

Development of DIY Fourier Transform Infrared (FTIR) Spectrometer

with optical range from Far-IR to mid-IR

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Introduction

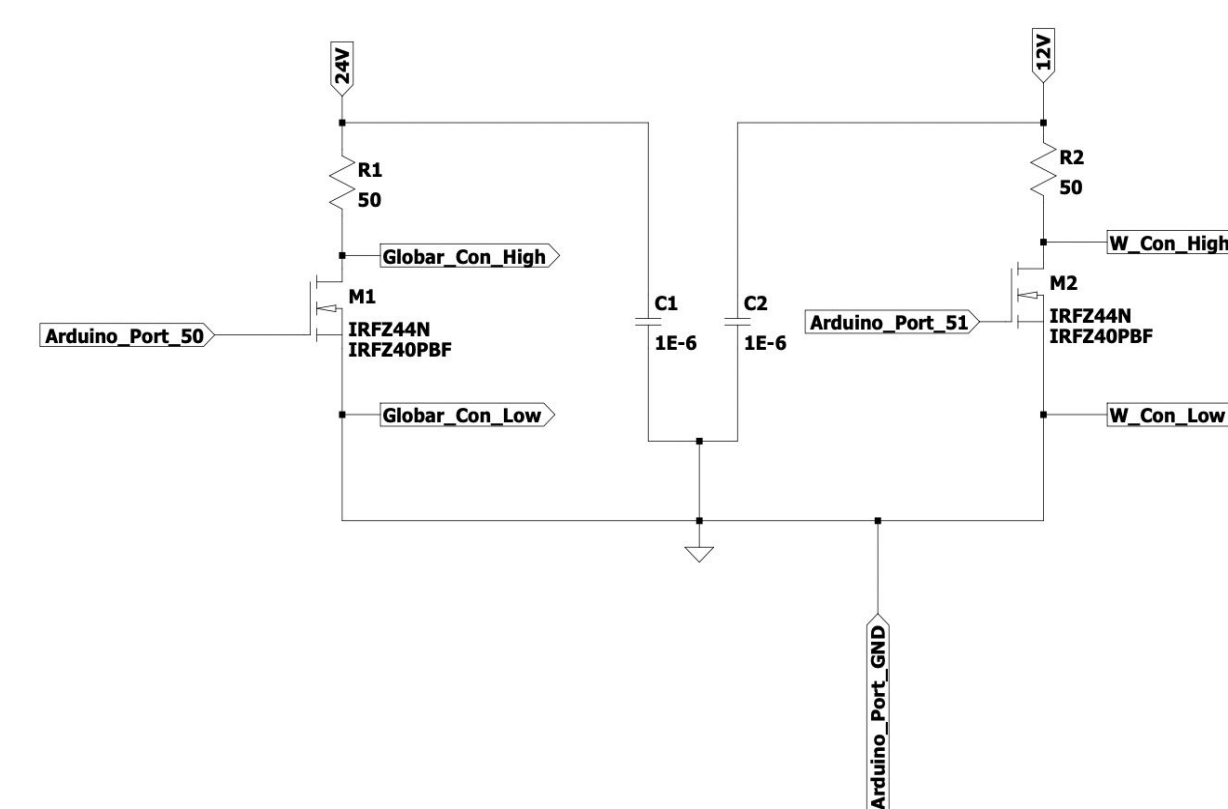
A Fourier-Transform Infrared Spectrometer, FTIR, is used to measure the transmittance and reflectance as per required by the individual application. The FTIR spectrometer is known to be a quick way to identify the composition of all kinds of compounds, both organic and inorganic. It is most known to be used for pharmaceutical and forensic analysis (Thermo Fisher Scientific, n.d.). The FTIR spectrometer works by allowing infrared (IR) radiation to pass through a specific sample in which some of the radiation is absorbed by the sample. The radiation that does not get absorbed is then recorded in order to identify the sample (Millipore Sigma, n.d.). Our project is centered on the development of the FTIR spectrometer itself. The main components of the spectrometer that we were focused on obtaining control over were the mirrors, the detector, and the light source. Once the spectrometer is ready to be in use, it will be in vacuum conditions, meaning we will not be able to manually adjust any of its components. The main goal of the project is to get the spectrometer to successfully detect the signals being sent and to be able to control its components automatically.

