Analysis of Optical Router in a Ring Network

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***Abstract*—In this paper MZI-FBG based optical add drop multiplexer is designed and its performance is analysed in the ring network. In the ring network nodes are composed of optical add drop multiplexer, transmitter and receiver. OADM is used to add or drop any frequency at intermediate nodes without affecting other channels. In this paper the performance of the ring network is carried out by varying various kinds of fibre with or without amplifiers.**

***Keywords*— All-optical Router; *OADM; Ring network; MZI-FBG*; optical Networks**

I. Introduction

Optical networks have been introduced commonly to satisfy the rapid increase of traffic demands. Optical ring network is to use an optical fiber channel to link all transmitter/receiver nodes so that the system cost is reduced due to only one optical fiber channel used.The optical add drop multiplexer (OADM) supports the wavelength-reuse; most optical ring networks employ it to enhance the transmitted capacity. Metropolitan networks have been attracting much attention as they impose a bandwidth bottleneck between the local access networks and the backbone. The synchronous optical network (SONET) is the most widely used optical network infrastructure now a day. The wavelength division multiplexer (WDM) is mainly used as a point-to-point transmission technology in a SONET ring network. The deployed circuit-switched SONET 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. There is a limit on the number of nodes in the network. It is difficult to increase the number of nodes, N, in the ring since the network needs N wavelength channels and each node needs N-1 receiver to accept dropped optical signals from the ring. The ring optical network is a unidirectional fibre ring network that comprises N nodes, where N equals the number of wavelengths 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 [1-5].

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. This access mechanism gives priority to in transit traffic by allowing a monitoring node to use only empty slots. Ring networks may be disrupted by the failure of a single link because a ring topology provides only one pathway between any two nodes. A node failure or cable break might isolate every node attached to the ring. FDDI (fiber distributed data interface) networks overcome this vulnerability by sending data on a circular and a counter clockwise ring in the event of a break; data are wrapped back onto the complementary ring before it reaches the end of the cable, maintaining a path to every node along the resulting C-Ring [6-7].

The main issue in the design of the OADM is crosstalk. It degrades the performance of the OADM. Crosstalk will affect the system performance. In the OADM two types of types of crosstalk arises homodyne and heterodyne. Homodyne crosstalk is induced between the add signal and the leakage of the drop signal at the same wavelength. Heterodyne crosstalk induced between the drop signal and the leakage of the remaining input signals at different wavelengths.

In this paper MZI-FBG (Mach Zehnder interferometer fiber Bragg grating) based OADM is designed because of the low insertion loss, back reflection and crosstalk. This paper organized into 5 Sections. Section I presents the introduction. Section II presents the simulation set up of OADM. Section III presents the simulation set up ring network. Section IV presents results and discussions. Section V presents conclusions.

II. Simulation Set Up of OADM

In this set up MZI-FBG based OADM is designed and its performance is analyzed in the ring network. The structure the OADM is shown in Figure 1. In MZI with FBG, one FBG is placed in one opposite arm of MZI. In MZI based optical add/drop multiplexer, the optical signal pass through the different sections, *i.e.* variable attenuator where 3 dB insertion loss is defined and are fed to the splitter, ideal dual arm MZI which has delay (P_s) 10 ms, tuning frequency/wavelength. The channel which is to be selected from input channel passes through splitter, band pass filter which has 15 stages, -3 dB two sided bandwidth, combiner and finally the signal is dropped to the drop port of the OADM. To the add port, the signal passes through variable attenuator where 3 dB insertion loss is defined and are fed to the splitter, combiner, band pass filter and again combiner. Finally the output is taken from output port and crosstalk is defined between add and drop channels by making use of variable attenuator (VA) in between the propagating signals as shown in Figure 1. In this paper MZI-FBG based OADM is designed because of the low degradation of signal and cost wise it is cheap. The MZI-FBG works like a notch filter.

