CONTROL SYSTEM OF 3 GeV RAPID CYCLING SYNCHROTRON AT J-PARC

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Abstract

Since the 3GeV Rapid Cycling Synchrotron (RCS) produces huge beam power of 1 MW, extreme cares must be taken to design the control system in order to minimize radiation due to beam loss. Another complexity appears in the control system, because each beam bunch of 25 Hz is required to be injected either into the Material and Life Science Facility (MLF) or into the 50GeV Main Ring (MR). Therefore, each bunch of 25 Hz must be operated with different parameters, and the data acquisition system also must collect synchronized data within each pulse. To achieve these goals, a control system via reflective memory and wave endless recorders have been developed. EPICS is adopted in the control system. Since the number of devices is huge, the management of EPICS records and their configurations need huge amount of time and man power. To reduce this work significantly, a Relational Data Base (RDB) for static machine information has been developed. This RDB stores (1) EPICS related information of devices, interfaces, and Input Output Controller (IOC) with a capability to generate EPICS records automatically, and (2) geometrical information of components with a capability to generate lattice files for various simulation codes. The status of the RCS control system focusing on the data acquisition system and the RDB will be presented.

INTRODUCTION

The RCS injects each beam pulse of 25 Hz into the MLF and the MR in a predefined order. Control parameters should be set differently depending on the destination [1]. Therefore, it is important to optimize the control parameter by Control Parameter Optimize system (CPO), and all 25Hz beams which inject different destination must be monitored distinctively in the Data Acquisition system (DAQ). On the other hand, since the number of EPICS record will be about 20,000, it is hard to configure and manage these EPICS records. To reduce this work significantly, RDB with Base Data Management system (BDM) has been developed.

CONTROL SYSTEM LAYOUT

The overview of RCS control system is shown in Fig.1. RCS control system mainly consists of HMI (Human Machine Interface), Components (Machines and Devices), DAQ system, CPO system and BDM system.

BDM system is a base system for RCS control system. This system mainly configures Component parameter DB (CmpDB) and Control parameter DB (CtlDB). They store static component information and generate static parameters for system configurations.

DAQ system collects and stores the operation data. This system is configured in OpeDB, Reflective Memory (RM), Wave Endless Recorder (WER) and so on. OpeDB collects the operation data via RM and LAN from machine controllers.

CPO system optimizes operation parameters to avoid errors in the operation parameter setting. This will be configured by Simulation DB (SimDB), operation parameter logger (OP Logger) and so on.

DATA FLOW

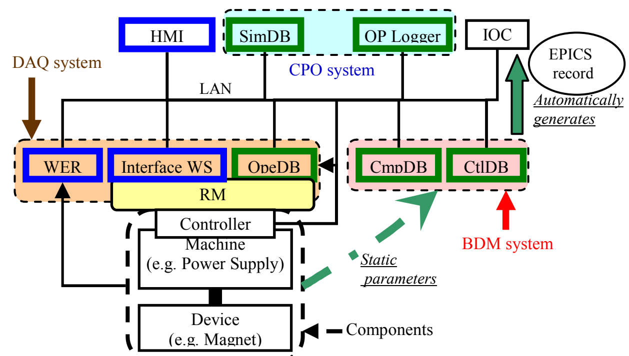

Figure 1: Overview of RCS Control System.

Outline of control parameter flow and operation data flow in RCS control system is shown Fig.2.

First, control parameters from MHI are sent to machine controllers via CPO system. CPO system examines control parameters by applying them in the simulation or compares with past control parameters logged in OP Logger. As a result, if the control parameters are judged to have a problem, CPO system will be useful to optimize or cancel them.

Then, RCS control system has several types of operation data, such as fast synchronized data (e.g. beam position data), synchronized data (e.g. output voltage data at pattern power supply) and slow data (not synchronized. e.g. status data of power supply). The fast synchronized data and synchronized data are sent to HMI after these data are matched by DAQ system. The slow data is sent to HMI from machine controllers directly.

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Finally, the static parameters in BDM are used MHI, CPO system and DAQ system to configure each system.

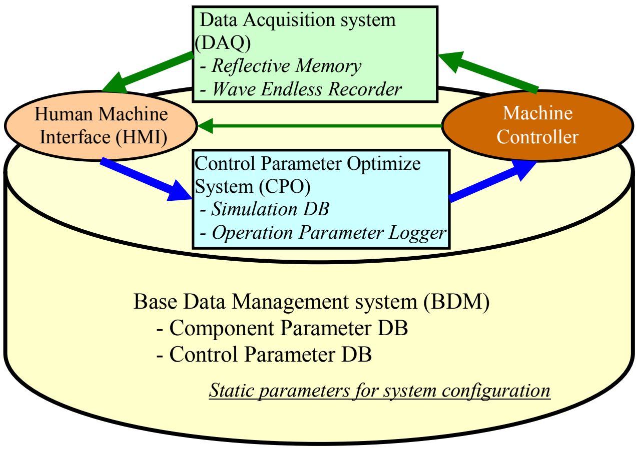

Figure 2: Outline of Data Flow.

