Quarterly Report
Fast Data Processing on MAST

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Overview

I am 1.5 years into my PhD with 2 years remaining. The primary hardware project which I am currently focussed on is EBW followed by Vertical stabilisation. This report is a summary of the last 6 months of work since the last quarterly report for July to September (no report was requested from September until March).

1 FPGA Hardware projects

1.1 EBW Project

This is a cutting edge FPGA project. We are using datasheets that are only a few weeks or months old to develop this system. The system will process data from 16 channels at 64Gb/s for the duration of a MAST shot (0.5 seconds). This is an unprecendented speed that is only possible at the low cost of ≈10k by using the standard FPGA model which Dr. Graham Naylor has promoted. I am working closely with Dr. Roddy Vann on the FPGA development. Initially we tried two approaches to the memory speed writing and both suceeded. My memory controller involves a portable solution, where as Roddy's is a lower level solution. Both achieve to within 1% the same speed. Following the development of the the memory controller Roddy has focused on the ADC and triggering and I have focused on the embedded Linux side. I would like to be involved with real-time processing, such as the real-time Hilbert transform for single side-band (SSB) seperation when the opportunity arises, as this is a good demonstration of FPGA power. This project is nearing completion.

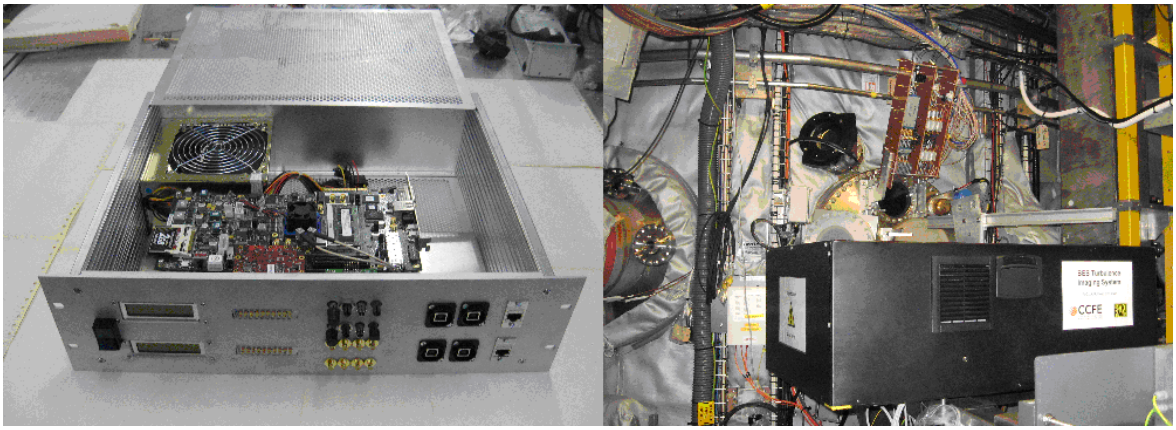

Figure 1: Left: A picture of the EBW FPGA system. Right: The port on MAST for the antenna array.

1.2 Vertical Stabilisation

The box has been developed and work is under way on this project. Initially some vertical position waveforms will be tested and measurements taken of the response of the FPGA system. There are already some interesting experimental proposals by other researchers to feedback from the Thomson Scattering smart trigger system developed by Dr. Graham Naylor.

1.3 Bolometer Upgrade

In conjunction with Dr. Anthony Field there is discussion of upgrading the 32-channel soft X-ray bolometer system at MAST. This is a key diagnostic where FPGAs can provide a good solution for an upgrade. It also allows interesting feedback possibilities by triggering off the soft X-rays in real time. It would be good for my PhD to work on this project as it is a good contribution to MAST whilst being a well defined project without any particularly extreme requirements (such as for EBW).

2 Collaboration

As a result of collaboration with the Faculty of Nuclear Sciences and Physical Engineering and the Institute of Plasma Physics in Prague I have co-authored a paper on remote participation [1]. This has been accepted for publication and should be published in a peer reviewed journal (Fusion Engineering and Design) sometime this year.

As a result of collaboration with the ESRF (European Synchrotron Radiation Facility), in particular Olivier Goudard, I am testing control systems (TANGO) on the FPGA. It is still an open question whether such a systems will be used directly on the FPGA in fusion and so I will not be focussing all of my time on this. One of the submitted abstracts to the ICALEPCS conference will use results from this collaboration.

