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ANALYSIS OF DIFFERENT MODULATION TECHNIQUES IN LTE SC-FDMA UPLINK

Ankita Bhatia[1] and Pooja Sharma[2]
[1]M.Tech Scholar, GGGI Dinarpur, Ambala, Haryana, India
[2]Assistant Professor, GGGI Dinarpur, Ambala, Haryana, India

ABSTRACT

The modern digital transmission systems offer better reliability in noise environment comparing to their analog counterparts. However, because of involvement of digital signals these systems are usually accompanied with a phenomenon known as inter symbol interference (ISI). In this phenomenon, the transmitted pulses are smeared out because of which the pulses corresponding to different symbols are not separable. The key reasons of ISI are multi-pathing and Doppler effect. In multi-pathing, the signal is received at same time through different paths of different delay which causes inter symbol interference. In addition, the wireless channel is usually dispersive. The result of data transmission over such a channel is that each received pulse is affected by adjacent pulse. This frequency-selective fading gives rise to ISI, where the received symbol over a given symbol period experiences interference from other symbols. As increasing signal power also increases the power of the ISI, this interference gives rise to an irreducible error floor that is independent of signal power. The irreducible error floor is difficult to analyze, as it depends on the ISI characteristics and the modulation format. The ISI characteristics further depend on the characteristics of the channel and the sequence of transmitted symbols.

***Keywords**: LTE UPLINK, SC-FDMA, ISI.*

INTRODUCTION

1. Inter symbol interference in digital transmission systems

The modern digital transmission systems offer better reliability in noise environment comparing to their analog counterparts. However, because of involvement of digital signals these systems are usually accompanied with a phenomenon known as inter symbol interference (ISI). In this phenomenon, the transmitted pulses are smeared out because of which the pulses corresponding to different symbols are not separable [1], as can be seen in Figure 1. The key reasons of ISI are Multi-pathing and Doppler Effect. In multi-pathing, the signal is received at same time through different paths of different delay which causes inter symbol interference. In addition, the wireless channel is usually dispersive. The result of data transmission over such a channel is that each received pulse is affected by adjacent pulse. This frequency-selective fading gives rise to ISI, where the received symbol over a given symbol period experiences interference from other symbols. As increasing signal power also increases the power of the ISI, this interference gives rise to an irreducible error floor that is independent of signal power. The irreducible error floor is difficult to analyze, as it depends on the ISI characteristics and the modulation format. The ISI characteristics further depend on the characteristics of the channel and the sequence of transmitted symbols. ISI usually arises in all pulse-modulation systems, including Frequency-shift keying (FSK), Phase-shift keying (PSK), and Quadrature amplitude modulation (QAM). Figure 1 shows the transmitted signal on the left and the received signal (affected by ISI) at the receiver shown on the right. The change in shape of the received signal is due to the pulse shaping at the transmitter end.

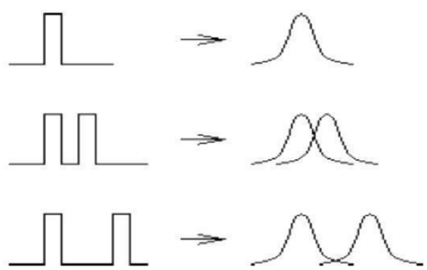

Fig 1: Inter Symbol [1].

The effect of ISI can be reduced using equalizers. These are based on equalization technique. There are also other processing techniques such as spread spectrum and multicarrier modulation that are used on the transmitter side to reduce the effects of ISI at the receiver end. Therefore, the research reported in this dissertation is focused on the equalization technique used in modern wireless communication systems such as SC-FDMA based long term evolution (LTE) systems.

BIT ERROR RATE AND SIGNAL TO NOISE RATIO

1 Bit Error Rate (BER):-

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. The bit error probability pe is the expectation value of the BER. The BER can be considered as an approximate estimate of the bit error probability. This estimate is accurate for a long time interval and a high number of bit errors. Measuring the bit error rate helps people choose the appropriate forward error correction codes. The BER may be improved by choosing strong signal strength by choosing a slow and robust modulation scheme or line coding scheme, and by applying channel coding schemes such as redundant forward error correction codes. Binary symmetric channel which is used in analysis of decoding error probability in case of non bursty bit errors on Additive white Gaussian noise (AWGN) channel without fading. A worst case scenario is a completely random channel, where noise totally dominates over the useful signal. In a noisy channel, the BER is often expressed as a function of the normalized carrier-to-noise ratio measured denoted Eb/N0 that is energy permit to noise power spectral density ratio, or Es/N0 that is energy per modulation symbol to noise spectral density. As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula: BER = number of errors / total number of bits sent, If the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered. The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used). Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. Bit error rate BER is a parameter which gives an excellent indication of the performance of a data link such as radio or fiber optic system. As one of the main parameters of interest in any data link is the number of errors that occur, the bit error rate is a key parameter. Knowledge of the BER also enables other features of the link such as the power and bandwidth, etc to be tailored to enable the required performance to be obtained.

