

The Impact of IMT System on ATSC System

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Abstract—Korea has made a plan to allocate CH 14~ CH 51(470 MHz~698 MHz) for DTV. Therefore, it is necessary to take into account compatibility between DTV and other potential service system in spare band. This paper assumes that DTV operates on CH 51 (692 MHz~ 698 MHz) and IMT system operates on CH 52 (698 MHz~704 MHz) in spare band, and then analyzes the interference probability from IMT system to DTV with Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT). For the simulation, two interference cases in four different scenarios are considered. In a result, a guard band of 8 MHz is required in the case of interference from IMT system downlink (DL) to DTV with considering the depolarization factor of 16 dB and the interference from IMT system uplink (UL) to DTV is negligible.

Keywords— DTV, IMT system, SEAMCAT, Guard band, Interference probability

I. INTRODUCTION

Currently, the plans of converting analogue TV into digital TV are being carried out by some countries, such as US, Korea, UK and Japan, etc. After 2012, frequency arrangement plan is illustrated in Figure 1 for DTV in Korea [1], the details are as follows: ① CH 2~6 (5 channels) will be assigned in preparation for DTV, but channelling arrangement will be reserved; ② CH 7~13 (7 channels) will be given priority to terrestrial DMB. If the channels can be reused in some areas, they will also be in preparation for DTV; ③ CH 14~51 (38 channels) will be used for DTV. ④ CH 52~ 69 (18 channels) are spare band.

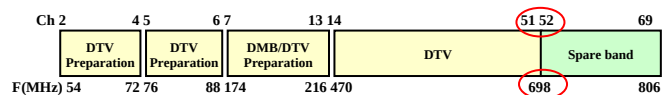


Figure 1. Frequency arrangement plan in Korea

However, compatibility and sharing between DTV and other potential service systems have to be taken into account ahead of schedule. Potential services may be IMT system,

WiMax, 4 G system and radio microphones, and so on [2]. This paper describes the interference of IMT system into DTV in Korea, therefore, assuming that DTV operates on channel 51 (692 MHz~ 698 MHz) and IMT system operates on channel 52 (698 MHz~704 MHz) in spare band. Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT)[3-5] is used to study on the interference effect IMT system on DTV under four different scenarios. For the simulation, two interference cases in each scenario are analyzed. The required guard band is considered to reduce IMT system interference effect on DTV.

II. SYSTEM PARAMETERS OF DTV AND IMT SYSTEM

DTV adopts US DTV standard (ATSC) in Korea, main relevant characteristics of DTV are summarized in Table 1 [6].

Table 1. Characteristics of DTV (ATSC system)

Characteristic	Value
Transmit power ERP	5 kW (67 dBm)
Frequency band	692 MHz~698 MHz
Bandwidth	6 MHz
Tx antenna height	300 m
Tx antenna gain	8 dBi
Rx antenna height	9 m
Rx antenna gain	10 dBi
Noise Figure	10 dB
Sensitivity	-75 dBm
C/I	15 dB
Propagation mode	ITU-R P.1546

The FCC rigid Emission mask for DTV is illustrated in Figure 2 [7].

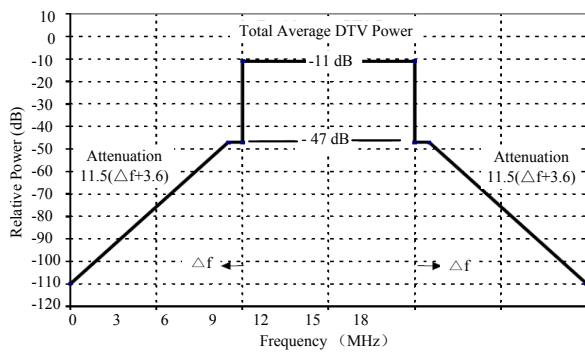


Figure 2. FCC DTV emission mask (based on measurement bandwidth of 500 kHz).

According to Figure 2, DTV emission limit is summarized in Table 2.

