A Design and Application of Inspection Instrument for Aviation Rocket Launch System

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ABSTRACT

A design and application of inspection instrument for aviation rocket launch system is presented, in which multiple low-cost STC series single-chip is used as the control core. A new type of single-chip task scheduling system is designed and applied in the instrument. This instrument can be used in aviation ordnance inspection field to measure electric pulse quality, aviation cable line quality, and rocket launch control equipment. Application in real airplane maintenance has proved that the instrument could automatically performance system test on a variety of models of aviation rocket launch systems and works well.

KEYWORDS


INTRODUCTION

Aviation Rocket is a common used weapon for ground attack, which is often equipped on the fighters, bombers and trainers. This paper aims at designing and developing a low-cost, high-reliability, fully functional portable aviation rocket launch system inspection instrument, the use of this instrument on airplane has proved that the instrument has a good adaptability of the needs above.

INSTRUMENT SYSTEM STRUCTURE

Two structures were considered at the beginning of the design:

The first structure
Use the PXI bus of National Instruments to build the inspection instrument, the system structure diagram is shown in Fig. 1.
As the PXI bus has been widely used in measurement and control system, its hardware modules and software development packages are relatively rich. So this design has a short hardware and software development cycle features. It is also full-featured, you could detect a variety of high and low frequency analog signals, digital signals. A relatively complete serial bus communication capacity, digital, analog output capacity, and real-time current and voltage detection capability are available too. But its shortcomings are also prominent, including huge volume, complex structure, resulting in poor portability and poor reliability. What’s more, its development costs are high. Therefore, this option is not used.

The second structure Use the STC single-chip controller, the system structure diagram is shown in Figure 2.

This design has the advantages of small volume as well as low cost. So the miniaturization of the instrument appearance could be achieved, which is very important for the front line maintenance. The reliability of the STC MCU is also high, and fully meets the high current and strong electromagnetic radiation conditions of work. The shortcoming is that the PCB need to be designed by the developer, the software does not have a common development kit, so the hardware driver and the
application software both need to be designed by the developer too. So the development cost is relatively high, and the development cycle is longer than the first design.

Considering all aspects of the factors, the author finally chose the second design. The production cycle and probation period of the instrument production has been finished by now. The appearance of the instrument is shown in Figure 3.

**HARDWARE DESIGN**

3 military grade STC MCUs are chosen for the main controller of this instrument, which are separately used for self-test, sampling and I/O control. Signal modification circuit, sampling circuit, I/O circuit and self-test circuit build up the whole instrument hardware.

**Signal Isolation and Adjust Module.**

Structure of the module is shown in Fig. 4. 32 operational amplifier circuits are designed to avoid accidental ignition of the rockets. These operational amplifier circuits isolate the high current within the instrument.

![Figure 3. Instrument Appearance.](image)

![Figure 4. Structure of Signal Isolation and Adjust Module.](image)
**Signal Sampling Module**

The structure of signal sampling module is shown in Fig. 5. Owing to the standalone A/D convertor (3MSa/s conversion rate) with 32 analog channels, each channel of the convertor could attain 10KSA/s sampling rate when working at the same time. Transmitted through isolation channels and adjust channels, the external input analog signals are transferred into digital, which are eventually stored into the FIFO. As the external input has 32 channels, the sampling circuit has multiple work modes, including single sampling, single channel scan, repeat cycle scan, multi-channel polling scan, etc. To realize the functions above, a soft sequence generator is equipped in MCU1, who could set up the ADC work mode and switch the channels according to the instrument work mode’s need.

**I/O Module**

Structure of I/O Module is shown in Fig. 6. The LED drive circuit is built up with 8050 transistors, who drives 16 high brightness LEDs on the front panel and make sure they are clearly visible in the hot sun light; The LCD drive circuit is built up with RA8835A, who drives a wide temperature monochrome LCD screen (work temperature: -10~70°C); The Keyboard drive circuit uses interrupt control, MCU2’s interruption service routines handle the user’s keyboard input requests.

**BIT Self-test Module**

A standalone MCU2 is used for self-test. It generates the plane’s rocket launch pulse simulatively, and loads it directly into the operational amplifier isolation circuit. This signal is transferred throughout the whole system circuit, so it could test the system circuit’s integrity. Problem in any part of the system can be detected by this self-test module.

![Figure 5. Structure of Sampling Module.](image1)

![Figure 6. Structure of I/O Module.](image2)
SOFTWARE DESIGN

KEIL μVision4 C51 SDK, STC development kit and emulator are used in this project. Since 51 MCU’s development data are plenty, so only some of the self-designed characteristic software design concepts are discussed below.

Design of Task Scheduling System

The core of software system is a self-designed task scheduling system, which operates on the STC series MCUs. Dividing tasks into real-time tasks and non-real-time tasks, this scheduling system has the most functions of a time sliced operating system. The two types of tasks are separately operated by real-time interruption manage system and non-real-time interruption manage system. Structures of the 3 MCUs are basically the same. Structure of task scheduling system of MCU2 is shown in Figure 4.

Different priority is put in the real-time task scheduling to ensure that the tasks with higher priority could be executed firstly and the response time is within the target range; the non-real-time tasks are scheduled by a standalone task scheduling function, who uses timer 0 of MCU0 in mode 0.

Switch of System Work Mode

A management style based on status is used in the software system, who divides all working modes into several patterns. System work mode could only be switched between the unique patterns defined by designer. And the current system pattern could only be one of the patterns defined before. In this way, the logical concept of the software concept is further abstracted, which brings the following benefits:

Reducing the human error in coding;
Improving the readability and maintainability of the codes;
Providing room for further expansion of system functions. Just one more pattern is needed to be added in when more system function is added.

Logic of MCU2 system pattern switching is shown in Figure 5.

Figure 4. Structure of MCU2 Task Scheduling System.
According to the system need, system pattern is switched between “wait mode”, “requesting mode”, “self-test mode1”, “testing over mode”, and “self-test mode 2”. In this way, the system work logic is built and organized orderly.

SUMMARY

An inspection instrument for aviation rocket launch system is designed and applied. The paper focuses on the overall design of the system hardware structure and software design as well as some other aspects of the system design. Application in real airplane maintenance has proved that the instrument could automatically performance system test on a variety of models of aviation rocket launch systems and works well. It could give out the test results and troubleshooting results which meets the actual work’s need. Using this instrument, the aviation rocket launch system test efficiency and maintenance quality should be enhanced significantly, the maintenance cost should be reduced as well.

REFERENCES