2 Signal to Noise Ratio (SNR)

Signal to noise ratios (Eb/No) are parameters that are more associated with radio links and radio communications systems. In terms of this, the bit error rate, BER, can also be defined in terms of the probability of error (POE). The determine this, three other variables are used. They are the error function (erf) the energy in one bit (Eb) and the noise power spectral density. It should be noted that each different type of modulation has its own value for the error function. This is because each type of modulation performs differently in the presence of noise. In particular, higher order modulation schemes (e.g. 64QAM, etc) that are able to carry higher data rates are not as robust in the presence of noise. Lower order modulation formats (e.g. BPSK, QPSK, etc.) offer lower data Rates but are more robust. The energy per bit (Eb) can be determined by dividing the carrier powerby the bit rate and is a measure of energy with the dimensions of Joules. No is a power per Hertz and therefore this has the dimensions of power (joules per second) divided by seconds. Looking at the dimensions of the ratio Eb/No all the dimensions cancel out to give a dimensionless ratio. It is important to note that POE is proportional to Eb/No and is a form of signal to noise ratio. By manipulating the variables that can be controlled it is possible to optimize a system to provide the performance levels that are required. This is normally undertaken in the design stages of a data transmission system so that the performance parameters can be adjusted at the initial design concept stages. The interference levels present in a system are generally set by external factors and cannot be changed by the system design. However it is possible to set the bandwidth of the system. By reducing the bandwidth the level of interference can be reduced. However reducing the bandwidth limits the data throughput that can be achieved. The mathematical expression of SNRis

3 Additive White Noise Gaussian (AWGN)

The term thermal noise refers to unwanted electrical signals that are always present in electrical systems. The term additive means the noise is superimposed or added to the signal where it will limit the receiver ability to make correct symbol decisions and limit the rate of information. Thus, AWGN is the effect of thermal noise generated by thermal motion of electron in all dissipative electrical components i.e. resistors, wires and so on. Mathematically, thermal noise is described by a zero-mean Gaussian random process where the random signal is a sum of Gaussian noise random variable and a dc signal

4 Rayleigh Fading

Since signal propagation takes place in the atmosphere and near the ground, apart from the effect of free path loss (Ls) the most notable effect of signal degradation is multipath propagation. The effect can cause fluctuations in the received signal's amplitude, phase and angle of arrival, giving rise to terminology multipath fading. Generally, there are two fading effects in mobile communications: large-scale and small-scale fading. Large-scale fading represents the average signal power attenuation or path loss due to shadowing effects when moving over large areas. On the other hand, small-scale fading refers to the dramatic changes in signal amplitude and phase that can be experienced as a result of small changes (as small as a half-wavelength) in the spatial separation between a receiver and transmitter.

INTRODUCTION OF SC-FDMA

LTE has recently come up as a solution to modern wireless communications systems. It is vastly and rapidly used because of its promising high speed and ability to handle multi-data at same time. This is why it is a subject of interest in research reported in this dissertation. The modulation used in the uplink of LTE is SC-FDMA, also often referred to as Fourier spread FDMA. The reason for favoring SC-FDMA in the uplink over orthogonal frequency division multiple access (OFDMA) is its reduced peak-to-average power ratio (PAPR) compared to OFDMA. The principal design ofa SC-FDMA communication system is shown in Figure (2).

