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STUDY OF WAVELENGTH DIVISION MULTIPLEXING BASED FIBER OPTIC LINK

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ABSTRACT

Wavelength division multiplexing multiplex various optical signals on a single optical fiber by using different wavelengths of laser light at the transmitter end and demultiplex them into multiple optical signals at the receiver end . In this paper, we have simulated WDM based Single mode fiber and multimode fiber links and compared their results on the basis of bit error rate and eye pattern obtained at the receiver. We have analyzed that MMF link have better BER performance than SMF link.

Keywords--Bit error rate (BER), Multimode fiber (MMF), Single node fiber (SMF), Wavelength division multiplexing (WDM),

I. INTRODUCTION

Wavelength-division multiplexing (WDM) is a technology which multiplexes multiple optical carrier signals on a single optical fiber by using different wavelength of laser light to carry different signals. This allows for a multiplication capacity, in addition to enabling bidirectional communications over one strand of fiber. This is a form of frequency division multiplexing (FDM) but is commonly called wavelength division multiplexing. Enormous bandwidth (huge capacity of carrying information) & ultra high speed are the major advantages of WDM systems. Apart from the major advantages, it also has ability to form highly flexible networks.

Passive Optical Network (PON), short haul network & long haul network, and undersea systems are the best applications of WDM systems. Increasing demand of internet bandwidth & speed can be achieved by WDM systems only so this technology has great scope in present & the future as well. There are different types of WDM; Broad wavelength division multiplexing (BWDM), Coarse wavelength division multiplexing (CWDM) and Dense wavelength division multiplexing (DWDM).In this paper we have used DWDM. Dense WDM utilizes many wavelengths spaced narrowly, and they are most commonly located in C-Band, the wavelength range from 1530nm to 1565nm. Dense WDM requires that transmitters, optical multiplexers and demultiplexers that have very tight control over the wavelength under all operating temperature conditions. One key advantage of Dense WDM is that the gain region of Erbium Doped Fiber Amplifiers (EDFAs) is also in the C-Band, which enables the entire wavelength to be amplified to overcome loss over long spans of fiber and/or high passive losses (from splitting, multiplexing etc.) Simply one can define the Wavelength Division Multiplexing is an optical technique combines/multiplexes the multiple, unique optical signals at different wavelengths/ colors onto a single strand fiber & finally splits/ demultiplexes them into multiple, unique optical signals.

II. SIMULATION AND RESULTS

At first a digital data stream is generated by PRBS Generator, and then it is converted into electrical pulse suitable for transmission by NRZ Pulse Generator. A high frequency carrier signal is generated by CW Laser. Further Mach-Zehnder Modulator (EOM) is used for the modulation. WDM Mux is used to combine the different wavelengths/colors of light. Optical fiber is used so that signal can propagate from transmitter to receiver end. Besides this Optical Amplifier/ EDFA is used to amplify the optical signal directly. Further Optical attenuator is used to reduce the power level of an optical signal in free space or optical fiber. In case of dispersion compensation a combination of SMF & DCF is used with loop control block to just repeat the arrangement of fiber in the link .WDM Demux is used to split the different wavelengths/colors of light. Further optical signal is converted into electrical signal using PIN/Avalanche type Photo Diode. Finally a Low Pass Filter like Butterworth/Chebyshev/Bessel type is used to get back the original signal. Oscilloscope is used to see the i/p & o/p signal. Optical Power meter is used to check the power of signal before & after the fiber .BER Analyzer is used to observe the Bit Error Rate by comparing i/p & o/p signals.

