NEW ELECTRON BEAM REFERENCE ORBIT MEASUREMENT SYSTEM AT DEDICATED SYNCHROTRON RADIATION LIGHT SOURCE SIBERIA-2

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Abstract

The paper focuses on the project of the electron beam closed orbit measurement system at SR source SIBERIA-2 realizing at present time at Kurchatov Institute.

The main purpose of new closed orbit measurement system creation is an improvement of the electron beam diagnostic system at storage ring. In addition, it will be a part of fast feedback system which will damp the distortions of the closed orbit at SIBERIA-2. 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.

The paper describes the new orbit measurement system, the principle of operation and its technical characteristics.

INTRODUCTION

The electron beam reference orbit measurement system which is currently operating at SIBERIA-2 is obsolete and outdated. The initial part of the orbit measurement system consists of 24 beam position monitors (4 pickups at one superperiod) and the preliminary signal processing electronic device located near each beam position monitor (BPM). The main purpose of this electronic devices are preliminary signal processing to transmit its to main control room for final processing and calculating electron beam horizontal and vertical positions (X and Z). Into the main control room all 96 signals from each button of BPM consecutively are digitized with the help the switch and one ADC made into the CAMAC standard bus. Control of the switch and the ADC as well as the beam center of gravity position calculation and results display are performed by micro controller Odrenok. As a result, the process of the electron beam reference orbit measurement takes a lot of time – 5 s.

Due to very slowly orbit measurement process it is possible to measure the electron beam orbit only in stationary accelerator operation mode. It is not possible to perform correct measurement of the beam trajectory during electron beam injection or acceleration process. It would also like to note the electron beam reference orbit correction process takes a lot of time - up 1 hour.

Now the synchrotron radiation light source SIBERIA-2 is being upgraded and the synchrotron radiation beam quality is being improved. New synchrotron radiation sources (superconductive and normal conductive wigglers), new synchrotron radiation beam lines and experimental stations are constructed. So both the synchrotron radiation and electron beam requirements will be only become stronger. 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	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 nearest future the existing electron beam reference orbit measurement system and the global orbit feedback system will be not able to provide required photon beam quality for all synchrotron radiation users.

NEW ELECTRON BEAM ORBIT MEASUREMENT SYSTEM

New electron beam reference orbit measurement system at dedicated synchrotron radiation source SIBERIA-2 is being created based on the electron beam position processor Libera Brilliance units developed by Instrumentation Technologies company, Slovenia. In all respects the new system is better the old one.

The architecture of the new orbit measurement system is looking like the old one. 24 Libera Brilliance processors are used to process the signals from BPMs. These processors are combined into 4 groups with the help of 4 Clock Splitter units and 4 ethernet switches. Each device group (6 Libera Brilliance units, 1 Clock Splitter and 1 Ethernet switch) is installed into one rack. The all 4 racks are mounted at the equal distance (one quarter of the accelerator circumference) from each other on the inner side of the shielding wall of the storage ring at a 1.5 m height from accelerator median plane. Such arrangement of racks with the equipment is allowed to reduce radiation background to the equipment. Measured radiation background at the place of racks location does not exceed the maximum radiation level for normal equipment operation.