3 Abstracts submitted for conferences

3.1 IAEA 8th Technical Meeting: Control, Data Acquisition and Remote Participation for Fusion Research

This is a conference which convenes once every 2 years. It is a high impact conference which presents a good opportunity to present relevant results to fusion research. I will present results on the the control and data acquisition aspect of the FPGA systems worked on.

24-02-2011: "Standardisation of FPGA systems incorporating embedded Linux".

3.2 International Conference on Accelerator and Large Experimental Physics Control Systems

The accelerator community has led the field in FPGAs on large physics systems. It is a good conference to highlight the shared collaboration with ESRF and possibly Diamond Light Source and learn about the developments in the accelerator field as well as how they can be applied to fusion. I will discuss FPGA hardware and software results which can equally be applied to the accelerator community. In fact at Diamond they have opted for an ML605/FMC108 solution as we have chosen for EBW. I aim to collaborate more with Diamond on this project.

01-03-2011: (Track 5 - Embedded + Realtime software): "Embedded Linux on FPGA instruments for control interface and remote management".
01-03-2011: (Track 11 - Hardware): "FPGA-based hardware instrumentation development on MAST".

4 FPGA Workshop

I setup an FPGA workshop for January the 24th and 25th. I obtained agreement with Doulos (a company which provides training on behalf of Xilinx) to borrow FPGA hardware and organise software licenses. This was a large logistical effort to get the 9 x SP605 FPGA boards, training rooms and setup a workshop design which everybody could use. Participants came from TUE (Netherlands), HAS (Hungary), IST (Portugal), Durham University, CCFE. It was a good opportunity for Graham and I to bring together people working on FPGAs in Fusion. Since the workshop there has been demand for another such workshop however when/where/how this will be done is unknown. I thank Dr. Graham Naylor for much help in setting up this workshop, and Dr. Nigel Dipper for letting me use a spare SP605 (and for attending!).

Figure 2: The participants of the FPGA workshop.

A key result of this workshop has been an effort to communicate as a community a set of requirements for FPGA based systems on ITER. A forum for this communication is a website hosted with the help of Dr. Mark Scheffer at TUE [2]. I regularly make updates to this website to keep people up-to-date on the latest developments, and seek to see what projects others are working on as a means to share ideas and expertise.

5 Important considerations

The MAST operating schedule is limited in experiment time. MAST is scheduled to shutdown for its upgrade on 31st March 2013 for two years. I will have to carefully plan my PhD so that I can draw some physics results from the hardware that I am assisting in development during the remaining experimental windows.

6 PHD Thesis

It is almost exactly two years until the end of my PhD and there is a considerable amount of work left to do. Broadly speaking after current progression and discussion with my supervisors my vision for my thesis will be 80% focused on the instrumentation developments and at least 20% on experimentation. I will focus on the physics where specifically related to FPGA feedback. There is a large amount of VERY interesting work to be done and this will likely be in collaboration with many other researchers. I need to avoid overlap with students who are doing their PhDs on the results of some of the instruments I am helping to build, this is particularly the case for EBW. Given that I need to have time to develop the material for my thesis I will stop developing instrumentation beyond EBW, Vertical Stabilisation and the Bolometer Upgrade.

7 Other

20-01-2011: Fusion Doctoral Training Network (FDTN) External Advisory Board (EAB) presentation at York. I gave a presentation on my research and highlighted the benefits of working at CCFE and being in the FDTN.

Appeared in the Culham Star publication for "The World's First Global Tokamak Experiment", available on www.ccfe.ac.uk.

I have emailed the editor of the Xilinx (Xcell) magazine and will create an article for the EBW project.

8 Publications

Balboa, Huang - 2010 - Laser Beam Combiner for Thomson Scattering Core LIDAR [3]. Published.
Svoboda, Huang - 2011 - Multi-mode Remote Participation on the GOLEM Tokamak [1]. Accepted.

9 Acknowledgements

I would like to thank all of my supervisors, Dr. Ray Sharples, Dr. Richard Myers and Dr. Graham Naylor. I especially thank Graham for his continued excellent supervision of my research at CCFE.

References

[1] V. Svoboda, B. Huang, J. Mlynar, G. Pokol, J. Stockel, and G. Vondrasek. Multi-mode remote participation on the GOLEM tokamak. *Fusion Engineering and Design, accepted.*, 2011.

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[3] I. Balboa, B. Huang, G. Naylor, M. Walsh, A. Sirinelli, P. Parsons, J. Fessey, M. Townsend, M. Beurskens, N. Conway, J. Flanagan, M. Kempenaars, and A. Kirk. Laser beam combiner for Thomson scattering core LIDAR. *Review of Scientific Instruments*, 81(10):10D534, 2010.