IOSR Journal of Engineering (IOSRJEN)
e-ISSN: 2250-3021, **p**-ISSN: 2278-8719
Vol. 3, Issue 3 (Mar. 2013), ||V2 || PP 27-32

Study of the BER performance in RoF-OFDM system modulated by QAM and PSK

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Abstract: Orthogonal frequency division multiplexing (OFDM) is considered as a one of the essential components in most of recent telecommunication systems. To maintain a high bit rate and provide a high bandwidth, using the OFDM as a modulation format in RoF system is preferred over other modulation formats. In this paper, up-converting a 20 Gb/s and a 30 Gb/s OFDM signal on a 20-GHz microwave carrier over 40 km SMF was applied under a different modulation methods of OFDM such as QAM and PSK in order to study the BER performance in all proposal cases.

Key Words: *Rof-OFDM, QAM, PSK, BER*

I. INTRODUCTION:

An increase in the broadband demands has induced many studies and researchers to discover urgent and temporary solutions that help to meet the present and future demand. This highest requirement in the broadband usage is related to the diversity of the traded signals among customers. After it was limited to only sending and receiving emails, the usage of broadband has extended to be a remarkable need in humans' lives for trading data, voices, and video signals. Besides this diversity in the use of broadband, broadband mobility shares to be another cause of this shortage. Now days by their smart phones, people checking their emails, Skype with each other, and access to downloading or uploading data [1]. As a one solution, RoF-based optical-wireless access is rated. The Rof technology helps to increase the converge, bandwidth, and mobility. The most challenge in the RoF system, as well in any traditional communication system, is to transmit and receive signals with a low bit error rate (BER). The modulation and demodulation methods of the transmitted signals in the RoF systems play a role in maintaining the BER. Picking a modulation method for any RoF systems depends on the capacity and the coverage that system works to accomplish [2] [3].

Orthogonal frequency division multiplexing (OFDM) is considered to be a promising modulation method for future optical wireless system. The amazing role of OFDM in encoding digital signals in multiple carrier frequencies makes it an appropriate modulation format in such an optical wireless system. Moreover, under bad conditions with high bit rate OFDM proves its ability to be an efficient format in this case. Because of having multiple carrier frequencies, OFDM needs specific modulation methods such as phase shift keying (PSK) or quadrature amplitude modulation (QAM). The PSK and QAM orders, such as 8-PSK and 16-QAM, have different impacts and drawbacks depending on how many bits per symbol need to be transmitted. The transmission and reception stages in the RoF system are not only the effects of increasing BER; however, the optical link between these two stages is another negative effect. To overcome this effect, passive optical networks (PON) s are recommended to use. Immunization against electro and magnetic interface and low power consumption are two fundmental impcats of PON. Interaction RF signal, that modulated by OFDM format, in a WDM-PON system has shown its ability to maintain the BER. Studying the BER at different modulation methods of RoF-OFDM is the main goal of this paper [1] [4] [5].

II. OFDM MODULATION

Inserting OFDM in transition and reception terminals of any communication schemes needs a specific modulation and demodulation process for transmitting signals. There are several appropriate modulation methods of OFDM; however, the most common methods are QAM and PSK. The requisite process of modulation and demodulation OFDM goes through is shown in the block diagram Figure 1. As in any communication system, block diagram represents the transmission and the receiving terminal. The transmission side process begins by mapping technique by using either PSK or QAM before serial to parallel conversion. The streaming signals pass into IFFT operation before they are protected from overlapping of their information by adding cyclic prefixes. The signal reconvert from parallel to series as preparing to send it through wireless channel. At the receiver side starts by a conversion from series to parallel in order to remove the cyclic prefix before goes through FFT. The reception process ends with a de-mapping either by using QAM or PSK after parallel to serial conversion [6].

