ESP32 Projects IoT Projects LoRa Projects

ESP32 LoRa Sensor Data Monitoring on Web Server

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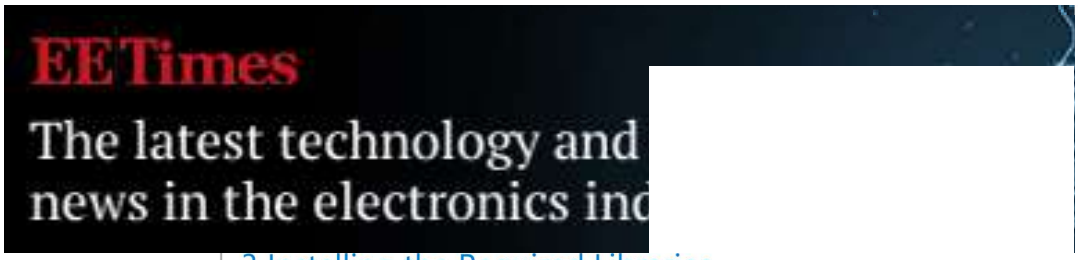
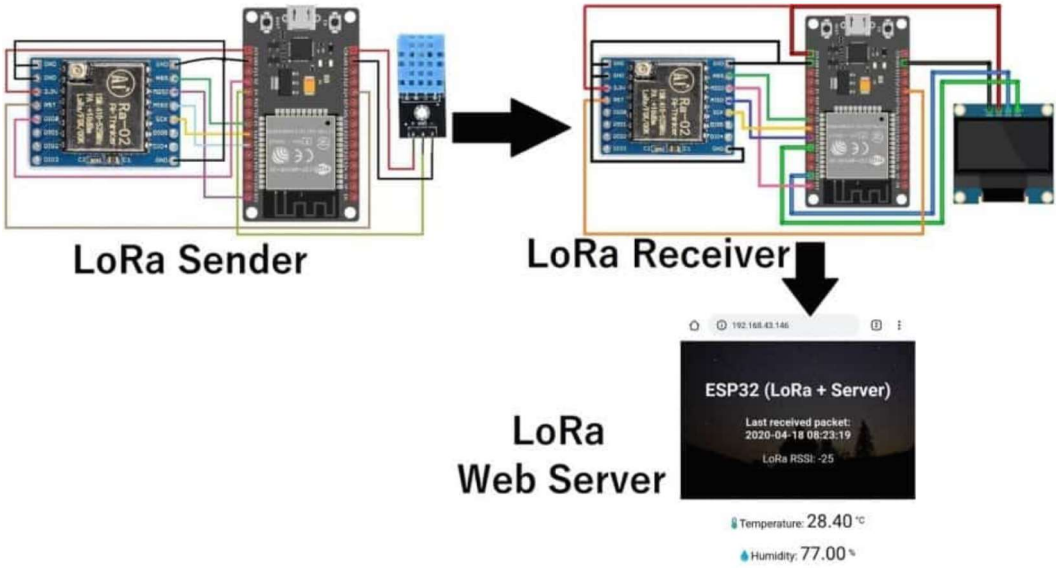
In this project, we will make a sensor monitoring system on Web Server using an ESP32 board & LoRa Module SX1278 or SX1276. The device will send temperature & humidity readings via LoRa radio to an ESP32 LoRa receiver. The receiver displays the latest sensor readings on a web server.



Overview

In the last couple of years, there is a number of communication technologies available for interaction between **IoT devices**. The most popular ones are the **Wi-Fi** Technology and **Bluetooth** Module. But they have few limitations like limited range, limited access points &

So, in this **IoT Project**, we will design **ESP32 LoRa Web Server** to monitor the sensor reading wirelessly from a few kilometer distances. The **sender** will read the **humidity** and **temperature** data using **DHT11 Sensor**. Then it transmits the data via **LoRa Radio**. The data is received by the **receiver** module which contains the **OLED Display**. The receiver has the capability of connecting the device to a **WiFi network**. The OLED will display the **IP Address**. Using the IP address, you can log into any web browser where the sensor reading is monitored. The basic overview of **ESP32 LoRa Web Server** is given below.



The LoRa receiver runs an **asynchronous web server** and the web page files are saved on the **ESP32 filesystem (SPIFFS)**. It also shows the date and time the last readings were received. To get date and time, we use the **Network Time Protocol** with the ESP32.

Before getting started, you can visit the following posts:

1. *Interfacing SX1278 (Ra-02) LORA Module with Arduino*: Check Here

2. *Sending Sensor Data Wirelessly with LoRa SX1278 & Arduino*: Check Here

3. *ESP8266 & LoRa SX1278 Transmitter Receiver with DHT11*: Check Here

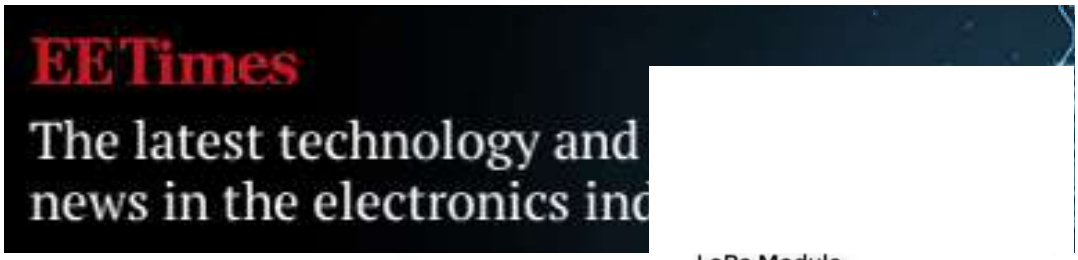
4. *ESP32 & LoRa SX1278/76 Transmitter Receiver with OLED*: Check Here

5. *ESP32 LoRa Thingspeak Gateway with LoRa Sensor Node*

Check Here

Bill of Materials

Following are the components required for making this project. All the components can easily be purchased from Amazon. The components purchase link is given below.



S.N.	COMPONENTS	DESCRIPTION	QUANTITY	amazon
1	ESP32 Board	ESP32 ESP-32S Development Board (ESP-WROOM-32)	2	https://amzn.t
2	LoRa Module	SX1278/76 Lora Module	2	https://amzn.t
3	OLED Display	0.96" I2C OLED Display	1	https://amzn.t
4	Connecting Wires	Jumper Wires	20	https://amzn.t
5	Breadboard	-	1	https://amzn.t
6	DHT11 Sensor	DHT11	1	https://amzn.t

Installing the Required Libraries

Several Libraries are required for the project to program the ESP32 Board with Arduino IDE.

