STATUS REPORT OF RAON CONTROL SYSTEM*

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Abstract

The RAON [1] is a new heavy ion accelerator under construction in South Korea, which is to produce a variety of stable ion and rare isotope beams to support various researches for the basic science and applied research applications. To produce the isotopes to fulfill the requirements we have planed the several modes of operation scheme which require fine-tuned synchronous controls, asynchronous controls, or both among the accelerator complexes. The basic idea and development progress of the control system as well as the future plan are presented.

THE RAON

The RAON consists of both the 400 kW In-flight Fragmentation (IF) facility and the 70 kW Isotope Separator On-Line (ISOL) facility. The IF accelerator system is designed to produce stable ion beams with maximum energy up to 200 MeV/u for uranium (600 MeV for proton). The ISOL accelerator system delivers rare isotope beams with maximum energy of 18.5 MeV/u. The two different systems should be operated both independently and concurrently with respect to the user requirements, which is the unique feature of RAON accelerator system.

REQUIREMENTS

The RAON accelerator designed to have three linear accelerators and two ion source generators is required to provide continuous and pulsed beam depending on the experiment. The frequency used in the acceleration is the subharmonics of 325 MHz and the master frequency is determined to be 81.25 MHz, 1/4 of it. The designed bunch length is 10-15 psecs. Most of machine operation should be controlled in these conditions automatically.

The control system should integrate all different subsystems such as RF system, beam diagnostics, power supply (PS), vacuum control, beam line control, and machine protection. The control system should monitor the important PV for the subsystems every 1-10 Hz and support the routines to control in a loop time of several Hz.

Approximately less than 50 μsecs of mitigation time is necessary for machine protection.

The control system should provide manual control of beam line elements such as dipole and quadrapole magnets and power supply. For the beam phase matching, the low level RF and beam diagnostics should be integrated using the fast devices mostly of the BPM systems and feedback to the low level RF manually.

* Work supported by the Rare Isotope Science Project funded by Ministry of Science, ICT and Future Planning (MSIP) and National Research Foundation (NRF) of KOREA.

All hardware systems should be integrated in EPICS framework and support 1-10 Hz of data collection from BPMs, PS, and I/O controllers.

ARCHITECTURE

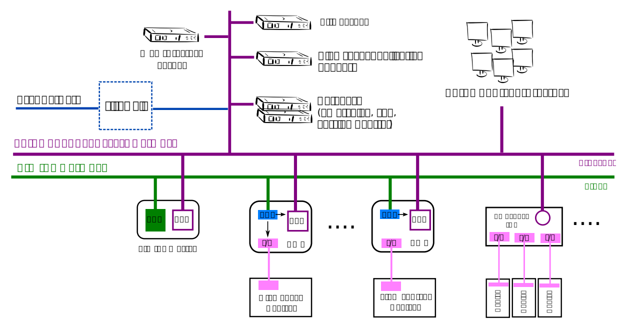

Figure 1: Overall architecture of the RAON control system.

The architecture of the RAON control system is designed to fulfill the requirements. The architecture as depicted in Fig. 1 is tightly integrated with the EPICS. The control system uses two network grids, one is to support the timing system and the other is to support EPICS channel access. The control unit, the key component for the control system, is bonded to the both network grids. The EPICS channel access network is linked to the database, high level application system and EPICS control interface for users.

THE CONTROL UNIT

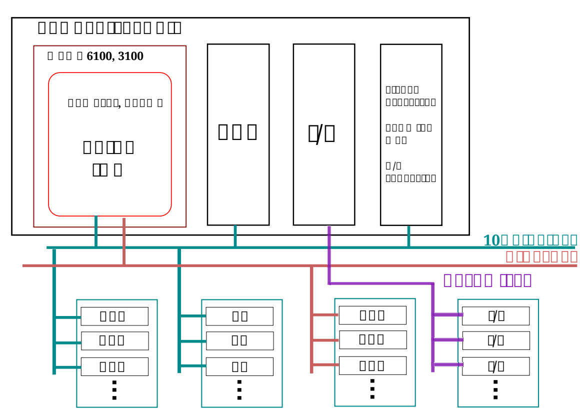

Figure 2: The control unit and its connection with other subsystems.

Figure 2 shows the structure of the control unit. The base platform for the control unit is VME architecture. The control unit consists of a single board computer (SBC) in

ISBN 978-3-95450-139-7

which VxWorks is installed as RTOS, a Event Receiver (EVR), and commercial or homemade I/O board for the flow control of analog or digital signals where the PLC or subsystems are connected. EPICS I/O controller (IOC) controls the PLC and subsystems as coded in EPICS DB. The Channel Access (CA) module is loaded in the SBC so that the user can communicate with the EPICS IOC via Ethernet connection with time stamps given by EVR. In addition to the I/O board, a commercial/homemade FPGA board will be used for the signal processing. The PLC will be used for the front-end interface to the subsystems. The several vendors for PLC providing robust products, such as Allen-Bradley and SIEMENS, are considered. In addition the domestic PLC providers, such as LSIS [2], are also considered in order to reduce the price.

