CONTROL SYSTEM FOR A PEFP FPC BAKING SYSTEM*

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Abstract

In order to bake PEFP fundamental power couplers (FPC) before their high-power RF conditioning, a PEFP FPC baking system has been designed. A control system for the baking system has been completed by using the LabView and A-B SLC-500 PLC programmes. In this paper, the server and client communication technology based on the Object Linking and Embedding (OLE) for Process Control (OPC) and LabView Datalogging and Supervisory Control (DSC) Module are described. The program of the SLC-500 PLC with four I/O modules has been written. The mechanical design and control process are described in detail.

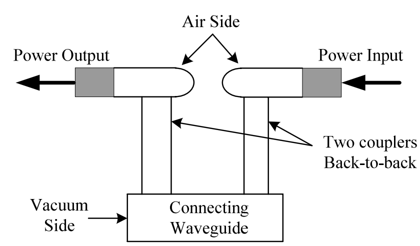
INTRODUCTION

Due to its high accelerating performances and low operating expenses, a superconducting radio frequency (SRF) accelerator is becoming the main accelerating structure of new particle accelerators[1~3]. The Proton Engineering Frontier Project (PEFP) is considering to develop and use SRF technology to accelerate a proton beam at 700 MHz in its present project and its extended project (PEP) [4, 5]. The first section of the PEFP SRF linac (SCL) is composed of low-beta cryomodules. Each cryomodule has three 5-cell cavities. Each cavity has one FPC, which is used to transfer RF power from the klystron to the beam, to maintain accelerating field in the cavity in the absence of beam, to provide peak RF power for processing cavity field emission, and to damp the non-accelerating modes of the fundamental passband [6].

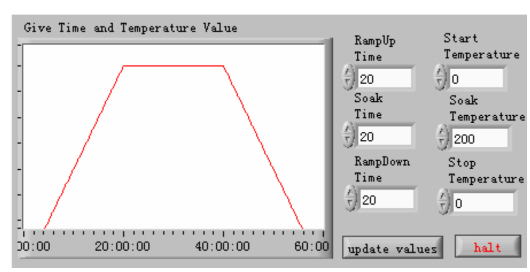
In order to meet the normal operation requirements, the FPC needs to be baked and processed under a high RF power. Before a high-power RF conditioning, each coupler will be baked for 24 hours at 200 degrees Celsius, as shown in Fig.1 [7]. The baking is performed to decrease the amount of water molecules absorbed on the vacuum exposed surfaces during a manufacturing, cleaning and assembly. Water molecules decrease the ability of high vacuum pumping systems to function effectively and interfere with a RF processing of the main power couplers. This paper describes the control system's hardware construction and software programming of the PEFP FPC baking system

DESCRIPTION OF THE CONTROL SYSTEM

The parts of the baking system include: a test cart with a waveguide and vacuum system, one baking box with a power controller, two cold cathode vacuum gauges (CCG), one CCG controller, two argon filled protection caps with thermodiodes, a thermodiod transfer, a Allen Bradley (A-B) SLC 5/05 PLC and some I/0 modules, a desktop PC with a LabView control program. Figure.2 shows a sketch of the baking system. The test cart supports a baking box and two FPCs, and also quickly produces a vacuum of ~10^{-10} Torr in the waveguide and couplers. The baking box is used to heat the couplers and produce a 200ºC environment in the box. The control system is used to monitor a couplers' vacuum, temperature in the baking box and to control the baking box to maintain a programmed temperature. And if the vacuum is broken, the interlock system will turn off the turbo pump power supply.



(a) Typical setup for the RF window baking.



(b) FPC baking procedure interface.

Figure 1: FPC baking setup and control interface.

