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EPICS interface to Libera electron beam position monitor

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Abstract SSRF diagnostics system will adopt a new generation digital electron beam position processor, Libera, as the signal condition, signal processing and data acquisition device for beam position monitor. In order to provide a uniform data and control interface for users, we developed an EPICS interface based on Control System Programming Interface (CSPI) layer, allowing the performance of the electron beam to be monitored through EPICS channels. In this interface a new record type for BPM was defined and its associated support routines were implemented.

Key words EPICS, Libera, BPM, SSRF

CLC number TL503.6

1 Introduction

Shanghai Synchrotron Radiation Facility (SSRF), one of the biggest scientific projects in China, is a low emittance 3rd-generation light source consisting of a 3.5 GeV storage ring, a full energy booster and a 150 MeV linac, as well as dozens of beam lines and experimental stations. Construction of the SSRF started at the end of 2004 and will be completed in early 2009[1].

The SSRF control system is based on Experimental Physics and Industrial Control System (EPICS), the most popular tool-kit for accelerator control system development[2]. As a part of the control system, the data acquire system of beam diagnostics is constructed on this platform to provide a uniform data & control interface for the users. On the other hand, the SSRF diagnostics system adopts a new generation digital electron beam position processor, Libera, as the signal condition, signal processing and data acquisition device for beam position monitor system[3]. Equipped with different configurations of clock and digital filter, this kind of device could cover applications of the linac, booster and storage ring. So far the manufacturer of Libera, Instrumentation Technologies Ltd., provides only a Control System Programming Interface (CSPI) library. So an EPICS support package has to be developed by ourselves based on CSPI layer.

2 Libera electron beam position monitor[4,5]

Libera is an all-in-one solution that enables trouble-free commissioning, accurate beam position monitoring, and local and global feedback building. It is the newest Instrumentation Technologies product family. A single 1U high 19 enclosure contains an analogue front-end, a digital board designed around the Xilinx FPGA Virtex II Pro and a Single Board Computer. The signals are eventually delivered to the Field Programmable Gate Array (FPGA) after the A/D conversion. Fig.1 shows the data flow in Libera.

The sampled data are passed through the DDC and then divided into three branches, i.e. the history buffer for Data-on-Demand, and continuous data streams for Fast Feedback and Slow Acquisition.

The ADC raw data can be read from a special buffer. The output from Data-on-Demand and Slow Acquisition is passed to the SBC, whereas the Fast Feedback output, which is too fast, is dealt with at the FPGA level instead.

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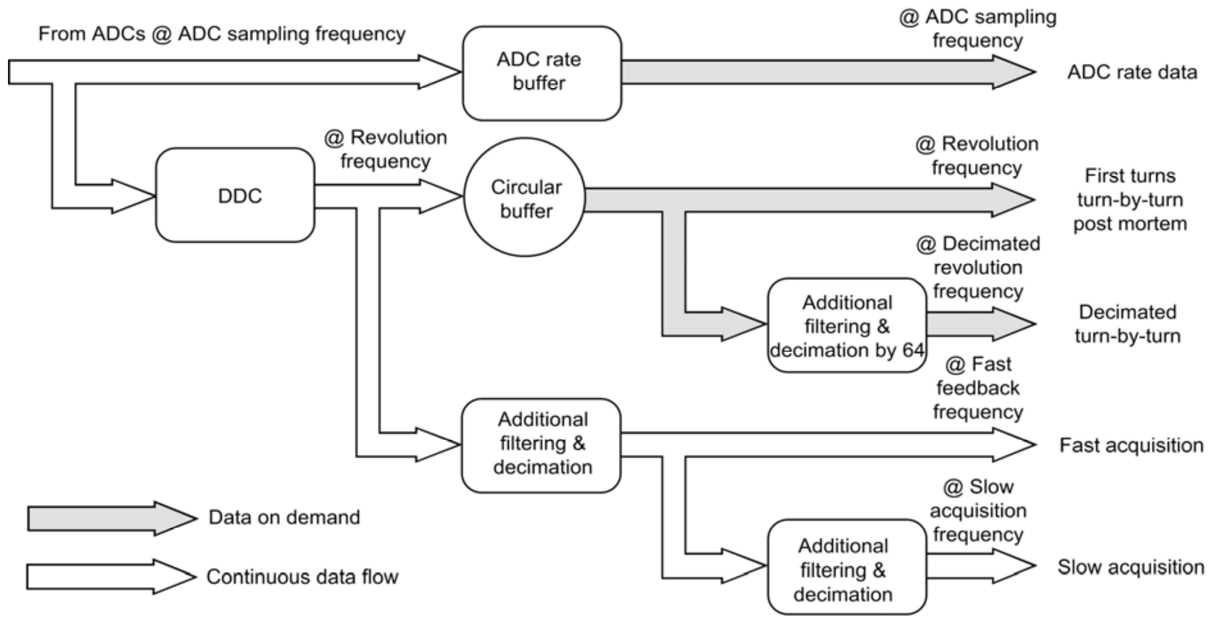

