PERFORMANCE ANALYSIS OF OPTICAL RINGO NETWORKS

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ABSTRACT

In this paper the ringo, comprising of various nodes has been demonstrated and signal is analyzed as it passes through the various nodes in the network with the help of optsim simulation tool. It is seen that Q factor increases as signal passes through various successive nodes in the ring network. When the whole ring structure is iterated with the help of iterative component called spans, then also improvement in Q factor is seen. Various other measures of increasing the quality factor of signal are studied and analyzed. Effect of other network element parameters like fiber length, on the various nodes is done and the optical spectrum of the signal is seen at every node to have the assessment of add and drop frequencies in the ringo network.

KEYWORD: *Ringo network, Add drop multiplexer, Quality factor, Optical spectrum*

I. INTRODUCTION

Metropolitan networks have been attracting much attention as they impose a bandwidth bottleneck between the local access networks and the backbone. The deployed circuit-switched SONET/SDH rings are relatively inefficient for dynamic traffic, and although several approaches to adapt circuit-switched techniques to data traffic are in the standardization stage, many efforts are oriented to the design of packet-switched techniques combined with WDM to increase the bandwidth [1,2]. Optical switching and repeating devices have been developed for the optical processing to overcome the electronic speed bottleneck in the networks. Photonic packet switching devices are expected to play one of the major roles in the development of the new generation networks. Since the optical devices and the technology using tremendous transmission bandwidth of a single mode fiber were introduced for telecommunications applications, studies on the architecture and the protocol for the all-optical networks have been a major concern. Among them, ring topology optical networks are of great interest [3,4]. Tsong-Ho Wu et al. studied a self- healing ring (SHR) SONET for survival interoffice fiber networks [5]. W.I. Way et al. proposed a self-routing WDM SONET ring network with a dynamic control mechanism using optical power limiting amplifiers [6]. These ring architectures, however have shortcomings, a limit on the number of nodes in the network. It is difficult to increase the number of nodes M, in the ring since the network needs M wavelength channels and each node needs M - 1 receiver to accept dropped optical signals from the ring.
The RINGO (ring optical network) metro network is a unidirectional fiber ring network comprises N nodes where N equals the number of wavelengths as shown in fig 1.1. Each node is equipped with an array of fixed–tuned transmitters and one fixed–tuned receiver operating on a given wavelength that identifies the node. Node j drops wavelength j from the ring. Thus, in order to communicate with node j, a given node i have to transmit data by using the laser operating on wavelength j. All wavelengths are slotted with the slot length equal to the transmission time of a fixed size data packet plus guard time. Each node checks the state of the wavelength occupation on a slot by slot basis avoiding collisions by means of a multichannel generalization of the empty slot approach (in the empty slot

approach one bit at the beginning of each slot indicates the state of the corresponding slot i.e. whether the slot is free or occupied). This access mechanism gives priority to in transit traffic by allowing a monitoring node to use only empty slots.

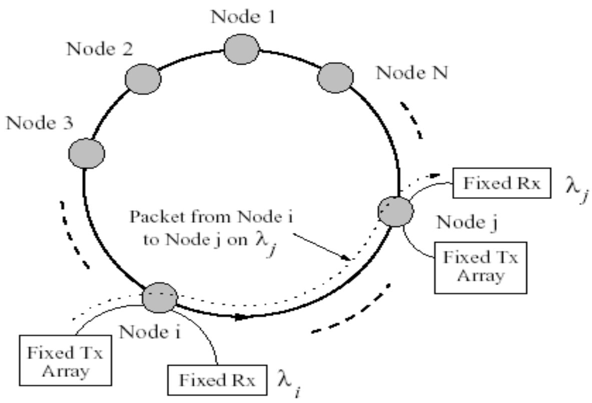

Figure 1.1: Ring metro WDM network.

Till now work is done on experimentally studying the feasibility of a WDM optical packet network based on a ring topology but very less work has been carried out to simulate the design to that the optimization can be done by avoiding the hardware costs involved. Effect of various network element parameters like changing the length of the fiber, effect of various filters on the optical signal to noise ratio are not analyzed properly, till now no optimization is done in this regard. All these measures have been taken in this paper, to have the assessment of signal evolution, as it passes through the various nodes in the optical ring networks.

