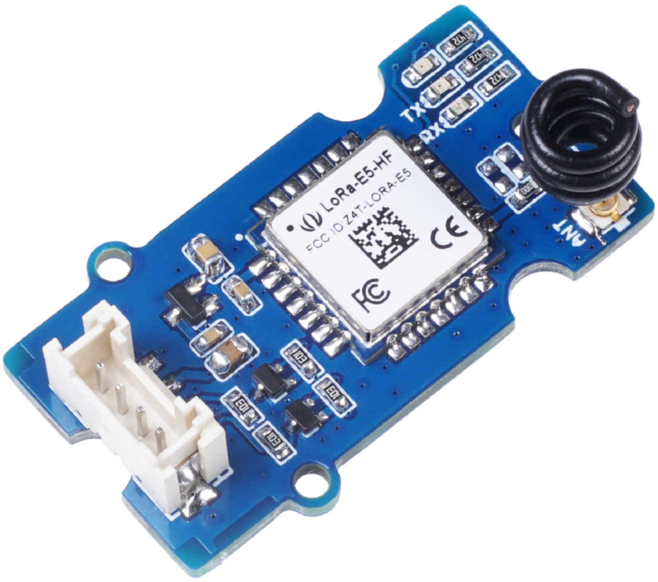
Grove - LoRa-E5



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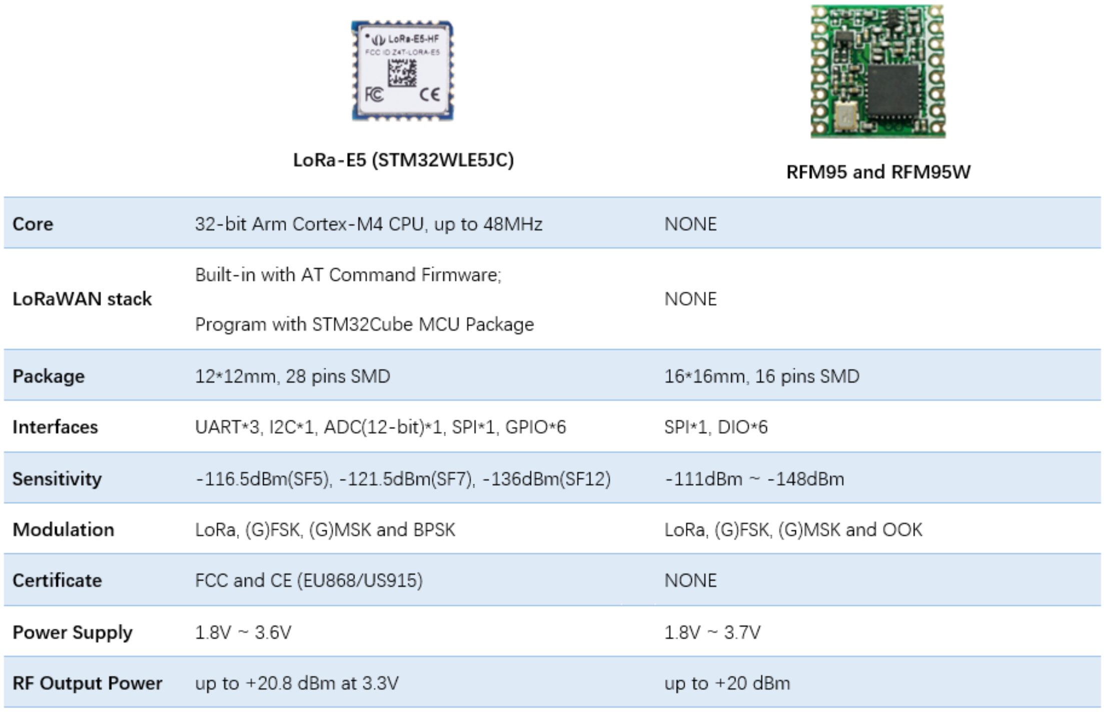
[https://www.seeedstudio.com/Grove-LoRa-E5-STM32WLE5JC-p-4867.html]

Grove LoRa-E5 embedded with LoRa-E5 STM32WLE5JC, powered by ARM Cortex M4 ultra-low-power MCU core and LoRa SX126x, is a wireless radio module supporting LoRa and LoRaWAN protocol on the EU868 & US915 frequency and (G)FSK, BPSK, (G)MSK, LoRa modulations. Grove - LoRa-E5 can endow your development boards' strong features of ultra-long transmitting range by easily plug and play with Grove connector on board.

As an upgrade of our old version - Grove - LoRa Radio [https://www.seeedstudio.com/Grove-LoRa-Radio-868MHz.html] - powered by RFM95 ultra-long-range Transceiver Module [https://www.seeedstudio.com/RFM95-Ultra-long-Range-Transceiver-Module-LoRa-Module-support-868M-frequency-p-2807.html], Grove LoRa-E5 embedded with LoRa-E5 STM32WLE5JC Module [https://www.seeedstudio.com/LoRa-E5-Wireless-Module-p-4745.html] is a high-performance and easy-to-use wireless radio LoRa module supporting LoRaWAN protocol.

LoRa-E5 LoRaWAN STM32WLE5JC module is the major functional part integrated into Grove - LoRa-E5. It is a LoRaWAN module that embedded with ARM Cortex M4 ultra-low-power MCU core and LoRa SX126x, as the world-first combo of LoRa RF and MCU chip into one single tiny module, it supports (G)FSK, BPSK, (G)MSK, and LoRa modulations, and is FCC, CE certified. (Learn more about LoRa-E5 from LoRa-E5 wiki [https://wiki.seeedstudio.com/LoRa-E5_STM32WLE5JC_Module/])

More comparison between the LoRa-E5 and RFM95 chip:



	LoRa-E5 (STM32WLE5JC)	RFM95 and RFM95W
Core	32-bit Arm Cortex-M4 CPU, up to 48MHz	NONE
LoRaWAN stack	Built-in with AT Command Firmware; Program with STM32Cube MCU Package	NONE
Package	12*12mm, 28 pins SMD	16*16mm, 16 pins SMD
Interfaces	UART*3, I2C*1, ADC(12-bit)*1, SPI*1, GPIO*6	SPI*1, DIO*6
Sensitivity	-116.5dBm(SF5), -121.5dBm(SF7), -136dBm(SF12)	-111dBm ~ -148dBm
Modulation	LoRa, (G)FSK, (G)MSK and BPSK	LoRa, (G)FSK, (G)MSK and OOK
Certificate	FCC and CE (EU868/US915)	NONE
Power Supply	1.8V ~ 3.6V	1.8V ~ 3.7V
RF Output Power	up to +20.8 dBm at 3.3V	up to +20 dBm

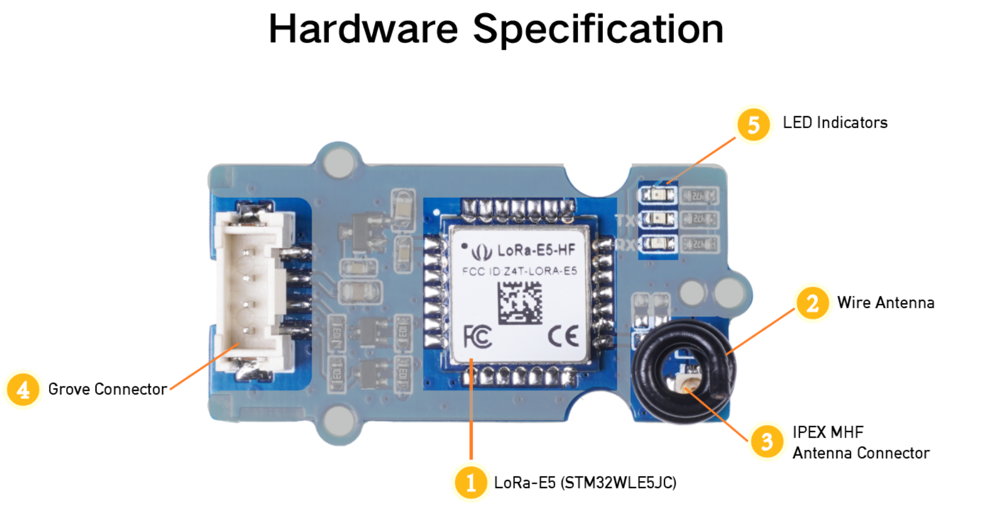
By connecting Grove - LoRa-E5 to your development boards, your devices are able to communicate with and control LoRa-E5 conveniently by AT command through UART connection. Grove LoRa-E5 will be a superior choice for IoT device development, testing, and long-distance, ultra-low power consumption IoT scenarios like smart agriculture, smart office, and smart industry. It is designed with industrial standards with a wide working temperature at -40℃ ~ 85℃, high sensitivity between -116.5 dBm and -136 dBm, and power output between 10 dBm and 22 dBm.

