PERFORMANCE ANALYSIS OF MITA INTERLEAVER ON HYBRID SYSTEMS USING DIVERSITY

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ABSTRACT

The demands of 5th generation communication devices such as greater throughput, coverage and reliability cannot be easily met by any one physical media. Recently, wireless and powerline channels were combined and diversity techniques were employed to improve reliability using only the OFDM technique. In this paper, the hybrid system with diversity techniques is implemented and evaluated using Interleave Division Multiple Access (IDMA) scheme. As the strength of the IDMA scheme heavily relies on the adapted interleaving algorithm, in the paper interleaving algorithms such as Random, Tree and recently proposed Multiplicative Interleaving with Tree Algorithm (MITA) interleavers are compared on the grounds of computation complexity, memory occupied and bit error rate (BER). For analysis of BER, over MATLAB environment, the hybrid system assumes Rayleigh fading channel and Additive White Gaussian Noise (AWGN) on wireless medium and Symmetric alpha stable (SαS) noise on powerline channel. The outcome of comparison parameters verifies the superior performance of MITA interleaver in a hybrid system over the IDMA scheme.

KEYWORDS

Broadband Powerline (BB-PL), Interleave Division Multiple Access (IDMA), Interleavers, Multiplicative Interleaving with Tree Algorithm (MITA) & Maximal Ratio Combining (MRC).

1. INTRODUCTION

As the 5th generation is paving its way towards the customers, the assurance of reliability and throughput of internet connection has embarked on the transformation of home appliances into smart devices [1, 2]. But the wireless signals in indoor space operate in the unlicensed band and are attenuated by reflections and interference from the obstacles in the vicinity. Also, the multiple devices in smart homes operate in an uncoordinated fashion leading to amplification in disturbances. Additionally, the surge in the internet-supported devices in smart homes exhausts the wireless spectrum rapidly rendering it unable to cater to the continuous demands of smart devices, hence a need of an alternative mechanism was felt. Broadband powerline (BB-PL) serves as the best alternative to wireless system in providing in-home network access to devices by utilizing powerline as a medium for the transmission of internet connection [3,4]. As the powerline runs throughout the home area, it can easily provide reliable and secure connection to any remote device by the use of a HomePlug, without any additional hardware costs [5]. BB-PL may have some advantages but the random switching of appliances over the grid creates impulsive noise that poses a huge hurdle in the performance of the powerline communication (PLC) system. Thus both wireless and powerline communications channels face disturbances and cannot suffice to the demands of smart home individually. A plausible remedy could be the integration of multiple channel technologies.

Wireless and BB-PL network have their own pros and cons [6, 7] and recently they have been collaborated to meet the demands of the 5th generation by harnessing their individual benefits through the use of diversity techniques [8-10]. Many researchers have tried integrating wireless and powerline channel in varied aspects to attain greater reliability and throughput of internet connection in indoor places. In [11], network-level integration was proposed to increase QoS but due to the network management issues, unifying was taken down to the physical level as standards for powerline and wireless channel are almost identical. In [12], powerline was employed as a relay in conjunction with the wireless network to increase system performance without any additional expenses. However in [13], signal over wireless and powerline was combined using diversity techniques to enhance the system performance. Orthogonal Frequency Division Multiplexing (OFDM) was applied to data signal for both powerline and wireless channels, which assumed Class A noise and AWG noise respectively. Bit error rate (BER) expression for the hybrid channel was derived for two modulation schemes i.e. Binary Phase Shift Keying (BPSK) and Quadrature Amplitude Modulation (QAM) schemes. For combining signals Saturated Metric Combining (SMC) and Maximal Ratio Combining (MRC) diversity schemes were employed and hardware implementation was carried out. In [14], coding diversity has been practically implemented over office environment and results show superior performance over modulation diversity however, modulation diversity has upper hand if the data rate was same. A modified version of the MRC technique was proposed in [15], where instead of noise variances, noise power spectral density (PSD) was considered for determining the weight of the link. Author Sayed, M. in [16], employed differential BPSK modulation scheme for transmission of data bits while considering impulsive noise on both channels. A combining technique, differential signal strength combining (DSSC), was proposed which took into account the absolute value of signal along with the log-likelihood ratio (LLR) function. In [17], from experimental deductions power spectral density combining (PSDC) technique proved to be superior over coherent modulation but Average SNR Combining (ASC) scheme worked better in situations where differential modulation was employed. The statistical modeling of the hybrid system in home networks was presented in [18] where channel attenuation, delay, coherence bandwidth, and time were analyzed. The real-time implementation of hybrid wireless/powerline scheme was presented in [19] using the MRC technique.

Hybrid systems have also been evaluated for relay systems and outage analysis. The analysis of hybrid system using a single relay channel was performed in terms of outage probability and data rates in [20], where the performance of hybrid system was superior to the wireless and powerline channel individually. The analysis of outage probability for wireless/powerline channel was also carried out using diversity techniques in [21]. Leonardo, et.al [22] carried out numerical analysis to compute and conclude that the data rates achieved via single channel was less as compared to a hybrid channel. Another researcher evaluated the capacity of the hybrid system over PLC system for different parameters in [23]. The results show that powerline outperformed hybrid system for parameters such as low relay gain and small distances but hybrid system supported mobility better than powerline, leading to a trade-off. Recently in [24], the power allocation concept was applied and evaluated on hybrid system. The numerical analysis revealed that if power allocation was not optimal individual systems performed better but for optimal power allocation hybrid system was better in presence of MRC and Selection Combining (SC) diversity techniques.

However a striking similarity in the analysis of various hybrid systems in literature was the usage of the OFDM technique owing to the negligible interference, but the impulsive noise in the powerline channel cannot be effectively dealt with by the same. Thus in the paper to counteract the impulsive noise in the powerline channel and interferences in wireless channel Interleave Division Multiple Access (IDMA) scheme is implemented. IDMA scheme is a derivative of the Code Division Multiple Access (CDMA) technique [25] and incorporates the advantages of the latter, but the distinguishing feature of IDMA is that the error-free transmission is feasible by only randomizing the data bits. The rearranging of the data sequence is performed by the user-specific interleaved and acts effectively in nullifying the effect of group or burst errors caused due to impulsive noise. The interleaved algorithm is the heart of the IDMA technique and with changes in interleaving sequence performance of the system varies. In literature, various interleaves have been proposed such as Random, Tree, MITA, etc., that have been implemented on both wireless and powerline systems but not for the hybrid system. Owning to the gap analysis in literature, the paper proposes to firstly analyze the performance of wireless, powerline and the hybrid system in terms of BER by employing the IDMA scheme. The diversity techniques Equal Gain Combining (EGC), MRC, and SC are exploited for evaluation of the behavior of a hybrid system. Also, the BER graph is plotted for Random, Tree, and MITA interleaves. Secondly, the behavior of the hybrid system using the MRC diversity technique and MITA interleaved is judged for varying parameter values such as iteration count, spread length, data length. Lastly, the effect of Convolutional coding is observed on the hybrid system.

