Research and Design of PLC Program of Emergency Alarm System for Nuclear Power Plant Based on Pro Unity Software

Ze-jun WU, Qiang XU and Jia-dian ZHANG
Centre of Information Technology, CGN Power Co., Ltd., Shenzhen City, China

Keywords: Sound alarm system, Premium PLC.

Abstract. Based on the sound alarm system of nuclear power plant, this paper discusses the practical application of Schneider PLC Premium in nuclear power plant. In unity Pro as a programming platform, the function block diagram programming language, to alarm mode, priority, fault alarm and prompt, detection platform operation, these spare drawer cabinet detection function realization has carried on the research and design.

Introduction of System

Sound alarm system for nuclear power plant to enter the nuclear emergency state, the relevant emergency response area issued a sound alarm, to remind the relevant personnel to evacuate or enter the emergency position.

The sirens installed inside and outside the nuclear island plant, conventional island of the plant and BOP of each building. Under accident conditions, from the main control room or remote stop stack station and Emergency command center operating table, from the reactor building and nuclear fuel plant in situ by broken glass button, KCP, KCS system linkage from the dry contact alarm information, enable staff to take corresponding measures when they hear different alarm sounds.

Hardware Design and System Structure of Control System

According to function requirement of sound alarm system, could determine the input point corresponding device is to be including the operating table, broken glass button, linkage dry contact, the output device to drive the siren action. The controller we choose for this system chooses is TSX P57 4634M in Premium type of Schneider company. Arrange three points in the power station, formed the alarm control system.

As following figure shows, the blue corresponds to the trigger part, the red corresponding control system, the green corresponding action part. It is means operating table (broken glass button, linkage signal) issued a command, deliver to the PLC system di (input) module, PLC fast scanning, the execution of the program, flush the output, change state of dissolved oxygen (output), which triggers the corresponding regional siren in accordance with the requirements of action.

Driving the power source of the siren is the drawer. According to the workshop divided in several regions. PLC control system of output corresponding to the drawer circuit breakers and contactors, one output could trigger two devices in one time.

Besides of the requirements of driving the most basic function of siren action, need to consider the priority of each operating table in practical systems, distinguish mode of action in different state of emergency, fault warning, spare drawer detection, detection platform operation, buzzer of operating table or indicator light shows, state of drawer lights indicate.
Control Requirement

(1) Alarm model
   Plant emergency alarm: 15 seconds to stop 5 seconds for a cycle, the alarm sound length of 3 consecutive cycles;
   Field area / off-site emergency alarm: 60 seconds to stop 10 seconds for a cycle, the alarm sound length of 2 consecutive cycles.
   Relevant information output to the drawer cabinet contactor, circuit breakers, operating table lamp and buzzer.

(2) Alarm priority
   Console priority: EM, 1#, 3# operating table (MCR+RSS), 2#, 4#, operating table (MCR+RSS) to the scene broken glass
   Alarm priority: field area/off-site emergency alarm, plant emergency alarm, nuclear reactor plant/nuclear fuel plant alarm

(3) Fault warning
   I/O fault, PLC running state, PLC control system power supply status, the drawer cabinet action is not consistent with these failures occur, the fault lamp continued to light up 10s while the buzzer rang 10s.

(4) Detection platform operation
   In case of without opening the protective key, detection each indicator light and button lights of the operating table are in normal.

(5) Spare drawer detection
   Is different from the in used drawer cabinet, turning the handle, the drawer cabinet can carry on the movement detection.

Control System Programming

FBD (function block diagram) is similar to that used in Boolean algebra logic graphic symbols to represent the control logic for process control, design need certain digital circuit basis, following the
function blocks can be used in the design, and then introduced the specific procedures and complicated logic provides a timing expiration of Ming.

