PRELIMINARY IMPLEMENTATION FOR RF AND BEAM CURRENT MONITOR USING EPICS*

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Abstract

The Proton Engineering Frontier Project (PEFP) is constructing a 100-MeV proton Linear Accelerator (Linac), consisting of a 50-keV proton injector, Low Energy Beam Transport (LEBT), a 3-MeV Radio Frequency Quadrupole (RFQ), a 20-MeV Drift Tube Linac (DTL), 100-MeV DTL, and beam lines [1].

In order to monitor signals measured from RF and beam components equipped to the 20-MeV proton linac, the commercial DSO (Digital Sampling Oscilloscopes (DSO) are equipped. The signals which are measured from the DSOs must be calibrated and transmitted promptly to accelerator operators. LabVIEW as Windows PC-based software, which equipped with various Virtual Instruments Software Architecture (VISA) interface as a standard I/O language for instrumentation programming, was chosen to do this data acquisition. On the other hand the LabVIEW was built with Experimental Physics and Industrial Control System (EPICS) middleware [2, 3]. In this paper, preliminary design and implementation of EPICS based software for the RF and Beam Current Monitoring (BCM) will be described.

INTRODUCTION

The remote monitoring system for RF and BCM is required to focusing operator's attention for the facility operation. To measure RF and beam signals from components of a 20-MeV proton accelerator, DSOs are equipped. The measured signals must be transmitted to operators for remote operation from a control room. The measured signals must be integrated with operation parameters. All DSOs have TCP/IP protocol based Ethernet interface. So, in order to minimize the development period and cost, National Instruments (NI) LabVIEW software is chosen as a graphic programming language in the first stage. To interface operation parameters with EPICS Input Output Controllers (IOC), LabVIEW based EPICS IOC is adopted. The description and results of the monitoring system are given in this paper.

MEASUREMENT ENVIRONMENT

In order to measure the beam current by current transformers (CT) and monitor RF signals driving SSA, forward, reverse, and cavity, the commercial digital sampling scopes are chosen. The schematic layout for RF and BCM measurement is shown in Fig. 1, 2.

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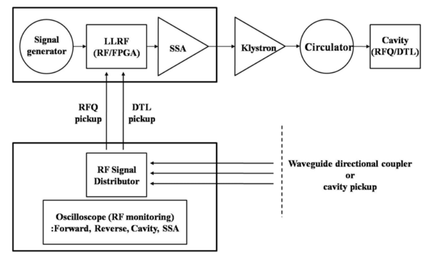

Figure 1: Diagram of RF system for the 20-MeV Linac.

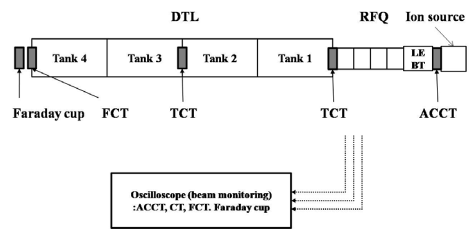

Figure 2: Diagram of beam current transformer and measurement system for the 20-MeV Linac.

The DSO setups for signal measurement of RF and BCM are shown in Table 1. The setup of the DSOs shows wide bandwidths of transmission data via Ethernet.

Table 1: Oscilloscope Setup Value for RF and BCM

	DSO	vertical [mV/div]	horizontal [us/div]	offset [mV]	MS/s	kS
RFQ forward, reverse, pickup, SSA	LeCroy 6030A	200	10 (delay: 120us)	-600	500	100
DTL forward (T1, T2,T3 ,T4)	LeCroy 104MXi	100	50	-300	500	250
DTL reverse (T1,T2, T3, T4)	LeCroy 104MXi	200	50	-600	500	250
DTL pickup (T1,T2, T3, T4)	LeCroy 6030A	100	50	-300	100	100
DTL klystron forward, reverse, SSA	TDS 7104	100 50 200	40	-300 -150 -600	250	100
ACCT, CT, Faraday cup, FCT	TDS 5054B	500 200 500 200	40 (delay: 100us)	500 0 1500 -400	1250	500

Because RF and beam signals are important variables for accelerator operation, the signals have to be transmitted to application tools and displayed on a monitoring system.