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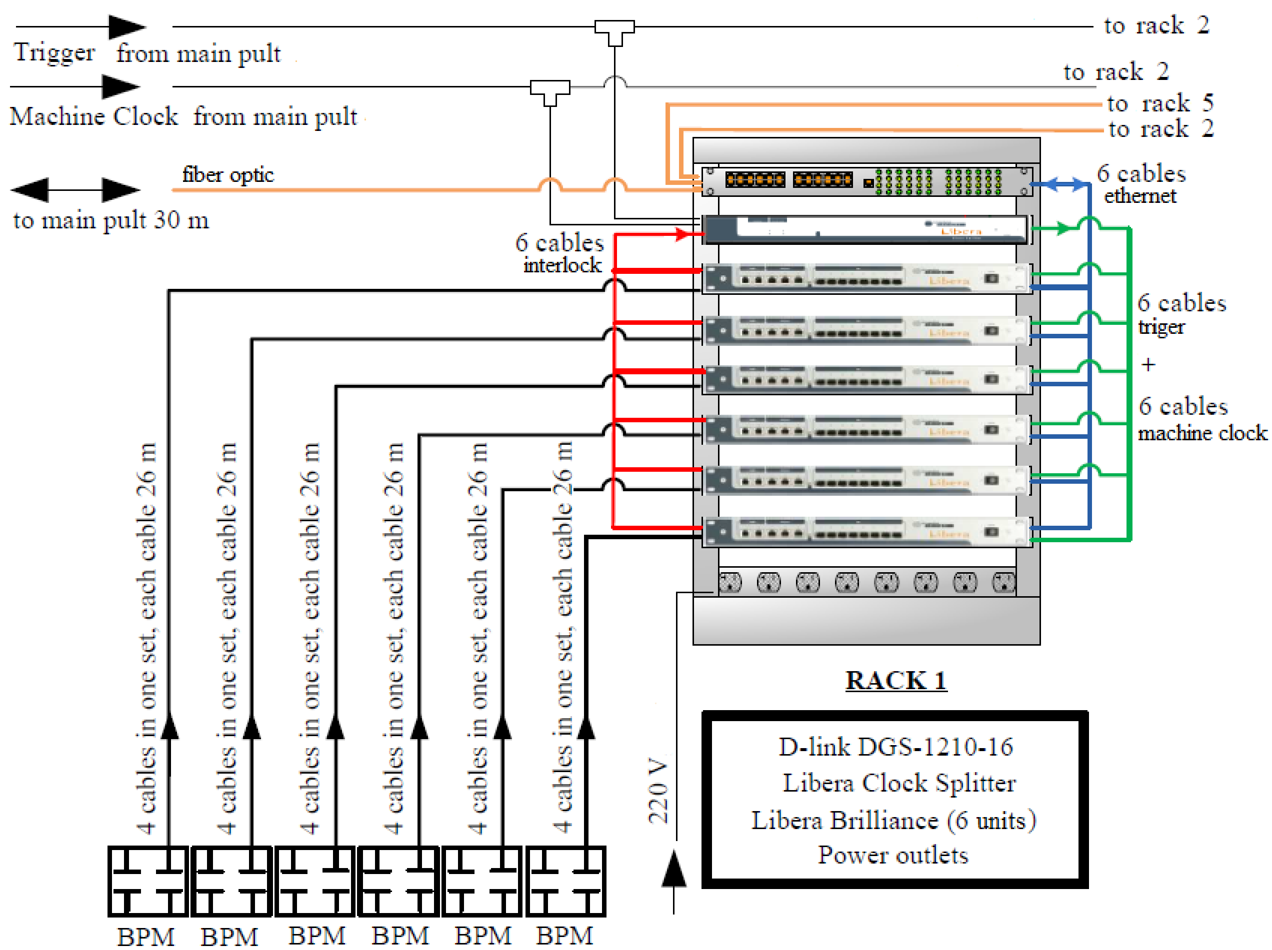

Figure 1: One rack with electron beam reference orbit measurement system equipment inside and all connections general layout.

Such choice of the equipment location is caused by the fact that one Clock Splitter can-not operate with more than 10 Libera Brilliance processors. At the same time, such distribution optimizes the RF cable lengths from BPM buttons to the Libera Brilliance units thus reducing the cost of cabling.

At the Fig.1 the general layout of one rack with electron beam reference orbit measurement system equipment inside and all connections is presented. All 4 racks with the orbit measurement system equipment are connected to a ring circuit type with the help a optic fiber cable and connected into the join accelerator local network. This type of connection is used to exchange the data between accelerator control system and Libera Brilliance processors.

The Clock Splitter installed into each rack is used to distribute clock signals to the Libera Brilliance instruments and combine Interlock signals. Synchronous events' arrival (Machine Clock, Trigger, Post-mortem) is essential for performing synchronized measurements using multiple Libera Brilliance processors. To synchronize the measurements two type of signals are necessary: Machine Clock and Trigger. Optionally it is possible to use System Clock and Post-mortem signals. All signals are LVTTL type.

The Machine Clock signal is used to specify zero separatrix. This signal is a continuous series of pulses with electron beam revolution frequency (in our case - 2.415 MHz).

The Trigger signal is a single pulse. This signal is used to start a single measurement of beam trajectory (for example, measurement a beam trajectory during injection process). The maximum repetition rate of this signal pulses is 20 Hz.

The Post-mortem signal is similar to the Trigger signal, but this signal is used to get and save a beam trajectory before the Post-mortem signal arrival. For example, when the electron beam is lost the accelerator control system sends the Post-mortem signal to Libera Brilliance processors. The control system then requests the so called "Post-mortem" data, which contains the electron beam trajectory data before a beam loss. This feature is very useful for an electron beam loss analysis.

Electron beam position processor Libera Brilliance is a main component of the new electron beam reference orbit measurement system. Libera Brilliance processors feature the high precision position measurement of the electron beam in the booster or storage ring. Digital signal processing inside the Libera units support programmable bandwidth and can facilitate all the position

