

Interference Analysis between Korea's DVB-T2 and Japan's ITS using 700MHz frequency band

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Abstract— In this paper, we analyze the effects of interference between Korea's ultra-high definition TV broadcasting system and Japan's intelligent transport system using the 700 MHz frequency band when considering a practical deployment of both systems. We performed Minimum Coupling Loss (MCL) method to evaluate how much interference from the Korean UHD TV system is imposed on the Japan ITS system. We also employ the Advanced Propagation Model (APM) and ITU-R P. 452-15 model to calculate the propagation loss occurring in ducts. To protect against interference between Korean and Japanese radio signals, the required additional attenuation loss is also calculated.

Keywords— DVB-T2 system, ITS system, Interference, Ducting

I. INTRODUCTION

Many countries converted their analog TV systems into digital TV (DTV). The South Korean government also allocated CH 14 through CH 51 (470-698 MHz) for DTV use [1] and recently determined to allocate additionally 30MHz (698-710 MHz and 753-771 MHz) for ultra-high definition TV (UHDTV) use [2].

In Japan, digital terrestrial TV broad-casting service is available at 460-710 MHz on the UHF band using the ISDB-T standard and a 9 MHz channel width in the 755.5-764.5 MHz radio frequency band will be used for Intelligent Transport System (ITS). It is the realization of safe driving support systems to reduce the number of traffic accidents. The 700 MHz frequency band is known for its good propagation characteristics in non-line-of-sight conditions such as behind buildings or large vehicles [3]. The 755.5-764.5 MHz frequency band partially overlaps with Korean UHDTV frequency band.

Although Korean UHDTV system and Japan ITS system are located with a sufficient separate distance, the potential interference would be produced because they use same frequency and the ducted signal between neighboring countries as may cause interference to distant wireless systems [4]. As the height and duration of the duct layer are not constant, it is difficult to predict the effects of this type of interference. To allow better radio communication services, we need to be able to predict the effects of interference and study a method of coexistence between the two countries.

In this paper, we analyze the effects of interference between UHDTV services in Korea and ITS service in Japan at the 700 MHz frequency band. We focus particularly on an interference

scenario of Korea's UHDTV to Japan's ITS, as this type of interference is more serious than the other interference scenario. Korean UHDTV is assumed in DVB-T2 system and the Minimum Coupling Loss (MCL) method is used for the interference analysis between fixed stations. We also employ the Advanced Propagation Model (APM) and ITU-R P. 452-15 model to calculate the propagation loss occurring in ducts. To protect against interference between Korean and Japanese radio signals, the required additional attenuation loss is also calculated.

II. INTERFERENCE SCENARIO AND METHODOLOGY

A. Interference scenario

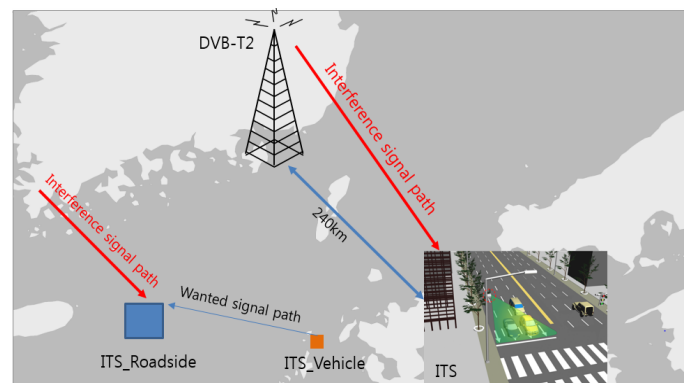


Figure 1. Interference scenario between Korea's DVB-T2 and Japan's ITS

Figure 1 shows a scenario for interference analysis from Korea's DVB-T2 system to Japan's ITS system. We assumed that Korea's DVB-T2 site transmits signals using the 759-765 MHz frequency band and Japan ITS system has a 9 MHz channel bandwidth using 755.5-764.5 MHz frequency band. The distance between Korea and Japan ranges from about 240 to 300 km, we assumed the separate distance between two systems is 240 km.

Japan ITS systems are supposed to consist of two types of systems: vehicle-to-vehicle communication systems that support safe driving by inter-vehicular radio communications at intersections with poor visibility, and roadside-to-vehicle communication systems that support safe driving by sending information from roadside units of traffic infrastructure to vehicles through radio communications [3]. We considered

only roadside-to-vehicle communication systems that vehicle transmit the signal to roadside units.

We evaluated whether the received interference power at the antenna of Japan's ITS receiver satisfies the maximum allowable interference power.