Features

- LoRa-E5 (STM32WLE5JC) embedded
- Support LoRaWAN protocol on EU868/US915 frequency band

- Ultra-long transmitting range up to 10km (Ideal value in open space)
- Easy control by AT command via UART connection
- Rapid prototyping with plug-and-play Grove interfaces
- Ultra-low power consumption and high performance

Harware Overview



1. LoRa-E5 STM32WLE5JC (Datasheet [https://files.seeedstudio.com/products/317990687/res/LoRa-E5%20module%20datasheet_V1.0.pdf])
2. MHF IPEX Connector
3. Wire Antenna
4. Grove Connector
5. LED Indicators

Platform Supported

Arduino	Raspberry Pi	

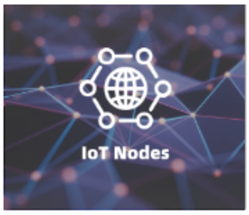
Specification

General Parameters	
Voltage Supply:	3.3V - 5V
Power Output:	Up to +20 dBm at 3.3V
Working Frequency	868/915MHz
Protocol	LoRaWAN
Sensitivity	-116.5dBm ~ -136dBm
Modulation	LoRa, (G)FSK, (G)MSK and BPSK
Current	Only 60uA in sleep mode
Size	20*40mm
Working Temperature	-40℃ ~ 85℃

Part List:
Grove - LoRa-E5 PCBA *1
Grove Universal Cable *1

Application

- Works for LoRaWAN sensor nodes and any wireless communication application
- IoT device testing and development



Application Notes

1. Factroy AT Firmare

LoRa-E5 series has a built-in AT command firmware, which supports LoRaWAN Class A/B/C protocol and a wide frequency plan: EU868/US915/AU915/AS923/KR920/IN865. With this AT command firmware, developers can easily and quickly build their prototype or application.

The AT command firmware contains a bootloader for DFU and the AT application. The "PB13/SPI_SCK/BOOT" pin is used to control LoRa-E5 to stay in the bootloader or jump to the AT application.

When PB13 is HIGH, the module will jump to AT application after reset, with a default baud rate of 9600. When PB13 is LOW (press the "Boot" button on LoRa-E5 Dev Board or LoRa-E5 mini), the module will stay in the bootloader, and keep transmitting "C" character every 1S at baud rate 115200.

> ⚠ **Attention**
>
> - Factory AT Firmware is programmed with RDP(Read Protection) Level 1, developers need to remove RDP first with STM32Cube Programmer. Note that regression RDP to level 0 will cause a flash memory mass to erase and the Factory AT Firmware can't be restored again.
> - The "PB13/SPI_SCK/BOOT" pin on the LoRa-E5 module is just a normal GPIO, not the "BOOT0" pin of the MCU. This "PB13/SPI_SCK/BOOT" pin is used in the bootloader of the Factory AT firmware, to decide to jump to APP or stay in bootloader(for DFU). The real "BOOT0" pin doesn't pinout to the module, so users need to be careful when developing the low-power applications.

2. Clock Configuration

2.1 HSE

- 32MHz TCXO
- TCXO power supply: PB0-VDD_TCXO

2.2 LSE

- 32.768KHz crystal oscillator

3. RF Switch

LoRa-E5 module ONLY transmits through RFO_HP:

- Receive: PA4=1, PA5=0

- Transmit(high output power, SMPS mode): PA4=0, PA5=1

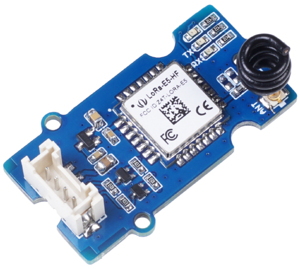
Getting Started

Preparations

Here is a demo showing you how to connect TTN (The Things Network) and Seeeduino XIAO module via Grove - LoRa-E5 module. These modules are able to collect temperature and humidity parameters from the environment and send them back to TTN. The flashing LED lights on the Seeeduino Xiao indicate the status of the temperature and humidity sensor as connecting to TTN cloud.

⚠ **Attention**
Please ensure the consistent of the frequency band among the end nodes, gateway, and TTN configuration you are using by following this instruction. The frequency plan this demo applied is for **EU868**.

Hardware Required

Seeeduino XIAO	Grove - LoRa-E5
	
Get ONE Now [https://www.seeedstudio.com/Seeeduino-XIAO-Arduino-Microcontroller-SAMD21-Cortex-M0+-p-4426.html]	Get ONE Now [https://www.seeedstudio.com/Grov Doppler-Radar-BGT24LTR11-p-4572.html]

Notes
If this is your first time using Seeeduino XIAO, please refer to Seeeduino XIAO's wiki [https://wiki.seeedstudio.com/Seeeduino_Lotus/]. If this is your first time to use Arduino, Arduino’s website [https://www.arduino.cc/] is a great resource for you to start your Arduino journey.

Hardware Connection

- **Step 1.** Connect the LoRa-E5 module directly to the "UART" slot.
- **Step 2.** Put DH11 into the "A0/D0" socket.
- **Step 3.** Download the code, please refer to the software part.

Software Preparation

Notes

If this is the first time you work with Arduino, we strongly recommend you to see Getting Started with Arduino [https://wiki.seeedstudio.com/Getting_Started_with_Arduino/] before the start. Click to learn about detail about how to install an Arduino Library [https://wiki.seeedstudio.com/How_to_install_Arduino_Library/]

Download Library

- **Step 1.** Install the u8g2 library [https://github.com/olikraus/U8g2_Arduino]
- **Step 2.** Install the DHT sensor library [https://github.com/Seeed-Studio/Grove_Temperature_And_Humidity_Sensor]

Software Code

Download the example; copy the code stick onto the Aruino IDE and then upload it.

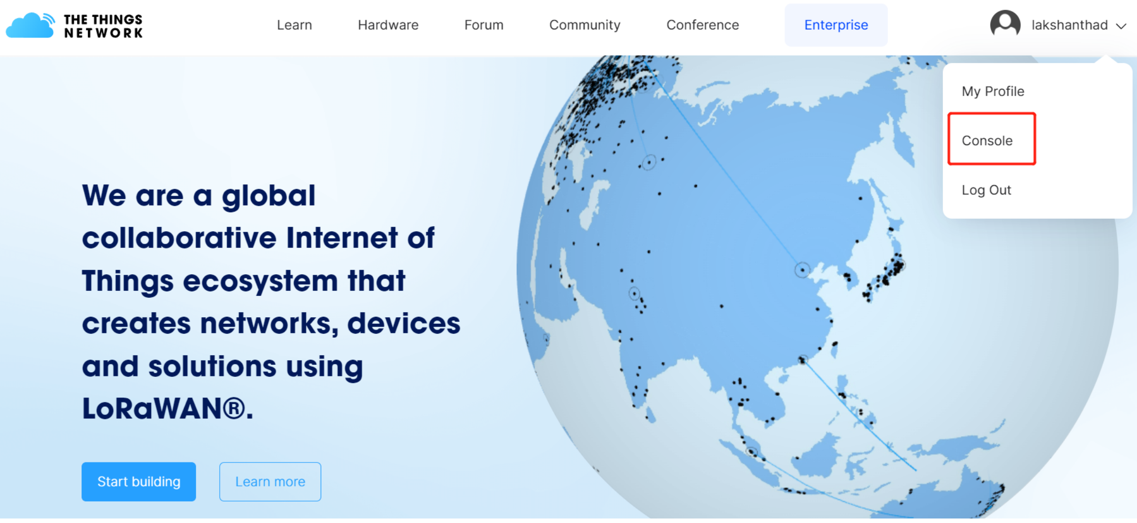
```
#include <Arduino.h>
#include <U8x8lib.h>
#include "DHT.h"

#define DHTPIN 0 // what pin we're connected to

// Uncomment whatever type you're using!
#define DHTTYPE DHT11 // DHT 11
// #define DHTTYPE DHT22   // DHT 22  (AM2302)
//#define DHTTYPE DHT21   // DHT 21 (AM2301)

DHT dht(DHTPIN, DHTTYPE);

