Implementation and Verification of OFDM Using Simulink For 5G Applications

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Abstract- *This paper presents the OFDM (Orthogonal Frequency Division Multiplexing) block implementation for 5G wireless communication. OFDM is essential to overcome the effects of multipath fading allowing high speed wireless communications, to increase data rate of wireless medium with higher performance, to overcome the frequency selective fading, inter-symbol interference (ISI) effectively and to reduce latency compared to 4G system. The main idea behind the high spectral efficiency of OFDM is elimination of guard bands and use of the orthogonal subcarriers. VHDL is used for RTL description and FPGA synthesis tool is used for performance analysis of the proposed core. A MATLAB code is written for the verification of the individual sub-blocks of the OFDM design developed by*

Simulink. Individual blocks are defined in the code for the standard parameters which are recommended for wireless communication system. It helps to check the orthogonality and the data signal enhancement in individual processing.

Keywords- OFDM (Orthogonal Frequency Division Multiplexing), QAM (Quadrature Amplitude Modulation), IFFT (Inverse Fast Fourier Transform), FPGA (Field Programmable Gate Array), VHDL (VHSIC Hardware Descriptive Language), 5G (5th Generation)

I. INTRODUCTION

The requirement of high data rate for transmission has been increased due to the usage of technology in multiple applications in human life. This has led to the improvisation and advancements in the existing techniques used for communication. In today’s scenario we focus on quality of service as well as high data rate. As wireless communication technology is improvised, it has become necessary to focus on multi-user supporting technique like OFDM for data security, reliability and efficiency during data transmission. OFDM is a special type of multi-carrier transmission technique where a single data stream is transmitted over a number of lower rate subcarriers. It is a technique of transmission of data which provides a well-organized utilization of the spectrum by the concept of overlapping of carriers. It is a combination of modulation and multiplexing which is used in the transmission of information and data. In high speed digital communication, the OFDM technique is widely used to overcome frequency selective fading and inter-symbol interference. This technique also has many applications such as Digital Video Broadcasting (DVB), Digital Audio Broadcasting (DAB), HDTV, and also in many wireless IEEE standards of wireless communication, and many others. The use of multiple-input multiple-output (MIMO) signal processing with orthogonal frequency division multiplexing (OFDM) provides an enhanced high data rate for the next generation wireless communication systems.

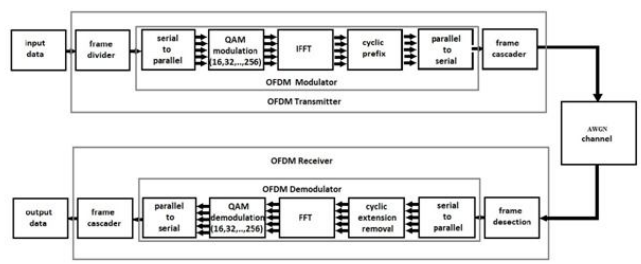

Figure 1: Block Diagram of OFDM

II. IMPLEMENTATION OF OFDM USING SIMULINK

Simulink, is a graphical programming tool used for modelling, simulating and analysing dynamic system. It is used in digital signal processing for multi domain simulation and model-based designs. It is the most preferred tool for integration and it supports system level design, code generation and verification of embedded systems.

