Vol 05, Article 09435, September 2014
http://ijves.com
International Journal of VLSI and Embedded Systems-IJVES
ISSN: 2249 – 6556

OFDM MODULATOR FOR WIRELESS LAN (WLAN) STANDARD

K.ANISH[1], K.S.SAGAR REDDY[2]
[1]M.Tech Student, VLSI, [2]Assoc.Professor, Department Of E.C.E, NEC, Nellore, Andhra Pradesh, INDIA
[1]anish424.k@gmail.com, [2]siddu.siddu12@gmail.com

ABSTRACT

Orthogonal Frequency Division Multiplexing OFDM has been adopted by IEEE 802.11's standard as a transmission technique for high data rate in WLANs. Multicarrier modulation is required for wireless 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 2012a and System generator tool from XILINX 14.2.MATLAB Simulation model based on IEEE 802.11a using different modulation and demodulation techniques such as BPSK, QPSK and QAM to analysis the best performance of IEEE 802.11a with implementation of OFDM..

Keywords: *OFDM ,IEEE 802.11A WLAN,BER,SNR,ICI,ISI,SIMULINK,SYSTEM GENERATOR.*

1. INTRODUCTION

Institute of Electrical and Electronics Engineers (IEEE) is the establishment of WLAN item executed IEEE standard 802.11 in 1997. IEEE 802.11's family has gotten to be extremely prominent in every distinctive environment because of their effortlessness, ease, simple establishment, area flexibility and high information rate. It gives simple approach to setup of computer system utilizing without complex wiring base. OFDM allows high speed for wireless communications. OFDM could be considered either a modulation or multiplex-ing 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.

2. FUNDAMENTALS OF OFDM AND IEEE802.11A STANDARD

2.1 OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels that are then allocated to users. However, OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers.

To generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform (IFFT) is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal.

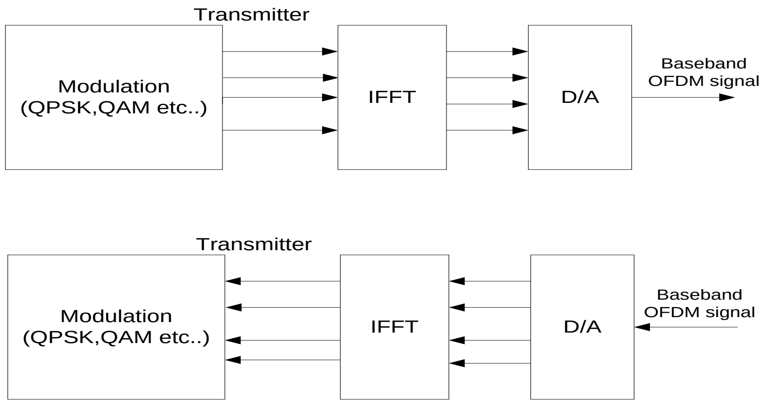


Fig.1.OFDM Transmitter and Receiver

The Fast Fourier Transform (FFT) transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal.

FIG.1 shows the setup for a basic OFDM transmitter and receiver. The signal generated is a baseband, thus the signal is filtered, then stepped up in frequency before transmitting the signal.

Advantages of OFDM

In general, OFDM systems have the following advantages:

(i) makes efficient use of the spectrum by allowing overlap; (ii) By dividing the channel into narrowband flat fading subchannels, OFDM is more resistant to frequency selective fading than single carrier systems are; (iii)Eliminates ISI and IFI through use of a cyclic prefix; (iv) using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel; (v) channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems; (vi) It is possible to use maximum likelihood decoding with reasonable complexity; (vii) OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions; (viii) Is less sensitive to sample timing offsets than single carrier systems are, and (ix) provides good protection against cochannel interference and impulsive parasitic noise

2.2 THE STANDARD IEEE 802.11A

The IEEE 802.11a, which is distributed by the IEEE LAN/MAN Standards Committee (IEEE 802.11) in 1999, is a wireless local area network standard in the 5 Ghz recurrence band .It characterizes the necessities for the physical layer (PHY) and the medium access control (MAC) layer. The physical layer characterizes how the crude bits in a parcel are transmitted over a correspondence interface and defines the encoding and indicating capacities that convert the crude bits into the radio waves. The MAC layer characterizes the interface between the physical layer and the interface transport of the machine. In this part, the physical layer of IEEE 802.11a standard will be clarified quickly.

