DEVELOPMENT OF THE CONTROL SYSTEM FOR PEFP 100 MeV PROTON LINEAR ACCELERATOR*

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Abstract

The 100 MeV proton linear accelerator of the Proton Engineering Frontier Project (PEFP) has been developed and will be installed in Gyeong-ju site. After the installation, the beam commissioning of the 100 MeV linac will be performed. The PEFP is currently developing control systems including the machine control system and user interface for remote control and monitoring. The final goal of the PEFP control system is to construct a network attached, distributed control system, and a standard communication protocol among the local subsystems. In this paper, we will present the details of the distributed control system development for PEFP 100 MeV proton linac.

INTRODUCTION

Proton Engineering Frontier Project is the 100 MeV proton linac development project which was launched at 2002 as a 21st century frontier R&D program of Korean government [1, 2]. The final goals of the project are constructing a proton linear accelerator with the final energy of 100 MeV and the peak beam current of 20 mA, developing technologies for the proton beam utilizations and the accelerator applications, and promoting industrial applications with the developed technologies.

The PEFP 100 MeV proton linac consists of two parts as shown in Fig. 1. One is the low energy components including a 50 keV ion source, a low energy beam transport (LEBT), a 3 MeV radio frequency quadrupole (RFQ), and a 20 MeV drift tube linac (DTL). The other part is the high energy components including seven DTL tanks which accelerator proton beams from 20 MeV to 100 MeV. The PEFP experiment hall includes 10 beam lines, 5 for 20 MeV beams and 5 for 100 MeV beams. One of the main characteristics of PEFP beam lines is using AC magnet to distribute proton beams into 3 target rooms in both 20 MeV and 100 MeV beam lines.

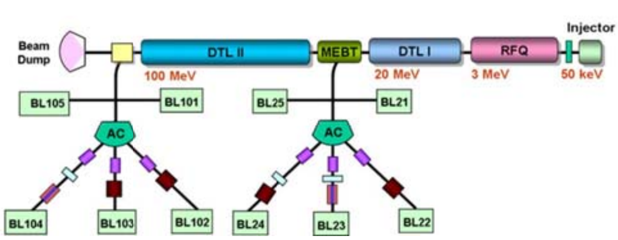

Figure 1: PEFP 100 MeV linac and extraction beam lines.

The 20 MeV linac has been successfully installed and tested at the Daejeon site of Korea Atomic Energy Research Institute (KAERI). In this operation of the linac from 2007 to 2011, the 20 MeV linac control systems were used to control and monitor the facility for 5 years. The control system consists of ion source, vacuum, magnet power supply, and low-level RF. The 20 MeV linac control systems have been disintegrated and moved to Gyeongju site. Some of the control systems for 20 MeV linac will be expanded for 100 MeV proton linac and the control systems including vacuum, beam monitoring, and timing are upgraded. There are also many tools that can be used to make operator interface and to make an archiving system.

CONTROL SYSTEM OVERVIEW

For the networked control system, network architecture is very important as a key infrastructure which dominates total performance. Backbone switches and workgroup switches are installed as shown in Fig. 2. The remote control systems of the local devices should be connected to a local control network for Ethernet communication. Most control systems are developed with VME-based IOCs which include VME I/O boards and VME PMC boards. The integrated operation will be realized by the network connections and by the interactions among control systems.

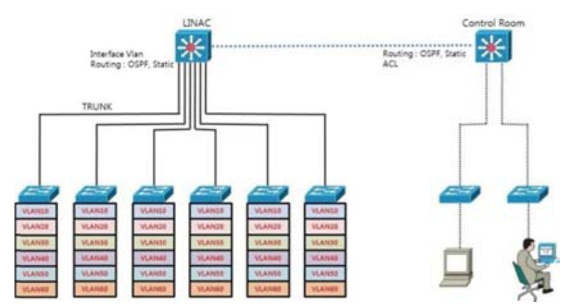

Figure 2: Schematic diagram of network architecture for PEFP 100 MeV proton linear accelerator.

The verified development tools, control infrastructure, and efficient maintenance are requirements for the PEFP software development tool. The EPICS tool provides the Channel Access (CA) communication protocol to make TCP/IP connections and transfer process variables among controllers [3, 4]. Figure 3 shows the schematic layout for the PEFP control system which is based on local control network, interlock network, and timing network. Most of communication is based on CA proton for a distributed control system.

