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Review Paper on OFDM-Concepts and Applications

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***Abstract* - CO-OFDM is a very attractive modulation and multiplexing technique that is used in wideband optical systems as well as optical wireless systems. Several advantages of optical orthogonal systems is good efficiency of spectrum utilization and channel robustness. Number of small subcarriers is used to transmit data from one source and generally termed as multicarrier transmission. OFDM, a modulation as well as multiplexing technique is the origin of several telecommunications standards counting DTT and radio broadcasting. OFDM is even the source of nearly all DSL standards, and within this situation OFDM is generally known as discrete multitone (DMT). Regardless of the benefits offered by OFDM and its prevalent usage in wireless communications, it has been considered for optical communications during the last years. OFDM is a technique in which sequential data tributary transformed into parallel stream. The concept of OFDM is to divide the broadcast bandwidth into a number of orthogonal subcarriers in order to transmit the symbols using these subcarriers in parallel.In this paper, description of OFDM systems their concepts has been discussed with their several applications.**

***Keywords* - OFDM , FFT, QAM, PARP, ISI**

I.INTRODUCTION

With the growth of optical communication technology, necessity for superior data rate services such as voice and data over different media. Advance modulation formats in terms of bandwidth competence are required to support higher data rates which are not supported by current systems. OFDM is a valuable clarification in order to mitigate the effects of ISI and chromatic dispersion. Dependence of arrangement at elevated data rates when multiple transmitted signals are used like In case of QAM and NRZ. In contrast, the complication of OFDM, and of setup using sequential modulation and frequency domain equalization, balance well as transmission rate and pulse width increase [1].Major and most important advantage of OFDM is the phase variation according to the frequency in digital domain by spending little or no cost. Description and advantages of OFDM is very complex to state, but basic concept of these systems is very simple[2].serialized data is send over dissimilar frequencies in parallel data stream, so the symbol rate is more than the simple serial systems.ISI is key factor to avoid in the systems, cyclic prefix is used to overcome this limitation.

Frequency division multiplexing and WDM are the very much popular in order to transmit high data rates over longer distances. In WDM systems all the channels are separated by a frequency band and analog filtering is needed in order to demultiplex the different wavelength channels. However in case OFDM there is theoretical concept of orthogonality between adjacent signals over one symbol period.IFFT is used to realize the concept of orthogonality and with computational way. Without analog filtering required, system able separate the overlapped spectrum in OFDM system arranged in orthogonal order with well theoretical concept.. FFT is used to demultiplex the encoded OFDM signals.

A. Orthogonal Frequency Disvision Multiplexing

Orthogonal frequency division multiplexing (OFDM) is a extensively used modulation and multiplexing expertise, noe becomes the key factor in telecommunications standards together with wireless LANs, DTT and radio distribution in to a large extent of the earth. .In the precedent time, as well as now, the OFDM is termed in the literature as Multi-carrier and Fourier Transform. OFDM is basically transmitting lower rate data over multi carrier in order to send long sequence in parallel data stream with IFFT orthogonal concept. The carriers are prepared orthogonal to each other by suitably choosing the frequency spacing among them. A multicarrier system, such as FDM or WDM divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to send in parallel.[3] It multiplexed a large number of low data rate carriers to make a compound high data rate communication system. Orthogonality provides the carriers a suitable cause to be narrowly spaced with overlapping without inter carrier interference. [4] In Frequency Division Multiplexing (FDM), the transmitted signal is split into a set of individual signals, known as subcarriers which are in the frequency domain. Then every subcarrier is modulated using a conventional modulation format, and later they are jointly combined to generate the FDM signal. Each of the subcarriers in FDM transmission is independently recovered by the receiver. If the subcarrier signals accomplish the orthogonality condition then this result in overlapping of spectrum and hence spectral efficiency is improved. This technique is known as Orthogonal Frequency Division Multiplexing (OFDM). Data with bit rate R is transmitted into N parallel channels, each one of them with separate frequencies. Over each channel, the total bit rate is spread in equal parts at rate R/N. In each channel the data will be mapped to represent an information symbol and then multiplied by its corresponding frequency. These parallel information symbols are summed to form one OFDM symbol. Thus the duration of each OFDM symbol is Ts=N/R.