```

```
U8X8_SSD1306_128X64_NONAME_HW_I2C u8x8(/* reset=*/U8X8_
// U8X8_SSD1306_128X64_NONAME_SW_I2C u8x8(/* clock=*/ S

static char recv_buf[512];
static bool is_exist = false;
static bool is_join = false;
static int led = 0;

static int at_send_check_response(char *p_ack, int time
{
    int ch;
    int num = 0;
    int index = 0;
    int startMillis = 0;
    va_list args;
    memset(recv_buf, 0, sizeof(recv_buf));
    va_start(args, p_cmd);
    Serial1.printf(p_cmd, args);
    Serial.printf(p_cmd, args);
    va_end(args);
    delay(200);
    startMillis = millis();

    if (p_ack == NULL)
    {
        return 0;
    }

    do
    {
        while (Serial1.available() > 0)
        {
            ch = Serial1.read();
            recv_buf[index++] = ch;
            Serial.print((char)ch);
            delay(2);
        }

        if (strstr(recv_buf, p_ack) != NULL)
        {
            return 1;
        }

    } while (millis() - startMillis < timeout_ms);
    return 0;
}

static void recv_prase(char *p_msg)
{
    if (p_msg == NULL)
    {
        return;
    }
    char *p_start = NULL;
    int data = 0;
    int rssi = 0;
    int snr = 0;

    p_start = strstr(p_msg, "RX");
    if (p_start && (1 == sscanf(p_start, "RX: \"%d\"\r\
    {
        Serial.println(data);
        u8x8.setCursor(2, 4);
        u8x8.print("led :");
        led = !!data;
        u8x8.print(led);
        if (led)
        {
            digitalWrite(LED_BUILTIN, LOW);
        }
        else
        {
            digitalWrite(LED_BUILTIN, HIGH);
        }
    }

    p_start = strstr(p_msg, "RSSI");
    if (p_start && (1 == sscanf(p_start, "RSSI %d,", &r
    {
        u8x8.setCursor(0, 6);
        u8x8.print("                ");
        u8x8.setCursor(2, 6);
        u8x8.print("rssi:");
        u8x8.print(rssi);
    }
    p_start = strstr(p_msg, "SNR");
    if (p_start && (1 == sscanf(p_start, "SNR %d", &snr
    {
        u8x8.setCursor(0, 7);
        u8x8.print("                ");
        u8x8.setCursor(2, 7);
        u8x8.print("snr :");
        u8x8.print(snr);
    }
}

void setup(void)
{
    u8x8.begin();
    u8x8.setFlipMode(1);
    u8x8.setFont(u8x8_font_chroma48medium8_r);

    Serial.begin(115200);
    pinMode(LED_BUILTIN, OUTPUT);
    digitalWrite(LED_BUILTIN, HIGH);

    Serial1.begin(9600);
    Serial.print("E5 LORAWAN TEST\r\n");
    u8x8.setCursor(0, 0);

    if (at_send_check_response("+AT: OK", 100, "AT\r\n"
    {
        is_exist = true;
        at_send_check_response("+ID: AppEui", 1000, "AT
        at_send_check_response("+MODE: LWOTAA", 1000, "
        at_send_check_response("+DR: EU868", 1000, "AT+
        at_send_check_response("+CH: NUM", 1000, "AT+CH
        at_send_check_response("+KEY: APPKEY", 1000, "A
        at_send_check_response("+CLASS: C", 1000, "AT+C
        at_send_check_response("+PORT: 8", 1000, "AT+PO
        delay(200);
        u8x8.setCursor(5, 0);
        u8x8.print("LoRaWAN");
        is_join = true;
    }
    else
    {
        is_exist = false;
        Serial.print("No E5 module found.\r\n");
        u8x8.setCursor(0, 1);
        u8x8.print("unfound E5 !");
    }

    dht.begin();

    u8x8.setCursor(0, 2);
    u8x8.setCursor(2, 2);
    u8x8.print("temp:");

    u8x8.setCursor(2, 3);
    u8x8.print("humi:");

    u8x8.setCursor(2, 4);
    u8x8.print("led :");
    u8x8.print(led);
}

void loop(void)
{
    float temp = 0;
    float humi = 0;

    temp = dht.readTemperature();
    humi = dht.readHumidity();

    Serial.print("Humidity: ");
    Serial.print(humi);
    Serial.print(" %\t");
    Serial.print("Temperature: ");
    Serial.print(temp);
    Serial.println(" *C");

    u8x8.setCursor(0, 2);
    u8x8.print("      ");
    u8x8.setCursor(2, 2);
    u8x8.print("temp:");
    u8x8.print(temp);
    u8x8.setCursor(2, 3);
    u8x8.print("humi:");
    u8x8.print(humi);

    if (is_exist)
    {
        int ret = 0;
        if (is_join)
        {

            ret = at_send_check_response("+JOIN: Networ
            if (ret)
            {
                is_join = false;
            }
            else
            {
                at_send_check_response("+ID: AppEui", 1
                Serial.print("JOIN failed!\r\n\r\n");
                delay(5000);
            }
        }
        else
        {
            char cmd[128];
            sprintf(cmd, "AT+CMSGHEX=\"%04X%04X\"\r\n",
            ret = at_send_check_response("Done", 5000,
            if (ret)
            {
                recv_prase(recv_buf);
            }
            else
            {
                Serial.print("Send failed!\r\n\r\n");
            }
            delay(5000);
        }
    }
```

```
        else
        {
            delay(1000);
        }
    }
```

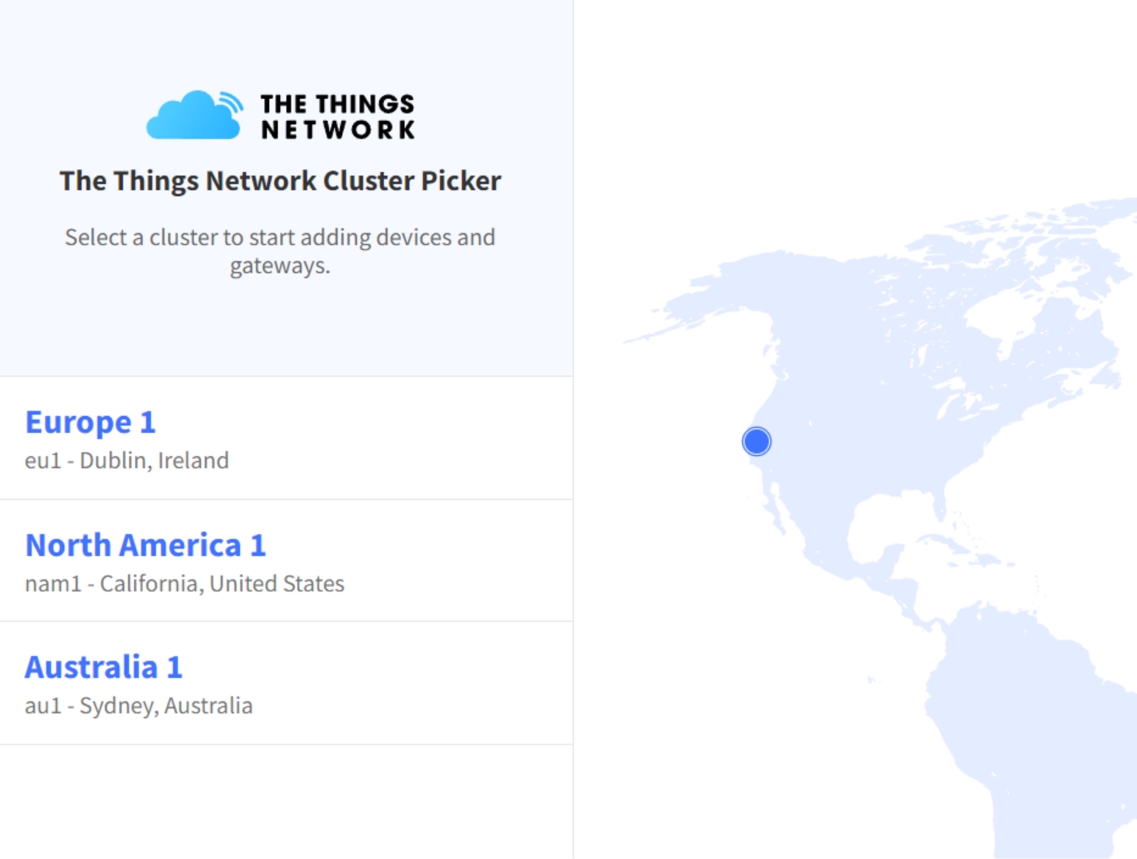
TTN Console Configuration Setup

- **Step 1.** Visit The Things Network [https://www.thethingsnetwork.org] website and sign up for a new account
- **Step 2.** After logging in, click your profile and select **Console**



We are a global collaborative Internet of Things ecosystem that creates networks, devices and solutions using LoRaWAN®.

- **Step 3.** Select a cluster to start adding devices and gateways



The Things Network Cluster Picker

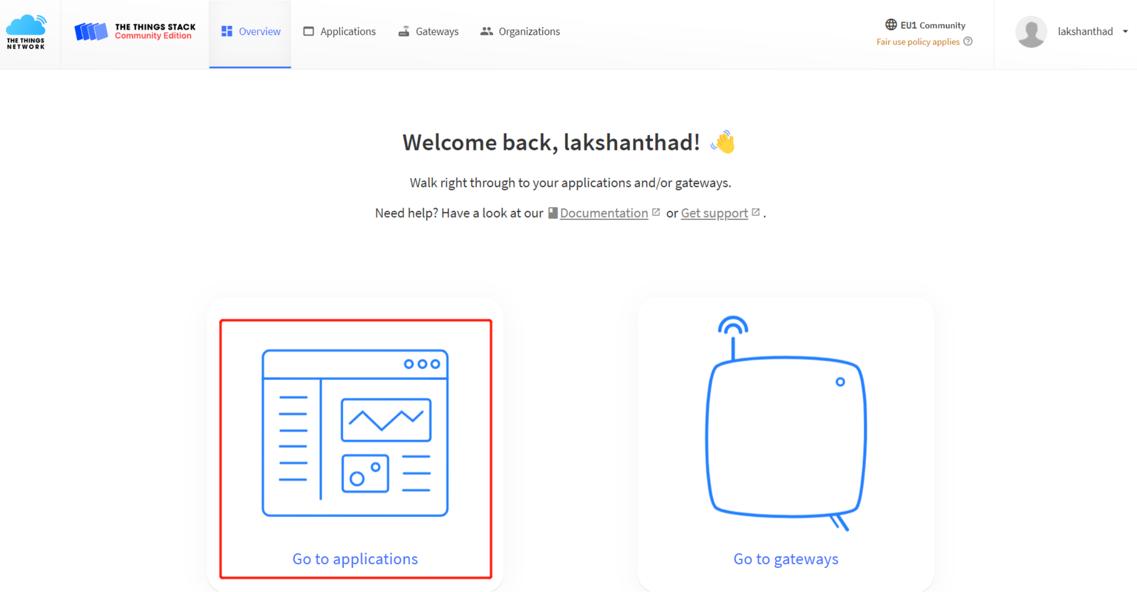
Select a cluster to start adding devices and gateways.

