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Designing High Data Rate Long Haul Optical Communication System 96 × 80 Gb/s transmission using hybrid Raman-Erbium doped optical amplifiers with Improved Performance using DWDM

KEYWORDS DWDM, Fiber Bragg Grating, EDFA, Fiber Dispersion, NRZ format.

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ABSTRACT *We have successfully demonstrated a long-haul transmission of 96 × 80 Gbit/s over single mode fiber of 500 km respectively by using RAMAN/EDFA hybrid optical amplifier as inline and preamplifier amplifiers. The measured Q-factors and BER of the 96 channels after 500 km is 11.9408 dB and (3.22X10-33) were higher than the standard acceptable value, which offers feasibility of the hybrid amplifiers including EDFA optical amplifiers for the long-haul transmission. The maximum transmission distance that could be achieved is 500km with NRZ modulation format*

I. INTRODUCTION

The optical communication system is the system which implement for the purpose of such type of requirements. The long haul communication system for higher bit rate can be designed using DWDM technology. At higher bit rates, the modulation format, type of dispersion compensation scheme, and channel power become important issues for optimum system design. The higher bit rates for long distance communication Optical fibers are widely used in fiber optic communications which permits transmission over longer distances and at higher bandwidths than other forms of communication. Optical transmission networks based on wavelength division multiplexing (WDM) architecture is dominating the all optical data transportation with bit rates exceeding several terabit per second rates to serve the ever increasing demand of Internet Protocol (IP) networks. Some of the main TCP/IP networking functions such as routing, add-drop multiplexing and demultiplexing and wavelength conversion, need to be functional to encapsulate the IP packet requirements into the optical layer. The linear as well as the nonlinear characteristics of the optical fiber at higher bit rates, seriously limit the data transmission performance and it is therefore becoming necessary to develop approaches to improve regeneration of transmitted data.

In fiber optic communication, there is degradation of transmission signal with increased distance. By the use of optoelectronic repeater, this loss limitation can be overcome. In optoelectronic repeater, optical signal is first converted into electric signal and then after amplification it is regenerated by transmitter. But such regeneration becomes quite complex and expensive for wavelength division multiplexing systems

So, to remove loss limitations, optical amplifiers are used which directly amplify the transmitter optical signal without converting it into electric forms. The optical amplifiers are used in linear mode as repeaters, optical gain blocks and optical pre-amplifiers. The optical amplifiers are also used in nonlinear mode as optical gates, pulse shaper and routing switches . The optical amplifiers are mainly used for amplification of all channels simultaneously in WDM light wave system called as optical in-line amplifiers. The optical amplifiers are also bit rate transparent and can amplify signals at different wavelengths simultaneously. The optical amplifier increases the transmitter power by placing an amplifier just after the transmitter called power booster. The transmission distance can also be increased by putting an amplifier just before the receiver to boost the received power. The optical amplifier magnifies a signal immediately before it reaches the receiver called as optical pre-amplifier.

