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Improving Fibre Optics Transmission with Wave Length Division Multiplex through Routed-Switching Network

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ABSTRACT

The Optics Fiber link is implemented to satisfy various types of networks, with a wide range of transmission capabilities and improved speed in signal delivery. The link carries multiple signals and for adequate transmission, multiplexing of signals, each signal component, is aggregated and transmitted over a common link which is regarded as multiplexing. The wavelength-routed network bridges the gap of the timeshare, which has retardation on speed and efficiency. The wavelength division multiplex (WDM) is a multiplexing technique designed to suit fiber optics and achieves speed demands, as against time-division multiplexing(TDM) for analog continuous signals (CT) and frequency division multiplexing(FDM) for discrete-time signals(DT). The synchronous optical network (SONNET) and synchronous digital hierarchy (SDH) and the Asynchronous transfer mode (ATM) create an inter-switching system using various matrix dimensions, of 2 X 2, 8 X 8 and other multiples to achieve a versatile routing switching technique. Wavelength division Multiplex and it's a dense modification (DWDM); have greatly improved the quality and speed of signal transmission over all other techniques.

Key Words: *Optic Fibre, SONNET, Routed- Switching Network, Wavelength division Multiplex.*

1. INTRODUCTION

Communications network constitute a large area of operation universally and uses various types of network topologies, both physical and logical, to satisfy the different networks; Linear, Star, Mesh, and Ring systems, to propagate information from source to destination. Multiplexing technique has vastly improved the network switching system, employing Time division Multiplex (TDM), for continuous analog signals, and Frequency Division Multiplex (FDM) for quantized digital signals [1]. The advent of Optics fiber for signal transmission and propagation, with its numerous advantages over other forms of transmission medium created the invention of Wave length Division Multiplex. The integration of added facilities of synchronous optical network (SONET), Synchronous digital hierarchy (SDH) and Synchronous transfer mode (ATM) [3], for ADD/DROP in switching routes have greatly improved the transmission system efficiency. This systems use the ANSIT1.105 Standards for (SONET) and ITU-T for (SDH) [3] operations' sequel to the large architecture of communications network all over the universe and the speed required to adapt to the switching system to serve and satisfy, the ever increasing computer/data network and telephone operators the wave length division multiplex routed switching technique became suitably credited.

The evolution of wave length routed technique has to a greater percentage satisfied the information dissemination requirement of the universe despite the short falls created by chromatic dispersion and other path loss indices.

This major development in delivering sophisticated information through the network has rapidly facilitated propagation of information exchange desired by institutions ,involved in the field of communications ,education, commerce, finance , National and International organization .The optical layer is used to describe the various functions in the hierarchy layered structure in network architecture. This optical layer provides the light path services over the switching links, just as the physical layer connects network links between nodes.

