Wind Speed Measurer

HOTWIRE ANEMOMETER

EEE 312- PROJECT

UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION

140141042 | UYGAR TOLGA KARA | EEE 312 | 25/07/2018

Introduction

This project is basically a hotwire anemometer. There is a probe resistor and a normal resistor in this circuit. The resistance of probe resistor changes with temperature. At the same time if wind passes through a resistor the temperature around resistor changes and with that change the resistance of the resistor changes. If we construct a voltage divider area and measure the change at the voltage (which changes with probe resistance change), there is a way to measure wind speed accurate enough with the resistance change. This project is accurate enough project, there are some errors in times.

Similarities With the Professional Anemometers

There are many wind speed measurers in many places. One of them looks like:

Figure 1- Professional Wind Speed Measurer

Now this looks very different from the measurer in this project. This measurer is named as tachometer as well. In my opinion this system looks like using a fan to try to measure the force that turns the fan and using the relation between force and wind speed. This device costs 35.67 dollars. Thinking 1 dollar is nearly 5 Liras, I guess we can

build a cheaper, accurate enough. There are other modes as well but I am planning to talk about related modes. So this looks very different than the anemometer in this project. What looks like it?

Figure 2- Professional Wind Speed Measurer 2

No, this looks different as well. But we are coming closer. In this measurer in my opinion the device tries to measure the wind speed with the applied force with the wind. The top area turns with the wind power. This device costs 129.60 euros. We can build an accurate enough wind speed measurer with less money. Can we find a more similar one if we try harder?

Figure 3- Professional Windspeed Measurer 3

Yes, this is actually very similar with the measurer in this project. They work with similar principle. If we remove the left part and insert another 16*2 1602A Lcd, the measurer looks more similar. Now, starting analyzing the device. At the right part there is a probe resistor. The resistance changes with the wind speed. It is a professional device but there is an error of course. At the left part there is an LCD, a battery area (9V supply), interface buttons, yellow opening or closing button and other parts. There is some modes, codes etc. At the basic principle the device gets some values at the probe and turns the value to the some values(wind speed, air pressure etc.) with some arithmetic operations I think. So there is a relation between that values. I did not look at that device's cost but I think before some time I saw a professional hotwire anemometer which costs nearly 1000 dollars or something like that. We can build cheaper anemometer.

PROJECT RECOMMENDATIONS

In introduction area I kind of explained the principle of the project. At the project building phase there are some advices I want to give. I hope these advices helps people before building the project.

- Make sure to use ideal equipment. At soldering phase I advise to use a clean soldering equipment with ideal thick soldering material.
- Do not give up. In case of some hard situations at testing the project keep trying and try to find what is wrong at the project.
- Use a LCD which is soldered to the header set. Test the LCD before testing the probe and value transformation.
- Use a wind source that you know the wind speed of. One of the other ways is to use a wind source that you know wind speed closely. Also using professional equipment(if a person can get) to measure the wind speed or calibrating the project at a wind speed known location.
- If you do not know soldering learn soldering by a professional or videos etc. Be careful to take security measures before soldering or probe preparing. For example using gloves is recommended.
- If you feel like there are parts with human mistakes at the project, preparing a new project is advised.

COMPONENTS

The required components for this project are as follows:

1. STM32F401 board (or Arduino Uno, Arduino Mega etc.)
2. Board USB cable
3. 1602A LCD (16*2 LCD for example)
4. 10K potentiometer(or 5K, 1K etc. The finetuning changes with the value)
5. Nearly 10 Ohm Resistor (Brown, Black, Black, Gold color code)
6. Jumper Cables (M-M and M-F)
7. Copper Plates with Holes
8. Old Type Lamp(s)
9. Breadboard(s)
10. A material to connect probe and electric bands for connecting
11. Soldering Equipment

If we take a look at the components picture by picture:

1) STM32F401 NUCLEO-64

There are many properties of this microcontroller. Also coding part of this microcontroller is not that hard. There are many technical properties as well. This board contains many properties however this project can be done in Arduino Uno, Arduino Mega, Arduino Robot and many more boards.

Figure 4- STM32F401 Nucleo-64 Front Side

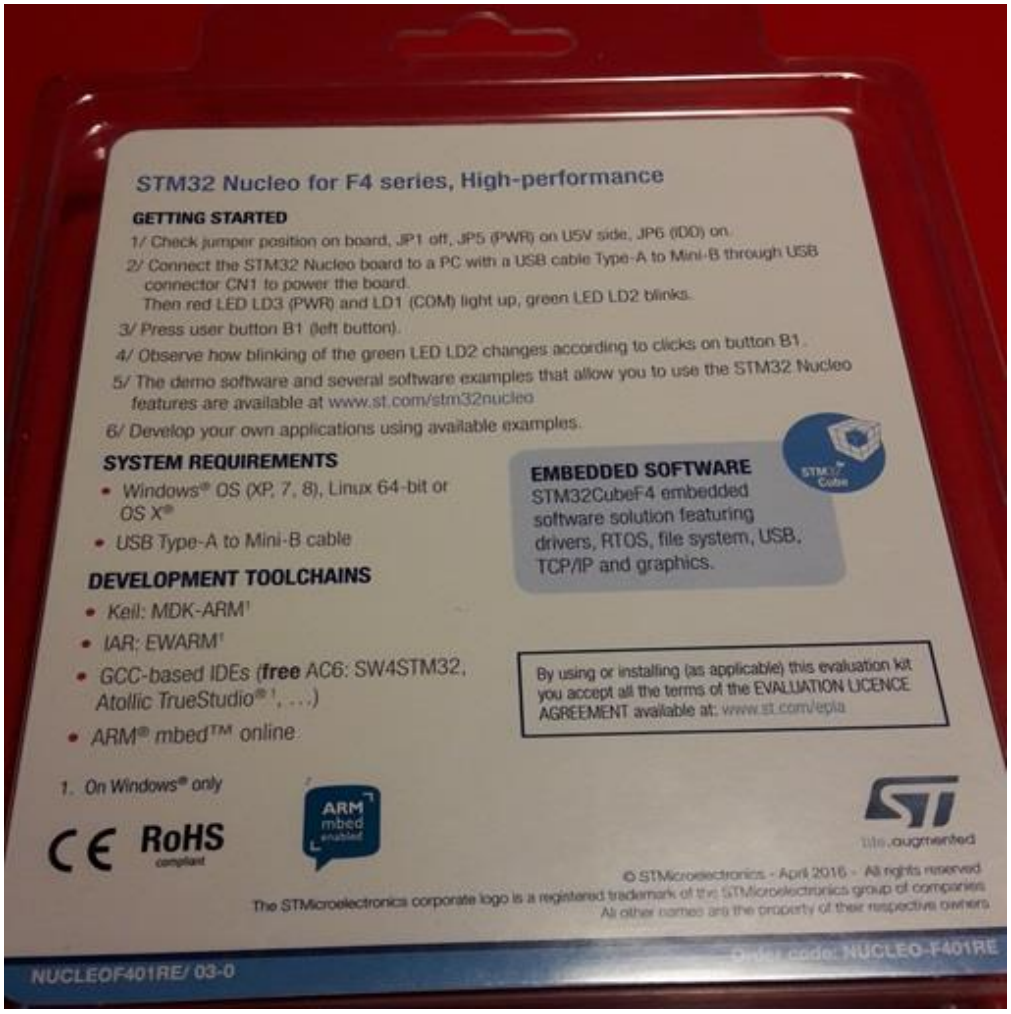


Figure 5- Backside of the F401 microcontroller

We can see that there are technical details on the label. In my opinion there are many similarities with Arduino Uno board. In this project, I used couple differences. If we remove the board, we get the following pin diagram:

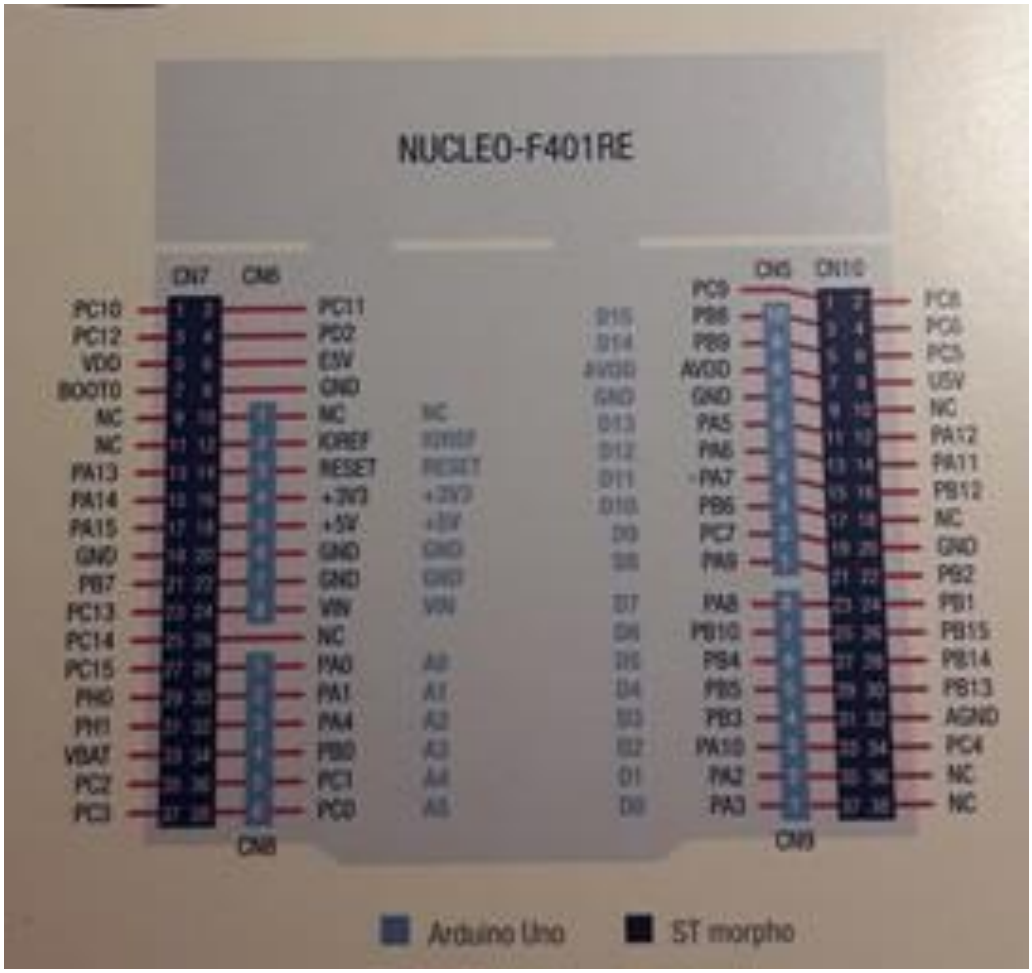


Figure 6- Pin diagram of the microcontroller

If we look at the board:

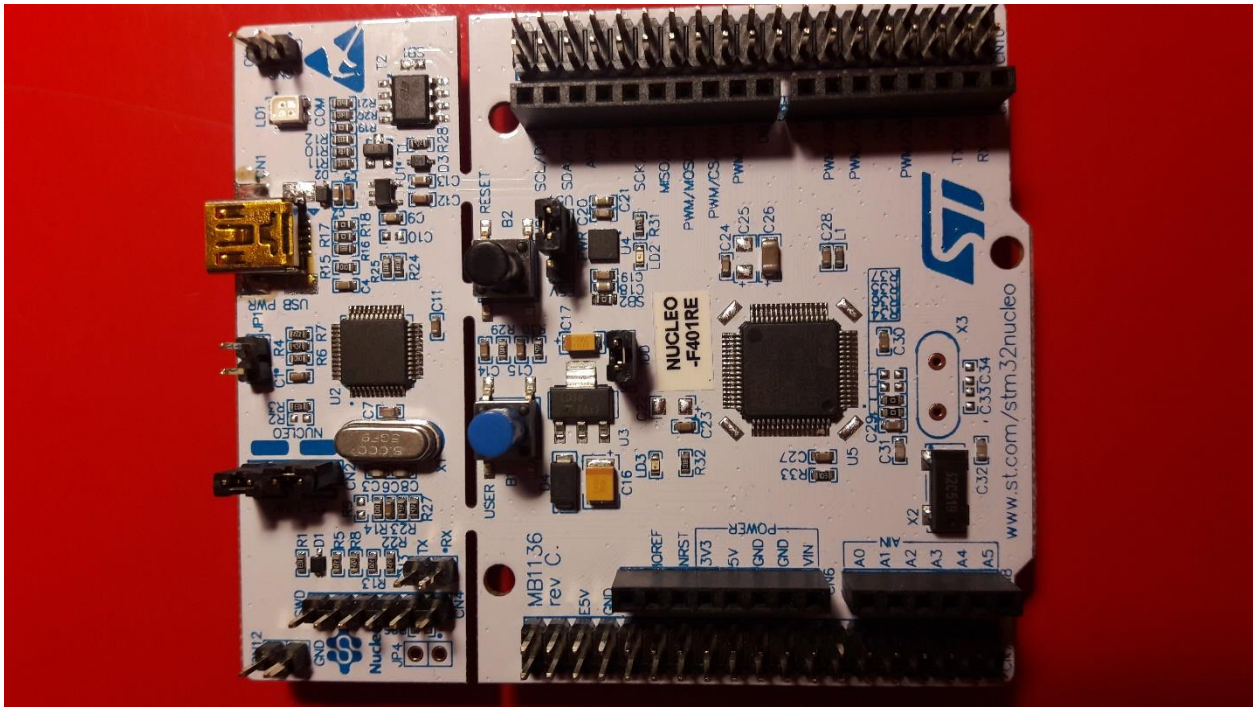


Figure 7- The NUCLEO -F401RE Board

There are many parts on this microcontroller. But after opening the package, we need to do the instructions at figure 5.

a) We need to make sure there are no black jumpers connected at JP1.
b) We need to connect the JP5 on U5V side. (Connecting two points)
c) We need to make sure black jumper is on JP6. (Connected not removed

Now after these steps, we need to buy a USB cable Type-A . The USB cable connected board looks like:

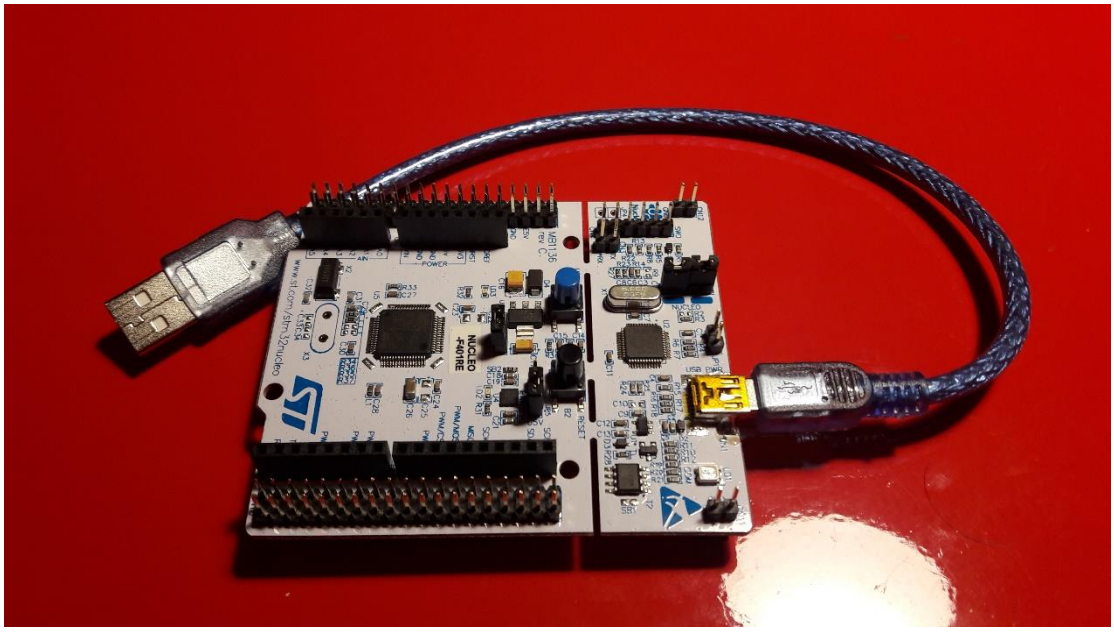


Figure 8- Usb Cable Connected Board

Tip: Going into the store with the F401RE board to find the usb cable and trying the cable in the store is my suggestion.

After connecting the Usb cables we need to connect the USB cable into the computer. If the red LED LD3 and LD1 light up and green LED LD2 blinks, the board works without problem. If there is no problem, pressing user button B1 is step 3. Observing the change in blinking with the button situation is at step 4. If all these steps are completed, we need to start connecting.

Also about drivers and setting up the board in PC, I am passing that step.

2) 10 OHM RESISTOR

In this project, I used 3 resistors with values nearly as:

Figure 9- Used resistors at the project

3) 1K OHM POTENTIOMETER

Also 5K, 10K potentiometers are compatible with this project as well. In this project I used a 1K potentiometer.

Figure 9- 10K Ohm Potentiometer (I used 1K pot. But I recommend 10K pot here.)

4) 1602A LCD AND HEADER SET

We need this part to show the values we get from the probe. The header set is also required.

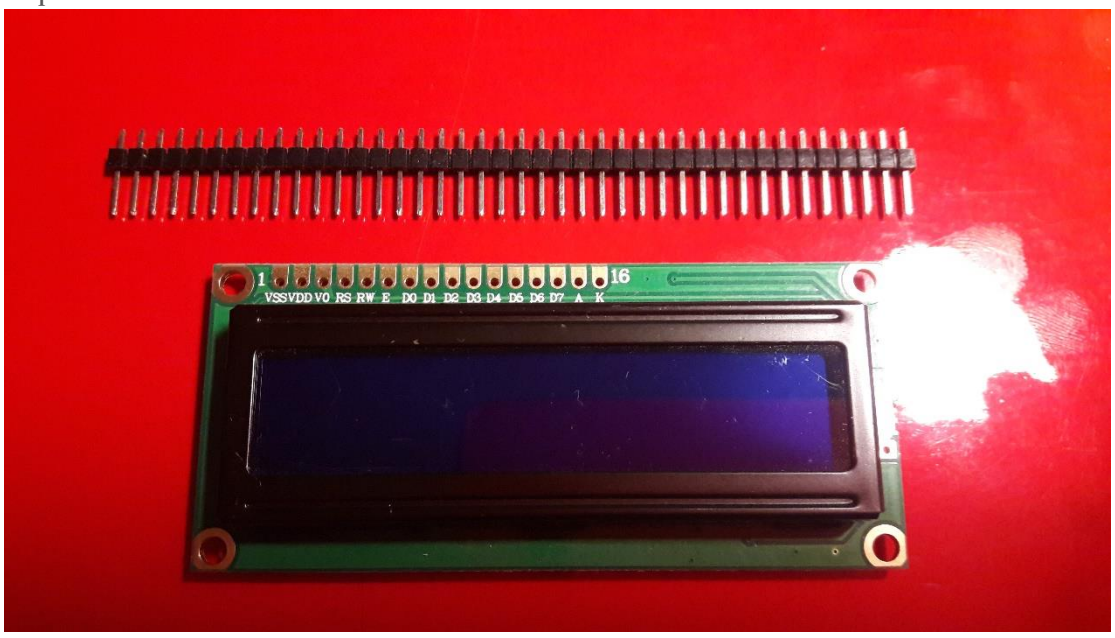


Figure 10- 1602 A LCD with Header Set

5) BREADBOARD

We need breadboard to build the project and simulate it.

