



Novel Detection Technique for SAC-OCDMA using Modified AND and SPD Detection Schemes

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Abstract—Optical Technology is on a speedy track to make the most of available fiber bandwidth and efficient transmission capabilities. To avail the broad spectrum capabilities with lesser noise and faster communication techniques in optical field developed techniques would be required to increase the communication and tackle transmission irregularities. In this paper we are presenting a modified detection scheme as for SAC- OCDMA (spectral amplitude coding optical code division multiplexing access) systems. This technique reduces MAI (multiple access interference), PIIN (phase induced intensity noise) effects, with use of single photo diode which reduces shot noise as compared to other conventional technique. We simulated the proposed detection scheme on OptiSystem 13.0 software. In the simulated setting near industrial effects of noise, nonlinearity attenuation and fiber dispersion were activated. The MDW (Modified double weight) codes were used for simulation. The results reveal that new modified SPD (single photo diode) detection scheme provides significant improvement as compared to other detection techniques especially modified AND and SPD technique.

Keywords— FBG, MAI, PIIN, SAC-OCDMA, SPD.

I. INTRODUCTION

Over the last decade OCDMA had been region of interest for optical engineers. Especially SAC-OCDMA had attracted the optical engineer's community a lot. Optimum utilization of available bandwidth of fiber with multiple users and asynchronous transmission without any centralized network control had pushed SAC -OCDMA on to high note on preference for research. SAC- OCDMA (spectral amplitude coding optical code division multiple access) is an incoherent type of OCDMA technology. In coherent OCDMA employs broad band sources such as LED, ASE (amplified spontaneous emission) etc [1,2]. These sources make the systems cost effective although performance of this light sources are as effective as coherent sources, and incoherent sources make receiver designs simpler as asynchronous communication is supported. SAC-OCDMA mitigates MAI (multiple access interference) when codes of unity cross correlation are used as signature sequences [3,4]. As MAI is the main degradation cause in the SAC- OCDMA system. A broad band source spectrum is fragmented into spectral slices of fixed width and these spectral chips are modulated as either on or off depending upon user code. Every user code is distinguished from other code. Orthogonality is maintained in code designs. Different codes are available with specific properties but codes with unity cross correlation are suggested for SAC- OCDMA systems. Codes differ from each other on basis of weight w , in phase cross correlation λ_c , length of codes N etc.

MDW(modified double weight) codes proved to be suitable for SAC-OCDMA scheme as these codes are having unity cross correlation properties. MDW code is advanced version of double weight code. In this code weight of the code can be a number multiple of 2 or greater than 2[5]. The length of code for weight of 4 is given by in eqn.(1)

$$L = 3K + \frac{8}{3} \left[\sin \left(\frac{K\pi}{3} \right) \right]^2 \quad (1).$$

Here L is length of code and K represents number of users. SAC-OCDMA is a suitable scheme for fiber LAN application as it is very result oriented scheme for FTTH.

II. SPD DETECTION SCHEME

As the name depicts this scheme uses a single photo diode for conversion of optical signals into electrical signals. Fiber Bragg gratings are used for decoders. The decoder section is divided into two parts one is decoder other one is subtractive decoder. Two FBG(fiber bragg gratings) in the decoder section are having identical spectrum to the intended encoder. Received signal is passed through decoder where the intended spectrum is filtered out and the rest interferer's spectrum is passed to subtractive decoder. The output of two FBG of decoder section is added, and the signal from subtractive decoder is subtracted from the output of decoder. After optical subtraction only intended encoder signal are left[7]. As a result of optical subtraction interference signals are cancelled in the optical domain only, mitigating the effect of both PIIN and MAI in the optical domain. SAC- OCDMA with fixed in phase cross correlation codes can also be implemented with this SPD detection technique. Theoretically it is assumed to be two interferer's signal to be equal and are cancelled at optical subtractor due to this only the single photo diode can be used [7]. At the receiver due to use of single photo diode the amount of optical to electrical conversion is reduced thus the shot noise generated at the receiver also reduces consequently thus more efficient receiver structure is SPD detector. Detection of desired signal by photo diode is

followed by low pass Bessel filter of fourth order to eliminate high frequency noise [8]. The schematic diagram of the SPD technique is given in figure 1.