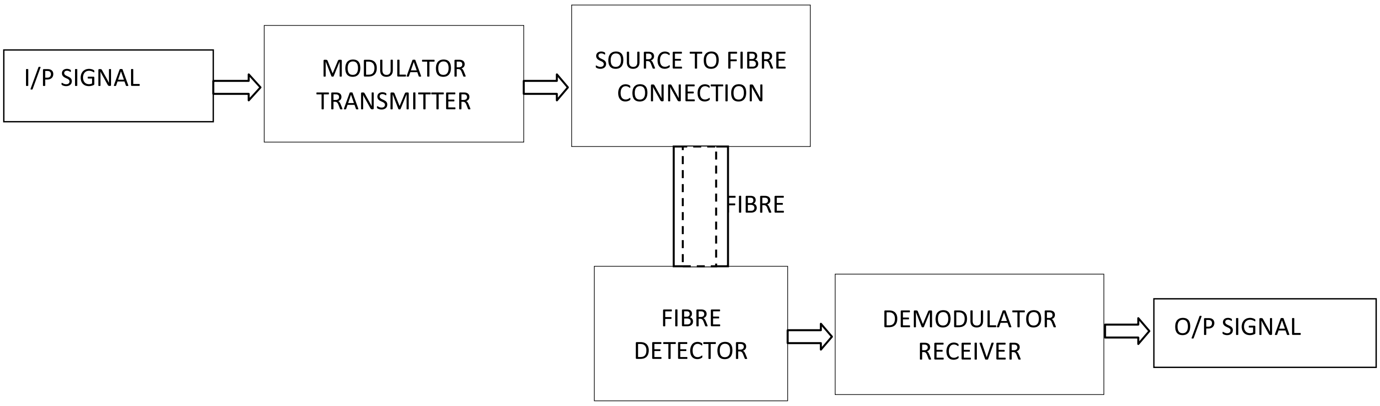

Figure 1: Schematic block diagram of fiber network

2. OPERATING PRINCIPLES AND METHODOLOGY OF ROUTED-SWITCHING SYSTEM

The introduction of wave Length Division Multiplex increased the capacity and capability of optic fiber medium and allows various optical channels to support different transmission format. It implies that by using separate and different modulated signals at any data rate, it can be sent simultaneously and independently over the same fiber link by coupling figure 2 (W-region) without the need for a common signal structure.

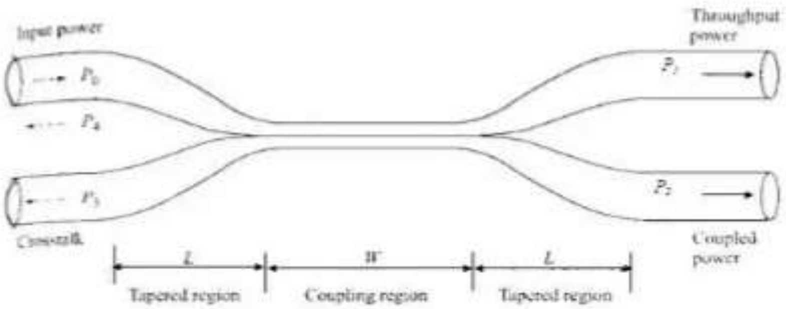

Figure 2: Cross-sectional view of a fused-fiber coupler with W indicating the coupler region.

Infact , there is need for isolation of channels bearing in mind that optical power intensity must be kept low ,this will prevent non-linearity effect and ensure adequate power budgeting. The non-linearity effect possessed by Brillouin scattering and four wave mixing, including degradation in the link .The distortion mechanism on fiber causes optical signal pulses to broaden as they travel along the fiber. If these pulses travel sufficiently, they will eventually overlap with neighboring pulses, thereby causing dispersion errors in the received output signal.

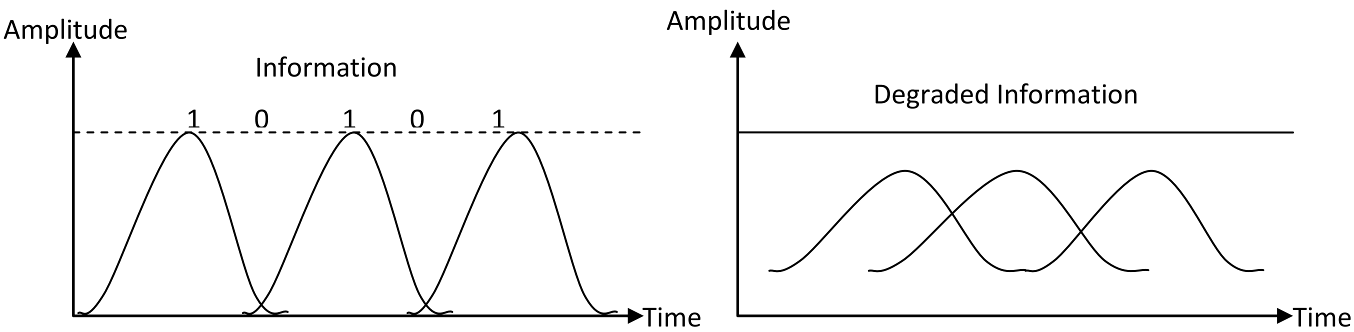

Figure 3: Pulse spreading causing information distortion as a result of Chromatic dispersion.

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This limits the capacity of the fiber. However with adequate amplifier installations along the link, on WDM that has inherent dispersion, the eye pattern produces quality signal output.

