Ohio University Vertical Wind Tunnel User's Manual

Last Updated: 2/23/2024

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About

The Ohio University Vertical Wind Tunnel started as a mechanical engineering senior design project in the fall of 2022. For senior design, local community members, or in the case of the Wind Tunnel Team, fellow university faculty, reach out to mechanical engineering professors with problems they would like solved. These problems are determined whether they would make good design projects and then are assigned to the senior year students in a 2-semester long capstone course.

Senior mechanical engineering students, Tag Fox, Greg Shaw, and Tony Tonkovich were assigned to the Wind Tunnel Team and spent fall and spring semesters working to develop a working product for Dr. John Schenk, the customer. Dr. Schenk was looking for a reliable method to aid in his research. He was hoping to use a vertical wind tunnel to produce a consistent way to analyze how different seeds disperse in the wind. The process of designing the product consisted of lots of research into aerodynamics, existing wind tunnel designs, coding and electronics, and some structural design. With new knowledge from reading literature and completing rapid learning models (RLMs), or small experiments, the team made informed decisions with guidance from the mechanical engineering senior design faculty. Ultimately, through a cycle of research, experimentation, and design, the final wind tunnel was approaching a working stage.

At the end of the year in spring of 2023, a working prototype was presented during "Senior Design Demo Day". While there were still some kinks to iron out, the function of hovering objects in the test section by controlling the speed of a fan was met. To finalize and further enhance the wind tunnel, work was continued as a research project under Dr. Jay Wilhelm, a mechanical engineering professor here at Ohio University. Through the summer and fall semesters of 2023, Tag Fox, member of the original Wind Tunnel Team, worked to improve the reliability and functionality of the wind tunnel. Some of the changes he made consisted of improved air flow with additional honeycomb meshes inside of the larger 3D printed contraction/flow straightener, a better graphical user interface (GUI) for testing, an improved microcontroller and sensors, and finally a more reliable velocity measurement system with the use of a Kiel Probe and differential pressure sensor. However, upon his graduation in fall of 2023, work was still unfinished.

Tag's work was picked up in December 2023 by Tony Tonkovich, a member of the senior design Wind Tunnel Team and now graduate student under Dr. Wilhelm. The main issues present in the current design were the size and power of the fan and an unfinished control interface. The previous design used a 48V fan with a CFM of 1026.8, which was overpowered. The senior design team chose the initial fan based on its physical size dimensions, as the goal was to maximize the diameter of the fan for flow quality purposes. However, the fan's airflow was too high for the size and weight of the desired seeds to be tested on.

While flow quality could be sacrificed by reducing the diameter of the fan, and therefore the diffusion ratio – or how much the diameter increases from the test section to the air outlet at the fan, a smaller fan would allow for the testing of the small seeds. Using a 12V – 67.9 CFM computer fan, a prototype mount was designed to test feasibility of using the smaller fan. Immediate success was seen as one of the sample seeds was able to hover in the airstream, there were no apparent reductions or issues with air flow quality.

The design was finalized by mounting the smaller fan and updates were made on the control and electronics side of things with the change in fan voltage requirements. Initially the fan's velocity was to be controlled directly and set by the user, but this was switched to simply controlling the throttle or PWM duty cycle of the fan instead. By controlling a duty cycle, the fan can be set to 0-100% throttle, which resulted in much more stable velocity readings during testing.

In February of 2024, Tony finalized all changes in the GUI and in the physical wind tunnel itself. These improvements allowed for actual testing of the desired seed size and resulted in a more reliable user control system.

Contact Information

For troubleshooting, servicing, or any other general questions, please contact one of the following people.

- Tony Tonkovich
    - Relation: Member of original senior design team. Currently (2024) a graduate student under Dr. Wilhelm at Ohio University, has worked on the tunnel most recently and finished the final product.
    - School/Work Email: mt024518@ohio.edu
    - Office Location: Stocker Center, Rm 296 or 255
    - Contact If: Help is needed in troubleshooting any physical, electronic, or software issues. If you have any questions regarding anything relating to the Wind Tunnel.

- Tag Fox
    - Relation: Member of original senior design team. Has some more knowledge relating to the deeper software and sensor topics.
    - School Email: tf825418@ohio.edu
    - Contact If: Tony cannot be reached first. Can help with some technical questions or help lead you to the next person to contact.

- Dr. Jay Wilhelm
    - Relation: Advisor for Tag and Tony while working on the project. Can help find a person to help solve any physical or technical problems with the tunnel.
    - Work Email: wilhelj1@ohio.edu
    - Office Location: Stocker Center, Mechanical Engineering Dept.
    - Contact If: No other contact has been reached or has been able to help.

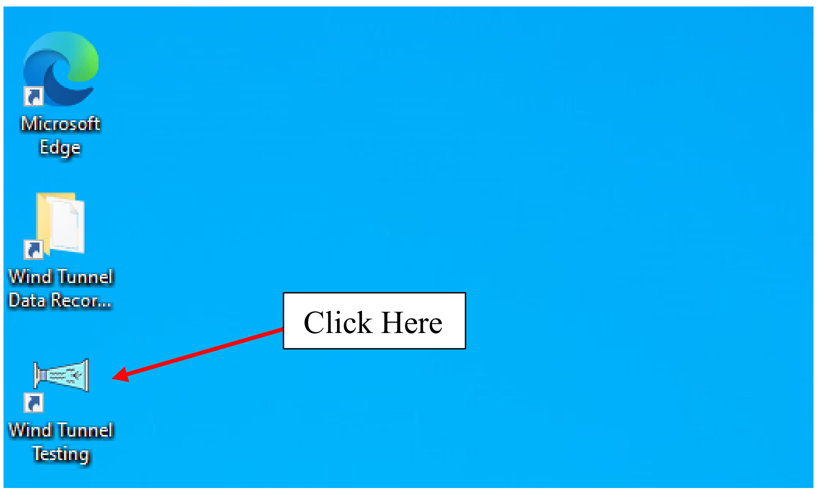
- Dr. John Schenk
    - Relation: Customer for the wind tunnel senior design project. Will likely be the one in charge of the tunnel upon reception of the product. Professor of PBIO at Ohio University.
    - Work Email: schenk@ohio.edu
    - Office Location: Porter Hall, Rm 401
    - Contact If: You are a student or researcher for Dr. Schenk and are working with the wind tunnel. He can help answer some questions and will direct any other questions and issues to the correct contact.

