Performance Analysis of RoF PON System based on Orthogonal Frequency Division Multiplexing Technique

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ABSTRACT
The requirement of high bandwidth, high flexibility, high mobility and high data rate at lower cost can be met with a real convergence of radio over fiber (RoF) and orthogonal frequency division multiplexing (OFDM) techniques. This paper compares the results of OFDM as a modulation for radio over fiber in passive optical network (PON) for 288km single mode fiber with that of dispersion compensator fiber. The four optical network units (ONUs) are connected by using 1:4 ratio passive optical splitter. A laser source of 1550 nm, bit rate of 10 Gbits/sec is used to simulate the system.

Keywords
RoF, OFDM, PON, QAM.

1. INTRODUCTION
A technology whereby light is modulated by a radio signal and transmitted over an optical fibre link to facilitate wireless access is referred to as Radio over Fibre (RoF). Although radio transmission over fibre is used for multiple purposes, such as in cable television (CATV) networks and in satellite base stations. Radio over fiber is becoming an increasingly important technology for the wired and wireless networks since it introduces a good data transmission rate and large bandwidth. Many other advantages of using radio over fibre are easy installation and maintenance, reduces power consumption, provides dynamic resource allocation, reduced complexity at antenna site. OFDM is used extensively in broadband wired and wireless communication systems because it is an effective solution to intersymbol interference (ISI) caused by a dispersive channel. Very recently, a number of papers have described the use of OFDM in a range of optical systems including optical wireless, multimode fiber and single mode fiber [1-3]. OFDM is the modified version of frequency division multiplexing in which the transmitted data is divided like small data of packets and then transmitted in parallel. OFDM consist of the transmitter and the receiver part. In transmitter section, the pseudo random binary source generated is converted from serial to parallel form. The mapping is performed by M-arry modulator which could be Quadrature Amplitude Multiplexing or Phase shift keying, in this paper we are using 4QAM mapping. After that, the signal is processed by IFFT and a guard interval is added to prevent the overlapping between subcarriers. The signal is then sent through the channel after performing a parallel to serial conversion [4]. In the receiver, the received serial data is converted to parallel and the guard interval is removed. It then goes through the FFT operation, and is demodulated using the M-Ary demodulator which could be either QAM or PSK. Finally, the data is converted back to serial to get the original data [5].

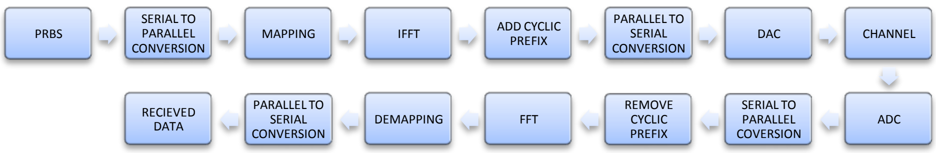

Figure 1 : OFDM BLOCK

Orthogonal frequency division multiplexing (OFDM) has very high spectrum efficiency and robust dispersion tolerance to improve system capability and transmission distance over fibre and air links. Recently, several OFDM based access systems have been proposed, such as OFDM modulated WDM-PON [6], OFDM based metro access [7], and OFDM-ROF system [8]. For long haul, OFDM is used to improve the efficiency of PON system. OFDM affords the high transmission rate and the preferred spectrum utilization with low cost optical components by using different types of M-array modulation, such as Quadrature Amplitude Modulation (QAM) or Phase-Shift Keying (PSK) [9]. This paper investigates the integration of RoF with OFDM PON using M-array QAM modulation.

