Design on Electromagnetic Compatibility of Aeronautic Electrical Power System Tester

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***Abstract*—This article analyses the electromagnetic interfering sources and its transmitting ways inside aeronautic electrical power system tester and expounds the anti-disturbing methods in designing the electromagnetic compatibility of aeronautic electrical power system tester. Among that the interfering sources are the rectifiers and inverse transformer in the AC frequency converter and the interference signals from electric network, the transmitting ways of the electromagnetic interfering signals include transmitting in electric wires, radiating and coupling through space, and the anti-disturbing methods have (a) separating the interference sources with the system or devices, (b) connecting filters in the output ends of interfering sources and the input ends of the devices easily to be interfernced, (c) shielding the interfering sources, (d) earthing correctly and reliably, (e) adding circuit power filters.**

***Keywords*—Aeronautic Electrical Power System, Tester, Electromagnetic Compatibility, Design**

I. INTRODUCTION

Aeronautic electrical power system tester is used to simulate the circuit connections and oprations of all chief units of aircraft electrical power system in lab and test the corresponding technical parameters. It mainly consists of the driving system for generator under test being rotated and changed its speed needed, simulative loads having the features of variable impedance, inductance and capacitance, and the testing system of the electrical parameters, among them the AC driving system with high power, direct-driving, changing speed through regulating power supplying frequence not only has high output shaft power, fast dynamic responsibility, strong mechanical characteristics, low noises, but also has constant power or torque controlling, high efficiency, high reliability, long maintenance period, low maintenance difficulty. Especilly, it has a better effect in electromagnetic compatibility.

The electromagnetic compatibility means the adaptability of the electronic devices in electromagnetic surroundings. The requriements of the designs on electromagnetic compatibility is that the electronic devices designed have not only not influenced on the other electronic equipment operating in the common environment, and but also not affected by the external electromagnetic interfering sources. Thus the designs of electromagnetic compatibility are just the designs of anti-intererence.

The specific contents for designing the electromagnetic compatibility include studying carefully the probable electromagnetic interfering sources, finding out the complete transmitting pathes and formulating the detailed effective measures for anti-interfering.

II. ANALYSES OF ELECTROMAGNETIC INTERFERENCE SOURCES IN THE TESTER

The electromagnetic interference commonly means the random and harmful electromagnetic and electrical signals appearing in the circuits of the devices under running, thus affecting the characteristcs of the devices or the transmissions of the useful signals. The electromagnetic interfering signals may make the useful signals changed, increase the errors, produce sembalances, and damage the normal operation of the devices or the systms.

The disturbances may be commonly classified according to the particular features.

According to the performance of disturbances, the interfernces can be divided into natural, manual and inherent interfernces. Among them the natural interference is produced by the atmospherics and the universal rays, the manual disturbance is mainly made up of the changing of electric loads, and the inherent interfernce is caused by the inherent noises.

According to the areas of the interfering sources, the interfernces can be categorized into the internal and external disturbances. The internal disturbances are the couplings of the every part in the system or itself, such as the coupling between the signals, the disturbances of electric power sources, earthing systems, transitional processes, inherent elements, anti-electromotive forces and transmissions, etc. The external interferences are from the outsides of the system, such as radiations, electric network and surrounding power consumption equipment, earthing systems, transmitting reflection, etc.

978-1-4244-1674-5/08 /$25.00 ©2008 IEEE CIS 2008

According to the coupling models of interferences, they can be divided into electrostatic, electromagnetic, leakage of electricity, common-impedance inductance and electromagnetic radiation disturbances. Among them the electrostatic disturbance is caused by the coupling electric fields of capacitors, the electromagnetic interference is produced by the magnetic fields of strong currents around the electronic devices through coupling loop, the coupling disturbances of leakage of electricity are made up of leakage currents for the decrease of insulating impedances, the common-impedance interferences are caused by the mutual coupling of the impedance of the common wires, earthing impedance and the internal impedance of power sources, the electromagnetic radiating interference comes from the radiation source which is much more than $\lambda/2\pi$ away from the disturbanced device through the radiating field in space.

