Machine Protection Working Group

Minutes of the 47th meeting held on August 5th 2005

Present: E. Carlier, K. Elsener, R. Fillipini, B. Goddard, G. Guaglio, C. Ilgner, M. Jonker, V. Kain, M. Lamont, D. Macina, B. Puccio, R. Schmidt, R. Steinhagen, B. Todd, V. Tsaplin, J. Wenninger, Thijs Wijnands, M. Zerlauth

Topics of this meeting:

- Specification for interlocking between SPS, LHC and CNGS
- Realisation of the interlocking between SPS, LHC and CNGS and open issues
- AOB

Specification for interlocking between SPS, LHC and CNGS (B. Goddard)

B. Goddard presented the specification describing the required interlock scheme for a safe and rapidly alternating extraction from the SPS to either the CNGS target or the LHC (see slides). The specification "Interlocking between SPS, CNGS, LHC Transfer Line and LHC Injection" is published as 'LHC-CI-ES-0002' and covers the required functionality, commissioning and test procedures. The specification is based on previous work of J. Wenninger and R. Schmidt (see MPWG meetings #40 and #42 for details).

The modified scheme has a hierarchical topology and segments the extraction interlock, using the TED beam absorber in the transfer lines as delimiters, into 5 zones for the CNGS/LHC 'beam 2' transfer line

- LSS4/TT40, TT41&CNGS, TI8 upstream, TI8 downstream and LHC injection in IR8

and 3 segments for the LHC 'beam 1' transfer line:

- LSS6/TT60, TI2 and LHC injection in IR2.

With the exception of the TEDs, the transfer line beam permit signals (magnet and power converter survey, beam loss monitors, screens etc.), will be collected by one Beam Interlock Controller (BIC) per zone. The output of the BICs and the TED signals are merged in one 'Master BIC' per SPS extraction line. In addition, the 'Master BICs' will receive information on

- safe SPS beam intensity,
- safe LHC parameters and
- general SPS timing in order to distinguish between beams intended for fixed target, CNGS and LHC physics (predetermining the transfer line to be used).

In total, there are up to 15 input signals per BIC. The Master BIC requires an extension of the simple 'AND' logic that is used in all other BICs in order to generate the SPS extraction and LHC injection interlocks. The detailed truth-tables can be found in the specification.

There are the following consequences of this scheme:

- The modified scheme comprises two more specialised (Master-) BICs.

- The complex logic in the Master BIC makes the commissioning of this BIC much more complex than for the other BICs.
- Because the LHC beam permit is used in the injection BIC, the LHC injection cannot be commissioned during LHC downtime.
- The scheme requires that the TED and 'CNGS Hadron Stop Cooling' signals have to be directly routed to the Master BIC, resulting in cable lengths of up to 3 km.
- The technical implementation of how the additional information (like timing) are handled in the Master BIC and its reliability are not yet established.

Another open issue is the generation of the SPS safe beam flag.

Realisation of the interlocking between SPS, LHC and CNGS (B. Puccio)

B. Puccio gave a functional overview of the Beam Interlock System (BIS) and the technical implications of the presented SPS, LHC and CNGS transfer line interlock scheme (see slides).
The BIS collects the LHC user system's permit status, evaluates their combined permit status using a logic 'AND' and, in case one of the input user permits switches to a 'FALSE' state, triggers a beam dump request in a safe and reliable manner.
The LHC Beam Interlock System consists of 16 Beam Interlock Controllers (BICs) distributed over the ring that collect and concentrate the individual user permit signals. The BICs are interconnected through optical fibre loops that carry a 10 MHz signal. The absence of the 10 MHz signal in one loop triggers a beam dump. The user may choose whether to act on a single beam or on both beams at the same time. There are in total four optical loops, one clockwise and one counter-clockwise per beam, in order to optimise the reliability and to minimise the longest case travelling delay to the beam dump system. The transmission of interlock signals from the user systems to the beam dump systems is highly redundant and designed to satisfy at least SIL3 requirements.

Except of the specialised 'Master BIC', that is being used for interlocking the SPS extraction to CNGS and LHC, all BICs are based on a common hardware and interlock logic (boolean 'AND' logic) with up to 14 inputs and additional process monitor functionality.

The technical implementation of the proposed transfer line interlock scheme with one 'Master BIC' per SPS extraction has the following open issues:

- For the time being, each BIC receives the user permit signals over a copper cable based RS422 connection, which is limited to a maximum length of 1.2 km. However, the 'Master BIC' requires user permits from the downstream TED in TI8 and the CNGS Hadron Stop Cooling which will be up to 3 km apart from the controller.
- The “regular” BICs receive their input information as logical user permits. The 'Master BIC' additionally requires information on 'LHC safe parameters', 'SPS timing' and 'SPS safe intensity flag', whose technical definitions are not yet finalised, to switch the logic between the different extraction modes (e.g. fixed target, CNGS, LHC). If possible, one has to find a mapping to relate those signals to user permit like signals.

- Since the Master BIC result depends also on SPS timing and LHC parameters, the test procedure becomes an issue. The local permit functionality can easily be tested by switching each user system into a test mode and changing the user permit signal manually. However, the timing and LHC parameters are less obvious to test since they cannot be changed as easily as user permits during operation and may be entangled with user system states.
- It has been suggested to use the energy approx. proportional by the dipole magnet current in the SPS to determine if the beam should be extracted to LHC, CNGS or Fixed Target. This requires the energy to be different by at least 0.5 %, in order to resolve the corresponding magnet current.

ACTION: B. Puccio & B. Todd

Discussion:
J. Wenninger inquires whether the additional functionalities and technical open issues can be solved till 2006. He further asks whether it would be acceptable to 'force' not yet implemented missing signals (like e.g. 'safe SPS intensity', 'SPS timing'/'beam type', 'LHC safe parameters' etc.) to a 'safe' state till their technical implementation becomes available.
For 2006, **J. Wenninger** indicates that the SPS schedule foresees to test the extraction to CNGS, high energy extraction to TI8 and the initial extraction to TT60. **B. Goddard** adds that one should test mixed B1/B2 extraction schemes as well. **R. Schmidt** points out that the focus should be kept on CNGS operation since for CNGS high intensity operation is planned for next year.
B. Goddard notes that for safe operation the SPS ring interlock system would be required, to connect the extraction kicker to the internal SPS dump, that would be triggered in case of an extraction kicker failure.
There is a window of 2 ms between charging of the LHC injection kicker, and the kick. The injection interlock system must already give permission to charge the kicker. The question was debated if this window is acceptable.

AOB

J. Wenninger reports that the engineering change request to modify the crowbars of the power converter that power the LHC cold MCB orbit correction dipole magnet was accepted. The additional resistors in the crowbar that would cause a reduced decay time constant in case of a power converter failure will be removed and the decay time restored to its original design value (~60-80 seconds, see MPWG meeting #46).

Next agenda (preliminary):
- Quench Levels (possibly combined meeting with collimation working group)
- Commissioning of the BIC (B. Todd)
- Commissioning of the Transfer Line Interlock System (J. Wenninger)