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Research Article

Self-OptimisingNetworks for Self-Interference Avoidance

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Abstract

Self Optimising Networks are the most promising technologies which has been evolved in the recent times. It was first introduced by third generation partnership project. It's an intelligent Self Automatic technology to monitor the overall cellular network without any human interaction .Self Optimising Networks are Self-Healing, Self-Organising, Self-Correcting, Self-Configuring, Self-Debugging Networks which has wide range of applications in Wireless communication LTE and LTE-ADVANCED Networks. To enhance the Coverage Capacity exponentially, the present day LTE and LTE ADVANCED Networks extensively apply SON. In our approach we reduce Self Interference by applying Layering techniques such as DBLAST and VBLAST , Duplex Filters, KASAMI encoding scheme, time space block codes, trellis code.

Keywords:

1. Introduction

The adjacent cells are in the close proximity in the heterogeneous networks which give rise subsequent amount of interference that can be decreased by optimising the channel capacity with the help of Key Performance Indicators. GSM being the 2nd generation mobile telecommunication network uses distinct frequency bandwidth to subside and mitigate the arising Inter Cell Interference.UMTS from 3rd generation mobile telecommunication network makes use of distinct codes for distinct cells in order to avoid and compensate the Inter Cell Interference. The LTE and LTE ADVANCED from 4th generation mobile telecommunication network utilises OFDM air interface. In the context of Inter Cell Interference Coordination (ICIC) many different technologies and methodologies with effective algorithms have been applied by varying many key factors to study the behaviour of the mobile telecommunication network.

The LTE and LTE ADVANCED are the evolving technologies in the near future which can be effectively enhanced in terms of quality of service and network efficiency with the help of Inter Cell Interference Coordination (ICIC). Neighbouring adjacent cells are operating the same frequency this gives rise to Inter Cell Interference. Interference vanishes automatically if the micro cells self-organises intelligently. SON was effectively utilised in ICIC to drastically decrease the human intervention and to upgrade plan3ning, deployment, network maintenance, self-organising. Effective resource scheduling algorithm can be employed with Inter Cell Interference Co-ordination (ICIC) .Downlink transmission can be achieved through ICIC techniques much more efficiently.The efficient cell architecture structure for micro cells can achieved with Inter Cell Interference Coordination (ICIC) which can serve the need of growing data traffic on mobile telecommunication network. Allocated spectrum reuse dynamically is one of the key functionalities of Inter Cell Interference Coordination (ICIC).

Self-Interference:- When wireless communication systems operate in half duplex mode i.e. transmission occurring in unidirectional way, there is no interference in the network. On the other hand when the wireless system operate in full duplex mode i.e. transmission occurring in bidirectional way on the same communication

channel increasing the spectral efficiency by two times , thereby utilising the spectral assets economically . However, full duplex mode is difficult to realise due to some practical challenges. In the wireless communication system, when a transmitter sends a radio frequency signal to some other receiver which is at a very large distance receives the signal. Meanwhile , the receiver which is present at the transmitting end absorbs some of the energy of the transmitted signal .Since , the transmitted signal energy is received by its own receiver , in wireless system networks this gives rise to unwanted , undesirable Self Interference . Self-Interference is a major technical issue in the LTE and LTE-ADVANCED networks because the signal received at the transmitting end will be very strong as it is heard from the same point of origin. Hence, this technical issue of Self Interference can be tackled well by either transmitting or receiving at different time slots. Half duplex mode is the only choice the network technicians are having to mitigate the effect of self-interference .The future of advanced telecommunication networks fundamentally depends on full duplex mode , so that the spectral efficiency increases exponentially in terms of frequency reusage and speed of transmission and reception . Self-Interference Cancellation is the need of the hour , which can give solutions to the present day problems like unwanted data consumption , network handling economically , improved quality of service , high velocity transmission by reduced redundancy and utilising the allocated spectrum effectively which serves the need of higher generation networks . Self-Interference Cancellation paves the way for the development of effective LTE technologies for many heterogeneous networks in many ways. Firstly, improved transmission capacity which can operate fully functional in full duplex mode.Secondly, Spectrum Isolator, in full duplexmode, the system should isolate the frequency from the received signal from the transmitted signal without degrading the signal strength.

