Performance evaluation of mTCA.4 High speed ADC card for direct sampling of RF signals in linear accelerator systems

Samer Bou Habib, Krzysztof Czuba

***Abstract*—Nowadays monitoring and control systems for linear accelerators require very complex high-precision RF detection and measurements systems that incorporate receivers with multi-channel down-converters and low noise LO generation systems[1]. Increasing requirements for speed, bandwidth and latency while maintaining precision reveal limitations of classical RF receivers. Modern advanced technology made it possible to design data acquisition modules allowing direct sampling of high frequency accelerator signals with sufficient resolution without the need for down-converters[2].**

This paper describes briefly the principle of direct sampling using under-sampling [3] and non-IQ detection for acquiring the parameters of RF signals and fields in the linear accelerator systems. The two-board system concept and design3 is then shown along with the architecture 1 and main blocks including Ultra-fast ADC circuits, high-precision DAC circuits, very low-noise and complex clocking and synchronization circuits 2, FPGA and digital circuits as well as management and diagnostics. The board is an ultra-fast digitizer[4] equipped with eight 800 MSPS, 12-bit ADC channels each with an input bandwidth up to 2.7 GHz and was designed and produced according to the mTCA.4 standard4 and 5.

The boards were tested in a laboratory environment as well as at the FLASH accelerator at DESY, Hamburg and the ELBE accelerator at HZDR, Dresden and revealed very good results.

The paper shows results of the measured sampling parameters such as SINAD, ENOB and derived system jitter, noise and latency.

Various sampling frequencies were tested with different non-IQ sampling schemes for acquiring the amplitude and phase of the detected RF cavity-field signals determining the precision of the analysis for LLRF and monitoring systems. The effect of different clock power on the amplitude and phase noise of the measurements was performed.

The Achieved results satisfy precision requirements for monitoring, synchronization and RF-control systems in machines like FLASH[5], The European XFEL[6], ELBE and ILC accelerators.