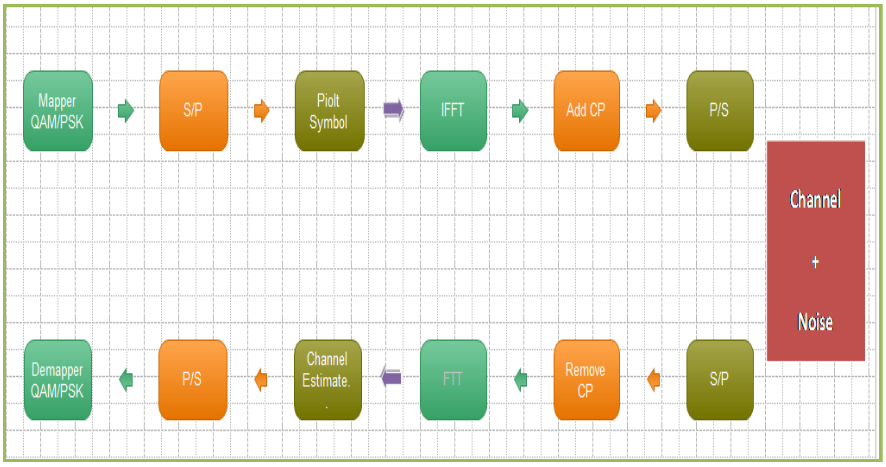

Figure 1: a block diagram of modulation and demodulation process in the OFDM

III. DESIGN CONFIGURATION

To study and analyze the BER performance in RoF-PON scheme based on the OFDM modulation format we built our proposed design in Optiwave V.11. Two of the most common methods were used in OFDM modulations which are QAM and PSK. Different types of QAM and PSK such as 16-QAM, 8-PSK, and 16-PSK were tried and compared to learn the performance of BER. Figure 2 shows a block diagram of one channel of our proposed design which contains four identical channels. In each single channel the transmitter side starts with a pseudorandom binary sequence (PRBS) with supplies a 20 Gb/s bit rate. The PRBS supplies a string of bit to OFDM modulation throughout either QAM or PSK modulation format with different orders. To change either QAM or PSK order, which is a power of 2, a symbol per bit value has to be changed in order to give the desired order. The OFDM modulator has two electrical output ports each one of them was connected to Mach–Zehnder modulator (MZM) via a low pass filter (LP). Two continuous wave laser diodes (CW) were connected to the optical inputs of MZM-1 and MZM-2. The two outputs of MZM-1 and MZM-2 were combined by using an optical power combiner. The added signal was inserted again to MZM-3, in order to be modulated with 20 GHz local oscillator (LO). Because of having for identical channel wavelength division multiplexing was used in order to send all these channels via one single mode fiber (SMF). The SMF length was chosen to be 40 km, whose chromatic dispersion and attenuation is 16 ps/nm/km and 0.2dB/km respectively. The receiving process begins with WDM demultiplexer which works to separate and distribute each channel. The separated signal reconverted from optical to electrical by using a photo diode detector (PD) before it connects to OFDM demodulator [7-11].

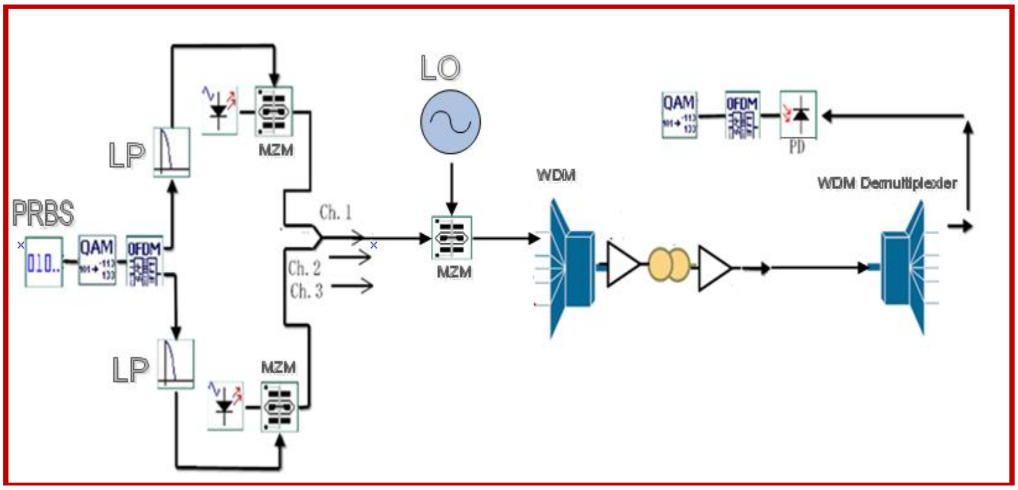

Figure 2. Block diagram for a single channel of RoF-OFDM proposal system.