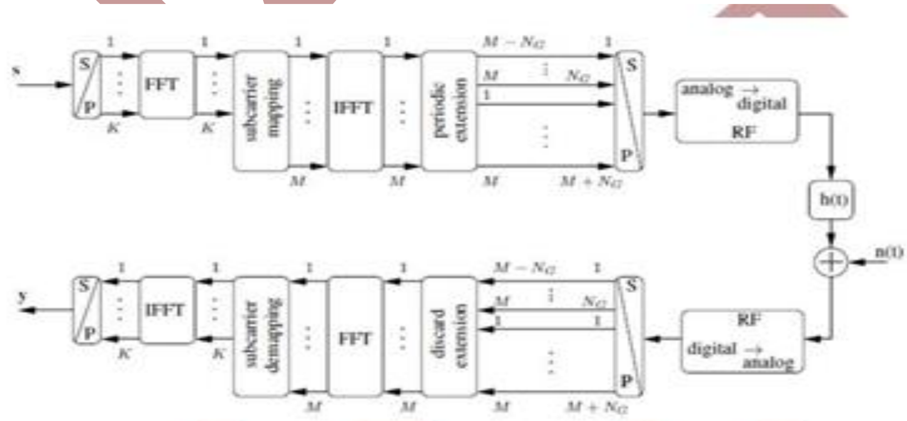

Figure 2: Signal processing for SC-FDMA [8].

Then the spread transmit symbols are mapped on the subcarriers of the OFDMA subsystem. This can be either performed localized (i.e. to a continuous block of subcarriers) or distributed (i.e. equally spaced over the subcarriers of the OFDMA system). Although the distributed mapping exhibits a lower PAPR than the localized mapping, it is favored over the distributed mapping due to an easier scheduling between the users and smaller vulnerability against frequency offsets. The mapped and spread symbols are transmitted over the channel using conventional OFDMA modulation. The conversion to the frequency domain is performed using an inverse FFT (IFFT), with the size of the IFFT depending on the subcarrier spacing and the total amount of bandwidth available in the system. After the transmission over the channel and the addition of white Gaussian noise, the received signal is demodulated by performing the inverse operations of the modulator. To keep the complexity for the simulations on a tolerable level, the maximum size of the IFFT in the transmitter is fixed to 512. Thus a maximum of 300 subcarriers are usable according to the specifications. Thus, OFDM based SC-FDMA is a multicarrier modulation technology, and can provide high spectral efficiency, low implementation complexity, less vulnerability to echoes and non– linear distortion. Because of these advantages of SC-FDMA system, it is vastly used in various modern communication systems. However, there are few problems such as fading, Multipath and ISI associated with implementing OFDM. These are associated with each other and one phenomenon is the cause of other. This is a key problem to SC-FDMA and causes hindrances to provide a reliable transmission over the LTE. Modern wireless communication systems mostly use coherent demodulation. In case of coherent demodulation (say QAM), the receiver is assumed to be able to generate reference signals; whereas, their phase and frequency are identical to those of the transmitted signals. However, a number of factors can affect the carrier phase and frequency of received signals in wireless communication systems, i.e. SC-FDMA in LTE. At receiver, the carrier phase and frequency can be recovered using equalizers. This is very essential for modern communication systems such as LTE. Equalization is a processing technique used on any signal at the receiver to counter act the effects of ISI. As discussed above, the frequency-selective fading gives rise to ISI, where the received symbol over a given symbol period experiences interference from other symbols that have been delayed by multipath. As increasing signal power also increases the power of the ISI, this interference gives rise to an irreducible error floor that is independent of signal power. Improved SNR at the receiver end may be acquired when use duo binary signaling with training sequence.