There are many schemes to eradicate the effects of Self Interference, some of them are discussed below:-

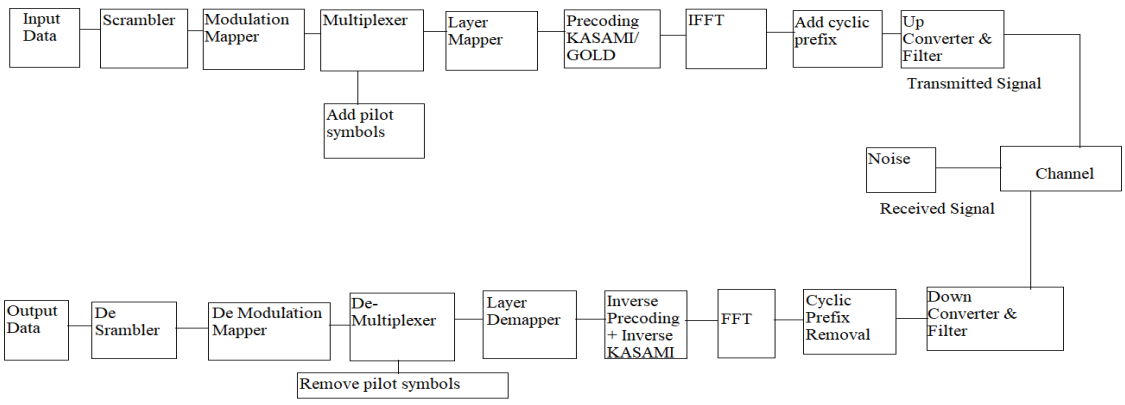
DUPLEX FILTERS:- MMSE filters , Kalman filters , Extended Kalman filters , Spatial time domain filtering , cross coupled switch RC mixer filter , Analog Least mean square adaptive filtering , optimised polarisation filtering , Recursive Least Square Kalman filter provides a more practical solution for self-interference .

GUARD INTERVAL / CYCLIC PREFIX : In wireless telecommunication network , Guard intervals are introduced in between subsequent frequency signals in order to avoid intercell interference . The cyclic prefix (CP) is the most common guard interval (GI). The GI is introduced initially to eliminate the inter cell interference . The cyclic prefix (CP) is a good alternative of the zero-padding GI. In the CP scheme, the GI is replicate of the transmitted signal. It is noted that the GI duration must be greater than the maximum channel delay time. Otherwise, it could not completely remove the Inter Cell Interference. When CP is employed instead of zero-padding GI, Inter Cell Interference is eliminated completely

ICIC in 4G/5G :-ICIC introduces a unique methodology to subside the ongoing traffic noise . There are many different interferences such as co channel interference , Adjacent Channel Interference , Self Interference and Multiple Access Interference which are being addressed by ICIC schemes . The reccursive algorithm or repetitive algorithms employed in ICIC subsides the noise to the greater extent . The 5G can be a near future with high adaptive algorithms of ICIC .

Proposed model for Self Interference Cancellation:-

Block diagram of LTE OFDM system with KASAMI/ GOLD precoding:-



2. Explanation for Block Diagram

1. Data Scrambler: -To provide better data compatibility at bothtransmitter and receiver, Data scrambling encoding scheme is employed at the transmitting node.

2. Modulation Mapper: Self Interference is dependent on the modulation coding schemes such as 64 bit QAM or QPSK,hence, a suitable modulation coding scheme is employed .This task is performed by Modulation Mapper.

3. Multiplexer: - In order to efficiently utilize the resource channel numerous signals are mixed either in frequency or time or both.

4. Layer Mapper:- Diversity Techniques are the process of transmitting the same information many times in a different channels . This can also be achieved by Layer Mapping techniques like Basic Bell Laboratory Layer space time code (BLAST) , Diagonal BLAST (DBLAST) , Vertical BLAST (VBLAST) .

5. Kasami Code / Gold Code:- The Kasami sequences are a set of sequences that have good cross-correlation properties.These are binary sequences of length 2^N-1 where N is a nonnegative, even integer.It refers to a special set of binary Random (Pseudo Random) sequence in which the correlation among member sequences is very small. Due to this property (small correlation), this is widely used for various wireless communication system as a scrambling code.

6. Cyclic Prefix: - CP is introduced at the transmitting end, circular transition be obtained at the receiving end. For this, Guard interval is allocated in front of the symbol with same period as of CP, which is referred as zero padding. However, ZP process is more energy-efficient due to silent guard period at the transmitting end and cyclic properties of the CP-OFDM enhances the detection probability in LTE wireless communication of CP to be adopted by most of the applications.

7. Duplex Filter: -There are many filters available at the receiver to filterthe unwanted high power noise signal. The important filters under discussion are Kalman filter, Extended Kalman filter.

Duplex Filters :-

3. Extended Kalman Filter :-

It is difficult to obtain an similar copy of the Self Interference signal due to the multipath signal fading or reflection of the signal from surrounding things . To effectively eradicate the SI in timedomain, two operations are needed: (1) detecting the self-interference signal at the receiving end and (2) using an self correlation filter to avoidthe SI signal for better quality. Hence , we apply the extended Kalman filter to achieve the above goals .

Error Free Signal at the Filter output = Obtained signal at receiver - Self Interference Error Signal .

