LHC BLM SINGLE CHANNEL CONNECTIVITY TEST USING THE STANDARD INSTALLATION

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Abstract: For the LHC beam loss measurement system the high voltage supply of the ionisation chambers and the secondary emission detectors is used to test their connectivity. A harmonic modulation of 0.03 Hz results in a current signal of about 100pA measured by the beam loss acquisition electronics. The signal is analyzed and the measured amplitude and phase are compared with individual channel limits for the 4000 channels. It is foreseen to execute an automatic procedure for all channels every 12 hours which takes about 20 minutes. The paper will present the design of the system, the circuit simulations, measurements of systematic dependencies of different channels and the reproducibility of the amplitude and phase measurements.

LHC BLM SYSTEM

- The LHC BLM has 25 crates (256 channels capability each), 4000 monitors, 2400 spares.
- Different monitor types are used: Ionisation chamber (IC), Secondary Emission Monitor (SEM) or 2 IC in parallel (IC2).
- The hardware link to the beam interlock system [1] is used to dump the beam or block injection.
- There are 2 hardware timers per crate to ensure regular triggering of the connectivity test and the Management of Critical Settings (MCS) Online Check [4].

A. The tunnel card BLECF [2] integrates the charges of the monitor for 40µs then sends it to the surface.

B. The processing card BLETC [3] generates longer integration windows (running sums) and compare them to thresholds to generate the beam permits [1].

C. One of these running sums is sent to the combiner card BLECS during the connectivity test by the central processing unit (CPU) one time per second.

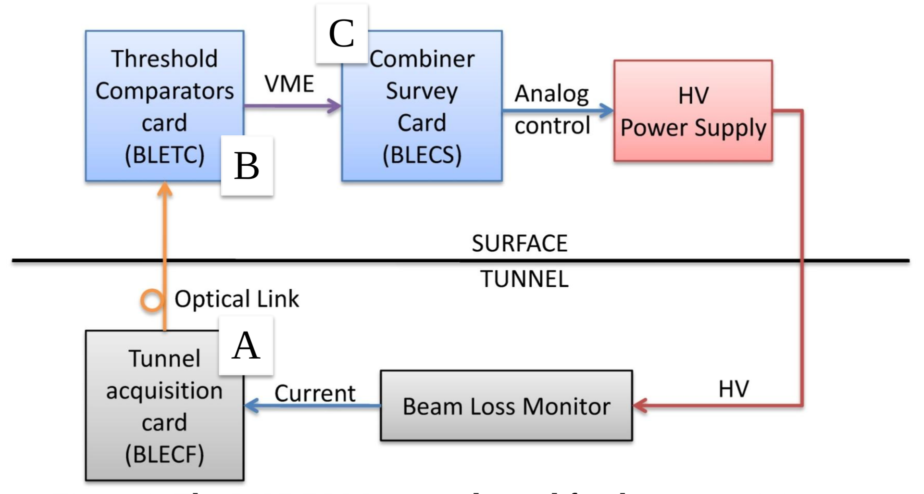

Figure 1: The LHC BLM system looped for the connectivity test.

TEST PURPOSE AND PRINCIPLE

- Test the integrity of about 4000 monitors cabling.
- Measure the variation of the components value over the time.
- Compare it to channel individual thresholds to detect changes.
- Block the next LHC injection in case of nonconformity.

