Design of a Detection and Maintenance Equipment Based on Arduino

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Abstract. The photoelectric encoder of a certain type of equipment has a high failure rate. When repairing, it is often unable to locate the fault accurately and judge the quality of the photoelectric encoder. At the same time, the battery performance of this type of equipment often affects its service life because it can not be maintained in time. In order to improve the technical support ability of the equipment, realize fast and accurate fault diagnosis and prolong its battery life, a detection and maintenance equipment based on Arduino is designed. The detection and maintenance equipment is simple to use and easy to operate. Keywords: Arduino; Detection and Maintenance; touch-display LCD; controller.

1. Introduction
In the process of using a certain type of equipment, the failure rate of photoelectric encoder is high, and it is difficult to locate when maintaining and repairing. Therefore, a certain type of testing and maintenance equipment is designed, which can accurately locate the fault and prolong the service life of the battery of the equipment.

2. Overall Framework
Figure 1 is the general block diagram of the detection and maintenance equipment. It consists of power module, V/F conversion circuit, conditioning circuit, constant current source circuit, Arduino control board and LCD circuit.

![Diagram of detection and maintenance equipment](image_url)

Figure 1. General block diagram of the detection and maintenance equipment
The power module provides power for the detection and maintenance equipment. The conditioning circuit is used for signal processing such as shaping and filtering of the encoded signal with 90 degree phase difference, which is output by the photoelectric encoder. Finally, it is sent to the Arduino control board. The control board is used to count the number of pulses, measure the amplitude, discriminate the forward and reverse pulse signals, and measure the angular velocity of the optical encoder. Constant current source circuit provides constant current source for charge and discharge maintenance of the equipment under test. V/F conversion circuit is used to realize the voltage conversion in charge and discharge circuit. Finally, it is collected and controlled by Arduino control board. LCD circuit is used to display the parameters of detection, and self-checking circuit is used to judge whether the detection and maintenance equipment itself works properly.

3. Hardware design

3.1. Interface circuit

Signal conditioning circuit is used to adjust the detection signal. It mainly sends the signal to the microcontroller for measurement after amplification, gating, limiting and operation.

Figure 2 is the block diagram of the conditioning circuit. The two sinusoidal signals A and B with phase difference of 90 degrees from the photoelectric encoder are transformed into two groups of square wave signals A and B by Schmidt flip-flop. A is divided into two groups: one passes through differential circuit, forming pulse signal d along the rising edge of square wave, and then output by gate circuit to form positive rotation pulse. The other way is through the inverter to form the inverted square wave c, and then through the differential circuit to form the pulse signal E. The gate circuit outputs the inverted pulse G. Group B square wave is directly connected to the control end of the two gate circuits, and serves as the selective signal of the two gate circuits.

![Figure 2. Conditioning circuit block diagram](image)

When the photoelectric encoder rotates forward, group B signals advance 90 degrees. Its positive half-wave corresponds to the rising edge of group a square wave without inverters. The positive half-wave makes the gate circuit turn on, and group D pulses form the positive turn pulse through the gate circuit. The rising edge of group C square wave corresponds to the negative half wave of group B square wave. At this time, although the differential circuit outputs E-pulse, the gate circuit is closed and the inverse phase pulse G cannot be output. When the encoder is inverted, the output is exactly the opposite. The final output pulses are fed into the control board for counting.

3.2. Constant Current Source Circuit

The internal integrated circuits of LM138 mainly include start-up circuit, reference voltage source, error amplifier, regulator, sampling circuit and protection circuit. Start-up circuit only works when the power is on, helping the constant current source to set up working point, once the regulator works properly, it will fail. LM series uses bandgap reference voltage source. It first obtains the sampling voltage through the resistance of the sampling circuit, then compares and amplifies the voltage through the ADJ terminal error amplifier, and then adjusts the voltage drop of the regulator to achieve
the purpose of stabilizing the voltage. The protection circuit includes over-current protection, short circuit protection, safety working area protection of adjusting tube and chip overheating protection [1].

LM138 series three-terminal adjustable regulator can provide more than 5A current in the range of 1.2V to 32V output voltage. It can be used in adjustable regulated power supply, constant current regulator and battery charger. The constant current source circuit module is shown in Figure 3. There are four independent LM138 mandatory constant current sources on the board. The pressure difference between foot 3 and foot 1 of LM138 is 1.25V. The constant current value depends on the pressure difference of 1.25V divided by the resistance value connected between foot 3 and foot1. Three independent constant current sources can be obtained, one is 1.25/0.62=2A, the other is 1.25/1.25=1A, and the other is 1.25/0.83=1.5A. The different combinations of three constant current sources can meet the requirements of constant current values 1A, 2A, 3A and 3.5A for testing and maintenance equipment.

\[ \text{Figure 3. Constant Current Source Circuit} \]

3.3. V/F Conversion Circuit

The circuit is powered by 25V, and the main chip adopts LM131 voltage/frequency converter. LM131 is a low-cost monolithic voltage/frequency converter, which can be used in analog-to-digital converter, voltage/frequency converter, frequency/voltage converter, long-time integrator, linear modem and so on. LM131 features: single power supply, power supply voltage 4.0V-40V can work normally; output level can be compatible with all kinds of circuits, and output to the ground or short circuit power does not damage the device; good stability, temperature coefficient < 50PPm /C; low power consumption, when the power supply is + 5V, power consumption is 15mW.

