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TRANSMISSION OF NG-PON FOR LONG HAUL NETWORKS USING HYBRID AMPLIFIER

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ABSTRACT:

A hybrid configuration of Raman amplifier and erbium-doped fiber amplifier (EDFA) is proposed to obtain a better performance in term of gain, noise figure and flat gain. It is based on the optimum parameter configuration of a singly-based Raman amplifier and EDFA. The best parameter for both amplification has been analyze in terms of its input signal power, pump power and their fiber length . All the parameters are varied to some values to get the optimum result. The simulation is done by using Optisystem 15.0 software. The hybrid amplifier consists of Raman amplifier with multi-pump power set up and bidirectional pump power of EDFA with the pump wavelength of 980 nm is designed and simulated in order to obtain higher gain and lower noise figure. Using these hybrid amplifiers the GPON and NGPON Networks are implemented with suitable upstream and downstream wavelength [1310 , 1270] & [1490, 1577] respectively. The triple play service information reaches at ONU'S located at different distance with splitter ratio of 1:64 and 1:32 are taken into account for distributing information at various distances from central office. The ber, quality factor & eye diagram are calculated for GPON & NGPON Networks.

Keywords— EDFA, RFA, HOA, WDM Gain, Gain flatness

I. INTRODUCTION

Fiber optic communication has been growing at a phenomenal speed over the past few years. As the demand for transmission over the global telecommunication networks will continue to grow, only fiber optics will be able to meet this challenge. For multichannel transmission and to efficiently utilize the fiber bandwidth, the wavelength division multiplexing (WDM) is a promising technique [1]. To improve reliability and efficiency of transmission, various efforts are undertaken to transmit the information signal in optical network. For long haul communication, sudden changes in network configuration may cause abrupt changes in the signal power. To ensure a good quality at the receiver, the use of optical amplifier is required. Optical amplifiers operate completely in the optical domain unlike repeaters, to boost the power levels of various light wave signals simultaneously. Due to the effect of nonlinearities and phase noise present in the optical amplifier, the use is restricted to limited applications in optical communications. So, there is a demand of optical amplifier which provides better performance in terms of transient response, gain bandwidth, and gain flatness. There are many optical amplifiers, some are rare earth doped amplifiers and some are semiconductor based [2]. Out of all the amplifiers Erbium doped fiber amplifiers (EDFAs) are widely used because they have the property to amplify the light signals and transmit them into the third window of optical communication [3], where the minimum attenuation takes place. One problem in implementing a system with EDFA is that, the EDFA gain spectrum is not uniform. Its impulsive nature causes difficulty in implementing a smooth WDM system.

EDFA does not amplify the wavelength of all the channels equitably. Numerous compensation methods were studied in the past few years to reduce the gain variations and based on these methods efforts were made to increase the transmission capacity of the optical communication system. M. Paul et al. [4] studied the gain flatness for simultaneous 16 channels amplification in C- band. Gain flattening filter is used in order to get flatten gain. Liu Kiaxian et al. [5] presented the design of uniform fiber brag grating, the transmission spectrum of gratings and the ASE spectrum of EDFA are complementary and the output gets flattened after transmission by gratings. Thyarajan et al. [6] presented a novel Raman amplifier that have flatness gain spectrum in the range of 1480 nm - 1511 nm. R.S. Kaler et al. [7] demonstrated a two stage hybrid optical amplifier composed of EDFA and Raman amplifier for DWDM system. After extensive literature survey, it has been observed that the hybrid optical amplifier (HOA) that is formed by the combination of different optical amplifiers with distinct gain bandwidths is the most promising technique to flatten the gain profile of EDFA. The hybrid configuration of EDFA and Raman amplifier presents better performance than any optical amplifier alone can do. This hybrid configuration could have benefits of both EDFA and Raman amplifier. Hence efforts have been carried out to make an efficient construction of hybrid EDFA/Raman. The parameters used for this hybrid configuration are pumping wavelength, conc., pump power, doped fiber length etc. After the introduction, the rest of the paper is organized as follows. In section 2, simulation setup is described. Section 3 contains results and discussions and at the end, section 4 gives the brief summary of all the simulations takes place and section 5 concludes all the findings and results obtained. Recommendations for the future studies also included in this section.

