Original Article

Eye Diagram Analysis in OXADM Protection Scheme – An Experimental Approach

Mohammad Syuhaimi Ab-Rahman

Spectrum Technology Research Division Research Group (SPECTECH) Department of Electrical, Electronic & Systems Engineering Faculty of Engineering and Built Environment Universiti Kebangsaan Malaysia 43600 UKM Bangi, Selangor, Malaysia

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ABSTRACT

A minimal loss, low-crosstalk and multifunction optical switch is most desirable for large-scale photonic network. To realize such a switch, we have introduced the new architecture of optical switch that embedded many functions on single device. With the use of MEMs technology has minimized the effect of crosstalk and return loss. The asymmetrical architecture of OXADM consists of 3 parts; selective port, add/drop operation, and path routing. Selective port permits only the interest wavelength pass through and acts as a filter. While add and drop function can be implemented in second part of OXADM architecture. The signals can then be rerouted to any port of output or/and perform an accumulation function which multiplex all signals onto one path and then exit to any interest output port. This will be done by the third part. At the same the signal can also be rerouted as ‘U’ turn to activate the blocking function. In this paper we present the experimental measurement and analysis on Eye Diagram (Width & Height) at three different function of OXADM; pass through, linear protection (accumulation) and Ring protection (‘U’ turn). We found the threshold of the parameters are determined by the sensitivity of the photoreceiver. The setup is tested under three different lengths at point-to-point configuration.

Key words: New architecture, optical switch, asymmetrical, hybrid device, OSNR.

Introduction

The OXADMs are new optical switching devices which have an asymmetrical architecture and can perform bi-directional functions similar to existing devices such as OADMs and OXCs (Tzanakaki, A., et al., 2003). The OXADM are located in the nodes, which have more than two switching directions in ring networks. The function of OXADM is to flexibility switch the wavelengths among the different input and output ports. 'Accumulation' is the most interesting feature and differentiates the OXADM from other previous devices such as ROADMs, TRNs, OADMs, OXNs and OXCs (Ab-Rahman, M.S. and Ibrahim, M.F., 2008; Ab-Rahman, M.S. and Wahab, H.F.A., 2008; Ab-Rahman, M.S. and Shaari, S. 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Tzanakaki, A., et al., 2003). OXADM is also known as optical cross add and drop multiplexing which is one of the optical device use in recent development of the optical fiber world. OXADM provide capability to add and drop function and cross connecting traffic in the network which is the characteristic of OADM and OXC (Tzanakaki, A., et al., 2003). Basically, OXADM consists of three main subsystems which are a wavelength selective demultiplexer, a switching subsystem and a wavelength multiplexer. OXADM is a newly invented device that can function as a node in both ring and mesh topology. Each OXADM is expected to handle at least two distinct wavelength channel each with granularities of 2.5 Gbps or higher. The signals can then be re-routed to any output port or/and an accumulation function can be performed which multiplexes all signals onto one path and then exit from any output port of interest. The OXADM node focuses on providing functionally such as transport, multiplexing, routing, supervision, termination and survivability in the optical layer with ring and mesh topologies (Ab-Rahman, M.S. and Ibrahim, M.F., 2008; Ab-Rahman, M.S. and Wahab, H.F.A., 2008; Ab-Rahman, M.S. and Shaari, S. 2006; Ab-Rahman, M.S. and Shaari, S. 2006; Eldada, L. and Nunen, J.V., 2000; Mutafungwa, E. 2000; Tzanakaki, A., et al., 2003). OXADM is a key element in the development of the optical layer for the future optical networking. OXADM consists of three main subsystems which are a wavelength selective demultiplexer, a switching subsystem and a wavelength multiplexer. OXADM is a newly invented device that can function as a node in both ring and mesh topology. Each OXADM is expected to handle at least two distinct wavelength channel each with granularities of 2.5 Gbps or higher. The signals can then be re-routed to any output port or/and an accumulation function can be performed which multiplexes all signals onto one path and then exit from any output port of interest.