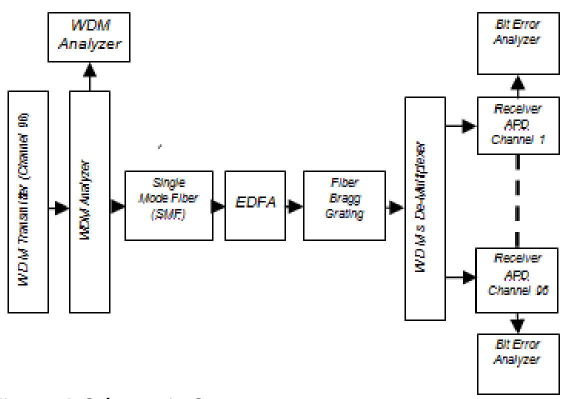


Figure 1 Schematic Setup

A 96 channel DWDM system are designed with channel spacing of 190 GHz, at the data rate 80Gbps, with the optimal parameters in NRZ modulation format to achieve the maximum transmission distance. Fiber Bragg Grating and Erbium Doped Fiber Amplifier are the key components for the implementation of high data rate long haul optical communication system. The maximum transmission distance that could be achieved is 500 km with NRZ modulation format. The long haul optical communication system designs are consisting amplifier and fiber Bragg Grating. The optical amplifiers are provided the gain factor and the fiber Bragg grating provide the fiber dispersion for long distance transmission. The Bandwidth requirement of optical communication system depends upon the number of users. Fibers are standard single mode fibers SMF with high group velocity dispersion enable larger repeater spacing and larger signal-to-noise ratio SNR. In this type of fiber, it is very important to consider the influence of group velocity dispersion, nonlinear effects, PMD, and their interplay on the transmitted signals. Increasing the capacity of optical systems may require either an increase in the bit rate, usage of WDM or ultimately both. At high bit rates, the modulation format, type of dispersion compensation scheme, and channel power become important issues for optimum system design..

The basic optical transmission system consists of three basic elements which are fiber media Transmission channel, light sources as the input convert electric signal into optic signal, and light detector as the output convert optic signal into electric signal.

Fiber Bragg Gratings is added for the design of Optical Transmission System. FBG is a key component in optical communication system as, dispersion compensators, filters and flatteners gain. FBG are very attractive components because of being passive, linear and compact, retain strong dispersion in both reflection and transmission. In the transmission section, the gratings are placed in the line with the fiber. It will achieve the maximum compression ratio.

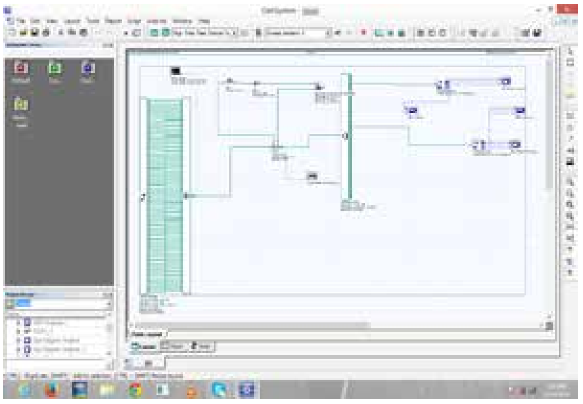


Figure 2: Simulation Setup

OptiSystem Simulator Software is an advanced, innovative, rapidly developing and powerful software simulator tool. OptiSystem offers optical transmission system design and planning from component to system level and present the analysis and scenarios visually. It can help the users to plan, test and simulate several applications such as WDM/TDM or CATV network, dispersion map design, transmitter, receiver and amplifier design and others. Optisystem is a product that does not depend on other simulation design. It is based on realistic optical fiber mode.

NRZ Coding. If the bit stream is to be sent as simply the presence or absence of light on the fiber (or as changes of voltage on a wire) then the simplest NRZ coding is possible. In this method a one bit is represented as the presence of light and a zero bit is represented as the absence of light. This method of coding is used for some very slow speed optical links but has been replaced by other methods for most purposes.

Results and discussion

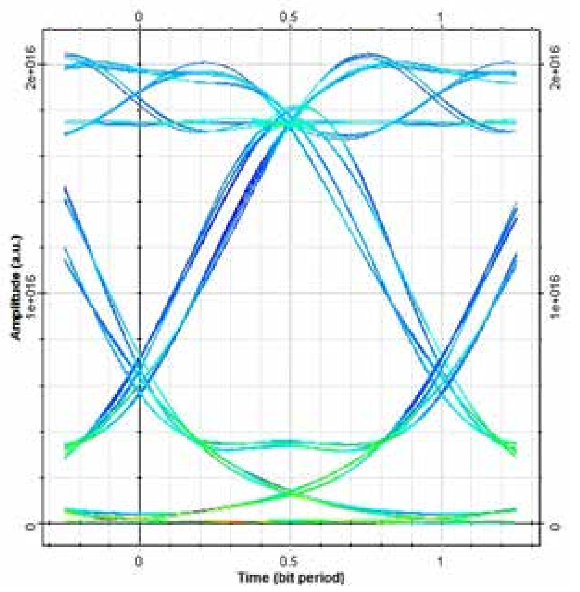


Figure 3 Eye pattern

In this project eye diagrams were used to obtain information and observe trends under varying system parameters of link length and transmission rate. The eye diagram is generated by superposition of random bit sequences, giving a statistical mean of signal pulses sequences. A properly constructed eye should contain every possible bit sequence from simple alternate 1's and 0's to isolated 1's after long runs of 0's, and all other patterns that may show up weaknesses in the design.

