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Design of Low power Reconfiguration based Modulation and Demodulation for OFDM Communication Systems

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Abstract

In any communication systems, transceiver is used to transmit and receive the modulated signal. Modulation and demodulation is the process to change and recover the original message signals. In recent times, quadrature amplitude modulation (QAM) and Differential phase shift keying (DPSK) modulation scheme has been used in the wide range of applications, because of high data rate and Spectral efficiency. To improve the data rate by enhance the QAM constellation, 64-QAM is provides high data rate compared to 16-QAM modulation. Different modulation techniques are present in the digital communication systems, but using only one modulation at the time of processing. To overcome the problem by introducing a reconfiguration technique in the transceiver. Reconfiguration process allows more than one modulation technique run in the same processing element. During the reconfiguration process power is highly dissipated. So to save the power by proposed a technique named as clock gating technique. This technique reduces the power dissipation in the circuit by avoiding the unnecessary switching activities. The proposed concept is applied into the OFDM based communication for performance and efficiency enhancements. The process is done in the Modelsim 6.3c and Xilinx simulation environment.

Keywords: DPSK, 16-QAM, 64-QAM, OFDM, clock gating, Reconfiguration

INTRODUCTION

Wireless communication has become a popular communication technology. OFDM is one of the emerging technologies in cellular communication. Software defined radio is the software implemented in hardware to carry some operations. SDR is more efficient than compared to conventional radio. Its function includes modulation, multiplexing, multiple accesses and other process. Modulation is a process of changing the original message signal into some other form. During the transmission carrier signal is transmit along with the message signal. The modulation process is done by using the device named as modulator. Transmission of data between the sender and the receiver is in free space, it occur noise and some other disturbance in the message signal. To avoid the disturbances in the message signal modulation technique is used in the wireless communication. Carrier signal is affected during the transmission in the air, message is remains same. Two different types of modulation used in the communication. First one is analog modulation and the second one digital modulation. Analog modulation is to transfer a baseband signal at different frequency. For example audio signal, TV signal etc. Digital modulation transfer digital bit stream over the channel. Mostly wireless communication uses digital modulation to transmit the data. Amplitude modulation, frequency modulation and phase modulation is comes under analog modulation scheme. Some of the digital modulation techniques are Amplitude shift keying, phase shift keying, quadrature phase shift keying etc, these are some famous modulation techniques. Modulation decides the performance of the communication system. Process to process the modulation technique and the performance of the modulation technique changed. Likewise, in the receiver side the demodulation performs the operation. Demodulation is the process of recover the original message signal from the modulated signal. Efficient modulation and demodulation have some special characteristics as good flexibility, universality, high speed and high data rate. To increase the capacity and speed of the communication should be done by using adaptive modulation technique. Adaptive modulation allows changing the modulation type depending on the channel conditions.

RELATED WORKS

In the wireless communication multimedia services on mobile are the recent advancements in today world. Wireless communication systems use many components to transmit and receive the data. One of the important modules is digital modulation; this technique allows the digitized data transmitted to the radio frequency channels. For uninterruptable communication maintain the higher data rate. Kangkan Thakuria et al. [1] proposed a new modulation scheme named as M-array PSK modulation in AWGN channel for higher data rate. Not only data rate also provide better bit error rate and bandwidth efficiency than compared

to other digital modulation techniques. Transmission range is increased between a transmitter and the receiver.

Now a day's wireless communication demands high quality of services with less number of transmission errors. MIMO-OFDM technology provides high data rate and high quality of services with low transmission errors. Swati Dutta and S. D. Sawarkar [2] presented a BPSK and QPSK modulation techniques with and without interleaving process. The interleaving process is reduced the bit error rate. Convolution coding is generally used in the MIMO system for error detection and error correction. Here OSTBC encoder is replaced the convolution encoder for forward error correction. The bit error rate of OSTBC code in AWGN channel using QPSK and BPSK modulation have less bit error rate than compared to convolution code in AWGN Channel.

Shihe Long et al. [3] introduced a modulation technique named as carrier less amplitude and phase modulation for optical orthogonal frequency division multiplexing. It is implemented in the transmitter side the complexity and peak to average power ratio should be less. CAP modulation is used for signal transmission over the telephone cables. CAP modulation in the visible light communication system provides higher spectral efficiency, and low power consumption at the transmitter side and the receiver side.

Optimization of antennas in digital modulation based communication systems are presented by Guilherme Franco Sanos et al. [4]. Here four base stations are arranged at equal distance, antenna is placed centre between the base stations. Main aim of the process is reducing the interference between the links for higher quality of services. In the four base stations three stations working with the 16-QAM modulation scheme, the remaining base station is work with 64-QAM modulation. Compared to the conventional method, it radiates less power in the link direction. In addition to avoiding the inter symbol interferences with the other carrier links.

Hardware reconfiguration provides better solution to use the same hardware for different kind of applications. It offers less hardware utilization and low power dissipation. Coarse grained reconfiguration and fine grained reconfiguration are the two types of reconfigurable architecture mostly used in the SoC system design. Dinesh Padole et al. [5] introduced the reconfigurable multicore architecture; it provides a new way to build the number of processing elements. The proposed system consists of array of processing elements, memory unit and main processor. Main processor control all operations related to the system operations. All processing elements are considered as homogeneous, some of the architectures are heterogeneous depends on the applications.

