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## To cite this version:

Sarah Benameur, Christelle Aupetit-Berthelemot, Malika Kandouci. Impact Of Optical Demultiplexers Based On Fiber Bragg Gratings On DWDM transmission system. First International Conference on Electrical Engineering and Control Applications ICEECA'2012, Nov 2012, Khenchela, Algeria. hal-00924566

**HAL Id: hal-00924566**

**https://hal-unilim.archives-ouvertes.fr/hal-00924566**

Submitted on 7 Jan 2014

# Impact Of Optical Demultiplexers Based On Fiber Bragg Gratings On DWDM transmission system

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***Abstract* - this study is to measure the impact of the insertion of demultiplexers based on Bragg grating filter on DWDM transmission system. An optical link has been developed using a simulator system.The impact of demultiplexers on 10 Gbit/s DWDM system is investigated for NRZ-OOK coding formats. Performances of demultiplexers with different crosstalk, filter bandwidth and insertion losses are analyzed to get the best system performance for 10 Gbit/s DWDM transmission system with high spectral efficiency. The simulations were conducted for different fiber's lengths to assess the impact of demultiplexer on the link performance in terms of Bit Error Rate (BER).***

***Key words*- optical link, fiber optics, DWDM demultiplexer, simulator system, BER, filter Bragg grating.**

## I. INTRODUCTION

The evolution of data transmission using fiber optics has progressed much since the emergence of wavelength division multiplexing, or WDMA (Wavelength Division Multiple Access). The WDMA considers that multiple wavelengths can propagate simultaneously in a single fiber without interfering with each other. It allows for transparency with respect to the format of the information conveyed and the signals carried by different wavelengths can be flow and varied formats. In order to increase the transmission capacity and transmission distance available with optical amplifiers, a DWDM (Dense wavelength division multiplexing) technique has been developed to provide channel spacing as narrow as possible to the appropriate optical amplification band. This has led to the use of spacing 1.6nm to 0.4nm from (200-50 GHz) bandwidth of 1500-1600 nm (C and L bands) [1, 2, 3, 4].

This development has complicated the design of systems associated with this technology as the number of parameters affecting the link performance is important. Also, the system simulators are a great help to find solutions, both at the component of the system [5].

In this context, we present the simulation results of a DWDM transmission system with 10GHz and 8 channels to characterize a demultiplexer based on Bragg grating filters in terms of efficiency, bandwidth, adjacent and nonadjacent channels isolation.

## II. SIMULATED TRANSMISSION SYSTEM:

A transmission system over optical fiber's role is to transmit without error some information capacity of a binary point (transmitter) to another (receiver), a few kilometers away. The role of the optical transmitter is to convert the electrical signal into optical form and launch the resulting optical signal into the optical fiber. Optical signals were transmitted through optical fiber to the optical receiver, and then the optical receiver converted the distorted and attenuated weak optical signal output from the fiber-optic lines to electrical signals [1, 2]. Figure (1) represents the simulated DWDM system architecture.

The system mainly consists of transmitter module configured external modulation, generating optical signals with a binary rate 10Gbit / s. The 8 channels are multiplexed with a spacing fixed at 50 GHz, is 0.4nm, a value recommended by ITU (International Telecommunications Union) [2].

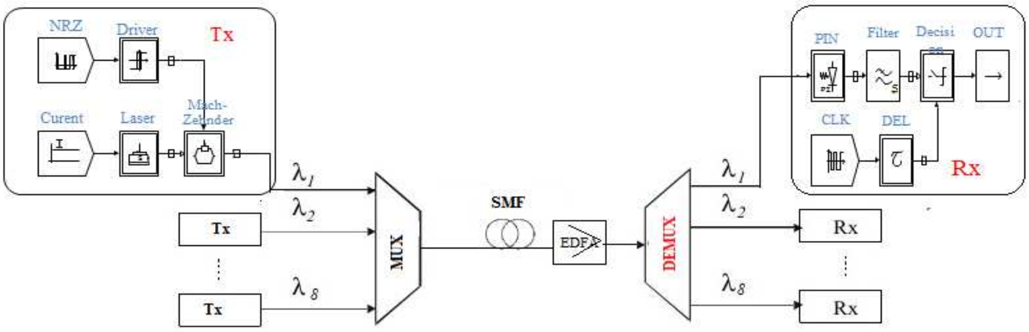

Figure 1. Configuration of the simulated link.

