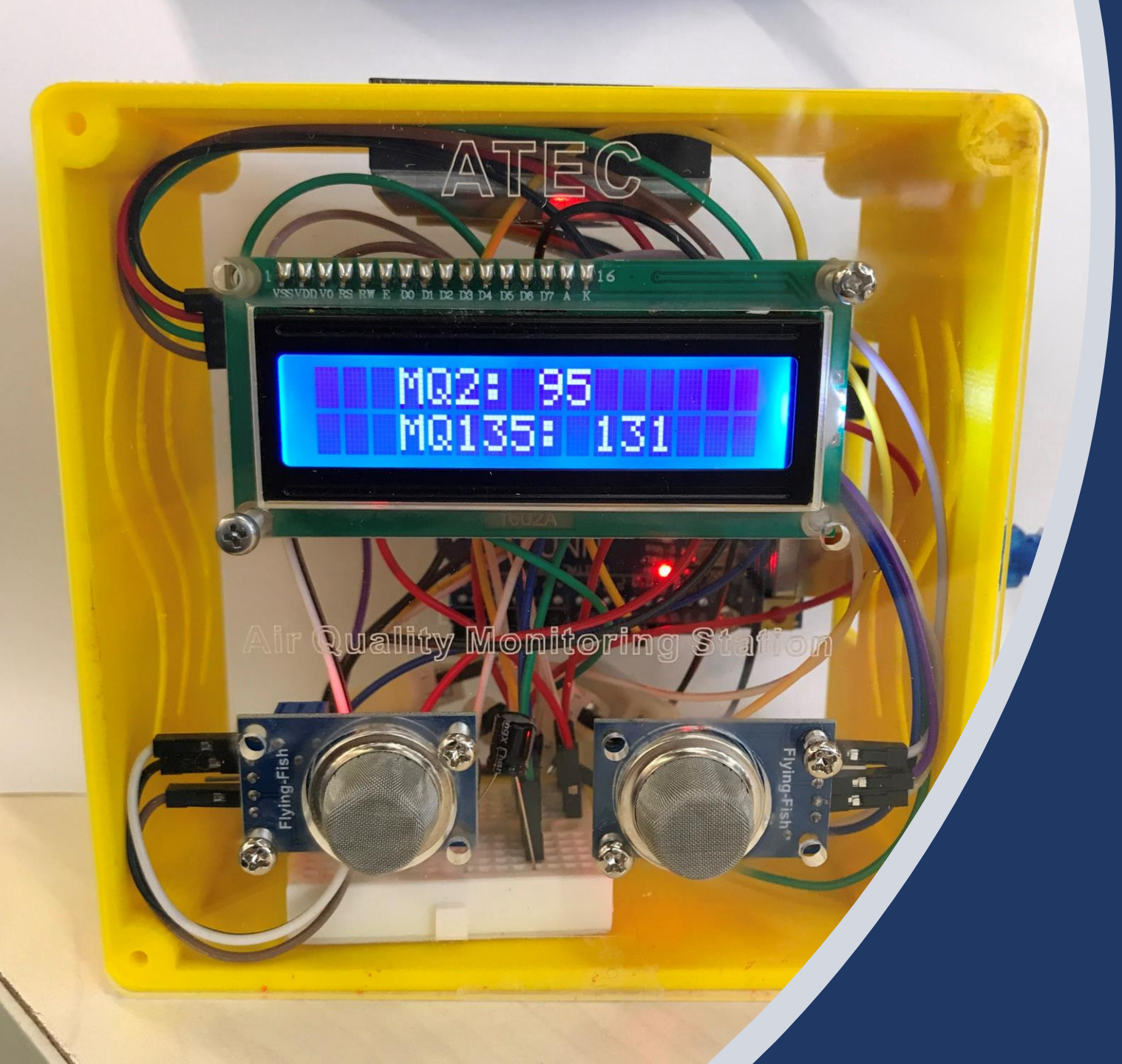
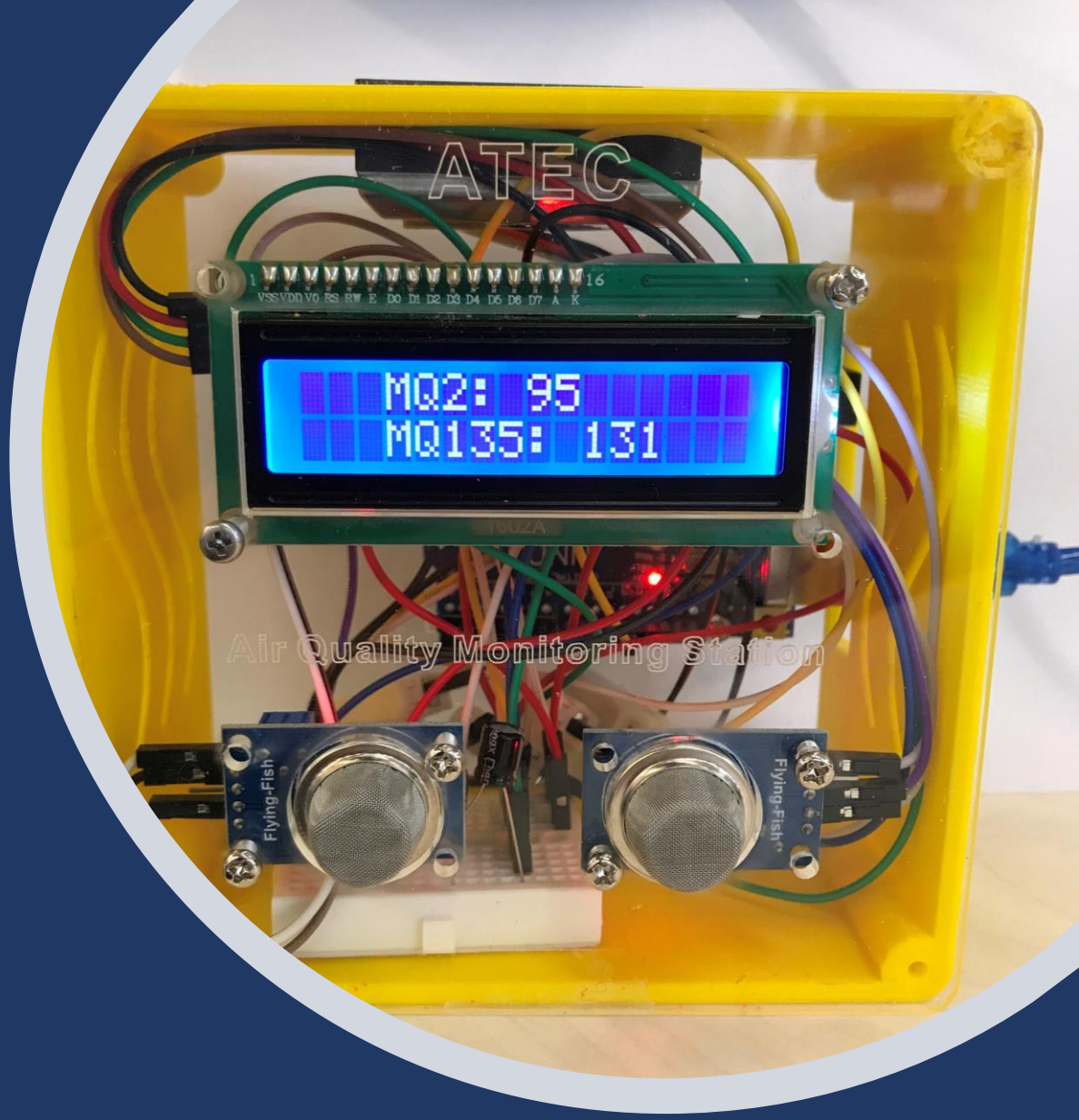


STEAM教育知識增益系列：「空氣質素監察儀」

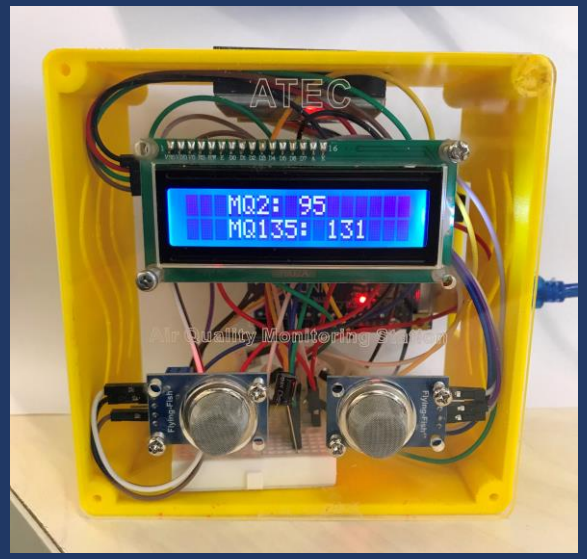
目標

- 利用Arduino，配合不同的氣體感測器，製作一個能夠監察室內空氣質素變化的儀器。
- 將傳感器量度到的指數即時顯示在LCD顯示屏中，以了解室內空氣質素變化的情況。
- 參加者可淺嘗另一功能設計較全面裝置的接駁及測試

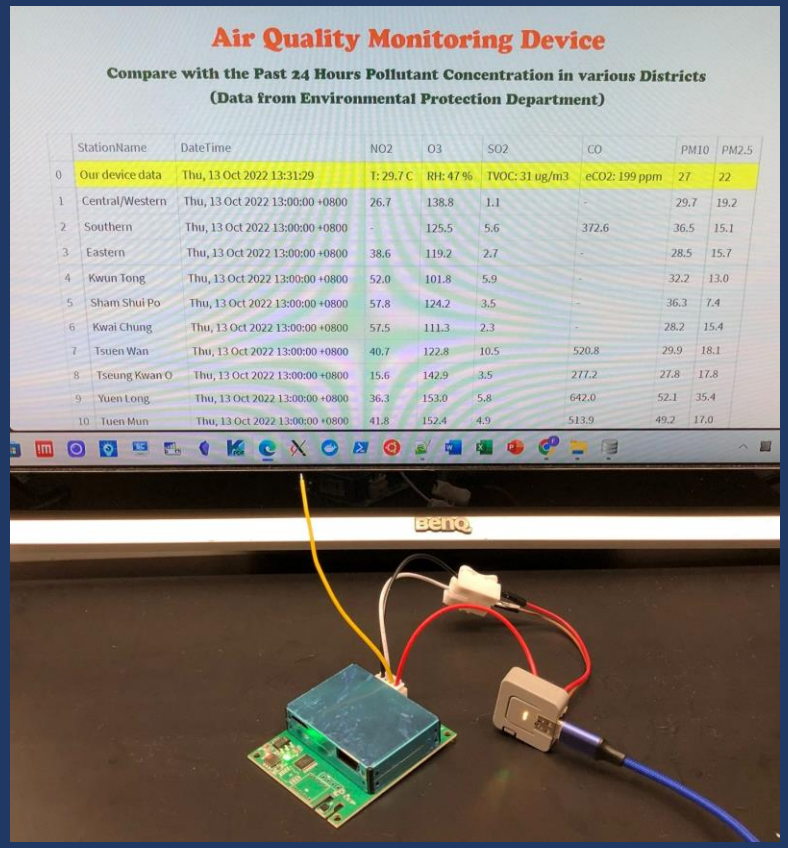


製作空氣質素監察裝置工作坊

參加者可於兩節工作坊中完成裝嵌以下監察裝置，當中包括電子元件與控制板的接線及裝置箱的繪製，並即場利用鐳射切割機製作自行設計的裝置箱面板。
(兩節均有出席的參加者可於第二節完結時取走此裝置)



