

# A Composite Grid Method for Calculating The Input Impedance Of Dipole Antenna

Ma Mengda

Communication University of China  
Information Engineering school  
Beijing,China  
124875828@qq.com

Guan Yalin

Communication University of China  
Information Engineering school  
Beijing,China  
ylguan@cuc.edu.cn

Lu Guizhen

Communication University of China  
Information Engineering school  
Beijing,China  
luguizhen@cuc.edu.cn

**Abstract**—This paper presents the thoughts about application of composite grid method to solve electromagnetic problems..It discusses the basic principle of the method and calculation steps, compares the calculated results with the single set of grid computing results, and summarizes the application process and development direction in the future.

**Keywords**—A composite grid method; Input impedance of dipole antenna;; COMSOL; Future application.

## I. INTRODUCTION

For some engineering applications,the electric field values and magnetic field values of all regions don't need to know exactly. Only some key position need to be calculated accurately to understand the electromagnetic properties. However,calculating the value of these region is often more difficult than the other region's. At the same time,if the mesh is too fine, it needs more computer memory and the computer's memory can't undertake the calculation amount, or the calculation process will take a long time not to satisfy the practical needs. A composite grid method (CGM) for determining those special problems appears as the times require based on the exact solution of the key position and the feasibility of parallel computer.

## II. THEORY

The grid is divided into coarse and fine grid in the application process of CGM. The overall calculation region is  $\Omega$ . The overall calculation area will be divided with coarse mesh.  $\Omega_f$  is the fine grid region,and  $\Omega_c$  is the course grid region not containing fine mesh,and  $\Gamma$  is the fine mesh area boundary. Because CGM can use the irregular grid, the coarse mesh and fine mesh unit forms in CGM can be triangular or quadrilateral element for a 2D problem. Figure 1 shows that the fine mesh grid region uses quadrilateral partition, and coarse mesh areas uses triangulation.

According to the calculation principle of CGM, assuming that there is a differential equation:

$$Lu = f \quad ..1$$

Wherein  $L$  represents a differential operator,  $u$  for solution of the unknown quantity,  $f$  as the source.

If the coarse grid operator and fine grid operator to express type, the previously mentioned formula can be expressed as:

$$\begin{cases} L_c v = f_c \\ L_f u = f_f \\ v|_{\Gamma} = u|_{\Gamma} \end{cases} \quad \dots$$

In the formula,  $L_c$  is the coarse grid differential operator.  $L_f$  is the fine grid differential operator.  $v \in S_H$ , the coarse mesh ukown to be calculated, and  $u \in S_h$ , the fine mesh ukown to be calculated.  $f_c$  is the coarse grid source,and  $f_f$  is the fine grid source.

Writing  $Lu = f$  type equivalent integral form, the calculation format may also be written as:

$$\begin{cases} (L_c v - f_c \bar{v})_M = ((L_c v - f_c) \bar{v})_{M_f} - ((L_f u - f_f) \bar{u})_{M_f} \\ (L_f u, \bar{u})_{M_f} = (f_f, \bar{u})_{M_f} \\ (L_f u, \bar{u})_{M_f} = (f_f, \bar{u})_{M_f} \end{cases} \quad \dots$$

$\bar{v}$  and  $\bar{u}$  are virtual displacement on type.

The basis function is  $\{\phi_j\}_{j=1}^{n_f} n_f$  of fine mesh. The basis function is  $\{\psi_j\}_{j=1}^{n_c} \psi = D\phi n_c$  of coarse mesh.  $\psi$  equal  $D\phi$ . In the trial, D is difference matrix.

$$D = \begin{bmatrix} d_{11} & \cdots & d_{1l} \\ \vdots & \cdots & \vdots \\ d_{m1} & \cdots & d_{ml} \end{bmatrix}, n_c \text{ is the coarse mesh nodes, and}$$

$n_f$  is the fine mesh nodes. So there is:

$$\begin{cases} v = \sum_{j=1}^{n_c} v_j \psi_j = V^T \Psi u = \sum_{j=1}^{n_f} u_j \phi_j = U^T \phi \\ \bar{v} = \sum_{j=1}^{n_c} \bar{v}_j \bar{\psi}_j = \bar{V}^T \bar{\Psi} \bar{u} = \sum_{j=1}^{n_f} \bar{u}_j \bar{\phi}_j = \bar{U}^T \bar{\phi} \end{cases} \quad \dots$$

On  $M_f$ ,  $\bar{v}$  is equal to  $\bar{V}^T D \phi$ .

The set of coarse operator  $L_c$  effecting on fine grid solving field quantity is  $u_c$ , and the set of fine grid operator  $L_f$  effecting on fine grid solving field is  $u_f$ . On  $M_f$ ,  $u_c$  is equal to  $v$ .

Therefore, calculation formula can be written as:

$$\begin{cases} (L_c v - f_c \bar{v})_{M_f} = ((L_c u_c - f_c) \bar{v})_{M_f} - ((L_f u_f - f_f) \bar{v})_{M_f} \\ (L_f u, \bar{u})_{M_f} = (f_f, \bar{u})_{M_f} \\ (L_f u, \bar{u})_{M_f} = (f_f, \bar{u})_{M_f} \end{cases} \quad \dots$$

On the left side in the first type of (5) formula,  $\bar{v} = \bar{V}^T \Psi$ . On the right side in the first type of (5) formula,  $\bar{v} = \bar{V}^T D \phi$ .

