PERFORMANCE ANALYSIS OF HYBRID OPTICAL COMMUNICATION SYSTEM

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Abstract : In today's era there is huge demand for long haul communication. To fulfill this demand an optimized hybrid optical communication system is designed for a bit rate of 2.5Gbps/channel. This proposed system composed of 8-channel wavelength division multiplexing with fiber optic link and wireless optical link for wide applications. OWC systems offers best performance in the presence of atmospheric effects. However the fiber undergoes some linear effects. In order to reduce these effects compensation techniques were employed. The system performance is analyzed with and without compensation by means of quality factor, Bit Error Rate and eye opening. The system is designed to transmit data for a distance of 350 km. The proposed system will be efficient for present and next generation long distance optical communication.

Index Terms **- Bit Error Rate (BER), Compensation techniques, Fiber optic link, Wireless optical link, Quality factor.**

I. INTRODUCTION

In the present technology there is huge demand for seamless connectivity that supports ultra-high bit rate with high speed. Radio frequency and optical communication are the two transmission techniques that have been spread out for wireless communication. Boundless research is based on RF wireless communication but optical wireless communication is also rapidly developing due to it's various commendable features such as extremely high data rate, license free operation and high security [1]. Our proposed work is a hybrid system which consists of both optical wireless communication channel (OWC) and optical fiber in order to provide a cost efficient system for long haul communication. OWC follows line of sight communication in which optically modulated data are transmitted over free space medium, i.e. atmosphere. OWC system can perform well for both indoor and outdoor services [2]. OWC based network technologies offer unique advantages. This is actually attributed to remarkable development in field of light sources, light-focusing optics, photo-detectors and superior optical signal processing techniques [3].However, optical fiber communication is also used for long distance transmission. In optical fiber information is transmitted from one place to another by means of light pulses. Optical fiber has large advantages over existing copper wire in long-distance, high-demand applications due to much lower attenuation and interference. Fiber-optic systems were complex and expensive to install and operate. For point to point communication, fiber optic link is suitable but not for multicasting purpose. In case of optical fibers, both linear impairment and nonlinear impairment degrades the working capacity of system [5, 6].For long haul transmission, optical communication link is aided with WDM (wavelength division multiplexing) operating at Gigabits. The WDM is becoming the preferred technique these days to cover the longer distance along with large number of channels. Using this technology number of channels can be increased on demand [4]. In previous works optical amplifiers such as EDFA, SOA and Raman are used in a hybrid form in order to provide optical amplification and to improve signal detection [7, 8]. Distributed hybrid optical amplifiers are also investigated for long reach optical access system [9]. Thus taking into the account of growing requirements and separately the advantages and disadvantages of the existing techniques, there comes the necessity of the implementation of a hybrid network, in which the limitations of one technology can be overcome via the coexistence of another technology, in the same network. The proposed hybrid optical communication system is a promising architecture for future access networks as it has pre-compensation, post-compensation and symmetric compensation techniques. The paper is organized as follows: Section II describes the system design, Section III elaborates the results and discussion and Section IV concludes the paper.

II. SYSTEM DESIGN

The system designed in this paper is a hybrid link which is different from the previous designs in terms of its transmission medium. We have used various parameters to investigate the performance of hybrid optical communication system. We have proposed the model for 8 channel WDM optical network using hybrid transmission medium and by employing pre-compensation, post-compensation and symmetric compensation techniques. We have experimented to give new direction for a system by using hybrid link and compensation techniques to boost the quality of system [10]. Our work has been split into two objectives: one is to analyze the performance behavior of 8-channel WDM- hybrid link and second is to design a compensated 8-channel WDM hybrid link and compare it with results obtained in first objective. Figure 1 shows the setup of 8-channel uncompensated WDM-hybrid link.

