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Comparatively analysis of without and single & double FBG optical filter in 75 Gbps Optical DCDM based communication system

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Abstract: In this paper, we design five user optical based DCDM system where FBG used as optical filter. The performance comparison of without and with single & double FBG filter has been done. The system performance is evaluated on the basis of the SNR, Q-factor and BER, for all five users. It has been observed that as number of FBG filer increases the performance of system also improves.

Keywords: Duty Cycle, Fiber Bragg Grating , Optical Filter.

I. INTRODUCTION

Multiplexing is the key issue to increase the capacity of communication systems. It allows different users to share the available carrier bandwidth and communicate simultaneously. The goals of all multiplexing techniques are to support as many users at as high speed and at the lowest cost as possible. In existing systems, the medium is normally shared based on time slot (TDM), carrier frequency (FDM/WDM) or spectrum coding (CDM) [2]. TDM is the most widely used multiplexing technique in communication systems today. However, for multiplexing high number of users with high data rates, high speed multiplexer and de-multiplexer are required, resulting in very high cost for TDM systems. At higher speeds clock recovery is another essential issue that may render the system highly complicated and costly for TDM systems. Therefore, many investigations have been done to design and develop reliable and cost-effective clock recovery modules for TDM in both the electrical and optical (thus, OTDM) versions [4]. A requirement for higher transmission capacity has drawn the attention of researchers worldwide to develop new modulation formats, multiplexing techniques and detection systems. This paper proposes a near futuristic approach for better utilization of the transmission capacity of optical fibers. A new multiplexing technique based on duty cycle division is proposed, thus the name Duty Cycle Division Multiplexing (DCDM). DCDM can be applied in both electrical and optical domains, for wired and wireless systems. This technique allows for more efficient use of time slots as well as the spectrum, taking advantage of both the conventional TDM and FDM. Here we have designed a 75 Gbps DCDM system, the system features multiplexing of the basebands in electrical domain (DCDM).

II. DUTY CYCLE DIVISION MULTIPLEXING (DCDM)

Duty cycle division multiplexing (DCDM) was proposed as an alternative multiplexing technique to obtain large spectral efficiency. In DCDM, different users can share the same channel for transmitting data simultaneously by using the same frequency band but each user uses different duty cycle for RZ encoding. The electrical adder adds up all signals and an optical source modulates the multiplexed signal. For multiplexing 'n' users, the value of the duty cycle for each user can be assigned in various ways. Here the duration for i user, T_i is defined as:

$$T_i = \frac{i \times T_s}{(n+1)} \quad \ldots\ldots\ldots (1)$$

Where, 'n' represents number of multiplexing users and T_S is symbol duration.

For example, assigning the duty cycle value for 5 users, using DCDM technique will results:

For the 1st user = Ts/6.
For the 2nd user = 2Ts/6.
For the 3rd user = 3Ts/6.
For the 4th user = 4Ts/6.
For the 5th user = 5Ts/6.

The DCDM technique is based on the unipolar RZ line code. In this technique, each user transmits a bit of 0 volts within T_S second (where T_S is symbol duration) and bit 1 is transmitted with A volts with a duration less than T_S seconds time slot but within their respective duty cycle as allotted. For multiplexing five users, the 1st , 2nd, 3rd, 4th & 5th user uses duration of T_S /6, (2×T_S)/6, (3× T_S)/6, (4× T_S)/6 and (5× T_S)/6 respectively to transmit bit 1s. The net

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multiplexed signal possesses multiple amplitude levels [1]. At the receiver side, the input signal can be extracted from the demodulated signal based on the signal voltage amplitude and the duty cycle's time duration.

III. FIBER BRAGG GRATING

A FBG is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects specific wavelengths of light and transmits all the other components**.** This is achieved by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength specific dielectric mirror. A fiber Bragg grating can therefore be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector. Optical fiber gratings are important components in fiber communication and fiber sensing fields. The FBGs are used extensively in telecommunication industry for dense wavelength division multiplexing, dispersion compensation, laser stabilization, and Erbium amplifier gain flattening, simultaneous compensation of fiber dispersion, dispersion slope and optical CDMA [3].

