Promotion of Electronic Product Performance by Optimizing PCB

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Abstract

Aiming at the problem of electromagnetic interference exceeding in switching power supply compatibility experiment of electronic system, and combined with the design example of LLC half bridge resonance switch power supply, this paper put forward the optimum design method of PCB electromagnetic compatibility. By taking switching power supply as research object, it firstly analyzed the effect of electromagnetic interference on PCB electromagnetic compatibility. Based on method of field circuit combination, PCB simulation model was established so as to analyze the PCB electromagnetic compatibility of switching power supply. Next, according to the figure of PCB surface current and the near field distribution of electromagnetic field, and based on optimization design process of PCB electromagnetic compatibility, valid rectification measures was taken so as to improve PCB design and enhance PCB electromagnetic compatibility. At last, the simulation results showed that electromagnetic field intensity has widely reduced, which verified the reasonability of the improvement of PCB in design phase.

Keywords: LLC; Field analysis; PCB design; Electromagnetic compatibility; Simulation analysis.

1 Introduction

In electronic technology field, with the increasing strengthening of the function of electronic system or equipment, the problem of electromagnetic compatibility (EMC) has gradually attracted people's attention. The generated changeable voltage and current in the main circuit of switching power supply will produce intense alternating electromagnetic field surroundings. It will not only increase its external radiation, but also generate electromagnetic interference in its adjacent pilot circuit, which has become a difficult problem of impeding the smooth production of switching power supply [1]. Therefore, accurate prediction on the magnetic field radiation, distribution rule and function of switching power supply main circuit, has great significance in enhancing and improving EMC [2-3].

As the basic unit of modern electronic system or equipment, PCB shoulders the dual ligation of electrical part and mechanical part[4], of which the fine degree of its design not only directly closely connected with its anti-interference ability, but also has important influence on the whole system or equipment. As for researches on PCB electromagnetic performance, and test on the problem of radiated interference exceeding, we usually adopt with the priority of intensifying smoothing [5], shielding and ground connection, but less to solve the problem from inside to outside of source PCB. For example, Zhao Quanbin [6], et al conducted modeling on Flyack switching power supply using finite-difference time-domain method, which has researched the distribution and rule of far field electromagnetic radiation in open space. Huang Huagao [7], et al conducted frequency domain simulation on Buck, Flyack power supply main circuit using software of finite element algorithm, which obtained the near field of switching power supply.

Based on the above research status, this paper conducted simulated analysis of electromagnetic compatibility on PCB using field simulation and established ligature simulation model of LLC switching power supply PCB using Allergro and Ansoft Designer, which has certain innovation. The research object is a set of 240w multiplexed output switching power supply. In the aspect of input, input in the range of 220V/50Hz, and it can work within ±20%. In output, three routes direct-current output, respectively 24V/6A, 12V/3A and 5V/3A. 15V/3A is boosting voltage, which provides power for driver chip. LLC half bridge resonance is output main circuit, and flyback circuit is accessory circuit.

2 Circuitry Design of Llc Half Bridge Resonance Switching Power Supply

Figure 1 and 2 are the adopted main circuit diagram and its working waveform. Figure 1 is LLC half bridge resonance converter theory, and Q1 and Q2 are respectively the power on the half bridge, of which the duty cycles are both 0.5. Cs is resonance capacitance. Tr is the centre-tapped transformer with equal number of vice edge turns. Ls is the leakage inductance of Tr. Lm is initiation inductance. In addition, in certain period of time, Lm can be a resonance inductance. Therefore, the resonance elements of LLC resonance variator include resonance capacitance Cs, inductance Ls and initiation inductance Lm. D1 and D2 refers to the diode of half

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bridge full wave rectification, and Cf refers to the output capacitance. Its working wave form is shown in Figure 2.

This paper adopted dual terminating controller chip L6599 in ST company as control circuit of LLC half bridge resonance, calculated the resistance-capacitance that conforms to the requirement of peripheral circuit so as to ensure the realization of electric function. As for flyback circuit, its transformer parameter was calculated according to design objective. The chip used in this paper is KA5M0265R, which can provide power directly as well as 5V of direct voltage for L6599.

