A compact plug-in module for LHC-like trigger emulation

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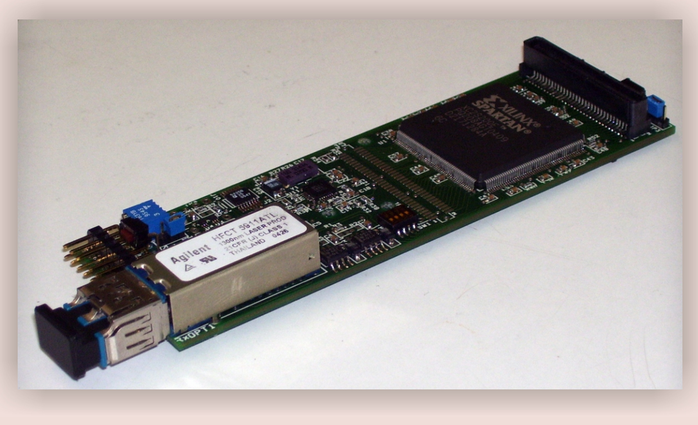
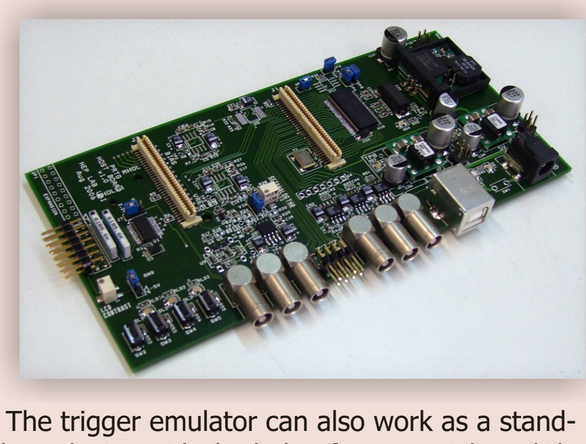


The trigger emulator plug-in module (12.3cm x 4cm x 1.2cm) can be plugged as a mezzanine on various readout systems i.e. VME64 [1]

Description

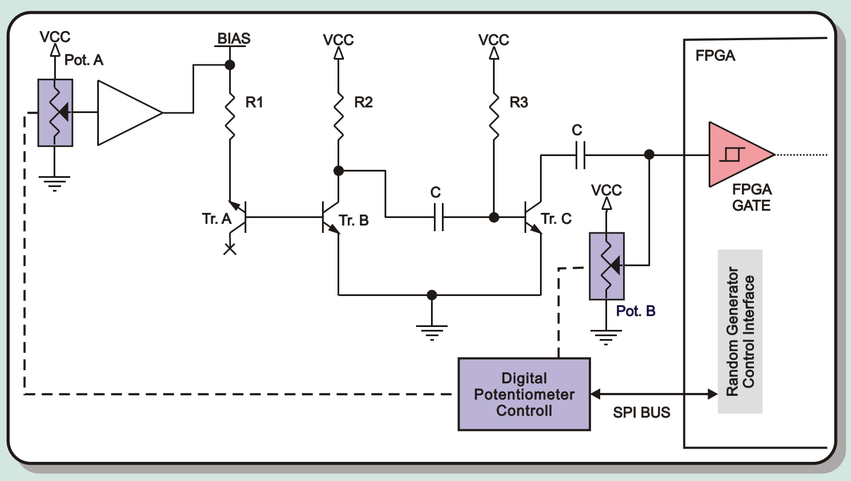
A device capable of realistically emulating the random arrival of particles on a detector has been developed, with the following features:

- True random number generation
- Ability to configure certain parameters e.g. mean rate & application specific trigger rules
- Mezzanine function on existing electronic systems
- Stand-alone operation
- Connection with a PC
- User friendly interface

