# Decoding For 8x8 MIMO System Using Convolution Coding Implemented In VLSI

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***Abstract***

**The joint detection and decoding for spatial multiplexing multiple- Input multiple-output (MIMO) system which utilize convolution Code is been proposed . The bit error rate (BER) performance of the proposed approach is significantly better than that of systems which utilize separate detection and decoding blocks. Formal algorithms with two possible system setups are presented and their performance. In particular, for a reference 8x8, 64-QAM System using a rate 1/2 convolution code with generator polynomial [247, 371] and a constraint length of 8, improves the Signal to noise ratio (SNR) of 2.5 db and 3 db are achieved over Conventional soft decoding at a bit error ratio (BER) of 10 . The proof of concept VLSI architecture for one algorithm is provided and a novel way to reduce memory usage is demonstrated. Results indicate that better Performance over conventional systems is achievable with comparable hardware complexity. The proposed Design was synthesized and layout with 65-nm at 334-MHZ clock frequency. An average throughput of 267.2 mbps at a SNR of 13 db with area equivalent to 632 k gates was achieved.**

## 1. INTRODUCTION

In Transmitter and receiver, the data rate is increased by many techniques. One among them is MIMO that uses multiple antennas to increase the data rate. MIMO has the benefit of random fading and BER Performance of MIMO-CDMA Systems in Multi user Environment reduces the multipath delay spread. MIMO systems must work reliably in the noisy environment to be successful [1]. CDMA systems are designed to operate in an interference free environment and for this reason it is used in modern cellular systems. The combination of MIMO and CDMA can further improve the system transmission rate over the traditional CDMA system. Multiuser MIMO CDMA systems are considered where each user has multiple transmit antennas, different transmit antennas of the same user use the same spreading code. The developing wireless services require higher data rates for future cellular wireless communication systems [3]. However, new radio frequency bands are very scarce if available at all. CDMA is a promising technique for beyond 3G wireless systems [2]. For the efficient bandwidth utilization in both the network and physical layers, some new solutions are necessary. The MIMO systems provide efficient coding, modulation methods, transmission adaptation schemes, and antenna systems. Multiple-input multiple-output (MIMO) communications based on multiple transmit and receive antennae is a very promising technique to increase bandwidth efficiency, and is seen as a potential key solution for fading channels with rich enough scattering. The frequency selectivity challenge means that the multipath delay spread of the channel is very large due to the large bandwidth, causing very severe inter symbol interference (ISI). Multiple-input and multiple-output (MIMO) is a technique to increase data rate significantly with multiple antennas at both the transmitter and receiver [6]. In MIMO systems, there are many spatial coding schemes including space time codes with spatial code rate less than or equal to 1 and spatial multiplexing with spatial code rate > 1 [5]. Combining both CDMA and MIMO will improve the system transmission efficiency when compared to the traditional CDMA system. Different modulation schemes are been followed in MIMO-CDMA architecture. The existing MIMO system using QPSK modulation is studied in [4]. The proposed Convolutional coded MIMO-CDMA system is compared with the existing modulation scheme in this paper.

## 2. RELATED WORK

D'Amours [2005] suggested the idea of using parity bit to be selected for spreading code technique, based on systematic linear block codes [7]. D'Amours et al., [2007] investigated the T-designs to design the different spreading permutations. In their work, they designed the spreading code permutations based on Space-Time Block Codes (STBC).They also showed that the STBC-based design can improve the error rate of the receiver over the flat fading channel without increasing the system complexity [8].

Z. Ding and M. Rice [2007] suggested the HARQ techniques in the emerging wireless systems that use bit-interleaved coded modulation (BICM). The design of BICM-based wireless systems involving HARQ is explained by a special case of IR-HARQ, where a different combination of bits of a mother code is sent in each transmission period. In optimal receiver implementations, IR-HARQ out performs CC-HARQ because of its coding gain. But in multiple-input multiple-output (MIMO) systems, the performance of IR-HARQ gets affected due to its sub optimal implementations [9].

