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ORIGINAL ARTICLES

The Importance of Uniformity on Received Power in Optical Ring Network System Performance

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ABSTRACT

This simulation study was carried out to study the effect of stability of the power received at each node on the overall ring network performance. Two transmission distances are introduced at two different transmission rates. Ring network performance is analyzed using BER performance indicators. The distance between two selected nodes of 60 km and 70 km span and the receiver's sensitivity is set at one rate of data transmission. The results obtained showed a good configurations of amplifiers is important in obtaining a stable output power and importance is in providing better network performance as a whole.

Key words:

Introduction

The increase of capacity in transmitting data over 10Gbps has limits the use of coaxial cable as medium for data transmission. Hence, fiber optic technology has been opted to fulfill the requirement for wide band transmission. Introducing WDM into the fiber optic technology has made it the transmission medium without limits that offers few advantages including higher capacity and speed, ability for transmitting long distance data and a better signal quality. Information transmitted in the domain optic is transferred via point line to point using SONET/SDH equipment to create ring and mesh topology network. In this network, the needs of the devices for add drop operation and cross-connecting optical line are executed by OADM and OXC respectively, (Tzanakaki *et al.*, 2003).

Any changes in the power level can be compensated or improved by amplifier gain. Optimizing the values can improve by extending the maximum length that can be achieved at minimum BER. Therefore, an optical amplifier configuration is vital to obtain a stable BER performance profile (slow decrement rate) in the secured optical ring network design (Ab-Rahman, 2008). The ideal amplifier gain value is determined by the system's load value as shown in equation (3). The connection between BER performance and amplification gain is in the form of Gaussian negative. Hence, an area called extreme high/active is created where the increase in gain value will deteriorate the value of this BER performance (Ziemer and Tranter, 2002). Therefore, research on amplification value profile is very important in order to avoid the BER profile in the ring network to be in the extreme high/active area.

In determining a suitable gain value for any ring network, the value of load line needs to be considered. Load line is referring to a total value of insertion loss of components that connect two optic nodes in any optic ring network. It is formulated based on theoretical value and is given by equation (1), (Ab-Rahman, M.S. *et al.*,, 2008):

Load Line = OADM Node Loss + Fiber loss (1)

Meanwhile, the Actual Insertion Loss is defined by equation (2):

Actual Insertion loss = Load Line (Theoretical loss value) + Operational loss (2)

Therefore the exact Gain value used to compensate losses defined as:

Gain value (dB) = Actual Insetion loss (3)

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Referring to the value of load line obtained, metropolitan ring network are developed with satisfying BER performance using optimum amplifed value. The connection between BER performance and amplification gain is in the form of gaussian negative. Hence, an area called extreme high/active is created where the increase in gain value will deteriorate the value of this BER performance (Ziemer and Tranter, 2002). Therefore, research on amplification value profile is very important in order to avoid the BER profile in the ring network to be in the extreme high/active area. Figure1 shows the extreme high/active area in connection of gain and BER performance (Node 7 to Node 9).

Many studies have been developed and presented which allow an overview of EDFA. Some of them are widening the distance between two spans with the presence of more effective EDFA configuration (Khaleghi *et al.,* 1996), controlling EDFA gain value to reduce the noise (Hashimoto *et al.*, 2001) and enhancing the EDFA performance in WDM switch packet network using clamp EDFA (Thomas *et al.*, 2007). The network performance can also be improved by increase the sensitivity of receiver by reducing the thermal noise value (Ab-Rahman *et al.*, 2008)(Ab-Rahman *et al.,* 2009). This is the alternative solution if the designer has decided not to use the amplifier for signal recovery.

Transmission Rate 622 Mbps (OC-12):

The network specification used in this simulation is:
Group A= 60 km
Group B = 70 km
Post Amplification Gain = 21 dB (Nod 1 until Nod 5) and 23 dB (Nod 6 until Nod 10)
Preamplification = 7 dB
Thermal noise = 3.1347 x 10^{-23} W/Hz
Photodetector Sensitivity = -25 dBm at 1530 nm (2.5 GHz)

Observed in Figure 1 decrease in the distance between two nodes (span) increases the power output at each node. Output power for 70 km distance between the nodes are in stable condition with a small increase in the power of 0:23 dBm/node), while for the distance 60 km, the power increase at 2:42 dBm/node. Post amplifier's gain is increased at the node to 5 in order to maintain power levels for both the graph is below the photosensitivity of -25 dBm. Based on observations in Figure 1, the suitable distance between two nodes that correspond to 622 Mbps data transmission rate with post amplifier's gain of 21 dB (nodes 1 to node 5) and 23 dB (node 6 to node 10) is 70 km to ensure the level of output power stable (constant).

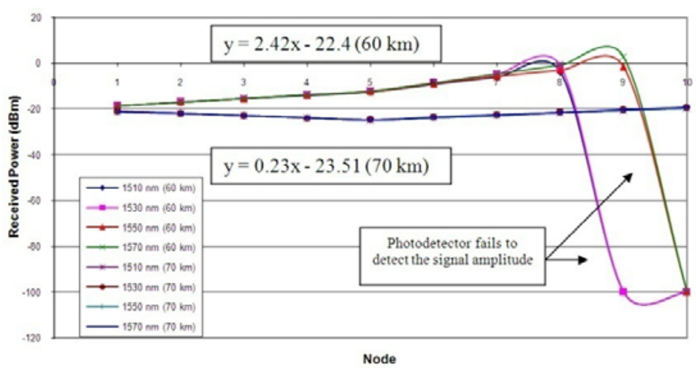

Fig. 1: Output power measured at 622 Mbps data transmission rate of the distance between two nodes 60 km and 70 km.