RESULTS

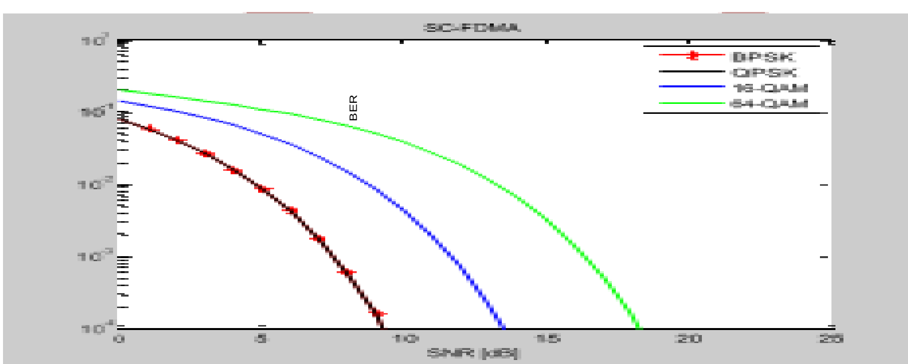

Fig 3: Plot of Ber Vs Snr for Different Modulation Scheme

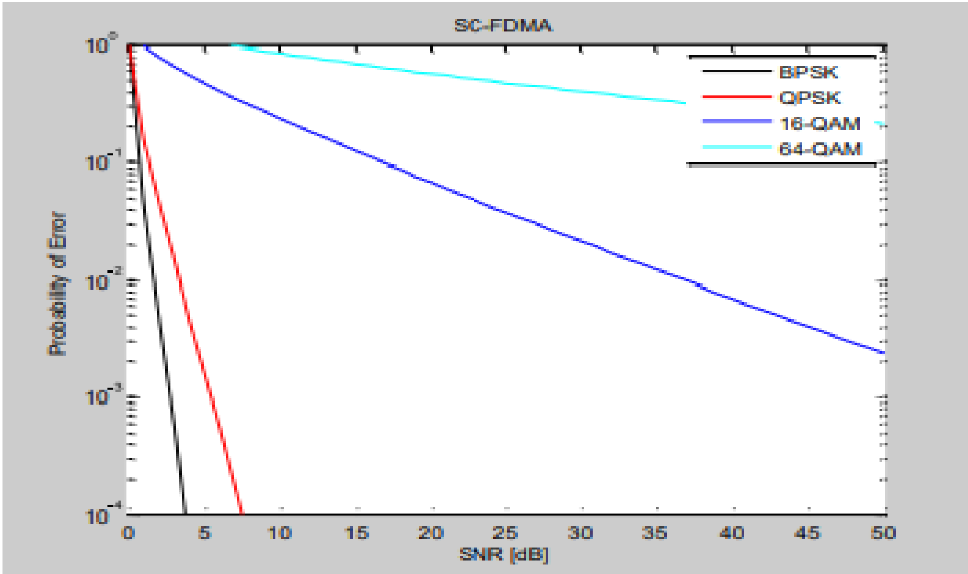

Fig 4: Plot of Error Probability for Diff Modulation Scheme

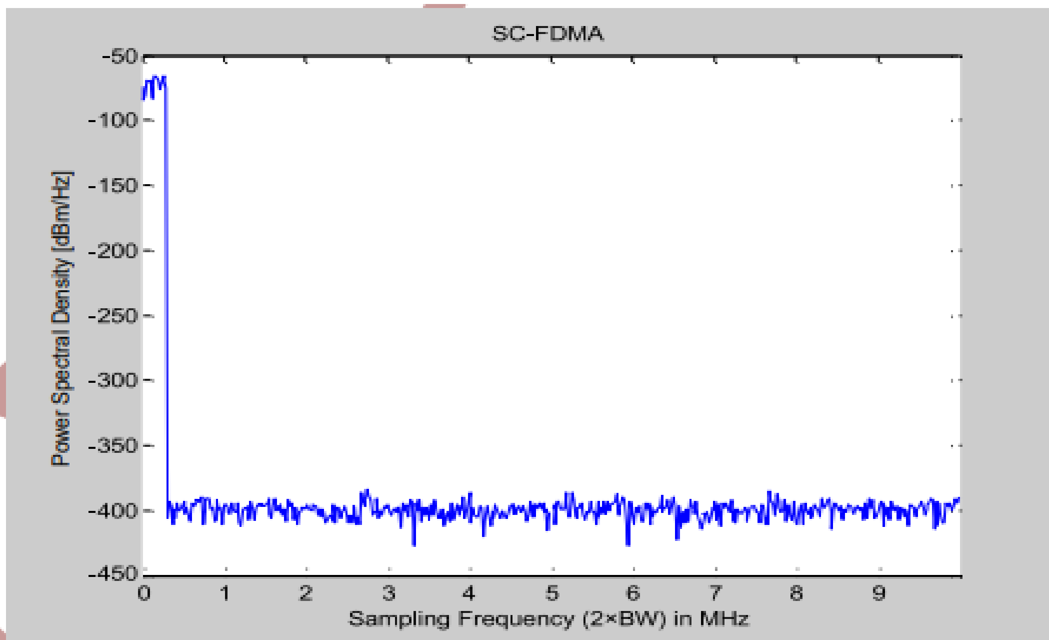

Fig 5: Power Spectral Density of Sc-Fdma

CONCLUSION

The research through this paper will be focused on implement of LTE SC-FDMA uplink for the wireless channels. We obtained the BER for different modulation scheme like as (BPSK, QPSK, 16-QAM, 64QAM) in SC-FDMA in which BPSK modulation has minimum BER. In this paper also show the graph of error probability for different modulation scheme and BPSK modulation has lowest probability of error.

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