**Function Block Description**

<table>
<thead>
<tr>
<th>NO.</th>
<th>CELL</th>
<th>FIGURE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RS: FF function block, reset priority</td>
<td><img src="RS.png" alt="RS Block Diagram" /></td>
<td>When the S input is changed to &quot;1&quot;, the output Q1 will be changed to &quot;1&quot;. Even if the input S is returned to &quot;0&quot;, the state remains unchanged. When the input R1 is changed to &quot;1&quot;, the output Q1 is restored to &quot;0&quot;. If the input S and R1 as &quot;1&quot; at the same time, the priority input Q1 will set the output R1 to &quot;0&quot;.</td>
</tr>
<tr>
<td>2</td>
<td>TON: switch on delay</td>
<td><img src="TON.png" alt="TON Block Diagram" /></td>
<td>If in change to &quot;1&quot;, internal time (ET) start; if the internal time to PT value, Q becomes &quot;1&quot;; if in becomes &quot;0&quot;, Q becomes &quot;0&quot; and internal time stop or reset; if the values in the internal time to PT before in to &quot;0&quot;, the internal time stop or reset, and Q are the same as those of the &quot;1&quot;.</td>
</tr>
<tr>
<td>3</td>
<td>F_TRIG: DIFD</td>
<td><img src="F_TRIG.png" alt="F_TRIG Block Diagram" /></td>
<td>If there is a jump from &quot;1&quot; to &quot;0&quot; in the CLK input, the output Q will become &quot;1&quot; and then return to &quot;0&quot;.</td>
</tr>
<tr>
<td>4</td>
<td>CTU: Add counter</td>
<td><img src="CTU.png" alt="CTU Block Diagram" /></td>
<td>The &quot;1&quot; signal at the R input will give the value &quot;0&quot; to the CV output. For the CU input every time from the &quot;0&quot; to &quot;1&quot; of the jump, will be CV plus 1. At the time, the Q output was set to &quot;1&quot;.</td>
</tr>
<tr>
<td>5</td>
<td>BOOL_TO_INT: Type conversion</td>
<td><img src="BOOL_TO_INT.png" alt="BOOL_TO_INT Block Diagram" /></td>
<td>The function converts the input value of the BOOL data type to the INT integer type.</td>
</tr>
<tr>
<td>6</td>
<td>COMPARE: Compare two integers</td>
<td><img src="COMPARE.png" alt="COMPARE Block Diagram" /></td>
<td>The function performs a comparison between two integers at that time, when IN1≠IN2, the DIF output is 1, otherwise the output is 0.</td>
</tr>
</tbody>
</table>

**Programming Design**

(1) Alarm mode program

![Program 1 Plant Emergency Alarm Mode](Program_1.png)

Figure 2. Program 1 Plant Emergency Alarm Mode.

![Program 2 Field / Off-site Emergency Alarm Mode](Program_2.png)

Figure 3. Program 2 Field / Off-site Emergency Alarm Mode.
Program 1, 2 program to achieve the same way, just adjust part time parameters and numerical, following is the emergency alarm mode timing diagram analysis for the field/off-site, plant emergency response alarm mode as the reference, as follows:

When the trigger signal to an instant (100ms), the output of 60 seconds, stop 10 seconds, two cycles. (2) Alarm priority

In the case of priority, two typical programs are listed above. 1#MCR trigger field/OTC alarm effectively conditions (program 3), 1#RSS (remote stop the dump) switch key not to on, 1#MCR key to nitric oxide and EM floor did not trigger the alarm (higher priority), press "field area/OTC alarm" button 100ms. The definition of the effective time (100ms) of the button is effectively avoided by the definition of the switch key and the local key control of the operating table.

Because all the alarm triggering priorities were higher than those of the linkage trigger, the linkage of 1KCP dry contact trigger effective realization conditions (4), all operating tables did not trigger field / OTC and plant alarm, 1# main control and shutdown station operating table did not trigger the alarm of 1RX workshop, 1RX field to break the broken glass button did not trigger the alarm. At the same time 1KCP linkage signal closed 100ms.

(3) Fault warning

PLC system has defined the various fault types, this program take%S40 RACK0ERR,%S41 RACK1ERR,%S10 IOERR,%S12 PLCRUNNING,%S67 PCMCIABAT0,%S119 LOcioERR six of the fault type and contains rack failure, input and output fault, PLC operation failure, storage card battery failure.
When the fault occurs, the operating table fault lamp light up (DO output to the fault lamp can be), do not make program instructions. Operating table buzzer will ring, the failure time is less than 10 seconds, the buzzer does not ring; the buzzer rings when the time of failure is between 10 and 20 seconds.; when the fault is greater than 20 seconds, the buzzer sounds 10s. Timing diagram is as follows:

(4) Operating table detection

When the system self-test button is pressed, the PLC output continued to 5S 1, respectively to the operating table lamp and lamp button and let the bright 5S, check it. %S12 system bit corresponding to the PLC running state, when the PLC can not be normal operation, the system is unable to be self-checked and gives the operator a hint of a system failure.

(5) Spare drawer cabinet inspection

When the spare drawer cabinet handle switch in the open position, circuit breaker, issued the sound of mechanical movement, 0.5s after closing contactor, also through the relay makes red indicator light (hardware). At this time, the chest of drawers in a circuit breakers and contactors are closed steady state, these movements and the indicating lamp can determine the availability of the drawer inside the device.
Conclusions

This manuscript provides possible solution for security alert in the form of alarm. Nuclear power plant sound alarm PLC control system also includes the communication between controllers, specific digital input and output and the definition of intermediate variables, action during the priority of the realization details, consider the space, this paper under the premise of the system architecture, only according to the system of the typical functions were program design. This program provides an example for the application of functional blocks on the one hand, and on the other hand, it can be directly copied to other applications other than the nuclear power plant.

References


