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Deutsche
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Climate Data Collection and Analysis Workshop

February 27, 2024



Today's Schedule

Day 2: Designing, Building, and Analyzing Data from Open-Source Sensors

09:30 – 10:00 Moving towards High-Frequency Data

10:00 – 10:30 Potential of Low-Cost Hardware to Improve Environmental Monitoring

10:30 – 10:45 Tea/Coffee Break

10:45 – 11:15 Designing and Building a Low-Cost River Monitoring Station

11:15 – 12:30 Practical Example – Collecting, Transmitting, and Processing High-Frequency Data

12:30 – 13:30 Lunch Break

13:30 – 14:00 Construction of a Low-Cost Weather Station

14:00 – 14:45 Practical Example – Combining Sensor and Satellite Data for Further Analysis

14:45 – 15:00 Tea/Coffee Break

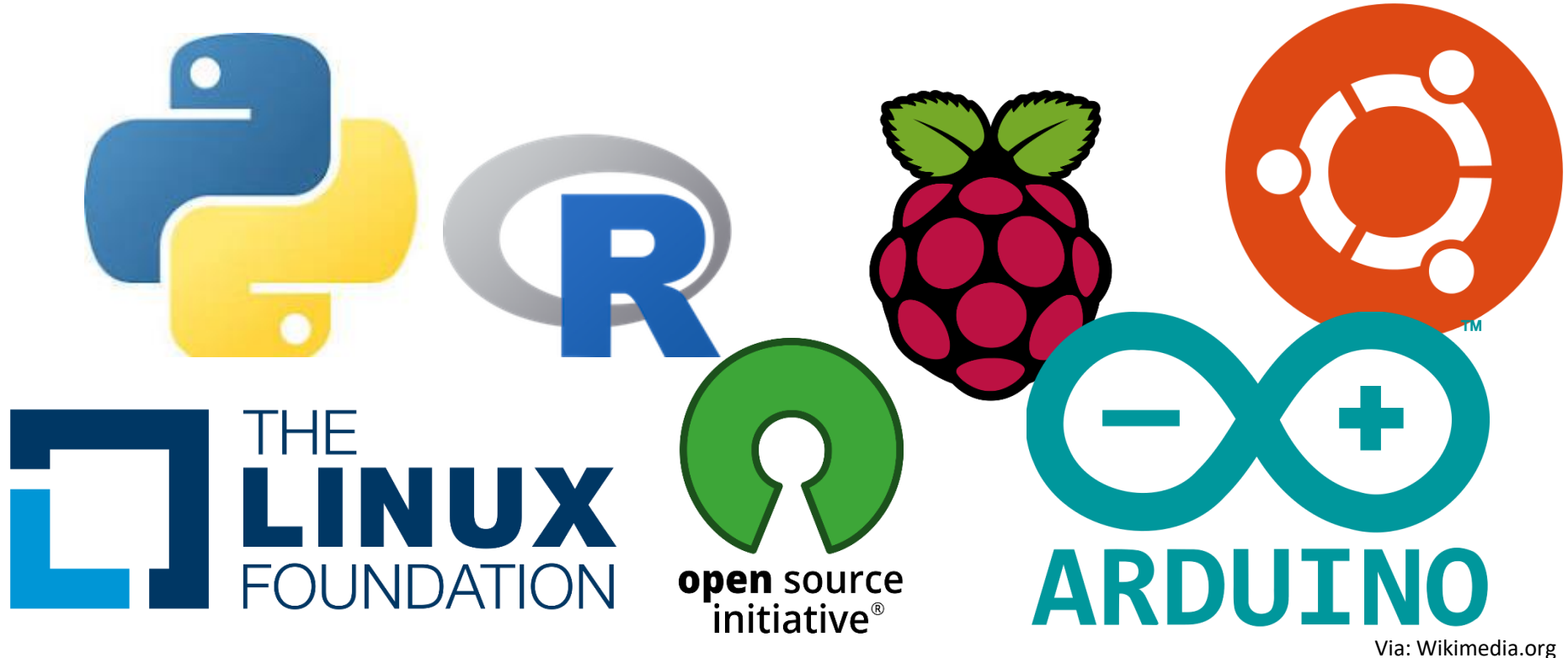
15:00 – 15:45 Research Outlook and Practical Applications in Nepal

15:45 – 16:00 Wrap Up and Further Resources

Overview of Open-Source Hardware

In the last ~20 years, there has been a massive decrease in the cost of computers

There has also been a huge expansion in the amount of free and open-source software



