OFDMA Simulations using GNU Radio

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***Abstract* — Orthogonal frequency division multiplexing (OFDM) is a very relevant and widely adapted digital modulation technique today. With applications in digital broadcasting, wireless networks advanced 4G networks and power line networks; it will be the prevalent modulation technique in the near future. The benefits range from increased data rate to better spectral efficiency, owing to its overlapped multicarrier nature.**

OFDMA has been implemented on GNU Radio. It provides a basis for advanced physical layer simulations in the areas like IEEE 802.16 Wireless MAN Standard (WiMAX) and IEEE 802.22 Wireless Regional Area Networks (WRAN).

Simulations have been conducted in areas like; wideband communication and TVWS scenario.

Keywords-OFDM; WRAN; WiMAX; GNU Radio;

I. INTRODUCTION

OFDM is an overlapped orthogonal subcarrier frequency division multiplexing scheme. Data is split into a large number of parallel data streams, which are then modulated using conventional methods like PSK or QAM at a lower rate but transmitted over a large number of subcarriers. [1]The main advantage of OFDM apart from the increased data rate and its inherent multiple user support are its resilience towards drastic channel conditions like multipath effects and narrowband interference.

Higher spectral utilization makes OFDM a suitable candidate for future data transmission schemes like LTE, Power line communications, WiMAX and WRAN.

II. WRAN

IEEE 802.22 WRAN is the first set of framework for a practical cognitive radio system. It specifies a 'frequency agile' radio operating in unused television channel in UHF band. The unique transmission properties of UHF band make it resilient towards losses due to buildings and enables transmissions over a range of kilometers. The typical support range for a WRAN system is 30 km. According to IEEE 802.22 standard, in the physical layer, the use of rate half binary convolution codes is mandatory with option for convolution turbo code, shortened block turbo code and LDPC. In applications demanding higher data rates puncturing can be used to achieve higher code rates as well. [2]OFDM symbols are created using 2048 FFT on 6 MHz bandwidth, which consist of 1440 data subcarriers, 240 pilot carriers and 368 guards and DC subcarriers. The cyclic prefix length can be ¼, 1/8, 1/16 and 1/32 of the symbol duration. Individual subcarriers are modulated using digital modulation schemes like QPSK, 16-QAM, 64-QAM.

