RECONSTRUCTIONS OF THE CONTROL SYSTEM FOR THE CHARGE EXCHANGE SYSTEM AT THE 3GEV RCS IN J-PARC

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Abstract

At the 3GeV Rapid Cycling Synchrotron(RCS) in J-PARC(Japan Proton Accelerator Research Complex), the beam commissioning is kept with intensity reinforcement and beam loss reduction. The RCS is accelerator that convert the H^- beam into the H^+ beam from the J-PARC Linear Accelerator(LINAC), and accelerates to 3GeV. The conversion method is adopted a stripping foil. This method is implemented by a charge exchange system. This system consists of three stripping foil device. The improvement of stability and safety of this system is indispensable to reduce the beam loss and to stable beam orbit. This system controls transfer rod and vacuum system. In September 2007, machine trouble with first stripping foil device when the RCS beam commissioning started. This trouble was caused by the magnetic coupling of the transfer rod decoupling and caught by gate-valve. To avoid the machine trouble, we were verified hardware and software to improve this system safety. We will install the new system from beam commissioning in September 2010.

This report describes design of the new control system.

INTRODUCTION

The charge exchange system of the RCS operates the process of driving a transfer rod and changing a foil. This system consists of the vacuum system and drive system. Therefore, it is necessary to be the integrated control system that manages the vacuum system and the drive system.

In September 2007, machine trouble is occurred. This trouble was caused by the control system which could not manage the dependence of the vacuum system and the drive system. This system had to be a collaboration of the vacuum system and the drive system. We designed the new control system which can manage the vacuum system and the drive system. The control system for the charge exchange system is composed of two controllers. The vacuum system is controlled by PLC(FA-M3, Yokogawa Denki Corp.) and the drive system MCU(Multi Control Unit; Hitachi Zosen Corp.). We set up a workstation which manages the PLCs and MCUs of this system. It aimed to improve operability, safety and stability of the control process.

In the J-PARC control system, accelerator remote control development tool "Experimental Physics Control System(EPICS)" has been adopted. It is possible to control remotely for accelerator devices via EPICS.

We have adopted machine model which defines abstract status. This machine model realized effective remote control via EPICS.

EPICS-BASE REMOTE CONTROL FOR THE CHARGE EXCHANGE SYSTEM

Experimental Physics Control System

EPICS is a set of open source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments such as a particle accelerators, telescopes and other large scientific experiments[1]. Figure 1 shows a component of control system for the charge exchange system.

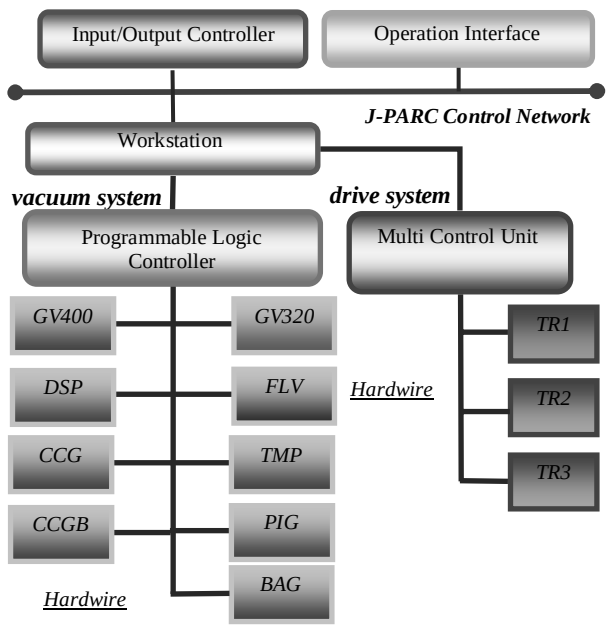

Figure 1: Components of control system for the charge exchange system.

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To connect the accelerator devices via EPICS, the workstation that manages the charge exchange system implemented virtual register of defined format. The workstation manages the information of PLCs and MCUs in the virtual register. The virtual register and the EPICS records become a pair. Therefore, it is possible to operate remotely the charge exchange system.

