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Efficient Transceiver Design for Digital Video Broadcast based orthogonal frequency division multiplexing and 4 quadrature amplitude modulation

Gamal A. Hussein
Department of Electronics and Communications Engineering, Ministry of High Education, Higher Institute of Engineering & Technology, K.M, Alex.
Email:gamal_ertu_sat@yahoo.com

Abstract: **Different modulation schemes have been used in variety of communications systems such as binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 8-PSK, 16 PSK, 32 PSK, differential binary phase shift keying (D-BPSK), D-QPSK, 4 quadrature amplitude modulation (4 QAM), 16 QAM, 32 QAM, and 64 QAM. On the other hand, different multiplexing schemes have been used such as: frequency division multiplexing (FDM), time division multiplexing (TDM), code division multiplexing (CDM) and orthogonal frequency division multiplexing (OFDM). Of all the addressed modulation and multiplexing techniques 4 QAM and OFDM respectively have been utilized in this paper to design efficient digital video broadcast (DVB) transceiver system. Also, the current paper presents efficient schemes to reduce the peak average power ratio (PAPR) a raised from multi-carrier of OFDM. OFDM has different advantages over the other kinds of multiplexing techniques such as; it is a multi-carrier transmission scheme uses both the inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT) algorithms in transceiver design, the use of FFT eliminates arrays of sinusoidal generators and coherent demodulation required in parallel data systems and makes the implementation of the technology cost effective, OFDM is the most promising candidates for efficient bandwidth utilization, and excellent behavior in the case of multipath reception. Moreover; provides the lowest multi-path distortion, highest data rate, lowest bit error rate (BER). In addition to; be able to eliminate inter symbol interference (ISI) and inter channel interference (ICI). On the other hand, 4 QAM provides the lowest error rate. Simulation results have been carried out using Matlab programming and approved that; the superiority of the addressed schemes for the system design over the conventional schemes of modulation and multiplexing, where we have got the lowest BER, reduced the disturbing issue of PAPR, and we have implemented the system's technology with low complexity in the design using the fast algorithms of both the IFFT and FFT for the modulator and demodulator respectively.**

Key words: **Efficient transceiver, DVB, OFDM, 4 QAM, FFT, IFFT, BER, PAPR.**

1. INTRODUCTION

Digital video broadcast (DVB) implementation system suffers from several problems such as; BER especially for higher degrees of QAMs, different forms of channel noise, peak to average power ratio (PAPR) arised from multi-carrier, bandwidth utilization, and complexity of the system design. Our manuscript proposed to enhance the system bandwidth using OFDM rather than using the traditional FDM, also the system complexity can be reduced by employing both the Inverse Fast Fourier Transform (IFFT) and FFT algorithms in the transceiver design. The FFT is proposed to speed up the process. Cooley and Tukey developed FFT algorithm in 1965 [1]. FFT and IFFT are both useful in OFDM transceivers to reduce the size of the physical components. The FFT algorithm is also suitable to ensure that we maintain the orthogonality in the OFDM transceiver and to avoid any interference. Moreover; the problem of BER can be optimized using lower degree of QAM and carrier aggregation technique (CA) in OFDM system. In addition to; the problem of high PAPR, several approaches have been presented in literature to overcome it such as; Peaks clipping technique [2], which was the one of the simplest techniques that can be used to reduce power by picking a maximum level for the transmitted signal [3] [4]. However, this technique had several drawbacks such as; in-band distortion, and out-of-band radiation. Also coding technique was used where code words are selected to minimize the PAPR, but its drawback is that when the code rate is minimized the bandwidth efficiency will suffer [5] [6]. Another technique called the probabilistic technique involves transmitting one of the lowest PAPR OFDM symbols to reduce the PAPR occurrence probability [7]. But this technique contains some disadvantages, including increased complexity when using higher numbers of subcarriers. The adaptive pre-distortion technique is another type, which can be used to eliminate nonlinear effect that appears when using high power amplifier (HPA). The current manuscript suggested to employ efficient algorithms to reduce the effect of PAPR using Partial transmit sequence (PTS) algorithm [8, 9] and selective mapping (SLM) algorithm [10, 11], these algorithms provided good results for optimizing the system performance. Furthermore, bandwidth extension using the technique of carrier aggregation (CA) can merged with the addressed techniques for PAPR reduction to increase the data rate and decrees the BER.

