Data Acquisition System for Monitoring Input Array of Pulse Beams in KOMAC

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1. Introduction

The 100MeV proton linac at the Korea Multi-purpose Acceleration Complex (KOMAC) consists of a 50keV proton injector, a 3MeV radio frequency quadrupole (RFQ), and a 100MeV drift tube linac (DTL). The proton beam is accelerated from 3MeV to 100MeV via 11 DTL tanks. KOMAC installed 10 beam lines, including 5 for the 20-MeV beam and 5 for the 100-MeV beam [1]. The accelerated proton beam from the linac is transmitted to the target room via the beam lines. Figure 1 illustrates the beam diagnostic systems located on the accelerator and beams.

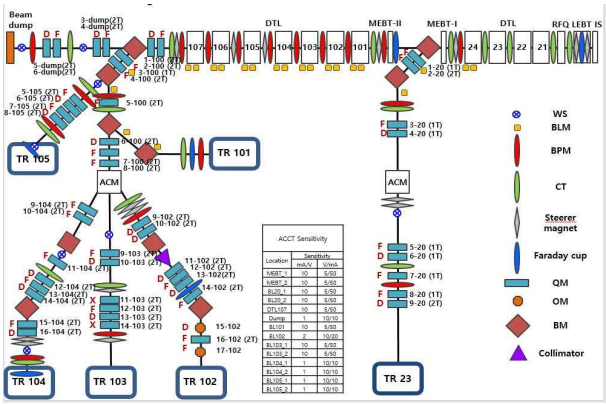

Fig. 1. Beam Diagnostic Layout installed on 100-MeV LINAC and beam lines

A control system is designed to allow beam signals measured at the 100-MeV linac and beam lines to be integrated and managed by remote access. The beam signal types collected from the beam diagnostic systems are processed into scalar and waveform data types. These waveforms should be monitored during beam operation. The data acquisition (DAQ) configuration for monitoring the beam signals consists of three types. The first is that an Experimental Physics and Industrial Control System (EPICS) Input Output Controller (IOC) is used to communicate with oscilloscopes to collect each waveform data in the linac. The second is the use of PCI digitizers to measure beam current and loss signals. The PCI digitizer is connected to a Linux-PC with a PCI slot, and the EPICS IOC requires a related functional library of device drivers. The third is to read waveform signals using an EPICS built-in data acquisition system formed by the System-on-Chip (SoC) architecture to measure beam signals in the beam lines [2].

This paper describes the implementation of DAQ systems for remotely monitoring beam signals.

2. Configuration of DAQ system with EPICS

The DAQ system with EPICS has been developed and applied to both linac and beam line control systems. The system configuration of the DAQ is shown in Fig 2.

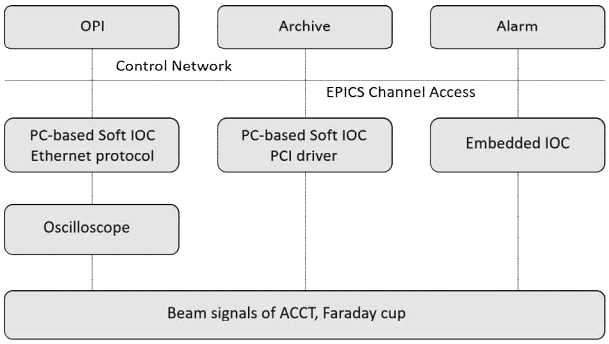

Fig. 2. System configuration for collecting beam signals

2.1 Data acquisition using Oscilloscopes

The oscilloscope has been adopted to monitor the waveforms and parameters in the beam signal. The PC-based platform with the Linux operating system is set up as a soft IOC that is connected to the oscilloscope via an Ethernet interface. The VIPC protocol to communicate with Ethernet-based oscilloscopes is integrated into EPICS. The soft IOC can read channel parameters of oscilloscopes. To capture waveforms, a Virtual Network Computing (VNC) is adopted. The VNC is a graphical desktop sharing system that remotely controls the oscilloscope using the Remote Frame-Buffer (RFB) protocol for remote monitoring of beam signals and high frequency signals. To implement EPICS support for VICP/Ethernet-based oscilloscopes, device support is built to communicate the oscilloscope with device drivers. The associated record support was generated using a link to device support.

