Upgrade of the Control System for the LHC High Level RF

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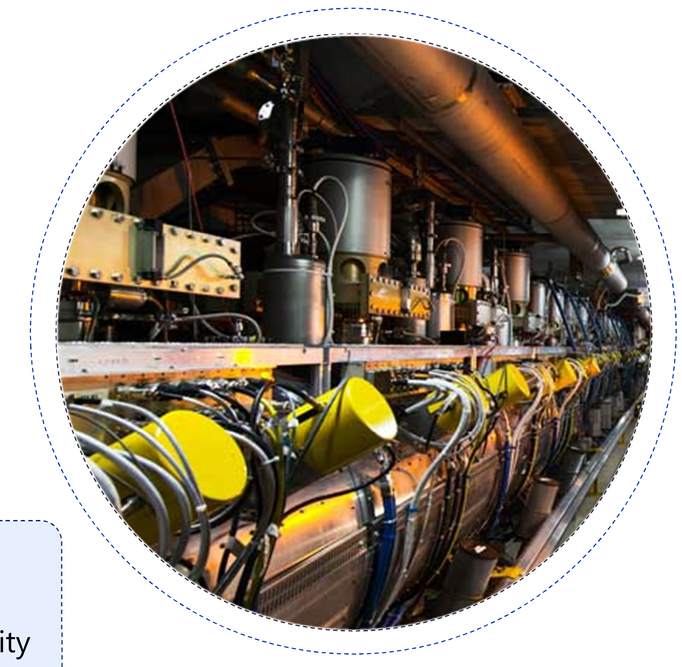
SUMMARY

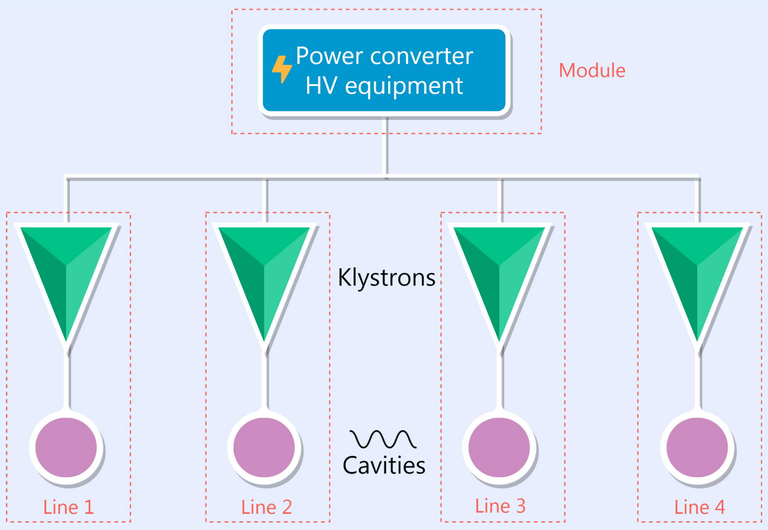
Any software needs recurring updates, and the control software for accelerator equipment at CERN does not differ. One year before the start of LS2, our team started the renovations of the software controlling the LHC 400 MHz RF system (ACS), which is based on FESA, and as a result we were able to validate the new software during one year of LHC operation.



RATIONALE

- Major update of the FESA (Front-End Software Architecture) framework (FESA3 7.x)
  - Migration of PLC communication to SILECS (Software Infrastructure for Low-level Equipment Controllers)
- Important changes planned on the control interface of power converters
- Variety of the control software
  - High-level control interfaces developed with standard tools by the CERN's Controls group (Beams dep.)
  - Expert interfaces implemented with LabVIEW

ARCHITECTURE OF THE SYSTEM



Logical view of one ACS module and four ACS lines

Sixteen superconducting radiofrequency cavities guarantee the acceleration of particles in LHC. They are installed in groups of four inside cryomodules, two per beam. Each cavity is powered by a 300 kW klystron and shares a 58 kV voltage power converter and a high voltage equipment bunker with the other cavities installed in the same cryomodule.

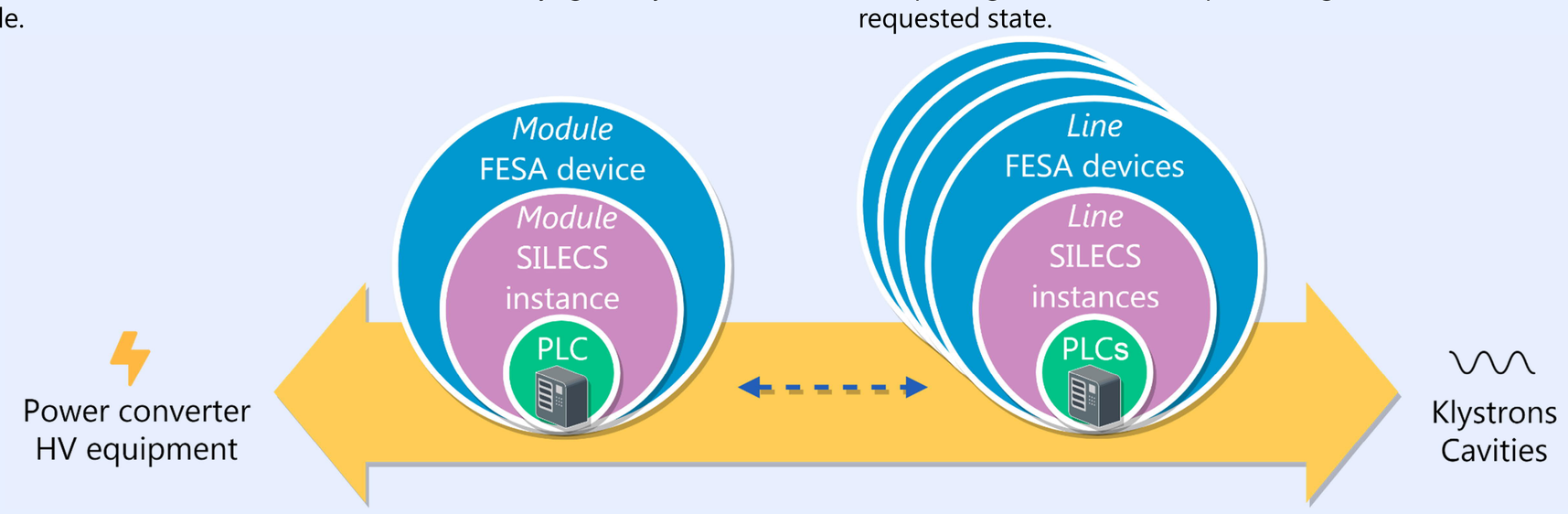
Line: full chain of devices controlling one klystron and one cavity
Module: one power converter and HV equipment related to each cryomodule
Services: beam dump fast interlock module, Faraday cage monitoring, etc.