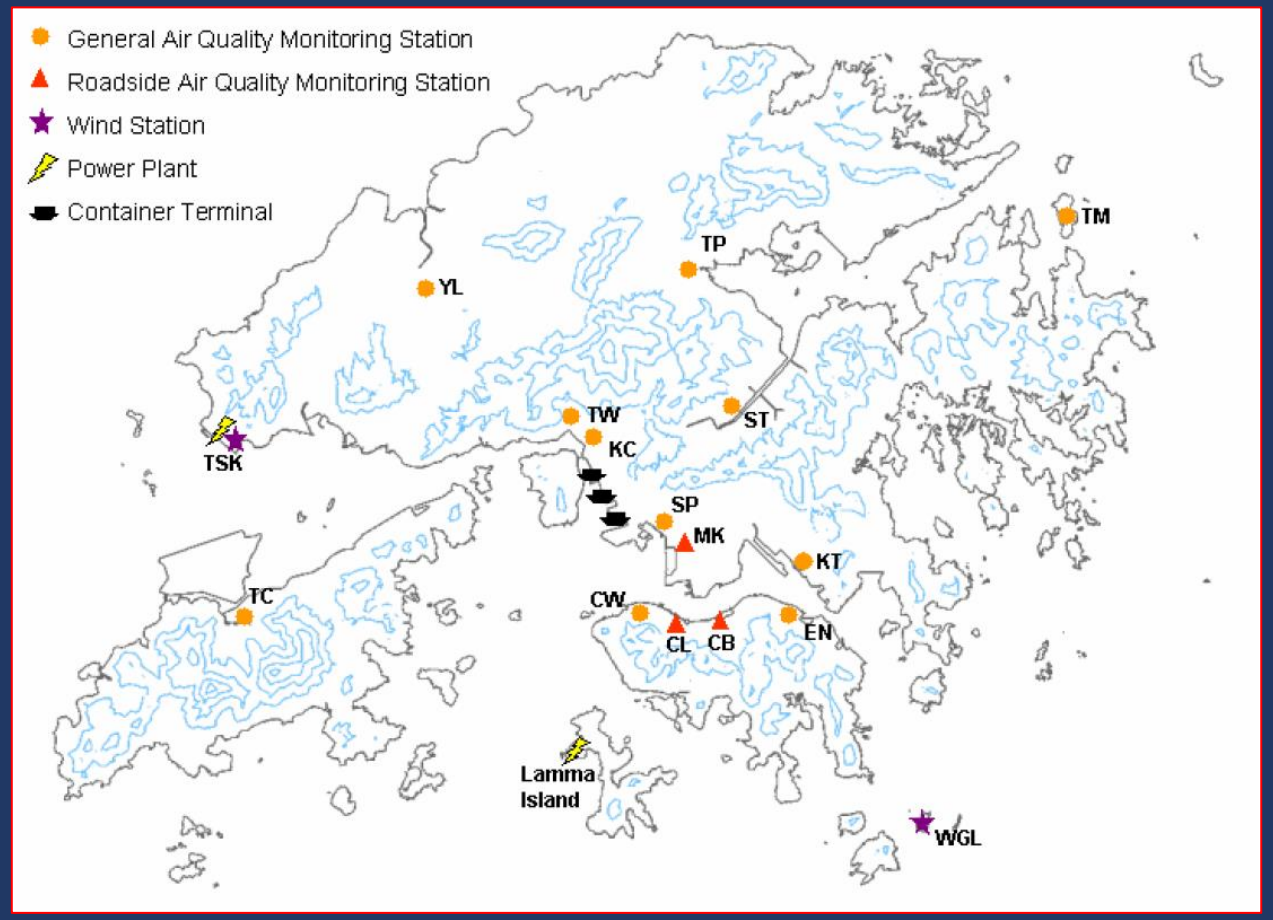
參加者亦可同時淺嘗另一功能設計較全面裝置的接駁及測試



	StationName	DateTime	NO2	O3	SO2	CO	PM10	PM2.5
0	Our device data	Thu, 13 Oct 2022 13:31:29	T: 29.7 C	RH: 47 %	TVOC: 31 ug/m3	eCO2: 199 ppm	27	22
1	Central/Western	Thu, 13 Oct 2022 13:00:00 +0800	26.7	138.8	1.1	-	29.7	19.2
2	Southern	Thu, 13 Oct 2022 13:00:00 +0800	-	125.5	5.6	372.6	36.5	15.1
3	Eastern	Thu, 13 Oct 2022 13:00:00 +0800	38.6	119.2	2.7	-	28.5	15.7
4	Kwun Tong	Thu, 13 Oct 2022 13:00:00 +0800	52.0	101.8	5.9	-	32.2	13.0
5	Sham Shui Po	Thu, 13 Oct 2022 13:00:00 +0800	57.8	124.2	3.5	-	36.3	7.4
6	Kwai Chung	Thu, 13 Oct 2022 13:00:00 +0800	57.5	111.3	2.3	-	28.2	15.4
7	Tsuen Wan	Thu, 13 Oct 2022 13:00:00 +0800	40.7	122.8	10.5	520.8	29.9	18.1
8	Tseung Kwan O	Thu, 13 Oct 2022 13:00:00 +0800	15.6	142.9	3.5	277.2	27.8	17.8
9	Yuen Long	Thu, 13 Oct 2022 13:00:00 +0800	36.3	153.0	5.8	642.0	52.1	35.4
10	Tuen Mun	Thu, 13 Oct 2022 13:00:00 +0800	41.8	152.4	4.9	513.9	49.2	17.0

室外空氣質素
(OUTDOOR AIR QUALITY)

- 空氣污染物包抱：
  - 二氧化硫（SO_2）
  - 氮氧化物（NOx）
  - 可吸入懸浮粒子（PM10）
  - 微細懸浮粒子（PM2.5）
  - 揮發性有機化合物（VOC）
  - 一氧化碳（CO）



室內空氣質素
(INDOOR AIR QUALITY)

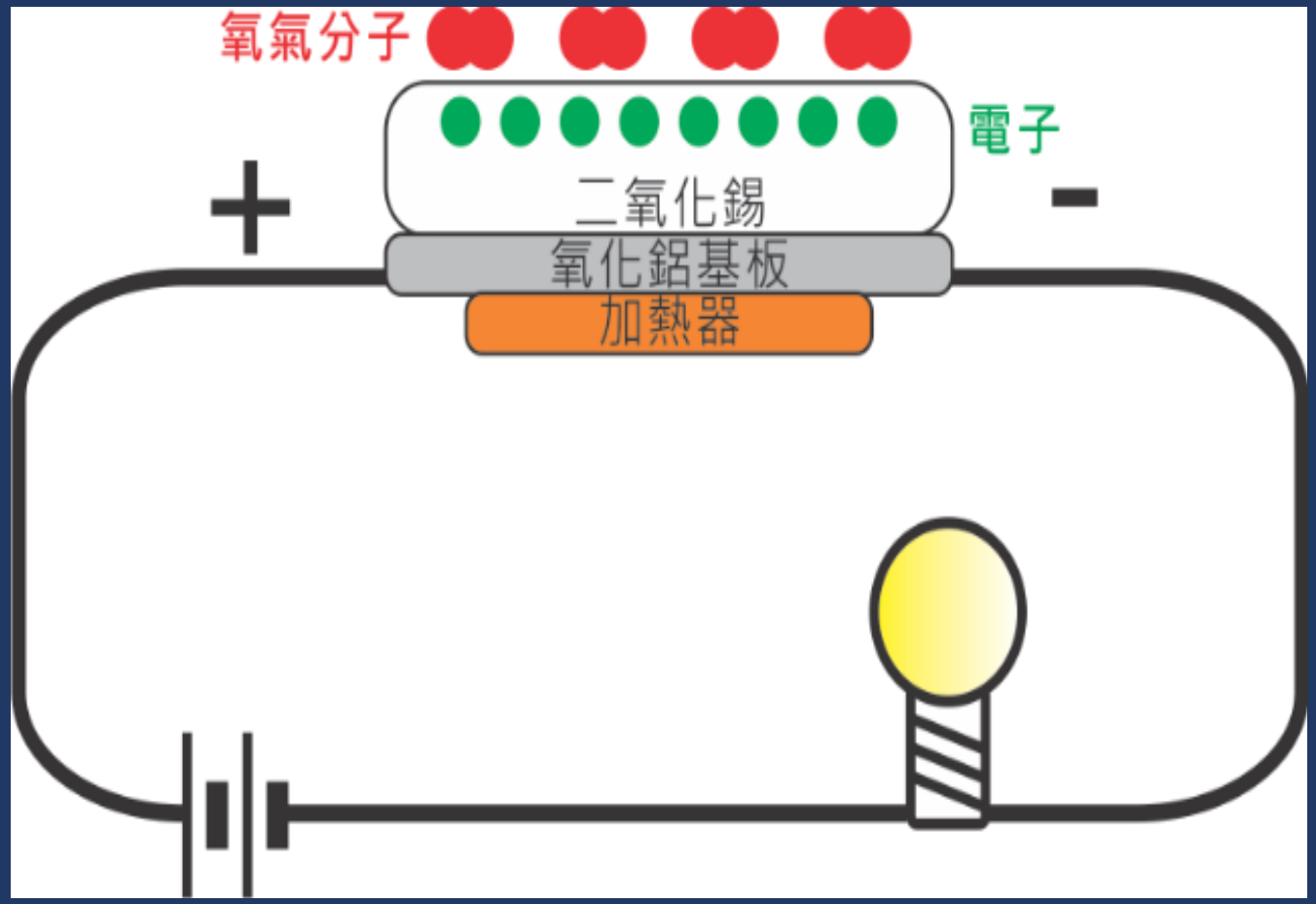
- 空氣污染物包括：
  - 二氧化碳
  - 生物污染物 包括細菌、真菌(霉菌)、過濾性病毒和塵蹣
  - 揮發性有機化合物 (VOC)
  - 甲醛
  - 室內燃燒煙草的煙霧（二手煙）:
  - 臭氧
  - 懸浮粒子

空氣質素監察裝置涉及的科學原理

1. 傳感器的應用原理
2. 模擬數碼轉換 ADC
   (Analog-to-digital conversion)

(1) 傳感器的構造原理

一般MQ系列傳感器結構圖及其使用電路圖：



(1) 傳感器的構造原理

- MQ系列的傳感器（MOS）表面，均有一薄層二氧化錫（tin dioxide, SnO_2）作為傳感材料，傳感材料是電子供體（electron donor），可吸附（adsorbed）氧氣分子
- 在「潔淨」的空氣中，例如沒有還原性氣體存在，傳感材料吸附氧氣分子，從而阻礙電路中電子自由流動（高電阻）

(1) 傳感器的構造原理

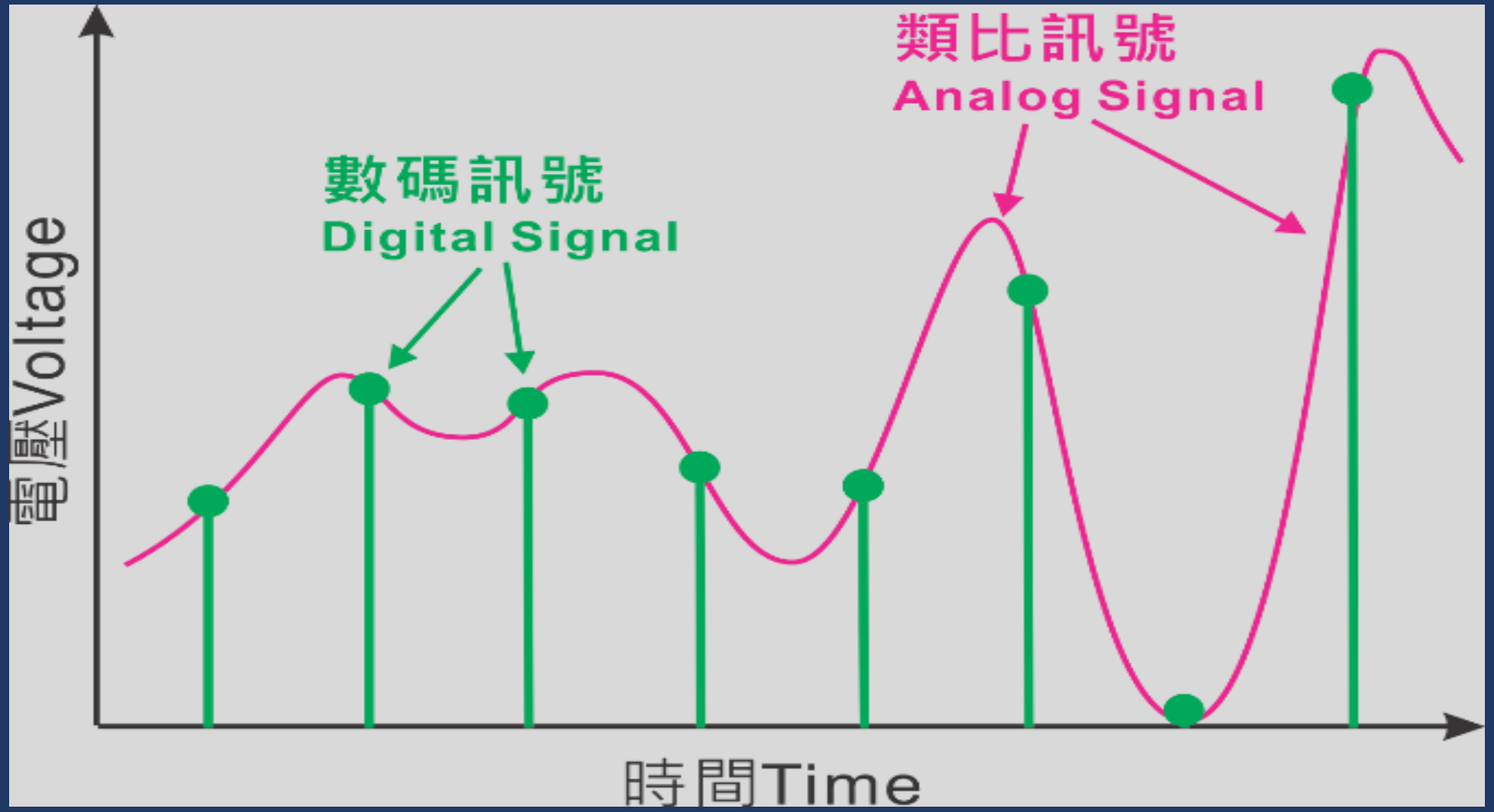
- 在有還原性氣體存在下，還原性氣體與氧進行反應，令吸附在傳感器表面氧氣濃度減少，電路中的電子可以自由流動（低電阻）
- 傳感器的電流大小是與檢測中還原性氣體的濃度成正比， Arduino 內的模擬數碼轉換器（ADC）的讀數亦然

(2) 模擬數碼轉換

- 模擬數碼轉換(ADC)是用於將模擬形式的連續訊號(Analog) 轉換為定時採樣數碼形式的離散訊號(Digital)的過程。
- 模擬數碼轉換器是常用的一類設備，可以進行ADC。

(2) 模擬數碼轉換

0 1 0 1 0 1 0 0 1 0

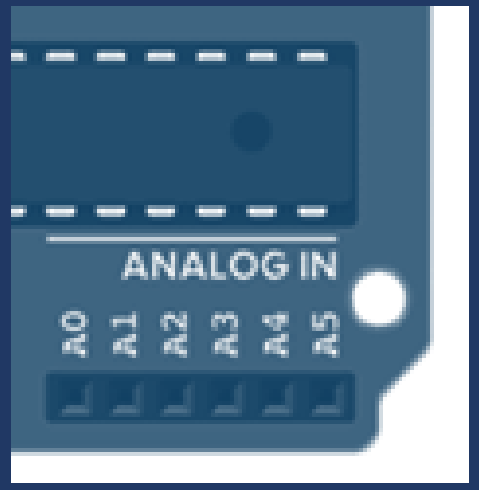

類比訊號
Analog Signal
數碼訊號
Digital Signal
電壓Voltage
時間Time

(2) 模擬數碼轉換

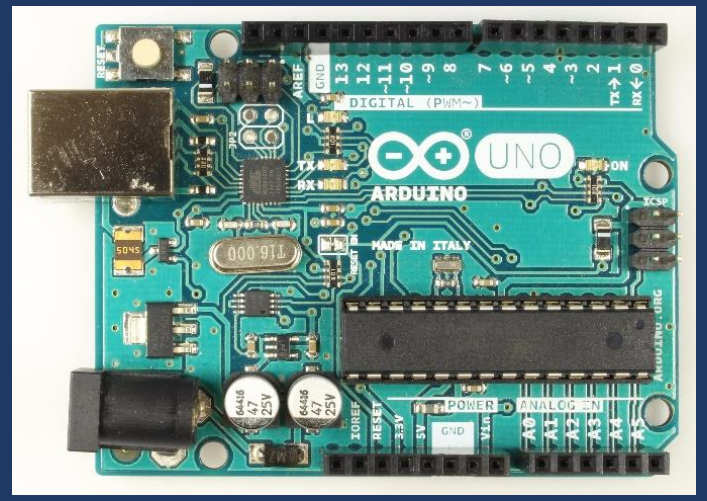
- 例如一個以5V操作的Arduino系統，使用A0（10 bit）進行模擬數碼轉換：
  1. 若量度電壓=3.9V，會產生數碼訊號 $3.9 \div 5 \times 1023 = 798$
  2. 若量度電壓=2.5V，會產生數碼訊號 512

