Research and Optimization of Electromagnetic Compatibility of a Hardened Computer

Chao Li1*, Tao Wang1, Tongguo Gao1

1Department of Computer, Jiangsu Automation Research Institute, 222061, China

*Corresponding author’s e-mail: sansking@163.com

Abstract. A hardened computer is an army vehicle equipment. During the testing of electromagnetic compatibility, the RE102 electromagnetic radiation test item appeared multiple points exceeding the standard. In view of this problem, the electromagnetic environment of a reinforced computer is analyzed, and it is found that there are adverse factors that cause electromagnetic leakage in the aspects of the case aperture, cable shielding, power protection, and grounding methods. After optimization, the device passed the RE102 test smoothly. The radiated emission level of the improved equipment has decreased significantly, and the radiated disturbance suppression measures adopted are easy to implement and universal, which provides a reference for subsequent research and the development of similar equipment.

1. Introduction

Electromagnetic compatibility (EMC) refers to the ability of electronic, electrical equipment or systems to work normally in their electromagnetic environment and not to constitute unsustainable electromagnetic disturbance to anything in that environment [1]. With the rapid development of science and technology in China, the number and functions of on-board electronic equipment are becoming more and more complex, and the electromagnetic environment in which they are located is getting worse and worse. It is increasingly important to conduct EMC testing of on-board equipment in accordance with relevant standards. Many research institutes and universities have conducted electromagnetic compatibility tests [1-11]. The electromagnetic compatibility test project exceeded the standard, on the one hand, it is related to the initial electromagnetic compatibility design of the product itself, and on the other hand, it is also importantly related to the configuration mode of the system test. Equipment EMC performance is not only related to its own working stability, but also affects the normal operation of the entire combat system and peripheral equipment. For single-frequency interference, as long as the interference source is found and targeted measures can be taken to solve the problem, [12] adopted shielding measures to solve the problem of exceeding the standard frequency point of vibration, and [13] adopted high-frequency grounding measures CPU reset signal interference. However, if the interference frequency distribution range is wide, it is often difficult to adopt a single measure at this time.

In this paper, the in-depth analysis of the super-standard points in the RE102 test project (10 kHz ~ 1GHz electric field radiation emission) of the vehicle-mounted rugged computer is carried out to explore the effective suppression measures of electric field radiation emission. This article describes and analyzes the problems of this type of launcher products in the RE102 project, accurately locates the problems, then proposes a detailed design rectification plan, and finally tests and verifies the rectified products.
2. The first experimental situation

2.1. Introduction to equipment and testing

A rugged computer is mainly composed of a motherboard, a power module, a filter, a chassis, and a connector. The input voltage of the rugged computer is 24VDC, which is converted to 5VDC by the power module to supply power to the motherboard. The reinforced computer case adopts a sealing structure, and the upper and lower cover plates of the chassis are sealed by conductive rubber strips. The connectors on the chassis mainly include power interface, CAN port and network port. During the test, the computer under test is reinforced with a 24VDC voltage, and the optical fiber communication function is turned on to perform data communication with the accompanying test equipment.

The RE102 test tests the external radiation field strength of the reinforced computer through antennas and receivers, thereby assessing the impact of the reinforced computer on other equipment. The test principle is shown in Figure 1.

![Figure 1 Schematic diagram of the RE102 test](image)

RE102 mainly detects the electromagnetic interference of the equipment under test to external equipment. According to the requirements of GJB151B-2013, the testing frequency of Army equipment is 2MHz to 1GHz. The curve of the RE102 bottom test of a rugged computer for the first time is shown in Figure 2.

![Figure 2 Curves of the first RE102 test of a rugged computer](image)

The straight line in Figure 2 is the limit standard. It can be seen that a large range of electromagnetic interference exceeded the standard in the test curve of RE102, and the highest value exceeded 51dBμV / m.