II. SIMULATION SETUP

In this paper, (i)simulation setup for 8 channels WDM system is analyzed in Opti - system software. The frequency range used for the transmission is 1537.39 nm to 1548.59 nm which lies in the third window of optical communication, where minimum attenuation takes place [8]. The channel spacing used between the adjacent channels is 200 GHz. The input power for these channels are given in the order of -20dbm and bit rate of 10 Gbps is kept for the analysis. the multiplexed signals are passed through EDFA of given length(5m) and GFF(gain flattening filter) provides us with flat gain around the bandwidth. The Bit error rate , quality factor and its eye diagram are obtained for these channels.(ii) simulation is done on EDFA and

RAMAN AMPLIFER separately by pumping with suitable pumping frequency 980nm for edfa and pumping frequency for raman amplifer is kept 100nm difference from the signal wavelength in order to get amplified over large bandwidth and various pump power are used to amplify the signals. The gain and noise fiqure is calculated over these optical amplifers and results are plotted.(iii) Using these hybrid amplifiers the GPON and NGPON Networks are implemented with suitable upstream and downstream wavelength [1310 , 1270] & [1490, 1577] respectively. The triple play service information reaches at ONU'S located at different distance with splitter ratio of 1:64 and 1:32 are taken into account for distributing information at various distances from central office. The ber, quality factor & eye diagram are calculated for GPON & NGPON Network.

i) WDM simulation

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WDM -8 CHANNEL USING EDFA AMPLIFIER

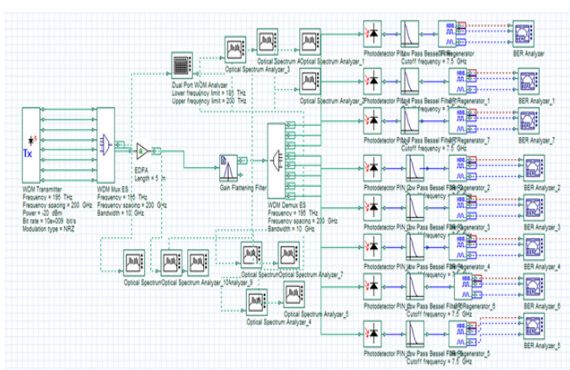


FIGURE 1.1 WDM -8 CHANNEL USING EDFA AMPLIFIER

The figure from [1.1-1.4] shows the output spectrum of wdm, EDFA output , gain flattening filter output , bit error rate and quality factor for wdm channels.