The control system is composed of sixteen *line* PLCs, four *module* PLCs and one *services* PLC.

SOFTWARE UPGRADES

<u>ACS Module</u>
Complete rewriting of the code handling the readback of data from the power converters. The software also interprets commands coming from the high level control interfaces, controls the RF system, communicating with the PLCs though SILECS, and, using RBAC and RDA3 libraries, sends the appropriate commands to the power converter devices.
In addition to this, the software maintains contact with the cryogenic system of every cryomodule.

<u>ACS Line</u>
The main feature of the software controlling the ACS lines is a finite state machine composed of eleven states. The state of the system is defined by monitoring a considerable number of parameters coming from the line PLCs. Once every second, the control software determines in which state the system is and, at the same time, it ensures the proper sequencing of actions which are sent to the line PLCs, interpreting commands and processing them in order to bring each ACS line to the requested state.

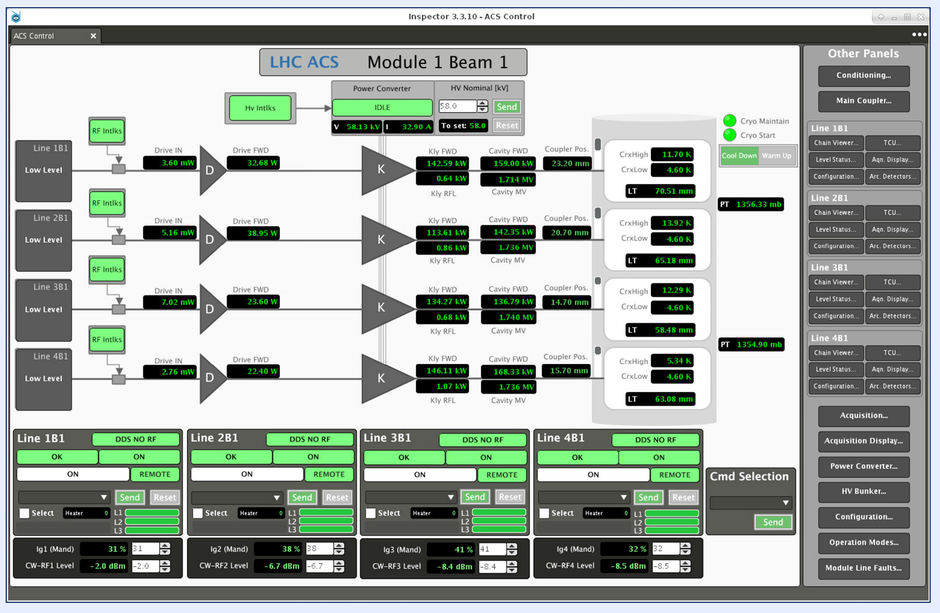


SOFTWARE COMMISSIONING

An ad-hoc laboratory installation composed of one module PLC, one line PLC and one services PLC was used to validate the system. The controllers were updated with the SILECS generated sources and three FESA classes were run on a test front-end to verify the functionality of the control software.

Following this phase, the new FESA classes for both modules and lines were deployed in LHC during the first months of 2018, before the restart of the machine after the winter break. The commissioning phase before the restart allowed to further fine-tune the sequencing and to restart the LHC with no delay. The FESA class controlling the external services was deployed during the TS1 (Technical Stop 1), that took place in June 2018.

A considerable effort was invested in the migration of high level LabVIEW control applications to the Inspector rapid application development environment. The migration of the twenty-five expert control applications was completed in less than six months. The Inspector applications were successfully integrated into CERN's control system and they are currently the main interfaces used to condition, monitor and control the ACS system.



Main control application for the ACS system

CONCLUSIONS

The LHC 400 MHz RF control software was renovated to follow the evolution of the CERN front-end software frameworks.
Three FESA classes were developed to substitute the existing six, using the latest control libraries. Communication with PLCs was achieved via the implementation of SILECS interfaces, and operator and expert applications were created using Inspector.
The software was successfully deployed and fully integrated into CERN's control system, allowing LHC nominal operation until the end of Run 2. The full software stack has been validated and stands ready to restart LHC in 2021.

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