OFDM Modeling and Analysis

Meera rose Benny
Department of Electronics and Communication
Amal Jyothi College of Engineering

***Abstract*- orthogonal frequency division multiplexing is a powerful modulation technique. It has been adopted in most wireless communication standard. The objective of this paper is to carry-out an efficient implementation of OFDM system using Simulink. It also evaluates the performance of system under various conditions such as different modulation scheme, different channels, and different delay models. Performance evaluation is done by calculating BER for each case and comparing them.**

Keywords- ***OFDM, Bit error rate (BER); Signal to Noise Ratio(SNR), Adaptive modulation; Rayleigh channel,AWGNchannel, Channel state information(CSI)***

I.INTRODUCTION

The increased use of wireless communication demands the need for high data rate and channel capacity. OFDM technology is capable of solving inter-symbol interference problem encountered with high data rate across multiple channels. The orthogonality of subcarriers in OFDM makes it possible to use different modulation schemes in different subcarriers. OFDM is a powerful technique used in communication system suffering from frequency selectivity. With the use of adaptive modulation OFDM proves to be robust against channel delay spread. Furthermore it leads to significant data rate with improved bit error performance.[1]

II SYSTEM MODEL

The input bit stream is divided into different sub streams and is modulated using a constellation mapper. Constellation mapper represents symbols selected by a particular modulation scheme in the complex plane. The encoded symbols are then multiplexed to a number of subcarriers by the inverse Fast Fourier transform (IFFT) and followed by a parallel-to-serial conversion. The output of the mapper is given to the IFFT block which provides orthogonality to the signal. A cyclic prefix containing a copy of last samples of the parallel-to-serial converted output of the N-point IFFT is then appended. The cyclic prefix is added to an OFDM symbol in order to combat the effect of multipath. Inter-symbol interference is avoided between adjacent OFDM symbols by introducing a guard period in which the multipath components of the desired signal are allowed to die out, after which the next OFDM symbol is transmitted. A useful technique to reduce complexity of the receiver is to introduce a guard symbol during guard period. Specifically this guard symbol is chosen to be a prefix extension of each block. The cyclic prefix turns linear convolution into circular convolution such that the channel is diagonalized by FFT. However, in order to do this guard interval should be greater than delay spread. Thus relative length of cyclic prefix depends on the ratio of the channel delay spread to the OFDM duration. The number of bits assigned to each subcarrier is a variable based on the signal to noise ratio.
In the receiver the individual signals are passed through OFDM demodulators which first discard the CP and then perform an N-point FFT. The output of OFDM demodulators are finally separated and decoded. The final receiving data are recovered by removing the pilot signals, demodulation, de-interleaving, and decoding of the OFDM receiver output signals. The assumption of the length of the CP being greater than or equal to the length of the discrete-time base-band channel impulse response guarantees that the MIMO fading channel indeed decouples into a set of parallel MIMO fading channels.[5]

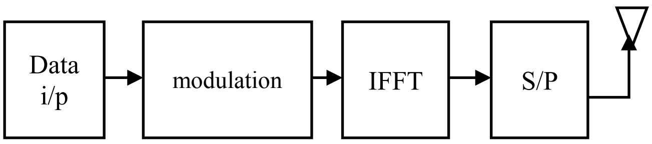

Fig: 1 Block Diagram of Transmitter Section

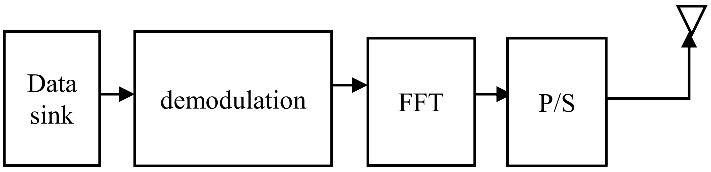

Fig: 2 Block Diagram of Receiver Section

III ADAPTIVE MODULATION

In OFDM, adaptive modulation is a technique of using different modulation modes in different subcarriers depending on instantaneous signal to noise ratio (SNR) ratio for each sub-channel. Channel conditions are estimated at the receiver and CSI is sent to transmitter to adapt the transmission accordingly. Parameters like transmitted power required, numbers of bits on each sub-carrier modulation scheme or combination of these can be adapted according to the channel condition. Nearly, all communication system requires some target BER as a constant. Another assumption that can be made is the knowledge of CSI for each subcarrier. When no adaptation is done, the system presents low SNR.[3][4] To maintain targeted BER, it is necessary to compensate the state of channel by adapting transmitted power level.

