ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 1, March 2016

# CFO freeuplink OFDMA using Hybrid Interference Cancellation

N.Padmavathi,
PG Scholar,
Dept. of ECE,
Kumaraguru College of Technology,
Coimbatore, India.
padmavathi.na93@gmail.com

N.Ambika,
PG Scholar
Dept. of ECE,
Kumaraguru College of Technology,
Coimbatore, India.
ambikasarojini@yahoo.co.in

***Abstract*—A demand for high speed mobile wireless communicationsis rapidly growing and which is the key part of research with a need of high data rate at low cost. Orthogonal Frequency Division Multiplexing Access (OFDMA) is a promising technique to achieve high data rate. The Carrier Frequency Offset (CFO) breaks the orthogonality among the subcarriers which causes Inter Carrier Interference (ICI) and Multi User Interference (MUI) in the OFDMA symbol; this affects the system performance severely. The above problem can be overcome by properly estimating the CFO followed by its compensation. The estimation is done using classen and moose method in frequency domain.Simulation results show that classenscheme hasachieved better performance in terms of Mean Square Error (MSE) than the moose scheme.AfterCFO estimation, compensation is carried out to mitigate the MUI using Time Domain Multi User Interference cancellation (TD-MUIC) scheme:Code-Aided Multi User Interference Cancellation (CA-MUIC) and Simple Time Domain Multi User Interference Cancellation(SI-MUIC). When applying Successive Interference Cancellation (SIC) algorithm itshows thatCA-MUIC performs better than SI-MUIC. The Proposed Selective Parallel Interference Cancellation(SPIC) algorithm was applied in CA-MUIC and compared with the existing work. The simulation result proves that the proposed technique has lower Bit Error Rate (BER) for higher frequency offset.**

***Index terms* — OFDMA, Multi user interference, Carrier frequency offset, Time Domain.**

## I.INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a popular technique for wireless communication due to its strengthcontrary to fast fading and Inter Symbol Interference (ISI).OFDM structure can be extended to multiple accesssituations to include multiple user broadcast. Orthogonal Frequency Division Multiple Access (OFDMA) is a multiple access technique based on OFDM which has been implemented in different standards such as IEEE 802.16 and Long Term Evolution (LTE).OFDMA is used in both downlinksas well as uplink transmissions due to several of its favorable characteristics such as capable usage ofspectrum, strength against frequency selective fading and flexible resource allocation. Carrier Frequency Offset (CFO) is the most significant term with reference to OFDMA systems.CFO occurs due to the frequencies mismatch and doppler shift.The carrier frequency misalignment destroys the orthogonality of the subcarriers, which causes Inter Carrier Interference and Multi User Interference among users.While theCFO can be estimated and corrected relatively easily in the downlink. In the uplink, the received signal is the summation of many signals coming from unlike users; each will have different CFO due mainly to oscillator instability and/or Doppler shift.These relative CFOs among users must be estimated and adjusted; otherwise the system performance degrades severely.

OFDMA is a multi-carrier modulation technique which is used to modulate many low bit rate data streams onto numerous narrowly spaced carriers. It is alike to OFDM but occupies less frequency spectrum than OFDM for the same number of users. In OFDMA, carriers are compactly packed when compared to OFDM technique.Fig1.depicts OFDMA system architecture. As shown in diagram OFDMA transmitter entails of FEC encoder followed by data modulation, time to frequency conversion by IFFT and addition of cyclic prefix. OFDMA receiverentails of front end synchronization to exact for any time, frequency or channel securities. This is shadowed by inversesections of the individualrevealed in the transmitter. It contains Cyclic Prefix elimination, FFT, data demodulation, de-interleaver and FEC decoder.

