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Optimum Interleaver Finding Analysis for varying word length

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Abstract: Interleaving is a technique of rearranging the order of data sequence in a one to one deterministic format. At the receiver end, the inverse of this process is performed that is called as de-interleaving which restores the received sequence to its original order. It is used to improve the error correcting capability of coding algorithms like turbo codes. The task is to choose an optimum interleaver technique with change in word length of information bits for best performance ofturbo codes. The performance of Turbo codes is analyzed for Random, QPP and UMTS interleaver. Out of analysis, it is seen that random interleaver performs better at lower word length while UMTS performs better at middle values of word length and QPP interleaver is the best for larger word length.

Keywords: Interleaver, UMTS (Universal Mobile Telecommunication System), QPP (Quadratic permutation polynomial), Random interleaver, BER (Bit error rate), SNR (Signal to noise ratio), RSC (recursive systematic convolution) codes, MAP (Maximum A-Posteriori).

I. INTRODUCTION

Turbo Codesarecurrently used error-correcting codes that can approach the Shannon limit through iterative decoding process and an efficient interleaver. The QPP Interleaver used for generating pseudo random number sequences is adopted by 3GPP LTE standard due to its simple formula and outstanding performance. It is very useful in avoidance of interleaver table storage ina turbo decoder and excellent in reduction of decodinglatency of parallel turbo decoding by maximumcontention-free property [1].

Low complexity interleaver design is in requirement that facilitates high throughput Turbo decoding for next generation wireless systems. While dealing with a parallel decoding structure, interleaver design is very important. The size ofinterleaver and its structure considerably affect Turbo code error performance. Generally, an interleaver was used to randomize the error locations, since this randomness affects the decoding performance. But Random interleaver is not only difficult to implement, but also creates problems in parallel decoding due to memory conflict. Therefore, research for interleaver to improve performance during parallel decoding is becoming important task [2].

The major drawback of turbo code is its high latency due to itsiterative decoding process.This work proposes the adoption of an advanced interleaver, Quadratic permutation polynomial (QPP)interleaver. When interleaver is replaced with QPP, the memory access contention is resolved [3].

In the proposed work, Random, QPP and UMTS interleaver techniques are analyzed by varying the word length on AWGN channel for BPSK modulated symbols with RSC-1 encoder and MAP decoding algorithm. It is been seen that different interleaver performs better at different word length. The result is discussed in simulation results and conclusion part.

II. RANDOM INTERLEAVER

The random interleaver is Pseudo random interleaver in the true sense because a pseudorandom number generator or a look up table is used to map the input sequence. This approachcan be good or bad and there are no analytical criteria, the selection is only based on softwaresimulation. Fig.1 shows the operation of the random interleaver with N=8 [11].

Input sequence

0	1	0	0	1	0	1	0

PN sequence

1	3	5	7	2	4	8	6

Interleaved sequence

0	0	1	1	1	0	0	0

Fig.1: Operation of the Random interleaver

III. QPP INTERLEAVER

Interleaving/de-interleaving is a key issue that is requiredto enable parallel decoding and thus memory access contentions occurs when MAP decodersimultaneously tries to read/write from/to memory. The QPP interleaver defined in the new3GPP LTE standard differs from previous 3G interleavers in that it is based on algebraicconstructions via permutation polynomials over integer rings. It is known that permutation polynomials generate contention-free interleavers [9, 10]. The QPP Interleaver can be represented by a mathematical formula given aninformation block length N the x-th interleaving output position is specified by simple quadratic equation(1):

$$f(x) = (f_2 x^2 + f_1 x) \bmod N \qquad (1)$$

Where parameters f1 and f2 are integers and depend on the block size N (0≤x,f1,f2<N) .For each block size, a different set of parameters f1 and f2 are defined. In LTE, all the blocksizes are even numbers and are divisible by 4and 8. The block size N is alwaysdivisible by16,32and 64 when is 512, 1024, and 2048,respectively.By definition, parameter f1 is always an odd number whereas f2 is always an even number.Through furtherinspection,we can list the following algebraic properties for the QPP interleaver

IV. UMTS INTERLEAVER

The structure of the turbo encoder which has beenapplied in Universal Mobile Telecommunication System(UMTS) standard is presented in Fig. 2. The encoder hasthree output sequences: information sequence (c0), paritybits sequence produced by the first component RSCencoder (c1), parity bits sequence formed by codingpermuted information sequence in the second RSCencoder (c2). The UMTS interleaver formats the input sequence in a predefined matrix and then permutes matrixelements using a pseudo-random algorithm defined inUMTS standard [8]. Reordered bits are afterwards sent to an interleaver output and coded in the second RSCencoder. Turbo code decoding process consists of manyidentical stages and requires the existence of twoindependent component decoders. In every decodingiteration, decoders exchange messages with soft decisions information.