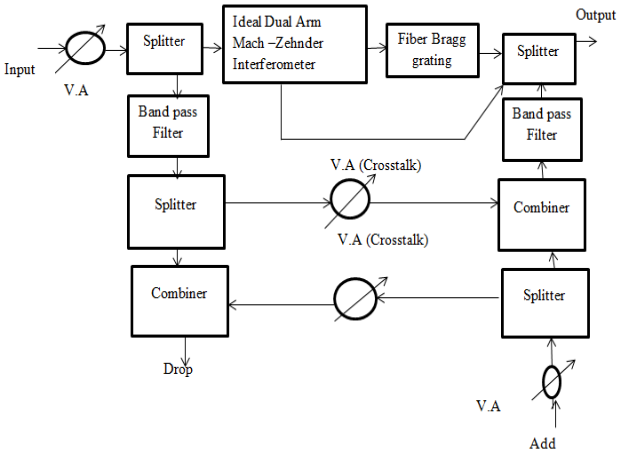

Figure 2 Structure of the OADM based on MZI-FBG

III. Simulation Set Up Of Ring Network

In this set up ring network is designed using OADM based on MZI-FBG. The block diagram of the ring network is shown in figure 2 where nodes are connected with each other in the form of ring. OADM is used to add or drop any frequency at intermediate nodes without affecting other channels. The OADM enhances the capacity of the network has dropped wavelength can be reused. Figure 3 shows the internal structure of node in which one channel is added and another channel is dropped.

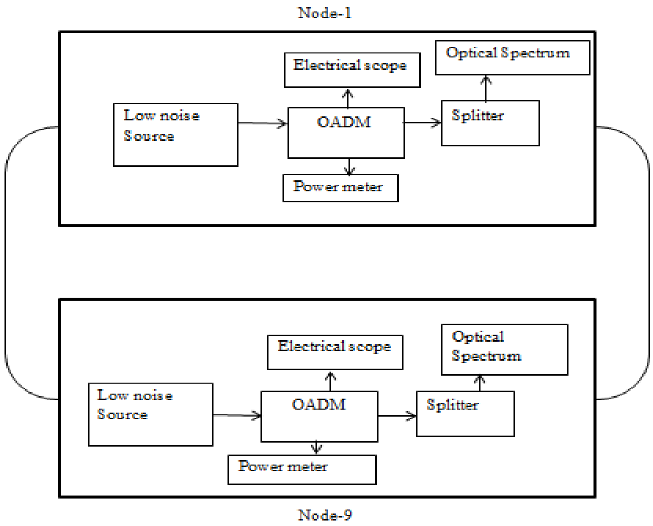

Figure 3 Block diagram of the ring network

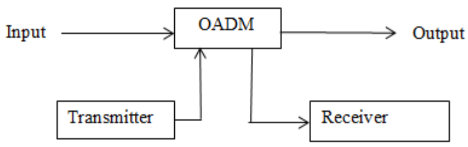

Figure 4 Internal structure of the node

Each node is equipped with array of fixed tuned transmitter and one fixed tuned optical receiver on wavelength that identifies the node. The nodes composed of optical add or drop multiplexer, transmitter and receiver. Low noise source is used as input source and it is connected to OADM of first node. After each node semiconductor optical amplifier is used to boost the signal. The frequencies of the nodes are f_1, f_2, f_3 and so on up to f_9. All these frequencies are used in circular fashion such that new frequency is added and previous one is dropped. The used frequencies in the ring optical network at the various nodes are shown in Table

1. Frequencies shown in Table 1 are used in a circular fashion in the ring, *i.e.* at node 1 the frequency f_1 is added and the frequency f_9 is dropped.

TABLE 1: FREQUENCY USED IN THE RING NETWORK

Frequency	Value (THz)
[1] f_1	[2] 193.35
[3] f_2	[4] 193.40
[5] f_3	[6] 193.45
[7] f_4	[8] 193.50
[9] f_5	[10] 193.55
[11] f_6	[12] 193.60
[13] f_7	[14] 193.65
[15] f_8	[16] 193.70
[17] f_9	[18] 193.75

