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Evaluation of 16 QAM OFDM Passive Optical Networks

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Abstract – In this paper, the performance of simultaneous transmission of 4 channels using 16 QAM OFDM Passive Optical Networks. The 4 channels transmit the data simultaneously over single fibre link. The performance is evaluated for 100 km fibre and results are compared with the different length of transmission. The system has been evaluated using BER calculations and Q-Factor values. An acceptable performance over a link length of 100 Km is observed for this transmission scheme.

Keywords *- 16-QAM, OFDM, Passive Optical Networks, Multiplexing, Optical Network Unit (ONU), Optical Line Terminal (OLT)*

I INTRODUCTION

In a basic communication system, the data is modulated in single carrier frequency which makes allocate the entire bandwidth to a symbol, which increase the inter-symbol interference. As the demand of higher data rate increasing, with less bandwidth available. The main focus is to enhance data transmission with less bandwidth which can be achieved by implementing the OFDM. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band subcarriers are transmitted in parallel, figure 1 shows the OFDM subcarriers in frequency domain. These carriers divide the available transmission bandwidth and less bandwidth is required for same data transmission. The separation of the sub-carriers is such that there is a very compact spectral utilization.

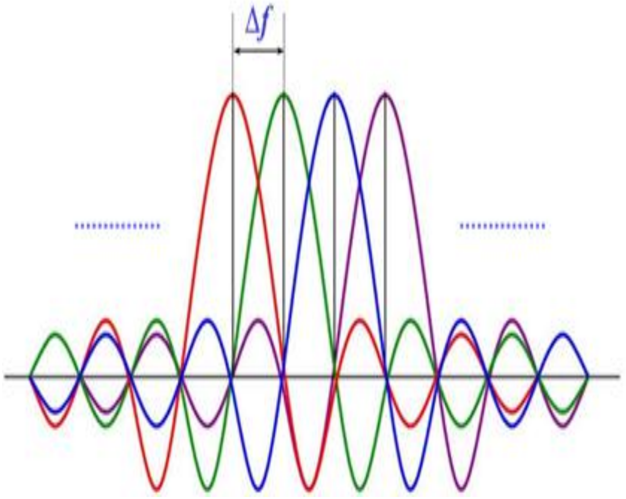


Figure 1 OFDM Subcarriers [3]

Ping Zhang, et.al, 2004 [1], Propose a combinational scheme of adaptive beam forming and adaptive loading for OFDM. Use frequency-domain adaptive loading to load the bits and transmit power to the individual subcarriers to counter with frequency selective fading. In this scheme, 16 QAM is used which means 4 bits per symbol is transmitted which make higher data rate to be transmitted Single OFDM [2] block is used for 4 channel transmissions with different position array (1696, 1888, 2080, 2272). By use of different position array higher data rate can be transmitted with less bandwidth requirement.

Although QAM appears to increase the efficiency of transmission for radio communications systems by utilizing both amplitude and phase variations, it has a number of drawbacks like it is more susceptible to noise because the states are closer together so that a lower level of noise is needed to move the signal to a different decision points. By implementing this rectangular QAM in this scheme higher efficiency can be achieved. By integrating the Passive Optical Network [4], a broadband scheme is introduced because PON allows remove all active components between server and client throughout the network. Its principal element is power splitter. Fig.2 shows the PON architecture. The usage of passive architecture can reduce costs and are mainly used in FTTH networks. By contrast, the bandwidth is not dedicated, but rather multiplexed in a single fiber in the network access point. In short, this is a point-to-multipoint configuration network.