Europe 1
eu1 - Dublin, Ireland

North America 1
nam1 - California, United States

Australia 1
au1 - Sydney, Australia

- **Step 4.** Click **Go to applications**

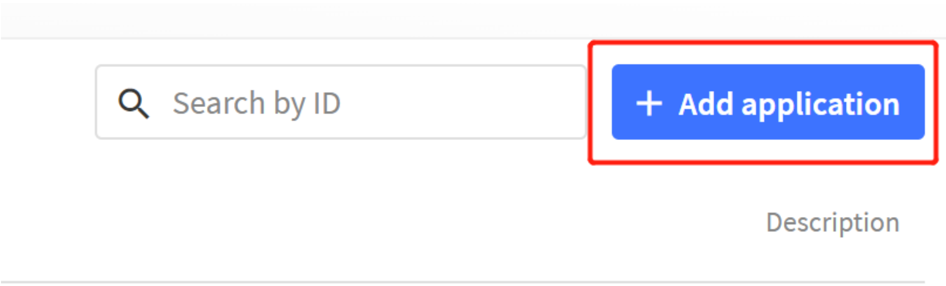


Welcome back, lakshanthad! 👋

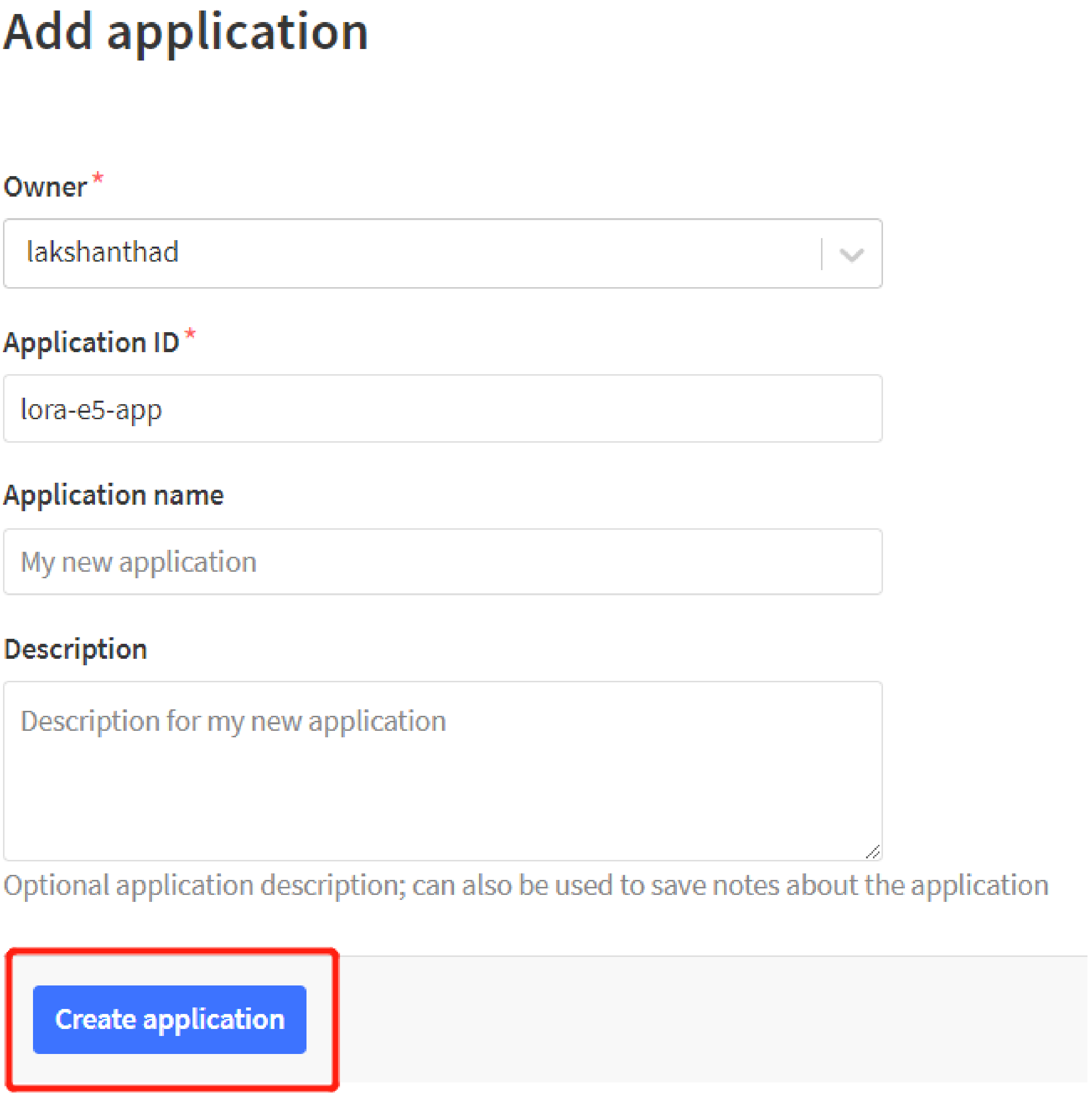
Walk right through to your applications and/or gateways.

Need help? Have a look at our Documentation or Get support .

- **Step 5.** Click **+ Add application**



- **Step 6.** Fill **Application ID** and click **Create application**


Add application

Owner*
lakshanthad

Application ID*
lora-e5-app

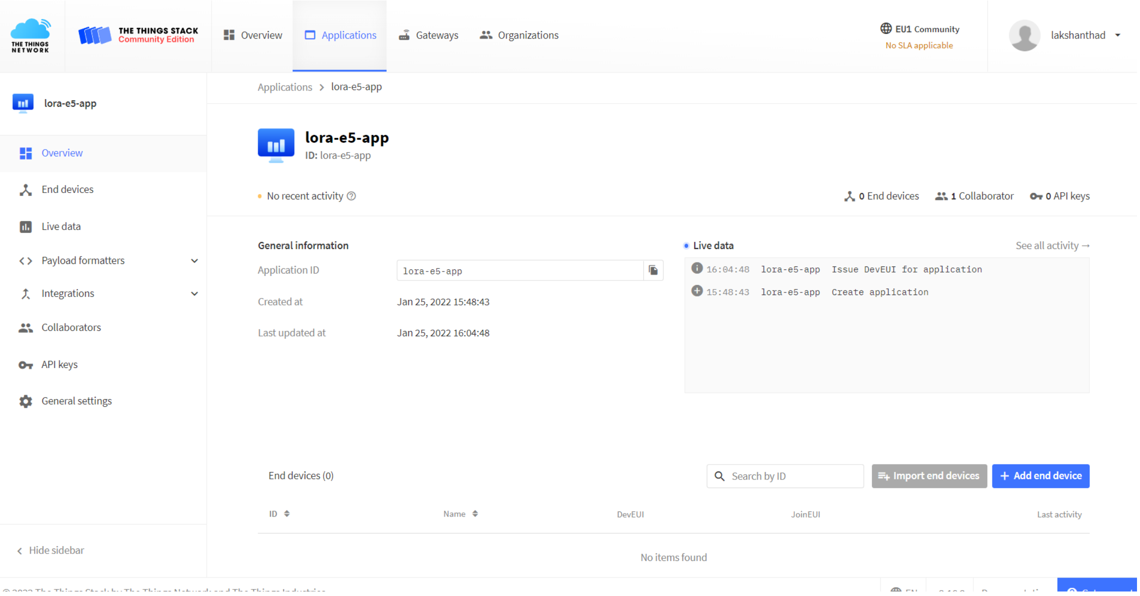
Application name
My new application

Description
Description for my new application

Optional application description; can also be used to save notes about the application

Note: Here **Application name** and **Description** are not compulsory fields. If **Application name** is left blank, it will use the same name as **Application ID** by default