The paper is divided into section as follows: Section 2 provides an understanding of the IDMA system and mathematical models of wireless and powerline channels. Section 3 deals with the understanding of Random, Tree and MITA interleaver. The diversity combining techniques are explained in Section 4 and software simulation results are plotted in Section 5. Finally the paper is concluded in Section 6.

2. SYSTEM MODEL

The system architecture of the wired/wireless system with IDMA scheme is presented in Figure 1. The data generated at the transmitter is coded via Convolutional encoder, modulated, spread and finally interleaved according to user specific interleaver before transmitting. The same set of chips are sent via two different links i.e. wireless and powerline, which are combined at the receiver according to the diversity technique, before feeding to the IDMA detector for chip by chip detection. The IDMA detector assembly, also referred as Turbo processor [26] includes elementary signal estimator (ESE), pair of deinterleaver and interleaver, de-spreader and decoder and functions as a chip by chip detector. The role of ESE is to compute the mean and variance of the received signal in order to calculate the log-likelihood ratios (LLR) which serve as the input to deinterleave block. The deinterleaved signal from the ESE is fed to the de-spreader and decoder block which is abbreviated as DEC. The DEC serves to compute the mean and variance of the decoded and de-spread signal which is interleaved and fed back to ESE. The feedback loop iterates a specific number of times and then the hard decision is made at DEC to receive the output.

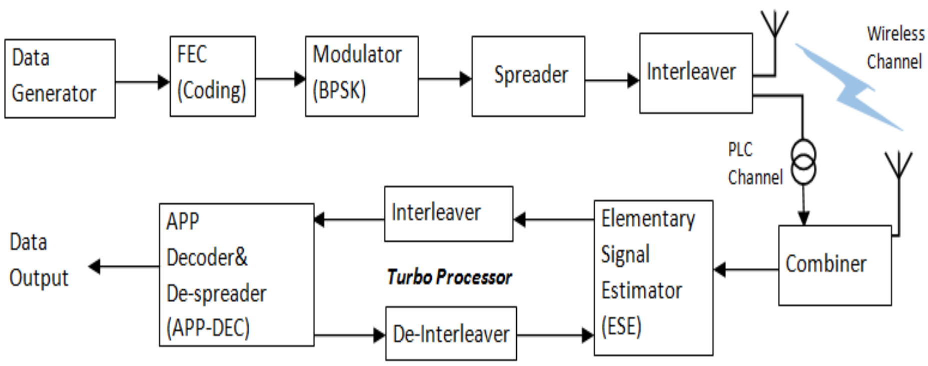


Figure 1. Block Diagram of Hybrid System

2.1. Mathematical Modelling of IDMA System

The IDMA system is designed for K consecutive users having length of data as *N*. The data of user k, a_k=[a_k(1),..,a_k(i).. a_k(N)] is encoded by employing Convolutional Coder of rate 1/2 and memory 2 [27] and then spreading operation is performed via a spreading sequence S=[+1,-1,+1,-1……] of length *sl* to produce s_k. The resulting data is permuted using interleaving algorithm π_k to produce the chip sequence x_k=[x_k(1),.., x_k(i),..,x_K(I)]. Lastly, signal from all users is combined to transmit over multiple access channel. The received signal r_k for a single channel can be written as:

$$r(k) = \sum_k h_k\, x_k(i) + \eta(i) \tag{1}$$

Where h_k is the channel transfer function for k^{th} user and η(i)resembles the noise of the channel. The received signal is fed to ESE which assists in suppressing the interference and hence improves BER performance. The output of ESE and decoders are expressed as extrinsic log-likelihood ratio (LLR) and is given as:

$$e\big(x_k(i)\big) = \log\left(\frac{\mathrm{p}(\mathrm{y}/\mathrm{x}_\mathrm{k}(\mathrm{i})= +1)}{\mathrm{p}(\mathrm{y}/\mathrm{x}_\mathrm{k}(\mathrm{i})= -1)}\right) \forall k, i \tag{2}$$

where input to the block is *y*. The LLR’s are denoted as e_{ESE} and e_{DEC} depending on the generation from ESE or DEC block. The stages of the iteration process are:

Step 1: Updating the values of Mean and Variance

Initially, $e_{DEC}(x_k\,(i))=0$. Then,

Then,

$$E\big(r(i)\big) = \sum_k \mathrm{h}_k E(x_k(i)) \tag{3}$$

$$Var\big(r(i)\big) = \sum_k |\mathrm{h}_k|^2 Var(x_k(i)) + \sigma^2 \tag{4}$$

$$E\big(\xi_k(i)\big) = E\big(r(i)\big) - h_k E\big(x_k(i)\big) \tag{5}$$

$$Var\left(\xi_k(i)\right) = Var\left(r(i)\right) - |h_k|^2 Var\big(x_k(i)\big) \tag{6}$$

Step 2: Generating the LLR’s

$$e_{ESE}(x_k(i) = 2h_k \frac{r(i) - E(\xi_k(i))}{Var(\xi_k(i))} \tag{7}$$

Step 3: Calculating Mean and Variance of Data

$$e_{DEC} x_k\big(\pi(i)\big) = \sum_{k=1}^{K} e_{ESE} x_k\big(\pi(i)\big) \tag{8}$$

IDMA performs chip by chip detection and the above steps are iterated for user-specified count before performing a hard decision on the output data. The additional benefit of the IDMA scheme is the drastic reduction in complexity as compared to CDMA system. The complexity of the CDMA system is expressed in terms of O(K^2) per user, whereas in the IDMA it is independent of user count and thus proves beneficial for larger user system [28].

2.2. Mathematical Modelling of Channels

In the hybrid system the two physical layers, wireless and powerline are combined to improve the system performance overall but the two media has different channel and noise characteristics, thus are configured separately. To accommodate for the multipath and fading effect in the wireless medium, Rayleigh Fading channel scenario is considered along with AWG noise, whereas for BB-PL channel bottom-up approach is adopted to derive the transfer function and to account for the impulse noise Symmetric alpha stable distribution function is assumed. The signal model given in Figure 2 demonstrates the flow of signal via wireless, ($Y_{wireless}=x*h_{wireless}+\eta_{wireless}$) and powerline, ($Y_{PLC}=x*h_{PLC}+\eta_{PLC}$) channels, where x is the input common to both channels, $h_{wireless}$ and h_{PLC} are complex channel coefficients and $\eta_{wireless}$ and η_{PLC} accounts for the interference and noise. The combiner block at the receiver operates on the principle of diversity techniques, described in the next section, to produce a strong signal for detection.

