DEVELOPMENT OF FAST CONTROLS FOR BEAM WIRE SCANNER FOR SuperKEKB

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Abstract

Recent development towards the data acquisition system of the wire scanner (WS) systems of the SuperKEKB injector linac (LINAC) and beam transport lines (BT's) is described. A VME based system, comprised of charge sensitive ADC (CSADC) board, scaler board, DAC board and Event receiver board, has been installed. The primary aim of the system is to utilise global linac event timing system for synchronized and mode-dependent data acquisition. A set of EPICS device driver has been developed for new hardware e.g. CSADC, scaler and DAC boards. The combination of latest versions of firmware and EPICS device driver for Micro Research Finland (MRF) Event receiver board is also evaluated and further incorporated in this system. The application software is developed for simultaneous acquisition of multiple beam mode data during multimode injection of the LINAC. The developed system is tested successfully after integrating with the existing wire scanner driving mechanism. The system enables the beam size measurements at four consecutive locations that derive Twiss parameters and ensure the reliable beam transport to four downstream storage rings.

INTRODUCTION

The KEK 8-GeV linac injects electron and positron beams with different characteristics into four storage rings: KEKB high-energy ring (HER), KEKB low-energy ring (LER), Photon Factory (PF) and PF-AR [1] [2]. The distance from the linac to the injection points of various storage rings is about 1km. A well controlled stable operation is required to maintain high luminosity. A wire scanner (WS) is useful for non-destructive monitoring of the beam profile for such long beam lines. A set of four WS are used for beam emittance and Twiss parameter calculation in optics matching. There are seven such matching sections in LINAC and BT's. The design of WS's and its measurement software were reported elsewhere [1, 3, 4].

At present, the WS's data acquisition system is comprised of CAMAC based front-end hardware e.g. CSADC, Scaler and DAC. A VME based supervisory system, running EPICS IOC on VxWorks 5.5, is used to control the pulse motor based WS system and Photomultiplier Tube (PMT) high voltage. An independent application program is used to acquire data from CAMAC hardware and save it in a memory based table. The supervisory system acquires the data from the table. The data acquisition process is synchronised with the beam pulse by an independent gate generation system. Since LINAC is used for injecting beam of different characteristic into three storage rings (HER, LER and PF) simultaneously [5], hence a system synchronised with LINAC timing system, may be useful to acquire various beam mode data simultaneously. A VME based system, as shown in Fig.1, is developed to utilise timing system events for WS data acquisition. The speed of the wire is also changed while scanning the beam for obtaining maximum data points in minimum scanning time.

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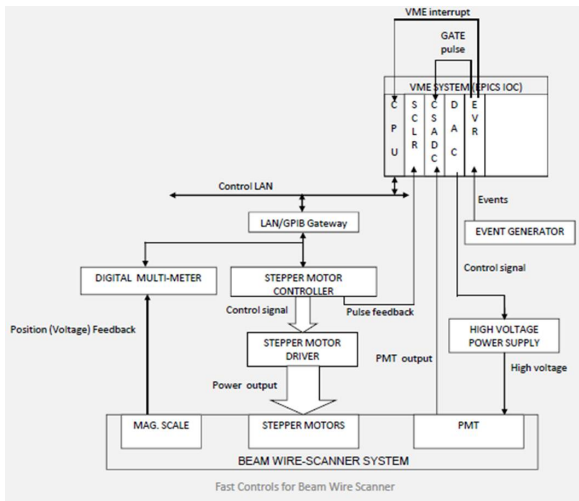

Figure1: Hardware architecture of the system.

HARDWARE

The new system is comprised of Motorola MVME-5500 CPU, Hoshin V004 Scaler, Hoshin V005 CSADC, PVME DAC, Agilent LAN/GPIB converter and Micro Research Finland Event Receiver (EVR). The system is connected to LINAC timing system using single mode optical fiber through EVR. The EVR is used to generate gate pulse for CSADC synchronised with incoming events from global event generator of the timing system. The movement of the wire is controlled through pulse motor controller using LAN/GPIB converter. A GPIB based multi-channel digital voltmeter is used measure the absolute wire position through potentiometric arrangement. The DAC is used to control the PMT bias voltage.

SOFTWARE

The Experimental Physics & Industrial Control System (EPICS), a standard open-source dual layer software tool for designing distributed control system, is adopted to

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implement the supervisory control software in LINAC as well as in all four storage rings. An EPICS Input-Output Controller (IOC), running on VxWorks 6.8, is developed for control and data acquisition for the WS system.

Since the user interface panels are developed and tested for the existing IOC of the WS system. Hence it is decided to retain the same software interface with user interface panel while developing the new system. The foregoing requirement is resolved by designing a new EPICS record, Wire Scanner (WS) record. In this record, data from various sources e.g. CSADC, Scaler, Beam Position Monitor (BPM) etc are acquired through input links and stored in a predefined array format while processing of the record. The maximum number of such array is to be specified while defining the record. To incorporate BPM data, options are kept for obtaining BPM signals and further calibration of the BPM signals. The Beam mode data is appended dynamically to the array through an additional field. A field is also provided to specify the delay in processing the record to fine tune the hardware e.g ADC with event signal. The record is designed as a ring buffer of the data array. A header is provided to specify total size of the buffer and the latest data position in the buffer. In this system, the buffer length is kept for storing 2048 events. On each event, the record acquires data from four scaler channel, three BPM signals and twelve CSADC channels.

