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BER Analysis of an Optical Cross-Connect Due to Cross-talk in DWDM System

Bishal Poudel

Abstract— ***This paper focus on analysing the Bit Error Rate of an optical cross connect due to cross-talk in Dense Wave Length Division Multiplexing system.***

Index Terms— ***Bit Error Rate, Dense wavelength division multiplexing (DWDM), Optical Cross-Connect(OXC), Wave length division multiplexing(WDM).***

I. INTRODUCTION

Wavelength Division Multiplexing (WDM) is a system in which the available bandwidth is divided into separate channels with each channels carrying one signal [1]. WDM networks are very promising networks because of their large bandwidth, greater flexibility and big possibility to upgrade the existing fiber networks to WDM networks [2]. The invention of erbium-doped fiber amplifiers (EDFA) is largely responsible for enabling this technique [3] to become popular. There are three variations of WDM that are commonly used: Broad WDM, Coarse WDM and Dense WDM (DWDM). However DWDM allows information at various channels to be transmitted in different wavelength with its huge channel capacity and link distance [4] and utilizes many wavelengths spaced narrowly, and is most commonly located in C-band, the wavelength range from 1539nm to 1565nm. DWDM has been utilized in the long distance network since 1995, and the first optical wavelength add/drop(OWAD) in 1998 and the first OXC was show-casted in industry conventions in 1997. DWDM fibers can transmit at speed of up to 400 giga-bits per second.

WDM has already been introduced in commercial systems. All-optical cross connects(OXC), however, have not yet been used for the routing of the signals in any of these commercial systems. Several OXC topologies have been presented in the literature [5], but their use has so far been limited to field trials, usually with a small number of input–output fibers and/or wavelength channels [5]. The fact, that in practical systems many signals and wavelength channels could influence each other and cause significant crosstalk in the optical cross connect, has probably prevented the use of OXC's in commercial systems [6]. Optical Cross-Connects (OXCs) are the important devices in optical communication. Some OXCs work on optical domain and connects optical channels directly in the photonic domain. This is known as photonic switching or transparent OXCs.

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***** Correspondence Author (s)
Bishal Poudel, He received his B.E. in Electronics and Communication Engineering Pokhara Engineering College, Pokhara University, Nepal.
Whereas hybrid cross-connects works on electrical domain.

Various topologies of OXCs have been developed but their uses are limited, with a small number of inputs-output fibers and wavelength channels. In practical system, many signals and wavelength channels could influence each other and cause significant cross-talk in the optical cross-connect. This fact has probably prevented the wide spread us of OXCs in commercial system. This crosstalk gives to an increased in bit error probability. The more dominant crosstalk is intra-band crosstalk [6]. This is the cross-talk within the same wavelength slot. This type of cross-talk degrade network performance. DWDM is bit-rate and format independent. OXC will offer service providers the ability to create a flexibility, high-capacity, efficient, efficient optical network with full optical bandwidth management. OXCs are very important for meeting the telecommunications demand of today and tomorrow. So here we are analyzing the performance of OXCs.

II. OPTICAL CROSS-CONNECTS

The switching matrix studied in this paper is based on a mechano-optical space switch. This switching matrix is embedded in an OXC topology (Fig. 1) that makes use of demuliplexers and multiplexers to select the wavelength channels.