Startup

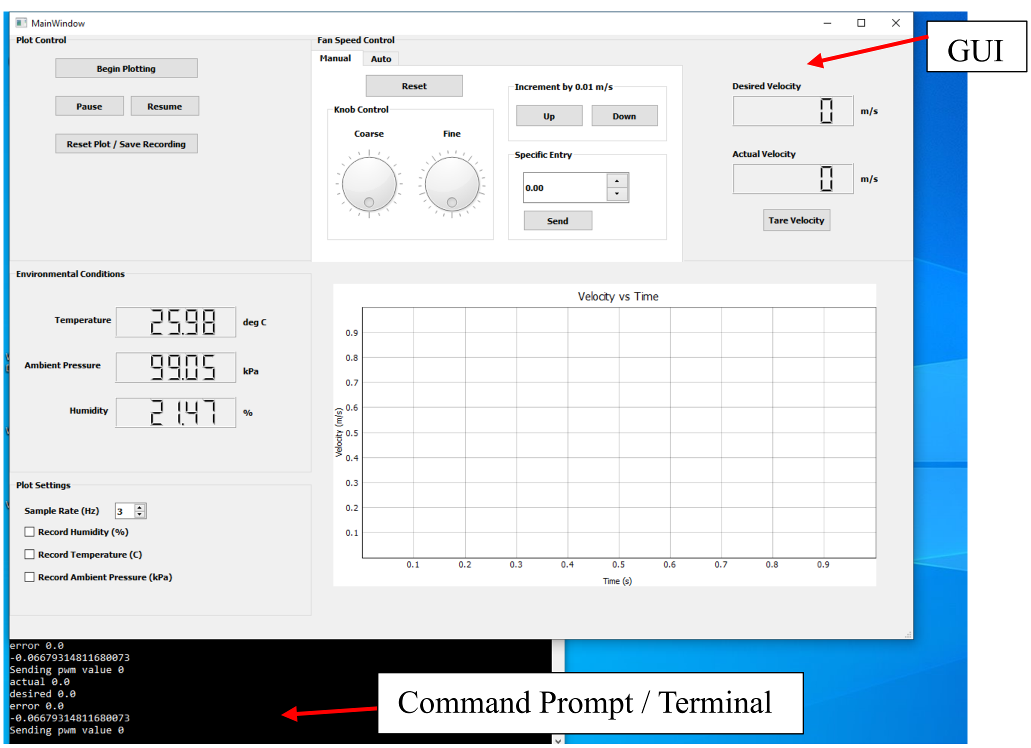
1. Turn on the power to the cart via the on-board power strip.
2. Power on the PC.
3. Log into the PC.

   Username: ou_wind_tunnel
   Password: wind

4. On the desktop, run the Wind Tunnel Testing script by clicking on the "**Wind Tunnel Testing**" icon.

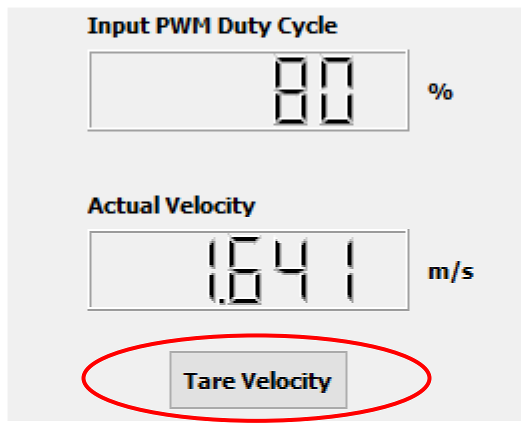


5. A graphical user interface (GUI) and terminal window should appear, as seen below:

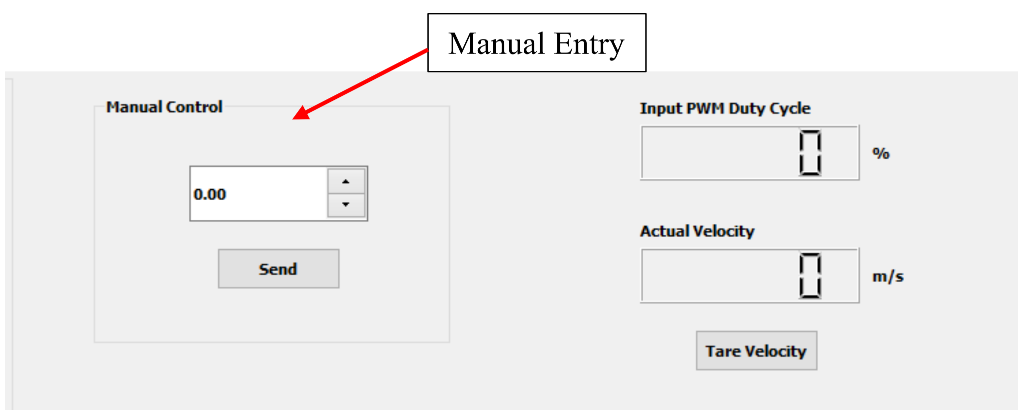


6. If values are not shown or are not constantly updating in the "Environmental Conditions" or "**Actual Velocity**" number boxes, please see the Troubleshooting section.

