ANALYSIS OF BIDIRECTIONAL LONG REACH WDM PON

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Abstract— Passive Optical Network (PON) implementing WDM plays a vital role in telecommunication system, due to its characteristics such as low energy consumption and higher bandwidth. In a bidirectional PON both upstream and downstream transmission can be done through the same fiber. This work demonstrates an architecture of PON system based on Fabry-Perot laser Diode (FP-LD) with two cascaded Array Waveguide grating (AWG). The architecture is expected to be effective and low cost compared to standard WDM bidirectional PON. AWG is used to multiplex or demultiplex different wavelengthsin WDM PON. FP-LD is used at the Optical Network Unit (ONU) as transmitter,which re-modulate the downstream signal with upstream data and re-sent upstream towards the central office. It can reduce cost of ONU. Further more, performance analysis of various architectures of WDM PON and the effects of nonlinearities in them and the bidirectional traffic in WDM PON have been done by using OptiSystem software. Various performance characteritics such as, BER, Q Factor are investigated.

Keywords— *PON,FP-LD,AWG,ONU,BER,Q Factor*

INTRODUCTION

According to CISCO forecast Project during the year of 2011-2016 the explosive growth in global internet traffic will reach up to petabytes per minutes including video signal in the range of millions per minutes. This key driving force shifted the technology in trends towards Next generation (NGA) Access network. PONs are the most promising candidate of NGA network because of its high bandwidth provision, low cost and low maintenance .There are several TDM-PON standards are introduced for accessing. But WDM-PONs are most advantageous because of its high bandwidth demand and security .

In a bidirectional WDM PON both upstream and downstream signals are send through the same fiber . PON consist of a Central Office (CO), a bidirectional channel, and an Optical Network Unit (ONU) at user side. ONUs use a unique upstream wavelength, different wavelength transmitters must be used at the end users but the simplest solution is to use fixed wavelength transmitters so long transmission distances and high speed transmission can be achieved with this solution So, a network deployment would be expensive with increased complexity in network operation, administration, and management.

TO avoid this wavelength re-use scheme is used. By this the ONU make WDM PON is cost effective. While using wavelength Reuse scheme the ONU doesn't need any source. In which the downstream wavelength is remodulated with the upstream data. This can be achieved by using the components like AWG, RSOA, and FP-LD.

OVERVIEW OF WDM SYSTEM

The architecture of WDM-PON employs a separate wavelength channel from the OLT to each ONU, for each of the upstream and downstream directions. This approach creates a point to-point link between the CO and each ONU, In the WDM-PON, each ONU can operate at a rate up to the full bit rate of a wavelength channel. Moreover, different wavelengths may be operated at different bit rates, if necessary; hence, different varieties of services may be supported over the same network. In other words, different sets of wavelengths may be used to support different independent PON sub networks, all operating over the same fiber infrastructure. The wavelength channels are routed from the OLT to the ONUs by a passive arrayed waveguide grating (AWG) router,[1] which is deployed at a remote node (RN),by which multiple spectral orders are routed to the same output port from an input port. This allows for spatial reuse of the wavelength channels. A multi wavelength source at the OLT is used for transmitting multiple wavelengths to the various ONUs. For the upstream direction; the OLT employs a WDM demultiplexer along with a receiver array for receiving the upstream signals. Each ONU is equipped with a transmitter and receiver for receiving and transmitting on its respective wavelengths.

Since ONU deals with different wavelength it required multi wave length sources it make ONU costlier. To avoid this wavelength reuse scheme is used. Wavelength reuse scheme is obtained by the aid of elements like FP-LD,RSOA which is used at ONU. The downstream wavelength also is used to wavelength seed RSOA located at the ONU. Each RSOA is operated in the gain saturation region such that the amplitude squeezing effect can be used to remove the downstream modulation on the seeding wavelength[4] .The resulting amplified RSOA output has a wavelength identical to that of the downstream wavelength and can be directly modulated with upstream data. The downstream and upstream wavelengths specified to and from an ONU are identical.

The AWG router is an important element in many WDM-PON architectures. Figure 1 shows a conventional AWG. These devices are capable of multiplexing a large number of wavelengths into a single optical fiber, thereby increasing the transmission capacity of optical networks. The AWGs consist of a number of input (1) / output (5) couplers, a free space propagation region (2) and (4) and the grating wave guides (3). The grating consists of a large number of wave guides with a constant length increment (L).Light is coupled into the device via an optical fiber (1) connected to the input port. Light diffracting out of the input wave guide at the coupler/slab interface propagates through the free-space region (2) and illuminates the grating with a Gaussian distribution. Each wavelength of light coupled to the grating wave guides (3) undergoes a constant change of phase attributed to the constant length increment in grating wave guides. Light diffracted from each waveguide of the grating interferes constructively and gets refocused at the output wave guides (5), with the spatial position, the output channels, being wavelength dependent on the array phase shift. It has a property of cyclic wavelength routing which makes the devices for wavelength reuse scheme[7]

