

Centre de formació i ocupació

Enginyers
Industrials de Catalunya

**Curs pràctic de programació d'electrònica
"embedded low-cost" per a la IoT**

Curs pràctic de programació d'electrònica "embedded low- cost" per a la IoT

<https://formacio.eic.cat/cursos/1123418>

Grup de Treball IoT & Embedded Systems

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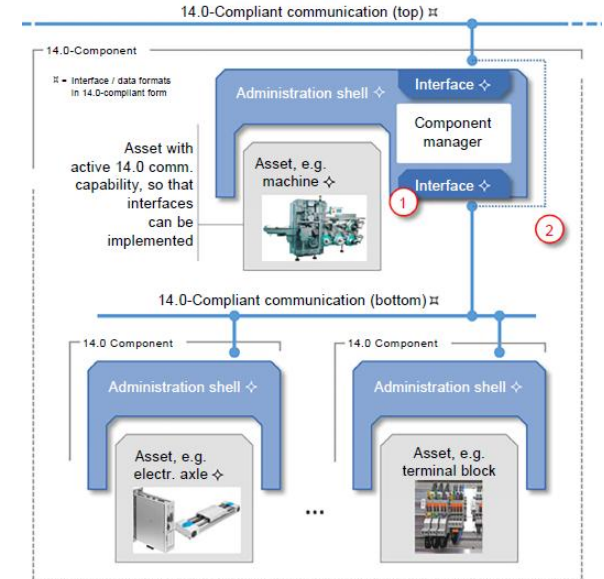
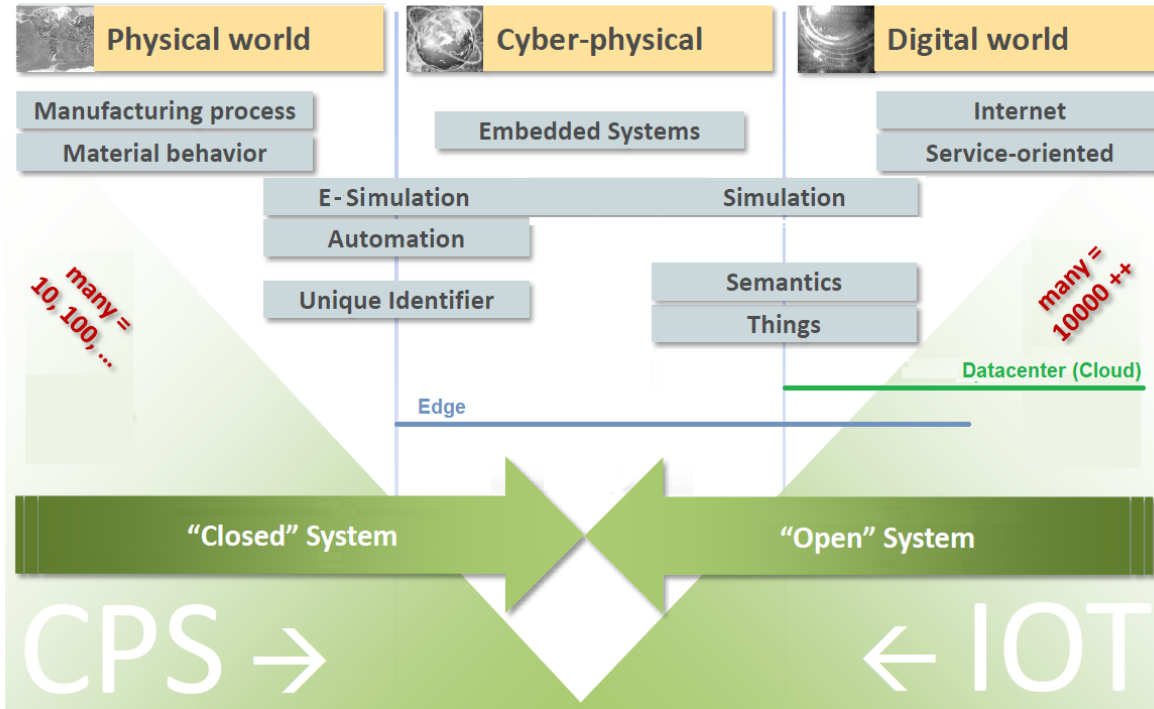
Índex

- Els embedded systems (Sistemes encastats)
- Elements centrals de la Indústria 4.0
- Exemples bàsics d'actuadors
- Exemples bàsics de sensòrica
- Internet de les coses
- Protocols de comunicacions IoT: MQTT i HTTP
- Cloud (núvol) i Edge
- Sensors i actuadors en entorns industrials

ELS EMBEDDED SYSTEMS

Elements centrals de la Indústria 4.0

Two Worlds coming together

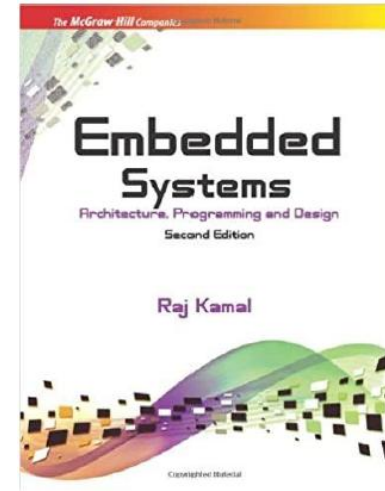


Nestability of I4.0 components

IEC PAS 63088

Tipus d'embedded systems

- Classificació del prof. Raj Kamal
 - Escala petita (Ex. Arduino)
 - Escala mitjana (Ex. ESP32)
 - Escala sofisticada (Ex. Raspberry Pi, Olimex)



Impacte del DiY en la recerca

[Published: 06 April 2017](#)

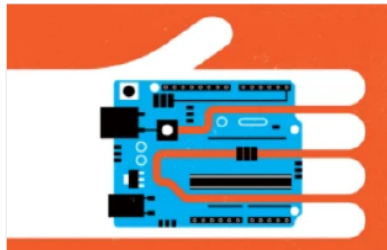
The DIY electronics transforming research

[Daniel Cressey](#)

[Nature](#) **544**, 125–126 (2017) | [Cite this article](#)

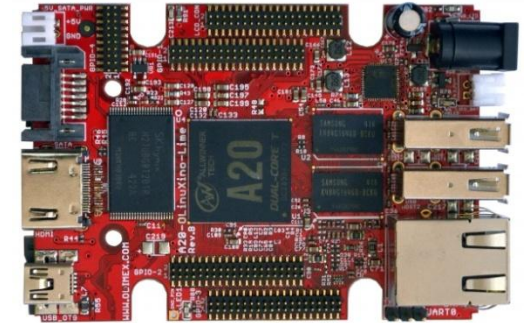
537 Accesses | **34** Citations | **336** Altmetric | [Metrics](#)

Cheap, stripped-down microcontrollers are allowing users to pack huge amounts of computing power into tiny spaces.



www.nature.com/articles/544125a

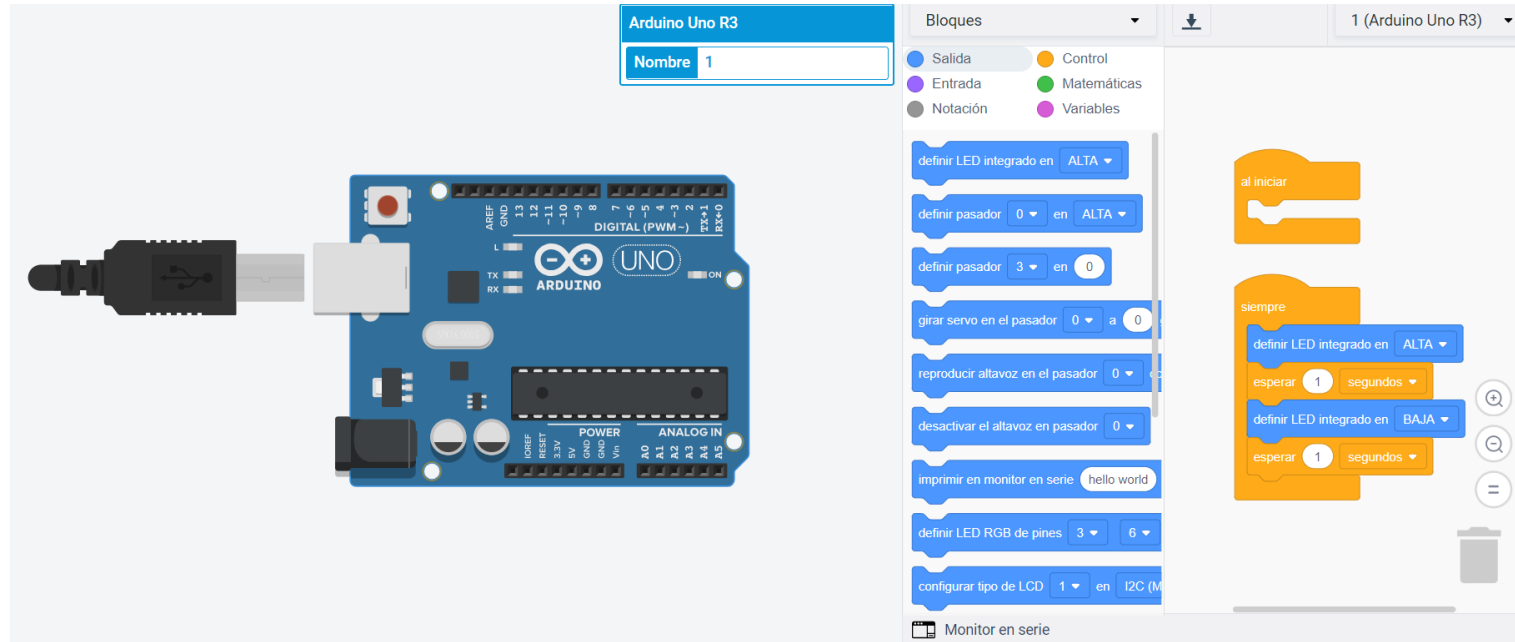
Impacte del DiY en la indústria



Proveïdors

- www.diotronic.com
- www.industrialshields.com
- www.amazon.com
- www.aliexpress.com