1. DHT11 Library

To read the temperature and humidity we need any temperature humidity sensor. For that DHT11 is the best and cheap sensor. We need to install DHT11 Library for that. Download the library from below and add to the Arduino IDE.

Download DHT11 Library

2. LoRa Library

We need an Arduino library for sending and receiving data using LoRa radios. The library supports module like Semtech SX1276, SX1277, SX1278, SX1279 and also HopeRF RFM95W, RFM96W and RFM98W.

Download LoRa Radio Library

3. OLED Libraries

We need two Library for OLED Display. Adafruit_SSD1306 is a library for our Monochrome OLEDs based on SSD1306 drivers. Adafruit GFX Library is the core graphics library for all our displays, providing a common set of graphics primitives (points, lines, circles, etc.).

Download SSD1306 Library & Download Adafruit GFX Library

4. NTPClient Library

The Network Time Protocol (NTP) is a networking protocol for clock synchronization between computer systems over packet-switched, variable-latency data networks. Every time the LoRa receiver receives a new LoRa message, it will request the date and time from an NTP server so that the last packet was received time can be obtained.

Download NTPClient Library

5. Asynchronous Web Server Libraries

To build the asynchronous web server we need two libraries, i.e ESPAsyncWebServer library & Async TCP Library.

SPIFFS lets you access the flash memory like you would do in a normal filesystem in your computer, but simpler and more limited. Using **SPIFFS** with the ESP32 board is especially useful to:

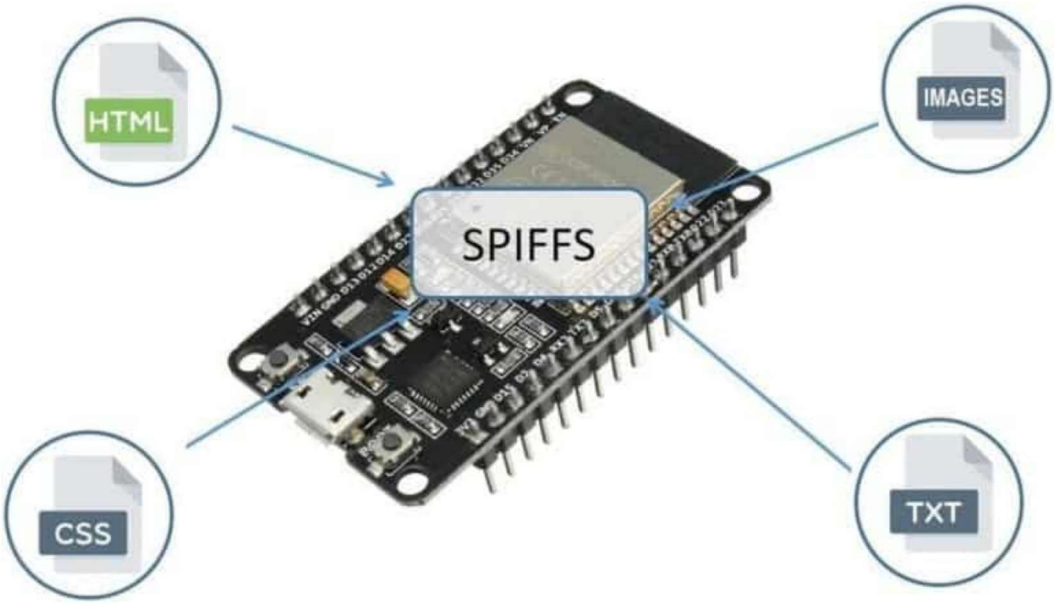
1. Create configuration files with settings

