THE LOW-LEVEL CONTROL SYSTEM FOR THE CERN PS MULTI-TURN EXTRACTION KICKERS – PHASE 1

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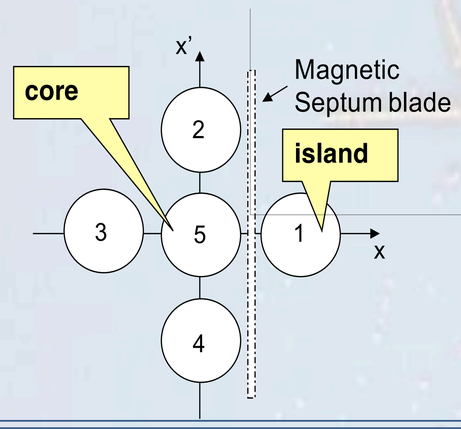
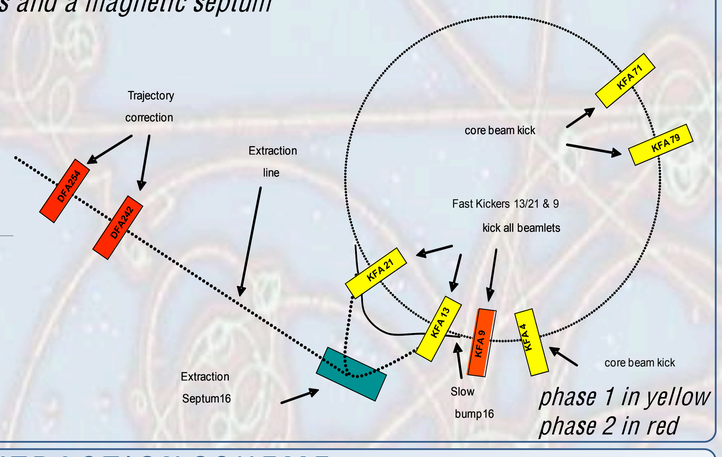
ABSTRACT

To reduce the beam losses when preparing high intensity proton beam for the CERN Neutrino to Gran Sasso (CNGS) facility, a new Multi-Turn extraction (MTE) scheme has been implemented in the PS. This project will be completed in two phases.
National Instruments® PXI systems are used to control the high voltage pulse generators and a SIEMENS® programmable logic controller (PLC) handles the centralised oil cooling and gas insulation sub-systems.

MTE EXTRACTION SCHEME

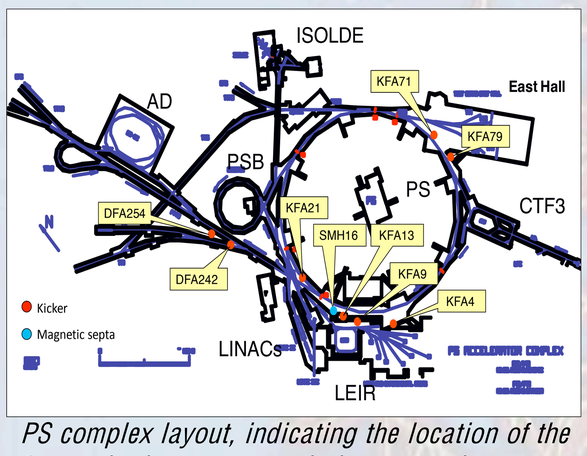
- *The beam is separated into a central beam and four islands by means of non-linear magnetic elements like sextupoles and octupoles.*
- *After ejecting the first beamlet, they are rotated in a clockwise direction (π/2) until the first four beamlets are ejected by KFA13 and KFA21, the center beamlet requires an extra kick supplied by KFA4 and KFA71/79 .*
- *Each beamlet is ejected using fast kickers and a magnetic septum*





