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Channel Estimation in SC-FDMA using Flower PollinationAlgorithm (FPA)

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Abstract— An important factor for any wireless communication system is estimation of its channel and channel parameters. In order to achieve good performance a communication receiver needs to know the impact of channel on received signal. This is called channel estimation. The motive of a channel estimation process is to minimize Mean Squared Error (MSE) between desired signal and received signal. Different channel estimation algorithm had been designed so as to achieve high performance. Using channel estimation algorithm impulse response of a channel and its behaviour can be approximated. By employing channel estimation techniques, coherent demodulation technique can be implemented at the receiver. In communication system for channel estimation a known signal sequence called pilot signals are inserted at specific location within the information signal. These symbol sequences allow receiver to extract channel attenuations and phase rotation estimates for each received symbol. By identifying channel parameters error in the received signal can be reduced. In this paper comparison of FPA optimization and without optimization with Rayleigh channel in 16, 32 and 64 bit modulation is performed.

Index Terms—optimization, FPA modulation, channel

I. INTRODUCTION

The wireless applications have now grown much rapidly. There is a demand of high quality as well as high speed in wireless communication applications. To cater to it, International Mobile Telecommunication (IMT) proposed 3rd Generation partnership project (3GPP) LTE system. The features of LTE system are as under:

1. To provide End-to-End quality service.
2. To provide high download rates of about 30Mbps and upload rates of 75Mbps.
3. To expand the capacity of cell so as to accommodate 200 active users.
4. To support user mobility of around 350Km/hr.

So as to provide these features, 3GPP Long Term Evolution system has adopted OFDMA for its down link transmission and SC-FDMA for its Uplink transmission. OFDM is a powerful and efficient modulation technique employed in wireless communication systems. OFDM uses orthogonal subcarriers to convey information to the receiver. OFDMA or Orthogonal Frequency Division Multiple Access is an OFDM based scheme which enables multiple users to access the channel simultaneously. OFDMA is preferred as it provides high data rate and can eliminate the problem of Inter Symbol Interference (ISI). It utilises spectrum efficiently and also provides robustness towards various multipath fading phenomenon.

An important issue of an OFDMA based system is its transmitted signal Peak-to-Average- Power Ratio (PAPR). In OFDMA superposition of many time-domain data subcarriers results in high values of PAPR. As large numbers of subcarriers are employed during transmission, this results in a time-domain signal exhibiting a Rayleigh characteristics and large amplitude variations in time domain. These large peaks of signal require power amplifiers of high power. The increase in the level of the signal causes various nonlinear distortions which leads to inefficient operation of power amplifiers. So, OFDMA has a disadvantage of high PAPR which causes increase in the size of user terminal and thus causes increase in overall cost of the system.

In Long term evolution (LTE) system OFDMA is adopted only for downlink transmission. As a substitution to the problem of PAPR, 3GPP LTE had employed SCFDMA system for its uplink transmission. SCFDMA based communication systems provide low Peak-to-Average-Power Ratio, which in turn utilises the power amplifiers more efficiently and saves battery power of User equipment.

A. Single Carrier- Frequency Division Multiple Access (SC-FDMA)

Single carrier frequency division multiple access is a multiple access technique employed for transmitting signal in uplink and is employed in 3rd generation partnership project (3GPP) Long Term Evolution system. SC-FDMA is basically linearly pre-coded OFDMA.

SC-FDMA signal is basically an OFDM signal in which data symbols in time-domain are transformed into frequency-domain by using discrete Fourier transform process.

At the SCFDMA transmitter, a baseband modulator maps the input bits stream into a sequence of complex numbers by using various modulation techniques like BPSK, QPSK, 16QAM, 64QAM etc. After this, the transmitter will group the modulation symbols into blocks which contain N different symbols. The transmitter then performs N-point DFT operation to convert signal into its frequency domain representation. The transmitter then maps each of its output N-DFT to any one of the M ($>N$) different orthogonal sub-carrier signal. A M-point IDFT operation then transforms these subcarrier amplitudes into a time domain signal.

