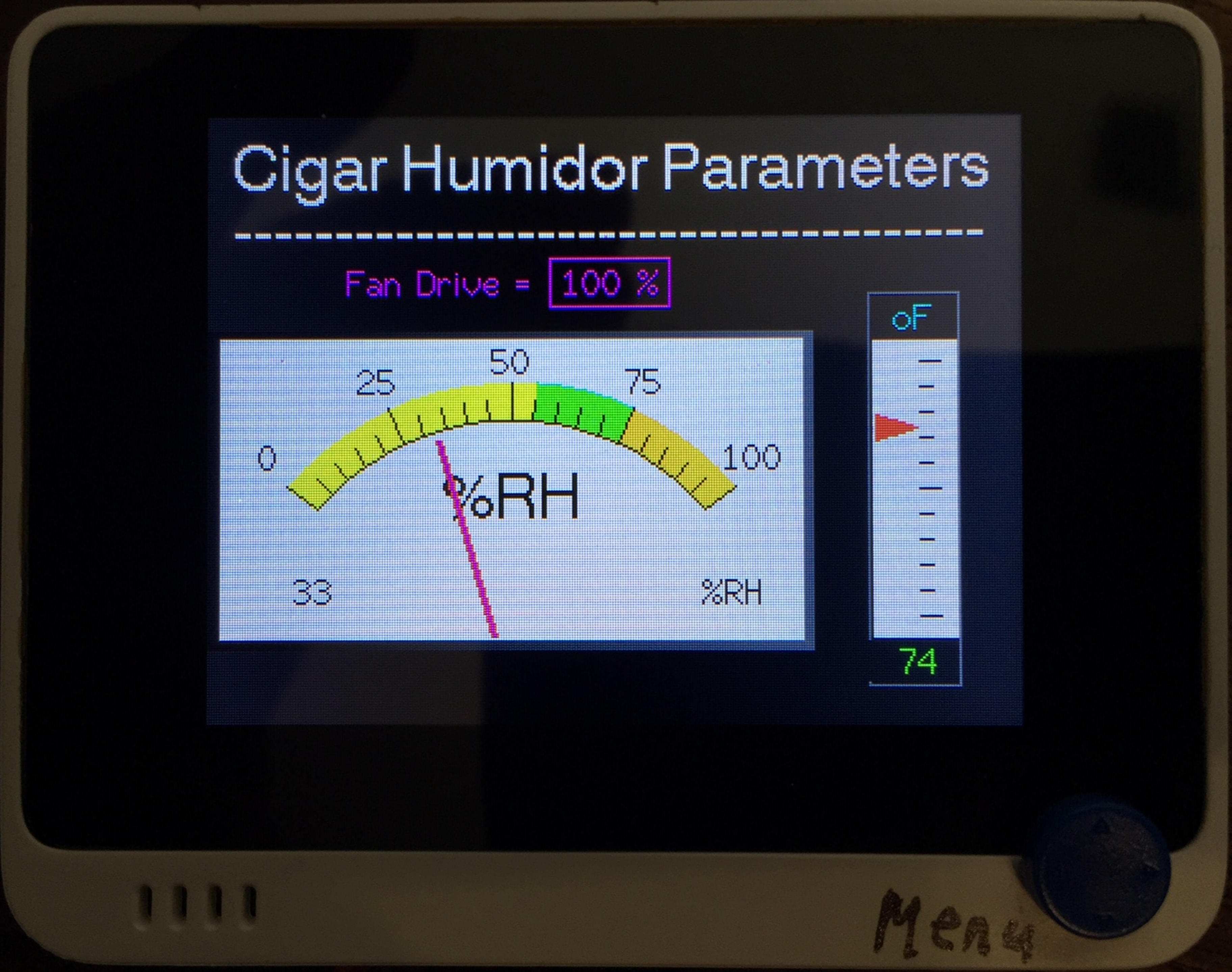

Cigar Humidor Parameters
Fan Drive = 100 %
0
25
50
75
100
%RH
33
%RH
oF
74
Menu

To Build the circuit follow the following:

WiFi Overview

Update the Wireless Core Firmware

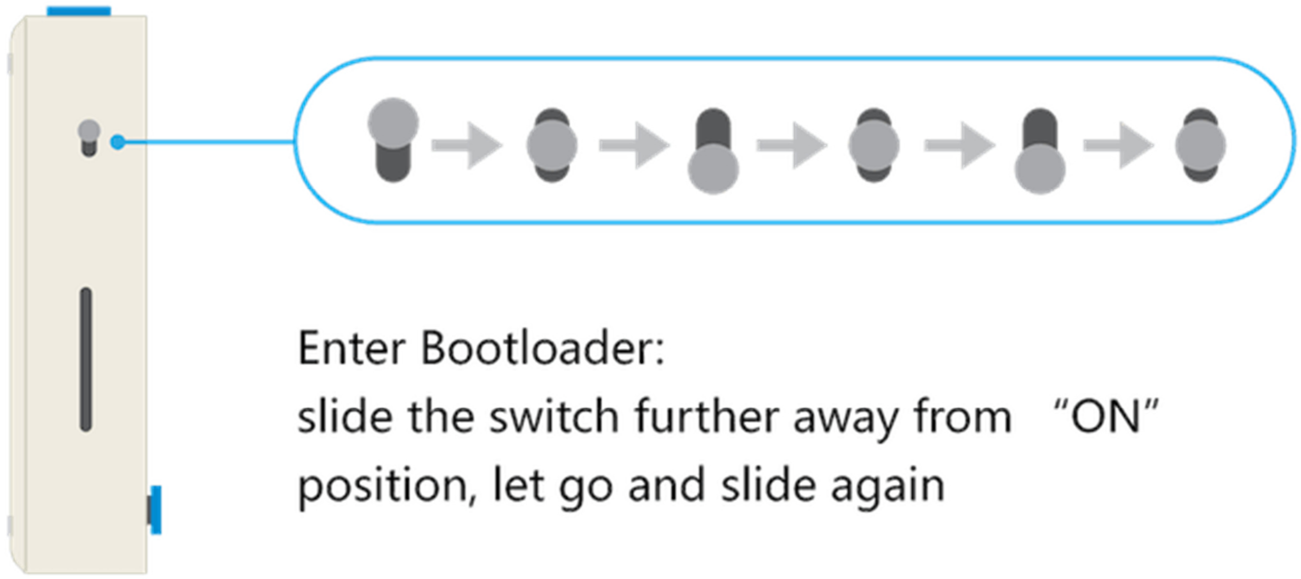
First, You need to update the firmware for the Realtek RTL8720 Wireless core on Wio Terminal.

Step 1 - Arduino Configuration

To be able to update the firmware on the RTL8720, we need to enable the Serial connection from SAMD51 to RTL8720. Seeed provides `uf2` methods of uploading Wio Terminal's firmware. Simply download the `uf2` files from below.

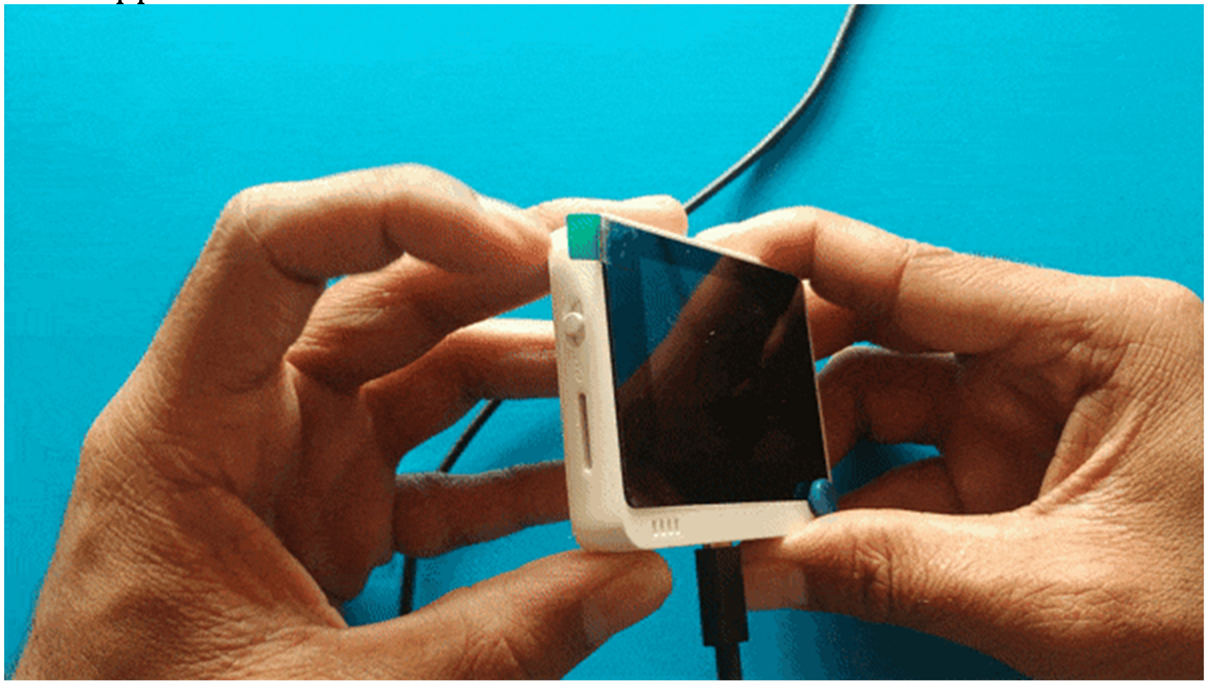
- Download the rtl8720_update_v2.uf2`uf2` files.

Step 1:1 Entering the bootloader mode by sliding the power switch twice quickly.
To Enter Bootloader: Slide the switch twice very quickly, as followed:


Enter Bootloader:
slide the switch further away from "ON" position, let go and slide again

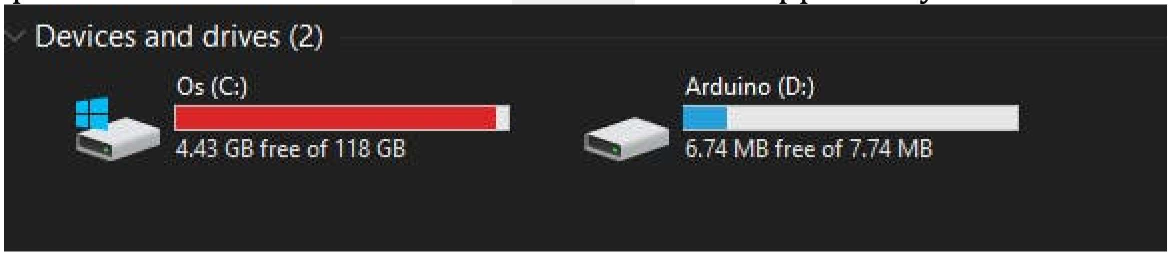
To Eneter Bootloader Mode

Once Wio Terminal is in the Bootloader mode, the blue LED will start to breathe in a way that is different from blinking. Check the port again and it should appear.