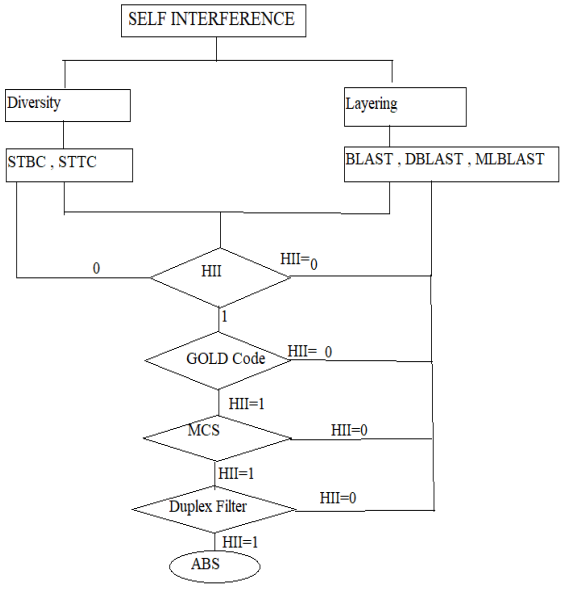
Digital Adaptive Non Linear Filter :-

To eliminate the effect of SI in the digital domain, various types of digital SI channel estimation schemes have been developed like least-squares , minimum-mean square error or maximum-likelihood estimation . Non-uniform Sampling can avoid unwanted SI in Orthogonal Frequency-Division Multiplexing (OFDM) schemes. In time domain scenarios , adaptive procedures can obtain SI estimate to varying parameters in the communication channel .

Zero Padding / Cyclic Prefix

The two important errors of wireless communication systems are signal quality fading and interference due to many factors like multipath propagation and surrounding things . OFDM system has become an attractive technique for broadband communications to eliminate the impacts of multipath fading and inter-symbol interference (ISI) by inserting cyclic prefix and zero padding between symbols . Hence to achieve with long delayed multipath, longer Cyclic Prefix is necessary .

Flow chart of the algorithm:-



Flowchart Algorithm Explanation :-

1. Self-Interference is observed in the transmission, Diversity techniques are employed with space time block codes and space trellis block codes.
2. Self-Interference can also be subsided by layering techniques such as Basic Laboratory Layered space time, Diagonal BLAST, Multiple layered BLAST.
3. If the High Interference indicator (HII) of the channel is still high then the signal is passed through GOLD code or KASAMI code for precoding process. Otherwise , it is ready for transmission .
4. If the High Interference indicator (HII) of the channel is still high then the signal is passed through Modulation Coding Scheme . Otherwise , it is ready for transmission .
5. If the High Interference indicator (HII) of the channel is still high then the signal is passed through Duplex Filter for filtering process. Otherwise , it is ready for transmission .
6. If the High Interference indicator (HII) of the channel is still high then the signal is passed through ABS .

4. Execution Scenario :-

SL NO	OFDM PARAMETERS(DL-SCH)	VALUE
1.	Antenna system	2*2 MIMO/4*4 MIMO
2.	FFT Size	512
3.	Number of used subcarriers	300
4.	Bandwidth, B	5MHz
5.	Sampling frequency, fs	7.68MHz
6.	Subcarrier spacing	15KHz
7.	Used Subcarrier index	-150 to -1,+1 to+150
8.	Cyclic Prefix duration	4.74µs
9.	Data Symbol duration	66.6 µs
10.	Total Symbol duration	71.3 µs
11.	Modulation	16QAM/BPSK
12.	Subframe Length	1ms
13.	Number of resource blocks	25
14.	Symbols per frame	140
15.	Channel model	Rayleigh/Gaussian channel

Experimental Results and Analysis :-

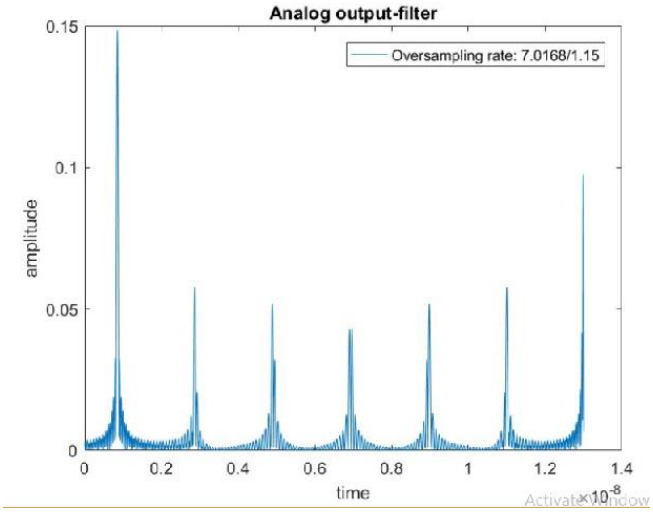


Figure (1)

Figure (1) shows the output of duplex filter at the receiver acieveing an oversampling rate of 7.0168/1.15 . The filter output gives amplitude graph with consideration of time . The filter reduces the interference noise to a considerable factor .

