OFDM Modulator for Wireless LAN (WLAN) standard

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Abstract— Multicarrier modulation is required for wirleiess communication system.OFDM is multicarrier modulation which provides good spectral efficiency and eliminates intersymbol interference and intercarrier interference.Proposed work is to simulate OFDM modulator for IEEE802.11a standard.OFDM modulator is simulated using Simulink tool from Matlab 2010b and System generator tool from Xilinx 12.2. and implemented on FPGA board.Sytem performance is evaluated as BER vs SNR using AWGN noise channel and Multipath Rician Fading Noise channel .

Index Terms - OFDM, FPGA,BER ,SNR,IEEE802.11a,ICI,ISI.

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INTRODUCTION

OFDM allows high speed for wireless communications. OFDM could be considered either a modulation or multiplexing technique, and its hierarchy corresponds to the physical and medium access layer. A basic OFDM system consists of a QAM or PSK modulator/demodulator, a serial to parallel / parallel to serial converter, and an IFFT/FFT module. FFT requires intensive calculation so OFDM modulator has been implemented on FPGA.FPGA provides less computationtime. This paper divides the work in VI sections; Section I presents the introduction; Section II presents the Related Work; Section III gives brief introduction of the Std.IEEE802.11a and fundamentals of OFDM. Section IV gives the block diagram and explanation of each block. Sections V explain the implementation and result and section VI discuss the conclusion.

1   RELATED WORK

 Author [1] has implemented OFDM transmitter for IEEE 802.11a standard only. This work uses System generator and Simulink. This work does not focus on suitability of FPGA for IF processing
Author [2] has implemented enhanced IEEE802.11a MAC layer which is applied to wireless LAN for Multimedia services
Author[3] has discussed detailed simulation of different OFDM systems with different constellation mapping schemes will be obtained using MATLAB-2011 program to study the effect of various design parameters on the system performance.
Author [4] has discussed a multiple carrier modulation technique known as OFDM (Orthogonal Frequency Division Multiplex). It focuses on problems that are specific for its use in the future mobile multimedia communications (MMC) in the range of 60 GHz.
Author [5] has implemented a data scrambler, convolution encoder, data interleaver and BPSK modulator for WLAN 802.11a transmitter, it also presents the synthesis and simulation results for the same using Xilinx CPLD XA9536XL-15-VQ44.3 Std.802.11a & OFDM Fundamentals

3.FUNDAMENTALS OF OFDM AND IEEE802.11A STANDARD

3.1 THE STANDARD IEEE 802.11A

The IEEE 802.11 specification is a wireless LAN (WLAN) standard it allows frequency band of 5GHz. IEEE802.11a frame format contains eight carriers are spaced across 200 MHz in the lower spectrum (5.150 - 5.350 GHz) and four carriers are spaced across 100 MHz in the upper spectrum (5.725 - 5.825 GHz). The channels are spaced 20 MHz apart, which allows for high bit rates per channel. Figure 2 shows the IEEE channel scheme.
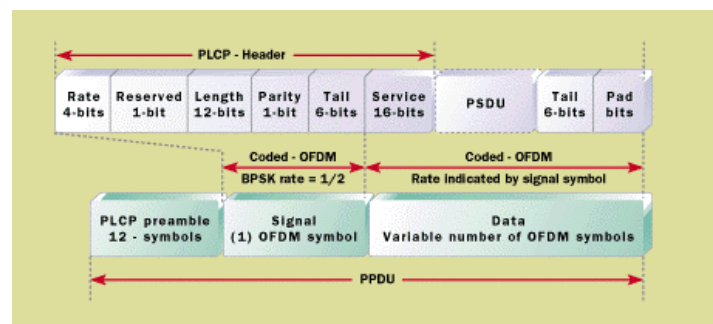

Figure1. IEEE 802.11a channel scheme

IEEE802.11a contains preamble data field and signal field.The first field of the PLCP header is called the preamble. The preamble consists of 12 symbols, which are used to synchronize the receiver. The second field is the signal field. The signal field is used to indicate the rate at which the OFDM symbols of the PSDU payload are transmitted.Data field data which is transmitted.