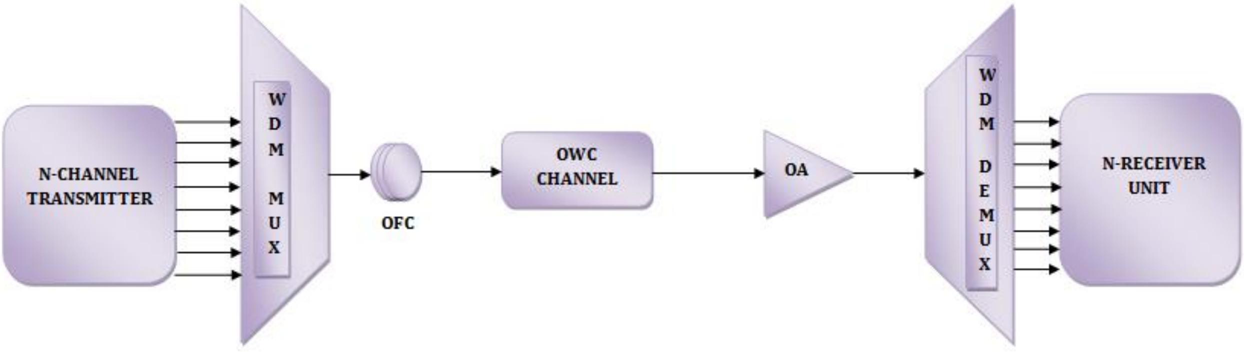


Fig.1 Block diagram of the proposed hybrid optical communication system

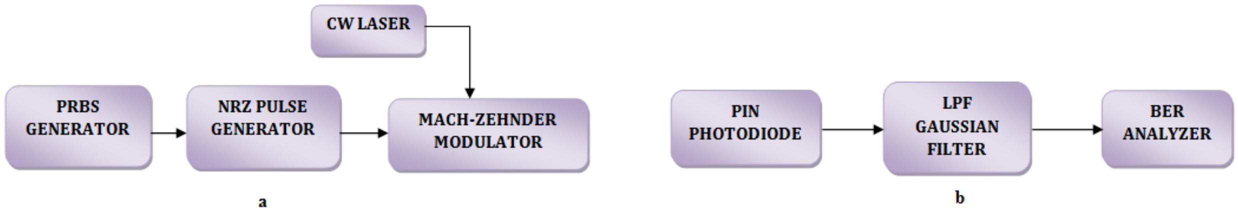


Fig. 2(a, b) Transmitter and receiver section for a single channel

The schematic and its operations are explained as follows: The transmitter section consists of CW laser, pseudorandom bit sequence generator, NRZ pulse generator and Mach-Zehnder modulator. Hence the transmitter performs the operation of converting the electrical signal into optical form and after multiplexing 8-channels it is transmitted over hybrid link i.e into the optical fiber and through OWC channel. On the receiver section reverse procedure takes place. The de-multiplexers separate the combined channels followed by Gaussian filter and the received signal is shaped to reduce the degradation of signals. Here optical amplifier is used in order to compensate the losses in fiber such as, fiber attenuation losses, fiber tap losses, fiber splice losses [11, 12]. At the receiver side it is difficult to detect the original signal due to these losses. So it is important to compensate all losses in a fiber in order to transmit signal over a long distance. Optoelectronic repeaters or optical amplifiers are used for compensating such losses. Optical amplifiers play an important role in increasing the capacity of optical communication systems. They offer high capacity and long-lifespan. Hence amplification is done after the optical wireless communication channel.

Table 1 Parameters for Hybrid link

Parameters	**Values**
PRBS bit rate(Gbps)	2.5
Communication	Hybrid i.e. fiber and OWC
Multiplexing	WDM
No of channels	8
Optical channel frequencies(THz)	193.1 to 193.8
Transmitted optical power(dBm)	3
OWC channel range(km)	300
Optical amplifier gain(dB)	20
Transmitter aperture diameter(cm)	15
Receiver aperture diameter(cm)	15
Source	CW Laser

In case of compensated hybrid links, the general schematic of 8-channel hybrid link is illustrated in Figs. 3, 4 and 5 for pre-, post- and symmetric compensation, respectively. Similar process may be followed in case number of users is to be increased.