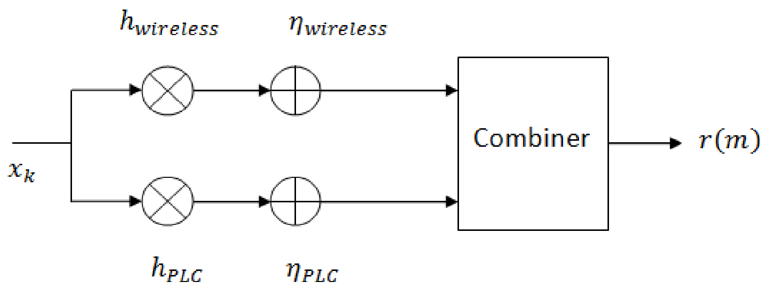


Figure 2. Signal Model of Hybrid System

2.2.1. Broadband Powerline Channel and Noise Model

The transfer function of BB-PL channel is derived by using bottom-up strategy [29, 30], wherein powerline is assumed to behave as a transmission line with parameters conductance G, resistance R, capacitance C and inductance L and for deriving the connection between input and output voltage and current of two-port network the chain parameter matrices representation is used and it is given as:

$$\begin{bmatrix} U_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} U_2 \\ I_2 \end{bmatrix} \quad (9)$$

The transfer function of network is expressed as:

$$H = \frac{U_2}{U_1} = \frac{Z_o}{AZ_o + B + CZ_oZ_S + DZ_S} \quad (10)$$

Where Z_o is the characteristic impedance, Z_s is the source resistance, γ is the propagation constant, l is length of powerline cable and parameter values of A, B, C, D are computed as [31]:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cosh(\gamma l) & Z_o \sinh(\gamma l) \\ \frac{1}{Z_o}\sinh(\gamma l) & \cosh(\gamma l) \end{bmatrix} \quad (11)$$

The value of characteristic impedance and propagation constant relies on the transmission line parameters R, L, G, C, which depend on the radius of cable. The noise in powerline channel comprises of impulse noise, colored noise and background noise, owing to the presence of electrical signal in the same layer and erratic switching of appliances on the network. The sudden increase or decrease of load gives birth to impulse noise which is a major noise component and therefore the noise model is assumed to an impulsive model. Middleton Class A (MCA) and Bernoulli- Gaussian (BG) distribution are the most commonly used due to their simplicity but recently Symmetric α-Stable (SαS) noise model is preferred for combining systems and on the fact that even noise tail can be modeled and its superior performance [32,33]. The characteristic function of SαS is described as [34]:

$$\varphi(x) = \exp(i\delta x - \gamma|x|^{\alpha}) \quad 12)$$

where α is the shape parameter that lies in the range (0,2]. The values of α =1 represent Cauchy distribution and α =2 denotes Gaussian distribution. δ is the shift parameter and the range is defined as $(-\infty, +\infty)$, whilst the extent of dispersion around δ is given by γ whose value is greater than 0.

2.2.2. Wireless Channel and Noise Model

In the home network, a wireless signal is assumed to operate in the unlicensed ISM band at 2.4 GHz, which is frequently reflected and scattered by the objects lying in the vicinity resulting in constructive or destructive interference at the receiver. To account for the fading and reflection in the confined space Rayleigh fading channel [35] is considered and it is expressed as: $h_{wireless} \sim CN(0, \sigma_w^2)$, where σ_w^2= E($|h_{wireless}|^2$), where E(.) denotes the expectation parameter. The noise $\eta_{wireless}$ is assumed to be stationary background AWG noise and is represented by Gaussian distribution with mean $\mu = 0$ and variance σ^2.

3. INTERLEAVERS

Interleaving is the phenomenon of permutation of data bits according to the user-defined algorithm to nullify the effect of burst error during transmission. Burst errors are group errors which affect the consecutive bits in the channel and are cumbersome to remove at receiver as occasionally the errors exceed the hamming distance. Interleaving can be accomplished based on various interleaver designs existing in literature out of which Random, Tree are employed in the paper along with MITA interleaver.

a) Random Interleaver (RI): The user data is rearranged randomly by using permuter indices which is defined by the user [36]. The advantage is the independence of interleaving sequence for various users and thus low interference. But as each user has its own interleaving sequence, too much memory and bandwidth is required for storing and transmitting the interleaving patterns and it increases with an increase in user count.

b) Tree Interleaver (TI): The Tree interleaver was proposed by Shukla in [37] and the purpose was to reduce memory and bandwidth consumption. The principle is that two orthogonal interleavers π_1 and π_2 are chosen randomly, which are used in generating the interleaving patterns for other users. Thus only memory and bandwidth equivalent to two interleavers are required and is irrespective of the number of users. The interleaver generation process is shown diagrammatically in Figure 3.

c) MITA Interleaver: Multiplicative Interleaving with Tree Algorithm (MITA) interleaver is recently proposed in [38] and is derived from Tree interleaver but with improved features, as shown in Figure 4. The Tree algorithm follows the principle of 2^n users in each stage, n being the stage count and MITA interleaver has 3x(n-1)-1 users in a stage, where x(n-1) being user count in the last stage thus having greater users in higher levels. Secondly, as the interleaving sequences for users in same stage are generated in one cycle, therefore number of cycles required is less for MITA than Tree interleaver for same number of users. Next, the user interleaver in a particular stage depends only on the past generated interleavers, whereas in MITA interleaver from second stage consecutive users are reciprocal of each other, thus less cycles are required for the generation of new interleaver at the receiver. Thus, collectively the design of MITA interleaver is computationally efficient than Tree interleaver. From the Figure 3 and 4, it can be observed that for a particular stage user count is different for both interleavers and the gap increases with increase in number of stages, thus increasing computational complexity in Tree interleaver as compared to MITA interleaver.

