No-Code Programming for Biology

Morning Session

09:00 Welcome & Lesson 1: Introduction

An introduction to us, the grove board, microcontrollers and the XOD IDE

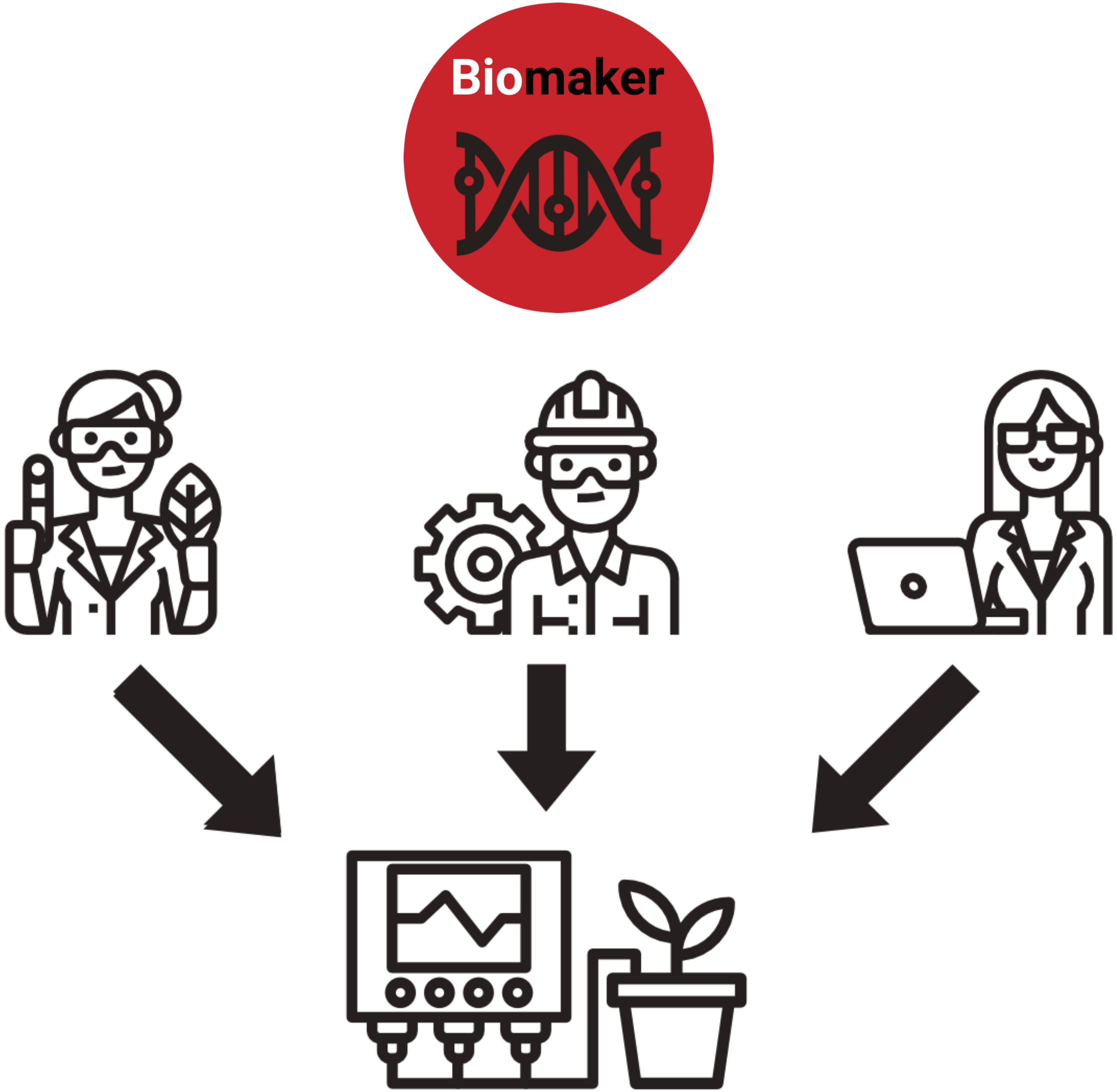
10:00 Break

10:30 Lessons 2 & 3: Getting Started & Explore XOD

Get started with using your board. We'll start with some simple tasks like flashing an LED, pressing a button and sounding a buzzer

Get to grips with some of the most useful nodes in XOD

12:00 Lunch


Biomaker

No-Code Programming for Biology

seeed studio

XOD

Before we Start

1 Downloaded the XOD Software

www.xod.io

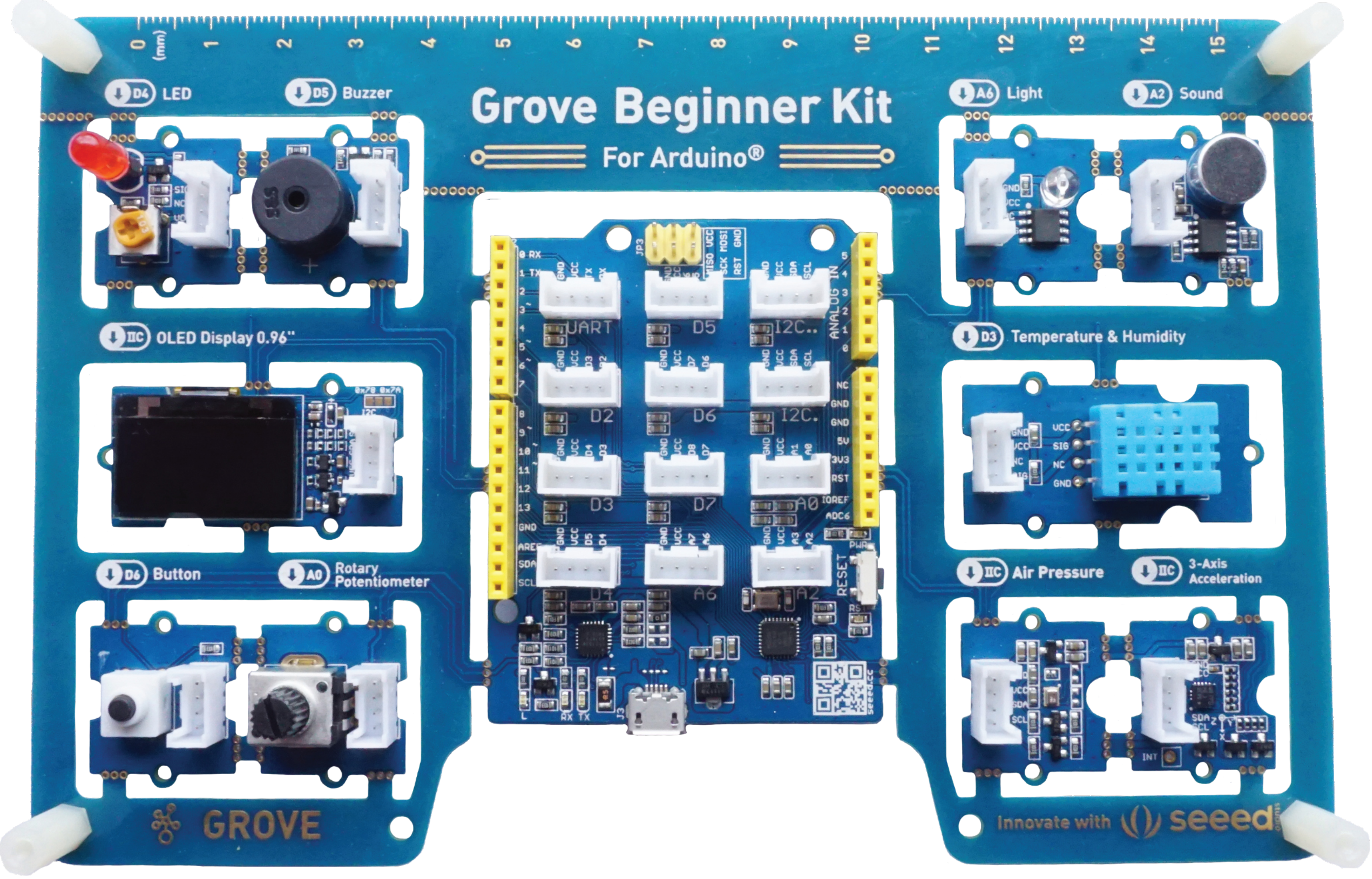
2 Downloaded the No-Code Programming Beginner’s Guide

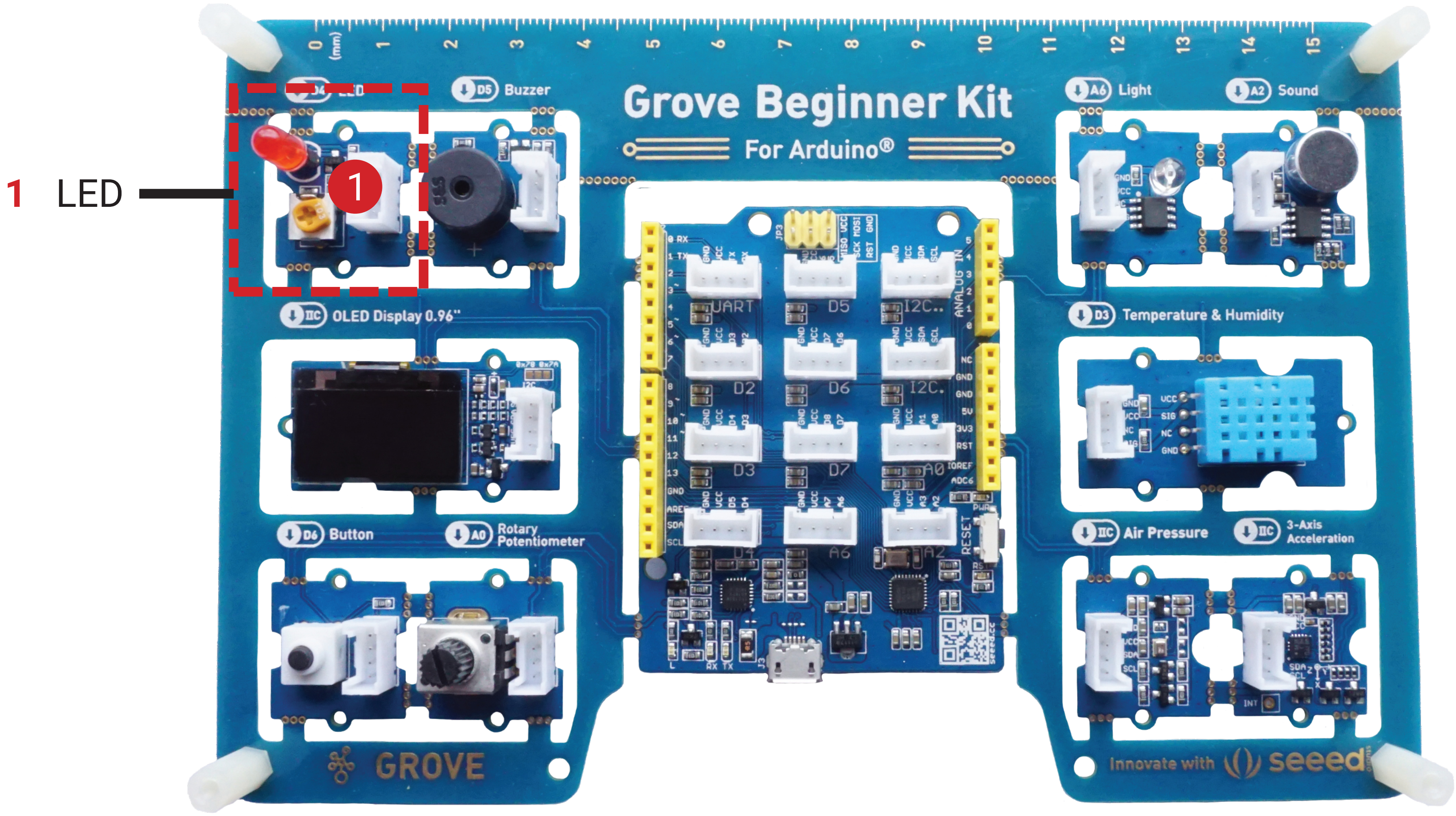
www.biomaker.org/nocode-programming-for-biology-handbook

3 Installed USB Drivers (if required)

www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers

The Starter Kit


Grove Beginner Kit
For Arduino®
D4 LED
D5 Buzzer
A6 Light
A2 Sound
IIC OLED Display 0.96"
D3 Temperature & Humidity
D6 Button
A0 Rotary Potentiometer
IIC Air Pressure
IIC 3-Axis Acceleration
GROVE
Innovate with seeed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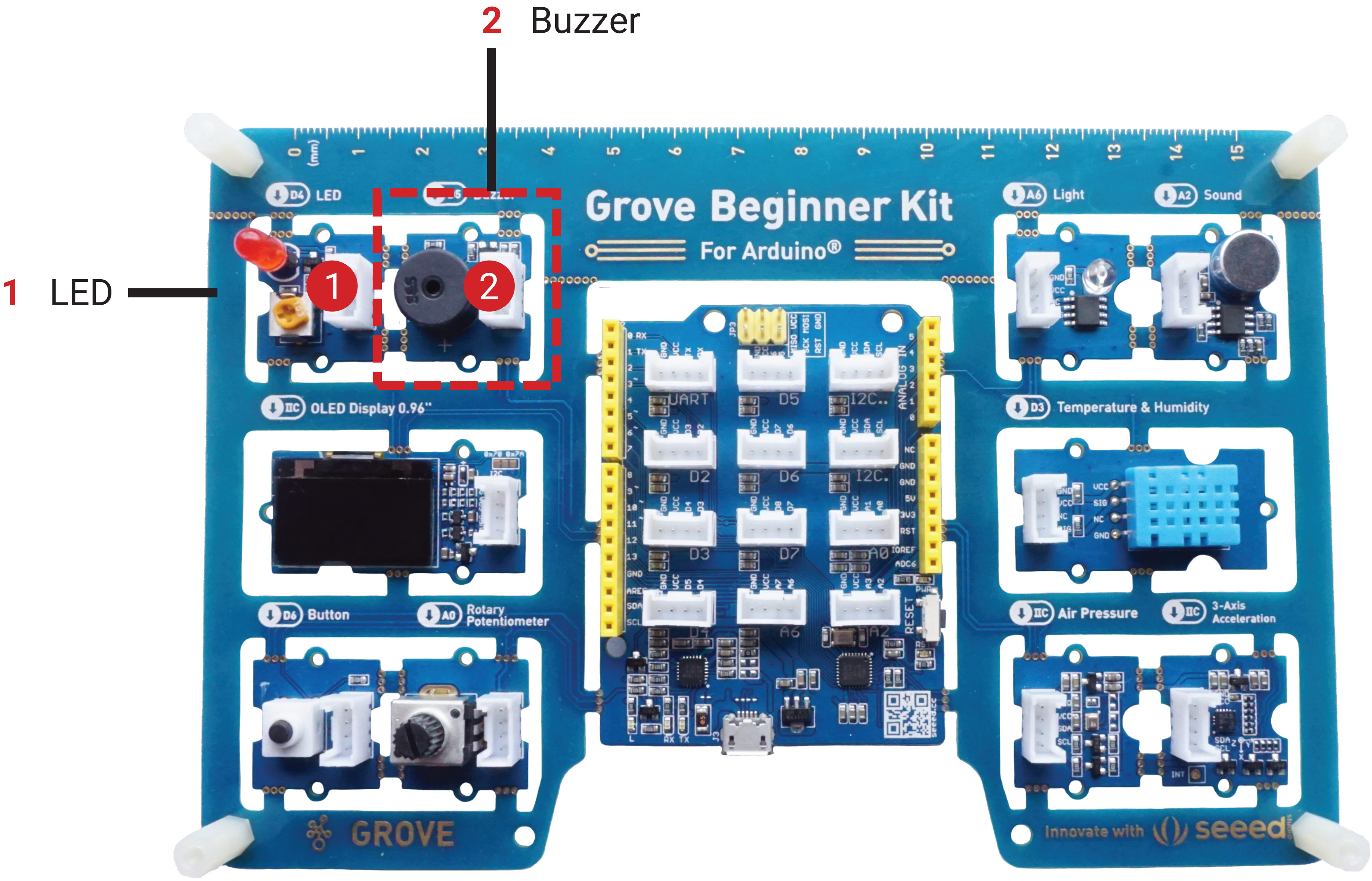
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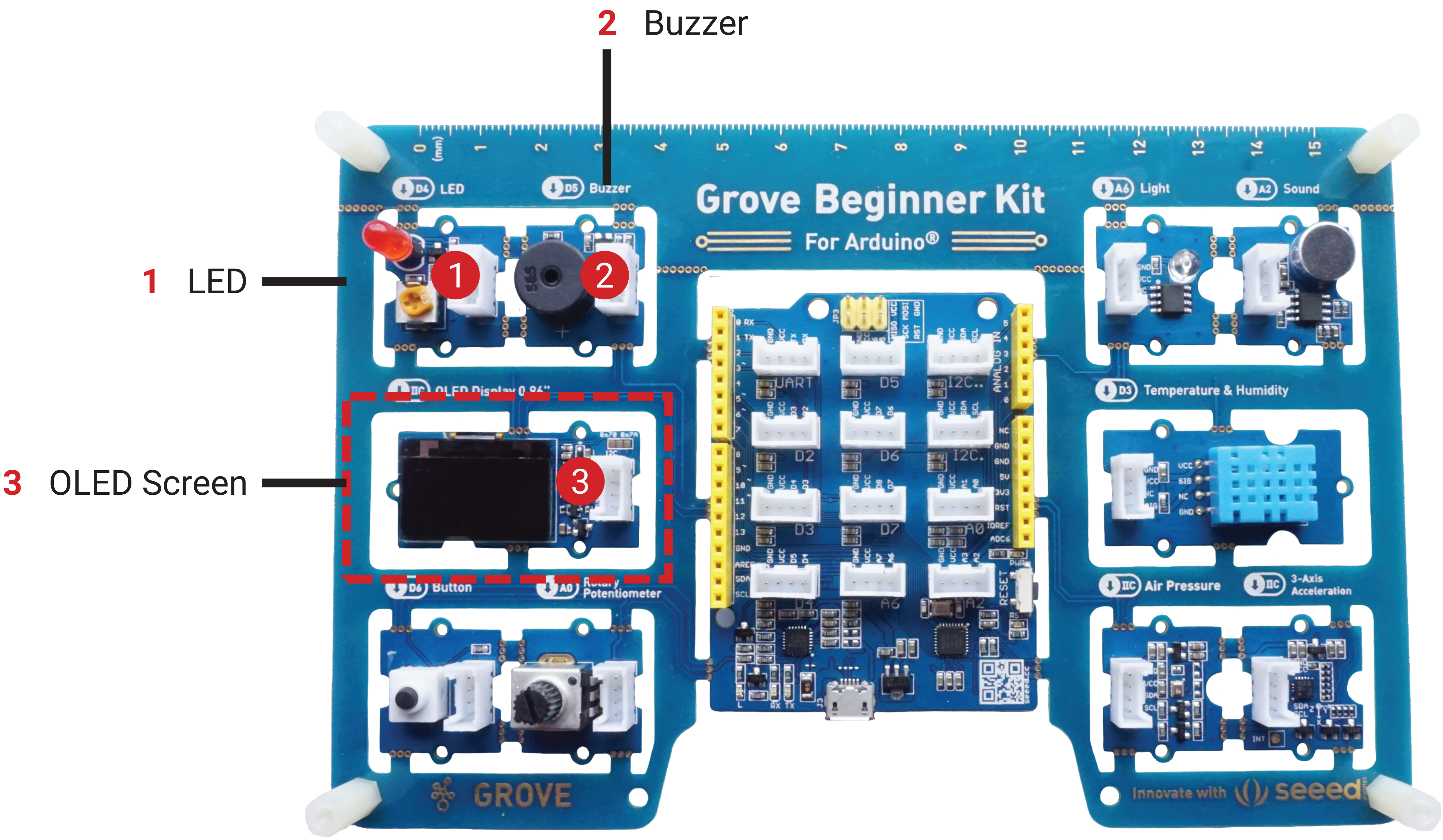
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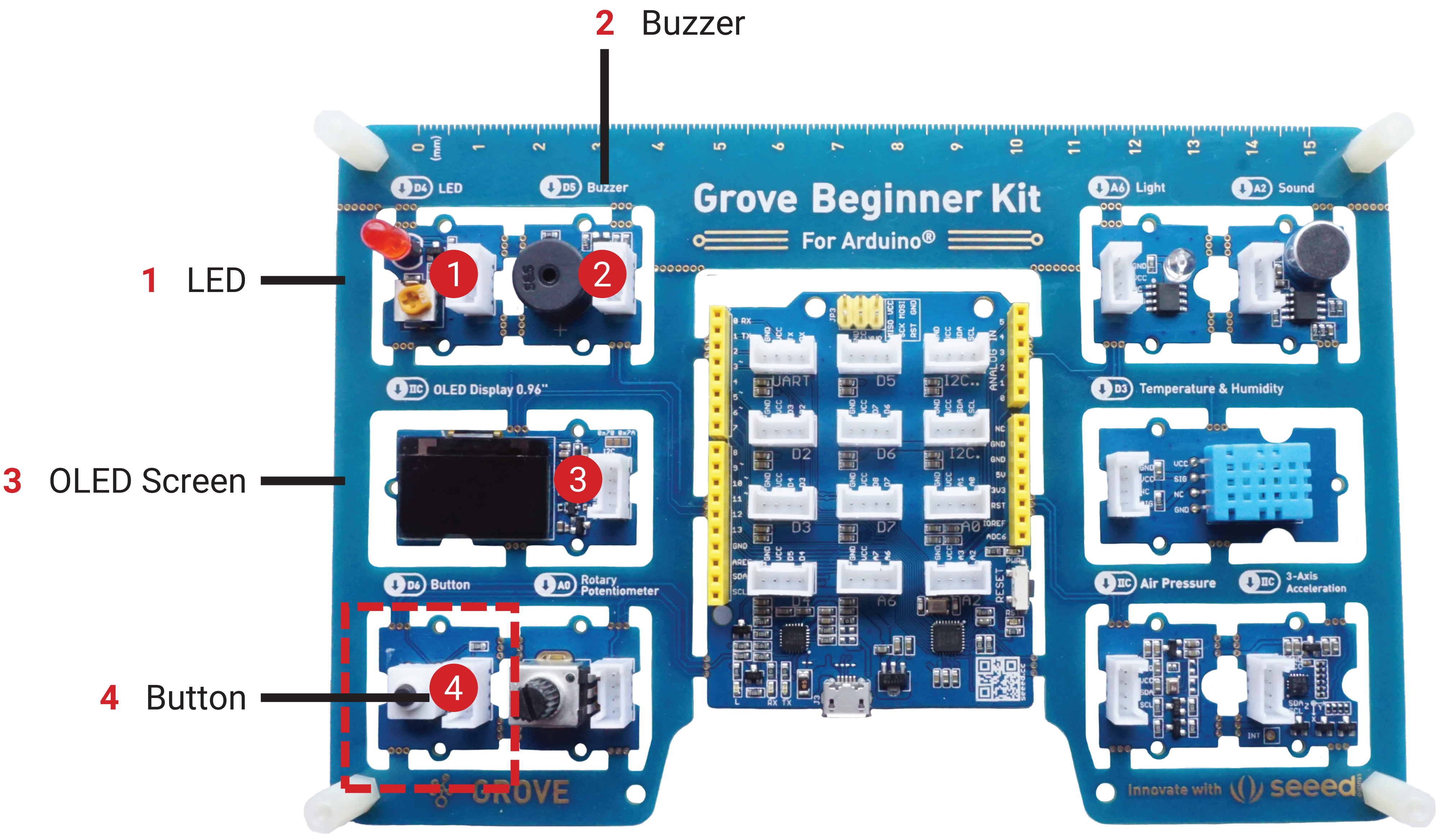
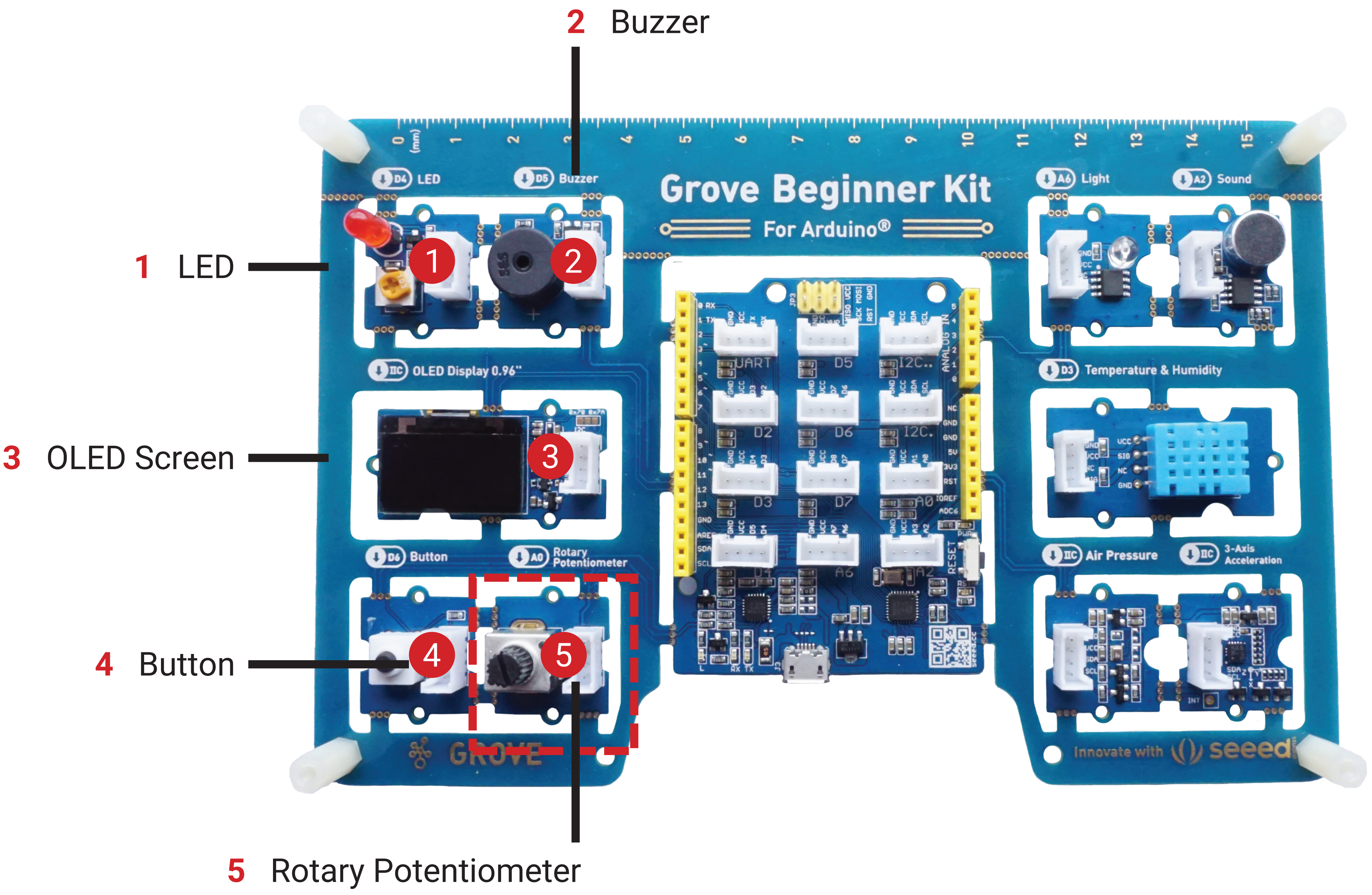


