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Analysis of the application of electromagnetic shielding technology in radio communication equipment

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ABSTRACT

This paper first analyzes the principle of electromagnetic shielding, and points out that it effectively blocks the interference of external electromagnetic interference source to radio communication equipment through the setting and grounding of conductor materials. Secondly, in terms of shielding methods, this paper introduces the electromagnetic field shielding, magnetic field shielding and electric field shielding techniques. Finally, the paper discusses the specific application measures of electromagnetic shielding in radio communication equipment, including continuous optimization of shielding methods, selection of appropriate shielding materials, strict control of gaps and connecting lines, so as to significantly improve the effect of electromagnetic shielding, and provide a strong guarantee for the normal operation of radio communication equipment.

KEYWORDS

Electromagnetic shielding technology; radio communication equipment; applications

In the field of radio communication, the complexity of the external electromagnetic environment often leads to the challenge of high-frequency interference. For example, when we use a mobile phone to talk, if a car just passes by, it may instantly feel the call quality decline or even temporarily interrupted. This is because the electromagnetic radiation generated by the car interferes with the mobile phone signal, which weakens the signal intensity, and then leads to the instability and distortion of information transmission. In order to effectively respond to this problem, electromagnetic shielding technology emerged at the historic moment, like a solid shield, which provides strong protection for radio communication equipment.

Through the clever application of this technology, can not only significantly improve the ability of the equipment to resist external electromagnetic interference, ensure the continuity and stability of the communication process, but also greatly enhance the security of communication data, prevent the risk of information leakage.

Furthermore, the precise application of electromagnetic shielding technology also promotes the leap in the precision of radio communication equipment, making the information transmission more efficient and accurate, and laying a solid foundation for the wide application of radio communication technology in the industrial field. The promotion of this technology has not only promoted the upgrading of industrial communication systems, but also accelerated the process of industrial automation and intelligence, which has injected strong impetus into the development of modern industry.

1 The basic principle of electromagnetic shielding

The core mechanism of electromagnetic shielding is to use the shielding body of specific materials (mainly metal shell or plate, etc.) to limit the propagation of electromagnetic waves in a limited space. This process covers three categories: electric shielding, magnetic shielding and electromagnetic field comprehensive shielding. In the selection of shielding materials, the key is to choose the selection of metal materials with excellent electrical performance, this kind of material can quickly absorb and reflect electromagnetic waves, so as to significantly reduce the interference of electromagnetic waves on radio communication equipment, to ensure the safety and stability of equipment operation.

To achieve efficient electromagnetic shielding, the conductor should be carefully placed in the circuit layout between the interference source and the sensitive equipment, and ensure that the conductor is effectively grounded [1]. This design aims to build a barrier to block the power line generated by the interference source from directly acting on the sensitive equipment, forcing the power line to terminate at the conductor, thus realizing the relative stability of the electric field environment and protecting the sensitive equipment from damage. In short, the strategic location of the conductor and its grounding treatment are a key step in building an effective electromagnetic shielding. In terms of inhibiting electromagnetic interference sources, electromagnetic shielding technology usually uses magnetic conductive materials with high magnetic conductivity. With their unique physical characteristics, these materials can serve as magnetic separation, guide the flow of magnetic field, and further enhance the magnetic shunt effect by auxiliary means. In this process, the magnetic field is effectively guided and controlled, ensuring that the radio communication equipment can still maintain the normal operation in the complex electromagnetic environment, and realize the efficient protection and maintenance of the equipment.

2 The shielding method of radio equipment

The shielding methods of radio equipment are mainly divided into three categories: electric field shielding, magnetic field shielding and electromagnetic field comprehensive shielding. Each method provides effective solutions for different types of electromagnetic interference.

2.1 Electric field shielding

The core of the electric field shielding is to reduce the electric field induction between devices or circuits, which can be seen as a reduction in the intercapacitive coupling. Electric field shielding is divided into two categories: electrostatic shielding and low-frequency electric field shielding. Electrostatic shielding requires that the shield body be complete and well grounded. By surrounding the electrostatic field source and grounding, the power line is closed inside the shield body, so as to isolate the interference of the electrostatic field source to the external environment. For low frequency electric field, high conductive material is made of shielding body and grounded to effectively shield the influence of low frequency electric field on sensitive equipment [2].

2.2 Magnetic field shielding

Magnetic field shielding is mainly for near fields of constant and low impedance field sources. In order to achieve efficient magnetic field shielding, high magnetic conductivity materials are often used and the thickness of the shield is increased to reduce the magnetic resistance. In design,

preferably high permeability ferromagnetic materials (such as steel, iron, pomo alloy) as the shielding body, these materials can guide the magnetic field line through, significantly weaken the magnetic field strength. By constructing a shield with low magnetoresistance characteristics, it can effectively resist the interference of magnetic field to radio equipment.