Via: Wikimedia.org

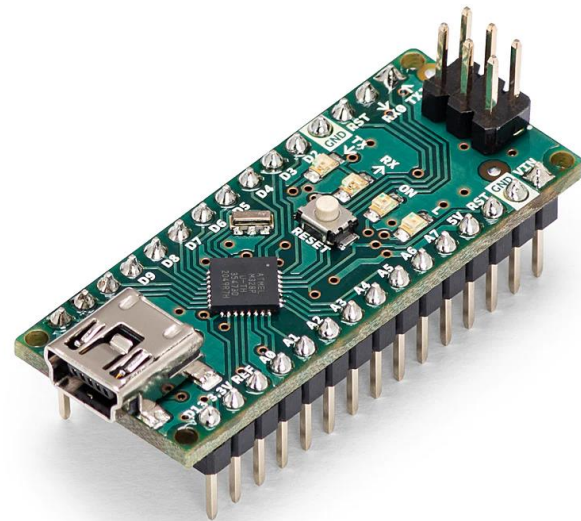
Focus on Open Hardware

There are several platforms that can be used to build open-source environmental monitoring platforms

The two most common, and the ones we will focus on, are the **Raspberry Pi** and **Arduino** platforms



Via: <https://www.deviceplus.com/raspberry-pi/the-history-of-raspberry-pi/>



Via: <https://store.arduino.cc/products/arduino-nano>

Focus on Open Hardware

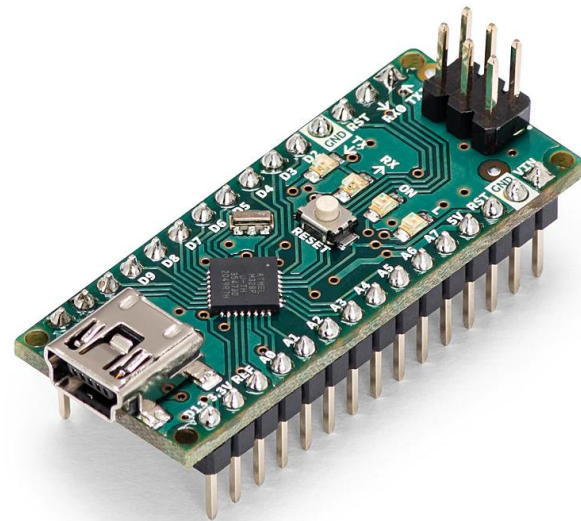
These cover two main tasks:

Processing Data



Via: <https://www.deviceplus.com/raspberry-pi/the-history-of-raspberry-pi/>

Connecting to Sensors



Via: <https://store.arduino.cc/products/arduino-nano>

Raspberry Pi

Raspberry Pi was founded in 2005 with the goal of making computers available for low-cost for educational purposes

The prices range between ~4 Eur and ~30 Eur

They have been used in a huge range of projects, and are ideal for many applications

They are based on the Linux programming language, and are the equivalent of a very small computer



Via: <https://www.raspberrypi.com/products/raspberry-pi-zero/>



Via: <https://www.raspberrypi.com/products/raspberry-pi-3-model-b/>

Raspberry Pi

They require very little power

They can access wifi or Bluetooth

They are idea for processing, storing, and transmitting data from environmental sensors

They can be used in a wide variety of settings, with many different pieces of hardware

The software is fully customizable!



Via: <https://www.raspberrypi.com/products/raspberry-pi-zero/>



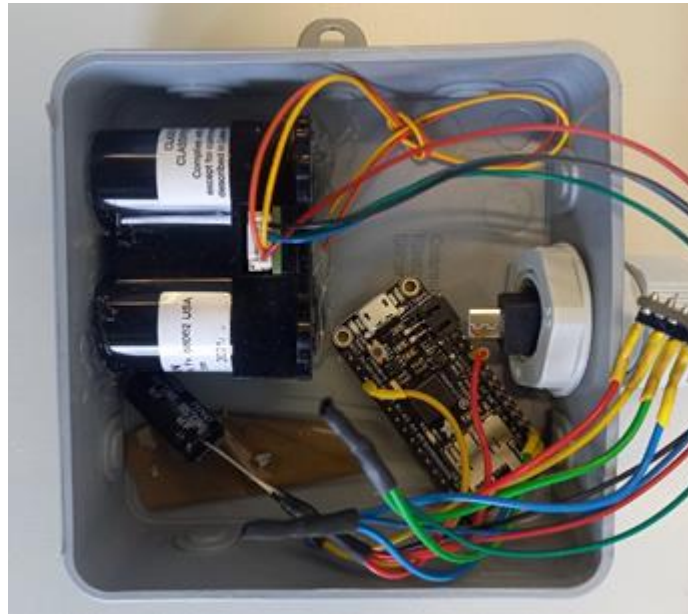
Via: <https://www.raspberrypi.com/products/raspberry-pi-3-model-b/>

