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PERFORMANCE IMPROVEMENT OF OCDMA BY FBG

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Abstract: **This thesis investigates the performance improvement of OCDMA. To improve the bit error rate of the system uniform fibre bragg grating is used at transmitter and receiver end with same reflectivity. With distance, performance of OCDMA decreases. To check the effectiveness of FBG on OCDMA in optisystem simulink software, various lengths of optical fibre are taken and bit error rate is checked. Comparison of BER and various parameters of eye diagram is done with FBG and without FBG. The overall work is done in optisystem tool specially designed for optical communication.**

Keywords: OCDMA, FBG,

1. INTRODUCTION

The use of optical fiber enables transmission of data at very high rates in excess of terabits per second and beyond over distances of thousands of kilometers. As the capacity of the backbone increases, bandwidth demanding applications have emerged. High resolution video conferencing is being introduced. High quality full length movies can be downloaded in digital format. Large and powerful application software can be purchased and immediately downloaded from the Internet. Multimedia and fully interactive web-pages have been developed to enable business to business (B2B) and business-to-consumer (B2C) e-commerce, distance learning and ultimately telemedicine. Optical fiber has been deployed very successfully in long haul communication. These long-haul links serve as the backbones of worldwide communication networks. As the demand for such bandwidth intensive applications continues to explode, the bandwidth of access networks will need to grow rapidly. Since most of these local networks currently employ traditional transmission media such as twisted pair and coaxial cable, their bit rate-distance products BL are restricted to 100s (Mb/s)-Km, while that of optical fibers can reach 1000s. To overcome this bandwidth bottleneck in the access market, optical fiber must be brought to the local area network (LAN). There exists an urgent need to develop efficient, economical optical local area networks. So to take the full advantage of the high speed in optical fibers, one of the basic concepts in fiber optical communication is the idea of allowing several users to transmit data simultaneously over the communication channel. This is called Multiple Access. There are several techniques to provide multiple accesses and one of them is Fiber Optic Code Division Multiple Accesses (FO-CDMA). OCDMA is the method of sharing the bandwidth of optical fiber among multiple active users. It plays a main role in digital communication, backbone networks, high speed LAN, MAN. Thus the main advantage of using optical fiber communication is high speed, large capacity and large reliability. Optical CDMA is most suitable to be applied to high speed LAN to achieve contentionfree, zero delay access, where traffic tends to be bursty rather than continuous. Optical systems use different types of optical codes. Codes can be bipolar or unipolar.

2. FIBRE BRAG GRATING

A Fibre Bragg Grating (FBG) is a periodic, or almost periodic, structure consisting of a variation of the refractive index along the length of a fibre. It acts as a band-rejection filter, reflecting any wavelength that satisfies the Bragg condition and passing all wavelengths that are not resonant with the grating. The advantages of FBGs in systems applications include low insertion loss, all fibre compatibility, relative ease of manufacture and low cost; but a major feature is that by changing the grating parameters such as induced index change, length, period chirp, fringe tilt, we can achieve the desired grating spectral characteristics. The FBG has a range of applications in the optical communications area, such as wavelength selection, laser stabilization, dispersion compensation, pulse shaping, etc.

The impulse response h(t) of a fibre grating is given by the inverse Fourier transform of its frequency response H(ω).

$$h(t) = \int_{-\infty}^{+\infty} H(\omega) e^{-j\omega t} d\omega$$

When a short pulse is reflected by a FBG, it is transformed into a pulse with a temporal shape given by the convolution of the input pulse and the impulse response of the grating

$y(t) = x(t)*h(t)$

According to Fourier transform theory, in the frequency domain

$$Y(\omega) = H(\omega)X(\omega)$$

Now we consider the FBG being used as a matched filter, which has a frequency response G(ω) and associated impulse response g(t). In the frequency domain, the result after the decoder is

