Simulation Analysis of 240gbps Hybrid OTDM System over Symmetrical Pulse Reshaping Module

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Abstract

Objective: Optical fibers are the fastest way to transmit the data or information from one place to another without any loss of data. Optical fibers are evolving since their invention, and hence number of researchers is currently working on its evolution Findings: This paper proposed a new approach in Optical Time Division Multiplexing (OTDM) at 240Gbps by incorporating using three different approaches. Different approaches consisting of transmission employing Return-Zero (RZ) transmitter for all time delayed signals, Non Return-Zero (NRZ) for signal and finally hybrid configuration Return-Zero to Non Return-Zero (RZ-NRZ). Hybrid technique is carried out to reduce crosstalk and interference among time multiplexed channels. Methods: The variety of experiments has been carried out under the controlled simulation environment with the help of optic system results reveal that very less crosstalk found in hybrid configuration. Proposed system is designed in such a way that it is capable to support 240gbps Optical Time Division Multiplexing (OTDM) over 180 km with acceptable bit error rate. Applications: The proposed technique is based on hybrid model and hence easily able to meet the huge demand for higher capacity and larger bandwidth, this system is able to provide high speed transmission.

Keywords: Hybrid System, Optical Fibres, OTDM System, Symmetrical Pulse Reshaping

1. Introduction

Our future networks should be skilled of moving several types of traffic in a dynamical manner. The growth of optical components has focused on the configuration of higher point-to-point capacity networks as a simple source to transport the essential data traffic1. There are several multiplexing techniques used for optical fiber communication including Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM) and Wavelength Division Multiplexing (WDM). With increasing demand for high capacity optical system OTDM system plays significant role to satisfy the demand2. As there is increasing demand for expanded transmission capacity, there is increase in ultra-high bit-rate light wave systems3. These increasing needs have resulted to increased attention in multi Gigabit-per-second Pulse Code Modulated (PCM) systems, and have highlighted the requirement for wide-band and high-speed electronics in light wave transmission and receiving systems. Further, it has commonly been probable to meet these demands with high-speed Si and GaAs circuits, but at Gbit/s bit rates, it gives even additional challenging to build up the essential digital electronic circuits. The method to get rid of this electronic speed limitation is to broaden the known techniques of electrical multiplexing into the optical field. Optical multiplexing is optical wavelength or frequency-division4,5 respectively multiplexing and time-division multiplexing6 are two main methodologies. Other researches related to improvement in this field have also been analysed7-12. OTDM system transmission was successfully established in (Bell Laboratory) first time. Since then, there is lots advancement in the bit rate of single wavelength channels of OTDM system. Therefore, to check the feasibility of very high-speed data transmission in fibers OTDM transmission technology is often considered being temporary technique. Signal strength can also be maximized with the help of patch antennas made by carbon nano tubes13.

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2. System Setup

In the Figure 1, the continuous wave laser source is used with 0 db line width, which is operating at 193.1 THz (1552.5243nm). The transmitter consists of fork 1*4 use to split the 60gbps channel into four channels. Four channels from the Continuous Wave (CW) laser are return-to-zero (RZ) modulated and alternatively NRZ with a different Pseudo-Random Bit Sequence (PRBS) generator. Among the four split channels each channel espouse from optical delay. Then it fed through the 4*1 power combiner. An OTDM signal is generated and passes through the 5 km single mode fiber with dispersion of 17 ps/nm/km. Then an Erbium Doped Fiber Amplifier (EDFA) is employed with gain of 5 dB. The higher bit rate of OTDM signal makes it more exposed to the Chromatic Dispersion (CD). So to compensate the dispersion, fiber length consists of Dispersion Compensating Fiber (DCF) 10 km to make the total dispersion null.