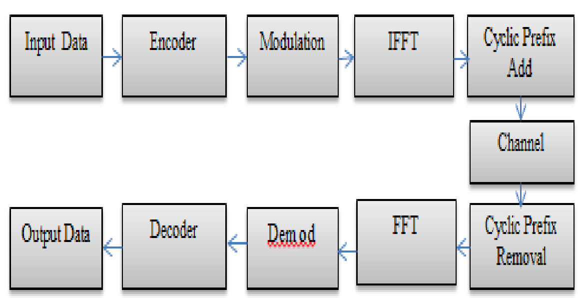



Fig1. OFDMA Block Diagram

The frequency synchronization is very much necessary for proper transmission in uplink OFDMA technique since the synchronization reduces the data loss in channel which is addressed in [1]. OFDM systems works with Robust timing synchronization algorithmthat utilize pilot-aided channel estimation depicted in [2] and the effect of timing

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Special Issue 1, March 2016

errors on the act of a pilot-aided OFDM system is categorized in the existence of timing errors in high delay spread fading environments. [3] depicts the comparisons in terms of bit error rate performance and bandwidth efficiency and three techniques are discussed where these methods are effective in mitigating the modulation schemes, the Maximum Likelihood (ML) and Extended Kalman Filter (EKF) methods perform better than the Self Cancellation (SC) method. By using estimated CFOs of the active users, the Linear Maximum Mean Square Error (LMMSE) equalization is accomplishedprior to ML frequency estimation for the interference cancellation thisadvance the estimation correctness for the residual CFO which is clearly observed from [5].Two effective CFO estimation schemes are used for performance analysis: Cyclic Prefix (CP) based estimation scheme in time domain and moose in frequency domain which is discussed in [6].

## II.MUIC SCHEME

The performance of the OFDMA uplink is severely degraded when the different carrier frequency offsets occur. The offset of the desired user can be compensatedbut the offset of the other user's carriers are misaligned and the interference due to this misalignment affects the reception. These relative CFOs among users must be estimated and corrected, otherwise the system performance degrades severely. CFO estimation in uplink OFDMA is done using frequency domain methods followed compensation in time domain with effective Selective Parallel Interference Cancellation (SPIC).

### *A.CFO Estimation*

The demodulation of a signal with an o□set in the carrier frequency can cause large bit error rate and may degrade the symbol synchronizer. Thus CFO estimation isrequired, which specifies the distortion in the transmitted symbolsand so it can be compensatedat the receiver section. Flow chart for estimation is shown in Fig 2.Estimation of CFO intime and the frequency domain techniques are explained below.

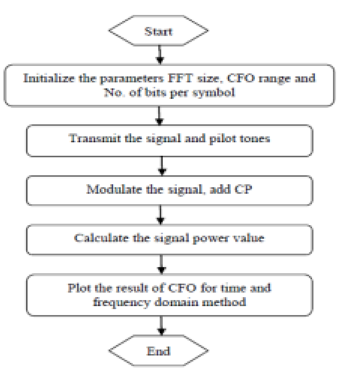



Fig2.Flow of CFO Estimation technique

#### *1) Time Domain Estimation*

Time domain estimation for CFO can be done using training symbols and the Cyclic Prefix (CP). This method is only useful for the fractional CFO. With perfect symbol synchronization, a CFO of $\varepsilon$ results in a phase rotation of 2πn$\varepsilon$/N in the obtained signal.2πN$\varepsilon$/N = $2\pi\varepsilon$ is the phase difference between CP and its corresponding rear part of an OFDMA symbol where this case is considered under the assumption of negligible channel effect. Then, the CFO can be establish from the phase angle of the product of obtained result.

Estimated CFO based on CP is,

$$\hat{\varepsilon} = \left(\frac{1}{2\pi}\right) \arg\{\textstyle\sum_{n=-Ng}^{-1} y_1^*[n] y_1[n+N]\} \quad (1)$$

where, n = -1, -2, .. . . -Ng. In order to reduce the noise effect,average of CP interval is taken over the samples.

#### *2) Frequency Domain Estimation*

The difficultiesmet in the time domain estimation of CFO can be undertaken well by the use frequency domain estimation approaches. CFO estimation is done here by Moose and Classen methods. Moose gives the Maximal Like hood (ML) and for Classen technique, CFO tracking is done by pilot tones which are inserted transmitted in every OFDM symbol. After the synchronization, it is removed at the receiver side.

Moose method uses ML approach to determine the relative offset $\hat{\varepsilon}$as,

$$\hat{\varepsilon} = \frac{1}{2\pi} tan^{-1}\left[\frac{\left(\sum_{k=-K}^{k} im[Y_{2k}Y_{2k}^*]\right)}{\left(\sum_{k=-K}^{k} Re[Y_{2k}Y_{2k}^*]\right)}\right] \quad (2)$$

Where $\hat{\varepsilon}$ is the ML estimate of the relative frequency offset defined as $\varepsilon = N\Delta f/B$, where B is bandwidth, N is the No of subcarriers and $\varepsilon$ is the CFO in Hz. InMoose's method, the estimation range is equal to 0.5 ± sub-carrier spacing. Moose uses shorter training symbolswith reduced the estimation accuracy to increase this range.