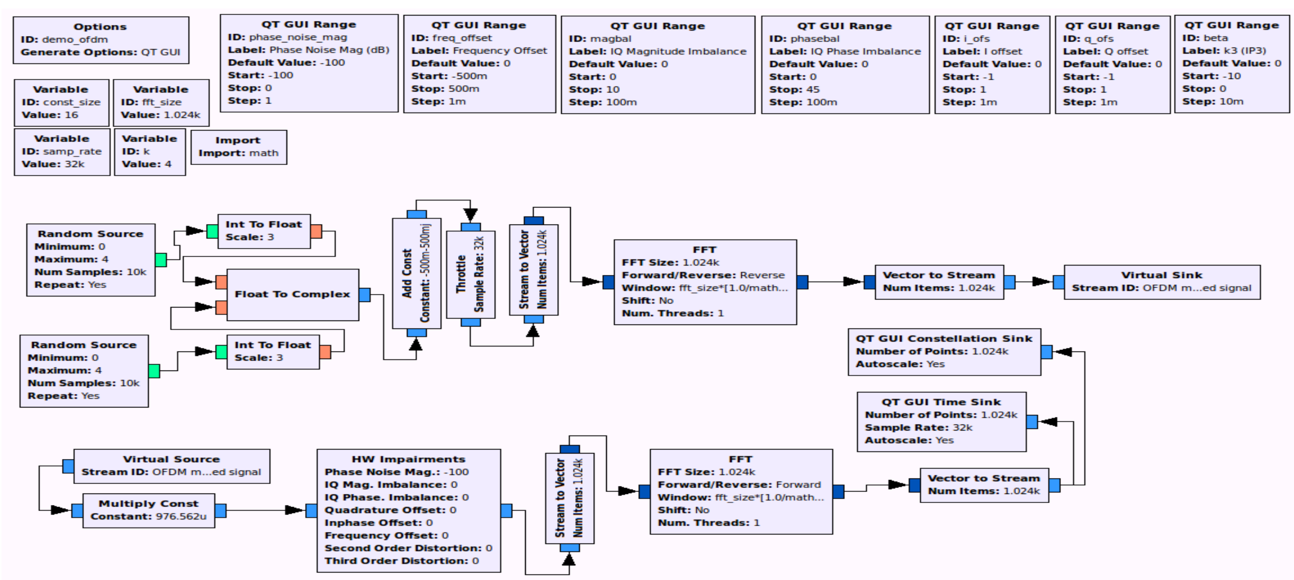

Figure 1. OFDM hardware impairement flowgraph

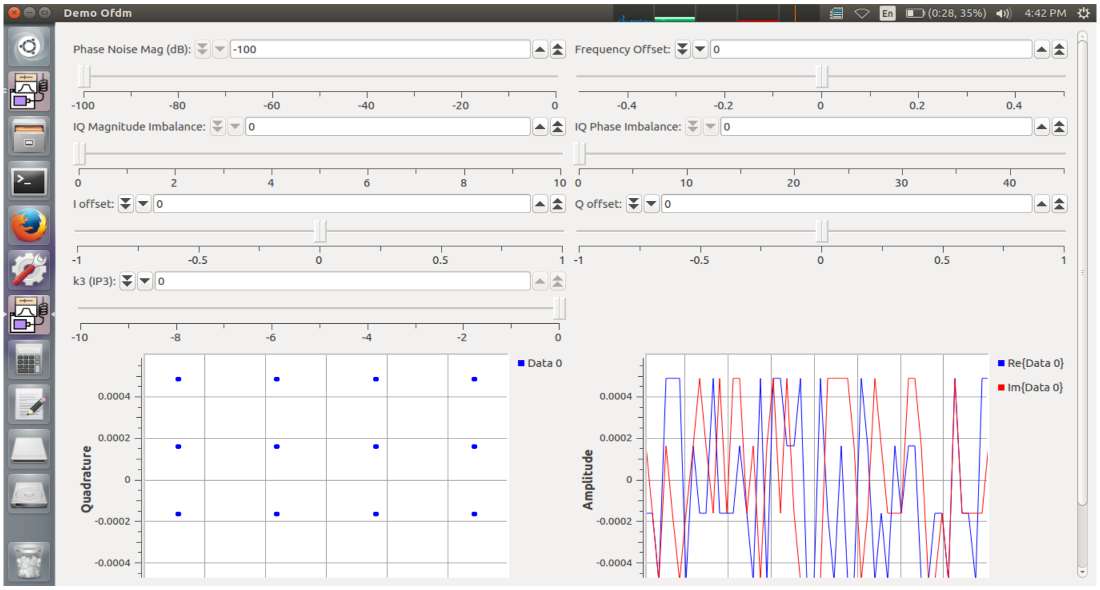

Figure 2. OFDM hardware impairment results

III. WRAN IMPLEMENTATION ON GNU RADIO

A. Hardware impairments analysis

Utilizing GNU Radio, a simulation environment was created to test WRAN systems against common hardware impairments like

- Phase Noise
- Frequency Offset
- IQ magnitude imbalance
- Offset value of the in-phase arm
- IQ phase imbalance (as an angle)
- Offset value of the quadrature arm
- k3 –level of the third order distortion

The system proves to be quite well under severe phase noise and IQ Magnitude and Phase imbalances, and maintains the constellation structure, but fails to tackle slightest changes in frequency offset.

B. PAPR analysis

PAPR or peak to average power ratio or squared crest factor indicates how much outliers peaks are in particular waveform. It is defined as:

$$PAPR = |f|^2_{peak}/(f)^2_{rms}$$

Where f is the signal in time domain. PAPR remains one of the most serious problems for OFDM based systems. High PAPR leads to lower signal to quantization ratio(SQNR)[3]

Extensive Simulations have shown that PAPR can be reduced using encoding techniques like convolutional encoding. [2]In this paper, ccsds -27 encoder and decoder blocks have been used, which are available build-in GNU Radio companion error toolbox. These are rate half, constraint length 7 convolutional encoder and decoder.[4]

The flow graph for PAPR estimation is described in figure 3. The results are summarized in table 1. As evident using better digital modulation and encoding reduces the PAPR by significant amount.[5,7]

TABLE I. PAPR ANALYSIS

Modulation	**PAPR**	
	Without Encoding	***With encoding***
BPSK	92.4	43.1
QPSK	76.8	32.8
16 QAM	54.8	15.8
64 QAM	23.4	5.16
256 QAM	15.7	3.6

