

# Connecting Sensors to Pi

Kyle McCarty and Marc Los Huertos\*

October 27, 2020

## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	What is particulate matter? . . . . .	1
<b>2</b>	<b>PMS5003 Particulate matter sensor</b>	<b>2</b>
2.1	Sensor Purchase . . . . .	2
2.2	Sensor Construction and Operation . . . . .	2
2.3	PMS5003 Sensor and IO . . . . .	2
2.4	Wiring . . . . .	3
2.5	Code and Testing . . . . .	5
2.6	Python Code . . . . .	9
<b>3</b>	<b>MQ Sensors</b>	<b>12</b>
3.1	Additional Sensors . . . . .	12

## 1 Introduction

### 1.1 What is particulate matter?

PM stands for particulate matter (also called particle pollution). Particulate Matter is a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

Particle pollution can be classified by size:

**PM10** inhalable particles, with diameters that are generally 10 micrometers and smaller; and

---

\*Acknowledgments: Much of the project is based on summer research conducted by Anna Burns.



Figure 1: PMS5003 Box, with sensor and static protective bag.

**PM2.5** fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

NOTE: The average human hair is about 70 micrometers in diameter — making it 30 times larger than the largest fine particle.

## 2 PMS5003 Particulate matter sensor

### 2.1 Sensor Purchase

The Digital Particle Concentration Laser Sensor Plantower PMS5003 PM2.5 PM10 is produced in China. With 25 purchases, they cost about \$23 each.

### 2.2 Sensor Construction and Operation

### 2.3 PMS5003 Sensor and IO

The PMS5003 is a blue case with a small fan (Figure 1).

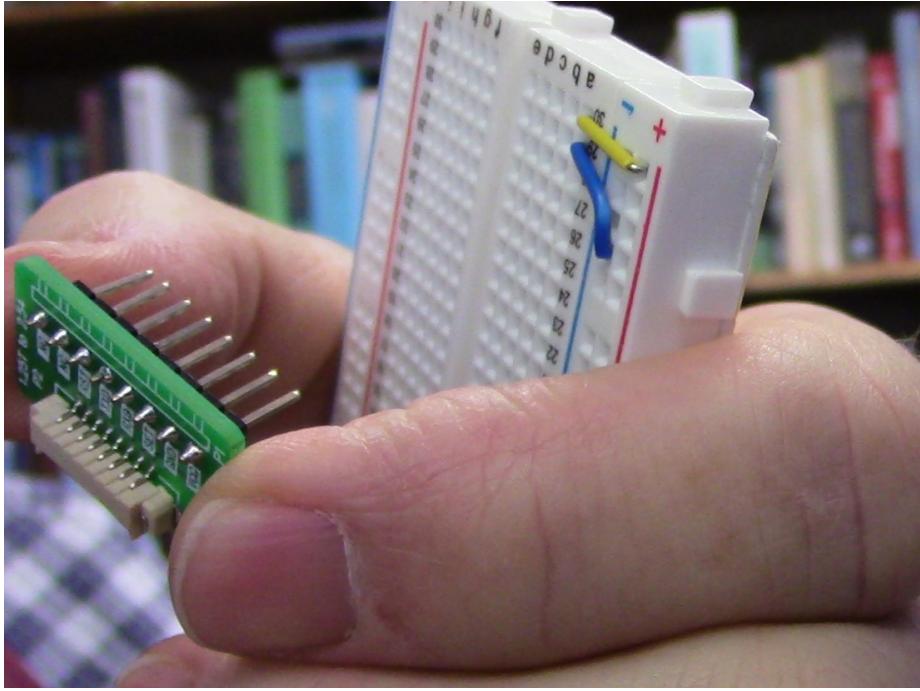


Figure 2: PMS5003 adapter board. Notice the labels for each pin, e.g. VCC (5V), GND (Ground).

This sensor comes with eight female-to-female connectors as well as an adapter for the Raspberry Pi, and a connector for the Raspberry Pi and the adapter itself.