V. EXPERIMENTAL PARAMETERS

There is a large effect on free distance in turbo codes due to interleaving and it lowers the error floor. When a curve is plotted between BER and SNR of Turbo code, the resulting curve has waterfall shape that abruptly flattens. This part is called error floor. The error floor condition occurs due to small minimum distance in turbo code as the performance curve flattens out as shown in Fig. 3. Appropriate interleavers are used for lowering error floor in turbo codes.

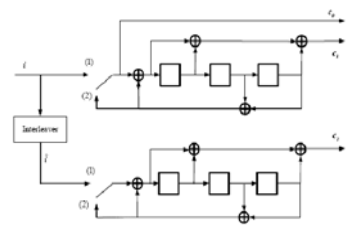


Fig. 2: UMTS turbo encoder structure.

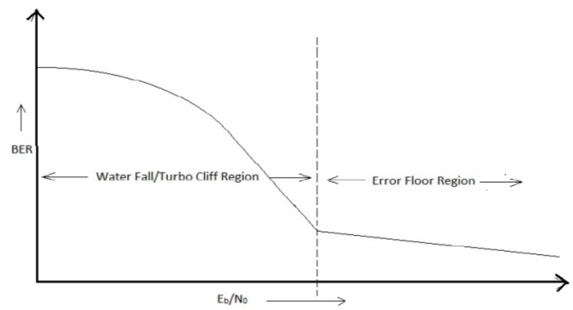


Fig. 3: A BER curve showing the waterfall region and the error floor

VI. SIMULATION AND RESULTS

The simluation is performed in MATLAB by taking RSC-1 encoding and MAP decoding technique on AWGN channel for random, UMTS and QPP interleaver. The BER vs SNR is plotted with change in word length upto four iteration as shown in fig. 4,5,6,7.

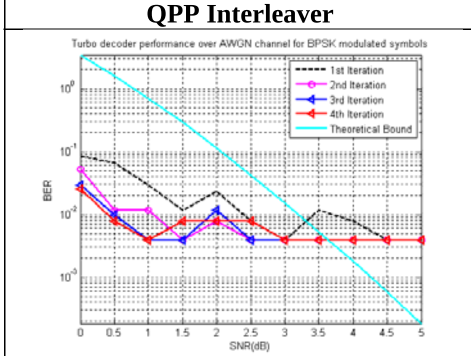
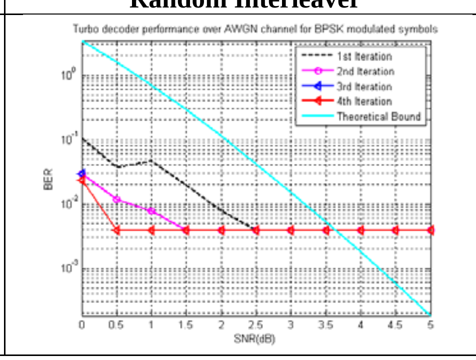
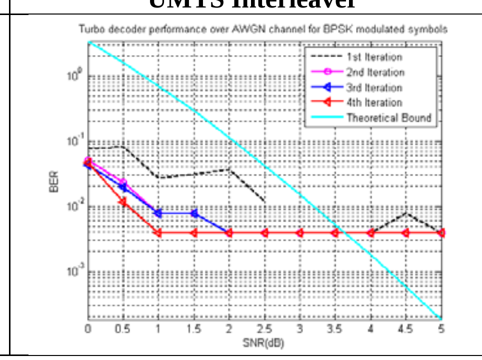
QPP Interleaver	Random Interleaver	UMTS Interleaver
		

Fig.4BER Vs SNR plot for QPP, Random and UMTS Interleaver at word length of 512.

