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Research on Emi Noise Suppression Method Based on Electromagnetic Shielding of Cabinet

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Keywords: *shielding effectiveness, CST, opening position, opening shape, shielding layer.*

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Research on Emi Noise Suppression Method based on Electromagnetic Shielding of Cabinet

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I. Introduction

Etal-shielded cavities have long been used to protect components and circuits inside electronic devices from electromagnetic interference and their shielding performance is measured by shielding effectiveness (SE). At present, domestic and foreign scholars have also done a series of research on the shielding effectiveness of the cavity. The EMC scanner directly obtains the electric field interference distribution on the surface of the transmission control cabinet, avoiding long-distance electromagnetic fields during wiring and reducing interference. Based on the interference situation and the coupling coefficient, [1] developed some auxiliary design software to solve some design problems of the electromagnetic compatibility of the transmission control cabinet. [2-6] used the time domain finite integration method to establish a coupled model of a cavity with plane wave radiation, and specifically studied the effect of the length, width and depth of the rectangular hole on the shielding effectiveness of the cabinet. [7-9] analyzed the scattering matrix equation and the transfer matrix equation of complex multi-cavity, and proposed a fast algorithm for multi-cavity shielding effectiveness based on electromagnetic topology theory, which improved the simulation efficiency and simulation precision. [10-12] used the pattern matching method and the matrix method to predict the shielding effectiveness of the metal-shielded cavity with perforated seams. Through cavity modeling, the shielding effectiveness of the metal-shielded cavity with perforated seams. Through cavity modeling, the shielding effectiveness of a square hole seam is better than that of the rectangular hole when the hole area is the same. Therefore, to obtain the best shielding efficiency under the working condition of the inverter circuit, it is necessary to optimize the design of the high-power inverter power supply cabinet to achieve the optimal electromagnetic shielding effect.

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II. Based on CST Cabinet Modeling

According to the actual inverter power cabinet, the cabinet model shown in Fig. One is established. The cabinet dimensions are 800mm × 500mm × 1500mm (width × depth × height), and the weight is 780Kg. The internal drive control circuit.

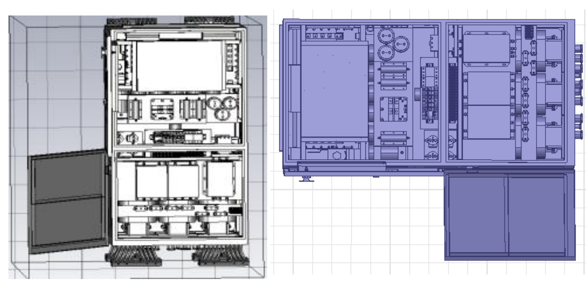


Fig. 1: Transmission control cabinet CST modeling

Because the simulation operation time is long and the efficiency is very low under this model, and the influence of the shock absorbers on the upper and lower sides of the cabinet on the shielding effectiveness of the transmission control cabinet is negligible, we have simplified the original model. The equivalent model is shown in Fig. 2.

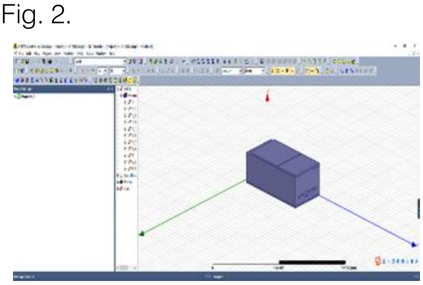


Fig. 2: A simplified model of the transmission control cabinet

The actual cabinet features such as cable bundle holes and gaps of the cabinet are reserved, and the material parameters of the simulation model are modified according to the actual cabinet material: The density at room temperature is 7850kg/m3; the resistivity is 1.3e-8 Ω/m, the relative magnetic permeability is set to 0.98, and the electrical conductivity is set to 0 (both inside and outside the cabinet are coated with insulating varnish). The thickness is 8mm. Based on the model construction, CST simulation is used to analyze the electromagnetic characteristics and shielding effectiveness of the inverter power cabinet.