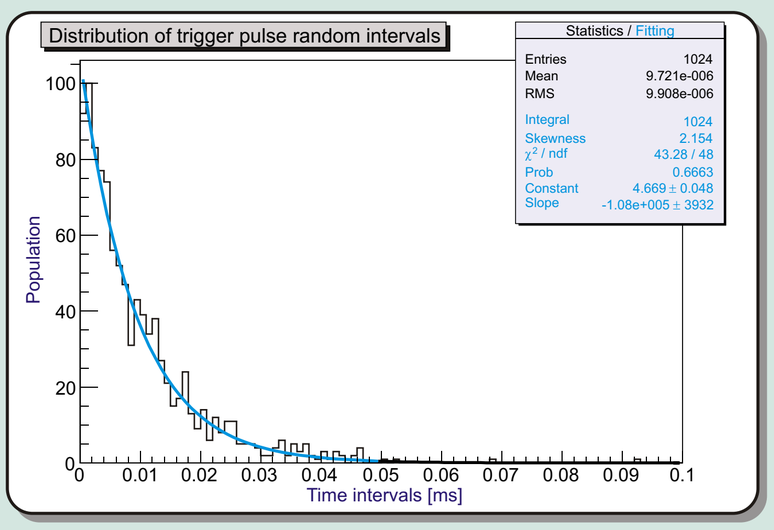


The trigger emulator can also work as a stand-alone device with the help of a support board that provides power and a USB 2.0 interface.

Hardware Implementation



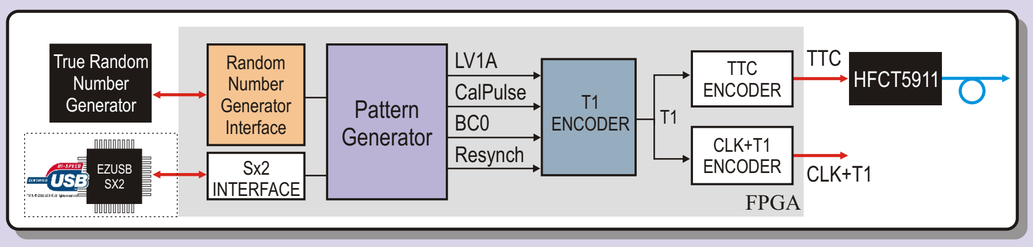
- Based on an FPGA and a random noise generation circuitry
- The analog circuitry produces pulses with random intervals
- The source of randomness is the avalanche effect on a transistor emitter-base diode [2]
- A digitally controlled voltage source biases the diode
- Changes on the diode biasing reflect to the mean value of the distribution of the generated random intervals
- The noise signal is amplified by a two stage transistor amplifier
- The amplified noise signal has a DC offset created by a digital potentiometer
- An FPGA internal gate acts as a comparator and produces random transitions



The output of the random generator is treated by a digital processing circuitry implemented in an FPGA. Its principal function is to measure the time intervals between the transitions generated at the output of the logic gate extracting in this way random numbers. Additionally it applies specific rules and functionality depending on the application. Finally the FPGA provides the necessary communication interface for setting the desired working parameters. The module also includes an optical transceiver for inter-connection with the various off-detector electronic systems.

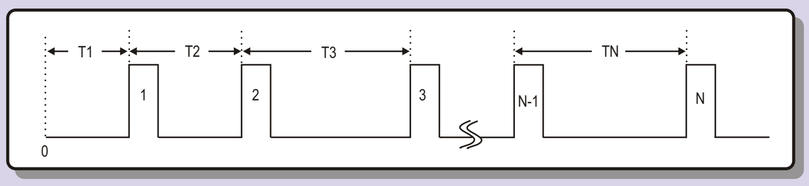
Functionality

- Trigger signal sequence generation (trigger patterns generation)
- Timing and fast command generation for the front-end systems
- Use of the 40.08MHz LHC clock signal as reference
- 40.08MHz clock produced locally by a QPLL [3] ASIC configured as a local oscillator using a 160.32MHz quartz [4] as a reference
- 4 identical stages work as pattern generators for the 4 supported fast commands (LV1A, BC0, Resynch, CalPulse)
- LV1A pattern generator can be loaded alternatively with true random content
- Up to 1024 triggers per burst can be generated
- Proton and Ion bunch disposition [5] at LHC can also be emulated
- Special output encoding (T1 [6], CLK+T1 [7], TTC-like [8])
- Optical as well as electrical outputs