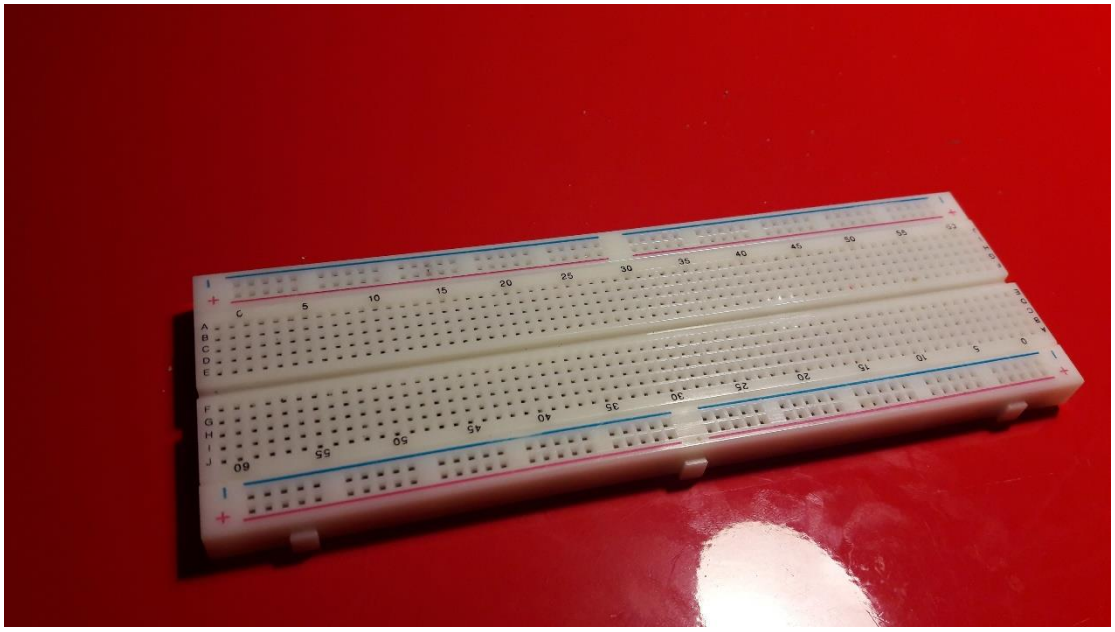


Figure 11- Breadboard

6) JUMPER CABLES

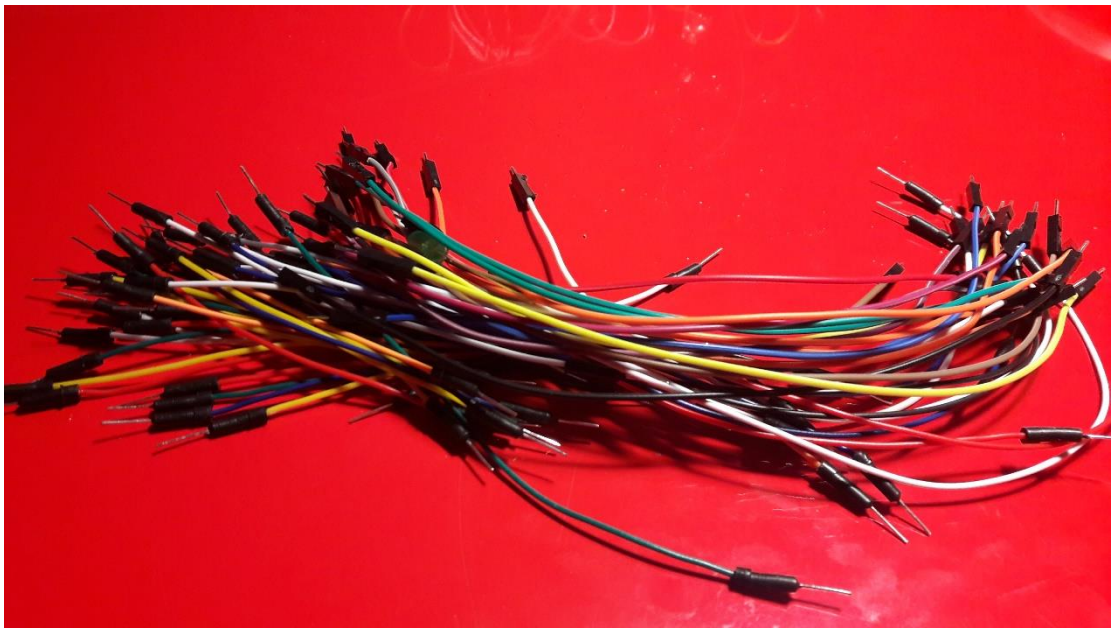


Figure 12- Jumper Cables

7) LAMP

We need a lamb to get the tungsten wire inside it. We especially need an old type lamp where the wires are open in the glass.

Figure 13- Open tungsten wired lamp

8) SOLDERING EQUIPMENT

Figure 14- Soldering Equipment

There are soldering iron, pump, sponge, copper plate with holes and soldering wire. Do not touch soldering iron when plugged. It is very hot and do not touch the soldering iron when plugged.

Building The Project

! Before continuing I built the project with these building steps but I think I did something wrong in the project, the measuring was with some more errors than the other project I finished I think. So the project can be done with these steps as well, but please do know that I removed switches. Even though I went for a new project, in my opinion these steps are legit for building a hotwire anemometer when done with no mistakes. Continuing to the steps that I wrote about: (Some of them)

We need to complete the soldering between header set and LCD. There are many videos about soldering an LCD. To solder we need the soldering set as explained before. A soldered LCD looks as the following:

Figure 15- Soldered 1602A LCD

After completing this step we need to start connecting the pieces together in a breadboard. If we go step by step:

A. Connecting Ground and 5V Onto Breadboard:

We connect two jumper cables at close locations onto breadboard.

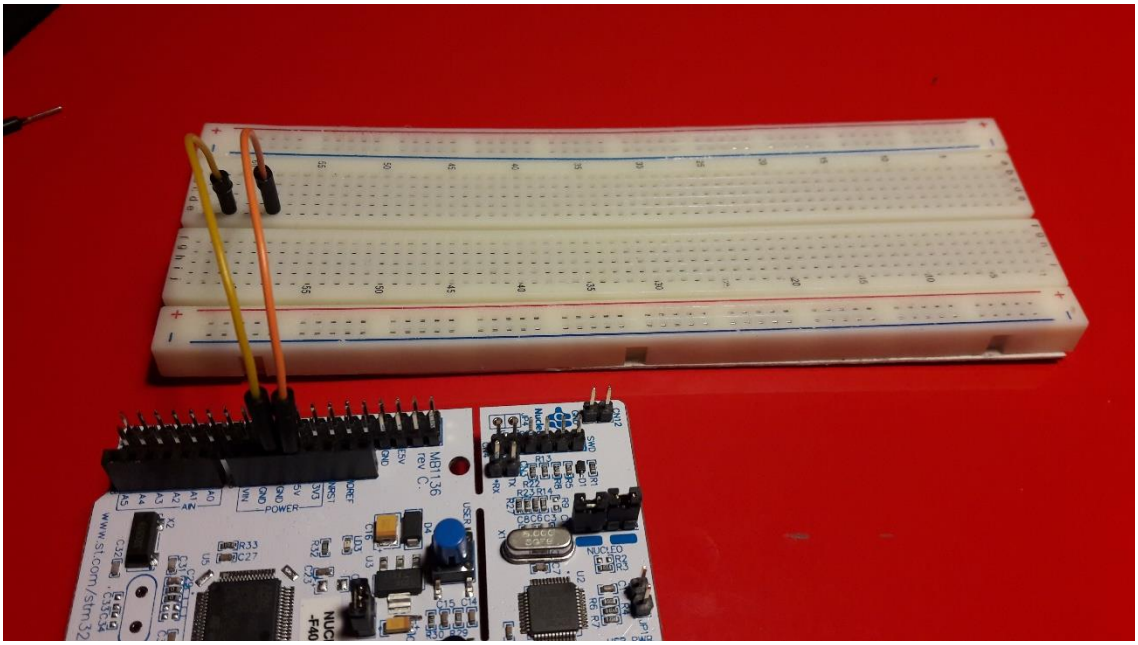


Figure 16- GND and 5V connected breadboard

B. Installing Switches and Connecting plus and minus rows

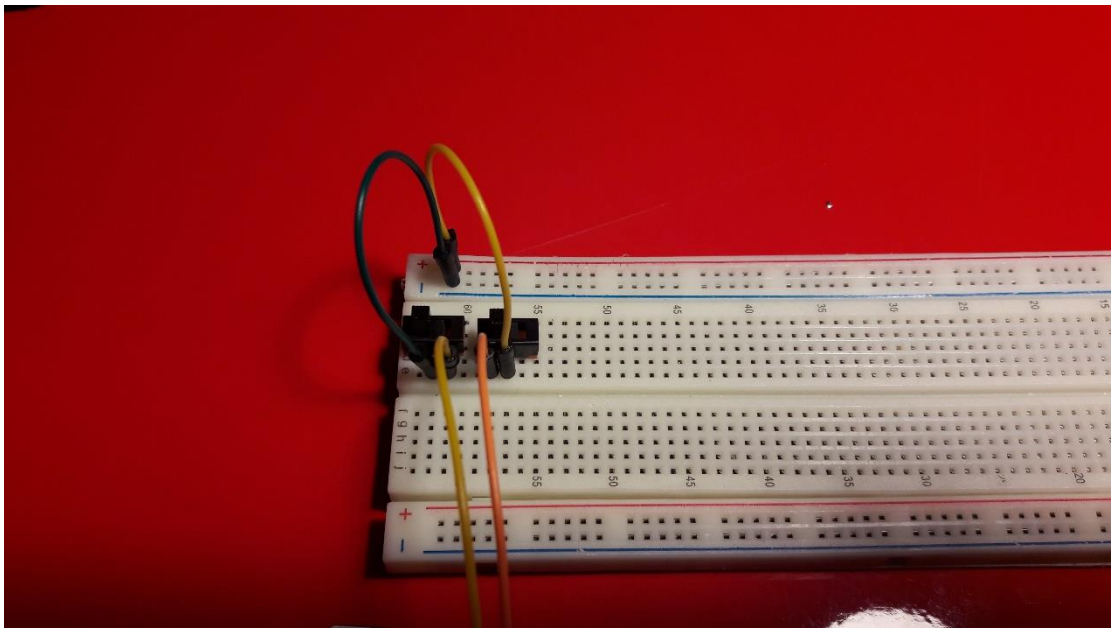


Figure 17- Switch and Positive- Negative Row Connections

The reason for doing is to open the model and close it when not using it. We can use the switches to cut voltage and ground connection on breadboard.

C. Connecting USB Cable and 1602A LCD(With Four Connections)

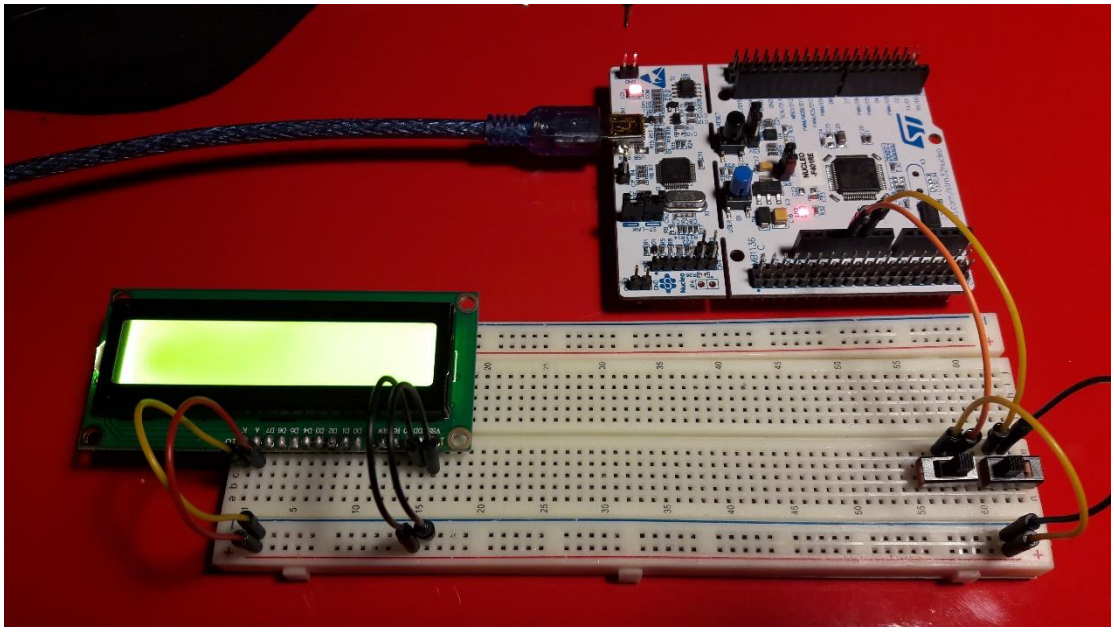


Figure 18- Usb Connection and 1602A 4 Pin Connection

In this step we need to change the required switch(es) to make sure connections are working and the breadboard getting voltage source and gound. Also we need to connect the LCD and connect:

- Pin A and Pin VSS of the LCD to Positive Row at The Breadboard
- Pin K and Pin VDD of the LCD to Negative Row at The Breadboard

Also we need to connect USB cable to the computer and observe if the LCD is working or not. If it is working we need to continue to next step:

D. Connecting Other Pins Of The 1602A LCD and Connecting The 10K Pot.

We need to connect the remaining pins as:

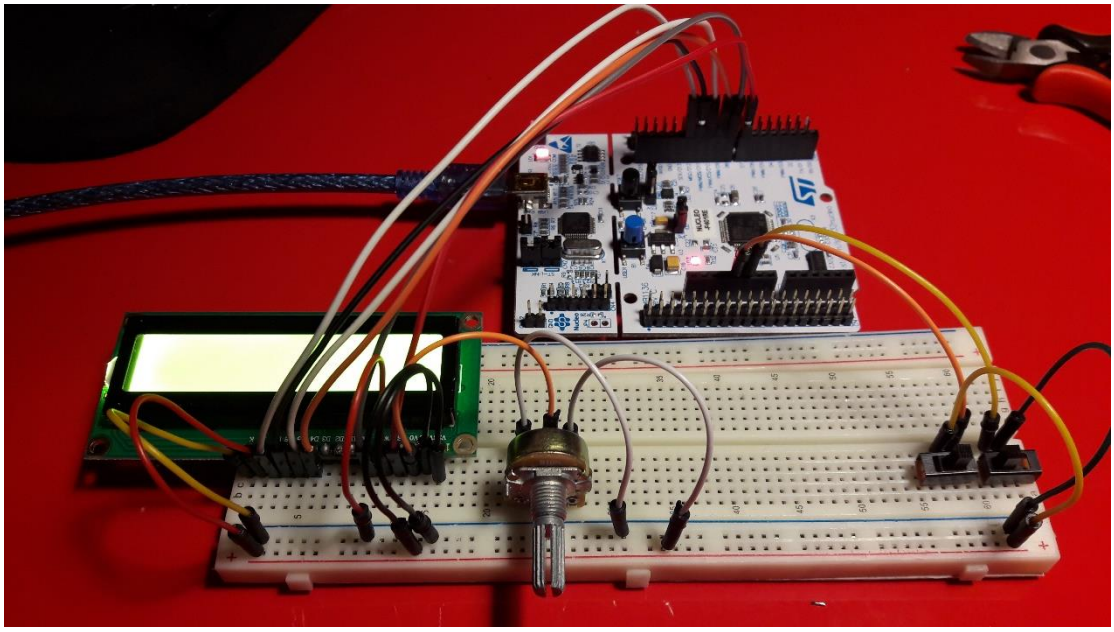


Figure 19- Some Other Connections

The connections are connected as:

- Potentiometer middle leg to Vo pin of the LCD
- Potentiometer right leg to positive row
- Potentiometer left leg to negative row
- LCD RS pin to D7 pin of the F401
- LCD RW pin to negative row
- LCD E pin to D8 pin of the board
- LCD D4 pin to D9 pin of the board
- LCD D5 pin to D10 pin of the board
- LCD D6 pin to D11 pin of the board
- LCD D7 pin to D12 pin of the board

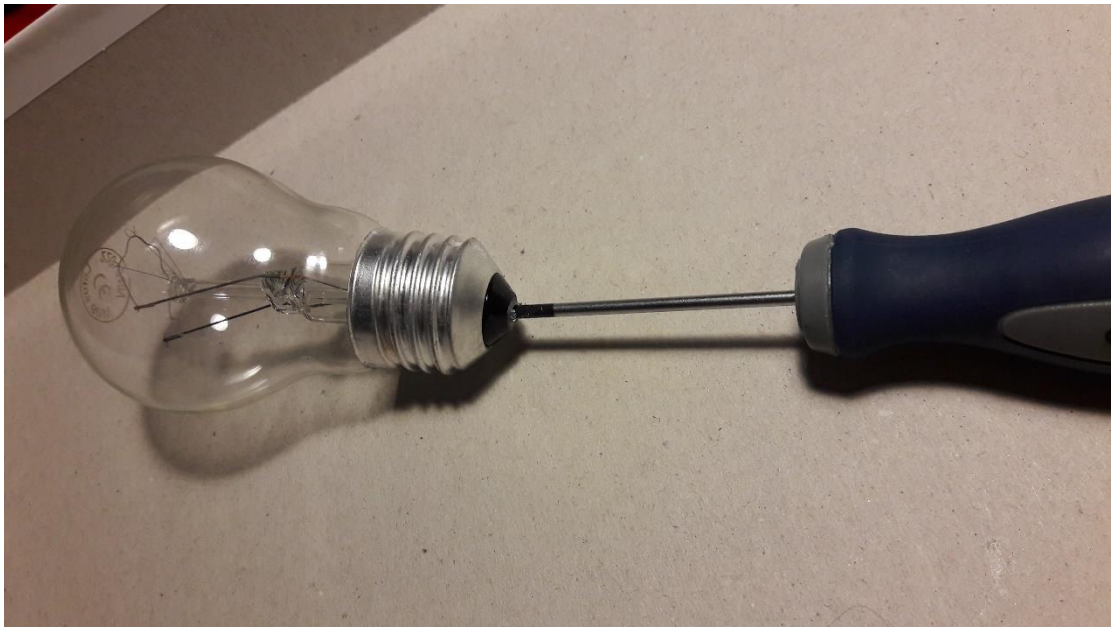
After these connections, we need to change the values of the potentiometer to see squares on the LCD. For next step, we need to prepare the probe.

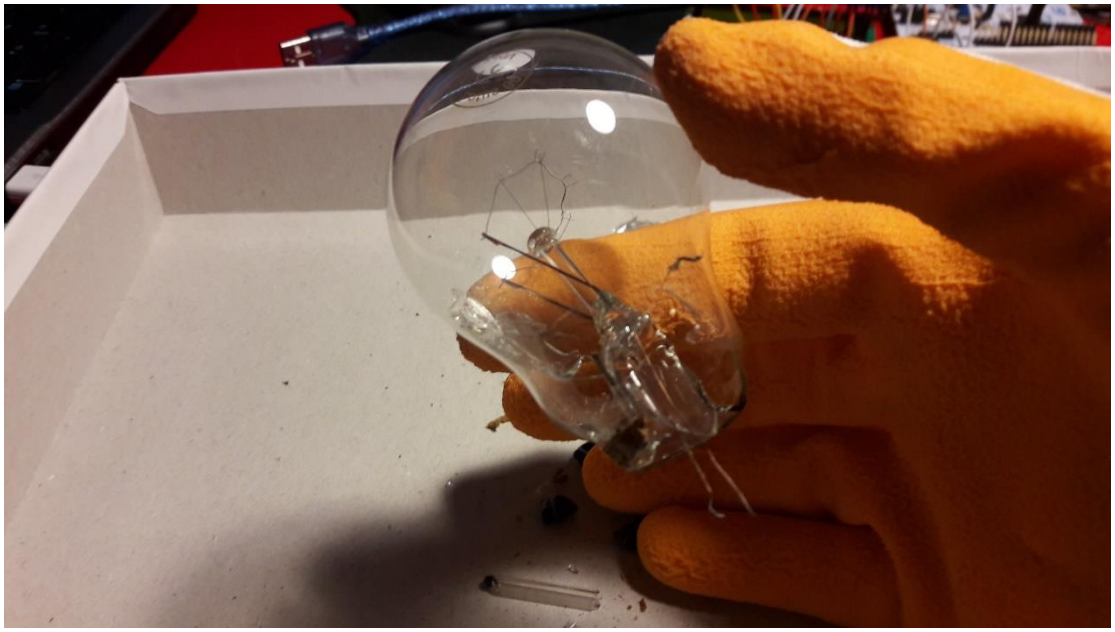
PREPARING THE PROBE

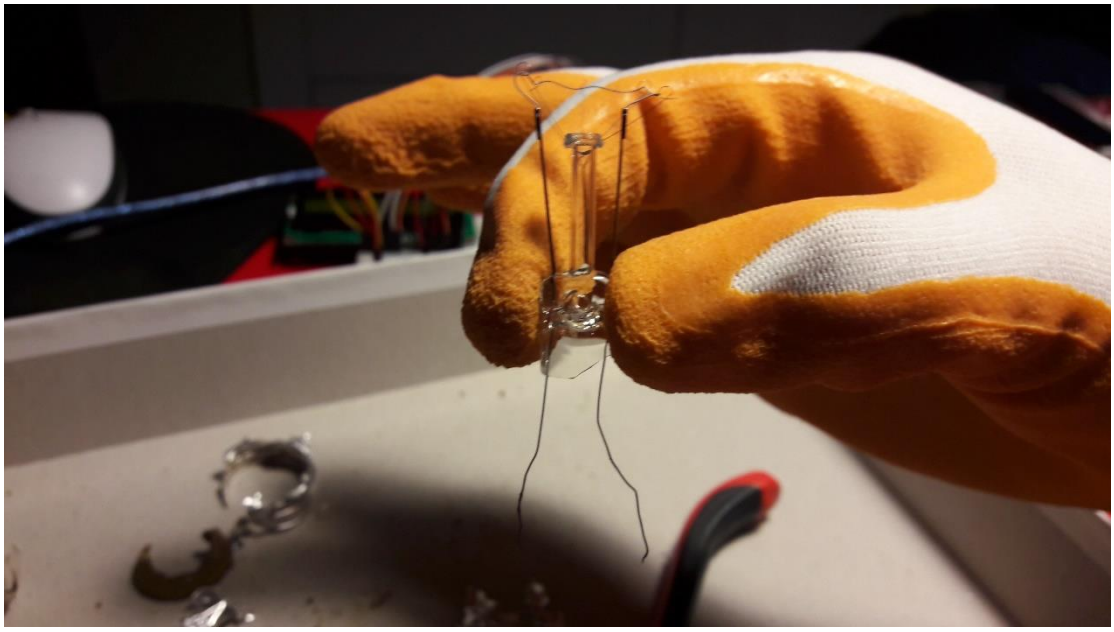
To prepare the probe we need to buy an old type lamb like following picture:

Figure 20- An Old Type Lamb

The thing about this type of lamb is the tungsten wire inside the lamp is open. We can access the wire. One of the ways to get current across the tungsten wire is to break the glass and open the lamp. We need to get the following tool onto the pressure point and push- turn at the time. Also we need to remove the white area. We need to continue turning the tool and remove the black parts as well. Also wearing a protective glove is my suggestion. After that we need to use the red tool and remove the gray parts around the lamp by prying. Also we need to protect the two wires that coming out of the top of the lamp. For next, we need to pry of the brown area with being careful to not cut the wire inside it. Also please wear gloves and do not cut the glass yet. At next, we need to apply minimum pressure to cut the glass from below(With Gloves!). After broken we need to take the base part of the lamp. After taking the part, we need to protect the wire area. One piece wire is required for the project. Multiple pictures about getting the probe:







Figures 21- Some Steps of Preparing a Probe From a Lamp

After completing, cleaning the glasses and getting the area secure is my suggestion. After preparing the probe, we need to add the resistor and probe connections onto the breadboard.

