EUDET-Memo-2010-11

The FORTIS EUDAQ Producer: Operating the TLU with a Dead-Time Free Readout

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November 29, 2010

Abstract

In 2010 the FORTIS sensor was beam-tested at CERN using the EUDET beam-telescope. The FORTIS was read out using the OptoDAQ system. OptoDAQ is dead-time free and outputs a sequence of frames taken from the sensor. The data is sent to an EUDAQ producer using a UNIX(Linux) "named pipe". The firmware modifications needed to embed trigger information in the FORTIS data-stream and veto triggers from the TLU when internal buffers fill are described. The result is a near dead-time free readout for a rolling-shutter sensor.

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1 Introduction

The FORTIS[1] sensor was mounted on a "sensor stack" system designed by Aspect Systems GmbH[2]. The OptoDAQ data acquisition system, (Rutherford Appleton Laboratory, Didcot, Oxford, UK) was centred around a $Virtex - II\,Pro^{TM}$ 20FF1152 FPGA board. The control signals required to drive the sensor were generated on this board. The acquired 14- bit digitised images were then transferred to a computer via a fiber optic link.
The FORTIS is a MAPS device with a rolling shutter readout. The firmware in the FPGA results in a continuous readout of data from the sensor and transmission down a Gigabit fibre ethernet link using the UDP/IP protocol. Part of the OptoDAQ system, a programme running on a PC, receives the data and writes it to a UNIX(Linux) named pipe. The frame data is read from the named pipe by an EUDAQ producer process, which scans the frame data for trigger information and divides the data into events. Finally the event data is transmitted to the EUDAQ data collector. This arrangement is illustrated in figure 1

1.1 Dead Time-Free Readout

The current EUDAQ system uses a triggered readout. When particles passing through the detector produce signals in scintillation detector. When a particle is detected a trigger is sent to the readout boards which transmit the sensor frame containing that trigger to the DAQ. Further triggers are vetoed until the current frame and the next are transmitted. This approach was taken for simplicity and robustness. However, when several particle arrive during the readout period of a single frame only the first one produced a trigger. The approach described here allows almost every particle to result in a trigger.

2 Triggering

Like similar rolling-shutter devices the FORTIS is not a triggered device. However, the EUDAQ software[4] and EUTelescope software[5] *do* divide the data into "events" each corresponding to a trigger. Trigger information is distributed by the TLU[6].
The OptoDAQ firmware was modified to monitor the trigger line coming from the TLU and to record the arrival of triggers in the frame data as extra columns in the image. The EUDAQ producer scans through the frame data. When a trigger is located the corresponding data is packaged into an event and sent to the EUDAQ DataCollector.

3 Flow Control

The trigger signal coming from the TLU is registered through two D-type flip-flops inside the OptoDAQ firmware. The output is used internally and also returned to the TLU