## 2.4 Wiring

1. Begin by connecting the sensor to the adapter. Take the black/red ribbon wires with white blocks on either end and attach them to both the sensor and the small adapter board (Figure 2); they attach with the “shiny” side up, and you need to give them quite a push to get them to go in fully. They should be snug, and not at all loose.
2. Next, we’ll connect two bare wires (small wires without black rectangles). Connect the positive rail (+ red strip on breadboard) to A30 and the ground rail (- blue strip on breadboard) to A29 (Figure 6).
3. Attach the PMS5003 adapter to the Breadboard address (row/column) 23b-30b, where the 30b aligns with the 5 volt power (Figure ??). When you press the adapter on, it will feel nice and snug. Note the little labels on the adaptor, e.g. VCC (5 volt), GRD (ground), TXD (transmit), and RXD

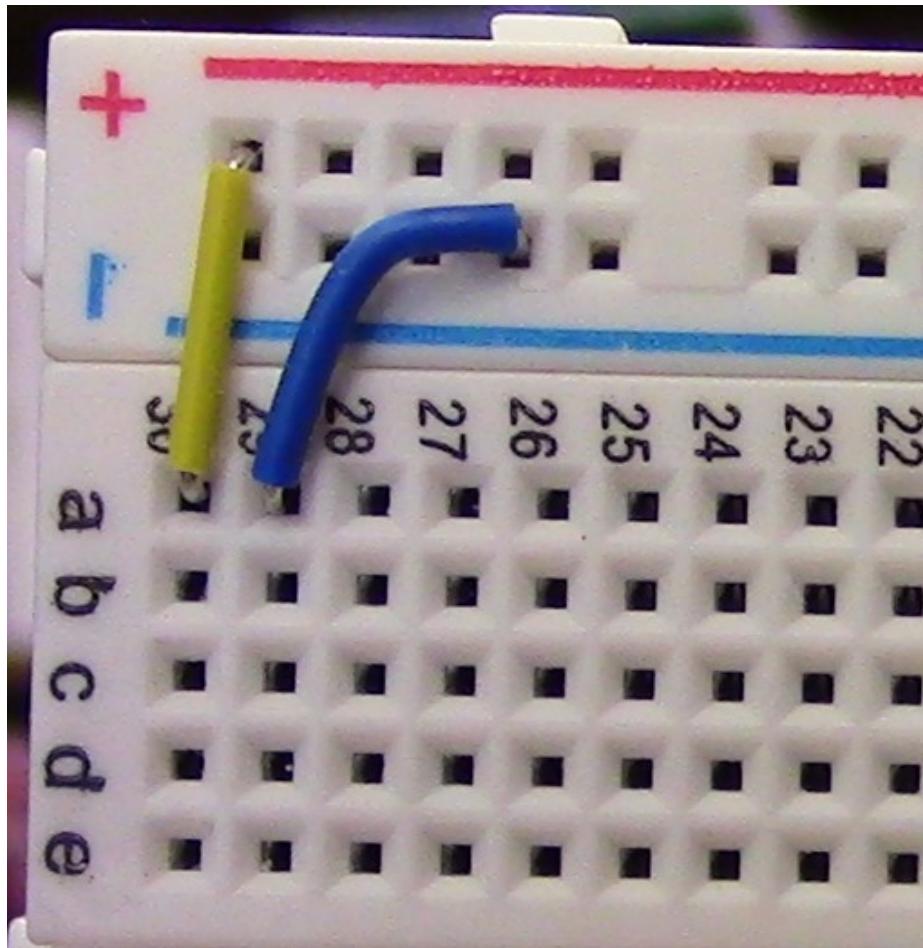


Figure 3: Positive and Ground wires connected from rails to specific breadboard rows.

(recieve), plus some others. This are the basic for UART communications, the basic communication protocol for USB cables. (Interesting...)

4. Connect 2 male-to-female jumpers (the ones with the black rectangles on either end):
  - Connect a jumper from 5V PIN 2 on the Raspberry Pi to the 5V rail on the breadboard.
  - Connect a jumper from the GND PIN 9 on the Raspberry Pi to the ground rail on the breadboard.
  - Connect the jumper wire from the row corresponding to the RXD (recieve) terminal (Breadboard d27) to TXD (transmit) PIN 8 on the Raspberry Pi.
  - Connect the jumper wire from the row corresponding to the TXD (transmit) terminal (Breadboard d16)to RXD (recieve) PIN 10 on the Raspberry Pi.
  - connect the resistor from the ground rail to the i21 on the breadboard (Figure ??).
  - connect the LED from the j21 to j22 (short wire in j21).
  - connect a jumper from (i22-electrically connected to the LED via row 22) to GPIO 24 (PIN 18).
5. Double check the wiring with the following images (Figure 7).