RDB FOR BDM SYSTEM

BDM system is configured from CmpDB and CtlDB.

CmpDB stores the static component information, such as magnet type and maximum voltage of power supply, and so on.

CtlDB stores the static control parameters, such as EPICS record names, register maps of PLC and etc. CtlDB is able to generate EPICS record definition files automatically, in accordance with stored parameters and related information of CmpDB. CtlDB also generates an EPICS ".dbprm" macro definition files each time when the same kind of machine is controlled by an IOC and an EPICS ".db" file for every machine. In the machine test for RCS kicker magnet power supply, we succeeded to control and monitor the power supply, using EPICS record which is generated by CtlDB. Additionally, in RCS and Linac, we have just designed and developed software to generate HMI configuration files automatically from BDM system. A demo test succeeded for Linac 60MeV test facility at KEK. This HMI used in the test It is shown Fig.3. This HMI is made using Java.

RDB FOR CPO SYSTEM

We know the necessity of CPO system to avoid the error operations, which may cause radiation due to beam loss. CPO system will consist of Simulation DB (SimDB), Operation Parameter Logger and etc.

SimDB assumes a role to connect CPO system with the accelerator simulation. SimDB stores input parameters of simulation code. The parameters together with geometry data from CmpDB are collected and transformed to a format of each simulation code by a generation program for a configuration file of simulation (sim-config-generator) in SimDB.

The sim-config-generator has been

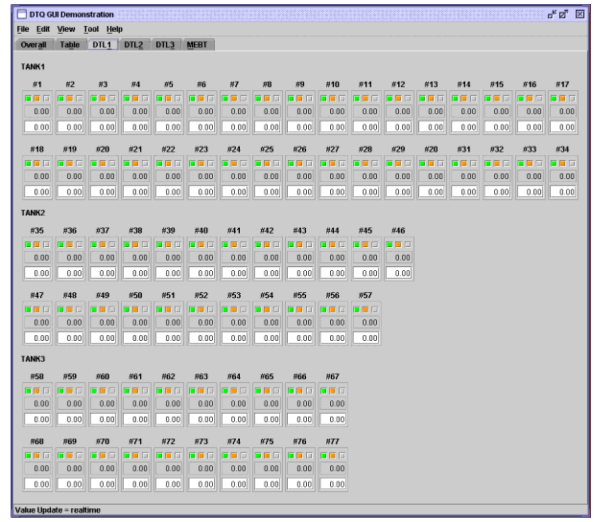

Figure 3: HMI for Demo Test for Linac 60MeV.

developed in Java. The purpose of it is to share various information between the real components and elements in simulation with the database and also to have consistent geometry and component parameter information among various simulation codes. There is a technical difficulty to divide elements in the simulation codes where overlap of two elements in the orbit coordinate is disallowed. This problem was solved by utilizing a class library of XAL code developed in SNS. The original XAL code has been developed to generate consistent input files for Trace3D and XAL.

We made test bench for Linac simulation code before applying the system to RCS. A detailed comarison of Twiss parameters between XAL and Trace3D was perfomed in the configuraion of Linac MEBT and consistent results were obtained. A code for SAD has been under development for RCS.

For accelerator commissioning, a prototype of SimDB which records history of machine parameters has been developed. By utilizing this and conversion between phyics and device parameters, the efficiency of commissioning with simulation will be improved. A HMI in Java was shown in Fig.4. A prototype test of basic functions of data input and output was successful in the beam test of MEBT1 in Feb. 2005.

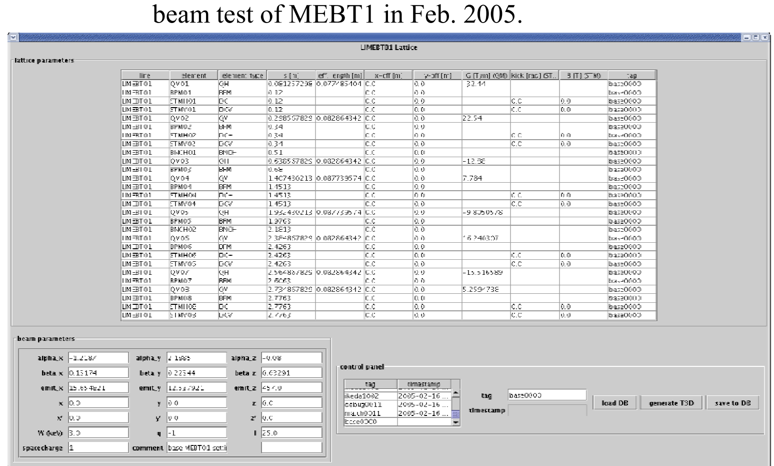

Figure 4: HMI for Beam Test of MEBT1.

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DAQ SYSTEM

Since different beam control parameters are required for the MR and the MLF, monitoring and control must be made distinct for each beam pulse. In order to realize this demand, synchronicity of data is indispensable.