The paper is divided into three sections. In the first section the basic ring optical network structure is being discussed. Second section includes the simulation set up for ring optical network, performance of ringo network is analyzed here. Third section gives the conclusion for the dependence of quality factor of signal on various parameters at every node in the ring.

II. SIMULATION SETUP

Ring networks can be used to provide a cost effective and an easily implement able way of achieving India's goals of becoming an IT superpower. The coverage of metro area network is possible as ring topology as main backbone among metropolitan cities. Here in this paper, the analysis of the ring optical network is done by taking 4 nodes. The signal is analyzed as it passes through each node in the ring optical network.

Set up in fig 1.2 illustrates how to simulate a ringo configuration with an unrolled equivalent configuration using the iteration feature. Simulation is done with the one of the standard simulation tool used in optics field i.e. OPTSIM ^{tm}4.0 by Rsoft Design Ltd A very low noise feeds an Iterate block and each span represents a loop cycle. Four spans are used here to have the assessment of the ring optical network. By increasing the number of iterations it is possible to improve the simulation accuracy. Four nodes compose the ring and at each node a channel is added and another channel is dropped. The analysis of results is made by mean of measurement blocks inserted in the iterated block. In this way it is possible to analyze the signal evolution (Spectra, Eye Diagrams) at each round of the loop. The latest iteration represents the most accurate evaluation of the "steady-state" signal.

The analysis of ring optical network is done by taking 4 nodes. The node is followed by fiber of length 50 km and splitter. To each node is attached an electrical scope to analyze the signal in terms of Q factor and jitter. Further the node is composed of nrz_tx, receiver and an OADM (optical add drop mux). At the four nodes the used frequencies are f1, f2, f3, f4. We have assumed that all these frequencies are used in circular fashion in the ring i.e. at the node 1 the frequency f1 is added and frequency f4 is dropped. At the node 2 the frequency f2 is added and frequency f1 is dropped and so on, means that at the node n wavelength λ^n is inserted and previous node wavelength λ^{n-1} is dropped. Simulation of the ringo optical network is done with the centre frequency of 193.4 THz and the reference bit rate of 10 GB/s.

Each node is further composed of OADM (optical add drop multiplexer), one transmitter source and one receiver source. Non return to zero transmitter is used here. The analysis of results is made by mean of measurement blocks inserted in the iterate block. The used frequencies in the ring optical network at the various nodes are like this, frequency f1 is equal to 193.35 THz, frequency f2 is 193.4 and further so on with the difference of .5 THz