Llenguatges low-code de blocs (Blockly)



www.tinkercad.com

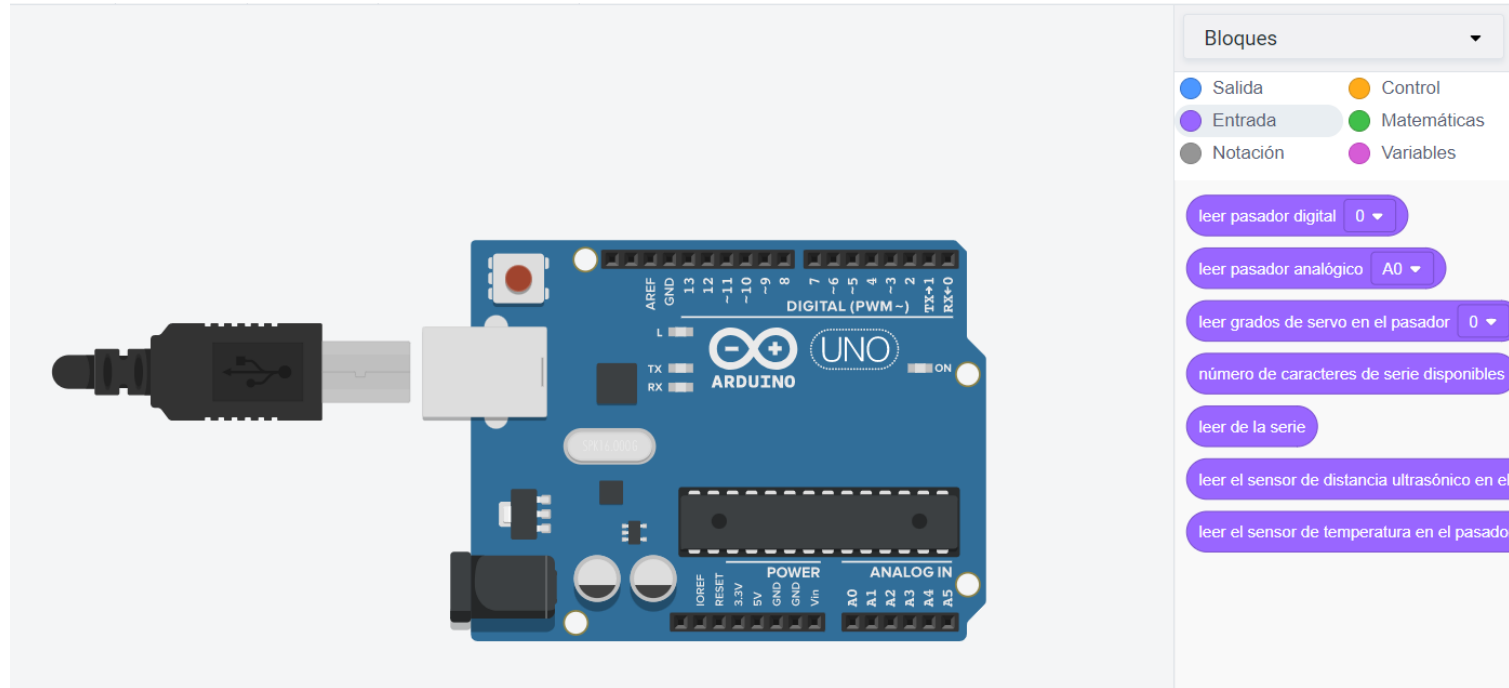
Arquitectura Super-Loop

(Atomatització industrial)

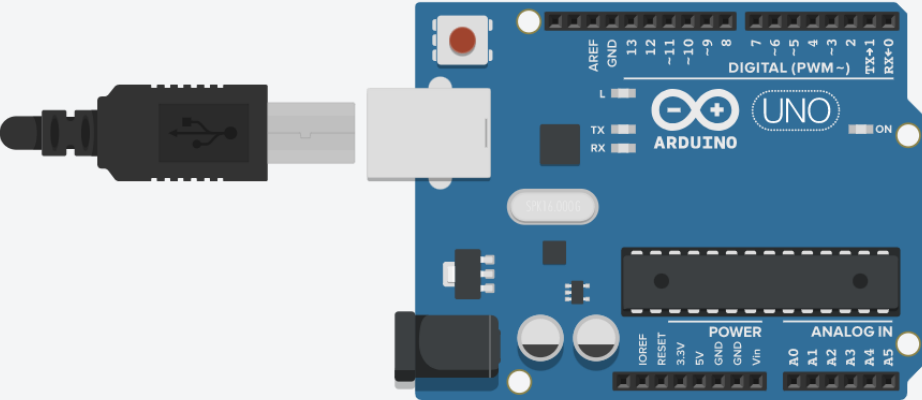
```
main() {  
    setup();  
    while (1) {  
        loop();  
    }  
}
```

http://www.xavierpi.com/cursiotpract/3_0_To_4_0.png

Entrades analògiques i digitals



Sortides analògiques i digitals



Bloques

- Salida
- Entrada
- Notación
- Control
- Matemáticas
- Variables

definir LED integrado en ALTA

definir pasador 0 en ALTA

definir pasador 3 en 0

girar servo en el pasador 0 a 0

reproducir altavoz en el pasador 0 cc

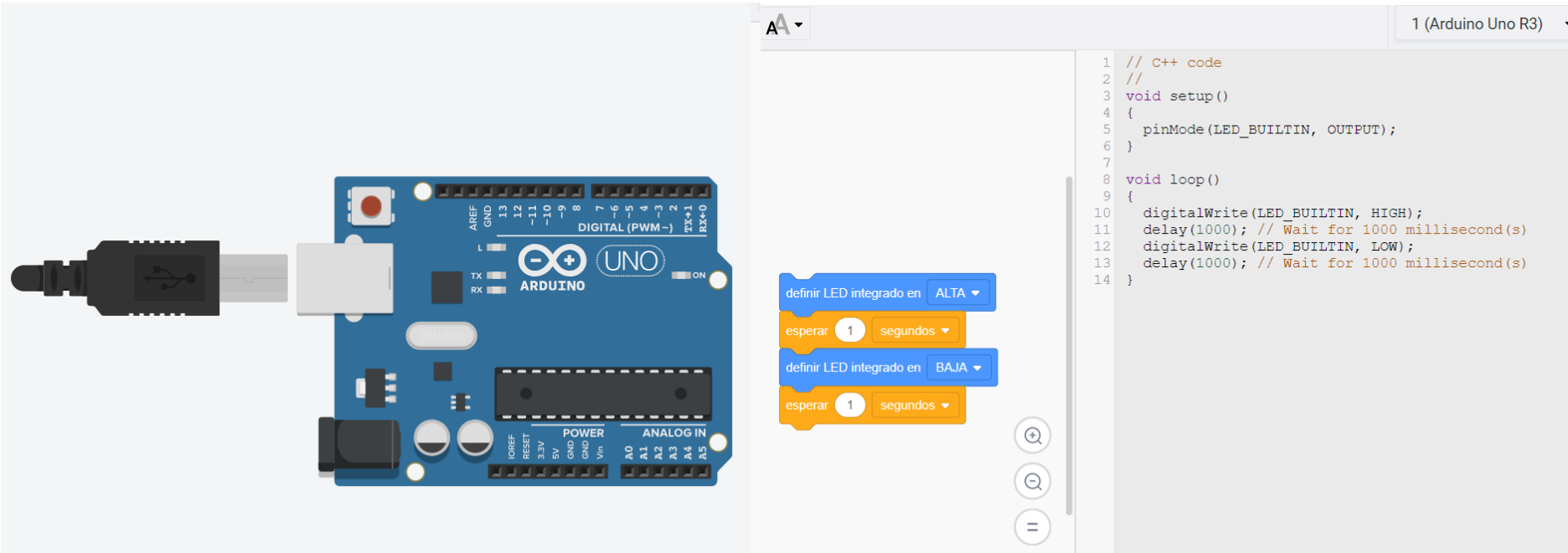
desactivar el altavoz en pasador 0

imprimir en monitor en serie hello world

definir LED RGB de pines 3 3

EXEMPLES BÀSICS D'ACTUADORS

Control d'un led (blink)



The image displays an Arduino Uno R3 board on the left and its IDE interface on the right. The IDE shows a C++ code editor with the following code:

```
1 // C++ code
2 //
3 void setup()
4 {
5   pinMode(LED_BUILTIN, OUTPUT);
6 }
7
8 void loop()
9 {
10  digitalWrite(LED_BUILTIN, HIGH);
11  delay(1000); // Wait for 1000 millisecond(s)
12  digitalWrite(LED_BUILTIN, LOW);
13  delay(1000); // Wait for 1000 millisecond(s)
14 }
```

