THE WIRE SCANNER CONTROL SYSTEM FOR C-ADS INJECTOR-II*

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Abstract

In order to measure the beam profile in the 5 MeV test CW linac of C-ADS (China Accelerator Driver System) project, a wire scanner system was designed and tested at Institute of Modern Physics (IMP). In this paper, the mechanical design and control system of this wire scanner system are introduced. A real-time, closed loop control system is being developed and tested for more repeatable and accurate positioning of beam sense wires. All of the electronic and computational duties are handled in one National Instruments compact reconfigurable input/output (cRIO) real-time chassis with a Field-Programmable Gate Array (FPGA). This control system was tested at IMP 320 kV beam line and works well.

INTRODUCTION

The C-ADS project [1] is a strategic plan to solve the nuclear waste problem and the resource problem for nuclear power plants in China. The layout of C-ADS project is shown in Fig. 1. The first phase itself will be executed progressively in several steps, with the first step to build two 5-MeV test stands of different front-end designs. Therefore, two different approaches of injector will be developed in parallel by two different teams, with IHEP (Institute of High Energy Physics) for Injector I and IMP for Injector II. The beam diagnostics system is essential for the beam commissioning and the machine operation. The detectors located at the MEBT (Medium Energy Beam Transfer) of Injector II are illustrated in Fig. 2 [1]. It consists of beam position monitors (BPM), ICT/FCTs (Integrated Current Transformer/ Fast Current Transformer), wire scanners and so on. In this paper, the mechanical design and control system of this wire scanner system in this beam line is introduced.

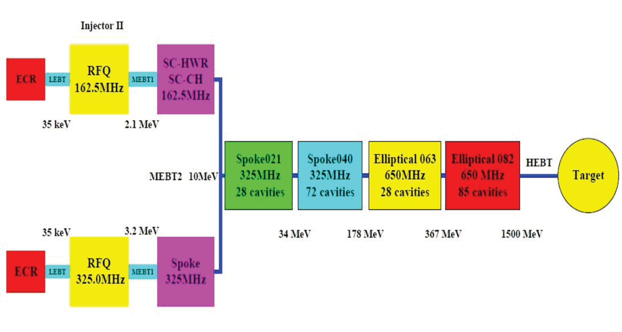

Figure 1: The layout of C-ADS project.

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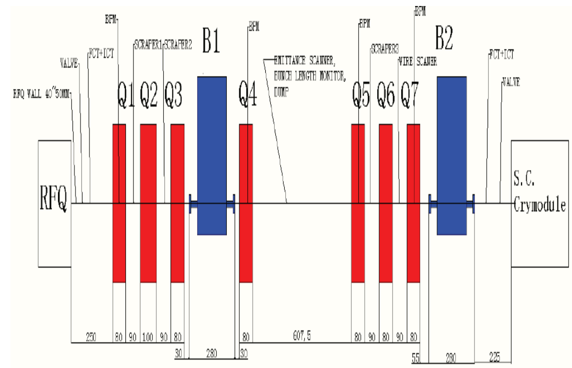

Figure 2: beam diagnostic devices which located at the MEBT.

WIRE SCANNER SYSTEM OVERVIEW

Wire scanners are diagnostic devices to measure the transverse beam profile [2] [3]. The C-ADS project wire scanner beam profile monitors provide accurate beam size measurement. Furthermore, Profile measurements can also be used to indirectly determine the beam emittance of a matched beam in a periodic focusing lattice [4]. There are two types of wire scanners used in the C-ADS project, Fig. 3 shows the wire scanner mechanical design with two beam halo scrapers, which was tested in the 320KV beam line. The other wire scanner only has one wire but without halo scrappers, such kind wire scanner is mostly used to measure the beam emittance accompanying with the slit. By moving the slit actuator and the wire scanner actuator co-ordinately, the slit position, wire scanner position and the wire signal information can be recorded. Accordingly beam emittance is calculated by using the normal formula [5][6].

