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COMPETENCY ESTIMATION OF FIXED CONSTRAINT LENGTH CONVOLUTION- ALLY CODED O-IDMA SYSTEM USING MULTIFARIOUS INTER-LEAVER

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ABSTRACT

Optical interleave division multiple access (O-IDMA) technique suits best when heavy traffic intensity and greater interfering environment. This technology has proved its supremacy on other existing multiple access technology like CDMA, OFDMA, FHSS etc. Inter-leavers play on major contribution in deciding specific users in multiuser detection method. In present article random, tree and prime inter-leavers are used for measuring the efficacy estimation of O-IDMA technique. Convolutional codes, for fixed number of memory units (fixed constraint length) are incorporated in encoder architecture for estimation purpose. The code rate has been changed and BER for different users has been examined for different inter-leavers.

Keywords: optical inter-leave division multiple access (O-IDMA), convolutional code, inter-leaver, constraint length, PN sequence (PNS), code rate.

1. INTRODUCTION

In recent communication techniques inter-leavers, are arranged for reducing channel noise enhancing error detection and estimation capability of a codes and to convert burst error into simple correctable errors. The motivating ethics developed by H. Chan. [1] to amalgamate the spreading and coding together extend the efficacy of CDMA systems. The problems associated on these systems that when user traffic intensity becomes higher quantity MAI & ISI comes in picture which increases BER. IDMA is the technique which has the least ISI and MAI. By using optical channel in IDMA improves crosstalk, SNR, losses as well as BER. There is a bundle of researcher focused on IDMA systems for improving its performance on various parameters like coding gain, spreading length, modulation parameter, coding schemes, different kind of inter-leavers etc.

The researchers have also analysed the various optical channel parameters like optical source type and its wavelength of transmission, optical power, optical pulses, fiber characteristics, its numerical aperture, length of fiber, detector characteristics its type (PIN or APD), its gain and efficiency, responsivity etc. [2].

In present work the research is focussed on coding section that is architecture of convolutional encoder. We have fixed the constraints length of code by fixing the number of shift registers in encoder design and varying the number of adders, to construct different possible higher code rate topologies. These optimum topologies are selected depending on d_{min} [Ref-12]. We have analysed various kind of inter-leavers for these optimum code rate topologies and compare and contrast the result so that optimum inter-leavers with best encoder design might be considered for O-IDMA system.

2. OPTICAL IDMA SYSTEM

The block diagram of proposed IDMA system containing transmitter and receiver are shown in Figure-1(a). There are k different users depicted as b_1, $b_2 \ldots\ldots\ldots b_k$. For sending the user signal error free in communication channel, in first step channel coding is done. The first block indicates channel coder [3-5]. I have used low rate convolutional coder for coding purpose. After coding all the users are spreaded with same PNS code. Spreading introduces security and interference rejection capability in the system. All the spreaded coded user signals are pass through π_1, $\pi_2 \ldots\ldots\ldots \pi_k$, k user specific inter-leavers. Interleaving enhanced error detection and correction capability of a code and also inherits the multiuser detection capability of users in noisy environment. After interleaving signals are converted from electrical to optical domain. For optical conversion we have taken 1550nm zero dispersion wavelength of optical source which is Laser diode. Optical channel parameter is selected properly and at the receiving side optical to electrical conversion has been carried out. For optical detection we have used high responsivity higher gain Avalanche photo diode. Since responsivity is wavelength dependent so APD characteristics is selected accordingly.

In receiver side (in Figure-1 b) the noisy, interference signal goes to the chip match decoding process and shifted to the elementary signal estimator (ESE) for user recognition. In ESE different sets of anticipated noise patterns are already stored and their cross corellation, autocorrelation, autocovariece, cross covariece among other user signal are existed in memory and its impact on incoming signal are checked chip by chip LLR (long likelihood ratio) is the prime component for distinguishing the particular user. If any misdetection containing user specific inter-leavers are connected in feedback path to properly check, correct and identify the particular users.