2. Save data permanently

3. Create files to save small amounts of data instead of using a microSD card

4. Save HTML and CSS files to build a web server

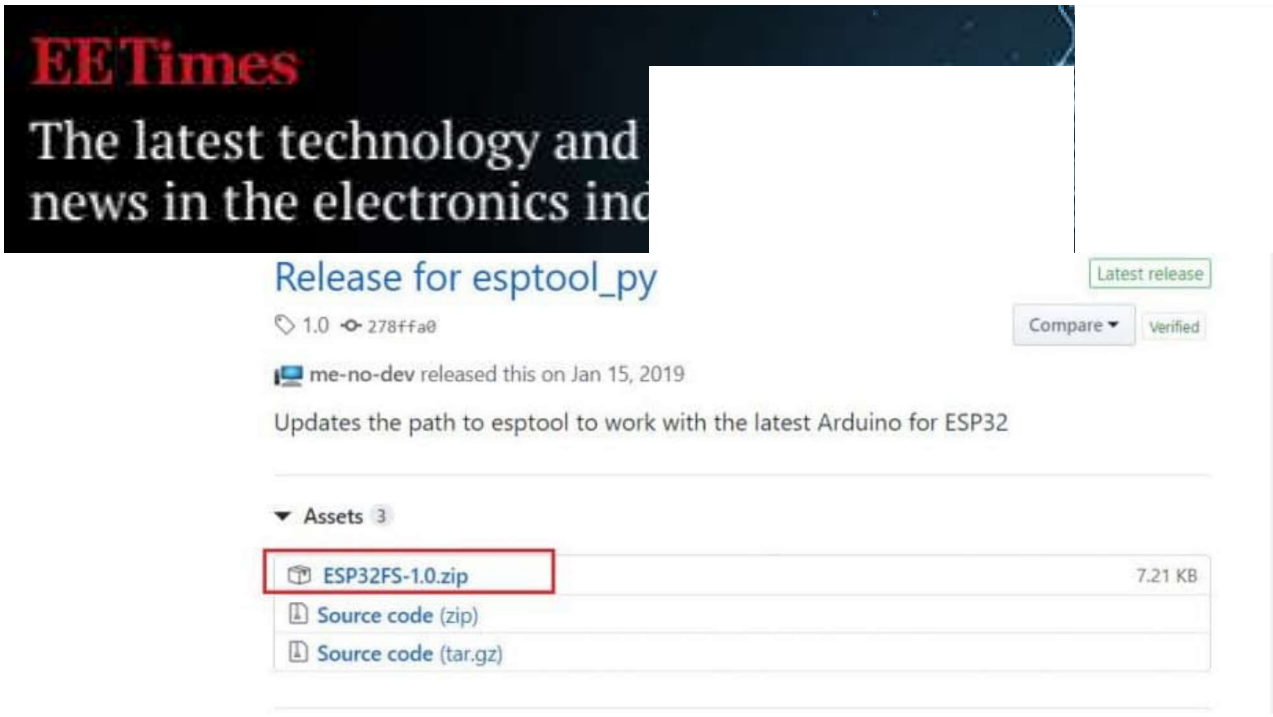
5. Save images, figures, and icons



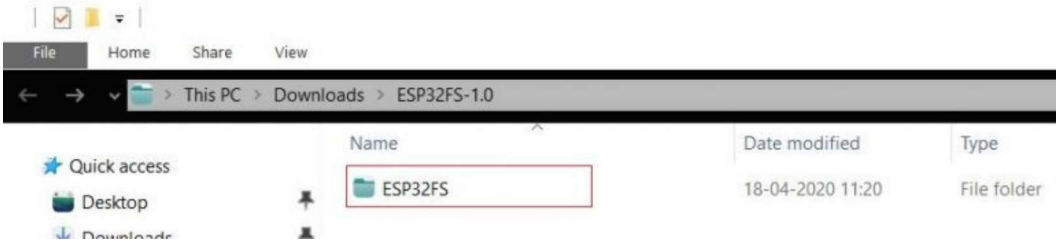
In this project we are going to upload **webpage** and **image** to the ESP32 File System.

Installing the Arduino ESP32 Filesystem Uploader

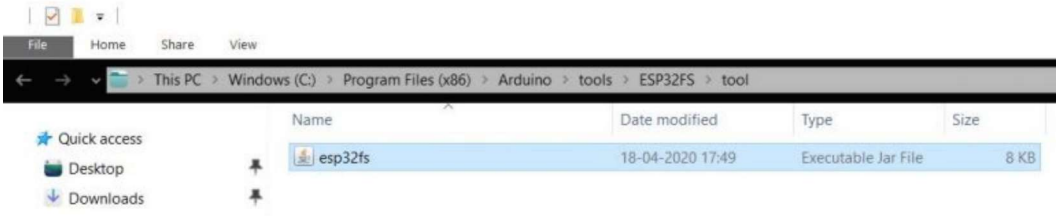
Follow the following steps to **install the filesystem uploader**:



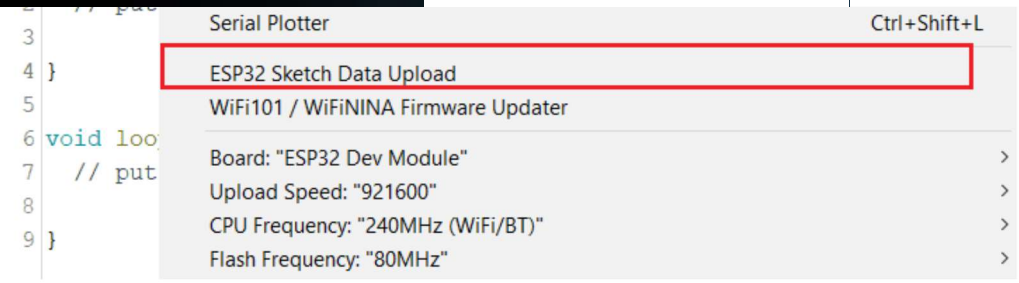
Step 2: Extract the folder ESP32FS-1.0.zip



Step 3: Move the the **folder ESP32FS** to location ***C:\Program Files (x86)\Arduino\tools***.



Step 4: Restart the **Arduino IDE**. Click on tools and there you can see "Sketch Data Upload" option.



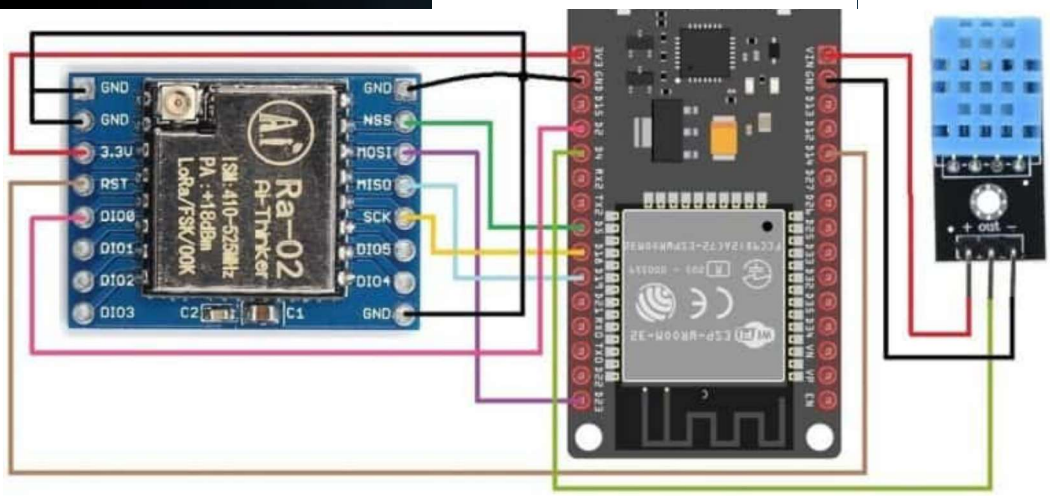
You have successfully installed the **SPIFFS plugin** now. The rest of the things need to be done on the receiver sketch below.

Circuit: ESP32 LoRa Sensor Data Monitoring on Web Server

Now let us see the **sender** and **receiver circuit** for building **ESP32 LoRa Web Server**. I assembled both the circuit on breadboard. You can make it on PCB if you want.