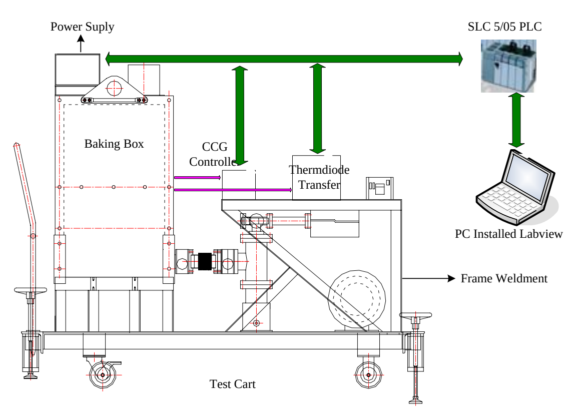


Figure 2: A sketch of the baking system.

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The heaters of the baking box are powered by a power control box, which transfers 220V electricity to the heaters. The output power of the power control box can be controlled by a voltage of +24~0.

SOFTWARE AND ARITHMETIC DESIGN

The whole control system can be separated into two pieces, the backbone and the nodes. The backbone performs the supervisory and communication function, and the nodes will control the automatic baking system. The backbone can be simplified to the key servers and the network. The software running in the key servers must manage the network transfers, data management, data visualization, alarms and events, and security. A key characteristic of the backbone is that it must be able to communicate with the rest of the hardware through a common protocol, such as TCP/IP. The software used at each machine in the network must support the same communication protocols. In addition, the key servers should support a variety of communication protocols so they can interface with legacy and next-generation machines in the system. Here we choose a software package LabView and its DSC module, which support many industry standard protocols, and also choose the A-B SCL5/05 for the node control module.

Software Design

In the baking control system, there are several layers of software that must work together to provide communication between LabView and the data registers in the PLC. LabView is a software development environment specifically for measurements, controls and automations. LabView Datalogging and Supervisory Control (DSC) is an add-on package to LabView. It gives LabView the ability to connect to an OLE for process control (OPC) server. Rockwell Automation's RS Linx Professional is the OPC server on the PC. It supplies OPC communication services between the PLC and LabView DSC, as shown in Fig. 3

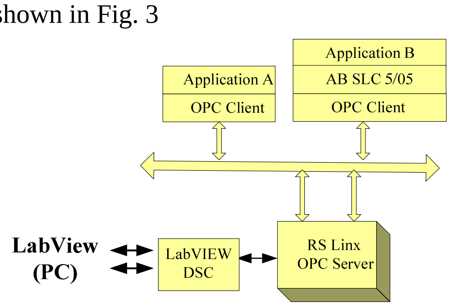

Figure 3: Software system.

The PLC system includes an A-B SLC 5/05 PLC on a 7-slot chassis, four modules: A-B 8 channel thermocouple input card, A-B 4 points voltage output card, A-B 16 point 24 VDC input card and A-B 16 point relay output, and other cables and the wires.

When the baking process begins, the program will judge which time span it is now, there are three time spans for a heating process, which are the ramp-up time, the soap time and the ramp-down time. Then the program runs in the specific time span: first the controller read the temperature value from a thermocouple, then it compares it with a given value which comes from the ideal temperature variable curve. If the subtraction is in the given range, the heaters run unchanged, otherwise it changes according to the PID arithmetic. There is one main program and four subprograms in the PLC program. The main program describes the frame of the whole heating process, and it decides when and which subprogram the PLC will run. The subprograms are Temperature Up (TU), Temperature Hold (TH), Temperature Down (TD), and Temperature Read (TR). At the beginning, the TU runs to make the temperature inside the baking-box ascend according to the temperature curve in Fig.1; after the given ramp-up time, the baking-box will hold the current temperature for all the given hold-times while the TH is running; at the last phase, the TR subprogram runs and the baking box temperature descends according the given curve for all the ramp-down times. The TR subprogram is running when the temperature value is being read.