2. SYSTEM DESIGN
The system design consists of three main parts which are the transmission part, the transmission link and the receiver part. For the transmission part the OFDM signal based on 4QAM is generated. The generated electrical QAM-OFDM signal is fed into dual Mach-Zehnder modulator in combination with light wave from CW laser. The RF up-conversion of the signal is performed in the QAM-OFDM transmitter block itself, as shown in Figure2. The signal generated is transmitted over single mode fiber for a length of 288km which is distributed between EDFA for different gain value in order to avoid polarization. The resulting signal is passed through 1:4 optical splitter to four different optical network units, which make this system passive optical network. The receiver consist of photo detector to convert optical signal to electrical signal, OFDM receiver module which decodes an electrical QAM-OFDM signal as generated by transmitter block and evaluates system performance characteristic specified by the output parameters: error-vector magnitude (EVM), symbol error rate (SER), as shown in figure:3.

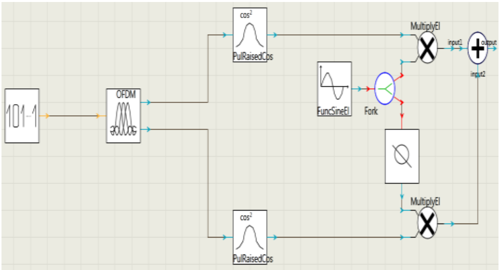

Figure 2: QAM-OFDM Transmitter block

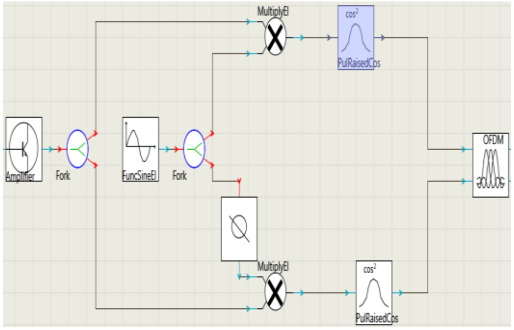

Figure 3 QAM-OFDM Receiver block

To design and implement the system VPItransmission maker software is used. After designing the system, several parameters must be taken under consideration to get the right results, these parameters are defined in **Table 1**. Figure4 shows the design for length 288km. The OFDM transmitter was defined for 4-QAM (2 bit-per-symbol). The signal from the OFDM generation was modulated by LiNbO3 Mach-Zehnder modulator with CW laser of 193.1 THz. The modulated signal is transmitted over single mode fiber for different length distributed between the EDFA for different gain value. This is done in order to avoid chromatic dispersion that occurs in long distance and power attenuation which distorts the signal being transmitted. This signal is then received by the photo-detector after passing through the optical splitter. The photo-detector transforms the electrical form to the optical form. The signal is passed through the QAM-OFDM receiver module. The received signal is analyzed by using signal analyzer. The signal distortion can be overcome to some extent by using Dispersion compensator fiber (DCF). The setup for this is shown in figure5.

