Vacuum Chamber Control System

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Introduction

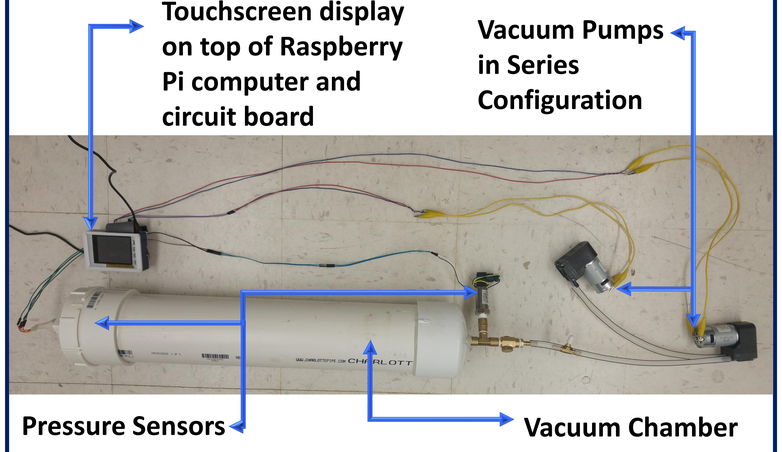
Vacuum chambers are enclosed systems from which gases are extracted by a vacuum pump creating a low-pressure environment for experimentation. The vacuum pump control system developed in this project will be used to test the efficacy of an acoustic temperature measurement system at various altitudes. One method of using sound to measure temperature is determining the time it takes sound waves to travel a certain distance and relating that speed with air temperature. This technology would be best employed at high altitudes where conventional temperature measurement systems are largely influenced by solar flux rather than the surrounding gas temperature.

Objective

Design a vacuum pump control system to simulate a low-pressure environment for testing an acoustic temperature measurement system

- Allow the user to select a desired air pressure on a touchscreen
- Maintain a constant pressure by monitoring the air pressure and controlling the vacuum pumps
- Remain compact

Major Components

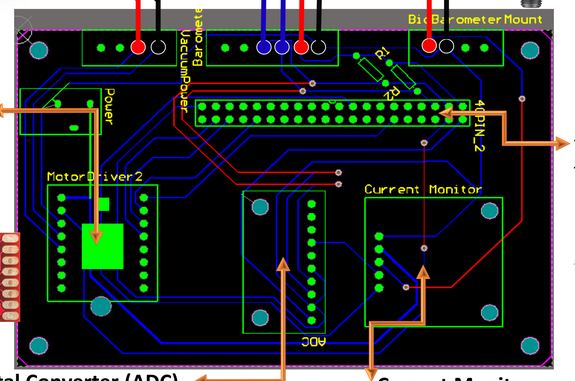


Circuit Board Design

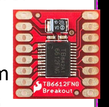
Vacuum Pump
Evacuates air from vacuum chamber

Sparkfun Pressure Sensor
Sits inside vacuum chamber. Sends live pressure readings to Raspberry Pi

Dwyer Pressure Sensor
Connected to vacuum chamber valve. Supply current is read by current sensor



Motor Driver
Receives signals from Raspberry Pi to control speed of two vacuum pumps



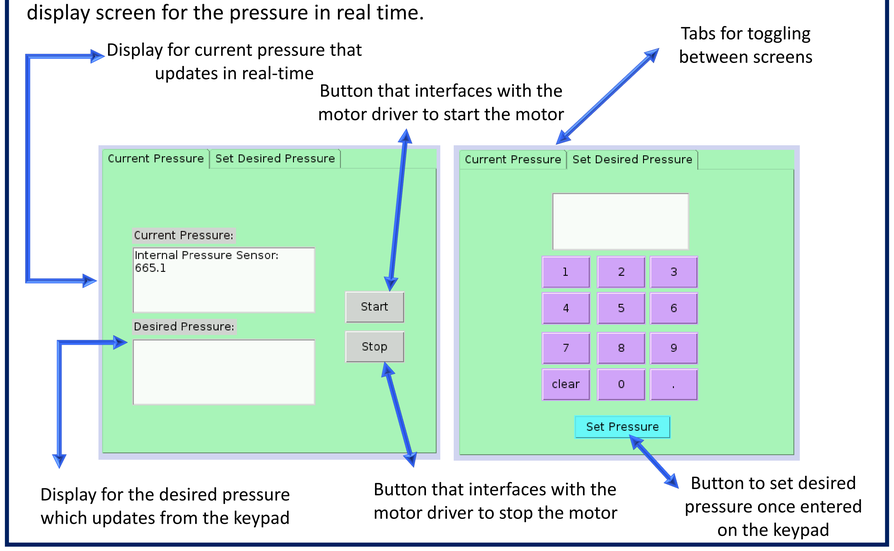
Ribbon Cable Connection
Ribbon cable connects Raspberry Pi to circuit board

Analog to Digital Converter (ADC)
Converts analog signals from current monitor to digital signals and sends them to Raspberry Pi

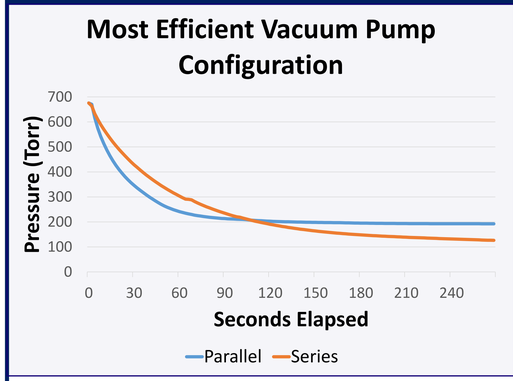
Current Monitor
Measures the current supplied to the Dwyer pressure sensor and sends signal to ADC

Software Design

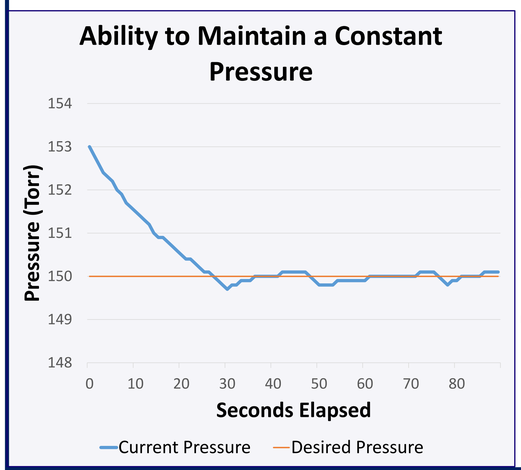
A GUI was created through PAGE (Python Automatic GUI Generator) which is a compatible program with the Raspberry Pi. The GUI utilizes a notebook structure where the user can switch between two tabs that display the keypad to enter the desired pressure and the display screen for the pressure in real time.



Results



- Two vacuum pumps in parallel can suck air faster
- Two vacuum pumps in series can reach lower pressures
- Adding more vacuum pumps in series could reach even lower pressure



- Once internal pressure reaches desired pressure value, vacuum pumps turn off
- Vacuum pumps turn on once internal pressure rises above the desired pressure
- Control system maintains air pressure to within +/- 0.2% of desired pressure

Conclusion

- User friendly GUI was created
- Efficient vacuum pump configuration determined
- Vacuum pumps can reach air pressure of 76 Torr, or 0.10 atmospheres
- Control system maintains pressure to within 0.2% of desired pressure
- Air pressure can be read with two different sensors, with the Sparkfun sensor being the most accurate

Future Work

- Add two more vacuum pumps to reach lower air pressure
- Create compact housing for vacuum pumps

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