Design of an autonomous low-cost FPGA-based gamma spectrometer environmental radiation monitoring

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Keywords: FPGA, MCA, gamma, detector, environment, radiation

In this report, we present the design of a low-cost environmental radiation monitor using Field-Programmable Gate Array (FPGA) technology. FPGAs have become the trend for digital signal processing [1]. Contrary to micro-controller units, they can perform many parallel computations at once and, therefore, are the top choice for the implementation of nuclear pulse detection algorithms. The main motivation is the prevention of nuclear accidents. Areas around nuclear facilities can be monitored, indicating the drift of radioactive plumes and whether the population will be exposed to radiation. Most environmental monitoring networks are based on one or more Geiger counters [2, 3], which makes it difficult to separate the contribution of different fission byproducts. Our monitor implements a multichannel analyzer (MCA) to separate the counts by pulse height, which is proportional to the gamma radiation's energy. The resulting spectra contain 4096 channels, which can be analyzed to infer the originating radionuclide. Figure 1 shows the basic components of the monitor station.

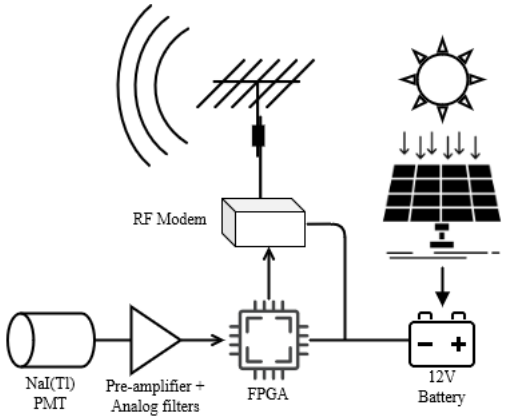

Figure 1. Diagram of the monitor station

Using the Verilog language, a pulse detection algorithm was implemented through a simple finite state machine. Counts for all 4096 channels are stored in a block random access memory (BRAM), managed through Xilinx's Block Memory Generator IP. Two memory channels were used, in such a way that the spectrum memory can be accessed concurrently by both the detector algorithm and the CPU core (Figure 2).

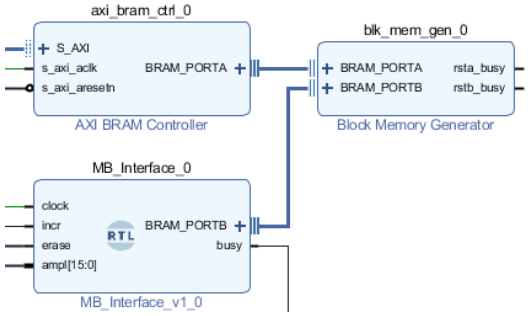

Figure 2. Spectrum's memory management

At regular time intervals, the spectrum is read from the BRAM and sent via a radio-frequency modem to a dedicated server in an indoor location far from the monitoring station. A web application was written in JavaScript language to receive the spectrum data and plot it in a HTML page. Figure 3 shows an example of a spectrum measured from gamma emissions of a ^{137}Cs source. The current design phase is focused on battery management and radio-frequency communication protocols.

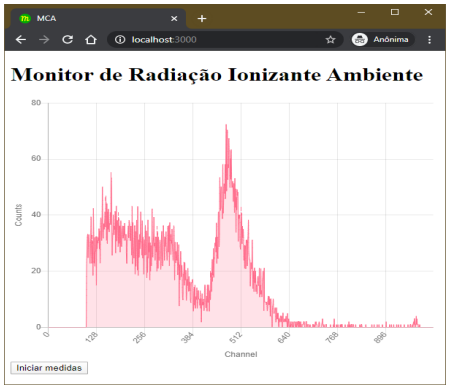

Figure 3. MCA web application in development

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