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Implementation of Distributed Control System for 1 MeV/n RFQ at KOMAC

Young-Gi Song*, Jae-Ha Kim, Sung-Yun Cho, Sang-Pil Yun, Han-Sung Kim, Hyeok-Jung Kwon
Korea Multi-purpose Accelerator Complex, Korea Atomic Energy Research Institute, Gyeongju 38180, Korea
**Corresponding author:ygsong@kaeri.re.kr*

1. Introduction

For multiple purposes, the 1 MeV/n RFQ has been developed at Korea Multi-purpose Accelerator Complex (KOMAC) [1]. The RFQ is four vane structure resonated at 200 MHz to accelerate ions of 25 keV/n to an energy of 1MeV/n. The beam accelerated by the RFQ is transmitted to two beam lines. The 1 MeV/n RFQ will be used for various purposes such as test-stand for accelerator research, ion beam implantation for semiconductors, neutron source for material study, and swift heavy ion applications. Fig. 1 shows the layout of the 1 MeV/n RFQ. Hardware of various form factors was used to build a remote control system for each component, and Experimental Physics and Industrial Control System (EPICS) software was adopted to integrate each control system [2]. This paper presents the development status and integrated operation results of the control system of the 1 MeV/n RFQ.

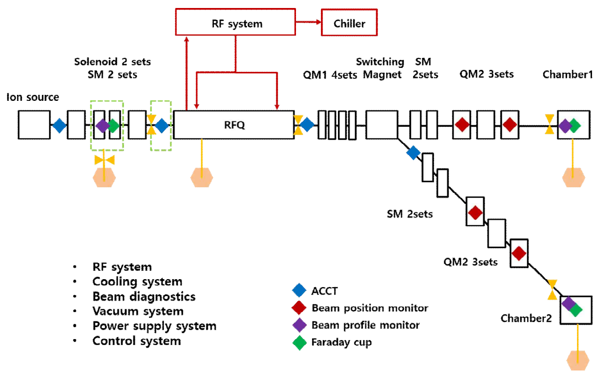

Fig. 1. Layout of 1 MeV/n RFQ machine

2. Integrated control system

The 1 MeV/n RFQ machine has a variety of equipment, including: power supply system (extraction, bias, BM, LEBT solenoid, LEBT steering magnet, QM, BL steering magnet), beam diagnostics (ACCT, BPM, faraday cup), vacuum system (pump, gauge, gate valve), RF system (LLRF, SSA, RF monitoring), timing system, control network, machine interlock (RF, beam), cooling system (chiller).

In order to establish a control system for each equipment, a communication interface and control hardware are selected, and Process Variable (PV) list and software driver are prepared. After the PV naming conventions are completed, the front-end and back-end software development process should be carried out simultaneously.

The control system is divided into low-level layer for local controllers of each equipment and high-level layer for user applications, and the control network is configured in a server and client model using the EPICS Channel Access (CA) protocol as shown in Fig. 2.

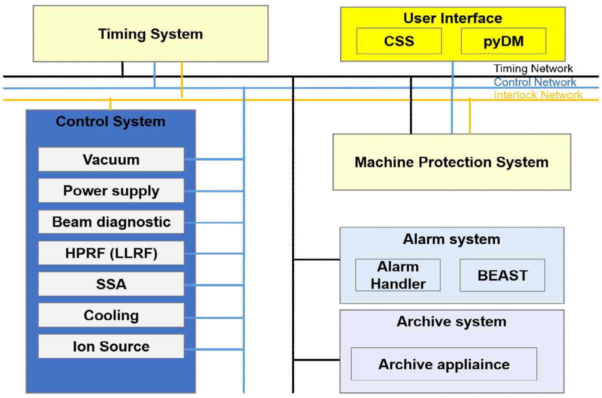

Fig. 2. Layout of EPICS based Control System

2.1 Control System

The EPICS tool was used as integrated software. EPICS is a set of open source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control system [2]. EPICS also supports a variety of modules that are suitable for various architectures and reduce development time. EPICS extensions support CA client applications, enabling user interface applications without difficulty.