Jung-Fu and Cheng [2006] analyzed and identified the performance of hybrid automatic repeat request (HARQ) schemes over incremental redundancy (IR) and Chase combining (CC). The above cases are induced by fast time-variant fading or long retransmission delays. The robust solution for the above case is provided by the self-decodable IR and the CC schemes. They evaluated and offered solutions for the enhanced performance of the conventional IR systems [10].

## 3. PROPOSED WORK

This design is targeted to process a system using Algorithm I with 512 bits (i.e., 64 channel realizations). The BER performance of such a system was presented.

The channel entries are represented using 7 bits for the integral part and 7 bits for fractional part and the path metrics are represented using 10 bits for the integral part and 5 bits for fractional part. The proposed joint MIMO decoder was designed and upgraded up to 8x8 for high data transmission.

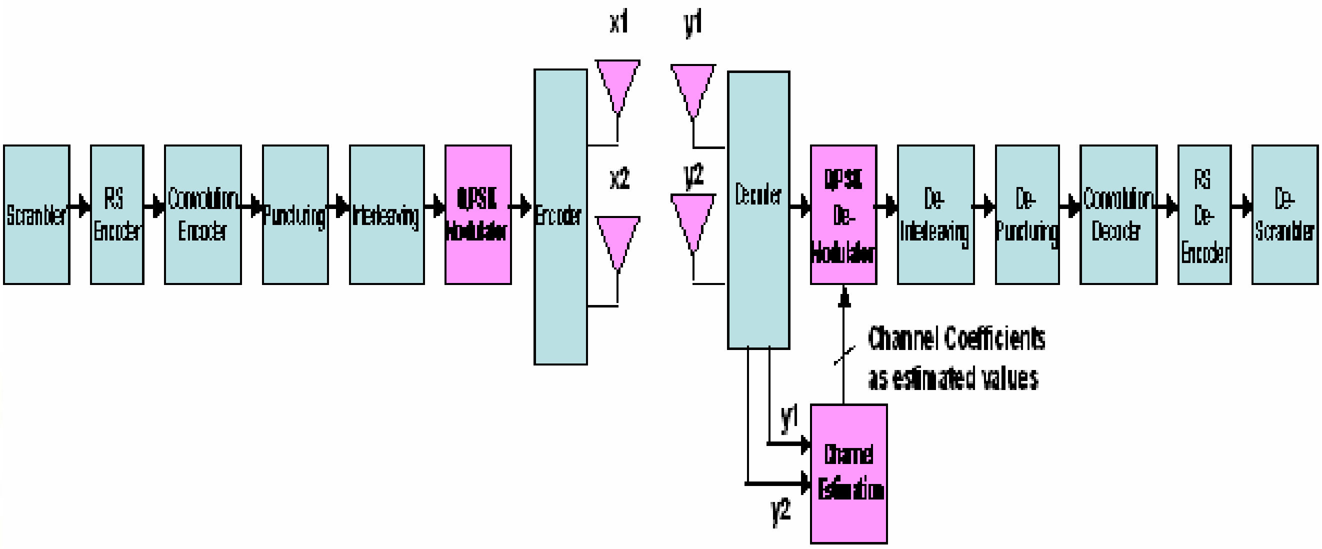


**FIG 3.1 Block Diagram of 8x8 MIMO system**

The above figure shows the proposed MIMO-CDMA architecture. The 8x8 MIMO systems have different blocks like QPSK modulator, ideal channel, channel estimation block and QPSK demodulation. QPSK modulator takes the binary bits as input. Here the inputs bits are taken as symbols. For example 00, 01, 10, 11 are 8 inputs symbols for QPSK. The symbols are converted into complex values. The complex output of the modulator is appended with the training sequence at 2 transmitters. Here the diversity technique is used to send the same data with different training sequences. The channel coefficients are multiplied with the modulated data. Here 8 paths are considered for 8x8 channels. The channel is an ideal channel i.e. the noise is not considered. The reliability is increased by employing the diversity technique i.e. transmitting the same information across multiple channels. The redundant data is transmitted so that the fading can be reduced. If one of the channel is not used or if the data is lost in space then the information/data can still be recovered from redundant transmission over the channels and hence the reliability of the communication system is improved. The data transmitted from transmitter tx1 across the channels h11 and h12 and received by both the receiver's rx1 and rx2. Here the use of the available channels is done to increase the capacity and reliability. Then the received sequence is taken into the channel estimation block to find the estimated channel coefficients. The received data from LS channel estimator block are the given to the decision block in the QPSK demodulator block to get back the sent binary sequence. The transmitted sequence is then checked with the received sequence at the QPSK modulator and the Demodulator block respectively.