BER performance at 622 Mbps data transmission rate of the distance between two nodes 60 km and 70 km are shown in Figure 2. Through observations, BER performance for the distance between two nodes 60 km still decreases with distance (after passing through the node to-5) shows that it is in a critical area where, theoretically, over increasing the input power will increase the value until reaching a maximum BER (BER = 1). This situation is different to the distance between two nodes of 70 km to restore of BER performance after passing through the node to-5 when the gain of the amplifier was increased by 2 dB. This shows the effect of stable output power profile (Figure 1) to the BER performance of the system is very significant. Mechanisms of critical condition (over active) occurs if the amplifier gain is increased too much (of which 21 dB and 7 dB is the proper gain for the distance between two nodes of 70 km at 2.5 Gbps) in a communication network or decreasing in the data transmission rate.

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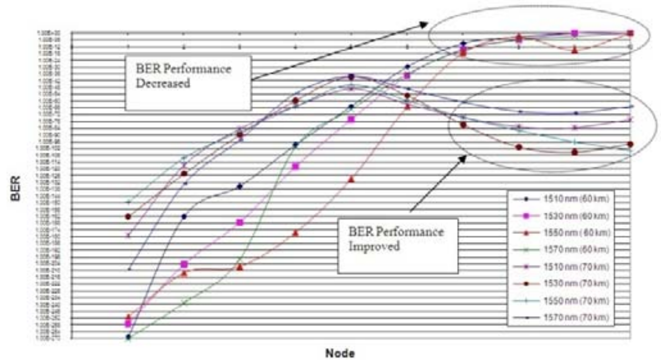

Fig. 2: BER performance at 622 Mbps data transmission rate of the distance between two nodes 60 km and 70 km.

Kadar Penghantaran Data 2.5 Gbps (OC-48):

Observed in Figure 3, decreasing the distance between two nodes will increase the output power at each node. Output power for 70 km span are in stable condition (objectives achieved) and at 60 km, its power increase at 2:44 dB / km. The resulting profile is similar to what achieve in Figure 1. The increase in the gain after node 5 still retains the power levels for both the graph below the sensitivity of -25 dBm.

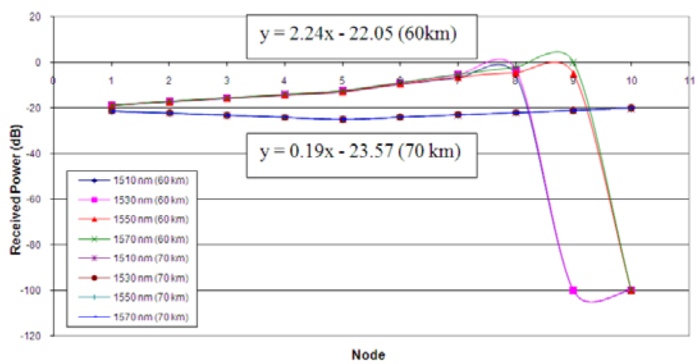

Fig. 3: Output power measured at 2.5 Gbps data transmission rate of the distance between two nodes 60 km and 70 km.

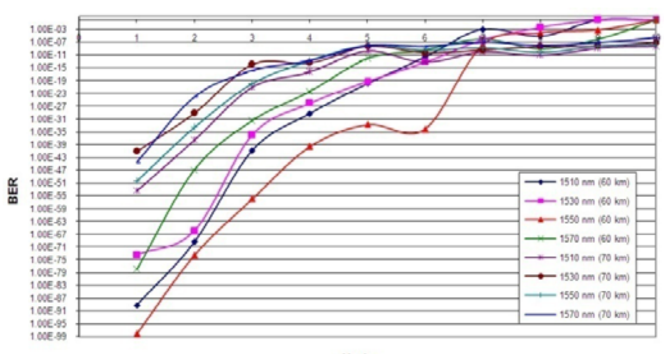

Fig. 4: BER performance at 2.5 Gbps data transmission rate of the distance between two nodes 60 km and 70 km.

Based on observations in Figure 3, the suitable distance between two nodes that correspond to 2.5 Gbps data transmission rates with post amplifier 21 dB (nodes 1 to node 5) and 23 dB (node 6 to node 10) is 70 km which gives a stable output power level . To stabilize the output power of the distance between the nodes 60 km, the required amplifier gain should be reduced based on the load line calculation. BER performance at 2.5 Gbps data transmission rates on the distance between two nodes 60 km and 70 km are shown in Figure 4 above. BER performance for the distance between two nodes 60 km decreases with transmission distance (after passing through the node to-5) as observed in Figure 2. This situation is different to the distance between two nodes to maintain 70 km of BER performance due to a stable power output profiles during Figure 4. BER performance for the distance between two nodes 70 km can be recovered with increased gain of 1 dB at the post amplifier. Here it can be concluded the excess power at each node also affects the BER performance of a system.

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