# Performance Analysis of Optical CDMA using Fuzzy Logic Generator

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***Abstract.*Multiple accesses which uses the spread spectrum technology for transmission has become very popular in cellular radio networks. In this thesis, a highly spectral-efficient transmission technique based on optical code division multiplexing (OCDM) is investigated. Optical transmission systems have to meet the rapid increase in the demand of data bandwidth and spectral efficiency. OCDM provides asynchronous transmission, secure communication, soft capacity on demand, and high degree of scalability. In this paper, we have applied OCDM technique along with fuzzy logic generator which gives us improvement .Fuzzy Logic generator accepts $V_{\pi}$ and $R_{on}/R_{off}$ and generates I/I0 in a non linear fashion.**

***Keywords*: CDMA (Code Division Multiple Access), OCDM (Optical Code Division Multiplexing), MAI Multiple Access Interference, BER (Bite Error Rate)**

## 1. Introduction

Optical CDMA is a technique in which user uses a specific unique code rather a specific wavelength or a time slot. Optical CDMA uses the spread spectrum technique of CDMA combined with the optical link for transmission of data. The key advantage of Optical CDMA is the multiple access technique which allows many users to share the same optical link simultaneously. This is done by giving each user a specific code which can be decoded only by the required user. OCDMA has many unique features that make it favourable data transmissions. Its characteristics make it suitable to increase the capacity and number of users in bursty networks. OCDMA can accommodate a large no. of channels on a single carrier frequency. It can utilize the bandwidth effectively through coding system. OCDMA systems provide high degree of scalability and security. Optical CDMA had the potential to generate some of the previously unused bandwidth ofthe optical fiber and to carry over to the optical domain the benefits of CDMA in radiofrequency systems. The Optical CDMA systems suffer fromthe problem of Multiple Access Interference(MAI). There is a limitation of speed also in optical CDMA systems-since very shortpulses are to be required within each bit time, therefore it limits the bit rate for a finitepulse width transmitter. There is also a problem of high optical splitting atencoder/decoder. Now as the complexity of the system increases it becomes difficult and eventuallyimpossible to make precise statments about its behaviour. At such a point of problem weuse fuzzy logic. Parametric selection of Mach Zehnder modulator of the OCDMA systemhas been done in non-linear manner using Fuzzy logic generator accepts Vπ and $R_{on}/R_{off}$as its inputs and generates I/I0 as its output. Performance comparison has been done forOCDMA system for both the cases viz. without and with fuzzy logic generator,Simulation and testing has been carried out using various test inputs and finally it hasbeen shown that fuzzy logic based OCDMA system shows significant performimprovements

## 2. Methodology

Mach Zehnder modulator has been configured by Fuzzy Logic Generator. It is shown in figure below:

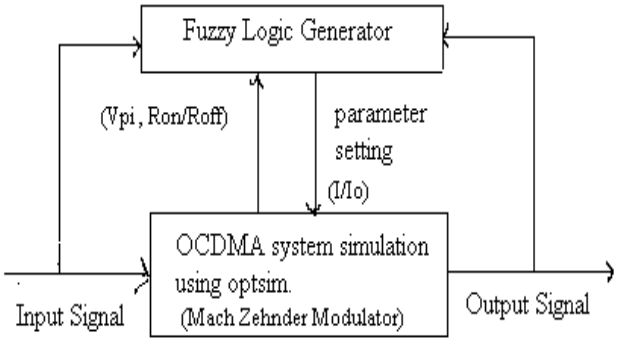


Figure 1: Optical CDMA System augmented with Fuzzy Logic Generator

For the Mach-Zehnder type modulator, the following intensity response function is used:

$$\frac{I_o}{I_i} = \begin{cases} \sin^2\left[\frac{\pi}{2}\left(\frac{V_{signal}+V_{bias}-V_{offset}}{V_{\pi}}\right)\right] & \frac{I_o}{I_i} \geq \frac{1}{R_{on/off}} \\ \frac{1}{R_{on/off}} & \frac{I_o}{I_i} < \frac{1}{R_{on/off}} \end{cases}$$