1 LED

2 Buzzer

3 OLED Screen

4 Button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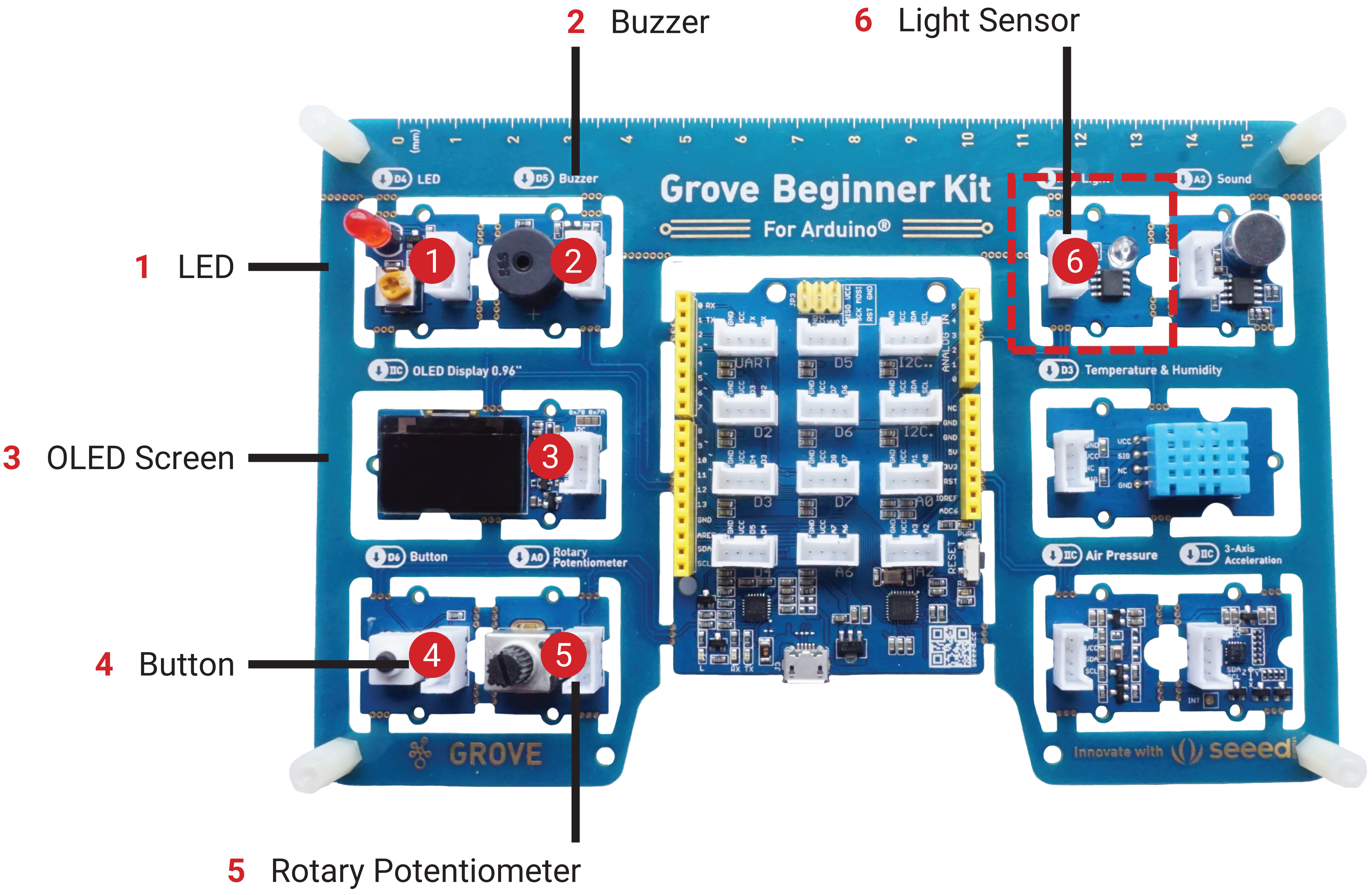
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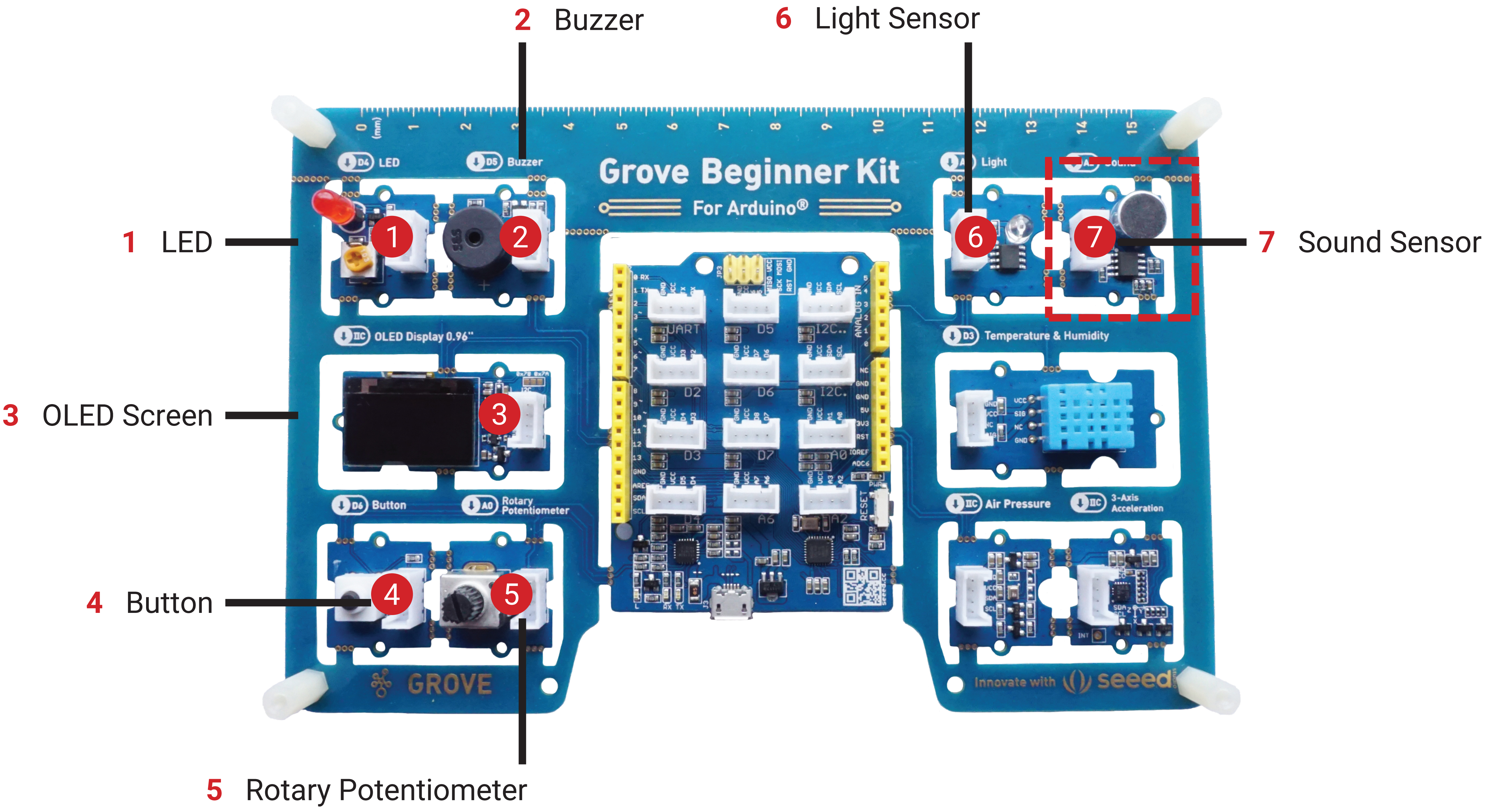
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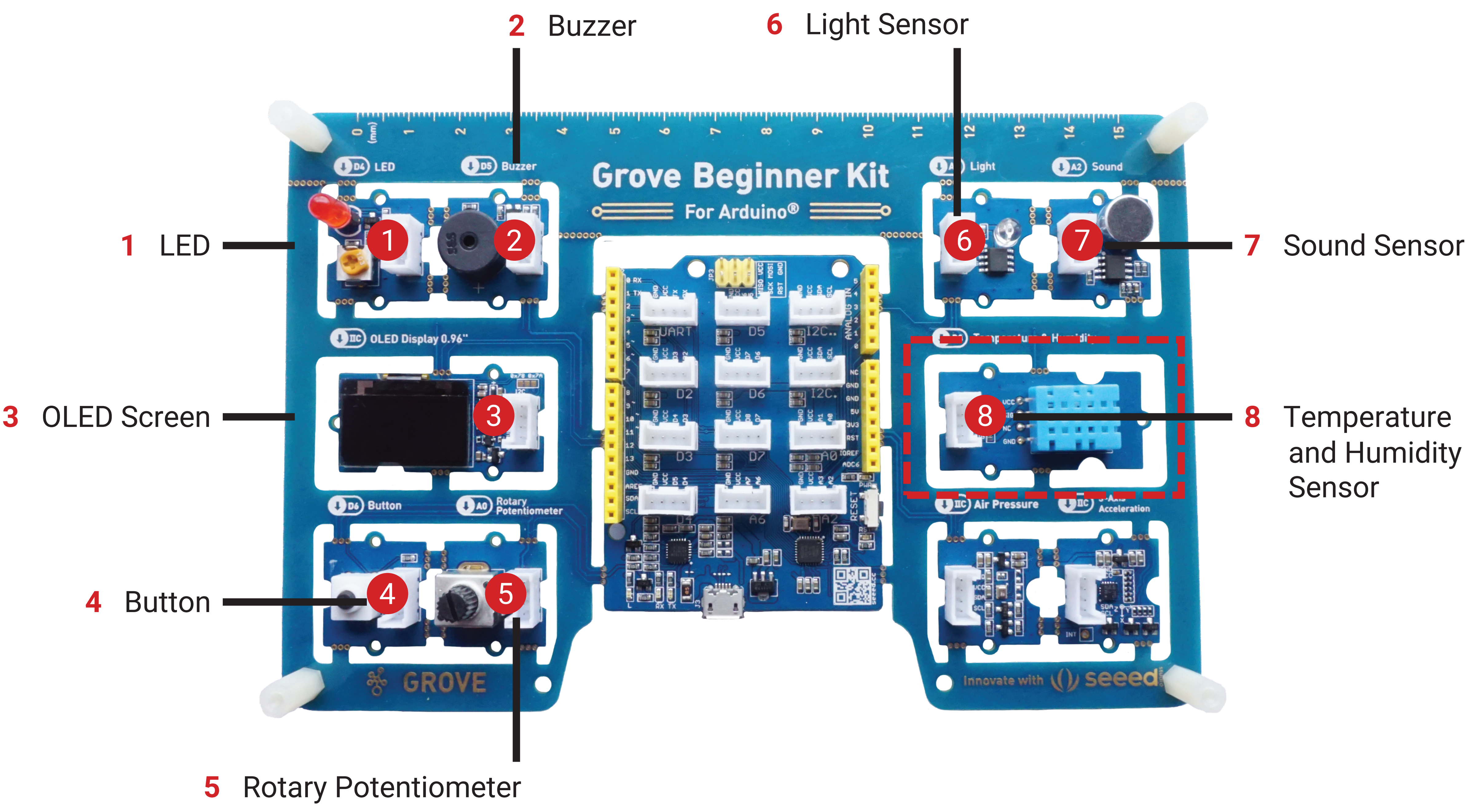
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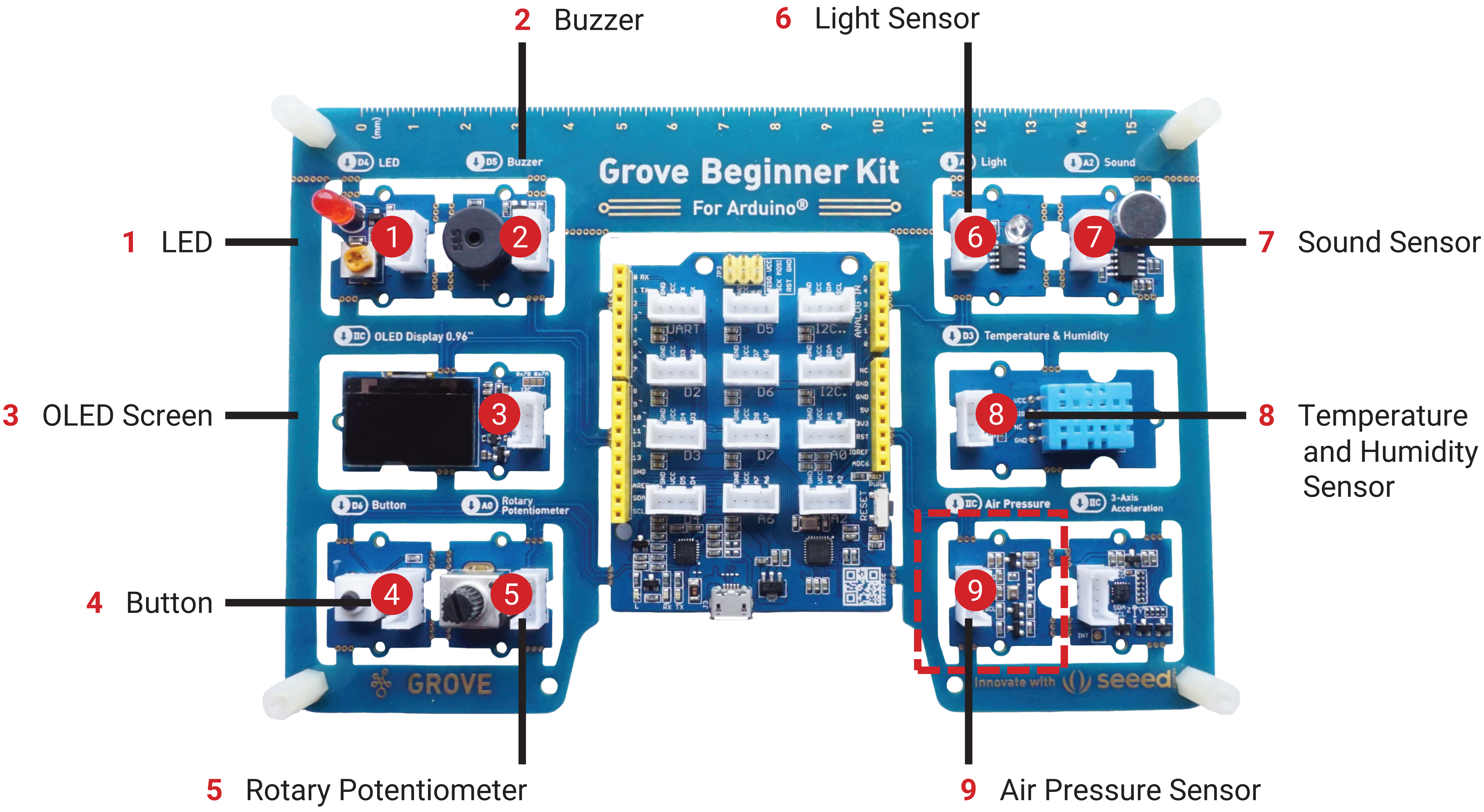
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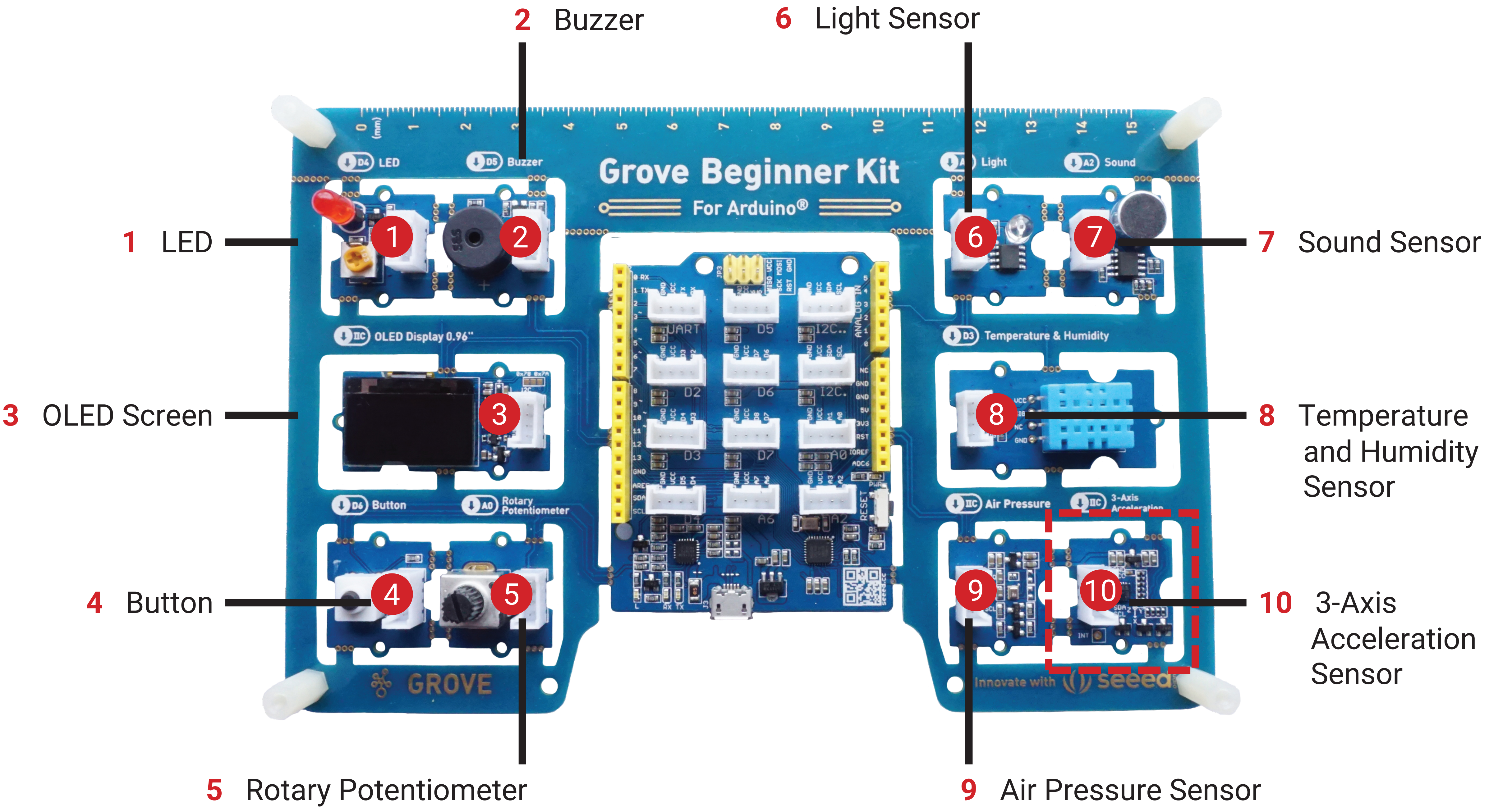
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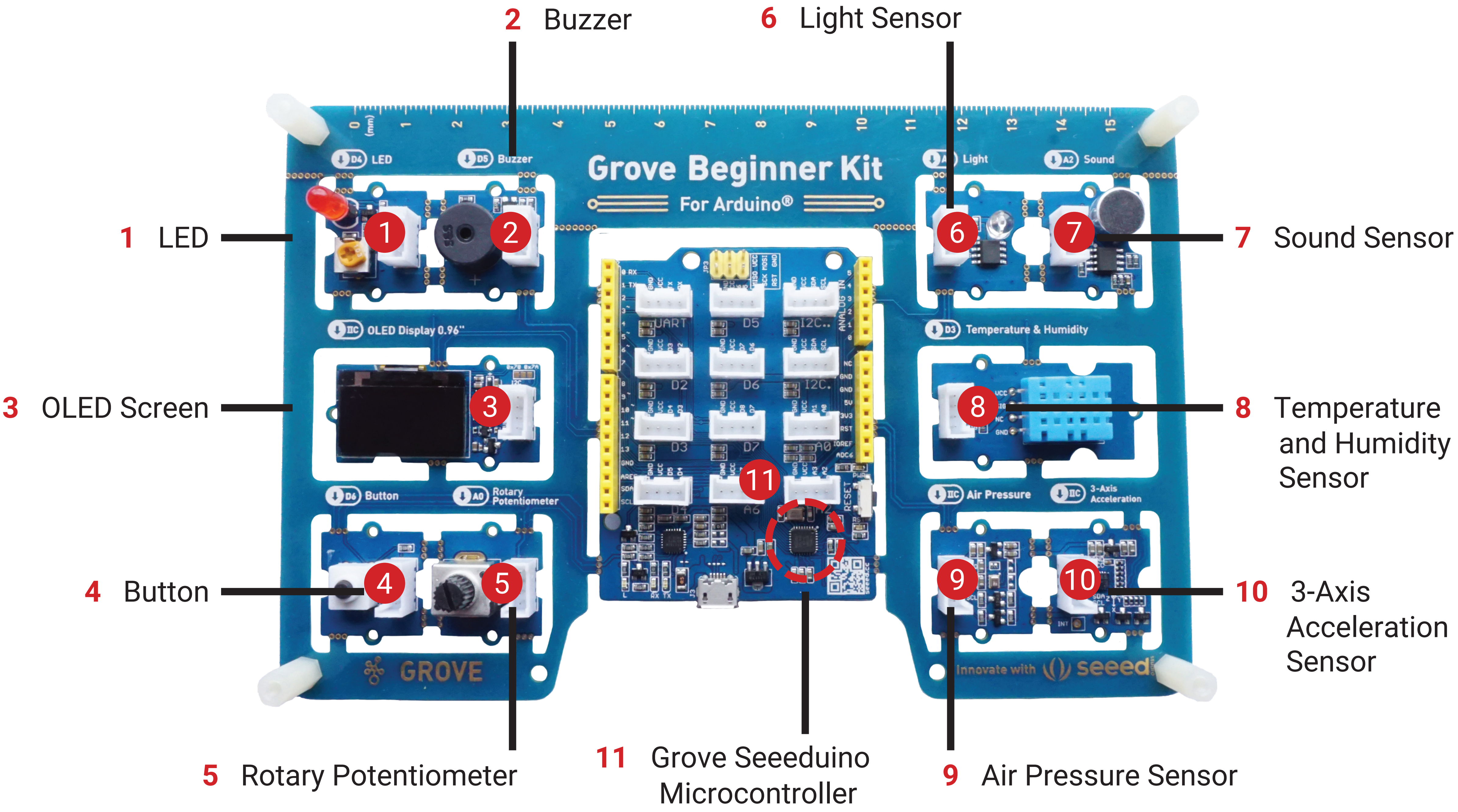
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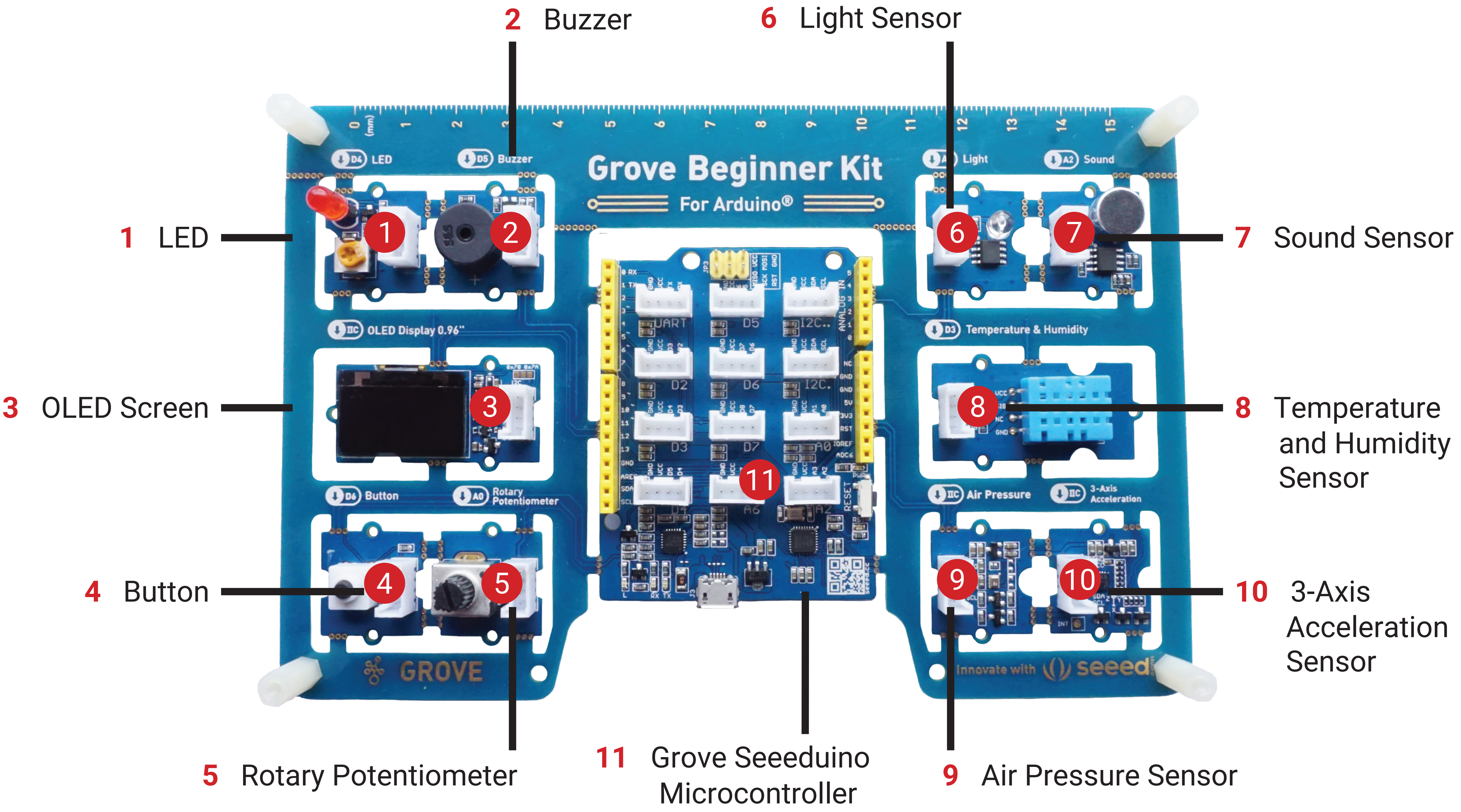
