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Spectral Efficiency for Orthogonal Frequency Division Multiplexing

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Abstract: *Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multicarrier modulation (MCM) with heavily spaced subcarriers as well as overlapping spectra was patented in the United States of America in 70s. Orthogonal Frequency Division Multiplexing has been popularly utilized in modern days due to its ability for spectral efficiency and robustness to noise and fading. It provides flexibility and agile spectrum allocation in case of cognitive radios. This paper will focus on OFDM research and simulation for enhancement of spectral efficiency. OFDM is especially compatible for high-speed wireless communication due to its resistance to Inter symbol Interference. As in modern days communication systems has increased their data transfer speed, the required time for each transmission has become very short. As delay time due to multipath remains constant, Inter symbol interference became limitation in high-data-rate communication. OFDM avoids this difficulty by transmitting numerous low speed transmissions simultaneously*

Keywords: Orthogonal Frequency Division Multiplexing (OFDM), Spectral Efficiency, Inter symbol Interference(ISI), Inter channel Interference (ICI)

I. INTRODUCTION

In a fundamental communication system, the information is modulated for a single carrier frequency. This information in the form of symbol occupies total available bandwidth. In such a situation, there are maximum chances of creating inter-symbol-interference (ISI). It happens especially at frequency selective channel. The grass root idea of orthogonal frequency division multiplexing is to divide total spectrum into number of orthogonal sub channels to have narrowband Most probably Sub channel faces flat fading. It is possible in OFDM, that sub channels may have overlapping sub in the frequency domain; Due to such arrangement transmission rate gets increased. In recent years orthogonal frequency division multiplexing has increased its interest. European digital broadcast radio system has also used OFDM, ADSL known as asymmetric digital subscriber line in wired environment also using OFDM.XDSL known as digital subscriber lines uses OFDM to provide higher transmission bit rate over twisted wires. OFDM has been majorly used in numerous higher data rate wireless communication network systems due to number of advantages it has. It provides Immunity at selective fading. OFDM appears highly resistant to frequency selective fading as compared to single carrier system. It does happen as overall channel gets divided in to number of segmented narrowband signals , these narrowband signals gets affected as a flat fading channel.

OFDM is also characterized with resilience to interference. These characteristics limit the interference over a channel. So it will not affect sub channels. As OFDM utilizes closely spaced overlapping sub carriers, it enables highly increase in spectrum efficiency. Another property of OFDM which leads to spectral efficiency is resilient to inter symbol interference and inter frame interference. It happens due to low data rate at each sub channel. OFDM is resilient to narrowband effects. Channel coding and interleaving at OFDM enables symbol lost recovery to avoid narrowband effects. Channel equalization at OFDM is much simpler leading toward increased spectral efficiency.

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II. SYSTEM DEVELOPMENT

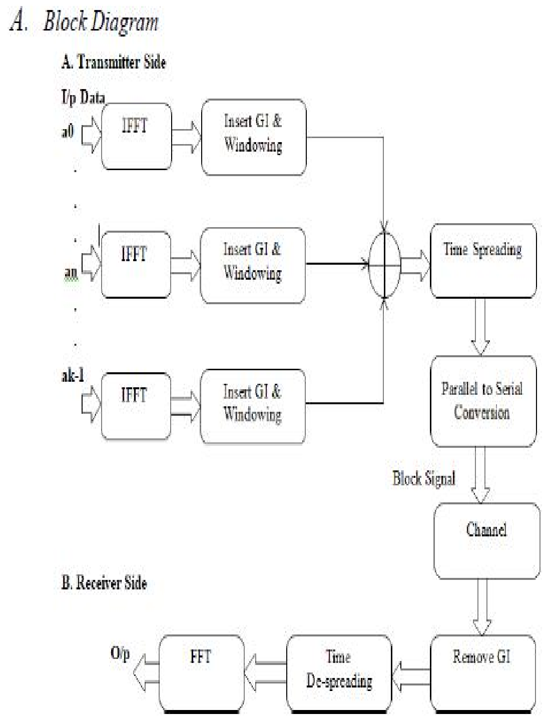

Figure 1:

As shown in figure.1 functional block works as below

1. Inverse fast Fourier transform (IFFT)*:

As shown in block diagram a0, an & a k-1 is frequency domain signals. These signals are converted in to time domain signal using IFFT block. The proposed system is based on time spreading hence it become essential to convert signal in to time domain signal first.