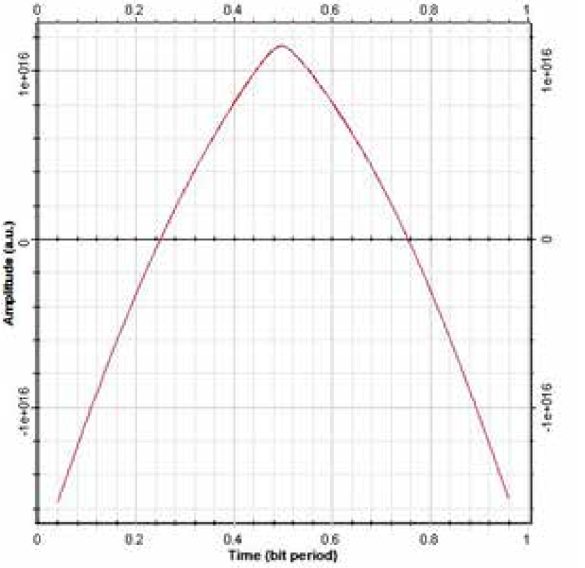


Figure 4 Eye height

Eye Openings and Eye Margins. The vertical eye opening and the horizontal eye opening are important characteristics of the eye diagram that aid in quantifying the\ signal quality. The vertical eye opening is measured at the sampling instant and is expressed as a percentage of the full eye height (not including over- or undershoots).

The horizontal eye opening is measured at the slice level and is expressed as a percentage of the bit interval.

Minimum BER

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion or bit synchronization errors.

The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. In telecommunication transmission, the bit error rate (BER)is the percentage of bits that have errors relative to the total number of bits received in a transmission. For example, a transmission might have a BER of 10-6, meaning that, out of 1,000,000 bits transmitted, one bit was in error. The BER is an indication of how often data has to be retransmitted because of an error. Too high a BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be present. The BER may be improved by choosing a strong signal strength (unless this causes cross-talk and more bit errors)

