IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 5.731
Volume 2, Issue 1, January 2022

Spectral Emission Mask Shaping for OFDM in Cognitive Radios

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Abstract: *Orthogonal frequency division multiplexing (OFDM) is characterized by spectral efficiency. It enables flexible and agile spectrum allocation. But still it lags as it suffers from spectral leakage in the form of large side lobes. It leads to inter-channel interference if not handled carefully.in proposed system spectral emission mask system is implemented to combat spectral leakage and ultimately avoiding adjacent channel interference. A spectral mask, also known as a channel mask or transmission mask is a mathematically-defined set of lines applied to the levels of radio (or optical) transmissions. The spectral mask is generally intended to reduce adjacent-channel interference by limiting excessive radiation at frequencies beyond the necessary bandwidth. The proposed system is implemented over MATLAB platform using script language.*

Keywords: MATLAB, Spectral Mask, OFDM, Inter Channel Interference.

I. Introduction

OFDM, Orthogonal Frequency Division Multiplexing is a nothing but a signal waveform or modulation that leads to some significant advantages for data links. Accordingly, OFDM, Orthogonal Frequency Division Multiplexing utilized for number of the recent wide bandwidth and higher data rate wireless systems, it includes Wi-Fi, cellular telecommunications and further more. Practically OFDM utilizes a vast number of carriers; each carries low bit rate data that means it is very resilient to selective multipath effects, interference, fading, while providing an effective spectral efficiency. Recent days systems using OFDM have the processing required for the signal format was comparatively high, but with modernization in technology, OFDM represents some of difficulties in terms of the processing required. The utilization of OFDM and multicarrier modulation has come to the limelight in recent years as it gives an perfect platform required for wireless data communications transmissions.

The concept of OFDM technology was first experimented and analyzed in the 1960s and 1970s while research into methods for minimizing interference in between closely spaced channels. With addition to this other requirements needed to have an error free data transmission in the presence of interference as well as selective propagation conditions.

Earlier the utilization of OFDM for major levels of processing was not feasible for general use. Some of the earlier systems to utilize OFDM were digital broadcasting. In it OFDM was able to provide a highly reliable form of data transport over a versatile variety of signal path conditions. One of example was DAB digital radio that was started in Europe and other countries. At Norwegian Broadcasting Corporation NRK. They launched the first service on 1st June 1995. OFDM was also utilized for digital television. After some years processing power increased as an outcome of incremental integration levels initiating OFDM to be introduced for the 4G wireless network communications systems which initiated to be deployed from approx. 2009. Wi-Fi also utilized OFDM for its implementation. Not only Wi-Fi but for other wireless service also OFDM was adopted. Though OFDM is so successful although it is characterized by spectral leakage. This spectral leakage leads to inter channel interference. In order to avoid spectral leakage and ultimately inter channel interference, spectral emission mask is proposed.

DOI: 10.48175/IJARSCT-2256

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II. Literature Review

The paper named as "Review Paper on OFDM-Concepts and Applications" authored by Sukhpal Singh, Harmanjot Singh, published in IJEDR Volume 3, Issue 3, 2015. States that "CO-OFDM is a very attractive modulation and multiplexing technique that is used in wideband optical systems as well as optical wireless systems. Several advantages of optical orthogonal systems is good efficiency of spectrum utilization and channel robustness. Number of small subcarriers is used to transmit data from one source and generally termed as multicarrier transmission. OFDM, a modulation as well as multiplexing technique is the origin of several telecommunications standards counting DTT and radio broadcasting. OFDM is even the source of nearly all DSL standards, and within this situation OFDM is generally known as discrete multitoned (DMT). Regardless of the benefits offered by OFDM and its prevalent usage in wireless communications, it has been considered for optical communications during the last years. OFDM is a technique in which sequential data tributary transformed into parallel stream. The concept of OFDM is to divide the broadcast bandwidth into a number of orthogonal subcarriers in order to transmit the symbols using these subcarriers in parallel. In this paper, description of OFDM systems their concepts has been discussed with their several applications." [1].

