ELECOMP CAPSTONE SUMMIT
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Automatic Laser Optimization and Production

AutoLase II

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IRADiON Ceramic Core CO_2 Lasers

Project Motivation

Mirror alignment is a crucial part of laser production but is a slow and tedious process. As of now, this process is done by a laser technician who will insert a long screwdriver into the system to adjust the mirror's screws in order to align the fully reflective mirror with the partially reflective mirror on the other side of the laser. This process is inconsistent from technician to technician. With this enhanced project, it will be possible to produce aligned mirrors at a much quicker pace which will in turn decrease the total time of production. The alignment will be replicable and more reliable as the process will be done through calculations instead of by human eye. A real-time GUI will allow the user to follow this process by monitoring the position feedback from the autocollimator and the limit of torque exerted onto the screws.

Key Accomplishments

- **Servo Motor and Driver:** The main goal for this project was creating a way for the user to know the torque on each screw while aligning the mirrors. Unlike stepper motors, servo motors power output is reliant on current. The servo motors used are displayed in **Figure 1**, and each have their own driver connected to the FPGA. The motors are too large to be directly behind the screws so they are offset and use turning belts to turn the hex bits in the middle holder.
- **FPGA and UART Communication:** The FPGA board connects everything together and communicates to the computer through the UART. The FPGA is behind the motors as shown in **Figure 2** which has the PMOD, UART, and drivers connected. The main purpose of the FPGA is to receive and transmit signals from the driver and the C# code. The UART communicates through serial data. Both the Vivado code and C# code have processes to handle this communication.
- **Calculation Code:** The C# code is the brains of the operation. Based off the information from the FPGA and autocollimator the code will calculate the number of turns each motor needs to do. While turning, the C# code will receive the voltage output of the driver and calculate the current through a known resistor. Using the current, the torque will be calculated and realize if the motors are going to exceed the max torque.
- **Torque and Current Relationship:** Conducting a simple experiment with a pulley system required the knowledge of the relationship of force, gravity, radius of the gear attached to the motor shaft, and mass unit hanging from the pulley. By measuring the current outputted from the driver and calculating the torque for the motor, the torque constant is found and implemented into the C# code. This allows the code to calculate the torque with respect to current while turning the screw.
- **3D Printing:** To hold the three motors in an organized fashion, a wall and base were designed and printed with an extra side of support to account for the increase of size and weight of the motors, as shown in **Figure 1**. A shaft to hold and extend the hex bit was designed, as well as a holder for the hex bits in the middle of the system. A stage for the motor system and for driver and FPGA setup attaches everything to the track system.
- **Analog to Digital Converter:** The voltage outputted from the V_{CC} pin of the encoder at the driver is sent through a known resistor to input the voltage into the A/D converter. This current value is then read in the C# code to calculate the torque output which relates to the current value at that moment.
- **Control and Communication Code:** The FPGA has processes to know what information to send and communicate to the C# code what is being sent. The block diagram from Vivado is seen in **Figure 4**. This represents how the FPGA is setup to receive and transmit data between each block. Shown in **Figure 3** is the GUI that the user will implement limits to and begin the process.
- **Mechanical Component Selections:** Through the help of a mechanical engineer at Iradion Laser, Inc., information of off the shelf mechanical parts were made available. The gears were chosen from a given catalog which matches and fits the motor's shaft diameter. The system will sit on a track system which will allow for ease of use for the technician. The hex bits are placed in the system for direct fit into the three mirror screws which will be turned.