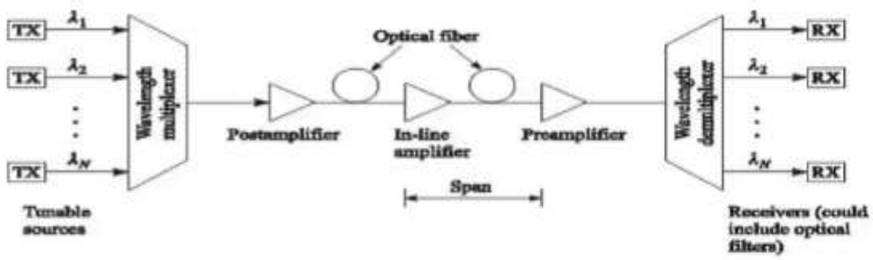

Figure 4: Typical WDM Network containing optical amplifiers.

The Implementation of WDM allows various signals with different data rate to be propagated over same fiber link. The purpose and general principles of switching integration in optical add/drop circuits, as well as optical cross connection converter, is to ensure that protocols are not violated. This implies that for effective modulation, protocols must be transparent. That is different sets of transmitting signaling modes (R1 – signaling R2 Signaling, and SS7-Signalling) can utilize different information protocols without affecting each other nodes in the network. In WDM, each emitted and modulated signal is a unique wave guide and are combined into a serial spectrum of closely spaced wave length and coupled into a single fiber for propagation. At the distant end, de-multiplexing is required to separate the optical signal into its separate channels using filters for signal processing as shown in Fig. 2 (tapering region L and coupling region W).

3. SWITCHING OPERATIONS

The switching operation is basically on matrix design and the configuration is dimensioned as: 2 x 2, 3 x 3,……8 x 8 and other dimensions as required by the network under development. Figure 5 shows a simple 2 x 2 matrix structure, with input wave lengths, λ_1 and λ_2. The analysis of a 2 x 2 guided wave coupler is regarded as a four (4) terminal device that possess two (2) inputs and two (2) output. The analysis of 2 x 2 guided wave coupler is regarded as a four (4) terminal.

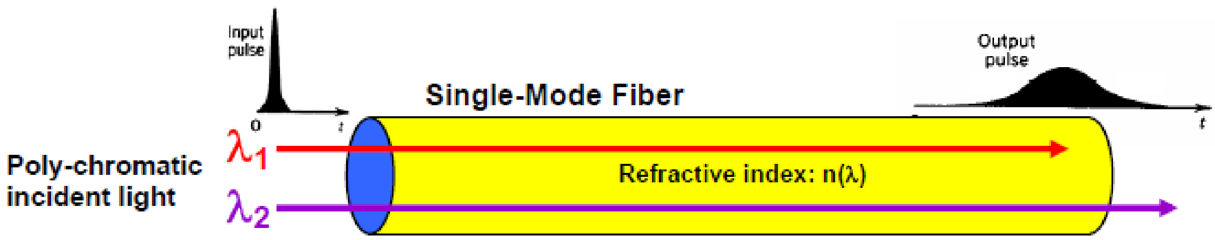

Figure 5. Polychromatic Incident Light in Single Mode Fibre

The input signals can be analyzed in terms of scattering matrix (also called propagation matrix or MEZU-ZANDER MATRIX and the design can equally be structured to achieve good result) are utilized to produce adequate routing in the network. Automatically this describes the two field strength represented in figure 5 and has destinations as a1 and a2 while the two output ports field strength is designated b1 and b2 by definition [4].

Mathematically, b = Sa -- (1)

where $b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$ a $= \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$ $S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$

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$Sij = |S_{ij}|\ exp(JQ_{ij})$ -- (2)

Representing the coupling efficiency of optical power transfer, from port i to output port j with $|S_{ij}|$ being the magnitude of S_{ij} and Q_{ij} being the phase at port j relative to port I. In this equation Maxwell Wave equation applies to the invert time invariance representing two solutions in opposite propagation, taking into account that it is of single Mode operation. Assuming no losses in the device the law of conservation of energy applies, hence

$S_{12=}S_{21}$--- (3)

Also since the device is lossless, the sum of the input intensity I_o is equivalent to the sum of output intensity I_i