The uniform means that the grating period Λ, and the refractive index change δn, are constant over whole length of the grating. Figure-1: shows the concept of uniform Biber Bragg Grating:

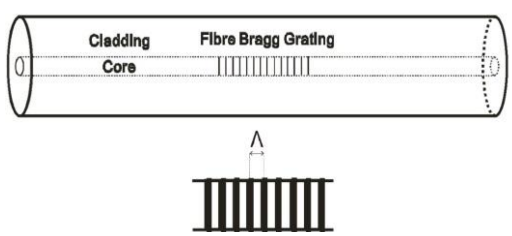

Figure-1: Illustration of a uniform Biber Bragg Grating

A grating is a device that periodically modifies the phase or the intensity of a wave reflected on, or transmitted through, it. The equation relating the grating spatial periodicity and the Bragg resonance wavelength is mentioned as below:

$$\lambda_{Bragg} = 2\eta_{eff} \wedge \ldots\ldots\ldots (2)$$

Where n_{eff} is effective mode index

In the case when the Bragg condition is not satisfied, the light reflected from each of the subsequent planes becomes progressively out of phase and will eventually disappear. Only when the Bragg condition is met, the contributions of reflected light from each grating plane add constructively in the backward direction to form a back-reflected peak with a center wavelength defined by the grating parameters, i.e., the Bragg wavelength. Figure-2, gives a reflection power spectrum as a function of the wavelength, in which the side lobes of the resonance are due to multiple reflections to and from opposite ends of the grating region.

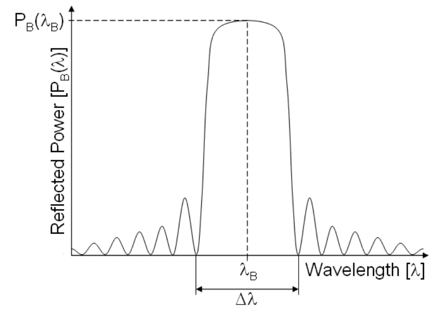

Figure-2: FBG reflected power as a function of wavelength

The wavelength spacing between the first minima or the bandwidth of grating is given by

$$\Delta\lambda = \left[\frac{2\delta\eta_o\eta}{\pi}\right]\lambda_B \ldots\ldots\ldots\ldots (3)$$

Where $\delta\eta_o$ is the variation in the refractive index.

IV. SIMULATION SETUP

Figure-3 shows the simulation setup of 5×15 Gbps DCDM based Optical Communication System. The data of each user is transmitted with a bit rate of 15 Gbps, that generated by RZ pulse generator with different duty cycle. The RZ-PG1 modulates 15%, RZ-PG2 modulates 30%, RZ-PG3 modulates 45%, RZ-PG4 modulates 60%, and RZ-PG5 modulates 75%. The last 25% is used for guard band purpose, to avoid symbol overlapping in communication system. The output of RZ pulse generators are electrically multiplexed using Electrical adder. The Output of electrical adder-4 is the electrical multiplexed signal of all users; the multiplexed data is converted in optical signal by modulating the continuous wave (CW) laser**.**

The output of Amplitude Modulator is sent down through an optical fiber cable of 100 km. The received optical signal is amplified by an optical amplifier and feed to FBG. The fiber bragg grating work as wave length filter, that reflect a single wave length signal and transmit others. Then these signals detected by a PIN detector which converts the optical signal in electrical form.