7. If "**Actual Velocity**" is consistently reading well above '0', hit the "**Tare Velocity**" button. Data updates will be paused for 5 seconds while the velocity is being tared.



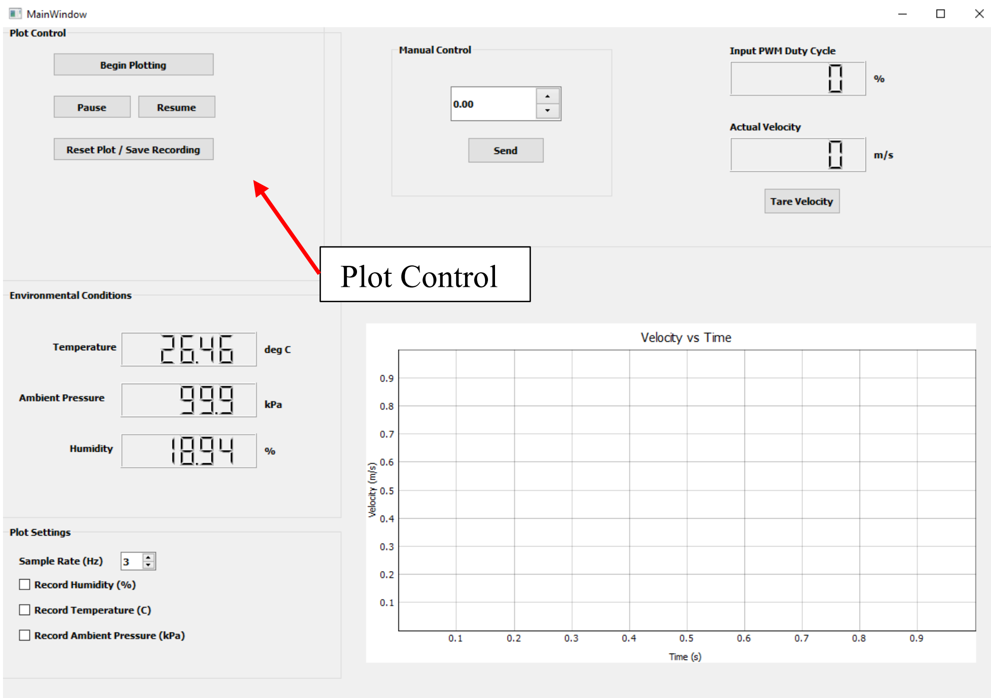
8. Begin testing by entering a desired duty cycle percentage into the manual control input. A duty cycle of 100% corresponds to the fan at full power, while 0% means the fan is off.



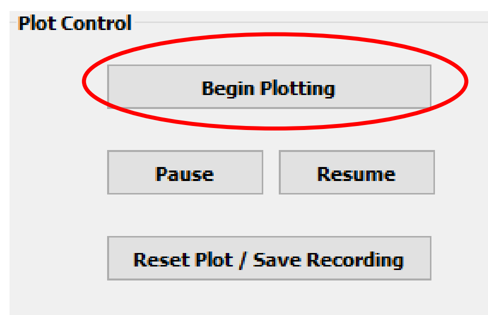
9. **WARNING**: If the program is closed without duty cycle being commanded to **0 percent**, the fan will continue to run at the last commanded value.

Data Recording

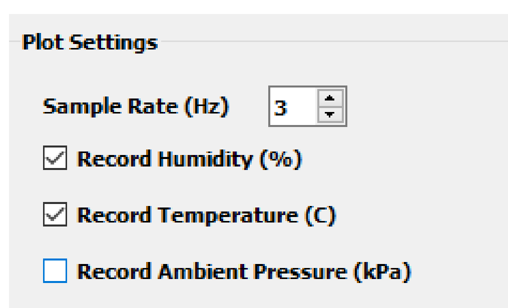
1. Wind tunnel Startup should be completed before beginning this section.
2. All plotting controls are in the top left corner of the GUI. See the image below.



3. With data coming in, begin plotting by simply clicking the "**Begin Plotting**" button. This will begin plotting the desired and actual velocities versus time on the plot in the GUI.

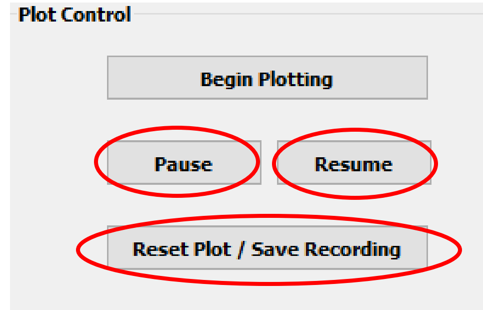


4. Adjustments to data plotting and recording can be made in the "**Plot Settings**" section. The sample rate adjusts the frequency data is recorded, while the other check boxes allow the user to select which environmental conditions to record. **However**, when selected, they are only recorded, **NOT** plotted.



5. For higher resolution in the data, the sample rate should be increased.

6. Data recording and plotting can be paused and resumed using the “Pause” and “Resume” buttons respectively.



7. To clear the plot, which will also save any recorded data, click the “**Reset Plot / Save Recording**” button. The desired and actual velocities, along with any selected environmental conditions, will be saved to a **.csv file**.

