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14-bit and 2GS/s low-power digitizing boards for physics experiments

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The new Matacq14 board described in this paper has been designed to digitize 4 channels with 14 bits of resolution at 2 GS/s with an analog bandwidth of 345 MHz. It is not based on commercial ADCs which don't reach these specifications, but on the low-power custom-designed analog circular memory called MATACQ. It can be triggered internally or externally, and several boards can easily be synchronized. It integrates USB, GPIB and 64-bit VME interfaces, permitting complying with most current acquisition systems. It can thus replace oscilloscopes for a lower cost in most applications where a much higher precision is needed.

Summary

The trend in data acquisition systems for modern physics experiments is to digitize analog signals closer and closer to the detector. The digitization systems have followed the progress of commercial analog to digital converters. The state of the art for these devices is currently at the level of 500MHz for a 12-bit range. Faster ADCs, originally dedicated to military applications are also available, but their resolution is lower and they are much more expensive and power-consuming. Moreover, their packaging, cooling, and huge output data rates make them very difficult to implement.

The new Matacq14 board, described in this paper, has been designed to improve these performances by an order of magnitude. It houses 4 channels of 14-bit resolution digitizers sampling analog data in the range between 2 GS/s and 50MS/s with an analog bandwidth of 345 MHz. It is based on the custom-designed patented MATACQ chip that samples signal with a very high dynamic range in an analog circular memory of 2560 cells. Its innovative design permits reaching these performances, yet in an old fashioned pure CMOS technology, with a power consumption as small as 1W. Sampling precision is of the order of 15ps rms and trigger datation of 50ps rms. The boards can be triggered either by internal (individual threshold on inputs, auto-trigger, software trigger, $\cdots$) or external signals and several boards can easily be synchronized. An external clock can be used in order to synchronize the board with another system. The board integrates USB, GPIB and 64-bit VME interfaces which permits a maximum readout speed close to 1Kevent/s with the 4 channels read. Those various interfaces permit complying easily with most current acquisition systems. Several other read-out modes permitting reading only a limited set of cells or of channels are available for faster readout operation if necessary. Channels can also be grouped in order to extend the sampling depth (2 channels with 5120 of one channel with 10240 samples). A 1Mbit flash EEPROM permits storing all calibration and user data on-board. The usual power consumption is as low as 13W and remains below 20W even in the worst acquisition case.

Because of its moderate cost and its design aimed at multi-channel operation, this board opens the fields of pulse shape discrimination, timing or charge measurement on very fast signals even in very high background environments. It can thus replace oscilloscopes for a lower cost in most applications where a much higher precision or a higher number of channels are needed.

Various evolutions of the MATACQ circular analog memory are under study, improving the sampling frequency, the sampling depth and the signal bandwidth. A patented continuous sampler will also be tested very soon. In parallel with high precision digitizing, those chips will open new doors into the domain of very high precision time measurements.

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