ATLANTIS PRESS

Advances in Engineering Research, volume 150

4th International Conference on Machinery, Materials and Computer (MACMC 2017)

Development of Test Equipment for Airborne Missile Launch Control System Based on Virtual Instrument Technology

Zhang Xiaoyu, Cai Guifang

Aviation Maintenance School for NCO, Air Force Engineering University, China

zxydyx1024@126.com

Keywords: Airborne missile, Launch control system, Test equipment; Virtual instrument; Fault test

Abstract. The missile launching control system is the core equipment of an air to ground missile fire control system, and the equipment equipped with the original test equipment has the problems of single function and low level of integrated support, so a new type of test equipment for airborne missile launch control system is developed by combining virtual instrument technology and traditional test methods. The main control computer is taken as the core of the system, the VC++ language is used to program, and many technologies are adopted such as the standard interface and bus technology, the virtual instrument technology, the fault test technology and the FIFO technology and so on. The test equipment has many advantages of reliable and stable operation, high accuracy and good expansibility. The automation level of test equipment is improved effectively. So the test equipment has certain practicability and promotion value.

Introduction

An airborne missile launch control system is the core equipment of missile fire control system, it is connected with airborne inertial navigation system radar, atmosphere data computer bus box and so on, it can complete the missile launch parameters settlement, and it complete the missile launch control according to the prescribed procedures and conditions, it plays a decisive role in the completion of the combat mission.

With the development of the air force transformation and the missile weapon, in order to improve the ability of the aircraft to carry out diversified military tasks, more advanced missile launching and control system is carried out on some airplanes. The new missile launch control system has more complex structure, more perfect functions and higher automation, so the forward higher requirements for performance test and fault diagnosis are put. The original launch control system test instrument an not meet the requirements of the new launch control system, therefore, a test equipment for launch control system based on virtual instrument technology is developed.

The fault diagnosis logic of test process can be classified by the test equipment, and the database can be established to save and manage. Computer control technology, artificial intelligence technology and virtual instrument technology are used to design; the equipment can automatically detect the corresponding incentive signals according to the process to access the system [1, 2].

Functions of Test Equipment

The test functions of the test equipment are as follows.

1. The signal cross linking between the missile launch control system and the test equipment is completed, and the test results are saved in the historical record database for retrieval statistics.

2. Automatic and manual test and 600-hour of fixed inspection to the main engine, battery, console, display, interface units and other components for the main purpose of maintenance.

3. During automatic test, the test can be executed automatically according to the working sequence of the launch control system, and the test results are displayed, and the fault information is given.

4. During manual test, the fault information is compared with the standard parameters of the system professional maintenance database, and the fault diagnosis is completed under the guidance of the maintenance expert system.

5. The hole process can be tracked and displayed dynamically to remind the operator whether the test result is correct or not [3].

Hardware Composition and Characteristics

The intelligent, integrated and modular design is used in the test equipment, the industrial control computer is used as the control core, and the design function of test equipment is achieved with simple hardware configuration. The hardware structure of the equipment is shown in Fig.1.

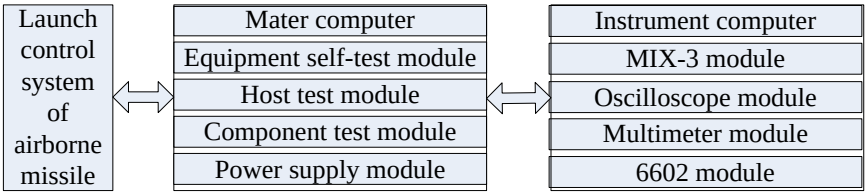

Fig.1 Hardware structure diagram of test equipment

Power Supply Module. The +28~115V 400Hz aircraft power supply and +5V lighting dimming power supply are provided to the components of launch control system and the test equipment by the Power supply module.