2.2. Problem analysis and location

High-frequency electromagnetic radiation is generally exceeded due to leakage, conduction, and interference. According to the internal and external structure of this device, the analysis is performed from the aspects of the shield integrity of the chassis, cables, power, and ground.

First focus on the radiation emission forms in each frequency band, including two types of dense spectrum radiation and single frequency radiation. Dense spectrum indicates that the interference
signal energy in this frequency band is large and concentrated, and the test curve is obviously arched upward. Generally, large-length holes are easy to form such radiation. In Figure 2, dense spectrum radiation occurs in the frequency range of 50MHz to 100MHz. Single-frequency radiation is most often caused by leaks in narrow holes or slits, and it easily occurs at a certain high-frequency point. Multiple single-frequency radiation appears in the frequency range from 100MHz to 1GHz in Figure 2. If the port in the device is connected to any cable, it may become an efficient radiation antenna. The signal in the device will be radiated out through the cable and become a larger radiation source.

Based on the above analysis, both situations exist. According to experience analysis, dense spectrum radiation may be caused by incompletely sealed conductive pads or poor grounding. If the conductive sealing rubber pad is misplaced, it will cause incomplete sealing, which will cause a large area of electromagnetic leakage. A plurality of connectors are installed on the reinforced computer case, and there is a layer of conductive rubber pad between the connector and the case wall. If the conductive effect of the conductive rubber pad is not good, electromagnetic leakage will also occur. From the location of the device, the connector of the device is close to the receiver antenna, and some of the connectors are facing the receiver antenna. Therefore, these connectors will become a cause of electromagnetic radiation exceeding standards.

In order to further effectively rectify the problem of RE 102 exceeding the standard, it is necessary to confirm the exact location of the interference source and its effective propagation path. Test with spectrum analyzer and electromagnetic near-field probe. After testing, it was found that the electromagnetic interference radiation intensity at the tail clip of the power cable connector exceeds 55dBμV / m, and the electromagnetic interference radiation intensity at the screw near the power connector exceeds 60dBμV / m. It is judged that these two places are the main interference leakage media. The cause of electromagnetic leakage is poor conductivity and poor grounding of the conductive rubber pads of the power connector.

3. Rectification measures and test verification
In order to strengthen the electromagnetic leakage of the computer, according to the above analysis, the following measures were taken:

1. Temporarily replace the conductive rubber pad of the power connector with a wave shield to ensure that the chassis is fully sealed.
2. Connect the filter case and the wall of the case inside the case through a wave shield to ensure good grounding. Ground multiple screws on the outside of the chassis through the wave shield to achieve multi-point grounding;
3. Add a magnetic ring to the 24VDC power cable outside the case, and keep the power cable only 2 meters in length. The 24VDC power supply was replaced with a military-specific power supply.

After the improvement, the preliminary analysis of the spectrum analyzer showed that the radiation phenomenon was significantly weaker than before. The improved equipment was tested in the same way as before, and placed in a microwave anechoic chamber for the RE102 test. The test results are shown in Figure 3.
It can be seen from FIG. 3 that the intensity of electromagnetic interference radiation is significantly reduced, indicating that the above improvement measures are effective. The protruded part of the original wave arched upward was restrained to a certain extent, and the electromagnetic radiation of the external environment was obviously weakened after the improvement. However, the phenomenon of electromagnetic radiation exceeding the standard still appears at the frequency of 125MHz, and it is speculated that it may be related to the internal frequency components of the chassis. It was found that there was a 125MHz crystal on the motherboard. An RC filter circuit is added to the clock source output to suppress the spike interference caused by signal reflection. The value of resistor R is equal to the characteristic impedance Z0 of the clock input line. The value of capacitor C must meet the time constant of RC filtering equal to 1/3 of the clock cycle. Since it is difficult to accurately calculate the characteristic impedance of the clock transmission line, the test can only be verified based on empirical values. Press the shielding layer around the mounting holes of the circuit board evenly on the chassis pillars with screws to ensure that the motherboard and the equipment shell make multiple contact to achieve multi-point grounding. The grounding path is the shortest and provides a low impedance path to the ground for the circuit.