III. Research on the Influence of Cabinet Shielding Effectiveness

a) Influence of opening position on shielding effectiveness of cabinet

CASE 1. According to the model, there are six circular holes on the top surface of the cabinet, each radius R=30mm, as shown in Fig. 3, the coordinates of the bottom corner of the cabinet is the coordinate origin (0,0,0), and the left side of the diagonal is (800,500,1500). The sweep range is set to 25Hz-1GHz and the sweep step is 10KHz.

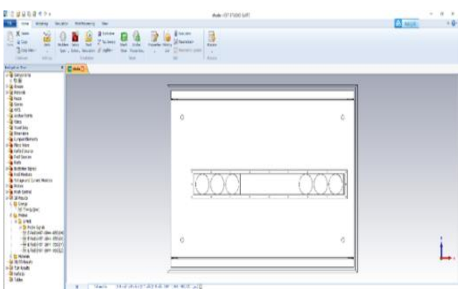


Fig. 3: Drive control cabinet model bottom opening view

CASE 2. Under the premise of not changing the number of openings and the area of the opening, modify the simulation model of the cabinet, and modify the opening position from the bottom side of the cabinet to the lower side of the back. The center of the opening is 50 mm away from the bottom edge to facilitate the cable bundle passed. The model is modified as shown in Fig. 4.

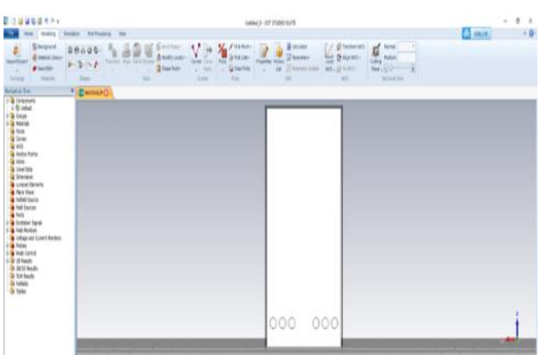
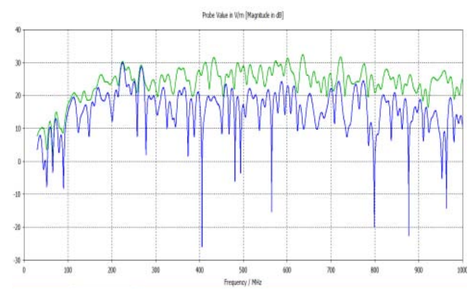


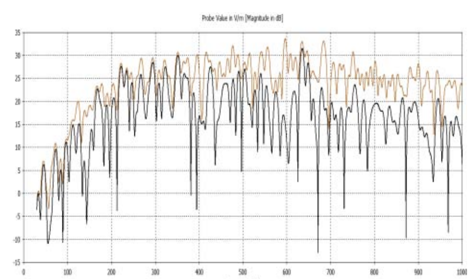
Fig. 4: Drive control cabinet model back opening view

Set the excitation source to a plane wave, the excitation source radiation size is 1V/m, and the radiation source location is set to the center of the model cabinet, that is,The plane wave center coordinate is (400, 250, 750). The plane wave incident direction is perpendicular to the plane of the hole slot (Z-axis positive direction), Three field probes are set. The probe one is placed 100mm away from the cabinet, the field probe coordinates (400, 250, -100), and the probe 2 and probe three are set to coordinates (400, -100, 750) and (400, 600, 750) respectively. Through simulation, the shielding effectiveness of the transmission control cabinet under plane wave excitation is analyzed.