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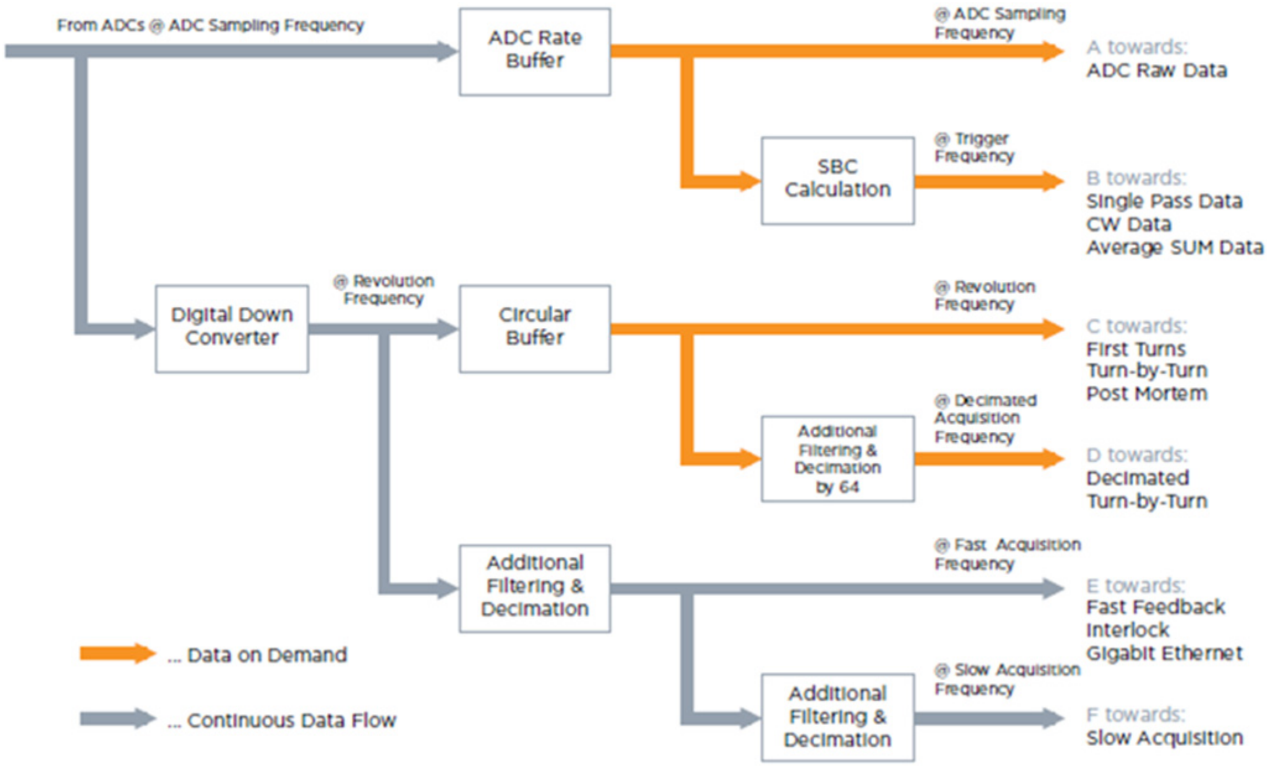

Figure 2: Data paths inside electron beam position processor Libera Brilliance.

measurements required: pulsed, first turns, turn-by-turn (measurement accuracy up to 0.35 µm) and regular closed orbit (measurement accuracy up to 0.07 µm).

The Libera electron beam position processors are fully customizable and can also be programmed to control the control units for corrector magnets. This can be carried out by the users with the FPGA development kit. So, there is a possibility to create the fast global orbit feedback system based on this new electron beam orbit measurement system. The maximum frequency update of electron beam orbit data is 10 kHz.

The Libera electron beam position processors are optimized to work with input signals from button BPMs. Variable attenuators on four parallel analog chains are used to adapt the input signal to the proper level. The signal processing chain on the units are composed of analog signal processing, digitalization for fast ADCs and digital signal processing. Each channel consists of a digital down-converter (DDC), which is followed by parallel processing in wideband and narrowband paths. Beam position is calculated using the standard equation.

There are several types of output data of the Libera Brilliance processor: pickup amplitudes (A, B, C, D), calculated beam position (X and Z) and the sum signal from 4 BPM buttons (this signal is proportional to the beam current). Also information about current operation mode of the equipment is available.

The Libera electron beam position processors provide several data paths at different sampling rates with different bandwidth and resolution (see Fig. 2) thus allowing detail machine studies and stable user operation. Acquisitions can be done simultaneously on all four major data paths (ADC raw data, turn-by-turn data, fast acquisition and slow acquisition data). The injection studies (efficiency, ramp-up) are supported by first-turns acquisition with turn-by-turn data as well as with rich raw ADC-data based single pass acquisition which returns the raw button signals, SUM value and position at every injection trigger. Fast acquisition data is provided through deterministic fast ports (SFP) at a 10 kHz data rate and serves as the input data for fast global orbit feedback.

Special software for Electron beam reference orbit measurement system will allow for automated monitoring and control of electron beam reference orbit and trajectory during injection process. Graphical user interface will enable the operator to set and control system operation modes, to control electron beam orbit at the current time. Special software will be developed by using the SCADA system and integrated into accelerator control system.

CONCLUSION

New electron beam reference orbit measurement system will lead the diagnostic system to a new level and allow improvement of both the electron and the photon beam quality. Farther new electron beam global orbit feedback system will be created based on this electron orbit measurement system.

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