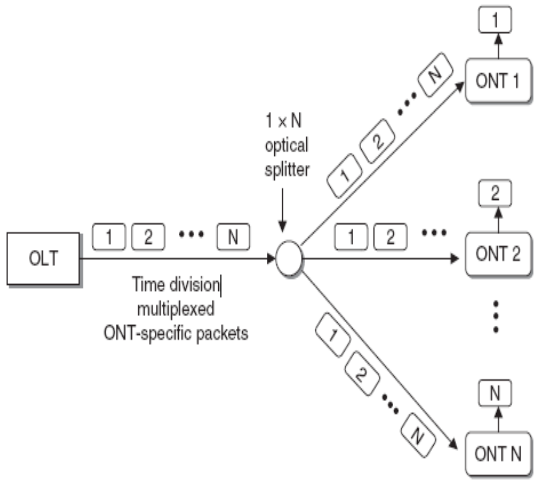


Figure 2 PON Architecture [5]

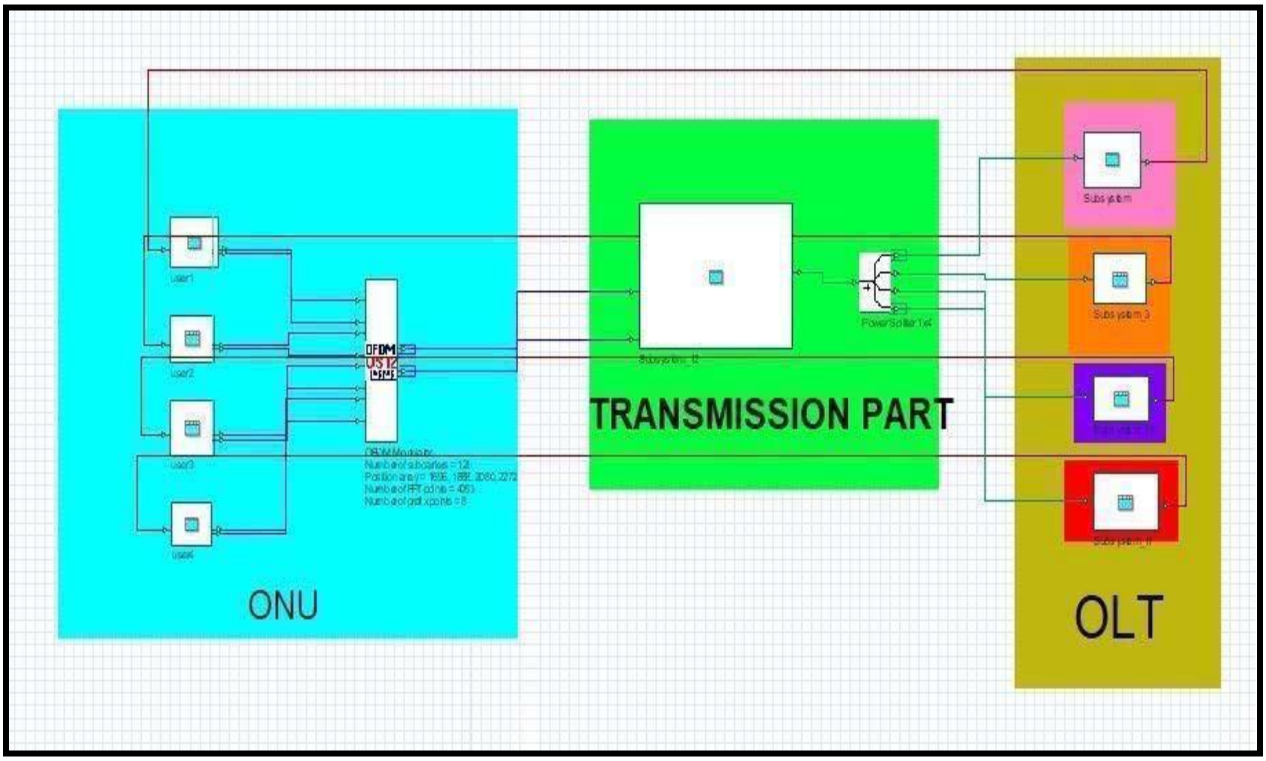


Figure 3 16 QAM OFDM PON Simulation Setup

II SIMULATION SETUP

Simulation setup contains following units:

- Optical Network Unit
- Transmission Part
- Optical Line Terminal

The block diagram of 16 QAM OFDM PON is shown in figure 3 which describes all the components interconnection (a) Optical Network Unit consists of 4 channels which have 10 Gbps of data rate of each channel which is followed by the data 16 QAM modulator which has 4 bits per symbol of modulation. This data is fed to OFDM modulator which modulates the signal in FFT form. In OFDM modulator, 128 subcarriers are used and 4096 FFT points are included. Position of array is - 1696, 1888, 2080, and 2272 for all four channels. Sequence length of 16384 is used.