Jagrit Kathuria et al [6] proposed a novel technique named as clock gating. In general clock signal is the great source of power dissipation because of load and high frequency. RTL clock gating is the common technique used for higher efficiency and power optimization. It is technique to optimize the power at gate level, system level and RTL. Clock signal is mainly used for synchronization not for any type of computations. Another important thing it does not carry any kind of information. Clock gating techniques save more power by reducing unwanted clock activities. Glitches and Hazards are the problems occurred in the output waveform. Latch based clock gating technique reduces the problem of hazards and glitches. Clock gating save more than compared to other techniques.

Nowadays power is an important parameter in any digital circuits and clock distribution networks. Clock gating is used to reducing the switching activities for saving the dynamic power. Mohsen Riahi et al. [7] proposed the new techniques can be classified into interconnect optimization, switching reduction, clock and power gating. Power gating is a method to avoid the active leakage power. Clock gating is used for high level synthesis tool for low power hardware design. This technique also reduces the energy wasting in low activity states. More power is saved when compared to previous clock gating technique.

DIGITAL MODULATION TECHNIQUES

Modulations play an important role in any of the communication system. In every transmitter modulation is one of the basic process; likewise the receiver side demodulation performs the process and recovers the original signals. Analog and digital modulation is two basic modulation types present in the communication system. Now a day's all transmitter and receiver uses only digital modulation scheme, because signals entering into the transmitter is digital in nature. The input of the modulator is represented as symbols. BASK, BFSK, BPSK, QPSK, OQPSK, QAM are efficient and frequently used modulation techniques. In any digital modulation uses a finite number of discrete signals to represent the digital data. Phase shift keying uses finite number of phases, each phases assigned a unique binary digits. QPSK or 4-PSK uses four points on the constellation diagram. QPSK modulator can code two bits per symbol. Compared to BPSK modulation QPSK transmits higher data within a given bandwidth. The data rate will be twice than BPSK data rate. Likewise quadrature amplitude modulation (QAM) is one of efficient modulation techniques in communication systems. QAM is the combination of both analog and digital modulation. It modulates the analog message signal by using Amplitude modulation (AM). In the same way digital modulation is done by using Amplitude shift keying (ASK). It contains two types of components one is Inphase component and another one quadrature component. Constellation diagram is used for any QAM based digital modulation. In QAM constellation points arranged in square grid. Most common QAM structures are 16-QAM, 64-QAM and 256-QAM. Higher number of constellation points is used to transmit more bits in a single

symbol. QAM modulator and demodulator basic operation circuit is shown in figure. 1 and 2.

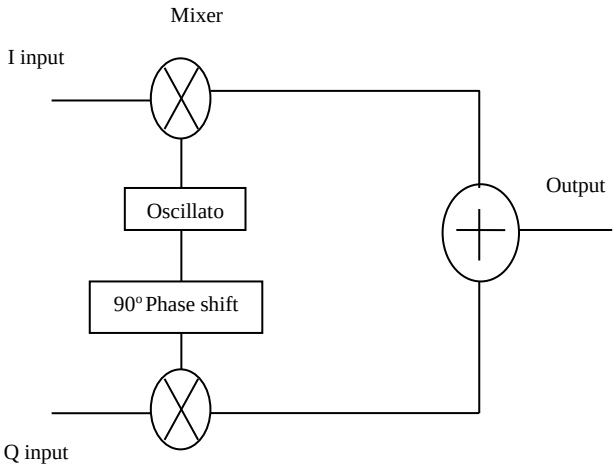

Figure. 1 QAM Modulator

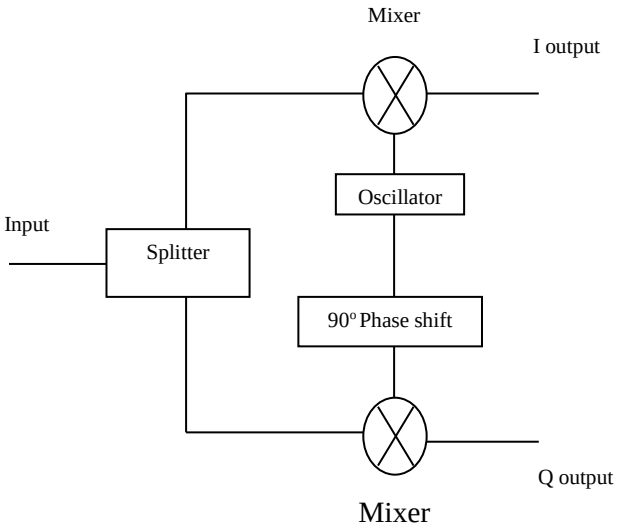

Figure. 2 QAM Demodulator

3. (A) 16- QAM

In 16-QAM transmits four bits per symbol. Data can be split into two channels named as I and Q, so the 16- State QAM contains four inphase components (I) and four quadrature components (Q) are used. Symbol rate is one by fourth of bit rate. 16-QAM constellation is not suitable for transmitting higher number of bits. It is mostly used for short range communication, because it conducts less number of bits per symbol. To overcome the problem by increasing the constellation points. It is possible to transmit more of bits per symbol. Constellation Point representation is given in eq. no. 1

$$\begin{aligned} &complexdata(d) \\ &d=(I+jQ)\times k \bmod \\ &K \bmod = 1/\sqrt{10} \\ &If\ Binary\ input\ is\ 1010 \\ &d=(-3-j3)\times\sqrt{10} \end{aligned} \tag{1}$$

