Ongoing Activities for Detection of Fast Failures in Magnets

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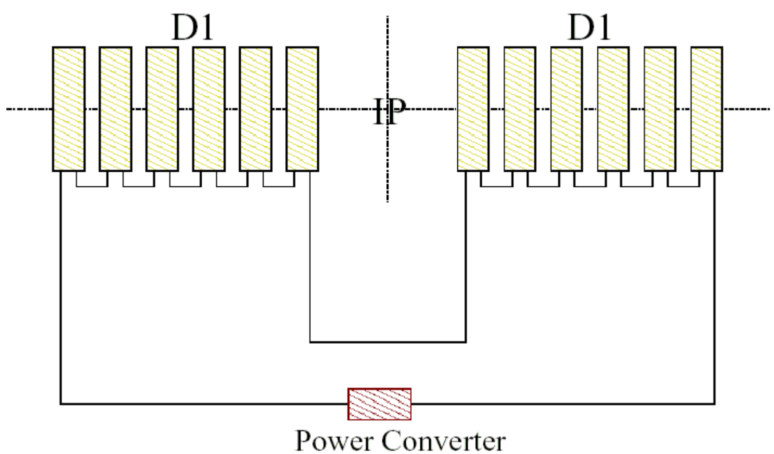
History

- **D1 failures - linear tracking (V. Kain, MPWG end 2002)**
- **D1 failures, proposal for a superconducting (MPWG 09.05.2003)**
- **D1 failures - linear versus nonlinear tracking (V. Kain, MPWG 29.08.2003)**
- **First discussions and tests for the SPS extraction septas (B. Goddard, R. Genand, R. Schmidt)**

Fast detection of magnet failures

- The need for fast detection of changes of magnetic fields (and consequently changes of the current in the magnet) became evident after tracking studies for failures of the warm D1 magnet

- As measurements of the current with high accuracy(10E-3 to 10E-4) were judged to be too difficult a passive solution using a superconducting coil in series with the circuit was proposed



- Could be a solution for this dedicated problem, but …. system needs space for installation (surface buildings for D1 system) and…

…later on…

- Similar problems have been identified by B. Goddard for the SPS extraction septa's

- Again an electrical circuit with weak time constants (23 ms) and small tolerance windows for allowed current (field) changes (in the order of +/-1E-3, based on a +/- 1 sigma orbit excursion)

- As this might not be the last one a more general solution for fast detection mechanisms should be found instead of developing dedicated systems for each single problem

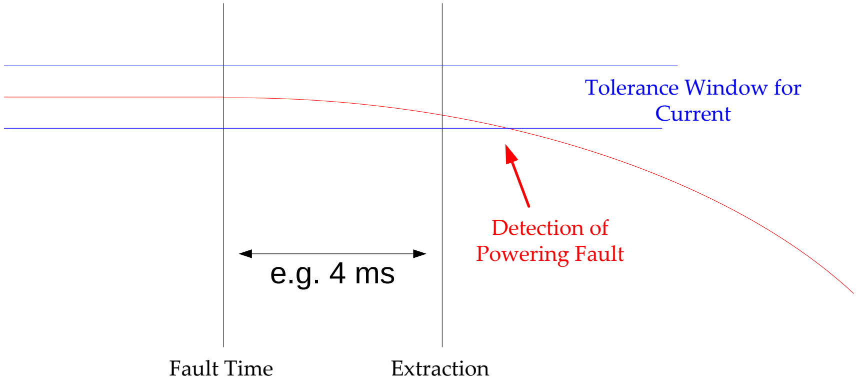
- As the goal is at first place the creation of a simple interlock signal, absolute values of current measurements with high accuracy (which require filtering and as such longer time) are not of primary interest but other methods may deliver the information -> **di/dt**

- Such first ideas have already undergone some first tests in the SPS and yielded promising results to follow them up