Three different sub carrier mapping techniques are employed:

1. Distributed subcarrier mapping: In this mode, N different DFT output signal are distributed over the entire bandwidth of the system. This is known as distributed FDMA or DFDMA.
2. Localized subcarrier mapping: In this mode, outputs of DFT block are assigned to N consecutive subcarriers with total M numbers of subcarriers (M>N) available. This is called Localized FDMA or LFDMA.
3. Interleaved subcarrier mapping: In this mode, the DFT outputs are distributed employing an equal distance between the occupied subcarriers. This is called Interleaved FDMA or IFDMA. In IFDMA output is allocated over the entire system bandwidth.

B. Channel Estimation:

In order to achieve good performance a communication receiver needs to know the impact of channel on received signal. This is called channel estimation. An important factor for any wireless communication system is estimation of its channel and channel parameters. The motive of a channel estimation process is to minimize Mean Squared Error (MSE) between desired signal and received signal. Different channel estimation algorithm had been designed so as to achieve high performance. Using channel estimation algorithm impulse response of a channel and its behaviour can be approximated. By employing channel estimation techniques, coherent demodulation technique can be implemented at the receiver. In communication system for channel estimation a known signal sequence called pilot signals are inserted at specific location within the information signal. These symbol sequences allow receiver to extract channel attenuations and phase rotation estimates for each received symbol. By identifying channel parameters error in the received signal can be reduced. The aim of most channel estimation algorithms is to minimize the mean squared error (MSE), while utilizing little computational resources in the estimation process.

II. LITERATURE REVIEW

Prittu Ann Thomas et al. in [1] had presented a survey on different modulation schemes which have higher performance for use in uplink communication. The authors had analysed OFDM scheme as a choice for high data rate wireless communication system. OFDM system provides tolerance towards multi-path delay spread and it is also robust to channel dispersions. One of the major limitations of OFDM considered is the large variation in signal amplitude which gives it a high value of PAPR. So the OFDM signals with high PAPR suffer from problem of nonlinear distortion due to non-ideal behaviour of High Power amplifiers. Also it is detrimental for battery powered devices like mobile phones which are power limited.

Hyung G. Myung in [2] gave an overview of SC-FDMA based system. The authors explained the complete SC-FDMA process. It gave a detail insight of the different techniques used by SCFDMA transmitter and receiver. The author gave PAPR characteristics of SCFDMA based system and also channel dependent resource scheduling scheme of SC-FDMA system.

Mohammad Irfanet al. in [3] presented a technique which employs M-ary pulse shaping in SC-FDMA system. The authors compared complementary cumulative distribution function for different M-ary signalling techniques. The authors concluded that by increasing the order M in M-ary signalling, the PAPR of the signal can be reduced. The authors had considered that Localised subcarrier mapping gives higher performance in terms of PAPR. The authors had made comparison of performance of 8-DPSK, 8-QAM, 8-PSK schemes and had concluded that 8-PSK scheme delivers better performance compared to others in terms of PAPR.

Md. Masud Rana et al. in [4] described different sub-carrier mapping schemes like IFDMA (Interleaved FDMA), and LFDMA (Localised FDMA) for LTE-SCFDMA systems. Through simulations the author had proved that IFDMA sub-carrier mapping scheme provides lower PAPR as compared to LFDMA by a level of 1dB. Further the authors had shown that IFDMA sub-carrier mapping scheme improves system performance significantly as compared to LFDMA mapping scheme.

Ishu et al. in [5] had done analysis of SCFDMA system using Partial Transmit Sequence (PTS) scheme. The authors had proposed SCFDMA system based on Wavelet for analyzing PAPR performance of system using PTS scheme. The authors had carried out analysis using different wavelets and with different number of carriers. The analysis had shown that there is improvement in the performance of wavelet based SCFDM by using PTS scheme.

