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Minimizing ISI And Maximizing Bit Rate Capacity Using OFDM Introducing To WDM Based Optical Network System

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Abstract
Orthogonal frequency division multiplexing (OFDM) is an attractive modulation format that recently received a lot of attention in the fiber-optic communication. The main advantage of optical OFDM is that it can cope with virtually unlimited amount of intersymbol interference (ISI). In high-speed optical transmission systems, ISI is caused for instance by chromatic dispersion of the fiber optic cable and it is serious issue in long-haul systems whose bit rate is higher. High order dispersion such as a third-order and higher-order dispersion effects are not fully compensated using the traditional dispersion compensating devices such as Dispersion compensating fiber (DCF), Optical Filters etc. Thus the received signals at the receiver end would be distorted dramatically, even if only a small outside effect affects the transmission link.
Generally this work devotion to evaluating the performance of wavelength division multiplexing (WDM) in terms of capacity and ISI, investigating the effect of introducing OFDM on the performance of the WDM optical network, and comparing the performance of WDM and OFDM based WDM optical networks by using opt software simulator.
***Key words**: ISI; WDM; OFDM; DCF; BER and Data Bit Rate*

1- INTRODUCTION

1.1- BACKGROUND

OFDM has been widely employed into numerous digital standards for broad-range of applications such as digital audio/video broadcasting and wire line/wireless communication systems [1]. Many key merits of the OFDM techniques [2] have been studied and proven in the communications industry. Recently, an equivalent optical domain multi-carrier format, called coherent optical OFDM has been proposed for long haul transmission [3].DCF is one of the dispersion management methods to recover signals after a period of distance. However, dispersion slops compensation and WDM transmission is very hard to fully compensate especially for very high date rate signals. Therefore, the equalizer systems which i.e. phase modulator is used before receiver and the equalizer is used to compensate not only group velocity dispersion, but also for third order dispersion [4, 5].

Coherent Optical OFDM is considered an enabling technology of the next generation optical communication system [6]. As a coherent system, the OFDM system maintains both signal amplitude and phase [7], thus increasing bandwidth utilization. The coherent optical communication system makes full compensation of chromatic dispersion, after optical/electrical conversion, possible. OFDM is a multicarrier transmission technique where a data stream is carried with many lower rate subcarrier tones that are high bit rate data stream is divided into several low bit rates streams that are simultaneously modulated onto orthogonal subcarriers. The OFDM modulation scheme also leads to a high spectral efficiency because of its partially overlapping subcarriers [8].Moreover, the cyclic prefix code of the OFDM system makes the system more resistant to ISI caused by chromatic dispersion and polarization mode dispersion (PMD) [9, 10].

1.2- STATEMENT OF PROBLEM

In current high-speed optical fiber transmission systems, ISI is caused for instance by chromatic dispersion of fiber cable and it is serious issue in long-haul systems whose bit rate is higher. To reduce this dispersion effect of WDM optical network uses dispersion compensating fiber (DCF) and is one of the dispersion management methods to recover signals after a period of distance. However, dispersion slop compensation and WDM optical network is very hard to fully compensate especially for very high date rate signals. As higher data rate requirement for this OFDM introducing is very important to minimize the effect of ISI and increasing capacity in optical fiber communication (OFC) link.

1.3- PROPOSED SOLUTION

As in the result discussion stated, the solution of the problem in WDM based optical system is introducing OFDM to increase the data capacity rate in the same fiber as decreasing the ISI or bit error rate (BER) occur by fiber dispersion in WDM system in OFC link. Therefore, the significance of the work is to reduce the ISI effect in OFC due to different cause of fiber optic dispersion and increasing number of users by minimizing ISI or BER.

2- SYSTEM MODELING OF WDM OPTICAL NETWORK

As in figure 1 shows WDM based optical network system design consists all the parts of OFC link, like transmitter, receiver and optical fiber cable, and the design parameters as Bit rate minimum and maximum values (10,100 or 250Gb/s) for the proposed system, Fiber attenuation (0.2dB/km), fiber length (100km), fiber dispersion (16ps/nm/km), minimum number of users four (4) and DCF length (20km). Figure 1 shows system design for four users with a Single Mode Fiber (SM).