In classen method, two different estimation modes are implementedfor CFO estimation they are acquisition and tracking modes. In the acquisition mode, CFO estimation donefor large range of an integer andfor the tracking mode, estimation of fine CFO is done. For acquisition mode CFO is estimated by,

$$\hat{\varepsilon}_{acq} = \frac{1}{2\pi T} arg\{\left|\textstyle\sum_{j=0}^{L-1} Y(p(j),\varepsilon)Y^*(p(j),\varepsilon)\right|\} (3)$$

where L, p(j) and denote the number of pilot tones and the location in the symbol period respectively. Meanwhile, the fine CFO is estimated by

$$\hat{\varepsilon} = \frac{1}{2\pi T} arg\{\left|\textstyle\sum_{j=0}^{L-1} Y(p(j),\hat{\varepsilon}_{acq})Y^*(p(j),\hat{\varepsilon}_{acq})\right|\} \quad (4)$$

In the acquisition mode, $\hat{\varepsilon}_{acq}$ and $\hat{\varepsilon}$ are estimated and sum of these terms is used for CFO compensation. In the tracking mode,$\hat{\varepsilon}$ alone is estimated and then compensated.

Mean Square Error MSE performed by,

$$MSE = \varepsilon - \hat{\varepsilon} \quad (5)$$

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
ional Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
pecial Issue 1, March 2016

*B.MULTI USER INTERFERENCE CANCELLATION SCHEMES*

*1) Multi-FFT receiver*

In multi-FFT receiver structure, each active user is assigned one FDM demodulator block, so that their CFOs can be compensated for independently in the time-domain. Demodulation block for multiple user is depicted in Fig 3. After CFO compensation, the output of the OFDM demodulator belonging to the u[th] user can be expressed:

$$Z_u^{mFFT} = S_u F_N c_{(-\varepsilon f_u)} r \qquad (6)$$

$$Z_u^{mFFT} = S_u\left(Y_u + \sum_{u_1=0;u_1\neq u}^{U-1} C_{(\varepsilon f_{u_1-u}^{mFFT})} Y_{u_1} + C_{(-\varepsilon f_u)} V\right) \qquad (7)$$

Where $C_{(-\varepsilon f_u)}$ represents the time-domain CFO correction by $-\varepsilon f_u$ and $[.]^{mFFT}$in superscript refers to the fact that multiple FFT blocks are employed. $\varepsilon f_{u_1-u}^{mFFT} = \varepsilon f_{u_1} - \varepsilon f_u$ Denotes the relative CFO between the $u^{th} and\ u_1^{th}$ users. Cross-interference term sometimes become larger due to the fact that the new CFO, $\varepsilon f_{u_1-u}^{mFFT}$, might be larger than the original one, $\varepsilon f_{u1}$ . This tends to cause significant performance degradation.

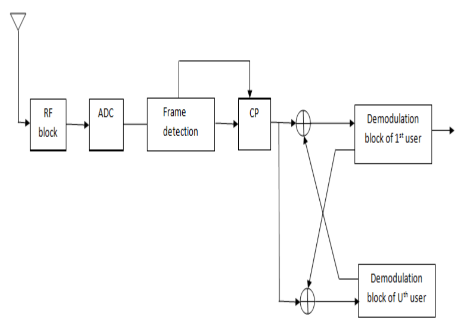



Fig 3. General Receiver Structure for TDMUIC

*2) SI MUIC SCHEME*

SI-MUIC stands for Simple Time Domain Multi-User Interference Cancellation Scheme Fig 3. Shows the block diagram of this scheme. This scheme is based on multi-FFT receiver. In this each active user is assigned one OFDMA demodulator block so that the CFOs can be compensated independently in time domain. The Frequency-Domain Multi-User interference Cancellation scheme that was employed before the SI-MUIC scheme had the disadvantage of power loss. This could be corrected by the SI-MUIC scheme. Assume that the users are sorted in order of their Received Signal Strength (RSS) and the BS processes from the user with the strongest received power to the one with lowest power, thus increases the chances of correct estimation and decoding.