According to the relation between the effective signal and interfering signal, the disturbances can be divided into series-modulus and common-modulus interference. The series-modulus interference means that the interfering signals are connected with the effective signals in series and applied on the effective signals. The common-modulus interference is caused with the voltage between the signal-ground and device-ground. In some circuits exist the series-modulus and common-modulus interference at the same time.

According to the waves of disturbances, the disturbances can be catigorized into AC and modulating interference inside. The AC disturbance is produced by the inductance of AC power source and included with elementary and resonant waves. The modulating interference inside is made up of the output signals are modulated by the disturbance signals.

According to the appearing laws of disturbances, they can be divided into inherent and random disturbances. The inherent interference is caused with the operations of near electric equipment. The random disturbances are produced by accidental interferences.

In the tester the rectifiers inside the AC frequency converter for controlling the driving motor are nonlinear loads as to the electric network. The resonant waves produced by the rectifiers may develop interferences to the electronic equipment and electrical devices connected with the near network. Besides, the inverse transformer adopting the technology of PWM in the the AC frequency converter in operation would make a lot of coupling noises because it runs at high switch on and off states. Therefore, it is certain that the AC frequency converter is a strong interfering source as for the electronic equipment, electrical devices and digital instruments assembled in the tester.

Actually, there are a number of resonant wave sources in all electrical network, such as verious rectification devices, AC/DC transformers, transistor voltage regulators, nonlinear loads and lighting units, etc. The loads mentioned above would force the waves of the voltage and current of electrical network to produce distortion. The interfering signals produced by the power supply are chiefly over-voltage, under-voltage, instantaneous power-off, tidal waves of voltage, peak impulses of voltage, and radio frequences.

III. ANALYSES OF THE TRANSMITTING WAYS OF THE ELECTROMAGNETIC INTERFERING SIGNALS

The transmitting ways of the electromagnetic interfering signals generally include transmissions, inductions and radiations.

The transmitting interference includes the input disturbance directly through electric wires and the coupling disturbance through the voltage drop on the common impedance. The interference input directly through electric wires may be transmitted through AC power lines or the input wires of effective signals, or indirectly through the controlling wires and signal wires. The interferences coupling through the voltage drop on the common impedances are coupled through the internal resistance of power source, the impedance of common lines, earthing wires, multi-output loop.

The responsing interference mainly consists of the electric field disturbance produced by the coupling of distributive capacitors and the magnetic field disturbance caused by the coupling of distributive inductors. The loop near the heavy currents is easily mushed by the responsing interference.

The radiating interference comes from the radiation source which is much more than $\lambda/2\pi$ away from the disturbanced device through the radiating field in space.

The electric power lines of the AC frequency converter in the tester are the main sources of the resonant waves. Because the electromagnetic energy of the resonant waves is very strong, the other electronic and electric devices installed in the tester would be interferenced strongly. The complete analysis is as follows:

1) Strong electromagnetic radiant energy may develop a serious interference to the electronic equipment, electric devices and digital instruments installed around the electric power lines of the AC frequence converter.

2) The resonant waves of voltages and currents may make the driving motor occur many noises and increase the iron-loss and copper-loss of the motor, so the heat produced by the driving motor rises sharply, its insulation is decreased obviousely, and its service life is shortened quickly.

3) The random and harmful electric signals are transmitted to the other power consumption equipment in the tester through inside electric network.

4) The random and harmful electric signals are transmitted to the near signale wires and data bus through space coupling. Otherwisely, the resonant waves of voltages and currents in electric network would produce secondary interference to the operation of AC frequence converter reversely, as a result that the tester may not run normally.

