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FREQUENCY TRANSFORMERS COMMUNICATION APPLICATION IN ANTI-COLLISION SYSTEM OF CRANES

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ABSTRACT

In the paper, the ultrasonic sensor checking device union PLC communication function was introduced, which was applied to anti-collision protect system of multiple bridge cranes stride over the same rack in the railroad service workshop. The hardware and software system were designed which could communicate directly between FX_{2N} series PLC and FREQROL series frequency transformers. PLC uses FX_{2N}-ROM-E1 functions expanded memory. When the two vehicles reach a safe distance, it can promptly control carts frequency transformers' operating frequency, realize information communication and the intelligent remote control between multiple bridges cranes stride over the same rack.

Keywords: *Bridge Crane, Frequency Transformers Communication, PLC, Ultrasonic, Anti-collision Device*

1. INTRODUCTION

Railway locomotive depot and rolling stock depot are engaged in daily repair of railway locomotives, and vehicles main component. Since the train parts are really clumsy and hulky, therefore the bridge cranes play very important roles in workshop repair handling, moving and adjusting device. Considering the convergence and cooperation of production process, and to enhance the operation efficiency and the space utilization rate, each workshop has more than one from 30 to 50t bridge type adjacent hoist crane operation stride over the same rack at the same time. Due to the large tonnage bridge crane's volume, the cab is fixed under a crane beam. The driver's sight is blocked by the high voltage electric tank of another crane beam. It is difficult to see the adjacent crane working state. The two adjacent cranes' workbench are closer, in the busy working, it is easy to collide.

Now the bridge cranes anti collision device widely uses stroke switch type in the workshop. Taking into account the jitter and the detection accuracy in working, the hit ruler and the induction detection body of anti-collision device can't too long, generally only two or three meters, that is very difficult to guarantee the safe distance in two cranes which are larger tonnage, high operation speed. With the industry control technology transforming the traditional bridge crane electrical control; PLC-variable speed system of frequency transformer was applied in control. This requires to synchronous transform traditional mechanical anti-collision device [1].

To study large-scale machinery safety anti-collision system, is extremely urgent and realistic task for reduce the damage of the collision accident. At present, safety anti-collision research more focused on the field of automobile. Zhang Guangxiang [2] studied the safe distance of the action collision system based on drivers. Based on safe distance, Wang Junlei [3] designed soft, and hardware about the main control unit system and radar distance measurement sub system, solved the key technology of pileup anti-collision on the expressway system function.

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Taking the TI Company DSP as core processor, using VPSS video technology, Zhou Mi [4] constructed the overall scheme of car visual anti-collision system. By use of the acousto-optic alarm technology, Yan Xinxin [5] designed the automobile three-dimensional safety anti-collision warning system in three-dimensional space. Based on millimeter wave radar warning technology, Yang Kaihe [6] studied signal process and analysis of active collision warning system.

On crane anti-collision, Yu Hui [7] studied embedded USB communication of bridge crane. Gao Yi [8] researched on tower crane anti-collision system based on risk prediction. Zhang Bing [9] studied the intelligent monitor and protection systems based on ARM. March 27, 2012, Special Equipment Supervision, Inspection Institute Wuhan City, Hubei province China, independently developed a tower crane group safety operation intelligent control system. It used the integrated electronics technology, prevented the collision between tower crane and tower crane, tower crane and stationary obstacles, the tower crane and the high-voltage wire, and prevented the objects illegally invade the forbidden area. Furthermore, based on the network monitoring platform, it realized the remote monitoring of the tower crane working site and run dynamics [10].

2. ULTRASONIC AND PLC SERIAL COMMUNICATION ANTI-COLLISION DEVICE SELECTION

Automatic anti-collision system must have the two aspects of the technology. One is automatic detection, on the other hand is automation control. With the non-contact detection technology, laser, infrared and ultrasonic switch element combined with PLC automatic control, communication function, and the same span crane can achieve automatic collision avoidance; ensure the reliable work in safety distance [11].

This system used the Mitsubishi FX2N-80MR model of PLC IPC (system requires version V3.0 or above), combined with the Mitsubishi FREQROL series frequency transformers, used full vector close-loop control mode, the crane cart, car and lifting mechanism were controlled by electrical speed. In the selection of anti-collision sensors, Ye Xuan [12] researched the embedded infrared detection anti-collision system for bridge cranes. However, taking into account the serious environmental pollution of bridge crane's workshops, there is dust, smoke, soot and steam interference, and it is easy to influence the accurate results of infrared detection, so it is not recommended infrared type.

