Channel Allocation Plan for DAB and DRM+ Systems in VHF Band III

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***Abstract*— Recently, analog radio systems are being replaced with digital radio systems. The digital radio can provide high quality services because it is robust to interference and it has a high power efficiency. Thus, an efficient channel allocation plan is needed. This paper proposes a channel allocation plan for Digital Audio Broadcasting (DAB) and Digital Radio Mondiale Plus (DRM+) systems in Very High Frequency (VHF) band III, and presents interference analysis results about this plan. In the channel allocation plan for only DAB system, some local stations lack extra available programs. Accordingly, DRM+ blocks are allocated to the local stations. This paper analyzes the interference between the DAB system and between the DRM+ system. These results will contribute to broadcast network planning of the digital radio.**

Keywords-Digital radio broadcast; DAB system; DRM+ system; Channel allocation plan.

I. INTRODUCTION

Recently, most communication systems are changing the digital systems [1] because analog communication systems are sensitive to noise and have a low frequency efficiency. Also many countries are promoting the introduction of the digital radio and some countries are actually providing digital radio service.

Digital radio is robust against interference, has a higher power efficiency than existing systems and can provide additional data service, such as a text messege, image, thus it can provide high quality of service that can enhance competitiveness of the radio medium. In particular, it can efficiently use the limited frequency resources because it can multiplex various programs on a single broadcast channel. So, existing broadcasters are able to provide additional services and the listener can obtain a variety of media by introducing new radio operators.

In this paper, we develop a channel allocation plan for the DAB system [7] and DRM+ system [8] in VHF Band III. In this paper, we present the interference analysis simulation results.

This paper content is: In Section 2, the DAB and DRM+ systems are presented. Section 3 describes the DAB and the DRM + channel assignment scheme in the VHF channel. In Section 4, we presents results of the interference analysis simulation. Finally, in Section 5, we present the conclusion.

II. DAB/DRM+ SYSTEMS DESCRIPTION AND FREQUENCY ASSIGNMENT SCHEME

A. DAB and DRM+ systems desription

The DAB system can provide a high quality service and excellent mobile reception quality by using audio compression technology based on Moving Picture Experts Group (MPEG) Audio Layer II [2]. Also, it has high efficiency of using frequency because it can transmit multiple programs to an OFDM signal called ensemble. In this paper, 9 programs are transmitted through one ensemble allotted 128kbps bit rate. The transmission method of DAB is Coded Orthogonal Frequency Division Multiplexing (COFDM).

TABLE I. DAB AND DRM+ SYSTEMS FEATURE

	DAB	DRM+
Frequency	Band-I, II, III, IV, L-Band	30MHz ~ Band-III
Transmission	COFDM	COFDM
Modulation	DQPSK	4-QAM 16-QAM
System bandwidth	1.536 MHz	100 kHz
Number of subcarriers	1536	213
Subcarrier spacing	1 kHz	444 Hz
Audio coding	MPEG Audio Layer II	MEPG-4 CELP MPEG-4 HVXC

Broadcast frequency of DRM+ system is extended to 240 MHz also bandwidth is increased to 100 kHz. It uses MPEG-4 Code Excited Linear Prediction (CELP) and MPEG-4 Harmonic Vector excitation Coding (HVXC) in audio coding. The DRM+ system can select one of 4-Quadrature Amplitude Modulation (QAM), 16-QAM modulation according to a service quality and robustness. The transmission method of DRM+ is COFDM and DRM+ system transmits 1 program per 1 block allotted 74.5kbps. Table 1 indicates a summary of the DAB and DRM+ systems [2][3].

B. DAB and DRM+ system frequency assignment scheme

The three DAB ensembles are assigned in VHF channel having a 6 MHz bandwidth. A guard band between each

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ensembles is set to 192 kHz. A lower guard band in front of ensemble A is set to 512 kHz, upper guard band beside ensemble C is set to 496 kHz.

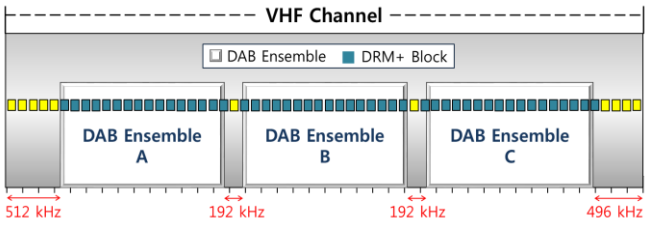

Figure 1. DAB ensembles and DRM+ blocks assignment in VHF channel.

