The new Broadcasting Channel allocation method for FM Digital Radio System

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Abstract

The Korean radio broadcasting system is analog. Compared with digital radio, the analog radio decreases the frequency efficiency. HD Radio is the method where the digital signal is transmitted on either side of the analog FM signal. Therefore, without relocating the analog frequency can transmit digital signals. If interference between analog and digital signal occurs it is impossible to receive smoothly. In this paper, to analyze HD Radio and analog signals, the effect of the interference. These results are able to give an efficient Channel Allocation Method for Korean HD Radio System.

Keywords : Digital Radio, HD Radio, Desired signal/Undesired signal ratio, Minimum Field Strength,

1. Introduction

The usage efficiency of digital broadcasting frequency is better than analog broadcasting. Digital radio is expected to result in compact disc (CD) quality of the received audio signal[1]. Consequently many countries have advanced the digital conversion of the radio.
These digital radio systems have been developed up until now: Digital Radio Mondiale (DRM) and High Definition Radio (HD Radio). The first was developed by a consortium based in Europe, with companies from around the world, and can be used in the long frequency (LF), medium frequency (MF) and high frequency (HF) bands. The second system was developed by the north-American iBiquity Company and was tested only in the MF band[2].
Hereafter Korea has the plan to advance to HD Radio systems. We analyze between the analog broadcasting and the HD Radio, then allocate channel for efficient installation.
In this paper, a brief description of the HD Radio system, we proposed efficient channel allocation of HD Radio for coexistence with existing analog broadcasting and with the interference through simulation.

2. Overview of HD Radio Technology

HD Radio is the brand name for new digital AM and FM radio technology developed by iBiquity Digital to allow existing radio stations to stream digital content simultaneously with their analog FM and AM signals. The digital transmission is based on adaptive orthogonal frequency-division multiplexing (OFDM)[3].
HD Radio is to add a digital signal to an analog FM host[4]. So HD Radio is continue to transmit analog AM and FM simultaneously with the new, higher-quality and more robust digital signals, allowing themselves and their listeners to convert from analog to digital radio while maintaining their current frequency allocations[5].
HD Radio has 3 different modes: Hybrid mode which transmits both the analog and the digital signal, Extended Hybrid mode which digital area is more expanded than Hybrid mode and All Digital mode which the analog spectrum is expanded to the digital area. Current HD Radio broadcasting is operated by Hybrid mode. It will be advanced to Hybrid mode to extended hybrid mode and to All Digital mode.

3. HD Radio Interference Analysis steps

Firstly, set up a desired station to analyze the interference. Secondly, set up co-channel and adjacent channel station which can cause the interference. Finally, set up the minimum field strength and D/U(desired signal/undesired signal ratio). Fig. 1 shows that HD radio interference analysis step.

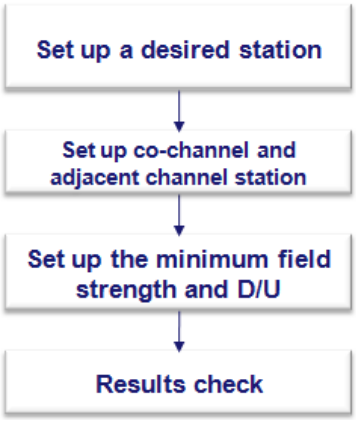

Figure 1: HD Radio interference analysis step

Analog and digital signals to compare and to analyze in four kinds of patterns.

- Case 1: The interference between two different FM signals
- Case 2 : HD Radio signal interferes FM signal
- Case 3 : FM signal interferes HD Radio signal
- Case 4 : HD Radio signal interferes the other HD Radio signal

3.1 **Set up a desired station**

In this paper Mt. Sik-Jang Mt transmitting tower was set as a desired station and then scan whether there was any interferences in Korea.

3.2 **Set up co-channel and adjacent channel station**

Firstly, According to D/U, set up a co-channel and an adjacent channel station. D/U is the ratio of size that the proportion of receiving desired signal to undesired signal. When the frequency gap is more than ±600kHz, D/U does not affect the interference to desired station. Thus, we set as an interference station only the gap is less than ±400kHz station.
HD Radio power is adjusted to match to FM power. HD Radio is a hybrid of digital and analog signals. Therefore, the total power is modified same as analog powers.

Table 1: Information of co-channel and adjacent channel station

Frequency / Item	97.1MHz (400kHz)	97.3MHz (-200kHz)	97.5MHz (0kHz)	97.7MHz (+200kHz)	97.9MHz (+400kHz)
Location	Mt. Baeg-Un	Mt. Gwan-Ak	Mt. Moo-Ryong	Mt. Hak-Ga	Mt. Moa-Ak
Distance (km)	114.9	134.8	189.6	108.6	72.8
Power	1 kW	10 kW	1 kW	1 kW	3 kW

3.3 **Set up the minimum field strength and D/U**

In this paper Mt. Sik-Jang Mt transmitting tower was set as a desired station and then scan whether there was any interferences in Korea. Table. 2 shows D/U, according to channel gaps and power. Case 1 and Case 2 are similar and Case 3 and Case 4 are similar because the desired signal of case 1 and case 2 is analog FM and the desired signal of case 3 and case 4 is HD Radio. Namely, the digital signal is less interfered then the analog signal.

