Appendix C: Preliminary Proposal for the ECAL Temperature Safety System (TSS)

1 General Temperature Safety System Requirements

The ECAL Temperature Safety System, as a part of the general ECAL Detector Safety System, will have to meet a number of rigorous requirements. The most important of these requirements, in terms of system's performance, autonomy, integration and reliability, are the following:

- Full system autonomy in all aspects;
- External, independent and continuous temperature monitoring of the ECAL VFE (+FE) environment;
- Complementary monitoring of VFE (+FE) PCBs temperature using integrated temperature sensors and readout through the DAQ system;
- Continuous archiving of temperature data and system status information for later analysis of system and detector performance;
- Reliable hardwired interlocks with High Voltage (HV) and Low Voltage (LV) Power Supplies systems;
- Prompt reaction on any critical change of temperature by issuing, in a proper time sequence, warnings and Alarms to:
  - HV System (hardwired interlock),
  - LV System (hardwired interlock),
  - System Operator (soft PVSS warning and alarm);
- Maximum possible level of robustness, reliability and maintainability;

The full system autonomy, concerning power supplies, communication channels and readout system, is crucial if we want to isolate the TSS from the possible malfunctioning of other ECAL sub-systems. For this reason, TSS should have independent power supplies and communication channels. For the same reason, the VFE temperature monitoring must not only rely on temperature sensors integrated in the PCBs and DAQ readout system. Instead, TSS ought to have additional sensors and a DAQ-independent readout of the VFE(+FE) environment temperatures.

The trend of these temperatures should be monitored and archived continuously. The monitoring application capability of issuing an early warning prior to software and hardwired alarms should also be present since it would leave the possibility for manual intervention and, eventually, problem resolution before the shutdown of HV and LV systems. In an alarm situation, all the interlock signals must be issued reliably and the LV and HV systems shutdown correctly, in a proper time sequence. This is necessary if we want to prevent damage to the FPPA chips on the VFE boards in the case that the LV is turned off while the HV is still on.

Particular attention should be paid to the requests for system robustness, reliability, radiation tolerance and maintainability. Robustness and reliability mean that the system hardware and software should be carefully designed to have the minimum level of hardware and software problem-dependence, and to be able to properly handle malfunctions and system errors in all foreseen scenarios. One of the ways to achieve this goal is to introduce appropriate redundancy in the system. Still, one should take care of trade-off between the level of redundancy introduced in the system and its cost.

The issue of radiation tolerance and system maintainability is a common issue to all CMS detector sub-systems. Therefore, the hardware components of the TSS system should be chosen in such a way to sustain at least the radiation dose present in ECAL during the operation time between detector maintenance periods. In addition, for the sake of system maintainability, common industrial solutions and components are preferred.

2 Preliminary proposals for TSS of CMS ECAL

Concerning all design objectives and the requirements mentioned above, as well as the requirement of a simple and cost saving system, four different solutions for the Temperature Safety System are proposed.

Solutions 1, 2 and 3 are based on PT100 sensors and "standard" radiation-hard/tolerant multiplexing, whilst the solution 3' uses radiation hard RBFE chips and radiation tolerant Maxim multiplexers for the temperature measurement, A/D conversion and channel multiplexing. Common to all solutions is that the readout system is based on the reliable PLC system - an industrial standard for the Integrated Automatics.

In all of these proposals we have considered two options for the measurement points inside the module: A position on the copper plates of the "last" front-end electronics PCBs (the closest PCBs to the output cooling pipe in the module) and/or any other favourable position in the module if the air temperature inside the module is measured (an option in accordance with the Lustermann-Dissertori proposal).

We have also considered two options for the number of sensors per each point: Two sensors per one point glued next to each other for the purpose of redundancy and easy cross control (so called "twin" sensors used in solutions 1, 3 and 3') and/or only one sensor per each measurement point (option used in solution 2).

It is important to note that all these considerations are preliminary and are still subject to further investigations so that eventual later versions, particularly that for the final TSS ECAL solution, may differ from the solutions proposed here.

Solution 1

This proposed solution is based on 10 twins (i.e. 20 single) sensors per module and consists of a total number of 2880 sensors distributed within ECAL (Fig.1). The system is organized (divided) into three levels: module, super-module and half-barrel.