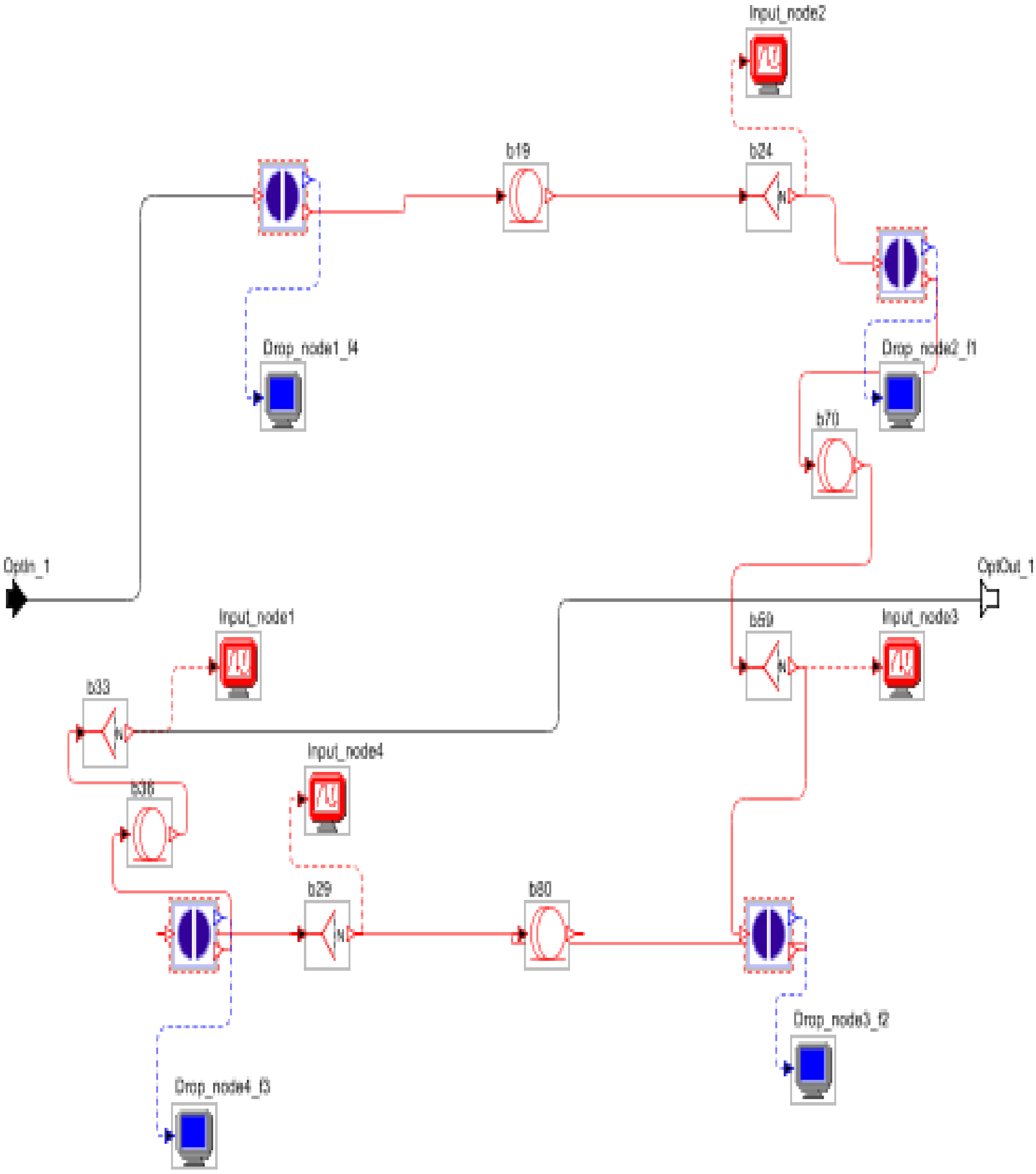

Figure 1.2: Set up for ring optical network

III. Results and Discussion

The results are in the form of eye diagrams from which various signal evolution parameters can be calculated. The eye diagram as shown in figure 1.3 gives the signal at node 1 captured in the first span.

