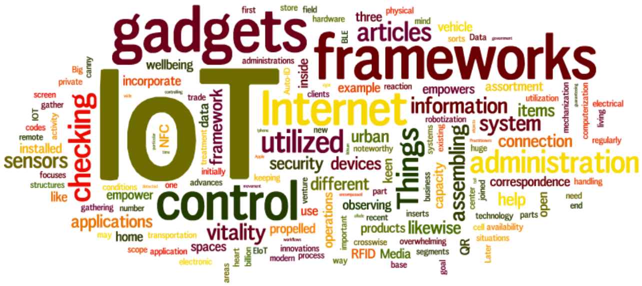
CS578: Internet of Things

Smart Home Monitoring
Using
ESP8266 and Webserver



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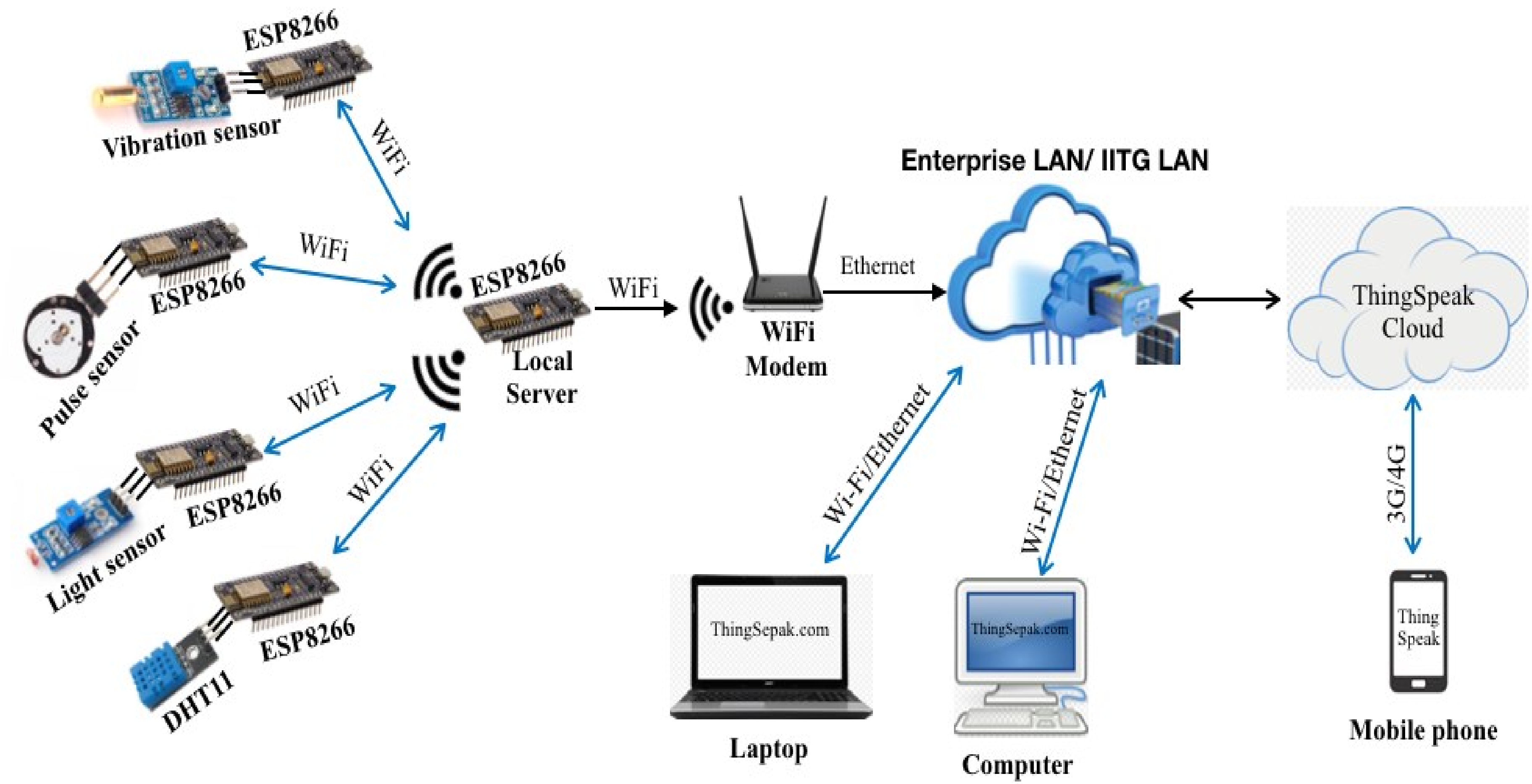
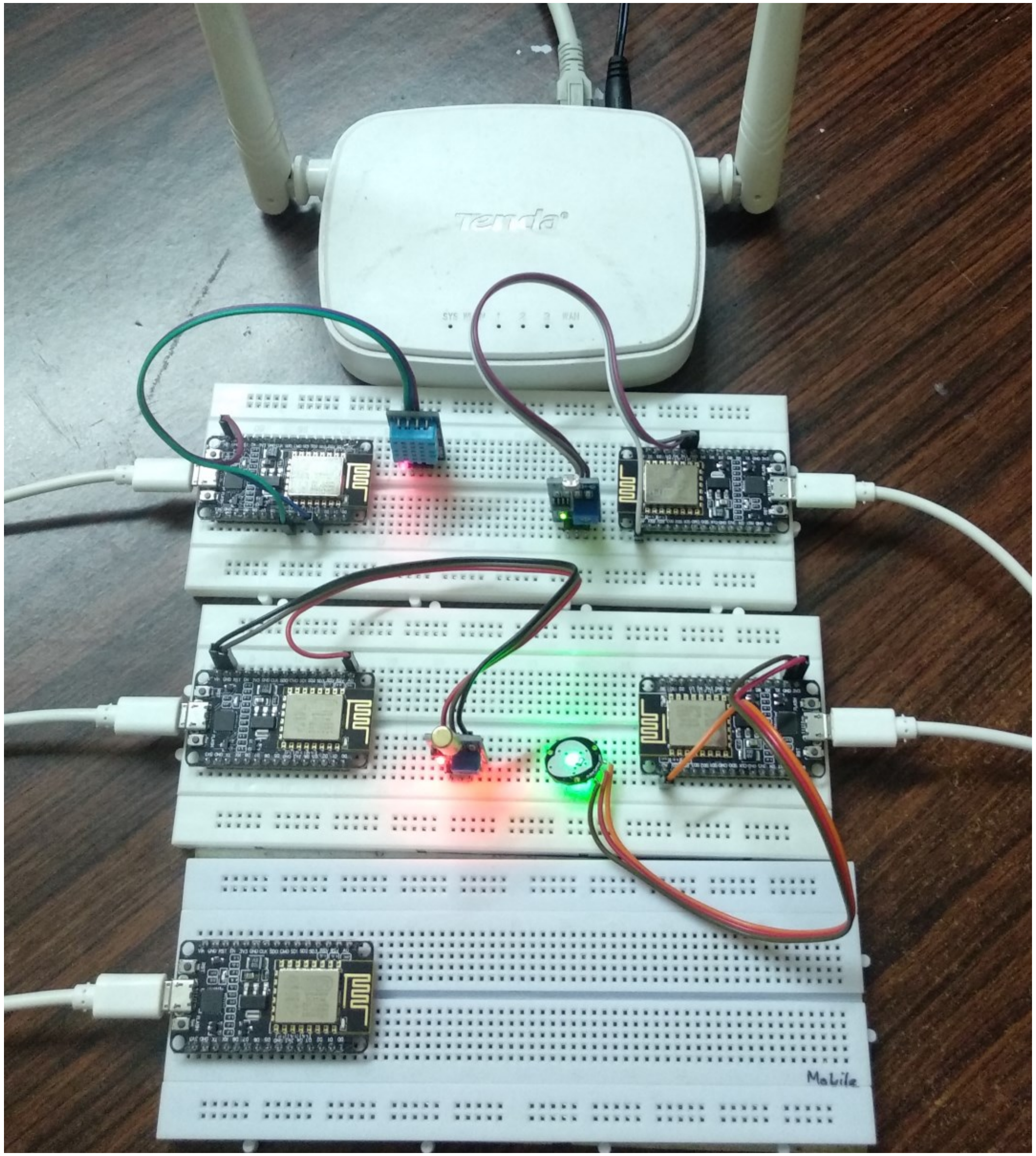
E-mail: manaskhatua@iitg.ac.in , URL: http://manaskhatua.github.io/

“Try not to become a man of success. Rather become a man of value.” – **Albert Einstein**

System Diagram

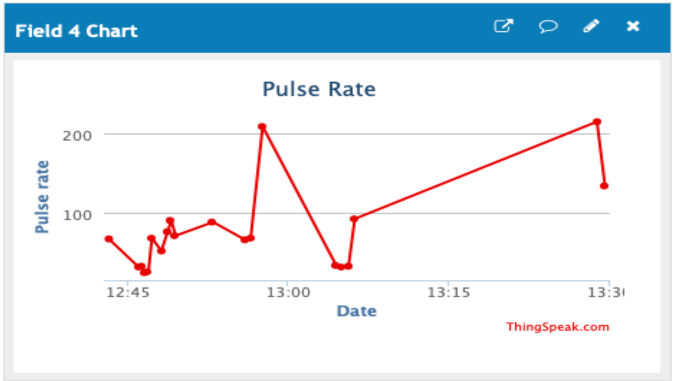


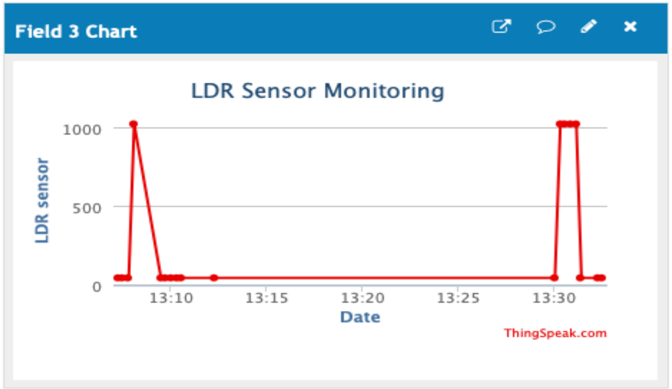
Physical Setup



ThingSpeak cloud server

accessing from a Laptop/PC/Smartphone





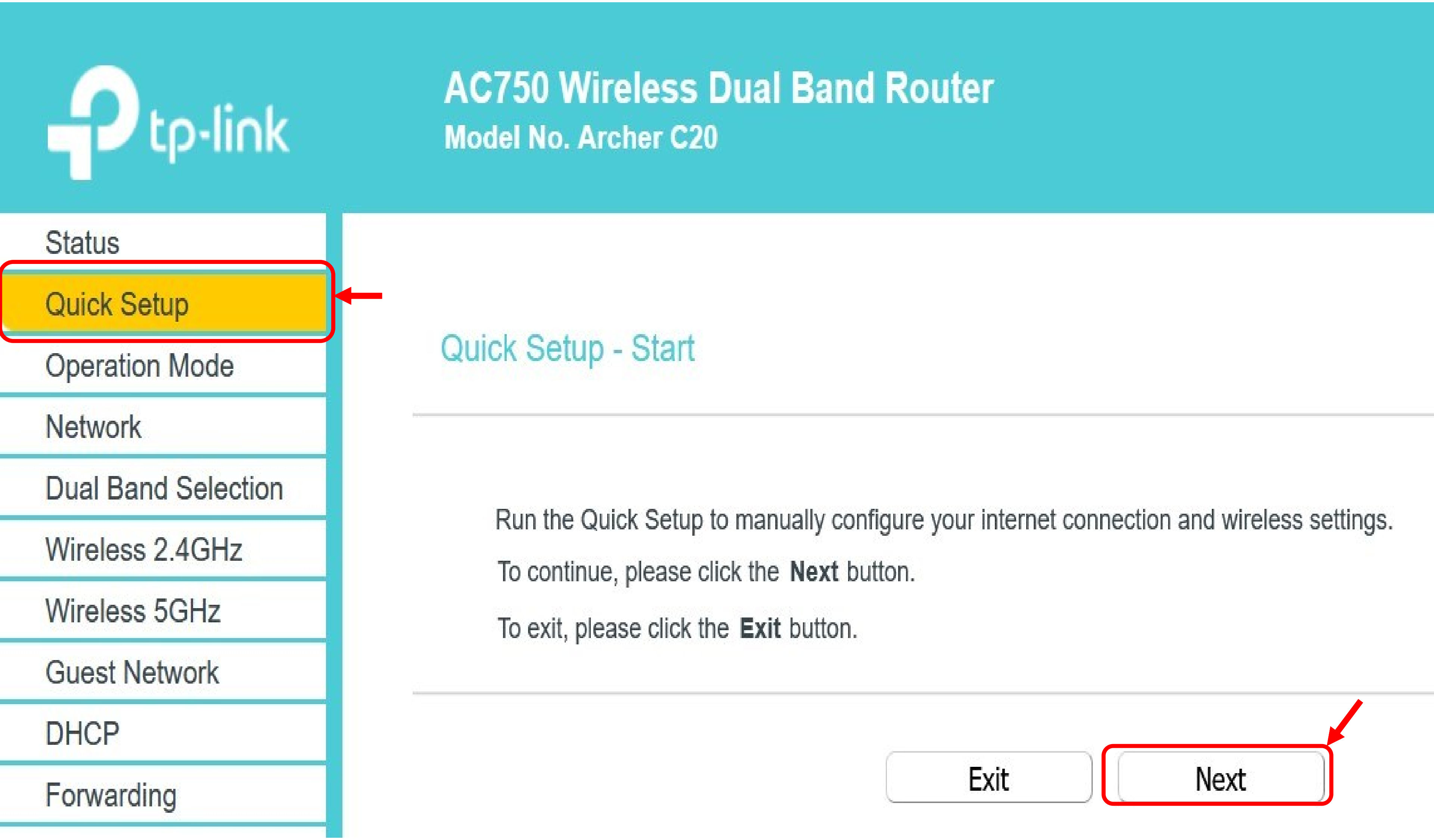
Router Configuration
To Connect with IITG Internet

Router Configuration

- This is TP-Link WiFi Router
- ESP8266 (local server) will connect to this WiFi AP
- Sensor data will be uploaded to ThingSpeak server through this WiFi AP.

- Login TP-Link WiFi using given IP (**192.168.0.1**) and password written on its label.
- Do the following:
  - Go to Quick Setup and click on Next.
  - Choose Operation Mode as Wireless Router and click on Next.
  - Select WAN Connection Type as Static IP and click on Next.
  - Set the **Static IP**, **Subnet Mask**, **Default Gateway**, **Primary DNS Server**, **Secondary DNS Server** and click on Next.
  - Select the radio bands (2.4 GHz and/or 5 GHz) and click on Next.
  - Setup the Wireless radio bands selected above and click on Next.
  - Confirm the setup by clicking on Save. The router reboots and reconnects.

Cont…



AC750 Wireless Dual Band Router

Model No. Archer C20

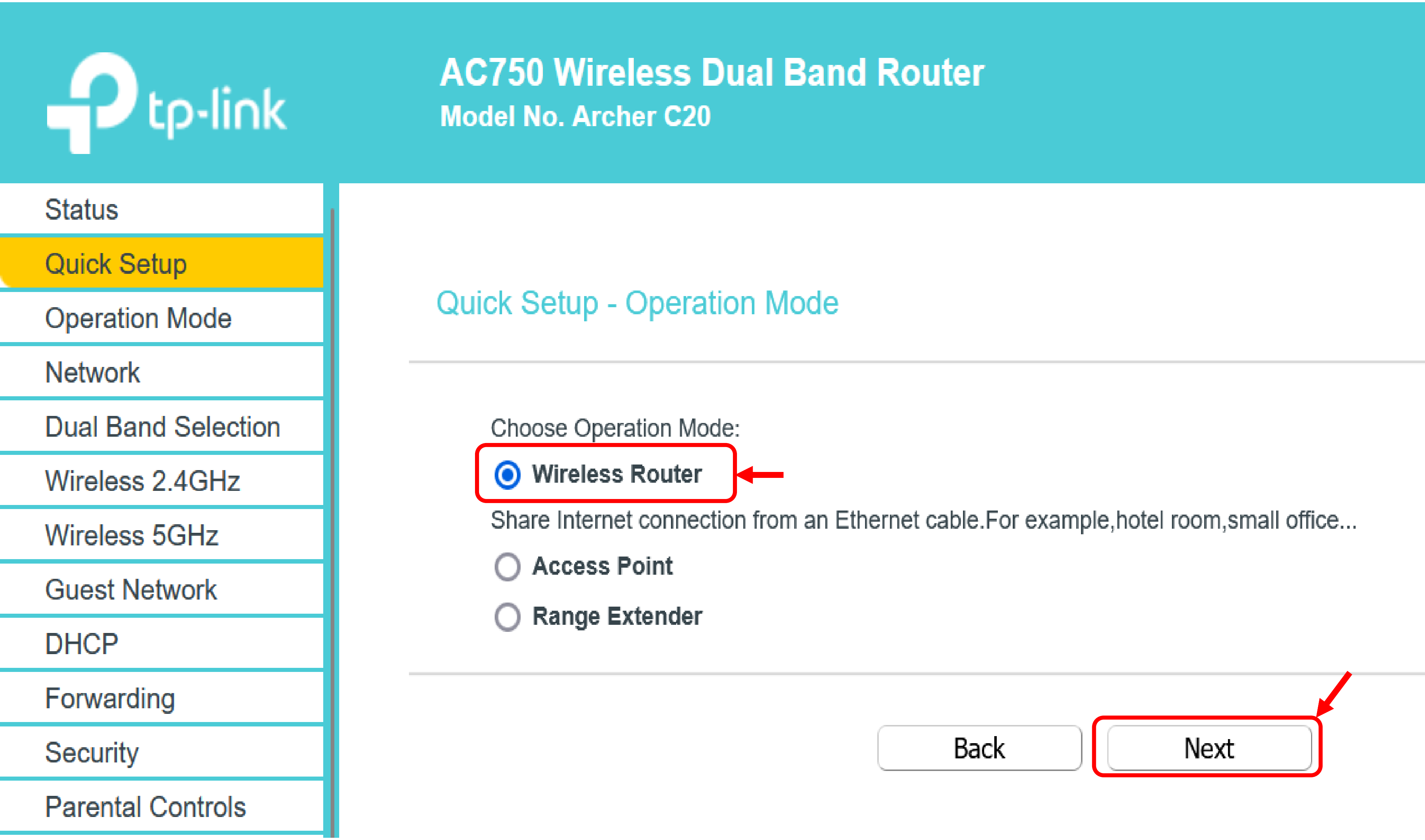
Quick Setup - Start

Run the Quick Setup to manually configure your internet connection and wireless settings.

To continue, please click the **Next** button.

To exit, please click the **Exit** button.

Cont…



AC750 Wireless Dual Band Router

Model No. Archer C20

Quick Setup - Operation Mode

Choose Operation Mode:

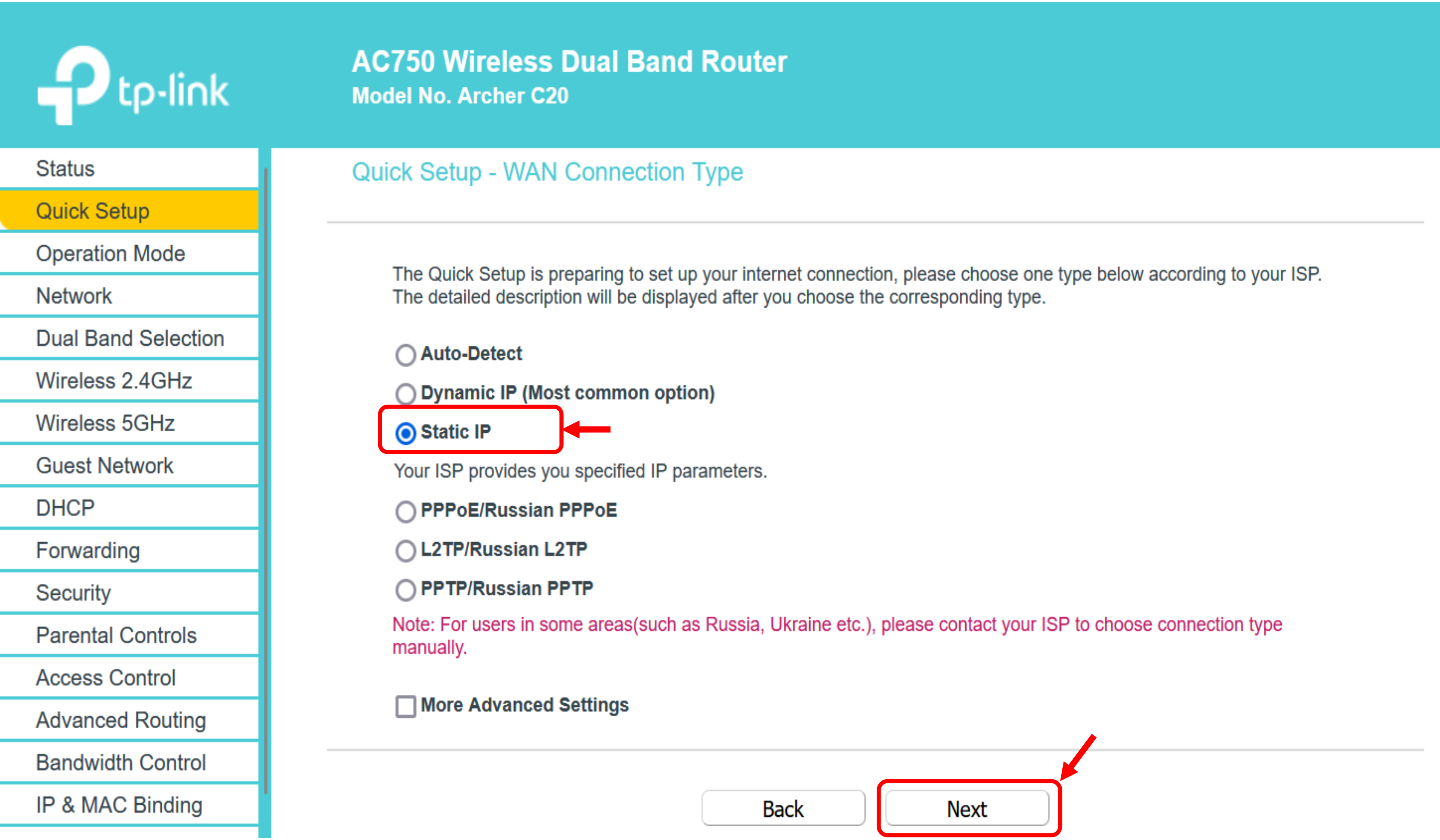
● Wireless Router

Share Internet connection from an Ethernet cable.For example,hotel room,small office...