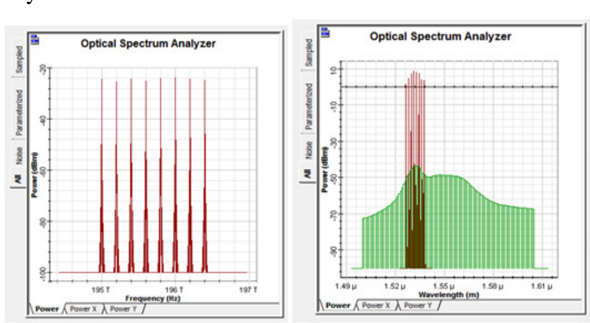


FIGURE 1.2 FREQUENCY SPECTRUM & EDFA OUTPUT

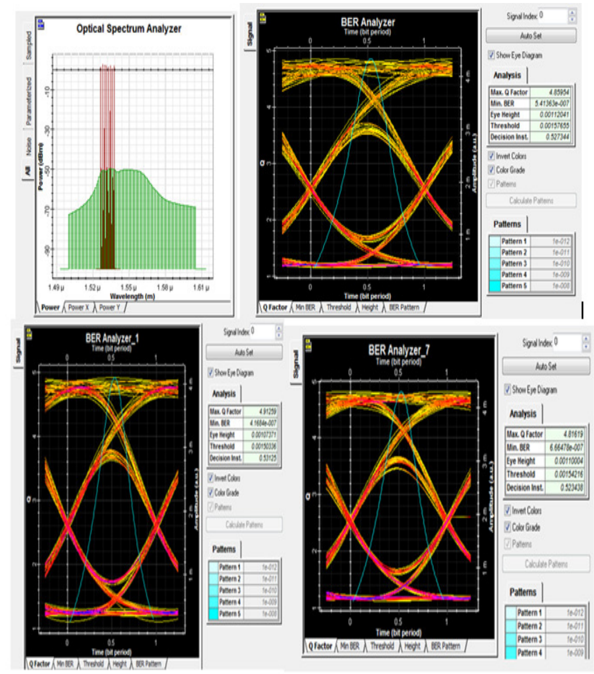
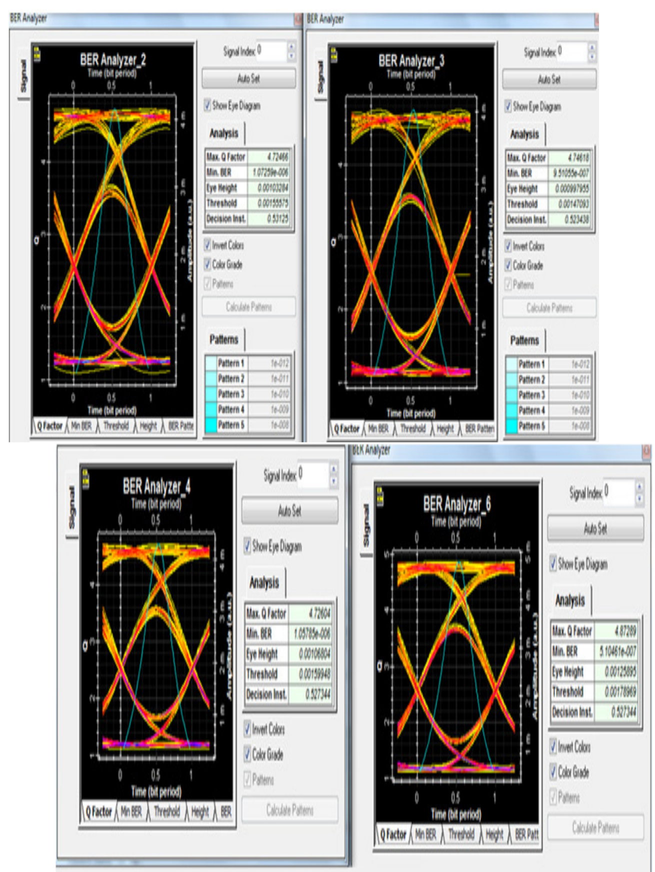


FIGURE 1.3 GAIN FLATTENING & EYE DIAGRAM



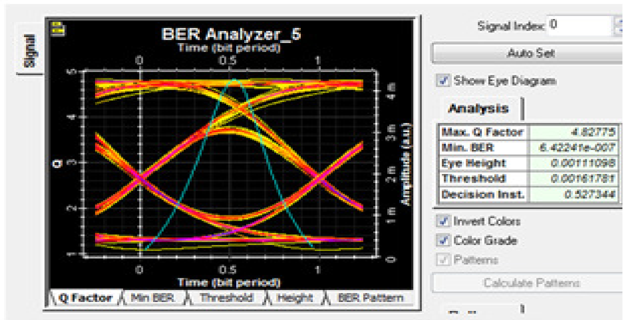
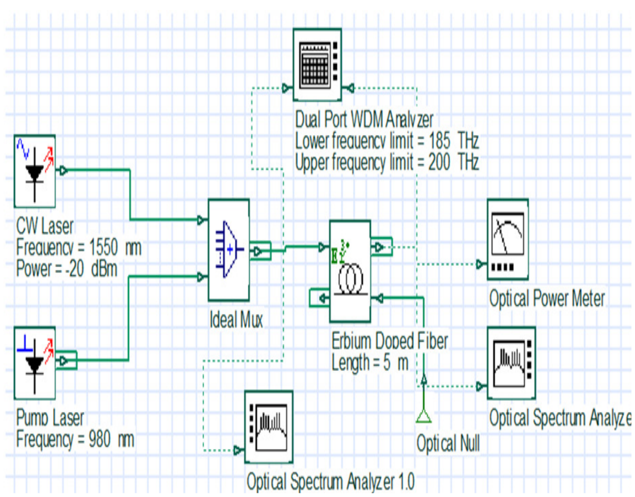


FIGURE 1.4 BER & QUALITY FACTOR

ii) a) EDFA SIMULATION

The simulation setup of EDFA consists of Continous wave laser source of 1550nm with input power of -20dbm / 0dbm is given as one input to multiplexer and another input is the pump laser with pump frequency of 980nm with variable pump power of 400mW / 800mW is provided with variable EDFA length. The gain and noise figure is calculated and its results are plotted. For less input power the gain is higher when compared to higher input power. The gain becomes moderate as input power increases.



The figure [2.1 - 2.4] shows the input and output spectrum of EDFA amplifer, gain and noise figure values for input power of -20dbm & 0dbm along with pump power values of 400 mW & 800 mW. For input power of -20db the gain reaches to 40.95db &38.70db for 800mW & 400mW respectively, for input power of 0db the gain reaches to 26db & 23.72db for 800mW & 400mW respectively. the noise figure is [3.859db & 3.864db] for -20dbm input power and [3.121&3.171]for 0dbm input power respectively.

