Jaswant singh, Jagtar singh / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 4, July-August 2012, pp.604-607

Dispersion Compensation in OCDMA system using DCF and Fiber Grating

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Abstract—
OCDMA is a technique by which large number of users can access the network simultaneously i.e. at the same time. As the number of user increases, the dispersion and interference begin to rise, which led to high bit error rate and low quality of service of the system. Due to high bit error rate, the transmission of data becomes unsecure and error prone. Therefore to remove or minimize the dispersion in 8 user OCDMA system with single mode fiber, DCF (Dispersion Compensation Fiber) and Fiber Grating technique is used along with the single mode fiber. In this paper, it is shown that with the use of DCF, dispersion is compensated to a large extent in 8 user OCDMA system. The comparison of DCF is made with Fiber Grating according to the results obtained, DCF is found to be better compensator as compared to Fiber Grating.

Index Terms--- Bit Error Rate; Optical Code Division Multiple Access; Multiple Access Interference; Quality of Service

I. INTRODUCTION

In recent years, with the rapid growth of internet business needs, people urgently need more capacity and network systems. So the demand for transmission capacity and bandwidth are becoming more and more challenging to the carriers and service suppliers. Under the situation, with its huge bandwidth and excellent transmission performance, optical fiber is becoming the most favorable delivering media and laying more and more important role in information industry. The optimal design and application of optical fiber are very important to the transmission quality of optical fiber transmission system. Therefore, it is very necessary to investigate the transmission characteristics of optical fiber. And the main goal of communication systems is to increase the transmission distance. Loss and dispersion are the major factors that affect fiber-optical communication being the high-capacity develops[1].

The major strengths in this type of communication being the security, capacity (number of users in the channel), data rate and the efficiency in overall performance which makes it one of the strongest and widest and used form of communication even in broadband applications. In the past times the optical fiber has been used for point to point communication.

As we know optical fiber offers high speed as compared to electronic signal processing at both ends of the fiber, So to be able to take the full advantage of the speed in optical fibers one of the basics concepts in fiber optic communication is the idea of allowing several users to transmit data simultaneously over the communication channel. This method is called multiple access. There are several techniques to provide multiple access and one of them is fiber optic-code division multiple access (FO-CDMA). In this each user is assigned one or more binary signature sequence, so called code words. The data to be send is mapped onto the code words and the different users code words are mixed together and send over the channel. At the receiver end a decoder, which is individual for each user, compares the incoming sequence with stored copies of the code words to be able to extract the information bits [2].
Interest in optical code division multiple access (OCDMA) has been steadily growing during recent decades. That trend is accelerating due to fiber penetration in the first mile and the establishment of passive optical network (PON) technology as a pragmatic solution for residential access. In OCDMA, an optical code (OC) represents a user address and signs each transmitted data bit. We define optical coding as the process by which a code is inscribed into, and extracted from, an optical signal. Although a prerequisite for OCDMA, optical coding boasts a wide range of novel and promising applications [3].

Fiber optic communications technology has not only already changed the landscape of telecommunications. Because of the telecommunication appetite for capacity, the bandwidth of commercial systems has increased more than a hundred fold. The potential information carrying capacity of a single fiber optic channel is estimated at 50 terabits a second (Tbit/s) but, from a practical point of view, commercial links have transmitted far fewer than 100 Gbps, an astounding amount of data that cannot be achieved with any other transmission medium.

Two recent major technological advances i.e. wavelength division multiplexing (WDM) and Erbium

Doped Fiber Amplifier (EDFA) have boosted the capacity of existing systems and have brought about dramatic improvements in the capacity of systems, now in development. In fact, WDM is fast becoming the technology of choice in achieving smooth, manageable capacity expansion. But, OCDMA combines the large bandwidth of the fiber medium with the flexibility of the CDMA technique to achieve high speed connectivity [3]. Therefore, the fiber optic communications is growing at a fast rate and to make a secure and error free transmission, dispersion has to be reduced and the interference has to be minimized.

To make this possible DCF (Dispersion Compensation Fiber) and Fiber Grating are used in the 8 user OCDMA system and both are compared, out of which DCF comes to be better, as the BER is less and Q factor is high in the case of DCF.