Methods

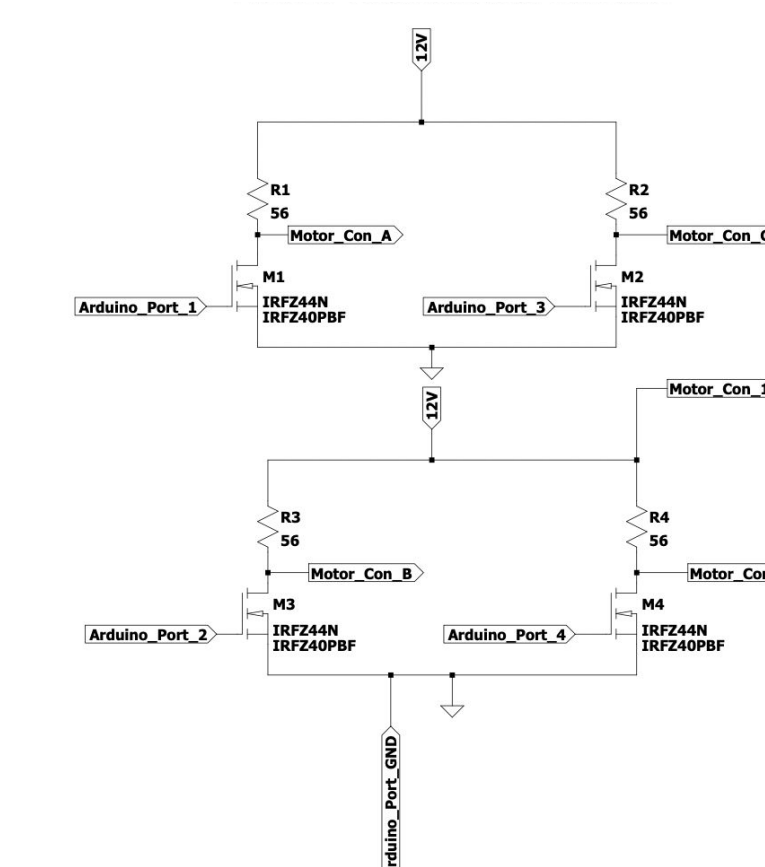
- Create two circuit boards for the power supply in order to be able to regulate the light sources and detectors by connecting it to a microcontroller
- Create circuit boards that can receive signals from the microcontroller that are sent to be able to drive the motors. In order to align the light beam once the machine is fully functional and in the vacuum state
- Write a program to read in the commands from the console of the microcontroller, based on the command send the appropriate signals to each individual motor circuit board in order to drive the motors.
- Modify the code to send a square wave of about 5 Volts for about 5 milliseconds which is sent to the main motor of the interferometer which is on the basis of electromagnetic induction
- Create a circuit board which can turn on the detector and preamplifies the signal voltage which is being sent to the microcontroller
- Write another program which can read the preamplified signal that was received through the microcontroller in order to be able to print it onto the console
- Test all the functionalities that have been implemented in the steps above
- If all the tests are successful, create a separate computer program which will be more user friendly that will communicate to the Audrino. The commands that were previously sent and received through the console of the Audrino are communicated between the program and Audrino through the serial port
- We used two detectors with different ranges and sensitivities to fully record the spectrum using the light source we need to obtain the signal
 - The two different detectors used are, MCD and DLaTGS.
- We first convert the analog signal to digital data signal using an analog to digital converter (ADC; DC1908A-C)
- This digital signal is serially sent to Audrino using the SPI bus, which is further processed to transfer asynchronously to the computer program.
- To test the functionality of our ADC we send in the signal using a function generator and reach the output from the Audrino

Results

Circuit Diagram for controlling the 24V/12V Light Source using a 5V digital signal.



Circuit Diagram for driving a 12V stepper motor using a digital signal from Arduino.



Circuit Diagram for amplifying the signal and reducing the noise from the detector. Signal is read using an external ADC which is fed to the Arduino.

