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Design of Position Measurement System Based on Photoelectric Encoder

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ABSTRACT:
In real life, we have many occasions where position measurement is required. Such as engine, reversing radar and so on. All need to accurately measure the position distance, so the measurement of the position is of great significance. This design wants to use the STC series of single-chip microcomputers and a position measurement system that uses photoelectric sensors to measure in real time. Including hardware display devices, photoelectric sensors, acquisition modules, etc. The software adopted is to use Keil to carry on the programming of C language.

Keywords: position measurement, single chip microcomputer, photoelectric encoder, motor

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I. INTRODUCTION

Because of the excellent function of the single-chip microcomputer, it has a wide range of applications in all aspects. The single-chip microcomputer itself is small in size, strong in performance and low in cost, and has been affirmed by more people. The measurement position is used in many places in daily life. Generally, the measurement of the position is achieved through the acquisition and processing of analog quantities. So far, this method of measurement has been relatively backward and has been abandoned by people. Nowadays, the rapid development of all-digital digital system measurement has led to the rapid development of large-scale integrated circuits. Among them, the processing ability of the pulse signal of the single chip computer is particularly prominent. After the measured results are fully digitally processed, the measurement accuracy and results will also be greatly improved.

This paper uses 51 series single-chip microcomputer, starting from improving the measurement accuracy, reducing the error sum, and analyzing the error, to carry out the software and hardware design of the position measurement system of this paper, it is also necessary to consider the actual situation of the hardware and the acquisition of hardware materials. Difficulty level and work environment. The circuit diagram should also be carefully analyzed and modified to minimize the error rate.

In industrial engineering, measurement systems for position are crucial. The precise measurement of position is inseparable from the detection of most CNC (Computer Numerical Control) machine tools. In aerospace, the space shuttle also requires a very precise position measurement system. This design designs a position measurement system design through the results of full digitization, which can be directly used in industrial inspection more conveniently, saving efficiency and time.

Not only the measurement of position is required in various projects, such as the operation and control of many rotating equipment such as engines and electronic machine tools. In daily life, the measurement of position is also necessary, and the taximeter of the car also needs the position for accurate measurement. Therefore, the position measurement system is of great significance, not only in the industry, but also inseparable from our daily life.

In most of the contemporary industries, mechatronics technology is inseparable, such as the application in military, industry, and aerospace technology, which has very high requirements for measurement, requires very precise measurement, and does not tolerate a little error. Therefore, accurate measurement of position using mechatronics techniques is important. There are many kinds of measurement methods involved in this subject, such as photoelectric speed measurement, stroboscopic speed measurement and so on. Although the single-chip microcomputer has just been introduced, it has strong functionality, small size and relatively low price. Because of these advantages, we then decided to use a microcontroller as the control element. Compared with other control components, the photoelectric sensor has more suitable advantages in terms of its structure and function, and its lifespan is more difficult to use than other control components, and it can also work under harsh environmental conditions. Compared with the harsh working environment of the motor, the photoelectric sensor is not only suitable for the more complex working environment, but also has strong functionality. Therefore, considering all the circumstances, a photoelectric sensor is used as the design sensor for this subject.

II. SYSTEM WORKING PRINCIPLE AND SCHEME

In this subject, the position measurement is realized by measuring the rotational speed of the motor. The number of circular motions performed by the motor in unit time is the rotational speed. As the speed changes, we can also see whether the system is working properly. Because, in engineering measurement, rotational speed measurement has always been a big problem. According to different theories, there are many different measurement methods: Analog velocity measurement, Synchronous velocity measurement, etc. This subject decides to use another kind of speed measurement method to realize, use the single chip microcomputer and the photoelectric encoder to form the position measurement system with higher precision, adopts the electronic timing counting method.