Control Relationship. The control panel is divided into the upper and lower tow layers of the upper panel, the DC voltmeter, AC voltmeter, DC ammeter and AC ammeter are arranged on the upper panel in turn from left to right, the DC power switch, the adjustment knob, the lighting power switch, the lighting adjustment knob and the AC power switch and etc. are arranged on the lower panel in turn from left to right. When the switch is switched on, the corresponding power indicator should light, the voltmeter and ammeter should indicate the corresponding number, and the lighting adjustment knob can adjust the lighting voltage.

Cross Linking Relationship. The real panel is the cross linking panel. The power supply socket, the DC output terminal system, the power output socket and the ground wire terminal and etc. are distributed on the panel in turn from left to right.

Master Computer. The Pentium computer and the Windows/NT operating system is selected, the MXI sockets are behind the computer, they can be connected with the 8330 sockets of the PXI instrument computer by MXI-3 cables to control virtual instrument module. The computer has the advantages of strong expansion, high reliability, strong anti-interference ability, shockproof, moisture-proof, small volume etc. The computer is the core of test equipment, the standard bus structure provides the basis for the selection of sophisticated hardware products, to avoid duplication of development, but also facilitate the hardware upgrade and repair plate rapidly [4].

Instrument Computer. The 220 volt electric power supply is provided to the instrument computer, the computer is connected with virtual instrument module by using MXI technology, the input signals of virtual components and the response signals corresponding detected units are generated, the instrument module is connected with the tested units through a 68-cores cable for output the input signals and testing the output signals of tested units

Integration of Instrument Modules. The instrument computer includes MXI-3 module, 6602module, 6508 module, 6670 module, oscilloscope module, multi-meter module and other virtual instrument modules. MXI-3 module is a multi extension interface module; its model is PXI 8330. MXI module is made up of PXI-8330 module, MXI-3 cables and PCI-830 module. Among them, the PXI-8330 module is inserted in the PXI chassis, PCI-8330 module is inserted in the PCI chassis, and the PCI chassis is connected with the PXI chassis by using MXI-3 cables. However, 6602 module, 6508 module and 6670 module are driven by the NI-DANQ low-level software. It can be set and self-tested by using the measurement and Automation virtue instrument management software. Variety of high-level language interfaces are used facilitate through DAQ module, the user uses standard control module programming, the module test results can be gotten by calling the internal DAQ control module. The oscilloscope module and the multi-meter module are driven by DAQ-IVI low level software, and the virtual instrument soft panel is used as the user interface. The user

operates the instrument on the soft panel, uses the mouse knob to select the measuring function and the range, the start and stop of the measurement is controlled by the function key or the soft panel's opening and closing.

Control Relationship. The front panel is a socket panel; the socket of 8330, 6602, 6508, oscilloscope probe and multi-meter pen socket etc. are arranged in turn from left to right. Among them, the 8330 socket is connected with the master computer through MXI-3 cable; 6602 socket is connected with the test unit through the special cable, 6508 sockets are connected with the host test unit and the component test unit respectively. 6607 socket is connected with the host test unit through the special cable; the oscilloscope socket is connected with the oscilloscope probe; the multi-meter pen socket is connected with the multi-meter pen.

Cross Linking Relationship. The rear panel is a cross linking panel, and the power control socket, the ground wire connection pile and the city electric power socket are arranged in turn. The ground connection pile is connected with the ground wire of the workshop; the power supply socket is connected to the 220V power supply through the two core power cable.

Equipment self-test module. By this module, the external signal excitation can be provided to the tested launch control system, the front-end conditioning of the test signals are connected, the aircraft power supply can be provided to the system and the self test can be performed.

Self Checking Circuit. The self checking circuit is composed of self checking switch, self checking diode, resistance regulator tube, and driver and so on. The working principle is as follow. The power switch is switched on, the current plows through the power switch, resistance and power supply lamp, the power indicator lamp is bright. By pressing the self-check button, the current flows through the self checking switch, the self checking diode, the self checking resistor, the luminous tube, all the indicators light show that the circuit is normal. By releasing the self checking button, all indicators are turned off. At the same time, the test results are processed and displayed through the digital tube.