Bootloader Mode

Step 1.2: An external drive named `Arduino` should appear in your PC.



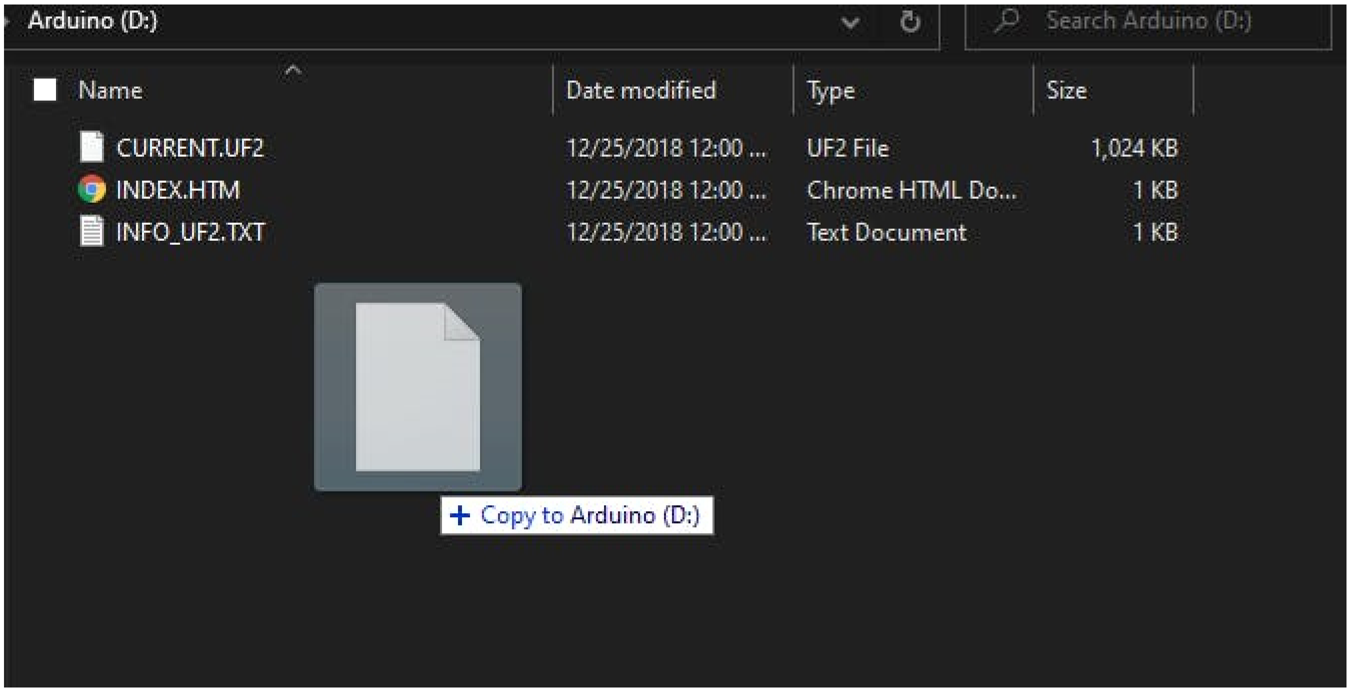
Devices and drives (2)

Os (C:)
4.43 GB free of 118 GB

Arduino (D:)
6.74 MB free of 7.74 MB

Arduino Drive

Drag the downloaded `rtl8720_update_v2.uf2` files into the `Arduino` drive and it will reset the Wio Terminal and loaded the sketch!


Arduino (D:)

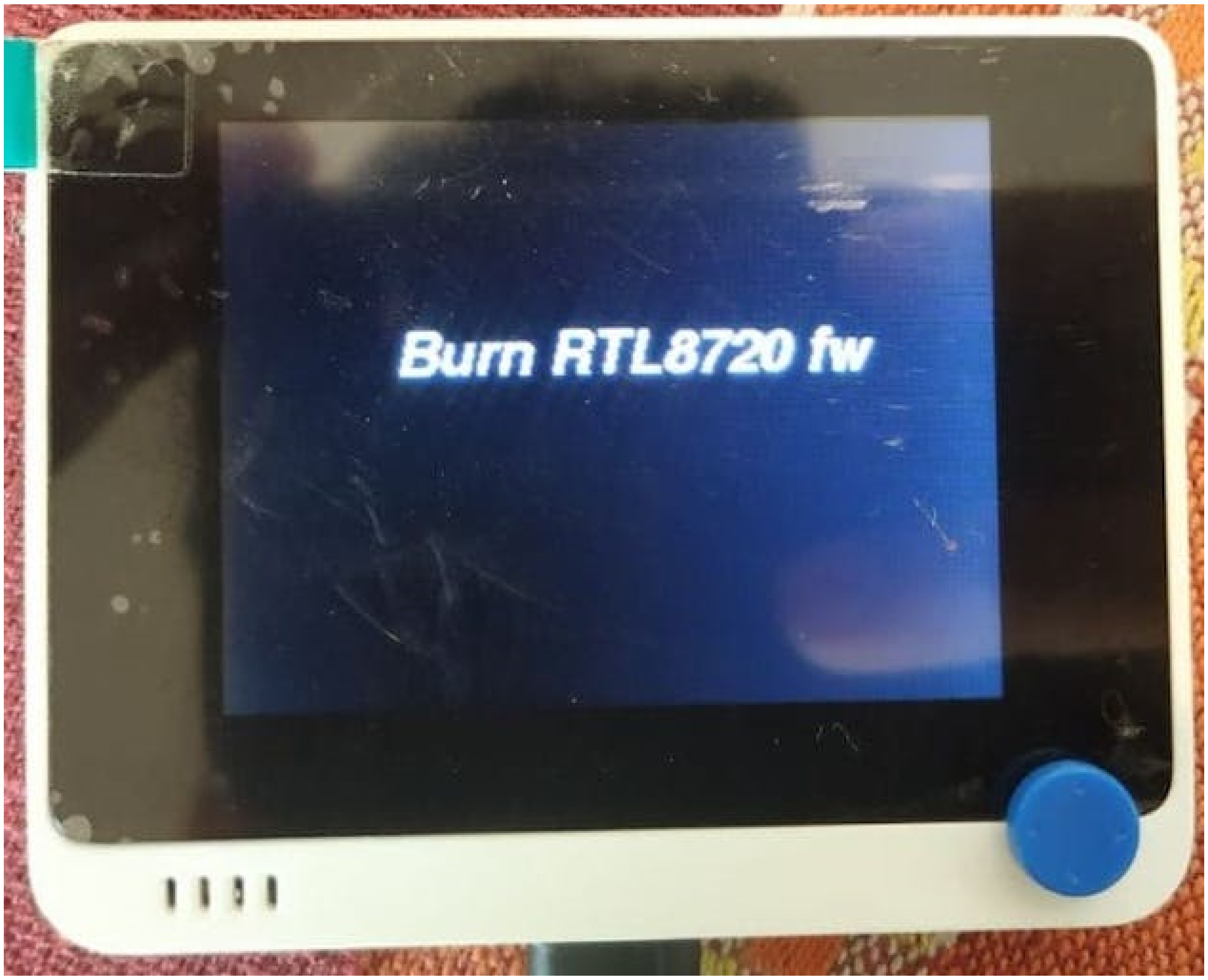
Search Arduino (D:)

Name	Date modified	Type	Size
CURRENT.UF2	12/25/2018 12:00 ...	UF2 File	1,024 KB
INDEX.HTM	12/25/2018 12:00 ...	Chrome HTML Do...	1 KB
INFO_UF2.TXT	12/25/2018 12:00 ...	Text Document	1 KB

+ Copy to Arduino (D:)

drag and drop the .uf2 files in to arduino drive

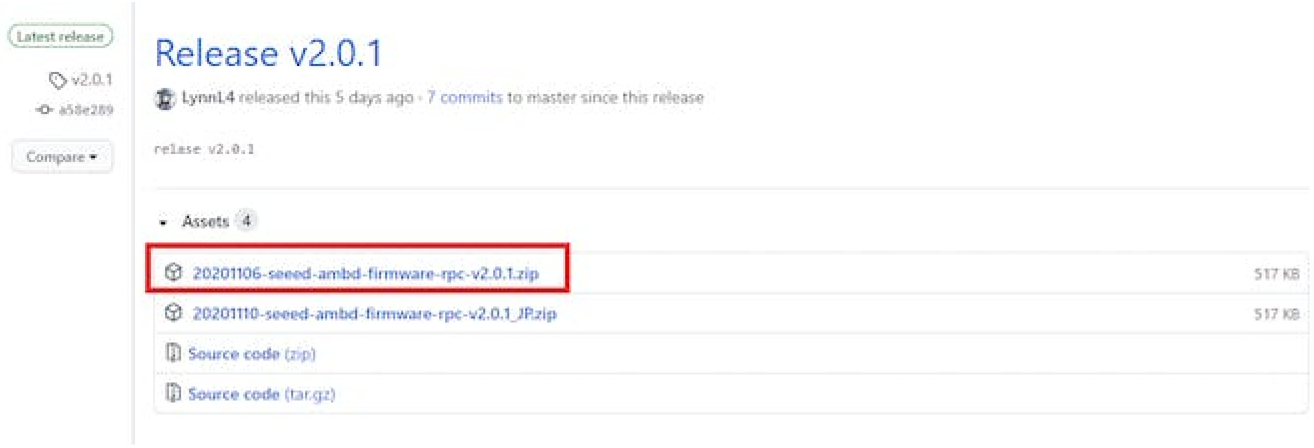
After that, you should see that Burn RTL8720 fw on the Wio Terminal's screen. This means that it is currently in the burning firmware mode!



Step 2 - Download the Latest Firmware

You can download the latest eRPC Structure Firmware for RTL8720

- Download the latest RTL8720 FirmwareHere.