## 4. IMPLEMENTATION

8x8 MIMO system is designed using VHDL and simulated in Modelsim. Each block separately verified for its functionality. Each block is synthesized and the integrated output is also verified by implementing Xilinx FPGA.

The top block of 8x8 MIMO system block diagram from Xilinx is shown in Fig.3.1 All the blocks in 8x8 MIMO system like QPSK modulator/demodulator, ideal channel and the LS channel estimation blocks are integrated and the connections are shown in Fig.4.1, with inputs and the outputs. The output of integrated 8x8 MIMO system design is as shown in Fig.4.2 The fig.4.3 shows the 8x8 MIMO system output waveform.

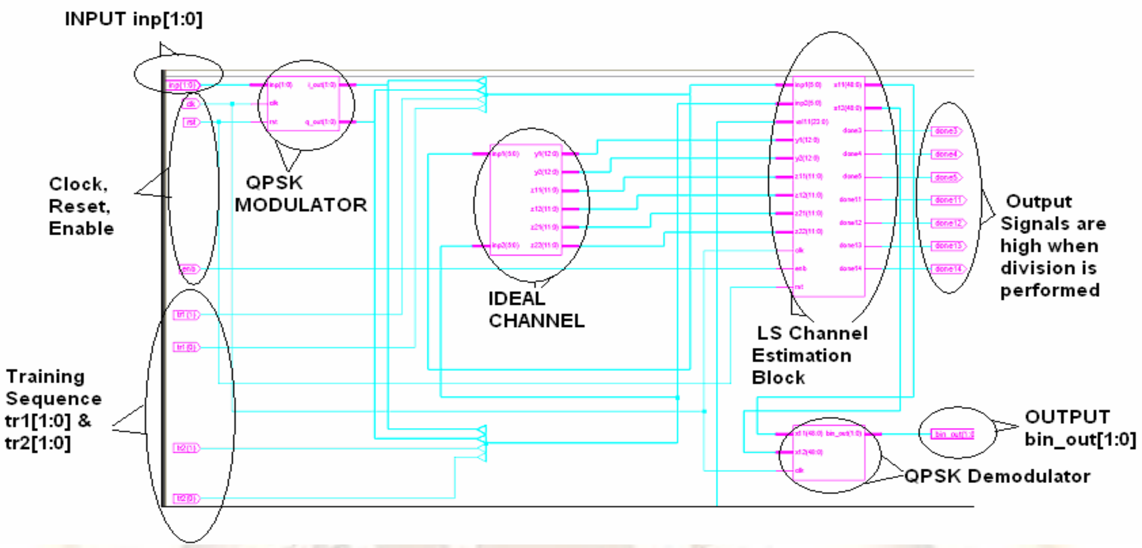


FIG 4.1 MIMO System with QPSK Design

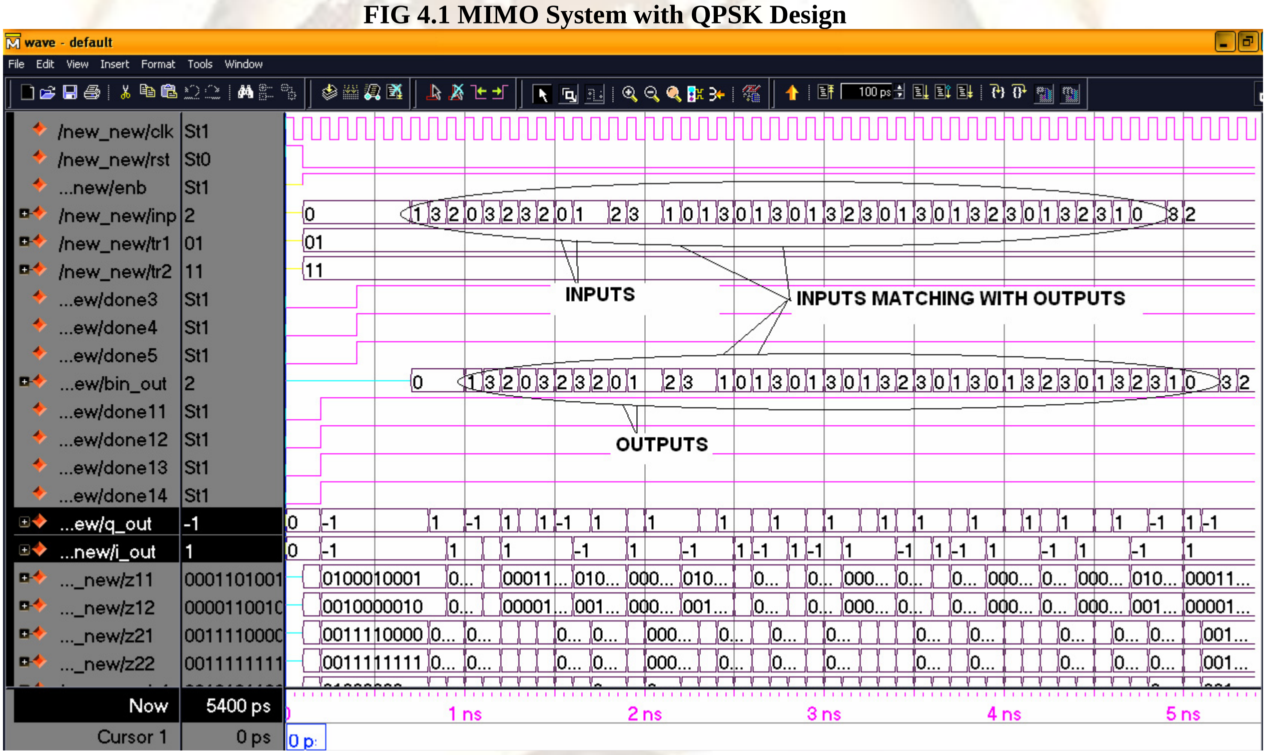


FIG 4.2 The 8X8 MIMO System output

The 8x8 MIMO system code is simulated in Modelsim and synthesized using Xilinx before giving to Design Compiler for timing analysis. Design compiler is tools which synthesize the design using the user given constraints, libraries and the RTL code. The clock is to be specified as a constraint for which approximately the design work is determined using Xilinx. A clock of 50-60% from Xilinx is created for timing verification. Clock network delay or min latency of 25% of the clock, uncertainty for setup is given as 10% of the clock, for hold 5% of the VLSI Implementation of Least Square Channel Estimation and QPSK Modulation Technique for 8x8 MIMO System.

| | |
|---|---|
| Antenna size | 8*8 |
| Modulation | 64-QAM |
| Scaled avg.th.put | 267.2 |
| System area(KGE) | 632 |
| SNR[dB]BER=10^-5 | 14.5 |
| Power (MW) | 33.6 |
| Frequency(MHZ) | 334 |
| Voltage(V) | 3.3 |