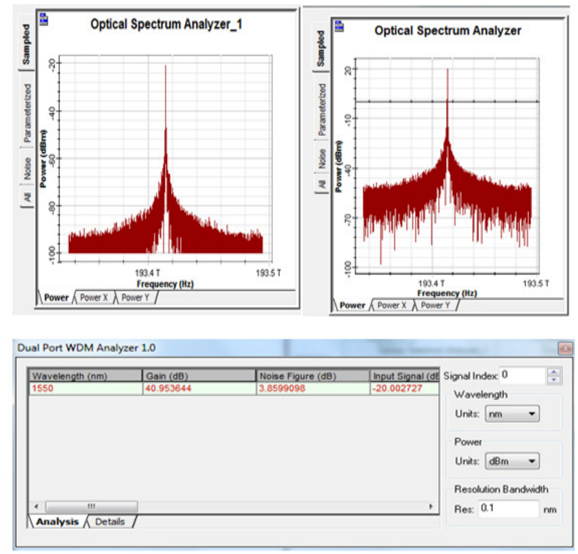


FIGURE 2.1 EDFA GAIN & NOISE FIGURE EDFA -5m POWER 800mW PUMP FREQUENCY -980nm INPUT = -20DB

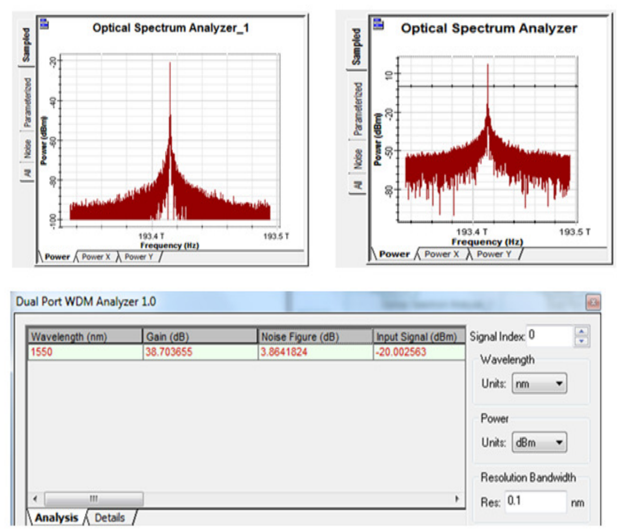


FIGURE 2.2 EDFA GAIN & NOISE FIGURE EDFA -5m POWER = 400mw PUMP FREQUENCY -980nm –INPUT =-20DB

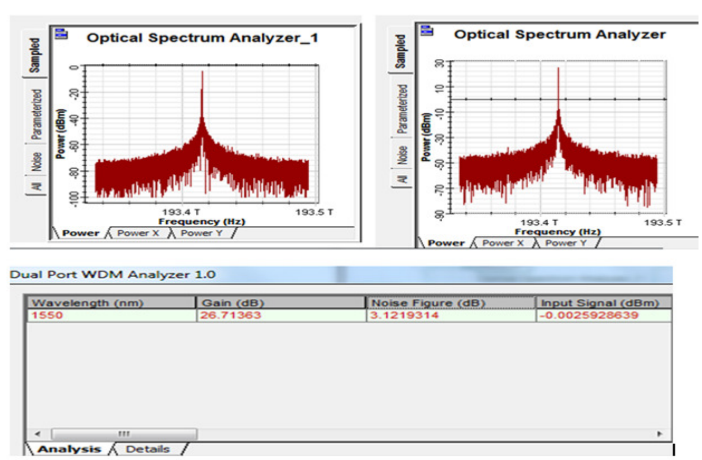


FIGURE 2.3 EDFA GAIN & NOISE FIGURE EDFA -5m POWER = 800mw PUMP FREQUENCY -980nm –INPUT =0DB

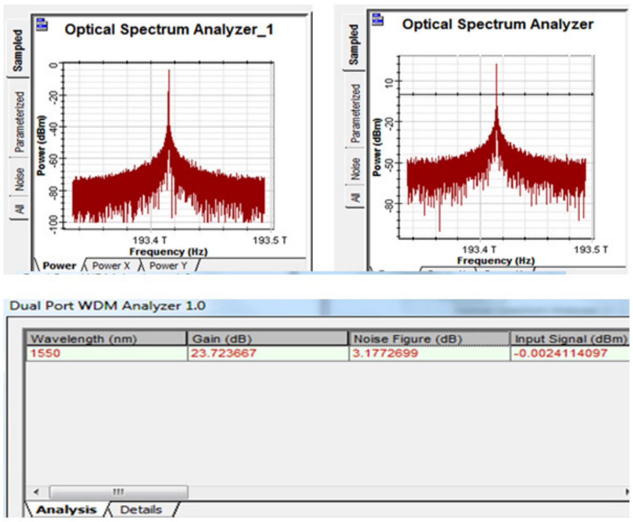


FIGURE 2.4 EDFA GAIN & NOISE FIGURE EDFA -5m POWER = 400mw PUMP FREQUENCY - 980nm –INPUT =0DB

b) RAMAN AMPLIFIER

This simulation setup deals with raman amplifer where there is no doping with raman amplifer ,the amplification purely depends upon pumping wavelength and fiber length It consists of array of CWLaser source starting with 1550nm to 1552.1nm of 0.8nm spacing between them given to multiplexer and pump laser array of wavelength just 100nm difference from the signal wavelength is provided with variable pump power to the raman amplifer of length 