On Performance of Optical hybrid OFDM-Nyquist WDM Long haul System

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Abstract : In this work we have implemented a system which uses optical OFDM along with nyquist WDM in order to reduce BER as compared to systems using only OFDM or WDM or both. For lower values of input power, Nyquist WDM helps getting lower BER for longer distance transmission by using coherent detection. A simulation model has been implemented which gives BER of $2*10^{-3}$ and $1.6*10^{-3}$ for OFDM-WDM systems and OFDM-NWDM systems respectively.

Index Terms **- Optical OFDM, Nyquist WDM (NWDM), BER**

I. INTRODUCTION

Success of OFDM technique in wireless systems provides a large research domain in optical systems. Optical OFDM systems are proven to be a better option for upcoming generation of high speed internet as systems provide high transmission rate.

OFDM is advantageous with regard to computation efficiency due to the use of fast Fourier transform (FFT), but the single carrier that incorporates cyclic prefix based on blocked transmission can achieve the same purpose. Perhaps the advantage of the OFDM has to do with the two unique features that are intrinsic to multicarrier modulation. The first is scalable spectrum partitioning from individual subcarriers to a sub-band and the entire OFDM spectrum, which provides tremendous flexibility in either device-, or subsystem-, or system-level design compared to single-carrier transmission. The second is the adaptation of pilot subcarriers simultaneously with the data carriers enabling rapid and convenient ways for channel and phase estimation [1].

Wavelength-division multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths. Nyquist WDM: when channel spacing of WDM is reduced to nyquist bandwidth, it's called dense WDM or nyquist WDM. Channel spacing or frequency spacing is reduced in NWDM by using nyquist filters so that spectral efficiency of the system is also improved.

Modulation technique plays an important role in system performance. For this work we have used 4-QAM modulation technique. This system can also be implemented with different modulation techniques with specified changes in OFDM parameters.

Coherent optical OFDM (CO-OFDM) represents the ultimate performance in receiver sensitivity, spectral efficiency, and robustness against polarization dispersion, but it requires the highest complexity in transceiver design [1]. As coherent detection allows information to be encoded in all the available degrees of freedom it is the most promising detection technique for achieving high spectral efficiency [3]. In coherent detection symbol decisions are made using in-phase and quadrature signal in the two field polarization.

II. SYSTEM MODEL

We consider a CO-OFDM system with 4- QAM modulation technique, NWDM for 2 transmitters each transmitting different data. A binary sequence generator generates a data string which is converted into light at different frequencies i.e. 193.05 THZ and 193.1 THZ. The electrical data is modulated with QAM and converted to optical form simultaneously. The modulated data from two different transmitters are multiplexed over wavelength division multiplexer after applying Nyquist filtering.

Nyquist WDM automatically adjusts the channel spacing between two different data which are going to be transmitted over single fiber. As we know that 60 km is optimum fiber length for lowest attenuation, here we are consider the distance of 60 km which is increased further.

Firstly we have checked the system performance in form of BER for different input power of LASER's i.e. -2 to -20dBm. Advantage of this system is, it provides lower BER for such low values of input power. Each transmitter has been given power from -2 to -20 dBm for transmission distance of 60 km. Figure 1 shows the simulation model of the system. As results show that we are achieving lower BER for the same, we then go for fixed value of input power and change the transmission distance from 60 to 100 km. At the receiving end we use coherent detection method to detect the two different data individually. Nyquist de-multiplexing is followed by individual detection and demodulation. BER analyzer compares the transmitted data and received data and gives the bit error ratio for each user.