$R(\omega)=Y(\omega)G(\omega)= X(\omega)H(\omega)G(\omega)$

To recover the input pulse X(ω) or x(t), it is required that

$G(w) = H^*(w)$ $\qquad$ $g(t)=h(-t)$

According to the discussion above, the superstructure function of the decoder grating is just the spatially reversed form of the structure used to write the encoder grating. Coupled mode theory is a straightforward, intuitive and accurate tool for modelling the optical properties, such as reflection and transmission spectra, of most fibre gratings. However it is time-consuming. Another often preferred approach for calculating the reflection and transmission spectra of a grating is the piece wise uniform approach, which takes the grating to be composed of a number of uniform pieces. Each section of the grating is identified by a 2×2 matrix. Then all the matrices can be multiplied together to obtain a single 2×2 matrix that describes the whole grating. For SSFBGs, the number of sections needed for the piecewise-uniform calculation is simply determined by the number of actual uniform sections in the grating. Figure 1 illustrates the DS-OCDMA encoder/decoder functions using SSFBGs. When the grating reflectivity strength is within the low reflectivity limit, the optical signal is able to penetrate the full grating.

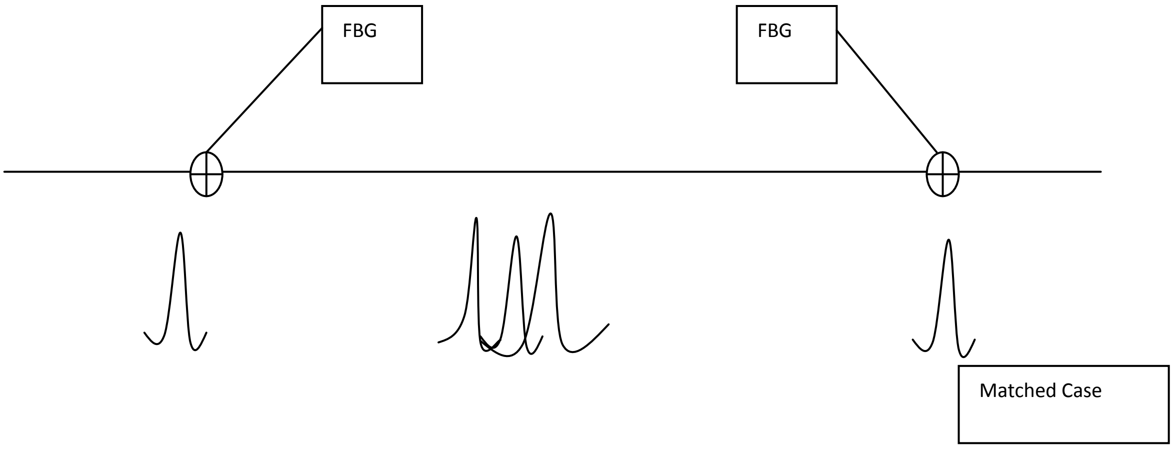

Figure1: SSFBG Based encoding- decoding process

3. RESULTS

The system model is shown in appendix. In the above layout, we have simulated a 3-user fiber bragg grating (FBG) based OCDMA network at 200 Mbit/s. Uniform FBGs are used to impelement the codes by spectral amplitude encoding. The signal is generated using an incoherent source modulated with NRZ PRBS data using a Mach-Zehnder Modulator. The optical link is 10 km of single mode fiber. The receiver is comprised of a spectral filter and a photo detector connected in a balanced configuration which performs the decoding with a low-pass filter and a BER analyzer. In this experiment User 1 and 2 are ON and User 3 is OFF. Figure 2 below shows the data pulse which are to be transmitted ahead. This is modulated with continuous wave laser source. Figure 3(a) and 3(b) demonstrate the spectra of the encoded data for User 1 and 2.