2.2 PCI-based data acquisition

The DAQmx, PCI-6143 digitizer has up to 3 MSPS sampling rates per channel and 16-bit vertical resolution. It supports 8 input channels and external trigger inputs. The PCI-6143 digitizer is available in the PCI slot as shown in Fig 3, and PCIe is integrated on the PC platform. The Linux PC with PCI-6143 is an EPICS IOC for developing waveform support using the manufacturer support driver. The digitizer stores the acquired data in the onboard data FIFO and then

transfers the data to the custom DMA buffer memory in the EPICS IOC. The sampled data is available on EPICS devices and drivers that interface with PCI ADC cards over the PCI bus and include dedicated equipment controllers that support data processing and waveform data generation.

Fig. 3. PCI-based data acquisition system with DAQmx, PCI-6143 digitizer

2.3 Embedded data acquisition

The Libera Digit 125 digitizer shown in Fig. 4 is based on the Xilinx ZYNQ SoC family, which provides power over Ethernet (PoE standard) at low power consumption [3]. The Digit 125 digitizer 14 bit 125 MSPS supports four concurrent channels. Four Digit 125 data acquisitions were applied to linac and beam line control systems. This is used to monitor ACCT and faraday cup signals in linac and beam lines for a long time

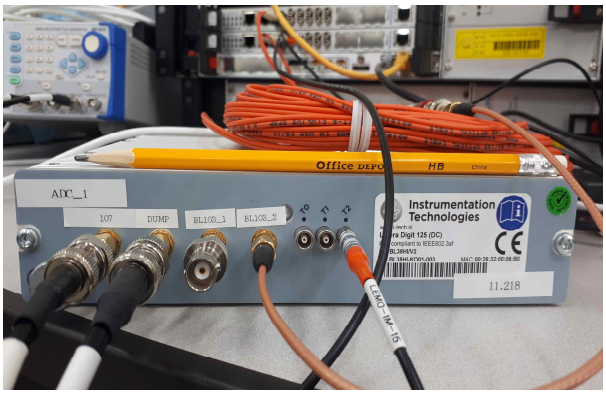

Fig. 4. Libera Digit 125 for beam current monitoring

The Digit 125 provides the ability for users to program their environment. The configuration of the digitizer is 100 MSPS sampling and 1 MB memory per channel to monitor beam waveforms up to 8 Hz beam repetition rate. The size of the CA array for the beam waveform monitor is 30,000, which is capable of 300 μS beam waveform monitoring.

A graphic user interface (GUI) has been designed to monitor the required waveforms, as shown in Fig 5, and waveform observations incorporate the Digit 125 digitizer and EPICS framework, which replaced the existing oscilloscope. The CS-Studio application was applied to operate and monitor accelerator and beam line control systems. The CSS user interface generates statistical parameters of beam waveforms and input arrays as shown in Fig. 5. The user interfaces are supported and operated in the console environment of the KOMAC control system.

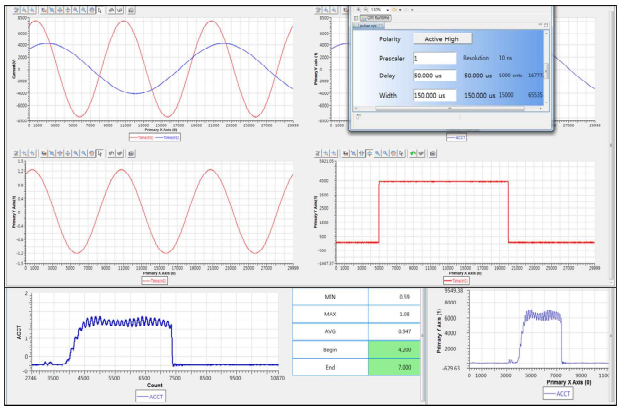

Fig. 5. User interface of monitoring waveform and generating statistical parameters of an input array

3. Conclusion

The data acquisition systems are implemented to collect beam signals. For Ethernet-based oscilloscope signal acquisition, EPICS IOC and VNC were applied. To use PCI digitizer, a PCI digitizer was installed on a Linux PC to monitor beam waveforms. We also recently applied Libera SoC digitizer to monitor and analyze real-time waveforms. All beam signals are monitored and archived through the user interface over the accelerator network.

REFERENCES

[1] Yong-Sub Cho, Hyeok-Jung Kwon, Dae-Il Kim, Han-Sung Kim, Jin-Yeong Ryu, Bum-Sik Park, Kyung-Tae Seol, Young-Gi Song, Sang-Pil Yun, and Ji-Ho Jang, “The Komac Accelerator Facility,” Proceeding of International Particle Accelerator Conference, Shanghai, China, 2013.
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[3] Libera Digit 125, http://i-tech.si.