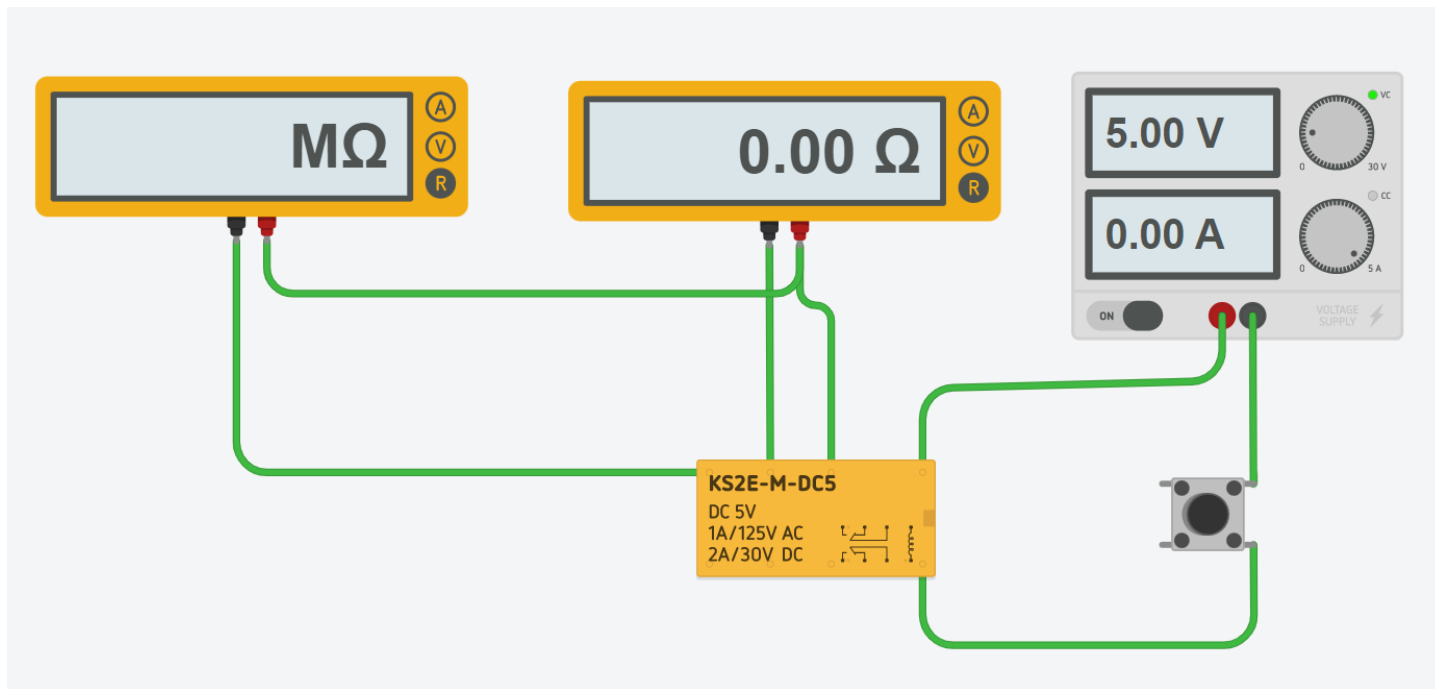
Below the code editor, the block-based programming interface shows the following sequence of blocks:

- definir LED integrado en ALTA
- esperar 1 segundos
- definir LED integrado en BAJA
- esperar 1 segundos



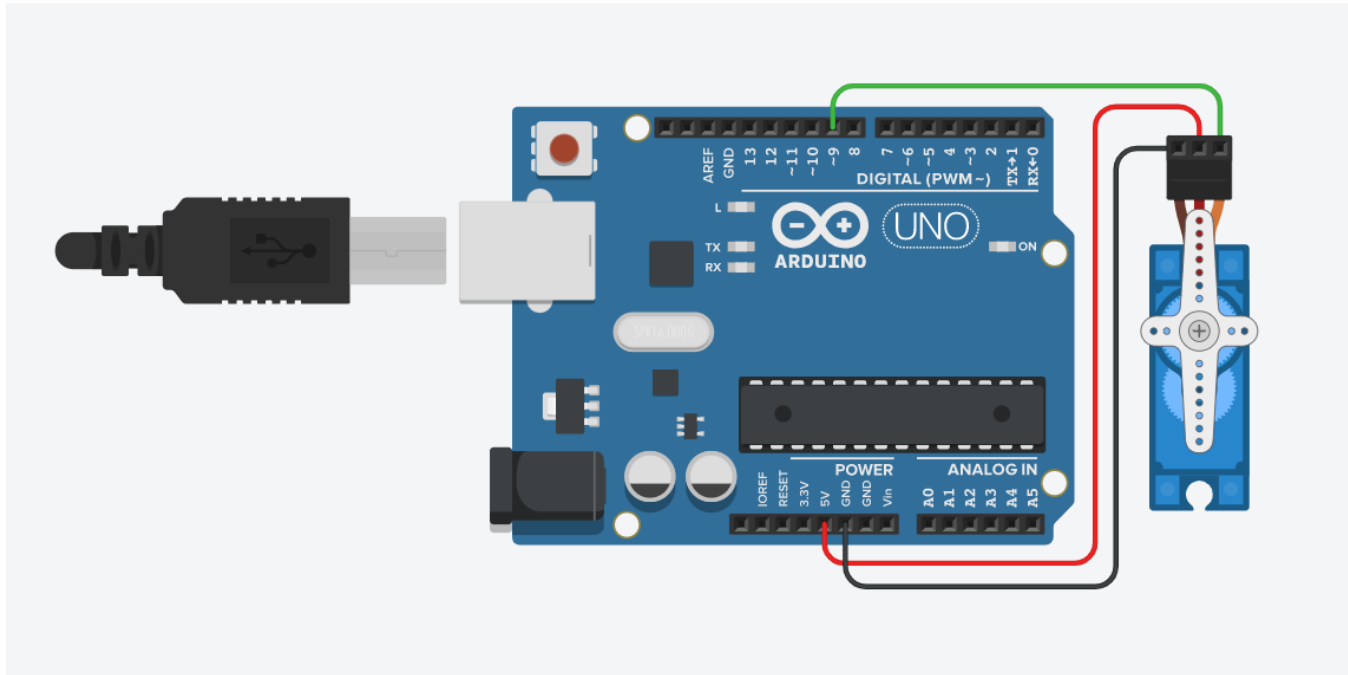
Exercici: Afegir un LED extern, amb la resistència corresponent.

Control d'un relé



<https://www.tinkercad.com/things/1O4C6ZoLpdB>

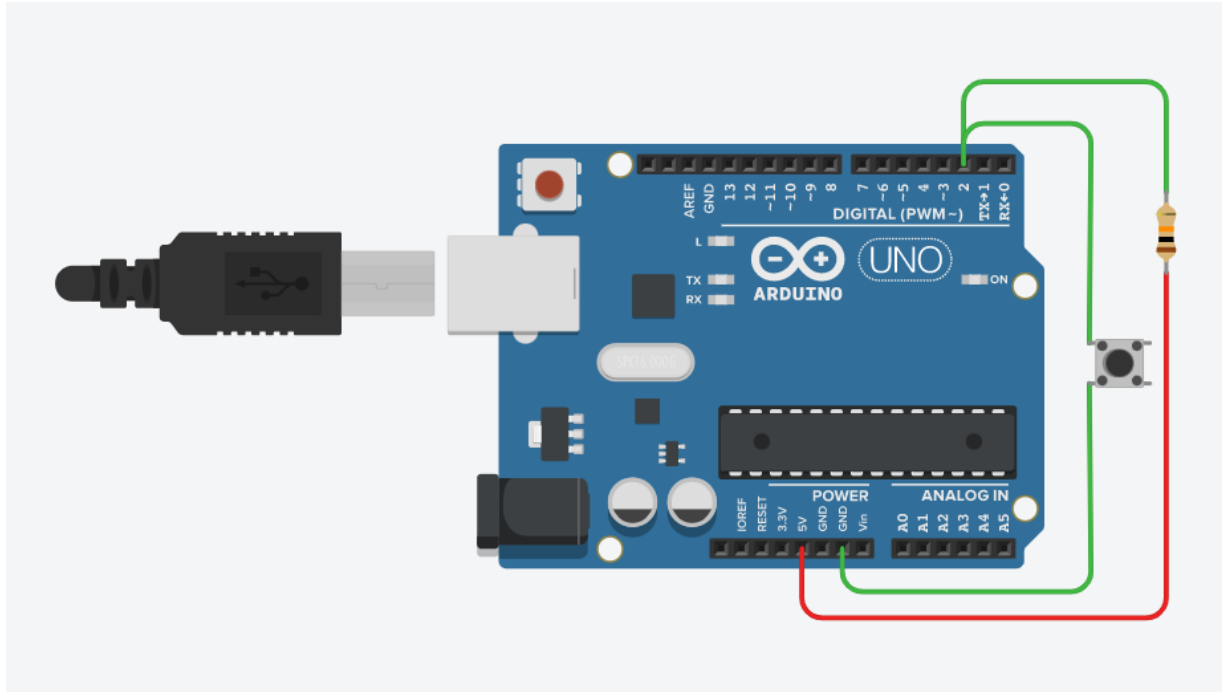
Control d'un servomotor



<https://www.tinkercad.com/things/3NPlinNEm8D>

EXEMPLES BÀSICS DE SENSÒRICA

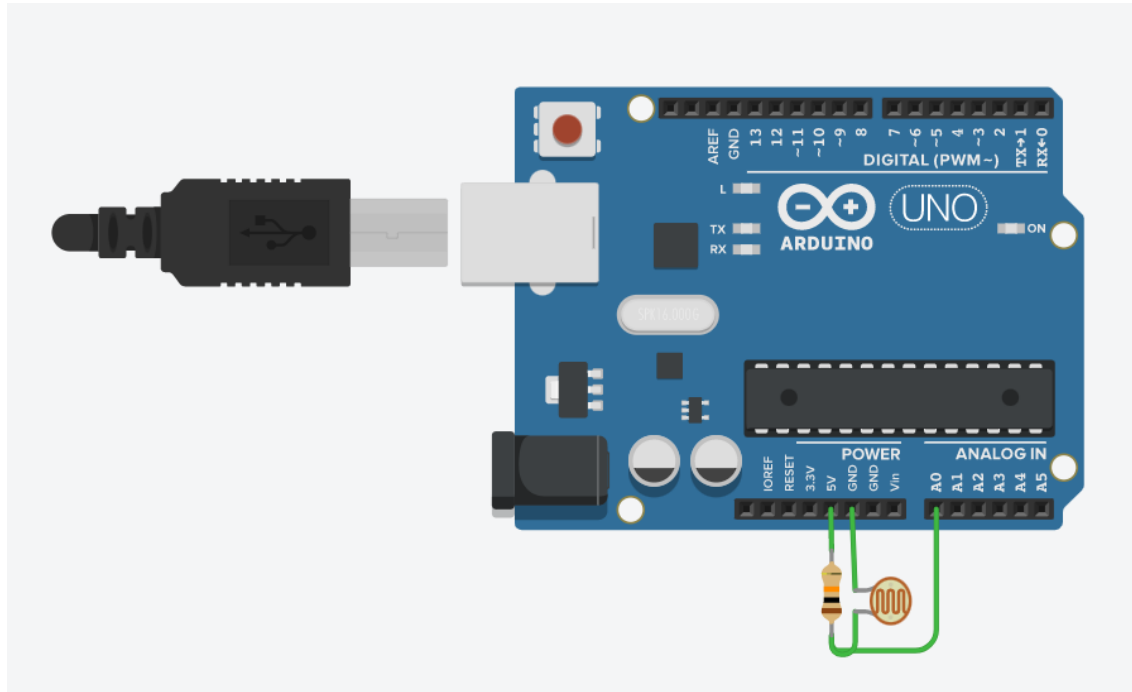
Detecció d'un final de carrera



(Noció de pull-up)