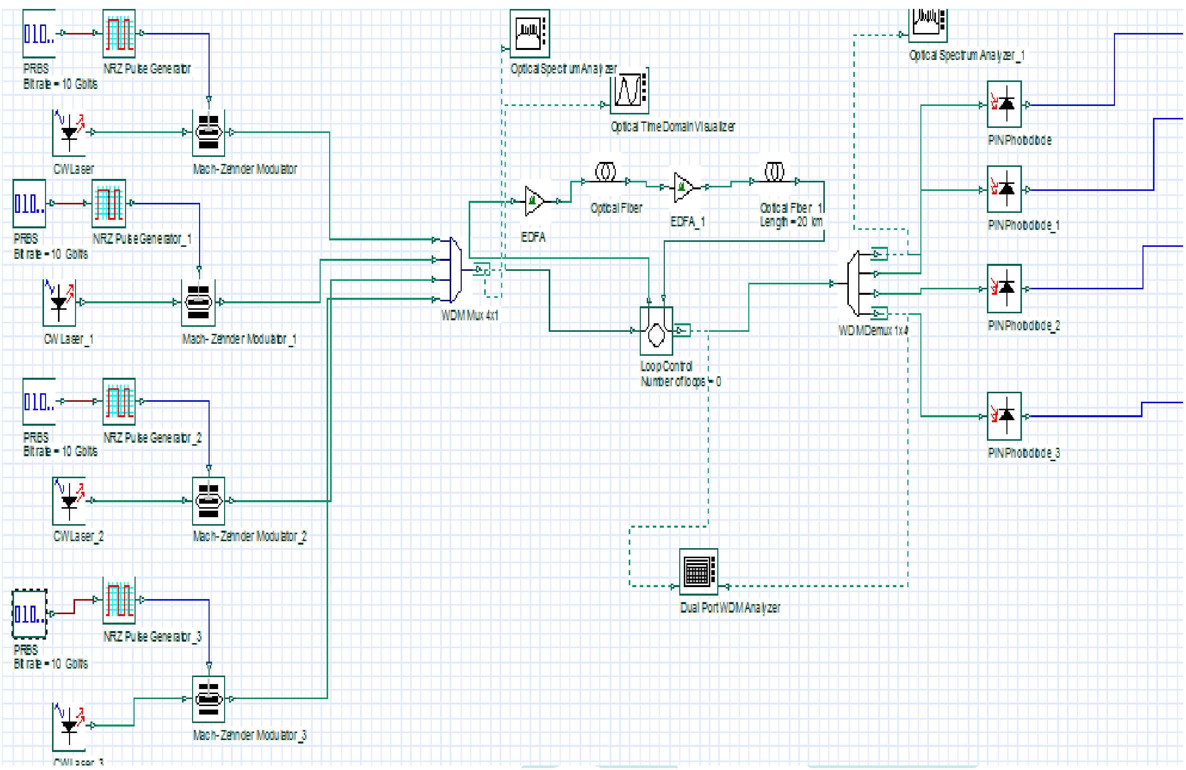


Fig. 1: system modeling of WDM optical network system

3- RESULTS AND DISCUSSION

3.1- PERFORMANCE ANALYSIS OF WDM

The results of WDM for different data rate(10,100,250 Gb/sec) are presented and discussed as in figures bellow. Therefore, figures 2 and 4demonstrates the optical signal spectrum, after modulating the input electrical signal with the optical carrier as in the system model of WDM, using Mach Zehnder Modulation (MZM). With input parameter SNR is 90.66dBm and output optical power achieved as shown in figures 3 and 5 is measured 12.3dBm, 8.87dBm and -2.45dBm respectively for data rate 10 and 100Gb/s of WDM at transmitter and 100Gb/s WDM receiver end. Therefore, the quality and strength of the optical signal at the receiver terminal is decreased with ISI and BER effects increased by the chromatic dispersion of fiber cable.

