



CRAFTING FORENSIC TOOLS FROM SCRATCH WITH ARDUINO

CLAY ALLRED

BUREAU OF ALCOHOL TOBACCO
FIREARMS AND EXPLOSIVES (ATF)

FORENSIC SCIENCE LAB - ATLANTA

OPINIONS STATEMENT

Points of view or opinions contained in this publication are those of the author and do not necessarily represent the official position or policies of the U.S. Department of Justice or the Bureau of Alcohol Tobacco Firearms and Explosives. References to specific agencies, companies, products, or services should not be considered an endorsement by the author or the U.S. Department of Justice. Rather, the references are illustrations to supplement discussion of the issues.

SAFETY WARNING

- This presentation is given as a proof of concept only and not a guide.

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- Consult an expert before attempting anything contained within.

WHAT IS ARDUINO

- **Arduino** ([/ɑːrˈdwiːnoʊ/](#)) is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices.
 - Source: [Wikipedia.org](https://en.wikipedia.org/wiki/Arduino)
- Arduino™ refers to a specific company and line of products: generic Arduino-style products are referenced in this talk

ARDUINO HISTORY

- The Arduino project began in 2005 as a tool for students at the [Interaction Design Institute Ivrea](#) in [Ivrea](#), Italy.
- The goal was to provide a low-cost, simple way for novices and professionals to create devices that interact with their environment using sensors and actuators
- The name *Arduino* comes from a bar in [Ivrea](#), Italy
 - Source: Wikipedia.org

WHAT CAN I DO WITH AN ARDUINO?

- Robotics
 - Automating repetitive tasks

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 - Automating repetitive tasks
- IOT (Internet of Things)
 - Controlling a window shade from your phone

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- Sensors
 - Humidity
 - Pulse
 - Distance
 - Color

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- Home Automation
 - Alarm System
 - Sprinkler control
 - Remote control anything
 - Connect motion sensors to lights

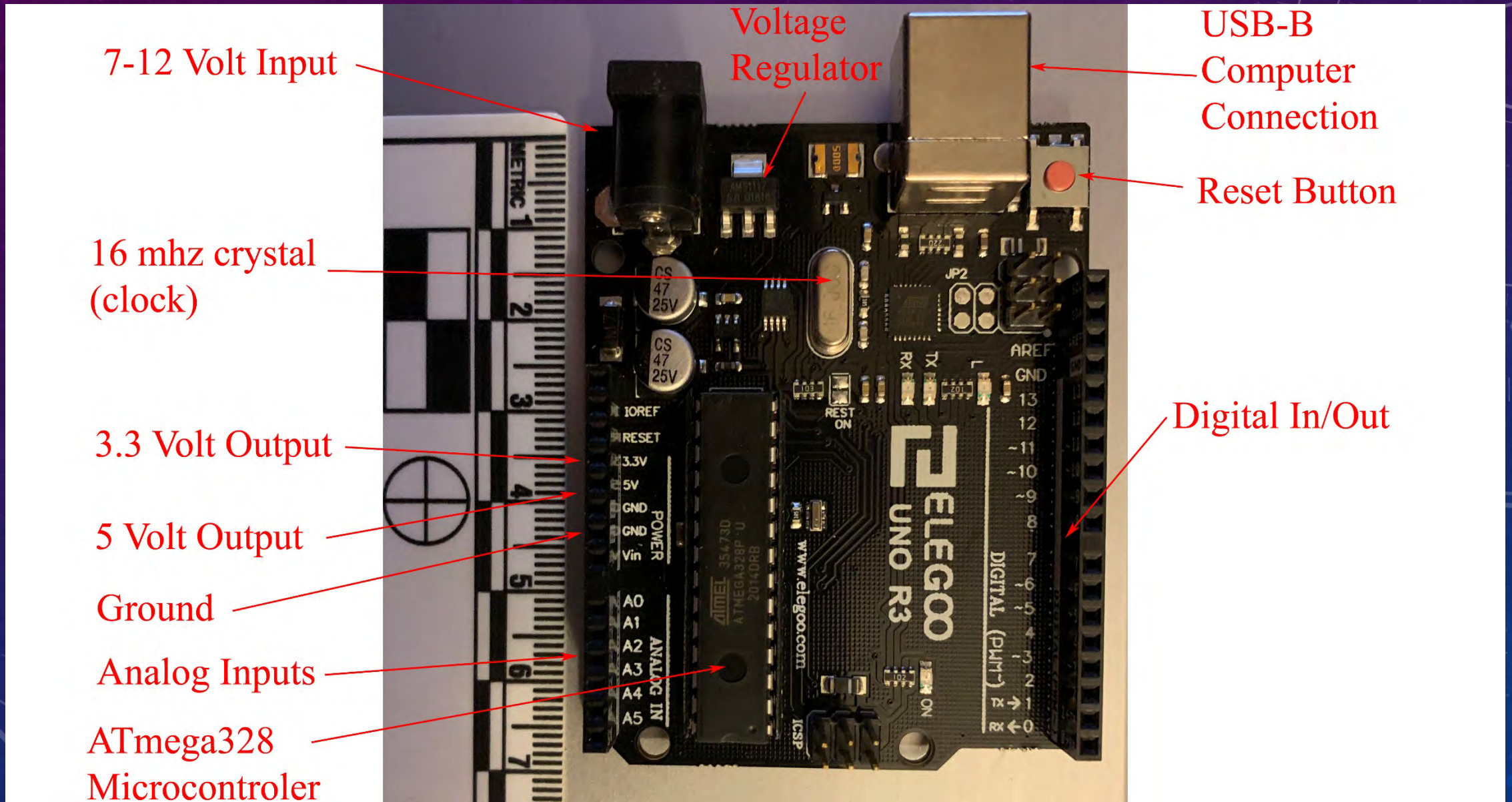
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- Change/modify/enhance any existing product that uses a battery or electrical plug

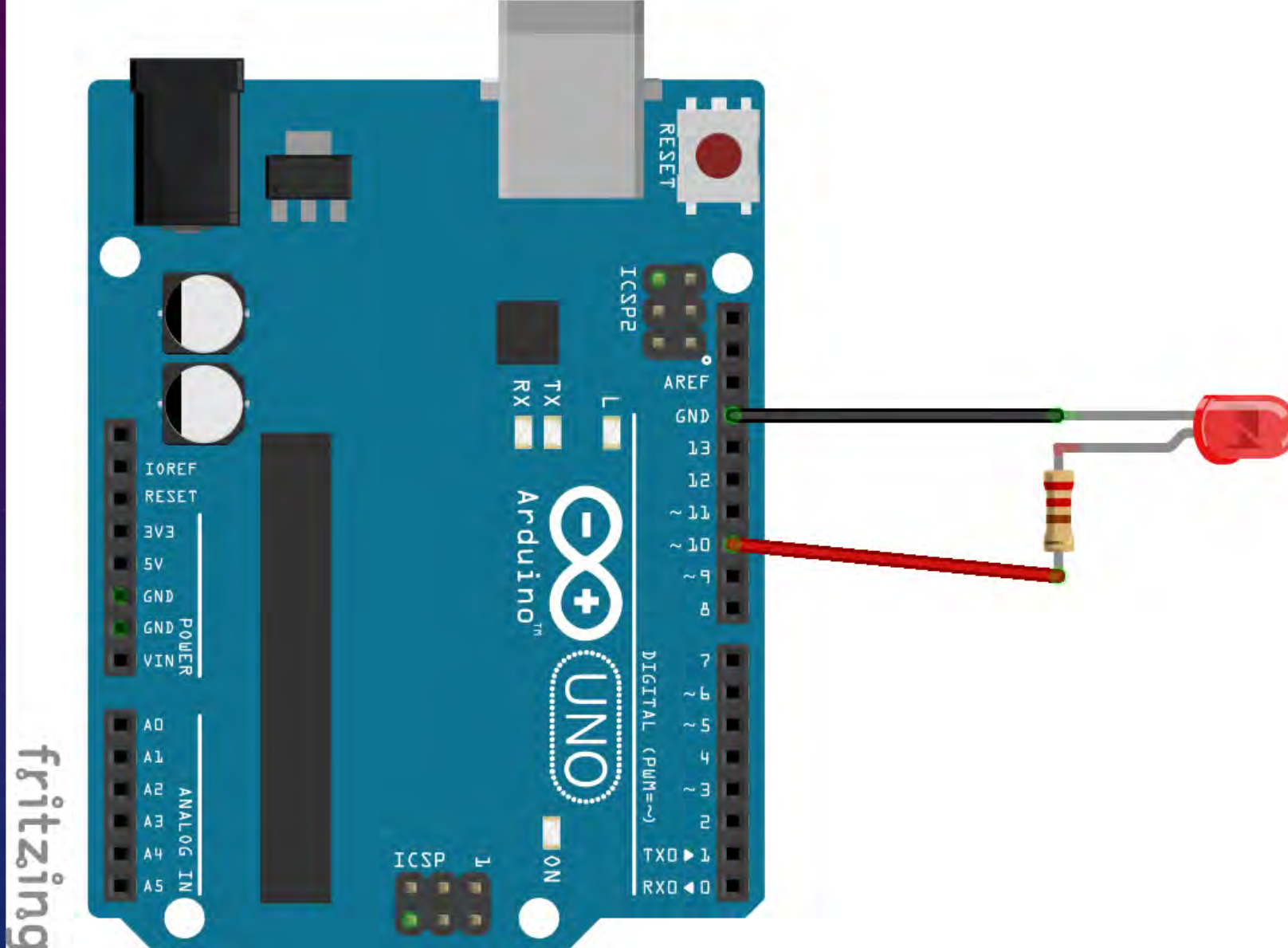
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- Change/modify/enhance any existing product that uses a battery or electrical plug
- A lot of other crazy stuff – Just google Arduino Projects

GENERAL LAYOUT: ARDUINO R3 – STYLE BOARDS



CREATING A BLINKING LED



CREATING A BLINKING LED

sketch_jan24a | Arduino 1.8.13

File Edit Sketch Tools Help



sketch_jan24a\$

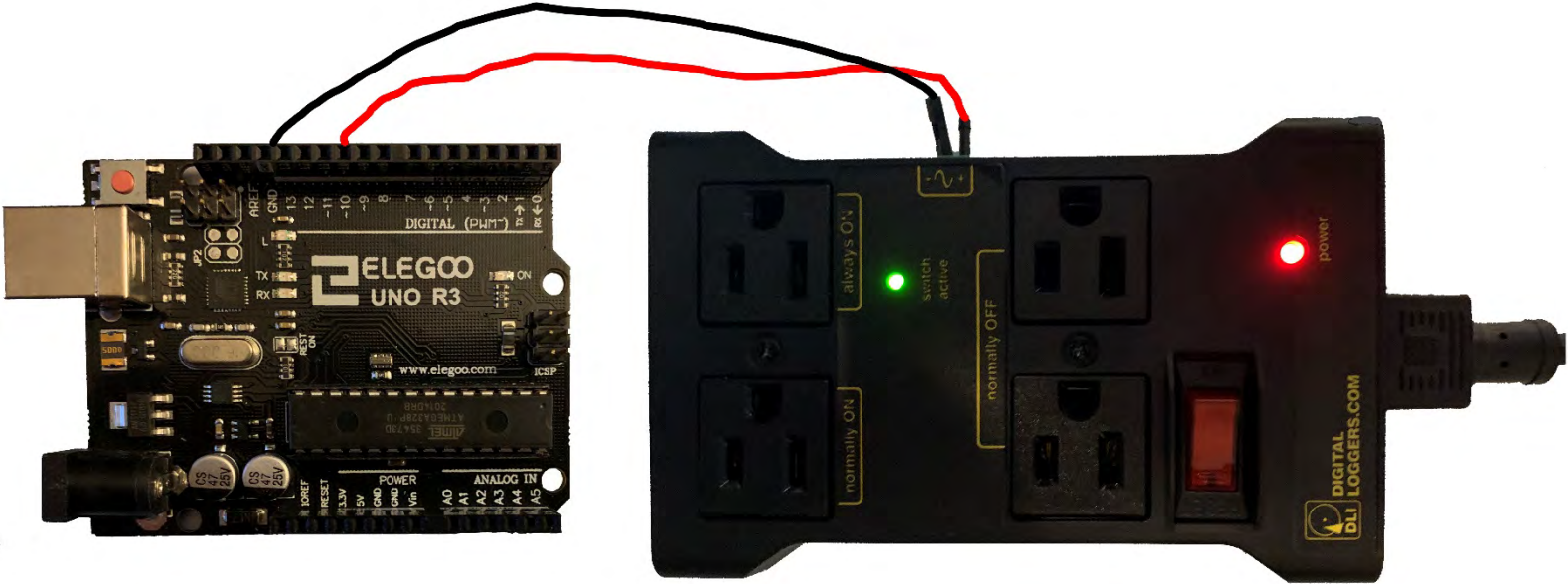
```
void setup() {  
  //assign pin 10 as an output  
  pinMode (10, OUTPUT);  
  |  
}  
  
void loop() {  
  
  digitalWrite(10, HIGH); //sending 5 volts to pin 10 to turn on the led  
  delay (1000); //waiting with the LED on for 1000 ms (1 second)  
  
  digitalWrite(10, LOW); //sending 0 volts to pin 10 to turn off the led  
  delay (1000); //waiting with the LED off for 1000 ms (1 second)  
}
```

CONTROLLING MORE THAN A 5 VOLT LED

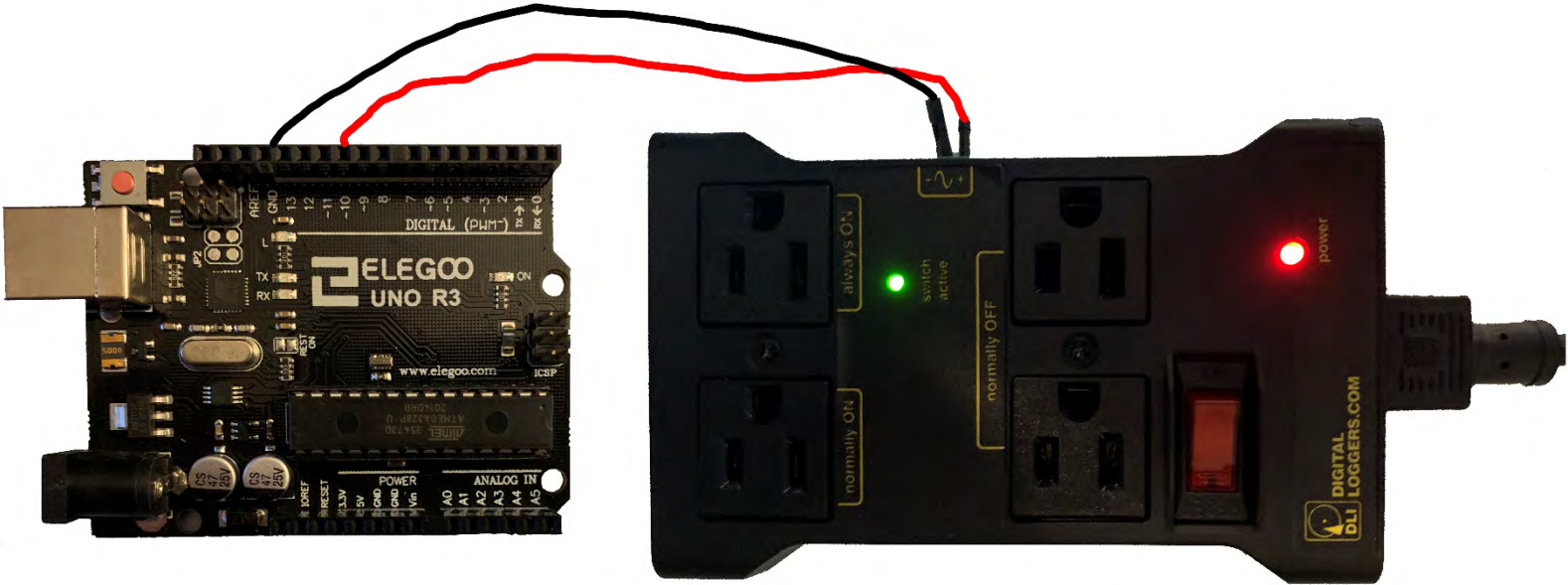
- AC/DC Control Relay (IOTRELAY.COM)
- Has four (4) AC Plugs
 - 1 x Always on
 - 1 x Normally on
 - 2 x Normally off
- Has a 12 Amp thermal circuit safety breaker
- Contains an optically isolated relay
- Relay is rated for >400,000 operations at 30/40 Amps