## 2.5 Code and Testing

1. Connect your Pi to power and PMS5003 fan should start.
2. Connect you computer to the Pi using the VNC connection.
3. Check to make sure that it is working. If not shut the Pi down (via the command ‘sudo shutdown’ and check the wiring.
4. Start the terminal window.
5. Enter “sudo raspi-config”.
6. Select Option 5 (“Interfacing Options”).
7. Enable ARM I2C by selecting it in this menu and then pressing Yes.
8. Then to enable Serial, select Option 5 (“Interfacing Options”) again and choose Serial on the menu.
9. A window will pop up asking, “would you like a login shell to be accessible over serial?”, and the answer is NO.
10. Next, a window will pop up asking, “Would you like the serial port hardware to be enabled?”, this time say YES, and exit the window.
11. Click Finish, you may be prompted to reboot, and select YES.

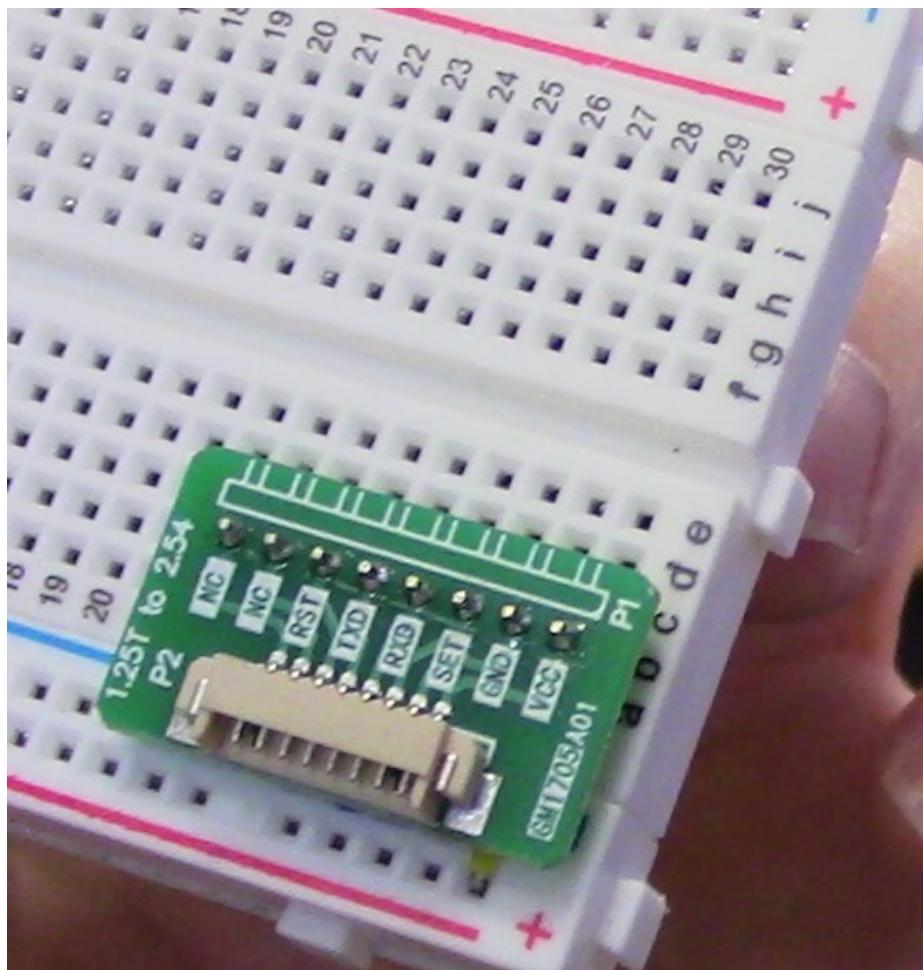


Figure 4: PMS5003 Adapter – without black and white ribbon.