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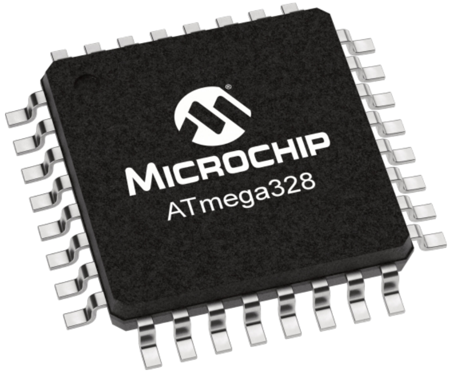
The Microcontroller

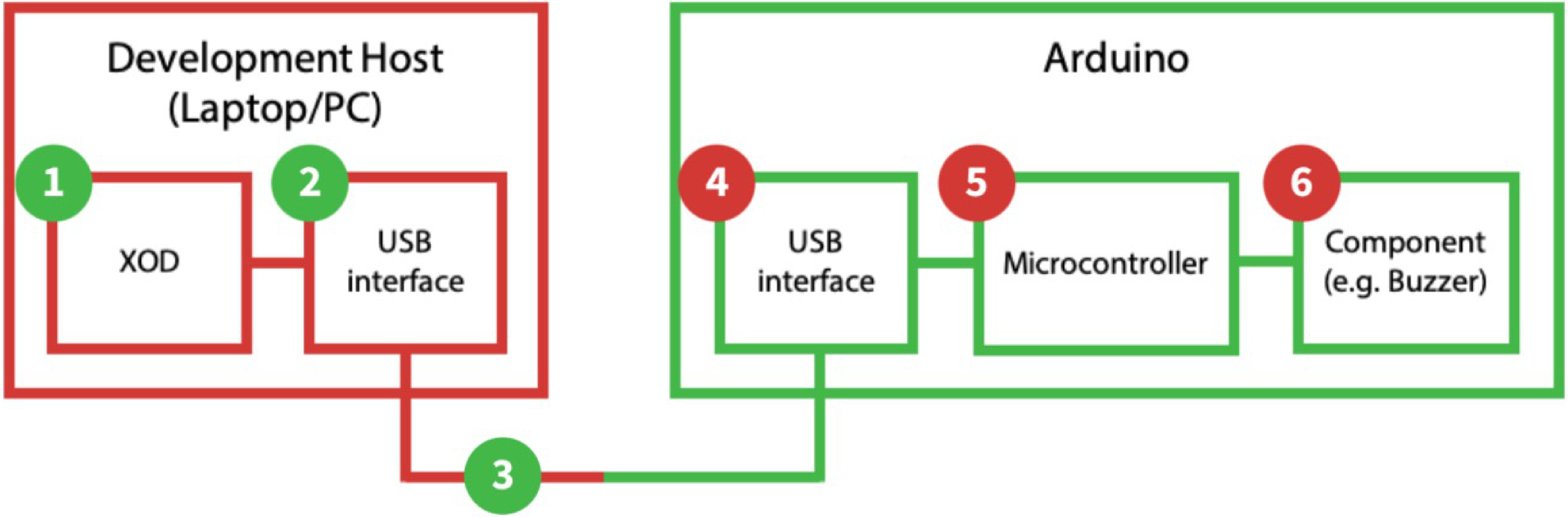


A0-A6 Analog

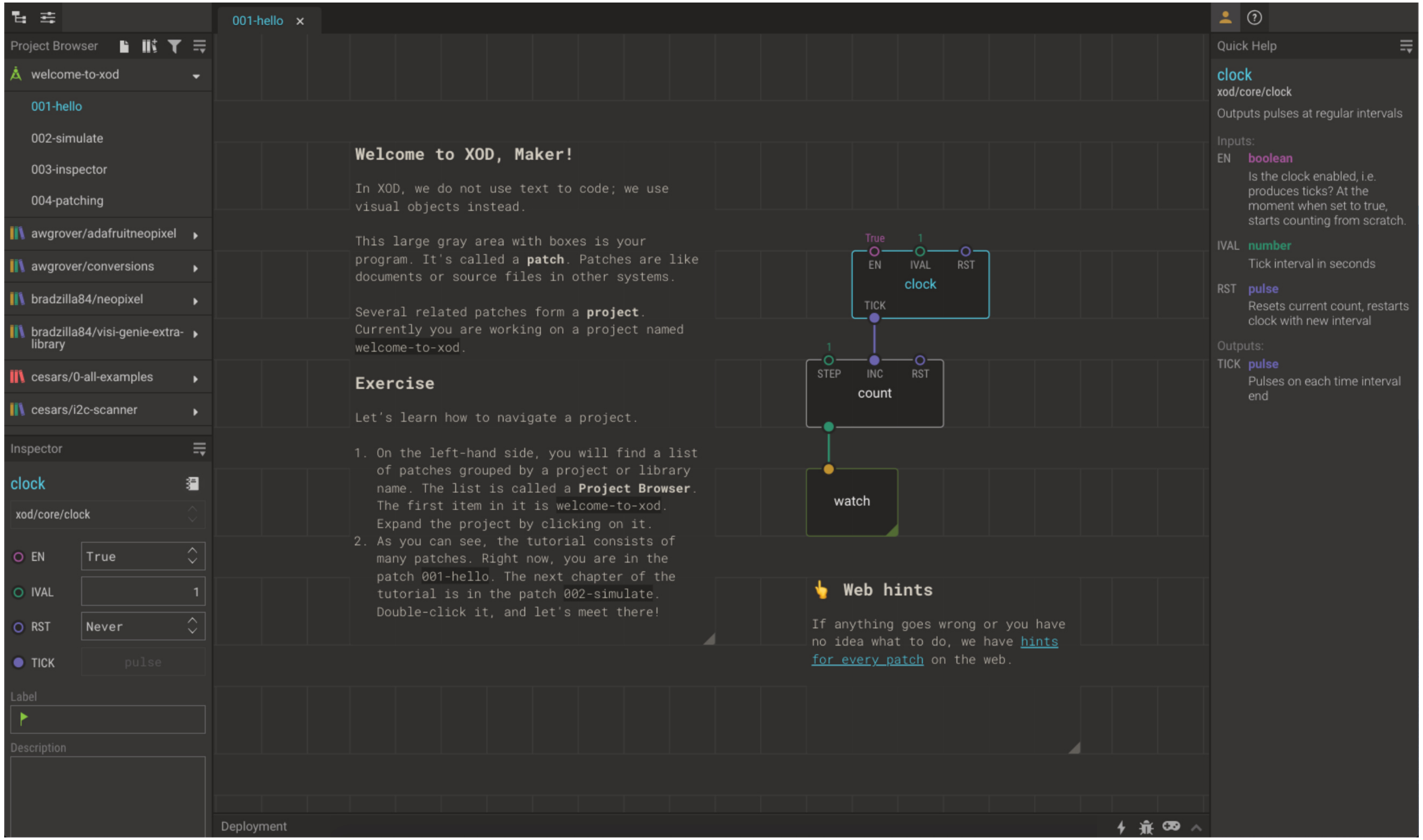
D0-D13 Digital

I2C I2C (require address)

PIN	DEVICE
A0	Rotary Potentiometer
A2	Sound Sensor
A6	Light Sensor
D3	Temperature and Humidity Sensor
D4	LED
D5	Buzzer
D6	Button
I2C (19h)	Three-Axis Accelerator
I2C (77h)	Air Pressure Sensor
I2C (3Ch)	OLED Screen


Development Host
(Laptop/PC)
1
XOD
2
USB
interface
3
Arduino
4
USB
interface
5
Microcontroller
6
Component
(e.g. Buzzer)

The XOD IDE



Welcome to XOD, Maker!

