Coherent Optical – OFDM using 64QAM to high data rates 1.60 Tb/s over 4500 km

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Abstract- Coherent optical orthogonal frequency division multiplexing (CO-OFDM) system with dense wavelength division multiplexing (WDM) was analyzed to reach high data rates of 1.60 Tb/s over 4500 km single mode fiber (SMF).

1.60Tb/s signal was generated by multiplexing 16 OFDM signals with 100 Gb/s for each signal. The system performance has been studied by measuring optical signal to noise ratio (OSNR) of each WDM channel, bit error rate (BER) and signal to noise ratio (SNR). It was found that as the BER decreased both OSNR and SNR was increased.

Index Terms- Orthogonal frequency division multiplexing OFDM, WDM, BER , OSNR.

I. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) has grown to be the most popular communications systems in high speed communications, (OFDM) is a multicarrier transmission technique, which divides the bandwidth into many carriers and uses the spectrum much more efficiently by spacing the channels much closer together. (OFDM) has great interest due the possibility to expend to higher level modulation formats and to realize next generation active optical networks [1]. one OFDM symbol is composed of a set of subcarriers, and each of them is modulated by an information symbol with its corresponding Quadrature and in-phase component. This is very similar to subcarrier multiplexing technique, except that subcarriers in OFDM overlap to maximize the spectral efficiency [2]. The Coherent optical orthogonal frequency-division multiplexing (CO-OFDM) has been extensively studied because of its advantages such as high spectral efficiencies, low required sampling rates, and flexible bandwidth scalability and allocation.

(WDM) is an optical multiplexing technique used currently in core and Metropolitan (metro) optical networks to help to increase system capacity. WDM provides an efficient means of utilising the large optical bandwidth available from a single optical fiber by transmitting multiple wavelengths with a given frequency separation [3]. OOFDM uses different subcarriers to send low rates in parallel data streams. The M-array Quadrature Amplitude Modulation (QAM) is used to modulate the subcarriers before being transported on a high frequency microwave carrier [4].

II. System Design

WDM CO-OFDM system was simulated and studied using an OptiSystem V.13.0.2 simulation tool. The system consists of three main parts: CO-OFDM Tx (Transmitter), optical fiber link and CO-OFDM Rx (Receiver).as shown in Figure (1) In the WDM system, 8 channels with 50 GHz channel spacing were used to support 16 OFDM bands, each with 100 Gbits/s bit rate to reach 1.6 Tbits/s data rate.

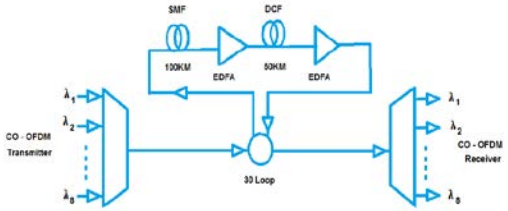

Figure (1). WDM CO-OFDM system

The global parameter of the system design is shown in table (1)

Table 1: Global Parameters

Sequence length	65536 Bits
Samples per bit	4
Number of samples	262144
Symbol rate	2.5e+009 symbols/s

A. CO-OFDM transmitter part

The bit stream was generated by an Pseudo Random Binary Sequence (PRBS) generator and mapped using 64-QAM encoder. The resulting signal was modulated using OFDM modulator as shown in Figure (2),

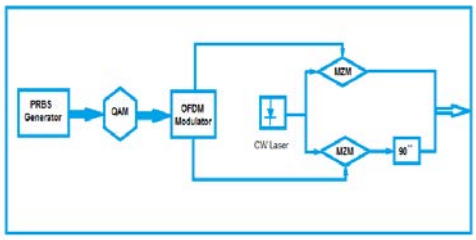

Figure (2). CO-OFDM transmitter block diagram

The OOFDM parameter is shown in Table 2.

Table 2: OFDM Modulator Parameters

Maximum possible subcarriers	1024
Number of prefix points	16
Average OFDM power	100 dBm
Subcarrier locations	512-1024

B. Optical part

The optical link consists of 30 spans of 100 Km SMF , with a dispersion coefficient of 17 ps/nm/Km and Dispersion Compensation Fiber (DCF) of 50 Km with a -80 ps/nm/Km coefficient in each span as shown in Figure (3).