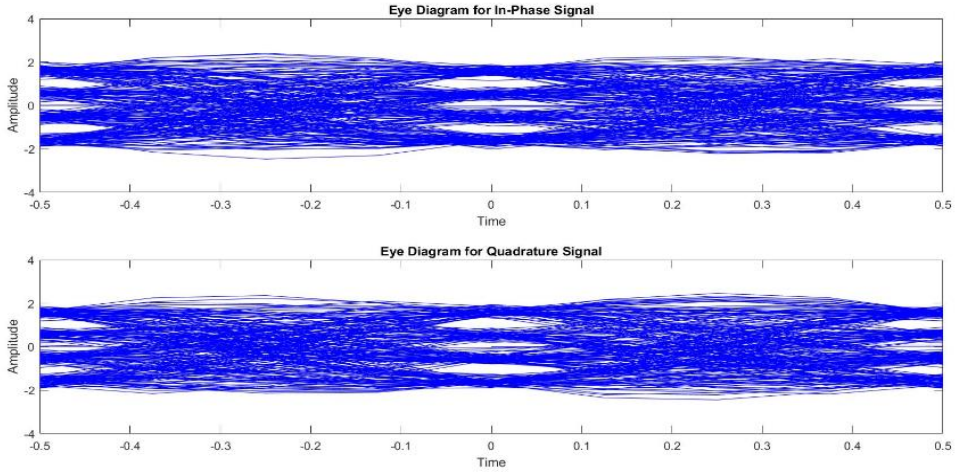


Figure (2)

Eye Diagram in figure (2) shows In Phase Signal and Quadrature Signal after 64 QAM / QPSK modulation schemes being employed . Eye Diagram gives a clear comparison of this technique and supporting Bit error rate plot .

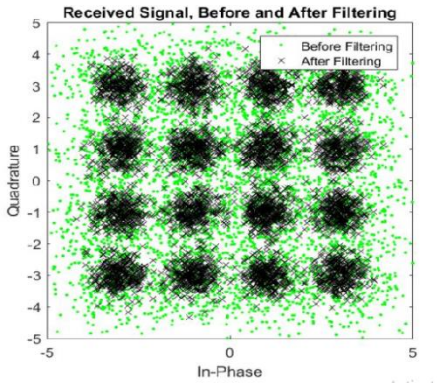


Figure (3)

Figure (3) shows the scatter plot of In phase and quadrature sampled signal before and after filtering . The diagram clearly depicts that the signal interference after filtering has subsided by a considerable amount . Filtering at both transmitter and receiver has refined the signal to noise ratio , thereby increasing the system throughput .

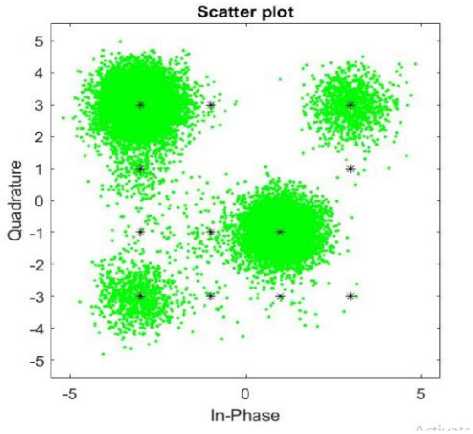


Figure (4)

Figure (4) shows the scatter plot of the signal transmitted at the beginning of the communication channel after applying QPSK / QAM and sampling In phase and Quadrature .

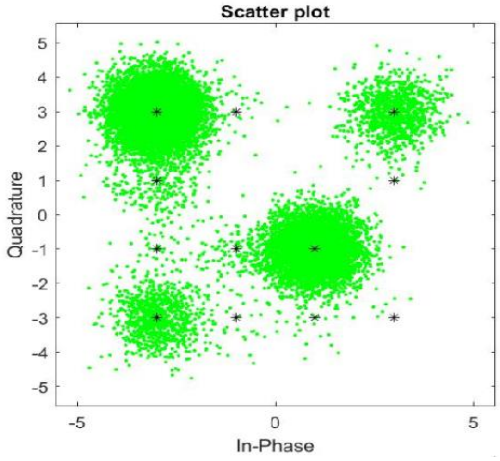
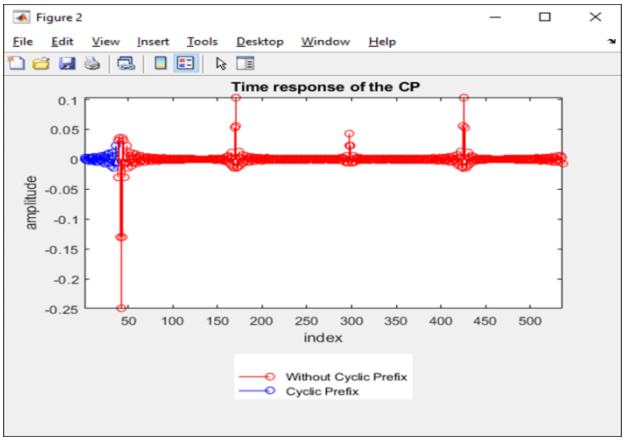