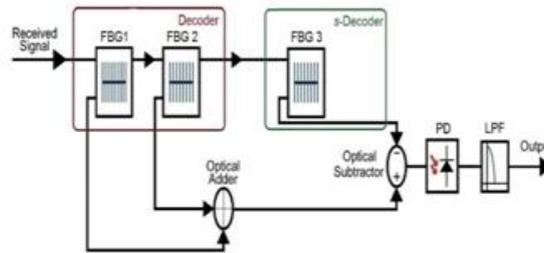


Fig.1: Single Photo diode detection technique

III. MODIFIED AND DETECTION SCHEME

Advanced version of AND detection technique is modified AND detection, incoming signal is divided into two sections with the help of an optical splitter. One part is again connected to an optical splitter signal which divides the optical signal and directs the signal towards decoder branches. These decoder branches are tuned as per the specific user wavelength/codes. The output of these two FBG is applied to an optical adder. The other decoder branch named as c-decoder is having a 3 dB attenuator prior to the FBG and the FBG gets overlapped bins from different interferers. The incoming optical signal is divided by half when signal other than specific user spectral response is there due to attenuator. The resultant signal is applied to two photo detectors connected in differential arrangement. Electrical subtractor subtracts the o/p of both detector signals and are applied to low pass filter. [5,6]. This technique avoid shot noise as signal is reduced to half. Modified detection technique reduces the number of FBG as compared to AND detection technique. Modified detection technique is represented as shown in figure 2.

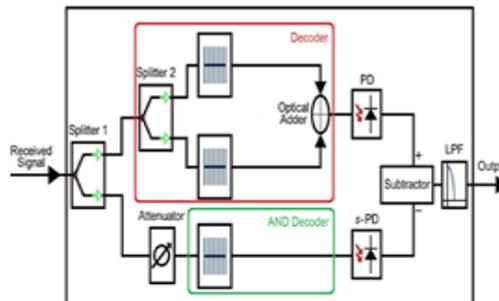


Fig. 2.: Modified AND detection technique.

IV. PROPOSED TECHNIQUE

In our proposed technique advanced version of SPD detection technique is modified SPD detection, incoming signal is divided in to two sections with the help of an optical splitter one part is again connected to a optical splitter signal which divides the optical signal and directs the signal towards decoder branches. These decoder branches are tuned as per the specific user wavelength/codes the output of these two FBG is applied to an optical adder[5] ,the other decoder branch named as c-decoder is having FBG which gets overlapped bins from different interferer's. This technique is a proposed technique where decoder of modified AND is connected with single photo diode[7]. This technique takes advantage of i/p signal power division at the receiver and reduction of shot noise by employing single photo diode, at the receiver, PIIN and MAI are eliminated by optical subtraction of interferers in optical domain only. Interferer's bins at the c decoder can be represented mathematically by AND operation. The diagrams of transmitter section and receiver sections are given in the figure 3 and 4 respectively.

