Simulation Accuracy of Normal-Mode Helical Antenna Used in Human Body

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Abstract – **Normal-Mode Helical Antenna (NMHA) is one of the promising antennas for implanted applications. Due to antennas put inside human body, electromagnetic simulations are needed to model human body and clarify electrical characteristics of antennas. In this paper, electromagnetic performances of NMHA were successfully clarified in human muscle condition by using Method of Moment (MoM) and Finite Element Method (FEM) scheme of a commercial electromagnetic simulator FEKO 7.0. Calculation results of MoM and FEM are compared to ensure simulation accuracy. Very good agreements between two simulation methods are obtained. By using correct simulation results, experimental results will be given.**

Index Terms **— NMHA, Human Body, FEKO, MoM, FEM**

1. Introduction

Previously, some kind of antennas were proposed for medical applications [1][2][3]. However, in case of implanted applications, surrounding of antenna is human tissues in which consists of electrical constants as permittivity, conductivity or dielectric loss. Therefore, effects of dielectric on antenna performances should be studied. Normal-mode helical antennas (NMHA) are well-known that can achieve rather high antenna efficiencies at very small sizes almost 1/100 wavelength [4][5]. So, this antenna is applicable for vaio sensors of human body. In this study, a small NMHA and a part of human muscle are modeling and calculated at implanted applications frequency of 402 MHz by commercial electromagnetic simulator FEKO 7.0 [6].

Physical antenna performances such as electromagnetic field distributions, input impedances and radiation pattern can be adequately recognized. In order to clarify simulation accuracy, calculated results by Method of Moment (MoM) and Finite Element Method (FEM) are compared.

2. Simulation Methods

Simulation model is constructed on electromagnetic simulator FEKO with human muscle is modeled as dielectric cylinder as shown in Fig. 1. Electric constants and dielectric block sizes are set similar to practical human muscle at 402 MHz. NMHA is put inside dielectric with ε_r = 53, so wavelength in material (λ_g) = 102 mm. Simulation parameters are summarized in Table. 1. Different mesh sizes of material are applied to investigate accuracy of calculation.

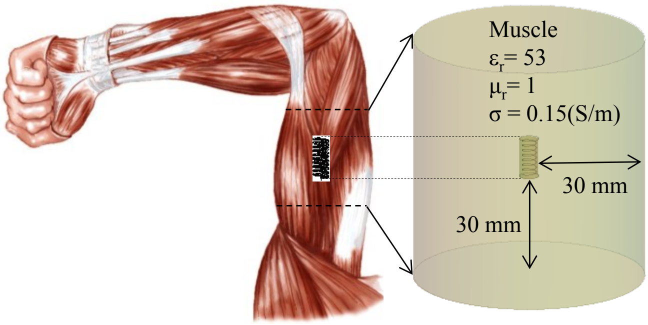


Fig. 1 Simulation model

TABLE 1: Simulation parameters

Method	MoM	FEM
Frequency	402 MHz	402 MHz
Dielectric Constant	ε_r= 53 σ = 0.15 (S/m)	ε_r= 53 σ = 0.15 (S/m)
Mesh size of Antenna Wire	λ_g/100	λ_g/100
Mesh size of Material	λ_g/20 ; λ_g/40; λ_g/50	λ_g/20 ; λ_g/40; λ_g/50
Metallic wire	Copper	Copper
Memory	669 MB	1552 MB
Calculation time	0.46 h/ sim	0.24 h/ sim

