The CluTim algorithm: an improvement on the impact parameter estimates


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Abstract

A fast readout algorithm (CluTim) for identifying, in the digitized drift chamber signals, the individual ionization pulse peaks and recording their time and amplitude has been developed as VHDL/Verilog code implemented on a Xilinx Virtex 6 FPGA. The CluTim algorithm, that we have been developed, is able to process the data in real-time. The date acquired and processed are from a 12 bits, 2 GSPS Analog–Devices ADC.

Drift chamber operation

A charged particle passing through a drift chamber creates ion-electron pairs along its path. Depending on the released charge, for each ionization act, the particle releases one or more ion-electron couples referred to as Cluster. The distance between two successive clusters follows an exponential distribution with average $\Lambda$ which represents the mean free path of the particle. A value depends on the gas nature, pressure and temperature. The time separation between consecutive ionization acts, in helium based gas mixture is of few ns. A high-speed read-out interface is need to process this signal.

Algorithm purpose

Identifies, in the digitized signal, the peaks corresponding to the different ionization cluster. Stores each peak amplitude and timing in an internal memory. Sends the data stored to an external device when specific trigger signals occur.

Hardware setup

ADC AD9625 Analog-Devices:
- Resolution: 12 Bits
- Sampling frequency: 2GSPS
- Differential analog input :1.2 $V_{pp}$
- High Speed 6 or 8 lane JESD204B serial out

FPGA XC6VLX240T-1 FFG1156:
- Logic Cells: 241.152
- Max Distributed RAM: 3650 Kb
- MMCM: 12
- Max operation frequency: 700 MHz

Algorithm description

Sixteen samples $S_{x,x}$ at 125MHz to the FPGA input.

**STEP 1:** Of the Sixteen samples $S_{x,x}$, where $K$ is the sample number among those available, and $X$ is the time instant in which they are present, the functions $D_{1,x,x}$ and $D_{2,x,x}$ are calculated with use of the following equations:

$$D_{1,x,x} = (2S_{x,x} - S_{x-1,x} - S_{x+1,x})/16 + 3$$
$$D_{2,x,x} = ((2S_{x,x} - S_{x-3,x} - S_{x+3,x})/16) + 5$$

**STEP 2:** The values of $D_{1,x,x}$ and $D_{2,x,x}$ and the differences between $D_{1,x,x}$ and $D_{1,x+1,x}$ and between $D_{2,x,x}$ and $D_{2,x+1,x}$ are compared with the thresholds proportional to the level of noise present in the input signal.

**STEP 3:** In order to transfer the data in memory, the last step before being sent to an external device is to check that there are no adjacent peaks.

Algorithm efficiency by varying $\alpha$, $\beta$, $\gamma$, $\delta$.

Eff$[\%]=100 \times (PF-Pfake)/Pr$

Pfake$[\%]=100 \times Pfake/Pr$

Pr is the total peak found in the signal, $Pr$ is the numbers of the real peak in the signal test. $Pf$ is the number of fake.