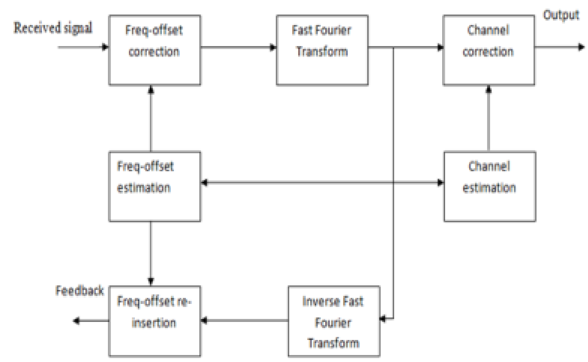



Fig 4. Demodulation Block for SI-MUIC Scheme

*3 CA-MUIC SCHEME*

CA-MUIC scheme stands for Code Aided Time Domain Multi-User Interference Cancellation Scheme. It is similar to the SI-MUIC scheme, however differs in the fact that the feedback is added in the scheme at the receiver in order to avoid the residual noise that is appeared in the SI-MUIC Scheme. The main difference between these two cancellation technique is that, the received signal itself is used to calculate the feedbackinstead of output of the OFDMA demodulator. CA-MUIC uses coder and decoder for to calculate the feedback signal which is depicted from the demodulation block of CAMUIC scheme shown in below Fig 4.

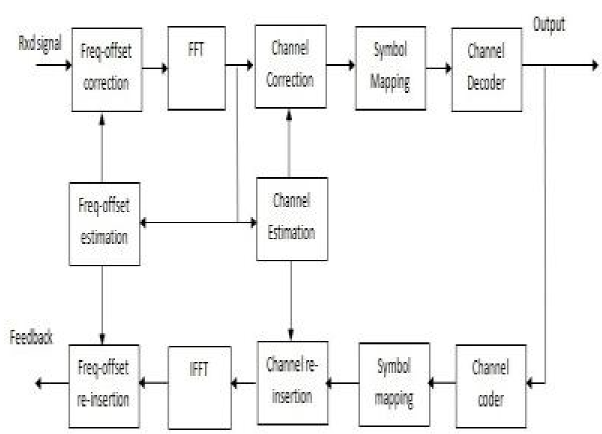



Fig 4. Demodulation Block of CA-MUIC Scheme

## III.MUIC ALGORITHM

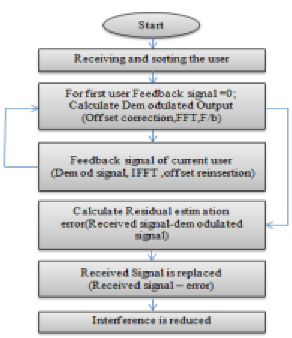
The performance of the uplink of the OFDMA is severely degraded when the different carrier frequency offsets occur. CFO compensation in Time and frequency domain can be done by SIC,PIC schemes for cancelling the Multiple User Interference.The performance is better when

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Special Issue 1, March 2016

the interference is weighted and then removed from the desired users signal. The cancellation is also performed to remove the interference due to others carriers of the same user, affected by the same frequency offset.

*A.Succesive interference Cancellation (SIC)*

The difference between the transmitter and the receiver frequency generally causes CFO that inturn causes Inter Carrier Interference and Multiuser Interference. Thus there is an effective algorithm needed to compensate this frequency offset. SIC is applied to compensate for frequency offset. The Multiuser interference due to frequency offset is reduced by removal of the interfering signals in the frequency domain.SIC method is used for CFO compensation where assumption is made that the frequency offsets of all uplink users are known at the receiver. Fig.5(a) and (b) shows the flow chart of SIC algorithm for SI-MUIC and CA-MUIC respectively. Different subcarriers are assigned to unlike users inOFDMA systems and this makes the signal possible to separate since theattenuations of subcarriers coming from different users are independent. As dissimilar users are assigned to adjacent subcarriers and their power levels are separate, SIC is used to remove the interference due to this frequency offset.