$I_0 = b_1^0 b_1 + b_2^0 b_2 = I_i = a_1^* a_1 + a_2^* a_2$……………………..(4)

Or $b^+ b = a^+ a$…………………………………………………………………..(5)

$*$: Complex conjugate,$+$: Transpose conjugate,

Substituting equations (7) and (8) into (9);

$S_{11}^* S_{11} + S_{12}^* S_{12} =$ 1……………………………………………………………….(6)

$S_{11}^* S_{12} + S_{12}^* S_{12}$ = 0…………………………………………………………….(7)

$S_{22}^* S_{12} + S_{12}^* S_{12} =$ 1 …………………………………………………………. (8)

Now ,if the signal into the coupler has a fraction of it $(1-\epsilon)$,if the optical power from input 1,is to appear at output 1 ,then the reverse of $\in$,enters port 2 ,hence $S_{11} = \sqrt{1-\epsilon}$,which is a real number between "0" and "1",therefore we assume that electric field of output 1 ,has zero phase ,then $S_{22} = \sqrt{1-\epsilon}$ with $\emptyset_{22}$ =0. Then zeros (0s) and ones (1s) are now fed into the output for analysis from the eye pattern. The logical interconnection of 8 x 8 coupler matrix wave length routing arrangement is as connected in fig. 6

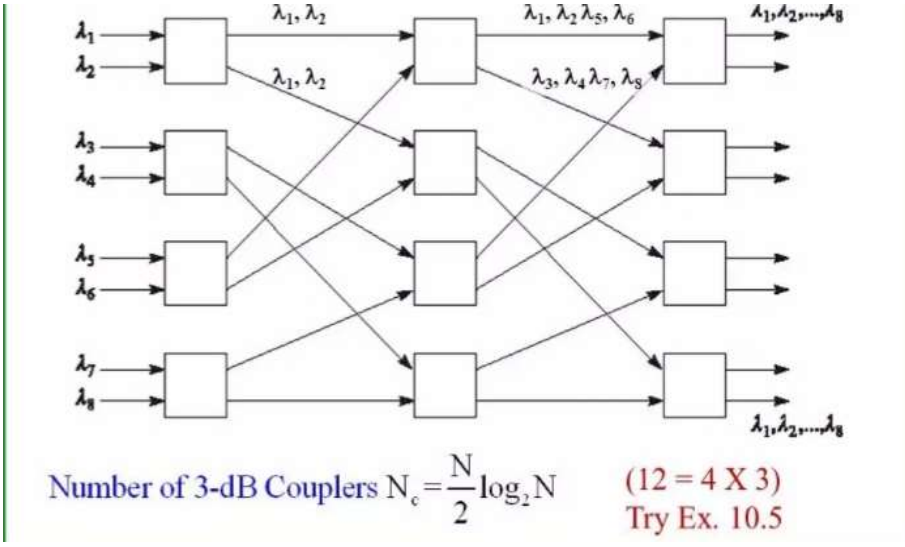

Figure 6. 8 x 8 Coupler matrix, with Node connections

In the connection of a different light path can be used to make tradeoff, resulting in a combination of different through-put. In reality one can make some trade-offs among the variables to get a better network performance. The major selection of network, when trying to expand extend for wider network requires more wave lengths as much as the number of nodes contained within the existing and the proposed expansion, for ease of routing except where some nodes will integrate Time–Sharing approach. This has