The eight multiplex channels to 10Gbit / s passes in a standard fiber (SMF Single Mode Fiber), whose characteristics are reported in Table 1, followed by an optical amplifier EDFA.

TABLE I. SMF PARAMETERS USED IN SIMULATIONS.

|  | Linear Loss | dispersion Coefficient | Dispersion slope | Section | A² |
|---|---|---|---|---|---|
| **Units** | dB/km | ps /nm.km | ps /nm².km | µm² | W/m² |
| **SMF** | 0.25 | 17 | 0.07 | 80 | $2.7.10^{-20}$ |

Preceded by a demultiplexer based on Bragg grating, the power receiving end of the chain of transmission is responsible for detecting and converting the optical signal into an electrical signal by providing the minimum degradation. It includes a PIN photodiode, followed by an electric filter low pass Bessel of order 5, cutoff frequency 0.8 times the highest rate [1, 6, 7and 8].

The model of our simulator available Demultiplexer system simulates a demultiplexer based on Bragg gratings characterized by the transfer function of the filter, coupled to a K channel, is given by the following equation [ 4, 6, 8 and 9]:

$$F_K(\lambda) = \left[\sum_{i=1}^{N} A_i R_0 exp\left[-\left(\frac{4Ln2}{BP^2}\right)(\lambda-\lambda_i)^2\right]\right].IL \qquad (I)$$

N : number of channels;
BP: channel filter bandwidth;
$R_0$ : Reflectivity of the filter;
$\lambda_i$ : Central wavelength of channel i;
$A_i$ : Channel isolation
  $A_i$ = 0dB if i = K
  $A_i$ = adjacent channel isolation if i=K±1
  $A_i$ = nonadjacent channel isolation if K other
IL : insertion loss

If “E” denotes the input of the demultiplexer, the output “$S_k$” associated with K channel is calculated as:

$$S_K(t) = E(t)*F_k(t) \qquad (II)$$

Where * means the convolution operator.

## III. RESULTS AND DISCUSSION :

### *A. Change in filter bandwidth BP (GHz):*

The first study concerns the impact of the filter's bandwidth on the received signal quality. The results of Figures 2 and 3 respectively represent the transfer function of filter associated to the channel 4 and the BER curve as a function of bandwidth for different lengths of fiber (20, 35, 50km), show that the best bit error rate (BER) is obtained for a bandwidth ranging from 13 to 20GHz. There is also, by increasing or decreasing the bandwidth, the transmission quality deteriorates beyond 20 GHz. This is reinforced by the eye diagrams (see Figure 4) where there is a gradual opening of the eye 5 to 20GHz. So beyond this range, the BER is decreasing, which increases the interference between symbols and penalizes link.

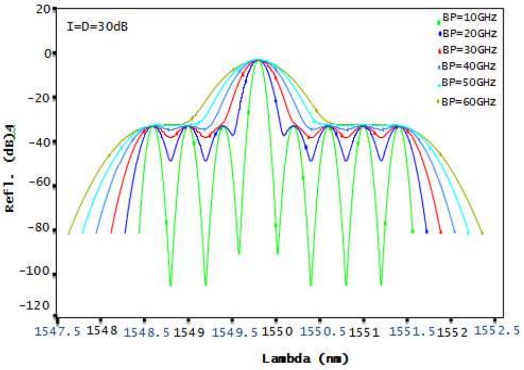

Figure 2. Transfer function for different values of BP.

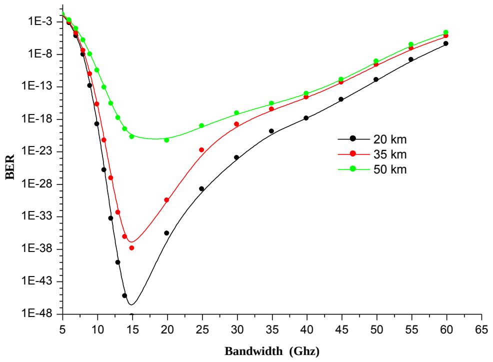

Figure 3. BER as a function of bandwidth BP.

