**Control of a Petawatt Laser**

**Team Members:**
- Electrical Engineering: Conner Carter
- Mechanical Engineering: Arsalan Shah and Ryan Wessel
- Advisors: Professor Jorge Rocca and Reed Hollinger

### Project Overview

Although this is a very fast and powerful laser, there are several problems that inhibit the full functionality for practical experimentation. Even though the laser can maintain its power at 0.85 petawatts with a repetition rate of 3.3 Hz, experiments cannot be completed this quickly due to positioning, power, and fault detecting constraints. This project automates the laser system which in turn, maximizes the efficiency of this laser so that it can operate at 3.3 Hz not only for the sake of benchmarks, but for research efficiency as well. The completion of this project will decrease the amount of time to conduct research by almost 1/60th.

### Software/Hardware

- **Software:** LabView, Fusion 360, Creo Parametric 3D Modeling
- **Hardware:**
  - NI-9401 DAQ Device
  - NI-9188 DAQ Device
  - NI-9185 DAQ Device
  - MBC25081-Stepper Drivers
  - Basler acA1600-20gm GigE camera
  - Mitek USB2.0 Color 3MP CMOS Camera

### Goals and Objectives

- **Energy Control**
  - This will allow the laser research team to conduct energy sweeps. They will be able to repeat any experiment at different energy levels.

- **Targeting**
  - Create a LabView program that will have accurate motion control of stepper motors. This includes finite motion given an input distance, fast/slow jogging, and jogging to limits switches.

- **Image Processing**
  - Create a program using LabView to monitor changes in light intensity and detect errors if the laser output is not as intended.

### Progress

#### Energy Control

- **Research**
  - Developed different designs and chose the least complex but most effective.
  - Created a physical circuit of 1 channel of the design (see image).
  - Involved finding components that fit the specifications.
  - Tested the circuit with a pulse generator to be sure the circuit functioned correctly.

- **Design**
  - Designed the final PCB.
  - Required replicating the testing circuit 19 times (10 Channels each for charge and trigger signals).

### Before/After

**Energy Control**

- Before this project, the method of controlling energy was by using foam blocks to prevent certain slab amplifiers' flash lamps from influencing the laser's energy.

- After assembly and initial testing, this design has proved successful in delivering the desired results: the PCB, when controlled through LabView or manual override switches, does control which slab amplifiers receive the charge/trigger signal resulting in total energy control.

**Targeting**

- The previous work that was done in order to control the target for the laser consisted of an enclosure that contained a controller with manual buttons that would move the target when pressed. The cons were that it could only control 2 axes, the controller had ramp up/down time, and there was no way to do precise movement.

- The work that has been done eliminates all those adverse effects. The hardware/software that has been implemented can now move the stepper motors with accurate finite movement, has eliminated the ramp up/down time, and can easily be duplicated to control more than 2 axes.

### Image Processing

- Previously images were recorded but manually checked for faults by human interaction and a MATLAB program that would create intensity profile.

- Currently the process is no longer 2 steps, has camera control while analyzing images and will be able to create a feedback to the camera automatically by detecting errors.

### Future Work

**Energy Control**

- This is a CAD drawing of the energy control enclosure. Once this is machined, the rest of the PCB can be soldered into place, which will conclude this part of the project.

**Targeting**

- Future steps that will be taken are fixing the timing issue with the finite motion and creating the enclosure for the DAQs and drivers.

- The goal is to use 6 DAQs and drivers inside of the enclosure which will allow the lab to control up to 8 stepper motors.

**Image Processing**

- The triggered grab is dependent on the camera used and might need to be generalized.

- Integration of all programs into one so that the interrupt created by the threshold intensity change detection can stop the laser from firing to avoid damage to lenses and targets.

- Creating image detection for targeting to introduce a feedback loop for better error detection in the stepper motors.

### Current Status

- **Energy Control**
  - LabView Program close to completed.
  - PCB is made and soldered as much as possible without enclosure.

- **Targeting**
  - LabView program creates finite motion, fast/slow jogging while holding button, and jog to the limit switches. Limit switches are incorporated for all types of motion with micro-steps.
  - Minor issue with timing of the finite motion and stopping the motion while moving need fixed.

- **Image Processing**
  - LabView Program functions properly on itself with most cameras.
  - The program is able to correctly show the intensity and detect changes that occur.

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