○ Access Point

○ Range Extender

Cont…



Quick Setup - WAN Connection Type

The Quick Setup is preparing to set up your internet connection, please choose one type below according to your ISP. The detailed description will be displayed after you choose the corresponding type.

○ Auto-Detect

○ Dynamic IP (Most common option)

● Static IP

Your ISP provides you specified IP parameters.

○ PPPoE/Russian PPPoE

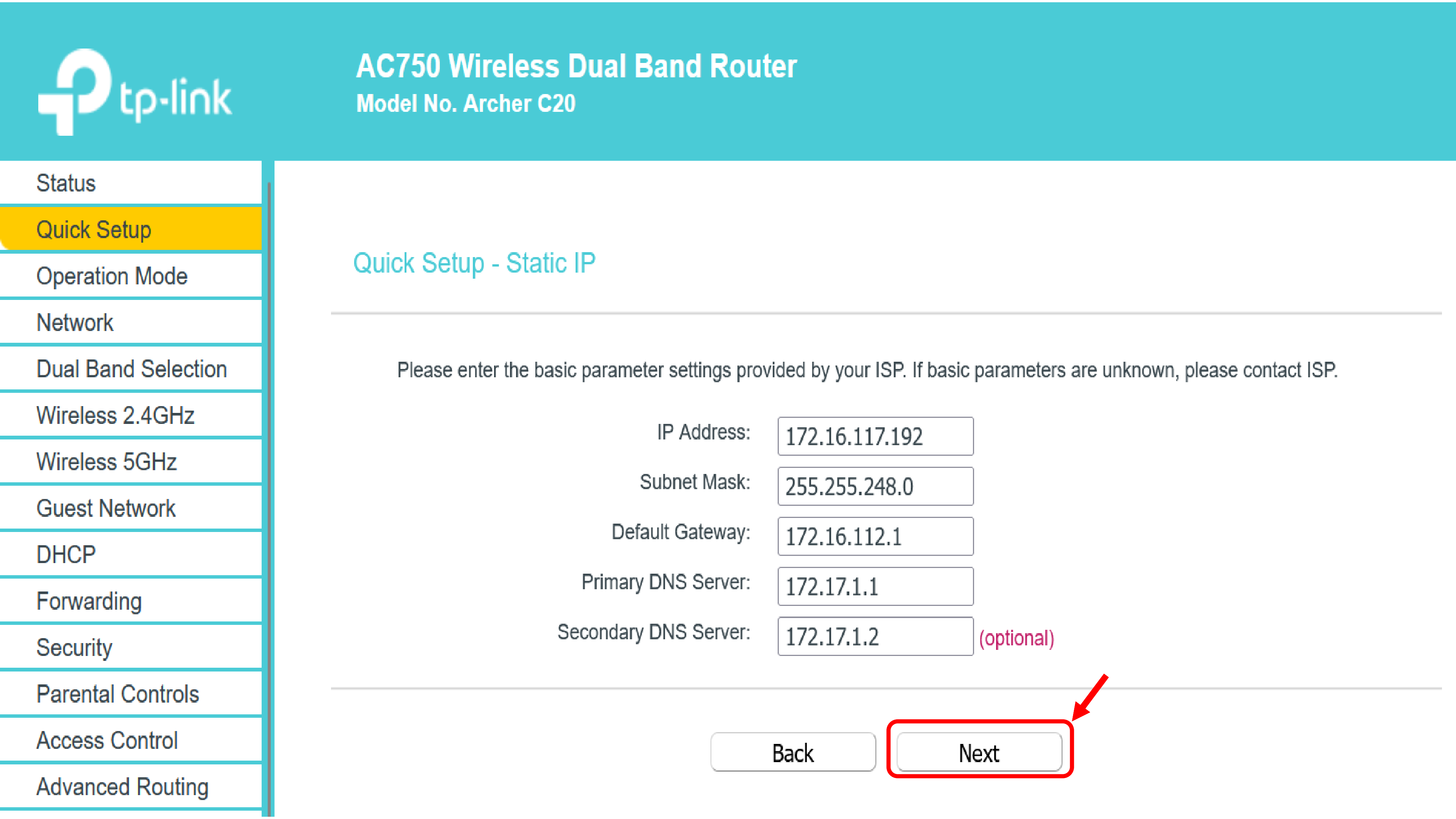
○ L2TP/Russian L2TP

○ PPTP/Russian PPTP

Note: For users in some areas(such as Russia, Ukraine etc.), please contact your ISP to choose connection type manually.

□ More Advanced Settings

Cont…



AC750 Wireless Dual Band Router

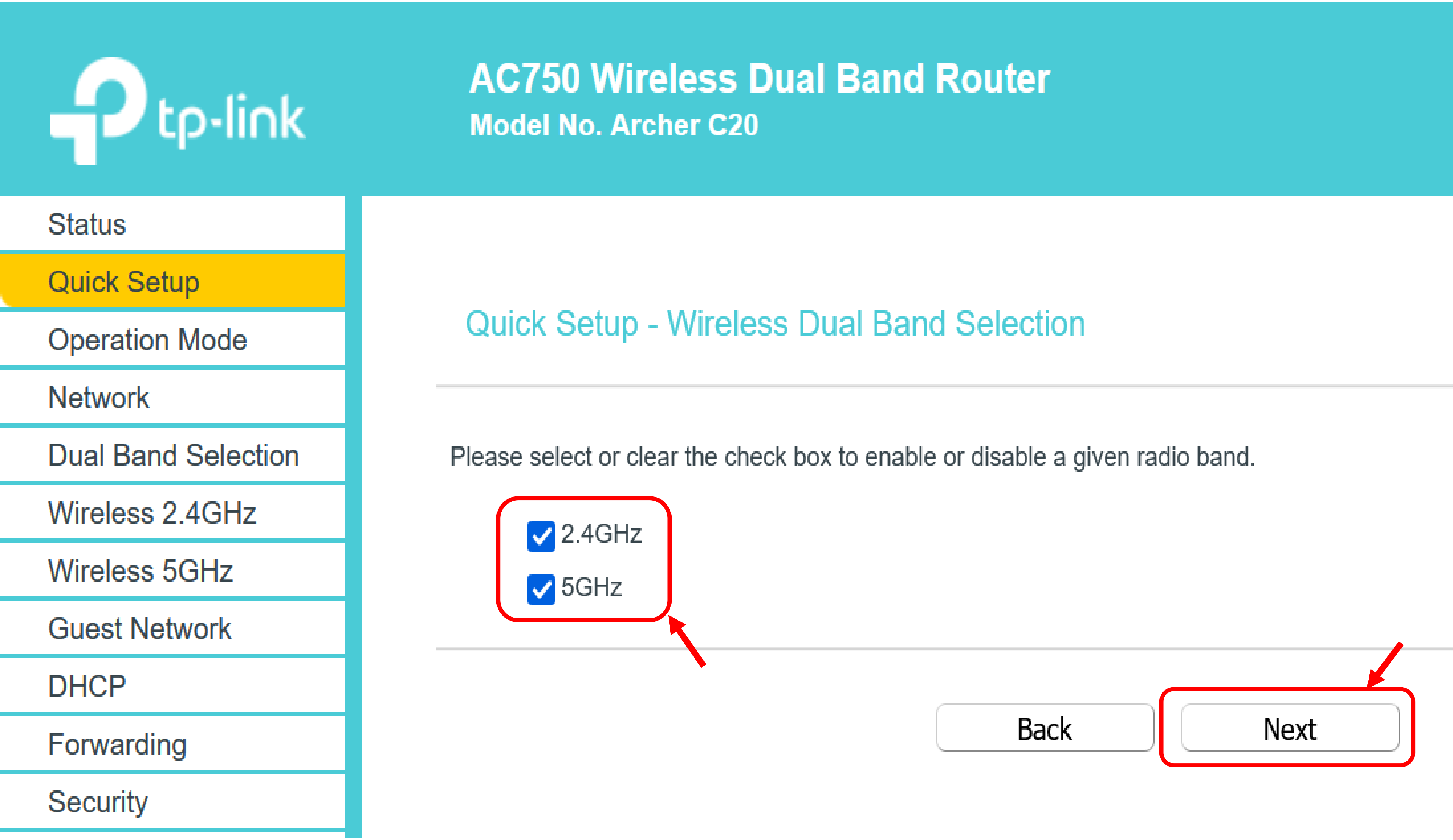
Model No. Archer C20

Quick Setup - Static IP

Please enter the basic parameter settings provided by your ISP. If basic parameters are unknown, please contact ISP.

IP Address:	172.16.117.192
Subnet Mask:	255.255.248.0
Default Gateway:	172.16.112.1
Primary DNS Server:	172.17.1.1
Secondary DNS Server:	172.17.1.2 (optional)

Cont…



AC750 Wireless Dual Band Router

Model No. Archer C20

- Status
- Quick Setup
- Operation Mode
- Network
- Dual Band Selection
- Wireless 2.4GHz
- Wireless 5GHz
- Guest Network
- DHCP
- Forwarding
- Security

Quick Setup - Wireless Dual Band Selection

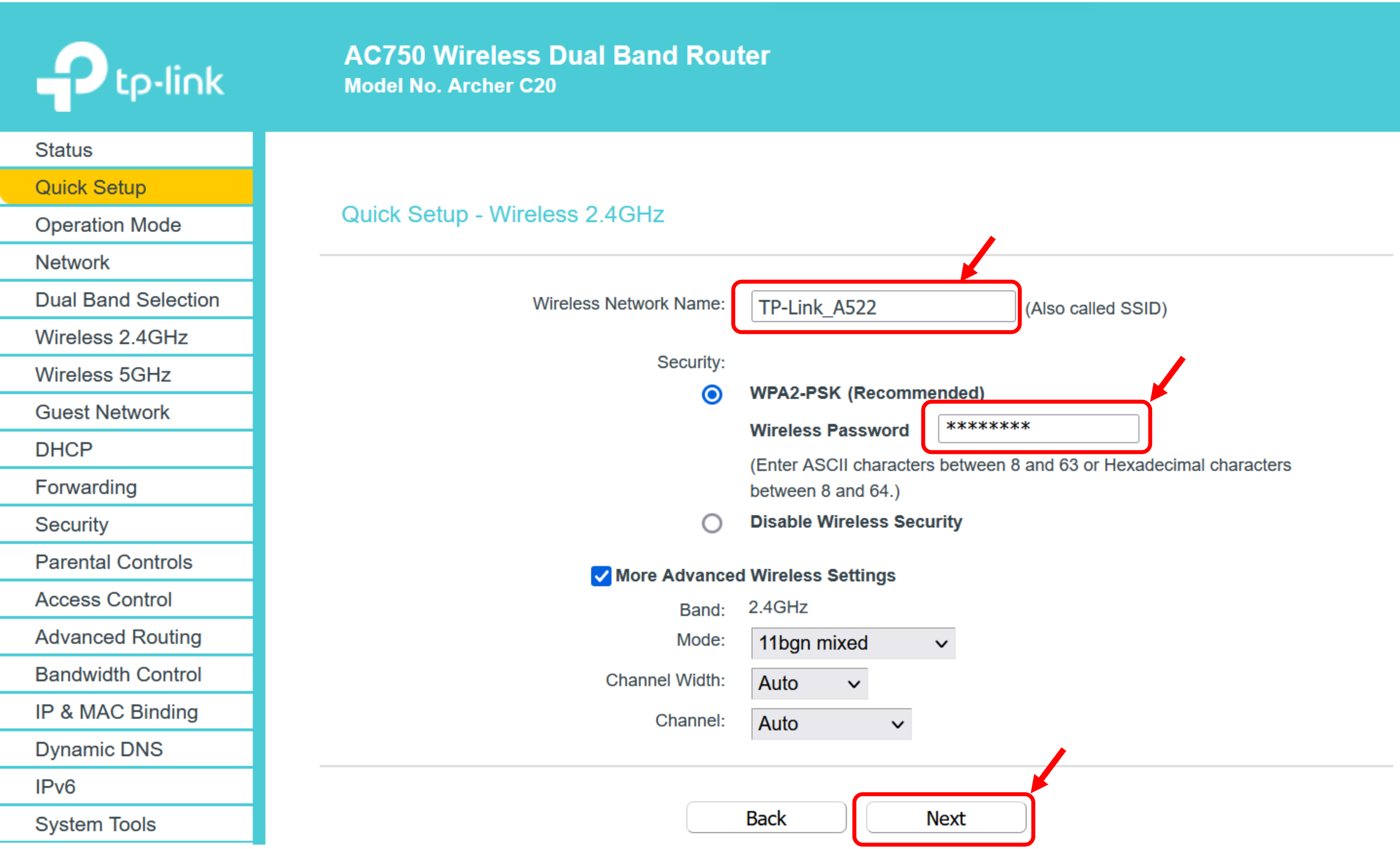
Please select or clear the check box to enable or disable a given radio band.

☑ 2.4GHz

☑ 5GHz

Back Next

Cont…



AC750 Wireless Dual Band Router

Model No. Archer C20

Quick Setup - Wireless 2.4GHz

Wireless Network Name: TP-Link_A522 (Also called SSID)

Security:

● **WPA2-PSK (Recommended)**

Wireless Password ********

(Enter ASCII characters between 8 and 63 or Hexadecimal characters between 8 and 64.)

○ **Disable Wireless Security**

☑ **More Advanced Wireless Settings**

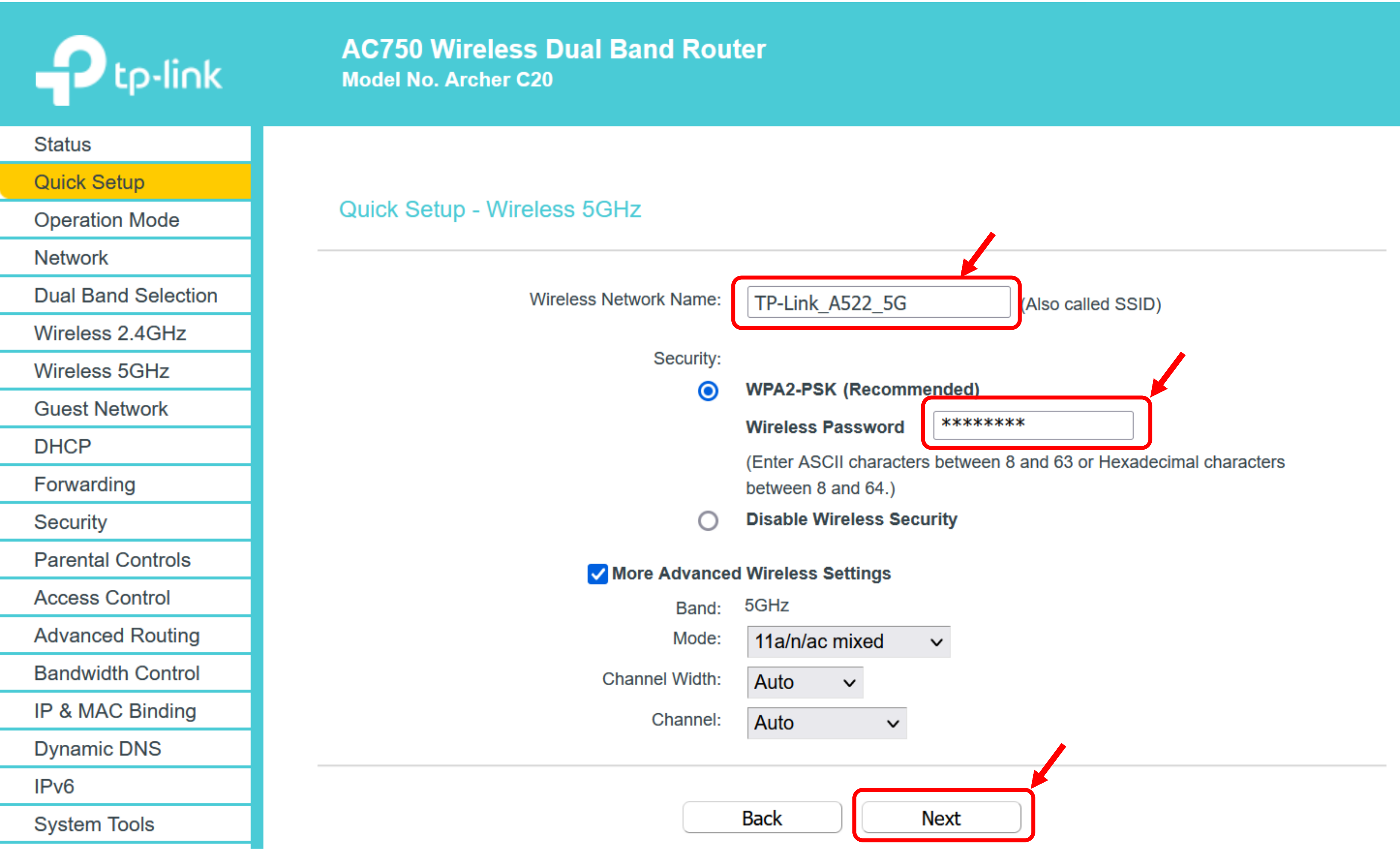
Band: 2.4GHz

Mode: 11bgn mixed

Channel Width: Auto

Channel: Auto

Cont…



AC750 Wireless Dual Band Router
Model No. Archer C20

Quick Setup - Wireless 5GHz

Wireless Network Name: TP-Link_A522_5G (Also called SSID)

Security:

● **WPA2-PSK (Recommended)**

Wireless Password *********

(Enter ASCII characters between 8 and 63 or Hexadecimal characters between 8 and 64.)

○ **Disable Wireless Security**

☑ **More Advanced Wireless Settings**

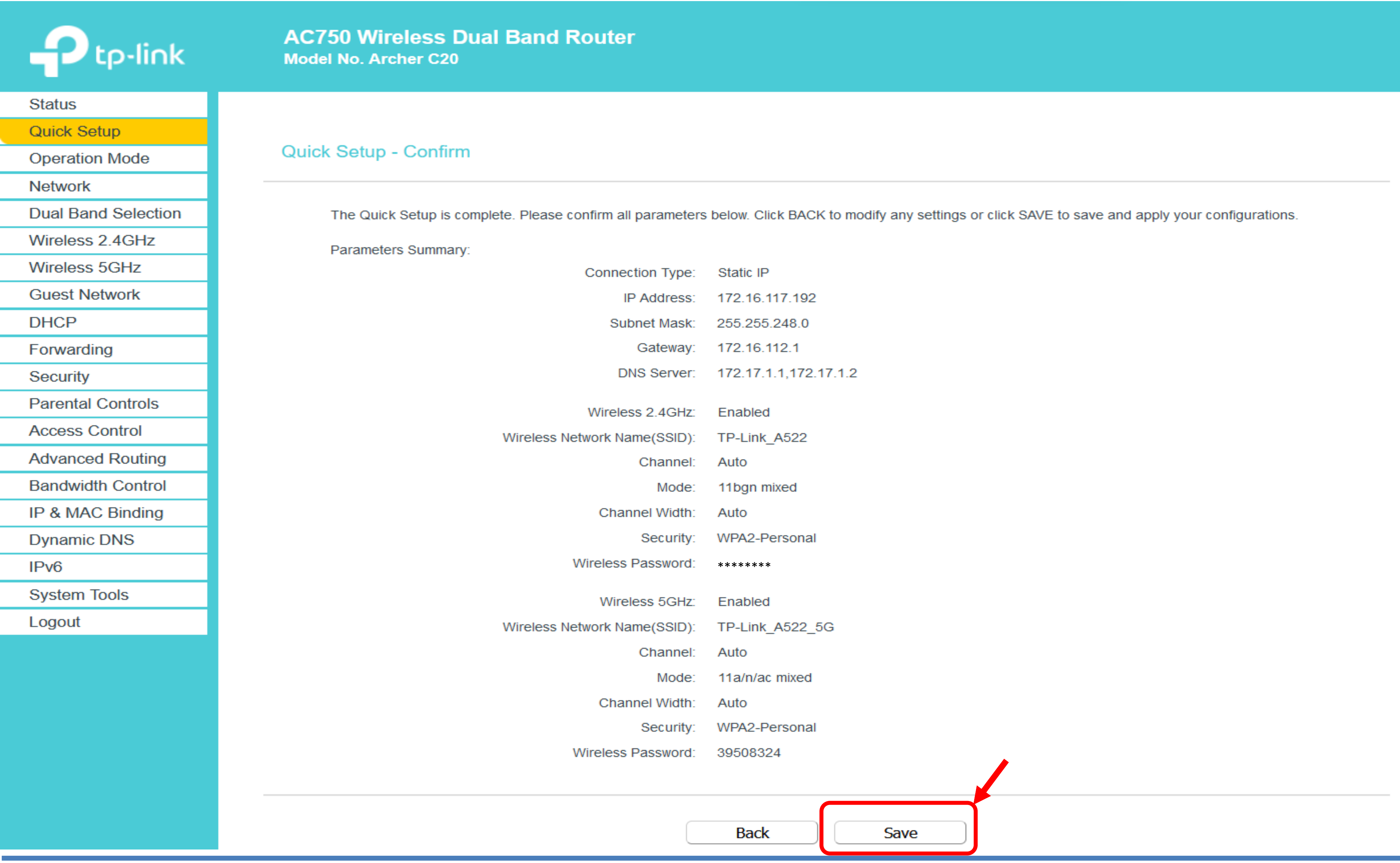
Band: 5GHz

Mode: 11a/n/ac mixed

Channel Width: Auto

Channel: Auto

Cont…



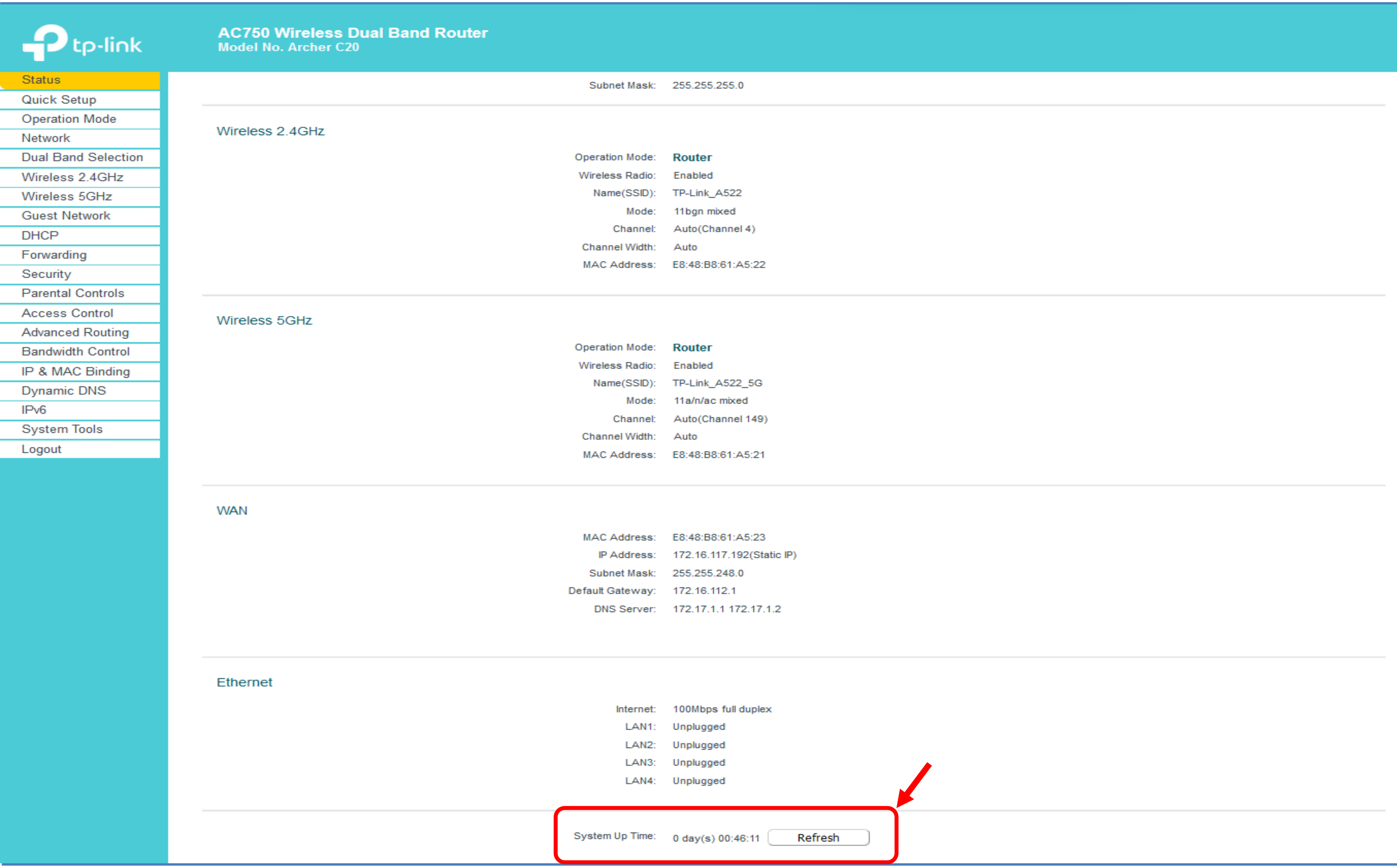
Quick Setup - Confirm

The Quick Setup is complete. Please confirm all parameters below. Click BACK to modify any settings or click SAVE to save and apply your configurations.

