Intro to electronics and programming with Beehive

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# Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
Part 1	**Introduction** - Physical computing - ESP32	**Timing** - reaction time task - Loops	**Logging data** - save/read data from file	**Beehive I** - General concept - turn on a fan	**Create your own task I**
Part 2	**Introduction to training board Digital IO** - Blink led - Detect button **Serial communication**	**Analog IO** - read potentiometer - set LED brightness	Time for review/issues/doubts/questions	**Beehive II** - Existing boards and how they can be combined for your experiments	**Create your own task II**

Physical computing & research applications

Examples of projects that use electronics

A

GUI

USB

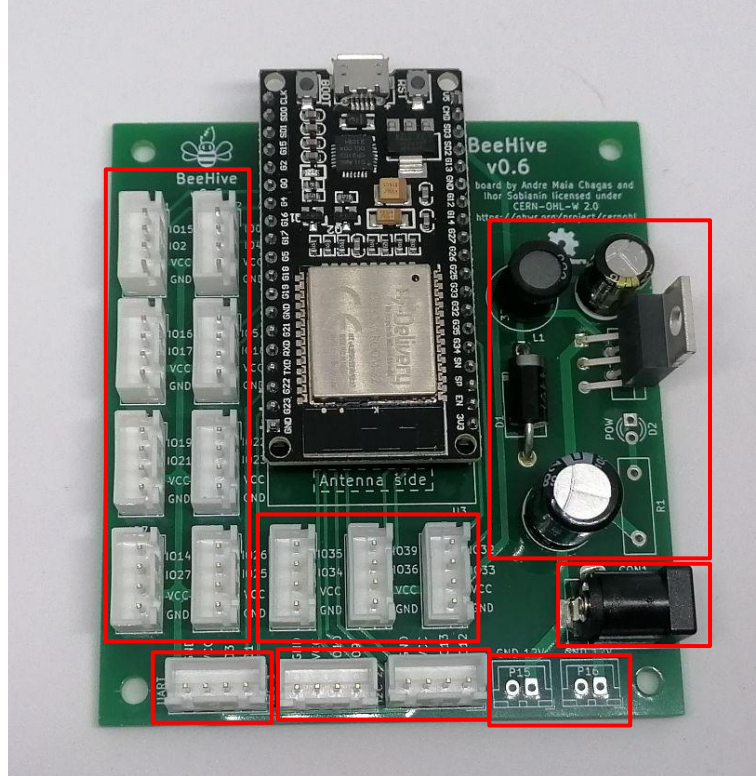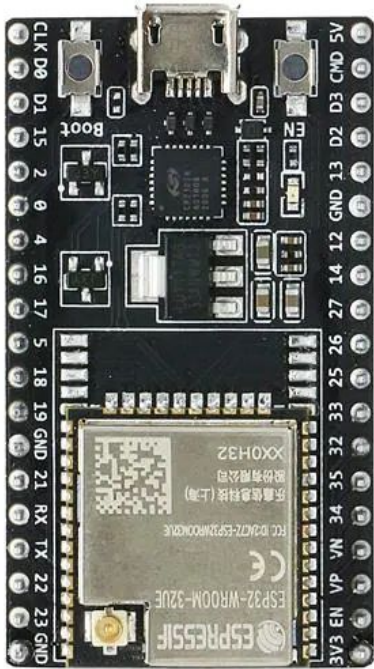Breakout board

