# Why we will use microPython

Rapid prototyping with microPython devices

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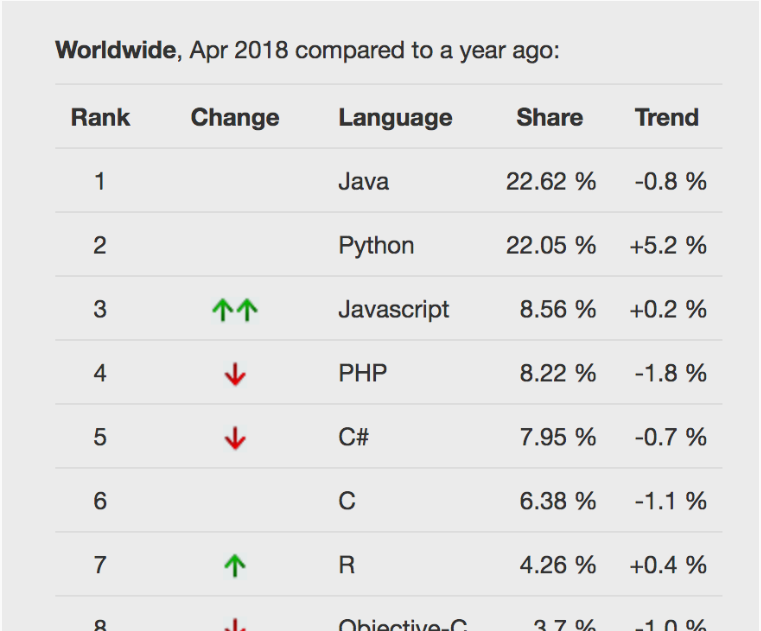
May 2, 2018

## Why micropython?

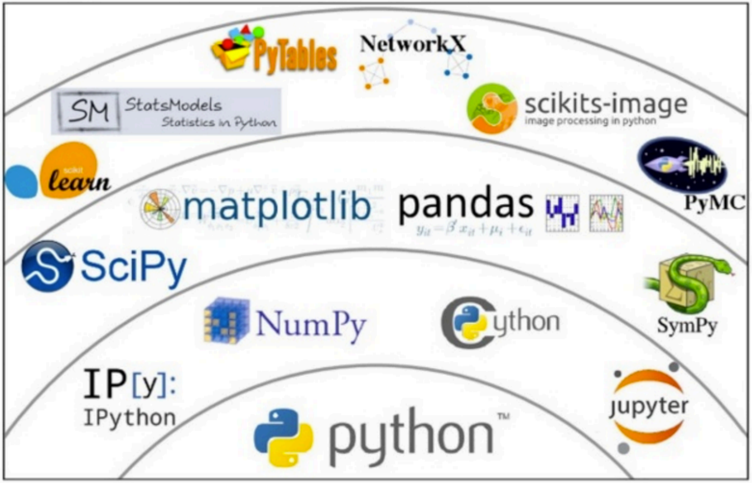
## python



**Worldwide**, Apr 2018 compared to a year ago:

| Rank | Change | Language | Share | Trend |
|---|---|---|---|---|
| 1 | | Java | 22.62 % | -0.8 % |
| 2 | | Python | 22.05 % | +5.2 % |
| 3 | ↑↑ | Javascript | 8.56 % | +0.2 % |
| 4 | ↓ | PHP | 8.22 % | -1.8 % |
| 5 | ↓ | C# | 7.95 % | -0.7 % |
| 6 | | C | 6.38 % | -1.1 % |
| 7 | ↑ | R | 4.26 % | +0.4 % |
| 8 | ↓ | Objective-C | 3.7 % | -1.0 % |

## python ecosystem



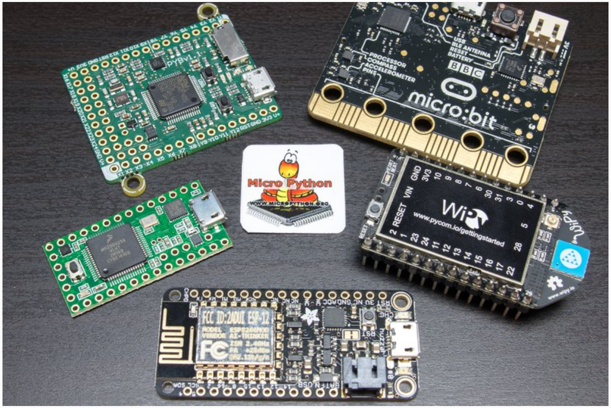
## micropython

MicroPython is a lean and fast implementation of the Python 3 programming language that is optimised to run on a microcontroller. MicroPython was successfully funded via a Kickstarter campaign and the software is now available to the public under the MIT open source license.

It ensures that the memory size/microcontroller performance is optimised and fit for purpose for the application it serves. Many sensor reading and reporting applications do not require a PC based processor as this would make the total application over priced and under-efficient.

Credit pycom.io

## micropython options



## pyboard

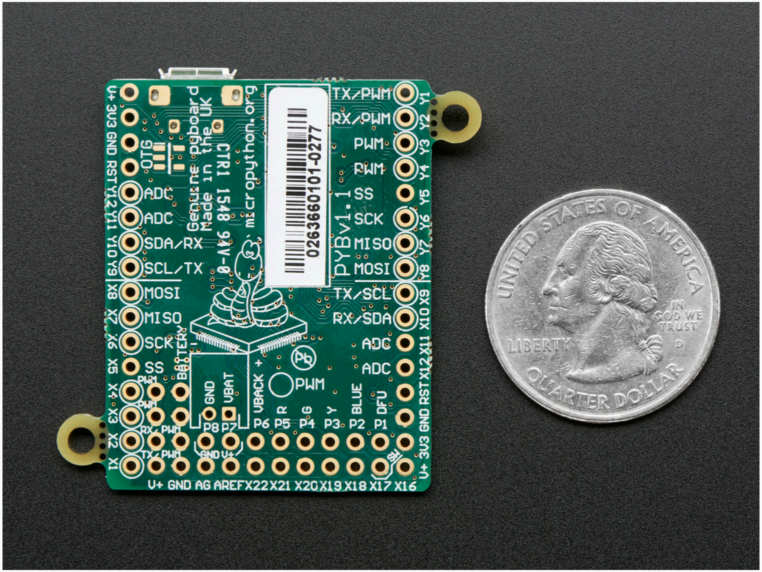
The MicroPython **pyboard** is a compact electronic circuit board that runs MicroPython on the bare metal, giving you a low-level Python operating system that can be used to control all kinds of electronic projects.

MicroPython is packed full of advanced features such as an interactive prompt, arbitrary precision integers, closures, list comprehension, generators, exception handling and more. Yet it is compact enough to fit and run within just 256k of code space and 16k of RAM.

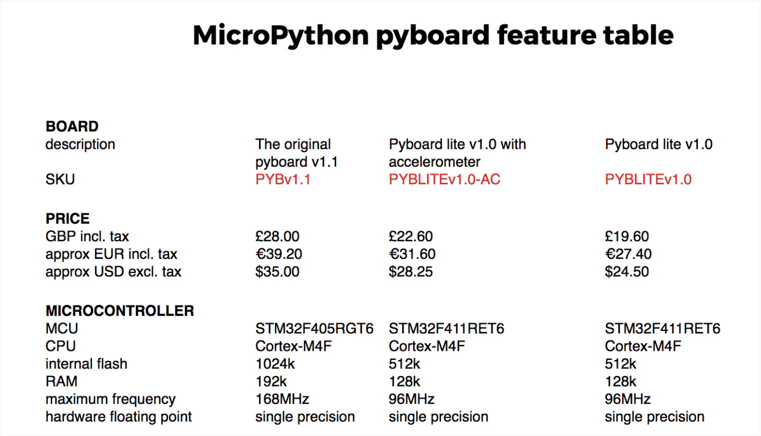
MicroPython aims to be as compatible with normal Python as possible to allow you to transfer code with ease from the desktop to a microcontroller or embedded system.