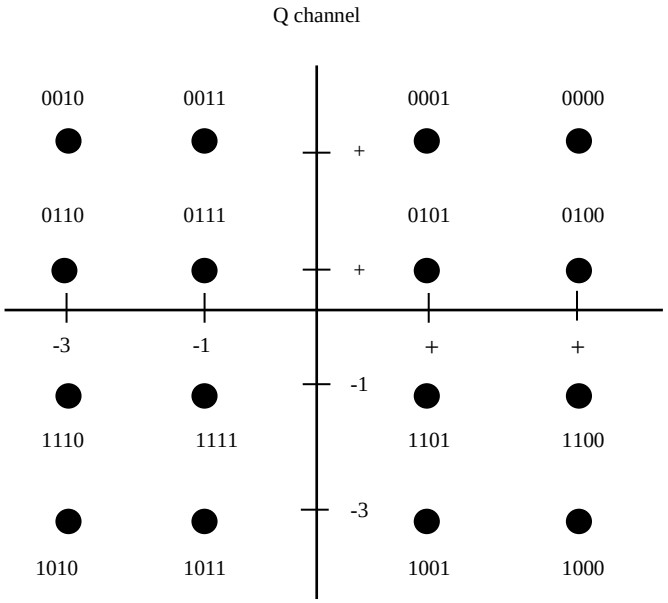

Figure. 3 Constellation Diagram of 16-QAM

3. (B) 64-QAM

In 64-QAM each symbols can be represented as 6 bits. A group of six bits is mapped into a single constellation point with real and imaginary parts. It is used in digital television and cable modem applications. Higher order constellation reducing the noise occurred in the signal during transmission, and also provides better SNR ratio without increasing the Bit error rate (BER). Also send more data within the same frequency spectrum, data increased up to 50% more than lower order constellation symbols. 64-QAM modulation have high complexity than compared to other type of modulations like 16-QAM, QPSK and BPSK. It provides more channels, but it's more susceptible to interference. In communication LTE technique allows 16-QAM and 64-QAM modulation schemes for uplink and downlink process. Constellation point of 64-QAM is given in eq. no. (2) and signal representation is given in eq. no. (3).

$$\begin{aligned} &d=(I+jQ)\times k \bmod \\ &k \bmod = 1/\sqrt{42} \\ &If\ Binary\ input\ is\ 001110\ means \\ &d=(+5+5j)\times 1/\sqrt{42} \end{aligned} \tag{2}$$