Krishnamoorthy et al. in [6] represented an analysis of MIMO-OFDM based system and its Bit Error Rate performance. The authors had achieved improvement in the performance of MIMO-OFDM system by employing Forward Error Correction (FEC) codes. The authorshad compared different codes in Additive White Gaussian Noise (AWGN) channel and Rayleigh fading channel. After analysis the authors had proposed three suitable codes for MIMO-OFDM system ieReed Solomon-Convolution Code (RS-CC), Convolutional Turbo Code (CTC) and Low Density Parity Check code (LDPC). The authors had found that CTC provide a coding gain of 0.2dB in AWGN channel and gain of 0.25dB in Rayleigh fading channel.

M. F Pervej et al. in [7] discussed different sub-carrier mapping techniques such as IFDMA (Localized FDMA), DFDMA (Distributed FDMA) and IFDMA (Interleaved FDMA) for SCFDMA system. The authors had analysed DFT SCFDMA scheme for improved performance with different sub-carrier mapping and modulation techniques. The authors had compared these results with that of conventional OFDMA system. The comparison had shown that the DFT-SCFDMA system greatly reduces the PAPR and improves SER for LTE uplink transmission in comparison to the conventional OFDMA.

Hen-GeulYeh et al. in [8] had proposed a modified scheme called as Hadamard SCFDMA which takes the advantage of Hadamard based spreading orthogonal CDMA code to lower PAPR in uplink transmission. The authors had compared the performance of pulse shaped Hadamard SCFDMA systems and pulse shaped SCFDMA systems. The authors had shown that Hadamard based SCFDMA systems have lower PAPR as compared to the pulse shaped SCFDMA systems and OFDMA systems. Also the authors had concluded that in Hadamard SCFDMA with IFDMA subcarrier mapping the PAPR improvement reduces as the roll-off factor α increases, which is same as in the case of SCFDMA. SER performance for the proposed scheme is tested in multipath channels.

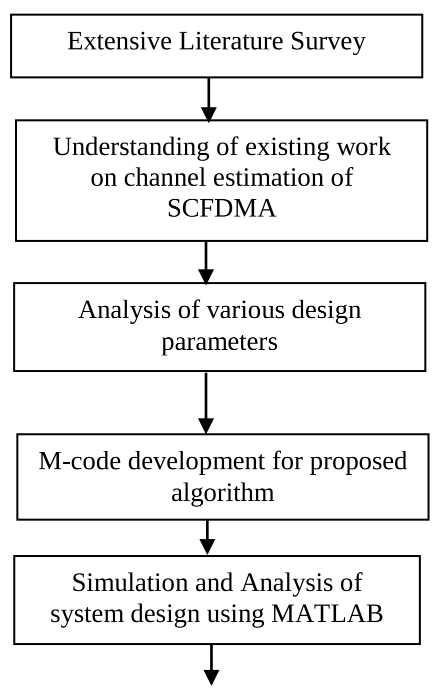
GauravMathur et al. in [9] had compared performance for different subcarrier mapping schemes in MIMO- SCFDMA system using STBC (Space Time Block Code).The authors had compared Bit Error Rate performance for different number of transmitters. In STBC, spatial diversity technique signals are coded through the transmit antenna which creates redundancy and thus reduces outage probability.

Sanjana T et al. in [10] discussed the problem of distortion in communication systems which are caused by fading, delay spread and multipath effect. The authors had designed various channel estimation and equalization techniques to provide improvement in performance of an OFDM based system. The authors had proposed the use of wiener filter for channel estimation. The simulation results of the proposed designs show that wiener filter provides better channel estimation. Also OFDM performs better under AWGN channel than fading channels. The authors conclude by plotting SER curves that wiener performs better in AWGN than fading channels and achieve better SER.

Divya Vijyan et al. in [11] had formulated an algorithm for estimating channel in SC-FDMA system using a variable step size based LMS algorithm. The weighting coefficients of the channel condition are updated by employing unbiased channel estimation method. The proposed design does not used information regarding channel and noise statistics rather it used a phase weighting scheme so as to eliminate the signal fluctuations caused due to noise and decision errors.

