CSU Accelerator Facility: Summer Internship 2012

Alysia Dong

Electrical Engineer student at University of Illinois at Urbana-Champaign

Graduation date May 2014

Table of Contents: Pages:

Introduction

Particle Accelerators are used today for medical, military, security, academic, industrial, and research purposes [1]. Accelerators are growing in demand and as such there is a need for qualified employees who understand and know how to use an accelerator. More facilities are being created to train and teach students about these devices.

One such facility is the Colorado State University (CSU) Accelerator Facility. Headed by Drs. Sandra Biedron and Steven Milton, the Accelerator Facility will have four major systems: an accelerator and FEL system, a laser laboratory, a microwave test stand, and a magnetic test stand [2]. The goal of the CSU Accelerator Facility is to educated and train high-school through post-doctoral students about accelerators and beams.

During the summer of 2012, I interned at the CSU Accelerator Facility. I am currently pursuing my bachelors in Electrical Engineering at the University of Illinois in Urbana-Champaign and as such had the necessary background that would help me in understanding accelerators. During my time in the CSU Accelerator Facility, the facility acquired quadruple magnets needed for the accelerator and FEL system. I worked mainly with the quadruple magnets in the magnetic measurement lab.

Quadruple magnets are used in linear accelerators to focus a beam of particles. They use electromagnetic forces to focus the charged particle beam. Using quadruple magnets for light focuses the light beam into two planes simultaneously. However, in a charged particle beam, the beam is focused only in one plane. Therefore quadruple magnets are used in pairs for accelerators to focus the charged particle beam into two planes. To characterize the quadruple magnets in a systematic, repeatable, and controlled manner and to collect the data easily, a

LabView program needed to be made. Also a mount for the hall probe of the Gaussmeter to measure the magnetic field of the magnet accurately needed fabrication. I accomplished both of those tasks as well as taking some preliminary data to start characterizing the quadruple magnets.

Chapter 1: CSU Accelerator Facility

The Colorado State University Accelerator Facility has four systems: the accelerator and FEL system, a laser laboratory, a microwave test stand, and a magnetic test stand. The accelerator is a 6-MeV linac and was constructed by the Los Alamos National Laboratory for the University of Twente. The University of Twente donated the linac to the CSU Accelerator Facility [2]. The laser laboratory will have a laser system donated by Boeing Company, which will be used as the drive laser for the photocathode and to perform independent experiments. The microwave measurement laboratory will be used as a training platform for electric field measurements of cavity structures. The magnetic measurement laboratory will serve as characterizing and evaluating components of the 6-MeV linac.

I was involved with the magnetic measurement laboratory. Recently quadruple doublet magnets were donated to the CSU Accelerator Facility from the University of Twente (see Appendix A). I was in charge of setting up the quadruple magnets in order for them to be characterized. For them to be characterized, I needed to create a program in LabView that helped find the saturation point of the iron as well as find the magnetic field of the magnets at certain currents and certain directions inside the magnet(length and width of the magnets).

The characterizations of the quadruple magnets are important because they will be used for the accelerator to focus charged particle beams. Quadruple magnets focus a charge particle beam in one direction using magnetic fields. Therefore, quadruple doublet magnets are used in accelerators to focus the beam in both the x and y directions. By characterizing the magnets, insight will be made on how high of a current is needed for the magnets to focus the beam in certain dimensions.

Chapter 2: My Tasks

My tasks for setting up the magnetic measurements of the quadruple magnets were to design a program in LabView that controlled and took measurements from a power supply and a Lake Shore Cryotronics, Inc. Gaussmeter. I also designed a mount for the hall probe of the Gaussmeter to measure the magnetic field from the quadruple magnet accurately.