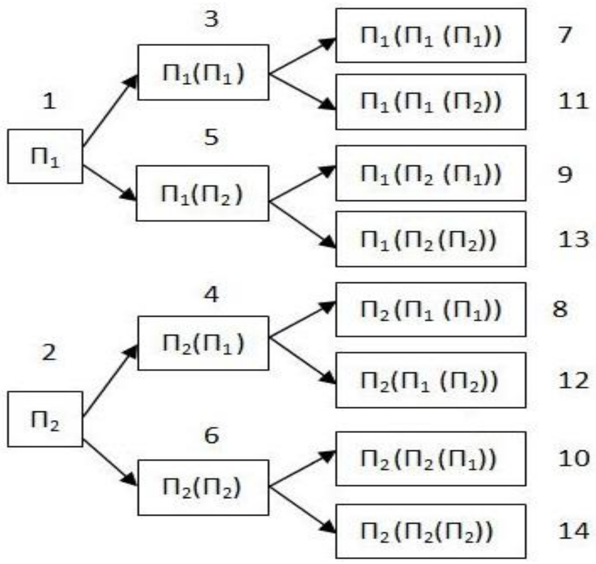


Figure 3. Tree Interleaving Mechanism

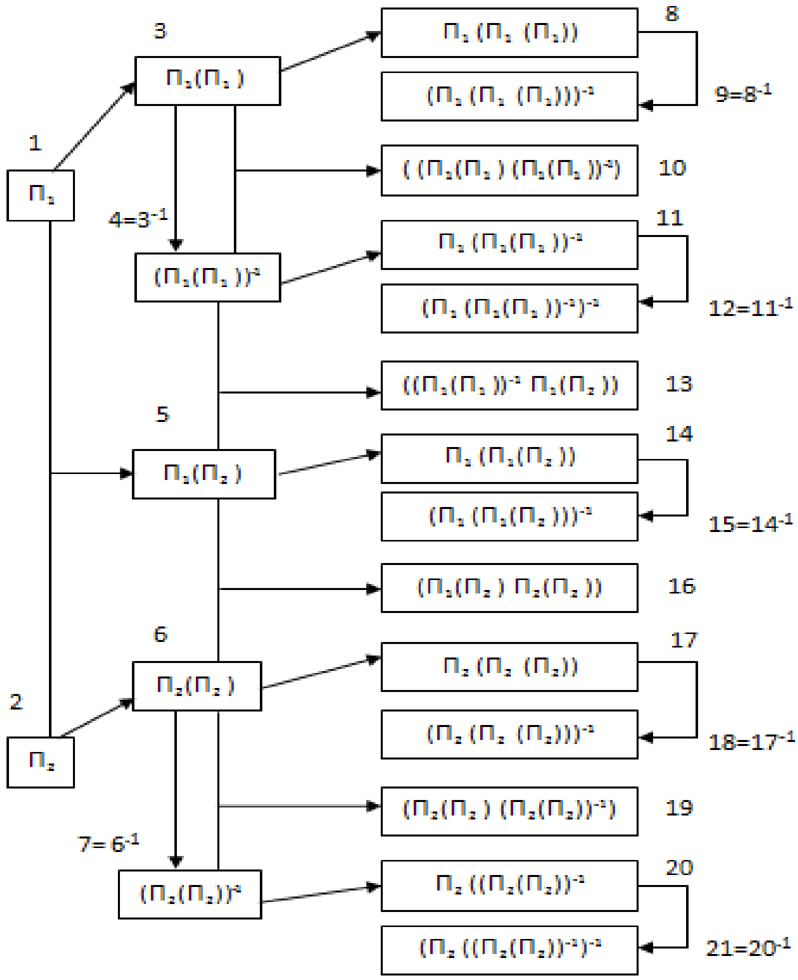
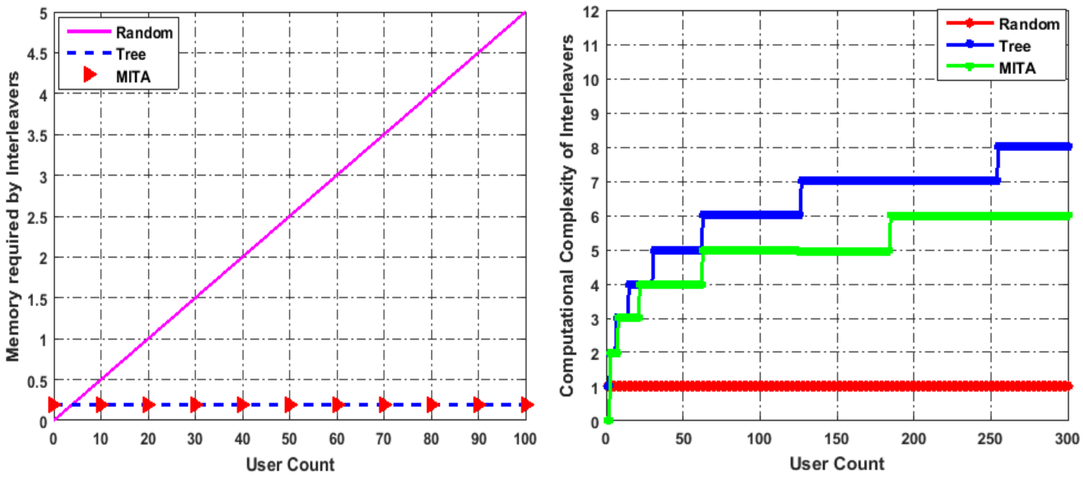


Figure 4. MITA Interleaving Mechanism

3.1. Comparison of Interleavers

The interleavers are commonly evaluated on the basis of memory required, complexity computation and BER. The Random, Tree and MITA interleavers employed in the paper were compared based on memory and computation complexity in this section, whereas BER comparison is performed in Section 5. Memory required is defined in terms of storage space needed at the base station for storing the interleaving sequences. Computation complexity is defined as the clock cycles needed for generation of interleaving sequences for *N* users. The comparison of interleavers is shown graphically in Figure 5. From the figure, it can be inferred that even though the complexity of Random interleaver is the least but memory required is the highest as all the interleavers are transmitted for regeneration at receiver. The memory consumed by Tree and MITA interleaver is same but with MITA interleaver the system design is better due to less computation complexity. Thus it can be safely inferred that for less memory requirement MITA can be preferred over Tree interleaver.



(a) Memory Requirement (b) Computation Complexity

Figure 5.Comparison of Interleavers based on Memory and Computation Complexity

4. DIVERSITY COMBINING TECHNIQUES

Diversity is a tool employed for improving the performance of channels, without any increment in bandwidth or power, by simultaneous transmission of data over multiple paths. In the paper, two transmit antennas have been considered, one for wireless channel and the other for powerline channel which are combined at the receiver by employing diversity techniques. At the receiver, the combining of communication signals over varied fading paths are based on the weight of the path. The diversity combining can be summarized mathematically as follow:

$Y = \sum_{p=1}^{N} w_p Y_p$ where, p denotes the paths, N is the number of paths, w_p is the weight of the path and Y_p is the signal on path p. In the paper, the three commonly used diversity mechanism, Equal Gain Combining (EGC), Selection Combining (SC) and Maximal Ratio Combining (MRC) are taken into account to evaluate performance of the hybrid system.