ISSN: 2278-0181

IV OFDM SIMULATION RESULTS

1. Frequency Domain Signal Obtained from Simulink model.

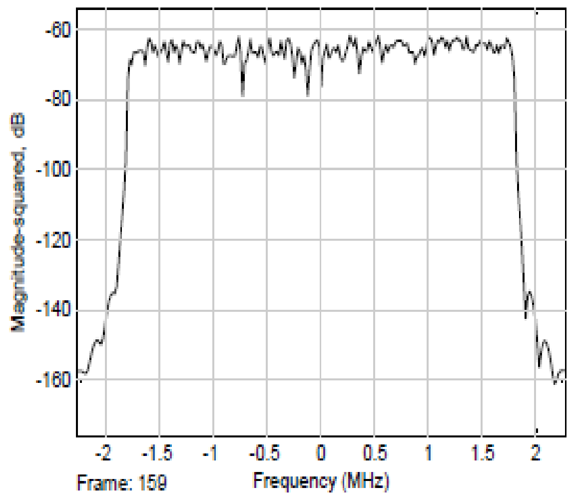

Fig:3: OFDM Signal in Frequency Domain

2.The Effect of Additive White Gaussian Noise (AWGN) to OFDM signal.

The effect of Additive White Gaussian Noise (AWGN) channel to the performanceof the OFDM system for two modulation techniques namely BPSK and QPSK are shown in the fig 4. It can be observed from the above figure to achieve a BERof 10-3, the OFDM system using BPSK modulation needs at least a SNR of 11dB, the OFDM system using a QPSK modulation needs at least14dB. It can also be analysed that since OFDM technique is not intended to overcome the effect of AWGN, hence the performance of OFDM is similar to a BPSK, QPSK, and single carrier digital transmission. However, the OFDM has an ability to overcome the effect of burst error. Due to sudden noise such as lightning by using parallel data transmission, so that instead of several adjacent bits being completely error, many symbols are only slightly distorted, and they can be fixed using a simple Forward Error Correction (FEC) method.[6]

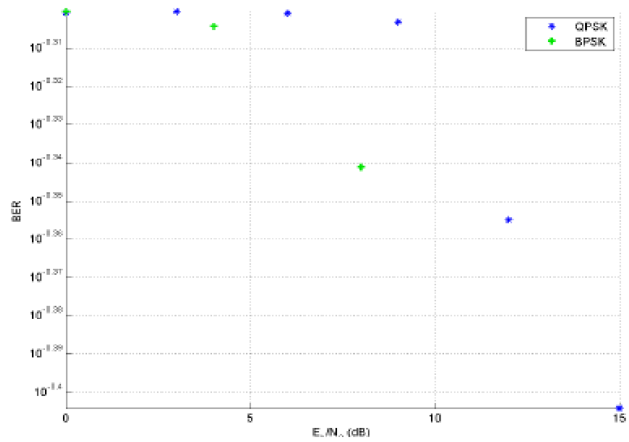

Fig:4:Comparisonof Different Modulation Schemes

3.Effect of Fading Channel on the performance of OFDM Signal:

Figure 5 shows the performance of the OFDM signal in the Fading channel versus that in normal AWGN channel. The fading channel used in the above case is that of the RayleighFadingChannel. The modulation used in this case is the QAM modulation. It is very much evident from the graph that OFDM is very muchtolerabletothefadingeffectinthechannel.Toachieve a BER of 10-3 in a fading channel approximately SNRof33dB isrequired. In case of a normal channel that SNR value isaround 27dB. So we can seeeven If34thechannelcharacteristic is changing drastically the SNR requirement is not muchaffected.Only an additional 6dB is required. So it is evident that OFDM scheme is very robust to thechannel fading effects like Rayleigh fading or frequency selective fading.[7][8]

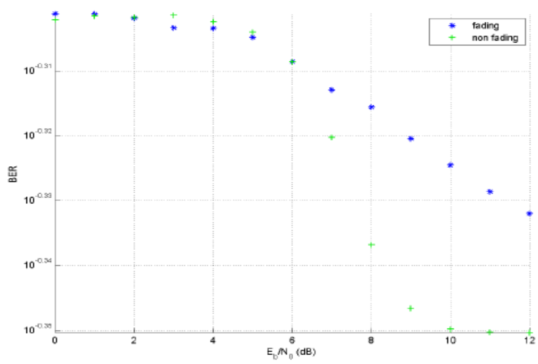

Fig:5: Effect on fading and Non Fading Channels

4. The effect of Doppler Shift on performance of OFDM Signal:

The study of the effect of Doppler Shift in Fading Channel on the Bit Error Rate in the signal transmission in OFDM system is done using the model designed using SIMULINK. It can be seen that BER tends to lower at very high Doppler shift and very low Doppler shift.[4]

ISSN: 2278-0181

5. The effect of SNR on constellation Diagram

At very low SNR the constellation appears to be scattered. But as the SNR increases the BER appears to be decreasing, that can be viewed by the significant change in the appearance of the constellation diagram. QPSK modulation needs at least 20 dB for BER to be of order 0.001.

