Mimo and OFDM in Wireless Communication

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***Abstract*—**In day to day life the need of usage of bandwidth has become very expensive. There should be a solution which will give us the maximum usage of bandwidth with less cost and maximum efficiency. The solution is to implement MIMO and OFDM in wireless communication. The combination of MIMO and OFDM with 802.11n wireless LAN implemented on FPGA gives the better performance in terms of speed. This paper includes necessity of MIMO and OFDM in wireless communication and the model designed using MIMO and OFDM in MATLAB simulink and implemented on FPGA.

Keywords*-MIMO,OFDM,FPGA*

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I. Introduction

A. MIMO

Bell laboratories in 1998 initially demonstrated MIMO technology under laboratory conditions. After that in following years Gigabit wireless inc and Stanford University developed a transmission scheme and jointly held a first prototype demonstration of MIMO [1].MIMO is advanced antenna technology for wireless communication. Here multiple antennas are installed at both transmitter and receiver. This gives us better performance of the system with better BER and low burst errors. Figure 1 gives general idea for MIMO channel

In figure 1 the 3×3 MIMO channel is shown. Three transmitters and three receivers are used to transmit and receive the signal no of transmitters and receivers can be implemented. These transmitter and receiver increases channel capacity and the signal to noise ratio is also improved. Spatial multiplexing and space time block coding are the formats of MIMO.They increases the reliability of the system in terms of the different forms of fading.

B. OFDM

OFDM is Orthogonal Frequency Division Multiplexing.OFDM use both modulation and multiplexing. In OFDM the channel is divided into number of subcarriers which are of low rate, due to this multiple symbols are transmitted in parallel. So spectral efficiency is high. In OFDM different modulation techniques can be employed like QAM ,QPSK,AM,PM.In OFDM data is divided into n no of subcarriers. These subcarriers are overlapped but as they are orthogonally separated so they do not get interfere with each other. Thus in OFDM n number of subcarriers carries data in parallel so the data rate is increased.

C. 802.11n WIRELESS LAN

802.11 is wireless LAN standard was initially designed to provide only limited range and bandwidth has come a long way. Since the first 802.11 standard data rates are increased from 2 to 64 Mbps.In 802.11a/g standard the data rates were achieved up to 54 Mbps but it caused loss in range.802.11a/g standard used 64 QAM to achieve such higher data rates so it