Different types of modulation mechanisms have been studied for their bit error rate (BER) with OFDM such as: BPSK, QPSK = 4QAM, 8-PSK, 16 PSK, 32 PSK, D-BPSK, D-QPSK, 16 QAM, 32 QAM, and 64 QAM BPSK, QPSK, 8-PSK, 16 PSK, 32 PSK, D-BPSK, D-QPSK, 4 QAM, 16 QAM, 32 QAM, and 64 QAM. Different forms of channel noise for

examples; Additive White Gaussian Noise (AWGN) and Rayleigh Fading have been investigated; BER rates for both these forms of channel noise are studied comparatively.

One of the major drawbacks of using an OFDM communications system is its requirement for high power transmitters due to high Peak to Average Power (PAPR) ratios. In this paper, we reduce the PAPR by using two efficient algorithms, (i.e.) the Partial Transmit Sequence (PTS) algorithm and Selective Mapping (SLM) algorithm. Furthermore, bandwidth extension can be performed by using the technique of carrier aggregation (CA). In this technique, we aggregate two sub-carriers to provide a greater bandwidth. CA is achieved by using two methods, contiguous CA and non-contiguous CA.

The main goals of this manuscript are: 1) evaluate the performance of OFDM with regards to its bit error rate (BER) and peak to average power ratio (PAPR). 2) Optimize the performance of OFDM system by employing efficient algorithms to reduce the effect of disturbing issue of PAPR. 4) Extend the band width using Carrier Aggregation (CA), and minimize the BER of the system. 3) Simplify the hardware design of the system by implementing IFFT and FFT in the transceiver layout. 4) Study, analyze and implement PAPR reduction schemes with carrier aggregation.

The rest of the paper is organized as: Section 2; introduces the recommended block diagram for DVB-Transceiver design. Section 3; is dedicated for the proposed schemes to enhance the performance of OFDM system. Section 4; presents the outcome of our simulation results for the proposed schemes. Section 5; gives the conclusion tailed by the set of more relevant references.

2. LAYOUT of the RECOMMENDED DIGITAL VIDEO BROADCAST TRANSCEIVER DESIGN

This section presents the recommended efficient digital video broadcast transceiver based OFDM as illustrated below in Fig. 2. Before transmitting the information bits over an AWGN channel, we use the 4-QAM modulation scheme where it can give the lowest BER as compared to the other higher degrees of QAM. The transmitter section converts the digital data to be transmitted into a mapping of the sub-carrier's amplitude and phase using modulation techniques.

The spectral representation of the data is then transformed into the time domain using an IFFT which is much more computationally efficient and is used in all practical systems [12, 13]. The addition of a cyclic prefix to each symbol solves both ISI and ICI [14, 15]. The addressed schemes for PTS and SLM are used to mitigate the harmful effect of PAPR, and the other scheme of CA is used for band width extension, hence increases the data rate and minimizes the BER. The digital data is then transmitted over the channel. After the time-domain signal passes through the channel, it is broken down into the parallel symbols and the prefix is simply discarded. The receiver performs the reverse operation to that of the transmitter. The amplitude and phase of the sub-carriers are then selected and converted back to digital data.