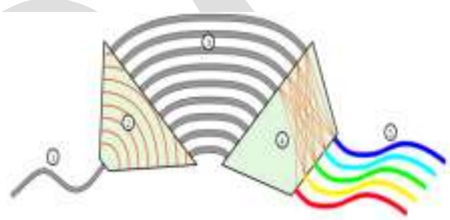

Figure 1: Conventional WDM coupler versus AWG

The FP-LD is considered a light emitting diode (LED) with a pair of end mirrors. The mirrors are needed to create the right conditions for lasing to occur. The input light will enter the cavity through the mirror on the left and will leave it through the mirror on the right. Some wavelengths will resonate within the cavity and it can pass through the mirror on the right but the other wavelengths will strongly attenuate[9]

If a random wave travels from the left-hand mirror to the right-hand mirror. At the right-hand mirror, this wave is reflected; hence, the wave experiences a 180 degree phase shift so this resonator does not support this The lateral modes will be formed in this situation .If a random wave travels inside a resonator wave. At the right hand mirror, the wave experiences a 180 phase shift and continues to propagate. At the left hand mirror, this wave again has the same phase shift and continues to travel. Thus, the second wave produces a stable pattern called a standing wave. The only difference between the two waves is their wavelengths. Thus, a resonator can support only a wave with a certain wavelength, the wave that forms a standing-wave pattern. This resonator supports many wavelengths that can form a standing wave.[11] Wavelengths selected by a resonator are called longitudinal modes. A resonator can support an infinite number of waves as long as they form a standing wave. However, the active medium provides gain within only a better shaping factor, flatter phase delay and flatter group delay than a Gaussian of the same order, though the Gaussian has lower time delay. Small range of wavelengths since a laser radiation is the result of the interaction of a resonator and an active medium.

SYSTEM DESIGN

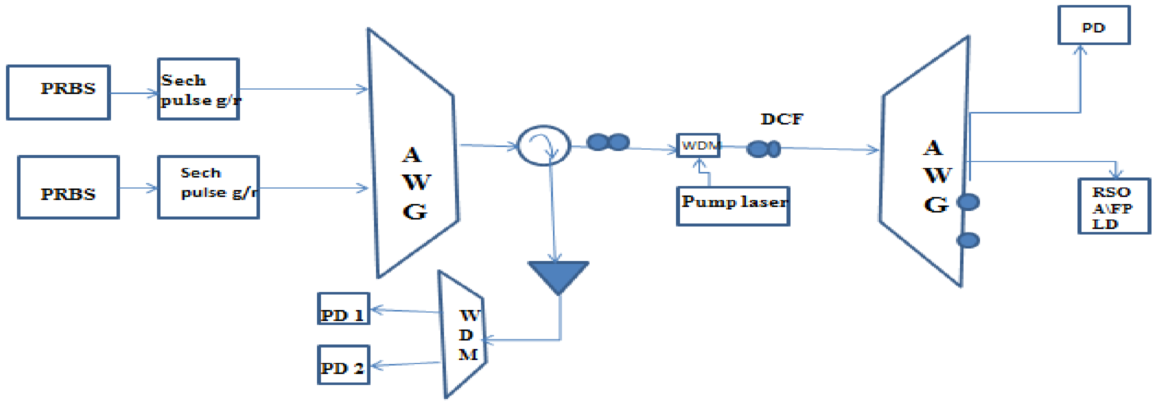

Fig 2: Architecture with sech pulse generator

Soliton pulses of wavelength 1550 and 1551 from sech pulse generator is directly modulated at downstream data 10 Gbps. We have kept channel spacing 1 nm to reduce effect of non linear and linear effect like FWM and chromatic dispersion. All those two wavelengths signals are multiplexed by using WDM MUX .After multiplexing; those entire two signals are transmitted via single mode optical fiber which is mostly used for practical application. After travelling through SMF of length 35 km, 10 km dispersion compensating fiber (DCF). The feeder fiber is compensated dispersion by a length of dispersion compensating fiber. The dispersion parameters for SMF at 1550nm are 16.75 ps/nm/km and 0.075ps/nm2/km,respectively, while those for DCF at 1550nm are -95ps/nm/km and -0.62ps/nm2/km. In the hybrid amplifier, the DCF is not only used to compensate fiber dispersion, but also used as part of Raman amplifier .Here, the dispersion compensating Raman amplifier (DCRA) is made of a Raman