Every node in the ring network has a transmitter in which the on off-keying (OOK) signal is launched into OADM. The OOK signal is formed by encoding a continuous wave (CW) lorentzian light source, and data in terms of non-return to zero (NRZ) format is launched into the optical amplitude modulator. The NRZ data were pseudorandom binary sequence (PRBS) with word length 2^7-1 at 10 Gb/s. The full-wave half-maxima line width CW light is 10 MHz The time domain simulation is performed at the centre wavelength 1546 nm with 4 THz bandwidth. In the ring network, each node is connected to another node by different types of fibre schemes, *i.e.* ring fibre, single mode fiber (SMF) and SMF with dispersion compensation fiber (DCF). The different parameter values of fibers are presented in Table 2.

$$L_2 = - D_1 L_1 / D_2 \quad (1)$$

Where L_1 and L_2 are the lengths of SMF and DCF, D_1 and D_2, are dispersion parameters for SMF and DCF.

For SMF, the value of dispersion parameters D at the operating wavelength is presented in Table 2. In the ring network, the distance between the nodes is 60 km. The input power applied to the add channel is 0 dBm and channel spacing between add and drop channel is 50 GHz. The length of the DCF is chosen in accordance to complete compensation ($\breve{D}$=0):

TABLE 2: FREQUENCY USED IN THE RING NETWORK

Parameters	Ring Fiber	SMF	DCF
[19] Attenuation (dB/km)	[20] 0.2	[21] 0.2	[22] 0.55
[23] D (ps/km/nm)	[24] 0	[25] 16.0	[26] -96.0
[27] $dD/d\lambda$ (ps/nm^2/km)	[28] 0	[29] 0.07	[30] -0.42

In this paper, comparative analysis is done with and without amplifier. Due to low noise source which is attached to the ring network produces lots of power penalty which is drawback of the ring network.

In this paper inline amplifier is used to reduce the power penalty. Two spans are used here for asses of the ring optical network. By increasing the number of the iterations, it is possible to improve the simulation accuracy. The analysis of ring optical network is done by taking 9 nodes. Each node is attached with electrical scope to analyse the signal in terms of quality factor and power meter is also attached to analyse the signal in terms of power.

IV. RESULTS AND DISCUSSIONS

In the ring network 9 nodes are designed in the form of ring. In the ring network new signal is added and previous one is dropped. The distance between the nodes is 60 km. In the ring network, low noise is attached to the first node of the network. Due to low noise source more power penalty occurs at the received output power. In the network at 0 dBm input power performance is analysed. As shown in Figure 4, a lot of power penalty is observed. In this network performance is analysed by using different kinds of fiber as shown in Figure 4.

To overcome that problem, in line amplifiers are used in the network which helps to improve the power. Amplifier is placed between the nodes which help to reduce the power penalty. Received power of drop channels with amplifier shown in Figure 5. It is clear from the figure that by using amplifier it gives better output power.

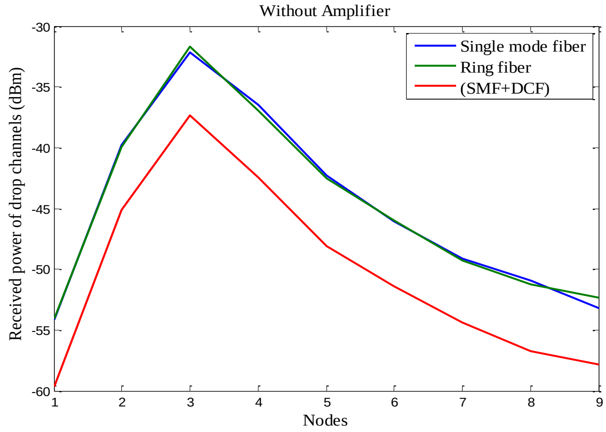

Figure 5 Received power of drop channels as fuction of nodes for different types of fiber links in a ring network without amplifier

