

# High Performance and Area Efficient Correlation for IEEE 802.16 OFDM Using FPGA

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**Abstract:** OFDM is a multicarrier modulation technique which is used for both wired and wireless techniques. It is high speed data transfer use in LTE system, but on a Other side there is a problem of resource utilization and power consumption problem in this system. this paper consists of how adder circuit can be reduce area. also Improve performance parameter like BER. there are lots of techniques to improve bit error rate. Among all of them ICI self cancellation techniques used in this paper.

**Key words:** OFDM, IEEE 802.16, ICI Techniques

## I. INTRODUCTION

Due to rapid growth of wireless and multimedia communication, there is a tremendous need for high-speed data transmission. Telecommunication industry provides variety of services ranging from voice to multimedia data transmissions, in which speed ranges several Kbps to Mbps. Existing system, may fail to support high speed efficient data transmission. To improve the speed and maximum amount of data transmission Orthogonal Frequency Division Multiplexing (OFDM) system may be used. Orthogonal Frequency Division Multiplexing (OFDM) was first developed in the 1950's. OFDM is a method of encoding digital data on to a numerous carrier frequencies. It has developed into a very popular scheme for wideband digital communication systems. Many researchers shown OFDM can be used in applications such as audio broadcasting, digital television, power line networks, wireless networks and 4G mobile communications [1].

In this paper implementation of OFDM transmitter and receiver on Spartan 6 FPGA. This work involves designing of 512-point IFFT and 512-point FFT blocks using radix-2 algorithm. Using these IFFT and FFT blocks, OFDM transmitter and receiver blocks are constructed.

## II. OVERVIEW OF IEEE 802.16

Wi max is a communication for wirelessly delivering high speed Internet services to large geographic area. wi-max far surpasses the 30-meter. Wi-max can Provide at home or mobile Internet Access across whole cities or countries. Here is basic block diagram of OFDM systems

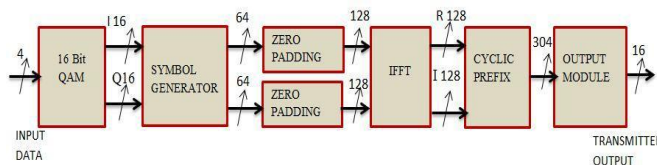


Fig.1.OFDM Transmitter Architecture

### A. OFDM Transmitter

QAM can be used as both analog and digital modulation Technique. It is mixer of ASK and PSK. The equation of 16 bit QAM carrier wave is given by

$$S(t) = x(t) \cdot \cos(2\pi ft) - y(t) \cdot \sin(2\pi ft) \quad (1)$$

Symbol generator is used to concatenate 16 bit bits of data 4 times to make 64 bit data. Main concept of zero padding is to fast calculation. IFFT is a spectrum of both amplitude and phase of each component in frequency domain to time domain signal. Cyclic prefix reference to proceeding of a symbol with a replication at the end. It serves as a guard interval which eliminates Inter-symbol interference from previous symbol.

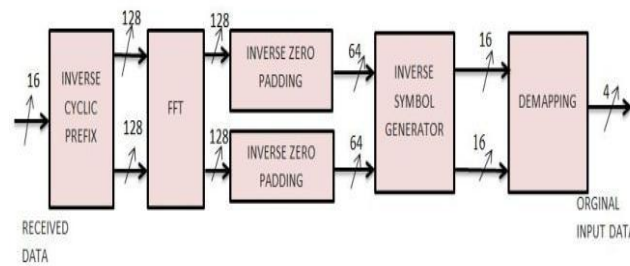


Fig.2. OFDM Receiver Architecture

### **B. OFDM Receiver**

Inverse CP is to remove predefined data bits that are used at transmitter. then FFT block is converted time domain to frequency domain. Inverse Zero padding are added at beginning and at each component of symbol generator output at the transmitter. Inverse Symbol generator converts 64 bit data to a 16 bit data. 16 bit data output of QAM is concatenated 4 times in order to make 64 bits at symbol generator of OFDM transmitter. finally De-mapping is used to regenerate original data from 16 bit output of inverse symbol generator block.

Specification of Wi-Max system [10]

- 16 QAM Modulation
- 16 QAM Demodulation
- 512 point FFT
- 512 point IFFT
- Convolution Encoder
- Viterbi Decoder
- Null sub carrier - 93
- Pilot sub carrier - 60
- Data sub carrier - 360

### **III OFDM 802.16 AREA RELATED PARAMETERS**

There are mainly three types of parameters used both Transmitter side and Receiver side.

