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# Performance Measure of FSO by Modified AND Subtraction Method

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Abstract: Free space optical (FSO) communication system plays a vital role in the optical communication which employing the spectral amplitude coding optical code division multiple access (SAC OCDMA) technique in various fields of application. Multiple-Access Interference (MAI) and Phase-Induced Intensity Noise (PIIN) which are the major noises in incoherent SAC-OCDMA systems, which degrades the performance of the entire system. The technique called Modified AND subtraction which applied here to eliminate the MAI and PIIN. These Modified AND Subtraction techniques investigate the APD gain impact on the bit-error rate (BER) performance and by implementing the single photodiode technique (SPD) here. In bad weather condition the performance degradation should be reduced by giving priority to the transmission parameters and achieve the high data rate transmission with low bit-error rate. The Modified AND Subtraction-FSO communication system is compare with the FSO system employing SAC OCDMA SDD technique. The results of this study show that the performance of the proposed system is better than the system employing the SAC OCDMA-SDD technique.

**Keywords:** FSO free space optical communication, SAC OCDMA spectral amplitude coding optical code division multiple access, Modified AND subtraction, MAI multiple-access interference

#### 1. Introduction

There are many studies on free space optic (FSO) it has found many applications in the area of communications. In the fiber optical communication, fiber act as the medium between the transmitter and receiver to carry the signals but in the FSO there is no external hardware is used to link between the transmitter and the receiver where air act as the medium here. FSO is a technology that can provide high speed point to point communication. FSO communication can be used in many optical links, such as building-to-building, ship-to-ship, aircraft-to-ground and satellite-to- ground. Optical code division multiple access (OCDMA) in optical fiber communication given a support for multiple users with a reliable communication link. OCDMA has various advantageous features such as asynchronous access ability, enhanced information security, and cost efficiency multiple-access interference (MAI) decays the performance and capacity of conventional OCDMA systems, which is its major disadvantage [3]. Of all the OCDMA techniques, spectralamplitude coding (SAC) warrants close attention to its ability to restrain MAI. when using a suitable detection approach despite having major advantages, these sources are thermal in nature and so suffer from phase-induced intensity noise (PIIN) [5]. PIIN depends on the number of interfering users, and the performance cannot be enhanced by increasing the transmitted power.SPD technique is proposed for eliminating the effects of PIIN and MAI in SAC OCDMA systems through cancelling the interfering signals in the optical domain [9-11]. Simulation results showed SPD technique can not only improves the performance, but also reduces the cost of the SAC-OCDMA receiver and the generated shot noise. FSO brings lower cost, higher-bandwidth, security, flexibility and reduced time to market [12]. Due to the different weather condition the performance of the entire systems

may gets degrade because of the effect of heavy rainfall, Fog, Haze the channels of the FSO links get affected, so the performance of the entire systems get suffered. The parameters of FSO should be more sensitive to the weather condition Without making the perfect proportion of all the parameters present inside the FSO the system will not getting the better performance. so the parameters should be arranged in the correct order because the decrease or increase of the particular parameter will not affect the rest of the parameter present in the FSO link.To do all this sequence in correct sense the new method called priority based parameter optimization technique is needed. In this priority based parameter optimization technique where the parameters are arranged in descending order[14], According to the priority given to the parameters the range should be increased or decreased until to get the better result. The parameters which selected here to reduce the degradation of the performance in weather condition are Optical amplifier, Laser power, Data rate, Aperture size and link range. The new technique determines the priority in the optimization of transmission parameters to achieve high-data rate transmission with low link attenuation and bit error rate. To get the better results it was found that the transmission parameters should be optimized in descending order of priority from the optical amplifier gain.