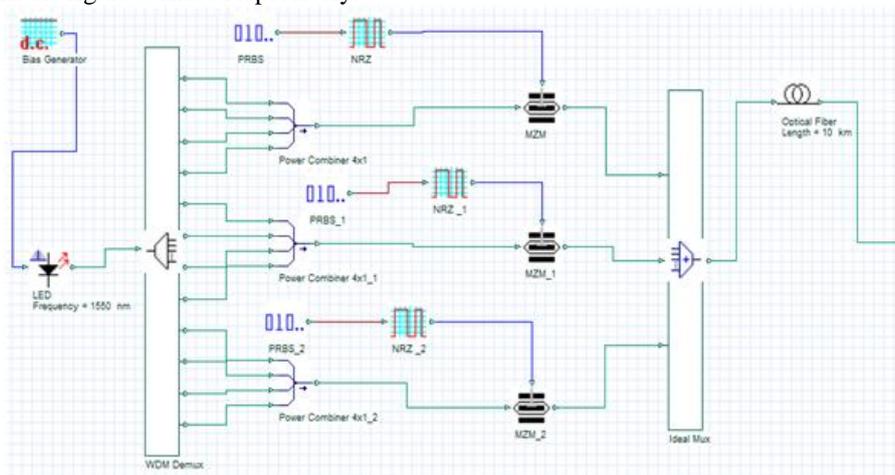


Fig.3: Design layout of transmitter section of modify SPD technique

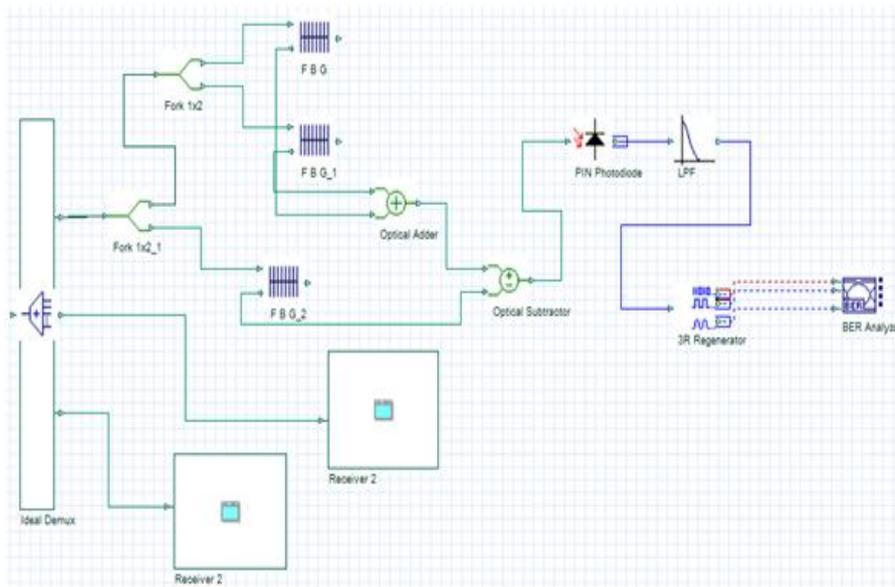


Fig. 4: Design layout of receiver section of modify SPD technique

V. SIMULATION & RESULTS

Simulation of OCDMA system was performed on Optisystem version 13 most used simulator for optical fiber simulations. The simulation were performed using incoherent broad band source LED .The spectrum of LED was sliced in to twelve wavelengths for three users using a WDM demultiplexer. Chip width was taken as 0.8nm.The ITU-TG.652 standard single mode fiber was used. Attenuation and dispersion were set at 0.25 dB/km and 18 ps/nm km respectively. Random noise was set with non correlation and non linearity effects were activated to make simulation near to real industrial environment. Value of dark current was set at 5 nA, and thermal noise coefficient was 1.8×10^{-23} W/Hz for the photo detector of PIN type. The bit rate chosen was 200 Mbps.The performance of the system is evaluated in terms of BER bit error rate. The eye patterns of three active users are shown in the figure.5,6,7.

TABLE 1: SIMULATION PARAMETERS OF RECEIVER

Parameters	Typical Value
Optical Bandwidth	3.75 THz
Electron charge	$1.60 \times 10^{-19} C$
Responsivity of photodiode	0.75
Receiver noise temperature	$300^0 K$
Receiver Load resistance.	1030 Ω