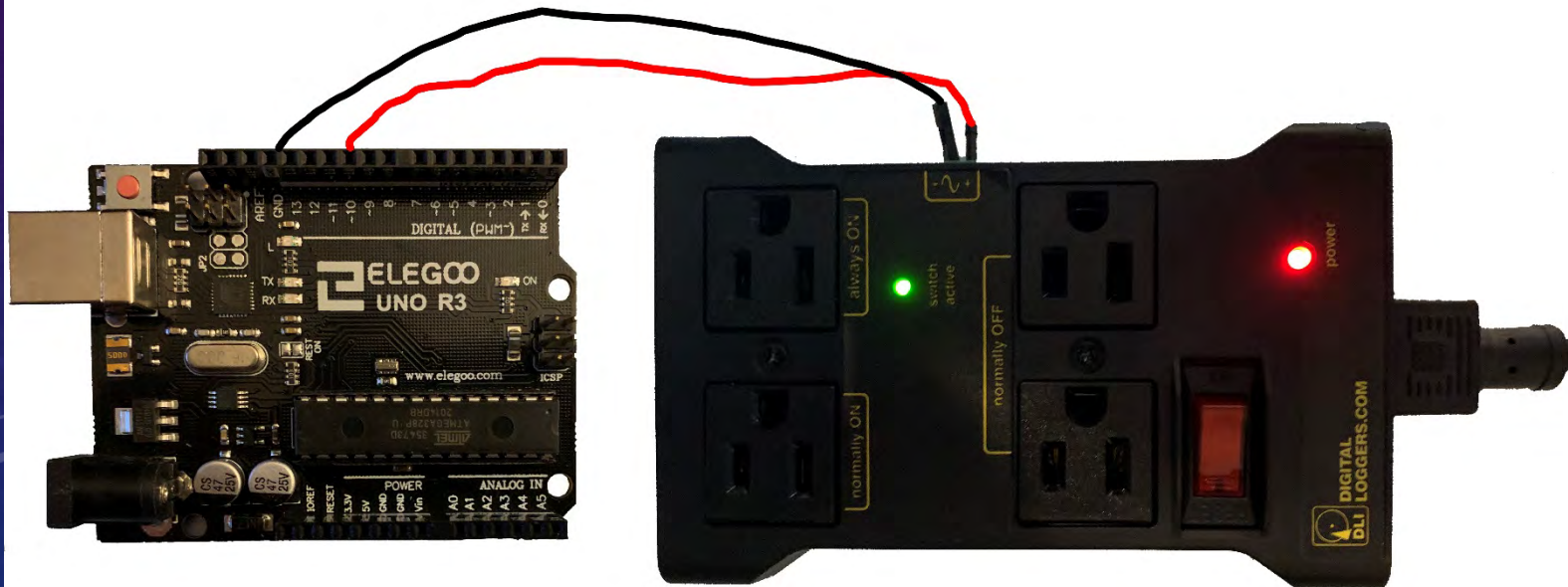
ARDUINO AND RELAY TO CONTROL 110 V



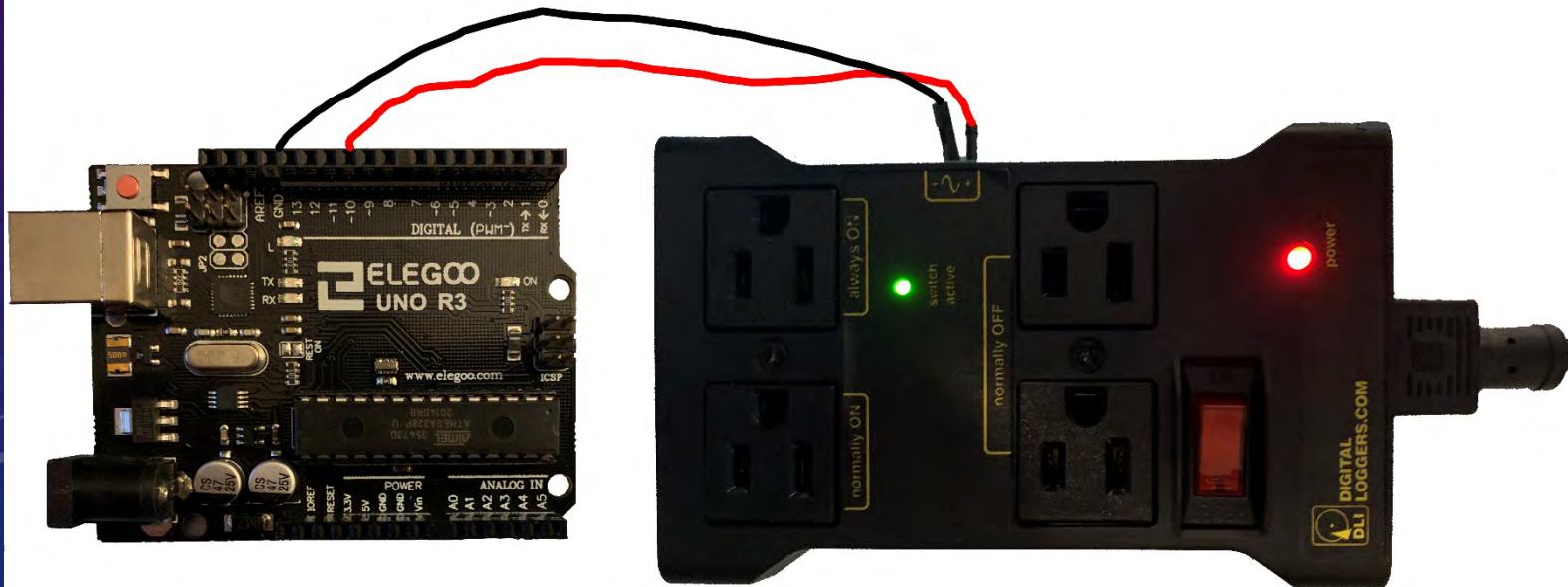
ARDUINO AND RELAY TO CONTROL 110 V



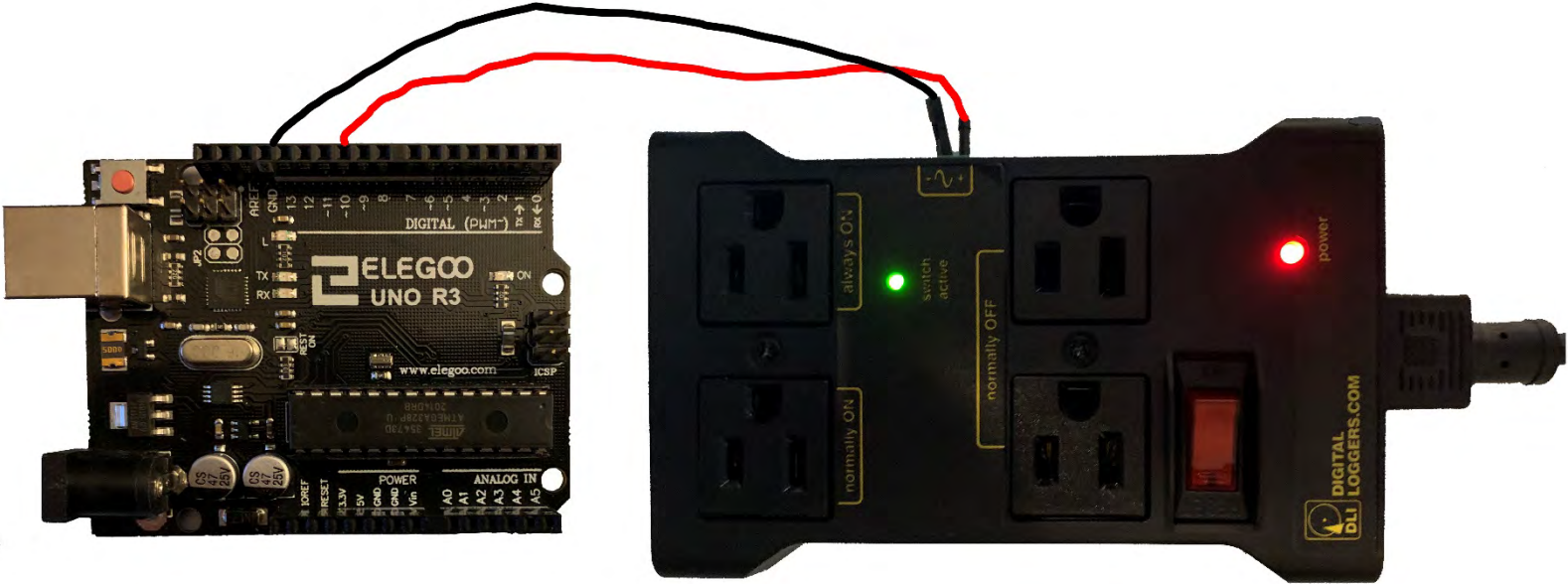
ARDUINO AND RELAY TO CONTROL 110 V



ARDUINO AND RELAY TO CONTROL 110 V

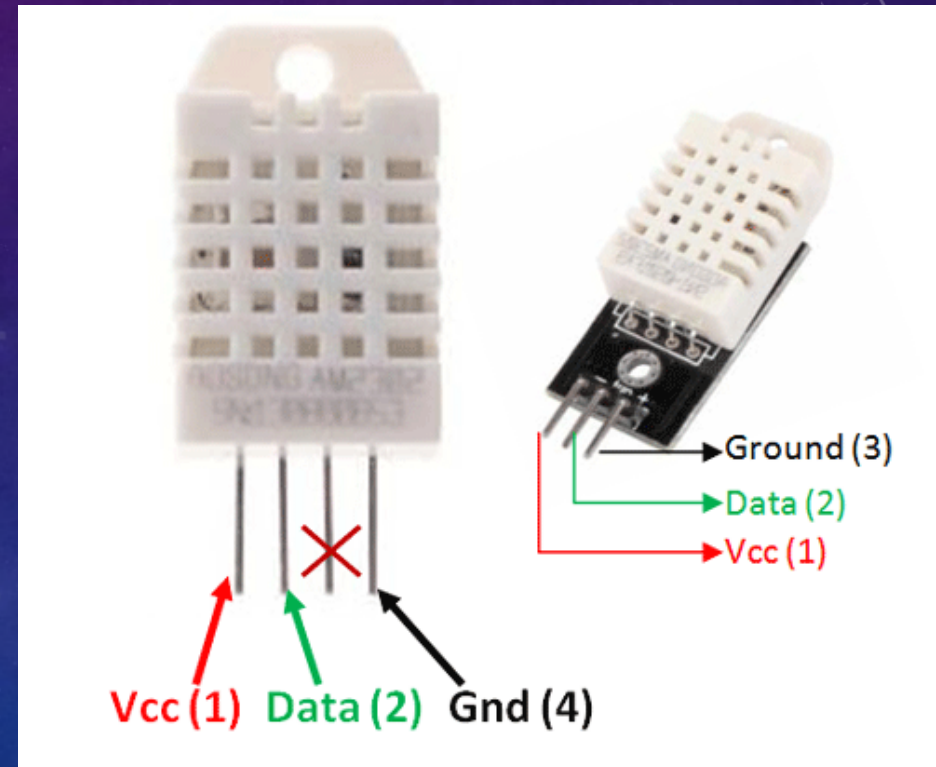


ARDUINO AND RELAY TO CONTROL 110 V

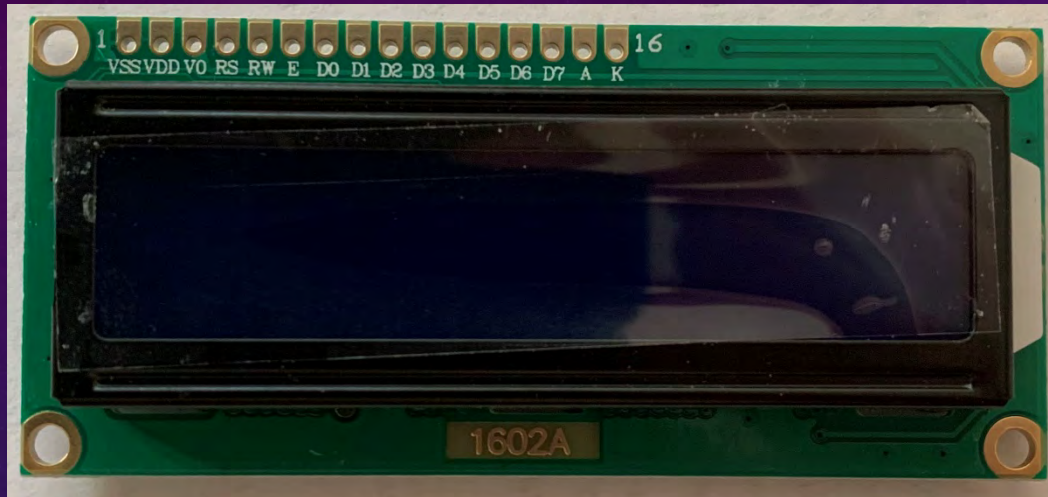


DHT22 TEMPERATURE AND HUMIDITY SENSOR

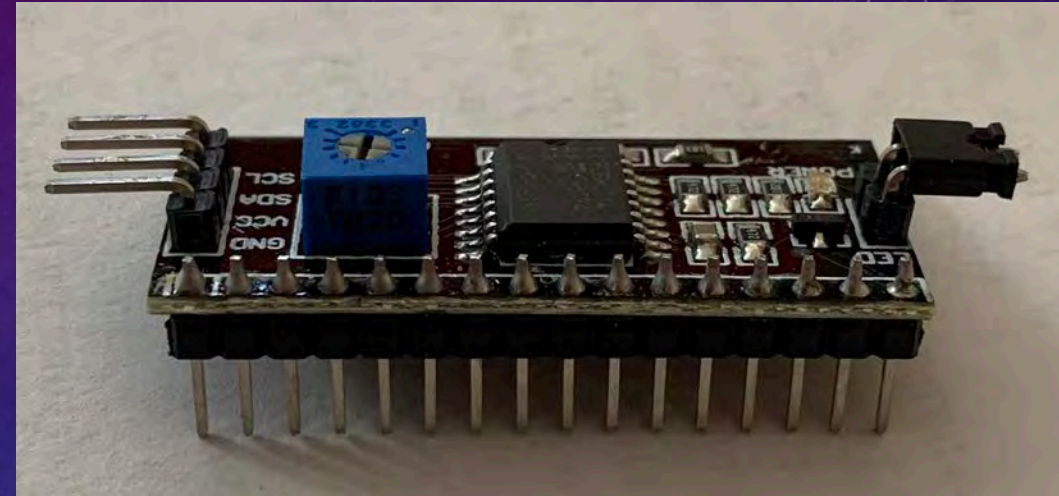
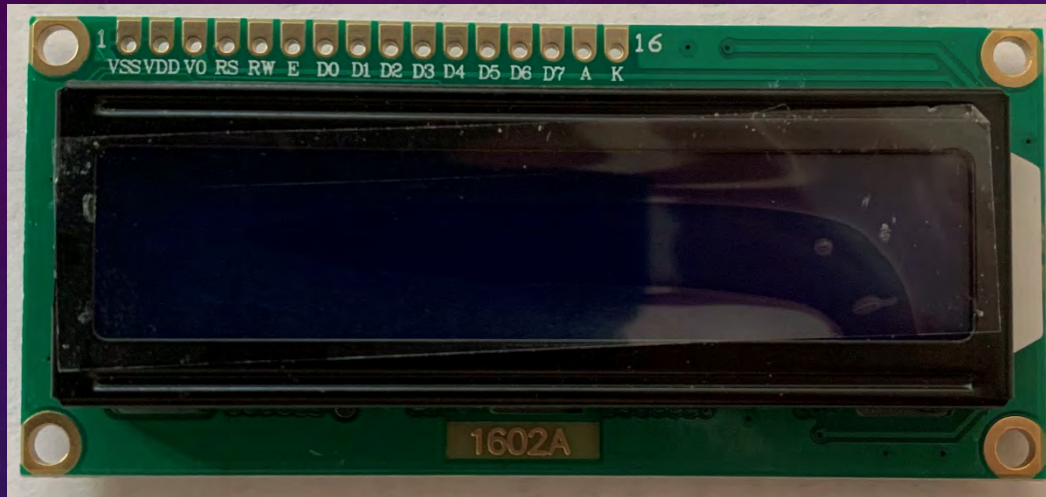
- **DHT22 Specifications**
- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: -40°C to 80°C
- Humidity Range: 0% to 100%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: $\pm 0.5^{\circ}\text{C}$ and $\pm 1\%$



