

Interference Analysis from LPR into BSDS Using Geographical Model

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Abstract— In this paper, we evaluate the interference effect of LPR on BSDS in 24.05-24.25 GHz band. The geographical model for the analysis is used and the dynamic simulation is performed, taking into account real environment. The results show that the received interfered power from LPR depends on the separate distance along the road and relative position. It is, also, realized that an appropriate location and pattern of the LPR's antenna may mitigate the interference to BSDS. This result could be used for planning LPR installation and also find out a suitable radiation pattern.

Keywords— BSDS, LPR, Interference, Geographical model

I. INTRODUCTION

In Korea, systems as like Intelligent Transport System (ITS), Blind Spot Detection Sensor (BSDS) and Auto Door Sensor (ADS) can be used at the frequency range 24.05 - 24.25 GHz band under the government's technical standard [1].

BSDS scan the blind spot area in the adjacent lanes of traffic continuously and notify a driver any potential risk, for example, via a LED spot. It is a kind of Short Range Radars (SRR) to be implemented on cars to ensure survey of the close environment of the cars for safety purpose [2-4].

Recently, it was considered that Level Probing Radar (LPR) can be used in the frequency range 24.05 - 26.5 GHz. LPR used as individually coordinated installations in many industries concerned with process control to measure the amount of various substances, mostly liquids or granulates [5].

When LPR and BSDS are in the same area, the potential interference would be produced because they use partially same frequency. Also it is difficult to move the LPR into other place after installed first time and cars are equipped with BSDS run here and there. If LPR and BSDS use the same frequency and at same area, interference analysis are required to enable the two services to share without causing unacceptable levels of interference to each other.

In this paper, we present interference scenario and geographical model for analysis the interference effect from LPR into BSDS. We conduct dynamic simulation of interference analysis using the geographical model for a single case with related parameters, also taking into account practical operational environment for both systems. We also show simulation result that can be used as deployment example of an LPR for interference avoidance.

II. SCENARIO AND GEOGRAPHICAL MODEL

Figure 1 shows the interference scenario from LPR system into BSDS system where receiving part of BSDS system would be interfered. We take into account the practical deployment environments for both BSDS and LPR system. We assume a car goes along a right line from +100m to -100m in the vicinity of the LPR antenna located at 4m away from the road with 7m of height. There are 8 lanes with the width of 3m in the road and the space in the central part of the road is assumed to be 1m. The antenna height of it is 0.5m for a car and 1.5m for a lorry. We calculate the received interference signal strength from an LPR by moving the car in the road. For the interference evaluation in this situation, we first model the deployment environment and used the geographical model in [6]

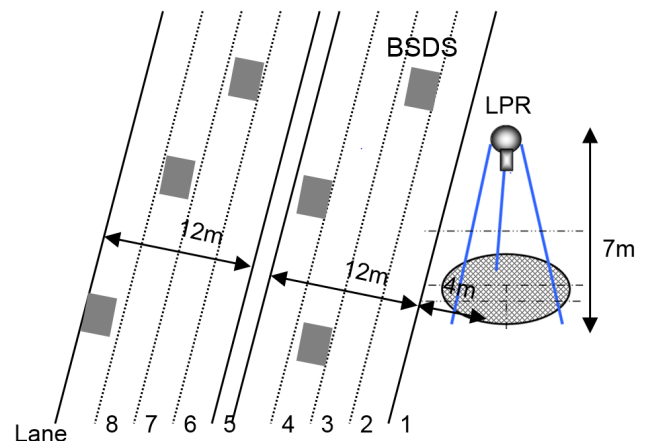


Figure 1. Interference scenario between BSDS and LPR

Figure 2 shows the geographical model representing an overview of the angles between the antenna of BSDS for a car and the antenna of LPR. The α is a pointing direction of the LPR compared to the vertical. The γ is an angle under which the car is seen for $Y=0\text{m}$ and $X=4\text{m}$. The Δh is the difference of antenna height between the car and the LPR. The coordinates of (X', Y', Z') is a new one in the referential (LPR, X', Y', Z'). The car is assumed to move parallel to the

