# PXI LOW-LEVEL CONTROL SYSTEM FOR THE CERN PS FAST PULSING KICKER MAGNETS

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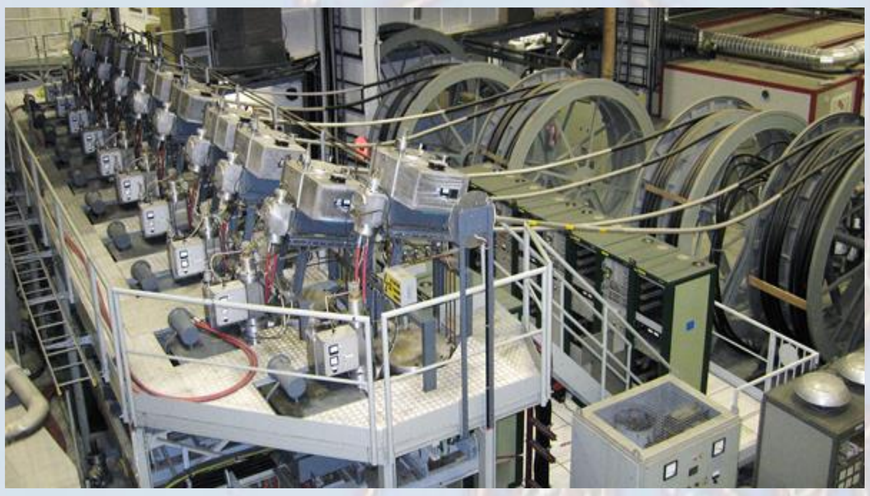
## ABSTRACT

Fast pulsed magnet (kicker) systems are used for beam injection and extraction in the CERN PS complex. A novel approach, based on off-the-shelf PXI components, has been used for the consolidation of the low-level part of their control system.

Typical functions required like interlocking, equipment state control, thyratron drift stabilisation and protection, short circuit detection in magnets and transmission lines, pulsed signal acquisition and fine timing have been successfully integrated within a PXI controller.



*Antiproton Decelerator (AD) extraction kicker system layout*

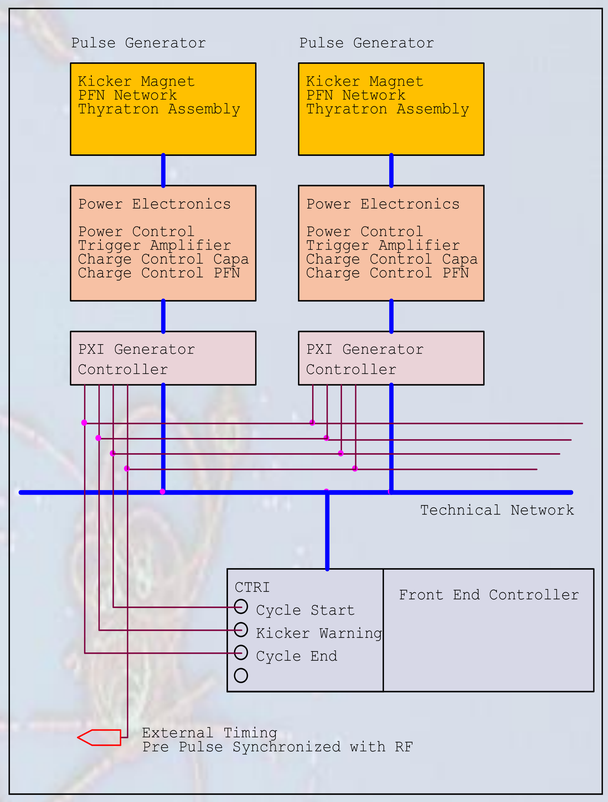
## KICKER MAGNET GENERAL CONTROL LAYOUT

A typical PS kicker magnet installation comprises a number of pulse generator modules that are individually controllable from the Frontend Controller (FEC).

The FEC acts as the master and data concentrator for all generators. The timing signals are generated at the FEC level and distributed to the different generator module(s).

