Engineering Portfolio

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Fall 2021

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MEMS Mirror Vibration Measurement System

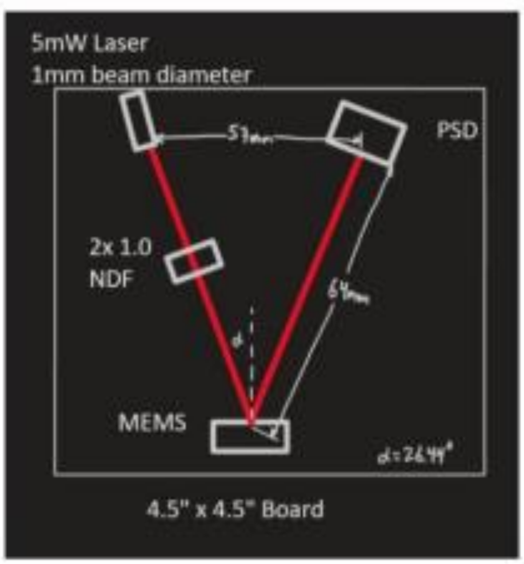
June 2021 – August 2021

The objective of the project is to design and build a system to measure the vibration of a MEMS mirror when it is subject to a sudden force.

The challenge is that with a 1mm diameter, the MEMS mirror is too small to measure by touching it with an accelerometer and or gyroscope. Thus, the system was designed using a laser and position sensitive detector (PSD), where the laser reflects off the MEMS mirror onto the PSD, measuring the movement of the mirror by the laser displacement on the sensor. See Figure 1

The PSD was hooked up to a DAQ box which plugged into a PC via USB. I used Python and a .NET interfacing library to extract position data at up to 1kHz from the PSD to write to CSV file for graphical analysis and calibration of the system. To calibrate the system, a calibration curve was produced, which related the signal to the displacement of the laser on the PSD. The system had the ability to detect a 1mrad change in angular displacement of the mirror.

Challenges included administering repeatable force to the system and differentiating changes in the signal between MEMS mirror angular displacement and the components moving relative to the sensor. The project took 2.5 months to complete the engineering design process of researching, designing, building, and testing the system. The most important lesson I learned was to understand the full system from end to end, knowing how every component works so you can easily diagnose problems and fully understand your output.



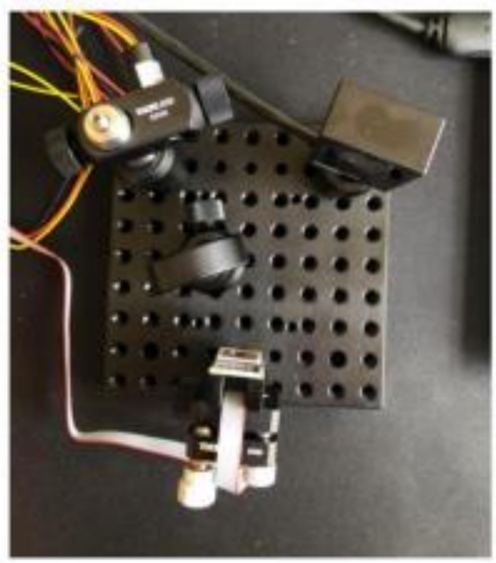


Figure 1: Vibration System Setup

See Figure 2 on next page for system output

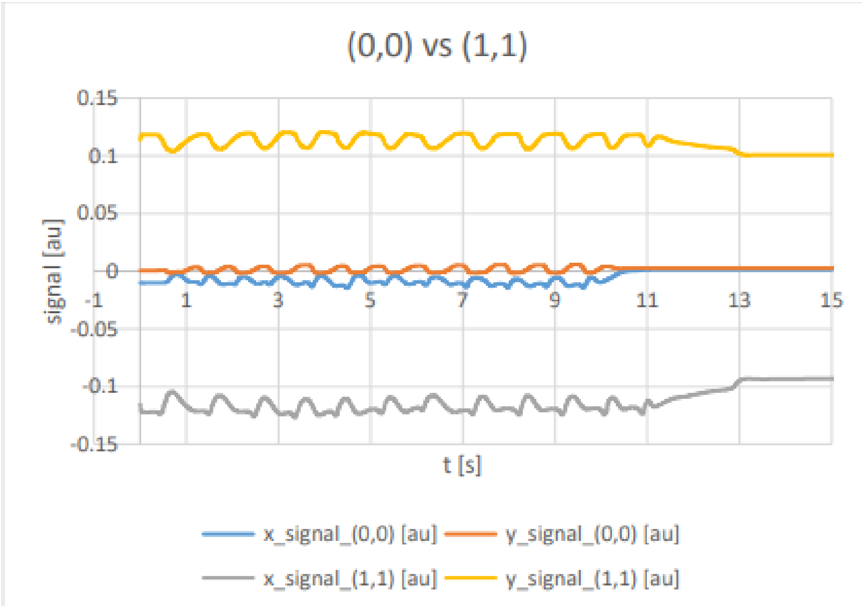


Figure 2: Signal from mirror while it's subject to repeated force

Autonomous Checkers Robot

November 2019

As part of a first-year engineering design course, myself and 2 classmates were tasked to build a mechatronic system using Tetrix and Lego EV3 Mindstorms.