The  $((L_c u_c - f_c) \bar{v})_{M_f}$  on the left side in the first type of (5) formula is the equivalent integral form of (6) formula on  $M_f$ , and the  $((L_f u_f - f_f) \bar{v})_{M_f}$  on the left side in the first type of (5) formula is the equivalent integral form of (7) formula on  $M_f$ . Among them, type (6) is the differential equation to be solved when coarse grid operators acts on the fine grid area, and type (7) is the differential equation to be solved when fine grid operators acts on the fine grid area.

$$\begin{aligned} L_c u_c &= f_c & \dots \\ L_f u_f &= f_f & \dots \end{aligned}$$

The first type of (6) formule, after derivation, can be written:

$$\begin{aligned} & ((L_c u_c - f_c) \bar{v})_{M_f} - ((L_f u_f - f_f) \bar{v})_{M_f} = \\ & \bar{V}^T D \left\{ \left( (L_c \phi^T, \phi)_{M_f} U_c - (f_c, \phi)_{M_f} \right) - \left( (L_f \phi^T, \phi)_{M_f} U_f - (f_f, \phi)_{M_f} \right) \right\} \\ & \left\{ \left( (L_c \phi^T, \phi)_{M_f} U_c - (f_c, \phi)_{M_f} \right) - \left( (L_f \phi^T, \phi)_{M_f} U_f - (f_f, \phi)_{M_f} \right) \right\} \end{aligned}$$

is known as the fine grid computing values of the coarse grid margin correction. In a fine grid computing allowance to the coarse grid mapping is residual correction through the first by D matrix to achieve.

### III. CALCULATION PROCESS

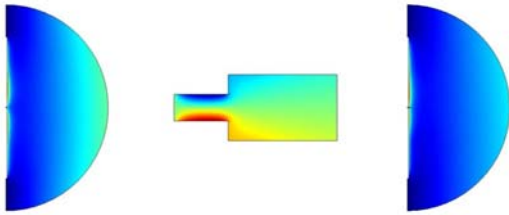
In antenna design, input impedance is a very important electrical performance parameters, we want to make the antenna parameters meet the requirements at the same time, the input impedance and the load need to be as consistent as possible to reduce the standing wave. It can increase the antenna efficiency. But the calculation of the input impedance is often difficult, and the calculation of complex antenna input impedance consume much computer memory and time. In a few words, calculation of the input impedance is not simple. Therefore, some new methods can try to calculate antenna input impedance to reduce the calculation time and computing memory consumption. CGM is a method of accurate calculation for some special positions of the electromagnetic properties. The dipole input impedance calculation will be introduced as an example to explain the method.

On the whole, we are using CGM with COMSOL software to calculate dipole input impedance. It will add a Magnetic current source after modeling the antenna, calculating the voltage value between two pole. After the coarse and fine mesh iteration to calculate the relatively accurate value, input impedance value can be calculated, so as to save computational time and memory.

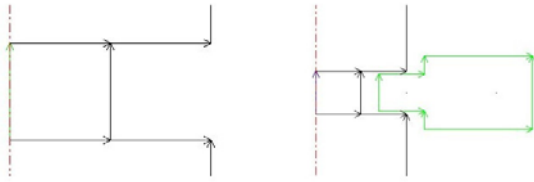
The following is the specific implementation process.

- First, dipole antenna is modeled in COMSOL, magnetic ring being the excitation source, And then divides the mesh and Calculates. Here, the grid division is equivalent to the coarse grid in CGM. In order to save computational time and reduce the burden of memory, the 2D symmetry axis of the TM wave template modeling can be used. Due to the dipole antenna being strictly symmetrical, the model will not affect the results, but also be greatly simplified. The following is the calculation results. Finally, it will output coordinates calculated data as the fine grid computing boundary conditions.
- Second, the part that is digged out need calculate with fine grid computing, and the portion need re-model. The output value of the coarse grid computing should be set as boundary conditions of the part that is re-modelled. The grid is encrypted and calculated. The following is the result of calculation. And the coordinates, calculated value need to be sequentially output.
- Third, there will build a new model. Middle digging part should be included in fine grid computing area. The boundary conditions output data can be applied to fine grid computing. The fine grid computing results need feed back to the coarse grid

computing. The following shows the calculation results.



The three picture sequentially shows the calculation results mentioned in the three steps.



The picture shows the differences of picture 1 and picture 3. The enclosed part of green line is the split part.

- Forth, the required accuracy results can be achieved by means of iterative calculation. After calculation, CGM and general method results's error can be in the acceptable scope, and it greatly reduces the computation time and memory.

#### IV. CONCLUSION

We can clearly find CMG saves a large amount of computer memory and computing time to achieve the same or similar order of magnitude results compared with conventional method through the calculation of input impedance of the dipole. Therefore, combination grid method can achieve a relatively complex antenna calculation. So we are provided a simple and practical method to calculate impedance.

#### REFERENCES

- [1] Gan Yan, Ruan Jiangjun, Zhang Yu, Peng Ying, Zhao Wei, et al. Composite grid method and [J]. transactions of China Electrotechnical Society in electromagnetic problems, 2008, 23 ( 11 )
- [2] Wang Desheng. The composite grid method and unstructured mesh generation [D]. Beijing: China Academy of mathematics and System Science Research Institute, 2001
- [3] Peng Ying, Ruan Jiangjun, Zhang Yu, and Gan Yan. A Composite Grid Method for Moving Conductor Eddy-Current Problem[J]. IEEE TRANSACTIONS ON MAGNETICS, 2007, 43(7).
- [4] Leonard P J, Lai H C, Hainsworth G D, et al. Analysis of the performance of tubular pulsed coil induction launchers[J]. IEEE Transactions on Magnetics, 1993, 29(1): 686- 691.
- [5] Zhang Yu, Ruan Jiangjun, Gan Yan, Peng Ying, and Du Zhiye. Application of a Composite Grid Method in the Analysis of 3-D Eddy Current Field Involving Movement[J]. IEEE TRANSACTIONS ON MAGNETICS, 2008, 44(1).