Table 2. DTV emission mask

Frequency Offset (MHz)	Attenuation in dBc
-9~-3.5	-[11.5 (Δf+3.6)-10.6]
-3.5~-3	-36.4
-3~3	0
3~3.5	-36.4
3.5~9	-[11.5 (Δf+3.6)-10.6]

DTV blocking response is defined in Table 3.

Table 3. Blocking response for DTV

Frequency Offset (MHz)	-15	-12	-6	-3	0	3	6	12	15
Blocking(dB)	40	40	40	0	0	0	40	40	40

Overall system parameters of IMT system are summarized in Table 4.

Table 4. Overall system parameters of IMT system

Parameters	BS	UE
Antenna height	100 m for rural co-located case (Scenario_1) 50 m for rural uncoordinated case (Scenario_2) 30 m for rural uncoordinated case (Scenario_3) 30 m for urban uncoordinated case (Scenario_4)	1.5 m
Transmit power	43 dBm	21 dBm
Bandwidth	3.84 MHz	
Antenna gain	12 dBi (cable loss included)	0 dBi

Horizontal diagram	Directional antenna with 65° horizontal opening at 3 dB	
Vertical pattern	ITU-R F.1336-1	
Noise floor	-103 dBm	-96 dBm
Sensitivity	-121 dBm	-114 dBm
Coverage radius	Rural: 40 km (co-located, scenario_1) Rural: 20 km (un-coordinated, scenario_2) Rural: 10 km (un-coordinated, scenario_3) Urban: 1 km (un-coordinated, scenario_4)	
Propagation mode	Extended Hata	

IMT system base station (BS) reference technical specification is the 3GPP TS25.104, User equipment (UE) reference technical specification is the 3GPP TS25.101. Therefore, IMT system BS spectrum mask is given in Table 5.

Table 5. MT system BS emission spectrum mask

Frequency Offset (MHz)	dBc	Ref Bandwidth (kHz)
+/-2.499	0	5000
+/-2.5	-57	30
+/-2.7	-57	30
+/-3.499	-69	30
+/-3.5	-56	1000
+/-12.499	-56	1000
+/-12.5	-79	100
+/-25	-79	30

And the IMT system UE emission spectrum mask is given in Table 6.

Table 6. IMT system UE emission mask

Frequency Offset (MHz)	dBc	Ref Bandwidth (kHz)
+/-2.499	0	5000
+/-2.5	-35	30
+/-3.499	-50	30
+/-3.5	-35	1000
+/-7.499	-39	1000
+/-7.5	-39	1000
+/-8.499	-49	1000
+/-8.5	-49	1000
+/-12.5	-49	1000

III. SCENARIO AND SIMULATION ANALYSIS

Four co-existence scenarios (coordinated and uncoordinated) in rural and urban areas between DTV and IMT system are analyzed with SEAMCT-3. The interference probability from IMT system to DTV is simulated and analyzed.

3.1 Co-existence scenarios

In rural area, three co-existence scenarios are considered as follows:

i) Scenario_1: Coordinated case where IMT system BS and DTV transmitter are collocated, as shown in Figure 3. IMT system antenna is placed at 100 m and the DTV transmitting antenna height is 300 m. The cell radius of DTV is 40 km and cell range of IMT system is 40km.

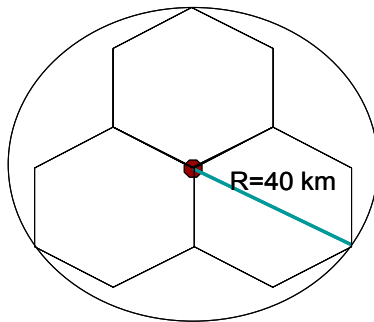


Figure 3. Scenario_1: Co-location co-existence scenario, IMT system BS and DTV transmitter are co-located

ii) Scenario_2: Uncoordinated case where three IMT system BSs with antenna height of 50 m are around of a high DTV transmitter antenna height of 300 m as shown in Figure 4. The IMT system cell range is 20 km and DTV cell radius is 40 km.