A. SIMULINK MODEL FOR OFDM:

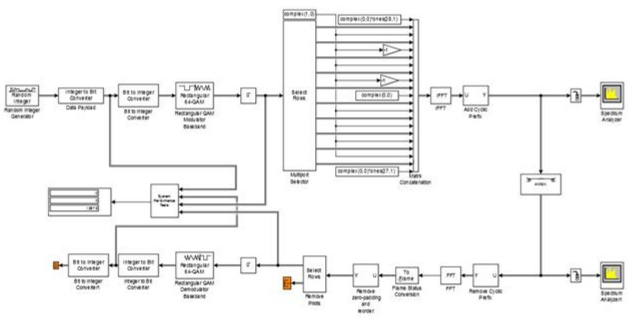

Figure 2: Design of OFDM model in Simulink

III. WORKING METHODOLOGY

A. OFDM TRANSMITTER:

Orthogonal frequency division multiplexing (OFDM) technology is used to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarrier. The high data rate range for transmission is achieved by using random input generator which is fed to the serial to parallel converter to make it compatible for the QAM block. QAM (Quadrature Amplitude Modulation) is a type of modulation which is used for modulating data signals for wireless communication. Here the 16 QAM modulates and enhances the signal, which is passed on to IFFT block which converts the frequency domain vector signals to time domain vector signals. To overcome the error in signal generated so far, we need to add cyclic prefix which adds an extra bit to each sub-carrier. The modified signal is transmitted through the AWGN channel, where white Gaussian noise is added to signal to overcome data losses.

B. OFDM RECIEVER:

At the receiver end initially, the extra added bits of cyclic prefix are removed as the added bits will lead to data manipulation and the signal is fed to the FFT block, where time domain vector signals are converted back to frequency domain vector signals which makes it in a compatible form to the demodulator. The QAM demodulator demodulates the signal to remove the added error and noise in it. The demodulated signal which is in parallel form is converted back to serial form using series to parallel converter. Finally, the signal which is processed over the transmitter and receiver of OFDM is effectively received which is suitable for wireless communication of 5G network.