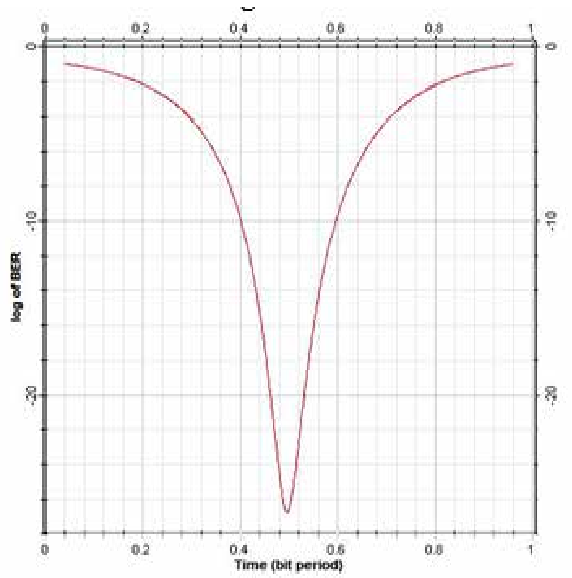


Figure 5 BER

Q-factor

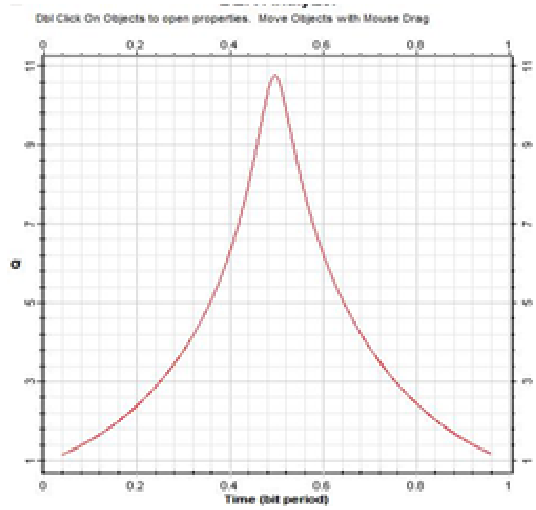
There is strong interest in understanding

and quantifying how polarization effects influence the performance of optical fiber communication systems. The most widely used

performance measures are the optical signal-to-noise ratio (OSNR), the Q-factor and the bit-error rate. These performance measures are progressively more fundamental but also more difficult to measure. Their complex relationship to each other, which is fully understood only in special cases, is significantly complicated by polarization effects. It is particularly difficult to characterize the impact of polarization effects on system performance since they are inherently stochastic in nature because of the random variations in the birefringence orientation and strength of optical fibers.

Signal-To-Noise Ratio

Signal-to-noise ratio (often abbreviated SNR or S/N) is a measure used in science and engineering to quantify how much a signal has been corrupted by noise. It is defined as the ratio of signal power to the noise power corrupting the signal. A ratio higher than 1:1 indicates more signal than noise.



Measurements recorded

NRZ simulation WDM analyzer Frequency (THz) and wavelength(nm) Characteristics for bit rate of 80Gbps at Transmitter

Frequency at min	200	200	200	200	200
Frequency at max	191	191	199.6	199.6	193.2
Wavelength at min	1498.96	1498.96	1498.96	1498.96	1498.96
Wavelength at max	1569.59	1569.59	1501.96	1501.96	1551.72

NRZ simulation WDM analyzer Frequency (THz) and wavelength (nm)Characteristics for bit rate of 80Gbps at Transmitter

Value	Signal Power (dBm)	Signal Power (W)	NoisePower (dBm)	Noise Power (W)	OSNR (dB)
Min	-20.198	9.56E-06	-72.413	5.74E-11	52.2176
Max	-13.048	4.96E-05	-69.544	1.11E-10	57.4889
Total	3.88342	0.00045	-52.915	5.11E-09	55.5698
Ratio max/min	7.14749	5.185	2.86916	1.93805	2.86916

NRZ simulation WDM analyzer Signal and Noise Characteristics for bit rate of80Gbps at Receiver

Value	Signal Power (dBm)	Signal Power (W)	Noise Power (dBm)	Noise Power (W)	OSNR (dB)
Min	-100	−1. 05E−01	-100	0.00E+00	0
Max	189.224	8. 36E+15	-100	5.19E-16	289.224
Total	189.224	8. 36E+15	-122.8	5.25E-16	0
Ratio max/min	289.224	7. 96E+16	0	1.00E+10	0

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IV. CONCLUSION

In this Paper, it is successfully shown that long-haul WDM transmissions using RAMAN/EDFA as amplifiers

for long distances of 500 km efficiently works for incorporated parameters . It is observed that at 500 km, we have an acceptable BER, Q-factor, Power and eye-opening.

After that we observed that the quality factor decreases and BER Increases . The performance of optical amplifiers was evaluated using the eye patterns, BER measurement, eye opening, Q-factor . — We have successfully demonstrated a long-haul transmission of 96 × 80 Gbit/s over single mode fiber of 500 km respectively by using RAMAN/EDFA hybrid optical amplifier as inline and preamplifier amplifiers. The measured Q-factors and BER of the 96 channels after 500 km is 11.9408 dB and (3.22X10-33) were higher than the standard acceptable value, which offers feasibility of the hybrid amplifiers including EDFA optical amplifiers for the long-haul transmission. The maximum transmission distance that could be achieved is 500km with NRZ modulation format

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