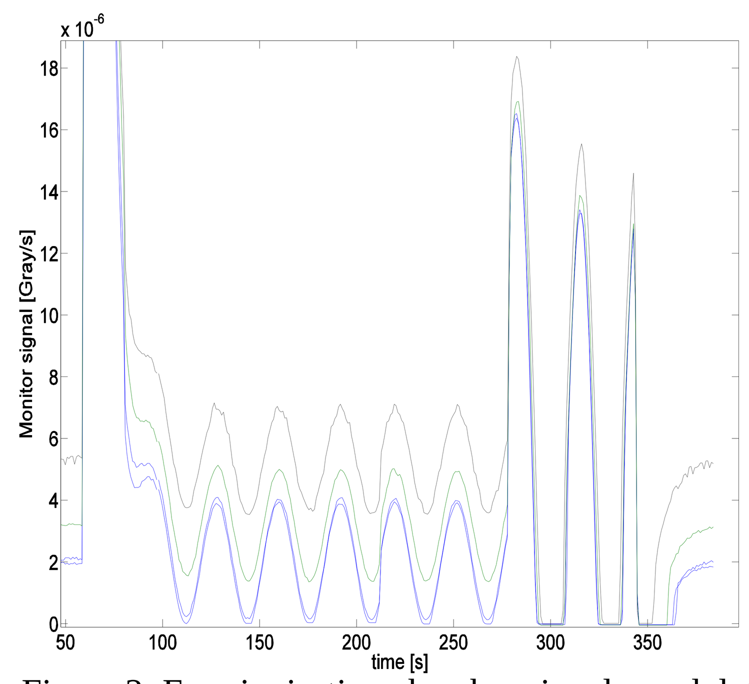

Figure 2: Four ionisation chamber signals modulated.

A. A small harmonic modulation is added to the high voltage supply of the monitors.

B. The modulated current (Fig. 2) is measured with the standard installation (Fig. 1).

If a cable is broken or missing, the measure does not show any harmonic variation.

SIMULATION

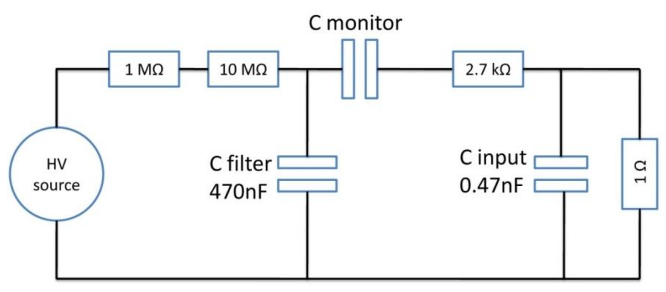

Figure 3: Simplified equivalent circuit.

- Simplified equivalent circuit (Fig. 3).
- C_{Filter} supply charges when a fast losses occurs
- The IC, IC2 or the SEM is represented by the capacitor $C_{Monitor}$.
- the integrator virtual ground and its input circuit inside the BLECF is represented as a RC filter and a shunt resistor.
- The contribution of the cabling is small compared to the component values and is ignored.

- To detect a change of the C_{Filter} value, the frequency of 30mHz was chosen for the test. It is due to the large dependency of the phase (Fig. 5) and low magnitude change (not shown).
- For this working point, the gain of the system is close to maximal (Fig. 4) and the monitor type can easily be recognized by measuring the current amplitude.

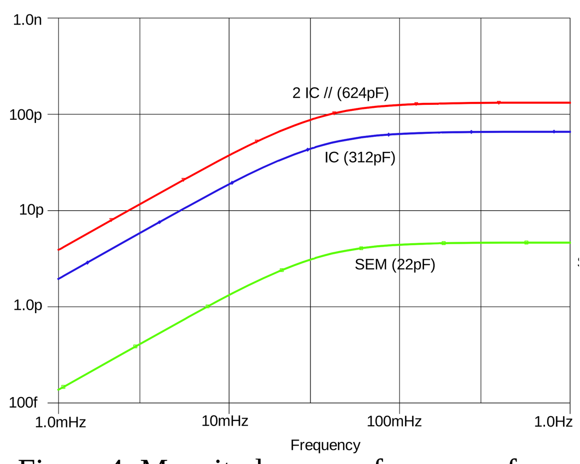

Figure 4: Magnitude versus frequency for the 3 monitor types.

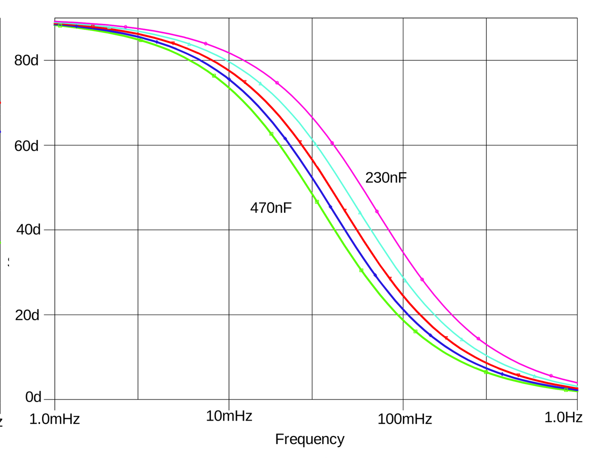

Figure 5: Phase versus frequency for the different values of C_{Filter}.