IV. RESULTS OBTAINED IN SIMULINK:

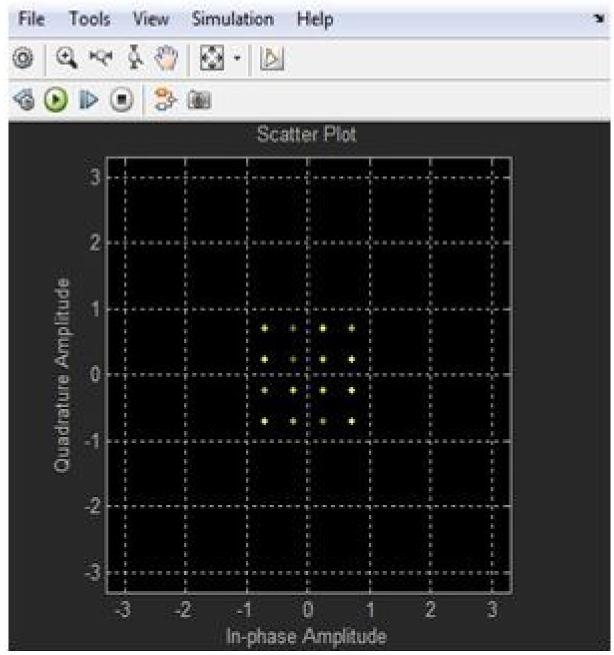

Figure 3: 16 QAM scatter plot

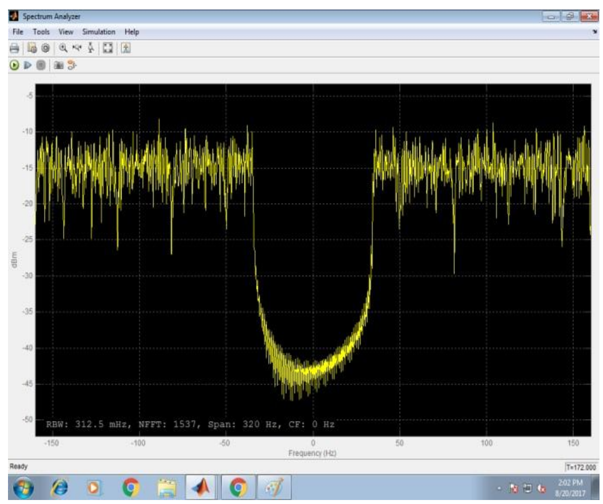

Figure 4: Double sided power spectral density

V. RESULTS OBTAINED FROM MATLAB CODE:

A. OFDM TRANSMITTER:

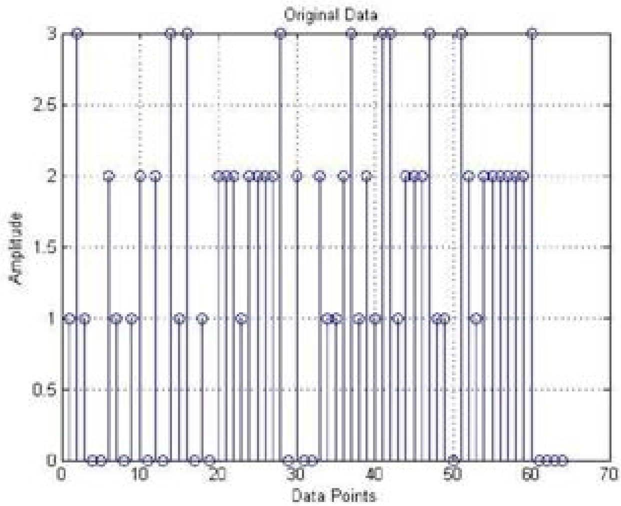

Figure 5: Input data

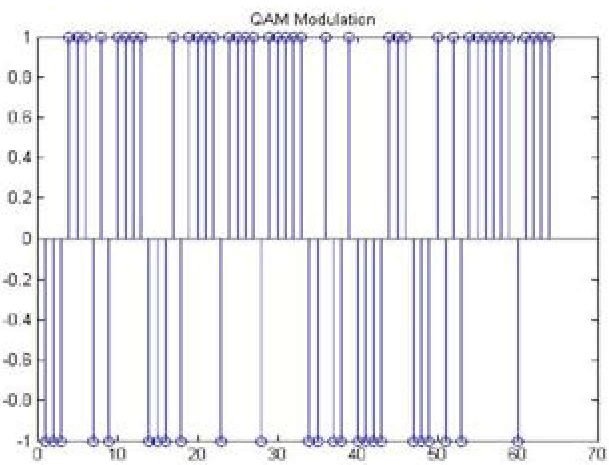

Figure 6: QAM output

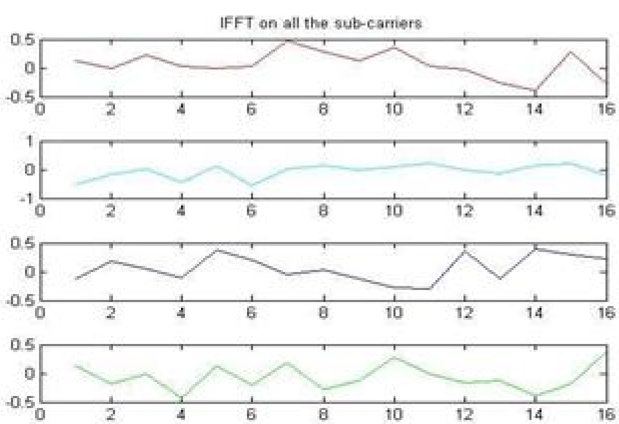

Figure 7: IFFT waveforms of individual sub-carriers

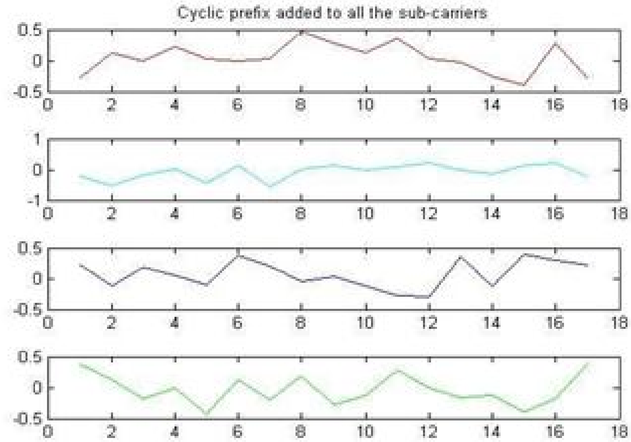