Control Relationship. The former panel is control panel. The AC power lamp, AC switch, AC voltage test hole, AC current test hole, lighting power supply lamp, lighting switch, lighting voltage test hole and lighting current test hole and so on are arranged in turn. The power supply is used to indicate the working state of the power supply of the equipment test unit, and the indicator lighting shows that the power supply is outputted to the tested pieces, the indicator turning out shows that the power is turned off.

Cross Linking Relationship. The rear panel is cross linking panel, there are 8 pieces of cross linking sockets and ground wire connection piles. It is connected with the component detecting unit, the master control system, the missile interface unit, the console and the display etc. through the special cable.

Host test module. The host test module is used to provide the external excitation signal to the host the master control system, connect with the front-end conditioning of the test signal and the aircraft power supply required by the host computer, and detect the host of the launch control system.

Host Test Circuit. The host test circuit is composed of test diode, test resistor, microprocessor interface expansion chip, ADC digital tube and etc.. The working principle is as follow. By connecting the power cable and turning on the power switch, the power indicator lights. By pressing the test button and putting the band switch at the neutral position, the indicator lighting shows that the corresponding line is conducted. By releasing the button, the indicator is off. At the same time, the statistical processing is completed by the process and display circuit, each part of the test results is restored and the final results are displayed through the digital tube. By using query buttons, the specific situation of each line can be found out. By pressing the rest button, digital tube is cleared; the next test task is ready. The test equipment should be used to detect hundreds of lines of the launch control system, it is necessary to solve the problem of rapid positioning of faults, so that the faults can be quickly found out and eliminated in practical application. To solve such above problem, the fault tree model is used, all possible faults of the launch control system are processed, every possible fault lines are displayed, the fault location can be determined quickly.

Control Relationship. The control panel is front panel, the host switch statues indicator, the power indicator lamp, the power switch and the power supply test holes etc. are equipped in it.

Cross Linking Relationship. The rear panel is the cross linking panel, there are 8 pieces of cross linking sockets and ground wire connection piles. It is connected with the instrument computer, the system detecting unit, the component detecting unit, the master control system etc. through the special cable.

Component Test Module. The component test module is used to provide the external excitation signal to the host the master control system, connect with the front-end conditioning of the test signal and the aircraft power supply required by the host computer, and detect separately the components of the launch control system. The module is mainly composed of resistance test circuit, insulation performance test circuit and other circuits.

Resistance Test Circuit. The circuit resistance test circuit is composed of three meter and wave switch and so on. The working principle is as follow. The host is connected with the launch controller through the control cable and test cable corresponding to the launch controller, the five toggle switches are putted in neutral position, and the power supply is disconnected, when detecting circuit, the toggle switches are placed on the corresponding line, and each resistor value which is the channel resistance value can be read out.

Insulation Performance Test Circuit. The insulation performance test circuit consists of high resistance meters and toggle switches etc.

Overall Test. The host is connected with the launch controller by using the test cable corresponding to the launch controller, disconnecting the power supply, a test clip of the high resistance meter is connected with the corresponding terminal column, and the other test clip is connected with the emitter shell. By pressing the high resistance meter test button, the insulation resistance is greater than 20 MΩ, which indicate that the insulation performance is good.

Single Line Test. The overall test failure, a test clip of high resistance meter is connected with the corresponding terminal, another clip is connected with the emitter shell, five toggle switch is putted in neutral position, when detecting the line resistance, the toggle switches are respectively arranged on the corresponding position, and the high resistance meter test button is pressed, the resistance should be greater than 20 MΩ.

In insulation resistance measurement module, by using DC boost technology, 9V DC voltage is boosted up to 500V, and such high voltage is outputted stably by using the isolation circuit, the insulation performance of the launch control system can be the measured accurately.

Control Relationship. The former panel is control panel, there are 8 pieces of switch status indicator lamps of display console, 10 pieces console switch status indicator lamps and 10 pieces of switch box status indicator lamps. Among them, 8display console switch status indicator lamps are used to indicate the switch status of the console.

Cross Linking Relationship. The rear panel is the cross linking panel, there are 10 cross linking sockets and ground terminals. It is connected with the instrument computer, system test units, host test units and display console of launch control system respectively through the special cables.