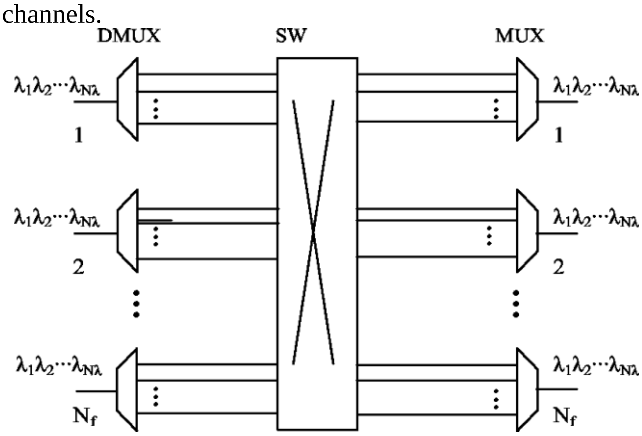

Figure: 2. optical cross-connect switch based on space switch

III. INTRA-BAND CROSS-TALK

Crosstalk will be one of the major limitations for the introduction of OXC in all optical networks. In this paper the influence of the components on the total OXC crosstalk is investigated. The different classes of crosstalk are first clarified .Different kinds of crosstalk exist, depending on their source. First one has to make a distinction between inter-band crosstalk and intra-band crosstalk. Inter-band crosstalk is the crosstalk situated in wavelengths outside the channel slot (Fig. 3) (wavelengths outside the optical bandwidth).

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This crosstalk can be removed with narrow-band filters and it produces no beating during detection, so it is less harmful. The crosstalk within the same wavelength slot is called intra-band crosstalk. It cannot be removed by an optical filter and therefore accumulates through the network. Since it cannot be removed, one has to prevent the crosstalk. In this paper intra-band crosstalk is studied since the network performance will be limited by this kind of crosstalk. Moreover, within the intra-band crosstalk, a distinction between incoherent and coherent crosstalk has to be made. These types of crosstalk are not well defined in literature and therefore a definition is given here. To make a distinction between both types of intra-band crosstalk one has to look at the consequences. The interference of the signal channel and the crosstalk channel at the detector results in a beat term. The crosstalk is called coherent crosstalk if the total crosstalk is dominated by this beat. If this beat term is very small compared with the total crosstalk, it is called incoherent.

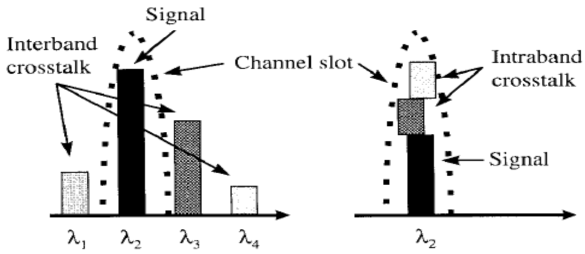
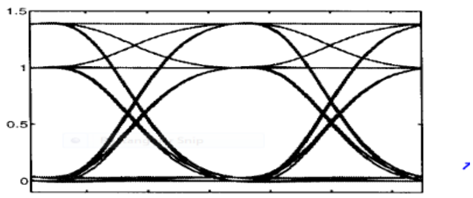
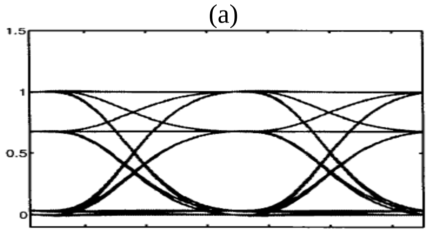


Figure:3 inter and intra band crosstalk



(a)



(b)

Figure4:Eye diagram for positive(a) and negative (b) sign, for a cross talk value of -15dB

From the eye diagrams shown in the figures one can conclude that interferent crosstalk is much more harmful for the "one" than for the "zero." In this paper, the calculated crosstalk is defined as the difference between a calculation without crosstalk sources and a calculation with crosstalk sources, for all "ones" at the input. In the case of coherent crosstalk all the beat terms have the same sign, resulting in a worst case situation. Summarized the calculated crosstalk is the difference between a "one" without crosstalk and a "one" with crosstalk

IV. ANALYTICAL EXPRESSION FOR BIT ERROR RATE

BER in WDM system is calculated by the equation:

$BER = .5\ erfc\ (Q/\sqrt{2})$ (1)

Here Q is a function proportional to the receiver signal-to-noise ratio (SNR). It is expressed as:

$Q = (Rb * Ps)\ ^2 / \sqrt{(\sigma ase^2 + \sigma c^2)}$ (2)

Rb = Bit Rate; in telecommunications and computing, bitrate (sometimes written bit rate, data rate or as a variable *R* or *f* b) is the number of bits that are conveyed or processed per unit of time. The bit rate is quantified using the bits per second (bit/s or bps) unit.

