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Method for Calculating Protection Ratio between Digital Broadcasting systems

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1. Introduction

According to the rapid development of the digital technology, the broadcasting environments are changing into the digital television transmission including the Advanced Television Systems Committee (ATSC), Integrated Services Digital Broadcasting–Terrestrial (ISDB-T), Digital Video Broadcasting - Terrestrial (DVB-T), etc of the high quality and high-efficiency from the existing analog television transmission. In the transition to digital broadcasting, the methods that can efficiently use the limited broadcasting frequency resources are studied in many countries. Particularly, in the digital television broadcasting environment, since the countries using the different digital television broadcasting system(for example ATSC in Korea, ISDB-T in Japan) is positioned nearby, the interference is generated each other and the frequencies are unable to be efficiently used. Therefore, the mutual interference effect must be analyzed through setting up the Protection Ratio(PR) which is interference allowed value between the different broadcasting systems and the digital broadcasting channel must be arranged to minimize the interference, then the broadcasting frequencies can be efficiently shared and used.

Until now, it is general that the field test data are used for setting up the PR between the broadcasting systems [1][2]. But it needs much time and cost in order to collect and analyze the field test data. Therefore, by drawing method for setting up the PR based on the computational simulation, it is easy to calculate the PR about the corresponding system. In this paper, we proposed the method for calculating the PR of the ATSC broadcasting system from the ISDB-T broadcasting system through the computational experiment. For this, the transmitter/receiver of the ATSC system and transmitter of the ISDB-T system were modeled. By integrating those, the computational simulator for setting up the PR of the ATSC system from the ISDB-T system was implemented.

2. ATSC and ISDB-T system Modeling

2.1 ATSC 8VSB System Modeling

The ATSC system was specifically designed to permit an additional digital transmitter to be added to each existing NTSC transmitter. The ATSC Digital Television Standard was developed by the Advanced Television Systems Committee in the Unite States [4][5]. The ATSC system was designed to transmit high-quality video and audio (HDTV) and ancillary data over a single 6 MHz channel. The ATSC Vestigial Sideband modulation with 8 discrete amplitude levels (8-VSB) system transmits data in a method that uses trellis-coding with 8 discrete levels of signal amplitude. A pilot tone provided to facilitate rapid acquisition of the signal by receivers. Complex coding techniques and adaptive equalization are used to make reception more robust to propagation impairments such as multipath, noise and interference. It can reliably deliver about 19.39 Mbps of data throughput in a 6 MHz bandwidth.

Fig 1 presents a functional block diagram of 8 VSB transmitter and receiver. The 8-VSB transmitter can represent to three parts, the Forward Error Correction (FEC), the Insertion of the sync signals, and 8-VSB modulation.

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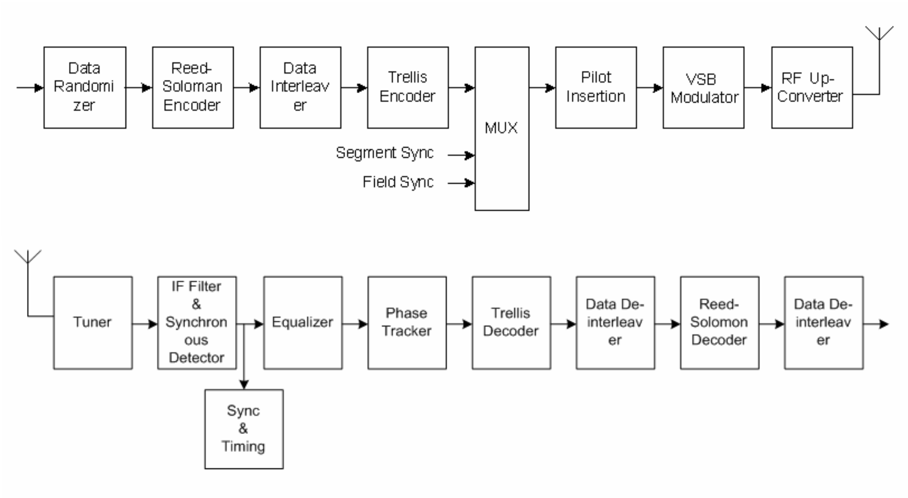

