Implementation of 10Gbps Downstream OFDM-EPON Transmission System

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***Abstract*— For the increasing demand for capacity of optical transmission systems, Ethernet-PON comes out to be a most prominent and assuring solution in todays world. The deployment of Ethernet-PON provides the evolution path to ever higher bandwidths. With OFDM, system achieves the high bit rate and higher bandwidth over other modulation formats. In this paper, we demonstrate a Ethernet PON based on orthogonal frequency division multiplexing employing OSSB modulation scheme. The simulated demonstration directs the transmission of single channel of 10 Gbps data rate to realize the proposed system and achieves the fiber link of 30km in downstream direction(OLT to ONU). The system performance can be witnessed by measuring the SNR and constellation diagram.**

Keywords- OFDM(Orthogonal Frequency Division Multiplexing), OSSB(Orthogonal Single Side Band), EPON(Ethernet Passive Optical Network)

I. INTRODUCTION

Now a days**,** multimedia applications such as internet protocol television (IPTV) and high definition (HD) video continue to conflagrate the development in bandwidth demand in multi-user access networks. An increase in the number of users are putting pressure on the comm-unication system vendors to offer higher data rates. The passive optical networks are the most significant class of fiber access systems to address the upcoming issues related bandwidth and data rates [1]. The PON technology proves to be very efficient solution to cope with the problems of broadband access networks. Also, PON technology has been confirmed the transmission of triple play servies such as voice,vedio and data in downstream link[2].EPON systems provides better performance on different wavelengths in both upstream and downstream direction. Recently, an asymmetric GPON originates with the capability of providing data rate of 2.5Gbps in downstream and 1.25Gbps in upstream channels, simultaneously [3]. In EPON systems, data packets are broadcasted to multiple ONUs in downstream direction and the intended ONU extracts the data packets that are ment for them. Here, EPON simply acts as a point-to-multipoint network and in upstream link, EPON acts as multipoint-to point network. Furthermore, only EPON nodes with privileged traffic can be WDM-upgraded by using either fixed or tunable transceivers [4]. However, there was a problem of chromatic dispersion which significantly limits the transmission distance[5]. As the data transmission speed of communication system goes to increase,a corresponding decay in time for each transmission occurs. Thus, the Intersymbol Interference (ISI) becomes a severe limitation on the high data rate communication[6]. To cope with this problem, OFDM technology along with PON comes into existence. OFDM yields high transmission rate and preferred spectrum utilization by making use of M-ary modulaton techniques such as QAM,PSK [7]. An OFDM-EPON allows flexible assignment of 4-QAM at 250 Mbps and 16-QAM LAN traffic at 500 Mbps bandwidth by allocating different number of subcarriers [8]. It is highly flexible in terms of supporting multiple granularities of bandwidth through high efficient digital modulation and dynamic resource management. The sharing of that bandwidth to all users is possible which is allocated to the sub-carriers through TDM mode [9]. The higher level of quadrature amplitude modulation (QAM) helps to increase the aggregated data rate while preserving the data bandwidth as it was i.e by making use of same number of OFDM subcarriers. The receiver sensitivities tends to increase on account of falling decision margins in the EVM calculations[13].The participation of orthogonal frequency division multiple access(OFDMA) technology for the LAN traffic transmission does not requires any change in existing EPON architecture. A single receiver at optical network unit(ONU) can detect both LAN and EPON downstream traffic, that makes the system economically good. Also, flexible assignment of LAN traffic bandwidth is analyzed by making use of different modulation formats as well as by assigning different number of subcarriers[14].Although optical fiber bandwidth is larger but the optical devices exhibits the limited bandwidth and the devices providing larger bandwidth gives rise to increase in cost. Hence, the bandwidth efficiency is the major issue. The OSSB transmission is the feature of modulation system that prove to be brilliant solution to increase the bandwidth efficiency by factor of two[10]. OFDM PON not only solved the problem of optical access network speed by improving the transmission speed,even it proved very convenient , low cost and flexible upgrade in the technology. This OFDM bsased optical access technology now become the tumid research hotspot[12]. In this work, we have demonstrated an OFDM based EPON system at 1550nm to measure the system performance at high data rate which is not elaborated earlier. The proposed system is investigated for successful transmission of downstream channel over the SSMF at high data rate and fiber link between ONU and OLT. The system is optimized at acceptable SNR of 15 dBm. This paper is organized as follows: Section I briefly describes need and year to year development in EPON system. Section II deals with the portrayal of simulated OFDM based EPON model and to measure the results. The section III puts light on the measured results in section II.Simulated OFDM based

DWDM-OSSB-EPON model and discussion on simulated findings. The section III puts light on the measured results in section II.