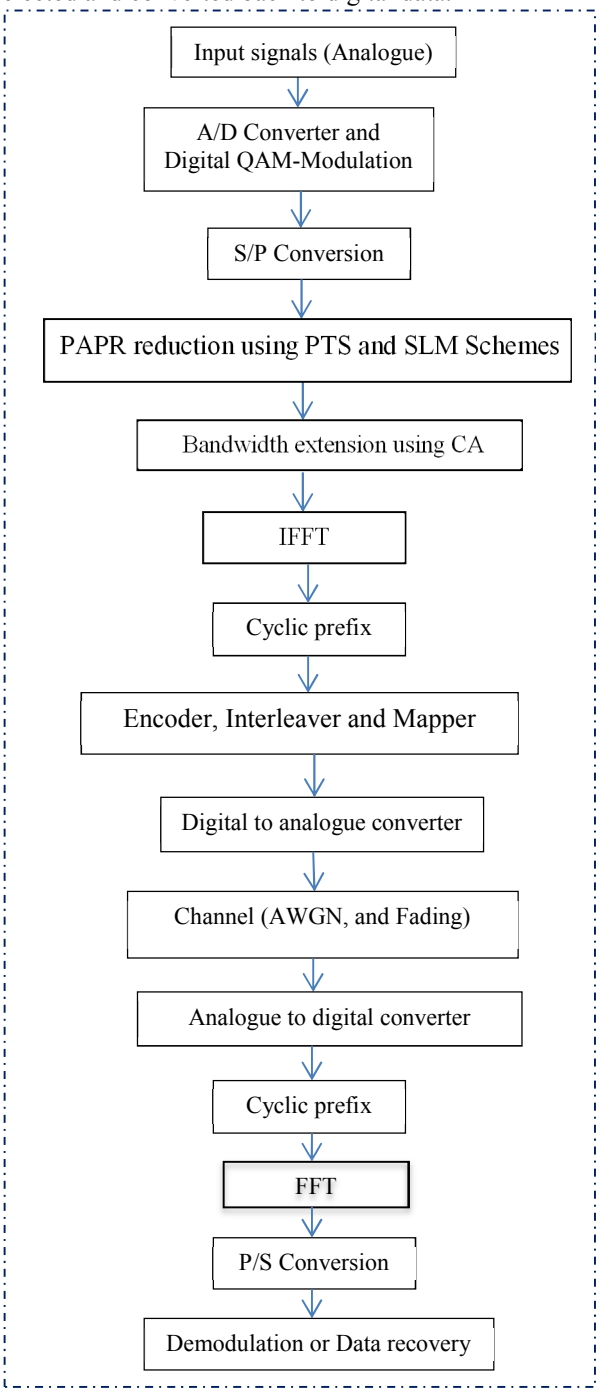

Fig.2: block diagram of the recommended DVB-transceiver

3. PROPOSED SCHEMES to ENHANCE the PERFORMANCE of OFDM SYSTEM

It is worth mentioning that; OFDM has several advantages as mentioned before, but suffers from PAPR due to the multi-carriers of OFDM; this PAPR requires linear transmitter

circuitry and suffers from poor efficiency. so this manuscript suggests to optimize the performance of the system by two approaches, the first approach suggests to decrease the BER or increase the bandwidth by using carrier aggregation (CA), and the second approach suggests to reduce the effect of PAPR using partial transmit sequence (PTS) and selection mapping (SLM) technique as clarified below:

First approach: Reducing the BER or increasing the bandwidth of the OFDM using Carrier Aggregation CA by using two components carriers (CCs) with different frequencies by the meaning carrier component one (CC1) at 102 MHz and carrier component two (CC2) at 95 MHz.

Second approach: Performance optimization of OFDM using PAPR reduction schemes. The current manuscript presents two schemes for PAPR reduction using PTS and SLM techniques. The PAPR of an OFDM technique is expressed mathematically by [16]:

$$PAPR = \frac{P_{peak}}{P_{Average}} = 10 \log_{10} \frac{\max[|(x(n)^2|]}{E[|x(n)^2|]} \quad (1)$$

Where

P_{peak} is the peak output power, $P_{Average}$ is the average output power of the OFDM transmitter, *x(n)* is the transmitted OFDM signal, and *E* denotes the expected value of *x (n)*. The previous equation states that; the PAPR of an OFDM depends mainly on the peak output power, but the OFDM signal consists of a several sub-carriers in a superposition technique. The outcome of this is a rise in the peak output power of the transmitted signal, hence causes an increase in the PAPR. A higher PAPR means that; we will require higher power from the output of power amplifiers for transmission. So, we can mitigate this problem by the addressed approaches using the schemes of PTS and SLM as clarified in our mat lab simulations below.

4. SIMULATION RESULTS for the PROPOSED SCHEMES

After merging both the addressed schemes of increasing the bandwidth or BER reduction by CA and PAPR reduction by SLM and PTS we have got the results of Matlab simulations in figures 3, 4, 5 and 6 respectively.

