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Research and design of mine water warehouse level measurement and control system

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Abstract. In the prevention and control of the mine water ， the water level of the dynamic monitoring storehouse play a pivotal role. Mine water warehouse water level measurement and control system which is designed by this paper is by programmable logic devices S7-200 and configuration king Wincc constitute a hardware and software. Between master of the computer and monitoring stations can bus is for data transmission. Laboratory simulation test and Field testing have a good effect, And it can realize the function of Sound and light alarm , dynamic display of water level-the time trend curve and data storage and reports, provide effective basis for coal mine water storehouse safety management and monitoring water-level.

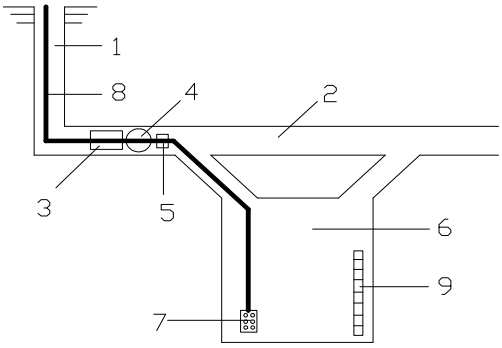
Foreword

Mine flooding is one of major common coal mine disasters, it will be serious harmful to the mine production safety if the production of the mine water timely is discharged out of the mine. Most coal mine to open the main drainage system of the pump and to switch to stop and choose to complete are main by the artificial which does not have the ability to stop the pump automatically open and remote monitoring capabilities according to the water level or other parameters. A few mine with automatic drainage, because of being out of touch with the actual situation of the mine the use of automatic drainage system, exit some defects that the control anti-interference system is weak, the stability is poor, the debugging is complex and so on, which result in the drainage equipment operation not to be ideal, and even some of them having been idle or removed. This design uses modular structure to solve the above problems, achieves the water storage level of inspection and monitoring, softly starting pumps, saving energy, reducing production costs, improving economic efficiency, to prevent the flood of great significance to the accident by the use of PROFIBUS-DP field bus technology, which including PROFIBUS-DP master PC, PROFIBUS-DP slave PLC and ET200 and field equipment, ultrasonic level sensors, ATS48 soft starters, etc.

System Design

Mine drainage as a whole body diagram is shown in Figure 1. Ultrasonic level sensor is installed at the top of the sump. The sump water level is set low, medium and high water level and PLC through cycle scanning mode continuously to detect ultrasonic level sensor data in order to calculate the actual height of the water storage level, and compare with the programmed level. When the

level is low, the system will have no action to detect, when the level reached at medium, three pumps will run in cycle time to prevent the pump and electrical equipment for spare or spared lines which are leaved long-term getting wet to make electrical and electronic equipment failed, when the level reach at a high level, the three pumps will open and trigger sound and light alarm at the same time, and it closes the closed door through ET200 immediately. In this start-up, any failure of a pump will automatically switch to the next response to the failure of a pump and monitor screen. At the same time, installed in the PC configuration software WinCC will real-time display and record the water level the bump start and built-up, and record the data of archiving, preparing for the future of statistics. In addition the system control also includes automatic, semi-automatic and manual repair three kinds of work. The overall structure is shown in Figure 2.



1 - auxiliary shaft; 2 - roadway 3 -substation;
4 -motor; 5 - pump; 6 - water warehouse;
7 - screen pack; 8 - drains; 9 - level sensor