Control Requirement

- The PLC program controls the heating process, the LabView allows for choosing the baking temperatures (transfer these values to the PLC), collects data of the temperature sensors, couplers vacuum, and monitors the temperatures and the coupler vacuum during the baking process.
- It is controlled by the LabView program when the PLC program starts or stops. After that, the PLC program will auto-run.
- If the user changes the baking temperatures or baking time in supervision interface, then press the "update" button, the baking program will run again.
- User can read the temperature and vacuum values and the history curves at any time.
- Warning lighter is bright, when the PLC program is running。

SIMULATION EXPERIMENTS

After we developed the PLC and LabView program for the baking system, the two programs were successfully debugged in their own development environments. In order to evaluate the monitoring program, a periodical server was developed to simulate the OPC Client, which should be established by Rockwell Automation's RS Linx Professional. LabView supplies a flexible tool for managing the project-project explorer. Here we adopted it to construct the monitoring program and create and edit the LabView projects. The baking program project is shown in Fig.4. In the directory tree, my Computer represents the local computer as a target in the project; the exercise server **130-vi** is the period server program simulating the PLC program, the baking systems shared variable tank is a periodic I/O server library simulating the server created by the A-B RSLinx. To operate it, deploy the tank in the library of baking systems shared variables tank through a shortcut menu; open the National Instruments Shared Variable Monitor through menu bar; given the initial variable value, and set the update into true, the server will run all along whether or not there is a client to read them.

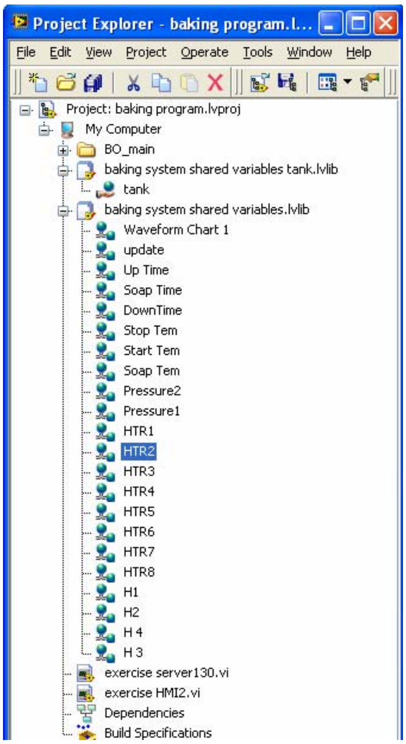

Figure 4: Baking program project.

The library of the baking systems shared variables is a network-published shared variables library that represents the data items in the periodic I/O server to the tank system. The BO_main file folder is the monitoring program which is organized by many sub-program files. When running the BO_main program, after providing the set-up value, press the Update button in Fig. 5 (a), the program will run all alone. Figure 5 (b) describes the process of writing the values to txt file, and (c) is the real time value and the history curves. The simulating results are reasonable.

SUMMARY

The mechanical setup and control system of a PEFP baking system are introduced in this paper. Based on the OPC communication mechanism, the software arithmetic systems are designed. In order to evaluate the supervising program, a periodical server is developed to substitute for the OPC server and the baking process. After that the PLC program which is used to control the baking process was verified in the RSLogix 500 development environment.

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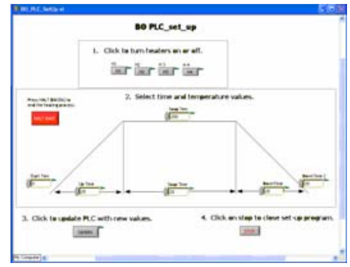
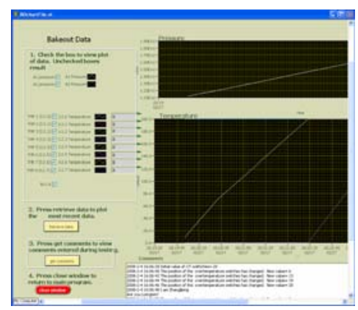


(a) The set-up screen.

(b) Write the shared variables to txt file.



(c) History curve of the temperature and pressure.

Figure 5: Simulated baking process.

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