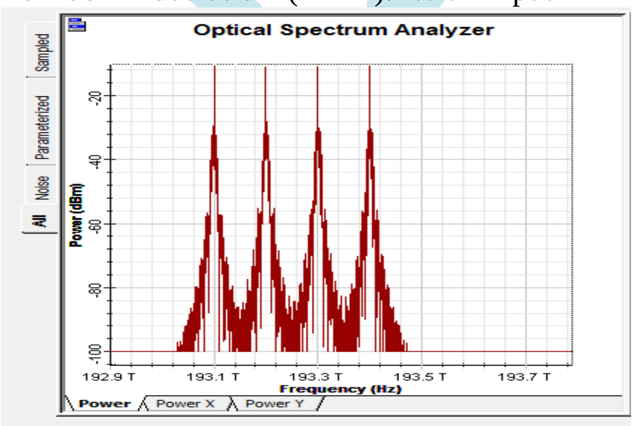


Fig. 2: Optical WDM Spectrum for 10Gbit/sec

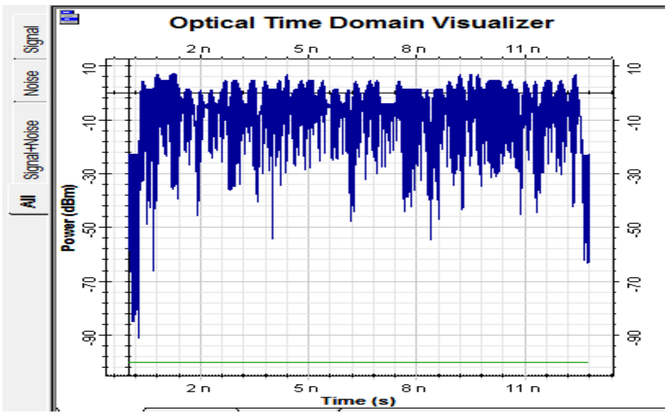
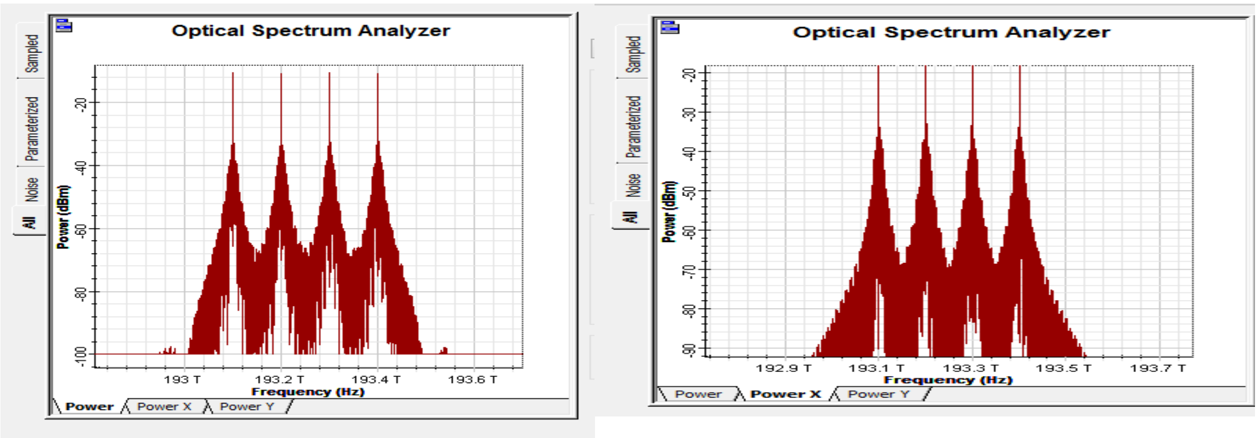
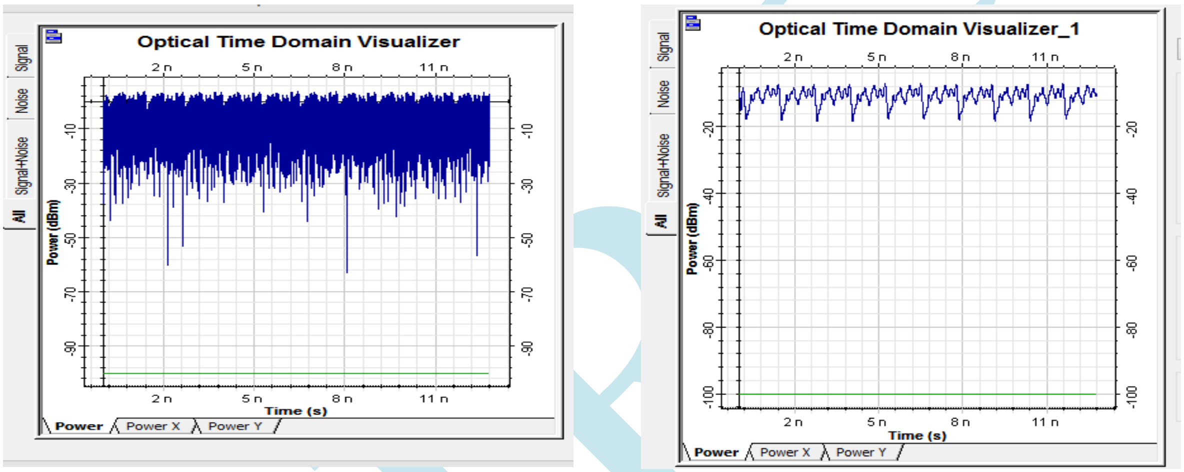