IMPLEMENTATION

- The generation of the modulation (Fig. 6) and the processing of the measurements (Fig. 7) are implemented inside the combiner and survey card BLECS.

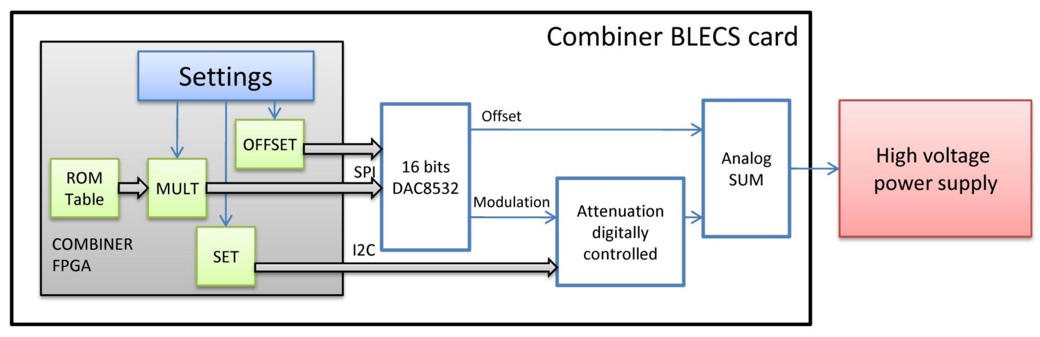

Figure 6: The generation of the digital harmonic modulation and its conversion to an analog signal to control the high voltage power supply.

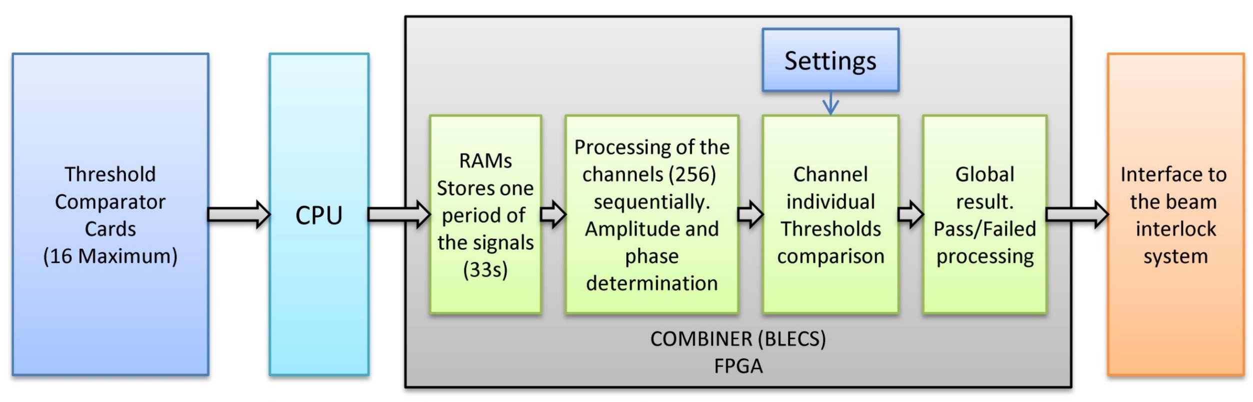

Figure 7: Data path from the surface generation of the running sums (BLETC) to the beam permit lines which allow a new LHC injection if the connectivity test is successful.

