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Research on Automatic Detection of Electrical Control Circuit by Single Chip Microcomputer

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Abstract

To install and debug electrical control equipment is a typical work position for students who major in automation in vocational college. In order to meet the needs of this position, the connection and designation of electrical control lines have become a required part for most of these students. This paper proposes a simple method of automation detection of electrical control circuit based on single chip microcomputer, which is convenient for students to learn by themselves and for teachers to reduce the work pressure in reaching practically. Considering automatic detection of electrical control circuit by single chip microcomputer, the method synthesizes the technology of single chip microcomputer and embedded technology, and codes to construct net lists with nodes through connecting electrical components, so it is a foundation to achieve automatic detection of circuit. Not only is this method economical and practical, but it also helps to gain a good effect in process of teaching.

Keywords: *Electrical control circuit; single chip microcomputer; embedded technology*

1. Introduction

At present, the electrical control is widely used in many fields, so in the teaching content selection, electrical control and design of wire connection have become compulsory in most of the higher vocational colleges in students' practical teaching of automation. But in the practical teaching process, when students finish a control circuit, the teacher must detect before trying in order to prevent the wrong connection, miss or fault and other issues. The detection process is usually that the teacher controls principle diagram by checking from the supply side to the terminal step by step to eliminate the wrong connection and misses. This kind of artificial detection method is not only tedious, error prone, but also increases the intensity of the teacher's work. Based on this situation, this paper presents a method of automatic detection of electrical control circuit based on single chip microcomputer. The automatic detection system is designed under the guidance of this method, which can completely replace the teachers for students to complete the connection detection circuit, so as to reduce teachers work intensity and improve the teaching effect.

2. Hardware Based Detection Method

The detection method of the hardware device is mainly composed of MCS-51 SCM, electrical control circuit wiring board (that is, the main equipment used in training), node transformation matrix, and decoding circuit. These parts can form a complete detection system. The system hardware block diagram is shown in Figure 1.

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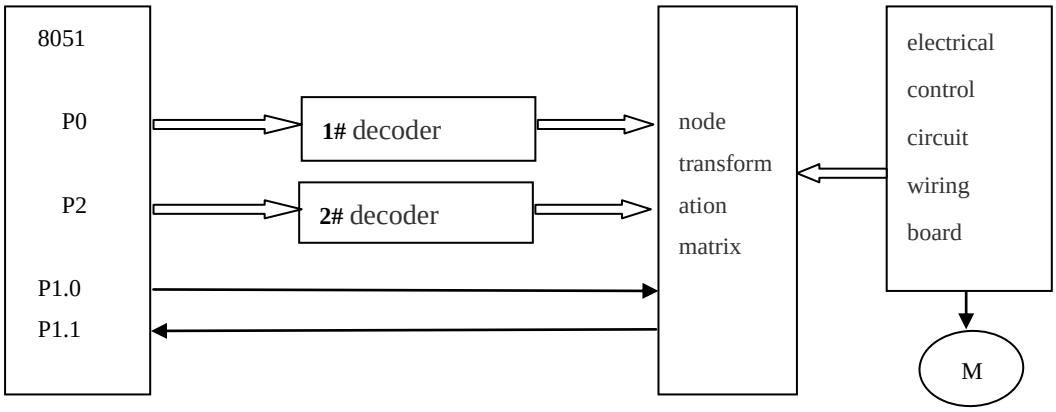

Figure 1. The Automatic Detection System Hardware Block Diagram of the Circuit

In the electrical control circuit board there arranges all kinds of switches, AC contactors, fuses, relays, buttons and other electrical components corresponding to the electrical control circuit. Students practice in wiring connection panel. Node switching matrix includes a main bus, from the bus, and the micro relay connection node corresponding to the electrical components. Each of the connection nodes in the electrical control circuit wiring board is respectively connected with the master-slave bus matrix through the micro relay nodes. The MCU P0 port is responsible for the transmission of the master node coding through the 1 decoder and P2 port is for transmission from the node coding through the 2 decoder. The main bus nodes P1.0 and SCM P1 port connect with P1.1 matrix, and P1.1 and node transformation matrix from the bus connect. The micro controller determines the correctness of the circuit connection according to the results of the consistence of the inspection of the output and input data.