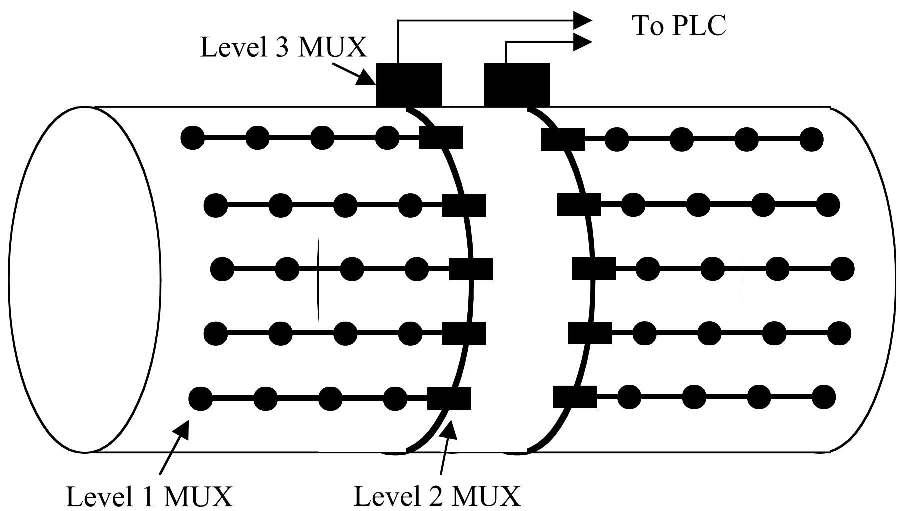

Figure 1.

Organization

- 2880 sensors (20 per module, 10 twins)
- 144 Level 1 MUXs
- 36 Level 2 MUXs
- 2 Level 3 MUXs
- 1 Control Electronics PCB (nearby the PLC).

Wiring

- 40 wires inside the module from sensors to Level 1 MUX (multiplied by 144 x 1m): 40x144x1m = 5760 m;
- 22 wires trough the Super-Module, from Level 1 MUX to Level 2 MUX (multiplied by 36SM x 3m and multiplied by 2 for talking ring): 22x36x3m = 2376m;
- 50 wires around the half-barrel, from the Level 2 MUX to Level 3 MUX (multiplied by 2HFx10m): 50x2x10m = 1000m;
- 25-30 wires from Level 3 MUX to PLC per half-barrel, (multiplied by 2HF*50m): 30x2x50m = 300m.

Solution 2

This proposed solution includes 10 single sensors per module (no twins sensors) making 1440 sensors in total. The system relies on three Levels of signal multiplexing (Fig. 2).

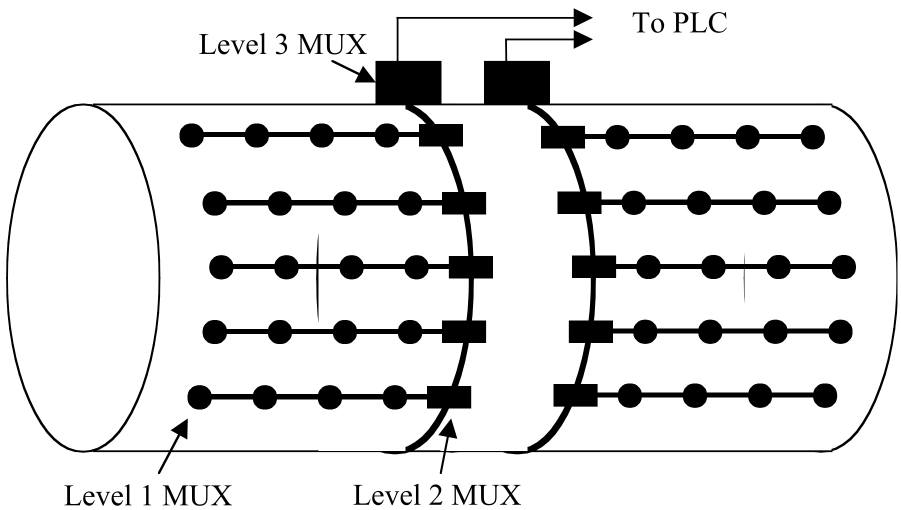

Figure 2.

Organization

- 1440 sensors (10 per module)
- 144 Level 1 MUX
- 36 Level 2 MUX
- 2 Level 3 MUX
- 1 Control Electronics PCB (nearby the PLC)

Wiring

- 20 wires inside the module from sensors to Level 1 MUX (multiplied by 144SMx1m): 20x144x1m = 2880m;
- 20 wires trough the super-module, from Level 1 MUX to Level 2 MUX (multiplied by 36SMx3m) (and multiplied by 2 for talking ring): 20x36x3m = 2160m;
- 50 wires around the half barrel, from Level 2 MUX to Level 3 MUX (multiplied by 2HFx10m): 50x2x10m = 1000m;
- 25-30 wires from Level 2 MUX to PLC per half barrel, (multiplied by 2HF*50m): 30x2x50m = 3000m.

Solution 3

This proposal is based on 2 sensors per module, which amounts to the total number of 288 sensors for ECAL (Fig. 3). The system relies on two levels of signal multiplexing.

