THE STATUS OF I NSTRUMENTATION &CONTROL FOR SSRF

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Abstract

Shanghai Synchrotron Radiation Facility (SSRF) is a third generation light source located on Zhang Jiang Hi-Tech Park of Shanghai, China. It consists of a 150MeV Linac, a 3.5 GeV Booster and a Storage Ring. Its grounding break was held on 25th of December 2004. All facility buildings are under construction on schedule and will be completed before the October of this year. Various equipment of utilities such as 35 KV power station is being installed now. Linac commissioning will start in early next year, Booster commissioning will start in August of next year. Storage ring commissioning will start in April of 2008. The experiment beam could be expected in the April of 2009 .Most of equipment is being tested now. The present instrumentation and control system of SSRF will be described in this paper.

INSTRUCTION

According to physical requirement to beam diagnosis and control system, the major parameters of SSRF project is following table 1.

Table 1: Main parameters of SSRF

Item	Specification
Energy of Linac	150MeV
Booster	150MeV-3.5GeV
Ring	3.5GeV
Ring current	Single bunch 5mA Multibunch 200-300mA
Emittance	3.9 nmrad
Harmonic Number	720 for Storage Ring
	300 for Booster
Rf frequency	499.654MHz
Stability of Ring beam position	Phase one <5μm Phase two < 1μm

I&C system will complete data acquisition and processing for around 300 beam monitors and more than 2000 various accelerator equipment .

BEAM INSTRUMENTATION

Specification

The accelerator beam instrumentation will play a vital role in commissioning and qualifying the SSRF accelerator. It will help us to see whether electron dynamics agrees with our theoretical predictions. It will help us verify accelerator parameters so that important beam parameters have met the design specifications. It will help operators to tune the accelerator quickly and serve user's requirements. Table 1 shows the SSRF beam diagnostics system specification.

Table 2: SSRF Diagnostics Specification

Item	Function		Specification	
			Qty	Notes
BPM	Orbit	Ring	140	1mm@first turn 10um@TBT1um@ 10Hz, 4kHz
		Booster	49	100um@200Hz
		LTB	3	50um@single pass
		BTS	5	50um@single pass
		Linac	3	50um@single pass
Tune	Tune Value	Ring	1	0.0001@1Hz
		Booster	1	0.001@200Hz
MBTF	Ring	Button	2	250MHz
		Strip Kicker	2	
Screen	Position & profile	Ring	2	0.5mm
		Booster	4	0.5mm
		LTB	3	0.2mm
		BTS	4	0.2mm
		Linac	5	0.2mm
DCCT	I	Ring	1+1	5uA@1Hz
		Booster	1	100uA@200Hz
Scraper & slit		Ring	2	15um
		LTB	2	15um
		BTS	1	15um
SRM	Profile	Ring	2	10um
	BL	SC	1	2ps
	Profile	CCD	1	100um
WCM	Longitudinal profile	Booster	1	Δf > 1GHz
		LTB	2	Δf > 1GHz
		BTS	3	Δf > 1GHz
		Linac	4	Δf > 3GHz
BCM	Beam charge	Linac	1	2%(ICT)
		BTS	1	2% (ICT)
		Linac	1	2%(Frady Cup)
Energy Analyzer	Energy spectrum For LINAC		1	Resolution 0.1%

System Architecture

Beam Diagnostic System is consists of various monitors, electronics and data processing system. The SSRF beam diagnostics data acquisition will be an EPICS-based distributed system, and four kinds of Input Output Controllers (IOC) will be used in diagnostics:

- ✧ VME bus IOCs (10 for ring, 2 for booster, 1 for Linac), running VxWorks real time operation system and EPICS core, will be equipped with timing module to deliver trigger signals for each diagnostics station.
- ✧ Libera[2] embedded IOCs (140 for ring, 40 for booster & transfer line, 3 for Linac), running Linux EPICS kernel, are dedicated devices for BPM signal processing and orbit feedback system. Two extra

Libera IOCs will be used for booster and storage ring tune measurement.