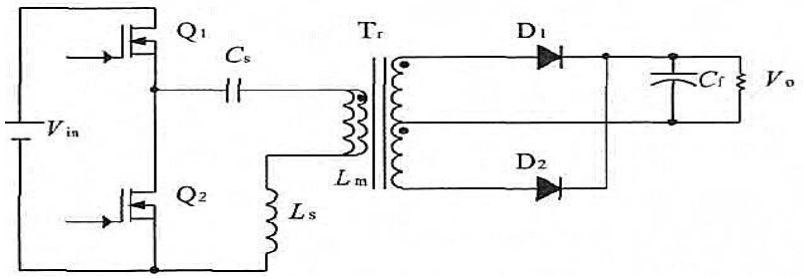


FIGURE 1 Circuit diagram of resonance converter

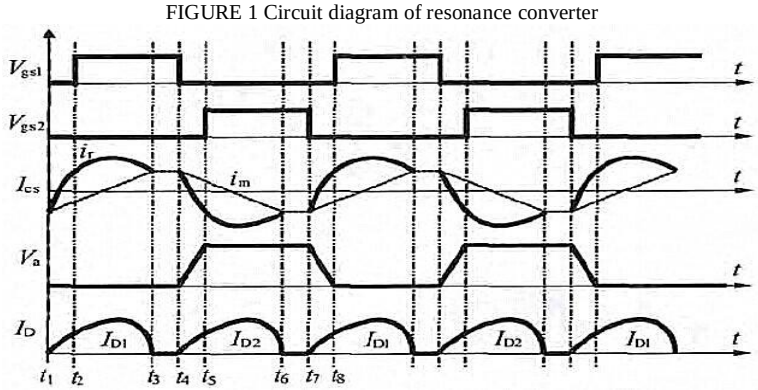


FIGURE 2 Working wave form of resonance converter

3 Electromagnetic Simulations and Improvement of Pcb

Generally, the design of switching power supply is to arrange the position of each functional circuit according to electrical schematic diagram. The layout should be benefit for the circulation of signals, and the circulate direction of signals should keep constant as much as possible [8]. With the characteristics of high power, high du/dt and relatively concentration of elements distribution, the electromagnetic interference problem of switching power supply is very severe. In order to conduct research on switching power supply compatibility using computer-aided analysis, this paper designed corresponding PCB according to the circuit diagram of LLC half bridge resonance switching power supply, which includes the electric theory design of switching power supply and EMC design [9]. The simulation analysis process of PCB electromagnetic compatibility is shown in Figure 3.

As for LLC half bridge resonance converter, according to detailed parameter, this paper selected and simulated active device. This paper analyzed its EMC characteristics through PCB model [10], drew corresponding circuit power supply schematic diagram in OrCAD and activated Ansoft Designer. According to the wiring rule in electromagnetic analysis and each layout and routing of optimal design layout, this paper adjusted the layer order and thickness and properly increased via holes, thus obtained solid model of PCB simulation. Then the components and parts that generated high-frequency interference and high frequency wiring were laid on layout, and locating and wiring was conducted by combining with field diagram for a simulation analysis. Figure 4 is the obtained near field distribution diagram of electromagnetic field. As for regions with strong field intensity, they were returned back to the locating and wiring of PCB changed by Cadence Allegro for changing the original PCB. According to the wiring rules and design principles of the performance problems of electromagnetic characteristics, its adjustment measures are: to keep the position of signal routing and sensing element away from regions of strong field intensity; to adjust the position of high-frequency drive signals, and to move it toward the margin of PCB layout and keep it far from signals that liable to be interfered; signal routing should keep smooth and with less corner piece as much as possible, and at the same time, to increase the width of signal routing. The post-improved PCB is shown in Figure 5.