After measuring the pulse signal change caused by the rotor rotation, we can calculate the distance of the position through the software. Generally, there are two methods of measuring frequency by electronic timing counting method. The first is the frequency measurement method: within a certain time, interval t, the number of repeated changes of the measured signal is counted N times, then the frequency of the measured signal is f x. Then it can be expressed as f x =N/t. The second is the multi-cycle frequency measurement method: within 1m cycles of the measured signal, count the number of clock pulses 2m, so as to obtain the measured signal frequency f x, then f x can be expressed as f x =1m fc/2m, 1m is determined by the measurement accuracy Sure. When the electronic timing counting method measures frequency, its measurement accuracy is mainly determined by two errors: one is the time base error; the other is the quantization ±1 error. When the time base error is one or two orders of magnitude smaller than the quantization ±1 error, the measurement accuracy is mainly determined by the quantization ±1 error. For the frequency measurement method, the relative measurement error is: 1Er = measurement error value/actual measurement value × 100 % = 1/N × 100 % [1-2].

From the above, it can be obtained that when the frequency of the measured signal is higher, the obtained N will be larger and 1Er will be smaller. Therefore, it is the correct method to measure the high frequency signal by measuring the frequency measurement method.

For a given clock pulse (Clock pulse) fc, if the frequency of the measured signal is low, 0m will be larger, and the obtained 2Er will be smaller, so the measurement period method is usually suitable for low frequency Signal (Low-frequency signal) measurement. In the multi-cycle frequency measurement method, the error is: 3Er = measurement error value / actual measurement value 100% = 1/2m × 100%. Therefore, we can see that the larger the measured signal pulse period 1m is, the larger the 2m will be [3]. Therefore, the accuracy of the measurement will be higher.

Not only can we use it when measuring high-frequency signals, but we can still use this test method in measurements with lower signal frequency bands. However, according to the change and improvement of frequency and accuracy, the time period required for sampling will become longer and longer. Because of the period, it takes too long to judge 1m, so it is not suitable for real-time measurement.

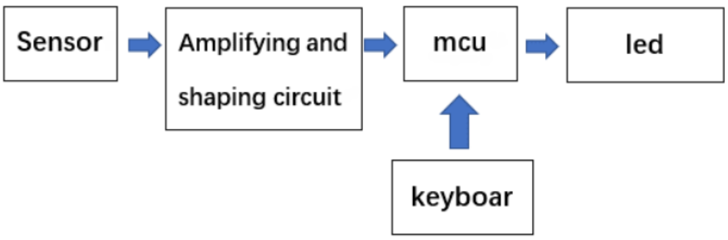

Fig. 1 Position Measurement Schematic

As shown in Figure 1, the frequency measurement method is used here. This method is based on calculating the number of signal pulses generated by the sensor within a certain period of time to generate the required position and distance.

The function and application of each part of the module:

①Sensor: Collects the signal of the element.
②Amplification and shaping circuit: By amplifying the signal, it is sent to the single-chip microcomputer for processing.
③Single-chip microcomputer: The signal processed by the single-chip microcomputer is converted into the accurate value of the position, and then sent to the LED display for external display.
④LED display: On the LED, the required position data is displayed.
⑤Keyboard: Switchgear for digital tubes.

III. SELECTION OF SYSTEM SOLUTIONS

The system design scheme of this subject needs to be considered in combination with many aspects, such as whether the structure of the sensor is suitable, whether the installation process is too complicated, whether the scope of the test meets the needs of the subject and the needs of life, and also considers the selected Whether the system solution can operate in various harsh working environments. After consulting materials and consulting teachers and students, two design schemes were initially confirmed. In some of the more important modules, it is also necessary to comprehensively consider the difficulty of the realization of the scheme and the familiarity of the system [4-5]. Based on the above-mentioned aspects, considering two more suitable project schemes, the following will conduct a detailed analysis and comparison of the two schemes.

SENSOR SELECTION

Scheme 1: Hall sensor measurement scheme
First of all, I thought about using a Hall sensor for measurement, which is measured by the Hall effect. The core element of the Hall sensor is a disc and a magnet. The working principle of the Hall sensor is shown in Figure 2.

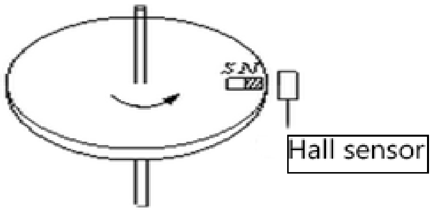

Fig. 2 Schematic diagram of the speed measurement of the Hall speed sensor

The Hall sensor attaches a magnetic steel next to the disc. When the disc rotates once, the Hall sensor next to it can feel a pulse signal. From this pulse signal, we can measure the rotation speed of the disc., through the frequency and the speed of rotation, the position of the displacement and the distance of the displacement can then be calculated.
From Figure 3, we can see that there are 2 windings in the Hall sensor. We say that the windings are divided into AB groups. Winding A and winding B are not only perpendicular to each other, but also connected to each other. We will connect the Hall electrodes of winding A and winding B in series as the output of the Hall sensor [6-7].