RJ45
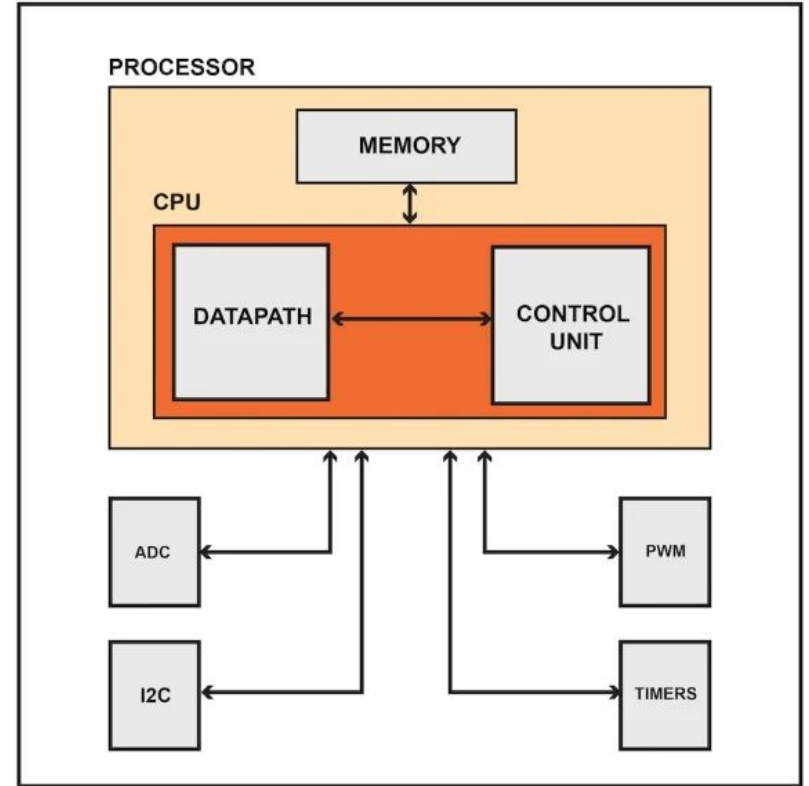
Behavioural setup
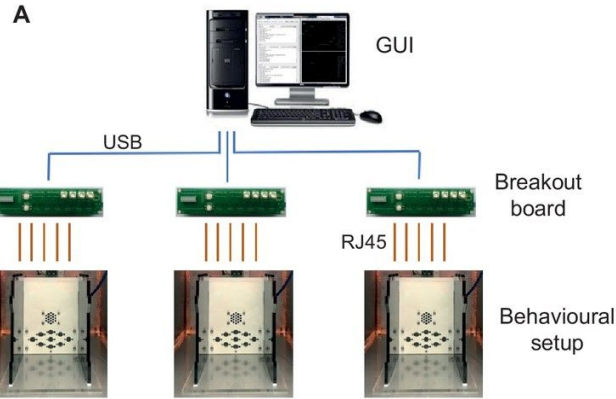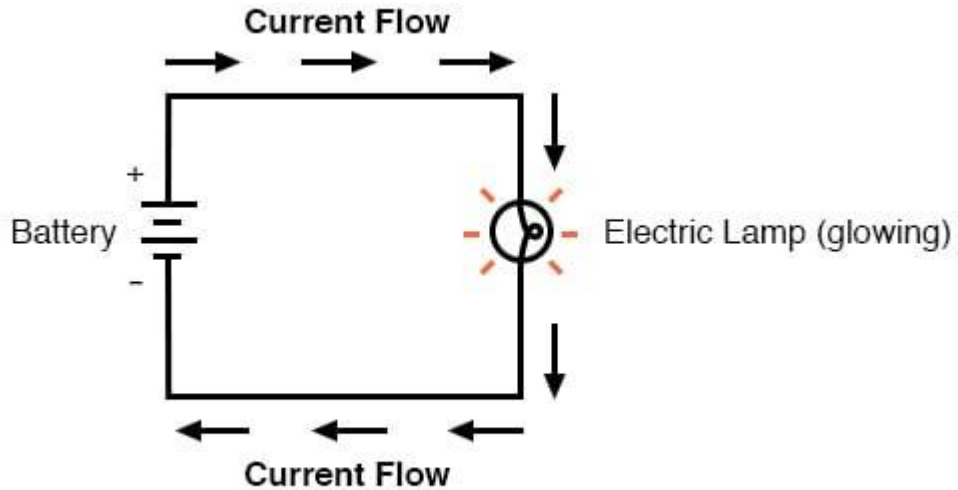
B Breakout board front
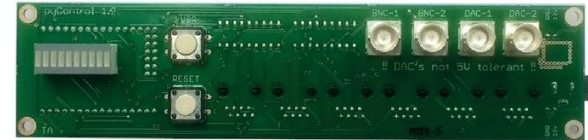
Breakout board back