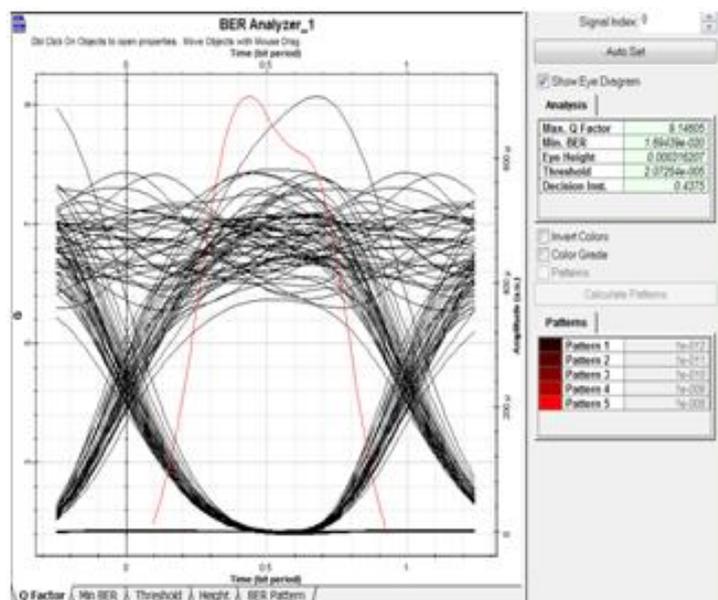


Fig. 5: Eye diagram of proposed detector technique of first user.

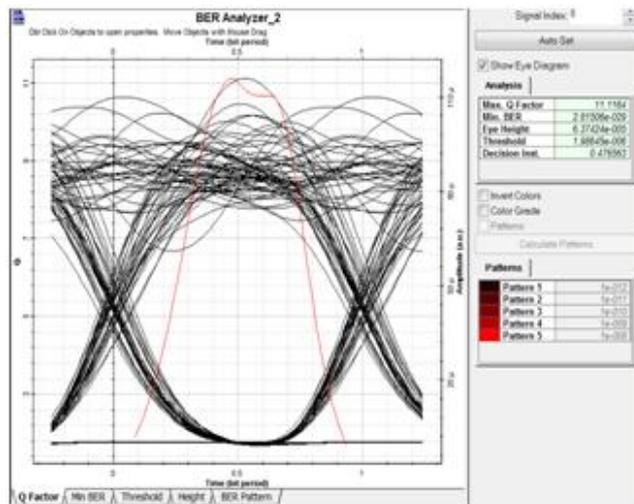


Fig. 6: Eye diagram of proposed detector technique of second user.

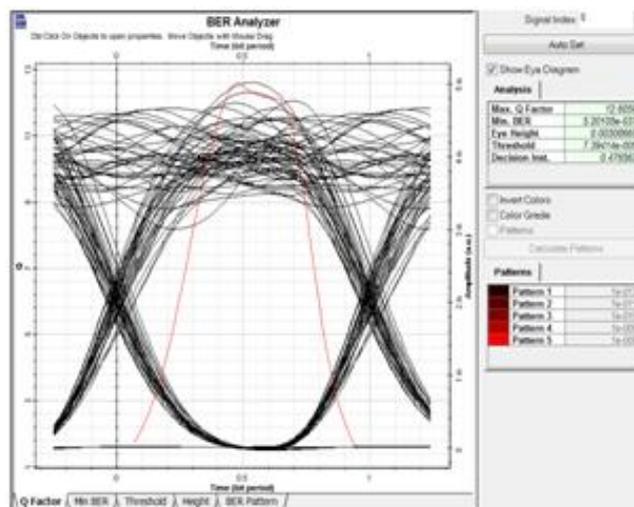


Fig. 7: Eye diagram of proposed detector technique of third user

TABLE 2 BER VALUES FOR THREE ACTIVE USERS OF DIFFERENT DETECTION SCHEMES.

	Modified AND technique BER at 200 Mbps	SPD technique BER at 200 Mbps	Modified SPD technique BER at 200 Mbps
USER 1	6.455e-027.	4.7333e-024.	5.201e-037.
USER 2	6.397e-020.	5.44729 e-30.	2.616e-029.
USER 3	4.5951e-021.	1.4686e-013.	1.694e-020.

VI. CONCLUSION

Results show that Modified SPD detection scheme is an better detection scheme, and results reveals that this scheme can be fruitful for SAC OCDMA systems. Further the scheme can be examined for different SAC OCDMA codes, and different data rates. This detection scheme can be a future candidate for detection in SAC OCDMA systems as shot noise is reduced due to single photo diode and also power is divided at the input of receiver .

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