IMPROVEMENT OF CHANNEL ESTIMATION FOR CHINESE DTMB SC-MODE

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ABSTRACT

Chinese Digital Terrestrial/Television Multimedia Broadcasting (DTMB) systems use pseudo random noise (PN) sequence instead of cyclic prefix for channel estimation. This paper proposes threshold and CIR width detection methods to improve the channel estimation and shows that threshold method combined with averaging and PN correlation reduction method needs special care for high DUR condition and that CIR width detection is another improvement method to solve the high DUR condition channel estimation.

Index Terms— DTMB, Single Carrier Mode, PN Sequence, Correlation, Equalization

1. INTRODUCTION

In a wireless communication system design, a multi-path environment which has the main and delay signal traveling paths from a transmitter to receiver has to be taken into account since it distorts the traveling signals. Then it very important to estimate the multi-path channel condition correctly.

Chinese Digital TV broadcasting system of DMBT SC (single carrier) mode uses a serially inserted PN sequence for channel estimation. This time-domain PN sequence method is different from conventional OFDM communication systems such as DVB-T (European Digital TV), ISDB-T (Japanese Digital TV), 802.11abgn (WLAN), and so on. In this paper, simulated result of DMBT SC mode is shown and DMBT SC mode channel estimation method and improvements will be discussed.

2. CHINESE DIGITAL TV SYSTEM

Chinese DTMB system has two transmission modes which are Single carrier mode (SC-MODE) and multi carrier mode (MC-MODE). This research is focused on single carrier mode. The block diagram of Chinese DTMB transmit and receive system is shown in Figure 1.

2.1. Frame Structure

Figure 2 shows frame structure of Chinese DTMB.

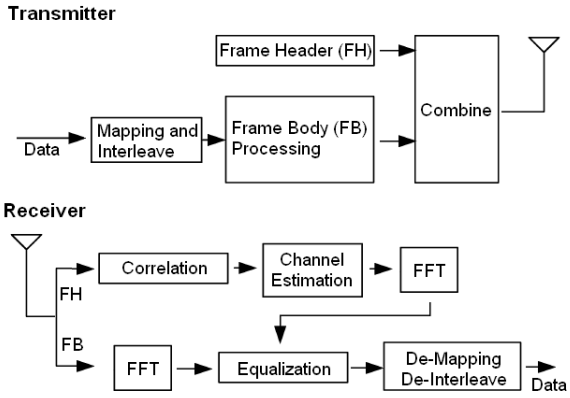

Fig. 1. Transmitter & receiver

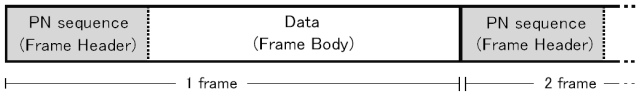

Fig. 2. Frame structure

The data are divided into a frame and transmitter sends broadcasting data by using the frame as a unit. Each frame contains a frame header (FH) and a frame body (FB). The FH is made Pseudo-Noise (PN) sequence. The PN sequence is generated linear feedback shift register. There are three different PN lengths of 420, 595 and 945 symbols. For example, circuit of PN420 is shown in figure 3.

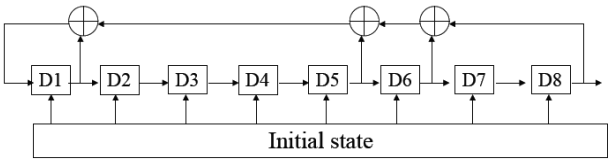

Fig. 3. Linear feedback shift register of PN420

Single carrier modes use the common PN sequence for each frame. This pre-determined PN sequence is utilized for channel estimation in Chinese digital TV system. On the other hand, the FB consists of system information and coded data.

2.2. Correlation

Channel impulse response (CIR) will be estimated by the PN sequence correlation calculation. Figure 4 shows an example of correlation calculation result for two path multi-path channel, 100 symbols delay.

