Crosstalk Analysis under the Impact of Line-width and Chirp in 8×10 GBPS WDM System Incorporating Optical Cross-Connector

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ABSTRACT

In this paper, a simulative experimental set up for OWDM communication system consist of two 4- optical channels with channel spacing of 0.1THz interconnected by means of a 2x2 OXC (an OXC with 2 input ports and 2 output ports) to route the data with less delay and high throughput is analyzed under the impact of laser line-width and modulator's chirp over the crosstalk introduced in OWDM system. Our results show that by using OXC, we can minimize the power degradation introduced in OWDM system due to crosstalk. In addition, the impact of laser line-width and modulator's chirp can not be ignored in reducing the crosstalk while dealing with long haul optical communication systems. The OWDM system is also reported under the influence of crosstalk at different bit rate varying from 1Gbps to 10Gbps in this work.

General Terms
Crosstalk Analysis

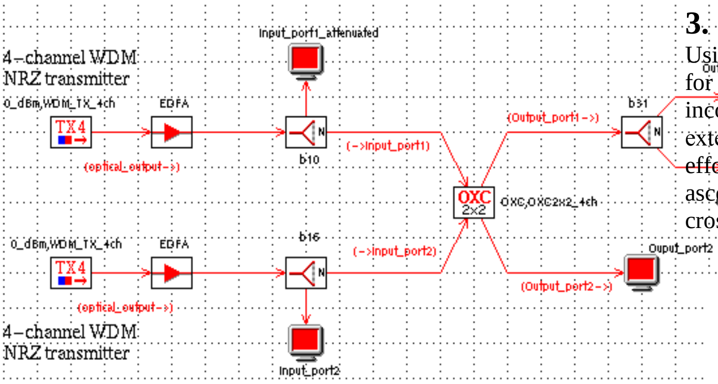
Keywords
Optical Cross-Connector (OXC), Crosstalk, Laser line-width, Modulator's chirp, Optsim simulation software

1. INTRODUCTION

Optical cross connects (OXCs) is an optical switch that can interconnect optical signals between multiple inputs and multiple outputs [1] and providing high switching speeds along with long- term reliability. Generally, electrical cross connects are attributed to the conversion of optical signals coming from the input optical fibers to the electronic signals in order to process the data, and followed by transformation of the electronic signals back to optical form to deliver them to the desired output fibers [2]. These conversions of the electronic to optical and optical to electronic may induce delay and crosstalk, especially in case of WDM/DWDM long haul optical systems. In contrast, OXCs are able to handle the optical signals in their native form and directly switch them from multiple input fibers to their desired output without the need of any optical to electronic conversion. Consequently, OXC greatly improves the switching throughput by reducing the crosstalk and delay. The OXCs are expected to play the important roles in the backbone of the fiber optical communication systems while electronic remains on the edges of the networks [3]. In OWDM systems, the crosstalk between wavelengths is a major problem that degrades the performance of the systems. It is found that the fiber nonlinearities lead to crosstalk between sub-carriers of different wavelengths traversing simultaneously through the fiber. Signal distortions in intensity-modulated direct detection WDM systems induced by interaction of fiber nonlinearity and dispersion were investigated [4]. Crosstalk between wavelengths in SCM-WDM optical communication systems has been studied [5]. It has been reported that in a dispersive fiber, crosstalk can be attributed to fiber nonlinearity combined with group velocity dispersion (GVD). Study of XPM- and SRS- induced crosstalk noise evolution as well as their interaction through a long lossy, non linear dispersive fiber in a cascaded IM-DD system was performed and it was found that it comes mainly from adjacent channels [6]. Power impairments and power penalty due to SRS in dispersion-managed fiber links were evaluated [7]. Transmission limitations due to XPM-induced crosstalk in SCM-DWDM systems were studied at wavelength spacing of 50- and 100- GHz [8]. The crosstalk of three optical cross connects based on Mach–Zehnder Interferometer (MZI) obtained at 4*10 Gbps WDM transmission through SSMF with 2 × 2 optical cross connects (OXC) is presented [9] but the impact of chirp and laser line-width of such systems are not reported. Further, this work is limited to only 40 Gbps WDM systems only. An experimental setup is investigated to observe the amount of intensity noise introduced in an optical system and the power penalty required to compensate this intensity noise at different optical distances under the impact of spectral width of optical source of 10 Gbps optical communication system under the individual and the combine impact of higher-order dispersion parameters [10]. This work is also limited to 10 Gbps optical system and crosstalk analysis at high bit rate is not reported. In this paper, we demonstrated a simulative experimental set up consist of eight optical channels transmitted through SSMF by means of a 2x2 OXC to observe the impact of laser line-width and modulator's chirp over the power degradation introduced in an 8*10 Gbps WDM system due to the crosstalk. The paper is organized into four sections. Section I presents the introduction followed by the section II that describe briefly about the simulation set-up of 8-channels OWDM system incorporating 2x2 OXC. The section III deals with the discussion of the results for the system based on optical cross connects at different modulator chirp parameter, laser line-width and bit rate. The section IV presents the conclusion drawn from our simulation results.