Arduino

The Arduino project was started with a similar goal – create low-cost and open source hardware for educational purposes

Arduino boards are **not** small computers – you cannot attach a keyboard, screen, or treat them like a normal computer

These small boards are meant to ***interface with other hardware***

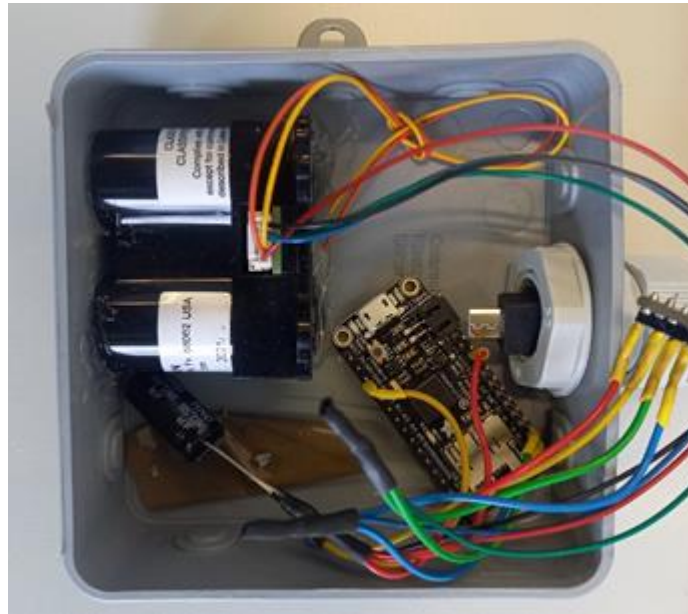


Arduino

Each board does **one task only** – it is perfect for taking data from any environmental sensor and **translating it into an easy to read format**

Since it is open source, there are **many different sensors** that can be used with the platform

Power consumption is very low, so they can even be used with a **battery**



Low-Cost Environmental Monitoring

Many environmental monitoring stations are very expensive

You are limited to which variables come with the commercial product



Prices for Automated Weather Stations (AWS)

Automated Weather Stations (AWS) pricing varies by vendor, configuration, and features. Different AWS vendors may offer a variety of different options and customisations. In general, AWS prices usually include the cost of hardware equipment, sensors, data loggers, communications equipment, software, and installation and maintenance.


For a basic AWS system, prices can range from a few thousand dollars to \$10,000 USD. This price range depends largely on the type and number of sensors selected, the frequency of data collection, the data storage capacity, the communication method (e.g., wired or wireless), and the vendor's brand and services.

Via: <https://www.niubol.com/All-products/Automated-Weather-Stations-AWS.html>

Main page » Sensors & Measurement Equipment »
Automatic Weather Stations »
Vaisala Automatic Weather Station AWS310

next » last » 9 Products in this category

VAISALA



Vaisala Automatic Weather Station AWS310

Produc... AWS310

7,776.00 USD

- 1 +

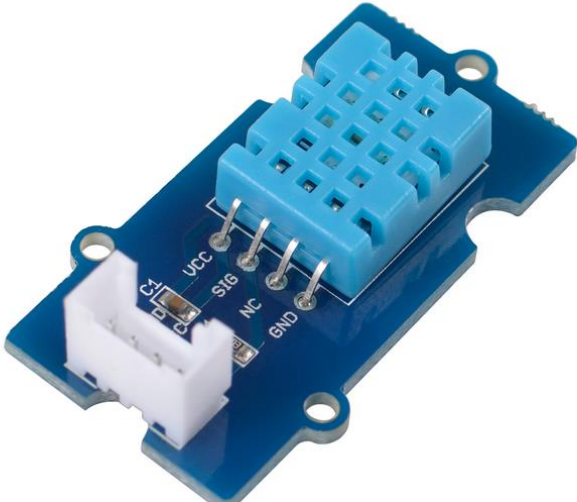
ADD TO CART

[Add to wish list](#)

https://shop.profec-ventus.com/product_info.php?language=en&info=p550_vaisala-automatic-weather-station-aws310.html

Low-Cost Environmental Monitoring

Alongside the development of low-cost computing, the price of monitoring the environment has also dropped significantly



Grove - Temperature & Humidity Sensor (DHT11)
SKU 101020011
★★★★★ 27 Reviews

Grove - Temperature & Humidity Sensor is based on DHT11, which has high measurement accuracy and wide range, and low-cost.

