Design and status of fast orbit feedback system at SOLARIS

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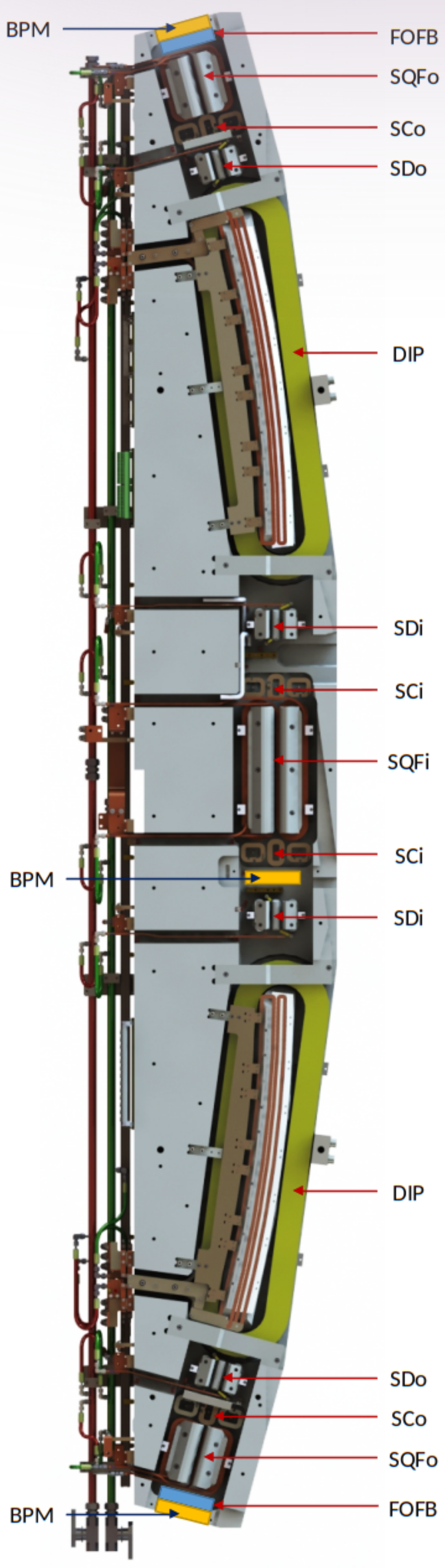

Fig. 1: SOLARIS DBA design

Introduction

The SOLARIS storage ring consists of 12 double bend achromat (DBA) cells. Conceptually, the magnet design is identical to MAX IV 1.5 GeV storage ring. All magnet elements are machined out of one solid block of iron, about 4.5 m long.
The, currently operational, Slow Orbit Feedback system is used for initial beam positioning and maintaining a stable orbit. It uses BPMs for reading beam positions and quadrupole modes of SCo and SCi magnets for steering.
Due to current rise time limitations in strong corrector magnets, it currently works with correction frequency of either 0.25 or 0.33 Hz, with theoretical maximum of 1 Hz.

Overview

The Fast Orbit Feedback is mainly used to further improve the stability of beam orbit, especially in higher frequency range. The designed correction frequency of this system is 10 kHz.
In order to achieve this, all calculations are performed by FPGA chips and all data transfer is done exclusively by hardware links such as optical fibres, serial connections and LVDS, in isolation from network based control system.