8. All files are automatically named in numerical order of recording and saved to the folder “**data_output**”, a folder shortcut is currently located on the desktop as “Wind Tunnel Data Recordings”.

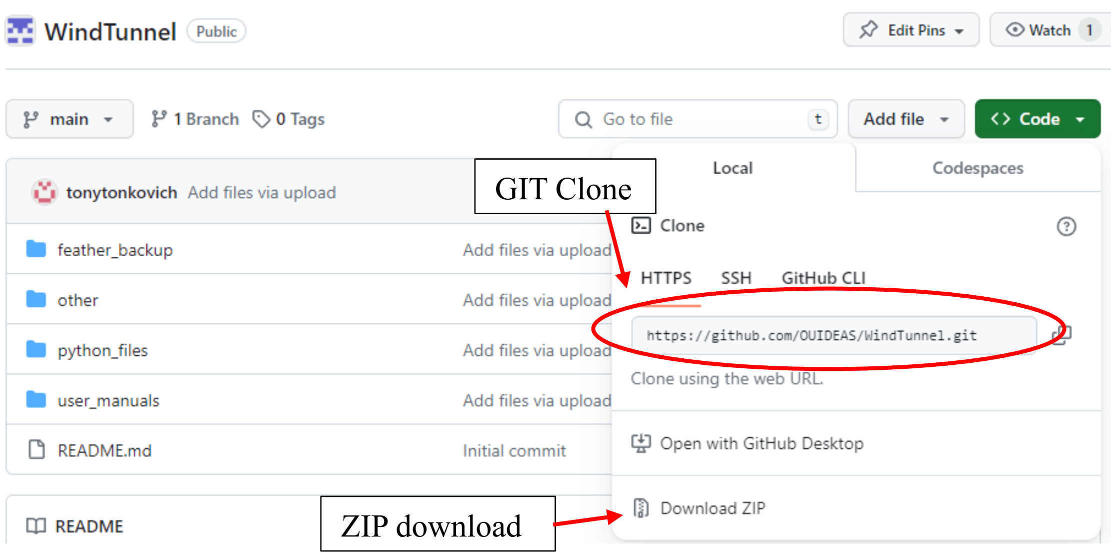
9. For post processing, data can be copied over to an external drive or sent via email (etc.) to be worked with on a separate computer. It is possible, but not suggested, to process data on the current wind tunnel PC.

New Computer Setup

This section outlines the process of setting up the wind tunnel testing GUI on a new computer.

Basic Setup

1. Python should already be installed on the new PC. If not, please refer to the [Python Installation] section of this document.
2. All files used for the Wind Tunnel GUI and backup Adafruit Feather files are located on a GitHub repository at this link: https://github.com/OUIDEAS/WindTunnel
3. The repository can be downloaded as a .zip file or cloned directly to the computer using a terminal window.



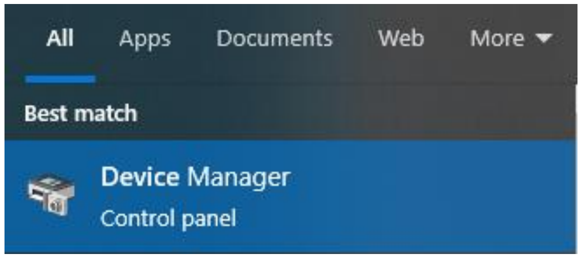
4. To clone, start by copying the clone link: https://github.com/OUIDEAS/WindTunnel.git
5. Open a terminal window by searching for "command prompt" in the Windows Start menu.
6. Navigate to the location you want the wind tunnel repository to be located, the Documents folder for example: "`cd Documents`".

7. Type "git clone" and then paste the copied link:

   "`git clone https://github.com/OUIDEAS/WindTunnel.git`"

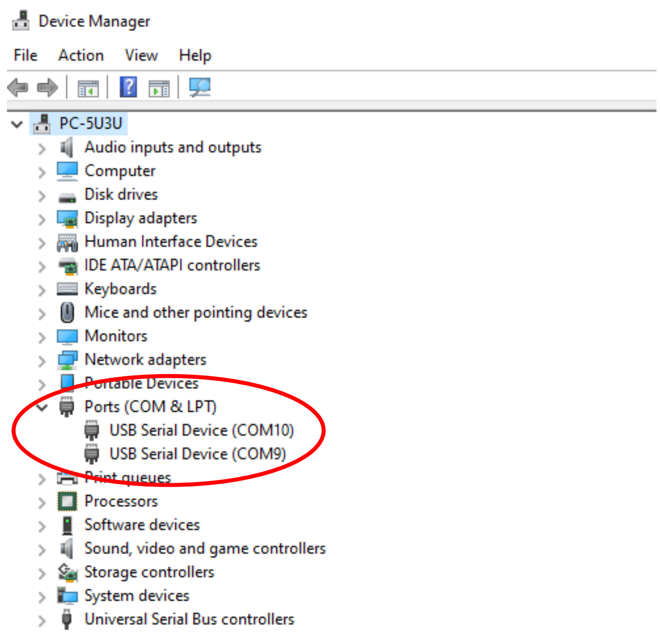
   Hit enter, the documents folder should now contain a **WindTunnel** folder with all the necessary files.

8. Plug the feather into a USB port on the computer and open Device Manager. If unable to locate, hit the "**windows**" key on the keyboard and type "**device manager**".