B. OFDM System Model

In distinction to conservative FDM, the spectral overlapping among sub-carriers are allowed in OFDM since orthogonality will ensure the subcarrier separation at the receiver, providing better spectral efficiency and the use of steep band pass filter was eliminated. Serial transmitted data is send to QAM modulator used to convert parallel signal and IFFT is used to mix frequency of different values and gaurd interval are inserted in order to avoid ISI.DAC are used to convert digital to analog conversion for time division transformation of signals.On receiver side analog to digital converter is used and guard retrieval for removal of guard bands. Demapping and parallel to serial conversion processed using QAM decoder and FFT.Figure.1. Represents the block diagram of OFDM.

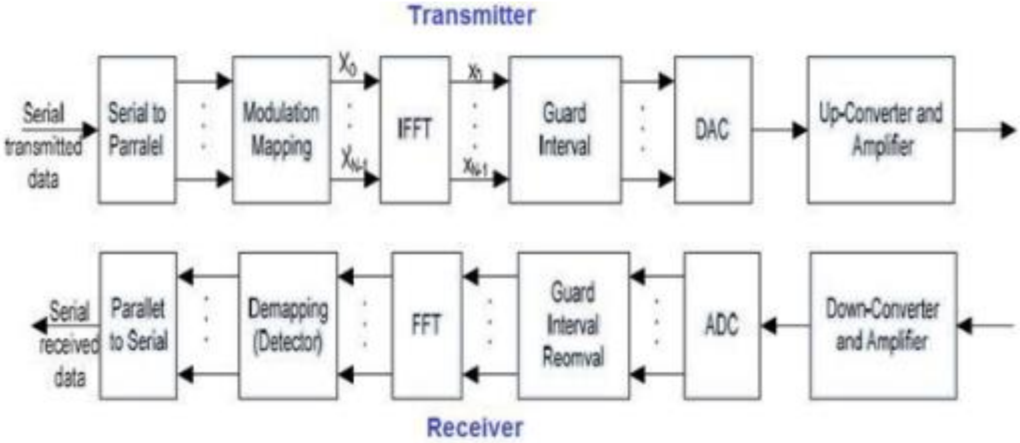

Figure.1.Block diagram of OFDM system

C. Types of OFDM

The two main categories of optical OFDM are Direct detection and Coherent detection. Over the last two decades direct detection had the stronghold for optical communications, while the latest growth in forward-looking research has distinctly pointed to the trend that the coherent detection is the future of optical communications.

Direct detection

DDO-OFDM has much extra variants in comparison to the CO-OFDM. Direct-detection OFDM is suitable for cost effective short reach applications and the common trait for DDOOFDM is that the direct detection is used at the receiver. According to how optical OFDM signal is being generated, DDO-OFDM is classified into two categories: (1) linearly mapped DDO-OFDM (LM-DDO-OFDM), in which the optical OFDM spectrum display a replica of baseband OFDM (2) nonlinearly mapped DDOOFDM (NLM-DDO-OFDM), in which the optical OFDM spectrum is not a replica of baseband OFDM [26]. The first report of the DDO OFDM shows that DDO-OFDM takes benefit of the OFDM signal which is more immune in CATV network to the impulse clipping noise.

Coherent detection

CO-OFDM requires the maximum complexity in transceiver design but also represents the vital performance in spectral efficiency, receiver sensitivity, and robustness against polarization dispersion. The basic principle of CO-OFDM is to attain high spectral efficiency as a result of overlapping subcarrier spectrum however avoiding the interference by using signal set orthogonality and coherent detection. Superior performance of CO-OFDM makes it brilliant candidate for long haul transmissions. In CO-OFDM systems, the local oscillator is used, as the optical carrier is generated locally by laser. Hence less transmitted power i.e. optical power is required in CO-OFDM in comparison to DDO-OFDM, although it is extra sensitive to the phase noise. The main advantages arising from the combination of OFDM with coherent optical communications are multifold: first is high spectral and computation efficiency, second is that the CO-OFDM is robust against polarization mode dispersion and chromatic dispersion, third is CO-OFDM offers high receiver sensitivity, fourth is less DSP complexity and less oversampling factor.

II.ADVANTAGES OF OFDM:

Optical OFDM has several advantages and some of the advantages are shown below:
1. A large amount of data can be transmitted and at receiver simple equalizer is used to detect that data.
2. Robust against intersymbol interference (ISI), intercarrier interference (ICI), chromatic dispersion. Cyclic prefix is used to nullify ICI and ISI.
3. Optical OFDM, without complex equalization can easily adjust to severe channel conditions.
4. Efficient implementation by means of FFT.
5. Low sensitivity to time synchronization errors.
6. Capable of power overloading and dynamic bit.
7. Ease of dynamic channel estimation.
8. Extra resistance to fading.
9. High bandwidth (spectral) efficiency since carrier spacing is reduced as the subcarriers in optical OFDM is orthogonal and overlaps with each other.