2. SIMULATION SETUP

The simulation set up schematically shown in Figure 1 consist of 8-channel WDM signals at different bit rate i.e. 1-/10-Gbps are modulated by means of external modulation technique using single arm Mach-Zehnder modulator over a continuous wave (CW) lasers with channel spacing of 0.1 THz at varying laser line-width from 10MHz to 100KHz with CW power of 1 mW.



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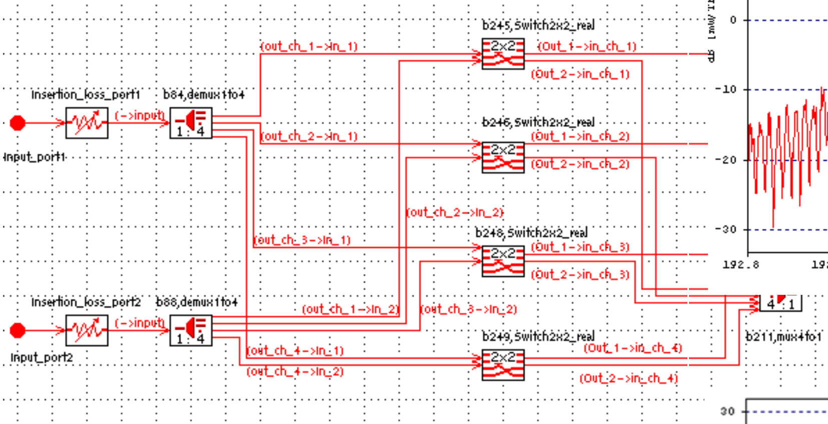

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Fig 1: (a) Simulation setup of two 4- channel OWDM system using 2x2 OXC (b) Different sections of 2x2 OXC

Table 1: System Parameters

Center Frequency: 193.1THz

Channel Spacing: 0.1THz
Filter Bandwidth: 5GHz
Filter Roll Off: 0.2
Laser Input Power: 1mW

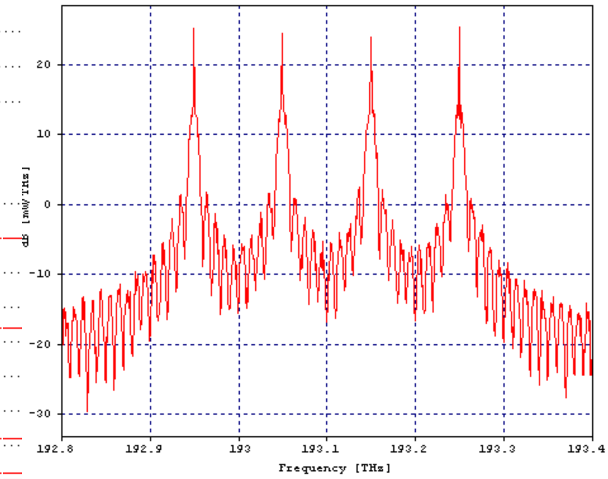
Insertion Loss: 2dB
Insertion loss switch: 0.5dB
Modulator Excess Loss: 3dB
Modulator Extinction Ratio: 30dB

These two set of four channels after amplification by using EDFA are interconnected by means of a 2x2 OXC that consist of three sections as de-multiplexer section that separates in frequency the optical channels of the WDM transmitted signals; realistic optical switches section that directs each channel towards an output port and multiplexer section that aggregates the channels at the output ports.