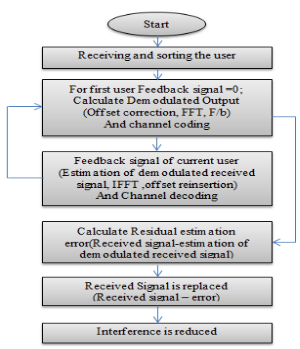




Fig 5(a). Fig 5(b).
(a) Flowchart of SI-MUIC (SIC) Algorithm.
(b) Flowchart of CA-MUIC (SIC) Algorithm

The SIC is disposed to error propagation. When errors occur during detection following the demodulation step, these errors will propagate to other users as MUI which is reconstructed incorrectly. Atlow SNR and large frequency offset casesitwill especially dominate. In order to decrease the amount of error propagation, the detected bits are coded and decoded again. This will reduce the number erroneous decisions and increasing the performance of the algorithm in the expense of larger complexity and delay which are referred from [9].

SIC Algorithm is given as,

*Initialization*:

*Set, Step* $i = 0$

*Feedback signal*, $\hat{r}_{u,i}^{\text{SI-MUIC}} = 0 \; for \; u = 0,1, \ldots . U - 1$

*Loop A* : $i = i + 1$ *and user*, $u = 0$

*Loop B* :

*Calculation of demodulation and new feedback signal.*

*Feedback*:

∗ *From output of OFDMA Demodulator (SIMUIC)*,

$$Z_{u,i}^{SI-MUIC} = S_u F_N c_{(\varepsilon f_u)} * \left(r - \sum_{u_1=0}^{u-1} \hat{r}_{u_1,i}^{\text{SI-MUIC}} - \sum_{u_2=u+1}^{U-1} \hat{r}_{u_2,i-1}^{\text{SI-MUIC}}\right) \quad (8)$$

$$\hat{r}_{u,i}^{\text{SI-MUIC}} = C_{(-\varepsilon f_u)} F_N^H Z_{u,i}^{SI-MUIC} \quad (9)$$

∗ *From Estimation of received Signal (CAMUIC)*,

$$Z_{u,i}^{CA-MUIC} = S_u F_N c_{(\varepsilon f_u)} * \left(r - \sum_{u_1=0}^{u-1} \hat{r}_{u_1,i}^{\text{CA-MUIC}} - \sum_{u_2=u+1}^{U-1} \hat{r}_{u_2,i-1}^{\text{CA-MUIC}}\right) \quad (10)$$

$$\hat{r}_{u,i}^{\text{CA-MUIC}} = C_{(-\varepsilon f_u)} F_N^H \hat{Y}_{u,i} \quad (11)$$

$u = u + 1$

*Until* $u \geq U - 1$, *go back to Loop B*

*Until* $i \geq N_{loop}$ *(No. of iteration), go back to Loop A*

$$\mathrm{I}_{u_1,i}^{\text{SI-MUIC}} = \begin{cases} Y_u & i = 0 \\ Y_u - S_u Z_{u,i}^{SI-MUIC} & i > 0 \end{cases} \quad (12)$$

$$\mathrm{I}_{u_1,i}^{\text{CA-MUIC}} = \begin{cases} Y_u & i = 0 \\ Y_u - S_u \hat{Y}_{u,i} & i > 0 \end{cases} \quad (13)$$

For PIC Algorithm,

$$Z_{u,i}^{SI-MUIC,PIC} = S_u \left( Y_u + \sum_{u_1=0}^{u-1} C_{(\varepsilon f_{u_1-u}^{mFFT})} \mathrm{I}_{u_1,i}^{\text{SI-MUIC}} + \sum_{u_2=u+1}^{U-1} C_{(\varepsilon f_{u_1-u}^{mFFT})} \mathrm{I}_{u_2,i-1}^{\text{SI-MUIC}} + C_{(-\varepsilon f_u)} V \right) \quad (14)$$

$$\mathrm{I}_{u_1,i}^{\text{SI-MUIC,PIC}} = \begin{cases} Y_u & i = 0 \\ Y_u - S_u Z_{u,i}^{SI-MUIC,PIC} & i > 0 \end{cases} \quad (15)$$

Where,

$c_{(-\varepsilon f_u)}$-Feedback signal from the u[th] user at the i[th] step.

$F_N$-Size-N FFT matrix.

$S_u$-Diagonal matrix of size N, acting as a filter to select only subcarriers belonging to the u[th] user.

$\hat{r}_{u,i}^{\text{SI/CA-MUIC}}$-Feedback signal from the u[th] user at the i[th] step.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Special Issue 1, March 2016

$Z_{u,i}^{SI/CA-MUIC}$-Output of demodulator block.