Research, Volume 6, Issue 2, February-2015, It states that "This paper discusses the structure and implementation of an OFDM modem employed in wireless communication. Orthogonal rate of recurrence Division Multiplexing (OFDM) is just about the latest modulation techniques used so that you can combat the frequency-selectivity from the transmission channels, achieving substantial data rate without inter-symbol disturbance. This technique is employed for bandwidth hogging applications including Video Conferencing, DAB, DVB, and many others. Multi-user capacity possible making use of MC-CDMA. OFDM is several techniques proposed to be employed in 4th Generation cellular Systems For the majority of all part, Orthogonal. The bit error rate along with the ISI in multipath surroundings in conventional techniques for instance QAM are very high which often can be reduced by putting into action the OFDM technique. Nonetheless, the occurrence of the actual potentially high peak-to-average electrical power ratio (PAPR) restricts the application. "[2]

The paper named as "Behavior and Techniques for Improving Performance of OFDM Systems for Wireless communications", authored by Alcardo Alex Barakabitze ,published in International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 1, January 2015.it states that" Orthogonal frequency division multiplexing (OFDM) is a special case of multicarrier transmission which transmits a stream of data over a number of lower data rate subcarriers. OFDM splits the total transmission bandwidth into a number of orthogonal and non-overlapping subcarriers and transmit the collection of bits called symbols in parallel using these subcarriers. This paper gives a total insight of various Peak -to Average Power Reduction (PAPR) techniques and principles of OFDM systems used in wireless communications. The research paper places a focus also on OFDM behaviors and techniques like Carrier Frequency Offset (CFO) estimation that improves performance of OFDM for wireless communications. Finally, the paper provides a number of wireless communication standards and many of the applications where OFDM systems are used."[3]

The paper named as "OFDM transmission and reception: review" authored by Amit Saini, published in International Research Journal of Engineering and Technology (IRJET), 2015. It states that" The paper concentrates on the review of Orthogonal Frequency Division Multiplexing (OFDM) technique, for digital data transmission and reception. OFDM is relied upon to be utilized as a part of future television and remote LAN (WLAN) systems. For instance, IEEE802.11 in the United States, ETSI BRAN in Europe [4], and ARIB MMAC in Japan have officially embraced the OFDM transmission technique as a physical layer for future broadband WLAN systems. In OFDM information transmission and reception uses IFFT and FFT in modulator and demodulator respectively. The literature review is carried from some of the journals."[4] The paper named as "Review on OFDM a Brief Survey", authored by Vishal Pasi, published in International Journal of Scientific and Research Publications, Volume 3, Issue 11, November 2013.it states that "Orthogonal frequency-division multiplexing (OFDM) effectively mitigates intersymbol interference (ISI) caused by the delay spread of wireless channels. Therefore, it has been used in many wireless systems and adopted by various standards. In this Paper, we present a comprehensive survey on OFDM for wireless communications. We address basic OFDM and related modulations, as well as techniques to improve the performance of OFDM for wireless communications, including channel estimation and signal detection, time- and frequency-offset estimation and correction, peak-to-average power ratio reduction PAPR, inter carrier interference (ICI) and multiple-input–multiple-output (MIMO) techniques. We also describe the applications of OFDM in current systems and standards."[5]

