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The Expandable Modular ATCA hardware design for high-energy physics experiment applications

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The CMS experiment has adopted ATCA standard for the upcoming Phase-II upgrade. We have developed a novel approach to the design of ATCA boards for this upgrade. Instead of relying on a regular single-PCB framework, with possibly some additional mezzanine cards, the X2O design is using a large heat sink as a main mechanical carrier, with various modules attached to it as needed. The modules designed so far are: Power module that includes DC-DC power converters and a control device based on Xilinx ZYNQ System-on-Chip (SoC), FPGA module based on XCKU15P FPGA, and an optical module based on industry-standard QSFP+ optical engines with the bandwidth of up to 25.78 Gbps. Additionally, the collaborating groups are designing their own FPGA and optical modules based on different FPGAs and optical engines.
A typical approach in ATCA hardware design for CERN experiments is to use two separate control devices: an IPMC controller is responsible for negotiating with ATCA Shelf Manager via IPMB protocol, and another microcontroller is typically used for all other control functionality, such as register settings, status readout, etc. This usually leads to considerable cost increase and reduces the PCB real estate.
We have combined both functions in a single device. It is a very inexpensive and small off-the-shelf module based on Xilinx ZYNQ-7000 SoC, running Centos 8 Linux. In order to do that, we have reworked an open-source software to operate as a full-featured IPMC controller in Linux environment. The entire IPMC project has been published in an open-source repository as well. The IPMC software is designed to be modular and expandable by users.

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