## 2. Methodology

The block diagram for SAC OCDMA Modified AND Subtraction technique is shown in Figure 1.The data's are generated in the Pseudo Random Bit Generator (PRBS) and it is given to the optical external modulator. Optical signal which came from the CW laser and it received by the optical external modulator. Here the Mach-Zehnder Modulator is used as the optical external modulator the modulator is carried over here then it is given to the fiber bragg grating which is act as the encoder here then it is send to the FSO link then it is received by the optical amplifier which boost up the signals. The received optical signal is split by splitter into two parts one is given to the upper decoding filters FBGs and the other signal is to the AND decoder through an attenuator. The set of signals from optical splitter is given to the upper decoding FBGs and the decoding performed here then the signal is given to the subtractor .The another set of signal is given to the AND decoder then the signal is given to the same subtractor where the upper decoded signal is already entered The subtraction of the signals that the results of getting zero is concluded that the MAI has been eliminated.



Figure 1: FSO-Modified AND Subtraction System

By using the single photo diode concept both the MAI and PIIN are eliminated here and the photo diode which used here is avalanche photodiode APD. In the parameter Optimization of bad weather condition it takes five parameters like optical amplifier gain, laser power, data rate, aperture size and link range. By giving highest priority to optical amplifier gain and the laser power to increase both the parameters value. At the same time the values of rest of the parameters should be fixed like data rate and aperture size, here the BER which obtained is better to compare with other results. The transmission parameters which should be

Tuble 1. Simulation I drameters	
Parameters	Values
Laser Power	10 dBm
Bit Rate	2.5 GBits/Sec
Attenuation	8.68 dB/km
FBG Bandwidth	0.3 nm
FBG Frequency	15550.9 nm
LPF Cutoff Frequency	3125*10 <sup>5</sup> Hz
Optical Attenuator - Attenuation	5dB

Optimized in descending order of priority from the optical amplifier gain to the laser power, data rate, aperture size and link range, as shown in Figure 2 [15]. Table 2 shows the attenuation value for the different weather conditions like clear sky, rain, Haze and Fog. The optimization of optical amplifier gain and laser power parameters and a standard aperture size of 15 cm to maintain an attenuation of less than 0.6dB/km and a bit rate of 2.5Gbps.



Figure 2: Priority Optimization [14]

The eye diagrams and bit error rate (BER) performance are shown in BER analyzer in OptiSystem 7 software and the results for clear, light and heavy haze weather conditions for new priority-based optimization technique is proposed for achieving the best system performance in the event of weather degradation. The results show that the optical amplifier gain increases with decreasing visibility, followed by attenuation rate of all weather conditions.

## 3. Results and Discussion

Simulation software Optisystem 7.0 is used to evaluate and compare the performance of the proposed FSO system with the FSO system employing the SAC OCDMA SDD technique. The input power, bit rate and attenuation for both systems are 10 dBm, 2.5 Gbps and 8.68 dB/km, respectively.





Figure 3 shows the BER performance carried out against the transmission distance for two different systems in FSO

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communication. It can be seen that the BER increases with the transmission distance. A longer range provides a larger dispersion and attenuation thus increasing the error rate. The results show that the performance of the FSO system using Modified AND subtraction technique is better than the FSO system using the SAC OCDMA with SDD technique. It was found that the system using Modified AND subtraction technique only up to 1.2 km and the FSO system using the SAC OCDMA system could perform sufficiently well up to 0.92 km and. The result shows that the transmission distance improves.



**Figure 4:** BER versus distance for the FSO system using Modified AND subtraction technique APD and the FSO system using Modified AND subtraction technique PIN

Figure 4 shows the variation of the BER versus the number of active users for the modified-AND using APD and PIN photo-detectors. The BER of the SAC-OCDMA system increases when the number of active users increases mainly due to PIIN. Nevertheless, the modified-AND APD detection is capable of achieving superior BER performance over the Modified AND Subtraction PIN detection technique. Moreover using the APD, the modified-AND is able to sustain better BERs than the PIN photodiode for a larger number of active users. The BER for APD is better than the BER for PIN which is shown in Figure 4.The SPD concept which included in the Modified AND subtraction favours to eliminate the PIIN and MAI for the number of active users.