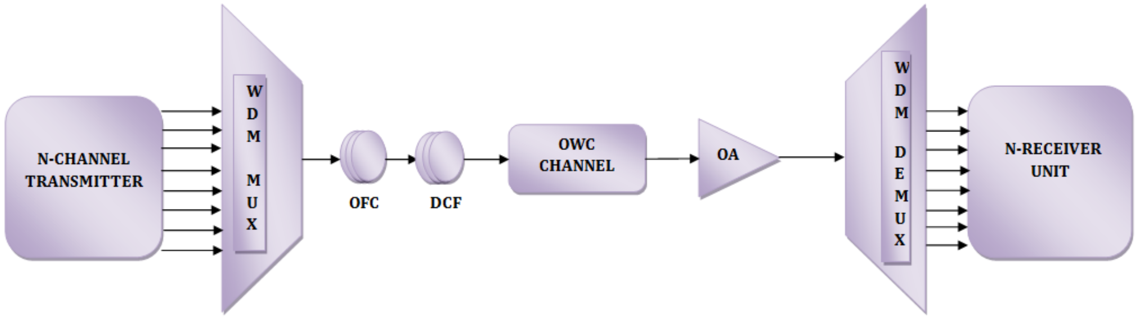


Fig. 3 Block diagram of the pre-compensated hybrid optical communication system

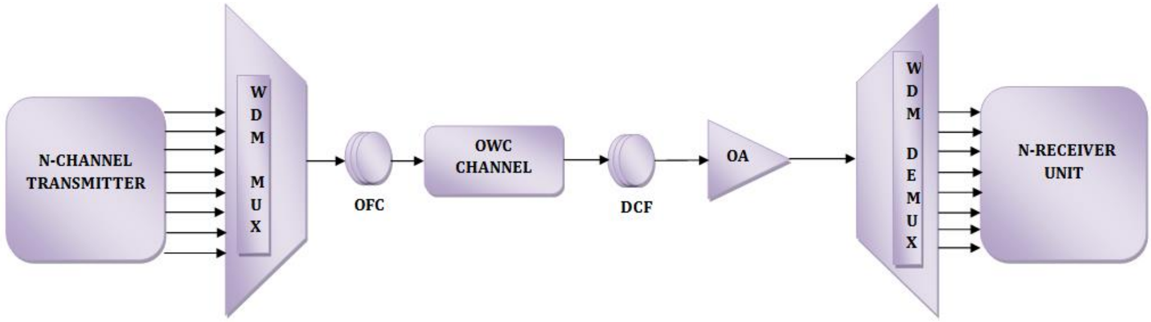


Fig. 4 Block diagram of the post-compensated hybrid optical communication system

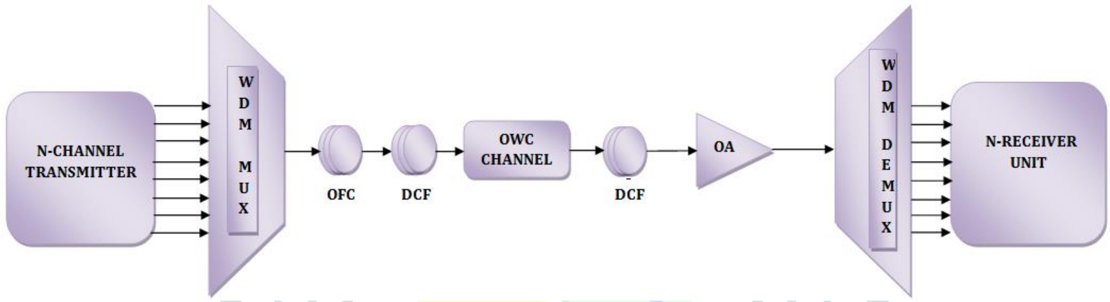


Fig. 5 Block diagram of the symmetrically compensated hybrid optical communication system

To diminish the loss of signal in fiber based communication dispersion compensation and optical amplification plays a most assuring role. When the dispersion is compensated using suitable length of dispersion compensating fiber (DCF), must give a better results when compared with uncompensated links. The parameters for Hybrid link and compensated links are given in table 1 and 2.

Table 2 Additional fiber parameters

Parameters	**Values**
Length of optical fiber(km)	50
Length of DCF(km)	10
Dispersion co-efficient of optical fiber(ps/nm/km)	16.75
Dispersion co-efficient of DCF(ps/nm/km)	-80

III. Results and Discussion

Figures 1, 3, 4 and 5 interpret the proposed designs that were used to investigate the working capacity of our system. The spectrum of 8-channel WDM-hybrid link is shown in figure 6. Figure 7 a, b, c, d depicting eye pattern of uncompensated and compensated hybrid link focus the superiority use of compensation mechanism.