II. OCDMA

OCDMA is a highly flexible technique to achieve high-speed connectivity with large bandwidth. Data access security and ability to support asynchronous, bursty data transmission are two of the main driving forces behind a lot of interest in the OCDMA techniques. O-CDMA is one of the multiple access technique to allow several users to transmit simultaneously over the same optical fiber. Optical CDMA has the advantage of using optical processing to perform certain network applications, like addressing and routing without resorting to complicated multiplexers or demultiplexers. The asynchronous data transmission can simplify network management and control. Therefore, OCDMA is an attractive candidate for LAN application and recent advances in wavelength division multiplexing (WDM) and time division multiplexing (TDM) technologies [4].

A. Conceptual and Block diagram of OCDMA

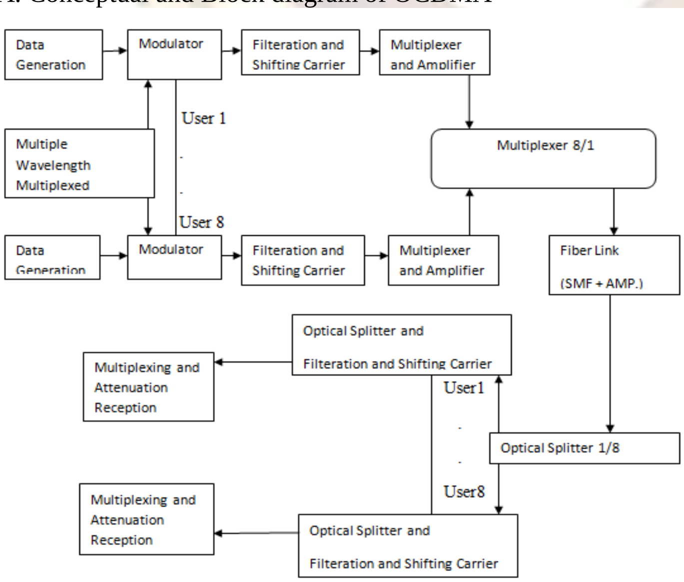

Fig1 OCDMA conceptual diagram

An OCDMA system for each user can be described by a data source, containing the data that will be sent, followed by an encoder and then a laser that maps the signal from electrical form to an optical pulse sequence. At the receiver end, an optical correlator is used to extract the encoded data. A large number of subscribers transmit data simultaneously. Each user has its own codeword, which is approximately orthogonal to all other code words. The encoded data is send to the N*1 star coupler, from where the optical channel carries the signal through the optical fiber and couples to a 1*N coupler and broadcast to all nodes. All users' encoded data are then added together chip by chip and the result is called the superposition and after that the data are sent over the channel [5].

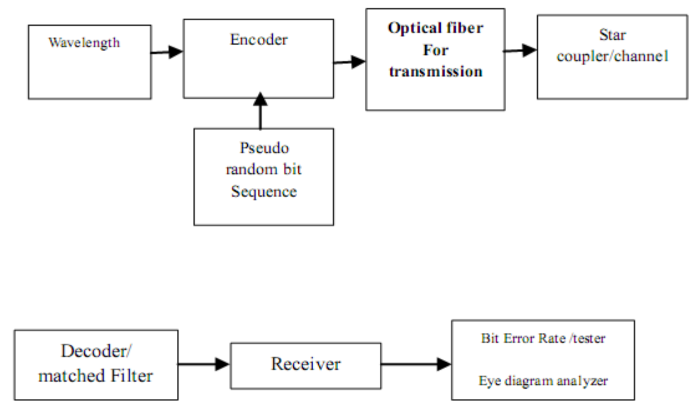

Fig 2 Block Diagram of OCDMA

B. Features of OCDMA

- OCDMA has the feature of having applications in optical communication as well as radio communication.
- The optical systems use unipolar codes, thus can be used in asynchronous environments. On the other hand the radio communications systems use bipolar codes and thus cannot be used in asynchronous environments.
- In OCDMA each user is allotted its own code sequence.
- OCDMA is a spread- spectrum technique employed in mobile telecommunication that allows a number of users to share the same broadband of transmission.
- OCDMA has Lower latency.
- The asynchronous data transmission can simplify network management and control
- Flexible network design