In XOD, we do not use text to code; we use visual objects instead.

This large gray area with boxes is your program. It's called a **patch**. Patches are like documents or source files in other systems.

Several related patches form a **project**. Currently you are working on a project named `welcome-to-xod`.

Exercise

Let's learn how to navigate a project.

1. On the left-hand side, you will find a list of patches grouped by a project or library name. The list is called a **Project Browser**. The first item in it is `welcome-to-xod`. Expand the project by clicking on it.
2. As you can see, the tutorial consists of many patches. Right now, you are in the patch `001-hello`. The next chapter of the tutorial is in the patch `002-simulate`. Double-click it, and let's meet there!

👆 **Web hints**

If anything goes wrong or you have no idea what to do, we have hints for every patch on the web.

clock

xod/core/clock

EN True

IVAL 1

RST Never

TICK pulse

Label

Description

clock

xod/core/clock

Outputs pulses at regular intervals

Inputs:

EN boolean
Is the clock enabled, i.e. produces ticks? At the moment when set to true, starts counting from scratch.

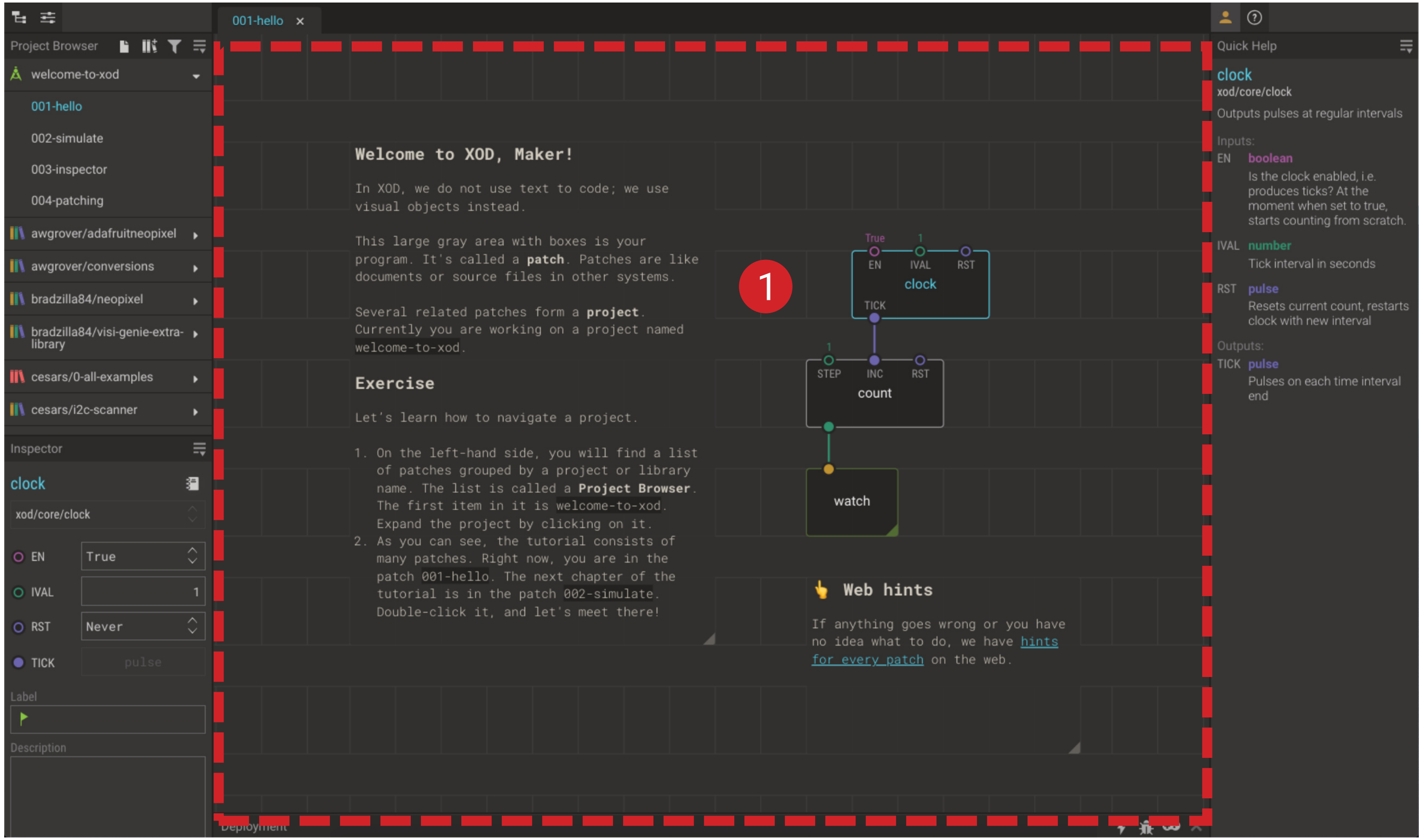
IVAL number
Tick interval in seconds

RST pulse
Resets current count, restarts clock with new interval

Outputs:

TICK pulse
Pulses on each time interval end

1 Your Patch



Project Browser

- welcome-to-xod
  - 001-hello
  - 002-simulate
  - 003-inspector
  - 004-patching
- awgrover/adafruitneopixel
- awgrover/conversions
- bradzilla84/neopixel
- bradzilla84/visi-genie-extra-library
- cesars/0-all-examples
- cesars/i2c-scanner

Inspector

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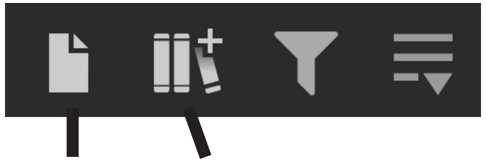
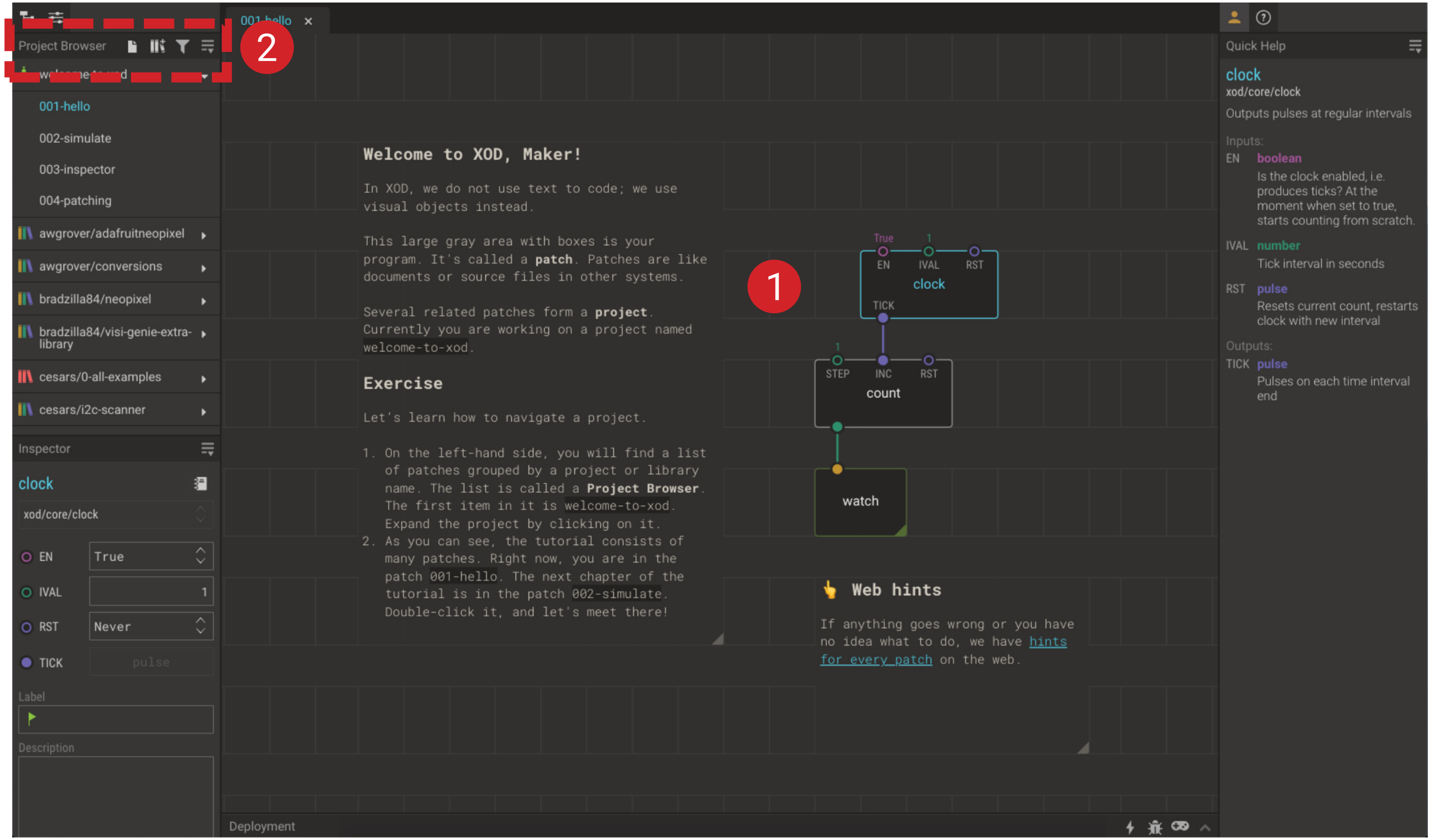


New Patch

Add Library

1 Your Patch

2 Project Browser: Buttons



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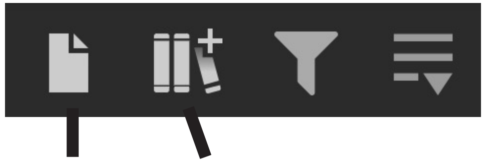

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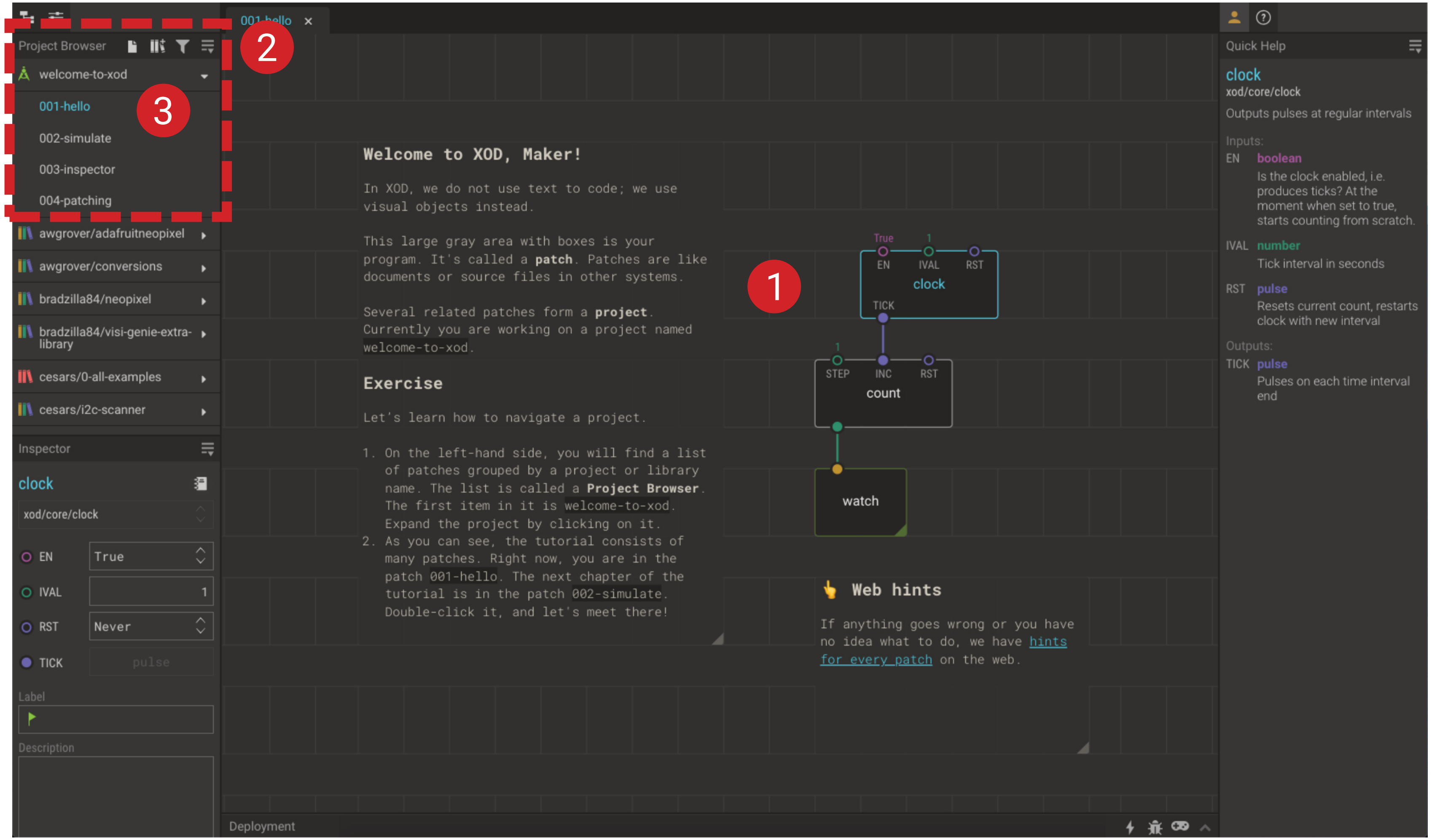
2 Project Browser: Buttons

3 Project Browser: Project Patches



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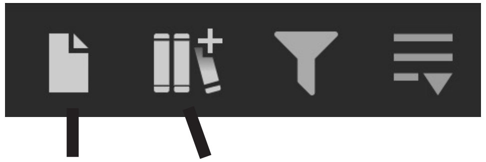


New Patch

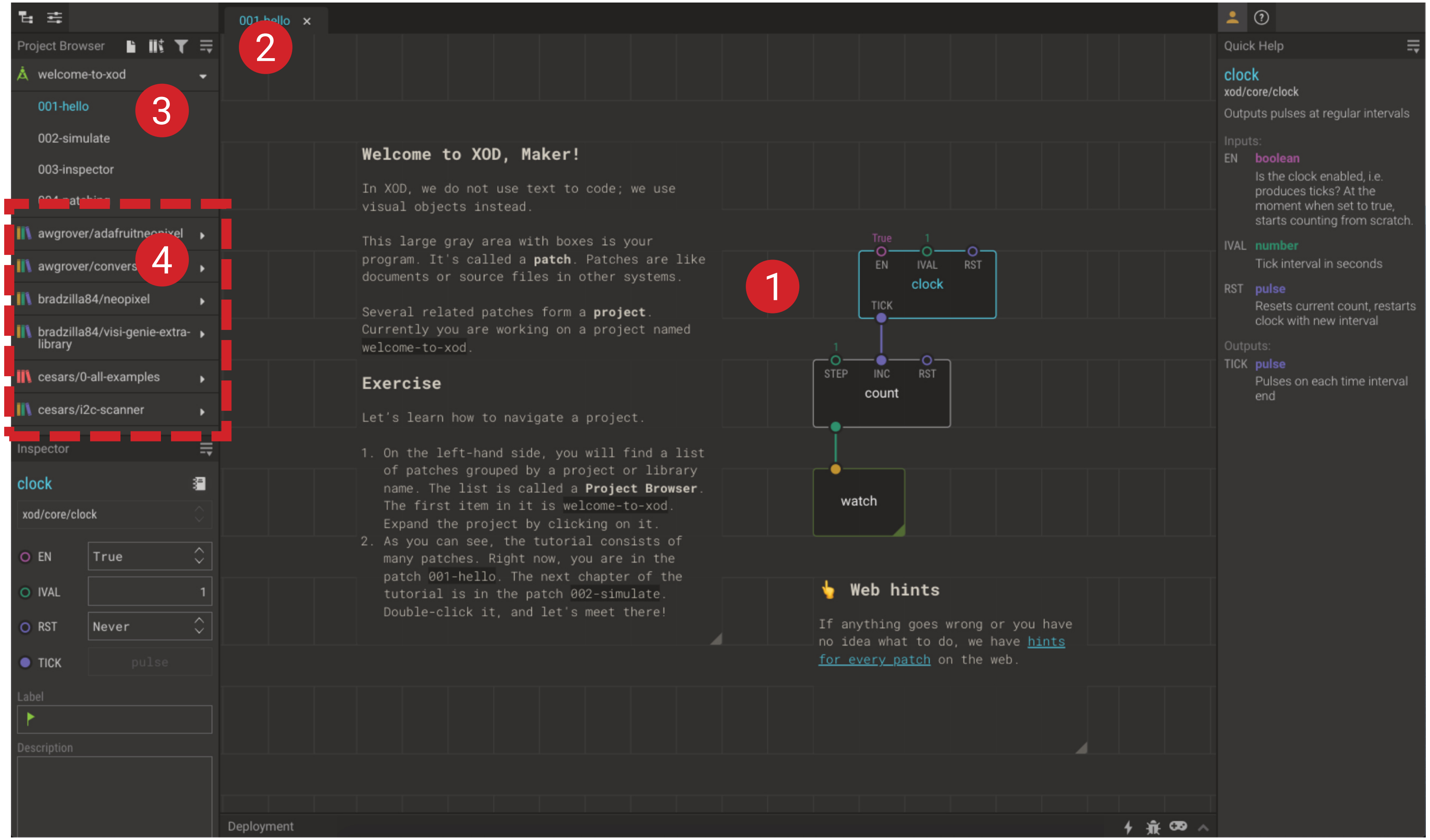
Add Library

1 Your Patch

2 Project Browser: Buttons

3 Project Browser: Project Patches

4 Project Browser: Libraries



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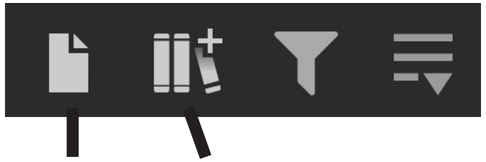