MONITORING SYSTEM

LabVIEW Software

The monitoring systems use the 2 PCs, 1 hub, 4 monitors and 6 oscilloscopes (TDS 7104, TDS 5054B of Tektronix and two WaveRunner 6030 and two WaveRunner 104MXI of Lecroy). The LabVIEW host PCs consist of Ethernet for communication with oscilloscopes as shown in Fig. 3.

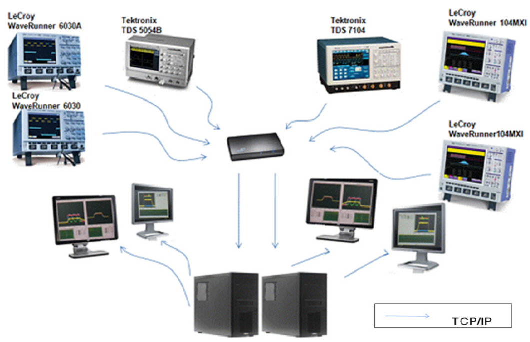

Figure 3: Diagram of LabVIEW based software structure.

The display functions based on LabVIEW are as follows:
- *BCM*
  - Monitor waveform data of 4 channels from each DSO.
  - Monitor voltage and current values about ACCT, CT1 , Faraday cup, and FCT.
  - Keep count of more than minimum current up to total number.
  - Save the current and ratio of FCT/CT1.
- *RF*
  - Monitor the 4 channel of waveform and chart type abo ut RF forward, reverse, cavity pickup, SSA, RFQ pick up and DTL tanks pickup respectively.
  - Use the Vi of Tektronix which is composed of four ch annels.
  - Applied the calibration for current value

LabVIEW provide easy way to design user interface. Figure 4 shows monitors to display RF and beam signals.

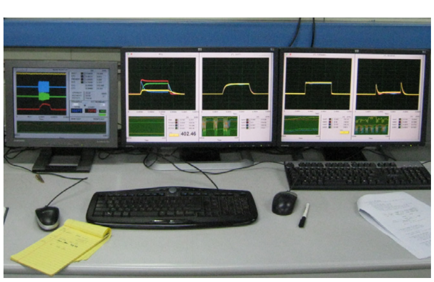

Figure 4: Display monitors of RF and BCM using LabVIEW user interface.

Shared Memory Interface to EPICS IOC

To interface RF and beam signals to facility control parameters, EPICS toolkit was adapted. The EPICS real-time software is a client/server model based on EPICS Channel Access (CA) protocol. All components of the PEFP facility can be integrated through the distributed controllers into the control network. The Shared Memory Interface linking LabVIEW variables to EPICS IOC process variables was developed by ORNL-SNS [2]. The monitoring system for RF and BCM is built on LabVIEW and EPICS based rack-mounted PC. The scope data acquisition must be integrated into EPICS variables. Fig. 5 describes schematic diagram of the LabVIEW based EPICS IOC using Shared Memory Interface.

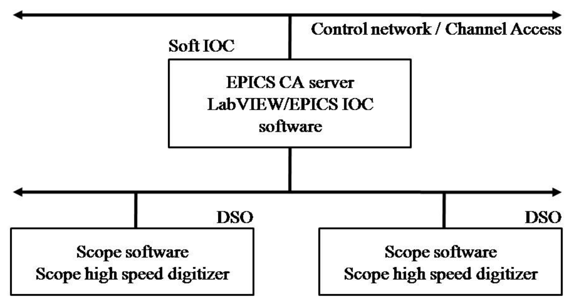

Figure 5: Diagram of EPICS based software structure.

The LabVIEW/EPICS IOC solution consists of device and record support, such as analog input (ai), analog out (ao), binary out (bo), and waveform as shown in Fig. 6. Figure 7 shows user interface as a server and a client. This way provides remote monitoring and control for beam operation.