Our team constructed and programmed a robot to play an entire game of checkers against itself. Built with a 3-axis movement system and gripper built with Tetrix and Lego Mindstorms. The controller was programmed in C with an original checkers algorithm. The project took 1 month to research, design, build, and test the system.

The biggest challenge was for the 3-axis movement system to be precise and repeatable. Using gears and rack and pinion, the movement system was precise enough to move to each spot on the board, pick up a piece and move it to the desired location. As for repeatability, the location of the gripper was stored and updated in the software. The location was updated each time it stopped at a square on the board, due to mechanical imperfections, the location error would build up. To fix this, buttons were placed on the robot that would update the location of the gripper in software to the actual physical location. Each time the robot moved to the zero location in the x or y axis, the button on the robot would be pressed by the frame, updating the location, and eliminating error.

See Figure 3 on next page.

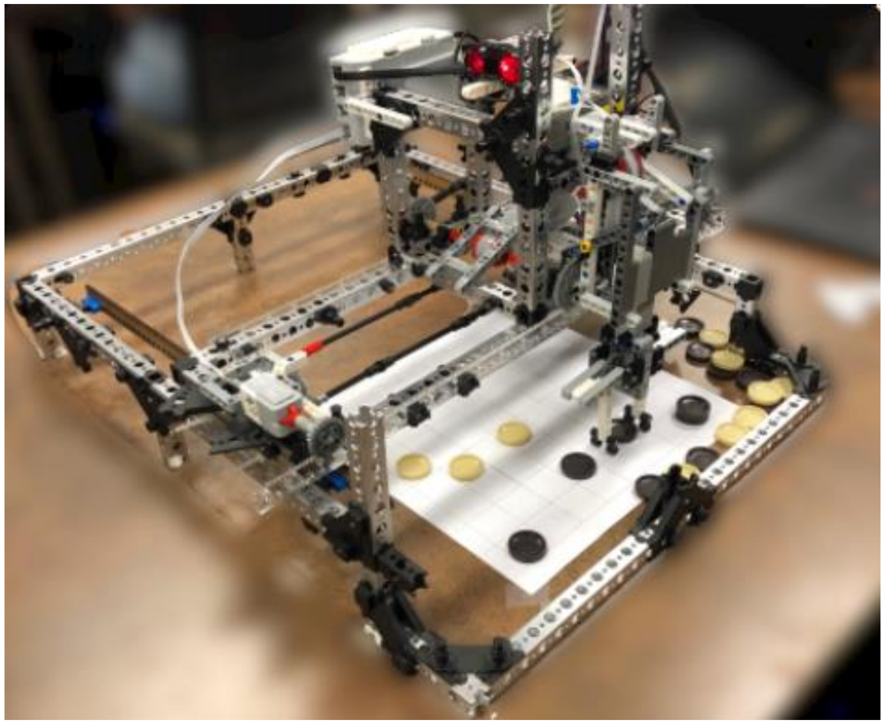


Figure 3: Autonomous Checkers Robot

Zemax DAT formatter

The objective was to eliminate the need to manually transcribe large spreadsheets into DAT files for Zemax, which would multiple hours.

Formats coating transmission data from excel for Zemax DAT file. Uses Python and Python libraries to format transmission data from manufacturers, into a format for use in a Zemax optic studio DAT file.

https://github.com/coopercole/Zemax-DAT-formatter

KPA101-Datalogger

The objective was to extract position data from the Thorlabs KPA101 DAQ box and write to a CSV. Third party software must be written since the KPA101 doesn't have first party software to write position data to CSV.

Provided by pythonnet library, using a .NET interface layer to communicate with the KPA101, the python file will extract the signal and PSD location data from the KPA101 and write it out to a csv file. Made for personal use case built off the original code from "ppakotze-sarao" on GitHub

https://github.com/coopercole/KPA101-python-datalogger

Personal Website

I wanted to have a personal website because it's cool and it gives me a reason to own the coopercole.ca domain. Built from scratch using HTML and CSS.

coopercole.ca

University Coursework

Studying mechatronics engineering, I get to learn a multidisciplinary blend of topics, from mechanical and electrical design to computer programming and automation technology. Through my courses, I have learned technical skills including C/C++, SolidWorks, 3D printing, GD&T, Soldering, Circuit design.