Credit micropython.org

## pyboard



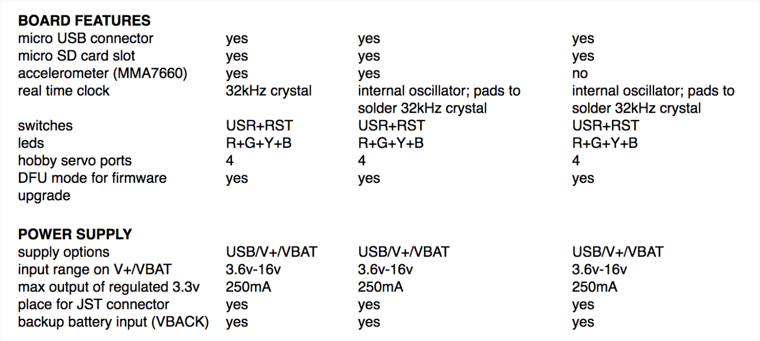
## pyboard



### MicroPython pyboard feature table

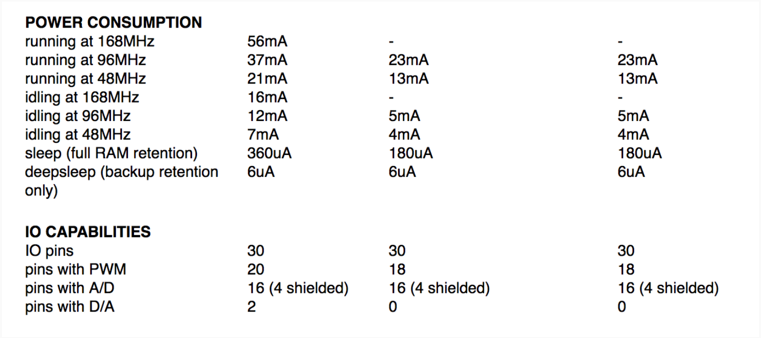
| | | | |
|---|---|---|---|
| **BOARD** | | | |
| description | The original pyboard v1.1 | Pyboard lite v1.0 with accelerometer | Pyboard lite v1.0 |
| SKU | PYBv1.1 | PYBLITEv1.0-AC | PYBLITEv1.0 |
| **PRICE** | | | |
| GBP incl. tax | £28.00 | £22.60 | £19.60 |
| approx EUR incl. tax | €39.20 | €31.60 | €27.40 |
| approx USD excl. tax | $35.00 | $28.25 | $24.50 |
| **MICROCONTROLLER** | | | |
| MCU | STM32F405RGT6 | STM32F411RET6 | STM32F411RET6 |
| CPU | Cortex-M4F | Cortex-M4F | Cortex-M4F |
| internal flash | 1024k | 512k | 512k |
| RAM | 192k | 128k | 128k |
| maximum frequency | 168MHz | 96MHz | 96MHz |
| hardware floating point | single precision | single precision | single precision |

## pyboard



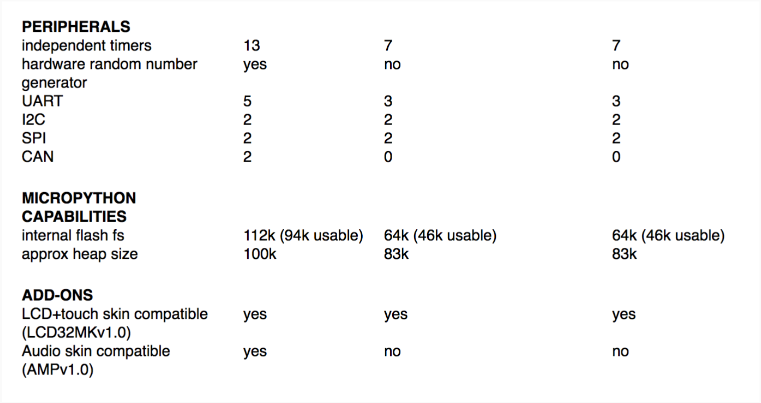
| | | | |
|---|---|---|---|
| **BOARD FEATURES** | | | |
| micro USB connector | yes | yes | yes |
| micro SD card slot | yes | yes | yes |
| accelerometer (MMA7660) | yes | yes | no |
| real time clock | 32kHz crystal | internal oscillator; pads to solder 32kHz crystal | internal oscillator; pads to solder 32kHz crystal |
| switches | USR+RST | USR+RST | USR+RST |
| leds | R+G+Y+B | R+G+Y+B | R+G+Y+B |
| hobby servo ports | 4 | 4 | 4 |
| DFU mode for firmware upgrade | yes | yes | yes |
| **POWER SUPPLY** | | | |
| supply options | USB/V+/VBAT | USB/V+/VBAT | USB/V+/VBAT |
| input range on V+/VBAT | 3.6v-16v | 3.6v-16v | 3.6v-16v |
| max output of regulated 3.3v | 250mA | 250mA | 250mA |
| place for JST connector | yes | yes | yes |
| backup battery input (VBACK) | yes | yes | yes |

## pyboard



| | | | |
|---|---|---|---|
| **POWER CONSUMPTION** | | | |
| running at 168MHz | 56mA | - | - |
| running at 96MHz | 37mA | 23mA | 23mA |
| running at 48MHz | 21mA | 13mA | 13mA |
| idling at 168MHz | 16mA | - | - |
| idling at 96MHz | 12mA | 5mA | 5mA |
| idling at 48MHz | 7mA | 4mA | 4mA |
| sleep (full RAM retention) | 360uA | 180uA | 180uA |
| deepsleep (backup retention only) | 6uA | 6uA | 6uA |
| **IO CAPABILITIES** | | | |
| IO pins | 30 | 30 | 30 |
| pins with PWM | 20 | 18 | 18 |
| pins with A/D | 16 (4 shielded) | 16 (4 shielded) | 16 (4 shielded) |
| pins with D/A | 2 | 0 | 0 |

