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Design of WDM-PON using RSOA for Long Haul Transmission

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ABSTRACT*-long-haul wavelength division multiplexed passive optical network (WDM-PON) is introduced in this paper which enable each subscriber to get 100Gb/s speed for the first time. In this research work loopback configuration is used. Directly modulated reflective semiconductor amplifier is used in loopback configuration which reduce the cost of operation on receiver end. At the receiving end electronic equalization techniques are used to tackle the limited bandwidth issue of RSOA. Four RSOA are used in each ONU for upstream transmission and there operating wavelength is bifurcated by free-spectral range (FSR) of the cyclic arrayed waveguide gratings used for demultiplexing the WDM wavelengths. The system is designed for upto 120Km and various characterstics such as Q-factor and Bit error rate are investigated.*

KEYWORDS - Optical Network Unit, Passive Optical Network, Remote node, Reflective semiconductor optical amplifier, central office, array waveguide grating.

1 INTRODUCTION

bandwidth demand by users have noticed an explosive growth and with arrival of latest internet services like, IP television (IPTV), video conferencing, online gaming, video on demand, close user group services, VoIP etc bandwidth demand will increase in near future. To cater this increased bandwidth demand fiber based solutions are evolved like FTTH (fiber to home) which promised huge bandwidth (1Gb/s and more per user). These types of network come in category of passive optical network (PON). In these passive optical networks, passive optical components are used for example- Arrayed waveguide gratings (AWG), fiber grating sensor[1]-[2].

In a standard PON network different wavelengths are modulated by set of laser which having different wavelengths at the central unit /optical line terminal (OLT), Besides, users equipment at ONU uses different set of wavelengths for upstream transmission. However, heat induced in ONU due to wavelength drift must be stabilized by using RSOAs at the ONU.

RSOA is low cost in operation and by placing the RSOA we halt the need of laser source on ONU which reduce the cost of infrastructure required at the ONU. Hence the need of tunable laser is diminished which makes ONU and cost efficient and “colourless” [3]. While designing the system Loopback configuration is used in which RSOA are Operating at 25Gb/s in directly modulated form [4]. CWDM filters are used which add all four RSOA output and generate a 100 Gb/s signal. Butterfly packaged RSOA is used (butterfly packaging reduce the electrical losses associated with the circuit) and at the receiving end electronic equalization techniques are used which helps RSOA to operate at higher speed. Erbium doped fiber amplifier (EDFA) is used to boast the power level at the remote end.

2 PROPOSED ARCHITECTURE OF WDM–PON SYSTEM USING RSOAS

Butterfly packaged RSOA is used to reduce the effects of unwanted electrical parasitcs like(capacitance generated in components), for operating the RSOA at higher speed modulation bandwidth is enhanced to 3.3GHz which is still not sufficient for greater speed (>12 GB/s) [6]. Results shows that if we operate the RSOA at higher speed power penalties shoots up. However butterfly pacakaged RSOA can be used at high speeds (>25Gb/s). Thus, for attainment of the efficient WDM PON capable to deliever 100Gb/s service to all subscriber, butterfly packaged RSOA is used at >25Gb/s together with coarse wavelength division multiplexing technique (CWDM) at remote end. Loopback configuration is used in proposed

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network. We combined the outputs of all RSOA operating at 25Gb/s, and generate a 100Gb/s upstream signal. Thus, four seed lights are propagated towards each ONU from the central unit. For multiplexing and demultiplexing the channels at the optical line terminal(OLT) and at optical network unit (ONU) we use cyclic arrayed waveguide(AWG), and the operating wavelengths of the seed light are bifurcated by the free spectral range (FSR) of the cyclic AWGs. Each ONU can accept set of four seed lights through a single mode fiber. CWDM filters are used to bifurcate the seed light with different wavelengths at the optical network unit (ONU) these light source are directed to RSOA (which is modulated at 25Gb/s using the upstream signal). The modulated output of these RSOAs are added again by the same CDWM filter and sent back to central unit. Erbium doped fiber amplifier (EDFA) is used to boast the power level of signals at the remote end. To compensate the chromatic dispersion Negative value dispersion compensating module are placed in the optical fiber which suppress the dispersion.