III. System Development

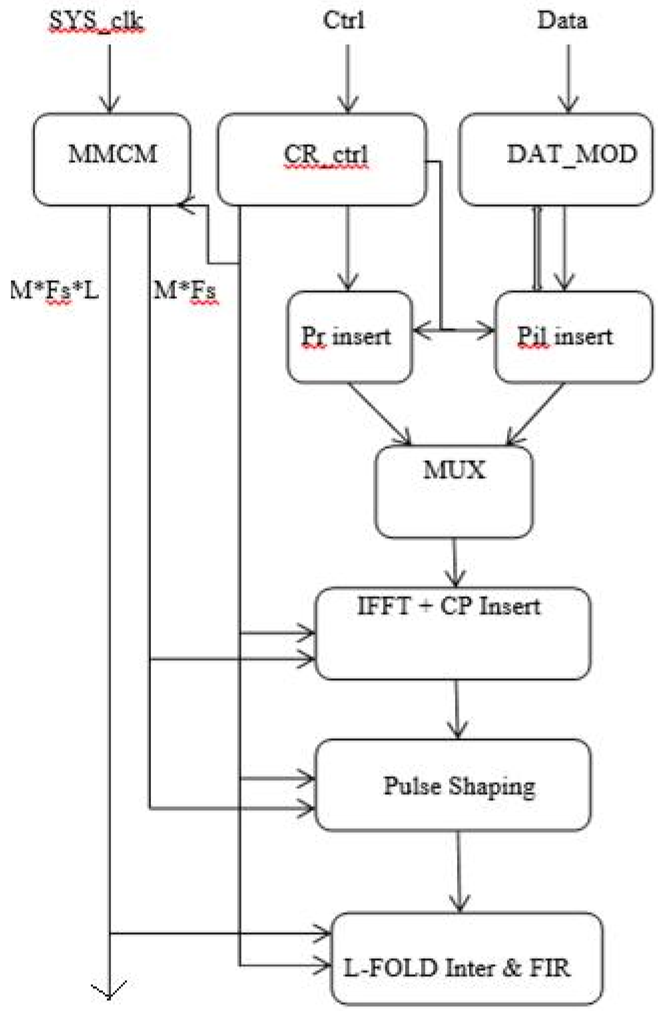

Figure 1: Proposed System

In a conventional approach, pulse shaping is only employed with small roll-off factors. This is because large roll-off factors involve longer filters, reducing the effective guard interval. Given the narrow frequency guard of the OFDM spectrum for the new standards, and the amount left after accounting for the effects of CIR and matching filters, pulse shaping under such constraints is unable to cancel the image spectrum: in fact, even if the entire guard interval was to be used, this may be insufficient for the very stringent class D SEM in 802.11p, and the SEM of 802.11af. Thus our new method takes a different approach. Instead of using a large proportion of the guard interval for FIR filtering, we allow the pulse shaping to occupy a significant portion of the guard space, with large roll-off factors. To obtain the significant spectral leakage reduction necessary, the frequency guard needs to be increased. It thus involves introducing a frequency guard extension technique. Then, given a wider frequency guard, pulse shaping with large roll- off factors can achieve significant side lobe compression of the OFDM signal, and the required transition band for FIR filtering is extended, which means a shorter FIR filter is able to attenuate the image spectrum.

The method thus involves three steps:

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The IFFT length is multiplied by a factor *M*, and the sampling frequency similarly in-creased by a factor *M*, to maintain the same subcarrier spacing. Given this, the allocation vector is formed to add data symbols at lower sub-carriers that are the same as those in the original IFFT, while the remaining sub-carriers are zero-padded.

Next, pulse shaping is applied in the normal way, to meet the given SEM constraint.

IV. Pulse Shaping Techniques for Efficient PAPR Reduction in OFDM System

Orthogonal Frequency Division Multiplexing is a multicarrier modulation technique that divides the available spectrum into subcarriers. Each subcarrier is orthogonal to each other [9]. The transmitter model which is used in our proposed pulse shaping technique is shown in Fig.2

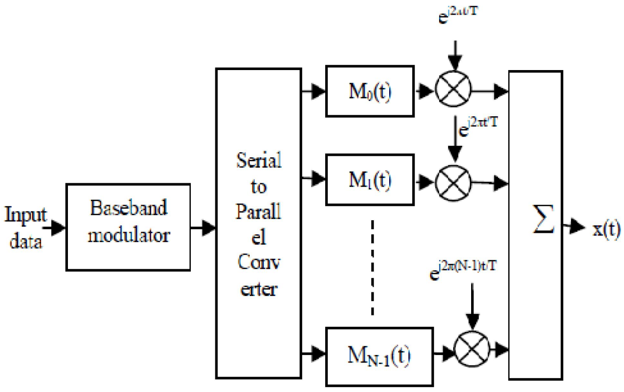

Figure 2: OFDM transmitter Model Using Pulse Shaping

The above figure illustrates the transmitter block diagram of OFDM system with N sub-carrier using pulse shaping technique. Here the incoming data is first modulated in baseband modulator using a bandwidth efficient modulation. The baseband modulated stream, with data rate1/Ts is then split into N parallel streams. Each stream is shaped by a time waveform (pulse shaping waveform) and transmitted over a given subcarrier [10]. However, only one IFFT is used in the transmitter section. Thus, the OFDM transmitted signal can be expressed as,

$$x(t)=\sum_{k=0}^{N-1} X_p(k) M_k(t) e^{j2\pi k\frac{t}{T}} \quad where\ pT \le t \le (p+1)T. \qquad (1)$$