Fig.1 Libera data flow.

The software structure of Libera is shown in Fig.2. The SBC computer runs a stripped down GNU/Linux operating system. All software interfacing the control system runs in user-space and connects to the hardware using a device driver integrated into the kernel. The most important and visible part from the end user point of view is the Control System Programming Interface (CSPI) library. It provides a consistent CAPI, making low level details transparent for an application developer. Together with a standard environment and GCC based development tool-chain, CSPI forms a highly efficient way of instrument integration into the accelerator control system.

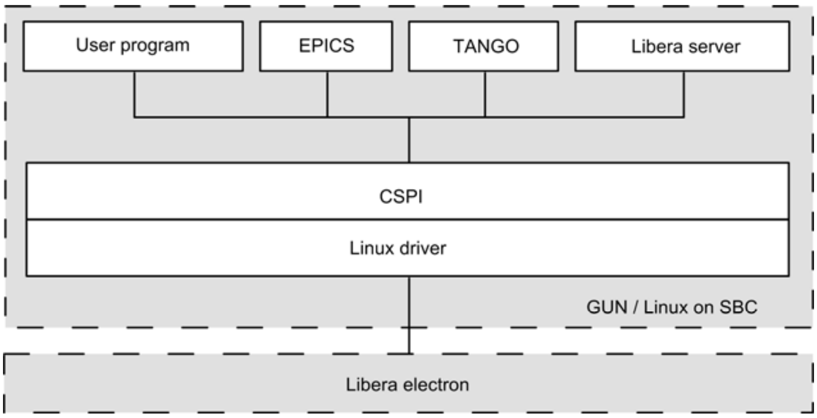

Fig.2 Libera software structure.

3 EPICS interface implement

In order to provide EPICS support for Libera electronics we developed a package (Fig.3), which includes a series of normal EPICS records, a global array, a custom designed new record type, associated record support module, device support modules and a demo EDM panel. Eight ai (analog input) records and eight waveform records were used to collect narrow band (10 Hz) beam position data and wide band (turn-by-turn, 694 kHz for SSRF) beam position data into control system respectively. Several longin (long input) records were used to monitor Libera electronics status such as PCB temperature, fan speed, etc. The custom designed record accomplishes the BPM data acquisition and process, and copies raw data to a global array that shared raw data with EPICS standard waveform records. The demo EDM panel gets BPM data via Channel Access and displays them on the operator console.