Laser range finder is also commonly used as a distance measuring sensor. However, the multiple cranes stride over the same rack are constantly moving, and the workshop also is half open, so it is easy interfered with moving objects and bright lights. To sum up, this paper chooses the ultrasonic sensor. The system selected Germany P+F UB6000-60GM-H3 ultrasonic reflection type products. Its detection distance is 0-6 meters, and it can output 4-20mA current signal, according to the measured distance.

Through the function modules FX_{2N}-4AD analog conversion, PLC converted the received current signal into the data 0-4000. The system arranged ultrasonic positioning system on the outer side of one crane cart's end beam, and arranged the reflecting plate on the outer side of the other one crane cart's main girder along crane cart's running direction. After received the distance data, the host uses PLC PPI serial communication function, realize data transmission and control of frequency converter. The system can adjust the control distance. It is suitable for various occasions, and it effectively improves the working efficiency, and ensures the prevention of collision events.

3. THE SELECTION OF PLC PPI INTERFACE COMMUNICATION MODE

Mitsubishi FX_{2N} series PLC has built-in PPI interface (i.e. the programming port), to provide users with a powerful communication function. The PPI interface physical structure characteristic is RS-422 or RS-232C communication interface; information exchange way adopts the string, duplex or work, asynchronous, serial communication. According to different protocols, it can achieve communication or network with different equipment [13]. When the communication control distance is long, it should use the combination of FX0N-485ADP and FX_{2N}-CNV-BD, transmission length can be up to 500 meters, and has strong anti-jamming [14].

The current PLC communication mode mainly include: parallel communication, N:N communications, computer link communication, without the agreement of RS instruction communication, optional programming port communication, extended memory converter communication , and so on. The first three types mainly apply for the communication between PLC and PLC, or between PLC and computer, the latter

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is mainly apply for the communication and transmission between PLC and the external equipment.

In generally, the number of railway workshops' bridge crane with the same rack is not much. Communication system is simple and the data transmission is not much. Considering the system run faster, it hopes that the control is fastest. Therefore it suggests direct use extended memory converter communication mode. This communication is in embedded a function expansion memory-FX2N-ROM-E1, under PLC panel. After connected communications module, it can directly write instruction, and realize to read, write parameters less than 8 converters; monitor and control various operation. It is very simple and convenient, easy to grasp.

4. CONVERTER COMMUNICATION SYSTEM SCHEME DESIGN

Following taking two bridge crane of the workshop's same span frame as an example, it design converter communication system scheme of extended memory.

4.1. Hardware System Design

System sets one as a master station, and another as the slave station, the master station PLC embeds a piece of FX_{2N}-ROM-E1, which is actually a piece of 16K step EEPROM memory. Considering the distance is long, the function modules of FX_{0N}-485ADP and FX_{2N}-CNV-BD modules. Crane control uses the Mitsubishi FREQROL -A500 series inverter with RS485 communication port. PLC and frequency converter connected with the main 1 pairs and 2 pair's connection mode. The two ways are only different in 2 pairs connection individually connect the two lines RDA and RDB, and it must be connected with grounding resistance between SDAand SDB. Two kinds of connecting ways is not very different on the function, figure 1 is the 2 pairs wiring connection mode. Figure 2 is PLC connection single converter. Figure 3 is PLC make communication control for the inverters by the distributor, up to 8 inverters.

4.2. The System Control Requirements

The system control has some requirements, as shown below.