The MSE Extraction Septa

CIRCUIT CHARACTERISTICS

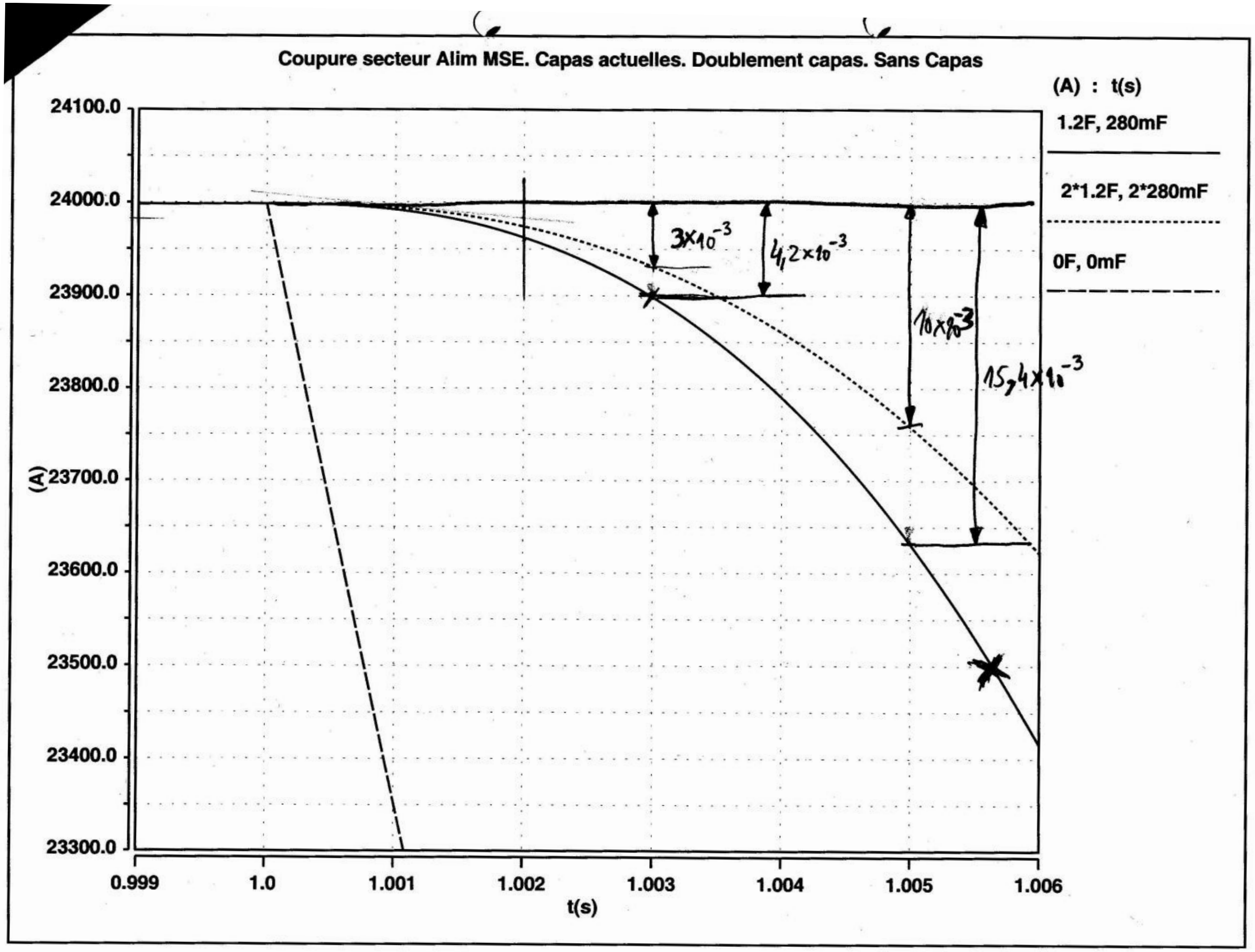
- 6 magnets in series
- Total R=3.59 mOhm (magnets, cables etc).
- Total L=0.083mH
- Nominal current 22kA (max 24kA)
- Resistive voltage 80.7V
- Ramp time ~300ms
- Inductive voltage 6.2V
- Time constant 23ms
- Interlock 'dead time' 5ms



- After ramping to nominal current, the field should be kept constant at least until extraction is finished

- Due to a tolerance window applied for the current before issuing a powering failure and the ‘dead time’ of 5 ms, failures occurring just some ms before extraction will lead to beams touching the aperture