III. SIMULATION MODEL AND RESULTS

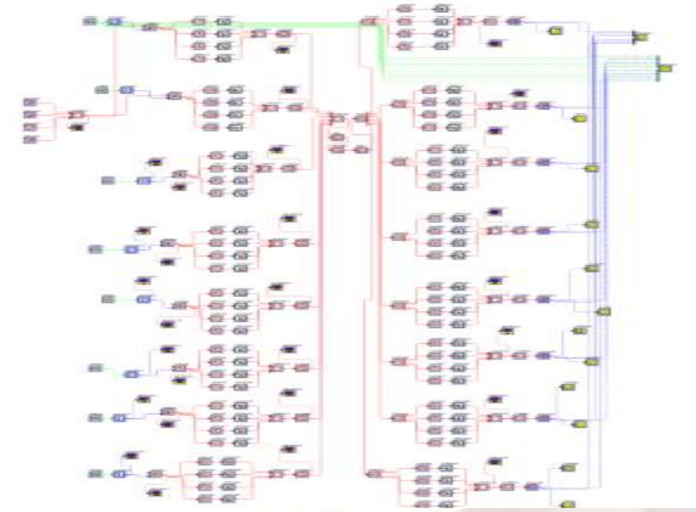

Fig 3 Simulation circuit

In the circuit diagram shown above the output of four laser sources is fed into the combiner (multiplexer) to form a dense WDM multi-frequency light source. The output of the multiplexer is fed into the input of modulator. Another input to the modulator is the data signal from PRBS generator. This generator generates the logical signal and this logical signal is converted into the electrical signal by the NRZ driver as shown in the diagram. So this electrical signal is then fed into the electrical input if the modulator. The modulator modulates the light according to the input electrical data. The next block in the circuit is the encoder, used for encoding the data. After the data is encoded the Amplifier model is used to boost the signal intensity due to long distance single mode fiber. Then the single mode fiber of length 100 km is placed.

Now after the data has been through this fiber, it comes the receiver for receiving the data. The receiver consists of the decoder which performs the reverse of the encoder. The decoder performs the function of converting the optical signal into electrical. To see the results and other important parameters eye diagram analyzer is used to visualize the eye diagrams, bit error rate tester is used to measure the bit error rate of the received signal after decoding. Spectrum analyzer is used to take the spectrum of signals at the beginning and at the end of transmission.

The above circuit shown in the figure 3 is simulated in the following three cases with simulating tool RSOFT OPTSIM v 5.2.

a). First with only Single Mode Fiber Including Dispersion.
b). With DCF for dispersion compensation
c). With Fiber Grating for dispersion compensation.

A. Results for Single Mode Fiber

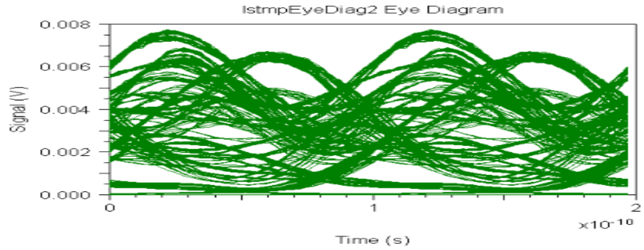

Fig 4 Eye Diagram with SMF having dispersion.

S.No.	BIT ERROR RATE	VALUE	MAI(Multiple Access Interference)
1	NORMAL	8.5828e-009	Very High
2	LOW	1.9011e-009	Very High
3	HIGH	3.6387e-008	Very High

Table 1 BER values for SMF

S.No.	QUALITY FACTOR	VALUE	MAI(Multiple Access Interference)
1	NORMAL	5.6384e+000	Very High
2	LOW	5.3842e+000	Very High
3	HIGH	5.8926e+000	Very High

Table 2 Q Factor values for SMF

As it can be seen from the fig.4 and table 1 shown above that the eye diagram is not open i.e. dispersion and interference is present and the BER is not within acceptable limits. The Q factor values for SMF are even not in the acceptable limits as shown in table 2. So in order to remove the dispersion DCF (Dispersion Compensation Fiber) is inserted and is compared with results when Fiber Grating is inserted.