$\hat{Y}_{u,i}$-Channel estimated Signal.

$I_{u_1,i}^{x}$- Residual error

*B.Selective Parallel Interference Cancellation (SPIC)*

The proposed HIC combines both SIC and PIC to the correct proportion so that the receiver performance is enhanced to reach the near optimal level. Christo Ananth et al. [7] discussed about Improved Particle Swarm Optimization. The fuzzy filter based on particle swarm optimization is used to remove the high density image impulse noise, which occur during the transmission, data acquisition and processing. The proposed system has a fuzzy filter which has the parallel fuzzy inference mechanism, fuzzy mean process, and a fuzzy composition process. In particular, by using no-reference Q metric, the particle swarm optimization learning is sufficient to optimize the parameter necessitated by the particle swarm optimization based fuzzy filter, therefore the proposed fuzzy filter can cope with particle situation where the assumption of existence of "ground-truth" reference does not hold. The merging of the particle swarm optimization with the fuzzy filter helps to build an auto tuning mechanism for the fuzzy filter without any prior knowledge regarding the noise and the true image. Thus the reference measures are not need for removing the noise and in restoring the image. The final output image (Restored image) confirm that the fuzzy filter based on particle swarm optimization attain the excellent quality of restored images in term of peak signal-to-noise ratio, mean absolute error and mean square error even when the noise rate is above 0.5 and without having any reference measures.The flow diagram of the HIC algorithm is shown in Fig 6.

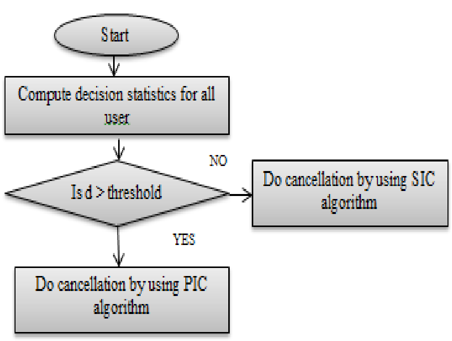



Fig 6. Flow chart for SPIC algorithm

## IV.SIMULATION RESULTS AND DISCUSSIONS

CFO compensation methods are used to improve the performance of uplink OFDMA system which can be achieved by applying Effective Interference Cancellation algorithms like SIC and SPIC in TDMUIC schemes.

*A.CFO ESTIMATION*

Carrier Frequency Offset is the most significant term with reference to OFDMA systems. CFO occurs due to many reasons. Firstly, this is caused due to the mismatch in frequencies between a transmitter and a receiver. Secondly, this can be caused due to the Doppler shift. This should be estimated correctly before cancellation and this can be done effectively by CP in time domain and Classen, Moose method in frequency domain. Here frequency domain methods are compared.

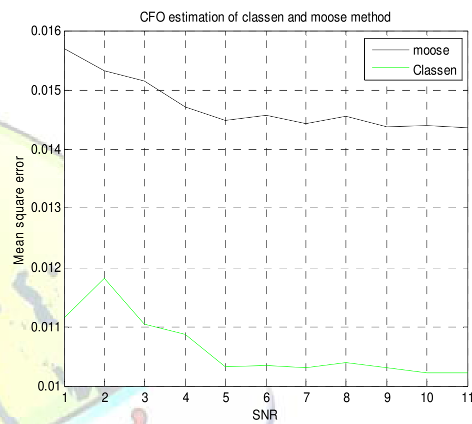



Fig 7. Frequency Domain CFO estimation

Fig 7. shows the MATLAB simulation results of CFO estimation using two frequency CFO estimation techniques. The simulation results show that, at 5dB SNR moose method of CFO estimation gives a MSE value of 0.0157 whereas classen method gives 0.0118 which is reduced upto 39%.

*B. MUI CANCELLATION*

The proposed hybrid interference cancellation algorithmfor OFDMA uplink was simulated using MATLAB. The simulation was run under different conditions and the error performance of the SIC is obtained for SI-MUIC and CA-MUIC. From the comparisons it's clearly addressed that CA-MUIC is better compared to SI-MUIC in case of SIC algorithm. In order to compare the performance of proposed SPIC with SIC schemes, CA-MUIC alone is taken for analysis because its already proven that CA-MUIC is better when compared to SI-MUIC.

