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Design for Crack Detection System of Wall in Houses Based on SCM

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Abstract: In order to understand the data of crack of wall in houses as much as possible and ensure the safety of life and property of residents, a kind of crack detection system of wall in houses based on SCM was designed to detect the crack of wall in houses. In the system, the main work includes the design for data acquisition module of crack in the wall and data receiving and processing control module. For detailed, the work can be divided into selection of sensor detecting cracks, hardware design and software design of the system. The hardware design consists of the design of data acquisition module and data receiving and processing control module, and the software design consists of the design of data acquisition program and data receiving and processing control program and so on. Finally, the hardware and software of system designed were debugged and it proved that the desired effect was achieved for the design in practice. *Copyright © 2013 IFSA.*

Keywords: Crack of wall in houses, SCM, Data acquisition, Data receiving and processing control.

1. Introduction

In recent years, geological disasters happened frequently in our country. It always threatens the lives and property of the people, and has become a serious constraint of economic development. In this case, and in the meantime, with the construction quality of houses reducing, there are large range of cracks appeared in the wall.

With the development of construction technology, cast-in-place shear wall structure is commonly used in high-rise buildings. Due to improper design or construction, this structure was prone to crack, thereby affecting overall performance and seismic performance of structures. The cracks in the reinforced concrete can be roughly divided into two categories: one is belonging to load crack, and the other is a deformation cracks. The former refers that tensile stress is generated inside the reinforced concrete under the load function. When the stress value exceeds the ultimate tensile strength of reinforced concrete, the crack will be produced. Deformation cracks refer that due to different reasons reinforced concrete produces deformation. Additional stress is produced inside reinforced concrete resulting from deformation coordination. When the additional stress exceeds the ultimate tensile strength of the reinforced concrete, the crack will be produced. According to reason of deformation crack forming, the deformation crack can be divided into shrinkage cracks, plastic shrinkage cracks, settlement cracks and temperature cracks [1].

It not only affects the appearance of the buildings seriously, but also leads to the collapse of the house and endangers safety of the residents [2, 3]. Crack of wall in houses is shown in Fig. 1 [4, 5].

At present, there is not dedicated system monitoring methods to detect crack of wall in our country. There are a number of companies producing crack width gauge at home and abroad through

research, which can apply to detect the crack width of different object quantitatively such as bridges, tunnels, walls, concrete pavement and metal surface.

Fig. 1. Crack of wall in houses.

In addition, the FA-2 cracks alarm has been produced by hydrogeology and environmental geology survey center of china geological survey bureau. The cracks alarm can be applied to detect the crack displacement of houses and rock automatically which caused by sudden geological disasters such as collapses and landslides. In the United States, the company successfully developed multiple access technology that can simultaneously manage multiple sensors and also design and manufacture sensors that support the technology. The technology may surpass 5000 sensor installments to take a network manage. All these sensors will be installed in various parts of the buildings to discover wall cracks and other problems in advance. But all these studies are not suitable to detect the wall cracks of houses specially, and the production is expensive and not conducive to practical application. [6-11].

Therefore, a kind of crack detection system of wall in houses based on SCM detecting width data of crack was designed. Through the demonstration and warning controlled by SCM, it can guarantee using of houses safely as far as possible. [12-15].

2. Design for Data Acquisition Module

The data acquisition module is used mainly for detecting width data of crack and sends the date to the data receiving and processing control module. In the design of this part, the main work is choice of sensors and the design of hardware and software.

2.1. Choice of Sensors Detecting Crack

In the choice of sensors detecting crack width, many kinds of design proposal is analyzed, such as using paste injection MS-02 strain sensor and infrared sensor, however, these programs have a variety of defects, such as too small range of inductive displacement, expensive, low applicability and so on. Therefore, resistance strain gauge is the most simple and convenient in the design. The principle of design is that, firstly, resistance strain gauges are attached to the elastic sensing element, then, elastic sensing element will be fixed to the wall, when crack width changes, elastic sensitive element will be affected by the action of force, and After resistance strain gauge induces to the change of contingency power, the signal will be output, thus through turning change of the crack displacement to the change of contingency power, the range of crack width can be detected in real time.