The IEEE802.11a is the first standard of IEEE 802.11 committee which uses the Orthogonal Frequency Division Multiplexing (OFDM) as the modulation technique. It transmits a analog waveform, changed over from a digital signal, over the Unlicensed-National Information Infrastructure (U-NII) groups, 5.15-5.25 GHz, 5.25-5.35 GHz and 5.725-5.825 GHz. Each one band holds 4 channels with a data transmission of 20 MHz and the yield power limits of these groups are 40 mw, 200 mw and 800 mw, individually.

The IEEE802.11a standard divides the 20 MHz channel into 64 sub-carriers with a frequency spacing of 312.5 KHz and uses 48 of them as data sub-carriers,4 of them as pilot sub-carriers and the others as guard sub-carriers to avoid the adjacent channel interference. Whereas the pilot sub-carriers transmit a predetermined symbol sequence for channel tracking, the data sub-carriers convey the information stream modulated by using Phase Shift Keying (PSK) or Quadrature Amplitude Modulation (QAM) techniques. The OFDM scheme enables the IEEE802.11a to transfer the raw data at a maximum rate of 54 Mbps. The standard also supports the data rates 6, 9, 12, 18, 24, 36 and 48 Mbps by changing the modulation type and the Forward Error Correction (FEC) coding rate of the data sub-carriers.The symbol duration is specified as 4 microseconds in the standard and 800 ns of it is used for cyclic prefix to ensure an ISI-free reception of the transmitted symbols over a channel with a delay spread up to 250 ns.

2.3.THE FRAME FORMAT OF IEEE 802.11A

Each frame in the physical layer of IEEE 802.11a includes Physical Layer Convergence Procedure (PLCP) Preambles, PLCP header, and Physical Layer Service Data Unit (PSDU), tail and pad bits, as shown in Fig. 2.1. The PLCP Preamble consists of 10 short preambles and two long preambles. The short preambles are used for frame detection, automatic gain control and timing synchronization. The frequency offset and channel response is also estimated through the long preambles that are sent immediately after the short preamble.

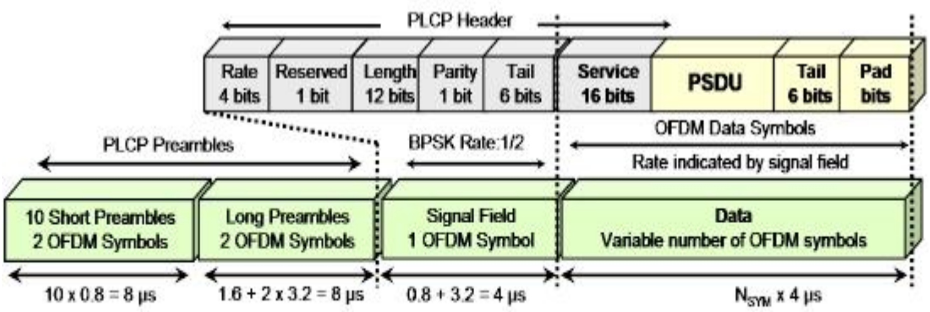


Fig.2. Frame Format of The Ieee 802.11a Standard

PLCP Preamble –The PLCP preamble contains of 10 small OFDM symbols and two extended symbols. The purpose of short OFDM symbols is to sequence the receiver to adjust AGC (automatic gain control) and improve estimate of the carrier frequency as well as channel. The long OFDM symbols are used to fine-tune during data transmission. There are 12 subcarriers for short OFDM symbols and 53 for the long. The transmission of preamble time is 16µs.The coding rate of R = 1/2 using BPSK at a data rate of 6 Mbps.

Rate-This field is used to encode the data rate. The 4 bit rate is used to encode the data rate. There are 8 likely accessible rates are: 6, 9, 12, 18,24,36,38 and 54 Mbps. Table 4.1 shows the bits used to encode each data rates

Reserved- The reserved must be set to a logic zero and can be reserved for upcoming usage.

Length- A 12 bits field require the number of octets in the PSDU surround with the MAC frame. It is used to send least significant bit (LSB) to most significant bit (MSB).

Parity- Parity is base on values of the Rate, Reserved, and Length fields and contains a single-bit value that is used to offer even parity for error checking.