Sinal is represented as

$$x(t) = A_I(t)\cos wt - A_Q(t)\sin wt \quad (3)$$

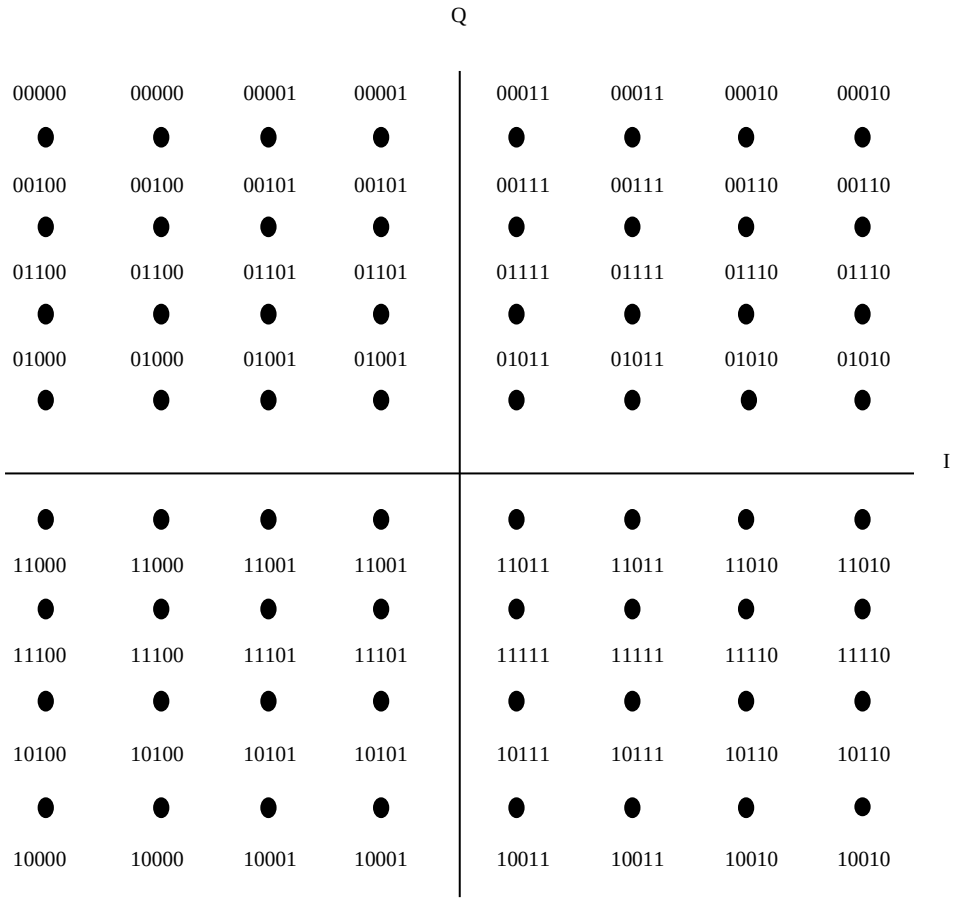

Figure 4: Constellation Diagram of 64-QAM

3. (c) Differential Phase Shift Keying Modulation and Demodulation

In the Differential phase shift keying (DPSK) modulated signal phase is shifted corresponding to the previous signal. Here any other reference signal is not considered. It does not need any oscillator for reference signal generation. DPSK modulation is similar to BPSK modulation. The transmitted signal is used as reference signal. In modulation data input is fed to the XNOR gate and the output is again feedback to the next input of XNOR gate. The output of the XNOR gate is mixed with carrier signal and gets a DPSK modulated signal. In the DPSK demodulator reversed bit phase and previous bit phase is compared, after the comparison the signal is enter into the low pass filter for getting the low frequency signal. Finally the signal is recovered by using shaper.

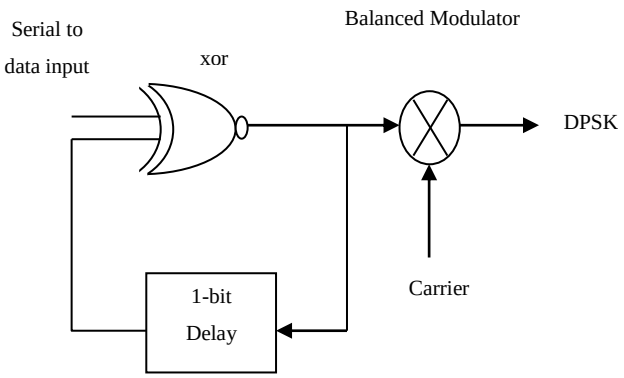

Figure 5: DPSK Modulator

Table 1. Comparison between different Modulation Techniques

Specifications	QPSK	DPSK	16-QAM	64-QAM
Number of bits per symbol	2	2	4	6
Symbol rate	1/2 of bit rate	1/2 of bit rate	1/4 of bit rate	1/6 of bit rate
KMOD	1/sqrt(2)	1/sqrt(2)	1/sqrt(10)	1/sqrt(42)

RECONFIGURATION APPROACH

Reconfiguration is mainly used for less hardware utilization and performs the actions at less power. Device reconfigurations are used for hardware reuse. It also offers flexibility and durability and low power. Two types of reconfigurable architecture named as fine grained and coarse grained reconfigurable architecture. Fine grained reconfigurable architecture is homogeneous in nature and worked at bit level. Likewise coarse grained reconfigurable architecture is heterogeneous in nature, worked at word level. Coarse grained architecture is easy to reconfigure and easy to design. But it is less flexible than the other reconfigurable architecture. Static reconfiguration and dynamic reconfiguration are the type of reconfiguration depends on processing methodology. Static reconfiguration changing the hardware, when the system stops the full process runs in the system. But dynamic reconfiguration is differing from static; it allows the system to changing the hardware configuration without stop any process in the system.

CLOCK GATING TECHNIQUE

In every digital circuits clock signal is one of the input to start and continue the process. Clock signal is mainly used for synchronization; it does not carry and kind of information. But it is the great sources of power dissipation because it operates in high frequency. To avoid the unnecessary clock activities in the gate module using clock gating technique. It reduces unwanted switching on the part of clock net. If one operation is running, at the time the main clock signal and the processing element clock signal is running, the remaining processing element clock signals are disabled. So it is easily accepted technique, to optimize the power. Architecture level clock gating and micro architecture level clock gating are types based on processing architecture.

5. (A) Architecture and Micro architecture Level clock gating

In a SoC design, the clock signal of the entire processor or a particular module is disabled until it receives the request from the power management unit or operating system. Likewise micro architecture level clock gating contains large architecture systems are built by various processing elements. These elements are mutually exclusive and not operated at same time.

5. (B) Gating Techniques

Different gating techniques are used to save the power in the digital circuits. The techniques are AND gate based, NOR gate based, MUX based, Latch based clock gating techniques. These techniques are most commonly used clock gating techniques to save the power and avoid the unwanted power dissipation in the circuits. This concept is applied into the reconfigurable architecture for designing the low power reconfigurable architecture.