MEASUREMENT ANALYSIS & THRESHOLD CALCULATION

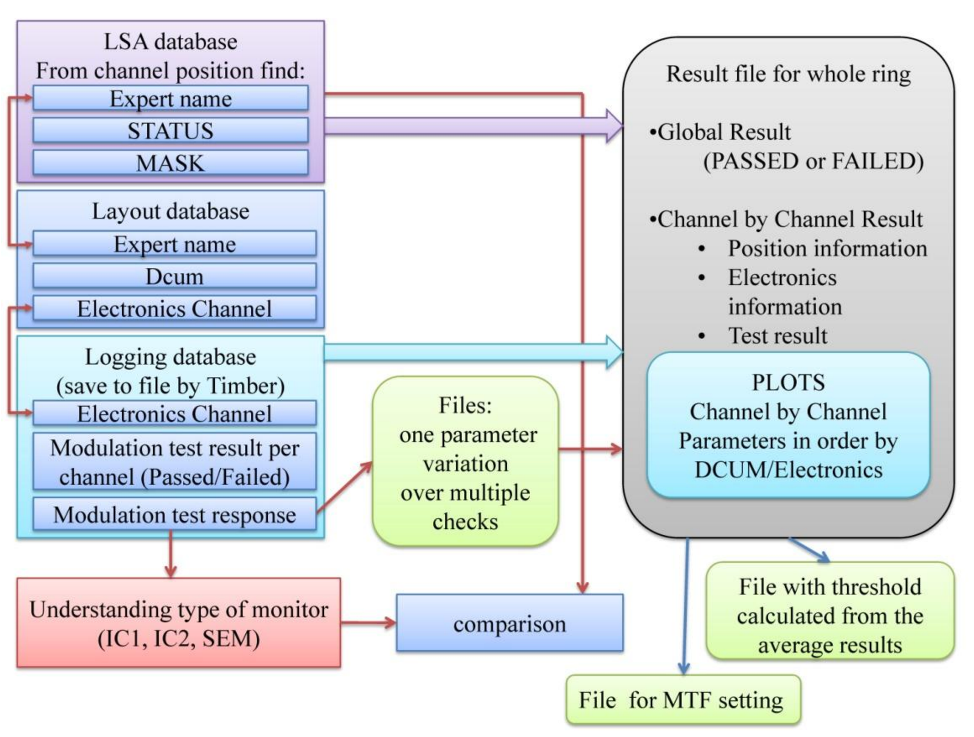

Figure 8: Overview of the analysis for system validation, parameter optimisation and threshold calculation.

- Data retrieving and analysis are described in Fig. 8.
- Multiple connectivity test have been conducted to check the variance of the amplitude (Fig. 9 top) and Fig. 10) and phase (Fig. 9 bottom) measurements.
- The optimal modulation voltage has been determined (10V) for good distinction of the monitor type (Fig. 9 top) and low variance of the induced current measured (Fig. 10).
- The monitor type identified in the analysis is compared with the expert name from the databases.