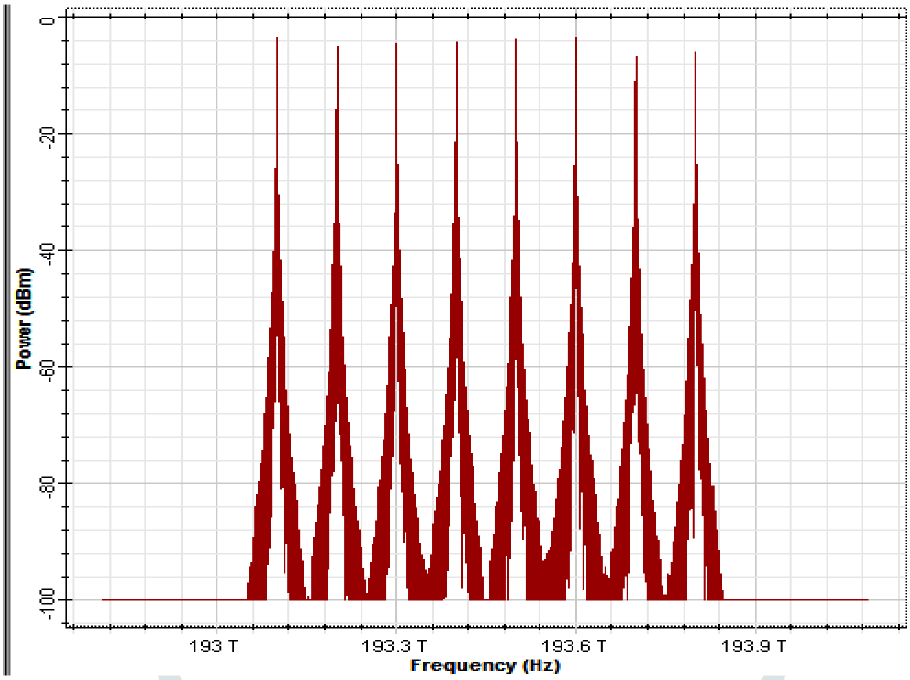
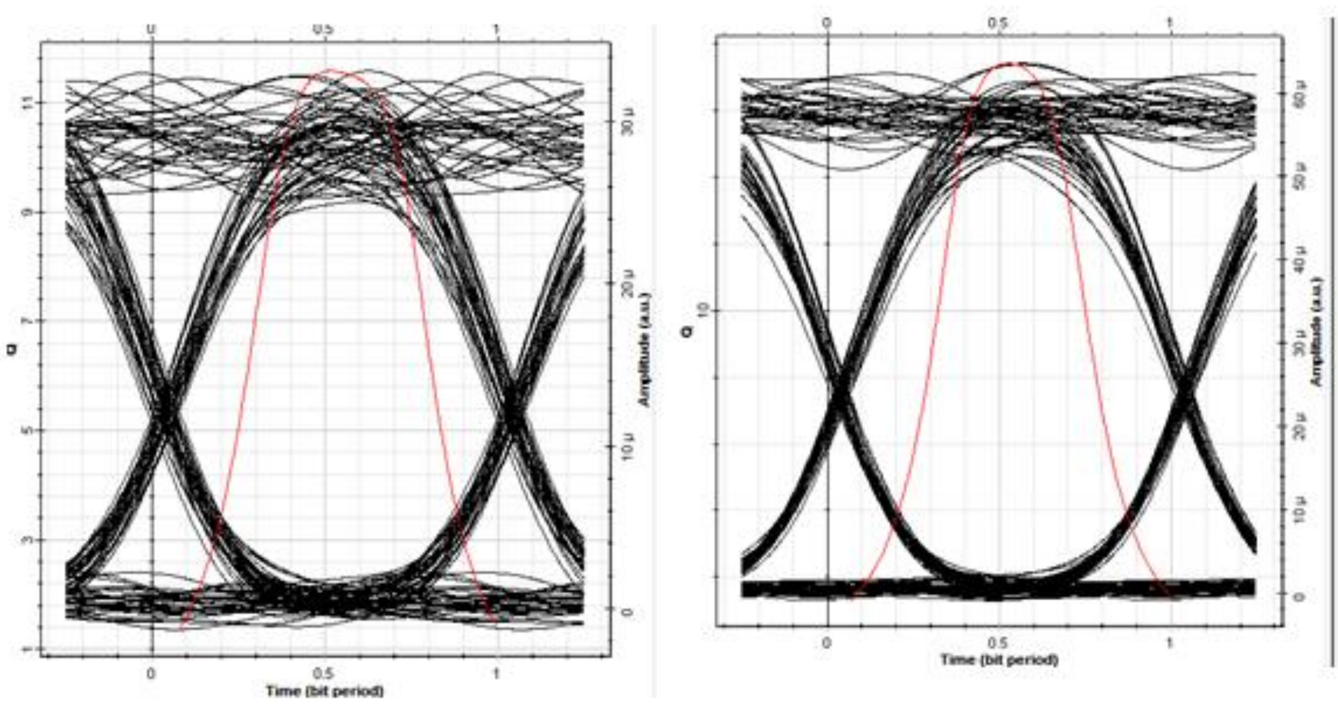