2. Insertion of GI and windowing:

In OFDM, the beginning of each symbol is preceded by a guard interval. As long as the echoes fall within this interval, they will not affect the receiver's ability to safely decode the actual data, as data is only interpreted outside the guard interval. Windowing method is used for efficient spectral shaping in orthogonal frequency division multiplexing (OFDM) based systems.

3. Time spreading

Time spreading and windowing both used to reduce both the frequency and time overhead. Time spreading converts signal in to block structured signals. These block structured signals helps to improve spectral efficiency.

4. Parallel to serial conversion

All these converted block structures are converted in to serial data before transmission over communication channel.

5. Removal of Guard Interval

To get original data at receiver side first step is to remove guard intervals inserted at transmitter between the signals. Once it is removed signal is fed to time spreading block.

6. Fast Fourier transform

The output of time de spreading block is in time domain format. To get signal in its original for that means in frequency domain format. The proposed system applies fast Fourier transform.

III. RESULTS AND CONCLUSION

In proposed system Signal to noise ratio vs spectral efficiency with and without channel coding is plotted and compared against F-OFDM. The proposed system is implemented over MATLAB platform. Implemented system clearly shows that signal to noise ratio is inversely proportional to bit error rate. As well as signal to noise ratio is analysed against spectral efficiency also. With increased signal to noise ratio, spectral efficiency is also increasing.

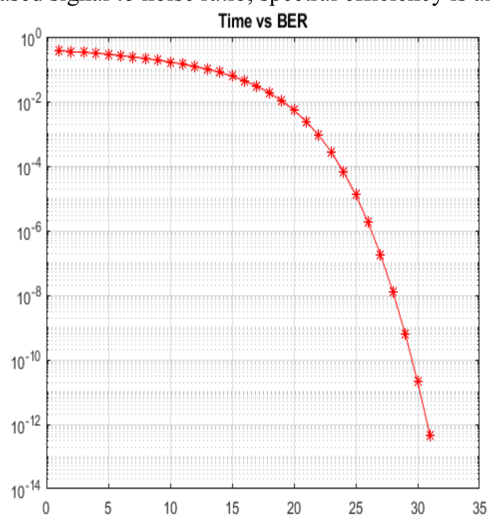

Figure 2

Figure shows graph of Time vs. Bit Error Rate. As time increases BER goes on decreasing. Which shows using decreasing exponential.

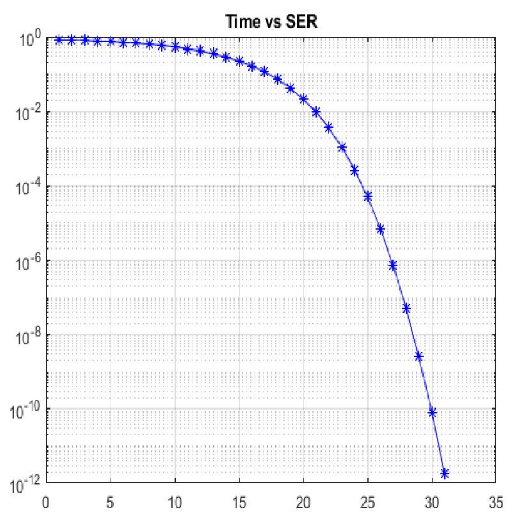

Figure 3

Figure shows a graph of Time vs. symbol error rate (SER).In which as time increases symbol error rate decreases in decreasing exponential.

