Machine Protection Working Group

Minutes of the 43rd meeting, held 15th April 2005

Present: R. Genand, R. Schmidt, J. Wenninger, V. Kain, B. Puccio, P. Dahlen, V. Montabonnet, J.P Pugnat, R. Steinhagen, C. Ilgner, R. Harrison, B. Todd, B. Goddard, M. Zerlauth, M. Werner, P. Proudlock

Meeting Agenda:

- Introduction to the Fast Magnet Current Change Monitor [MZ]
- Requirements of the Fast Magnet Current Change Monitor [VK]
- Design and Testing the DESY Fast Magnet Current Change Monitor [MW]

R. Schmidt began the meeting by introducing the overall scope and need for the Fast Magnet Current Change Monitor (FMCCM) describing the problems experienced at HERA which now employs 14 such detectors. In the LHC this would protect against failures in warm magnets having very short time constants.

Introduction to the Fast Magnet Current Change Monitor [MZ]

M. Zerlauth made a presentation introducing the concept of a fast current change monitor that is needed to protect the LHC against fast changes in magnet current. This problem has already manifested itself in the testing of the transfer line TI8 and has already become a problem for HERA at DESY.
Three solutions have previously been explored by CERN to handle the fast failure of critical magnets, the first is a *passive* measure added into the power converter – magnet chain. An inductance can be added preventing the magnet current from rapid decay, but coming at a cost of around 480kCHF per installation. The alternative measures are *active* supervision of the current flowing through the magnet chain by adding a device to monitor the magnet voltage, either by precision voltage measurement, or field measurement via a hall probe. Field measurement is very inaccurate, due to noise; the technique chosen by M. Werner is based on precision voltage measurement. This is cheaper, first estimates put a price of around 15kCHF per unit the design of which is technically challenging with high precision and response time requirements.
R. Schmidt noted that the BLMs will detect the extra beam losses due to a failing magnet; the FMCCM will act in conjunction with these, decreasing the MPS response time. **B. Goddard** added that the FMCCM will give a direct indication of fault location, having a key role in the transfer lines, where safety depends on a single-shot approach versus that of a circulating beam in LHC.
M. Zerlauth continued to describe the FMCCM function, researched at DESY involving taking magnet voltage, modelling the magnet, and deriving a current. The test setup was with an older converter, attached to a single MSE, with a circuit time constant of around 39ms. Typical time constant values for the SPS are 23ms. A second setup was done with a normal conducting separation dipole (D1) on a similar magnet test bench with a natural time constant in the order of 1.5 seconds.
B. Puccio asked whether there was a need to locate the device closer to the magnet or power converter. **M. Werner** replied that it makes little difference, the filtering effect of the cable only slightly changes the response of the voltage at the Magnet, for cabling and radiation reasons it's better to have it at the Power Converter.

Requirements of the Fast Magnet Current Change Monitor [VK]

V. Kain made a presentation describing the results of studies showing the need for the FMCCM. Single magnet failure simulations have been coupled with simulations due to mains failure of the larger subsections, it was shown that the failure of a sub-sector can mean the loss of beam has 5x more effect. **B. Goddard** explained that this was due to the loss of focussing and defocusing quadrupoles simultaneous to the sweeping effect the beam experiences. **V. Kain** then gave an example of time scales after a worst case failure particles begin to hit the collimators after around 15 turns, in just 30 turns the damage level of the collimators is reached. The specification of the FMCCM is a direct result of these studies - it must react within *10 turns in the case of the D1 magnet*. In this time the current in the magnet only changes by around *0.05%*. The FMCCM must also be wary of causing false dumps and faulty inhibits.
R. Schmidt then asked how many of these are foreseen in LHC. **B. Goddard** said the Transfer Lines would need between 10 and 15 of these devices. **J. Wenninger** agreed, saying this figure could change depending upon the architecture of the machine power distribution.

Design and Testing the DESY Fast Magnet Current Change Monitor [MW]

M. Werner made a presentation showing the fundamental design of the FMCCM and how it performed in the tests previously described in **M. Zerlauth**'s presentation. The FMCCM is an analogue system having a digital monitor, it has a small circuit corresponding to the electrical characteristics of the magnet it is monitoring – once subjected to the magnet voltage, the magnet current is derived which is then filtered to remove noise. In the case of the LHC the device stores 120ms of data with a sampling period of 20us regarding the current from before and after an alarm is given, this sampling period can be altered, to change the overall capture length This means that for Post-Mortem purposes the device can be interrogated for this information. The FMCCM also records the high and low values of current it has seen, for this to make any sense in the Extraction and Injection situation, where it's supervising a pulsed magnet, it needs to be synchronised to the pulse via an external trigger. The threshold of the FMCCM is determined by the setting of a potentiometer local to the device, this cannot be written remotely; it can, however be read remotely.
Two observations were made on the Power Converter: the MSE Voltage has a 25% peak-peak noise superimposed at 600Hz due to 3-phase thyristor switching. The MSE Current has a 0.5% peak-peak current superimposed at 50Hz and 600Hz. This means that the test-setup could be a flawed approximation to the real world application, as the Power Converters in LHC have a much lower output noise level.
The response of the FMCCM was shown in comparison to the change of a Hall probe signal, and the output from a DCCT. Both the DCCT and the Hall Probe had large levels of noise. The typical response was shown for the FMCCM; it was scaled to react on a 0.1% change in current.
The effect of eddy-currents was also demonstrated, by adding a copper 1.5 wall-thickness tube in the magnet The eddy-currents cause the magnetic field in the vacuum chamber to decay more slowly than the FMCCM derives (around 1.5ms was demonstrated) thus adding a further inherent safety margin.
For the extraction functionality, a glitch was shown when the magnet was charging up, **M. Werner** said this could be removed by modifying the programming of the FMCCM. The idea of the FMCCM having a lower limit of 5% $\cdot I_{nom}$ before giving TRUE to the Beam Interlock System, it was also discussed whether the trimming of magnets could cause a trigger, first discussions indicate that this is not the case.

Various Members discussed the future of the project, in particular who will be responsible for it at CERN. A meeting will be arranged between members of CO and PO who are most likely candidates for this task.

AOB

none

Next Meeting
Friday 29th April 2005 at 10:30 in room 864-1-C02

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