3.2 OFDM FUNDAMENTALS

OFDM is multi-carrier modulation and multiplexing technique. OFDM contains 52 subcarriers per channel in the 5-GHz band. Out of these channels, only 48 carry actual data.

The remaining four subcarriers are used as pilot subcarriers, which assist in phase tracking for coherent demodulation.
Table 1 shows the Physical layer parameters of OFDM Modulator.

Table 1 Physical layer parameters [2]

Parameter	Value
NSD : Number of data subcarriers	48
NSP : Number of pilot subcarriers	4
NS : Number of subcarriers, total	52(NSD + NSP)
ΔF : Subcarrier frequency spacing	0.3125 MHz
TFFT : IFFT/FFT period	3.2 μs (1/ΔF)
TPREAMBLE : PLCP preamble duration	16 μs (TSHORT + TLONG)
TSIGNAL : Duration of the SIGNAL BPSK-OFDM symbol	4.0μs(TGI+TFFT)
TGI : GI duration	0.8μs (TFFT /4)
TGI2 : Training symbol GI duration	1.6 μs (TFFT /2)
TSYM : Symbol interval	4μs (TGI + TFFT)
TSHORT :Short training sequence duration	8μs(10 ×TFFT /4)
TLONG : Long training sequence duration	8 μs (TGI2 + 2×TFFT)

The OFDM signal is generated through the use of complex signal processing such as fast Fourier transforms (FFTs) and inverse FFTs in the transmitter and receiver. One of the advantage of OFDM is it eliminates the intersymbol interference in a channel. Also OFDM is spectrally efficient.

4 SYSTEM BLOCK DIAGRAM

Figure 2 shows Block diagram of OFDM modulator for IEEE 802.11a standard.
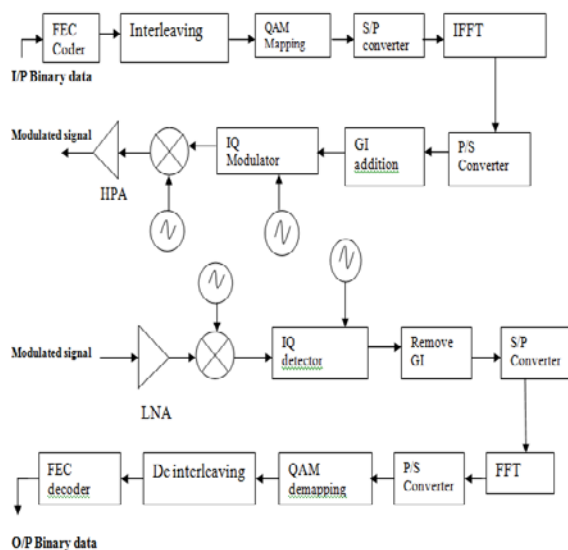

Figure.2: Block diagram of OFDM transreceiver.

The OFDM Physical layer (PHY) transmitter contains following blocks such as FEC Coder/decoder, Interleaving/deinterleaving, IFFT/FFT, Guard Interval (Cyclic Prefix)addition /GI Removal.

4.1 FEC CODER/DECODER

This is channel encoder which encodes the digital data at the transmitter side and decodes at the receiver side with coding rate R = 1/2, 2/3, or 3/4, corresponding to the desired data rate.

4.2 INTERLEAVING/DEINTERLEAVING

Interleaving is applied to randomize the occurrence of bit errors. Due to interleaving coded bits are permuted in a certain way, which makes sure that adjacent bits are separated by several bits at the transmitter side and vice versa operation take place at receiver side.