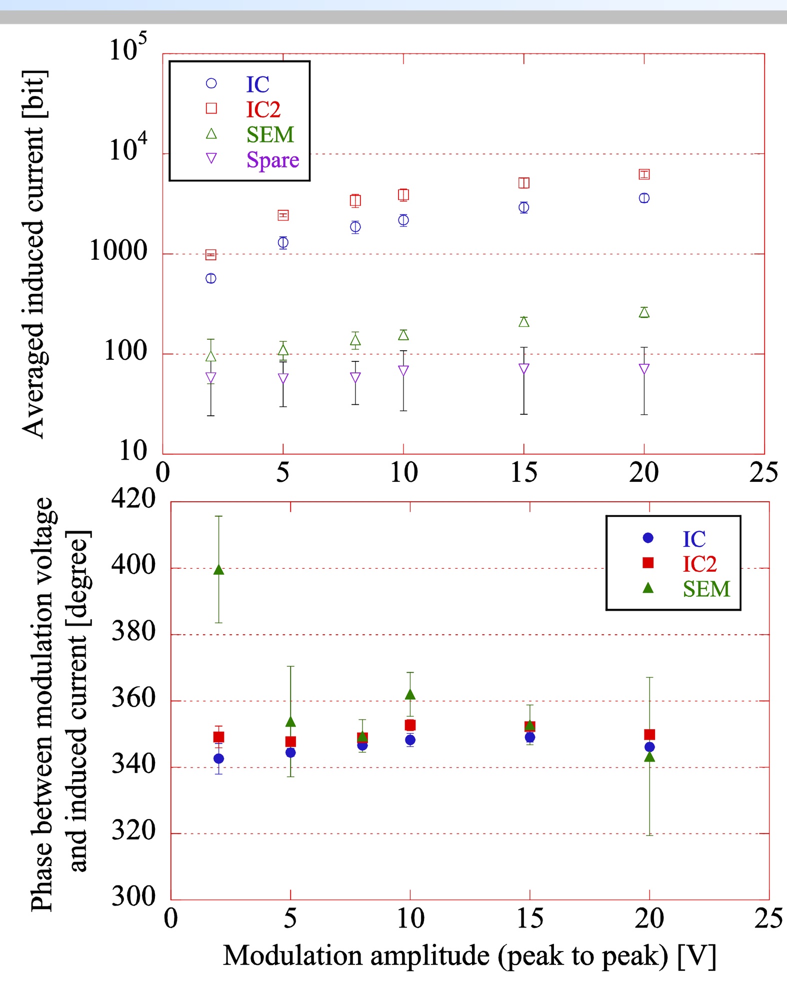

Figure 9: Average induced current (top) and phase (bottom) versus different modulation amplitudes. Data are collected from the LHC point 8 right and straight section.

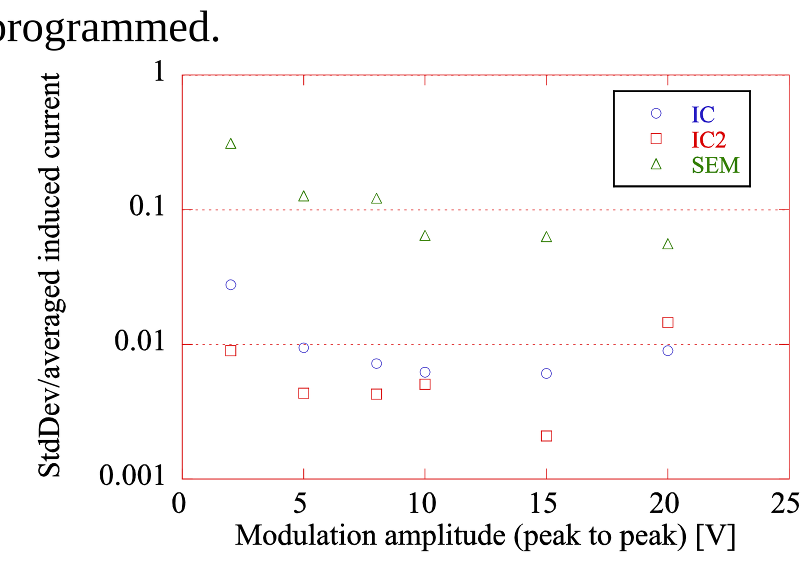

Figure 10: Measurement reproducibility versus modulation amplitude. Different options are being investigated to reduce the SEM error.

- Average over multiple measurements are used to produce the thresholds for each of the 4000 monitors. A margin is added according to the variance in Fig. 10 and Fig. 9 bottom.
- The thresholds are written to the LSA database to be included in the BLM master table [4]. From there, the front-end electronic card memories are programmed.

Complementary information

[1] Engineering Specification, *"The Beam Interlock System For The LHC"*, LHC Project Document No. LHC-CIB-ES-0001-00-10, version 1.0, 17-02-2005.
[2] E. Effinger, B. Dehning, J. Emery, G. Ferioli, C. Zamantzas, *"Single Gain Radiation Tolerant LHC Beam Loss Acquisition Card"*, Proceeding of DIPAC'07, Venice-Mestre, Italy.
[3] C. Zamantzas, B. Dehning, E. Effinger, J. Emery, G. Ferioli, *"The LHC Beam Loss Monitoring System's Surface Building Installation"*, Proceeding of LECC'06, Valencia, SPAIN
[4] C. Zamantzas, B. Dehning, J. Emery, J. Fitzek, F. Follin, S. Jackson, V. Kain, G. Kruk, M. Misiowiec, C. Roderick, M. Sapinski, *"Configuration and Validation of the LHC Beam Loss Monitoring System"*, these proceedings.

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