Figure 1: Functional block diagram ATSC transmitter/receiver

Table 1: Parameters for ATSC 8VSB transmission modes

Parameter	ATSC 8VSB
Bandwidth	6 MHz
Excess bandwidth	11.5%
Symbol rate	10.76 MSPS
Bits/Symbol	3
Trellis FEC	2/3 rate
Payload data rate	19.39 Mb/s
C/N threshold	14.9 dB

2.2 ISDB-T System Modeling

In this chapter, we review the ISDB-T system adopted as the standard of the digital broadcasting in the Japanese is reviewed [6]. The ISDB-T modulation scheme, also called BST COFDM (Band Segmented Transmission Coded-OFDM), was developed to broadcasting digital terrestrial TV with the use of flexible modulation. The 6-MHz channel band is divided into 13 segments of width 429 kHz each. In the same channel, it is possible to transmit one HDTV signal with 64QAM modulation and one signal of “one-segment TV for reception by a narrowband portable receiver. ISDB-T system uses frequency band of 188 MHz~192 MHz and 2535 MHz~2655 MHz, and applies to the frequency and time interleaving.

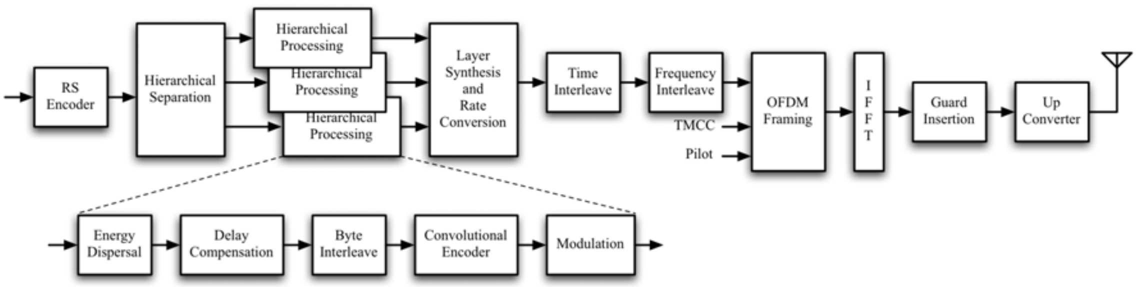

Figure 2: Functional block diagram of ISDB-T transmitter

Fig 2 presents a functional block diagram of ISDB-T transmitter. As shown in the figure, a transmitter is comprised of the RS encoder, the Hierarchical Processing, the Rate Conversion, the Time and Frequency Interleaving, the OFDM Framing, the IFFT block and Guard Interval Insertion, etc. In the hierarchical processing, each hierarchical layer performs the Energy Dispersal, the Delay Compensation, the Bute Interleaving, the Convolutional encoding, and Modulation.

Table.2: Parameters for ISDB-T Transmission Modes

Parameter	ISDB-T
Bandwidth	5.575MHz
Sampling rate	8.127 MHz
Modulation	64QAM
FEC	3/4
Guard Interval	1/16
Time Interleaver	200 ms
Data rate	19.3 Mbps
C/N threshold	18.9 dB

3. Simulation for Protection ratio

3.1 Simulation Method

Here, we describe the method for calculating the PR of the ATSC system from the ISDB-T system through the computational experiment. For this, the transmitter/receiver of the ATSC system and transmitter of the ISDB-T system were modeled. The wanted transmitter and receiver use the ATSC 8-VSB system and the interfering transmitter uses the ISDB-T system. In order to simplify the simulation complexity, it modeled sending/receiving signals in the IF band instead of those in the RF band. It was assumed that one received signal was considered in the channel modeling and there’s no AWGN. In ATSC receiver, the SER 0.2 of the trellis decoder input signal was used as the TOV performance[3].