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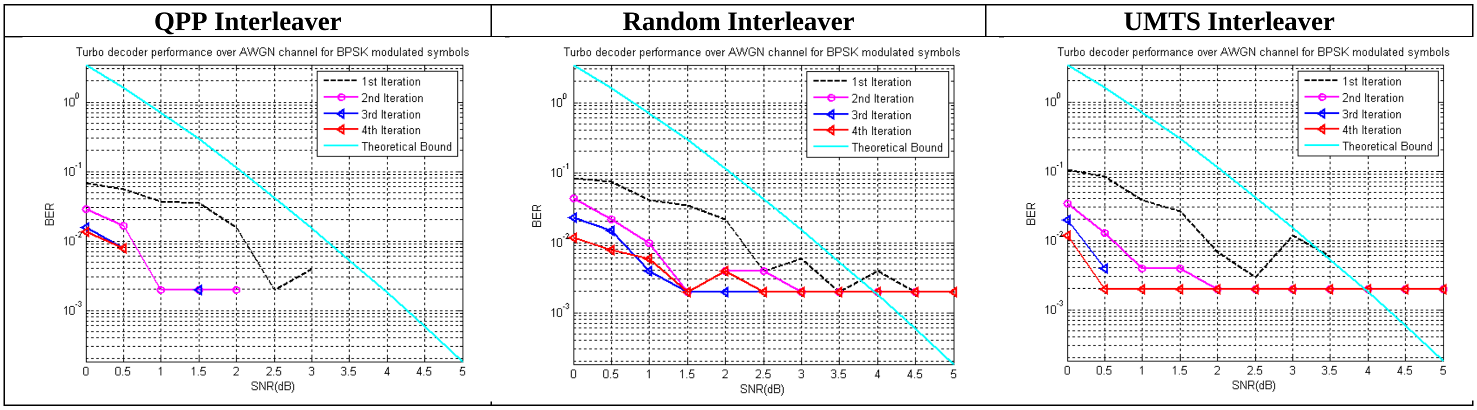

Fig. 5BER Vs SNR plot for QPP, Random and UMTS Interleaver at word length of 1024.

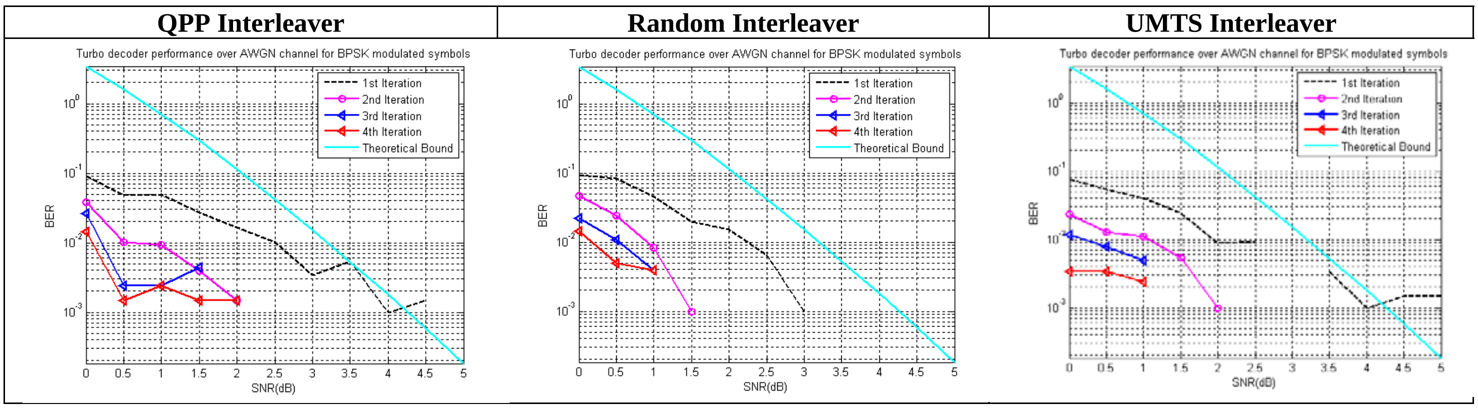

Fig. 6BER Vs SNR plot for QPP, Random and UMTS Interleaver at word length of 2048.