III. METHODOLOGY

The proposed work of system design will begin with understanding of present work on channel estimation techniques for SCFDMA system. This will include considering various parameters such as noise reduction, Bit Error Rate, Signal to Noise Ratio and average power of SC-FDMA system.



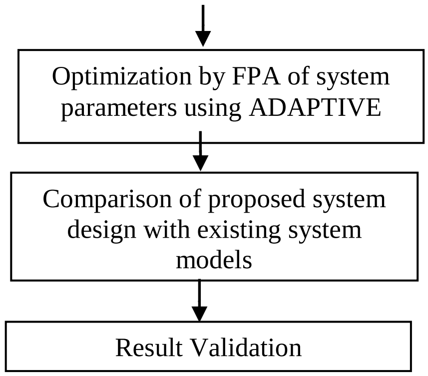


Figure 1: *Methodology adopted*

The development of proposed system design for SC-FDMA system will include LMS based adaptive channel estimation technique so as to reduce error rate. The modulation schemes employed are BPSK, QPSK, 16 QAM. The system design channel parameters will be optimized using ADAPTIVE or Flower pollination optimization technique. This technique is employed for optimization of parameters of wiener filter which is a part of Least Mean Square (LMS) channel estimation technique. The simulation and analysis of system design will be carried out in MATLAB12 environment

The proposed system simulation consists of three parts:

I. Transmitter system
II. Channel
III. Receiver system

The block diagram in the fig shows design of proposed system.

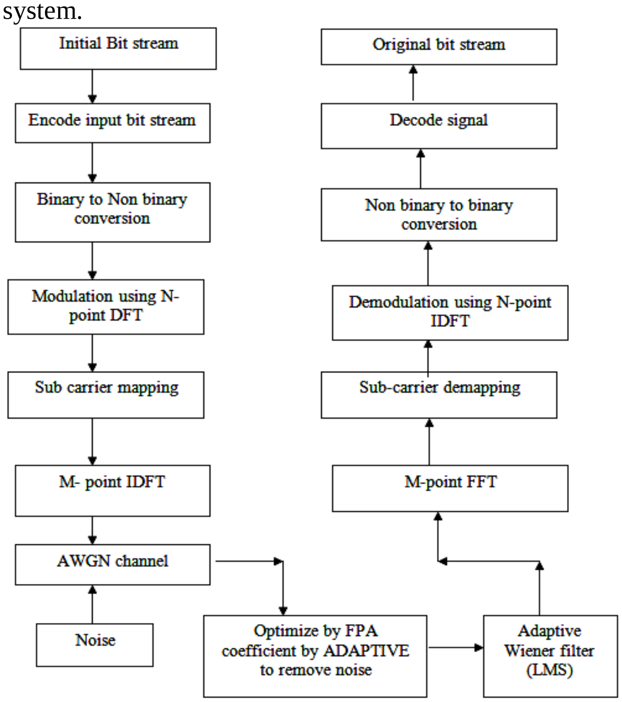


Figure 2:*Block diagram of proposed system*

A. Transmitter

At SCFDMA transmitter various modulation schemes like BPSK, PSK, 16QAM, QPSK are employed. In the proposed system model, a randomly generated bit stream is encoded. This encoded bit stream is modulated using any of these modulation techniques: BPSK, 16QAM or QPSK in various proposed system designs. The transmitter groups the modulation symbols into blocks each containing N symbols.

The discrete Fourier transform (DFT) is used to convert a finite sequence of equally spaced samples of a function into list of coefficients of a finite combination of complex sinusoids, ordered by their frequencies, that has those same sample values.

The next step maps each of the N-DFT outputs to one of the (M>N) orthogonal sub carriers that can be transmitted by a radio channel mapping. A **subcarrier** is a sideband of a radio frequency carrier wave, which is modulated to send additional information.