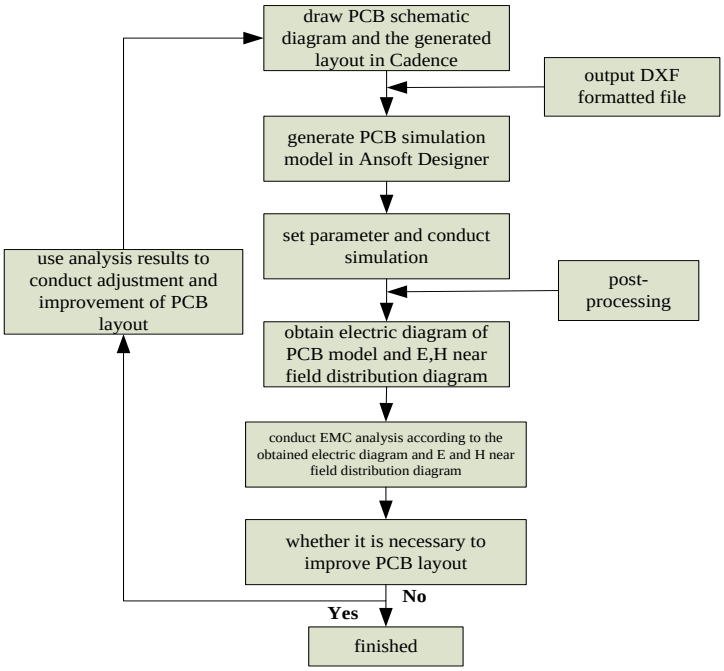


FIGURE 3 Simulated analysis process of PCB electromagnetic compatibility

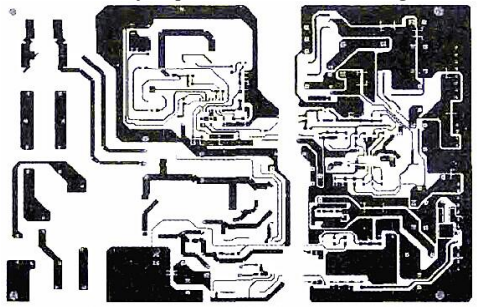


FIGURE 4 The pre-improved PCB layout

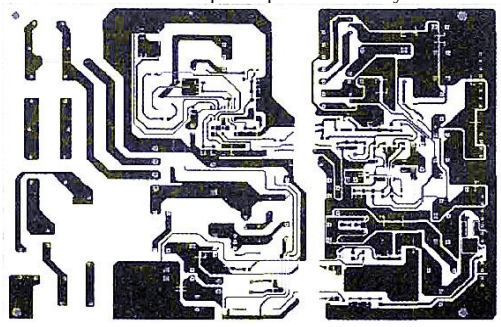


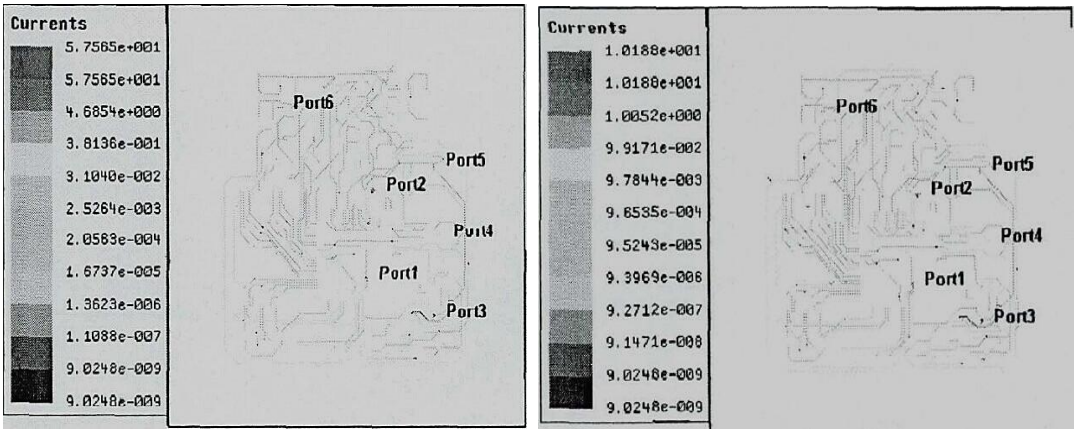
FIGURE 5 Post-improved PCB

4 Simulated Analysis of Pcb Electromagnetic Field

This paper mainly adopted Ansoft Designer to import PCB layout in the format of DXF, and studied the performance of whole system in time domain and intra-domain, thus to finish the settling of parameter. When selected parameter, the specific frequency sweeping selected linear stepping. The selected three