Hardware of the Charge Exchange System

The drive system consists of 3 charge stripping foil. Figure 2 shows the hardware component of the drive system and Figure 3 shows the vacuum system.[2]

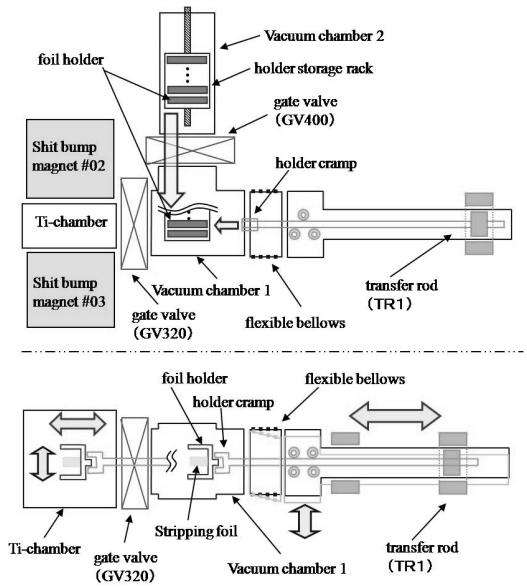

Figure 2: Hardware components of the drive system.

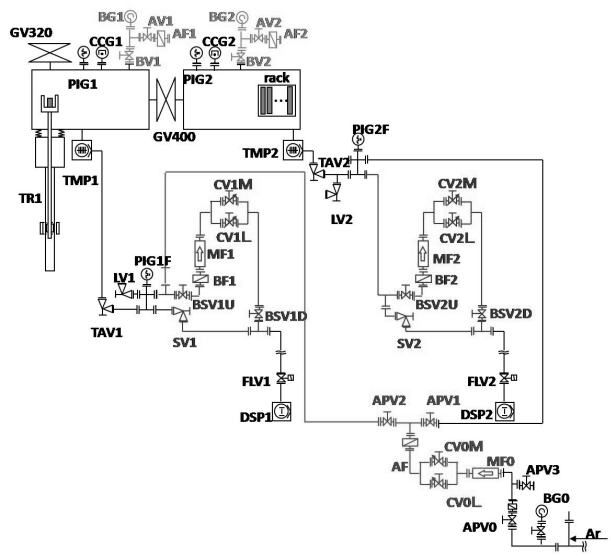

Figure 3: Hardware components of the vacuum system.

J-PARC Machine Model

The machine model is the method in which the machine status is made to transit by defined process. As shown in Figure 4, the machine model is composed of six statuses.

1. DOWN
2. STOP
3. STANDBY
4. RUN
5. FAULT
6. EMERGENCY

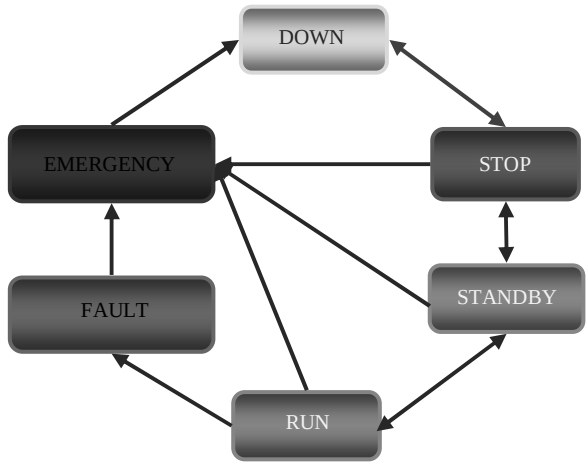

Figure 4: The machine transition cycle.

The Status of the accelerator devices are transited by the machine transition cycle, and the status transition of accelerator devices are done by a status transition command(command) which adapted to the machine model from the J-PARC control system. The accelerator devices that received the command start the process of status transition. Table 1 shows the status transition command list.