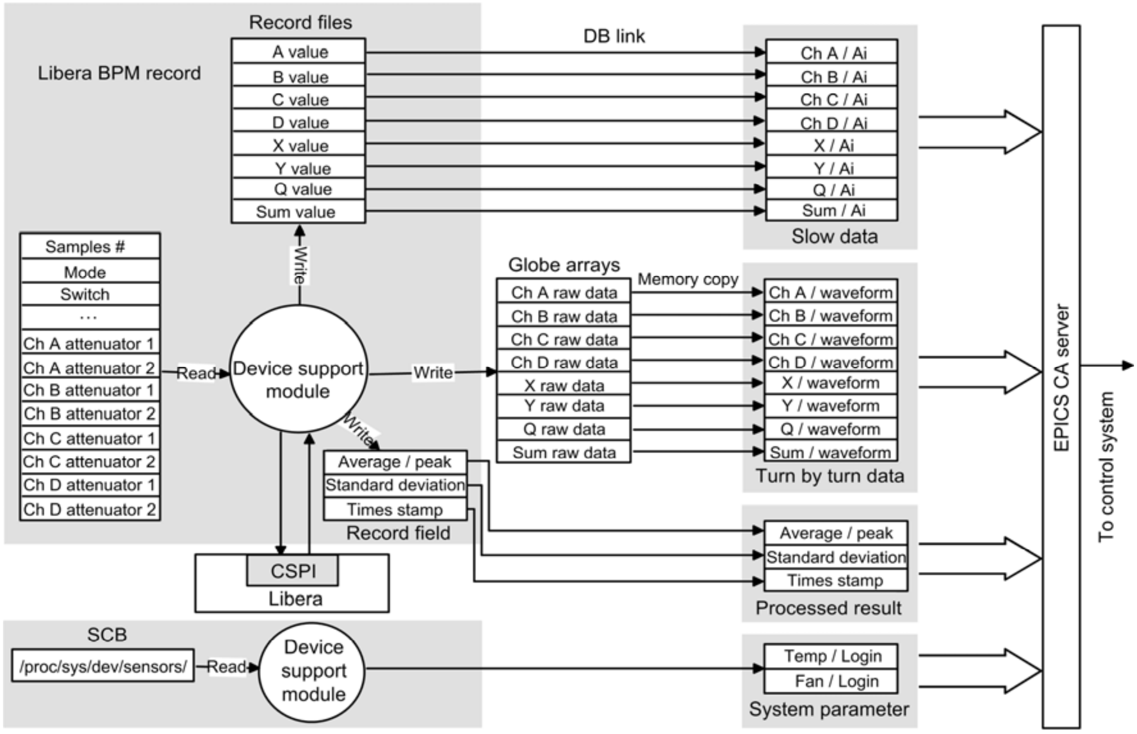

Fig.3 EPICS support package architecture (ch = channel).

3.1 Libera BPM record

Based on the analysis of BPM data acquisition subsystems, we defined a new EPICS record type for BPM application. In this way, we could transmit the block datum more effectively and make them synchronized more easily. Besides the common fields, we added several dedicated fields for BPM application. For instance:

(1) SOUR, the type of data sources, we have chosen Data-on-Demand (DD), Slow Acquisition (PM), Post Mortem (PM) and ADC-rate buffer (ADC),

(2) MODE, continuous/pulse, which is valid for Data-on-Demand,

(3) TYPD, raw I-Q data or synthetic data,

(4) STAM, on/off option of timestamp,

(5) OFFS, data retrieval point in machine time,

(6) SWIT, on/off option of analog switch configuration,

(7) SIZE, the number of samples,

(8) MTIM, machine time,

(9) eight fields for attenuators coefficients,

(10) eight buffers for BPM samples, i.e. the amplitude of electrodes A, B, C and D, horizontal and vertical beam position, quadropole signal and sum of the four amplitudes,

(11) eight fields for the average/peak of BPM samples and eight fields for standard deviation,

(12) eight fields for the system time in year, month, day, hour, and minute.

3.2 Record support module

In order to allow new record types and new device types without impacting the core IOC system, the concept of record and device support is to create a record support module for each record type, and it is responsible for all record-specific details. A record support module consists of a standard set of routines referred as database access routines. These routines implement record-specific code. A set of device support routines specific to our new record type is defined as follows:

```
static long init_record();
static long process();
static long get_units();
static long get_precision();
static long get_graphic_double();
static long get_control_double();
static long get_alarm_double();
static void checkAlarms(bpmRecord *pbpm);
static void monitor(bpmRecord *pbpm);
```

3.3 Device support module

A device support routine has knowledge of the record definition. It also knows how to talk to the hardware directly or how to call a device driver which interfaces to the hardware. Thus, device support routines are the interface between hardware specific fields in a database record and device drivers or the hardware itself. Device support modules can be divided into two basic classes: synchronous and asynchronous. Synchronous device support is used for hardware that can be accessed without delays for I/O.