The optical power spectrum at each output port is analyzed by using Optical spectrum analyzer and optical power meter to observe and measure the cross-talk effect. The different system parameters used to simulate this system are tabulated in Table 1.

3. RESULT AND DISCUSSION

Using our simulation set-up, the results have been mentioned for power degradations introduced due to crosstalk by incorporating OXC at different bit rate under the impact of external modulator's chirp parameter and laser line-width. An effort has been made for the exhaustive investigation to ascertain the impact of chirp parameter and laser line-width on crosstalk in WDM communication systems.



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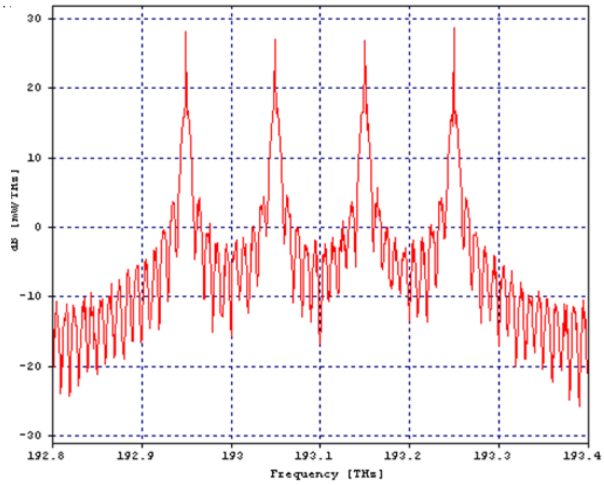
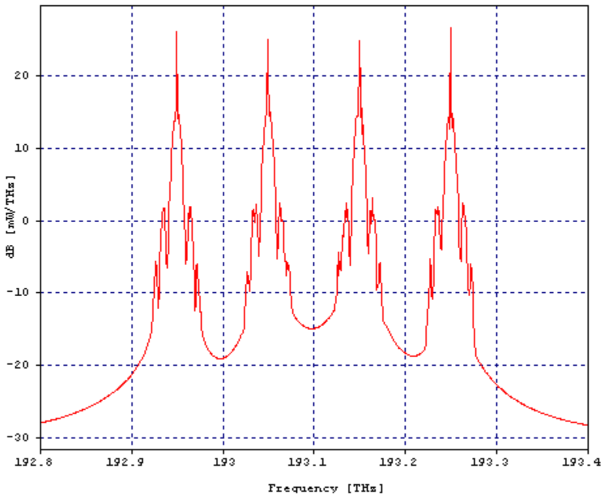


(b)

Fig: 2 Optical Spectrum before OXC of (a) input port 1 and (b) input port 2 with laser line-width 10MHz and zero chirp at 10Gbps

The Fig 2 depicts the input optical spectrum at the transmission end of port 1 and port 2 before interconnected to an OXC with laser line-width of 10 MHz and modulator's chirp parameter is set to zero value. The 4-optical channels of each port with channel spacing of 0.1 THz are transmitted at bit rate of 10 Gbps. The interference in the optical spectrum can be clearly seen from Fig 2. But as the crosstalk decreases from 0 dB to -50 dB, this interference reduces as shown in Fig 3 after using OXC. Further, this crosstalk is also reduced if the channels are transmitted at bit rate of 1 Gbps as shown in Figs (4-5). Further, it is observed that the power degradation due to crosstalk introduced in the system increases as the crosstalk increases but reduces as laser line-width decreases as depicted in Fig 6. The Fig 7 depicts that not only the laser line-width and bit rate, the chirp parameter is also a dominant factor in reducing the crosstalk. As the chirp reduces from 3 to 0, the power degradation due to crosstalk reduces as shown in Fig 7.



