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EDFA Gain Evaluation in WDM Transmitting System of the Free Space Optics FSO

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Abstract

This work propose Free Space Optics Systems (FSO) which is considered as one of the most effective solutions to the optical communication environment. It is intended to design a new modified WDM transmitter operating for 16 channel multi users with Erbium Doped Fiber Amplifier (EDFA). As slicing in Wavelength Division Multiplexer(WDM) systems, in the transmitter channel at frequency 1558nm and chip spacing 0.8 nm , power equal to -23.5dBm,while the output power will record 28.4mw (14.54dBm) measured by the optical power meter. plus by using NRZ modulation format, while the input power is generated with a CW laser, The spectrum-sliced WDM channel operating at high data rate such as 1Gbps,have been transmitted signal to more than 300 Km, no interference occur. This is done by the use of simulation software version 7.

Keywords: CW Laser; EDFA; NRZ; WDM transmitter technique; FSO.

1. Introduction

Optical communications is a novel technology that offers special features and merits over conventional electrical communication. It provides high speed data rate and enormous capacity. Optical transmission system consists of transmitter part, ideal multiplexer, Opti-System is a comprehensive software design suite that enables users to plan, test, and simulate optical links in the transmission layer of modern optical networks. It is an innovative optical communication system simulation package which was explored by opti Wave Company in order to meet the academic requirement of the system designers, optical communications engineers, researchers [1].

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1.1. Non-return to zero (NRZ)

In the NRZ format the pulse remains on throughout the bit slot and its amplitude does not drop to zero between two or more successive bits. As a result, pulse width varies depending on the bit pattern. In the early days or in commercial system NRZ are used in fiber-optical communication, due to a) it is not sensitive to laser phase noise b) it requires a relatively low electrical bandwidth for transmitters and receivers compared with RZ; c) it has the simplest configuration of transmitter and receiver; d)less cost. Unfortunately, NRZ modulation format is not appropriate for high bit rate and long distances optical communication system [2]. NRZ modulation may be better in case of large number of channels.

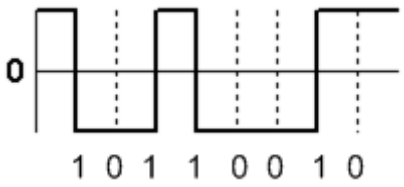

Figure 1: NRZ data format

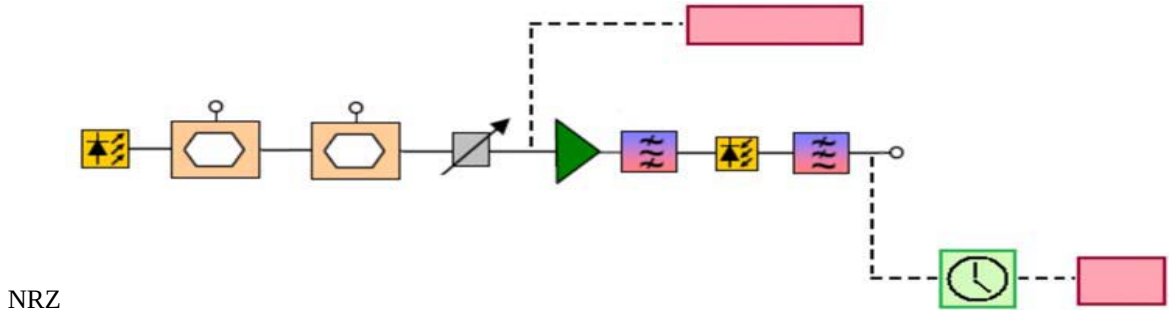

Figure 2: Structure for NRZ-OOK

For case of OOK the modulator is predisposed at 50% transmission and is driven to maximum to minimum transmission as illustrated in Fig [2].

The significant of broadband and multimedia telecommunications is still increasing and the use of fiber –optic technology in the access network is growing very fast in order to meet customers demand. Along with the higher bandwidth demand, increasing number of subscribers. And advances in the Wavelength Division Multiplexing (WDM) device technology. WDM system offers many advantages such as, asynchronous, ability to support variable bit rate, and sociability of the network. This is done in order to obtain using one or more passive and fixed optical splitters in the fiber path [4].