The reason behind adopting EGC, MRC and SC diversity technique is the simplified working algorithm and implementation of the fore-mentioned methods. Secondly, the evolution of new algorithms is based on the principle of either of discussed techniques. Lastly, the primitive diversity techniques aid in analyzing the behaviour of interleavers more accurately.

4.1. Equal Gain Combining (EGC)

As the name suggests, the outcome of EGC diversity technique relies equally on the signal power of all branches for the performance and the weight w_p of all the links is same. For a hybrid system, the two signals are co-phased and summing is done using the w_p of both links as ½ and the resultant signal is given as [39, 40]:

$$Y = \frac{1}{2}(Y_{wireless} + Y_{PLC}) \quad (13)$$

The principle of EGC method is quite simple, but the performance is lower than MRC, as the former sums all the signals equally i.e. even the weakest link has a major contribution in the overall signal strength which can degrade the signal quality.

4.2. Maximal Ratio Combining (MRC)

MRC technique is the optimum method for combining the signals on different links by weighting them proportionally to their channel gains after being co-phased [39, 40]:

$$Y = h^*_{wireless} Y_{wireless} + h^*_{PLC} Y_{PLC} \tag{14}$$

Where $h^*_{wireless}$ and h^*_{PLC} are the conjugate channel complex coefficients. The mechanism takes into account all the signal branches and their gains i.e. the stronger signal has a larger contribution as compared to a weaker signal. The performance of the communication system achieved with this method is the highest, but with a liability of the knowledge of channel coefficients.

4.3. Selection Combining (SC)

SC mechanism selects the link having the highest signal to noise power ratio by comparing all the signals at the receiving end. Although the principle is quite simple, but the performance is lower than MRC, as the latter sums up all the signals thereby enabling better detection of bits [39, 40]. For this method the number of paths $N=1$. The main drawback of this technique is that the comparing mechanism is repeated after successive intervals, but for some time duration the selected signal goes for detection even if it does not matches the threshold level. A trade-off exists between the time interval and the hardware limitations, too small time interval will result in faster scanning mechanism at will have an adverse effect on the hardware.

5. SIMULATION RESULTS

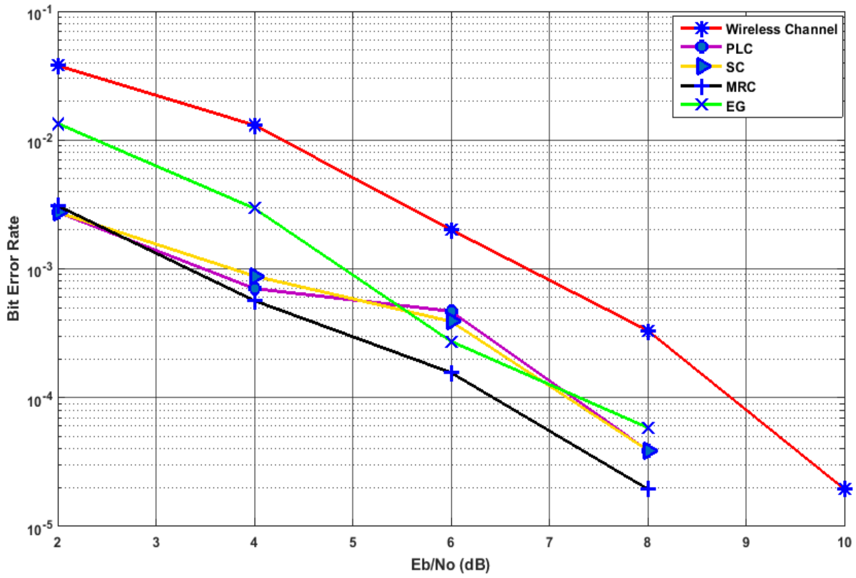
In this section, simulation results analyzing the performance of diversity schemes for hybrid, Wireless and PLC channel are presented over IDMA system for multiple interleavers such as Random, Tree and MITA. The effectiveness of diversity schemes was evaluated on the basis of BER which was plotted as a function of bit energy to noise ratio (E_b/N_o) in dB in MATLAB environment. For simulation, Rayleigh fading channel along with AWG noise have been assumed for wireless channel, and Symmetric α-stable noise has been considered in powerline channel. The noise model values for PLC channel were taken as α=1.85, δ=0 and γ=0.25. BPSK modulation technique was hired as it assisted in better assessment of diversity gain. For simulation of PLC channel over MATLAB, the following parameter values were assumed [30]:

Table 1. Simulation Parameters for PLC Channel

Parameters	Values
f	100 kHz
μ	4πe-7 H/m
μ_r	1
ε	8.85e-12 F/m
ε_r	3.6
σ_c	5.8e7S/m
a	1.12e-3 m

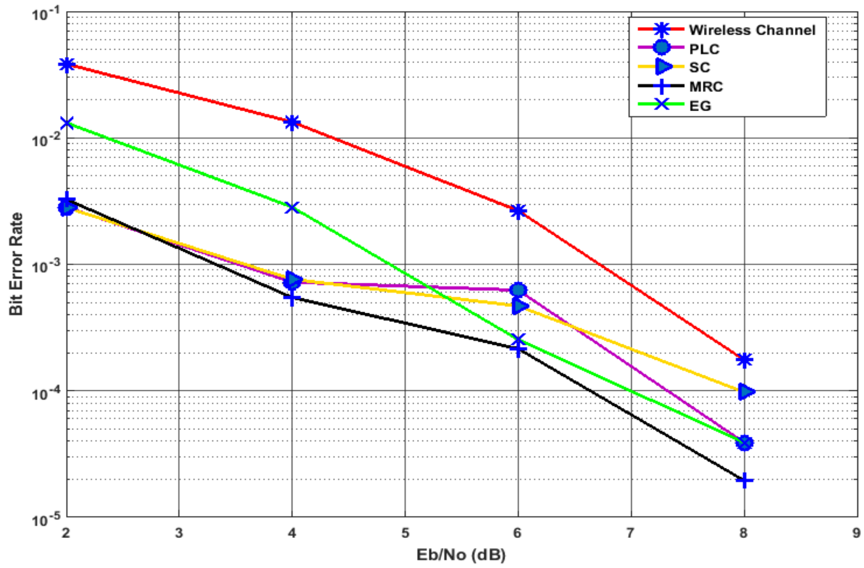
5.1. Analysis Based on Interleavers

To study the impact of interleavers on diversity gain, uncoded IDMA system was investigated for data length=*512*, spreading length=*8*, number of blocks=*100* and number of iterations of IDMA receiver was considered as*10*. The diversity gain analysis has been performed for diverse interleavers as the IDMA scheme relies on the effectiveness of interleavers. Figure 6 (a), (b) demonstrates the effect of diversity techniques on hybrid system using Random and Tree interleaver.



