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ESRF RAMPING INJECTOR POWER SUPPLY CONTROLLED BY TANGO

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Abstract

A new design of ESRF booster power supply system has been developed and installed. A multiple power supplies control through network including real time control is now operational at ESRF. It manages 4 power supplies to generate 3 waveforms defined with 3x1600 values in a setpoint file. The power supplies states are managed by PLCs. The ramping waveforms are managed by a real time program running on a FPGA board. A high level control on top of them is assumed by a TANGO [1] multiple classes system. This paper presents how these three levels of controls are interlinked and shows the results achieved**.**

OVERVIEW

Originally, a ten Hertz resonating circuit was supplying the current in the three main ESRF booster magnets chains. Although this equipment ran more than 25 years without major trouble, there are in the circuits huge specific transformers for which the time to repair is of one month and, furthermore, some components of the power circuits are now discontinued. Decision was made that this whole equipment was to be replaced by a new one, based on ramping of the current. The new functionality brought to the current behaviour is the possibility to correct any point in the slope (6400 Hz). This allows the stabilization of the tunes during the ramping to improve the efficiency of the electron beam cleaning in the booster [2].

General Layout

From the mains electrical network to the current delivered to the magnets, the path is the following (see figure 1):

- Transformers to adapt the voltage from the mains
- Rectifiers with digitally controlled thyristors
- Capacitor to store the energy and prevent the flicker
- Voltage controlled PWM power bridges

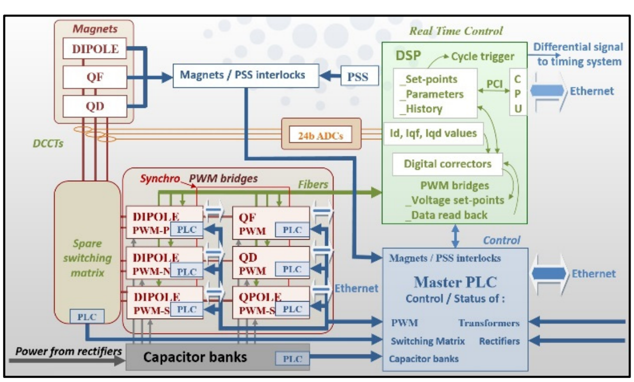

Figure 1: Layout.

From the latter stage, the voltages delivered are remotely controlled to finely adjust the current. The four PWM bridges units are connected to the FPGA board dedicated to the real-time control by means of optic fibers driven by Rocket IOS, Aurora (Xilinx) and serial ebone (ESRF) [3] (see figure 2).

The main advantage of this architecture is the easyness to perfectly synchronize the current in the three magnets families: dipole, focusing quadrupole and defocusing quadrupole. Indeed, the three control loops run inside the central FPGA and therefore, the computed voltages are sent synchronously to the four units every 156µs. The four units reply with informations that are stored in an history file available by the Tango server.

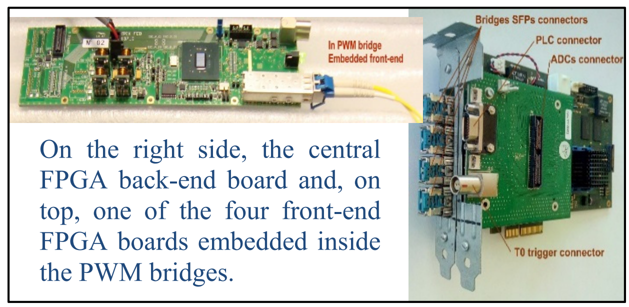

Figure 2: Real time control hardware.

All pieces of equipment are equipped with a dedicated PLC connected to a server through Ethernet. These PLCs are controlling the states of the different units and reporting to a master PLC itself controlled by a remote Tango application. All commands and safety aspects are managed by the master PLC while the history of events goes directly from each PLC to the Tango server.

TANGO CONTROL

The main challenge was to drive 4 power supplies synchronously through PLCs and FPGA.

Implementation

As shown on figure 3, on top level a TANGO device manages and sequences different features.

The 15 PLCs (power supplies, switching matrix,…) are controlled by a TANGO device server through TCP/Modbus sub devices.