The following is the newly created application



lora-e5-app
ID: lora-e5-app

No recent activity

0 End devices 1 Collaborator 0 API keys

General information

Application ID lora-e5-app

Created at Jan 25, 2022 15:48:43

Last updated at Jan 25, 2022 16:04:48

Live data

See all activity →

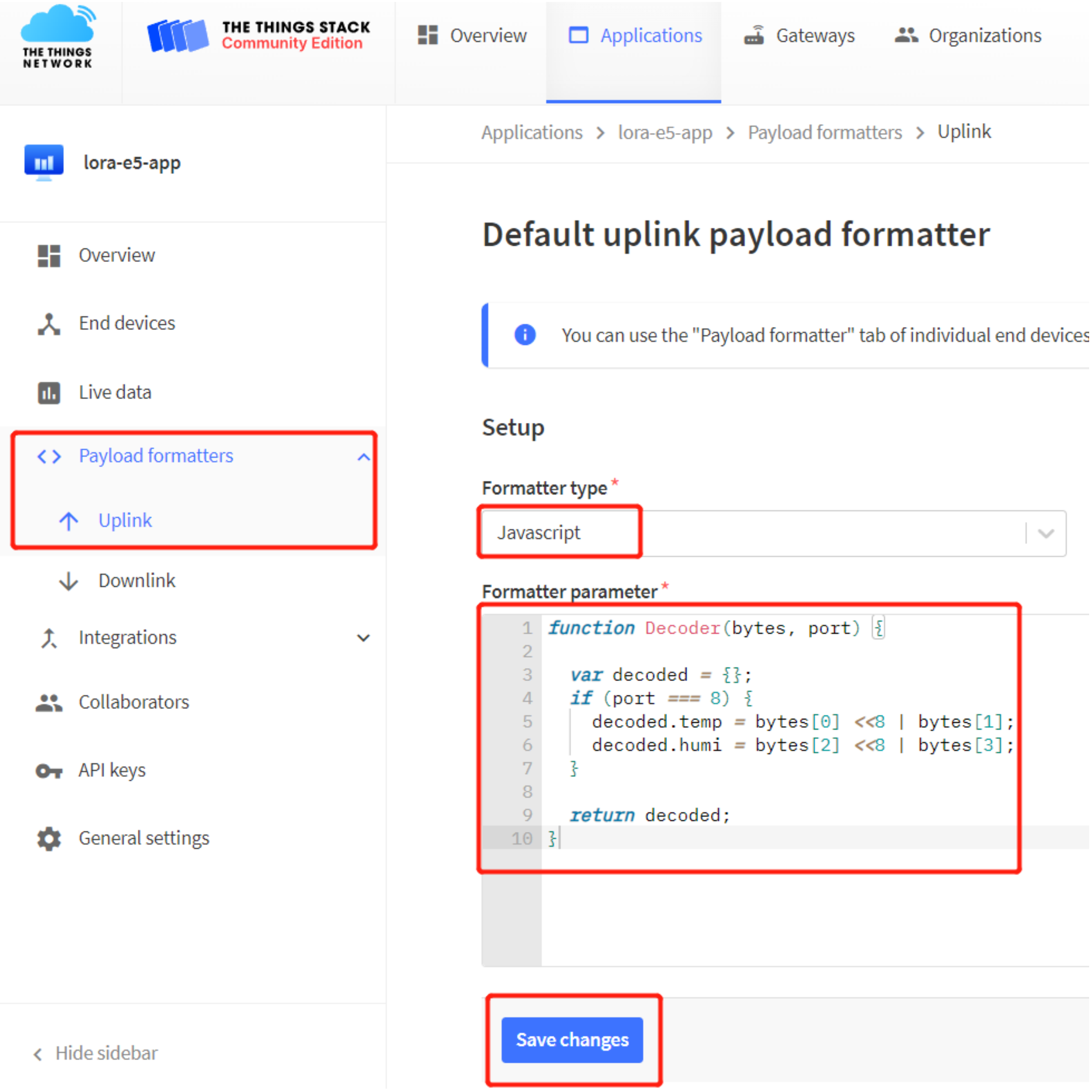
```
16:04:48  lora-e5-app  Issue DevEUI for application
15:48:43  lora-e5-app  Create application
```

End devices (0)

ID	Name	DevEUI	JoinEUI	Last activity

No items found

- **Step 7**: Navigate to `Payload formatters > Uplink` , select **Formatter Type** as **Javascript** and fill the **Formatter parameter** as follows



Default uplink payload formatter

You can use the "Payload formatter" tab of individual end devices

Setup

Formatter type *

Javascript

Formatter parameter *

```
function Decoder(bytes, port) {

  var decoded = {};
  if (port === 8) {
    decoded.temp = bytes[0] <<8 | bytes[1];
    decoded.humi = bytes[2] <<8 | bytes[3];
  }

  return decoded;
}
```

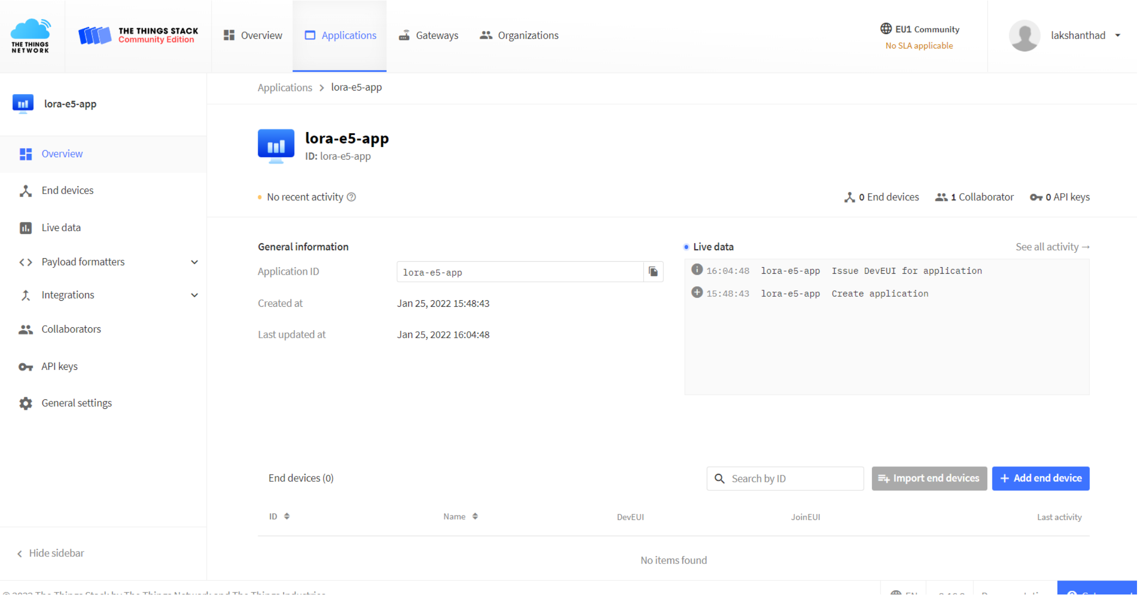
```
function Decoder(bytes, port) {

  var decoded = {};
  if (port === 8) {
    decoded.temp = bytes[0] <<8 | bytes[1];
    decoded.humi = bytes[2] <<8 | bytes[3];
  }

  return decoded;
}
```

- **Step 8**: Upload the Arduino code to Seeeduino XIAO as explained before, and open serial monitor to see the following output

```
Humidity: 50%       Temperature: 25.00 *C
AT+JOIN
+JOIN: Start
+JOIN: NORMAL
+JOIN: Join failed
+JOIN: Done
AT+ID
+ID: DevAddr, 24:40:00:7C
+ID: DevEui, 2C:F7:F1:20:24:90:03:63
+ID: AppEui, 80:00:00:00:00:00:00:07
+JOIN: Join failed
```

Note down **DevEui** and **AppEUi** generated above

- **Step 9**: Go back to the **Overview** page of the created application and click **+ Add end device**



lora-e5-app
ID: lora-e5-app

No recent activity

0 End devices 1 Collaborator 0 API keys

General information

Application ID: lora-e5-app
Created at: Jan 25, 2022 15:48:43
Last updated at: Jan 25, 2022 16:04:48

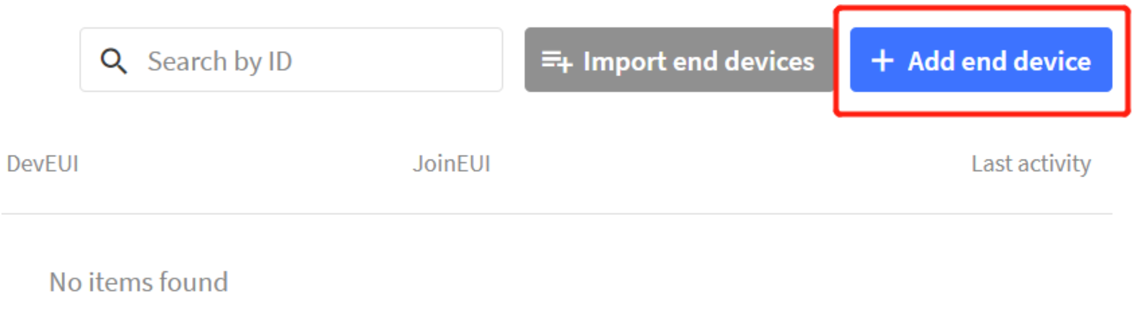
Live data

See all activity →

```
16:04:48  lora-e5-app  Issue DevEUI for application
15:48:43  lora-e5-app  Create application
```