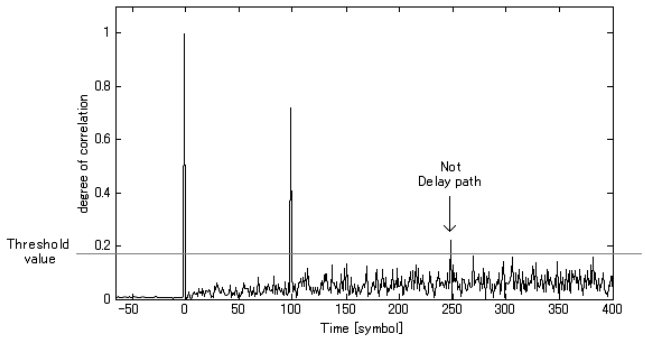

Fig. 4. Correlation result

In the result of the correlation calculation, a big peaks are generated when the received PN sequence matches all of the PN sequence. The biggest peak and second big peak corresponds to main signal and delayed signal, respectively. As a result, correlation outputs correspond to channel impulse response. However, although data and PN sequence have no correlation theoretically, low level noise-like correlation output is obtained. It has a negative impact. Because noise might be considered as one of CIR when the value is more than threshold.

3. CHANNEL ESTIMATION IMPROVEMENTS

3.1. Threshold method

3.1.1. Averaging

In order to improve the CIR estimation, firstly an averaging method is evaluated. Since the noise floor mainly depends on data, CIR averaging reduces the noise floors effectively. Figure 5 shows correlation of after averaging method.

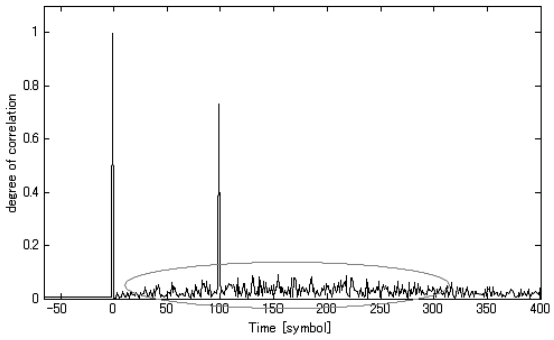

Fig. 5. Threshold method after Averaging

3.1.2. Fixed PN noise reduction

However, a remaining noise floor exists by the correlation between received common PN sequence and generated PN sequence. The noise is circle part's noise floor of arch shape in Figure 5. This arch shape's noise can be generated PN sequence + zeros and PN sequence correlation. Figure 6 is this image and correlation result. Zeros mean FB value reaching zero value by averaging CIR.

When the remaining noise floor is canceled from the averaged correlation signal, the noise-like outputs can be reduced further. This effect shows Figure 7.

Therefore, these methods can reduce threshold value as low as possible. Receiver will be detectable for much weaker level multi-path.

3.2. Power Profile Width Detection Method

Another proposal is power profile width detection method instead of threshold method explained in previous section 3.1. Since low level CIR peak might be miss-detected when the peak is lower than threshold. This method calculates power of correlation result and determines CIR path length as shown in Figure 8.