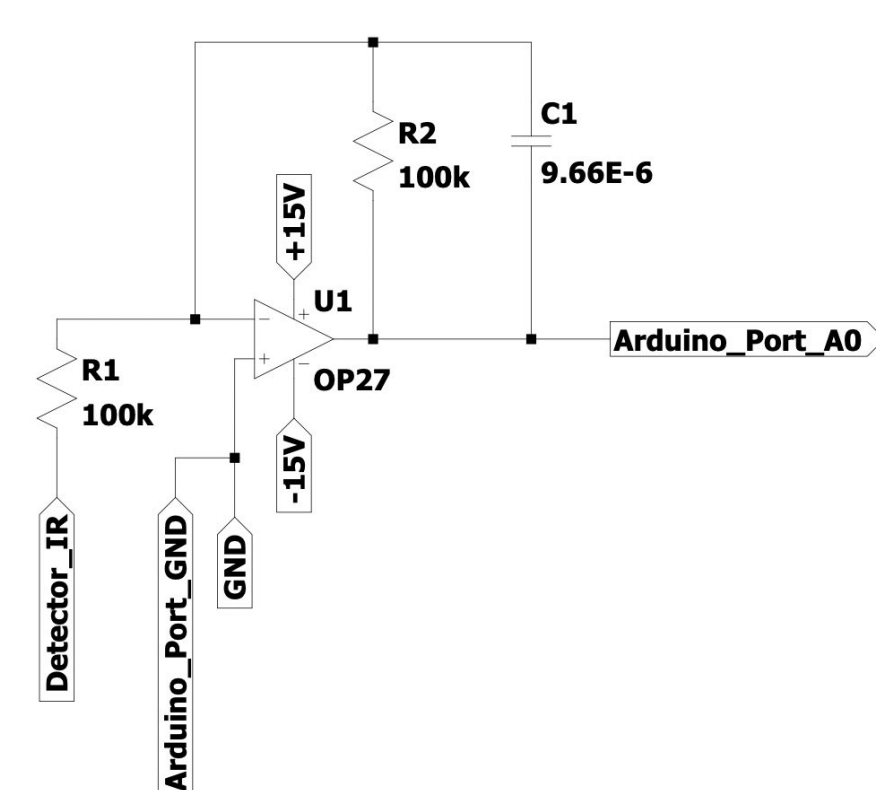


Image illustrating the circuit diagram for driving a 12V stepper motor using a digital signal from Arduino.