**Table** 2: Attenuation for different weather condition

Weather condition	Attenuation(db/km)
Very clear sky	0.065
Light haze	0.55
Heavy haze	2.37
Rain	8.68
Heavy Fog	26



**Figure 5:** BER for SAC OCDMA SDD versus Modified AND Subtraction technique at the bit rate of 10 Gbits/sec

In the Figure 5, To set the bit rate at the range of 10 Gbits/sec then the overview of the performance of SAC OCDMA SDD technique and the performance of Modified AND subtraction technique. Here it can see that the performance of Modified AND subtraction is better than the SAC OCDMA SDD, at the range of 1.1 km the modified AND subtraction attains the BER of 9.5 e<sup>-5</sup> and performs better communication. But in SAC OCDMA SDD the communication will not be established beyond 1 Km. so at the longer distance the better communication could be obtained in Modified AND Subtraction technique.



Figure 6: BER reduced by increasing the power in Modified AND Subtraction

Figure 6 shows that the result in the Modified AND subtraction technique if the power is increased the BER will be reduced, it could be applicable for both single and multiple users, whatever the range of communication distance might be if the power is increased it will get the better results of BER in modified AND Subtraction technique.



Figure 7: BER of Modified AND Subtraction for fixed link range and data rate

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From the Figure 2 priority optimization [15] the highest priority is given to the optical amplifier gain and the communication range where the data rate is fixed then it can be obtained that the decreased values of BER by increasing the power and amplifier gain. It is shown in Figure 7 and here the power and optical amplifier gain is increased in same time data rate and link range made to be fixed and the value of power starts from 10 dBm and optical amplifier gain is 5db.Then giving priority to the next parameters of data rate, aperture size and link range the obtained BER is compared with the BER of amplifier gain results. The result of highest priority given optical amplifier gain is best one to reduce the performance degradation in the Bad weather condition.



Figure 8: BER obtained in Eye diagram for Clear sky

Thus the new priority-based optimization technique is proposed and simulated for achieving the best system performance in the event of weather degradation. The results show that the attenuation increases with decreasing visibility, followed by increasing rainfall rate. Hence, for a fixed link range, to maintain a particular bit rate, the optical amplifier gain and laser power should be increased with increasing haze level and rainfall level. The value of attenuation for different weather condition is given in the Table 2.Figure 8 shows that the BER obtained in the EYE Diagram for clear sky. The same procedure is followed for rain, haze and fog. In order to increase the received power under haze and rain conditions, the aperture size may be increased. The laser power was set to a constant value of with 30 dBm, and the optical amplifier gain was set to a value of 50 dB.



Figure 9: BER obtained in Eye diagram for Heavy haze.



Figure 10: BER obtained in Eye diagram for Rain.

In order to further increase the data transmission rate under haze and rain conditions, the link range may be reduced, the aperture size set to 30 cm, the data transmission rate may be further increased and obtain the BER. Examples of eye diagrams under various haze and rain conditions are illustrated Figure 9 and figure 10 respectively. For Haze, a BER of  $3.27 \times 10^{-11}$  was achieved. For rain, a BER of 2.19 x  $10^{-15}$  was achieved.

## 4. Conclusion

In this paper, the performance of SAC-OCDMA systems using modified-AND detection with APD has been evaluated in comparison to the SAC-OCDMA SDD detection scheme. Our results confirm that using APDs with low gain have improved the performance of SAC-OCDMA systems. Furthermore, the modified-AND detection is capable of realizing better BER performance than the SAC-OCDMA SDD detection technique. Superior performance and cost-effectiveness have been made by the SPD technique, Its usefulness is mainly because of its ability to eliminate both PIIN and MAI. This implies the feasibility of SAC-OCDMA system based on modified-AND detection technique is used for future optical access networks. To reduce the performance degradation of FSO in bad weather conditions, it was demonstrated that the transmission parameters should be optimized in descending order of priority from the optical amplifier gain to the laser power, data rate, aperture size and link range there by obtain the better performance in bad weather conditions.

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