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An Overview: Peak-to-Average Power Ratio Reduction in OFDM System Using Block Coding Technique

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***Abstract* — One of the challenging issues for Orthogonal Frequency Division Multiplexing (OFDM) system is its high Peak-to-Average Power Ratio (PAPR). In this paper, we review and analysis different OFDM PAPR reduction techniques, based on computational complexity, bandwidth expansion, spectral spillage and performance the proposed scheme is termed sub-block complement coding (SBCC). Performance results obtained with SBCC are given and compared with that of the standard complement block coding (CBC), cyclic coding (CC), simple block coding (SBC), modified simple block coding (MSBC) and simple odd parity code (SOPC) for the same purpose. The results show that, at the same coding rate 3/4, the proposed scheme can achieve almost the same performance as the cyclic code but with lower complexity. But under the same coding rate, the PAPR reduction obtained by using SBCC is better than the rest schemes. The flexibility on choosing the coding rate and low complexity makes that the proposed scheme SBCC is more suitable for the large frame size with high coding rate and can provide error detection. We also discuss some methods of PAPR Reduction.**

***Keywords* - Sub-Block Complement Coding (SBCC), (OFDM) Orthogonal Frequency Division Multiplexing, High Power Amplifier (HPA), Peak-to-Average Power Ratio (PAPR).**

I. Introduction

Wireless digital communication is rapidly expanding resulting in a demand for wireless systems that have high data rate communication and has been deployed in many standards. OFDM is one of the MCM which offers high spectral efficiency, multipath delay speed tolerance, immunity to freq selective fading channels and power efficiency**.**

With the rapid growth of digital communication in recent years, the need for high-speed data transmission has increased. The mobile telecommunications industry faces the problem of providing the technology that be able to support a variety of services ranging from voice communication with a bit rate of a few kbps to wireless Multimedia in which bit rate up to 2 Mbps. Many systems have been proposed and OFDM system based has gained much attention for different reasons. Although OFDM was first developed in the 1960s, only recently has it been recognized as an outstanding method for high-speed cellular data communication where its implementation relies on very high-speed digital signal processing, and this has only recently become available with reasonable prices of hardware implementation.

II. Block Coding

A simple block coding scheme was introduced by Jones *etal.* [3], and its basic idea is that mapping 3 bits data into 4 bits codeword by adding a Simple Odd Parity Code (SOBC) at the last bit across the channels. The main disadvantage of SOBC method is that it can reduce PAPR for a 4-bit codeword. Later, Wulich applied the Cyclic Coding (CC) to reduce the PAPR [11]. In 1998, Fragia como proposed an efficient Simple Block Code (SBC) to reduce the PAPR of OFDM signals [12].

However, it is concluded that SBC is not effective when the frame size is large. Subsequently, Complement Block Coding (CBC) and Modified Complement Block Coding (MCBC) schemes were proposed to reduce the PAPR without the restriction offrame size [13], [14]. CBC and MCBC are more attractive due to their flexibility on choosing the coding rate, frame size and low implementation complexity. CBC and MCBC utilize the complementary bits that are added to the original information bits to reduce the probability of the peak signals occurrence.

In [15], [16], [18], authors used the Golay complementary sequences to achieve the PAPR reduction, in which more than3-dB PAPR reduction had been obtained. Codes with error correcting capabilities has been proposed in [17] to achieve more lower PAPR for OFDM signals by determining the relationship of the cosets of Reed-Muller codes to Golay complementary sequences. While these block codes reduce PAPR, they also reduce the transmission rate, significantly for OFDM systems with large number of subcarriers.

Even if it is possible, the complexity is still too high. Based on this motivates, authors of [19] proposed a novel method of computation and reduction of the PAPR and it mainly introduced a specific phase shift to each coordinate of all possible code words where phase shifts are independent of the code words and known both to transceiver, then it can be freely obtained more 4.5-dB PAPR reduction by using the optimized phase shifts. From this viewpoint, we also consider the coding scheme of PAPR reduction as a special phase optimization.

In summarization, the inherent error control capability and simplicity of implementation make coding method more promising for practical OFDM systems design. However, the main disadvantage of this method is the good performance of the PAPR reduction at the cost of coding rate loss.

