Development of the Data Acquisition System for the Beam Current Monitoring System at the KOMAC Proton Linac

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1. Introduction

Beam current monitoring is one of the most critical diagnostic functions in proton linear accelerators. It provides essential information for accelerator tuning, beam transmission efficiency evaluation, and machine protection. At the KOMAC proton linac, pulsed proton beams are accelerated up to 100 MeV with repetition rates of up to 60 Hz, and lower energy sections operate at higher repetition rates, such as 120 Hz at 20 MeV. Accurate and reliable measurement of beam current is required across all operating conditions. AC Current Transformers (ACCTs) are widely used for non-destructive beam current measurement. These devices generate voltage signals proportional to the time-varying beam current. However, to extract accurate beam current information, the analog signals must be acquired with sufficient sampling speed, resolution, and synchronization with beam timing signals. To address these requirements, a DAQ system based on the LIBERA ADC platform has been adapted [1]. The LIBERA ADC provides high-speed sampling capability, flexible EPICS integration, and waveform-based data acquisition [2]. Additionally, advanced signal processing techniques have been implemented within the EPICS framework to convert voltage signals into calibrated beam current values and analyze waveform characteristics.

2. System Overview

The beam current monitoring system consists of ACCT sensors, analog signal conditioning components, the LIBERA ADC module, and an EPICS-based control and data processing system. The ACCT sensors installed along the linac and beamlines as shown in Fig. 1 generate voltage signals proportional to the beam current. These signals are transmitted through coaxial cables to the LIBERA ADC input. The LIBERA ADC digitizes the analog voltage signals at a sampling rate of 10 MHz. The digitized waveform data are transferred to the control system via EPICS drivers, where signal processing and analysis are performed. The processed data are then made available for real-time monitoring, archiving, and accelerator control applications. The overall system enables continuous monitoring of beam current waveforms, peak current, pulse shape, and integrated charge.

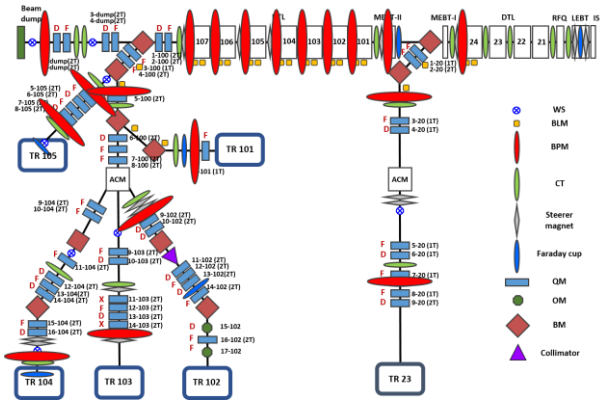

Fig. 1. Beam diagnostics installed along the linac and beamlines at KOMAC

3. Hardware Configuration

The hardware configuration is centered on the LIBERA ADC system as shown in Fig. 2, which provides high-performance analog signal acquisition. The LIBERA ADC has an input impedance of 1 MΩ and an input voltage range of ±1.2 V, allowing direct acquisition of ACCT output signals.

Fig. 2. Hardware using LIBERA ADC Digitizer system

To ensure compatibility with the expected signal amplitude and to protect the ADC input stage, a 1/10 voltage divider is used between the ACCT output and the LIBERA ADC input. This configuration reduces the signal amplitude while preserving signal fidelity. The ADC sampling rate of 10 MHz provides sufficient temporal resolution to capture detailed beam pulse structures. Given the typical pulse widths and repetition rates of the KOMAC proton linac, this sampling rate enables accurate reconstruction of the beam current waveform. The ACCT sensors produce voltage signals proportional to the beam current based on their calibration constants. These voltage signals are

transmitted with minimal distortion to the ADC input, ensuring accurate digital representation of the beam current profile.

4. EPICS-based Data Acquisition and Processing

The EPICS framework is used to interface with the LIBERA ADC and process the acquired waveform data. The LIBERA ADC is integrated into the EPICS environment through a dedicated EPICS driver, which provides waveform records representing the digitized voltage signals. Fig. 3 shows the installation of the DAQ systems at KOMAC klystron gallery.

Fig. 3. Installation and operation of LIBERA ADC and EPICS

To convert the acquired voltage signals into beam current values, EPICS aCalcout records are used. The aCalcout record performs mathematical calculations on waveform data [3], applying calibration constants and scaling factors. The conversion process accounts for the ACCT sensitivity and the voltage divider ratio, enabling accurate beam current reconstruction from the measured voltage waveform. The aCalcout record performs this calculation automatically in real time, producing beam current waveform data from the raw ADC voltage waveform. In addition to current conversion, waveform analysis is performed using waveAnl records. The waveAnl record provides advanced waveform processing capabilities [4], including peak detection, average calculation, integration, and statistical analysis. These functions enable extraction of key beam parameters such as peak current, pulse duration, and integrated beam charge. The waveform analysis is performed automatically upon acquisition of each beam pulse, ensuring real-time availability of beam diagnostics information.

5. System Operation and Performance

The developed DAQ system operates synchronously with the beam repetition rate. At repetition rates of 20 Hz, 60 Hz, and higher, the LIBERA ADC reliably acquires waveform data without data loss. The high sampling rate ensures accurate reconstruction of fast beam pulse structures. The use of EPICS-based processing provides flexibility and scalability. The aCalcout records enable precise conversion of voltage signals into beam current values, while the waveAnl records enable detailed waveform analysis without requiring external data processing software. The system provides stable and repeatable measurements over extended operation periods. The high input impedance of the LIBERA ADC minimizes signal distortion, and the voltage divider ensures safe operation within the ADC input range. Real-time visualization of beam current waveforms allows operators to monitor beam stability and detect abnormal conditions. The processed beam current data can also be archived for long-term analysis and performance evaluation.

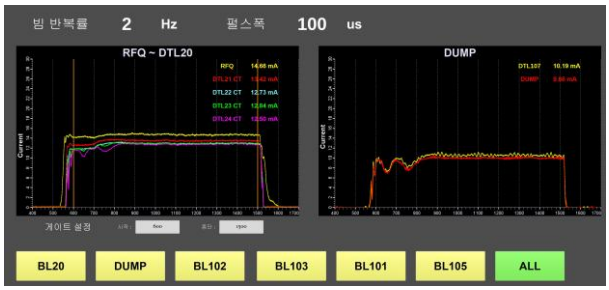

Fig. 4. Beam current monitoring by using CS-Studio.

5. Conclusions

A high-performance data acquisition system for beam current monitoring has been successfully developed using the LIBERA ADC and ACCT sensors at the KOMAC proton linac. The system provides accurate and reliable acquisition of beam current waveforms with a sampling rate of 10 MHz and supports beam repetition rates of up to 20 Hz. The integration of the LIBERA ADC with the EPICS control system enables real-time data acquisition, signal conversion, and waveform analysis. The use of aCalcout records allows precise conversion of voltage signals into beam current values, while waveAnl records provide advanced waveform analysis capabilities. The developed system improves beam diagnostics capability, enhances operational reliability, and provides a flexible platform for future upgrades. The successful implementation demonstrates that the LIBERA ADC combined with EPICS provides an effective solution for high-resolution beam current monitoring in proton linac applications.

Acknowledgement

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