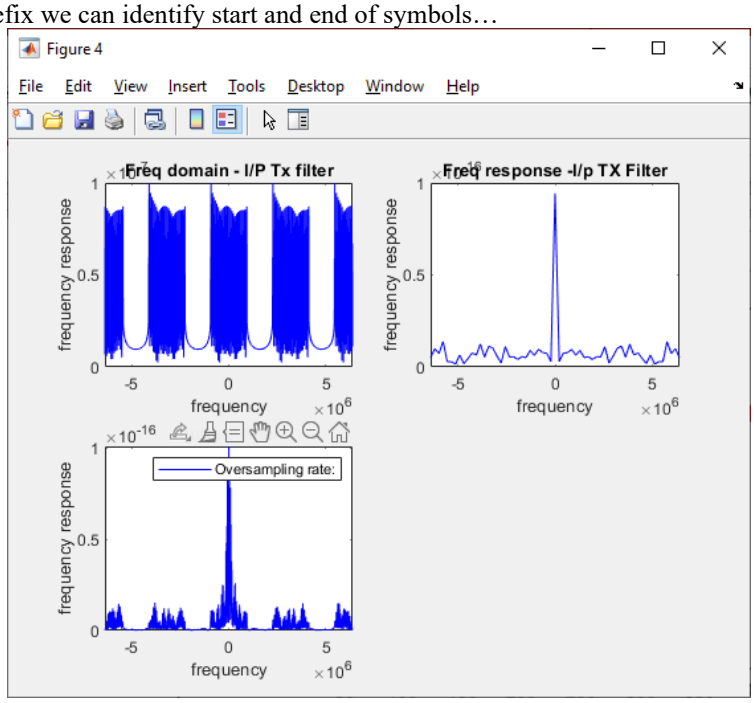
Figure (5)

Figure (5) shows the scatter plot of the signal received at the terminal point of the communication channel after applying KASAMI code / GOLD code , cyclic prefix , sampling and filtering . There is a drastic difference in the scatter plots of signal before applying the techniques as depicted in this figure.



Figure(6)

We use of Cyclic Prefix to detect start and end of symbol. Since as we see that by using Precoding with Kasami code we are having strong autocorrelation developed. Hence the plot shows for both with cyclic Prefix and without Cyclic Prefix we can identify start and end of symbols…



Figure(7)

Fig-a and Fig-b shows the transmitted frequency response after passing through Filters.

By using Duplex Filters at Receiver as in Fig-c we are having not as much better response as that one at Walsh Hadamard Code but still the performance is improved by using Kasami Encoding.

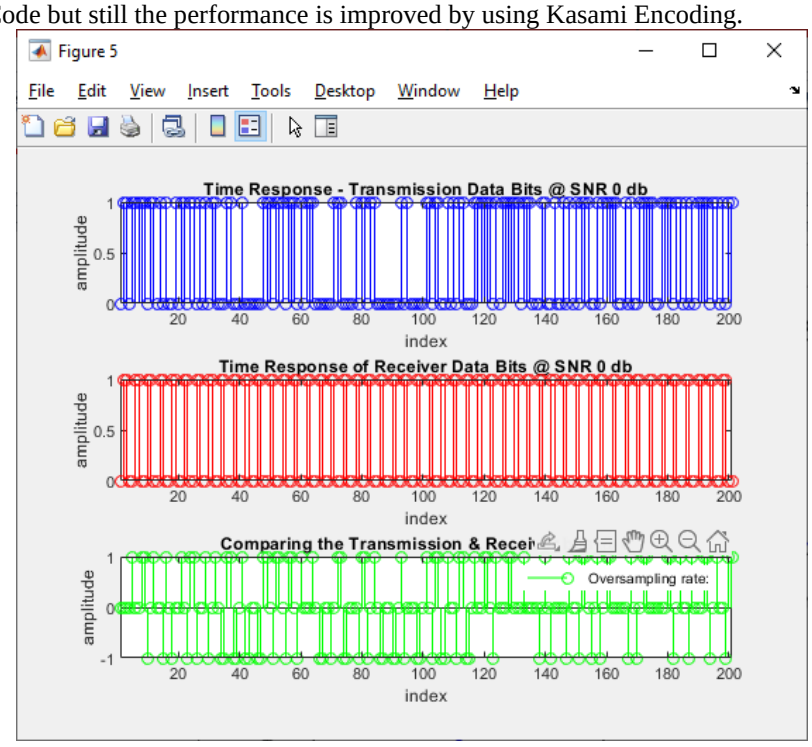


Figure (8)

Fig-a Time response shows that Kasami encoding doesnot have much fading as well as transmitted symbols are not equally time separated.

Fig-b Time response shows that Kasami encoding doesnot have much fading as well as received symbols equally time separated due to autocorrelation properties of Kasami codes.