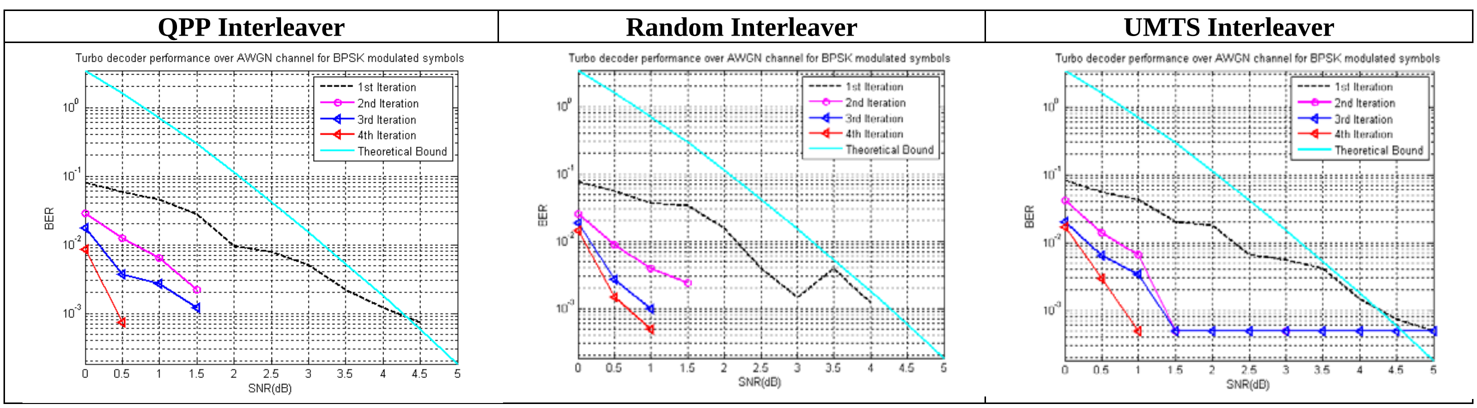

Fig. 7BER Vs SNR plot for QPP, Random and UMTS Interleaver at word length of 4096.

Fig. 4 is plotted for word length of 512 and it shows that random interleaver performs better than other two. Fig. 5 and 6 are plotted for word length of 1024 and 2048 respectively, they show that UMTS interleaver technique works better in these word length. While fig. 7 is plotted for word length of 4096 and plotted graphs shows that QPP interleaver performs better at higher word length.

VII. CONCLUSION

Interleaver is very important for improving the performance of the turbo codes. In the proposed analysis, it is been concluded that if with change in word length interleaver is switched then performance of the turbo code can be improved. Like for lower word length Random interleaver gives optimum performance. For word length in between 512 to 2048 UMTS performs better. While for higher word length if system is switched to QPP interleaver then the overall performance of turbo codes can be significantly improved.

REFERENCES

[1] I. Poonguzhali, C. Arun, "Effect of Interleaver Algorithm on the Performance of Modified Turbo Codes", Middle-East Journal of Scientific Research, 2016.

[2] Prabhavati D. Bahirgonde Shantanu K. Dixit, "Ber Analysis of Turbo Code Interleaver", International Journal of Computer Applications, Volume 126, No.14, Sept 2015.

[3] P. Deborah Roseline, G. Thavaseelan and R. Rani Hemamalini, "Design of Hybrid Log-MAP Algorithm for Turbo Decoding Using QPP Interleaver", Middle-East Journal of Scientific Research, 2015.

[4] Guohui Wang, HaoShen, Yang Sun, Joseph R. Cavallaro, Aida Vosoughi, and YuanbinGuo, "Parallel Interleaver Design for a High Throughput HSPA+/LTE Multi-Standard Turbo Decoder", IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS, 2014.

[5] Ching-Lung Chi, "Quadratic Permutation Polynomial Interleavers for LTE Turbo Coding", International Journal of Future Computer and Communication, Vol. 2, No. 4, Aug 2013.

[6] HoriaBalta, RaduLucaciu, Paul Gajitzki and AlexandruIsar, "QPP Interleaver Based Turbo-code For DVB-RCS Standard", 4th International Conference on Computer Modeling and Simulation, 2012.

[7] Cheng-Chi Wong and Hsie-Chia Chang, "High-Efficiency Processing Schedule for Parallel Turbo Decoders Using QPP Interleaver", IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS, VOL. 58, NO. 6, JUNE 2011.

[8] Srđan S. Brkić and Predrag N. Ivaniš, "Performance Evaluation of HARQ Technique with UMTS Turbo Code", Telfor Journal, Vol. 3, No. 2, 2011.

[9] O.Y. Takeshita, "On maximum contention-free interleavers and permutation polynomials over integer rings", IEEE Trans. Inform. Theory, Mar2006.

[10] J. Sun, O.Y. Takeshita, "Interleavers for turbo codes using permutation polynomialsover integer rings", IEEE Trans. Inform. Theory, Jan 2005.

[11] C. Fragouli and R. D. Wesel, "Semi random interleaver design criteria," in Global telecommunication Conference' 99, (Rio de Janeiro, Brazil), December 1999.