Research on Electromagnetic Compatibility Technology Based on Airborne Electronic Equipment

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Abstract. As more and more types and quantities of airborne electronic equipment are used, the frequency band becomes more and more wide, and the radiation power becomes more and more large, which makes the electromagnetic environment where airborne electromagnetic equipment work become increasingly complicated. The electromagnetic compatibility of airborne electronic equipments should be well designed so that they can work normally in complex electromagnetic environment. In this paper, the basic concept of electromagnetic compatibility (EMC) is pointed out first of all, the fundamental principle of EMC is then analyzed, and finally the three elements of electromagnetic interference (EMI) and the basic methods of EMC design are put forward, which provides guidance for design of the follow-up airborne electromagnetic equipments.

Keyword: Airborne electronic equipment · Electromagnetic compatibility · Design objectives

1 Summary

As informatization progresses in modern society, electrical and electronic equipments are widely used and increase rapidly in types and quantities. The trend for future electrical and electronic equipments is digitalization, miniaturization and integration. However, when these equipments work, electromagnetic energy will always be produced, which makes various electromagnetic waves available everywhere and every time. These electromagnetic energies make surrounding electromagnetic environment more complicated, causing electromagnetic interference (EMI) and electromagnetic radiation between high frequency communication equipments become increasingly serious. Electromagnetic wave now lives up to its reputation as a kind of environment pollution. However, the working environment of airborne electronic equipment is sensitive and special, which is characterized by the following. Many airborne electronic equipments of different functions are placed in a small space where cables are installed in a centralized manner; frequency band is wide, transmit power is large; receiver is highly sensitive and can

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be interfered by many approaches. Electromagnetic interference deteriorates the performance of equipments and systems or causes damage to them, which have a severe impact on their reliability and performance. Consequently, it is an important issue for design of airborne electronic equipments and systems to improve their viability in complicated environment.

Electromagnetic compatibility is also referred to as EMC. The purpose of safety requirements for EMC is to make the signal amplitude generated by the airborne electronic equipments designed or produced by ourselves meets the requirements of others. And at the same time, the airborne electronic equipments designed or produced by us should work normally in the event of EMI caused by other airborne electronic equipments. As a result, EMC is part of airborne electronic equipment safety. One of the important researches related to military equipments conducted by developed countries is to improve the anti-electromagnetic interference resistance and electromagnetic compatibility of airborne electronic equipments and promote the defense capability by making equipments, systems and subsystems coexist for the same objective under the electromagnetic conditions of battlefield. Complete and accurate EMC analysis on airborne electronic equipments, cables as well as harnesses can provide important references for addressing the EMC problem of airborne electronic equipment during model research.

2 Standard Requirements

EMC problems were taken seriously step by step since the foundation of SAC/TC 79(Standardization Administration of the People's Republic of China/ Technical Committee) in 1968 and the issue of military standard GJB151-86. In 1997, national military standards on EMC, i.e. GJB151A-97 Electromagnetic Emission and Susceptibility Requirements for Military Equipment and Subsystems, GJB152A-97 Measurement of Electromagnetic Emission and Susceptibility for Military Equipment and Subsystems as well as other confidential committee standards were issued and enforced, EMC technologies made enormous progress.

In December 2001, Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) announced Administrative Regulations for Certification of China Compulsory Products, replacing the previous Licensing System for Safety and Quality of Exported Products and Certification System for Safety of Electrical Products by compulsory certification system. China Compulsory Products, abbreviated with "CCC", is referred to 3C certification. 3C certification stipulates the safety, EMC, anti-electromagnetic radiation and other performance of electronic products in detail. Related departments of China attach creasing importance to EMC in recent years. Many units and colleges have set up or transformed EMC labs with various EMC measurement and test capabilities.

Normally, aeronautical (air force) products need going through the following EMC test items as seen in Table 1.

Table 1. EMC inspection items for aeronautical (air force) products

No	EMC inspection items
1	CE102 10kHz ~ 10MHz conducted emission of power leads
2	CE106 1MHz ~ 18GHz conducted emission of antenna terminal
3	CE107 conducted emission of power lead spike signal (time domain)
4	CS101 25 Hz ~ 50 kHz conducted susceptibility of power leads
5	CS106 conducted susceptibility of power lead spike signal
6	CS114 10kHz ~ 400MHz injection conducted susceptibility of cable bundle
7	CS115 conducted susceptibility of injection pulse excitation of cable bundle
8	CS116 10kHz ~ 100MHz conducted susceptibility of damped sinusoidal transients of cable and power leads
9	RE102 2MHz ~ 18GHz radiated emission of electric field
10	RS103 30MHz ~ 18GHz radiated susceptibility of electric field

3 Electromagnetic Compatibility Implementation and Design Principles

With the widely use of electronic equipments and information—based equipments, the electromagnetic environment in battlefield includes the signal environment of communication, radar, computer, photoelectric equipments as well as the signal environment of electronic countermeasures. The sources of electromagnetic radiation and electromagnetic signals in modern battlefield become highly intensive and their types become more complex, which make it difficult to precisely grasp the electromagnetic environment. The electromagnetic environment, which produces an effect on war process, has become an important part in battlefield.