(2) 模擬數碼轉換

- Arduino: 具有多個模擬數碼轉換器，可以提供把電壓模擬訊號轉為轉換為表示一定比例電壓值的數碼訊號
- 可用來量度如某氣體濃度或某液體溫度等不同物理數據。



電子元件



Arduino Uno 電子板

Dupont Line
杜邦線

輸入元件

MQ2 & MQ135

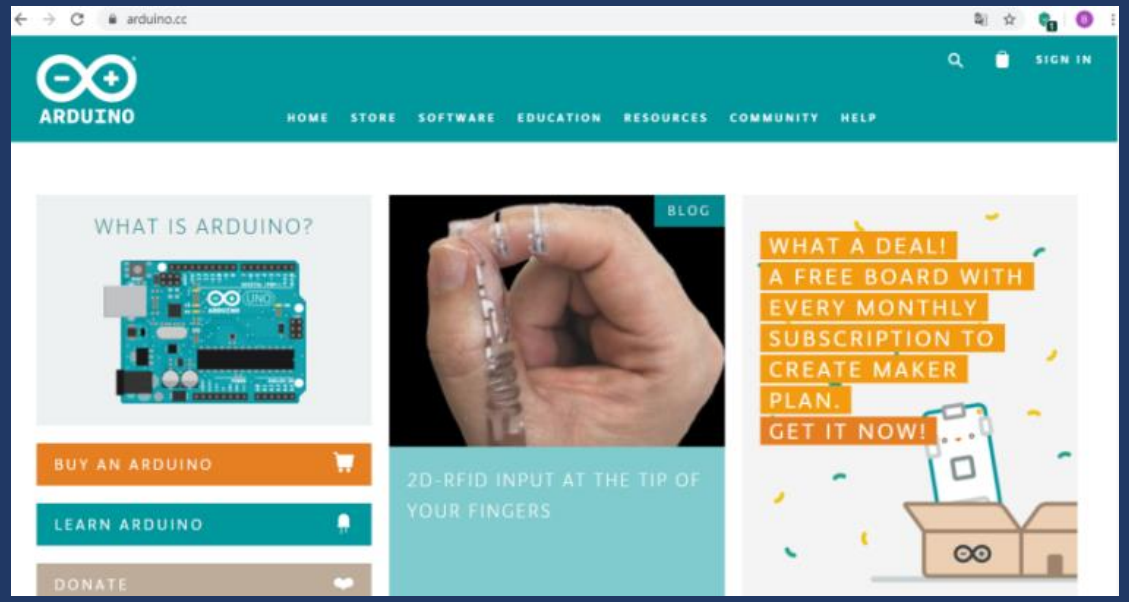
灰塵傳感器

輸出元件

I²C 1602
液晶屏幕

Arduino 簡介

- Arduino 是一塊包含多個輸入及輸出 (I/O) 接口的開源控制板。
- 透過Arduino IDE編寫程式，並將程式上載到控制板中，從而製作出不同的專題習作和互動裝置。

