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Spectral Precoding Technique and Method For Multiuser Using OFDM In Cognitive Radio Systems

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Abstract: ***Cognitive radios are aware of their surroundings and bandwidth availability and are able to dynamically tune the spectrum usage based on location, nearby radios, time of day and other factors. This provides for a more efficient use of the spectrum as well as reducing power consumption, and enabling high priority communications to take precedence if needed. OFDM is a method of digital modulation in which a signal is split into several narrowband channels at different frequencies. In an effort to improve radio spectrum management and promote a more efficient use of it, regulatory bodies are currently trying to adopt a new spectrum access model. At the same time, cognitive radio technology has received a lot of interest as a possible enabling technology. OFDM systems super from high out-of-band radiation. Consequently, they require methods reducing those spectral out-of-band components .This project investigate the spectrum, out-of-band radiation (OBR) and the use of extended guard interval (EGI) to reduce the out-of-band radiation of an OFDM signal when passing through different nonlinear devices for cognitive radio network. The above said work is going to be implementing on Blade RF SDR platform and the performance is going to be analysed. BladeRFx40 is a Software Defined Radio (SDR) platform designed to enable a community of hobbyists and professionals to explore and experiment with the multidisciplinary facets of RF communication. It supports, 2x2 MIMO configurable with SMB cable, expandable up to 4x4, RF frequency range 300MHz - 3.8GHz, Stable Linux, Windows, Mac and GNU Radio software support, On-board 200MHz ARM9 with 512KB embedded SRAM (JTAG port available), On-board 15KLE or 115KLE Altera Cyclone 4 E FPGA (JTAG port available).***

Keywords: Cognitive Radio, OFDM, SDR, OBR, EGI, Blade RFX40 SDR

1. Introduction

A cognitive radio is an intelligent radio that can be programmed and configured dynamically. Its transceiver is designed to use the best wireless channels in its vicinity. Such a radio automatically detects available channels in wireless spectrum, then accordingly changes its transmission or reception parameters to allow more concurrent wireless communications in a given spectrum band at one location [1]. This process is a form of dynamic spectrum management.

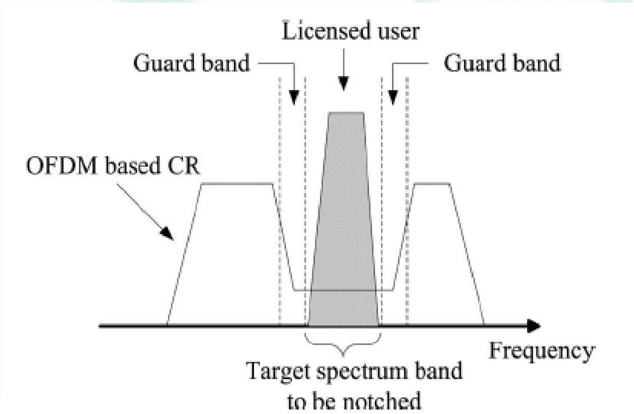

Figure 1: CR-OFDM system coexisting with the licensed user.

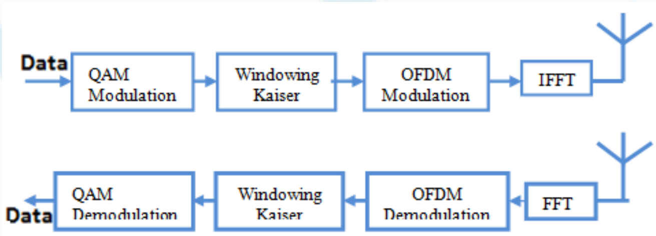

Figure 2: Main Block diagram of spectral precoding.

2. Explanation of Main Block of Spectral Precoding

A. Spectral Precoding

Spectrally precoded orthogonal frequency-division multiplexing (OFDM) is a promising rectangularly pulsed OFDM signaling format which can provide very small power spectral sidelobes, while allowing for efficient implementation by fast Fourier transform and guard interval insertion.