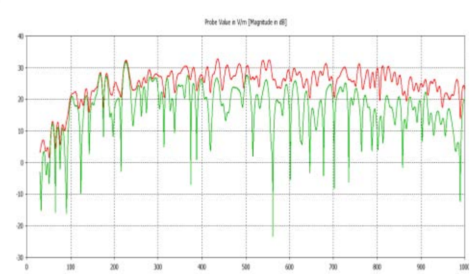
The data of the simulated electric field curves in the two aperture modes are fitted, and the results are shown in Fig. 5.



a. Comparison of electric field shielding effectiveness of probe 1



b. Comparison of electric field shielding effectiveness of probe 2



c. Comparison of electric field shielding effectiveness of probe 3

Fig. 5: Comparison of electric field shielding effectiveness

By observing the comparison of the shielding effectiveness, it is found that the shielding effectiveness of the back-opening model is better than the bottom opening model by 5.63dB and 4.15dB, respectively, at the position of the field probe 1 and the field probe 2. The shielding effect of the bottom-opening model of the field probe three position is better than the back-opening model of 1.98dB. Also, since the back of the transmission control cabinet is generally placed on the side of the ship, the back side is the ship's silo shell, and the sensitive receiving equipment is not facing. In summary, we have found that under the premise of the same number, shape and area of the same opening, the shielding effect of the back opening is better than that of the bottom opening.

b) Effect of opening shape on shielding effectiveness of cabinet

To better study the influence of the transmission control cabinet structure on the shielding effectiveness of the cabinet, the shielding effectiveness was analyzed by changing the shape of the opening from a circle to a square and a regular hexagon. Due to the strict requirements on heat dissipation and cable bundle width, it is necessary to ensure the same opening area. The radius of the circular opening is 30mm. According to the principle of equal area, when the shape of the opening is changed to square, the length of the opening should be set to 53.17mm. When the shape of the opening is a regular hexagon, the side length of the opening is set to 32.99 mm.

Plane incident waves with a radiation size of 1 V/m are placed in the center of the cabinet. Since the opening position is set on the back, the shape of the opening has little effect on the shielding performance at the positions of the probes 1 and 2. Therefore, only the shielding effectiveness of the position of probe three at the back of the opening is discussed, and the shielding effectiveness simulation is shown in Fig. 6 and Fig. 7. Among them, green, blue and red are regular hexagonal, circular and square opening shielding effectiveness.

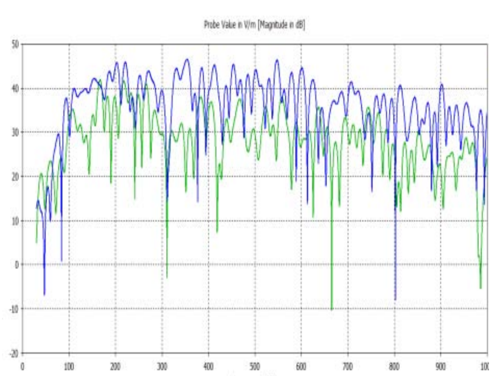


Fig. 6: Comparison of shielding effectiveness between regular hexagon and circular

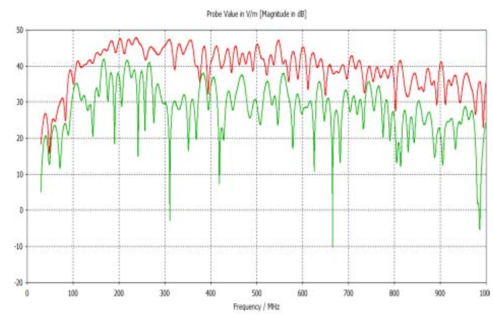


Fig. 7: Comparison of shielding effectiveness between regular hexagon and square

The shielding performance of the regular hexagon is almost better than the square in each frequency band. It can be seen from the calculation that the shielding performance of the entire frequency band is better than the circular 3.32dB. Therefore, it is determined that the opening is a regular hexagonal opening with a side length of 32.99 mm and a position of 50 mm from the bottom side of the back side.

