Abstract--The high quality signal demands at user end and introduction of impairments due to increased network capacity and data rates made it essential to monitor quality of signal at different points while it travels from source to destination. One of the important parameter to quantize the signal quality is OSNR. In the proposed work effect of Power, Bit Rate, Noise Figure and Signal Gain on OSNR of signal has been studied. The simulation work has been done in OPTSIM and behavior of network obtained is compared with experimental data. The OSNR calculated for 1m and 3m fiber cable is 17.0645 dB and 16.0513 dB respectively.

I. INTRODUCTION

Increase in demand of bandwidth application and various new broadband services have brought increase in internet traffic. As a result network complexity has also been increased, presenting difficulties in controlling the optical networks. This has made all optical networks even more challenging to manage. Therefore to manage faults in physical layer and maintaining the networks, optical performance monitoring (OPM) has been proposed [1]. OPM includes various parameters to monitor like OSNR, Q-Factor, Bit Error Rate, Jitter etc. OSNR is an important parameter of OPM to monitor because it provide information on the signal transmission and signal quality.

Number of methods has been suggested to monitor OSNR in the past literature using Mach Zender modulator, polarization nulling, birefringence, beat noise analysis etc [2-10]. The technique using Mach-Zender modulator is accurate and requires the information of signal amplitude and thereby system calibration is required by turning the noise off [2-4]. Another method to monitor OSNR using Polarization nulling requires two main parameters namely transmitted signal and the noise present in receiver. The signal sent is coherent while the noise is incoherent. To improve the accuracy of this technique, technique using birefringence is proposed [6]. Birefringence shows that when signal is transmitted through optical fiber, the state of polarization of different channels can be changed due to the effect of their intensity. This technique has more complexity then the previous methods. Reduced complexity and high accuracy was shown by other technique based on an optical parametric amplifier [7].

Beat Noise Analysis is proposed for PSK signal analysis [8-9].

In this paper, OSNR monitoring based on electronic processing technique has been demonstrated. For obtaining the network behavior, a simple 10 Gbps network of length 1Km has been simulated in OPTSIM. The response of network is obtained at destination in form of eye diagram, optical spectrum which is being analyzed to calculate the amount of OSNR present in different system configuration. The experimental work is being carried out for 1m and 3m length of fiber cable and results obtained are compared with simulation result. In this paper section1 includes introduction to basic principles. Section 2 starts with the need of monitoring and causes of signal degradation, while section 3 discuss simulations and experimental set up used for OSNR monitoring has been discussed in section 4 followed by results, discussion and conclusion.

II. BACKGROUND

I. Need for Optical performance monitoring:

The need of optical performance monitoring is a natural extension as communication systems are moving from electronic to optical. In Electronic performance monitoring health of an electronic system is being checked by monitoring the quality of electronic signals. On the other hand optical performance monitoring (OPM) checks the quality of optical signals. Optical performance monitoring is necessary to manage high capacity optical transmission and switching systems [1]. OPM has extremely vast and large range of functionality which is supposed to be included in a communication network to improve the quality of network and performance [10-11]. Both current and future Wavelength Division Multiplexing (WDM) or Dense Wavelength Division Multiplexing (DWDM) optical networks require reliable and economical methods for performance monitoring without interrupting the client connections. For the efficient operation and maintenance of the network, it is important to monitor various parameters like wavelength, optical power, optical signal-to-noise ratio (OSNR), and optical paths, etc. On the other hand there are some factors which leads to signal degradation in optical domain.
II. OSNR

Optical signal noise ratio is the measure of the ratio of the signal power in an optical channel. In optical communication systems, the signal usually consists of the modulated light which is compromised of optical power, distributed over a large wavelength range. There is noise which arises in optical amplification and is better thought of as a power density rather than a total power. OSNR can be monitored by analyzing this noise. OSNR is important because it suggests a degree of impairment when the optical signal is carried by an optical transmission system that includes optical amplifiers.

The equation for OSNR has been derived from Q-Factor and Bit Error Rate.

The BER can be related to the Q factor by using the decision-circuit method introduced by Personic in [12] and enhanced by Bergano et al. in [13].

The equation for OSNR may be derived from Q-Factor and Bit Error Rate expressions as specified in [12, 13, 14] as

\[
\text{OSNR} = \frac{Q^2 + \sqrt{Q}}{2}, \quad \text{where}, \quad Q = \frac{2 \sqrt{2 \text{SNR}}}{1 + \sqrt{4 \text{SNR}}} \quad \text{and}
\]

\[
\text{BER} = \frac{1}{2} \text{erfc} \left( \frac{Q}{\sqrt{2}} \right)
\]

1. Experimental setup

The research is carried out by the basic experimental kit for optical fiber communication Tx and Rx Trinity kit (FO-1304).