Any EMI effect must have 3 fundamental conditions, namely, interference source, coupling path and sensitive equipment (Fig. 1).

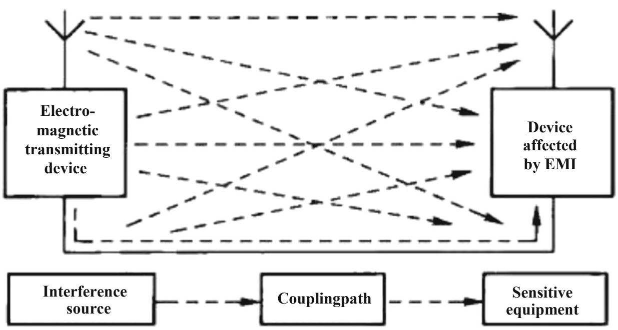

Fig. 1. F3undamental elements that cause EMI problem

Interference source: an object which can produce electromagnetic energy. The interference source can generate radiated electromagnetic interference having a certain strength, no matter the electromagnetic interference is intentionally or unintentionally emitted.

Coupling path: a channel or medium through which the energy of EMI is transmitted to sensitive equipment. Based on the transmission approach of interference source, coupling path is normally divided into radiative coupling and conductive coupling. It is through coupling path that the radiated electromagnetic energy transmits and furthermore has an influence on the normal operation of airborne electronic equipments (Fig. 2).

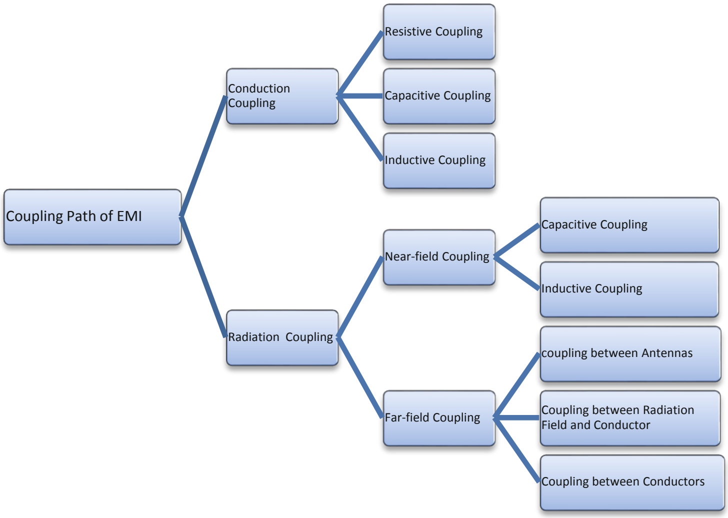

Fig. 2. Classification of coupling path of EMI

Sensitive equipment: The production of an EMI must have equipments that are susceptive to EMI. This kind of equipment is called sensitive equipment. Upon receiving the EMI signal through the coupling path, the sensitive equipment responds to the signal. The response normally manifests as performance degradation or loss of function. Sensitive equipment is the collective name for interfered objects which may be a component, an equipment or a set of a system.

For the 3 elements of EMI (interference source, coupling path and sensitive equipment), efforts can be made during EMC design by suppressing interference source, cutting the coupling path and increasing the immunity of sensitive equipment.

(a) Suppressing interference source: Suppress the electromagnetic energy of useless interference source. Analyze the electromagnetic environment where the airborne electronic equipment or system is located and relevant requirements. Select the correct design direction. Take a full account the electromagnetic environment of airborne electronic equipment during design stage.

(b) Cutting the coupling path. Increase the isolation between sensitive equipments. Meticulously select the frequency used by the airborne electronic equipment. Develop an EMC requirement and control plan.
(c) Increasing the immunity of sensitive equipment. Apply rational interference suppression and protection technologies to components, modules and circuits.

For the 3 elements of EMI, EMC control on one element is closely connected with the other two elements. For example, when good control is achieved in radiation energy of interference source, the requirement for isolation of sensitive equipments can be lowered. Once the isolation from sensitive is large enough, the requirement for suppressing electromagnetic energy of interference source can be lowered. In actual engineering, EMC design is concurrently performed in interference source, coupling path and sensitive equipment. Implementation of comprehensive and rational strategies and technical measures for EMI suppression is the prerequisite for EMC assurance.

4 EMC Design

EMC design can be carried out for airborne electronic equipments according to the following aspects based on the characteristics of equipments.

Firstly, conduct functional design. Select the components, devices and recruits which have low interference on each other. Make rational layout. On the basis that functional requirements are met, modify parameters including transmit power, operation frequency, receiving sensitivity and reselect components, in order to make EMC parameters meet standard requirements.