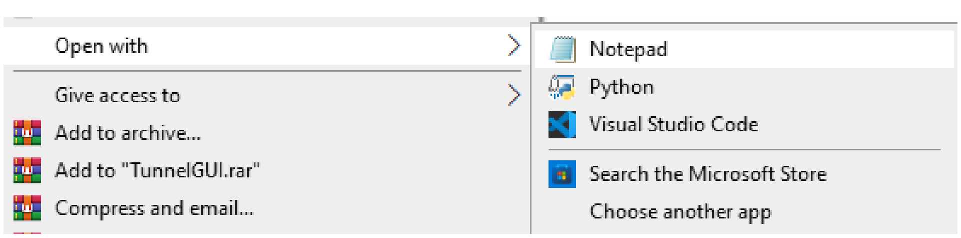


9. Within Device Manager, click on "**Ports (COM & LPT)**" to open its drop-down tab.

   This step is to locate which COM ports the feather is named under. There should be two new ports, if unable to recognize which are new, unplug all other USB devices (keyboard/mouse is fine) from the PC. The two feather COM ports should be consecutive numbers.

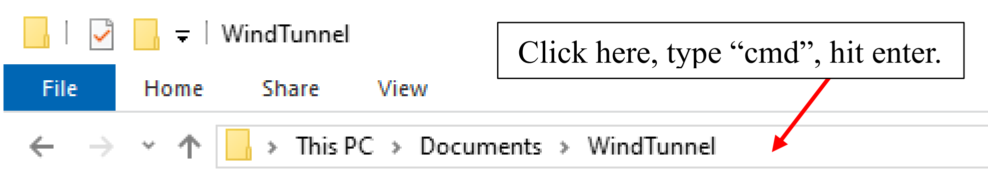


10. Denote which two ports correspond to the RP2040 Feather.
11. Navigate to the new location of the "**WindTunnel**" and open "**TunnelGUI**" by right clicking, selecting "**Open With**", and choosing "**Notepad**".



12. In Notepad, scroll down to line 70 (see bottom right corner) and change the COM values to the corresponding COM ports of the new PC. The "`self.console_port`" should be the lower #, while "`self.data_port`" is the higher port #.

13. Save the edits and close Notepad.
14. Return to the "**WindTunnel**" folder in File Explorer, click on the address bar while inside the "**WindTunnel**" folder, type "**cmd**", and hit enter.



15. In the command window, type "`python TunnelGUI.py`" and hit enter. You may need to try "`python3 TunnelGUI.py`" depending on Python version. The GUI should open, refer to the Startup section for operation.

Complete Setup

Instead of using the command prompt to start the GUI, the complete setup will list instructions on how to setup a desktop shortcut to start the GUI automatically.

1. Complete steps 1-9 in the Basic Setup section.
2. Open the "WindTunnel" folder and shift+ctrl+right click on the folder named "**python_files**" to copy the folder "**as path**", it should look similar to below:

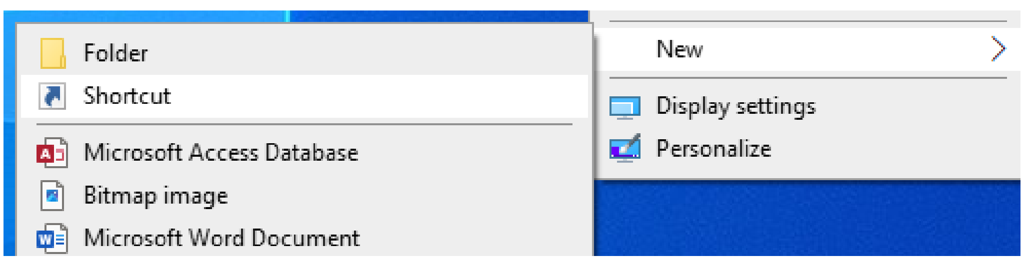
   ```
   "C:\Users\-----\Documents\WindTunnel\python_files"
   ```

3. Now enter the folder named "other" and edit the "**execute**" file by right clicking. The file should have three lines of code:

   ```
   @echo off
   cd C:\Users\ou_wind_tunnel\Documents\WindTunnel/python_files
   python3 TunnelGUI.py
   ```

   Replace the highlighted text with the folder path that was just copied and hit save. Double clicking on the "**execute**" file should now run the GUI. This can be taken a step further by making a desktop shortcut.

4. Return to your desktop and right click. Select "**New**" and then select "**Shortcut**".



5. Select the previously edited "**execute**" file for the item to create a shortcut for. The file path can be copy and pasted or you can simply browse for the file.
6. Name the shortcut "**Wind Tunnel**" or something similar. Other settings can be changed by right clicking on the shortcut and selecting "**properties**".
7. This shortcut should now successfully open and run the Wind Tunnel GUI.

Python Installation

This section lays out instructions on how to install Python to a PC to run the GUI.

1. Navigate to Python's downloads page on your browser using this link: https://www.python.org/downloads/ to download a specific version or for an operating system other than Windows (macOS or Linux), or download the same Windows version used on the original Wind Tunnel PC here:

   https://www.python.org/ftp/python/3.8.10/python-3.8.10-amd64.exe

2. Run the installer application once downloaded and finish the installation process.
3. Follow any other instructions the installer provides. Installation should be complete; tutorials are available online as well for extra help.

   How to install Python: https://youtu.be/nU2Egc3Zx3Q?si=iHFgzhdvFqYpWrRa

4. Ensure that the WindTunnel GitHub page was cloned. Follow steps 2-7 in the Basic Setup section.
5. Open a command line: "**Command Prompt**" on Windows or "**Terminal**" on macOS and Linux.
6. Navigate to the location of the "**requirements.txt**" file on the new PC in the terminal. It should be located inside of the folder named "**other**".
7. Install the required packages to Python by entering: `"pip install -r requirements.txt"`.