Fig 8. Describes the comparison of BER performance for different frequency offset values between two time domain MUIC schemes using SIC algorithm.

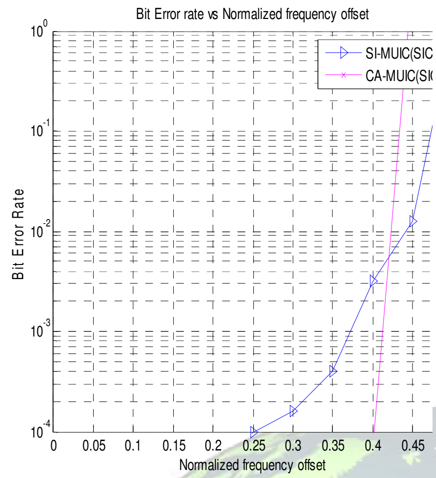



Fig 8. Frequency offset versus BER

Fig.9 portrays BER performance with different SNR values. It's seen from the below graph that the Code Aided-MUIC scheme performs well when using SIC than Simple TDMUIC.

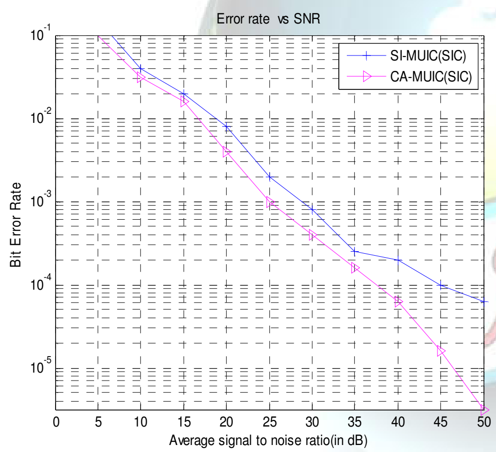



Fig 9.SNR versus BER

Fig. 10illustrates the BER performancefor different number of users in the system.As the number of users increase, the error rate also increases. SIC schemes can accommodatemore users. Again, the CA-MUIC shows much better performance than the SI-MUIC.

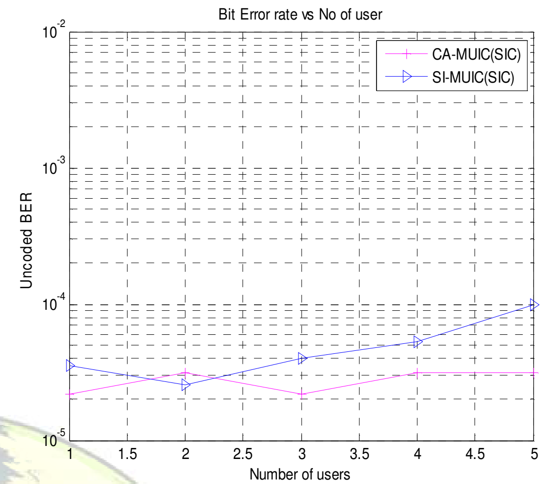



Fig 10.No of users versus SNR

Fig 11. shows the comparison of CA-MUIC scheme applied for compensating the MUI when applying SPIC and SIC. Since CA-MUIC is better than SI-MUIC in case of SIC it is alone taken for comparison. CA-MUIC is performed under two cancellation schemes that are SIC and SPIC. Simulated results gives that SPIC algorithm for interference cancellation gives lower Error rate per symbol for increase in frequency offset than SIC algorithm.

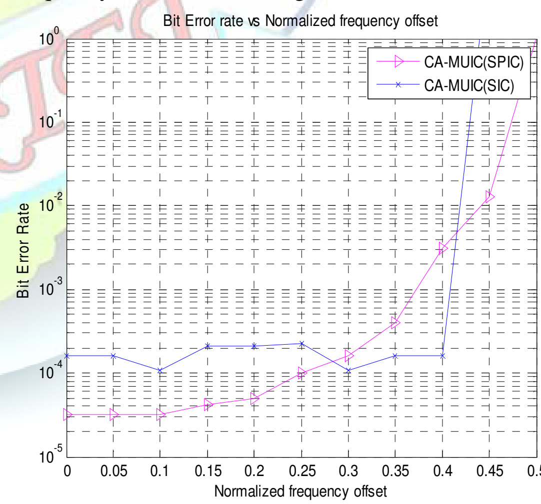



Fig 11.Frequency offset versus SNR

## V.CONCLUSION AND FUTUREWORK

In this paper, moose and classen method of CFO estimation techniques in frequency domain forOFDMA system is compared. The MSE criterion is takenfor the comparison. classen method of CFO estimation in frequency domain hasbetter performance than moose method. Once the