Secondly, conduct protective design. Design includes filtering, shielding, grounding and bonding. Time isolation, space isolation, frequency avoidance and other technical measures should also be taken. The purpose is to reduce the interference level and increase the attenuation of interference along the coupling path. Filtering is the most direct and most efficient method to suppress conducted interference. Good filtering is beneficial to resolve radiation interference problems. Shielding is an efficient approach in suppressing radiation interference. Shielding also includes relocation far from sensitive equipments and cutting interference path. It should be noted that shielding, only when used in conjunction with grounding, can play a role. Rational grounding is the most economical and most efficient EMC design technology.

When AC 115V and DC 28V are used at the same time in airborne electronic equipment, AC ground wire and DC ground wire should be designed separately for this system with hybrid power supply. Moreover, the two ground wires should be isolated reliably. The purpose is to reduce the interference of coupling between ground wires.

Thirdly, conduct layout design, including inspection of overall layout, cable layout and distribution, location inspection and adjustment of aperture, layout inspection and adjustment of assemblies and printed board.

Layout design includes the relative location and traces between units of airborne electronic equipments and internal modules of airborne electronic equipments. The fundamental principle is incompatibility and division, which means that PCB areas should be divided, based on the functions of circuits and that input/output elements should be placed as far from each other as possible. The connection between elements which are closely connected should be shortened so as to ensure that the signal flows smoothly and rationally. Sensitive elements should be placed as far from interference source as possible. Input port and output port should be isolated properly. High frequency and low frequency cables should be laid separately. The device within the case of airborne electronic equipment should be designed in layout, trying the best to make interference source be far away from sensitive elements and radiated electromagnetic source be far away from the hole of the case. The circuit elements and signal pathways should be designed to decrease the coupling with undesired signal to the maximum. The component with low level signal should be placed far from component with high level signal and can't be configured with power lead which isn't filtered. Avoid using long parallel line for the traces on PCB. When an element is laid out on a PCB, sensitive circuit should be separated from high level circuit and the circuit which can produce transient process. Take full advantage of the uncorroded part of PCB for grounding and use it as the shielded object. The shielded object should be connected to the main case as possible as we can. Use magnetic shielding around the sensitive circuit to reduce the magnetic coupling with power leads and to diminish low frequency interference.

Above all, airborne electronic equipment should be designed to meet the functional requirements, on the basis of which, combined methods such as grounding, shielding, filtering and rational layout should be adopted to carry out individually targeted and comprehensive design. The purpose is to reduce or even eliminate the effects caused by EMI, making ensure the airborne electronic equipment can operate normally.

5 Basic Methods for EMC Design

Normally, there are 3 basic methods for EMC design, which are problem solving method, specification method and system method.

Problem solving method is used for improvement when an airborne electric equipment is detected faulted. Problem solving method is to address a problem when it comes into being and tends to solve a problem by a specific but limited method. This method comes into being when EMC theory was incomplete and EMC design methods were unsystematic. Because this method is targeted, it is widely used by engineers. However, it works as a remedy for the EMC problems exposed at the late development stage of circuits, airborne electric equipments and systems. Therefore, this method is very passive. It is used at the late development stage of airborne electric equipment, so the change of technical status is very costly and considerably difficult.

Specification method is a design approach used at the development stage of airborne electronic equipments by complying with related EMC standards, to solve the problems of airborne electronic equipments which may appear at early stage. Because EMC standards and specifications reveal the common problems which exist in systems and of airborne electronic equipments and the rules of resolving problems to a certain extent, specification method provides prescient and comprehensive measures. Therefore, specification method is relatively rational and progressive compared to problem solving method.

System method is to build the model of elements, modules and circuits which may have an impact on the EMC of airborne electronic equipments and conduct EMC analysis, prediction, control and distribution by means of auxiliary tool, laying a foundation for airborne electronic equipments meeting requirements. This method can be used throughout the design of airborne electronic equipments. Electromagnetic coupling factors can be considered comprehensively. Design at all stages can be evaluated and corrected continuously.

In summary, EMC design of a system should be carried out at the beginning of development of circuits, airborne electronic equipments as well as systems by EMC prediction, analysis and design. We can gain the initiative to make overall plan for EMC measures for circuits and systems, test and calculate the EMC, and deploy EMC design together with system reliability, maintainability, supportability, testability, safety and environment adaptability. To accomplish design goals, problem solving method, specification method and system method should be combined when it is necessary. The effectiveness of methods should be based on the actual operation and test results of airborne electronic equipments.

6 Summary

EMC technology is an integrated discipline which is rapidly developing and also an application technology which is characterized by highly engineering. It is playing an increasingly important role in fields related to electronics. A comprehensive method should be adopted for EMC design. On one hand, noise source should be suppressed and on the other hand, the immunity of sensitive equipments should be increased. The two sides both are of importance. Any single measure taken won't achieve the desired result. For this reason, the EMC should be considered at the beginning of system design on a system level and improved during equipment manufacturing, operation and maintenance, ensuring that the design of airborne electronic equipments meet EMC standard requirements and that these equipments can work reliably. EMI and EMC are the common thread that run through design, finalization, production and use of aircrafts and have an important role in the safety and reliability of aircrafts. Approaches for resolving EMC problems and fundamental methods for EMC design are put forward, which provides guidance for EMC design of follow-up airborne electronic equipments.

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