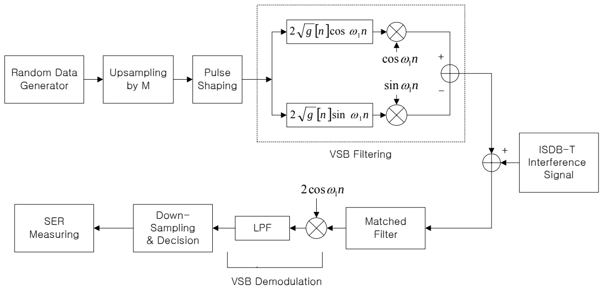

Figure 3: Simulation block diagram

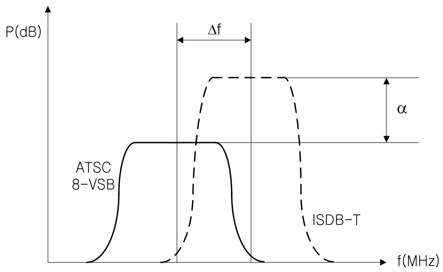

Figure 4: Wanted/interfering signal modeling

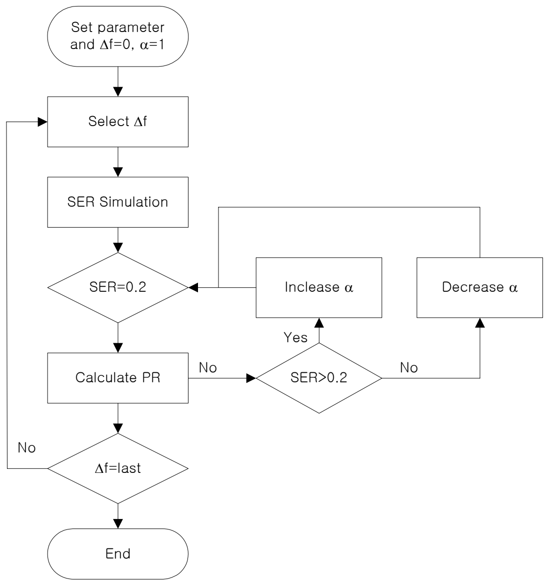

Figure 5: Flowchart for calculating protection ratio

Fig.3 shows the simulation block diagram for the protection ratio calculation for ATSC from ISDB-T. The implemented simulation system comprises 8-VSB transmitter/receiver and ISDB-T interfering signal transmitter. The transmitting signal moves to 5. 38MHz of the IF band after the Random Data Generator and Up-sampling, Pulse Shaping, and the Modulation of the ATSC 8-VSB system. Next, 8-VSB wanted signal in IF band is added with the ISDB-T interfering signal, and arrives the receiver end. Fig. 4 shows the wanted/interfering signal modelling. The Δf is the difference between the center frequencies of interfering and desired signal and α is the relative power between the desired and interfering signal. The PR for the ATSC system from the ISDB-T system is measured by calculating the SER value. Figure 5 shows the flowchart for calculating the PR.

1) Set up the Δf=0 and α =1.
2) By controlling the α, find the α when the SER value becomes 0.2, that is the protection ratio in co-channel
3) Change the Δf.
4) By controlling the α, find the α when the SER value becomes 0.2.
5) Repeat 3), 4) until the Δf is final value.

3.2 Simulation Result

Fig 6 shows PR values according to Δf. The maximum bandwidth of ISDB-T, 5.575MHz is smaller than 6MHz of ATSC, and PR value does not change in -1 to +1 of Δf. Except for such case, we can confirm that the PR value decreases as the Δf increases. Because the affect of the interference signal is decreased as the Δf increases, although it transmits relatively low power of the signal, SER=0.2 can be obtained.

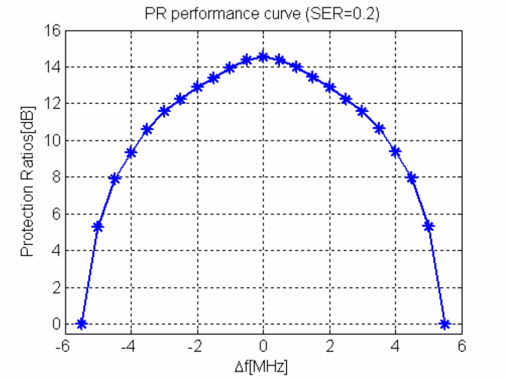

Figure 6: Protection ratios according to Δf [dB]

4. Conclusions

In this paper, we proposed the method for calculating the PR among broadcasting systems through the computational experiment, and calculate the PR value of the ATSC broadcasting system from the ISDB-T broadcasting system. As the technology develops, the new broadcasting system shows up. But whenever the new broadcasting system shows up, it is hard to find the PR through a measurement. Therefore, by using this kind of method, it will be able to easily calculate the PR between the new digital broadcasting systems.

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