Tail- 6 bits is set to “0” for the tail signal.

Services-The finishing field is the 16 bit services field. The 0-6 bits are set to 0 to initialize.

Scramble-The left over bits 7-15 reserved for future use.

Date rate (Mbps)	Bits (Transmission Order)
6 Mbps	1101
9 Mbps	1111
12 Mbps	0101
18 Mbps	0111
24 Mbps	1001
36 Mbps	1011
48 Mbps	0001
54 Mbps	0011

Table.1. Date Rate Bits

2.4 OFDM PHY LAYER PARAMETERS

The presentation of the system ideal tested through different modulation schemes such as BPSK, QPSK, 16QAM and 64 QAM with an AWGN channel and OFDM modulator and demodulator are used in the MATLAB. Ideally, IEEE 802.11a operates in PHY layers specification as well as similar Bit Error Rate (BER) performance of the simulation over Additive White Gaussian Noise (AWGN).

IEEE 802.11a PHY used OFDM modulation with the arrangement of different modulation schemes and convolution coding rates. There are eight operation modes which deliver data rates between 6 Mbps and 54 Mbps.

The OFMD cyclic prefix and Symbol Interference (ISI) has been assumed for modulation techniques in this MATLAB simulation. In other to examine the performance of the OFDM based WLANs IEEE 802.11a standard. Table: 5.1 Show the IEEE 802.11a conditions OFDM modulation Rate dependent limits. These limitations can also be used for IEEE 802.11a.

Data rate (Mbps)	Modulation	Coding rate (R)	Coded bits per subcarrier (N_{BPSC})	Coded bits per OFDM symbol (N_{CBPS})	Data bits per OFDM symbol (N_{DBPS})
6	**BPSK**	**1/2**	**1**	**48**	**24**
9	**BPSK**	**3/4**	**1**	**48**	**36**
12	**QPSK**	**1/2**	**2**	**96**	**48**
18	**QPSK**	**3/4**	**2**	**96**	**72**
24	**16 QAM**	**1/2**	**4**	**192**	**96**
36	**16 QAM**	**1/2**	**4**	**192**	**144**
48	**64 QAM**	**2/3**	**6**	**288**	**192**
54	**64 QAM**	**3/4**	**6**	**288**	**216**

Table.2. Rate-dependent parameters of 802.11a

3. IEEE 802.11A WLAN PHYSICAL LAYER BY USING SIMULINK

This signifies an end-to-end baseband model of the physical layer of a wireless local area network (WLAN) according to the IEEE 802.11a standard. The model maintenances all mandatory and optional data rates: 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s. The IEEE 802.11a also demonstrates adaptive modulation and coding over a dispersive multipath fading channel, whereby the simulation varies the data rate dynamically. Reminder that the model uses an theatrically high channel fading rate to make the data rate adjustment more rapidly and thus make the imagining more animated and useful.

Parameter	Value
N_{SD} : Number of data subcarriers	48
N_{SP} : Number of pilot subcarriers	4
N_{ST} : Number of subcarriers, total	52 (N_{SD} + N_{SP})
ΔF : Subcarrier frequency spacing	0.3125 MHz (=20 MHz/64)
T_{FFT} : IFFT/FFT period	3.2 µs (1/ΔF)
$T_{PREAMBLE}$: PLCP preamble duration	16 µs (T_{SHORT} + T_{LONG})
T_{SIGNAL} : Duration of the SIGNAL BPSK-OFDM symbol	4.0 µs (T_{GI} + T_{FFT})
T_{GI} : GI duration	0.8 µs (T_{FFT} /4)
T_{GI2} : Training symbol GI duration	1.6 µs (T_{FFT} /2)
T_{SYM} : Symbol interval	4 µs (T_{GI} + T_{FFT})
T_{SHORT} : Short training sequence duration	8 µs (10 × T_{FFT} /4)
T_{LONG} : Long training sequence duration	8 µs (T_{GI2} + 2 × T_{FFT})

Table.3. Timing-related parameters of 802.11a

3.1 OFDM TRANSCEIVER

i.)First, the N input complex symbols are padded with zeros to get Ns symbols that are used to calculate the IFFT. The output of the IFFT is the basic OFDM symbol.

ii.)Based on the delay spread of the multi-path channel, a specific guard-time must be chosen (say Tg). A number of samples corresponding to this guard time must be taken from the beginning of the OFDM symbol and appended at the end of the symbol. Likewise, the same number of samples must be taken from the end of the OFDM symbol and must be inserted at the beginning.

iii.)The OFDM symbol must be multiplied with the raised cosine window to remove the power of the out-of-band sub-carriers.

iv.)The windowed OFDM symbol is then added to the output of the previous OFDM symbol with a delay of Tr, so that there is an overlap region of bTr between each symbol.