3. The Realization of the Detection Method

This method is mainly based on the electrical control circuit wiring board every electrical component such as number, we can use a sixteen hexadecimal digits to represent each electrical component. After numbering the electrical components, each node connecting every electrical component needs to be numbered. We can use the 8 binary digits to represent each connection nodes, 4 for electrical component coding, Low encoding sequences of 4 for each terminal node in electrical components. Two nodes are defined master nodes and slave nodes. Connection with the main nodes and wires from the node must exist between the can with a 16 bit binary digits to represent the high 8 bits, the master node coding, the low 8 bits from the node coding. Through the analysis of the circuit, the circuit can traverse all connections, which we call the node connection network.

MCU delivers the master node coding in the network node connection to No. 1 decoder, through P0, making the micro relay node close corresponding to the main node of the transformation matrix. The master node communicates with the main bus which sends the network node from the node table corresponding to the code to the 2 decoder through the P2 port. The transformation matrix from the node corresponding with the micro relay is closed. The from node and from the bus is connected. Then the micro controller judge if P1.0 and P1.1 is connected so as to determine whether there is the wire connection between two nodes. This paper mainly takes the examples of the positive and negative rotation control circuit motor contactor interlocking to introduce a single-chip electric control circuit of automatic detection method based on the principle and the realization method.

3.1. The Number of Electrical Components

Because the contents of experiment and training of the students are mainly based on the preliminary understanding of motor control circuit, the electrical control circuit contains relatively a small number of electrical components involved in the experiment, generally not more than 16. So we can use 16 base a base sixteen of the digital 0-F to represent each electrical element number. Assume that the number of the first wiring of electrical components for electrical components number No. 0 and the last line for F (15 decimal). Students' basic training only exists between the two elements. The middle part of the control circuit can be different according to the different addition of electrical components. Electric control circuit for general initial connection node is power. We will make up for the No.0 element. The object is the last line of motor electrical components. We call them number of F electrical components. We will take the positive and negative rotation control circuit motor contactor interlocking as an example to introduce the number of the electrical control of the electrical components in the circuit. According to the analysis of motor contactor interlocking positive inversion control circuit principle diagram, between 0 electrical components and the power of F motor, there are electrical components including KM1 AC contactor, thermal relay, AC contactor, KM2, FR, normally closed button SB3, normally open button SB1, normally open button on the SB2. They can be numbered as follows AC contactor, KM1 for 1 KM2 AC contactor electrical components, electrical components for the No. 2, No. 3 FR thermal relay normally closed button SB3 electrical components, electrical components for the No. 4, No. 5 normally open button SB1 for electrical components, normally open button SB2 6 electrical components.

3.2. Connection Node Coding

After numbering the electrical components, in electrical control circuit each node in the electrical connections should be encoded. The numbering should reflect the two aspects of the meaning of the connection node coding, namely the node which belongs to the electrical components and the node sequence number in the electrical components. Assume that each connection node coding using 8 binary digits (2 hexadecimal number 16), 4 for the electrical components of coding, the low 4 bits represent sequences encoding the connection node in electrical components. Coding each node is given in Figure 2 the motor contactor interlocking positive inversion control circuit principle diagram.