Fig. 3: Optical time domain of WDM at transmitter for 10Gbit/sec



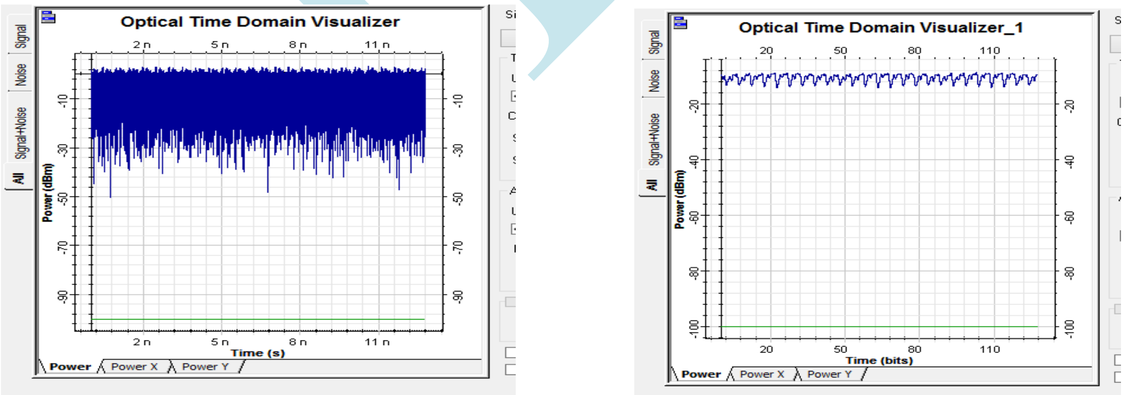
(a) (b)

Fig. 4: (a) Optical WDM Spectrum for 100Gbit/sec, (b) Optical WDM Spectrum for 250Gbit/sec



(a) (b)

Fig.5: (a) optical time domain of WDM at the transmitter for 100Gbit/sec, (b) optical time domain of WDM at the receiver for 100Gbit/sec



(a) (b)

Fig.6: (a) optical time domain of WDM at the transmitter for 250Gbit/sec, (b) optical time domain of WDM at the receiver for 250Gbit/sec.

As in Figure 6shows with input SNR 89.2dBm and the output optical power is obtained 8.3dBm and -4.3dBm at WDM transmitter and receiver terminal respectively for data rate of 250 Gb/s. So that, the result indicates as data rate increases, ISI and BER increases in WDM optical network in the same fiber, receiver end signal quality and strength is distorted and weak. Then, we can decide the problem of WDM optical system network resolved by introducing OFDM technique.

3.2- PERFORMANCE OF OFDM INTRODUCING TO WDM

The process starts by introducing OFDM to WDM optical system networks to evaluate the effect of OFDM on WDM optical transmission network. The effect of OFDM can be seen that in figures 7, 8, 9, 10 and 11 for data rate 10, 100 and 250 Gb/s in series value of the figures at the transmitter and receiver end of OFDM-WDM. With input SNR 65, 90.66, and 92.7dBm for 10, 100 and 250 Gb/s respectively, the output optical power achieved -19, -19.1 and 9.8 dBm at the OFDM-WDM transmitter end and -31.7, -31.7 and -1.17 dBm at receiver end for 10, 100 and 250 Gb/s respectively. Therefore, this shows as introducing OFDM to WDM optical network system, the signal quality and strength increases with data rate increases at the optical transmitter and receiver end.