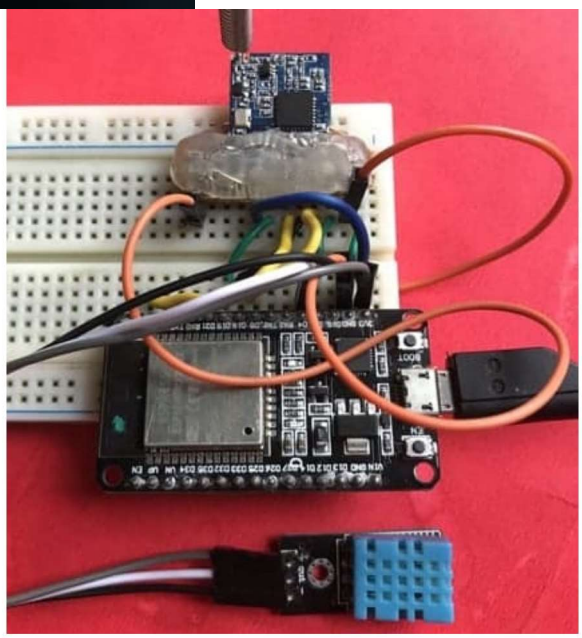
Sender Circuit for ESP32 LoRa Web Server

Here is an **ESP32 LoRa Module SX1278 Sender Circuit** with DHT11 Sensor. This part work as a **transmitter**. The humidity and



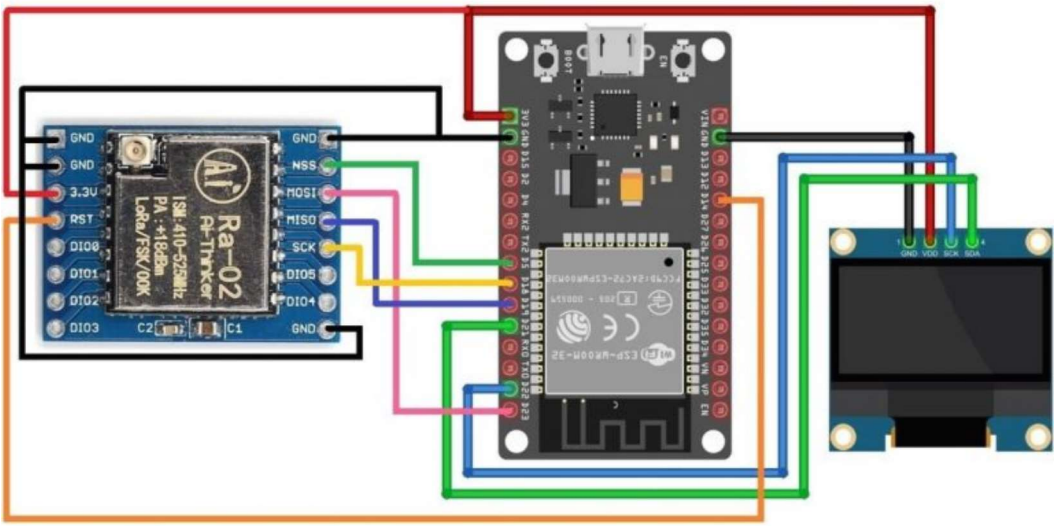
The connection is fairly simple. Simlarly connect the Lora **SX1278** & **ESP32** as follows.

ESP32 PINS	SX1278 PINS
GND	GND
3.3V	VCC
D5	NSS
D23	MOSI
D19	MISO
D18	SCK
D14	RST
D2	DIO0

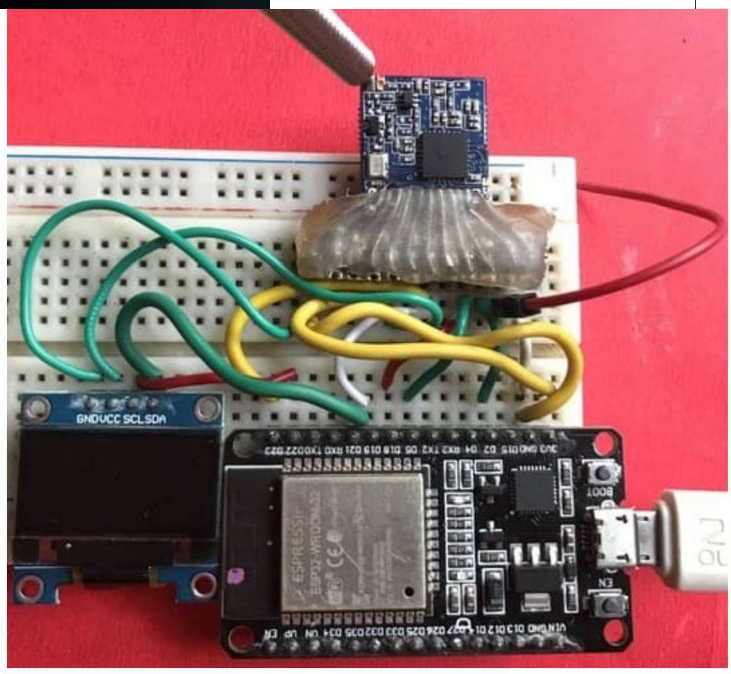


Receiver Circuit for ESP32 LoRa Web Server

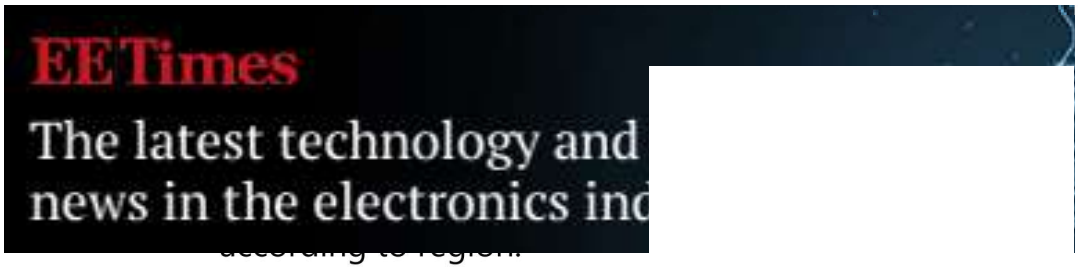
Here is an **ESP32 LoRa Module SX1278 Receiver Circuit** with OLED Display. This part work as a **Receiver**. The humidity and temperature data is received using **LoRa Radio**.