2.2. Design of Hardware and Software for Data Acquisition Module

Design concept in the design of this module's hardware: the resistance strain gauges are used to collect data of crack width, then signals collected will be amplified through the amplification module, and the A/D conversion module will convert analog signals into digital signals, finally digital signals will be sent through serial port transmission module controlled by SCM, design diagrams as shown in Fig. 2.

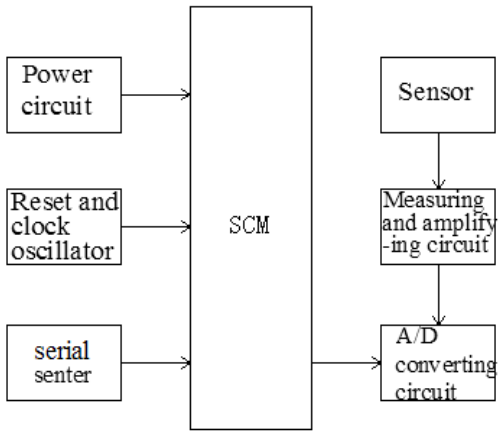

Fig. 2. Design diagram of data acquisition module.

Design of hardware circuit mainly includes the design of minimum system circuit in SCM, the serial communication circuit, measuring and amplifying circuit, and A/D converting circuit. The common STC89C52 SCM and ADC0809 converters are selected. The main circuit as shown in Fig. 3, Fig. 4, Fig. 5 and Fig. 6.

In Fig. 5, AD620 instrumentation amplifier is used in the design which takes the form of half-bridge wheat stone bridge circuit. In Fig. 6, ADC0809 is used as the A/D switch. The four group analog data are inputted separately through IN0, IN1, IN2, IN3 port. The input of address signal is controlled by P2.0, P2.1 and P2.2 port. The input of clock signal is controlled by P2.4. The input of enable signal is controlled by P2.5. The start of A/D switch is controlled by P2.3 and P2.6 port.

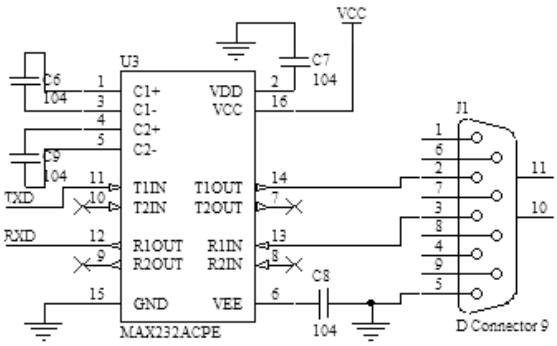

Fig. 3. Circuit of serial communication.

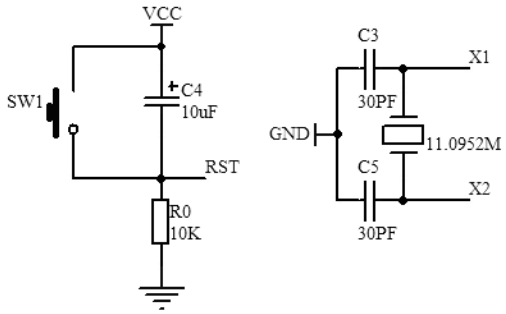

Fig. 4. Circuit of reset and clock oscillation.

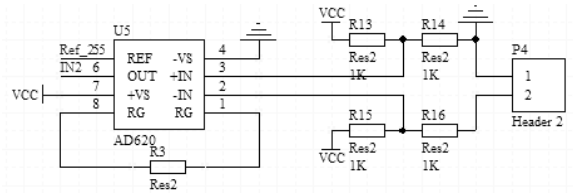

Fig. 5. Circuit of measuring and amplifying.

