An OFDM Transmitter and Receiver using NI USRP with LabVIEW

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Abstract- **Orthogonal Frequency Division Multiplexing (OFDM) is a multi- carrier modulation technique which divides the available spectrum into many carriers. OFDM uses the spectrum efficiently compared to FDMA by spacing the channels much closer together and making all carriers orthogonal to one another to prevent interference between the closely spaced carriers. In this project we are implementing an OFDM transmitter and receiver using LabVIEW. Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a system-design platform and development environment for a visual programming language from National Instrument. The main aim of this project is to design a baseband Orthogonal Frequency Division Multiplexing transmitter and receiver including 8 point Fast Fourier Transform (FFT), 8 point Inverse Fast Fourier Transform (IFFT), core processor, QPSK modulator, demodulator, serial to parallel convertor and parallel to serial converter.**

Keywords- Orthogonal Frequency Division Multiplexing (OFDM), Laboratory Virtual Instruments Engineering Workbench (LabVIEW), Fast Fourier Transform (FFT),Inverse Fast Fourier Transform (IFFT),Inter Symbol Interference(ISI), Peak to Average Power Ratio (PARP).

I. INTRODUCTION

1.1 Overview

In modulations, information is mapped on to changes in frequency, phase or amplitude (or a combination of them) of a carrier signal. This deals with allocation/accommodation of users in a given bandwidth (i.e. it deals with allocation of available resource).OFDM is a form of multicarrier modulation. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another.

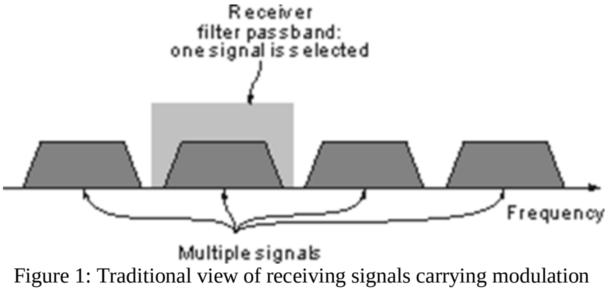

Figure 1: Traditional view of receiving signals carrying modulation

Figure 1 shows the traditional view of receiving signals carrying modulation. This acts as a bank of demodulators, translating each carrier down to DC. The resulting signal is integrated over the symbol period to regenerate the data from that carrier. The same demodulator also demodulates the other carriers.

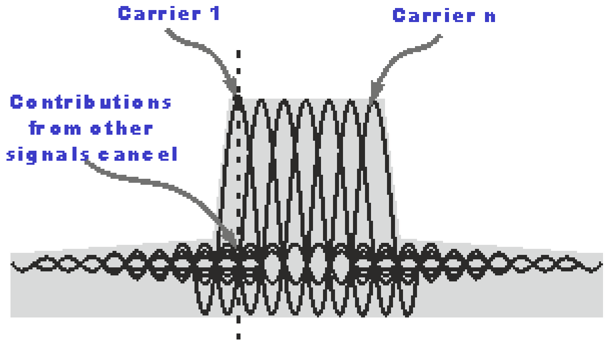

Figure 2: OFDM Spectrum

Figure 2 explains about the OFDM spectrum. One requirement of the OFDM transmitting and receiving systems is that they must be linear. Any non-linearity will cause interference between the carriers as a result of inter-modulation distortion. This will introduce unwanted signals that would cause interference and impair the Orthogonality of the transmission. In terms of the equipment to be used the high peak to average ratio of multi-carrier systems such as OFDM requires the RF final amplifier on the output of the transmitter to be able to handle the peaks whilst the average power is much lower and this leads to inefficiency. In some systems the peaks are limited. Although this introduces distortion that results in a higher level of data errors, the system can rely on the error correction to remove them.

1.2 Objectives

OFDM is very effective for communication over channels with frequency selective fading (different frequency components of the signal experience different fading). It is very difficult to handle frequency selective fading in the receiver, in which case, the design of the receiver is hugely complex. Instead of trying to mitigate frequency selective fading as a whole (which occurs when a huge bandwidth is allocated for the data transmission over a frequency selective fading channel), OFDM mitigates the problem by converting the entire frequency selective fading channel into small flat fading channels (as seen by the individual subcarriers.