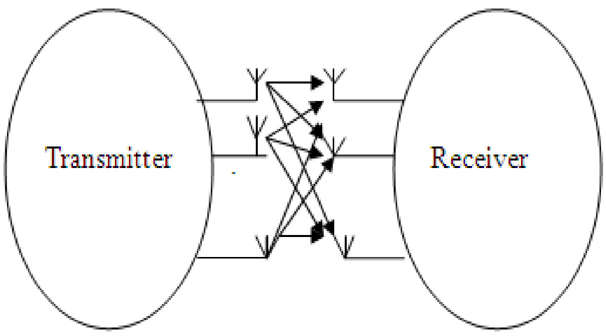

Figure 1MIMO Channel

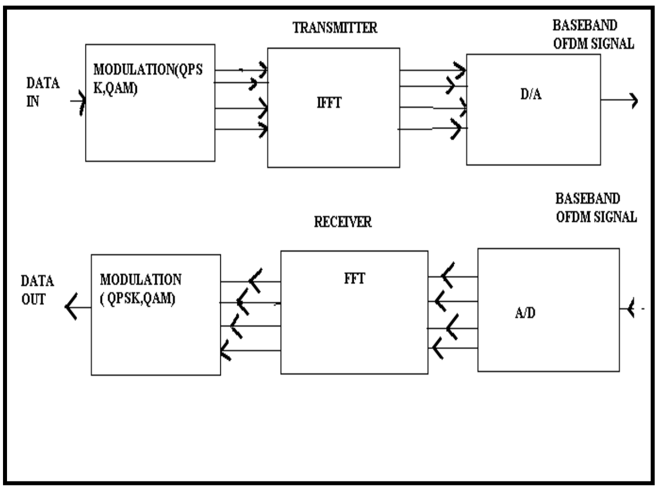

Figure 2 OFDM transmitter and receiver

requires high SNR. Due to this there was loss in range. To overcome all these problems MIMO OFDM technique was deployed in 802.11n standard. It operates at maximum data rate from 54 Mbps to 600 Mbps.Figure 3 shows 802.11n standard transmitter system. In this transmitter scrambler makes the message unintelligible to the receiver if it id=s not equipped with the proper unscrambling device, then this data is encoded using convolution encoder in which uses viterbi algorithm. In mapper data bits are punctured and mapped. This encodes the data with higher bit rate and less redundancy. After that MIMO parser performs operation on the data using spatial multiplexing and space time block coding.Interleavers and pilot are to avoid intersymbol interference.