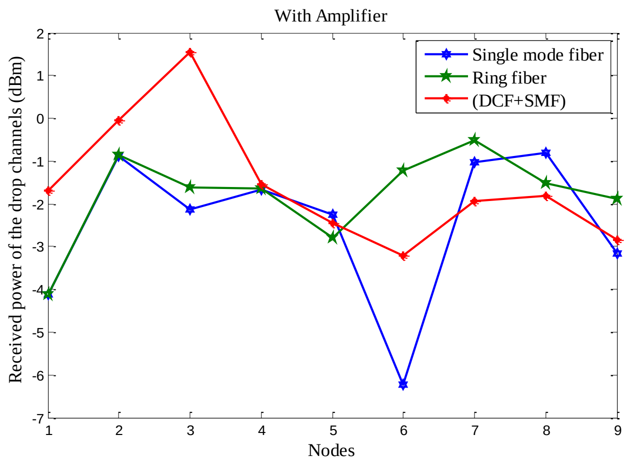

Figure 6 Received power of drop channels as function of nodes for different types of fiber links in a ring network with amplifier

Figure 5 shows the received power of the drop channels as function of nodes for different kinds of fiber with amplifier. The parameters of fiber are shown in Table II. It is observed from the figure that the combination of DCF and SMF has low penalty as compared with the single mode fiber and ring fiber. This gives better results as compared with the Figure 4 which shows good agreement with ref. [8]. Figure 6 shows the quality of the drop channels as the function of nodes for different types of fiber links in a ring network at 10 Gb/s without using amplifier. It is clear from the figure that the ring fiber and (DCF+SMF) has highest quality factor of 40 dB which means there is no degradation of the signal. The SMF has lowest quality as compared with the Ring and the combination of (DCF+SMF). From Figure 4, it is seen that there is lot of power penalty without using amplifier to reduce the power penalty in line amplifiers are used which helps to reduce the power penalty. The effect on quality by using amplifiers in the ring network is shown in Figure 7

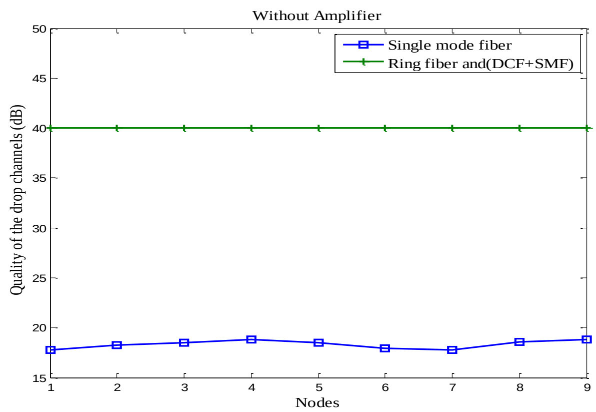

Figure 7 Quality of the drop channels as the function of nodes for different types of fiber links in a ring network at 10 Gb/s

It is clear from the Figure 7 that single mode fiber has low quality as compared with the ring and combination of (DCF+SMF). Ring fiber has better quality as compare with the single mode fiber. The realization of Ring fiber is difficult.

The combination of SMF and DCF with in line optical amplifier gives good quality as compared with the other fibers.

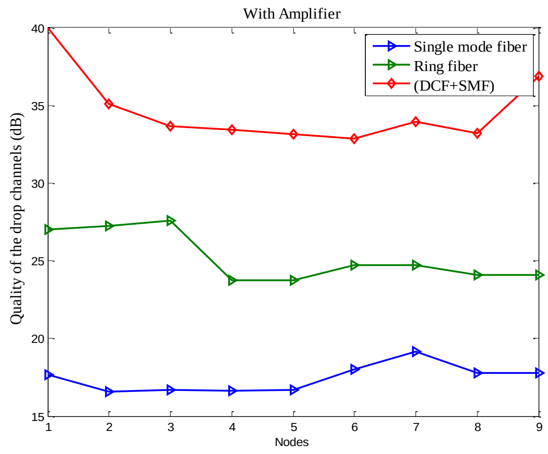

Figure 8 Quality of the drop channels as the function of nodes by using different kinds of fibers

V. CONCLUSIONS

In this paper, the ring optical network is designed by using 9 nodes, where new signal is added and previous one is dropped & its performance is analyzed on the basis of quality and output power received of the drop channels using different kinds of fiber links. It is concluded that the combination of DCF and SMF fibers has good quality and better received output power as compared with the SMF and ring fiber in the ring network by using in line amplifiers.

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