The control system is divided into host-based Input Output Controller (IOC) and target IOC. Host-based IOC runs in the same compiled environment and is called softIOC. Vacuum, power supply, and cooling control systems are developed as softIOC. Target IOC is a cross-compilation system that runs in a different environment from compilation, consisting of systems such as vxWorks and RTEMS. LLRF, beam diagnosis, and timing systems are developed as target IOC.

2.2 EPICS IOC

Asynchronous interface control systems, such as vacuum, power supply, and cooling, are developed using asynDriver and StremDevice modules supported by EPICS. Asynchronous Driver provides many facilities for communicating with modbus, RS232, and Ethernet [3]. StreamDevice is a generic EPICS device support for devices with a “byte stream” based communication interface by sending and receiving strings [4]. The EPICS driver of the LLRF and beam diagnostic system is developed using vxWorks-based interrupt handler and EPICS I/O interrupt record processing. The PV record is processed when hardware interrupt occurs. Interrupt handler calls scanIoRequest with the ioscanpvt value for driver source.

To control the vacuum gate valve, it is possible to control 24V using the relay contact point of the MOXA ioLogix product. As hardware for beam measurement, Digilent zybo-z7-20 shown in Fig. 3 and Analog Device AD7605 ADC are adopted. A development environment is established with Vivado Design Suite and Petalinux for the development of ADC devices and EPICS IOC servers on Zynq SoC. The timing system consists of MRF EVG and EVR as shown in Fig. 4. The timing system provides a complete timing distribution system including timing signal generation.

Fig. 3. Zynq SoC DAQ control system

Fig. 4. Event timing system for timing distribution

2.3 User Interface

The graphical user interface tool is an integral part of the EPICS clients. Control System Studio (CSS) was applied as an integrated user interface. CSS is an Eclipse-based collection of tools to monitor and operate RFQ local control systems. Vacuum and RF operation data can be monitored in real time as shown in Fig. 5, and archived data can be browsed.

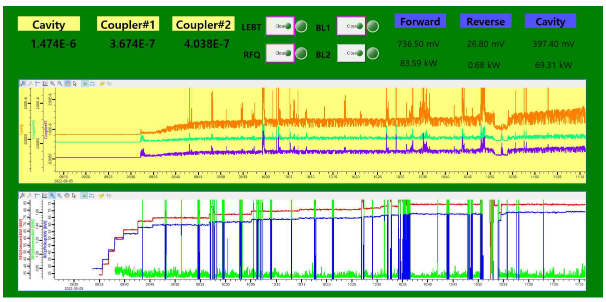

Fig. 5. User interface using EPICS CSS

The RF interface displays operation parameters and waveforms such as PI gain, RF amplitude and phase, as shown in Fig. 5.

Fig. 6. User interface using EPICS CSS

The Zynq DAQ system monitors beam signals using four channels. The DAQ operates with the timing system, and the monitoring signal is shown in Fig. 7.

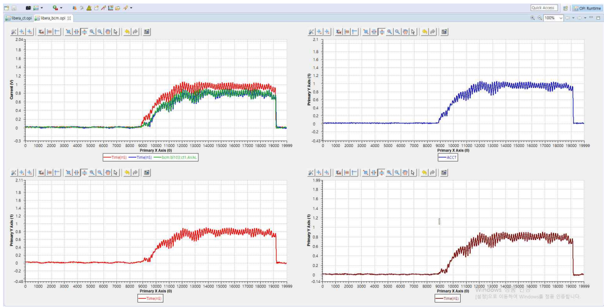

Fig. 7. User interface for beam signal monitoring

3. Conclusion

The control system for 1 MeV/n RFQ has been developed with various hardware and EPICS software. The integrated test of the control system has been completed and used without any problems in the test operation. In the future, the timing and beam diagnostic control system, which will be newly upgraded, will be tested and evaluated using the RFQ machine.

Acknowledgement

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