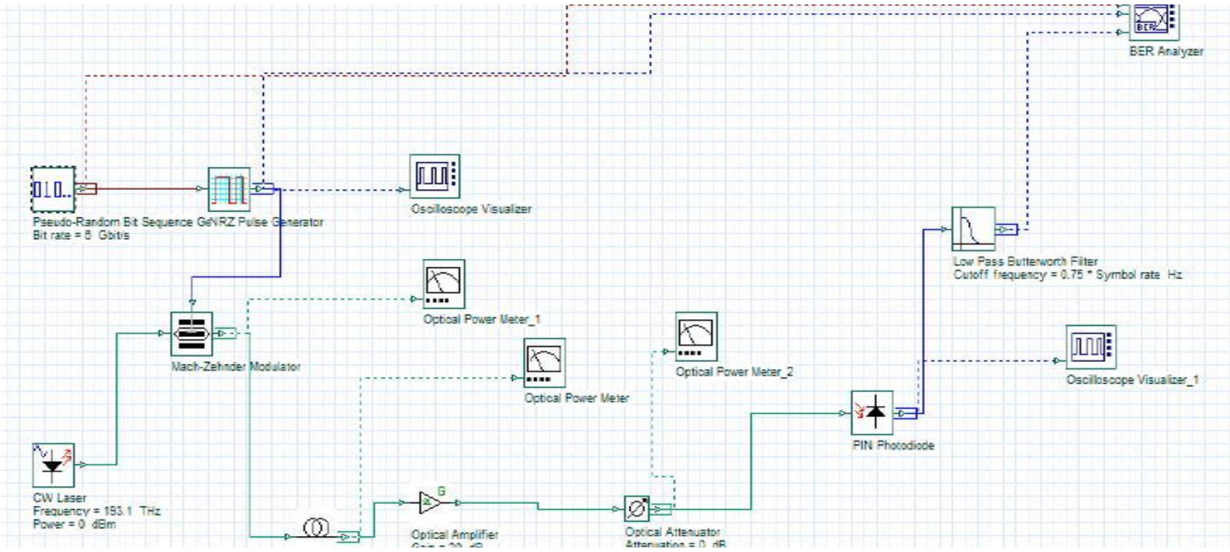

Fig. 1.1 Schematic of WDM based 1x1 SMF Link at 1310nm

In the above drawn schematic we have designed a 1x1 SMF link. Here PRBS Generator is generating a random sequence, which then passes through NRZ pulse Generator .The NRZ pulse Generator converts random sequence to non return to zero line code. The output of NRZ combines with signal coming from CW Laser and is then allowed to pass through MZ Modulator. After the signal is modulated it is passed through optical fiber, optical amplifier, attenuator, pin photodiode and filter successively. The output of filter is given to BER Analyzer where it is compared with input signal and then BER pattern is obtained.

Figure 1.2 shows eye pattern obtained for WDM based 1X1 SMF link at 1310nm. We have obtained Q factor equals to 14.89 and BER equals to10^{-50} .We have simulated the same link at 1550 nm and observed that 1X1 SMF link at 1550nm gives much better Q factor and less BER. We have obtained Q-factor 31.43 BER 10^{-217}.This is due to low loss at 1550nm as compared to 1310nm.