Fiber optic transmitters are composed of three components named as buffer circuit, driver and light source. Driver circuit provides electrical power to the optical light source so that it duplicates the data pattern which is being transmitted. Lastly, the optical source converts that power into light energy with the same pattern. In the Receiver end, photodetector converts the light energy into the electrical energy. Pattern imparted to the optical energy will reproduced as an electric current with the same pattern as it was transmitted.

The output waveforms (Sine waveform) has been obtained by providing the different input signals and also by using different fiber cables of length 1m and 3m respectively. After generating output waveforms on DSO it is processed in MATLAB.

Fig 1. Basic principal for optical network

Fig 2 Sine wave generated on DSO (1m)
OSNR calculated for 1m and 3m fiber cable comes out to be 17db and 16db respectively. However through simulations OSNR has been varied from 12db to 24db.

III. SIMULATION SETUP

In order to assess the effectiveness of proposed work simulated network is shown in Fig.4.

Through the desire model Eye diagram, Optical spectrum and Electrical spectrum is obtained and corresponding OSNR is calculated.
A 10 Gbps signal at 1550 nm wavelength and a CW signal are coupled together and fed to a dispersion flattened highly nonlinear photonic crystal fiber (PCF). The simulation setup (Fig. 1) consists of simple single-channel transmission link. RZ modulated channel at 10.7 Gbps bitrate is setup into 1km long transmission section. Output signal from transmission section passes through Optical Filter and Attenuator before reaching Receiver.

Depending on Transmitter and Receiver sections parameter setting one can detect different values of OSNR in the system. The system symbol rate is 32 Gbaud, the bandwidth is 0.512 THz and the number of samples per symbol is 20. The OSNR is measured over a bandwidth of 12.5 GHz, typical for optical spectrum analyzers. The transmitted spectrum at the output of the fixed power optical amplifier and Eye diagram at receiver sensitivity obtained is shown in Fig 5 & Fig 6.

OSNR has been varied from various parameters which are named as Power, Noise Figure, Bit Rate and Signal Gain. The behavior of OSNR with respect to these parameters is described in following paragraphs.

a) Power: OSNR change is proportional to the average of input power changes at every amplifier. A simple assumption that the system penalty is a function of only the output power can lead to an over-generalization error in a system performance analysis, as the OSNR penalty is independent from the output power. However there is strong correlation between the output power changes and OSNR changes because the final output power and the average power have certain correlation when the number of amplifier is small. The continuous wave laser have the specific power of 10dbm and the frequency is of 193.1THz. The line width used in the model is of 10MHz. optical fiber having the reference wavelength of 1550 nm of the normal mode is used. The length of the optical fiber is assigned to be equal to 10 km. Then the power has been varied from -8db to 15db. As the power is varied corresponding to it OSNR has also been changed from 14db to 24 db. The graph so obtained is shown in Fig 7.

b) Noise Figure: NF changes differently with respect to fiber length and pump power for different pumping schemes i.e. forward and backward pumping schemes. Keeping the frequency at 193.1 THz, Noise is increased from 0db to 9db. With the increase in noise OSNR has been decreased from 20db to 13db. The graph between OSNR and NF is shown in Fig 8.

c) Bit rate: Bit rate has a large effect on OSNR. The bit rate is the number of bits that pass a given point in a network at a given amount of time. It has been varied from 1 Gb/s to 50 Gb/s and it is observed that with the increase in bit rate OSNR has been decreased from 24dB to 13dB. Graph so obtained is shown in Fig 9.

d) Signal Gain: Signal gain is present in the optical amplifier. Keeping the transmission power fixed at 3 dB, Frequency at 193.1THz. The signal gain has been changed from 1db to 20 db and it is noticed that OSNR has also been decreased from 22 dB to 17 dB. Graph is shown in Fig 10.
Fig 7 Power vs OSNR

Fig 8 Noise figure vs OSNR

Fig 9 Bit rate vs OSNR

Fig 10 Signal gain vs OSNR
IV. CONCLUSION

OSNR monitoring method is presented by implementing Electronic Post Processing of signal. The OSNR when calculated for simulated network is found to be varying from 12db to 24db depending on various parameters like Bit rate, Power, Noise Figure and Signal Gain. OSNR calculation through experimental set up for 1m and 3m fiber cable is found to be 17.0645 dB and 16.0513 dB respectively. The technique used here is cheap and has high accuracy.

REFERENCES