Coverage Prediction for ATSC interference form ISDB-T system

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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 ATSC, 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. The PR is the minimum value of wanted-to-unwanted signal ratio, usually in decibels (dB) at the receiver input. By this analysis, the digital broadcasting channel must be arranged to minimize the interference, then the broadcasting frequencies can be efficiently shared and used.
In this paper, we measured the PR of the ATSC broadcasting system from the ISDB-T broadcasting system through the laboratory test. By using the measured PR value, the coverage prediction considering the interference was performed between the adjacent nations which use the different digital broadcasting system.

2. ATSC and ISDB-T system

2.1 ATSC system

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 United States. 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.
The 8-VSB transmitter can represent to three parts, the Forward Error Correction (FEC), the Insertion of the sync signals, and 8-VSB modulation.

2.2 ISDB-T system

In this chapter, we review the ISDB-T system adopted as the standard of the digital broadcasting in the Japanese is reviewed [5]. 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. The ISDB-T system uses RS (Reed-Solomon) code (204, 188, 8) as the outer code and the convolutional code as the inner code. The ISDB-T system uses 4 types of modulation of DQPSK, QPSK, 16QAM and 64QAM. It is classified as the various transmission modes according to 3 FFT modes of 2K, 4K, 8K and the combination of 4 guard intervals of 1/4, 1/8, 1/16, 1/32. It uses the MPEG-2 Layer II, AC-3, and the MPEG-2 AAC as the audio coding, the multiplex of the MPEG-2 mode.

ISDB-T 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 1: ATSC transmission parameter

Parameter	ATSC 8VSB
Bandwidth	6 MHz
Excess bandwidth	11.5%
Symbol rate	10.76 MSPS
Trellis FEC	2/3 rate
Reed-Solomon FEC	T=10(207,187)
Segment length	832 symbols
Payload data rate	19.39 Mb/s
C/N threshold	14.9 dB

Table 2: ISDB-T transmission parameter

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. Laboratory Measurement for PR

Here, we describe for measuring the PR of the ATSC system from the ISDB-T system through the laboratory measurement. Figure 1 shows the measurement block diagram for ATSC from ISDB-T. The implemented measurement system mainly comprises 8-VSB transmitter/receiver, ISDB-T interfering signal transmitter and spectrum analyzer.

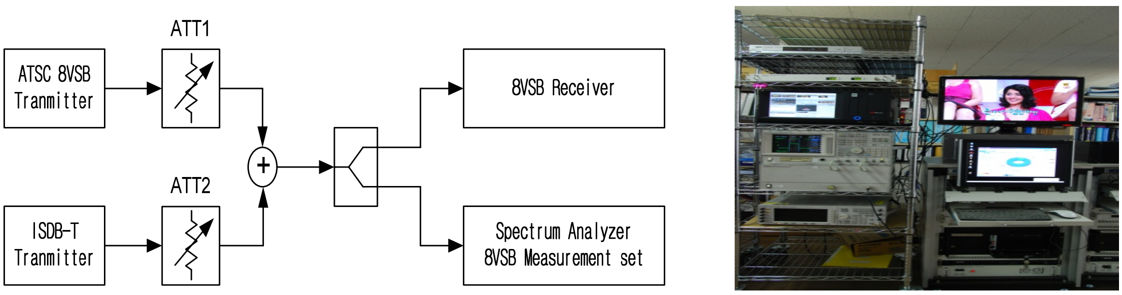


Figure 1: Block diagram and picture for measurement

The ATSC and ISDB-T transmitting frequency sets as 635 MHz, the centre frequency of TV channel 41, which is the middle of UHF TV band and input power level in the ATSC receiver sets as -68dBm, that is weak input signal level. As the ISDB-T interference signal power is slowly increased, we measure the input power level of the ISDB-T signal in the point that the screen begins to be broken.

As the frequency difference, Δf increase by 0.5MHz, above process is repeated. The Δf is the difference between the centre frequencies of interfering and desired signal. Therefore, we can measure the ISDB-T input power level and calculate the PR by 0.5MHz. Figure 2 shows PR values comparison between simulation and measurement according to frequency, Δf. The maximum bandwidth of ISDB-T, 5.575MHz is smaller than 6MHz of ATSC, and PR value almost 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.

