Design of Certain Missile Integrated Test System Based on CPCI Bus

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Abstract: For meeting the urgent need of radar guided missile in-situ testing and ground simulation control training, design a set of RF signal and control logic integrated test system of radar guided missile. The system is used synthetically computer automatic testing technology, CPCI bus control technology, RF signal real-time receiving and analyzing technology, video image de-noising enhancement technology, It can complete the comprehensive testing of missile launching control logic and line, simulation of missile response information, continuous wave RF information, and so on. The system can provide effective means for missile simulation, missile launching control and ground detection of RF command control, being great significance to improve the maintenance and support capability of the new type aircraft fire control system.

1. Introduction

At present, China's second generation fighters, third second generation fighters and even fourth second generation fighters are generally equipped with the most advanced air-to-air radar-guided missiles available in our country. The launch control circuits and devices of modern air-to-air radar-guided missiles have knowledge-intensive, high technical content, complex structure and large cost characteristics, etc., their operation reliability is directly related to use effect and fighting efficiency of the aircraft.

During army training, before the regular checking of plane and the practice with live ammunition, the radar continuous wave radiation and missile launch control logic and lines need to be tested to determine the status of the system, find problems in time and troubleshoot [1].

In addition, there are limited service life and high price for the missile, and it is impossible to directly use actual equipment for training when training ground personnel and familiarizing with on-board operations.

Driven by the dual needs of equipment support and ground crew training, we have designed and developed a set of missile integrated detection system based on the CPCI bus which can comprehensively detect radar continuous wave radiation, advanced air-to-air radar projectile control logic and circuits, and can provide missile simulation functions[2].

2. System design

2.1 Overall design

Because this system has many kinds of signals to be measured, the number is large and the range is great, through the analysis of specific characteristics of different detection signals in detail, the author determines the detection scheme and decides to use the detection platform based on the CPCI bus. The overall structure of the detection equipment is shown in Fig.1, which mainly includes four parts: conversion control and conditioning of test signal, test information processing, CPCI main control computer and integrated power supply.

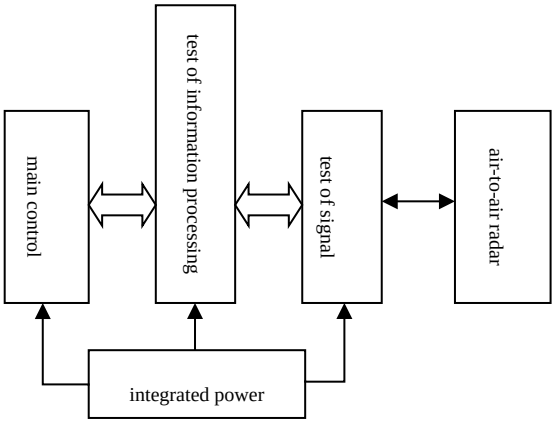

Fig.1 overall structure diagram of the detection platform based on the CPCI bus

2.2 Hardware scheme

Based on the analysis of detection needs, the author selects all kinds of high-performance hardware suitable for integrated testing systems, including inspection equipment, hand instruction display and peripheral three parts. The internal modules of the inspection equipment mainly include: CPCI bus module, power module, signal conditioning module, local oscillator module, multiple clock frequency source, special board, microwave receive module, video signal processing module, 429 bus communication board, serial communication module, temperature control module, etc. Peripheral include: antenna frame, antenna, microwave cable, RF test cable, test cable of launch and control signal, 28V power line, etc. Its basic principle is shown in Fig.2.