frequency point in this paper, respectively 600MHz, 800MHz and 1.0GHz, were used for specific analysis on the distribution of current intensity, near electric field intensity and near magnetic field intensity.

A. PCB CURRENT INTENSITY DIAGRAM AND ITS ANALYSIS

The current intensity of PCB under different frequencies is shown from Figure 6 to 8.



Pre-improvement a post-improvement b

FIGURE 6 Diagram of current intensity distribution with 600MHz frequency

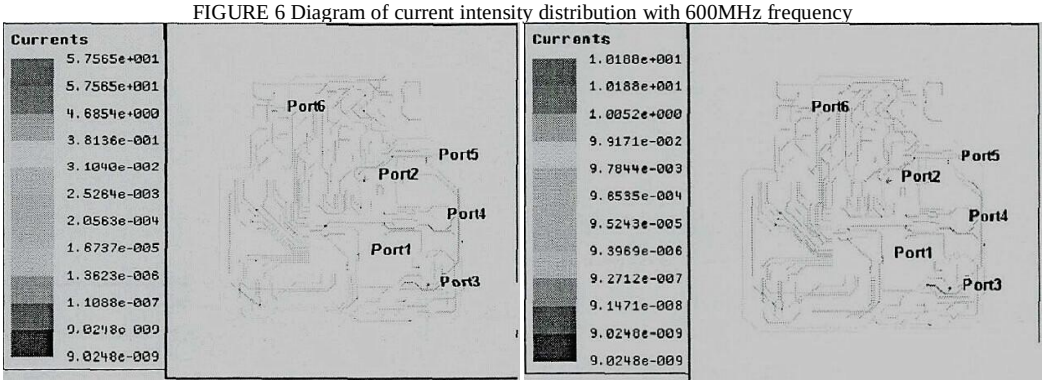


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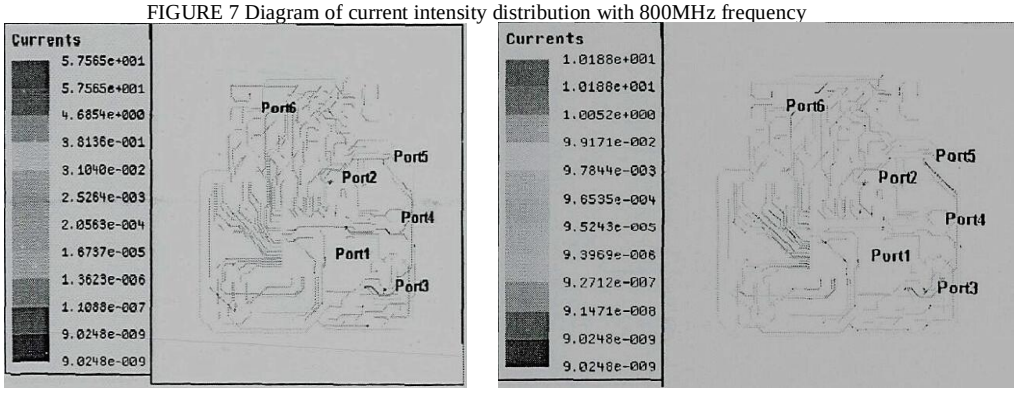
FIGURE 7 Diagram of current intensity distribution with 800MHz frequency



