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LANSCE QAC/DAQ WIRE SCANNER INSTRUMENTATION UPGRADE*

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Abstract

High density instrumentation has been developed to upgrade wire scanner beam diagnostic capability in all areas downstream of the Coupled Cavity (CCL) LINAC (Linear Accelerator). Transverse beam profile measurements were originally obtained using legacy electronics known as Computer Automated Measurement and Control (CAMAC) crates. CAMAC has become obsolete, and a new wire scanner diagnostic system was developed as a replacement. With high wire scanner device density located in each area, instrumentation was developed to meet that need along with the ability to interface with legacy open-loop controlled actuators and be forward compatible with upgraded closed-loop systems. A high-density system was developed using a Quad Actuator Controller (QAC) and Data Acquisition (DAQ) chassis that pair together using a sequencer when taking measurements. Software improvements were also made, allowing for full waveform functionality that was previously unavailable. Deployment of 52 wire scanner locations in 2022 increased device availability and functionality across the facility. Hardware and software design details along with results from accelerator beam measurements are presented.

INTRODUCTION

Legacy diagnostic instrumentation used at the Los Alamos Neutron Science Center (LANSCE) have become obsolete with no readily available spares for CAMAC systems. Because of the density of devices downstream of the CCL a high-density solution was needed.

A new wire scanner instrumentation system has been developed and implemented by the LANSCE controls hardware team to replace CAMAC and interface with legacy devices. Software was developed to interface the old devices with the new hardware, primarily the embedded and client software.

SYSTEM OVERVIEW

Wire scanners are electro-mechanical beam interceptive devices that provide cross-sectional beam profile measurements that describe beam shape and position. A wire scanner system consists of an actuator to drive the sense wires across the beam, and data acquisition to obtain the waveform data from the current induced by the proton beam impinging on the wire. The wire scanner hardware architecture diagram is shown in Fig. 1.

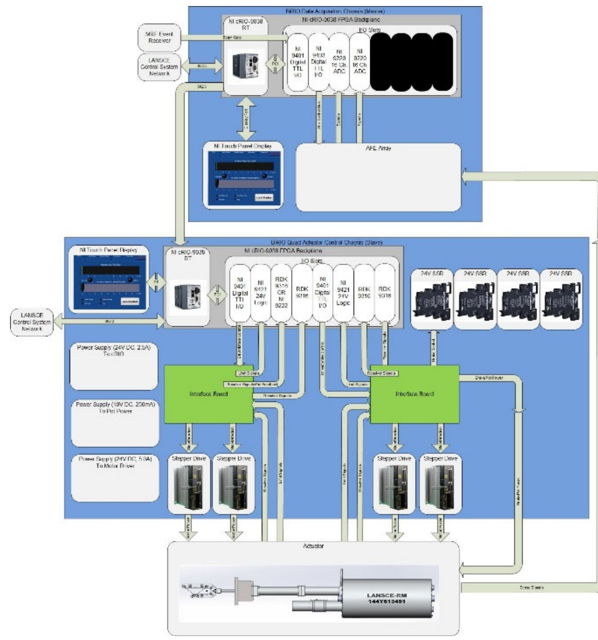

Figure 1: Wire scanner hardware diagram.

CONTROLLER HARDWARE

The electronic hardware consists primarily of two separate chassis, each controlled using a National Instruments (NI) 9038 compact Reconfigurable Input/Output (cRIO) packaged in 4U rack mountable enclosures configured as input output controllers (IOC). The QAC chassis controls the wire scanner actuators, and the DAQ chassis is used for data acquisition from the beam induced current on the wire.

Quad Actuator Controller

The QAC chassis was designed to control up to four stepper motor actuators, two actuators simultaneous. The chassis is compatible with both open loop and closed loop motion control to be forward compatible with potential actuator upgrades to resolver position closed loop control as was done on the LANSCE risk mitigation project [1].

Within the cRIO controller on the QAC is housed NI I/O modules, and serve as the interface between the wire scanner actuator and the cRIO and perform the functions as follows:

- NI 9401 digital I/O for stepper motor and brake control
- NI 9421 sinking digital input for limit switch indication
- NI 9222 voltage input potentiometer position feedback, for open loop control
- RDK 9316 resolver to digital converter, for closed loop only

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In addition to the cRIO, the QAC chassis consists of four stepper motor drivers, four solid state relays for electrically released brake, two signal distribution boards, a touch display, 10V potentiometer power supply and 24V power supplies for the cRIO and actuator power. The QAC chassis is shown in Fig. 2.