Table 2: D / U of Case1, 2, 3, 4

Kind of Interference	D/U		
	Co-Channel	±200kHz Adjacent Channel	±400kHz Adjacent Channel
Case1 (FM-FM)	45 dB	7 dB	-20 dB
Case2 (FM-HD)	45 dB	21 dB	-14 dB
Case3 (HD-FM)	3 dB	-23 dB	-40 dB
Case4 (HD-HD)	3 dB	-22 dB	-42 dB

The minimum field strength is based on the broadcasting range when the station powered. Minimum field strength of HD Radio with the digital signal is 38dBμV/m that is better than the analog signal. However, the power of HD Radio that we set is designated the total power which is a hybrid analog signal. Therefore, the HD Radio minimum field strength is applied 48dBμV/m to increase 10dB. Because digital signals are not affected by the noise rating of high, medium and low noise, all areas is set 48dBμV / m.

4. Simulation Results

Table. 3 is a result of the interference analysis from co-channel, ±200kHz and ±400kHz adjacent channel. In this Case 2, there are three places that increase interference area in comparison with Case 1. Because HD Radio in Case 2 is applied to the interference signal. In the other hand the noise of the minimum field strength value FM analog stations in the metropolitan area receives at least 60dBμV / m, but HD Radio 48dBμV / m is applied to the broadcasting area gets larger. In contrast to Case 1, 2, because of Case 3, 4, high-performance digital signal it receives the interference area was reduced to Case 1, 2.

Table 3: A result of the interference analysis from co-channel, ±200kHz and ±400kHz adjacent channel

Item \ Frequency		97.1MHz (400kHz)	97.3MHz (-200kHz)	97.5MHz (0kHz)	97.7MHz (+200kHz)	97.9MHz (+400kHz)
Location		Mt. Baeg-Un	Mt.Gwan-Ak	Mt. Moo-Ryong	Mt. Hak-Ga	Mt. Moa-Ak
Distance (km)		114.9	134.8	189.6	108.6	72.8
Power		1 kW	10 kW	1 kW	1 kW	3 kW
Case 1	Interference area (%)	0	4.58	0.25	0.29	0.79
	Variations (%)	benchmark				
Case 2	Interference area (%)	0	13.02	0.25	2.15	2.39
	Variations (%)	0	+8.44	0	+1.86	+1.60
Case 3	Interference area (%)	0	0.87	0	0	0.01
	Variations (%)	0	-3.71	-0.25	-0.29	-0.78
Case 4	Interference area (%)	0	0.91	0	0	0.01

	Variations (%)	0	-3.67	-0.25	-0.29	-0.78

Table. 4 is a result of the interference analysis to co-channel, ±200kHz and ±400kHz adjacent channel. In this Case 2, there are four places that increase interference area in comparison with Case 1. Because HD Radio Case 2 is applied to the interference signal.

Table 3: **A** result of the interference analysis to co-channel, ±200kHz and ±400kHz adjacent channel

Item \ **Frequency**		**97.1MHz (400kHz)**	**97.3MHz (-200kHz)**	**97.5MHz (0kHz)**	**97.7MHz (+200kHz)**	**97.9MHz (+400kHz)**
Location		Mt. Baeg-Un	Mt. Gwan-Ak	Mt. Moo-Ryong	Mt. Hak-Ga	Mt. Moa-Ak
Distance (km)		114.9	134.8	189.6	108.6	72.8
Power		1 kW	10 kW	1 kW	1 kW	3 kW
Case 1	**Interference area (%)**	0.06	2.58	1.69	0.83	0.20
	Variations (%)	benchmark				
Case 2	**Interference area (%)**	0.11	9.97	1.69	4.31	0.36
	Variations (%)	+0.05	+7.39	0	+3.48	+0.16
Case 3	**Interference area (%)**	0	0.22	0	0.03	0
	Variations (%)	-0.06	-2.36	-1.69	-0.80	-0.20
Case 4	**Interference area (%)**	0	0.24	0	0.03	0
	Variations (%)	-0.06	-2.34	-1.69	-0.80	-0.20

5. Conclusions

HD Radio has the analog signal and digital signal at the same time so if it caused the interference, it couldn't receive the signal smoothly. Therefore, you need to analyze the interference between the HD Radio and the previous FM broadcasting.

This paper analyzed the interference based on simulation at a Mt. Sik-Jang transmitting station as criteria in Korea. As a result of analyze the interference; we can see HD Radio broadcast area is expanded but interference area is decreased than the previous FM broadcasting. In case2, the interference was expanded. However some of the area we had interferences but it wasn't a big different, the frequency gap was big and had a little interference from previous FM broadcast, when we applied HD Radio, it was effective to make a little interference but the broadcasting area was expanded.

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