

# SOFT IOC APPLICATION IN SSRF BEAM DIAGNOSTICS SYSTEM

Y.B. Yan, Y.B. Leng

Shanghai Institute of Applied Physics, CAS, Shanghai 201800, P.R.China

## Abstract

Soft IOC is an ideal solution for high level global application of accelerator control and beam diagnostics due to easy online modification and rebooting. SSRF beam diagnostics system employees two soft IOCs to handle the global tasks such as BPMs group access, orbit performance analyze and online data reliability analyze, which are hardly performed in bottom level IOC side and OPI side. This paper introduces the current status and future upgrade plan.

## OVERVIEW

Shanghai Synchrotron Radiation Facility (SSRF) is a low emittance third generation light source located at Shanghai, P.R.China. It consists of a 3.5GeV storage ring, a full energy booster and a 150MeV Linac, as well as dozens of beam lines and experiment stations.

In SSRF beam diagnostics system, over two hundred IOCs have been integrated into the EPICS<sup>[1]</sup> based control system. There are five kinds of Input Output Controllers (IOC) used. Libera<sup>[2]</sup> embedded IOCs, running Linux operation system, are dedicated devices for beam position measurement and orbit feedback system. PXI based IOCs are used for DCCT, slit, scraper and SRM subsystem. Scope embedded IOCs are used to acquire raw WCM, ICT and FC data. VME based IOCs are dedicated devices for timing system<sup>[3]</sup>. Two soft IOCs are introduced to handle the global tasks such as BPMs group access, orbit performance analyze and online data reliability analyze, which are hardly performed in bottom level IOC side and OPI side. The whole system architecture is shown in Figure 1.

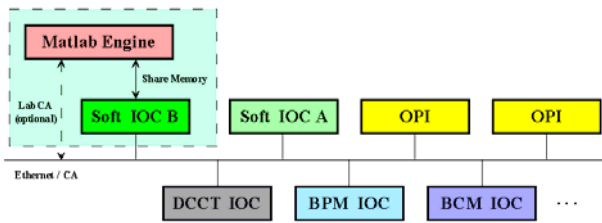


Figure 1: Beam diagnostics system architecture.

In this system, soft IOC A is based on an EPICS online data analysis software package, which is developed using C language. Soft IOC B is based on Matlab calculation engine. Date translation between them is implemented through shared memory interface. The detail of system implementation and some applications will be reported in this paper.

## SOFT IOC A

This kind of soft IOC is used to implement some basic high level applications, such as data statistic analysis and beam parameters calculation. The core of the soft IOC is a unified common online data analysis software package, as shown in Figure 2.

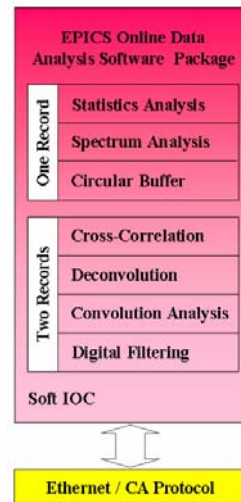


Figure 2: EPICS online data analysis software package.

The soft IOC periodically obtains the values of PVs which need to be analyzed via Channel Access (CA) protocol. Generally they are put into the circular buffers except the waveform record. Then the related processing or calculation is performed, such as statistical analysis and spectrum analysis, as well as cross-correlation, deconvolution, convolution analysis, digital filtering and so on.

A lot of macros are used for building the run-time database template. After the source code compiled on the Linux platform, the users only need to load the specified database files with corresponding macro replacements to start the soft IOC and use the data analysis software package.

The software package has good real-time performance, portability and extensibility, and has been widely used in the beam diagnostics system, running as soft IOC. Just as the applications of the BPM subsystem, soft IOC collects beam position data from all Libera IOCs of the booster and storage ring, and then provides the related parameters, for instance the RMS noise, spectrum and so on online. Figure 3 shows the result of the vertical orbit data analysis.