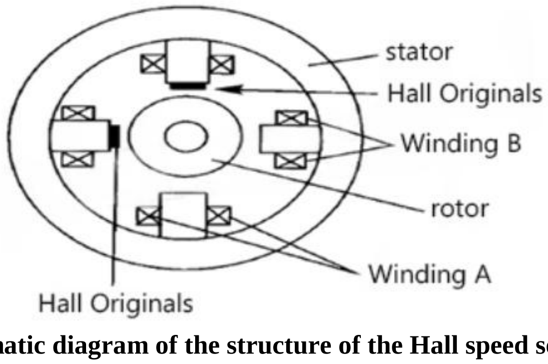

Fig. 3 Schematic diagram of the structure of the Hall speed sensor

Disadvantages: At that time, when measuring with Hall sensors, we would find that Hall sensors often had insufficient sampling accuracy. When the Hall sensor is used for too long and the work is too large, the magnetism of the magnetic steel becomes smaller, which reduces the magnetic response of the magnetic steel, which will affect the accuracy of the pulse signal sampling.

Scheme 2: Photoelectric Sensor Solution

After comparison, I also considered using a photoelectric sensor for this design. The working principle of the light spot sensor is to convert the measured data into an optical signal, and the optical signal is converted into an electrical signal. This method includes three essential parts: light source, photoelectric element and optical circuit. This measurement method can not only achieve relatively high precision, but also achieve fast response speed. Moreover, the parameters obtained by this system will be more than those obtained by other methods. Compared with other sensors, the composition of this photoelectric sensor is relatively simple, and the form will be more diverse [8-10].

Photoelectric sensors have various styles and are widely used. For example, dialysis type, direct shooting style, etc. The basic principle of photoelectric sensor is that when the light of the transmitting tube is irradiated on the receiving tube, the receiving tube will be induced and the signal from the reflecting tube will be received.

The photoelectric encoder used in this paper is shown in Figure 4. The design is to add a motor to the transceiver section of the photoelectric sensor, and install a turntable on the disc. First, align the circular hole with the sensing part of the photoelectric sensor so that it can sense the change of light. It is also necessary to dig some holes around the circular hole to transmit light. When there is an obstacle between the high-sensitivity phototransistor and diode, the photoelectric sensor will emit a lower-level signal. If there is no obstruction between the diode and the phototransistor, a higher rating will be output, and then a pulse signal will be formed. The pulse signal is a pulse signal emitted by the light emitted by the light source irradiating the photoelectric element to make the element photosensitive [11]. Whenever the disc rotates, the photoelectric sensor will send out several pulse signals due to the change of light. Then the obtained signal is converted into electric pulse, and then the pulse signal obtained in unit time is calculated by the microcomputer, and the required position data is obtained through the calculation of the software system. Figure 5 is the schematic diagram [12].

