The Final Multi-Chip Module of the ATLAS Level-1 Calorimeter Trigger Pre-processor

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Abstract

The final Pre-processor Multi-Chip Module (PPrMCM) of the ATLAS Level-1 Calorimeter Trigger is presented. It consists of a four-layer substrate with plasma-etched vias carrying nine dies from different manufacturers. The task of the system is to receive and digitise analog input signals from individual trigger towers, to perform complex digital signal processing in terms of time and amplitude, and to produce two independent output data streams. A real-time stream feeds the subsequent trigger processors for recognising trigger signals, and the other provides a deadtime-free readout of the Pre-processor information for the events accepted by the entire ATLAS trigger system. The PPrMCM development has recently been finalised after including substantial experience gained with a demonstrator MCM.

Summary

This paper describes the final version of the ATLAS Pre-processor Multi-Chip Module (PPrMCM). Considerable experience has been gained from a demonstrator version previously presented at this workshop series.

In the ATLAS Level-1 Calorimeter Trigger, the ATLAS PPrMCM combines pre-processing and readout for four trigger-tower signals on a single substrate. The electrical boundaries of the PPrMCM package were placed at locations in the processing chain where a minimum number of signals enter and leave of the package. The MCM features analog input and digital output, and therefore houses both mixed-signal and purely digital chips. Some of them are

commercially available and others are application specific. A Pre-processor ASIC (PPrAsic) developed at the ASIC laboratory of the University of Heidelberg forms the heart of the system and carries out digital processing of four trigger towers. In total the PPrMCM contains nine dies: four FADCs, one Pre-processor ASIC, three LVDS serialisers for the digital data transmission to the subsequent processors, and a timer chip required for the phase adjustment of the FADC strobes with respect to the analog input signals.

The tasks of the PPrMCM are:

- To digitise four analog trigger-tower signals at 40 MHz with 10-bit resolution. Digitisation at 12-bits is used to extend the effective number of bits.

- To process digital trigger-tower data in terms of energy calibration and bunch-crossing timing identification.

- To serialize processed trigger tower data using high-speed Bus LVDS chip-sets.

- To provide deadtime-free readout of the data from four trigger towers.

In order to achieve these, the MCM consists of:

- Four 12-bit FADCs manufactured by Analog Devices (AD9042).

- One four-channel PPrAsic, providing readout and pre-processing;

- One timer chip (Phos4) for the phase adjustment of the FADC strobes with respect to the analog input signals.

- Three Bus LVDS Serialisers, 10-bits at 40 MHz (400 Mbps user data rate, 480 MBd including start- and stop-bit).

The physical substrate of the PPrMCM is a combination of three flexible Polyimid foils, laminated onto a rigid copper substrate to form four routing layers. Plasma etching is used for so-called buried via connections to adjacent layers, and routing structures are formed in copper using conventional etching techniques. The surface of the top layer is gold-plated to permit safe bonding of aluminium wires. The technology described is implemented in the TwinFlex MCM-L technology provided by the company Würth (Germany).

Detailed simulations of electrical, thermal and timing properties of the PPrMCM have been carried out. The layout of the substrate has been finalised. The production of a pre-series consisting of 10 PPrMCMs is expected for the autumn of 2001.