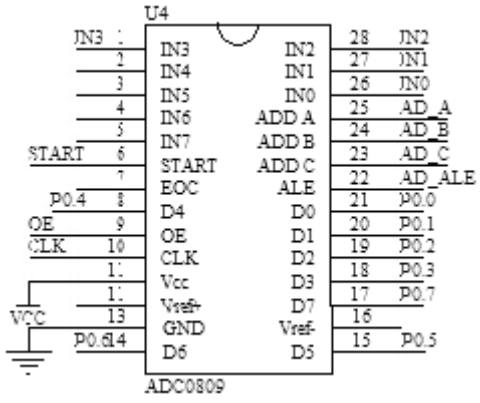

Fig. 6. Circuit of A/D transformation.

In the design of this module's software, firstly, both A/D and serial port are initialized. Then the A/D transformation channel is selected and the A/D transformation is started and stored the converted data until the completion of A/D conversion. Serial send procedure is called and the flag data, data 1, data 2, data 3 and data 4 will be sent in turn. The flow chart of main program is shown in Fig. 7.

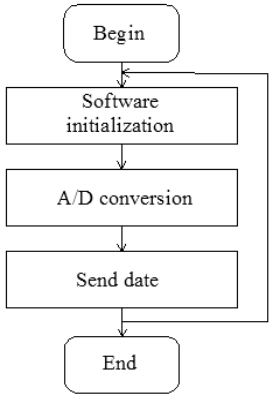

Fig. 7. Flow chart of main program of data acquisition module.

3. Design for Data Receiving and Processing Control Module

Data receiving and processing control module is used to receive and process the data sent from the data acquisition module and through displaying and alarm to remind people to ensure the personal safety and property of people. The main work is the design of hardware and software.

Design concept in the design of this module's hardware: signals of crack width are received by the serial communication module controlled by SCM, and then the date processed will be displayed by the LCD. In the meantime, the alarm limit will be set by the keyboard, and when the value of date processed exceed this limit, speaker will be alarm and indicator will be light. A design diagram is shown in Fig. 8.

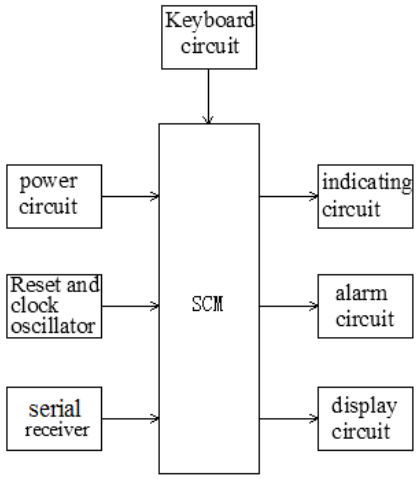

Fig. 8. Design diagram of data receiving and processing control module.

In addition to the design of minimum system circuit in SCM and the serial communication circuit, design of hardware circuit mainly also includes the design of keyboard circuit, display circuit, indicating circuit, alarm circuit and the circuit of the RF receiver. The main circuit is shown in Fig. 9, Fig. 10 and Fig. 11.

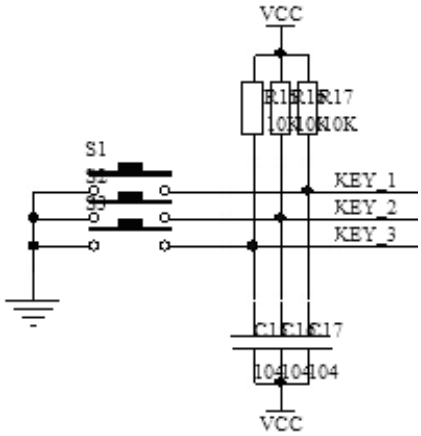

Fig. 9. Circuit of keyboard.