Many register-based devices are synchronous devices, while the GPIB devices and other devices, which are accessed via I/O requests that may take quite lot of time to complete, are asynchronous devices. However, through tests we found our device takes only several milliseconds to complete the entire connection, so the synchronous device support was chosen, although it is accessed via requests. In our device support routine, we implemented two functions: init_record and read_bpm. Fig.4 shows the flow chart of read_bpm, which is the kernel of our interface.

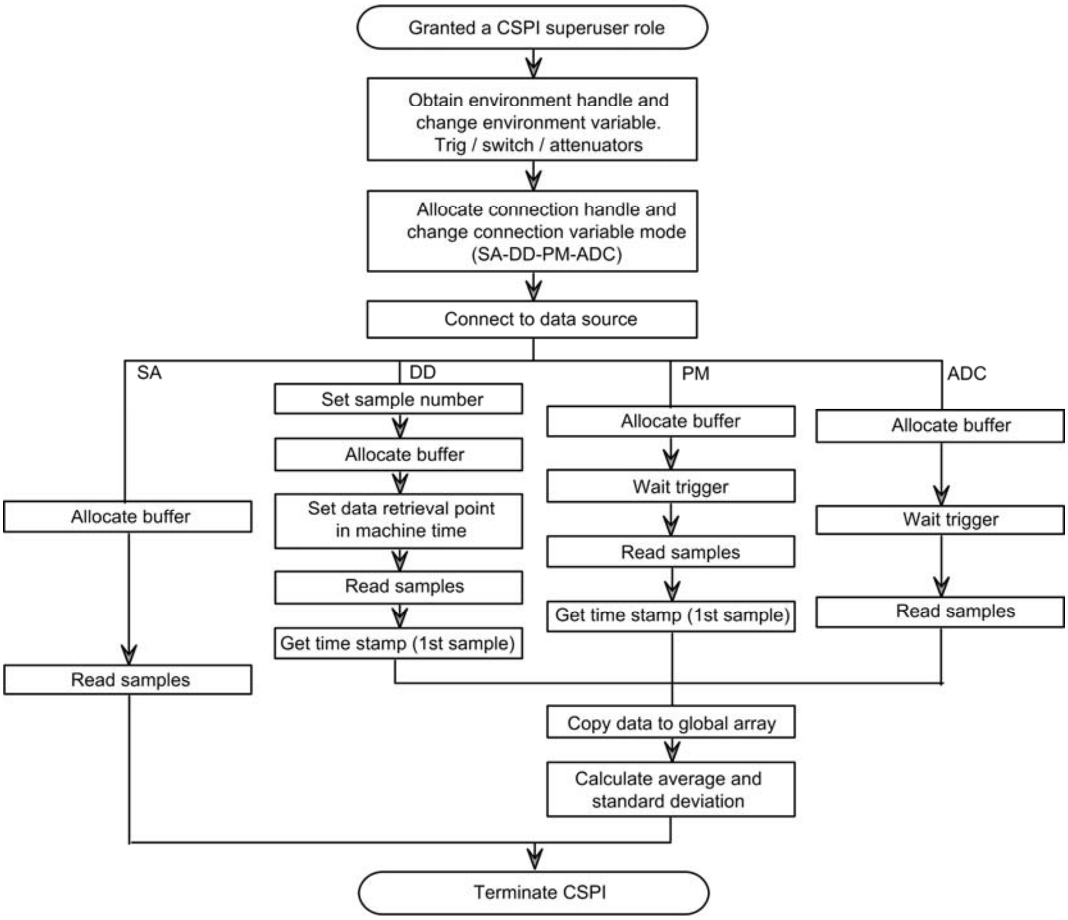

Fig.4 Flow chart of Libera data acquisition.

A super user role is requested first to obtain write access for Libera electronics configuration including operation mode, crossbar switch factor, and input attenuator factor, etc. The settings apply to all subsequent data connections allocated on the environment handle. A data connection handle is then allocated to connect to target data source.

