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BER Performance Comparison of TCM and BICM for fast Recovery of Data at the Receiver

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Abstract: Trellis coded modulation is a technique in which coding and modulation are done jointly unlike earlier uncoded modulation in which coding and modulation were done separately and hence TCM gives more coding gain without escalating the signal bandwidth required.TCM uses set portioning based signal labeling to achieve a high free Euclidian distance. However decoding and demodulation are complex process in Trellis coded modulation. Bit interleaved coded modulation (BICM) reduced the decoding complexity of TCM by incorporating random interleavers to the coded scheme. BICM combines convolution codes with bit interlavers. Then BICM is modified for iterative decoding and demodulation and this modified BICM technique is known as BICM-ID. This scheme uses signal portioning as in TCM but enhances the BICM free Euclidian distance space. so better utilization of bandwidth with less complexity can be achieved with above defined schemes. In this research work a comparison of coded modulation schemes (TCM, BICM, BICM-ID) is done for finding better BER performance. According to results iterative bit interleavers are better choice than other two.

Keywords: BICM, TCM, BICM-ID, AWGN, BER, SNR.

I. INTRODUCTION

In today's scenario of wireless communication, signal is transmitted from source to destination through signals not through wires. But the signal at the receiver end, we get, is distorted due to different obstacles in non line of sight that is called fading. To overcome fading error detection and correction codes are used. [1] Error detection is the recognition of error due to noise or other deterioration during transmission. Error correction is the recognition of errors and reformation of the original data with no error. Error detection and correction can be done by simply adding some extra bits to a message which receiver can use to check compactness of the delivered message. Error correction codes are differentiated as– convolution codes and block codes. [2] Block codes are processed on a segment basis and convolution codes on symbol basis. Convolution codes are the error correcting codes in which parity symbols are generated by sliding application (convolution of encoder over data) of a Boolean polynomial function to a data steam. Convolution codes are used to attain reliable data transfer in fields like mobile communication, satellite communication etc. So in today's wireless communication convolution codes can be used in different schemes like in trellis coded modulation, bit interleaved coded modulation and iterative decoding.

In section 1, basic introduction of the error correcting codes is being discussed. Section 2 is about what methodology is used for the research work. Old works are reviewed in section 3. Section 4 discuss about the results that have been achieved during the research work.

II. METHDOLOGY USED

- To study modulation and coding techniques – Trellis coded modulation and Bit interleaved coded modulation.
- To compare between trellis coded modulation and bit interleaved coded modulation.
- BER v/s SNR performance comparison is done between TCM and BICM
- To improve the performance of BICM new technique is introduce called iterative decoding. That works with BICM.

TRELLIS-CODED MODULATION

Trellis coded modulation is the composition of coding which is done digital and modulation which is done in analog as a single function. 'Trellis' stands for the use of trellis (also called convolution code). It has non linear nature of performance and its performance is measured by coding gain over an uncoded signal. By the use of convolution coding TCM is bandwidth efficient modulation. The trellis coded

modulation function contains a Trellis code and a Constellation Mapper. The function of Convolution coder of rate R = N/N+1 and an M-ary signal mapper that maps $M = 2^N$ input points into bigger constellation of $M = 2^{N+1}$ constellation points are combined in TCM.

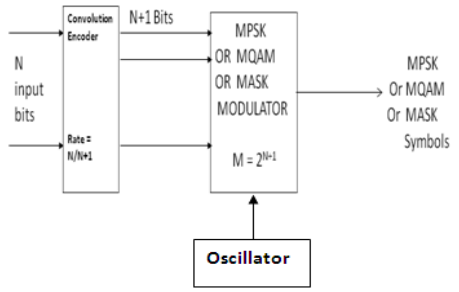

Figure:1. General diagram of Trellis Coded Modulation

BICM

Bit interleaved coded modulation is considered as the powerful strategy to achieve high data rates with general signal constellation. It uses powerful family of binary codes with any modulation format.

As in the figure 2 , [4] BICM for a binary code, can be designed by putting an encoder (ENC) with a memory less modulator over a specific signal set (x) through a bit interleaver π and (μ) is used for one to one binary labeling map. Binary labeling depicts that BICM works on the hamming distance not on Euclidian distance in decoding metric. At first The code sequence is interleaved and then it is again subdivided into subsequences of specific bits. At the end resultant signal is transmitted over the vector channel. In BICM [6] channel encoder and modulator are distinct by a bit level interleaver, providing more flexibility in choosing the code rate and constellation autonomously. Previous results [5] have depicted that the major performance of BICM making use of convolutional codes in non-fading channels can be considerably improved when interleaver is detached from the BICM design. The design with detached interleaver is considered as BICM trivial that had been formally depicted in [8] and is revealed to give performance as good as one dimensional (1D)- TCM. In [5], the performance of BICM transceiver is increased by making use of hierarchical constellations, a bit-level multiplexer and multiple interleavers. Influenced by the results presented in [5] . In BICM [10] channel encoder and modulator are diinguished by a bit level interleaver, increasing the flexibility in choosing the code rate and constellation individually.