Latest release

v2.0.1

a58e289

Compare ▾

Release v2.0.1

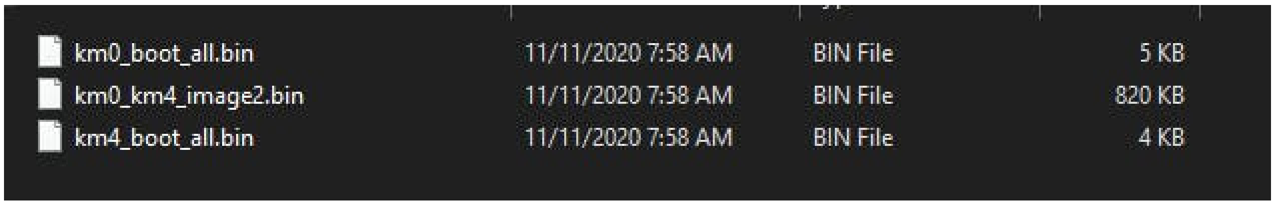
Lynn1.4 released this 5 days ago · 7 commits to master since this release

```
relase v2.0.1
```

▾ Assets 4

20201106-seeed-ambd-firmware-rpc-v2.0.1.zip	517 KB
20201110-seeed-ambd-firmware-rpc-v2.0.1_JP.zip	517 KB
Source code (zip)	
Source code (tar.gz)	

Note that the version might change in future.



km0_boot_all.bin	11/11/2020 7:58 AM	BIN File	5 KB
km0_km4_image2.bin	11/11/2020 7:58 AM	BIN File	820 KB
km4_boot_all.bin	11/11/2020 7:58 AM	BIN File	4 KB

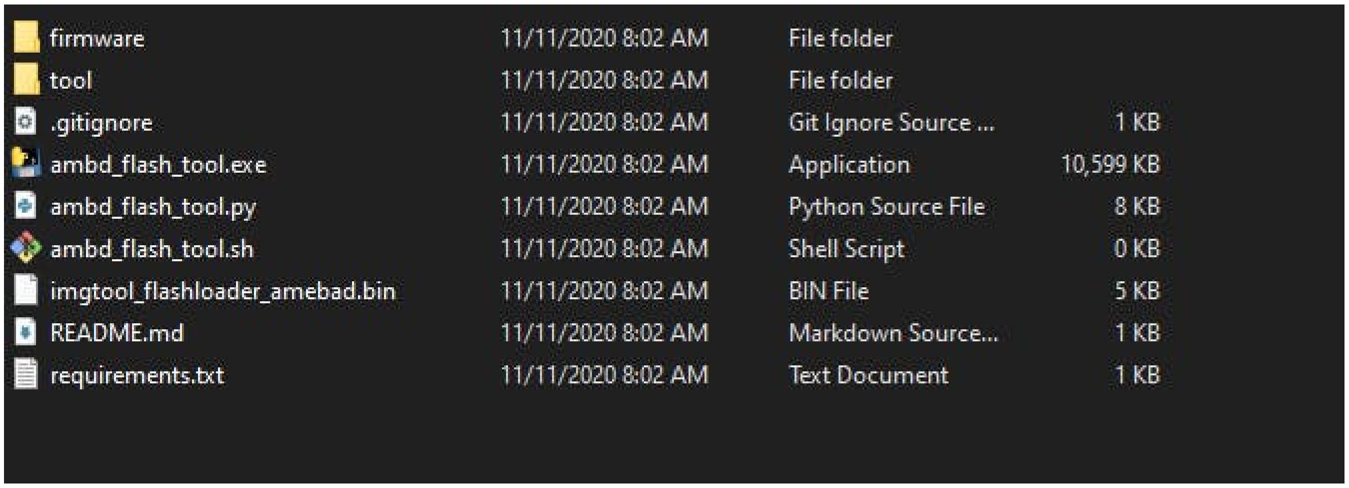
Firmware binary

Step 3 - Download Flash Tool

Next, you can download the flash tool.

Goto LynnL4/ambd_flash_tool and download the whole repo by clicking download ZIP or simply click here

Unzip the file and you can see the tool



firmware	11/11/2020 8:02 AM	File folder	
tool	11/11/2020 8:02 AM	File folder	
.gitignore	11/11/2020 8:02 AM	Git Ignore Source ...	1 KB
ambd_flash_tool.exe	11/11/2020 8:02 AM	Application	10,599 KB
ambd_flash_tool.py	11/11/2020 8:02 AM	Python Source File	8 KB
ambd_flash_tool.sh	11/11/2020 8:02 AM	Shell Script	0 KB
imgtool_flashloader_amebad.bin	11/11/2020 8:02 AM	BIN File	5 KB
README.md	11/11/2020 8:02 AM	Markdown Source...	1 KB
requirements.txt	11/11/2020 8:02 AM	Text Document	1 KB

Flash tools

After downloading the tools you can flash the RTL8720 firmware to Wio Terminal using the CLI methods.

- For macOS and LinuxOS, please use the `ambd_flash_tool.py` script.
- For Windows OS, please use the `ambd_flash_tool.exe` script.

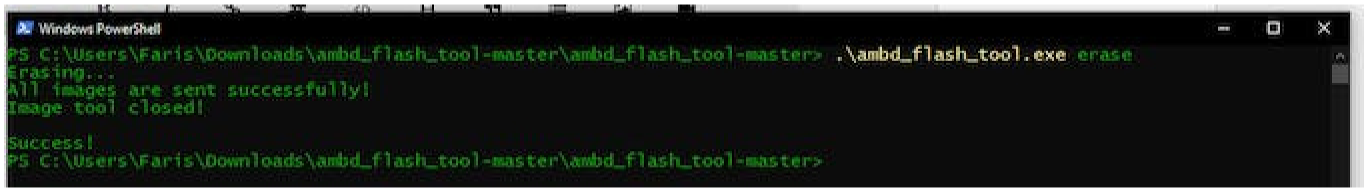
Since I was using the windows, I'll go with the `ambd_flash_tool.exe` to flash the firmware on wio terminal.

Note – Highlight the ambd_flash-tool.exe file, and then go to the “file” heading on folder, and click the option to run in windows powershell as administrator.

Step 4 - Erase Initial Firmware

First, we need to erase initial firmware inside the RTL8720, for that run:

Open the flash tool folder and open the PowerShell from the directory or you can open PowerShell and navigate to the directory.



```
PS C:\Users\Faris\Downloads\ambd_flash_tool-master\ambd_flash_tool-master> .\ambd_flash_tool.exe erase
Erasing...
All images are sent successfully!
Image tool closed!

Success!
PS C:\Users\Faris\Downloads\ambd_flash_tool-master\ambd_flash_tool-master>
```

erase

To Erase

```
.\ambd_flash_tool.exe erase
```

note that, it will take about 3 minutes some times to complete the erasing process, so please wait until you get the success message.

Step 5 - Flash New Firmware

Note – I placed all "3" bin files in a folder called "New_Firm" located on my Desktop

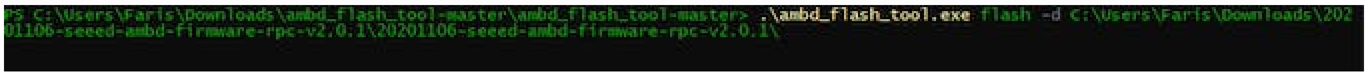
To flash the newly downloaded firmware into the RTL8720, run:

```
.\ambd_flash_tool.exe flash -d [RTL8720-firmware-path]
```

Note – For this next step ensure that Arduino is open and that you have conne cted to the "Com Port"

For it's on the download folder and I need to mention the full path.

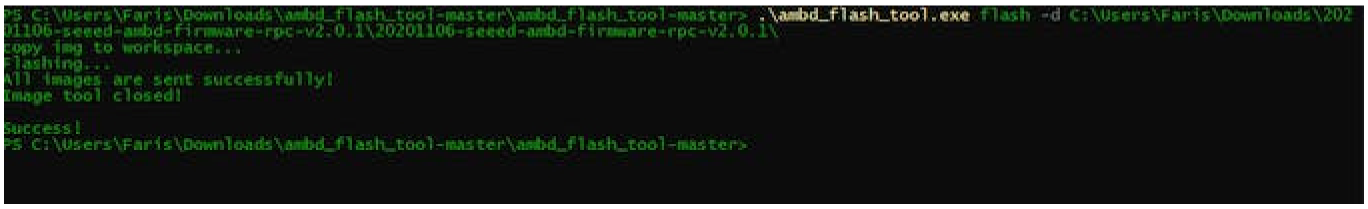
```
.\ambd_flash_tool.exe flash -d C:\Users\u003r\Desktop\New_Flas
h
```



```
PS C:\Users\Faris\Downloads\ambd_flash_tool-master\ambd_flash_tool-master> .\ambd_flash_tool.exe flash -d C:\Users\Faris\Downloads\202
01106-seeed-ambd-firmware-rpc-v2.0.1\20201106-seeed-ambd-firmware-rpc-v2.0.1\
```

Flash

Please wait until you get the success message



```
PS C:\Users\Faris\Downloads\ambd_flash_tool-master\ambd_flash_tool-master> .\ambd_flash_tool.exe flash -d C:\Users\Faris\Downloads\202
01106-seeed-ambd-firmware-rpc-v2.0.1\20201106-seeed-ambd-firmware-rpc-v2.0.1\
copy img to workspace...
Flashing...
All images are sent successfully!
Image tool closed!

Success!
PS C:\Users\Faris\Downloads\ambd_flash_tool-master\ambd_flash_tool-master>
```

Great, Flashing Completed 🔥. If you facing any issues while flashing, post your queries at SeeedStudio Forum

Installing Libraries

As part of the ePRC Firmware, seeed provided few libraries that are needed for the wireless connectivity.

- Seeed_Arduino_rpcBLE
- Seeed_Arduino_rpcWiFi
- Seeed_Arduino_FreeRTOS

The rpcWiFi software library calls Seeed Arduino rpcUnified to implement WiFi and BLE function compatibility with Arduino-ESP32. To reduce the cost of using the software, you can import your favourite ESP32 wifi app and BLE app directly, with minor changes, and then use it. You'll find that your favourite ESP32 app has 5G features and has BLE5.0 features, runs on ARM and other architectures.

1. Install the Seeed_Arduino_rpcWiFi

Visit the Seeed_Arduino_rpcWiFirepositories and download the entire repo to your local drive.

- Visit the Seeed_Arduino_rpcWiFirepositories and download the entire repo to your local drive.
- Now, the Seeed_Arduino_rpcWiFi library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_rpcWiFi` file that you have just downloaded.

2. Install the Seeed_Arduino_rpcBLE

Visit the Seeed_Arduino_rpcBLE repositories and download the entire repo to your local drive.

- Visit the Seeed_Arduino_rpcBLE repositories and download the entire repo to your local drive.
- Now, the Seeed_Arduino_rpcWiFi library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_rpcBLE` file that you have just downloaded.

3. Install the Seeed_Arduino_rpcUnified

Visit the Seeed_Arduino_rpcUnifiedrepositories and download the entire repo to your local drive.