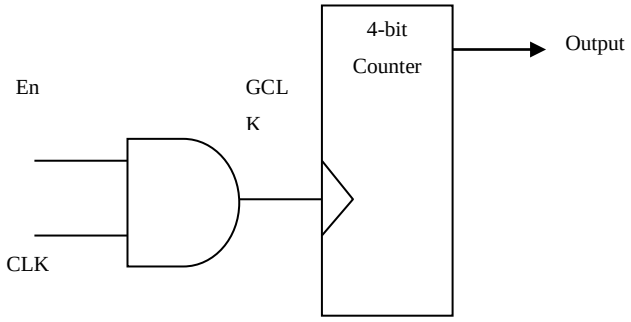

Figure. 6 AND based Clock Gating

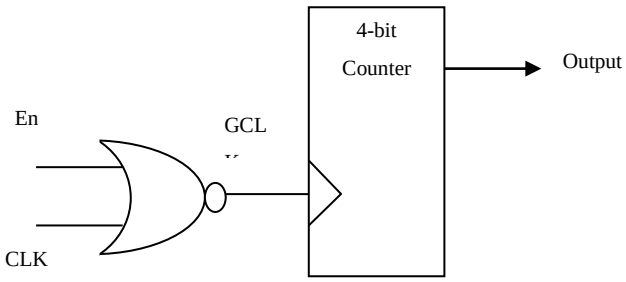

Figure 7: NOR based Clock Gating

The above figures shows the Basic logic circuit of AND and NOR based clock gating techniques. It is implemented into the reconfigurable logic for low power consumption.

SYSTEM ARCHITECTURE

In any communication system transmitter and receiver is the main processing element. In the transmitter block contains many component, one of the key component is modulator. Likewise in the receiver side demodulator is one of the key components. Without this two processing elements the communication does not happens. So need an efficient modulator and demodulator for secure and fast transmission. The process of modulator is to change the original signal is named as modulation, in the same way to recover the original

signal from the modulated signal is named as demodulation. Efficient modulation and demodulation provides fast and error free data transmission. Quadrature Amplitude modulation (QAM), DPSK is the recently used modulation techniques. QAM constellation is extended up to 256 and above. The enhancement of constellation point is transmitting more number of data rate within the same bit rate error. Different modulation techniques are available in the communication, but only one modulation is used at a time. Modulation characteristic is varying depends on the input signal. If suppose the input signal characteristics is suitable for DPSK, but the system using QAM means the modulation process is to be done, but efficiency of the system gets decreased.

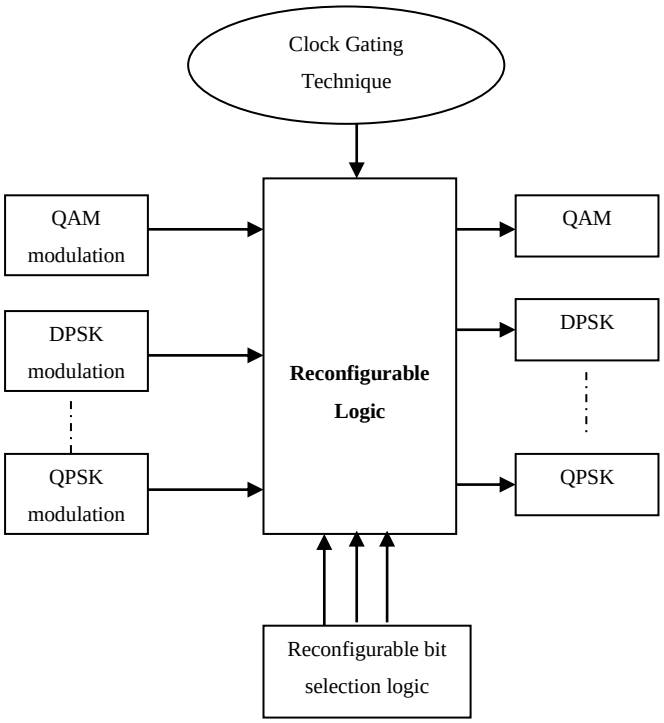

Figure 8: System Architecture for clock gating based Reconfiguration

To manage this type of situation by using reconfiguration. Reconfiguration is a technique to reduce the hardware utilization and power usage. Within a single processing element can implement more than one operation. The suitable and needed operation is selected by switching technique. Now the different modulation schemes are implemented into the same processing elements and reconfigure or select the correct modulation. One of the important issues in the reconfiguration is power dissipation. The designer also concentrates the power dissipation in the circuit. To avoid the power dissipation during reconfiguration is done by using clock gating technique.

Clock gating technique is used to avoid the unnecessary switching activities. If one process is going on the remaining process is still disabled. This type of process is implemented in the communication systems can improve the system performance and efficiency of the data rate. In figure. 8 show the architecture of clock gating based reconfigurable system. Reconfigurable bit selection logic is used to change the selection bit to get a required technique.

SIMULATION RESULTS AND ANALYSIS

A Low power clock gating based reconfigurable modulation technique is designed for wide range of applications. One of the important applications is MIMO- OFDM system. In general all communication system needs modulation and demodulation technique, today OFDM is the emerging field for high speed communication. The reconfigurable modulation technique is applied into an OFDM system and gets an efficient communication system. The design was done by using modelsim 6.3c and the analysis is taken from Xilinx simulation environment. The simulation results are shown in figure. 9 and 10. The result analysis of different modulation schemes are shown in table no. 3, 4 and 5. Table 6 shows the result of the OFDM transmitter with different modulation methods (QAM and QPSK). The above results are taken from Xilinx ISE spartan3 family with xc3s200 device.