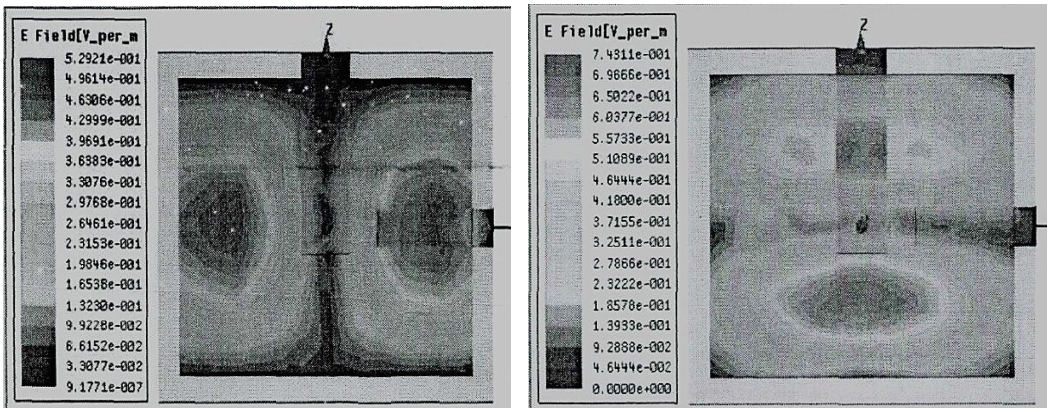
Pre-improvement a post-improvement b

FIGURE 8 Diagram of current intensity distribution with 1.0 GHz frequency

From Figure 6 to 8, it is clear that the current intensity of same frequency after improvement has apparently decreased. The maximum decreasing amplitude of current intensity has reached 28%, which has weakened its influence on the surrounding wires. According to the data in figure, it is clear that the intensity of inductance is dramatically declined on the wire that has suffered the biggest influence, and the EMC of PCB has improved greatly.

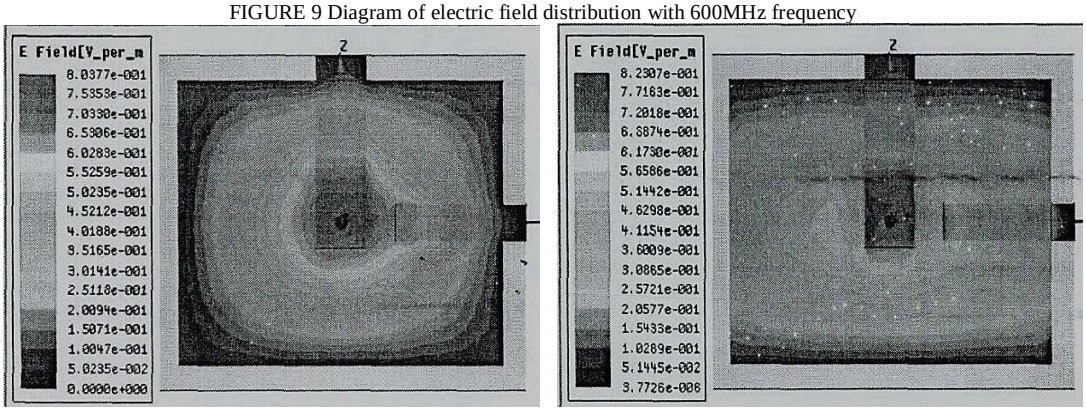
B. PCB NEAR ELECTRIC FIELD INTENSITY DIAGRAM AND ITS ANALYSIS

Similarly, this paper calculated the near electric field distribution diagram that the frequency point was between 100MHz and 1.0GHz, and their initial phases were both 0. 3 frequency points were selected for conducting comparative analysis, as shown from Figure 9 to 11.



