A distributed control system for picosecond accelerator at SINAP

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Abstract The picosecond accelerator (PA) is a low energy electron linear accelerator facility under commissioning, which is built for the experiment of ps level pulse radiolysis in Shanghai Institute of Applied Physics (SINAP). A practical distributed DA&C system for this facility has been developed. In view of the upgrading-ability and maintainability of the control system and controlled devices, Advantech© distributed intelligent DA&C products are adopted into the control system. ADAM 5000/TCPs with the protocol of Modbus/TCP are employed to accomplish data acquisition and device control. The PC-compatible programmable logic controller, ADAM-5511, is also adopted to handle the interlocks and the emergency events. On the software side, the integrated software package Kingview©V6.5, which friendly supports all Advantech products, has been used to develop the upper layer control logic and process the data. This paper describes the control system design and system architecture. The intelligent ADAM controllers and the software platform are also discussed in detail.

Key words Control system, Distributed DA&C, Picosecond pulse radiolysis, Ethernet, ADAM, Kingview

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1 Introduction

With the development of accelerator technology and electronics, picosecond level pulse radiolysis has become a strong tool for the research on the ultra-fast reaction of particle. PA is a linear accelerator with electron energy of 5MeV to 15MeV and electron pulse width of 5 ps. In experiments, pulsed electron beam of PA is used to irradiate the sample to make it in process of ionization or excitation. PA is installed in the tunnel surrounded by a maze, and all the I/O controllers are placed in the control room. During the running of PA, users have to enter the tunnel frequently to lay the sample. So, a precise and reliable control system is needed to keep PA devices running well and ensure users and operators safety.

2 PA components and control system architecture

The control system is responsible for the power supply(PS) tuning, the electron gun operation, the step motors driving, the beam measurement and control, the dosage monitoring, the interlock, and the data analysis. Fig.1 gives a schematic layout of the architecture of the control system. An industrial PC running Windows 2000 is used for upper layer logic and operating interface. Three ADAM 5000/TCP (5KTCP) controllers accomplish the control of most variants with low traversal frequency. The ADAM-5511 PLC is indirectly connected to Ethernet via the local RS-485 network gateway of the ADAM 5000/TCP. The communication between the PC and the three 5KTCPs is through Ethernet with the primary protocol of Modbus/TCP. The communication between the PC and ADAM-5511 as well as the step motor system and electron gun system is via the Modbus/RTU serial protocol. A simulator receives the interlock signals and realizes the triggering synchronization of the electron gun, 2856MHz and 476 MHz microwave power system.

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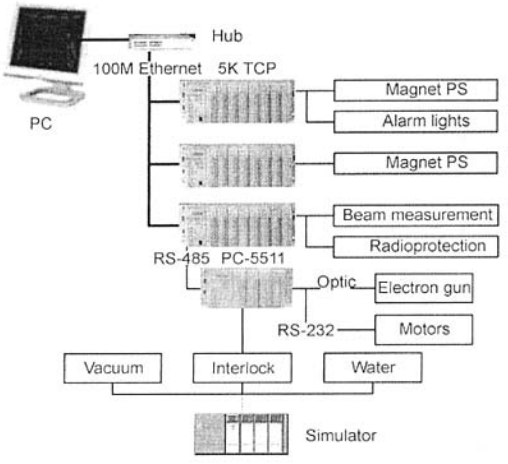

Fig.1 Overview of the PA control system.

3 Hardware system

In PA, all the signal cables have been gathered to the control room from tunnels, and many devices are stacked in tanks. So we choose the Advantech 5KTCP distributed intelligent DA&C UNIT, which has 8 slots and can handle 128 points at most, as basic controller. 5KTCP can be connected to local area network (LAN) directly by 100Mb Ethernet and has powerful processing ability with the response time less than 5ms[1] by a built-in 32 bit RISC CPU. 5KTCP supports all ADAM-5000 series modules (except 5090). Table 1 lists the modules used in PA control system.

The modules in the above list are integrated with 5KTCP .They provide the following functions:

- The analog out/in modules such as 5024 and 5017 set and read back the current of the PS.
- The digital out/in modules such as 5056S and 5051S send on/off commands to the PS and monitor status of the PS as well as all alarm lights and bells around the work area.
- The relay output module 5060 operates all devices in beam measurement system, including the on/off of cameras and lights, and the Up/Down of profile monitors.
- The module 5080 monitors dosage by calculating the instantaneous voltage pulses.

Besides DA&C functions, 5KTCP also provides a local RS-485 network interface for other Modbus devices. In the control system, ADAM-5511 is integrated with one 5KTCP by a RS-485 cable using Modus/RTU as communication protocol. ADAM-5511 is a compact PC which includes an 80188 CPU and a built-in ROM-DOS system. The program written by Borland C in ADAM-5511 deals with interlock[2] and events about personnel safety. The events are listed in the following:

- The protection of power supply malfunction,
- The operation of the emergency buttons,
- The enable keys on console,
- The illogical opening of the tunnel door.

