### Constructing a cost effective weather station using microcontroller technology

Robby Dorsey  
Mentored by Mr. Michael Padovani

#### Introduction

An important yet often overlooked aspect of everyday life is the usefulness of weather data. From choosing what to wear on a given day to planning outdoor events, the forecast plays a significant role in decision making (Ram & Gupta, 2016). However, most people do not stop to consider the ways that such data on the weather is collected. Data used to predict the weather is acquired through networks of weather stations collecting data such as temperature, relative humidity, and pressure. While many of these stations are professionally owned and operated, weather hobbyists and enthusiasts can participate as well. They can maintain their own weather stations and even submit their data to the National Oceanic and Atmospheric Administration (NOAA).

Unfortunately, the barrier to entry is quite high, as the necessary instruments and equipment can easily cost hundreds or thousands of dollars. However, there are a great number of sensors and instruments available online, many of which are significantly cheaper than their professional counterparts (Baker, 2014). The goal of this project was to assemble a DIY weather station composed of these inexpensive parts and an Arduino microcontroller. The purpose was ultimately to determine whether or not the data from this station was comparable to that of a highly-calibrated, professionally operated station.

#### Materials and Methods

This station made use of the ESP32, a microcontroller with a high storage capacity, as well as Bluetooth and Wi-Fi capabilities. This ESP32 ran the code that was developed for the station. An AM2315 sensor was used to measure temperature and relative humidity, while pressure was measured by a BME280. A TSL2561 collected data for light levels and was reported in lux. To measure soil temperature, a waterproof DS18B20 temperature sensor was utilized, while a hygrometer was used to measure soil moisture. Lastly, an Adafruit anemometer was used to collect wind speed.

In addition to the sensors above, a DS3231 real time clock module was used to attach timestamps to reported values. In order to get more accurate results from the anemometer and hygrometer, an ADS1115 analog-to-digital converter was added. Lastly, an SD card reader/writer was utilized to save data to an SD card.

The logic for the code can be found in Figure 1. The code first retrieved the raw data from each of the sensors. Next, the data was converted from raw values to appropriate units that could be interpreted by humans. Lastly, the data was saved onto an SD card and uploaded to ThingSpeak, an online resource for creating databases.

The sensors were connected to a printed circuit board (PCB), which was designed in Autodesk EAGLE (Figure 2). The PCB was cut from an FR4 copper clad board with pin headers and resistors later soldered onto it. After testing for short circuits, the sensors were then fitted onto the PCB.

The AM2315 required a solar shield, a structure which minimizes the effect of direct solar radiation on the temperature readings. The design of a bracket was necessary to join the sensor and the solar shield (Figure 3). The bracket was designed in Autodesk Fusion 360. The station was constructed out of wood to resemble a birdhouse, shown in Figure 4. The station had a wing-like structure on the side to hold the AM2315 and solar shield. The station had small holes for wires to go through and an acrylic panel to allow light into the station for the TSL2561. The station was powered by a 12 volt battery that was charged with a 5 watt solar panel. A charge controller regulated the voltage for the ESP32 and peripheral sensors by connecting the solar panel, battery, and PCB together. The solar panel was mounted to the front of the station, since both the panel and station needed to be facing south.

#### Materials and Methods (cont.)

![Sensors send data to ESP32](image)

Figure 1: The simplified process of the code. The flowchart illustrates the logic for the code, where the sensors send data to the ESP32 and the ESP32 sends the data to ThingSpeak and saves it to the SD Card.

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#### Results

During the development of the station, a small number of values were collected for the ESP32 station before it was placed outdoors. The ESP32 station was placed on the same pole as a Davis Instruments Vantage Pro2 station which was owned and operated by the Science and Math Academy. Data was supposed to be collected over a few days. However, when the SD Card was retrieved for testing, it was discovered that no data had been collected. When the station was analyzed, it was noted that multiple sensors had not been functioning properly, despite working normally in the classroom. The issues could not be fixed in a timely manner and no data was collected for testing.

#### Conclusion

The goal of the project was to create a weather station that was less expensive than professional weather stations but still give comparable data. Unfortunately, the station was unable to collect data for comparison. This illustrates one of the difficulties of collecting data, being that faulty equipment can inhibit collection. Regarding professional weather stations, there is a much lower chance of sensor failure on a scale from which this station endured. A clear opportunity for further research would be to investigate what caused this station to fail and to take measures to prevent an event like this from recocurring.

#### References


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