\$5.00 10+: \$3.50

1+ in stock

DHT20 Temperature & Humidity Sensor **DHT11**

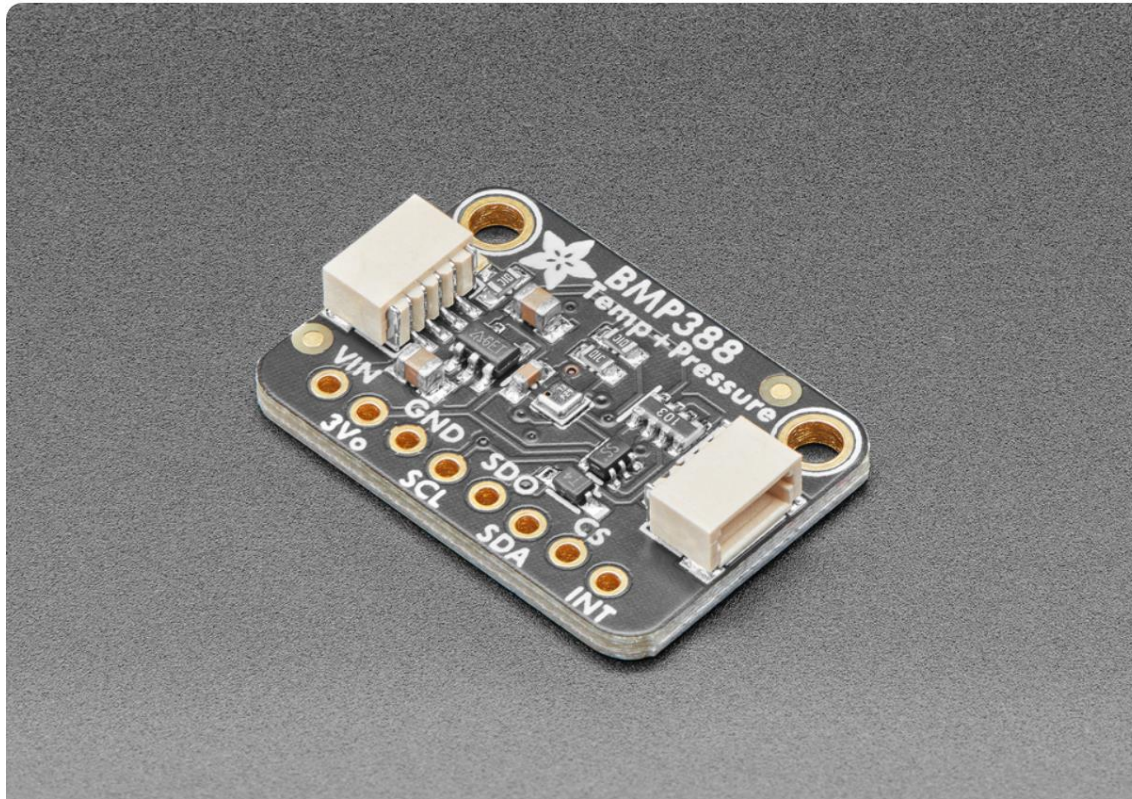
DHT22 AHT20-Industrial Grade

- 1 + DE Warehouse

<https://www.seeedstudio.com/Grove-Temperature-Humidity-Sensor-DHT11.html>

Low-Cost Environmental Monitoring

Alongside the development of low-cost computing, the price of monitoring the environment has also dropped significantly



Adafruit BMP388 - Precision Barometric Pressure and Altimeter - STEMMA QT

Product ID: 3966

\$9.95

In stock

1

Add to Cart

☐ Also include 1 x [STEMMA QT / Qwiic JST SH 4-pin to Premium Male Headers Cable](#) (\$0.95)

| Qty | Discount |
|-------|----------|
| 1-9 | \$9.95 |
| 10-99 | \$8.96 |
| 100+ | \$7.96 |

Add to Wishlist ▾

[Description](#)