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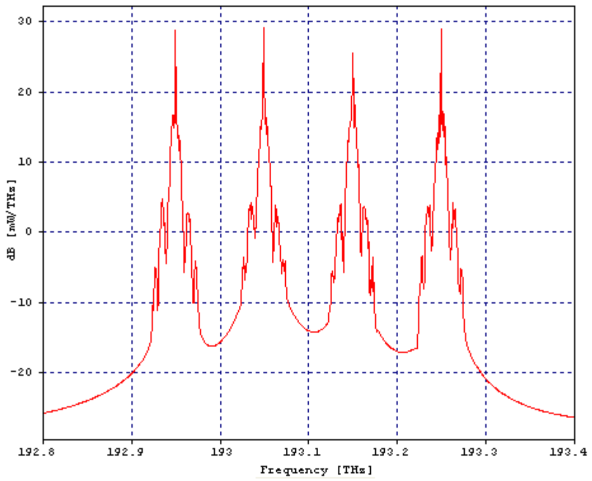

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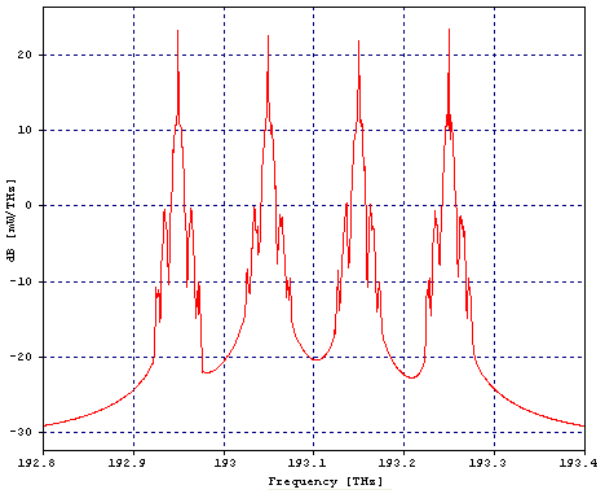

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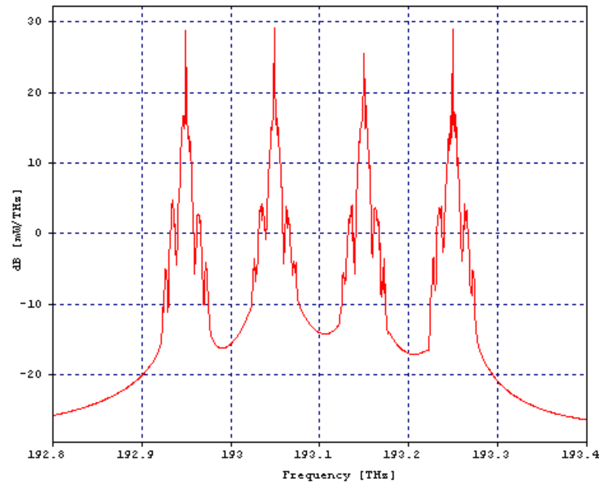
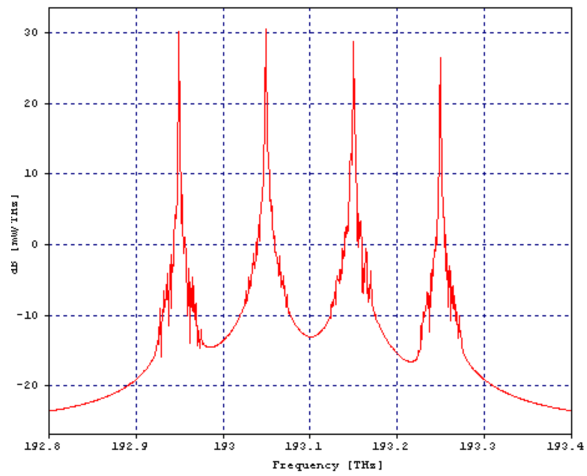


(d)

Fig: 3 Optical Spectrum after OXC of input port 1 with (a, b) crosstalk = -50dB and of input port 2 with (c, d) crosstalk = 0dB with laser line-width 10MHz and zero chirp at 10Gbps