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M.S. and Shaari, S. 2007; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2006; Ab-Rahman, M.S., et al., 2009; Ab-Rahman, M.S., et al., 2008; Ab-Rahman, M.S., et al., 2008; Ab-Rahman, M.S., et al., 2008; Ab-Rahman, M.S., et al., 2009; Ab-Rahman, M.S., et al., 2008). There are eight ports for add and drop functions, which are controlled by four lines of MEMs switch. The other four lines of MEMs switches are used to control the wavelength routing function between two different paths (see Figure 1a). The functions of OXADM include node termination, drop and add, routing, multiplexing and also providing mechanism of restoration for point-to-point, ring and mesh metropolitan and also customer access network in FTTH (Ab-Rahman, M.S., et al., 2006; 2007; 2006; 2006; 2009; 2009; 2008). With the setting of the MEMs optical switch configuration, the device can be programmed to function as another optical devices such as multiplexer, demultiplexer, coupler, WSC, OADM, WRB an etc for the single application. In ring architecture, OXADM perform as a node and the function is similar to the parallel connection add drop multiplexer (ADM) in which the drop port of one ADM is connected to Add port and vice versa (Ab-Rahman, M.S. et al., 2008; 2008). The architecture is depicted in Figure 1b and 1c. From the analytical study we found OXADM is lacking with scalability features as compare to existing device such OXN. The scalability of OXADM is half of maximum number of ports and wavelength that can be allocated to OXC device (Ab-Rahman, M.S., et al., 2006; 2009; Shen, Y., et al., 1999; Stevens, 2005). But this feature can be improved by using a minimum crosstalk of optical switch device in OXADM architecture as mentioned in (Kirihara, T., et al., 1993).

Fig. 1: The block diagram of OXADM (a). OXADM is similar to the two ADM connected in parallel, which the drop port connected to add port and vice versa. This enable the cross-connecting (b) and U turn mechanism (c) can be implemented.

In this paper we present the experimental measurement and analysis on Eye Diagram (Width & Height) at three different function of OXADM; pass through, linear protection (accumulation) and Ring protection (‘U’ turn). We found the threshold of the parameters are determined by the sensitivity of the photoreceiver. The set up is tested under three different length at point-to-point configuration; 0 km, 15.2 km and 50.4 km.

*Eye Diagram Analysis:*

*Eye Height:*

It refers to the distance between the based until the peak points and is measured in units of voltage. The minimum of eye height value allowed figure points inversely proportional to the photodetector sensitivity. A high sensitivity of photodetector able to translate data at the low altitude diagrams of eye’s height while low sensitivity requires very high altitude diagrams to interpret the data (eg in the photodetector sensitivity of -22.8 dBm, the detected height of the eye diagram is 5.5 μV and sensitivity is -18 dBm at the height of 10 μV). If the setting on the sensitivity is fixed, an increase in the rate of data transmission gives the eye diagram of the same height.

*Maximum Q Factor:*

The maximum Q factor of the diagram refers to quality of eye diagram to be analyzed (Keiser, G., 2000). The value is fixed and same for all values of sensitivity to various data transmission rates. The value of Q factor of the maximum allowed is 6 in the latest communications systems to obtain BER value equal to 1x10⁻⁹.
Jitter:

Deterministic jitter refers to the displacement that occurs with time rise and fall in the received signal against the original signal is sent at the transmitter and the value measured by the period of the intersection. It is measured in units of UI (unit interval) and the maximum value allowed is 0.2 UI.

Jitter is usually produced and give the real impact on transmission systems exceeding 1 Gbps.

Eye Area:

Eyes Area refers to the distance between bit 0 and bit 1 and the distance between the intersection of the embedded derivative, the right and left. Parameters used in the mask technique to assess the quality of the received signal. Acreage in this area is important in distinguishing the bit and bit a bit empty and the sequence of the first and the second bit. Wider the eye area is the higher the level of received data quality and facilitates the process of sampling signals.

![Eye Diagram and parameters which determine the quality of received signal.](image)

**Fig. 2:** Eye Diagram and parameters which determine the quality of received signal.

Eye Height:

Figure 3 shows the relationship between the height of eye diagram and input power for pass through operation. No change in magnitude of eye diagram height with respect to input power changes at distance 0 km and 15.2 km. But an increase of 4.60 mV/dBm is happened to the eye height of the data transmission distance of 50.4 km. The same situation occurs for the 1:1 linear protection operations and the rate of increase is 2.62 mV/dBm at a distance of 50.4 km. The significant increment with the rate of 196 mV/dBm at the input power of -5 dBm to -3 dBm caused major changes in the magnitude of OSNR and small received power in this range (Figure 5.67). This is shown in Figure 4 below. The same situation applies to the transmission distance of 15.2 km for the ring protection. The increment rate of 4.88 mV/dBm occurs until -2 dBm and then increase at rate 0.40 mV/dBm (Figure 5). The effect of received power on eye diagram pattern is highly impact under ring protection operation due to the distance has been doubled. Therefore at very low injected signal the received power has no enough energy to develop the eye pattern bit.
Fig. 3: Eye height at different input power for pass through operation in OXADM point-to-point configuration.

