2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Electromagnetic Field Exposure Assessment for X-band High Radiated Radar

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A vessel traffic service (VTS) system can cause electromagnetic field exposure to surrounding area because a radar of the system uses high radiated pulse signals to transmit information from the source to faraway targets. The average received power may be low, however, there is the possibility of exposure to the nearby radar facility because of instantaneous high peak power. The ICNIRP standards recommend for the field strength of pulse wave not exceed 32 times the field strength of frequency dependent acceptable levels, and the IEEE C95.1 standards also recommend on the base on the peak value of pulsed fields [1]. This paper investigates what effect the high radiated pulse radar affects the surrounding area by using ray tracing on a modeling of the nearby environment and in-site measurement.

Electric field is analyzed over a geographical modeling of terrain surface and sea level, which the geographical modeling includes difference of elevation within a square kilometer. Specifications of the transmitter antenna including operating frequency, radiated power, radiation pattern, and antenna gain are also modeled as a point source to analyze propagation characteristic. The transmitted signal uses a pulse waveform at the operating frequency of X-band. After the modeling, ray tracing is applied on the modeling to get the electric field distribution over the surrounding area, and the effect to the surrounding area from the high radiated radar is analyzed by showing RMS values of electric field intensity in 1.7 m from the ground on the direction of main lobe. Ray tracing calculates how much electric field affects the nearby environment where analysis volume of the target area is larger than hundreds of wavelengths. Electric field can be obtained equivalently by using ray tracing on surface current of an arbitrary scattering body with Green's functions instead of obtaining boundary conditions at high frequency.

The tendency of ray tracing results is verified with in-site measurement. The measurement is conducted on the very site of the modeling target area, we measure the electric field intensity in several points on a radial line from the radar using a portable electric field probe. The measurement process follows the ICNIRP standards that recommend measurement of electric field intensity in average over 6 minutes. The main lobe direction of the high radiated radar observes the horizon, so the effect to the nearby area is mainly from sidelobe of the high radiated radar. We found that the high radiated radar in operation radiates the pulse signal that has the short pulse and the long duty ratio, which can be obtained from the sidelobe intensity of the radar signal. Electric field is generated by induced current when an incident ray grazes the ground surface, and the electric field distribution along the distance shows a spreading from the radiated radar that has some nulls as phase changes.

Acknowledgement
This work was supported by Institute for Information & Communications Technology Promotion (IITP) grant funded by the Korea government (MSIT) [2017-0-00961, Study on the EMF Exposure Control in Smart Society].

1. International Commission on Non-Ionizing Radiation Protection, "ICNIRP statement on the guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)," *Health physics*, **74**, 4, April 1998, pp. 494-522.