Software Program Design

Software is the key of virtual instrument. When designing a virtual instrument system, different instrument functions can be realized by designing different software after the basic hardware determined.

The design of virtual instrument system software usually consists of two parts. One part is the equipment driver for the system hardware equipment; another part is the application software program which can display, analysis and processing data obtained from the system hardware equipment. The data acquisition card manufacturers are equipped with the corresponding device driver, through the application interface provided by the driver, the acquisition card can be accessed directly and the action of the acquisition card can be controlled. As a kind of text programming language, Visual C++ language is a kind of object-oriented full-featured development tools, it can

operate directly on the hardware, some control parameters are set directly by it through the low layer operation instruction[5].

The software of the test equipment is developed with VC++ in WINDOWS environment, and has friendly and clear graphical user interface. The functions of the test equipment are classified into the drop-down menu and button in the window. The user doesn't need to remember the specific commands corresponding to each task, just click the corresponding button with the mouse.

The test software is designed modular, it mainly consists of equipment maintenance, project detection, results processing, etc.. Its structure is shown in the Fig.2.

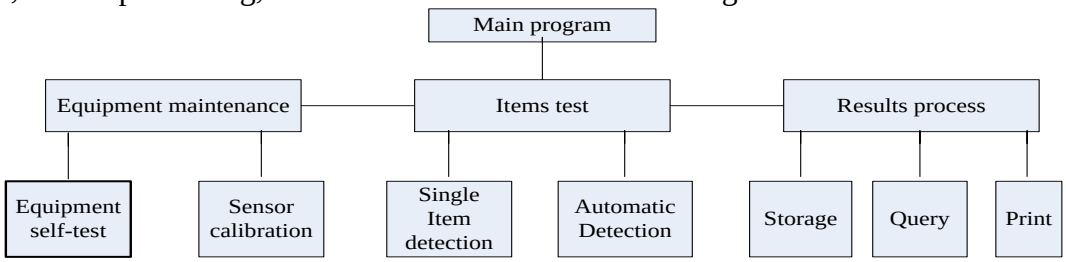

Fig.2 Software design diagram

Equipment maintenance module mainly includes equipment self-test, sensor online calibration and so on. The set and working state of power, interface card and sensors can be tested through the equipment self-test program. The sensor stator module is used to recalibrate the sensor in the specified calibration period or in a special case. The detection module is the core project of testing procedures, is mainly used to establish project conditions of each tested item, acquire test parameters and process test data and so on. At the same time, different test method such as a single detection, automatic detection is provided.

Many functions such as the standardization of test results, report generation, archiving, query and print are completed through results processing and other modules.

Due to the use of virtual instrument technology in the software design, all parameters of the equipment are displayed on the screen, which makes the test instrument has double redundancy control interface, simple operation and high reliability and maintenance.

Key Technologies

Virtue Instrument Technology. Virtue instrument is a kind of new type instrument with high quality and low price, it has many basic functions of both the ordinary instrument and new instrument, and is has a special set of hardware and software based on the existing computer. The virtue instrument is composed of computer, software and hardware. Among them, software is the core of virtual instrument technology, its main function is to combine computer hardware combined with instrument hardware organically, combine computer powerful data processing capability with hardware test control ability, so that the display, storage, processing and analysis of data is realized. The pattern of traditional instrument which defined by the manufacture and cannot be changed by users is broken by virtual instrument completely. By using common instrument hardware platform and different test software, the user can constitute instruments with different functions. Any user can change and increase the function, the scale and even the nature of the instrument only by adjusting and modifying the software of the instrument. At present, the application of virtual instrument technology is very common, and it is widely used in automatic control, product testing, mechanical fault diagnosis, experimental research and teaching and other fields [6].

Standard Interface and Bus Technology. In order to achieve universal test equipment, the standard bus interface and bus technology is used. It can make automatic test equipment conveniently connected with the intelligent instrument based on GPIB bus and RS-232 bus, realize the information transmission and sharing of resources, make the equipment develop to the direction of modular, standardization, integration and automation [7].