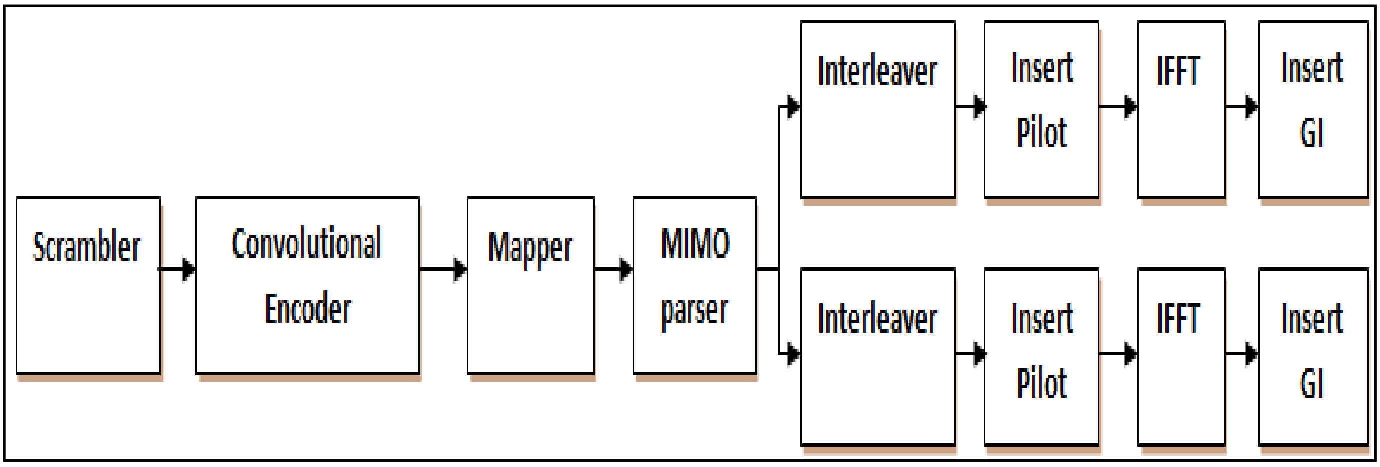

Figure 3 802.11nTransmitter system

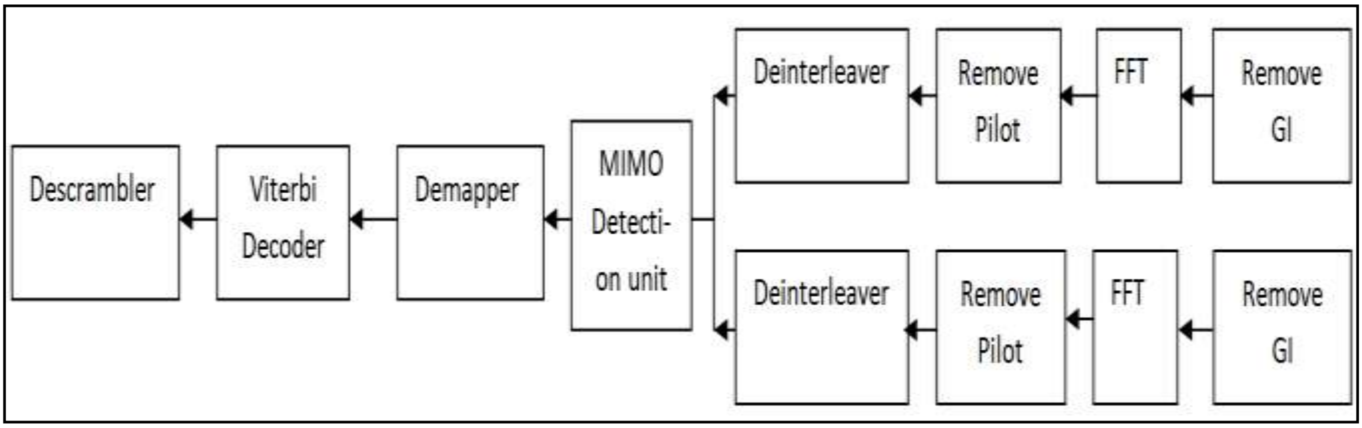

Figure 4: 802.11n Receiver system

Then IFFT is used to convert this data into time domain. Then finally guard interval is inserted to avoid ISI.A system which do not include guard interval gives low bit error rate. Figure 4 shows receiver system for 802.11n standard. At the receiver the data is deinteleaved, decoded by viterbi decoder and then descrambled at the end.

II. SYSTEM DEVELOPMENT

In system development first stage is verification of each block in MATLAB and implementing these blocks in Matlab simulink. Then a VHDL code will be imported into Simulink via Xilinx. Then system generator block set which will create accurate hardware model. Figure 5 shows the methodology and flow diagram for system development

A. 2.1 4×4 MIMO OFDM model–System level design

Initially the system level model is designed in Matlab simulink.Simulink gives us the real time approach to the system so it is used to develop the model. Here 4×4 MIMO OFDM system is designed in simulink. Following figure shows the 4×4 MIMO OFDM model. Figure 6 shows 4×4 MIMO OFDM model. Here 4 transmitters and 4 receivers are used so it is named as 4×4 model. In above figure the audio signal is provided to the model via gateways (which converts the input from simulink type to Xilinx type).Then this signal is applied to the subsystem, which is the transmitter module for the model. And subsystem 1 is the receiver module for the system. Scopes are connected in the system to see the plots at the output of the blocks. Here bit error rate is also calculated by comparing the bit transmitted and bit received. The respected transmitted i.e. original waveform and the received waveforms can be seen on the scope and scope 1 respectively. Here 15 db noise is added to see the behavior of the system. In this JTAG cosim block is used to co-simulate with the FPGA hardware. The hardware which is used is digilent sparten6 (xc6ls45s) atlys board. Data can be transferred to this FPGA board via this JTAG block.