1.2. Wavelength Division Multiplexer

The main principle of WDM is that contain of two parts multiplexer and de multiplexer ,the function of multiplexer is to combine a number of standard SONET data channels and generate a series data output. The

operation and functional characteristics of the following multiplexer for example are based on the Philips OQ2535HP.This multiplexer combines 32x 78 Mb/s data channels into a single 2.5 Gb/s data stream in compliance with OC48/STM-16 format. Some of the most important operating characteristics of the multiplexer are:

- High input sensitivity.
- 5v TTL clock output.
- Low power dispersion.
- CML data and clock outputs.
- 3.3v TTL compatible data inputs.

For example if we have five users with different wavelength (U1=1550nm,U2=1550.1nm,U3=1550.2nm,U4=1550.3nm, and U 5=1550.4nm), at chip spacing equal to 0.1nm, and these five users data will be collected in the multiplexer device and then send them in one cable to the receiver side , in the receiver there were a second part called DE multiplexer device which is used to submit the cable with data of five users and divide them into five wires towards the detector channel that mean U1 to the detector 1,U2 to detector 2,U3 to detector 3, U4 to detector 4 and U5 to detector 5. In the past there were a compiler working as a multiplexer, and splitter working as a divider, but the difference is that they modified the techniques of splitter and compiler and using instead of them a multiplexer and DE multiplexer just setting a high quality filters built in them. So by using the DWM technique we can decreases the noise and attenuation in the data .Figure 1. Below shoes the WDM technique which clearly appear the working of multiplexer and De multiplexer, depending on the number of users (λ).

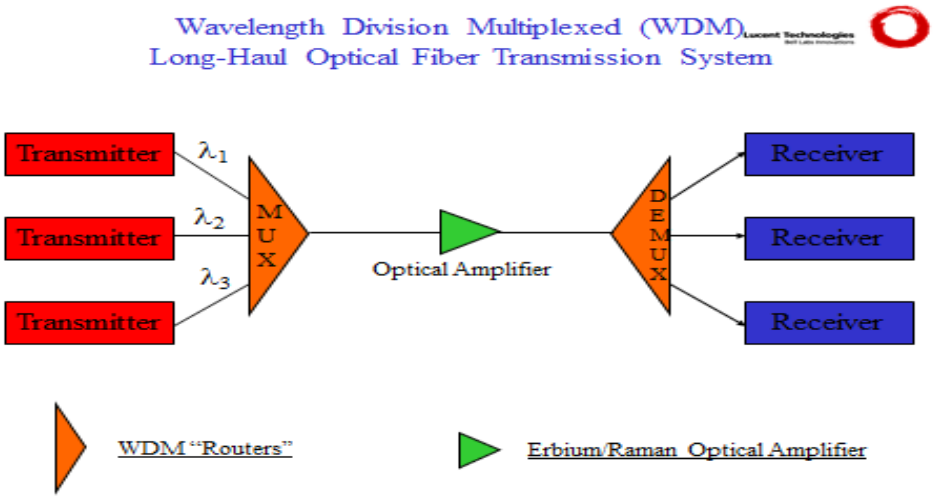

Figure 3: Block diagram of WDM long –haul

Benefit of WDM: WDM technology allows multiple connections over one fiber thus reducing fiber plant requirement. This is mainly beneficial for long-haul application, campus application requires cost benefit analysis .while the WDM technology can also provide fiber redundancy, and provides a managed fiber service.

The main principles of the WDM techniques of the transmitter and receiver transmitted signal will be illustrated clearly in figure 2.abearing two signal visa versa direction for every single pair fibers.