The **ESP32** & **LoRa SX1278** connection same as above. But the OLED need to be connected here. Connect the I2C Pins of OLED Display, i.e



ESP32 LoRa Sender Code

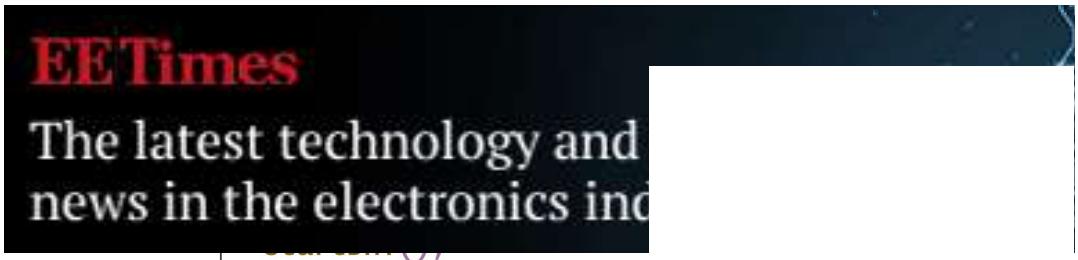


according to region.

```
#define BAND 433E6    //433E6 for Asia, 866E6 for Europe, 915E
```

```
//Libraries for LoRa
#include <SPI.h>
#include <LoRa.h>

//Libraries for LoRa
#include "DHT.h"
#define DHTPIN 4          //pin where the dht11 is connected
DHT dht(DHTPIN, DHT11);

//define the pins used by the LoRa transceiver module
#define ss 5
#define rst 14
#define dio0 2

#define BAND 433E6    //433E6 for Asia, 866E6 for Europe, 915E

//packet counter
int readingID = 0;

int counter = 0;
String LoRaMessage = "";

float temperature = 0;
float humidity = 0;



//Initialize LoRa module
void startLoRA()
{
  LoRa.setPins(ss, rst, dio0); //setup LoRa transceiver module

  while (!LoRa.begin(BAND) && counter < 10) {
    Serial.print(".");
```

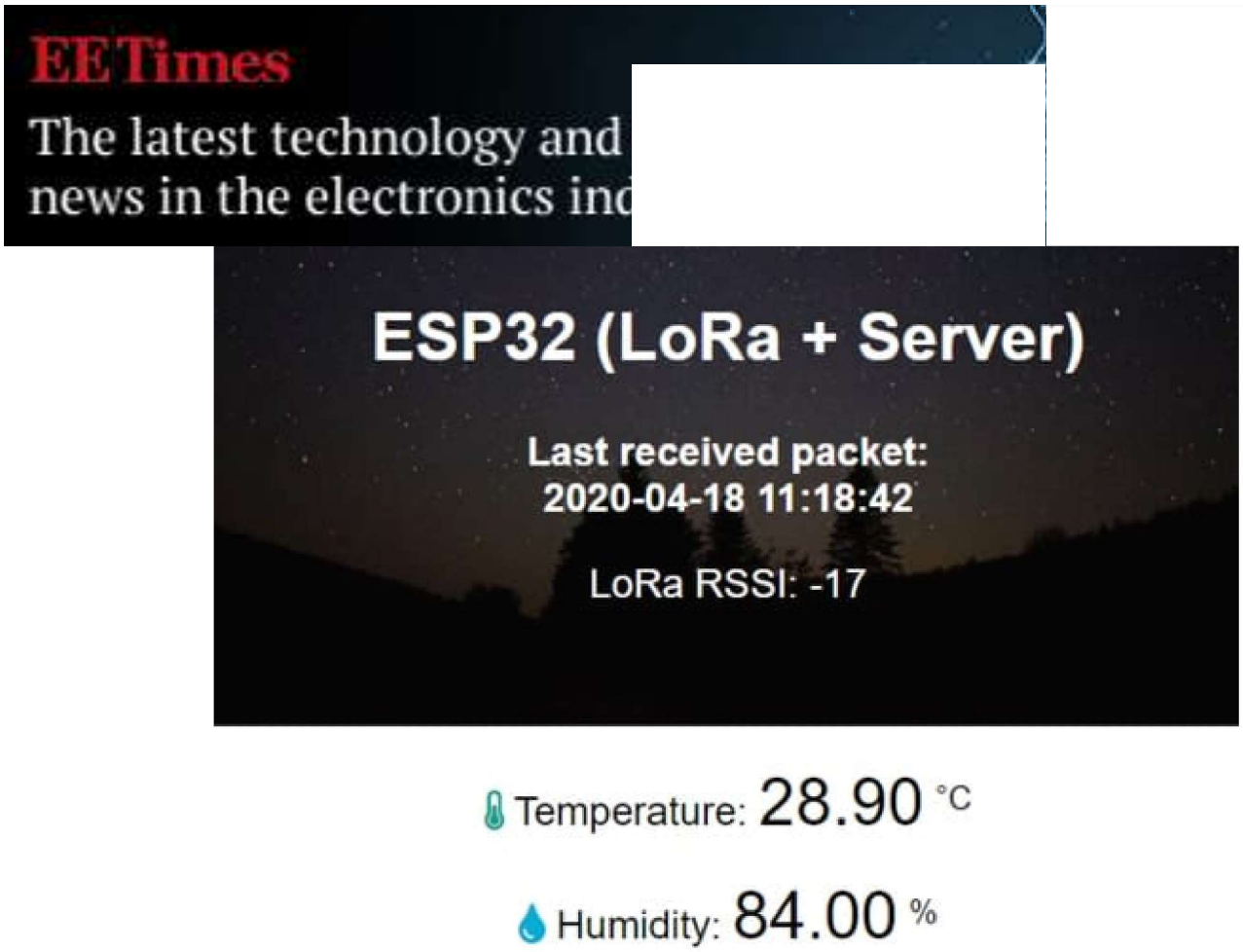
```
    readingID++;
    Serial.println("Starting LoRa failed!");
  }
  Serial.println("LoRa Initialization OK!");
  delay(2000);
}

void startDHT()
{
  if (isnan(humidity) || isnan(temperature))
  {
  Serial.println("Failed to read from DHT sensor!");
  return;
  }
}

void getReadings(){
  humidity = dht.readHumidity();
  temperature = dht.readTemperature();
  Serial.print(F("Humidity: "));
  Serial.print(humidity);
  Serial.print(F("%  Temperature: "));
  Serial.print(temperature);
  Serial.println(F("°C "));
}

void sendReadings() {
  LoRaMessage = String(readingID) + "/" + String(temperature)
  //Send LoRa packet to receiver
  LoRa.beginPacket();
  LoRa.print(LoRaMessage);
  LoRa.endPacket();

  Serial.print("Sending packet: ");
  Serial.println(readingID);
  readingID++;
  Serial.println(LoRaMessage);
}
```




```
  startLoRA();
}
void loop() {
  getReadings();
  sendReadings();
  delay(5000);
}
```

ESP32 LoRa Web Server Receiver Code

The **LoRa Receiver** gets incoming LoRa packets and displays the received readings on an **asynchronous web server**. Besides the sensor readings, it also displays the **last time** those readings were received and the **RSSI** (received signal strength indicator).