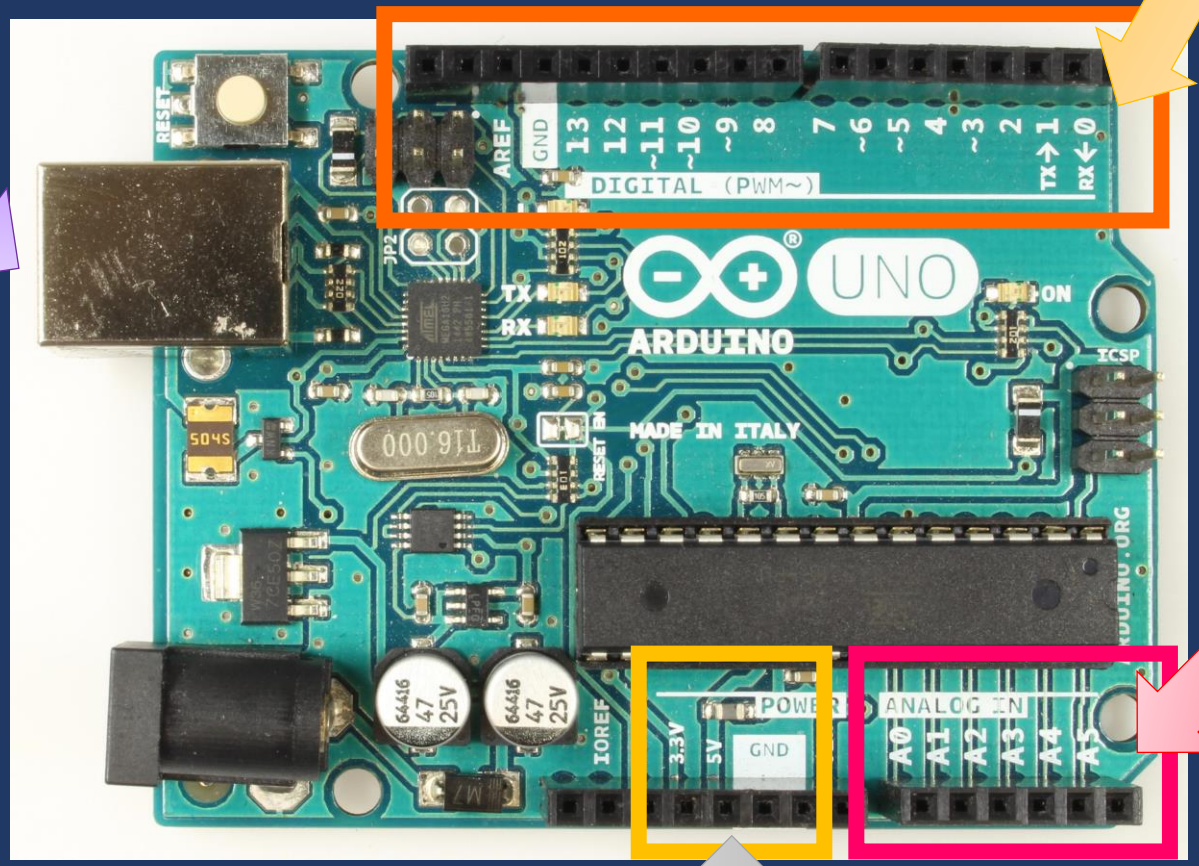


Arduino 簡介

數位輸入、輸出腳位

數位訊號
0或1

USB連接埠



類比輸入腳位

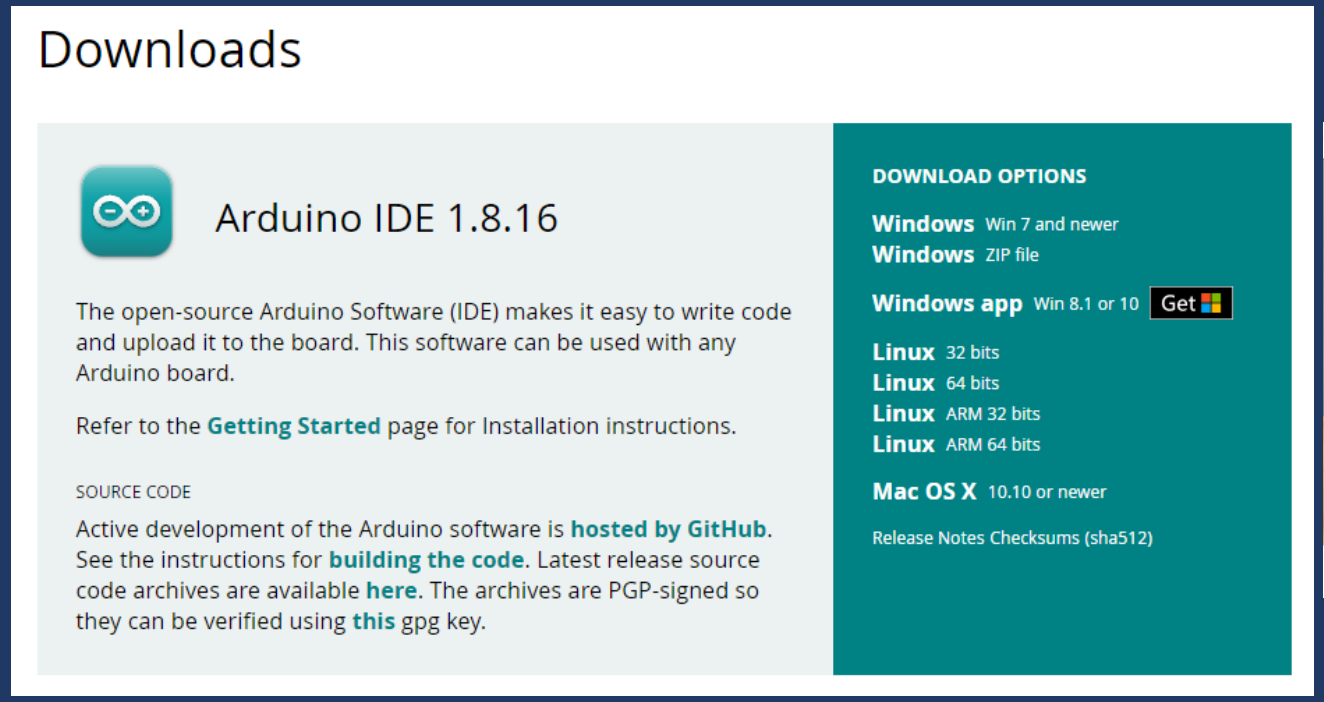
類比訊號
0至1023

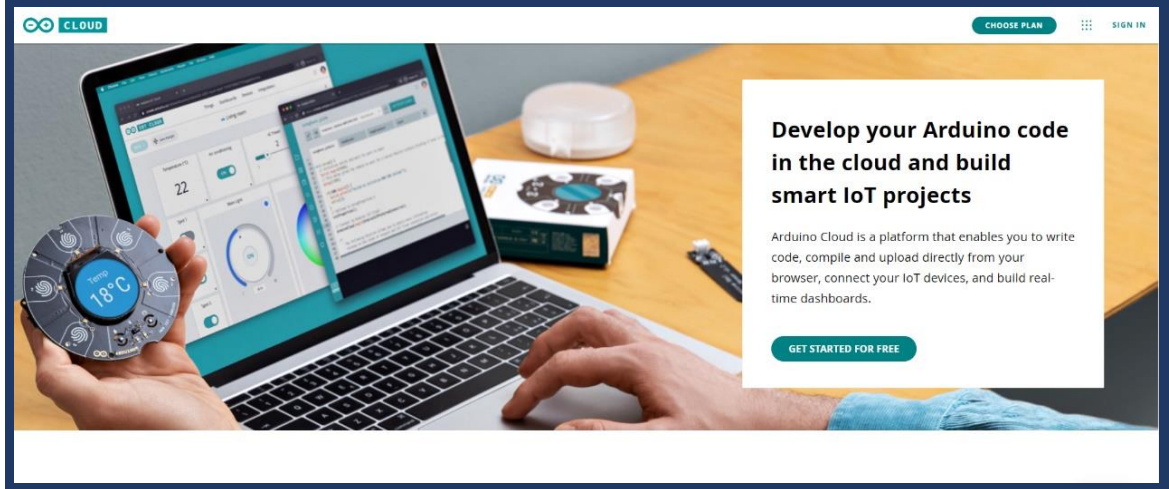
3.3V, 5V, GND

Arduino 編程

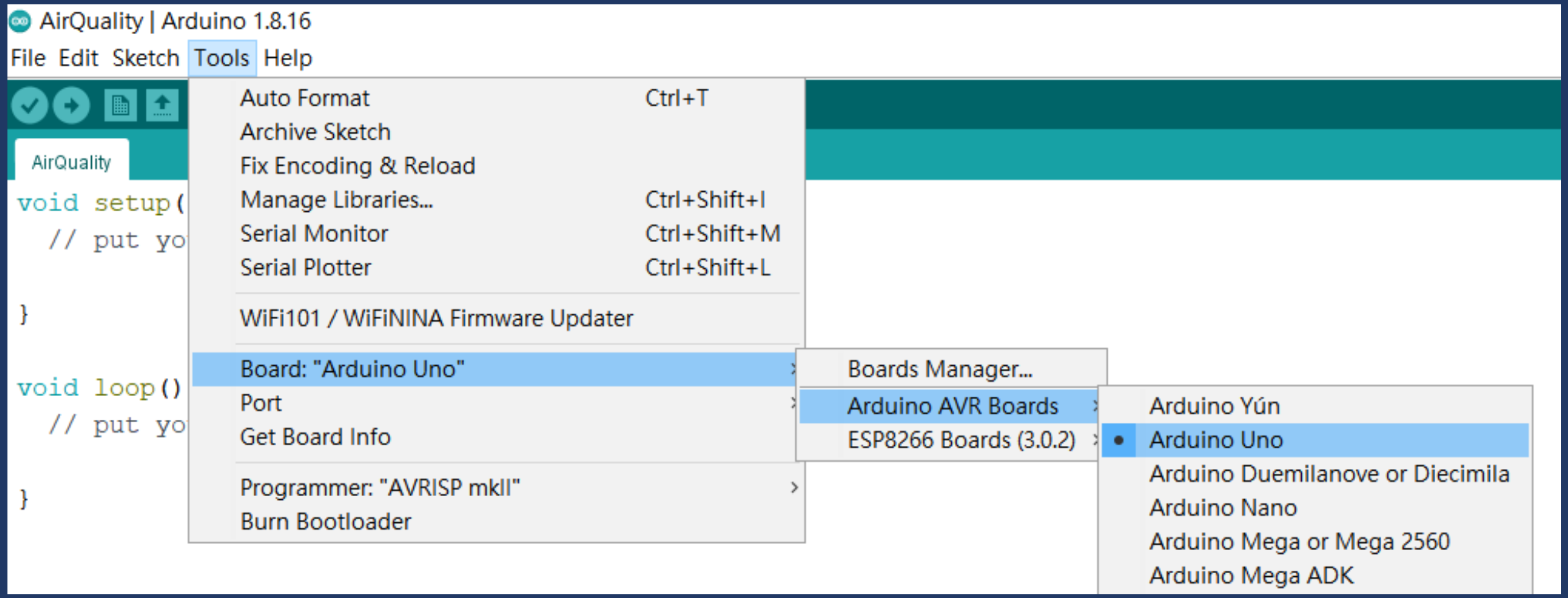
- 安裝Arduino 開發工具軟體IDE

https://www.arduino.cc/en/software

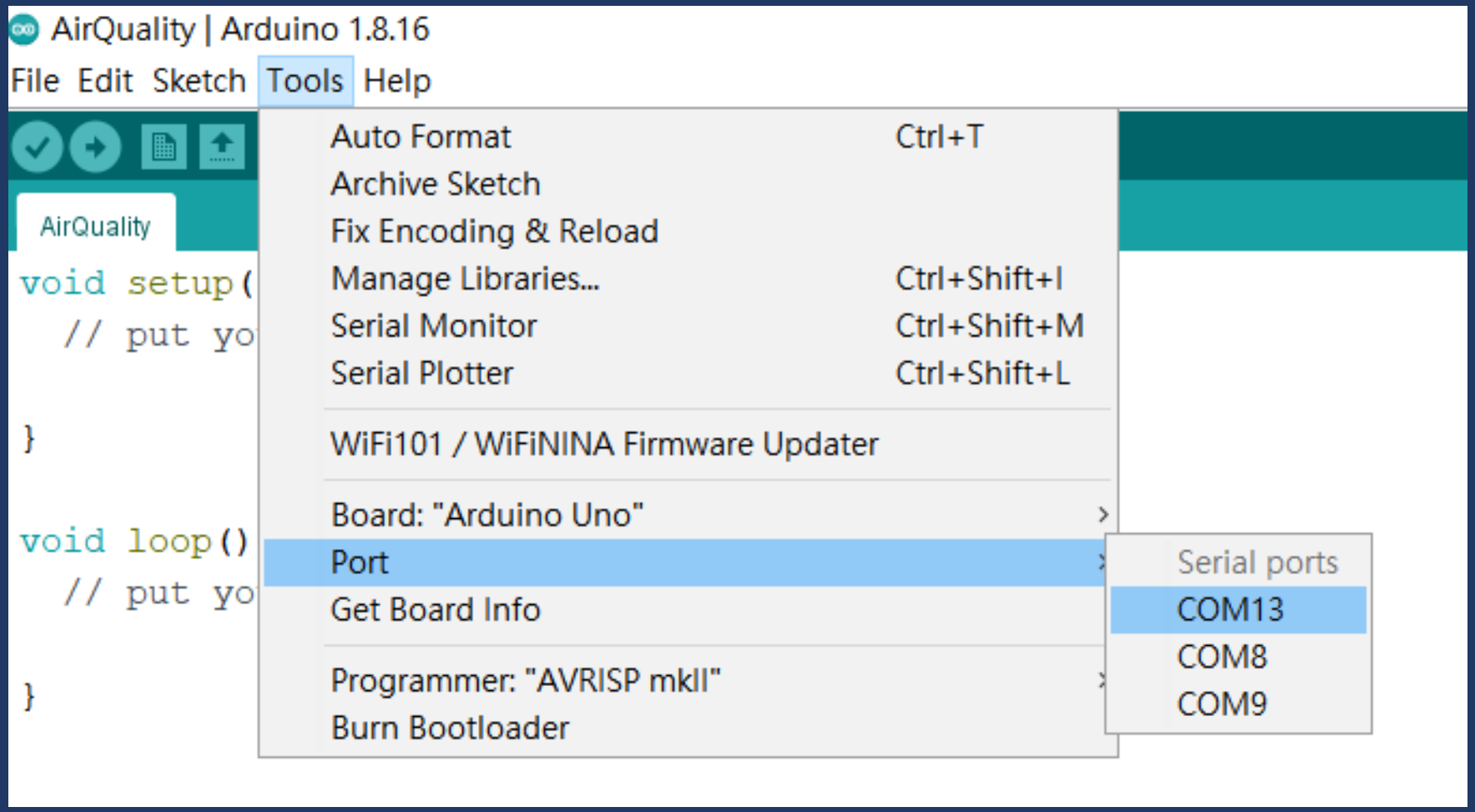




Arduino 編程


AirQuality | Arduino 1.8.16
File Edit Sketch Tools Help
AirQuality
void setup(
// put yo
}
void loop()
// put yo
}
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Manage Libraries... Ctrl+Shift+I
Serial Monitor Ctrl+Shift+M
Serial Plotter Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
Board: "Arduino Uno"
Port
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
Boards Manager...
Arduino AVR Boards
ESP8266 Boards (3.0.2)
Arduino Yún
Arduino Uno
Arduino Duemilanove or Diecimila
Arduino Nano
Arduino Mega or Mega 2560
Arduino Mega ADK

Arduino 編程


AirQuality | Arduino 1.8.16
File Edit Sketch Tools Help
AirQuality
void setup(
// put yo
}
void loop()
// put yo
}
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Manage Libraries... Ctrl+Shift+I
Serial Monitor Ctrl+Shift+M
Serial Plotter Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
Board: "Arduino Uno"
Port
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
Serial ports
COM13
COM8
COM9

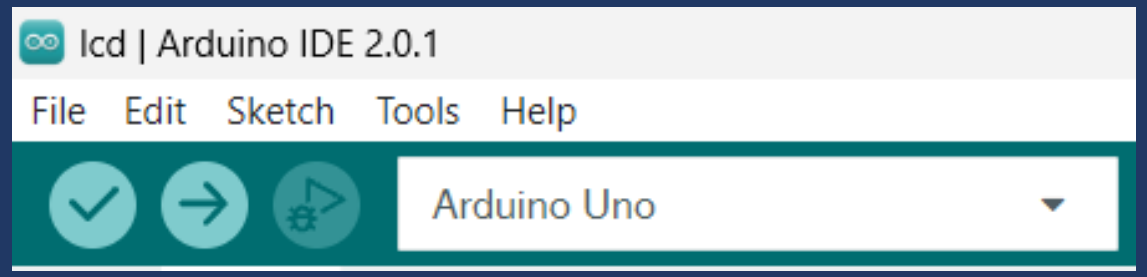
Arduino 編程

```
void setup() {
  // put your setup code here, to run once:

}
```

```
void loop() {
  // put your main code here, to run repeatedly:

}
```