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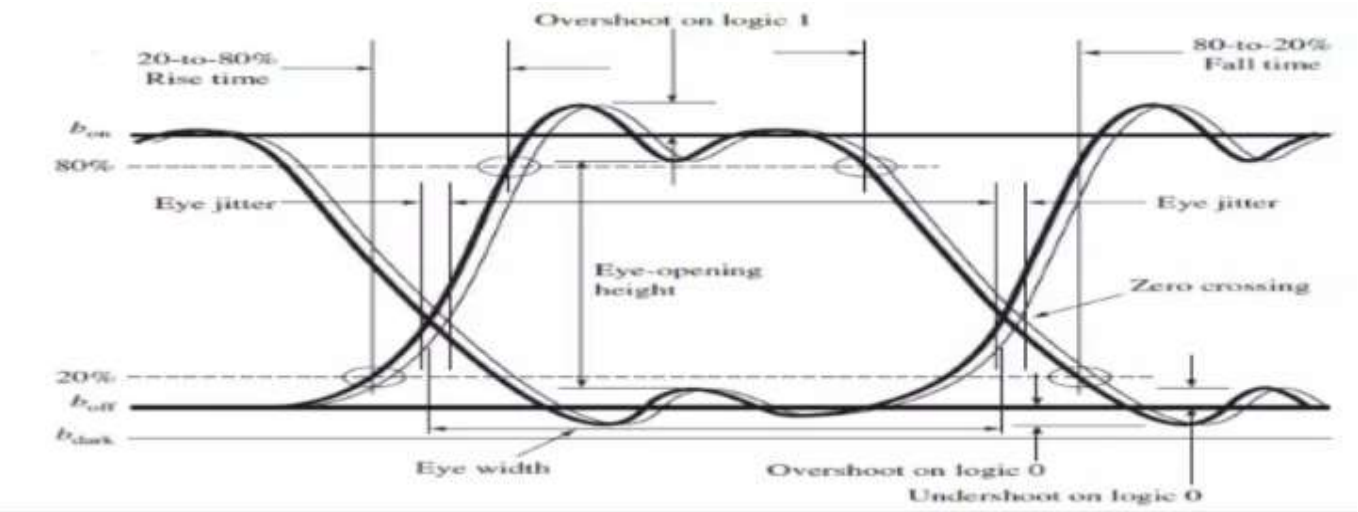
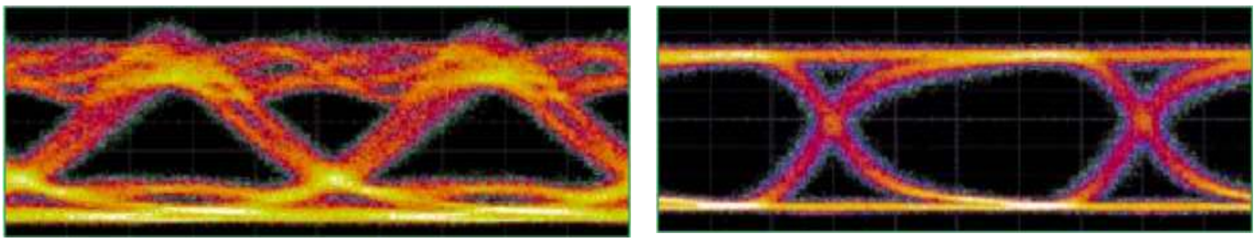
delay factor and reduces efficiency. However if the network expansion depends on this mode of operation ,the switching system will lack free flow of traffic,with call dropping and ,difficult hands shakes will be experienced. The only way out will be to install along the route optical booster amplifiers thereby increasing the cost of provision.The utilization of passive star coupler, necessitates the use of wave length re-use converters in optical switching which is not recommended for satisfactory operation,hence the implementation of wave length division multiplex routed matrix system to block the defects of re –use in star couplers. The physical topology of a wave length router, consist of optical wave router interconnected by point-to-point fiber link in arbitrary mesh configuration to aid the light path. The optical cross connection (OXC), architecture employs a high degree of light path modularly designed, capacity scaling and flexibility in ADD/DROP ,switching of channels[5].

4. EYE-PATTERN

The output of the discrete signals of 1s and 0s delivered are fed into the eye pattern set–up which depicts the quality and situation of the received signal. When the received signal is distinct the quality is a replica of transmitted signal. Inversely, in Figure 7 if the signal is blurred then it has been affected by path loss indices apparently in this situation chromatic dispersion.



a. analysis of eye-pattern



b. distorted blur output **c. distinct output of WDM**

Figure 7. Eye-pattern analysis (a,b,c)

5. CONCLUSION

The application of Wave length division in optic fiber signal propagation with galvanized scatter matrix provides a satisfactory switching through–put for end users. Universally this should be deployed all over to achieve the objective of communication engineering which states that for adequate communications, the received signal (data) must be the exact replica of the transmitted signal (data).

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