<https://www.tinkercad.com/things/jcljb4UQUPd>

Mesura d'un nivell de lluminositat



<https://www.tinkercad.com/things/eZBCioTaA5V>

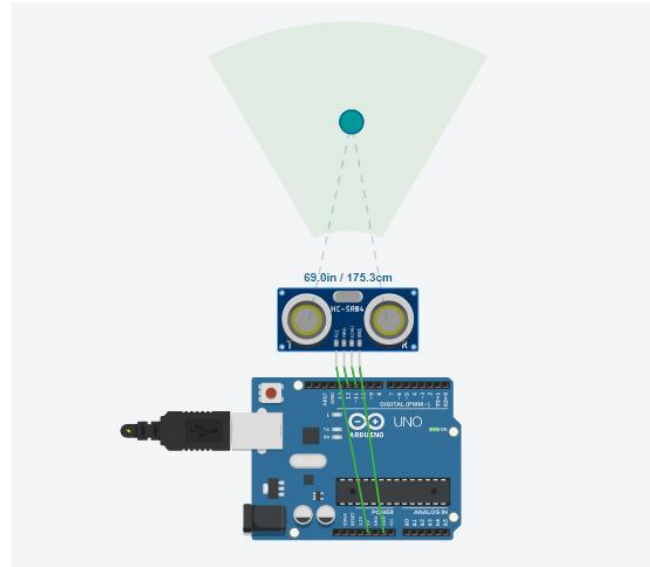
Detecció d'un llindar de lluminositat

- Exercici:



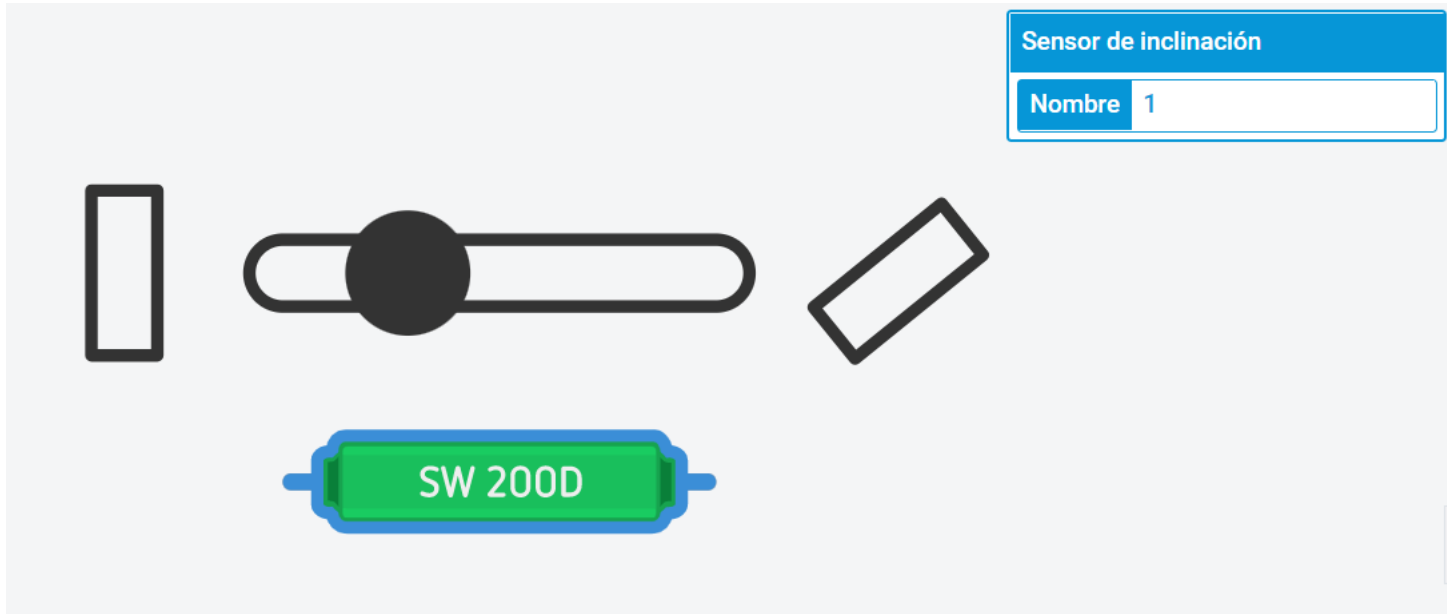
Ampliar l'exemple anterior per a encendre i apagar un LED si traspassa un valor llindar de lluminositat.

Mesura d'una distància



<https://www.tinkercad.com/things/9I2rZw0cjLS>

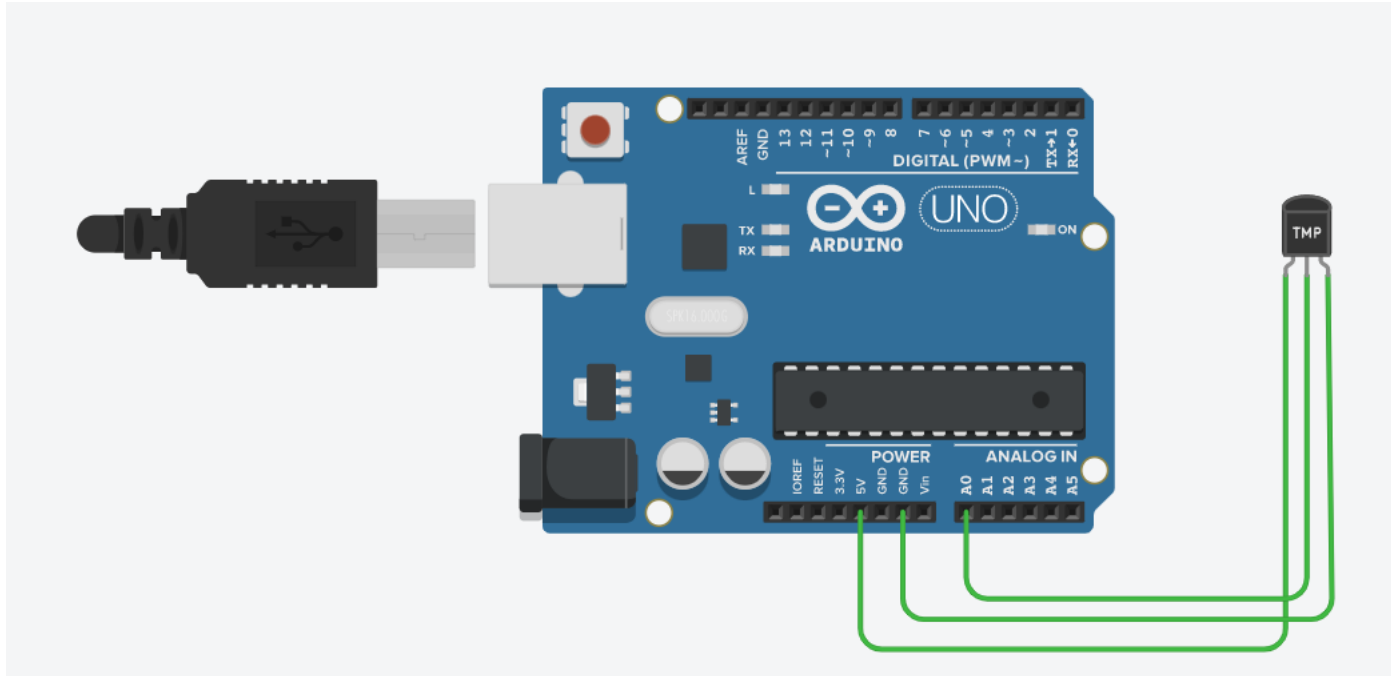
Mesura d'inclinacions (acceleracions)



Exercici!