B. Channel

The transmitted signal in the system model suffers from fading because of path loss as well as interference due to multipath signals. So it is required to select a proper channel model so as to make simulations near to real one. Many different channel models are employed like Rayleigh, Rician and AWGN channel.

Randomly generated noise is the part of system. The amount of noise present in the system is measured by Signal to Noise Ratio (SNR). SNR is defined as ratio of received power P_r to the power of noise present within the transmitted signal bandwidth.

For Gaussian noise which has uniform power spectral density,

$PSD=N_o/2$ (3.1)

Bandwidth=2B (3.2)

Received SNR=Pr/N=Pr/NoB (3.3)

Another important term with regard to proposed system design is Bit Error rate or BER. Bit Error rate is defined as the number of bits in error divided by the total number of transferred bits during a particular time interval. BER for AWGN channel is defined as

$BER=1/2erfc\{sqrt(E_b/N_o)\}$ (3.4)

Where, E_b/N_o=Normalized carrier to noise ratio

BER of communication system is affected by transmission channel noise, distortion, attenuation, multipath fading phenomenon etc

In the proposed system design, performance of the system is observed in both Rayleigh and AWGN channel in terms of SNR and BER of the system. The Gaussian noise added to signal while passing through channel is removed using adaptive wiener filter. The parameters of Adaptive filter are optimized using Meta heuristic optimization technique ie Particle swarm optimization.

C. Receiver

The process carried at SCFDMA receiver is reverse to the process carried at SCFDMA transmitter. A SCFDMA receiver has to perform function of Inverse Discrete Fourier Transform, demodulation of modulated signal, frequency domain equalization etc.

The proposed SCFDMA receiver firstly transforms the received signal into frequency domain via M-point FFT (Finite Fourier Transform) with radix -2. The receiver than de maps the frequency domain subcarrier signals to time domain and performs frequency domain equalization.

The flow chart of adaptive channel estimation is given below:

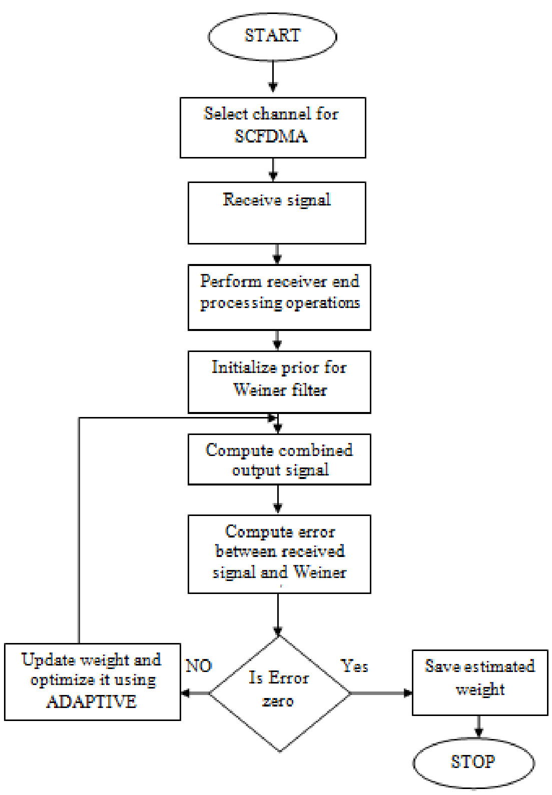


Figure 3:*Flow chart of adaptive channel estimation*

Step1: Start
Step2: In this step, for SCFDMA select the channel.
Step3: When channel is selected then receive the signal.
Step4: In this step when signal is receiving then perform receiver end processing operations.
Step5: For the Weiner filter initialize the prior.
Step6: In this step, Compute combined output signal.
Step7: In this step, the error between received signal and Weiner o/p is computed.