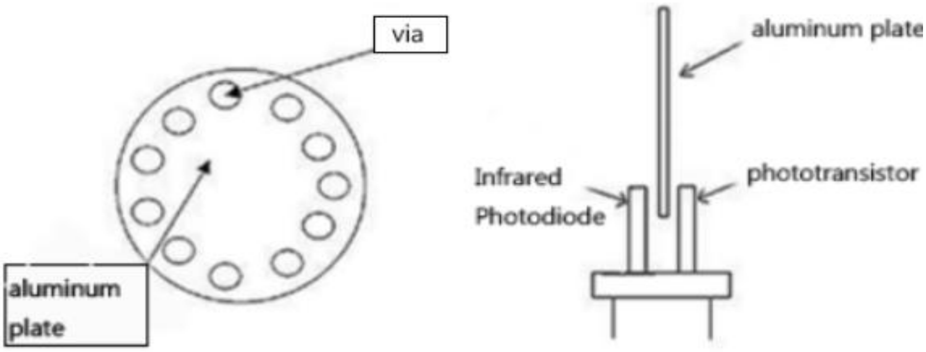

Fig. 4 Pulse generator hardware structure diagram

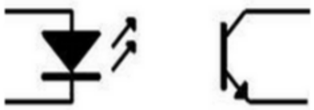

Fig. 5 Photoelectric sensor schematic

Usually, our measurement system is measured through a toothed disc with 60 teeth, that is, 60 electrical pulse signals are generated by one rotation of the toothed disc. The photoelectric sensor is used for temporary position measurement, and the measurement of the use position is realized by one pulse signal on the rotating shaft. However, position measurement in long-term or temporary situations can be implemented using micro processing. That is, through the period of the photoelectric signal, the position and speed of the rotation of the shaft are converted. The principle is to first convert the obtained position signal into an electrical pulse signal through the photoelectric sensor, and then count the number of pulse signals that occur in a unit time, and then after the calculation of the software, the position data we seek can be obtained. Usually m=60, then the number of pulses N in 1 second is the speed n, $n=N/(MT)=N/60\times1/60=N$ [13].

Through the above situation, we consider the working environment, performance and price, etc., we choose to use the photoelectric sensor to design and measure the system, which is the best solution for this design.

CHOICE OF CONTROL CHIP

When considering the selection of control chips, as students, we should first consider whether the resources that come with the chip are suitable. If the resources that come with the chip are closer to the purpose of the design, the development and completion of the design will be more convenient. Simple. Another point is that we need to consider the power consumption of the chip, not only whether it will affect the normal operation of the design, but also factors such as energy saving and environmental pollution. In terms of price, it is also something I have been considering. Choosing a cost-effective chip will play a key role in my design. The STC series microcontrollers used in this design are introduced below [14-15].

DESIGN OF THE CORE SYSTEM CIRCUIT OF STC SERIES SINGLE-CHIP MICROCOMPUTER

The one-chip computer control chip that this design chooses is STC89C52 one-chip computer. In terms of performance, the STC89C52 microcontroller has a CMOS8-bit microcontroller, which is relatively low in power consumption. The selected microcontroller can also program the Flash program. The microcontroller control chip is manufactured by the high-density non-volatile storage technology developed by Atmel Corporation of the United States. These microcontrollers and storage technologies improve the flexibility of the system when the microcontroller is applied.

As the key point of the whole system, the single-chip microcomputer plays a vital role in the system. The single-chip microcomputer is connected to the hardware. When the single-chip microcomputer detects the information sent by the photoelectric sensor, it processes the information, and then controls the on and off of the LED light.

