

cRIO-based Data Acquisition and Control System for Low Flux Proton Irradiation Facility at KOMAC

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1. Introduction

Korea multi-purpose Accelerator Complex (KOMAC) has been operating 20 MeV and 100 MeV proton beam-lines to provide proton beams for various applications. A new beam line with low flux proton densities has been constructed and started beam service to user for simulation of the space radiation-like environment in 2018 [1][2]. The irradiation room of the low flux beam line has been upgraded with new beam diagnostics instruments and new control system for efficient beam tuning process and the improved beam quality assurance. The irradiation room for the low flux proton facility consists of some beam diagnostics for beam characterization and sample stage. The sample stage is controlled during the proton irradiation experiment. The beam signal from AC current transformer and Faraday cup is acquired using high performance data acquisition system. The control system is implemented with PLC, ADC, and EPICS [3] toolkits. In this study, the details on the control system for the low flux irradiation room will be presented.

2. Low Flux Proton Beam Line

The schematic of the new proton beam line for low flux density at KOMAC is shown in Fig. 1.

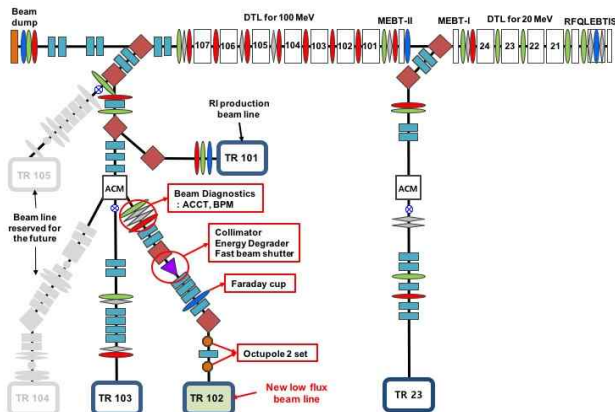


Fig. 1. The schematic of new low flux beam line at KOMAC.

The beam transport system for low flux density consists of a collimator, energy degrader, octupole magnets, 25° and 45° bending magnets, quadrupole magnets, a beam window, and a fast gate valve. For the

beam diagnostics, one stripline-type beam position monitor and an AC current transformer are installed before the collimator. For the low-current beam measurement, a retractable Faraday cup is installed after the collimator. In addition, the fast gate valve is installed to protect the accelerator from a sudden rupture accident of the beam window.

3. Proton Irradiation Facility

The low flux proton facility consists of three rooms; the irradiation room, process room and control room. In the irradiation room, there are some beam diagnostics for beam characterization and sample stage including the 2D array ionization chamber, farmer type ionization chamber, the energy measurement, a beam shutter, and an energy degrader. Figure 2 shows the configuration of proton experiment set up. First of all, a new support frame was installed to rearrange the beam diagnostic devices. Compared with the previous one, a transmission ion chamber and a monitor chamber are added for in-situ flux density monitoring and a new test collimator driven by a radiation-hardened servo motor is produced.

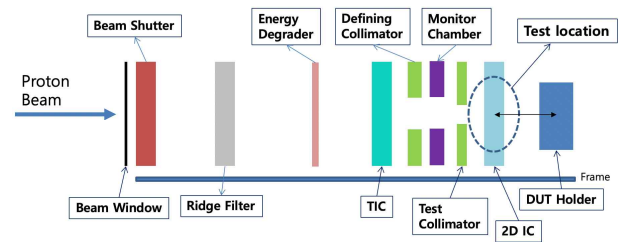


Fig. 2. The configuration of proton experiment set up to upgrade.

4. Data acquisition and control system

The 100 MeV linac at KOMAC is controlled by an experimental physics and industrial control system (EPICS) input-output controllers (IOC) framework. The signals of all beam diagnostics are integrated and controlled in the control room using the EPICS. The operation of pneumatic cylinders and servo motors in the irradiation room can be controlled by programmable logic controller (PLC) and the control status of PLC is also integrated to the EPICS IOCs. Figure 3 shows the

schematic signal flow to control the beam experiment stage and acquire signals from beam diagnostics.