Table I : Comparison with different coding schemes

N	n	R	PAPR Reduction (dB)			
			CBC	SBC	MCBC	CC
4	1	3/4	3.56	3.56	-	3.56
8	1	7/8	2.59	2.52	-	3.66
	2	3/4	2.67	3.72	2.81	3.66
16	1	15/16	2.74	1.16	-	3.74
	2	7/8	2.74	2.52	-	
	3	15/16	2.74	-	-	
	4	3/4	2.74	2.98	3.46	

To make comparisons, some results of the PAPR reduction obtained with different coding schemes have been shown in Table I, in which the number of sub block is 2 and the coding Rate $R = 3/4$ for MCBC. About 3-dB PAPR reduction can be obtained when coding rate $R > (N-2)/N$ by using CBC with long frame size. It is also shown that the PAPR reductions obtained with CBC when coding rate $R = (N-1)/N$ are almost the same as that when $R < (N-1)/N$. In addition,when coding rate is 3/4, more than 3-dB more PAPR reduction can be obtained using MCBC than the other schemes with any frame size. The flexibility in coding rate choice and low complexity makes the proposed CBC and MCBC schemes attractive for OFDM systems with large frame sizes and high coding rates.

III. DVBT MODEL

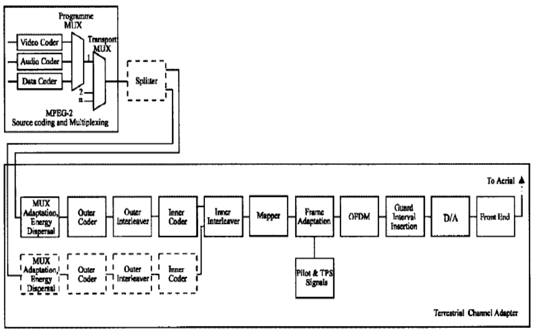


Fig.1.1. DVB-T transmitter [1]

A block diagram of the European DVB-T standard is shown in Figure 1.1. Most of the processes described in this diagram are performed within a digital signal processor (DSP), but the drawbacks occur in the physical channel; i.e., the output signal of this system. Therefore, it is the purpose of this project to provide a description of each of the steps involved in the generation of this signal and the Matlab code for their simulation.

DVB-T as a digital transmission delivers data in a series of discrete blocks at the symbol rate. DVB-T is a COFDM transmission technique which includes the use of a Guard Interval. It allows the receiver to cope with strong multipath situations. Within a geographical area, DVB-T also allows single-frequency network (SFN) operation, where two or more transmitters carrying the **same** data operate on the same frequency. In such cases the signals from each transmitter in the SFN needs to be accurately time-aligned, which is done by sync information in the stream and timing at each transmitter referenced to GPS.

The length of the Guard Interval can be chosen. It is a trade off between data rate and SFN capability. The longer the guard interval the larger is the potential SFN area without creating intersymbol interference (ISI). It is possible to operate SFNs which do not fulfill the guard interval condition if the self-interference is properly planned and monitored.

IV. MATHEMATICAL ANALYSIS

1) Characteristics of OFDM Signals:

Let a block of N symbols $X = \{Xk, k = 0,1 \dots\dots N-1\}$ is formed with each symbol modulating one of a set of subcarriers $\{fk, k = 0,1 \dots\dots N-1\}$, where N is the number of subcarriers. The N subcarriers are chosen to be orthogonal, that is $fk = k\Delta f$,

Where $\Delta f = \frac{1}{NT}$

And T is the original symbol period. Therefore, the complex envelope of the transmitted

OFDM signals can be written as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \, e^{j2\pi fkt}, \; 0 < t < NT$$

2) Definition of PAPR:

A) Baseband PAPR:

Continuous-time PAPR:

In general, the PAPR of OFDM signals s(t)is defined as the ratio between the maximum instantaneous power and its average power

$$PAPR[x(t)] = \frac{0 \le t \le NT[x(t)^2]}{P_{av}}$$

B) Passband PAPR:

OFDM system usually does not employ pulse shaping, since the power spectral density of the band-limited OFDM signal is approximately rectangular. Thus, the amplitude of OFDM RF signals can be expressed as

$$x_{PB}(t) = \{\Re\{x(t)e^{j2\pi fct}\}$$

C) Block coding :

Consider as an example that BPSK modulation is used in conjunction with an *N* carrier system.

The power of each individual carrier is normalised to 1 W while the envelope power is equal to *p(t) = s(t)s*(t)* where

$$s(t) = \sum_{n=1}^{N} d_n(t) e^{j(2\pi fnt + \varphi n)}$$

In the above formula, $\varphi n$is the initial phase and for simplicity is assumed to be equal to zero, *d,(t)* is the data stream applied to the Nth carrier represented by f l , and A is the frequency of the Nth carrier.

