MOPHA008

LIPAc RFQ Control System Lessons Learned

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Abstract

The Linear IFMIF Prototype Accelerator (LIPAc) [1] Radio Frequency Quadrupole (RFQ) will accelerate a 130 mA deuteron beam up to 5 MeV in continuous wave. Proton beam commissioning of RFQ cavity, together with Medium Energy Beam Transport Line (MEBT) and Diagnostics Plate, is now ongoing to characterize the accelerator behavior [2]. The RFQ Local Control System (LCS) was designed following the project guideline. It was partially assembled and verified during the RFQ power test in Italy [3]. The final system configuration was preassembled and tested in Europe, after that it was transferred to Japan, where it was installed, commissioned and integrated into LIPAc Central Control System (CCS) between November 2016 and July 2017, when the RFQ Radio Frequency (RF) conditioning started [4]. Now the RFQ LCS has been running for 2 years. During this time, especially in the initial period, the system required several adjustments and modifications to its functionality and interface, together with assistance and instructions to the operation team. This paper will try to collects useful lessons learned coming from this experience.

LIPAc RFQ Local Control System

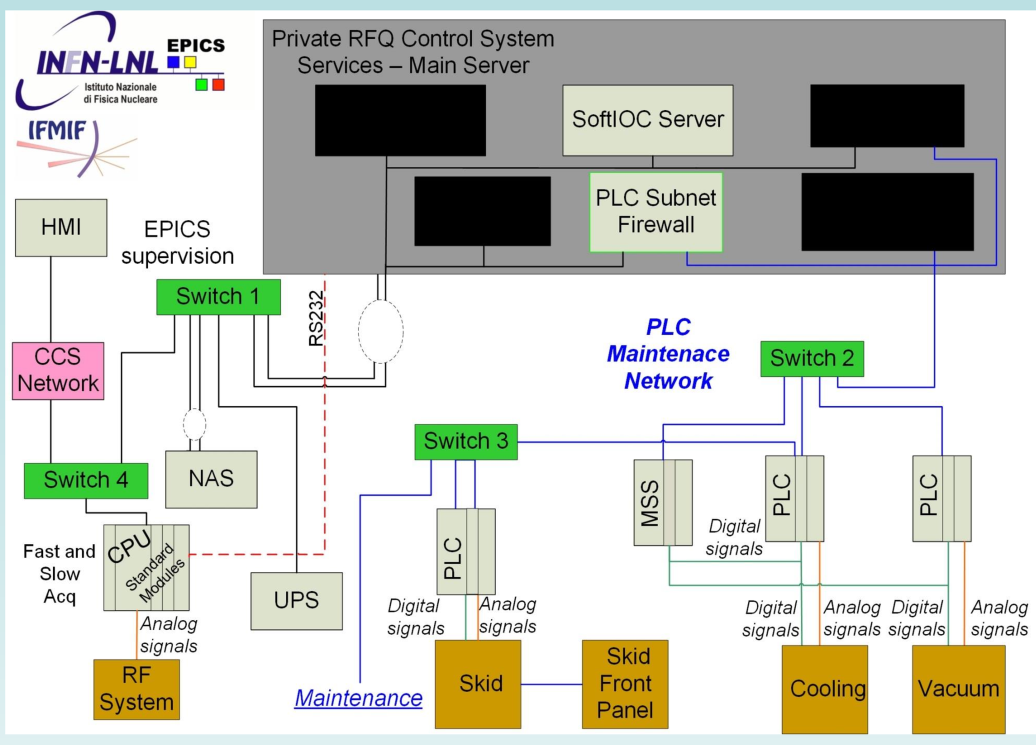
The RFQ LCS architecture is designed to optimize reliability, availability, safety and performance, minimizing costs. The control system network is composed by:

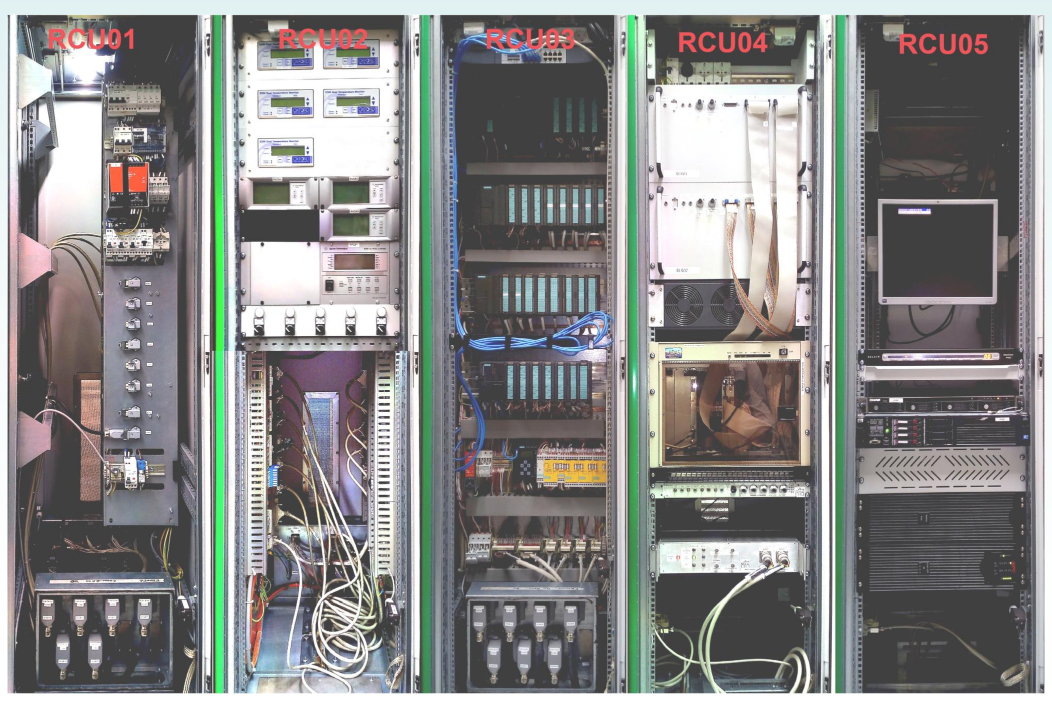
- physical hosts for critical tasks;
- virtual hosts where more relaxed requirements are adequate.

The main functionalities are:

- Fast acquisition system for the RFQ cavity power;
- Vacuum system;
- Cooling system;
- Machine Protection System.

Object	N.
IOCs	4
Databases	25
PVs	8852
Archived PVs	450
Control Panels	21





Installation and Commissioning

Installation and commissioning started in Nov. 2017, it included in several phases:

- partially installation and standalone configuration for the RFQ baking;
- complete installation and integration into CCS;
- functional checkout of the control system;
- commissioning of the controlled systems (vacuum, cooling, RF acquisition, etc.);
- integration with other LIPAc subsystems.

Installation of the partial configuration (including connections of cubicles and junction boxes, installation of cable tray along the RFQ, installation of HMI console, first stage of LCS integration, preliminary checkup and predisposal for the RFQ baking) took only 3 people for 12 working days. Installation, power up and connection of the 5 cubicles took only 2 days saving the time for SW integration. The RFQ LCS commissioning ended in Dec. 2017 with the official conclusion of LCS acceptance test which verified the complete integration.

Commissioning of the Controlled System

Vacuum System

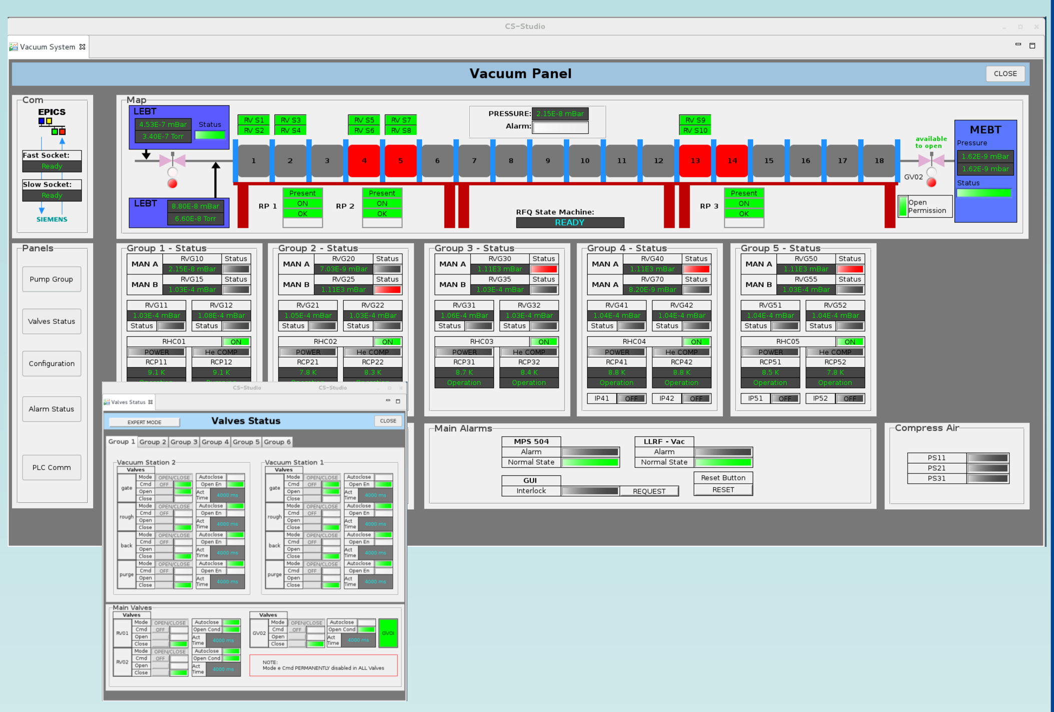
- To operate the single devices the HMI includes enable and deny signals, which required to consult the operation manual.

