

# A STUDY OF OWC FOR INTERSATELLITE SYSTEMS

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**Abstract**— In this paper the important method to set up a link between satellites in different types of earth orbits such as Geosynchronous Earth Orbit (GEO), Medium Earth Orbit (MEO) and Low Earth Orbit (LEO) is inter satellite communication is discussed. As with its merits, there are some demerits also which use have discussed in this paper, but these limiting factors of IsOWS can be reduced by using more efficient techniques. The IsOWC system can be further improved or enhanced by using various techniques such as advanced modulation techniques and diversity techniques. IsOWC link system is best technique to achieve very high data rate.

**Keywords**— *IsOWC, pointing error, QPSK, MEO, OWC*

## I. INTRODUCTION

Optical wireless communication is basically a transmission of laser light signals in the vacuum or space. It uses light signal of infrared frequency range. Air is considered in the transmission of signals for lower earth layers of environment and vacuum is in the beyond environment region. So generally OWC is stated as the transmission of the signals as carrier signal in the air. For optical wireless communication the basic components are the sender and recipient. The data source, pulse shaper and light intensity signals these three basic blocks are incorporated in transmitter. Receiver is used for decoding or detection. In which data is decodes or detect through the photo-detectors. Communication channel or medium is air or vacuum in between the two satellites [1]. Optical wireless takes the advantages of optical communications and supports the high speed in several Gbps. In electromagnetic frequency spectrum, optical wireless communication is operated in the range of infrared region. Free space technology reliant on the carrier signal that is generated through the laser source.

Free space optical communication is well competent and excellent technology which provides the demands of fast and speedy inter-satellite networks. This optical wireless technology is far better than the radio communication. There are no. of benefits of using this technology such as the fast speed, wide bandwidth, compact size of antenna and low weight, power efficient, high security for transmission [2]. OWC, incorporated three essential components such as the sender, medium for propagation and recipient that consists of decoder and detectors. Figure 1.1 represents the block diagram of optical wireless communication.

The previous wireless links were reliant on the radio frequency communication. Today, this radio or microwave frequency communication is replaced by the all optical communication due to numerous benefits over RF transmission [3]. With the increases of the satellite networks, a technique is needed to cater the demands of high speed satellite networks. Till now, the communication was conventional such that there was no relay communication among satellites. However, owing to numerous benefits, optical laser communication provides the access of relay communication which is used for reducing the time and cost of the networks. Optical computers, laser beams and data accessing is the essential part of the optical wireless communication[4].

Wireless transmission is so called because it depends only on the sort of message, which is reliant on the space or environment as the broadcast channel. It is different from the radio, without a wired medium in optical uses the infra region luminosity for the context of transmission. Systems, which are used in this domain, have three sections that are sender, recipient and communication medium. The wireless channel is free space channel and there is not a big difference in the optical channel and the OWC channel. It is well thought-out to be external space where it is tacit to be void and that's way it is free from atmospheric power loss factors.

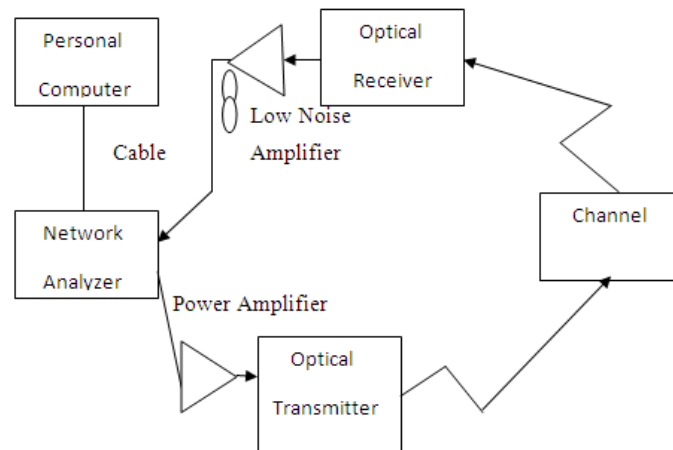


Figure 1.1 Optical wireless communications

### 1.1 ADVANTAGES OF OWC

- 1 It is cheap in cost.
- 2 Base-band circuit designs
- 3 Bandwidth requires is in less amount compared to wired transmission
- 4 High data rates (Gbps)
- 5 The security in Optical communication is very high
- 6 It's a less Distortion communication.

### 1.2 DISADVANTAGES OF OWC

- 1 It cannot penetrate through walls. That's radiation problems is occurs in mobile connection.
- 2 It Sensitive to blocking.
- 3 Users can use transmit Power in only limited range.