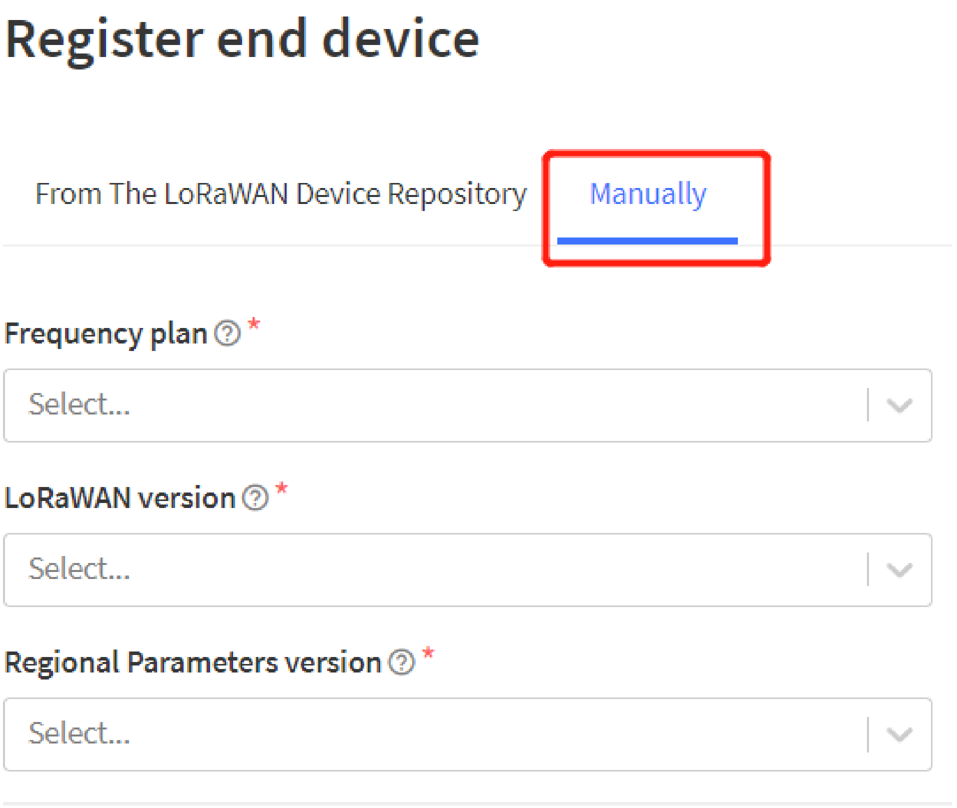
End devices (0)

No items found



No items found

- **Step 10.** Click **Manually**, to enter the registration credentials manually



Register end device

Frequency plan ? *

Select...

LoRaWAN version ? *

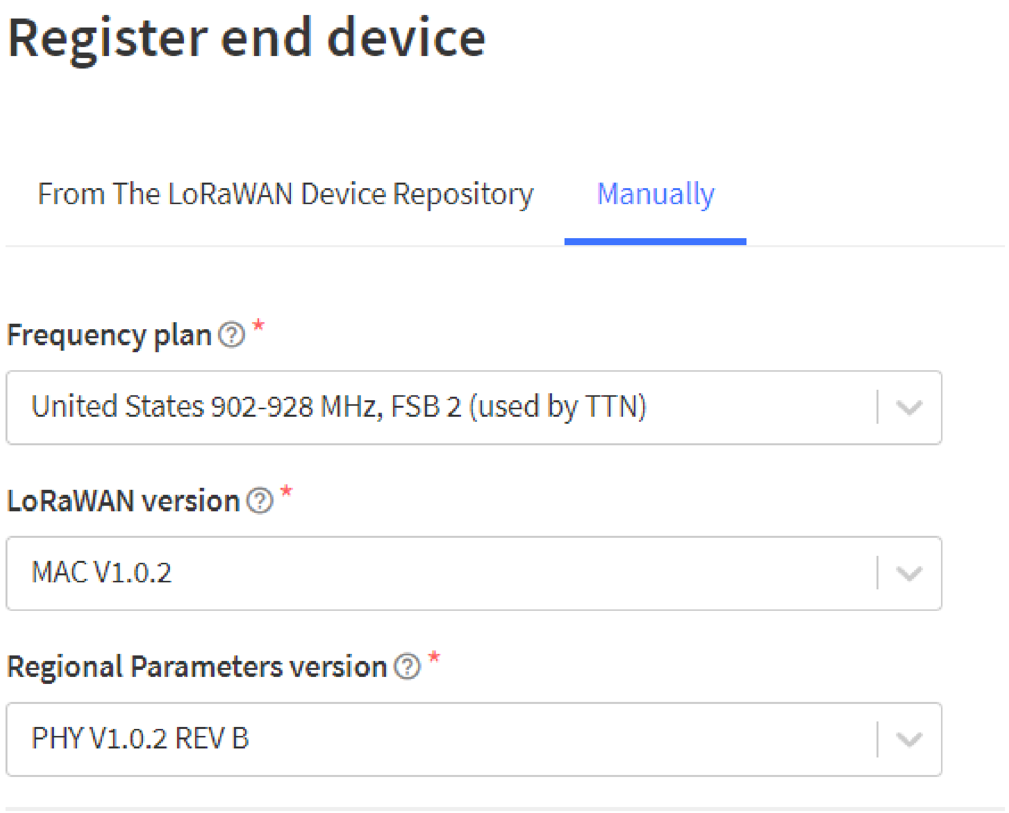
Select...

Regional Parameters version ? *

Select...

- **Step 11.** Select the **Frequency plan** according to your region. Also make sure you use the same frequency as the gateway in which you will connect this device to. Select **MAC V1.0.2** as the **LoRaWAN version** and **PHY V1.0.2 REV B** as the **Regional**

Parameters version. These settings are according to the LoraWAN stack of LoRa-E5.



Register end device

Frequency plan *

United States 902-928 MHz, FSB 2 (used by TTN)

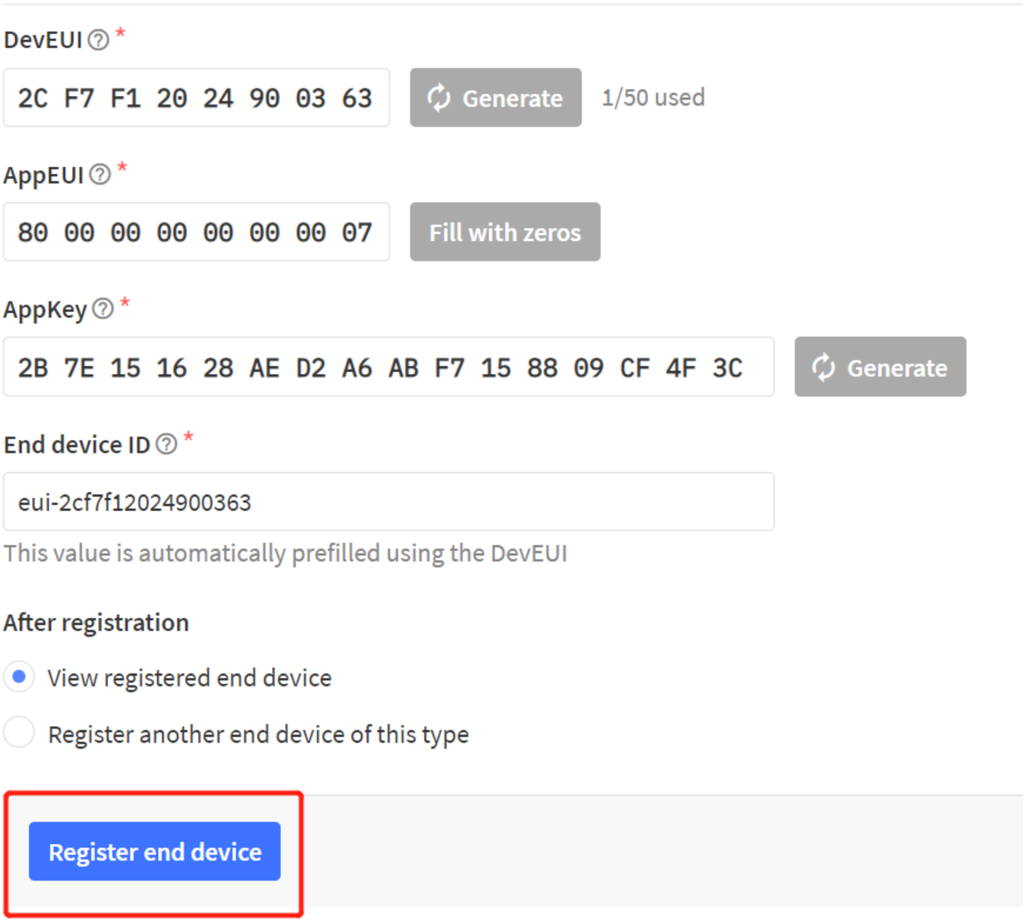
LoRaWAN version *

MAC V1.0.2

Regional Parameters version *

PHY V1.0.2 REV B

- **Step 12.** Copy and paste the previously obtained information from **step 8** into **DevEUI** and **AppEUI** fields. **End device ID** field will be automatically filled when we fill **DevEUI**. For **AppKey** field, use: 2B7E151628AED2A6ABF7158809CF4F3C.



