CONSOLIDATING THE FLASH LLRF SYSTEM USING DOOCS STANDARD SERVER AND THE FLASH DAQ

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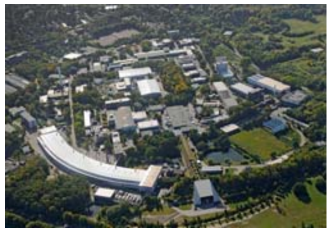
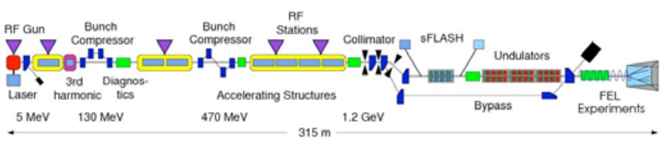
The Free electron LASer in Hamburg (FLASH)

FLASH the Free electron laser (FEL) in Hamburg at DESY (Germany) produces laser light of short wavelengths from the extreme ultraviolet down to soft X-rays. The reached peak brilliance is one billion times more intense than that of the best synchrotron light sources today.
FLASH is a high-gain FEL which achieves laser amplification and saturation within a single pass of the electron bunch through an undulator. The requirements for amplitude and phase stability to achieve lasing are very high, so precise LLRF regulation is needed.





Abstract

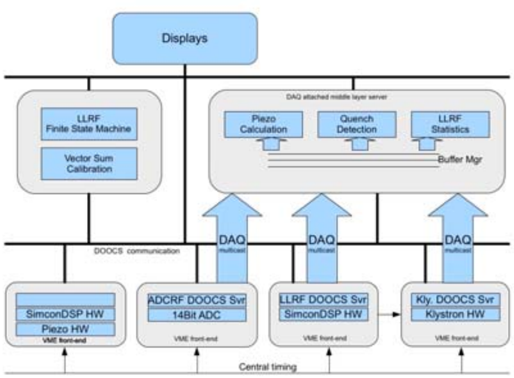
Over the last years the LLRF group developed many different flavors of hardware to control the RF systems at the Free Electron Laser in Hamburg (FLASH). This led to a variety of firmware version as well as control system server and display panels.
A joined attempt of the LLRF and the controls group was made over the last year to consolidate hardware, improve the firmware and develop one DOOCS front-end server for all 6 RF stations. Furthermore, DOOCS standard server are used for automation, like simple state machines, and the FLASH DAQ for bunch-to-bunch monitoring tasks, e.g. quench-detection.
An outlook of new developments for the upcoming European XFEL, using xTCA technologies, will be given.

Introduction

Over the period of the last 15 years, FLASH has evolved from a small test facility just with a Gun and one 8 cavity-accelerator module, running at about 100MeV to a photon science user facility. After the last shutdown, starting from September 2009, FLASH has been upgraded to 7 accelerator modules with eight 1.3GHz cavities each, plus a rd harmonic module with four 3.9GHz cavities. This set-up allows FLASH to run at a maximum beam energy of about 1.2GeV. Presently six RF stations are required to supply the gun, the rd harmonic- and the seven 1.3 GHz modules with RF.
Over this long period, the controls for the Low-Level RF (LLRF) developed with the changes of the accelerator. Many different flavors of LLRF controller hardware, starting from a pure analogue-based system for the first gun, a successfully used DSP system for the modules and different versions of Simcon and SimconDSP systems were developed. All these systems came with there dedicated firmware, device server software and operator display panels, leading to a very inhomogeneous global control system. Such a system was hard to maintain, because some of the personnel is not any more available. Applying global automation procedures was very difficult, because of the different structure and naming convention of every device server.
The effort to consolidate the LLRF system during the last shutdown will be described.

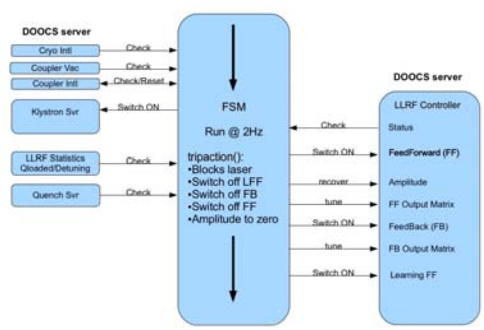
LLRF concept

This picture show the overall concept for one RF station with all required front-end computer and the middle-layer server based on DAQ and standard communication. Currently 4 front-end computer are involved for 1 RF section for the klystron, LLRF control, LLRF monitoring and piezo controls. bunch-to-bunch data is send via DAQ multicast to a shared memory and used by middle layer server.
Automation server and display tool are communicating via DOOCS calls.



Automation

The concept to automate the RF is based on a simple Finite State Machine FSM approach. The main purpose are to simplify the switching on/off procedure and faster recovery from trip.
This FSM is realized in the standard DOOCS server framework with the addition of the DOOCSdfsm library, which provides simple classes for monitoring float values, recover set-values or resetting interlocks. The FSM is the central server for the automation, it starts up or switches off the whole RF. All actions in other server are triggered by the FSM, giving the operator one central location to look for the status or problems of the RF system; no other software should switch the RF.
The FSM runs with a repetition rate of 2Hz, checking several things, like interlocks, coupler vacuum, klystron status or quenches. In case of a problem in a state, the so called tripaction() function is triggered to bring the system to a save condition. Then the FSM tries to recover the RF system.



Outlook

For the upcoming European XFEL project, it is planned to use xTCA as hardware platform, because of the modern PCIx communication and the standardized remote monitoring capabilities. The required down-converter and fast ADCs µTCA cards are already available, the LLRF controller board is in the design phase. Porting of the LLRF controller server code from the old SPARC VME CPU to a resent INTEL x86 CPU is in progress. The goal is to have one source code base only by exchanging the hardware interface through compile flags. Due to the much better performance of the INTEL CPUs, it will be possible to run most of the middle layer server, like quench detection locally.

This picture shows the new µTCA ADC SIS8300 from the company Struck with the following features :

- Ten 16-bit ADC 125MS/s sampling
- Two 16-bit DAC outputs
- Xilinx Virtex V FPGA
- PCI Express communication
- Rear transition connector for analog IO (PICMG for Physics standard)
- IO for clock signal
- Twin SFP Card Cage for High Speed System Interconnects

Summary

The LLRF system at FLASH has been consolidated to one unified setup for all RF stations in terms of hardware, firmware, software and naming convention. Operator panels have been simplified and better expert panels have been designed.
The concept of a simple FSM is in standard operation, but some improvements have to be implemented to sort out conflicts between operator intervention and FSM recovery action. The Learning Feed Forward algorithm has been ported from a MatLAB tool into the LLRF controller server and is in standard operation as well. Applications like Vector Sum calibration or quench detection are implemented as DOOCS server already, but need more commissioning and tighter integration into the FSM framework. Further work is needed to improve the reproducibility of the RF system.
It is reasonable to say, that the first user run showed already improved performance of the LLRF controls and the new structure will be well-suited to be the base for the European XFEL.