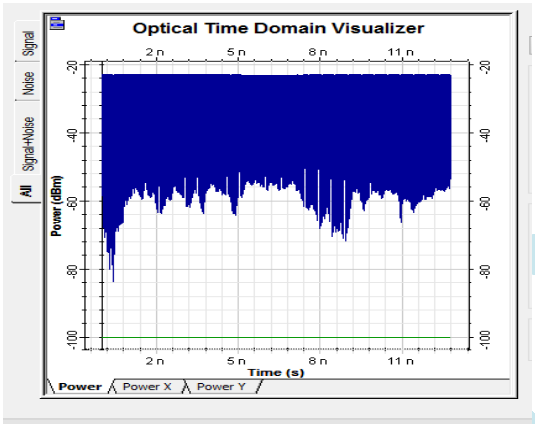


Fig.7: Optical time domain of OFDM-WDM at transmitter for 10Gbit/sec

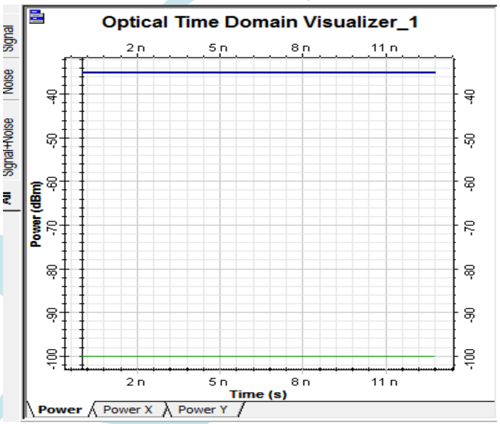
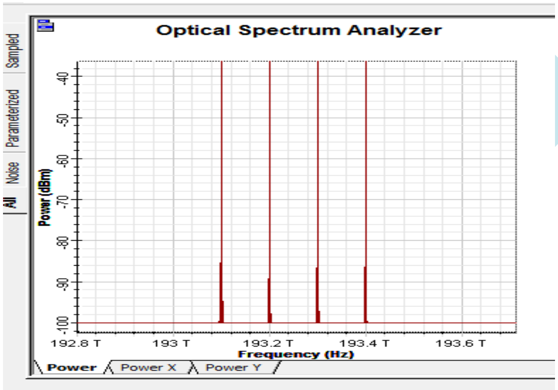
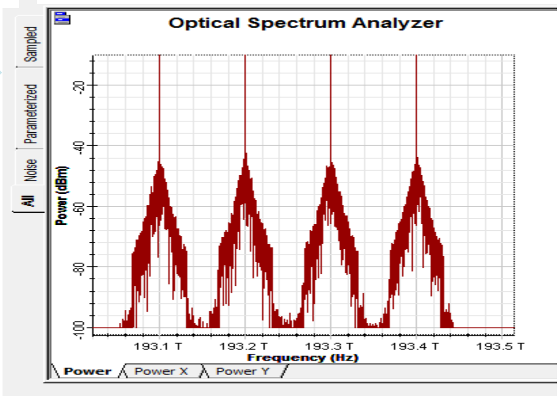


Fig.8: Optical time domain of OFDM-WDM at the receiver for 10Gbit/sec

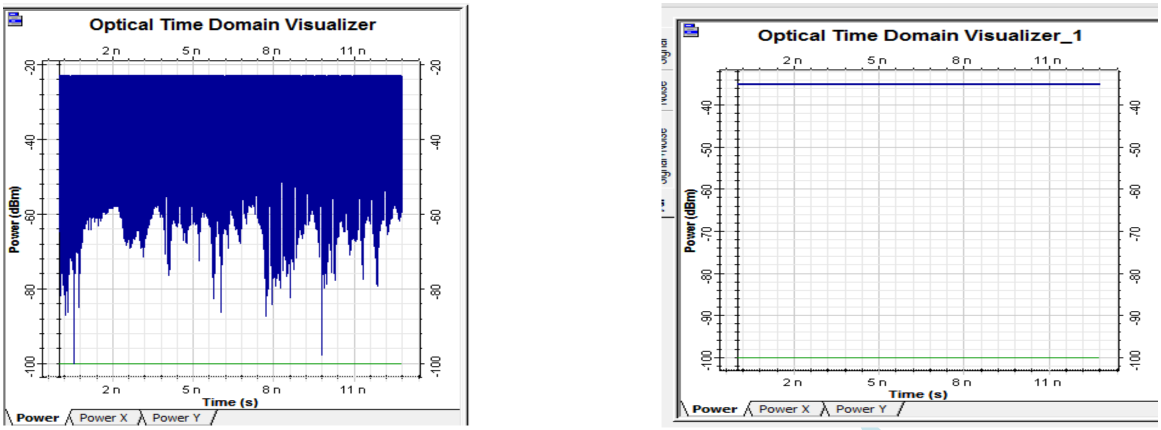


(a)