Current Decay in the MSE (Simulation)



di/dt Measurement

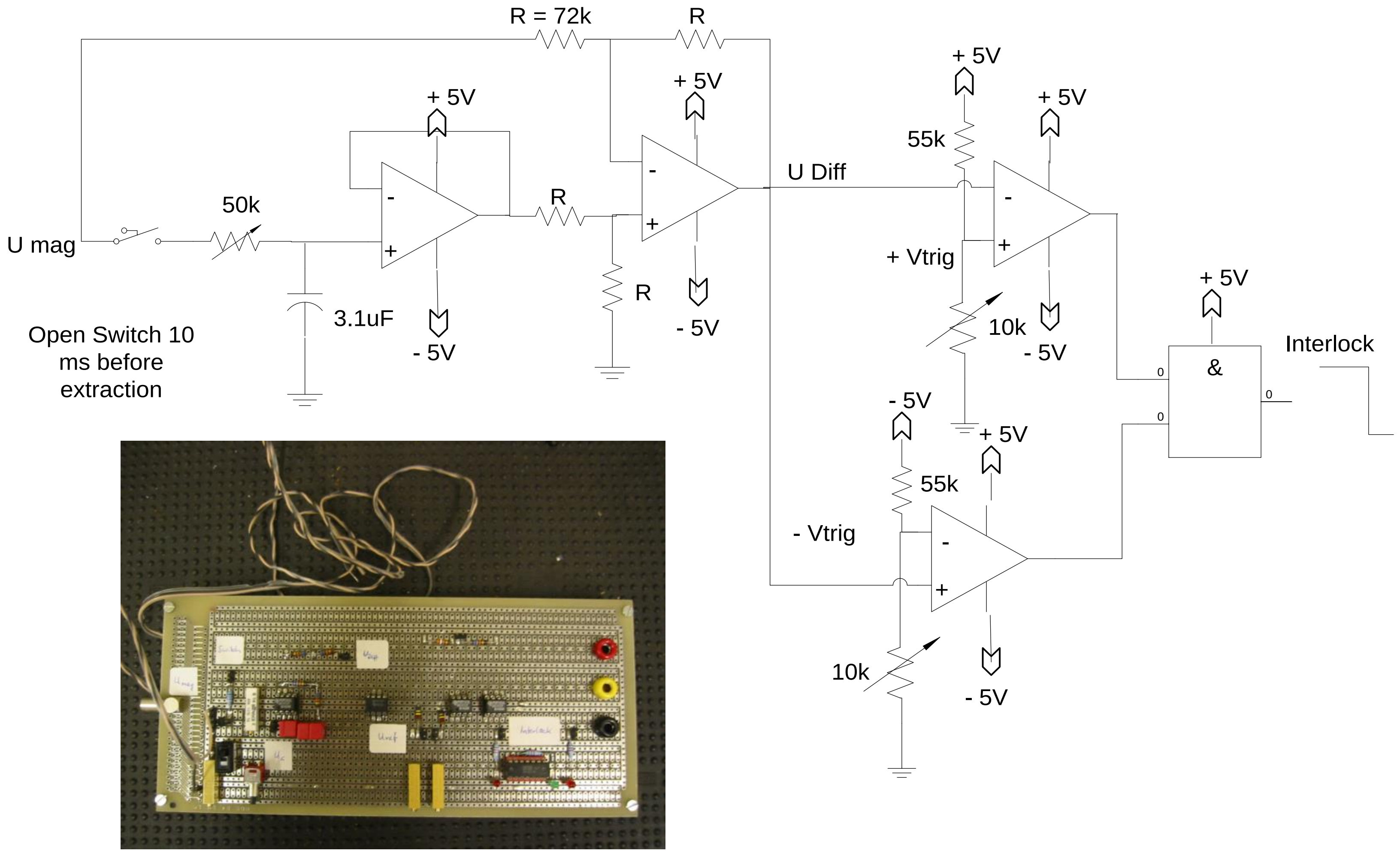
- The first proposal is based on a measurment of the very high di/dt during a decay of the current after a failure in the electrical circuit.

- The di/dt is measured via the voltage drop over the magnet. Even though the inductance of the MSE magnets is very low, the measured voltage is in the range of some Volts due to the high di/dt of around 20kA/s

- Before extraction a reference value will be generated via a S&H and compared with the actual value. If a fault occurs, the rise of voltage over the magnet will be detected and will trigger an interlock signal