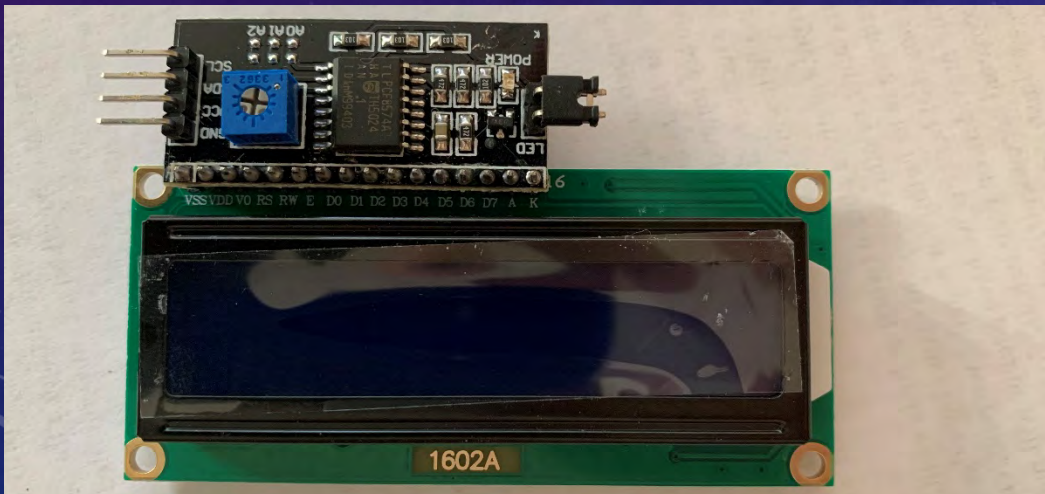
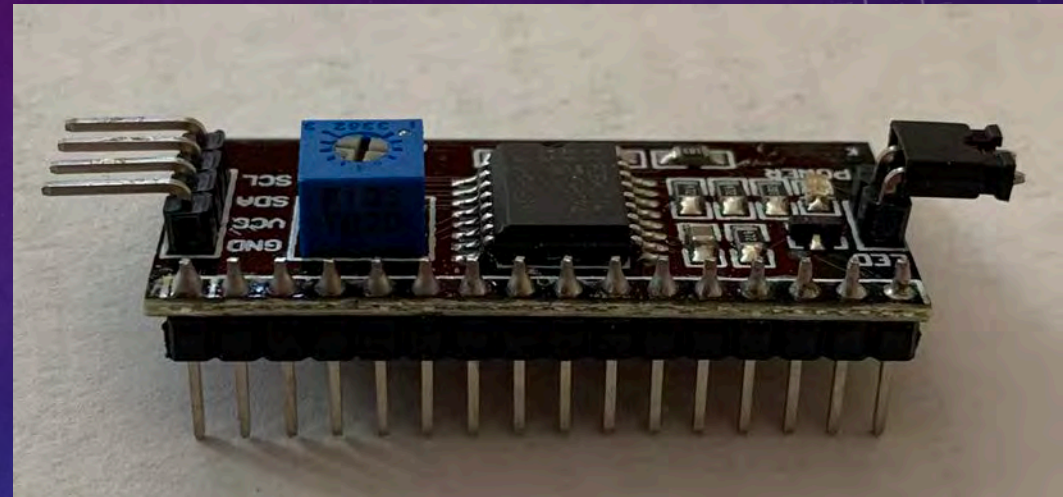
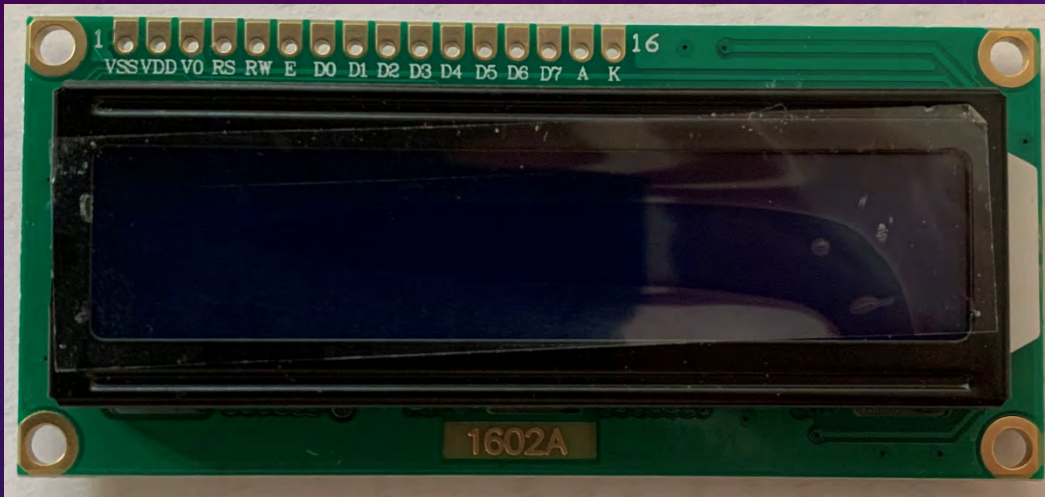
1602 DISPLAY BOARD WITH I2C



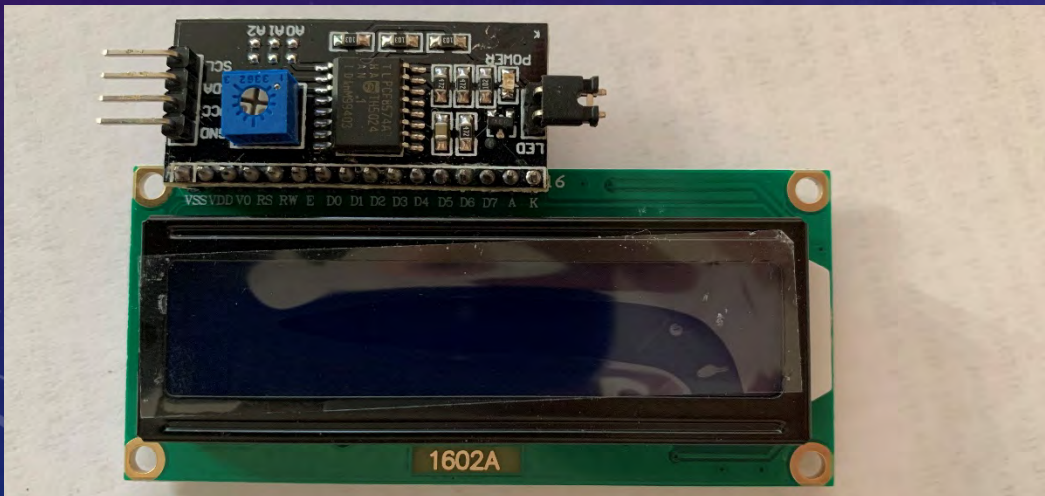
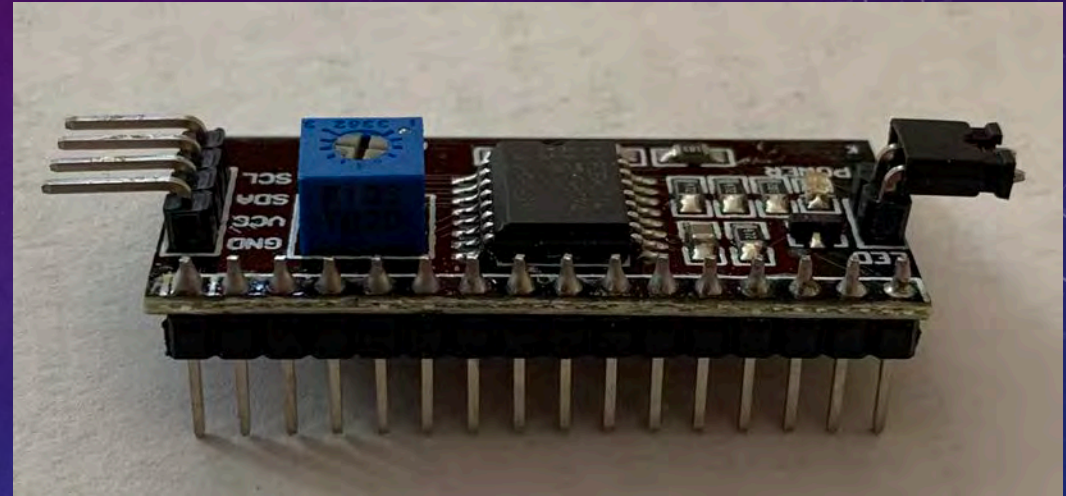
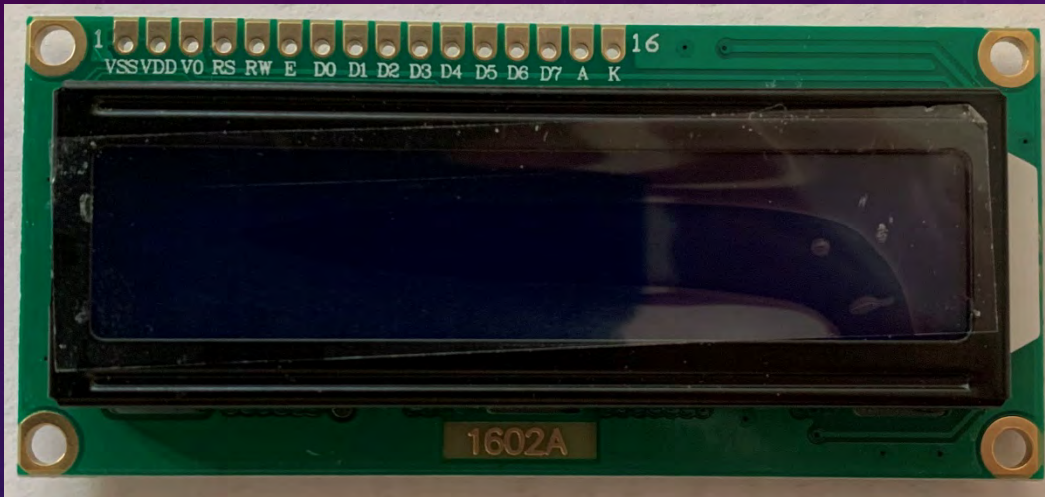
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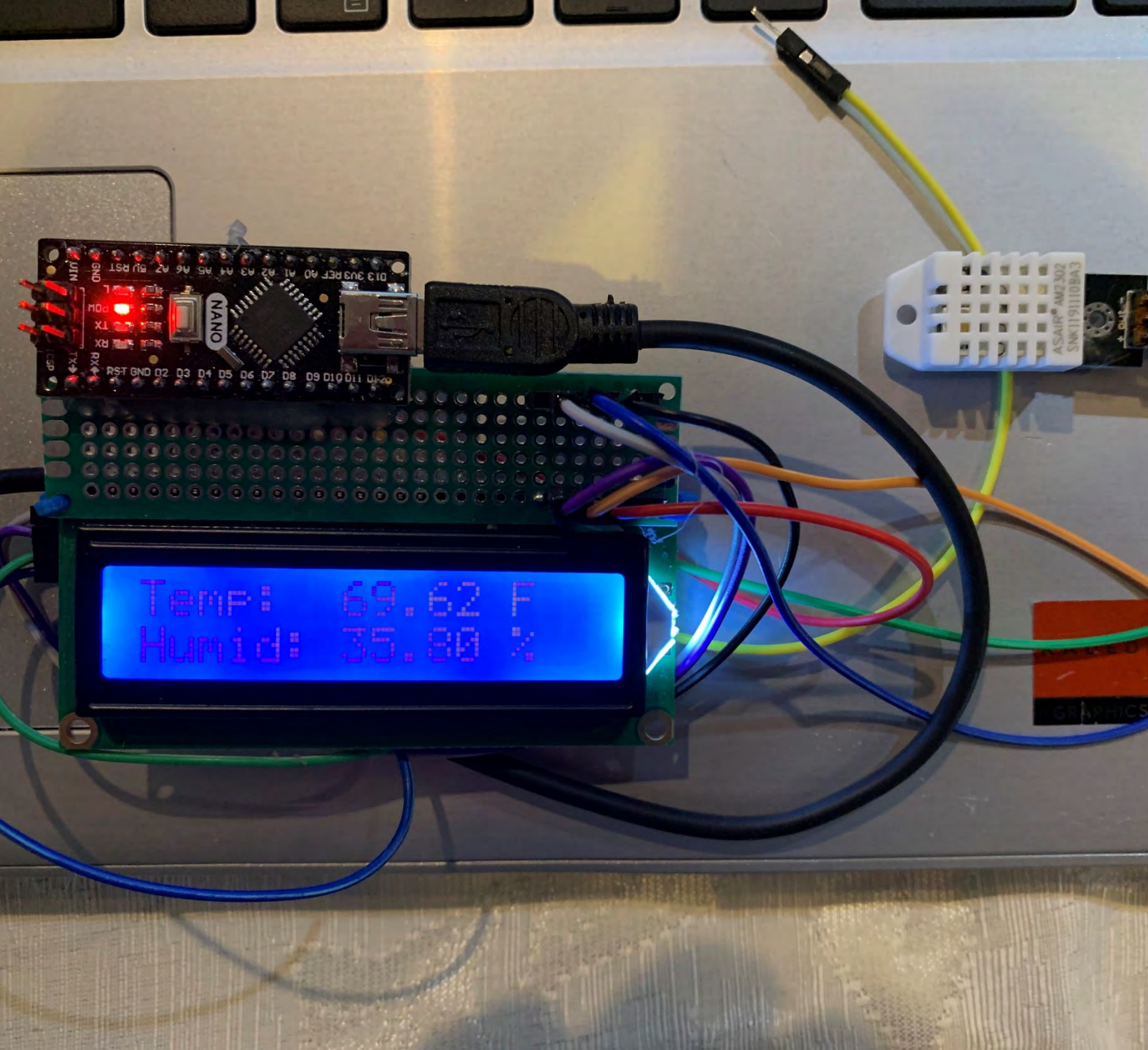


1602 DISPLAY BOARD WITH I2C



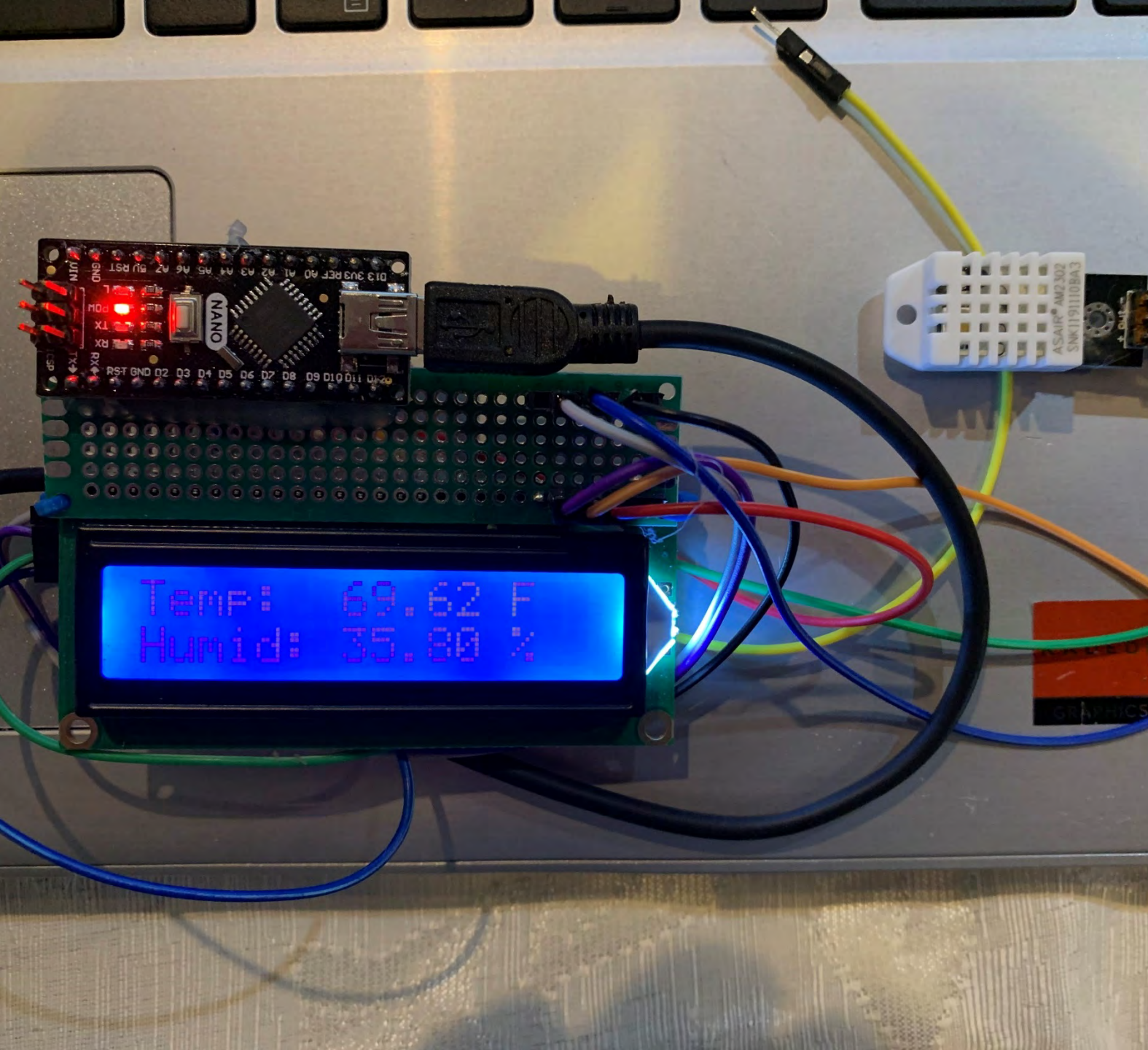
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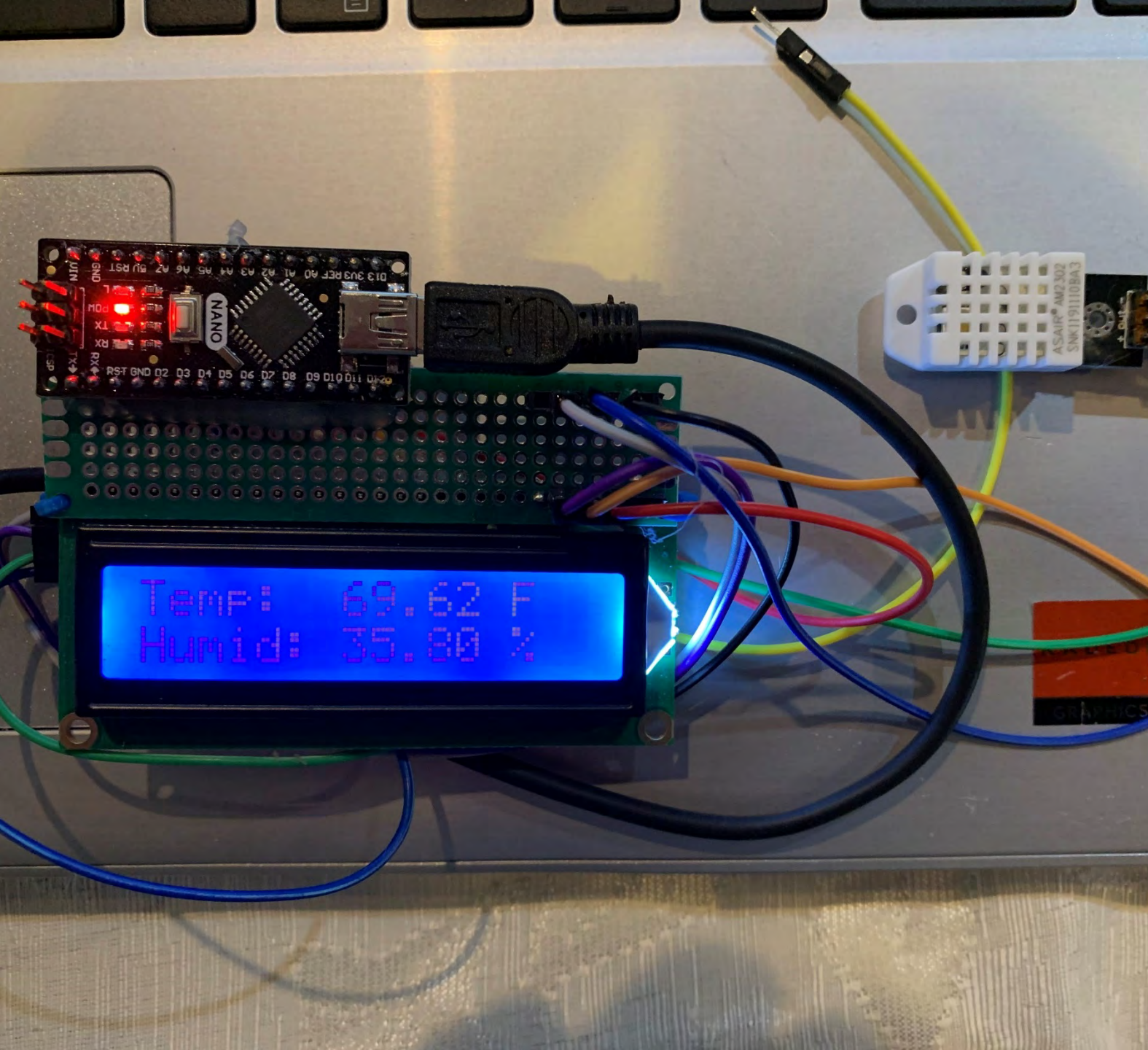
WHAT IS THIS
THING?





