Design of a Miniature Testing Equipment

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Abstract. During the long-term use of a certain type of equipment in the army, it is necessary to carry out regular technical inspection and testing. The traditional inspection and testing equipment usually uses a larger industrial control computer for measurement and control, which is inconvenient to operate. In order to detect the equipment more quickly and easily, a new type of testing device based on Arduino integrated development environment is designed. Using Arduino as the main control system, the communication control between Arduino board and the terminal of programmable intelligent liquid crystal touch display is realized. Combining with the fault diagnosis system, the equipment performance inspection and fault diagnosis are realized. The testing equipment is simple and convenient to operate, which a certain reference value for products developed has based on Arduino integrated development environment.

1. Introduction
During the long-term use of a certain type of equipment in the army, regular maintenance is required. In the technical inspection and testing of this type of equipment, there are many necessary equipments, and the steps are tedious. It is difficult to complete the inspection and testing of the whole process. The traditional testing equipment usually uses active and large industrial control computer to measure and control, which will bring some problems: 1. After using industrial control computer, the cost of testing equipment is higher and the volume is larger, which is not suitable for mobile carrying of troops; 2. Traditional testing equipment usually has keyboard or mouse, which makes human-computer interaction inconvenient; 3. The development cycle of the traditional testing equipment is relatively long, and once a fault occurs, the fault judgment and repair time of the testing equipment itself is longer.

Arduino is an electronic product development platform based on MCU system. Its hardware and software systems are highly modular and easy to expand. Arduino's software system is completely open source. It can download and use the official free IDE programming environment [1-2]. The development environment is simple.

This paper presents a design scheme of a certain type of testing equipment based on Arduino development environment, which can collect the key signals of a certain type of equipment and carry out preliminary fault diagnosis.
2. Total Design
The detection device is mainly composed of interface circuit, generating circuit of AC and DC excitation signal, interface processing circuit, AC voltage sampling circuit, DC voltage sampling circuit, Arduino control board, LCD Circuit, fault diagnosis system and so on, as shown in Figure 1.

3. Hardware Design

3.1. Generating Circuit of AC/DC Excitation Signal
As shown in Figure 2, the control signals of 50Hz generated by the Arduino control board control the 110V power supply generated by the power supply module, forming the + 110V, - 110V, AC110V voltage output from OUT1, OUT2 ports. The voltage is used as the excitation signal of the tested equipment. The circuit uses Toshiba's photoelectric coupler TLP521-2. It is a two-channel photo coupler with an input current of 50 mA and an isolation voltage of up to 2500 V. It can completely isolate the control signal from the load, ensure the safety of the front-stage circuit and reduce the interference of the front-stage and back-stage. The high voltage switch 2N5551 used in the circuit is a NPN type high back voltage triode with 160V withstand voltage, 0.6A maximum current and 0.625W power, which meets the requirements of 110V high voltage circuit.

![Figure 1. System chart](image1)

![Figure 2. Generating Circuit of AC/DC Excitation Signal](image2)

3.2. DC Voltage Sampling Circuit
The DC voltage sampling circuit is shown in Figure 3, which mainly includes voltage dividing circuit and operational amplifier circuit. Voltage dividing circuit consists of four resistors: R1, R2, R3 and R4.
Among them, R2 is an adjustable resistor, which is used for voltage dividing of different voltage signals. The operational amplifier circuit uses CA3140 high input impedance operational amplifier, which makes the sampling value of voltage more accurate. It is a BiMOS high voltage operational amplifier developed by American Radio Corporation. The CA3140A and CA3140BiMOS operational amplifiers ensure that the transistor input circuit in the gate (PMOS) of the MOSFET provides very high input impedance, very low input current and high speed performance. Operating power supply voltage ranges from 4V to 36V (single or dual). It combines the advantages of piezoelectric PMOS transistor technology and high voltage double-donor transistor, and has excellent performance.

3.3. AC Voltage Sampling Circuit
As shown in Figure 4, the AC voltage sampling circuit is mainly composed of two-stage operational amplifiers. The former uses OPA2604 chip, which has the characteristics of ultra-low Harmonic distortion, low noise and high gain bandwidth. The latter stage uses OP27 chip, which has very low input offset voltage, good drift characteristics, high speed and low noise characteristics.

![Figure 3. DC Voltage sampling circuit](image3)

It can achieve excellent dynamic accuracy in high-speed data acquisition system. Because the IO port of the Arduino control board can only collect positive voltage, a diode is added to the output to make the output positive voltage.