Microcontroller

Microcontroller

DC circuits

Current Flow

Battery

+

−

Electric Lamp (glowing)

Current Flow

Ohm's law:
I [A] = U [V] / R [Ohm]

Ohm's law review
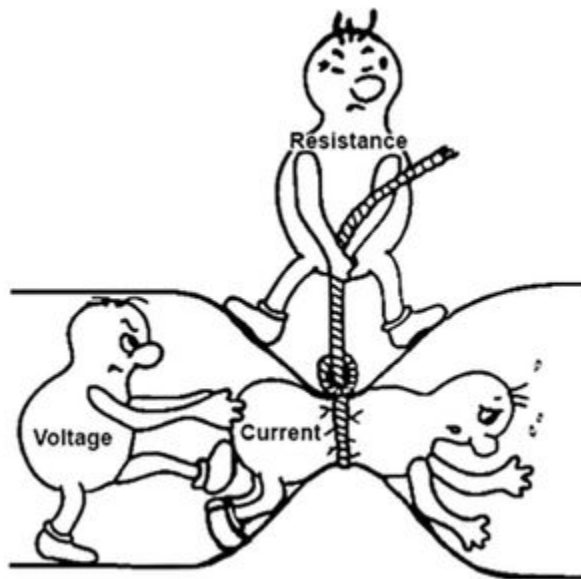
Add info about binary system and how numbers are conveyed in binary

Binary representation-how digital computers communicate

Bits, bytes, words:

byte (8-bits)

word (16-bits, 2 bytes)

Register:

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

MSB > | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | < LSB

5 V — V_{CC}
2.7 V — V_{OH}
2 V — V_{IH}
0.8 V — V_{IL}
0.4 V — V_{OL}
0 V — GND
Standard 5 V TTL
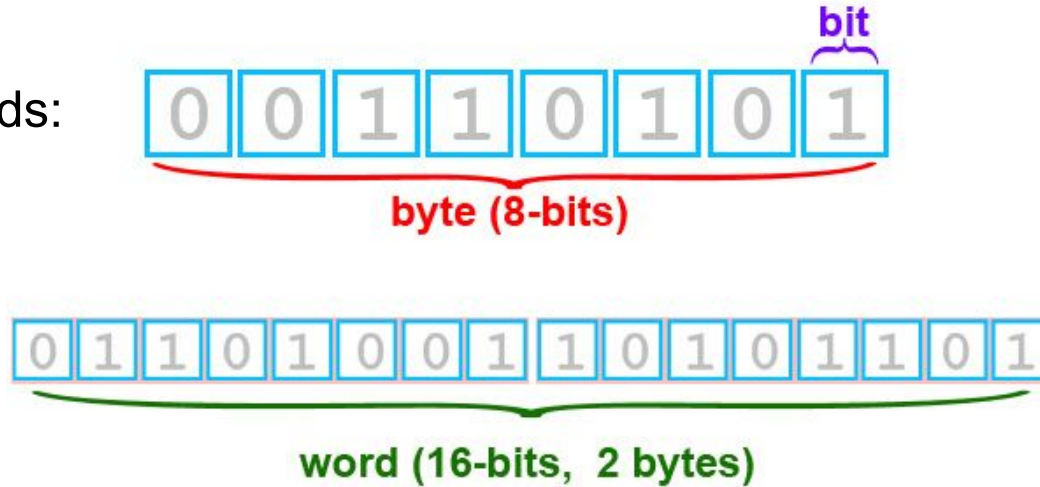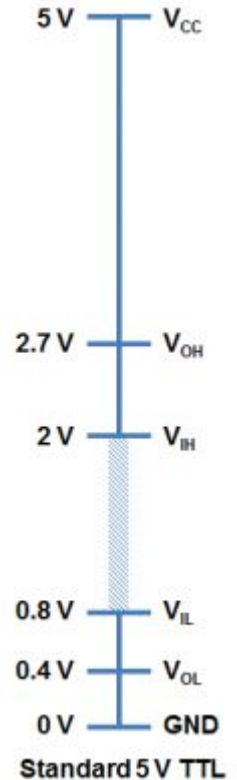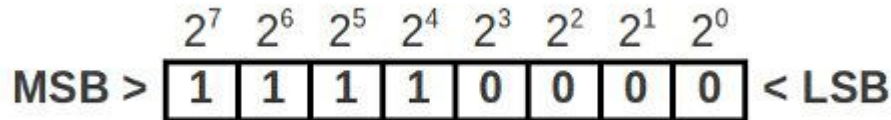
Training board