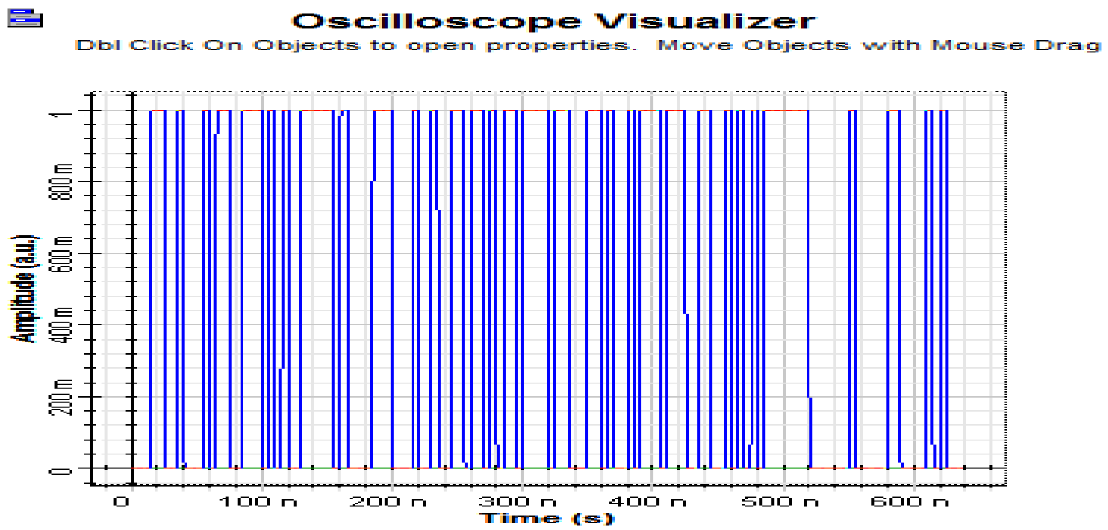

Figure 2: Input Data to be transmitted

Below shown figure 4(a) (b) and 5 shows the eye diagram of received signal in time domain and BER graph for user 1 and 2 respectively. In my work I have kept user 3 off uptill now. Later on we will check the affect of including user 3 in transmission and verify the effect on received signal.