Fault Diagnosis Technology based on Data Fusion. During the test and repair process of an airborne missile launch control system, fault detection is the premise and important guarantee for the

successful completion of the equipment repair. Because the testing process is carried out before and after the equipment repair, the data obtained are the corresponding performance index data of the equipment. Therefore, the test data of a single project cannot fully characterize the failure module of the equipment, so the fault diagnosis technology based on data fusion is used. The analysis process of the detection mechanism is shown in the Fig.3.

In this way, the most probably fault module can be identified according to a certain criterion when the sample number is limited. At the same time, a fault detection software module embedded software platform is developed by combining computer software programming technology and data transfer and cross link technology, So the reasonable maintenance methods and measures are provided for maintenance personnel, and the maintenance efficiency and level are improved.

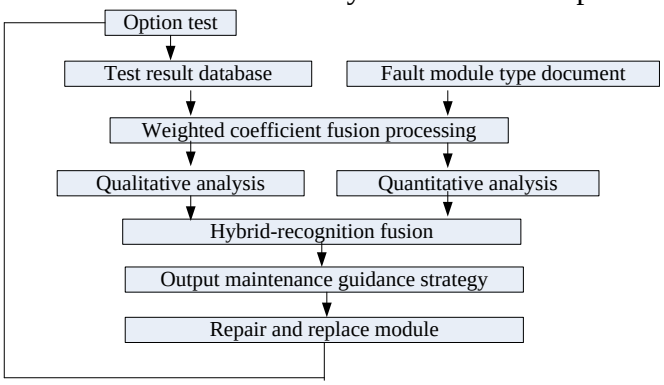

Fig.3 Chart of fault test

FIFO Technology. FIFO means an acquisition board with FIFO registers; the data acquired by instrument is stored in FIFO temporarily, when the data stored up to half of the memory, the interrupt request is sent to the CPU, after the CPU response, the data is transferred to other memory by means of I/O.

The equipment has two advantages by using FIFO technology: the first is beneficial to programming in the windows environment; the second is that CPU has a buffer time because the application is interrupted half memory to store the acquisition data. It ensures that the acquisition data will not be lost because of the unexpected response of the CPU, and the reliability of the data acquisition system will be improved.

Conclusions

To design the test equipment of a certain type airborne missile launch control system based on virtual instrument technology, on the one hand, some defects of traditional detection system is overcome, many excellent characteristics for the new test equipment is brought, the function is enhanced further; on the other hand, the future test equipment will be gradually over to the virtual instrument test equipment, by using virtual instrument technology, the application and development of virtual instrument technology in the field of test equipment will be promoted further.

References

[1] Yin Niandong. Virtual Instrument Technology and Application Prospect, Measurement and Testing Technology, China, 2002(6), pp. 86~89.

[2] Cheng Yang, Wu Chuanhui. Design of Portable PPM Performance Testing Device, China Test Technology, China, 2008, 34(1), pp. 105~106.

[3] HUANG Hanqiao, ZHOU Jun, YU Xiaozhou. Design and Simulation on an Improved Missile Test Platform Based on DAQ and LabVIEW, Measurment and Control Technology, China, 2009, 28(7), pp. 64~67.

[4] Li Yingshun, Xu Changqing. Ammunition Transport Vehicle for Bomb System Fault Diagnosis Based on the Fuzzy Neural Network, Electronic Design Engineering, China, 2013, 21(6), pp.186~188.

[5] Su Jian, Chen Yuqiang, Chen Junwei. Fire Control System Fault Diagnosis Expert System Based on Fault Tree Analysis. Computer Measurement and Control. 2013, 21(11):3008~3010.

[6] Liu Xiaobin, Feng Zhensheng, Wang Xiao, Li Wensheng. A Sort of Portable Automatic Testing System of Missile, Modern Electronic Technology, China, 2002, 5(136), pp. 22~23.

[7] Li Caiyi, Zhou Bing, Wang Dayong, Design and Realization of Signal Testing Equipment for One Type Missile Launching Vehicle, Instrument Technology, China, 2010(6), pp. 56~58.