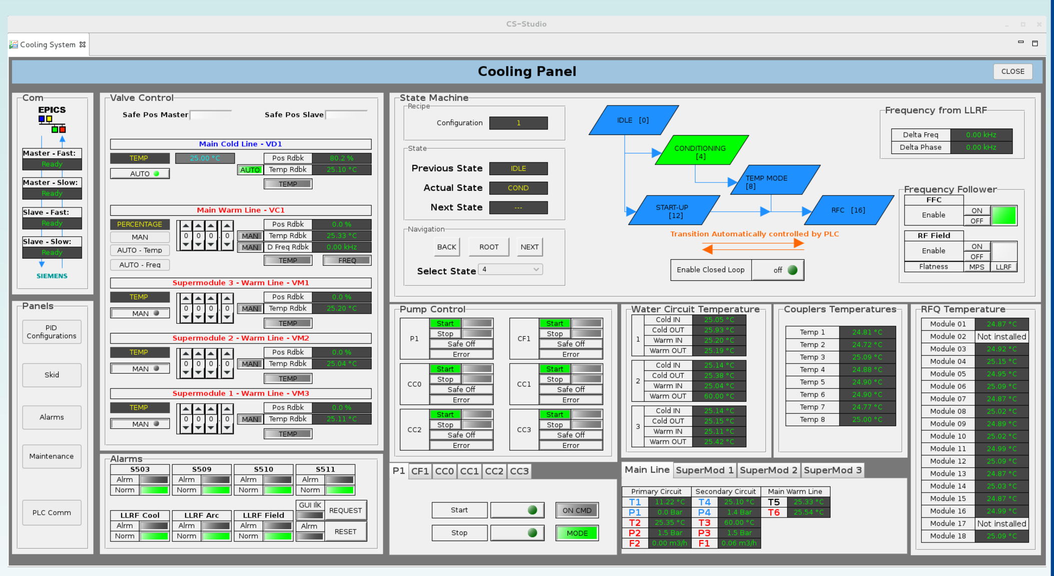
Cooling System

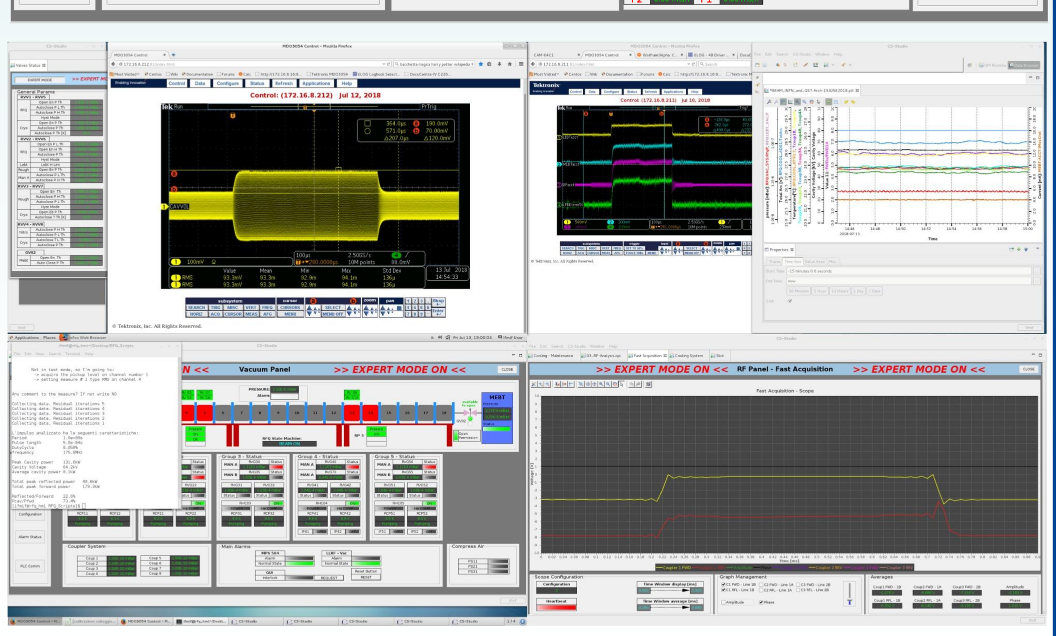
- The system integration was checked at LNL, but it was not possible to perform functional test. Once onsite the system required HW modifications to be started.
- Premature brake of pressure, temperature and flow sensors.
- Integration with LLRF for RFQ frequency close loop control needed SW implementation to link the different sets of information provided/required.

