74th Meeting of the HL-LHC Technical Coordination Committee – 18/04/2019

Participants: G. Arduini, V. Baglin, N. Beev, O. Brüning (chair), H. Burkhardt, M. Cerqueira Bastos, D. Delikaris, M. Maciejewski, M. Martino, M. Mentink, D. Mirarchi, T. Otto, D. Perini, L. Rossi, A. Siemko, Y. Thurel, S. Yammine, D. Wollmann, M. Zerlauth.
Excused: A. Apollonio, Y. Papaphilippou.

The slides of all presentations can be found on the website and Indico pages of the TCC.

After a review of today's agenda, the minutes of the last meeting where approved without any further modification.

Class 0 Power Converters: update on ADC development and testing – N. Beev, slides

N. Beev reviewed the design principle of the Class 0 power converter. The employed ADC plays a central role because it measures the current that is used for regulation by the digital controller. The disturbance in the measured current cannot be suppressed (it is actually amplified in certain regions of the frequency spectrum) by the control loop before arriving at the load which acts like a low-pass filter, naturally damping the voltage source. M. Cerqueira Bastos and M. Martino clarified that Class 0 power converters are foreseen for the new triplets and optionally for the dipole circuits in the arcs where the beta-functions are larger due to the ATS optics.
The present ADC (DS22) is built with discrete components, temperature stabilized and improved with respect to the first design. However, it is not sufficient for HL-LHC, as it contains obsolete components and presents recurrent problems such as idle tones. The strategy for HL-LHC is to improve the design of the original DS22 with a new ADC (the new design denominated DS24) to address the issues mentioned above. Another strategy is to use the HPM7177 commercial digitizer.
The DS24 studies and changes with respect to DS22 are documented in an EDMS note (2054292). G. Arduini asked clarification on the idle tones. M. Cerqueira Bastos and M. Martino explained that they can be visible after down-sampling as well in the few Hz frequency range of the spectrum. The voltage noise of DS24 dropped by a factor of 5 with respect to DS22. Commercial 24-bit digitizers have been compared and the AD7177 (in the newly designed HPM7177 board) shows the best performance in terms of low-frequency noise. At full scale and low frequency, the noise is dominated by the voltage source (LTZ100 the best in the last 30 years) and both AD177 and DS24 behave the same. In terms of linearity, DS22, DS24 and HPM7177 are similar. Both digitizers fulfil the HL-LHC specifications. The HPM7177 allows self-calibration, bidirectional communication and fully differential signals. The DS24 is compatible with FCG 2 and FCG 3.2, while HPM7177 is compatible only with FCG3.2.
DS24 is in production, HPM7177 will have performance testing ready in 2020 and decision among the two solutions will be taken in one year.

Discussion

O. Bruning asked if it is cost effective to implement the new ADC for the arcs in a second stage. M. Martino replied that this is entirely possible, as it is fairly easy and cost-neutral to launch a second production series. G. Arduini asked if the new ADC needs to be built in the context of consolidation. M. Cerqueira Bastos clarified that sufficient spares are available for the DS22 and that no consolidation was foreseen. A. Siemko asked why there are two DCCTs installed. M. Cerqueira Bastos clarified that this is used as diagnostic for failures (small difference raise a warning, a large one raise an abort), redundancy and ultimately for reducing the noise floor by sqrt(2). A. Siemko asked also about the calibration procedures. M. Cerqueira Bastos clarified that the LHC system is much better than initially specified. For HL-LHC, the specifications have been worked out from the requirements to avoid over specifications. M. Martino and M. Cerqueira Bastos added that the ADC and DCCT is just one part of the power converter and the next step is the power part which presents its own challenges.

Protection of magnet circuits for hollow e-lens – D. Perini and M. Maciejewski, slides, slides

D. Perini reviewed the e-lens design concepts. The system of solenoids is optimized and frozen. The correctors are still under final definition as beam dynamics studies are on-going in BIMP. The list of changes was presented with respect to the last review in 2017, including the ones from the review and additional ones, which emerged afterwards (see link of WP5 meeting).

Y. Thurel asked how many circuits are foreseen. The answer was 6 main ones and 7-8 additional ones for corrector magnets. Y. Thurel pointed out that this may have cost implications. D. Perini and O. Bruning clarified that the number of circuits is needed for protections and tunings.

M. Maciejewski introduced the topic of quench protection analysis for the busbars, magnets, and circuits. The studies done so far represent a quick preliminary analysis, solely done to prove the feasibility of a quench protection system and anticipate potential issues and show-stoppers for the baseline assumptions. A detailed analysis will only follow if the e-lens becomes part of the HL-LHC baseline.

The analysis was done in an iterative way in order to meet the required maximum hot-spot temperature minimum voltage to ground. The inductance is considered constant and the internal resistances discarded for simplicity. L. Rossi asked if the assumption of constant inductance if well justified. D. Perini clarified that this is not studied as the iron yoke is being optimized. L. Rossi suggested to look carefully as soon as the detail of the iron will be clarified.

M. Maciejewski reviewed the detailed analysis of the E-gun cathode, solenoids after valve, bending solenoids and main solenoid. For the latter, additional studies need to be carried out by TE-EPC on the power converter. In conclusion all circuits are protectable with EE systems, although the main solenoids needs in their present configuration an additional re-design of the power converter.

Discussion

O. Bruning asked about the cost of the power redesign. Y. Thurel clarified that the present LHC 600 A power converter cannot be used with the proposed overall layout in the case of the main solenoids, as they will fail if converter output stage voltage to ground is exceeded (known safe limit around 450 V); this case can happen in case of an earth

fault in the circuit during a discharge.A specific HL-LHC power converter to come could be used instead, for which no re-design is needed as they will be designed for handling 1 kV to ground. This concerns just the main solenoids, and not the rest of the circuits (pending further verification). M. Martino clarified that the LHC 600 A power converters could be reused for the HEL DC magnets with minor refurbishment. Y. Thurel added that the recuperation of the LHC 600 A power converters is going to be only partial (DCCTs and other electronics/equipment will not be recovered from LHC during LS2) so some refurbishment will indeed be necessary. M. Martino is writing an HL-LHC Decision Document on this topic that will also summarize these issues which only became known after the dedicated WP1-WP6B meeting. L. Rossi suggested to consider using a quench heater, adding that it could allow to be put in series with the main circuits. A. Siemko commented that the use of quench heaters will be more expensive than a protection by EE systems. M. Mentink added that a third option would be available with an energy extraction system installed on either polarity side of the power converter. O. Bruning concluded that the present scenario with the HL-LHC power converter should be further analyzed in terms of costs and used as a working proposal. D. Wollman added that the question of the correctors is not trivial and will need to be addressed in detail in the future. L. Rossi asked if a quench-back is possible. M. Mentink replied that it should be possible but needs to be studied.

AOB

L. Rossi reported on the very positive discussions with the Russian institutions in particular for the recent agreements for the TAXS-TAXN and solid-state RF amplifier for the crab cavities. Additional contributions are also being discussed.

The next TCC meeting will take place on the 2nd of May 2019.