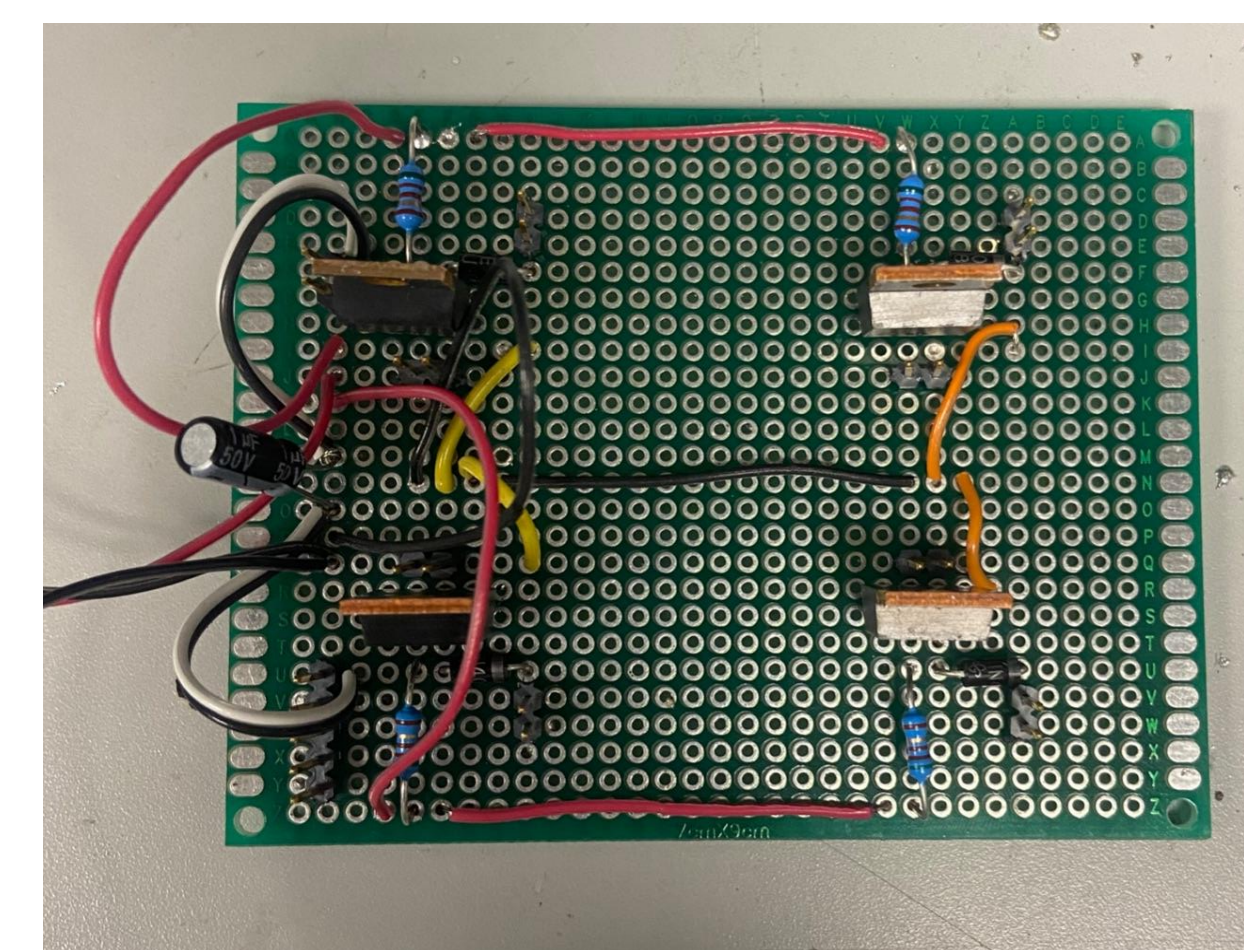


Image illustrating the final assembly of all the circuit boards along with power supplies and Arduino.