## II. BASICS OF OWC

It is a transformation of data or signal in a open space from transmitter to receiver. Optical wireless communication always uses a laser light as its channel for transmission of data or signal. Laser performs a function as carrier in this technique. According to its name we can understand that OWC uses wireless medium. OWC is also called a laser communication because all the transmission depends upon the laser light, which is its carrier that transmits the data or signal to receiver. When the number of users is increases, it requires a higher bandwidth. By increasing the no. of users speed is also increased. It's only reason, to fulfill these demands, that's way we uses a OWC because it provides a high speed in fastest communication process, than RF and microwave technology [5]. If we compare it with other communication, due to its advantage, this wireless technology is also used for space communication and when we used this technology for the communication between two or more satellites, then this technology called as inter-satellite optical wireless communication (IsOWC). Figure 1.2 represents the inter-satellite communication among more than two satellites.

By reducing the size of the payload, the mass and the cost of the satellite is also decreased. Another reason for using OWC is that it uses a small wavelength of laser. But the RF links are usage a longer wavelength as compared to lasers. Beamwidth that is used in optical communication is also in narrower amount. But RF system usages a large beamwidth than the FSO. These are characteristic of optical communication or simultaneously these are advantages over RF communication. By all of these reason, the loses that occurs in optical communication is lower in amount compared to RF although it requires a very high accurate tracking system so that the connected satellites are having line of sight and it is properly aligned in way. So, major advantages of OWC is that it provides a high q factor, high information rate, fastest speed, it is more secure in nature.

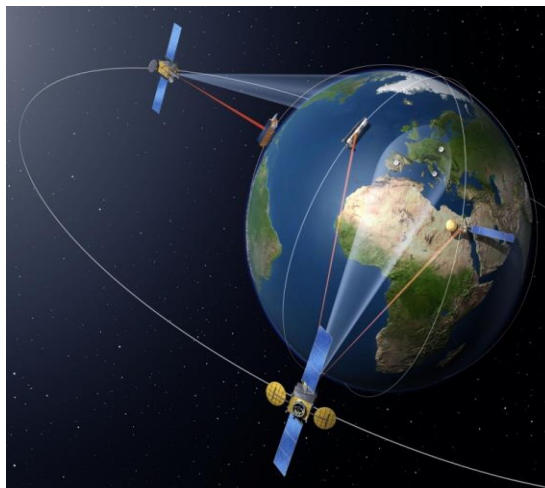


Figure 1.2 Inter satellite optical communications

### III. WORKING PRINCIPLE OF OWC

As we know that the optical communication is categories in three main parts that are sender, receiver and communication carrier. We already discuss about these main parts or its essential component in previous section. Figure 1.3 shows the inter-satellite wireless communication setup with its important components, transmitter and receiver. Figure shows that sender and receiver are in the different satellite compare to one another. In between the sender and receiver there is little distance and at this state OWC acts as the transmission medium which carry light signal. The Main function of this system is that the transmitter receives information from satellite's Telemetry, Tracking and Communication (TT&C) system. The information signal that continually transmitted through a outpost are such as the satellite location as well as attitude tracking, captured representation for long distance measuring outpost, and smooth tone information for telephone system using satellite.

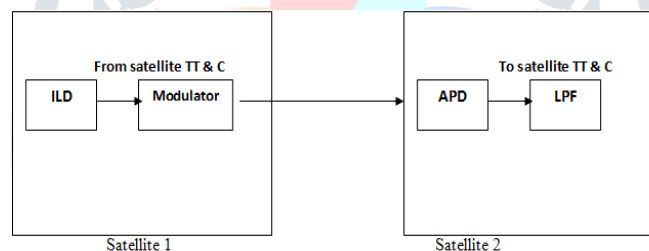


Figure 1.3 IsOWC basic system block diagram for simplex

Main sources that are used for light signal are light-emitting diode (LED) and injected laser diode (ILD). These lighting devices are mainly prepared from semiconductor devices. So, it is always in positive or negative charge like semiconductor device or generates light energy [6]. The Light that is generates in the laser is of only single color and same phase of these laser devices, among serial pulses also has great radiance. That's way it is widely used for the broadcasting . The light that produced by the laser can pass through multiple LED. For this reason, laser is used in this type of transmission.

The information which is mainly transferred by the air or space is the case of wireless systems. By this mean of sending signals is known as radio propagation. In this technique, signals transmitted over the network by using air or space and finally reached to the destination.

### IV. OPTICAL ORBITS FOR SATELLITE COMMUNICATION

The route or the path that object follows around a star or planet is referred to as the orbit of communication. The size and shape of the orbit is ellipse and placement of the satellite is in the two focus of ellipse. Figure 1.4 shows the satellite orbits revolving around the Earth. According to its distance or height, orbits are divided into three categories like: Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geosynchronous Earth Orbit (GEO).