The system controller and DAQ are based on National Instrument's CompactRIO which contain servo motor to be as the wire scanner's actuator .

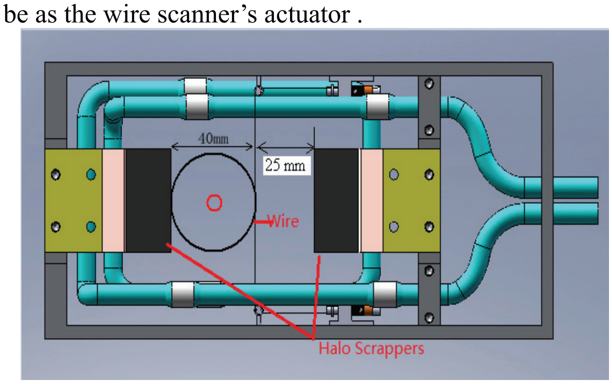

Figure 3: Scheme of slit-grid system.

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CONTROL SYSTEM AND DAQ

The Wire Scanner Control System Architecture

The wire scanner control system architecture used NI cRIO device is showed in Fig. 4. It is mainly composed of motion control and data acquisition parts. The NI cRIO analog and digital cards installed in the NI 9116 chassis which is controlled by the NI 9024 core controller is used to accomplish these two functions . The NI 9516 card installed in the chassis is a motion controller. The NI 9223 card is a 4-Channel, 1 MS/s, 16-Bit Simultaneous Analog Input Module which is used to acquire the wire signal ,beam halo scrapers and potentiometer value. Meanwhile, a NI card 9403 is used to change the electronic range accompanying the beam current [7].

During the measurement, the procedure is as followed: 1)The PC host send the motion control commands published in the NI network shared variables(NSVs) mode to NI 9024 and then received by NI 9516, 2) The 9516 controls the actuator mounted on the wire scanner to move ,3)meanwhile, the NI 9223 acquire the wire signal while the actuator is moving,4) Save the acquired raw wire signal data and process the data,5) publish the test results in the NSVs mode which can be accessed in the whole network.

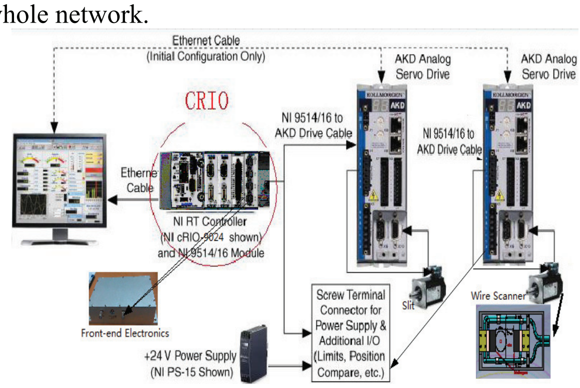

Figure 4: Wire scanner control system

Motion Control

For the motion control, the servo motor is selected. The reasons why the servo motor is choose but not stepper motor are as followed [8]: 1) The servo motor has a closed-loop feedback, 2) The radiation is very high in this project, the mass heat is one of the main factors that causes the wire failure, the servo motor can run fast enough without leaking set points, and 3） The servo motor can keep the high power while moving fast. Furthermore, because every closed servo system normally requires at least one feedback device for sending actual values from the motor to the drive，depending on the type of feedback device used, information will be fed back to the drive using digital or analog means. The Resolver feedback type is chosen on account of high radiation in this project.

NI 9516 module was used as the motion control module which supports two encoder channels that allow for dual-loop feedback and enhances system stability and precision and provides backlash compensation [7]. The state machine framework is introduced to control the wire scanner's motion which has better expansibility. Meanwhile, the whole control system is based on the producer-consumer (data) design mode. The operator sends the control commands in the network shared variables mode from the host PC interface to RT. The motion state machine flow chart is showed in Fig. 5.