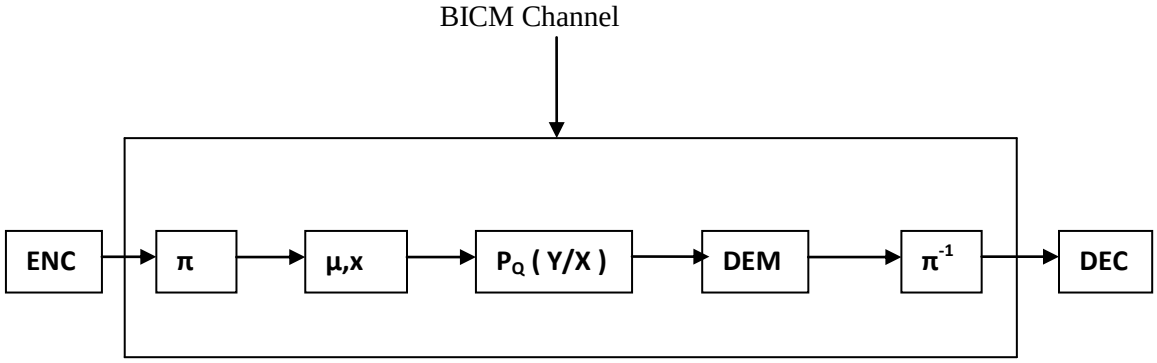

Figure 2: Block diagram of BICM transmission over a fading AWGN channel.

BICM-ID:

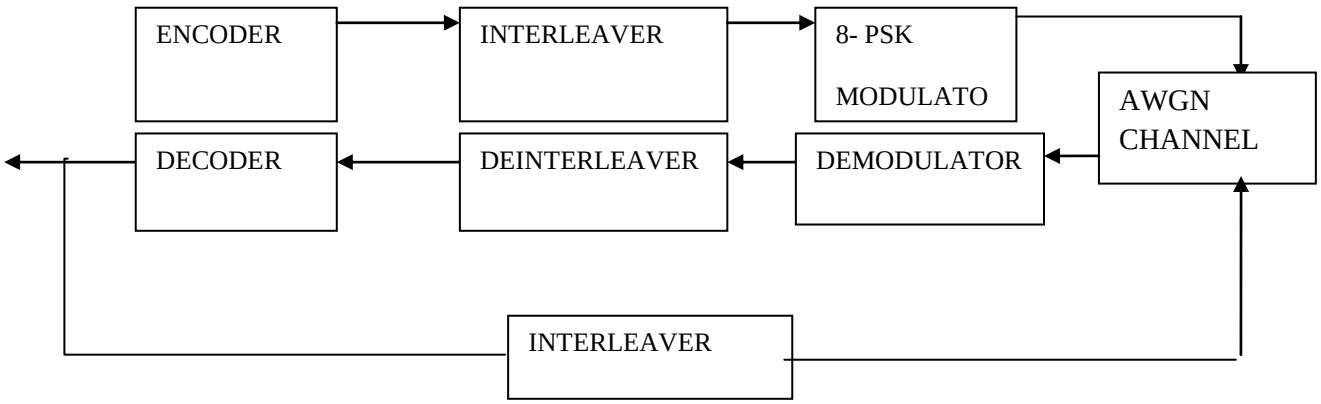

Figure: 3. Block diagram of BICM – ID scheme

Bit interleaved coded modulation with iterative decoding is a technique in which decoding and demodulation is made simpler than both BICM and TCM as it takes the bit interleaver as a feedback to maximize the free Euclidian space and lessen the complexity by signal mapping that belongs to the technique of set portioning to maximize the gain and reduced BER. So it takes the full advantage of bit interleaving with the aid of soft-decision feedback based iterative decoding. Iterative decodig at the interleaver ca be done in two ways. First is soft decision feedback based iterative decoding and second one is hard decision feedback based iterative decoding. Second one is put between forward error correction decoder and demapper to reduce the complexity but at the same time it lowers the performace of correcting the errors. First one is complex but does not affect the performance. First one works better in AWGN channel environment.

