

# My Personal Expectations about Electromagnetics Analysis and Simulation Techniques for Next 50 Years

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**Abstract** – In this paper, I will describe my personal expectations about electromagnetics analysis and simulation techniques for next 50 years. I wish this article would give your new research topic in electromagnetics analysis and simulation field.

**Index Terms** — EM simulation, FDTD method, method of moment, finite element method, EM wave theory, Antenna and propagation

## 1. Introduction

At present, EM simulation techniques are important to develop antennas, EM systems and so forth. The Maxwell's equations are indicated as below.

$$\nabla \times \mathbf{E}(\mathbf{r}, t) = -\frac{\partial \mathbf{B}(\mathbf{r}, t)}{\partial t} \quad (1)$$

$$\nabla \times \mathbf{H}(\mathbf{r}, t) = \frac{\partial \mathbf{D}(\mathbf{r}, t)}{\partial t} + \mathbf{J}(\mathbf{r}, t) \quad (2)$$

$$\nabla \cdot \mathbf{D}(\mathbf{r}, t) = \rho(\mathbf{r}, t) \quad (3)$$

$$\nabla \cdot \mathbf{B}(\mathbf{r}, t) = 0 \quad (4)$$

The Maxwell's equations sway the electromagnetic phenomena. Therefore, almost all of the numerical analysis techniques in EM field are utilizing Maxwell's equations.

In recent years, EM simulation techniques are widely applied for variety fields such as propagation model in air plane or inside of human body. I think this reasons are as follows. In this year, computers are drastically getting up speed. Furthermore, commercial softwares are becoming popular. I think the EM simulation techniques will be getting high-performance more and more. In this paper, I will describe my personal expectations about electromagnetics analysis and simulation techniques for next 50 years. I wish this article would give your new research topic in electromagnetics analysis and simulation field.

## 2. Categorizing EM simulation procedure

The EM simulations are composed of some procedure such as modeling, making algorithm, calculating equation

along the algorithm and so on. In this chapter, EM simulation procedure is categorizing to expect these futures.

The EM simulation procedure is categorized by 5 elements such as “Equations”, “Algorithm”, “computer calculation techniques”, “visualization”, “modeling techniques”. In this paper, my personal expectations about “Equations”, “computer calculation techniques”, “modeling techniques” will be described in the next chapter.

## 3. EM simulation techniques for next 50 years

### 3.1 Equations in EM simulations for next 50 years

The Maxwell's equations are categorized by Classical electromagnetism. Therefore, Maxwell's cannot be treat quantum mechanics. On the other hand, EM simulations are applying wide frequency range which including photonics frequency range. In the photonics frequency range, quantum mechanics works with EM phenomena. In order to analysis these phenomena, the Schrödinger equation is indicated as follows.

$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial y^2} - qyE_y + V \quad (5)$$

In this equation, an electric field  $E_y$  is appeared. The electric field can be calculated by Maxwell's equation. This technique is called as “Multi-physics simulation”. I think to obtain quite accurate result the Multi-physics simulation is necessary. The Multi-physics simulation will be developed in the next 50 years.

### 3.2 Computer calculation techniques in EM simulations for next 50 years

In 2000s, GPU (Graphics Processing Unit) were applied to calculate numerical problems, because, GPU has a thousand calculation units. This technique is called as GPGPU (General-purpose GPU). If the GPU is getting high-performance, the calculation time of is drastically decreasing, then real-time simulation can be realized. If real-time simulation is established, antenna fabrication and antenna simulation can be performed simultaneously.

### 3.3 modeling in EM simulations for next 50 years

The modeling techniques are important, therefore, calculation accuracy is strongly depends on modeling accuracy. I think the antenna can be modeled by using its CAD data, however, a solder or a connector is not included in the CAD data. Therefore, there is no exact model of antennas including solver or so on. On the other hand, 3D scanner is developed to model complicated structures. If 3D scanner can be applied to making antenna model, antenna measurement and antenna simulation can be performed simultaneously

### 4. Result in antenna simulation for next 50 years and conclusion

I described my personal expectations of antenna simulations. At present, I think antenna simulation and antenna fabrication is different things. I believe that the antenna simulation and the antenna fabrication will be performed simultaneously in 50 years.

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