Figure 2: QAC chassis.

Data Acquisition

The DAQ chassis is capable of 32 channel, 100 kS/channel, simultaneous waveform acquisition (10µs resolution) with a compact Peripheral Component Interconnect backplane with two high density 16 channel each, gain adjustable, 2 kΩ input impedance Analog Front End (AFE) conditioning card capable of reading from 270 µA down to 3 µA current levels [2]. The NI I/O modules installed into the cRIO consist of an NI 9403 for AFE gain setting, two NI 9220 digitizers, and an NI 9401 digital I/O for beam gate input. The DAQ chassis is expandable from 32 channels to 80 by adding AFE cards and 9220 digitizer modules depending on the area device density.

Sequencer

A sequencer was implemented as a soft IOC to coordinate motion and data acquisition between the QAC and DAQ hardware during a scan. The sequencer also sets all scan parameters for the measurement. When in scan mode the sequencer initiates the scan, awaits a beam gate trigger, and acquires the waveform for that beam pulse, commands the next actuator position and repeats until a scan is completed.

BEAM MEASUREMENT RESULTS

Beam profile measurements were taken using Long Bunch Enable Gate beam, set to 4 Hz rep rate with 150 µs beam length. As shown in Fig. 3, a Gaussian profile was obtained.

The full waveform can be seen in Fig. 4 for the same scan taken in Fig. 3. Each trace is a waveform from a separate beam pulse as the wire scanned across the beam.

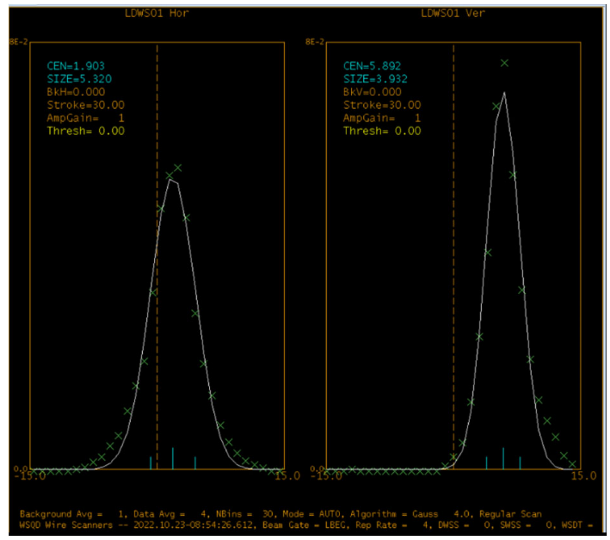

Figure 3: Vertical and Horizontal Axis Beam Profiles.

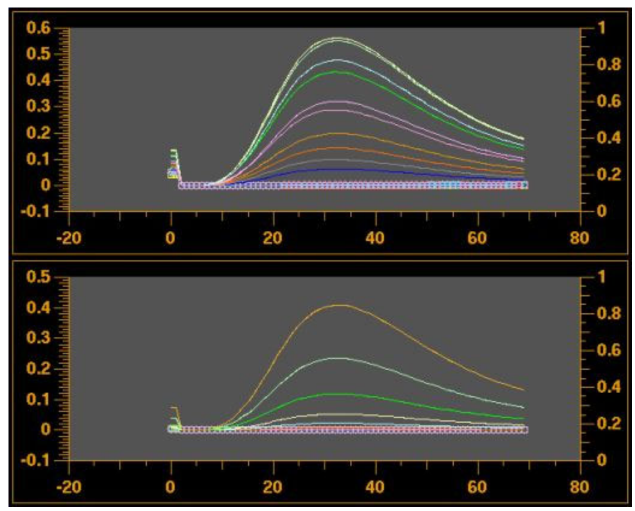

Figure 4: Vertical and horizontal axis waveform.

Challenges

The challenge encountered during development was insufficient gain on the 2K AFE in obtaining data from Micro Pulse Enable Gate (MPEG) beam. To mitigate the lack of gain, legacy transimpedance amplifiers were used in a dual stage amplification in conjunction with the 2K AFE which was sufficient in providing the amplification needed to obtain beam profile waveforms.

A transimpedance AFE was implemented to accommodate the wider gain range and allow for dependence on legacy amplifiers to no longer be needed. [3]

CONCLUSION

All 52 wire scanner locations have been successfully upgraded with each device tested and validated with beam, providing beam profile measurements for each location this past run cycle during the 2022 calendar year.

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