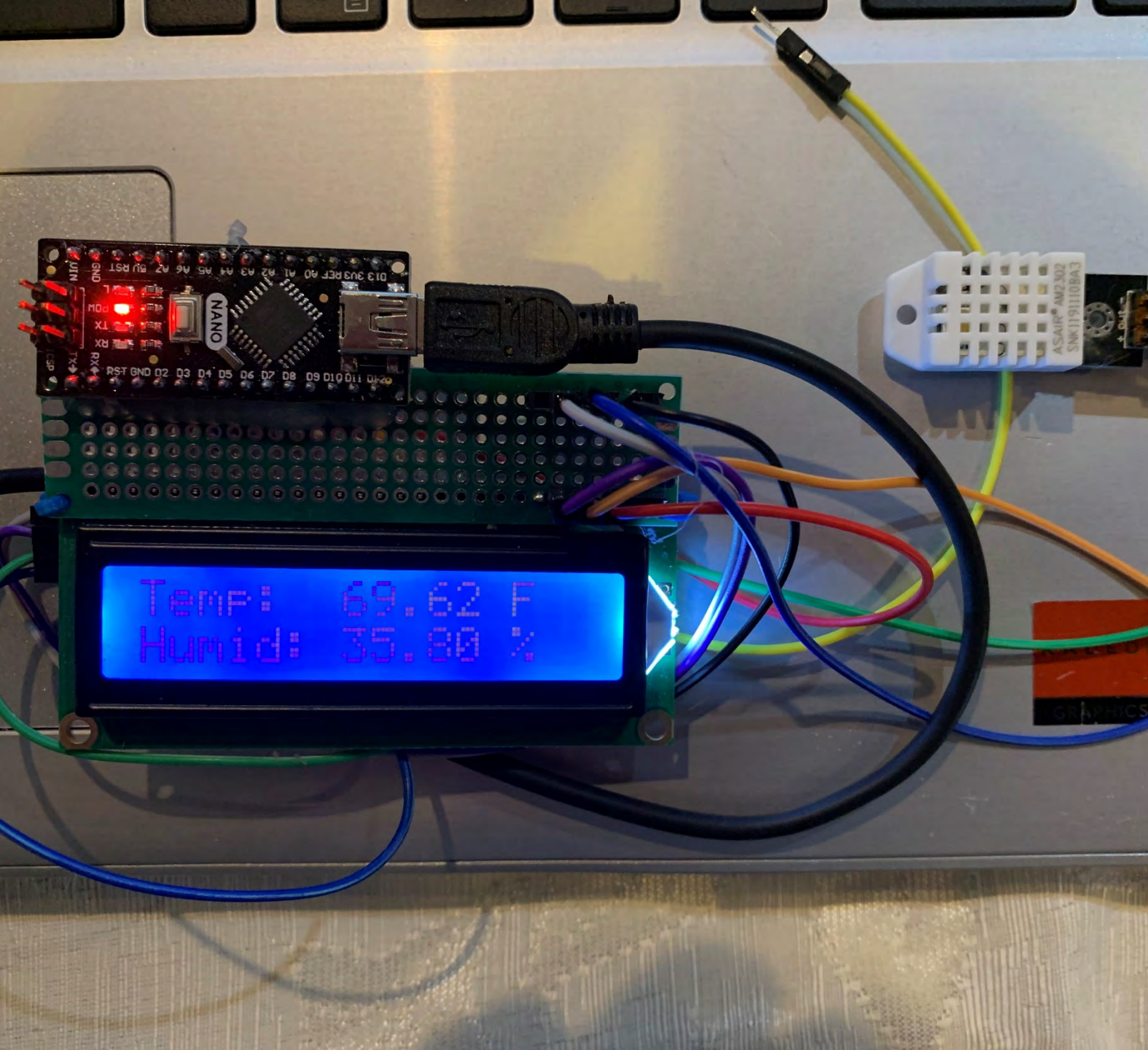
WHAT IS THIS THING?

- The control module for a cigar humidor.



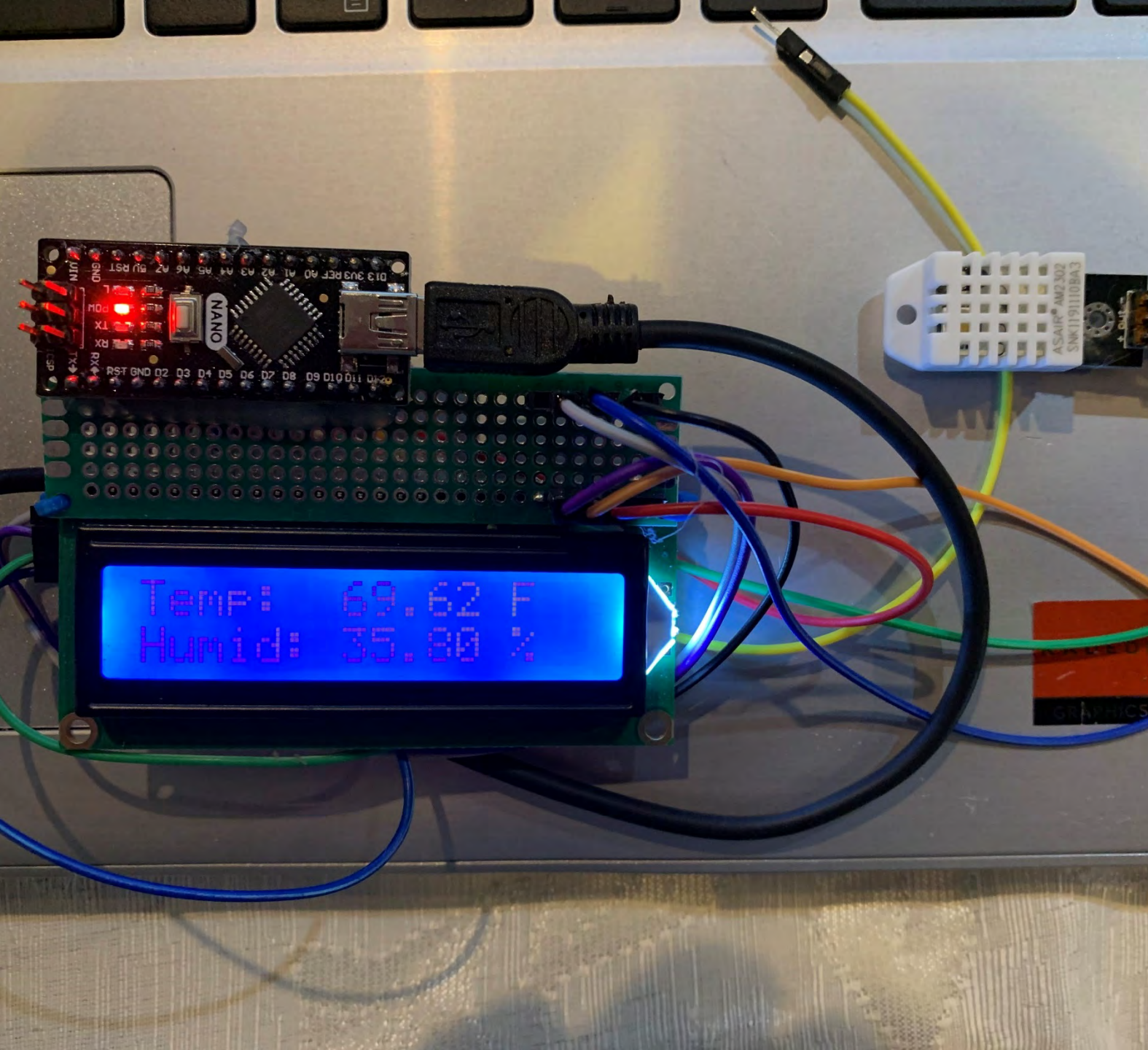
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- The control module for a cigar humidor.
- The start of a new career as a cantaloupe farmer.



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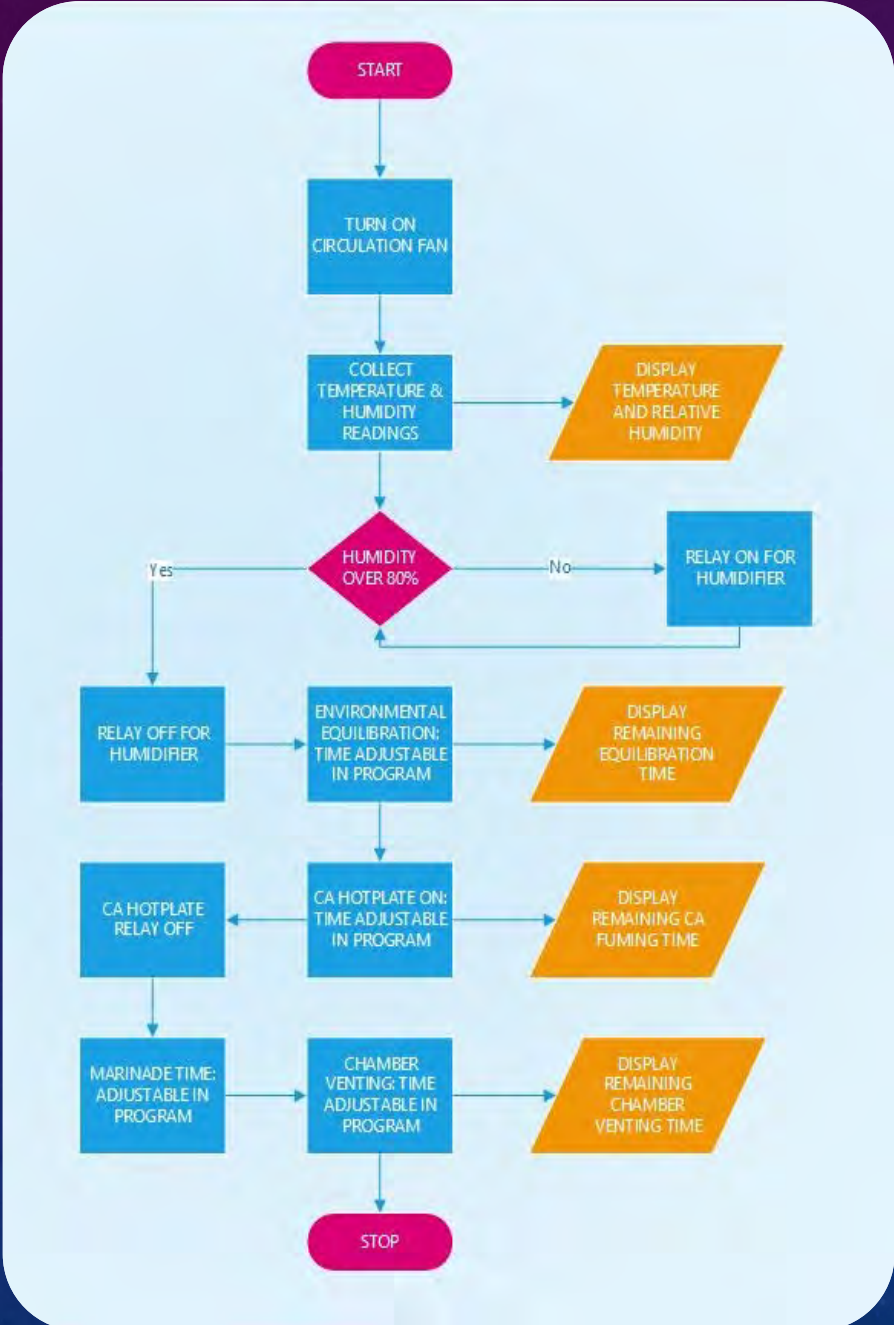
- The control module for a cigar humidor.
- The start of a new career as a cantaloupe farmer.
- The guts of a home weather station.



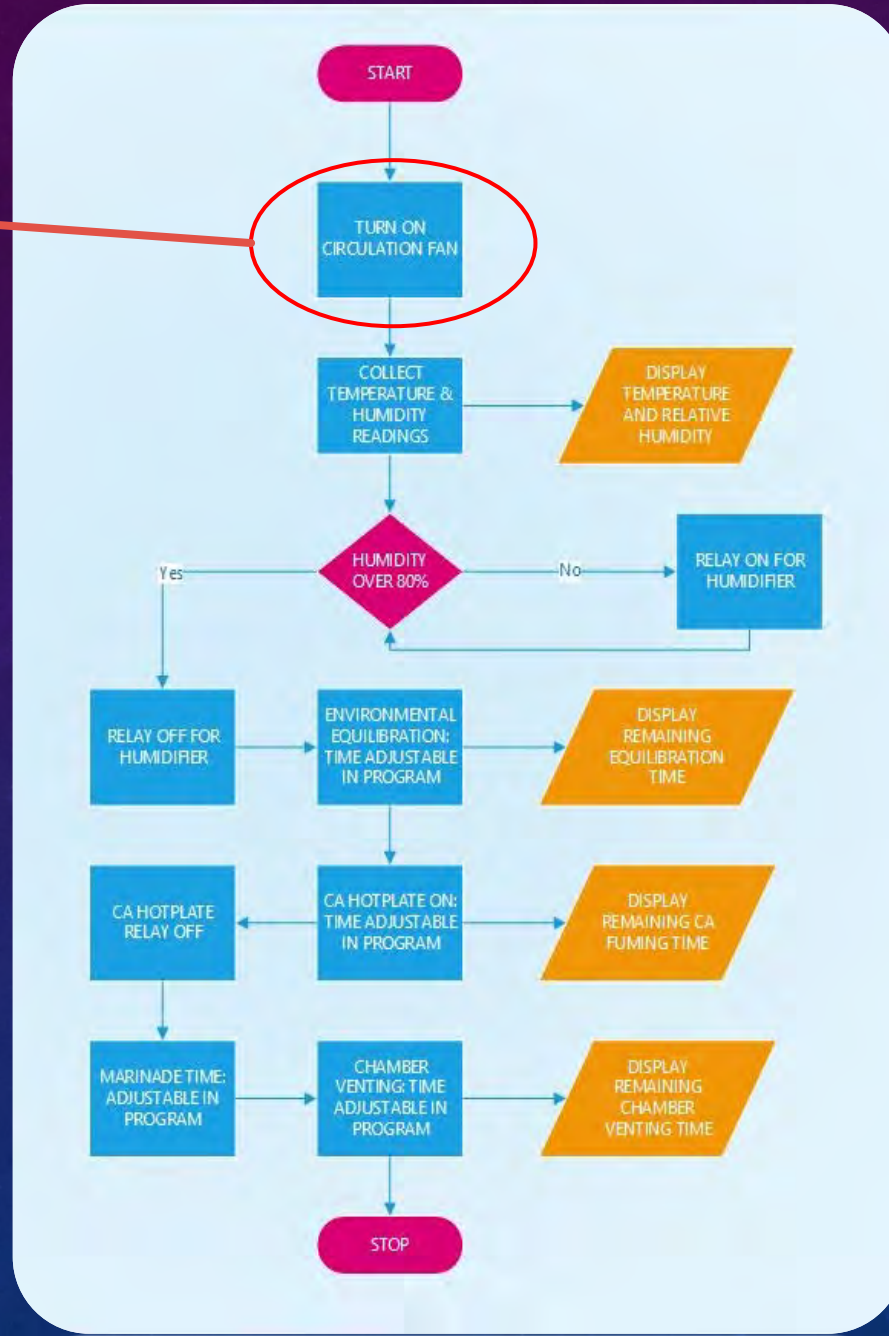
WHAT IS THIS THING?

- The control module for a cigar humidor.
- The start of a new career as a cantaloupe farmer.
- The guts of a home weather station.
- All of the above.