II. Model Description & Result Discussion

The proposed customer access EPON system using OFDM is shown in Figure 1. In our proposed OFDM-PON system, Quadrature Amplitude Modulated(QAM) data signals are generated using 4QAM sequence generator consisting of 2 bit per symbol. This QAM data signals are then modulated by OFDM modulator which uses 512 subcarriers and FFT size of 1024 to generate OFDM analog data signals. These signals are then QAM modulated at 7.5 GHz frequency. This QAM-OFDM treated analog data signals are then modulated by means of $LiNbo_3$-dual electrode MZM modulator, phase of that signals gets shifted by phase shifter and an optical source at 1550 nm to generate OSSB signals. These signals are then transmitted over SSMF fiber without using any active device in between OLT and ONU. All design parameters are taken into consideration as IEEE 802.3 ah standard [11]. The SMF fiber parameters are chosen as nonlinear reflective index coefficient = 2.6×10^{-20} m^2/W; effective area, A_{eff} = 80 m^2; attenuation = 0.2 dB/km; dispersion = 17 ps/nm/km; and dispersion slope = 0.075 $ps/nm^2/km$. The system is simulated using Optisys^{TM} software.

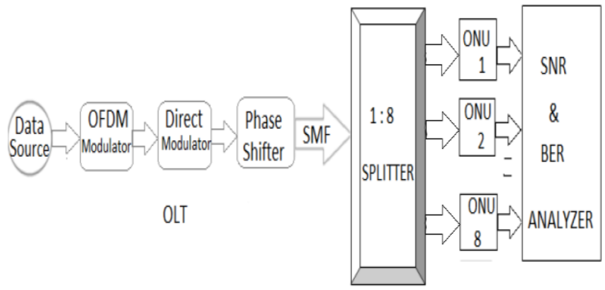
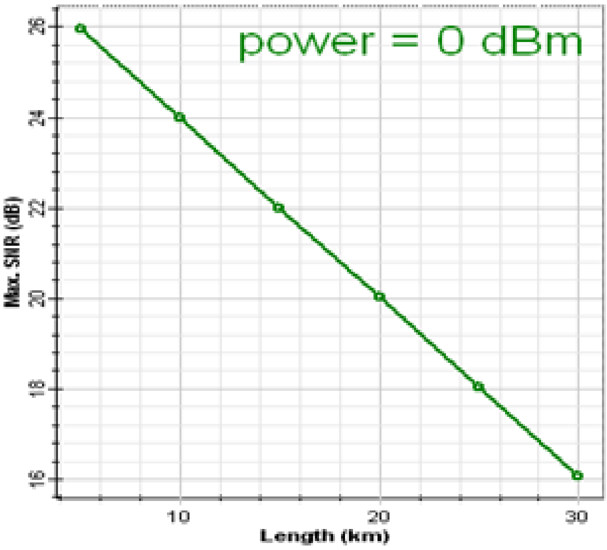


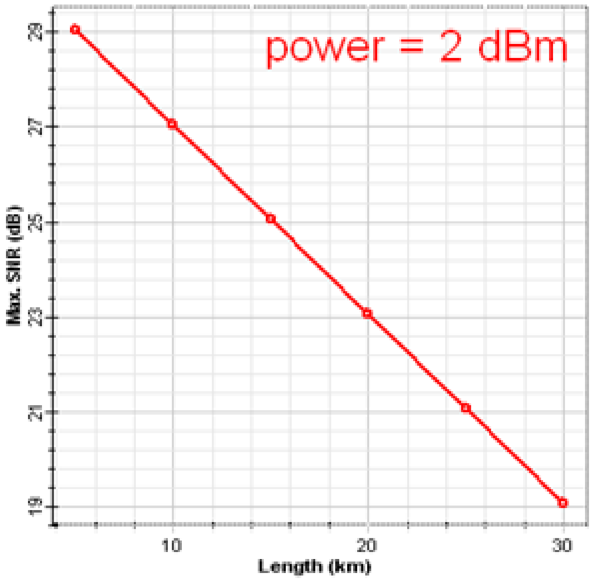
Figure 1. Block diagram of downstream OFDM-OSSB-EPON system

The PIN photo-detector for converting the optical signal into electrical signal with sample rate of 40 GHz; responsivity of 1 A/W; dark current of 10nA; OFDM demodulator with 512 sub-carriers, position array 256 and number of FFT points 1024 are used at the receiver end for electrical transmission. Different spectrum analyzers such as SNR analyzer to measure the signal to noise ratio and BER analyzers for bit error rate measurement are connected after 3R regenerator at the receiver side to investigate the observations.An optical power meter is also connected after the passive splitter to check signal strength at each node.