8. Installation process finished.

Troubleshooting

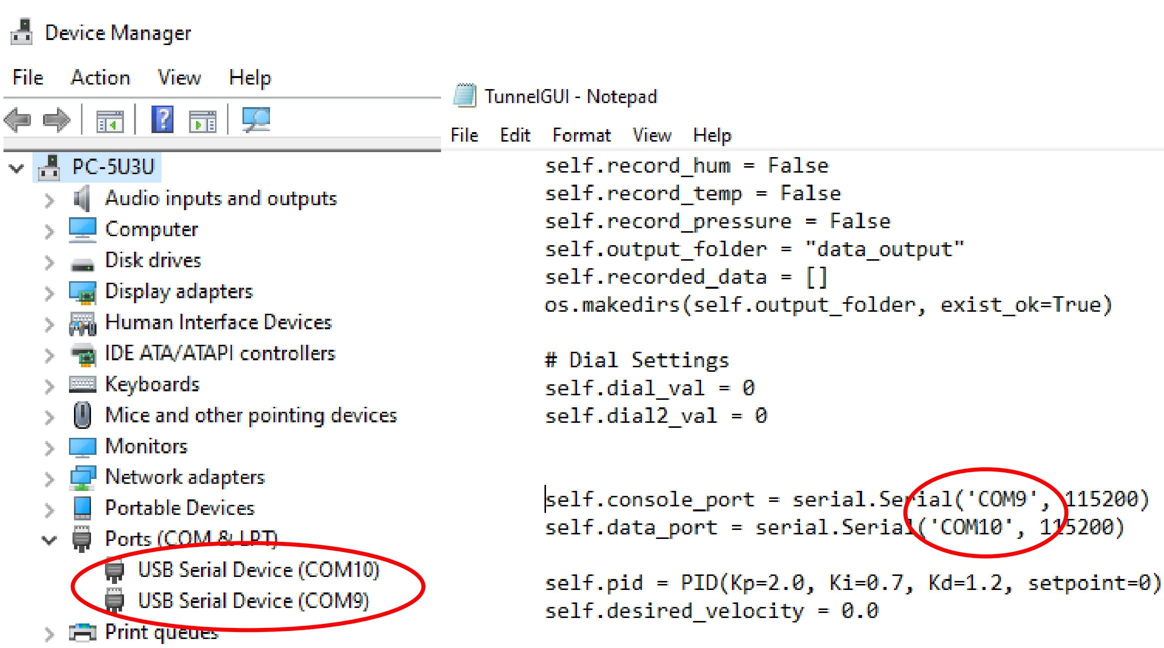
This section will be populated with solutions to issues as they arise. Currently the wind tunnel has been consistently working properly with very few issues. Some basic troubleshooting checks will be outlined below.

1. If seeing errors in the terminal window that relate to ports and objects having “**no attributes**”, like in the image below, check that both USBs are plugged into the PC.

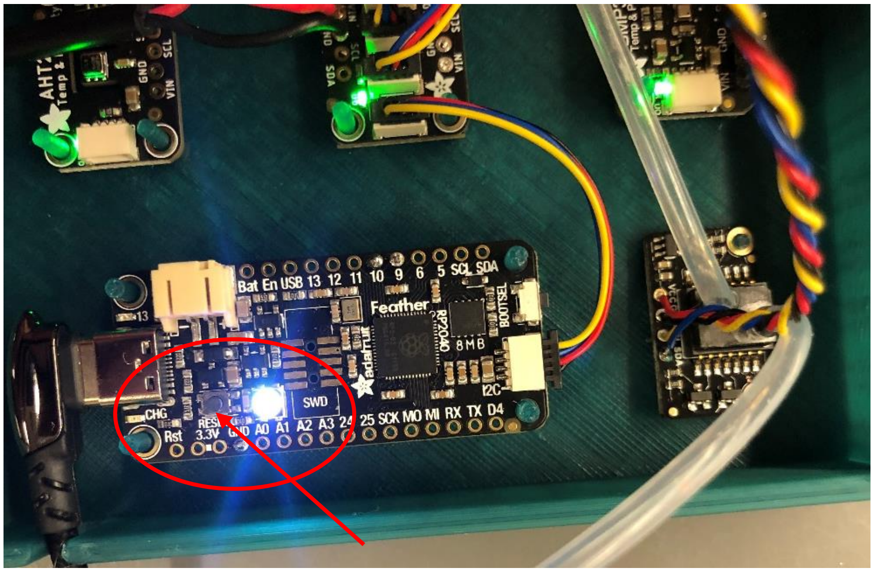
```
AttributeError: 'MainWindow' object has no attribute 'console_port'
Traceback (most recent call last):
  File "c:/Users/tonyt/Documents/TunnelCode/newTunnelGUI.py", line 242, in update_data
    data = self.get_data(self.console_port, self.data_port)
AttributeError: 'MainWindow' object has no attribute 'console_port'
Traceback (most recent call last):
  File "c:/Users/tonyt/Documents/TunnelCode/newTunnelGUI.py", line 242, in update_data
    data = self.get_data(self.console_port, self.data_port)
AttributeError: 'MainWindow' object has no attribute 'console_port'
Traceback (most recent call last):
  File "c:/Users/tonyt/Documents/TunnelCode/newTunnelGUI.py", line 242, in update_data
    data = self.get_data(self.console_port, self.data_port)
AttributeError: 'MainWindow' object has no attribute 'console_port'
```

2. If USBs are plugged in and all sensors and the Adafruit Feather are lit up with green LEDs, but the same (or similar) errors are occurring, check the COM port numbers in the **device manager** and in the **TunnelGUI.py** code.