IV. DESIGN OF ANTI-INTERFERING METHODS

It is known from it mentioned above that forming electromagnetic interference (EMI) must have three factors at the same time, namely electromagnetic interfering sources, transmitting ways of electromagnetic interfering signals and the systems or devices interfered by electromagnetic interfering signals easily. Therefore, the interference-free

methods should start from how to remove some one or two factors of the forming interference conditions.

In consideration of the simplicity and economy of the tester, only one factor is eliminated is OK, but it is better for two factors being removed as for reliability.

The methods of anti-interference could begin from hardware or software, or meanwhile. Among them adopting hardware to anti-interfering is simple, economic and efficient.

The general principles adopting hardware to anti-interfering are as follows:

1) Restraining or removing the interference sources.

2) Cutting out the pathes between the interference sources and the electronic equipment, electric devices and digital instruments.

3) Reducing the sensitivity of the system or devices to the interference signals.

We adopted the comprehensive methods of separating, filtering, shielding and earthing.

A. Separating the Interference Sources with the System or Devices

The separation means that the electromagnetic interfering sources and the system or devices easily to be interferenced are separated completely in circuits. The transformers for cutting off noises are used to separate the electric power with the amplifiers in circuits so as to cut off transmitting interferences in the AC driving system.

B. Connecting Filters in the Output Ends of Interfering Sources and the Input Ends of the Devices Easily to be Interfernced

C. Shielding the Interfering Sources

Shielding the interfering sources is the most effective methods to suppress interferences. Because the frequence converter itself is shielded by iron-cover, it is needed that the input and output electric power lines are only shielded, that is to say, the electric power lines are passed through steel-pipes or magnetic rings, and the electric power lines must be crossed with the signal wires. The signal wires use twin-wires or multi-wires with metal shielders, and the steel-pipes and metal shielders must be earthed correctly and reliably.

D. Earthing Correctly and Reliably

It is true that earthing is an important method for suppressing noises and interferences. The correct earthing could restrain the coulping noises inside the system sharply and resist the outside interferences efficiently.

The AC frequence converter itself has a special earthing end, it must be earthed so that ensuring safety and reducing noises. The earthing wires cannot be connected with the cover of electric devices or the O-line of three-phase circuit power. The earthing wires should be as short and thick as possible and must be connected with the earth correctly. The earthing impedance should be less than 100 Ω .

E. Adding Circuit Power Filters

In order to decrease the interference signals to circuit power, the input ends of circuit power should be connected in electric filters. The input ends of the AC frequency converter must be added AC reactors so as to suppress the resonant waves of current in the input sides of the AC frequency converter and improve the electric power factor. Besides, the output end of the AC frequency converter is added AC reactors so as to remove the noises of the driving motor.

The block diagram of the anti-interfering methods in the aeronautic electric power system tester is showen in Fig.1.

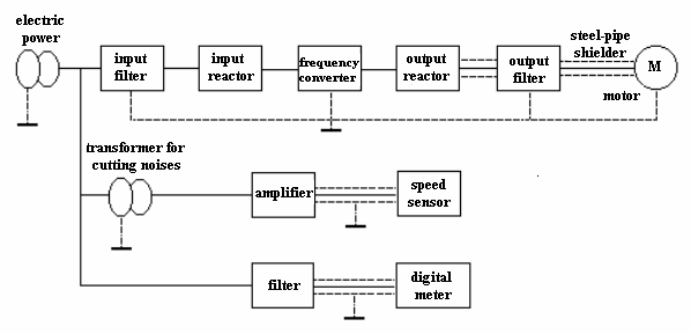

Figure 1. Block Diagram of the Anti-interfering Methods in the Aeronautic Electric Power System Tester

V. CONCLUSION

The design on the electromagnetic compatibility of the aeronautic electric power system tester is a complicated engineering practice with mechanical driving, electronic controlling and displaying, electric controlling and testing. As for various hardware construction and disposition, the designing methods are in endless variety. Only if the careful analyses for the interference sources of the complete system and impossible transmitting pathes are carried out and the debugging must be executed again and again, the correct methods of anti-interefering can be found out.

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