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Turbo Code Based Transmitter Module For MIMO-OFDM System

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Abstract: *Multiple Input Multiple Output (MIMO) transmission system is one of the most promising technologies which uses multiple antennas in the transmitter as well as receiver side and is currently used for high-rate wireless communication. MIMO uses multiple transmitters and receivers to transfer more amounts of data at a time. Orthogonal Frequency Division Multiplexing (OFDM) is a multiple carrier modulation scheme in which a data stream which is at high rate is split into multiple low rate data stream and then it is modulated using subcarriers which are effectively orthogonal to each other. MIMO-OFDM is the air interface that is used for 4G and 5G wireless communication. Channel coding is the fundamental building block of all the communication system. High performance codes which have low encoding and decoding complexity are a must for wireless system. The most powerful channel coding schemes are Turbo coding and LPDC (Low density parity check) coding. Both are based on the principle of iterative decoding. This paper discusses and simulates the turbo code transmitter for a 3X3 MIMO - OFDM system using the turbo encoder of code rate ½.*

Keywords: *MIMO, OFDM, 4G, 5G, Turbo Codes, LDPC codes, BER (Bit Error Rate).*

I. Introduction

In past few years, wireless communication is facing new challenges due to continuous evolution of new mobile standards like 2G, 3G, and 4G. In today's world the need for fast communication has been driving the ever growing demand of multimedia and the growth of Internet content which leads to providing high speed communication with higher data rates. All this has led to the evolution of 4G standard which uses Orthogonal Frequency Division Multiplexing (OFDM). The different services offered by cellular communication systems have enhanced from first generation (1G) to fourth generation (4G) with each generation adding more services to the previous generation.

The first generation (1G) only had voice calls while the second generation (2G) added text messaging services to first generation. The next generation (3G) provided mobile Internet services. Currently 4G offers high capacity mobile multimedia content at 1 Gbps thus making it 250 times better than the 3G. 5G New Radio (NR) is the latest evolution of mobile technology which is expected to be ready for public domain use by the year 2020 with a wide range of services that will be way beyond that of 4G. The 4G. The success of a communication network depends on providing high data rates and also the coverage offered by it.

The most important challenge encountered by future wireless communications systems is providing high-data- rate wireless comunication with high quality service. Multiple Input Multiple Output (MIMO) technology has bees considered as the most significant breakthrough in modern communication which uses multiple antenna arrangements both at transmitter and receiver side thtereby providing high capacity. The combination of OFDM with MIMO antenna systems forms a robust and formidable solution for providing high capacity communication services.

A. Multiple Input Multiple Output (MIMO)

Multiple Input Multiple Output (MIMO) uses multiple antennas both at the transmitter & receiver in order to improve performance of the communication. It is one of various forms of smart antenna technology. MIMO has become an attractive technology in wireless communications because it offers significant increase in data throughput and signal range without increasing bandwidth or transmitting power. This is done by distributing the total transmit power over the antennas to get an improved spectral efficiency and to achieve a diversity gain that improves signal reliability .Because of all these characteristics MIMO is an important part of modern wireless communication system standard.

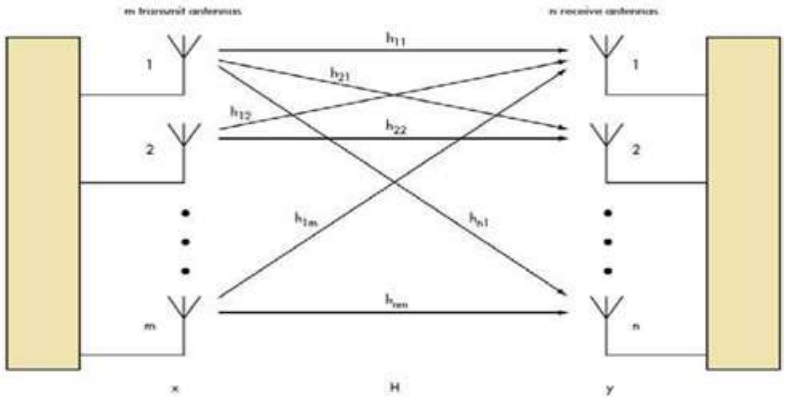

Fig.1. MIMO system

Fig.1 above shows a basic MIMO system. MIMO technology make use of the advantage of the phenomenon called multipath in which the transmitted information get bounced off walls, and other objects and reaching the receiving antenna multiple times at different angles and at slightly different times. This phenomenon called multipath occurs naturally in all radios sources.

B. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a multicarrier transmission scheme which divides the spectrum available into many carriers and each carrier is modulated by a data stream of low rate. OFDM is somewhat similar to Frequency Division Multiple Access (FDMA). FDMA sub-divides the bandwidth into multiple channels, which are allocated to users. However OFDM uses the available spectrum in a more efficient way by simultaneously spacing the channels more closely. It achieves this by making all the carriers orthogonal to one another thereby preventing interference between them.

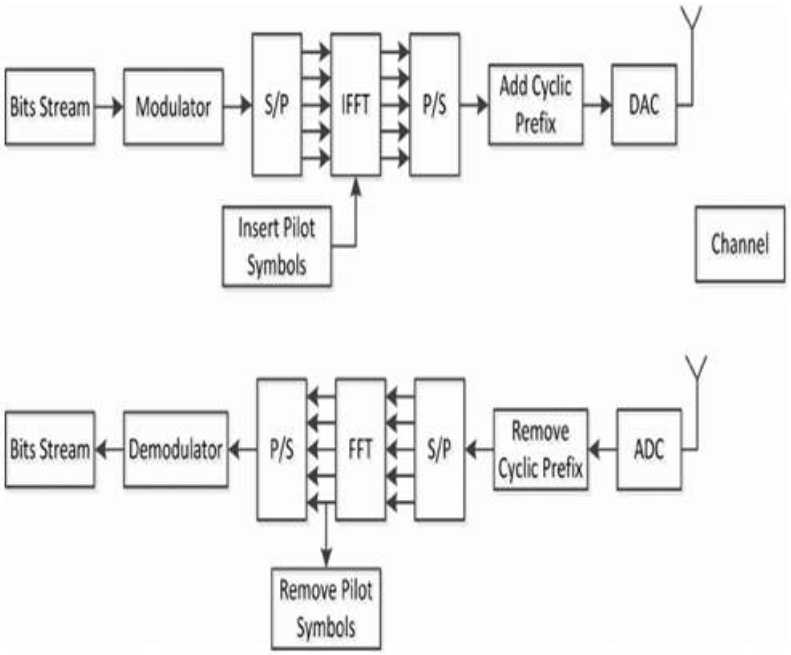

Fig.2 OFDM Block Diagram

Fig 2 above shows a block diagram of OFDM system.

The main advantage of OFDM system are its multipath delay spread tolerance. Also its modulation and demodulation can be done using inverse fast Fourier transmission (IFFT) and fast Fourier transmission (FFT) operation. In OFDM system the signal is first divided into independent channels then modulated by data and then it is re-multiplexed to create the OFDM carrier signal. In OFDM signal it is possible to arrange the carriers so that the sidebands of individual carriers overlap over each other but the signals can be received without any

adjacent carriers' interference.

Multiple Input Multiple Output - Orthogonal Frequency Division Multiplexing (MIMO-OFDM) is a key technology that is being used in next generation wireless communication systems.

C. Channel Coding

Channel coding is a process of detecting and correcting errors occurring in bits in digital communication systems. It is also known as forward error control coding (FECC). In any communications system channel coding is considered as the most fundamental building block. It is performed both at the transmitter and at the receiver. The error correction coding techniques helps the communication system to achieve the performance very close to the limits of channel capacity. There are different channel coding schemes available like turbo codes, Low-Density Parity-Check (LDPC) codes, and polar codes. These schemes are selected as candidates channel coding schemes for 5th generation wireless communications because of their good performance, and low complexity. Turbo code is one of the most powerful error correcting code used in modern wireless communication system. It is class of high- performance forward error correction (FEC) codes that emerged around 1993. They are a class of codes that performs very close to the channel capacity limit. Due to the low error probability of turbo codes they are used in various applications like deep space communications, 3G and 4G mobile communication. But turbo codes still face high complexity problems. There is another class of forward error correction codes called Low-density parity-check (LDPC) codes. They are first proposed in the 1962 by Gallager. These codes were mostly ignored as they were considered very complex for practical implementation. However In 1996 the LDPC codes were rediscovered by Mackay. He showed that the performance of LDPC codes approaches the Shannon limit same as turbo codes or even betters them. LDPC codes are one of the most powerful error correcting codes that are available today. Their lower decoding complexity has made them the choice for most wired and wireless applications. Turbo codes are recommended for moderate code rates due to their better performance, whereas LDPC code are recommended for higher code rates because of their better performance as well as lower complexity as compared with turbo code. In the past few years, it has been proven that LDPC codes beat turbo codes in terms of the error floor and performance for the higher code rates. The main difference between turbo codes and LDPC codes is that the turbo codes have low encoding complexity but high decoding complexity. On the other hand LDPC codes have high encoding complexity and low decoding complexity.

