Implementation of OFDM and other Multicarrier Modulations on SDR

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Abstract—OFDM has developed into a popular scheme for wideband digital communication, used in different applications such as digital television and audio broadcasting, Internet access, wireless networks and 4G mobile communications etc. SDR has become a universal platform for implementing any type of waveform in software. During the transmission, some data is lost due to transmission impairments. The loss in the signal can be detected at the receiver side. We use Universal Software Radio Peripheral (NI USRP-2920) as SDR to transmit and receive the OFDM signal. MATLAB and LABVIEW software are used to design the OFDM to encode the digital data into multicarrier frequencies. Computer was used to generate and processing of the signal with the help of MATLAB and LABVIEW software. We implemented SLM and Clipping & Filtering technique to reduce PAPR in OFDM of the transmitted signal using SDR.

I. INTRODUCTION

To communicate at long distances and to transmit our information we use some modulation techniques, hardware (modulator circuit, signal converter, transmitter, receiver and antennas etc). There are many real-time problems that occur during the transmission of the signal due to transmission impairments.

OFDM is a multi-carrier modulation technique that is extremely popular in new wireless networks of IEEE standard, digital TV, audio broadcasting and 4G mobile communications. The main advantage of OFDM over single-carrier scheme is its ability to deal with severe channel conditions without the requirement of difficult equalization filters. By eliminating the ISI and improving SNR the long distance communication quality is improved [1]. Conventional designs of OFDM based cognitive radio systems mainly focus on the system throughput. Since nowadays the energy efficiency of wireless systems becomes more and more important. In [2], authors discuss the energy optimization of OFDM based cognitive radio systems using water filling aided search method. There are numerous types of broadband wireless air interfaces and its variants including single carriers, orthogonal frequency division Multiple Access (OFDMA). Others are Wideband Code Division Multiple Access (WCDMA) a cellular 3G technology and Universal Mobile Telecommunications System (UMTS) also called cellular 3G. Orthogonal Frequency Division Multiplexing (OFDM) has become a popular technique for transmission of signals over radio waves [3].

In modulations, information is mapped on the changes in frequency, amplitude, phase of a carrier signal. OFDM is a combination of Multiplexing and Modulation. In [4], authors discussed the BER analysis of clipping technique of OFDM-FDMA signals. Multiplexing deals with allocation of available resource or bandwidth. OFDM is a multicarrier modulation technique, which provides several carriers, within the allocated bandwidth, to transmit the information from source to destination. Every carrier may use one of the numerous existing digital modulation techniques for example BPSK, QPSK, QAM etc. In many latest and budding broadband wireless and wire-line communication systems OFDM is widely adopted because of its capacity to transmit a high-speed data stream using multiple spectral-overlapped lower-speed subcarriers. Orthogonal frequency division multiplexing (OFDM) signals have a generic problem of high peak to average power ratio (PAPR) which is defined as the ratio of the peak power to the average power of the OFDM signal. The drawback of the high PAPR is that the dynamic range of the power amplifier and digital-to-analog converter during the transmission and reception of the signal is higher. As a result, the total cost of the transceiver increases, with reduced efficiency [5]. Software Defined Radio system is a special type of very flexible radio in which operations and components, originally implemented using dedicated hardware are developed in terms of software modules [6]. The USRP is an SDR RF hardware design, that is used to build and test the digital communication systems. The USRP is generally used by researchers as a wireless prototype platform and for teaching purpose. National Instruments has further developed graphical programming software called LABVIEW, which is used to design the system platform [7]. SDR employs a reconfigurable hardware that may be programmed over-the-air or software to function under different Wireless standards [8]. We focus principally on OFDM transceiver styles due to their bandwidth scalability and their popularity in many next generation wireless air interfaces. These concepts are critical for the adoption of software defined radio in 21st century broadband wireless networks. [9]. Using the SDR (software
defines radio) we transmit and receive that that signals. SDR that we use is NI USRP-2920.

II. SDR (SOFTWARE DEFINE RADIO)

Now a day’s SDR is one of the most working signals processing method at the transceiver. It is used to create the variety of wave forms like frequency modulated, phase modulated and used to perform various functions and we can also switch between different ranges of frequencies [6]. Using the SDR, it makes easier to implement all these abilities. We can also use the SDR as a filter, modulator, mixer and demodulator etc. With the help of SDR the production cost of electronics components is reduced. The parameters of SDR can be modified and reconfigured according to requirement suited to different applications because it is a software based platform. A Software Defined Radio (SDR) is a radio which can tune to any frequency band, transmit and receive different modulations and different physical parameters across a large frequency spectrum by using a programmable hardware and powerful software [10].

III. USRP-2920

We use USRP (Universal Software Radio Peripheral) as a SDR and the tunable radio frequency range of USRP transceiver is 50 MHz to 2.2 GHz. There are many advantages of USRP over commercial and dedicated SDR hardware like low cost, easy programming easy hardware replacement etc. It is used as the measuring instrument and connected with computer via Gigabit Ethernet connectivity cable. The drivers and software of USRP allows different kind of programming environment such as MATLAB, C and C++ etc. Signal processing and syntheses are done in USRP via NI LABVIEW to develop and explore algorithms. To simulate or process the live signal NI modulation toolkit and LABVIEW add-ons are used.

