FIRST OPERATION OF NEW ELECTRON BEAM ORBIT MEASUREMENT SYSTEM AT SIBERIA-2

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Abstract

The paper focuses on the results of commission and usage of the electron beam orbit measurement system at synchrotron radiation source SIBERIA-2 realized at present time at Kurchatov Institute.

The main purpose of new orbit measurement system creation is an improvement of the electron beam diagnostic system at the storage ring. This system provides continuous measurements of the electron beam closed orbit during storing, ramping and operation for users. Besides, with the help of the system it is possible to carry out turn-by-turn measurements of the electron beam trajectory during injection process. After installation of new orbit measurement system we obtained a very good instrument to study electron beam dynamics into the main storage ring in detail.

The paper describes the new orbit measurement system, its technical performance, the results of commission and our experience.

INTRODUCTION

The SIBERA-2 is the 2nd generation synchrotron radiation light source. At the present time we carry out different works to upgrade and improve consumer quality of synchrotron radiation beams. In particular, new synchrotron radiation beam lines and user's experimental stations are constructed, new systems are installed, a replacement of some execution units and control electronic devices is carried out, acquired, stored and analyzed data are progressively extend, the requirements to quality of synchrotron radiation and electron beams are made more stringent and much more. Some electron beam parameters at storage ring SIBERIA-2 are presented at Table 1.

Table 1: Electron beam parameters at SIBERIA-2

Beam current, mA	1 - 200
Revolution frequency, MHz	2.4152
Beam emittance, nm·rad	18 - 98
Lifetime at 160 mA current, h	~ 20
Number of bunches	1 - 75
Bunch sizes, mm: σ_x, σ_z, σ_s	0.34, 0.059, 20.0

In the spring of 2013 existing electron beam orbit readout system has been replaced by modern electronics providing more flexibility in data readout and high-speed interfaces. Libera Brilliance from Instrumentation Technologies has been adopted for the electronics upgrade.

The accelerator has 24 beam position monitors (pickups) around the ring. For data processing from one pickup one Libera Brilliance unit is used. All Libera Brilliances units are concentrated in 4 groups and installed in 4 racks inside the accelerator tunnel on the inner side of the shielding wall of the storage ring just above the accelerator median plane (See Fig.1). Measured radiation background at the place of racks location does not exceed the maximum radiation level for normal equipment operation.

All racks are interconnected with synchronization signals (Machine revolution clock, Trigger) and Ethernet connection. Each devices group consists of 6 Libera Brilliance, 1 Clock splitter and 1 Ethernet switch. See the Figure 2 for detail.

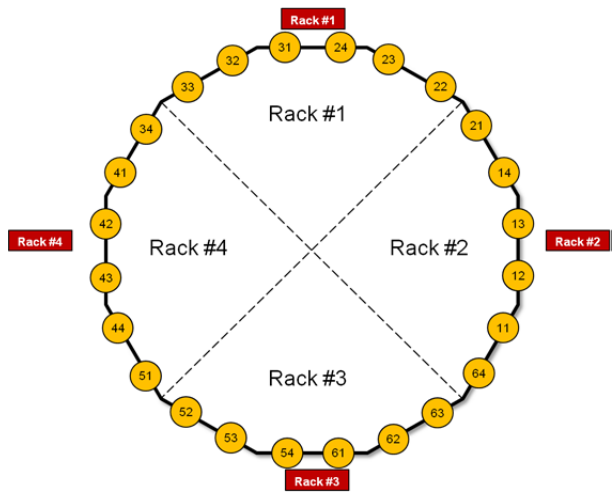

Figure 1: Distribution of BPMs and electronics.

The instruments run on embedded Linux OS (armel). In the first stage, EPICS IOC provides the control and data readout to the control system. EPICS IOC (is used as IO server) and EDM screens (is used as graphical user interface) are controlled under Ubuntu Linux operation system.

The detail description of Libera Brilliance units functionality is presented in the reference [1].