![Figure 1. System setup.](image1)

The length of DCF is 10 km with dispersion -85 ps/nm/km. At the receiver side Electro Absorption Modulator (EAM) or Mach-Zehnder Modulator (MZM) are used with PRBS and return to zero (RZ) pulse generator. PIN photo detector is use with responsivity of 1 A/W and dark current 1 nA. Low Pass Filter (LPF) is employed with cut off frequency of 0.75*Bit rate. The BER analyzer is use to measure Q value and the BER.

Three different cases have been studied in this work on 240gbps OTDM systems. In first case all four time delayed signals are using return to zero line coding for data encoding. When signal are transmitted over symmetrical dispersion compensation module, it can travel to 60km only. This travel limitation is due to bandwidth inefficiency and crosstalk effects of RZ signals due to same line coding.

In second case, all the four time delayed signals consisting of non return to zero bit format have been employed. In this case 240gbps signal travel over dispersion compensation module to 80km link distance. In this case nonlinearities are more but by using less power these limitations are overcome. In this case due to bandwidth efficiency and less crosstalk, more link distance transmission is achieved.

![Figure 2.](image2)

![Figure 3. Optical spectrum analyzer after (a) Transmitter (b) 180km.](image3)
Finally, different pulse shapes are considered to see crosstalk and non linear effect in OTDM. For realization of crosstalk immune 240gbps OTDM systems, use of RZ and NRZ pulses has been done for alternate time delayed signals. Majorly two advantages for hybrid transmission have seen of better performance and less crosstalk. Signals are time delayed to realize OTDM and suffer from less crosstalk moreover due to different pulse shapes very less interference is observed in this case. RZ pulse has been taken for first signal, NRZ for second and again RZ for third and finally NRZ for last signal. System is capable to travel over 180km in acceptable BER range.

3. Result

OTDM system in this work operated on 240gbps and 60gbps for one channel by providing time delays. Carrier is measured after transmitter with the help of optical spectrum analyzer. Optical spectrum analyzer shows frequency with respect to power. It is able to show even multiple carrier signal operated at different frequency ranges. Spectrum is shown after transmitter and 150km to see degradation in case of hybrid transmitter as shown in Figure 2.

As same as OSA, optical time visualizes depicts multiplexed data after optical time division and after 150 Km. After travelling through link distance 150 Km crosstalk and power degradation of data is observed as shown in Figure 3.

Figure 4. Optical time domain visualizer data measurement after (a) Transmitter (b) 180km.

After transmission, signal to noise ratio also studied in three cases and results revealed that maximum OSNR is in case of hybrid transmitter module as shown in Figure 4. With the increase of distance signal to noise ratio decreases. But maximum reduction found in same Rz transmitter and least in hybrid transmitter.

Further, Graphical representation has been shown in a Figure 5 with Q-factor and distance for three different schemes.

Now, demultiplexing is carried out with clock signal and MZM modulator for first channel and other channels by providing respective negative delays. Decoded bit for first channel is given in 3.4. From all peaks, only first channel data is extracted from all data as shown in Figure 7 and 8.

Figure 5. Optical time domain visualizer data measurement after (a) Transmitter (b) 180km.

Figure 6. OSNR vs distance.
For decision and maximum supportable data and distance, observations are taken from bit rate analyzer. It shows Q-factor, BER which tells that q-factor should be more than 6 and BER less than $10^{-9}$. Eye diagrams also depicts in Figure 9-11 for three different setups.

![Figure 7. Q-factor vs distance.](image)

![Figure 8. First channel data after decoding.](image)

### 4. Conclusion

A new approach in optical time division multiplexing at 240gbps has been done using three different approaches. Different approaches consisting of transmission employing RZ transmitter for all time delayed signals, NRZ for signal and finally hybrid configuration RZ-NRZ. Hybrid technique is carried out to reduce crosstalk and interference among time multiplexed channels. Results revealed that very less crosstalk found in hybrid configuration. Proposed system’s capable to support 240gbps OTDM over 180km with acceptable bit error rate.

![Figure 9.](image)

![Figure 10.](image)

![Figure 11.](image)
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