\* Work supported by Chinese Academy of Science  
 yanyingbing@sinap.ac.cn

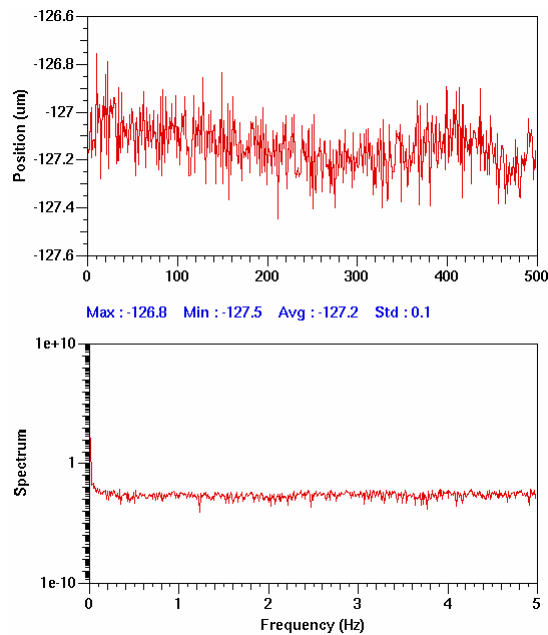


Figure 3: Vertical orbit data analysis of storage ring.

Here we store 500 points in the circular buffer and update the result at 10Hz. All these analysis and processing parameters such as buffer size and update rate can be configured in the IOC start-up scripts.

## SOFT IOC B

In this soft IOC, Matlab is used as the data processing engine for complex compute-intensive applications, such as multi-records processing, data simulation and so on. Matlab communicates with the soft IOC using shared memory interface, which implemented as a dynamic linked library. Matlab applications obtain raw data from shared memory, process them and store the results into it, which can be accessed by EPICS clients such as EDM. The system architecture is shown in Figure 4.

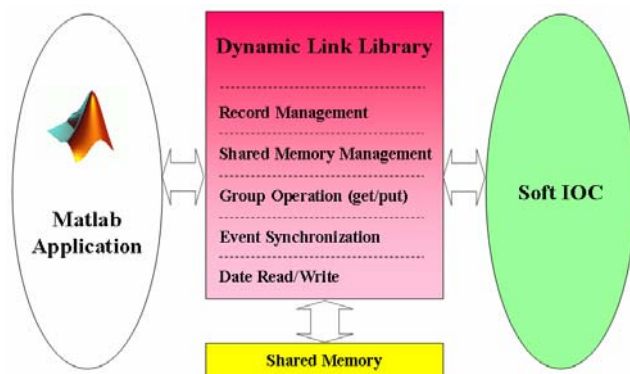


Figure 4: Matlab based soft IOC architecture

As shown above, it consists of three components: dynamic linked library (DLL), soft IOC and Matlab applications.

## DLL

The DLL is implemented using standard system functions under Linux operation system. It is not dependent on the EPICS or Matlab, and can be used without either. Data is shared equally between the applications attached to the DLL.

The DLL provides functions of read/write the shared memory, and supports the event handling. One application can signal another application waiting on the data to synchronously process the data. Group operation (get/put) is available, which is very useful for the BPM subsystem. At present the support data type is integers, floats, string and single dimension arrays.

## IOC

During the IOC initializing the shared memory is allocated and related variables are created, which are linked to the record data fields. If there is any error occurred, such as enough free space available in the memory, the IOC initialization process will be aborted.

After the initialization, the records can call their record/device support routines to complete data process. In this solution, the shared memory is treated as a kind of special devices. The IOC calls the DLL functions to write data into shared memory devices or read data from them.

## Matlab Applications

The Matlab applications can be implemented very easily, and programmer needs only minimal EPICS knowledge to use the interface.

For the Matlab Applications, there are only four functions available in the DLL, which is smget(), smput(), wait() and signal(). They are used to read/write data form/to the shared memory, or synchronize the data processing.

## Performance

In order to evaluate the performance of the DLL, a series of tests were performed, as shown in Table 1.

Table 1: The performance of the DLL

Array Size	Read Long (usec)	Write Long (usec)	Read Double (usec)	Write Double (usec)
8000	56	54	63	56
4000	36	34	46	40
2000	32	30	33	32
1000	30	27	29	28
100	28	26	27	26
10	27	25	26	25

The times to read/write long/double precision arrays are measured on a 2.50G Intel Xeon E5420.

Examples

Figure 5 shows the temperature of all Libera electrons around the storage ring.