Connecting things for the first time

Exercise: Digital Output

- Blink some leds on the training board!
- Steps:
    - Connect cables from the main board to appropriate section on the training board
    - Make sure to note to which IO pins on the main board the cables are connected.
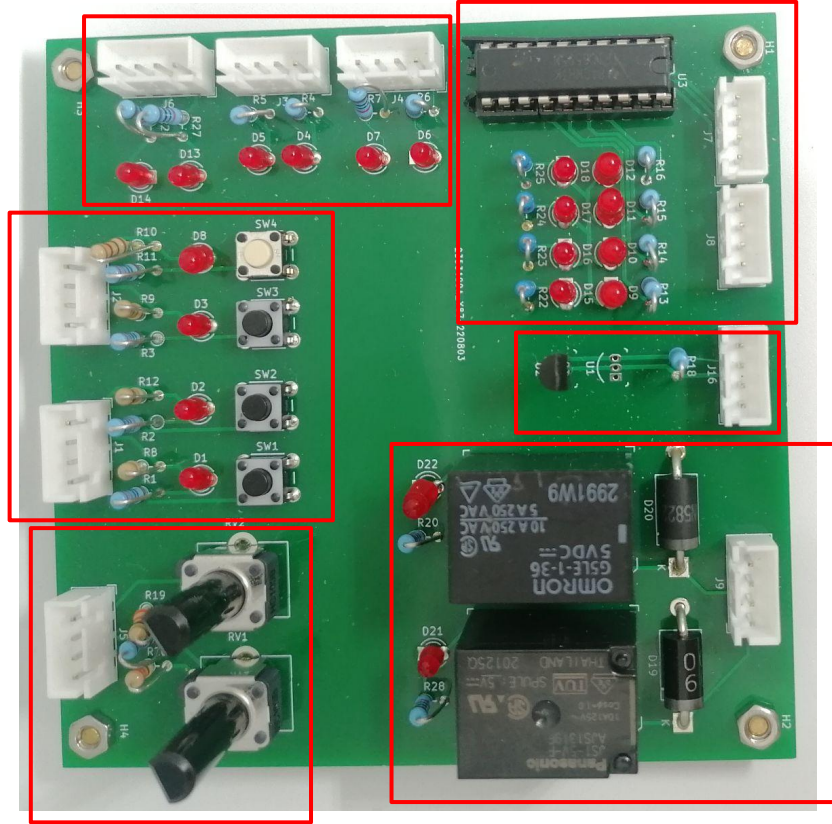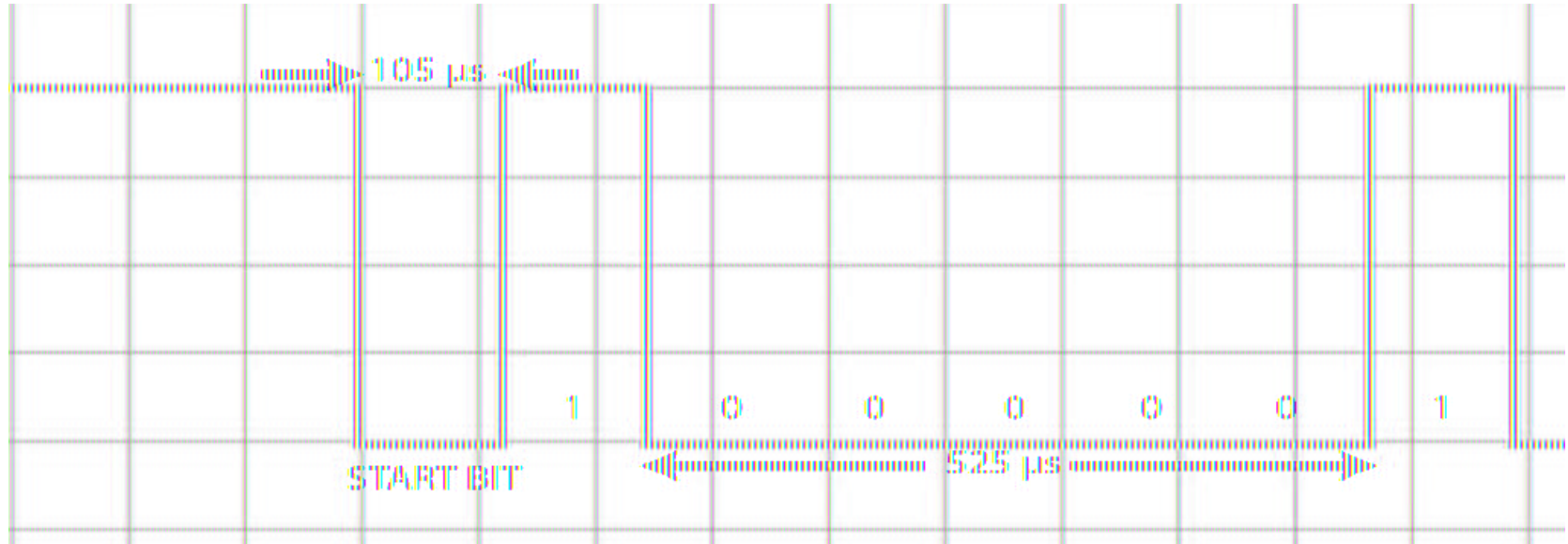
- Now blink the other leds on the board, can you change the amount of time they stay on and off?
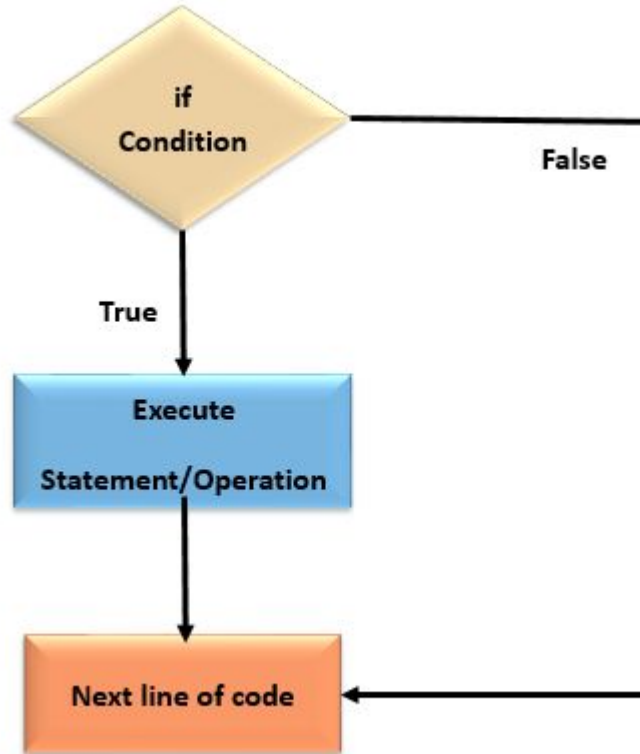
Exercise: Digital Input

