Linux-based PXIe System for the Real-Time Control of New Painting Bumper at CERN

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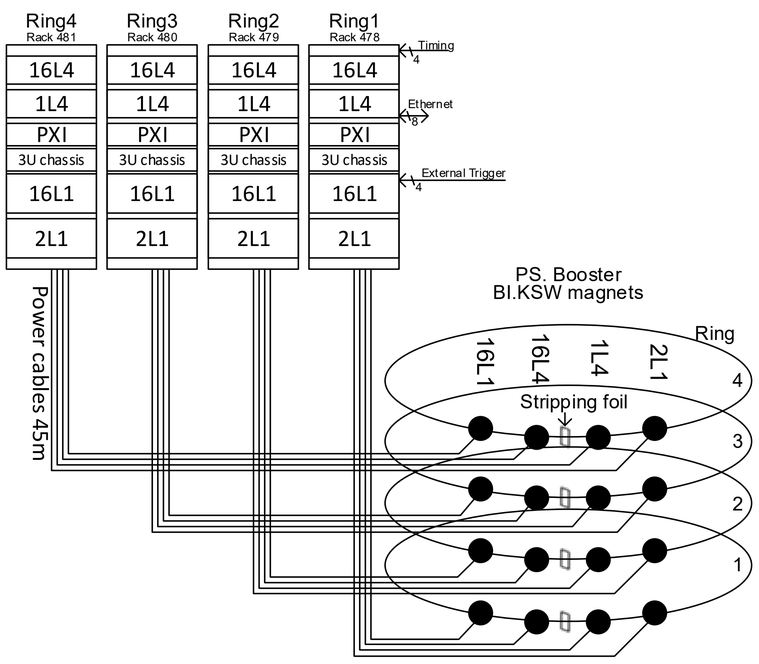
ABSTRACT

In the framework of the LHC Injectors Upgrade Project, the new connection from Linac4, injecting a 160 MeV H- beam into the Proton Synchrotron Booster (PSB) requires a set of four slow kicker magnets (KSW) per PSB ring to move the beam on a stripping foil, remove electrons and perform phase space painting. A new multiple-linear waveform generator based on a Marx topology powers each KSW, allowing adjustment of the current discharge shape with high flexibility for the different beam users.

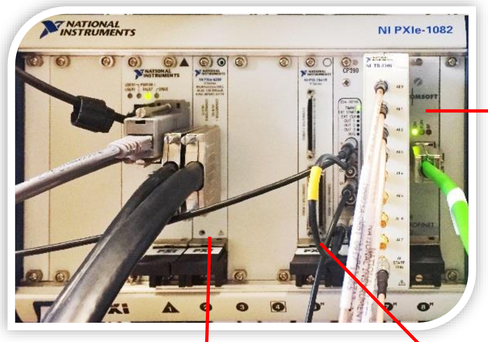
To control these complex power generators, National Instruments (NI) PXIe crates fitted with a set of modules (A/D, D/A, FPGA, PROFINET) are used. Initially, control software developed with LabVIEW has validated the test bench hardware. A full software re-engineering, accessing the hardware using Linux drivers, C APIs and the C++ framework FESA3 under Linux CentOS7 was achieved for operational deployment.

This poster describes the hardware used, and the integration of NI PXIe systems into CERN controls environment, as well as the software architecture to access the hardware and provide PSB operators and kicker experts with the required control and supervision.

Four racks with generators and PXI controller

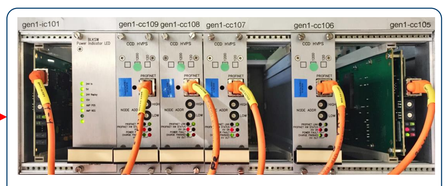


PXI Chassis composition and relevant software controlled components



KUNBUS DF ProfiNet IO

PROFINET master controller



Charger discharge + Interlock control

6 per Generator

PXIe-6358

DAC module

PXI-7841R

FPGA Module

The setup selected, to control the four generators, consists in a NI PXIe-1082 chassis equipped with a PXIe-8821 controller. To interface with the PROFINET modules, a Kunbus® DF-Profinet-IO operates as fieldbus controller. The control crate hosts as well a field-programmable gate array, NI PXIe-7841R, controlling four power amplifiers acting directly in synchronisation with timing triggers.