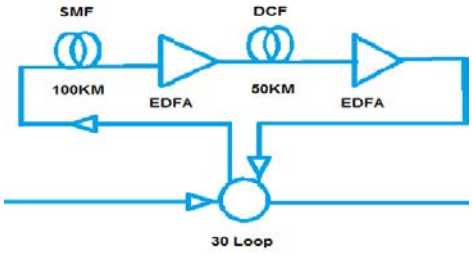

Figure (3). Schematic of Optical Link

C. CO-OFDM Receiver part

To recover the I/Q component of the OFDM signal, two pairs of balanced PIN photodetectors and Local Oscillator lasers were used **,** The balanced detectors perform the I/Q optical to electrical detection and help perform the noise cancellation **,** after that the balanced detectors demodulated the resulting signal using the OFDM demodulator with similar parameters as the OFDM modulator. The parameters of the LO are shown in table (3), After the signal is fed into a 64-QAM decoder, the BER was calculated as shown in Figure (4).

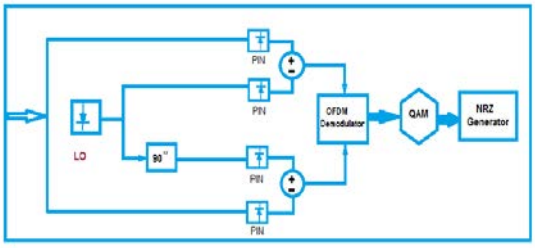

Figure (4). CO-OFDM Receiver block diagram

Table (3): Parameters of the LD

Parameter	Value
Frequency	193.1 THz
power	0 dBm
Line width	0.1 MHz
Initial phase	0

III. Results and Discussion

Figure (5) shows measurement the RF spectrum analyzer after low pass Roll off filter, where the power of the RF is approximately 32 dBm, the carrier frequency of the signal is 12.4 GHz.

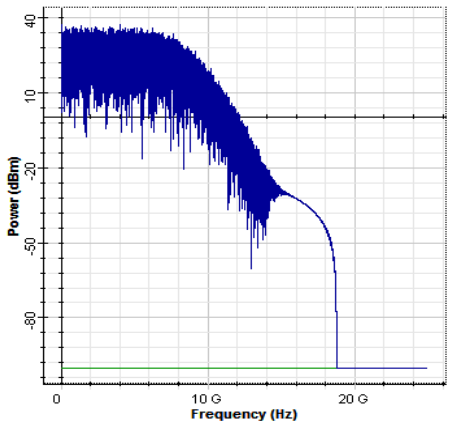

Figure (5) RF spectrum transmitter

Figure (6) shows the RF spectrum after 4500 Km SMF. The power of the RF is increase to -38.96 dBm, and carrier frequency is 12.4 GHz , The OSNR is 42.7 dB and SNR is 46.75 dB .

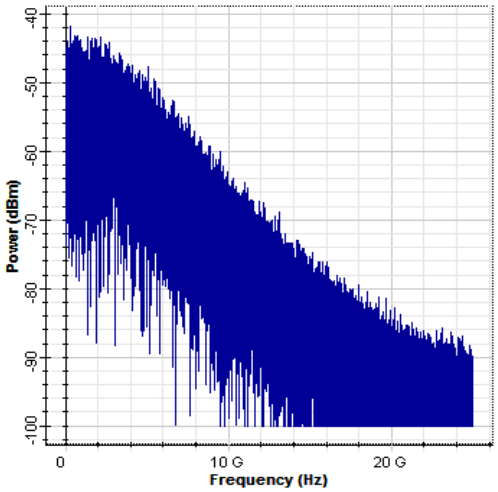

Figure (6) RF spectrum receiver

After the optical combiner the Spectrum of the signals from 193.08 THz to 194.12 THz with 50 GHz of channel space for 100 Gb/s in figure (7)

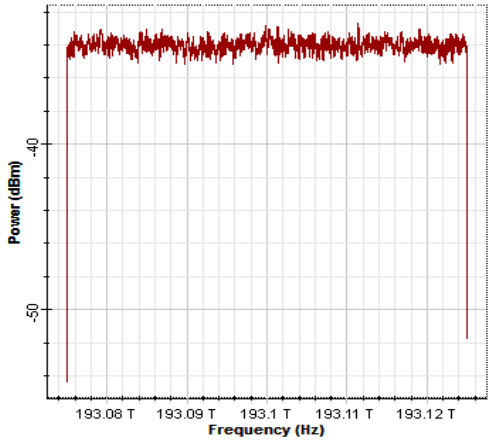

Figure (7) Optical spectrum analyzer transmitted signal

Figure (8) shows the received constellation diagram of 64 - QAM digital modulator to high data rates 1.050 Tb/s over 3600 km.