(b) For transmission part, data received from the OFDM modulator (I & Q signals) is fed to the two arms of LiNb Mach-Zehnder Modulator for RF to optical up conversion, which is modulated using CW laser which has frequency of 193.1 THz and power of 4 dbm. The optical fibre of length 100 Km is used for the data transmission. Splitter is used to split the received signal to the all network units present at Optical Line Terminal (OLT). Splitter split the power of signal (c) now at the OLT the signal from splitter is decoded by the OFDM demodulator block which decode the signal which is require for specific array. Then the 16 QAM decoder is used for decoding the signal. After this scheme to be implemented, the different analyzers are used to analyze the results of this simultaneously transmission of data.

III RESULTS AND ANALYSIS

Here we analyze how 4 channels of 16 QAM OFDM channels are transmitting data to simultaneous receiver at ONU. In this scheme, fig.4 shows RF spectrum of the transmitted signal, which shows that the 7.5 GHz is the total bandwidth which is needed for the transmission of all 4 channels. So, at low bandwidth the entire transmission can be successfully done. At the transmitter side only single OFDM modulator is required for the multiplexing. So, cost of implementation decreases.

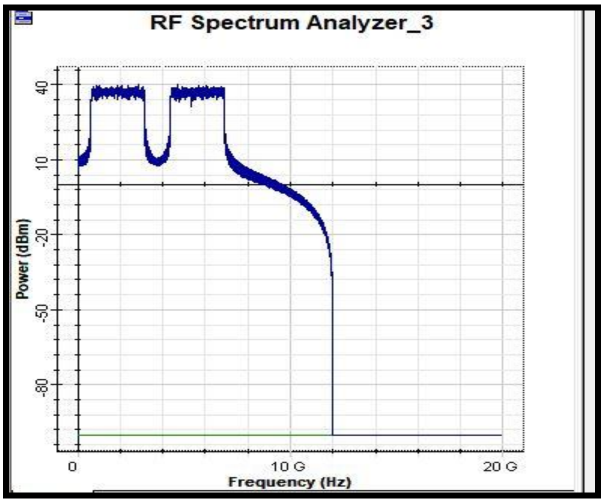
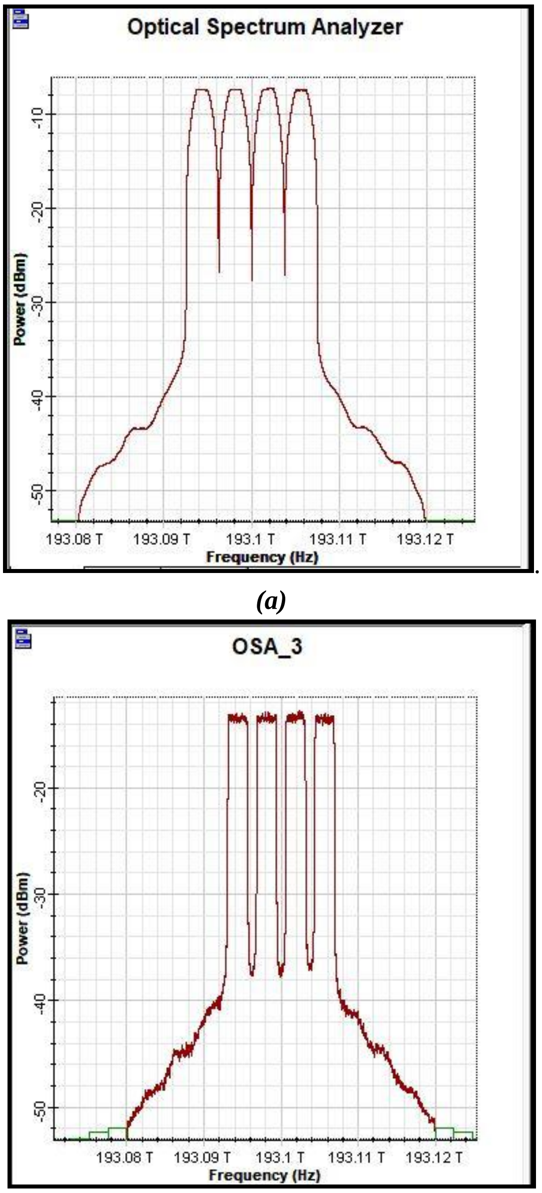