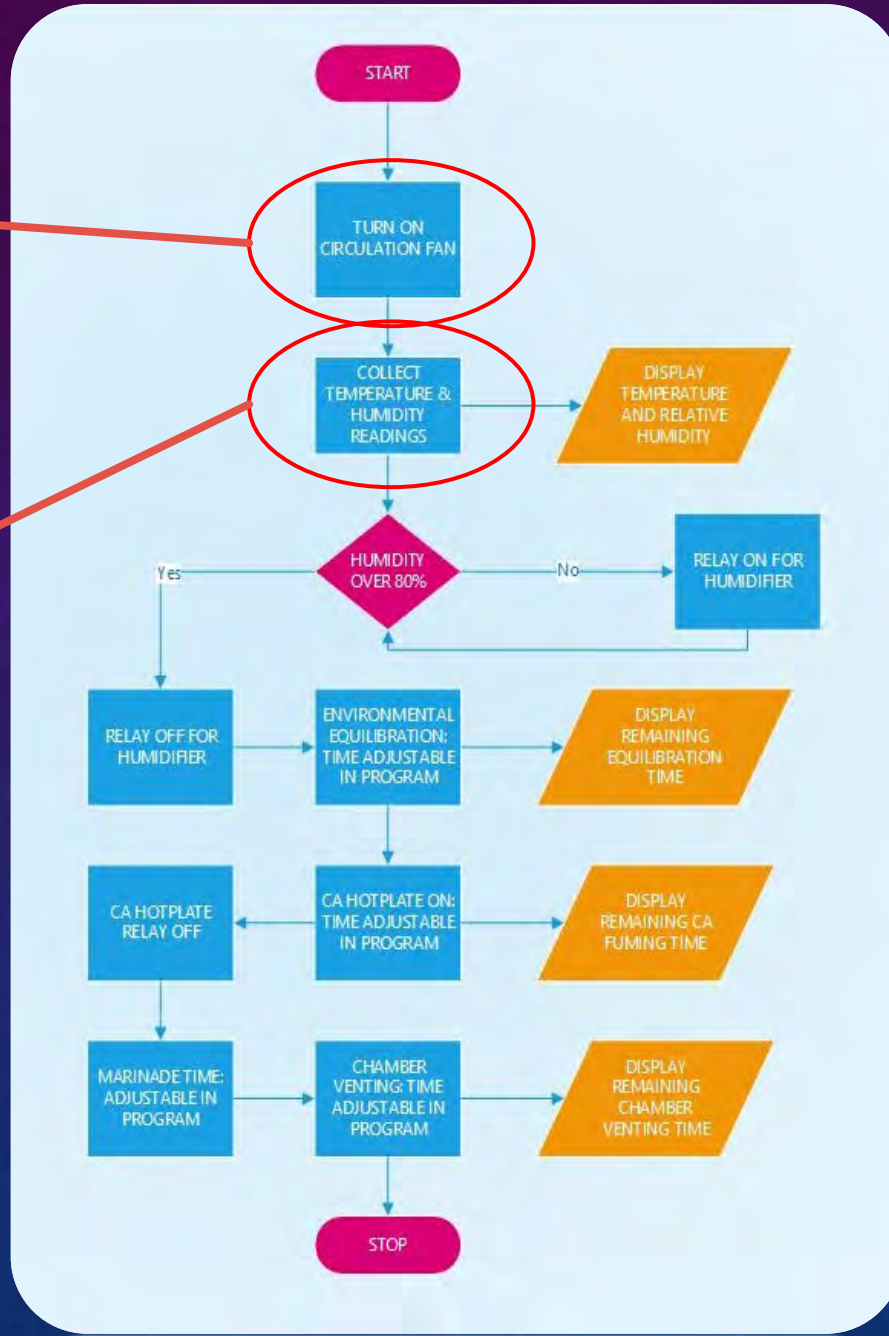
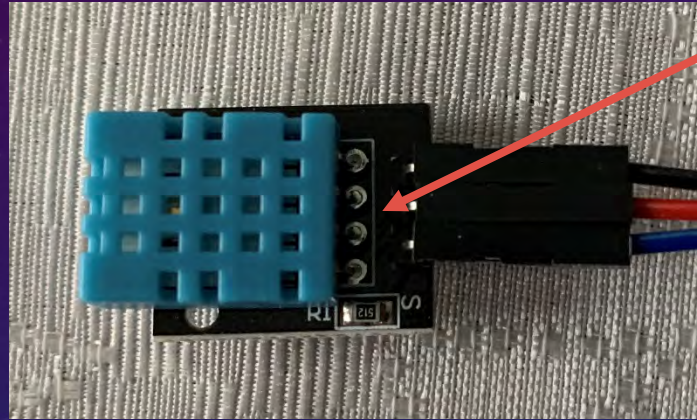
BASIC CA CHAMBER PROCESS FLOWCHART