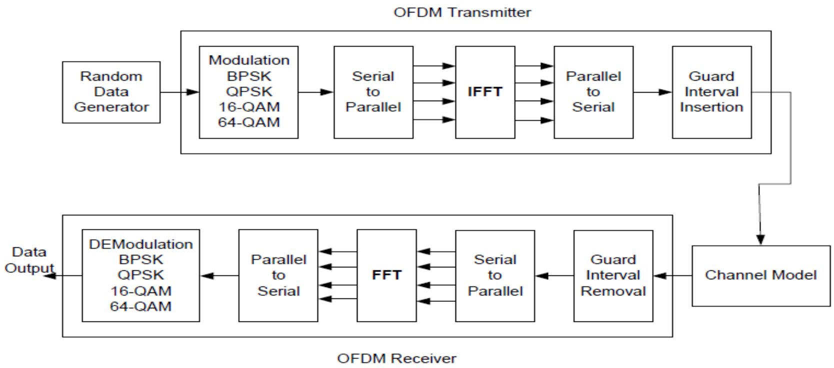


Fig.3..OFDM System Block Diagram

OFDM system design, as in any other system design, involves a lot of tradeoff's and conflicting requirements. The following are the most important design parameters of an OFDM system. The following parameters could be a part of a general OFDM system specification:

Bit Rate required for the system.

- Bandwidth available.
- BER requirements. (Power efficiency).

Guard Time

Guard time in an OFDM system usually results in an SNR loss in an OFDM system, since it carries no information. The choice of the guard time is straightforward once the multi-path delay spread is known. As a rule of thumb, the guard time must be at least 2-4 times the RMS delay spread of the multi-path channel. Further, higher-order modulation schemes (like 32 or 64 QAM) are more sensitive to ISI and ICI than simple schemes like QPSK. This factor must also be taken into account while deciding on the guard-time.

Symbol Duration

To minimize the SNR loss due to the guard-time, the symbol duration must be set much larger than the guard time. But an increase in the symbol time implies a corresponding increase in the number of sub-carriers and thus an increase in the system complexity. A practical design choice for the symbol time is to be at least five times the guard time, which leads to an SNR loss that is reasonable.

Number of Sub-carriers

Once the symbol duration is determined, the number of sub-carriers required can be calculated by first calculating the sub-carrier spacing which is just the inverse of the symbol time (less the guard period). The number of sub-carriers is the available bandwidth divided by the sub-carrier spacing.

Modulation and Coding Choices

The first step in deciding on the coding and modulation techniques is determining the number of bits carried by an OFDM symbol. Then, a suitable combination of modulation and coding techniques can be selected to fit the input data rate into the OFDM symbols and, at the same time, satisfying the bit-error rate requirements. The choice of modulation and coding techniques are lot easier now, since each channel is assumed to almost AWGN and one doesn’t need to worry about the effects of multi-path delay spread.

3.1.1 OFDM Transmitter

TX Controller: Receives information from the MAC. Adds header data before actual payload and generates control for all the subsequent blocks. Scrambler: Randomizes the data stream to remove repeated patterns.

FEC Encoder: Encodes and adds some redundancy to data making it possible for the receiver to detect and correct errors. The encoded data is punctured to reduce the transmitted number of bits.

Interleaver: Interleaves bit stream to provide robustness against burst errors. Mapper: Passes interleaved data through a serial to parallel converter, mapping groups of bits to separate carriers, and encoding each bit group by frequency, amplitude, and phase. The output of the Mapper contains the values of data subcarriers for an OFDM symbol.

Pilot/Guard Insertion: Adds the values for pilot and guard subcarriers to OFDM symbols.

IFFT: Converts OFDM symbols from the frequency domain to the time domain.