Y axis. The azimuth (θ_B) and the elevation (ϕ_B) of the BSDS in the direction of LPR can be expressed as

$$(\theta_B, \phi_B) = (az, elev) = (\tan^{-1}(Y/X), \sin^{-1}(\Delta h / dist)) \quad (1)$$

where $dist = \sqrt{X^2 + Y^2 + (\Delta h)^2}$. The azimuth (θ_L) and the elevation (ϕ_L) of the LPR in the direction of BSDS can be expressed as

$$(\theta_L, \phi_L) = (\sin^{-1}(Y' / (dist' \times \cos(\phi_L))), \sin^{-1}(Z' / dist')) \quad (2)$$

Where $dist' = \sqrt{X'^2 + Y'^2 + Z'^2}$ and the coordinates in the reference (LPR, X' , Y' , Z').

We can use (3) to calculate the interfered received signal strength at the BSDS.

$$I_{BSDS} = \frac{p \cdot g_t(\theta_L, \phi_L) \cdot g_r(\theta_B, \phi_B)}{PL} \quad (3)$$

Where I_{BSDS} is the interference signal power due to the LPR; p denotes the transmitting power from the LPR; $g_t(\theta_L, \phi_L)$ is the gain of the transmitting LPR in the direction of BSDS receiver; $g_r(\theta_B, \phi_B)$ is the gain of a BSDS in the direction of transmitting LPR; PL is the free-space transmission loss between the BSDS and the LPR.

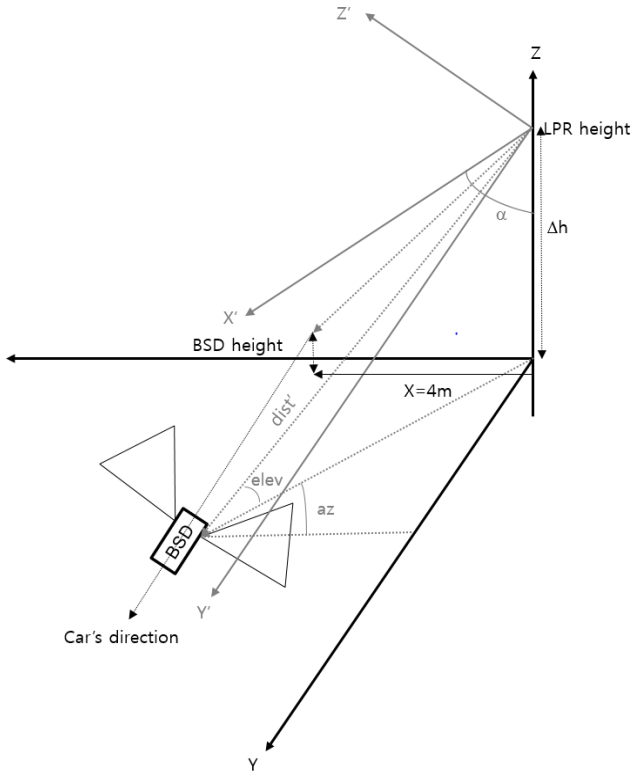


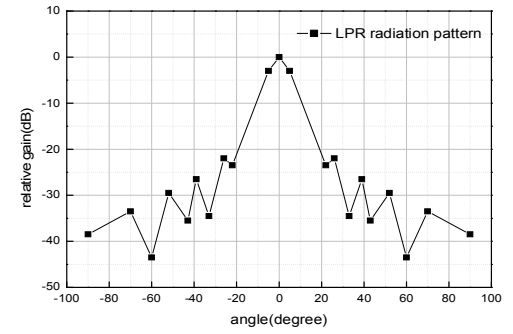
Figure 2. Geographical representation of the angles seen from the LPR Antenna