4.1 Peak-to-Average Power Ratio of OFDM System

One of the major drawbacks of OFDM system is high PAPR which can be defined as the maximum power occurring in the OFDM transmission to the average power of the OFDM transmission [14]. Mathematical representation has been given below.

$$PAPR = P_{peak} / P_{average = max(} x_{N\,(t)\,)}^2 / E\,[x_{N(t)}]^2 \qquad (2)$$

Where, Ppeak = Peak power of the OFDM system,

Paverage = average power of the OFDM system and $E\,[\,\cdot\,]$ is the expectation operator. Assuming uncorrelated symbols within each OFDM block, the maximum PAPR is obtained as

$$PAPR = 1/N \max_{0\le t\le T} \sum_{k=0}^{N-1} (a_{k(t)})^2 \qquad (3)$$

This is a function of the number of subcarriers N and the pulse shape used at each subcarrier. With large number of subcarriers, the maximum of the PAPR occurs with very low probability.

4.2 Narrowband Pulse Shaping Techniques

The most commonly used narrowband pulses are Sine, Tukey window and Kaiser Window pulse. We have already derived the mathematical model of two narrowband pulses, Sine and Tukey window, in our previously published work. In this paper the different characteristics of those pulses have been analyzed and compared with the existing system.

Here, another narrowband pulse, Kaiser window pulse, has been employed in the transmitter section of OFDM system for reducing the PAPR. The mathematical model of Kaiser window pulse is derived [14].

A. Kaiser Window Pulse

The subcarrier pulse shape which is tested in this section is created through the windowing of a rectangular pulse by the Kaiser window. The time domain Kaiser window shape will be examined and considered for comparisons with previously tested sine pulses. Because Kaiser Window produces similar time domain shapes to the sine pulse, more specific characteristics can be investigated to quantify the difference in performance with sine pulses for PAPR reduction. The following equations are formulated to the shape of the window according to beta which is an arbitrary real number

$$w[n] = \begin{cases} \dfrac{I_0[\pi\beta(1-[\frac{2n}{M}-1]^2)^{1/2}]}{I_0(\pi\beta)}, 0 \le n \le N. \\ 0, otherwise \end{cases}$$

$$for\,\beta = \begin{cases} 0.1102(A-8.7), \quad A > 50dB \\ 0.5842(\alpha-21)^{0.4} + 0.07886(A-21), \quad 21 \le A \le 50dB. \\ 0(rec\tan gular \quad window), \quad 0 \le A \le 21dB \end{cases}$$

(4)

Here, I0 is the zero[th] order modified Bessel function of the first kind and M is an integer.

4.3 Broadband Pulse Shaping Techniques

Broadband pulse shapes are very flexible and can control the correlation between the OFDM block samples without destroying the orthogonality property between the subcarriers of the OFDM modulated signal. Some of broadband pulses named raised cosine and square root raised cosine pulses [14].

A. Raised Cosine Pulse

The raised cosine pulse has been designed such that its shape no longer adheres to rectangular shape with sharp transitions, but rather smoothed decaying transitions which were more practically achievable [14]. The investigation of pulse characteristics will begin with the following time domain equation.

$$p(t) = \text{sinc}(2wt)\left(\frac{\cos(2\pi\alpha wt)}{1-(4\alpha wt)^2}\right) \quad where \quad T_b = \frac{1}{2w}. \tag{5}$$

The time domain raised cosine pulse will be used to compare with narrowband pulses.

B. Square Root Raised Cosine Pulse

The square root raise cosine pulse is a similar pulse that is based on the raised cosine pulse. The frequency response of the square root raised cosine pulse is achieved through the square root of the raised cosine magnitude response in the frequency domain. The equation that specifies the square root raise cosine time domain pulse can be defined by the following expression:

$$p(t) = \begin{cases} 1-\alpha+4\dfrac{\alpha}{\pi}, & t=0 \\ \dfrac{\alpha}{\sqrt{2}}\left[\left(1+\dfrac{2}{\pi}\right)\sin\left(\dfrac{\pi}{4\alpha}\right)+\left(1-\dfrac{2}{\pi}\right)\cos\left(\dfrac{\pi}{4\alpha}\right)\right], & t=\pm\dfrac{T}{4\alpha} \\ \left[\sin\left(\pi(1-\alpha)\dfrac{t}{T}\right)+4\alpha\dfrac{t}{T}\cos\left(\pi(1+\alpha)\dfrac{t}{T}\right)\right] \Big/ \left[\pi\dfrac{t}{T}\left(1-\left(4\alpha\dfrac{t}{T}\right)^2\right)\right] & for \quad all \quad other \end{cases}$$