VOL. 14, NO. 2, JANUARY 2019 ISSN 1819-6608
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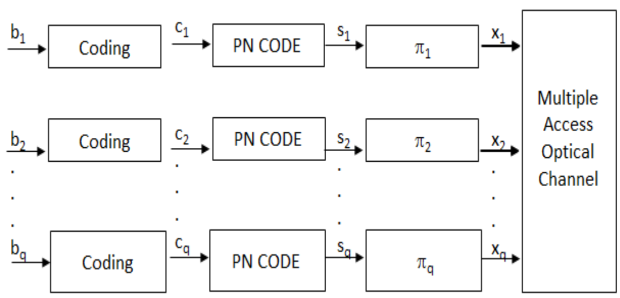

Figure-1 (a). The IDMA transmitter structure.

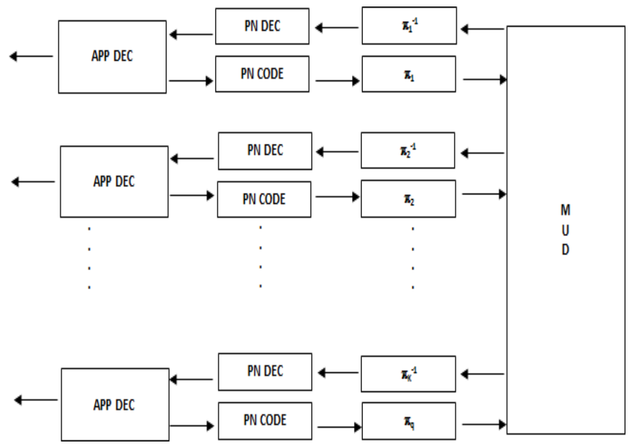

Figure-1 (b). The IDMA receiver structure.

3. INTER-LEAVER

Interleaving is technique of rejumbling the ordering of a data stream in a one to one specific permutation and combination which should be deterministic [6-7]. It is a practical approach to enhances the error finding competency of a code. It expands burst of errors into small errors which is easily distinguishable. Due to scrambling or rearranging bits it increases the uncorrelated data so enhances of code free hamming distance or reduces the numbers of code words with small distances so overall improves the BER.

A very common inter-leaver which scrambles the data bit with any random permutation is known as random inter-leavers. It requires larger memory spaces so used on that place where no storage crisis. Tree inter-leaver is a modified, organized form of random inter-leaver where initially two unsystematic selected master inter-leavers are taken. These inter-leavers possess orthogonal property having zero cross correlation. All the other inter-leavers are made of combinations of these two, arranged like a tree and users are put on tree branches according to certain rule. For examples consider 14 users we have selected two master random inter-leavers. According to number of users levels of tree is chosen which is denoted by L. Each user is arranged in tree branch with maximum distance 2L (L=1,2). In present example L is chosen as (1 & 2) which makes level as 2 & 4. In the given tree 1 & 2 users are treated as master random inter-leavers. In the first level L = 1 upper branch contains odd number users that is 3, 5 & lower branch 4, 6 that is even number of users are arranged with more distance 2. In the next higher level (L = 2) users are arranged with maximum distance (2L) 4 that is upper branch contains users [7, 11] [9, 13] & lower branch having [8, 12], [10,14]. If larger users exist which is more than 14, then level is increases as 4L, 8L etc.

Prime inter-leavers are designed on the basis of specific seeds [8-10]. Seeds are basically prime numbers output bits are unsystematised in such a way that each generated output bit differs with input bit by specific seeds. It gives the optimum and best result among all three inter-leavers discussed earlier.

4. CONVOLUTIONAL CODING

Convolutional coding is significant coding technique that is used in error correction [9-10]. Generally, convolution encoder is made up of combination of flip-flops and logic gates, D- flip-flops as its peculiar shifting property are commonly used in encoder hardware design. Constraint length depends on number of shift registers used in encoder. Normally constraint length is one ahead of number of registers used in encoder. Ex-OR gates are used in design of encoder to produce uncorrelated code-words. Convolutional codes are designated as [X Y Z] where X stands for number of output bits, Y stands for input bits and Z indicates number of memory elements inherit by encoder. The ratio between Y and X is termed as code rate [Y/X]. As the number of Ex-OR gates are increasing the outputs bits X increases makes the code rate as ½, 1/3 & ¼ etc. with fixed number of input bits Y = 1.