The DRM+ system has a bandwidth of 100 kHz per one block and sets the center frequency interval at 100 kHz. Therefore, it sets a total of 60 blocks in VHF Channel. DAB ensembles and DRM blocks assignment in VHF channel are represented in Figure 1.

III. ALLOCATION PLAN FOR DAB AND DRM+ SYSTEMS

A. *Allocation plan for DAB system*

Terrestrial Digital Multimedia Broadcasting (T-DMB) in Korea is being transmited without configuring the SFN (Single frequency Network) in some areas because of the interference effect of the existing analog TV channel. However, we assume SFN area configuration in this paper, since the DTV transition is completed from the analog TV. T-DMB channel of Jeolla-do is divided into three channels. It is integrated into 8 channels. T-DMB channel of Gyeongsangbuk-do that is divided into two channels. It is integrated into 7 channels. T-DMB channel of Gyeongsangnam-do that is divided into two channels. It is integrated into 12 channels. Table 2 shows the integrated channels and the existing the T-DMB channel.

TABLE II. THE RE-ALLOCATION CHANNELS AND THE EXISTING THE T-DMB CHANNEL

Existing T-DMB Channel		Re-allocation channel
Jeollanam-do	8	8
Jeollanam-do (Eastern)	7	
Jeollabuk-do	12	
Gyeongsangbuk-do (Southern)	7	7
Gyeongsangbuk-do (Northern)	9	
Gyeongsangnam-do (Eastern)	12	12
Gyeongsangnam-do (Western)	9	

We were placed in regional DAB ensemble using a derived available channel. The available channels of region are shown in Figure 2. Ensembles of each local station are allocated based on the number of FM broadcasting which is currently broadcasting. For example, in the case of Seoul, Seoul Tx is broadcasting on 23 FM radio. When FM broadcastings are replaced by DAB ensembles, three ensembles are required. Thus, we allocate ensemble A, B, C of Channel 7. Others also allocate DAB ensembles to another area in the same way shown in Figure 3. FM broadcasting programs are marked with yellow and the allocated DAB ensemble numbers are marked with green in Figure 3. The cases requiring interference analysis for co-channel or an adjacent channel are connected with the arrow and marked in orange. There are 8 cases requiring simulation analysis. The cases are shown in Figure 3.

In the case of Seoul, three DAB ensembles are allocated in Seoul TX and Seoul TX is able to accommodate 27 programs and is broadcasting 23 programs. Therefore, it can transmit further 4 programs. In the same way, extra available programs for each local TX are shown in Table 3.

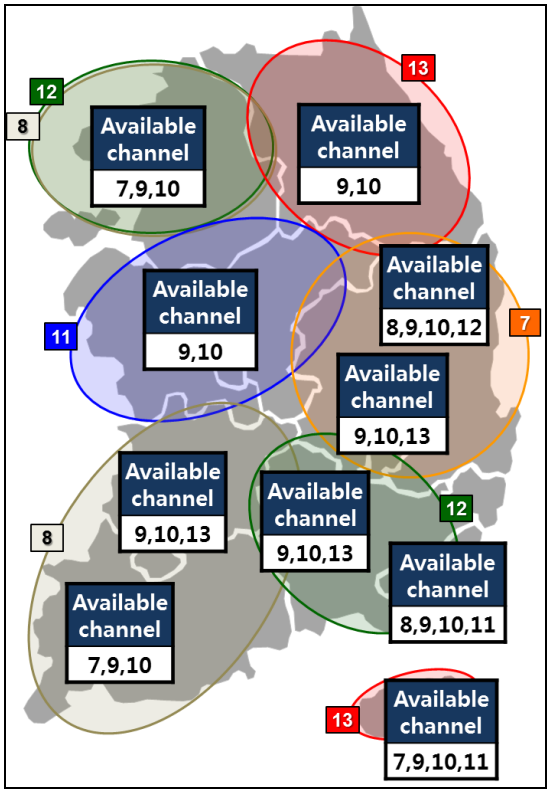

Figure 2. The available channel by region in Korea.

The number of extra available programs is different by region. Cheongju TX cannot introduce a new broadcaster because, in this case, the number of additional available programs is zero. In this paper, in order to solve this problem, we propose an allocation plan for DAB and DRM+ systems in the area with the less than 6 available programs.

