High-Level Software Tools for LLRF System Dedicated to Elliptical Cavities Management of European Spallation Source Facility

Kacper Kłys

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Department of Microelectronics and Computer Science, Lodz University of Technology
http://www.dmcs.p.lodz.pl
Agenda

➢ European Spallation Source
➢ LLRF control system
➢ EPICS and E3
➢ Piezo Driver management and monitoring software
➢ LO Distribution Tool
➢ IPMI Manager supporting software
European Spallation Source

➢ ESS is an accelerator-driven neutron spallation source.
➢ It generates protons from the ion source.
➢ They are accelerated to suitable energy and driven to target.
➢ Protons are accelerated with energy from Radio Frequency system.
➢ High Beta and Medium Beta sections are composed of 84 and 36 elliptical cavities.

Fig. 1 Block diagram of the ESS accelerator
Low Level Radio Frequency Control System

➢ Control of electrical field’s parameters in the superconductive cavities (phase and amplitude).
➢ Compares current value against a group of desired data.
➢ Uses PI controller.

Fig. 2 Schematic of the LLRF section
EPICS and E3

- Experimental Physics and Industrial Control System (EPICS) – software toolkit for distributed control system.
- Bases on client/server idea.
- Data stored and accessed in Process Variables (PVs).
- ESS EPICS Environment (E3) – environment where EPICS applications are compiled and launched.
- Helps to keep consistency, easier long term maintenance.
- Focuses on device integration.

Fig. 3 Logos of EPICS and E3
IOCs Architecture and E3

- EPICS structure is encapsulated into E3 module.
- IOC uses C++ asyn class to communicate with device.
- Asyn reads/loads data from/to PVs in database.
- PVs are used by users to set device parameters.

Fig. 4 Standard IOC structure
Piezo elements are used for fast compensation of detuning.
- Detuning can be caused by the Lorentz force, microphonics.
- Designed as Rear Transition Module (RTM), MicroTCA.4 standard
- Bases on FPGA board.

Fig. 5 Piezo control system of the ESS accelerator
Piezo Driver – IOC structure

Fig. 6 Piezo Driver IOC block diagram structure
LO Distribution Tool – Overview

➢ LLRF control system needs to master phase reference clock and propagate system clock.

➢ Local Oscillator (LO) RTM device is responsible for the generation of the local oscillator signal.
➢ It is used for RF down-conversion.

➢ The device was implemented as RTM module in MTCA.4 standard.
➢ Uses same drivers as Piezo Driver.
LO Distribution Tool – IOC structure

- e3-LOdistribution
  - (e3-iocStats, e3-autosave, e3-recsync)
  - LODistribution.db
  - asyn driver
    - ics-lo-lib
    - ics-xdriver-core
    - ics-xdriver-lib

Fig. 7 LO IOC block diagram structure
IPMI Manager – Overview

➢ Major part of the LLRF system is based on MTCA.4 architecture.
➢ Its control layer bases on IPMI (Intelligent Platform Management Interface) protocol.
➢ It can be used to monitor the whole system and attached modules.

➢ IPMI Manager is a scalable software.
➢ Dynamical detection of available modules and generation of PVs.
➢ Uses OpenIPMI library.

Fig. 8 MTCA.4 crate
IPMI Manager – IOC structure

Fig. 9 IPMI IOC structure
Summary

➢ All the tools are still being developed (looking for bugs, making them more user-friendly).

➢ They have been tested with real devices.

➢ Those measurements and their results were recorded as videos.