Fig. 3 holds a comparison between the *PAPR* of the original *OFDM* signal without carrier aggregation *(CA)* and the *PAPR* of *OFDM* with employing *CA*. From the red curve of the original OFDM signal without CA it is obvious that; the PAPR of the OFDM signal is high for lower values of CCDF. This asserts that; high energy transmission is necessary for OFDM system in order to maintain a desirable PAPR. With the increase in bandwidth in CA reduces the BER but the average peak power of transmitted signal is also increases, hence leading to a proportional increase in its *PAPR* as illustrated in the blue curve in fig10. Since *PAPR* is plotted on a logarithmic scale and because we are considering 2 component carriers *(CCs)* for this experiment, this increase in *PAPR* as illustrated is around 10 $\log_2$ = 3.01 dB Higher *PAPR* means that a high power transmitter will be required.

To overcome the issue of high *PAPR* which leads to the need of expensive higher power amplifiers, we have suggested employing the scheme of *PTS* algorithm to reduce *PAPR* ratio as our simulation result expresses that in Fig. 4. It is clear that; employing the algorithm of *PTS* has effective enhancement in the performance of the system, where it reduced the *PAPR* by around 6 dB as compared to the original *OFDM* signal with *CA*.

Fig. 5 shows the effect of employing the second proposed scheme to reduce the disturbing issue of *PAPR* by using *SLM* algorithm. It is obvious that; this scheme of *SLM* is also effective to reduce the PAPR, but not like the *PTS* algorithm, where it provides improvement in *PAPR* reduction about 3 dB as compared to the original *OFDM* signal with *CA*.

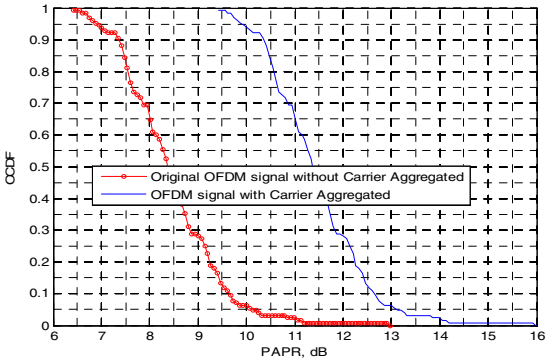

Fig.3: *PAPR* for Carrier Aggregated *OFDM* System with 2 *CCs*

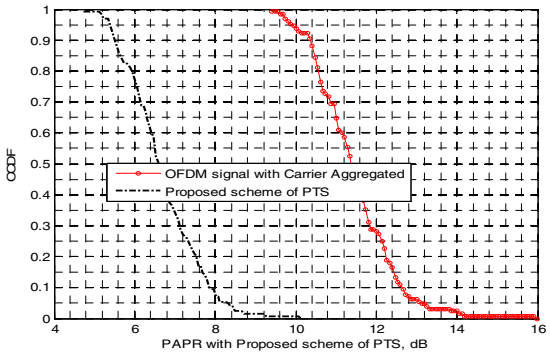

Fig.4: *PAPR* for Carrier Aggregated *OFDM* System with *PTS* Algorithm.

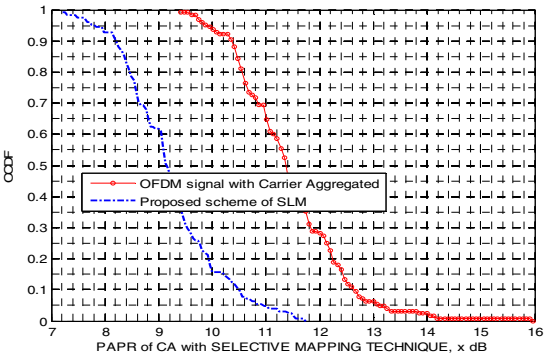

Fig.5: *PAPR* for Carrier Aggregated *OFDM* System with *SLM* Algorithm

Fig. 6 in our Matlab simulations holds a comparison among the effect of *PAPR* reduction using *OFDM* with *CA*, proposed scheme of *PTS* algorithm, and the proposed scheme of *SLM* algorithm. It is obvious that; the suggested scheme of PTS algorithm performs much better as compared to SLM scheme with a difference in PAPR of around 4 dB. So we conclude that; both of these signal scrambling techniques PTS and SLM can be employed in OFDM in order to optimize its performance for PAPR reduction, hence to get better power mangement. This reduction of PAPR means that; the OFDM system will not require high energy transmitters and itd power usage will be kept minimum. Finally, both the suggested schemes of *PTS* and *SLM* provide superiority for optimizing the system performance.