SYSTEM OVERVIEW

Upgrade Steps

The upgrade to the new readout system required installation of new RF cables including removal and re-fitting of the BPM connectors. The installation of new cables and complete setup of Libera Brilliance instrument

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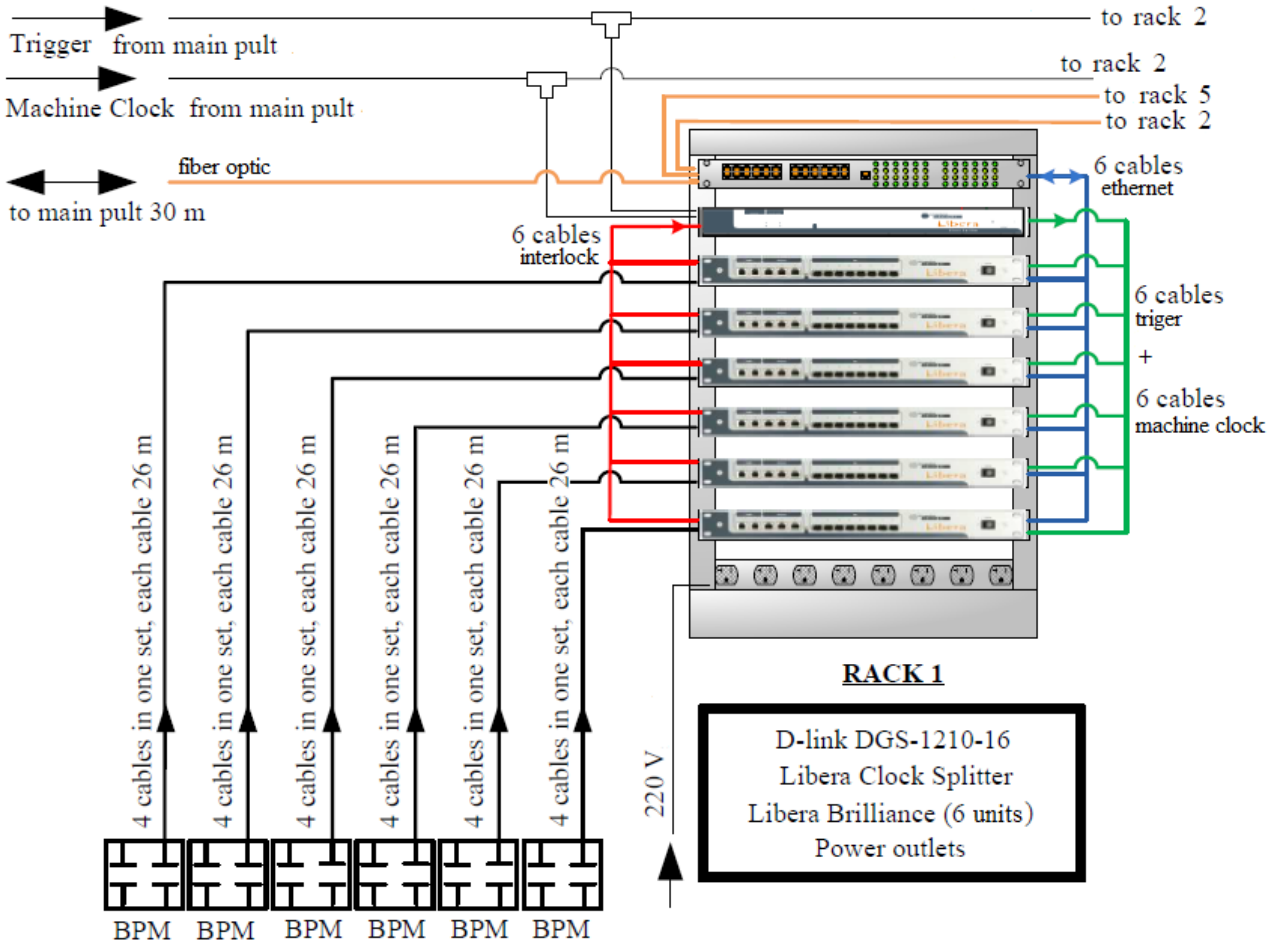

Figure 2: One rack with electron beam reference orbit measurement system equipment inside and all connections general layout.

took only 3 days followed by additional 3 days of control system installation and establishment of connections to the new instruments. SIBERIA-2 was started as per original shutdown plan with no hiccups due to the new readout electronics. The initial control system is based on EDM and provides a closed orbit view, first-turn measurements as well as turn-by-turn and single-pass measurements (Figure 3).