II LITERATURE SURVEY

"OFDM Based Multi- node transmission in the presence of phase noises for small cell backhaul"[1]. In this paper, the phase noise (PN) effect on orthogonal frequency division multiplexing based multi-node transmission for small cell backhaul is studied. In this paper, a PN compensation scheme for multi-node transmission is proposed, which can effectively mitigate the effect of the multiple PNs. Phase – Noise is arising from the short term phase fluctuations that occur in a signal.

"High diversity transceiver for low power differential encoded OFDM system"[8]. In this work, we investigate differentially encoded blind transceiver design in low signal-to-noise ratio (SNR) regimes for orthogonal frequency-division multiplexing (OFDM) signalling.

"Image Transmission over OFDM System using Trigonometric Transforms"[11].This paper proposes a system for transmission of image through OFDM system. To improve performance of system in terms of peak to average power ratio (PAPR) and Peak to signal noise ratio (PSNR), Trigonometric Transforms such as DCT and DST are used.

"Evaluating the performance of OFDM transceiver for image transfer using PSK and QAM modulation schemes"[4]. In this paper, we investigate the effects of two different modulation schemes for image transmission using an OFDM (Orthogonal Frequency Division Multiplexing) transceiver.

III METHODOLOGY

OFDM TRANSMITTER

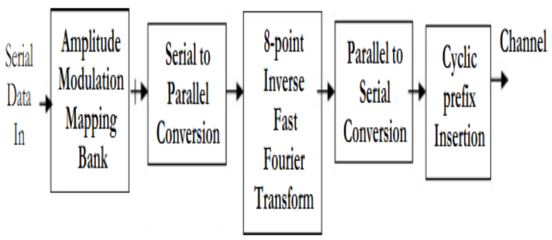

Figure 3: OFDM Transmitter

Figure 3 shows the simplified block diagram of OFDM transmitter. The generation of OFDM signal started from amplitude modulation mapping bank. The serial input data is mapped to appropriate symbol to represent the data bits. These symbols are in serial and need to convert into parallel format since IFFT module requires parallel input to process data. The serial to parallel module does the conversion. These parallel symbols are transformed from frequency domain into time domain using IFFT module. These signals are converted into serial format and add acyclic prefix to data frame before being transmitted.

OFDM RECEIVER

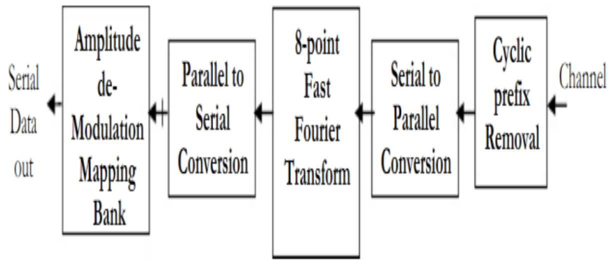

Figure 4: OFDM Receiver

Figure 4 shows the basic block diagram for receiver module. There are five modules in the receiver block and as mention before, cyclic prefix removal will not be included into the design. The received data is in serial format, thus, since FFT input is in parallel, a parallel to serial converter. The conversion is required since the serial data need to be transmitted. Finally the serial output is module which use to converts from serial to parallel is required .Output from FFT is converted back to serial format through demodulated using de-mapping module to get the transmitted data.

3.1 FLOW CHART

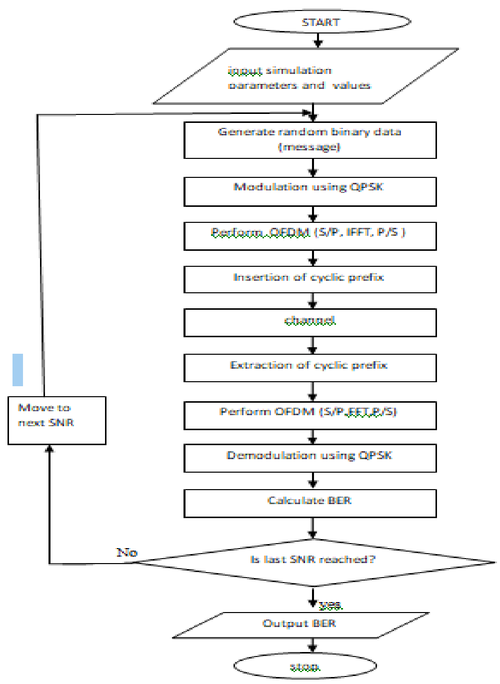

Figure 5: Flow chart for OFDM transmitter and receiver.