phase 1 in yellow
phase 2 in red

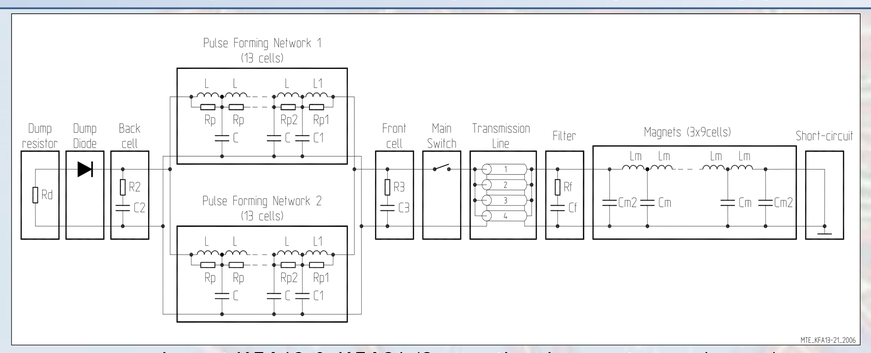
MTE EXTRACTION SCHEME



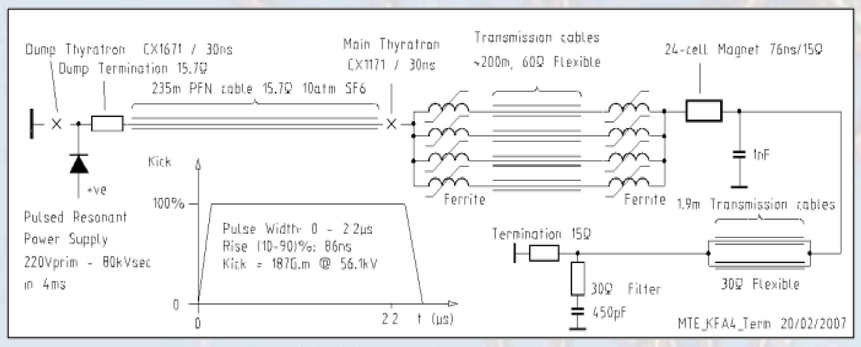
PS complex layout, indicating the location of the fast pulsed magnets and the magnetic septum SMH16 implied in the new PS multi-turn extraction scheme.

The MTE complex can be seen with, in blue, on the ground floor the Pulse Forming Networks (PFN's) and on the platform, in the green racks, the kicker control electronics.

KFA13/21 AND KFA4 GENERATOR LAYOUT



Layout KFA13 & KFA21 (2 operational generators + 1 spare)

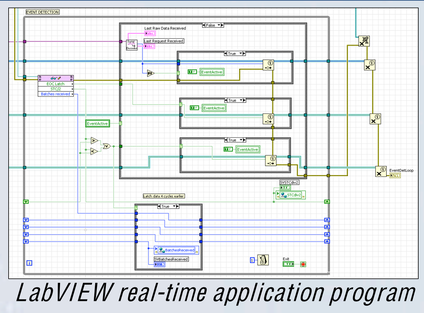


Layout KFA4 (1 operational generator + 1 spare).

HV PULSE GENERATOR CONTROL - SOFTWARE

Front-End Software Configuration
- *CERN developed C++ Front-End Software Architecture (FESA) used for development of MTE kicker control Class.*
- *Front-End to PXI communication via ethernet with LabWindows/ CVI Network variable libraries allowing access to the LabVIEW Shared Variable libraries .*
- *VME interface hardware for global timing control of kickers*