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2 Project Browser: Buttons

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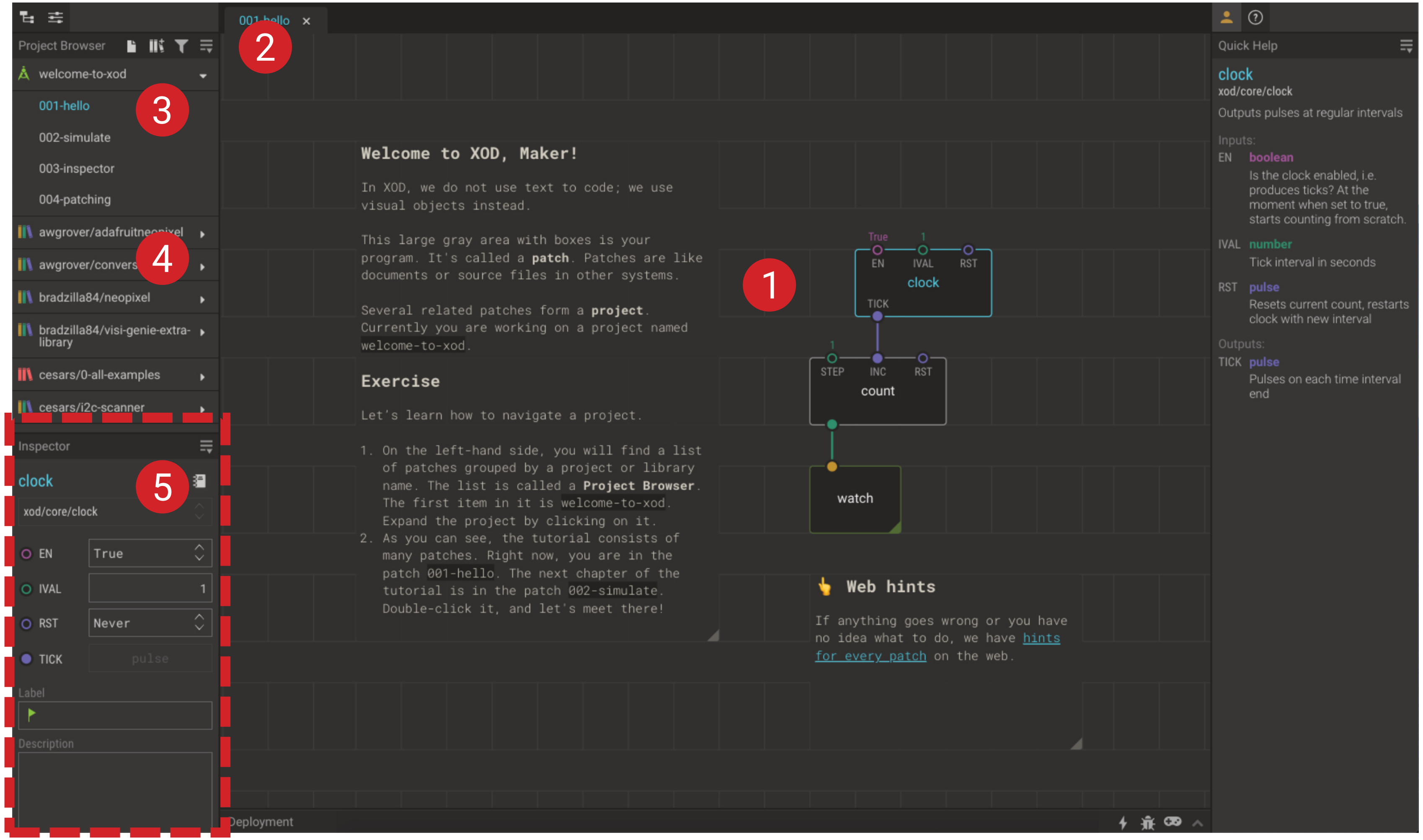
4 Project Browser: Libraries

5 Inspector



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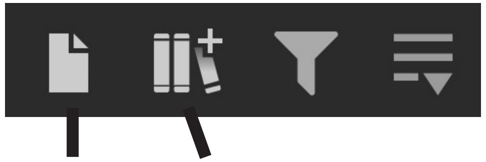

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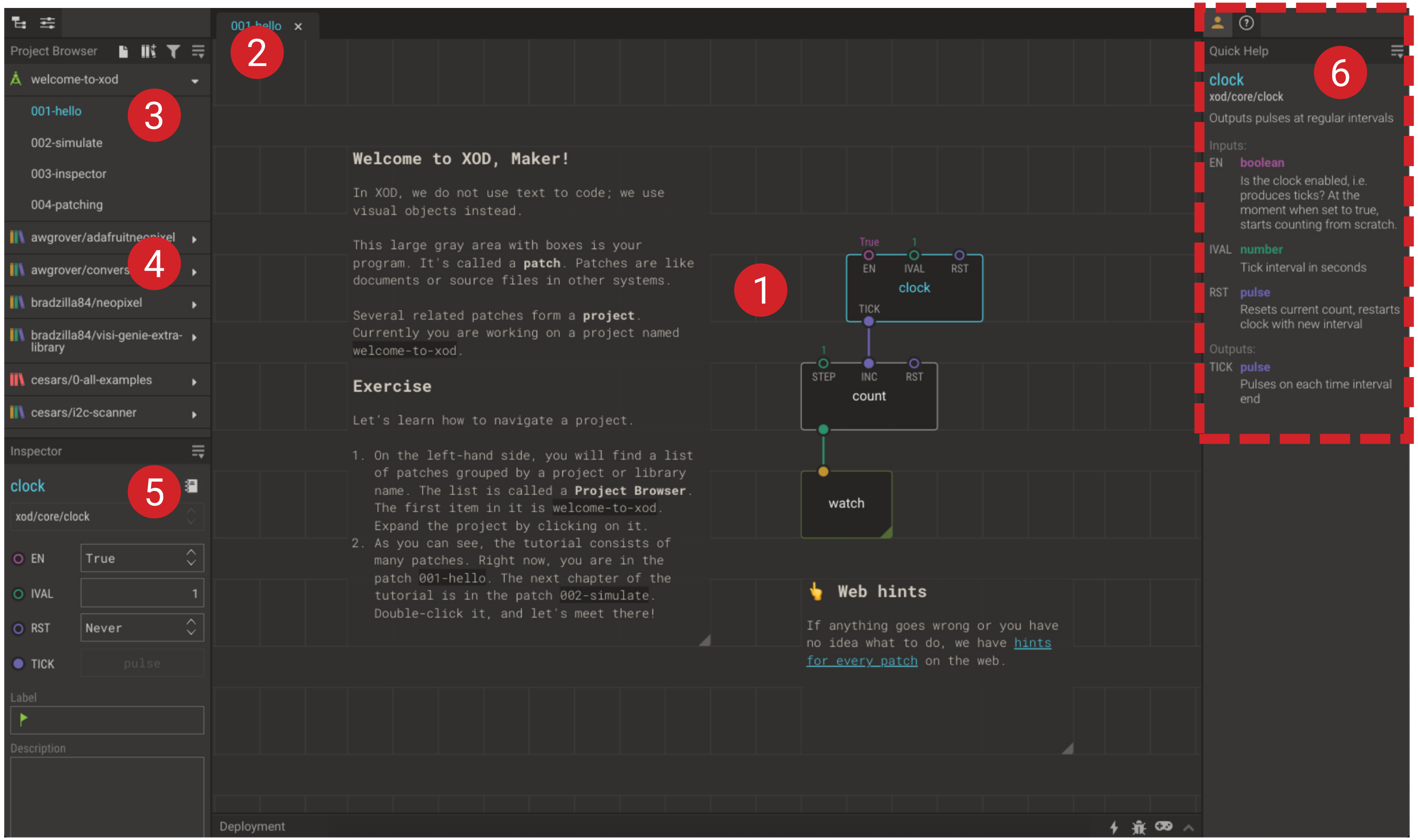

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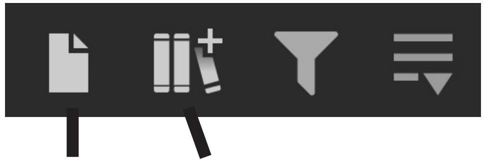
6 Quick Help

2 Project Browser: Buttons

3 Project Browser: Project Patches

4 Project Browser: Libraries

5 Inspector



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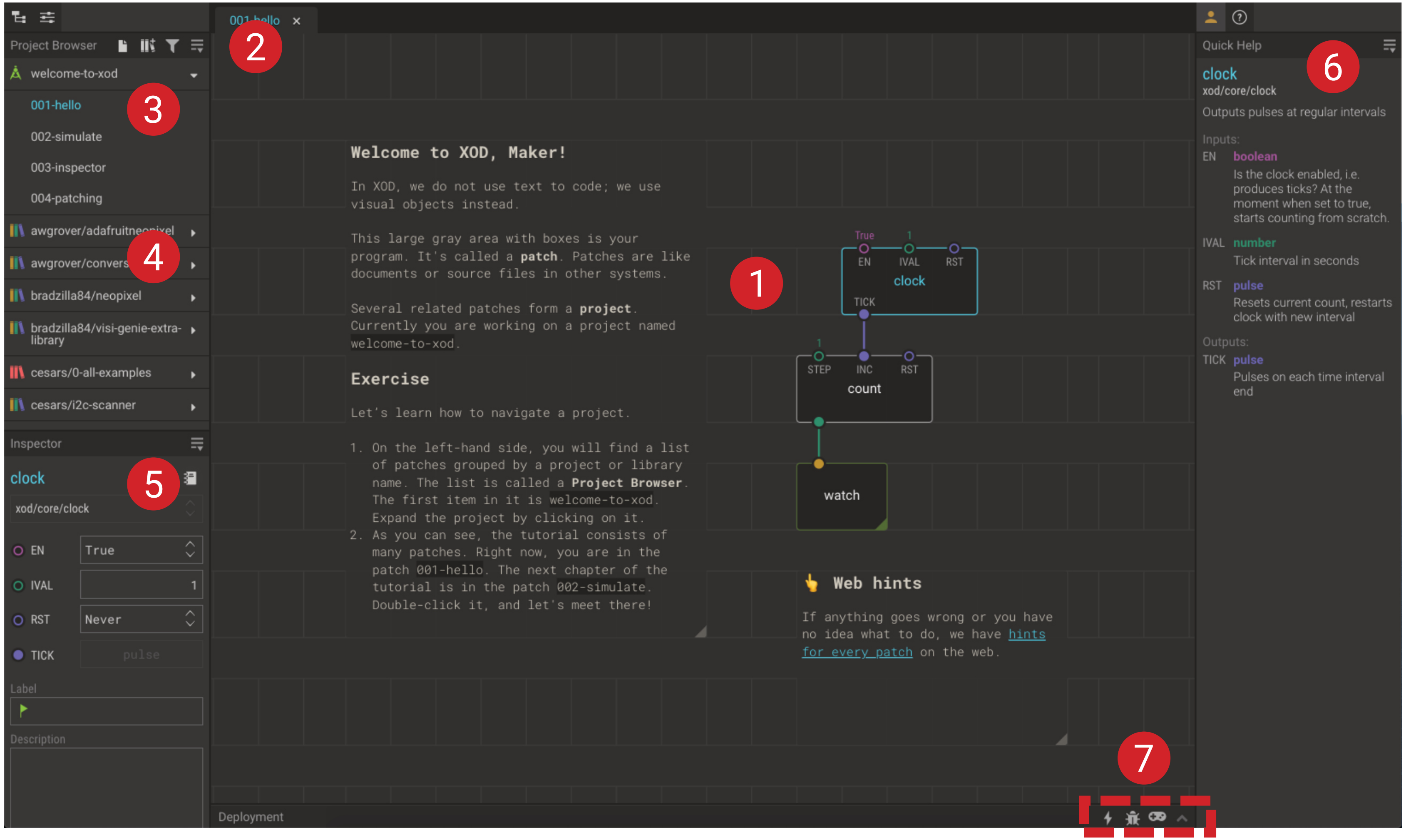

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In XOD, we do not use text to code; we use visual objects instead.

This large gray area with boxes is your program. It's called a **patch**. Patches are like documents or source files in other systems.

Several related patches form a **project**. Currently you are working on a project named `welcome-to-xod`.

Exercise

Let's learn how to navigate a project.

1. On the left-hand side, you will find a list of patches grouped by a project or library name. The list is called a **Project Browser**. The first item in it is `welcome-to-xod`. Expand the project by clicking on it.
2. As you can see, the tutorial consists of many patches. Right now, you are in the patch `001-hello`. The next chapter of the tutorial is in the patch `002-simulate`. Double-click it, and let's meet there!

👆 **Web hints**

If anything goes wrong or you have no idea what to do, we have hints for every patch on the web.

clock

xod/core/clock

Outputs pulses at regular intervals

Inputs:

EN boolean
Is the clock enabled, i.e. produces ticks? At the moment when set to true, starts counting from scratch.

IVAL number
Tick interval in seconds

RST pulse
Resets current count, restarts clock with new interval

Outputs:

TICK pulse
Pulses on each time interval end

2 Project Browser: Buttons

3 Project Browser: Project Patches

4 Project Browser: Libraries

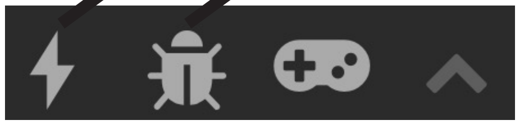
5 Inspector

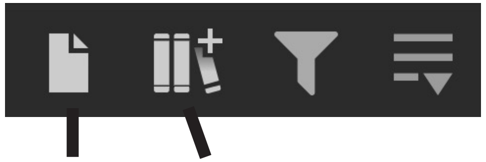
6 Quick Help

7 Upload Buttons

Upload

Upload And Debug





New Patch

Add Library

1 Your Patch

2 Project Browser: Buttons

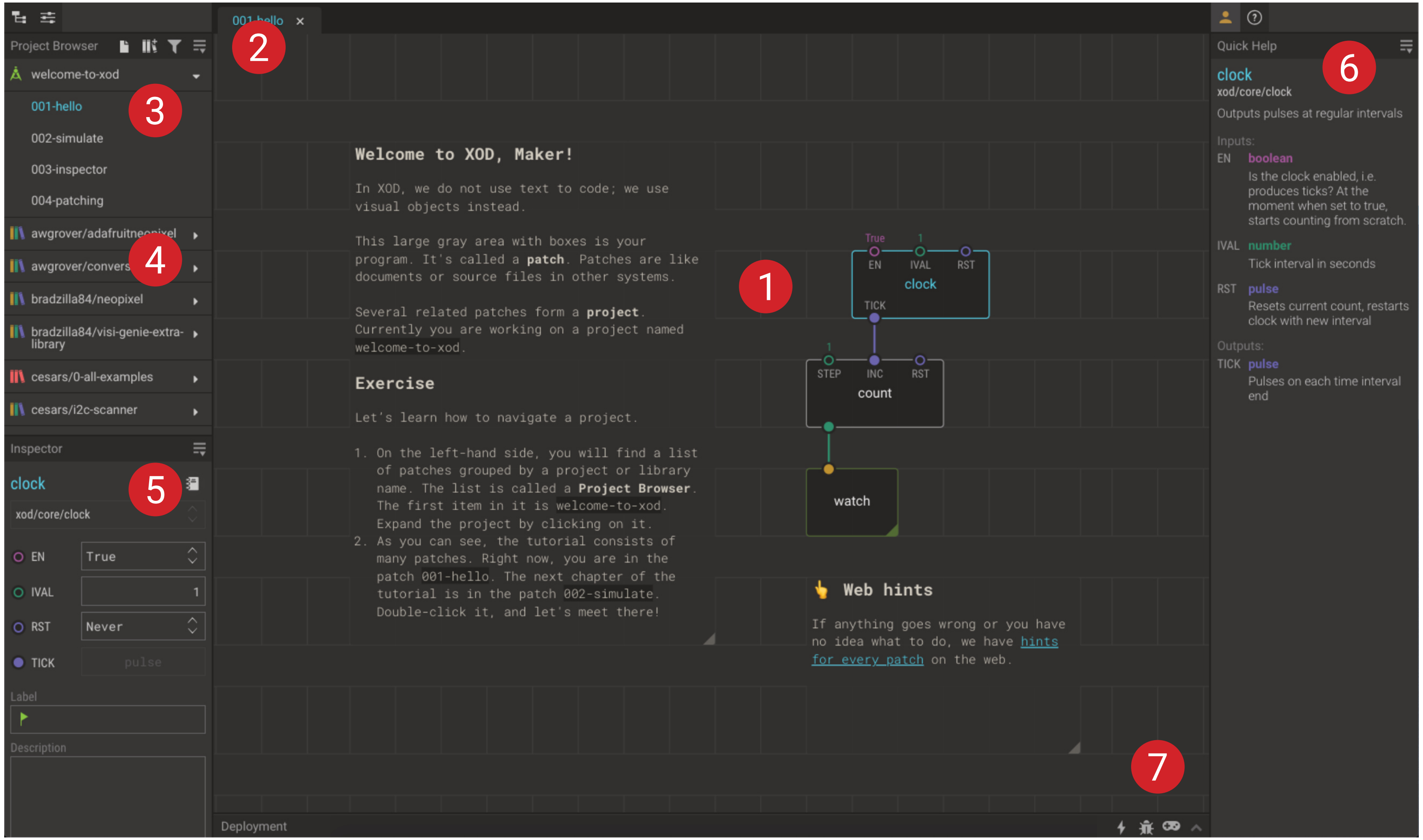
3 Project Browser: Project Patches

4 Project Browser: Libraries

5 Inspector

6 Quick Help

7 Upload Buttons



001-hello ×

Project Browser

welcome-to-xod

- 001-hello
- 002-simulate
- 003-inspector
- 004-patching

awgrover/adafruitneopixel

awgrover/convers

bradzilla84/neopixel

bradzilla84/visi-genie-extra-library

cesars/0-all-examples

cesars/i2c-scanner

Inspector

clock

xod/core/clock

○ EN	True
○ IVAL	1
○ RST	Never
● TICK	pulse

Label

Description

Welcome to XOD, Maker!

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Deployment

Quick Help

clock

xod/core/clock

Outputs pulses at regular intervals

Inputs:

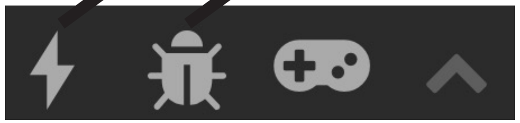
EN	boolean	Is the clock enabled, i.e. produces ticks? At the moment when set to true, starts counting from scratch.
IVAL	number	Tick interval in seconds
RST	pulse	Resets current count, restarts clock with new interval

Outputs:

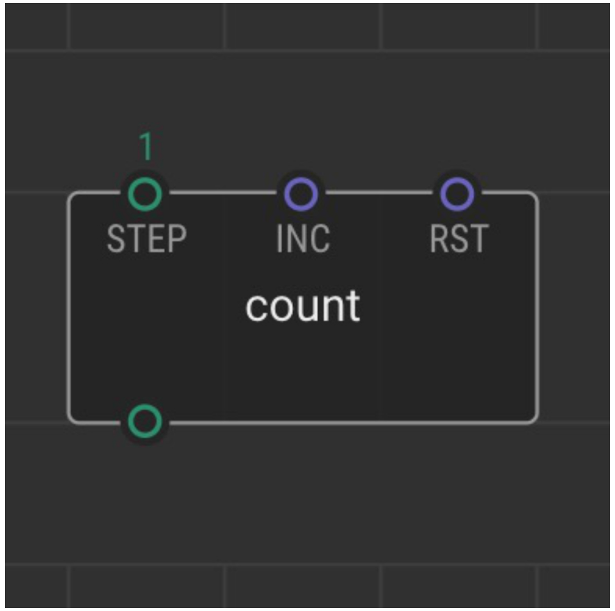
TICK	pulse	Pulses on each time interval end

