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The Master Control System Design of Desalination

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Abstract. This design uses a PLC-based control scheme and uses industrial Ethernet, modbus fieldbus, and distributed control hybrid networking techniques to complete the desalination master control system design.

Keywords: Master Control System, Desalination, Industrial Ethernet

DESIGN OVERVIEW

The entire seawater desalination system is provided with a programmable logic controller (PLC) control system, with a color monitor, keyboard, and mouse as the main monitoring and control means. No conventional monitoring instruments are provided. Through the programmable logic controller (PLC) to complete the seawater desalination system to achieve automatic control, program control and remote operation, in the PLC with the necessary protection and locking function. The control level will be set in accordance with the “local unattended” setting, ie, the start, stop, and normal operation of the process system can all be controlled and monitored at a remote location. In case of an emergency, the control system sets up automatic interlocking and protection actions (including stop of the equipment). Functionality to prevent accidents from expanding. Except for some preparations in the start-stop phase that need to be checked by the operator, the start, stop, normal operation and abnormal condition treatment of the seawater desalination system can be completed in the control room. When abnormalities, failures, or accidents occur in the seawater desalination system, the relevant equipment and systems can be automatically removed through interlocking and protection functions; at the same time, accident records are recorded and accident parameters or conditions are recalled.

One PLC control unit is set in the seawater desalination control room, and redundant CPU modules, redundant communication modules, redundant power supply modules, control cabinets, and mounting baseboards are used to configure the configuration mode. Engineer station and operator station are configured. Network switches, printers, etc. constitute the entire desalination control system. PLC is responsible for the automatic control and operation of the entire seawater desalination system, as well as the data acquisition and control output and system centralized monitoring requirements of the system's process parameters, equipment status, etc., and taking into account the network's expansion

capabilities, reserved network interfaces, and ensure the same with the main system. The clock is unified.

Design Requirements

The control system should be easy to configure, easy to use and easy to expand. The design of the control system should use appropriate redundant configuration and diagnostics to the module channel level self-diagnosis function to make it highly reliable. Failure of any component in the system should not affect the work of the entire system. Various self-diagnosis means of the control system can make the system internal fault be detected before it affects the process.

The bidder’s I/O allocation plan must meet the following requirements in order to achieve the purpose of this project's cable merger optimization design:

The control and feedback models (ie, AO, AI, DO, and DI signals) of any equipment (such as a motor, pump, regulator valve, and electric door) are required to be located on the same side of the same cabinet.

The control and feedback models (ie, AO, AI, DO, and DI signals) of any equipment locally controlled in the cabinet require that they be arranged on the same side of the same cabinet.

During the engineering design process, if the control function and process I/O configuration need to be modified due to changes in the relevant technical conditions and requirements, the design should be updated in time.

The GPS clock synchronization interface provided provides clock synchronization.

The control loop should follow the principle of protection and chain control priority to ensure the safety of the unit equipment and personnel. PLC design should follow the following failure safety guidelines:

A single fault should not cause an overall failure of the PLC system. No matter what happens, the PLC system should move the equipment in a safe direction.

When analog control, sequence control, interlock protection control, and individual operation work together on the same object, the priority of the control instruction should be the order in which the interlock control is the highest, the individual operation is the next, and the analog control and the sequence control are the lowest.

When the analog quantity control, sequence control, and interlocking control operation share the same switching quantity signal, the switching quantity signal is first sent to the protection circuit with the highest priority, that is, the switching quantity signal shared by several circuits enters the priority of the specific circuit or The distribution order should also be the highest in protection chain control, the second in individual operation, and the lowest in analog control and sequential control.

When the control loop shares the same analog signal, the analog signal should be sent to the analog control loop first. And the availability of the entire control system should be at least 99.9%.

The system should be able to accept grounding with a common grounding grid (PLC can meet the requirement of grounding resistance $<4\Omega$) and does not require a separate grounding grid for the control system. The grounding cable in the PLC system is provided by the bidder, and the demarcation point of the grounding cable is on the terminal block grounded in the PLC cabinet.

The operator station should be able to achieve soft manual / automatic operation function.

Hardware Design

Programmable Logic Controller (PLC)

The programmable logic controller (PLC) should be configured as a dual-system hot backup system, that is, two racks, each rack containing a CPU module, a power supply module, 2 Ethernet communication module, a remote communication Module (if needed); remote I/O network uses Ethernet ring IO network (or dual bus) to ensure high reliability of the system.

In the PLC system, the address of the redundant Ethernet can be automatically and undisturbed in the hot backup system. No matter which PLC is switched to the host, the IP addresses of the host and the standby can always be automatically switched so that they always remain unchanged.

The data exchange of the hot backup system adopts 1000M optical fiber or twisted pair, and is directly connected to the fiber interface or RJ45 port on the CPU to ensure the efficiency of data exchange.

The hot backup switching time is strictly controlled within one scan period to ensure that it does not affect the control process.