For this we need to store the image on the **ESP32 filesystem (SPIFFS)** along with the **HTML file**.

Creating index.html webpage

Copy the following code from below and paste it on **Notepad**. Save the file with name ***index.html*** so that final webpage can be published.

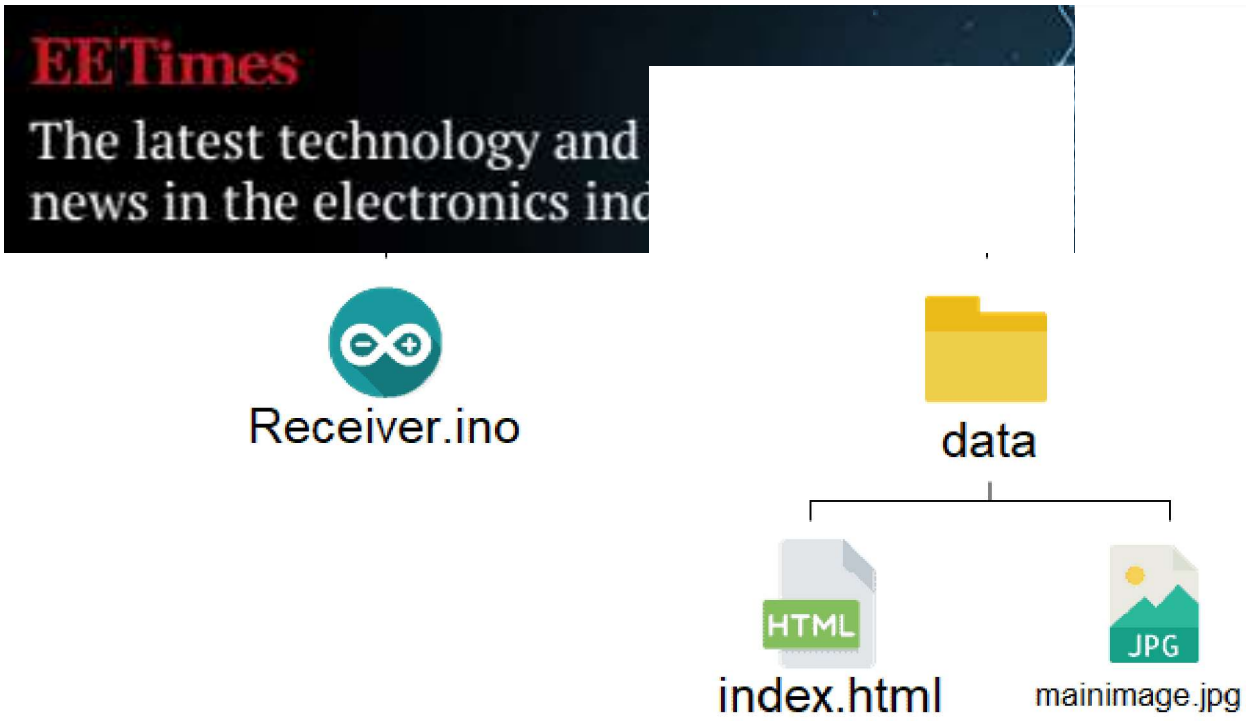
```
<!DOCTYPE HTML><html>
<head>
  <meta name="viewport" content="width=device-width, initial-s
  <link rel="icon" href="data:,">
  <title>ESP32 (LoRa + Server)</title>
  <link rel="stylesheet" href="https://use.fontawesome.com/rel
  <style>
    body {
      margin: 0;
```

```
      padding-bottom: 5vh;
      overflow: hidden;
      background-image: url(mainimage);
      background-size: cover;
      color: white;
    }
    h2 {
      font-size: 2.0rem;
    }
    p { font-size: 1.2rem; }
    .units { font-size: 1.2rem; }
    .readings { font-size: 2.0rem; }
  </style>
</head>
<body>
  <header>
    <h2>ESP32 (LoRa + Server)</h2>
    <p><strong>Last received packet:<br/><span id="timestamp">
    <p>LoRa RSSI: <span id="rssi">%RSSI%</span></p>
  </header>
<main>
  <p>
    <i class="fas fa-thermometer-half" style="color:#059e8a;">
    <sup>&deg;C</sup>
  </p>
  <p>
    <i class="fas fa-tint" style="color:#00add6;"></i> Humidit
    <sup>&#37;</sup>
  </p>

</main>
<script>
setInterval(updateValues, 10000, "temperature");
setInterval(updateValues, 10000, "humidity");
setInterval(updateValues, 10000, "rssi");
setInterval(updateValues, 10000, "timestamp");

function updateValues(value) {
```

```
  xhttp.open("GET", "/" + value, true);
  xhttp.send();
}
</script>
</body>
</html>
```


Creating data folder & its content

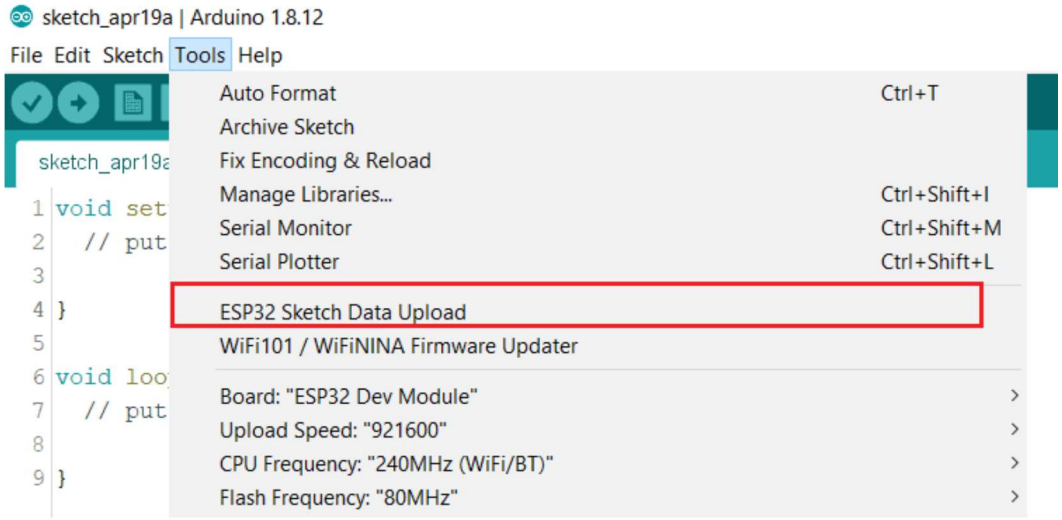
Create the folder name **data** and move the **index.html** file in it. Also download this image and place it in the same folder. The image name should be kept as ***mainimage***. You can use any other image if you want but the image name should be same.