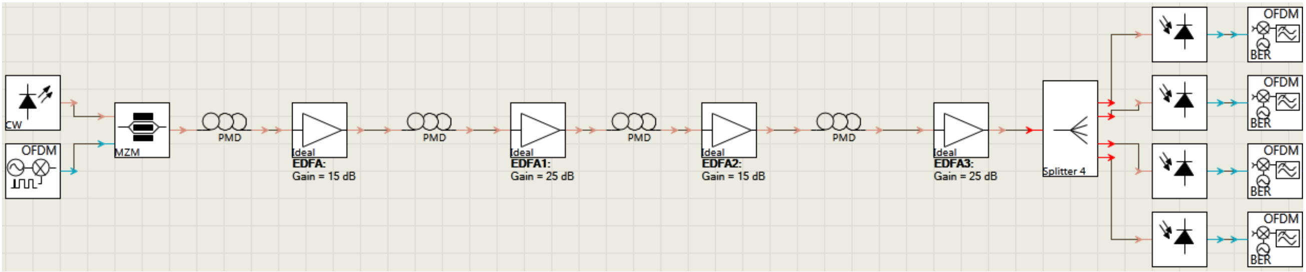

Figure 4: RoF OFDM PON system

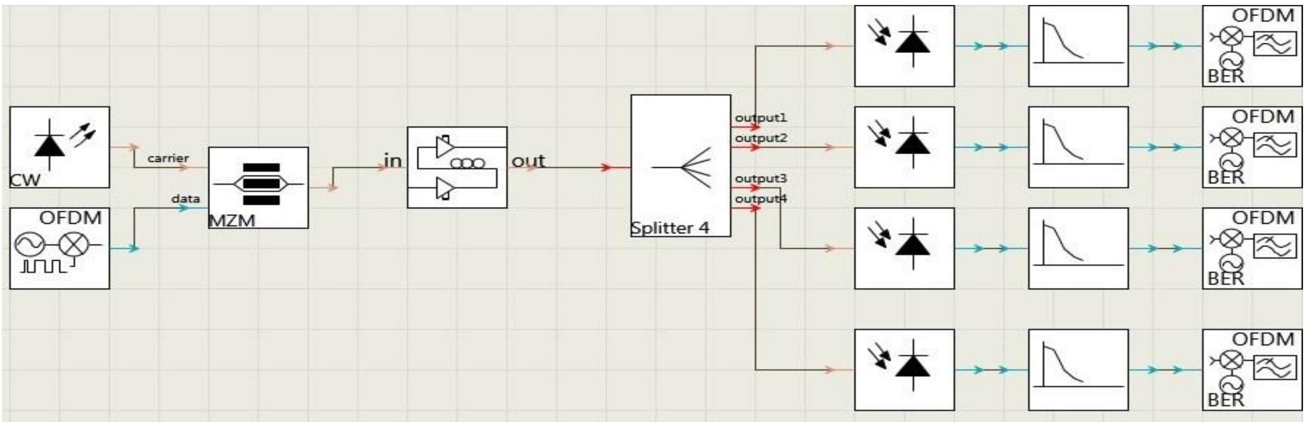

Figure 5: RoF OFDM PON system using DCF

3. RESULTS AND DISCUSSIONS

A constellation diagram is a two dimensional representation of a signal after it is modulated using digital modulation schemes such as: PSK or QAM. The modulated signal symbols are mapped as points in the complex plane with y axis representing the imaginary part of the symbol and x axis as the real part. It can measure the distortion and interference in a signal. Different modulation schemes have different constellation diagrams. Figure6 show the distorted received constellation for distorted signal for 288 km. This distortion occurs due to the chromatic dispersion. The improved constellation diagram can be shown in the figure7, which is the result of using the Dispersion compensator fiber clearly showing the quality signal. The optical and electrical spectrum received are shown in figure 8,9(resp.).

Table: 1

Parameters:

1.	Baud rate	5GHz
2.	Symbol rate	80GHz
3.	Number of subcarriers	64
4.	Cyclic prefix	0.125
5.	Roll off	0.2
6.	Rf frequency	7.5GHz
7.	Coding	QAM (m=2)
8.	Laser Wavelength	1550 nm