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Special Issue 1, March 2016

estimation is over compensation of CFO is carried out using TD-MUIC scheme along with SIC algorithm. Time domain CAMUIC andSIMUIC techniques areapplied for compensating CFO.Existing SIC method has high iteration of process with low complexity and Parallel Interference Cancellation method has limited delay with high receiving design structure. These analysis gives out the new scheme called SPIC and from the simulated results, it shown that the proposed SPIC algorithm in uplink OFDMA system gives better performanceat the value of 0.25 frequency offsetthan the existing SIC method.

REFERENCES

[1] Z. Cao, U. Tureli , D. Yao, and P. Honan, "Frequency synchronization for generalized OFDMA uplink," *Proc. IEEEGlobecom* in 2004.
[2] T. M. Schmidt and D. C. Cox, "Robust frequency and timing synchronization for OFDM," *IEEE Trans. Commun.,* Dec. 1997.
[3] SangaviDhanasekaran, M.ArulPugazhendhi , "An efficient Inter-carrier Interference Cancellation Scheme for OFDM Systems" *International Journal of Electrical and Electronics Research, Vol*. 3, Issue 2, pp: (5-10), April 2015.
[4] D.Huang and K.B.Lataief,"An interference cancellation scheme for CFO correction in OFDMA system" *IEEE Trans. Commun*, vol. 53, no. 7, July 2005.
[5] Zhang Wei, Wang Jing, Chen Xiang, "CarrierFrequency Offset Estimation for a generalized OFDMA Uplink," *IEEE Signals , Systems and computers* ,vol.17 no.4, Dec. 2011.
[6] Ishtiaq Akbar and A. NaveedMalik,"Performance Analysis of Carrier Frequency Offset Estimation Techniques for OFDM Systems,"*Research Journal of Applied Sciences, Engineering and Technology* 6(11): Dec 2000.
[7] Christo Ananth, Vivek.T, Selvakumar.S., Sakthi Kannan.S., Sankara Narayanan.D, "Impulse Noise Removal using Improved Particle Swarm Optimization", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Volume 3, Issue 4, April 2014,pp 366-370
[8] J. Choi, C. Lee, H. W. Jung, and Y. H. Lee,"Carrier frequency offset compensation for uplink of OFDM-FDMA systems," *IEEE Commun.Letters*, vol. 4, no. 12, pp. 414-416,December.2000.
[9] Huan Cong Nguyen , Elisabeth de Carvalho, and RamjeePrasad "Multi-User Interference Cancellation Schemes for Carrier Frequency Offset Compensation in Uplink OFDMA." *IEEE transactions on wireless communications*, vol. 13,no. 3, March 2014.
[10] P. H. Moose, "A technique for orthogonal frequency division multiplexing frequency offset correction," *IEEE Trans. Commun.,* vol. 42, pp. 2908–2914, Oct. 1994.
[11] M. Gudmundson and P.-O. Anderson, "Adjacent channel interference in an OFDM system," in 1996 *IEEE Vehicular Technology Conference – Spring.*
[12] H. C. Nguyen, E. de Carvalho, and R. Prasad, "Multi-user interference cancellation scheme(s) for multiple carrier frequency offset compensation in uplink OFDMA," in 2006 *IEEE PIMRC*.
[13] D. Galda, H. Rohling, and E. Costa, "On the effects of user mobility on the uplink an OFDMA system," in Pric, 2003 *IEEE VTC – Spring*, vol. 2, pp. 1433–1437.
[14] S. Benvenuti, R. Fantacci and M. Michelini, (2001). "Performance of a Selective Parallel Interference Cancellation Receiver for MC-DS/CDMA systems," Proc. Of WPMC01, 1175-1180
[15] Marco Michelini, Enrico Del Re, Romano Fantacci, Stefano Do, Dept. of Telecommunication, Universit` a di Firenze ,"A Selective Parallel Interference Cancellation Receiver to mitigate Multiple Access Interference in a MC-DS/CDMA system,"in 2010.