Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 5, Issue 2 April-June, 2018, pp. 110-112
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http://www.krishisanskriti.org/Publication.html

A Review on OFDM-FSO System

Harsimranjit Kaur[1], Kuldeepak Singh[2] and Tarandeep Singh[3]

[1,2,3]Dept. of ECE, Guru Nanak Dev Engg. College, Ludhiana, India
E-mail: [1]harsimranjit613@gmail.com, [2]gne.kuldeepaksingh@gmail.com, [3]gne.tarandeepsingh@gmail.com

Abstract—*Free space optics (FSO) is a type of communication that uses air as medium to transfer data from one point to another. Mostly, FSO can be used in the areas where network connectivity lacks and also where normal fiber implementation is not feasible. FSO is a license-free operation so that it provides high data rate transmission, higher bandwidth and low power consumption. However, the quality of signal received at the receiver side is degraded. This is due to atmospheric attenuation. Orthogonal frequency-division multiplexing (OFDM) is a method of digital signal modulation containing a data stream which is divided into many different narrowband channels having different frequencies. OFDM is more combative to fading i.e. frequency selective fading. By using the combination of Orthogonal Frequency Division Multiplexing (OFDM) scheme with FSO system provides better compensation for different atmospheric effects. In this paper several different techniques are discussed that mitigates the atmospheric turbulence in OFDM-FSO system.*

Keywords*: atmospheric attenuation, Free Space Optics (FSO), Orthogonal Frequency Division Multiplexing.*

1. INTRODUCTION

Free space optics is a optical wireless communication technology that uses air as medium to transfer data between any two points. It can be used in areas where physical connections are not feasible [1]. FSO is very useful because of its license-free operation, high data rate transmission, full duplex transmission, higher bandwidth and as well as the power consumption is very low in the case of FSO. But the quality of the received signal is degraded due to the atmospheric attenuation. FSO system is prone to different weather conditions like fog, snow, rain and dust particles. FSO system is used to reduce the volatility of the signal which is occurring due to the atmospheric turbulence. Phase fluctuation and intensity scintillation causes the instability in the signal. FSO is used in so many applications like in biomedical, under water communication etc. Orthogonal frequency division multiplexing (OFDM) is a reliable modulation scheme to access broadband because of it provides high channel efficiency and also the effect of multipath fading is reduce [2]. Using this modulation scheme each subcarrier is modulated by carrier signal information. The inter symbol interference (ISI) can be reduced between subcarriers because they are orthogonal to each other. Using correlation scheme the separation becomes easier at receiver side [6]. So by using OFDM multiple channel transmission is viable in FSO system.

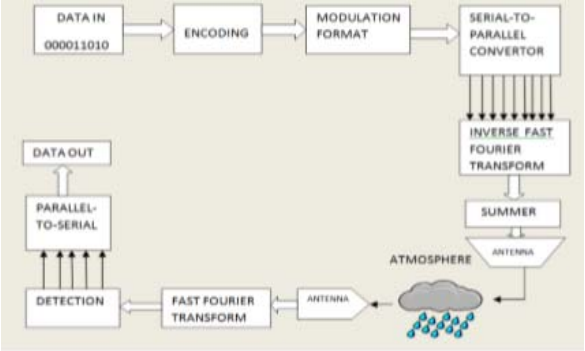

Fig. 1: Block Diagram of OFDM-FSO System

2. OFDM-FSO SYSTEM DESCRIPTION

Fig1. Shows the block diagram of OFDM-FSO system. There are basically two subsystems, One is the OFDM transmitter and other is OFDM receiver subsystem. Firstly the input data is send which is encoded by the OFDM transmitter by using any one of the modulation formats. Some modulation formats like Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM) [6], Polarization Shift Keying (PolSK), Dual Polarization shift Keying (DPSK) can be used. After that, the data stream is passed through a serial-to-parallel convertor where the serial data converted into the parallel. The inverse fast fourier transform is used to transmit the lower data rate over the multi carrier in parallel data stream. The transmitted signal travels through the channel which is free space or air. The signal quality gets degraded during its transmission in air because of the atmospheric attenuation. In the receiver side there is a receiving antenna. The received signal is detected by using a detection method. Two types of detections can be used i.e. Direct detection and coherent detection. Similarly, the whole process of OFDM receiver subsystem is just the reverse process of OFDM transmitter subsystem.

