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INTER-SATELLITE OPTICAL WIRELESS COMMUNICATION SYSTEM DESIGN AND SIMULATION

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Abstract- The mobile satellite communications systems of next generation will provide high-quality and flexible multimedia services to users at anywhere and at any time [1]. Communication between any two places in earth is an attractive goal. One of the feasible solutions to achieve this goal is networking the satellites together with the earth stations. Especially when the communication is required between two places, which are opposite to each other of the globe, then the information should be transmitted through the nearby satellite, the satellite then sends the information to its nearby satellite and so on. By virtue of this inter-linking process the group of satellites transmits the information down to the ground destination station. Thus inter-satellite link (ISL) plays an important role for the communication purpose for global coverage. These satellites should have high speed switching and processing capabilities. This system is complicated and made up of many units. The traditional Geostationary Earth Orbit (GEO) satellites are not suitable for this purpose because, they have i) high propagation loss; ii) large transmission delay. Instead of this kind of satellites, the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites are highly suitable for the global coverage and communication purpose. Teledesic, Sativod, Celestri, Sky-bridge and M-star systems are few of the examples [2]. ISL using optical link has many advantage comparing to microwave link such as i) higher band width; ii) lower transmission power; iii) smaller size and weight of the terminals; iv) higher immunity to interference etc. All of these reasons are vital for a satellite communication system, because it can reduces the payloads and consequently reduces the costs. But due to small beam divergence, pointing, acquisition and tracking are more critical in optical link. The required tracking accuracy is typically on the order of 1 µrad [3]. This requires closed-loop tracking, which is the only disadvantage of the system. This can be taken care by using servo-motors, which locks the beacon signals of the satellites [4] [5].

The proposed inter-satellite optical wireless communication (IsOWC) system uses lasers as a signal carrier. This is the key technology for realizing an ultra-high speed and long-haul communication system. The coverage distance of the IsOWC system depends upon many parameters such as type of modulation used, input power, operating wavelength, receiver sensitivity etc. Hashim et. al. proved that among all ON-OFF keying techniques non-return-to-zero (NRZ) is the best scheme, for obtaining maximum coverage distance of the link [6]. Comparing to ON-OFF keying techniques phase shift keying (PSK) technique is preferable for free space optical communication, as it does not require any adaptive thresholding method [7] [8]. Sodnik et. al. used binary phase shift keying (BPSK) modulation technique for inter-satellite link [9]. In this paper, we have used coherent optical quadrature phase shift keying (QPSK) technique, as it is spectrally more efficient then BPSK technique [10].

The proposed system is designed and simulated up to the bit-rate of 400 Gbps. The system is a non-diffused link or line of sight setup, which uses coherent optical quadrature phase shift keying modulation technique. The performance of the system is analyzed in terms of Q-factor, bit error rate, eye opening etc. The coverage distance observed with an input power level of 30 dBm for a bit-rate of 400 Gbps, 160 Gbps and 100 Gbps are 4,767 km, 7542 km and 9532 km respectively. Finally, the maximum bit-rate that can be communicated, for inter-satellite link at different orbits such as LEO, MEO and GEO are also presented.

Keywords- Optical wireless communication; inter-satellite link; line of sight system; quadrature phase shift keying; Q-factor.

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