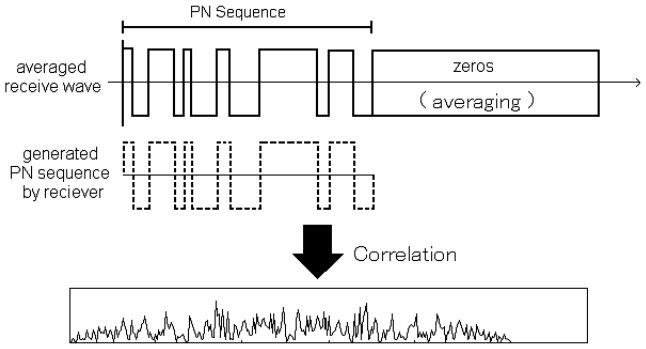

Fig. 6. Removing fixed PN noise

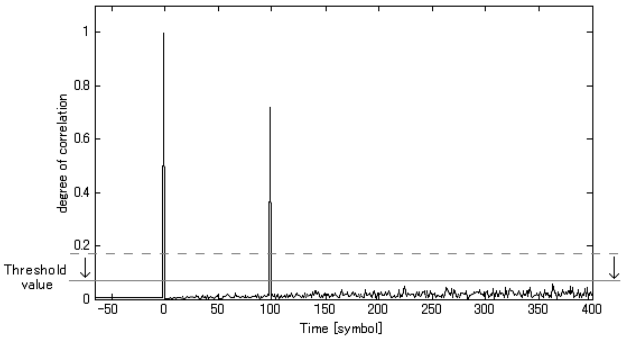

Fig. 7. Threshold method after Averaging & Removing

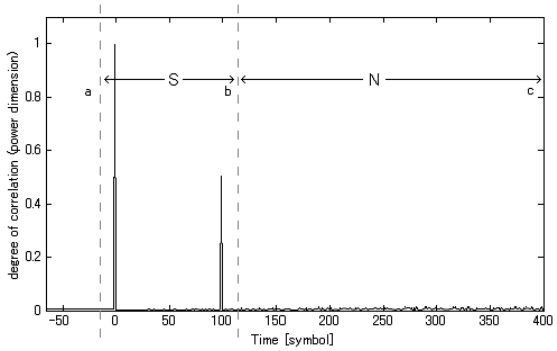

Fig. 8. Power profile

The power profile is divided into 2 ranges such as S-range and N-range.

$$S = \int_a^b |correlation(x)|^2$$
$$N = \int_b^c |correlation(x)|^2$$

S and N show power between a to b, and b to c. By defining S/N value, the border b between S-range and N-range can be calculated. Once S-range is determined, CIR length is determined.

4. SIMULATIONS AND RESULTS

Table 1 is the simulation parameters for simulation and cannel estimation parameter for threshold method. Table 2 shows channel estimation parameters for Power Profile Width Detection Method.

Table 1. threshold method specifications

modulation		64 QAM		
CNR		30 dB (AWGN)		
channel model		2 waves multi-path		
delay time		13 μ s (100 symbol delay)		
DUR		0〜30 dB		
GI length		55.56 μ s (420 symbol)		
channel estimation	averaging	×	8 frame	8 frame
	PN reduction	×	×	○

Table 2. power width detection method specifications

channel estimation	averaging	8frame	16frame	32frame
	PN reduction	○	○	○
other item : same table1				

Figure 9 and 10 shows BER by DUR simulation results for threshold and Width Detection Methods, respectively. According to figure 9, if delayed path is lower than the threshold, CIR estimation miss has large impact on BER performance, although averaging and removing is effective. According to figure 10, more than 32 symbol average is needed to detect the adequate CIR range detection. Once the CIR range is detected BER degradation does not happens even for large DUR range.

5. CONCLUSION

This paper evaluated time-domain PN based channel estimation for SC mode of Chinese DTMB. Threshold method com-

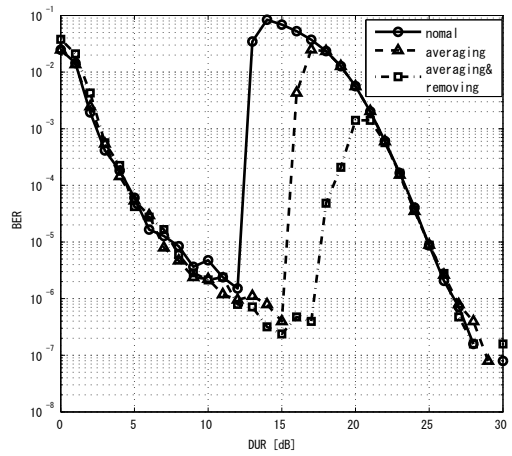

Fig. 9. BER vs. DUR of threshold method

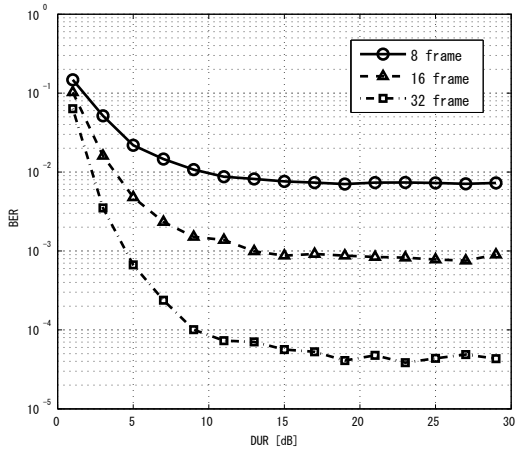

Fig. 10. BER vs. DUR of power width method

bined with averaging and PN correlation reduction needs special care for high DUR condition. CIR width detection is another improvement method to solve the high DUR condition channel estimation.

6. REFERENCES

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