Inter-satellite Optical Links in ZCC SAC-OCDMA system

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Abstract— Satellite communication is an inseparable part of today and tomorrow communication techniques. It is communication technique which provides larger communication than others. Hence in this communication, high speed and high data rate can be obtained by using optical wireless channels in Inter-satellite Optical Link system. To make it a secure communication technique, SAC-OCDMA with ZCC coding scheme can be used. In this paper different numbers of optical wireless channels are used in ZCC SAC-OCDMA inter-satellite optical links system to analyse its performance by bit error rate (BER), quality value and receiver apertures diameters for 10 numbers of users. Also ZCC code is compared with RD and MD code with inter-satellite optical links. The system is analysed for 5500 km distance at bit rate of 10 Gbps in the presence of thermal noise. The simulation result analysed in optisystem 7.0.

Keywords—*Inter-satellite Optical Wireless Channel (IsOWC), Multi- Diagonal (MD), Optical Wireless Channel (OWC) Random Diagonal (RD), Spectral Amplitude Coding-Optical Code Division Multiple Access (SAC-OCDMA), Zero Cross Correlation (ZCC).*

I. INTRODUCTION

Future communication system demands high bandwidth, high data rate and high security due to increasing in internet traffic day by day. Hence OCDMA (Optical Code Division Multiple Access) is such a technique which fulfils all these demands [1]. OCDMA is a multiple access technique in which users are not allocated only on frequencies and timeslots but on an individual optical code [2]. The spectral amplitude coding (SAC) in OCDMA is more beneficial because it reduce MAI (Multiple Access Interface) with coding [3]. ZCC (Zero Cross Correlation) code in SAC-OCDMA reduce MAI with the property of no overlapping between different codes, which makes it best code than others [4]. As wireless technology is more efficient than wired in setup configuration, less cost and security. So to fulfil the future demands of users for outdoor applications optical wireless communication is a solution [5].

As the satellite communication is a global communication technique.LEO (Low Earth Orbit), MEO (Medium Earth Orbit) and GEO (Geostationary Earth Orbit) are three earth orbits in which the satellites revolves by covering different earth areas [6]. To connect these three different orbit's satellites for transmitting data, video and voice at high data rate, low delay and low attenuation optical wireless communication technique i.e. IsOWC(Inter-satellite Wireless Channel) is used. IsOWC is an optical or light communication for information transmission [7]. By using a multiple access technique in satellite communication IsOWC, it can be make more beneficial. Hence SAC-OCDMA is that technique which makes it a secure communication technique by using a unique code for each user. As there are many codes are in SAC-OCDMA but ZCC code is best because in this code, there is zero cross correlation between two codes [8].

In this paper optical wireless channels are used in ZCC SAC-OCDMA inter-satellite optical link system. Thus the performance of this system measured by BER, quality value and varying receiver apertures diameters for 10 number users at bit rate of 10 Gbps. Also the comparison is done with RD and MD code for 5 numbers of users. The inter-satellite optical links i.e. OWCs (Optical wireless Channels) used with distance of 5500 km. The whole system is analysed in the presence of thermal noise. The simulation results analysed in optisystem 7.0.

II. SAC-OCDMA CODES

There are some of following codes in SAC-OCDMA. All following codes are written in binary form in a matrix.

A. RD Code

RD code is a matrix which is designed in two parts data segment and code segment. For example for weight w=4 and users u = 3, the code length l will be 8 [9].

$$l=u+2w-3$$

$$\mathrm{RD}(w=4)=\begin{bmatrix}0&0&1&0&1&1&0&1\\0&1&0&1&1&0&1&0\\1&0&0&1&0&1&0&1\end{bmatrix}$$

B. MD Code

MD code is a zero cross-correlation code which support high data rate. It is designed by combining diagonal matrixes. For weight w=1 and user u=5, the code length will be 5 [10].