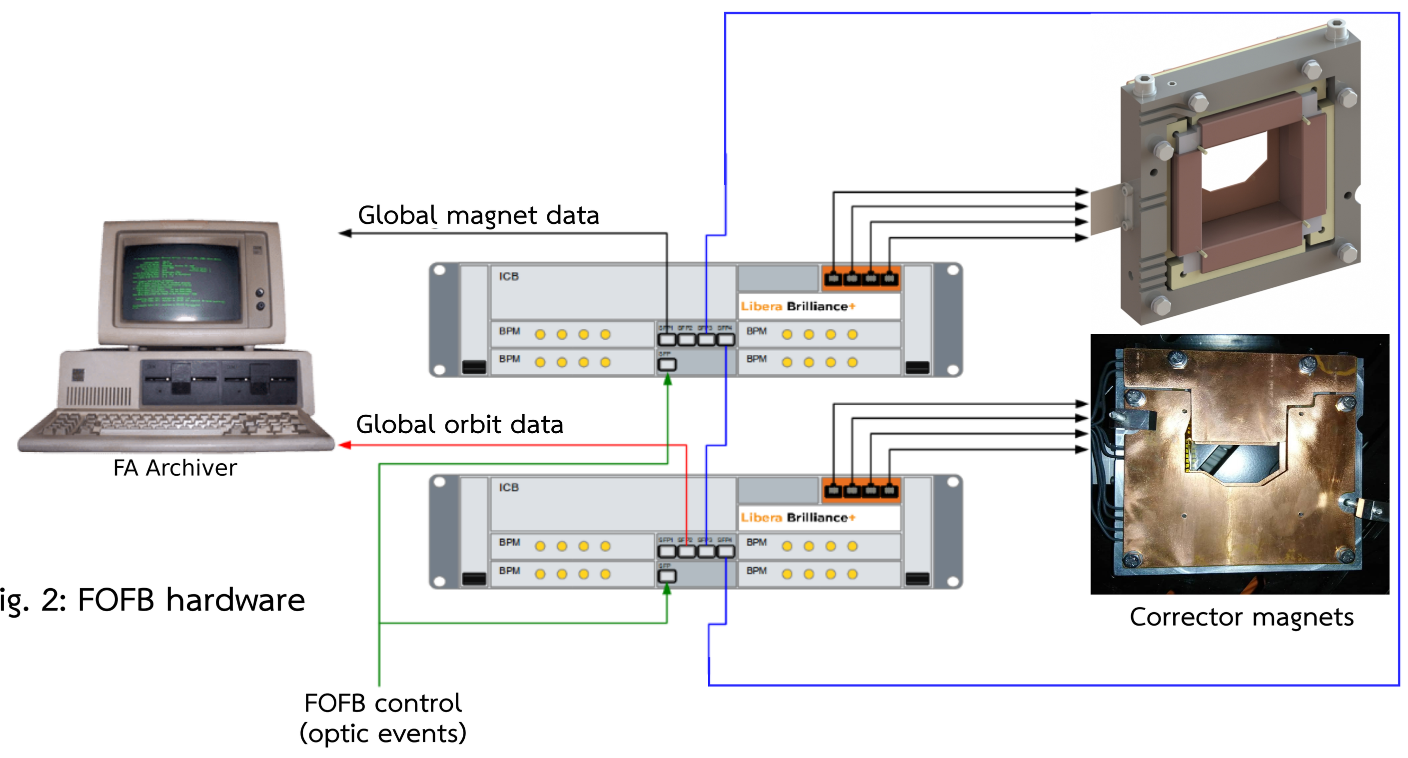

Fig. 2: FOFB hardware

The core of the system is Libera Brilliance+ instrument, which, in addition to BPMs, provides modules with FPGA chips and necessary communication interfaces. Here, the global orbit data is accumulated, and correction is calculated with response matrix and golden orbit provided beforehand. The correction setpoints are then streamed via RS485 link directly to fast corrector power supplies.

The fast correctors are small ferrite core/copper coil quadrupole magnets mounted at each end of each DBA cell, in places where steel vacuum chamber was mandated by DBA design. The magnets are based on design by MAX IV and manufactued by Scanditronix.

The power supplies used are Itest BE5495, which are specifically designed to support fast setpoint changes required by Fast Orbit Feedback application. Fast current changes come at expense of available range - the fast correctors can only be driven with ±2 A.
The modules support communication over Ethernet and RS485.

For FOFB diagnostics and fast phenomena observation the Diamond FA Archiver is used, which continuously captures the accumulated Fast Acquisition orbit data.

