Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

# Study of Polar Code Using BPSK

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***Abstract*—** **Polar codes are capacity achieving codes having low encoding and decoding complexity. These code uses polarization for achieving Shannon limits. These codes have fixed, low and deterministic o (Nlog$_2$N) encoding and decoding. These codes are easy to implement and having higher efficiency. Polar codes are also non-universal meaning the code changes significantly with the design-SNR. These codes are theoretically very interesting because it saturates symmetric channel capacity. In this paper BER performance of polar code is studied for different block lengths.**

***Keywords*— *Polar code, bit channels, Successive Cancellation Decoder,BER***

## I. INTRODUCTION

Polar code Construction is algorithm that selects K best among N possible bit channels at design signal to noise ratio (SNR) in terms of bit error rate (BER).Polar codes proposed by Arıkan [1] are the first constructive codes (as opposed to the random codes) that provably achieve the symmetric capacity of binary-input memory less channels (BMCs). This capacity-achieving code family uses a technique called channel polarization. Shortly after the polar code was invented, the channel polarization phenomenon has been found to be universal in many other signal processing problems, such as source coding information secrecy memory channels and other scenarios

Binary polar codes are specified by a triple (N, K, I), N is code length, K is length of the message, and |I | ⊆ N , |I| = K is the set of indices which is known as information bit indices. The remaining N − K indices are called as frozen bit indices, N is a power of 2, we define n ≜ log2 (N).

For a (N, K, I) polar code, the generator matrix is

$G = (F \otimes n)_I$ Therefore, given a message vector u of K information bits, a codeword x is generated as

$$x = u \cdot G = d \cdot (F \otimes n)$$

Where d is a vector of N bits including information bits such that dI = u, dIc = 0, and I c ≜N \I. The bits dIc are called as frozen bits, these are set to zero. Due to the recursive construction of the matrix F ⊗n, we can perform this matrix-vector multiplication in Θ(N log N) only.

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## II. LITERATURE SURVEY

Edral Arikan "Channel Polarization: A Method for constructing capacity achieving codes "he stated in his paper that basic idea that channels tend to polarize with respect to rate and reliability under certain combining and splitting operations. And investigated a particular polarization scheme analytically tractable, and provided strong evidence that channel polarization is compliance phenomenon, which is almost impossible to avoid as long as channel are combined with a phenomenon ,which is almost impossible to avoid as long as channels are combined with sufficient density and mix connections, whether chosen recursively or random. The study of channel polarization in such generality is an interesting theoretical problem.

Harish Vangala, ''Permuted Successive Cancellation Decoder for Polar Codes'' stated a new variant of Arikan's successive cancellation decoder (SCD) for polar codes. New decoding algorithm on a new decoder graph is proposed in this paper, where the various stages of the graph are permuted. Further he stated that, even though the usage of the permuted graph doesn't affect the encoder, it can significantly affect the decoding performance of a given polar code. The new permuted successive cancellation decoder (PSCD) typically exhibits a performance degradation, since the polar code is optimized for the standard SCD. Then present a new polar code construction rule matched to the PSCD and show in simulations that this can yield BER gains for high code rates. For lower rates we observe that the polar code matched to a given PSCD performs as well as the original polar code with the standard SCD. We also see that a PSCD with a reversal permutation can lead to a natural decoding order, avoiding the standard bit-reversal decoding order in SCD without any loss in performance.

Meghana M N, Comparative analysis of Channel coding using BPSK Modulation stated Minimum Bit Error Rate is the aspiration of any communication system, so the performance of the system is improved. To achieve this, the best way is the use of channel codes in communication system. The performance is compared for Hamming Code, Convolution code, RS code, Turbo codes, LDPC codes and Polar codes with BPSK modulations in terms of BER.

Qingshuang Zhang, Aijun Liu, Xiaofei Pan and Kegang Pan In paper CRC Code Design for List Decoding of Polar Codes stated that cyclic redundancy check (CRC) assisted list successive cancellation decoding (SCLD) makes polar codes competitive with the state-of-art codes. In this paper they try to find the optimal CRC for polar codes to further improve its performance. Error probability of CRC aided SCLD as well as the characteristics of Hamming weight distribution of polar codes. Based on these characteristics, a multilevel SCLD-based searching strategy with moderate list size is proposed to compute the minimum Hamming weight distribution (MHWD) of different CRC-concatenated polar codes. Using the searched MHWD, the optimal CRC for polar codes are presented in this paper. Simulation results show that the performance of optimal CRC-aided SCLD significantly outperforms the standard one, especially at high code rate.

Koya Watanabe, ''Performance of Polar Codes with MIMO-OFDM under Frequency Selective Fading Channel'' This paper presents the BER performance analysis of polar codes with

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MIMO-OFDM under frequency selective channel, which has not been disclosed so far. Multiple-input multiple-output (MIMO) has been widely implemented or standardized to improve the throughput performance of wireless communications. Forward error correction (FEC) codes are also key techniques for stably improving bit error rate (BER) and have been studied as well as a demodulation scheme. FEC is required to be composed of simple encoder and decoder while achieving good BER performance as much as possible. Polar codes emerged as a promising FEC scheme. This code has a simple recursive encoder structure by using a phenomenon called "channel polarization". polar codes provably achieve the theoretical limit for communication systems with a successive cancellation decoder based on likelihood ratio.

