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Inter Symbol Interference Reduction Using OFDM in Data Transmission

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Abstract— This paper studies reduction of Inter Symbol Interference (ISI) using Orthogonal Frequency Division Multiplexing (OFDM).OFDM is multicarrier data transmission modulation scheme. In multipath data transmission ISI is introduces. Therefore, in OFDM to separate the multisymbols guard bands are added. For reduction of ISI Cyclic prefix (CP) are introduced. CP uses the padding of bit symbols in the system and eliminate the ISI. Peak to average power ratio (PAPR) is also reduce by using clipping.
Keywords— OFDM, ISI,CP,PAPR,Clipping,Guard Band, Padding.

INTRODUCTION

Orthogonal Frequency Division Modulation (OFDM) is very efficient multicarrier method. Conventional transmission uses single carrier, which is modulated with all the data to be sent. In OFDM first break the data into small portions then use a no of orthogonal subcarriers to transmit the data. OFDM have no of advantages like low implementation complexity, high spectral efficiency, low Inter symbol interference(ISI) .Therefore it has been widely used in many systems like, wireless communication systems, Digital audio Broadcasting (DAB) systems, Digital Video Broadcasting(DVB) systems, Wireless Local Area Networks (WLANs) [1].

The basic principle of OFDM is gaining a popularity in wireless transmission systems. OFDM is one of the technique employed in fourth generation wireless systems. In serial data transmission systems data send one by one with frequency spectrum and each symbol occupies its bandwidth , but in high rate data transmission symbol occupies very short duration and there is a chance to introduce ISI[3]. In conventional OFDM, the transmitted signals are Bipolar or Complex. OFDM improves the ISI while communication via multiple transmitting antennas improve the Bit Error Rate (BER) performance of transmission. In OFDM systems Cyclic Prefix (CP) are used to filling the guard space. This scheme utilizes to minimize the ISI and Inter Carrier Interference (ICI), other method is also used which is called Zero-Padding (ZP) and it is proposed where CP is replaced by non-zero padding. In ZP-OFDM zero samples are used to equalization performance [2]. While in CP-OFDM improve the performance of transmission by reducing the ISI and Inter Block Interference (IBI).

OFDM is used in both time domain and frequency domain.

In Time Domain:

$$\int_{-\infty}^{\infty} Xi(t)X_j^*(t)dt = \begin{cases} 1, & i = j \\ 0, & i \neq j \end{cases} \quad (1)$$

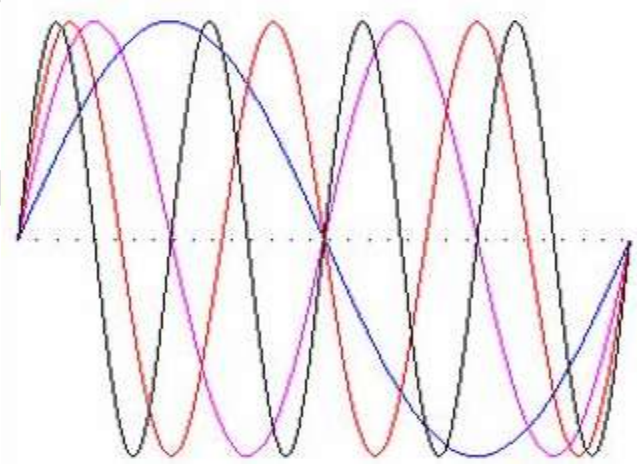

Fig. 1 The four subcarriers within one OFDM symbol

Frequency Domain:

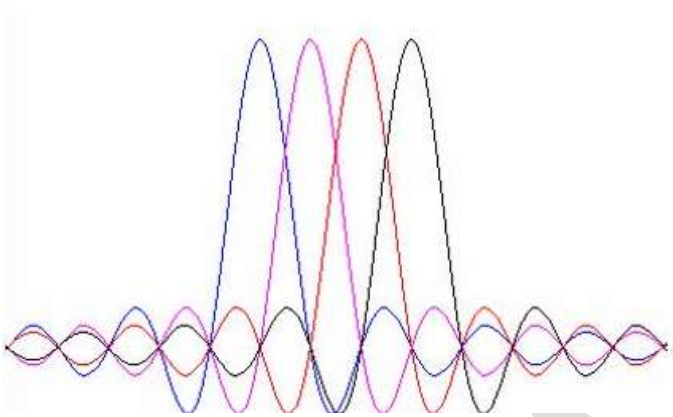

Fig. 2 Spectra of individual subcarriers

$$\int_{-\infty}^{\infty} Xi\,(f)X_j^*(f)df = \begin{cases} 1, & i = j \\ 0, & i \neq j \end{cases} \quad (2)$$

The major drawback of OFDM is Peak to Average Power Ratio (PAPR), So PAPR reduction is required in OFDM. There are no of methods used like clipping, Digital amplitude Predistortion and Residue number method.