Fig. 6 Spectrum of 8-channel WDM transmitter system



a b

Fig. 7(a,b) Eye diagram for uncompensated Hybrid link and precompensated Hybrid link

Figure 7(a) depicts the eye pattern for an input power of 3dBm at a distance of 350km.It has been observed that a quality factor of 11.58 and a bit error rate of 10^{-31} has been attained. Figure 7(b) depicts the eye pattern for an input power of 3dBm at a distance of 350km.It has been observed that a quality factor of 17.40 and a bit error rate of 10^{-68} has been attained.

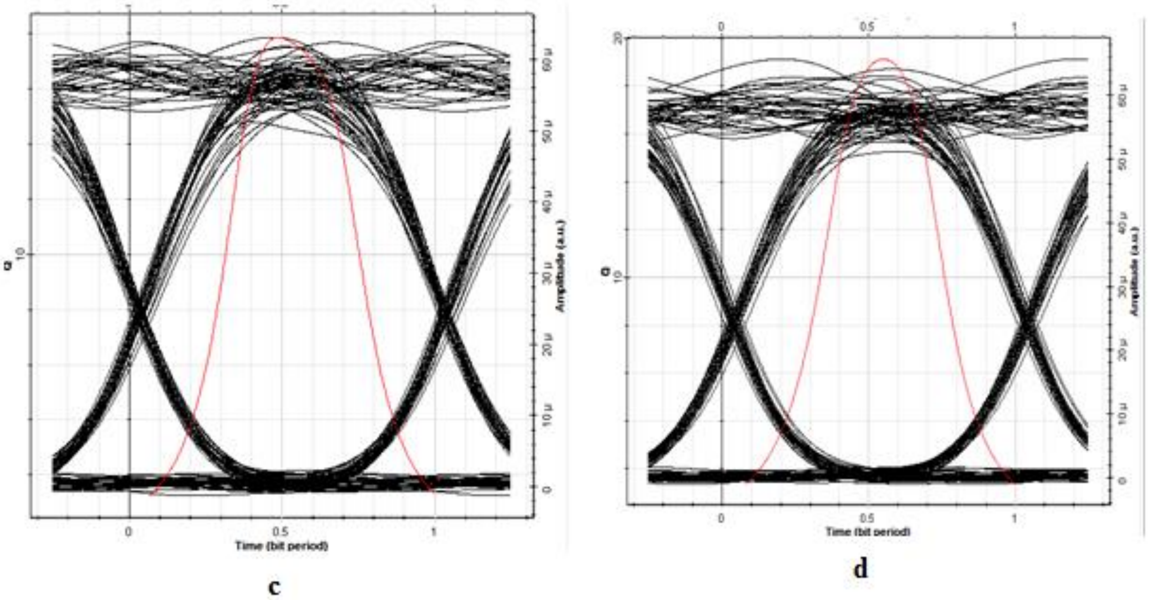


Fig. 7(c,d) Eye diagram for Post-compensated Hybrid link and symmetrically compensated Hybrid link.

Figure 7(c) depicts the eye pattern for an input power of 3dBm at a distance of 350km.It has been observed that a quality factor of 17.89 and a bit error rate of 10^{-72} has been attained. Figure 7(d) depicts the eye pattern for an input power of 3dBm at a distance of 350km.It has been observed that a quality factor of 19.82 and a bit error rate of 10^{-82} has been attained.

