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Thermal and Humidity Monitoring in ”Cold” Detector Control and Safety System

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As high readout channel density and compact design become the norm for HEP detectors so is operation at temperatures below the experimental site dewpoint. This increases the importance of humidity and temperature monitoring systems that are also adapted to the detector environment. In what follows we describe the systems we developed targeting compactness, cost and integration to our DCS/DSS systems. The proposed temperature monitoring system is aimed at thousands of RTDs with low space and price requirements. For humidity measurements, we have identified a potential sensing element and designed conditioning electronics capable of nulling the capacitance of the long cables.

Summary (500 words)

Modern High-Energy Physics (HEP) detectors contain many millions of readout channels that dissipate hundreds of kW power causing detectors to heat and thus making powerful cooling systems an indispensable detector part used to distribute coolant at subzero temperatures throughout the detector structure. For Silicon-based detectors, cooling provides a double benefit. Besides heat removal, it reduces the leakage currents caused by irradiation. When detectors get cooled at temperatures lower than the outside dewpoint, the danger of catastrophic condensation effects makes dewpoint (therefore relative humidity) and permanent temperature monitoring essential.

The temperature sensors of choice, Pt (Platinum) RTDs that have been proven to survive the detector environment (irradiation and up to 4T magnetic field) are also efficiently read out over long cables by using a 4-wire connection therefore the only problem for using them is that of a cost-effective, multi-platform, easy to deploy monitoring system.

On the other hand, is challenging to find industrial market humidity sensors that could survive and operate in the harsh environment of HEP detectors among the integrated devices, which suffer from the lack of radiation resistance of the on-board conditioning electronics. Neither is it easy to find compatible devices among the bare sensing elements, be they resistive or capacitive, which generally require short cable runs to the conditioning electronics.

After several searches and evaluations on commercially available sensors, we identified the sensing element that can be deployed in a HEP detector and provide an indication that the internal atmosphere is compatible with cold operations. The sensor is of a capacitive type with an almost linear response to irradiation, the response that can then be easily parametrized in order to compensate for them algorithmically.

This capacitive sensor requires the readout system to compensate for the parasitic capacitances of the necessarily long cables connecting it to the conditioning electronics and readout system, far in excess of the sensor capacitance and even more so of the changes for a relative humidity step. We have thus developed conditioning electronics capable to nullify the cable capacitance and produce a signal proportional to the observed relative humidity. Besides cable parasitic capacitances, the designed circuit effectively nullifies the effect of the leakage resistance. The leakage resistance represents the effects of the condensation and pollution on the sensor, and, in the equivalent electrical circuit of the sensor, is connected in parallel to the sensing capacitor. The data that will be presented in the paper are quite promising.

Provisions for the integration of both sensor systems into the CMS Cold Detector DCS (Detector Control System) are also imperative for their use. Finally, the ability to switch a subset of the temperature sensors from the monitoring system to the safety system constitutes another major requirement, and we have studied how to implement this in the connections of the sensors.

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