BLOCK DIAGRAM OF OFDM

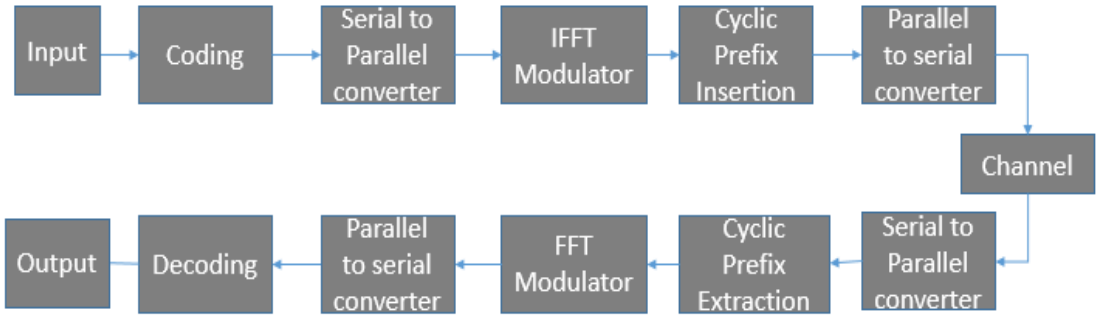

Fig. 3 Data transmission method of OFDM

Transmitter:

Input data signal is baseband modulated signal. Various modulation schemes are used like, BPSK, QAM, DPSK. Data encoded in the form of frame and this frame is called Discrete Fourier Transform (DFT) frame. Modulation is performed at each parallel substream, that is one symbol belonging to adjacent DFT frames. The serial data symbol is converted inti parallel by using serial to parallel converter that is into N different substreams. Each substream will modulate by IFFT modulator. Cyclic prefix is added to eliminate IBI and ISI. The data again converted into serial to form the OFDM symbol. Then OFDM will modulate the high rate data before transmission through the channel. Data is transmitted through the channel, channel may be the single wire cable, Twisted- pair cable or Fiber optic cable.

Receiver:

The data are down converted to the baseband and cyclic prefix are removed. FFT is used to retrieve the exact form of transmitted symbols. The data are then serially converted by parallel to serial converter. Demodulation is done to estimate the transmitted symbols.

FFT and IFFT:

FFT and IFFT are two linear transformations on signals and they are inverse to each other and it is needed for modulation in digital form .In OFDM each channel should modulate by 1 different frequency. Suppose we need 32 frequency then we should implement the system using 32 oscillator and it is expensive , hard to implement and need more space , but by using IFFT and FFT in digital form just 1 oscillator required.

IFFT performs N point IFFT operations . IFFT transform a spectrum into time domain signal. Therefore, output is N point samples. That is IFFT is used to multiplex data stream onto orthogonal subcarriers. According to the mathematical distributions IDFT forming the following equation:

$$x(n) = \sum_{k=0}^{N-1} X[k].e^{jk2\pi n/N}, \quad n = 0,1,.,N-1 \tag{3}$$

$$x(n) = \sum_{k=0}^{N-1} X[k].\left(cosk\frac{2\pi}{N}n\right) + j(sink\frac{2\pi}{N}n)) \tag{4}$$

The received signal in time domain, FFT converts this signal into frequency domain. That is demultiplex data into single stream. The FFT demodulator takes the N time domain transmitted signal and determine the amplitude and phases of sine and cosine waves forming the following equation:

$$X[k] = \frac{1}{N}\sum_{n=0}^{N-1} x[n].e^{-\frac{jn2\pi}{N}k} \quad k=0,1.,N-1 \tag{5}$$

$$X[k] = \frac{1}{N}\sum_{n=0}^{N-1} x[n].((\cos k\frac{2\pi}{N}n) - j\ (\sin k\frac{2\pi}{N}n)) \tag{6}$$