However, the time when the HMI has received the operation data via LAN can be different from the time when the apparatus has collected the data. So, we configured test bench of RCS DAQ system which secures the synchronicity.

In our first test, we decided to manage the data which requires synchronicity with the beam tag. The beam tag is the trigger number which counts every operation cycle of J-PARC timing system. We are able to obtain synchronized data, after the collected data has been referred by beam tags.

In RCS control system, we will configure the DAQ system to enable synchronized data collection. The system is configured from RM, WER and etc.

Reflective Memory

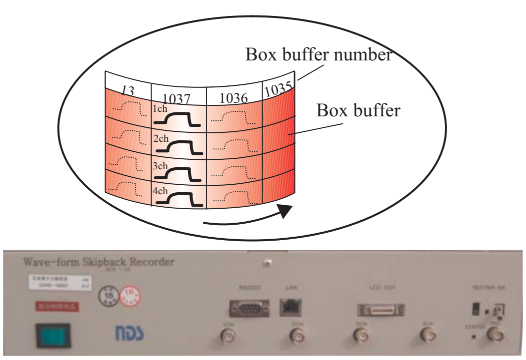
RM is adopted to configure RCS DAQ system which realizes collecting fast synchronized data, such as beam position data. We have performed the bench test of DAQ system using RM [2]. In the test, we confirmed that the 25Hz fast synchronized data can be collected and the data distinction of MR cycle tag is possible by configuring the ring memory with the RM space.

Based on the bench test result, we are designing and developing RCS DAQ system based on the RM.

Wave Endless Recorder

As well as being useful in monitoring the synchronized operation data, WER is very useful in getting to the data for post mortem.

We design WER with a circular-buffer and LAN. A circular buffer is divided to the beam size, called the circular box buffer, because J-PARC is a pulse driving machine. The box shifts by the beam trigger, and the trigger number (beam tag) is allocated to the box. To collect the loss data, the supervisory computer can get the loss data easily, since the data is managed by the beam tag. The beam tag may not coincide among measuring instruments because we used a lot of WER. Therefore, the beam tags in all WER are made to coincide by the mechanism like NTP (Network Time Protocol) [3]. Figure 5 shows the hardware image of WER.



OS: uITRON (Realtime OS)
CPU: SH4(200MHz)
Memory: 32MB
1024(Box buffer) x 8k(B/Box biffer) x 4ch
ADC: 12bit (isolated) x 4ch, 10MS/s, differential input
Trigger: TTL

Figure 5: WER Image of Measuring Instrument.

The test result of WER with one measuring instrument before using RCS is shown in Figure 6. This data was obtained on the RFQ test bench at J-PARC. Software is written by Java. In this software, the recorded event can be made to animation. Confirming the event by animation gives big information to an analytical person.

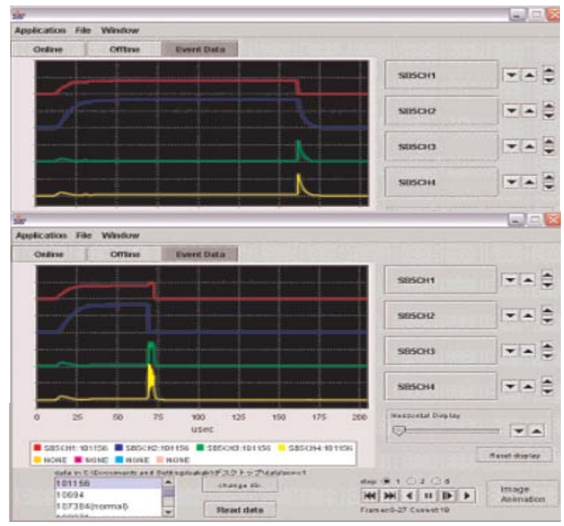


Figure 6: Test Result of WER.

CONCLUSION

In this paper, we showed status of RCS control system. RCS control system mainly configured with BDM system, CPO system and DAQ system.

DB in BDM system developed which can generate EPICS record definition files automatically. A prototype of SimDB in CPO system has been developed which generates input files for accelerator simulation codes.

DAQ system is being developed and the performance is confirmed capability by the result of bench test.

In the future, we will design and develop each system and RCS control system will be configured.

REFERENCES

[1] H.Takahashi, et al., "SUMMARY OF 3GeVRCS CONTROL SYSTEM'', Proc. of 1st Annual Meeting of Particle Accelerator Society of Japan, 2004. (In Japanese)

[2] H.Takahashi, et al., "25HZ SYNCHRONIZED DATA COLLECTION SYSTEM IN J-PARC 3GEV RCS", Proceedings of PCaPAC2005 in Japan

[3] H.Sakaki, et al., "DEVELOPMENT OF THE TRIGGER MANAGEMENT DEVICE FOR THE WAVWFORM RECORD DEVICE'', Proc. of 29th Linear Accelerator Meeting in Japan, 2004. (In Japanese)