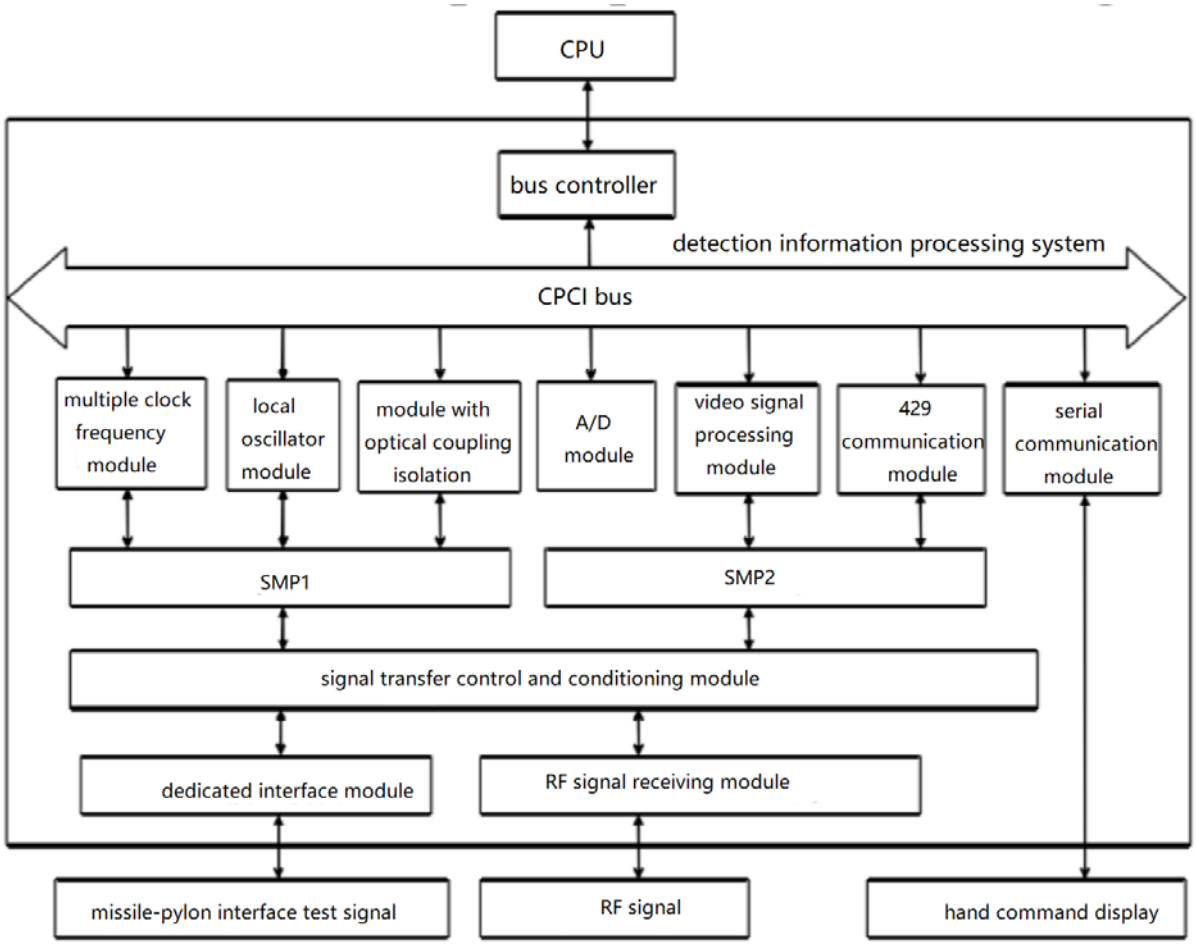

Fig.2 block diagram of composition and working principle of detection system

2.3 Software scheme

The design of the detection system software mainly considers the following aspects: human-computer interface design, result data display design, record reports, communication functions, etc.

The software development platform uses Lab windows/CVI as the development language to write software interface and test code. Lab windows/CVI is a virtual instrument software development platform, it is convenient for data collection, analysis and display, supports WYSIWYG visual interaction technology, and easily completes the management of the CPCI bus and the development of various module functions [3].

This integrated inspection equipment is designed to select testing project on the main interface of the main control computer, and observes and records the test results in the pop-up child test interface after selection. After the test is completed, the child test interface automatically closes and returns to the main interface.

3. Key Technologies

3.1 Method of combining centralized management and decentralized control based on CPCI bus

This test system is based on the CPCI bus platform, adopts method of combining centralized management and decentralized control, designs and integrates signal adaptation, radio frequency demodulation, and video modulation systems, realizes high-speed and real-time acquisition and processing for AC, DC, and RF signals of launch and control of two types of missiles. This paper proposes an embedded information processing unit architecture withPDSP+FPGA, designs a parallel correlation pipeline system based on large scale integrated circuit, solves complex solution of multiple launch and control logic and the real-time processing of multi-process integrated control information., and meets the digitalized integrated test needs of missile launch and control system.

3.2 Adaptive signal conditioning technology

In order to meet the real-time and accuracy requirements of the integrated detection, the multi signal common input channel is optimized and arranged, and two kinds of adaptive conditioning technologies are synthetically used, and the signal adaptive conditioning module is designed.

The input signal enters into the conditioning channel through the multi-channel commutation switch, and implements program control through the multi-channel switch, can select the appropriate signal conditioning channel, so as to realize the flexible configuration of hardware structure of conditioning module and the automatic adjustment of detection range.