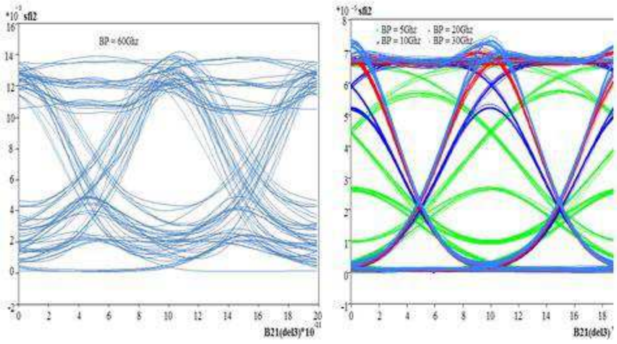

Figure 4. The eye diagrams after filtering for a variable bandwidth.

### *B. Change nonadjacent channel isolation D (dB):*

Analysis of the crosstalk's impact on the link performance Figure 5, shows the evolution of BER based isolation D, ranging from 0-35 dB. We note that more isolation between nonadjacent channels increases better is the BER, by cons latter remains unchanged when the isolation reaches 25 dB and beyond. This is confirmed by the appearance of important parasitic lines on the 5 other channels for an isolation D = 0 dB that an isolation D = 25 dB (see Figure 6).

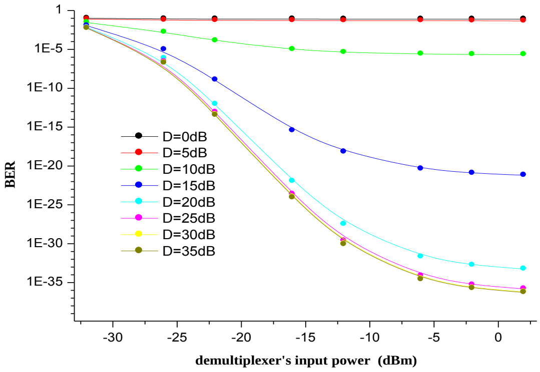

Figure 5. BER as a function of demultiplexer's input power for different values of D.

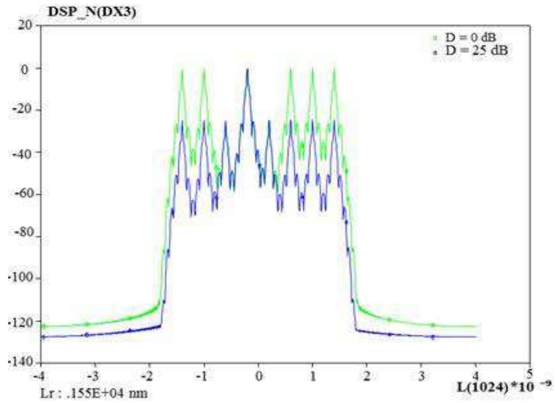

Figure 6. Power spectral density at the demultiplexer output.

### C. *Variation of adjacent channel isolation ( I)*

The analysis of the crosstalk's impact on link's performance Figure 7, shows the evolution of the BER as a function of adjacent channel isolation "I" and precise that beyond 25dB, the BER remains unchanged. We observe in Figure 8, the decrease of "I " leads firstly to the reduction of the eye opening and also to increased noise. The signal to noise ratio decreases and the interference between symbols penalize more the system performance.