For the generation of OFDM treated single side band signals, the input channel is applied to both the electrode of MZM modulator suchlike that the input signal is given directly at one electrode and at another electrode with 90^0 phase shift. This OFDM treated OSSB modulated channel at 1550 nm of 10 Gbps data rate is transmitted over SSMF simultaneously at distance of 30km to realize OFDM-based OSSB-PON access system.The OSSB modulation technique is the most efficient technique for transmitting baseband digital data with minimum fiber dispersion over long distances. There is no any active component such as amplifier is used between optical line terminal (OLT) and optical distribution network (ODN).Then at the optical distribution end (ODN) a Passive splitter which acts as a Hub will split the single channel data into eight different ONUs.The data packets will get received by only intended ONU. Each onu can recognize its own data packets depending upon the MAC address.Then at the receiver end, the photodetector will convert the optical transmitted signal into the electrical signal for further use. The analysis of the demonstrated system are teken by using different analyzers.

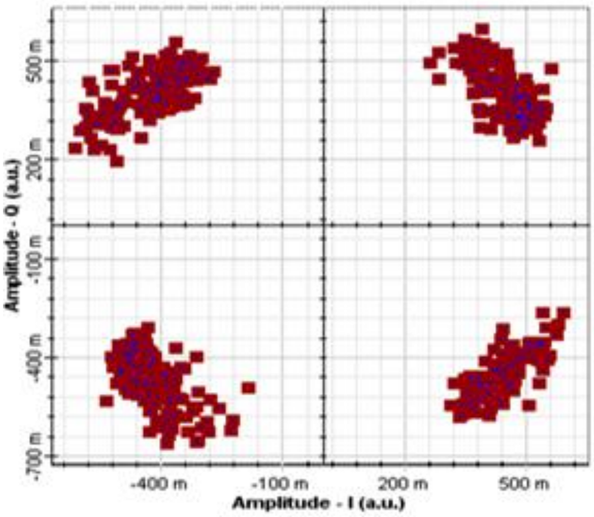


(a)

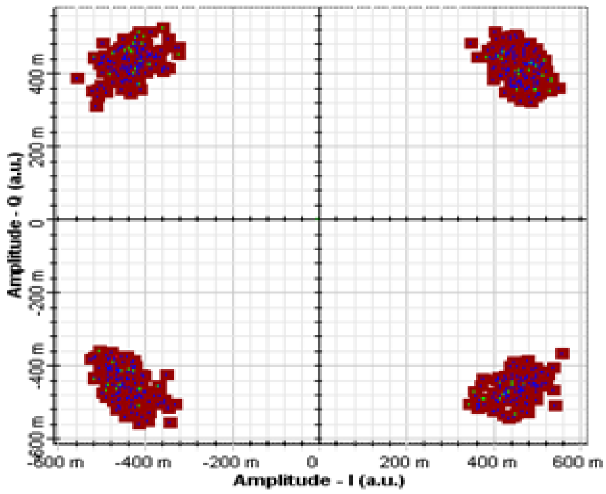


(b)

Figure 2. Measured SNR versus channel length at laser power (a) 0dBm (b) 2dBm, at 10 Gbps



(a)



(b)

Figure 3. Measured constellation diagram at data rate 10 Gbps at power (a) 0dBm (b) 2dBm

As demonstrated, the measured SNR realization for downstream EPON system is shown in figure 2 at different power.The system is capable of achieving the fiber length of about 30km with split ratio of 8 at 1550nm wavelength.On comparing the results obtained in fig (a) & (b), an improvement of about 3 dBm is acheived in SNR at 2dBm power as shown in fig(b) than SNR at 0dBm as shown in fig(a) over an optical span of 30km.it is noticed that the decay in SNR with the incrase in channel length is more at 0dBm. The measurements of constellation diagram are shown in fig.3. The signal shows the great improvement in terms of quality at 2dBm than at 0dBm. Here, the blue points shows the noise that comes from the laser diode and the red points indicates the signal. So it is indicated that the OFDM based EPON system provides better system performance with high split ratio with low BER.

III. CONCLUSION

We have proposed and demonstrated a multi-carrier multiplexing i.e OFDM based OSSB-EPON system.The system performs much better when laser power is increased. High split ratio over a long optical span with low BER is achieved by single channel transmission at 10Gbps. Hence, OSSB scheme is very effective in providing bandwidth efficiency and low chromatic dispersion over long haul communication. From this results, we have concluded that system shows the SNR within the acceptable limits even at low power. Accordingly, OFDM based system is recommended to accomplish better optical span with high split ratio at SNR within the acceptable limits.

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