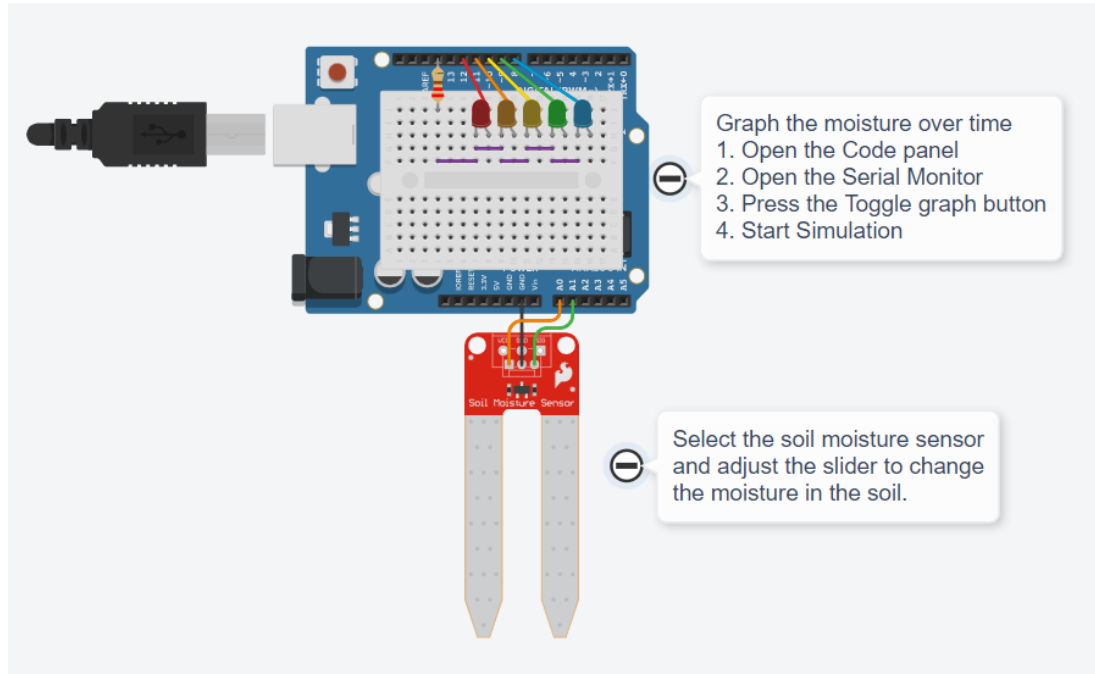
Exercici: Analitzar el funcionament amb el multímetre

Mesura temperatura



<https://www.tinkercad.com/things/6M4rpEIIvRE>

Mesura d'humitat



Exercici!

Moisture **Arduino Starter**. Exercici: Analitzar i entendre l'exemple.

PROTOCOLS DE COMUNICACIONS IOT: MQTT I HTTP

Protocol MQTT. PubSub vs client-server

← → ↻ github.com/pixavier/mqtt4snap ☆ 🔒 ⚙️ □ × ⋮

W Corporate social res... 🌐 Nueva pestaña

☰ README.md ✎

MQTT4Snap !

MQTT4Snap ! is a Snap ! library for using [MQTT](#) in [Snap !](#) (in the cloud) and [Snap4Arduino](#) (in the edge).

MQTT is an open and [secure](#) publish-subscribe protocol for the Internet of Things, suitable for industrial applications and [Digital Twins](#).

There are several [MQTT public server/brokers](#) for rapid testing purpose, such as [test.mosquitto.org](#), [mqtt.eclipseprojects.io](#) or [www.emqx.com/en/mqtt/public-mqtt5-broker](#). Never use these servers for production. One way to start is using [Mosquitto](#) on your own server, which is a popular open-source option available for Linux, Windows and Mac, fast and easy to install. For accessing directly to a MQTT broker from a browser, [WebSockets support must be activated on the broker](#). To monitor de broker activity, [MQTT Explorer](#) is an excellent free tool.

[Snap !](#) can be considered a block-based [low-code programming language](#), unlike [Node-RED](#), that can be regarded as a flow-based low-code tool.

Hello World!

This Hello World! example shows how PubSub-based aqchitectures let implement IoT with no friction.

Blocks and usage

Old library

Packages

No packages published
[Publish your first package](#)

Contributors 3

- [pixavier](#) Xavier Pi
- [bromagosa](#) Bernat Romagosa
- [jump-pi](#)

Environments 1

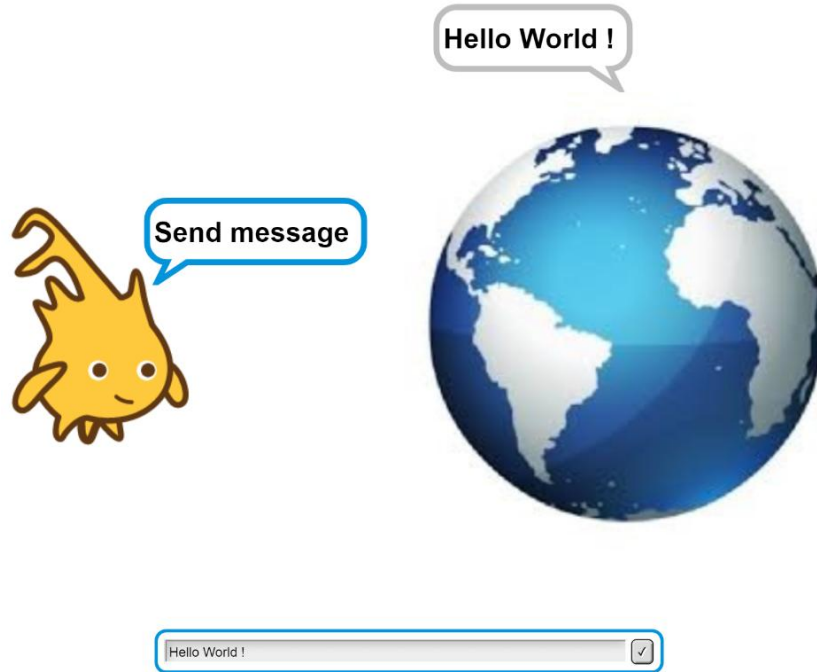
- [github-pages](#) Active

Languages

- JavaScript 91.3%
- HTML 6.0%
- C++ 2.1%
- Python 0.6%

<https://github.com/pixavier/mqtt4snap>

Protocol MQTT: Hello World !

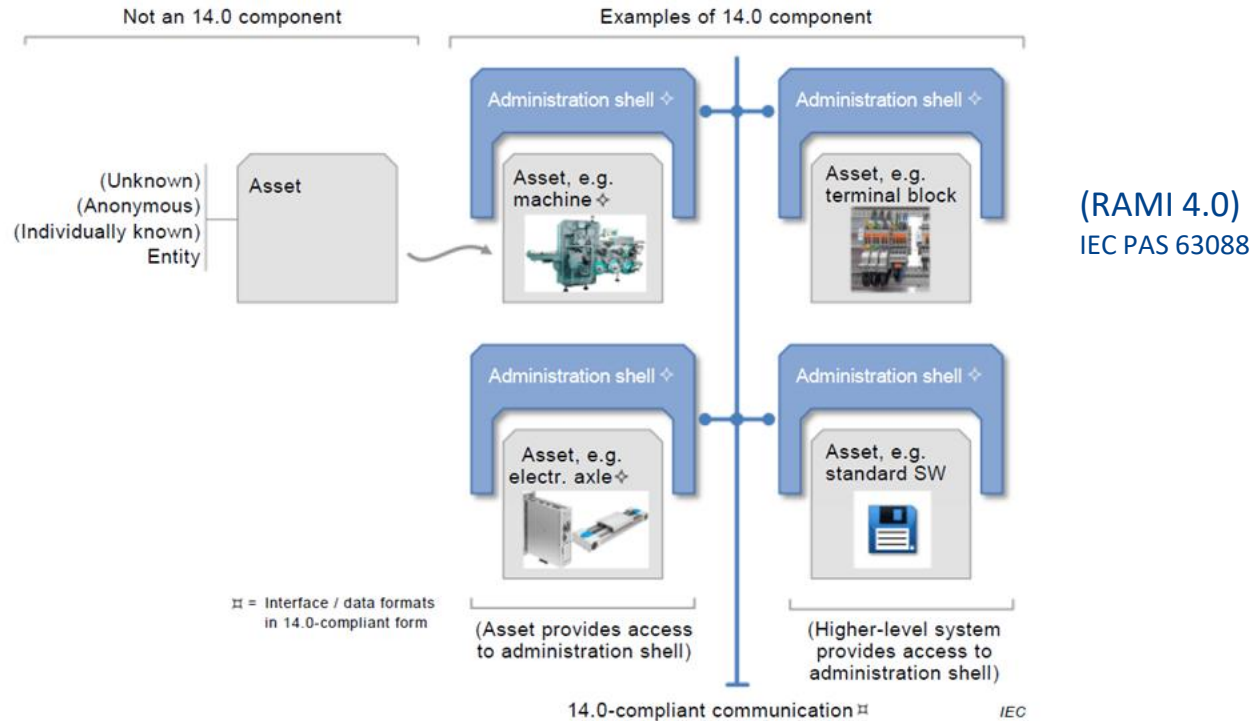


<http://extensions.snap.berkeley.edu/snap/snap.html#run:http://raw.githubusercontent.com/pixavier/mqtt4snap/master/examples/HelloWorld.xml>