III. RESULT AND DISCUSSION

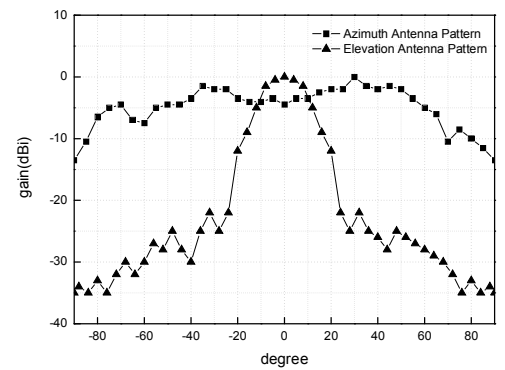
Table 1 present the operational system parameters for both BSDS and LPR for simulation, respectively. Also Figure 3 are the antenna patterns of LPR and BSDS's antenna pattern used [5, 6]. It is quite important to find protection criterion for harmful interference threshold, so we assume -6 dB and -20dB of I/N which is given in ITU-R Recommendation M.1461-1 [7]. The permissible interference level calculated from this protection criterion is -117dBm/MHz and -131dBm/MHz while the noise level is calculated, noise figure of 3dB is assumed.

Table 1 System parameters for simulation.

Parameter	LPR	BSDS
frequency	24.15GHz	
Bandwidth	1000MHz	200MHz
EIRP	-14dBm/MHz(mean), -8dBm/MHz(peak)	20dBm
Modulation	FMCW	FMCW
Pulse Repetition Frequency	1.8MHz	
Antenna height	7m	0.5m, 1.5m
tilt	90°	0°
Noise figure	-	3dB