The embedded information processing unit architecture with PDSP+FPGA is adopted, the parallel correlation pipeline system based on large scale integrated circuit is designed to solve the complex solution of multiple launch control logic and real-time processing problem of multi process integrated control information under the environment of electromagnetic interference, which meets the needs of digitalized integrated test needs of missile launch and control system [4].

3.3 Interference processing technology

With regard to mutual interference of system modules, the first is the interference caused by the ground impedance, which adopts the composite single-point ground for processing, in this way; it can prevent the baseband signal from interfering with the radio frequency part through the ground network. The second is the application of magnetic beads and varistor elements in the circuit design, the both ends of high-frequency cable of receiving antenna are embedded with magnetic beads, the pressure sensitive resistor is added to the antenna matching circuit, whose purpose is to filter out the highorder harmonic interference of the signal itself and the external interference through capacitance or inductive coupling, respectively, moreover, it prevents static pulses to damage the device when human hands touching the antenna [5].The third is that the baseband part and the radio frequency part

of the demodulation circuit are equipped with the metal shield cover, which mainly prevents the line from radiating electromagnetic waves; it has a good attenuation effect on the electric field, considering heat radiation, there are circular holes in the shield cover that will cause electromagnetic leakage, therefore, the inner side of the chassis is coated with oil to further absorb the leaked electromagnetic wave and reduce the interference among the systems.

Because the non-linearity of the device can cause the signal to generate high order harmonic, and the difference between the doubled local oscillator signal and the source generate image interference signal, which will mix into the system and cause interference. With regard to the processing of this interference noise, in the process of direct conversion of signal, since the radio frequency downlink signal is converted to the basic frequency band in the early stage of the whole receiving process, the only local oscillator signal may be conducted or radiated to RF input end of the mixer through a non-designed path, cause self-mixing phenomenon, the unnecessary DC component and low-frequency interference components are generated in the output of the mixer. In addition, the leakage of the local oscillator signal may affect the input end, resulting in the stronger interference effect after amplification. Moreover, the existence of the baseband coupling, the ground potential beat, the conductor radiation, and the coupling of capacitance and electromagnetic field these interference factors may also cause interference signals in the frequency band, which again results in self-mixing phenomenon. In order to eliminate these interfering signals, the signal data extraction model which integrates improved wavelet packet and singular value decomposition is established in the design, frequency denoising and parallel computing methods of RF signals are proposed, the FPGA adaptive filter is used to realize adaptive conditioning of RF signals with different modulation ways and different signal-to-noise ratios[6]. Fig.6 shows the structure of the adaptive filter.

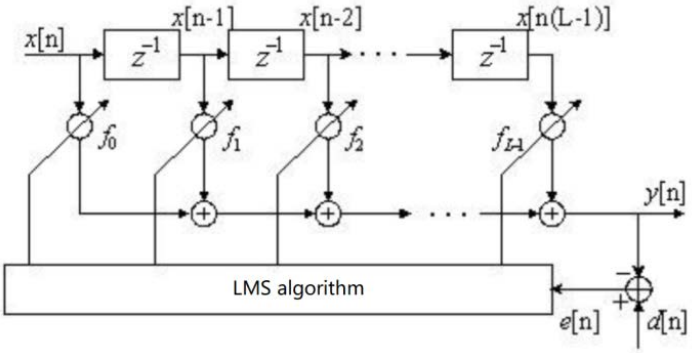

Fig.3 structure of adaptive filter

3.4 Rapid detection technology

The device can also detect signals under the non-cooperative condition without any prior knowledge and detects the whole wide band. In order to can detect signals quickly, the demodulation circuit divides the whole frequency band into many narrow frequency bands. Each frequency band is set up by changing the center frequency of the wavelet transform, and simultaneously detecting the presence and frequency of signals in each frequency band, the existence and frequency of signals in each frequency band are simultaneously detected, rapid detection can be done. Moreover, the signal frequency band is divided into many narrow frequency bands, the interestedfrequency band can be detected, especially when frequency hopping detection, some commonly used frequency hopping points are detected in accordance with demand.

4. Conclusion

This integrated detection system uses computer automatic detection technology, CPCI bus control technology, radio frequency signal real-time receiving and analysis technology and denoising enhancement technology of video and image, which can complete launch and control logic, line comprehensive inspection, missile response information simulation and continuous wave radio

frequency information detection of two air-to-air radar missiles mounted on different types, etc., it has complete functions and stable performance, provides effective means for ground detection of missile simulation, aircraft launch and control and radio frequency command functions, and it is of great significance to improve the maintenance and support capacity of the army's new aircraft fire control system.

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