15km. the input signal and pump wavelength signal are counter propagated over the fiber. The gain and noise figure are calculated and input and output spectrum are also plotted.

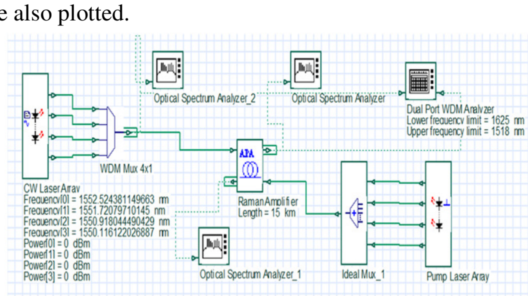


FIGURE 2.5 RAMAN AMPLIFIER

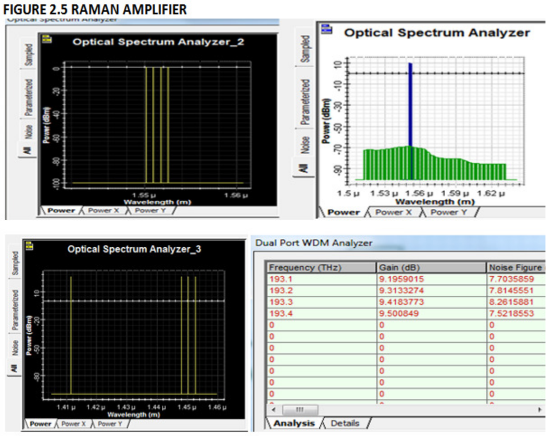


FIGURE 2.6 RAMAN AMPLIFIER GAIN SPECTRUM & NOISE FIGURE INPUT POWER = 0 db LENGTH 15 km

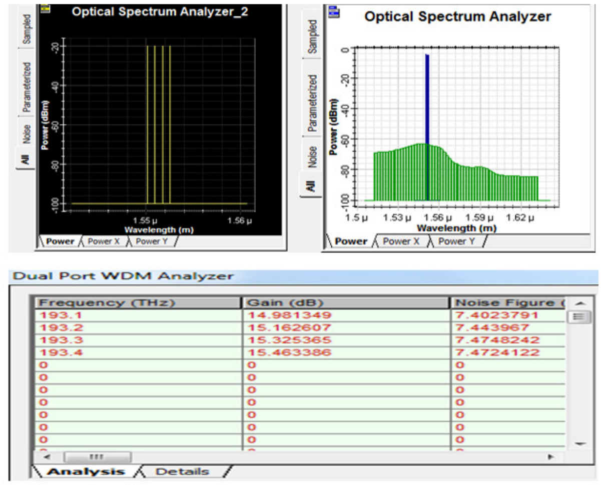


FIGURE 2.7 RAMAN AMPLIFIER GAIN SPECTRUM & NOISE FIGURE INPUT POWER = -20db LENGTH 15 km

From figure [25.-2.7]For input signal wavelength ranges from 193.1 to 193.4 and for input power of -20dbm & 0dbm along with suitable pump power the gain and noise figure are calculated. For input power of -20db the gain reaches to 14.98 db,15.16 db,15.32 db &15.46 db and its noise figure value reaches to 7.4 db, 7.44 db ,7.47 db &7.472 db respectively.
For input power of 0db the gain reaches to 9.19db,9.31db,9.41db &9.50db and its noise figure value reaches to 7.7db,7.8db,8.2db & 7.2db respectively.