Functionalities

The EDM screens have been provided by Instrumentation Technologies and customized specially for SIBERIA-2. Configuration of parameters can be done globally (same for all) or individually per instrument. The configuration panel provides a colour-based status for MC PLL locking and Interlock. Instruments are organized in a grid based on their location in the ring (super-period & BPM), see Figure 4.

First-turn data acquisition is supported by a single-pass orbit view that displays horizontal & vertical position and SUM of the bunch. This function is of great help locating the potential issue in the orbit during the injection. First turn trajectory can also be monitored with orbit view, where orbit position can be seen from turn to turn (the number of turn is selectable from 1 to 1000).

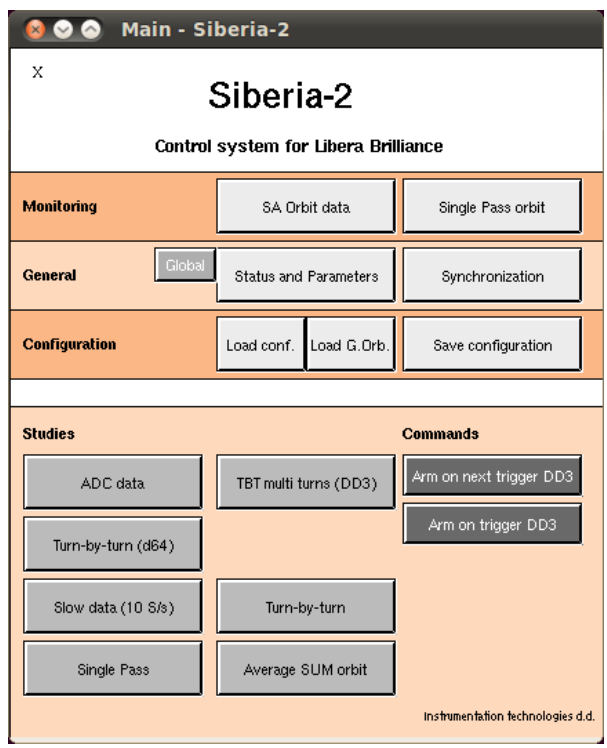

Figure 3: The main control window.

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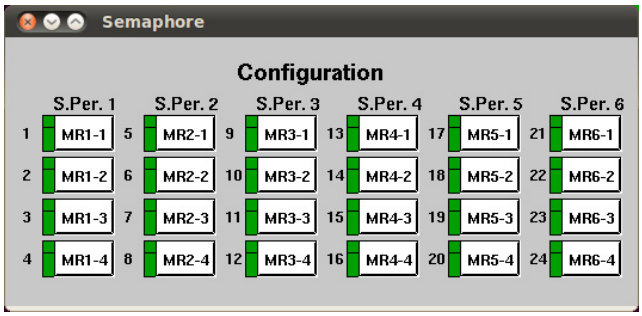

Figure 4: BPM selection panel.

Turn-by-turn data is accessible from all instruments individually, too. The data includes position as well as channel amplitudes readings. Additional buffer contains a decimated turn-by-turn data (decimation factor 64) which is appropriate for continuous use. It produces 64 times less network traffic.

MACHINE START-UP

SIBERIA-2 is a storage ring that is fed by booster synchrotron SIBERIA-1. The injection is done every 25-40 seconds. The first orbit view was seen at 0.08 mA current. Oscillations of the thousands of first turns were checked with turn-by-turn data in super-period 1 BPM 1, which is the first BPM after the injection point. Oscillations were in the range of 4 mm in horizontal and ~2.5 mm in vertical directions. Increase in the SUM signal is nicely seen from Figure 5 (green line). SUM is presented in arbitrary units but could be normalized to beam current.

