OFDM 시스템에서 PAPR 감소 방안에 관한 연구

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A Study for Reducing the PAPR in OFDM System

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Abstract

In this paper, we proposed new scheme to reduce the Peak-to-Average Power Ratio (PAPR) in Orthogonal Frequency Division Multiplexing (OFDM) system. OFDM system is highlighted for multi-media communication system, however it has large PAPR. To reduce the PAPR in OFDM systems, several techniques have been proposed such as clipping, coding and so on. Our proposed method is a case of block coding and proposed system be termed Sub-Coding OFDM (SC-OFDM) system. We also compare the performance between conventional and our proposed OFDM system by computer simulation.

I. Introduction

Recently, the requirement for the high-speed transmission becomes larger and larger in wireless communications. In the wireless communications, the channel is basically the multipath channel, and this feature makes high-speed transmission difficult to be achieved. The multipath environment means that the receiver receives several reflected rays resulting in Inter-Symbol Interference(ISI) [1]. OFDM is an effective technique for high speed digital transmission in a severe frequency selective fading channel. OFDM has variety of applications for telephone line, terrestrial digital television broadcasting and wireless local area networks [2]. The advantage and disadvantage of OFDM system is following.

◎ Advantage

(1) One users data is parallel-converted and transmitted with several carriers. By doing so, an influence of frequency selective fading is relieved.
(2) The data rate becomes larger than that of single carrier case, because of the orthogonal overlapping of carriers in frequency domain.

◎ Disadvantage

(1) Sub-carrier orthogonality requires accurate frequency synchronization, since frequency error will produce Inter-Carrier Interference (ICI).
(2) The OFDM signals always have high PAPR, which makes the linearity requirement on the transmitter amplifier quite stringent [3 - 4].

To reduce the PAPR in OFDM systems, several techniques have been proposed such as clipping, coding, two-branch combining, and constant peak OFDM(CP-OFDM). Coding schemes are the most attractive ones due to their inherent error control capability and the simplicity of implementation [5]. In this paper, we propose the method named Sub-Coding technique of reducing the PAPR in OFDM system. The SC technique is a method of block coding that has 3/4, 6/8 and 12/16-code rate. The SC technique is operated by Exclusive-OR and NOT and we explained the SC technique in section.III concretely.

II. Conventional OFDM system, PAPR

The principle of OFDM is to provide high bit rate transmission by using a number of low bit rate carriers. The frequency bandwidth is divided into

small ones and these low rate carriers handle each of them. An OFDM system, because of the orthogonal overlapping of carriers, it can increase the bandwidth efficiency. The data bit is transmitted in parallel at N different carriers [3, 6]. The incoming data bits with bit duration T_b are serial-to-parallel converted into N parallel bit streams with symbol duration $T=NT_b$. After the serial-to-parallel conversion, the symbols on each low-rate branch are modulated by N different carrier signals. Then parallel-to-serial converter adds each modulated signal. Thus, the transmitted signal as follows.

$$s(t)=\sum_{k=0}^{N-1}\cos(f_0+k\triangle f)t,\ \text{N: carrier number} \quad (1)$$

$$\triangle f=\frac{1}{T_b},\ T_b\text{: Time duration of the bit}$$

At the receiver, serial-to-parallel converter separates the received signal, and each branch demodulated each data. The Peak Envelope Power (PEP) and Average Power (AP) is defined maximum and average value of one symbol frame. And the relation is represented as formula (2) and (3).

$$P_{PEAK}=Max\{|S_l(t)|^2\},\ (0\le t< T,\ -\infty< k<\infty) \quad (2)$$

$$P_{AVERAGE}=Mean\{|S_l(t)|^2\},\ (0\le t< T,\ -\infty< l<\infty) \quad (3)$$

And the PAPR is defined as formula (4)

$$PAPR=10\log_{10}\left\{\frac{P_{PEAK}}{P_{AVERAGE}}\right\}[dB]$$

PAPR means the non-linearity of the transmission signal in OFDM system. High PAPR of the transmission signal in OFDM system grows into ICI and interference signal caused by non-linearity. Thus, the reducing method of the PAPR in OFDM system is required and many researches were carried out. Here, we propose a method of block coding to solve the PAPR problem, which has 3/4, 6/8 and 12/16-code rate.