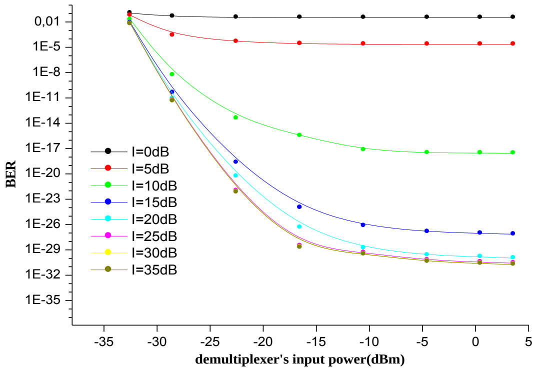

Figure 7. BER as a function of demultiplexer's input power for different values of I

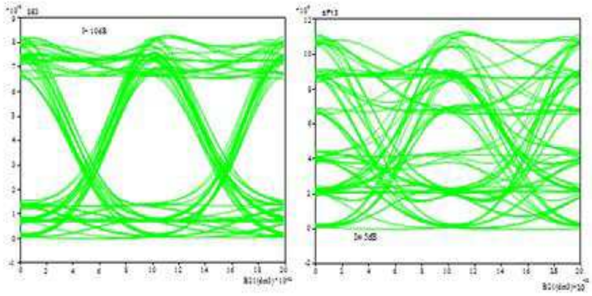

Figure 8. Impact of adjacent channels isolation on the signal quality.

### D. *Variation of insertion losses (IL)*

The variation of BER as a function of demultiplexer's input power in Figure 9, for different values of insertion loss (IL), shows that for the maintenance of a BER less than $10^{-9}$ with insertion loss equal to 3dB, it is necessary to have power at the entrance of the demux, than -27.5 dBm.

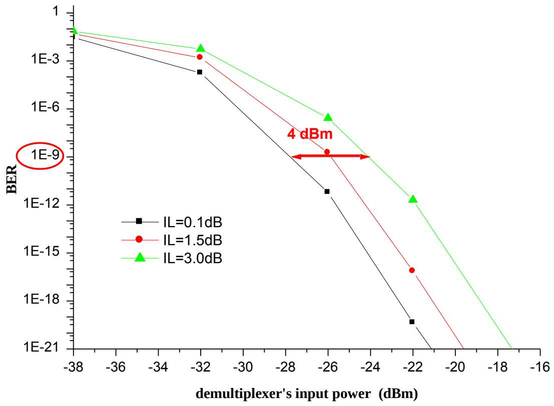

Figure 9. BER as a function of demultiplexer's input power for different values of IL.

### E. *Effect of varying the fiber's length*

The last step is to see the effect of varying the fiber's length on the signal quality. The simulations are performed at a rate of 10Gb / s and for fixed insertion loss (0.5dB).

The fiber length ranges from 20-80 km in 10 km. Figure (10 ) shows that we can maintain a BER less than $10^{-9}$ for a fiber length not exceeding 60 km.

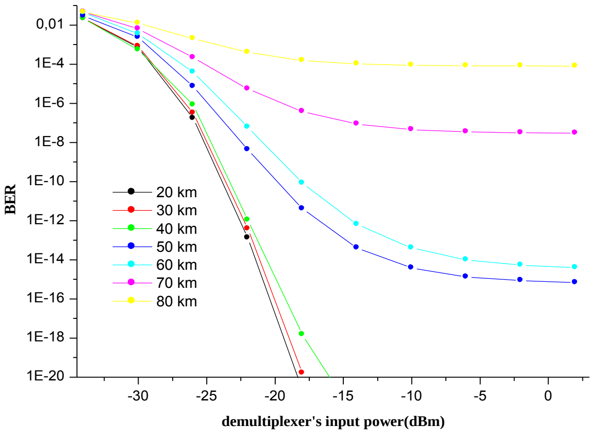

Figure 10. BER as function of the demultiplexer's input power for different fiber's lengths.

It can be inferred that beyond a distance of 60km, amplification and dispersion compensation will be required to improve the BER: to counteract this attenuation, dispersion and the onset of nonlinear effects which increase with the fiber length.

## IV. CONCLUSION

The various simulations on an optimized point-to-point DWDM transmission system with 10Gbit /s , 8 channels and a channel spacing of 50 GHz was simulated, to characterize the demultiplexer, have allowed the study of the impact of various parameters such as filter bandwidth, crosstalk, insertion losses .. etc. ..

We consider that crosstalk strongly penalizes the link's performance, regarding the insertion losses, more the input power of demultiplexer increases less losses affect the BER. Finally, simulations of BER for different lengths of fiber show a BER of 10-9 is maintained for a fiber length of less than 60km.

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