Parameters Summary:

Connection Type:	Static IP
IP Address:	172.16.117.192
Subnet Mask:	255.255.248.0
Gateway:	172.16.112.1
DNS Server:	172.17.1.1,172.17.1.2
Wireless 2.4GHz:	Enabled
Wireless Network Name(SSID):	TP-Link_A522
Channel:	Auto
Mode:	11bgn mixed
Channel Width:	Auto
Security:	WPA2-Personal
Wireless Password:	********
Wireless 5GHz:	Enabled
Wireless Network Name(SSID):	TP-Link_A522_5G
Channel:	Auto
Mode:	11a/n/ac mixed
Channel Width:	Auto
Security:	WPA2-Personal
Wireless Password:	39508324

Cont…



AC750 Wireless Dual Band Router
Model No. Archer C20

Subnet Mask: 255.255.255.0

Wireless 2.4GHz

Operation Mode: Router
Wireless Radio: Enabled
Name(SSID): TP-Link_A522
Mode: 11bgn mixed
Channel: Auto(Channel 4)
Channel Width: Auto
MAC Address: E8:48:B8:61:A5:22

Wireless 5GHz

Operation Mode: Router
Wireless Radio: Enabled
Name(SSID): TP-Link_A522_5G
Mode: 11a/n/ac mixed
Channel: Auto(Channel 149)
Channel Width: Auto
MAC Address: E8:48:B8:61:A5:21

WAN

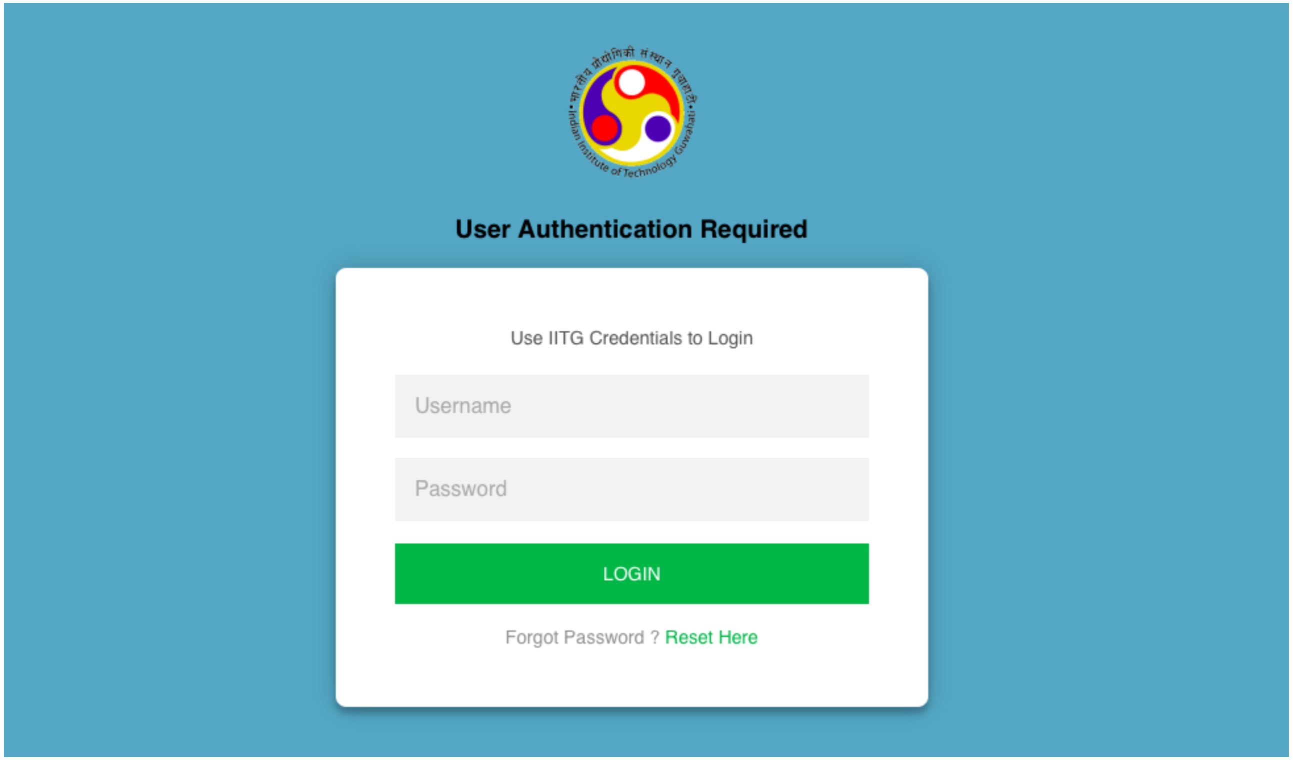
MAC Address: E8:48:B8:61:A5:23
IP Address: 172.16.117.192(Static IP)
Subnet Mask: 255.255.248.0
Default Gateway: 172.16.112.1
DNS Server: 172.17.1.1 172.17.1.2

Ethernet

Internet: 100Mbps full duplex
LAN1: Unplugged
LAN2: Unplugged
LAN3: Unplugged
LAN4: Unplugged

System Up Time: 0 day(s) 00:46:11

Connecting with Internet



User Authentication Required

Use IITG Credentials to Login

Username

Password

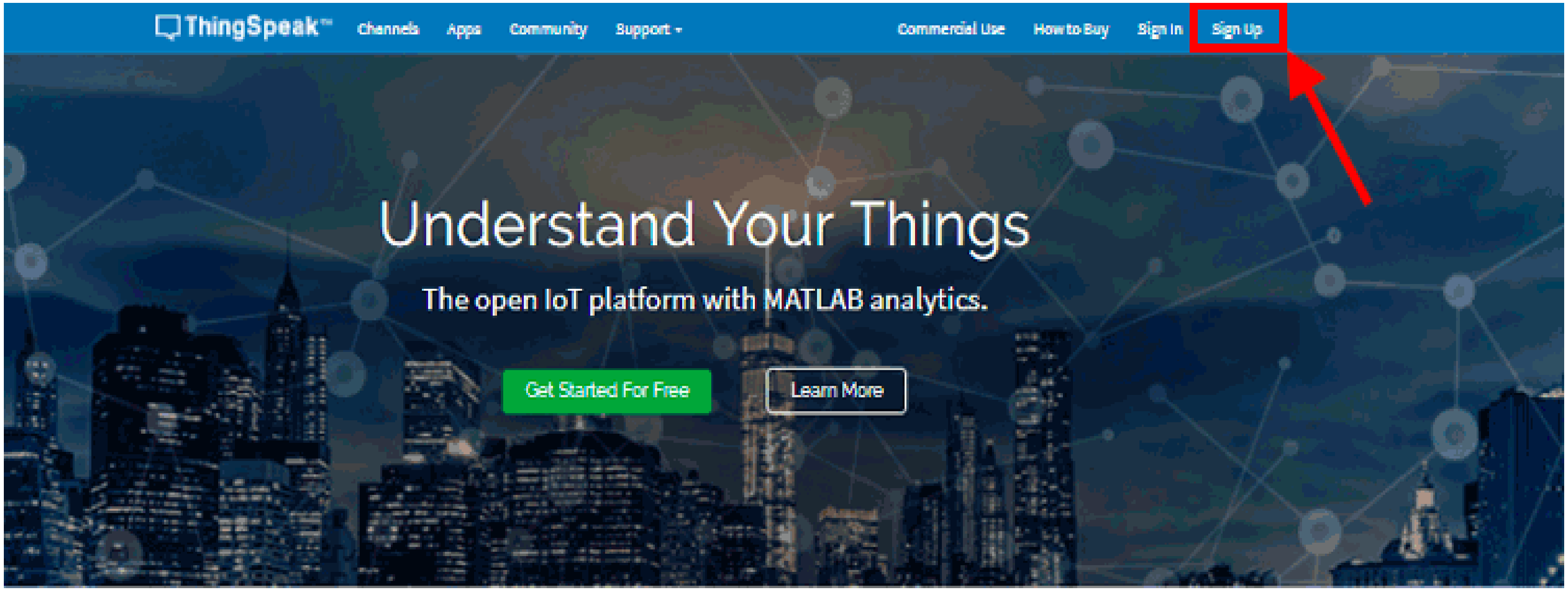
LOGIN

Forgot Password ? Reset Here

- You should be able to access Internet in your Mobile/Laptop using TP-Link WiFi AP

Cloud Server Configuration to Access Web Service

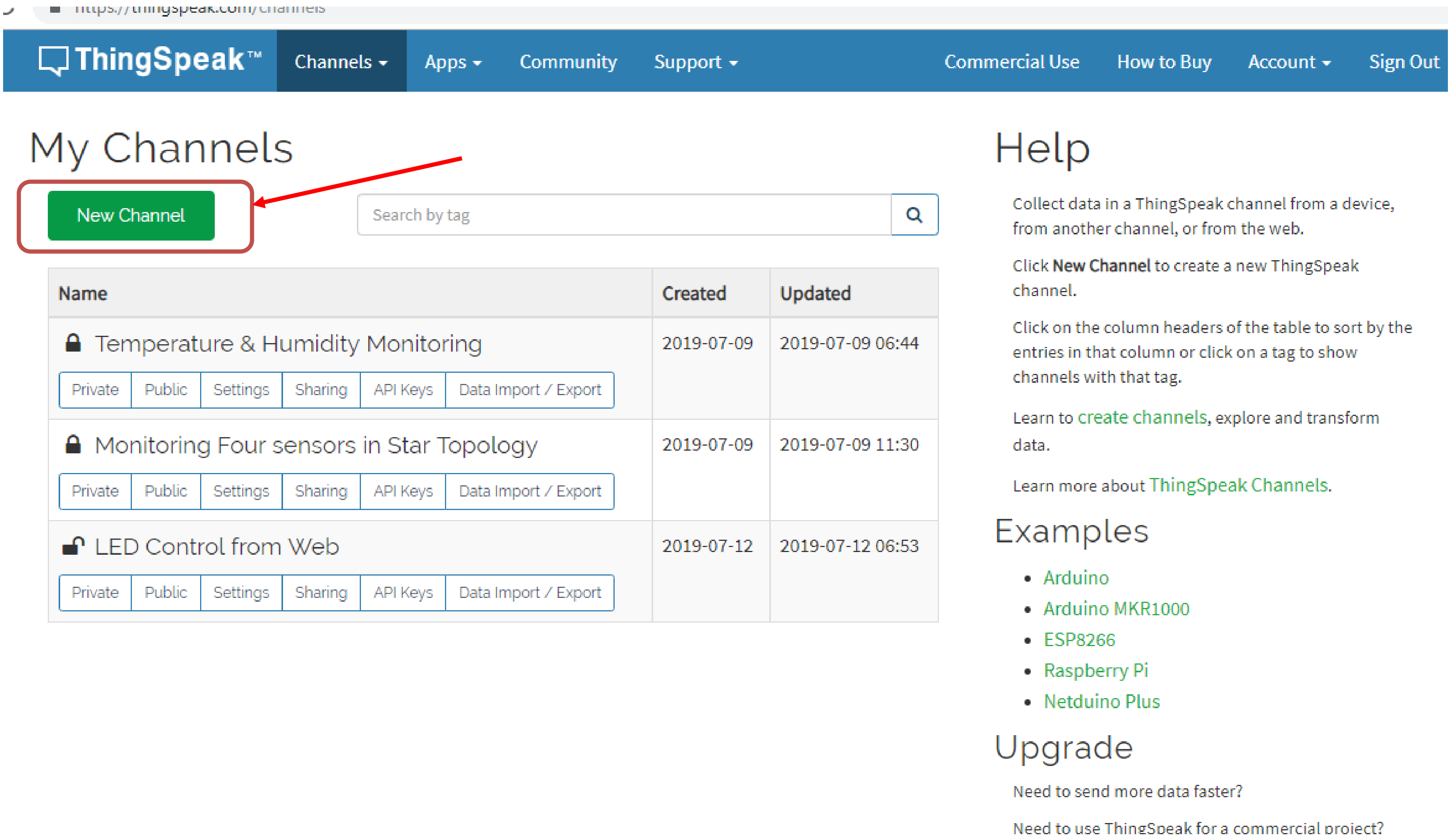
Configure to use Cloud Server



- We use ThingSpeak server http://www.thingspeak.com

- First create an user account
- Then create a channel on the ThingSpeak to upload the data

Cont...



https://thingspeak.com/channels

My Channels

New Channel

Search by tag

Name	Created	Updated
Temperature & Humidity Monitoring Private | Public | Settings | Sharing | API Keys | Data Import / Export	2019-07-09	2019-07-09 06:44
Monitoring Four sensors in Star Topology Private | Public | Settings | Sharing | API Keys | Data Import / Export	2019-07-09	2019-07-09 11:30
LED Control from Web Private | Public | Settings | Sharing | API Keys | Data Import / Export	2019-07-12	2019-07-12 06:53

Help

Collect data in a ThingSpeak channel from a device, from another channel, or from the web.

Click **New Channel** to create a new ThingSpeak channel.

Click on the column headers of the table to sort by the entries in that column or click on a tag to show channels with that tag.

Learn to create channels, explore and transform data.

Learn more about ThingSpeak Channels.

Examples

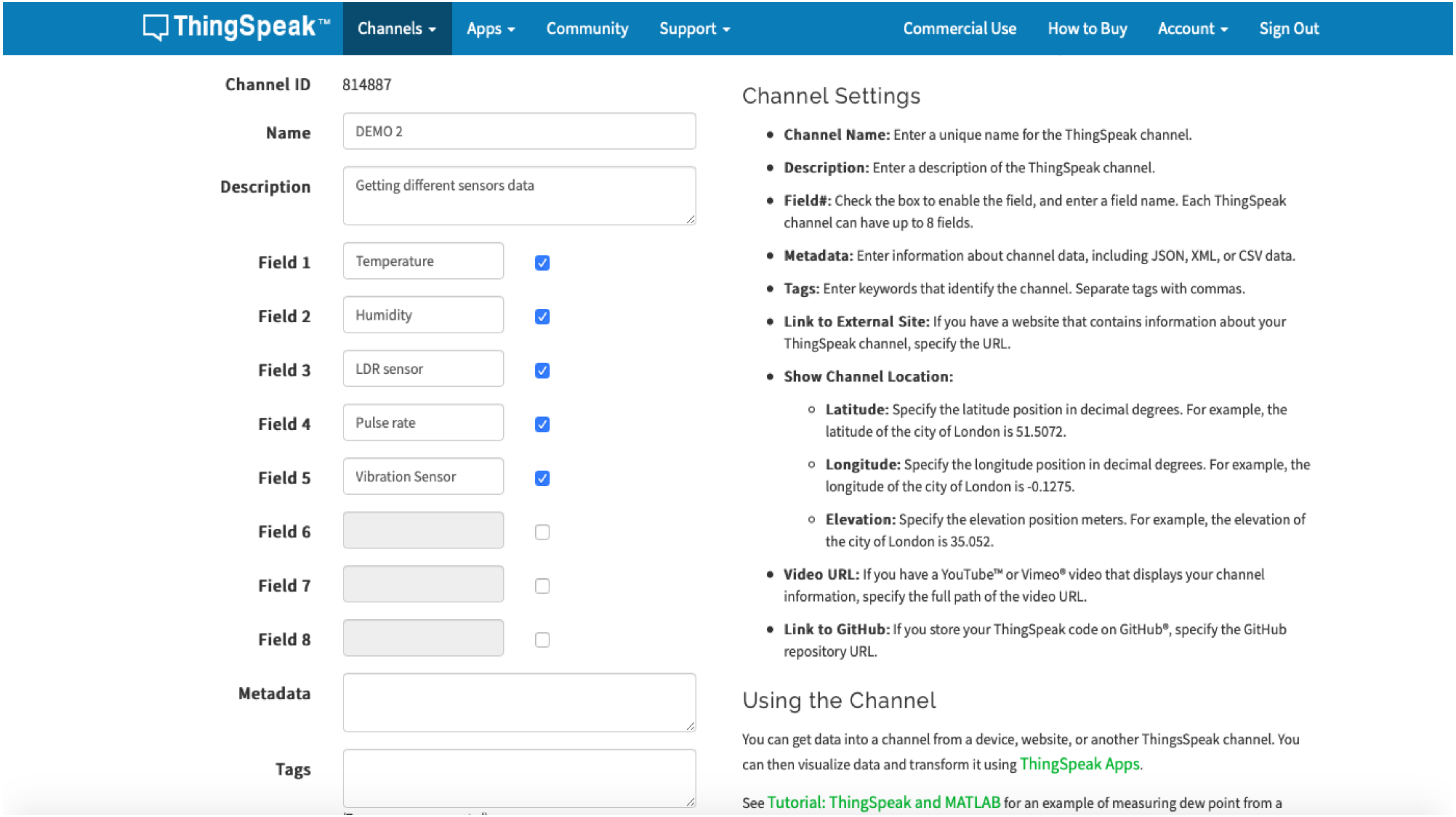
- Arduino
- Arduino MKR1000
- ESP8266
- Raspberry Pi
- Netduino Plus

Upgrade

Need to send more data faster?

Need to use ThingSpeak for a commercial project?