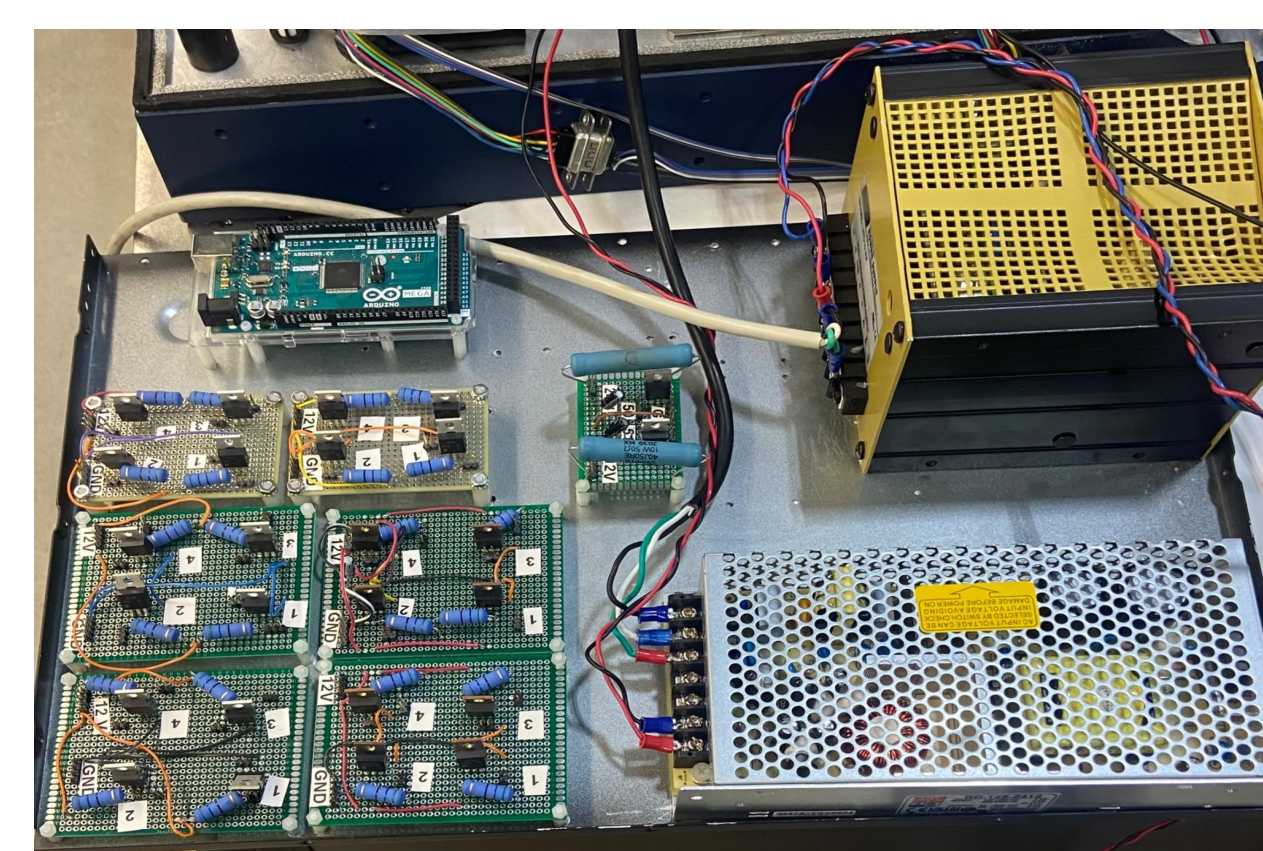
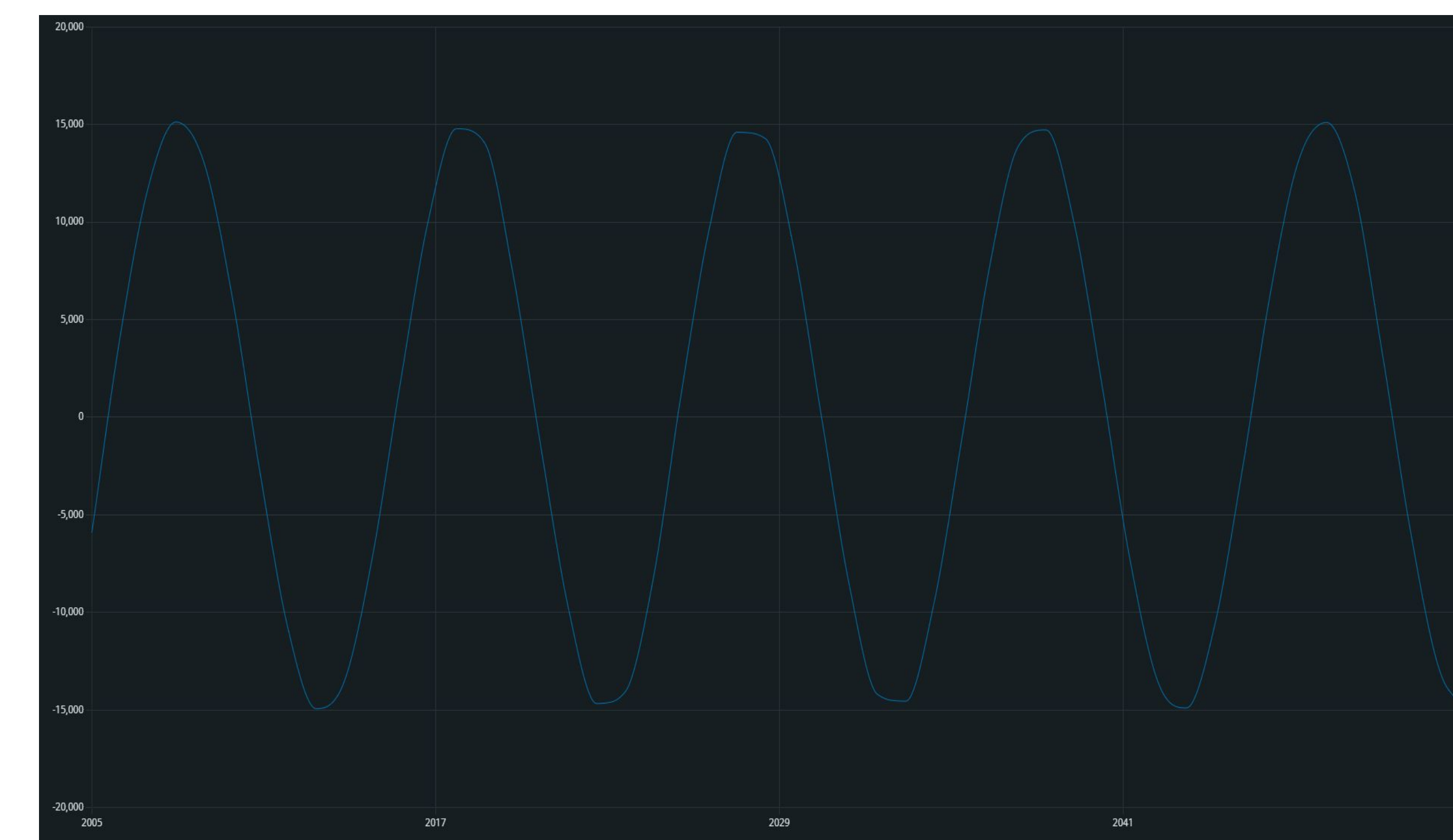
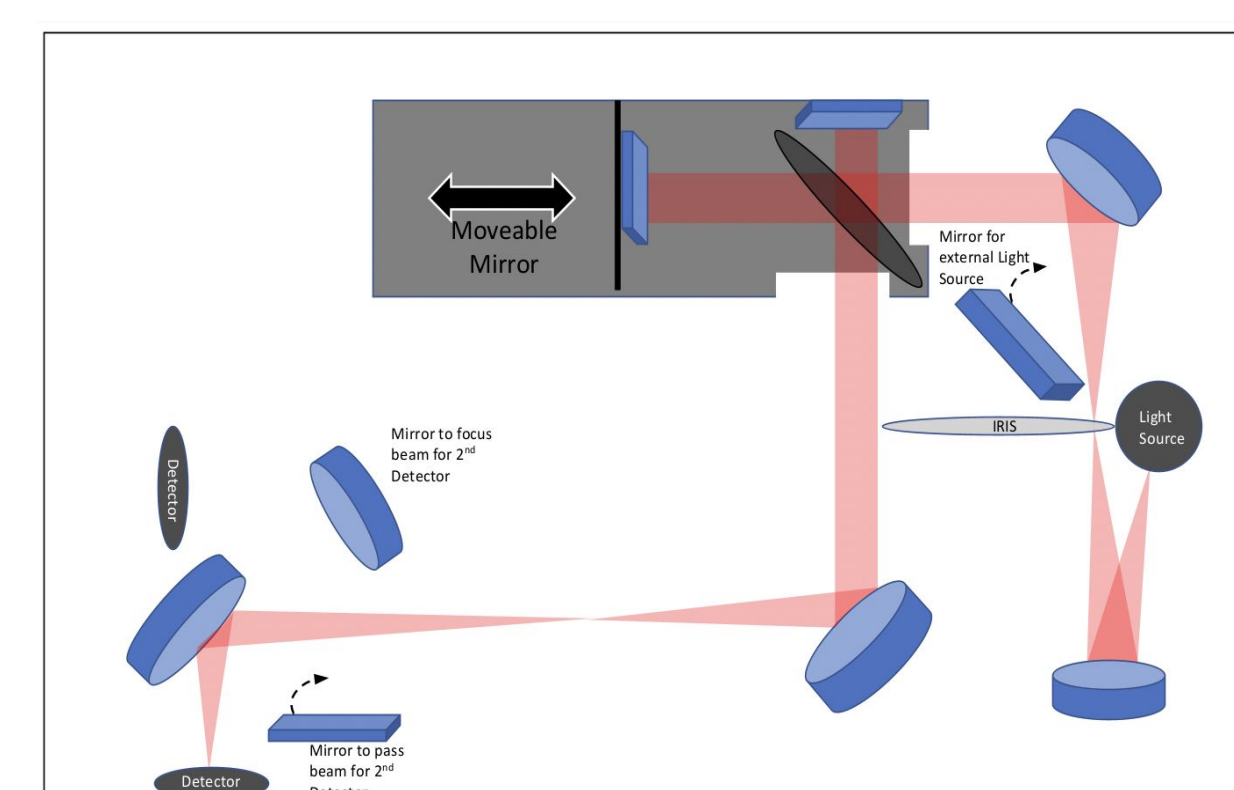


Diagram of the typical optical path for the FTIR spectrometer.



Test signal output read by the Arduino with help of External ADC. The test signal was fed using a function generator to produce a sine wave of 1.5MHz frequency, to verify the high response time.

Conclusion

In this work, we were able to successfully integrate the building blocks for the FTIR controller. Functionality of each component was successfully checked individually and are able to calibrate the light path with the help of the motors using GUI, along with reading and saving the signal from the detector with help of external ADC and GUI.

Acknowledges

I would like to thank Dr. Guangxin Ni for allowing me to work in his laboratory. I would also like to thank Dr. Songbin Cui and my mentor Aakash Gupta for sharing their knowledge and guidance throughout the entirety of the project.

References

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