Job Summary: Research Support Specialist

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

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1. Co-op Work Assignment

1.1 Overview of CLASSE

CLASSE develops and operates facilities needed to research particle accelerators, particle physics and photon science. CLASSE includes Cornell University's electron-positron collider, a high energy synchrotron, the Superconducting Radio Frequency research group, a test facility for a next-generation accelerator based X-ray light source, and the Energy Recovery Linac (ERL). CLASSE also conducts research and development of crucial technologies for the International Linear Collider, a TeV-scale electron-positron linear collider proposed as the next major particle accelerator after the Large Hadron Collider at CERN.

1.2 Overview of ERL

X-ray beams generated by synchrotrons are indispensable for the study of a range of materials from airplane wings to protein structures. Synchrotron users demand less divergent and more mono-energetic X-ray beams with increased brightness in order to study samples on a nanosecond scale. Shorter, sub-picosecond pulses allow for time resolved study of chemical and physical processes.

Linear accelerators can provide beam quality that is significantly better than current synchrotron designs, but must do so at smaller beam currents. A 5 GeV beam (needed to produce hard X-rays) with a current of 100 mA (as is typical in synchrotrons) would have a beam power of 500 MW. This is roughly the capacity of a nuclear reactor. Unlike circular synchrotrons, a linear collider cannot store accelerated particles for several hours, and hence must generate small beam currents. The Cornell ERL aims to decelerate the electron beam and restore its energy into the fields of the accelerating cavities. The ERL will combine the excellent beam quality of a linear accelerator with the high beam current of a synchrotron - and provide significantly improved X-ray beams.

2. Selected Projects

A broad definition of my role: electronics systems design and development for the ERL prototype injector.
2.1 Data Acquisition board for DESY Advanced Mezzanine Card

The ERL is a very complex system that incorporates many sensors for measurement of various beam parameters. These sensors generate a data at very high rates. I designed a circuit to collect this data and pass it on to Advanced Mezzanine Cards (AMC) (see section 2.3) for analysis. This system was designed to meet the following major requirements:

- Data I/O should be compatible with protocols used in parts of the system before and after my circuit (like TTL and LVDS)
- The circuit should use existing laboratory infrastructure for communication of I/O
- The circuit should facilitate reasonable flexibility in the number and location of data sources and destinations

I was given complete ownership of this project. I designed the circuit schematic, laid out the PCB, defined requirements for board components, supervised purchase of components and fabrication of the board, and tested the board. This was the first time I was involved in the evolution of a system from start to end. I learned a lot from this project: not just the realities and non-idealities of a practical design but also skills needed to successfully cooperate with different teams and companies involved in the system’s development.

2.2 Laser Position Detector (LPD)

This was my favorite project of fall 2011. Unlike other projects I worked on, this one needed a lot of work before the beginning of the design - to define requirements that the design had to meet. I carried out extensive scripting and simulation to outline what could be expected from the LPD and performance metrics that would be reasonable design targets.

The ERL uses a laser to generate an electron beam. The quality and intensity of the electron beam is very closely related to how precisely the laser can be aimed at its target. The LPD measures the laser beam’s position. A feed-back system uses the measurement data to re-position the laser beam.

The LPD design emphasized three major parameters:

- Excellent noise performance: to guarantee the highest resolution for laser position measurement
- Bandwidth: the ERL is able to produce short trains of electron bunches because it uses a laser which is operated at GHz repetition rates. Hence it is essential for the LPD to measure laser positions accurately and precisely across a large bandwidth.
- Dynamic range: the LPD has to operate in the linear regime for the normal range of laser beam positions.

A considerable amount of simulation was required to decide the optimal trade-off between the three parameters.

Another important part of this project was effectively communicating the board’s design and usability. All my work at CLASSE is documented, but this project had particularly stringent documentation
demands. The LPD will be used by physicists who may not necessarily be familiar with the board’s design. As the ERL and specifications for the laser mature, it is likely that new iterations of the LPD will be required. The board’s design was documented well enough to minimize resources required to design future iterations of the LPD.

2.3 Rear Transition Module for xTCA Shelf
Advanced Telecommunications Computing Architecture (ATCA) is series of specifications used primarily in the design of electronics for the communications industry. It has been adapted for use in physics laboratories as the xTCA standard. Advanced Mezzanine Cards and micro Rear Transition Modules (µRTMs) designed to xTCA specifications are being introduced in CLASSE for data acquisition and analysis.

My current project is to design a µRTM to enhance the data acquisition capabilities of a Physics Module AMC that uses a XILINX FPGA for data processing.

3. Evaluation

3.1 Work Environment
Before working at CLASSE, I associated fast-paced work schedules, steep learning curves, rigid deadlines and pervasive cost-consciousness only with large private-sector corporations. The last 6 months have changed my perceptions. CLASSE is an academic institution with graduate students, post-docs, engineers and senior staff scientists. CLASSE employees always have deadlines: for publishing papers, submitting grant proposals and making sure the ERL development stays on schedule. Staying on schedule and cost-consciousness is particularly important in the current economic situation where government agencies find it difficult to defend funding high-energy physics.

An average day in CLASSE is fairly relaxed, and does not reveal the pace of work because of the prevalent work-ethic. Independent initiative is emphasized. I work largely un-supervised. CLASSE does not have a stream of employee-enrichment programs. How much I get out of my co-op position is largely up to me.

3.2 People
I have an assigned supervisor, a physicist (Dr. Loehl) and an assigned mentor, an engineer (Mr. Dobbins). My personal experience has been fantastic. Initiative goes a long way in CLASSE. My supervisor and mentor are both very approachable and willing to guide me while letting me work in a way that best suits me.

3.3 Assignments
I enjoyed the assignments given to me, and felt that they gave me exactly the experience I was looking for in a co-op. They were challenging, and required a significant amount of independent learning. I found that course work at Cornell did not prepare me to execute the kind of tasks I was given, but they did teach me to ask the right questions.
Note: CLASSE is located in Cornell's Ithaca campus and a description of housing, transportation and recreational activities is redundant.