- Visit the Seeed_Arduino_rpcUnifiedrepositories and download the entire repo to your local drive.
- Now, the Seeed-Arduino-FreeRTOS library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_rpcUnified` file that you have just downloaded

4. Install the Seeed_Arduino_FreeRTOS ¶

Visit the Seeed_Arduino_FreeRTOS repositories and download the entire repo to your local drive.

- Visit the Seeed_Arduino_FreeRTOSrepositories and download the entire repo to your local drive.
- Now, the Seeed-Arduino-FreeRTOS library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_FreeRTOS` file that you have just downloaded.

5. Install the File System Library

- Visit the Seeed_Arduino_FS repositories and download the entire repo to your local drive.
- Now, the FS library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_FS` file that you have just downloaded.

Installing the Dependent SFUD Libraries

- Visit the Seeed_Arduino_SFUD repositories and download the entire repo to your local drive.
- Now, the SFUD library can be installed to the Arduino IDE. Open the Arduino IDE, and click `sketch` -> `Include Library` -> `Add .ZIP Library`, and choose the `Seeed_Arduino_SFUD` file that you have just downloaded.

6. Install the Seeed_Arduino_mbedtls - search for "seeed mbedtls" under libraries

After installing all the required libraries, you are all set to do some BLE and WiFi Hacks .

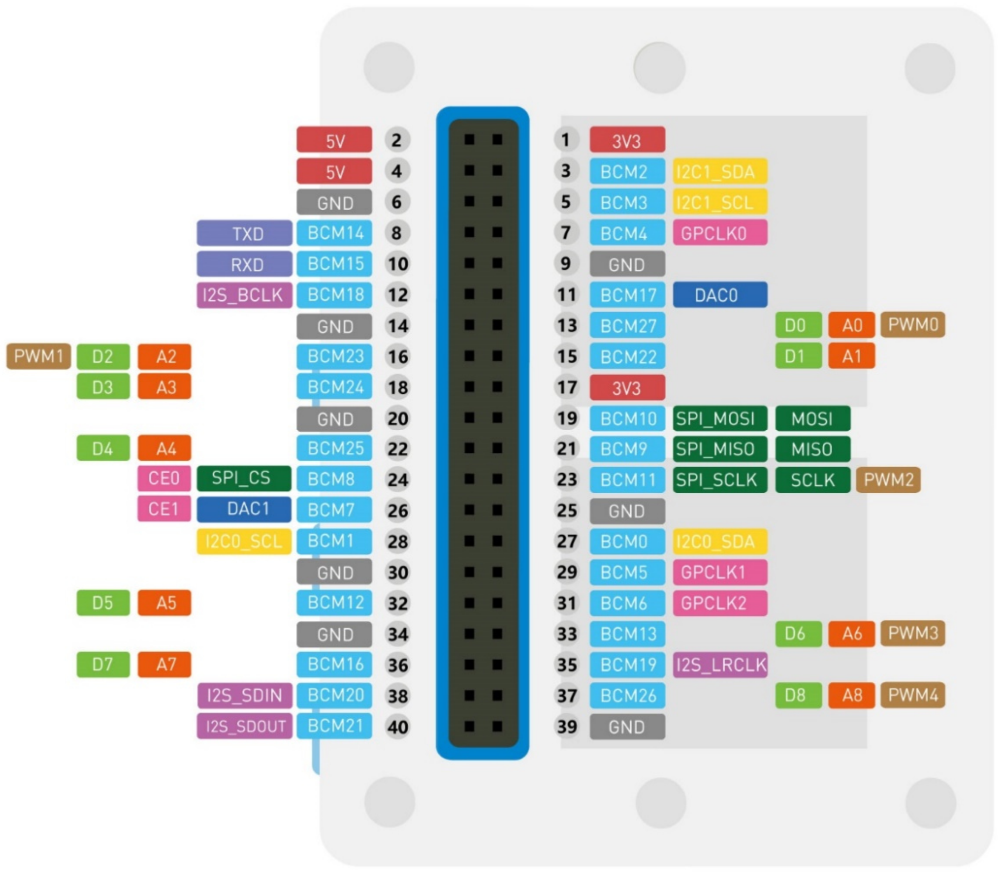
I tried to scan both available WiFi access point and Bluetooth devices together, and it works like a charm

7. Install the following additional support libraries available on “GITHUB” using the “ZiP” install method above:

- **FlashStorage_SAMD.h // Used to store EEPROM Settings from Menu**
- **DNSServer.h**
- **WebServer.h**
- **WiFiManager.h // Seed Studio version**
- **DHT.h // Groove DHT Temperature and Humidity library**
- **PubSubClient.h // Arduino MQTT Library**

Note – if you get a compiling error be sure to look at the “include statements” which are the libraries that were installed, to ensure that you are not missing any!

Hardware Pinout Quick Overview:


5V 2 1 3V3
5V 4 3 BCM2 I2C1_SDA
GND 6 5 BCM3 I2C1_SCL
TXD BCM14 8 7 BCM4 GPCLK0
RXD BCM15 10 9 GND
I2S_BCLK BCM18 12 11 BCM17 DAC0
GND 14 13 BCM27 D0 A0 PWM0
PWM1 D2 A2 BCM23 16 15 BCM22 D1 A1
D3 A3 BCM24 18 17 3V3
GND 20 19 BCM10 SPI_MOSI MOSI
D4 A4 BCM25 22 21 BCM9 SPI_MISO MISO
CE0 SPI_CS BCM8 24 23 BCM11 SPI_SCLK SCLK PWM2
CE1 DAC1 BCM7 26 25 GND
I2C0_SCL BCM1 28 27 BCM0 I2C0_SDA
GND 30 29 BCM5 GPCLK1
D5 A5 BCM12 32 31 BCM6 GPCLK2
GND 34 33 BCM13 D6 A6 PWM3
D7 A7 BCM16 36 35 BCM19 I2S_LRCLK
I2S_SDIN BCM20 38 37 BCM26 D8 A8 PWM4
I2S_SDOUT BCM21 40 39 GND

Code Description (Shown at the end of this document):

This is a program that monitors a DHT sensor for Temperature and Humidity and feeds a PI Controller that has adjustable setpoints, gains, and humidity alarm setpoint that also works with many different sensors (just uncomment out sensor type and change the data pin number if not using the same one "D1")

<u>The Program Offers the following Functions:</u>

1) Displays the Temperature and Humidty Locally on Display (analog & digital values)

2) Contains on-Screen Instructions for setting Up WiFi

3) Auto reconnects Wifi if it is dropped

4) Detects Sensor failure and displays an error message

5) Top Left Buttun Resets WiFi Settings (press and hold upon power-up only).

6) Contains a Built in WiFi Manager to connect Wio Device to your home router via a Graphical User Interface.

7) Provides the following button functionality:

*   Bottom Right swith (Push in) = Menu Operations to set parameters

*   Top Right Button = (+) to adjust menu parameters

*   Top Middle Button = (-) to adjust menu parameters

*   Top Left Button = (Enter) to store menu parameters

8) Fan Control is PWM controlled through pin "A8" and GND and +3.3v via a 2N3904 driver transistor (see schematic).

9) Parameters are stored in EEPROM and read into program once set, otherwise they start as “default”.

10) Contains an internal buzzer when humidity falls below the user setpoint.

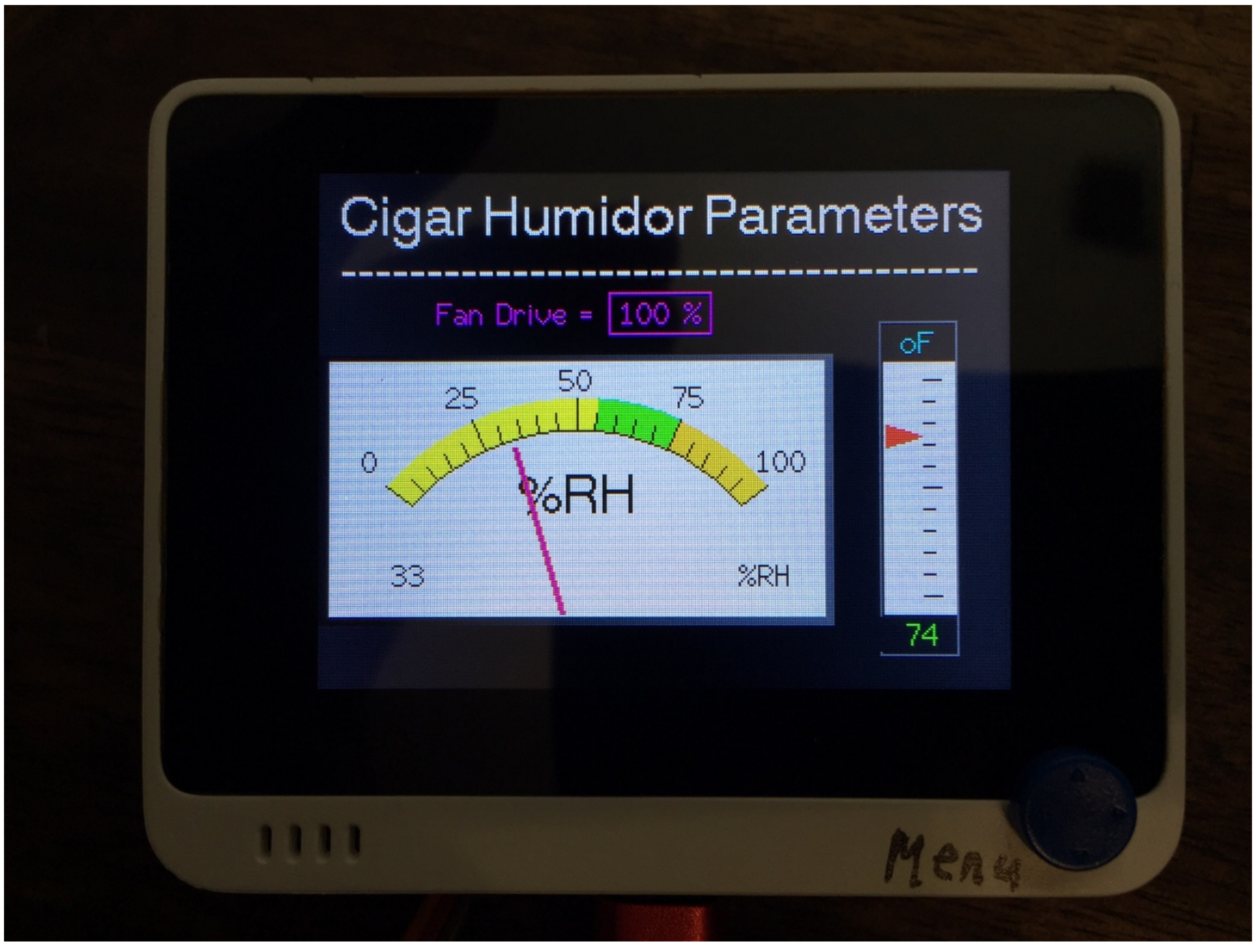
11) WiFi settings are saved once set up. If you get a message to "open browser.." * cycle power and that uses fixes.