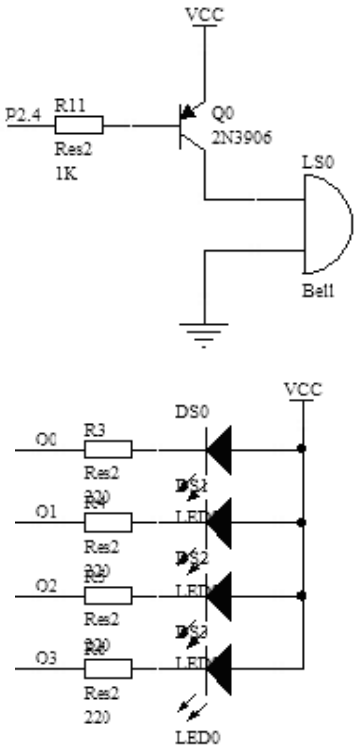

Fig. 10. Circuit of alarm and indicating.

In Fig. 9, the system is controlled through independent keyboard in the design, and the three keys are connected P3.3 to P3.5 of P3 port. One button is used to set alarm limits, when it is pressed twice, the crack limit will be set, if it is pressed other times, the set is finished and real-time data are displayed. Another two keys are used to set the addition and subtraction of limiting value.

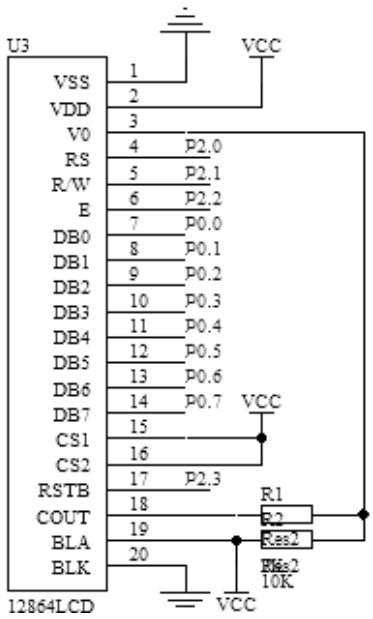

Fig. 11. Circuit of LCD.

In Fig. 10, four light-emitting diode is used in the design. It is connected the four I/O port of P0 port through74HC573 latch. If one I/O port is at the state of low level, the corresponding led will be lit. In the meantime, Speaker alarm is used in the design and controlled by the P2.4 port.

In Fig. 11, the OCMJ4X8C 128*64LCD is used in the design. The data / command selection RS, read / write selection R/W, enable signal E and the reset RSTB of LCD module are controlled by the P2.0 to P2.3 of P3 port.

In the design of this module's software, subroutine is written firstly, then main program call various some subroutines.

In the preparation of LCD subroutine, all date will be converted to liquid crystal character firstly. In the first line of the display, it will show the value of first inclination, with the second line showing the value of second inclination, the third line showing the value of third inclination and forth line showing the value of forth inclination. Then, it will be cleared, and the dynamic date will be displayed cyclically. The flow chart of LCD subroutine is shown in Fig. 12.

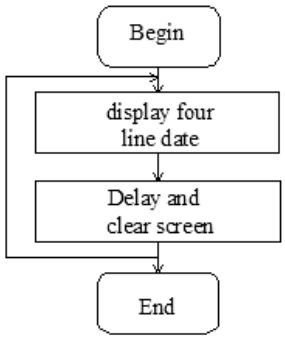

Fig. 12. Flow chart of LCD program of data receiving and processing control module.

In the preparation of key handling, whether the set key under is determined firstly. When the set key is pressed down one time, the real-time data is displayed properly. If the set key is pressed down two times, value of limit inclination will be set. Under this condition, if plus key is pressed, value of limit inclination increase, otherwise, the value decrease. The flow chart of key handling subroutine is shown in Fig. 13.