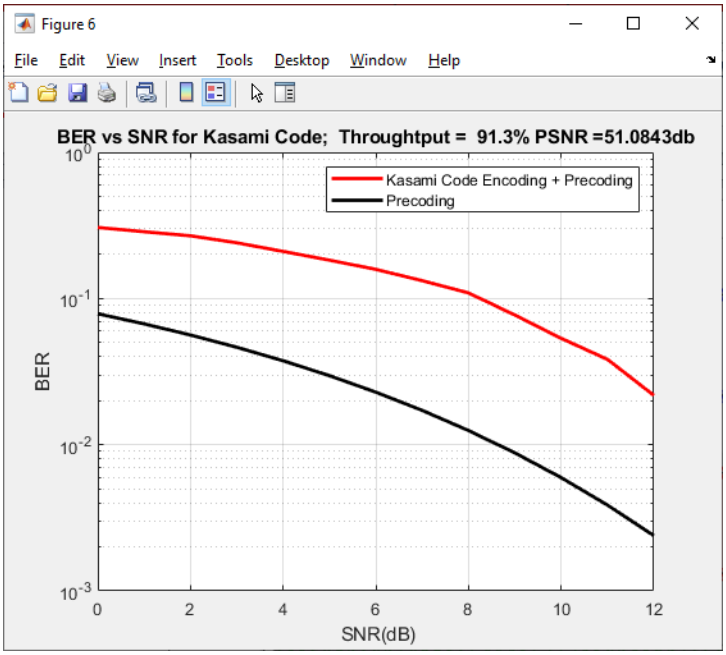


Figure (9)

By using Kasami encoding along with Precoding we find that BER is more for same SNR as with Normal Precoding. This is disadvantage of extra encoding with Kasami code.

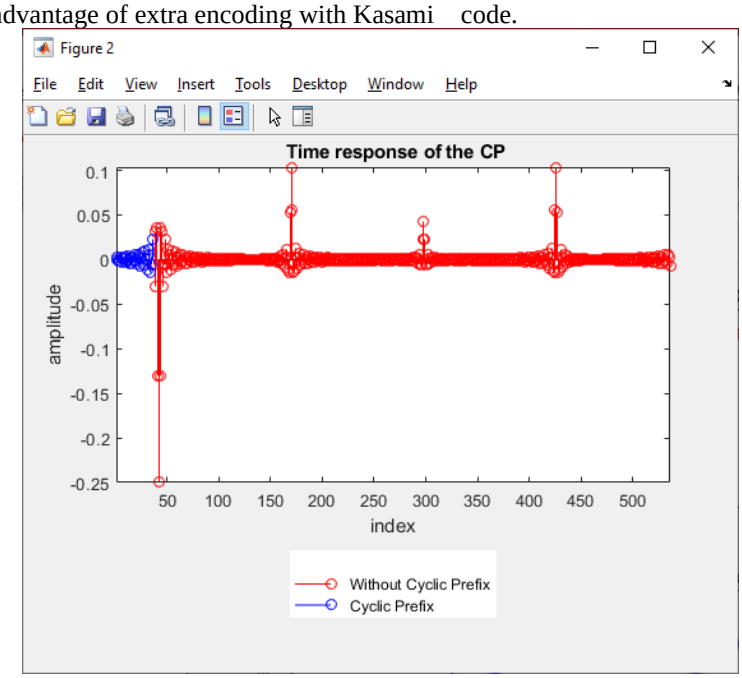


Figure (10)

We use of Cyclic Prefix to detect start and end of symbol. Since as we see that by using Precoding with Kasami we are having strong autocorrelation developed. Hence the plot shows for both with cyclic Prefix and without Cyclic Prefix we can identify start and end of symbols…