Upload

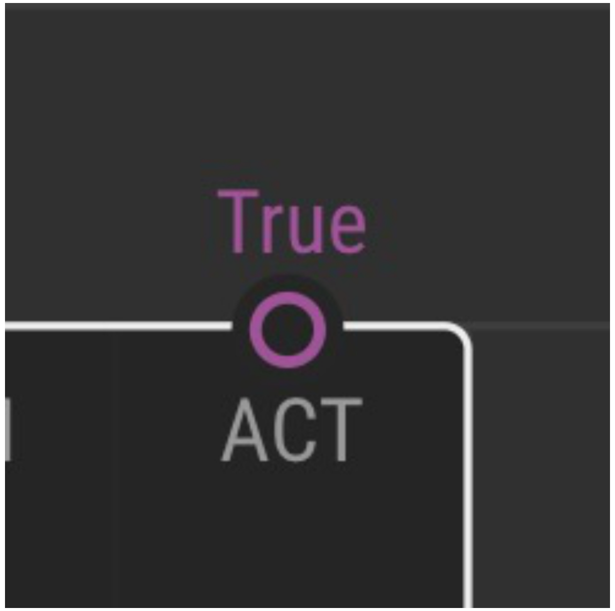
Upload And Debug



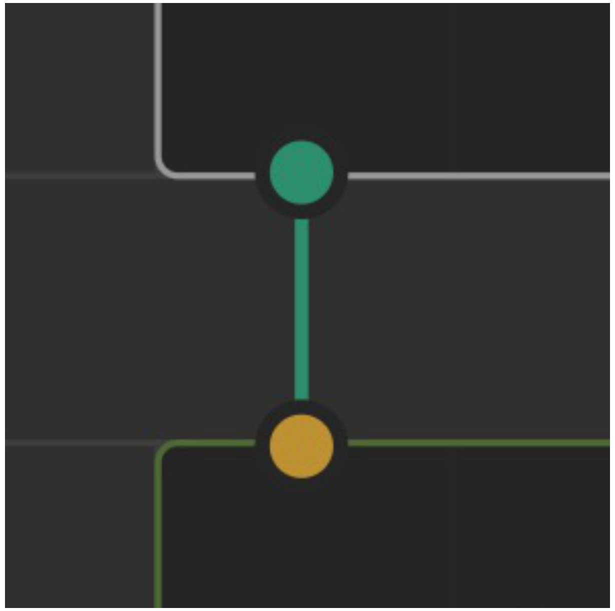
Nodes



Pins



Links



Pins

Pulse

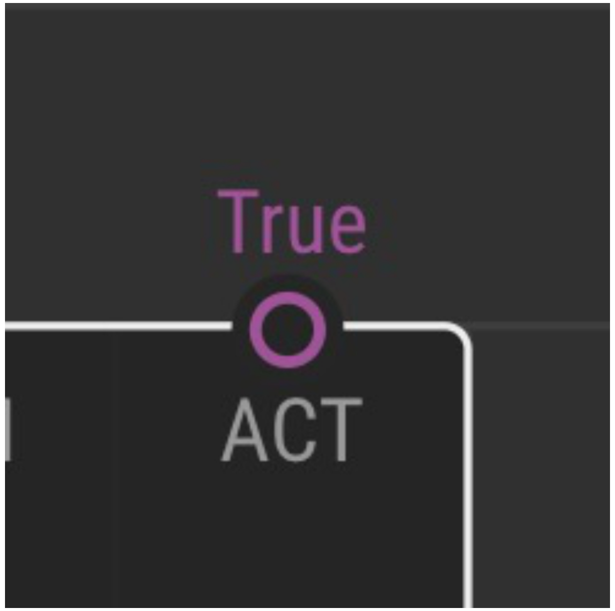
String

Boolean

Port

Number

Byte



Break
30min

Testing Your Board

Try it Yourself – 20min

1 Work in small groups (introduce yourselves if necessary)

2 Complete Task 1

3 Step-by-step instructions are in the Guide (**p20-25**)

4 Ask if you need help

Inputs and Outputs

Try it Yourself – 20min

1 Work through Task 2 in groups

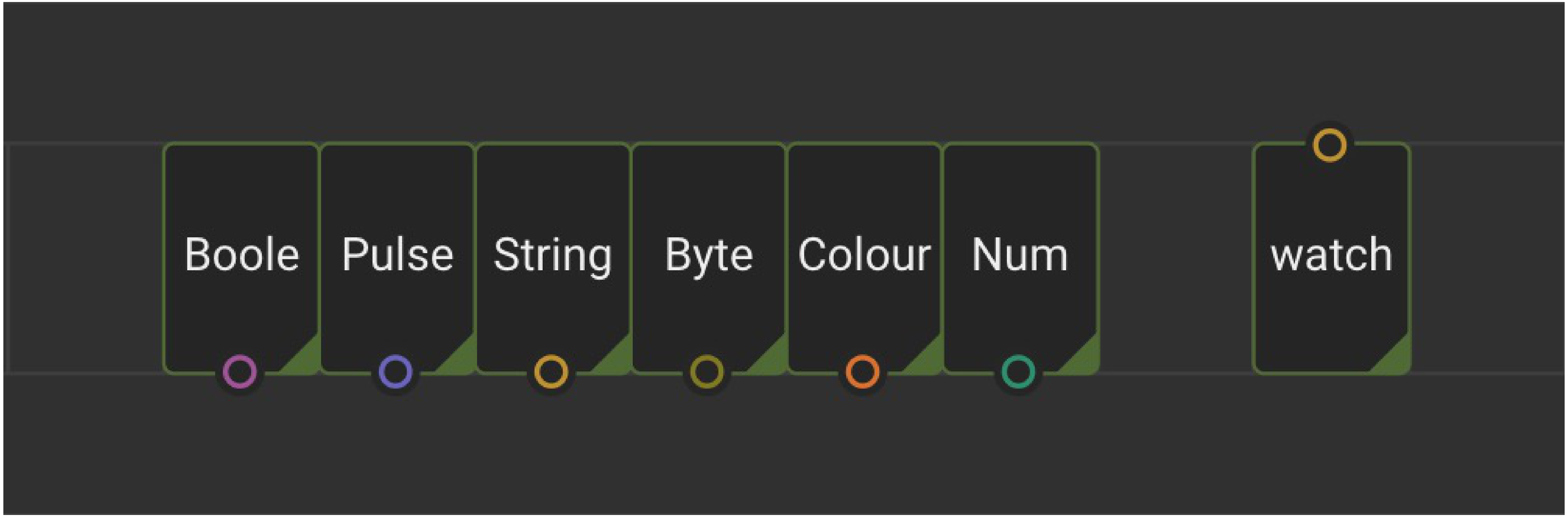
2 Step-by-step instructions are in the Guide (**p26-29**)

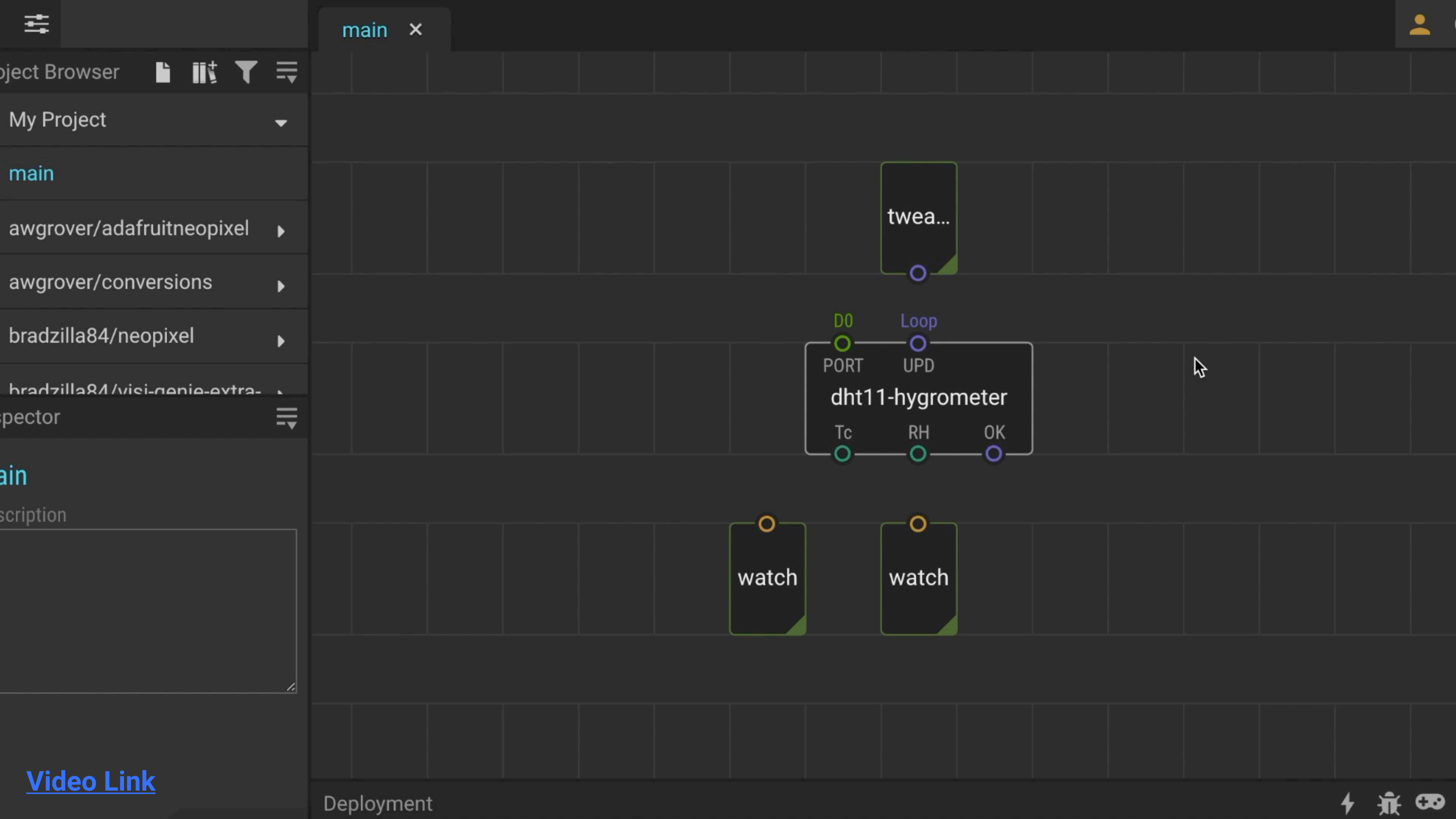
3 Ask if you need help

Congratulations!

You can now programme an Arduino Board!

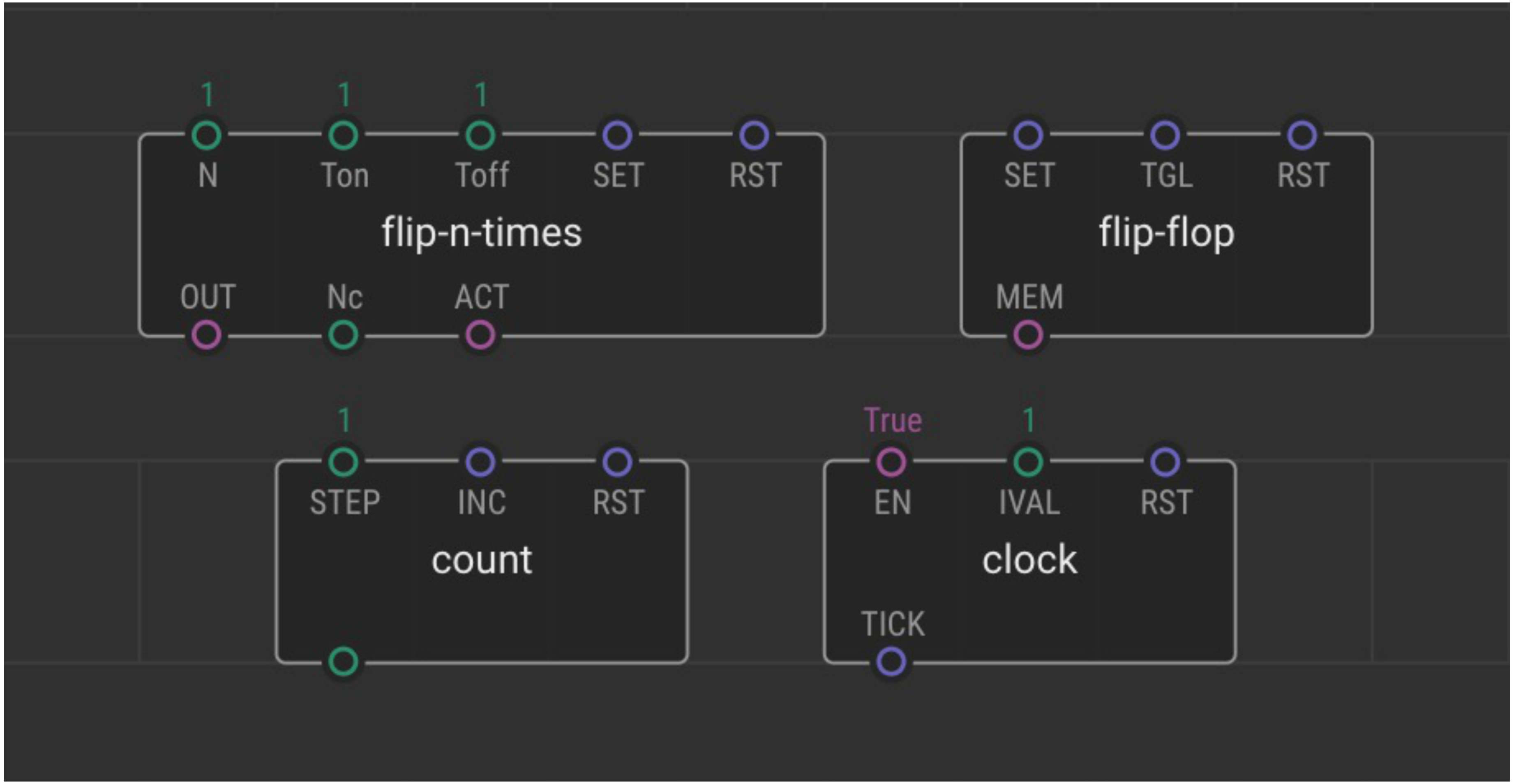
Tweak and Watch Nodes

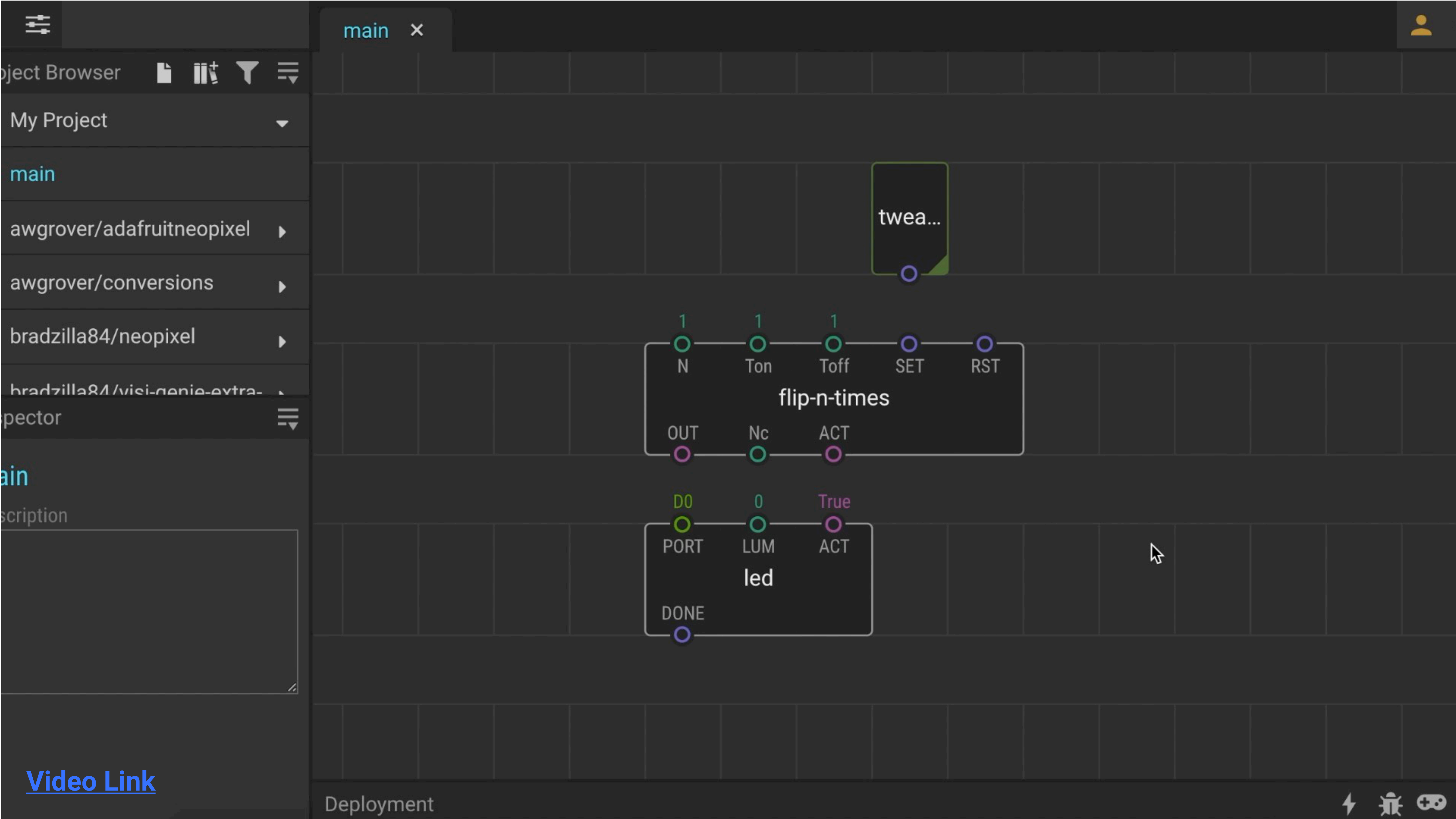

Boole
Pulse
String
Byte
Colour
Num
watch


main
oject Browser
My Project
main
awgrover/adafruitneopixel
awgrover/conversions
bradzilla84/neopixel
bradzilla84/visi-genie-extra-
spector
ain
scription
twea...
D0
Loop
PORT
UPD
dht11-hygrometer
Tc
RH
OK
watch
watch
Deployment

Video Link

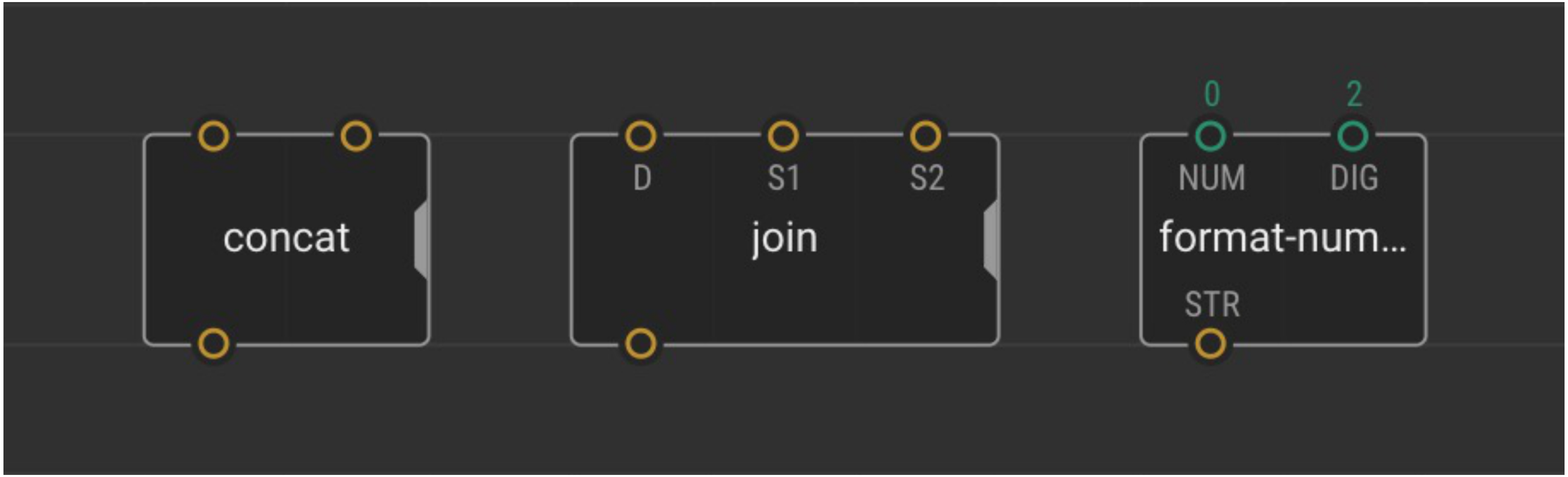
Flip, Clock and Count Nodes

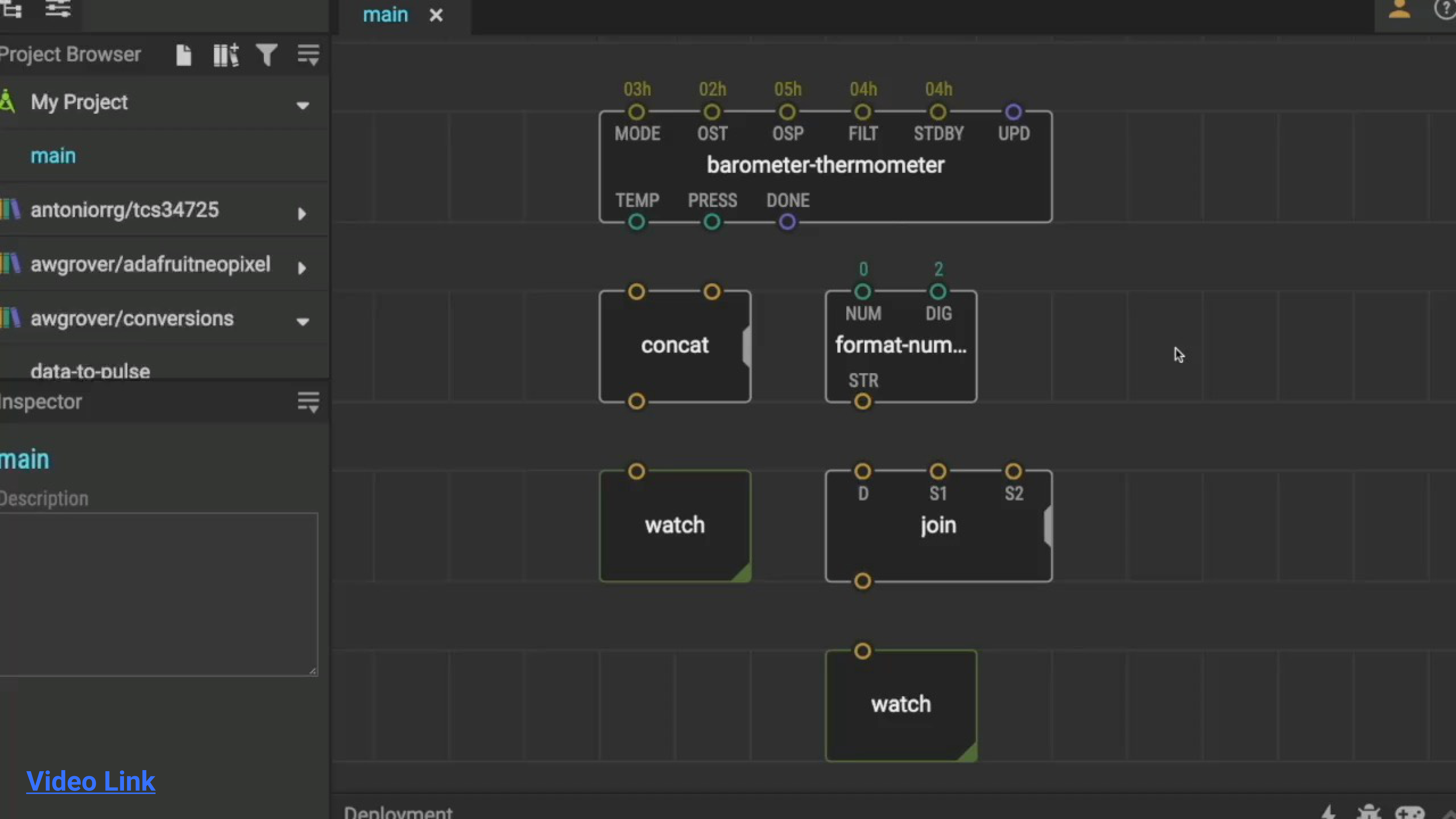

1
1
1
N
Ton
Toff
SET
RST
flip-n-times
OUT
Nc
ACT
SET
TGL
RST
flip-flop
MEM
1
STEP
INC
RST
count
True
1
EN
IVAL
RST
clock
TICK


main ×
oject Browser
My Project
main
awgrover/adafruitneopixel
awgrover/conversions
bradzilla84/neopixel
bradzilla84/visi-genie-extra-
spector
ain
scription
twea...
1
N
1
Ton
1
Toff
SET
RST
flip-n-times
OUT
Nc
ACT
D0
PORT
0
LUM
True
ACT
led
DONE
Deployment