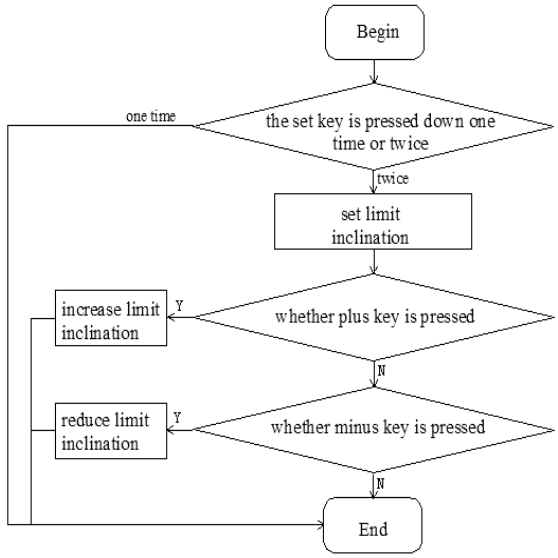

Fig. 13. Flow chart of keyboard control program of data receiving and processing control module.

In the preparation of main program, firstly, all software is initialized. Then the serial communication is set to receive mode, and the date processed will be displayed by the LCD and compared with the value of limit inclination. When it exceeds the limit, the system will prompt dangerous. The flow chart of main program as shown in Fig. 14.

4. Running Experiments of the System

The debugging work mainly includes the check of the circuit board and the circuit schematic, and the debugging of procedure. System can run normally through debugging of the entire system. The debugging results of system as shown in Fig. 15 and Fig. 16.

5. Conclusion

Crack detection system of wall in houses based on SCM is full application of serial communication technology to detect the crack width of the wall. If the crack of the wall is more serious, people should move to others timely. And when the crack is little, people should repair houses regularly. The two measures are as follows:

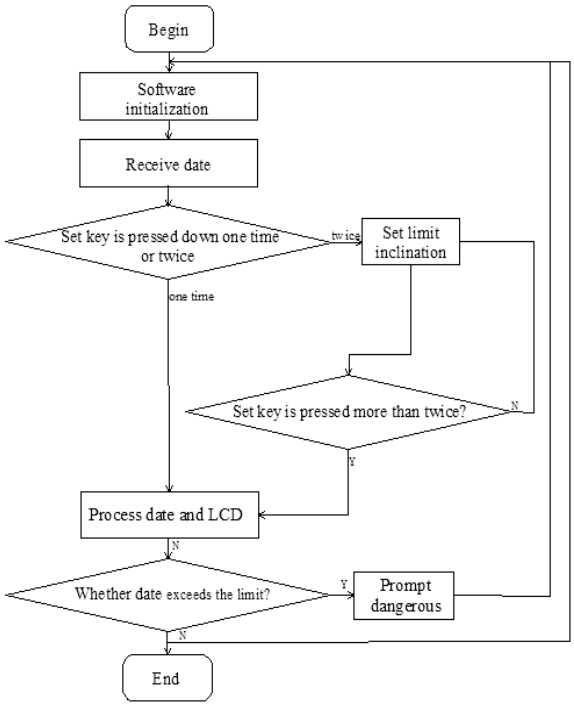

Fig. 14. Flow chart of main program of the part of data receiving and processing control.

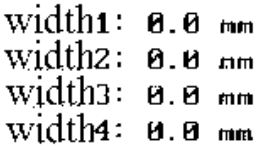

Fig. 15. Initial values of data.

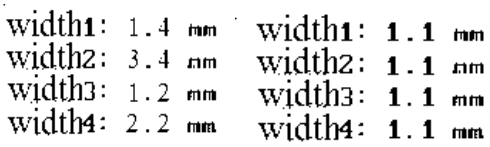

Fig. 16. Experimental values of data in different experiment.

1) When the crack width is less than 0.2 mm and cracks is shallow, cement mortar or polymer cement paste is brushing in the cracks.

2) When the crack width is more than 0.2 mm and cracks is deep, firstly, the crack is hewn V-groove, then the V-groove will be painted clean and wetted. Finally, XYPEX waterproof material will be packed in the crack, and in this way, cracks in concrete can be automatically healed

In this way, it can not only increase the awareness of the people and reduce the economic losses, at the same time safeguard the people's life, but also there is great significance for research improving the monitoring of crack of wall in the houses.

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