4.1 Design constraint of convolutional encoder by increasing Ex-OR gates

In the present design of convolutional encoder Figure-2 which is low rate (1,2) encoder having two memory element (shift register) and two adders are taken which makes constraint length 3 [13]. The optimum network topology considering the trellis diagram using MATLAB program is 3[5,7] which is taken from paper reference 12 [convolutional coder chapter 10], where 5 and 7 are written in octal number representation. By adding Ex-OR gates one by one in basic hardware of Figures 2, 3, 4 and 5 has been generated. The optimum trellis obtained for each case has been decided by the reference 12. In reference 12. the table is formed for different constraint lengths for (1,2), (1,3), (1, 4) and (1,5) encoders separately and optimum trellis structure in octal number with hamming distance d_{free} has been given for each cases. Since bit error rate depends on d_{free} so results of P_e has been derived on that basis.

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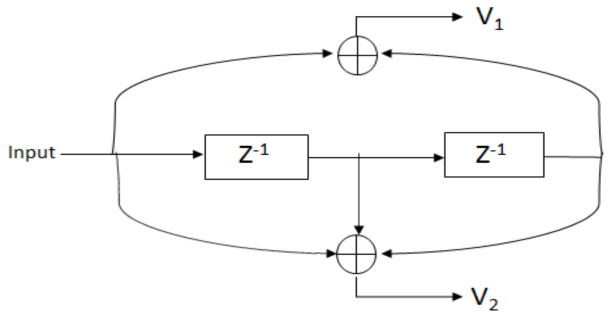

Figure-2. Convolutional encoder [1,2], 2 – Ex-OR gates network topology [3(5,7)].

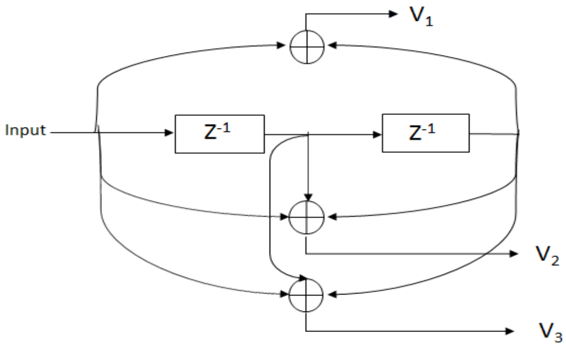

Figure-3. Convolutional encoder [1,3], 3 – Ex-OR gates network topology [3(5,7,7)].

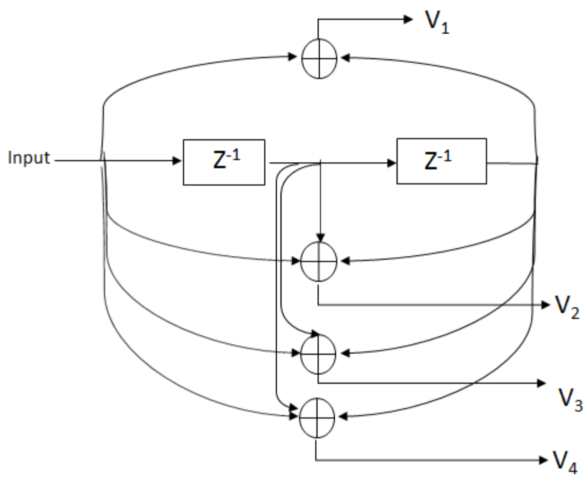

Figure-4. Convolutional encoder [1,4], 4 – Ex-OR gates network topology [3(5,7,7,7)].