To construct a general signaling format to facilitate the precoder design of the spectrally precoded cyclic prefix-OFDM that can provide fast decaying side lobes block partitioning is adopted [1].

A new precoder structure reduces an OFDM signal's out-of-band emission by tens of decibels while allowing a receiver to employ a classical OFDM channel estimator.

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B. Kaiser Window

The Kaiser window is an approximation to the prolate-spheroidal window, for which the ratio of the mainlobe energy to the sidelobe energy is maximized. For a Kaiser window of a particular length, the parameter β controls the sidelobe height. For a given β, the sidelobe height is fixed with respect to window length. The statement Kaiser (n, beta) computes a length n Kaiser window with parameter beta [2].

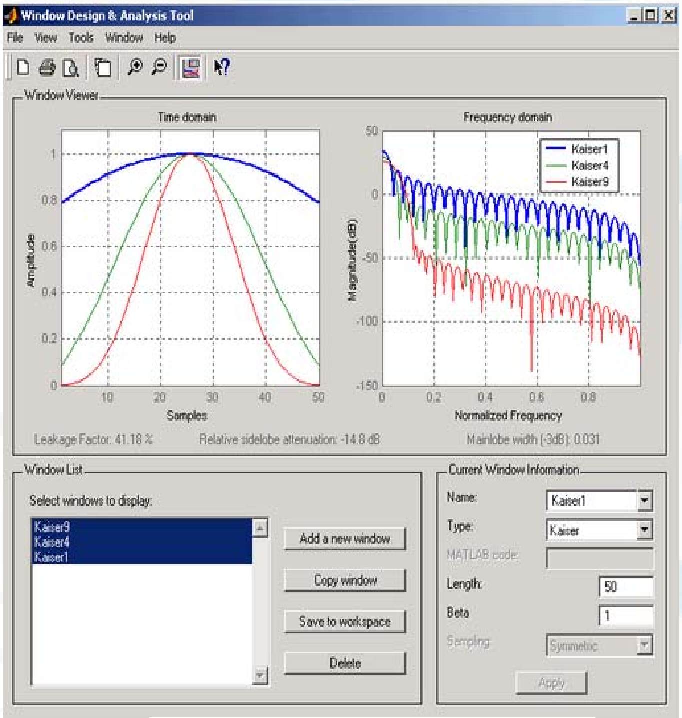

Figure 3: To create these Kaiser windows using the MATLAB command line.

C. Kaiser Windows in FIR Design

There are two design formulas that can help you design FIR filters to meet a set of filter specifications using a Kaiser window. To achieve a sidelobe height of -α dB, the beta parameter is

$$\beta = \begin{cases} 0.1102(\alpha - 8.7), & \alpha > 50 \\ 0.5842(\alpha - 21)^{0.4} + 0.07886(\alpha - 21), & 50 \geq \alpha \geq 21 \\ 0, & \alpha < 21 \end{cases}$$

For a transition width of Δω rad/s, use the length

$$n = \frac{\alpha - 8}{2.285\Delta\omega} + 1$$

Filters designed using these heuristics will meet the specifications approximately, but you should verify this. To design a low pass filter with cut-off frequency 0.5 π rad/s, transition width 0.2πrad/s, and 40 dB of attenuation in the stopband [4]. The kaiserord function estimates the filter order, cutoff frequency, and Kaiser window beta parameter needed to meet a given set of frequency domain specifications. The ripple in the passband is roughly the same as the ripple in the stopband. As you can see from the frequency response, this filter nearly meets the specifications. As β increases, the sidelobe height decreases and the mainlobe width increases. This win tool shows how the sidelobe height stays the same for a fixed β parameter as the length is varied.

C. QAM Modulation

M-QAM - Quadrature amplitude modulation is a combination of ASK and PSK so that a maximum contrast between each signal unit (bit, dibit, tribit, and so on) is achieved [1]. We can have x variations in phase and y variations of amplitude. x • y possible variation (greater data rates). M represents the multiples constants to increase the readability of signal.