III. SIMULATION OF GPON & NGPON NETWORKS

. The simulation work deals with implementation of GPON &NGPON Networks. Here the setup consists of GPON and NGPON Transmitter operating at a downstream wavelength of 1490nm &1577nm respectively. And these transmitted signal wavelength are multiplexed along with pumping wavelength with suitable power that EDFA requires for amplification. These multiplexed signals are transmitted through the bidirectional fiber over 50km and reach various ONU located at variable distance from the central office via optical splitter of 1:64 &1:32 ratio designed for gpon & ngpon networks. GPON provides 2.5 Gb/s downstream and up to 1.25 Gb/s upstream. The NGPON provides for 10 Gb/s downstream and a range of upstream speeds including the possibility of 10Gb/s. The various ONU at the receiver also transmits signals using upstream wavelength 1310nm and 1270nm designed for gpon & ngpon networks. These upstream signals are also amplified using raman amplifier pumped with appropriate pumping frequency with suitable power so as to provide a flat gain at the output. The isolator which are kept in order avoid unwanted power reflecting back to source. The band pass filter used at both sides to receive the appropriate signals to the receiver in order to avoid any unwanted frequency entering the receiver. The received signals are converted back to electrical signals using pin diode or avalanche photodiode then low pass filtered and given to 3R regenerator which would re-shape and reamplify the waveforms which is later visualized using visualizers.

The simulation is carried out for GPON &NGPON networks where Signals are reaching out for various ONU located over [50-70km] from the central office. The differential distance are also taken into account from the splitters that reaches ONU located at different distances. The upstream and downstream output are analysed using bit error rate, quality factor and eye diagram for various optical network unit [ONU] designed for gpon &ngpon networks located at different distance from the central office. A symmetric implementation will be provided giving 40/40 and 80/80 Gb/s capacity respectively that can be carried out using ngpon networks. The splitter ratio reduces as the distances increase reaching out for various optical network unit. Hence care should be taken in selecting the split ratio.

The figure [3.1-3.5] shows us the implementation of GPON&NGPON network with results of GPON upstream and downstream outputs, NGPON up/down stream outputs reaching out over 70 km from the OLT. The bit error rate and quality factor are shown using the eye diagram . Outputs of Raman/pump/combiner & outputs of Transmitter /pump power EDFA output 1&2 - GPON & XGPON are also analysed and their results are plotted.