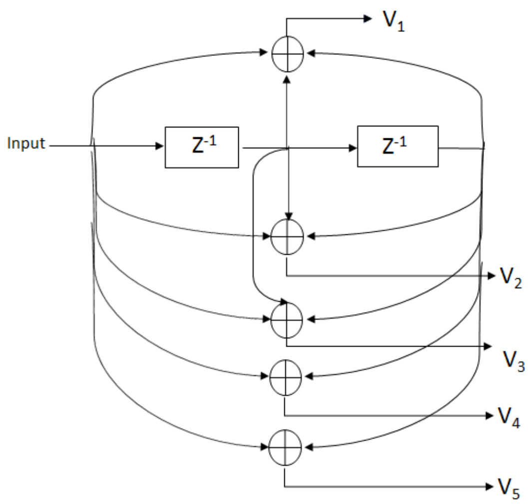

Figure-5. Convolutional encoder [1,5], 5 - Ex-OR gates Network topology [3(7,7,7,5,5)].

5. SIMULATION RESULT AND DISCUSSION

OIDMA system has been implemented on MATLAB organized by programming various section like coding, spreading, interleaving, channel optical source, optical detector, de-interleaving and decoding. For input parameters, I have fixed the PN Sequence Length = 32 and Input Data m = 1024 and block length is of 50. I have fixed the constraint length L = 3 by fixing the shift registers in encoder hardware as 2. The optical wavelength for transmission is selected as 1553 nm. The optical source parameters are selected as initial peak power 1 mw, Gaussian type pulse having bit rate $1G_{bps}$. The fiber is selected with parameter effective fiber cross section 8×10^{-11}, losses 0.15, fiber length 80 km and zero dispersion. The optical detector is APD having gain 1000, efficiency 0.85, I have programmed tree, random and prime inter-leaver separately and included in OIDMA for detection purpose, I have used high responsivity APD have gain 1000 and responsivity 90 % system and compared the BER evaluation for each cases separately.

From the Table-1 Figure-6 is framed between number of users verses BER for random inter-leaver at different code rates. The numbers of users are varied from 250 to 500. We see from the graph that for code rate (1, 2), BER is 1.3469×10^{-6} and increasing continuously as number of users becomes 500 (BER is 3.2758×10^{-6}). The trends suggest that as traffic intensity (number of users) becomes larger BER increases gradually. The reason behind that for heavier traffic intensity more ISI (more MAI) produced which enhances the BER. As the code rate increases to (1, 3), we find appreciably good results that is BER becomes 2.2969×10^{-7} (250 users) which is approximate 10 times superior that case (1, 2). In this case also as number of users increase BER increases slowly. The improvement in result is due to the fact that by increasing number of adders in encoder produces code words with larger d_{min} which improves error detection and correction capability and shows significantly improvement in BER. In the code rate (1, 4) and (1, 5), we

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find similar results and having appreciably implemented in BER (1.2500×10^{-8}) for rate (1, 4) 250 users and no error for rate (1, 5) 250 users.

In Figure-7, Table-2 which is framed for tree inter-leaver gives the result with same trend as obtained in random inter-leaver case. At most of instance the observed results for tree inter-leaver is inferior to random one. But as number of users becomes larger results of tree inter-leaver is better than random one for instance in case (1, 3) random inter-leaver BER is 7.8985×10^{-7} (500 users) which is improved as 6.1562×10^{-7} (500 users). Similar results were found for (1, 4) case also showing random (1, 4) BER is 6.8125×10^{-8} (500 users) which was improved as 2.2650×10^{-8} (500 users). The reasons behind that as number of users increases they are properly arranged in the tree branches of tree inter-leavers with minimum design complexity and less memory which reduces errors as obtained in random case.

In graph 8, Table-3 results are plotted between BER verses number of users for different code rates. The observed results show the same fashion as obtained in random and tree cases. By analyzing and comparing this results with previous two results prime inter-leavers gives the best results for instance in (1, 2) case random BER for 500 users is 3.2758×10^{-6} for tree 3.4234×10^{-6} (500 users) and for prime 3.2100×10^{-6} (500 users). Among three results prime inter-leaver results is best one on most of cases. This supremacy of result is obtained due to unique design of prime inter-leavers. Prime inter-leavers are designed with specific seed which is prime number that generate unique, un-distinguishable code ward with greater d_{min}. As d_{min} is more P_e drops down that's why results for BER is best one. The best results for (1, 5) code rates with BER is 2.2120×10^{-10} 350 users is also obtained for prime inter-leaver case.