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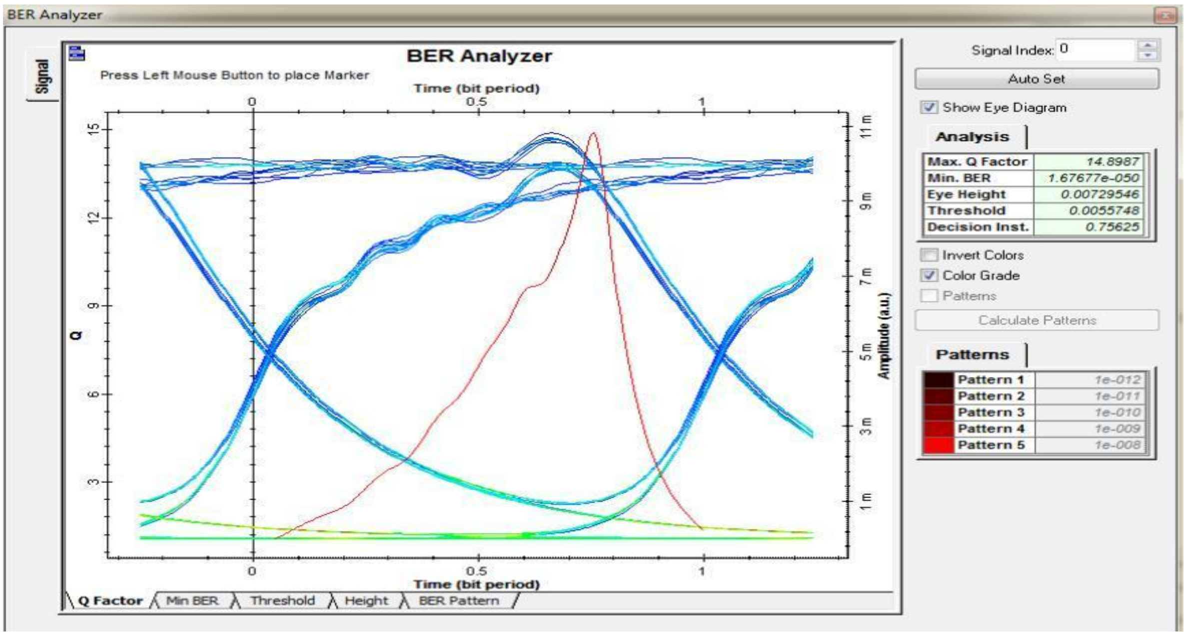

Fig. 1.2 Eye pattern obtained for 1x1 SMF Link at 1310nm

We have simulated the link for different values of data rates and we obtained that up to 4Gbps link is working. At 4Gbps we obtained BER 10^{-45}.We have also simulated WDM based 1X1 MMF link at 1550nm having data rate 4.1Gbps,we obtained Q factor 35.43 and BER almost equals to zero which is better than 1X1 SMF link. 2X2 WDM based MMF link at 1550nm has been simulated as shown in figure 1.3.