Cont…



Channel ID	814887	
Name	DEMO 2	
Description	Getting different sensors data	
Field 1	Temperature	☑
Field 2	Humidity	☑
Field 3	LDR sensor	☑
Field 4	Pulse rate	☑
Field 5	Vibration Sensor	☑
Field 6		□
Field 7		□
Field 8		□
Metadata		
Tags		

Channel Settings

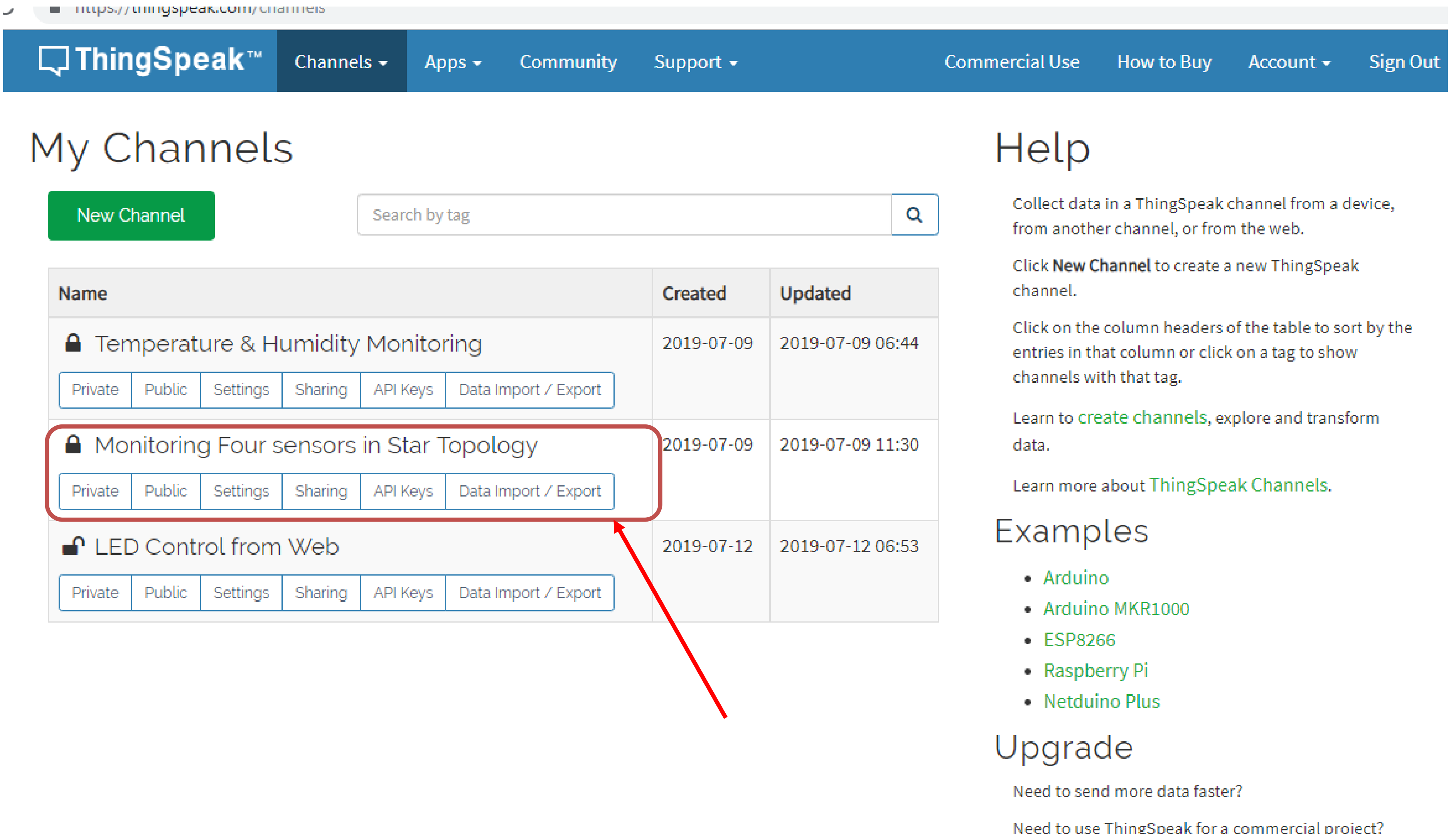
- **Channel Name:** Enter a unique name for the ThingSpeak channel.
- **Description:** Enter a description of the ThingSpeak channel.
- **Field#:** Check the box to enable the field, and enter a field name. Each ThingSpeak channel can have up to 8 fields.
- **Metadata:** Enter information about channel data, including JSON, XML, or CSV data.
- **Tags:** Enter keywords that identify the channel. Separate tags with commas.
- **Link to External Site:** If you have a website that contains information about your ThingSpeak channel, specify the URL.
- **Show Channel Location:**
  - **Latitude:** Specify the latitude position in decimal degrees. For example, the latitude of the city of London is 51.5072.
  - **Longitude:** Specify the longitude position in decimal degrees. For example, the longitude of the city of London is -0.1275.
  - **Elevation:** Specify the elevation position meters. For example, the elevation of the city of London is 35.052.
- **Video URL:** If you have a YouTube™ or Vimeo® video that displays your channel information, specify the full path of the video URL.
- **Link to GitHub:** If you store your ThingSpeak code on GitHub®, specify the GitHub repository URL.

Using the Channel

You can get data into a channel from a device, website, or another ThingsSpeak channel. You can then visualize data and transform it using ThingSpeak Apps.

See Tutorial: ThingSpeak and MATLAB for an example of measuring dew point from a

Cont…



https://thingspeak.com/channels

My Channels

Name	Created	Updated
🔒 Temperature & Humidity Monitoring Private · Public · Settings · Sharing · API Keys · Data Import / Export	2019-07-09	2019-07-09 06:44
🔒 Monitoring Four sensors in Star Topology Private · Public · Settings · Sharing · API Keys · Data Import / Export	2019-07-09	2019-07-09 11:30
🔓 LED Control from Web Private · Public · Settings · Sharing · API Keys · Data Import / Export	2019-07-12	2019-07-12 06:53

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Examples

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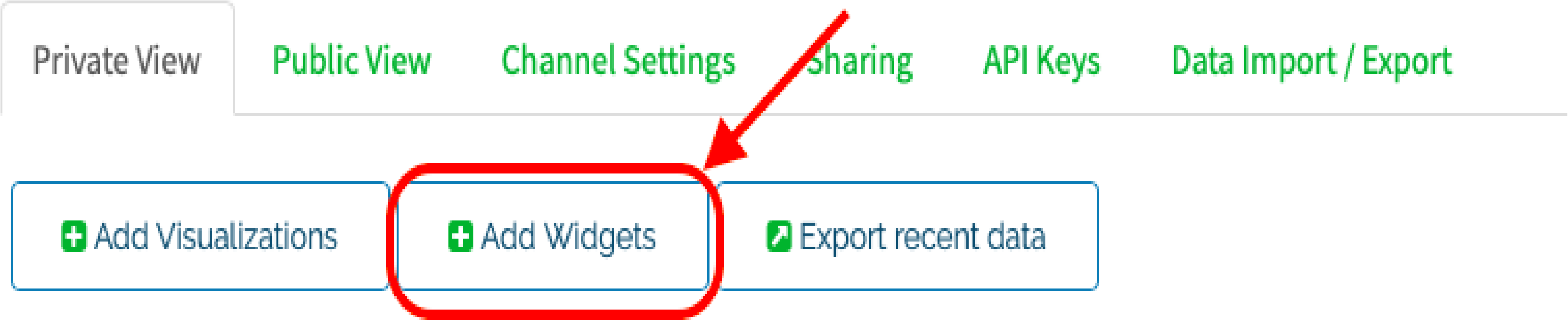
- Arduino MKR1000
- ESP8266
- Raspberry Pi
- Netduino Plus

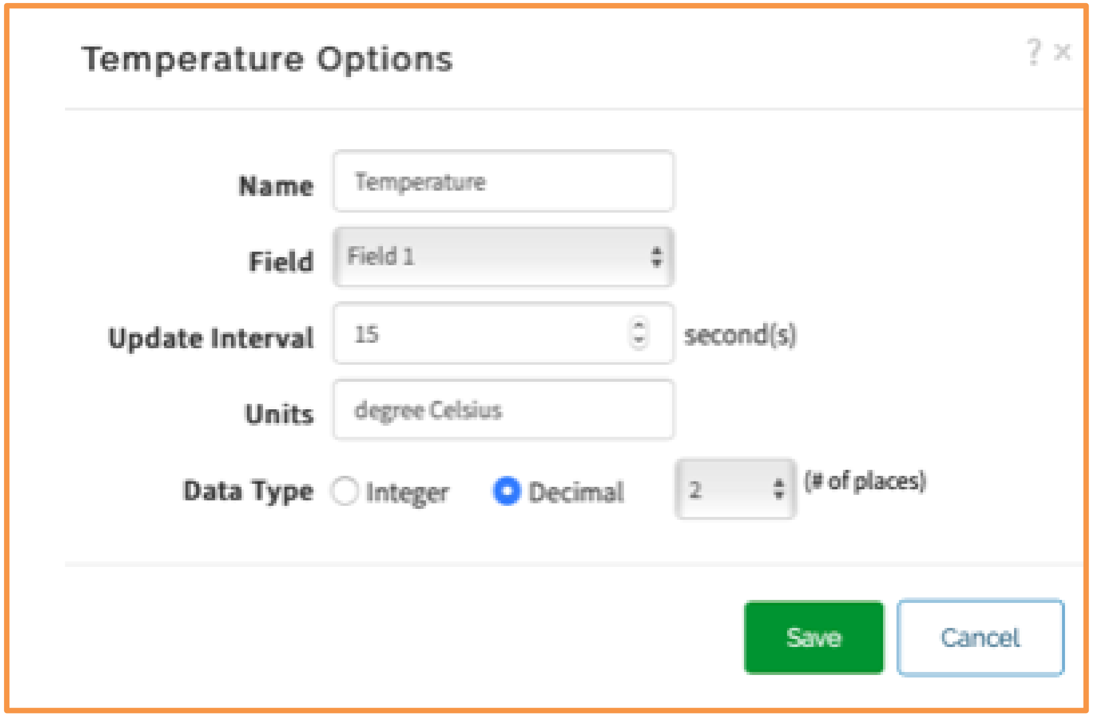
Upgrade

Need to send more data faster?

Need to use ThingSpeak for a commercial project?

Create Channel Display



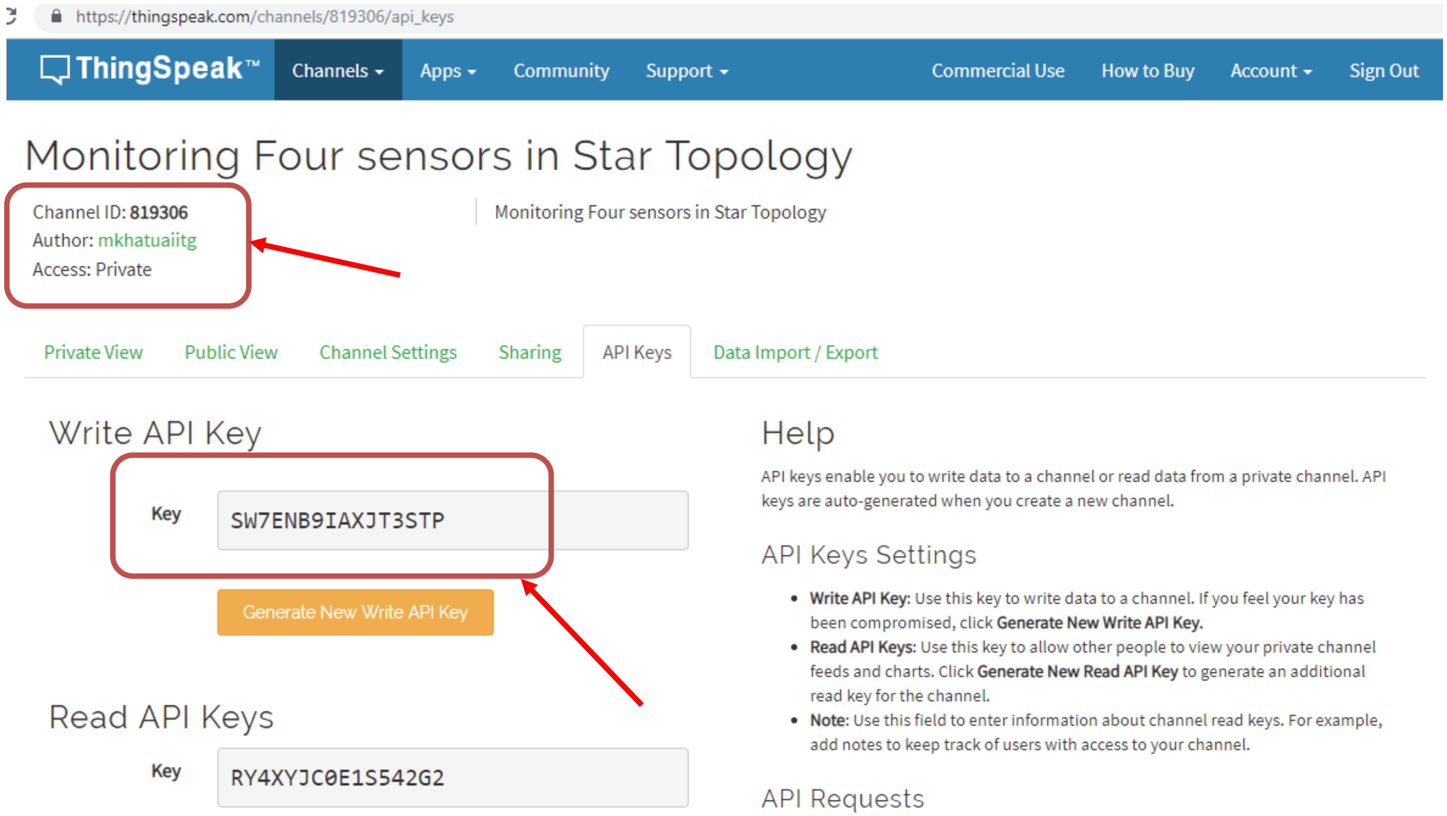


Temperature Options

Name	Temperature
Field	Field 1
Update Interval	15 second(s)
Units	degree Celsius
Data Type	○ Integer ● Decimal 2 (# of places)

- Select **Private View** of the created channel.
- Click **Add Widgets**
- Select the Numeric Display widget, and then set the display options.

API Key and Channel ID



https://thingspeak.com/channels/819306/api_keys

Monitoring Four sensors in Star Topology

Channel ID: **819306**
Author: mkhatuaiitg
Access: Private

Monitoring Four sensors in Star Topology

Write API Key

Key: SW7ENB9IAXJT3STP

Read API Keys

Key: RY4XYJC0E1S542G2

Help

API keys enable you to write data to a channel or read data from a private channel. API keys are auto-generated when you create a new channel.

API Keys Settings

- **Write API Key:** Use this key to write data to a channel. If you feel your key has been compromised, click **Generate New Write API Key.**
- **Read API Keys:** Use this key to allow other people to view your private channel feeds and charts. Click **Generate New Read API Key** to generate an additional read key for the channel.
- **Note:** Use this field to enter information about channel read keys. For example, add notes to keep track of users with access to your channel.

API Requests

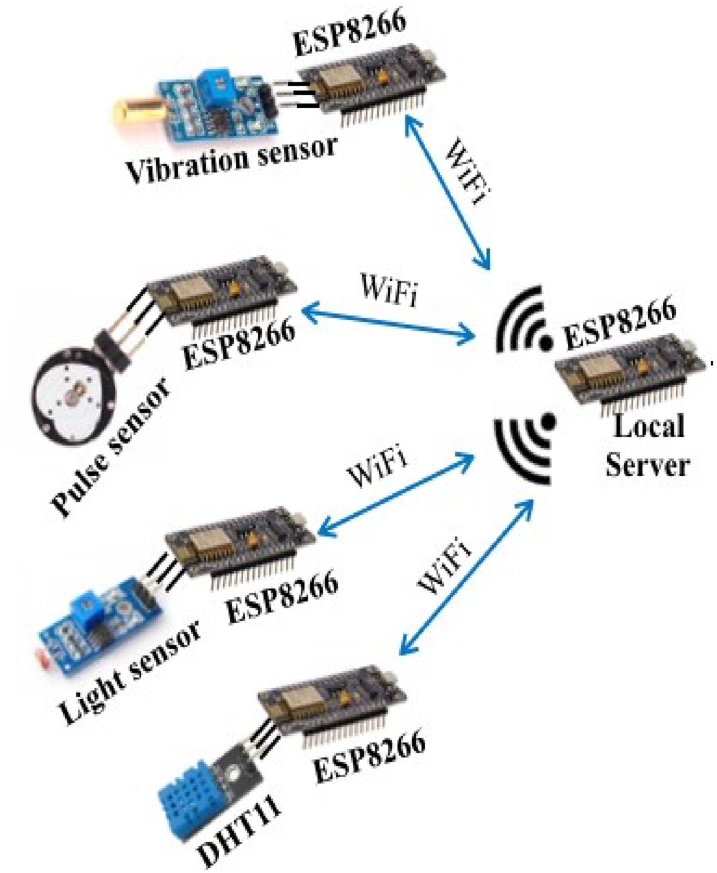
- To send data to ThingSpeak, we need unique write API key and Channel ID, which will be used later in code to upload the data to ThingSpeak website

- Click on “API Keys” button to get your unique “Write API Key”
- “Channel ID” is also given on the top

IoT Network Configuration

IoT Network Configuration

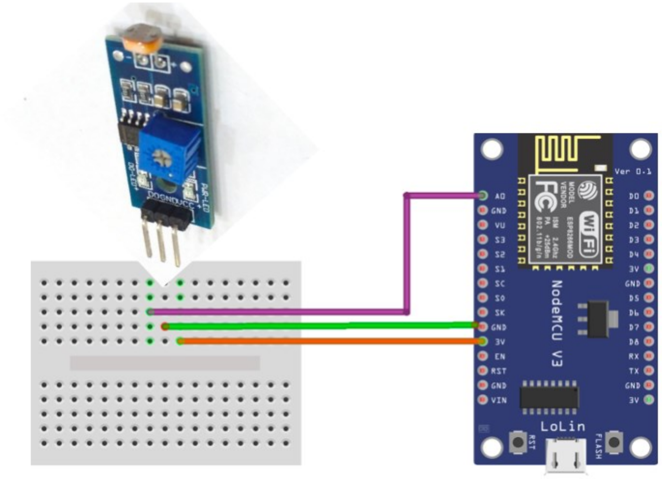
- There are total five ESP8266
  - one is acting as server,
  - other four as clients in local network.



- ESP1- ESP8266 acting as local server
- ESP2- ESP8266 with Light sensor
- ESP3- ESP8266 with Pulse sensor
- ESP4- ESP8266 with vibration sensor
- ESP5- ESP8266 with temperature & humidity sensor

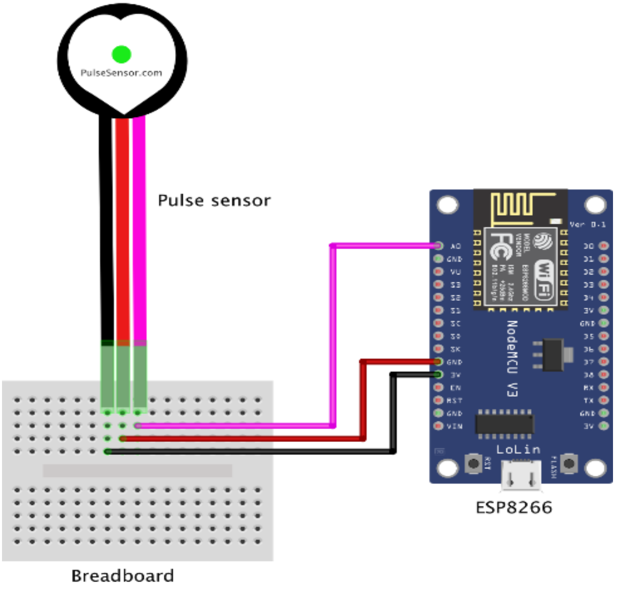
- **Note**: Unique ID for each ESP will be needed in programming

Sensor Configuration



ESP8266 with LDR Sensor

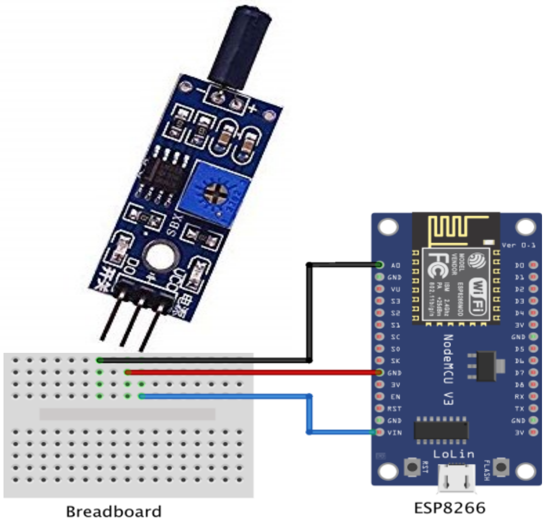
- Connect VCC pin of LDR sensor with 3V3 pin of ESP2
- Connect GND pin of LDR sensor with GND pin of ESP2
- Connect DATA OUT pin of LDR sensor with A0 pin of ESP2.