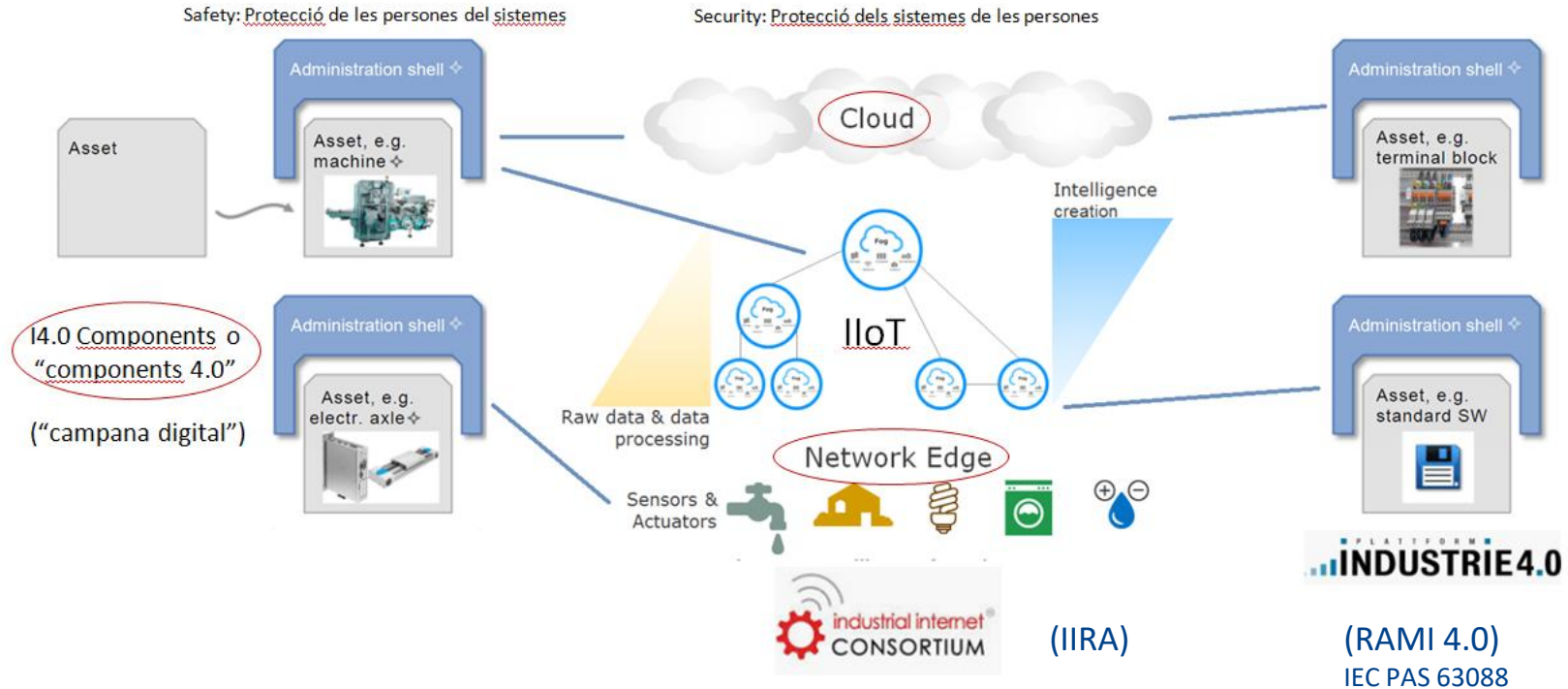
Llenguatges low-code de blocs (Snap!, Scratch)

The screenshot displays the Snap! IDE interface. On the left, the 'Scripts' category is selected, showing a sequence of blocks: 'MQTT connect to broker.emqx.io', 'MQTT subscribe to broker.emqx.io topic name on each message run say payload for 2 secs input names: payload topic', 'MQTT publish to broker.emqx.io topic name payload hello', 'MQTT response broker.emqx.io topic name reply MQTT example response reporter payload payload topic topic input names: payload topic', and 'MQTT request broker.emqx.io topic name response topic timer payload hello say resp for 2 secs'. The main workspace shows a 'Sprite' object with a 'draggable' checkbox checked. The stage area is empty. On the right, a list of steps is visible: 'Step 0: Connect to the broker', 'Step 1: Subscribe to a topic', 'Step 2: Publish a message', 'Step 1: Activate the responder', and 'Step 2: Send a request (timer acts as idCall)'. The browser address bar shows the URL: snap.berkeley.edu/snap/snap.html#open:https://raw.githubusercontent.com/pixavier/mqtt4snap/master/examples/Demo.xml.

Noció de núvol. Cloud i Edge computing



Noció de núvol. Cloud i Edge computing



Llenguatges low-code de fluxos (Node-RED)

The screenshot displays the Node-RED web interface in a browser. The address bar shows the URL: `vps656540.ovh.net:51800/#flow/d775676113e223e0`. The interface includes a top navigation bar with a 'Deploy' button and a user profile icon. On the left, there is a 'filter nodes' search bar and a list of nodes categorized into 'common' and 'function'. The 'common' category includes nodes like 'inject', 'debug', 'complete', 'catch', 'status', 'link in', 'link call', 'link out', and 'comment'. The 'function' category includes 'function', 'switch', 'change', and 'range'. The main workspace, titled 'Flow 1', contains a flow with two nodes: a blue 'timestamp' node connected to a green 'msg.payload' node. On the right side, a 'debug' console is open, showing the output of the flow: `node: 417da6efa7f5b383`, `msg.payload: number`, and the value `1651022933026`.

<http://vps656540.ovh.net:5x880>

Connexió al núvol

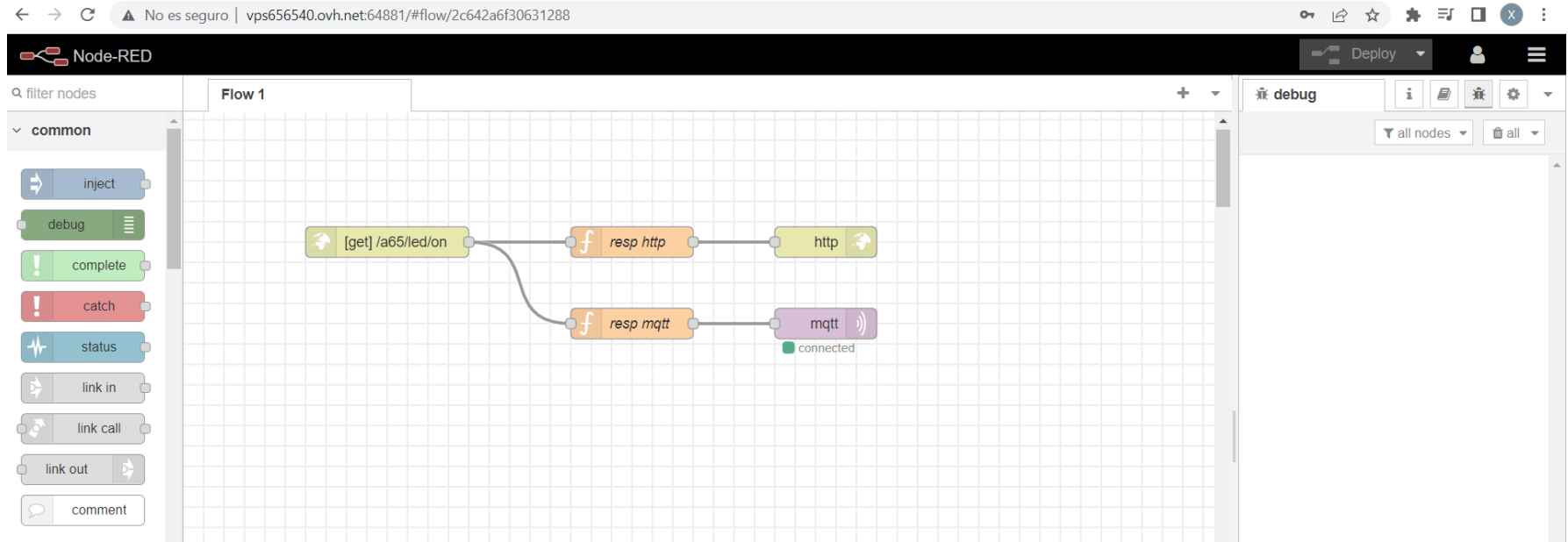
Noció de Bessó Digital (Digital Twin)

The screenshot displays a Snap3D workspace titled "Minimal_DT". The interface is divided into several sections:

- Left Panel:** A menu with categories like Motion, Control, Looks, Sensing, Sound, Operators, Pen, Variables, DT, and MQTT. Below the menu are various motion and control blocks such as "move 10 steps", "turn 45 degrees", "point in direction 90", "go to x: 0 y: 0", "glide 1 secs to x: 0 y: 0", "change x by 10", "set x to 0", "change y by 10", "set y to 0", "if on edge, bounce", and "position" (x, y, direction).
- Center Stage:** A dark workspace containing a script for a "Sprite" object. The script starts with a "when clicked" block, followed by two "MQTT connect to broker.emqx.io" blocks. The first is followed by an "MQTT subscribe to broker.emqx.io topic: topicName/off on each message run" block and a "switch to costume ESP32_blink_0" block. The second is followed by an "MQTT subscribe to broker.emqx.io topic: topicName/on on each message run" block and a "switch to costume ESP32_blink_1" block. At the bottom, there are two "MQTT publish to broker.emqx.io topic: topicName/off payload" blocks, one with an "on" button and one with an "off" button.
- Right Panel:** A 3D model of an ESP32 microcontroller board with a red LED connected to a pin. To the left of the board are two toggle switches labeled "ON" (green) and "OFF" (red). Below the board is a control panel with three buttons: "Sprite", "on", and "off".

https://snap.berkeley.edu/snap/snap.html#run:https://raw.githubusercontent.com/pixavier/mqtt4snap/master/LateralProjects/DT/loT_DT_min.xml