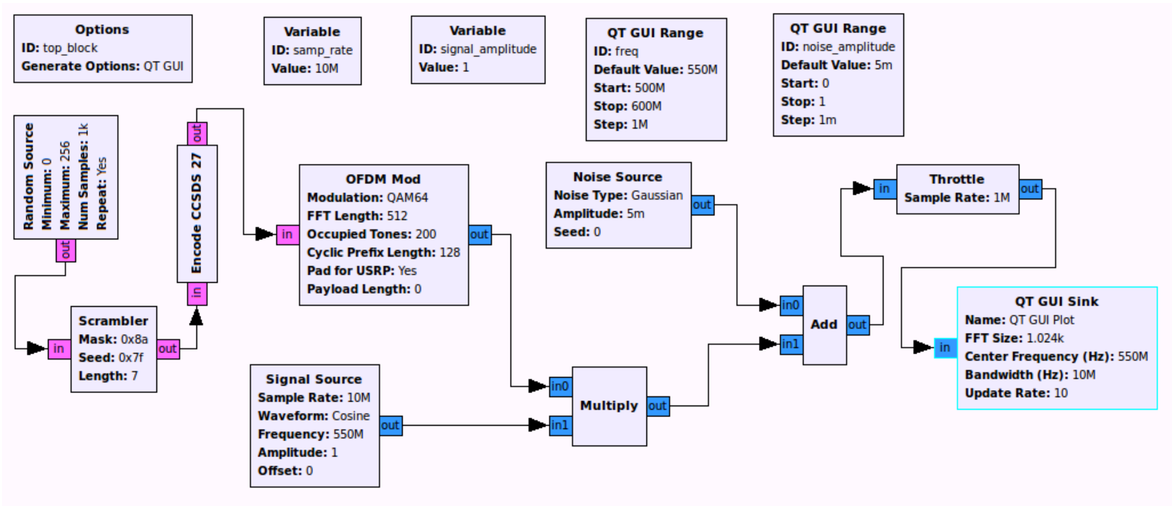

Figure 3. Flowgraph for OFDM with encoding for PAPR analysis

C. *BER analysis*

Bit error rate has been calculated in a frame based manner. The values presented in Table 2. represents the erroneous bits per 1000 bits. The fft length assumed for simulation was 2048 with 1440 data subcarriers. Each subcarrier was modulated using digital modulation techniques such as Phase Shift Keying and Quadrature Amplitude Modulation.[6,7]

TABLE II. BER RESULTS

Modulation	***Error per 100 bits***
BPSK	0.52
QPSK	0.57
16 QAM	0.48
64 QAM	0.47

IV. CONCLUSION AND FUTURE WORKS

Simulations were conducted in domains of OFDM based systems like IEEE 802.22 WRAN and WiMAX. The results demonstrate the strengths and weaknesses of a OFDM based utilization of TV Whitespaces. Future investigations are planned to incorporate fading channel models for simulations like Rayleigh and frequency selective fading channel. Practical realization and field trials are also among the future course of inquiry.

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REFERENCES

[1] Ramjee Prasad, “OFDM for Wireless Communication systems”, Artech House Publisher, 2004

[2] Marwanto, Arief, et al. "Experimental study of OFDM implementation utilizing GNU Radio and USRP-SDR." *Communications (MICC), 2009 IEEE 9th Malaysia International Conference on*. IEEE, 2009.

[3] Fuxjäger, P., et al. "IEEE 802.11 p transmission using GNURadio." *6th Karlsruhe Workshop on Software Radios (WSR)*. 2010.

[4] Maio, Marcus. "Design and implementation of an OFDM-based communication system for the GNU radio platform." *Master's thesis, IKR, University of Stuttgart* (2009).

[5] Zivkovic, Milan, Dominik Auras, and Rudolf Mathar. "OFDM-based Dynamic Spectrum Access." *New Frontiers in Dynamic Spectrum, 2010 IEEE Symposium on*. IEEE, 2010.

[6] Reddy, Kumar, B. Siva, and B. Lakshmi. "Channel Coding and Clipping in OFDM for WiMAX using SDR." *International Journal on Recent Trends in Engineering & Technology* 9.1 (2013).

[7] Aust, Stefan, R. Venkatesha Prasad, and Ignas GMM Niemegeers. "Performance study of MIMO-OFDM platform in narrow-band sub-1 GHz wireless LANs." *Modeling & Optimization in Mobile, Ad Hoc & Wireless Networks (WiOpt), 2013 11th International Symposium on*. IEEE, 2013.