$$l=u\times w$$

$$\mathrm{MD}(w=1)=\begin{bmatrix}1&0&0&0&0\\0&1&0&0&0\\0&0&1&0&0\\0&0&0&1&0\\0&0&0&0&1\end{bmatrix}$$

C. ZCC Code

ZCC code is a zero cross-correlation code. For weight w=2 and user u=3, code length l will be 6 [11].

$$l=w\,(w+1)$$

$$ZCC(w = 2) = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 \end{bmatrix}$$

III. SIMULATION SETUP ANALYSIS

The block diagram of ZCC SAC-OCDMA system with OWCs is shown in Fig 1. The transmitter consists of laser as an input source because it can send the data with data bit rate and for longer distances in kilometres, of PRSB (Pseudo Random Bit Sequence), NRZ (Non Return to Zero) and Mach-Zehnder Modulator with ZCC code [12].Then laser power split into 40 wavelengths from 1478.8 nm to 1510 nm with chip spacing of 0.8 nm between two adjacent wavelengths. Power splitter split all the incoming power and fed into OWCs having reference wavelengths of 1550 nm and 5500 km distance. The receiver consists of APD photodetector, low pass filter, 3R regenerator and BER analyser [11]-[14].

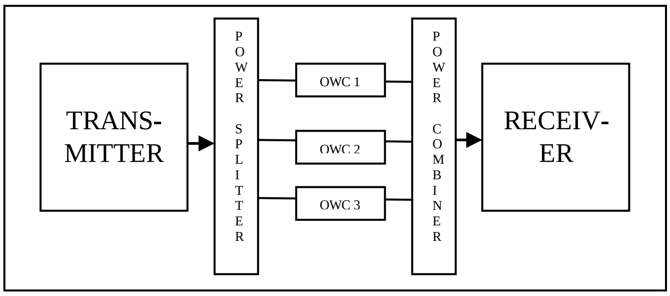

Fig. 1: Block diagram of inter-satellite optical link system in ZCC SAC-OCDMA system with three OWCs [13]-[14]

TABLE I. PARAMETERS USED [13]-[14]

S.No.	Parameters Used	Values
1	Input power	20 dBm
2	Reference wavelength for OWCs	1550 nm
3	Data bit rate	10 Gbps
4	Transmitter Aperture Diameter	20 cm
5	Receiver Aperture Diameter	40 cm
6	OWCs distance	5500 km
7	Dark current	10 nA

IV. RESULTS AND DISCUSSIONS

The performance of inter-satellite optical links in ZCC SAC-OCDMA system for 10 numbers of users by using 1 to 10 OWCs in the presence of thermal noise is shown in Fig. 2.

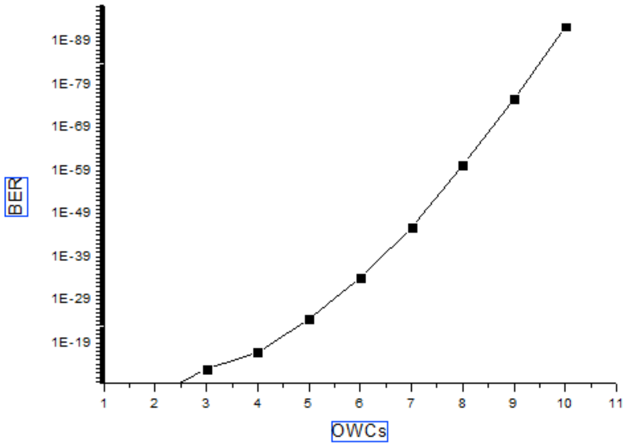

Fig. 2: BER performance of ZCC SAC-OCDMA system for 10 numbers of users with different numbers of OWCs