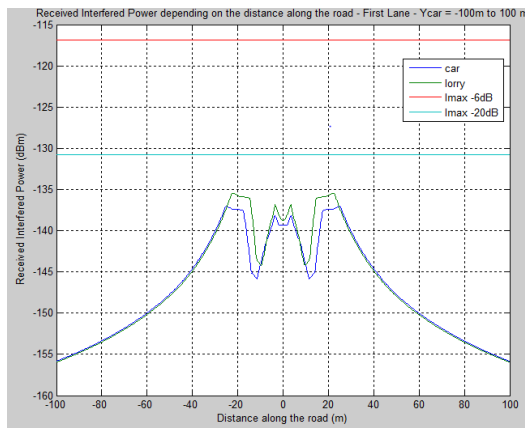


(a) LPR

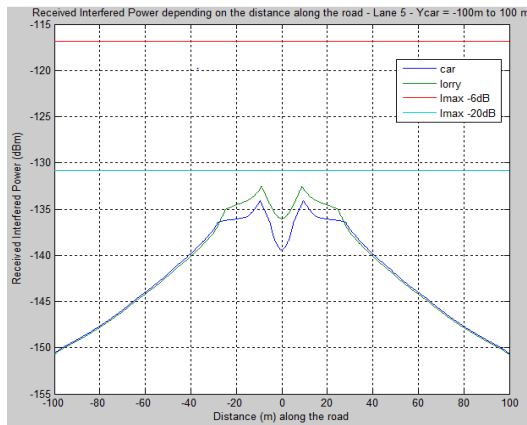


(b) BSD

Figure 3. Antenna pattern



(a) First Lane, mean EIRP

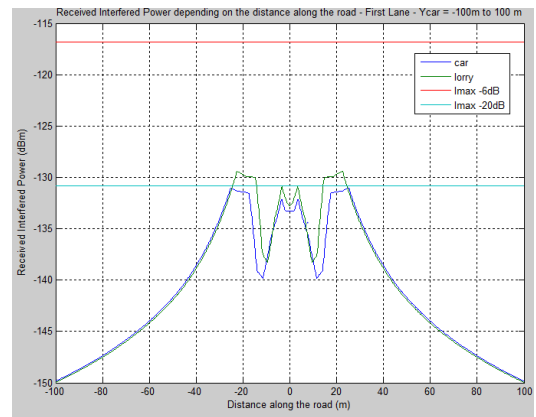


(b) Fifth Lane, mean EIRP

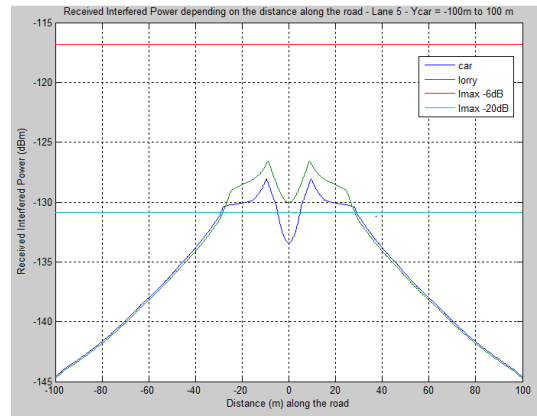
Figure 4. Simulation Result 1

Figure 4 shows simulation results of the interfered received signal strength at the BSD from LPR for 1 car deployed on each of the lanes for an LPR pointing to in a downwards direction. Figure 4(a) shows the received interfered signal strength through 1 lane and 4(b) shows the simulation result through 5 lane when the LPR transmitting power is the mean EIRP. Figure 4 indicates that the received interference signal strength at the BSD may satisfy permissible interference level from +100m to -100m in the vicinity of the LPR antenna.

Figure 5 shows the interfered received signal strength at the BSD from LPR for having peak EIRP. Figure 5(a) shows the received interfered signal strength through 1 lane and 5(b) shows the result through 5 lane. Figure 5 indicates that the received interference signal strength at the BSD may not satisfy permissible interference level some section. This inspection tell us immediately that exists the possibility of the interference at the BSD from LPR, for the -20dB of I/N protection criterion. A car in the first lane have shorter separate distance than car in the 5-lane with the LPR, so it expected that the path loss is small and the effect of interference is more. But the simulation results show that the car in the 5-lane received the greater interfered signal power. This is due to antenna pattern of BSD and LPR which determined by the relative position between them.



(a) First Lane, Peak EIRP



(b) Fifth Lane, Peak EIRP

Figure 5. Simulation Result 2

From this result, we see that an appropriate location or pattern of LPR antenna may mitigate the interference signal level in some degree. Figure 6 shows received interfered power through 5 lane for having peak EIRP when varying the LPR pointing angle to in a downwards direction. We confirm that adjusting the relative angle to the vertical direction mitigate the interference signal level.

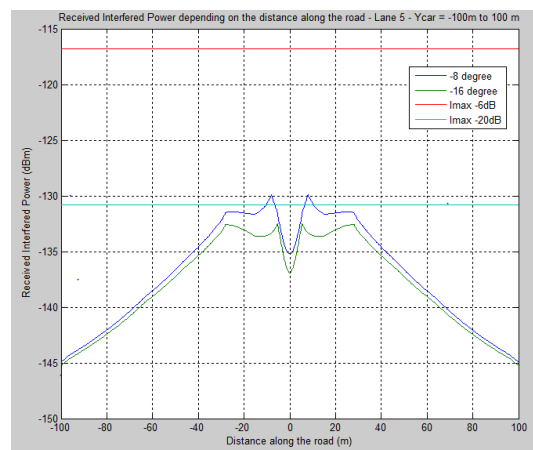


Figure 6. Simulation Result 3

IV. CONCLUSIONS

In this paper, we analyzed the interference effect from LPR to BSDS using 24.05 - 24.25GHz frequency band. We used a geographical model to calculate the level of interference signal and the simulation for single interferer case is done. From the result, the occurrence of interference cases depends on I/N protection criterion and LPR EIRP. In the case of I/N of -6dB, the interference criterion is met in all cases while for I/N of -20dB, interference may occur for LPR peak EIRP. We can confirm that an appropriate location of the LPR antenna may mitigate the interference strength in some degree from simulation result. The used geographical model would be a great help to solve an appropriate location of the LPR antenna.

ACKNOWLEDGMENT

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