(a) Random Interleaver

From Figure 6 (a) & (b), it can be observed that powerline performs better than wireless as the former is a wired medium and among the diversity scheme MRC supersedes the rest two techniques as it exploits both wireless and wired signals in proportionate manner. The marginal improvement on applying Tree interleaver becomes significant when the system is to be operated for large number of users with longer data length. The sudden end of the graph indicates that at the specific E_b/N_o the signal power is sufficient for successful detection resulting in negligible error.



(b) Tree Interleaver

Figure 6. BER vs E_b/N_o for Wireless, PLC and Hybrid System for Random and Tree Interleaver

The next simulation was executed using MITA interleaver and is shown in Figure 7. It can be deduced from the figure, that performance of MITA interleaver is almost same as Tree interleaver but better than Random interleaver. The advantage of reduced memory consumption and lesser computation for higher number of users makes MITA interleaver a preferred option.

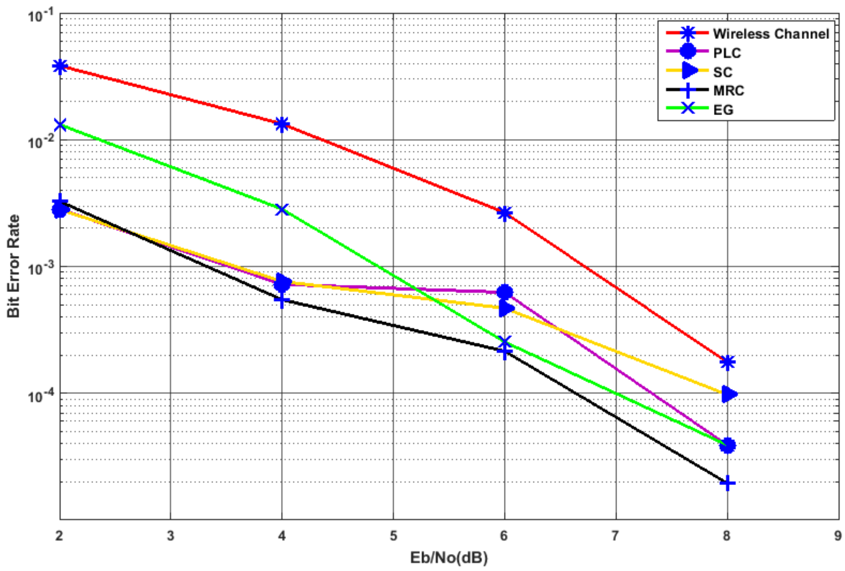


Figure 7. BER vs E_b/N_o for Wireless, PLC and Hybrid System for MITA Interleaver

To provide a clear discrimination in the performance of interleavers, comparison was performed using only MRC technique and the graph is plotted in Figure 8. The graph validates the conclusion drawn above that MITA and Tree interleaver perform almost the same and better than Random interleaver.

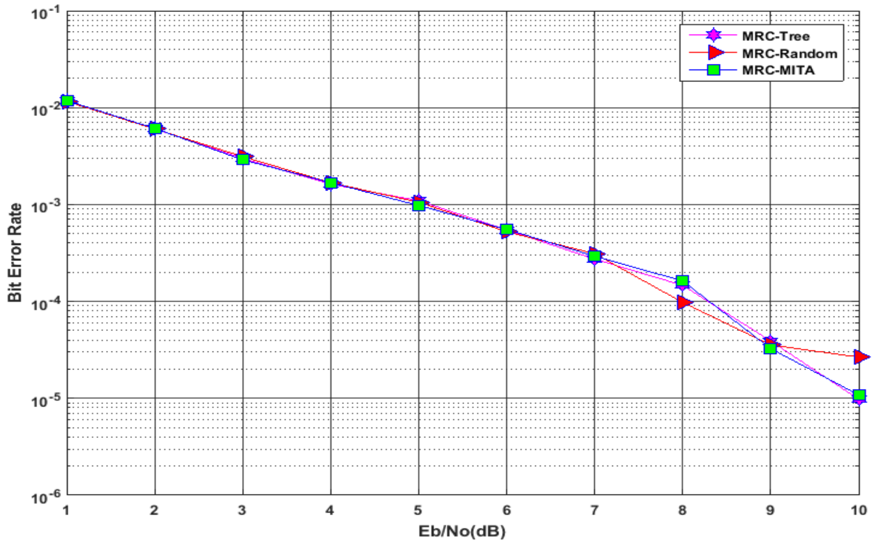


Figure 8. Comparison of Random, Tree and MITA interleaver using MRC diversity technique

As inferred from the graphs plotted, the MRC diversity technique provides highest gain therefore further analysis of the hybrid system was carried out by using Maximal Ratio Combining for figuring out optimal parameter values.

5.2. Analysis Based on Variations in Parameter Values

Analysis of Hybrid system with MRC diversity technique was carried out using MITA interleaver for varying parameters such as data length, spreading length, iteration count and coding. The first simulation was performed for variation in number of iterations which plays an important role in the IDMA decoding process. For the simulation, blocks were taken as 100, data length as 1024. From the Figure 9, it is noticed that BER performance gets better with increase in number of iteration as the estimate of the data bit improves with larger iteration count. However there is a trade-off, computation complexity escalates with hike in number of iterations and thus iterations should be set to an optimum value. Another important observation drawn is that increase in iteration count after 5 increases complexity proportionally, but with no advantage in BER. Thus the optimal value of iteration count is 5.

