UPGRADE OF THE PF RING VACUUM CONTROL SYSTEM

Y. Tanimoto#, T. Nogami, T. Obina, KEK, Tsukuba, Japan

Abstract

Vacuum control system of the KEK Photon Factory (PF) storage ring has been upgraded in the summer of 2004 for the first time since the PF ring operation started in 1982. The new vacuum control system is based on PLC (Programmable Logic Controller) and EPICS (Experimental Physics and Industrial Control System)[1]. The vacuum interlock system was also upgraded to the PLC-based system. With this upgrade, reliability, operability and maintainability of the vacuum control system were improved.

INTRODUCTION

Vacuum system of the PF ring has been working satisfactorily since the operation of the PF ring started in 1982. Currently, vacuum pressure in the ring is so low that the beam lifetime is not limited by gas scatterings, but by the Toushek effect.

However, the superannuation of the vacuum control system was one of the problems in the operation of the vacuum system. For instance, sometimes the status of a certain vacuum device was not properly updated in the control display, so the reliability of the system was not high. And as for the operability, remote controls of the vacuum devices were handled only in a stand-alone PC though CUI (Character User Interface). In addition, it was difficult to maintain or renew the vacuum components, because the control software was written in BASIC language and device interfaces between the control PC and vacuum device controllers were composed of numerous NIM modules.

In order to solve these problems, the vacuum control system was upgraded to the PLC/EPICS-based system in the summer of 2004. All vacuum devices except rough pump systems are controlled by the PLCs, which function as device interfaces between the EPICS system software and the vacuum device controllers, and also as intelligent controllers for the vacuum interlock system. EPICS manages information of the vacuum devices, and provides GUI (Graphical User Interface) control panels and an easy-handling data logging system.

VACUUM COMPONENTS

Major Components of the PF ring vacuum system are listed in Table 1. Total effective pumping speed along the 187m-circumference ring is roughly 30,000 l/s. When a 2.5GeV-450mA electron beam is stored, the vacuum pressure average of 50 B-A gauges is about 2×10^{-8}Pa, and then the beam lifetime is about 60 hours [2].

All these components are remotely controlled and monitored by the vacuum control system. And the safety interlock system protects the vacuum components and chambers from unexpected troubles. All parameters of these components are logged for vacuum data analysis.

Table 1: Major components of the PF ring vacuum system

Bayard-Alpert Gauges	50
Sputter Ion Pumps	50
Distributed Ion Pumps	25
Titanium Sublimation Pumps	92
Gate Valves	12
Cooling Water Flow Detectors	102
Resistance Temperature Detectors	70

Table 2 shows the vacuum components in the PF-BT (Beam Transport) line from the linac. The states of cold cathode gauges and gate valves are monitored for the PF-BT vacuum interlock system.

Table 2: Components of the PF-BT vacuum system

Cold Cathode Gauges	7
Sputter Ion Pumps	5
Gate Valves	3

CONCEPTUAL DESIGN OF THE NEW VACUUM CONTROL SYSTEM

To solve the problems in the old vacuum system, we developed a new vacuum control system, which was designed to achieve the following purposes:

- Integration of the functions of the old numerous NIM modules with a small number of intelligent controllers (Reconstruction of the device interfaces).
- Reliable interlock system to protect the vacuum components and chambers.
- Remote controls for all vacuum components listed in Tables 1 and 2 from GUI control panels in network-connected PCs.
- Reliable and easy-handling data logging system for vacuum data analysis.

For the reconstruction of the device interfaces and for the reliable interlock system, PLCs consisting of two CPUs were installed. And for the remote controls and for the data logging system, EPICS (Ver. 3.14.6) was adopted as the system software. And EPICS drives the PLCs

#yasunori.tanimoto@kek.jp

through Ethernet using EPICS Device/Driver Support Modules for PLCs [3].

PLC/ EPICS-BASED VACUUM CONTROL SYSTEM

Overview

Figure 1 shows the architecture of the PLC/EPICS-based vacuum control system.

We installed new devices in "User Interfaces", "IOC", and "Device Interfaces (CPU/Relay)" layers. The Device Interfaces (CPU) are the OMRON PLCs. And also we installed the relay modules for the interfaces between the present device controllers and the new PLCs.

Most of vacuum device controllers (in "Device Controllers" layer) remained unreplaced, and the workstations are shared with other groups.

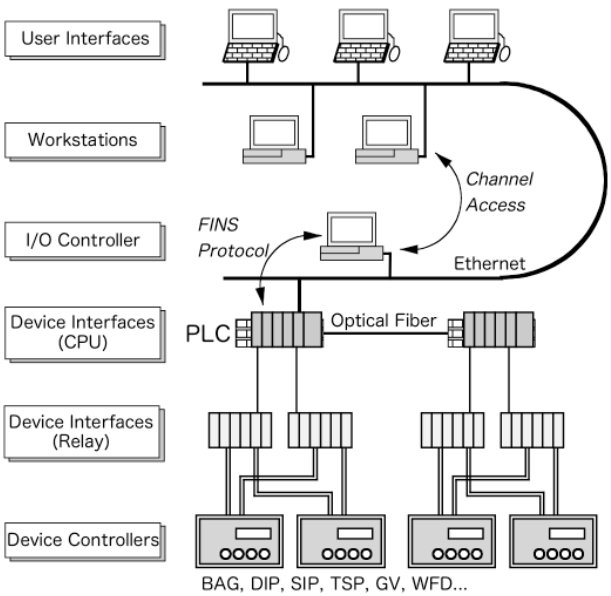

Figure 1: Architecture of the PLC/EPICS-based vacuum control system.

