

The U-Board - a heterogeneous platform for digital signal processing in radio astronomy

G. Grutzeck^{*(1)}, I. Krämer⁽¹⁾, C. Giese⁽¹⁾ and B. Klein⁽¹⁾

(1) Max-Planck-Institute for Radioastronomy, Bonn, Germany, <https://www.mpifr-bonn.mpg.de/>

1 Extended Abstract

The increasing demand for processing power in modern radio astronomy, due to increasing instantaneous bandwidth, calls for equally powerful processing platforms. Typical digital signal processing applications on an Field-Programmable Gate-Array (FPGA) are limited by the available high bandwidth memory on the FPGA. Heterogeneous architectures, which combine different processing architectures, offer the possibility to overcome these limitations. In a heterogeneous architecture, it is possible to combine the advantages of each architecture, in such a way that the disadvantages of each architecture are compensated.

The U-Board is a platform (s. figure 1) that connects a set of high speed Digital-Analog-Converts (DACs) and Analaoog-Digital-Converts (ADCs) with a closely coupled, heterogeneous processing architecture, which combines the advantages of FPGAs with those of Graphics Processing Units (GPUs). The two processing systems are closely linked, as they are connected via PCIe, which offer simple direct highspeed data transfers in both directions. This architecture allows the development of real-time streaming applications, which combine the hard real-time capabilities and integer processing power of an FPGA with the floating point processing power and available highspeed memory of a GPU. On the FPGA side the UltraScale+ family from Xilinx is used. On the GPU side the Jetson Orin AGX modules from NVIDIA are used. These combine an 12-core ARM64 CPU with a 2048 CUDA core GPU and 64 GB of RAM on one module.

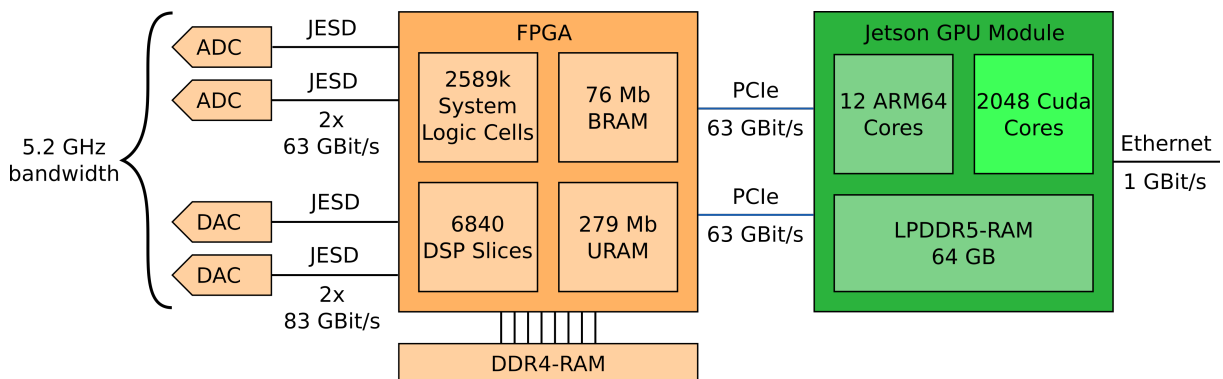


Figure 1. A schematic overview of the U-Board platform, with the wideband analog frontend, and the heterogeneous processing architecture.

Instrumentation for radio astronomy as well as laboratory spectroscopy have the need for phase coherent signal generation and acquisition over wide bandwidths, combined with a powerful signal processing, which can be fulfilled by the U-Board platform. In instrumentation for mm- and submm-astronomy such an application is a readout for Microwave Kinetic Inductance Detectors (MKIDs). MKIDs can be used to build incoherent cameras with a high number of pixels, due to the multiplexing in the frequency domain. In the coherent regime the U-Board can handle Fast-Fourier-Transform-Spectrometers (FFTS) with millions of channels over a broad instantaneous bandwidth. In the field of laboratory spectroscopy the Chirped-Pulse-Spectroscopy (CPS) has the need for wide band, phase coherent signal generation and acquisition.

We will present the U-Board platform and its application. The platform currently has two incarnations. First, a prototype of commercial off-the-shelf components for fast prototyping and development. Second, a custom PCB with all components integrated on it to achieve a compact solution, which is important for applications directly at the telescope.