B. Results for DCF and Fiber Grating

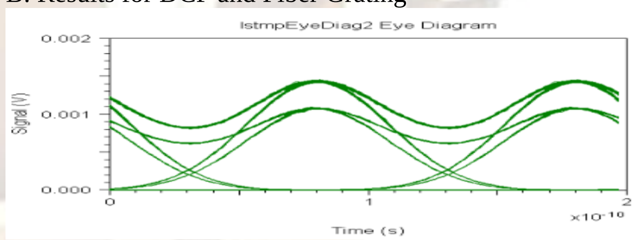

Fig 5 Eye Diagram of DCF with less Dispersion

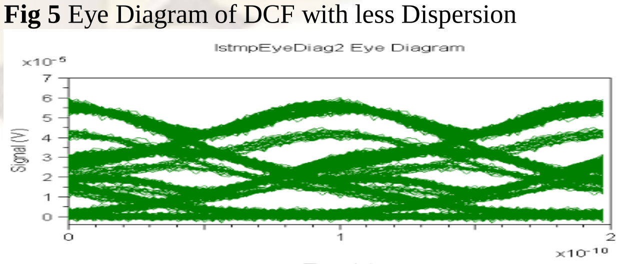

Fig 6 Eye Diagram of Fiber Grating

As it can seen from the above figure that the eye diagram in the case of DCF is more open and sharp, whereas the eye diagram in the case Fiber Grating is very less open.

As from the above point it is clear that insertion of Fiber Grating in the system is not reducing the dispersion as required, but the insertion of DCF has reduced the dispersion to a large extent and the system is efficient and secure for a fast transmission. Therefore by analyzing the eye diagram graphs, it can be said that DCF is better compensator of dispersion as compared to Fiber Grating.

S.No.	BIT ERROR RATE	VALUE	MAI(Multiple Access Interference)
1	NORMAL	0.0000e+000	Very Less
2	LOW	0.0000e+000	Very Less
3	HIGH	0.0000e+000	Very Less

Table 3 BER values for DCF

S.No.	BIR ERROR RATE	VALUE	MAI(Multiple Access Interference)
1	NORMAL	7.0000e-010	High(less than SMF)
2	LOW	1.2379e-010	High(less than SMF)
3	HIGH	3.6804e-009	High(less than SMF)

Table 4 BER values for Fiber Grating

As it can be seen from the table shown that the BER value for DCF is nearly zero and BER value for Fiber Grating is $7*10^{-10}$, which is not acceptable. Therefore the again on the basis of value of BER, DCF has proved to be better compensator of dispersion than Fiber Grating.

S.No.	QUALITY FACTOR	VALUE	MAI(Multiple Access Interference)
1	NORMAL	3.9309e+001	Very Less
2	LOW	3.7537e+001	Very Less
3	HIGH	4.1081e+001	Very Less

Table 5 Q factor values for DCF

S.No.	QUALITY FACTOR	VALUE	MAI(Multiple Access Interference)
1	NORMAL	6.0555e+000	High(less than SMF)
2	LOW	5.7825e+000	High(less than SMF)
3	HIGH	6.3285e+000	High(less than SMF)

Table 6 Q factor values for Fiber Grating

From the table shown, it is clear that Q factor value for DCF is 39 db, where as the Q factor value for Fiber Grating is 6 db, so it can be said that Q value is more for DCF i.e. less interference and dispersion. Therefore again on the basis of Q factor value, DCF has proved to be better compensator of dispersion than Fiber Grating.

IV. CONCLUSION

In this paper the two techniques have been compared on the basis of various parameters, which are the analyzers of the communication system. These include eye diagram analyzer. BER tester and Quality factor values. On the basis of these parameters, in all the cases DCF has proven to be the best compensator for dispersion and interference and other causes such a noise etc as compared to Fiber Grating.

Although when the Fiber Grating is used along with the single mode fiber, it has compensated the dispersion to a small extent, but not in comparison to DCF. So we conclude that on the basis of results obtained by simulating the 8 user OCDMA circuit in OPTSIM v 5.2 (Simulating Environment) DCF has proved to be superior than Fiber Grating.

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