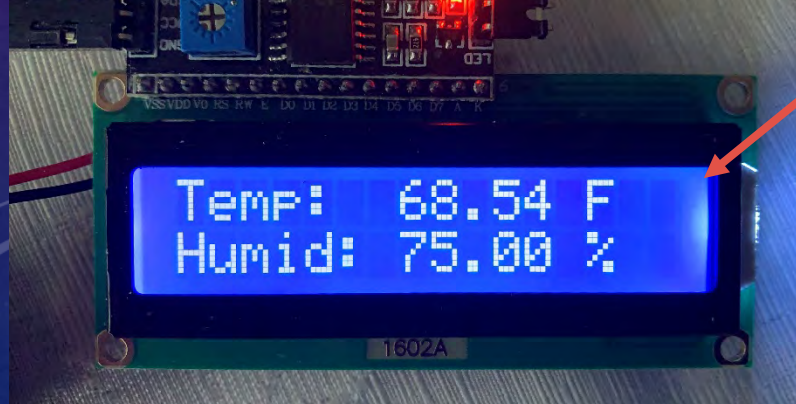
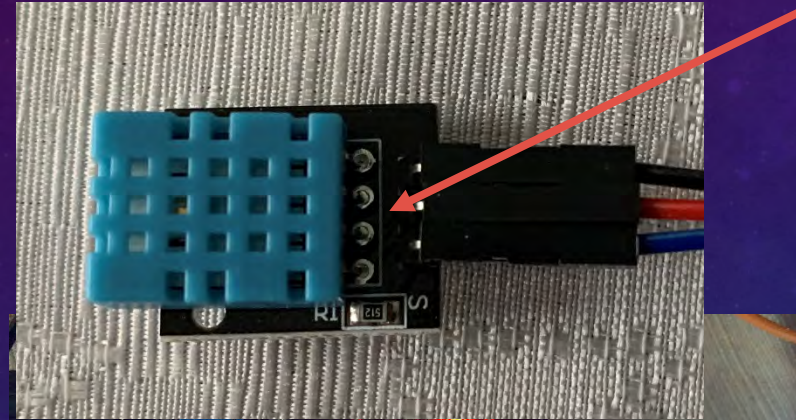
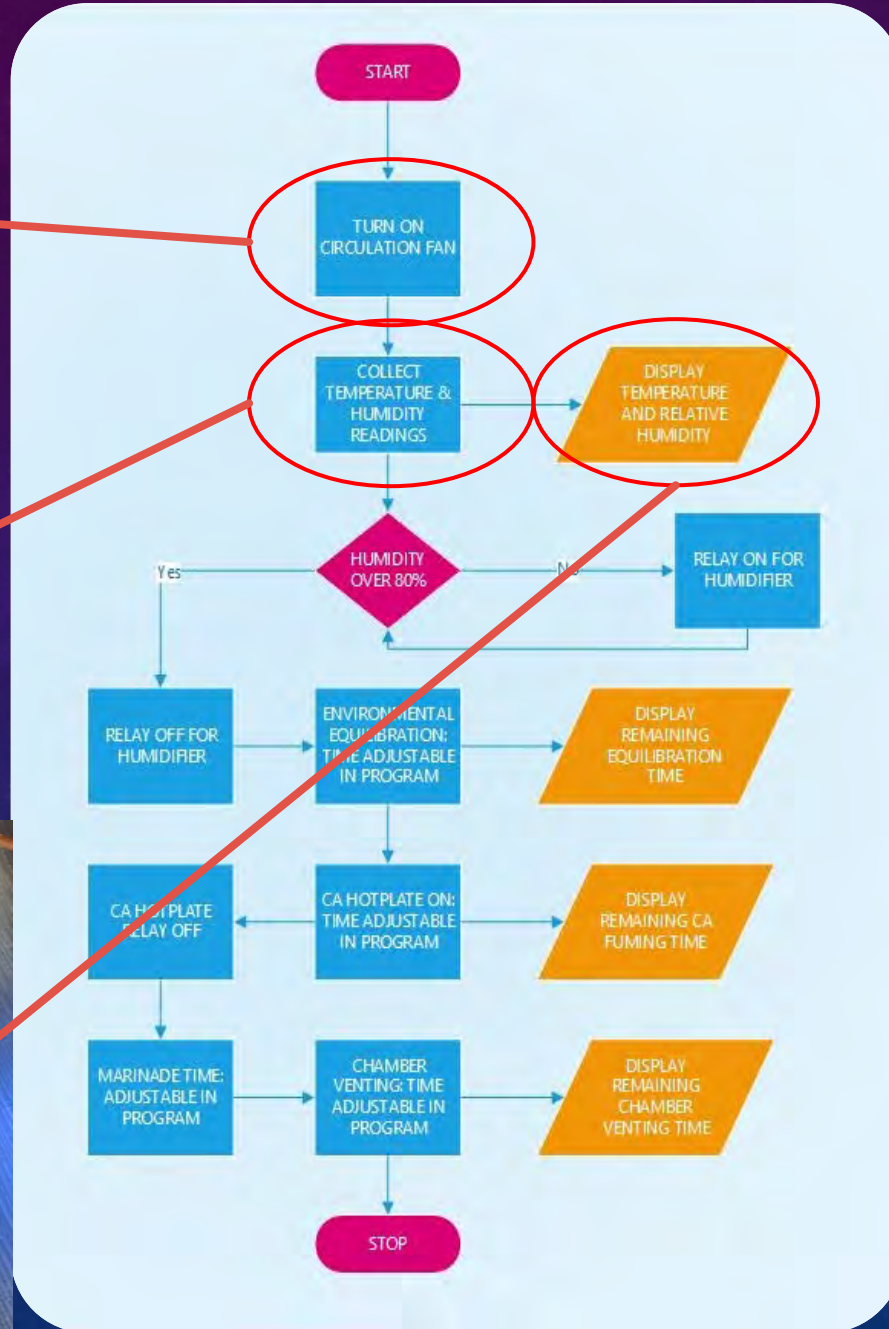
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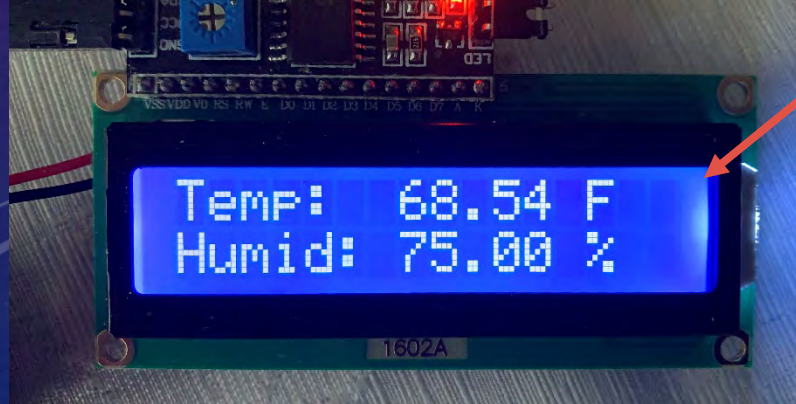
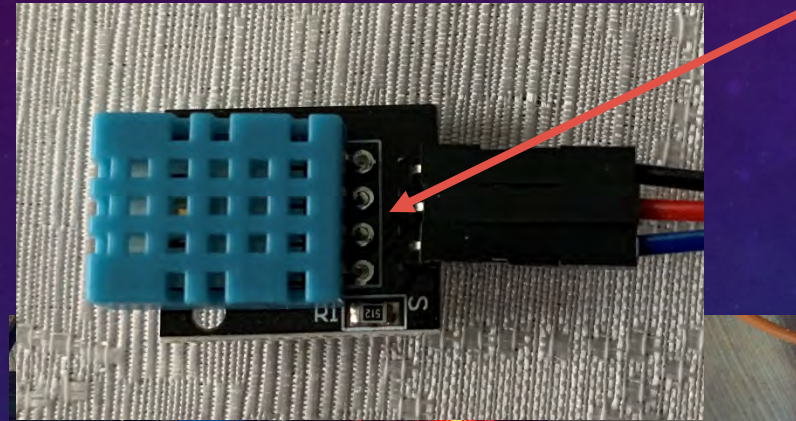
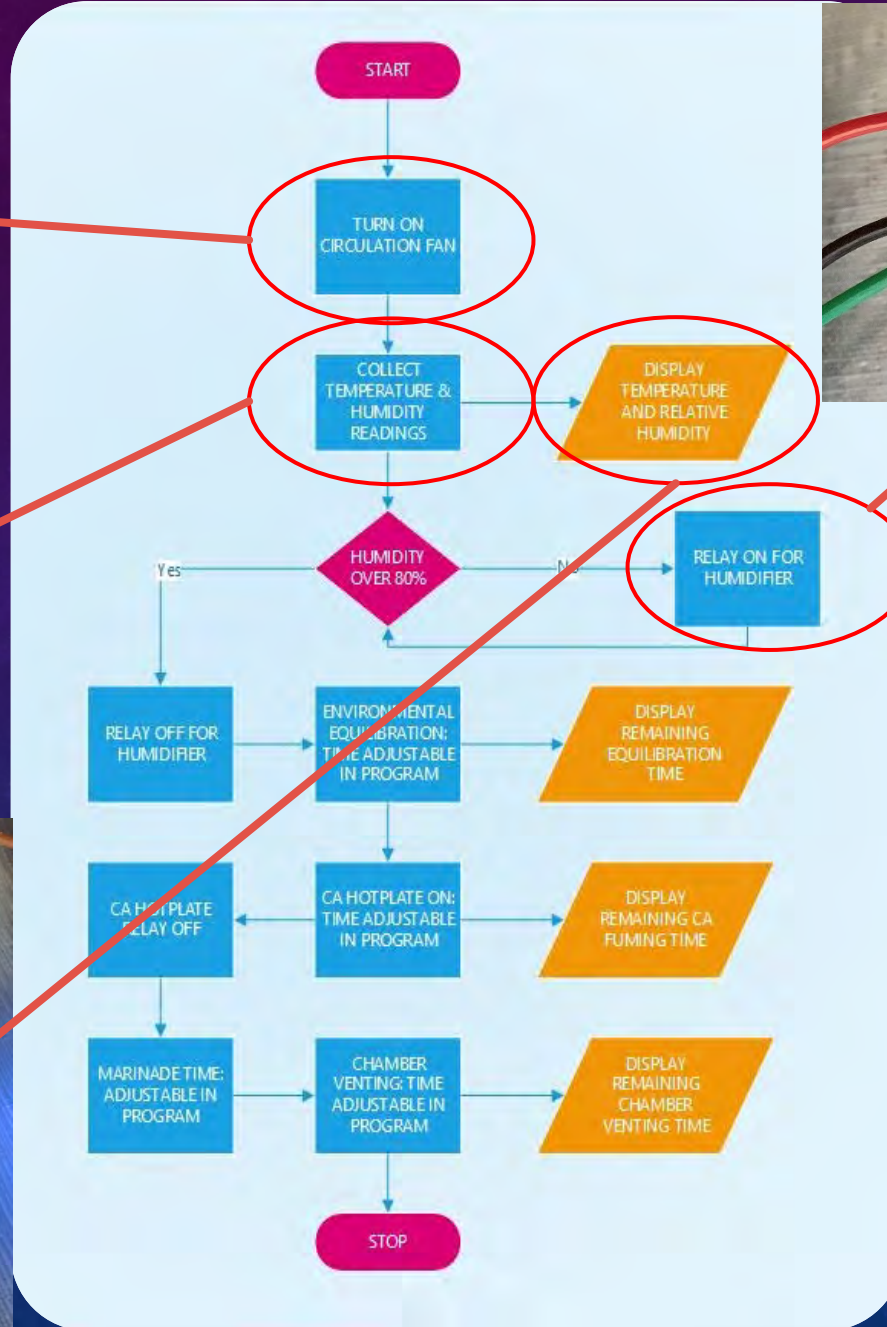
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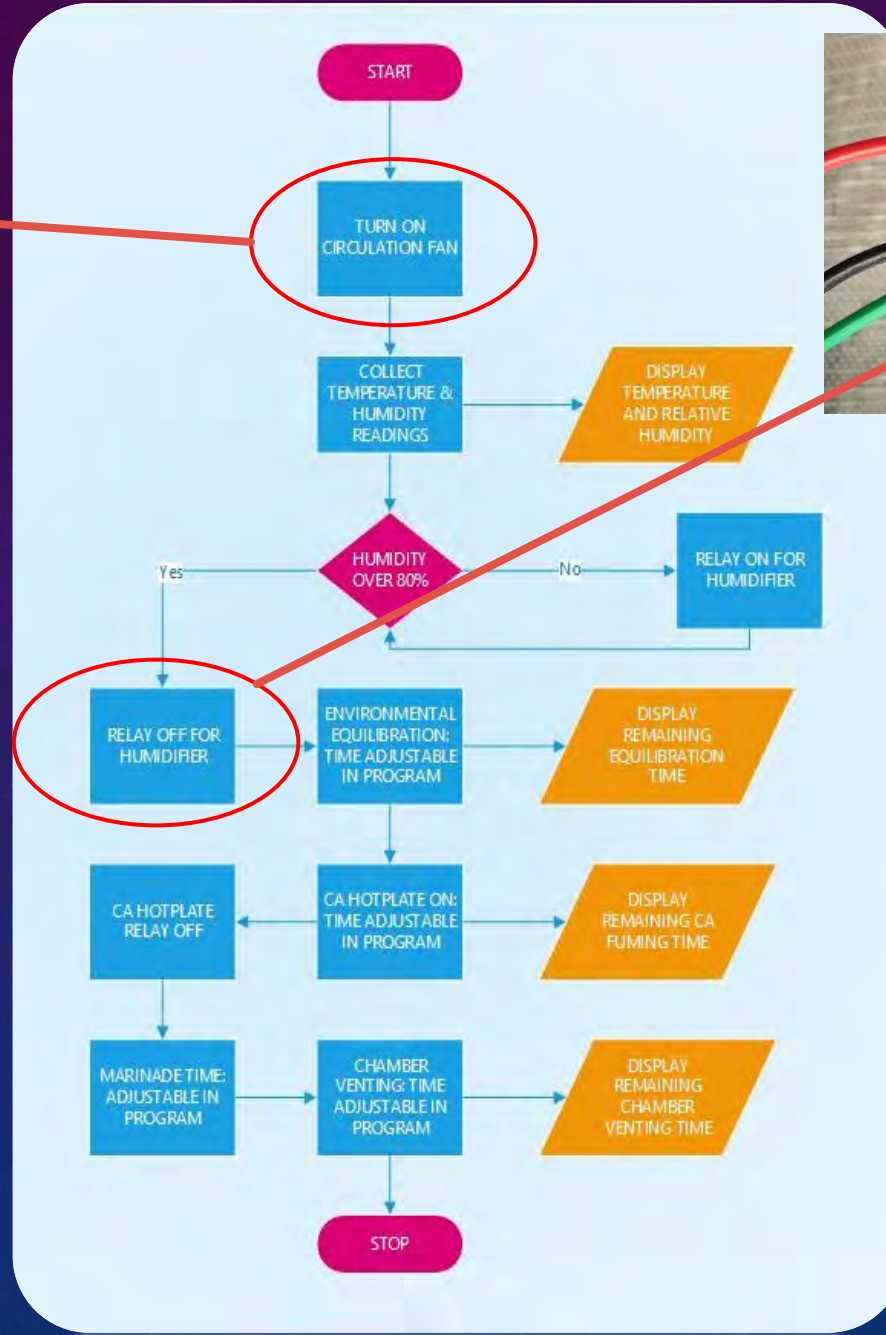
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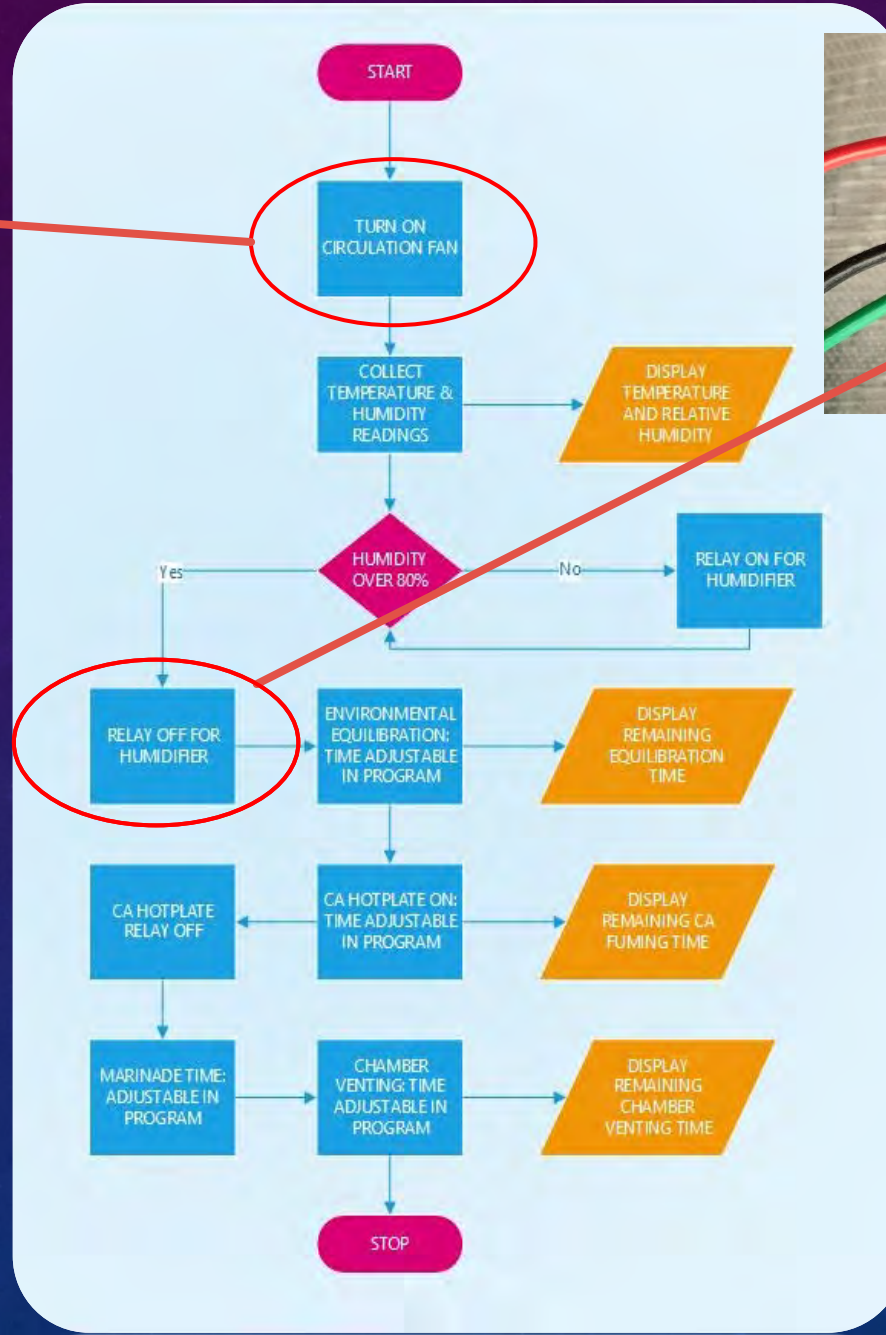
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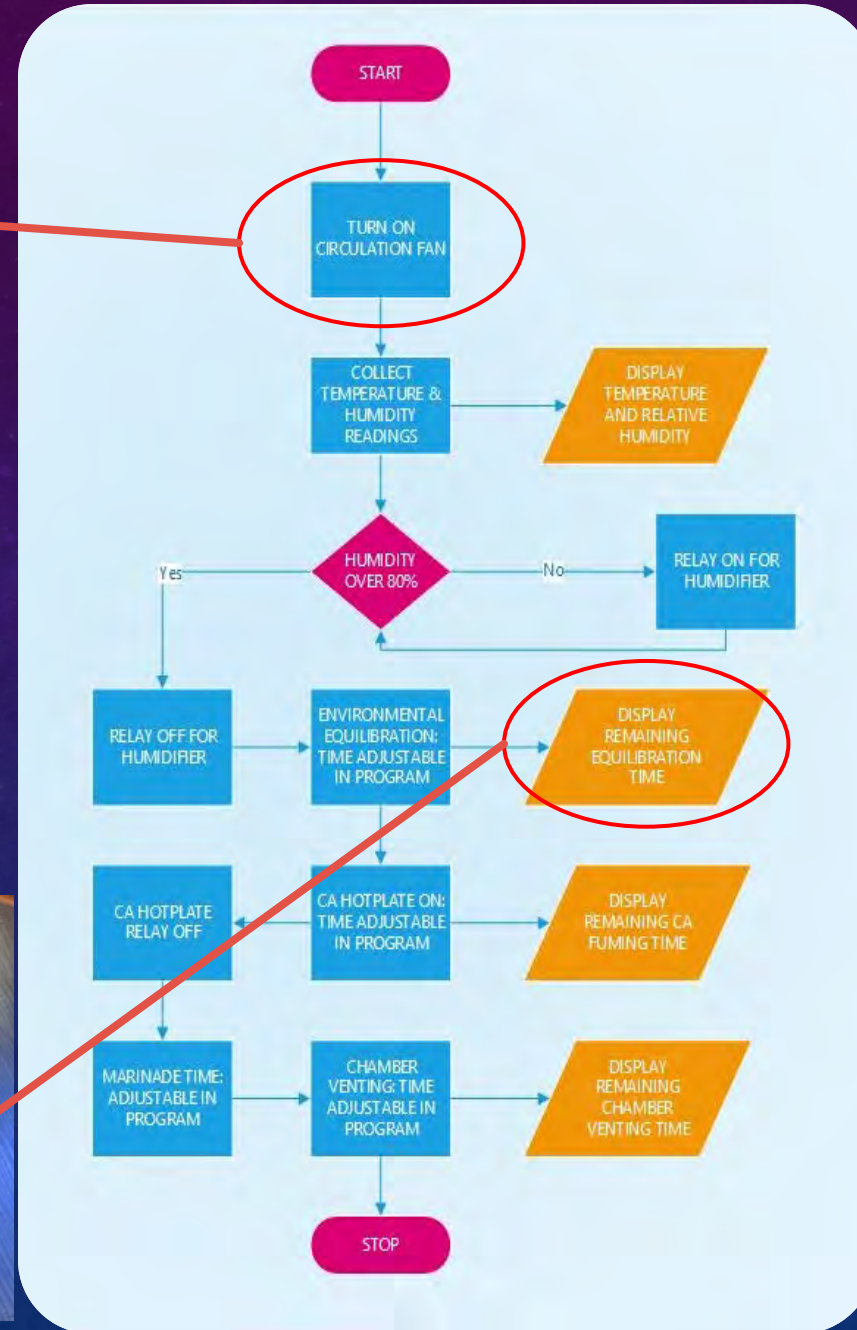
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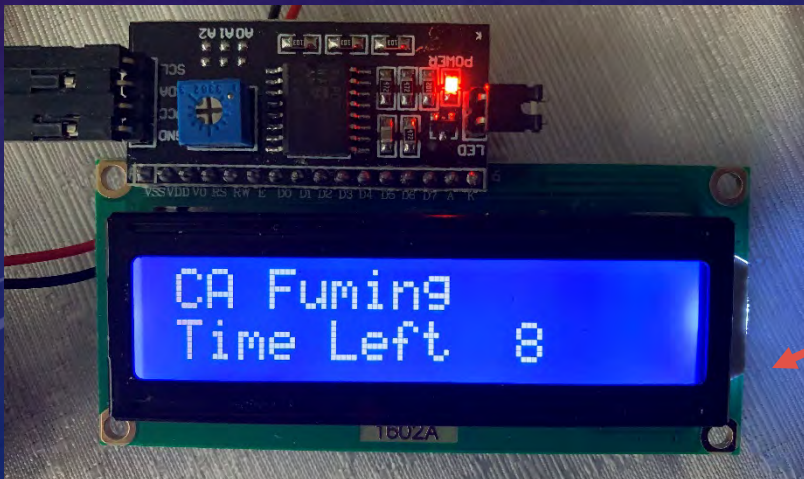
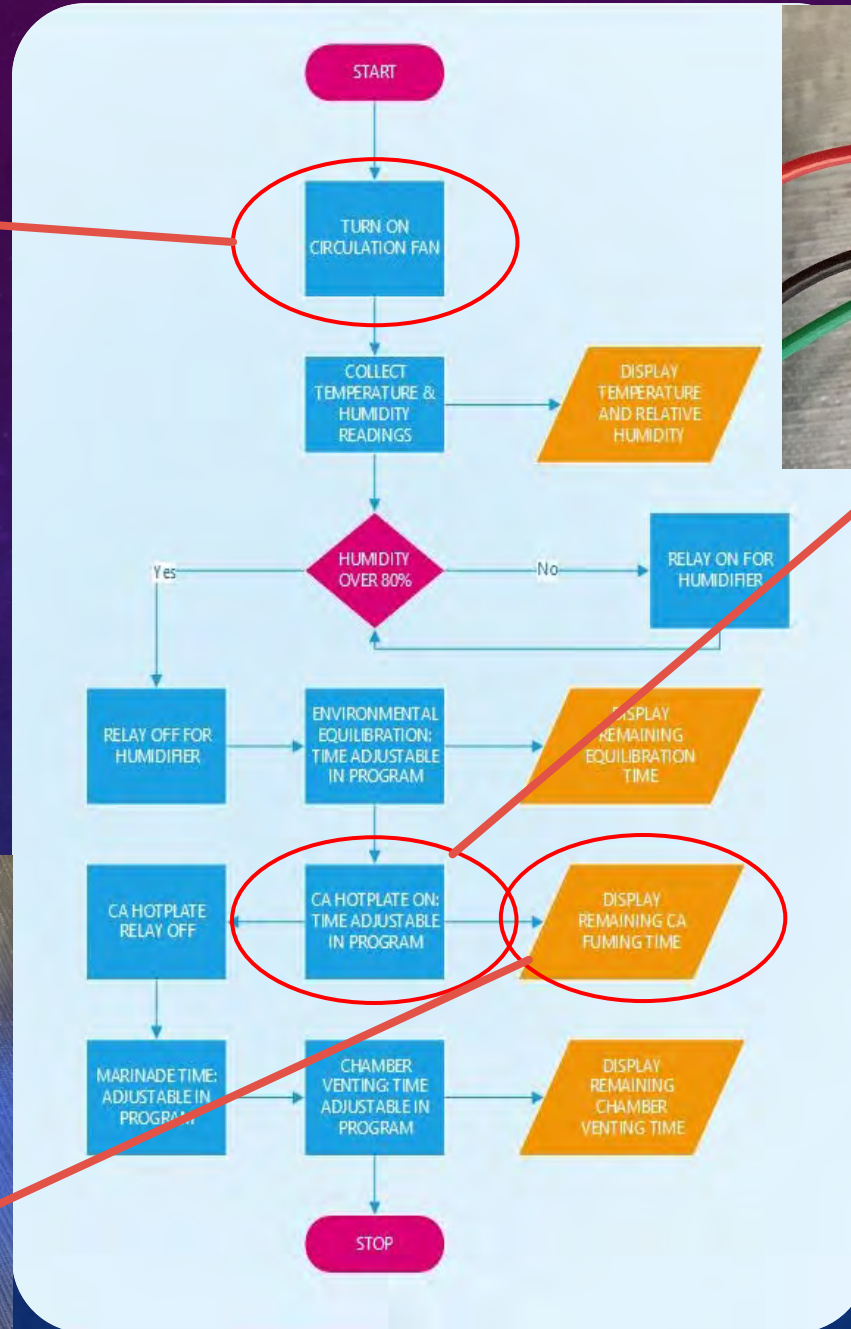
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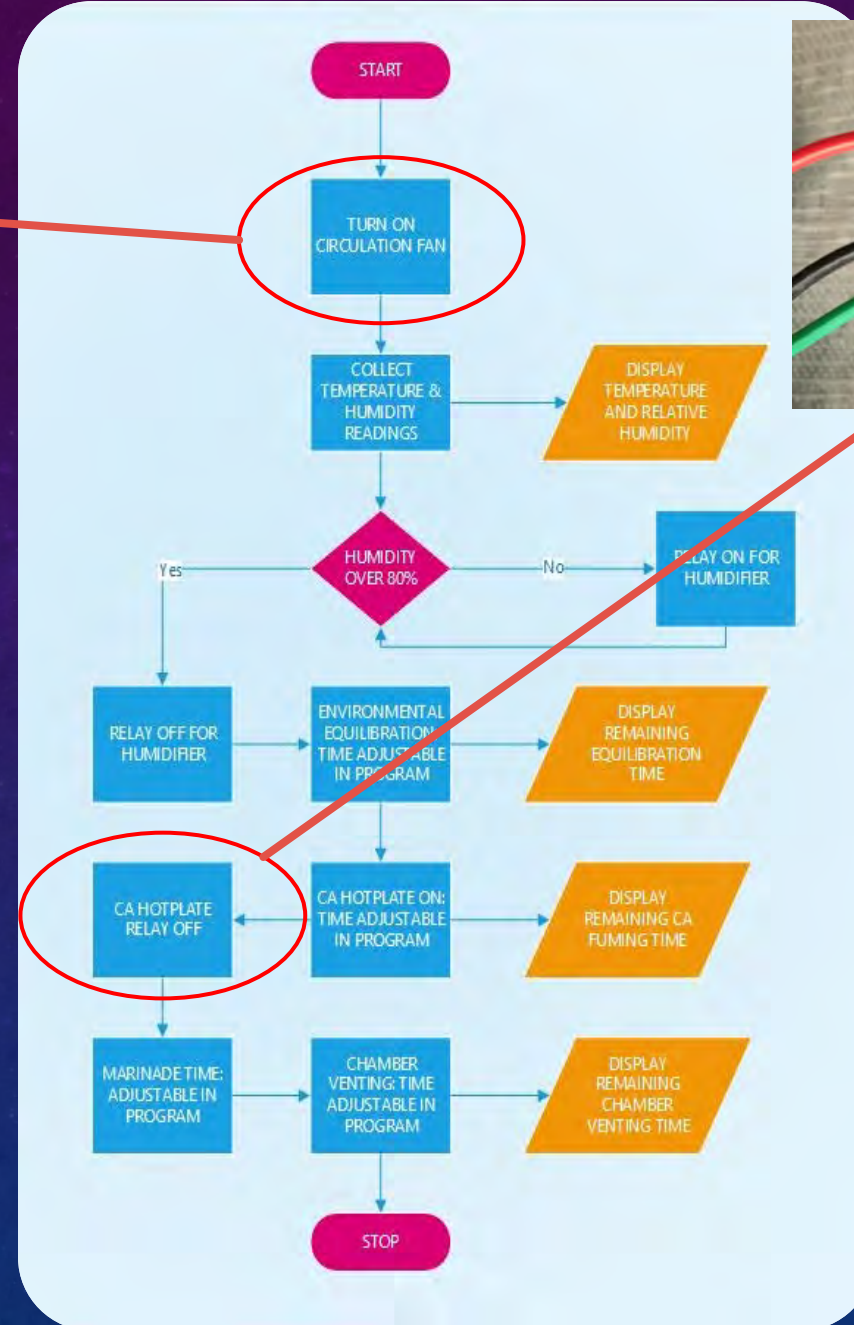
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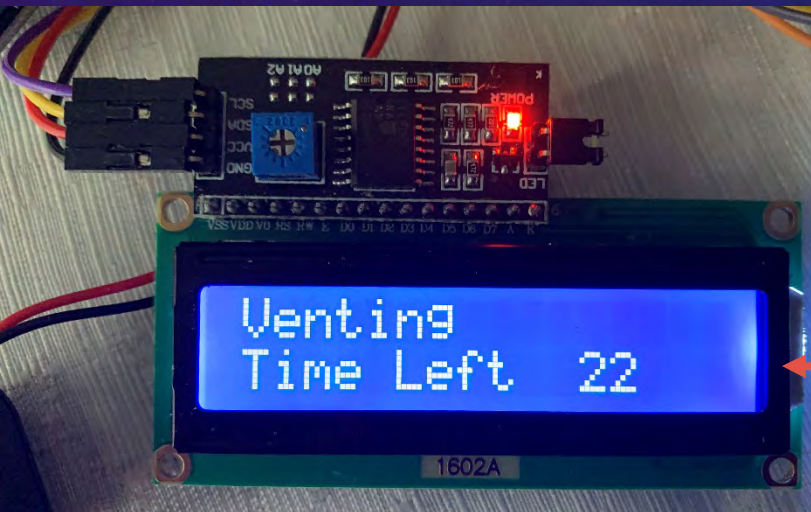
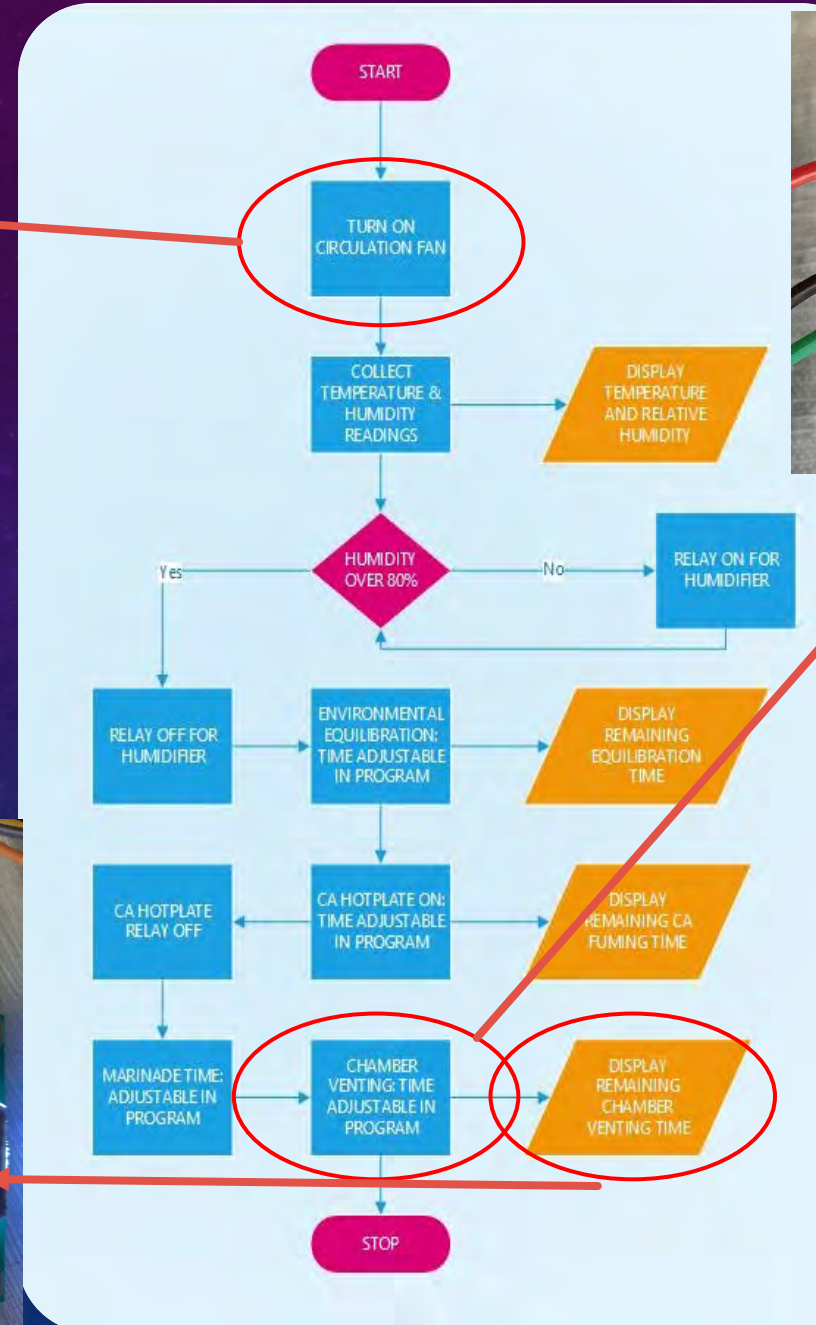
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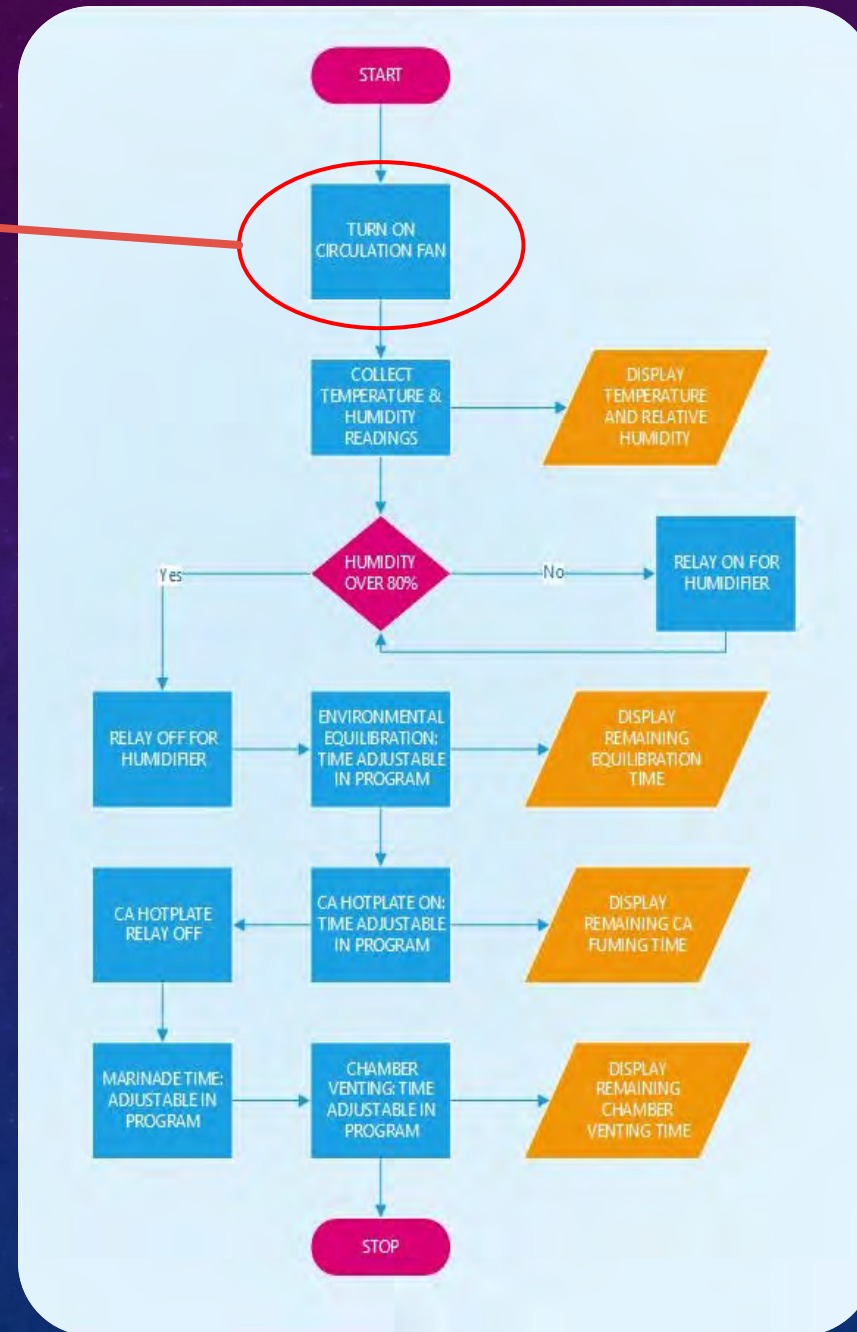
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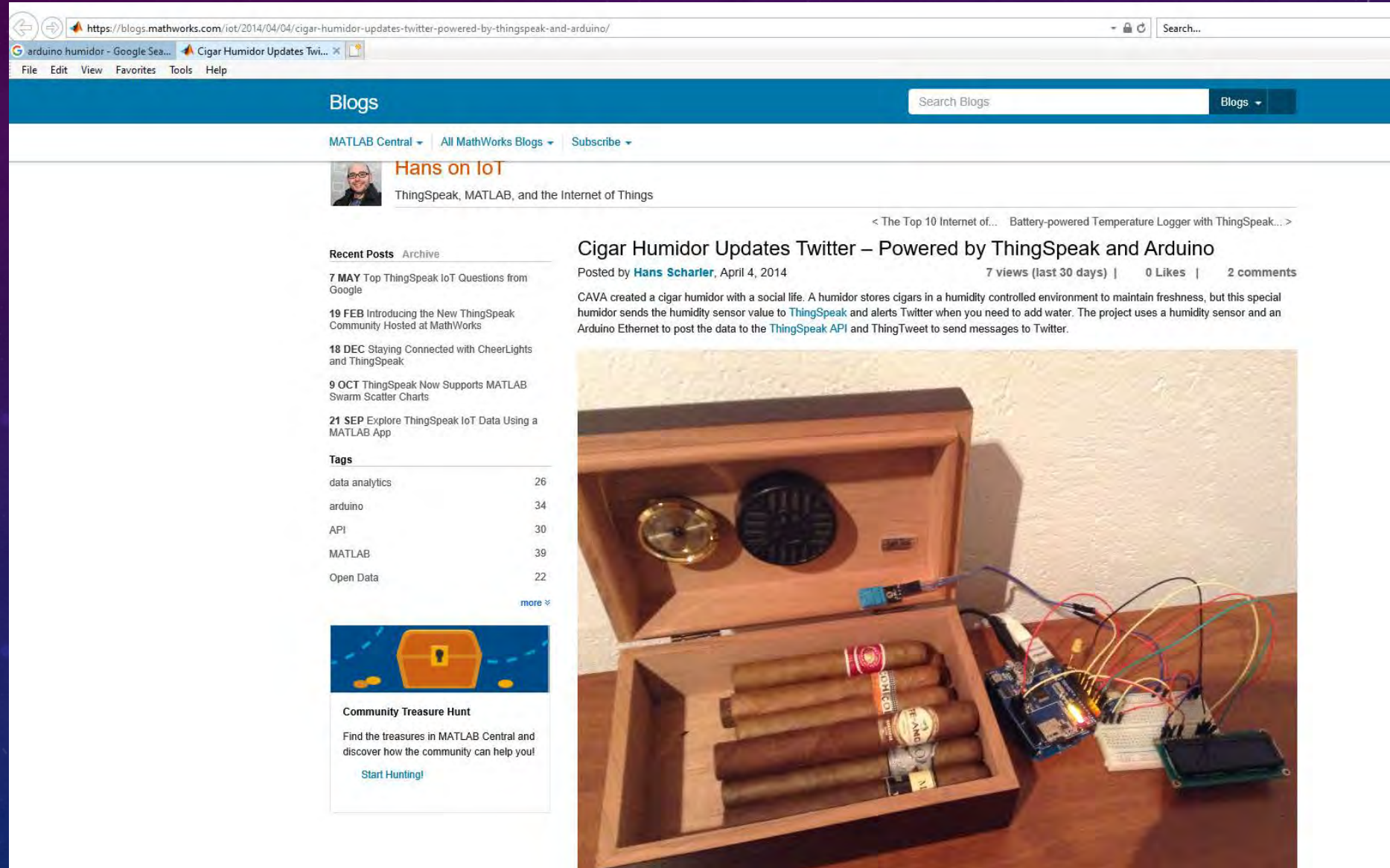