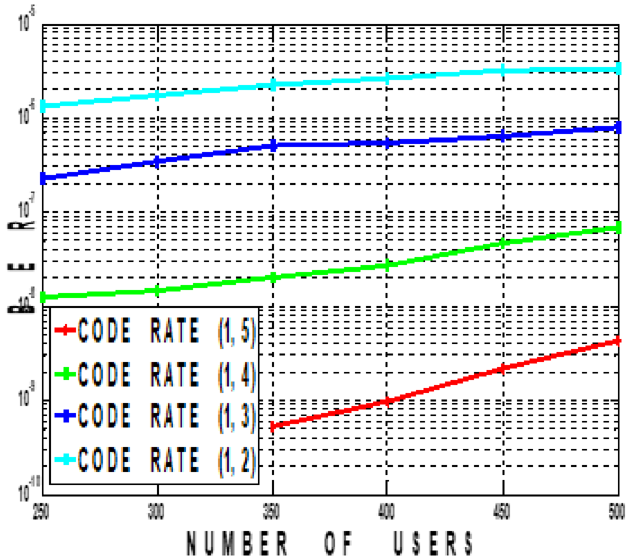

Figure-6. Random Inter-leaver using various code rate.

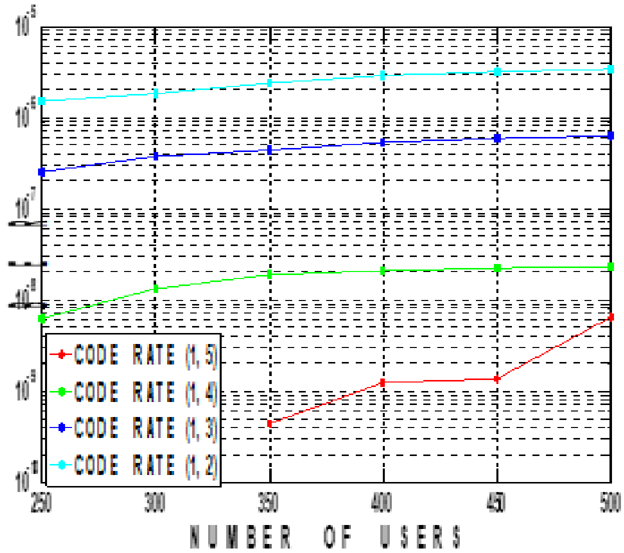

Figure-7. Tree inter-leaver using various code rate.

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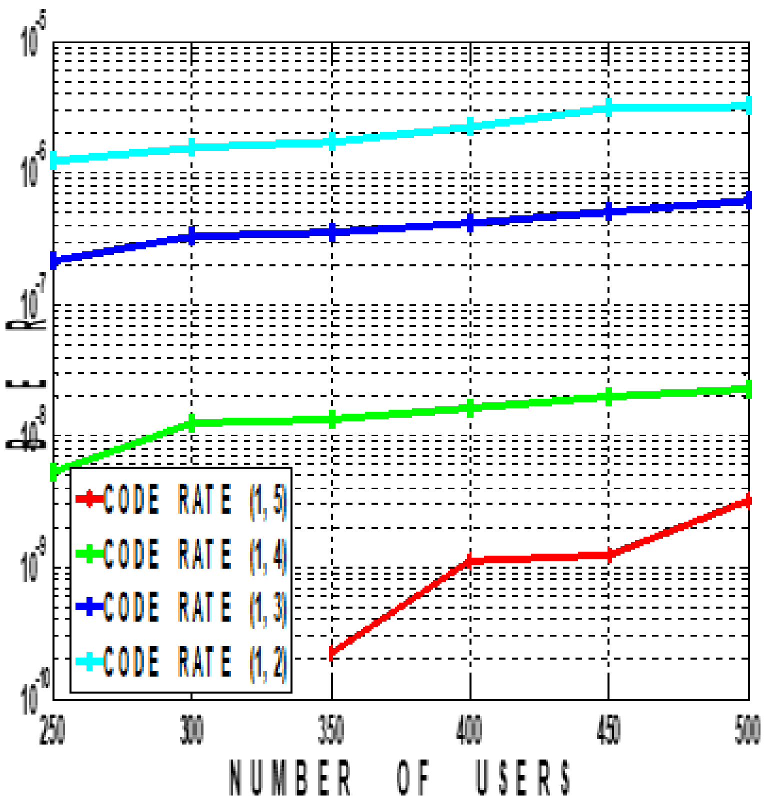