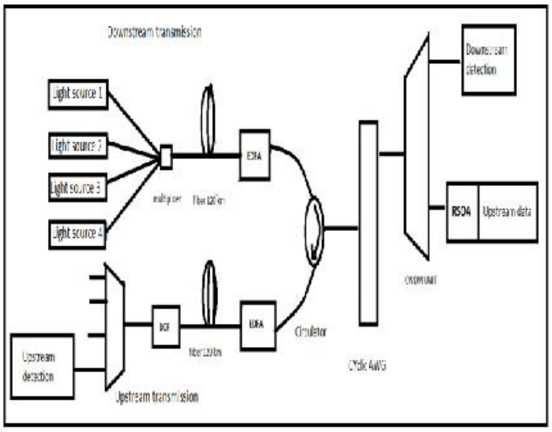

Fig 1. Proposed scheme for long reach WDM-PON capable of providing 100Gb/s service to each user

3 SYSTEM DESCRIPTION

Optisystem 14 of optiwave corporation is used for simulation. The performance analysis is done by comparing the respected Q-factor and BER with received power of all the channels at upstream and downstream transmission. The objective of this work is to analysis the100Gb/s date rate at upstream transmission link. Fig.2 demonstrated the long-haul WDM PON using the directly modulated RSOAs which provide a data rate of 100Gb/s . The length of optical fiber used is 120 Km. At the central unit(CO) we combined a set of four seed light (operating at 1530.08 nm, 1538.88 nm, 1547.68 nm, 1556.48 nm) and sent them to ONU. EDFA is used to amplify the seed lights at the remote end (RN). Different wavelengths channels are separated by free spectral range of AWG with channel spacing at 100Ghz(0.8nm). 1*4 CWDM filters are used to bifurcate the seedlight wavelengths at the ONU and sent back to RSOA by using the feeder cables. Dispersion compensating fibermodule, (DCF) (dispersion used here- 1650 ps/nm at 1550nm) used to compensate the dispersion accumulated in the fiber and Erbium doped fiber amplifier (EDFA) is used to boast the signal strength and to reduce the insertion losses associated with DCF module. However if we want to eliminate these DCF modules we can use fiber grating for compensating the dispersion accumulated in the fiber. The upstream signal is demultiplexed at OLT by using the optical bandpass filter (OBPF and Q-factor and BER are compared and analysed. Bit rate is evaluated from the received sampled data in the upstream.

Power losses are directly dependent on the wavelengths. Larger power losses occur for longer wavelengths due to increased chirp of RSOA. Due to reliance of the EDFA gain, RSOA gain, and the losses associated with CWDM filter on wavelength received power is variable for each channel.

The operating wavelength range of the proposed WDM-PON is mainly relied on the gain bandwidth of RSOA and EDFA.

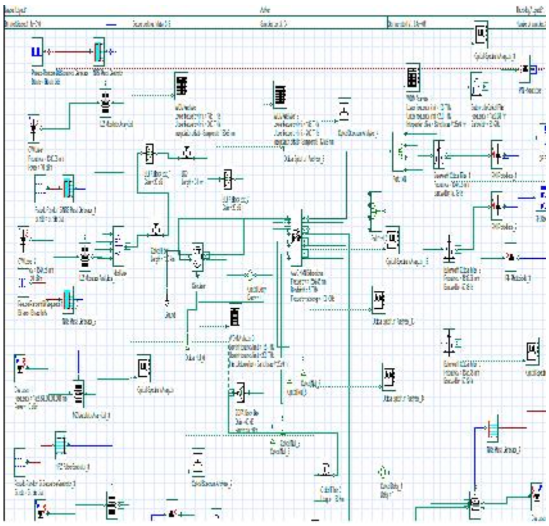

Fig.2 Long-haul WDM-PON simulation setup

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Table 1

The parameters and their values for long haul WDM PON Network

Parameter	Value
Layout Parameter	
Bitrate(Downstream),(Upstream)	10Gbps,25Gbps
Sequence length	512 bits
Samples per bit	128
Number of Samples	65536
Optical Transmitter (CW laser)	
Laser Power input, PIN	1mW,0 dBm
Frequency/Wavelength	1530.08,1538.88, 1547.68, 1556.48 nm
Laser line Width	10 MHz
Optical link	
Length (Km)	120 Km
Attenuation	0.22 dB/Km
Dispersion	16.75 ps/nm/Km
Optical Receiver (PIN Photo detector)	
Responsivity	0.9 A/W
Dark Current	10 nA

