UPGRADING THE CONTROL SYSTEM OF THE MOVABLE MASKS FOR KEKB

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Abstract

The positron ring and the electron ring of KEKB have their own dedicated movable masks to cut off spent electrons/positrons near the beam orbit to reduce background in the detector. The stepping motor drivers of the movable masks were controlled by a Programable Logic Controller (PLC), which was supervised by a VME-based IOC (Input Output Controller). The IOC and the PLC was connected with each other by using GP-IB interface for the communication. Recently, however, the GP-IB connection came to be unstable causing communication errors between the IOC and the PLC. In order to solve the problem, a new type of EPICS (Experimental Physics and Industrial Control System) IOC, which runs Linux on a CPU module of FA-M3 PLC, has been adopted. The CPU functions with standard I/O modules of FA-M3 on the PLC-bus. In this control system, we replaced an existing ladder CPU with the IOC and the ladder program with an EPICS sequencer program for the efficiency of software development and ease of maintenance. The new IOC has been successfully serving since it was put in operation in September 2008. In this paper, we describe the details of the new control system and its experiences up to the date.

INTRODUCTION

The KEKB main ring is comprised of a high energy ring for the electron beam and a low energy ring for the positron beam. In order to reduce the background in the detector it is crucial to cut off spent electrons/positrons near the beam orbit. For this purpose, each ring has movable beam masks at four stations, each of which installs eight masks. The positioning of the masks is executed by using FA-M3 PLCs with positioning modules. The system had been stably operated for more than ten years without serious problems. Recently, however, communication errors increased on the GP-IB connection between the PLC and an IOC that supervises the PLC. To solve the problem, we upgraded the movable mask control system by using a newly released PLC's CPU. The next section describes the former control system and the following sections describe the upgraded system in detail.

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FORMER CONTROL SYSTEM

Configuration of Former Control System

The former control system was composed of a VME computer, a PLC and a digital multimeter to read back positions of the masks. These devices are conected by a GP-IB interface. The control logic of the movable masks was executed by ladder programs running on PLC's CPU.

There were four positioning modules, a digital output module, a digital input module, and a GP-IB module in the PLC unit. The positioning module controlled stepping motor drivers of the movable masks. One positioning module covered two movable masks, so that one PLC took care of eight movable masks. A digital output module were used to generate emergency stop signal for the stepping motor drivers. A digital input module read the status signal of the cooling water system for the movable masks. And the GP-IB module interfaces a digital multimeter with the VME IOC.

The movable masks are remotely controlled through EPICS GUI-based application. The application send a operation-command to the VME-based IOC via Ethernet. And then the IOC send a command to PLC's CPU via GP-IB connection.
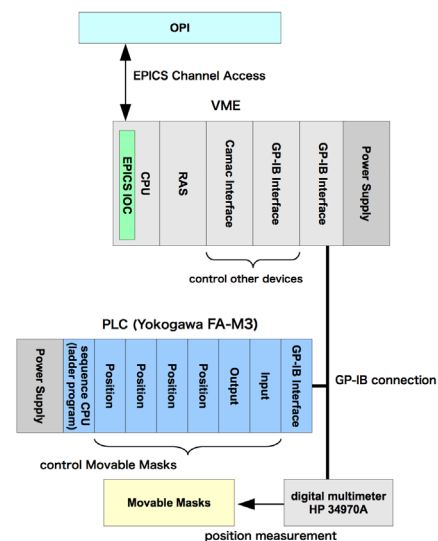

Figure 1: Configuration of former control system.

Problems of Former Control System

In the former system, while the control logic of the movable masks was implemented by usual ladder program, EPICS-based control was used on the VME computer. As a result, learning both development environments was needed to increase the learning cost.

In addition, the communication errors on GP-IB connection came to occur between the VME IOC and the PLC to prevent the system from stable operation.

To solve these problems, the upgrade of the movable mask control system was required.

DESIGN OF NEW CONTROL SYSTEM

This section describes design considerations for a new system to eliminate the GP-IB connection between the IOC and the PLC. Two possible candidates were available.

netDev

One possible method is to connect the IOC and the PLC using Ethernet. For this purpose, a library, netDev, was available. netDev is an EPICS device support for network-based controllers to communicate with devices via Ethernet. In this case, however, an Ethernet module needs to be added to the former PLC unit since it dose not have one.

Moreover, in order to connect the digital multimeter with the IOC, an additional LAN/GP-IB Gateway, which interfaces Ethernet with GP-IB, is also necessary (Figure 2-B). Although it is possible to connect with the digital multimeter by using the GP-IB module of the PLC, it is unsuitable for this upgrade scheme since development of an additional new ladder program is necessary.

F3RP61

For another possibility, we evaluated the adoption of F3RP61 for the new system. F3RP61 is a new PLC's CPU, which can replace or work with an ordinary CPU that executes ladder programs. Because F3RP61 adopts Linux for its OS, it can run EPICS IOC core program on it. As a result, PLC's CPU itself becomes an EPICS IOC for movable mask control to eliminate the GP-IB connection between the IOC and the PLC. In addition, by replacing ordinary PLC's CPU with F3RP61, we can shift from ladder programs to EPICS sequencer programs. EPICS sequencer, which is written in State Notation Language (SNL) is widely used in EPICS-based control systems. SNL has the notion of state and a syntax to wait events in a simple manner. Moreover, C-programmers are accessible to SNL since the syntax is similar to the language. Therefore, shifting to the EPICS sequencer improves readability and maintainability of the software. Another advantage of the switchover from ladder program to EPICS sequencer is that we only get to need only open software supported by EPICS community. Exclusive software to develop ladder programs is no more necessary.