II. Literature Review

In 2017 Lixia Xiao, Yue Xiao, Yan Zhao, Ping Yang, Marco Di Renzo, Shaoqian Li and Wei Xiang presented their work "Time-Domain Turbo Equalization for Single-Carrier Generalized Spatial Modulation". This IEEE paper introduces low-complexity TDTE detectors for ZP-SC-GSM systems. Further, three low-complexity TDTE detectors are proposed to improve their performance. The simulation results showed that the proposed detectors of achieves considerable performance gains with a reduced decoding complexity. Among these, the proposed TDTE detectors showed a considerable performance gain.

In 2016 Arun Agarwal and Saurabh N. Mehta presented their work "Design and Performance Analysis of MIMO- OFDM System Using Different Antenna configurations" International Conference on Electrical, Electronics, and Optimization Techniques. This paper analyses the performance of a simple MIMO OFDM system using different antenna configuration in AWGN channel. This paper concludes that higher antenna configuration give best performance. The results show that the system has good BER performance when the number of the receiving antennas is greater than that of the transmitting antennas. But the system gives better performance if the number of tansmitting and receiving antennas is same.

In 2014 Jyoti Chand and Deependra Pandey presented their work "Performance Analysis of Turbo Coded OFDM System" in International Journal of Engineering Research and Applications. This paper proposes to enhance the throughput of the OFDM system by adding turbo codes. The noise channels used for simulation are Rayleigh and AWGN channels. QAM and QPSK modulation schemes are used. In both the cases the greater generator polynomial gives better performance.

In 2013 Ahmad Hasan Khan, Dr K C Roy presented their work "Comparison of Turbo Codes and Low Density Parity Check Codes" in IOSR Journal of Electronics and Communication Engineering. In this paper they compared the performance and complexity of Turbo codes and LDPC codes. For a fair comparison same input word length and code rate is used. The simulation results show that LDPC codes have a lower complexity than Turbo codes at same parameters.

In 2012 Alaa Eldin.S. Hassan, Moawad Dessouky, Atef Abou Elazm and Mona Shokair presented their work "Evaluation of Complexity Versus Performance for Turbo Code and LDPC Under Different Code Rates". This paper compares the performance and complexity of turbo codes and ldpc codes. Different code rates are

used for making the comparison between the two codes. The performance of turbo codes at moderate code rates (rate 1/2) is better than LDPC whereas performance of LDPC is better for high code rates (rate 7/8) than the Turbo Codes. The complexity of LDPC code decreases with increasing code rates. Simulation results indicate that turbo codes have better performance at moderate code rates. LDPC codes have better performance and less complexity for higher code rates.

Year	Author	Title	Result
2017	Lixia Xiao, Yue Xiao, Yan Zhao, Ping Yang, Marco Di Renzo, Shaoqian Li ,Wei Xiang	Time-Domain Turbo Equalization for Single-Carrier Generalized Spatial Modulation	Proposed TDTE detector gives good performance gain.
2016	Arun Agarwal, Saurabh N. Mehta	Design and Performance Analysis of MIMO-OFDM System Using Different Antenna configurations	More antennas give better system performance.
2014	Jyoti Chand, Deependra Pandey	Performance Analysis of Turbo Coded OFDM System	Throughput of the system is increased using turbo codes.
2013	Ahmad Hasan Khan, Dr K C Roy	Comparison of Turbo Codes and Low Density Parity Check Codes.	LDPC have a lower complexity than Turbo codes at same parameters.
2012	Alaa Eldin.S. Hassan, Moawad Dessouky, Atef Abou Elazm and Mona Shokair	Evaluationof Complexity Versus Performance for Turbo Code and LDPC Under Different Code Rates	LDPC codes have better performance and less complexity for higher code rates.