Cyclic Prefix:

OFDM transmits data in blocks. For transmission any channel can be used and this will spread the OFDM symbol they causes the signal blocks interfere to each other. This interference is called Inter Block Interference (IBI) and this leads to ISI. In ISI two symbols will overlap and causes distortion. So to minimize this silence period is added between two transmitted frames, this is known as zero prefix and zero prefix consist of zero samples added to front of each symbol. The effect of before transmitted frame will affect on zero padding portion of frames. Then this samples discarded to receiver and unaffected samples used for demodulation of the signal transmission. But the zero padding is not the permanent solution because zero padding can destroy the periodicity of the carriers and this periodicity is needed for demodulation which is done by FFT.

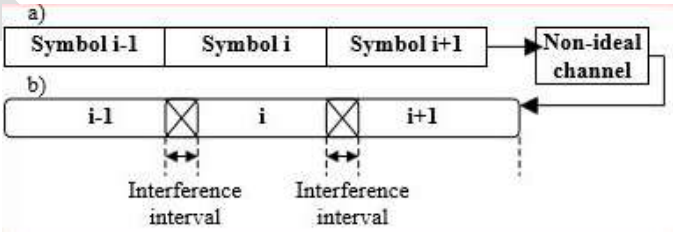

Fig.4 a) The transmitted symbols frame structure
b) The received symbols are overlapping during interference interval

So , instead of zero padding the cyclic prefix are used .CP is use at the beginning of the each symbol and it consist of L samples of the OFDM symbols that are copied in front of the data block. If CP duration span is large than the multipath delay the residual contribution is absorbed by the cyclic prefix samples that are thrown up to the receiver. This is also happen when using zero prefix but by using cyclic prefix receiver carrier synchronization is done. Since some signals are without silence period transmitted and also maintain the carrier periodicity, because periodicity is important to simplify the proper reconstruction of the signal using DFT.

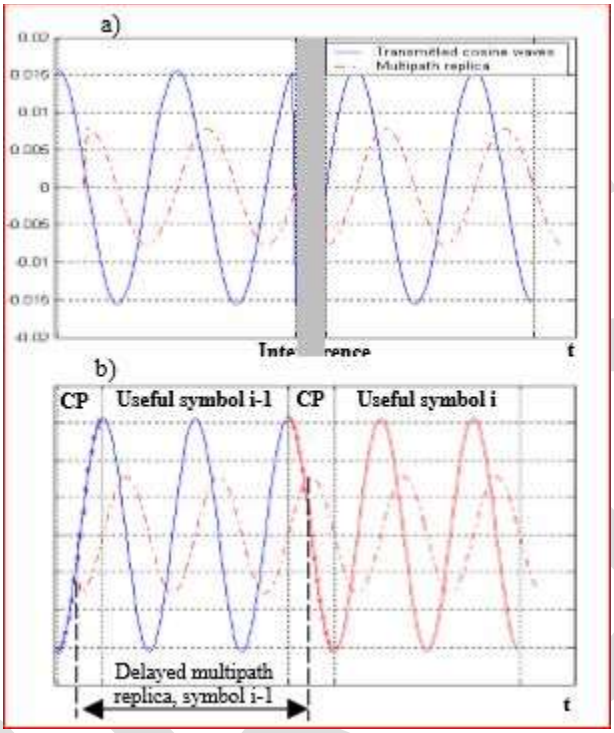

Fig. 5 a)Symbol interference ,b) Cyclic prefix eliminates the ISI

If the guard interval is longer than multipath delay ,the useful content is not discarded to the receiver by the delayed replica shown in fig. b).The delayed replica is affect on the next received signal. It is shown in fig (a) labeled as interference. If a cyclic extension is ,Tg=T/4 (Time duration) Inserted in front of the data the delayed replica of the first symbol will affect the cyclic prefix portion of the second symbol and this is discarded at the receiver. the channel effect on the transmitted signal can be totally eliminated by a simple , frequency domain equalizer.

CONCLUSION

OFDM uses orthogonal frequency subcarriers to transfer the data. Inter symbol interference is minimized by using cyclic prefix by adding multipath delay.

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