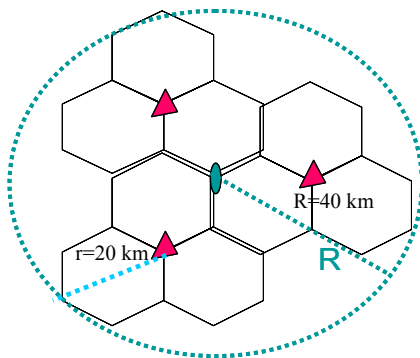


Figure 4. Scenario_2: Uncoordinated co-existence scenario, three IMT system BSs around one DTV transmitter

iii) Scenario_3: Uncoordinated case where the cellular IMT system network is composed of IMT system BS with antenna height of 30 m, DTV transmitter with antenna height of 300 m is placed at the center of IMT system network, as shown in Figure 5. The IMT system cell range is 10 km and DTV cell radius is 40 km.

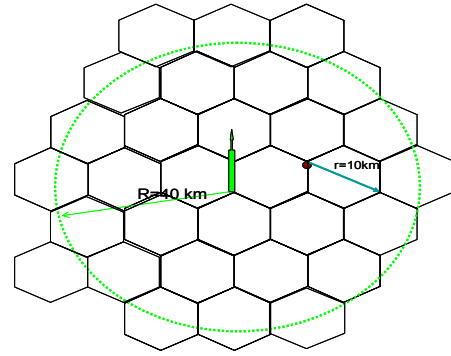


Figure 5. Scenario_3: Uncoordinated co-existence scenario, IMT system BS at height of 30 m with cell range of 10 km around a DTV transmitter at height of 300 m

In urban area, the co-existence scenario_4 is very similar to the rural area scenario_3 described above, as shown in Figure 6. Cellular IMT system network is composed of tri-sector IMT system BSs at height of 30 m. DTV transmitter is located at the center of the urban area at height of 300 m. The study area is within the DTV coverage area with cell radius of 30 km. The IMT system cell range is 1 km.

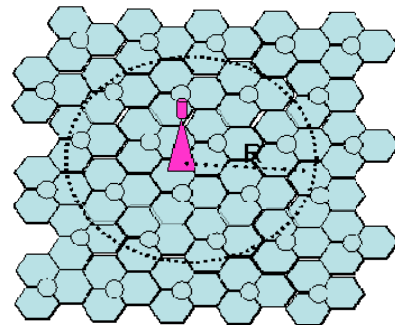


Figure 6. Scenario_4: Uncoordinated co-existence in urban area

3.2 Simulation Results

In order to evaluate the interferences of IMT system into DTV, the studies are performed with SEAMCAT-3. Two interference cases are simulated in each scenario as follows:

Case_1: Probability of interferences from IMT system DL to DTV

Case_2: Probability of interferences from IMT system UL to DTV

The interference from IMT system UL/DL to DVB-T is simulated based on the $C/I=15$ dB, both blocking effects and unwanted emissions are taken into account in the simulations.

When the antenna depolarization factor is used, for the interference case from IMT system DL to DTV, 16 dB depolarization factor is used. For the interference case from IMT system UL to DTV, 10 dB depolarization factor is used by considering that IMT system UE is at ground level.

1) The Co-Location Co-Existence (Scenario_1) in Rural Area

The simulated interference probabilities from IMT system DL to DTV receiver are given in Table 7.

Table 7. Probability of interference from IMT system DL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	1.9%	0.6%	0.3%	0.3%
With depolar factor(16 dB)	0%	0%	0%	0%

Table 7 shows that for co-located co-existence scenario, the probability of interference from IMT system DL to DTV receiver are not problem, especially when the depolarization factor of 16 dB is taken into account, the probability of interference from IMT system DL to DTV receiver is negligible.

The simulated interference probabilities from IMT system UL to DTV receivers are given in Table 8.