Ps = Signal power in dbm.

σc = Crosstalk.

σase = ASE (amplified spontaneous emission) noise induced by parametric gain and spontaneous Raman scattering in optical fiber Ramen amplifier. It is an unwanted noise

$\sigma ase = \sqrt{((G-1)*nsp*h*\nu*\beta o)}$ (3)

Here G = Gain

nsp = Spontaneous Emission Factor or Population-Inversion Factor

h = Planck's constant = $6.634*10^{-34}$

ν = Frequency of the signal = c/L

c = speed of light = $3*10^8$

L= wavelength

βo = Band Width a measure of the width of a range of frequencies, measured in hertz. Using 1 and 2 equation , the BER in WDM system for the same input power crosstalk can be calculated for different number of channels and hops using the equation

$\sigma^2 = M*b^2*Rd^2*Ps^2*(2*\acute{\epsilon}adj + (N-3)\acute{\epsilon}nonad + Xswitch)$ (4)

Where

M = Number of Hops.

b = Ratio of signal peak power.

N = Number of channels.

Rd = Detector responsivity.

Ps = Input Power

έad = Effective adjacent channel crosstalk.

έnonad = Effective Non adjacent channel crosstalk.

Xswitch = Crosstalk value (in linear units) of the optical switch fabric.

V. RESULT ANALYSIS

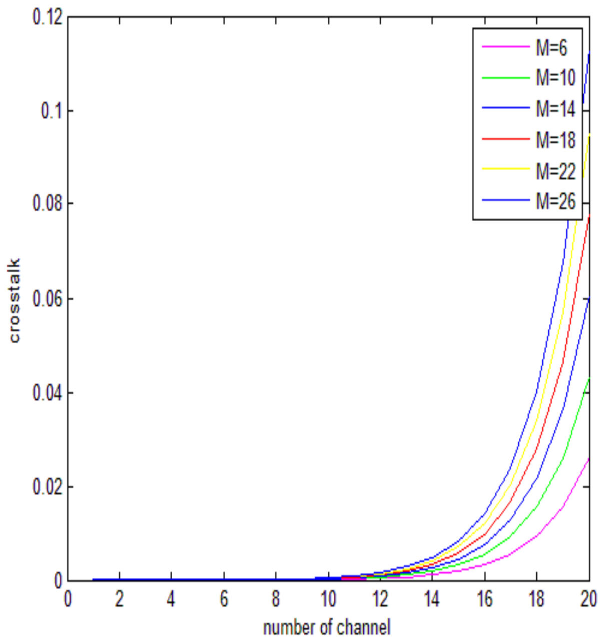


Figure:5. BER versus number of channels

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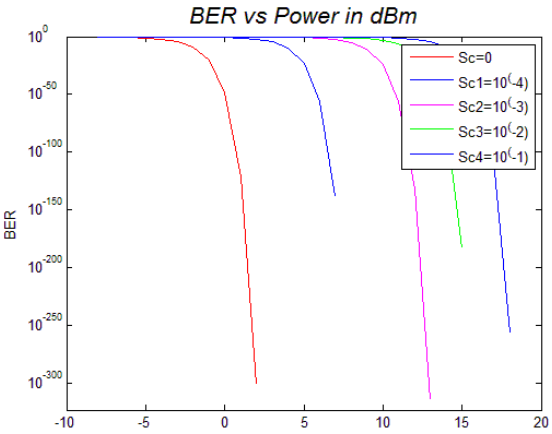

Figure:6 BER versus input power(dBm)

VI. CONCLUSION

In this paper the performance of optical cross connect in DWDM system under the influence of intra-band crosstalk has been analyzed and found that the BER rate increases with the increase in the number of channels and with number of hobs.

VII. ACKNOWLEDGEMENT

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Bishal Poudel He received his B.E. in Electronics and Communication Engineering Pokhara Engineering College, Pokhara University, Nepal. He is currently a Communication Engineering Student at Kathmandu University, Nepal. His research interests are Optical Communications and Wireless security.

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