Step8: After computing the error a condition is applied, if error is zero then save the estimated weight and STOP program. If error is not zero update the weight and optimize it using ADAPTIVE and go to the step6.

IV. PROPOSED ALGORITHM:

Flower Pollination Algorithm: In nature, the primary motivation behind the flowers is reproduction by means of pollination. Blossom pollination is identified with the exchange of dust, which is finished by pollinators, for example, creepy crawlies, flying creatures, bats, different creatures or wind. Some blossom sorts have exceptional pollinators for effective pollination. The four tenets of pollination have been defined in view of the motivation from flowering plants and they shape the fundamental refreshing conditions of the bloom pollination calculation.

1. Cross-pollination happens from the dust of a bloom of various plants. Pollinators comply with the standards of a Lévy distribution by hopping or flying inaccessible steps. This is known as global pollination handle.

2. Self-pollination happens from the dust of a similar bloom or different flowers of the same plant. It is local pollination.

3. Blossom steadiness is the relationship of pollinators and bloom sorts. It is an improvement of the bloom pollination handle.

4. Local pollination and global pollination are controlled by likelihood between 0 and 1, and this likelihood is called as the switch likelihood.

A. Global Pollination:

$$x_i^{t+1} = x_i^t(x_i^t + g^*)$$

g^*= current best solution
L= length of the pollination

x_i^t= a solution in the present optimization problem

V. RESULTS

Figure 4 show the QPSK modulation on SCFDMA channel on AWGN noise. In this figure comparison between wiener filter and FPA optimize Adaptive Filter which optimize the prior of adaptive that's why reduce the BER more than Weiner Filter.

Figure 5 show the BPSK modulation on SCFDMA channel on AWGN noise. In this figure comparison between wiener filter and FPA optimizes Adaptive Filter which optimize the prior of adaptive that's why reduce the BER more than Wiener Filter. But if we compare it with figure 4 and figure 5 QPSK reduce BER but BPSK increase SNR.

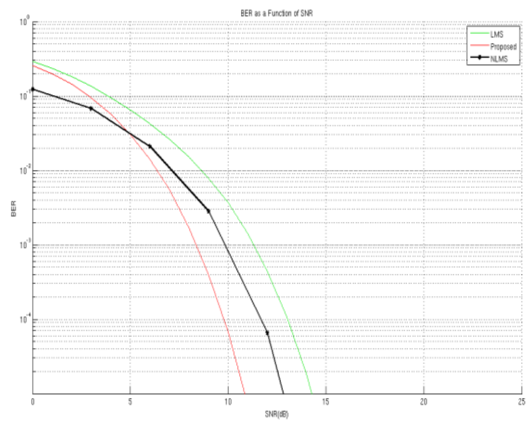


Figure4*: BER as a function SNR*

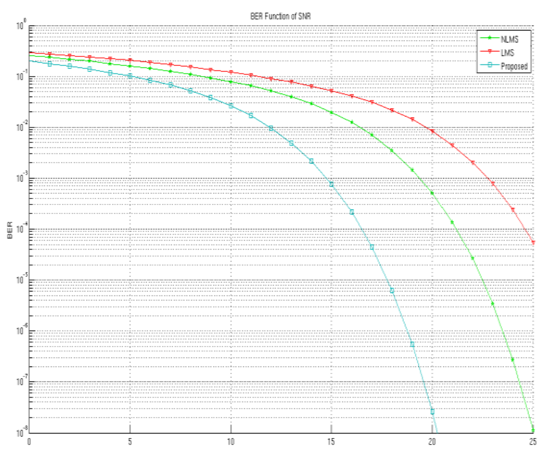


Figure 5: *BER as a Function Of SNR*

Figure 6 show the QAM modulation on SCFDMA channel on AWGN noise. In this figure comparison between wiener filter and FPA optimize Adaptive Filter which optimize the prior of adaptive that's why reduce the BER more than Wiener Filter. Which is better perform than QPSK and BPSK modulation.