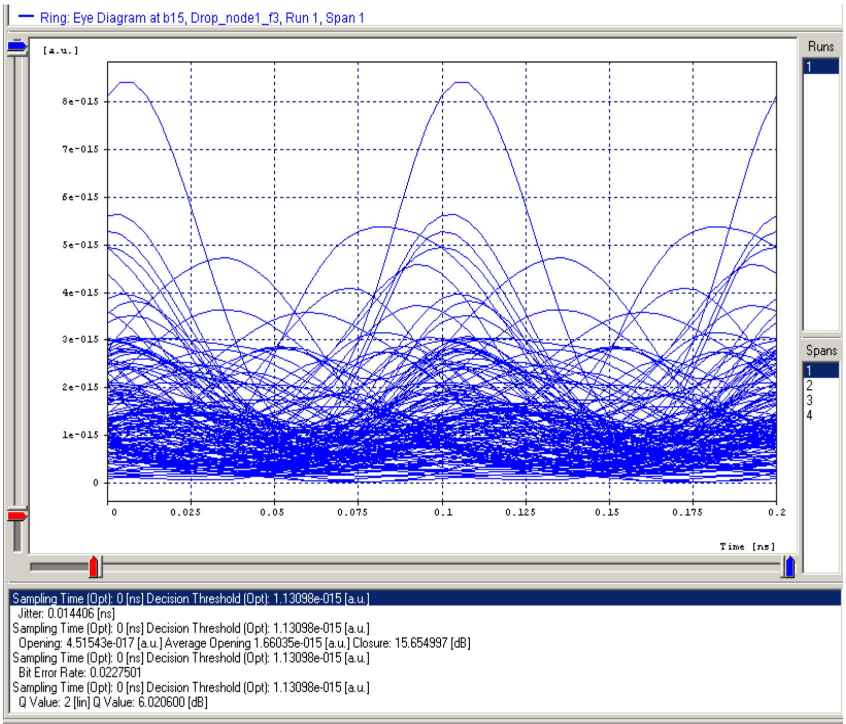

Figure 1.3: Eye diagram for Node 1

At the node 1 the jitter is 0.014406 ns and average eye opening is 1.66035e-015. The BER is 0.0227501 and the Q value is 6.020600 dB. Since the impact of low noise source is predominant so these metrics are not yet sufficient for analysis of signal evolution. The simulation bandwidth is from 1549.11488438 nm to 1551.11865477 nm.

The eye diagram shown in figure 1.4 gives the signal at node 2 captured in the first span.

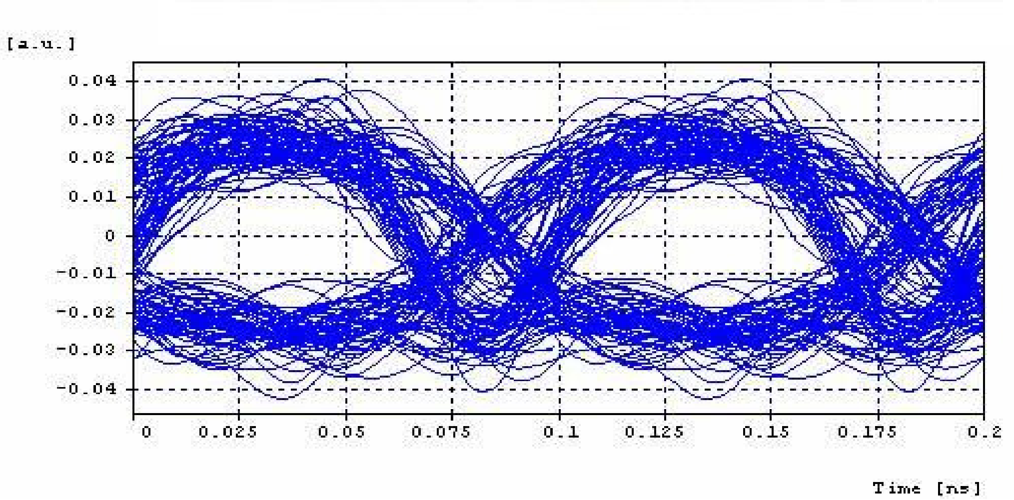

Figure 1.4: Eye diagram for Node 2

At the node 2 the jitter is 0.0240403 ns and average eye opening is 1.20984e-005. The BER is 1e-040 and the Q value is 30.359835 dB. It is seen that there is high rise in quality factor of the signal captured in the first span. This is due to the fact that effect of noise in more on the starting number of users.