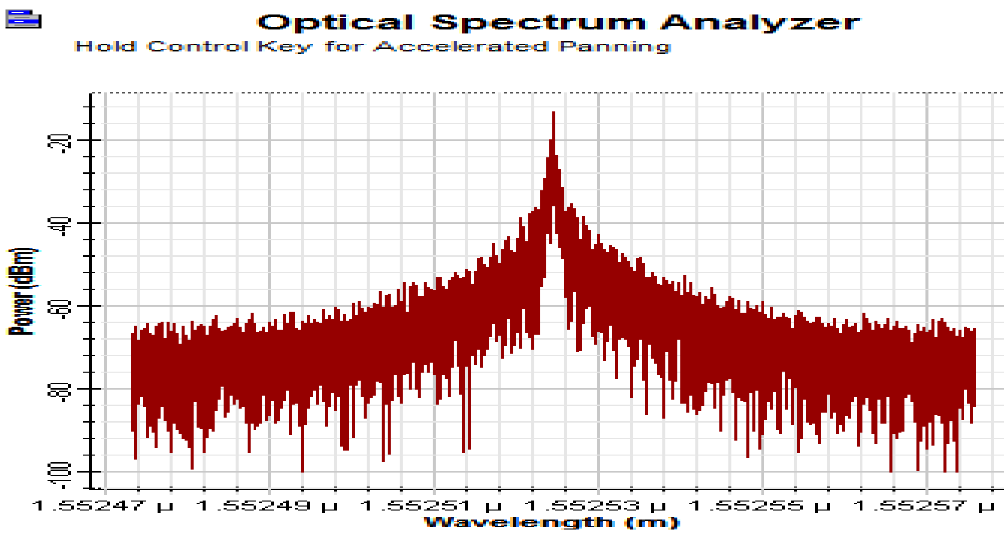

Figure 3(a): Power Spectrum of encoded data of user 1

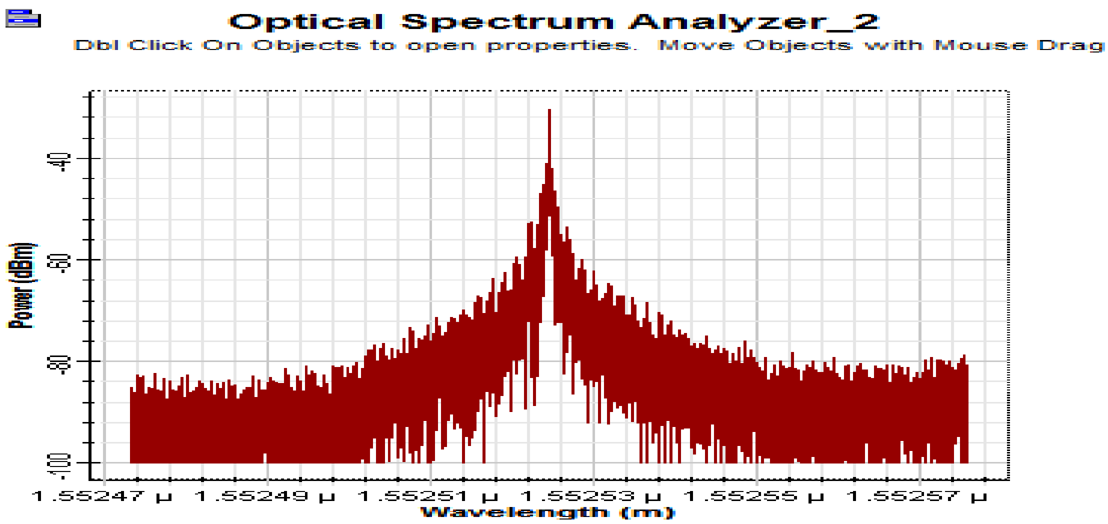

Figure 3(b): Power Spectrum of encoded data of user 2

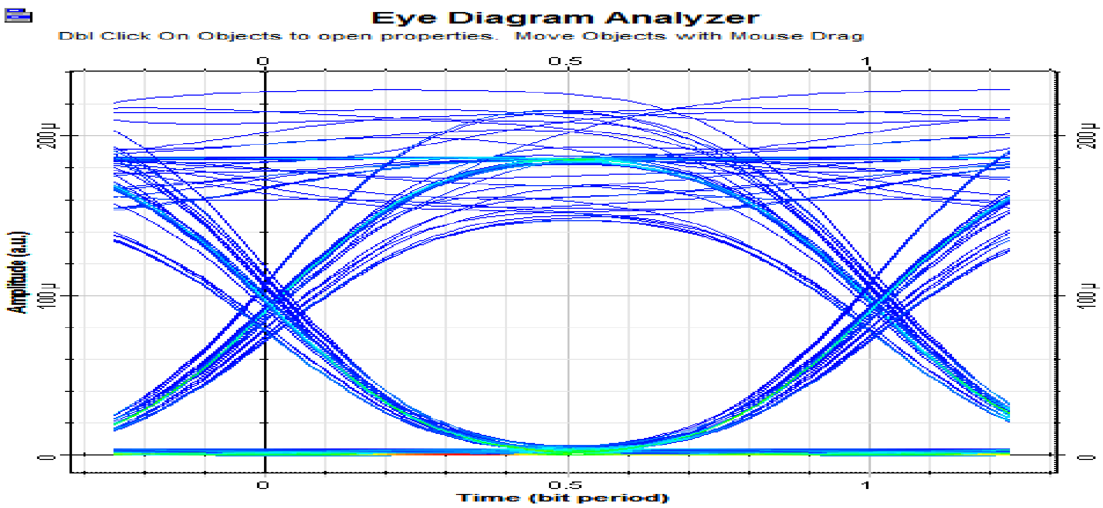

Figure 4(a): Eye diagram of received signal of user 1

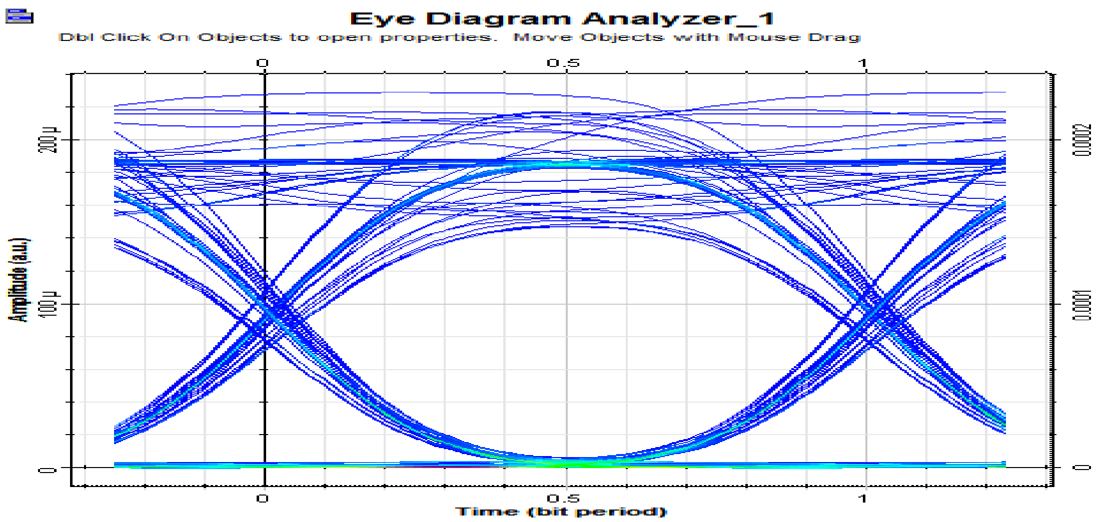

Figure 4(b): Eye diagram of received signal of user 2

To compare the bit error rate and eye diagram a comparative table is prepared as shown in table 1.

Table1: Comparative parameters value for user 1 and user 2

	User 1	**User 2**
Max Q factor	9.05215	9.03629
Min BER	4.4656e-020	5.15501e-020
Eye Height	0.000120525	0.000120624
Threshold	1.63345e-005	1.62399e-005

Above table clearly depicts the similarity in both users. The difference in bit error rate of both users is 0.68491e-020. That shows that even by using fibre bragg grating OCDMA signal received for 2 users is same as transferred.

If one more user is also added in OCDMA transmission then comparative table for all these three users is shown in table 2. Table 2 shown in appendix, shows for user 3 received signals is not good as compared for user 1 and 2. Bit error rate is high in comparison to user 1 and 2, but still its upto acceptable level as in communication BER should be in range of 10^{-6}. To show the better effect of FBG on OCDMA a comparative table is constructed which compares the parameters of all three users for FBG in system and FBG not in system. It proves bit error rate without FBG is increased. So by application of FBG at receiver and transmitting end with same refractive index BER is reduced. This BER in OCDMA also depends upon the length of optical fibre cable. To prove this point a table is constructed by recording different values of BER for different length of optical fibre cable.

Table 2: BER for different optical fibre length

	Length of Optical Fibre (km)	BER with FBG	
1	10	4.4656e-20	0.00023013
2	20	5.05958e-20	0.000766438
3	30	6.89428e-20	0.00235985
4	40	1.25919e-19	0.00496315
5	50	3.01409e-19	0.0122292
6	60	1.1457e-17	0.0161514
7	70	1.4003417e-17	8.75164e-005

A graph in MATALB is constructed separately for fibre length vs BER with FBG and another is comparative graph between BER with FBG and without FBG vs fibre length. Figure 5(a) tells as length of OFC increases, BER with FBG also increases, but 5(b) depicts something else. It tells that in case of without FBG BER is very high than with FBG. For without FBG BER first increase but decreases sharply after 60 km. Graph for BER with FBG in figure 5(b) is lied with Y axis because of large range of BER values on x axis.