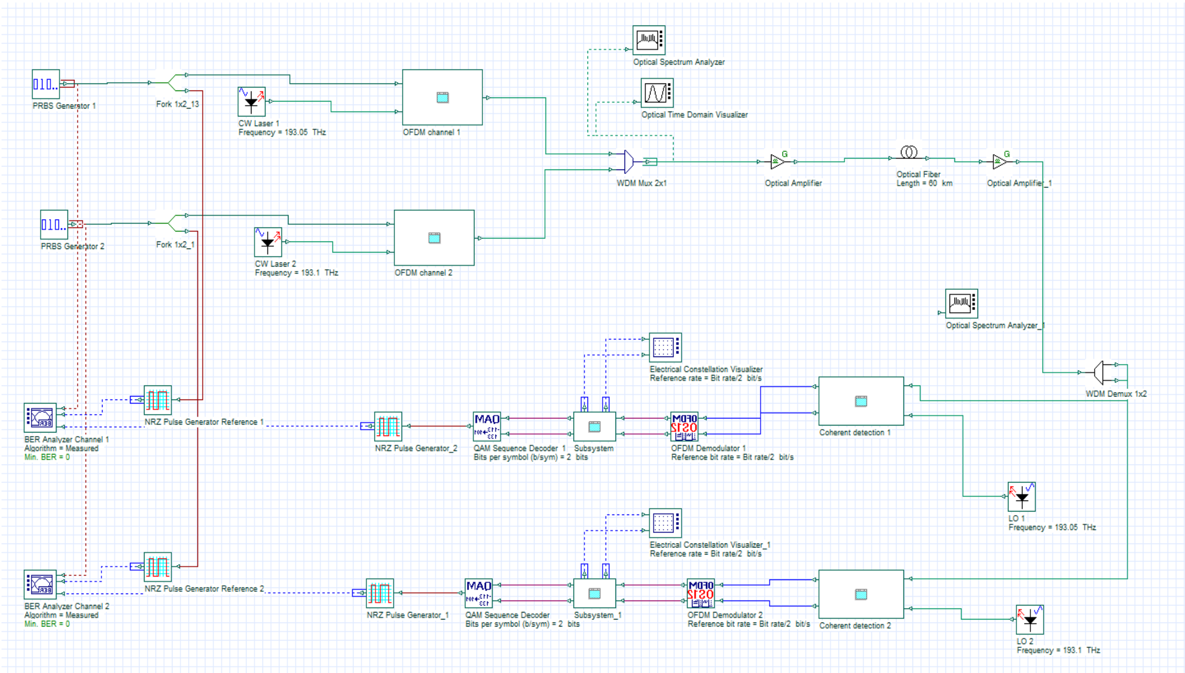

FIG.1 Experimental setup

The BER of M-QAM-OFDM is given by [5][6]

$$Pe = 1 - \left[1 - 2\left(1 - \frac{1}{\sqrt{M}}\right) Q\left(\frac{\sqrt{3RS}}{M} - 1\right)\right]^2 / \log_2 M \qquad (1)$$

Where RS is SNR per symbol.

III. EXPERIMENTAL SETUP AND SYSTEM PARAMETERS

Figure 1 shows the setup of the system in simulation software.
Table 1 shows some important system parameters.

PARAMETER	VALUE
Reference wavelength	1550 nm
Bit rate	12e+009 bits/s
Symbol rate	10e+009 symbols/s
No. of FFT points	1024
No. of subcarriers	512
No. of prefix points	64

TABLE 1: System parameters

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IV. SIMULATION RESULTS

(1)WDM technique

We calculated BER for 60 km distance for two data with different frequency of 193.05 THz and 193.1 THz figure 2 shows the results of BER vs launched power (dBm).

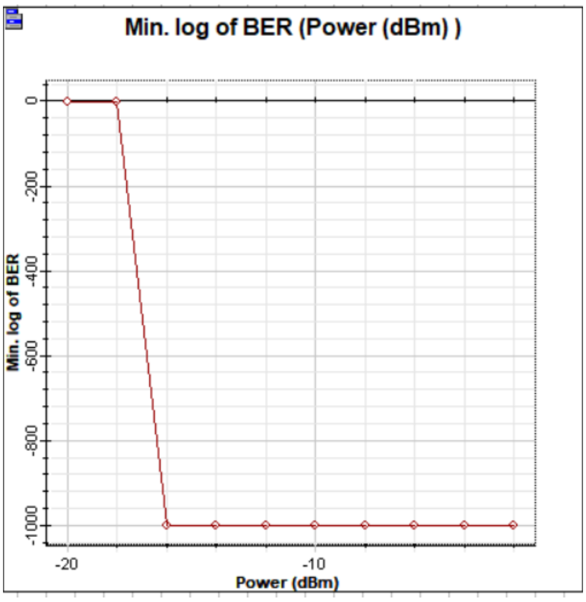
Figure 2 and 3 shows that the BER for channel 1 and channel 2 for OFDM-WDM combination is $3*10^{-3}$ and $2*10^{-3}$ respectively.

(2)NWDM technique.