- ✧ PXI bus IOCs (3 for ring, 4 for booster, 1 for Linac), running Windows operating system and Shared Memory IOC EPICS interface, will be used for screen monitor, slit, scraper, SRM, BCM, DCCT and MBTF control.
- ✧ Scope embedded IOCs (1 for ring, 2 for booster, 1 for Linac), running Windows operating system and Shared Memory IOC EPICS interface, will be used for wall current monitor and faraday cup data sampling.

Totally, there are 208 IOCs in diagnostics system.

Beam Position Monitor (BPM)

Two kinds of beam position monitor will be used in SSRF: two pairs of 50Ω strip line and button type monitor with four diagonal electrodes. The strip line pickup was chosen in the Linac, Booster and transport line for high sensitivity. The button pickup was chosen in the storage ring because of small size and low coupling impedance.

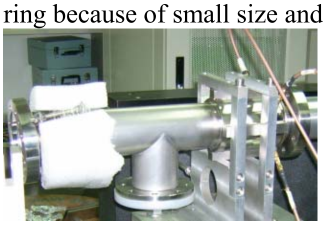

Figure 1: BPM for Booster.

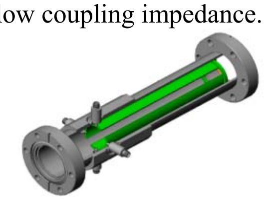

Figure 2: BPM for LINAC.

In the ring there are seven BPMs for each cell. The two of at either ends of insertion straights will be high performance and high stability type, called IDBPM. It provides a reference beam position and can also be used to determine position and angle through the insertion device for local correction. The others are arc BPMs, which will evolve into close orbit measurement and slow orbit feedback. The gap between button and housing is controlled in 0.3mm to minimize coupling impedance. Two kinds of prototype were evaluated in the first stage. Both of them met the requirements of SSRF. The TDR test for these prototypes of BPM assembly showed very good uniformity.[1]

Electronics

The SSRF BPM signal processing and data acquisition have two kinds of electronics: Libera digital EBPM processor and Bergoz. Libera is provided by Instrumentation Technologies. Since Libera samples RF signal directly and produces beam position data using DDC and digital filtering technologies, it has capability to deliver turn-by-turn data, fast orbit data and slow orbit data simultaneously.

The Linac, LTB and BTS Libera units will be configured into the external trigger, single pass mode, synchronized with “Gun trigger”, “Booster injection”, “Booster extraction” events via main timing system respectively. The Booster Libera units will be configured into the external trigger mode too, synchronized with “Booster injection” to deliver turn by turn (1.67MHz) and decimated turn-by-turn (200Hz) data. The Ring Libera units will be configured into the continuous mode to deliver turn by turn (694kHz), fast orbit (4kHz) and slow orbit (10Hz) data.

A tryout module of Libera has been evaluated in past few months. The bench CW test results (Figure 6 and Figure 7) showed that the position resolution of close orbit measurement met the specification of the SSRF storage ring and booster application.

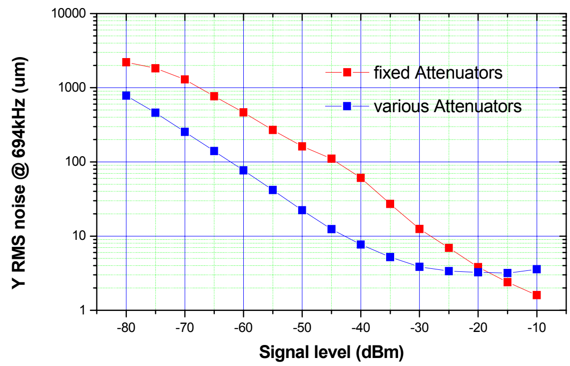

Figure 3: Libera resolution test @ CW mode

Other Diagnostics

The profile monitor and Wall Current Monitor (WCM) has been proved very useful in earlier SINAP 100MeV accelerators and will be adopted in the SSRF. Additionally a custom designed Faraday Cup (FC) and two Integrated Current Transformers (ICT) provided by Bergoz Electronics will be installed to perform precise electron charge measurements. The detailed design of multi bunch transverse feedback (MBTF) system is underway.