![Figure 4. AC Voltage sampling circuit](image4)

3.4. Arduino control board
Arduino Due microcontroller developed in Italy is used in the testing equipment. Arduino Due is a microcontroller board based on ATML SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino based
on 32-bit ARM core. It can process 32-bit data in one clock, which is more powerful than previous versions of Arduino [3-5]. It includes 54 digital IO ports (12 of which can be used for PWM output). Each IO port can be used as an input and output port. The IO port works at 3.3V. If the voltage exceeds 3.3V, for example, 5V is sent to an IO port, the chip may burn. It has 12 analog input ports, each of which has 12 bit accuracy. By default, the analog input accuracy is 10 bits, and the pin measurement range is 0 to 3.3V. It has two analog output channels (DAC); four UART hardware serial ports; 84 MHz clock frequency; one USB OTG interface; two TWIs; one power outlet; one SPI interface; one JTAG interface; one reset key and one erase key; 84 MHz CPU clock frequency; 96 Kbytes SRAM; 512 Kbytes Flash (all available storage space can be directly addressed). Because the carrying voltage of the IO port and analog input port of Arduino due is 3.3V, the 5V signal generated by the interface conditioning circuit cannot be collected directly. The detection device integrates 5V signal into 3.3V signal through sn74lvc4245 chip and collects it.

3.5. LCD Circuit
Programmable Smart LCD (PS-LCD) developed in China is used in the equipment. PS-LCD hardware communication interface is simple, and any control unit with serial port can easily connect with it to realize the human-computer interaction interface of the system. PS-LCD, as an advanced intelligent man-machine interface product, can easily and flexibly interact with external control unit through communication interface. At present, PS-LCD supports two communication protocols: CTP (Cooky Talking Protocol) protocol and User Define protocol. The first communication protocol CTP protocol is adopted in this testing equipment. In CTP communication mode, PS-LCD will execute immediately after receiving the communication command, and return the result to the main controller. Because the serial communication protocol of PS-LCD is inconsistent with the communication protocol of Arduino Due microcontroller, it is necessary to transform and control in the process of communication. In order to cancel the automatic reply message of PS-LCD command execution result, in CTP communication mode, the automatic reply of PS-LCD is cancelled by calling ctpSet(“reply”, 0) function.

When the detection socket is CZ3, the detection interface of PS-LCD is shown in Fig. 5.

![Figure 5. Detection Interface](image)

4. Software design

4.1. Main Procedure Flow
The software part of the testing equipment is designed by modularization, as shown in Figure 6. The whole software consists of main program, AC and DC sampling and acquisition subroutine, LCD control subroutine and fault diagnosis subroutine. The main program is the core of the management and control of the whole system. After the system is powered on, the self-inspection is carried out by operating the display screen first, and the self-inspection can be used only after it is qualified [6]. Select different test
sockets and connect the corresponding cables to test the equipment. The pin signals on the socket are detected and sampled, and displayed on the LCD screen. The collected data are judged. If the judgement is not qualified, the fault diagnosis and location are carried out according to the measured signals.

![Flow chart of main program](image)

**Figure 6.** Flow chart of main program

4.2. **Fault Diagnosis Program**

Fault tree analysis is used to analyze the faults of the inspected equipment, and PCB of the inspected equipment is divided into functional modules. According to the priority level of the measured signal, the signal is corresponded to the divided functional modules. Based on the deep understanding and analysis of the internal working principle of the inspected equipment, an accurate fault diagnosis system is constructed. When there are faults, the output information or directly display one or more possible faulty PCB, and arrange according to the fault location probability in order to determine the fault PCB. According to the diagnostic information, the inspector inserts and replaces the printed circuit board in turn. Each time, the inspector carries out a test to determine whether the fault is eliminated or not.

4.3. **LCD Control Subprogram**

When using the custom communication protocol, in the control action script of the design interface, the `sysCom0.Write()` or `sysCom0.WriteString()` functions are directly invoked to send any custom data or strings under the specified trigger conditions. `sysCom0.read()` function is called to read valid serial data in the action script of the system control Serial Port 0. PS-LCD automatically receives serial port data according to the set threshold, frame head and frame tail attributes and puts it into the buffer and triggers action script according to specified conditions to complete data reading.

5. **Conclusion**

This paper mainly introduces the design of a micro-detection device, realizes the communication control between Arduino micro-control board and PS-LCD, displays the signal of the detected device and diagnoses and locates the fault points through the screen. The actual test shows that the detection equipment can reliably complete the detection and fault diagnosis tasks of a certain type of equipment. Because Arduino is an open software and hardware platform for developing man-machine interaction products based on single chip computer, it has good reference value for electronic production contest and electronic detection products based on Arduino development environment.
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