2.3 Electromagnetic field shielding

Absorption: When the electromagnetic energy is in contact with the shielding body, part of the energy is absorbed by the shielding body material and converted into other forms of energy, thus reducing its interference to the internal equipment. The surface and interior of the shielding material can effectively block and absorb electromagnetic energy, to ensure that the equipment is free from electromagnetic field interference. Reflection: For the shield body mainly composed of metal materials, there is impedance discontinuity at the interface between the surface and air and other media. This characteristic makes the electromagnetic wave reflect when it spreads to the shield body surface, and cannot penetrate into the communication equipment, so as to achieve the shielding effect. Reflection and absorption act at the same time: in a complex electromagnetic environment, the shield body further weakens the electromagnetic interference by reflecting and absorbing the electromagnetic field energy for many times. This dual action mechanism enables electromagnetic shielding technology to fully play its effectiveness in radio communication equipment and ensure the stability and security of signal transmission.

3 Electromagnetic shielding application measures of radio communication equipment

3.1 Careful selection of the shielding body materials

To ensure the effectiveness and pertinence of the electromagnetic shielding strategies, the staff must deeply understand and accurately match the working frequency and the interference type, so as to scientifically select the most appropriate shielding material. This process is not only a profound application of the principles of electromagnetism, but also a cornerstone to ensure the stable operation of radio communication equipment in a complex electromagnetic environment.

For high-frequency electronic equipment, the frequency of electromagnetic waves is high, short wavelength, and its penetration is relatively strong, so it is necessary to adopt shielding materials that can effectively absorb and reflect high-frequency electromagnetic waves. Good conductor materials such as copper and aluminum, with their excellent conductive performance and good electromagnetic wave reflection characteristics, have become the first choice of high-frequency electronic equipment shielding. These materials can form a layer of conductive"barrier",limiting high frequency electromagnetic waves inside or outside the device, preventing their mutual interference, thus ensuring the purity of the signal and the stability of the transmission [3]. In contrast, the electromagnetic shielding of low-frequency electronic devices faces different challenges. Low frequency electromagnetic wave has low frequency and wavelength, so it is easier to produce magnetic field effect, so it is necessary to use materials that can guide the magnetic field line and reduce the strength of the magnetic field. Ferromagnetic materials, such as steel, silicon steel sheet and electrical software, are based on this principle and are widely used in the shielding of low-frequency electronic devices. These materials have high magnetic conductivity, which can effectively guide the magnetic field lines into the material, thus reducing the interference of the magnetic field to the external or other circuits inside the device.

In the specific magnetic field shielding technology, iron, alloy and other ferromagnetic materials

have shown its irreplaceable advantages. Their high magnetic conductivity allows the magnetic field lines to form closed circuits inside the material, thus significantly reducing the influence of the magnetic field on the surrounding environment. This characteristic makes ferromagnetic materials an ideal choice for magnetic field shielding technology, widely used in transformers, motors and other equipment that need strict control of magnetic field distribution. For the electric field shielding, the goal is to reduce the impact of the electric field on the device or the human body. In this case, good conductor materials such as copper and aluminum once again play a key role. They can use their own conductive properties to direct the charge in the electric field to the surface of the material and redistribute it, thus forming isopotentials inside the material. This equipotential state allows the electric field to be weakened or even eliminated inside the material, thus achieving effective shielding of the electric field. At the same time, the reflection effect of the good conductor material also further enhances the effect of the electric field shielding, making it difficult for the external electric field to penetrate the shield and cause interference to the internal equipment.

3.2 Strict control of gap management

When designing the shield body of radio communication equipment, choosing the closed or open design scheme is a decision process that needs to weigh many factors. Closed shielding body, as the name suggests, its structure is complete, no holes or gaps, can form a tight electromagnetic barrier, theoretically can provide the best shielding efficiency. However, this design is more difficult to achieve because it requires that all possible electromagnetic leakage paths are fully taken into account in the design stage, and that the machining accuracy and assembly quality be strictly controlled during the manufacturing process. In addition, the closed design may also bring about problems such as heat dissipation and maintenance inconvenience, which often become obstacles to its promotion in practical application. In contrast, the open shield, while more flexible in design, also faces the significant challenge of gap processing. As one of the main ways of electromagnetic leakage, the existence of the gap can significantly reduce the overall effectiveness of the shielding body. Therefore, how to effectively control the electromagnetic leakage of the gap has become the core problem of the open shield design.

To solve this problem, the engineers have used many technical methods. Among them, the conductive sealing liner is a commonly used solution. This pad is usually made of conductive material, with good conductivity and elasticity, can closely fit in on both sides of the gap, forming a conductive "bridge", thus blocking the leakage path of electromagnetic waves. The selection of conductive sealing liner should be considered according to the size of the gap, working frequency and environmental conditions to ensure that the shielding effect meets the requirements of [4]. In addition, copper coated reed is also an effective gap treatment means. By plating the reed with a layer of copper and other conductive materials, it can have good conductive performance, and adapt to the small changes in the gap through its elastic deformation, to ensure the reliability of the seal. Copper-coated reed is usually used for the gap sealing of the side plate and cover plate of the chassis, which can effectively reduce the leakage of electromagnetic wave. In addition to the conductive sealing liner and copper-plated reed, there are some other technical means that can be used for gap processing, such as the use of electromagnetic shielding tape, filling with conductive foam, etc. The common goal of these measures is to minimize electromagnetic leakage from gaps as much as possible and ensure the integrity of the shield. In practical application, in order to obtain the best shielding effect, it is often necessary to use a variety of technical means. For example, in the chassis design, rationally layout the gap position and optimize the gap size, strictly control the machining accuracy and assembly quality in the machining process, regularly check the gap sealing condition in the later maintenance and replace the aging sealing materials in time. Through the

comprehensive application of these measures, we can minimize the electromagnetic interference inside and outside the chassis of communication equipment, and ensure the stable operation and high-quality transmission of radio communication equipment.