Channel spacing is reduced to Nyquist bandwidth which gives better performance in form of BER. Figure 4 and 5 shows results for channel 1 and channel 2 for 60 km transmission.

As shown in figure 4 and 5 by applying nyquist WDM BER is reduced. BER for channel 1 and channel 2 is $2*10^{-3}$ and $1.6*10^{-3}$ respectively.

Then we fixed launched power to -20 dBm and increased the distance. Figure 6 shows the BER result for 2 channels at 100 km distance. It shows better results for channel 2.



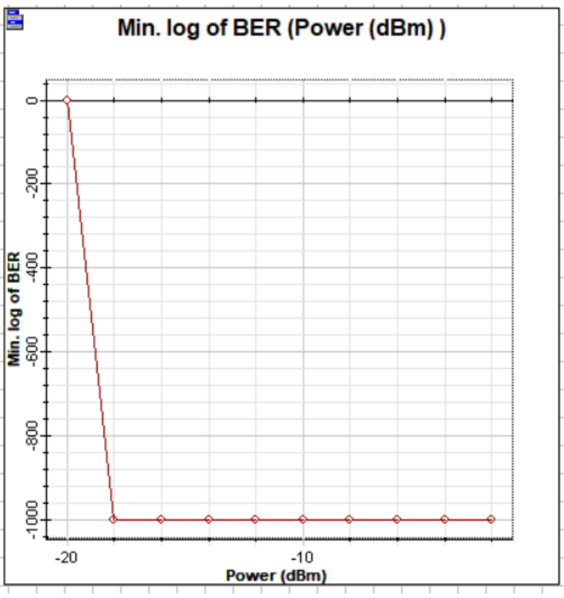
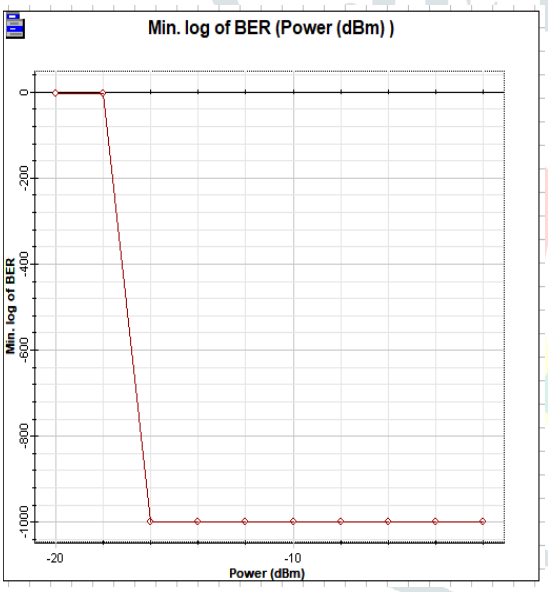


FIG. 2 FIG. 3

Fig. 2: BER for channel 1 for launched power of -2 to -20 dBm (WDM)
Fig. 3: BER for channel 2 for launched power of -2 to -20 dBm (WDM)



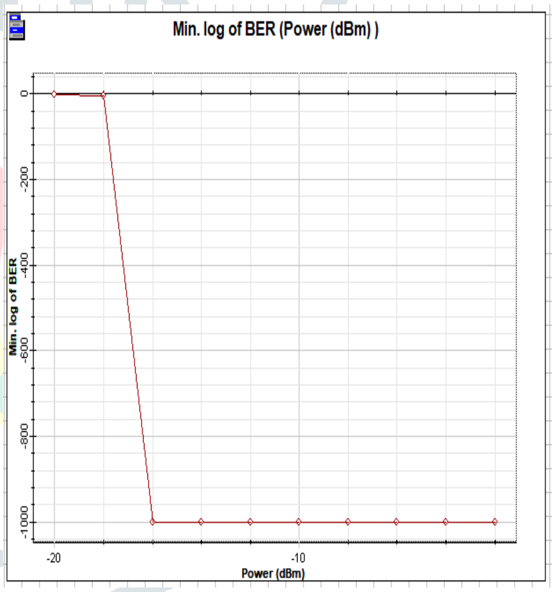


FIG. 4 FIG. 5

Fig. 4: BER for channel 1 for launched power of -2 to -20 dBm (NWDM)
Fig. 5: BER for channel 2 for launched power of -2 to -20 dBm (NWDM)

To improve the results for longer distance transmission we used EDFA. By using EDFA we get better result of BER which can be seen in figure 7.