Figure 4 RF Frequency Analyzer

After the multiplexed signal of 4 channels the signal is transmitted to RF to optical up conversion. Now the figure 5 (a) shows the optical spectrum analyzer of the transmitter signal and figure 5(b) shows the optical spectrum analyzer of received signal after the transmission of 100 Km single mode fibre.

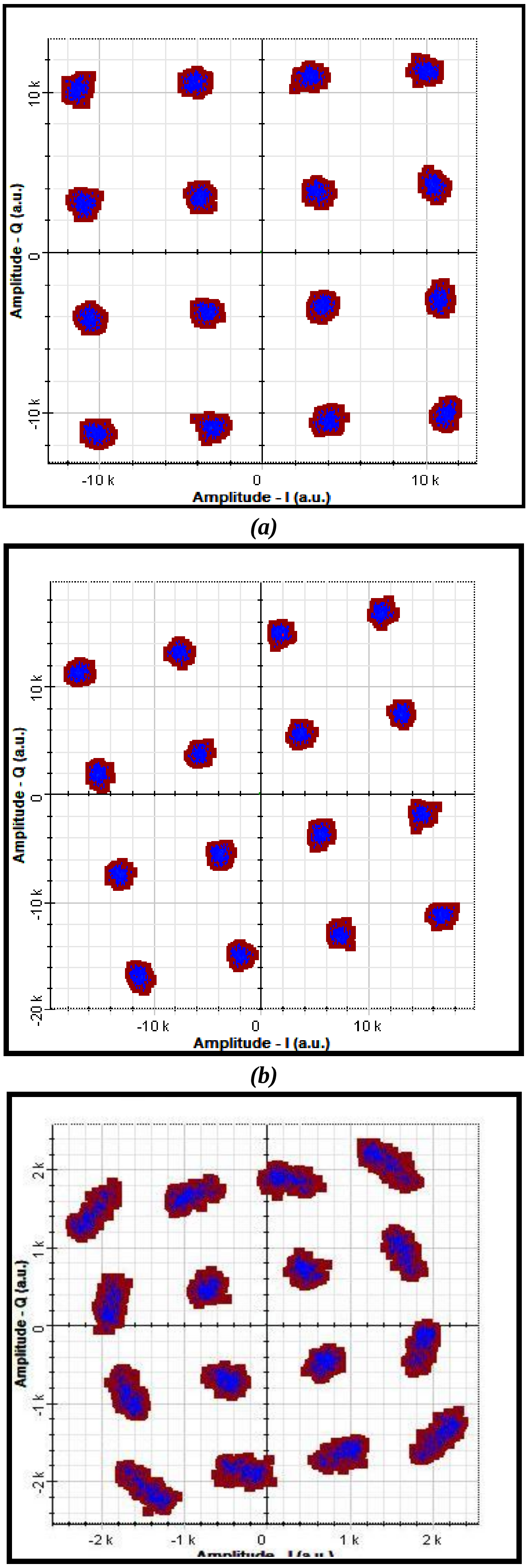


(a)

(b)

