High-level Programmed FPGA Computing Platforms for Radio-Astronomy Correlators, Spectrometers and Focal-Plane Arrays.

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ABSTRACT

Commercially available Field Programmable Gate Array (FPGA) computing platforms that can be programmed by graphical and high-level description languages have lowered development time and costs of radio-astronomy signal-processing systems. Systems with hundred of inputs may be readily constructed from off-the-shelf components. Because the hardware is programmable at a high level, so called "smart antennas" and "software radios" may be quickly designed by assembling a small number of signal processing library components.

An example of a "smart antenna" is the Phased Array Demonstrator (PHAD) which is being built to investigate the feasibility of large array feeds for multi-beam reflector antennas. When complete, the PHAD will consist of a 2D array of ~200 Vivaldi antennas. It will be tested at the prime focus of the DRAO 26-m paraboloid. Initially, the frequency range of the array will be 1 to 2 GHz. The signal-processing system digitally forms a polarized beam from the antenna elements at the reflector focus. To do this, twelve boards made by Lyrtech, of Quebec City, are used. Each has sixteen high-speed analog to digital converters (ADCs) and a large FPGA. The ADCs have 14-bit resolution, 250-MHz bandwidth, and 105-MHz maximum sample-rate, while the FPGA is a 3-million gate part made by Xilinx. For the PHAD each board samples, filters and combines the signals from a set of antennas, which are combined with the outputs of other boards to form the polarized beam. The system is programmed graphically by selecting processing and interface functions from libraries. A variety of processing functions are provided, from simple multipliers and counters to Finite Impulse Response filters and complex Fast Fourier Transforms. Using the software one can connect ADC outputs to filter functions, apply complex weightings and combine these to form a beam.

In this paper we investigate the use of Field Programmable Gate Array computing platforms for radio-astronomy signal-processing systems generally, and specifically for a 512-channel spectrometer with 400 MHz of bandwidth and the Phased Array Demonstrator. Of interest is the overhead and performance loss due to a programmable system. Is it significant, or are we on the verge a paradigm shift.

Keywords: FPGA computing, correlator, spectrometer, focal-plane array, beam forming, radio astronomy