CP Insertion: Copies some samples from the end of the symbol to the front to add some redundancy to the symbols to avoid Inter-Symbol Interference. The block also adds a preamble before the first transmitted symbol. After CP insertion, OFDM symbols are outputted to a DAC, which converts them to analog signals which can them be transmitted.

3.1.2. OFDM Receiver

The receiver roughly applies the transmitter transformations in reverse. However, it requires some additional feedback to help synchronize to the expected phase. Synchronizer: Detects the starting position of an incoming packet based on preambles.

Serial to Parallel (S/P): Removes the cyclic prefix (CP) and then aggregates samples into symbols before passing them to the FFT. It also propagates the control information from the RX Controller to subsequent blocks.

FFT: Converts OFDM symbols from the time domain into the frequency domain.

Channel Estimator: Compensates for frequency-dependent signal degradation based on pilots and corrects the errors caused by multi-path interference.

Demapper: Demodulates data and converts samples to encoded bits.

Deinterleaver: Reverses the interleaving and restores the original arrangement of bits.

FEC Decoder: Uses the redundant information to detect and correct errors occurred during transmission.

Descrambler: Reverses the scrambling.

RX Controller: Based on the decoded data, the RX Controller generates the control feedback to S/P block.

3.2 STRUCTURE OF IEEE 802.1A WLAN PHY

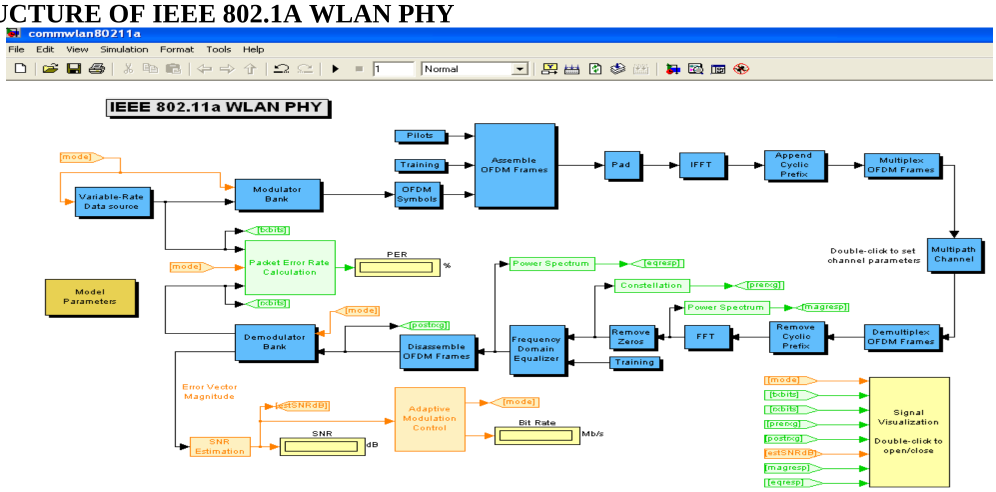


Fig.4. Structure of IEEE 802.11a WLAN

Vol 05, Article 09435, September 2014
http://ijves.com
International Journal of VLSI and Embedded Systems-IJVES
ISSN: 2249 – 6556

1. Generation of random data at a bit rate that differs during the simulation. The varying data rate is expert by allowing a source block sometimes for a duration that depends on the desired data rate.
2. Coding, interleaving, and modulation using one of several schemes specified in the standard.
To study these tasks, select the Modulator Bank block and select Look Under Mask from the window's Edit menu. Then choice any of the modulator blocks in the subsystem and choose Look Under Mask from the window's Edit menu.
In particular, each modulator block in the bank performs these tasks:
Convolutional coding and puncturing using code rates of 1/2, 2/3, and ¾.Data interleaving.BPSK, QPSK, 16-QAM, and 64-QAM modulation
3. OFDM (orthogonal frequency division multiplexing) transmission using 52 subcarriers, 4 pilots, 64-point FFTs, and a 16-sample cyclic prefix.
4. PLCP (physical layer convergence protocol) preamble showed as four long training sequences.
5. Dispersive multipath fading channel. You can arrange channel properties using the dialog box of the Multipath Channel block.
6. Receiver equalization.
7. Viterbi decoding.