We needed a way to accurately measure the magnetic field with varying current. We had three transitional mounts in order to move the hall probe in the x, y, and z-axis's of the magnet (length, width, and height). What we did not have was a mount to keep the hall probe of the Lake Shore Gaussmeter in place. Hence a design was created to mount the hall probe (See Appendix B). The mount made sure that the hall probe of the Gaussmeter was held at a constant position that was recorded from the transitional mounts.

The LabView program, which measured the magnetic field of the quadruple magnets, consisted of controlling and gathering data from the power supply and the Gaussmeter and transferring the data into a specific file.

To find the saturation point of the iron around the magnets, the current going through the magnet must oscillate from low to high. To do this, the program has 5 inputs that it requires the user to input. First the user must input where it wants the collected data to be stored in (ie. choose a file). Then input what voltage it wants to start at (initial voltage). The user must input the maximum voltage and minimum voltage. Then the number of recordings the user wants to accomplish. By oscillating the current a number of times the users is able to find the saturation point of the quadruple magnets.

The LabView Program also needed to be able to record the magnetic field of the magnets at a constant current and varying position inside the magnets. The magnetic field varied inside the quadruple magnet depending on where the field was measured. To do this a stop button was added, so that the hall probe was moved using the transitional mounts and then the magnetic field was measured. By varying the position of the hall probe inside the magnet, we are able to create graphs that characterize the quadruple magnets (see Appendix C).

Chapter 3: My progress

Creating the program in LabView required a step by step process until I had a finished product. I had never used LabView before, so my first task was to vary the voltage of the power supply and put the measurements from the power supply into a document. I struggled with this task, since I was unfamiliar with the LabView program. Once I completed this task, I was asked to add the Gaussmeter to my program so that I could take measurements from both the power supply and Gaussmeter and store them into a document. The next step toward the final program was timing the change of the current to the magnet with the measurement of the Gaussmeter, so that the magnetic field measurement was accurate. My final program had step by step processes that changed the current in the power supply, and then took a measurement from the Gaussmeter, and finally placed the data into a document (see Appendix D).

At this time, I also completed a Test Plan. The test plan included how to run the program and my plan to test the quadruple magnets that I was to characterize. I needed to test the magnetic field of the quadruple magnet with a constant current. I was to test the magnetic field when moving the hall probe length-wise and width-wise inside the magnet.

The hall probe of the Gaussmeter also needed to have a mount to keep the hall probe in a constant position in order to measure the magnetic field accurately. I created a design to mount the hall probe, and then another intern at the CSU Accelerator Facility put my designs into a program called Solid Works. From there we submitted the designs to the machine shop to be created.

Chapter 4: Conclusion

During my internship at the CSU Accelerator Facility, I learned about particle accelerators, quadruple magnets, and what setting up a fully functioning accelerator requires. Designing and creating both the hall mount designs and the LabView program were viable skills that will help me in later aspects of my life. Learning about particle accelerators has given me an appreciation of a direction I could take as a career using my bachelor's degree in Electrical Engineering.

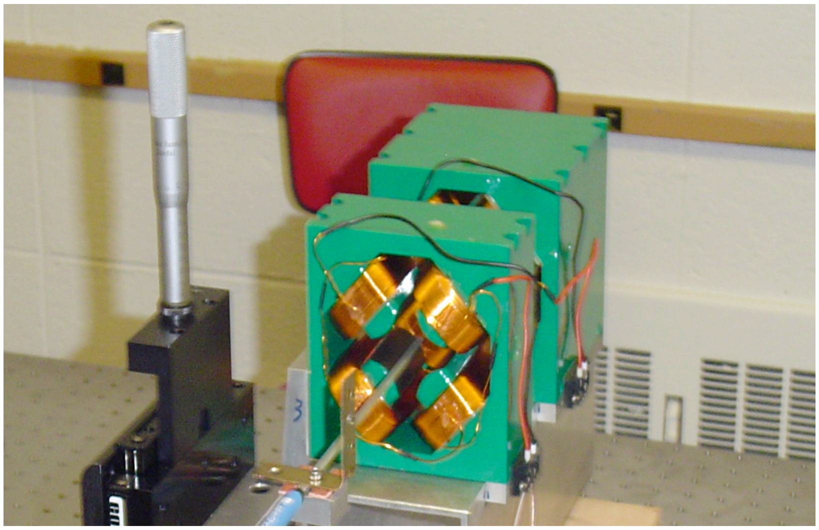
Accelerators are used in everyday life and are growing more in demand. Thus, more engineers and physicists are needed to run and fix accelerators in industry. By interning at the CSU Accelerator Facility this summer I have taken the steps to continue my education in the field of particle accelerators and as such contribute to this field growing in the world today.