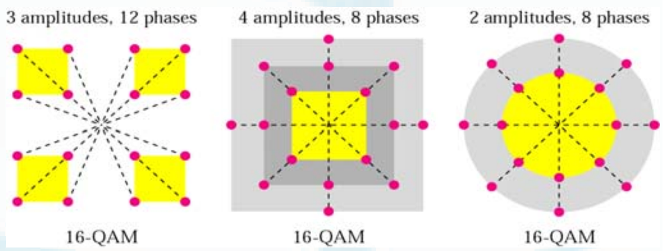

Figure 4: To increase readability of signal, measurable differences between shifts are increased.

D. OFDM Modulation / Demodulation

Cyclic prefix insertion is commonly used in orthogonal frequency division multiplexing (OFDM) systems as a way to mitigate the effects of intersymbol-interference (ISI). It copies the end section of an inverse fast Fourier transform (IFFT) packet to the beginning of an OFDM symbol. Usually the length of the cyclic prefix is longer than the length of the dispersive channel to completely remove ISI. OFDM modulation therefore mostly revolves around cyclic prefix: OFDM modulation includes IFFT operation and cyclic prefix insertion; OFDM demodulation includes cyclic prefix removal and FFT operation [5].

Modern communications systems feature highly dynamic scalability, which often requires changing system parameters on-the-fly based on channel conditions and user quality of service (QoS) requirements.

3. Hardware – Blade RFX40

Figure 5: Blade RFX40 Hardware Kit

The bladeRF x40 is a low-cost USB 3.0Software Defined Radio. The 40KLE option makes the bladeRF the essential low-cost RF transceiver kit for both hobbyists, and RF enthusiasts.

It supports;

- 2x2 MIMO configurable with SMB cable,
- expandable up to 4x4,
- RF frequency range 300MHz - 3.8GHz
- Stable Linux, Windows, Mac and GNU Radio software support.

4. Software – GNU Radio Companion (GRC)

Since it is easier to handle information flow graphically, GNU Radio offers with its application GNU Radio Companion the possibility to form a flow chart with graphical block elements. This application provides numerous predefined blocks, organized in different groups like signal sources, signal sinks as well as modulation and demodulation functions.

As signal source for instance, Blade RFx40, audio card, wav files, signal generators or UDP/TCP ports may be used. Being installed with GNU Radio, GRC can be run from Linux by simply typing “grc” in an xterm shell. GRC is best illustrated by the typical FM radio receiver.