4 RESULTS AND DISCUSSION

In this research work, we authenticate the working of long-haul WDM-PON network. In WDM-PON we are using four different wavelengths (ƛ1, ƛ2, ƛ3, ƛ4) is transmitted at 10 GB/s data rate in downstream and 25Gb/s in upstream .The channels are separated by the free spectral range (FSR) of 100GHz(0.8nm). Table 2 shows the respectable BER for various channels in downstream channels and the fig.(3(a),3(b),3(c),3(d)) attached below shows the Q-Factor vs time for downstream channels. Table 3 shows the respectable BER for various channels in upstream channels and fig.(4(a),4(b),4(c),4(d)) attached below shows the Q-Factor vs time for upstream channel. The analysis shows that if we increase the distance of transmission BER reduces drastically for all the users.BER and Q-factor of different wavelengths are mentioned in tabular form. The values indicates that successful error free transmission is possible in both sides in downstream and upstream with the help of using RSOA in the upstream. RSOA significantly reduces the cost of infrastructure. However still we cannot increase our distance to (>160Km) due to insertion losses of equipment and very bad reception in upstream. Fig. 5 shows the wavelength vs received power which shows the power level at respective ends.

Table 2

Resulting parameters for downstream link

Wavelength	Q-factor	BER
ƛ1 =1530.08	9.409	1.6045e-021
ƛ2 =1538.88	10.18	7.479 e-026
ƛ3 =1547.68	9.237	8.566 e-021
ƛ4 =1556.48	6.771	4.560 e-012

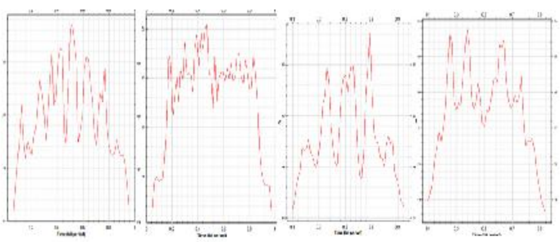

Fig.3(a) Fig.3(b) Fig.3(c) Fig.3(d)
Fig.3((a),(b),(c),(d)) Shows Q-factor vs time bit period for upstream transmission

Table 3

Resulting parameters for upstream link

Wavelength	Q-factor	BER
ƛ1 =1530.08	6.5339	2.8524e-011
ƛ2 =1538.88	6.9493	6.9493e-012
ƛ3 =1547.68	6.5309	6.5390e-011
ƛ4 =1556.48	6.4340	1.7590 e-012

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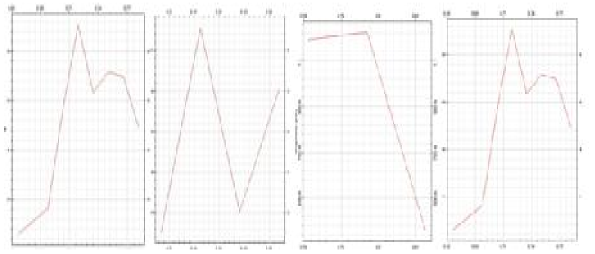

Fig.4(a) Fig.4(b) Fig.4(c) Fig.4(d)

Fig.4((a),(b),(c),(d)) Shows Q-factor vs time bit period for upstream transmission

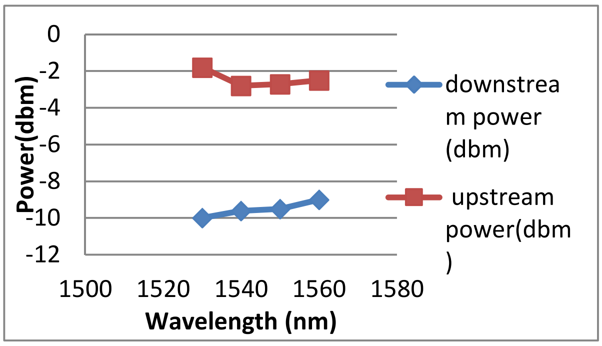

Fig.5 Received power vs wavelength for upstream and downstream transmission

5 CONCLUSION

Long-haul WDM-PON access network has been assessed in this research work and satisfactory results are produced. We demonstrated the long–haul WDM-PON upstream link with 100Gb/s with 120 km by using directly modulated RSOA. Butterfly packaged RSOA in used to minimize the electrical losses. For the 100Gb/s upstream transmission per ONU, CWDM filters are used for combining the outputs of four RSOAs functioning at 25Gb/s. The result shows that the error free transmission achieved for all four channels in both upstream and downstream direction. Results shows that long haul WDM-PON using RSOA is highly capable to provide 100GB/s service to each subscriber for distance upto 120 Km. However if we increase the distance more than 160 km received Q-factor and BER is below satisfactory levels and poor quality signal is received at both end. Hence in this research work shown that Directly modulated RSOA is highly efficient and cost effective in long haul transmission.

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