c) Impact of shielding layer on cabinet shielding effectiveness

When there is alternating current or alternating the electromagnetic field in the cabinet, the induced the electromagnetic field inside the cabinet is unevenly distributed, and the current is concentrated in the "skin" part of the cabinet. That is to say, the current is concentrated on the thin layer on the surface of the cabinet, and the closer to the surface of the cabinet, the greater the density of the current, so that the power loss of the cabinet is also increased. This phenomenon is called skin effect. Skin depth expression is

$$\delta=\frac{1}{\sqrt{\pi f \mu \sigma}} \tag{1}$$

In the actual engineering rectification, the magnetic permeability, $\mu=4\pi\times10^{-7}H/m$ conductivity, $\sigma=5.82\times10^{7}/\Omega\cdot m$ The formula (1) can be simplified to

$$\delta=\frac{1}{\sqrt{\pi f \mu \sigma}}=\frac{1}{15.185\sqrt{f}}(\mathrm{m}) \tag{2}$$

According to the establishment of the previous theoretical shielding model, the absorption loss of the shield can be expressed as .After the electromagnetic wave passes through the metal shield, the power loss is caused by the presence of the induced current. In addition, the heat of the material absorbs a certain amount of electromagnetic wave energy, and the magnitude of the field strength decreases exponentially. We can simplify the expression of absorption loss to

$$20\lg e^{rt}=8.686\cdot rt=8.686\frac{t}{\delta} \tag{3}$$

It can be seen from the expression of absorption loss:

1. When the shielding cabinet material is the same, the absorption loss is related to the thickness of the shielding cabinet. The thicker the shielding cabinet, the greater the absorption loss;
2. When the shielding cabinet material and thickness are the same, the absorption loss is related to the electromagnetic wave frequency that the shielding cabinet is traversed. The higher the frequency, the larger the absorption loss;
3. The absorption loss of the shielding body is also related to the skin depth, that is, the electrical conductivity and magnetic permeability of the shielding cabinet material. At the same frequency, the greater the conductivity and magnetic permeability of the shielding material, the greater the absorption loss.

According to the skin effect, using the previously optimized transmission control cabinet, under the model of the regular hexagonal hole on the back side, optimize the setting again, and set a layer of copper foil on the inside of the cabinet, the thickness is set to 0.065mm, and the copper foil is laid. After that, the field probe is set and simulated in the same position. The comparison between the shielding performance and the unshielded layer is shown in Fig. 8. Blue and brown are the shielding effectiveness before and after the shielding layer is laid.

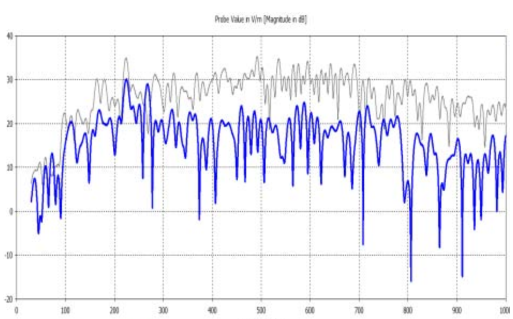


Fig. 8: Comparison of shielding effectiveness of cabinets before and after shielding

From the shielding effectiveness diagram, we can find that the shielding layer can greatly improve the shielding effectiveness of the cabinet. The shielding effectiveness is optimized to an average of 7.63dB compared to when not laid. Therefore, the shielding layer has the greatest influence on the shielding effectiveness of the transmission control cabinet, and the adoption of this measure is also indispensable in suppressing radiated EMI noise.

IV. Conclusion

This paper mainly uses CST electromagnetic simulation software to model and analyze the electromagnetic shielding effect of the cabinet under different models. The simulation results show that the shielding effectiveness of the back opening is better than that of the bottom opening under the premise that the number, shape and area of the same opening are the same; the shielding effect of the regular hexagonal opening is better than that of the circular opening and the square opening; The laying of the shield copper foil can improve the shielding effectiveness of the cabinet by about 7.63dB. It provides a theoretical reference for optimizing the characteristics of the actual transmission control cabinet.

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