Now copy the data folder and paste it on receiver sketh folder along with ino file.

Uploading html & image to SPIFFS

After above all steps, now you can upload the now you can upload the file system:



LoRa Receiver Code

After uploading the html page and image to SPIFFS, you can copy the below code and upload the reciver code to ESP32 Board. In the below

```
// Import Wi-Fi library
#include <WiFi.h>
#include "ESPAsyncWebServer.h"

#include <SPIFFS.h>

//Libraries for LoRa
#include <SPI.h>
#include <LoRa.h>

//Libraries for OLED Display
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

// Libraries to get time from NTP Server
#include <NTPClient.h>
#include <WiFiUdp.h>

//define the pins used by the LoRa transceiver module
#define ss 5
#define rst 14
#define dio0 2

#define BAND 433E6    //433E6 for Asia, 866E6 for Europe, 915E

//OLED pins
#define OLED_SDA 21
#define OLED_SCL 22
#define OLED_RST -1
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
```

```
WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP);

// Variables to save date and time
String formattedDate;
String day;
String hour;
String timestamp;


// Initialize variables to get and save LoRa data
int rssi;
String loRaMessage;
String temperature;
String humidity;
String readingID;

// Create AsyncWebServer object on port 80
AsyncWebServer server(80);

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, O

// Replaces placeholder with DHT values
String processor(const String& var){
  //Serial.println(var);
  if(var == "TEMPERATURE"){
    return temperature;
  }
  else if(var == "HUMIDITY"){
    return humidity;
  }
  else if(var == "TIMESTAMP"){
    return timestamp;
  }
  else if (var == "RRSI"){
    return String(rssi);
  }
  return String();
```

```
  digitalWrite(OLED_RST, LOW);
  delay(20);
  digitalWrite(OLED_RST, HIGH);

  //initialize OLED
  Wire.begin(OLED_SDA, OLED_SCL);
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3c, false, false))
    Serial.println(F("SSD1306 allocation failed"));
    for(;;); // Don't proceed, loop forever
  }
  display.clearDisplay();
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.setCursor(0,0);
  display.print("LORA SENDER");
}

//Initialize LoRa module
void startLoRA(){
  int counter;

  //setup LoRa transceiver module
  LoRa.setPins(ss, rst, dio0); //setup LoRa transceiver module

  while (!LoRa.begin(BAND) && counter < 10) {
    Serial.print(".");
    counter++;
    delay(500);
  }
  if (counter == 10) {
    // Increment readingID on every new reading
    Serial.println("Starting LoRa failed!");
  }
  Serial.println("LoRa Initialization OK!");
  display.setCursor(0,10);
  display.clearDisplay();
  display.print("LoRa Initializing OK!");
  display.display();
```

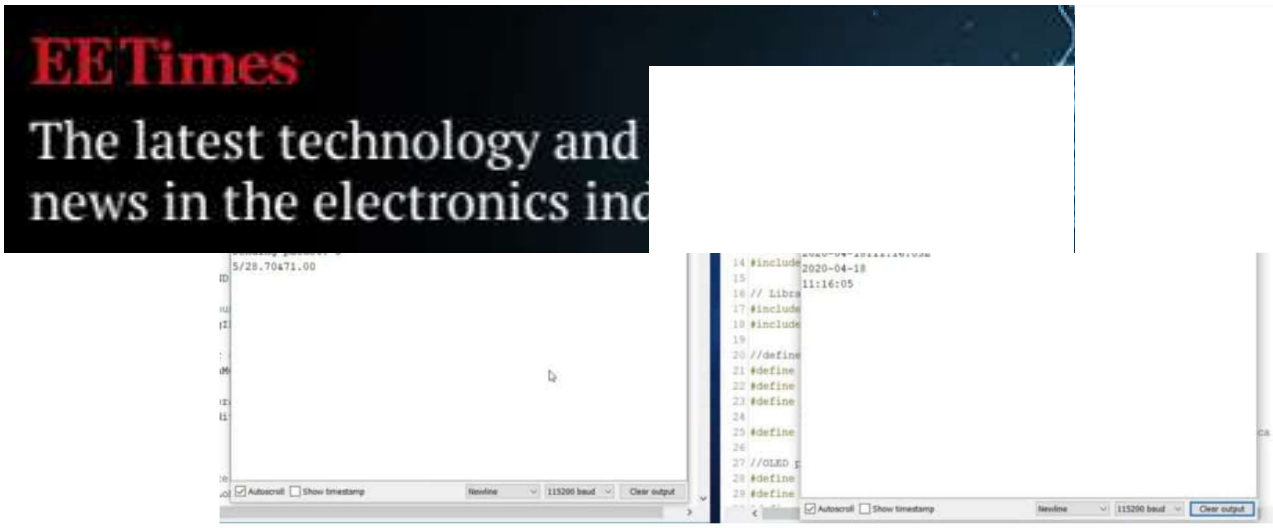
```
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  // Print local IP address and start web server
  Serial.println("");
  Serial.println("WiFi connected.");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  display.setCursor(0,20);
  display.print("Access web server at: ");
  display.setCursor(0,30);
  display.print(WiFi.localIP());
  display.display();
}

// Read LoRa packet and get the sensor readings
void getLoRaData() {
  Serial.print("Lora packet received: ");
  // Read packet
  while (LoRa.available()) {
    String LoRaData = LoRa.readString();
    // LoRaData format: readingID/temperature&soilMoisture#bat
    // String example: 1/27.43&654#95.34
    Serial.print(LoRaData);

    // Get readingID, temperature and moisture
    int pos1 = LoRaData.indexOf('/');
    int pos2 = LoRaData.indexOf('&');
    readingID = LoRaData.substring(0, pos1);
    temperature = LoRaData.substring(pos1 +1, pos2);
    humidity = LoRaData.substring(pos2+1, LoRaData.length());
  }
  // Get RSSI
  rssi = LoRa.packetRssi();
  Serial.print(" with RSSI ");
```

```
    timeClient.forceUpdate();
  }
  // The formattedDate comes with the following format:
  // 2018-05-28T16:00:13Z
  // We need to extract date and time
  formattedDate = timeClient.getFormattedDate();
  Serial.println(formattedDate);

  // Extract date
  int splitT = formattedDate.indexOf("T");
  day = formattedDate.substring(0, splitT);
  Serial.println(day);
  // Extract time
  hour = formattedDate.substring(splitT+1, formattedDate.lengt
  Serial.println(hour);
  timestamp = day + " " + hour;
}

void setup() {
  // Initialize Serial Monitor
  Serial.begin(115200);
  startOLED();
  startLoRA();
  connectWiFi();

  if(!SPIFFS.begin()){
    Serial.println("An Error has occurred while mounting SPIFF
    return;
  }
  // Route for root / web page
  server.on("/", HTTP_GET, [](AsyncWebServerRequest *request){
    request->send(SPIFFS, "/index.html", String(), false, proc
  });
  server.on("/temperature", HTTP_GET, [](AsyncWebServerRequest
    request->send_P(200, "text/plain", temperature.c_str());
  });
  server.on("/humidity", HTTP_GET, [](AsyncWebServerRequest *r
    request->send_P(200, "text/plain", humidity.c_str());
```