TIMING SYSTEM AND MACHINE PROTECTION

The timing system requires low latency, deterministic operation, high speed signal processing for RF phase and machine control, and low level RF feedback. The components satisfying such requirements can be found in commercial standards, i.e., the EVG/EVR hardwares from Micro Research Finland (MRF) [3] and the Libera BPM products from ITech [4]. However, since there is an issue on budget, developing a homemade BPM component and using the open source hardware products such as White Rabit (WR) [5] are also considered.

Since the same properties are also required like as the timing system, the machine protection should be tightly integrated with the timing system. The mitigation latency is required to be less than 50 μsecs after an event occurred. The main issue of machine protection is on the latency of the identification of problematic event, since the hardware latency and mechanical time delay can be estimated and resolved somehow. The mitigation functions will be implemented on the FPGA logic control with the multi-channel analog to digital converter.

DATA MANAGEMENT AND SYSTEM INTEGRATION TOOL

Database

The control system should monitor and achieve the data (signals, PVs, HW/SW configuration..) from the components. In addition, the control system should provide various tools to access the data and configuration stored in the database.

There are several open-source database solutions, such as PostgreSQL, MySQL, and SQLite for the database development. The PostgreSQL database will be the most suitable for the control system demands, however, it is still flexible depending on the data type and functional requirements.

User Interface

The user interface should be intuitive and easy to access to the control system devices. The graphical and command-line user interfaces will be developed by using generic script languages, e.g. Python, Perl, C/C++, Matlab/Octave, Java, and LabView with EPICS CA client Application Programming Interface. In addition, the user interfaces of the RAON control system should be EPICS standalone as follows : ALH (Alarm Handler), Channel Archiver, Control System Studio (CSS), EDM (Extensible Display Manager), MEDM (Motif Editor and Display Manager), caQtDM (An MEDM replacement based on Qt), and StripTool (Strip-chart plotting tool).

High Level Application

Since XAL [6] has proved its usability and stability at Spallation Neutron Source (SNS) for several years, many recent accelerator projects such as CSNS, ESS, GANIL, TRIUMF, and FRIB, adopt this framework for building their own high level programming infrastructure. Moreover, the RAON control system demands the capabilities provided by XAL from the beginning of beam commissioning to the actual operation. Thus, the OpenXAL [7], an open source version of development framework, is selected as a high level application solution of the RAON control system. Using the object-oriented feature of Java, a hierarchical structure of the accelerator components will be modeled. Since there are many works to do, however, the international co-work is necessary.

STATUS

The Control Unit for Timing System

The control unit for timing system prototyping is the main subject of the fiscal year 2013. As shown at Fig. 3, two test VME crates consisting of EVG, EVR, and MVME6100 with VxWorks 6.9 are prepared for the prototyping. These crates connected with Ethernet for EPICS channel access and fiber cables for event system is under the test of jitter, delay time and latency. The timing system prototype is planned to use for operating a test version of injector and superconducting LINAC system. As soon as the assembly of the test LINAC system is completed, the system configuration and test operation using the timing system will start.

The Vacuum Control System

In parallel with the timing system prototyping, a testbed for the vacuum control system in Fig. 4 is now being developed with a domestic company. The vacuum system controlled by PLC will be integrated with EPICS and be used for the test facilities.

Naming Convention

The naming convention is important for the system integration with EPICS, because it is related not only to the user comprehension but also to the issues on network and

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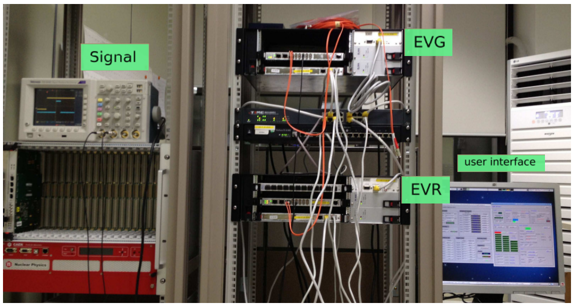

Figure 3: A timing system prototyping.

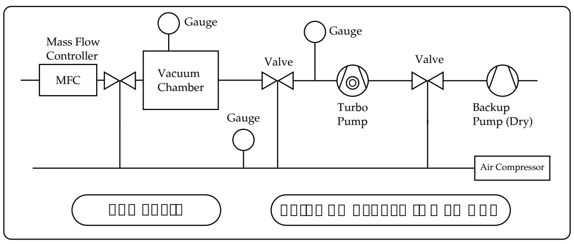

Figure 4: The vacuum control system.

hardware I/O and data management. A primitive naming convention study has been done and shown as following:

DDDDIII-SSSS:TTTT,

where DDDDIII is a device identifier, SSSS is a system name, and TTTT is the PV name followed by the EPICS DB convention. This naming convention is not fixed but being improved regarding the user's request.

SUMMARY & OUTLOOK

The goal of RAON control system is to provide good environment to operate the IF and ISOL accelerator systems. The notion of system architecture and the control unit are being developed. The development of a testbed for vacuum control system and a prototype of timing system together with MPS are also proceeding. Since a test facility for injector and linear accelerator is planned to be finished in next year, the two prototyping of control and timing system will be tested and evaluated. In addition the engineering design of central control system will start soon.

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ISBN 978-3-95450-139-7