## pyboard



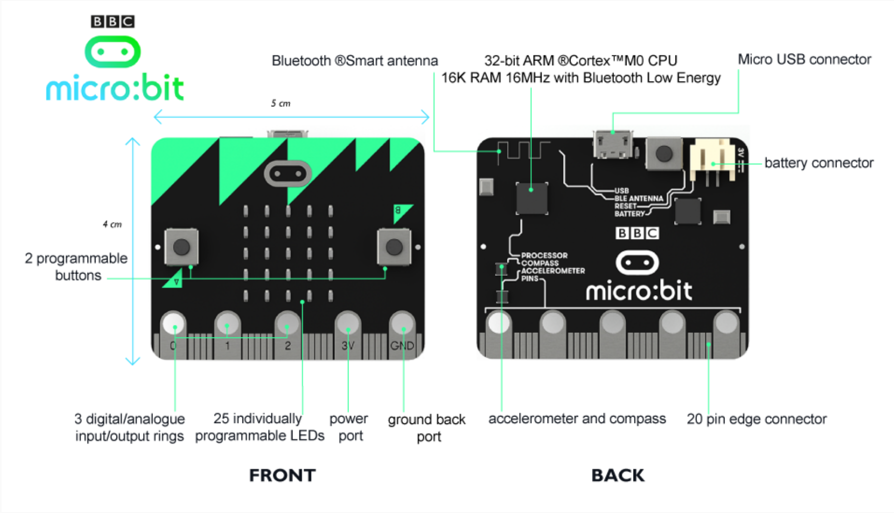
| | | | |
|---|---|---|---|
| **PERIPHERALS** | | | |
| independent timers | 13 | 7 | 7 |
| hardware random number generator | yes | no | no |
| UART | 5 | 3 | 3 |
| I2C | 2 | 2 | 2 |
| SPI | 2 | 2 | 2 |
| CAN | 2 | 0 | 0 |
| **MICROPYTHON CAPABILITIES** | | | |
| internal flash fs | 112k (94k usable) | 64k (46k usable) | 64k (46k usable) |
| approx heap size | 100k | 83k | 83k |
| **ADD-ONS** | | | |
| LCD+touch skin compatible (LCD32MKv1.0) | yes | yes | yes |
| Audio skin compatible (AMPv1.0) | yes | no | no |

## ESP8266: low cost

## ESP8266: characteristics

- 802.11 b/g/n
- Built-in TCP / IP protocol stack
- Built-in PLL, voltage regulator and power management components
- 802.11b mode + 19.5dBm output power
- Built-in temperature sensor
- off leakage current is less than 10uA
- Built-in low-power 32-bit CPU: can double as an application processor
- SDIO 2.0, SPI, UART
- standby power consumption of less than 1.0mW

## BBC Micro:bit

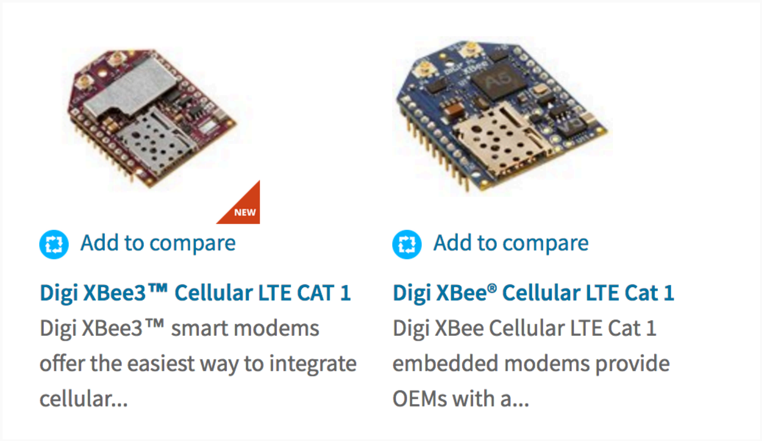


## BBC Micro:bit

The Micro Bit is an ARM-based embedded system designed by the BBC for use in computer education in the UK.

The board has an ARM Cortex-M0 processor, accelerometer and magnetometer sensors, Bluetooth and USB connectivity, a display consisting of 25 LEDs, two programmable buttons, and can be powered by either USB or an external battery pack. The device inputs and outputs are through five ring connectors that are part of the 23-pin edge connector.

## Digi



Add to compare

**Digi XBee3™ Cellular LTE CAT 1**

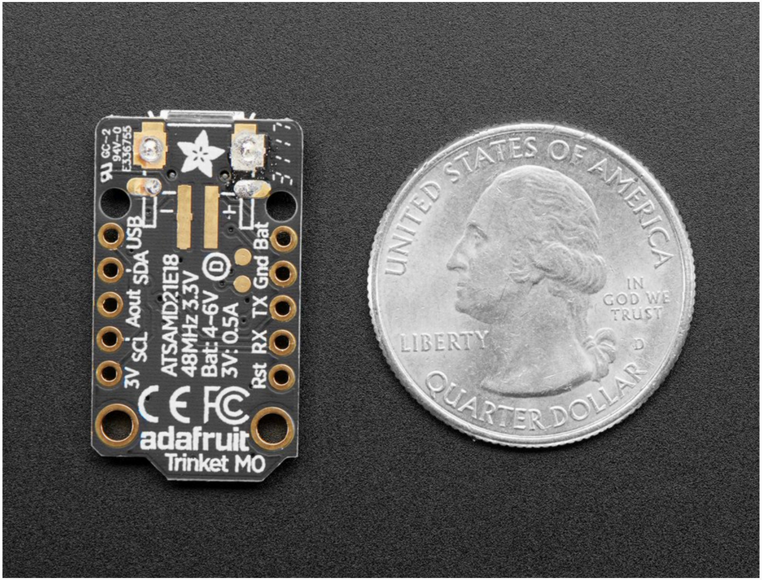
Digi XBee3™ smart modems offer the easiest way to integrate cellular...

Add to compare

**Digi XBee® Cellular LTE Cat 1**

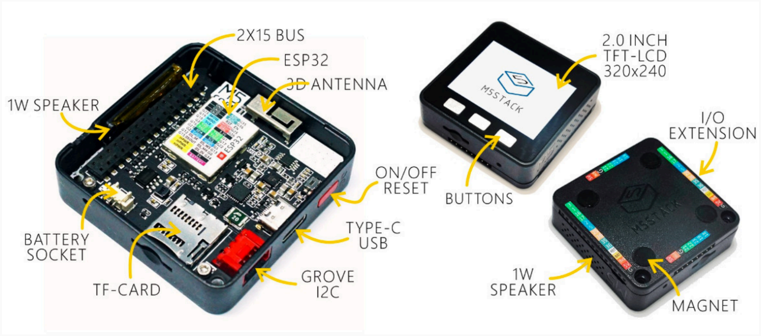
Digi XBee Cellular LTE Cat 1 embedded modems provide OEMs with a...

## Trinket

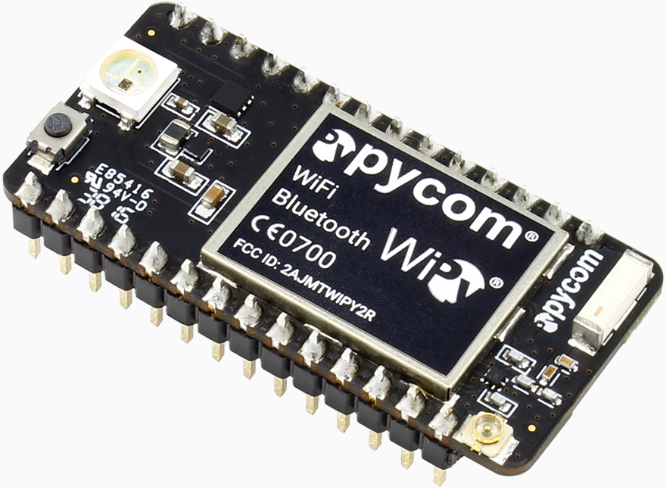


USB
SDA
Aout
SCL
3V
ATSAMD21E18
48MHz 3.3V
Bat: 4-6V
3V: 0.5A
Bat
Gnd
TX
RX
Rst
adafruit
Trinket M0

## M5stack


2X15 BUS
ESP32
3D ANTENNA
1W SPEAKER
ON/OFF RESET
BATTERY SOCKET
TYPE-C USB
TF-CARD
GROVE I2C
2.0 INCH TFT-LCD 320x240
I/O EXTENSION
BUTTONS
1W SPEAKER
MAGNET