IV. RESULTS AND DISCUSSION

By using Optwave V.11, we built the proposed design in order to study the BER of the received signals at different parameters. Two different cases of the system were studied by using different OFDM modulation methods which are 8-PSK, 16-PSK and 16-QAM. The first case was to up-converted 20 Gb/s OFDM signals on a 20-GHz microwave carrier over 40-km SMF. The second case was up-converted 30 Gb/s OFDM on a 20-GHz microwave carrier over 40-km SMF.

V. 20 GB/S OFDM SIGNALS OVER 40-KM SMF

PRBS supplied 20 Gb/s to OFDM throughout PSK coder with 3 symbols per bit (8-PSK). Figure 3-a shows an electrical constellation of the received signal after 40-km SMF. It is clearly can be seen each point in the constellation diagram, which contains 3 bits, has enough space without any scattering. Having separated points in the constellation diagram represents a high quality of a received signal. As a one change was applied to PSK coder and decoder, the symbol per bit value was increased from 3 to 4 in order to get 16-PSK and left the other parameters as they were. The constellation diagram of the received signal when16-PSK modulation technique used is portrayed in Figure 3-b. To find a comparison between using PSK and QAM modulation techniques of RoF-OFDM, we replaced the PSK coder and decoder to 16-QAM. Figure 3-c shows a high quality of tne received RoF-OFDM by using 16-QAM.