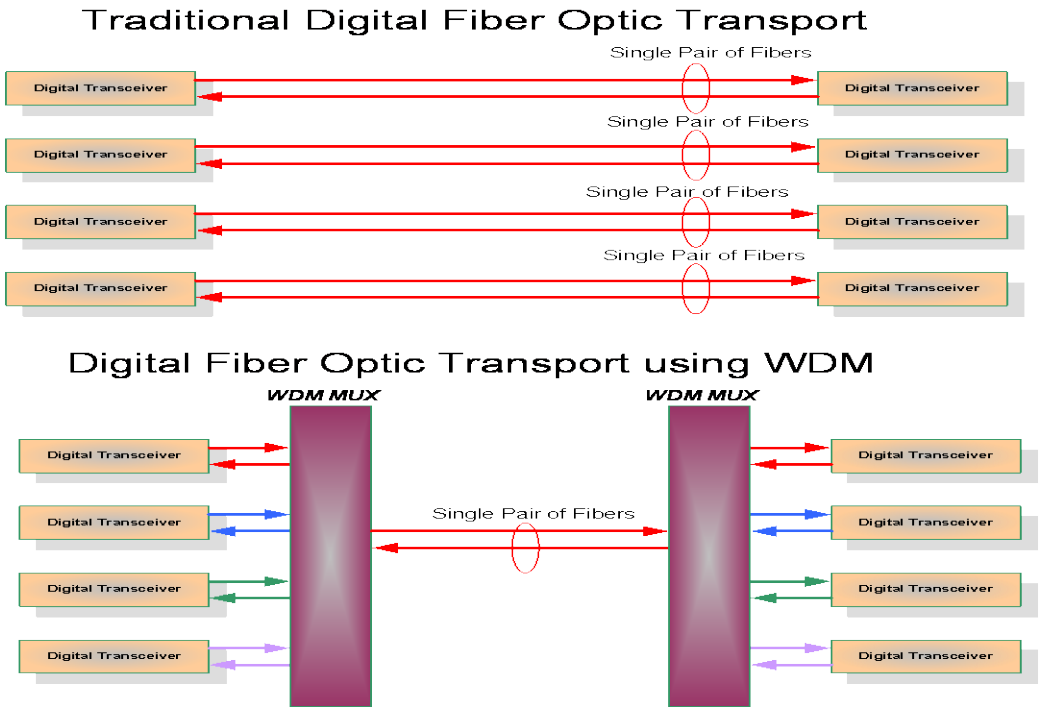

Figure 4: WDM fiber optic transponder

The principle of WDM is similar to FDM; each channel corresponds to a specific wavelength band. The theoretical limit of WDM is close to one thousand channels per fibre [4] and today's systems use 160 channels.

1.3. Erbium Doped Fiber Amplifier (EDFA)

Erbium Doped fiber amplifiers are the by far most important fiber amplifier in the context of long-range optical fiber communications; they can efficiently amplify light in the 1.5-µm wavelength region, where telecom fiber have their loss minimum.

Setup and Operation Principle

A typical setup of a simple erbium-doped fiber amplifier (EDFA) is shown in Figure 1. Its core is the erbium-doped optical fiber, which is typically a single-mode fiber. In the shown case, the *active fiber* is "pumped" with light from two laser diodes (bidirectional pumping), although unidirectional pumping in the forward or backward direction (co-directional and counter-directional pumping) is also very common. The pump light, which most often has a wavelength around 980 nm and sometimes around 1450 nm, excites the erbium ions (Er^{3+}) into the $^4I_{13/2}$ state (in the case of 980-nm pumping via $^4I_{11/2}$), from where they can amplify light in the 1.5-µm wavelength region via stimulated emission back to the ground-state manifold $^4I_{15/2}$. (See also Figure 5 in

the article on erbium-doped gain media) [7].

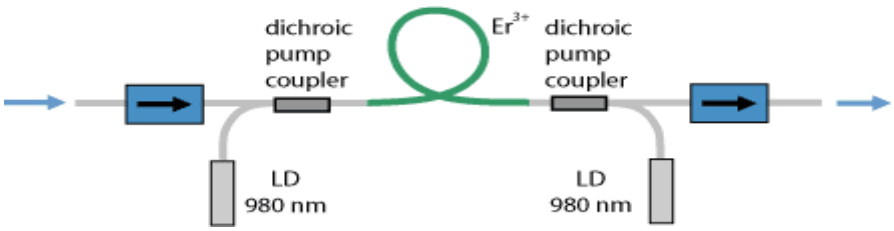

Figure 5: Schematic setup of a simple erbium-doped fiber amplifier.

Two laser diodes (LDs) provide the pump power for the erbium-doped fiber. The pump light is injected via diachronic fiber couplers. Pig-tailed optical isolators reduce the sensitivity of the device to back-reflections [8]

2. Simulation setup

The simulation has been carried out by using opt system software version 7.The system is represented by three sections: transmitter section, fiber optic section and receiver section. In the transmitter part consists of five components: pseudo random bit sequence (PRBS) generators, non-return-to-zero (NRZ) pulse generators, CW laser, filters, and external AM modulators. In this occupation we used 16 channels, with one EDFA amplifier,. The input signal was at 1558 nm wavelength. At the receiver part it shows the equipment at the customer premises. The modulators are Mach-Zehnder modulator, which is an intensity modulator based on an interferometer principle. The signals that coming from the transmitter will be combined by multiplexer and drive through Free Space Optical (FSO). The Free Space length section used for the transmission at 1550 nm wavelength.