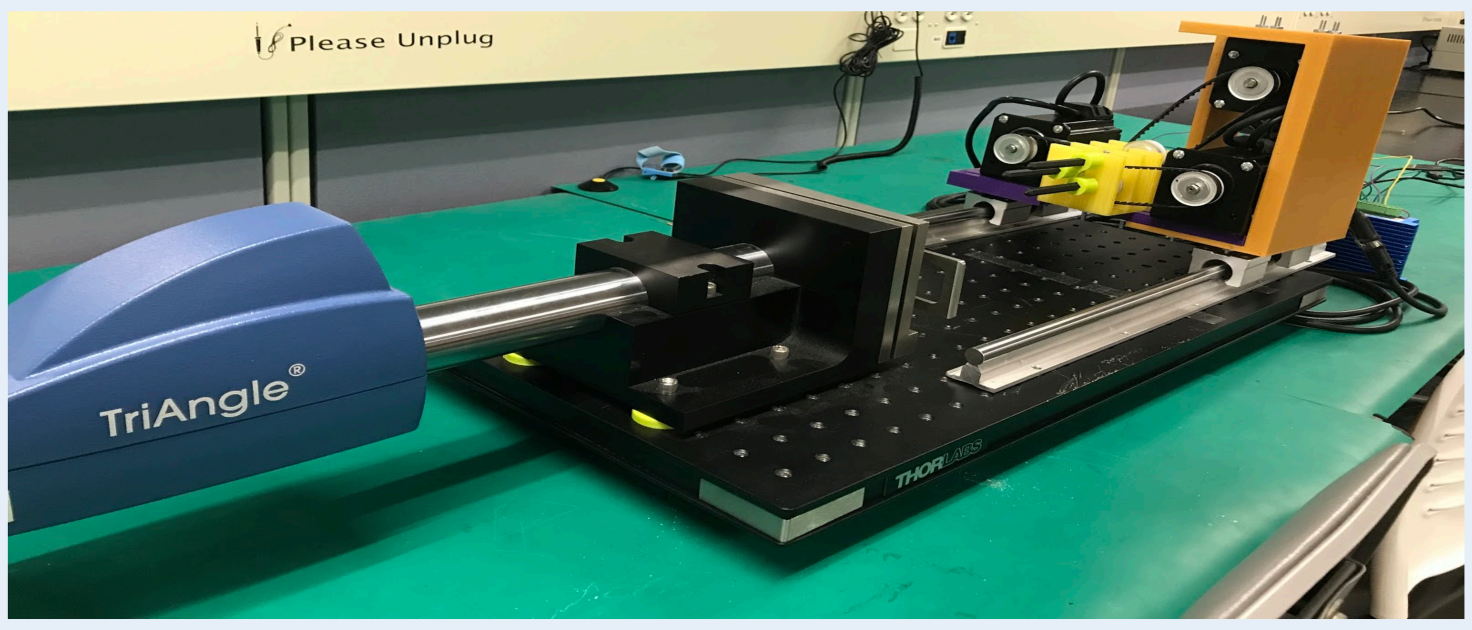

Figure 1: Side view of the bases with motors on the rail.

Anticipated Best Outcome

This project will have a big impact for Iradion Laser, Inc. with the best outcome being a production-ready workstation in a cleanroom environment that can auto-align a mirror for their lasers. Based off the work completed by last years team, improvements to the mechanical setup, materials, and motors was necessary before the company could integrate it in the assembly line. The final project will require parts that Iradion Laser, Inc. can purchase off the shelf, metal pieces that can live in a cleanroom environment, and allow the user to know the torque on each screw.

Project Outcome

Results towards achieving the Anticipated Best Outcome will be presented at the Summit presentation.