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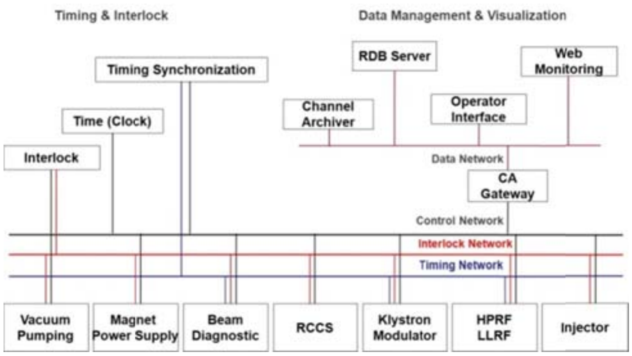

Figure 3: Block diagram of networked control system.

Timing System

The 20-MeV timing system is composed of pulse delay generators, including DG535 from Stanford Research Systems, BNC565 from Berkeley Nucleonic Corporation, and fan-outs that distribute a trigger delivered from the delay generator. The stability can be improved by changing the DG535 from an internal to an external reference signal of a 10-MHz reference clock supplied by the master oscillator. However, this timing system has a defect providing the fixed clock and trigger from a pulse delay generator. This means the fan-out distributes a fixed delay and width of the timing signal received from a delay generator, with is not changeable on each channel. The timing system is required to improve the performance and functionality to deliver the diverse timing signals to the accelerator facility and beam lines.

Hence, we decided to upgrade the timing system for efficiency and reliability. Basically the timing system provides clock synchronization, RF gate generation, beam gate generation, triggering for beam diagnostics, and AC magnet gate generation. MRF event timing system has been decided as a main timing system, which can be triggered out of different clocks with a very low jitter. The event system consists of a VMEEVG-230, seven VME-EVR-230RFs with RF recovery, a VME-FOUT-12, TTL, and optical fiber output modules. Figure 4 shows a schematic layout of the timing system using MRF event system.

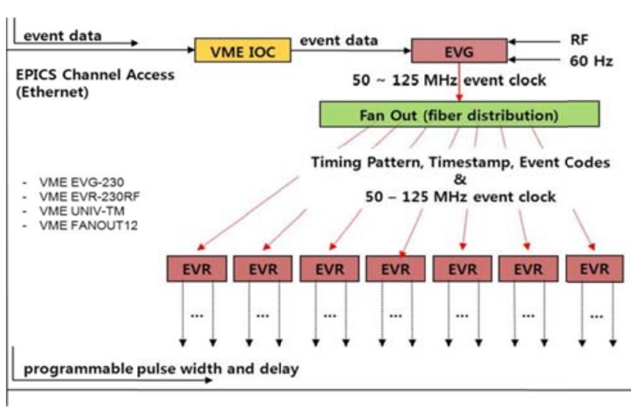

Figure 4: Architecture of upgraded timing system.

The event system has various types of outputs to avoid external level converters. Most triggers require TTL levels terminated into 50 Ω and a few optical links. All triggers should have a low jitter performance of a few hundreds of picoseconds.

Data Acquisition

The proton linac has various electronic devices, such as beam current monitor (BCM), beam position monitor (BPM), and beam loss monitor (BLM). The Log-ratio BPM electronics module of the Bergoz Instrumentation directs beam position from the pickup signals. The signal from the BPM is through the 350 MHz band pass filter and signal divider for measured beam phase, after then the x-axis and y-axis position signals are produced from electronics modules. At 100MeV proton accelerator operation, 12 BLM are installed to inform the beam loss to operator and transmit the signal to the MPS (Machine Protection System).

For data acquisition, Industrial Pack (IP) ADC boards are adopted. The IP ADC has the specification like 16 bit resolution, 16 channel, and Max 200k sampling rate. A VME carrier board makes it possible to equip a total of four IP ADCs. The ADC can process a total of 64 input signals. Figure 5 shows schematic layout for beam monitoring.

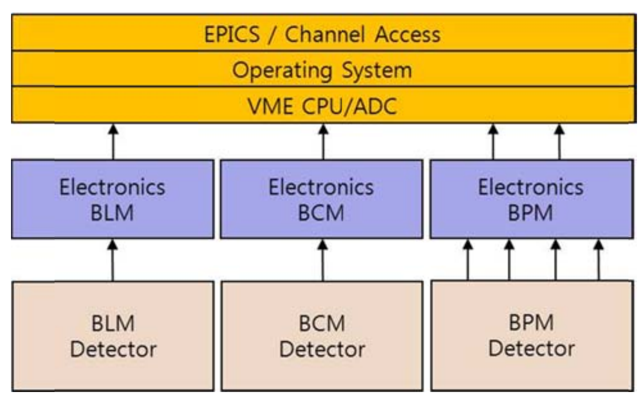

Figure 5: Schematics layout of EPICS system for beam monitoring.

Application Software

In the control room, console machine must support several functions for the linac remote operation and the entire management. The PEFP operator interface systems support the remote control and monitoring of the operation parameters from the local control systems, such as beam, radio frequency, vacuum, magnet power supply, cooling, ion source, etc.