setup() {
內裡指令只會執行一次
}

loop() {
內裡指令會無限循環
}



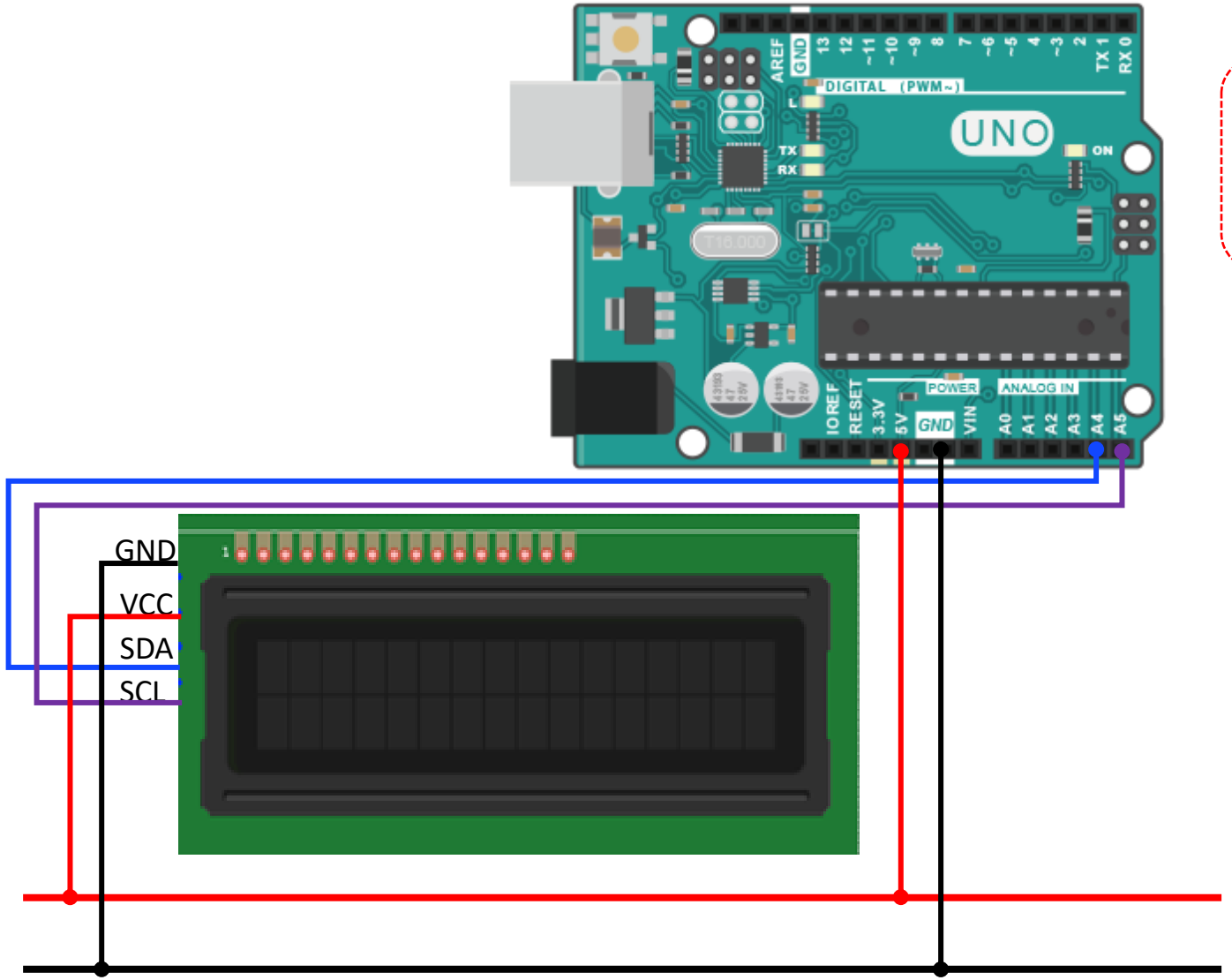
檢查程式是否有誤

將程式上載至Arduino板

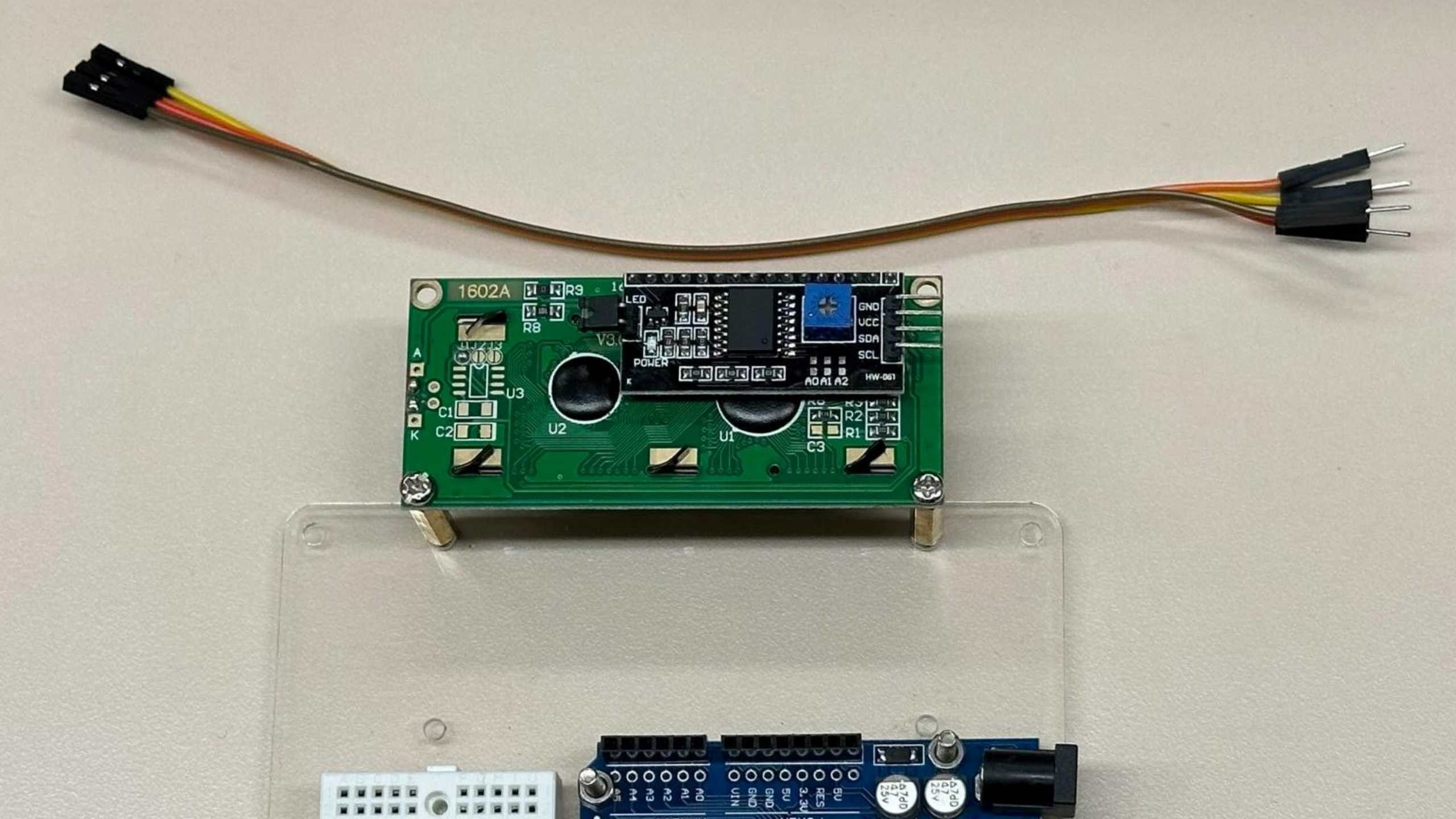
I²C 1602 液晶屏幕

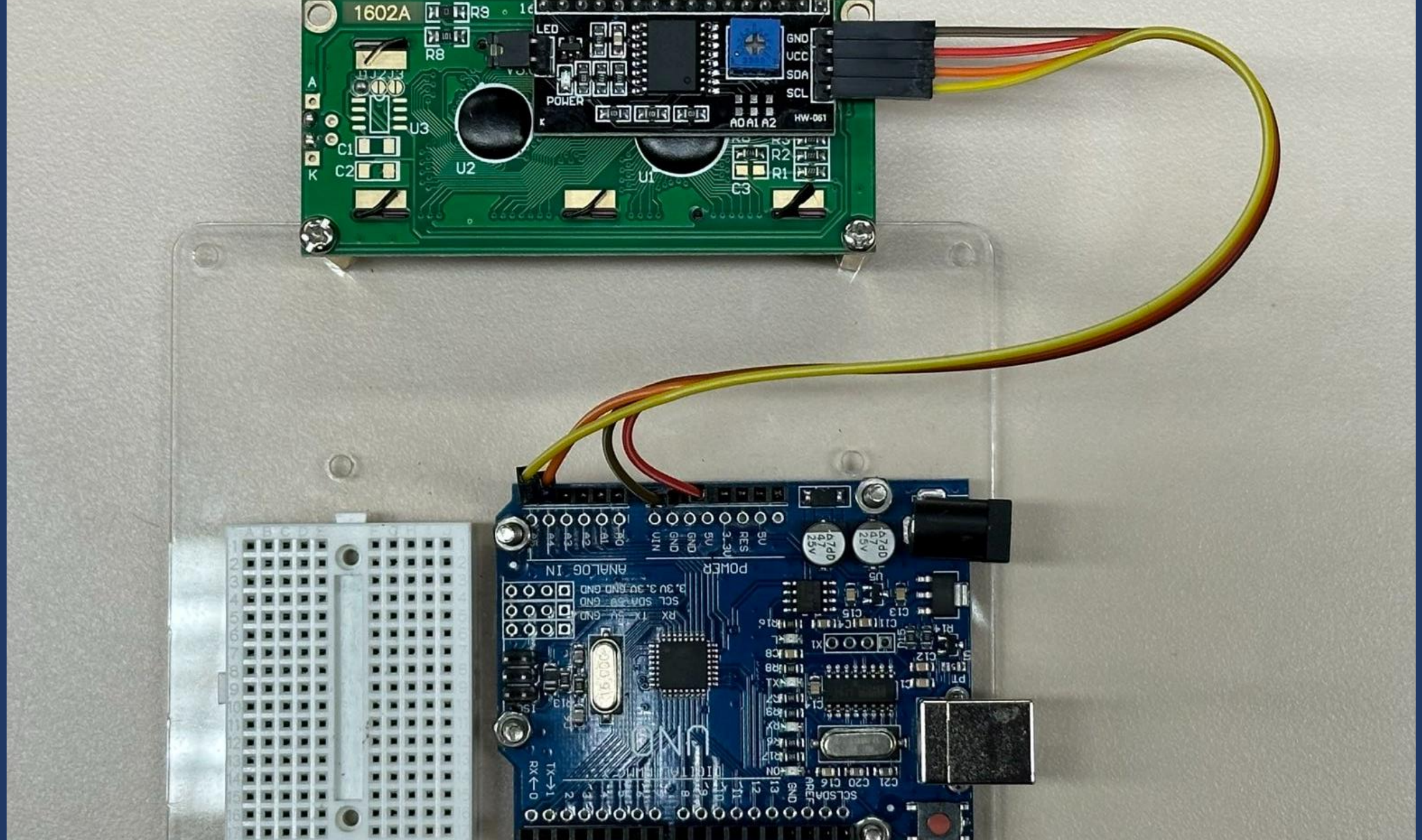
- I²C：Inter-Integrated Circuit，讓微控制器以較少的接腳數連接多個低速週邊裝置
- 資料線SDA（Serial Data Line）及時脈線SCL（ Serial Clock Line ）需要接駁
- 1602：在液晶屏幕中，最多可以顯示兩行，每行16個字符。

I²C 1602 液晶屏幕與Arduino 板的連接



- SDA → analog pin 4 (A4)
- SCL → analog pin 5 (A5)
- VCC → 5V
- GND → GND


1602A
R9
R8
LED
POWER
GND
VCC
SDA
SCL
A0 A1 A2
HW-061
U3
C1
C2
U2
U1
R2
R1
C3
A
K


1602A
R9
R8
LED
POWER
GND
VCC
SDA
SCL
A0 A1 A2
HW-061
A
K
U3
C1
C2
U2
U1
R2
R1
C3
ANALOG IN
POWER
5V
RES
3.3V
5V
GND
GND
VIN
A5
A4
A3
A2
A1
A0
3.3V 3.3V GND GND
SCL SDA 5V GND
RX TX 5V GND
15,000
TX→1
RX←0
DIGITAL (PWM~)
13
12
11
10
9
8
7
6
5
4
3
2
GND
AREF
SCL SDA
C21 C20 C16
ON
L
TX
RX
C13
C15
C12
U5
R14
PT
C1
C14
X1
C11
C4
R16
C8
R8
R9
R7
R6
R5
R4
R3
R2
R1
7dP
47
25v

I²C 1602 液晶屏幕：顯示ATEC

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

void setup()
{
  lcd.init();
  lcd.backlight();
  lcd.setCursor(3,0);
  lcd.print("ATEC");
  delay(3000);
  lcd.clear();
}
```

- 將編碼複製至Arduino IDE中。
- 上載至Arduino板內。

0x3F

I²C 1602 液晶屏幕：顯示走動字串