3.2 ADVANTAGES

OFDM has been used in many high data rate wireless systems because of the many advantages it provides. Immunity to selective fading, Resilience to interference, Spectrum efficiency, Resilient to ISI, Resilient to narrow-band effects, Simpler channel equalization.

3.3 DISADVANTAGES

High peak to average power ratio, another disadvantage of OFDM is that is sensitive to carrier frequency offset and drift. Single carrier systems are less sensitive.

3.4 APPLICATIONS

OFDM is a promising technology and provide edge over WDM systems in terms of bandwidth efficiency and channel robustness. Some of the applications are Digital television and high definition TV, Local area networks using wireless media, Wireless access or WiMax, Advanced digital subscribers loop G.992.1, Long term evolution, Wireless ATM transmission system

3.5 HARDWARE SPECIFICATION

- Universal Software Radio Peripheral (USRP 2901)- 70MHz-6GHz

- Vertical antenna (900 -1800MHz)

3.6 SOFTWARE SPECIFICATION

- Lab VIEW (Laboratory Virtual Instruments Workbench)

IV RESULTS

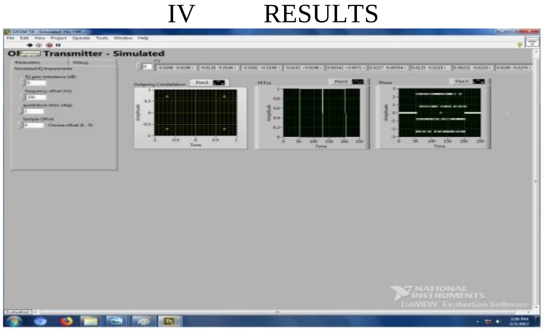

Figure 6: Transmitter (0 Sample offset)

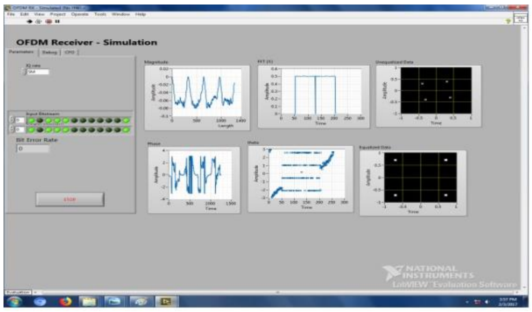

Figure 7: Receiver (0 Sample offset)

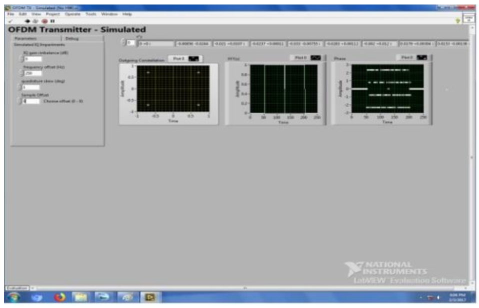

Figure 8: Transmitter (9 sample offset)

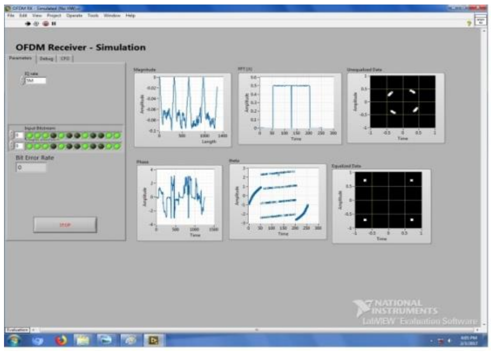

Figure 9: Receiver (9 sample offset)

V CONCLUSION

In this paper we bring out an OFDM system with carrier frequency offset estimation to provide the synchronization between the successive OFDM symbols to reduce inter symbol interference using NI USRP module. We also compare the generation of OFDM symbols with respect to time and frequency offset while transmitting 5 million symbols.

VI FUTURE EXTENSION

In this project we are using OFDM system. The proposed OFDM system is working well for AWGN and Rayleigh channels, it can be extended for Rician fading channels. These methods can be employed in MIMO OFDM, which is currently used in IEEE WLAN 802.11n standard for higher data rates. The ICI cancellation can be employed with proposed methods.

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