The algorithm

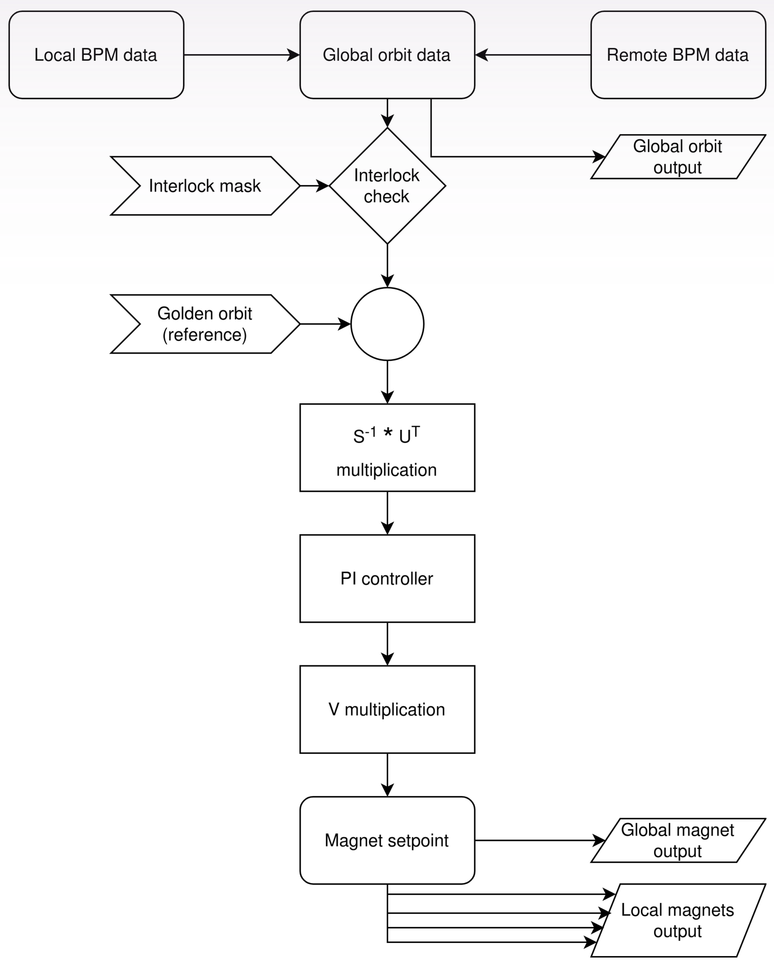

Fig. 3: FOFB algorithm

On the low level, the FOFB system uses an algorithm developed by Instrumentation Technologies together with MAX IV Laboratory. The algorithm consists of data aggregation from multiple BPM boards, matrices multiplication and PI controller. Finally, resulting corrector setpoints are pushed out via optical link or serial connections directly to power supplies.
The global orbit data is combined with desired golden orbit and multiplied by SVD-decomposed corrector response matrix.
The system is controlled via timing system events.

Control software

A simple application for controlling the feedback loop has been developed. Currently, it can be used to send FOFB commands via timing system and to check Libera Grouping status and status and configuration of magnet outputs. It can also be used for manual control of the corrector magnets.
Development of more sophisticated status and control is in progress.


