Machine Protection Working Group

Minutes of the 5th meeting held on July 13th 2001

Present: F. Balda, F. Bordry, E. Carlier, E. Cennini, C. Dehavay, B. Dehning, R. Denz, B. Jeanneret, W. Koelemeijer, J. Pett, B. Puccio, R. Schmidt, J. Wenninger

Excused: E. Ciapala, L. Serio

Main topics of this meeting:

- Proposal for LHC powering zones - follow up (R. Schmidt + E. Cennini)
- Energy information & septa magnet surveillance - follow up (R.Schmidt + J.Pett)
- AOB :
  - Reliability engineering : training & software (F. Balda)
  - Collimation in case of unsynchronised beam dump (R.Schmidt)
  - Powering Review – protection of triplet
  - SPS interlocks (J. Wenninger)

Proposal for LHC powering zones – follow up (R. Schmidt and E. Cennini)

R. Schmidt recalled the proposal for powering zones made by **B. Puccio** (MPWG meeting of June 1rst). This proposal must be checked for compatibility with the access and cryogenics systems. He also informed the audience that the naming for the machine protection controllers had been settled to be "Power Interlock Controller" and "Beam Interlock Controller", i.e. "Permit" was finally replaced by "Interlock". The controllers will give Power Permit and Beam Permit signals.

E.Cennini gave as a general rule for the definition of the access zones the requirements for a minimum number of access equipment (so as to minimize the possible faults due to the system) and the requirements to allow flexible equipment tests. The definition of the zones involves the following steps:

- Identify the powering zones and the equipment that is concerned.
- Identify the access points and their limits.
- Add a safe area (zone tampon) around the test zone.
- Define the access modes of the zone.
- Link the test zones and modes to the keys in the control room.

Discussion: **F. Bordry** said that contrary to LEP and SPS, there is no need for a test zone that would cover the whole LHC machine, since the powering is always "local" to one arc or insertion. He also stressed once more that he needs to know the access

conditions for the power converters (which circuits must be interlocked (max. current) for access?) and he asked who actually defines those conditions. **R. Schmidt** said that at DESY, all main circuits had to be below a certain threshold current (~ 1 kA) for access, while at BNL there was no interlock at all.

Action: **R. Schmidt** will organize discussions on the access conditions for PCs with TIS, the AIWG and SL/PO. He will also organize informal discussions on the powering and access zones, which requires layout maps of the access points.

Energy information & septa magnet surveillance - follow up (R. Schmidt and J. Pett)

R. Schmidt first presented a summary of the sub-WG meeting held on June 8th 2001 (the minutes are on the WEB under "Documents"). He recalled that:

- The septa must track the beam energy within about ±0.5%.
- The dump kickers have similar constraints.
- The effect on the extracted beam trajectory of the Q4 quadrupole, which are installed between the kickers and the septa magnets, must be evaluated. **M. Gyr** is studying this question.
- The amplitude of trims to be made on the septa magnets must be estimated. The order of magnitude is ~ 1%. To be confirmed by **M. Gyr**.

The outcome of the meeting was that:

- The septa magnets would be controlled using a standard PC (with standard controller….).
- A monitoring system would be built to ensure that the magnets track the energy. This system would correct all input currents for the known relation between current and field (and therefore energy).

The surveillance of the septa would be made in the following way:

1. The dipole currents in sectors 5-6 and 6-7 are measured with a certain number of DCCTs.
2. A dedicated module receives the DDCT signals as input and generates an output signal proportional to the beam energy. This is the "Beam Energy Monitor" (BEM).
3. The same module is also used to track the septa currents using at least one underground DCCT (note that the septa PCs are on the surface!).
4. A comparison is made of the "energy values" obtained from :
    - The dipoles in sector 5-6
    - The dipoles in sector 6-7
    - The septum of beam I
    - The septum of beam II

A beam dump signal is generated whenever one of the signals differs by more than ~ 1% from the others. **E. Carlier** mentioned that it was not sufficient to track the septa current, but that one also had to check the magnetic fields. **R. Schmidt** replied that **M. Sassowsky** and collaborators in the SL/MA group are addressing this issue.

A possible hardware solution for the BEM was presented by **J. Pett**. It consists of:

- A 16 bit ADC, which accepts input signals in the range 0 to 10 V.
- A micro-controller with 128kB flash memory (EPROM type) which is able to perform a non-linear correction of the input signal based on a look-up table with an accuracy better than 10^{-4}.

The overall delay between input and output is ~ 0.5 ms. The signal can be sampled every 50 μsecs and averaged/filtered to produce one output value every 1-5 ms. This solution uses the minimum number of chips, is cheap (50.- CHF for the chips) and, if required, one could afford to use 3 such systems in redundancy/majority vote to guarantee the reliability. **J. Pett** stressed that this was a minimal design and that someone had to address the problem of the interconnections and of the comparator. He agreed to provide a prototype for a proof of principle, but he said that the participation of other people was required for the longer term. As a next step one will have to look at the signal comparator. **F. Bordry** said that it was important to define a team that is responsible for such a system. **R. Schmidt** stressed that a team of ~ four people working together with **B.Puccio** was needed for the development and installation of the electronics of the LHC machine protection (powering interlock and beam interlock controllers). This manpower has not yet been identified, and therefore it is out of question that **B.Puccio** would take over the responsibility for the BEM. Groups that are potentially interested by the BEM are SL/BT, SL/HRF and SL/BI.

AOB

F. Balda presented a memorandum to be sent to SPL to justify (and speed up) the purchase of the RAMS software. The cost would be 51 kCHF for 5 floating licences. The company proposes 4 to 5 day training sessions with one teacher for a group of 5 to 6 persons. The price would be ~ 2-3 kCHF/day for a group. The training would take place at CERN.

R. Schmidt informed the members of the WG that a draft version of the design report of the interlock system – " Machine Protection for the LHC - Architecture of the Beam and Power Interlock Systems" - will be send out in the next few days.

R. Schmidt also reported from the SL/TC that in the event of an unsynchronised dump, the collimators could be damage. This issue is being followed up by B.Jeanneret and others.

Following the powering review, it was decided that the protection of the inner triplets would have to be studied. This will happen between the concerned people and the outcome will be reported to this WG.

J. Wenninger informed the audience that **R. Giachino** and himself had been appointed as "Dr. Interlocks" for the SPS. The role of Dr. Interlock is not precisely defined, but it consists mainly in specifying requirements for the interlock systems. Following a recent controls review of the LHC & CNGS transfer lines, it became clear that a new hardware interlock system had to be designed and build for the extraction to

LHC and CNGS. This system should be “cycle-aware” (i.e. take into account which beam is in the SPS to define the extraction permit). A presentation of the SPS system and its future requirements (including interface to LHC) will be made to this WG in the fall.