Figures

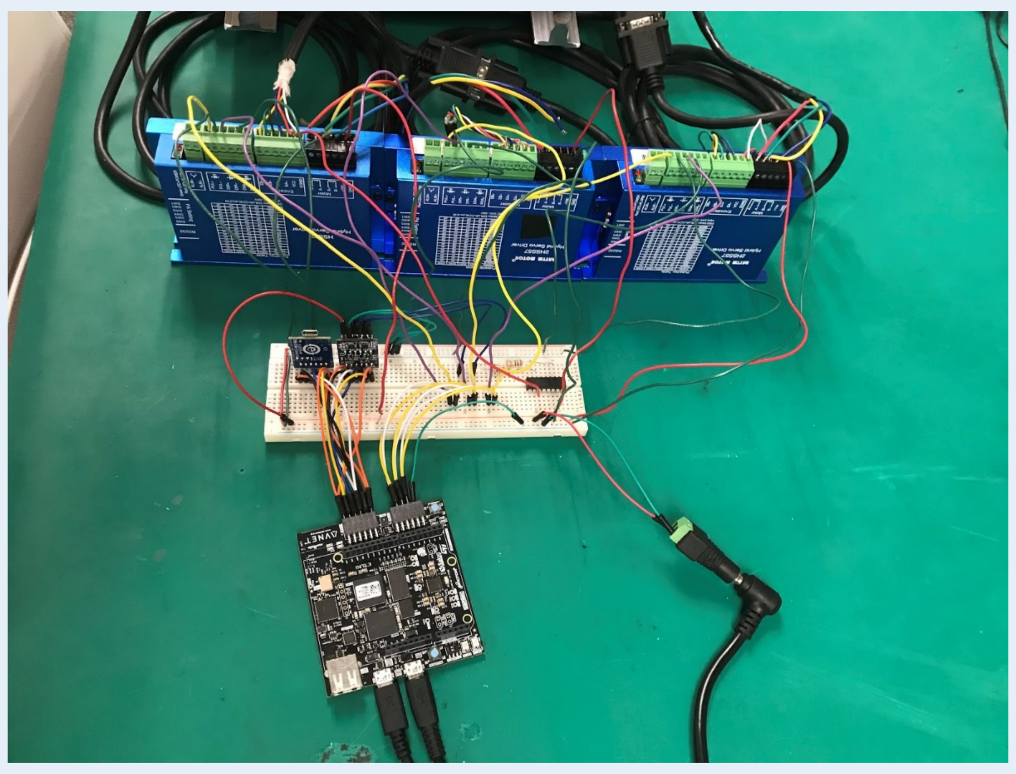

Figure 2: Back view of the setup with drivers and FPGA.

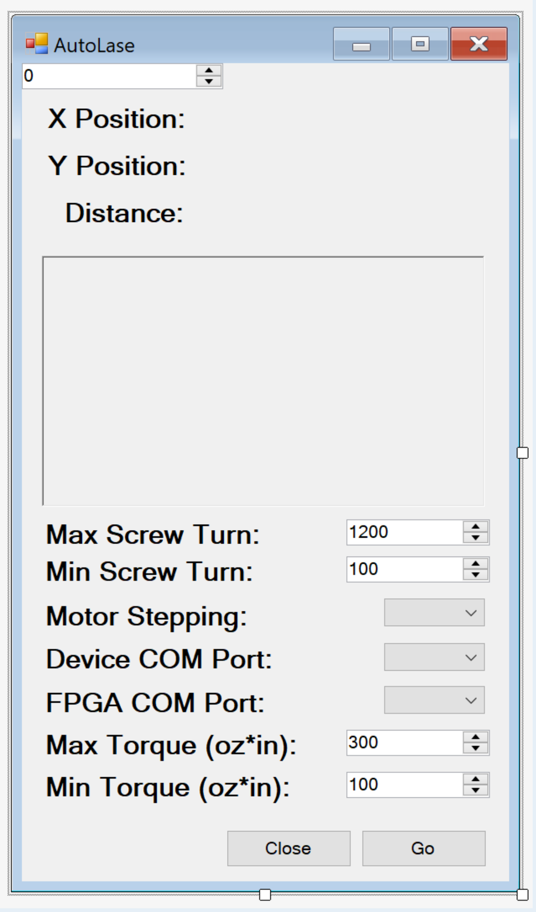

Figure 3: Graphical user interface to display the feedback from the autocollimator and FPGA.

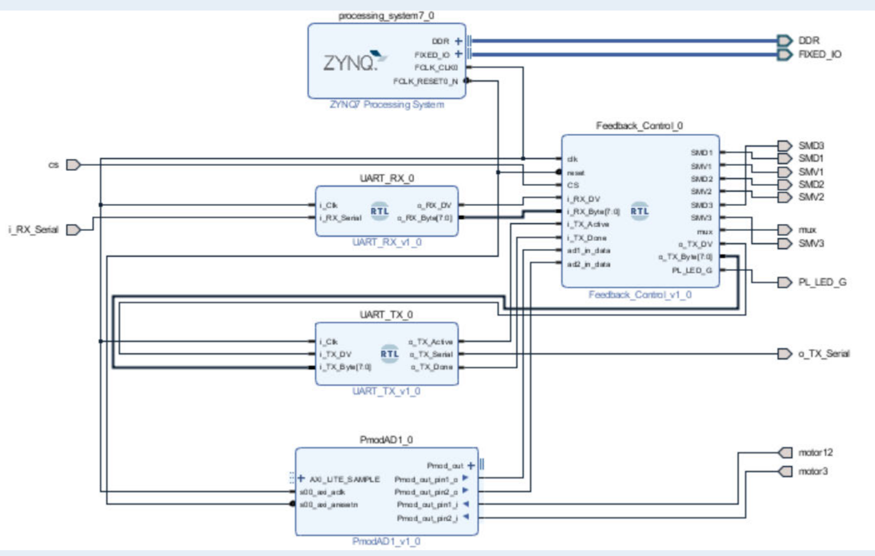

Figure 4: Block diagram for the Vivado code representing the FPGA, UART, and A/D data.

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