Figure-8. Prime inter-leaver using various code rate.

6. TABULAR FORM OF BER RESULTS FOR VARYING NO. OF USERS IN CODED OIDMA

Table-1(a). Constraint length for (1,2), (1,3), (1, 4) and (1,5) encoders separately and optimum trellis structure in octal number with hamming distance d_{free}.

Random Inter-leaver, PN Sequence Length = 32, Input Data Length m = 1024 Constraint Length (L) = 3 and block =50				
No. of users	**Conv. Code (1, 2)**	**Conv. Code (1, 3)**	**Conv. Code (1, 4)**	**Conv. Code (1, 5)**
250	1.3469×10^{-6}	2.2969×10^{-7}	1.2500×10^{-8}	No Error
300	1.7279×10^{-6}	3.4115×10^{-7}	1.4375×10^{-8}	No Error
350	2.2567×10^{-6}	5.000×10^{-7}	1.9935×10^{-8}	5.2376×10^{-10}
400	2.6602×10^{-6}	5.4102×10^{-7}	2.7344×10^{-8}	9.7656×10^{-10}
450	3.1684×10^{-6}	6.4063×10^{-7}	4.6755×10^{-8}	2.1850×10^{-9}
500	3.2758×10^{-6}	7.8985×10^{-7}	6.8125×10^{-8}	4.2321×10^{-9}

Table-1(b). Constraint length for (1,2), (1,3), (1, 4) and (1,5) encoders separately and optimum trellis structure in octal number with hamming distance d_{free}.

Tree Inter-leaver, PN Sequence Length (S.L.=32), Input Data Length (m)=1024, Constraint Length (L) = 3 and block =50				
No. of users	**Conv. Code (1, 2)**	**Conv. Code (1, 3)**	**Conv. Code (1, 4)**	**Conv. Code (1, 5)**
250	1.5078×10^{-6}	2.4844×10^{-7}	6.2500×10^{-9}	No Error
300	1.7969×10^{-6}	3.7370×10^{-7}	1.3021×10^{-8}	No Error
350	2.3257×10^{-6}	4.3750×10^{-7}	1.8973×10^{-8}	4.3250×10^{-10}
400	2.8730×10^{-6}	5.351×10^{-7}	2.0878×10^{-8}	1.2150×10^{-9}

450	3.1259×10^{-6}	5.7726×10^{-7}	2.1833×10^{-8}	1.3480×10^{-9}
500	3.4234×10^{-6}	6.1562×10^{-7}	2.2656×10^{-8}	6.4137×10^{-9}

Table-1 (c) . Constraint length for (1,2), (1,3), (1, 4) and (1,5) encoders separately and optimum trellis structure in octal number with hamming distance d_{free}.

Prime Inter-leaver, PN Sequence Length (S.L.=32), Input Data Length (m)=1024, Constraint Length (L) = 3 and block =50				
No. of users	**Conv. Code (1, 2)**	**Conv. Code (1, 3)**	**Conv. Code (1, 4)**	**Conv. Code (1, 5)**
250	1.2465×10^{-6}	2.1534×10^{-7}	5.3120×10^{-9}	No Error
300	1.5382×10^{-6}	3.2920×10^{-7}	1.2465×10^{-8}	No Error
350	1.7340×10^{-6}	3.4925×10^{-7}	1.3222×10^{-8}	2.2120×10^{-10}
400	2.2142×10^{-6}	4.2122×10^{-7}	1.6462×10^{-8}	1.1122×10^{-9}
450	3.1024×10^{-6}	5.1340×10^{-7}	2.0015×10^{-8}	1.2500×10^{-9}
500	3.2100×10^{-6}	6.1012×10^{-7}	2.2920×10^{-8}	3.2400×10^{-9}

