Home Weather Station Documentation

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A picture containing text, building, brick, outdoor

Description automatically generated

Figure 1

A picture containing computer

Description automatically generated

Figure 2

Introduction

The scope of this project is to implement a home weather station with the capabilities to measure quantities such as air temperature, humidity, air pressure, VOCs (Volatile Organic Compounds, and wind speed using a raspberry pi and various sensors, with the capacity to add further sensors later. Additionally, several parts to the apparatus have been designed and 3D printed from scratch. Data is collected from the home weather station and sent to Weather Underground website where it can be displayed, tracked, and accessed.

Hardware

To implement the design of the home weather station, the following hardware was purchased:

* Raspberry Pi 3A+
* Adafruit BME680 (<https://www.adafruit.com/product/3660>)
* Reflective IR sensor with included resistors (<https://www.adafruit.com/product/2349>)
* QILIPSU Hinged Cover Junction Box (Amazon)
* Jumper cables
* Breadboard
* Several minor components to aid in design

In addition, several components were 3D printed to assist in the hardware demands. These components include:

* Wind vane
* Wind vane support structure

Circuit Diagram:

Chart, line chart

Description automatically generated

Figure 3

Software

Software for this project was implemented with the use of Python. The latest code for this program can be found on my GitHub page. (<https://github.com/AndrewNowak/Home_Weather_Project>)

Before implementing the software, several variables should be changed to fit your needs. The vane radius in line 15 must be changed to the radius (in meters) of your vane to properly calculate wind speed. Additionally, line 49 and 50 must be changed to reflect the station ID and password given by Weather Underground so that information can be properly sent. For more information on connecting to Weather Underground and retrieving this information, see resource 2. Depending on this information that is going to be sent to Weather Underground, lines 55 through 63 may need to be updated as well.

Design and Build Process

The Raspberry Pi was chosen as the main computing power for this project because of its of internet capabilities for uploading data to the Weather Underground website. Due to supply shortages and increased demand, however, new Raspberry Pi’s have become exponentially difficult to purchase. For this reason, an older model, the Raspberry Pi 3A+, has been used in this project, but any Pi with internet access should work. Furthermore, because the station is meant to mounted outdoors, care should be taken in considering how the Pi will be protected from outdoor conditions. I chose to purchase the QILIPSU weatherproof junction box 8.6” x 6.7” x 4.3” to house the sensitive hardware. This product provides the necessary space to house the components, plus extra space for the addition of future sensors, while protecting for potentially hazardous conditions.

The sensors attached to the Raspberry Pi include the BME680 sensor and the IR reflective sensor purchased from Adafruit. The appropriate manual should be referenced when connecting any equipment to the Pi.

The BME680 is capable of detecting temperature, pressure humidity, and VOC content. While VOC content may be interesting and useful to measure, it is not used in this project as it does not seem that Weather Underground has a useful way to display this information at the time of writing. The BME280 sensor is a simpler version that measures the same quantities, beside VOC, and may be used as replacement. The circuit diagram given inf figure 3 shows the pinouts of how the BME680 is connected to my Pi. From left to right, Vin on the BME680 is connected to Pin 17 of the Pi, GND is connected to Pin 39, SCK is connected to Pin 5, and SDI is connected to Pin 3 of the Pi. The BME680 sensor in my station is mounted outside of the main housing through a hole drilled in the side so that the sensor can get a better reading of the ambient air, however, to avoid hazardous conditions it is contained within a PVC elbow glued externally.

The IR reflective sensor is used in this project to detect wind speeds. The IR sensor works by emitting an infrared signal with the hope to detect the signal again if it is reflected back to the sensor. From my experience, the sensor is best for detecting from within about a half inch. The circuit diagram in figure 3 can be viewed for implementation of this sensor with the Raspberry Pi. For this project, air movement will cause a protruding wind vane to spin. Attached to shaft of the wind vane, located inside the weatherproof housing is a small disc that will rotate with the wind vane. The disc should be black with approximately one quarter of it being white. I 3D printed a disc using black PLA and used white paint make a mark covering one-quarter of the disc. When the disc rotates with the wind vane, the sensor can be used to measure how many times the white marking has passed, in other words, how many times the wind vane has rotated. By defining a period of measurement, the number of rotations, along with some physical dimensions, can be used to find the average wind speed over the time interval. For my purposes, the entire vane was made from 3D printed parts and a pen for the shaft. Additionally, due to the dimensions of the housing, a stand was 3D printed for the pen to rest on. The components can be seen in the figures 1 and 2.

The Raspberry Pi is mounted to the housing with screws, while the breadboard is designed to stick to the back plate. The reflective sensor also needs to be mounted to hover just below the disc of the wind vane so that it can properly detect rotation. For my station, I used a small metal wrench for the IR sensor to rest on, and some tape on either side to ensure it does not slide.

Finally, it is recommended that the Raspberry Pi is set to run the program automatically upon bootup. I have found this useful so that the program doesn’t have to be manually run remotely from another computer if something happens to the station or it loses power.

Improvements and Future Considerations

After approximately 3 weeks of implementation a few flaws have been noticed that could be approved upon in future designs.

First, the placement of the weather station seems to be very important. Currently, my station is mounted to a brick wall in an enclosed patio area. Due to the enclosure, the station does a poor job of measuring wind speeds because wind hardly has a chance to reach it. Readings can be made on windier days, but with diminished results. While wind speed values may not be accurate, changes in wind speed may still be an approximately useful tool in determining whether it is a light or strong wind day.

Additionally, due to the station placement, it comes within direct sunlight around mid-day. This seems to have the effect of displaying much higher temperatures during this time than may be expected. Like the wind vane, while the temperature may not always be fully accurate, it gives a very good picture of the change in temperature throughout the day. Additionally, this may give a decent indication of temperature in direct sunlight as well. To correct this issue, however, it is recommended placing the station in a location with plenty of shade.

Finally, the location of the wind vane seems to be one of the biggest flaws subject to design improvements. Protruding from the top of the station, this creates a hole where precipitation may enter the housing to inflict damage on the Pi or other hardware. Future improvements will focus on fixing this design flaw in a way to move the wind vane to the side of the junction box, possibly using a PVC attachment, much in the same way the BME680 is positioned. This would do much to improve the ability of the design to prevent moisture from entering the housing, while also possibly allowing the station to read wind better.

Additional Resources

1) The YouTube channel Explaining Computers does an excellent job showing tutorials on tons of projects with Raspberry Pi. The following link shows a video of their design of an anemometer using the same sensing technology. My design is heavily adapted from what they show in this video, so I must give much praise and highly recommend watching.

<https://www.youtube.com/watch?v=1LPEPZ02-t8&t=485s>

2) The following tutorial proved immensely useful in learning how to use Weather Underground for the purpose of uploading data. I highly recommend reading through to get an understanding of how the information is uploaded through the Software.

<https://projects.raspberrypi.org/en/projects/uploading-weather-data-to-weather-underground>