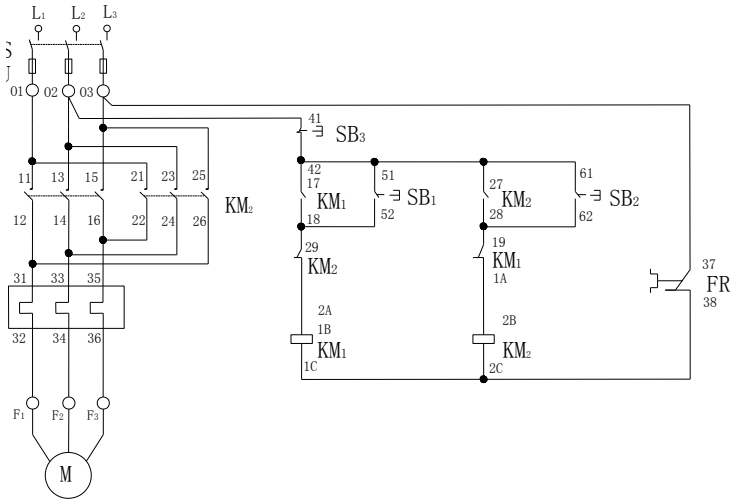

Figure 2. Positive Inversion Control Circuit Schematic Diagram of Each Node Encoding Motor Contactor Interlock

The principle diagram of control circuit is divided into two parts as the main circuit and the control circuit. Reversible coding control of each component and the connection node circuit are given in the motor contactor interlocking, namely positive inversion control circuit of the electric element number and the connection node coding table motor contactor interlocking which is shown in table 1.

Table 1. The Electrical Components Number and Connection Node Code Table

Electrical components.	Electrical component coding	The main circuit diagram Each node coding	The control circuit diagram Each node coding
Electric source	0	01H、02H、03H	
Communication Contactor KM1	1	11H、12H、13H、14H、15H、16H	17H、18H、19H、1AH、1BH、1CH
Communication Contactor KM2	2	21H、22H、23H、24H、25H、26H	27H、28H、29H、2AH、2BH、2CH
The thermal relay FR	3	31H、32H、33H、34H、35H、36H	37H、38H
The Normally closed button SB3	4		41H、42H
The normally open button SB1	5		51H、52H
The normally open button SB2	6		61H、62H
…	…	……	……
Motor	F	F1、F2、F3	

3.3. Construction of Network Node Table

In Figure 2 each node connection is encoded. We call the two nodes which need to be connected the call master nodes and slave nodes. The master node and the wires from the nodes should be connected with a 16 bit binary number (4 hexadecimal number 16), 8 said the master node coding, low 8 bits from the node coding. So through the analysis of the circuit, we can conclude the circuit connection table node network correct wired network, node connection table contains multiple data connections between nodes and wires from the master node should exist. Each set of data represents the master node and slave nodes which should have the wire, composed of two bytes, namely high byte oriented node coding and low byte from the node coding. The number of nodes in network data in the table should be the number of connection in the circuit. The same is true to the case of positive inversion control circuit of motor contactor interlocking. After the analysis of the circuit principle diagram, we can know the motor contactor interlocking positive inversion control circuit node connection network list shown in table 2. The table reflects that the positive inversion control circuit takes a few lines for the 29 motor contactor interlock.

Table 2. The Motor Contactor Interlocking Positive Inversion Control Circuit Node Connection Network

Electric road name	The main circuit	The control line
Section Point Network	0111H、0121H 0213H、0223H 0315H、0325H 1231H、1226H 1433H、1424H 1635H、1622H 32F1H 34F2H 36F3H	0241H 0337H 4217H、4251H、4227H、4261H 1829H 5229H 2A1BH 1C2CH、1C38H 2819H 6219H 1A2BH