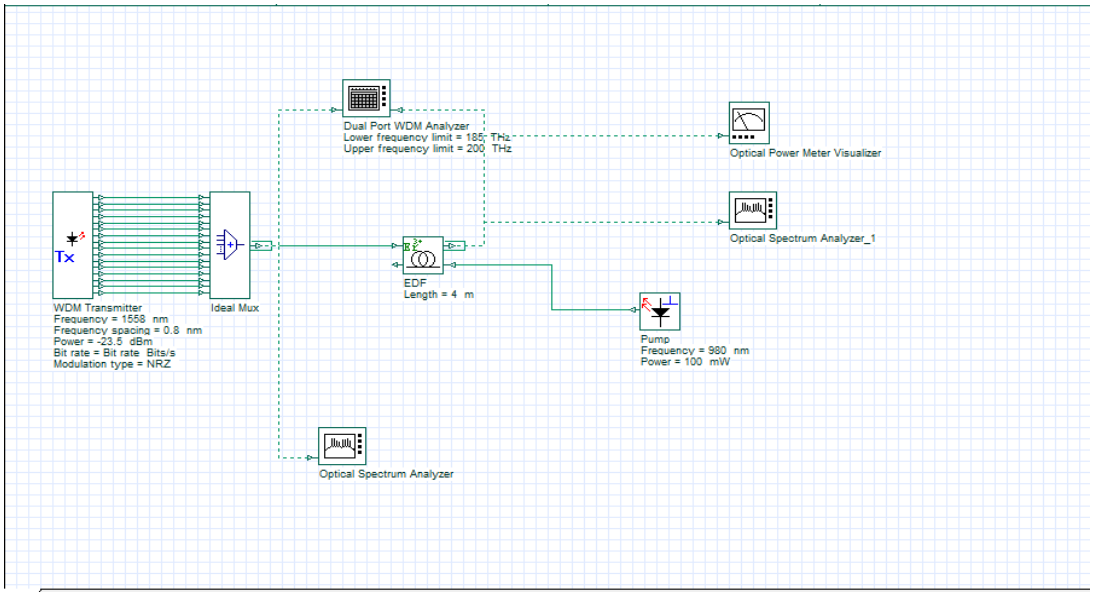

Figure 6: simulation setup system design

Figure 6 referring to the system design of the EDFA with WDM transmitter drawing by software version 7. This

system added to the free space optical channel (FSO) design to perform our system working[9].

3. Results of Experimental work

In this design the wavelength value starting from 1558.0 nm and slicing into 16 channels every chip slicing is 0.8nm so the distributed is illustrated as the table flowing:

Table 1: Specifications of 16 users

No.	Wavelength(nm)	Gain(dB)	Noise figure(dB)
1	1558.0	30.50	3.90
2	1558.8	30.13	4.27
3	1559.6	29.65	4.28
4	1560.4	29.12	4.14
5	1561.2	28.35	4.09
6	1562.0	27.85	3.87
7	1562.8	27.11	4.61
8	1563.6	26.41	4.37
9	1564.4	25.61	4.27
10	1565.2	24.83	3.98
11	1566.0	24.01	3.81
12	1566.8	23.25	4.57
13	1567.6	22.49	4.34
14	1568.4	21.64	4.14
15	1569.2	20.89	3.87
16	1570.0	20.06	3.70

The idea of this that we can transmit 16 users in the same time depending on the WDM transmitter techniques. Therefore we can use only almost 12 nm as a bandwidth for all 16 channels.

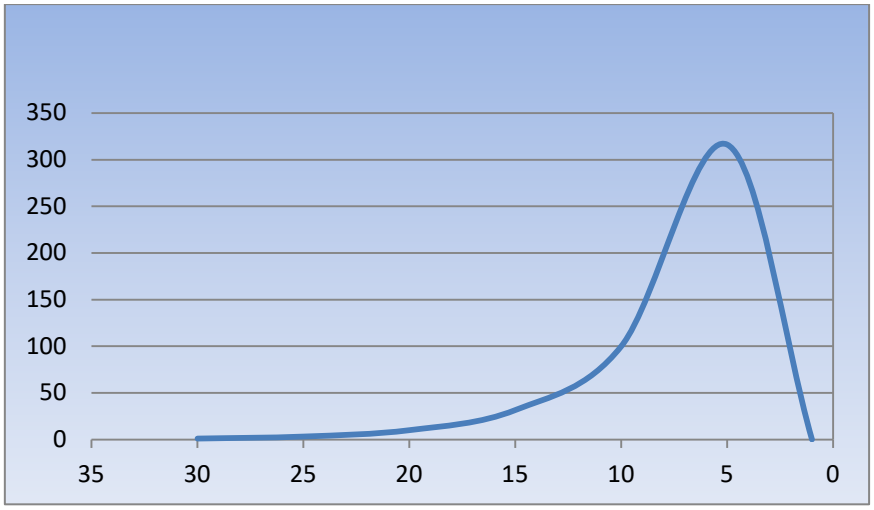

Figure 7: The variation of input power

Figure 7 referring to the variation of input power from 1mw to 1µw, the same value of BER and Eye diagram

values will remain constant, with no change. This is who the system is very stable, more than 1µw the system will be change.