B. Methodology for an interference analysis

The possibility of frequency spectrum sharing depends on whether the received signal-to-interference plus noise ratio at the antenna of victim receiver satisfies the minimum signal-to-interference plus noise needed to process (vice just detect) a signal.

$$P_S - (P_N + P_I) \geq SINR_{\min} \quad (1)$$

where P_S is the received signal power from vehicle's transmitting signal, P_N is the thermal noise power of the receiver and P_I is the received interfered signal power from Korean DVB-T2 transmitting signal. In an interference-limited environment, equation (1) can be approximated as follow

$$P_N + P_I \approx P_I \quad (2)$$

The tolerable interference signal power can be determined using the following equation

$$P_{I, target} \leq P_S - SINR_{\min} \quad (3)$$

The required additional attenuation loss (L_a), in dB, of the interfering system on the victim system can be determined using the following equation [5]:

$$L_a = P_t + G_t + G_r - PL(d) - P_{I, target} \quad (4)$$

where P_t is the transmit power of the interfering system in the reference bandwidth in dBm, G_t is the gain of the interferer antenna in the direction of the receiver in dBi, G_r is the gain of the victim receiver antenna in the direction of the interferer in dBi, $PL(d)$ is a basic transmission loss for separation distance d between the interferer and receiver in dB, and $P_{I, target}$ is the tolerable, or target, interference power at the receiver.

The basic transmission loss is the most important factor to predict the interference level and determine the additional required attenuation loss. For a calculation of this basic transmission loss occurring in a duct, we used ITU-R P.452-15 [6] and hybrid propagation model called an Advanced Propagation Model (APM). APM uses a flat earth (FE) model region, at ranges of less than 2.5km and for all elevation angles of above 5° . For beyond the FE region, where the grazing angles of the reflected rays from the transmitter are

above a small limiting value, the ray optics (RO) model is used. The PE model is used for ranges beyond the RO region, but only for altitudes below a maximum PE altitude as determined by the maximum allowed 1024-point Fast-Fourier transform (FFT). For ranges beyond the RO region and heights above the PE region, an extended optics (XO) method is allowed, which can operate at the maximum PE altitude [7-8].

III. RESULT AND DISCUSSION

Table 1 and 2 present the operational system parameters for the DVB-T2 and ITS systems used for simulation, respectively. Figure 2 shows the vertical pattern of the DVB-T2 antenna [9]. A free space propagation model is used to calculate the path loss between ITS's vehicle and ITS's roadside. An ITU-R P.452-15 propagation model and APM are used to calculate the path loss between Korea's DVB-T2 and Japan's ITS and Table 3 shows the path loss using the P.452-15 model. Table 4 shows the modified refractivity index of Pohang provided by the WMO station. The values represent a surface-based duct and elevated ducts in June. Hwang-Ryeong Mountain was chosen as Korean DVB-T2 site, which located near Japan. Figure 3 shows the path loss between Korea's DVB-T2 and Japan's ITS calculated using the APM for simulation parameter.

Table 1 DVB-T2 system parameters for simulation.

Parameter	Value
Center frequency	762MHz
Channel bandwidth	6MHz
Transmitting Power	67dBm
Antenna gain	10dBi
Antenna height	450m
Location	35° 15' 80'' 129° 08' 22''
Antenna pattern	horizontal omni vertical ITU-R F.1336

Table 2 ITS system parameters for simulation.

Parameter	Value
Center frequency	760MHz
Channel bandwidth	9MHz
Vehicle's radiated Power	20dBm
Road-side antenna height	7m
Road-side antenna gain	13dBi
Road-side noise figure	6dB
Minimum SNR	13dB
Vehicle antenna height	3m
Vehicle antenna gain	0dBi

Table 3 Path loss using ITU-R P.452-15.

Time rate (%)	Path loss(dB)
1	144.2dB
10	172.8dB
50	179.6dB

Table 4 Modified refractivity – WMO data.

Height(m)	Modified refractivity
0	337
16	339
47	343
72	334
1933	559
2055	551
3054	661

