Performance Evaluation of ONU in Bidirectional WDM PON

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***Abstract*—WDM-Passive Optical Network (PON) 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 single fiber. This work demonstrates architecture of PON system based on Fabry-Perot laser diode (FP-LD) and Reflective Semiconductor Optical Amplifier (RSOA) and Arrayed waveguide (AWG).This architecture is expected to be effective and low cost compared to standard WDM bidirectional PON. AWG is used to multiplex or demultiplex different wavelengths in WDM PON. FP-LD and RSOA is used at the Optical Network Unit (ONU) as transmitter. So it can re-modulate the downstream signal with upstream data then re-sent upstream towards the central office. Entire system performance characteristics for effective data transfer can be done by OptiSystem software, and the performance parameters such as Q factor, Minimum BER and eye diagram can be analyzed.**

Keywords: Wavelength Division Multiplexing,AWG , Filter, Q Factor , bit error rate.

I. 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

II 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, 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 .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

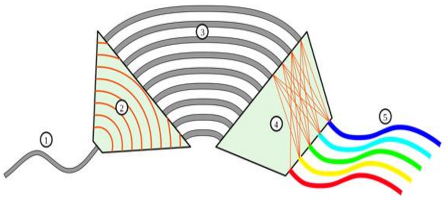


Figure 1: Conventional WDM coupler versus AWG.

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

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

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. 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.

III SYSTEM DESIGN

In downstream, CW laser with 193.1THz frequency is modulated by MZM using 10 Gbps NRZ downstream data to generate the desired downstream signal. The generated signal is sent to the first AWG at CO which multiplexed it then it is sent over the bidirectional Optical Fiber. It passes through the second AWG at RN which multiplexed the input signal again. The multiplexed signal is sent to ONU. At the ONU, using optical splitter/coupler, portion of the multiplexed signal is fed to a balanced receiver. For upstream, the other portion of the downstream multiplexed signal from the splitter/coupler is re-modulated using 2.5 Gbps NRZ upstream data by FPLD in the ONU. The re-modulated OOK signal re-passes through the AWG which demultiplexed the upstream signal then it is sent over bidirectional Optical Fiber. The upstream demultiplexed signal passes through the first AWG then it is received in CO. By using the circulator to avoid influencing the downstream signal, the upstream signal is sent to a PD is used to receive the upstream signal in the CO.

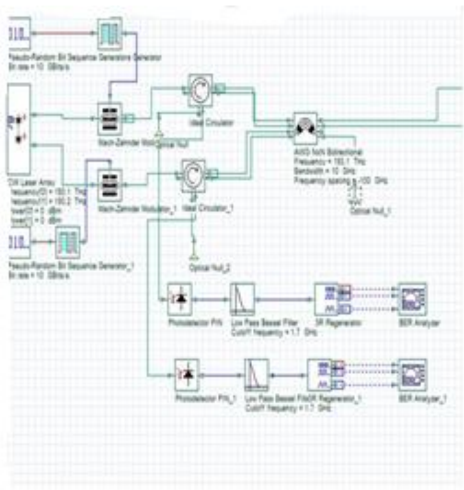


Figure. 2. Circuit diagram of FBG based demux of Bessel filter

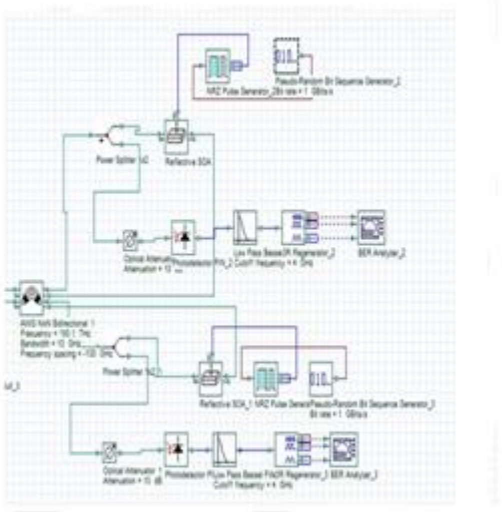


Figure. 3. Internal structure of transmitter subsystem

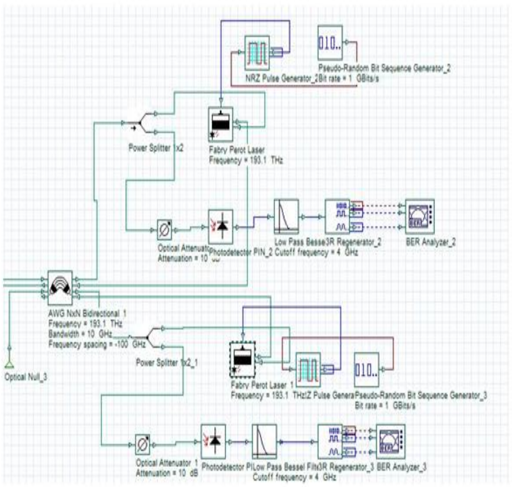
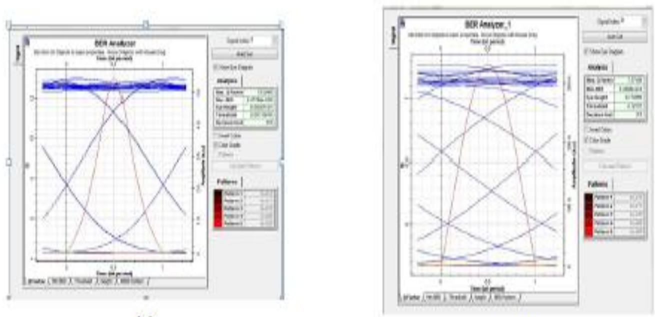


Figure. 4. Internal structure of Demux subsystem

The simulation block of ONU with RSOA is shown in figure 3 .Here RSOA is used to remodulate the upstream signal.ONU is also consist of receiver unit of downstream signal. FP-LD is also used as a remodulator for upstream data. Figure 4 is the simulation block of ONU with FP-LD as a remodulator.

IV RESULTS AND DISCUSSION

Simulation is done with the OptiSystem V.12 software and all the block for the optical detection systems are set as per the previous section to do simulation. Different types of visual parameters are used to obtain the performance analysis. The main analysis tools taken into account are Q-factor and BER.



(a) (b)

Figure 5. Eye diagram of Upstream signal (a) RSOA (b) FP-LD

The eye diagram obtained for upstream signals with RSOA and FPLD is shown in figure 5

(a) (b)

Variation of detected power with BER Upstream signal (a) RSOA (b)FP-LD

A graph is plot to show the influence of power variation on BER in upstream signal .The figure 6 (a) shows the variation of BER with detected power for FP-LD as remodulator. Here the minimum BER obtained is 1.42x10-10.The detected power at that point is -20 db. The figure 6 (b) graphs shows the variation of BER with received optical power. The minimum BER is 2x10-10.Detected power at that point is -19 dB

TABLE 1 comparison of ONUs

Architecture	Bit Error Rate	Received Optical Power(dB)	Q-Factor
Down stream (with AWG)	4.14 x10-10	-10	13.004
Up stream (with RSOA)	2.2 x10-10	-18	7.27
Up stream (with FP-LD)	4 x10-10	-11	8.95

V. CONCLUSION

The performance analysis of ONU with FPLD and RSOA is done . The Q-factors and BER values of ONU with both these components are tabularized and compared.. it is note that FPLD is better than RSOA, because the upstream BER with FPLD is lower than the upstream BER with RSOA.

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