Numerical Analysis of EMI Characteristics of Active Implantable Medical Devices in 3G/4G and 5G sub-6GHz bands using finite element method

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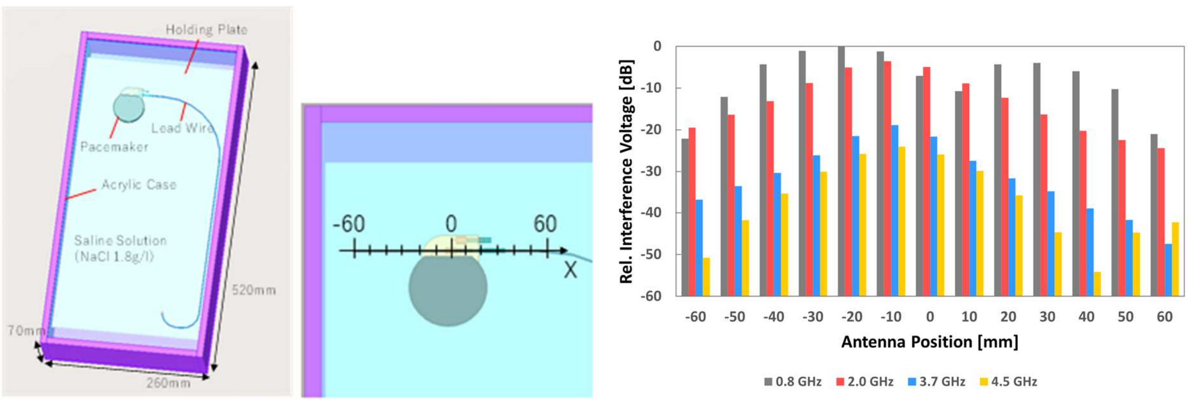
The purpose of this research is the prediction of electromagnetic interference (EMI) effects on implantable medical devices (implantable cardiac pacemakers/implantable cardioverter defibrillators) due to exposure to radio frequency (RF) electromagnetic fields (EMF) [1][2]. A numerical model consisting of a human torso phantom with an implantable cardiac pacemaker is used for the estimation. The interference voltage induced at the connector of the pacemaker is calculated by numerical simulation based on the finite element method (FEM). In this analysis, the human torso phantom is assumed to be exposed to EMF in the 3G/4G and 5G sub-6GHz frequency bands. A flat torso phantom with a pacemaker is used for the estimation, as shown in Figure 1(a). It consists of an acrylic case and saline solution (NaCl 1.8 g/l). The pacemaker is placed on the support plate so that its top surface is 5 mm from the phantom surface. The interference voltage induced at the resistor connected to the pacemaker terminal is calculated. The half-wavelength dipole antenna is placed in line with the center of the pacemaker connector. The distance from the antenna to the pacemaker is 20 mm. The antenna input power is set to 1 mW at each frequency. In this analysis, the antenna position is varied by 10 mm within a range of ±60 mm in the x-axis direction, as shown in Figure 1(b). The interference voltage in each case of antenna position is evaluated by FEM-based analysis.

Figure 1(c) shows the relationship between the antenna position and the interference-induced voltage in 3G/4G and 5G bands. The interference voltage at 0.8 GHz is the highest, followed by 2.0, 3.7, and 4.5 GHz. The maximum value at 0.8 GHz, 0 dB (26.4 mV), is about 16 times higher than that at 4.5 GHz, -24 dB (0.06 mV). This is because the lower the frequency, the deeper the RF wave penetrates into the saline solution, and the electric field coupling at the pacemaker connector becomes dominant.

The simulation results show that the interference voltage increases monotonically as the frequency decreases. We plan to study the frequency characteristics in more detail in the future. In addition, we need to evaluate the validity of the simulation result by measurement.



(a) Numerical model (b) Antenna position (c) Interference voltage

Figure 1. Numerical simulation for active implantable medical device EMI

References

[1] Takashi Hikage et al., Physics in Medicine and Biology, Volume 61, Number 12, pp. 4522-4536, June 2016.
[2] Shuhei Waki et al., proc. of 2022 URSI-Japan Radio Science Meeting (URSI-JRSM 2022), KP-4, p.174, Sep. 2022.

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