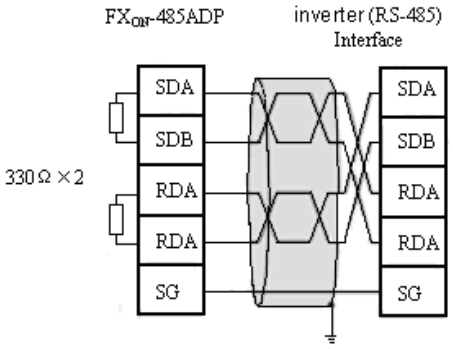

Fig. 1. The Connection On The Mode Of 2 Pairs Wiring Connection

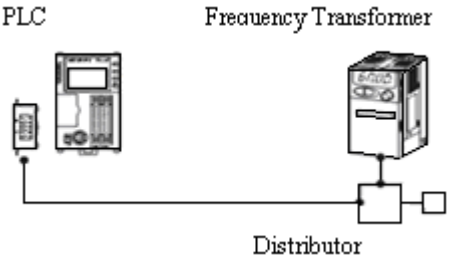

Fig. 2. PLC and frequency transformer

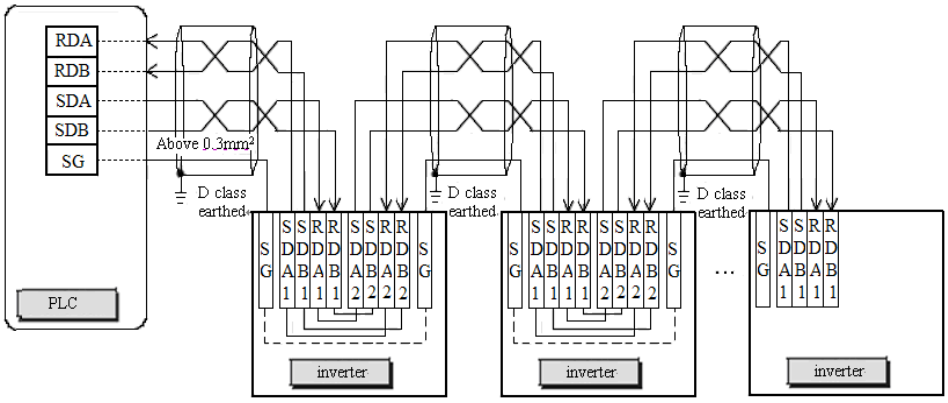

Fig. 3.PLC Connects With Multi Frequency Converter

(1) When the two adjacent cranes near to set distance (set by host data register D1), ultrasonic detector output analog signal (two actual car distance), converted the data into D0 by the 4AD (K0), and set the braking distance D1 (CMP), if D0 is less than a predetermined value D1, then the M0

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as ON, trigger PLC to implement upper procedures, and keep two converters (K1, K2) communicate through instruction.

(2) When it executes communication control, master PLC directly incorporated F=0 in the machine and the adjacent machine cart converter addresses by instructions, the cart immediately stop, and trigger the acousto-optic alarm. It reminds the driver to take decisive measures, avoid collision accidents.

(3) Through the program modifying, it can read the temperature, starting and acceleration time and other parameters, but also design and input other parameters to frequency converter by PLC. As necessary, it can be externally connected with a human-machine interface, which can direct display, provide a very good interactive function.

(4) Establish automatic control of production line level, and lay the foundation for the factory integrated system control.

4.3. COMMUNICATION System Software Design

Commonly used programming language of Mitsubishi FX2N series is the GX-Developer (this scheme requires SW7 or above), it can run on a general computer. Connecting PLC through MPI the computer serial port and one PC/MPI adapter cable, it can conveniently off-line program and online monitor the variables on-off of each input / output or state point in program, it brings great convenience for debugging.

4.3. 1. Plc communication parameters setting

Table 1 is PLC communication parameters D8120 setting of the system based on inverter communication:

Tab.1. Set PLC Communication Format

Number of Item	Name	Content	Binary Expression
b0	Data length	7	0
b1b2	Odevity	Even	1，1
b3	Stop bit	1	0
b4~b7	Transmission speed	19200bps	1，0，0，1
b8	Start bit	No	0
b9	Stop bit	No	0
b10b11	control line	Using FX0N-485ADP and FX2N-CNV-BD board	1，1
b13~b15	Computer link communication using	No	0，0，0

By calculation, available communication parameters can be gotten: D8120=C96H.

4.3. 2. Converter communication parameters setting

System require for set inverters communication parameters and PLC to a consistent. Frequency converter Pr.117-Pr.124 parameter is used to set the communication parameters, it can use the control panel or the frequency converter setting software FR-SW1-SETUP-WE and set them in PU port.

Tab. 2. Set The Converter Communication Format

Number of Parameter	Name	Value	Description
Pr.117	No.of converter station	1	Setting a frequency transformer is No. 1
Pr.118	Communication rate	192	Set the baud rate is 192 bps
Pr.119	Data length/ Stop bit	10	1 Stop, 7 Data,
Pr.120	Parity checking	2	parity checking setting in the communications data
Pr.123	Setting wait time	9999	
Pr.124	Have CR/LF instruction or not	1	Have CR，heven’tLF
Pr.79	Operation mode	0	the external operation mode as the power is on
Pr.122	Communication check interval	9999	Communication check abort

4.3. 3. Frequency transformer communication program

The master station control program was shown as below.

5. CONCLUSION

After system transformation operation, the effect is good. It mainly has the following characteristics:

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(1) High reliability of anti-collision, big safety distance. Considering of different tonnage braking distance, according to the actual production situation, in the arbitrarily 0-6 m range, set the D1, regulating anti-collision distance.

(2) High control precision. Anti collision device emits ultrasonic detection plate on the detection range of 220 mm × 110 mm. It reduced the gnawing rail, offset direction as crane on the track and other factors effect on inspection. The measurement error is less than 5mm, and its precision can meet the system control requirements.