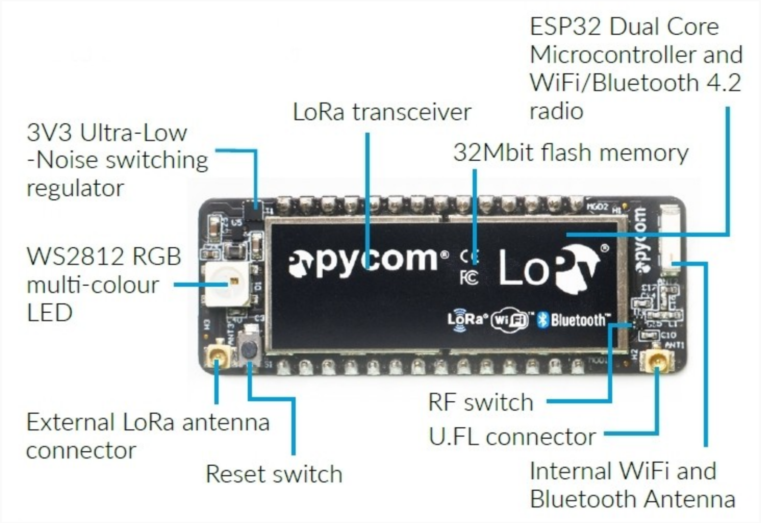
## pycom: WiPy


pycom
WiFi
Bluetooth
CE0700
FCC ID: 2AJMTWIPY2R
WiPy
pycom
E85416
94V-0

## pycom: WiPy

- Espressif ESP32 chipset
- Dual processor + WiFi radio system on chip
- consuming 25uA
- 2 x UART, 2 x sPI, I2C, I2S, micro SD card
- Analog channels: 8×12 bit ADCs
- Hash/Encryption: SHA, MD5, DES, AES
- Bluetooth
- Memory, RAM: 512KB, External flash: 4MB
- Hardware floating point acceleration

## pycom: LoPy


ESP32 Dual Core Microcontroller and WiFi/Bluetooth 4.2 radio
LoRa transceiver
3V3 Ultra-Low -Noise switching regulator
32Mbit flash memory
WS2812 RGB multi-colour LED
pycom
LoPy
LoRa
WiFi
Bluetooth
RF switch
U.FL connector
External LoRa antenna connector
Reset switch
Internal WiFi and Bluetooth Antenna

## pycom: SiPy

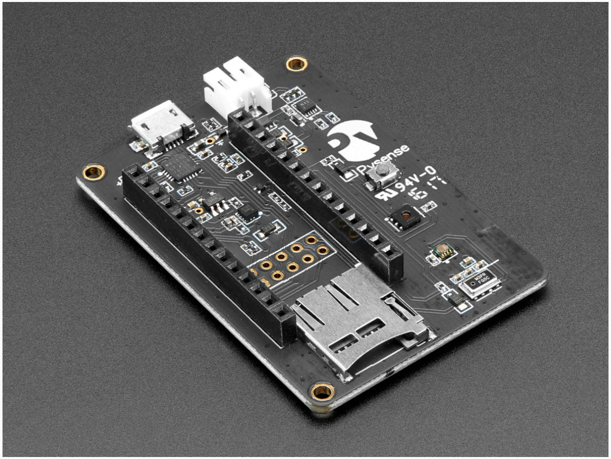
pycom
SiPy
Model: SiPy 1.0
CE 0700
FCC ID: 2AJMTSIPY1R
Bluetooth
WiFi
sigfox
e-s.lu

## pycom: LoPy4

- Espressif ESP32 chipset
- Quadruple network MicroPython enabled development board (LoRa, Sigfox, WiFi, Bluetooth)
- RAM: 4MB (vs 512KB)
- External flash: 8MB (vs 4MB)

## pycom: Expansion Board

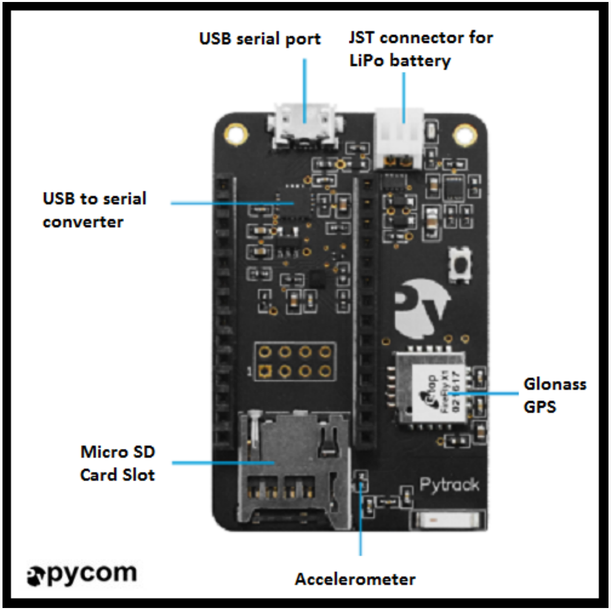
## pycom: PySense



## pycom: PySense

- Ambient light sensor
- Barometric pressure sensor
- Humidity sensor
- 3 axis 12-bit accelerometer
- Temperature sensor
- USB port with serial access
- LiPo battery charger
- MicroSD card compatibility
- Ultra low power operation ( 1uA in deep sleep)

## pycom: PyTrack



## pycom: PyTrack

- GNSS + Glonass GPS
- 3 axis 12-bit accelerometer
- USB port with serial access
- LiPo battery charger
- MicroSD ard compatibility
- Ultra low power operation ( 1uA in deep sleep)

## Our Lab equipment

- Pycom LoPy4
- PySense
- PyTrack
- microUSB cable

## Plan of the week

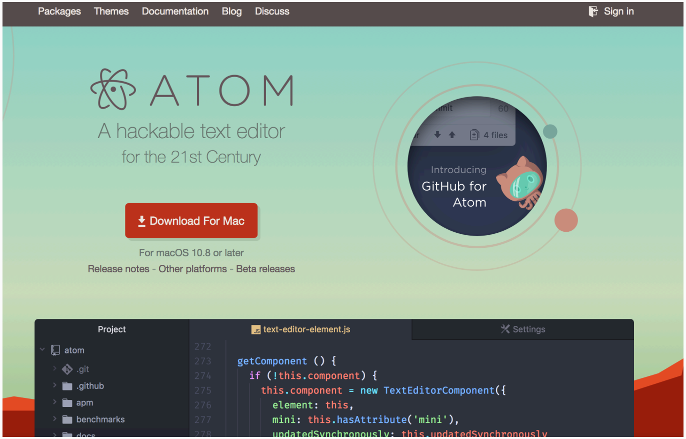
## plan for the week

During the lab sessions we will cover:

1. Pycom workflow
2. Hello World for IoT: LED switching
3. Saving data to internal flash
4. Reading sensors using the PySense
5. Connecting to WiFi, measuring signal strength and setting the clock
6. Reading position using the PyTrack
7. Using external Grove sensors
8. Saving data to InfluxDB and visualizing them using Grafana
9. Using MQTT
10. Using LoRaWAN

You will have simple code snippets and will develop more complex code as exercise.