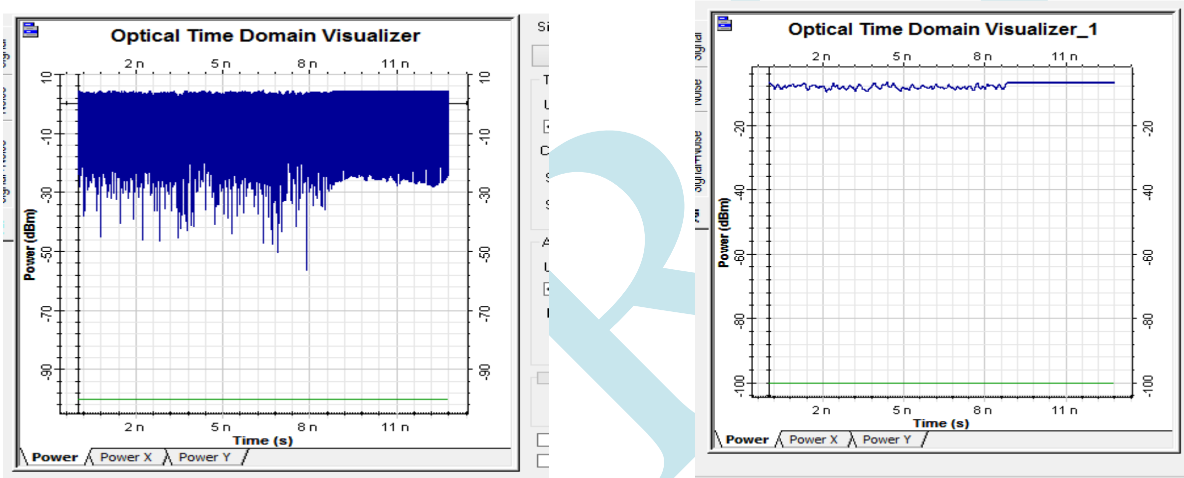
(b)

Fig.9: (a) Optical OFDM-WDM Spectrum for 100Gbit/sec, (b) Optical OFDM-WDM Spectrum for 250Gbit/sec



(a) (b)

Fig.10: (a) optical time domain of OFDM-WDM at the transmitter for 100Gbit/sec, (b) optical time domain of OFDM-WDM at the receiver for 100Gbit/sec

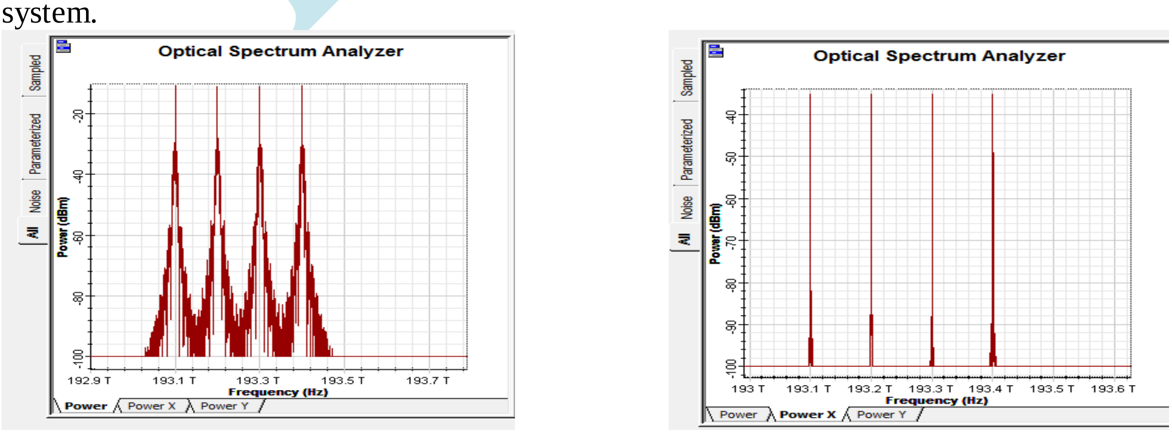


(a) (b)

Figure 11: (a) optical time domain of OFDM-WDM at the transmitter for 250Gbit/sec, (b) optical time domain of OFDM-WDM at the receiver for 250Gbit/sec