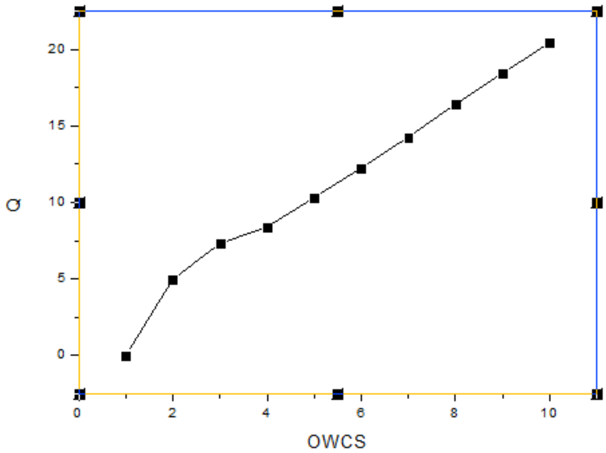

Fig. 3: Quality Value performance of ZCC SAC-OCDMA system for 10 numbers of users with different numbers of OWCs

From Fig. 2 it is clear that by using only one OWCs the BER is 3.06×10^{-07} . But when the OWCs increases from 1 to 10 then its BER also decreases and decrease in BER means better communication from transmitter to receiver for 10 numbers of OWCs as compared to others. In Fig. 3, the quality factors is shown for OWCs from 1 to 10.As from the figure it is clear that by using 10 OWCs in ZCC SAC-OCDMA system, BER in minimum and Q value is very high as compared to others.

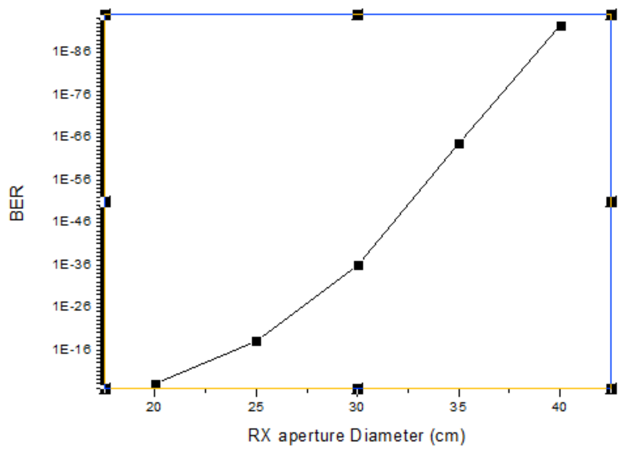

Fig. 4: Performance of ZCC SAC-OCDMA system for 10 numbers of users with different receiver aperture diameters (cm)

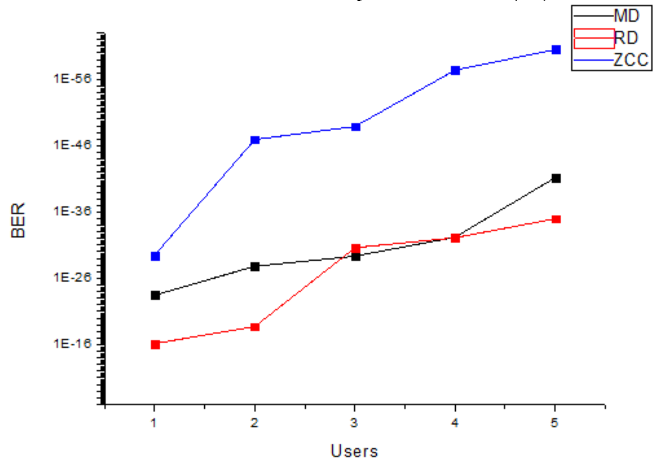

Fig. 5: Comparison of ZCC code with MD and RD code for 5 numbers of users with one OWC in SAC-OCDMA