III. LITERATURE REVIEWS

Different papers are reviewed for the research work to accomplish our research. Different reviews study is depited as:

G.Caire, G.Taricco, E.Biglieri in [8] give a brief idea about Bit interleaving coded modulation (BICM) and in what ways it is better than trellis coded modulation. Paper is focussed on evaluation of its perforrmance on different fading channel like AWGN and Rayleigh fading. Comparative study results shows superiority of bit interleaved codes over Viterbi's orthogonal Convolutional codes (OCC). BICM specifications involve minimum hamming distance, minimum Euclidean distance and number of nearest neighbors which indicates the performance of BICM.

Vincent K.N Lau [9] proposed an error correcting method, Adaptive Bit interleaved coded modulation for bandwidth efficiency in wireless system. Bit interleaving is preferred over TCM due to bit by bit interleaving instead of symbols. In ABICM according to channel conditions code rates and modulation level are varied. By less sufficiency feedback link – in good channel state modulation level and code rate are increased and vice versa in band channel state to maintain targeted error level. ABICM focused on multilevel puncturing and interleaving. In terms of signal to noise ratio and output significant performance improvement is obtained.

Author of [10] proposed a bandwidth efficient method over fading channels that is BICM - ID. Compared to trellis modulation soft decision iterative decoding has large diversity with small Euclidean distance. According to results Performance efficiency of BCIM- ID depends on error free feedback.

Naghi H. Tran and Ha H. Nguyen [11] investigated different mapping techniques for 8-ary constellation in BICM – ID. Main is put on Euclidean distance and Mutual information for mapping techniques. Free squared Euclidean distance (FED) distance parameters are also discussed in this paper. After comparing different mapping schemes Io Maximized mapping scheme was found to be most suitable for 8-ary constellation BICM – ID system. Results shown that BER (bit error rate) at high SNR for an uncoded system oven an additive white Gaussian noise channel (AWGN) is minimized by Io mapping in 8-ary constellation.

In [12] Hierarchical constellations are used to protect a data stream from channel impairments. BER performance of single data stream is improved by using Constellation. Multiplexer and interleaver are also used for Nakagami-m fading channels.

Bit interleaved coded modulation with iterative decoding in two way relaying communication (TWRC) is proposed in [13]. For multiple access (MA) phase iterative decoding is adopted relaying on quaternary code representation. Bit error probability is successfully deducted in this paper with the use of iterative decoding and XOR based network coding at the relay.

For enlarged capacity of bit interleaved coded modulation technique advanced constellation and SSD technique are used in [14]. QAM is used as advanced constellation technique as it offer high data rate but less resilient to noise and interference. For broadcasting the information signal space diversity is used to enhance the sturdiness of the system. Results of both the techniques demonstrated that the performance is better when these are used separately than the combination of both.

As the paper [15] illustrates that BICM can also be used in increasing the performance of 3D- Turbo codes. Simulation results of the paper depicted that the this system can obtain about 0.8-1.0 dB gain at bit error rate (BER) of 10^{-6}, compared with the existing BICM system with Gray mapping QAM. Rotated mapping QAM is combined with 3-D turbo code to improve the performance. Rotated mapping is type of modulation diversity techniques used by rotating the constellation of classical mapping QAM

IV. RESULTS AND DISCUSSION

This research represents the Implementation of on study of coded convolution codes like trellis coded modulation (TCM), Iterative bit interleavers and bit interleaved coded modulation (BICM) for robust error correction of codes. In wireless communication error correction codes and interleaving have an important application due to fading. Implementation research papers have TCM, BICM-ID and BICM with different techniques and methods used in it. Papers show different modulation schemes used with TCM for various applications. Different algorithms are used with

BICM for improving bit error rate and improving bandwidth efficiency in Implementation. Different techniques like Iterative decoding and Constellation mapping are used with BICM, BICM-ID and TCM to improve Bit error rate (BER) and signal to noise ratio (SNR).

GRAPH 1: BER V/S SNR over AWGN and RAYLEIGH fading for TCM

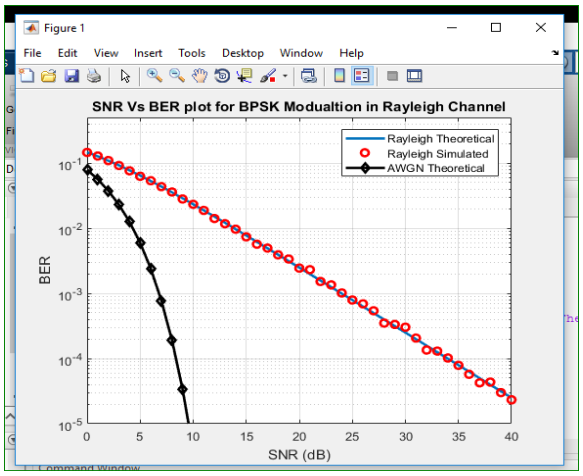

Figure 4. TCM BER V/s SNR for AWGN and Rayleigh channels.