3. LITERATURE REVIEW ON OFDM-FSO SYSTEM

The atmospheric attenuation that affects overall system performance is the major drawback in the system. The parameters that get affected are bit error rate, outage probability, quality factor etc. Performance of the system can be improved by using OFDM with FSO system. Fig1 shows block diagram of OFDM-FSO system having OFDM transmitter and receiver subsystem blocks in which changes can be done for performance improvement in either of the subsystems in FSO system [5].

The subcarriers are modulated by a information signal using different modulation formats in OFDM technology. As told before, the different modulation schemes can be selected according to system's requirement. The author compared the Quadrature Amplitude Modulation (QAM) and Phase Shift Keying modulation (PSK) formats and found that Quadrature Amplitude Modulation format provides better quality factor than Phase Shift Keying modulation format [6].

With M-QAM, the communication distance can be increased. OFDM modulation is used with M-ary Quadrature amplitude modulation encoder in this technique. The author observed that the acceptable BER value was achieved for distance upto 7km and also outage probability value gets increased as the number of subcarriers increased. Further, if the number of subcarriers and distance increased the system gives worst performance [8].

A demonstration of CDMA-FSO coherent detection system is reported in this work to achieve 10 Gbps-FSO link with acceptable range of SNR under different weather conditions like haze, rain and fog etc. Further, the work is extended to weigh the proposed CO-CDMA-OSSB-FSO transmission system against OFDM-OSSB-FSO direct detection system [10].

4. TYPES OF OFDM

Basically, Orthogonal Frequency Division Multiplexing (OFDM) system is of two types i.e. Direct Detection and Coherent Detection.

Direct Detection OFDM is used for short range applications. DDO-OFDM is further of two types:

(1) Linearly Mapped DDO-OFDM (LMDDO-OFDM):

Here the optical OFDM spectrum is a replica of baseband OFDM.

(2) Nonlinearly Mapped DDOOFDM (NLM-DDO-OFDM):

Here the optical OFDM spectrum is not a replica of baseband OFDM.

DDO-OFDM takes benefit of the OFDM signal which is more immune in cable data networks (CATV) network to the impulse clipping noise.

Coherent detection CO-OFDM required more complex transceiver design which shows the crucial performance in spectral efficiency and receiver sensitivity etc. [7]. CO-OFDM is suitable for long haul transmissions and provides high spectral efficiency and it also avoids the interference by using signal set orthogonality. In CO-OFDM systems the optical carrier is generated by laser with the use of local oscillator thus the less transmitted power required by the CO-OFDM system although it is more sensitive to phase noise. The main advantages of CO-OFDM are (1) It provides high spectral efficiency (2) Robustness against PMD and CD (3) CO-OFDM provides high receiver sensitivity and less oversampling factor.

5. ADVANTAGES OF OFDM

There are so many advantages of OFDM. Some of the advantages are:

1. Huge amount of data can be transmitted by using OFDM Scheme and can be detected by the equalizer at the receiver end.
2. Intersymbol Interference (ISI), Intercarrier interference (ICI) and as well as the chromatic dispersion can be reduced by using OFDM scheme.
3. Implementation is more efficient by means of fast fourier transformation.
4. Time synchronization errors is less sensitive.
5. Power overloading and dynamic bit capability is good.
6. More combative to fading and dynamic channel estimation.
7. Spectral efficiency is larger due to less carrier spacing.

6. DISADVANTAGES OF OFDM

There are so many disadvantages of Orthogonal Frequency Division Multiplexing. These are shown below:

1. Complexity.
2. High synchronization accuracy.
3. Minimization of multipath fading.
4. Superposition of signals leads to distortion because of peak-to-mean power ratio.
5. More complex than single-carrier Modulation.
6. Linear power amplifier requirement is more in OFDM. The main problem in RF system is in the power amplifiers at transmitter side where amplifier's gain saturates during large input power.
7. The Peak-to-Average Power Ratio is high which is the major drawback of OFDM.

7. APPLICATIONS OF OFDM

Some of the applications of orthogonal frequency division multiplexing (OFDM) are given below:

1. OFDM used in Wireless ATM transmission system and in WiMax
2. Digital television and high definition television.
3. Advanced digital subscribers loop G.992.1 and in Long term evolution
4. Digital audio broadcasting and used in wireless local area networks.

8. CONCLUSION

Even FSO suffers from atmospheric turbulence but it provides many advantages as compared to other communication system. Research is going on to improve FSO link impairments caused by atmospheric turbulence. Many new technologies implemented in FSO system like Orthogonal Frequency Division Multiplexing Free Space Optics (OFDM-FSO) technique. The system performance gets better using OFDM-FSO. Such a system has a big scope in future for long reach applications.

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