   This process is outlined in the Basic Setup section. Follow similar steps to check if the COM ports in both locations match.

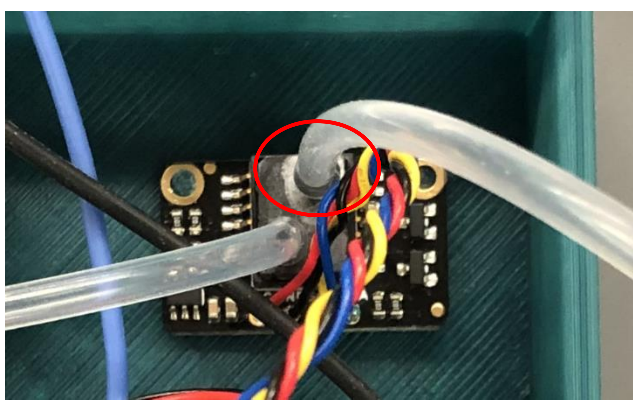


3. If the GUI opens, but values are frozen and there is a white LED showing on the Feather, it usually means there has been an issue with either the Feather or one of the sensors.



This issue can be a bit sporadic and finicky but resetting the Feather by clicking the button shown at the end of the arrow, unplugging both USB cables, and by moving and straightening out some of the sensor wires, this error can usually be solved.

4. If the velocity does not appear to be changing with a change in the fan duty cycle, or if values just seem to be inconsistent and off, check to see if pressure tubes are connected properly.



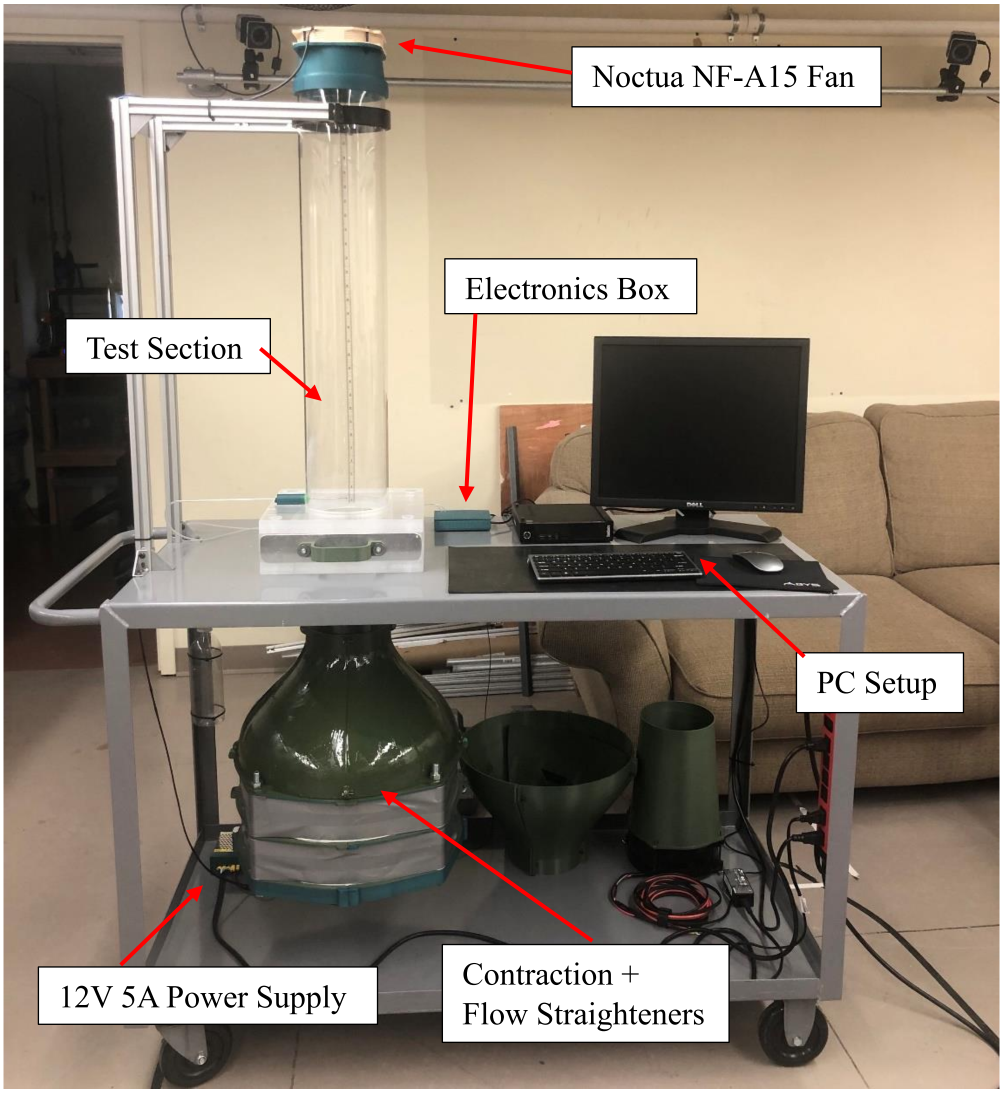
Both tubes should be snug over the DP sensor fittings. The tube with a red circle in the image above should be connected to the Kiel Probe, which is located inside the tunnel.

5. If inconsistency continues with velocity readings and both tubes are connected securely, check the other end of the tube that is not connected to the Kiel Probe.