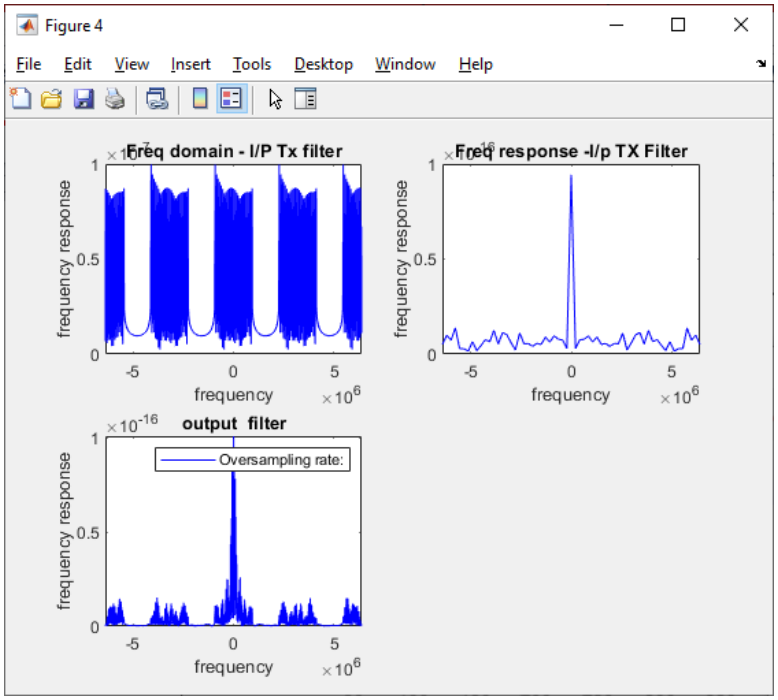
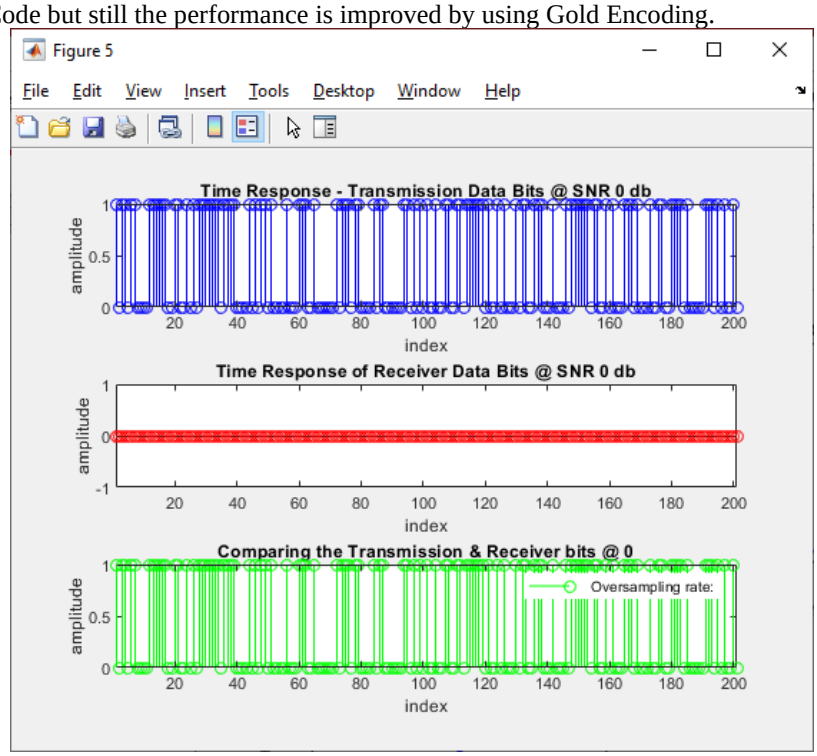


Figure (11)

Fig-a and Fig-b shows the transmitted frequency response after passing through Filters.

By using Duplex Filters at Receiver as in Fig-c we are having not as much better response as that one at Walsh Hadamard Code but still the performance is improved by using Gold Encoding.



Figure(12)

Fig-a Time response shows that Gold encoding doesnot have much fading as well as transmitted symbols are not equally time separated.

Fig-b Time response shows that Gold encoding have much fading as such that the symbols get totally vanished at receiver for 1 Unit transmitting Power at Transmitter suggesting we need to use 200 Unit transmitting power as in Walsh Hadamard encoding.

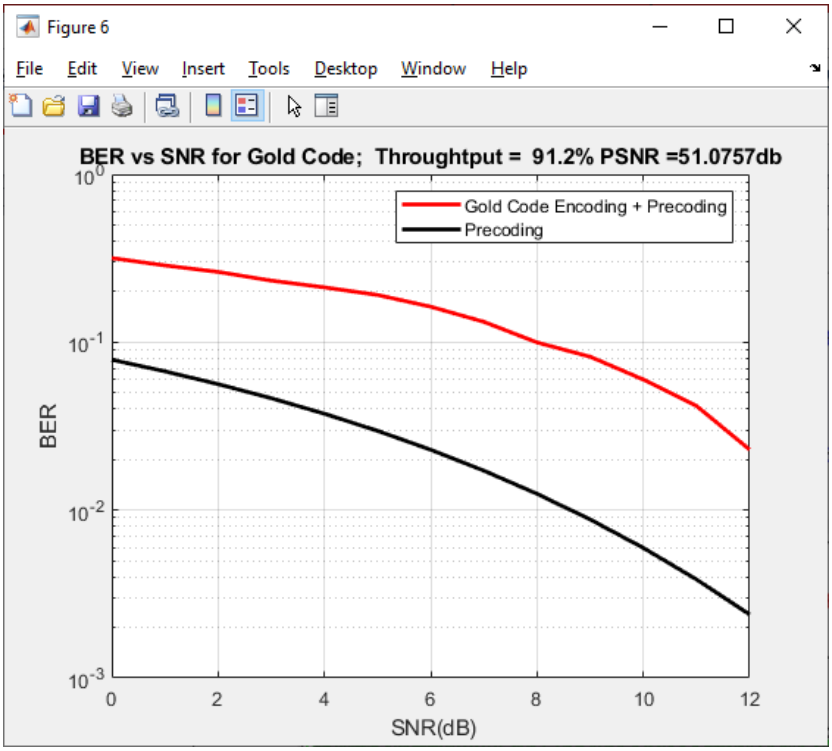


Figure (13)

By using Gold encoding along with Precoding we find that BER is more for same SNR as with Normal Precoding. This is disadvantage of extra encoding with Gold code.