In LINAC and BT, the simultaneous top-up injections to three rings, KEKB-HER, KEKB-LER, and PF is realised by a global fast event-based control system [6]. In this system, various beam line equipments are controlled through a set of event codes, broadcasted sequentially for each beam mode. An event generator, clock synchronised with RF, is used to sent event codes along with clock to various event receivers distributed along the beam line through optical link. The event receivers decode the event codes and generate timing signals for the related IOC's to control subsequent beam line equipments e.g. klystrons, magnets etc. A set of Micro Research Finland event generator and event receiver modules are used for timing system in LINAC and BT. There are maximum six event codes e.g. preparation, klystron-1, klystron-2 etc. for each beam mode in the present configuration. In the wire scanner system, the event signals for klystron 1 & 2 are used for data acquisition. The event signal for klystron-1 is used to set the gate width and gate delay value in EVR depending on the beam mode. The subsequent klystron-2 signal is used for gate generation and data acquisition.

A set of EPICS device drivers are developed for CSADC, Scaler and DAC hardware, while ‘asynDriver’ is used for LAN/GPIB and existing latest driver is used for EVR. Since there are three distinct positions of the wire scanner for maximum signal, peak, in PMT. Hence a combination of slow and fast speed is used during scanning to get maximum data at the desired wire position keeping overall scanning time to a minimum. The options are provided for specifying high speed, slow speed, peak positions and width around the peaks by the user.

TESTING & TEST RESULT

The new wire scanner system is installed in the Sector – 5 of the LINAC. After installation, the gate delay and width are adjusted with PF, PF Study, AR and AR Study modes. The wire speed, peak positions and width are optimised after multiple scanning. Some minor changes are also done in the user panel to adopt software interface of the new system. The final system is tested with PF and PF Study modes. The test results are shown in Fig. 2 & 3.

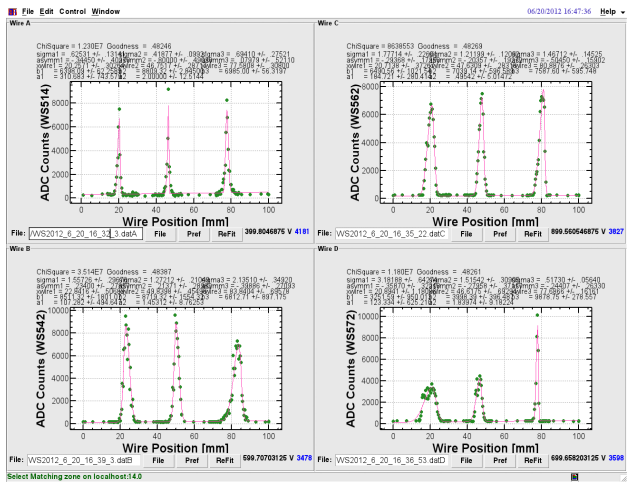

Figure 2: Test results.

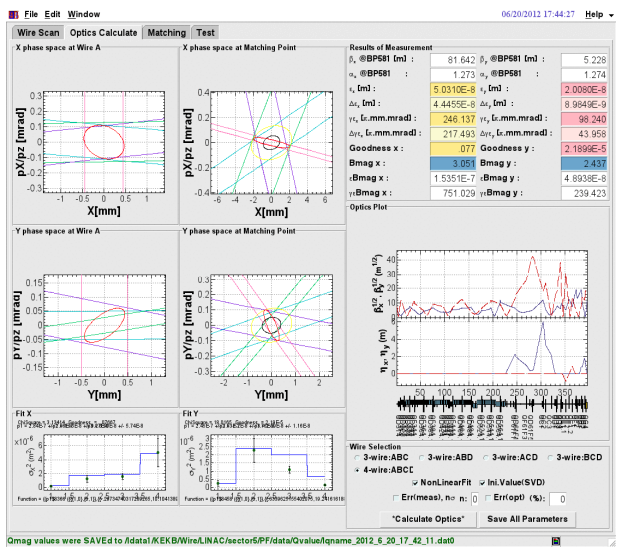

Figure 3: Test results.

It can be seen that the wire speed is fast at the beginning of scan and becomes slow down around the three wires. Owing to that, we can speedily take the data points enough for obtaining the width of the peak although the beam repetition rate is constant, e.g. 10 pps. A user panel is developed using EPICS MEDM tool for fine tuning of the system by specifying various parameters e.g. wire speed, peak position, width, beam mode etc. It is shown in Fig.4.

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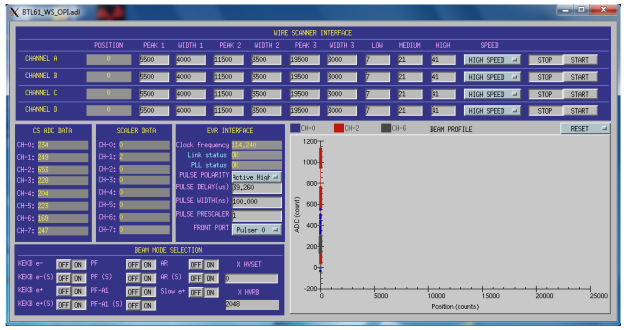

Figure 4: User panel.

CONCLUSION

The new system is developed to acquire wire scanner data of multiple beam modes simultaneously. This system will contribute significantly for beam tuning during SuperKEKB commissioning and subsequent stages.

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