7. CONCLUSIONS

By comparing and contrasting the observation derived for three cases (tree, random and prime) in OIDMA systems, most of the cases prime inter-leaver gives the best results. If we examine the results between random and tree for smaller number of users random gives better results as compared to tree but as user increases result were pessimistic. By varying the quantity of memory units number of shift registers simultaneously with adder the result might be more improved, since increasing the constraint length produces larger length uncorrelated code word which increases the number of nodes in code tree branches and improves BER. Overall we conclude that by using prime inter-leaver with higher code rate this OIDMA system might be a prominent solutions of removing ISI and MAI is modern 4G and 5G wireless and mobile systems.

REFERENCES

[1] Chan H, Griot M, Vila Casado A, Wesel R, Verbauwhede L. High Speed Channel Coding Architecture for the Uncoordinated OR Channel. Application-specific Systems, Architectures and Processors (ASAP'06) 0-7695-2682-9/06 $20.00 © 2006 IEEE.

[2] Krishna M. Raja Murali, Ashish M.Tata, Bhuvaneswari Ch., Vinod H, Rao R.V.Ch.Sekhar. 2014. Performance Analysis of Turbo Codes In CDMA Under AWGN And Fading. IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834, p- ISSN: 2278-8735. 9(2): 46-55.

[3] Chung Yeon Ho. 2007. Performance and Bandwidth Efficient Interleave-Division Multiple Access Scheme with High-Spread Interleavers. Division of Electronics, Computers and Telecommunications, Pukyong National University, Busan, Korea Information, Communications & Signal Processing, 2007 6th International Conference on 10-13 Dec.

[4] Bisht Pradeepti, Mishra Saurabh. 2014. Comparative Study of Interleaves in Communication System: IDMA Overview. IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735. 9(3): Ver. VI (May - Jun. 2014), pp. 66-72.

[5] Chavan Pragati N, Jadhav H. M. 2012. Survey on Interleavers in IDMA System. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Impact Factor (2012): 3.358 Volume 3 Issue 12, December 2014 www.ijsr.net Licensed Under Creative Commons Attribution CC BY.

[6] Reddy S. VikramaNarasimha, K Kumar Charan., Koppala Neelima. 2013. Design of Convolutional Codes for varying Constraint Lengths. International Journal of Engineering Trends and Technology. 4(1):. ISSN: 2231-5381.

[7] Somendra Shukla, Shikha Pandey, Vipul Dixit and M. K. Shukla. Analysis and Design of Optimum Interleaver for Iterative Receivers in Indoor Wireless Optical IDMA Scheme. Global Journal of Enterprise Information System (GJIS) DOI: 10.15595/gies/2014/v612/51847.

[8] Preeti Tiwari and Vikash Srivastava. 2015. A Comparative Study: Various Interleavers for IDMA

Technology. International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), 4(1): 33 ISSN: 2278-909X.

[9] Yeon H. C. 2007. Performance and bandwidth the efficient interleave-division multiple access scheme with high-spread interleavers. 6th International conference on Information Communications and Signal Processing, Singapore. pp. 1-5. DOI: 10.1109/ICICS.2007.4449895.

[10] Shukla M, Srivastava VK, Tiwari S. Performance Analysis of Tree Based Interleaver with Iterative IDMA Receivers using unequal power allocation algorithm. International Journal.

[11] Viterbi A.J. 1990. Very low rate convolutional codes for maximum theoretical performance of spread spectrum multiple access channels. IEEE Journal of selected areas in communications. 8(4):641-649.

[12] Dr. Chih - Peng Li. Chapter 10 Convolutional codes. Wireless Information Transmission Sytem Lab. Institute of Communications Engineering National Sun Yat – sen University

[13] Andrew J. 1079. Viterbi. Spread Spectrum Communication: Myths and Realities. Originally published in IEEE Communication Magazine. 17(3).