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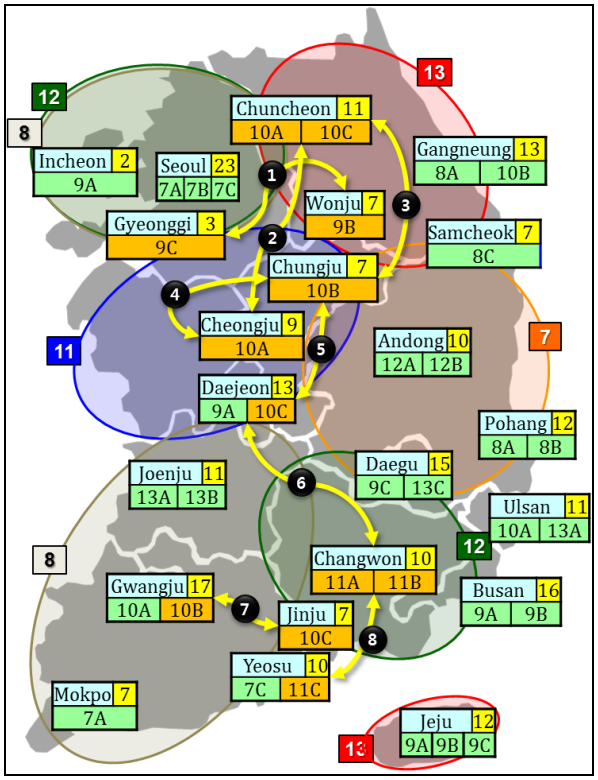

Figure 3. DAB ensemble allocation results by local stations.

B. *Mixed allocation plan for the DAB and DRM+ systems*

Upper guard band (496 kHz) and lower guard band (512 kHz) are in VHF channel with DAB ensemble. Four DRM+ blocks are allocated in each guard band as shown in Figure 5. Frequency offset between the DRM+ block 4 and DAB ensemble A in lower guard band is 930 kHz. Frequency offset between DRM+ block 57 and DAB ensemble C in upper guard band is 930 kHz.

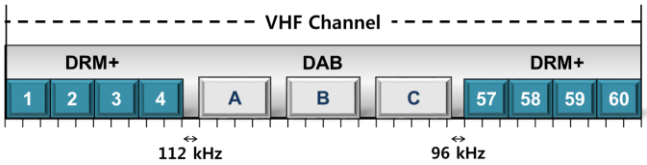

Figure 4. DAB ensembles and the DRM+ blocks allocation in VHF channel.

According to ITU-R standard [4], when the frequency offset between DRM+ block and DAB ensemble is 100 kHz and DAB system is wanted signal, D/U ratio is -36 dB. When Frequency offset between DRM+ block and DAB ensemble is 100 kHz and DRM+ system is wanted signal, D/U ratio is -40 dB. Accordingly, the interference effect between DRM+ block and DAB ensemble is not considered.

TABLE III. EXTRA AVAILABLE PROGRAMS FOR EACH LOCAL TX

Local Broadcasting	Num. of FM program	DAB ensemble (Total available program)	Num. of extra available program
Seoul	23	9A, 9B, 9C (27)	4
Gyeonggi	3	7C (9)	6
Incheon	2	7A (9)	7
Gangneung	13	8A, 10A (18)	5
Wonju	7	7A (9)	2
Chuncheon	11	7B,10B (18)	7
Samcheok	7	8C (9)	2
Daejeon	13	13A, 13B (18)	5
Chungju	7	10A (9)	2
Cheongju	9	10C (9)	0
Andong	10	12A, 12B (18)	8
Daegu	15	8A, 8B (18)	3
Pohang	12	10B, 10C (18)	6
Changwon	10	8C, 10A (18)	8
Jinju	7	11C (9)	2
Busan	16	11A, 11B (18)	2
Ulsan	11	13A, 13B (18)	7
Joenju	11	10A, 13C (18)	7
Gwangju	17	11A, 11B (18)	1
Yeosu	10	10B, 10C (18)	8
Mokpo	7	9A (9)	2
Jeju	12	12A, 12B, 12C (27)	15

The DRM+ blocks and the DAB ensemble are allocated as shown in Figure 4; the total of 56 DRM+ blocks are secured from VHF channel 7 to 13. We proposed a plan that secures extra available programs in local stations. DRM+ blocks is allocated for the number of lacking extra program. The final result of allocated DRM+ blocks is shown in Figure 5.