E. Adding Resistor and Probe Onto the Breadboard

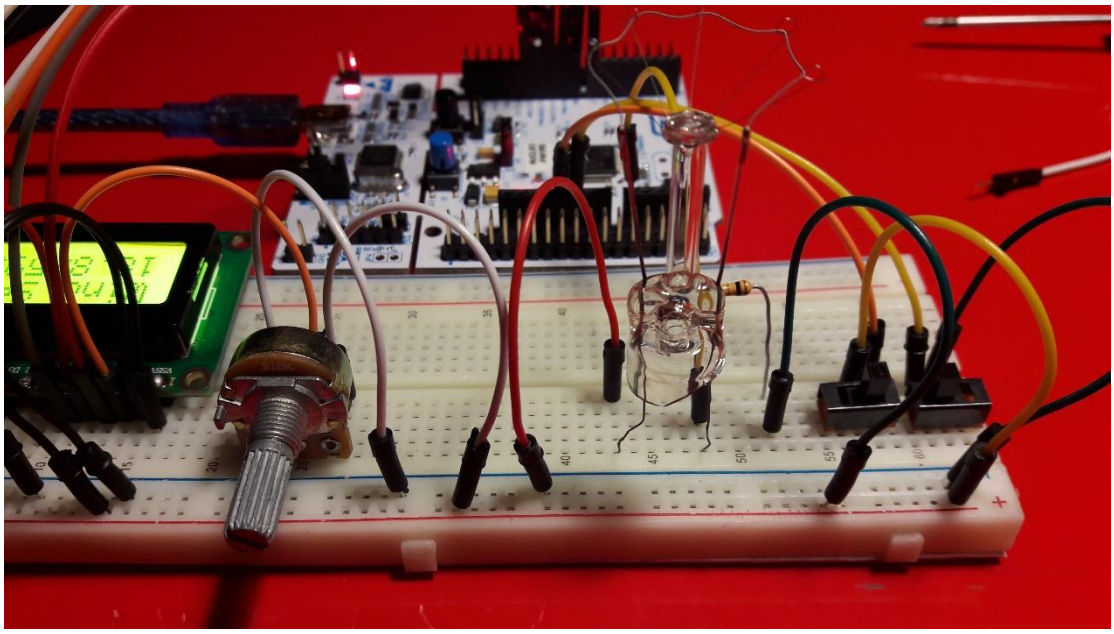
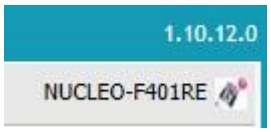


Figure 22- Resistor and probe added circuit

Voltage comes from positive row, the it passes onto the resistor. At that area the circuit connects to Ao pin in the board. Also we connect the probe leg at that area and finish the small circuit with connection to ground row. After completing this step, we need to start coding with mbed.

F. Coding The Program



- Entering https://os.mbed.com/
- Starting an account
- Clicking compiler button(yellow)
- Changing the board at right upper side:
- Starting a new program
- Clicking the main.cpp twice.
- Writing the code

At this point I wrote the following code: (!!! Again sorry but the following code is for a switchless circuit, it is for the final model I prepared for the project. I am planning to prepare a Proteus drawing and upload the model photo at later stages.)

```
#include "mbed.h"

#include "TextLCD.h"


TextLCD lcd(D7, D8, D9, D10, D11, D12);


AnalogIn probe(A0);


int main() {


   lcd.locate(0,0);

   lcd.printf("Wind Speed");

   lcd.locate(0,1);

   lcd.printf("Measurement Sys.");

   wait(3);

   lcd.cls();


   lcd.locate(0,0);
```

```
lcd.printf("Starting The");
lcd.locate(0,1);
lcd.printf("Anemometer in 3");
wait(1);
lcd.cls();

lcd.locate(0,0);
lcd.printf("Starting The");
lcd.locate(0,1);
lcd.printf("Anemometer in 2");
wait(1);
lcd.cls();

lcd.locate(0,0);
lcd.printf("Starting The");
lcd.locate(0,1);
lcd.printf("Anemometer in 1");

float probeValue1;
probeValue1 = probe.read();
wait(1);
lcd.cls();
while(1){

   lcd.locate(0,0);
   lcd.printf("Wind Speed");

   float probeValue2;
```

```
probeValue2 = probe.read();

lcd.locate(0,1);

lcd.printf("%f", (abs(probeValue1-probeValue2)*100));

lcd.locate(9,1);

lcd.printf("m/s");

wait(0.2);

lcd.cls();}}
```

We need to click save and compile. If there is no error and the download is successful, we need to get the file into USB connected NODE_F401RE. We can find it in the computer. When the file is throwed to that part, the program starts working on the circuit. (There are writings in the LCD etc.) So after completing the coding part, we need to start soldering. Also there is an easy access to reset the program, we can push black button on the board to reset.

Soldering Phase

Before this part, I need to remind that soldering iron is very hot while it is working and I really recommend to not to touch the metal part of the soldering iron. Also before the soldering making sure ventilation is good is recommended. (Again, at the final model of the project, I did not use switches.)

