A low-cost multi-channel analogue signal generator

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A scalable multi-channel analogue signal generator is presented. It uses a commercial low-cost graphics card with multiple outputs in a standard PC as signal source. Each color signal serves as independent channel to generate an analogue signal. A custom-built external PCB was developed to adjust the graphics card output voltage levels for a specific task, which needed differential signals. The system furthermore comprises a software package to program the signal shape.

The signal generator was successfully used as independent test bed for the ATLAS Level-1 Trigger Pre-Processor, providing up to 16 analogue signals.

Summary

The presented signal generator provides up to 12 independent analogue signals on a low-cost basis. It consists of a standard PC hosting a commercial multi-monitor graphics card that acts as source for the analogue signals. It furthermore comprises a software package to program the signal and an external device for conditioning of the signal.

Each color channel of the graphics card serves as independent signal source. It is an unipolar signal with an 8-bit resolution of the output voltage at a time resolution ("pixel clock") of up to 5ns. This can be considered sufficient to represent an analogue signal for systems operated at a lower speed, like e.g. many 40MHz systems at the LHC.

The signal is represented by a fixed image consisting of three signals at a time (red, green, blue). The longest possible continuous signal is in the order of 10us, which corresponds to one line on the screen. The total signal length is up to 10ms, the minimal frequency about 100Hz ("monitor frequency").

It is an intrinsic effect of the graphics card that the signal features a blanking space at the end of each line and each screen, where the electrical output is zero. This typically takes 20% of the total time.

In order to maximize the number of channels, graphics cards with multiple monitor outputs were tested, from which the model with the best electric properties was chosen.

A software package was developed to program and create the signals. A graphical tool offers basic pulse shapes and the possibility to import external data. It stores pulse shapes in a generic file format. Three signals are merged into a fixed image which at the output correspond to the desired signal shape. Thus the program drives the graphics card, using a dedicated linux X window server.

An external device was developed to condition the output signal to the voltage levels for a specific task. It is a PCB that consists of several buffer stages to calibrate for gain and offset. Up to six monitor outputs can serve as inputs. One channel is explicitly used to apply a global offset on all other signals in order to also allow negative signals. The output are 16 differential signals, which can be configured by an upstream fan-out stage.

The signal generator was used in a test bed for the analogue parts of the ATLAS Level-1 Calorimeter Trigger Pre-Processor in a setup with 8 independent channels that are fanned out and converted to 16 differential signals. An additional device was developed to provide a clock synchronous to the 16 channels on the basis of another dedicated channel of the graphics card. It uses a PLL to bridge the intrinsic blanking space of the graphics card signal.

The presented signal generator is applicable in all fields with need for multiple analogue signals where a blanking space is no drawback, or can be compensated as shown. The advantages are multiple, easily programmable signals with acceptable quality at very low expenses.

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