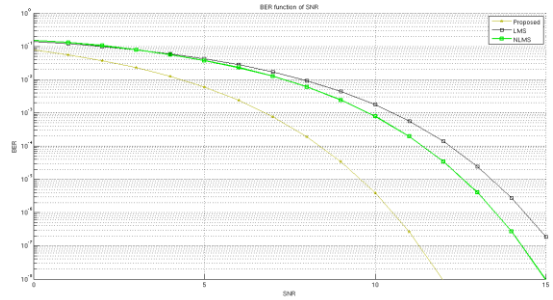


Figure6: *BER function of SNR*

Figure 7 show the SCFDMA channel on Rayleigh noise. In this figure comparison between wiener filter and FPA optimize Adaptive Filter which optimize the prior of adaptive filter that's why reduce the BER more than Werner Filter. But Rayleigh channel not significant increase performance of FPA because of Rayleigh channel highly variable noise

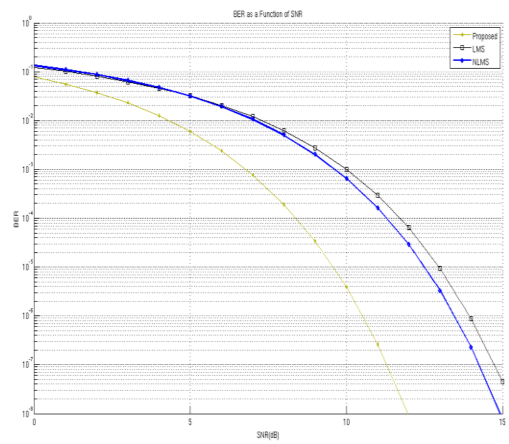


Figure 7: *BER as a function SNR*

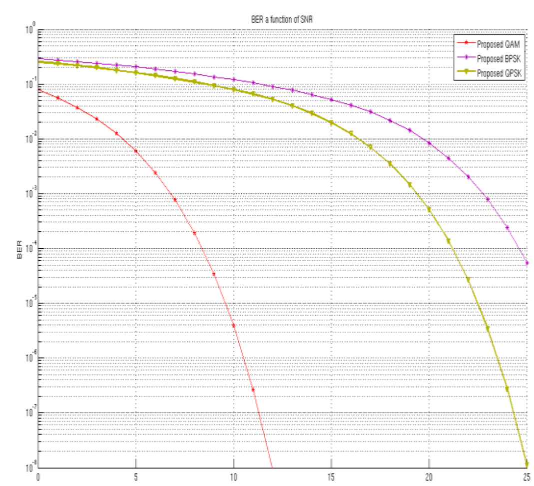


Figure 8: *BER a function of SNR*

Figure 8 depict the comparison on different modulation on proposed approach which refine the modulation selection in proposed approach and in graph also conclude QAM modulation approach effective or significant improve BER comparison to others.

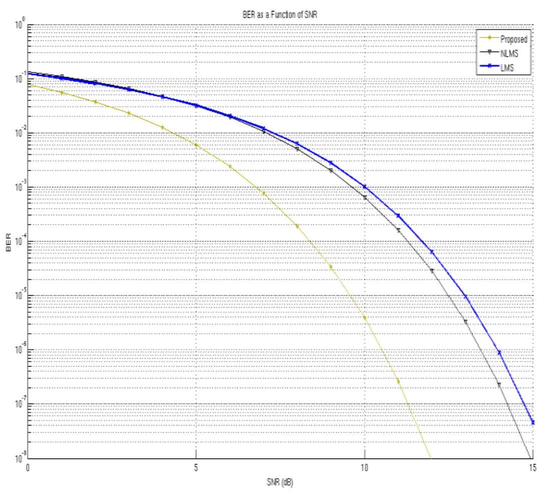


Figure 9: *BER as a function SNR*

Figure 9 show the QAM modulation on SCFDMA channel on AWGN noise. In this figure comparison between wiener filter and FPA optimize Adaptive Filter which optimize the prior of adaptive that’s why reduce the BER more than the Wiener Filter. But if we compare with figure 1 and figure 2, QPSK reduces BER, but BPSK increase SNR.