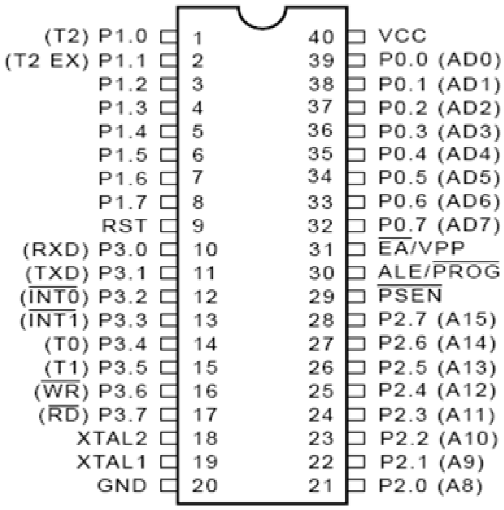

Fig. 6 Pin Diagram

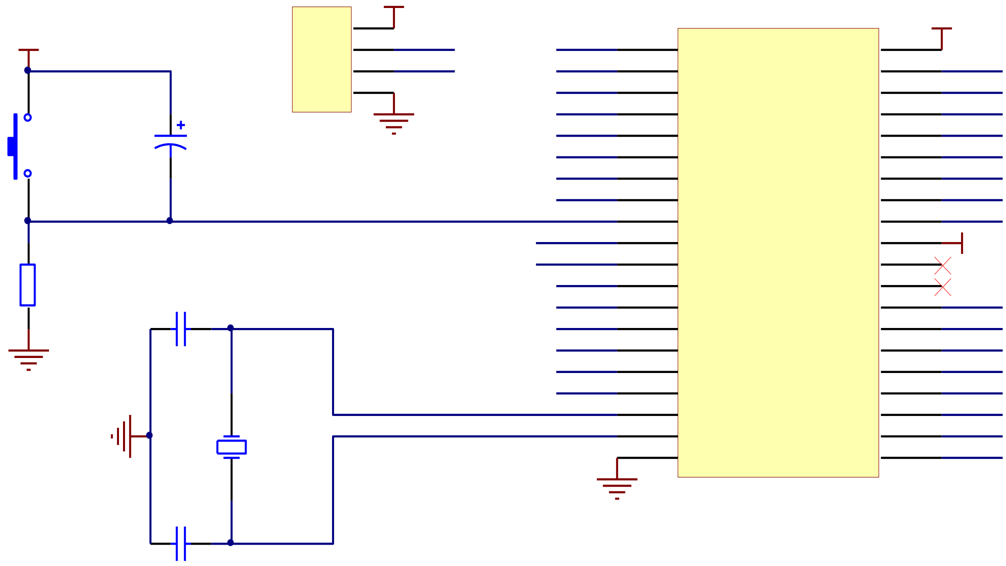

Fig. 7 System circuit diagram

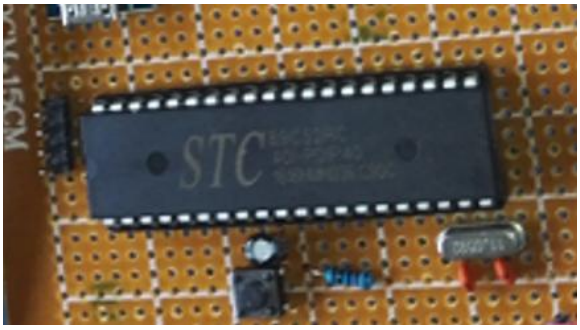

Fig. 8 Real picture of single chip microcomputer

The circuit schematic for this design was done using the Altium Designer tool. This software has technologies such as circuit simulation, PCB drawing and editing, which can perfectly combine analysis and design. If you can operate this system proficiently, you will make yourself faster and more convenient in circuit design, work more efficiently, and reduce your own mistakes. The overall circuit diagram is shown in Figure 9.

SOFTWARE DESIGN
KEIL C51

This design uses Keil C51. This program is a programming software designed to be compatible with the development of single-chip microcomputers in C language. Among all kinds of languages, C language has obvious advantages in its powerful functionality and maintainability. The library functions of this software are very rich, and the debugging and development tools are also very powerful. The generated assembly code is also very clear, which is easier to understand for a beginner like me, which makes it easier for me to develop and test the system [16]. Figure 4.1 is the operation interface of Keil C51.

