The PLC control system for the RF upgrade of the Super Proton Synchrotron

Joao Carlos Oliveira†, Luca Arnaudon and Alejandro Diaz Fontalva, CERN BE/RF, Geneva, Switzerland

SPS Upgrade
LIU Project

INTRODUCTION

During the long shutdown 2 (LS2), the LHC injection chain is being updated to increase the beam intensity supplied to the LHC in order to increase the collision luminosity.

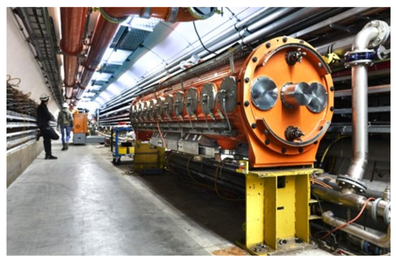
In the Super Proton Synchrotron (SPS), the 200 MHz main acceleration system is being upgraded for this purpose.

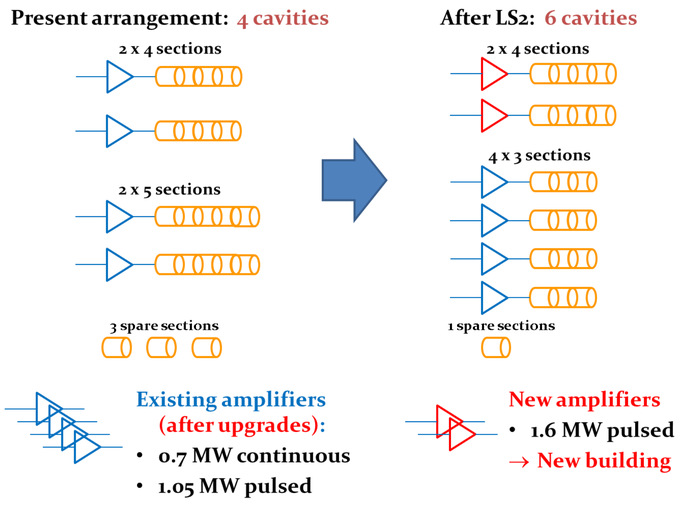
It will go from 4 TWC (traveling wave cavities) with 2x4 sections + 2x5 sections to 6 TWC of 2x4 sections + 4x3 sections.

The two new cavities, of four sections each, will be powered by a new solid-state amplifier complex that will provide 1.6 MW to each cavity.

The other 4 cavities, of 3 sections each, will continue to use the old tube amplifiers with 1.05 MW each.

The whole system (Cavity, amplifiers, etc.) is controlled by PLCs (programmable logic controllers).

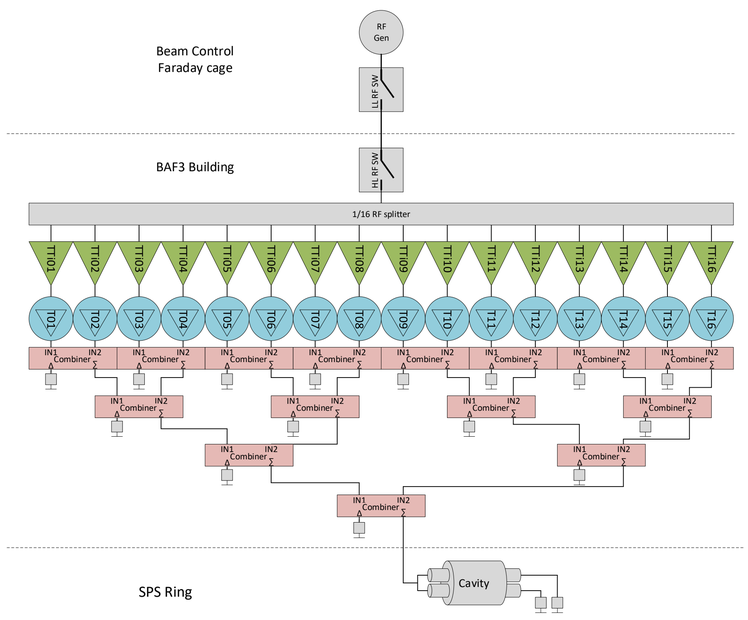




THE NEW SOLID STATE POWER AMPLIFIER (SSPA)

The new system is composed as follows:

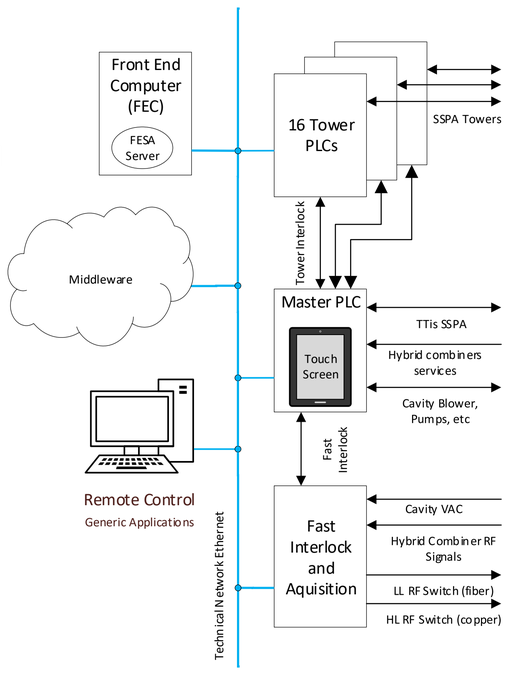
- The RF signal is generated by the beam control.
- Two fast RF switches, the Low Level (LL) RF Switch and the High Level (HL) RF Switch.
- 16 pre-drivers (TTis) of type TTi Norte SSPA delivering 1250 Wp each. The RF drive signal is split in 16 to feed the 16 pre-drivers.
- 16 Thales towers, with 80 SSPAs each, which deliver 115 kWp per tower. The output signals of the 80 SSPAs are combined to power the cavity.
- The RF signal to the cavity will be 1.6MWp