```
void loop()
{
  for (int i= 0; i < 17; i++) {
  lcd.setCursor(i,0);
  lcd.print("HELLO");
  delay(500);
  lcd.clear();
  }
}
```

- 將編碼複製至loop()中。
- 上載至Arduino板內。

MQ傳感器

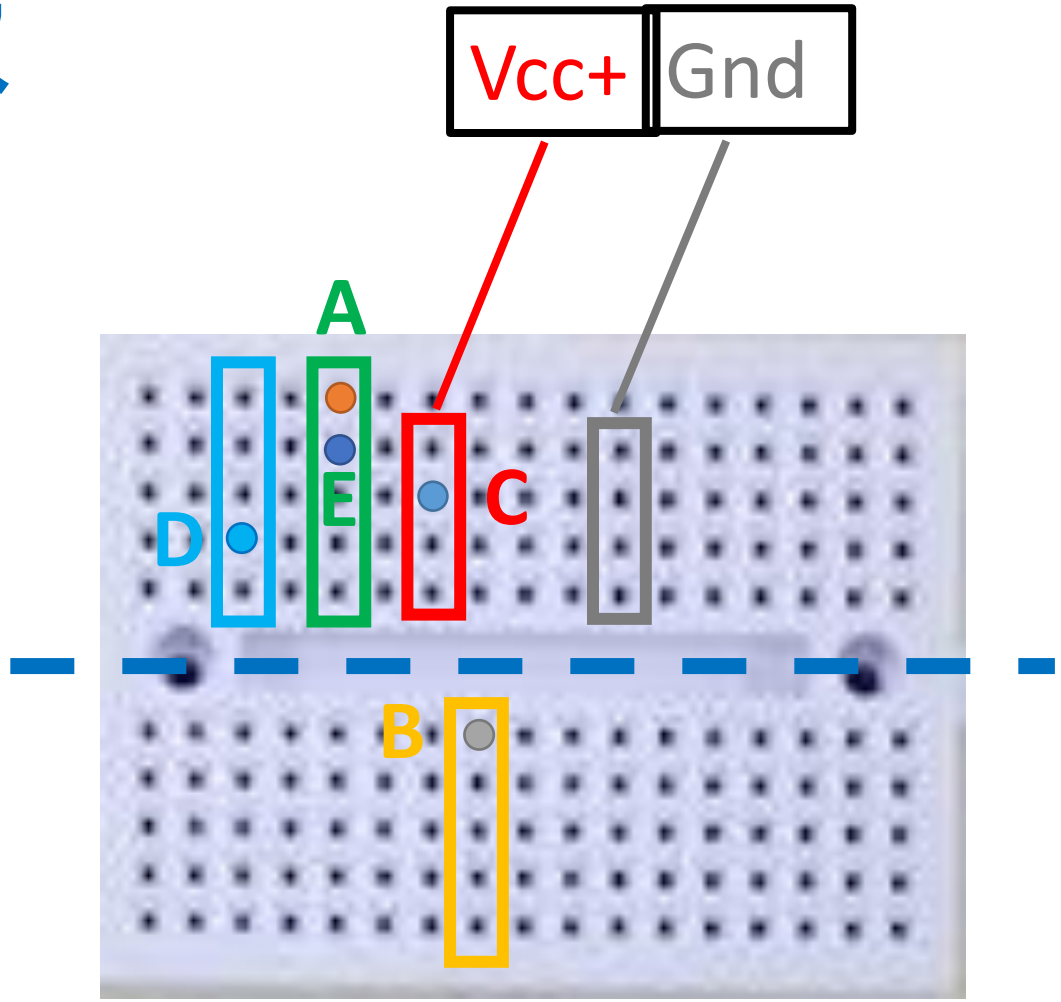
- MQ-2 煙霧(甲烷/液化氣/可燃氣體)
- MQ-3 酒精乙醇
- MQ-4 天然氣/甲烷
- MQ-5 液化氣/天然氣/城市煤氣
- MQ-6 丙烷 / 丁烷 / 液化氣
- MQ-7 一氧化碳
- MQ-8 氫氣
- MQ-9 一氧化碳可燃氣體
- MQ-135 空氣質量/有害氣體

MQ傳感器

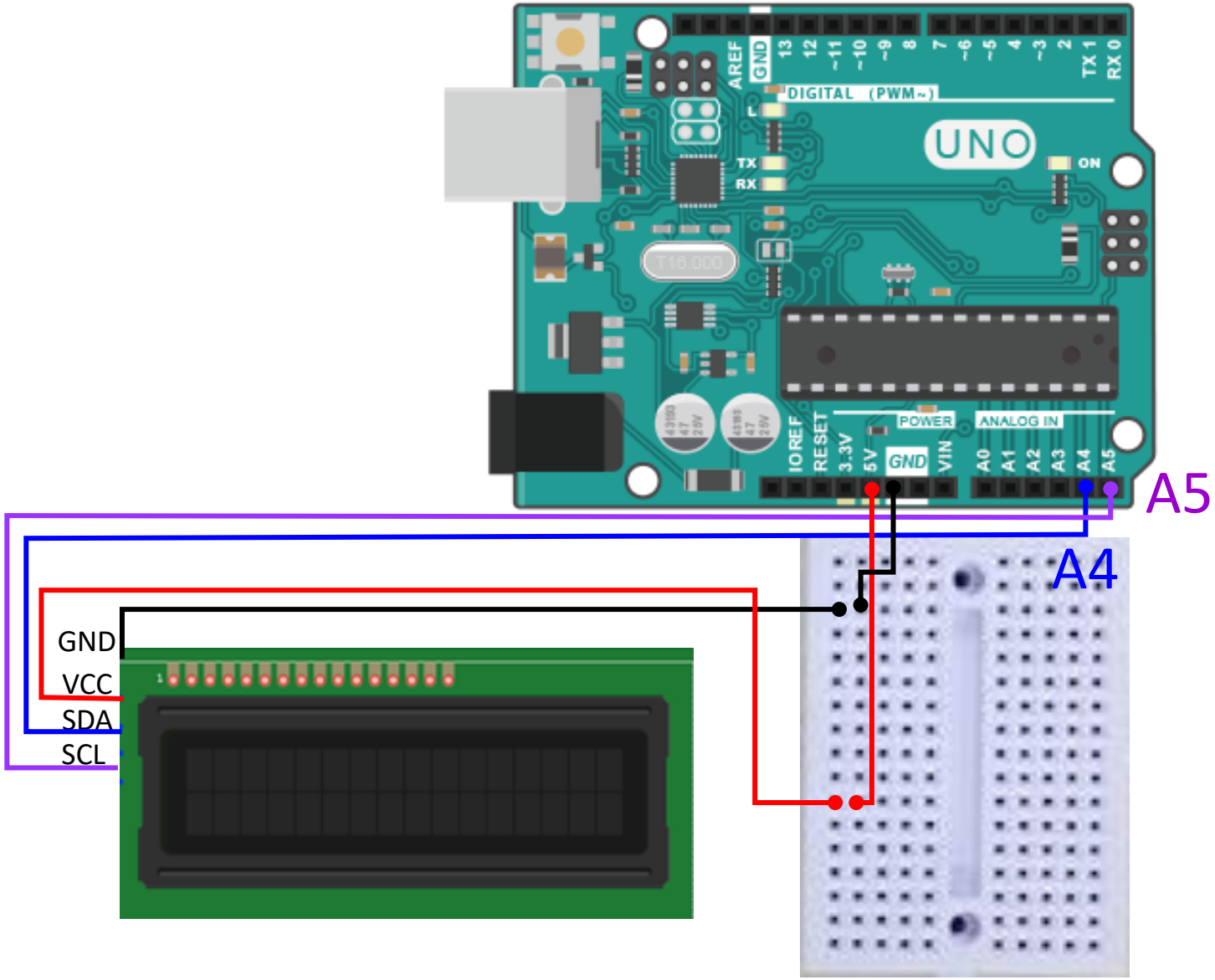
- MQ-2 煙霧氣敏傳感器
(甲烷/液化氣/可燃氣體)

- MQ-135 空氣質量傳感器
(空氣質量/有害氣體)

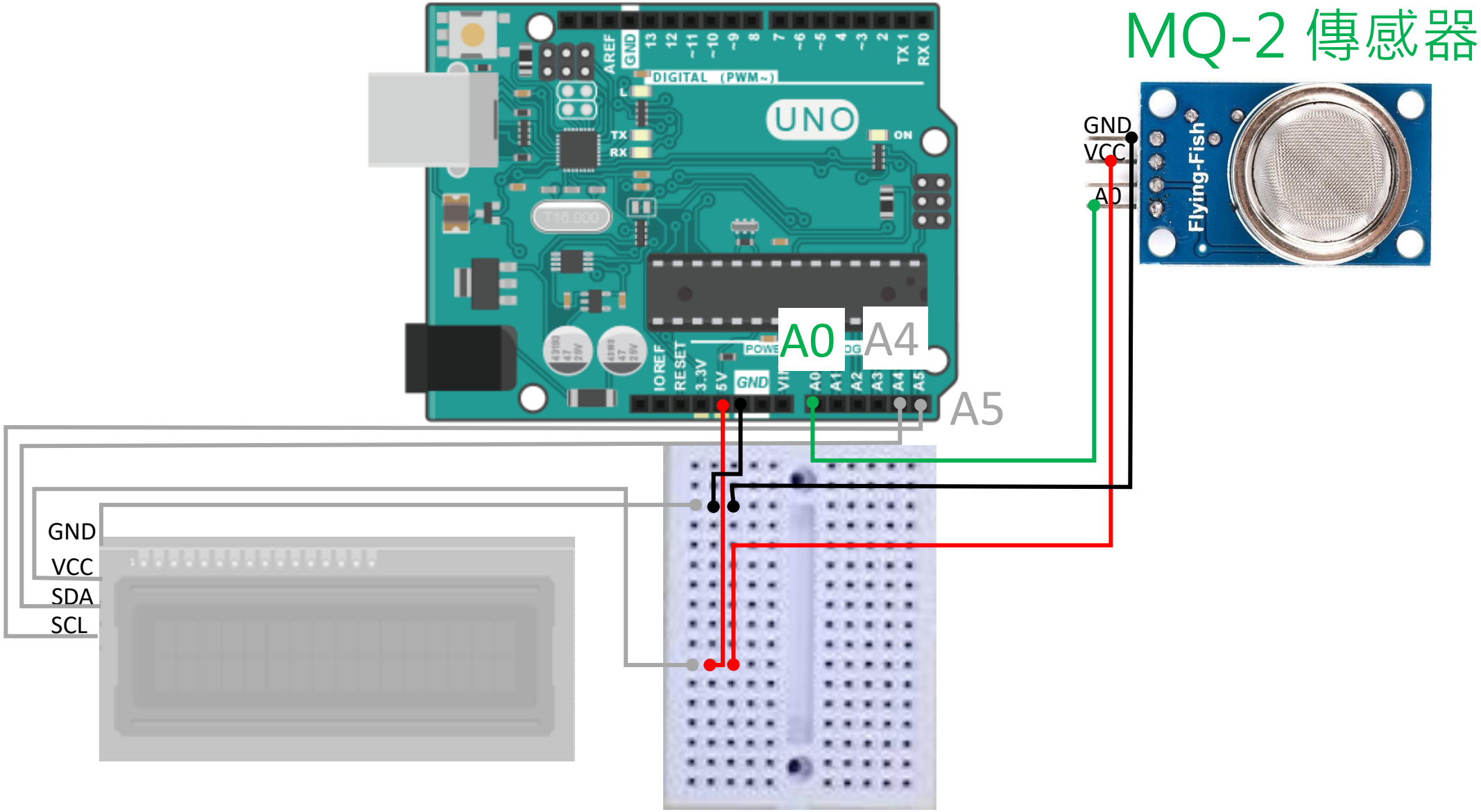
麵包板



I2C 1602 液晶屏幕：



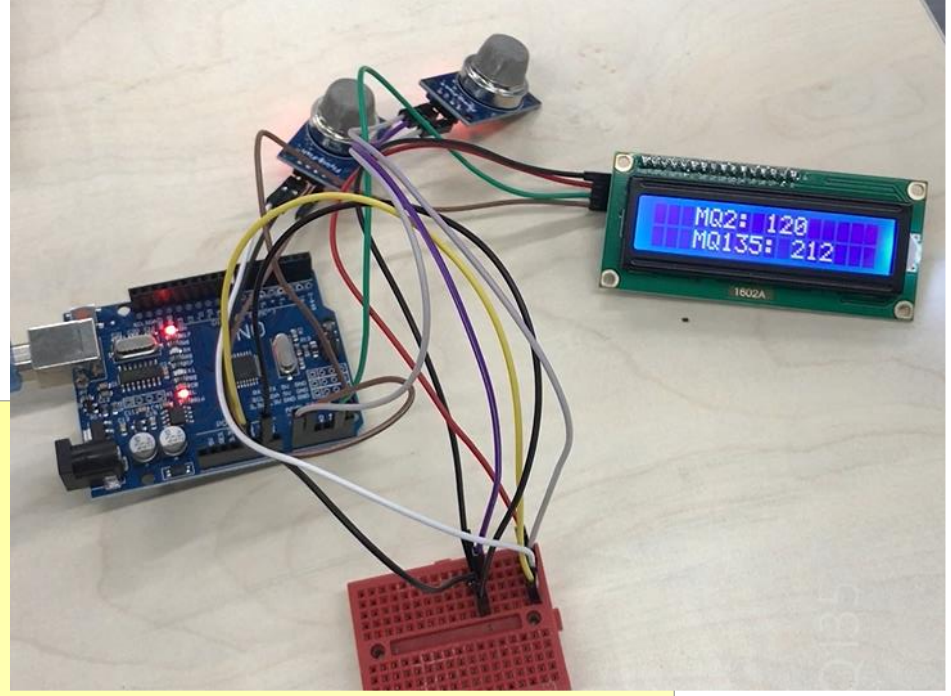
MQ-2傳感器


MQ-2 傳感器
GND
VCC
A0
Flying-Fish
UNO
DIGITAL (PWM~)
A0
A4
A5
GND
VCC
SDA
SCL

MQ-2傳感器

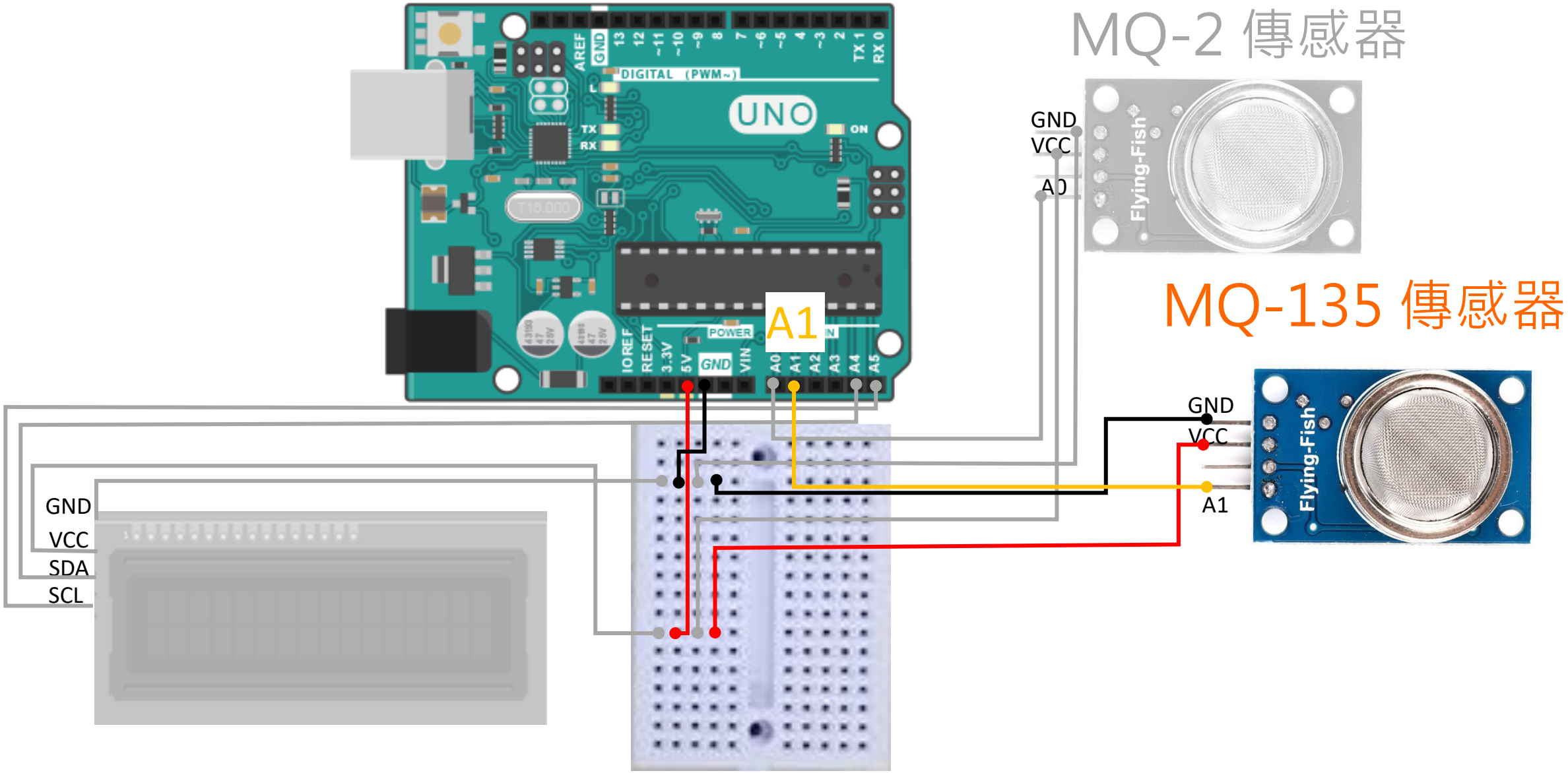
```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

int MQ2Pin = A0;

void setup()
{
  lcd.init();
  lcd.backlight();
  lcd.setCursor(2,0);
  lcd.print(“STEM Edu Ctr");
  delay(3000);
  lcd.clear();
}
```

MQ-2傳感器




```
void loop()
{
  int data_MQ2 = analogRead(MQ2Pin);
  lcd.setCursor(3,0);
  lcd.print("MQ2: ");
  lcd.print(data_MQ2);
  delay(3000);
}
```

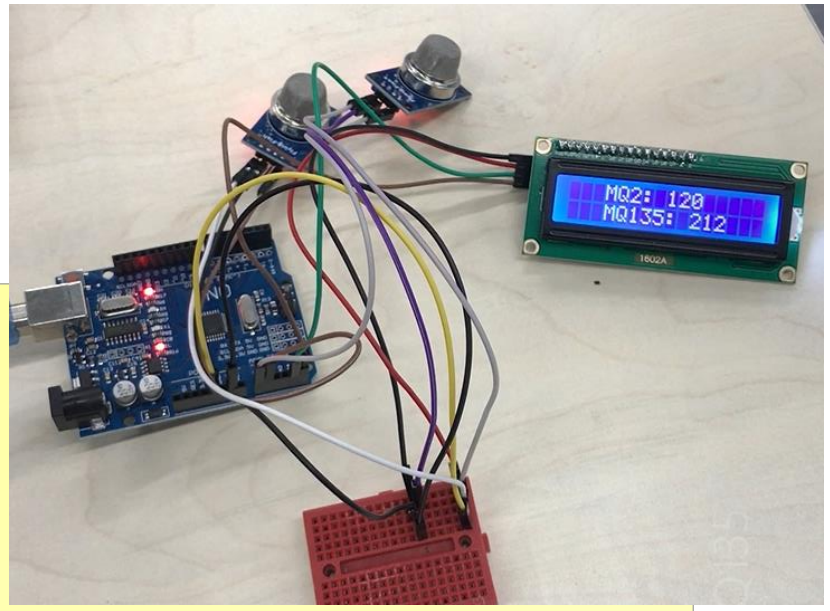
MQ-135傳感器


MQ-2 傳感器
GND
VCC
A0
Flying-Fish
MQ-135 傳感器
GND
VCC
A1
Flying-Fish
A1
UNO
DIGITAL (PWM~)
POWER
GND
GND
VCC
SDA
SCL

MQ-135傳感器

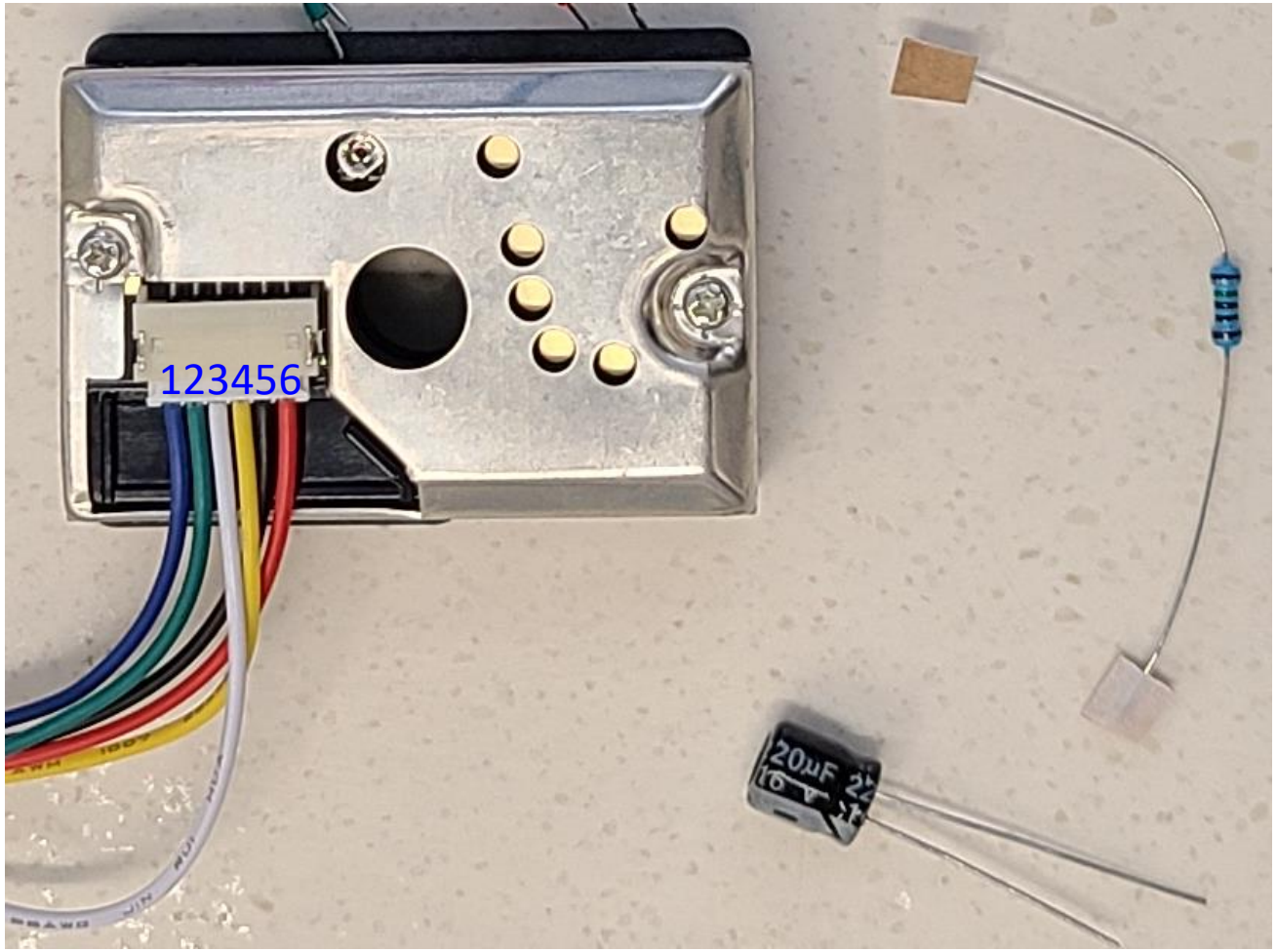
```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