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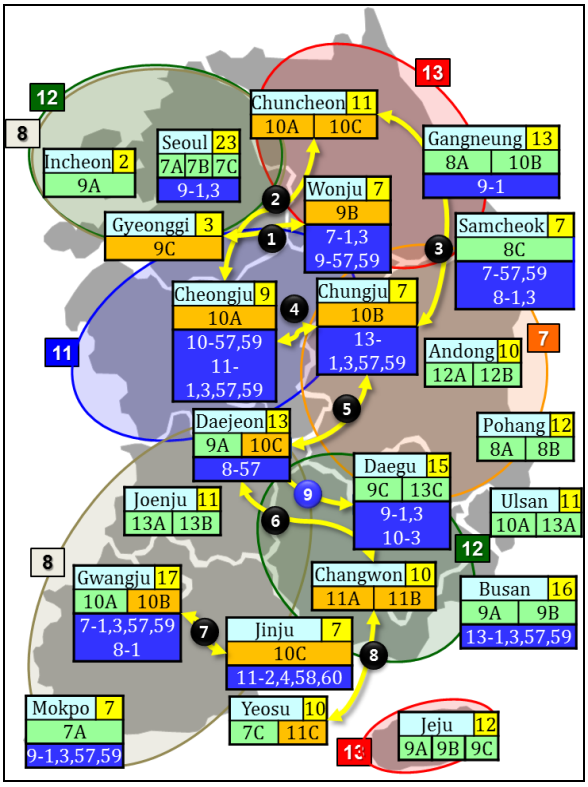


Figure 5. DAB ensemble and DRM+ block allocation results by region broadcasting in Korea.

This plan has the same case considering the interference analysis between DAB ensemble as the only DAB ensemble allocation plan. Frequency offset between DRM+ block of Daejeon and DRM+ block of Daegu is 400 kHz. Hence, we execute an interference analysis for case 9 in Figure 5.

IV. SIMULATION RESULT

We use the Spectrum Management Intelligence system (SMIs) in order to verify the reliability of the derived results. SMIs is a frequency analysis system for broadcast networks that is used to analyze the interference and the field strength of propagation in Korea. This system was offered by the Korea National Radio Research Agency (KNRRA) of Korea Communication Commission (KCC).

Protection Ratio (PR) for DAB system interfered with by DAB system is set by ITU-R standards [4][5]. PR for DRM+ system interfered with by DRM+ system is set by ITU-R standards [4][6]. Each PR is shown in Table 4 and Table 5.

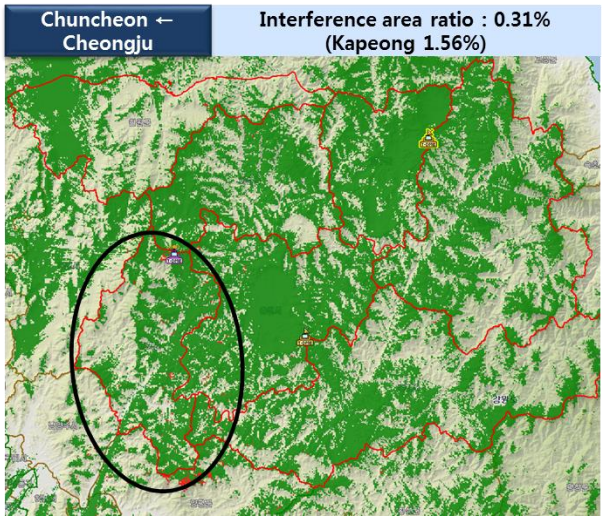
TABLE IV. PR FOR THE DAB SYSTEM INTERFERED WITH BY THE DAB SYSTEM

Channel offset	PR between DAB system
Co-channel	10
Adjacent channel	-37

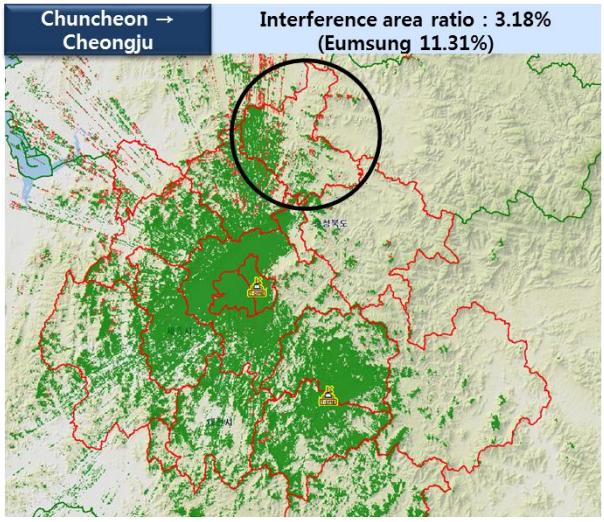
TABLE V. PR FOR THE DRM+ SYSTEM INTERFERD WITH BY THE DRM+ SYSTEM

Frequency offset	PR between DRM+ system
0	4
±100	-16
±200	-40
±400	-63

The interference influence from Cheongju in Chuncheon is shown in Figure 6 (a). The interference area is 0.31% of the coverage area of Chuncheon. The interference area in Kapeong is 1.56% of the total coverage area of Chuncheon. This interference area is 3.18% of the coverage area of Cheongju. The interference area in Eumsung is 11.31% of the total coverage area of Cheongu.