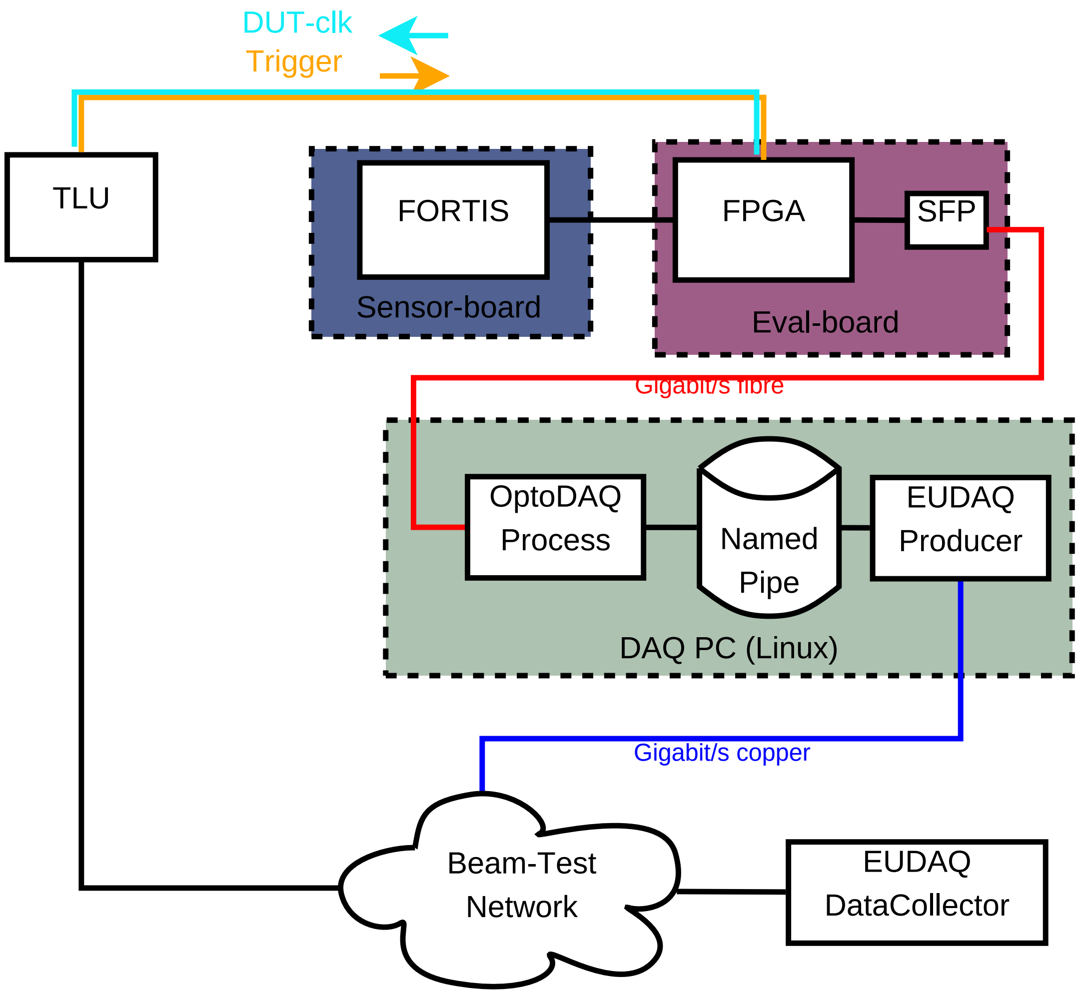

Figure 1: Data flow from FORTIS to Data Collector

as a busy signal. Thus the FORTIS/OptoDAQ readout can use simple trigger/busy handshaking with very little extra firmware.
The OptoDAQ readout has no dead-time, however occasionally the data collector will be unable to keep up with the data rate and the buffers will fill. Inside the FPGA there is extra protocol on top of the UDP/IP link in order to ensure correct receipt of the data at the PC. Hence the FPGA is able to detect when data transmission to the PC has stalled and the buffers inside the FPGA are starting to fill. At this point the DUT_Clk line to the FPGA is raised. The firmware inside the TLU was modified to allow a DUT to veto triggers by raising the DUT_Clk line outside a trigger handshake sequence.
Vetoing triggers before any buffers overflow prevents data loss. In practice the OptoDAQ vetoed triggers for only a very small fraction of the time.

4 Software

4.1 TLUProducer

The TLUProducer programme was modified to add the **EnableDUTVeto** parameter. This is a bit-mask variable corresponding to the DUT inputs. If the **EnableDUTVeto** parameter is set in the [**Producer.TLU**] section of the control file then the bits that are set indicate DUTs that can veto triggers by raising their DUT_CLK line outside a trigger/busy sequence.

4.2 FORTISProducer

The Optodaq process writes data from every frame to a named pipe. The FORTISProducer process, an EUDAQ producer, reads the data from the pipe and sends frame data from events with one or more trigger on to the EUDAQ data collector.
If a trigger is detected in a frame then the data from that frame and the succeeding one is sent to the data collector. The entire frame data for the two frames, with no zero suppression, is packaged into an EUDAQ event transmitted. This frame data includes the trigger information.
For frames which contain more than one trigger, the frame information is sent followed by empty events matching the additional triggers.

5 Future Work

Sending empty events where there is more than one trigger in a frame is inelegant. A more general solution, and one that would be easier for users to implement is to modify the methods used to transmit data to the data collector: A single block of data could have one or more triggers attached to it, rather than the single trigger at the moment. The data collector would also be modified to match up data from different data producers with different numbers of triggers associated with each block of data.

6 Conclusion

The FORTIS sensor was used to prototype a “dead-time free” readout system for rolling-shutter sensors. This approach could be used for other sensors “as is”, or the EUDAQ framework could be changed slightly to allow multiple triggers to be associated with each block of data.

References

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