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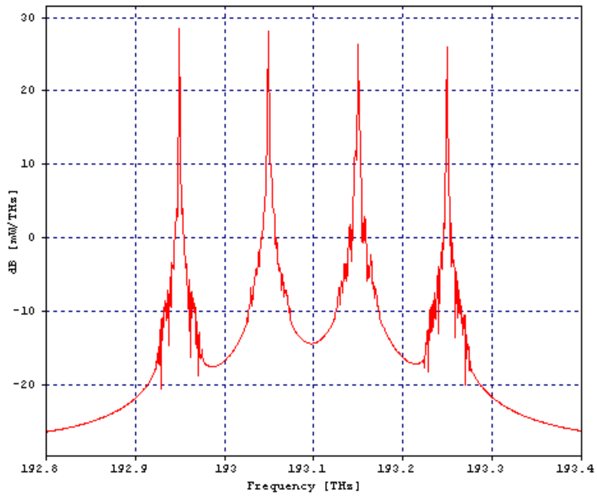

(b)

Fig: 4 Optical Spectrum after OXC of (a) input port 1 and (b) input port 2 with laser line-width 100 KHz, a zero chirp at 1Gbps at crosstalk = 0dB

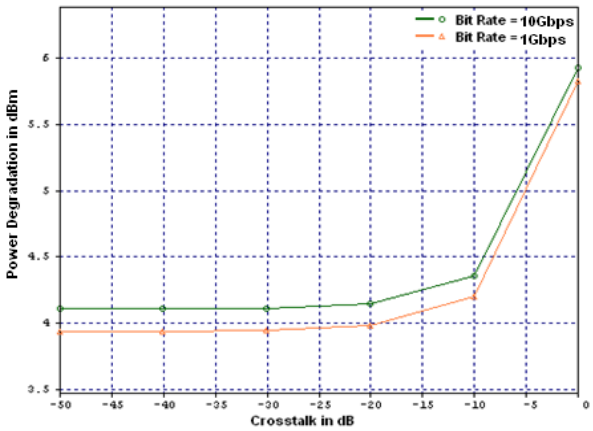

Fig: 5 Power degradation vs crosstalk at different bit rate with laser line-width of 100 KHz at zero chirp

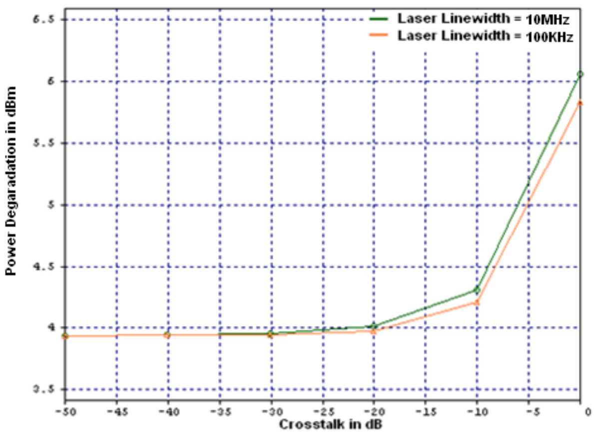

Fig: 6 Power degradation vs crosstalk at different laser line-width with zero chirp at bit rate of 10 Gbps

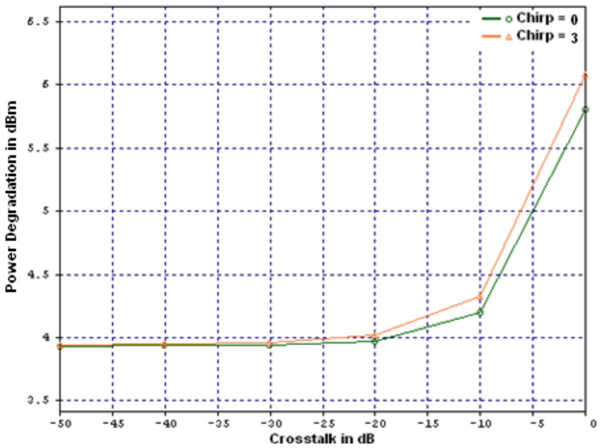

Fig: 7 Power degradation vs crosstalk at different chirp with laser line-width of 100 KHz at bit rate of 10 Gbps

4. CONCLUSION

Demonstration of the impact of laser line-width and modulator's chirp over the crosstalk introduced in 8*10 Gbps WDM system incorporating a 2x2 OXC is carried out in this paper, and observed a reduction of power degradation introduced in an 8-channel WDM system due to crosstalk. The crosstalk reduces as we reducing the laser line-width to 100 KHz in conjunction with the reduction of modulator's chirp.

5. REFERENCES

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