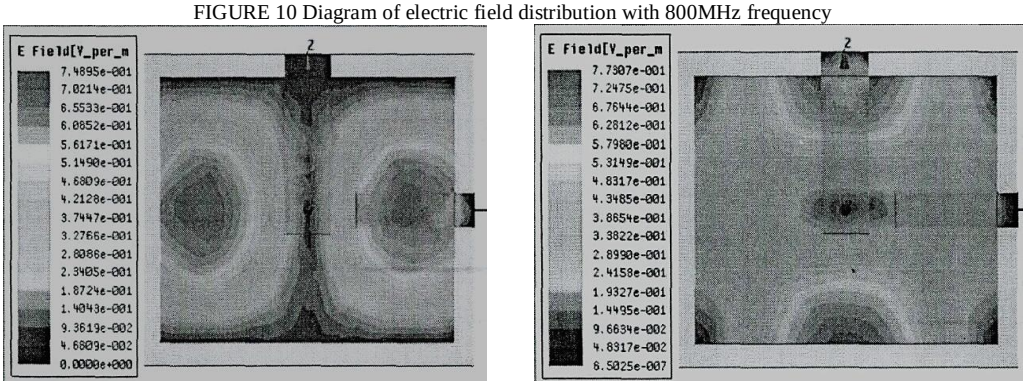
Pre-improvement a post-improvement b

FIGURE 9 Diagram of electric field distribution with 600MHz frequency



Pre-improvement a post-improvement b

FIGURE 10 Diagram of electric field distribution with 800MHz frequency



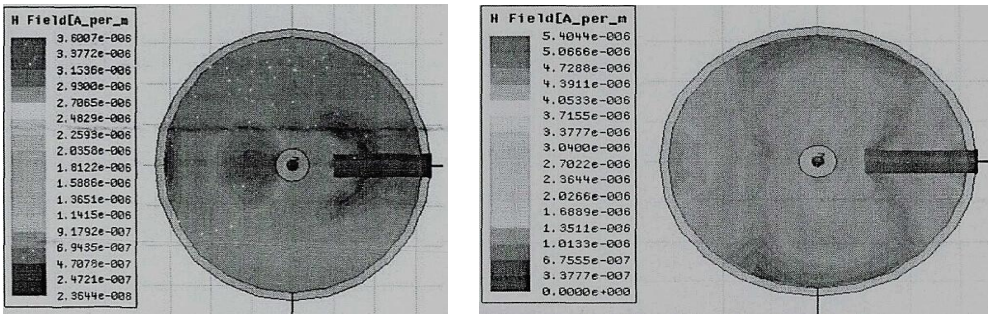
Pre-improvement a post-improvement b

FIGURE 11 Diagram of electric field distribution with 1.0 GHz frequency

From the analysis, we can get that field intensity region of optimized near electric field became smaller and deviated. The area with relatively strong field intensity also apparently decreased. Within the region of existing and relatively strong field intensity, there were no obvious interferential signal lines and sensitive elements. The performance of PCB electromagnetic compatibility has improved.

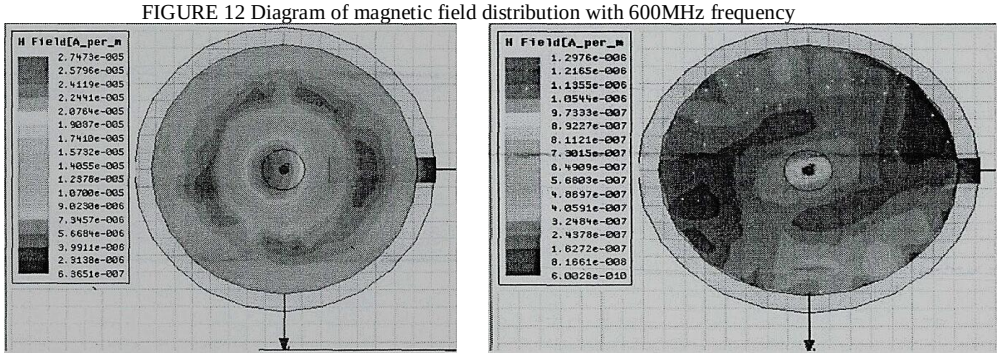
C. PCB NEAR MAGNETIC FIELD INTENSITY DIAGRAM AND ITS ANALYSIS

In addition, this paper respectively calculated the near magnetic field distribution diagram of each frequency point and their initial phases were both 0. Similarly 3 frequency points were selected for conducting comparative analysis, as shown from Figure 12 to 14.