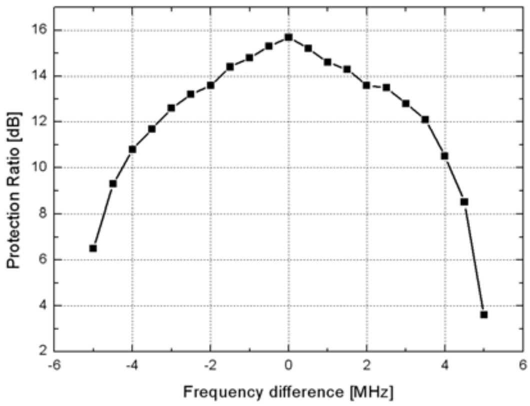


Figure 2: Protection ratios according to Δf [dB]

4. Coverage Prediction

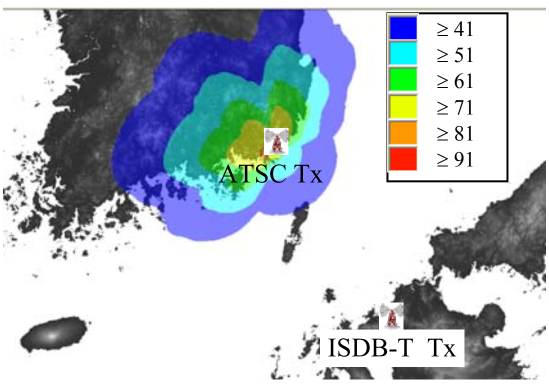
By using the measured PR value, we analyze about the interference effect when the countries using the different broadcasting system (ATSC in Korea, ISDB-T in Japan) are adjacent. Here, ATSC transmitter regarded as the wanted one and ISDB-T transmitter as unwanted one. The ATSC signal in the service area receives the understanding interference effect from the ISDB-T signal.

We use the ITU-R 1546 propagation model. The desired signal applies 90 % of time and interfering signal applies the 10 % of time variability. The straight distance is about 170 km between two transmitting sites. The minimum field strength of the ATSC system assumed to 41 dBμV/m. The specific parameters of the transmitters used for the coverage prediction showed in the Table 3.

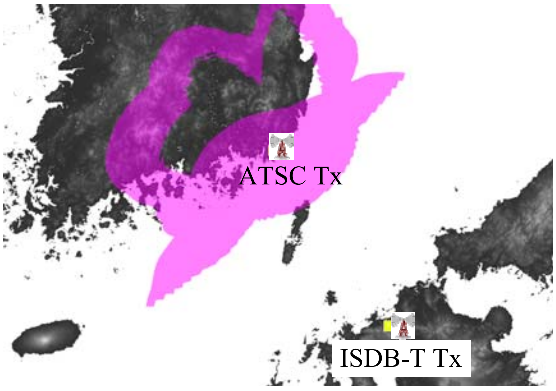
Table 3: Parameters for transmitters

Parameter	Wanted Tx	Unwanted Tx
Site name	ATSC Tx	ISDB-T Tx
Latitude	35° 09′ 33″	34° 10′ 38″
Longitude	129° 04′ 56″	130° 21′ 51″
Antenna Height	420 m	580 m
Antenna pattern	4 dipole, 4 Bay (0° 90° 180° 270°)	
Transmitted power	1kW(ERP)	
Polarization	Horizontal	
Center frequency	473 MHz	

As you can see in Figure 3, the interference region in the total ATSC broadcasting coverage mainly shows up in the sea, but there are a part of interference is generated in the land bordering the sea. It can not be served the ATSC broadcasting in that region. To serve in the region where the interference is occurred, it is necessary to install the additional TV Repeater and assign the other RF channel. The other way is reduction of the interference from ISDB-T signal. To reduce the interference, it is required the change of the ISDB-T transmitting parameters. Therefore, in order to use a co-channel in two transmitting stations, the output power or antenna gain of the interfering transmitter have to be reduced, and the antenna directivity has to be changed.



(a) Field strength of ATSC transmitter



(b) Interference region

Figure 3: ATSC and ISDB-T signal spectrum

5. Conclusion

In this paper, we measured the PR value of the ATSC broadcasting system from the ISDB-T broadcasting system and analyzed about the interference effect when two transmitters are located adjacent. As the technology develops, another new digital broadcasting system will show up. By using this kind of procedure, the coverage prediction considering the interference can be performed between different digital broadcasting systems. Through this result, it will be helpful to the interference coordination between the adjacent countries using the different broadcasting system

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