HARDWARE COMMISSIONING 2010 AND BEYOND

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Abstract

For the years to come, extensive re-commissioning of the superconducting circuits is expected. In order to reduce the time and resources required for the recommissioning, ideas how to improve the efficiency are discussed. Some of the steps during the re-commissioning can be optimised. Reducing the number of interfaces between different teams is suggested. The different software tools can be improved and partially combined, in order to better follow up the evolution of a circuit and to optimise the coordination between different teams.

Personal safety is vital, and rationalising the safety procedures is proposed.

Another important aspect is the general organisation, including the definition of responsibility for the commissioning and the transition between shutdown, hardware commissioning and beam operation. The preparation for the next commissioning campaign should start soon, since it will take some time to implement upgraded tools.

WHY HARDWARE COMMISSIONING IN THE FUTURE?

For several years, extensive re-commissioning of the superconducting circuits is expected, after total or partial warm up of the LHC sectors. Warm-up will be required for adding relief valves, for consolidation of splices and for other activities. Hardware commissioning will also be needed to prepare the LHC for operation at 5 and 7 TeV. To go to 7 TeV, an extensive training of the magnets is required.

Upgrade and modifications of power converters, powering interlock system and QPS (e.g. for example replacement with radiation tolerant electronics) will required some recommissioning. Most plans for other upgrades would also imply some recommissioning.

It is worth to invest time and effort into further optimisation of hardware commissioning since this would reduce time and resources.

There are several questions that should be addressed:

- What needs to be done? (Does it really have to be done?)
- What can be improved?
- What can be automated
- Resources – what is required?

As a long term objective it is proposed to set an ambitious objective: perform the powering tests in three weeks.

WHAT IS HARDWARE COMMISSIONING?

Hardware commissioning includes many different type of activities. Part of the activities are planned and then performed by the different teams in the underground areas:

- Lock off power converters
- Disconnect the power cables to current leads
- ELQA at warm
- Start monitoring main circuits during cool down
- Cool down and cryo tuning
- Stop monitoring main circuits during cool down
- ELQA at cold
- Connect the power cables to current leads
- Unlock power converters

Other activities are coordinated from the CCC, partially done remotely, partially requiring access underground:

- Preparation of QPS (charge quench heaters, close interlock loops and prepare QPS system for powering)
- Powering tests

ORGANISATION OF HARDWARE COMMISSIONING

It is proposed to coordinate activities underground by EN-MEF (shutdown coordination team). This would include cool down and ELQA at cold.

Activities driven from CCC (mainly powering tests), interleaved with planned and unplanned activities underground would be coordinated by operation with the support of experts. It is understood that during this period major contributions from several groups in TE and EN are required.

The system with four “point owners” to follow up the detailed progress in the LHC underground areas worked well and should be retained. One point owner taking care of two sectors is appropriate. It could be envisaged to have point owners from EN-MEF, BE-OP and TE.

WHAT WENT WELL

- The procedures were ready in time.
- Operation in powering in phase I (low current) and II (high current) was complex, but the split in the two phases allowed to progress with powering at low current in parallel to activities in adjacent sectors.
- Shifts during 7 days, with 3 shifts per day were essential as soon as several sectors are available for powering.

- Grouping accesses on Tuesday (and possibly Wednesday) during the morning for the different teams was useful. As during 2009, for giving access, the operations group needs help during working days, between 7:00 and 18:00.
- The support from MP3 and from QPS experts is essential.
- The powering test pages are essential for following up progress.
- Superlocking of circuits with an issue, and simple locking of circuits worked well (some ideas for improvements, see below).
- Software tools are in general very good.
- Automatic analysis for PIC tests – good experience, can be extended to more tests and other systems, reducing the need for experts.

WHAT SHOULD BE IMPROVED

For the DFB there are too many interfaces and a reorganisation will lead to simplification. As an example, there is a team for performing ELQA, a team for connection and disconnection of cables, a team for cryogenic interventions (valves, …) and a team for locking / unlocking power converters. In case of problems with the water cooled cables another team is required. The organisation will become even more complex with additional systems (such as an interlock on the current lead temperature).

It is proposed to have only one team for all electrical interventions on DFBs. This is being tried out during this technical stop. Since this is additional work for the ELQA team, the organisation and resources need to be addressed.

During the period with many activities in the tunnel, it would be helpful to open doors in the centre of a sector (see presentation of Julie Coupard).

The existing software tools are very performing. The automatic analysis should be extended to other tests.

Powering phase I and II: the RB circuit can be powered at 110 A in phase I, for starting the circuits and for checking interlocks. It has been shown successfully in December 2009 that the RB can operate at 100A.

Whenever access to the underground areas was given, all circuits were locked using the powering interlock system. The restart off all the systems causes frequently trouble. It is suggested to ramp down all circuits to injection current, and the RB circuit to 110A. The energy stored in the circuits is below 100kJ and the risk for massive helium release negligible. A mechanism is proposed to prevent an accidental increase of the current in a circuit at the level of the FGC during access.