## workflow: Atom



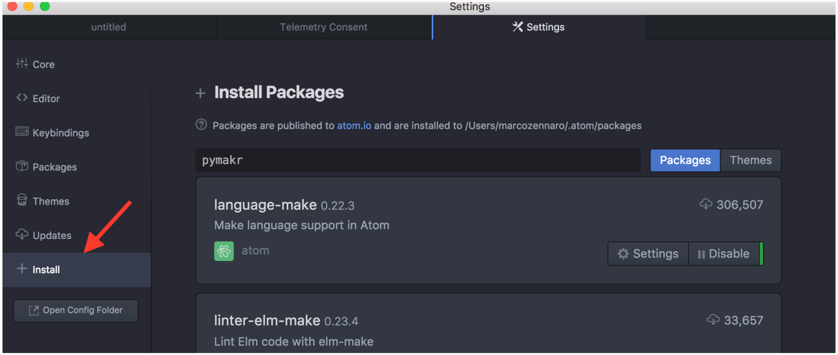
```
getComponent () {
  if (!this.component) {
    this.component = new TextEditorComponent({
      element: this,
      mini: this.hasAttribute('mini'),
      updatedSynchronously: this.updatedSynchronously
```

Please install Atom from

www.atom.io

## workflow: install the pymakr package

Preferences -> Settings -> Install -> search **Pymakr**



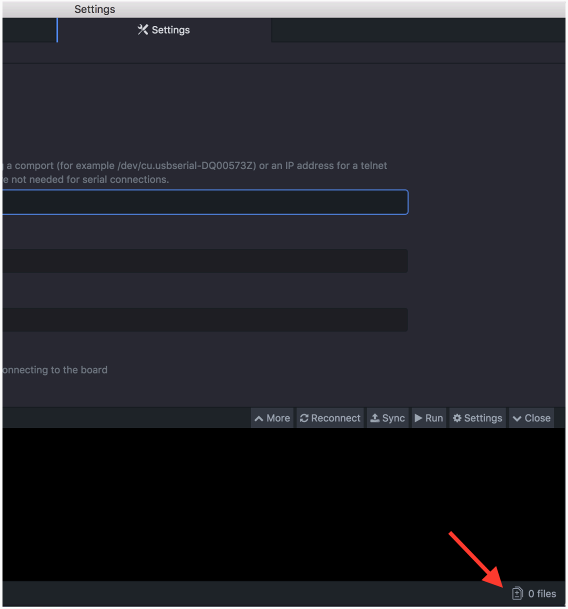
Packages are published to atom.io and are installed to /Users/marcozennaro/.atom/packages

```
pymakr
```

language-make 0.22.3 — 306,507
Make language support in Atom
atom

linter-elm-make 0.23.4 — 33,657
Lint Elm code with elm-make

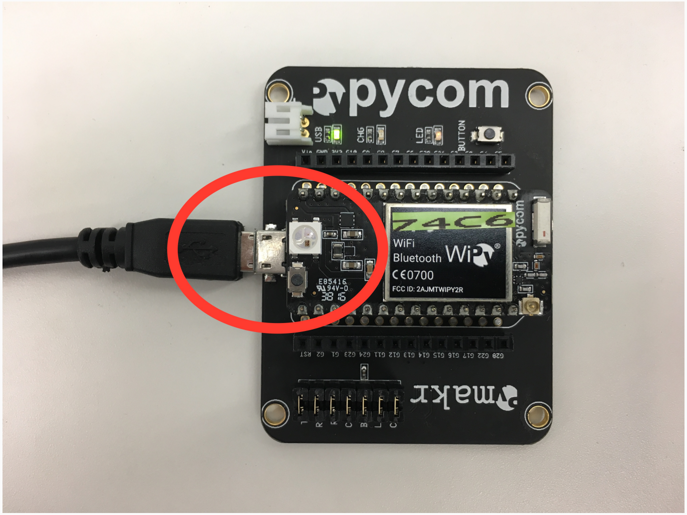
## workflow: update packages if necessary



a comport (for example /dev/cu.usbserial-DQ00573Z) or an IP address for a telnet
e not needed for serial connections.

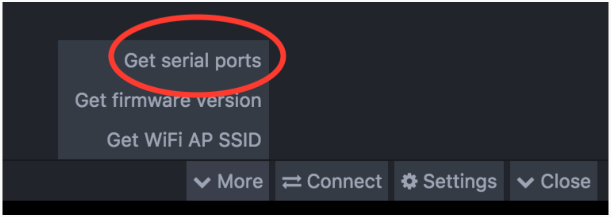
onnecting to the board

## workflow: connect board via USB

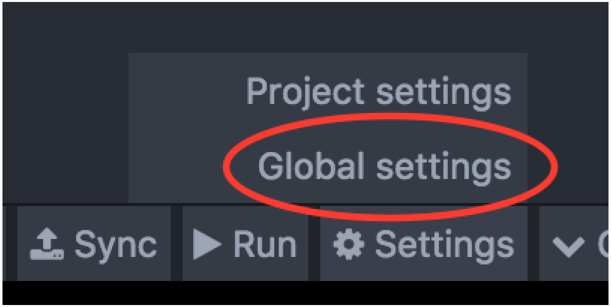


Make sure the LED and the microUSB are on the same side!

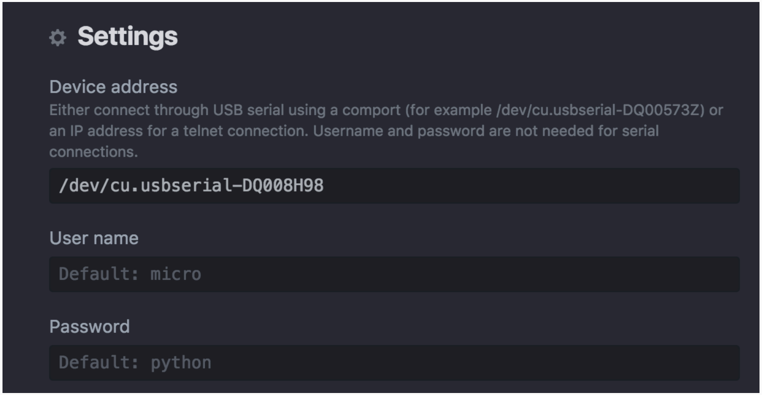
## workflow: get serial port



## workflow: global settings



## workflow: insert correct device address



Settings

Device address

Either connect through USB serial using a comport (for example /dev/cu.usbserial-DQ00573Z) or an IP address for a telnet connection. Username and password are not needed for serial connections.

```
/dev/cu.usbserial-DQ008H98
```

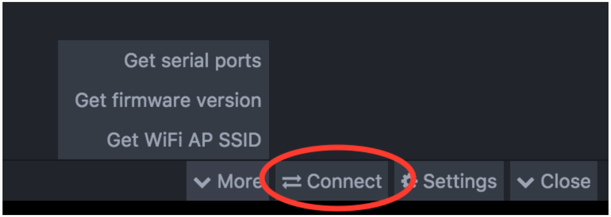
User name

```
Default: micro
```

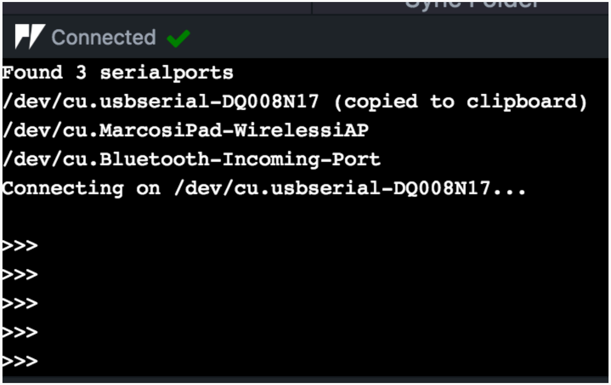
Password

```
Default: python
```

## workflow: connect!



## workflow: REPL



```
Found 3 serialports
/dev/cu.usbserial-DQ008N17 (copied to clipboard)
/dev/cu.MarcosiPad-WirelessiAP
/dev/cu.Bluetooth-Incoming-Port
Connecting on /dev/cu.usbserial-DQ008N17...

>>>
>>>
>>>
>>>
>>>
```

## REPL console

REPL stands for **Read Print Eval Loop**. Simply put, it takes user inputs, evaluates them and returns the result to the user.