4.3 PSK AND QAM MAPPER/DEMAPPER

These block performs the constellation mapping and demapping of input binary data according to modulation schemes such as BPSK, QPSK, 16-QAM and 64-QAM. QAM is used extensively as a modulation scheme for digital telecommunication systems. Arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel

4.4 IFFT/FFT

By using this block the symbol is modulated onto 52 subcarriers by applying the Inverse Fast Fourier Transform (IFFT) and demodulated by using Fast Fourier Transform at receiver side to recover 52 carrier values.

4.5 GI ADDITION/REMOVAL

The inter symbol interference is almost completely eliminated by introducing a guard time for a each OFDM symbol. The guard time is chosen larger than the expected delay spread such that multipath components from one symbol cannot interfere with the next symbol.

4.6 IQ MODULATOR

Using an IQ modulator, the signal is converted to analog, which is up converted to the 5 GHz band, amplified, and transmitted through the antenna.

5 IMPLEMENTATION

5.1 IMPLEMENTATION

OFDM was simulated using Xilinx System Generator which runs under MATLAB Simulink for verification.
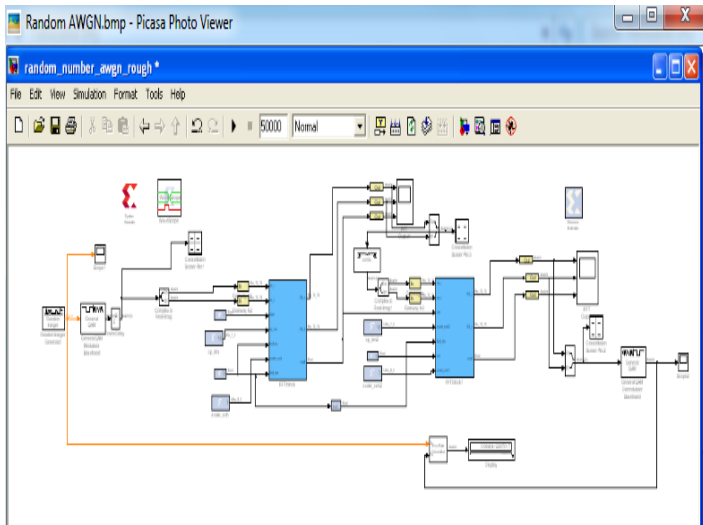
Figure. 3 Implementation of OFDM transreceiver.

In the transmitter random data source generates the information signal. Then QAM modulator block from simulink maps this signal into constellation diagram using 64QAM. Output of QAM modulator is given to complex to real imag block which converts complex signal into real and imaginary signal. This complex signal is given to IFFT block where IFFT block modulates this signal. Then AWGN channel add noise in modulated signal gives to FFT block. FFT block demodulates this signal to recover subcarriers. Complex to real imag block converts this real and imaginary signal into complex signal. Then this complex signal is given to QAM demodulator which demapps the signal into information signal.

Mcode: - It calls a Matlab .m file and executes it inside the simulation.

5.2 DESCRIPTION OF SYSTEM GENERATOR BLOCKSET

Gateway In: - It makes an approach to the behaviour of a signal in hardware.

Gateway Out: - It returns an approach of the behaviour of a signal in hardware to the simulation mode

System Generator: - It provides control of the system and simulation parameters. It is used to invoke the generated VHDL code

Resource Estimator: - It presents the resources of the device used in the simulation of the circuit like LUT's, IOB's etc.

Work scope: - Similar type as that of Simulink Scope which shows analog/digital waveform within hardware system.

In OFDM modulator for random data source Bit error rate versus signal to noise ratio performance is calculated using AWGN and Multipath Rician fading nose channel.