Figure 5 Optical Spectrum Analyzer of (a) Transmitted signal (b) Received Signal

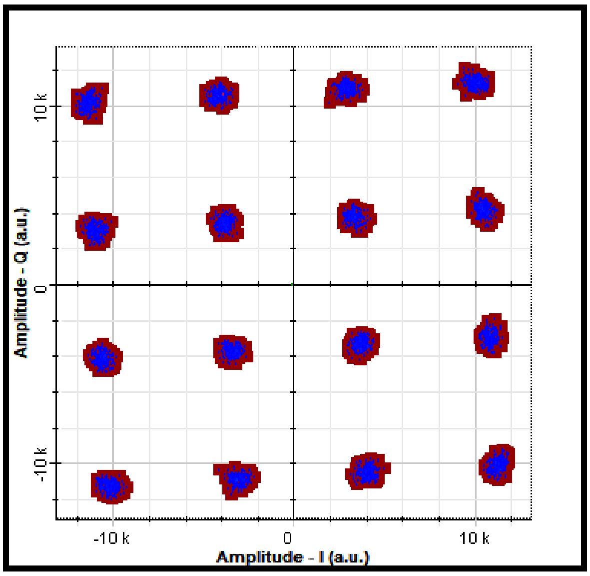
The coherent detection use pin diode to detect the signal now we have some noise which is shown in green colour in the fig.6 as we know that the signal is degraded at the 7.5 GHz. At the receiver side as shown, the incoming optical signal is detected by two identical pairs of balanced coherent detectors with a local oscillator (LO) to perform the I/Q optical to electrical conversion and cancel the noise. Each detector consists of two couplers and two PIN photo-detectors. Each PIN photo-detector has a dark current of 10 nA, a responsively of 1 A/W, thermal noise of 1×10-24 W/Hz and a centre frequency of 193.1 THz. At the receiver side, after the OFDM demodulator the m-ary analyzer is used to analyze the constellation diagram of the received signal fig.6 shows the constellation diagram of all four channel.



(a)

(b)

(c)



(d)

Figure 6 Constellation diagram of
(a) Channel 1 (b) Channel 2 (c) Channel 3 (d) Channel 4

Data transmission for different length is compared for a particular channel is shown in fig 7 which shows the quality factor vs. fibre length. This describes the relationship of quality factor decreases as the length increases.

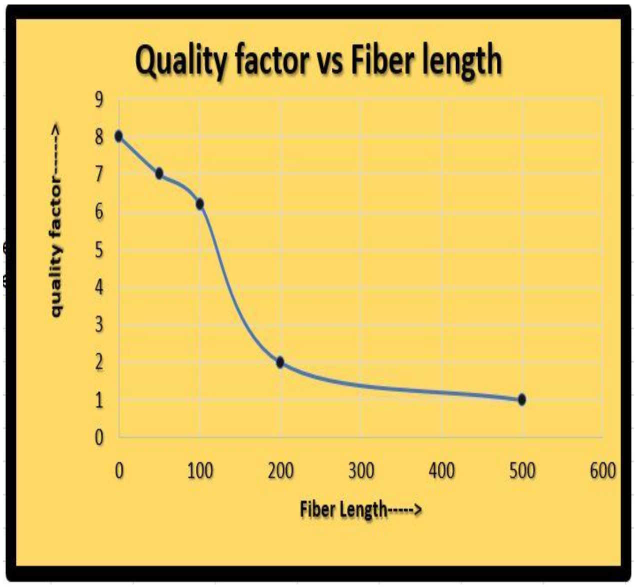


Figure 7 Quality factor vs. Fibre length

IV CONCLUSION

In the above simulation design, we analyze the scheme of transmission of 4 channel 16 QAM signals which is modulated on OFDM multiplexing for 100 km data transmission which is then received with quality factor of 6.22 and BER of 5.2 e-10. By this scheme, the bandwidth is reduced because of transmission of more data with less bandwidth requirement and the cost of building of Optical Network Unit is very less because of single OFDM modulator is required. Use of position array also improve higher data rate with less bandwidth requirement.

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