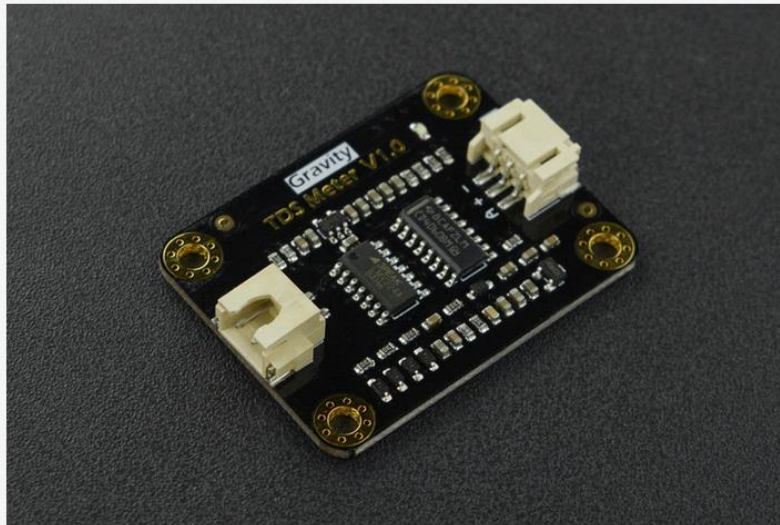
[Technical Details](#)

<https://www.adafruit.com/product/3966>

Low-Cost Environmental Monitoring

Alongside the development of low-cost computing, the price of monitoring the environment has also dropped significantly

Sensors / Liquid Sensors / Gravity: Analog TDS Sensor/ Meter for Arduino



Gravity: Analog TDS Sensor/ Meter for Arduino

SKU:SEN0244

Brand:DFRobot

Reward Points: 129

\$11.80

In Stock

Quantity Based Price

Categories: Sensors All Products Liquid Sensors
Topic: Gravity

| QTY | DISCOUNT |
|-----|----------|
| 3-4 | \$11.40 |
| 5-9 | \$11.20 |
| 10+ | \$10.80 |

* Model:

Quantity:

BUY IT NOW

ADD TO CART



<https://www.dfrobot.com/product-1662.html>

Low-Cost Environmental Monitoring

The availability of Arduino-based sensors is also massive!

It is very likely that you can find a sensor that measures what you want, and that it is affordable

It is possible to duplicate the main functions of a weather station (or other monitoring station) for a fraction of the cost

The main difference is that you need to build it yourself – it does not come in a simple package

This requires some knowledge and willingness to try things out

<https://www.adafruit.com/category/42>



ESP8266 WiFi Module
PRODUCT ID: 3282
This interesting module is a lot of fun for hobbyists and students who are interested in experimenting with the ESP8266 WiFi chipset. We bought a bunch of these modules, called them the Internet of Things, and wrote some Arduino code to give a webpage. We do not have a detailed tutorial at this time, this chip/module is for the curious and...
[More Info](#) [Discontinued](#)



Adafruit FONA 808 Shield - Mini Cellular GSM + GPS for Arduino
PRODUCT ID: 3534
Cellular + GPS tracking, all in one, for your Arduino? Oh yes! Introducing Adafruit FONA 808 GSM + GPS Shield, an Arduino-compatible phone module with that lets you add location-tracking, voice, text, SMS and data to your project. In Arduino shield format for easy use. Please note: The T-Mobile GSM network which is shutting down in the USA over the course of 2015...
[More Info](#) [Discontinued](#)



RageBridge v2 from Equal Zero Designs
PRODUCT ID: 3587
RageBridge 2 from Equal Zero Designs is a multi-core and robust dual-channel DC motor controller for robotic and vehicular drivetrain applications. It can supply 40 amps per side continuously and up to 90A in bursts depending on cooling conditions. An ultra-wide (3 to 40 volt) input range maximizes versatility and allows it to be used in many different systems. It...
[More Info](#) [Discontinued](#)



Espressif ESP32 WROVER KIT - E
PRODUCT ID: 3384
The ESP-WROVER-KIT from Espressif supports the most distinguishing features of the ESP32. Whether you need external SRAM for IoT applications, or an LCD/touchscreen interface, it has you covered! The ESP-WROVER-KIT is a newly-launched development board built around ESP32. This board comes with an ESP32 module already. The version of this kit now comes with the...
[More Info](#) [Discontinued](#)



Adafruit CCS811 Air Quality Sensor Breakout - VOC and eCO2 - STEMMMA QT / Qwiic
PRODUCT ID: 3566
Discontinued - you can grab the Adafruit SGP30 Air Quality Sensor Breakout - VOC and eCO2 - STEMMMA QT / Qwiic instead! Breathe easy - we finally have an I2C VOC/eCO2 sensor in the Adafruit shop! Add an quality monitoring to your project and with an Adafruit CCS811 Air Quality Sensor Breakout. This sensor from AIAQ is a gas sensor that can detect a wide range of...
[More Info](#) [Discontinued](#)