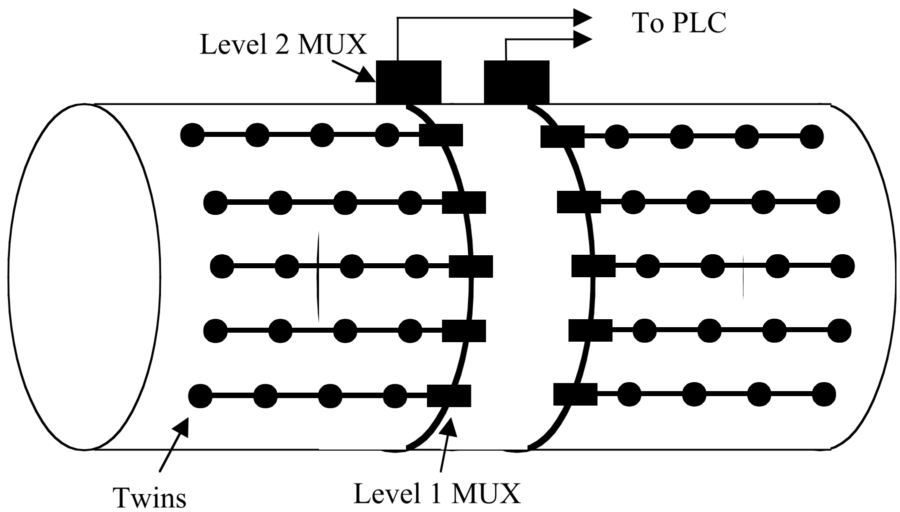

Figure 3

Organization

- 288 sensors (2 per module)
- 36 Level 1 MUX
- 2 Level 2 MUX
- 1 Control Electronics PCB (nearby the PLC)

Wiring

- 18 wires trough the supermodule, from sensors to Level 1 MUX (multiplied by 36SM*3m): 18x36x3m = 1944m;
- 40 wires around the half barrel, from the Level 1 MUX to Level 2 MUX (multiplied by 2HF*10m): 40x2x10m = 800m;
- 20 wires from Level 2 MUX to PLC per half barrel, (multiplied by 2HF*50m): 20x2x50m = 2000m.

Solution 3'

This proposal is also based on 2 sensors per module, which amounts to the total number of 288 sensors for ECAL (Fig. 3'). Unlike the system proposed in Solution 3, this system relies on one MUX level realized by T-MUXs also used for the High Precision Temperature Measurements.

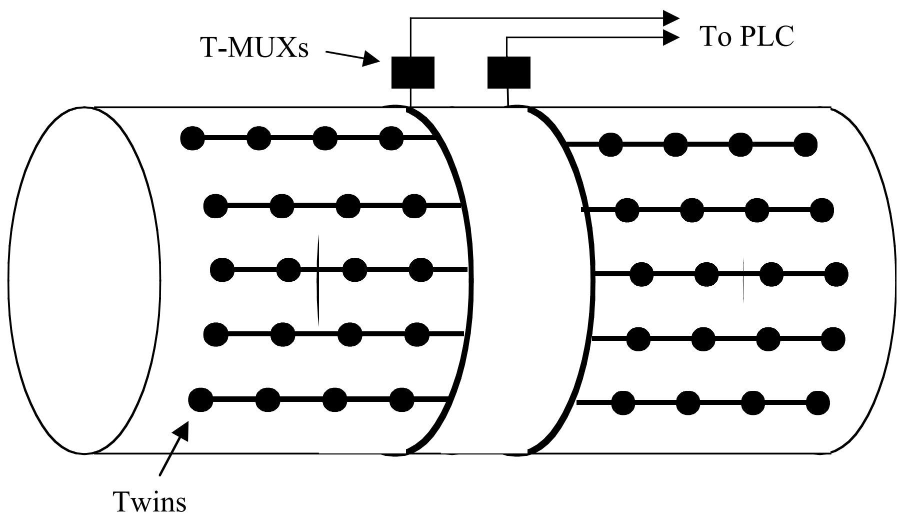

Figure 3'.

Organization

- 288 sensors (2 per module)
- 36 T-MUXs
- 1 Control Electronics PCB (nearby the PLC)

Wiring

- 16 wires through the Supermodule (SM), from sensors to the SM patch panel (multiplied by 36SM x 3m): 16 x 36 x 3 = 1728m;
- 36 x 16 wires inside the ECAL Barrel and CMS, from the SM patch panel to the T-MUX racks (multiplied by 40m): 36 x 16 x 40 = 23040m;
- 58 wires from T-MUX Racks to the PLC inside the Counting Room (multiplied by 130m): 58 x 130m = 7540m.

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