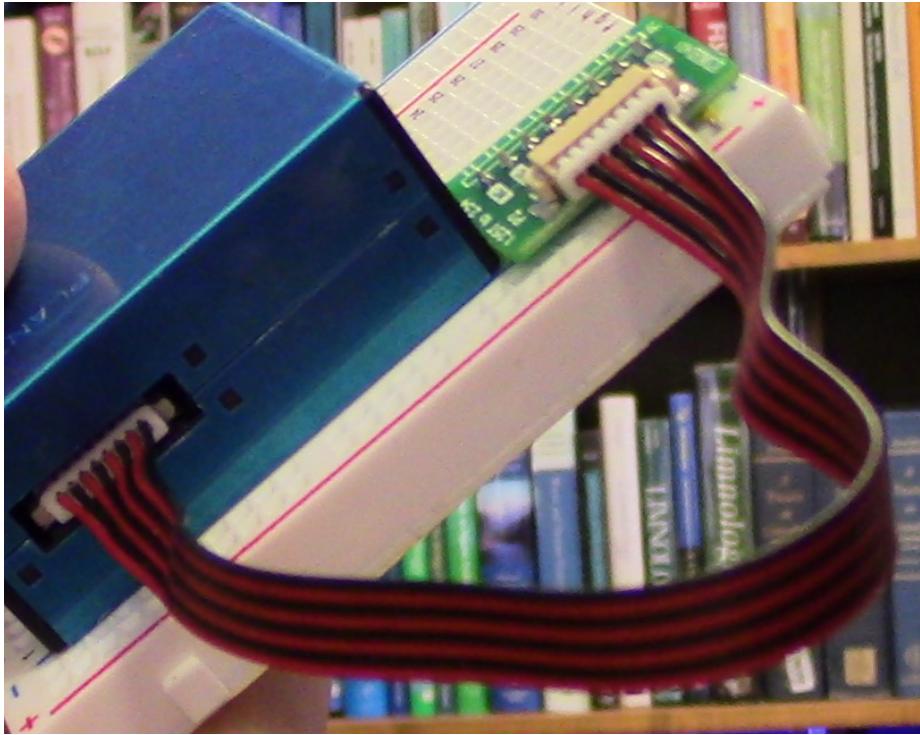


Figure 5: PMS5003 Adapter and PMS5003 connected with black and white ribbon.

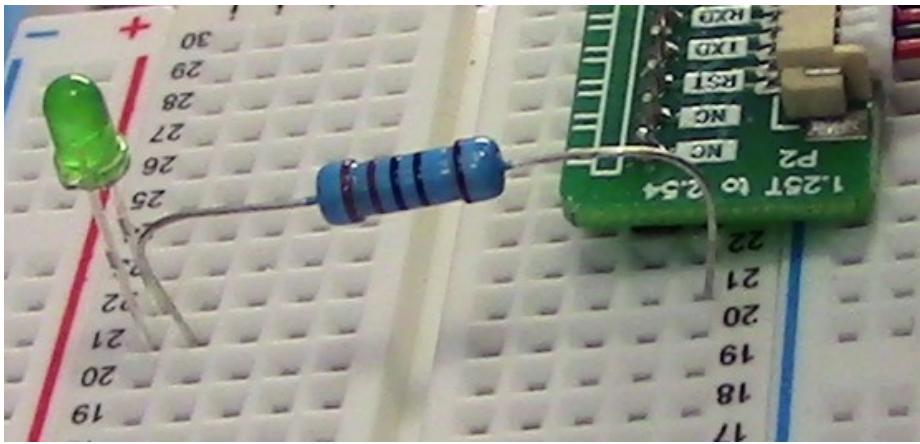


Figure 6: LED (green — you may have a different color) and Resistor (colors signify the resistance, measured in Ohms)