As the results for the TCM code shows the comparison is done between two channels to examine the efficiency of TCM over AWGN and Rayleigh fading channels. As we know that there is less noise so fading effects are also low in AWGN. TCM works better in the AWGN channel environment as compared to Rayleigh as in AWGN channel BER is less as compared to Rayleigh.

5.2. GRAPH 2: BER V/S SNR over AWGN and RAYLEIGH fading for BICM

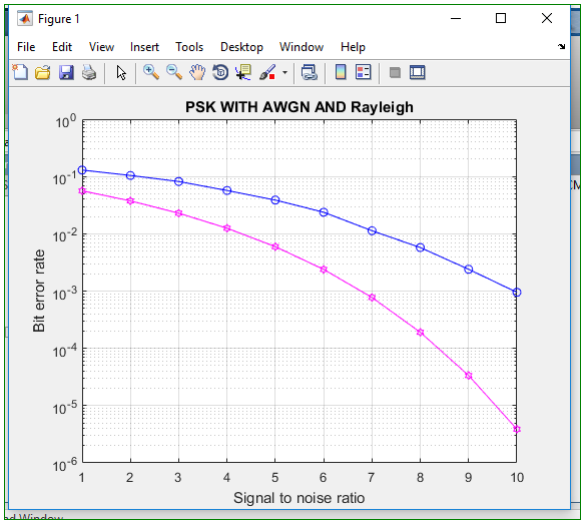

Figure: 5. BICM BER V/S SNR for AWGN and Rayleigh channel.

In figure 5, there are two curves for the BER of AWGN and Rayleigh channel. The curve (pink colored) shows the BER for BICM Rayleigh channel which is quiet low and gives best result for BICM. The upper curve (blue colored) shows BER for AWGN which have high BER. As the results suggests BICM works better in Rayleigh channel fading.

5.2. GRAPH 3: BER V/S SNR over AWGN and RAYLEIGH fading for BICM-ID

In Figure 6, we compare BICM-ID BER over AWGN and Rayleigh fading channel. As the graph shows when SNR is increased BER is reduced in parallel. For Rayleigh fading channel BER is lower for high SNR as compared to AWGN channel where BER is slightly higher at the same SNR. In comparison with conventional TCM and BICM, BER for BICM-ID is lower for both the channel fadings. Whereas TCM was giving better BER for AWGN channel and BICM was giving better BER for Rayleigh fading environment as BICM uses interleavers and deinterleavers to combat the effect of fading.

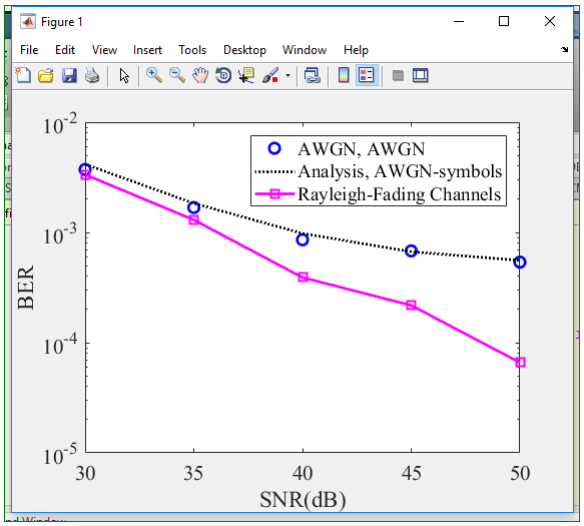

Figure. 6 . BICM-ID BER V/S SNR for AWGN and Rayleigh channel

V. CONCLUSION AND FUTURE WORKS

Transmission of the information with any data loss is major requirement of today's communication system. Error correction codes should have great efficiency for the detection and correction of the information. TCM a combination of coding and modulation achieves the better BER but at the cost of complexity at the receiver in the decoding and demapping process. Putting interleaver and deinterleaver between coding and modulation reduces the complexity but reduces the free Euclidean space as in

BICM. Iterative decoding took advantages of both and hence uses less signal bandwidth and have larger Euclidian space. Other techniques can be employed with iterative decoding to improve the efficiency more in iterations and reducing the complexity.

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