You have a complete python console!

Try to enter 2+2 and press Enter.

Now enter:

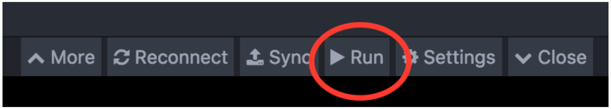
print(”Hi! I am a python shell!”)

## executing code

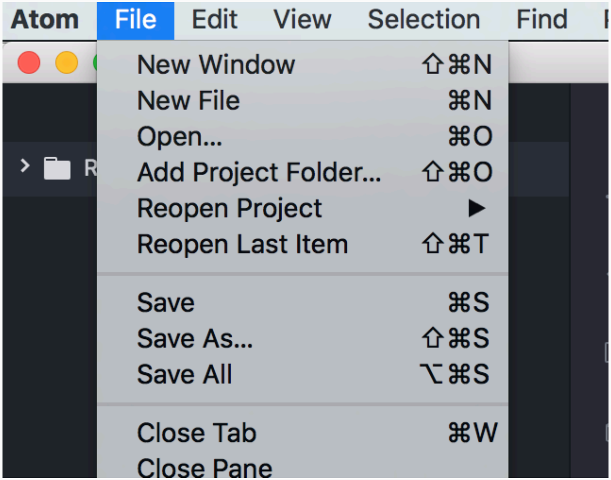
There are three ways to execute code on a Pycom device:

1. Via the **REPL** shell. Useful for single commands and for **testing**.
2. Using the **Run** button. Code in the Atom editor will be **executed**, but will not be stored in the device. If you reboot, the code will not be executed again.
3. **Synching** the device with the Project folder in Atom. In this way, the code is stored in the Pycom device and will be executed again if you reboot the device.

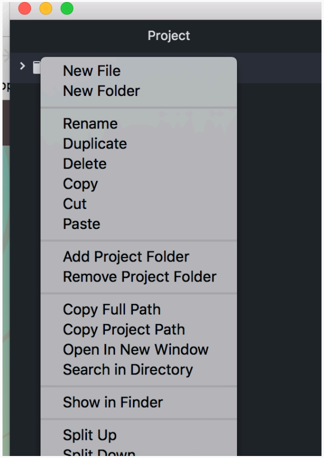
## workflow: Run



## workflow: add Project folder



## workflow: ONE Project folder



It is easier if you only have one Project folder. Make sure you Remove any other Project folders and keep only the one you want to use.

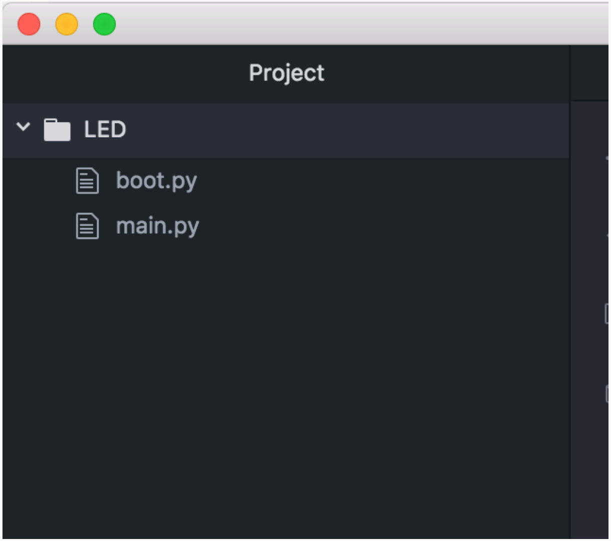
## workflow: Project folder

The Project folder should contain all the files to be synched with the device.

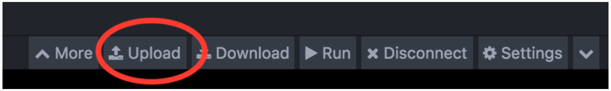
You should always have two files: **boot.py** (executed at boot time) and **main.py** (containing the main code).

The folder can also include libraries and other python source code.

## workflow: example of Project folder



## workflow: upload Project



## workflow: boot.py

The boot.py file should always start with following code, so we can run our Python scripts over Serial or Telnet.

```
from machine import UART
import os
uart = UART(0, 115200)
os.dupterm(uart)
```

## LED

## LED

In this example, we will create and deploy the proverbial 1st app, “Hello, world!” to a Pycom device.

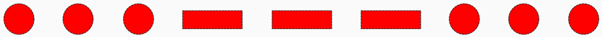
The LoPy module has one LED (big, white LED on the same side as the microUSB).

## code: LED

Check the LED folder and sync the two files to your active project folder.

Exercise:

Try to send an SOS message using the LED. The SOS is line-line-line-dot-dot-dot-line-line-line in morse code, where a line is three times longer than a dot.



## Writing data on Flash memory

## Flash

In this example, we will learn how to:

1. access and operate the device file system;
2. create and write a file in the /flash folder;

## Folder structure

Connect to a Lopy via the Atom console and import the basic operating system module (os): `import os`.

Once imported:

to know you current working directory: `os.getcwd()` (most probably the /flash folder);

to list folders and files in your current working directory: `os.listdir()`;

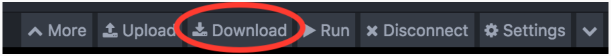
to create a new folder/directory named ”log”: `os.mkdir('log')`;

## Writing and reading

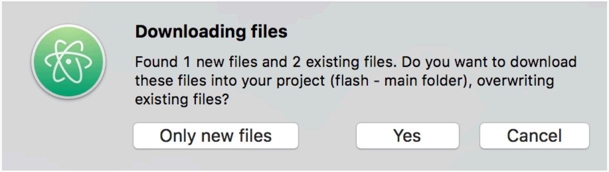
In the simplest case, to create and write a new file:

```
os.listdir('/flash')

# create/open, write, close a file
f = open('log/my\_first\_file.log', 'w')
f.write('Testing␣write␣operations␣in␣a␣file.')
f.close()

# open, read, close an existing file
f = open('log/my\_first\_file.log', 'r')
f.readall()
f.close()
```

## workflow: download file from flash



## workflow: download file from flash


Downloading files

Found 1 new files and 2 existing files. Do you want to download these files into your project (flash - main folder), overwriting existing files?

## Connect via WiFi

- Connect to the WiFi network produced by your LoPy. Find out the name using More –> Get WiFi AP SSID. The password is www.pycom.io
- Using your browser, ftp://192.168.4.1 with username micro and password python.
- Download the file.

## Exercise

Write a script writing a file named ”log.csv” in /flash/log/ folder so that:

it writes ”start”, writes a string for ten times, writes ”finish” and repeats this for five times.

## PySense

## PySense high-level modules

In this lab, we will provide a series of examples:

- accelerometer in src/pysense/acceloremeter

- measuring ambient light in src/pysense/ambient-light

- measuring temperature and atmospheric pressure in src/pysense/temp-bar

- measuring temperature and humidity in src/pysense/temp-hum

Pycom provides a library abstracting the implementation details of sensor chips. This library is already included in labs source code under the lib folder of each example.