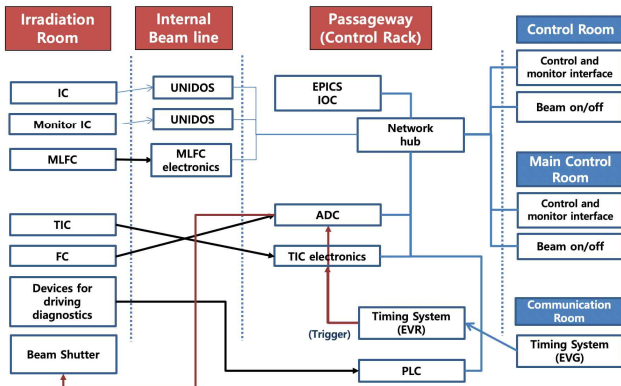


Fig.3. The configuration of control system interface to upgrade.

The cRIO NI 9223 consists of IO modules, including 1MS/ch/s ADC, DI/O, and AI/O as shown in Fig. 4. The cRIO features FPGA-based fast feedback control and 3 DMA FIFOs to use for data transfer.



Fig. 4. NI 9223 cRIO –based data acquisition system

The NI Compact-RIO was chosen for applications of beam diagnostics such as data acquisition of the fluence from the inputs of the fluence measurement devices and control of beam shutter. The FPGA, which samples fluence signal over 50 microseconds from ADC, transfer multiple channels of data through on DMA FIFO using interleaving on FPGA and then decimating the array on the RT processor. The RT processor monitors the fluence from the inputs of the fluence measurement devices and generates a digital output 5 V/TTL signal for driving the beam shutter when the total fluence reaches to the objective value.

Figure 5 shows a user interface to monitor the AC current transformer and Faraday cup, and to accumulate the fluence from the inputs of the fluence measurement devices. The cRIO ADC is synchronized with the timing system for accurate beam sampling.

Beam status needs to share with the main control room using the EPICS control interface. There are several ways to integrate LabVIEW and EPICS to take advantage of the commercially available hardware that are available through LabVIEW. The cRIO-based EPICS server is implemented as plug-ins to the I/O server from LabVIEW RT. Figure 6 shows a user

interface created by Control System Studio (CSS).

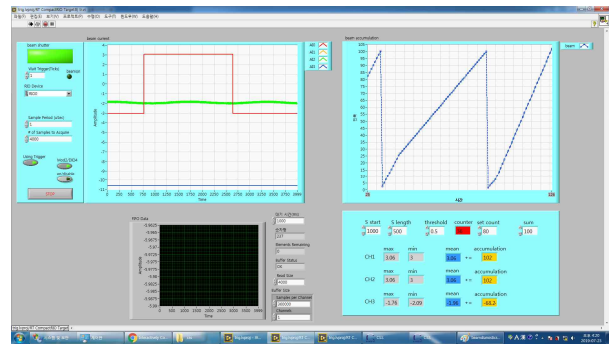


Fig. 5. LabVIEW user interface for monitoring beam current and input signal of a fluence measurement device.

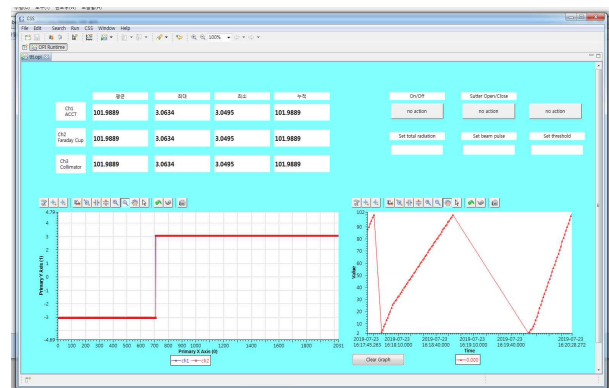


Fig. 6. User interface connected with cRIO EPICS IOC through Channel Access (CA)

5. Conclusion

We have an advantage to running EPICS IOC on cRIO. All beam diagnostics and the sample stage devices are integrated and managed with the EPICS framework. With cRIO, the control system and acquisition system could be developed faster and more deterministic data acquisition system. In addition, we could consider EPICS closed loop control. The cRIO-based data acquisition and control system will be used as general-purpose control system for beam diagnostics and RF signal processing.

REFERENCES

- [1] H.J. Kwon *et al.*, “Design of the 100 MeV Proton Beam line for the Low Flux Application”, in Proc. IPAC’16, Busan, Korea, 2016 p.938.
- [2] S. P. Yun *et al.*, “Initial Operation of the Low-flux Proton Beamline at the KOMAC 100 MeV Linac”, in Proc. IPAC’17, Copenhagen, Denmark, 2017 p.585.
- [3] Experimental Physics and Industrial Control System (EPICS), URL:<http://www.aps.anl.gov/epics>