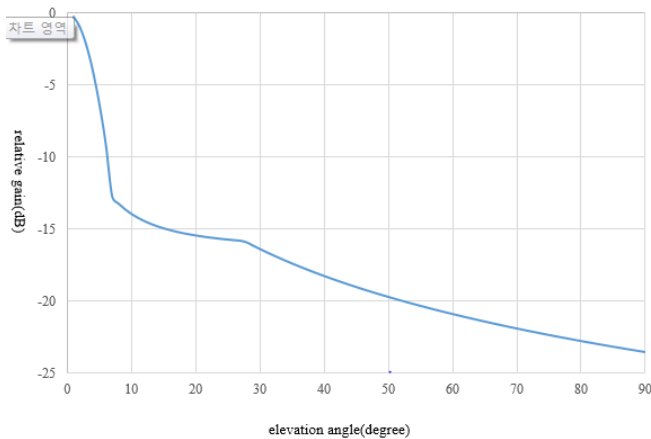


Figure 2. DVB-T2's antenna vertical pattern

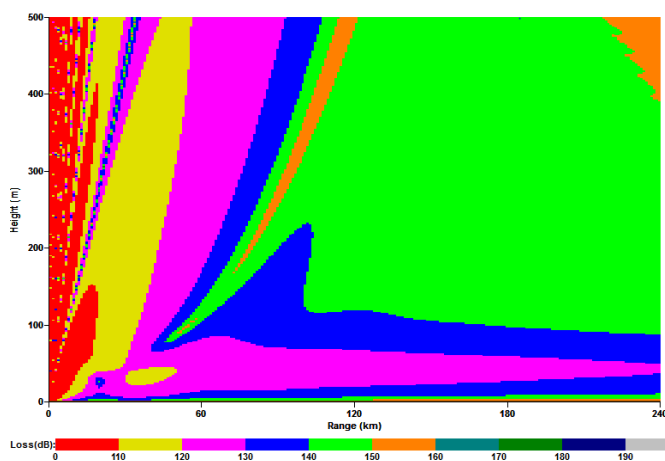


Figure 3. Path loss between Korean DVB-T2 and Japan ITS using APM

Figure 4 shows the received wanted signal strength and interfering signal strength ratio at the victim receiver, roadside of ITS, for the time rate and propagation model. The received signal-to-interference plus noise ratio appears to be dependent on the separate distance between roadside and vehicle of ITS. The target signal-to-interference plus noise ratio may be satisfied depending on the separate distance. The target interference level appears to be satisfied at separate distance below 150 m for a 1% time rate and APM.

The additional attenuation loss required for the receiving antenna height of ITS's roadside is shown in Figure 5. These are calculated using equation (4) and the parameters listed in Table 1 and Table 2. When the heights of the receiving antenna of ITS's roadside is 5 m, an additional attenuation loss of above 8 dB is required to satisfy the target interference level for 500m cell coverage. In addition, when the heights of the receiving antenna of ITS's roadside is 7 m, an additional attenuation loss of 11 dB is required. From the result, we confirm that the target interference level may be satisfied depending on the antenna height.

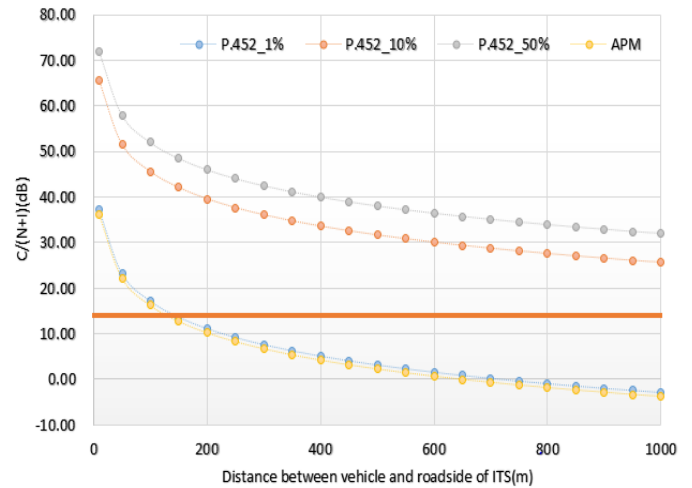


Figure 4. Received signal-to- interference plus noise ratio according to the time rate at the roadside of ITS

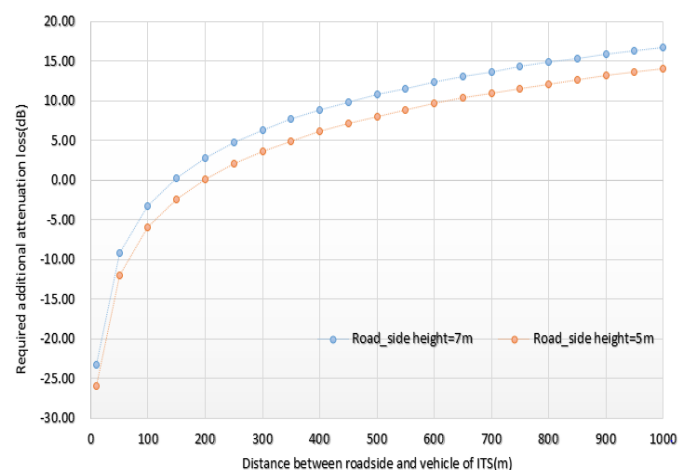


Figure 5. Additional attenuation loss required for receiving antenna heights

The additional attenuation loss required, as shown in Figure 5, can be used as a guideline for allowing the deployed Japan ITS system and Korean DVB-T2 to avoid an unacceptable amount of interference between systems.

IV. CONCLUSIONS

In this paper, we analysed the effect of interference between UHDTV services in Korea and ITS service in Japan at the 700 MHz frequency band when encountering a ducting phenomenon. The MCL method is used for an interference analysis, focusing on an interference scenario of Korea's UHDTV to Japan's ITS. The ITU-R P.452-15 model and APM were used to calculate the propagation loss in the ducts, and the modified refractivity indexes of a surface-based duct and an elevated duct as provided by a WMO station were applied.

The received signal-to-interference plus noise ratio and the required additional attenuation loss at Japan's ITS roadside occurring from Korea's DVB-T2 were simulated. We confirmed that the strength of the received interfering signal depends on the antenna height, and that the target interference level may be satisfied by adjusting the antenna height.

This paper can be used to evaluate the interference effects and find a spectrum-sharing method between Korean DVB-T2 and Japan ITS. It can also be useful for deployment planning by each system, resulting in an interference impact that is acceptable to both parties.

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