## III. MODEL DEVELOPMENT

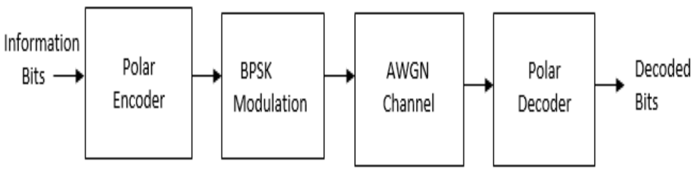


Fig. 1. Polar Codes for AWGN Channel

### A. Polar Encoder

Binary polar codes are specified by a triple (N, K, I), N is code length, K is length of the message, and |I | ⊆ N , |I| = K is the set of indices which is known as information bit indices. The remaining N − K indices are called as frozen bit indices, N is a power of 2, we define n ≜ log2 (N).

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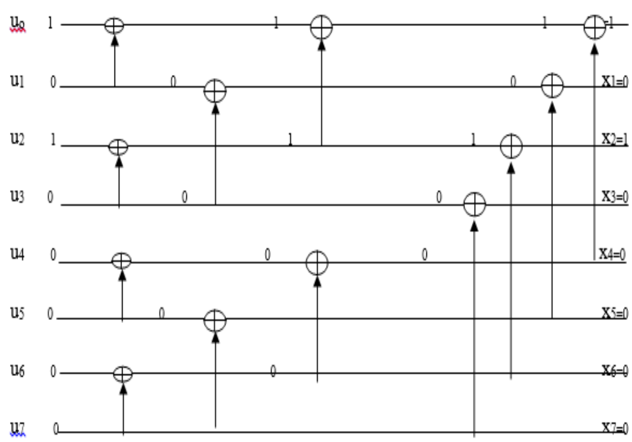



Fig 2.Polar encoder graph for N=8

### B. Polar Decoder (Successive Cancellation Decoder)

The recursive structure of the polarization transform permits a very simple decoding scheme based on successive cancellation (SC). If we consider the polarization transform of length 2, we see that it is nothing more than a truncated parity check code, where the truncated part from the output is the bit u0. Based on this, we can immediately see that the decoding can be performed by replacing the XOR and connection nodes by the probabilistic f and g nodes shown in Figure 3(a). For input LLRs La and Lb, those nodes calculate

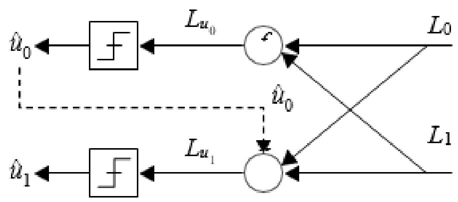



Fig. 3(a). SC polar decoder of length 2

The recursive structure of the polarization transform permits a very simple decoding scheme based on successive cancellation (SC). If we consider the polarization transform of length 2, we see that it is nothing more than a truncated parity check code, where the truncated part from the output is the bit u0. Based on this, we can immediately see that the decoding can be performed by replacing the XOR and connection nodes by the probabilistic f and g nodes shown in Figure 2a. For input LLRs La and Lb, those nodes calculate where us is termed the partial sum, which is the sum of the previously decoded bits that are participating in the current sum (or node g, from the decoder point of view). In this example, us = u0 because there is no other bit that is participating in this sum Since u0 is not present at the output then its L-value is zero and therefore we end up only with the extrinsic information from the parity bit and u1. This is what node f calculates, and it can be done in a robust manner using the

Min-Sum approximation, i.,e.

$$f\,(La, Lb) \approx \mathrm{sign}(La)\mathrm{sign}(Lb)\min(|La|, |Lb|) \quad (1)$$

Node g on the other hand has an L-value for u1 and therefore it can add it up to the extrinsic information from the other bits. A critical point here, is that node g assumes that us is totally correct, meaning that it affects the calculation of the extrinsic information by only changing the sign of parity bit L-value. For polar codes, the first bit u0 is usually frozen and so it is set to zero. Since the decoder knows the frozen set, it sets u0 to zero as well and produces an LLR for u1 equal to

$$Lu1 = g(L0, L1, u0) = L0 + L1, \quad (2)$$

Which improves the reliability of u1, thus producing the coding gain. For the remaining part of the thesis, we adopt the following terminology shown in Figure 2.bThe LLRs through the decoder are addressed through which stage (columns) s and which bit channel (rows) i they are at, with stage zero being the channel LLRs stage. This is denoted as L(s) in the figure. The sequence of decoding a polar code of length 4 is shown in Figures 3 b

If a specific bit is frozen, then we can directly set it to zero. The partial sum us can be calculated recursively as well. There is no specific way, it can be figured out directly from the polarization transform.