Other categories monitors used for the Ring and booster is being fabricated and tested .

CONTROL SYSTEM

SSRF control system is a hierarchical standard accelerator control system based on OPI, IOC and intelligent controller for hardware structure. The system software is base on Linux system supported the EPICS development, component based OPI and other middle ware development environment. The server will use Red Hat Linux Fedora core 4.

Control System Network

Control system network uses 1000Mb Ethernet. The network backbone can reach to 2Gb. Main switch use 3 layer device and others will use 2 layer. Control system sub LAN will adopt VLAN (Virtual Local Area Network) that can be divided in group and re-combine easily. The software system has full network manage ability and application oriented QOS ability. The backbone redundancy design will ensure network reliability.

Remote access can be allowed by security authentication and monitor.

Subsystem Control

There are 800 sets power supply used for various magnets along accelerator beam line. The digital power supply controller has been adopted experience of SLS Diamond light source and PLS .Now the digital power controller[2] is being tested with various high power supplies which is developed in China. A digital power supply prototype has being developed and the software and hardware solutions have been tested.

As shown in Fig.4, EPICS base and device/driver support modules have been compiled and downloaded.

Figure 4: Digital power controller.

A real time database used for subsystem has been adopted. Its functions including waveform (using internal trigger), have been tested as shown in Fig 5.

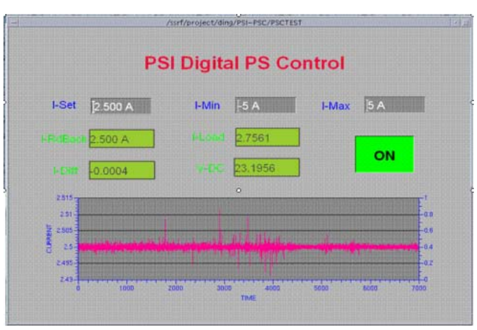

Figure 5: Digital Controller tested on EPICS.

Device Controller Based on Ethernet

According to present technique of network, SSRF adapted the control network VLAN instead of field bus for most of low speed device controller, like the PLC and lot of serial based device(using protocol translate: serial to Ethernet translator), all of this was connected by the control network and using soft IOC. The soft IOC can be managed by multi IOC which is running configure system. We have tested various PLC such as GE, Yokogawa and Omron with full Ethernet EPICS device driver support in success.

We used this method to test on Soft IOC of EPICS (Linux PC server) has been tested with Vacuum Gauge: VARIAN Multi Gauge for long time without any problem.

Timing System

In order to synchronize the electron bunch from gun to inject booster and ring, a low jitter timing system [3]based events trigger developed by APS ,SLS is adopted. We have set up a prototype system which have been tested. Now we are going to set whole timing system for SSRF.

MPS System

Machine protection system is being developed based on hardware and PLC controller. Various interlock flowchart are being checked now.

Software System

1. Device driver

Various softwares are based on EPICS Version 3.14. Some device drivers have been tested, such as PLC EPICS Driver which can support GE9030, Omron and Yokogawa FM3. Driver Net Power v1 for digital power controller has been developed.

2. Archive system

The SSRF data archive system adopts RDBMS for data storage and data management and the distributed archive engine are used. The archive engine employs XML engine configuration and native XML data type of database with XML schema. The engine runs on Linux Fedora core 4 with distributed form (multi engine). Database connection is based on ODBC. All the data can be access by the Web service.

3. High level physical application software

A basic development environment have been set up with Matlab V.7.1 on the LINUX, some physical application software have been tested.[4]

4. Data base

The database will support access and setting for various accelerator parameter which run time configured failure report and invalid record. It also recordes various real time data and history data of accelerator, These data can be used for various analysis and calculation. The hardware platform is set up based on SAN and database server cluster. Now the MS SQL Server 2005 has been tested. The Oracle 10g with RAC will be adopted recently.

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