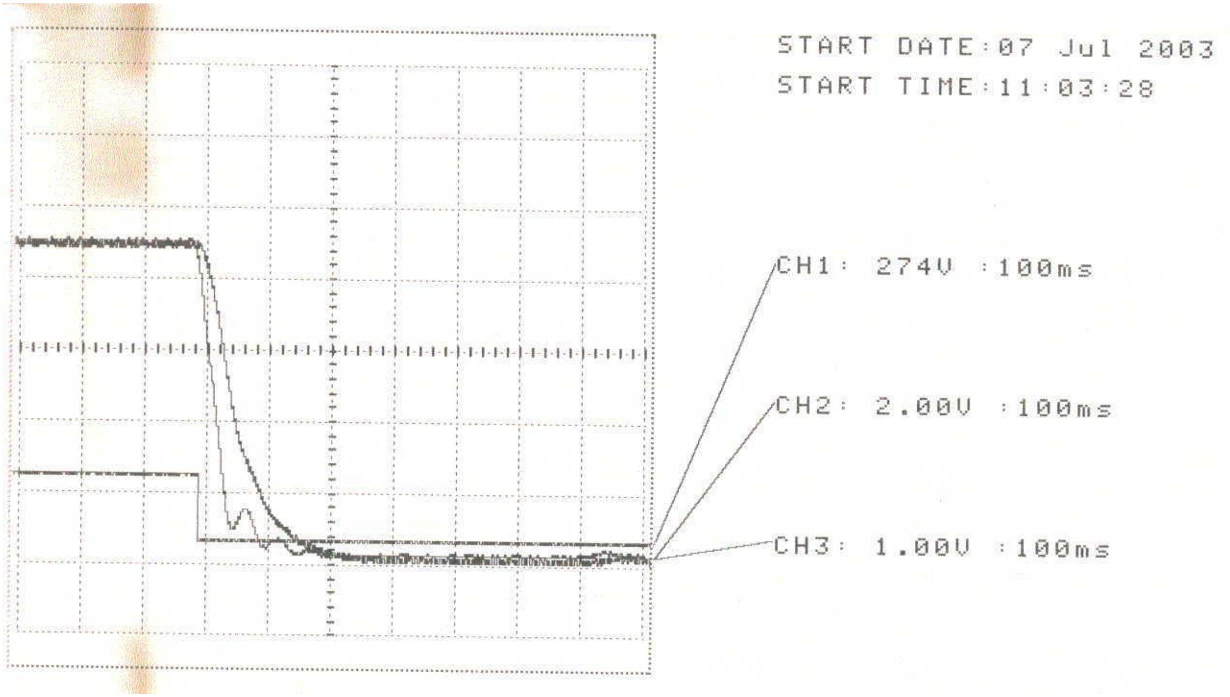
- To avoid timing events introduced to the circuitry, a continuous monitoring with a frequency of e.g. 10kHz could be performed, while the status of the interlock signal is verified before extraction is permitted (Connection to SPS extraction interlock system?)