ESP8266 with Pulse Sensor

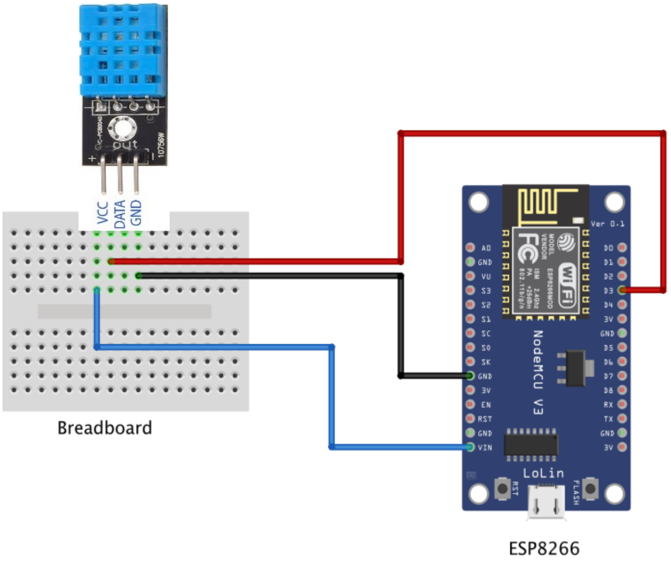
- Connect VCC pin of pulse sensor with 3V3 pin of ESP3
- Connect GND pin of pulse sensor with GND pin of ESP3
- Connect SIGNAL pin of pulse sensor with A0 pin of ESP3

Cont…



ESP8266 with Vibration Sensor

- Connect VCC pin of vibration sensor with VIN pin of ESP4
- Connect GND pin of vibration sensor with GND pin of ESP4
- Connect DATA OUT pin of vibration sensor with A0 pin of ESP4



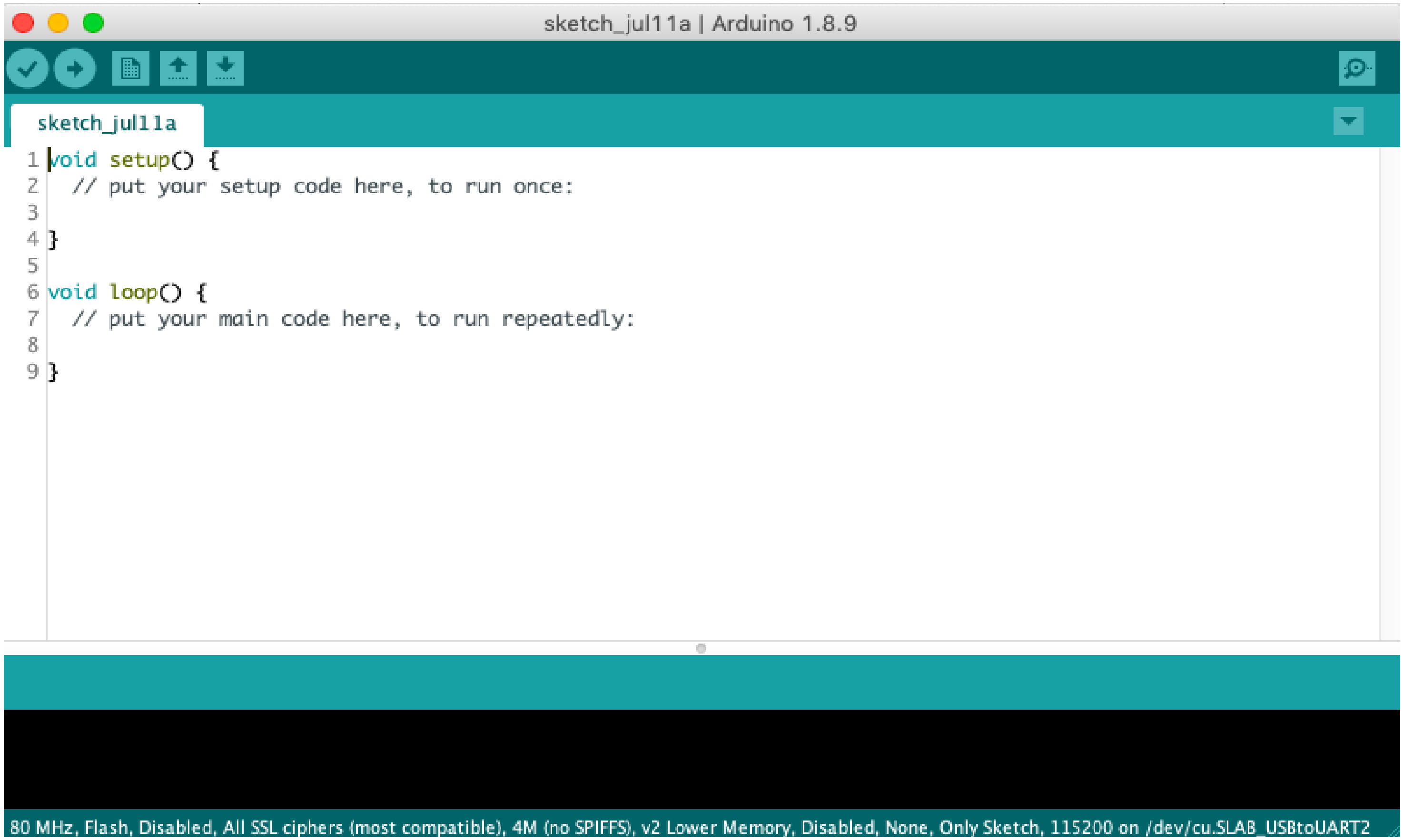
ESP8266 with Temperature & Humidity Sensor (DHT11)

- Connect VCC pin of DHT11 with VIN pin of ESP5
- Connect DATA OUT pin of DHT11 with D3 pin of ESP5
- Connect GND pin of DHT11 with GND pin of ESP5

Arduino
Tool Configuration

Configure Arduino IDE

- **Download and Install Arduino IDE** https://www.arduino.cc/en/Main/Software
- When the Arduino IDE first opens, this is what you should see:

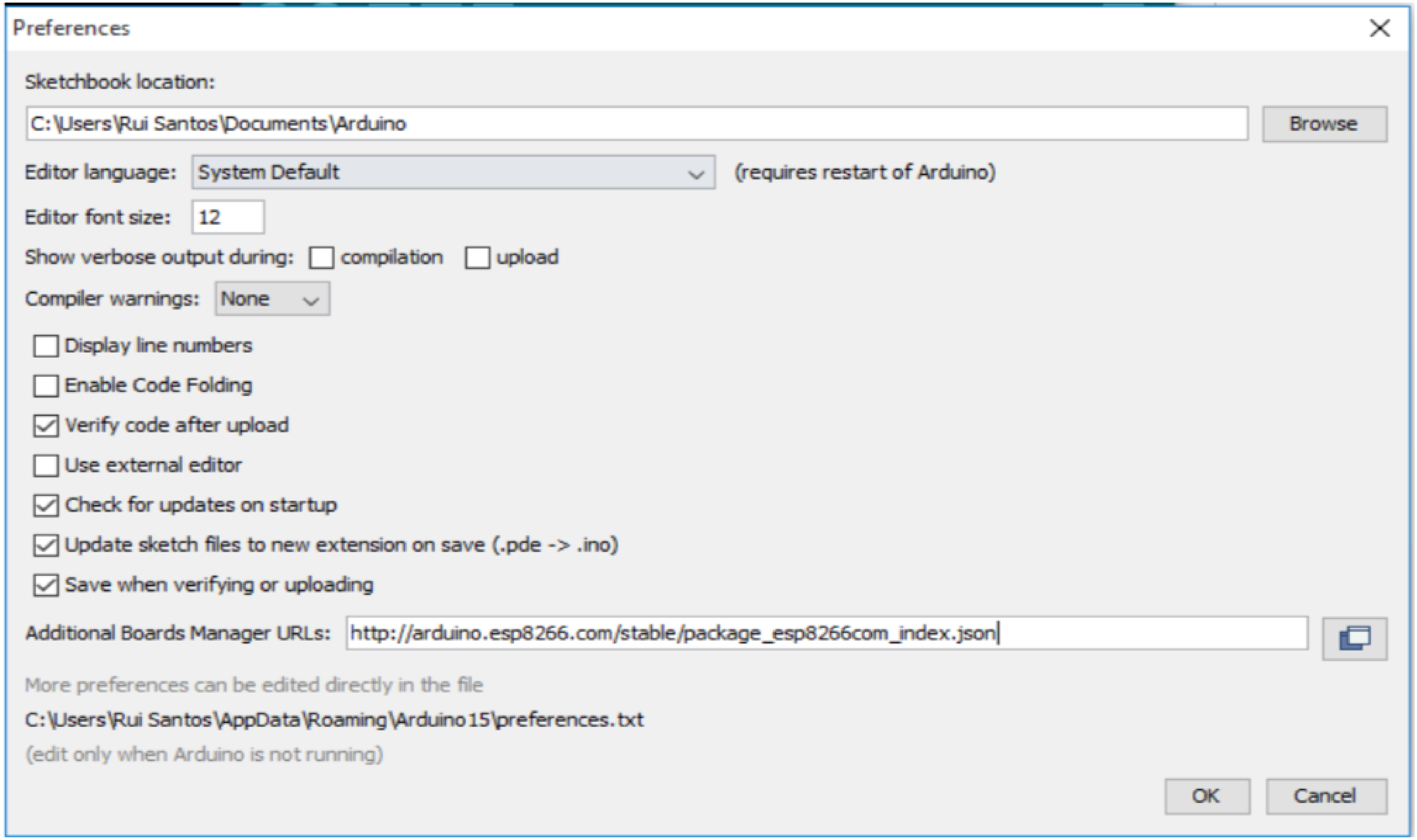


```
void setup() {
  // put your setup code here, to run once:

}

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

}
```

80 MHz, Flash, Disabled, All SSL ciphers (most compatible), 4M (no SPIFFS), v2 Lower Memory, Disabled, None, Only Sketch, 115200 on /dev/cu.SLAB_USBtoUART2

Install ESP8266 Board in IDE

- Go to **File --> Preferences**
- Enter the below URL into **Additional Board Manager URLs** field and press the “OK” button http://arduino.esp8266.com/stable/package_esp8266com_index.json OR https://github.com/esp8266/Arduino/releases/download/2.3.0/package_esp8266com_index.json



Preferences

Sketchbook location:

C:\Users\Rui Santos\Documents\Arduino [Browse]

Editor language: System Default (requires restart of Arduino)

Editor font size: 12

Show verbose output during: □ compilation □ upload

Compiler warnings: None

□ Display line numbers

□ Enable Code Folding

☑ Verify code after upload

□ Use external editor

☑ Check for updates on startup

☑ Update sketch files to new extension on save (.pde -> .ino)

☑ Save when verifying or uploading

Additional Boards Manager URLs: http://arduino.esp8266.com/stable/package_esp8266com_index.json

More preferences can be edited directly in the file

C:\Users\Rui Santos\AppData\Roaming\Arduino15\preferences.txt

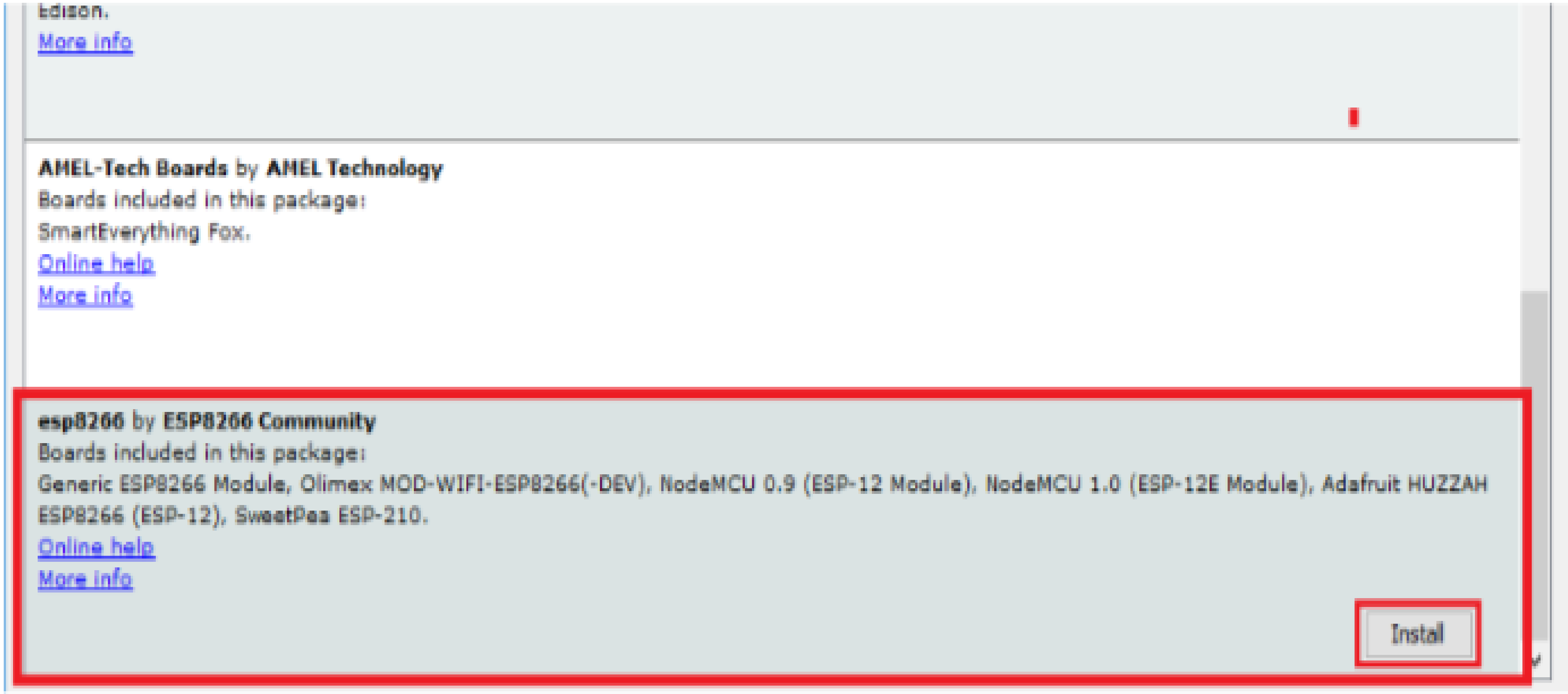
(edit only when Arduino is not running)

[OK] [Cancel]

Cont…

- Go to **Tools > Board > Board Manager**

- Scroll down, select the ESP8266 board menu and **install** "**esp8266 by ESP8266 Community**"

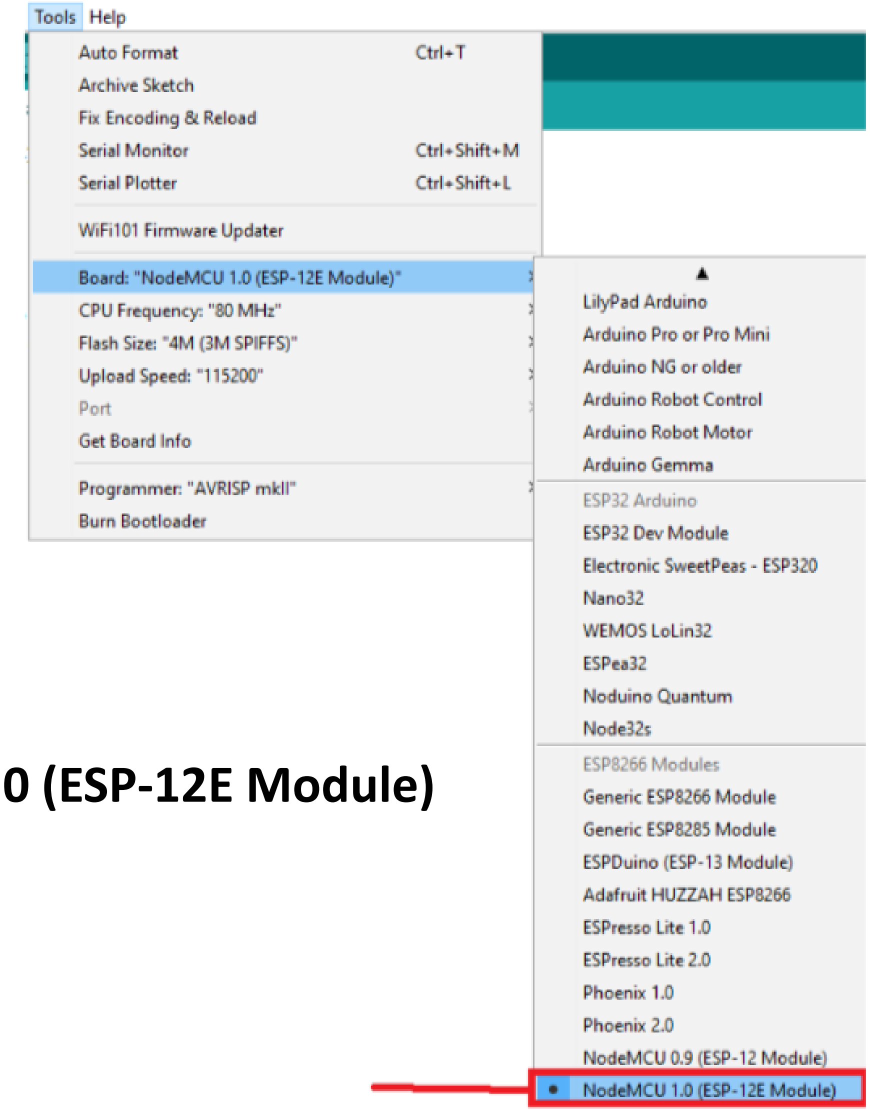


Edison.
More info

AMEL-Tech Boards by **AMEL Technology**
Boards included in this package:
SmartEverything Fox.
Online help
More info

esp8266 by **ESP8266 Community**
Boards included in this package:
Generic ESP8266 Module, Olimex MOD-WIFI-ESP8266(-DEV), NodeMCU 0.9 (ESP-12 Module), NodeMCU 1.0 (ESP-12E Module), Adafruit HUZZAH ESP8266 (ESP-12), SweetPea ESP-210.
Online help
More info

Cont…



Board: "NodeMCU 1.0 (ESP-12E Module)"

CPU Frequency: "80 MHz"

Flash Size: "4M (3M SPIFFS)"

Upload Speed: "115200"

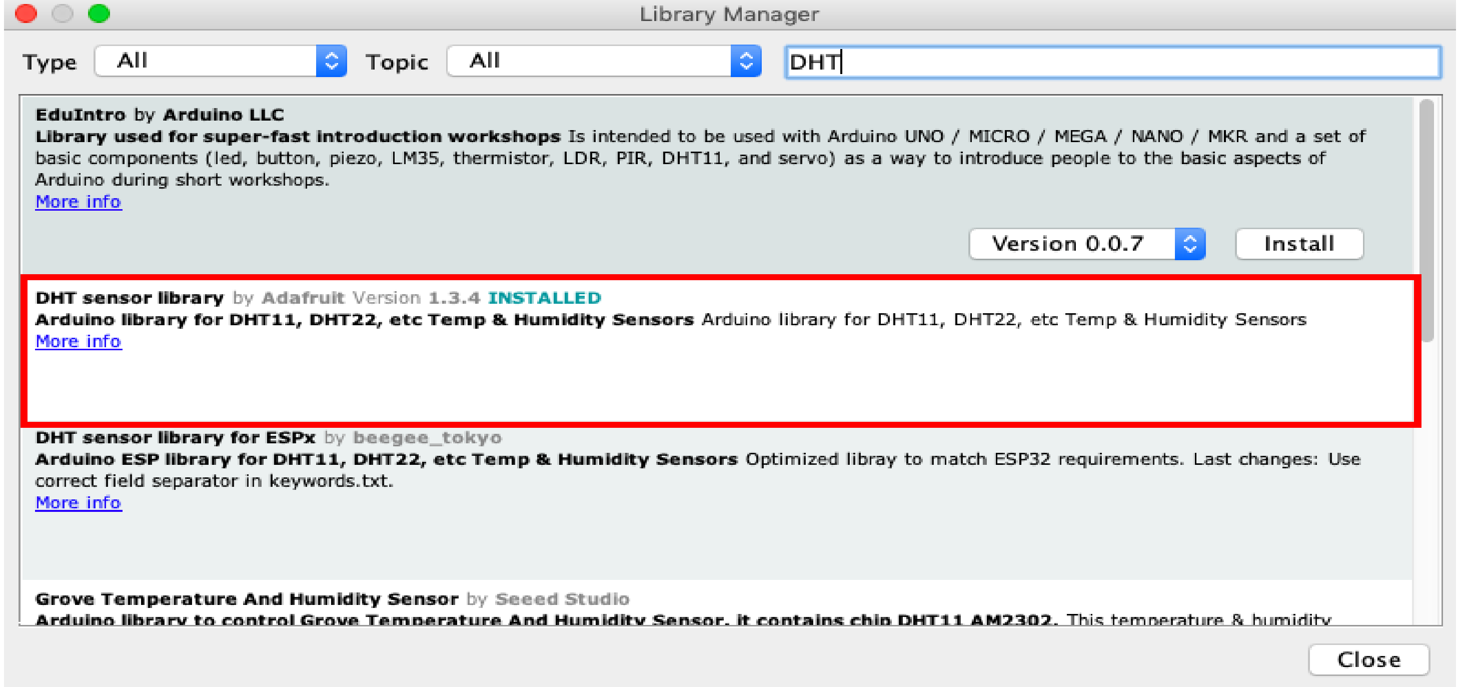
Programmer: "AVRISP mkII"

- Select the appropriate board
  - Go to **Tools** >**Board > NodeMCU 1.0 (ESP-12E Module)**
- Finally, re-open the Arduino IDE

Install Sensor Libraries

- In this demo, we use DHT11 sensor for which we will be using **DHT.h** header file in the code. So, this header file should be installed.

- **Install Using the Library Manager**
  - click to **Sketch** menu then **Include Library > Manage Libraries**
  - Search for “**DHT**” on the Search box and install the DHT library from **Adafruit**.



EduIntro by **Arduino LLC**
Library used for super-fast introduction workshops Is intended to be used with Arduino UNO / MICRO / MEGA / NANO / MKR and a set of basic components (led, button, piezo, LM35, thermistor, LDR, PIR, DHT11, and servo) as a way to introduce people to the basic aspects of Arduino during short workshops.
More info

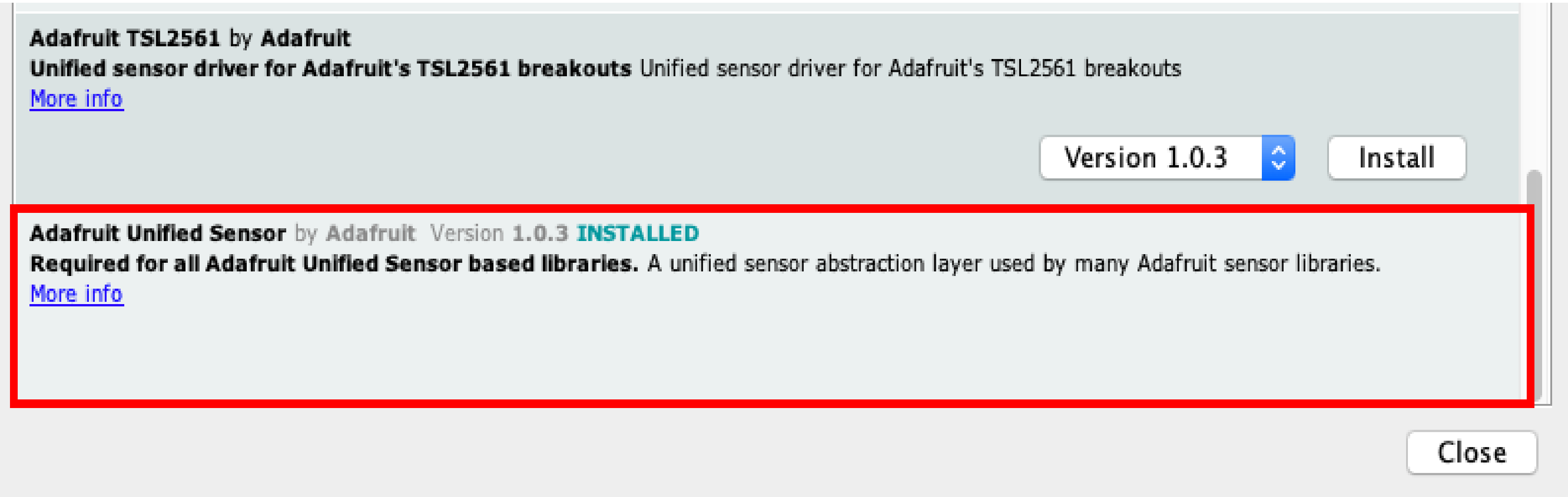
DHT sensor library by **Adafruit** Version **1.3.4** **INSTALLED**
Arduino library for DHT11, DHT22, etc Temp & Humidity Sensors Arduino library for DHT11, DHT22, etc Temp & Humidity Sensors
More info

DHT sensor library for ESPx by **beegee_tokyo**
Arduino ESP library for DHT11, DHT22, etc Temp & Humidity Sensors Optimized libray to match ESP32 requirements. Last changes: Use correct field separator in keywords.txt.
More info

Grove Temperature And Humidity Sensor by **Seeed Studio**
Arduino library to control Grove Temperature And Humidity Sensor. It contains chip DHT11 AM2302. This temperature & humidity

Cont…

- After installing the DHT library from Adafruit, install "**Adafruit Unified Sensor**" libraries.