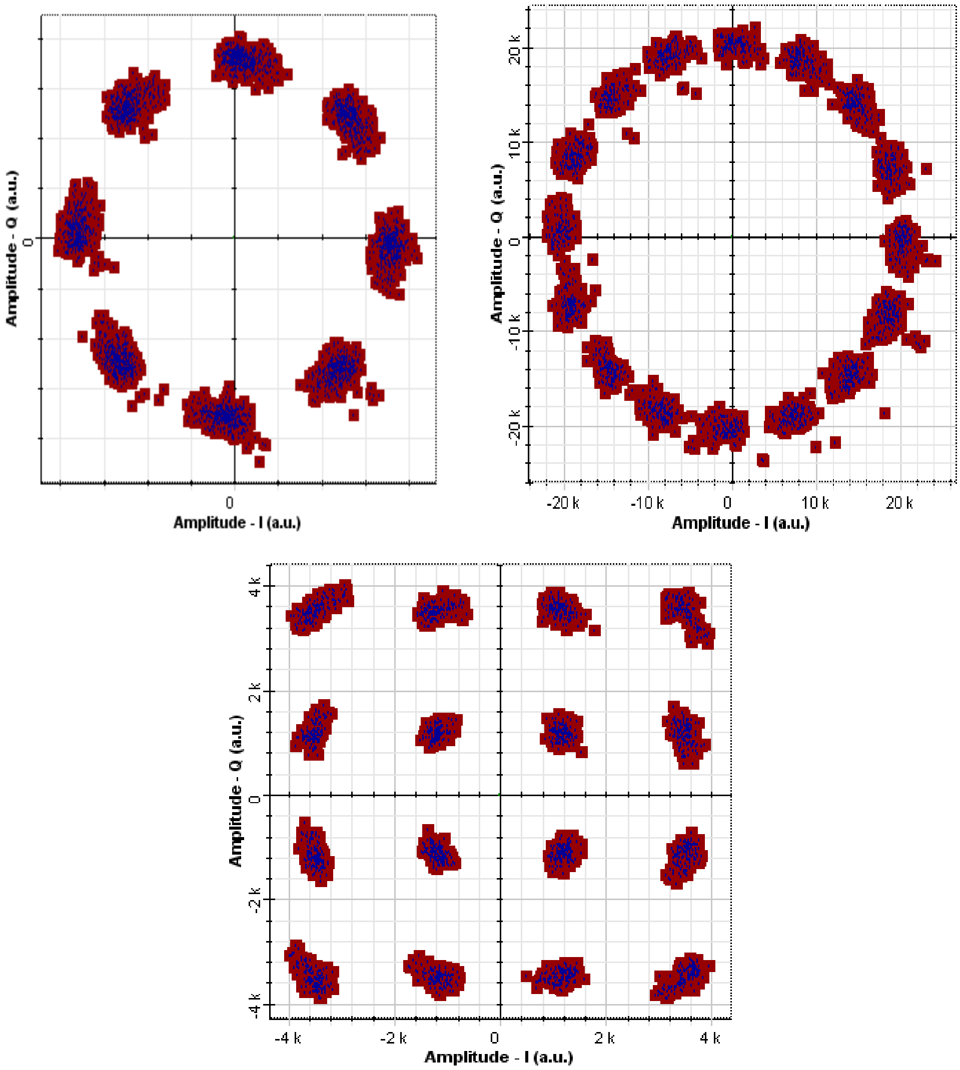

Figure 3. Constellation diagram of the received signal at different modulation of OFDM a) 8-PSK b) 16-PSK c) 16-QAM at 20 Gb/s up-converted

Table 1 has a comparison between the three modulation methods based on the received power, OSNR. The highest OSNR was occurred when 16-QAM used, however the minimum was at 8-PSK. The 16-QAM and 16-PSK have the same capacity; however, in the received power and the OSNR value 16-QAM has the highest value. The reason why 16-QAM is preferred to be used rather than 16-QAM is when the bandwidth is premium while the 16-PSK is preferred to be used when the received power is a premium. The received power and OSNR of 8-PSK and 16-PSK were almost the same that means 16-PSK is preferable in case of having a high capacity.

Table 1: OSNR and received power of the received signal at different modulation formats at 20 Gb/s

	8-PSK	**16-PSK**	**16-QAM**
OSNR dB	78.7466	78.8159	97.3369
Received power (dBm)	-21.2534	-21.1841	-2.66307

Figure 4 shows a comparison between 8-PSK and 16-PSK in BER vs OSNR. The 16-PSK has a higher BER than 8-PSK. The reason is why BER is higher in 16-PSK than 8-PSK is related to the capacity which is bigger in 16-PSK than 8-PSK. Another reason is related to the orthogonality which is affected by the overlapping in subcarriers. Having a high order of PSK means having a high number of subcarriers which causes overlapping and affect the orthogonality as a result the BER goes higher. The other evidence shows the BER is higher in 16-PSK is in Figure 5 which represents a plot of the received power vs log of BER. The log of BER of 8-PSK is higher than 16-PSK which leads to have a low BER if both 8-PSK and 16-PSK have almost the same values of received power.

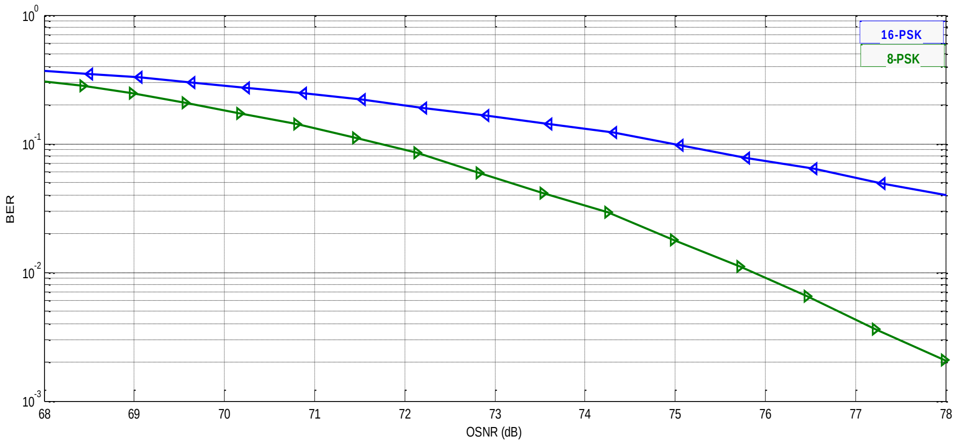

Figure 4. OSNR vs BER of the received signal when 8-PSK and 16-PSK used at 20 Gb/s