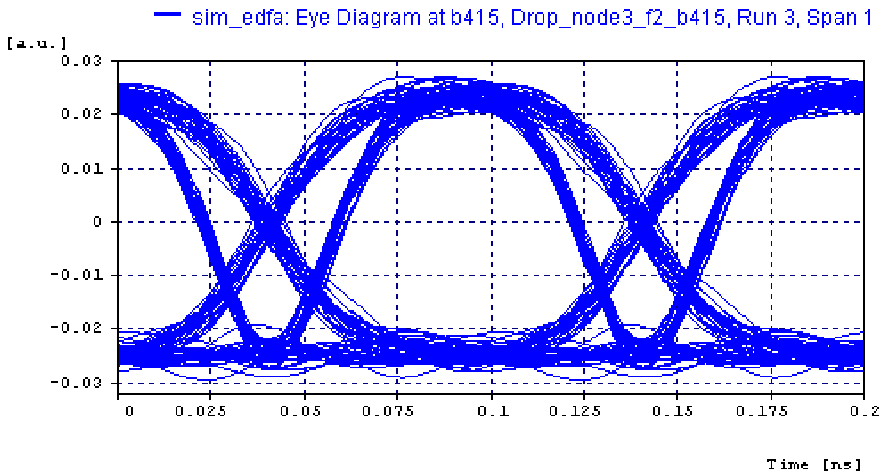

Figure 1.5 Eye diagram for Node 3

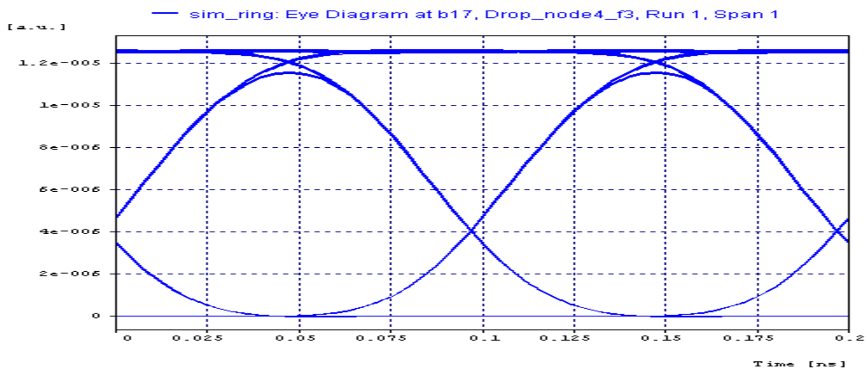

Figure 1.6 Eye diagram at Node 4

There is an improvement in jitter showing improvement in signal in figure 1.6. At the node 3 the jitter is 0.0238927 ns and average eye opening is 1.20706 e-005. The BER is 1e-040 and the Q value is 31.297732 dB. At the node 2 Q factor is 30.35, but here at the node 3 it has risen to the value of 31.29, depicting further increase in Q factor. Thus as the signal passes through the successive nodes improvement in quality factor is seen.

At the node 4 the jitter is 0.02405 ns and average eye opening is 1.2062 e-005. The BER is 1e-040 and the Q value is 32.454378 dB as depicted in figure 1.6.

The analysis of results is made by mean of measurement blocks inserted in the iterated block. Clear observation can be made from the graphs shown in figures 1.3-1.6, that as the signal passes through every node improvement in quality factor is seen. The latest iteration represents the most accurate evaluation of the "steady-state" signal. Also with iteration feature improvement in quality factor is seen as illustrated in figure 1.7. As is evident from the diagram as the ring optical structure keeps on iterating, its quality factor is also improving. With every span improvement in quality factor is seen.

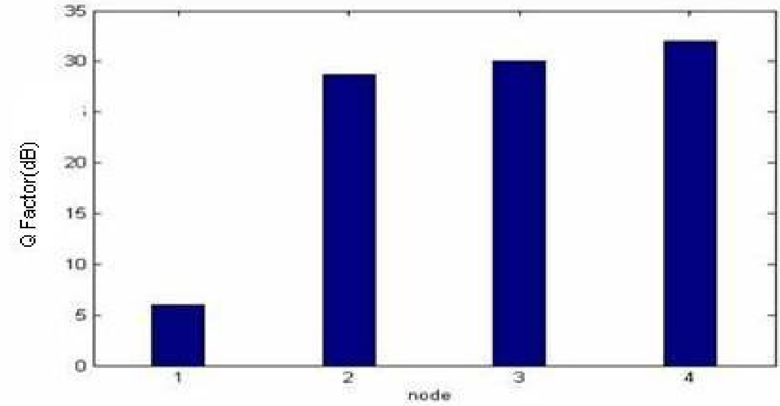

Figure 1.7 Q factor vs. Node .