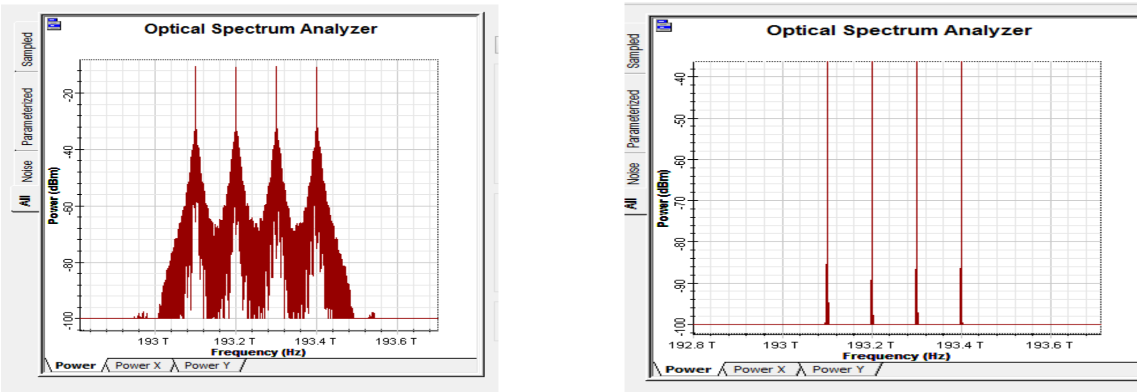
4- COMPARISON OF WDM AND OFDM-WDM OPTICAL NETWORK

From the discussion results, we can compare WDM and OFDM-WDM as shown in figures 12, 13 and 14. The signal interference of the four inputs or channels as in figures 12, 13 and 14 part (a) signals are more interfered as compared to part (b). Therefore, we can say OFDM introducing to WDM optical network is affected to ISI and BER minimizing in the optical system.



(a) (b)

Fig.12: optical spectrum of WDM and OFDM-WDM for 10 Gbits/sec



(a) (b)

Fig. 13: optical spectrum of WDM and OFDM-WDM for 100 Gbits/sec

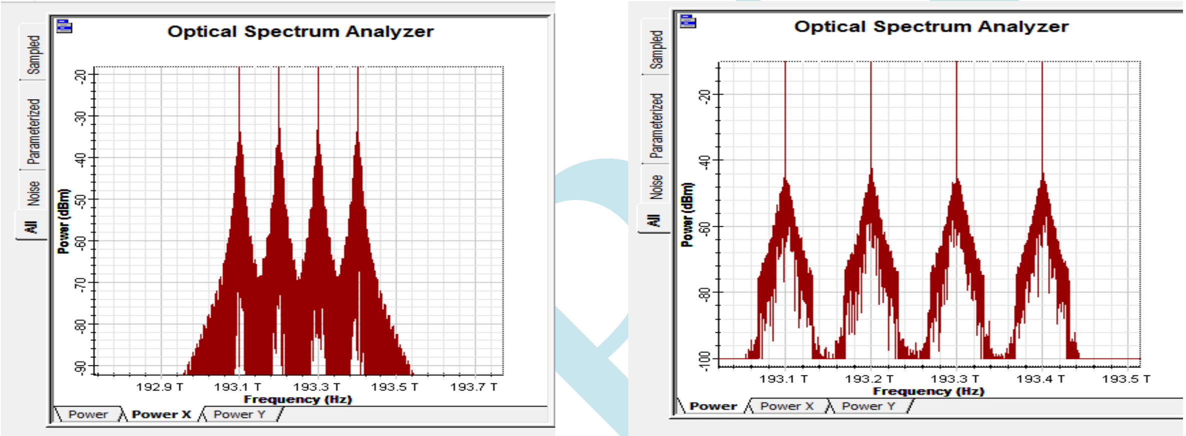


Fig. 14: optical spectrum of WDM and OFDM-WDM for 250 Gbits/sec

5- CONCLUSION

This project aimed to find a solution for ISI effect for high data rates in today's optical based transmission. Coherent Optical OFDM is technology for the optical communications, since it integrates the advantages of both coherent systems and OFDM systems. It has the ability to overcome many optical fiber restrictions such as chromatic dispersion (CD) and PMD. Moreover, integrating the coherent optical OFDM with WDM systems will provide a transmission system with a significant data rates, and a high spectral efficiencyand also to eliminate ISI problems. Integration of OFDMand WDM has been proposed as a solution for increasing data rates and minimizing ISI.The results show that the system is reliable and can provide a hihgsignal quality and strength at the receiver end.

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