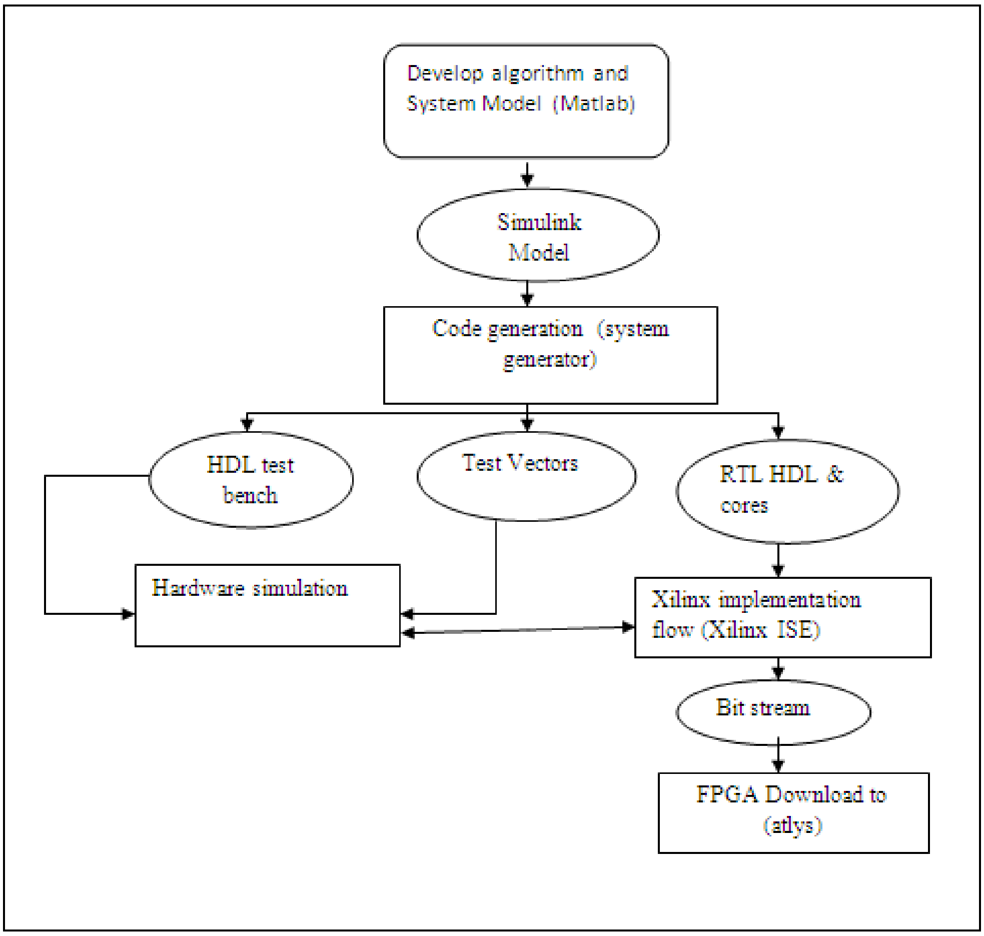

Figure 5 Methodology and flow diagram

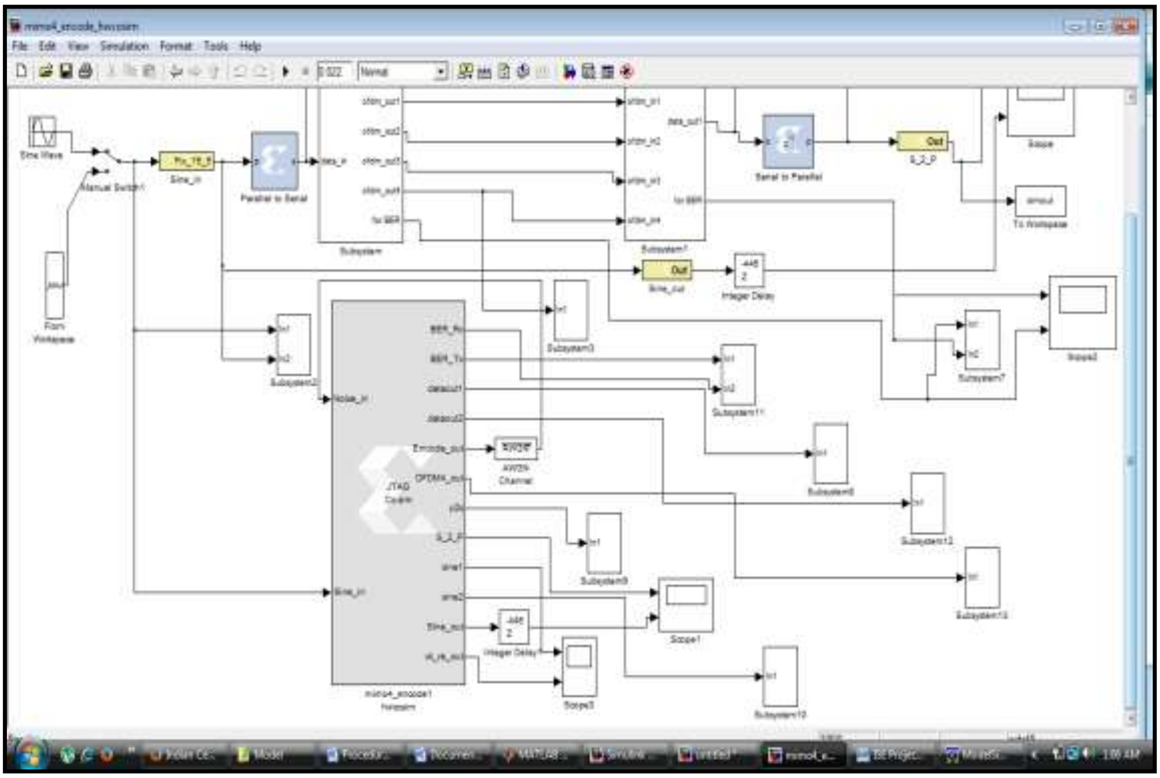

Figure 6 4×4 MIMO OFDM model with hardware co-simulation

III. 3.EXPECTED RESULTS

The main aim of this system is to achieve maximum data rates up to 60 Mbps. Here data rates can be changed by changing the parameters in Matlab workspace. Figure 7 shows the sampling time and sampling frequency in Matlab workspace

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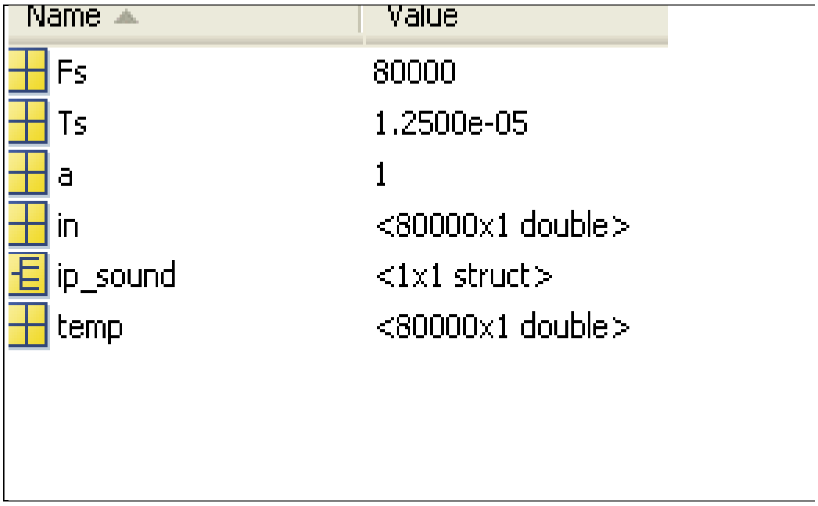

Name	Value
Fs	80000
Ts	1.2500e-05
a	1
in	<80000x1 double>
ip_sound	<1x1 struct>
temp	<80000x1 double>

Figure 7.Parameters in Matlab workspace

The sampling time for these particular parameters can be seen on sampling time block. Figure 8 shows the sampling time for above parameters.In figure 8 Ts i.e. sampling time is 4.167e-007.So the sampling frequency (Fs) will be 1/Ts=1/4.167e-007=2.3998e+006.Thus we get speed of near about 2.4 Mbps.Here maximum speed of 216 Mbps can be achieved. Figure 9 gives the received waveform and original waveform, which can be seen on scope.