III. System Model

The transmitter receiver pair using turbo codes for 3X3 MIMO - OFDM system is simulated first. The input bits are first applied to the turbo encoder. The input bits are turbo encoded and interleaved to produce output bits. For a 3X3 MIMO system two turbo encoders are used. The turbo encoded output bits are applied to the OFDM transmitter which modulates these bits and generates symbols for transmitting over the channel. The noise channels used are AWGN, Rayleigh, and Rician channels. The modulation scheme used here is PSK. The data sent by the transmitter is received by the receiver over the channel which is demodulated and decoded using turbo decoder to get the output bits. The bit error rate (BER) calculated is used as baseline for comparison. In the proposed work the turbo codes are replaced by LDPC (Low-density parity-check) codes. In the transmitter the turbo encoder is replaced by LDPC encoder and on the receiver side LDPC decoder is used.

On the receiver side we are proposing two receivers.

Receiver 1 -: In the proposed first receiver, the data received is first applied to multiple OFDM receivers. The generated is data is then equalized using an equalizer. The output of equalizer is then decoded using LDPC decoder to produce the output data.

Receiver 2 -: In the proposed second receiver, the data received is first applied to multiple OFDM receivers. Then the data from individual OFDM receivers is applied to individual LDPC decoders. The resulting data from these decoders is then equalized using an equalizer to produce the output data.

The proposed receiver with the lowest BER is selected and the results are compared with the BER calculated using turbo codes.