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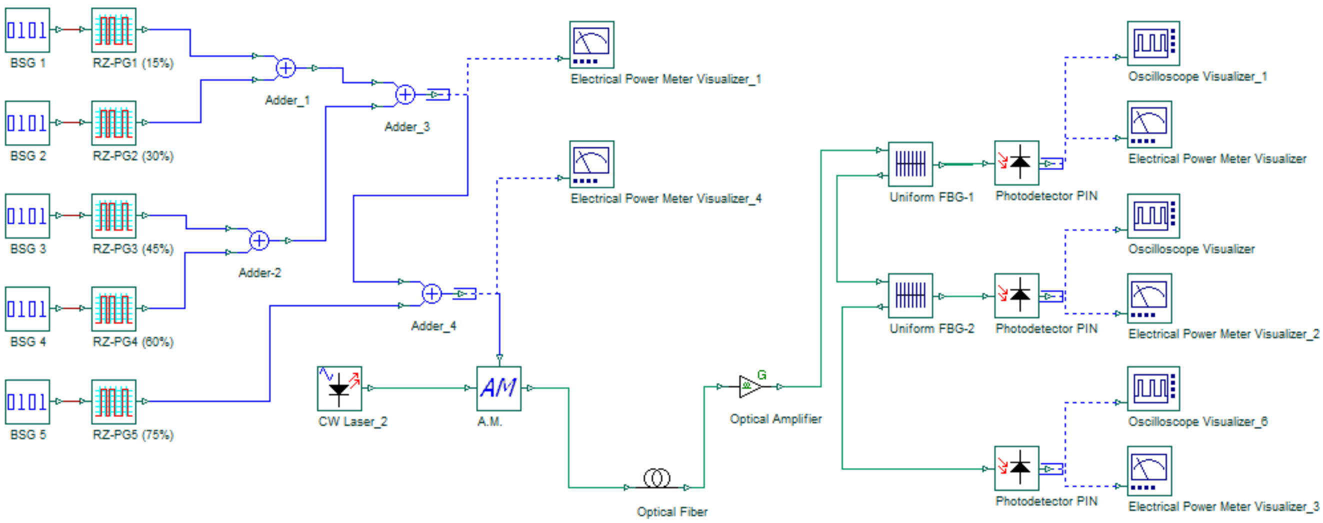

Figure-3: Simulation setup of 5×15 Gbps DCDM system with double FBG filter

Table 1: Setup parameter for five user DCDM system

Transmitter section (common parameters)-

S.N.	Setup parameter	
1	No. of bit sequence generator	5
2	Pulse Generator	RZ
3	Bit rate, Gbps	75
4	Operating wavelength, nm/THz	1552.5/193.1
5	Launched power mw	2
6	Distance , km	10-100

Receiver section-

S.N.	Setup parameter	w/o FBG	I-FBG	II-FBG
1	Optical amplifier , Gain (dB)	20	20	20
2	Photo detector PIN	1	1	1
3	FBGs	0	1	2

V. **RESULTS**

V.I SNR vs LENGTH

Figure-4 shows the graph of received electrical SNR versus length for the 75 Gbps DCDM systems with three different cases. As length increases the SNR decreases and to improve the SNR, the number of FBG filter should be increased.

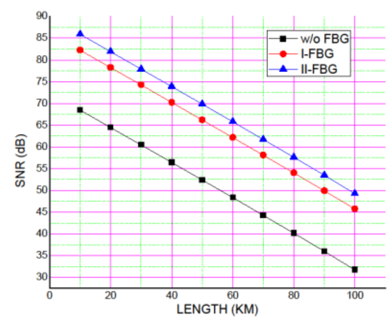

Figure-4: SNR vs Length

V.II Q-FACTOR vs LENTGH

Figure-5 shows the graph of received Q-factor versus length for the 75 Gbps DCDM systems with different filters. As length increases the Q-factor also decreases. The Q-factor of II-FBG filter is best among, all the three filters.

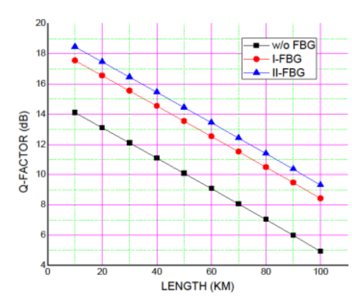

Figure-5: Q-factor vs Length

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V.III BER vs LENGTH

Figure-6 shows the graph of received BER versus length for the 75 Gbps DCDM systems with three different filters. Here the BER of II-FBG filter is better than I-FBG and without filter outputs, to maintain minimum BER 10^{-9} for communication system.

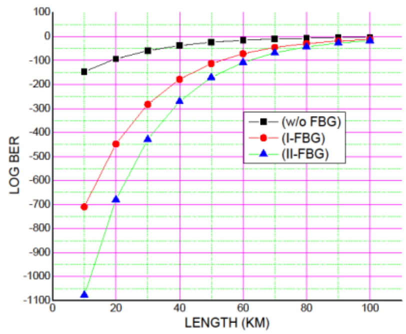

Figure-6: BER v/s Link length

VI. CONCLUSION

The comparatively analysis of without and with single & double FBG optical filter in 75 Gbps Optical DCDM based communication system has been simulated. The system performance has been is evaluated on the basis of the SNR, Q-factor and BER, for all five users. It has been observed that as number of FBG filer increases, the performance of system also improves.

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