Modeling Thermo-Fluid Dynamics of a Processing Unit of the Fast-track Trigger for ATLAS

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Abstract

We describe the thermal modeling of a crate hosting boards with Associative Memories (AM) designed for the Fast Tracker Trigger (FTK) system of the ATLAS detector at the CERN Large Hadron Collider [1]. The FTK is a highly parallel hardware system designed to provide global tracks reconstructed in the inner detector. The hardware system is based on AM for pattern recognition and fast FPGAs for track reconstruction. This work is focused on the thermal management of the associative memories located inside a crate. The crate is hosted in a rack with the layout of Figure 1. The power supply (PS) of each Processing Units (PU) must be positioned in the rack on top of the PU crates. The cooling system of the rack includes fan trays, heat exchangers on top of the crates and the PS units, a turbine and an air deflector. No more than two PU crates can be contained in one rack. Figure 1 shows also the proposed PU crate layout.

FTK performs tracking using the PU with the AM system. The AM system consists of AM chips, ASICs designed and optimized for this particular application, and two types of boards: the Local Associative Memory Board (LAMB), a mezzanine where the AM chips are mounted, and the Associative Memory Board (AMB), which holds four LAMBs (Figure 2). Both the AM chip and the two boards have a long development history and the power consumption, that take place mainly in the AM chips, varies depending on the version of these chips. The estimated PU crate power consumption for the final system is more than 5 kW, which makes the design of the rack cooling system challenging.

Numerical simulations can be very helpful to verify in advance if the cooling system will be able to keep the temperature of the AM chips at safe values.

For this, we set a COMSOL Multiphysics® model to solve a conjugate heat transfer problem (Heat Transfer in Solids for the PCBs and the crate aluminum structure coupled to the CFD model of the turbulent air flown). To simplify the analysis, we have drawn 1/3 of the whole PU crate, because the fans at the bottom inlets are placed as a 2 rows x 3 columns matrix, and preliminary isothermal CFD simulations have been showed an almost repetitive air flow respect to the 3 columns. Instead of the layout of Figure 1, it has been considered the worst thermal case of the crate filled only by AMBs.

The results obtained by the stationary simulation with a dissipated power of 2.5 W per AM chip, and a temperature of the air at the fans of 20 °C, are shown in Figs. 3 and 4. The fans have been modeled as boundary conditions giving the static pressure curve data taken by the 6400 rpm fan datasheet. The simulated thermal map matches quite good the

preliminary measurement tests, thus this COMSOL model will be helpful for sizing the cooling system of future revisions of the presented system.

Reference

[1] J. Anderson et al., FTK: a Fast Track Trigger for ATLAS, Journal of Instrumentation, Vol. 7, pp. 1-8 (2012)

Figures used in the abstract

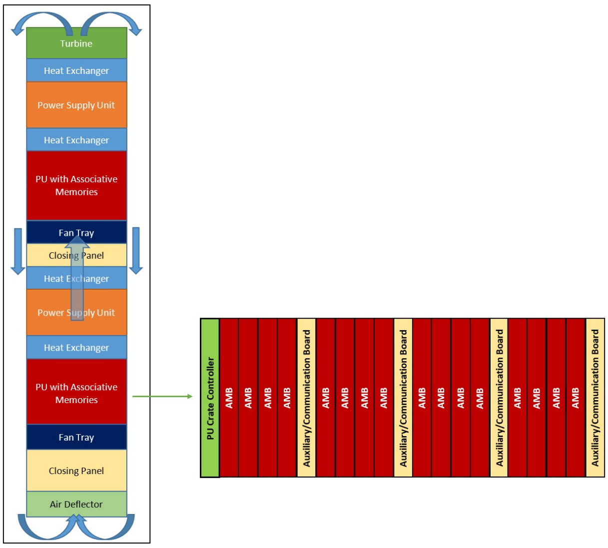

Figure 1: Rack layout (left), and PU crate layout (right). The blue arrows show the airflow path inside the rack.

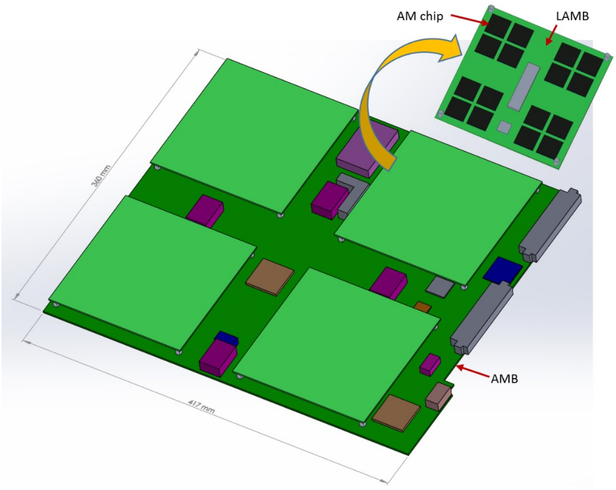

Figure 2: Simplified 3D geometry of the Associative Memory Board used in the COMSOL model.

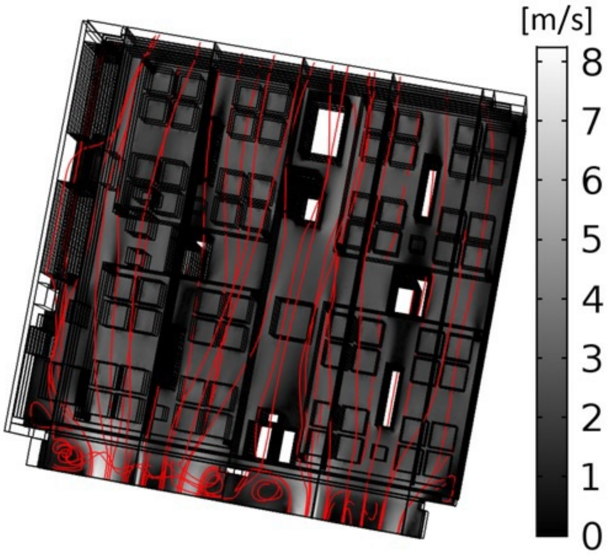

Figure 3: Air speed in a slice between the two AMB in the middle of the 1/3 simulated crate.

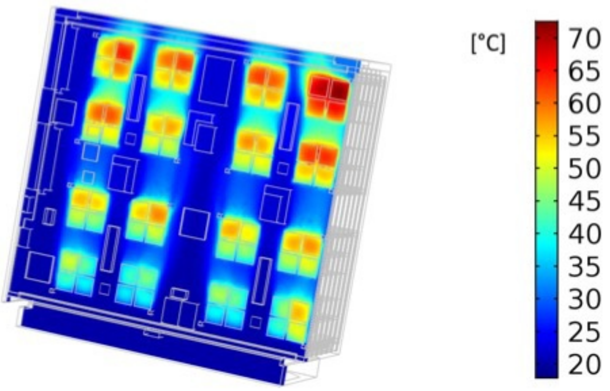

Figure 4: Thermal map of a slice passing through AM chips of the AMB placed near a wall of the crate (worst case).