The Testboard

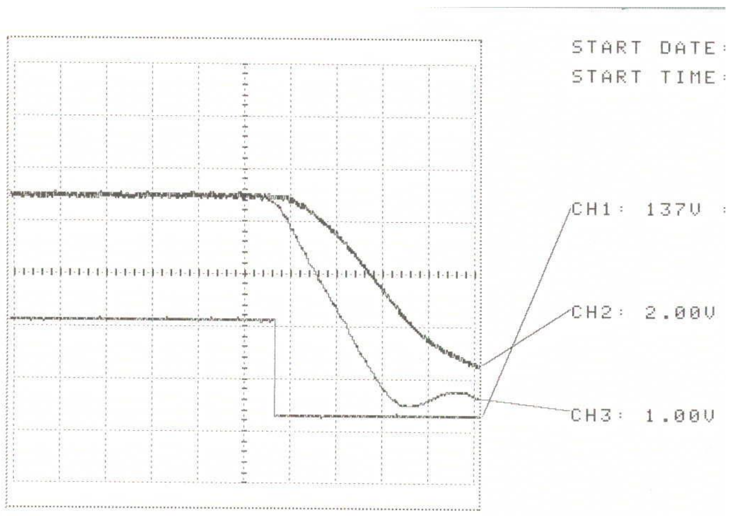


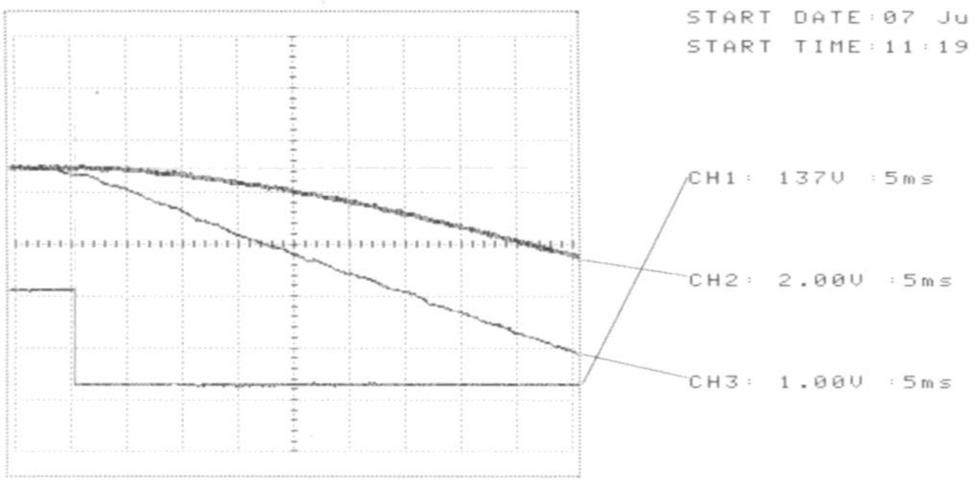
First Results

- After some measurements of R. Genand to determine the current and voltage ripples, the board has been connected to the power converter of the MSE circuit located in BA4
- The power converter was ramped in a scenario simulating a fault in the circuit (rise time 300ms, flat top 500ms, ramp down 0ms)



First Results

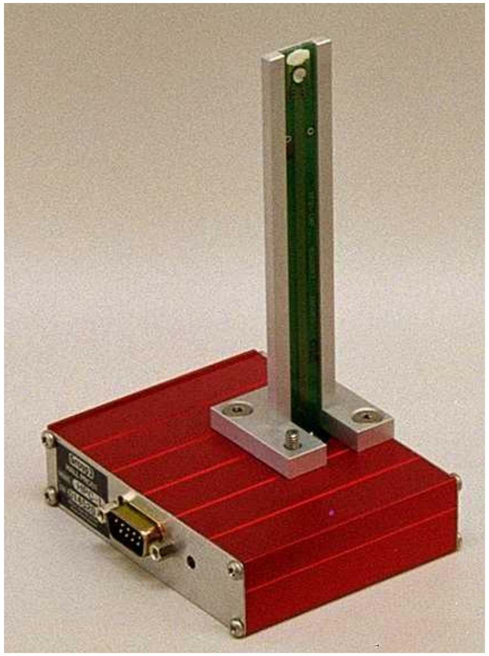


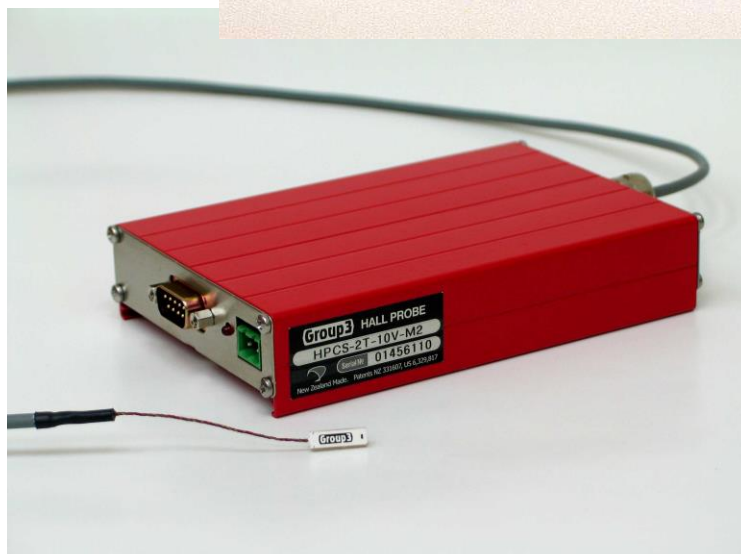


Field Measurement

- A second possibility could be a direct measurement of the magnetic field
- Due to the inaccessibility of the magnet this could be performed in a smaller 'reference coil' or for higher currents (such as for the MSE) even via measuring the field on the surface of the conductor
- Devices based on hall-probes have been found, claiming accuracies of (0.02% of full scale + 0.01% of field +0.00002) Tesla with a bandwidth of up to 10 kHz (full scale range of 0.1 T – 2T)
- Output is scaled to a 10V range and can be used to generate the interlock signal via simple electronics
- Distributor in Switzerland offers us a systems for tests (keep or return)

Measurement Devices





Conclusions and further activities

- Other measurement methods look promising but need further investigations to determine their validity for all problems known up to now (warm D1, extraction septas…)
- They are more universal, easier to install and much cheaper solutions to support other protection principles (beam loss monitors, detection of fast orbit changes…)
- Combinations of the principles are possible, maybe in one common rack
- Tests for the MSE will be repeated on the test bench with a direct connection to the magnet
- Hall Probe system will be ordered and investigated