Research Project and Expectations for Jatin Khilani

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May 8, 2015

Summary and overall goal of research project:
A high resolution PET imaging system for simultaneous PET/MRI imaging of small animals has recently been constructed by the PET Instrumentation Lab. Successful operation of this system requires implementation of a slow control system that provides low level system support to the detectors. The overall goal of this research project is to functionalize a new version of the slow control system, allowing it to report system status to the host PC, be controlled by a user from the host PC, and automatically compensate for gain variations due to temperature drift of the PET system.

The current version of the slow control hardware is designed to be capable of the following:

- Supply low voltage power to the detectors (+/- 2.8V)
- Supply bias voltage (~ -27V) to the detectors.
- Monitoring detector temperature
- Monitoring detector voltage levels and bias currents.
- Recording detector event rates.
- Automatically adjusting bias voltage to compensate for detector gain drift due to temperature change.
- Networking to the host PC (i.e. main system control PC) via Ethernet to report system/detector status and accept commands (e.g. changing bias voltage).

The system is modular in design, with each 2U rack mount unit including the following:

- A power distribution board that accepts a 24V DC input and supplies low voltage and bias voltage supplies.
- A Beagle Bone Black microcomputer for system control and communication
- Up to 8 detector interface cards, each supporting one detector module. These cards connect to a detector via HDMI cable and provide signal conditioning to convert the signals from 100 ohm differential to 50 ohm single ended. The interface cards each have a Texas Instruments MSP430FG477 microcontroller with onboard ADCs and DACs for controlling detector bias and monitoring detector performance and communicating with the Beagle Bone Black. The microcontrollers are programmed via external JTAG connector. The interface boards also have several front panel LEDs for visual status communication.
- Up to 2 OpenPET connector output cards to connect the detector output signals to the OpenPET system detector boards.
- A backplane into which the other cards connect.
- An LCD display to print information about the system.

This document describes the initial goals that will need to be accomplished in order to functionalize the new slow control system. Due to the evolving nature of the system and its requirements, this is not a complete description of the scope and deliverables for the research project.

Initial stage goals for research project:
In phase 1 of the research work, the primary aim is to demonstrate that the detector interface board will provide all required functionality. This will require writing firmware for the embedded microcontroller and creating software, both for the host PC and the Beagle Bone Black, allowing a user to control the detector interface card and monitor the status of the detector. Key milestones in this phase are:

- Demonstrate the ability to control the detector bias and set to a desired value.

- Demonstrate the ability to monitor the bias voltage and bias current using the microcontroller ADCs.
- Demonstrate the ability to monitor the detector temperature by monitoring the temperature sensor voltage line.
- Demonstrate the ability to monitor the detector event rate by using a counter on the microcontroller.
- Demonstrate the ability to report the values measured by the microcontroller to the Beagle Bone Black embedded computer and control parameters on the detector board with commands from the Beagle Bone Black.
- Demonstrate the ability to control the system from a host PC with a graphical user interface (GUI).

Expectations for Performance of Research Work:

It is expected that the following conditions will be adhered to:

- Research activities will be continuously documented in an electronic lab notebook, found at: http://140.193.59.74/mediawiki/sites/PETLabWiki/index.php/Jatin_Khilani_Lab_Notebook. This notebook should be complete, documenting activity on a daily basis and providing ongoing details about development progress, identified bugs, and results.
- Software and firmware developed in this work shall be organized and documented. The software and firmware shall be stored in a repository stored on BitBucket.org, with regular updates. The function of individual features and/or functions shall be fully described in the wiki site: http://140.193.59.74/mediawiki/sites/PETLabWiki/index.php/Slow_Control_System_Software_and_Firmware
- The student will spend time equivalent to a full time position (i.e. ~40 hours/week) working in the research lab during the summer months.
- The student will meet at least bi-weekly with the lab supervisor.