(3) Fine control stability. The system overcomes the jitter effect on the anti-collision detecting when crane operates, and reduces the mechanical impact on anti-collision device. Its performance is stable and reliable.

(4) Converter direct communication contrast to the traditional RS non-protocol communication, it solves a series of technical problems, such as the non-data coding, calculate checksum, framing, parity, and so on. And the programming workload is greatly simplified, it can directly use instruction, omit the time and error of digital-analog conversion, thus improve the control rate.

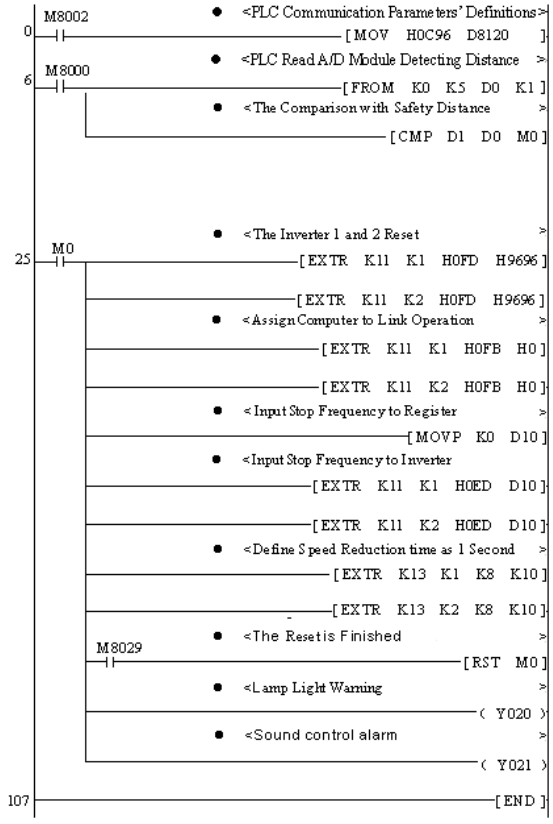

Fig. 4. The Master Station Control Program

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REFRENCES:

[1] Zhang Ke, "Crane safety device application", *Hoisting and Conveying Machinery* (Beijing, China), Vol. 4, No. 4, April 15, 2008, pp. 88-89.

[2] Zhang Guangxiang. "Study on Safe Distance of the Action Collision System Based on Drivers", *Jilin university* (Jilin, China),2011,3:25-35.

[3] Wang Junlei. "Develop on warning system of Pileup Anti-collision on the Expressway", *Chang'an University* (Chang'an, China),2005,3:16-29.

[4] Zhou Mi "The Research of Automobile Vision Collision Avoidance System Based on DSP", *Wuhan University of Technology* (Wuhan, China) ,2010,3:5-23.

[5] Yan Xinxin. "The Design and Development of the Vehicle's Three-Dimensional Safety Collision Warning System", *Taiyuan University of Technology* (Taiyuan, China) ,2011,3:7-26.

[6] Yang Kaihe. "Signal Process and Analysis of Active Collision Warning System Based on Millimeter-Wave Radar System", *Jilin university* (Jilin, China),2011,3:12-33.

[7] Yu Hui. "Embedded USB Communication of bridge crane",*Science and Technology Innovation Herald*(Beijing, China),Vol. 3, No. 3, January 15,2010, pp. 90-91.

[8] Gao Yi. "Research on Tower Crane Anti-Collision System Based on Risk Prediction", *Dalian University of Technology*. (Dalian, China), 2012, 10,pp. 90-91.

[9] Zhang Bing. "Intelligent Monitor and Protection Systems Based on ARM", *Dalian University of Technology*. (Dalian, China), 2010, 6,pp. 14-26.

[10] Shuang Mu. "Tower crane safety operation anti-collision system successfully developed" [N].*China Reconstructs News Paper* (Beijing, China),2012,3,27:6.

[11] Xinglin Qu, "Crane infrared anti-collision technology in the Jinan Third Steelmaking Plant Application", *Machinery & Electronics* (Guiyang, China),,Vol. 26, No. 4, April 15,2008, pp. 89-90.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[12] Ye Xuan. "Design of embedded infrared detection-based anti-collision system for bridge cranes", *Hoisting and Conveying Machinery* (Taiyuan, China) ,2010,2:23-25.

[13] Mitsubishi Electric Automation Limited, Mitsubishi programmable controller user manual (Communication), Mitsubishi Electric Automation Limited, Japan, 2005:1-126.

[14] Mitsubishi Electric automation limited, on the application of FX2N-ROM-E1, Mitsubishi Electric Automation Limited, Japan, 2008, http://www.gongkong.com.