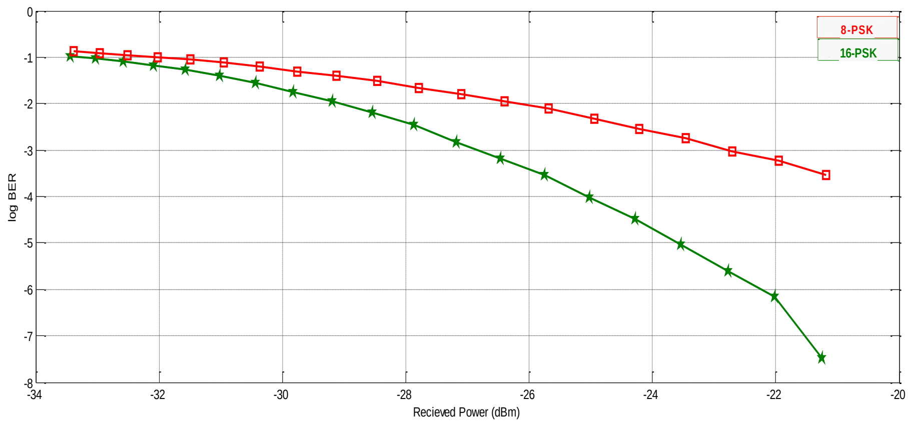

Figure 5. The received power vs log of BER of the received signal when 8-PSK and 16-PSK used at 20 Gb/s

VI. 30 GB/S OFDM SIGNALS OVER 40-KM SMF

In this case the same procedures in part were applied to an increase in the bit rate value from 20 Gb/s to 30 Gb/s. The constellation diagrams of all three modulation methods were impacted by this change as in Figure 6. Because of this increase, the constellation points of 8-PSK and 16-QAM became closer to each other while in 16-PSK they osculated each other. These crowded points in the constellation diagrams represent a received signal with lower quality in all the three modulation techniques.

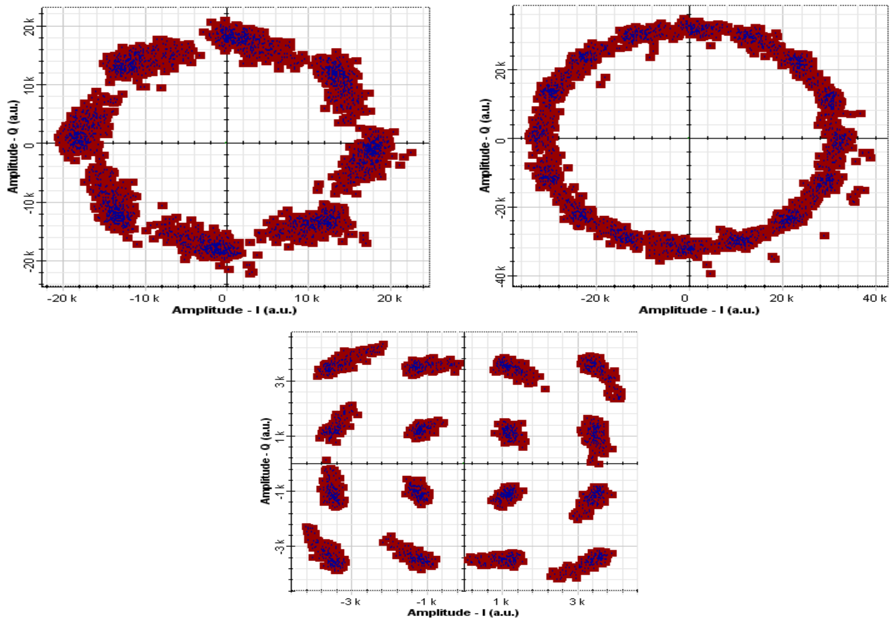

Figure 6. Constellation diagram of the received signal at different modulation of OFDM a) 8-PSK b) 16-PSK c) 16-QAM at 30 Gb/s upconverted

Table 2 has a comparison of the three modulation methods in OSNR and received power. The arrangement of which one of these methods has a highest OSNR and received power did not change with increasing the bit rate. The highest OSNR and received power happened when 16-QAM was used, while still almost the same values of OSNR and received power for both 8-PSK and 16-PSK. Even though, the bit rate increased the OSNR and received power of all methods did not dramatically decrease; however, a little drop happened.