3.3 Results and Displays

To outlook data in detail, open the display window by double-clicking the Signal Visualization icon. The plots within the display window appearance
1.)A portion of the random binary data, expected to help you imagine the varying data rate.
2.)Scatter plots of the received signal before and after equalization. Since the plot of the equalized signal, you can express which modulation type the system is currently using, since the plot look like a signal constellation of 2, 4, 16, or 64 points.
3.)The power spectrum of the received signal before and after equalization, in dB. The dynamics of the signal's spectrum earlier equalization depend on the Fading mode parameter in the Multipath Channel block.
4.)The approximation of the SNR based on the error vector magnitude.
5.)the bit rate of the transmission.
6.)The bit error rate per packet. For most packets, the BER is zero. Because this plot uses a logarithmic scale for the vertical axis, BER values of zero do not appear in the plot.
The following blocks display numerical results:
1.)The PER block displays the packet error rate as a percentage.
2.)The SNR block at the top level of the model displays an approximation of the SNR based on the error vector magnitude. The SNR block in the Multipath Channel subsystem displays the SNR created on the received signal power.
3.)The Bit Rate block displays which of the bit rates stated in the standard is currently in usage.

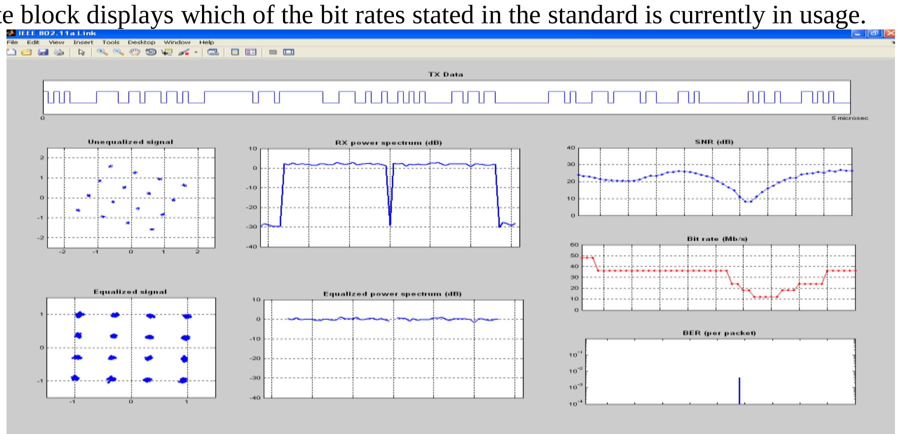


Fig.5.output wave forms

4. IMPLEMENTATION OF IEEE 802.11A BY USING SYSTEM GENERATOR

4.1 DESCRIPTION OF SYSTEM GENERATOR BLOCKSET

Gateway In: - It makes an approach to the behaviour of a sig-nal 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.
Serial to Parallel:-Serial to Parallel block is programmed in the Data Types, Elements, Basic, and Index Xilinx Blockset library. The Serial to Parallel block holds a series of inputs of whichever dimensions and generates a single output of a specific multiple of that dimension.

International Journal of VLSI and Embedded Systems-IJVES
ISSN: 2249 – 6556

Parallel to Serial:-The Parallel to Serial block is available in the Data Types, Elements, Basic, and Index Xilinx Blockset library. The Parallel to Serial block would receive an input word and splits it into N output words which are time multiplexed,whereas N defines the ratio of number of input bits to output bits.

AWGN Channel:-The Xilinx AWGN Channel reference block would add white Gaussian noise which is ascend to an input signal. The noise is produced by the White Gaussian Noise Generator reference block and is scaled depending on the SNR to attain the preferred noise variance