## Exercises

- Change the color of the LED based on accelerometer measurements (green, orange, red if the values of acceleration are small, medium or large)
- Find where is the temperature sensor and where is the light sensor
- Log the measurements of temperature every 10 seconds and the measurements of humidity every 30 seconds into the /flash/log folder (while LED blinking green)
- Build a pendulum, measure its acceleration and visualize the result. See https://en.wikipedia.org/wiki/Pendulum

## WiFi

## WiFi

In this lab, we will provide a series of examples:

- connecting to a WiFi network using WPA authentication (in src/WiFi/WPA)

- measuring signal strength (in src/WiFi/RSSI)

- synchronizing the internal clock using a webserver (in src/WiFi/Sync-no-NTP)

## Connecting to WiFi using WPA

Modify the following lines to reflect your Access's Point name and password:

```
ssid = 'MyAP'
password = 'MyPassword'
```

Scan for all networks and check if there is any network with the name of your Access Point:

```
nets = wlan.scan()
for net in nets:
    if net.ssid == ssid:
        print('Network␣found!')
```

Connect!

```
wlan.connect(net.ssid,auth=(net.sec,password, timeout=50
```

## Measuring signal strength

RSSI stands for Received Signal Strength Indicator and reflects the received signal level. Don't forget it's a negative value (and -70 indicates a stronger signal than -80).

Scan for all networks:

```
nets = wlan.scan()
```

and print the RSSI value of each network:

```
while True:
    for net in nets:
        print(net.ssid, net.rssi)
```

## Synchronizing the clock with a server

In this example we will be using a WiFi connection to connect to the SODAQ time server in order to retrieve the current date and time stamp and update the internal RTC.

The example code first connects to the WiFi Access Point, then connects to the time.sodaq.net sever on port 80 and gets a string as an output. It splits the output and take the row which corresponds to the seconds (the seventh row). It finally sets the local time to this value in seconds and visualizes the new time.

## Exercises

- Try to move around the lab and check the RSSI values. How far can you go while still receiving the APs? Use the LED color to show the RSSI value.
- Log and plot the RSSI values over time. How much does the RSSI fluctuate?
- Synchronize the clock and use the correct time to timestamp temperature and humidity measurements. Log time, T and H in a file in the internal flash. You now have a data logger!

## PyTrack

## GPS

In this lab, we will use a Lopy on a Pytrack board to access the position given by the internal GPS.

To get a GPS fix (which means to get the exact position) you must have an unobstructed view of the sky. It will not work in the lab! You must use the Pytack outdoors.

## PyTrack

Pycom provides a library (a set of Python modules) abstracting the implementation details of the GPS. This library is already included in labs source code.

Enable the GPS:

```
py = Pytrack()
gps = L76GNSS(py, timeout=30)
```

get the measurements and print them:

```
(lat, lon, alt, hdop) = gps.position()
print("%s␣%s␣%s␣%s" %(lat, lon, alt, hdop))
```

## Exercises

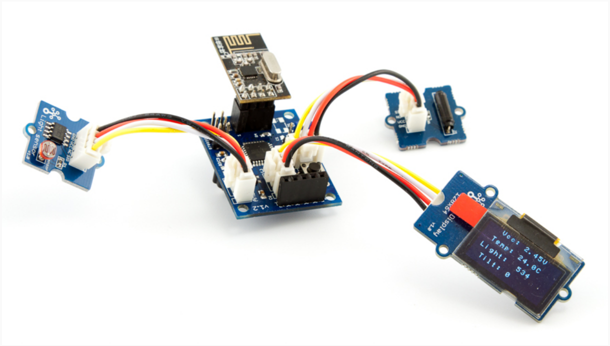
- Go out to get a GPS fix! Use the LED to make sure you have a fix. Save the positions provided by the Pytrack in a file (call it log.cvs) and download it on your computer using the "Download" button in Atom. Visualize the places you have visited using the instructions provided here: `http://www.cartagram.com/5648/from-excel-to-google-maps/` or use this online tool: `http://www.gpsvisualizer.com/`
- Design a "WiFi counter" that measures how many WiFi networks are available in a certain place. Log the GPS position and the number of WiFi networks in a file. Visualize the results around the ICTP campus!

