A Co-Simulation Analysis Method for Improving PCB EMC Performance

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Abstract. Based on the principle of the combination of field and circuit, the co-simulation method of the PCB EMC for switching power supply is carried out in this paper. We used the frequency variable source as the simulation excitation, which is closer to the actual work situation of PCB than the traditional sweep source. According to the distribution of the E and H near field, the EMC performance of PCB can be predicted, and we improved the structure of PCB by reducing the number of vias and increasing the trace width. The EMC performance of the switching power supply PCB is improved, and this method also has the advantages of reducing design costs and shortening the development cycle.

1. Introduction

With the deterioration of electromagnetic environment, electromagnetic interference (EMI) has become a key problem in electronic and communication devices [1]. Since PCB is responsible for the dual connection function between the electrical part and the mechanical part of the switching power supply, its design directly affects the performance of the power source. When the system clock reaches 120MHz, the PCB designed based on traditional methods will not work [2]. Therefore, considering the EMC performance in the PCB design process has become a necessary means.

At present, the commonly used methods for studying EMC of PCB mainly include the method of road, the method of field, and the method of field-circuit integration. The simple road method or field method is difficult to solve practical engineering problems, and the combination of field and roads will greatly improve the breadth and depth of solving problems [3, 4]. In this paper, SIwave and Designer software are used to carry out field-circuit co-simulation on the PCB based on the field-circuit method, and then make targeted improvement on PCB.

Before using SIwave to make the simulation of PCB, we need to add simulation excitation. Traditionally, we set up the excitation by adding the frequency sweep voltage source or current source at the key traces of PCB, the characteristic of this kind of excitation is that the voltage or current amplitude will not change with the frequency, and it is idealization compared with the real situation. In order to get closer to the real work situation of PCB, frequency variable source is used as simulation excitation in this paper.

2. Simulation object

We take the auxiliary power supply of the EDM system as the simulation object. It is a flyback switching power supply of 380V AC input, three-output of ±15V/0.5A and +24V/2A. The switching
frequency is 100 kHz, the output power is 65W and the power efficiency is 80%. The block diagram of auxiliary power supply is shown in Fig.1, it mainly includes the EMI filter circuit, input rectification filter circuit, clamp circuit, high frequency transformer, output rectification filter circuit and feedback control circuit.

![Block diagram of auxiliary power supply.](image)

**Figure 1.** Block diagram of auxiliary power supply.

3. Field-circuit simulation and analysis

3.1. Simulation model establishment
Firstly, we need to draw the schematic diagram of the PCB in Cadence, and import the generated netlist into Allegro, then draw the PCB. The diagram of the PCB is shown in Fig. 2.

![The diagram of PCB.](image)

**Figure 2.** The diagram of PCB.

After the design of PCB is completed, it is saved as a file in .brd format. And then import it into SIwave. The number of PCB layers is two, the color of the top layer is green, the bottom layer is blue, and the thickness of the medium layer is 1.5mm. After setting up, we should import the S parameters of switching power supply components into SIwave. The S parameters are mainly includes the parasitic parameters of resistance and capacitance, this step can make the model closer to the actual working conditions. So far, the simulation model has been completed, and we can see from the Fig. 3.

![SIwave model of PCB.](image)

**Figure 3.** SIwave model of PCB.
3.2. Production of frequency variable source
The key traces selected in this paper are (1) and (2), and the Port1, Port2, Port3, Port4 are set at both ends as shown in Fig.3. The S parameters of two traces are extracted by SLwave, and then import it into Designer software. Furthermore, we can build the simulation circuit, and make simulation at time domain, then obtain the voltage and current waveforms of each port. After Fourier transform, we can make the frequency variable source file and save it in .txt format. This file is used as an incentive for near field simulation.

3.3. Analysis of simulation results in near field
In this Near field simulation, we set the sweep frequency from 100MHz to 900MHz, and choose 100 MHz, 300 MHz, 500 MHz, 700 MHz, and 900 MHz equally spaced frequency points to analyze the radiation situation of the electric field(E) and magnetic field(H) strength specifically.

The simulation results of the E near field are shown in Fig.4. The simulation diagram at each frequency point includes two small graphs (the graph above represents the before improvement and the below represents the after improvement), in which the illustrations of the E near field are set in the same range from +8.057E-12V/m to +1.198E-06V/m. And the Plot Scale is unified as the Log value. By comparing the color distributions, it can be seen intuitively that the main radiation area is the crossing area of the key traces. At each frequency point, the radiation value of the E near field after improvement is smaller than before improvement, furthermore, the improvement effect is more obvious at 900 MHz.
Similarly, we get the simulation results of H near field, the illustrations are set in the same range from \(+7.926E-15\text{A/m}\) to \(+6.198E-9\text{A/m}\) as shown in Fig.5 and the Plot Scale is set as Log value uniformly. Through analysis, we can know that the radiation value of the H near field after improvement is smaller than before improvement.

**Figure 4.** Radiation diagram of 100MHz~900MHz E near field.

**Figure 5.** Radiation diagram of 100MHz~900MHz H near field.
According to the simulation results, the comparison curve shown in Fig.6 is drawn by Matlab. The value of each frequency point corresponds to the maximum value of the PCB radiation field intensity at the frequency point. Through analysis, we can see that the electric and magnetic field value show an increasing trend broadly with the increase of frequency. Under the 100MHz~900MHz frequency condition, the radiation intensity is reduced after improvement, especially in 900MHz, and the EMC performance of the PCB is improved obviously.

![Figure 6. Comparison diagram of electric and magnetic field.](image)

4. Conclusion
This paper takes the auxiliary power PCB of EDM machine as the simulation object, and makes the frequency variable source by SIwave and Designer, we use it as the excitation of the PCB near field simulation, which makes the simulation closer to the actual work situation. According to the near field simulation results, there are targeted improvements to the PCB such as reducing the number of vias, avoiding 90° corner trace, and increasing the width of traces appropriately, the EMC performance of the PCB is improved obviously. This simulation relies on the method of “field circuit” combination, and the result is more realistic. It has certain guiding significance for studying the EMC performance of PCB.

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