RF Signal Acquisition

- Designed for CW operation (>4ms pulse width for field flatness acquisition, max 8 signals at 250kHz as waveform at the HMI). Oscilloscope was integrated to improve the sample rate in order to monitor short pulse operation and execute measurements useful also for RF system calibration.
- Trigger required different connections and upgrades.







Usage Experience and Support

HMI and CCS services

- The HMI host was a physical machine equipped with CentOS, EPICS environment and CS-Studio. During integration and maintenance, software updates were required and CCS archiver service was migrated from an RDB to the new EPICS appliance. Due to incompatibility issues two different versions of CS-Studio were installed during the time needed to update the panels.
- The isolated architecture of the CCS, which not provides remote access services increase system security, but limited the possibility to provide remote assistance.

Support to the operation

- A control group member was always present during the first period of system usage; to support and train, to solve issues and to implement modification.
- Additional tools and applications, manly based on Python language, were developed to optimize work efficiency; as tools for RF measurement, RF system calibrations and beam transmission automatic setup were provided to the LIPAc community.

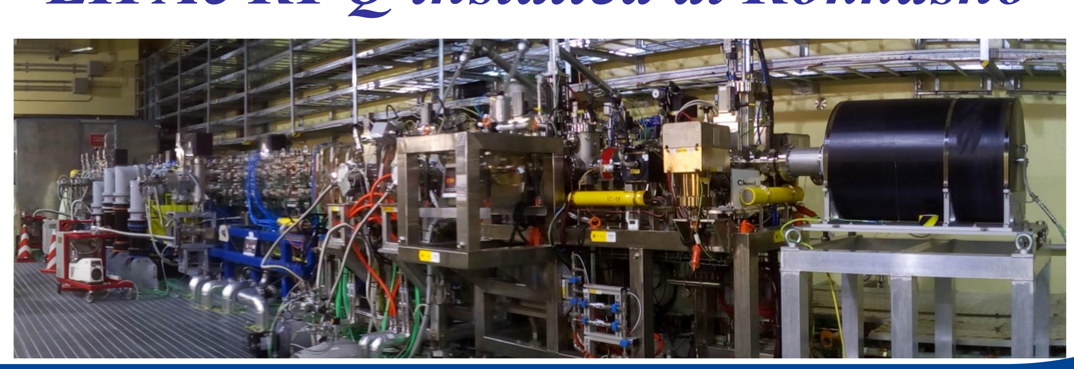
Conclusion and Lesson Learned

- Factory functional test (as RFQ power test) produced real step forward for the control system maturity, allowing to detect and fix hardware problematic.
- Installation and commissioning required large information sharing and competencies distribution among the working team and the onsite people to overcome issues related to onsite resources.
- Electrical interface shall be well defined and tested before the integration.
- Functionality involving different subsystem has to be considered, clarified and detailed defined since the beginning of the development of each system to don't forget parts difficult or impossible to be included in a second time.
- Design of signal acquisition has to consider the requirements of enhanced performance or functionality respect to the normal operation and also the possibility of integrate additional instrumentation.
- The possibility to easily customize, develop and include additional functionality to the system make user proactive and collaborative.
- Test and operation in real environment are mandatory steps of system commissioning; brakes and faults are parts of the game.

IFMIF: http://www.ifmif.org
INFN-LNL: http://www.lnl.infn.it
EPICS@LNL: https://web.infn.it/epics

RFQ LCS Team

LIPAc RFQ installed at Rokkasho



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