Adafruit TSL2561 by **Adafruit**
Unified sensor driver for Adafruit's TSL2561 breakouts Unified sensor driver for Adafruit's TSL2561 breakouts
More info

Adafruit Unified Sensor by **Adafruit** Version **1.0.3** **INSTALLED**
Required for all Adafruit Unified Sensor based libraries. A unified sensor abstraction layer used by many Adafruit sensor libraries.
More info

- There exist other methods for installing libraries
  - **Importing a .zip Library**
    - Sketch --> Include Library --> Add .Zip Library
  - **Manual Installation of Library**
    - Download the library as .Zip --> extract it
    - Place the files in File --> Preferences --> Sketchbook location
    - Restart Arduino IDE

MCU Programming

ESP8266 with Local Server

For **ESP1**, write the following code in the Arduino IDE and save as **Local_Server_ESP1.ino** Install **ThingSpeak.h** library. Change the **red colored text** in code according to your setup.

```
#include <ESP8266WiFi.h>              //Including ESP8266 library
#include<ESP8266WebServer.h>          //Including ESP8266WebServer library for web server
#include<ThingSpeak.h>                 //Including ThingSpeak library

 IPAddress IP(172,16,117,192);         //Static IP address of local server
 IPAddress gateway(172,16,112,1);      //Gateway of the network
 IPAddress mask(255, 255, 248, 0);     //Subnet mask of the network
 WiFiClient client;
 WiFiServer server(80);

 unsigned long myChannelNumber = 2244718;  //Replace with channelID of ThingSpeak channel ID
 const char * myWriteAPIKey = "T4N14GFNKOPDWIWL";  //Replace WriteAPIKey of channel

 const char* softAPssid = "ESP1_Server";         //SSID of the hotspot of ESP8266 acting as local server
 const char* password = "12345678";              //Password of the hotspot of ESP8266 acting as local server

 const char* wifissid = “TP-Link_A522";          //Replace with SSID of WIFI router providing internet access
 const char* pass = "12345678";                  //Password of WIFI router providing internet access
```

Cont…

```
void setup() {
  WiFi.mode(WIFI_AP_STA);                //station mode and access point mode both at the same time
  Serial.begin(9600);                    //Serial communication at baud rate of 9600 for debugging purpose
  delay(100);
  Serial.println(WiFi.getMode());
  Serial.print("Configuring SoftAP....");
  Serial.println(WiFi.softAPConfig(IP, gateway, mask)? "Ready" : "Failed");
  delay(10);
  Serial.println("Setting SoftAP...");
  Serial.println(WiFi.softAP(softAPssid, password));
  delay(10);
  Serial.println(WiFi.softAPIP());
  delay(500);
  WiFi.begin(wifissid, pass);
  while(WiFi.status()!=WL_CONNECTED)  {
    Serial.print(".");
    delay(500);
  }
  Serial.print("Connected to Wifi with ssid ");
  Serial.println(wifissid);
  Serial.print("WiFi IP address: ");
  Serial.println(WiFi.localIP());        // WIFI router IP address
  ThingSpeak.begin(client);
  server.begin();                        //Start local server
}
```

- Two functions exist in the programme: setup () and loop ()
  - **setup():** This function runs once when ESP first boots
  - **loop():** This function reads the LDR sensor value and connects to local server then send sends data to local server

Cont…

```
void loop() {
  Serial.printf("Stations connected = %d\n", WiFi.softAPgetStationNum());
  WiFiClient client = server.available();          //Waiting for the incoming data if client is ready to send
  if (!client) {return;}
  String select_fun = client.readStringUntil('\r');             //Reads the ESP8266 ID (of clients)

  if(select_fun==“5") {                                         //If ESP5 sends the data
    String temp = client.readStringUntil('\r');                 //Reads the temperature value
    String Humidity = client.readStringUntil('\r');             //Reads the humidity value
                          //Upload the temp value to ThingSpeak server as first field of channel

    ThingSpeak.writeField(myChannelNumber, 1, temp, myWriteAPIKey);
    delay(15000);         //Wait for 15 sec after one entry
                          //Upload the humidity value to ThingSpeak server as second field of channel

    ThingSpeak.writeField(myChannelNumber, 2, Humidity, myWriteAPIKey);
    Serial.print("Temperature: ");
    Serial.print(temp);
    Serial.print(" degree celsius, Humidity: ");
    Serial.print(Humidity);
    Serial.print("%. ");
    Serial.println("Sent to ThingSpeak Server...");
   }
```

Cont…

```
  if(select_fun=="2") {                                   //If ESP2 sends the data
      String LDRval = client.readStringUntil('\r');            //Reads light sensor value
                                //Upload the light sensor value to ThingSpeak server as third field of channel
      ThingSpeak.writeField(myChannelNumber, 3, LDRval, myWriteAPIKey);
      Serial.print("LDR sensor data value: ");
      Serial.println(LDRval);
      Serial.println("Sent to ThingSpeak Server...");
   }
 if(select_fun=="3") {                                    //If ESP3 sends the data
      String pulseRate = client.readStringUntil('\r');        //Reads pulse rate
                                //Upload the pulse rate to ThingSpeak server as fourth field of channel
      ThingSpeak.writeField(myChannelNumber, 4, pulseRate, myWriteAPIKey);
      Serial.print("Pulse rate: ");
      Serial.print(pulseRate);
      Serial.println(" BPM. Sent to ThingSpeak Server..");
   }
   if(select_fun=="4"){                                   //If ESP4 sends the data
      String Vibval = client.readStringUntil('\r');           //Reads vibration sensor data
                                //Upload the vibration sensor data value to ThingSpeak server as fifth field of channel
      ThingSpeak.writeField(myChannelNumber, 5, Vibval, myWriteAPIKey);
      Serial.print("Vibration Sensor data: ");
      Serial.print(Vibval);
      Serial.println(" Sent to ThingSpeak server..");
   }
   delay(15000);                //waits for 15 secs after each transmission
}
```

ESP8266 with LDR Sensor

For **ESP2**, write the following code in the Arduino IDE and save as **LDR_client.ino**

```
#include<ESP8266WiFi.h>              // Including ESP8266 library

 char ssid[]="ESP1_Server";          //Network ssid of hotspot of local server
 char pass[]="12345678";             // Password of hotspot of local server
 int val;
 int LDRpin = A0;                    //LDR Pin Connected to A0 pin
 IPAddress server(172,16,117,192);                // IP address of local server
 WiFiClient client;
```

- Change the IP address of Local Server (i.e. ESP1)
- Change the SSID and Password of WiFi AP hosted in Local Server

- Two functions exist in the programme: setup () and loop ()
  - **setup():** This function runs once when ESP first boots
  - **loop():** This function reads the LDR sensor value and connects to local server then send sends data to local server

Cont…

```
void setup()
{
   Serial.begin(9600);                 // Serial communication at baud rate of 9600 for debugging purpose
   delay(10);
   WiFi.mode(WIFI_STA);                // ESP8266 in station mode
   Serial.print("Connecting to ");
   Serial.println(ssid);
   WiFi.begin(ssid, pass);
   Serial.println();
   while (WiFi.status() != WL_CONNECTED)
   {
      Serial.print(".");
      delay(500);
   }
   Serial.println();
   Serial.println("WiFi connected");
   Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
   Serial.println("MAC:" + WiFi.macAddress());
   Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
   Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());          // MAC address of access point
}
```

Cont…

```
void loop()
{
   val = analogRead(LDRpin);                        // Reads the light sensor value
   if(client.connect(server,80))                    // Connect to local server
   {
      client.print("2\r");                           // before sending data first send ESP8266 ID as 2
      Serial.print("LDR sensor value: ");
      Serial.println(val);
      String LDRval = String(val);
      LDRval += "\r";                               // Add end delimiter
      client.print(LDRval);                         // Send to local server
      Serial.println("Sent to Local Server..");
      delay(15000);
   }
   client.stop();
}
```

ESP8266 with Pulse Sensor

```
#define pulsePin A0                    // Pulse sensor input pin A0
#include<ESP8266WiFi.h>                // Including ESP8266 library

 char ssid[] = "ESP1_Server";          // Replace with SSID of hotspot of local server
 char pass[] = "12345678";             // Replace with password of hotspot of local server
  IPAddress server(172,16,117,192);               // IP address of local server
 WiFiClient client;

 int rate[10];                          // array to hold last ten IBI value
 unsigned long sampleCounter = 0;  // used to determine pulse timing
 unsigned long lastBeatTime = 0;        // used to find IBI
 unsigned long lastTime = 0, N;
 int BPM = 0;                // int that holds raw analog in 0. updated every 2mS
 int IBI = 0;               // int that holds time interval between beats! Must be seeded!
 int P = 512;               // used to find peak in pulse wave, seeded
 int T = 512;               // used to find trough in pulse wave, seeded
 int thresh = 512;          // used to find instant moment of heart beat, seeded
 int amp = 100;             // used to hold amplitude of pulse waveform, seeded
 int Signal;                // holds incoming raw data
 boolean Pulse = false;                // "True" when heartbeat is detected. "False" when not a "live beat".
 boolean firstBeat = true;             // used to seed rate array so we startup with reasonable BPM
 boolean secondBeat = true;            // used to seed rate array so we startup with reasonable BPM
 boolean QS = false;                   // Becomes true when ESP8266 finds a beat
```

For **ESP3**, write the following code in the Arduino IDE and save as **Pulse_client.ino**

Cont…

```
void setup()
{
  Serial.begin(9600);                    // Serial communication at baud rate of 9600 for debugging purpose
  delay(10);
  WiFi.mode(WIFI_STA);                   // ESP8266 in station mode
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, pass);
  Serial.println();
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.println("WiFi connected");
  Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
  Serial.println("MAC:" + WiFi.macAddress());
  Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
  Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());     // MAC address of access point
}
```

Cont…

```
void loop(){
 if (QS == true){                                  //if ESP8266 finds a beat
    if (client.connect(server, 80)){              // Connect to local server
     client.print("3\r");                          // before sending data first send ESP8266 ID as 3
     String pulseRate = String(BPM);               // Convert into string
     pulseRate +="\r";                            // Add "r" as end delimiter
     Serial.print("Pulse rate: ");
     Serial.print(BPM);
     Serial.println(" BPM.");
     client.print(pulseRate);                     // send data to local server
     Serial.println("Sent to local server..");
   }
   QS = false;
   client.stop();
   delay(15000);
  }
  else if(millis() >= (lastTime + 2)) {
   readPulse();
   lastTime = millis();
  }
}
```

Cont…

```
void readPulse() {
  Signal = analogRead(pulsePin);            //Read pulse sensor value
  sampleCounter += 2;                       // Keeps track of the time in mS
  int N = sampleCounter - lastBeatTime; // Monitor the time since the last beat to avoid noise
  detectSetHighLow();                       // find the peak and trough of the pulse wave
                                             // Now it's time to look for the heart beat
                                            // signal surges up in value every time there is a pulse
  if(N > 250){                               // avoid high frequency noise
   if((Signal > thresh) && (Pulse == false) && (N > (IBI/5)*3))
     pulseDetected();
  }
  if (Signal < thresh && Pulse == true) {
    Pulse = false;
    amp = P - T;
    thresh = amp / 2 + T;
    P = thresh;
    T = thresh;
  }
  if (N > 2500) {
    thresh = 512;
    P = 512;
    T = 512;
    lastBeatTime = sampleCounter;
    firstBeat = true;
    secondBeat = true;
   }
}
```

```
void detectSetHighLow() {
   if(Signal < thresh && N > (IBI/5)* 3)
                 // avoid dichrotic noise by waiting 3/5 of last IBI
    {
      if (Signal < T) {           // T is the trough
        T = Signal;              // Keep track of lowest point in pulse wave
      }
    }
   if (Signal > thresh && Signal > P) // thresh condition helps avoid noise
    {
      P = Signal;                // P is the peak
    }                             // Keep track of highest point in pulse wave
}
```

Cont…

```
void pulseDetected()
{
   Pulse = true;          // set the pulse flag when there is a pulse
   IBI = sampleCounter - lastBeatTime; // time between beats in mS
   lastBeatTime = sampleCounter;      //keep track of time for next pulse
   if (firstBeat)                    // if it's the first time beat is found
   {
     firstBeat = false;              //clear firstBeat flag
     return;
    }
   if (secondBeat)                   // if this is second beat
   {
      secondBeat = false;   // clear secondBeat flag
      for (int i = 0; i <= 9; i++)
      {
        rate[i] = IBI;
      }
    }
    word runningTotal = 0; // clear the runningTotal variable
    for (int i = 0; i <= 8; i++) //Shift data in the rate array
    {
     rate[i] = rate[i + 1];        // and drop the oldest IBI value
     runningTotal += rate[i];   // add up the 9 oldest IBI value
    }
    rate[9] = IBI;              // add the latest IBI to the rate array
    runningTotal += rate[9];    //add the latest IBI to runningTotal
    runningTotal /= 10;          // average the last 10 IBI values
```

```
     BPM = 60000 / runningTotal;
     // how many beats can fit into a minute? that's BPM!
     QS = true;
     if (client.connect(server, 80))  //Connects to local server
     {
       client.print("3\r");
                  //before sending the data sends ESP8266 ID as 3
       String pulseRate = String(BPM);
                  // Converting integer data into string
       pulseRate +="\r";
                  // Add end Delimiter "r" in the data
       Serial.print("Pulse rate: ");
       Serial.print(BPM);
       Serial.println(" BPM.");
       client.print(pulseRate);       //sends data to locals server
       Serial.println("Sent to local server..");
     }
     client.stop();
     delay(15000);
                  // Wait for 15 seconds after each transmission
   }
```

ESP8266 with Vibration Sensor

For **ESP4**, write the following code in the Arduino IDE and save as **Vibration_client.ino**

```
#include <ESP8266WiFi.h>             // Including ESP8266 library
#define vib A0                       // sensor input from A0 pin of ESP8266

 char ssid[] = "ESP1_Server";        //Replace with SSID of hotspot of local server
 char pass[] = "12345678";           // Replace with password of hotspot of local server

IPAddress server(172,16,117,192);              // IP address of local server
WiFiClient client;
```

- Change the IP address of Local Server (i.e. ESP1)
- Change the SSID and Password of WiFi AP hosted in Local Server

Cont…

```
void setup(){
   Serial.begin(9600);                  // Serial communication at baud rate of 9600 for debugging purpose
   delay(10);
   pinMode(vib, INPUT);                 // Input of vibration sensor
   WiFi.mode(WIFI_STA);                 // ESP8266 as station mode
   Serial.print("Connecting to ");
   Serial.println(ssid);
   WiFi.begin(ssid, pass);
   Serial.println();
   while (WiFi.status() != WL_CONNECTED)   {
      Serial.print(".");
      delay(500);
   }
   Serial.println();
   Serial.println("WiFi connected");
   Serial.print("LocalIP:"); Serial.println(WiFi.localIP());        // IP address of local server
   Serial.println("MAC:" + WiFi.macAddress());
   Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
   Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());    // MAC address of access point
}
```

Cont…

```
void loop(){
   int val = analogRead(vib);              // Reads the sensor value
   if(client.connect(server,80))           //connects to local server
   {
     client.print("4\r");                  // Before sending the data sends ESP8266 ID as 4
     Serial.print("Vibration sensor value: ");
     Serial.println(val);
     String data = String(val);            // Converting integer data into string type
     data += "\r";                         // Add end delimiter "r" in the data
     client.print(data);                   // sends sensor data to local server
     Serial.println("Sent to Local server..!! ");
     delay(15000);                                       // After each transmission wait for 15 seconds
     client.stop();
  }
}
```

ESP8266 with DHT11 Sensor

For **ESP5**, write the following code in the Arduino IDE and save as **Temp_Humidity_Client.ino**

```
#include<DHT.h>                    //Including temperature and Humidity sensor library
#include<ESP8266WiFi.h>            //Including ESP8266 library
#define DHTPIN 0                   // D3 pin of ESP8266

 char ssid[] = "ESP1_Server";      //Replace with ssid of hotspot of local server
 char pass[] = "12345678";         // Replace with password of hotspot of local server

 IPAddress server(172,16,117,192); // Static IP address of local server. Replace whatever you want.
 WiFiClient client;

 DHT dht(DHTPIN, DHT11);           // Data of DHT11 sensor in D3 pin of ESP8266
```

- Change the IP address of Local Server (i.e. **ESP1**)
- Change the SSID and Password of WiFi AP hosted in Local Server

- Install the **DHT11** library and **Adafruit Unified Sensor** library for DHT11 sensor

Cont…

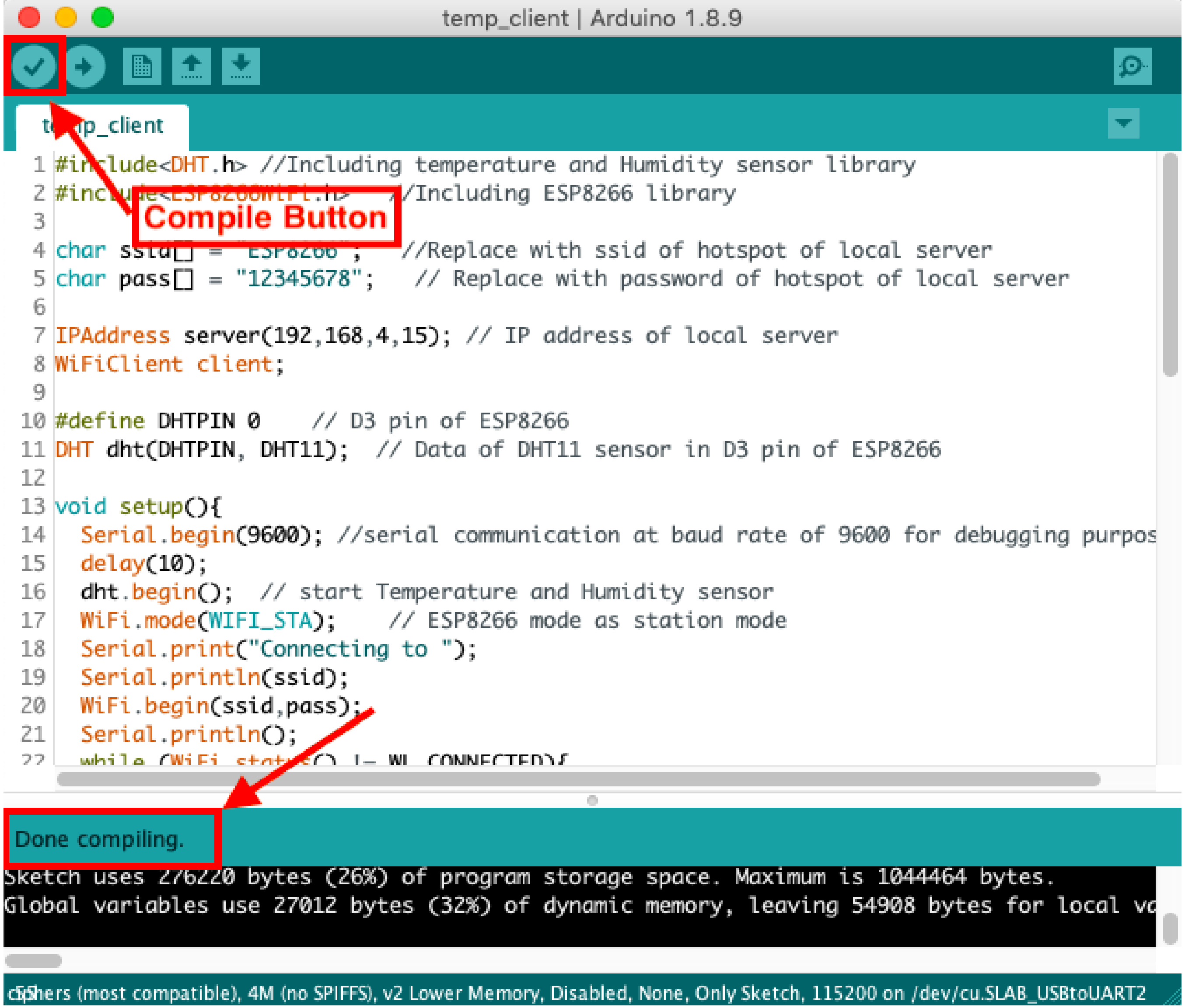
```
void setup() {
  Serial.begin(9600);              //serial communication at baud rate of 9600 for debugging purpose
  delay(10);
  dht.begin();                     // start Temperature and Humidity sensor
  WiFi.mode(WIFI_STA);             // ESP8266 mode as station mode
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, pass);
  Serial.println();
  while (WiFi.status() != WL_CONNECTED)   {
   Serial.print(".");
   delay(500);
  }
  Serial.println();
  Serial.println("WiFi connected");
  Serial.print("LocalIP:"); Serial.println(WiFi.localIP());
  Serial.println("MAC:" + WiFi.macAddress());
  Serial.print("Gateway:"); Serial.println(WiFi.gatewayIP());
  Serial.print("AP MAC:"); Serial.println(WiFi.BSSIDstr());    // MAC address of access point
}
```

Cont…

```
void loop() {
   float h = dht.readHumidity();               // Read Humidity value from sensor
   float t = dht.readTemperature();            // Read temp value from sensor
   if(isnan(h) || isnan(t))     {
      Serial.println("Failed to read from DHT sensor");                  // Error message
      return;
   }
   if(client.connect(server,80))                // Connect to local server
   {
      client.print(“5\r");                      // before sending the data first send ESP8266 ID as 5
      String temp = String(t);
      temp += "\r";                            // Add “r” as end delimiter
      client.print(temp);                      //  send temperature to local server
      Serial.print("Temperature: ");
      Serial.print(t);
      Serial.print(" degree celsius, Humidity: ");
      Serial.print(h);
      Serial.print("%. ");
      String humidity = String(h);
      humidity += "\r";                        // Add “r” in data as end delimiter
      client.print(humidity);                  // send to Local server
      Serial.println("Sent to local server ");
      delay(15000);                            // delay of 15sec after each transmission
   }
   client.stop();
}
```