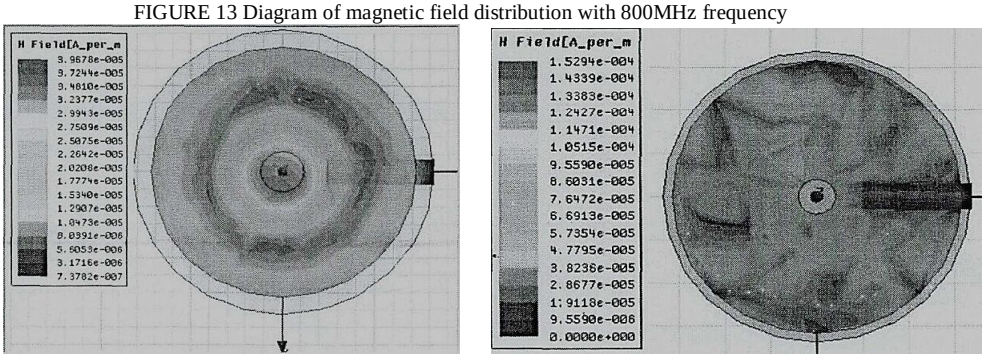
Pre-improvement a post-improvement b

FIGURE 12 Diagram of magnetic field distribution with 600MHz frequency



Pre-improvement a post-improvement b

FIGURE 13 Diagram of magnetic field distribution with 800MHz frequency



Pre-improvement a post-improvement b

FIGURE14 Diagram of magnetic field distribution with 1.0 GHz frequency

From the analysis, we can get that the improved field region that near magnetic diminished or deviated. The magnetic field intensity near the frequency point of 1.0 GHz decreased about 5 times. Within the range of relatively high electromagnetic intensity, there were basically without signal routings and sensitive elements that were easy to be influenced by electromagnetic field of high-frequency. The electromagnetic performance of PCB has improved a lot. According to the above comparative analysis of magnetic field intensity of PCB before and after improvement, the correlation curve drew as shown in Figure 15 could obtain same conclusions.

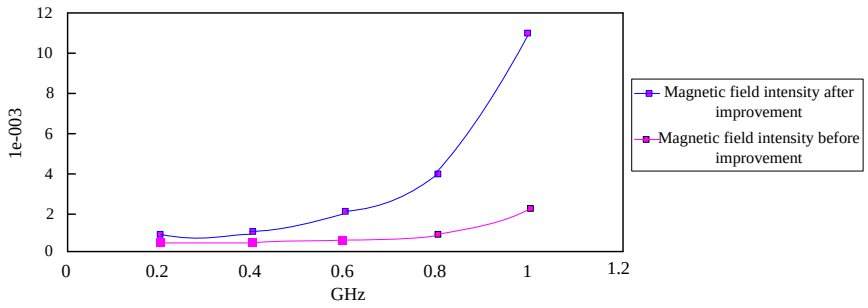


FIGURE 15 The change trend contrast diagram of magnetic field intensity with the change of frequency before and after optimal design

Similarly, we can draw the near field diagram of electric field and electric intensity diagram of PCB before and after improvement. Through comparison, we can get that the optimization of PCB wiring has decreased its influence on the integrity of other signals. Moreover, the performance of system or equipment also has obtained certain improvement [11]. It means that the optimization of PCB electromagnetic compatibility has gained preferable effect.

5 Conclusion

This paper conducted elaborate simulation analysis and improvement on the PCB electromagnetic compatibility of switching power supply. Through the analysis of PCB electric intensity and distribution diagram of near field radiation, we drew the relation between near field distribution and PCB locating and wiring and further improved it. The experiment verified that the improvement of electromagnetic compatibility before and after improvement has increased the product performance and provided certain reference for product design in future.

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