VI. CONCLUSION AND FUTURE SCOPE

The motive of a channel estimation process is to minimize Mean Squared Error (MSE) between desired signal and received signal. Different channel estimation algorithm had been designed so as to achieve high performance. Using channel estimation algorithm impulse response of a channel and its behaviour can be approximated. By employing channel estimation techniques, coherent demodulation technique can be implemented at the receiver. In communication system for channel estimation a known signal sequence called pilot signals are inserted at specific location within the information signal. These symbol sequences allow receiver to extract channel attenuations and phase rotation estimates for each received symbol. By identifying channel parameters error in the received signal can be reduced. The aim of most channel estimation algorithms is to minimize the mean squared error (MSE), while utilizing little computational resources in the estimation process.

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REFERENCES

[1] P. A. Thomas, M. Mathurakani **“**SC-FDMA -An Efficient Technique For PAPR Reduction in Uplink Communication Systems -A Survey”, International Journal of Research in Engineering and Technology, Volume: 03, pp. 53-59, 2014.

[2] H. G. Mung, “Introduction To Single Carrier FDMA”, Proceeding of 15th European Signal Processing Conference, pp. 2144-2148, 2007.

[3] M. Irfan, N. Ahmad, H. A. Shah, A. U. Rabi, “PAPR Optimization of SC-FDMA Signal Using M-ARY Signalling”, IEEE 3rd International Conference on Computer, control & Communication (IC4), pp.1-4, 2013.

[4] Md. M. Rana, J. Kim, and W. K. Cho, “Performance Analysis of Sub-carrier Mapping in LTE Uplink Systems” IEEE 9th International Conference on Optical Internet, pp 1-3, 2010.

[5] Ishu, N. Kumar, “PAPR Reduction in Wavelet Based SC-FDMA Using PTS Scheme for LTE Uplink Transmission” IEEE International Conference on Advances in Computing, Communications and Informatics, pp. 1810 – 1814, 2014.

[6] R. Krishnamoorthy, N. S. Pradeep , “Forward Error Correction Code for MIMO-OFDM System in AWGN and Rayleigh Fading Channel”, International Journal of Computer Applications , Vol. 69, No.3, pp 8-13, 2013.

[7] M. F. Pervej, M. Z. I. Sarkar, T. K. Roy, M.M. Hasan, M. M. Rahman and S. K. Bain “Analysis of PAPR Reduction of DFT-SCFDMA System Using Different Sub-Carrier Mapping Schemes” IEEE 17th International conference on computer and Information Technology,pp.435-439, 2014.

[8] H. G. Yeh and H. M. Abdul “Hadamard SCFDMA- A Modified Uplink Transmission Scheme with Low PAPR and SER”, IEEE 9th Annual International Systems Conference, pp. 711 – 715, April 2015.

[9] G. Mathur, T. Ramya, Jagadish. M, “Performance Analysis of Single-Carrier FDMA in 2x1 MIMO Systems”, IEEE International Conference on Communication and Signal Processing, pp.1050-1053, 2014.

[10] Sanjana T and Suma M N, “Comparison of Channel Estimation and Equalization Techniques for OFDM Systems*”,* Circuits and Systems: An International Journal (CSIJ), Vol. 1, No. 1, pp 1-10, January 2014

[11] D. Vijyan, P. Singh, “Adaptive channel estimation for SC-FDMA system”, International Conference on Recent Advances in Sciences and Engineering (ICRASE) 2013, Vol. 3, pp 131-133, May 2013.

[12] H. Myungkim, D. Kim, T. K. Kim, G. H. Im, “Frequency Domain Channel Estimation for MIMO SC-FDMA Systems with CDM pilots”, IEE Journal of Communications and Networks, Volume 16, No. 4, pp 447-457, 2014.