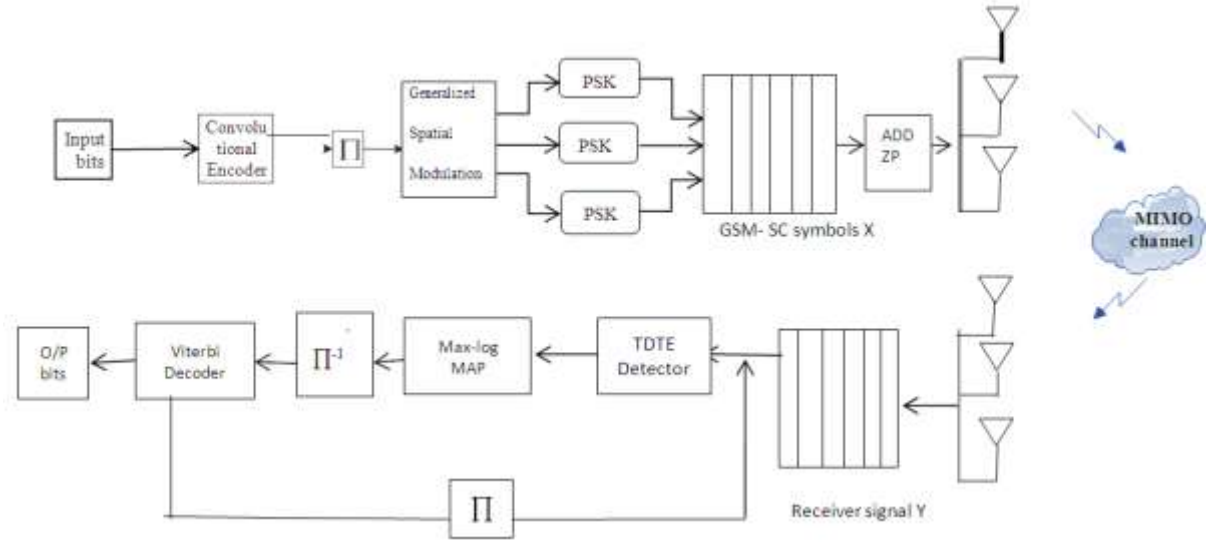

Fig.3 Turbo Code based Transmitter-Receiver

IV. Simulation Results

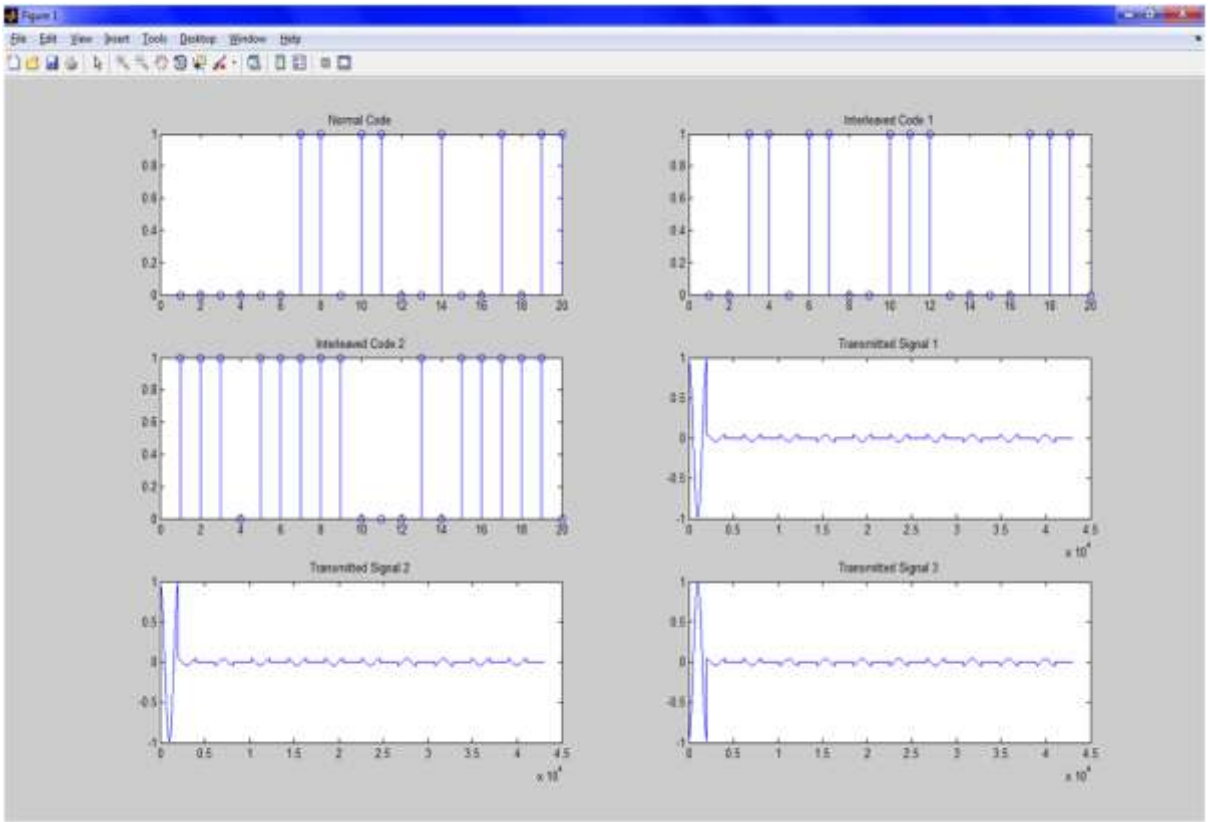

Fig.4 Transmitter Simulation result for BPSK modulation using turbo encoder (code rate 1/2)