Code Compilation and Upload

Code Compilation



```
#include<DHT.h> //Including temperature and Humidity sensor library
#include<ESP8266WiFi.h>  //Including ESP8266 library

char ssid[] = "ESP8266";   //Replace with ssid of hotspot of local server
char pass[] = "12345678";   // Replace with password of hotspot of local server

IPAddress server(192,168,4,15); // IP address of local server
WiFiClient client;

#define DHTPIN 0    // D3 pin of ESP8266
DHT dht(DHTPIN, DHT11);  // Data of DHT11 sensor in D3 pin of ESP8266

void setup(){
  Serial.begin(9600); //serial communication at baud rate of 9600 for debugging purpos
  delay(10);
  dht.begin();  // start Temperature and Humidity sensor
  WiFi.mode(WIFI_STA);    // ESP8266 mode as station mode
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid,pass);
  Serial.println();
  while (WiFi.status() != WL_CONNECTED){
```

Done compiling.

```
Sketch uses 276220 bytes (26%) of program storage space. Maximum is 1044464 bytes.
Global variables use 27012 bytes (32%) of dynamic memory, leaving 54908 bytes for local va
```

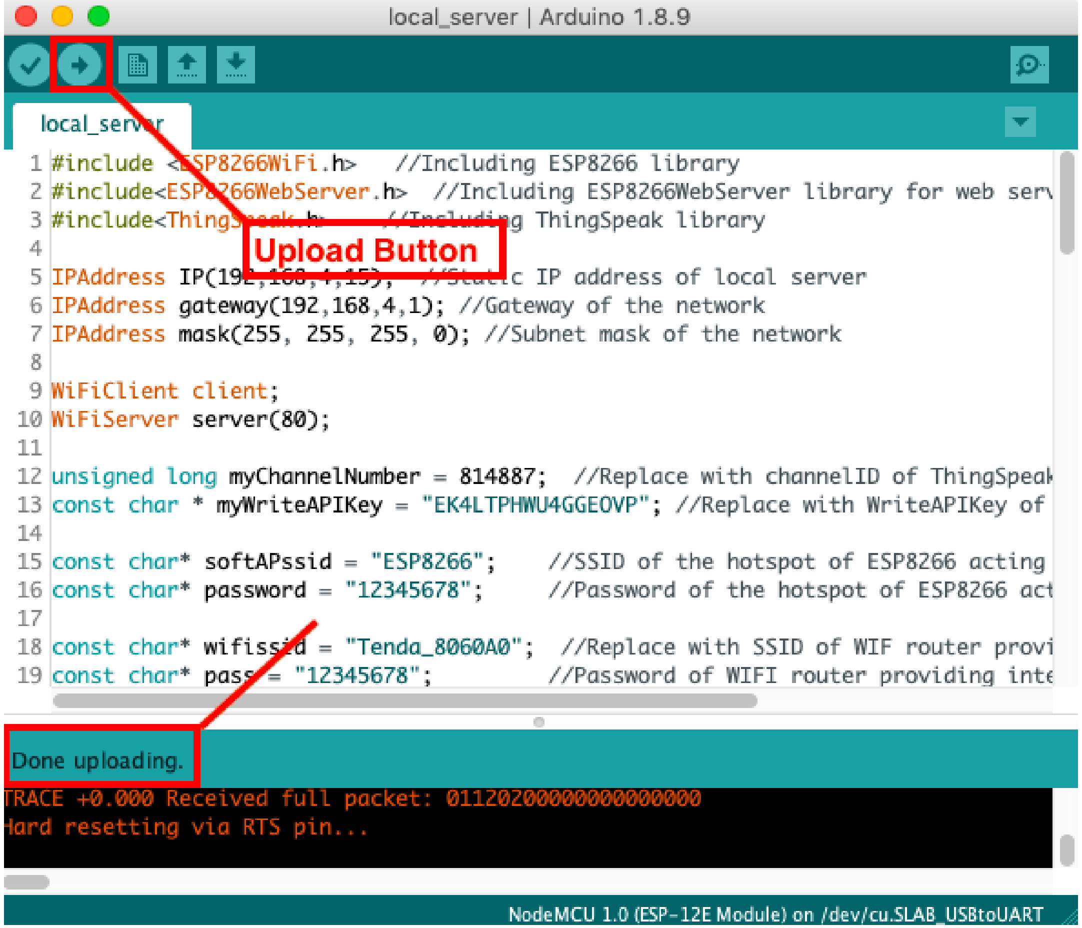
ciphers (most compatible), 4M (no SPIFFS), v2 Lower Memory, Disabled, None, Only Sketch, 115200 on /dev/cu.SLAB_USBtoUART2

Compilation successful message in bottom left corner.

Code Uploading

- Plug in the ESP8266 boards one by one to PC/Laptop via USB cable
- Go to **Tool** menu, select Board "**NodeMCU 1.0 (ESP-12E Module)**" and Port "**COM3**".
- Open the corresponding code and do uploading code in Node MCU.

Note: If COM port is not detected automatically then it is needed to install. Download port drivers from the given link and then install and then restart the system: https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers



```
#include <ESP8266WiFi.h>   //Including ESP8266 library
#include<ESP8266WebServer.h>  //Including ESP8266WebServer library for web serv
#include<ThingSpeak.h>    //Including ThingSpeak library

IPAddress IP(192,168,4,15);  //Static IP address of local server
IPAddress gateway(192,168,4,1); //Gateway of the network
IPAddress mask(255, 255, 255, 0); //Subnet mask of the network

WiFiClient client;
WiFiServer server(80);

unsigned long myChannelNumber = 814887;  //Replace with channelID of ThingSpeak
const char * myWriteAPIKey = "EK4LTPHWU4GGEOVP"; //Replace with WriteAPIKey of

const char* softAPssid = "ESP8266";     //SSID of the hotspot of ESP8266 acting
const char* password = "12345678";      //Password of the hotspot of ESP8266 act

const char* wifissid = "Tenda_8060A0";  //Replace with SSID of WIF router provi
const char* pass = "12345678";          //Password of WIFI router providing inte
```

Done uploading.

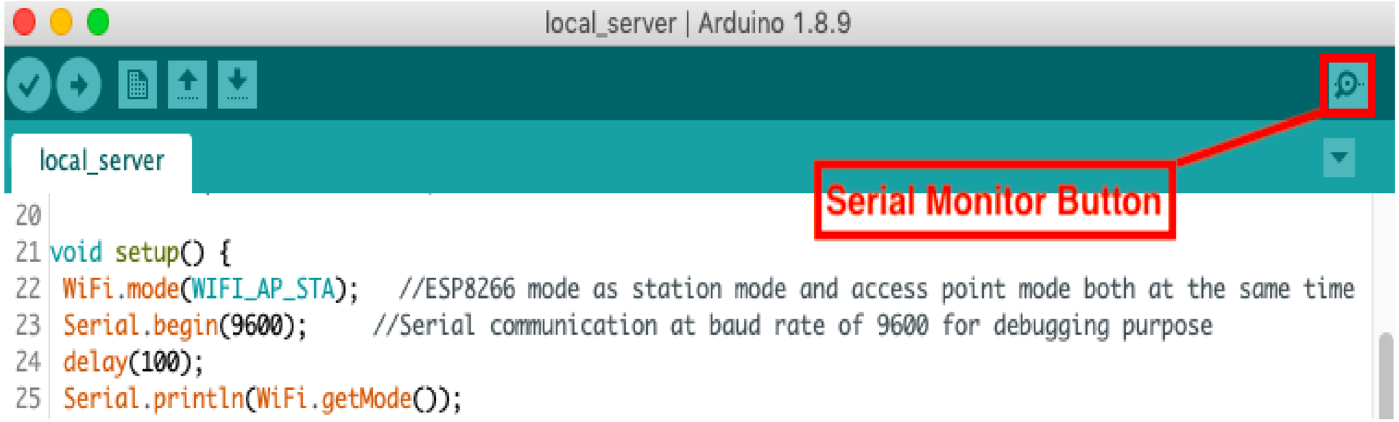
```
TRACE +0.000 Received full packet: 01120200000000000000
Hard resetting via RTS pin...
```

NodeMCU 1.0 (ESP-12E Module) on /dev/cu.SLAB_USBtoUART

Observe Outputs

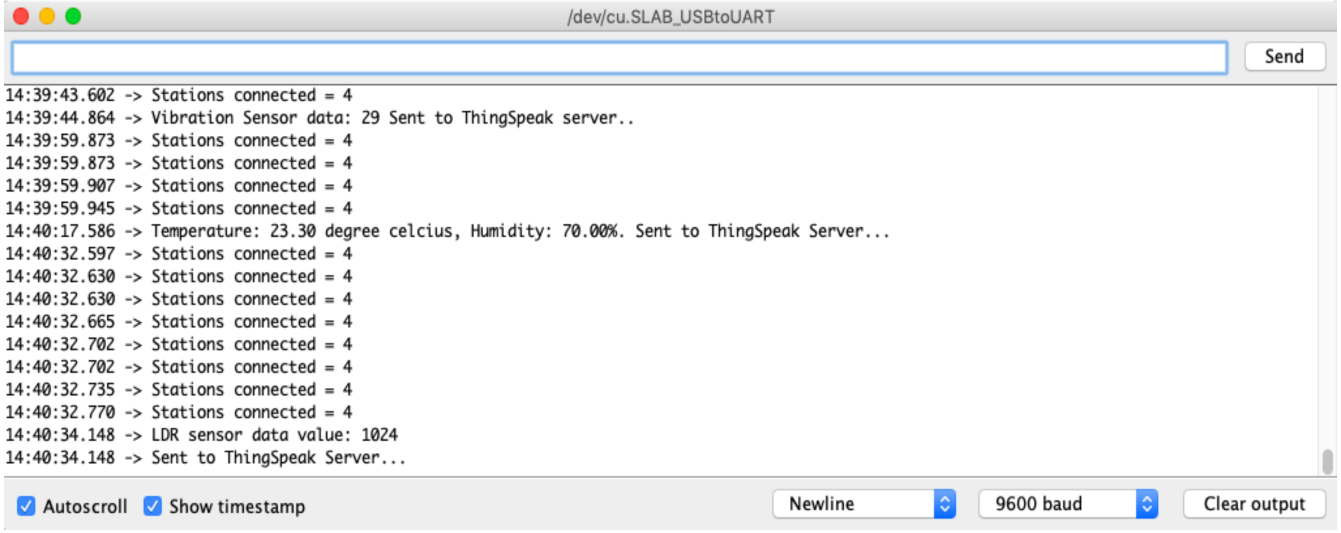
Open Serial Monitor

- First **select the port** (go to Tools > Port:) to which the board is connected then click the icon of **Serial Monitor** on the top right side of the Arduino IDE



```
void setup() {
 WiFi.mode(WIFI_AP_STA);    //ESP8266 mode as station mode and access point mode both at the same time
 Serial.begin(9600);     //Serial communication at baud rate of 9600 for debugging purpose
 delay(100);
 Serial.println(WiFi.getMode());
```

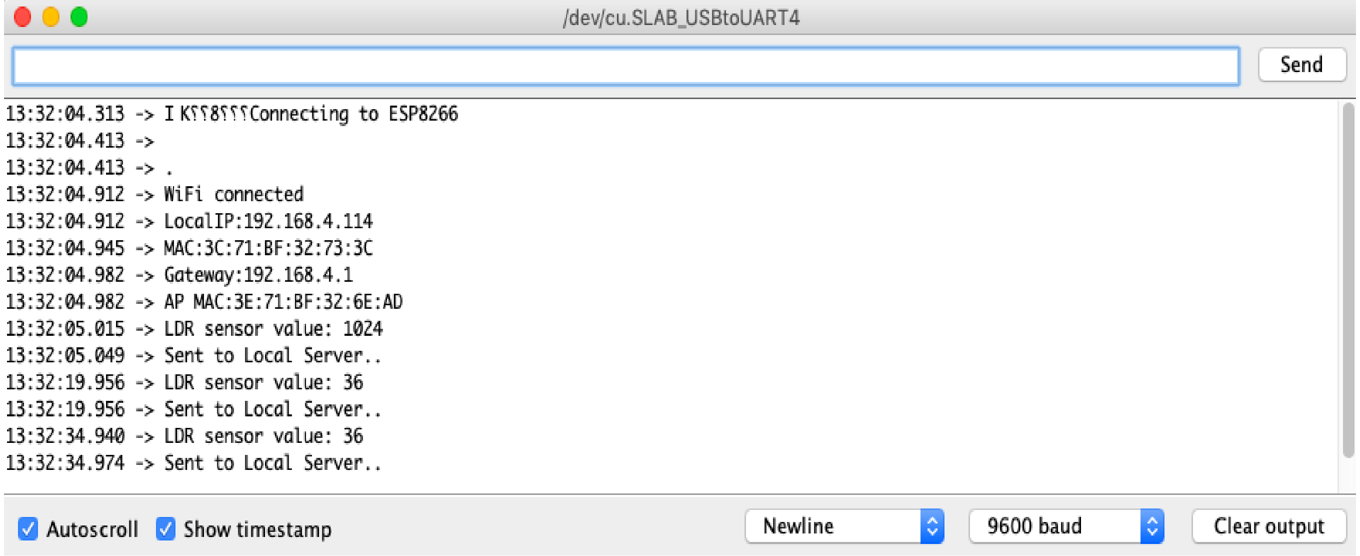
Serial Monitor of Local Server



```
14:39:43.602 -> Stations connected = 4
14:39:44.864 -> Vibration Sensor data: 29 Sent to ThingSpeak server..
14:39:59.873 -> Stations connected = 4
14:39:59.873 -> Stations connected = 4
14:39:59.907 -> Stations connected = 4
14:39:59.945 -> Stations connected = 4
14:40:17.586 -> Temperature: 23.30 degree celcius, Humidity: 70.00%. Sent to ThingSpeak Server...
14:40:32.597 -> Stations connected = 4
14:40:32.630 -> Stations connected = 4
14:40:32.630 -> Stations connected = 4
14:40:32.665 -> Stations connected = 4
14:40:32.702 -> Stations connected = 4
14:40:32.702 -> Stations connected = 4
14:40:32.735 -> Stations connected = 4
14:40:32.770 -> Stations connected = 4
14:40:34.148 -> LDR sensor data value: 1024
14:40:34.148 -> Sent to ThingSpeak Server...
```

☑ Autoscroll ☑ Show timestamp Newline 9600 baud

Cont…

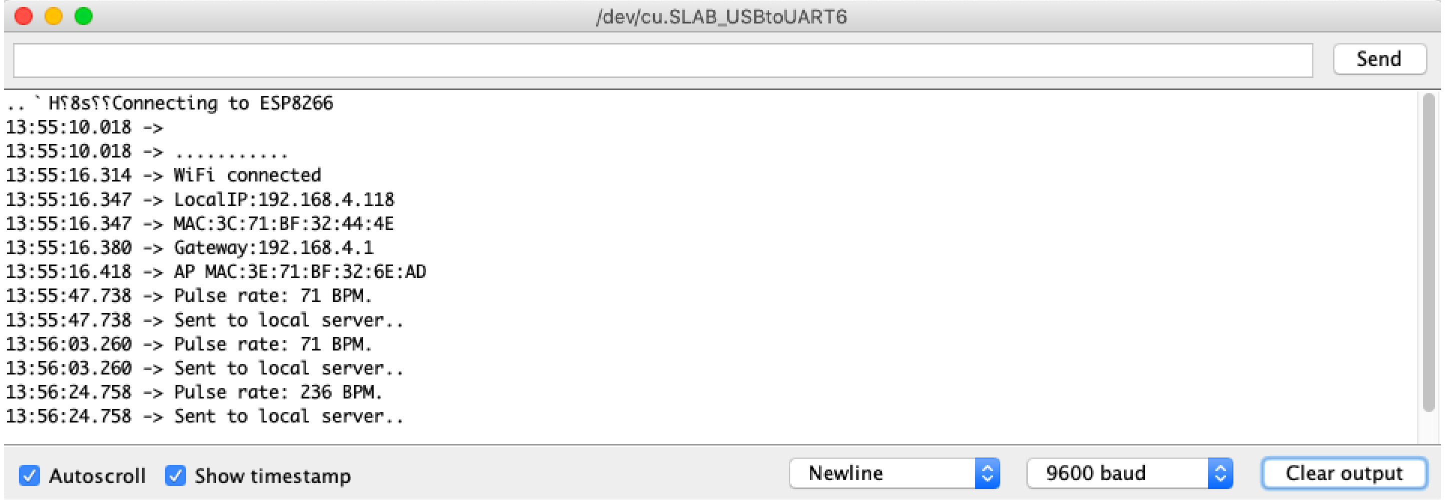


```
13:32:04.313 -> I K⸮⸮8⸮⸮⸮Connecting to ESP8266
13:32:04.413 -> 
13:32:04.413 -> .
13:32:04.912 -> WiFi connected
13:32:04.912 -> LocalIP:192.168.4.114
13:32:04.945 -> MAC:3C:71:BF:32:73:3C
13:32:04.982 -> Gateway:192.168.4.1
13:32:04.982 -> AP MAC:3E:71:BF:32:6E:AD
13:32:05.015 -> LDR sensor value: 1024
13:32:05.049 -> Sent to Local Server..
13:32:19.956 -> LDR sensor value: 36
13:32:19.956 -> Sent to Local Server..
13:32:34.940 -> LDR sensor value: 36
13:32:34.974 -> Sent to Local Server..
```

☑ Autoscroll ☑ Show timestamp Newline 9600 baud

Serial Monitor
of ESP2

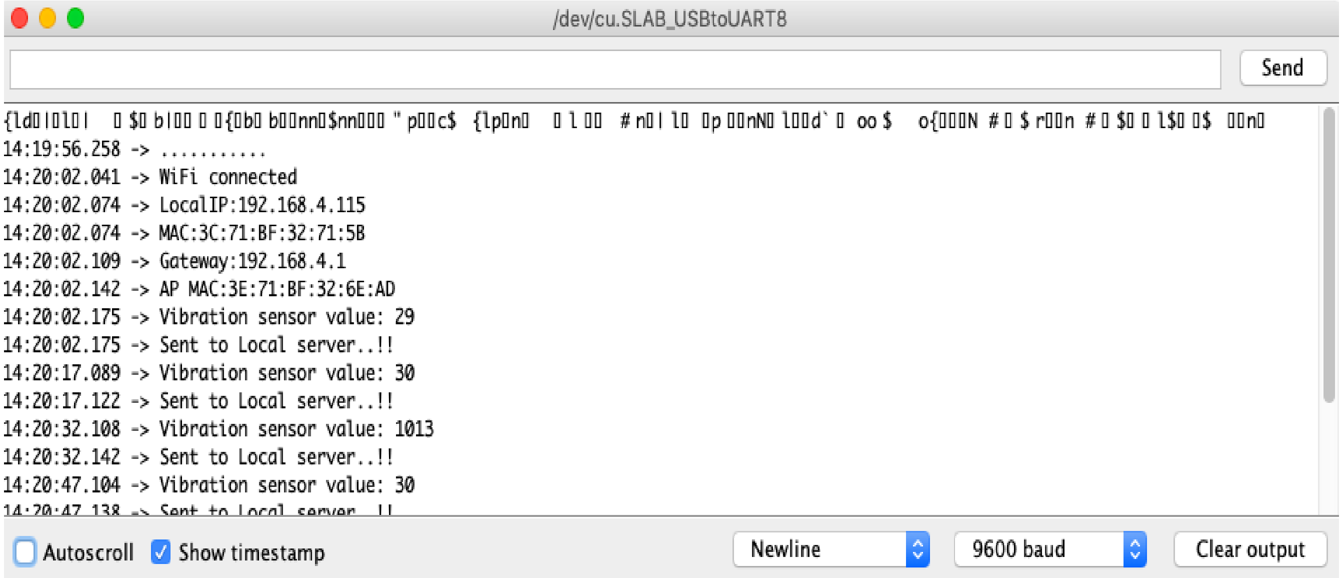
Serial Monitor
of ESP3



```
.. ` H⸮8s⸮⸮Connecting to ESP8266
13:55:10.018 -> 
13:55:10.018 -> ...........
13:55:16.314 -> WiFi connected
13:55:16.347 -> LocalIP:192.168.4.118
13:55:16.347 -> MAC:3C:71:BF:32:44:4E
13:55:16.380 -> Gateway:192.168.4.1
13:55:16.418 -> AP MAC:3E:71:BF:32:6E:AD
13:55:47.738 -> Pulse rate: 71 BPM.
13:55:47.738 -> Sent to local server..
13:56:03.260 -> Pulse rate: 71 BPM.
13:56:03.260 -> Sent to local server..
13:56:24.758 -> Pulse rate: 236 BPM.
13:56:24.758 -> Sent to local server..
```

☑ Autoscroll ☑ Show timestamp Newline 9600 baud

Cont…

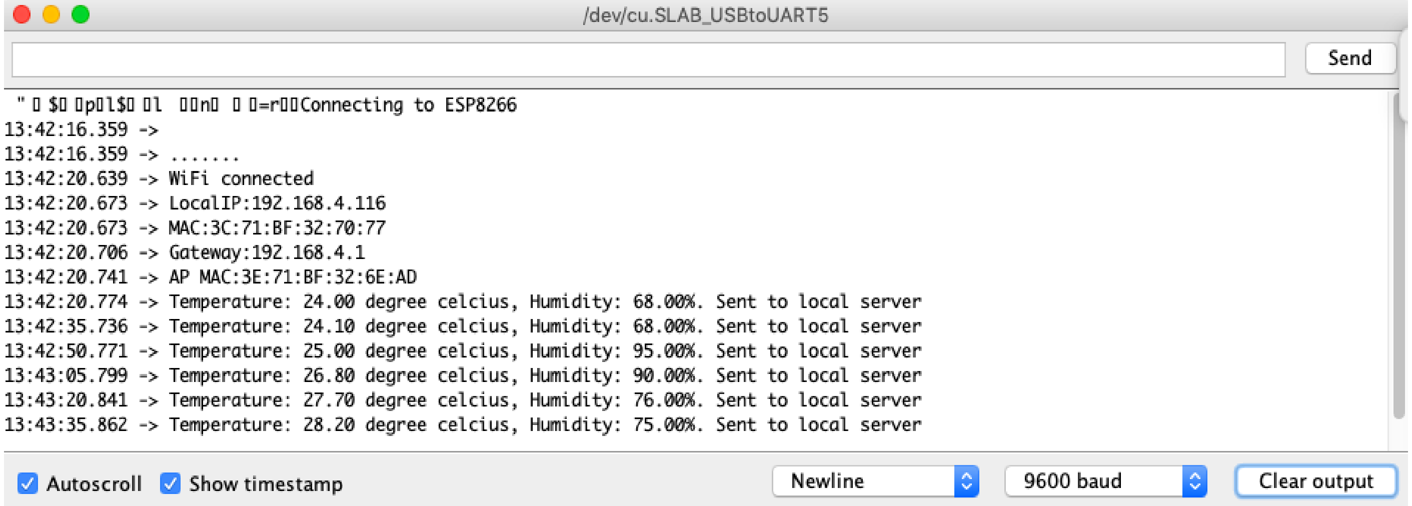


```
{ld□|□l□|   □ $□ b|□□ □ □{□b□ b□□nn□$nn□□□ " p□□c$  {lp□n□   □ l □□  # n□| l□  □p □□nN□ l□□d` □  oo $   o{□□□N # □ $ r□□n # □ $□ □ l$□ □$  □□n□
14:19:56.258 -> ...........
14:20:02.041 -> WiFi connected
14:20:02.074 -> LocalIP:192.168.4.115
14:20:02.074 -> MAC:3C:71:BF:32:71:5B
14:20:02.109 -> Gateway:192.168.4.1
14:20:02.142 -> AP MAC:3E:71:BF:32:6E:AD
14:20:02.175 -> Vibration sensor value: 29
14:20:02.175 -> Sent to Local server..!!
14:20:17.089 -> Vibration sensor value: 30
14:20:17.122 -> Sent to Local server..!!
14:20:32.108 -> Vibration sensor value: 1013
14:20:32.142 -> Sent to Local server..!!
14:20:47.104 -> Vibration sensor value: 30
14:20:47.138 -> Sent to Local server..!!
```