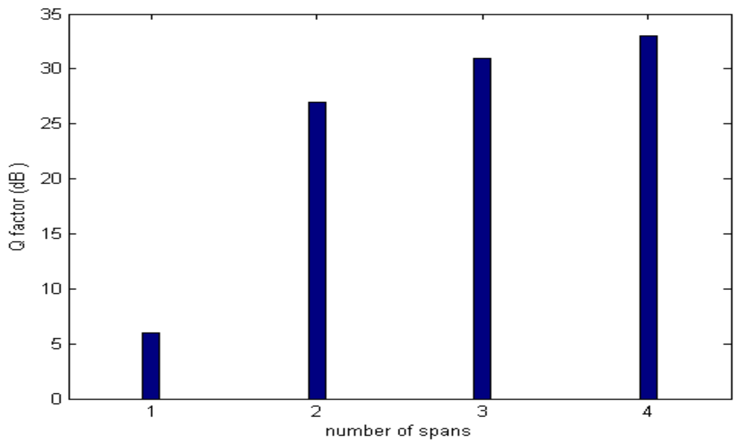

Figure 1.8: Q factor vs. Span number

At every OADM i.e. optical add drop multiplexer, one frequency is dropped and other added [10]. This is clear from the optical spectrum taken at every node. As shown in figure 1.13, at the node 1 the frequency f1 193.35 is added and the frequency f4 193.5 is dropped. It is assumed that all these frequencies are used in circular fashion in the ring, at the node n wavelength λ^{n} is inserted and previous node wavelength λ^{n-1} is dropped. Here at the node 2 the frequency f2 193.4 is added and the frequency f1 i.e. 193.35 is dropped as shown in figure 1.9.