If no interlock events occur, ADAM-5511 sends three 'ok' triggering signals to simulator, which are electron gun, 2856MHz and 476MHz microwave power system respectively. Because the controllers for motors and electron gun were built with processors, a 4-port RS-232 module ADAM-5090 is integrated into ADAM-5511 to accomplish the bi-directional communication between the upper layer and the controllers.

Table 1 Hardware modules of control system

Module	Name	Specification	Reference
Analog in	5017	16-bit,3000V_{DC} isolated,8-ch	Read-back of analog variants
Analog out	5024	12-bit,3000V_{DC} isolated,4-ch	Setting of analog variants
Digital in	5051S	16-ch,2500V_{DC} isolated	Read-back of digital variants
Digital out	5056S	16-ch,2500V_{DC} isolated	Setting of digital variants
Digital i/o	5055S	8 In/8 Out,2500V_{DC} isolated	Read-back and setting of digital variants
Relay output	5060	6-ch,500 V_{AC} isolated	Relay out
Frequency	5080	4-ch,Input,1000 V_{RMS}	Frequency input

4 Software system

The software for the industrial PC has been developed based on human machine interface (HMI) software KingviewV6.5 which friendly supports Advantech products. One obvious characteristic of Kingview software is that it has special hardware drivers for more than 400 products respectively (e.g. controllers of Siemens or Mitsubishi or Advantech)[3] (Fig.2), so that it shortens the software development cycle greatly. The application of KingviewV6.5 in PA produces a real-time synchronous data acquisition and control system. Kingview mostly deals with the data acquired from 5KTCP, and generates alarms and warning for each subsystem. To ensure real-time operation, the control processes for the setting commands have higher priority than getting commands. The command is executed as soon as the setting parameter changes, such as the current setting of the PS. And the acquisition frequency of most read-back points is 100ms. KingviewV6.5 is also user-oriented and provides many convenient functions, such as OPC interface, DDE, Report, Web server[4] etc. Fig.3 shows the application of a part of tools in PA. For example, dosage values are loaded in database per second and are described in history curve synchronously (Fig.4). The last alarm information from alarm database is listed in alarm window (Fig.5). Actually it's also very convenient to do the network upgrade of the control system by replacing the soft-dog, and this is another reason for us to choose KingviewV6.5 as a HMI software tool. The experiment indicates that Kingview can achieve enough efficiency and flexibility for a configured control system.

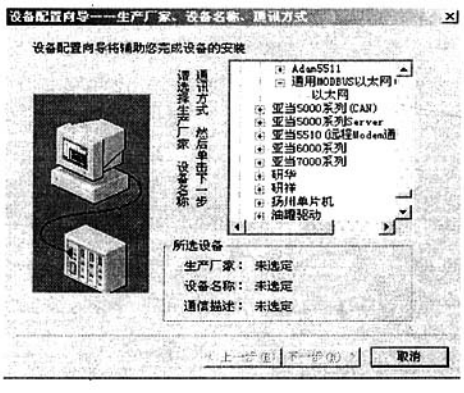

Fig.2 The products supported by Kingview6.5.

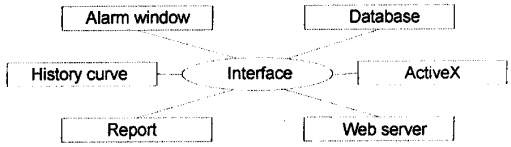

Fig.3 Application of the software development tools.

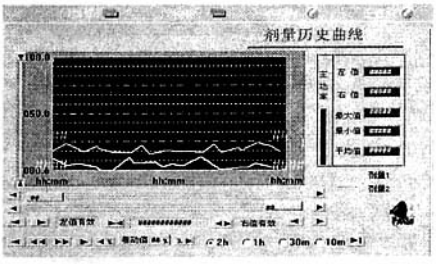

Fig.4 The dosage values in history curve.

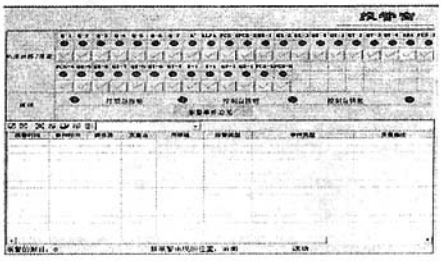

Fig.5 The real-time alarm window.

5 Summary

So far, most of the subsystems of PA mentioned above have been accomplished, and the achieved system performance is as good as expected. About 200 points have been controlled and monitored well and the traversal read back cycle is within 200ms. Next step, we will upgrade the control system to the mode of Web Server. All of functions of the monitor and control can be accomplished by an authorized person with remote web-browser which connects to the network.

References

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