int MQ2Pin = A0;        // add MQ2 sensor pin
int MQ135Pin = A1;

void setup()
{
  lcd.init();
  lcd.backlight();
  lcd.setCursor(2,0);
  lcd.print(“STEM Edu Ctr");
  delay(3000);
  lcd.clear();
}
```

MQ-135傳感器

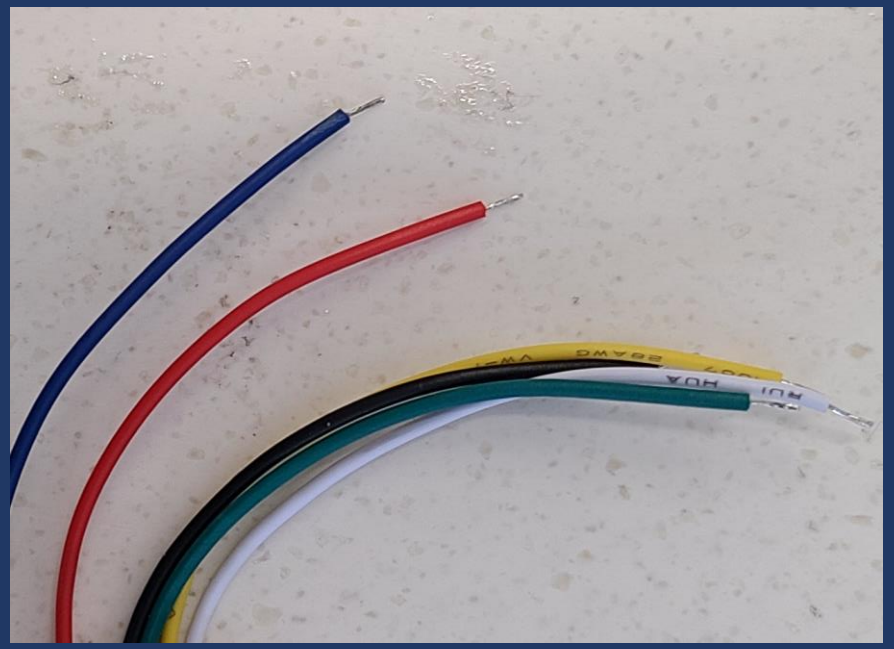


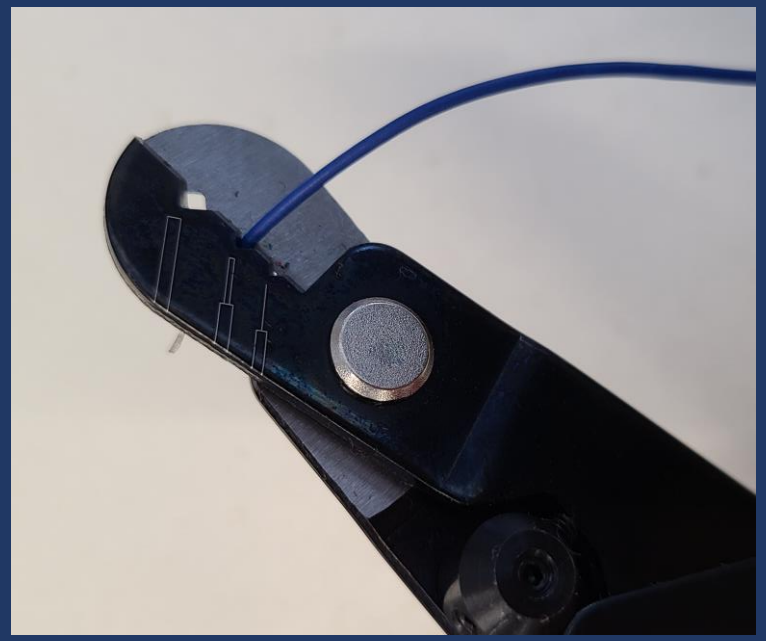

```
void loop()
{
  int data_MQ2 = analogRead(MQ2Pin);
  int data_MQ135 = analogRead(MQ135Pin);
  lcd.setCursor(3,0);
  lcd.print("MQ2: ");
  lcd.print(data_MQ2);
  lcd.setCursor(3,1);
  lcd.print("MQ135: ");
  lcd.print(data_MQ135);
  delay(3000);
}
```

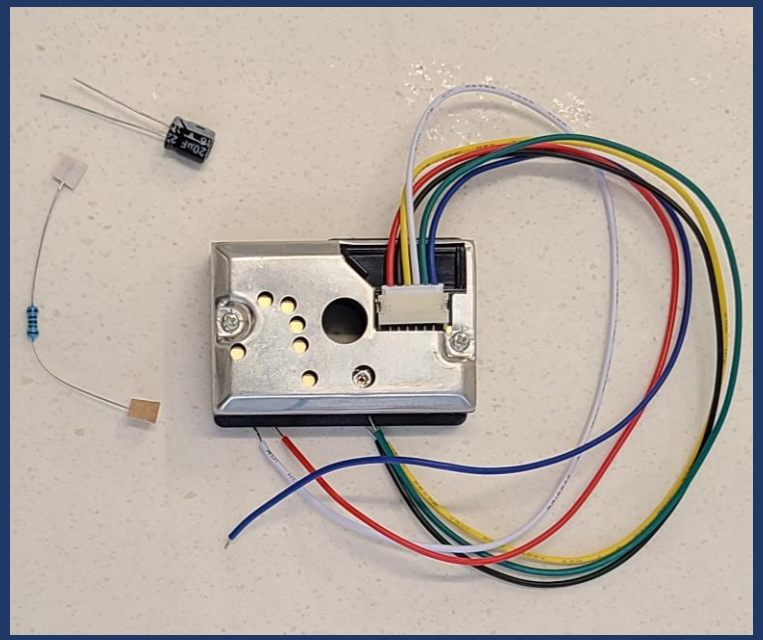
灰塵傳感器

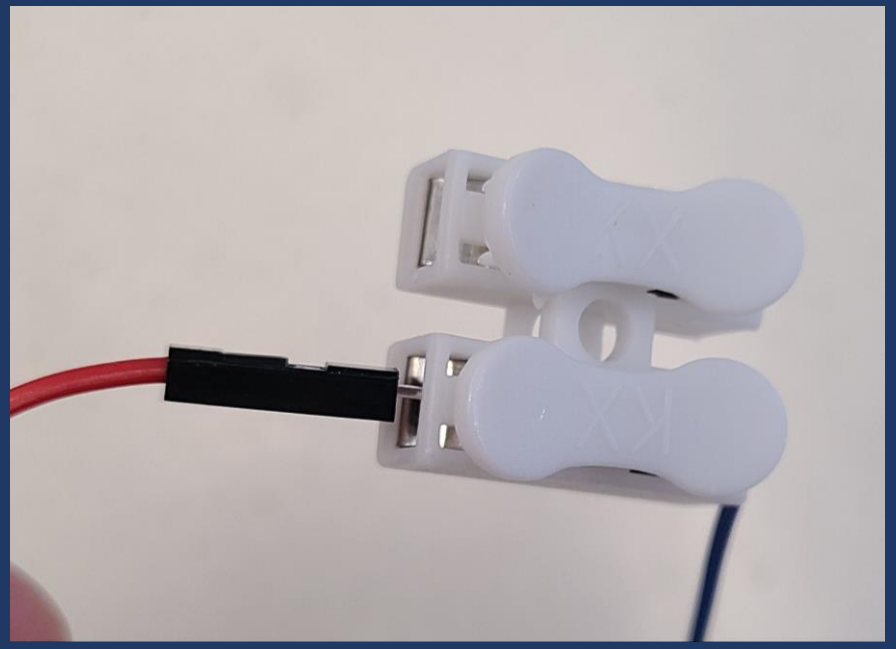


1. Pin 1 (V-LED) -> 5V
   串聯1個150歐姆的電阻
   最好在電阻一側和GND之間再串聯一個220uf 的電容
2. Pin 2 (LED-GND) -> GND
3. Pin 3 (LED) -> Arduino PIN 7 (開關LED)
4. Pin 4 (S-GND) -> GND
5. Pin 5 (V2) -> Arduino A2 pin
   空氣質量數據通過電壓模擬信號輸出
6. Pin 6 (Vcc) => 5V



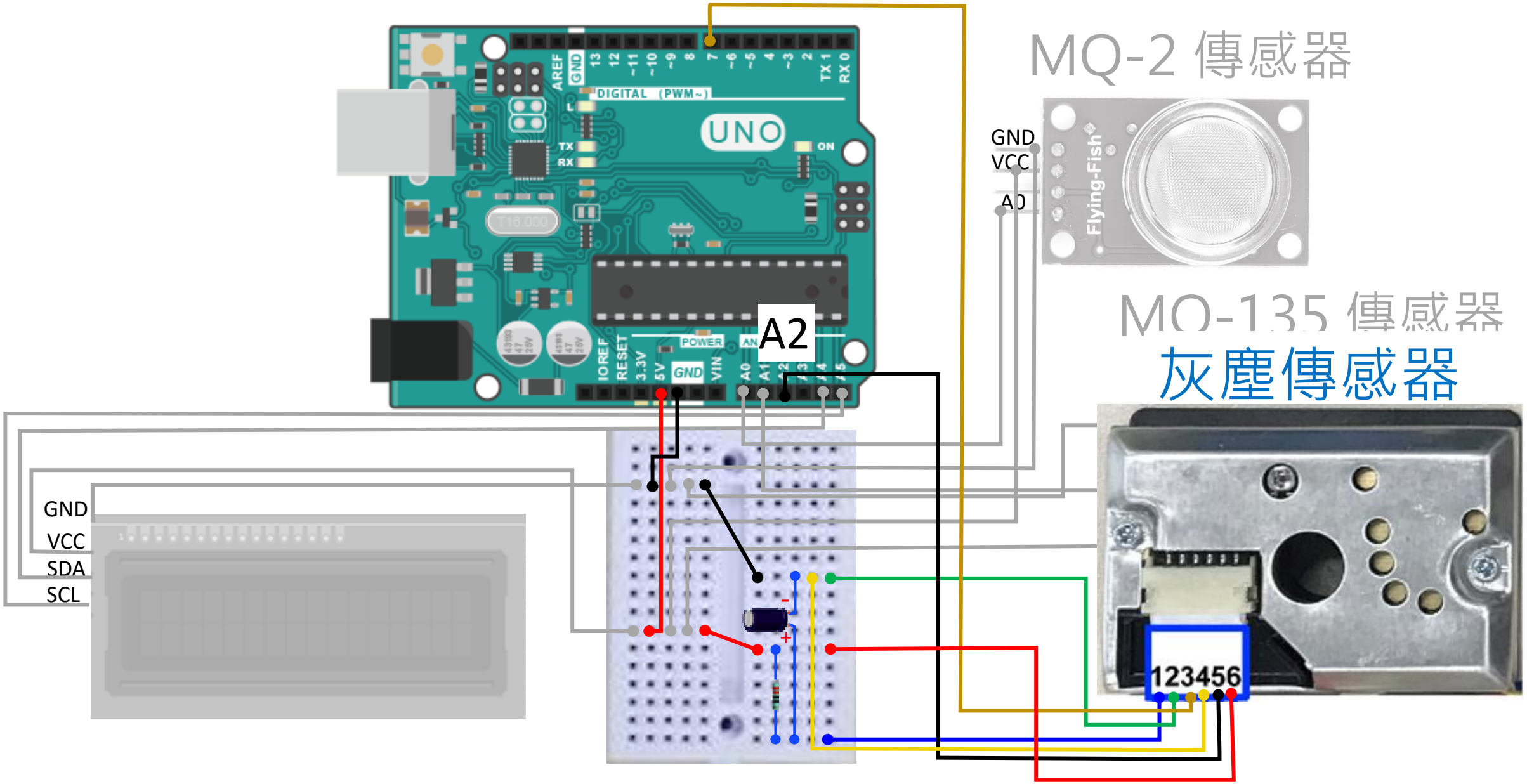






灰塵傳感器

灰塵傳感器


MQ-2 傳感器
GND
VCC
A0
Flying-Fish
MQ-135 傳感器
灰塵傳感器
A2
UNO
DIGITAL (PWM~)
POWER
ANALOG IN
GND
VCC
SDA
SCL
123456

灰塵傳感器

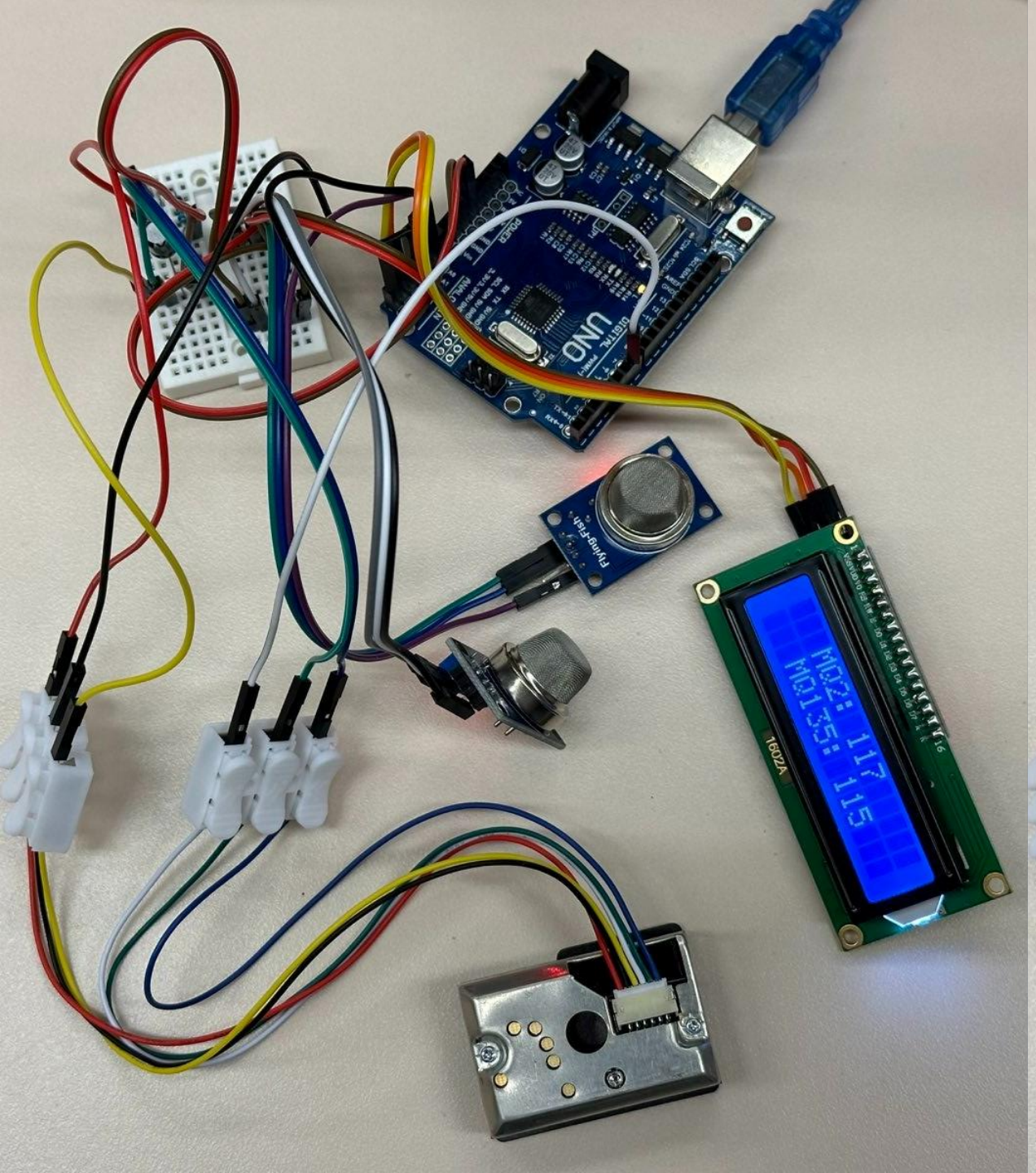
```
int MQ2Pin = A0;
int MQ135Pin = A1;