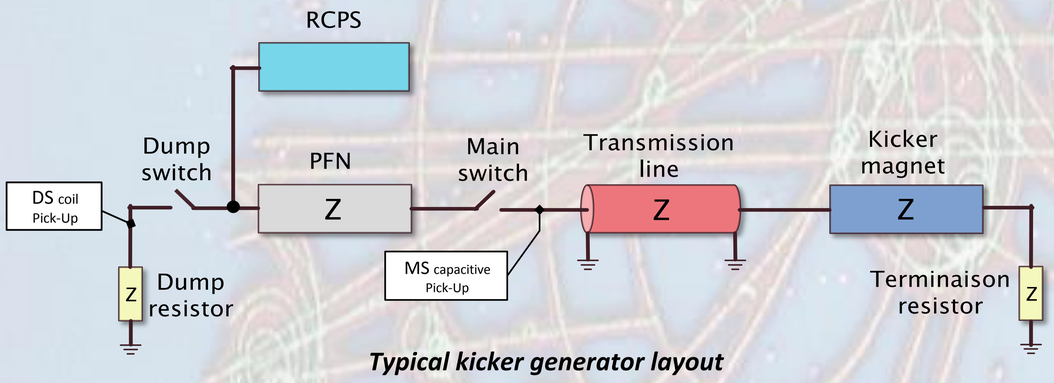
A generator module can be seen as three different subcomponents:

- The kicker magnet with its pulse forming network and fast thyratron switches;
- The power electronics for power distribution, triggering and charge control;
- The generator electronics, for state control, interlocking logic, fast protection, signals acquisition and data monitoring.




*Kicker magnet control layout*

## TYPICAL KICKER GENERATOR LAYOUT




*Typical kicker generator layout*

A typical kicker system module consists of a cable Pulse Forming Line (PFL), resonantly charged to a given high voltage with the so-called Resonant Charging Power Supply (RCPS), connected via a high-voltage switch to a magnet load.

The PFL is discharged by a Main Switch thyratron (MS) into the magnet. The other end of the PFL is connected to a terminating resistor and a Dump Switch thyratron (DS) that allows for kicker pulse length adjustment.

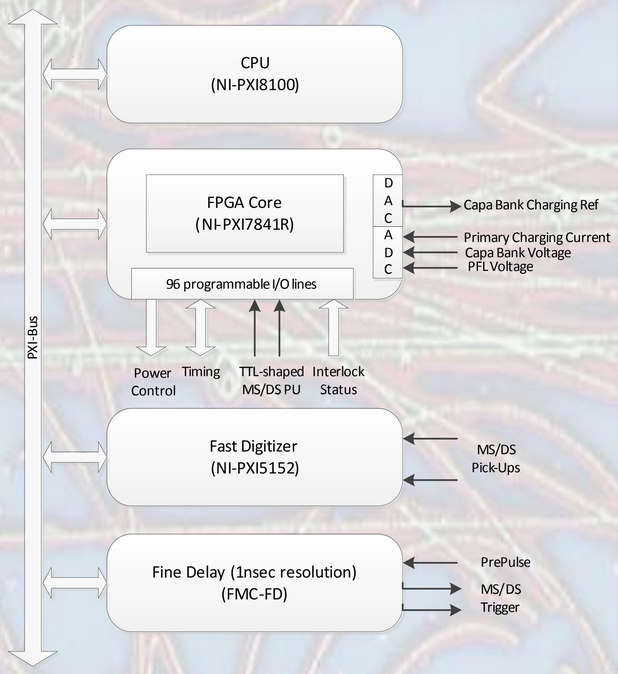
## PXI HARDWARE ARCHITECTURE

The former PS kicker magnet control system was built up using conventional electronic modules. All these functions have now been integrated into one PXI system.

The following parts form the PXI controller:

- NI PXI-8100 RT, 2 GHz CPU
- NI-PXI-7841R multifunctional RIO module
- NI-PXI5152 300 MHz 1GS/s digitizer
- PXI-FMC 1ns resolution delay generator

This system configuration can be ‘software’ tailored to the different needs of the variety of existing kicker installations.



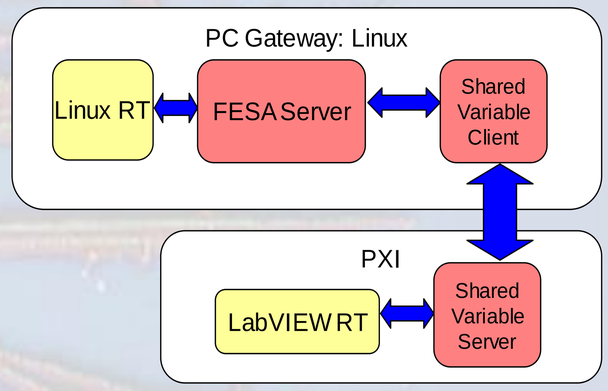

*PXI architecture*

## SOFTWARE CONFIGURATION

The RT program is an event driven program that receives every machine cycle the operational kicker settings for the next cycle from the FEC. Upon reception it passes the settings to the FPGA.