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

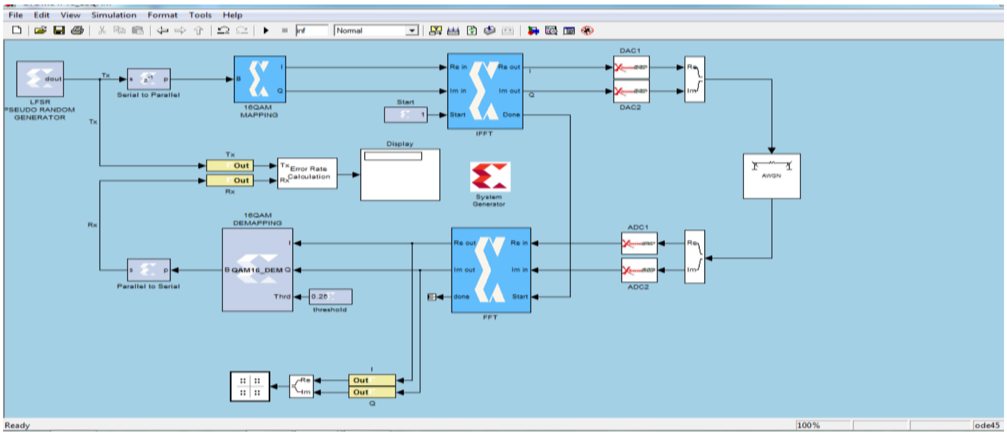


Fig.6.Xilinx Simulink Design of WLAN using OFDM transceiver

XtremeDSP Analog to Digital Converter:-The Xilinx Xtreme DSP ADC block would let the System Generator blocks to connect to two analog input channels on the Nallatech BenAdda board if the model is set for hardware co-simulation. Different ADC blocks, ADC1 and ADC2 are given for first and second analog input channels, respectively

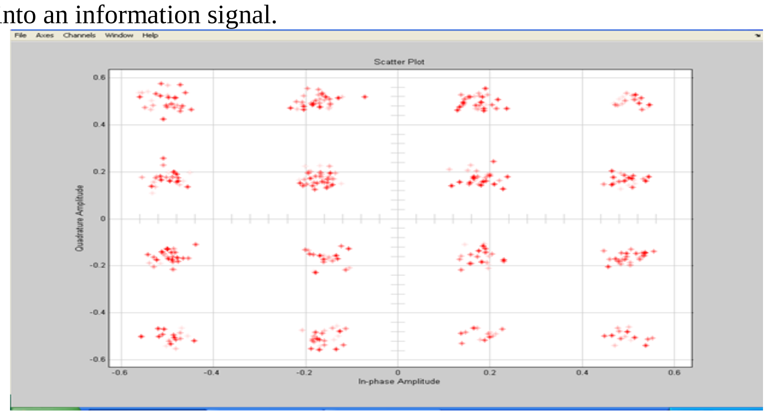
XtremeDSP Digital to Analog Converter:-The Xilinx XtremeDSP DAC block would let the System Generator components to be connected to two analog output channels on the NallatechBenAdda board after the model is set for hardware co-simulation. Different DAC blocks, DAC1 and DAC2are given for first and second analog input channels, respectively.

LFSR:-LFSR block is available in the Basic Elements, Memory, DSP, and Index of Xilinx Blockset library. The Xilinx LFSR block performs the functions of the Linear Feedback Shift Register and would support both the Galois and Fibonacci models by using any of the XOR or XNOR gate and a reloadable input is allowed to alter the current value of the register at any instant of time. The LFSR output and the reloadable input is configured as serial or parallel.

The authors can acknowledge any person/authorities in this section. This is not mandatory.

Fast Fourier Transform 7.0:-Fast Fourier Transform 7.0 block can be found in the DSP and Index blockset of Xilinx. The Xilinx Fast Fourier Transform 7.0 block performs an efficient algorithm to compute the Discrete Fourier Transform.

At the transmitter random data source generates the information signal. Then QAM modulator block from simulink maps the information signal generated at the transmitter into constellation diagram using 64QAM. Output of QAM modulator is then given to complex to real image conversion block which converts complex signal into real and imaginary signal. AWGN channel adds noise to modulated signal and the resultant is given as input to FFT block which demodulates the given input signal to recover subcarriers. Complex to real image block converts this real and imaginary signal into complex signal and is given to QAM demodulator where the signal is demapped into an information signal.