References

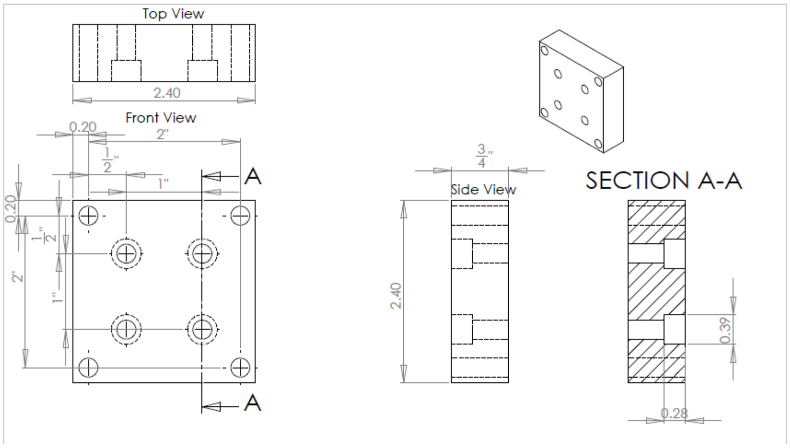
[1] "Accelerators for America's Future," Department of Energy, Office of Science, 2010.

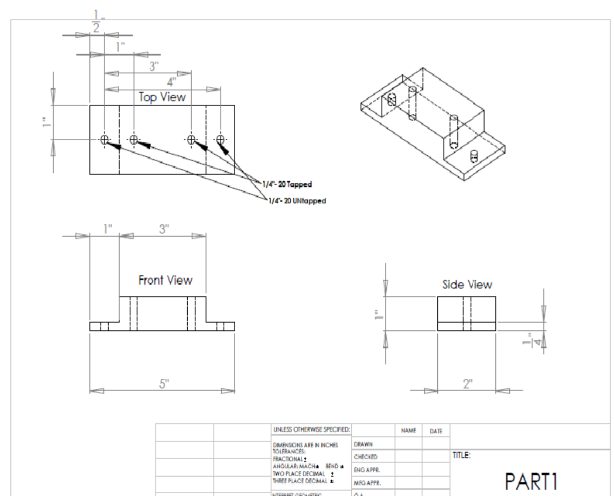
[2] S. Milton, S. Biedron, T. Burleson, C. Carrico, J. Edelen, C. Hall, K. Horovitz, A. Morin, L. Rand, N. Sipahi, T. Sipahi, P. van der Slot, H. Yehudah, A. Dong, "The CSU Accelerator and FEL Facility," Proceedings of the 2012 Free-Electron Laser Conference, Nara, Japan, accepted for publication, to be published in 2013 in JACOW.