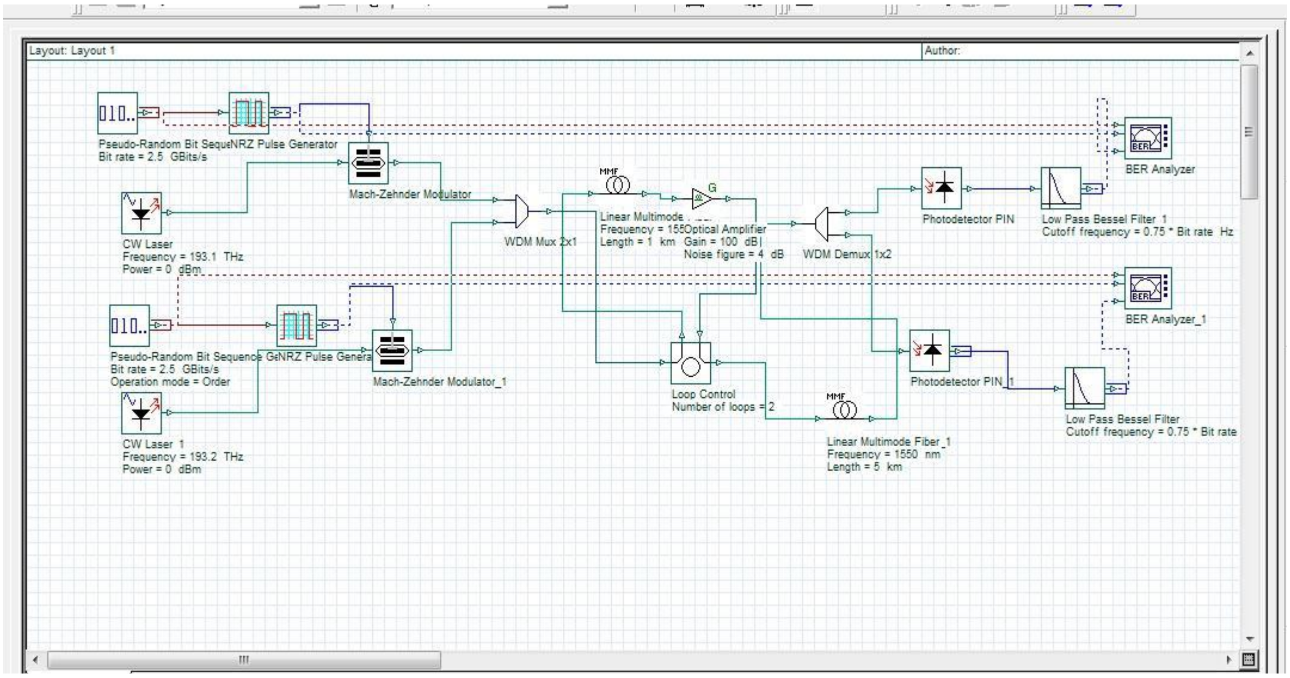

Fig. 1.3 Schematic for 2x2 MMF Link at 1550nm at data rate 2.5Gbits/s

Here we are simulating a 2x2 MMF link at 1550nm. Now we have incoming signals from two different sources the value of Bit Rate is same for both the PRBS generator. However the value of CW LASER is different and it is 193.1 THz and 193.2 THz. For Multiplexing purpose we have multiplexer at the transmitting side and demultiplexer at the receiver side. There are two BER analyzer present. The BER pattern shown by first analyzer is better than second on because in second BER analyzer cross talk is involved which causes disturbance.

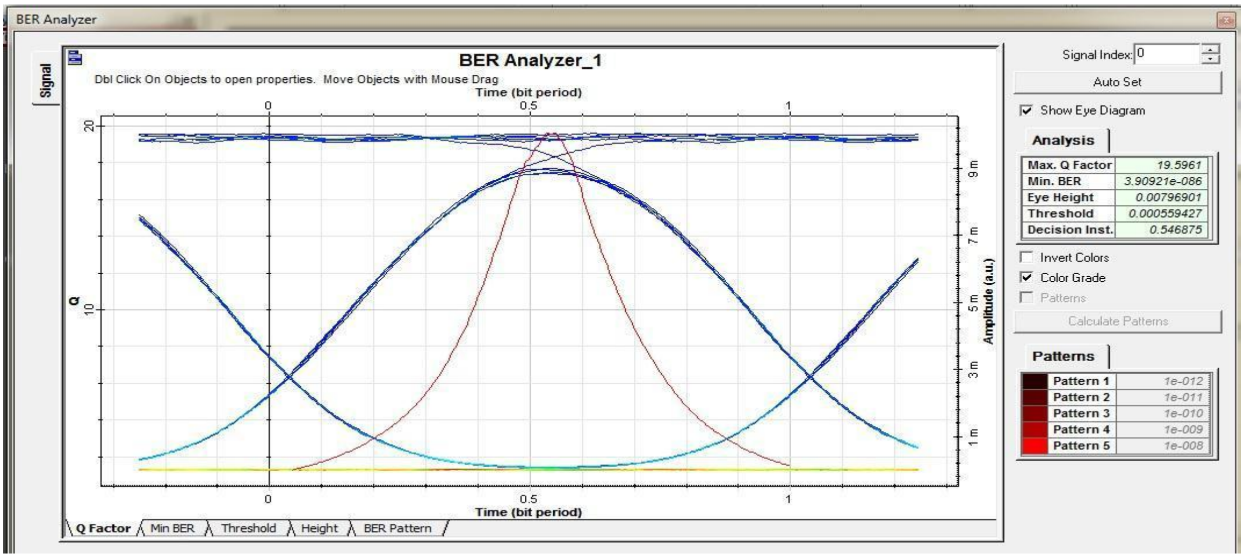

Fig. 1.4 Eye pattern obtained for 2x2 MMF Link at 1550 nm

After the simulation of WDM based 2X2 SMF Link at 1550 nm , we have obtained Q-factor 19.59 and BER 10^{-86} .After simulating the WDM based 1x1 and 2x2 link, now we have simulated WDM based 4x4 link for MMF. Unlike 2x2 link there are four PRBS Generator which are set at the same bit rate. But the frequency of the four CW laser is different .It is 193.1 THz for CW1,193.2 THz for CW2,193.3 THz for CW3 and 193.4 THz for CW4. The BER pattern obtained from BER analyzer is best for BER analyzer1 because in other three BER analyzers cross talk will be present.