Wi-Fi Add-on Board for Sony SPRESENSE IS10B
PRODUCT ID: 3510
The Sony IS10B is a Wi-Fi Add-on board for SONY SPRESENSE. Low power consumption is realized by adopting Teit G2C200M02. Equipped with SPI (standard) and UART (optional) interfaces. In compliance with IEEE802.11b / g / n (2.4GHz), it supports Wi-Fi Direct and WPS as well as access point mode and station mode. This add-on board is already equipped with a chip...
[More Info](#) [Discontinued](#)

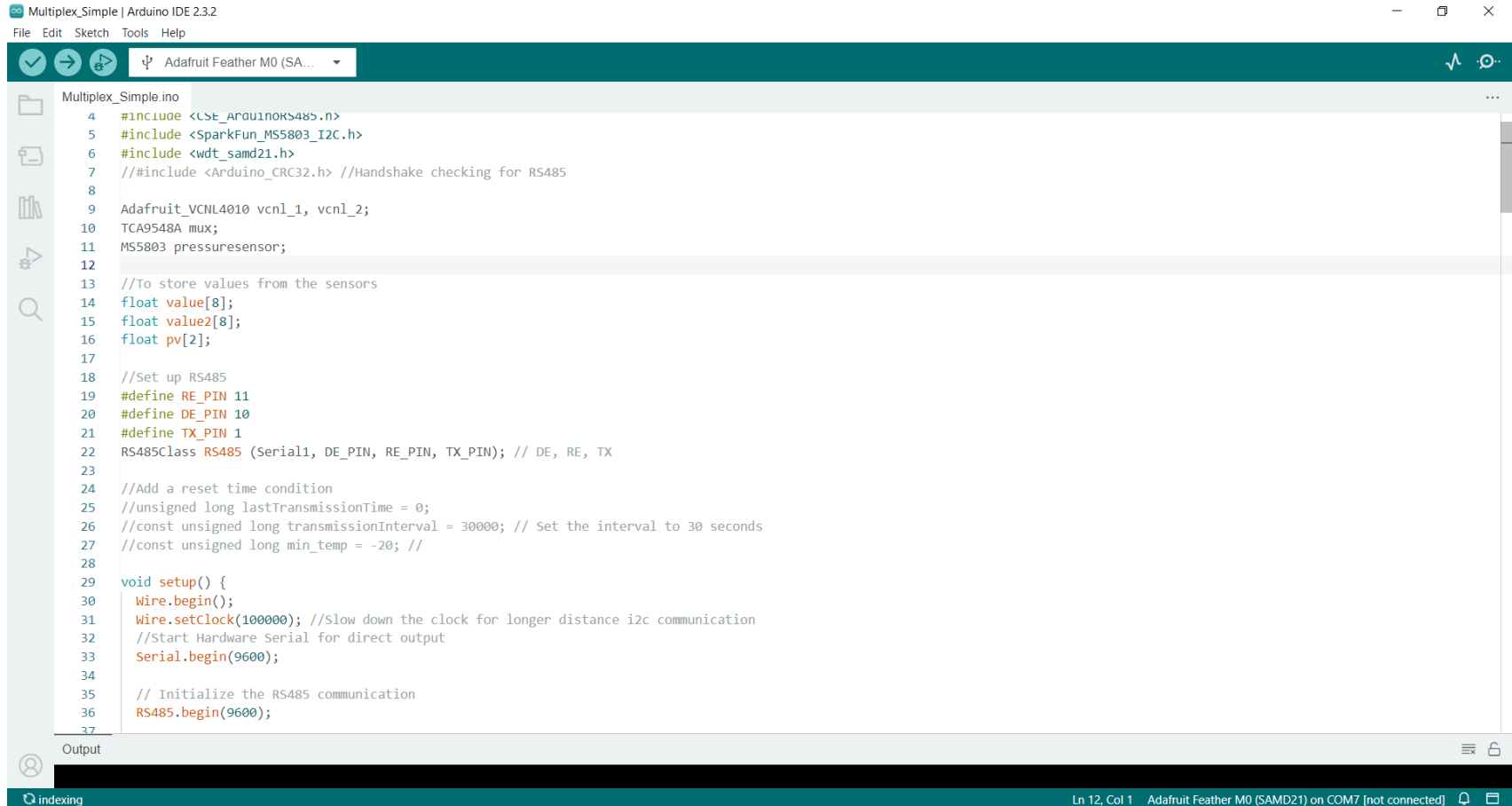


Particle Photon without Headers
PRODUCT ID: 2722
The Photon is a \$50 tiny 80+ development kit for creating connected projects and products for the Internet of Things. It's easy to use, it's powerful, and it's connected to the cloud. The team that make up the Photon's ecosystem (and come along with the board) are designed to let you build and create whether you're an embedded engineer, web developer, Arduino...
[More Info](#) [Discontinued](#)