The waveform on wavescope shows the output of modulated and demodulated signal.When Vout signal goes high then output waveforms are observed which isshown in figure 4.
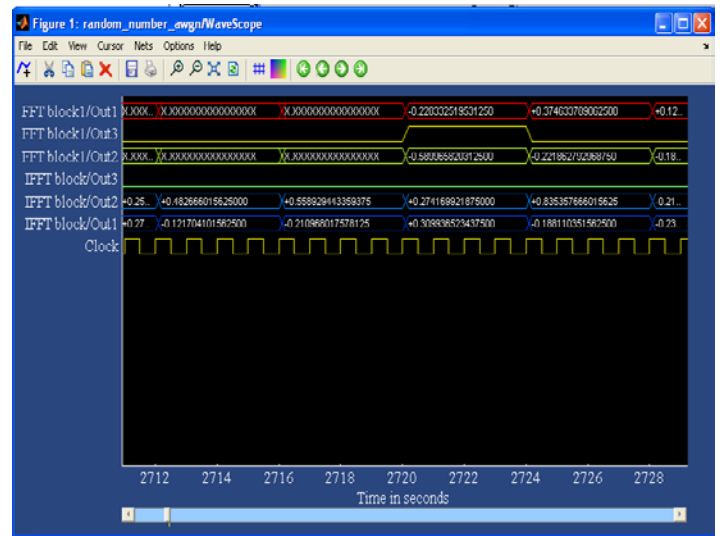

Figure 4: OFDM Modulated and demodulated waveform on Wavescope.

Figure 5 shows the RTL schematic which gives the idea of internal connection of difeernt block which are simulated using system generator tool
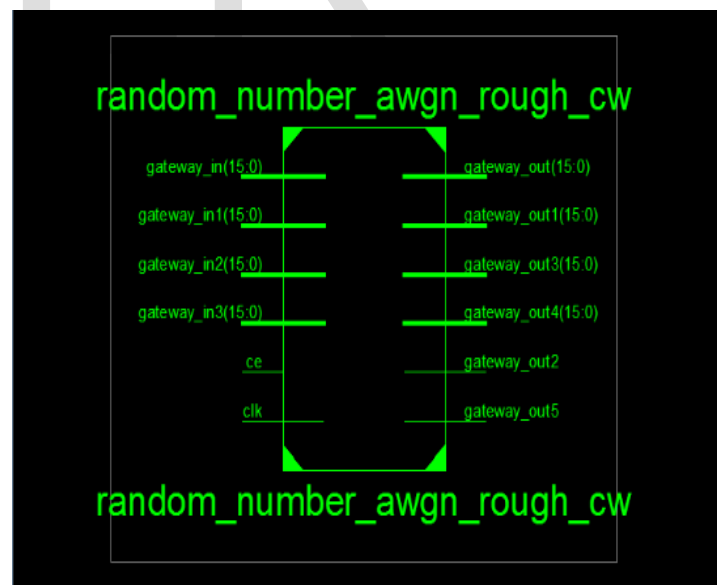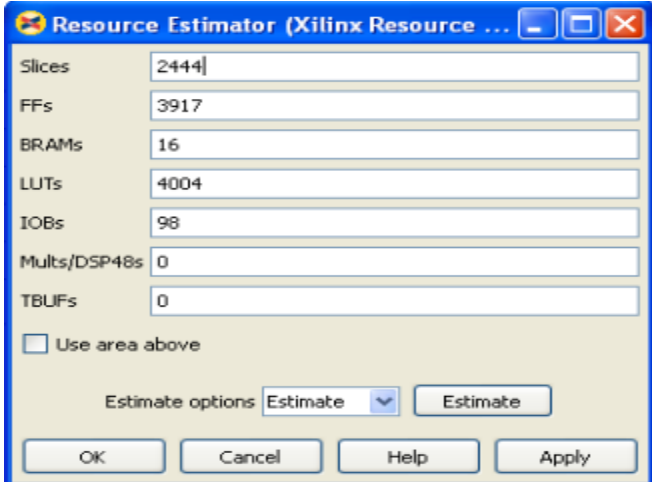

Figure.5: RTL Shematic of OFDM Modulator and Demodulator

The Xilinx Resoource Estimator block provides fast estimate of FPGA   resources required to implement a system generator sub system or model.These estimates are computed by invoking block-specific estimator for Xilinx blocks,and summing these values to obtain aggregated estimator of flip-

flops(FFs),block memories(BRAM),18x18 multipliers tristate buffers,and I/Os .