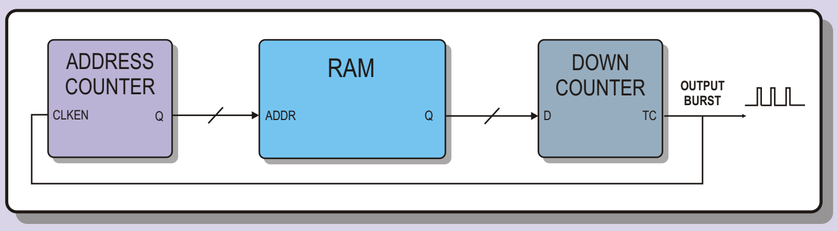


Block diagram of the trigger emulator.

The pattern generator is developed in such a way that it can generate bursts of triggers by specifying the time between consecutive triggers, expressed in clock cycles.

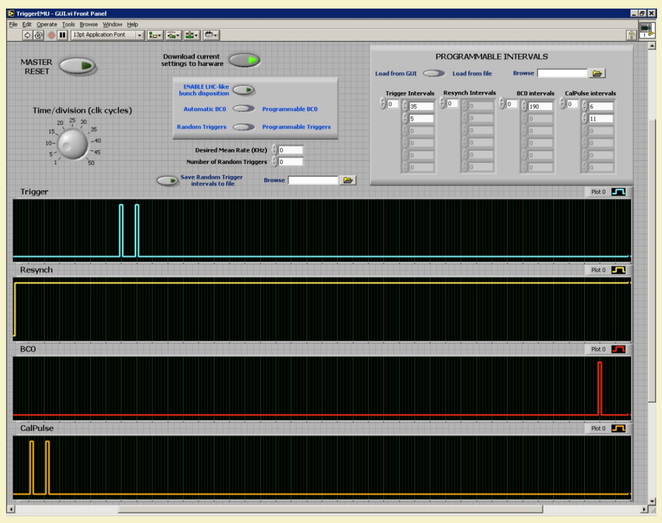


The implementation of the pattern generator is based on a RAM, where the values T1, T2, T3 etc are stored. Initially, the address pointer is reset and therefore the first value (T1) stored in RAM appears at its output. This value is then loaded to a decrementing counter. When the counter reaches zero, the terminal count output is asserted. At the same time the address pointer of the RAM is incremented providing the next value (T2) to the decrementing counter and so on.



User Interface

The trigger emulator comes with a LabVIEW [9] user's interface when it works in stand-alone mode. This LabVIEW interface allows the user to define the working parameters (such as desired mean rate, number of triggers, etc).
The LabVIEW application includes among others, a graphical display of the fast timing signals generated by the emulator. It is worth mentioning that the application developed is compatible with both Windows and Linux operating systems.



SUMMARY AND CONCLUSION

A plug-in module able to emulate trigger and fast commands for LHC applications was built. The most important feature of this device is the ability to produce trigger patterns based on true random number generation. The source of randomness is the avalanche effect on a transistor emitter-base diode, biased by a digitally controlled voltage source. The emulator produces randomly generated trigger pulses with time intervals following an exponential distribution with programmable mean between 1 KHz and 1 MHz (trigger rate). Therefore it can be used in emulating the arrival of particles on a detector enabling in this way the testing of the corresponding on and off-detector electronic systems. The device can either be used as a mezzanine card on various systems (VME based systems) or in stand alone mode controlled by a PC running LabVIEW.
Such a device, apart from being useful for High Energy Physics experiments, is also suitable for nuclear physics and radiology experiments where the emission of a radioactive source needs to be emulated.

REFERENCES
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ACKNOWLEDGMENT
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