Table 3 Evaluation of Q-factor and BER for uncompensated, pre-compensated, post-compensated and symmetrical compensation

Channels	CH1		CH2		CH3		CH4		CH5		CH6		CH7		CH8	
	Q	BER	Q	BER	Q	BER	Q	BER	Q	BER	Q	BER	Q	BER	Q	BER
Without compensation	11.5	10^{-31}	13.5	10^{-42}	10.7	10^{-27}	10.9	10^{-28}	10.7	10^{-27}	11.9	10^{-33}	11.7	10^{-32}	11.7	10^{-32}
Pre-compensation	17.4	10^{-68}	18.9	10^{-80}	14.3	10^{-57}	17.2	10^{-67}	17.4	10^{-68}	16.1	10^{-59}	19.1	10^{-78}	19.9	10^{-65}
Post-compensation	17.8	10^{-72}	19	10^{-81}	16.3	10^{-60}	17.9	10^{-72}	18.8	10^{-83}	20.1	10^{-72}	17.4	10^{-68}	16.2	10^{-59}
Symmetrical compensation	19.8	10^{-82}	20.9	10^{-97}	19.5	10^{-85}	18.3	10^{-75}	19.2	10^{-80}	21.8	10^{-91}	18.6	10^{-82}	16.9	10^{-89}

Table 3 further simplifies the analysis between various forms of compensated 8-channel (at 2.5 Gbps) WDM-hybrid links. Clearly the compensated hybrid link shows a better performance for a distance of 350 km. Here the compensation technique has been proposed in order to improve the link reliability and enhance coverage area. Appropriate amplification is done either at transmitter or at receiver, giving rise to three different configurations of pre-, post- and symmetric compensation, respectively.

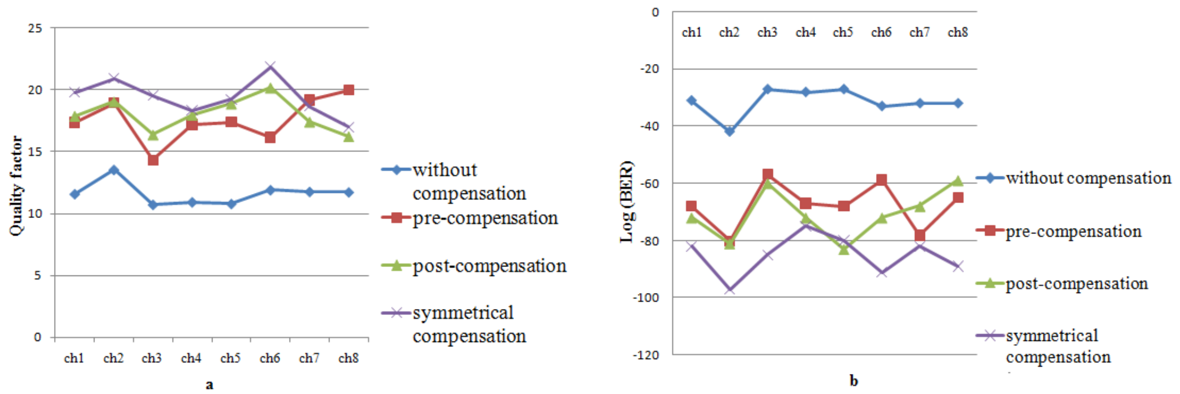


Fig. 8(a, b) Quality factor and BER comparison for un-compensation, pre-, post- and symmetrical compensation

Figure 8(a) depicts the comparison of quality factor for un-, pre-, post- and symmetrical compensation. This graph clearly shows that the quality factor is decreased without compensation and it is increased by employing compensation techniques. Symmetrical compensation provides much better performance in terms of quality factor when compared with pre- or post- compensated hybrid link. Figure 8(b) depicts the comparison of BER for un-, pre-, post- and symmetrical compensation. From the graph it is clear that, symmetrical compensation provides much better performance in terms of quality factor and BER when compared with pre- or post-compensated hybrid link.

IV. Conclusion

In this paper we have successfully modeled the system encompasses an 8-channel hybrid optical communication link operating at 2.5 Gbps/channel. In addition to this dispersion compensation techniques were also illustrated and verified. The pre-, post- and symmetric compensated hybrid link bear a good BE of 10^{-68},10^{-72} and 10^{-82} respectively. The results of un-compensated link is compared with compensated links in terms of BER and Quality factor in simulation. Hence the proposed hybrid optical communication system is proved to be an efficient architecture for future access networks.

V. Acknowledgment

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