Amplifier with 160mw pump power at 1480-nm and 10-km DCF. In order to boost up the signal power before the ONUs, the optical signal transmitted through feeder fiber with the help of hybrid amplifier. The analysis of backscattered signal for downstream data signal is done at circulator 1 by calculating optical power of backscattered signal. Bidirectional circulator which has insertion loss equal to 3dB. Further, all those two difference wavelengths signal are demultiplexed by AWG and which are given to 50:50 splitter. The optical power received at the ONU was divided into 50% to the RSOA and 50% to the downstream detector.The eye diagrams and Bidirectional traffic of the network is analyzed.The simulation block is shown in Fig 3

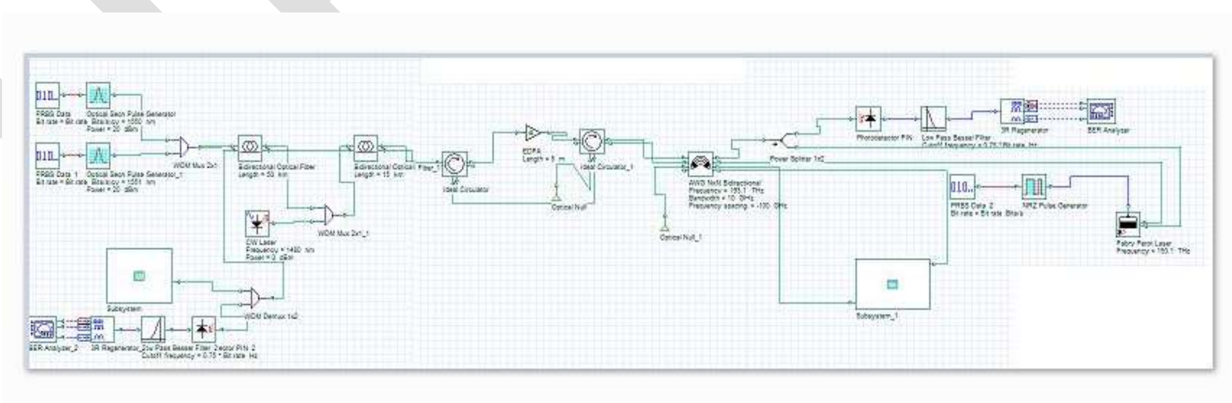

Fig 3 : Simulation Block of architecture with sech pulse generator

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RESULTS AND DISCUSSION

Length (m)	Wavelength (nm)	Power (dB)	BER	Q factor
560	1582	-1.58	$1x10^{-40}$	43
1227	1594	-1.83	$1x10^{-40}$	42
2775	1575	-2.08	$1x10^{-40}$	33
3000	1584.5	-6	$1.37x10^{-19}$	32
9000	1593	-7	$1.3x10^{-19}$	28
25000	1560	-6	$4.80x10^{-19}$	28
50000	1572	-9.5	$4.80x10^{-19}$	25
65000	1550	-10	$5x10^{-19}$	23

Table 1 : Downstream Traffic

Length (m)	Wavelength (nm)	Power (dB)	BER	Q factor
560	1582	- 0.58	$1x10^{-40}$	43
1227	1594	- 0.83	$1x10^{-40}$	42
2775	1575	-1.08	$1x10^{-40}$	33
3000	1584.5	-1.20	$1.37x10^{-19}$	32
9000	1593	-3	$1.3x10^{-19}$	28
25000	1560	-5	$4.80x10^{-19}$	28
50000	1572	-8	$4.80x10^{-19}$	25
65000	1550	-9.5	$5x10^{-19}$	23

Table 2 : Upstream Traffic

Table 1 and Table 2 gives the results of Downstream and Upstream traffic analysis .From the tables it is note that the power level is verymuch changable.This is due to the Fiber set parameters such as wavelength and nonlinearities.The power level doesn't falls below -9 dB.For the smaller transmission distance obtained much better Q factor and BER.From the analysis and comparison with other architecture (without any compensation and amplification) the network can safely operate in 65 Km transmission length, the BER is at the range of 10^{-19}.The eye diagram of Up stream and down stream signal is shown in Fig :4