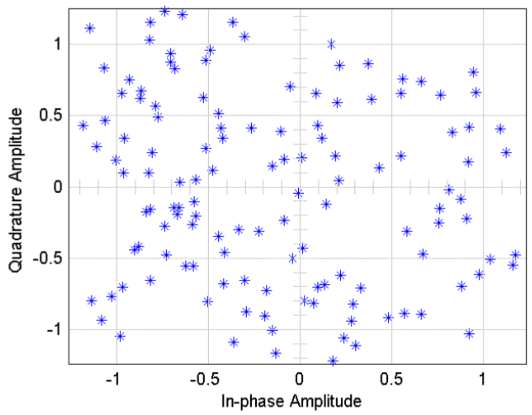

Fig:6: Constellation Diagram at SNR=1

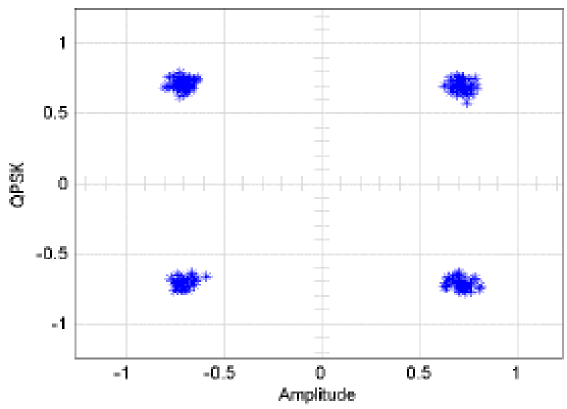

Fig:7: Constellation when SNR=20

ADAPTIVE SWITCHING MECHANISM

Hence from the above studies, an adaptive switching mechanism could be inbuilt into the simulink model, that estimates SNR and correspondingly choose the required modulation scheme, so as to lower the bits in error at the receiver. This is done based on the feedback provided from the estimated SNR to the modulator. Consider the case where SNR is 1, and then simple BPSK modulation could be employed rather than higher order modulation schemes that reduces the complexity as well as the cost. But for this a threshold limit may be specified by the user which is used for the comparison with estimated SNR.

CONCLUSION

In this paper the performance of OFDM system has been studied. Its performance in the presence of noise, various fading effects like multipath fading, frequency selective fading, and Doppler Effect has been analysed.

It has been found that –

1. From the BER vs. SNR for a fading channel, it was observed that OFDM is very tolerant to the channel fading effects. Although, the BER for higher SNR is somewhat greater in a fading channel than an AWGN channel but the difference is very less and the two responses are almost similar. Hence it can be concluded that OFDM is suitable for use in a fading channel.
2. The effect of Doppler shift on the performance of OFDM system has also been analysed. It was observed that at very high and very low Doppler shift frequency, BER tends to increase and have a high value as compared to that in the mid-frequency region.
3. Full-filling an adaptive switching mechanism based on the estimation of SNR at the receiver enables us to lower the BER by, choosing the corresponding modulation scheme as required.
4.OFDM promises to a suitable technique for data communication in a mobile radio channel and is going to play a major role in wireless communication in present and future.

REFERENCES

[1] Guillermo Acosta, *OFDM Simulation using MATLAB,* August 2000.
[2] Anibal Luis, Orthogonal Frequency Division Multiplexing
[3] Simon Haykins, *Communication Systems*, Wiley Publication
[4] T.Rappaport, *Wireless Communications, Principle and Practice,IEEE Press*, Prentice Hall1996
[5] H.Bolcskei and A.J.Paulraj,*Space –frequency coded broad band OFDM systems*,in Proc. IEEE WCNC-2000,Chicago,II,Sept.2000,pp.1-6.
[6] Anupriya et al,*International Journal of Emerging Technologies in Computational and Applied Sciences*,5(6),June-August,2013,pp.561-567
[7] Monika Jain,Sandeep Singh and MeghGupta, *Optimal modulation and coding for spatial multiplexing under flat fading channel*,IOSR Journal of Engineering(IOSRJEN)Vol.3,Isseue 6(June2013)
[8] Nuzhat Tanseem Awon, Md.Mizanur Rahman,Md Ashraful Islam,A.Z.M. Touhidul Islam,*Effect of AWGN &Fadin(Rayleigh and Rician) channels on BER performance of WiMAX communication System*,(IJCSIS) International Journal of Computer Science and Information Security,Vol.10,No.8,August 2012