Table2 shows the Resource Estimation of OFDM Modulator and Demodulator

Table 2 Resource Estimation of OFDM Modulator and Demodulator.

The device utilization summery of OFDM modulator and demodulator using ISE 12.1 simulator is discussed in table 3. Target device selected for reference is Vertex 5.Device utilization summary gives the idea of FPGA resources required to implement a system generator sub system or model on specific target device.

Table 2. Device utilization summery of BPSK Demodulator
(Target Device-Vertex 5 xc5xs50t-ff136, Xilinx ISE design Suite-12.1)

Device Utilization Summary				[−]
Slice Logic Utilization	Used	Available	Utilization	Note(s)
Number of Slice Registers	4,960	32,640	15%	
Number used as Flip Flops	4,960			
Number of Slice LUTs	4,511	32,640	13%	
Number used as logic	2,862	32,640	8%	
Number using O6 output only	2,175			
Number using O5 output only	55			
Number using O5 and O6	632			
Number used as Memory	1,502	12,480	12%	
Number used as Shift Register	1,502			
Number using O6 output only	1,472			
Number using O5 output only	30			
Number used as exclusive route-thru	147			
Number of route-thrus	293			
Number using O6 output only	199			
Number using O5 output only	94			
Number of occupied Slices	1,624	8,160	19%	
Number of LUT Flip Flop pairs used	5,454			
Number with an unused Flip Flop	494	5,454	9%	
Number with an unused LUT	943	5,454	17%	
Number of fully used LUT-FF pairs	4,017	5,454	73%	

Figure 6. shows the BER Vs SNR graph for OFDM modem is evaluated the performance parameter using AWGN channel and Multipath Rician Fading noise channel. Simulation graph shows that, when SNR increases BER decreases.
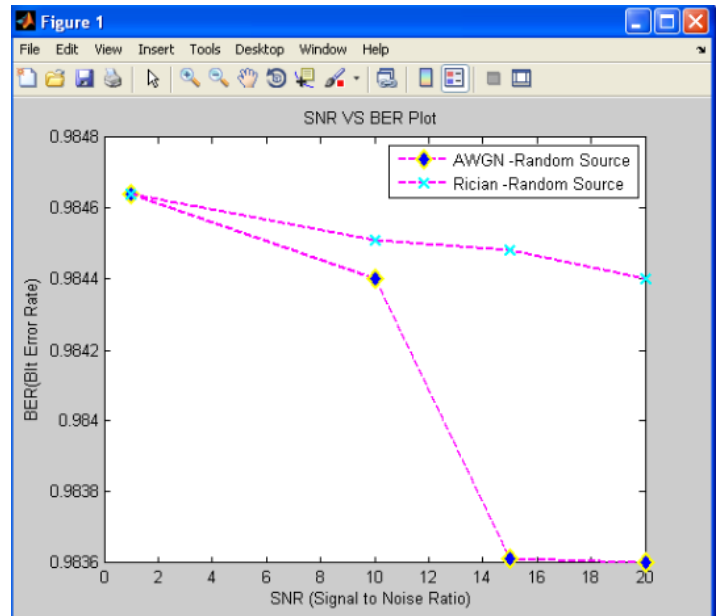

Figure 5: BER Vs SNR performance for AWGN and Multipath Rician fading noise channel.

From the result for both noise channel if signal to noise ratio goes on increasing then BER goes on decreasing. AWGN Channel has good performance as compare to Multipath Rician fading noise channel.

7. CONCLUSION AND FUTER SCOPE

7.1 CONCLUSION

OFDM modulator is simuklated for different noise channel if signal to noise ratio goes on increasing then BER goes on decreasing. AWGN Channel has good performance as compare to Multipath Rician fading noise channel.

7.2 FUTURE SCOPE

The next goal of this work is to implement the OFDM modulator using FPGA device and to use it for applications.

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