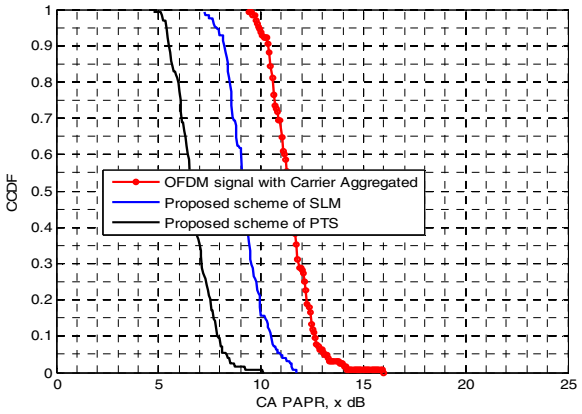

Fig.6: *PAPR* Comparison for Carrier Aggregated *OFDM* signal, *PTS* Algorithm, and *SLM* Algorithm.

6. The SUGGESTED DIGITAL MODULATION SCHEME to GET EFFICIENT PERFORMANCE for DVB BASED OFDM SYSTEM

After carrying out different experiments to investigate the performance of different modulation schemes with BER to support DVB based OFDM; Fig. 7 illustrates the outcome of this investigation for performance evaluation of BPSK, QPSK, 8-PSK, 16 PSK, 32 PSK, D-BPSK, D-QPSK, 4 QAM, 16 QAM, 32 QAM, and 64 QAM. The simulation result asserts that; of all the addressed modulation schemes, 4-QAM is the most promising technique to implement efficient DVB based OFDM. From this Fig. 4-QAM provides the lowest BER with adequate E_b/N_o in the system design.

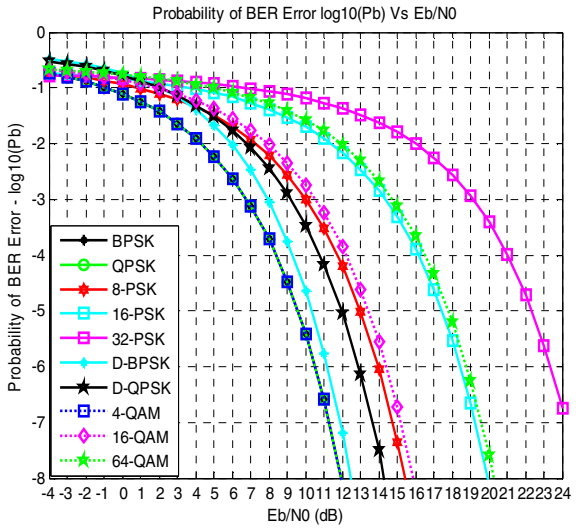

Fig. 7: Probability of BER versus Eb/N_o for different modulation schemes for DVB-OFDM.

5. CONCLUSION

Our manuscript addressed efficient schemes to design efficient DVB broadcast transceiver system based OFDM and 4 QAM. The performance of OFDM system has been analyzed and the bandwidth has been extended by employing carrier aggregation (CA). Also; we have addressed schemes for band width extension and to tackle the problem of PAPR of OFDM system. From our analysis and simulation using matlab we have noticed that; the bandwidth has been extended and the BER reduced using CA scheme. Moreover; the disturbing issue of PAPR has been reduced using both Partial Transmit Sequence (PTS) and Selection Mapping Technique (SLM) and confirmed their effectiveness for dealing with this problem professionally. With the PTS algorithm, we could achieve 6 dB lower PAPR ratios, while with the SLM algorithm; we achieved 2 dB difference. Thus, PTS performs much better than SLM with regards to PAPR. On the other hand concerning the modulation schemes; after carrying out different experiments to investigate the performance of different modulation techniques with BER to support DVB based OFDM; The simulation results assert that; of all the addressed modulation schemes, 4-QAM is the most promising technique to implement efficient DVB based OFDM, where it has provided the lowest BER with adequate E_b/N_o in the system design. So based on our simulation results and analysis we conclude that; all the addressed schemes in the overall system design have fruitful effect for optimizing the system performance and implementing the hardware simply and cost effectively by both the IFFT and FFT.

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