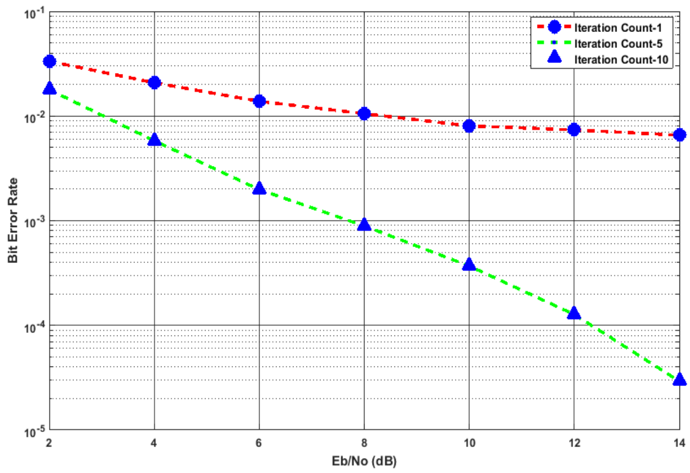


Figure 9. Variation in Iteration Count for Hybrid System with MITA interleaver

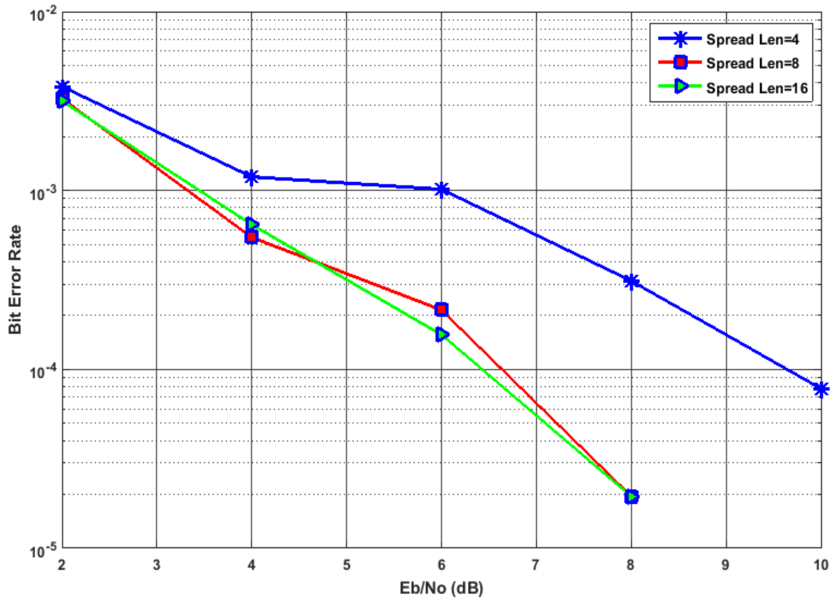
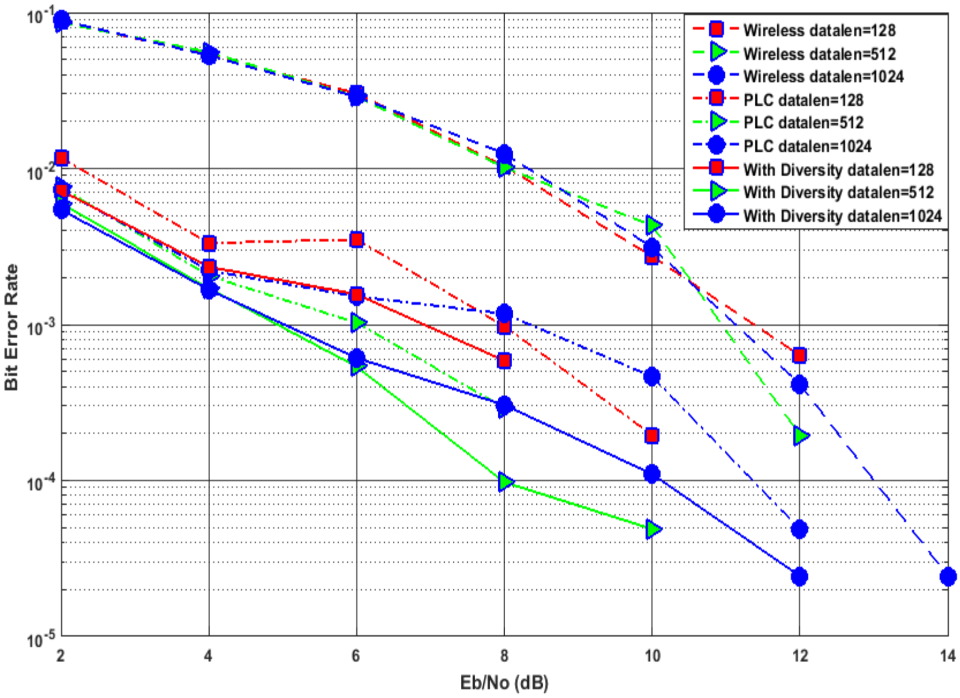
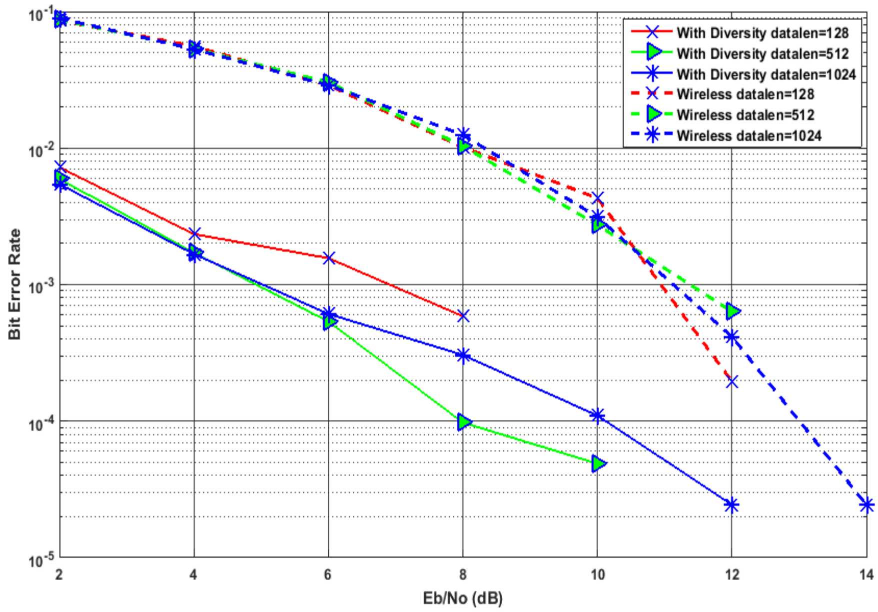


Figure 10. Variation in Spread Length for Hybrid System with MITA interleaver

In the Figure 10, performance analysis of Hybrid system with diversity is demonstrated for varying spread length. Spreading is employed in communications to increase the bandwidth of the signal thus making it difficult to jam or intercept. However, large spread length will result in bandwidth crunch and also large data increases the possibility of interference, therefore an optimum value for spread length is of importance. From the Figure 10, it can be observed that BER performance improves as spread length increases but not too much beyond spread length 8 due to interference. The next parameter for examination is the data length which is demonstrated in the graph in Figure 11. Figure 11(a) illustrates the effect on Wireless, PLC and hybrid system, and in Figure 11(b) depicts the performance of hybrid, and PLC system only so as to get a clear portrayal.