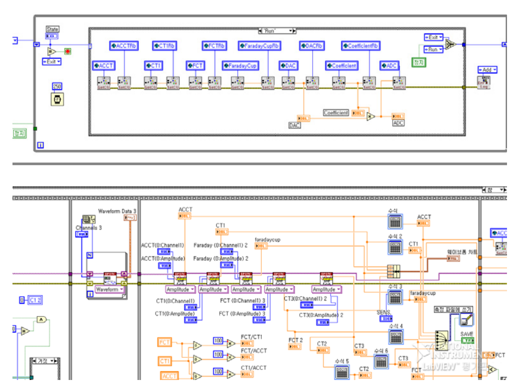

Figure 6: LabVIEW VI diagram using LabVIEW/EPICS shared memory interface.

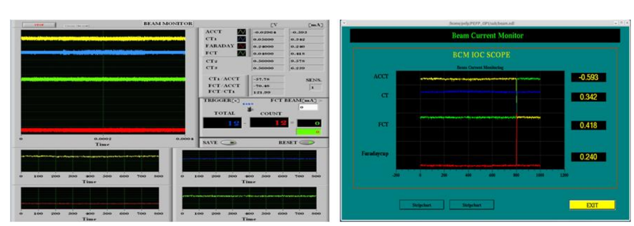

Figure 7: LabVIEW GUI and EPICS EDM panel.

As an improved method for integrating the control points, the architecture of the distributed control system using EPICS was adopted. The measured data by the digital sampling scopes are integrated to the EPICS based SoftIOC.

PXI EPICS IOC

The monitoring system need to measure beam and RF operation at high repetition rate. Therefore, the PC based system must be improved. That is because the PC based system isn't synchronized with operation gate signal and have low repetition. So, National Instruments (NI) PCI eXtension Instrumentation (PXI) system was considered as an upgrade system. BCM data is acquired via Analogue to Digital Converters (ADC). NI PXI adopted for upgrading the PC-based monitoring system is shown in Fig. 8. As a compact embedded IOC, EPICS Shared Memory Interface and LabVIEW Datalogging and Supervisory Control (DSC) module will be considered as shown in Fig. 9.

The NI PXI 5105 high-resolution digitizer has following features:

- 8 channels simultaneously sampled at 12-bit resolution
- 60 MS/s real-time sampling
- 60 MHz bandwidth
- 512 MB of onboard memory
- Edge, window, and digital triggering

Figure 8: NI PXI for monitoring RF and BCM

In order to implement a compact EPICS IOC, NI PXI system consists of following modules:

- NI-SCOPE driver
- LabVIEW Express VIs
- DSC EPICS server I/O module

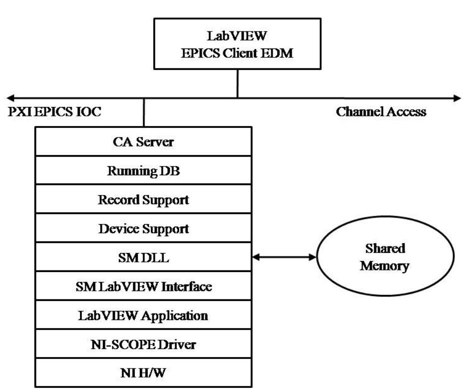

Figure 9: Schematic diagram of software modules using PXI NI-SCOPE and LabVIEW EPICS IOC scope

CONCLUSION

As a very powerful system, DSOs were equipped for measuring operation parameters of the facility. At low repeated operation, Network based monitoring system provides a possibility. The LabVIEW based EPICS Shared Memory IOC on the rack-mounted PC supports portable way to be connected with other operation parameters through EPICS CA protocol. But the reason that the PC based system isn't synchronized with operation gate signal and have low repetition requires the current monitoring system upgraded. So, NI PXI EPICS IOC will support commissioning and operation as a prototype of the monitoring system for the PEFP 100-MeV facility.

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