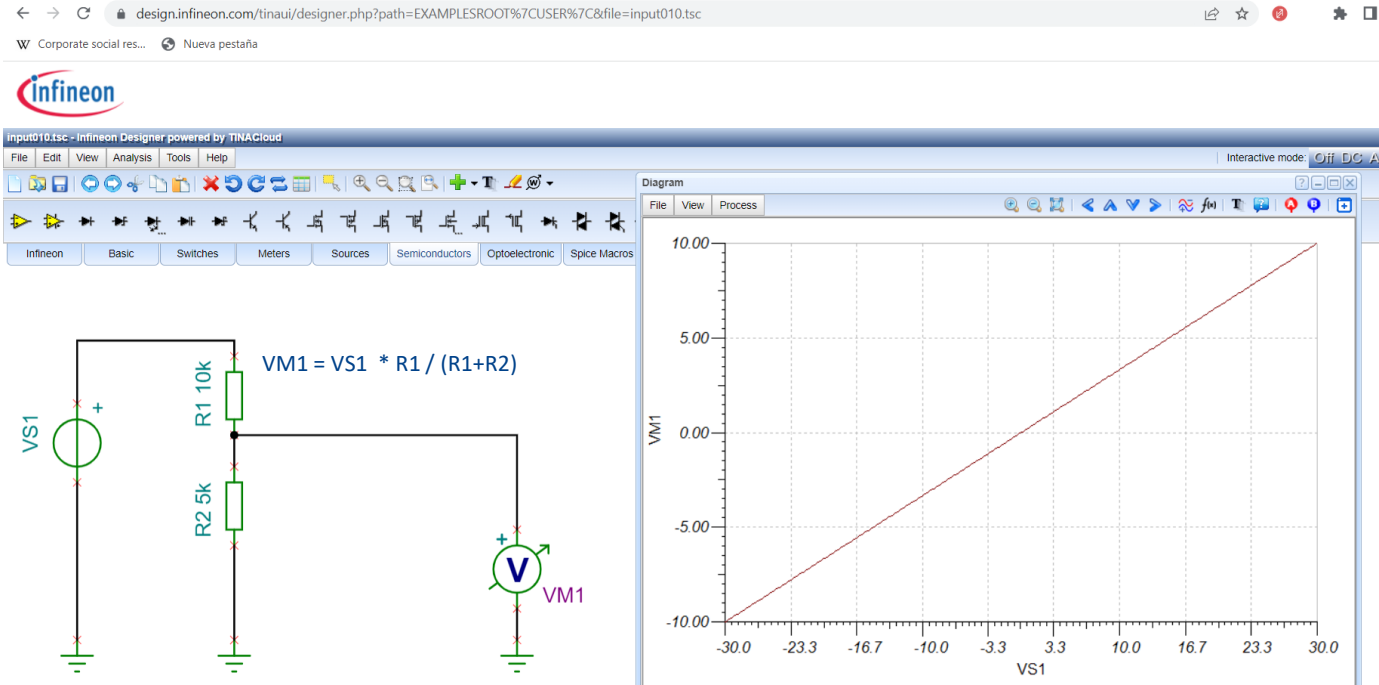
Protocol HTTP. Noció d'URL. Bridge HTTP-MQTT



<http://vps656540.ovh.net:64881/a65/led/on>

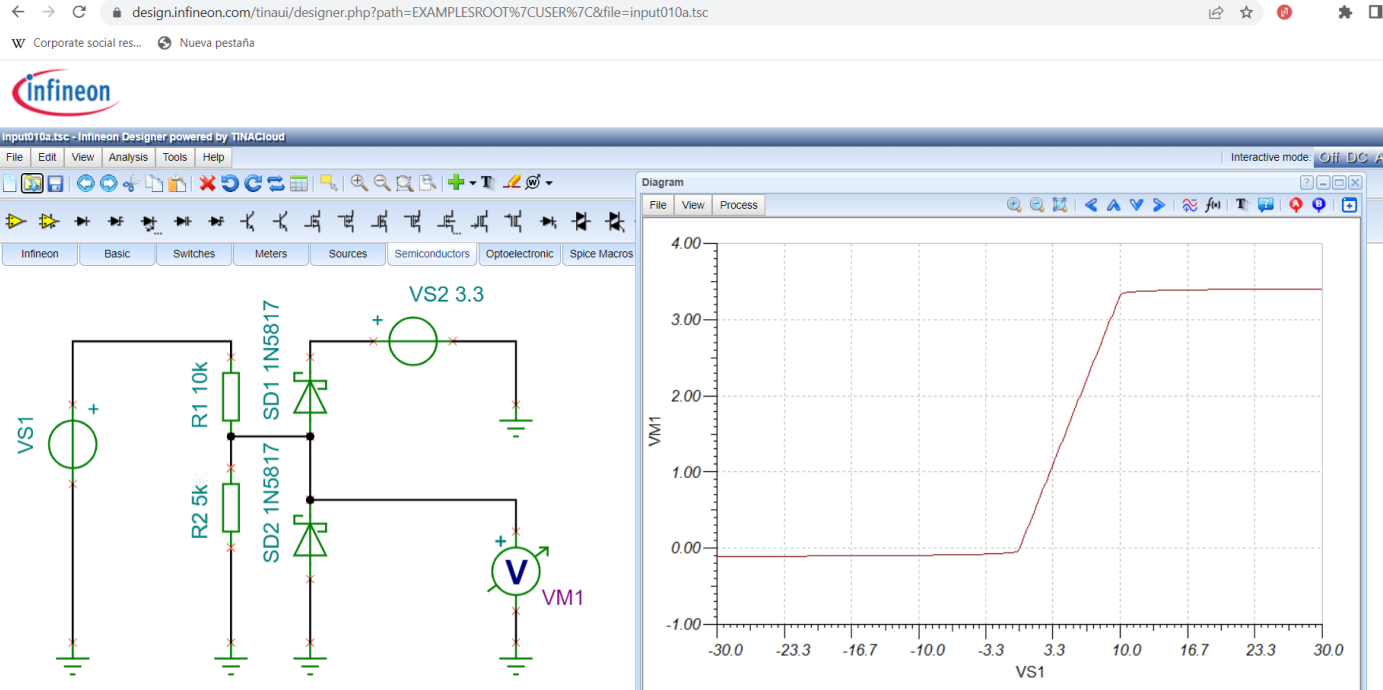
SENSORS I ACTUADORS EN ENTORNS INDUSTRIALS

Entrades analògiques i digitals.10V,24V

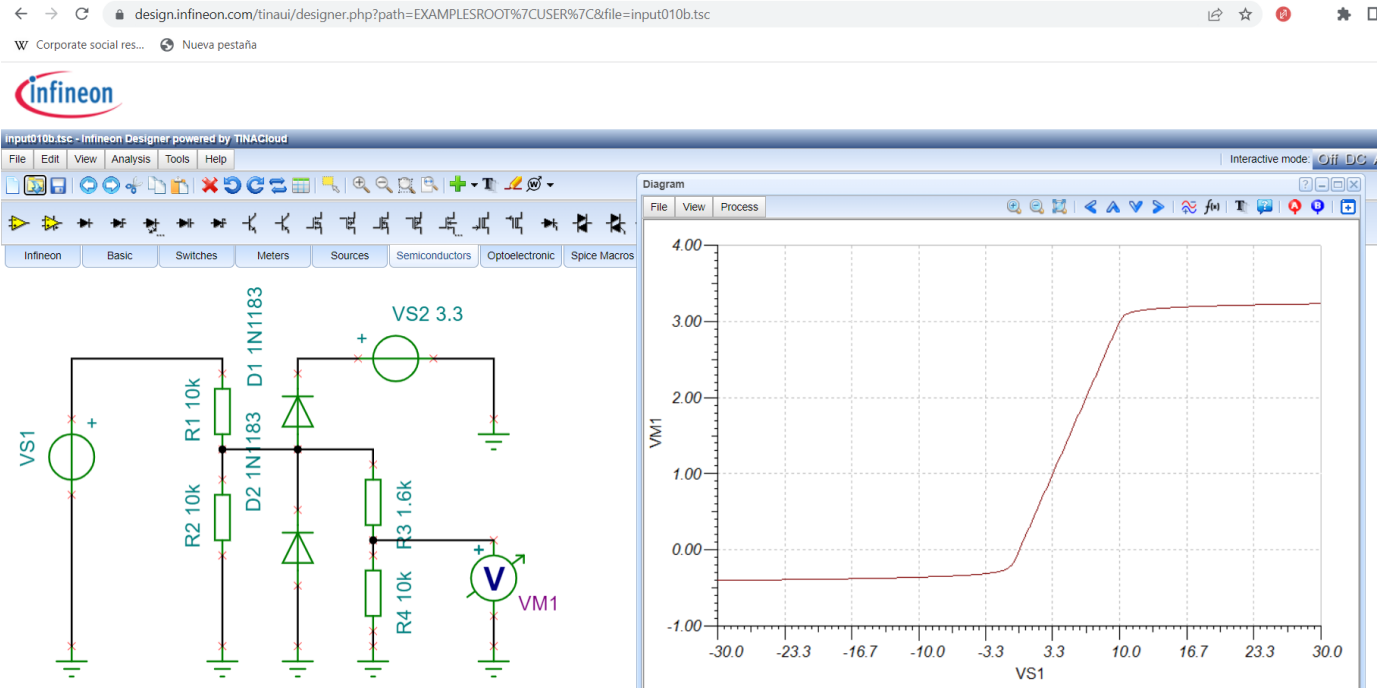


<https://design.infineon.com/tinaui/designer.php?c=62266a588651e>

Entrades analògiques i digitals. 10V, 24V

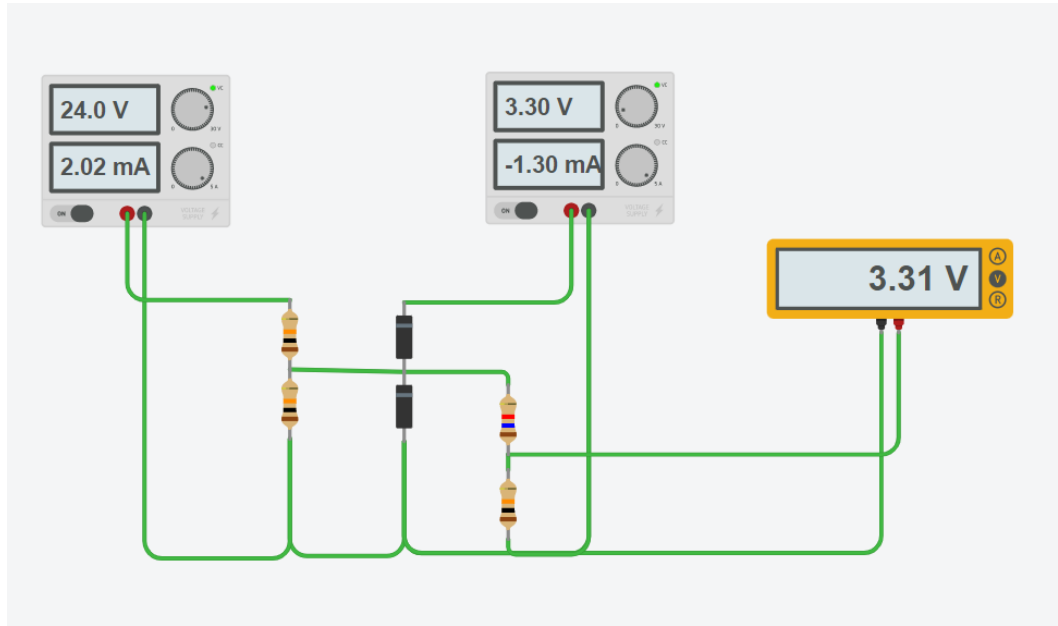


Entrades analògiques i digitals.10V,24V



<https://design.infineon.com/tinaui/designer.php?c=63394a77db71b>

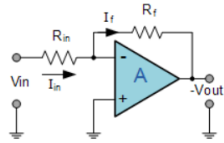
Entrades analògiques i digitals. 10V, 24V