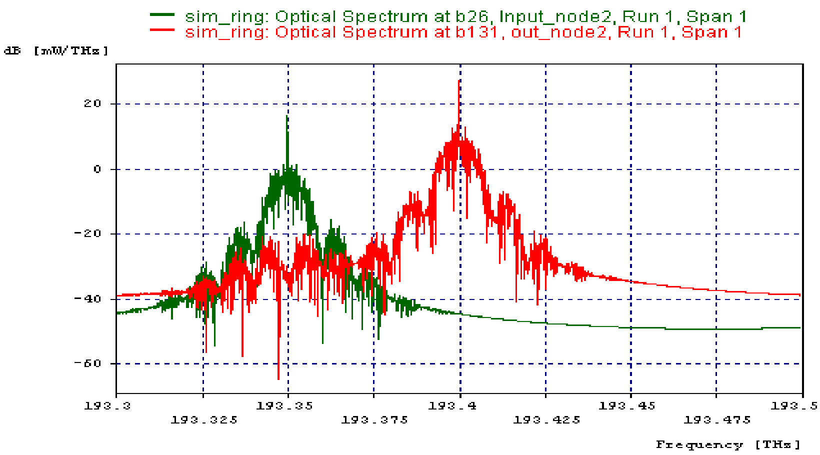

Figure 1.9 Optical Spectrum at node 1 before and after transmission

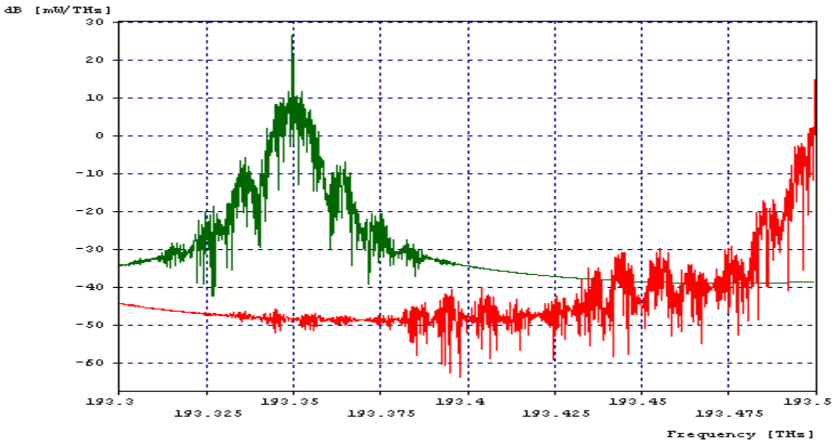

Figure 1.10: Optical Spectrum at node 2 before and after transmission

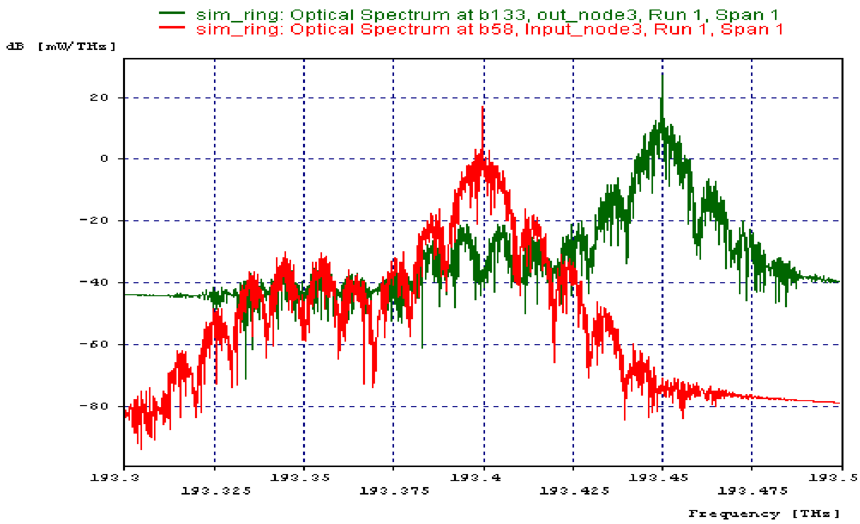

Figure 1.11: Optical Spectrum at node 3 before and after transmission

Similarly at the node 3 the frequency f3 is added and the frequency f2 is dropped. Now at the node 4 the frequency f4 is added and the frequency f3 is dropped. If we want to increase the number of nodes in the network, the circle goes so on i.e. add the frequency f^n at the node n and drop the frequency f^{n-1} of the previous node.

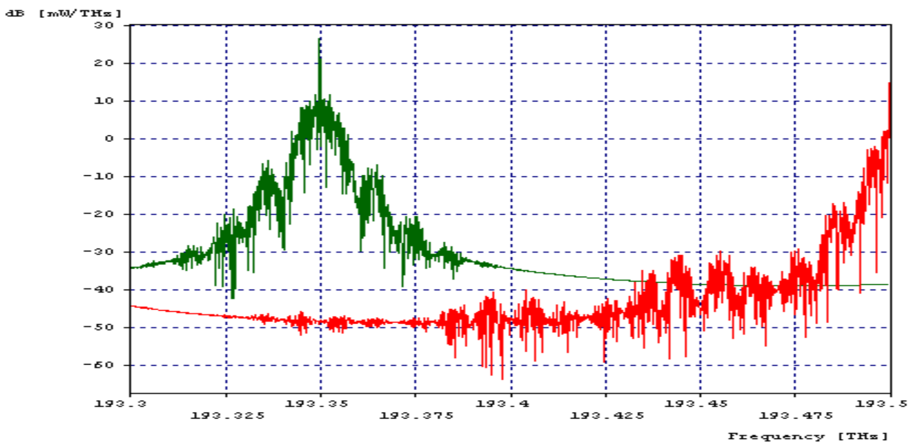

Figure 1.12: optical spectrum at node 4 before and after transmission

It is observed that if we keep on increasing the signal input power, improvement in received optical power is observed.[12] As the input power increases, the output power also increases for all the users. The power penalty goes on increasing with increase in the signal input power. At low value of signal input power i.e. -20 dBm or below, the effect of amplified spontaneous emission (ASE) noise power is quite high [15], therefore the quality of signal goes on decreasing. At high value of signal input power -10 dBm or above, the gain fluctuation occurs at high rate.