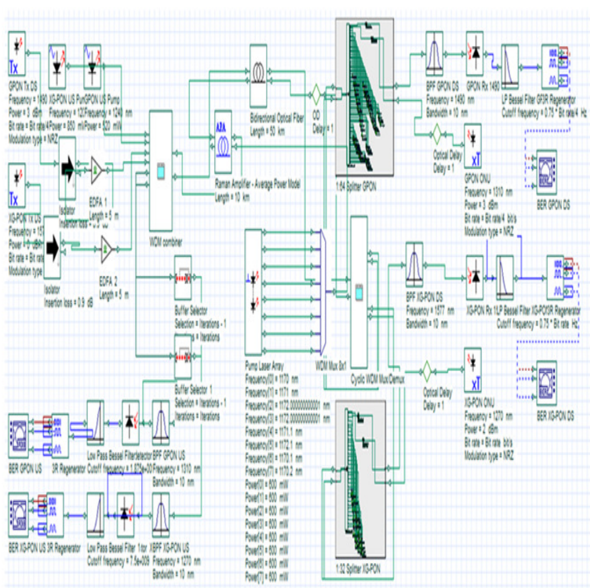


FIGURE 3.1 IMPLEMENTATION OF GPON & NGPON

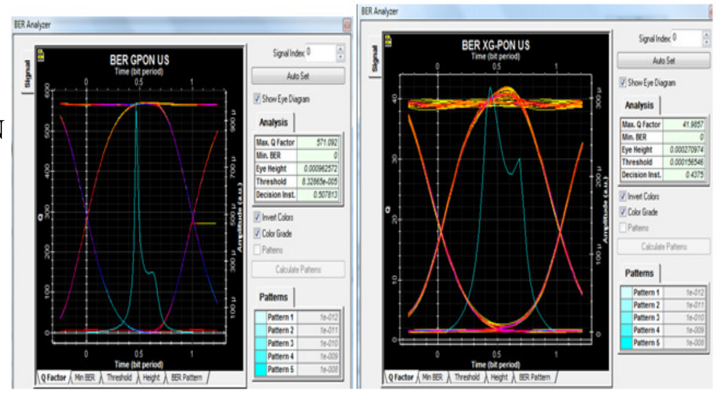


FIGURE 3.3 ONU UPSTREAM OUTPUT

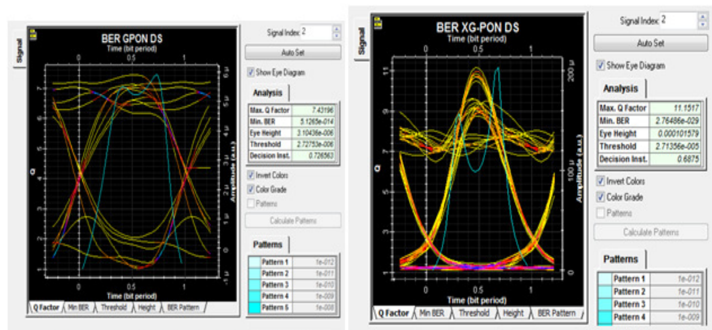


FIGURE 3.2 ONU DOWNSTREAM OUTPUT

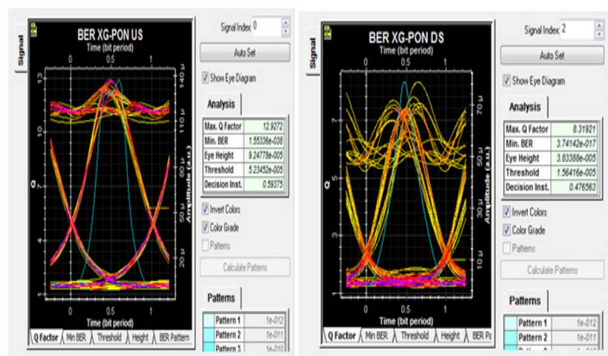


FIGURE 3.4 ONU BER & QUALITY FACTOR -70KM

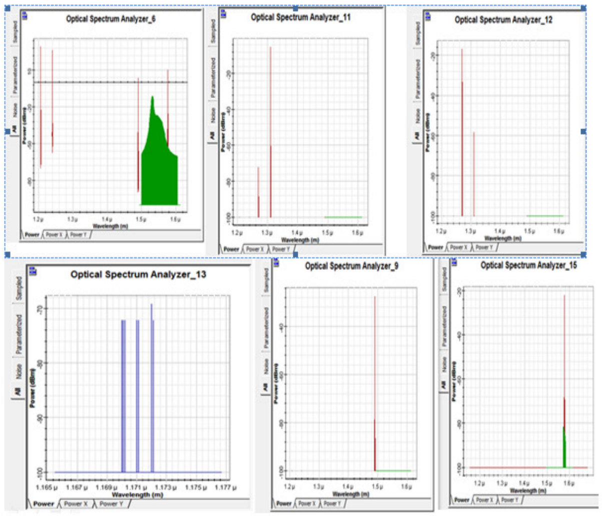


FIGURE 3.6 RAMAN/PUMP/WDM COMBINER OUTPUT

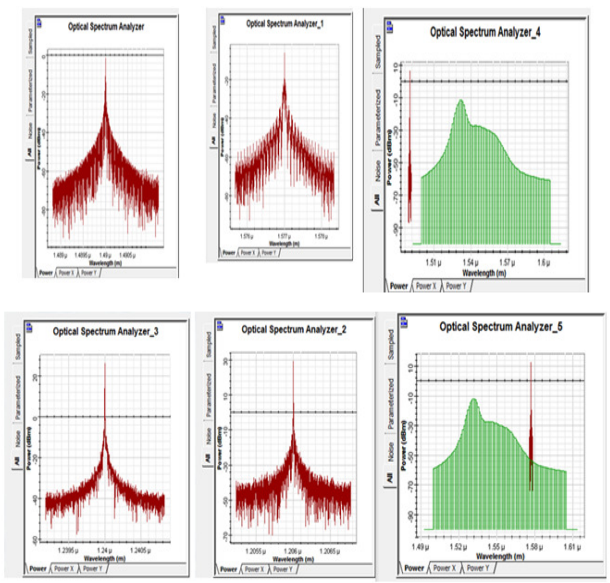


FIGURE 3.5 TRANSMITTER /PUMP POWER EDFA 1&2 - GPON & XGPON

IV. SUMMARY

The results obtained from studying and optimizing the different simulation designs are summarized in the table 1, shown below.

TABLE 1 SHOWS THE COMPARISON BETWEEN DIFFERENT AMPLIFIERS.