Battery voltage V1 of the tested equipment is directly input to the input port of LM131 through resistance R1. LM131 converts analog voltage into frequency signal and sends it to 54HC00 for processing. The characteristics of 54HC00 are: Wide Operating Voltage Range of 2 V to 6 V; Outputs Can Drive Up to 10 LSTTL Loads; Low Power Consumption: ICC 20-µA (Maximum); ±4-mA Output Drive at 5 V; Low Input Current: 1 µA (Maximum).

The frequency signal is transformed into F1 by 54HC00 and sent to the IO port of the control board. The frequency signal is received by the single chip computer. The working principle of V/f conversion circuit is shown in Fig.4.
3.4. Arduino control board

The Arduino Due microcontroller developed in Italy is used in the testing and maintenance equipment. Arduino Due is a microcontroller board based on ATML SAM3X8E CPU. It is the first Arduino based on 32-bit ARM core. Due with 32-bit ARM core is more powerful than other Arduino with 8-bit AVR core: 32-bit core can process 32-bit data in one clock. The control board consists of 54 digital I/O pins (including 12 PWM outputs), 130 mA total output current of IO port, 12 analog input channels and 2 analog output channels (DAC). 3.3V port output capacity 800 mA, 5V port output capacity 800 mA, SRAM 96 KB (two parts: 64KB and 32KB), Flash 512 KB (all space can store user programs), clock rate 84 MHz [2-4].

Because the working voltage of Arduino due is 3.3V. The IO port can also carry a voltage of 3.3V. The 5V pulse generated by the conditioning circuit cannot be sent to the IO port for sampling. The detection and maintenance equipment reshapes 5V pulse to 3.3V pulse through sn74lvc4245 chip.

3.5. Display Circuit

Programmable Smart LCD (PS-LCD) developed in China is used in this testing and maintenance equipment. PS-LCD is an intelligent display module which includes LCD display screen, LCD controller, touch screen, man-machine interface processing system and communication interface. It connects with external control unit (such as 51 MCU, ARM, DSP, PC, PLC, bus equipment) through optional communication interface to realize man-machine interface of the system. The specific steps are as follows:

The new Designer project defines interface resolution, interface switching effect and main interface, setting background, adding/setting controls, defining event actions, etc. PS-LCD uses JavaScript scripting language. JavaScript is the most popular scripting language on the Internet. It exists in all Web browsers all over the world and can enhance the interaction between users and Web sites and Web applications. The LCD screen can display the number of pulses collected and sent by the microcontroller in real time through scripting, and judge them. Use LCD simulator to verify the interface effect and communication process, repeat the previous steps until satisfactory.

PS-LCD, as an advanced intelligent human-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. CTP protocol is the first communication protocol used in this test and maintenance 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 that of Arduino Due microcontroller, it is necessary to convert 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. PS-LCD controls the work of microcontroller through serial signal generated by communication protocol at the same time, and realizes the effect of human-computer interaction [5-7].

The output file SPF of the interface is generated, and then the SPF file is downloaded to PS-LCD by Flex, a special software tool for PS-LCD to verify the final interface effect. The testing interface of PS-LCD part of the testing and maintenance equipment is shown in Fig 5.

4. Software design
The software part of the controller adopts modular design. The whole software consists of main program, self-test program, pulse counting subroutine, battery charging control program and battery discharge control program. The main program is the core of the management and control of the whole system. After the system is powered on, the first step is to self-check the testing and maintenance equipment, focusing on judging whether the conditioning circuit, constant current source circuit, V/F conversion circuit and display circuit are working properly. The number of pulses generated by the conditioning circuit is stored in the register in the Arduino main control board to facilitate the reading and judgment of the main control board. Finally, the collected data is displayed on the LCD screen and the results of the display are judged.

![Figure 5. Detection Interface](image)

5. Conclusion
This type of detection and maintenance equipment can check the performance of photoelectric encoder of the equipment being inspected and locate the fault accurately, facilitate the repair of the equipment being inspected, maintain the batteries of the equipment being inspected, and improve the service life of the equipment being inspected.

References
[1] Chen Huixiang Liu Duowen. Design of 12V linear regulated power supply [J]. Digital Technology and Application, 2012,4:126-128.
[2] Yang Jizhi and Yang Yuhuan. Innovative design of network interactive products based on Aduino [J]. Development and innovation of mechanical and electrical products. 2012,25 (1):99-101.
[3] Ji Xinran. Design of intelligent light-seeking car based on Aduino development environment [J]. Modern electronic technology, 2012,35(15):161-163.
[4] Cai Ruiyan. Principle and application of Arduino [J]. Electronic design engineering, 2012,20(16):155-157.
[5] Bender P, Kussmann K. Arduino based projects in the computer science capstone course[J]. Journal of Computing Sciences in Colleges, 2012, 27(5):152—157.
[6] Ji Songbo, Hou Ting. Design of interface between intelligent LCD touch display terminal and MCU [J]. Modern electronic technology, 2010, 31(12):16-18.
[7] Meng Qingtao, Bai Sichun et al. Design of temperature display and alarm circuit based on single chip computer simulation function [J]. Instrument technology, 2011, (8): 47-49.