☐ Autoscroll ☑ Show timestamp   Newline   9600 baud

Serial Monitor of ESP4

Serial Monitor of ESP5

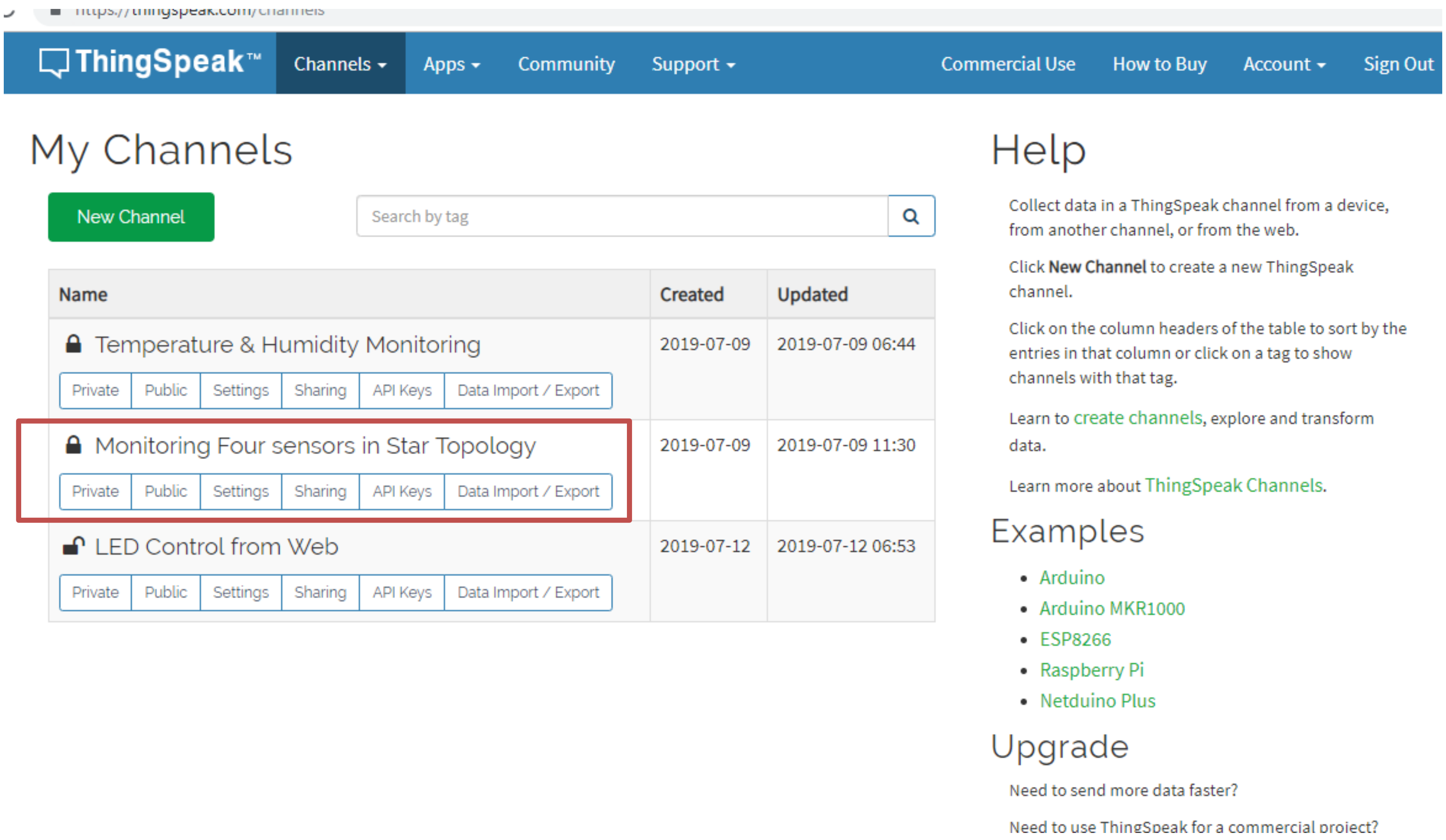


```
 " □ $□ □p□l$□ □l  □□n□  □ □=r□□Connecting to ESP8266
13:42:16.359 ->
13:42:16.359 -> .......
13:42:20.639 -> WiFi connected
13:42:20.673 -> LocalIP:192.168.4.116
13:42:20.673 -> MAC:3C:71:BF:32:70:77
13:42:20.706 -> Gateway:192.168.4.1
13:42:20.741 -> AP MAC:3E:71:BF:32:6E:AD
13:42:20.774 -> Temperature: 24.00 degree celcius, Humidity: 68.00%. Sent to local server
13:42:35.736 -> Temperature: 24.10 degree celcius, Humidity: 68.00%. Sent to local server
13:42:50.771 -> Temperature: 25.00 degree celcius, Humidity: 95.00%. Sent to local server
13:43:05.799 -> Temperature: 26.80 degree celcius, Humidity: 90.00%. Sent to local server
13:43:20.841 -> Temperature: 27.70 degree celcius, Humidity: 76.00%. Sent to local server
13:43:35.862 -> Temperature: 28.20 degree celcius, Humidity: 75.00%. Sent to local server
```

☑ Autoscroll ☑ Show timestamp   Newline   9600 baud

Results & Graphs in Web

- Open the ThingSpeak page and click on **Channels > My channels**
- Now select the channel that is created for this experiment (In this case '**Monitoring Four Sensors in Star Topology**').



My Channels

Name	Created	Updated
Temperature & Humidity Monitoring	2019-07-09	2019-07-09 06:44
Monitoring Four sensors in Star Topology	2019-07-09	2019-07-09 11:30
LED Control from Web	2019-07-12	2019-07-12 06:53

Help

Collect data in a ThingSpeak channel from a device, from another channel, or from the web.

Click **New Channel** to create a new ThingSpeak channel.

Click on the column headers of the table to sort by the entries in that column or click on a tag to show channels with that tag.

Learn to create channels, explore and transform data.

Learn more about ThingSpeak Channels.

Examples

- Arduino
- Arduino MKR1000
- ESP8266
- Raspberry Pi
- Netduino Plus

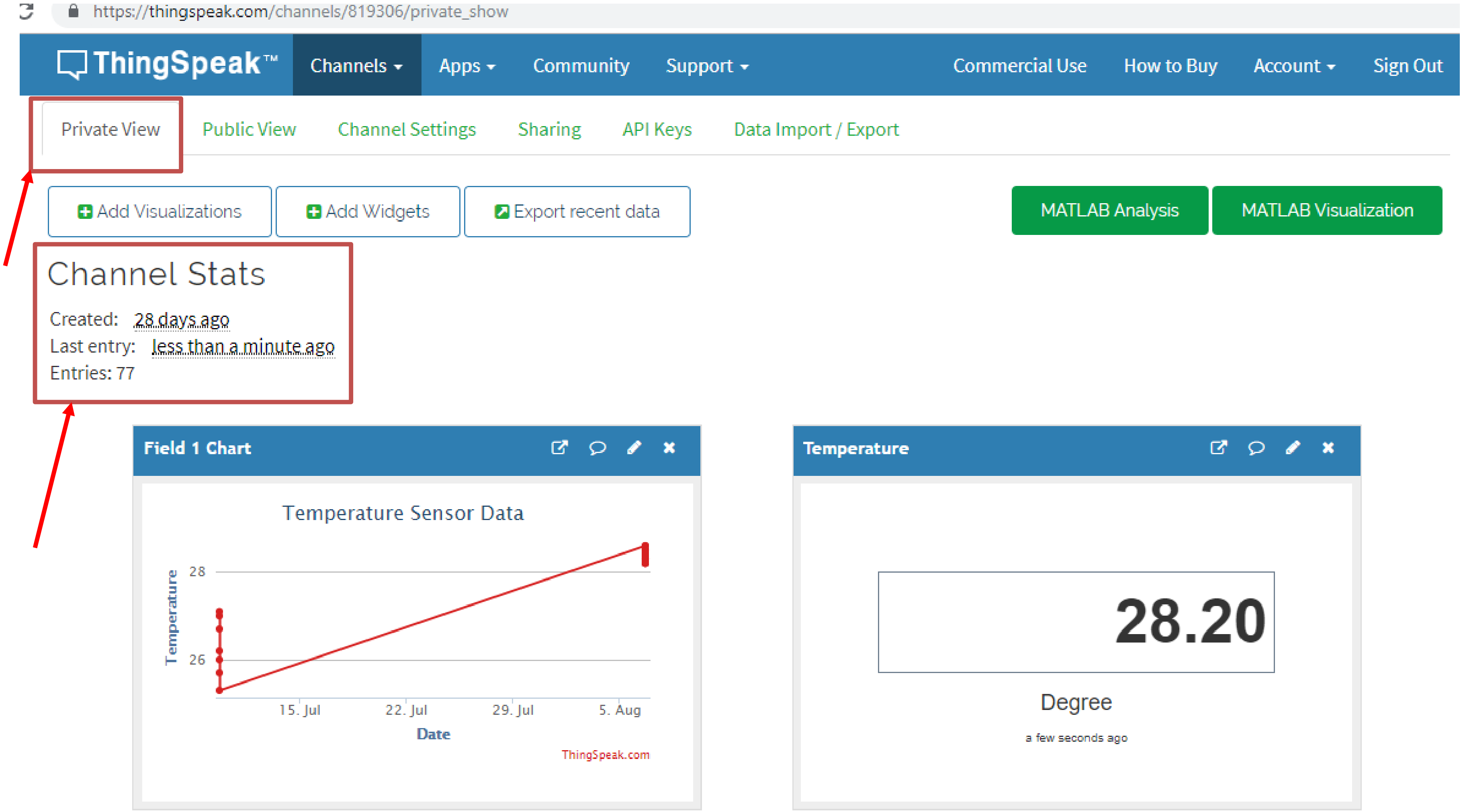
Upgrade

Need to send more data faster?

Need to use ThingSpeak for a commercial project?

Cont…

- click on ‘**Private View**’ to see the uploaded data



https://thingspeak.com/channels/819306/private_show

Channel Stats

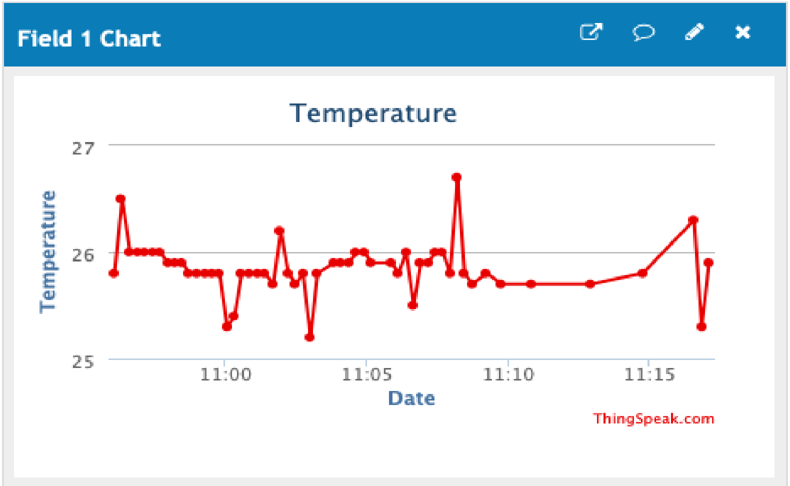
Created: 28 days ago

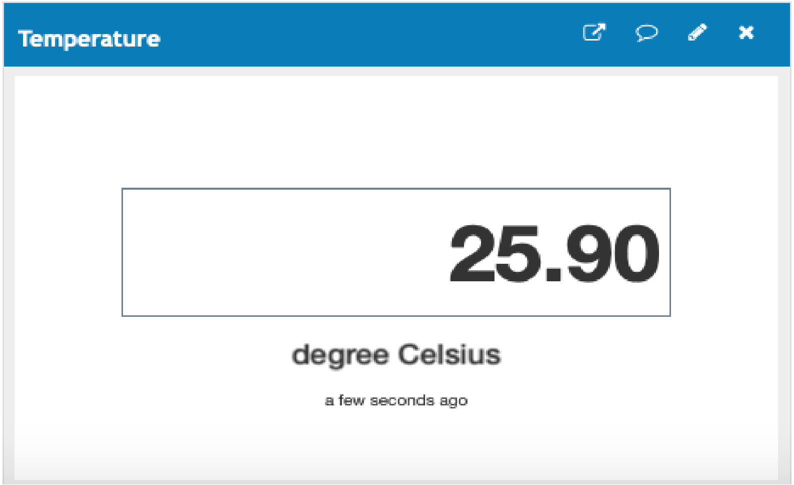
Last entry: less than a minute ago

Entries: 77

Cont…

- Temperature and Humidity

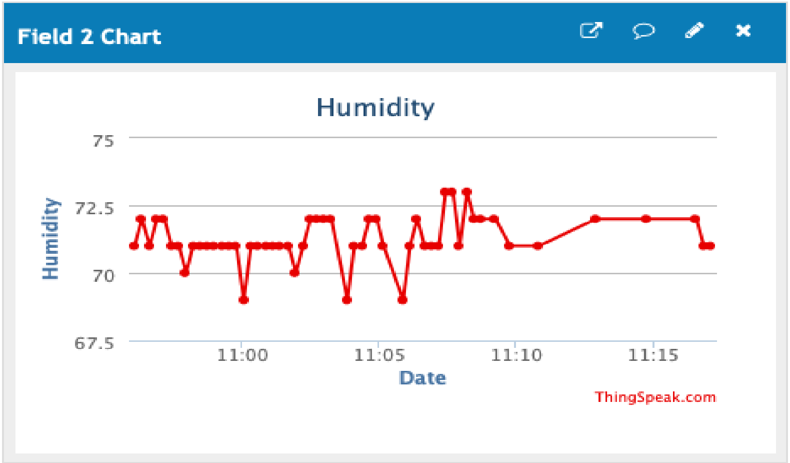


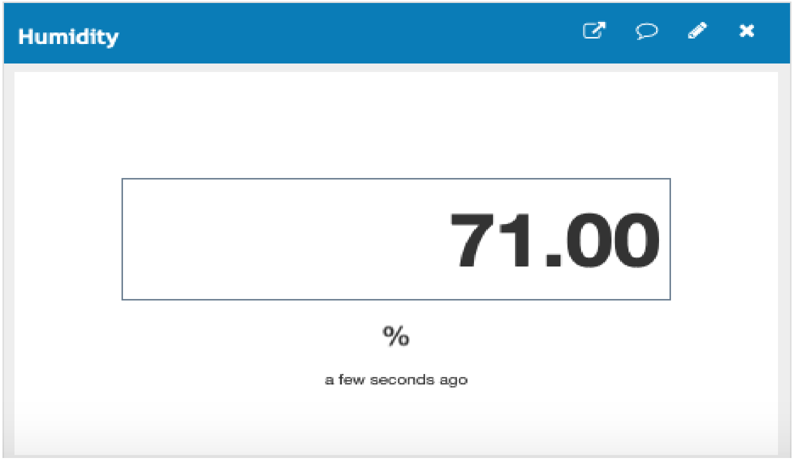

Temperature

25.90

degree Celsius

a few seconds ago




Humidity

71.00

%

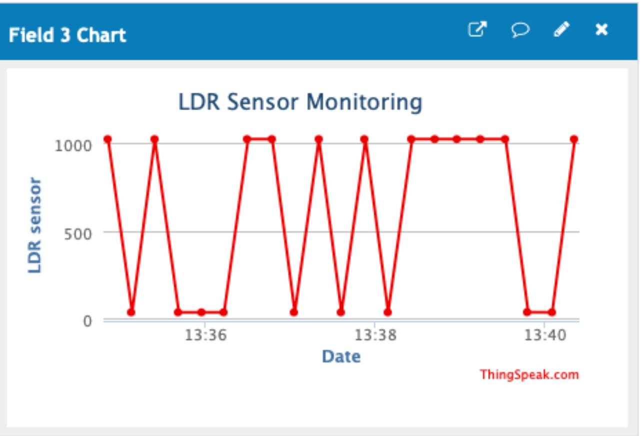
a few seconds ago

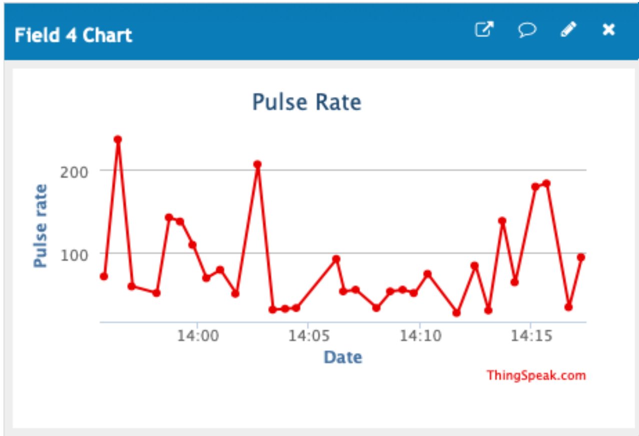
Cont…

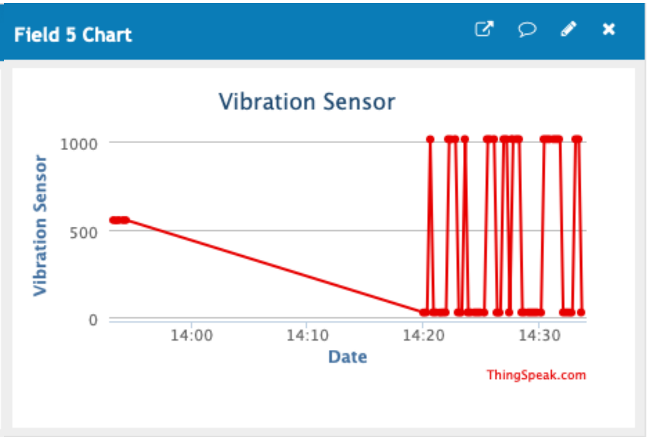
Light Sensor

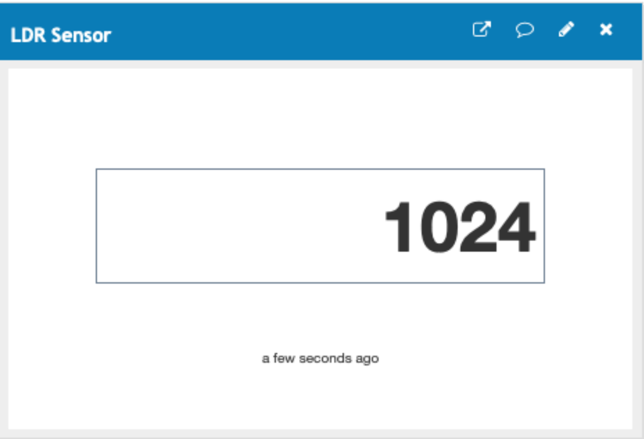
Pulse Sensor

Vibration Sensor



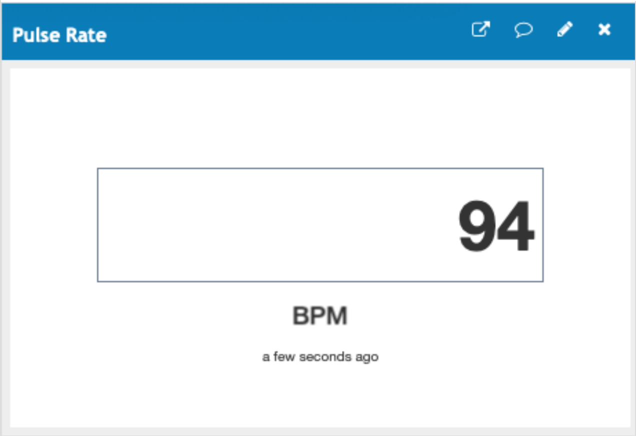





LDR Sensor

1024

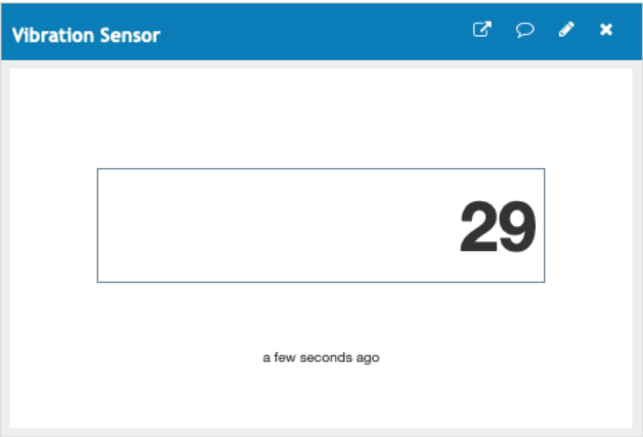
a few seconds ago


Pulse Rate

94

BPM

a few seconds ago


Vibration Sensor

29

a few seconds ago

Thanks!