- Detect when the a button was pressed
- Steps:
    - Connect cables from the main board to appropriate section on the training board
    - Make sure to note to which IO pins on the main board the cables are connected

Serial communication

Conditional statements
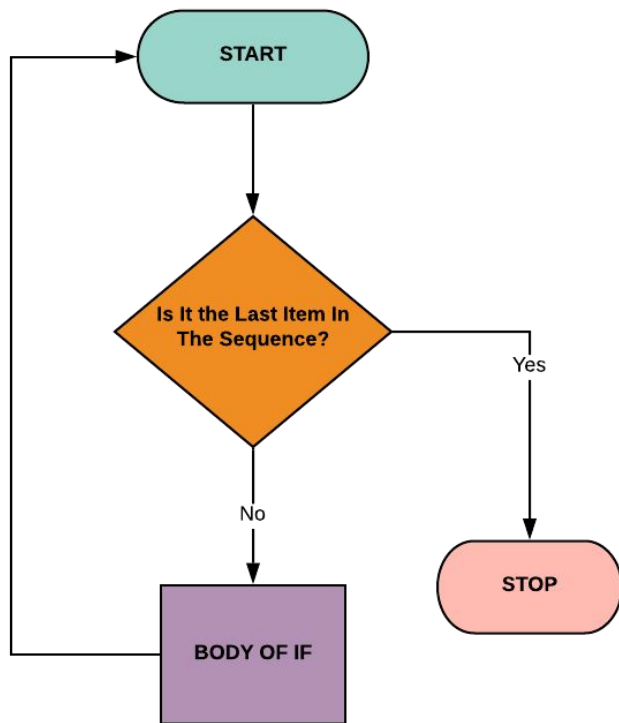


```
if (condition)
{
Print statement or operation;
}
```

```
Python                                                    >>>
1  >>> x = 20
2
3  >>> if x < 50:
4  ...      print('(first suite)')
5  ...      print('x is small')
6  ... else:
7  ...      print('(second suite)')
8  ...      print('x is large')
9  ...
10 (first suite)
11 x is small
```

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Loops

Python

```python
for <var> in <iterable>:
    <statement(s)>
```

Python For Loop Syntax

Let us understand the for loop syntax with an example:

```python
1  x = (1,2,3,4,5)
2  for i in x:
3      print(i)
```

Output: 1

2

3

4

5

Exercise: Timing

- Press a button when LED is turned ON/OFF
    - Does this seem similar to anything in Neurosciences?
    - What if we count the time in between the LED turning on and the button being pressed?