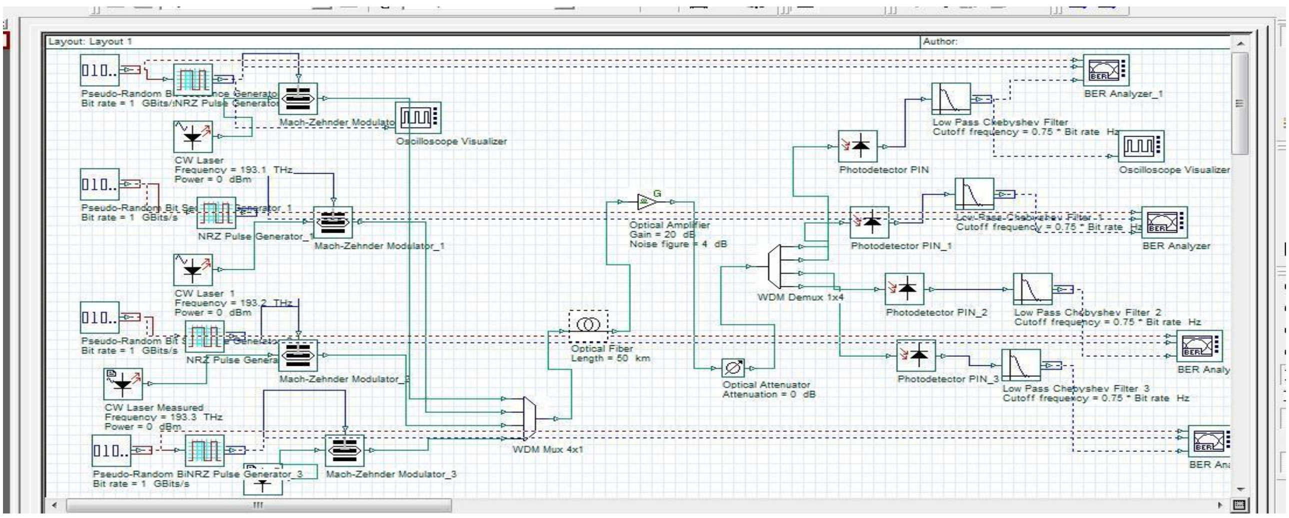

Fig. 1.5 Schematic for 4x4 MMF Link at 1550nm at data rate 1Gbits/s

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We have compared BER for WDM based 1X1 SMF and MMF link. We can see from the table 1.1 that at 1550nm with data rate approximately equals to 5Gbps MMF link have less BER as compared to SMF link.

Table 1.1 Comparison of BER for 1X1 link at same Data Rate

Data Rate (Gbps)	BER(SMF)	BER(MMF)
5.2	10^{-36}	10^{-79}
5.2	10^{-27}	10^{-45}

Table 1.2 shows different values of BER at different data rates for WDM based 4X4 MMF link. We can see that up to 4Gbps 4X4 MMF link is working.

.**Table 1.2 Data Rate v/s BER for 4x4 MMF link**

DataRate (Gbps)	BER1	BER2	BER3	BER4
1	10^{-59}	10^{-71}	10^{-106}	10^{-153}
2	10^{-29}	10^{-26}	10^{-36}	10-79
3	10^{-27}	10^{-48}	10^{-56}	10-93
4	10^{-12}	10^{-14}	10^{-15}	10^{-14}

III. CONCLUSIONS

In this paper we have determined BER for WDM based 1X1, 2X2, 4X4 SMF and MMF links. We have compared the results obtained for WDM based 1X1 and 2X2 Single Mode Fiber and Multimode Fiber link and found that MMF link is better than SMF due to less BER performance. We have also done simulation for 4X4 MMF link and found that the link works up to 4Gbps.

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