LabVIEW specialist application progam

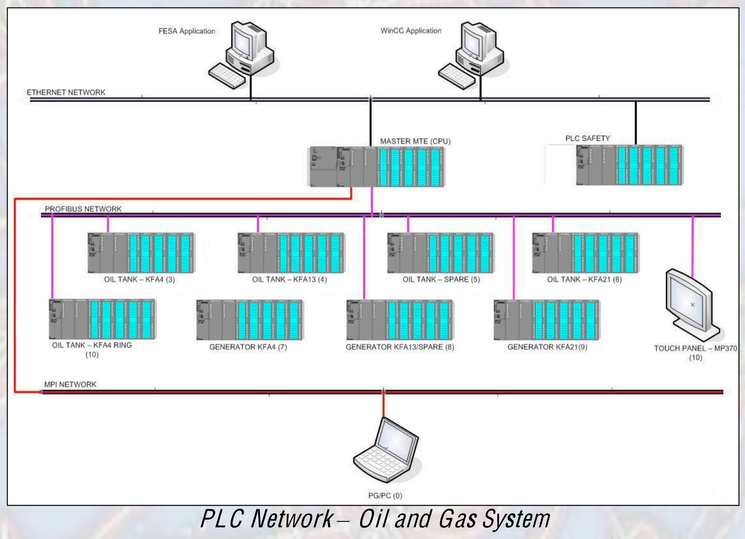


LabVIEW real-time application program

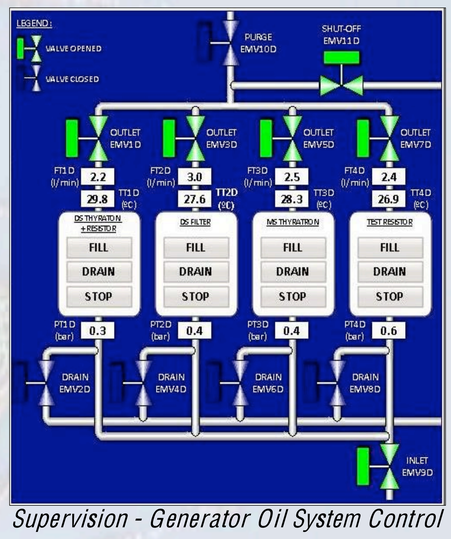
PXI Software Configuration
- *All PXI software development in LabVIEW.*
- *Real time task (event driven) runs on PXI-CPU communicates with Front-End using NI Publish-Subscribe Protocol*
- *FPGA configuration, communicating with generator hardware.*
- *Specialist application programs addressing FESA via CMW (Common Middleware using RADE)*
- *Specialist application program addressing PXI directly*
- *Specialist programs via web browser addressing PXI directly*

Specialist Application programs developed with RADE
RADE is a Rapid Application Development Environment based on LabVIEW integrated into the CERN control systems and developed at CERN..

OIL AND GAS SUB-SYSTEM CONTROL



PLC Network – Oil and Gas System



Supervision - Generator Oil System Control

Oil and Gas system control based on SIEMENS S7-300 PLC
- *Control (regulation valves, circulating pumps, oil/water heat exchanger…).*
- *Instrumentation monitoring (pressure, flow, temperature).*
- *Regulation loops for temperature and flow (PI)*
- *Automatic sequences for draining, filling...*
- *Supervision with WinCC (remote) and touch panel MP377 (local).*

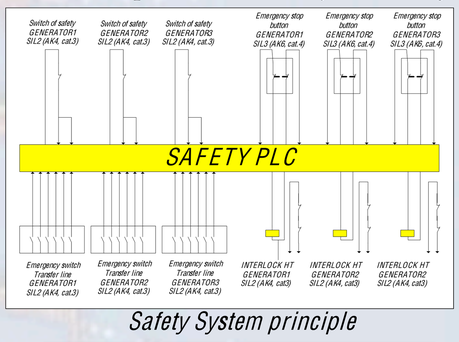
SAFETY SUB-SYSTEM CONTROL

A safety PLC has been incorporated in the existing PLC control structure in order to ensure the monitoring of the HV connections of the transfer lines and to guarantee the operator's security in case of an intervention.

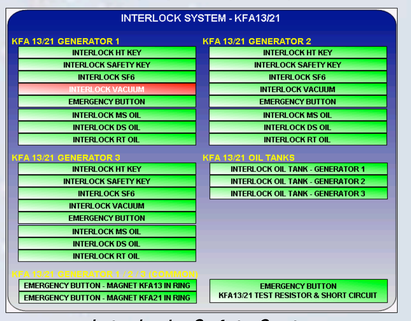
Two levels of safety protection have been implemented in order to avoid to pulse the system under unsafe conditions.