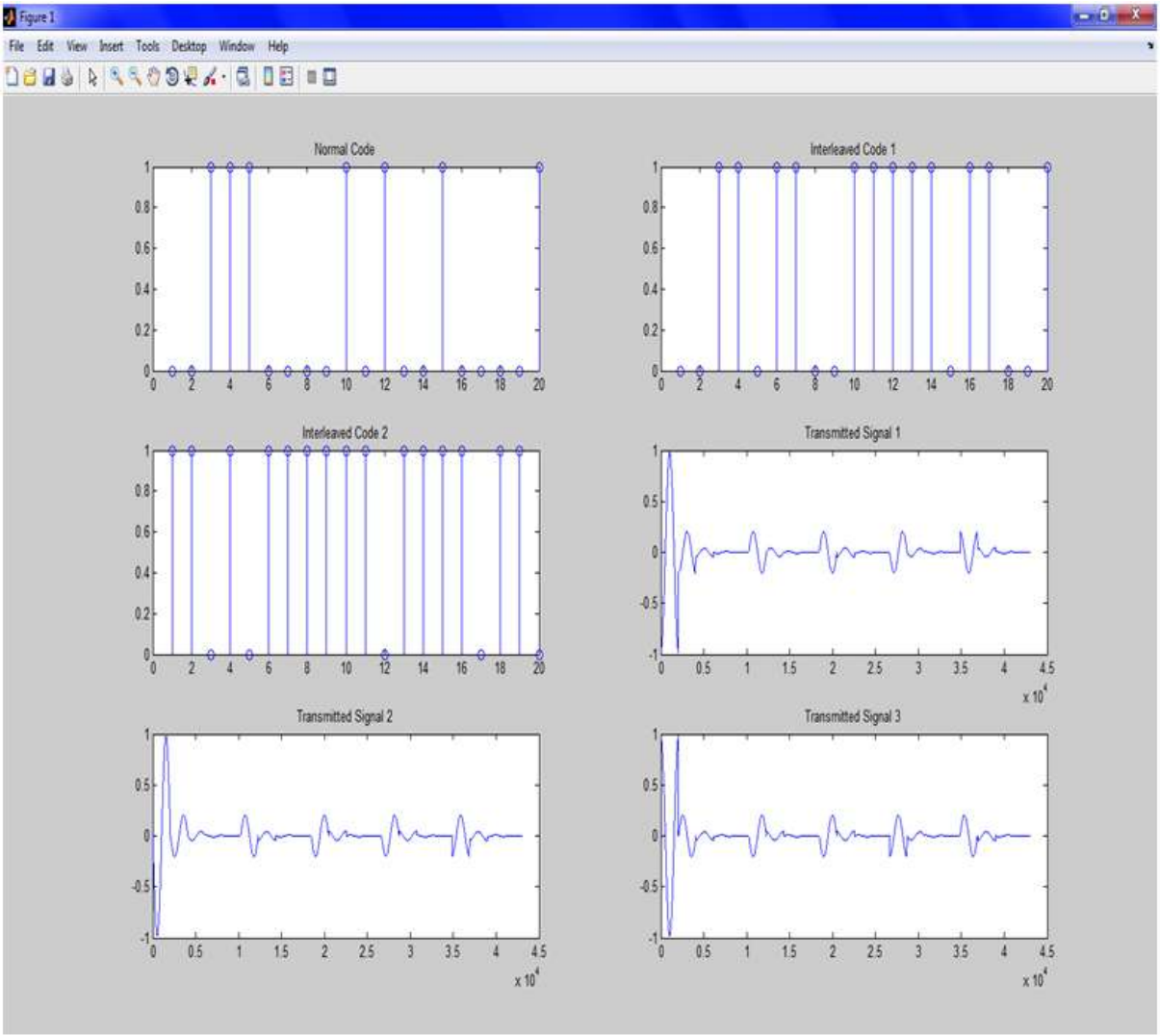

Fig.5 Transmitter Simulation result for QPSK modulation using turbo encoder (code rate 1/2)

In the transmitter the random bits are applied as input bits. Here 10 random bits are used as input. The no. of input bits can be increased. These bits are applied to turbo encoder. As this is a 3X3 MIMO system two turbo encoders are used. The output of turbo encoders gives three outputs namely normal code, interleaved code 1 and interleaved code 2. For interleaving gold code interleaver is used. These output bits are then modulated. The modulation used is PSK. It can be used to perform all types of PSK modulations. An IFFT is used to convert the frequency-domain signal to time-domain signals. To prevent the problem of ISI, guard intervals are inserted between each symbol so that the symbols don't interfere with subsequent symbols. This generates three output signals transmitted signal 1, transmitted signal 2 and transmitted signal 3.

V. Conclusion

OFDM is a digital modulation scheme where large numbers of orthogonal subcarriers are used to carry data. The LDPC codes are found to have low complexity and are preferred for higher code rates as compared to turbo codes. LDPC codes also shows good system performance at higher code rates. This paper simulates transmitter module using turbo codes for a 3X3 MIMO- OFDM system.

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