![Fig.1. NI USRP-2920 module](image)

We are going to implement on OFDM and other Multicarrier Modulations schemes by using LABVIEW software and NI USRP-2920 hardware and software kit. We will design the whole the system including transmitter and receiver in LABVIEW software and transmit and receive the signal using the NI USRP-2920 hardware. We transmit the signal using RX1 & TX1 terminal of the USRP and receive at the RX2 terminal of the USRP. Using this technique we will try to reduce PAPR in OFDM and also monitor the spectrum of the received signal.

IV. ALGORITHM IMPLEMENTED AND RESULTS

During the designing of the system, we design of the OFDM system in LabVIEW with the help of different communication blocks and signal processing blocks and MATLAB coding. Some blocks are available in the LabVIEW software for the use but, some were designed according to the need or requirement of the system in MATLAB. The system was designed along with the transmitter and receiver of the OFDM system. Figure shows the diagram of the transmitter of the OFDM system:

![Fig.2. Transmitter of OFDM system with USRP blocks](image)

<table>
<thead>
<tr>
<th>Parameter at Transmitter</th>
<th>Value used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>5MHz</td>
</tr>
<tr>
<td>Carrier frequency</td>
<td>910MHz</td>
</tr>
<tr>
<td>Frame size</td>
<td>96 bit</td>
</tr>
<tr>
<td>Total no. of frame</td>
<td>100</td>
</tr>
<tr>
<td>Subcarriers</td>
<td>64</td>
</tr>
<tr>
<td>Gain at transmitter</td>
<td>9db</td>
</tr>
<tr>
<td>Transmission of signal</td>
<td>TX1 of USRP</td>
</tr>
</tbody>
</table>

In the front panel diagram of the OFDM system the outgoing constellation graph of the 16 QAM is shown along with which the FFT and the phase of the signal are shown. The waveform graph shows the generated OFDM signal. In the Tab control the different parameters of the transmitter are shown. Fig. 3 shows the front panel of the transmitter. Similarly, the block diagram of the receiver could be draw according to the system requirements. Fig. 4 shows the block diagram of the OFDM receiver.

<table>
<thead>
<tr>
<th>Parameter at Receiver</th>
<th>Value used</th>
</tr>
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<tbody>
<tr>
<td>Bandwidth</td>
<td>5MHz</td>
</tr>
<tr>
<td>Carrier frequency</td>
<td>910MHz</td>
</tr>
<tr>
<td>Gain</td>
<td>3db</td>
</tr>
<tr>
<td>Reception of signal</td>
<td>RX2 of USRP</td>
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</table>
PAPR is one of the major problems in the OFDM communication system. So we use different techniques to reduce the PAPR in the OFDM system and compare them. First we find the PAPR of the normal OFDM signal then we apply the SLM technique to reduce the PAPR. After PAPR reduction we find the efficiency of the SLM to reduce the PAPR. Fig. 6 shows the PAPR reduction in OFDM signal.

After the SLM technique we apply the CLIPPED and FILTER technique to reduce the PAPR in OFDM and find the efficiency it. Fig. 7 shows PAPR reduction graph by clipped and filter technique in OFDM.

After implementation of both PAPR reduction techniques, we compare efficiency of both techniques. The efficiency of the clipped and filter technique is more than the SLM technique. So, according to the results the clipped and filter technique reduces more PAPR than SLM technique. So we take the clipped and filter signal for the transmission.

**TABLE III. COMPARISON OF DIFFERENT PAPR REDUCTION TECHNIQUE**

<table>
<thead>
<tr>
<th>Technique used</th>
<th>PAPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal OFDM</td>
<td>17.2928</td>
</tr>
<tr>
<td>SLM OFDM implemented</td>
<td>14.7824</td>
</tr>
<tr>
<td>Normal OFDM</td>
<td>15.4856</td>
</tr>
<tr>
<td>Clipping and Filtering implemented</td>
<td>2.24966</td>
</tr>
</tbody>
</table>
V. CONCLUSION AND FUTURE SCOPE

With the help of SDR kit, the implementation of OFDM system becomes very simple because it replaces all hardware that is used in the traditional communication system with software. The main focus was to implement the OFDM system in LABVIEW and the PAPR reduction in OFDM system through NI USRP-2920. We use the combination of the MATLAB and LABVIEW to implement OFDM through USRP-2920. From the results, the implementation of OFDM system in SDR is easy with the help of LABVIEW software and the MATLAB software. PAPR reduction in OFDM system was implemented. We use SLM and Clipping and Filtering methods to reduce the PAPR in OFDM system. In the SLM method the PAPR reduction efficiency is less than the Clipping and Filtering method. So we use the Clipping and Filtering OFDM signal for the transmission.

SDR has a lot of potential for implementing the emerging wireless applications. A lot of research is being done on the SDR in different applications to make it available for commercial use.

References