For 20 MeV linac operations, EPISC Extensions tools were used as shown in Fig. 6. It includes EDM, Strip tool, and ALH. The storage system was based on MySQL and Web viewer using EPICS command line tool as shown in Fig. 7.

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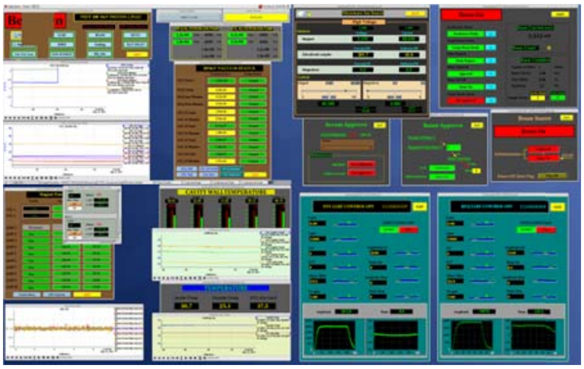

Figure 6: Operator interfaces for 20-MeV proton linac.

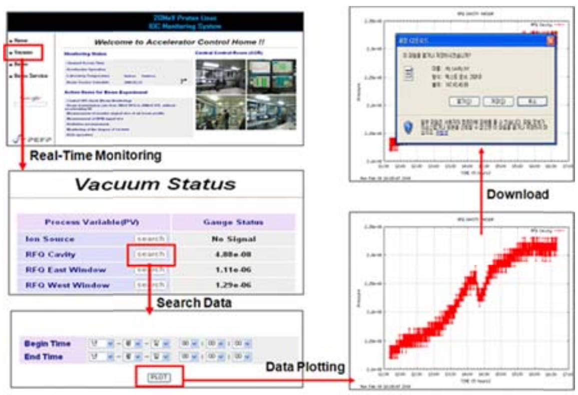

Figure 7: Web viewer for 20-MeV proton linac.

For the PEFP proton linac operation, an eclipse-based Control System Studio (CSS) will be used [5]. We have studied how the CSS can be used for the operator interfaces and which features in CSS can be used for specific control requirements. The RDB Archiver with MySQL and the alarm viewer using CSS is under test as shown in Fig. 8 and 9.

To reduce communication traffic on the control network, OPIs and IOCs are connected by using the CA gateway [6]. Internally, the CA gateway makes a virtual connection to reduce the number of CA connections on the EPICS IOC.

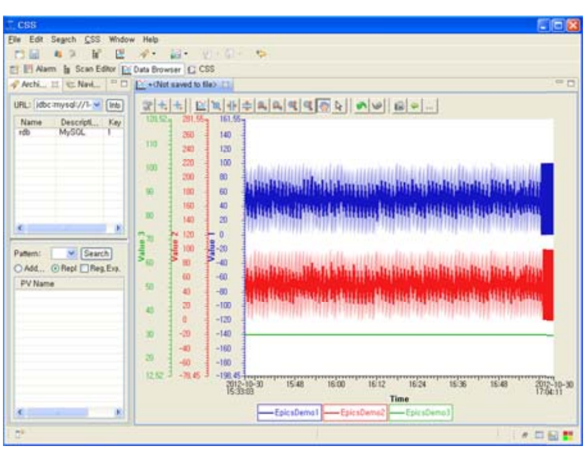

Figure 8: CSS viewer with RDB and archive engine.

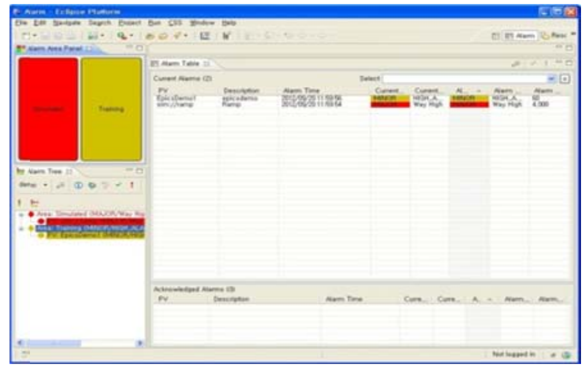

Figure 9: CSS alarm viewer.

The PEFP control system using the EPICS CA protocol allows operators in the control room to focus an accelerator operation and control management easily and efficiently.

CONCLUSION

The 20 MeV linac control system was developed to operate the linac for 5 years and debugged and upgraded for 100 MeV linac control system. The 20 MeV linac control systems have been extended for the PEFP 100 MeV proton linac. The 100 MeV proton accelerator control system has been developed with EPICS tool. All of the IOCs can be integrated by using CA protocol. There are also new control system like timing system and beam monitoring system. The control system will be commissioned and used for beam commissioning. In the future, the control system will be continually managed and upgraded.

ACKNOWLEDGEMENTS

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