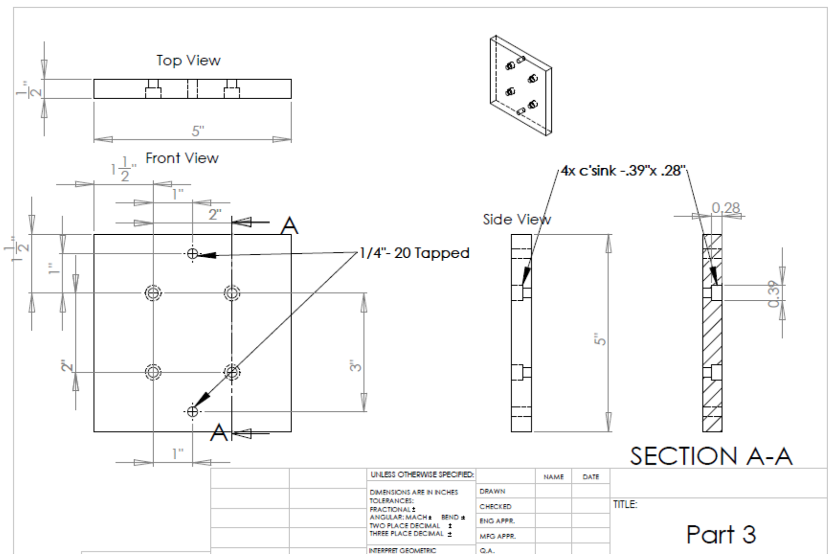
Appendix A: University of Twente quadruple doublet magnets

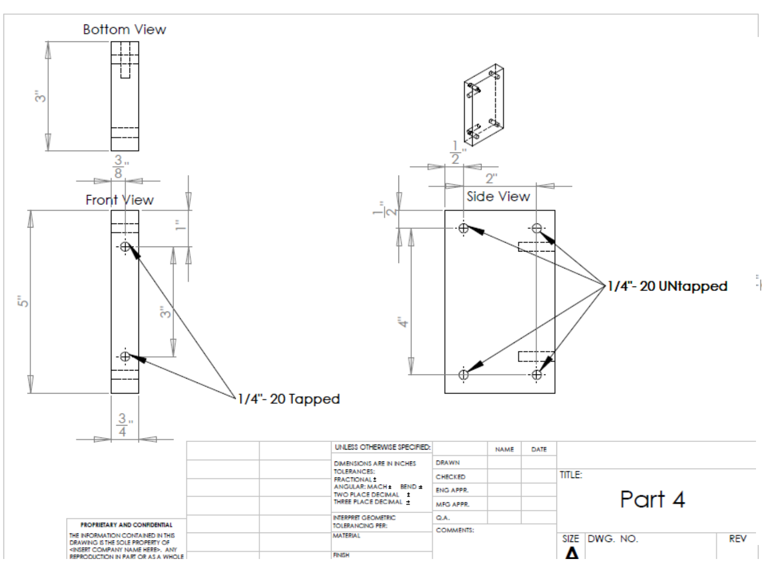


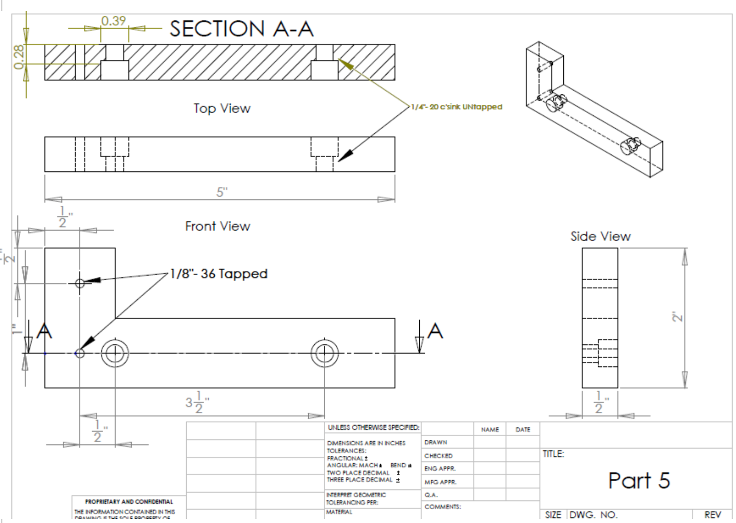
Appendix B: Designs of the Gaussmeter Hall Probe Mount