Communication with the FEC is done by means of the National Instruments Publish-Subscribe protocol (NI-PSP) and the associated CERN IEPLC communication tool.

The CERN Rapid Application Development Environment toolkit (RADE) allows integration into the controls environment. PXI systems are controlled via the FEC and its standardized Frontend Software Architecture (FESA).

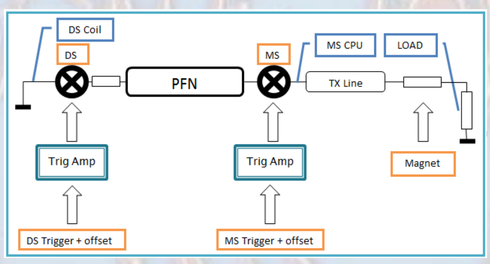



***PXI – FEC communication***

## PXI EMBEDDED FONCTIONS

PXI embedded fonctions are:

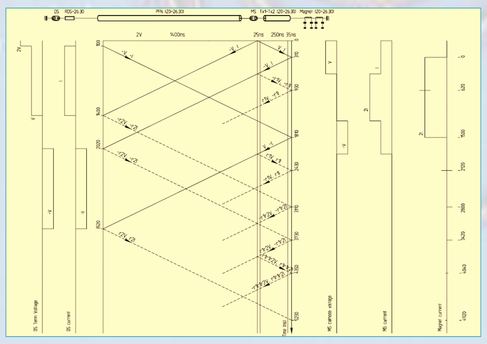
- Timing gating, analysis and measurement.
- RCPS control, monitoring and protection.
- Maskable interlock and status handling.
- Generator state control.
- Thyratron monitoring and protection.
- Short circuit detection in transmission line and magnet.
- Thyratron drift stabilisation.




***Thyratron protection unit***

The Bewley Lattice reflection diagram shows a short circuited magnet with the current doubling in the magnet. With the help of this diagram reflection patterns can easily be traced and analysed.

Current pick-ups are used to measure these reflection patterns and help to provide the requested protection.

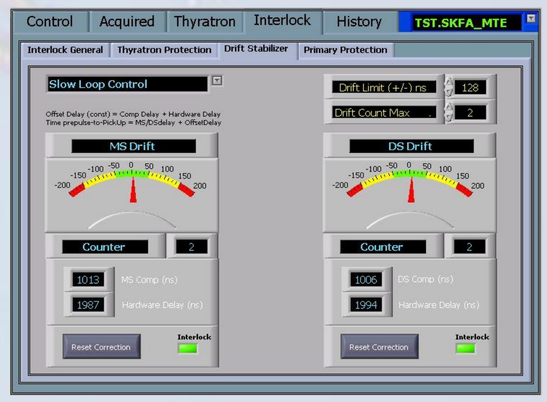


***Bewley Lattice diagram***

## THYRATRON DRIFT STABILIZATION

The drift stabilizer compensates deterministic drift inside the trigger amplifiers and the thyratrons that will vary depending on equipment characteristics and aging effects.

The system makes use of the fast digitizer for precise measurement of thyratron switching characteristics and corrects instabilities by adjusting the high precision fine delays in the triggering chain.

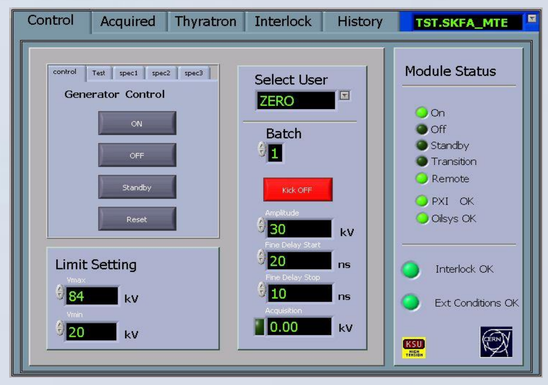



***Drift stabilizer display***

## SPECIALIST INTERFACE

In addition to the embedded real time software and FPGA configuration, National Instruments LabVIEW development tools have also been used to develop several application tools available for the expert.

Specialist access to the system parameters is done either by directly accessing the PXI shared variables or via the FESA framework.




***PXI control and status via FESA***