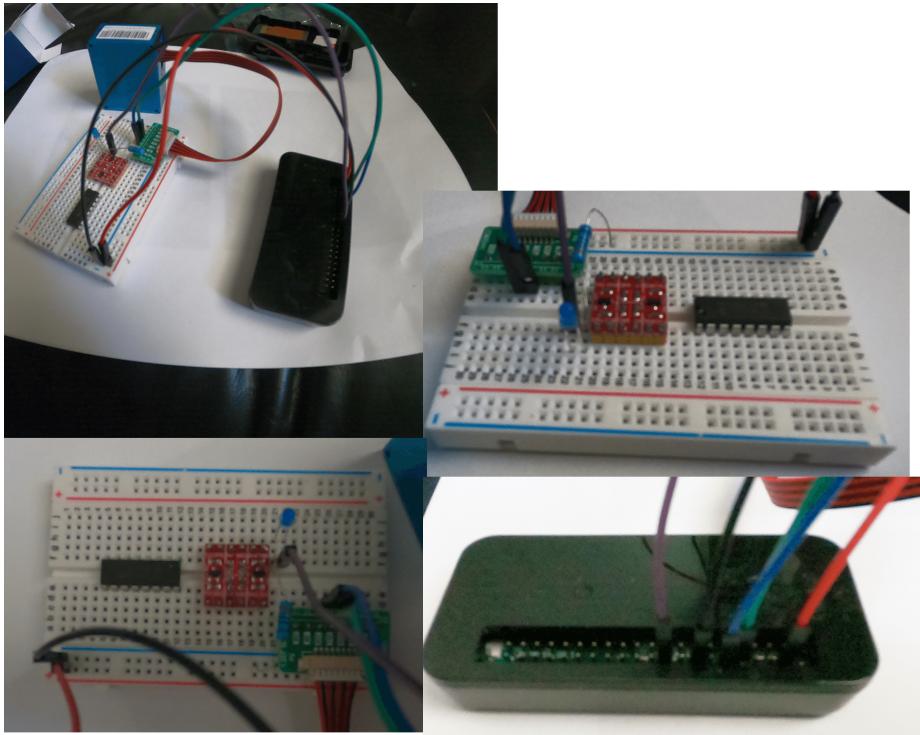


Figure 7: Wiring for PMS5003, LED, and Pi for deployment. I put the case top in the Pi to create a realively clean set up. The LED is programmed to flash every reading (1/minute).

## 2.6 Python Code

We have made the code available on the EJnPi Respository, so you can download it directly from the web onto your Pi or follow the steps below:

1. Using the Pi's webbrowser, navigate to the EJnPI Respository. Since the Pi's internet can be excruciating slow, we recommend that you navigate to the code via your computer browser, then paste in the [https://github.com/marclos/EJnPi/blob/master/code/Air\\_quality\\_code\\_v2.py](https://github.com/marclos/EJnPi/blob/master/code/Air_quality_code_v2.py) to the Pi's browser "Chromium".
2. When you can get to the diretory, click on 'Raw' in Github to view the Air\_quality\_code\_v2.py, then click right click to save on the home directory.