III. Proposed OFDM System

In this section, we consider the operation of technique, called SC technique, to reduce the PAPR in OFDM system concretely. The PAPR of conventional OFDM system is large because of the effect of transmitted signal of conventional OFDM system having large peak value. Thus, we propose the system that constrains the peak value of OFDM system and explain the method concretely in following. Figure.1 shows the structure of the proposed system that has 4 carriers. First, a 3-bit information bit stream is divided into each bit and the forth bit, which can be represented by formula (5), is generated from these three bits by the operation of Exclusive OR and NOT . By using the 3/4-encoder, 3-information bits can be transmitted simultaneously.

$$d_4=\overline{d_1\oplus d_2\oplus d_3} \quad (5)$$

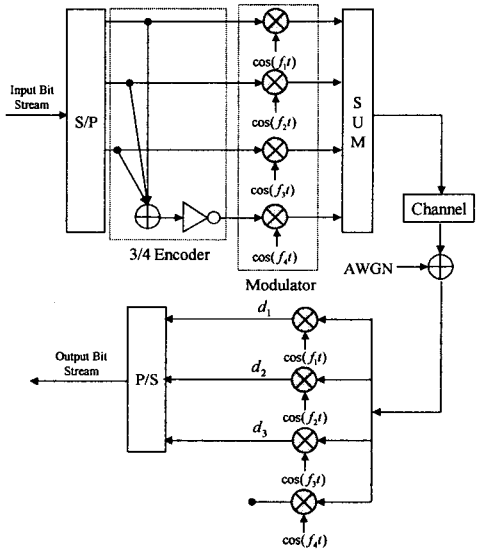

Fig.1 Proposed OFDM system (4-carriers)

In Table.1, we represent information bit and encoded bits generated by using the proposed system. From encoded bits part, we cant observe two bits, 0000 and 1111, existing in conventional OFDM system case. In SC technique, the PAPR can be reduced as the redundancy bit, the fourth bit, plays a role of constraining the peak power of the transmitted signal. At the receiver, the system receives 4-bits at a time and can detect the information bits, which are recombined by

parallel-to-serial converter, by removing the forth bit, because the redundancy bit, the fourth bit.

Information bit	Encoded bit
0 0 0	0 0 0 1
0 0 1	0 0 1 0
0 1 0	0 1 0 0
0 1 1	0 1 1 1
1 0 0	1 0 0 0
1 0 1	1 0 1 1
1 1 0	1 1 0 1
1 1 1	1 1 1 0

Table.1 Information bit and Encoded bit

Now we consider system having 8-carrier number case, which can be designed by using parallel combination of 3/4 encoders, and the code rate is 6/8. In Fig.2, we represented our proposed system which carrier number is 8.

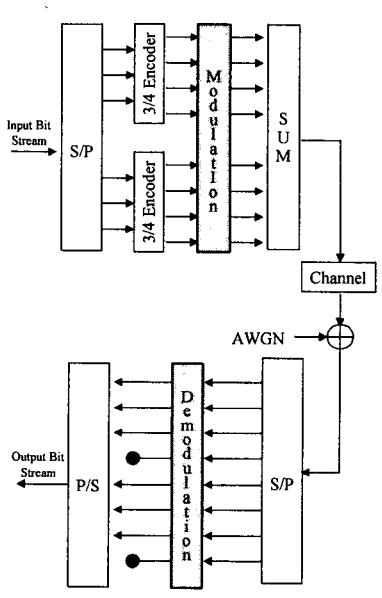

Fig.2 Proposed OFDM system (8 carrier case)

First, a 6-bit information bit stream is divided into two of 3-bit information bit streams. Passing through the parallel combination of 3/4 encoders, 6 information bits are converted into 8 encoded bits that are transmitted simultaneously. Though the number of carrier is increased, we can construct the OFDM system easily by using parallel combination of the 3/4-encoder system and reduce the value of the PAPR of the OFDM system.

IV. Simulation Results

We simulated that conventional OFDM system and our proposed system that has carrier 4, 8 and 16 carrier numbers cases respectively. Simulation environments is without noise channel. Simulation results shows that the proposed OFDM system produces good results as compared with conventional OFDM system (see Table.2).

Carrier number	System	PAPR [dB]	Improvement [dB]
4	Conventional	4.7537	0.8529
	Proposed	3.9008	
8	Conventional	5.0150	0.7661
	Proposed	4.2489	
16	Conventional	4.8167	0.9162
	Proposed	3.9005	

Table.2 The performance of conventional and proposed OFDM system

In Table.2, we show the simulation results and can know that the proposed system improves the PAPR by around 0.8dB when comparing to conventional OFDM system case.

V. Conclusions

Recently, the requirement for the high-speed transmission becomes larger and larger in wireless communications and OFDM is an effective technique for high speed digital transmission over wireless communication system. But its main problem is large PAPR which has a bad effect in capability of OFDM system. We propose the new scheme named SC technique to reduce the PAPR and observe that the SC technique improves the PAPR from the simulation results. Our proposed system improved that the PAPR around 0.8dB as compared conventional OFDM system. In conclusion, our proposed system can apply to many wireless

communications system such as multi-media communication system and mobile communications systems to improve the performance.

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