Table 8. Probability of interference from IMT system UL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	0%	0%	0%	0%
With depolar factor(10 dB)	0%	0%	0%	0%

The interference from IMT system UL to DTV receiver is not a problem. Even without taking into account the depolarization factor. This can be explained by the fact that not all of outdoor IMT system UE transmitter at the maximum power, a majority of IMT system UE transmitter at limited power due to power control.

2) The Uncoordinated Co-existence (scenario_2) in Rural Area

The simulated interference probabilities from IMT system DL to DTV receivers for the uncoordinated co-existence (scenario_2) in rural are given in Table 9 below.

Table 9. Probability of interference from IMT system DL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	2.8%	0.7%	0.6%	0.6%
With depolar factor(16 dB)	0%	0%	0%	0%

For the uncoordinated co-existence scenario_2 in rural, the probability of interference from IMT system DL to DTV receiver are not problem, especially when the depolarization factor of 16 dB is taken into account, the probability of interference from IMT system DL to DTV receiver is not serious.

The simulated interference probabilities from IMT system UL to DTV receivers are given in Table 10.

Table 10. Probability of interference from IMT system UL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	0%	0%	0%	0%
With depolar factor(10 dB)	0%	0%	0%	0%

In case of the uncoordinated co-existence (scenario_2) in rural, the interference from IMT system UL to DTV is negligible.

3) The Uncoordinated Co-Existence (Scenario_3) in Rural Area

The simulated interference probabilities from IMT system DL to DTV receiver are given in Table 11 below.

Table 11. Probability of interference from IMT system DL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	20.6%	13.6%	10.4%	10%
With depolar factor(16 dB)	4.0%	1.2%	0.8%	0.6%

It can be seen that the utilization of the depolarization factor is important for the good co-existence between IMT system and DIV, when it is used, the interference from DTV to IMT system UL receiver is negligible.

The simulated interference probabilities from IMT system UL to DTV receiver are given in Table 12. It can be seen that the interference from IMT system UL to DTV is not a problem.

Table 12. Probability of interference from IMT system UL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	0%	0%	0%	0%
With depolar factor(10 dB)	0%	0%	0%	0%

4) The Uncoordinated Co-existence (scenario_4) in Urban Area

The simulated interference probabilities from IMT system DL to DTV receivers for the co-existence (scenario_4) in urban are given in Table 13.

Table 13. Probability of interference from IMT system DL to DTV receiver

Guard band (MHz)	0	2	4	6	8
Without depolar factor	43.3%	28.5%	26.9%	24.8%	24.4%
With depolar factor (16 dB)	12.7%	6.6%	6.2%	5.5%	4.3%

For the uncoordinated co-existence (scenario_4) in urban, a depolarization factor of 16 dB can efficiently reduce interference from DTV, therefore, a guard band of 8 MHz is

required to keep interference probability from IMT system DL to DTV receiver 5 % below.

The simulated interference probabilities from IMT system UL to DTV receivers are given in Table 14.

Table 14. Probability of interference from IMT system UL to DTV receiver

Guard band (MHz)	0	2	4	6
Without depolar factor	0%	0%	0%	0%
With depolar factor(10 dB)	0%	0%	0%	0%

In the case of the uncoordinated co-existence scenario_4 in urban, the interference from IMT system UL to DTV is not a problem.

IV. CONCLUSIONS

This paper analyses interference effect of IMT system on DTV with four different scenarios. The simulation results lead to the following conclusions:

1) The interference from IMT system UL to DTV does not appear as a problem for all considered co-existence scenarios, even without any additional guard band. This can be

explained that IMT system UE are at the ground level, the efficient power control makes the IMT system UE transmit at limited power, in consequence, the interference from IMT system UE to DTV receivers becomes very small.

2) The interference from IMT system DL to DTV is decreasing with the guard band. A guard band of 8 MHz is needed for keeping the interference probability 5% below with considering the depolarization factor of 16 dB. Moreover , IMT system BS receiver blocking level is supposed to be redefined in order to efficiently reduce the guard band.

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