3.4. The Detection Process Based on Single Chip Microcomputer

The node connection network data in the table is stored in the microcontroller circuit according to which the students' correction of circuit connection is checked when students train. The core of the method is the transformation matrix of node. In the node transformation matrix there are the main, from the detection of the main bus and bus, MCU P1.0 is connected from the bus and single chip microcomputer P1.1, at the same time, from the other end of the bus is grounded through a resistance. Connection node of each component in Table 1 is connected by wires to the mini relay nodes in the matrix. Then the connection through the micro relay node is connected with the main, from the master node connected to the bus, which is connected with the main bus, from the node and from the bus. 1# decoder structure chart of the hardware detection system used in drive is connected with the main bus relay which is used to drive the relay, 2# decoder and the pull from the bus. The students connect circuit detection, SCM connection node of the network in order to read the data in the table, will represent the main node 8 send 1# code decoder, representatives from the nodes of the lower 8 bits of 2# decoder, the decoding after the mini relay correspondingly, the winner node and the main bus is connected. From the node and from the bus is connected. If the wire connection between the master and slave nodes, it is connected between the master-slave bus, namely P1.0 and P1.1 connected, then the signal sent out from P1.0 can be received by the P1.1. Node switching matrix diagram is shown in figure 3.

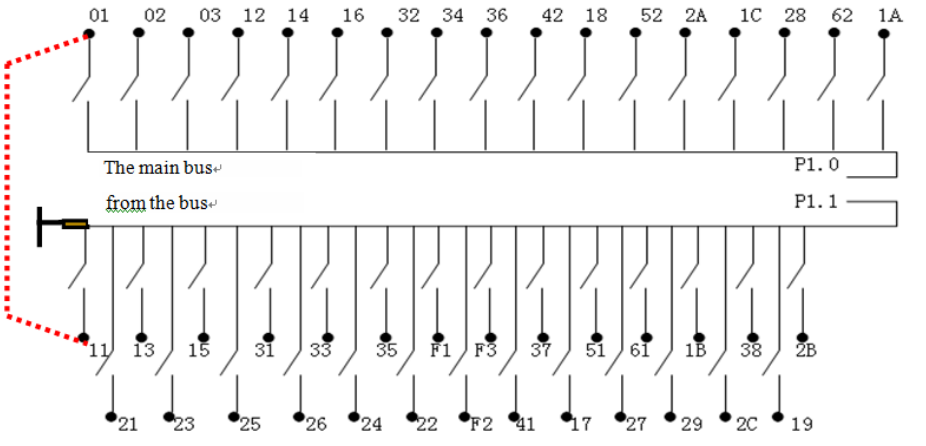

Figure 3. Schematic Diagram of Node Transformation Matrix

In the process of detection chip by the P1.0 bus to the main hypothesis by 1MHz Fang Bo (10101010 AAH), if the slave bus between the wires, P1.1 reads the data AAH. If there is no connection between the master-slave bus, then the P1.1 reads the data of 00H

(from the bus grounding). From the above analysis we read from the P1.1 data it can reflect the connection wiring two nodes in the master-slave bus. For example, to read the data in the table of 0111H nodes in the network, the high 8 bits 1# decoder decoding, decoding drive the relay, the 0 electrical components (power) of the 01 node and the main bus are connected, while the lower 8 bits 2# decoder decoding, decoding, driving the corresponding relay so, 1 electrical components (KM1 AC contactor) No. 11 node and from the bus are corrected. If a wire is connected between the 01 node and 11 node, AAH value sent from the P1.0 can be read by P1.1, namely, the test results for AAH. If there are no wires between 01 nodes and 11 nodes, AAH value sent from the P1.0 can be read by P1.1, the test results for 00H, SCM will each test results are saved or sent to PC to save, as the circuit connection on the basis of judgment and evaluation. When all the nodes of the network to read the data in the table are completed, the control circuit will detect all over. After all if all test results for AAH, the connection of all right, if the detection result is not AAH, there is 00H that the connection is wrong.

4. Conclusion

This method involves less hardware and it is easy to apply. Because of making full use of the single chip microcomputer, it has the advantages of small volume, low price, convenient use and so on. Combined with the teaching content and teaching process of the specific design, it not only can save time, ensure the quality of teaching and improve the learning efficiency, but also can avoid the teacher's wrong detection in the detection process and reduce the intensity of the teachers' work, but also eliminates the potential safety hazard of charged detection. It has a high application value in the practice teaching process of higher vocational students.

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