THE NEW CONTROL SYSTEM

The new control system is composed as follows:

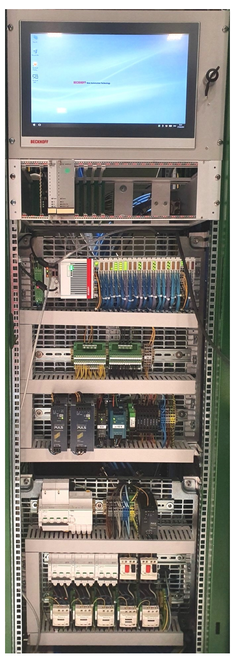
- A master PLC of the brand Beckhoff
- Sixteen tower controllers of the brand Beckhoff
- An in-house designed fast-interlock system coupled with an analog acquisition system to monitor RF signals.
- A FESA server running on FEC



Master PLC

Their main features and functions performed are:

- HW signal acquisition of several devices.
- 2 modes of control: local or remote.
- Local monitoring & supervision by means of a GUI (Graphical User Interface).
- Communication with the Fast Interlock system by Ethernet using Modbus TCP.
- Framework communication with the tower PLCs by means of the Beckhoff ADS protocol.
- Event handling and fault registration.
- Continuous storage of critical system data.
- Selection of the cavity operation mode, processing of cavity control commands.
- Startup interlock sequence of the cavity



Tower PLC

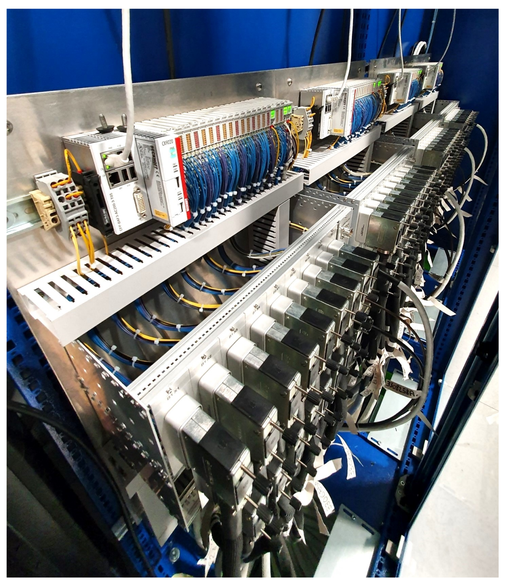
Each tower is provided with several service signals such as 400V three-phase powering detection, water temperature and water flow measurements and water leak detection.

On the SSPA side, a total of 80 outputs and 160 inputs are used by each Tower PLC in order to carry out the control and getting the status of each SSPA. Furthermore, there is a HW link between the master and each tower PLC which gives 2 functionalities to the master PLC.

First of all it gives to the master PLC a general feedback of the towers status, and also having the control of allowing the switching ON of the SSPAs. Interlock cable also allows a quickly turning OFF of the SSPAs in case of loss of the Ethernet connection.

The main tasks performed by the Tower PLC are:

- Monitoring signals incoming from the services and switch off all the amplifiers in case of fault.
- Monitoring signals incoming from the amplifiers and switch off the faulty one in case of fault.
- Receives commands from the master PLC and executes it.
- Returns the state of the tower to the master PLC.
- Keeps the list of faults in memory and sends them to the master PLC.



Fast Interlock and Analog acquisition

This system is responsible for acquiring the analogue signals “reverse” and “forward”, received from hybrid combiners and also for activating the LL & HL RF switches.

Furthermore, in case any of the critical signals are missing then it will open the two RF switches.

These signals are the cavity vacuum, the “PLC Master OK” and the selected “reverse” signals.

CONCLUSIONS

The controllers for the SSPA towers are all installed in the new amplifier hall.

During the last 3 months, six towers and their controllers have been fully tested.

The others will be tested following the reception of the SSPAs from Thales.

A full system test of 16 towers, with the master PLC and the fast interlock system, is planned by end of 2019. The final hardware test of the two new cavities will be carried out starting September 2020.

Remote control will be implemented using the standard tools from CERN’s Controls group.

ACKNOWLEDGMENTS

The authors would like to thank Eric Montesinos’s team in the CERN BE/RF/PM section, which has actively participated during the design phase of the system, and all the technicians from the CERN BE/RF/CS section for the construction of the required hardware.

ICALEPCS 2019