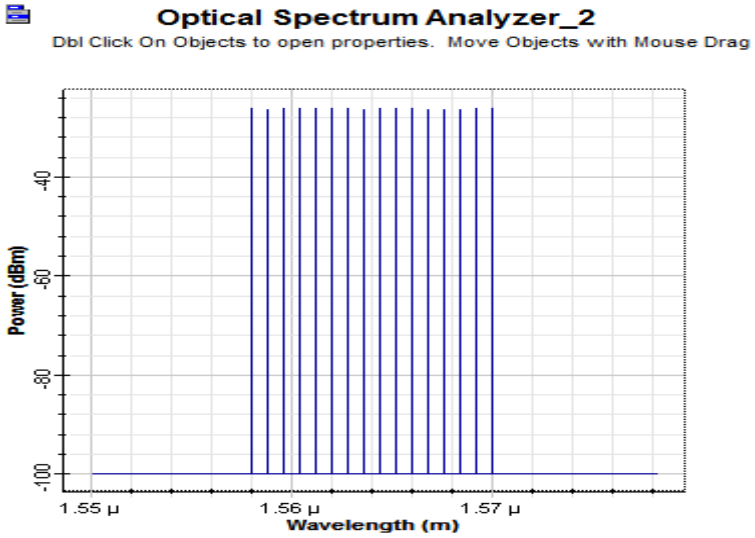

Figure 8: Input 16 user to the EDFA channel

Figure 8. shows the slicing input channel using multiplexing techniques between wavelength for 16 channels in the transmitter channel, starting from 1.65µm,ending to the 1.57µm.it mean that by almost 0.01 µm is the time interval for all 16 channels , in the second hand the power consumes is already equals to -33dBm this the useful things of this work to be transmitted from the transmitter channels to the receiver channel through the free space optics channel.

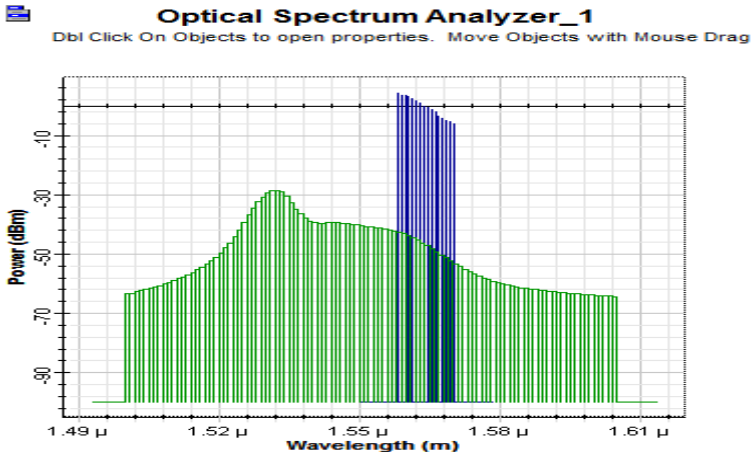

Figure 9: Signal output from the EDFA at length 4 m

Figure 9. Referring to the signal slicing of the 16 users from the EDFA stage, and the relation of power output and wavelength at wavelength changing from 1.56 µm to 1.57µm and the power is less than -5dBm.