EPICS Device/Driver Support for PLCs

Communication tools with OMRON PLCs through Ethernet, called EPICS Device/Driver Support for OMRON PLC, had already developed by the KEKB control group. EPICS with this module can communicate with OMRON PLCs by the OMRON original protocol (FINS protocol) so that EPICS can directly read or write I/O memories in the PLCs.

Software Input/Output Controller (IOC)

More than 2500 parameters (channels) are to be controlled by the IOC. We adopted a software IOC running on PC/Linux, which is less expensive than VME/IOC.

Monitor and Control Panels

Remote controls of the vacuum components from network-connected PCs are required not only in the accelerator control room but also in the ring tunnel during vacuum works. EPICS's X-window system is suitable for these purposes.

Most of the monitor and control panels are created with the DM2K software, one of the display editors and managers in EPICS. For example, Figures 2 and 3 show the monitor panel of the PF ring vacuum system status and the control panel of the sputter ion pumps, respectively.

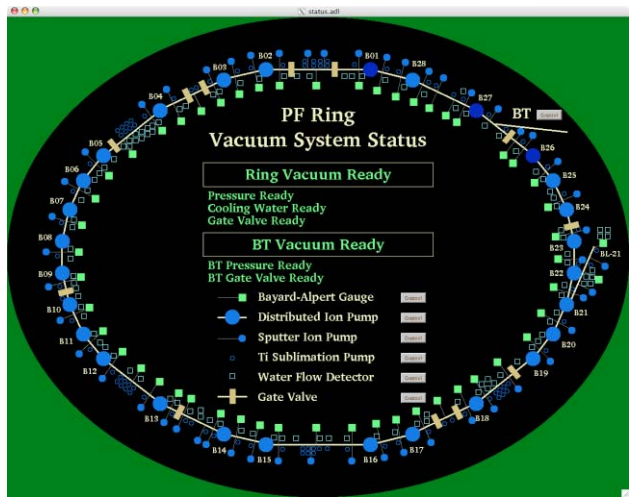

Figure 2: Monitor panel of the PF ring vacuum system status.

Figure 3: Control panel of the sputter ion pumps.

Data Logging

Reliable data logging and easy data handling are important in vacuum control system, for example, during accelerator commissioning or in case of a vacuum trouble.

We adopted an easy-handling logging system called Channel Archiver, one of the data logging systems in EPICS, with which users can access or obtain logged data

via a web server. 100~150MB/day of data is logged for the entire vacuum system.

PLC-BASED INTERLOCK SYSTEM

The vacuum interlock system is designed to protect the vacuum devices and the vacuum chambers from unexpected troubles, such as a vacuum leak or a cooling water leak.

Since the vacuum device controllers are dispersed along the ring, two PLCs are being used on account of the simplification of wiring. They are connected by an optical fiber cable to share the information of the vacuum devices. This seamless control enables a flexible construction of the vacuum interlock system.

PF Ring Vacuum Interlock System

If at least one of three conditions blow is triggered, the PF ring vacuum interlock status becomes "**Ring Vacuum Fail**". And if the accelerator is in operation, stored beam is aborted with the beam stopper by the accelerator interlock system.

"Pressure Fail"

≡ Pressures at both of adjoining two B-A gauges exceed $1x10^{-5}$Pa.

And immediately two gate valves at both sides of the concerning section are closed and ion pumps (both sputter ion pumps and distributed ion pumps) in the concerning section are turned off.

"Cooling Water Fail"

≡ Water flow rate at more than one flow sensor is less than the lower limit.

"Gate Valve Fail"

≡ More than one of twelve gate valves in the ring is not opened.

PF-BT Vacuum Interlock System

If at least one of two conditions blow is triggered, the PF-BT vacuum interlock status becomes "**BT Vacuum Fail**". And in this condition, the accelerator interlock system prohibits the beam injection.

"BT Pressure Fail"

≡ Pressure at more than one of seven cold cathode gauges exceeds $1x10^{-2}$Pa.

And immediately all of three gate valves are closed and all of five ion pumps are turned off.

"BT Gate Valve Fail"

≡ More than one of three gate valves is not opened.

SUMMARY

In the summer of 2004, the PF ring vacuum control system was upgraded to the PLC/EPICS-based system. The vacuum interlock system is controlled by the reliable and flexible PLCs. The new system, including newly introduced EPICS Device/Driver Support for OMRON PLCs and software IOC running on PC/Linux, has been working well so far. With this upgrade, reliability, operability and maintainability of the vacuum control system were improved.

ACKNOWLEDGEMENT

We would like to thank J. Odagiri for the development of EPICS Device/Driver Support for PLCs and his support for the installation in our system.

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