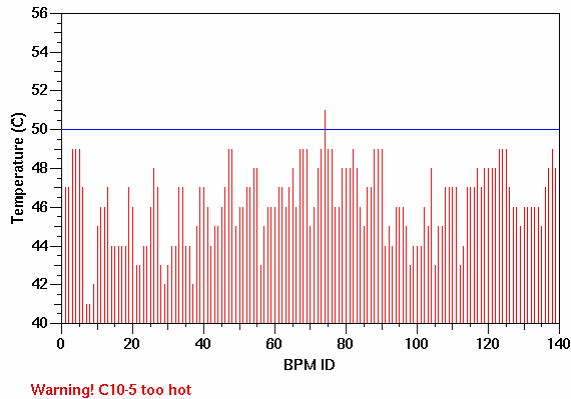


Figure 5: Temperature of all 140 Libera electrons.

If the temperature is too hot, the Matlab application (status monitor and fault analysis) will output warning tips to the shared memory. This information is displayed on the EDM panel through a string PV finally. The application can also complete some other diagnostics, such as the fan status, network connection, trigger signal and so on. In this way, the operators and engineers can respond quickly to device failure.

The DLL support group operation, so the orbit data can be accessed as a waveform directly, as shown in Figure 6.

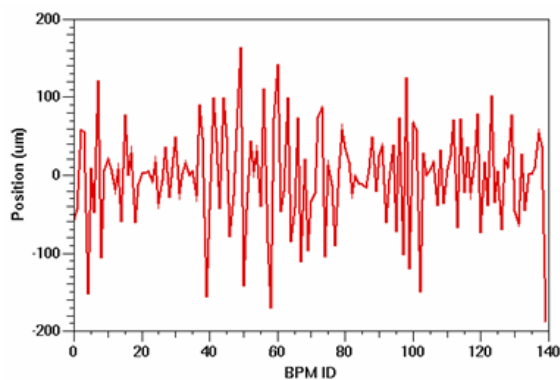


Figure 6: Horizontal orbit (display directly).

Figure 7 shows the RMS of vertical orbit changed from the reference orbit during the beam current (blue) decay in the last 2 hours.

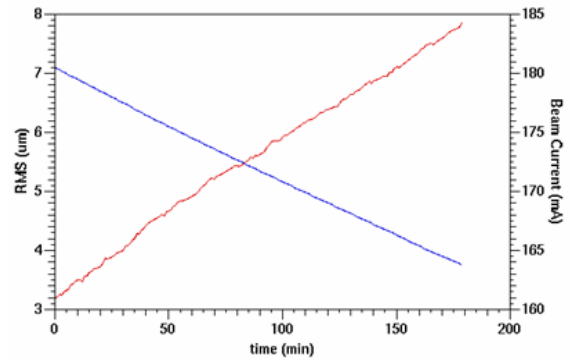


Figure 7: RMS of vertical orbit changed vs. current.

Figure 8 shows the power spectrum of vertical orbit data.

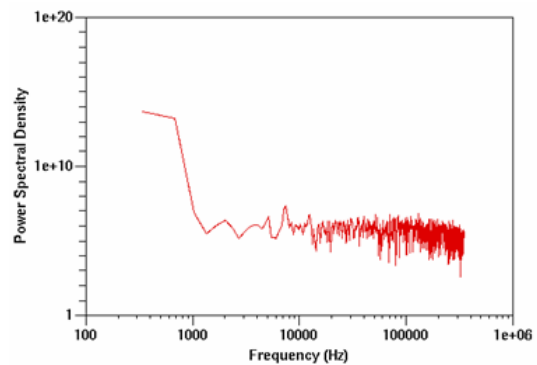


Figure 8: Power spectrum of vertical (Turn-by-Turn).

All the figures above are EDM screenshots on the OPI, and the data are update per 1 min.

**SUMMARY**

In this paper we describe the soft IOCs implementation and application in SSRF beam diagnostics system. They are fast enough for most applications, have good reliability, and have become powerful tools for machine studies and daily operation.

In the future, more high level applications will be added into this soft IOC for machine study, status monitor and fault analysis, and a plan to build an accelerator expert system is under considering.

**ACKNOWLEDGEMENTS**

We would like to thank everyone who contributed to SSRF beam diagnostics system through discussions and suggestions. Many thanks have also to be addressed to Guenther Rehm (DLS), Michael Abbott (DLS) and Kees Scheidt (ESRF).

**REFERENCES**

- [1] [www.aps.anl.gov/epics](http://www.aps.anl.gov/epics)
- [2] [www.i-tech.si](http://www.i-tech.si)
- [3] Y.B. Leng, W.M. Zhou, etc. Beam Instrumentation System Development and Commissioning in SSRF, EPAC'08, Genoa, Italy