LEVEL 1 → stop system charging
- *Surveillance of the HV connections on each generator and its associated magnet;*
- *Surveillance of internal hardware and software state.*

LEVEL 2 → stop the electrical distribution
- *Surveillance of all emergency stops in the powering area and in the tunnel near the magnet location;*
- *Surveillance of all the electrical protection micro-switches on each generator.*



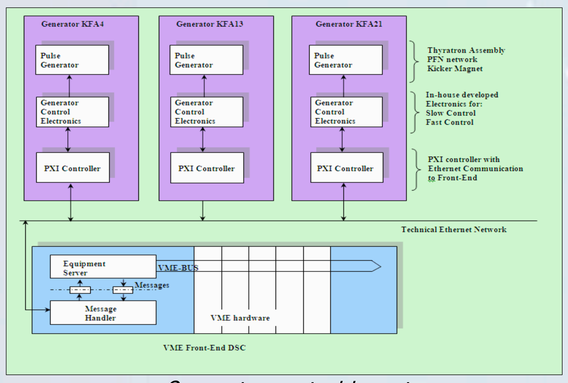
Safety System principle



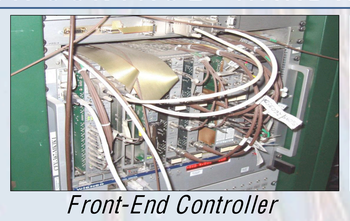
Interlocks Safety System

HV PULSE GENERATOR CONTROL - HARDWARE

Pulse Generator Controller
- *Thyratron timing and delays, with 1 ns resolution*
- *PFN reference and acquisition voltages*
- *PFN charging/discharging protection*
- *Interlock and thyratron protection*
- *Power control for all the different units*



Generator control layout



Front-End Controller

PXI Controller

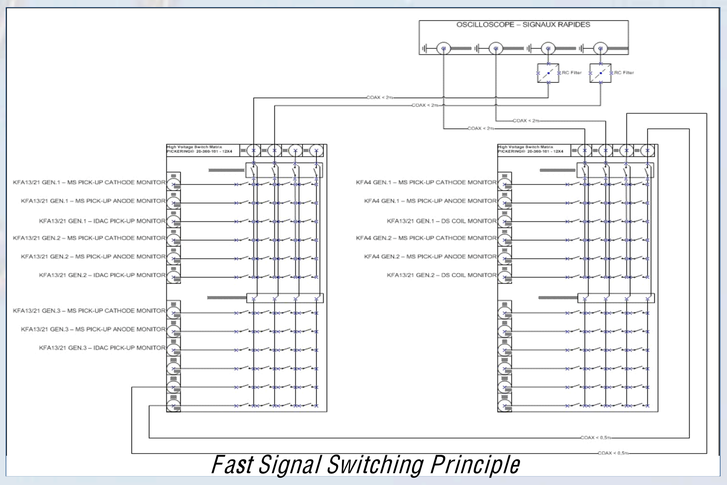
PXI Controller (National Instruments)
- *Communication between the generator hardware and the Front-End.*
- *CPU with LabVIEW Real Time embedded controller.*
- *FPGA card with reconfigurable I/O, DAC and ADC.*

VME – Front-End Controller
- *Master and data concentrator for all the kicker magnets.*
- *VME hardware controlling the global timing and fine delays for the extraction.*

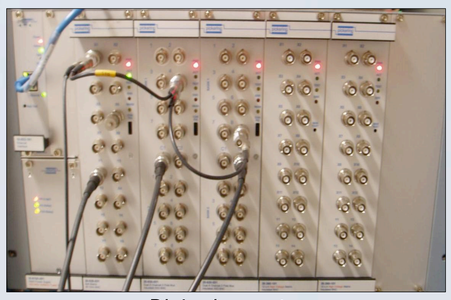
MONITORING

Analog monitoring system based on 50MHz pickering signal multiplexer

- *Dynamic measurement signal multiplexing in accordance with generator/magnet matching.*
- *Signals distribution to local oscilloscopes for performance follow-up and for diagnostic features.*



Fast Signal Switching Principle



Pickering system