DevEUI ⓘ *
2C F7 F1 20 24 90 03 63

1/50 used

AppEUI ⓘ *
80 00 00 00 00 00 00 07

AppKey ⓘ *
2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C

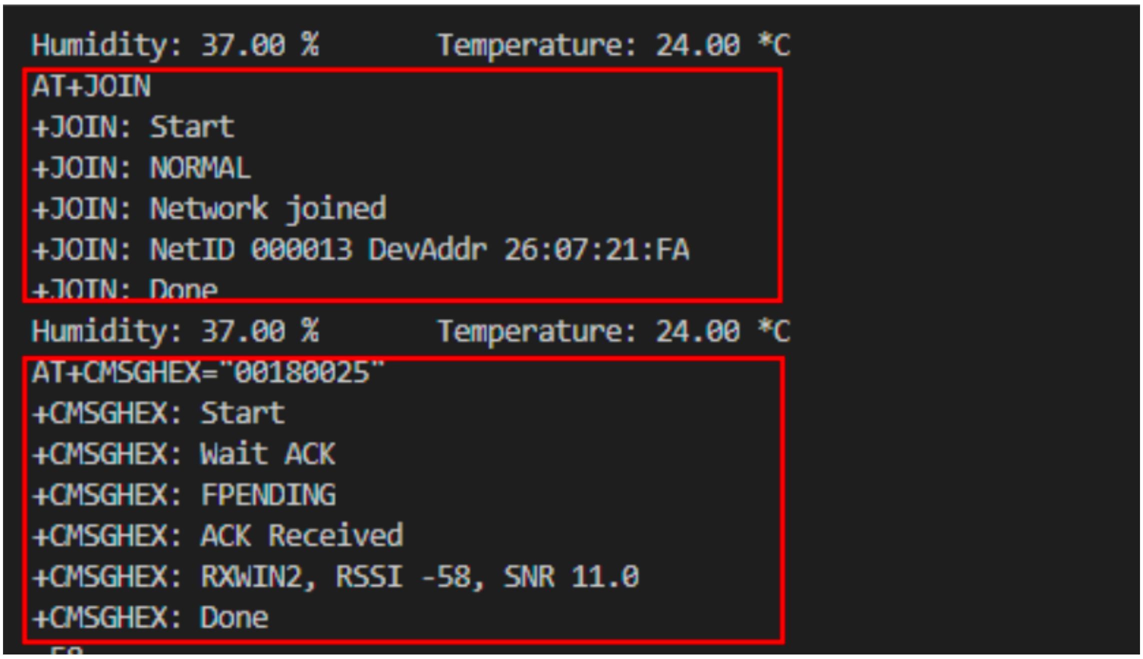
End device ID ⓘ *
eui-2cf7f12024900363
This value is automatically prefilled using the DevEUI

After registration
● View registered end device
○ Register another end device of this type

Finally click **Register end device**

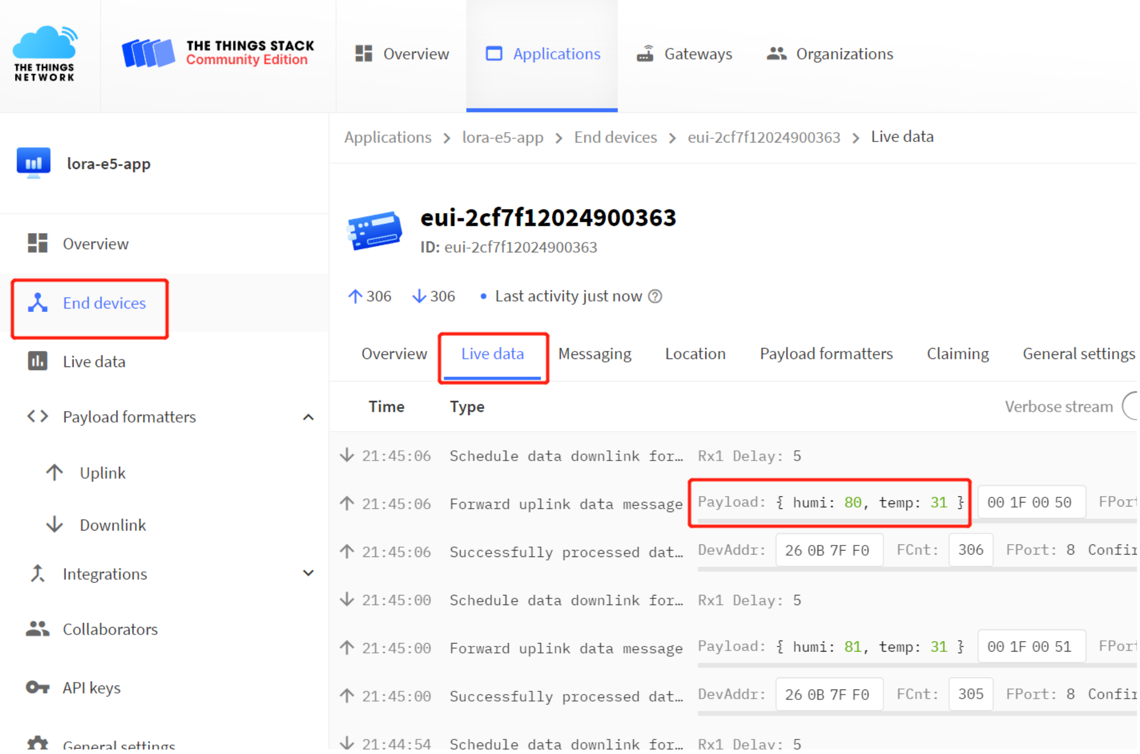
- **Step 13.** Register your LoRaWAN Gateway with TTN Console. Please refer to the instructions shown here [https://wiki.seeedstudio.com/The-Things-Indoor-Gateway/#step-2-gateway-registration-on-ttn-console]

If you see the following output on serial monitor after everything is setup, that means the Seeeduino XIAO is successfully connected with TTN and sending the temperature and humidity sensor data!



```
Humidity: 37.00 %       Temperature: 24.00 *C
AT+JOIN
+JOIN: Start
+JOIN: NORMAL
+JOIN: Network joined
+JOIN: NetID 000013 DevAddr 26:07:21:FA
+JOIN: Done
Humidity: 37.00 %       Temperature: 24.00 *C
AT+CMSGHEX="00180025"
+CMSGHEX: Start
+CMSGHEX: Wait ACK
+CMSGHEX: FPENDING
+CMSGHEX: ACK Received
+CMSGHEX: RXWIN2, RSSI -58, SNR 11.0
+CMSGHEX: Done
```

- **Step 14.** Go back to the application page and navigate to **End devices**, select the created device and click **Live data**



