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Lessons from integrating CMS Phase-2 back-end electronics and first results from Serenity-S1, a production optimised ATCA blade.

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The Serenity-S1 is a Xilinx VU13P based Advanced Telecommunications Computing Architecture (ATCA) processing blade that has been optimised for production. It incorporates many developments from prototype cards and where possible adopts solutions being used across CERN. It uses many new parts because commonly used parts have disappeared from the market during the semiconductor crisis with only some returning.

We discuss improvements to simplify manufacture, the performance of new components, some of the more difficult aspects of procurement, the performance of production-grade Samtec 25 Gb/s optical firefly parts and issues with the rack cooling infrastructure.

Summary (500 words)

At least 500 Serenity-S1 cards will be needed to provide back-end electronics to the CMS Tracker, Level-1 Trigger, and High Granularity Calorimeter. They will be used to interface to the front-end electronics within the detector and also provide a firmware platform for processing data, particularly for running trigger algorithms.

The card uses a modular approach that splits the service area, which provides infrastructure that is needed on all ATCA cards, and the payload area, which contains all application-specific components. The service area is situated towards the backplane and includes the Intelligent Platform Management Controller (IPMC), an Ethernet switch, and a Xilinx KRIA System-on-Module (SoM) that is based on a Zynq Ultrascale+ System-on-Chip (SoC).

The payload is specific to the Serenity-S1 board and includes a Xilinx VU13P FPGA as the main processing unit as well as Samtec FireFly optical transceivers that are used to transmit data to and from the FPGA. There are 10 FireFly 12-channel transmitters and receivers each, as well as one single 4-channel bi-directional FireFly on the board, all of which are capable of running at 25 Gb/s depending on the type of firefly installed.

The card also contains features to protect itself in case of unexpected events. For example, loss of 48 V power will trigger a controlled shutdown of the card within a few ms before locally stored energy is exhausted. This ensures all power supply sequencing requirements are met, not just at power-up, but also at power-down.

Due to component shortages, we were not able to use the already evaluated Skyworks Si5395A jitter cleaners and switched to the recently released Microchip ZL30274 as well as new power supply modules for the FPGA. Because the availability of our core power supply, the LTM4700, is still uncertain, we also implemented a redundant solution using high-current power connectors and an additional power module based on industry-standard multiphase converters.

To accommodate the increased power requirement of ATCA cards new 2U, short depth heat-exchangers have been designed to remove up to 7 kW instead of the 2.3 kW 1U heat exchangers used for Versa Module Eurocard (VME). However, they require increased water flow and water pressure, which has an implications on the rack cooling infrastructure. An investigation into racks used by the Tracker for test and development will be presented, along with how it pertains to the underground system.

Production is expected to span 2024 and 2025 starting with a pre-series of about 50 cards in early 2024. Procurement is complicated by several issues. For example, the cards must be manufactured with a high yield due to high cost of free-issued components, but simply demanding this risks deterring companies from tendering.

The 25 Gb/s FireFly optical links are a new product which has also required extensive performance evaluation (Bit-Error-Rate (BER), pattern integrity and attenuation tolerance) and lifetime testing.

First results from Serenity-S1 will presented along with a discussion of the issues raised above.

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