Table 1: The Status Transition Command

Command	Status transition
Go-Stop	[DOWN=>STOP] or [STANDBY=>STOP]
Go-Standby	[STOP=>STANDBY] or [RUN= > STANDBY]
Go-Run	[STANDBY =>RUN]
Reset	[FAULT=>STOP]

J-PARC MACHINE MODEL FOR THE CHARGE EXCHANGE SYSTEM

Software Design

As shown in Figure 2, transfer rod (TR1) move to the RCS-ring passing gate-valve (GV320) bottom. It is necessary to decide the machine model for this system, while the interference of the transfer rod and gate-valve is considered. It is important to effectively utilize information of the device status and interlock in order to avoid the interference of gate-valve and transfer rod. We thrashed out the status and interlock about transfer rod and gate-valve. The software was redesigned in order to avoid from the interference using the information.

Machine Model for the Charge Exchange System

A MCU get the gate-valve information from a PLC. The transfer rod control would be able to carry out sequence of which the dependence of gate-valve and transfer rod was considered, and the transfer rod control and gate-valve were not asynchronously carried out. Therefore, the transfer rod control and gate-valve control were possible to construct the machine model with the cooperation. The interlock of this system allows local reset only. When the interlock works, the event causes the system to transition to "EMERGENCY" status.

Table 2: The Machine Model for the Charge Exchange System

STATUS	Requirement
DOWN	breaker off; GV320 close
STOP	foil position origin; foil clamp open; GV320 close
STANDBY	foil position origin; foil cramping; GV320 close
RUN	foil insert; GV320 open
EMERGENCY	heavy trouble

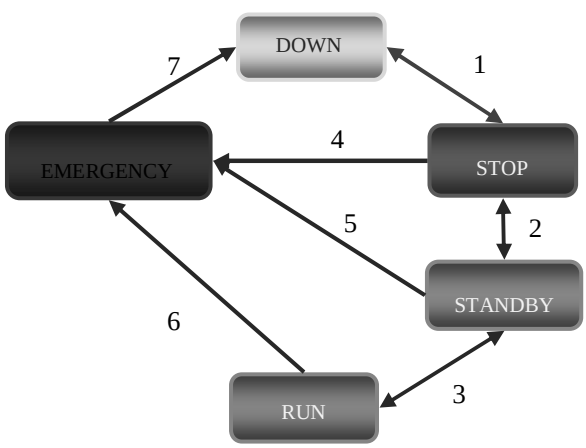

Figure 5: The machine status transition diagram for the charge exchange device.

Table 2 shows the machine model, and Table 3 shows sequence of the machine status transition. Figure 5 shows the machine transition cycle.

Table 3: Sequence of the Machine Status Transition

	status transition	process	status transition command
1	DOWN => STOP	Vacuum ready OK; turn on the breaker	Go-Stop
	STOP => DOWN	Vacuum not-ready; turn off the breaker	
2	STOP => STANDBY	Foil clamp operation [clamp]	Go-Standby
	STANDBY => STOP	Foil clamp operation [open]	Go-Stop
3	STANDBY => RUN	Foil driver operation [insert]	Go-Run
	RUN => STANDBY	Foil drive operation [draw]	Go-Standby
4	STOP => EMERGENCY	Heavy trouble	
5	STANDBY => EMERGENCY	Heavy trouble	
6	RUN => EMERGENCY	Heavy trouble	
7	DOWN => EMERGENCY	Heavy trouble	
	EMERGENCY => DOWN	Normal status	Hard reset

SUMMARY

We developed the EPICS-base remote control system for the charge exchange system. The transfer rod control would be able to carry out the safety control system of which the dependence of gate-valve and transfer rod were considered. RCS beam commissioning carries out by using the charge stripping foil. By using the new control system with safety and stable, the study will be able to carry out efficiently. In the future, the machine model is also decided on 2nd and 3rd foil, and the control system with the universality will be constructed.

REFERENCES

[1] http://www.aps.anl.gov/epics/.
[2] M.Yoshimoto et al., in this proceedings.