Should be complete with input and output modules, memory, enclosure, dedicated connection cables and connectors, and real-time operating systems, etc. All hardware should be the manufacturer's standard product or standard selection.

(2) All modules in the system should be plug-in and easy to replace. Each type of I/O measurement point in each cabinet should have 10% of spare capacity, and each cabinet should also have 15% of module slot spare capacity. Spare slots should be equipped with the necessary hardware to ensure that modules can be put into operation in the future.

(3) All switch outputs and analog I/O modules should have isolation devices.

(4) The control power supply should be equipped with surge protection. The control system should be able to accept one 230VAC single-phase 50Hz AC power supply. When the control system needs other voltage level power supply, it needs to be equipped with a transformer or a regulated power supply.

(5) The PLC system can operate continuously in high electrical noise, wireless battery interference and vibration environments. The electromagnetic interference and radio frequency interference with a working frequency of 470 MHz and a power output of 5 W are emitted beyond 1.2 meters away from the PLC device and should not affect the normal operation of the system.

(6) All hardware in the programmable controller system can operate continuously in the ambient temperature range of 0 to 60°C and relative humidity of 5 to 95% without condensation.

(7) Central Processing Unit CPU;

 The CPU module integrates three Ethernet interfaces and one USB interface and supports Ethernet IP and Modbus two kinds of Ethernet communication protocols.

 CPU module comes with integrated storage space of not less than 8M, while supporting extended load memory up to 4GB to meet future needs.

 CPU boolean application execution speed is not lower than 10Kinst/ms

 CPU load rate cannot be higher than 40%

 When using the EEPROM memory, the stored program and data are stored on the battery for at least 6 months. When the battery is replaced, the program or data must not be lost, and the low-voltage alarm indicator should be set.

 The programmable controller includes at least the following functions: real-time clocks and calendars, relays and latch relays, transition contacts, timers, counters, arithmetic operations, logic functions, shift registers, and so on.

 Power failure is a recoverable failure of the system. Once the power is restored, the controller module should automatically resume normal operation without any intervention from the operating personnel.

(8) Input/Output (I/O) Modules

1) The PLC's I/O modules can receive or output the following types of signals according to the tenderer's requirements:

a. Analog input

DC current signal 4~20 mA,

Thermal resistance signal index number Pt100

Input Impedance Current Input < 250 Ω

Voltage input > 500 KΩ

b. Analog output

DC current signal 4~20 mA, load capacity > 1000 Ω

DC voltage signal 1~5 V, load capacity > 600 Ω

c. Switch input

Logic level 24V.DC, input impedance > 1000 Ω

Contact input normally open, normally closed dry contact

d. Switch output

Contact output normally open, normally closed dry contact

Each contact should be able to meet the following capacity at the same time:

 230 V.AC, 2A (resistive load)

 230 V.AC, 1A (inductive load)

 220 V.DC, 0.4 A (inductive load)

 110 V.DC 5A

2) The I/O processing system is "intelligent" to reduce the processing load of the control system. The I/O processing system should be able to complete functions such as scanning, data setting, digital input and output, linearization, process point quality judgment, and engineering unit conversion.

3) All I/O modules have LED indications and other diagnostic displays indicating I/O status, such as module power indications.

4) When distributing control loops and I/O signals, the impact on the safe operation of the unit is minimized when a controller or I/O channel board is damaged.

5) When the controller I/O power supply fails, the I/O is in a safe state to the process system, and no malfunction occurs.

6) When using I/O channels for information exchange with other control systems, there should be electrical isolation measures.

7) The signal paths of all I/O channels should be isolated from each other. It can provide an effective isolation value above 1500V between the I/O module's field wiring and other I/O modules.

8) All I/O modules meet the requirements of ANSI/IEEE 472 "Surge Voltage Susceptibility Test Capability Guidelines (SWC)". Do not damage the system if you accidentally add 250V DC voltage or AC peak-to-peak voltage.

9) When the transmitter adopts a two-wire system of 24V.DC power supply, power is supplied by the module. Each transmitter power is independent.

10) The processing of redundant input thermal resistance and transmitter signals is accomplished by different I/O modules. Failure of a single I/O module cannot cause any device failure or tripping.

11) Provide open and short circuit of the RTD and 4~20mA signal and the inspection function of the input signal beyond the possible range of the process. This function is completed during each scan.

12) For thermal resistance input signals, there is a separate bridge for each input signal.

13) The supply voltage of the I/O module to the field contact should be at least within the range of 24VDC.

14) All contact input modules have anti-shake filtering. If the input contact signal is still dithered after 4 milliseconds, the module does not accept the contact signal.

15) The zero drift and gain corrections are automatically and periodically performed using corresponding means.

16) The PLC-to-actuator circuit's switching output signal uses an I/O channel with a relay output or an additional relay, and provides the operating power to the relay coil.

17) The minimum threshold current required by the digital input module to detect a pair of closed contacts is 10mA, which avoids the use of an external load resistor.

18) When the required load current is higher than the rated current of the output contact in the output module, set the intermediate relay to handle the high load demand value.

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