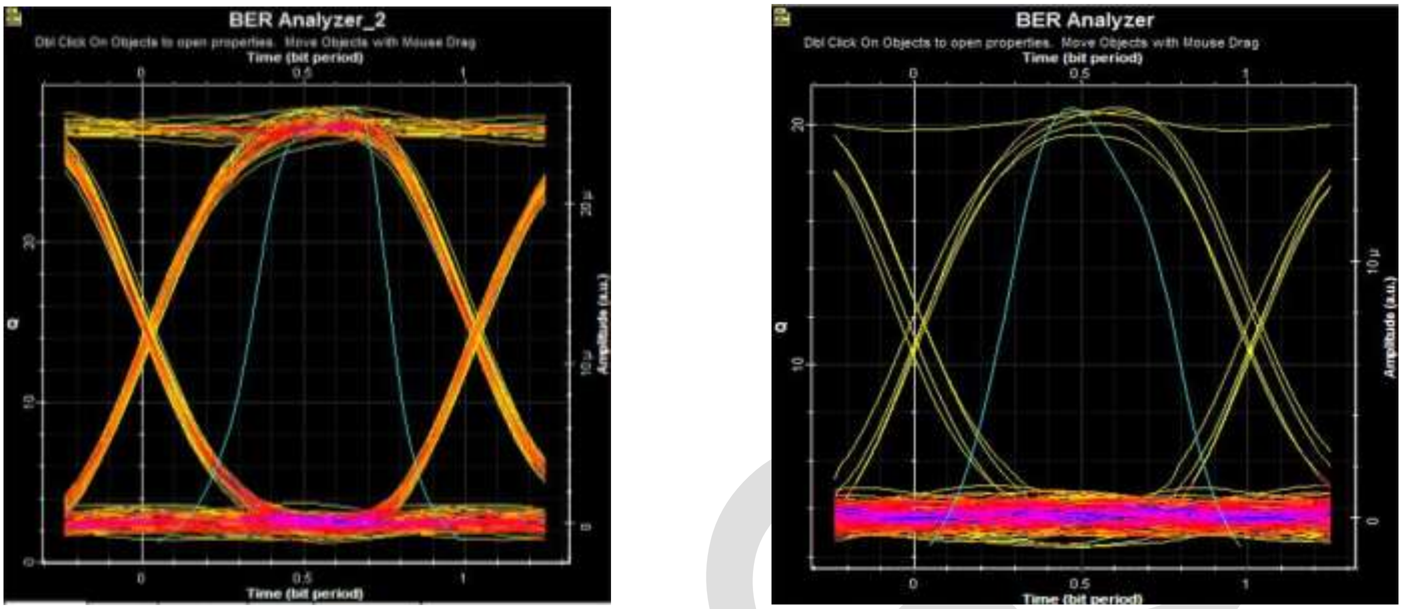

FIG. 4. EYE DIAGRAM FOR (A).DOWNSTREAM AND (B) UPSTREAM SIGNAL

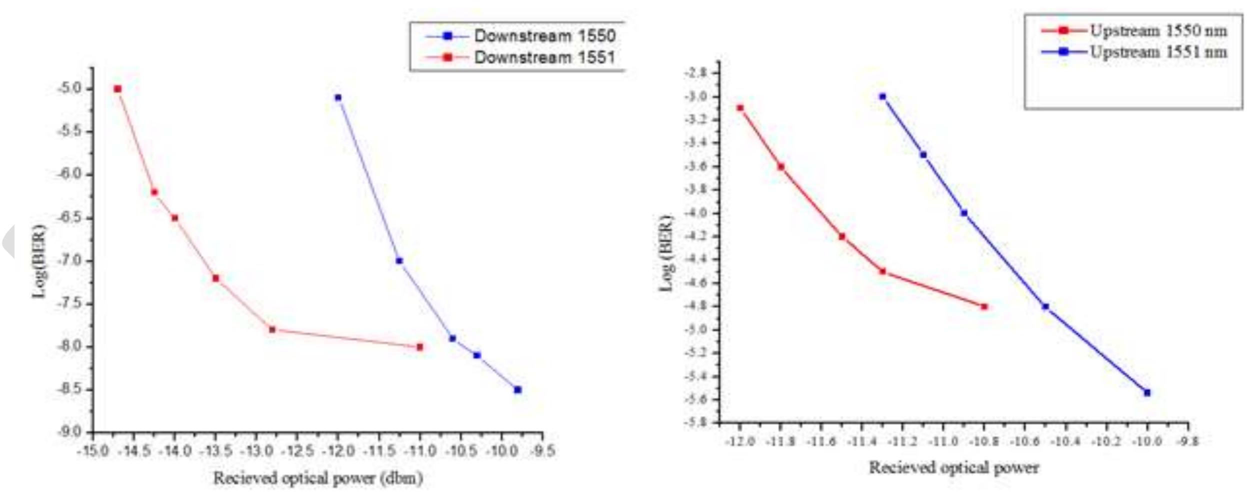

Fig. 5.Transmission performance of downstream and Upstream data

The graph above shows the variation of Recieved power with BER.At minimum BER the detected power will be high.As the BER is increasing the recieved power is decreasing.

CONCLUSION

It is successfully demonstrated that wavelength division multiplexing passive optical network (WDM-PON) system can be successfully implemented for 65Km. It delivers downstream 20-Gbps data and upstream 10-Gbps data on a single wavelength. To perform this function it uses pulse source- mode locked laser that generates a single pulse of "sech" shape with specified power and width i.e. soliton pulse. The transmission distance of the proposed WDM-PON system can be expanded while the performance is maintained.

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