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Since the digital multimeter has only GP-IB interface, a GP-IB module for FA-M3 is required. Message-based transaction over GP-IB can also be implemented by using the EPICS sequencer.

Another advantage is that this scheme reduces the number of devices included in the movable mask control system to simplify the system significantly (as shown in Figure 2-C).
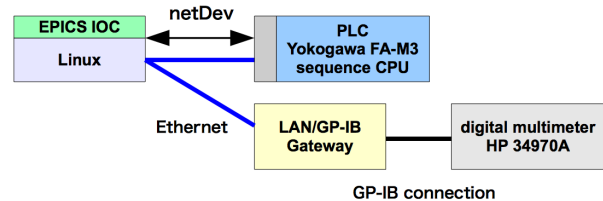
Feasibility Test

We carried out tests to evaluate the feasibility for both schemes described above to confirmed that they both works fine. Finally, F3RP61 was adopted because the solution does not require additional hardware and simplifies the configuration of the system.
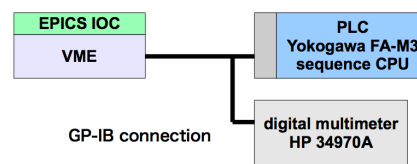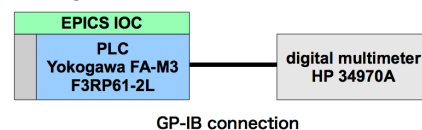

Figure 2: Each control system's configuration.

CONFIGURATION OF NEW CONTROL SYSTEM

In the upgraded system, an F3RP61 CPU executes EPICS IOC core program on Linux to serve as a dedicated IOC for movable masks. The IOC covers the positioning of the movable mask and read back of the masks positions using the digital multimeter. The I/O modules included in the PLC unit are four positioning modules, a digital input module, a digital output module and a GP-IB interface module. By reusing all of the existing I/O modules we could save hardware resources.

The EPICS sequencer was used for both controlling movable masks and communication through the GP-IB interface. As a result, a ladder program for mask control and

a device support for GP-IB communication were replaced with EPICS sequencer. The EPICS sequencer programs were implemented by using templates with associated parameter files that describes the details of each devices. It allowed us to maintain the program much easier than before. The adoption of Linux as its OS enhanced the productivity in the software development since developing programs in the user space is easier and quicker than doing it in the kernel space. It is of importance to reduce the time and cost required for the development of application software since it was frequently updated throughout their lifetimes.

In summary, a simpler, efficient system in achieved both respects of hardware and software.
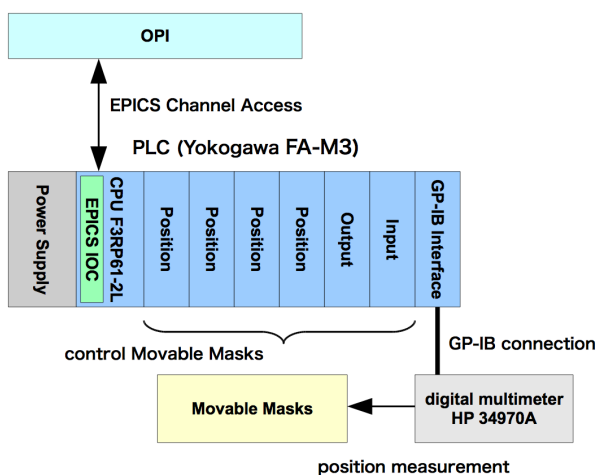

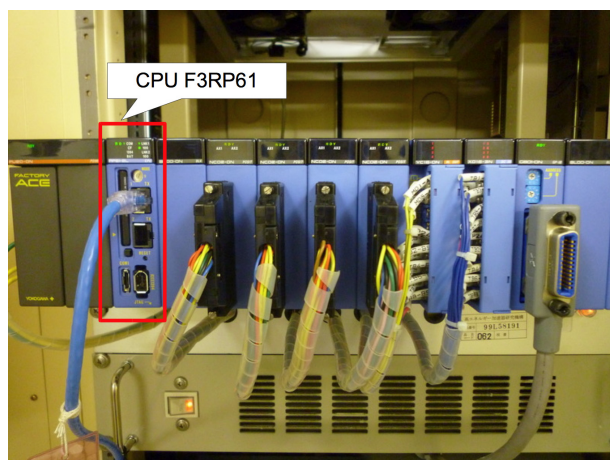Figure 3: Configuration of new control system.

Figure 4: F3RP61 on PLC unit.

OPERATIONAL EXPERIENCE

As of October 2009, the control systems of the movable masks has been upgraded for all of the four stations and ready to run. Two out of four stations has experienced accelerator operations. The first station had been put in op-

eration in September 2008. The next station followed it in April 2009. Up to the present, we have not experienced any troubles at all on both of the stations. The operation of the remaining two stations is scheduled to start in the next accelerator operation from October 2009.

FUTURE PLAN

There are several subsystems, of which control system to be upgraded by using F3RP61 CPU, such as vacuum component other than movable masks, the low level RF system, and so forth. The experience acquired through the upgrade of the movable mask control system can be the base of the possible upgrades of those systems. For this reason, we are planing to enhance the reusability of the software developed for the new mask control system so that it can be reused for other control subsystems with ease.

SUMMARY

The movable mask control system has been updated using F3RP61 CPU running Linux as an IOC. By replacing ladder programs with EPICS sequencer programs, the burden of the maintenance of the application software was significantly reduced. The upgraded system has been operated stably more than a year without any troubles. The experience of the upgrade formed the base for the other control subsystems to be upgraded in the near future.

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