12) Incorporates the MQTT Protocol to work with a "Broker Server" IP Addree = 192.168.50.68 (which is mine). Be sure to change this address in the code, before you compile.

13) This circuit works with "Node Red" running on a “Raspberry Pi” (Broker Server) to make "API" calls to "Blynk" so you can view parameters on your phone or laptop or Tablet.

Note – Refer to Node Red circyuits on this Web Page to see the Node Red code and setup of the “Broker Server”.

Picture of Wio Terminal once completed code is uploaded, and everthing is functional:



```
/*
 * This is a program that monitors a DHT sensor for Temperature and Humidity
 * and feeds a PI Controller that has adjustable setpoints, gains, and humidity
 * alarm setpoint that also works with many different sensors (just uncomment out
 * sensor type and change the data pin number if not using the same one "D1")
 *
 * The Program Offers the following Functions:
 * ---------------------------------------------
 * 1) Displays the Temperature and Humidty Locally on Display (analog & digital values)
 * 2) Contains on-Screen Instructions for setting Up WiFi.
 * 3) Auto reconnects Wifi if it is dropped.
 * 4) Detects Sensor failure and displays an error message.
 * 5) Top Left Buttun Resets WiFi Settings upon power-up only.
 * 6) The Web-Server operates by typing in the Wio Device IP
 *    Address in a Browser Window and Displays the current
 *    Temperature and Humidy with an "Auto-Refresh" of Browser
 *    Every 5 seconds.
 * 7) Contains a Built in WiFi Manager to connect Wio Device
 *    to your home router via a Graphical User Interface.
 * 8) Provides the following button functionality:
 *    - Bottom Right swith (Push in) = Menu Operations to set parameters
 *    - Top Right Button = (+) to adjust menu parameters
 *    - Top Middle Button = (-) to adjust menu parameters
 *    - Top Left Button = (Enter) to store menu parameters
 * 9) Fan Control is PWM controlled through pin "A8"
 * 10) Parameters are stored in EEPROM and read into program once started.
 * 11) Contains an internal buzzer when humidity falls below the user setpoint.
 * 12) WiFi settings are saved once set up. If you get a message to "open browser..."
 *     cycle power and that uses fixes.
 * 13) Incorporates the MQTT Protocol to work with a "Broker Server" IP Addree = 
 192.168.50.68
 *     with "Node Red" to make "API" calls to "Blynk" so you can view parameters on 
 your phone.
 */

// Libraries:
// ----------
#include <FlashStorage_SAMD.h>
#include <rpcWiFi.h>
#include <DNSServer.h>
#include <WebServer.h>
#include <WiFiManager.h>
#include <TFT_eSPI.h> // Hardware-specific library
#include <SPI.h>
#include "DHT.h" // Groove DHT Temperature $ Humidity library
#include <PubSubClient.h>
TFT_eSPI tft = TFT_eSPI();       // Invoke custom library

// Global Variables:
// -----------------
#define TFT_GREY 0x5AEB
int count = 0; // Menu Counter
int Kp = 50;  // Proportional Gain (must be less than 255)
int Ki = 5;  // Integral Gain (must be less than 255)
int address = 100;
int flag = 0; // Program Flag to lock menu
int Ha = 10; // Humidity Alarm Setpoint
int Sp = 70; // Controller Setpoint
int PI_Out; // Custom Control Function Return Value
const double delta_time = 1.2; // 0.5 Second Sample Rate in Auto (glaobal variable)
double I_Term = 0.0; // Integral Term (global variable)
double output = 0.0;
const double windup_guard = 60.0; // Integral Windup prevention
double error = 0.0;
double Hum; // Humidity storage Variable
double TemperatureC; // Temperature storage variable for Deg C
double TempF; // Temperature storage variable for Deg F
int Fs; // % Fan Speed
// double h = 68; // Test Value, replace with actual humidity reading
```

```
unsigned long startMillis;  // Non Latency Timed Function
unsigned long currentMillis;
const unsigned long period = 1000;  //the value is a number of milliseconds (3 seconds)
unsigned long startMillis1;  // Non Latency Timed Function
unsigned long currentMillis1;
const unsigned long period1 = 6000;  //the value is a number of milliseconds (6 seconds)
#define FLASH_DEBUG  0
#define TFT_GREY 0x5AEB
#define LOOP_PERIOD 35 // Display updates every 35 ms
float ltx = 0;    // Saved x coord of bottom of needle
uint16_t osx = 120, osy = 120; // Saved x & y coords (osx = 120, osy = 120)
uint32_t updateTime = 0;       // time for next update
int old_analog =  -999; // Value last displayed
int old_digital = -999; // Value last displayed
int value[6] = {0, 0, 0, 0, 0, 0};
int old_value[6] = { -1, -1, -1, -1, -1, -1};
int d = 0;
boolean interlock = true; // Stops Program execution while in Menu
char msg_1[50];  // MQTT Character Messege
char msg_2[50];  // MQTT Character Messege
String Tf1; // String version of TempF
String h1; // String version of Hum

// MQTT Parameters:
// ----------------
// Add your MQTT Broker IP address, example:
const char* mqttServer = "192.168.50.68";  // Raspberry Pi Broker Server "Static IP Address"
const int mqttPort = 1883;
//const char* mqttServer = "broker.mqtt-dashboard.com";

// DHT Sensor Characteristics (Uncomment whatever type you're using)
// ----------------------------------------------------------------
//#define DHTTYPE DHT11   // DHT 11
#define DHTTYPE DHT22   // DHT 22  (AM2302)
//#define DHTTYPE DHT21   // DHT 21 (AM2301)
//#define DHTTYPE DHT10   // DHT 10
//#define DHTTYPE DHT20   // DHT 20
#define DHTPIN D1     // Data Pin we're connected to
DHT dht(DHTPIN, DHTTYPE);   //   DHT11 DHT21 DHT22
//DHT dht(DHTTYPE);         //   DHT10 DHT20 don't need to define Pin

// Motor Drive Pin:
// ----------------
#define PWM_Pin A8 // Motor Drive Pin

// Set up WebServers & MQTT:
// -------------------------
WebServer server(80);  // Create Server on Port 80
// wio terminal wifi
WiFiClient wclient;
PubSubClient client(wclient); // Setup MQTT client

// Main Program:
// =============

void setup() {
  Serial.begin(115200);
  tft.init();
  tft.setRotation(3);
  //tft.setTextSize(2);
  tft.fillScreen(TFT_BLACK);
  tft.setTextColor(TFT_WHITE);
  tft.drawString("Cigar Humidor Controller", 10, 10, 4); //prints strings from (x, y, font size)
  tft.drawString("With Advanced Features", 10, 50, 4);
  tft.drawString("By; Roy H Guerra Jr.", 10, 90, 4);
  pinMode(WIO_5S_UP, INPUT_PULLUP);  // Enable Wio Button puulup Resistors
  pinMode(WIO_5S_DOWN, INPUT_PULLUP);
  pinMode(WIO_5S_LEFT, INPUT_PULLUP);
  pinMode(WIO_5S_RIGHT, INPUT_PULLUP);
  pinMode(WIO_5S_PRESS, INPUT_PULLUP);
  pinMode(WIO_KEY_A, INPUT_PULLUP);
  pinMode(WIO_KEY_B, INPUT_PULLUP);
  pinMode(WIO_KEY_C, INPUT_PULLUP);
  pinMode(PWM_Pin, OUTPUT); // PWM Channel
  pinMode(WIO_BUZZER, OUTPUT); // Internal Wio Buzzer
  dht.begin(); // Initialize DHT sensor
  delay(2000);  // 2S loop delay
  tft.fillScreen(TFT_BLACK);
  WiFiManager wifiManager;
    if (digitalRead(WIO_KEY_C) == LOW) {
    Serial.println("WiFi Reset");
    wifiManager.resetSettings();
    tft.fillScreen(TFT_BLACK); // Clear Screen
    tft.setTextColor(TFT_RED);
    tft.drawString("WiFi Settings Are Reset", 10, 30, 4); //prints strings from (x, y, font size)
    tft.drawString("Turn Off Power Button", 10, 66, 4);
    tft.drawString("Re-Start The Wio Device", 10, 102, 4);
    }
  //delay(2000);  // Delay 2 seconds
    //set callback that gets called when connecting to previous WiFi fails, and enters Access Point mode
    wifiManager.setAPCallback(configModeCallback);
    //Fetches ssid and pass from RTL8720 and tries to connect
    //if it does not connect it starts an access point with the specified name
    //here  "AutoConnectAP"
    //and goes into a blocking loop awaiting configuration
    // delay(2000);  // Delay 2 seconds
    wifiManager.autoConnect("Wio Humidor");
    //if you get here you have connected to the WiFi
    Serial.println("WiFi Is Connected");
    Serial.println("IP Address = ");
    Serial.println(WiFi.localIP());
    Serial.println("SSID = ");
    Serial.println(WiFi.SSID());
    long rssi = WiFi.RSSI();
    Serial.println("RSSI = ");
    Serial.println(WiFi.RSSI());
    tft.fillScreen(TFT_BLACK); // Clear Screen
    tft.setTextColor(TFT_YELLOW);
    tft.drawString("Wifi Connected", 10, 30, 4); //prints strings from (x, y, font size)
    tft.setTextColor(TFT_CYAN);
    tft.drawString("SSID = " + String(WiFi.SSID()), 10, 70, 4);
    tft.setTextColor(TFT_MAGENTA);
    tft.drawString("IP Add = " + String(WiFi.localIP().toString()), 10, 110, 4);
    tft.setTextColor(TFT_BLUE);
    tft.drawString("RSSI = " + String(rssi) + " dBm", 10, 150, 4);
    delay(5000);  // 5 second Delay
    tft.fillScreen(TFT_BLACK); // Clear Screen
  client.setServer(mqttServer, 1883);  //set mqtt server
  connectmqtt(); // Connect to MQTT
  updateTime = millis(); // Next update time
  startMillis = millis();  //initial time stamp
  startMillis1 = millis();  //initial time stamp
  analogMeter(); // Draw analog meter
  plotLinear("oF", 260, 70); // Draw 1 linear meters
}

void loop() {
   currentMillis = millis();  // Get a time Stamp
   currentMillis1 = millis(); // Get a time Stamp
   if (digitalRead(WIO_5S_PRESS) == LOW) {
     Serial.println("5 Way Button Press");
     interlock = false; // Set interlock
     count = 1; // Set Counter
```

```
        Serial.println("Count = " + String(count));
       }
      switch (count) {
       case 1:
        tft.fillScreen(TFT_BLACK);
        tft.setTextColor(TFT_CYAN);
        tft.drawString("Set Humidity Alarm SP", 10, 10, 4); //prints strings from (x, y,