Table 2. OSNR and received power of the received signal at different modulation formats at 30 Gb/s

	8-PSK	**16-PSK**	**16-QAM**
OSNR dB	78.5721	78.7345	97.2627
Received power (dBm)	-21.4279	-21.2655	-2.73728

Another evidence for the impact of bit rate increase is shown in Figure 7 which exhibits a plot of OSNR vs BER when 8-PSK and 16-PSK were used. The BER is still higher in 16-PSK, whilst it became higher in both cases after the bit rate increase. Even though, only 50 % of bit rate was taken into the system, the BER increased more than twice a value of the BER at bit rate 20 Gb/s. Figure 8 shows a plot of the received power vs log of BER of 8-PSK and 16-PSK.

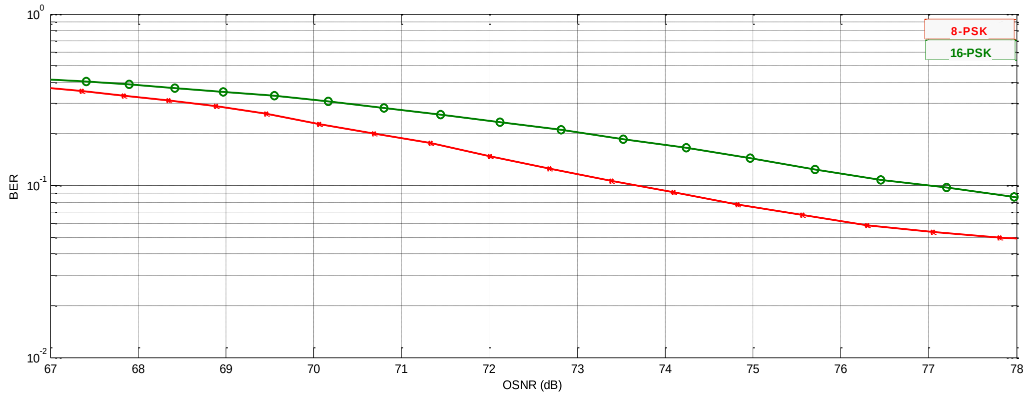

Figure 7. OSNR vs BER of the received signal when 8-PSK and 16-PSK used at 30 Gb/s

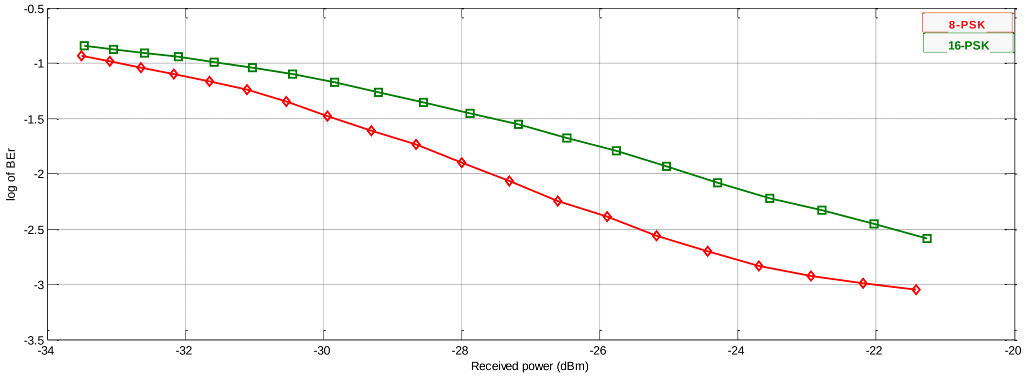

Figure 8. The received power vs log of BER of the received signal when 8-PSK and 16-PSK used at 30 Gb/s

VII. CONCLUSION

In this paper we studied the BER performance in RoF-OFDM system that modulated by different modulation techniques such as QAM and PSK. The study was under two cases of up-converted 20 Gb/s and 30 Gb/s OFDM signals on the 20-GHz microwave carrier over 40 km SMF. In both cases the lowest BER and the highest received power appeared when 16-QAM was used, while the highest BER occurred when 16-PSK modulation used. The capacity of 16-QAM and 16-PSK are almost the same; however, using 16-PSK is necessary when the received power is a premium. As a comparison between using 8-PSK and 16-PSK we found using 16-PSK caused a higher BER than using 8-PSK. The increase in BER when 16-PSK used might refers to the difficulty in maintaining the orthogonality in the OFDM. After increase the bit rate of 30 Gb/s the BER values in all modulation cases are not clear evidence of having a received signal with high quality.

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