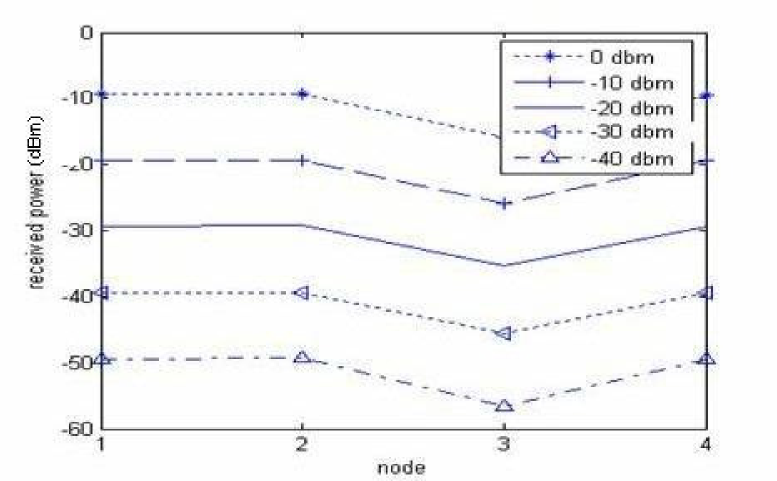

Figure 1.13: Received Power at different Input Powers

Therefore gain drops hence causes power penalty. The power value should neither so high nor so less because with high power, the degradation in performance through self phase modulation can occur. On the other hand, too little power results in not enough gain.
For the low signal input power of -40 dBm, the received power is very less. But as input power keeps on increasing the up to 0 dBm, the received power also increases. Hence it can support more number of users by increasing the signal input power up to a certain range. This is because with the increase in input power, the output received power also increases. By increasing the input power from -5 dBm to 0 dBm and onwards, input power increases in excess and saturation comes thus gain starts decreasing and the gain of the amplifier reduces. This effect is known as gain saturation [16].This decrease in gain further decreases the quality of the signal. But input power can't be increased to a high value as device structure imposes a limit on the maximum high input power.

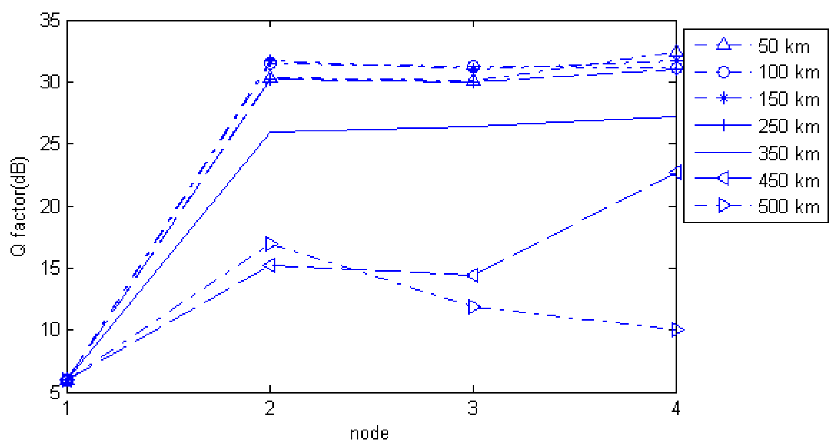

Figure 1.14: Q factor variation for various lengths

In the long-distance network, the majority of embedded fiber is standard single-mode (G.652) with high dispersion in the 1550-nm window, which limits the distance for transmission. Dispersion can be mitigated to some extent and at some cost using dispersion compensators. Non-zero dispersion-shifted fiber can be deployed for transport but higher optical power introduces nonlinear effects. In the short-haul network, PMD and nonlinear effects are not so critical as they are in long haul systems, where in higher speeds (OC-192 and higher) are more common. First we simulate our model taking fiber lengths of 50 km and 100 km. Effect of fiber length on Q factor wrt to various spans is not much. But as simulation is carried out for the various lengths of fiber in fig 1.14 it is seen that we can increase the fiber length up to maximum 250 km, after that its Q factor keeps on deteriorating. Except for the first span, not much improvement in Q factor is seen, but as the fiber length is increased, improvement can be seen for fiber length up to a certain range.

IV. CONCLUSION

It can be concluded from eye diagrams and jitter values taken at every node that there is no appreciable signal degradation in the ring network. It is seen that there is increase in Quality factor i.e. signal keeps on improving as it passes through the successive nodes. This is one of the main advantages of ringo networks. As signal goes from node 1 to node 2 its quality factor value changes from 6.02 to 30.02. When the whole ring structure is iterated with the help of spans, then improvement in signal value is seen, as it passes through the various spans. Analysis of the Q factor is done taking different length of the fiber. It is seen that there is no appreciable signal degradation till the length of fiber is increased up to 250 km. But after that decrease in quality factor can be seen.
For the low signal input power of -40 dBm, the received power is very less. But as input power keeps on increasing the up to 0 dBm, the received power also increases. Hence it can support more number of users by increasing the signal input power. This is because with the increase in input power, the output received power also increases. By increasing the input power from -5 dBm to 0 dBm and onwards, input power increases in excess and saturation comes thus gain starts decreasing and the gain of the amplifier reduces. Optical spectrum of the signal is seen at every node, to have the assessment of the add and the drop frequencies in the ring. Thus complete analysis of the ring optical network is done here which proves to be beneficial for the deployment of ring as the main backbone in our present infrastructure.

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