int dustPin=A2;
int dustVal=0;
int delayTime=280;
int delayTime2=40;
float offTime=9680;
int ledPower=7;
```

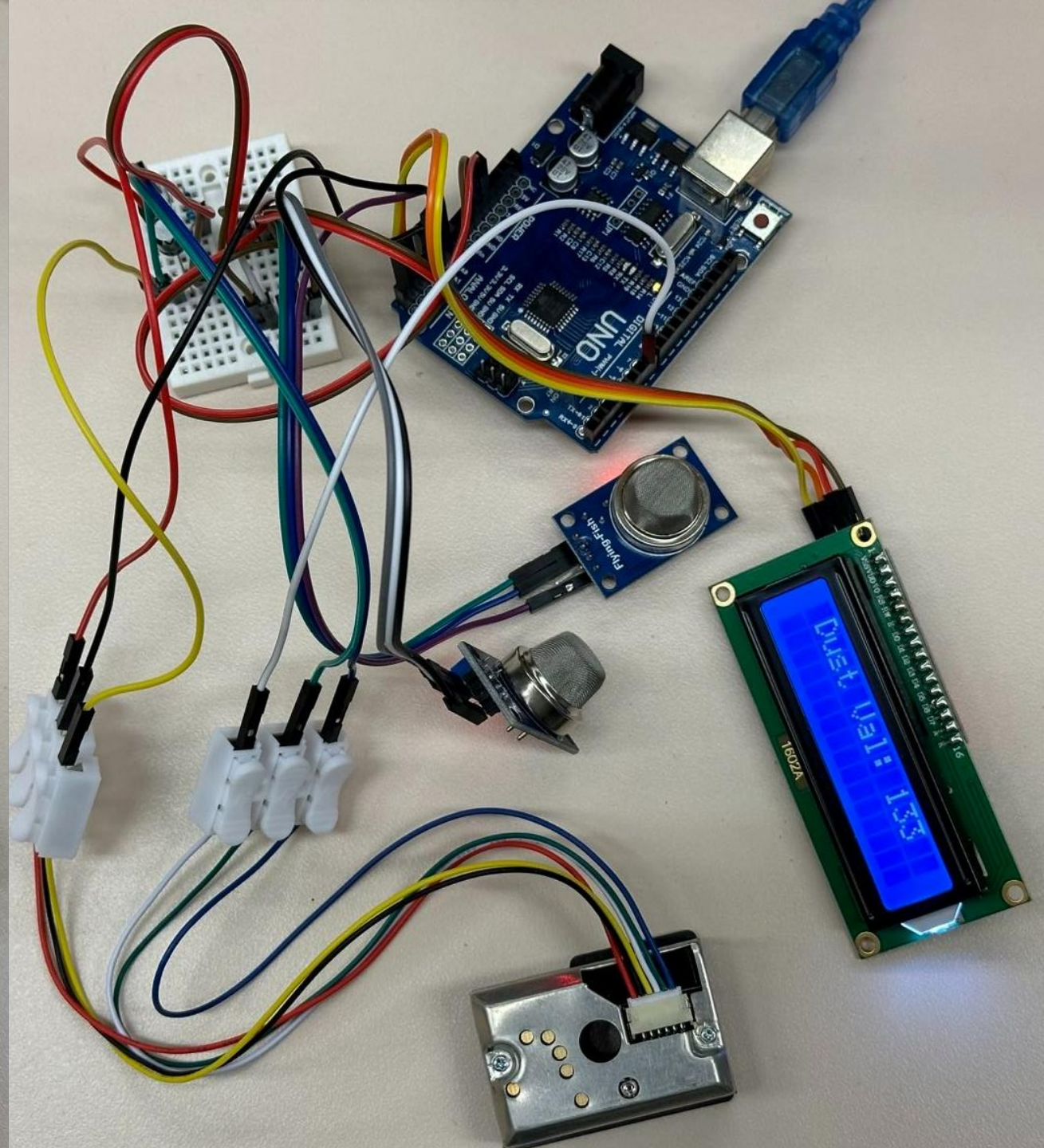
灰塵傳感器

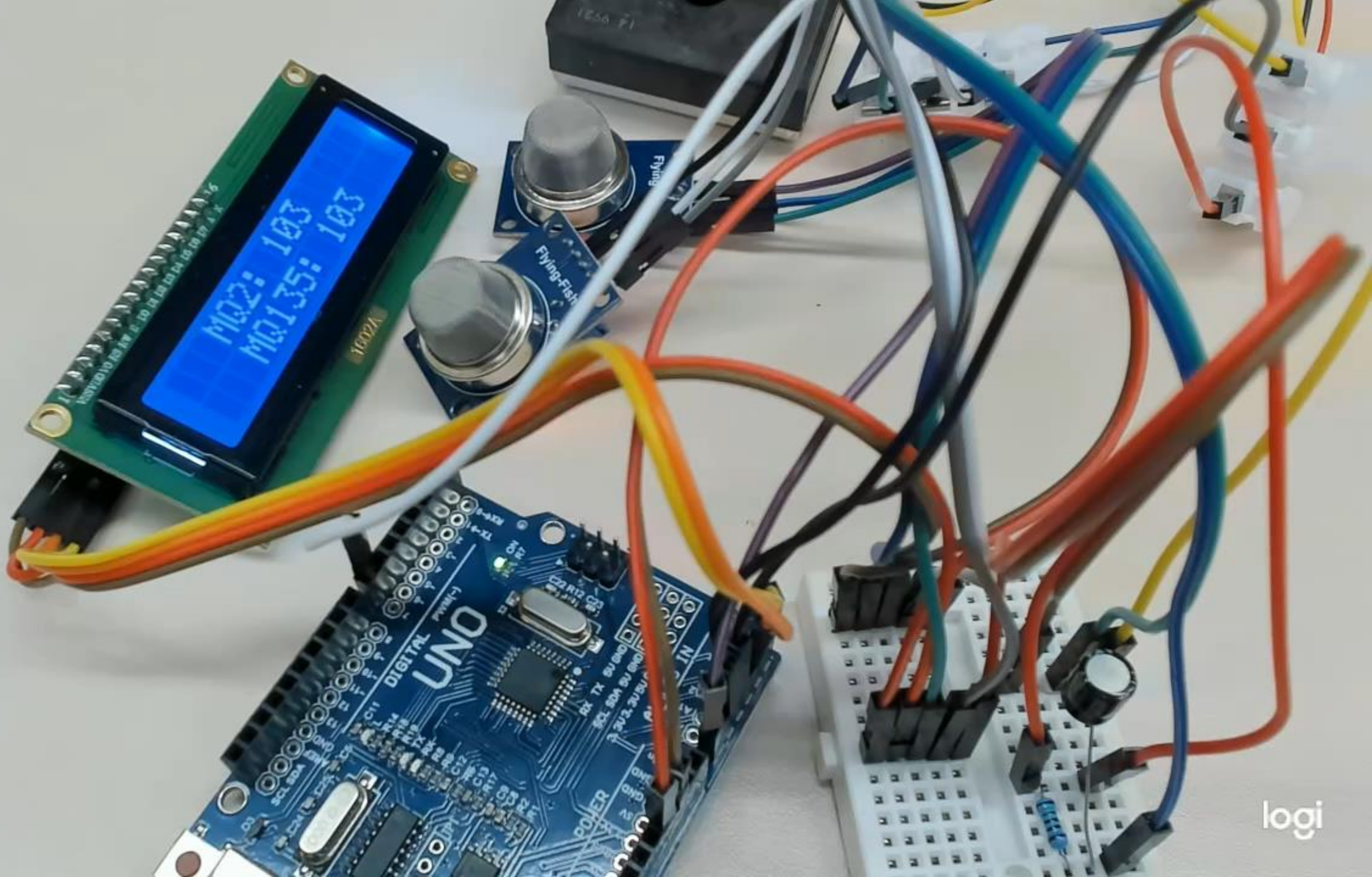
```
int delayTime=280;
int delayTime2=40;
float offTime=9680;
int ledPower=7;

void setup()
{
  lcd.init();
  lcd.backlight();
  lcd.setCursor(2,0);
  lcd.print(“STEM Edu Ctr");
  delay(3000);
  lcd.clear();
  pinMode(ledPower, OUTPUT);
}
```

灰塵傳感器

```
lcd.print(data_MQ135);
  delay(3000);
  lcd.clear();
  digitalWrite(ledPower,LOW);        // power on the LED
  delayMicroseconds(delayTime);
  dustVal=analogRead(dustPin);        // read the dust value
  delayMicroseconds(delayTime2);
  digitalWrite(ledPower,HIGH);       // turn the LED off
  delayMicroseconds(offTime);
  lcd.setCursor(1,0);                 // Set cursor to first line in the LCD
  lcd.print("Dust Val: ");
  lcd.print(dustVal);
  delay(3000);
  lcd.clear();
}
```


MQ2: 117
MQ135: 115
1602A
Flying-Fish
UNO


Gas Val: 133
1602A
Flying-Fish
UNO


MQ2: 103
MQ135: 103
UNO
DIGITAL
POWER
Flying-Fish
logi

Arduino編程部份完