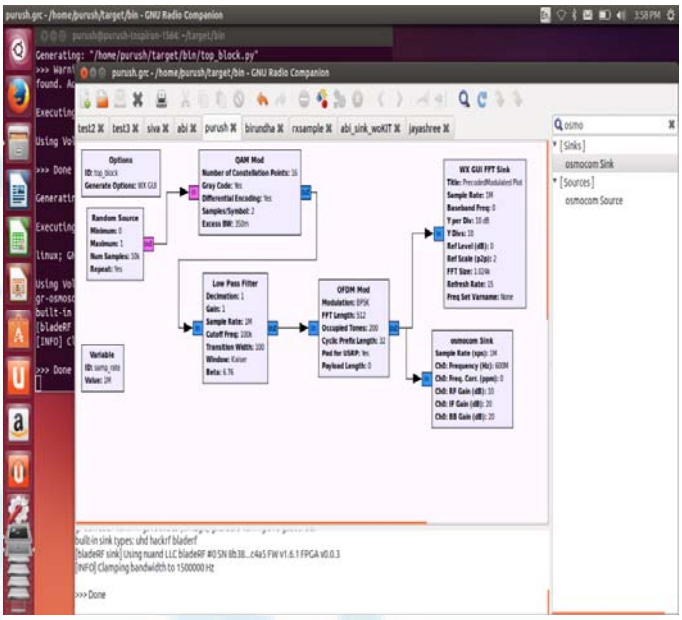

Figure 6: Picture of Transmitter block in SDR – Screenshot

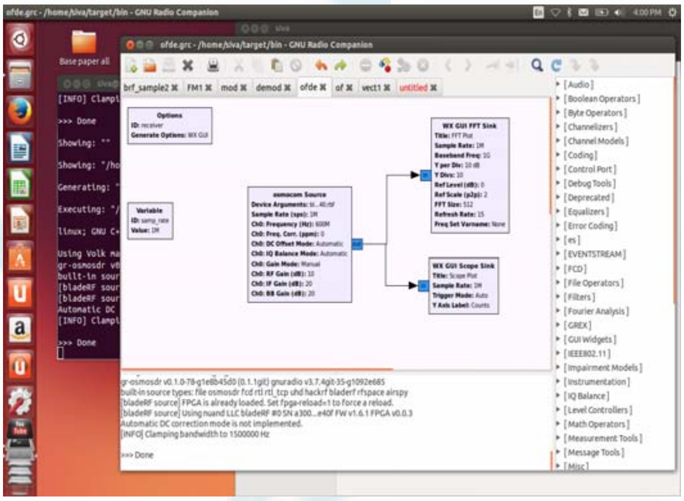

Figure 7: Picture of Receiver block in SDR – Screenshot

5. Results

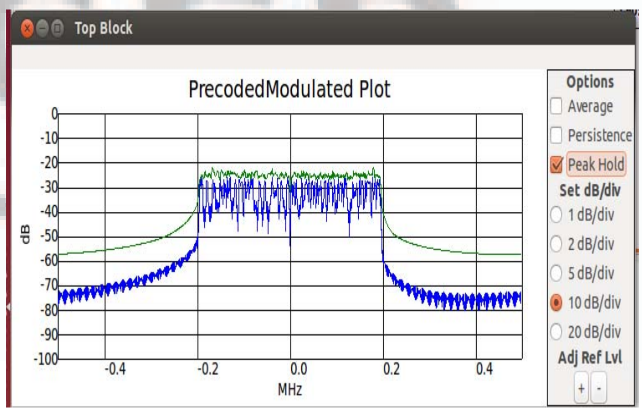

Figure 8: Picture of Simulation results – Transmitter

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Figure 9 (a): Picture of Simulation results – Receiver

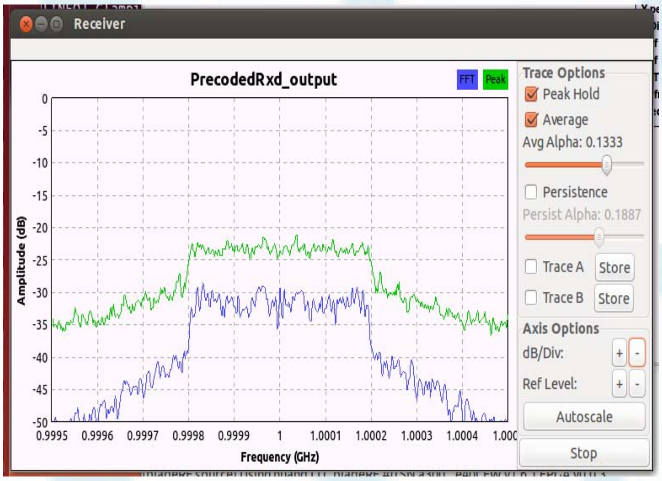

Figure 9 (b): Picture of Simulation results – Receiver

6. Conclusion

Finally, we have proposed a spectral precoding scheme for multiple OFDM-based CR users to enhance spectral compactness. By constructing individual precoders to render selected spectrum nulls, our scheme ensures user independence and provides sufficient OOB radiation suppression without BER performance loss. We have also considered the selection. Investigating the spectrum, out-of-band radiation (OBR) and the use of extended guard interval (EGI) to reduce the out-of-band radiation of an OFDM signal when passing through different nonlinear devices for cognitive radio network. This above job is implementing on Blade RFx40 SDR platform and the performance is analyzed. BladeRFx40 is a Software Defined Radio (SDR) platform designed to enable a community of hobbyists, and professionals to explore and experimented.

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