1. CONNECTING THE SWITCHES

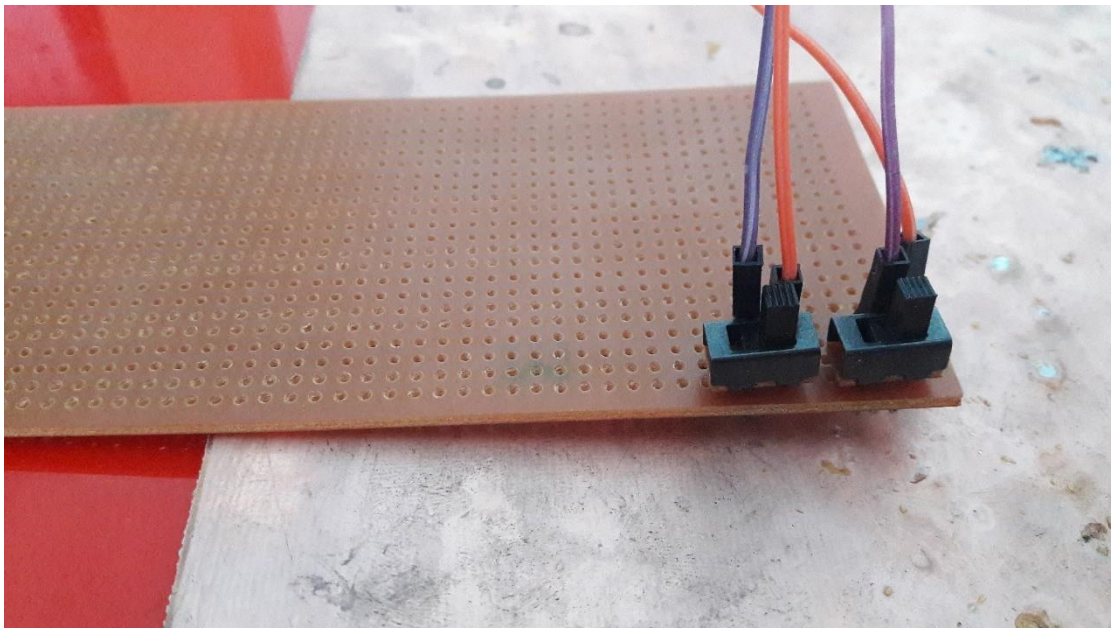


Figure 23- Switch Connected PCB

Figure 24- Backside at Step 1

2. CONNECTING 5V AND GND CONNECTION ROWS

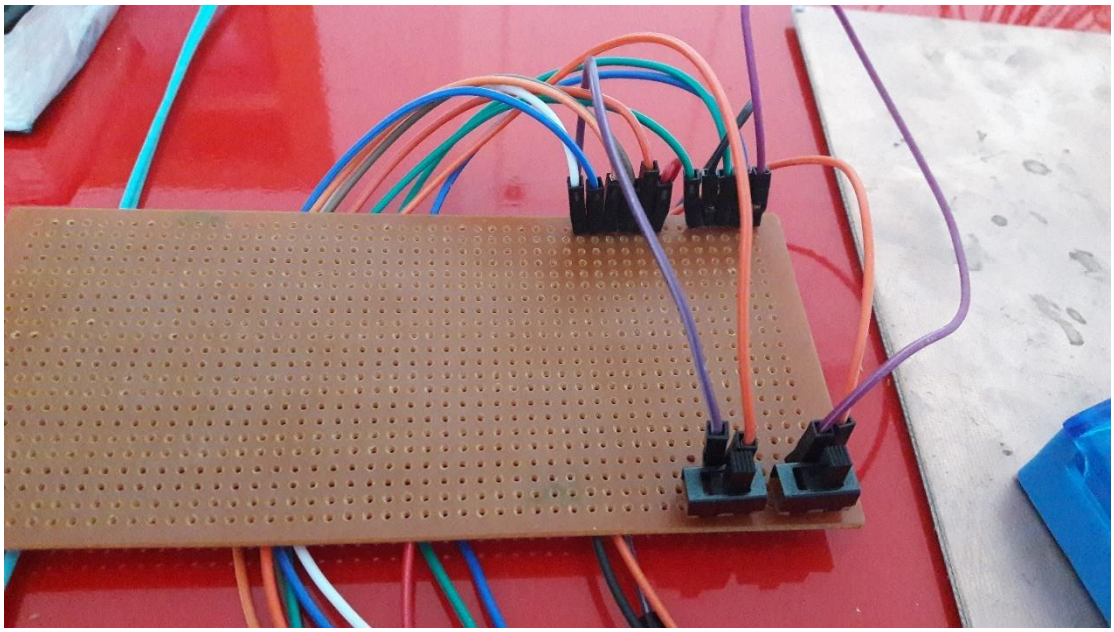


Figure 25- Step 2 Frontside

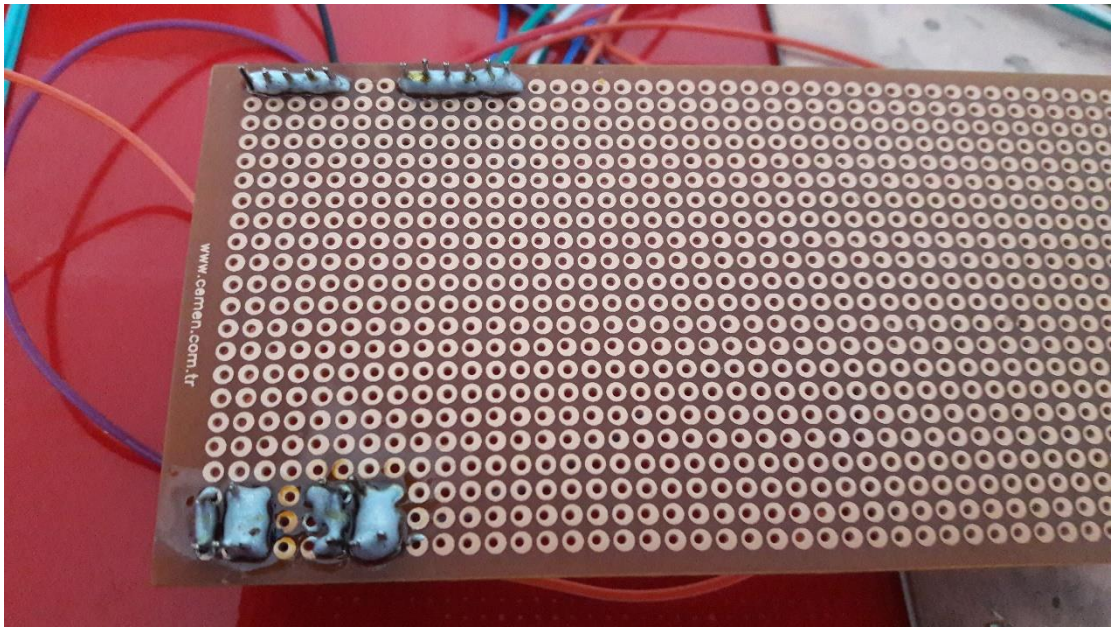


Figure 26- Step 2 Backside

3. SOLDERING POTENTIOMETER

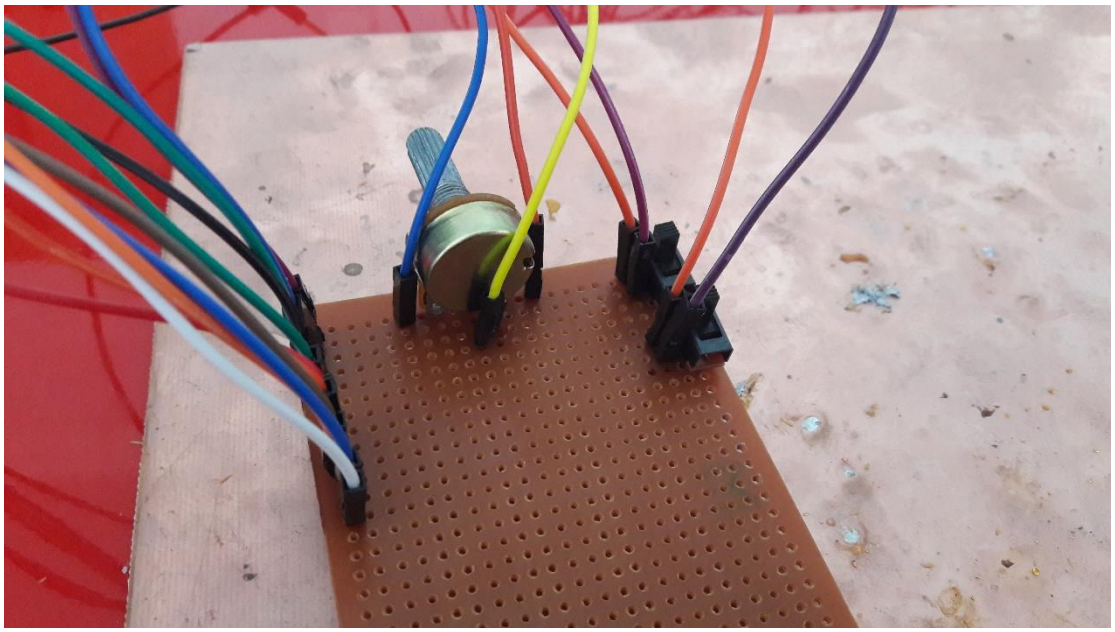


Figure 27- Potentiometer Soldered PCB

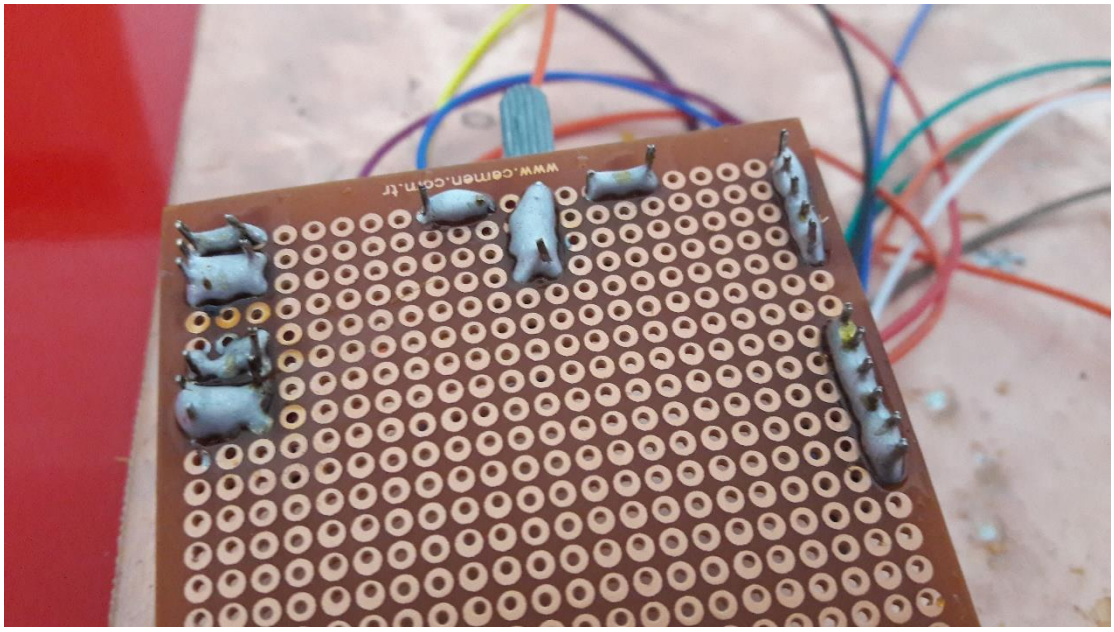


Figure 28- Step 3 Backside

4. CONNECTING RESISTOR AND PROBE

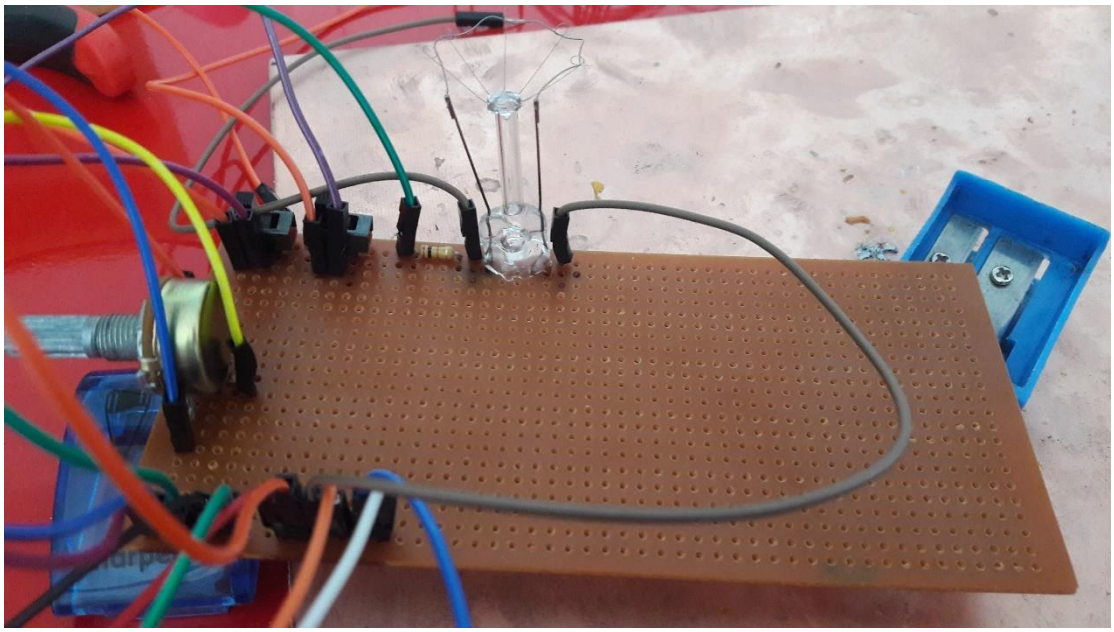


Figure 29- Step 4 Frontside

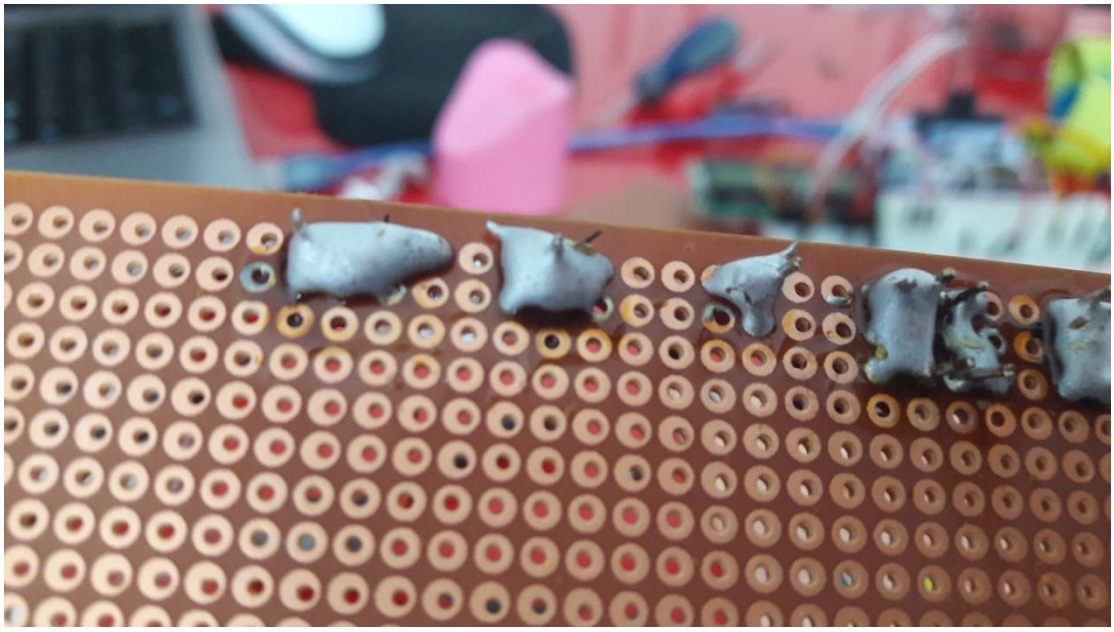


Figure 30- Backside of Step 4