10. Tolerance to linear impairments - Alike coherent detection QPSK, OFDM can compensate to linear impairments in the electrical field. This is one of the advantages of OFDM, which enables a better tolerance towards PMD and dispersion.
11. Oversampling - One of the important advantages of OFDM is that oversampling can be realized using unmodulated subcarriers. The Nyquist frequency is 5 GHz and sampling rate of the AWG is 10 GHz. In this case, Oversampling is realized by only modulating 190 subcarriers out of the 256 subcarriers. An oversampling factor of 1.34 is realized due to the 66 unmodulated subcarriers. Because of this oversampling, ~2.5 GHz spectral gap is present in between the aliasing products and the OFDM signal. A low pass filter can be used to eliminate the aliasing products.

III.DISADVANTAGES OF OFDM

On the other hand, OFDM offers some disadvantages. The complexity is one of the effective disadvantages of OFDM, where OFDM is a multicarrier modulation (MCM) that is more complicated in comparison to single-carrier modulation and along with this more linear power amplifier is required by OFDM.Some of the disadvantages of OFDM are shown below:

1. Accuracy of the synchronization is very high
2. In order to avoid the orthoganality mismatch, multipath fading should be minimized
3. Superposition of signals cause distortion problem due to peak-to-mean power ratio.
4. More compound than single-carrier Modulation.
5. Requires a more linear power amplifier. In the RF systems, the main problem lies at the transmitter end in the power amplifiers, at which the amplifier gain will saturate on large input power. The power amplifier needs to be operated at “back-off” regime at which the signal power is lesser in comparison to the amplifier saturation power, so to avoid comparatively “peaky” OFDM signal. But for the power amplifier, this needs an excess high saturation power that certainly leads to low power efficiency.
6. It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT. The two major disadvantages of OFDM are phase noise and frequency offset sensitivity which leads to intercarrier interference (ICI) due to its long symbol length in comparison to that of the single carrier. Frequency offset sensitivity can be removed through frequency compensation and estimation . This frequency offset is generally compensated by use of adaptive frequency correction (AFC), and also the phase noise sensitivity is mainly resolved by the careful and proper RF local oscillator design that will satisfy the necessary phase noise specification.
7. One of the most important drawbacks of the OFDM is high PAPR. An OFDM signal is created by addition of a number of independent subcarriers. This can result in a PAPR as soon as all the subcarriers are added coherently, shown in figure 1.20 high peak at time (t=0.23).

V.APPLICATIONS OF OFDM

OFDM is a promising tehnology and provide edge over WDM systems in terms of bandwidth efficiency and channel robustness. Some of the applications are described below

1. OFDM used in digital audio broadcasting.
2. Digital television and high definition TV
3. Local area networks using wireless media
4. Wireless access or WiMax
5. Advanced digital subscribers loop G.992.1
6. Long term evolution
7. Wireless ATM transmission system
8. IEEE 802.11a

VI.CONCLUSION

Orthogonal frequency division multiplexing (OFDM) due to its spectral efficiency has fascinated interest in recent years for the idea to be applied in optical domain for high-speed optical fiber transmission. OFDM plays a major part in the modem telecommunications for both wired and wireless communications. It has been established that optical OFDM is a capable technique of noticeably raising the spectral efficiency in high-speed optical fiber channel, while improving the polarisation mode dispersion (PMD) tolerance. OOFDM- RoF system has fascinated considerable interest for the future gigabit broadband wireless and wired communication. In OOFDM–RoF system, OFDM modulation technique is included into Radio over Fiber (RoF) system. This system includes the advantages of both, as OFDM can allocate the data over huge numbers of subcarriers which are spaced out at particular frequencies with overlapping bands, and on the other hand RoF systems can make use of the optical network’s high capacity all along the mobility of wireless networks. Hence OOFDM-RoF system can be used for long haul as well as short distance transmissions at high data rates. This system enhances the system flexibility without increasing system’s cost as well as complexity. In this Paper, concepts of OFDM have been explained and a review is presented.

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