# Analog-to-digital converter
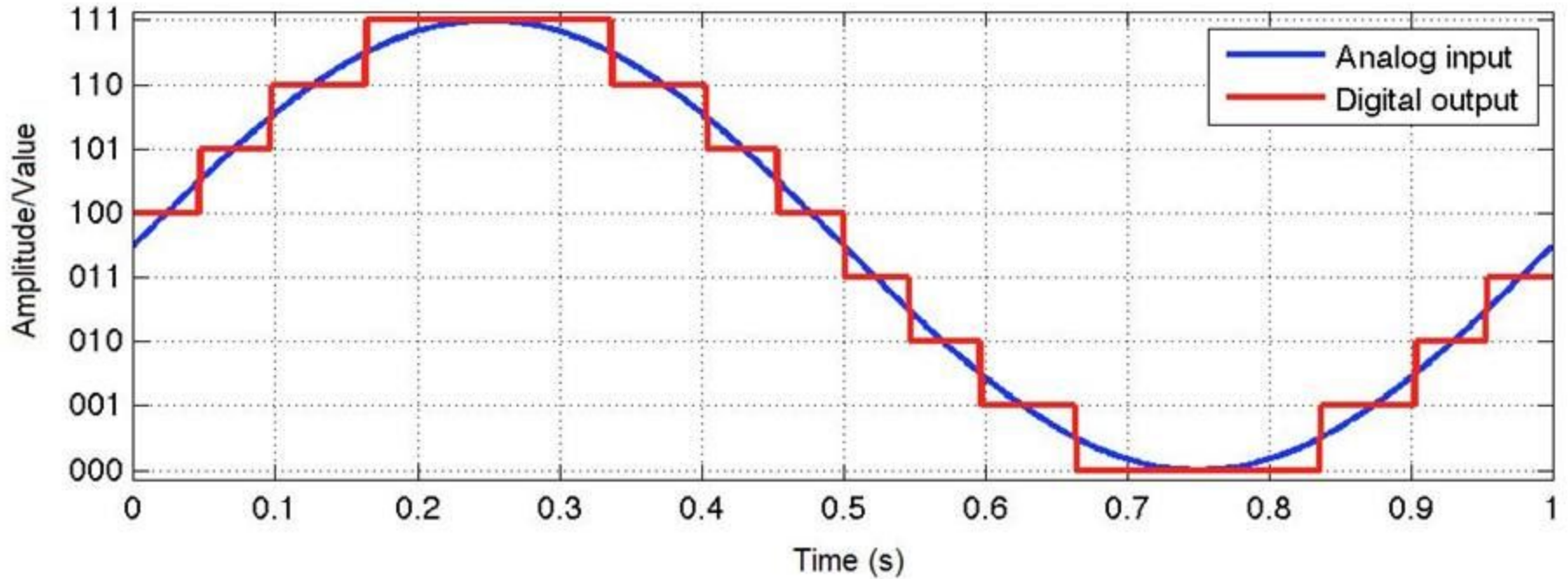
Exercise: Analog input

- Read from a potentiometer
- How do we transform volts to integer values (ADC)

Exercise: Analog output

- Dim an led
- How do we convert integer values to volts (DAC)

Data Logging

- Constraints of microcontrollers
    - How much data can be transmitted at a certain amount of time
    - Time critical periods in applications
    - Record locally (SD card) or remotely (PC)
- Working together with PC
    - Capture data being transmitted/store it to file
    - Different file types.
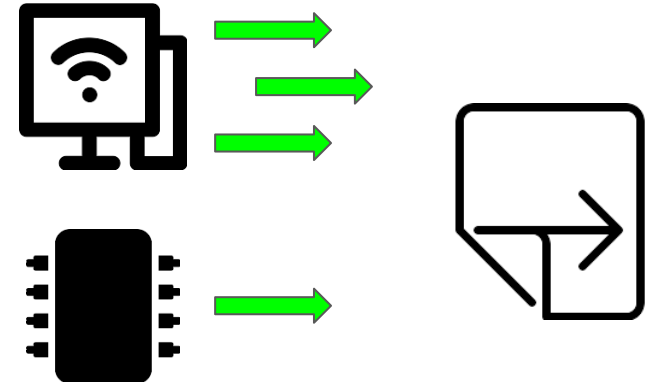
Exercise: Data Logging

- Show how to send data with mpremote code and than point to Dexter's library.

Q&A - course midpoint

Exercise at home

- Please write a small text about what kind of tool you would like to create for your research needs.
    - Try to think about how this would be implemented in code
        - This can and should be done without coding at a first stage! Create sketches, block diagrams and/or a list of logical steps on what your application needs to do.

BeeHive I

- Please share with us the task you thought about at home
    - Lets get examples from 2-3 pairs

- Are there common points in these tasks?
    - If so, do we need to reinvent the wheel every time?

- What if we had a system with pre-configured building blocks?

BeeHive I

Beehive presentation

Exercise: BeeHive I application

- Turn on a DC motor/peltier element/fan

BeeHive I other examples

Other boards and actuators/sensors that can be controlled with them.

BeeHive II

- Using the existing blocks for your experiments
  - Match your task with existing beehive boards

Create your own system

- Using the training board and your new coding skill, start implementing the programming logic for your task!

Closing remarks