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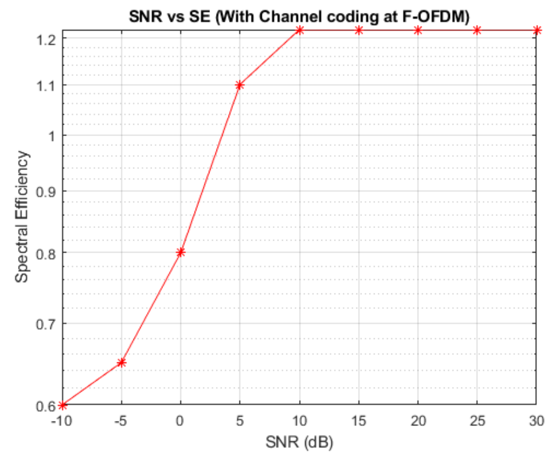

Figure 4

Figure shows a graph of Signal to Noise Ratio (SNR) VS Spectral Efficiency (SE) with channel coding at Filtered OFDM (F-OFDM).Which shows spectral efficiency increases with signal to noise ratio as increasing exponential. At specific value of SNR spectral efficiency became constant.

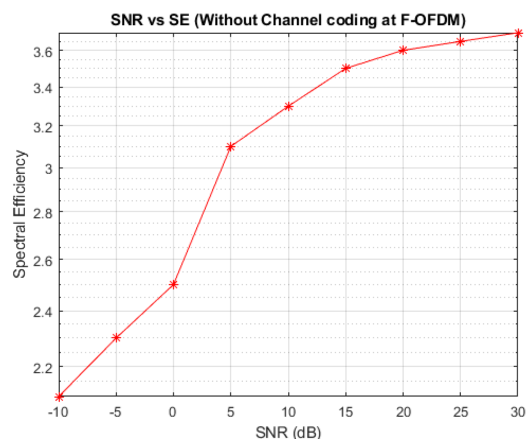

Figure 5

Figure shows graph of SNR vs. Spectral Efficiency (SE) without channel coding with Filtered OFDM (F-OFDM). Graph shows spectral efficiency exponentially increases

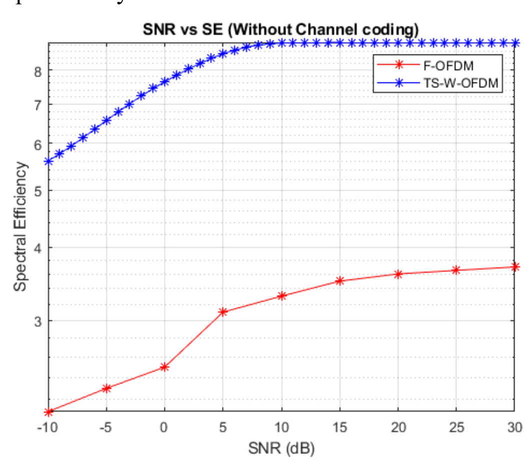

Figure 6

Graph shows result of spectral efficiency of Filtered OFDM (F-OFDM) & Time Spread Windowed OFDM (TS-W-OFDM) without channel coding.

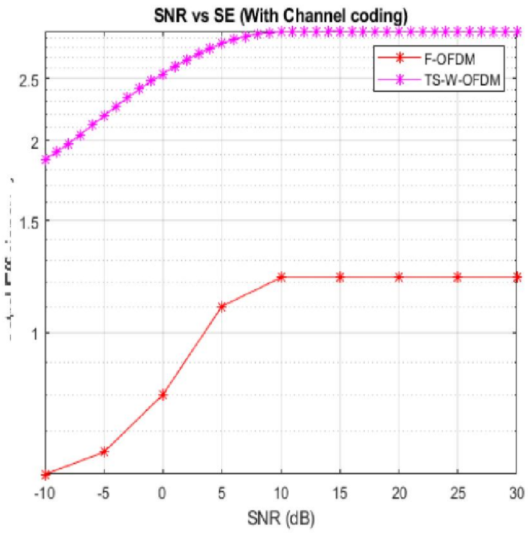

Figure 7

Graph shows result of spectral efficiency of Filtered OFDM (F-OFDM) & Time Spread Windowed OFDM (TS-W-OFDM) with channel coding

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