Video Link

Concat, Join and Format-Number Nodes


concat
D
S1
S2
join
0
2
NUM
DIG
format-num...
STR


main
Project Browser
My Project
main
antoniorrg/tcs34725
awgrover/adafruitneopixel
awgrover/conversions
data-to-pulse
Inspector
main
Description
03h
02h
05h
04h
04h
MODE
OST
OSP
FILT
STDBY
UPD
barometer-thermometer
TEMP
PRESS
DONE
concat
0
2
NUM
DIG
format-num...
STR
watch
D
S1
S2
join
watch
Deployment

[Video Link](#)

Lunch

60min

Afternoon Session

13:00 Lesson 4: Building Devices

Learn how to make more complex programmes in XOD using logic nodes, sequences and loops.

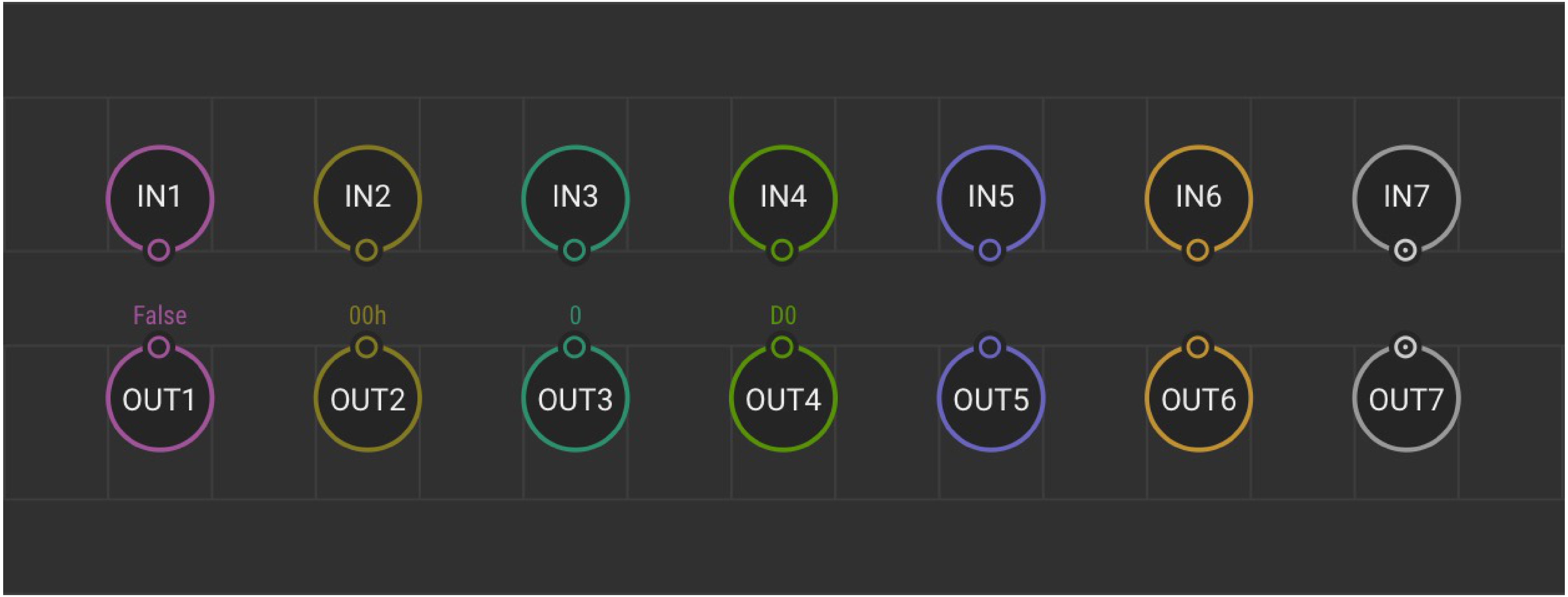
15:00 Break

15:30 Lesson 5: Next Steps

Learn how to expand your programming and hardware building capabilities to start building your own devices, and take a look at some previous projects.

16:25 Round-Up

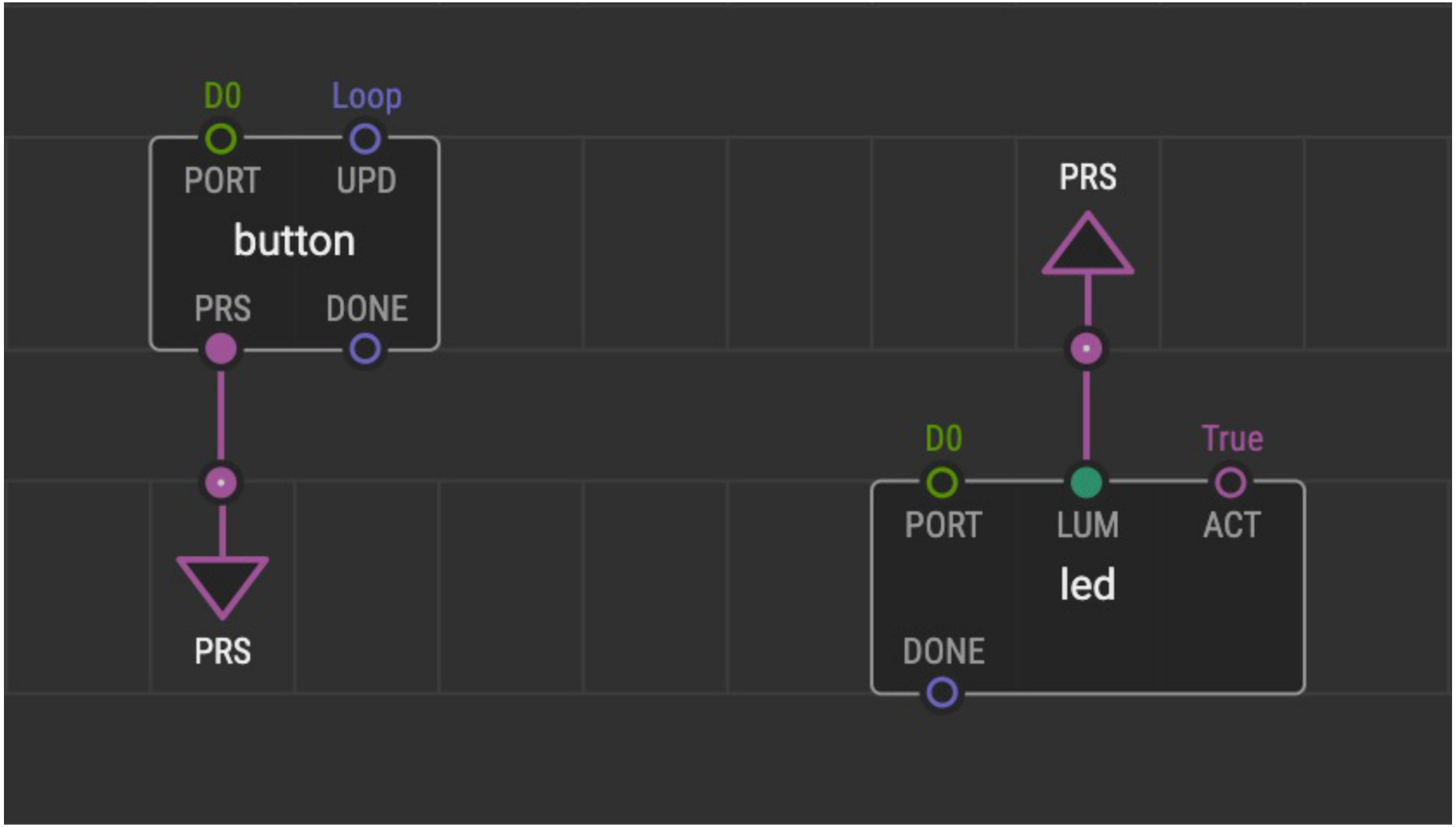
Creating New Nodes


IN1
IN2
IN3
IN4
IN5
IN6
IN7
False
00h
0
D0
OUT1
OUT2
OUT3
OUT4
OUT5
OUT6
OUT7

Try it Yourself – 15min

1. Work though Task 6 in groups
2. Step-by-step instructions are in the Guide (**p50-54**)
3. Ask if you need help

Using Buses


D0
Loop
PORT
UPD
button
PRS
DONE
PRS
PRS
D0
True
PORT
LUM
ACT
led
DONE

Try it Yourself – 5min

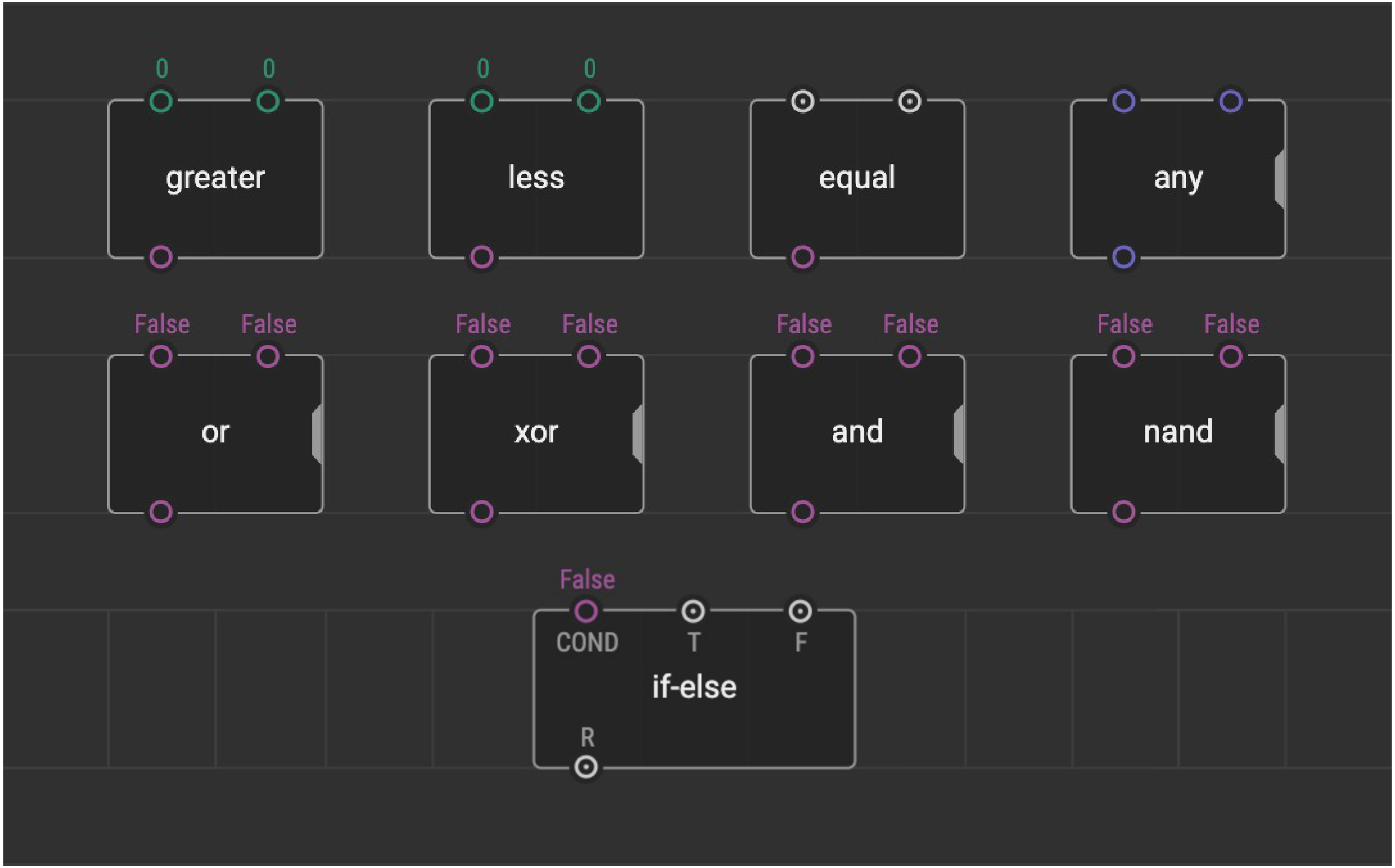
1 Modify your *write-text-to-oled* node so that the *ssd1306-oled-i2c-device* DEV pin is linked to each of the other DEV pins by a bus rather than by links.

2 There is an example of this on **p57** of the guide.

3 Ask if you need help

(Task 7 of the guide provides another task to practice this if you have time)

Logic Programmes


0
0
greater
0
0
less
equal
any
False
False
or
False
False
xor
False
False
and
False
False
nand
False
COND
T
F
if-else
R

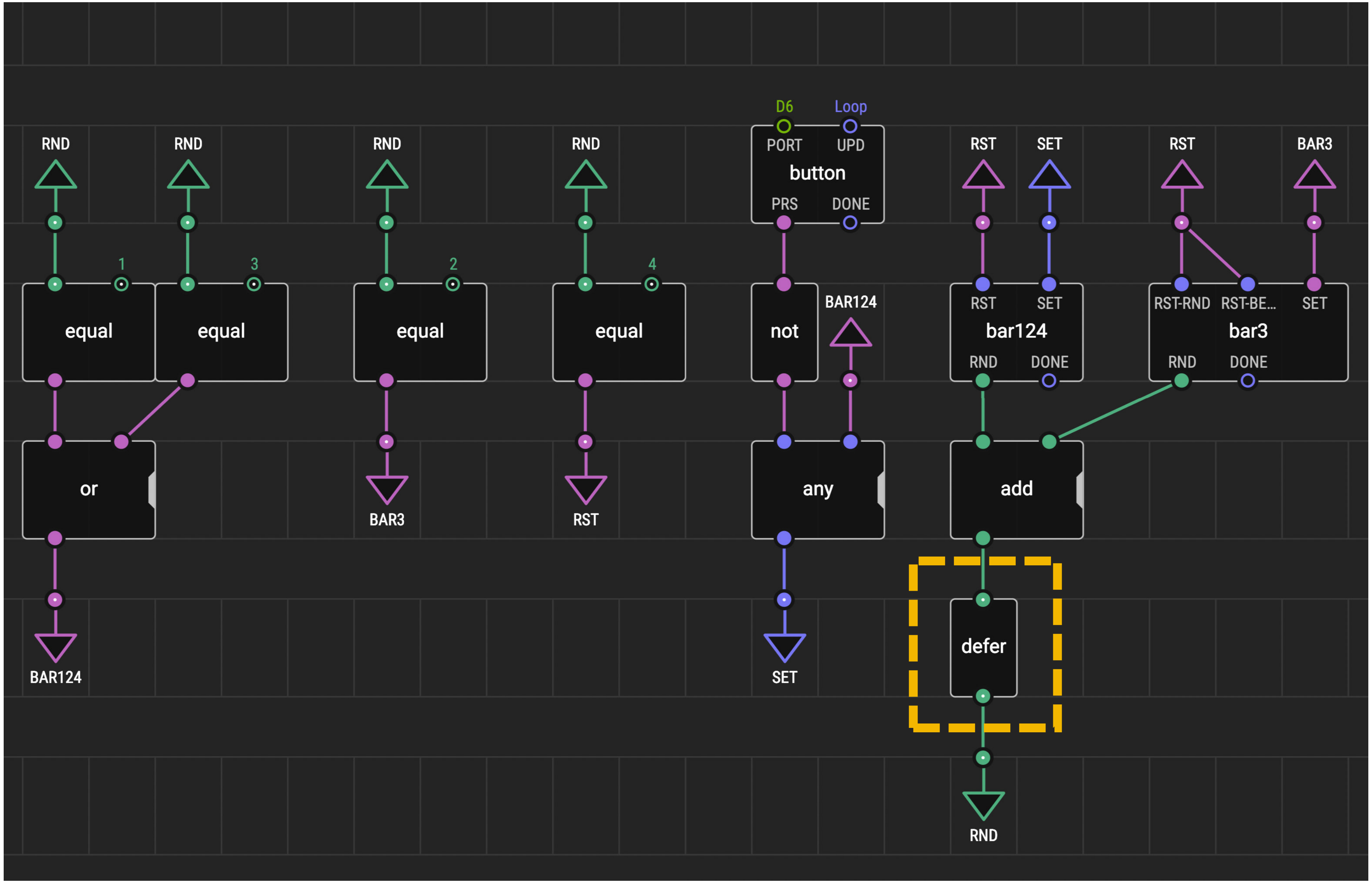
Try it Yourself – 20min

1 Work though Task 8 in groups

2 Step-by-step instructions are in the Guide (**p60-63**)

3 Ask if you need help

Sequences and Loops


RND
RND
RND
RND
D6
Loop
PORT
UPD
button
PRS
DONE
RST
SET
RST
BAR3
1
3
2
4
equal
equal
equal
equal
not
BAR124
RST
SET
bar124
RND
DONE
RST-RND
RST-BE...
SET
bar3
RND
DONE
or
BAR3
RST
any
add
defer
BAR124
SET
RND

