimoto, Y., Contestabile, G., Presi, M., et al. (2009). 1.28 Terabit/s (32 9 40 Gbit/s) WDM transmission system for free space optical communications. IEEE Journal on Selected Areas in Communications, 27, 1639–1645.
[5] Rashidia, F., He, J., & Chen, L. (2017). Spectrum slicing WDM for FSO communication systems under the heavy rain weather. Optics Communications, 387, 296–302.
[6] Lee, K., Lim, S. D., Jhon, Y. M., Kim, C. H., et al. (2012). Broadcasting in colorless WDM-PON using spectrum-sliced wavelength conversion. Optical Fiber Technology, 18, 112–116.
[7] Kaneko, S., Kani, J.-I., Iwatsuki, K., Ohki, A., et al. (2006). Scalability of spectrum-sliced DWDM transmission and its expansion using forward error correction. Journal of Light Wave Technology, 24, 1295–1301.
[8] Thakur, A., Nagpal, S., & A. Gupta. (2018). Kerr effect based spectrum sliced wavelength division multiplexing for free space optical communication. Optik - International journal for light and electron optics, 157, 31–37.
[9] G Bosco, A Carena, V curn, R gaudino and P poggiolini, "On the use of NRZ, RZ and CSRZ modulation at 40 gbps with narrow DWDM channel spacing" J lightwave technol.20,1964- 1704 (2002).
[10] M. I . Hayee, and A.E Wilner, "NRZ versus RZ in 10-40 Gbps dispersion managed WDM transmission systems" IEEE photonics technol. Lett. 11,991-993 (1999).
[11] T Hoshida, O vassilieva, K yamada, S.choudhary, R pecquer and H Kuwahara, "optimal 40 Gbps modulation formats for spectrally efficient long-haul DWDM systems IEEE J.Lightwave technol.20, 1989-1996 (2002).