Then open Thony and load the file, it should look like this. NOTE: Don't try to copy and paste this code – the PDF has hidden characters that will mess us up.

```
1 # New Version — PMS and Air Quality Template
2 # Import packages (which sensor uses which package is noted)
3
4 # Datetime
5 import datetime
6 #import spidev # MiCS-2714
7 #import os # MiCS-2714
8 import serial # PMS5003
9 from collections import OrderedDict # PMS5003
10 #import board # BME280
11 #import busio # BME280
12 #import adafruit_bme280 # BME280
13 import csv # All
14 import time # All
15 import RPi.GPIO as GPIO # For LED
16
17 GPIO.setmode(GPIO.BCM) # For LED
18 GPIO.setwarnings(False) # For LED
19 GPIO.setup(24,GPIO.OUT,initial=GPIO.LOW) # For LED
20
21
22 # MiCS-2714 Code
23 #spi = spidev.SpiDev()
24 #spi.open(0,0)
25 #spi.max_speed_hz=1000000
26
27 #def ReadChannel(channel):
28 #    adc = spi.xfer2([1,(8+channel)<<4,0])
29 #    data = ((adc[1]&3) << 8) + adc[2]
30 #    return data
31
32 #def ConvertVolts(data, places):
33 #    volts = (data * 3.3) / float(1023)
34 #    volts = round(volts, places)
35 #    return volts
36
37 #def ConvertNO2(data, places):
38 #    NO2 = ((data * 10.05)/float(1023))+0.05
```

```

39 #  NO2 = round(NO2, places)
40 #  return NO2
41
42 #NO2_channel = 0
43
44 # MQ-131 Code
45
46 #def ConvertO3(data, places):
47 #  O3 = ((data * 1001)/float(1023))+1
48 #  O3 = round(O3, places)
49 #  return O3
50
51 #O3_channel = 1
52
53 # PMS5003 Code
54 class Sensor():
55     def __init__(self, tty = '/dev/ttyS0'):
56         self.tty = tty
57
58     def open(self):
59         self.serial = serial.Serial(self.tty, baudrate = 9600)
60
61     def close(self):
62         self.serial.close()
63
64     def read_bytes(self, data, idx, size = 2):
65         return int("".join(data[idx : idx + size]), 16)
66
67     def read(self):
68         data = self.serial.read(32)
69         data = ["{:02X}".format(d) for d in data]
70
71         if data[0] != '42' or data[1] != '4D':
72             return None
73
74         res = OrderedDict()
75         res['DateTime'] = datetime.datetime.now()
76         res['pm1_cf'] = self.read_bytes(data, 4)
77         res['pm25_cf'] = self.read_bytes(data, 6)
78         res['pm10_cf'] = self.read_bytes(data, 8)
79         res['pm1'] = self.read_bytes(data, 10)
80         res['pm25'] = self.read_bytes(data, 12)
81         res['pm10'] = self.read_bytes(data, 14)
82
83         return res
84
85     # BME280 Code
86     #i2c = busio.I2C(board.SCL, board.SDA)
87     #bme280 = adafruit_bme280.Adafruit_BME280_I2C(i2c)
88     #bme280.sea_level_pressure = 1013.25
89
90     # CSV Code
91     def write_to_csv():
92         if __name__ == "__main__":
93             with open('/home/pi/airquality_data.csv', mode
94             ='a') as csv_file:
95                 csv_writer = csv.writer(csv_file)
96                 csv_writer.writerow([data])

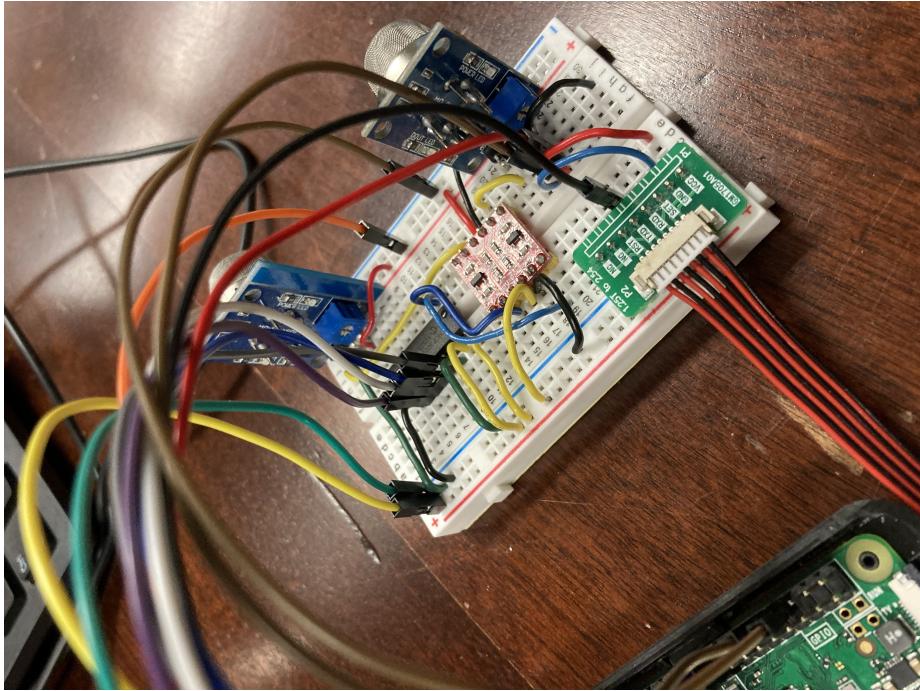
```

```

95         with open('/home/pi/airquality_data.csv', mode
96 = 'r') as csv_file:
97             csv_reader = csv.reader(csv_file)
98             for row in csv_reader:
99                 print(row)
100
101 # Command
102 if __name__ == "__main__":
103     while True:
104         GPIO.output(24,GPIO.HIGH)
105         # MiCS-2714 output
106         #NO2_level = ReadChannel(NO2_channel)
107         #NO2_volts = ConvertVolts(NO2_level,2)
108         #NO2      = ConvertNO2(NO2_level,2)
109         # MQ-131 output
110         #O3_level = ReadChannel(O3_channel)
111         #O3_volts = ConvertVolts(O3_level,2)
112         #O3      = ConvertO3(O3_level,2)
113         # PMS5003 output
114         sensor = Sensor()
115         sensor.open()
116         data = sensor.read()
117         sensor.close()
118         # Write to csv, sleep for 60 seconds
119         write_to_csv()
120         time.sleep(2)
121         GPIO.output(24,GPIO.LOW)
122         time.sleep(58)

```

3. Open the file using Thorny and hit run. You should see the results being displayed in the lower window.
4. It should release a reading of the different measurements specified at intervals of 60 seconds, and compile the data into a CSV file.



### 3 MQ Sensors

#### 3.1 Additional Sensors

We have provided the electronics to evaluate other air quality parameters using MQ Sensors. You can read about how these sensors work and a list of types of sensors in this sensor guide.