Transmitter side parameters

- 16 QAM Modulations
- 512 point IFFT
- Convolution Encoder (m=1, n=2, k=7, code rate= 1/2)

Receiver side Parameters

- 16 QAM Demodulation
- 512 point FFT
- Viterbi Decoder

### **IV OFDM PERFORMANCE BASED TECHNIQUES**

There are lots of parameters through which we can improve the performance of OFDM system like BER, PAPR, CCDF, SNR etc.

This paper describes only one parameter among them which is BER. Major source of improved BER is

#### **A. ICI Introduction**

The basic Principle of OFDM is to divide the available bandwidth into 'N' narrow sub-channels at equidistant frequencies [2]. The sub-channels spectrally overlap each other but the subcarrier signals are still orthogonal. But one of the major weaknesses of OFDM system is ICI, which results from Doppler shift in the channel or by difference between the Transmitter and Receiver local oscillator frequencies. This ICI destroys the Orthogonality of the spectrum and signal can't be received without interference.

The problem can be solved by various techniques like Frequency domain Equalizer, Time domain Windowing, ICI self cancellation Scheme.

There are different techniques through which we can improve the ICI.

#### **1. Frequency Domain Equalizer:**

This technique is approach for reduction by ICI by suitable equalizer technique. But main limitation of this technique is that it is only used when flat fading channel is present. But in mobile communication it is a multi fading channel so it is not useful for this technique. This technique is very expensive and time consuming.

2. Time domain windowing:

It can only reduce the ICI caused by band limited channel which channel which is not the major source of ICI[2].The above method cannot address to it. Windowing is done frame by frame & hence it reduces the spectral efficiency to a large extent. Hence the method is not effective one.

3. ICI self cancellation techniques:

The main idea of this scheme is to modulate the input data Symbol onto a group of subcarriers with predefined coefficients such that the generated ICI signals within that group cancel each other, hence the name self- cancellation. This technique is used in both the flat and multi path fading. and it is a simple, less complex and effective.

**V. PROPOSED DESIGN FOR OFDM**

**A ICI Self Cancellation Modulation**

The main concept of this scheme is to modulate the input data symbol onto a group of sub carrier with predefined coefficient such that the generated ICI signal within that group cancel each other, hence the name self cancellation. The ICI self cancellation Scheme requires that the transmitted signal be constrained such that  $x(1) = -x(0), x(3) = -x(2), \dots \dots x(N-1) = -x(N-2)$ , then the Received signal on subcarrier  $k$  becomes[11]

$$Y'(K) = x(l) [S(l-k) - S(l+1-k)] + n_k \quad (1)$$

Similarly the received signal on subcarrier  $k$  becomes

$$Y'(K+1) = x(l)[S(l-k-1) - S(l-k)] + n_{k+1} \quad (2)$$

In such case, the ICI coefficient is denoted as

$$S'(l-k) = S(l-k) - S(l+1-k) \quad (3)$$

$$\text{It is found that } S'(l-k) \ll S(l-k) - S(l+1-K) \quad (4)$$

**B.ICI Cancellation Demodulation**

ICI modulation Introduces redundancy in the received signal since each pair of subcarrier transmit only one data symbol. This redundancy can be improving the system power performance while it surely decreases the bandwidth efficiency[11]. so due to this advantage this redundancy the received signal at the  $(K+1)^{th}$  subcarrier, where  $k$  is even, is subtracted from the  $k^{th}$  subcarrier. This can be expressed by

$$Y''(K) = Y'(K) - Y'(K+1) \quad (5)$$

The ICI co-efficient for the Received signal becomes

$$S''(l-k) = -S(l-k-1) + 2S(l-k) - S(l-k+1) \quad (6)$$

*B Area related parameter:*

In this OFDM system maximum number of adder are used which is design y a serial adder circuit.

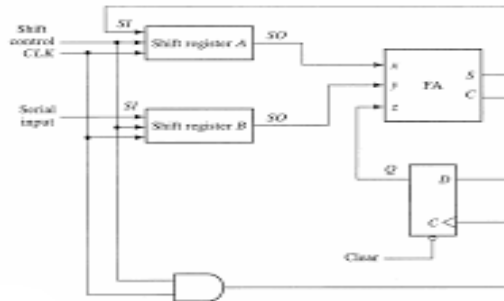


Fig 3: serial adder

Comparison of Multiplier and Adder circuit:

OFDM parameter	No of multiplier	No of Adder
16 Qam modulation	32	16
16 Qam Demodulation	32	16
512 IFFT	771	1542
512 FFT	771	1542