where *Ron/off* is the extinction ratio of the modulator in linear units (to be input by useras parameter on/OffRatio in dB units) and $V_{signal}$represents the electrical signal afterbeing modified by the parasitic frequency response and optionally being level-shiftedsuch that the average level is zero, modelling the behaviour of the bias circuitry. The sinefunction is used instead of the cosine function in the Mach-Zehnder modulator so that themodulated signal will have the same polarity as the original binary sequence. This isimportant for increased numerical accuracy in simulation. To deactivate the extinctionratio modification to the signal, set the extinction ratio parameter to 0.

## 3. Simulation and Testing:

Optsim simulation has been done for OCDMA system for both the cases viz.withoutFuzzy Logic Generator and with Fuzzy Logic generator.

No. of user(s): 2.

**Case I: Testing without Fuzzy Logic generator**

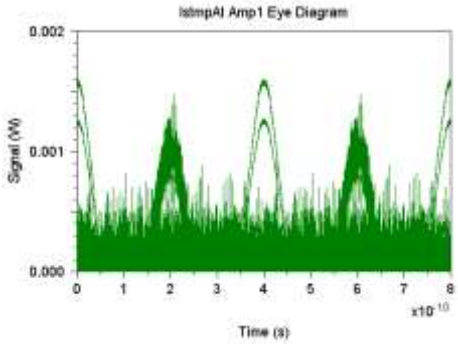


Fig.2:Eye diagram without Fuzzy controller after encoder

The above diagram shows the Eye diagram without Fuzzy controller taken after the firstencoder.

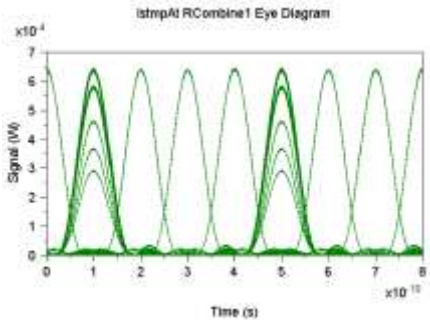


Fig.3:Eye Diagram without Fuzzy Controller after combiner

The above diagram shows Eye diagram without Fuzzy controller taken after the combiner

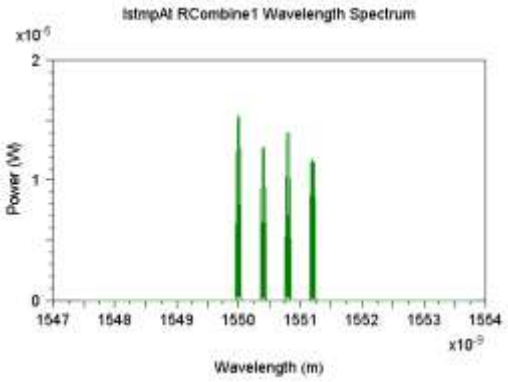


Figure 4: Wavelength spectrum without fuzzy controller

The above diagram shows the Wavelength Spectrum diagram without Fuzzy controllertaken after the combiner.

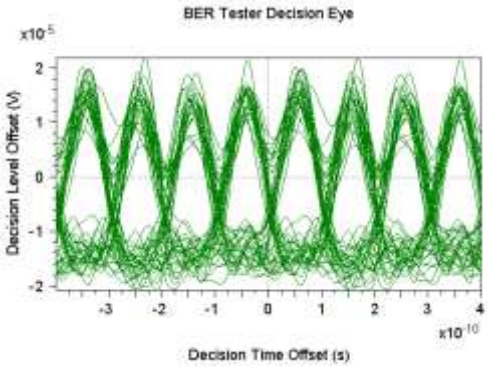


Figure 5: BER tester decision eye diagram without Fuzzy Controller

The above diagram shows the BER Tester Decision Eye Diagram without Fuzzy Controller take at the receiver.