After taking the above improvement measures, retest the RE102 project of the hardened computer. The test curve is shown in Figure 4. It can be seen from Figure 4 that the improved radiation emission levels have all dropped below the qualified curve, and good test results have been achieved, which have met the requirements of electromagnetic compatibility.

![Figure 4 Final test results of a rugged computer RE102](image)

4. Conclusion
Aiming at the phenomenon that the electromagnetic radiation of a certain reinforced computer RE102 exceeds the standard, this paper analyzes the causes of electromagnetic energy leakage, proposes improvement measures, and after the improvement, it suppresses electromagnetic radiation to a large extent, and passes the electromagnetic compatibility test.

RR102 can best reflect the degree of product design's satisfaction with electromagnetic compatibility, and do a good job of electromagnetic compatibility analysis and improvement of equipment to better eliminate adverse factors and reduce product development costs. A lot of rich experience has been obtained on the design rectification of this type of product, especially the problem location methods, design rectification methods and measures in this article have certain reference value for other similar products for electromagnetic compatibility design or rectification.

References
[1] Yin Hang, Yaolingzhou, Wang Bo. Quality Control and Evaluation of Electromagnetic Compatibility [J]. Automobile Practical Technology. 2019 (12): 224-225.
[2] Zhang Xinyu, Zhang Feng, Han Yufeng. Analysis on the Evolution of Foreign External Radio Frequency Electromagnetic Environment Standards [J]. Aerospace Standardization. 2019 (02): 43-46.
[3] Tao Gai, Chen Haibo. Tailoring the RE102 limit of spaceborne equipment based on simulation model [J]. Safety and EMC. 2014 (01): 36-38.
[4] Lu Xituan, Liu Shaohua, Zang Pinyang. Analysis and Improvement of Exceeding Electromagnetic Radiation of a Reinforced Network Switch [J]. Electronic Science and Technology. 2014, 27 (06): 75-77.
[5] Xiao Wenguang, Chen Zhita. Stand-alone electromagnetic compatibility design of a satellite carrier control [J]. Journal of Air Force Early Warning Academy. 2017, 31 (03): 171-174.
[6] Chen Xiaolong, Zheng Kunpeng, Su Zhongwen, et al. Structural design of electromagnetic compatibility for a certain reinforced display [J]. Modern Industrial Economy and Information Technology. 2019, 9 (08): 32-34.
[7] Lu Yunzhi. Analysis on the electromagnetic compatibility optimization scheme of track circuit products [J]. Railway Communication Signal Engineering Technology. 2019, 16 (S1): 51-52.
[8] Xu Yaguang, Mao Jianzhou. Development of electromagnetic compatibility for foreign forces [J]. Ship Electronic Engineering. 2019, 39 (09): 1-3.
[9] Wei Wenbin, Zhang Baibao, Zhou Yuanxing. Analysis of Electromagnetic Compatibility of Tethered UAV [J]. Modern Industrial Economy and Information Technology. 2019, 9 (12): 34-35.
[10] Li Juan, Ma Jing, Yang Xiaofeng, et al. Testing and suppression of emission interference on display consoles [J]. Safety and EMC. 2019 (06): 64-67.
[11] Liu Peng, Yang Yan, Li Guodong. Development status of electromagnetic compatibility standards for medical electrical equipment [J]. China Medical Devices Information. 2019, 25 (11): 8-9.
[12] Tian Jin, Qiu Weifeng, An Weigang, et al. EMC analysis and design improvement of spaceborne receivers [J]. Space Electronics Technology. 2014, 11 (03): 94-98.
[13] Zhang Xingguo, Zhou Xinf, Jiang Gengfeng, et al. Analysis and discussion of electromagnetic interference problems of a certain spaceborne electronic equipment [J]. Aerospace Control. 2014, 32 (04): 86-90.