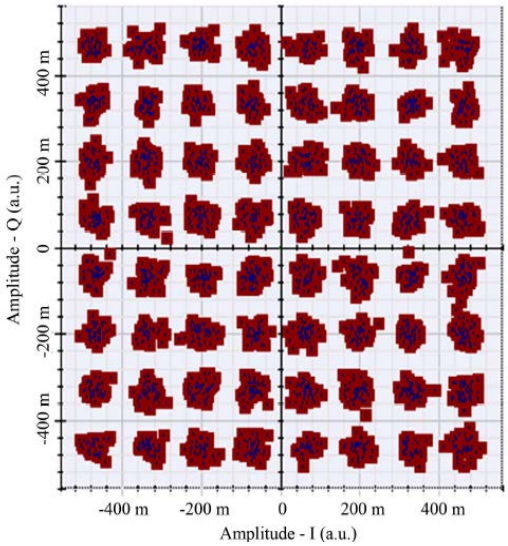

Figure (8) constellation diagram

Figure (9) shows the received constellation diagram of 64 - QAM digital modulator to high data rates 1.60 Tb/s over 4500 km.

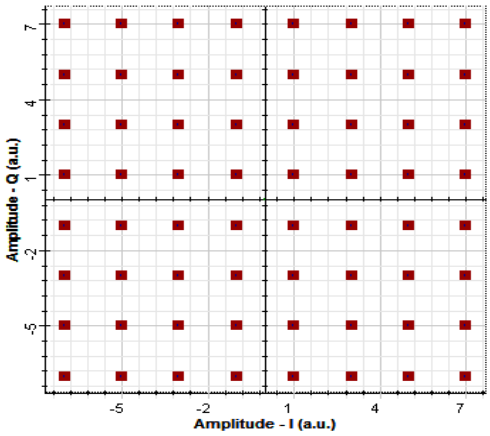

Figure (9) constellation diagram

Figure (10) shows the BER comparison OSNR and it is clear that as OSNR increase the BER decrease , the OSNR is 11.64 dB for 50 Gb/s and 12.43 for 100 Gb/s at BER=10^{-14}

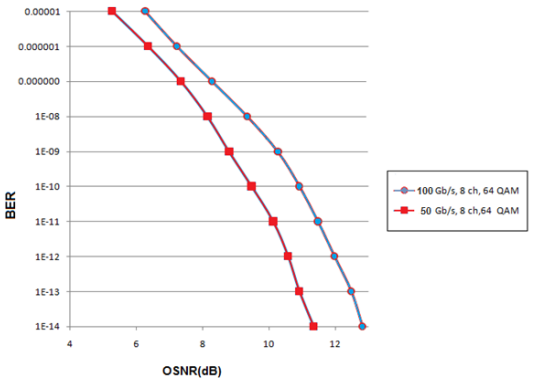

Figure (10) BER comparison OSNR for 50 Gb/s and 100 Gb/s

Figure (11) shows the BER comparison SNR and it is clear that as SNR increase the BER decrease , the SNR is 8.47 dB for 50 Gb/s and 10.32 for 100 Gb/s at BER=10^{-14}

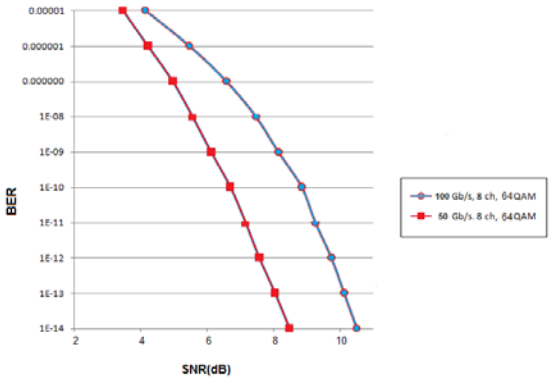

Figure (11) BER comparison SNR for 50 Gb/s s and 100 Gb/s

IV. Conclusion

In this study, the structure of WDM systems is studied by using Co-OFDM. The simulation was designed by 8 WDM channels spaced at 50 GHz, and 16 OFDM signals, each with 100 Gbits/s bit rate to produce 1.6 Tbits/s . it note the results has a good performance according to the BER ,OSNR and SNR values , the system showed a clear constellation diagram of 64-QAM at receiver, compared with others simulation study Optical-OFDM using 64 QAM over 3600km and the obtain BER 10^{-12} .

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