Fig.1 Schematic diagram of the overall mine drainage

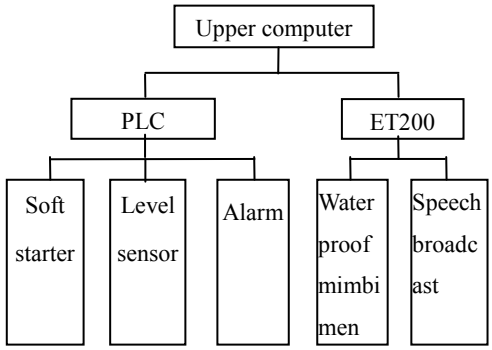


Fig.2 System architecture

Communication is using the master-slave mode on the CAN-DP field bus. The system consists of CAN-DP master station's PC installed WinCC, CAN-DP slave S7-200PLC, ET200 and field equipment. PC regards PC as the main station, to mainly realize monitoring and the control of pump starting and stopping. PC uses two PC backup for each other, one as the main monitor, the other one as from the monitoring machine. It can immediately switch to another machine as the main monitor when the main control dose not runs, which improves the stability of the system. Plus lower machine adopts PLC and ET200 communication module and EM277-site as the On-site control station from the station to achieve on-site equipment control, data acquisition and feedback control. PC through PCI slot in an ordinary PC to add to CP5611 communication card to communicate to the next machine.

System hardware design

The system hardware mainly includes superior machine Lord Stand PC, slave station S7-200 and ET200, explosion-proof ultrasonic a sensor, EM235 analog expansion modules, EM277 communication module, PROFIBUS cables and connectors, ATS48 soft starter and so on.

S7-200PLC. Programmable logic controller(PLC) is a kind of digital computing operations of the electronic system and is designed for industrial environment application. It adopts programmable stores. In its internal storage used to perform the logic operation, sequence control, timing, count and arithmetic operation instruction. And through the digital module type of input and output, it can control of the various types of machinery or the production process.

This system from the Siemens company stood s7-200 cpu222, cpu222 has 180 mA output, integration and 8 input/4output of 14 a digital quantity I/O point. It can connect two expansion modules and connect two expansion modules, 6 Kbytes of the program and data storage space, four independent 30 kHz high-speed counter, 2 independent 20 kHz high speed pulse output, 1 RS485 communication/programming mouth. It has PPI communication protocol, MPI communication protocols and free way communication ability.

Explosion-proof ultrasonic level sensor. It adopted explosion-proof ultrasonic level gauge, the sensor doesn't need to be installed in liquid, and completely solves the general sensor short-circuit leaking, corrosion, wave interference detection problem of common liquid surface. It's suitable for measuring the corrosion of the mud or sewage, hydrochloric acid, etc all kinds of corrosive medium. Range: 15cm - 5.48m, precision: plus or minus 0.25% full range, the resolution: 3 mm. Its range, precision meets the height is 4 m monitoring the water warehouse requirements.

EM235 analogue input module.EM235 is the most commonly used analogue expansion module; it realized the number 4 analogue inputs and 1 road simulated output function. Figure 3 for sensor and the EM235 hookup.

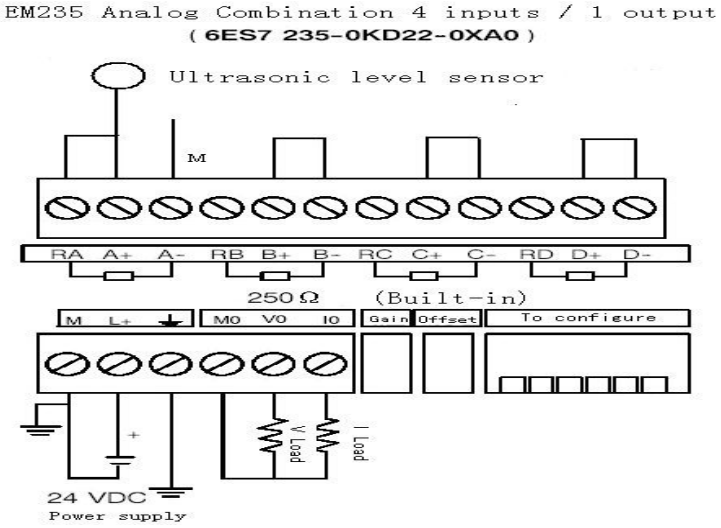


Fig.3 Wiring diagram of sensor with the EM235

The output signal of the ultrasonic level sensor ranges from 4 mA to 20 mA, and the settings of the DIP Switch are presented in Table 1.

