Olivier Martineau-Huynh June 20th, 2013.

GRAND-prototype electronics

We present here some requests for the trigger and digitization system of the GRAND-prototype array. This setup is a prototype for a giant detector (several thousands of antennas) to be deployed in the next 5 years by the TREND collaboration. GRAND-proto is in its first stage an array of 30 radio detection units. The active element of a detection unit is an antenna measuring electromagnetic waves along 3 directions (x,y,z). The electronics unit has the task to trig on the electromagnetic signals, digitize them and send them to the central DAQ system.

This document is a complement to the presentation given on June 13 during the meeting at NAOC.

Trigger logic

1- Normal mode

In the "normal" mode, the TREND trigger is associated with a threshold level A_{th}, defined as a multiple of the standard noise level on this channel: $A_{th} = N_i \times \sigma_i$. The standard noise level σ_i should be recomputed for every channel i at every second (adjustable parameter), while N is an adjustable parameter, typically between 6 and 10.

If at any moment the voltage of any one of the antenna channels exceeds A_{th}, then a subset of the signals from the 3 channels should be recorded. This recorded subset is called the "**waveform**". Its duration should be in the 3-5µs and adjustable. The waveform should be roughly centered on the trigger time. The fraction of time before the trigger is called the "**pretrigger"**, and should therefore be 1-3µs.

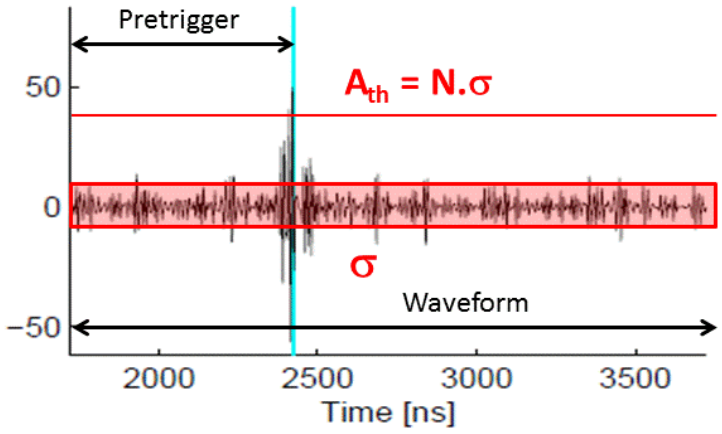

Figure 1 : example of a waveform recorded on TREND with the present acquisition system, as the signal exceeds the threshold value N.σ.

No other trigger should be accepted by the DAQ in the waveform timeframe. A possible scheme for the trigger logic is presented below.

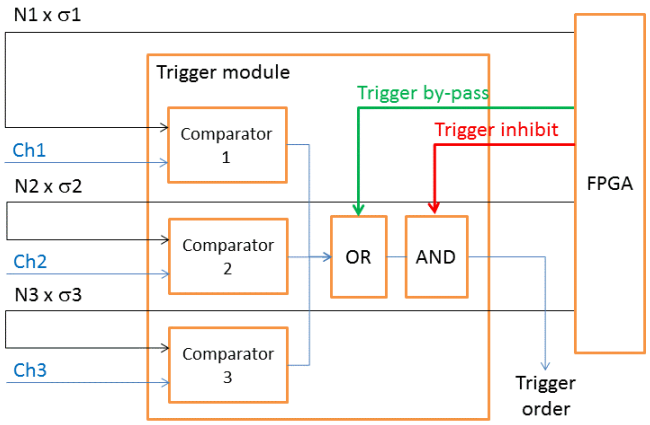

Figure 2 : possible trigger logic. The analog signal from each channel Ch*i* (i=1, 2, 3) is compared to the threshold value N*i*.σ*i* computed by the FPGA. If one signal exceeds its threshold value, then the trigger order is given. This logic can be by-passed by a trigger order given by the FPGA in certain specific cases (see text). The FPGA can also inhibit the trigger system. This is the case in particular during one waveform timeframe (3-5µs around one trigger).

Additional note: the trigger logic defined here is extremely basic. Note however that we may want to refine it in a later stage of the prototype development. It was in particular observed with the present TREND setup that many background signals are characterized by very long transient signals, or impulses with repetitive patterns. These features are absent in the case of radio signals from EAS (Extensive Air Showers, the signals we are looking for). A trigger system allowing only for prompt (<300ns) and isolated (no other transient within ±2µs) transient signals could therefore significantly reduce the trigger rate, without affecting the EAS detection efficiency. It is foreseen that we will investigate this possibility in the future. Therefore the present trigger logic should be designed to leave some possibility for evolution.

2- External mode

In some cases (calibration of the antennas in particular), the trigger will be provided by an external command only. In the scheme presented above, this mode could correspond to very large values of N*i* (N*i*=1000 for example) to prevent triggers from the antennas, and a trigger order sent through the trigger by-pass (combined with trigger inhibit set to 0).