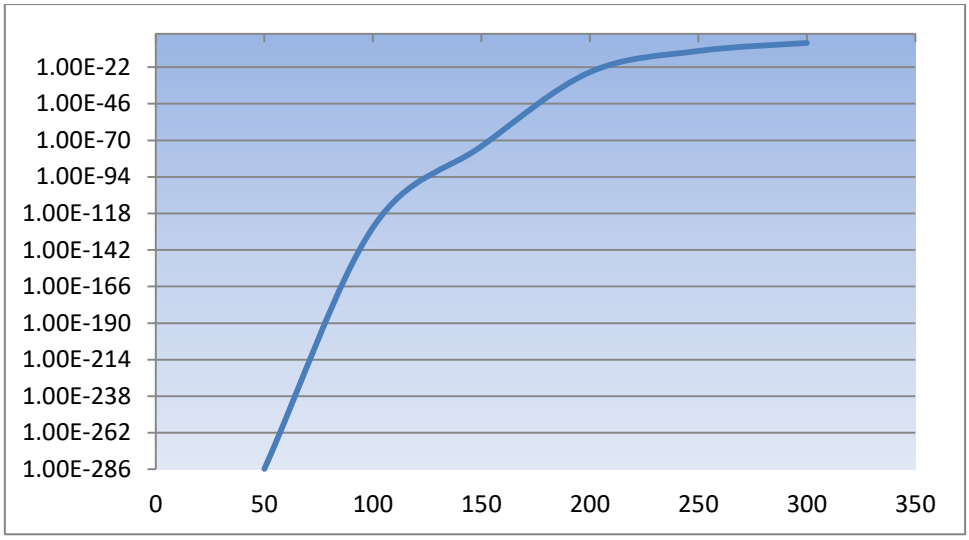

Figure 10: Relation between fiber length and BER

Figure 10 below referring to the distances fiber length maximum 300Km distance which is equal to 7.77x 10^{-7} BER value, and lower distance equal to 50 Km, 1.89 x 10^{-296} BER value. Also figure 8 showing the Eye diagram at 50Km and figure 12 the Eye diagram at 300 Km distances.

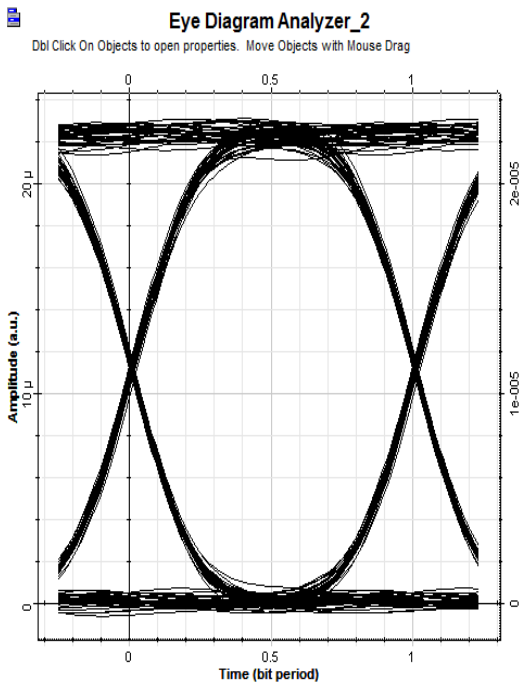

Figure 11: Eye diagram at 50 Km equal to 7

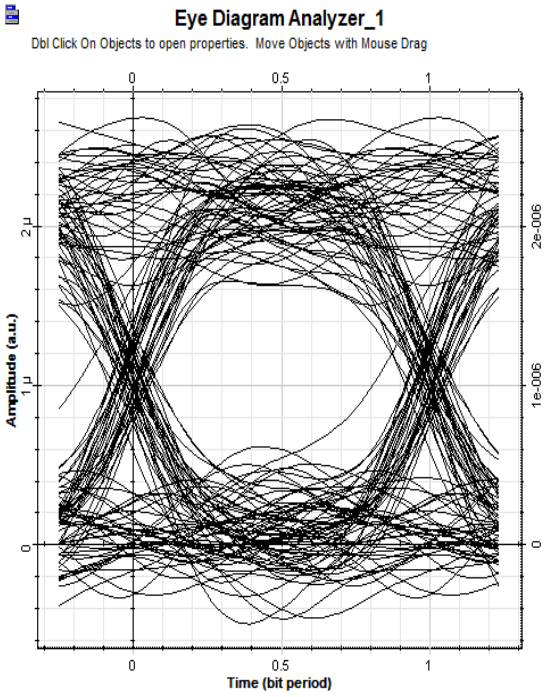

Figure 12: Eye diagram at 300 Km equal to 7.77x10- 4.72 x10^{-296}

Eye diagram is extremely active outcome can be used to present the output signals qualifications.

4. Conclusion

The idea of a system in communication is how can design transferee system with low cost in component and have large distance transmitting signal, as a result we can see this system goes to the goal, we get 300 Km distance, and using low coast in system design. Besides the new designing among 16 users included in the input channel having perfect idea, and can use another design with more than 16 users.

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