Fig. 4: FOFB control application

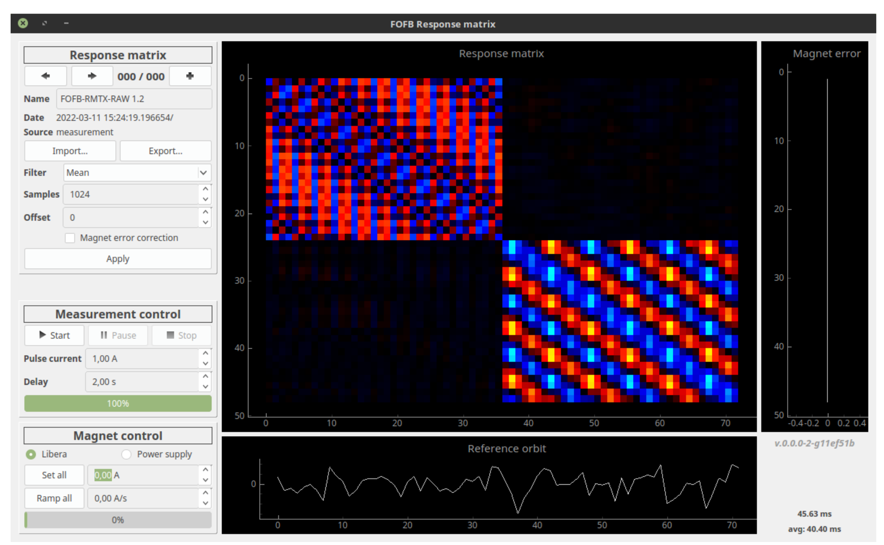
Fig. 5: Response matrix measurement application

An application for measurement of corrector response matrix has been developed. It allows measurements in different configurations controlling the power supplies either via Libera instruments or directly via the control system. For each corrector, an entire fast acquisition buffer of each BPM is retrieved. At the response matrix calculation stage, an operator can either use single samples from these buffers or calculate over mean or median value of multiple samples.
The response matrix can be reformatted for the Libera instrument and loaded into its registers, however this feature is still a work in progress

Status and tests

Currently, all hardware installations have been finished. Hardware connections were verified and tested.
First proof-of-concept measurements and test runs were performed. The core of the work focuses now on experimentally determining parameter values, control software development and solving problems as they arise.The machine studies time is shared with other new developments, but we expect to have first FOFB-enabled operations this year.

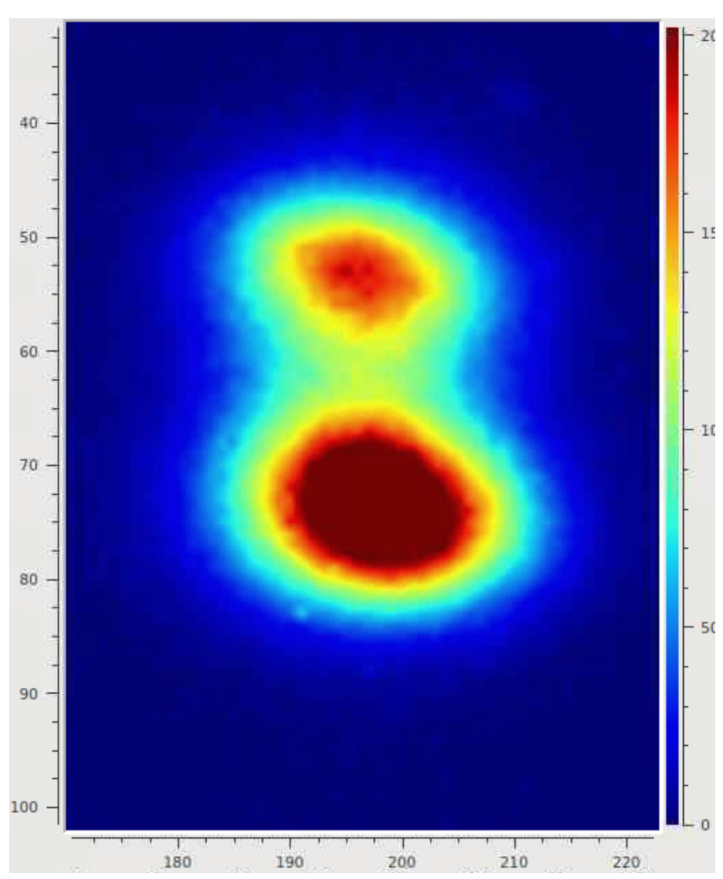
Fig. 6: Test run; rapid switching between two stable positions

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