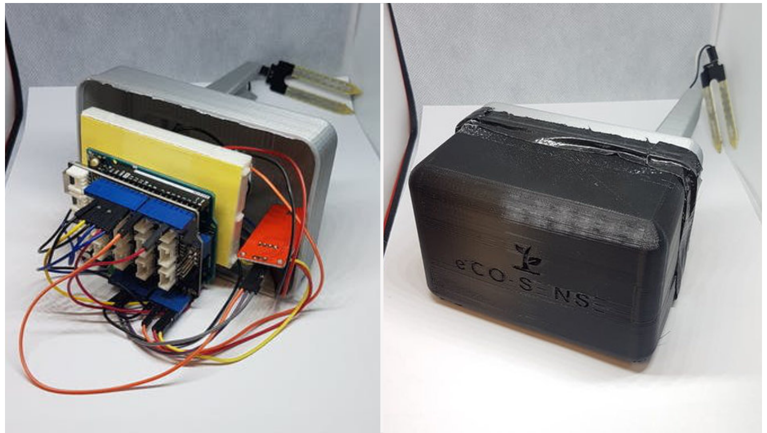
Try it Yourself – 20min

1. Work though Task 9 in groups
2. Step-by-step instructions are in the Guide (**p64-70**)
3. Ask if you need help

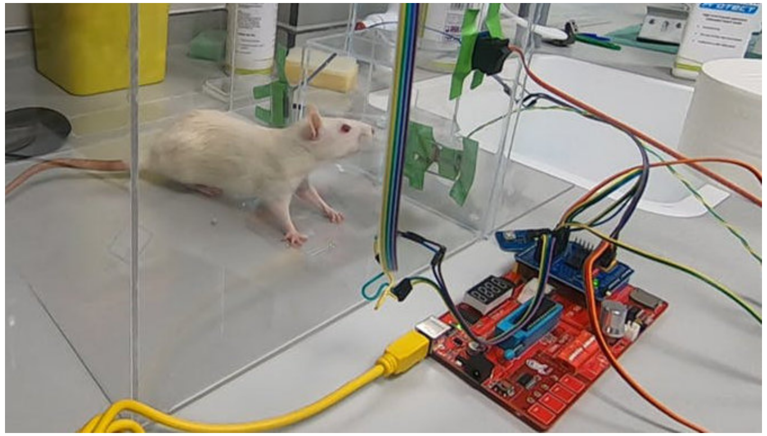
Break
30min

Case Studies

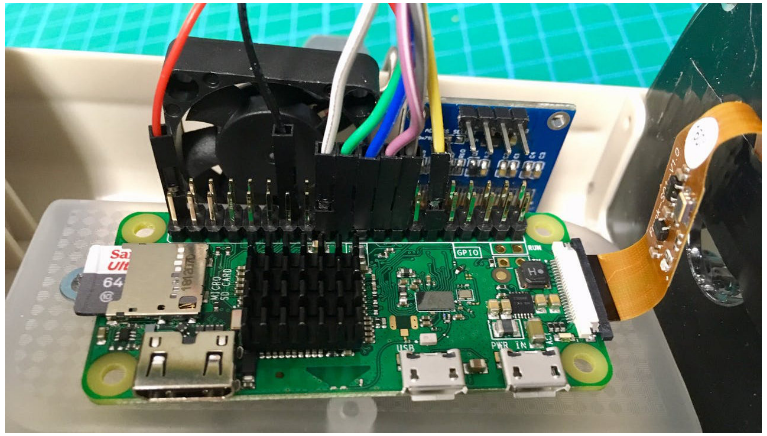
eCO-SENSE: Soil Sensors Powered by Plant Photosynthesis



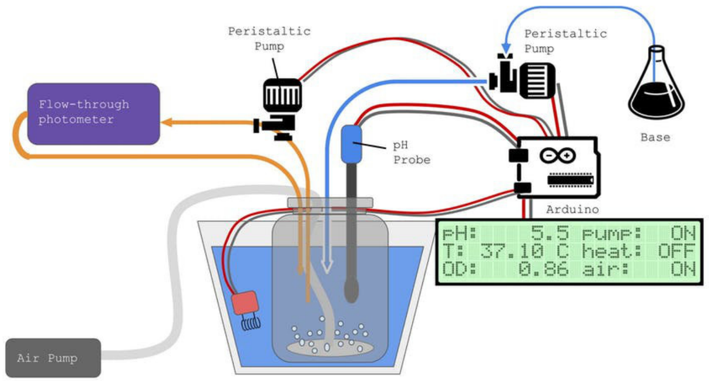
Behavioural Chamber to Evaluate Rodent Forelimb Grasping



Camera for Monitoring Plant Pollination Events



Open Source Microbial Bioreactor



www.hackster.io/biomaker

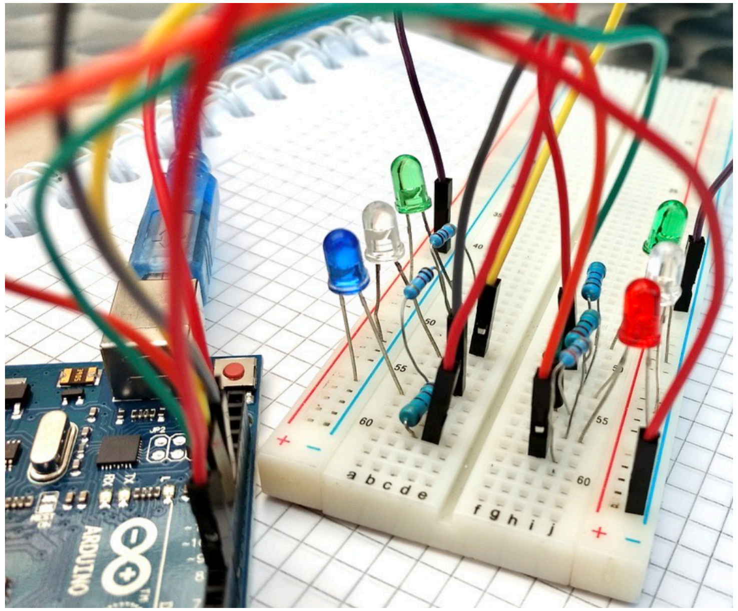
Discussion – 15min

1. Read through the case studies (**p80-83**)
2. Discuss in groups
3. Which of this devices is most relevant to your research?
4. What extra hardware or programming skills would you need to create one of these devices?

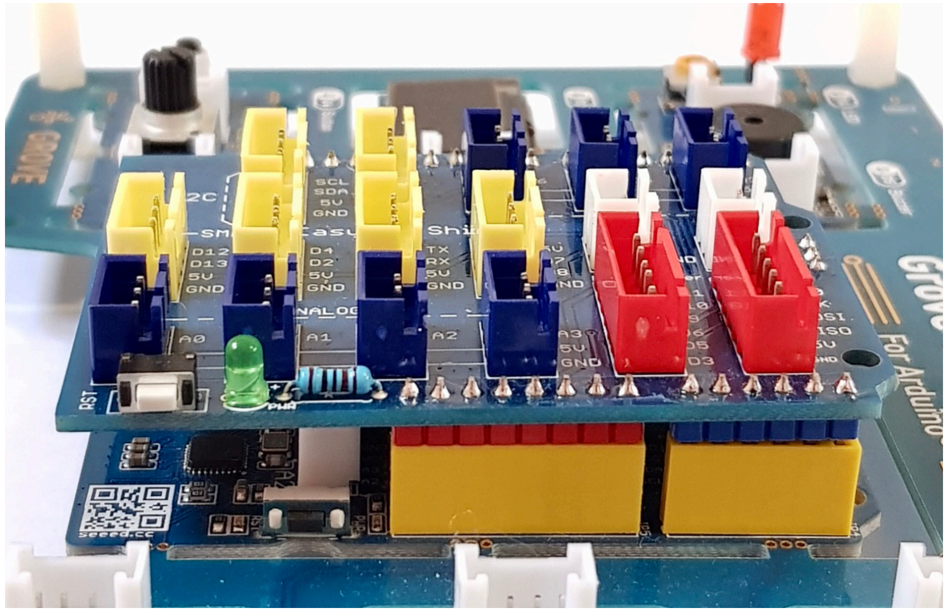
Expanding Your Capacity

Expanding Your Capacity

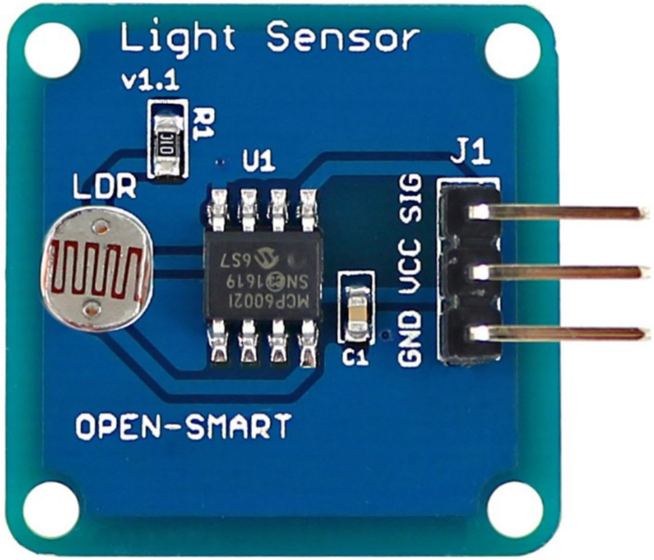
Wires



Shields



Breakout Boards



Plug-and-Play Components

seeed studio
The IoT Hardware Enabler

www.seeedstudio.com
> Shop > Grove

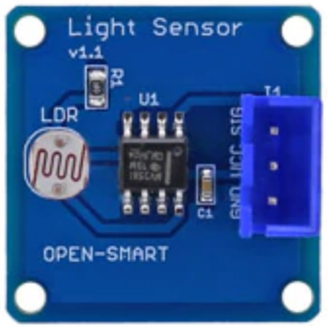
M5STACK

www.m5stack.com
> Store > Unit

Plug directly into white sockets
on the board

OPEN-SMART

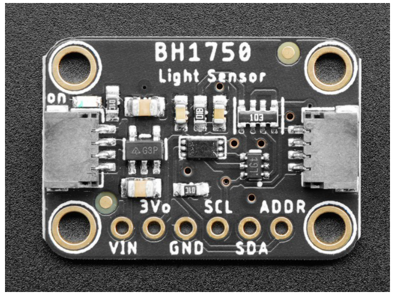
open-smart
.aliexpress.com



Plug into Open Smart
Expansion Shield
(or use JST PH to
JST XH cables)

adafruit

www.adafruit.com
> Products >
STEMMA/STEMMA QT



Plug directly
(STEMMA 4 pin)
Plug with JST PH to
JST SH cable
(STEMMA QT 4 pin)

Wired Breakout Boards

OPEN-SMART

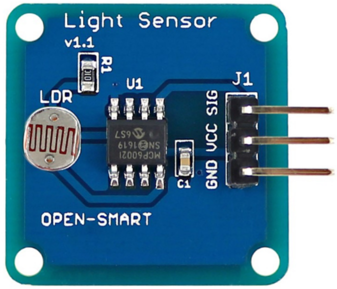
sparkfun ELECTRONICS

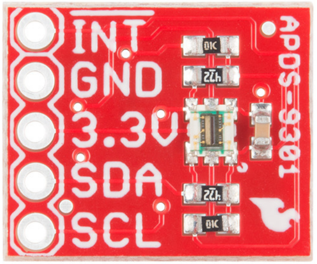
adafruit

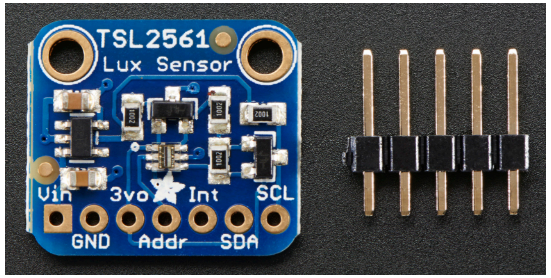
open-smart
.aliexpress.com

www.adafruit.com

www.adafruit.com







Connect using expansion shield or Grove-to-female wires (make sure pin labels match up)

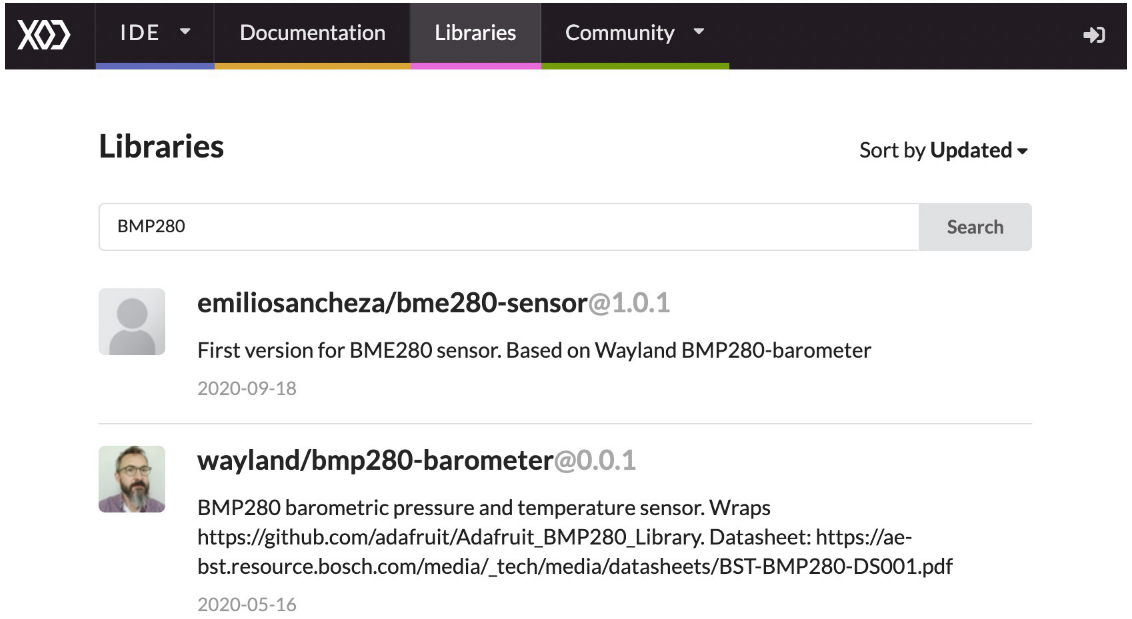
Solder pins to board. Connect using Grove-to-female wires (make sure pin labels match up)

Finding XOD Nodes

Search using ‘reference designator’
e.g. BMP280 (barometer) or SSD1306 (OLED screen)

www.xod.io/libs

forum.xod.io



Libraries

BMP280

emiliosancheza/bme280-sensor@1.0.1

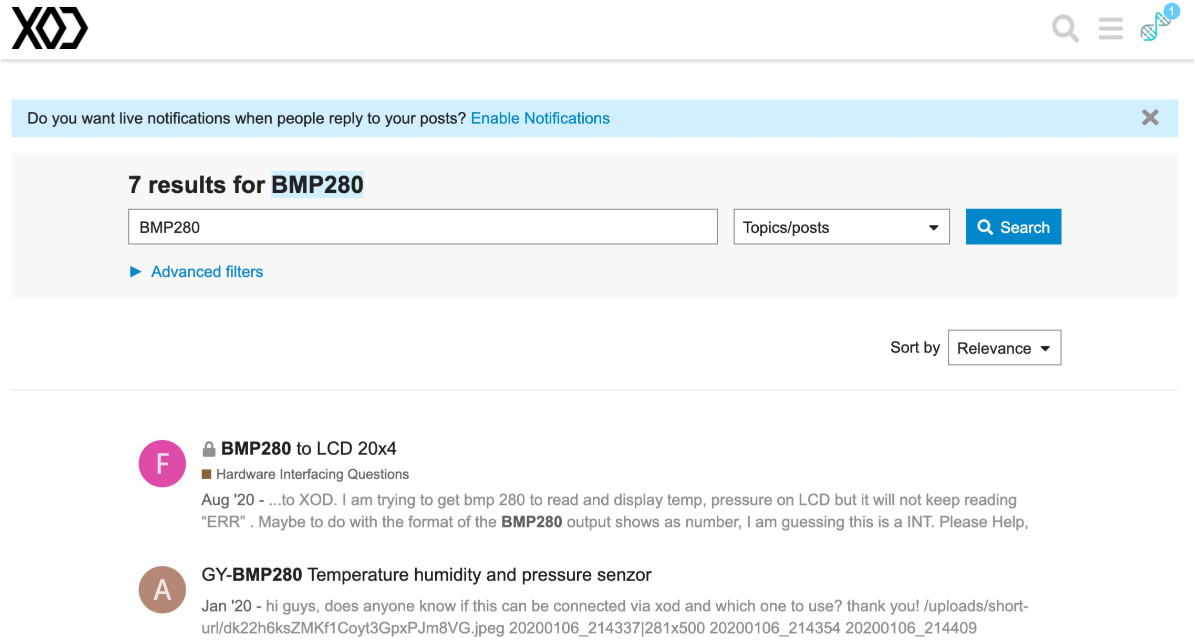
First version for BME280 sensor. Based on Wayland BMP280-barometer

2020-09-18

wayland/bmp280-barometer@0.0.1

BMP280 barometric pressure and temperature sensor. Wraps https://github.com/adafruit/Adafruit_BMP280_Library. Datasheet: https://ae-bst.resource.bosch.com/media/_tech/media/datasheets/BST-BMP280-DS001.pdf

2020-05-16



Do you want live notifications when people reply to your posts? Enable Notifications

7 results for BMP280

BMP280

BMP280 to LCD 20x4

Hardware Interfacing Questions

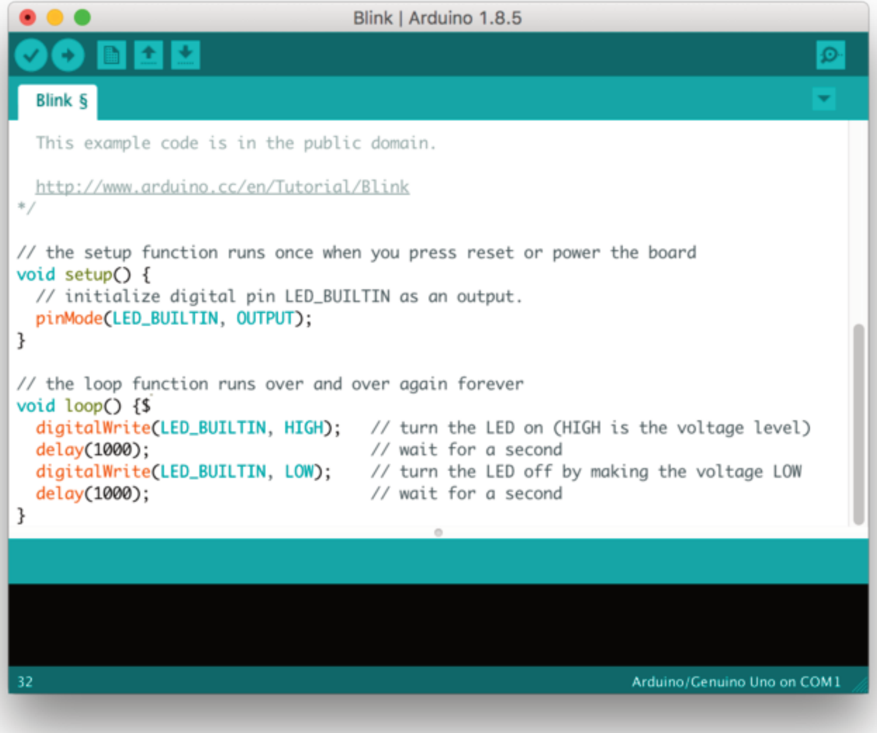
Aug '20 - ...to XOD. I am trying to get bmp 280 to read and display temp, pressure on LCD but it will not keep reading “ERR” . Maybe to do with the format of the **BMP280** output shows as number, I am guessing this is a INT. Please Help,

GY-**BMP280** Temperature humidity and pressure senzor

Jan '20 - hi guys, does anyone know if this can be connected via xod and which one to use? thank you! /uploads/short-url/dk22h6ksZMKf1Coyt3GpxPJm8VG.jpeg 20200106_214337|281x500 20200106_214354 20200106_214409

Arduino IDE

Arduino provides it's own free IDE software, which uses
C++ coding language to programme the board.
www.arduino.cc/en/software



```
  This example code is in the public domain.

  http://www.arduino.cc/en/Tutorial/Blink
*/

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {$
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```

Converting Arduino libraries for use in XOD
bit.ly/arduino-to-xod

Combining XOD and Arduino IDE
XOD menu > Deploy > 'Show Code for Arduino'

More complex programming
www.arduino.cc/en/Tutorial/HomePage

What would you build?

Discussion – 20min

1. What instruments would be useful in your own research?
2. How would you go about building such a device?
3. What additional hardware/programming would you need?
4. Do some research – has something like this already been done? Can you find the things you need?

Questions? Contact the Biomaker team: **coordinator@synbio.cam.ac.uk**

Thank You

More info:

www.biomaker.org

Biotechnology and Biological Sciences Research Council

Engineering and Physical Sciences Research Council

Natural Environment Research Council

NSF

OpenPlant

SynBio IRC

UNIVERSITY OF CAMBRIDGE