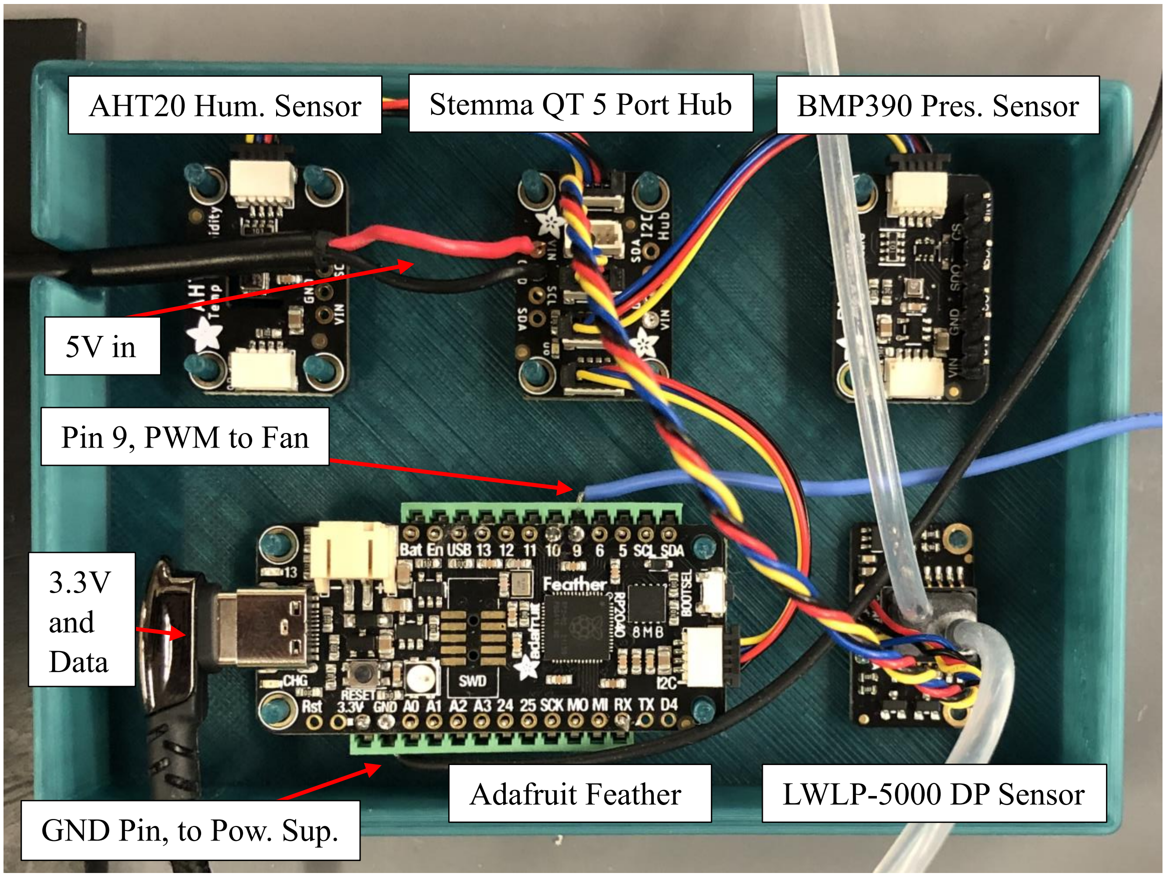
The other end of this tube is to read the atmospheric pressure in the room. To ensure the readings do not fluctuate drastically, the tube end is inside of a bottle (with a few holes drilled in it). This ensures that drafts or other air disturbances in the test room do not influence the velocity. If this tube is not in the bottle, it could cause inconsistencies.

Figures

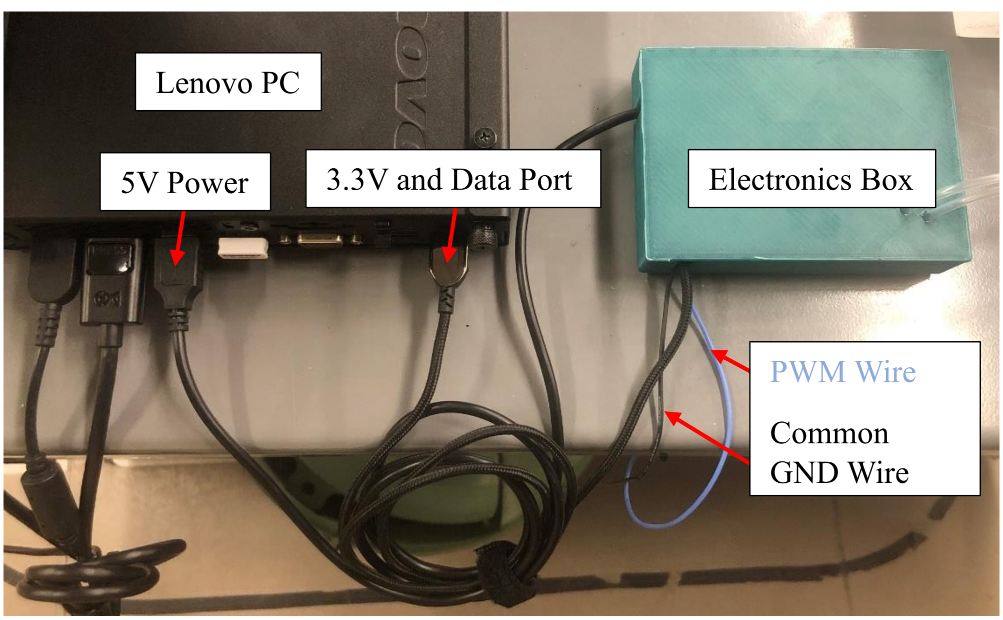
Complete Wind Tunnel System Diagram



Electronics Box Diagram



PC Cable and Port Diagram



Power Supply Diagram