        font size)
        tft.drawString("-------------------------------", 10, 30, 4);
        tft.setTextColor(TFT_YELLOW);
        tft.drawString("Press Top Right Button (+)", 10, 70, 4);
        tft.drawString("Press Top Mid. Button (-)", 10, 110, 4);
        tft.setTextColor(TFT_WHITE);
        tft.drawString("Humidity Alarm SP = ", 10, 160, 4);
        tft.drawRect(245,150,55,35,TFT_WHITE);
        tft.drawString(String(Ha), 250, 160, 4);
        tft.setTextColor(TFT_RED);
        tft.drawString("Press Top Left Button To", 10, 192, 4);
        tft.drawString("Save Configuration (exit)", 10, 215, 4);
        flag = 1; // Change program flag
        while (flag == 1) {
          if (((digitalRead(WIO_KEY_B) == LOW)) && (count == 1)){
            Serial.println("B Key pressed");
            if (Ha > 0){
               Ha -= 1;
               tft.fillRect(245,150,55,35,TFT_BLACK);
               tft.drawRect(245,150,55,35,TFT_WHITE);
               tft.setTextColor(TFT_WHITE);
               tft.drawString(String(Ha), 250, 160, 4);
              }
            Serial.println("Ha = " + String(Ha));
            }
            if (((digitalRead(WIO_KEY_A) == LOW)) && (count == 1)) {
               Serial.println("A Key pressed");
               if (Ha < 80){
                 Ha += 1;
                 tft.fillRect(245,150,55,35,TFT_BLACK);
                 tft.drawRect(245,150,55,35,TFT_WHITE);
                 tft.setTextColor(TFT_WHITE);
                 tft.drawString(String(Ha), 250, 160, 4);
                }
             Serial.println("Ha = " + String(Ha));
             }
            if (((digitalRead(WIO_KEY_C) == LOW)) && (count == 1)) {
              Serial.println("C Key pressed");
              /***
              The function EEPROM.update(address, val) is equivalent to the following:
              if( EEPROM.read(address) != val ) {
               EEPROM.write(address, val);
              }
               ***/
               EEPROM.update(address + 20, Ha);
               EEPROM.commit();
               Serial.println("Wrote " + String(Ha) + " To EEPROM  Address 120");
               tft.fillScreen(TFT_BLACK);
               tft.setTextColor(TFT_CYAN);
               tft.drawString("Humidity Alarm SP Saved", 10, 70, 4);
               delay(2000);  // 2S loop delay
               tft.fillScreen(TFT_BLACK);
               flag = 0;  // Reset flag
               count = 2; // Next menu Option
             }
        delay(150);  // 150mS loop delay
        }
        break;
       case 2:
        tft.fillScreen(TFT_BLACK);
        tft.setTextColor(TFT_MAGENTA);
        tft.drawString("Set Controller SP", 10, 10, 4); //prints strings from (x, y, font
        size)
        tft.drawString("------------------------", 10, 30, 4);
        tft.setTextColor(TFT_YELLOW);
        tft.drawString("Press Top Right Button (+)", 10, 70, 4);
        tft.drawString("Press Top Mid. Button (-)", 10, 110, 4);
        tft.setTextColor(TFT_WHITE);
        tft.drawString("    Controller SP = ", 10, 160, 4);
        tft.drawRect(245,150,55,35,TFT_WHITE);
        tft.drawString(String(Sp), 250, 160, 4);
        tft.setTextColor(TFT_RED);
        tft.drawString("Press Top Left Button To", 10, 192, 4);
        tft.drawString("Save Configuration (exit)", 10, 215, 4);
        flag = 1; // Change program flag
        while (flag == 1) {
          if (((digitalRead(WIO_KEY_B) == LOW)) && (count == 2)){
            Serial.println("B Key pressed");
            if (Sp > 50){
               Sp -= 1;
               tft.fillRect(245,150,55,35,TFT_BLACK);
               tft.drawRect(245,150,55,35,TFT_WHITE);
               tft.setTextColor(TFT_WHITE);
               tft.drawString(String(Sp), 250, 160, 4);
              }
            Serial.println("Ha = " + String(Sp));
            }
            if (((digitalRead(WIO_KEY_A) == LOW)) && (count == 2)) {
               Serial.println("A Key pressed");
               if (Sp < 80){
                 Sp += 1;
                 tft.fillRect(245,150,55,35,TFT_BLACK);
                 tft.drawRect(245,150,55,35,TFT_WHITE);
                 tft.setTextColor(TFT_WHITE);
                 tft.drawString(String(Sp), 250, 160, 4);
                }
             Serial.println("Ha = " + String(Sp));
             }
            if (((digitalRead(WIO_KEY_C) == LOW)) && (count == 2)) {
              Serial.println("C Key pressed");
              /***
              The function EEPROM.update(address, val) is equivalent to the following:
              if( EEPROM.read(address) != val ) {
               EEPROM.write(address, val);
              }
               ***/
               EEPROM.update(address + 30, Sp);
               EEPROM.commit();
               Serial.println("Wrote " + String(Sp) + " To EEPROM  Address 130");
               tft.fillScreen(TFT_BLACK);
               tft.setTextColor(TFT_MAGENTA);
               tft.drawString("Controller Setpoint Saved", 10, 70, 4);
               delay(2000);  // 2S loop delay
               tft.fillScreen(TFT_BLACK);
               flag = 0;  // Reset flag
               count = 3; // Next menu Option
             }
        delay(150);  // 150mS loop delay
        }
        break;
       case 3:
        tft.fillScreen(TFT_BLACK);
        tft.setTextColor(TFT_GREEN);
        tft.drawString("Set Proportional Gain", 10, 10, 4); //prints strings from (x, y, font size)
        tft.drawString("------------------------------", 10, 30, 4);
        tft.setTextColor(TFT_YELLOW);
        tft.drawString("Press Top Right Button (+)", 10, 70, 4);
        tft.drawString("Press Top Mid. Button (-)", 10, 110, 4);
        tft.setTextColor(TFT_WHITE);
        tft.drawString("Proportional Gain = ", 10, 160, 4);
```

```
      tft.drawRect(245,150,55,35,TFT_WHITE);
      tft.drawString(String(Kp), 250, 160, 4);
      tft.setTextColor(TFT_RED);
      tft.drawString("Press Top Left Button To", 10, 192, 4);
      tft.drawString("Save Configuration (exit)", 10, 215, 4);
      flag = 1; // Change program flag
      while (flag == 1) {
        if (((digitalRead(WIO_KEY_B) == LOW)) && (count == 3)){
          Serial.println("B Key pressed");
          if (Kp > 1){
             Kp -= 1;
             tft.fillRect(245,150,55,35,TFT_BLACK);
             tft.drawRect(245,150,55,35,TFT_WHITE);
             tft.setTextColor(TFT_WHITE);
             tft.drawString(String(Kp), 250, 160, 4);
            }
          Serial.println("Kp = " + String(Kp));
          }
          if (((digitalRead(WIO_KEY_A) == LOW)) && (count == 3)) {
             Serial.println("A Key pressed");
             if (Kp < 100){
               Kp += 1;
               tft.fillRect(245,150,55,35,TFT_BLACK);
               tft.drawRect(245,150,55,35,TFT_WHITE);
               tft.setTextColor(TFT_WHITE);
               tft.drawString(String(Kp), 250, 160, 4);
              }
           Serial.println("Kp = " + String(Kp));
           }
          if (((digitalRead(WIO_KEY_C) == LOW)) && (count == 3)) {
            Serial.println("C Key pressed");
            /***
            The function EEPROM.update(address, val) is equivalent to the following:
            if( EEPROM.read(address) != val ) {
             EEPROM.write(address, val);
            }
             ***/
             EEPROM.update(address, Kp);
             EEPROM.commit();
             Serial.println("Wrote " + String(Kp) + " To EEPROM  Address 100");
             tft.fillScreen(TFT_BLACK);
             tft.setTextColor(TFT_GREEN);
             tft.drawString("Proportiional Gain Saved", 10, 70, 4);
             delay(2000);  // 2S loop delay
             tft.fillScreen(TFT_BLACK);
             flag = 0;  // Reset flag
             count = 4; // Next menu Option
           }
      delay(150);  // 150mS loop delay
      }
      break;
     case 4:
      tft.fillScreen(TFT_BLACK);
      tft.setTextColor(TFT_BLUE);
      tft.drawString("Set Integral Gain", 10, 10, 4); //prints strings from (x, y, font
      size)
      tft.drawString("------------------------", 10, 30, 4);
      tft.setTextColor(TFT_YELLOW);
      tft.drawString("Press Top Right Button (+)", 10, 70, 4);
      tft.drawString("Press Top Mid. Button (-)", 10, 110, 4);
      tft.setTextColor(TFT_WHITE);
      tft.drawString("    Integral Gain = ", 10, 160, 4);
      tft.drawRect(245,150,55,35,TFT_WHITE);
      tft.drawString(String(Ki), 250, 160, 4);
      tft.setTextColor(TFT_RED);
      tft.drawString("Press Top Left Button To", 10, 192, 4);
      tft.drawString("Save Configuration (exit)", 10, 215, 4);
      flag = 1; // Change program flag
      while (flag == 1) {
        if (((digitalRead(WIO_KEY_B) == LOW)) && (count == 4)){
          Serial.println("B Key pressed");
          if (Ki > 0){
             Ki -= 1;
             tft.fillRect(245,150,55,35,TFT_BLACK);
             tft.drawRect(245,150,55,35,TFT_WHITE);
             tft.setTextColor(TFT_WHITE);
             tft.drawString(String(Ki), 250, 160, 4);
            }
          Serial.println("Ki = " + String(Ki));
          }
          if (((digitalRead(WIO_KEY_A) == LOW)) && (count == 4)) {
             Serial.println("A Key pressed");
             if (Ki < 50){
               Ki += 1;
               tft.fillRect(245,150,55,35,TFT_BLACK);
               tft.drawRect(245,150,55,35,TFT_WHITE);
               tft.setTextColor(TFT_WHITE);
