MHz Range Analysis by FDTD/Autoregressive Moving Average Model Method

Takuji Arima*, Kenta Kuwabara, and Toru Uno
Tokyo University of Agriculture and Technology, Tokyo, JAPAN
*t-arima@cc.tuat.ac.jp

MHz frequency range is widely used as Induction Heating (IH) heater, wireless power transfer (WPT) system and so on. On the other hands, the FDTD method is powerful tools for complicated models. However, long calculation time is required in MHz range analysis by FDTD method, because, time period of MHz range becomes long, and the time step size of the FDTD method should be small with cell size reducing. In this paper, in order to accelerate of FDTD MHz range analysis, we utilize an Autoregressive moving average model (ARMA) for MHz range FDTD analysis. In this paper, we calculate input impedance of dipole antenna.

In the ARMA model, linear transfer function $H(z)$ as indicated below is used to estimate calculation result such as input impedance of the antenna.

$$H(z) = \frac{a_0 + a_1 Z^{-1} + a_2 Z^{-2} + \cdots + a_q Z^{-q}}{1 + b_1 Z^{-1} + b_2 Z^{-2} + \cdots + b_p Z^{-p}} \quad (1)$$

In the input impedance of a dipole antenna calculation, a numerator and a denominator of (1) should be feeding voltage and current of feeding point respectively. Therefore, H(z) is indicated as the input impedance of antennas. $a_0 \cdots$, a_p, b_1, $\cdots$, b_p are unknown coefficients that should be determined. In ARMA calculation, $a_0 \cdots$, a_p, b_1, $\cdots$, b_p can be determined by using system equations.

Analysis model and result are indicated in Fig.1 and Fig.2(a)(b).

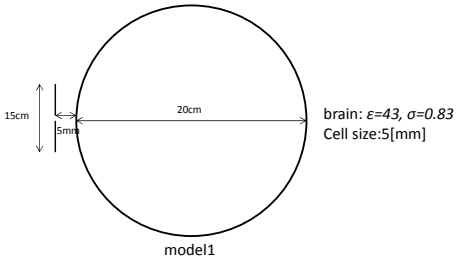

Fig.1 model

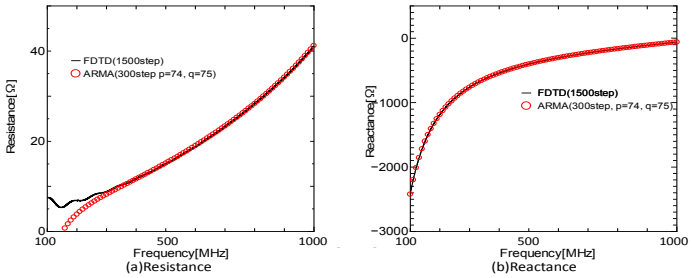

Fig.2 Input impedance of dipole antenna

The analysis model is a 15 cm dipole antenna which is placed vicinity of lossy dielectric sphere. The electric properties of dielectric sphere are, ε_r=43.0, σ=0.83, respectively. The FDTD cell size of these calculations is set as 5 mm. The dielectric sphere is imitated as human head. Fig.2(a)(b) shows calculated input impedance of dipole antenna. The solid lime is calculated by ordinary FDTD method. In this calculation, 1,500 time steps are required to obtain correct result. The Circles is indicated ARMA/FDTD results. From Fig.2, input impedance which calculated by ARMA/FDTD is good agreement with ordinary FDTD result, however, the ARMA/FDTD requires 300 time steps to obtain correct result. Therefore, the calculation time of the ARMA/FDTD was 1/5 of ordinary FDTD method.

Reference

[1]F. Yang, and A. Elsherbeni, and J. Chen "A hybrid spectral-FDTD/ARMA method for periodic structure analysis" , Proc. 2007 IEEE Antennas and Propagation Society International Symposium, pp.3270-3723, Jun. 2007

[2]Kuwabara Kenta, Toru Uno, Takuji Arima, "An Efficient MHz Range Analysis by ARMA-FDTD Method with AIC" , Proc. 2014 International Symposium on Antennas and Propagation, pp.141-142, Kaohsiung Taiwan