Fig. 4: Eye height at different input power for 1:1 linear protection operation in OXADM point-to-point configuration.

Fig. 5: Eye height at different input power for ring protection operation in OXADM point-to-point configuration.
Eye Width:

Figure 6 shows the relationship between the width of the eye diagram and the input power for pass through operation. No change in magnitude of eye width with respect to input power changes at distance 0 km and 15.2 km. The increase occurs exponentially on the width of eye for data transmission distance 50.4 km. The same situation occurs for the 1:1 linear protection operations. The dramatically increment at the input power of -5 dBm to -3 dBm caused major changes in the magnitude of OSNR and received little in this range. This is shown in Figure 7 below. The relationship between the width of the eye and the power input to the protection ring is shown in Figure 8. No changes in the width of eye to 0 km transmission distance due to high power received at the receiver enable bits can be interpreted successfully. The exponentially increment for transmission distance of 15.4 km which shows depreciation in eye width at a small launch power. Through the comparison made in Figure 5.81, the minimum value for the width of eye is about 340 ps.

![Fig. 6: Eye width at different input power for pass through protection operation in OXADM point-to-point configuration](image1)

![Fig. 7: Eye width at different input power for 1:1 linear protection operation in OXADM point-to-point configuration](image2)
Fig. 8: Eye width at different input power for ring protection operation in OXADM point-to-point configuration

Conclusion:

OXADM security architecture that was introduced a solution to the lack of efficiency of existing devices that carry the ring protection mechanisms and techniques of linear loss and re-added (Eldada & Nunen 2000). In addition to the requirements of the external switching circuit for directing operations for the repair of routes eliminated. OXADM provides three mechanisms of protection on one device for both the network topology is a ring and mesh through the protection ring, linear and multiplexing. Switching directly and make it more flexible than the existing limitations in the OADM and OXC devices. OXADM security scheme is developed for the refurbishment of damage based on the level and type of damage done to avoid the quarantine process as practiced in the security system (Eldada, L. and Nunen, J.V. 2000). Characterization of both hardware security mechanisms and operating OXADM direct access has been studied using the parameters of Eye height and Eye width of the Eye Diagram. We found no change in magnitude of eye diagram height with respect to input power changes at distance 0 km and 15.2 km for pass through and 1:1 linear protection operations respectively. But an increase of 4.60 mV/dBm and 2.62 mV/dBm happen to the eye height of the data transmission distance of 50.4 km for both case respectively. The significant increment with the rate of 196 mV/dBm at the input power of -5 dBm to -3 dBm caused major changes in the magnitude of OSNR and small received power in this range. The same situation applies to the transmission distance of 15.2 km for the ring protection. The increment rate of 4.88 mV/dBm occurs until -2 mV and then increase at 0.40 mV/dBm.

No change in magnitude of eye width with respect to input power changes at distance 0 km and 15.2 km. The increase occurs exponentially on the width of eye for data transmission distance 50.4 km for pass through and 1:1 linear protection operations. The dramatically increment at the input power of -5 dBm to -3 dBm caused major changes in the magnitude of OSNR and received small power in this range. The relationship between the width of the eye and the power input to the protection ring shows no changes in the width of eye to 0 km transmission distance due to high power received at the receiver enable bits can be interpreted successfully. The exponential increment for transmission distance of 15.4 km which shows depreciation in eye width at a small launch power. Through the comparison that has been made, the minimum value for the width of eye is about 340 ps. Conclusions from characterization of these experimental has proved OXADM survivable node provides better performance for digital signal transmission and protection mechanisms.

We found the threshold of the parameters are determined by the sensitivity of the photoreceiver. The set up is tested under three different length at point-to-point configuration; 0 km, 15.2 km and 50.4 km. At higher sensitive photoreceiver the smaller threshold point of eye height and width can be detected.

Reference