Conclusion:- This novel procedure has been employed to mitigate the self-interference arising due to numerous reasons . Every subsequent stage decreases the noise levels. The block diagram depicts nicely the steps one by one, starting with QPSK/64 QAM modulation schemes, KASAMI / GOLD precoding, cyclic prefix, duplex filters involved in holistic approach for interference noise degradation.

The simulation results shows a close proximity with real expected values. The throughput in KASAMI code is 91.3% and PSNR= 51.0843 dB, whereas the throughput in GOLD code is 91.2 % and PSNR= 51.0757 db.In the future scope of this novel paper, we can employ WALSH HADAMARD code with different Layering schemes such as VBLAST, DBLAST and modulation schemes.

References

[1] A Self Interference Nulling Filter Using Efective Channel Information for Full Duplex Systemsby Hyunjong Na and • Chungyong Lee in Wireless Personal Communications (2020) .

[2] Self-Interference Cancellation for Full-Duplex Radio Transceivers Using Extended Kalman Filter by Areeba Ayesha and Shabbir Majeed Chaudhry in The National Academy of Sciences, India 2020 .

[3] Solving Self-Interference Issues in a Full-Duplex Radio Transceiver by Miguel Franco-Martínez , Francisco-Javier Martínez-Alonso and Roberto López-Valcarce in Signal Processing in Communications Group, University of Vigo, 36310 Vigo, Spain .

[4] Integrated Wideband Self-Interference Cancellation in the RF Domain for FDD and Full-Duplex Wireless by Jin Zhou, Student Member, IEEE, Tsung-Hao Chuang, Student Member, IEEE, Tolga Dinc, Student Member, IEEE, and Harish Krishnaswamy, Member, IEEE in IEEE JOURNAL OF SOLID-STATE CIRCUITS, VOL. 50, NO. 12, DECEMBER 2015 .

[5] Combining filters and self-interference cancellation for mixer-first receivers in Full Duplex and Frequency-Division Duplex transceiver systems by Gert-Jan Groot Wassink, bachelor student Electrical Engineering at University of Twente .

[6] Analog Least Mean Square Adaptive Filtering for Self-Interference Cancellation in Full-Duplex Radios by Anh Tuyen Le, Le Chung Tran, Xiaojing Huang, Y. Jay Guo, and Lajos Hanzo in IEEE WIRELESS COMMUNICATIONS .

[7] Optimized Polarization Filtering Based Self-Interference Cancellation Scheme for Full-Duplex Communication by Fengqi Bai, Fangfang Liu, Chunyan Feng in IEEE globalsip 2019

[8] State-Space Adaptive Nonlinear Self-Interference Cancellation for Full-Duplex Communication by Hendrik Vogt, Gerald Enzner, Aydin Sezgin Department of Electrical Engineering and Information Technology Ruhr-Universit¨at Bochum, Germany in SUBMITTED TO IEEE TRANSACTIONS ON SIGNAL PROCESSING .

[9] Self-Interference Cancellation for Co-Located TDD Radios Sharing the Same Band by Joel Brand Kumu Networks, Sunnyvale, Calif in microwave journal .

[10] Performance Analysis of Cyclic Prefix and Zero Padding Equalization Technique for MIMO-OFDM System by Preeti Sondhi and Vinit Grewal* ECE Guru Nanak Dev University Jalandhar, Punjab, India in International Journal of Advanced Science and Technology Vol.100 (2017) .

[11] A Survey of Self-Interference Management Techniques for Single Frequency Full Duplex Systems by CHINAEMEREM DAVID NWANKWO in Digital Object Identifier 10.1109/ACCESS.2017.2774143 .

[12] Full Duplex Spatial Modulation System Performance Depending on Self-interference Cancellation Accuracy by Yanni Zhou, Florin Hutu, Guillaume Villemaud in Univ Lyon, INSA Lyon, Inria, CITI, F-69621, Villeurbanne, France .

[13] Modulation and Multiple Access for 5G Networks by Yunlong Cai, Zhijin Qin, Fangyu Cui, Geoffrey Ye Li, and Julie A. McCann in Y. Cai and F. Cui are with the College of Information Science and Electronic Engineering, Zhejiang University, Hangzhou 310027, China .

[14] All-Digital Self-Interference Cancellation Technique for MIMO Full-Duplex Systems by J. Soma Sekhar M. Tech, E.C.E Department Gudlavalleru Engineering College Gudlavalleru, A.P, India and E. V. Vijay Assistant Professor, E.C.E Department Gudlavalleru Engineering College in International Journal of Computer Applications (0975 – 8887) Volume 148 – No.10, August 2016 .