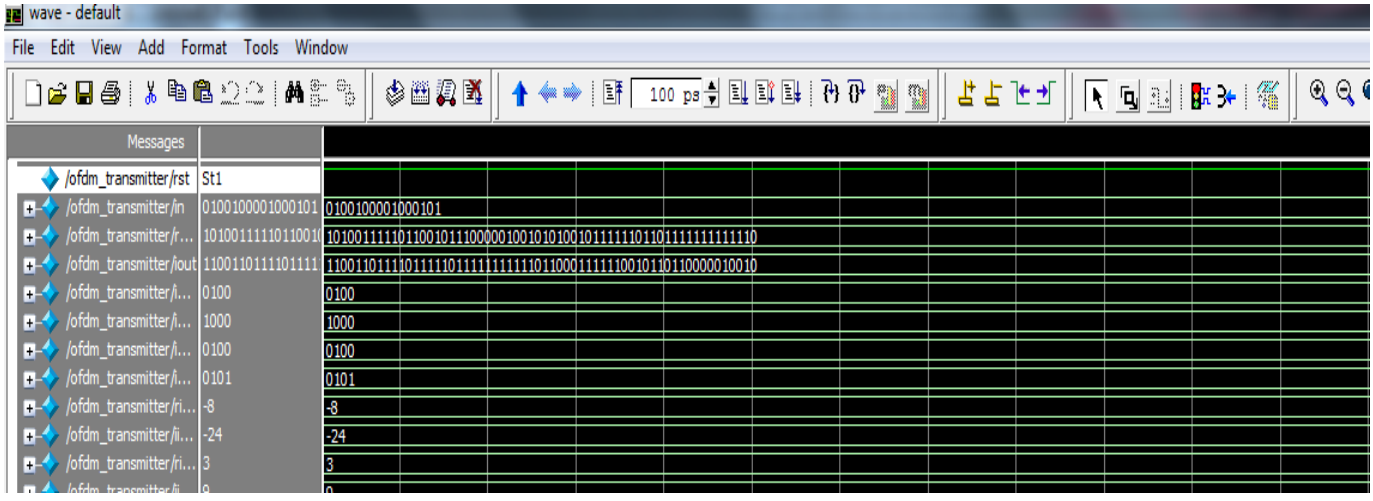

Figure 9: Simulation output for OFDM Transmitter

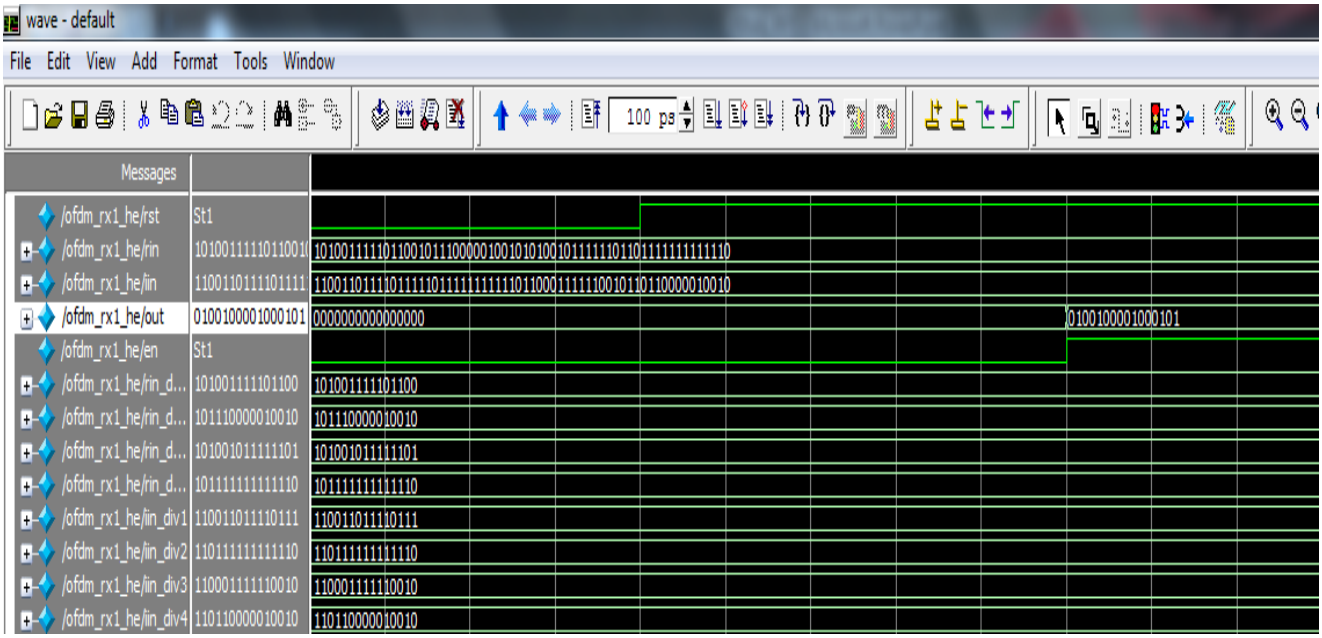

Figure 10: Simulation output for OFDM Receiver

Table 2: Comparison of different modulation schemes with different parameters

Modulation				
Parameters	**16-QAM**	**64-QAM**	**DPSK**	**QPSK**
LUT s	8	82	2	4
Occupied Slices	4	43	1	2
Delay (ns)	2.637ns	6.418ns	2.410ns	2.571ns
Power(w)	5.503w	7.879w	0.238w	18.645w