**Table 4.1 Synthesis and Timing Verification of 8x8 MIMO system**

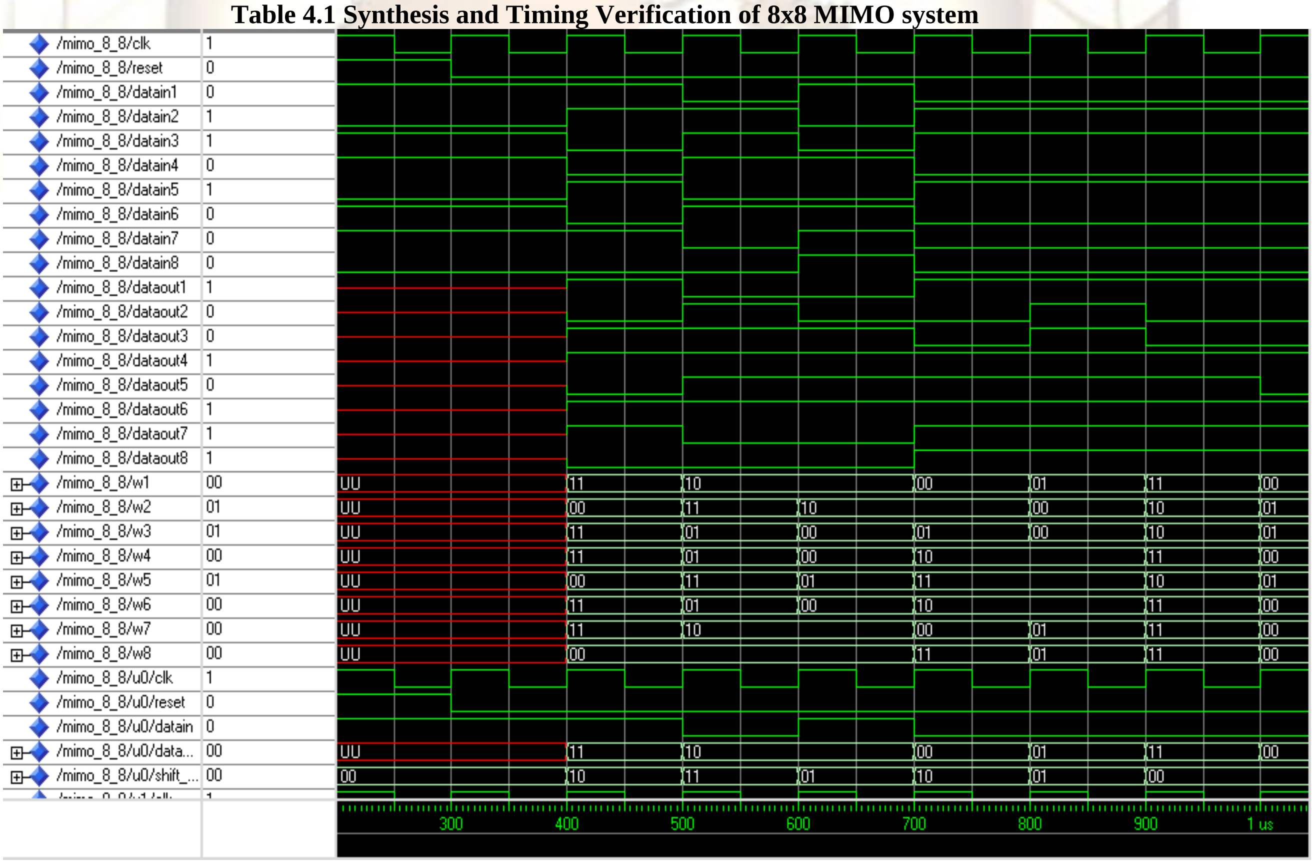

**Fig.4.3 Output wave form of 8x8 MIMO using convolutional code**

## 5. CONCLUSION

The simple working of a MIMO system is carried till backend of the VLSI flow. The designs simulated in to arrive at the specifications. The RTL code is successfully simulated in Modelsim . The design is synthesized and implemented on board. The synthesis and timing is verified and the timing is met for both setup and hold in DC and PT. DFT is also carried without timing violation. The top design takes about 3999 number of slices out of 4928 slices i.e. in Virtex2Pro the device selected is 2vp7ff896 at speed grade of 06 with operating frequency 7.27MHz and minimum period of 137.548ns. Timing verified is all met with positive slack with zero violations .In the design the channel is considered to be ideal. In the future work the noise is to be added and the estimation of channel using different channel models is to be carried. Different channel estimation is to be simulated in and then taken to the complete VLSI flow. The frequency of the design is to be optimized. The complete backend flow has to be completed till the tape-out of the design.

Scope of the future work is to improve the design further for the noise to be included in the channel and use any improved matrix inversion technique for improving the design frequency of operation. This can be done using VHDL algorithm. Iterative algorithm is applied for the design so as to reduce the effect of noise on data. The iterative algorithms like Recursive LS, Least Mean Square,, etc. Channel estimation and compensation for different channel models for delays is to be implemented. Fixed point implementation of the design is to be carried out by obtaining the floating point values from because the fixed- point representation will be more efficient. MIMO performance can be improved by using by incorporating the performance of the overall system can be improved.

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