There are four kinds of data source available for user: Slow Acquisition (SA), Data on Demand (DD), Post-Mortem (PM) and ADC raw data (ADC). An SA source is a 10 Hz DSP chain on the Libera digital board. An application copies the sequential data stream with a function that is implemented in CSPI. The function blocks until an SA sample is available for reading. The DD source is a History Buffer on the Libera digital board. An application sets the data retrieval point in the History Buffer and fetches a specified number of samples from the History Buffer. The application also obtains a timestamp, corresponding to the beginning of the returned vector of samples.

A PM source is History Buffer, too. The same limitations apply with one exception, the trigger and accompanying timestamp indicate the end of a sequence (the last sample), rather than the beginning of retrieved sequence. On each post-mortem trigger, a fixed set of samples is copied to the post-mortem buffer and stored for later retrieval. ADC-rate data represents a new type of data stream on Libera Electron. On triggering, a fixed number of 12-bit ADC samples is copied to the ADC-rate buffer and stored for later retrieval. Up to 1024 samples can be stored in the ADC-rate buffer and retrieved by an application.

After data acquisition, data source is disconnected and the device handle is freed in a reverse order.

3.4 Operator interface panel

An EDM[6] panel was developed to demonstrate the function of Libera electronics (Fig.5). Main configuration parameters, such as operation mode, attenuator factors, raw data sample numbers and data source could be modified on the panel. The data shown include averaging position, position deviation, raw data (waveform), and timestamp, etc.

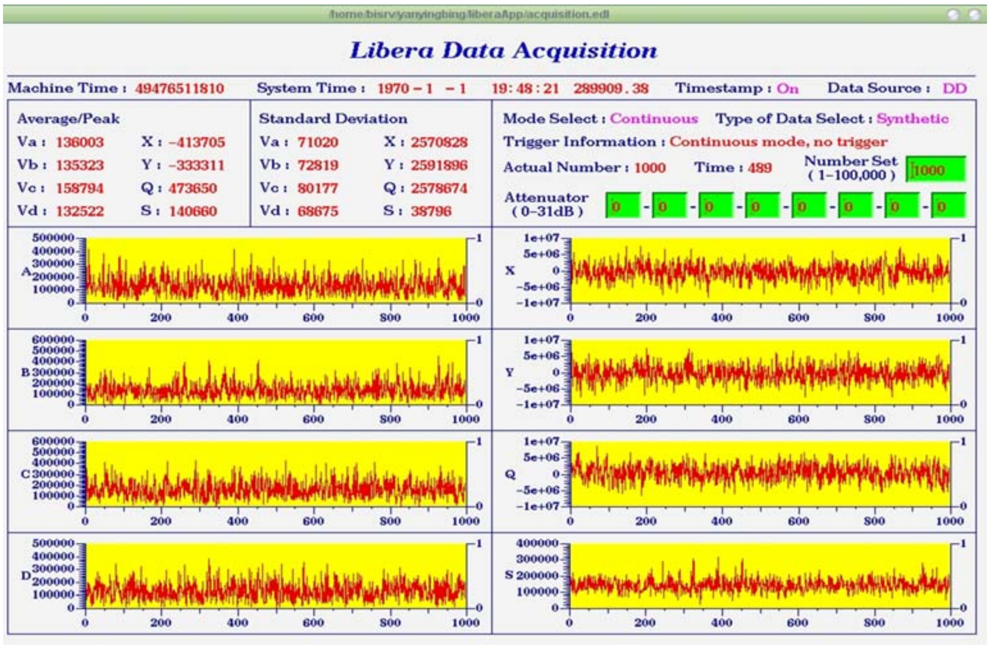

Fig.5 Operator interface panel.

4 Conclusion

The Libera electron beam position monitor is adopted in the SSRF beam orbit monitor system. In order to work with control system, an EPICS support package for this instrument was developed based on CSPI layer, allowing the performance of the electron beam to be monitored through EPICS channels. In this package a new record type was defined for dedicated BPM application for the first time and its associated support routines were implemented. In this way, we could transmit the block datum more effectively and make them synchronized more easily. The completed software has been used in Libera electronics evaluation successfully.

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