3. Simulation Accuracy

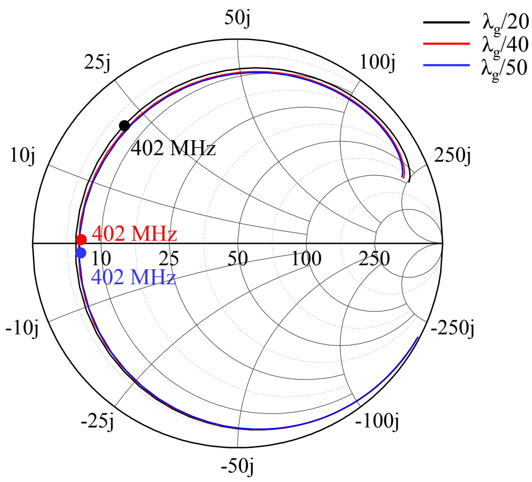


Fig. 2 Resonant condition of MoM

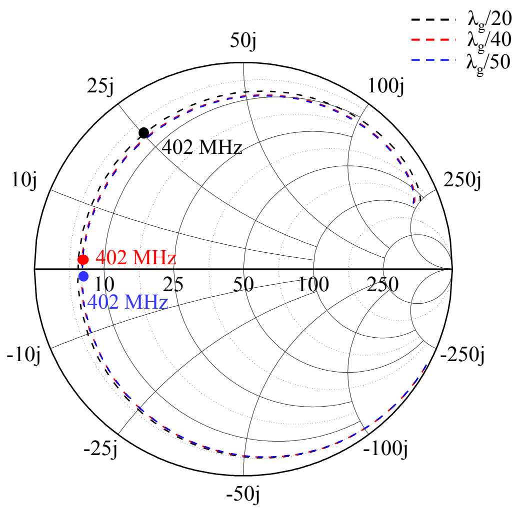


Fig. 3 Resonant condition of FEM

A model is simulated with different material mesh sizes of $\lambda_g/20$; $\lambda_g/40$ and $\lambda_g/50$ to determine resonant condition. In both cases of MoM and FEM, resonant points of 402 MHz are convergent with material mesh sizes of $\lambda_g/40$ and $\lambda_g/50$. However, in case of $\lambda_g/20$, 402 MHz is not resonant point as shown in Fig. 2 and Fig. 3. Therefore, material mesh size of $\lambda_g/40$ is reliable and selected to save memory and calculation time. From resonant conditions, self-resonant structures of NMHA in human body are determined as presented in Fig. 4. MoM and FEM show a good agreement of self-resonant structures. Antenna diameters reduce in the increasing of number of turns (N) [7].

To ensure simulation accuracy, antenna performances of structure A in Fig. 4 are also investigated by MoM and FEM. Electric field distributions and radiation patterns of NMHA in human body are shown in Fig. 5 and Fig. 6, respectively. Very good agreements between two simulation methods are achieved. So, calculations of antenna performances can be considered correct.

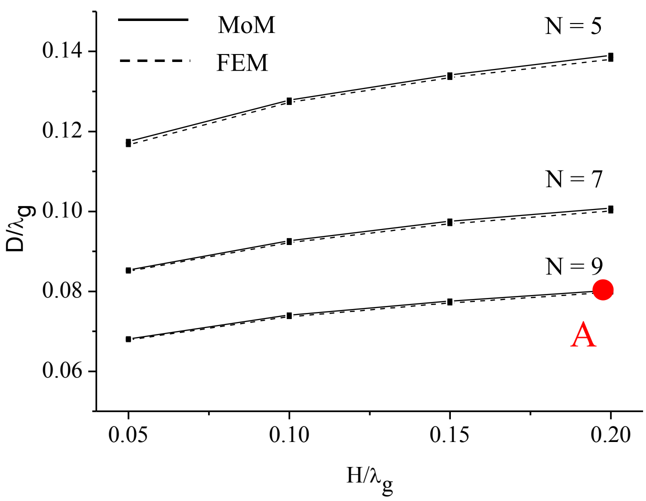
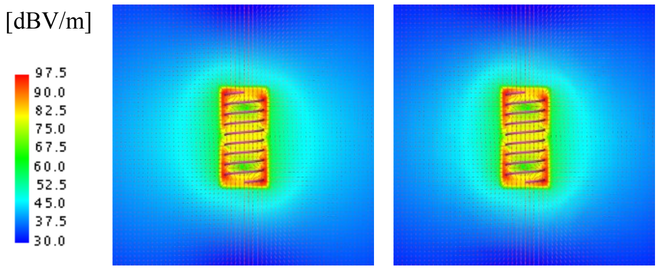


Fig. 4 Self-resonant structures



(a) MoM (b) FEM

Fig. 5 Electric field distributions

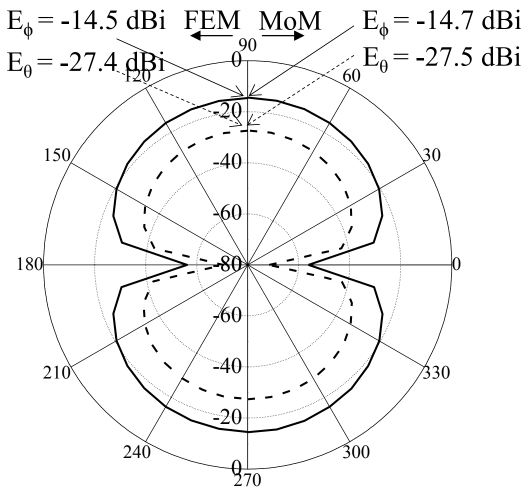


Fig. 6 Radiation patterns

4. Conclusion

By using two simulation methods of MoM and FEM, antenna performances of NMHA used in human body can be confirmed. Experimental results will be given in the next study.

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