***Index Terms*—LLRF, direct sampling, field detection, fast ADC, mTCA.4**

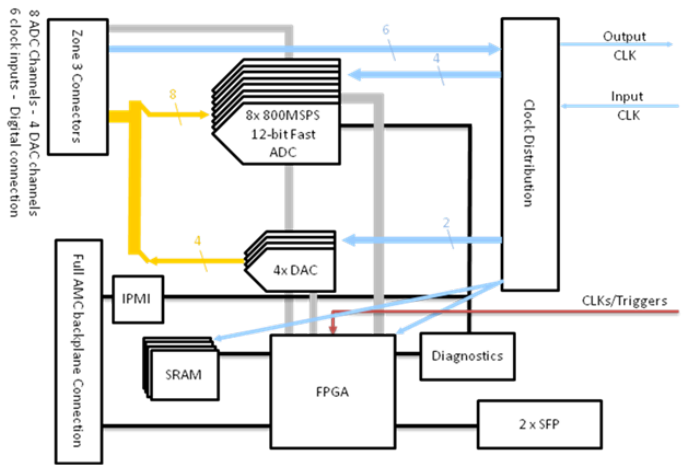

Figure 1. DAMC-DS800 general architecture

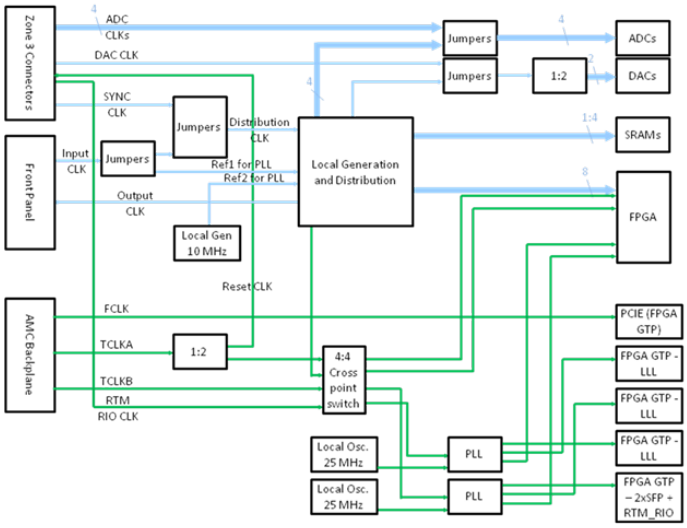

Figure 2. Clock generation and distribution scheme

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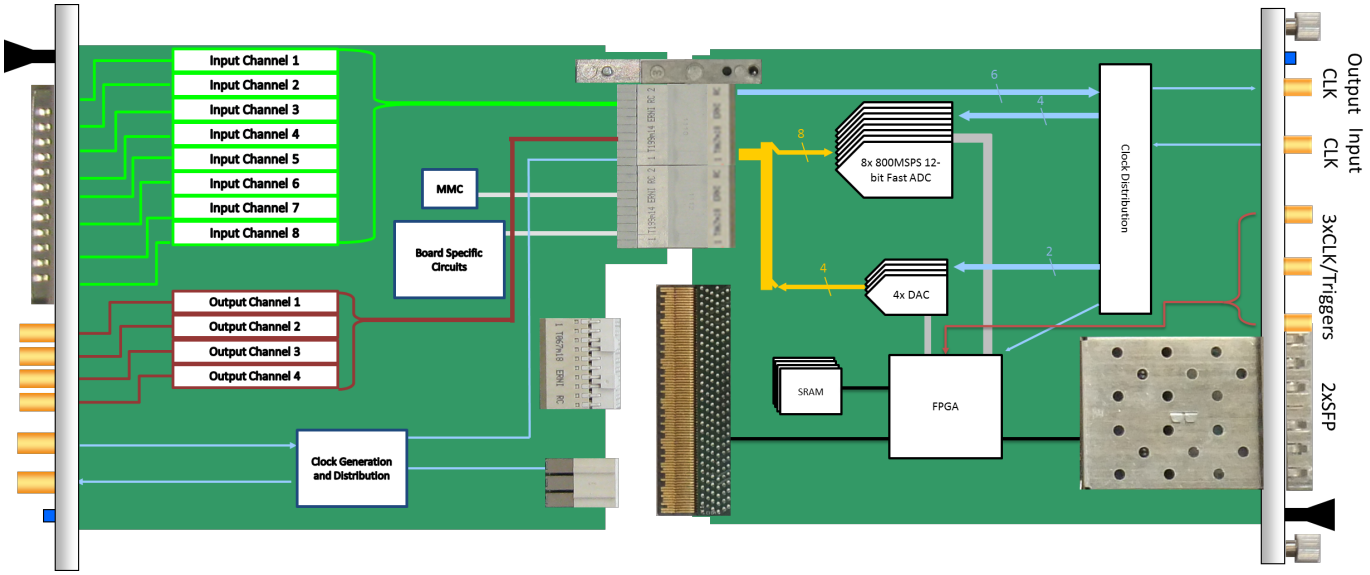

Figure 3. Two-board system architecture

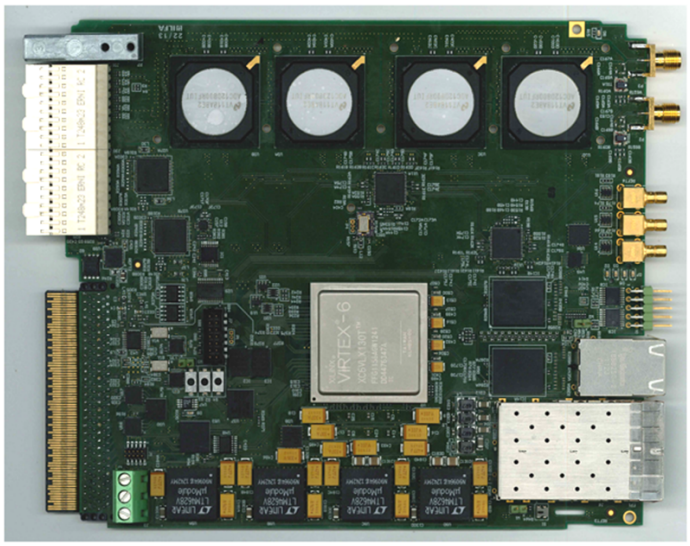

Figure 4. DAMC-DS800 PCB top layer

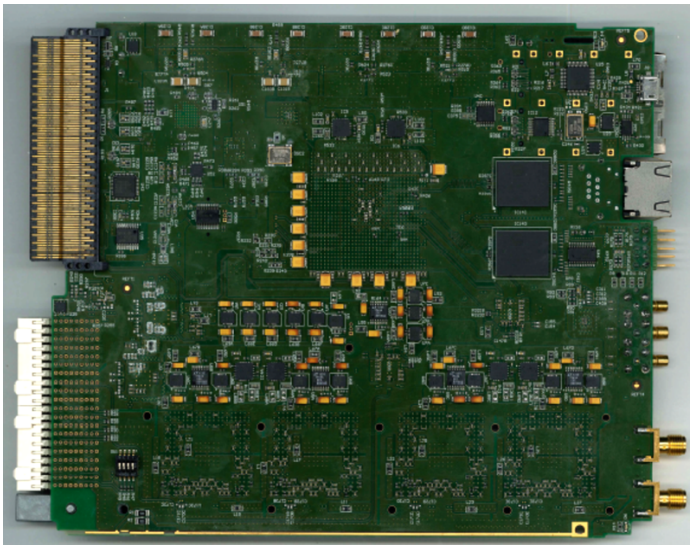

Figure 5. DAMC-DS800 PCB bottom layer