Table 3: Comparison of different Demodulation schemes with different parameters

Demodulation				
Parameters	**16-QAM**	**64-QAM**	**DPSK**	**QPSK**
LUTs	35	124	5	22
Occupied slices	19	63	3	12
Delay(ns)	9.185ns	14.441ns	3.193ns	6.443ns
Power(w)	0.038w	0.041w	0.217	0.048w

Table 4. Comparison of with and without clock gating

Power (Watts)		
Technique	**Modulation**	**Demodulation**
Reconfiguration with Clock Gating	1.749w	0.229w
Reconfiguration without Clock Gating	3.381w	0.241w

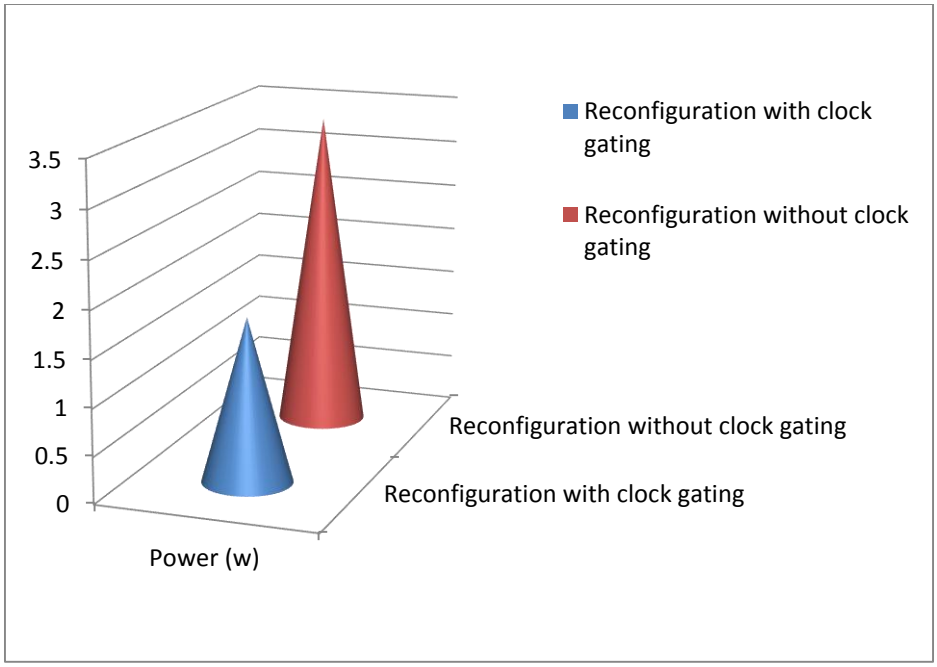

Figure 11: Comparison Graph of with and without clock gating

Table 5. Comparison of OFDM transmitter with different modulation

	LUTs	Slices	Delay(ns)	Power(w)
OFDM Transmitter with QAM modulation	294	61	23.28ns	9.501w
OFDM Transmitter with DPSK modulation	316	158	23.42ns	8.857w