Tab.1 DIP switch settings of ultrasonic level sensor

Single polarity						Full range input	resolution
SW1	SW2	SW3	SW4	SW5	SW6		
ON	OFF	OFF	OFF	OFF	ON	0～20mA	5μA

The output current of the sensor ranges from 4 mA to 20 mA and the standard electrical signal of the analogs is A_0 - A_ω (for instance: 4-20 mA). The value converted by the A/D is Δ_0 - Δ_ω (for instance: 6400-32000). We use A to represent the standard electrical signal of the analogs, and use the symbol Δ to represent the corresponding value converted by the A/D. The relationship between them is linear, and can be expressed as formula 1.

$$A = (\Delta - \Delta_0) \times \left[(A_\omega - A_0) / (\Delta_\omega - \Delta_0) \right] + A_0 . \quad (1)$$

According to equation 1, the value of A can be evaluated conveniently on the basis of Δ. We can get formula 2 through the inverse transform of formula 1.

$$\Delta = (A - A_0) \times \left[(\Delta_\omega - \Delta_0) / (A_\omega - A_0) \right] + \Delta_0 . \tag{2}$$

If the height of a water sump is 4 m and the output current of the sensor ranges from 4 mA to 20 mA, after being converted by the A/D, the value we can get is 6400～32000, ie,0-4m is corresponding to 4-20 mA. If we use η to represent the distance between the sensor and the liquid level, use H to represent the actual height of the liquid level, and use $AI_{\omega 0}$ to represent the sample value of the analogs of PLC, we can immediately get formula 3 according to the formula above.

$$\eta = 4 \times (AI_{\omega 0} - 6400) / 25600 . \tag{3}$$

Therefore，the actual height of the liquid level(H) can be calculated through formula 4.

$$H = 4 - \eta . \tag{4}$$

We can use H to display the height of the liquid level directly.

The EM277 Communication Module. The S7-200 CPU can't communicate through being connected to the PROFIBUS Net directly. It must be connected to the net through PROFIBUS-DP Module-EM277. In the PROFIBUS Net, the EM277 Communication Module can only appear in the form of the slave station of PROFIBUS. As a slave station of DP, the EM277 Communication Module receives multifarious configurations of I/O, and sends and receives different numbers of data. This character makes it possible for the user to alter the volume of the data that are transferred, and meet the need of the practical application. Unlike other DP stations, the data transferred by the EM277 Communication Module are not just FO data. The EM277 Module can read and write the data block of the variable which is defined in S7-200CPU. This way, the user can exchange all kinds of data with the master station.

The address of the slave station is corresponding to the settings of the EM277 Module when it configures. The EM277 Module is sated through its rotate switch. The user must start the power of the CPU after changing the rotate switch, so that the new address of the slave station is at work.

The Soft Starter. In order to avoid the strike to the motor when it starts at full pressure, and to prolong the life of the motor, the design use the ATS48 Soft Starter produced by Schneider. This device has high reliability, thorough functions and competitive defensive functions. As it takes the special anti-jamming measures, the movement is accurate and reliable. It has many defensive functions, such as good overload and over current protection, broken phase protection and leakage lockout protection, etc.

Software design

System is programming modular structure and function to debug and expansion. It mainly make up by the control program, simulation of the collection and calculation, motor running time statistics, 3 pump rotation and alarm subroutine. The important thing is how to control the main program and rotation judgment procedure and to ensure 3 pump of start / stop between each other rotation. With 3 oil pump running time as work and spare pump rotation as the criterion, the time is long 2 sets of working as a pump; time is short of 1 as a backup pump.

There is main Siemens PLC programming software called STEP7 Micro WIN V4.0 and Siemens WinCC configuration software.

Communication and network. CAN is the most popular one of field bus technology. PROFIBUS-DP is linked by high-speed and cheap communication after optimization. It is designed for automatic control system communicating with scattered the I/O device level. They are more distributed to control system data transmission.

System uses SIEMENS series S7-200 PLC, add EM277 module access underground CAN backbone. The 2 core shielded twisted pair cable as the transmission medium.

PC software STEP7 Micro WIN V4.0 through the CAN cable and PLC for serial communication, easy to realize the program the uploading, download, operation, stop etc. function. Configuration software WinCC to establish friendly real-time operating interface, through the in ordinary PC PCI slot an increase in CP5611 communication card and a machine under PLC, realize the real-time monitoring water warehouse water level.