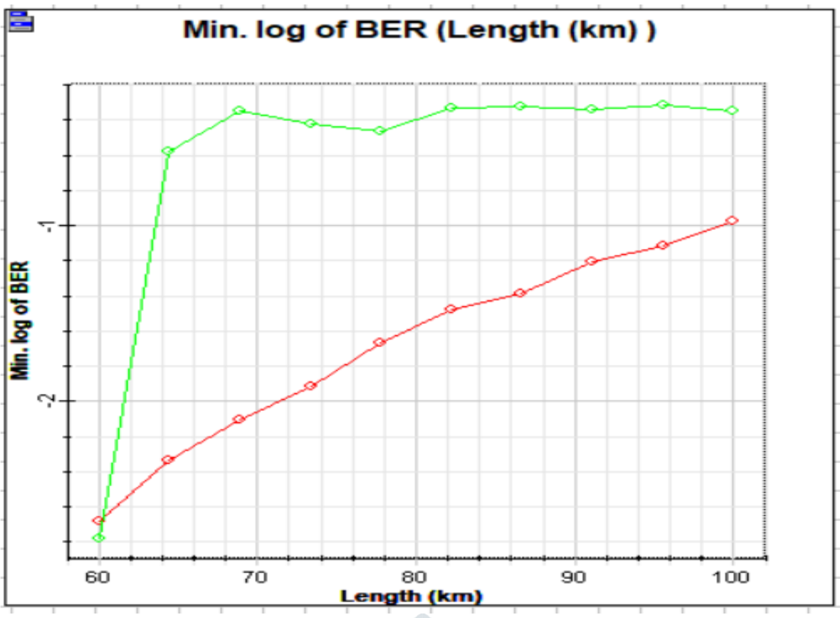


FIG. 6: BER for 2 channels for 60 to 100 km transmission distance.

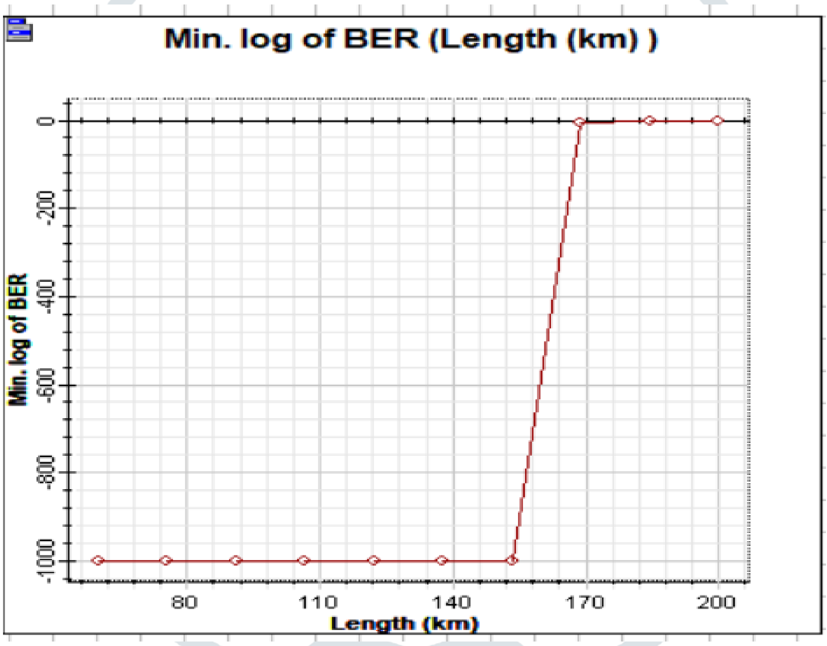


FIG. 7: BER for channel 2 for 60 to 200 km transmission (using EDFA)

As we can see in above figures; use of EDFA gives better performance in form of BER.

V. FUTURE WORK

We are currently working on improving the system performance in forms of BER, PAPR by applying various techniques i.e. FEC, advanced modulation schemes etc.

VI. CONCLUSION

In this paper we have analyzed the optical system which uses CO-OFDM and Nyquist WDM to improve the performance of the system in form BER, transmission distance. Results show that nyquist WDM works better than WDM technique along with coherent detection and improved amplification technique. The performance of the system can also be increased by implementing advanced techniques.

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