BASIC CA CHAMBER PROCESS FLOWCHART



GETTING STARTED

BUILDING A HUMIDOR AS A FIRST (OR SECOND) STEP



The image shows a screenshot of a web browser displaying a blog post on the MathWorks website. The browser's address bar shows the URL: <https://blogs.mathworks.com/iot/2014/04/04/cigar-humidor-updates-twitter-powered-by-thingspeak-and-arduino/>. The page header includes the MathWorks logo, navigation links for 'MATLAB Central', 'All MathWorks Blogs', and 'Subscribe', along with a search bar and a 'Blogs' dropdown menu.

The main content area features a profile for 'Hans on IoT' with a bio: 'ThingSpeak, MATLAB, and the Internet of Things'. Below this is a list of 'Recent Posts' with dates and titles, such as '7 MAY Top ThingSpeak IoT Questions from Google' and '19 FEB Introducing the New ThingSpeak Community Hosted at MathWorks'. A 'Tags' section lists categories like 'data analytics', 'arduino', 'API', 'MATLAB', and 'Open Data' with their respective counts.

The featured article is titled 'Cigar Humidor Updates Twitter – Powered by ThingSpeak and Arduino', posted by Hans Scharler on April 4, 2014. The article text reads: 'CAVA created a cigar humidor with a social life. A humidor stores cigars in a humidity controlled environment to maintain freshness, but this special humidor sends the humidity sensor value to ThingSpeak and alerts Twitter when you need to add water. The project uses a humidity sensor and an Arduino Ethernet to post the data to the ThingSpeak API and ThingTweet to send messages to Twitter.'

Below the text is a photograph of the project: an open wooden cigar humidor containing several cigars. An Arduino Ethernet board is connected to the humidor's internal components, including a humidity sensor and a small fan. A smartphone is also connected to the setup via a USB cable.

At the bottom of the page, there is a 'Community Treasure Hunt' section with an illustration of a treasure chest and the text: 'Find the treasures in MATLAB Central and discover how the community can help you! Start Hunting!'.

WHAT DOES ALL THIS COST?

Genuine Arduino Uno
\$21 (Amazon)

Generic Arduino Uno
\$12 (Amazon)

Electronics > Computers & Accessories



Arduino Uno REV3 [A000066]
Visit the Arduino Store
★★★★★ 2,550 ratings | 142 answered questions
Amazon's Choice for "arduino uno"

List Price: \$29.95 Details
Price: **\$21.00** Get Fast, Free Shipping with Amazon Prime & FREE Returns.
You Save: **\$8.95 (30%)**

Get \$50 off instantly: Pay \$0.00 \$24.00 upon approval for the Amazon Rewards Visa Card. No annual fee.


Available at a lower price from other sellers that may not offer free Prime shipping.

Specific Uses For Product Personal
Series Rev 3
Brand Arduino
Screen Size 1.5 Inches
Human Interface Input Buttons

About this item

- This board is your entry to the unique Arduino experience: great for learning the basics of how sensors and actuators work, and an

Electronics > Computers & Accessories > Computer Components > Single Board Computers



ELEGOO UNO R3 Board ATmega328P with USB Cable(Arduino-Compatible) for Arduino
Visit the ELEGOO Store
★★★★★ 3,867 ratings | 96 answered questions
Amazon's Choice for "elegoo uno"

Was: \$43.99 Details
Price: **\$11.99** Get Fast, Free Shipping with Amazon Prime & FREE Returns
You Save: **\$2.00 (14%)**

Get \$50 off instantly: Pay \$0.00 \$44.99 upon approval for the Amazon Rewards Visa Card. No annual fee.

Available at a lower price from other sellers that may not offer free Prime shipping.

Specific Uses For Product Personal
Model Name EL-CB-001
Operating System Windows 10
CPU Model Cortex
Brand ELEGOO

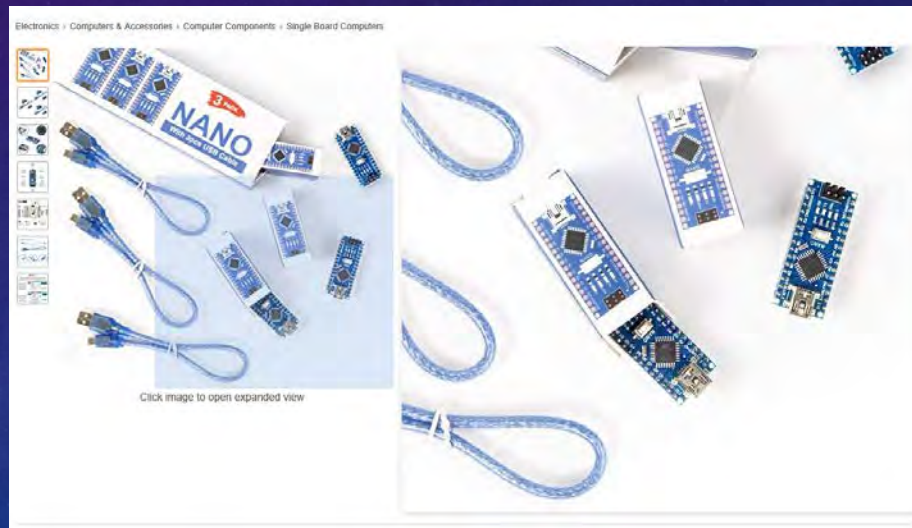
About this item

WHAT DOES ALL THIS COST?