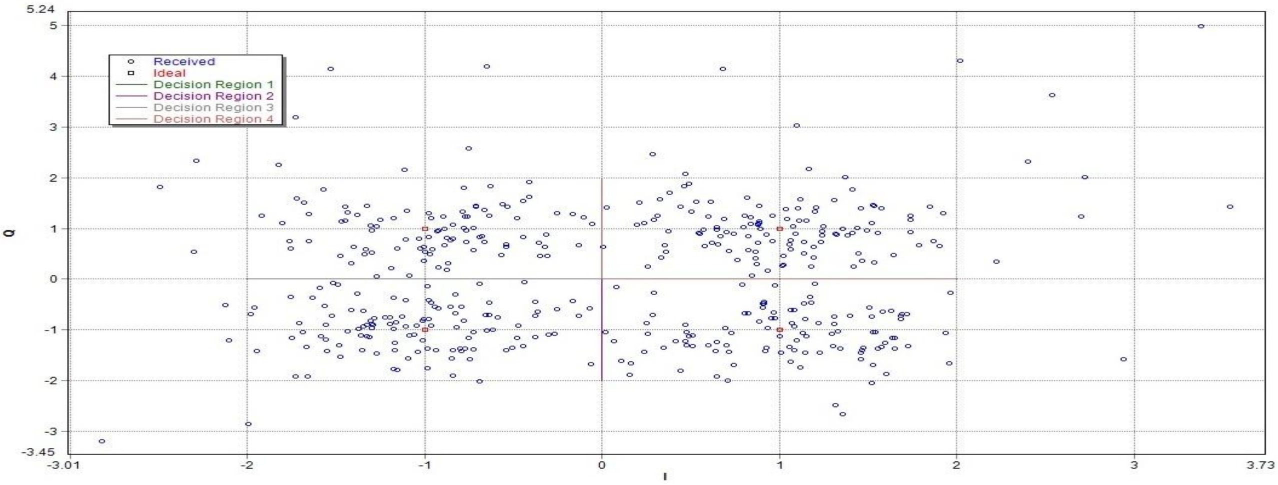

Figure6: Received Constellation without DCF

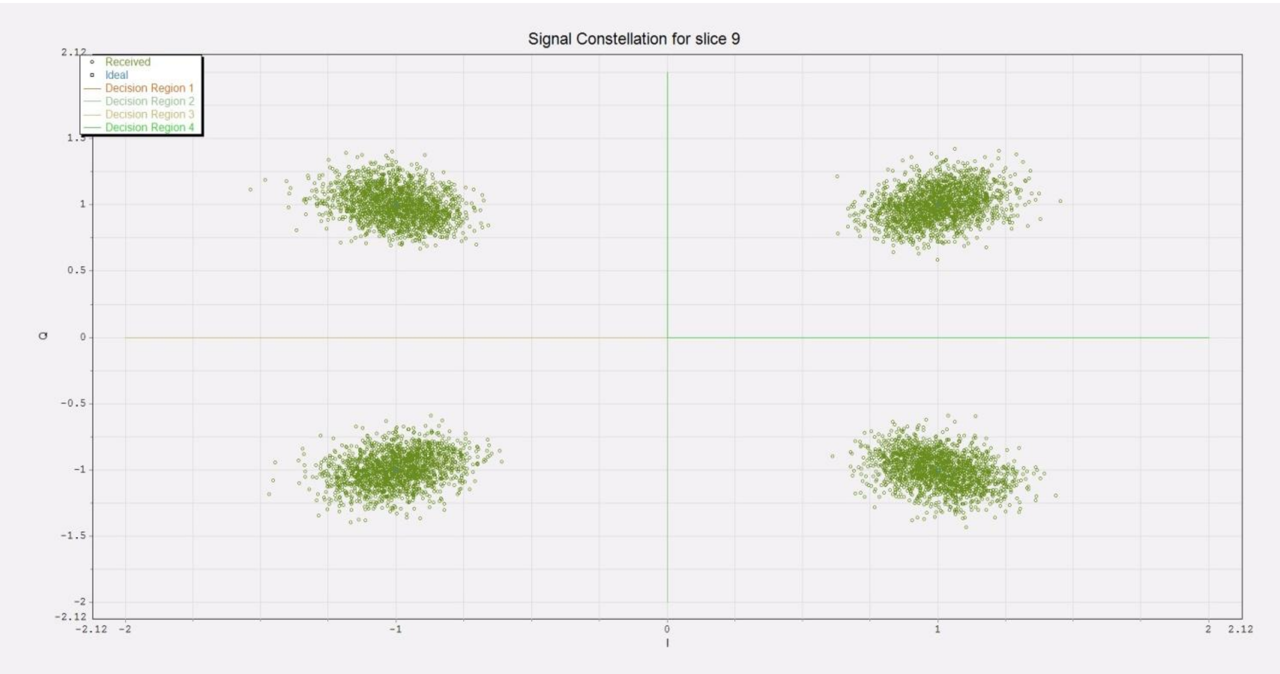

Figure 7: Improved constellation by using DCF

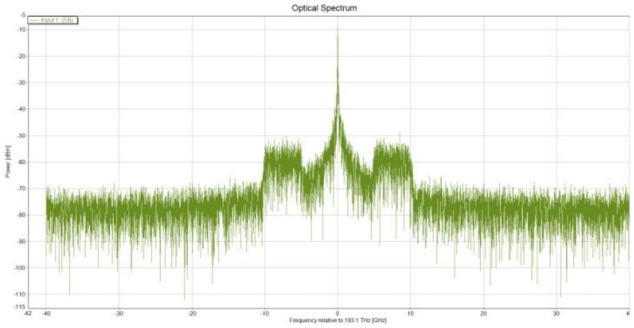

Figure8: Optical spectrum for DCF

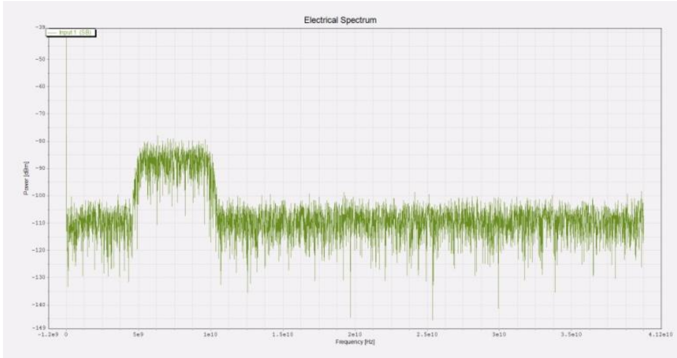

Figure9: Electrical Spectrum for DCF

Figure8 shows the optical spectrum of 4QAM received for DCF for frequency 193.1GHz. Figure 9 shows the electrical spectrum of 4QAM for carrier frequency 7.5GHz and the power is varying from -80 to -130dbm.

Figure 10 shows Symbol error rate versus OSNR. The value of SER decreases as the OSNR value increases, the value of SER is about 10^{-2}.