3.3 Fine processing of connecting lines

As the potential path of electromagnetic radiation, the treatment way of the connection line can not be ignored. Therefore, in the wiring process, enough attention must be given to the wiring line, and corresponding measures should be taken to reduce its negative impact as a potential path of electromagnetic radiation. First of all, the wiring should follow the "avoidance principle", that is, to avoid the connection line close to the hole and gap as far as possible. Vids and gaps are the main channels of electromagnetic radiation leakage. If the connection line is close to these areas, it is easy to become the "antenna" of electromagnetic radiation, exacerbating electromagnetic interference. Therefore, in the wiring planning, the structural characteristics of the chassis should be fully considered, the direction of the connecting line should be reasonably planned, and the crossing or being close to the holes and gaps should be avoided as far as possible. Secondly, the separate layout of ground lines and signal lines is an important measure to reduce mutual interference. The ground wire plays an important role in the circuit, which is not only the path of current reflux, but also undertakes the task of shielding and anti-interference. However, if the ground line is intermixed with the signal line, it is very likely that the current fluctuations in the ground line will interfere with the signal line and affect the signal quality. Therefore, when wiring, we should clearly distinguish between the ground lines and the signal lines, and lay them out separately, and maintain a certain spacing, so as to reduce the electromagnetic coupling and interference between each other. Furthermore, special attention should be paid to prevent the leakage of electromagnetic radiation when the connecting line must pass through the inside of the shielding case. At this point, inhibitory devices such as a magnetic ring can be installed on the connecting wire. Magnetic ring is a kind of annular device made of ferrite and other materials. It has good high-frequency impedance characteristics and can effectively absorb and inhibit high-frequency electromagnetic radiation. By installing a magnetic ring on the connecting line, an electromagnetic barrier can be formed to prevent the electromagnetic radiation from leaking out along the connecting line, thus protecting the electronic equipment inside the chassis from external electromagnetic interference [5].

3.4 Special shielding processing of the display

In the radio communication equipment, the display serves as the key information display interface, and its electromagnetic shielding performance directly affects the overall electromagnetic compatibility and signal transmission quality of the equipment. To meet this challenge, the use of screen glass has become both an efficient and practical solution. Shielded glass, as the name suggests, is a special glass with electromagnetic shielding function. By adding a conductive layer or embedded metal grid on the glass substrate, it has the ability to reflect, absorb or guide the electromagnetic waves, so as to effectively isolate the influence of external electromagnetic interference on the internal circuit of the display. In the display application of radio communication equipment, the shielding glass not only protects the display screen from the damage of electromagnetic radiation, but also improves the overall electromagnetic shielding efficiency of the equipment.

To further enhance the electromagnetic shielding performance of the display, conductive rubber strips are usually installed on the plates and panels of the shielding glass. These conductive rubber strips have good electrical conductivity and elasticity, and can be held close to the edge of the glass,

forming a continuous conductive barrier. They not only enhance the structural stability of the display, but also connect the shielding glass to the grounding system of the equipment through the conductive connection, ensuring the integrity and effectiveness of the electromagnetic shielding. In addition to the application of shielding glass and conductive rubber strip, the power supply filter, filter device and good grounding measures are also an important means to optimize the electromagnetic shielding effect of radio communication equipment. The power filter can filter out high frequency noise and interference signals from the power cord and prevent them from entering the device through the power cord. Filters are widely used in signal transmission lines to ensure the clarity and stability of signal transmission by suppressing unnecessary electromagnetic signal transmission. And good grounding measures are the cornerstone of the entire electromagnetic shielding system, which can guide the electromagnetic interference inside the equipment to the earth, so as to reduce its impact on the equipment itself and the surrounding environment.

4 Conclusion

In today's highly information age, the electromagnetic shielding technology of radio communication equipment has become a key element to ensure the stability and security of data transmission. Its wide application not only permeates every corner of daily work, but also has a profound impact on our daily life. In order to ensure that these devices can operate efficiently and stably in the complex and changeable electromagnetic environment, it is particularly important to conduct in-depth analysis and accurate control of the electromagnetic shielding characteristics of the devices. Therefore, the staff need in a comprehensive analysis of radio communication equipment electromagnetic shielding, on the equipment environment further study and use has mastered the electromagnetic shielding technology mechanism, on the basis of reasonable scientific shielding methods and measures, to ensure that the radio communication equipment in the complex and changeable electromagnetic environment keep stable running state, and achieve high quality data transmission.

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