Software installed

- Configuration

Open the SIMATIC NETCOM CAN, new added a configuration, stood for SOFTNET-DP, from the station is EM277 CAN-dp. Host addresses selection from 1 to 126. From the address of the station to choose from three to 99, standing here standing address is set to 1, 3 and EM277 carried address from the address of the agreement. Then use the software from the configurations to stand: open from standing attribute, Configure option in, the choice of 8 bytes in / 8 bytes out (can be selected according to the actual need). In Parameterize can choose in migration address, corresponding to the series S7-200 PLC data area (namely V area). The default is 0, that is, from VB0 begun. After the completion of the configuration, Export (Export) NCM files, generating *. TXT and *. LDB files.

- Set PG/PC interface

In the Access Point of the application of CP_L2_1 choice, in the interface parameter assignment choose CP5611 (CAN). In the attribute of the activation DP agreement, and DP-Database of parameters input *. LDB file completely path. After the completion of the set can be diagnosed hardware configuration is correct, communication success.

- WinCC Settings

In WinCC variables manager to add a new driver, new driver select CAN-DP. CHN, choose CP5611 (A1) Board 1, set Parameters in the system parameters. CP5611 (A1) Board 1 parameters for 1, said the card of numbers. Create a new connections, address and EM277 from standing the address of the agreement.

- Create variables

The variable type WinCC is In and Out. In and Out of the Lord is relative to it, that is In WinCC said from series S7-200 PLC of input data, Out to said WinCC series S7-200 PLC write data. In and Out and data storage area V corresponding to the area. In this example, Out and PLC the data stored VB0 the VB7 corresponding, In VB8 VB15 with corresponding.

Laboratory simulation

Will CP5611 communication card into the PC PCI slots. The EM235 analogue flat cable expand module, EM277 linking to module and CPU222. CAN cables and connectors connect from standing and standing. Ultrasonic sensor and a EM235 analogue expansion module of I/O connection. Connect the soft starter and three-phase servo motor. Connect the power cord and ground.

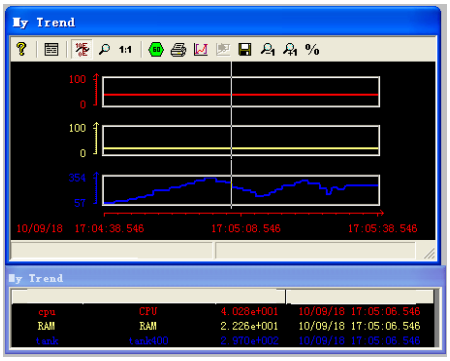


Fig.4 Water storehouse online table control menu

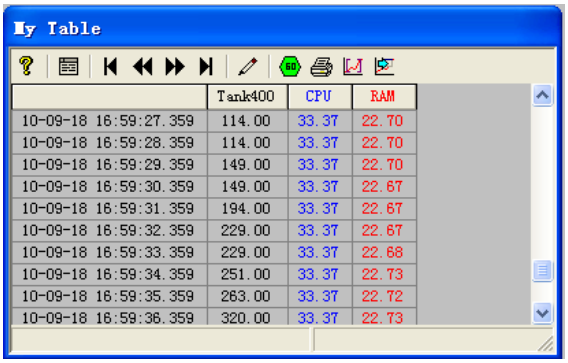


Fig.5 Water storehouse online trend control menu

Figure 4 and figure 5 for real-time trends and statements that picture real-time water warehouse water level, the utilization rate of the RAM and CPU, and put these data archive records.

Conclusions

Laboratory simulation proves PLC and field bus and monitoring configuration design technology of mine water warehouse water monitoring system is feasible.

(1) The use of advanced CAN field bus technology distributed control, network speed, high reliability, open good, strong anti-interference ability. (2) The configuration software WinCC writing the friendly man-machine interface intuitive, complete functions, easy to operate. Using soft starter motor, improves security, prolong the service life of the motor. (3) Because the software and hardware is using modular structure, installation, debugging and maintenance easy and convenient. Used in coal mine must be able to improve production efficiency and management level, for coal mine safety efficient operation provide guarantee.

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