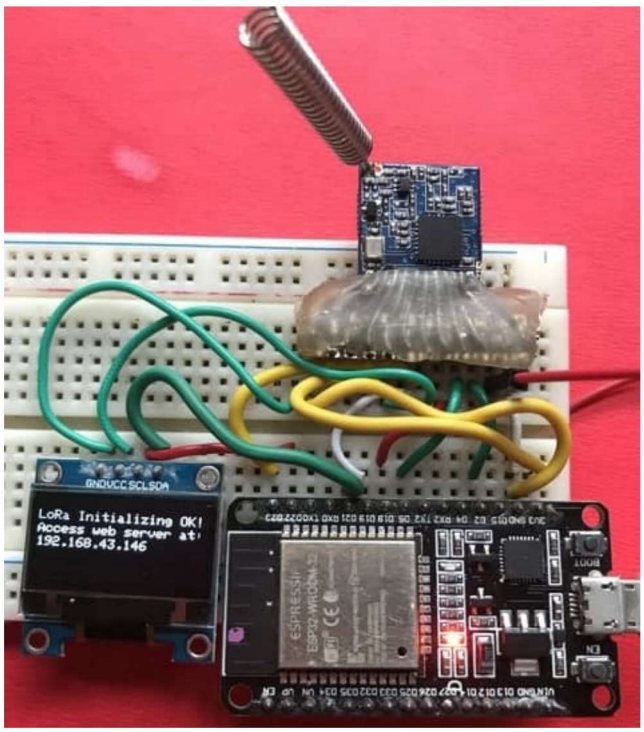
```
  });
  server.on("/mainimage", HTTP_GET, [](AsyncWebServerRequest *
    request->send(SPIFFS, "/mainimage.jpg", "image/jpg");
  });
  // Start server
  server.begin();

  // Initialize a NTPClient to get time
  timeClient.begin();
  // Set offset time in seconds to adjust for your timezone, f
  // GMT +1 = 3600
  // GMT +8 = 28800
  // GMT -1 = -3600
  // GMT 0 = 0
  timeClient.setTimeOffset(0);
}

void loop() {
  // Check if there are LoRa packets available
  int packetSize = LoRa.parsePacket();
  if (packetSize) {
    getLoRaData();
    getTimeStamp();
  }
}
```

Testing the Sender & Reciver with ESP32 LoRa Web Server

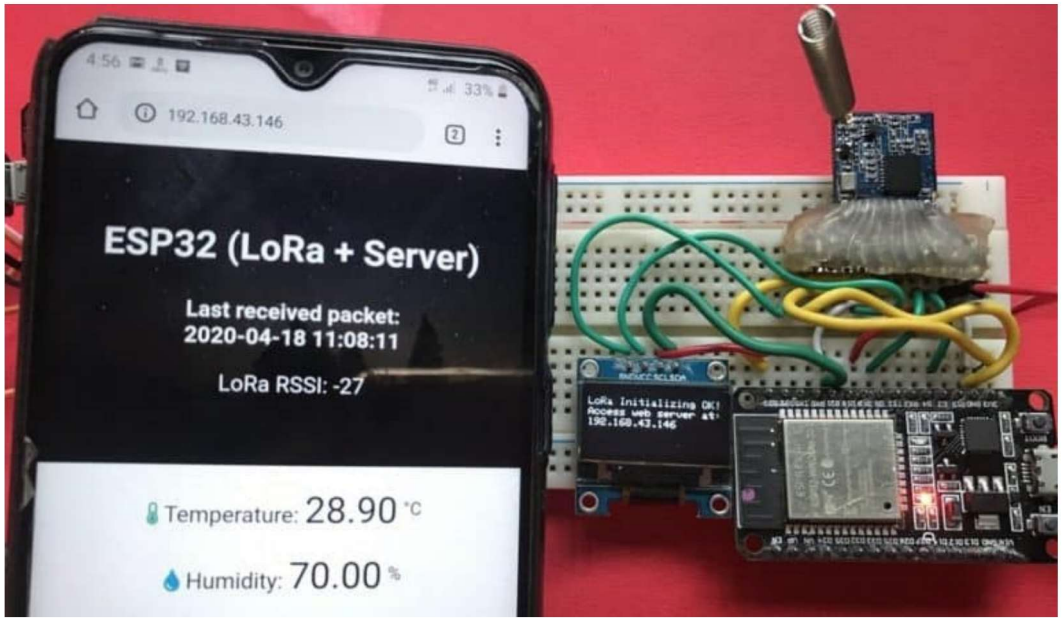
Once the code is uploaded you can open the Serial Monitor and see the following sending and receiving result on Serial Monitor.



You can check the OLED display on the receiver side. You can see the OLED display displaying the IP Address.



Open any web browser either on a mobile phone or on a computer. Visit the same **IP address** shown in the **OLED Display**. You can see the beautiful display of LoRa Received message on **Webserver**. The received **temperature** and **humidity** data is display along with **RSSI value**. The **time** of last received packet is also display on the webpage.



Video Tutorial & Demonstration

ESP32 LoRa Web Server || Monitor LoRa Sensor Data on Webpage

Watch this video on YouTube.

Reference & Credit: Random Nerd Tutorials