               tft.drawString(String(Ki), 250, 160, 4);
              }
           Serial.println("Ki = " + String(Ki));
           }
          if (((digitalRead(WIO_KEY_C) == LOW)) && (count == 4)) {
            Serial.println("C Key pressed");
            /***
            The function EEPROM.update(address, val) is equivalent to the following:
            if( EEPROM.read(address) != val ) {
             EEPROM.write(address, val);
            }
             ***/
             EEPROM.update(address + 10, Ki);
             EEPROM.commit();
             Serial.println("Wrote " + String(Ki) + " To EEPROM  Address 110");
             tft.fillScreen(TFT_BLACK);
             tft.setTextColor(TFT_BLUE);
             tft.drawString("Integral Gain Saved", 10, 70, 4);
             delay(2000);  // 2S loop delay
             tft.fillScreen(TFT_BLACK);
             flag = 0;  // Reset flag
             interlock = true; // Reset Interlock
             count = 0; // Next menu Option
             NVIC_SystemReset(); // Re-Start Program
           }
      delay(150);  // 150mS loop delay
      }
     break;
     default:
      count = 0; // Default
     break;
    }
  // delay(100);  // 100mS loop delay
  if (interlock == true){
   // No Operation of Program past this point once interlock is set while in menu's
  if (currentMillis - startMillis >= period){  // Test whether the period has elapsed
      SensorData(); // Goto Function
      controller(); // Goto Function
      h1 = String(Hum,2);  // Contert humidity to a String
      h1.toCharArray(msg_1,h1.length()+1);  // Convert string to a Character Array
      Tf1 = String(TempF,2); // Convert Temperature to a String
      Tf1.toCharArray(msg_2,Tf1.length()+1);  // Convert string to a Character Array
      Serial.println("Message_1 = " + String(msg_1));
      Serial.println("Message_2 = " + String(msg_2));
      client.publish("/sensor1/hum", msg_1);
      client.publish("/sensor1/temp", msg_2);
      tft.setTextColor(TFT_MAGENTA);  // Text color
      tft.drawString("Fan Drive = ", 55, 58, 2); // SCREEN Header
      tft.fillRect(135,56,48,20,TFT_BLACK);  // Draw a Rect to erase previous data
      tft.drawRect(135,56,48,20,TFT_MAGENTA);  // Draw a Rect.
      tft.drawString(String(Fs) + " %", 140, 58, 2); //prints strings from (x, y)
      if (WiFi.status() != WL_CONNECTED) {   // reconnect WiFi if it gets dropped automatically
         WiFi.reconnect();
      }
      if (!client.connected()) {  // Re-Connect MQTT in case it drops out
         reconnect();
       }
      startMillis = currentMillis;  // New Time Stamp
   }
  if (currentMillis1 - startMillis1 >= period1){  // Test whether the period has elapsed
      buzzer(); // Goto Function
      startMillis1 = currentMillis1;  // New Time Stamp
    }
   if (updateTime <= millis()) {
      updateTime = millis() + LOOP_PERIOD;
    //value[0] = map(analogRead(A0), 0, 1023, 0, 100); // Test with an actual value
    // value[0] = 50 + 50 * sin((d + 0) * 0.0174532925);   // Create a Sine wave for testing
     plotPointer(); // Goto Function
     plotNeedle(int(Hum), 0);  // Goto Function
    }
  }
  client.loop(); // Keep looping for MQTT
 }

 // PI Controller Function:
 // -----------------------
 float Calculate_PI () {
   // Read EEPROM Kp & Ki, Ha, & Sp:
    Kp = EEPROM.read(address);
    Serial.println("Kp = " + String(Kp));
    Ki = EEPROM.read(address + 10);
    Serial.println("Ki = " + String(Ki));
    Ha = EEPROM.read(address + 20);
    Serial.println("Ha = " + String(Ha));
    Sp = EEPROM.read(address + 30);
    Serial.println("Sp = " + String(Sp));
    if ((Kp == 255) || (Ki == 255) || (Sp == 255) || (Ha ==255)) { // Guards against EEPROM not being set
      Kp = 50;
      Ki = 5;
      Ha = 50;
      Sp = 70;
    }
    error = Sp - Hum; // Error Term, h = feedback
   I_Term += (error * delta_time); // Intergral Term
   if (I_Term > windup_guard){ // Positive Integral Windup Guard
     I_Term = windup_guard;
   }
   if (I_Term < - windup_guard){ // Negative Integral Windup Guard
     I_Term = - windup_guard;
   }
   if (isnan(I_Term)){ // Reset if NAN
     I_Term = 0;
   }
  output = (Kp * error) + (Ki * I_Term); // Controller Output (Proportional + Integral)
  output = constrain(output, 0, 255); // Limits Controller Range
  Serial.println("Kp = " + String(Kp)); // Debug
  Serial.println("Ki = " + String(Ki)); // Debug
  Serial.println("Setpoint = " + String(Sp)); // Debug
  Serial.println("Feedback (humidity) = " + String(Hum)); // Debug
  Serial.println("Error = " + String(error)); // Debug
  Serial.println("I_Term = " + String(I_Term)); // Debug
  Serial.println("Ki *I_Term = " + String(Ki * I_Term)); // Debug
  Serial.println("P_Term = " + String(Kp * error)); // Debug
  Serial.println("Output = " + String(output)); // Debug
  Serial.println("Alarm Setpoint = " + String(Ha)); // Debug
  return int(output); // Return PI Control Value as an integer
 }
```

```

// Function to Sound Buzzer:
// --------------------------
void buzzer(){ // Buzzer Function Block
  if (Hum < Ha){
    analogWrite(WIO_BUZZER, 128);
    delay(1000);
    analogWrite(WIO_BUZZER, 0);
    delay(1000);
   }
}

// Function to Read Control Loop and set PWM and Speed Indication:
// -------------------------------------------------------------
void controller(){ // Controller Function Block
  PI_Out = Calculate_PI(); // Calculate new PI Control Value
  Serial.println("PI_Out = " + String(PI_Out)); // Debug
  analogWrite(PWM_Pin, PI_Out); // PWM Value (0-255)
  Fs = map(output, 0, 255, 0, 100); // Rescale controller output to % fan speed
  Serial.println("Fan Speed = " + String(Fs)); // Debug
}

// Read Sensor Function
// ---------------------
void SensorData(){
  Hum = dht.readHumidity(); // Measure the humidity
  Serial.println("Humidity = " + String(Hum));
  TemperatureC = dht.readTemperature(); // Measure the temperature
  TempF = ((TemperatureC * 9/5) + 32); // Convert temperature to degrees Fahrenheit
  Serial.println("Temperature = " + String(TempF));
  // Compare temperature & humidity events and perform a check sum.
  if (isnan(TemperatureC) || isnan(Hum)){ // Print "0" for a bad reading
    TempF = 0;
    Hum = 0;
    Serial.println("Bad Connection or Sensor");
   }
}

// Draw the Horizontal Analog Meter & Menu on the screen
// -----------------------------------------------------
void analogMeter() {
    // Meter outline
    tft.fillRect(0, 85, 239, 126, TFT_GREY); // 0, 0, 239, 126 (x, y, w, h)
    tft.fillRect(5, 88, 230, 119, TFT_WHITE); // 5, 3, 230, 119,
    //tft.fillRect(5, 10, 100, 50, TFT_WHITE); // SCREEN Header
    tft.setTextColor(TFT_WHITE);
    tft.drawString(" Cigar Humidor Parameters", 5, 10, 4); // SCREEN Header
    tft.drawString(" --------------------------------------", 5, 35, 4); // SCREEN
    Header
    tft.setTextColor(TFT_BLACK);  // Text color
    // Draw ticks every 5 degrees from -50 to +50 degrees (100 deg. FSD swing)
    for (int i = -50; i < 51; i += 5) {
        // Long scale tick length
        int tl = 15;
        // Coodinates of tick to draw
        float sx = cos((i - 90) * 0.0174532925);
        float sy = sin((i - 90) * 0.0174532925);
        uint16_t x0 = sx * (100 + tl) + 120; // 120
        uint16_t y0 = sy * (100 + tl) + 220; // 140
        uint16_t x1 = sx * 100 + 120; // 120
        uint16_t y1 = sy * 100 + 220; // 140
        // Coordinates of next tick for zone fill
        float sx2 = cos((i + 5 - 90) * 0.0174532925);
        float sy2 = sin((i + 5 - 90) * 0.0174532925);
        int x2 = sx2 * (100 + tl) + 120; // 120
        int y2 = sy2 * (100 + tl) + 220; // 140
        int x3 = sx2 * 100 + 120; // 120
        int y3 = sy2 * 100 + 220; // 140
        // Yellow zone limits
        if (i >= -50 && i < 1) {
          tft.fillTriangle(x0, y0, x1, y1, x2, y2, TFT_YELLOW);
          tft.fillTriangle(x1, y1, x2, y2, x3, y3, TFT_YELLOW);
        }
        // Green zone limits
        if (i >= 1 && i < 25) {  // 0
           tft.fillTriangle(x0, y0, x1, y1, x2, y2, TFT_GREEN);
           tft.fillTriangle(x1, y1, x2, y2, x3, y3, TFT_GREEN);
        }
        // Orange zone limits
        if (i >= 25 && i < 50) {
           tft.fillTriangle(x0, y0, x1, y1, x2, y2, TFT_ORANGE);
           tft.fillTriangle(x1, y1, x2, y2, x3, y3, TFT_ORANGE);
        }
        // Short scale tick length
        if (i % 25 != 0) {
            tl = 8;
        }
        // Recalculate coords incase tick lenght changed
        x0 = sx * (100 + tl) + 120; // 120
        y0 = sy * (100 + tl) + 220; // 140
        x1 = sx * 100 + 120; // 120
        y1 = sy * 100 + 220; // 140
        // Draw tick
        tft.drawLine(x0, y0, x1, y1, TFT_BLACK);
        // Check if labels should be drawn, with position tweaks
        if (i % 25 == 0) {
            // Calculate label positions
            x0 = sx * (100 + tl + 10) + 120; // 120
            y0 = sy * (100 + tl + 10) + 220; // 140
            switch (i / 25) {
                case -2: tft.drawCentreString("0", x0, y0 - 12, 2); break;
                case -1: tft.drawCentreString("25", x0, y0 - 9, 2); break;
                case 0: tft.drawCentreString("50", x0, y0 - 6, 2); break;
                case 1: tft.drawCentreString("75", x0, y0 - 9, 2); break;
                case 2: tft.drawCentreString("100", x0, y0 - 12, 2); break;
            }
        }
        // Now draw the arc of the scale
        sx = cos((i + 5 - 90) * 0.0174532925);