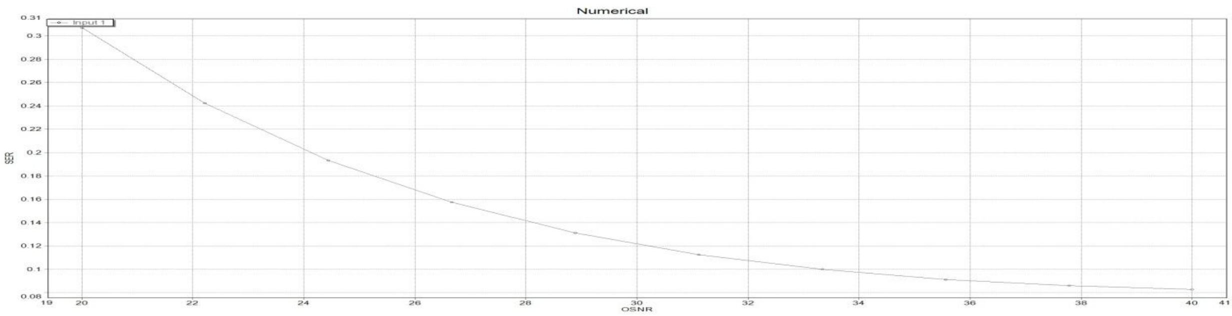

Figure10: SER vs. OSNR

4. CONCLUSIONS

In this paper has analyzed the performance of Rof-OFDM-PON with single mode fiber and dispersion compensator fiber for 288 km length by using VPI software. The four optical network units were connected using 1:4 splitter. Signal analyzer is being used to analyze the performance of the system. The study suggests that the distortion is reduced by using Dispersion compensator fiber but at the same time it makes the system complex to handle making it not flexible and cost effective. The same system with DCF can be used for high data rates as the future work.

5. REFERENCES:

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