

A Near-field to Far-field Transformation Method Research Based on Interference Source Reconstruction

Zhang Mengze¹, Yan Zhaowen^{*2}, Xiong Ying³

¹EMC lab, Beihang University, Beijing, China, ¹zhangmengze2012@163.com

²EMC lab, Beihang University, Beijing, China, ²yanzhaowen@buaa.edu.cn

³xiongying9110@163.com

Abstract

This paper focused on the transformation problem from near-field to far-field data of integrated circuit (IC). The near-field data was obtained by near-field measurement, while the far-field data was what we needed. The key point was learning the nature of interference sources. A method was proposed to compute equivalent sources. Firstly, the value of EM field in the measurement plane was achieved and the parameters of the equivalent source were extracted by adopting least-squares method. Then an equivalent combined source model was put forward to create the far field data. Finally, an example was made to verify the correctness of this method.

1. Introduction

To measure radiation emission of RF integrated system, near-field probe is adopted for its little size and high frequency brand. But it can't determine whether the radiation level is in accordance with EMI standard [1] through near-field measurement and far-field data needs to be obtained. So, the nature of interference sources should be studied firstly. In [2], the chip was modelled by some a set of dipoles and their magnitudes were determined by TEM cell measurements. In [3], physical model of IC was extracted by near-field scanning method. In [4], the TEM cell and OATS measurements of a radiated device were correlated by six dipole moments. In [5], the electronic circuit was modelled as a set of electric and magnetic dipoles by near-field measurement. In [6], the IC radiation emission model was modelled by three dipole moments. In [7], the regularization technique was proposed to solve the reverse problem. This paper focuses on the transformation problem from near-field to far-field and an equivalent source reconstruction method is put forward to solve it.

2. The Source Reconstruction Method

The key point of this method is to compute the equivalent interference sources. Firstly, the interference source is modelled by dipole moment. Besides, the near-field measurement data is got to compute the interference source. Then, the combination model of the equivalent interference source is build. Finally, the far-field data is obtained by simulation. So that, the transformation work from near-field measurement data to far-field data is completed well. In this part, the IC is modelled as a set of dipole. A complete set of six dipole moments are necessary to represent emissions, including three electric ones Px, Py, Pz and three magnetic ones Mx, My, Mz. As the height of a typical IC is always smaller than its dimensions in x and y directions, Px, Py and Mz cannot be the dominant dipole moments, considering a large PEC ground plane under the IC. So that, vertical Pz, dipoles

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M_x and M_y are enough. The IC is equivalent to $N \times N$ dipole moments in the ground, including P_x , P_y and M_z . Figure 1 shows that the size in near-field measurement plane is $M \times M$. The EM field parameters contain four components, E_x , E_y , H_x , H_y .

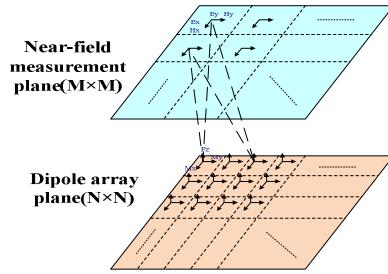


Fig. 1 The near-field measurement and the dipole array plane

The relationship between near-field data and dipole moments is shown in equation (2.1) and T is a transform matrix. In this part, the equivalent array is computed by the least square method. The near-field data can be obtained through measurement and simulation. Then it needs to be made normalization processing along with the parameters of equivalent dipole arrays. They are recorded as F_n and X_k respectively. The minimizing objective function H_1 is defined to compute the dipole arrays' parameters and the parameter (X_k) can be computed in equation (2.2).