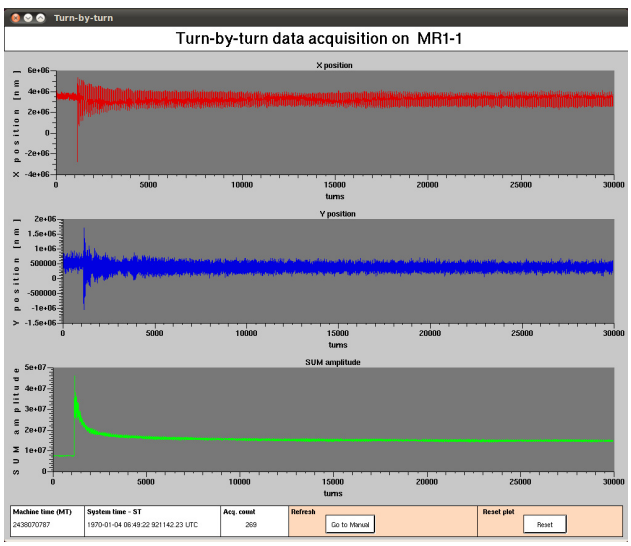

Figure 5: First turns on the BPM after injection point.

Closed orbit is shown in the main part of Figure 6. The source data for the closed orbit is so called Slow Acquisition data stream that is read out at approximately 10 samples / second rate.

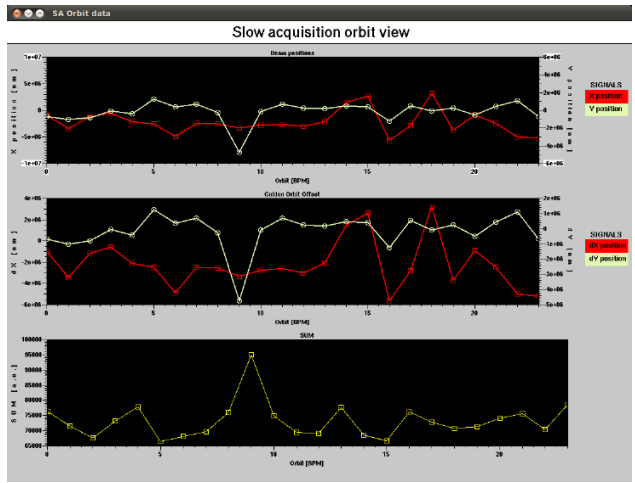

Figure 6: First orbit view.

PLANS FOR THE FUTURE

At the present time new electron beam reference orbit measurement system is use as stand along system without connection to the facility control system. It is a problem. For example, it is a very difficult to full integrate the system into our control system and use data from it for automated global or local electron beam orbit correction.

Just now we upgrade our facility control system (both software and some hardware part) with full integration of all used equipment. The server and upper level of our new control system is based on CitectSCADA system. This SCADA system provides algorithms assignment, data exchange, storing data, any processes visualization, alarms control, detailed report preparation, etc.(See for detail reference [2]).

The another direction of our plans is to evolve algorithms of electron beam orbit correction used at our facility.

CONCLUSION

New electron beam reference orbit measurement system significantly increased the possibilities of the diagnostic system at the main storage ring SIBERIA-2. We have at our disposal a very good instrument for studying the electron beam dynamics. At the present time the described system is integrated to new control system of the accelerator complex. This will allow to use all available capabilities of new electron beam reference orbit system.

REFERENCES

[1] Ye. Fomin and al., New electron beam reference orbit measurement system at dedicated synchrotron radiation light source SIBERIA-2, Proc. of RuPAC 2012.

[2] V. Dombrovsky and al., New automated control system at Kurchatov synchrotron radiation source based on SCADA system Citect, Proc. of ICALEPCS 2013.

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