Figure 8: Addition of cyclic prefix

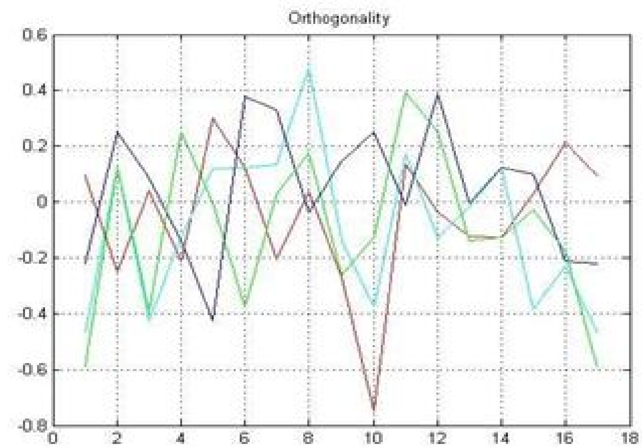

Figure 9: Orthogonally

B. AWGN CHANNEL:

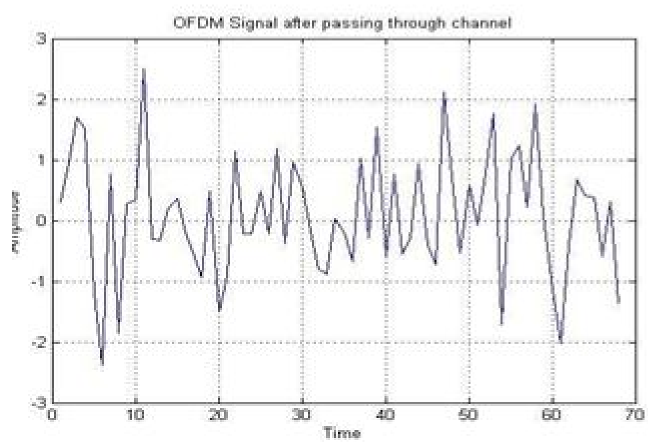

Figure 10: Output across AWGN channel

C. OFDM RECIEVER:

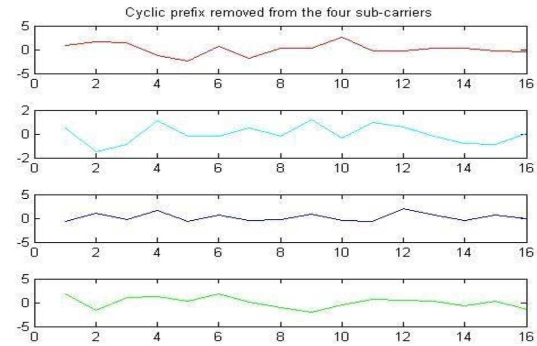

Figure 11: Removal of cyclic prefix

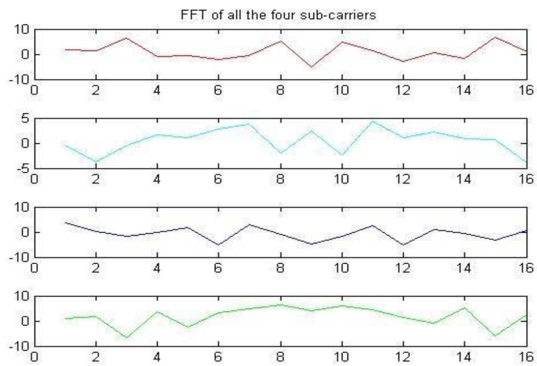

Figure 12: FFT of individual sub-carriers

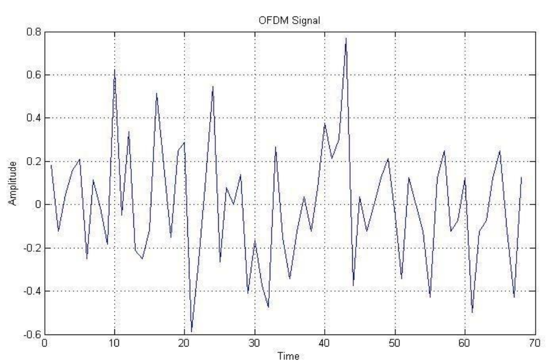

Figure 13: Final OFDM signal output

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