Amplifier used	Pump wavelength (nm)		Pump power (mW)	Gain variations	Noise figure variations
EDFA	980nm	i/p power =-20db	400 mW & 800mW	38.70db 40.95db	3.859db & 3.864db
		i/p power =0db		26db & 23.72	3.121db& 3.171db
RAMAN	1170nm,1171nm, 1172nm,1171.1nm,1172.1nm &1170.1nm		i/p power= -20db 400 mW & 800mW	Gain = 14.98db, 15.16db,15.32 db &15.46 db	7.4db,7.44 db , 7.47db & 7.472 db
				i/p power=0db gain=9.19db ,9.31db,9.41 db &9.50db	7.7db,7.8db, 8.2db & 7.2db
GPON	Downstream/upstream wavelength		1490nm &1310nm	Ber= 5.12e-014 Ber=0	Quality factor=7.43 & 571
NGPON	Downstream/upstream wavelength		1577nm& 1270nm	Ber= 2.7e-029 Ber=0	Quality factor=11.15 & 41
NGPON	Downstream/upstream wavelength		1577nm& 1270nm	Ber=3.7e-017 Ber=1.55e-038	Quality factor=8.3 & 12.92

V CONCLUSION AND FUTURESCOPE

This work deals with Transmission of GPON & NGPON over long haul Networks using wide range of optical amplifiers [EDFA and RAMAN] pumped at suitable pumping frequency and power for amplification. The upstream and downstream wavelength are carefully selected over the optical medium in order to have Reasonable gain. The splitter ratio such as [1:64 & 1:32] are used to provide integrated service such as voice data & video signals reaching various ONU [optical network unit] located at different distance from the central office unit.It has been found that EDFA provides us with good gain over 40 db with slightly increase in noise figure. Raman amplifier provides moderate gain with less noise figure over a long distance having 100nm difference between the pumping and signal wavelength. The dispersion compensation fiber is used to overcome the non linear distortion in the fiber.The simulation on GPON and NGPON is performed over bidirectional fiber reaching out various ONU located at different distances with upstream wavelength 1310 nm and 1270 nm and downstream wavelength 1577 nm and 1490 nm respectively. The optical signal to noise ratio[OSNR] and BER and quality factor is calculated for different ONU at various distances.

Implementing Hybrid amplifier at both ends to meet Reasonable BER and less noise figure. This analysis can be implemented in a WDM network for better transmission in the presence of lossy components. Suitable EDFAs with different pumping techniques can be deployed to compensate the attenuation loss. DCFs can be installed in the WDM network for longer transmission with minimum dispersion

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REFERENCES

[1] Hyo Sang Kim, Seok Hyun Yun, Hyang Kyun Kim, Namkyoo Park and Byoung Yoon Kim, "Actively Gain-Flattened Erbium-Doped Fiber Amplifier Over 35 nm by Using All-Fiber Acoustooptic Tunable Filters", IEEE photonics technology letters, vol. 10, no. 6, June 1998.

[2] M. Arumugam, "Optical Fiber communication-An overview", Journal of Physics, Indian Academy of Sciences, vol. 5, pp. 849–869, 2001

[3] Buxens, Azcoaga, Henrik Nørskov Poulsen, A. T. Clausen, and Palle Jeppesen. "Gain flattened L-band EDFA based on upgraded C-band EDFA using forward ASE pumping in an EDF section", IEEE Electronics Letters 36, vol. 9, pp. 821-823, 2000

[4] Mukul Paul Chandra, S. W. Harun, N. A. D. Huri, A. Hamzah, Shyamal Das, Mrinmay Pal, Shyamal Kumar Bhadra, "Wideband EDFA based on erbium doped crystalline zirconia yttria alumino silicate fiber", Journal of Lightwave Technology vol. 28, no. 20, pp. 2919-2924, 2010

[5] Liu. Kaixian and Du Juan, "Research of EDFA gain flattening based on chirped fiber Bragg grating", In Broadband Network &Multimedia Technology, 2nd IEEE International Conference,vol.5, pp. 418-421, 2009

[6] K. Thyagarajan, and Jagneet Kaur, "A novel design of an intrinsically gain flattened erbium doped fiber", Optics communications 183, no. 5, pp. 407-413, 2000

[7] Simranjit Singh and R.S. Kaler, "Multistage gain-flattened hybrid optical amplifier at reduced wavelength spacing", Optik-International Journal for Light and Electron Optics, vol.18, pp. 5357-5359, 2014

[8] John M. Senior, "Optical Fiber Communications", 2nd Edition, Prentice Hall of India, 2004.