Particle Electron Cellular IoT Kit - 2G Global
PRODUCT ID: 3235
The Electron is a small cellular IoT board made by Particle. This tiny development kit has everything you need for creating 2G cellular connected products. Includes a prepaid, no contract data plan and instant web access to your Photon with wireless programming. Kit includes Microcontroller, Particle SIM card with service in more than 100 countries worldwide. 3...
[More Info](#) [Discontinued](#)

Example Arduino Code



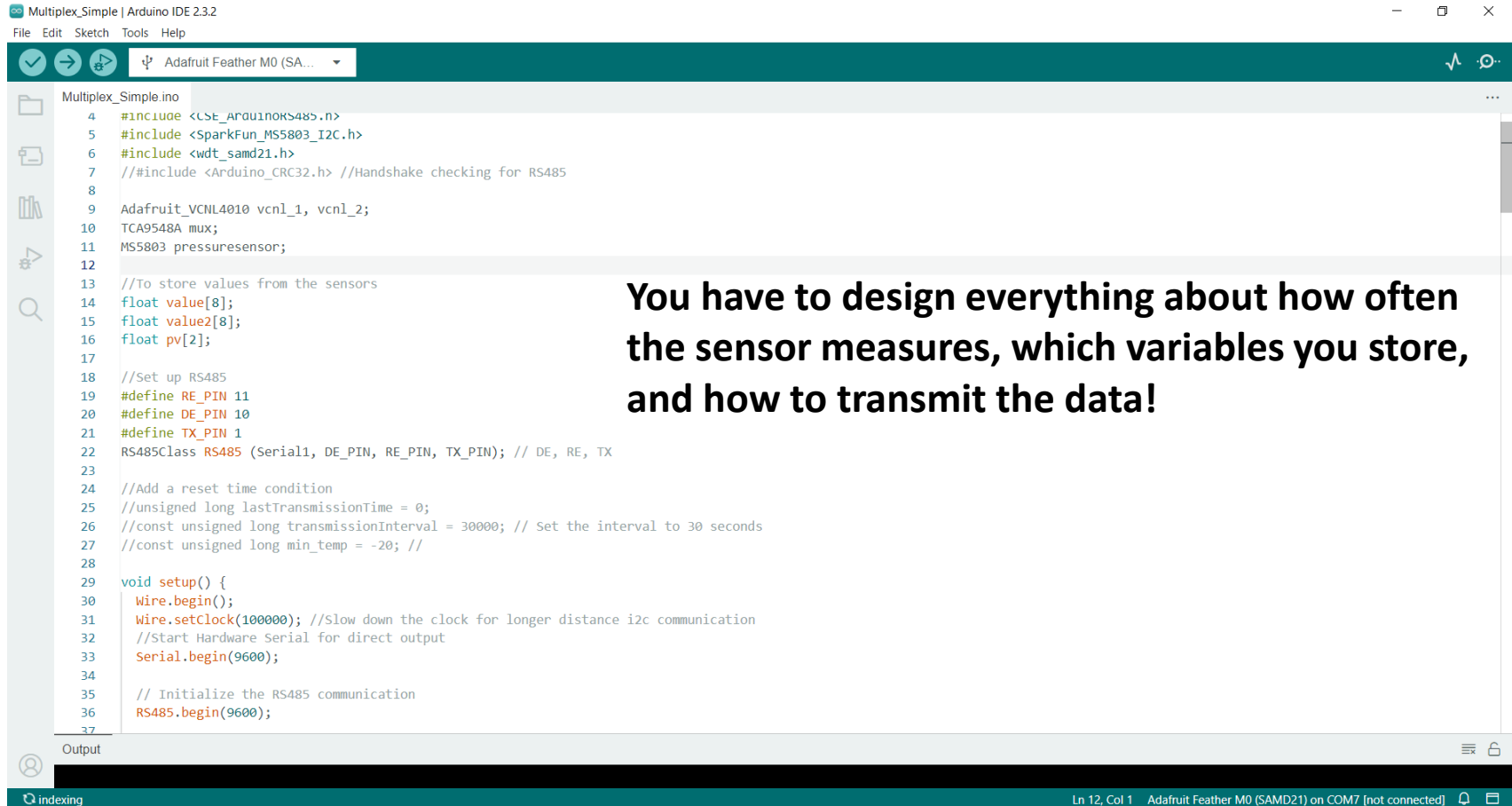
```
Multiplex_Simple.ino
4  #include <RS485.h>
5  #include <SparkFun_M5S803_I2C.h>
6  #include <wdt_samd21.h>
7  // #include <Arduino_CRC32.h> //Handshake checking for RS485
8
9  Adafruit_VCNL4010 vcnl_1, vcnl_2;
10 TCA9548A mux;
11 MS5803 pressuresensor;
12
13 //To store values from the sensors
14 float value[8];
15 float value2[8];
16 float pv[2];
17
18 //Set up RS485
19 #define RE_PIN 11
20 #define DE_PIN 10
21 #define TX_PIN 1
22 RS485Class RS485 (Serial1, DE_PIN, RE_PIN, TX_PIN); // DE, RE, TX
23
24 //Add a reset time condition
25 //unsigned long lastTransmissionTime = 0;
26 //const unsigned long transmissionInterval = 30000; // Set the interval to 30 seconds
27 //const unsigned long min_temp = -20; //
28
29 void setup() {
30   Wire.begin();
31   Wire.setClock(100000); //Slow down the clock for longer distance i2c communication
32   //Start Hardware Serial for direct output
33   Serial.begin(9600);
34
35   // Initialize the RS485 communication
36   RS485.begin(9600);
37 }
```