        sy = sin((i + 5 - 90) * 0.0174532925);
        x0 = sx * 100 + 120; // 120
        y0 = sy * 100 + 220; // 140
        // Draw scale arc, don't draw the last part
        if (i < 50) {
            tft.drawLine(x0, y0, x1, y1, TFT_BLACK);
        }
    }
    tft.drawString("%RH", 195, 180, 2); // Units at bottom right
    tft.drawCentreString("%RH", 120, 140, 4); // Large Center Label
   // tft.drawRect(5, 88, 220, 119, TFT_BLACK); // Draw bottom bezel line
    plotNeedle(0, 0); // Put meter needle at 0
}

// Update needle position
// This function is blocking while needle moves, time depends on ms_delay
// 10ms minimises needle flicker if text is drawn within needle sweep area
// Smaller values OK if text not in sweep area, zero for instant movement but
// does not look realistic... (note: 100 increments for full scale deflection)
// ---------------------------------------------------------------------
void plotNeedle(int value, byte ms_delay) {
    tft.setTextColor(TFT_BLACK, TFT_WHITE);
    char buf[8]; dtostrf(value, 4, 0, buf);
    tft.drawRightString(buf, 50, 180, 2); // Corrected to 50 & 180 for data humidity
    digital display left value
    if (value < -10) {
        value = -10;    // Limit value to emulate needle end stops
    }
    if (value > 110) {
        value = 110;
    }
    // Move the needle util new value reached
    while (!(value == old_analog)) {
        if (old_analog < value) {
            old_analog++;
        } else {
            old_analog--;
        }
        if (ms_delay == 0) {
            old_analog = value;    // Update immediately id delay is 0
        }
        float sdeg = map(old_analog, -10, 110, -150, -30); // Map value to angle
        // Calcualte tip of needle coords
        float sx = cos(sdeg * 0.0174532925);
        float sy = sin(sdeg * 0.0174532925);
        // Calculate x delta of needle start (does not start at pivot point)
        float tx = tan((sdeg + 90) * 0.0174532925); // 90
        // Erase old needle image
        tft.drawLine(120 + 20 * ltx - 1, 205, osx - 1, osy + 82, TFT_WHITE); // 120 keep, osy to osy +90
        tft.drawLine(120 + 20 * ltx, 205, osx, osy + 82, TFT_WHITE);
        tft.drawLine(120 + 20 * ltx + 1, 205, osx + 1, osy + 82, TFT_WHITE);
        // Re-plot "RH" text under needle
        tft.setTextColor(TFT_BLACK);
        tft.drawCentreString("%RH", 120, 140, 4); // Changed
        // RePlot Bezel with RH text data and RH label
        // tft.drawRect(20, 174, 220, 30, TFT_BLACK); // Draw bottom bezel line
        // Store new needle end coords for next erase
        ltx = tx;
        osx = sx * 98 + 120;
        osy = sy * 98 + 140;
        // Draw the needle in the new postion, magenta makes needle a bit bolder
        // draws 3 lines to thicken needle
        tft.drawLine(120 + 20 * ltx - 1, 205, osx - 1, osy + 82, TFT_RED); // 120 keep, osy to osy +90
        tft.drawLine(120 + 20 * ltx, 205, osx, osy + 82, TFT_MAGENTA);
        tft.drawLine(120 + 20 * ltx + 1, 205, osx + 1, osy + 82, TFT_RED);
        // Slow needle down slightly as it approaches new postion
        if (abs(old_analog - value) < 10) {
            ms_delay += ms_delay / 5;
        }
        // Wait before next update
        delay(ms_delay);
    }
}

// Draw a meter on the screen:
// ---------------------------
void plotLinear(char* label, int x, int y) {
    int w = 36;
    tft.drawRect(x, y, w, 155, TFT_GREY);
    tft.fillRect(x + 2, y + 19, w - 3, 155 - 38, TFT_WHITE);
    tft.setTextColor(TFT_CYAN, TFT_BLACK);
    tft.drawCentreString(label, x + w / 2, y + 2, 2);
    for (int i = 0; i < 110; i += 10) {
        tft.drawFastHLine(x + 20, y + 27 + i, 6, TFT_BLACK);
    }
    for (int i = 0; i < 110; i += 50) {
        tft.drawFastHLine(x + 20, y + 27 + i, 9, TFT_BLACK);
    }
    tft.fillTriangle(x + 3, y + 127, x + 3 + 16, y + 127, x + 3, y + 127 - 5, TFT_RED);
    tft.fillTriangle(x + 3, y + 127, x + 3 + 16, y + 127, x + 3, y + 127 + 5, TFT_RED);
    tft.drawCentreString("---", x + w / 2, y + 155 - 18, 2);
}

// Adjust the vertical linear meter pointer positions:
// ---------------------------------------------------
void plotPointer(void) {
    value[0] = int(TempF); // Assign TempF to Value.
    int dy = 187;  // 187
    byte pw = 16;  // 16
    tft.setTextColor(TFT_GREEN, TFT_BLACK);
    // Move the 6 pointers one pixel towards new value
    for (int i = 0; i < 1; i++) { // i < 6
        char buf[8]; dtostrf(value[i], 4, 0, buf); //dtostrf(value[i], 4, 0, buf)
        tft.drawRightString(buf, i * 40 + 287, 207, 2); // Value display (x, y, font size)
        int dx = 263 + 40 * i; // Red Pointer "X" position
        if (value[i] < 0) {
            value[i] = 0;    // Limit value to emulate needle end stops
        }
        if (value[i] > 100) {
            value[i] = 100;
        }
        while (!(value[i] == old_value[i])) {
            dy = 180 + 17 - old_value[i]; // Red Pointer "Y" position
            if (old_value[i] > value[i]) {
                tft.drawLine(dx, dy - 5, dx + pw, dy, TFT_WHITE); //dx, dy - 5, dx + pw, dy, TFT_WHITE
                old_value[i]--;
                tft.drawLine(dx, dy + 6, dx + pw, dy + 1, TFT_RED); //dx, dy + 6, dx + pw, dy + 1, TFT_RED
            } else {
                tft.drawLine(dx, dy + 5, dx + pw, dy, TFT_WHITE); //dx, dy - 5, dx + pw, dy, TFT_WHITE
                old_value[i]++;
                tft.drawLine(dx, dy - 6, dx + pw, dy - 1, TFT_RED); //dx, dy + 6, dx + pw, dy + 1, TFT_RED
            }
        }
    }
}

// WiFi CallBack Routine:
// ----------------------
void configModeCallback (WiFiManager *myWiFiManager) {
  Serial.println("Entered config mode");
  Serial.println(WiFi.softAPIP());
  //if you used auto generated SSID, print it
  Serial.println(myWiFiManager->getConfigPortalSSID());
  tft.fillScreen(TFT_BLACK); // Clear Screen
  tft.setTextColor(TFT_WHITE);
  tft.drawString("On a phone, Tablet or PC", 10, 10, 4); //prints strings from (x, y, font size)
  tft.drawString("Goto Wifi Settings", 10, 34, 4);
  tft.setTextColor(TFT_GREEN);
  tft.drawString("Connect to Wio Terminal", 10, 70, 4);
  tft.setTextColor(TFT_CYAN);
  tft.drawString("Enter in SSID & Passwword", 10, 104, 4);
  tft.drawString("In Graphical Interface", 10, 128, 4);
  tft.setTextColor(TFT_RED);
  tft.drawString("If no Graphical Interface", 10, 164, 4);
  tft.drawString("Type 192.168.1.1", 10, 190, 4);
  tft.drawString("Inside a WEB Browser", 10, 216, 4);
  delay(1000); // 1 second delay
}

// MQTT Callback Function:
// ------------------------
void callback(char* topic, byte* message, unsigned int length) {
  Serial.print("Message arrived on topic: ");
  Serial.print(topic);
  Serial.print(". Message: ");
  String messageTemp;

  for (int i = 0; i < length; i++) {
    Serial.print((char)message[i]);
```

```
      messageTemp += (char)message[i];
    }
    Serial.println();

    // Feel free to add more if statements to control more GPIOs with MQTT

    // If a message is received on the topic esp32/output, you check if the message is
    either "on" or "off".
    // Changes the output state according to the message
    if (String(topic) == "esp32/output") {
      Serial.print("Changing output to ");
      if(messageTemp == "on"){
        Serial.println("on");
       // digitalWrite(ledPin, HIGH);
      }
      else if(messageTemp == "off"){
        Serial.println("off");
        //digitalWrite(ledPin, LOW);
      }
       if ((char)message[0] == 'O' && (char)message[1] == 'N') //on
      {
     // digitalWrite(LED, HIGH);
      Serial.println("on");
      client.publish("outTopic", "LED turned ON");
      }
     else if ((char)message[0] == 'O' && (char)message[1] == 'F' && (char)message[2] ==
     'F') //off
      {
     // digitalWrite(LED, LOW);
      Serial.println(" off");
      client.publish("outTopic", "LED turned OFF");
      }
    Serial.println();
    }
  }

  // MQTT Function to Re-Connect:
  // ----------------------------
  void reconnect() {
    // Loop until we're reconnected
    if (!client.connected()) {
      Serial.print("Attempting MQTT connection...");
      // Attempt to connect
      if (client.connect("Wio Humidor")) {
        Serial.println("connected");
        // Subscribe
        //client.subscribe("Wio Humidor");
      } else {
        Serial.print("failed, rc=");
        Serial.print(client.state());
        Serial.println(" try again in 5 seconds");
        // Wait 5 seconds before retrying
        delay(5000);
      }
    }
  }

  // MQTT Connection Function:
  // -------------------------
  void connectmqtt(){
    client.connect("Wio Humidor");{ // Wio Terminal will connect to mqtt broker with
    clientID

      tft.fillScreen(TFT_BLACK);
      tft.setTextColor(TFT_GREEN);
      tft.drawString("Connected to MQTT", 10, 30, 4); //prints strings from (x, y, font
      size)
      Serial.println("Connected to MQTT");
      delay(2000); // 2 second delay
      tft.fillScreen(TFT_BLACK);
      if (!client.connected()) {
        tft.fillScreen(TFT_BLACK);
        tft.setTextColor(TFT_RED);
        tft.drawString("Not Connected to MQTT", 10, 30, 4); //prints strings from (x, y,
        font size)
        Serial.println("Not Connected to MQTT");
        delay(2000); // 2 second delay
        tft.fillScreen(TFT_BLACK);
        reconnect();  // Goto Function
        NVIC_SystemReset(); // Re-Start Program
      }
    }
  }
```