MTE 140 Algorithms and Data Structures

Structured software design data structures, abstract data types, recursive algorithms, algorithm analysis and design, sorting and searching, hashing, and problem-solving strategies.

MTE 262 Microprocessors and Digital Logic

Number systems, logic gates, Boolean algebra. Karnaugh maps and combinational logic design. Implementation of combinational logic circuits on Field Programmable Gate Arrays (FPGA) boards. Sequential logic and state machines. Programmable Logic Controllers (PLCs) and PLC programming using ladder logic and statement list. Microcomputer structure and operation, I/O, and interfacing and interrupts. VHDL programming. Assembly language programming.

Laboratory work includes microcomputer and PLC programming.

MTE 219 Mechanics of Deformable Solids

Introduction to mechanical response of materials and stress-strain relationships. Behaviour of prismatic members in tension, compression, shear, bending and torsion. Stress and strain transformations.

As part of the course project, built a bridge out of balsa wood that weighed 46.4 g and could hold 14 kg before failure, thus holding 300 times its own weight. See Figure 4

Figure 4: Balsa Wood Bridge

MTE 220 Sensors and Instrumentation

Review of circuit theory; input-output relationships, transfer functions and frequency response of linear systems; operational amplifiers, operational amplifier circuits using negative or positive feedback; diodes, operational amplifier circuits using diodes; analog signal detection, conditioning, and conversion systems; transducers and sensors, difference and instrumentation amplifiers, active filters.

Lab work includes building signal conditioning circuits for robot sensors and actuators. Lab project was to build a line following robot by designing the necessary circuits and soldering components on a PCB. Line following is done by photodiodes and an infrared emitting diode. See Figure 5

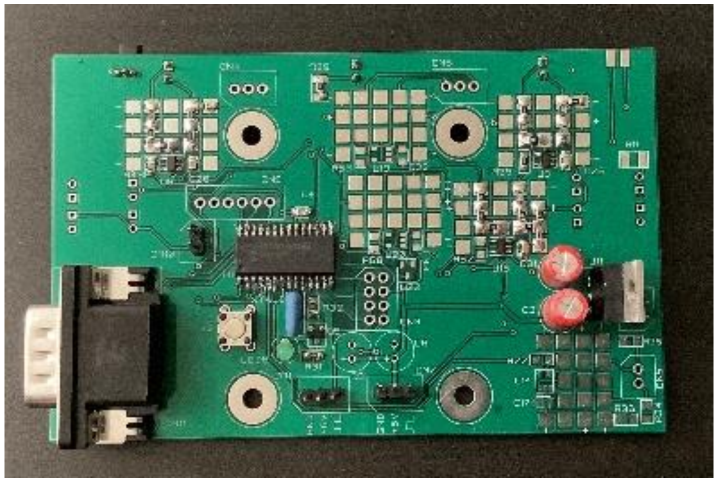


Figure 5: PCB for MTE 220

MTE 241 Introduction to Computer Structures & Real-Time Systems

Introduction to computer organization, basic real-time concepts, process management, interprocess communication and synchronization, memory management, resource management, interrupt handling, concurrent programming, file systems.

Lab work consists of programming in C to implement real time systems on LPC1768 development boards with ARM Cortex-M3 processors. See Figure 6

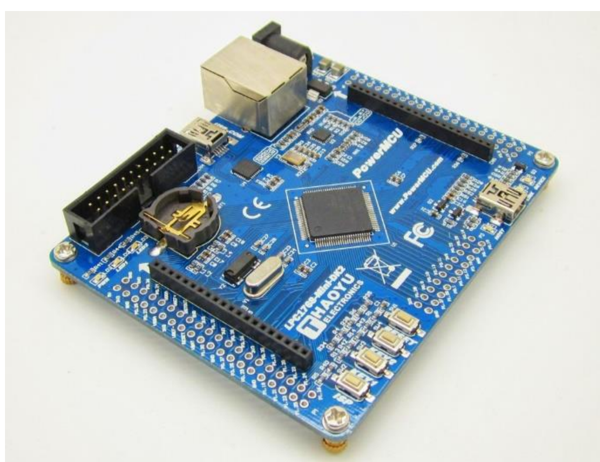


Figure 6: LPC1768 Dev board