$$\begin{pmatrix} [E_x]_{M^2 \times 1} \\ [E_y]_{M^2 \times 1} \\ [H_x]_{M^2 \times 1} \\ [H_y]_{M^2 \times 1} \end{pmatrix} = T \begin{pmatrix} [P_z]_{N^2 \times 1} \\ [M_x]_{N^2 \times 1} \\ [M_y]_{N^2 \times 1} \end{pmatrix} \quad (2.1) \quad H_1 = \|F_n - T_{nk} X_k\|^2 \quad (2.2)$$

$$X_k = [T'_{nk} T_{nk}]^{-1} T'_{nk} F_n$$

Considering that a little electric dipole P_z can be expressed by a short wire antenna and little magnetic dipoles M_x , M_y can be regarded as small loop antennas, an combination model with three antennas has been put forward to make simulation, which greatly reducing the computing time. The combination model is shown in figure 2(a). To validate the correctness of this combination method, simulations are made for a short wire antenna, two small loop antennas and the combination antenna in HFSS simulation software. The field intensity results have been recorded respectively. Figure 2(b) shows the comparison of field intensity results between the superposition of the three antennas and the combination antenna. It's easily to see that the simulation result of the combination antenna agrees well with the superposition result of three antennas.

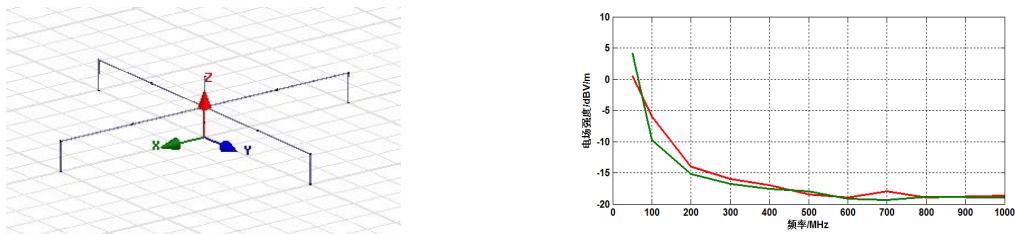


Fig. 2 (a) Left: The equivalent combination sources model (b) Right: The comparison between two results

3. Examples of Equivalent Radiated Source

In this part, a radiating trace, shown in figure 3(a), is modelled as an example of interference source. The trace is 10mm high above the ground plane and a 1V voltage source is added to it. The near-field measurement plane is 50mm high above the trace. The reference plane is 100mm high, whose EM field distribution figure is shown in figure 3(b). The values of field intensity are obtained to compute the interference source. After getting the parameters of equivalent source, a combination model is built to

make simulations and the EM field distribution in the 100mm plane is obtained. Finally, comparing the result by simulation and the result by computing, we can take measures to improve the method.

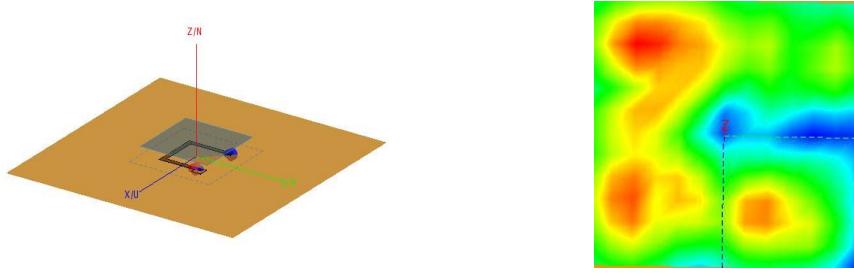


Fig. 3 (a) Left: The model of the radiating trace (b) Right: the simulation graph in the reference plane (100mm)

Firstly, the number of the dipole array is set to four, so that the number of sampling point in the near-field is three. The EM field values in three different places in near-field measurement plane are obtained by simulation. According to the parameters, the simulation model with four dipole arrays is made in HFSS software. The simulation model and the EM field intensity in the 100mm high plane are shown in figure 4(a) and (b) respectively. Comparing figure 4(b) with figure 3(b), it's easily to see that the computing result and the simulation result are different. The equivalent model with four dipole arrays can hardly reflect radiated emission from the interference source. As a result, this model can't be used to substitute the interference source.