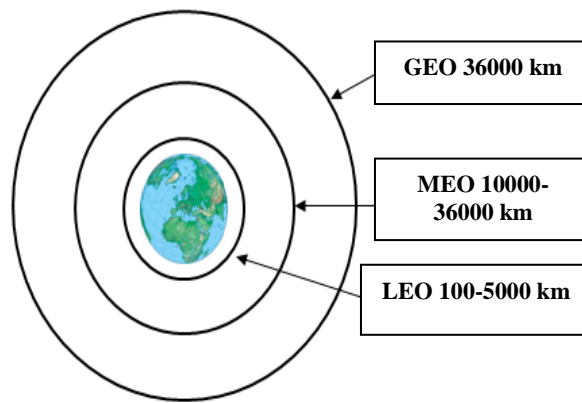


Figure 1.4 Earth Satellite Communication Orbits

Now the separation of the satellite orbits is based on its distance from the ground. Upto the distance of 1000 km, a orbit is called as the lower orbit of earth. Earth orbit that is at lower distance is tries to be in circular shape. As the distance or height increasing from earth or ground, typical at the height of 5000 km to 25000 km, is called as the Medium Earth Orbit (MEO). Medium earth communication plays an important role in large distance satellite surveillance. Geosynchronous satellites are place in GEO orbit and typically at the height more than 36000 km. The placing time of satellite in this orbit is 24 hours. Three satellites in GEO placed  $120^\circ$  apart from equator cover most of the world for communications purposes [7].

## V. HISTORICAL BACKGROUND AND PROGRESS IN WIRELESS COMMUNICATION

The timeline examination has been done in the past for different components such as lasers, modulators. To understand the performance of the modulators, modulators tested by European Space Agency .Agency tests done at high speed in 1977 [8]. Towards the better development in optical transmission this examination is done after totally analyzed the work of lasers and modulators. ESA R&D urbanized a large amount of study contracts as well as it finds a hardware enhancements. In the middle of the year 1980, used a ESA in a optical network we understand the usages of semiconductor laser OWC (SILEX), or we understand its role in the direction to display a preoperational transmission and connection in space. In the past of optical period, Initial and first connection was carried in year 2001 and considered amid SPOT-4 and ARTEMIS satellites, in this period Advantage of optical communication was defined by used these devices. So, optical network can be consistently reliable in free space. After that, this technology tested by different nations and experiments were done by JAPAN and established a dual way system connection among its OWC Test Satellite as well as ARTEMIS, related to this study in 2008, The Germany research team also carried out the experiments on space transmission between the near-field infrared experiment satellite and SAR-X satellites to focus on light broadcast technology.

The Japan research agency and team again worked on collaboration to carry out OWC link and the beginning of OWC Test Satellite (OICETS) in addition to its LCT commonly known as the light utilizing transmission apparatus. OICETS was come through a Dnepr rocket. Dnepr rocket covered the range of 610 km. In addition to understand the whole process of laser in optical network, ARTEMIS were experimented on Dec, 2005. Different SPOT-4, OICETS is talented to provides delivery of broadcast information and consequently, it established all over world's in normal speed of data at two Mb/s in addition to 50 Mb/s broadcast. The LUCE terminal was made through the association of Japanese NEC in addition to Toshiba.

The technical capacities indistinguishable to the solitary fatal on SPOT-4 by means of the subsequent exceptions: the radius or diameter was noted of the size 260 mm, diameter of the beam sender 130 mm, the power or strength light source is hundred milliwatt as well as the weight of the LUCE is near about one seventy kilogram. On April of year 2007, the one more satellite which used called as NFIRE into lower earth orbit through  $48.23^\circ$  inclination in addition to this, after 2 month or 60 days, on June 15, 2007, the TerraSAR-X outpost was launched into a LEO orbit with five hundred ten altitudes as well as  $97.45^\circ$  inclination. Subsequent to collaboration of both spacecraft, the original triumphant inter-satellite contact relationship by means of homo phase method was carried out on February 2008 [9].

## VI. APPLICATION OF ISOWC

- 1) Space Activities:- An OWC link is used in space and it is better option for exchanging information, sharing experimental data, internet accessibility at high rate.
- 2) Earth Monitoring Missions:-An OWC system is used in monitoring the earth system. The system needs high resolution and precise values. Several gigabits data rate are required by satellite single satellite don not work for one specific area but the entire earth is covered.
- 3) Communication with Satellite:-Work is divided among various satellite which work under earth to convey data to each other a robust network is used. Which needs proper synchronization and proper control and for this IsOWC is best technique.

## VII. CONCLUSION

The main purpose to choose optical wireless communication links instead of radio frequency links because its advantages of data with small size payload can be sent to large coverage areas (thousands of kilometers)[10] and IsOWC is latest technique which is used to provide the communication between the satellites IsOWC has vast advantages which completes the system requirement. As with its merits, there are some demerits also which use have discussed in this paper, but these limiting factors of IsOWS can be reduced by using more efficient techniques. The IsOWC system can be further improved or enhanced by using various techniques such as advanced modulation techniques and diversity techniques. IsOWC link system is best technique to achieve very high data rate.

## VIII. ACKNOWLEDGMENT

This study was supported under the guidance of Dr. Amandeep Singh Sappal (Assistant professor, Department of Electronics and Communication Engineering, Punjabi University, Patiala). I thank my colleagues from [UCOE, Punjabi university, patiala] who provided insight and expertise that greatly assisted the study briefly.

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