(6)

V. Result and Conclusion

The proposed system has been implemented successfully. It is found that spectral emission mask is working accurately as shown in figure. 3 to avoid spectral leakage by avoiding

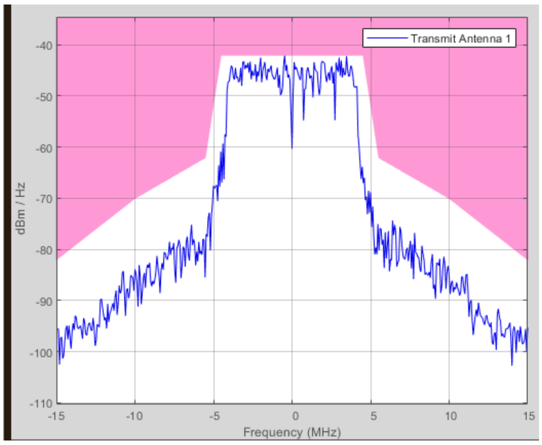

Figure 3: The proposed system will play important role to make OFDM more effective.

REFERENCES

[1]. Md. Abdullah Al Baki, Mohammad Zavid Parvez “Peak To Average Power Ratio (Papr) Reduction In Ofdm Based Radio Systems” Electrical Engineering Blekinge Institute of Technology, May 2010.

[2]. Krongold, B. S. and D. L. Jones, “PAPR reduction in OFDM via active constellation extension,” IEEE Trans. on Broadcasting, Vol. 49, 258–268, Sept. 2003.

[3]. Employment of Pulse Shaping Techniques for Efficient PAPR Reduction in OFDM System Tangina Sultana and Shamim Ara Shawkat Institute of Information and Communication Technology (IICT).

[4]. Sukhpal Singh, Harmanjot Singh, “Review Paper on OFDM-Concepts and Applications” IJEDR Volume 3, Issue 3, 2015.

[5]. Brijesh Kumar, “ A Review paper on orthogonal frequency division multiplexing (OFDM)”, International Journal of Scientific & Engineering Research, Volume 6, Issue 2,February-2015.

[6]. Alcardo Alex Barakabitze, “ Behavior and Techniques for Improving Performance of OFDM Systems for Wireless communications”, International Journal of Advanced Research in Computer and Communication Engineering Vol.4, Issue 1, January 2015

[7]. Amit Saini,” OFDM transmission and reception review”, International Research Journal of Engineering and Technology (IRJET), 2015

[8]. Vishal Pasi, “ Review on OFDM a Brief Survey”, International Journal of Scientific and Research Publication, Volume 3, Issue 11, Nonember 2013

[9]. Neha pathak, OFDM simulation using MATLB, (IJERT) International Journal of Engineering Research & Technology, Vol. 1 Issue 6, August 2012

[10]. Mary Ann Ingram and Guillermo Acosta, Smart Antenna Research Laboratory using Matlab, 2000. [E-book] Available: toodoc ebook [Accessed Sep. 23, 2009].

[11]. K. Mallikanti, "Analysis of OFDM System by Using Pulse Shaping Filters for DSP Applications," SSRG International Journal of Electronics and communication Engineering, pp. 22-27, 2017.

[12]. T. H. Pham, S. A. Fahmy and I. V. McLoughlin, "An End-to-End Multi-Standard OFDM Transceiver Architecture Using FPGA Partial Reconfiguration," IEEE Access, vol. 5, pp. 21002-21015, 2017.

[13]. T. H. Pham, S. A. Fahmy and I. V. McLoughlin, "Spectrally Efficient Emission Mask Shaping for OFDM Cognitive Radios," Digital Signal processing, vol. 50, pp. 150-161, 2016.

[14]. T. Taheri, R. Nilsson and J. Beek, "Asymmetric Transmit-Windowing for Low-Latency and Robust OFDM," in Globecom Workshops, 2016.