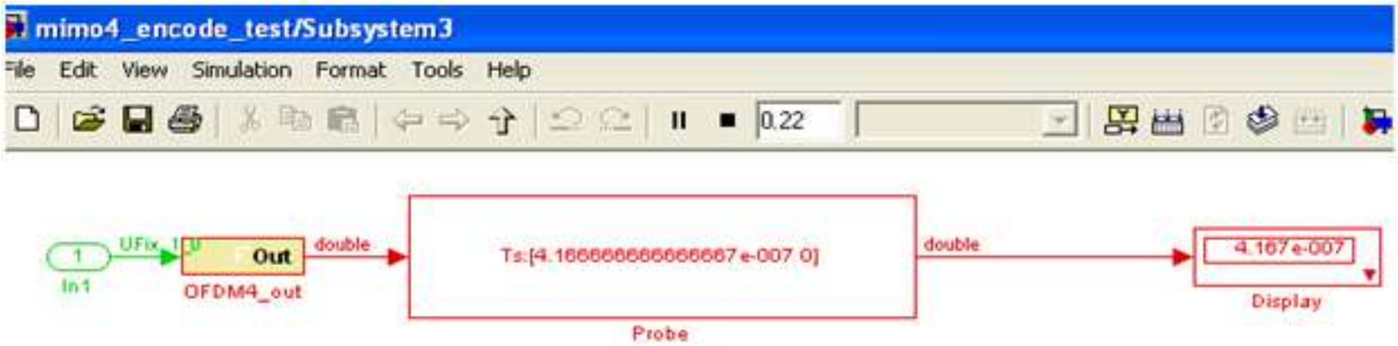

Figure 8 Sampling time parameter on probe

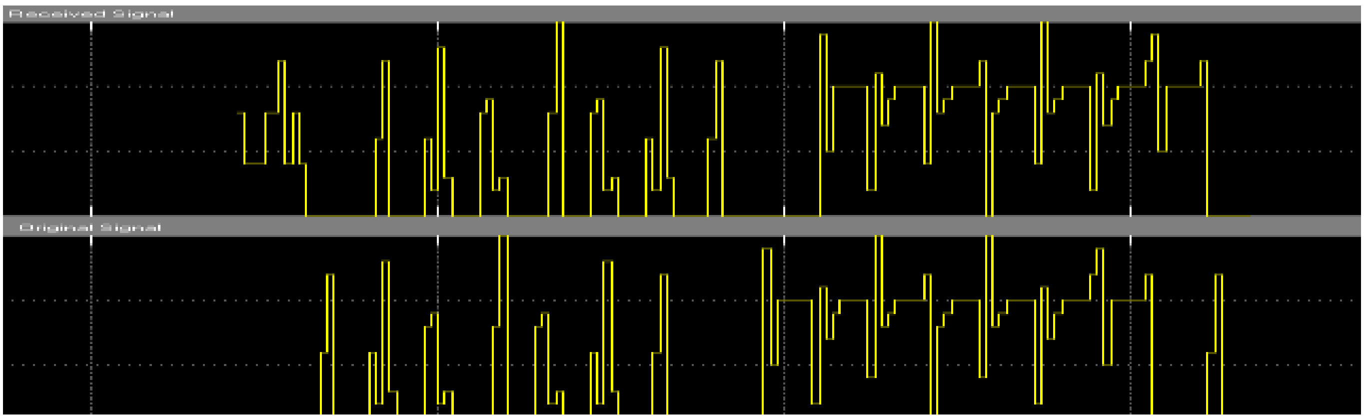

Figure 9 Received signal and original signal on scope

IV. CONCLUSION

MIMO –OFDM gives the solution for the ever increasing data rates. Implementation of MIMO OFDM on FPGA gives the high speed data for the wireless communication. By selecting the proper values of one of the sixteen constellations we can fulfill the need for data transmission for wireless LAN with reasonable price of hardware implementation. In future higher data rates can be achieved by implementing one of sixteen constellation scheme we can achieve higher data rates. Here we designed 4×4 MIMO OFDM model, by designing higher order model more data can be transferred in particular channel with more efficiency.

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