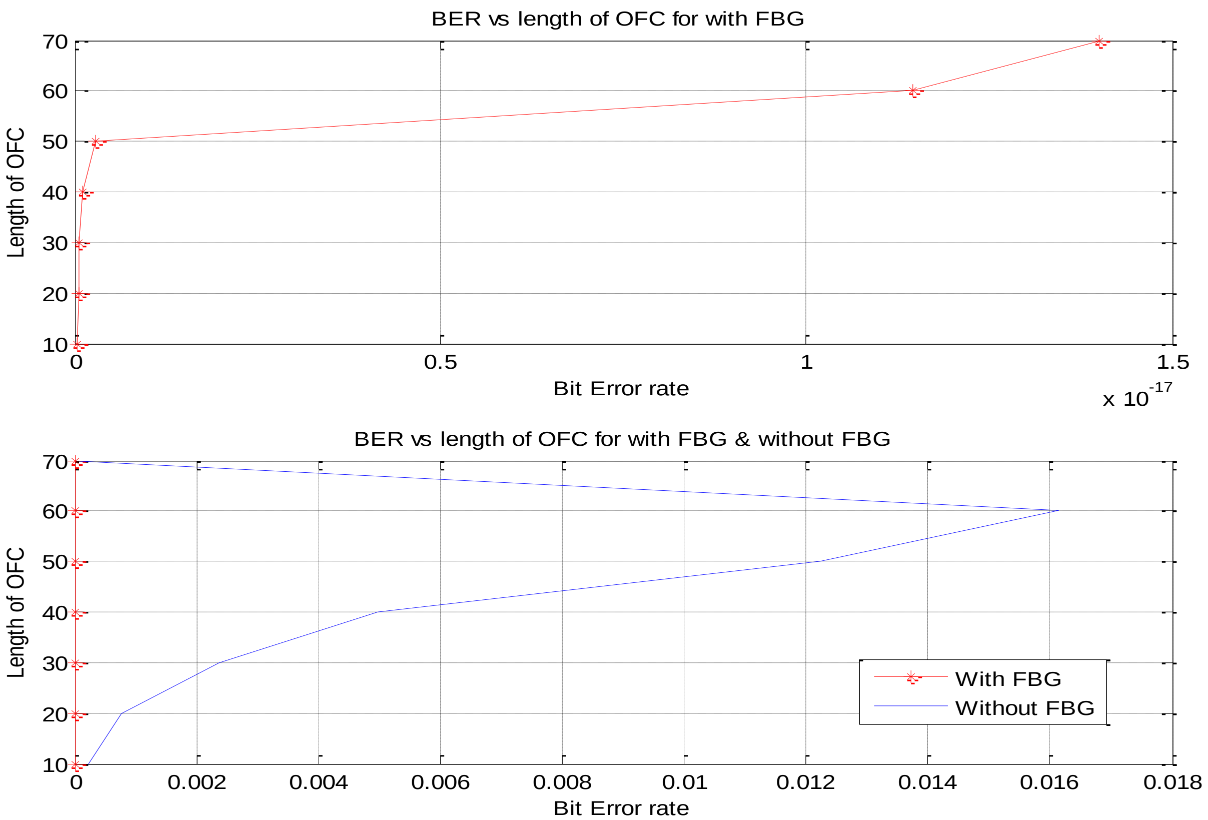

Figure 5: BER vs OFC length for without FBG and with FBG

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APPENDIX

A. Table

Table 3: Comparative parameters value for user 1, user 2 and user 3

	User 1	**User 2**	**User 3**
Max Q factor	9.05215	9.03629	1.50696
Min BER	4.4656e-020	5.15501e-020	0.0535008
Eye Height	0.000120525	0.000120624	-0.000268437
Threshold	1.63345e-005	1.62399e-005	3.3924e-005

Table 4: Comparative parameters value for user 1, user 2, and user 3 for FBG and without FBG

	User 1		**User 2**		**User 3**	
	With FBG	Without FBG	With FBG	Without FBG	With FBG	Without FBG
Max Q factor	9.05215	3.43767	9.03629	3.39789	1.50696	3.340131
Min BER	4.4656e-20	0.00023013	5.15501e-020	0.00026502	0.0535008	0.000260593
Eye Height	0.000120525	2.95579e-005	0.000120624	2.7119e-005	-0.000268437	2.74294e-005
Threshold	1.63345e-005	6.58039e-005	1.62399e-005	6.53233e-005	3.3924e-005	6.44814e-005

System Mode