The FPGA board is controlled by another TANGO device through a library developed at ESRF. It manages 58 attributes to be able to adjust each loop parameters, start/stop ramping, measures, status,…. It is able to load the waveform file in FPGA memory as set point. During the ramping phase, it get a set of 23x1600 measures and status from

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the FPGA at 4Hz and save these information in a file to be analyzed later by a dedicated application.

A TANGO device is able to generate the waveform file using MATLAB [4] library.

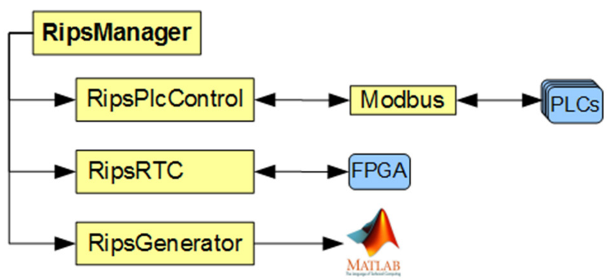

Figure 3: TANGO control device servers.

A dedicated application GUI displays the status of all equipment components on a synoptic and allows to set parameters, send commands, load and generate waveforms and execute diagnostics on the full system (see figure 4).

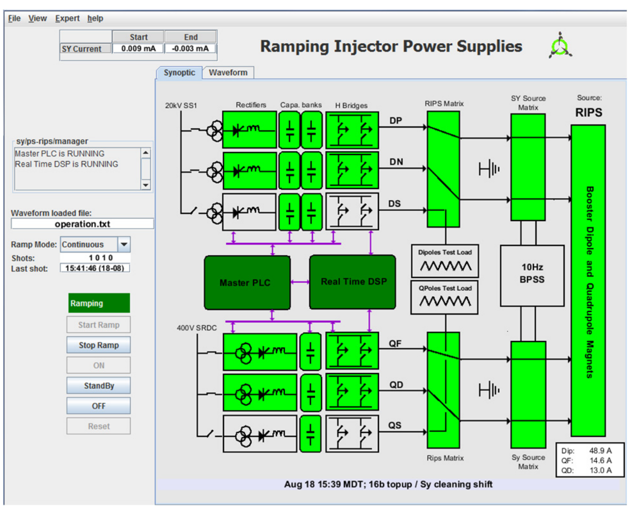

Figure 4: GUI during operation.

Operation

The whole equipment was operational for the first time in spring 2017 and was, at that time, running only twice a day for the refills of the storage ring. From the restart of the machine after the summer shutdown it is running in top-up mode, every few minutes, time depending on the filling pattern.

Results Achieved

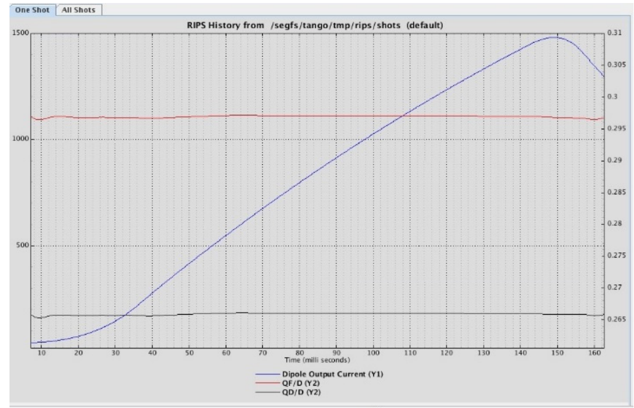

Figure 5: Dipole current and ratio Q/D

The current flowing in the magnets is raised following a specific shape computed to give the best voltage shape. Indeed this latter must never hang with the maximum available voltage at the bridges inputs, i.e. 1000V for the Qpoles and 1500V for the Dipole. The ratio between Dipole and Qpole current must stay stable within 10^{-3} (see figure 5).

The Ramping Injector Power Supply system is now fully operational for day to day operation. It is used since end of May. During July and a part of September it has been for automatic top-up (every 20 mn) without problem.

Acknowledgement

T.Perron, R.Versteengen, S.White and TANGO developer team.

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