<https://www.tinkercad.com/things/428kNkFBRgR>

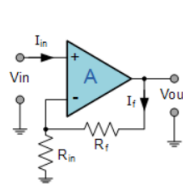
Sortides digitals 24V

Inverting Op-amp



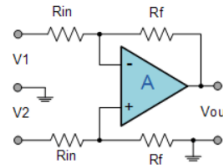
$$A = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$$

Non-inverting Op-amp



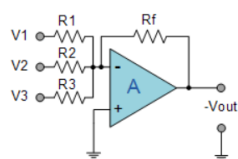
$$A = \frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_{in}}$$

Differential Op-amp



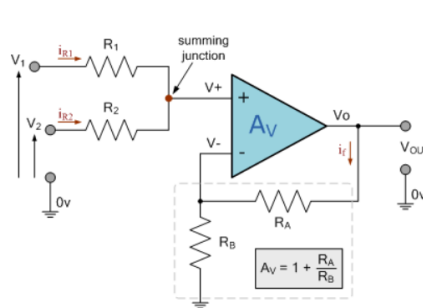
$$V_{out} = \frac{R_f}{R_{in}} (V_2 - V_1)$$

Inverting Summing Op-amp



$$V_{out} = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

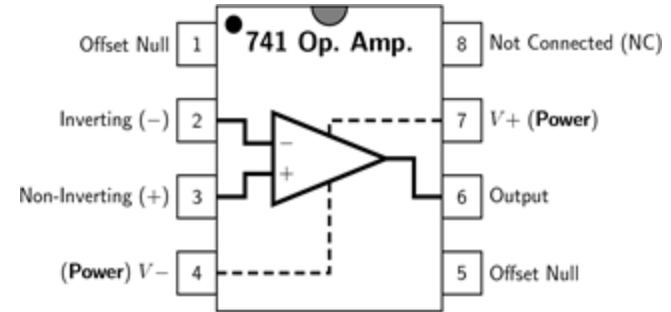
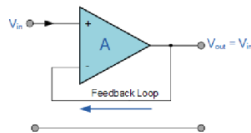
Non-inverting Summing Op-amp



$$A_v = 1 + \frac{R_A}{R_B}$$

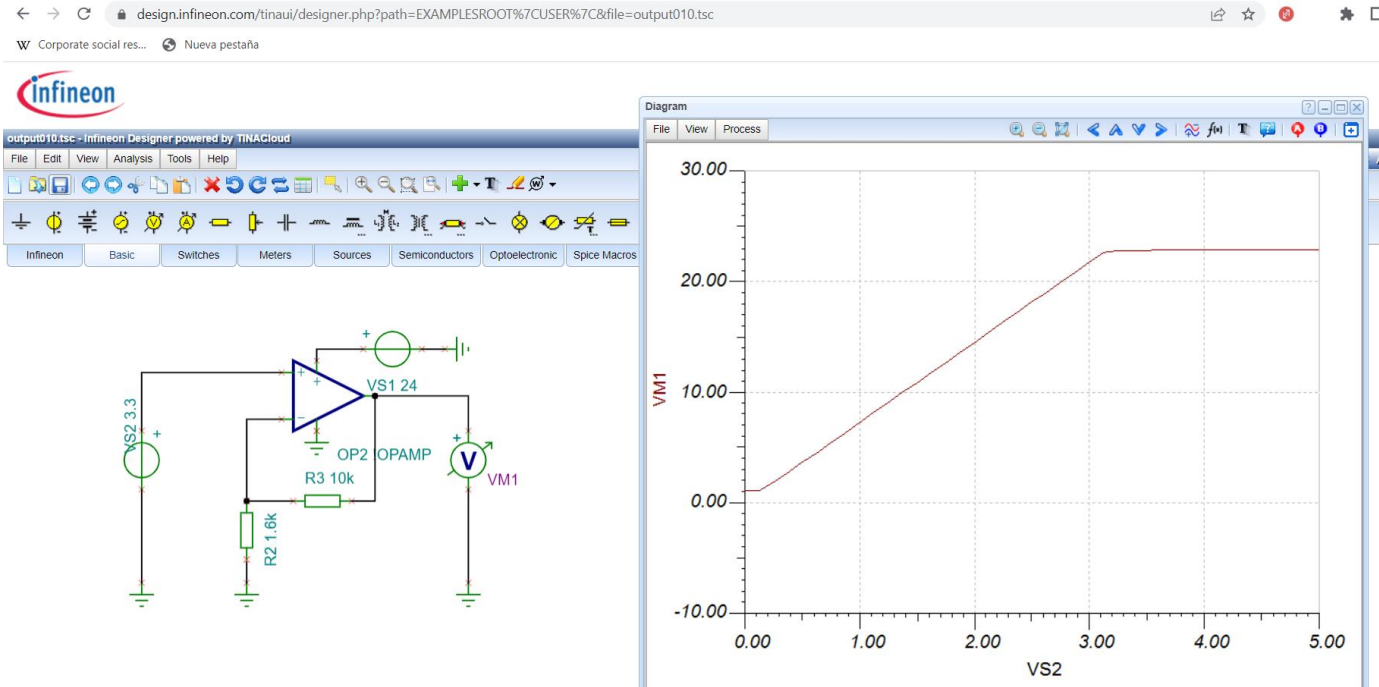
$$V_{out} = (V_1 + V_2) A_v / 2$$

Voltage Follower



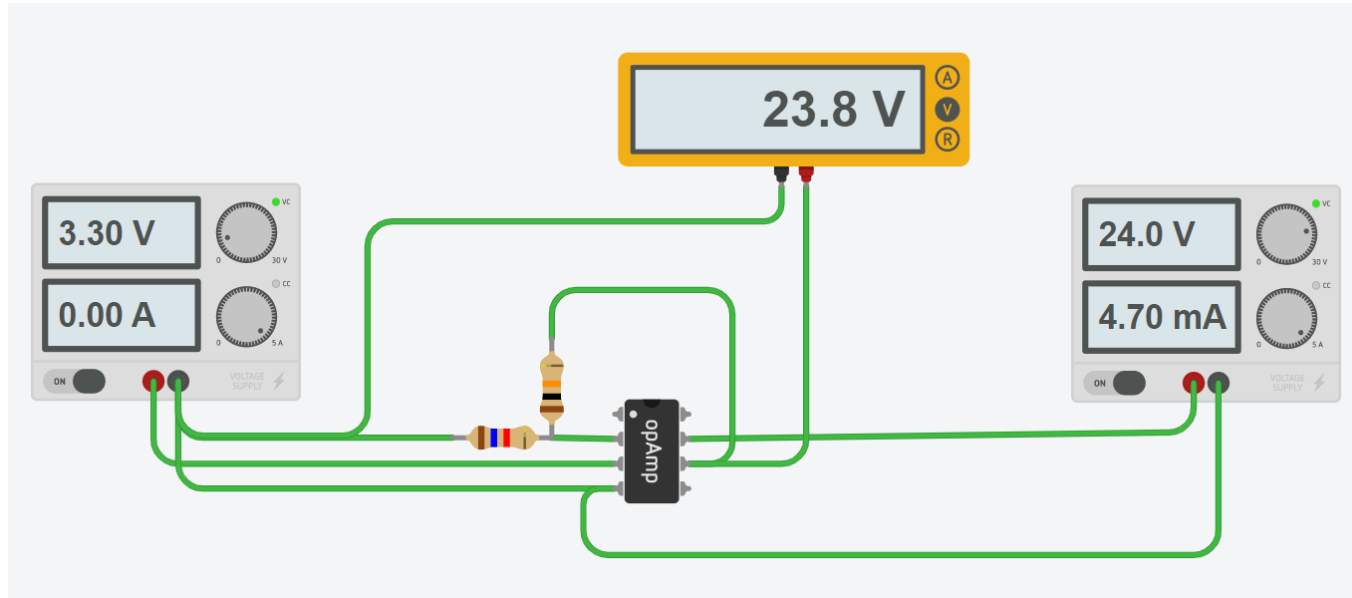
https://www.electronics-tutorials.ws/opamp/opamp_3.html

Sortides digitals 24V



<https://design.infineon.com/tinaui/designer.php?c=633969e35341e>

Sortides digitals 24V



<https://www.tinkercad.com/things/2QMMBjVqQFp>

Gràcies !

Xavier Pi

xpi@enginyers.net

<https://www.eic.cat/content/gt-embedded-systems-iot>

www.comissioindustria40.cat

Centre de formació i ocupació

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