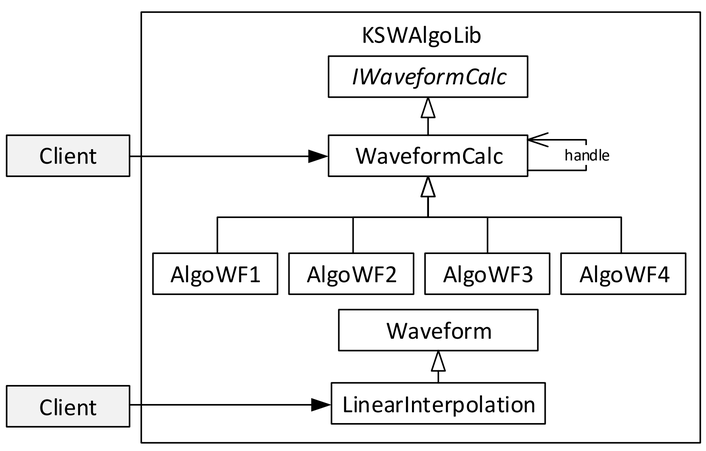
The control crate also features a central timing receivers board and a digitizer. Being part of other projects, no further detail will be exposed on those modules.

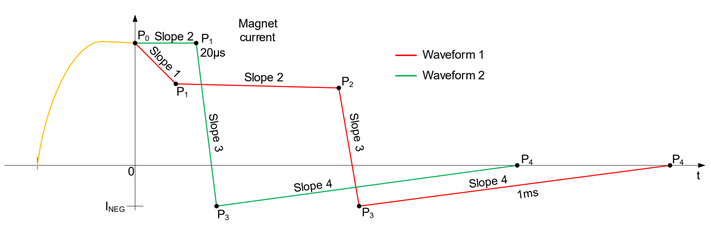
Software architecture

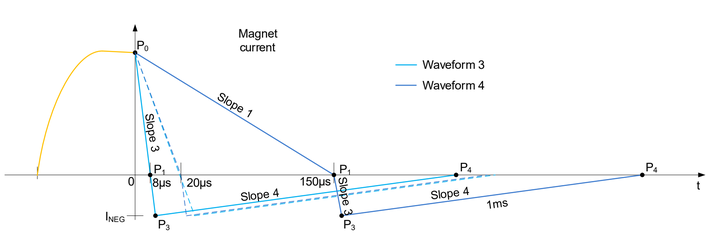
KSWAlgoLib

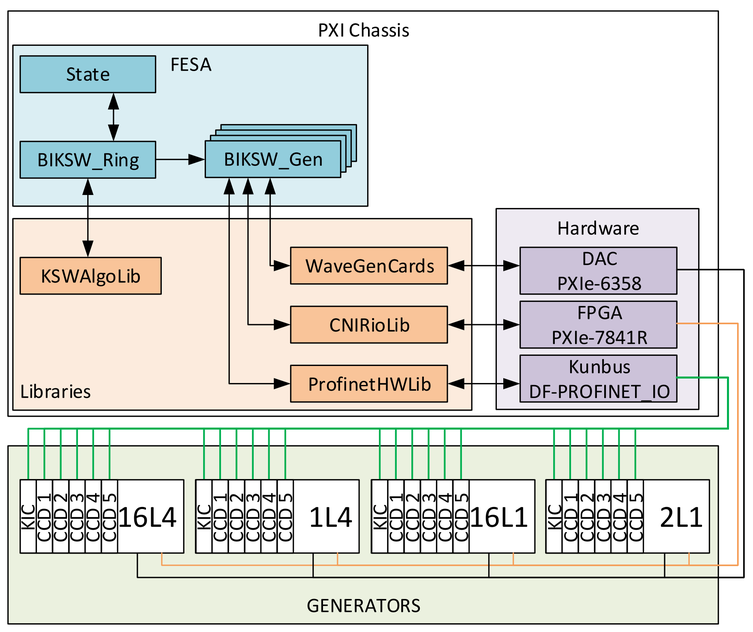
Algorithm library

computes and generates parameters for four possible discharge shapes









CNIRioLib

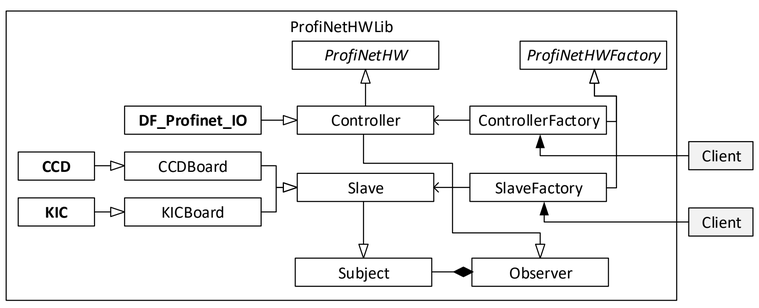
Fast logic library

Project specific library that simplifies the access to the NI RIO FPGA device from the KSW control software. takes care of the driver initialization and the loading of the bit stream into the FPGA exposing business logic methods with structured parameters.

ProfinetHWLib

Communication library

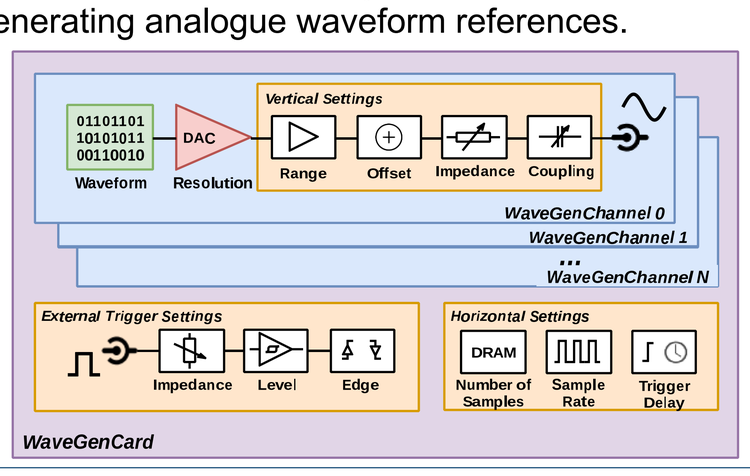
PROFINET devices factory featuring automatic network discovery and configuration with hot swap.



WaveGenCards

Waveform library

Hardware abstraction layer for the DAC control generating analogue waveform references.



CONCLUSION AND OUTLOOK

Through this project, the use of non-proprietary operating system and software has been successfully validated on a PXI platform using only off-the-shelf modules. Nevertheless, the use of a proprietary software solution at the early stage of the project has permitted to validate the different power components with at the same time an easiest and flexible approach to implement, test, validate and modify the required control functionalities. The re-engineering of the available proprietary based software within the CERN accelerator control system has permitted to optimise the software structure while keeping the available hardware. This approach opens the door for a reduction on the dependencies from proprietary software, while homogenising the control software across different type of equipment.

The results obtained on the test bench implementing a full vertical slice of the control system shown a great performance, with an average of 56ms, to compute and configure all the hardware for a ring.

The second valuable aspect of this project is its organisation around generic libraries for PROFINET communication and waveform generation providing a reusable base for future projects.

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ICALEPCS 2019