Safety for people and simplicity for operation: a hardware link between the access system and the powering system, possibly via the powering interlock system, should be studied.

The access matrix should be reviewed, in light of the operational experience and of further improvements of the sealing between the sectors, in order to allow access in one sector while performing powering tests in the adjacent sectors.

Powering tests require many experts in CCC. One expert for the operation of the magnet powering system mastering the QPS system and the question related to the magnet system should be appropriate. This requires training and improved tools.

ELQA

The ELQA procedures are already well optimised, however, some ideas:

- Avoid warming up to above 80K
- Review what needs to be repeated
- Is it possible doing it differently?
- Is it possible to further automating the tests?

The number of test systems should be increased to avoid any limitation by the number of such systems. The ELQA test could be done in a shorter time window if more resources would be available. Therefore test systems should require little training is to perform tasks by non experts. We still will rely on help from outside collaborators, but more help from inside CERN could also be envisaged. It must be stressed that qualified personnel is required.

Non conformities take a long time to understand and to repair. It is better to invest time before into quality control, for example during cabling campaigns, to avoid non conformities. Members of the ELQA team should be involved from the moment when equipment is designed that needs to withstand high voltage.

MP3

MP3 is responsible for writing the procedures together with the hardware commissioning coordination team.

Ideas for future re-commissioning should be worked out – what needs to be redone? This depends on the circuit history (warm up to room temperature to 80K,…..).

The procedures need to be cleaned up and made coherent starting soon, and not some weeks before the next commissioning campaign. Clear responsibilities need to be defined – who should drive this effort?

Simplifying retesting groups of circuits (test of main interlock functionalities) should be considered.

QPS

Further consolidation of the QPS system will lead to less test steps failing. Non conformities take a long time to understand and to solve.

The nQPS commissioning procedures needs to be integrated into the general RB and RQF/D commissioning procedures.

Monitoring during cool down to detect problems: can it be extended using the nQPS system?

A system similar to the nQPS to measure the bus bar resistance for individual powered magnets needs to be developed. This will require new steps in commissioning.

The QPS is very complex, and the expert knowledge needs to be spread to more colleagues.

It is suggested to merge MP3 and QPS operation support teams. This is also considered as a long term commitment to keep the competence.

POWERING INTERLOCK SYSTEM AND POWER CONVERTERS

The resources required for the tests of the powering interlock system did substantially decrease from 2008 to 2009, due to the automation of the analysis. Automation can be extended, further reducing the resources required during commissioning.

This is similar for the tests of power converters, some further automation of the analysis is possible.

One test that always takes long time is cutting the water of the RB and RQF/D circuits, since someone needs to go to the underground area to close the valve. The remote operation of the valves for these circuits is recommended.

CRYOGENICS SYSTEM

There was a remarkable improvement of the stability of the cryogenic system between 2008 and 2009, and very little downtime during hardware commissioning due to the cryogenic system in 2009.

Frequent replacement of the valves for 600A circuit were an issue, and took quite some time and effort from several teams. This requires locking off the entire DFB, could a procedure be defined that does not require the locking?

Cryo tuning is one of the limiting factors before starting powering (such as boil-off, etc.). Does it have to be repeated? Can it become more automatic and possibly faster?

Sometimes it is required to force a parameter related to one circuit (such as a temperature of a lead or a valve) to provide power permit for a powering subsector, thus allowing operation of many other circuits. In this case, only one circuit cannot be operated. A link between the supervision of the cryo system and the powering interlock system should be considered that allows cryo experts to superlock the circuit, not relying on exchange of emails.

TRACKING CIRCUITS: ONLY ONE ENTRY

Several tools are being used today to track the commissioning progress for one circuit. One tool for tracking all aspects during the life of a circuit is suggested that includes information on:

- power converter locked off / unlocked
- circuit ready for ELQA (cryo start and cryo maintain)
- cable connected / disconnected
- ELQA at warm and at cold
- connection and disconnection of monitoring systems before start of cool down (for main circuits)
- QPS individual system tests finished (heaters charged, other conditions, …)
- powering test steps (powering tests pages)

Having all information in one tool would lead to more safe commissioning (less error prone), to improved tracking of the progress (faster), and to simpler communication between teams (less errors, faster).

LONG TERM OBJECTIVE: POWERING TESTS IN THREE WEEKS

As a summary, the main proposals:

Organisation: Coordination by TE-MEF before powering, and BE-OP when powering starts. Retain the system with four “Point Owners”.

DFBs: Define responsibilities and reduce the number of interfaces.

Tools: Prepare one tool (or at least on entry into the set of tools) for the status of the circuits.

In order to be more efficient, the preparations must start soon. A team should prepare future hardware commissioning with the mandate to:

- propose improvements of tools, follow up the development
- follow up updating of the commissioning procedures
- get new people involved into this activity

The team should include members from BE (OP, CO), EN (MEF, ICE), TE (MPE, Cryo, MSC, EPC) and MP3/QPS.

As a milestone, it is suggested to organise a workshop and write a report later this year.