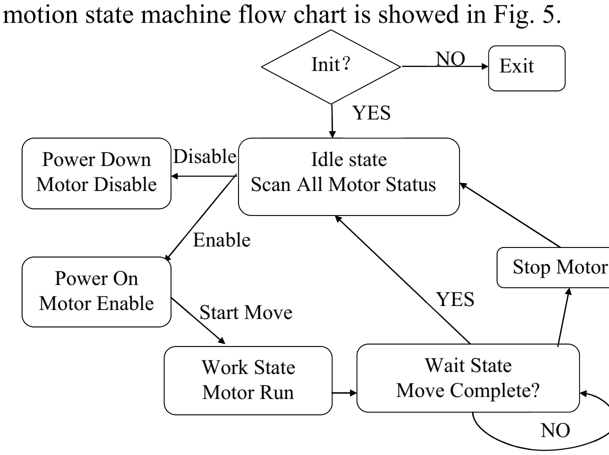

Figure 5: Motion state machine flow chart.

Data Processing and Storage

For this application, the wire scanner sensors the beam current by secondary electrons emission, and the beam current information will be converted into voltage by the front-end electronics. For each channel of the front-end electronics, there are three ranges to fit for the beam current range, the low current range passing through the electronics is from 1nA to 100nA, the middle current range is from 100nA to 10uA, the high current range is from 10uA to 1mA. During the experiment, the front-end electronics is set in the high current range in order to protect the electronics; next a proper current range is set according to the beam type and its energy. Above all, the linear relationship between the input current and the output voltage should be calibrated for the front-end electronics.

Data acquisition is done on FPGA, and the DMA FIFO (Direct Memory Access First In First out) is used to transfer the data to RT. The data is averaged firstly and then transferred to host PC and monitored in the central control room. Meanwhile, the raw data is saved into the RT controller's memory which will be acquired by FTP alternately by the users.

CONCLUSIONS

The software of motion and data acquisition control system for the wire scanner system works well in 320KV beam line, and this control system will be used for the other wire scanners. The wire scanner has been mounted in the moveable test bench for the ADS project. More detailed data analysis will be done for the next work. Furthermore, the noise depresses from the field environment, electronics, bias voltage must be processed for the beam profile calculation, and the electronics

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performance characters must be taken into consideration for the control system.

REFERENCES

[1] Jingyu Tang, Zhihui Li *et al.*, “Conceptual Physics Design on the C-ADS Accelerators”.
[2] D. Barr, *et.al.*, “Design and Experience with the WS/HS Assembly Movement Using LabVIEW VIs,National Instrument Motion Controllers, and Compumotor Electronic Drive Units and Motors”, PAC2001 Chicago, IL, (2001).
[3] Yan-feng SUI, Jian-she CAO, Li MA, “Wire scanner for transverse beam parameter measurement in BEPCII”, Proceedings of EPAC08, Genoa, Italy, (2008).
[4] C.Y.Yao, J.W.Hurd, JSageWire, “Scanner Data Analysis for the SSC Linac Emittance Measurement”, Conf.Proc. C930517 (1993) 2444-2446 SSCL-PREPRINT-473, C93-05-17.
[5] H. Hayano， *et al.*, “WIRE SCANNERS FOR SMALL EMITTANCE BEAM MEASUREMENT IN ATF”， XX International Linac Conference, Monterey, California, (2000).
[6] M.C. Ross, J.T. Seeman，*et al.*, “Wire Scanners for Beam Size and Emittance Measurements at the SLC”, IEEE Particle Accelerator Conference, San Francisco, CA, U.S.A., May 6-9, (1991).
[7] NI 9516 Operating Instructions and Specifications, http://www.ni.com/compactrio/zhs/.
[8] Stanley Cohen, Sandeep Babel, *et al.,* “Closed Loop Wire Scanner Actuator Control for LANSCE Accelerator Beam Profile Measurements”, BIW08, Tahoe City, CA, U.S.A, (2008).

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