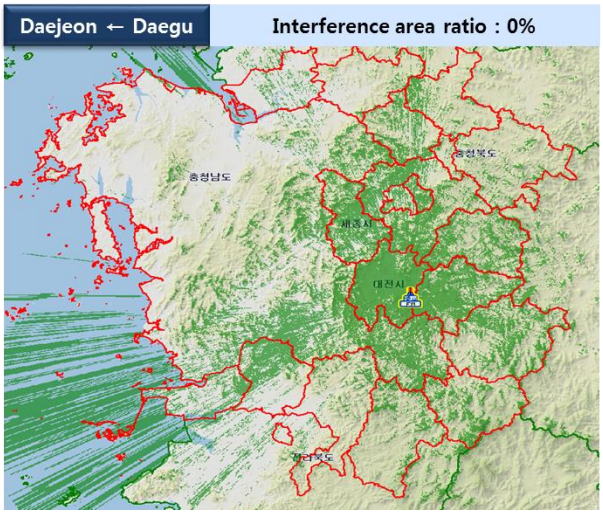


(a) Interference influenced from Cheongju in Chuncheon.

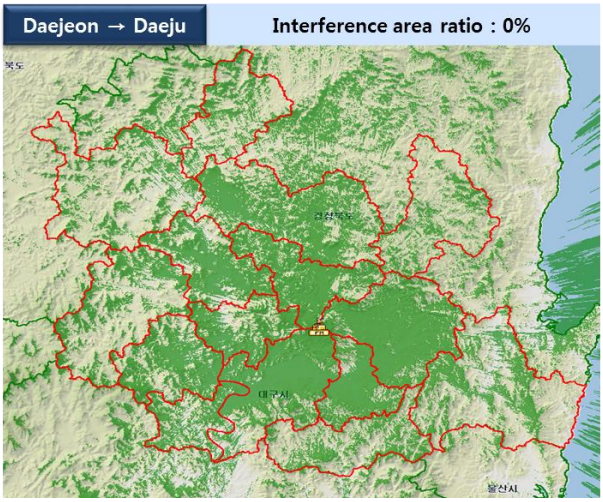


(b) Interference influenced Chuncheon from in Cheongju.

Figure 6. Inteference analysis result between Chuncheon and Cheongju.



(a) Interference influenced from Daegu in Daejeon.



(b) Interference influenced from Daejeon in Daegue.

Figure 7. Inteference analysis result between Daejeon and Daegue.

The case 9, interference analysis has confirmed that there is no interference between DRM+ systems. The simulation result is shown in Figure 7. Besides, stations that derived more than 5% interference are organized in Table 4.

As a result of interference analysis, there is no interference between DRM+ block. We derived the results that secure extra available programs without additional interference situation in DAB ensemble allocation plan. The final result is shown in Table 6.

V. CONCLUSION AND FUTURE WORK

When we allocate only DAB ensemble in local stations, some local stations lack extra available programs. In this paper, we proposed a broadcast network plan that allocates DAB system mixed with DRM+ system in order to solve the problem.

TABLE VI. STATIONS THAT OCCURRED MORE THAN 5% INTERFERENCE AREA RATIO

Case	Wanted signal	Interference area ratio	
①	Gyeonggi	·	0%
	Chuncheon	·	0%
②	Chuncheon	Kapeong	1.56%
	Cheongju	Eumsung	11.31%
③	Chuncheon	·	0%
	Chungju	·	0%
④	Cheongju	Eumsung	17.23%
	Chungju	Cheongju	32.92%
⑤	Chungju	Cheongwon	0.73%
	Daejeon	Eumsung	20.75%
⑥	Daejeon	Muju	4.34%
	Jinju	Hamyang	7.25%
⑦	Gwangju	Hadong	11.05%
	Jinju	Hadong	1.82%
⑧	Changwon	·	0%
	Yeosu	·	0%
⑨	Daejeon	·	0%
	Daegu	·	0%

A total of nine cases are derived from allocating DAB ensemble and DRM+ block in each local station. As a result of interference analysis, additional interference case did not occur and local stations that have the extra available programs of less than 6 secure 6 extra available programs. In this paper, the frequency of DRM+ system is allocated with DAB system having no interference. Accordingly, if the DRM+ system is used in guard band in the DAB system, frequency efficiency is improved. The presented results can be used as a basis for broadcast network planning of the digital radio in Korea.

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