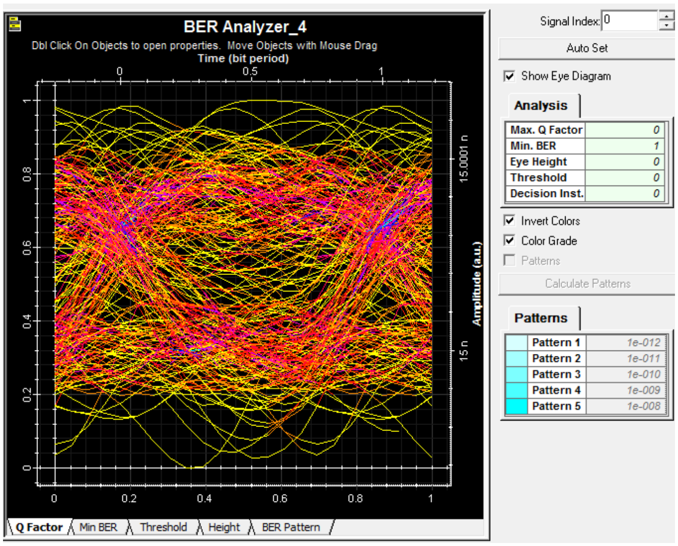

Fig. 6: Eye Diagram of one of user in 10 users ZCC SAC-OCDMA inter-satellite optical link system with one OWC

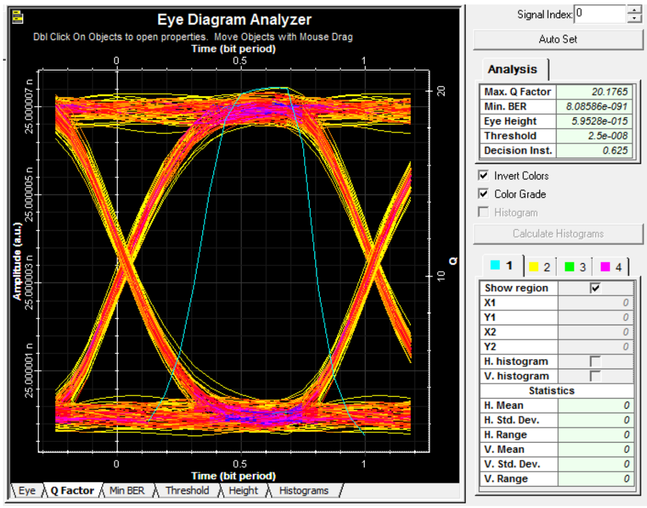

Fig. 7: Eye Diagram of one of user in 10 users ZCC SAC-OCDMA inter-satellite optical link system with 10 OWCs

In Fig. 4 the same ZCC SAC-OCDMA code system is analysed with different receiver aperture diameter with fixed transmitter aperture diameter of 20 cm. As the receiver aperture diameter is increases from 20 cm to 40 cm there is decrease in BER and which again shows the better communication at 40 cm as compared to 20 cm receiver aperture diameter.ZCC code then compared with RD and MD code in SAC-OCDMA for 5 numbers of users with 1 OWC in the presence of thermal noise. Fig. 5 shows that ZCC code has low BER as compared to RD and MD code in OWC system. Fig. 6 and Fig. 7 shows the eye diagrams for 10 number of users in ZCC SAC-OCDMA system with only one OWC and 10 OWCs respectively and it is clear that 10 OWCs gives better result.

V. CONCLUSION

In this paper inter-satellites optical links are analysed for 10 users in ZCC SAC-OCDMA system to connect the different satellites orbits in the presence of thermal noise. To fulfil the future demands in satellite communication, ZCC SAC-OCDMA is a good solution because it provides high speed, high data rate, quality and security. As the numbers of inter-satellites optical links increases, quality of system for satellite communication increases. Also increase in the receiver aperture diameters further increase the quality of satellite communication. As compared to others codes in SAC-OCDMA, ZCC code more beneficial. Hence a good inter-satellite communication can be obtained for 5500 km at bit rate of 10 Gbps with ZCC SAC-OCDMA.

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VII. REFERENCES

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