Table 1: Comparison Table

- Number of Complex Multiplier in FFT =  $N/2 * \log 2N$
- Number of adder in FFT =  $N \log 2N$
- Every QAM modulator required 2 multiplier and 1 adder
- Every QAM Demodulators required 2 multiplier 1 adder

**VI Result**

**A. Schematic View of OFDM Transmitter**

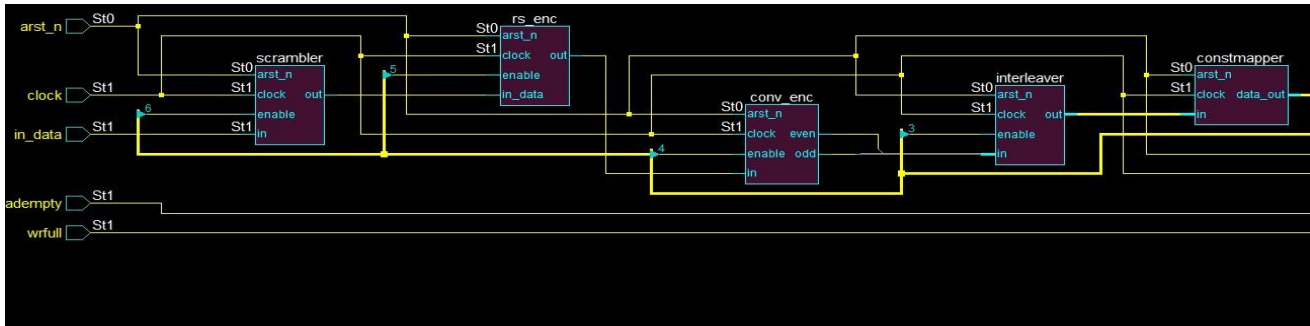


Figure 4 : Schematic View of OFDM Transmitter

**B. Schematic View of a OFDM Transmitter**

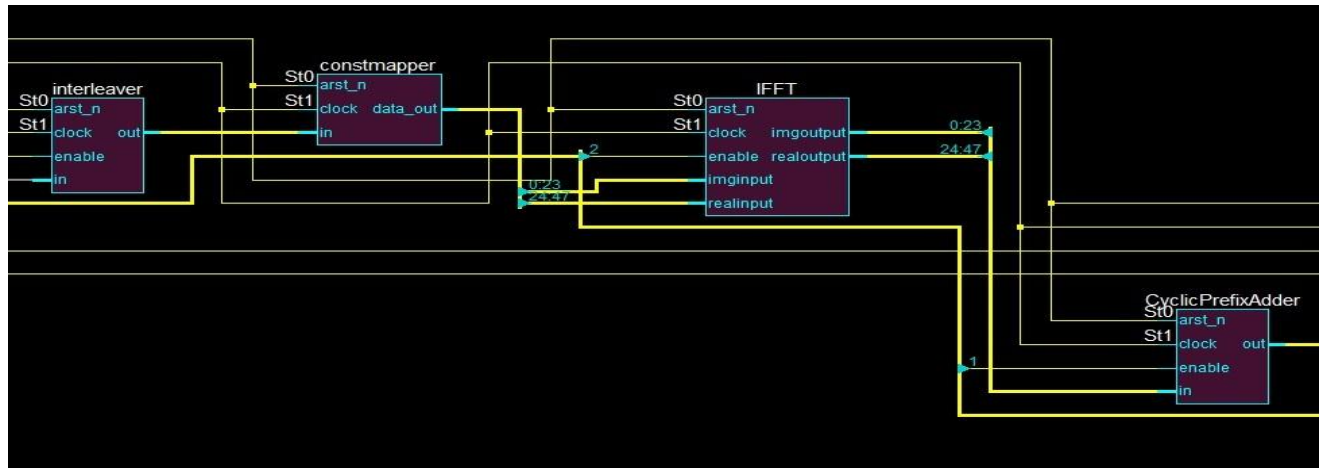


Figure 5: Schematic View of OFDM Transmitter

**C. Schematic View of a OFDM Receiver**

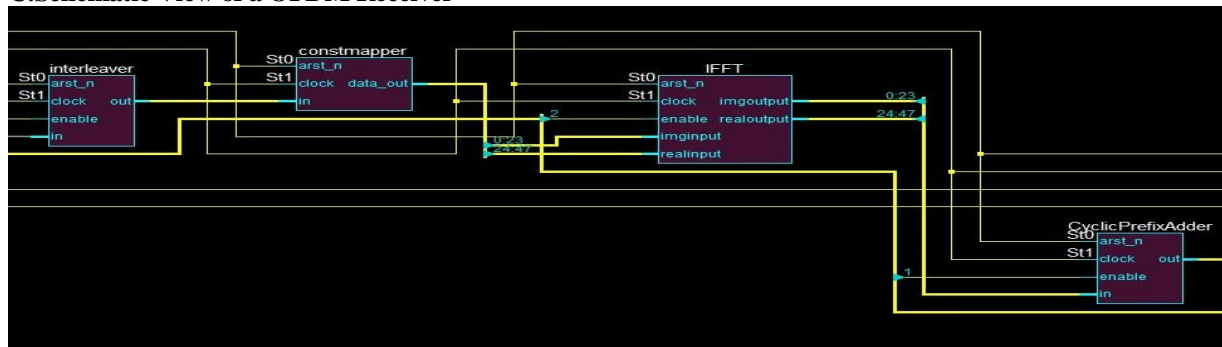
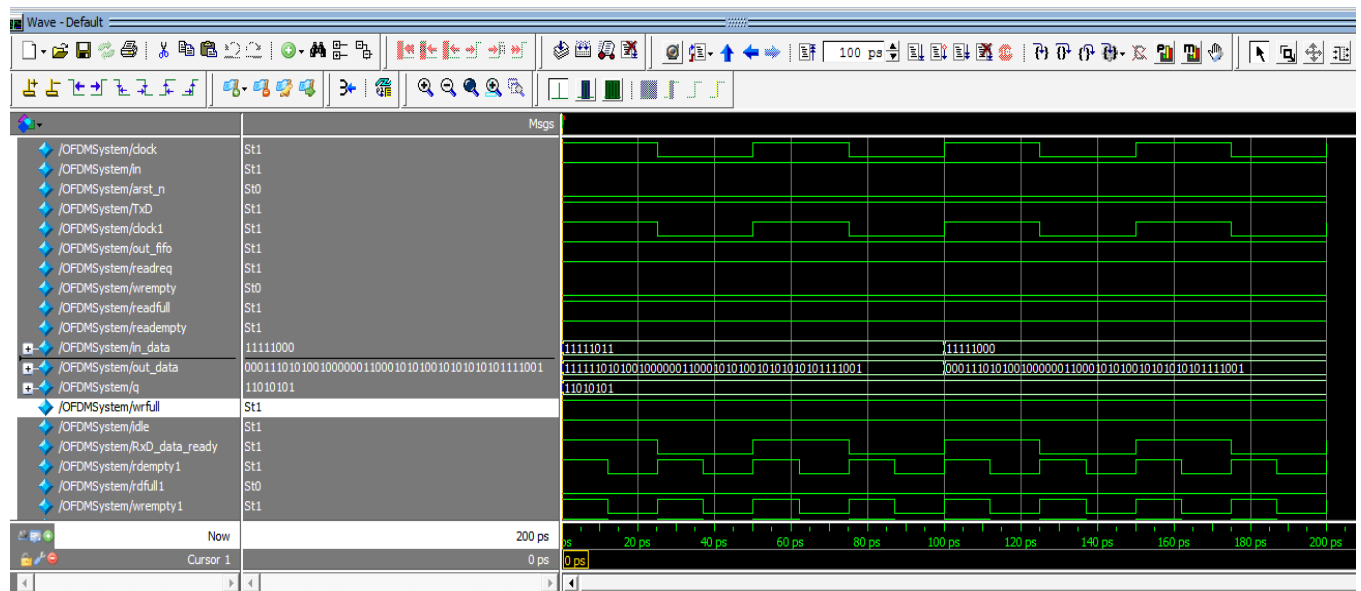


Figure 6: Schematic view of OFDM Receiver

**D. Wave form of a OFDM System:**



**Figure: 7 OFDM System Wave form**

**E Comparision Table :**

OFDM parameter	Previous Result	Current Result
Area	8145	1650
Bit Error Rate	0.4963	0.4917

**Table 2 : Comparison Table**

**VII. Conclusion**

This paper proposed an overview of widely used on OFDM system. In OFDM system a large number of multiplier are used both transmitter and receiver side in transmitter side there are three block which is Encoder,IFFT(Inverse Fast Fourier Transform) and QAM Modulation and same way at receiver side QAM Demodulation,FFT and Decoder is used. we can reduces number of multiplier using adder circuit and same time we can design Inter carrier Interface Self cancellation Techniques which can improves the performance parameters. In this way the whole paper considers both parameter area as well as performance for wi-max System.

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