3- Random mode

We will also need to be able to perform random triggers on the signals. In the proposed scheme, this can be performed by running in normal mode with N*i*=0, or by sending by-pass trigger orders at random times. Random mode trigger could in particular be used to retrieve antenna signals and use them to compute the standard noise level on each channel σ*i*, which is then used to compute the trigger threshold A_{th} = N*i* x σ*i*.

Data format

The data associated to a trigger will be a chain composed of a header + waveforms of all channels in DAQ. In the header, at least the following information should be available:

- Antenna/Unit ID

- Input (antenna or load[1])
- Trigger mode (normal, external or random)
- Trigger time (absolute precision should be 20ns)
- Number of active channels (1, 2 or 3)
- Waveform length

And in addition, for normal mode:

- Threshold value A_{th} = N*i* x σ*i* for each channel at trigger time.
- Triggering channel.

Monitoring

Several monitoring information should be provided by the system at regular intervals of time (typically, one minute, but should be adjustable).

These infos should include the following:

- Temperature at meaningful points inside the electronics box.
- Voltage & intensity at meaningful points on the electronic board
- Evolution of the threshold for each channel since last monitoring info (time step = 1s)
- ~5ms of data from each channel registered in random mode.

Commands & adjustable parameters

It should be possible to send to the units present in the system a certain number of commands from remote. It should be possible to broadcast these commands to all units, or to send them only to some specific units. These commands should include:

- Switch ON/OFF the unit.
- Switch ON/OFF each channel.
- Short cut the channel input of by a 50 0hm load.
- Define acquisition type (normal run, calibration run, …)
- Define trigger mode (normal, external, random)
- Start/stop acquisition (and log corresponding time info)
- Set waveform & pretrigger duration.
- Switch ON/OFF monitoring.

In normal mode:

- Set individual threshold values N*i.*

It should be possible to adjust all parameters from one run to the other. Note however that it is will not be necessary to modify them during one acquisition.

Find below a proposition of the complete scheme for the electronics logic.

[1] It should be possible to short cut the input by a 50 0hm load, which will be used for checks and calibration purposes.

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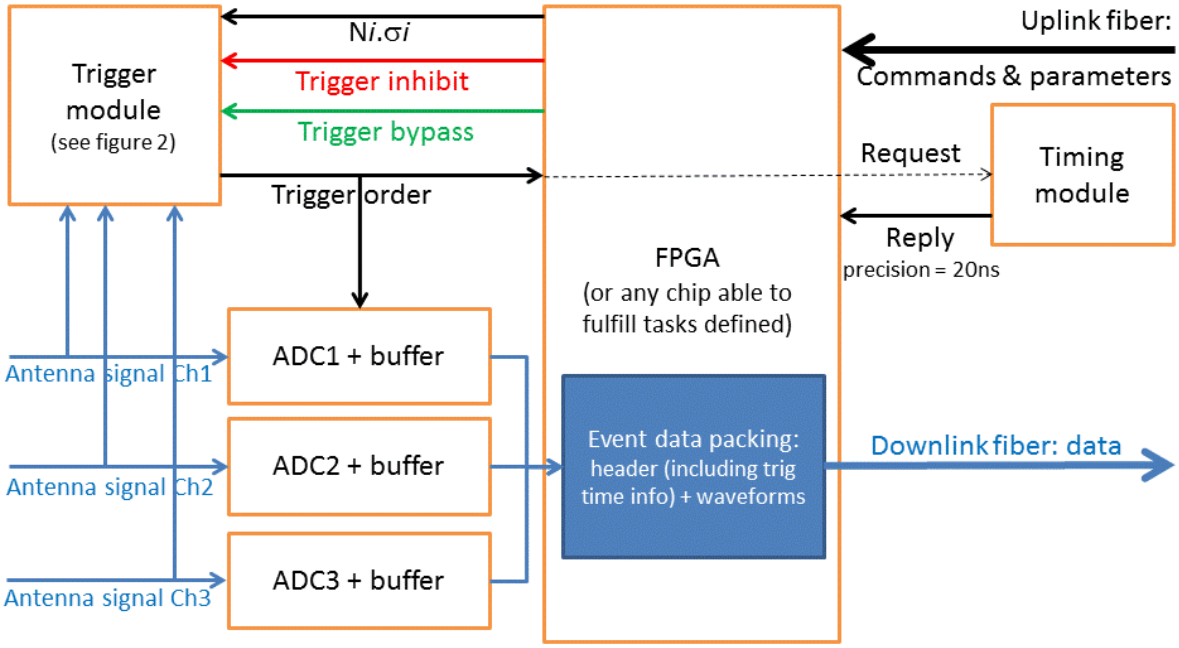

Trigger rate foreseen up to 1kHz.
Relative offset between the 3 ADCs up to 2ns acceptable.
Absolute precision of the trigger time tagging: 20ns or better.