## ICTP-IAEA Grove shield

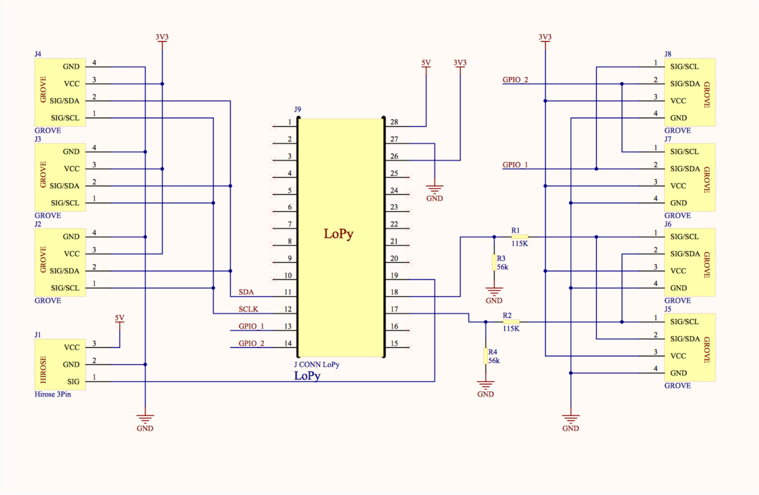
## Grove sensors

www.seeedstudio.com/category/Sensor-for-Grove-c-24.html

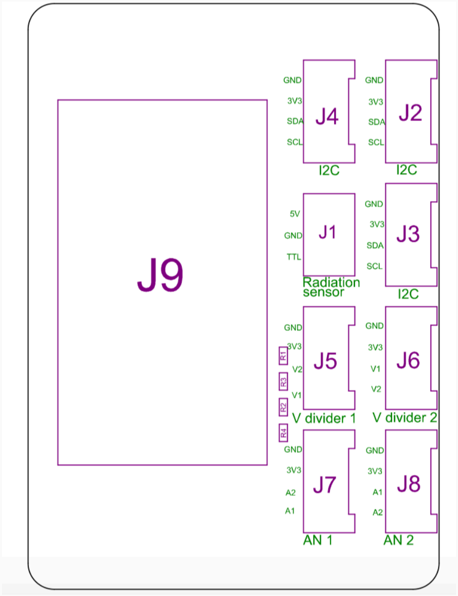
## Grove sensors



## ICTP-IAEA Grove shield



## ICTP-IAEA Grove shield



## ICTP-IAEA Grove shield

J4: I2C

J2: I2C

J1: radiation sensor

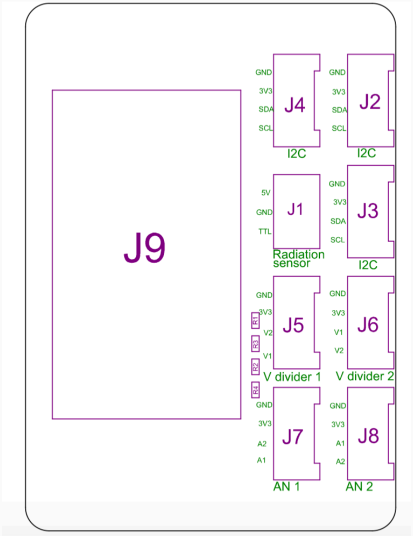
J3: I2C

J5: analog

J6: analog

J7: digital

J8: digital



## ICTP-IAEA Grove shield

J4: Sda on Pin11, Scl on Pin12

J2: Sda on Pin11, Scl on Pin12

J1: Pin17

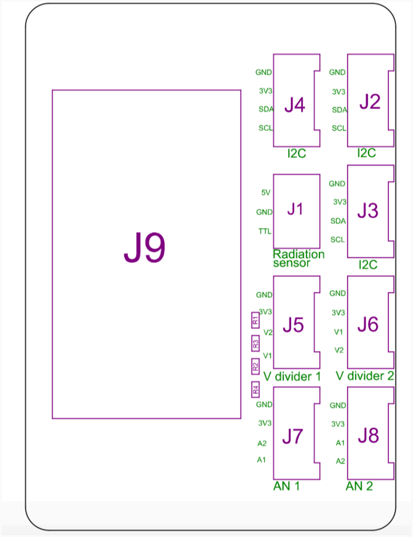
J3: Sda on Pin11, Scl on Pin12

J5: P16 on Pin18

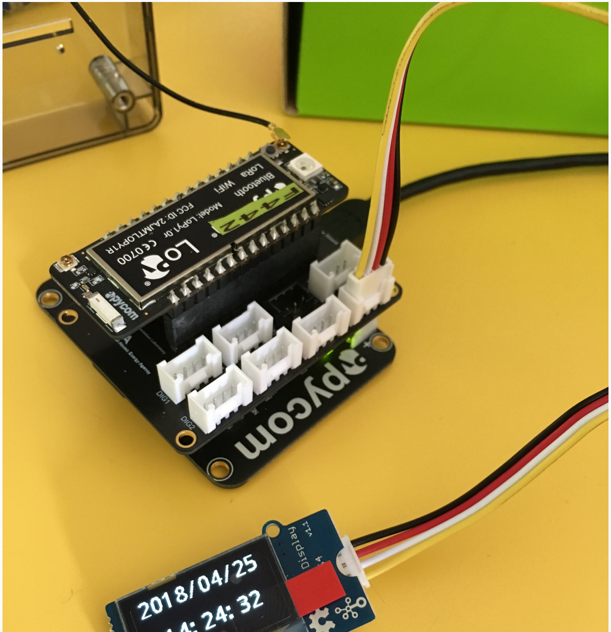
J6: P15 on Pin17

J7: P12 on Pin14

J8: P11 on Pin13



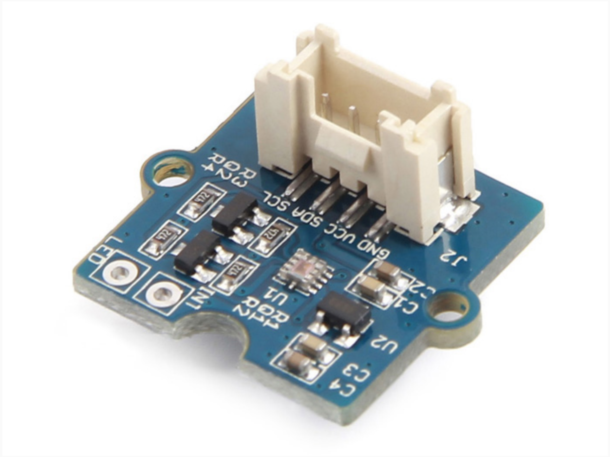
## ICTP-IAEA Grove shield



## Grove - OLED Display 0.96”: I2C sensor

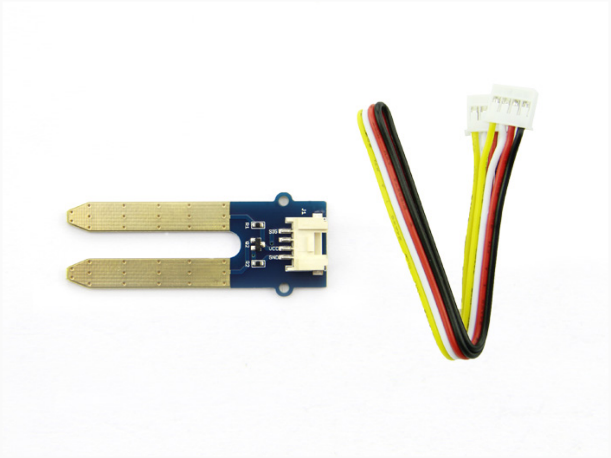
https://www.seeedstudio.com/Grove-OLED-Display-0.96%26quot%3B-p-781.html

## Grove - Sunlight Sensor: I2C sensor



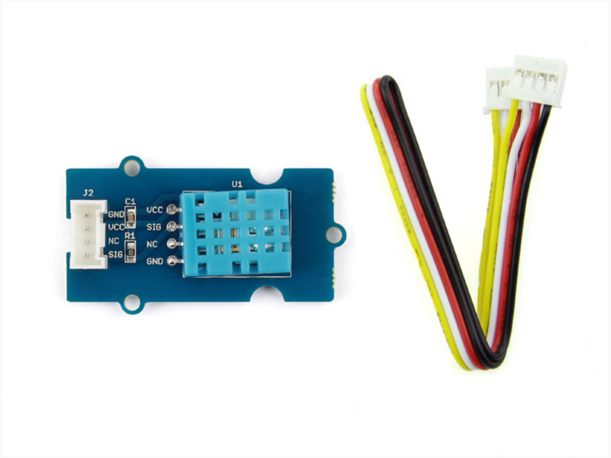
https:
//www.seeedstudio.com/Grove-Sunlight-Sensor-p-2530.html

## Grove - Moisture Sensor: Analog sensor



https://www.seeedstudio.com/Grove-Moisture-Sensor-p-955.html

## Grove - T and H Sensor DHT11: Digital sensor

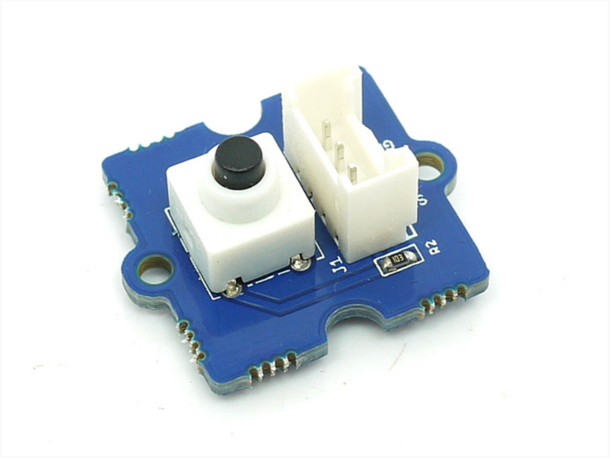


https://www.seeedstudio.com/Grove-Temperature-%26amp%3B-Humidity-Sensor-%EF%BC%88DHT11%EF%BC%89-p-745.html

## Grove Buzzer: Digital Sensor

https://www.seeedstudio.com/Grove-Buzzer-p-768.html

## Grove Button: Digital sensor



https://www.seeedstudio.com/Grove-Button-p-766.html

## Exercises

- Check all the examples (in src/grove_board)
- Show temperature and humidity on the display for 5 seconds, then light for 5 seconds, then temperature and humidity again, and so on.
- Design a sensor node for agriculture. Measure temperature, humidity, light and soil moisture. Save the data and time in the internal flash memory. Test your device outdoors!