V. Proposed Model

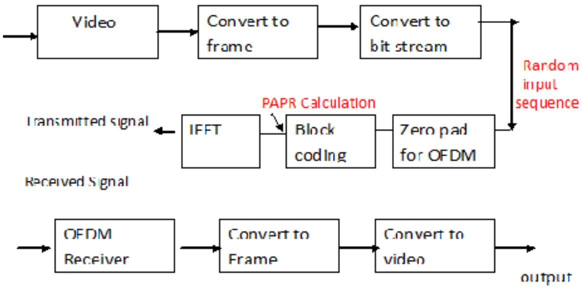


Fig.2. Block diagram

In this model, we will transmit video which consist of frames. This frame is converted into bit stream which is passed through OFDM transmitter. We will calculate PAPR without applying any method. Then after applying Block Coding Technique we will calculate the PAPR. Further the signal is received by the OFDM receiver.

VI. Simulations and Results

In this section, a BPSK OFDM system is assumed to be used for SBCC to compare with some well-know results of CBC, SBC, MSBC, SOPC and cyclic coding (CC).

It is an example to see the PAPR reduction improvement for SBCC over CBC in OFDM systems, where N = 16 and each with '®' stands for one complemental bit, and coding rate R = 3/4 as shown in Fig. 3.

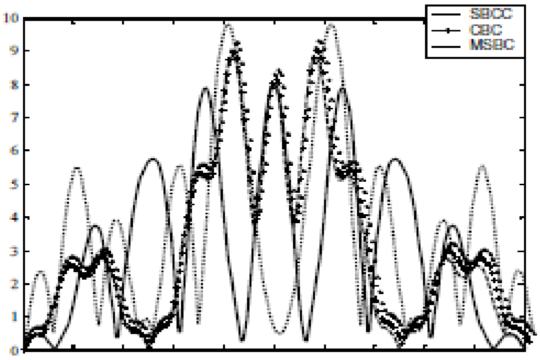
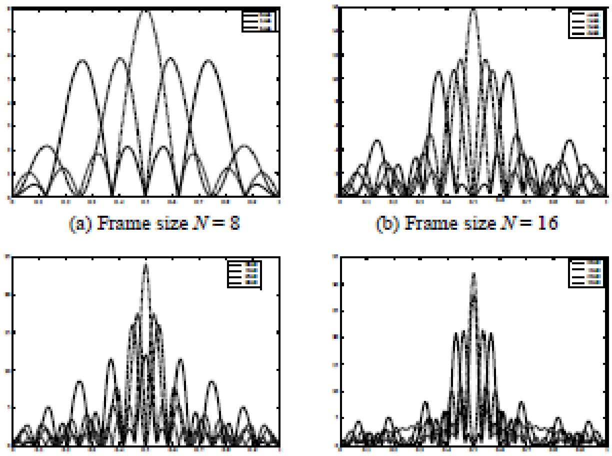


Fig.3. Performance improvement by using SBCC with frame load 0101®®010101®®01, with two sub-blocks

The PAPR reduction ΔPAPR =6.03 (dB) when the SBCC is used, and the ΔPAPR = 5.15 (dB)for CBC [7], and the ΔPAPR = 4.78 (dB) for MSBC and SBC[5] [6]. In order to be directly perceived the SBCC effective through the sense, the PAPRs maximum of different frame sizes obtained by SBCC with the same coding rate R = 3/4 and the each OFDM frame is divided to different sub-blocks are shown in Fig.4 and detailed values are given in Table. Some results of the maximum PAPR and the maximum PAPR reduction obtained with SBCC are given in Table, where n is the number of sub-blocks in each frame. In order to make comparisons, some results of PAPR and PAPR reduction obtained with CBC [7], MSBC [5], SBC [5] [6], SOPC [6] and CC [2], are also presented. From these tables, it can be observed that, under the same coding rate 3/4, the performance of the proposed scheme (SBCC) is almost the same as that of the cyclic coding. But under the same coding rate, such as 7/8 or 3/4, the PAPR reduction obtained by the proposed scheme SBCC is better than the rest schemes, like CBC and MSBC.



(a) Frame size N = 8 (b) Frame size N = 16
(c) Frame size N = 24 (d) Frame size N = 32

Fig.4. The maximum PAPR obtain by SBCC with the same coding rate 3/4and the OFDM frame divided into different sub-blocks

Frame Size N	PAPR (dB)		
	Sub-block n	SBCC	CBC
8	2	6.24	6.38
16	2	8.56	9.28
	4	8.49	
24	2	10.26	11.03
	3	7.80	
32	2	11.52	12.22
	4	11.31	

Table I. PAPR comparisons for SBCC and CBC under the same coding rate 3/4 but frame sizes are different

VII. Conclusion

OFDM is a very attractive technique for wireless communications due to its spectrum efficiency and channel robustness .One of the serious drawbacks of in OFDM systems is PAPR .In this paper ,we described several important aspects and Block Coding Technique .Specifically, a simple added bit code has been applied across the channels of a multicarrier system in order to reduce the peak power present. This has been achieved with a minimal increase in complexity and regardless of the number of channels present.

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