(a)



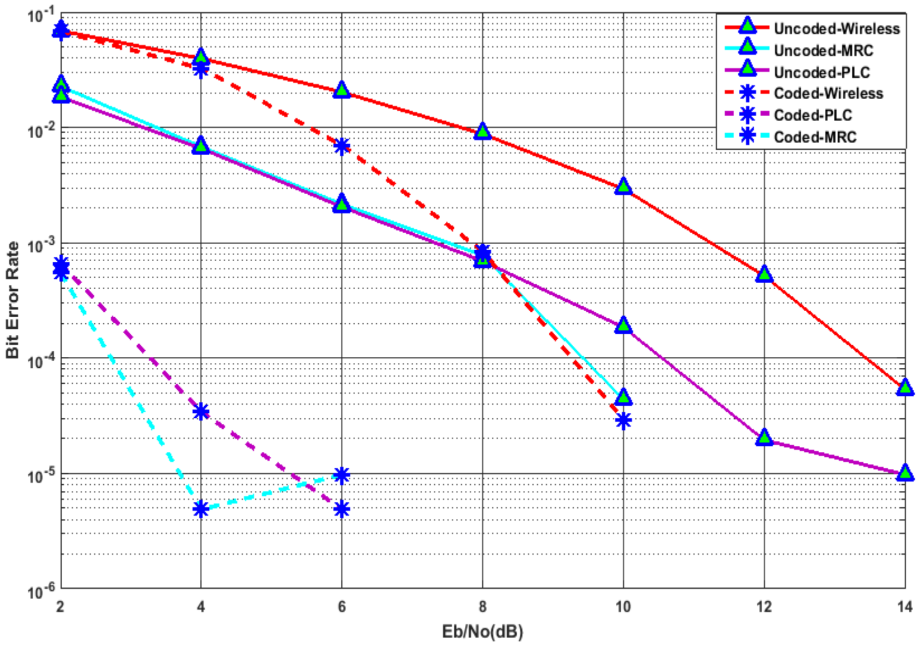
(b)

Figure 11. Variation in Data Length for Hybrid System with MITA interleaver

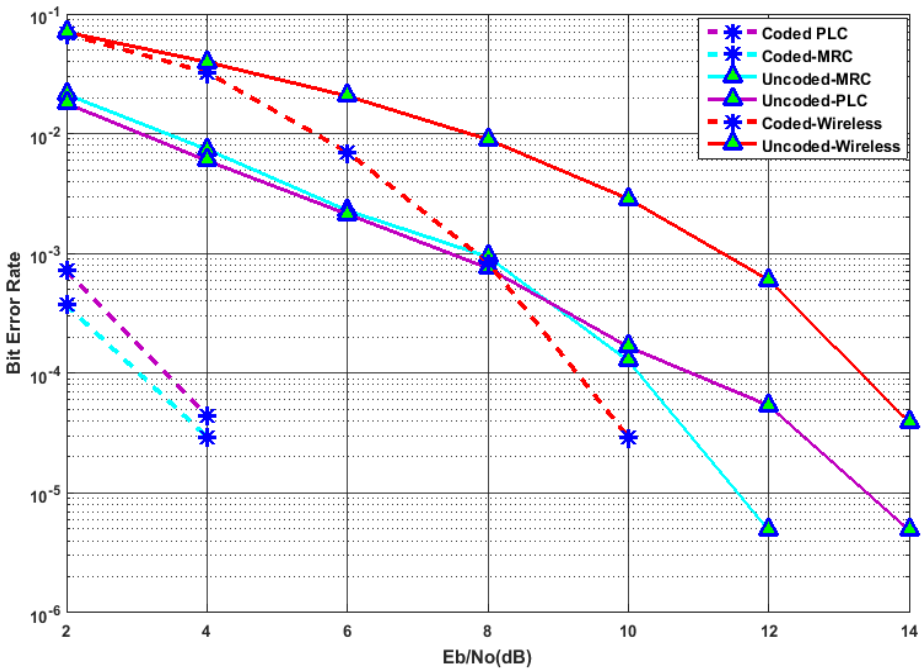
The key observation is that as the data length increases the BER performance improves owing to the fact that with larger data length higher is the possibility of combinations of orthogonal interleavers and thus lesser interference. But on increasing the data length further, the performance slightly degrades as too large signal length causes greater dispersion and interference which surpasses the capability of improvement by interleavers.

5.3. Analysis on Basis of Coding Technique

The last analysis was performed to inspect the behaviour hybrid system in the presence of Convolutional coding having coding rate as ½ and memory as 2.



(a) Random Interleaver



(b) MITA Interleaver

Figure 12. Effect of Convolutional Coding on Hybrid System for Various Interleavers

From Figure 12, it can be deduced that the convolution coding provides the extra gain in the system performance for both Random and MITA interleaver, however on comparing the two plots MITA interleaver improves the BER performance more than Random interleaver.

6. CONCLUSION

The 5th generation has led to the revolutionary idea of home appliances being connected to the internet, however, with increase in devices requiring uninterrupted network connection, it has become challenging for any individual network connection to cater to demands. Thus giving rise to the concept of integration of wireless and powerline channels. In literature, hybrid system has been evaluated for various surroundings conditions but with the use of OFDM technique. In the paper, the IDMA scheme was implemented on a hybrid system and to further enhance the performance, diversity techniques were employed. As the IDMA scheme relies on interleaver for its performance, the interleavers were compared on the grounds of computation complexity, memory required and BER. The computation complexity of MITA interleaver is the less than Tree but memory requirement is same as Tree. Thus for applications requiring lower computation complexity MITA interleaver can be preferred. For BER evaluation, graphs were plotted using MATLAB environment. The first set of simulations focussed on analyzing the behaviour of interleavers over wireless, powerline and the hybrid channel. The performance of Tree and MITA interleavers was almost same and the performance of hybrid system was best when MRC diversity technique was employed. Next, optimal values of various simulation parameters such as iteration count, spreading length and data length were computed for hybrid system using MRC diversity technique and MITA interleaver. Lastly, the improvement in the systems diversity gain with application of coding was presented. Thus to fulfil the demands of 5th generation, hybrid system with MRC diversity technique using IDMA scheme could be implemented and the system throughput efficiency can be improved by employing MITA interleaver and convolution coding. This work can be extended for OFDM-IDMA system for QPSK and QAM modulation schemes.

CONFLICTS OF INTERESTS

The authors declare no conflict of interest.

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