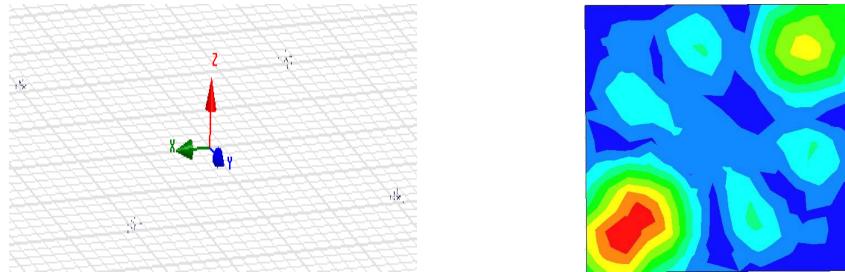


Fig. 4 (a) Left: The simulation model with 4 dipole arrays (b) Right: Its EM field intensity distribution

To improve the accuracy of the equivalent model, the number of the dipole array is set to eight, so that the number of sampling point in the near-field is six. The EM field values in near-field measurement plane are obtained through simulations. According to the parameters obtained above, the simulation model with 8 dipole array is made in HFSS software. The simulation model and the EM field intensity in the 100mm high plane are shown in figure 5(a) and (b) respectively. It can be concluded that there is a big difference between figure 5(b) and 3(b). But in some places, it can produce similar EM field intensity distribution as the reference distribution figure. The model can't express the interference source well and it also needs to be improved.

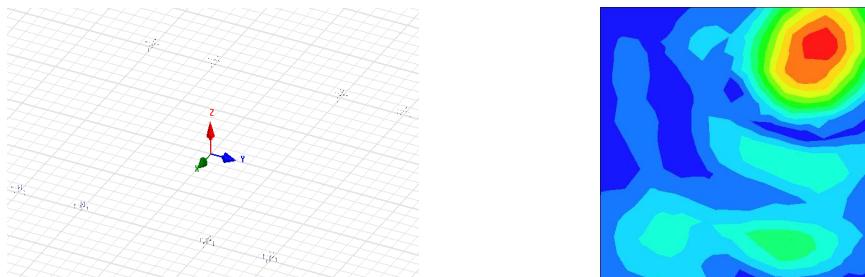


Fig. 5 (a) Left: The simulation model with 8 dipole arrays (b) Right: Its EM field intensity distribution

To make the results more accurate, the number of dipole arrays is added to 12 and the number of the sampling points in near-field plane is set to 36. The EM field values in three different places in near-field measurement plane are obtained through simulations. According to the computing parameters, the simulation model is made in HFSS software. The model and its field intensity distribution are shown in figure 6(a) and (b) respectively. Comparing figure 6(b) with 3(b), the two results are very

similar. The trend of interference source can be concluded from the EM field distribution. But the strength of the EM field intensity distribution is not accurate enough. We can't improve the accuracy of the model only by adding the number of dipole arrays, we should take other measures.

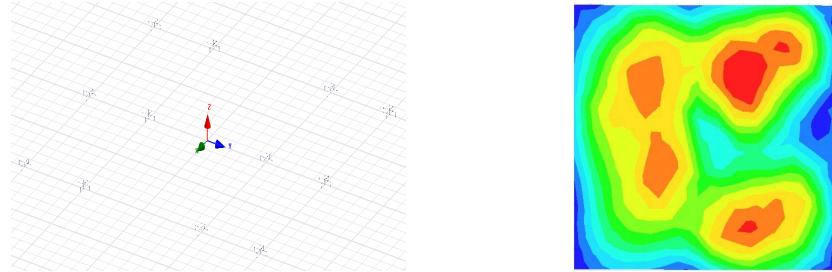


Fig. 6 (a) Left: The simulation model with 12 dipole arrays (b) Right: Its EM field intensity distribution

4. Conclusion

This paper focuses on the transformation problem from near-field data to far-field data. The main task is to compute the equivalent interference sources. A set of dipole is built to substitute the interference sources. The near-field data is obtained by measurement or simulation and the parameters of the dipole moments is computed by the least squares method. An equivalent combination source model is built and the far-field data is obtained through simulation. The method is proved to be feasible, but there still exists some problems. The accuracy of the equivalent substitution can't be improved only by increasing the number of dipole arrays. The combination model is also needs to be improved, and the error during the test and simulation should be noticed. Some other effective method, such as regularization technique [7], should be studied in our next phase of work.

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6. References

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