Output

indexing

Ln 12, Col 1 Adafruit Feather M0 (SAMD21) on COM7 [not connected]

Example Arduino Code



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38 }
```

You have to design everything about how often the sensor measures, which variables you store, and how to transmit the data!

Ln 12, Col 1 Adafruit Feather M0 (SAMD21) on COM7 [not connected]

Low-Cost Environmental Monitoring

Since the hardware and the software are both open source, there are **many learning resources online**

<https://www.arduino.cc/education/courses>

<https://docs.arduino.cc/learn/starting-guide/getting-started-arduino/>

<https://www.arduino.cc/en/Tutorial/HomePage>

<https://www.instructables.com/Intro-to-Arduino/>

<https://www.raspberrypi.org/courses/learn-python>


<https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started>

Creating Custom Hardware

The last step that has changed in the past few years is the availability of custom hardware

Services like <https://jlcpcb.com/> allow you to design small hardware and have it quickly built and shipped

This means the availability of different environmental sensors is even larger!


Add gerber file

OR

Layers

1

2

4

6

More

Dimensions

100

X

100

mm

Quantity

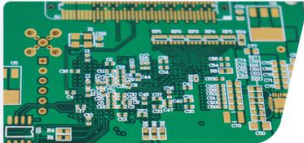
5

Instant Quote

News

Jan 12, 2024

Get Free Flexible PCBs with Our Exclusive \$15 Coupon Offer →



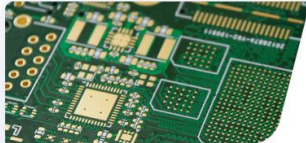
1 - 4 Layers

From **\$2** /5pcs | Build Time: 24 hours

- 1-2L - \$2 for 100×100mm PCBs
- 4L - \$2 for 50×50mm PCBs
- FR4, Aluminum, Copper, Rogers, PTFE

Quote Now

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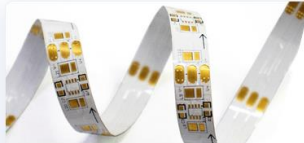
6 - 20 Layers

From **\$2** /5pcs | Build Time: 4 days

- 6-8L - \$2 for 50×50mm PCBs
- 6-20L - Free via-in-pad with POFV
- Controlled impedance PCB

Quote Now

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Flex PCBs

From **\$15** /5pcs | Build Time: 4 days

- Electro-Deposited (ED) copper
- Support PI, FR4, 3M tape stiffeners
- Support PCB Assembly

Quote Now

Learn More >



PCB Assembly

From **\$8** /5pcs | Build Time: 24 hours

- 430,000+ In-stock Parts
- Free DFM File Check
- Support Rigid and Flex PCBs

Quote Now

Learn More >

Questions?