The SC decoder suffers from two major drawbacks, the first one is its sub optimality. It can be seen that the way the decoder proceeds is in a stage

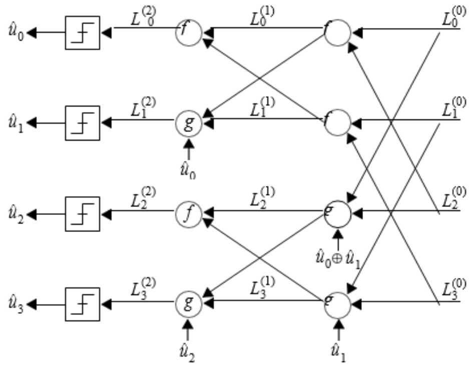
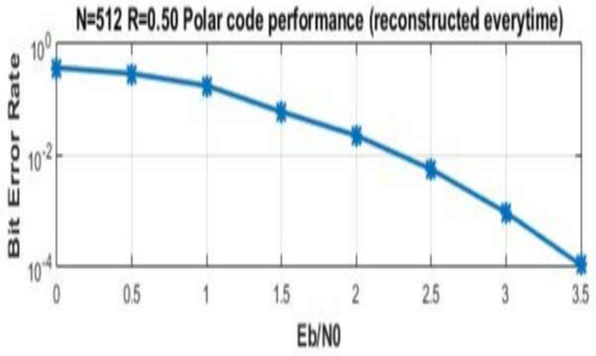
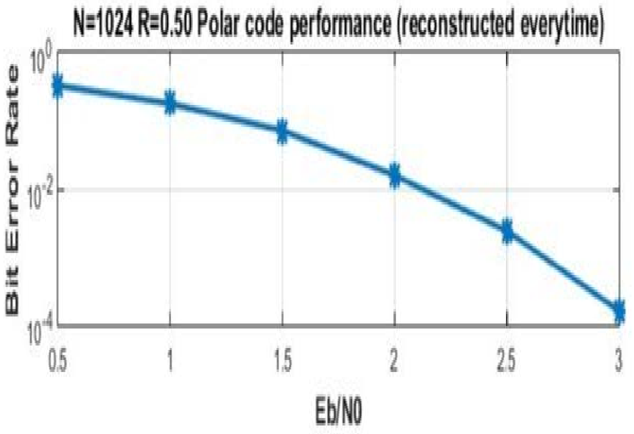
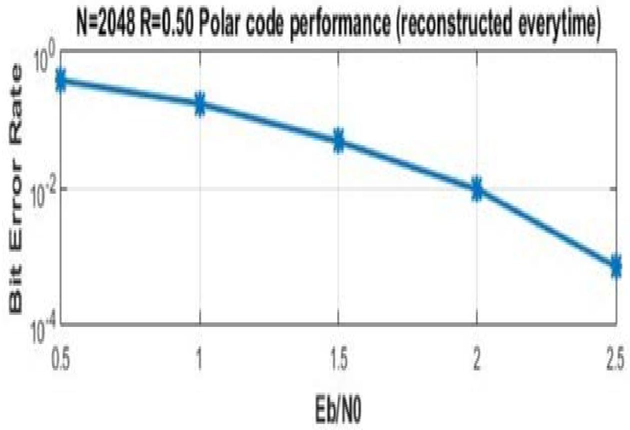


Fig. 3(b). SC polar decoder of length 4

## IV.RESULTS




## V.CONCLUSION

In this paper study of Polar Coding technique is introduced which is based on a recent concept of channel polarization. The performances in term of BER of was tested over a AWGN channel for different code rates and code lengths, where BPSK is used as modulation scheme and the results shown that for a fixed coding rate, the BER of polar codes improves when N increases

## REFERENCES

[1] E. Arıkan, “Channel polarization: A method for constructing capacity achieving codes for symmetric binary-input memoryless channels,” IEEE Trans. Inf. Theory, vol. 55, no. 7, pp. 3051-3073, Jul. 2009.

[2] Harish Vangala,Emanuele viterbo “A Comparitive Study Of Polar Code Constructions For AWGN Channel,2015”

[3] Harish Vangala,Emanuele viterbo“Efficient Algorithm for Systematic Polar Encoding,2016

[4] N. Hussami, S. B. Korada, and R. Urbanke, “Performance of polar codes for channel and source coding,” in Proc. IEEE Int. Symp. Inform. Theory (ISIT), pp. 1488-1492, Jul. 2009.

[5] D.Wu,Y.Li,and Y Sun, “Construction of nlock error rae analysis of polar code over AWGN channel based on Gaussian approximation”,IEEE Communication Letters,2014

[6] Ingshuang Zhang, Aijun Liu, Xiaofei Pan and Kegang Pan “CRC Code Design for List Decoding of Polar Codes(2016) IEEE 1089-7798.

[7] Koya Watanabe Performance of Polar Codes with MIMO-OFDM Under Frequency Selective Fading Channel, The 20th International Symposium on Wireless Personal Multimedia Communications (WPMC2017)