**Case II: Testing with Fuzzy Logic generator**

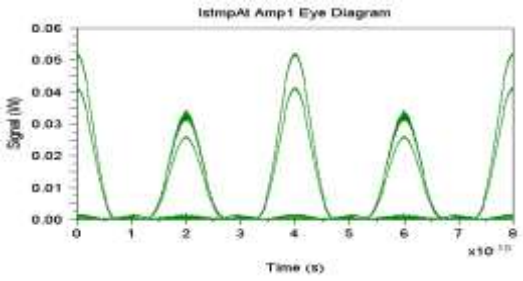


Figure 6:Eye diagram with Fuzzy Controller after encoder

The above diagram shows the Eye diagram with Fuzzy controller taken after the firstencoder

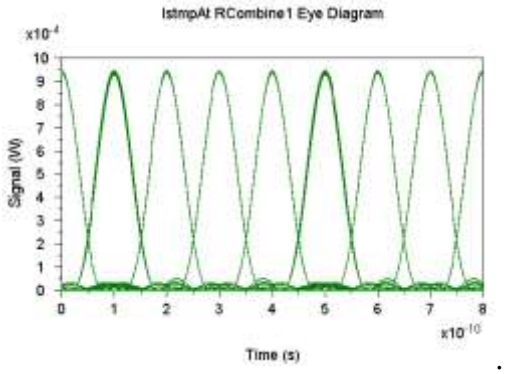


Figure 7: Eye Diagram with Fuzzy Controller after combiner

The above diagram shows Eye diagram with Fuzzy controller taken after thecombiner.

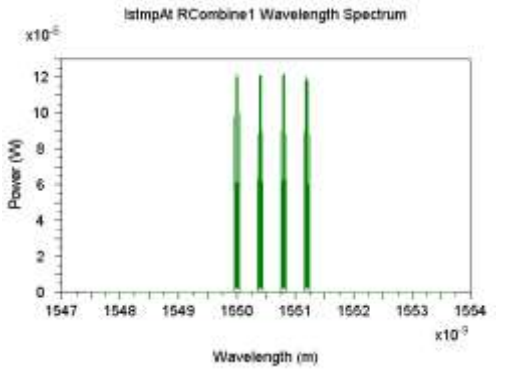


Figure 8: Wavelength spectrum with fuzzy controller

The above diagram shows the Wavelength Spectrum diagram with Fuzzy controller taken after the combiner.

## 4. Results

A highly spectral-efficient transmission technique based on optical code-division multiplexing (OCDM) is investigated in this work.It has been demonstrated that properly designed fiber optical CDMA using Fuzzy Logic Generator is more robust to the effect of non-linearity in terms of bit-error –rate performance. We have demonstrated that OCDMA system using Fuzzy Logic Generator has improved the performance of the system by means of various graphs and diagrams such as Wavelength spectrums, Eye diagrams and BER Tester Eye Decision diagrams. Two cases have been considered ,without fuzzy and with fuzzy.First the cases have been considered for the no. of users equal to 1 and then for the no. of users equal to two.(Although here we have mentioned only cases for users equal to 2) Fuzzy Logic generator accepts $V_\pi$ and $R_{on}/R_{off}$ and generates I/I0 in a non linear fashion. Such fuzzy logic augmented OCDM has shown better performance which is quite evident from various diagrams of BER Tester Decision Eye diagrams and Eye Diagrams.

## 5. Conclusion and Future Scope

We have experimentally demonstrated a highly spectral efficient OCDM system using Fuzzy Logic generator. This system results in a considerable performance improvement as compared to the conventional systems. The proposed system offers a larger flexibility and bandwidth for transmission.The OCDMA technology is well suited to increase the capacity and the number of users of bursty networks. Its performance can be further enhanced by using the Fuzzy Logic generator as proposed in this work.A multitude of different application spaces can be benefitted from this system, such as passive optical networks (PON),local and metro area networks, free space optics, and interconnect for computing.

## 6. References

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