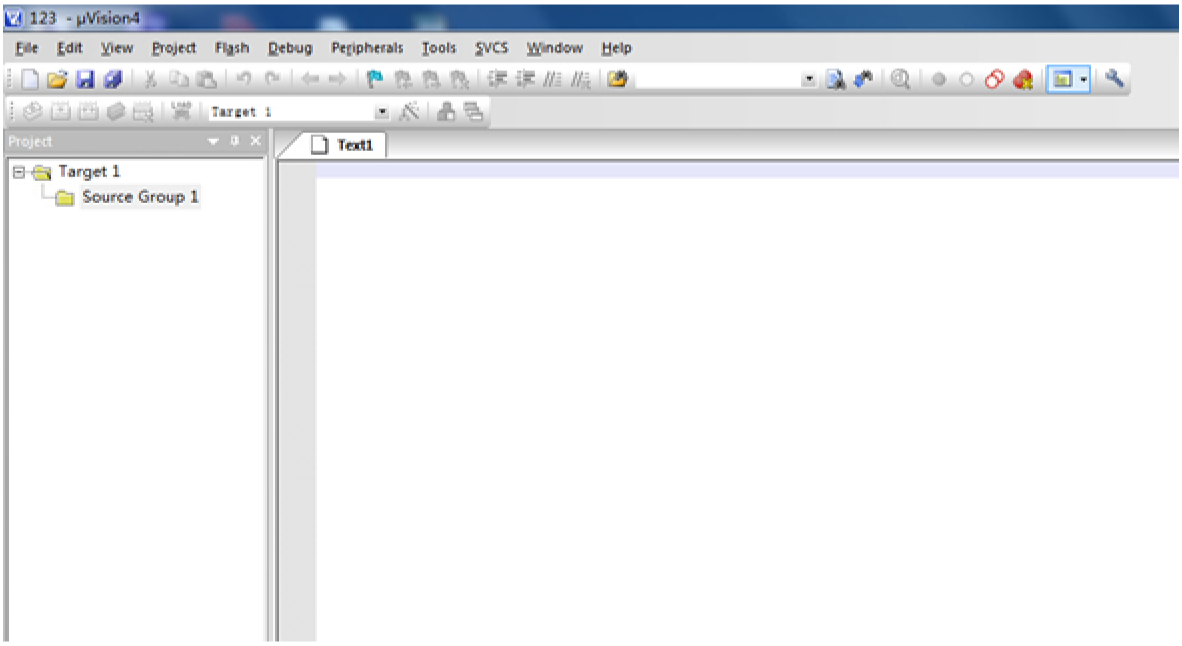

Fig. 9 Operation interface of Keil C51

IV. WELDING AND SYSTEM DEBUGGING

CIRUIT SOLDERING

Today, mechanical welding has long replaced manual welding. However, in the maintenance and debugging of small parts, we also choose manual welding, because manual welding can be operated more accurately. Having learned this skill will be helpful to my future work or life. With more practice and practice, my skills will be refined. Compared with the other two methods of holding the soldering iron, this method is most suitable for soldering components and circuit maintenance and improvement.
Manual welding is divided into four steps:

Prepare for Soldering: Carefully remove dirt and dust from the components to prevent them from affecting the current path. It is also necessary to shake the electronic components, which is convenient for welding, avoids mutual influence, and increases the difficulty of welding.
Heating welding: dip a little tin on the head of the electric soldering iron. When the tin is softened by high temperature, gently place the head of the electric soldering iron on the component to be soldered. After about a few seconds, the electric soldering iron can be removed. If there is a welding error during soldering, you can heat the electric soldering iron and place it at the component soldering tin, shake the component gently and slowly take out the component to avoid damage to the component.
Clean up the soldering surface: If there is too much tin in the components to be soldered, you can heat the soldering iron, place it in a place with a lot of tin, and gently "dip" some tin out. If you feel that there is too little solder, and you are afraid of loose components, you can perform repair welding.
Check solder joints: Carefully inspect the soldered circuit boards to see if there is continuous soldering or no soldering, which affects the operation of the system.

SYSTEM DEBUGGING

Because the skills in this area are not skilled enough, there may be some inappropriate operations during the welding process. This will lead to some loopholes in the soldered circuit, so we need to debug it. On the other hand, I also need to use software to do the measurement of the position of the fit. If the software is different, the effect of the system is not the same. If you want to transfer the components on the microcontroller to other hardware, you need to debug it first.
Before the circuit board is energized, in order to prevent the circuit components from burning out, first check the solder joints to check whether there is less soldering and more soldering, and avoid series connection between components. In order to prevent the sensor from being burned out by too much power, I also added a

controllable resistor to control the motor to prevent the element from being burned out by too much power. This can also control the rotational speed, making the measurement results more accurate.

V. CONCLUSION

Through comparison, this design selects STC89C52 single-chip microcomputer as the basis, uses C language to write the program, and the photoelectric sensor is used as the data acquisition tool. In the middle, I encountered the phenomenon that the program I wrote could not run normally, the circuit was welded in series, etc. After careful checking and inspection, I overcame these difficulties and completed my own design.

When implementing this design, due to my own carelessness, the components are connected in series. Since the motor had no resistance control at that time, the motor burned out. In the second rectification, after welding the original parts, first check the solder joints, and then connect a controllable resistance to the motor. This can not only prevent the motor from burning, but also control the motor speed, which is convenient for more accurate position measurement.

The design can also add a timing device in the future to measure real-time speed. On the power supply side, a power supply can be configured to make this design ready to use. The measurement of position should be improved so that the motor can be reversed for testing.

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