5. CONNECTING LCD AND BOARD

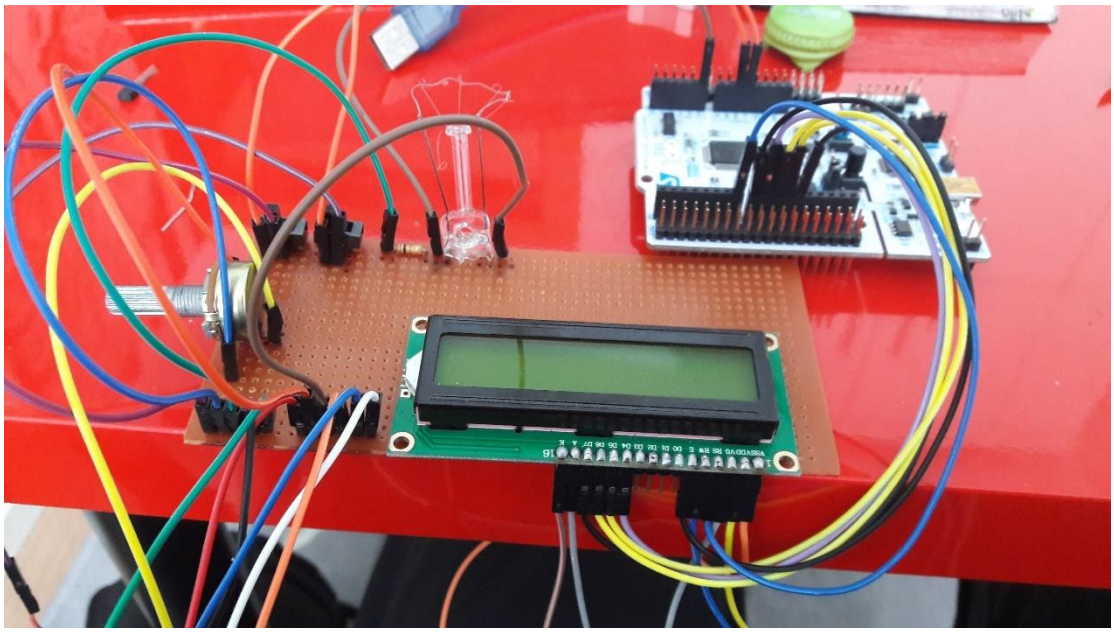


Figure 31- LCD and Board Connected PCB

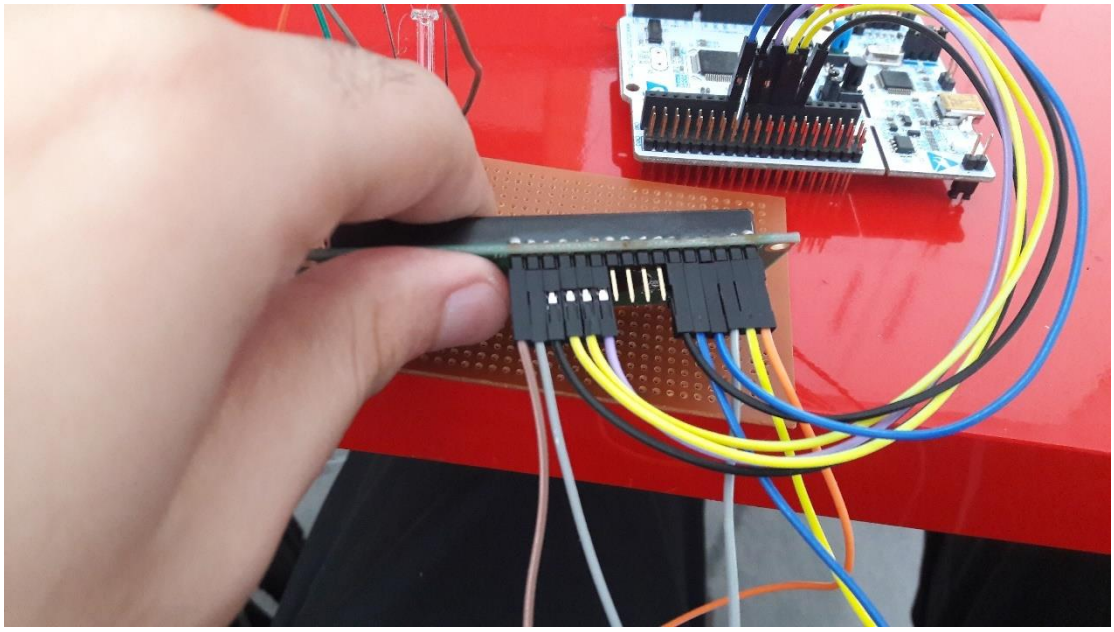


Figure 32- Backside of Step 5

6. INSTALLING THE PROJECT ON A BOX

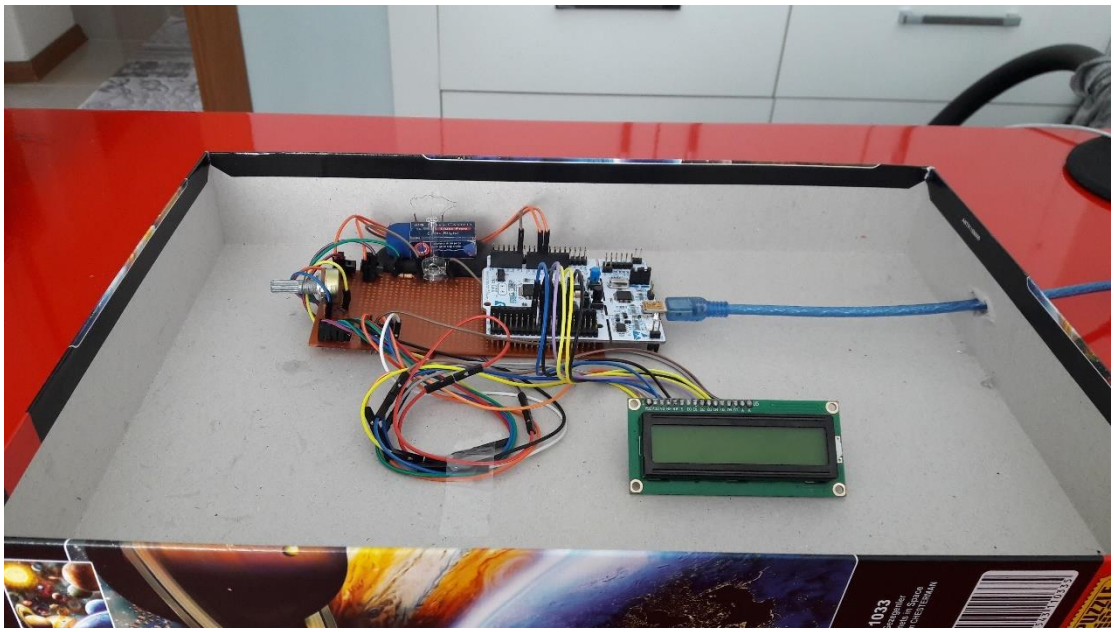


Figure 33- Box Installed Project

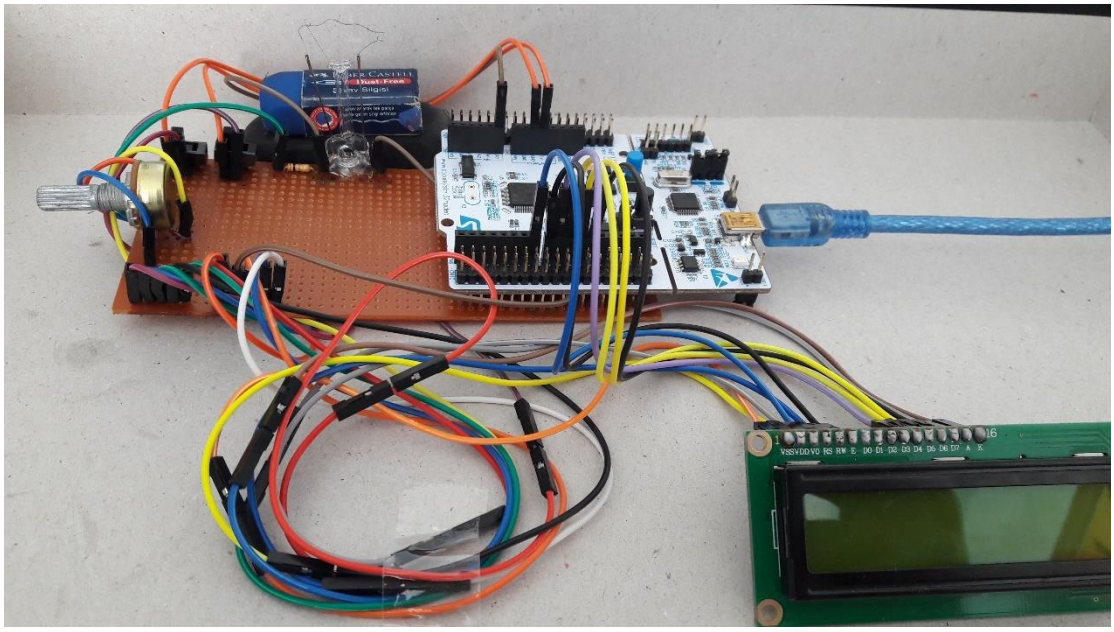


Figure 34- A Closeup Picture

FINAL MODEL OF THE PROJECT

As I said, I built another model of a project to use as a final model. The project looks as: (Without mounting on a box and without board usb cable)

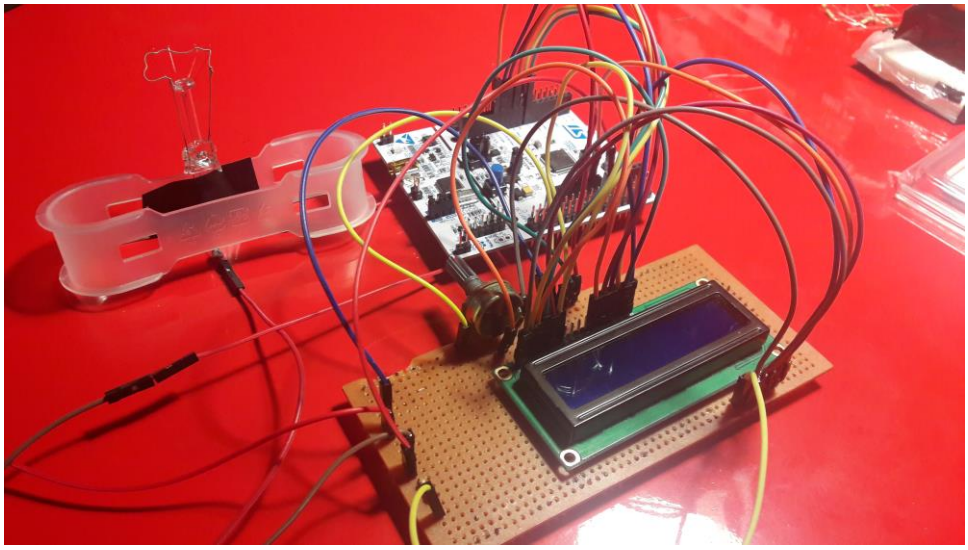


Figure 35- Final Model Of The Project

If we look into the probe part closely:

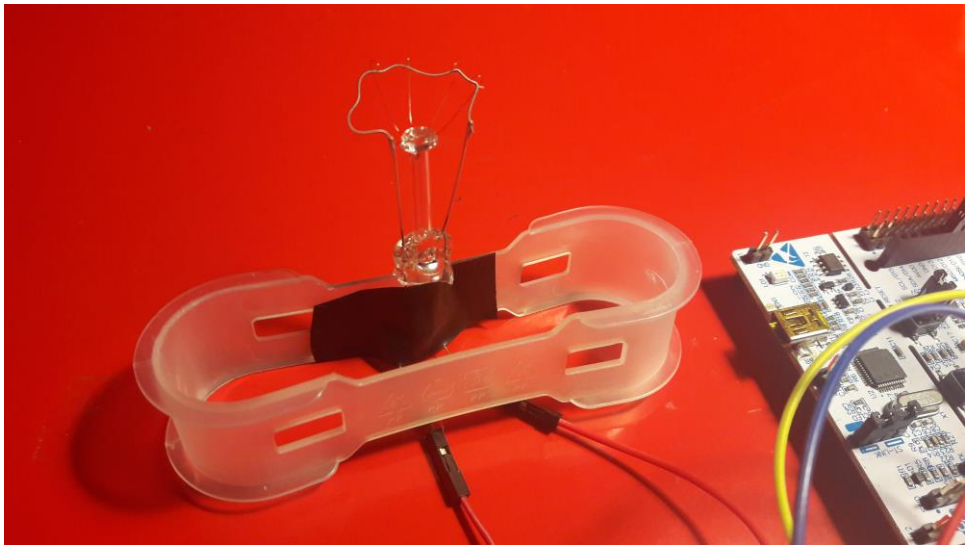


Figure 36- Probe Area

If we look into Lcd area closely:

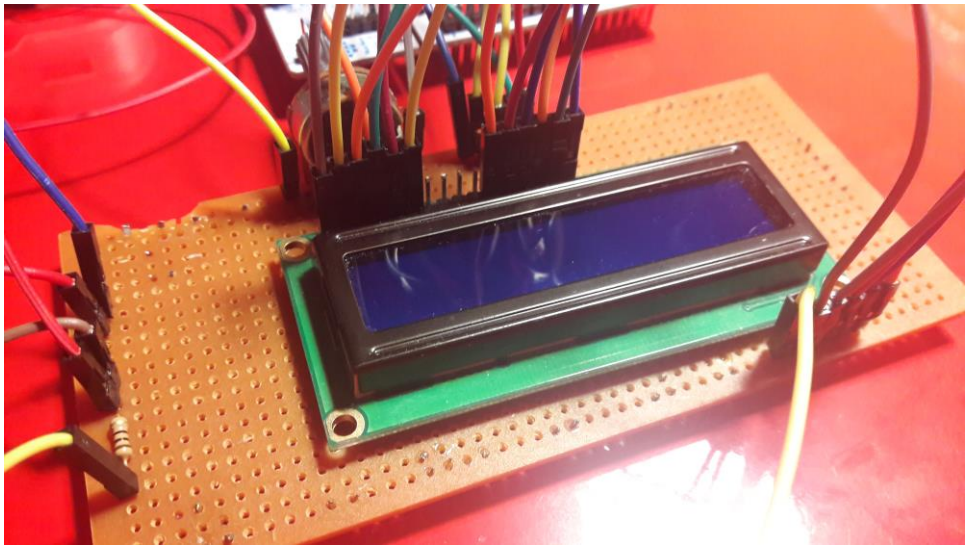


Figure 37- Lcd Area

If we look into the board closely:

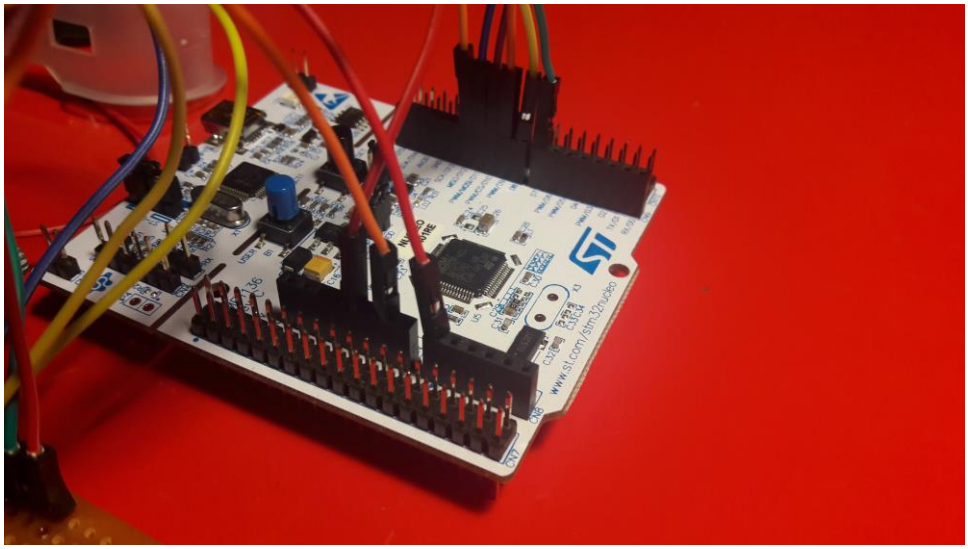


Figure 38- Board Area

After drawing close enough model at the proteus it looks like:(I am not sure about how to find F401 library for proteus for free, so I draw a rectangle)

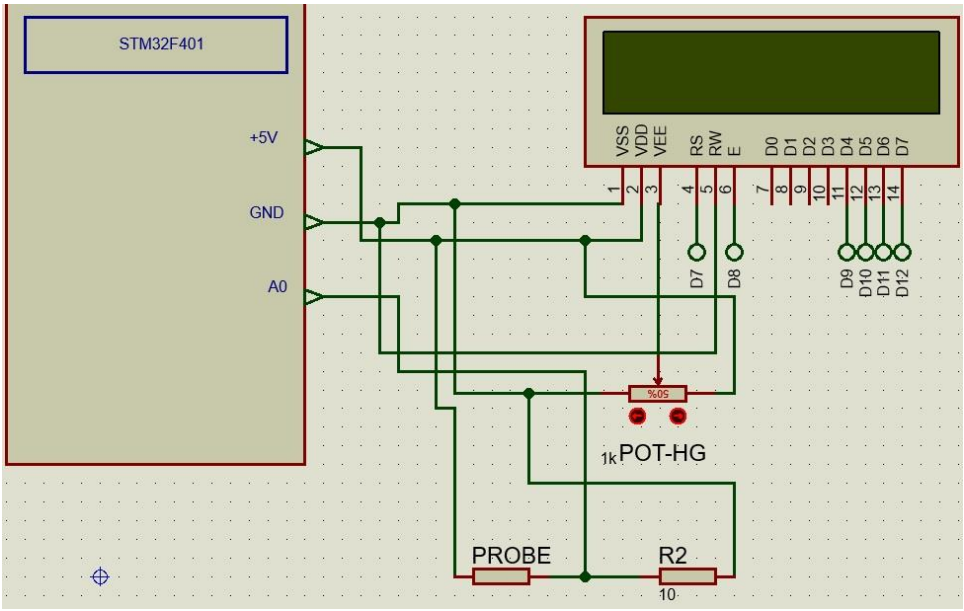


Figure 39- proteus scheme

Also, I did not install the project on a box yet, I plan to do that after the final calibration of the project.

Final Preparations of The Project

Now before completing the project, I need to make sure the assumed wind speed that shown in the lcd is accurate enough with the real wind speed. A fan like that can be useful to this project:

Figure 40- A 12 V DC Mini Fan

The advantage of using a fan like this is the capability to measure constant enough wind speed between project start and reset and/or reset time. I need to observe the values onto Lcd and change multiplier number in code if necessary.

I observed some values when I puff onto the probe. For step 1 I think I need to multiply the number by 10. At the code I tried to change 100 to 1000. The area in the code looks like this:

lcd.printf("%f", (abs(probeValue1-probeValue2)*1000));

I clicked compile button at mbed compiler and tried to carry the bin file to the usb part at computer.

After installing the final model of the project onto the setup box:

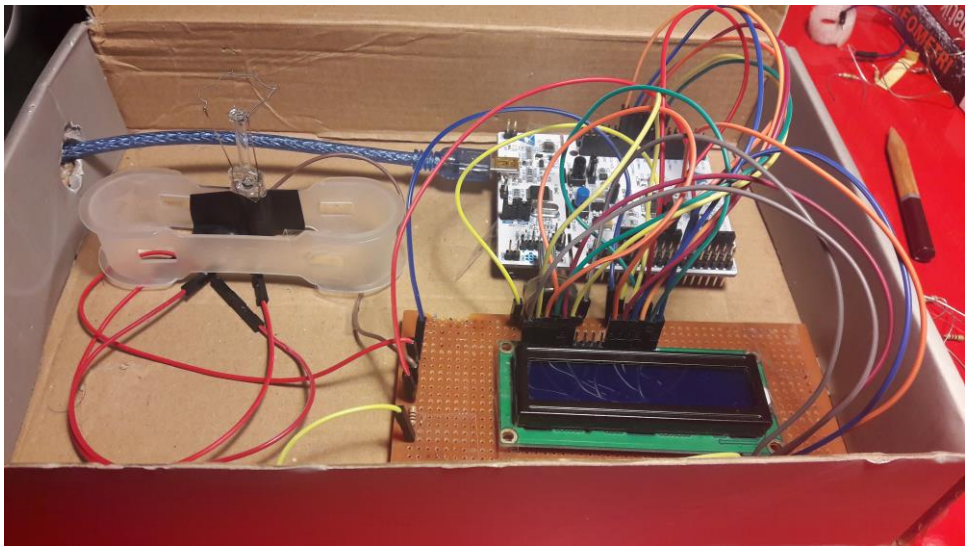


Figure 41- Box installed project

REFERENCES

1. About the author This post was writen by Johan van Tongeren. "Behind the Scenes: CSS-Only Clock." *Dreamdealer RSS*, 21 Oct. 2012, www.dreamdealer.nl/tutorials/connecting_a_1602a_lcd_display_and_a_light_sensor_to_arduino_uno.html.
2. "Hot Wire Anemometer (Thermal Method)." *Instrumentation and Control Engineering*, instrumentationandcontrollers.blogspot.com/2012/03/hot-wire-anemometer-thermal-method.html.
3. "STM32F401 ." *STLM20 - Analog Temperature Sensor, Ultra-Low Current 2.4 V, High Precision - STMicroelectronics*, www.st.com/en/microcontrollers/stm32f401.html?querycriteria=productId.
4. "Analog Input | Mbed." *IR and RF Remote Controls | Mbed*, os.mbed.com/users/yoonghm/notebook/analog-input/.
5. "Electronics Primer: How to Solder Electronic Components." *Science Buddies*, www.sciencebuddies.org/science-fair-projects/references/how-to-solder.