Genuine Arduino Nano
\$21 (Amazon)



Generic Arduino Nano
< \$5 Each (Amazon)



WHAT DOES ALL THIS COST?

DHT 22 Temp and Humidity
\$7 (Amazon)



HiLetgo 2pcs DHT22/AM2302 Digital Temperature And Humidity Sensor Module Temperature Humidity Monitor Sensor Replace SHT11 SHT15 for Arduino Electronic Practice DIY

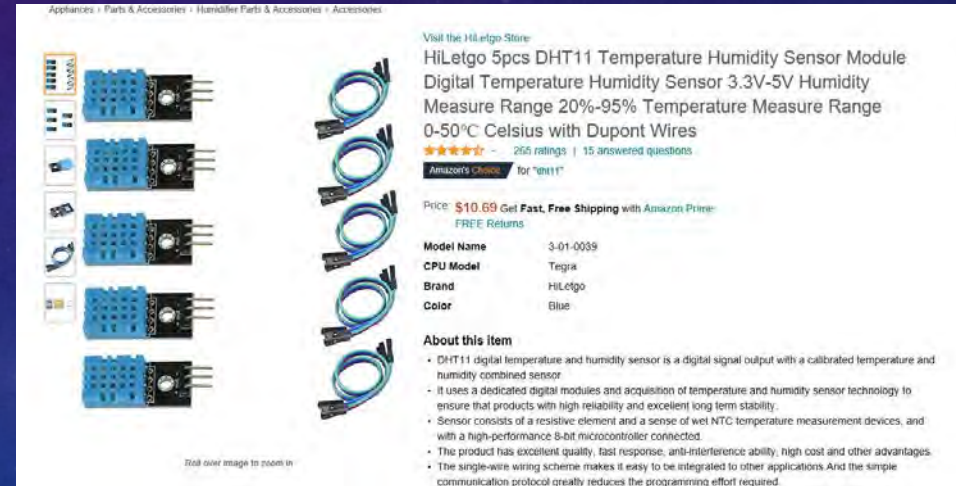
Price: **\$14.49** (\$7.25 / Count) Get Fast, Free Shipping with Amazon Prime & FREE Returns.

Size: **2 Count (Pack of 1)**

- 1PC: \$8.49 (\$8.49 / Count)
- 2 Count (Pack of 1): \$14.49 (\$7.25 / Count)**

- Main Chip: AGSONG AM2302 High Sensitive Temperature Humidity Sensor
- Single-bus digital signal output, bidirectional serial data
- With fixing screw hole, convenient to install and fixed
- Temperature range: -40 to 80 degree celsius, Temperature measurement accuracy: +/- 0.5°C degree celsius
- Humidity measuring range: 0-100%RH, Humidity measurement accuracy: ±2% RH

DHT 11 Temp and Humidity
\$2 Each in bulk (Amazon)



HiLetgo 5pcs DHT11 Temperature Humidity Sensor Module Digital Temperature Humidity Sensor 3.3V-5V Humidity Measure Range 20%-95% Temperature Measure Range 0-50°C Celsius with Dupont Wires

Price: **\$10.69** Get Fast, Free Shipping with Amazon Prime & FREE Returns

Model Name: 3-01-0039

CPU Model: Tegra

Brand: HiLetgo

Color: Blue

About this item

- DHT11 digital temperature and humidity sensor is a digital signal output with a calibrated temperature and humidity combined sensor
- It uses a dedicated digital modules and acquisition of temperature and humidity sensor technology to ensure that products with high reliability and excellent long term stability.
- Sensor consists of a resistive element and a sense of wet NTC temperature measurement devices, and with a high-performance 8-bit microcontroller connected.
- The product has excellent quality, fast response, anti-interference ability, high cost and other advantages.
- The single-wire wiring scheme makes it easy to be integrated to other applications. And the simple communication protocol greatly reduces the programming effort required.

WHAT DOES ALL THIS COST?

1602 Display with I2C
\$10 (Amazon)



Electronics > Computers & Accessories > Computer Components > Single Board Computers

JANSANE 16x2 1602 LCD Display Screen Blue + IIC I2C Module Interface Adapter for Raspberry pi 2 Pack
Brand: JANSANE
★★★★★ 119 ratings | 3 answered questions

Price: **\$9.99** Get **Fast, Free Shipping** with Amazon Prime & FREE Returns

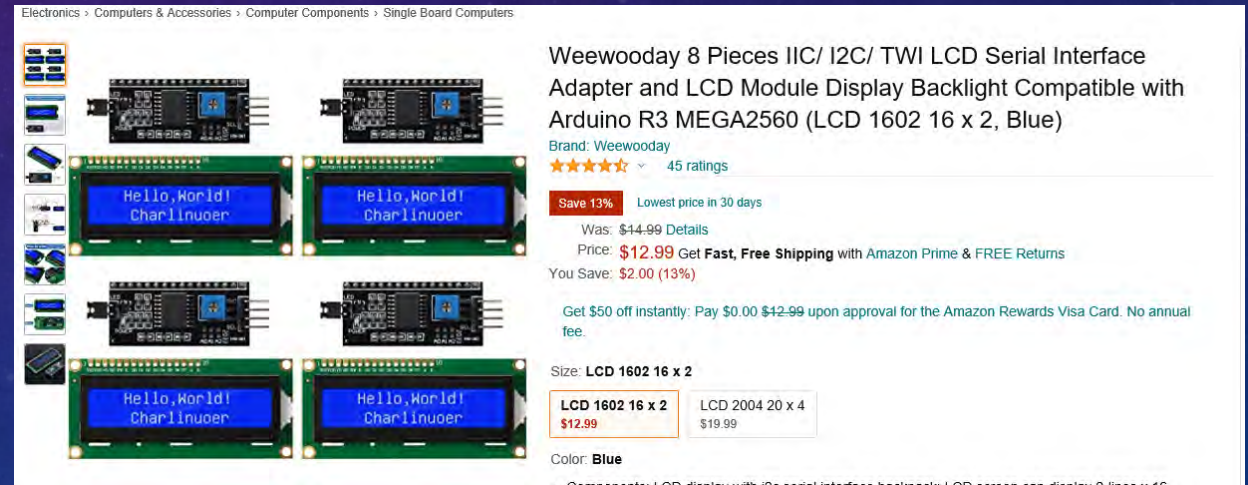
Get \$50 off instantly. Pay \$0.00 \$9.99 upon approval for the Amazon Rewards Visa Card. No annual fee.

Color: **1602 LCD**

\$9.99 ~~\$16.99~~

- Components: Blue 16x2 1602 lcd display + I2C serial interface backpack; 1602 lcd screen can display 2-lines x 16-characters with built-in industry standard HD44780 equivalent LCD controller;
- Default Address: 0x27 for PCF8574T chip; 0x3F for PCF8574AT chip. Please check which chip you have on I2C interface. (Before you upload the code to the control board, please download the LiquidCrystal_I2C library).
- Four Pins: VCC, GND, SDA and SCL used for connecting Dupont Line or IIC dedicated cable.
- Display Function: Can be used to display real time clock, temperature, humidity etc. (A potentiometer is also necessary to adjust the contrast. Working Voltage: Only 5V.)
- Wide Application: Commonly used in copiers, fax machines, laser printers, industrial test equipment and networking equipment such as routers and storage devices.

1602 Display with I2C
\$3 Each in bulk (Amazon)



Electronics > Computers & Accessories > Computer Components > Single Board Computers

Weewooday 8 Pieces IIC/ I2C/ TWI LCD Serial Interface Adapter and LCD Module Display Backlight Compatible with Arduino R3 MEGA2560 (LCD 1602 16 x 2, Blue)
Brand: Weewooday
★★★★★ 45 ratings

Save 13% Lowest price in 30 days

Was: ~~\$14.99~~ Details
Price: **\$12.99** Get **Fast, Free Shipping** with Amazon Prime & FREE Returns
You Save: **\$2.00 (13%)**

Get \$50 off instantly. Pay \$0.00 \$12.99 upon approval for the Amazon Rewards Visa Card. No annual fee.

Size: **LCD 1602 16 x 2**

LCD 1602 16 x 2 \$12.99	LCD 2004 20 x 4 \$19.99
--	----------------------------

Color: **Blue**

- Components: LCD display with I2C serial interface backpack; LCD screen can display 2 lines x 16

WHAT DOES ALL THIS COST?

lot Relay

\$30 (Amazon)


5 V Relay with optocoupler

\$2 Each in bulk (Amazon)

*** Dangerous ***

*** Use Extreme Caution ***

Electronics > Computers & Accessories > Computer Components > Single Board Computers



lot Relay - Enclosed High-Power Power Relay for Arduino, Raspberry Pi, PIC or WiFi, Relay Shield

Brand: Digital Loggers

★★★★★ 952 ratings | 147 answered questions

Amazon's Choice for "lot relay"

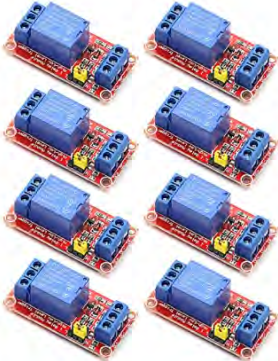
Price: **\$29.95** & FREE Returns

Get \$50 off instantly: Pay \$0.00 \$29.95 upon approval for the Amazon Rewards Visa Card. No annual fee.

- Safe, Reliable Power Control
- One circuit, 4 outlets, 2x NC, 2x NO
- Wires to your Arduino, Raspberry Pi, PIC, or other micro
- Takes the place of a relay board. Fully assembled and ready to use.
- Includes surge suppression, debounce, safety breaker

New (4) from **\$29.95** & FREE Shipping.

Industrial & Scientific > Industrial Electrical > Controls & Indicators > Relays



DaFuRui 8Pcs DC 5V 1 Channel Relay Module Board Shield with Optocoupler Support High/Low Level Trigger Compatible for Arduino

Visit the DaFuRui Store

★★★★★ 71 ratings

Amazon's Choice for "5v relay"

Price: **\$14.99** Get Fast, Free Shipping with Amazon Prime & FREE Returns

Color: **1 Channel 5V**

12V	\$12.99	5V	\$14.99	12V	\$11.99	5V	\$12.99	5V	\$12.99
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Brand: DaFuRui

Contact Type: Normally Open, Normally Closed

Current Rating: 10 Amps

Maximum Switching Current: 10 Amps

About this item

- ★This Relay Board Maximum load: AC 250V/10A, DC 30V/10A With power and relay action indicator.

WHAT DOES ALL THIS COST?

High-end Build Cost

Luxury Edition	
Arduino Uno	\$ 21.00
DHT 22 Temp and Humidity Sensor	\$ 7.00
1602 Display with I2C	\$ 10.00
IOT Relay (x 3)	\$ 90.00
Wires and Miscellaneous	\$ 20.00
Chamber	\$ 200.00
Coffee Cup Warmer	\$ 12.00
Vent with Carbon Filtration	\$ 150.00
Humidifier	\$ 20.00
TOTAL	\$ 530.00

Low-end Build Cost

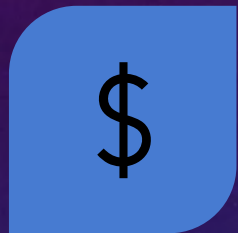
Poor Man's Version	
Generic Nano	\$ 5.00
DHT 22 Temp and Humidity Sensor	\$ 2.00
1602 Display with I2C	\$ 3.00
Cheap Chinese Relay (x 3)	\$ 6.00
Wires and Miscellaneous	\$ 10.00
Broken beverage Refrigerator	\$ -
Coffee Cup Warmer	\$ 12.00
Old Vacuum Cleaner for vent	\$ -
Used humidifier	\$ 10.00
	\$ 48.00

SO WHY BUY WHEN I CAN DIY?



BUILDING A UNIT YOURSELF
IS TIME CONSUMING. YOUR
TIME HAS A MONETARY
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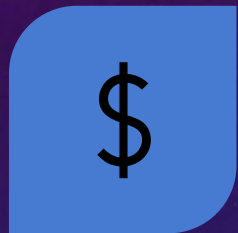


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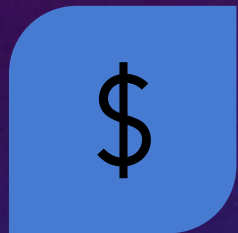


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DIY UNITS WILL PROBABLY LACK MANY OF THE SAFETY FEATURES ASSOCIATED WITH A COTS UNIT

The background is a gradient from dark purple to dark blue, overlaid with faint technical diagrams. These include circular gauges with numerical scales (e.g., 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260) and various circular patterns, some solid and some dashed, with arrows indicating direction. A large, solid white circle is positioned on the right side of the image, partially overlapping the background.

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BUILD ONE?

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If something breaks, the repair cost is minimal

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Addition of a data logger to monitor environmental conditions.

OTHER POSSIBLE ARDUINO BUILDS FOR A LAB



Humidity chamber for Ninhydrin (an easier starting build – Think Humidor)

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Environmental monitors
and data loggers

- Temperature (Refrigeration and ambient)
- Air quality dust, humidity

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- Temperature (Refrigeration and ambient)
- Air quality dust, humidity



Automation of repetitive processes, like dispensing and transferring of liquids

GETTING STARTED

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Have patience. This is like learning any language. At first it seems difficult, but with some practice, you can easily pick up the parts needed to get by.

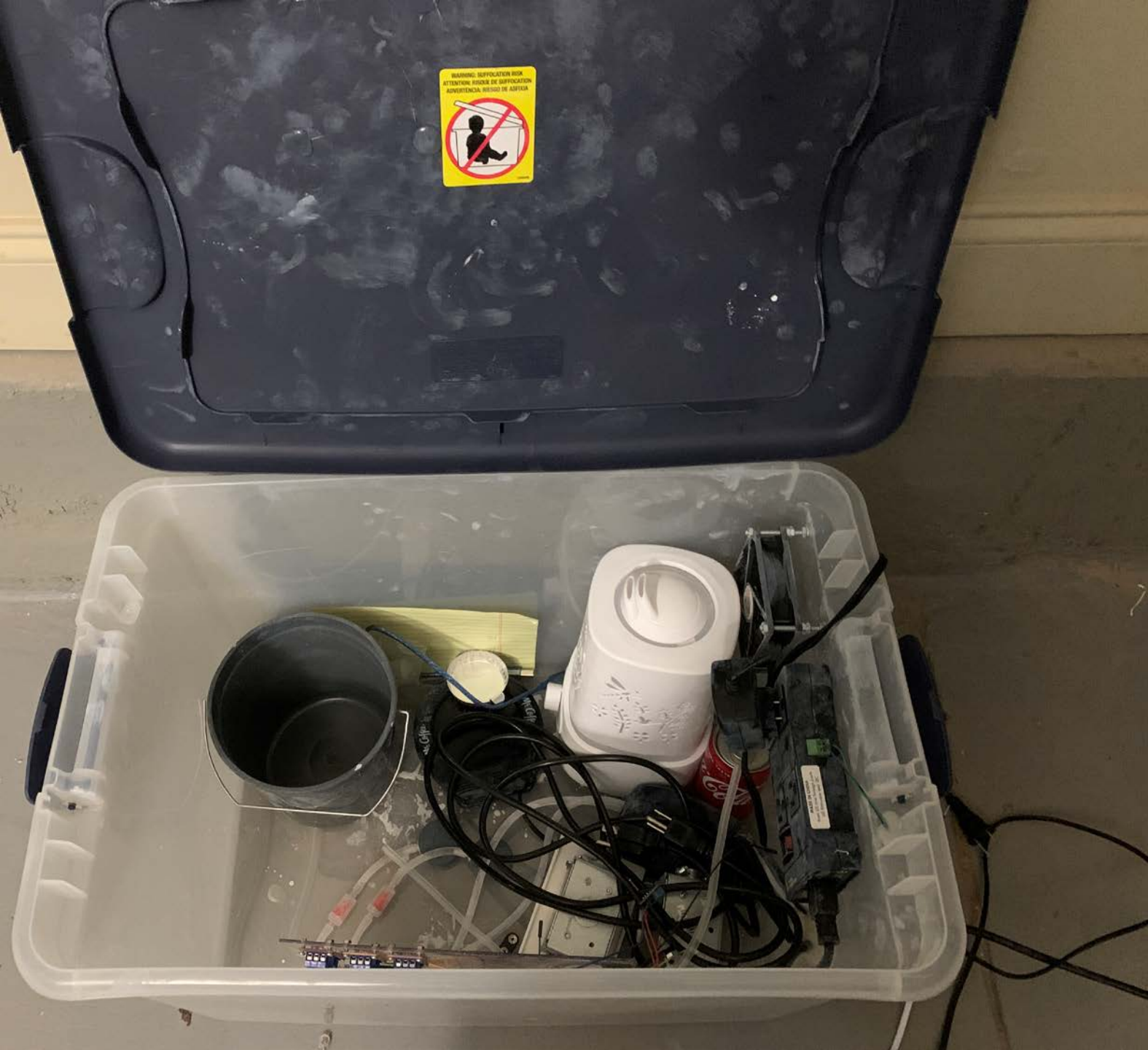


Roll over image to zoom in

ALTERNATIVE TO ARDUINO (RASPBERRY PI)

- A full computer, not just a microprocessor
- Fits in the palm of your hand
- Runs on Python, not C/C++
- Built in ports (USB 2.0,3.0; Wi-Fi, Bluetooth, micro-HDMI)
- More expensive
- Better for more complex projects

- Image source: [amazon.com](https://www.amazon.com)



THE WORKING PROTOTYPE

- Clay Allred
- Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF)
- Forensic Science Laboratory – Atlanta