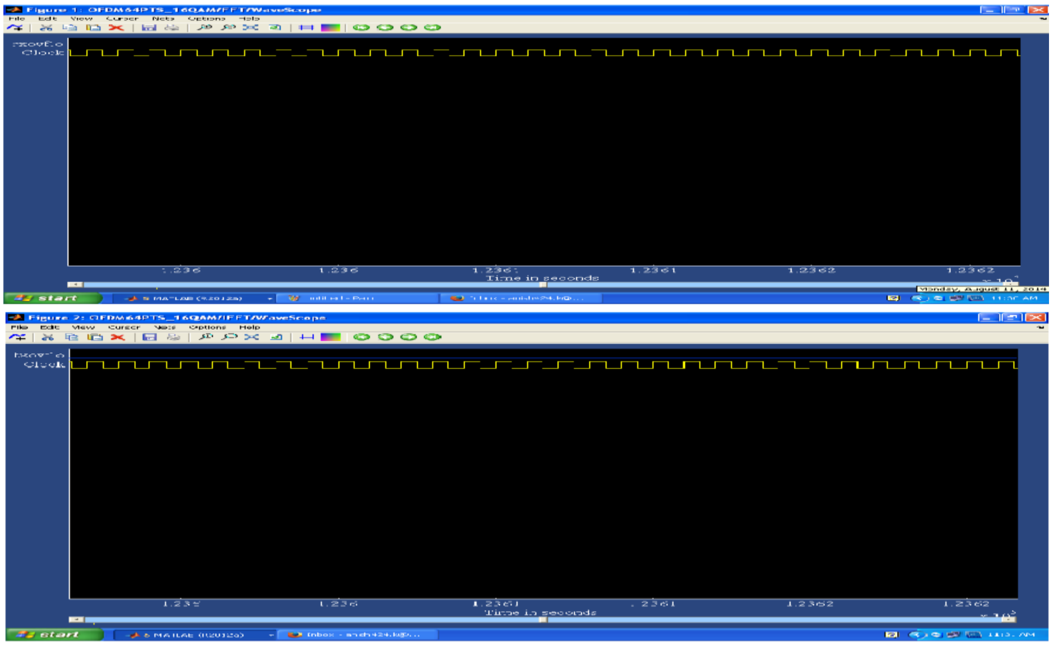


Fig.7. Simulation results of WLAN using OFDM Transceiver

CONCLUSION

The Orthogonal Frequency Division Multiplexing (OFDM) is one of the most promising transmission technique among the existing technologies due to its unique features. This project aimed at implementation of the physical layer of the IEEE802.11a Wireless LAN standard, which is one of the OFDM based IEEE standard. Before starting the implementation, the overall IEEE802.11a system has been modeled and simulated in MATLAB Simulink environment. According to the simulations, the receiver has been developed in such a way that it is more reliable and easily implemented. The timing and frequency synchronization problems of the OFDM technique have been exclusively considered to yield a good performance.

The transmitter and receiver blocks, which support all the data rates defined in the standard, are designed using the “Xilinx System Generator" through which DSP systems with high performance can be developed and the designs are more reliable and can be done easily.

FUTURE SCOPE

As a future work the design of WLAN using OFDM Transceiver can be implemented on FPGA. Advances in FPGA technology along with the augmentation of well organized tools for simulation, modeling and synthesis made FPGA an extremely helpful platform. FPGA is the medium of selection for the hardware development and execution of high performance applications which requires rigorous computations. FPGA technology has turn into a feasible target for the execution of algorithms that are well matched to Digital Signal Processing applications.

REFERENCES

[1] Joaquin Garcia,Renu Cumplido “On the design of an FPGA-Based OFDM modulator for IEEE 802.11a” IEEE Computer, pp. 19–21, September 7-9,2005.
[2] Ramjee Prasad “OFDM for Wireless Communications Systems” Year of publication 2004.
[3] Anibal Luis Intini, “Orthogonal Frequency Division Multiplexing For Wireless Network” in 7th International OFDM Workshop 2002, Dec 2000.
[4] Dusan Matix,” OFDM as a possible modulation technique for multimedia applications in the range of mm waves” Intro-duction to OFDM, II edition.
[5] Y. Kim, H. Jung, H. Ho Lee and K. Rok Cho and F. Harris , “MAC Implementation for IEEE 802.11Wireless LAN”, ATM (ICATM 2001) and High Speed Intelligent Internet Symposium, 2001. Joint 4th IEEE International Conference on, pp. 192–195, Apr. 2001.
[6] Haimaa A.S, Fadiya Al-Wardi, Firas.S and Weidong Xiang , “Experiment and Analysis on the Comparison of the IEEE 802.l11 a and 802.llg Wireless Local Area Networks”, University of Michigan, Dearborn.
[7] M.A.Mohmad’, “Study Of Performance Parameters Effects On OFDM Systems” IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 3, No 2, May 2012.