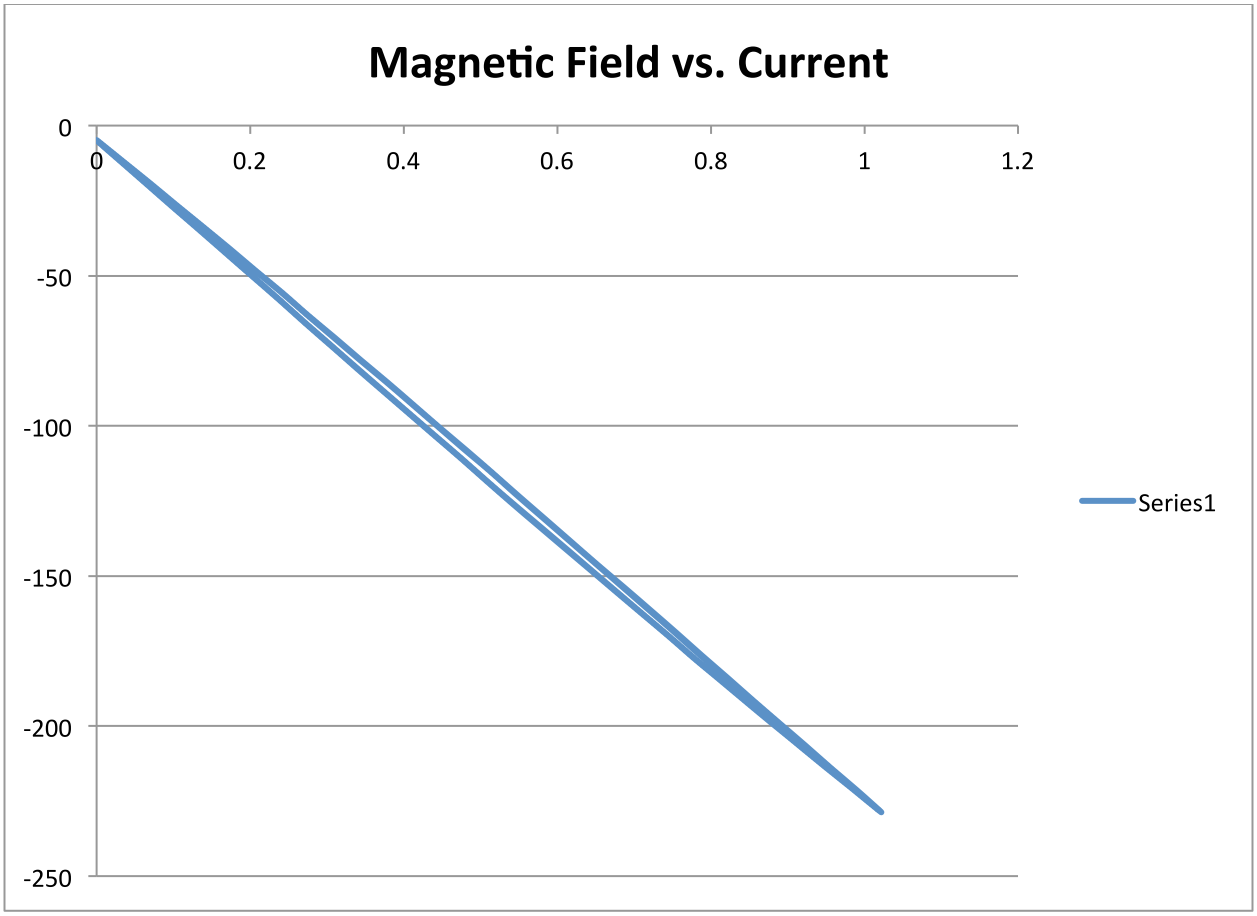








Appendix C: Preliminary Data for Characterizing the Quadruple magnets



Appendix D: LabView Program