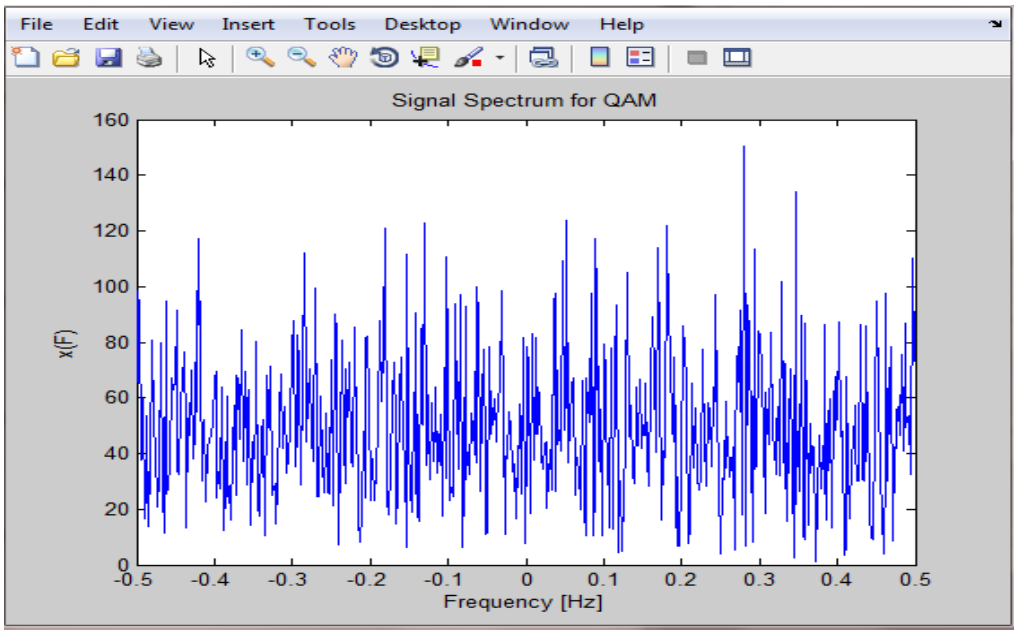

Figure 12: Signal Spectrum for QAM

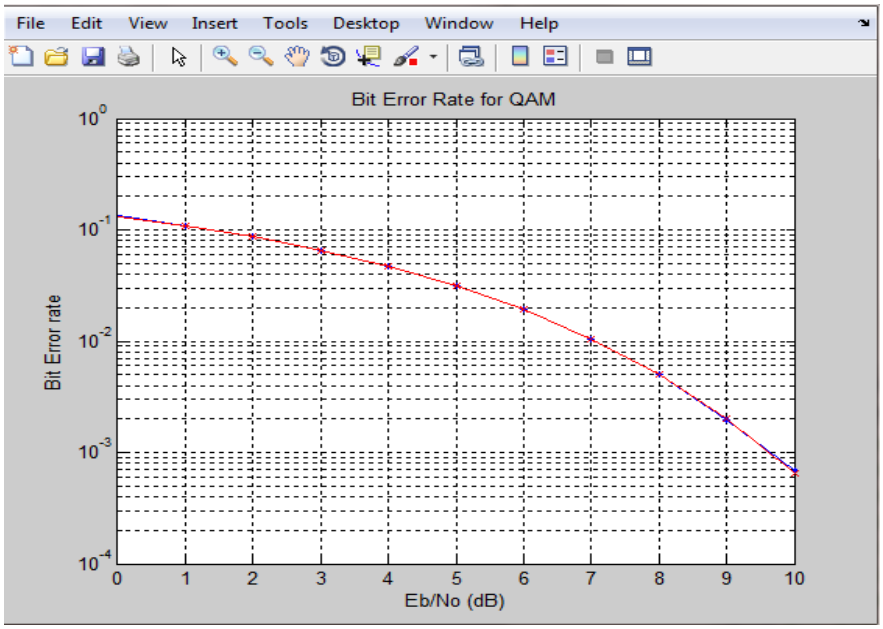

Figure 13: Bit Error Rate for QAM

The figure no.12 and 13 shows the Matlab results of signal spectrum and Bit error rate.

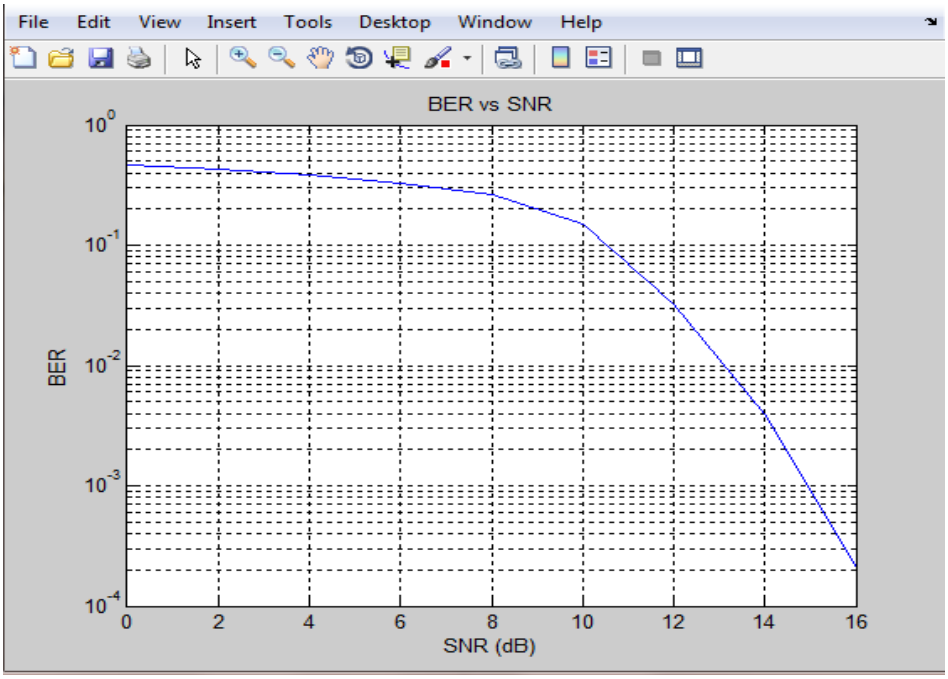

Figure 14: BER vs. SNR of OFDM System

CONCLUSION

In any communication system, modulation and demodulation is an important process. It decides the quality of the entire communication system. Different efficient modulation schemes are 16-QAM, 64-QAM, QPSK, DPSK etc. In this paper proposed a reconfigurable based modulation and demodulation schemes. Main advantage of the method is to use more one technique in the same system. Clock gating is combined with reconfiguration for low power consumption. It reduces the more power consumption during the reconfiguration logic. The proposed concept is greatly reduces the power consumption in the communication system. This concept is applied into the OFDM system in future. The analyzed reports are shown in the above tables.

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