Applications > lora-e5-app > End devices > eui-2cf7f12024900363 > Live data

eui-2cf7f12024900363

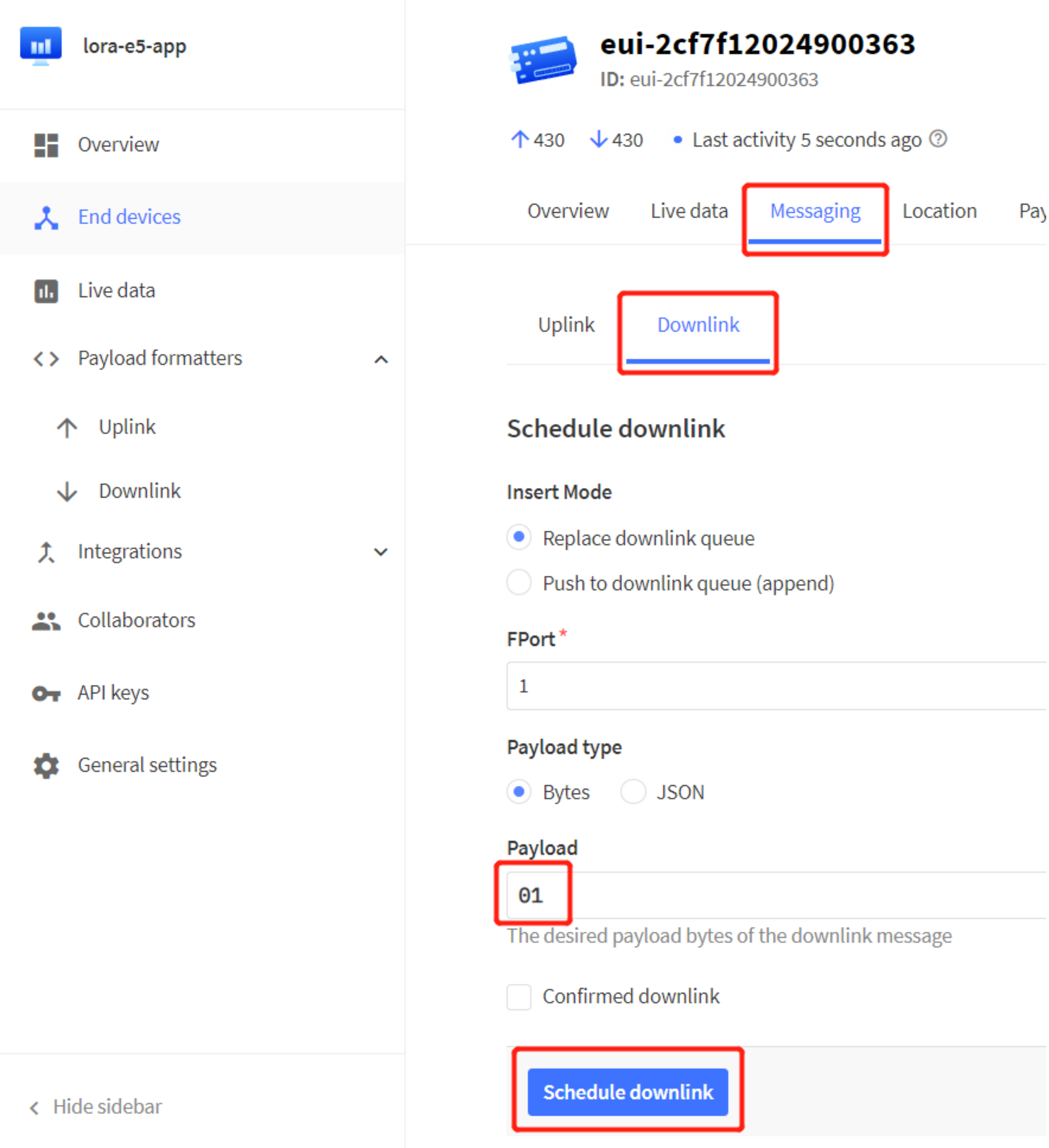
ID: eui-2cf7f12024900363

↑306 ↓306 • Last activity just now

```
Time      Type
↓ 21:45:06 Schedule data downlink for… Rx1 Delay: 5
↑ 21:45:06 Forward uplink data message Payload: { humi: 80, temp: 31 }  00 1F 00 50  FPor
↑ 21:45:06 Successfully processed dat… DevAddr: 26 0B 7F F0  FCnt: 306  FPort: 8  Confi
↓ 21:45:00 Schedule data downlink for… Rx1 Delay: 5
↑ 21:45:00 Forward uplink data message Payload: { humi: 81, temp: 31 }  00 1F 00 51  FPor
↑ 21:45:00 Successfully processed dat… DevAddr: 26 0B 7F F0  FCnt: 305  FPort: 8  Confi
↓ 21:44:54 Schedule data downlink for… Rx1 Delay: 5
```

Here you will see the temperature and humidity sensor data displayed in real-time!

- **Step 15.** Navigate to `Messaging > Downlink`, type **01** under **Payload** and click **Schedule downlink** to **turn on** the **built-in yellow LED** on the Seeeduino XIAO.



Schedule downlink

Insert Mode
● Replace downlink queue
○ Push to downlink queue (append)

FPort*
1

Payload type
● Bytes ○ JSON

Payload
01
The desired payload bytes of the downlink message

□ Confirmed downlink

- **Step 16.** Send the **Payload** as **00** to **turn off** the **built-in yellow LED**

Grove - LoRa-E5 P2P Example

This is the example of how to build a Point-to-Point Transmission Application with Grove - LoRa-E5 and Seeeduino XIAO.

Preparations

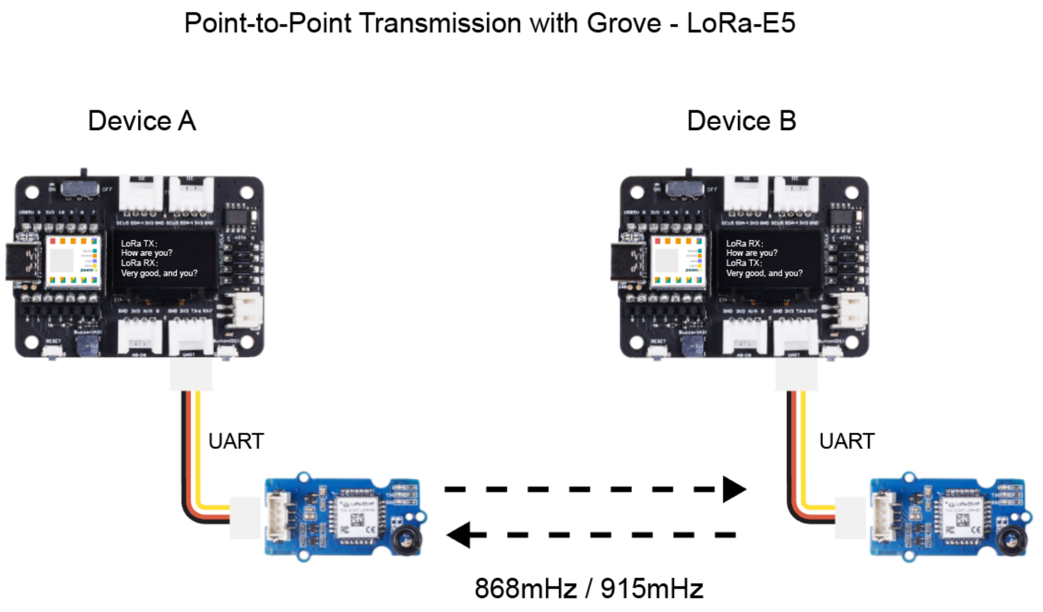
- Grove - Lora E5 * 2
- Seeeduino XIAO * 2
- Seeeduino XIAO Expansion board * 2
- USB typc cable * 2

If this is your first time using Seeeduino XIAO, please refer to Seeeduino XIAO's wiki [https://wiki.seeedstudio.com/Seeeduino-XIAO/].

If this is your first time using Arduino, Please put hand on here [https://wiki.seeedstudio.com/Getting_Started_with_Arduino/] to start your Arduino journey.

Connecting hardware

We can connect the LoRa-E5 module to the UART socket directly as the below picture shows.



Download Library

The u8g2 [https://github.com/olikraus/u8g2] library must be installed for this demo. Click to download the library and install it (How to install an Arduino Library [https://wiki.seeedstudio.com/How_to_install_Arduino_Library/]).

Download the example

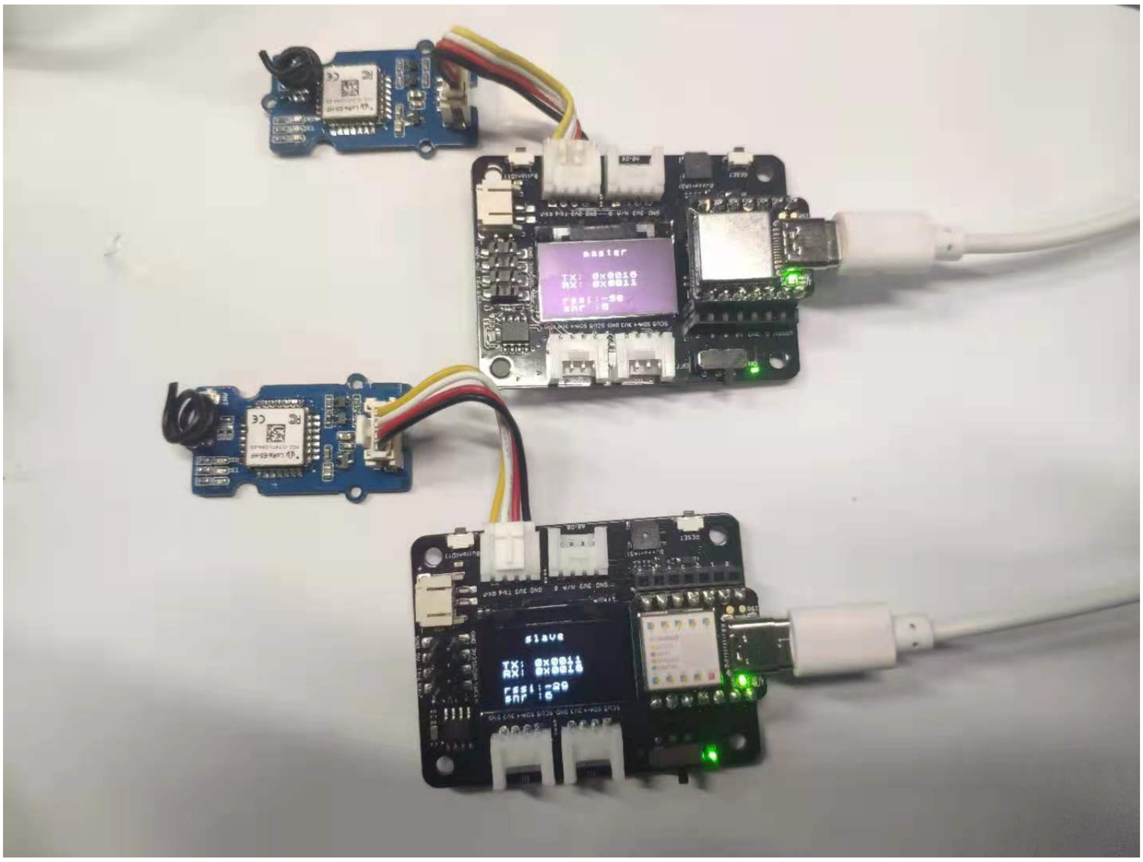
Copy the code stick on the Aruino IDE then upload it. One of them is used as a master, and the NODE_SLAVE macro definition in the code needs to be commented out, and the other is used as a slave, and the NODE_SLAVE macro definition in the code needs to be turned on.

```
#include <Arduino.h>
#include <U8x8lib.h>

```

```
// #define NODE_SLAVE

U8X8_SSD1306_128X64_NONAME_HW_I2C u8x8(/* reset=*/U8X8_
// U8X8_SSD1306_128X64_NONAME_SW_I2C u8x8(/* clock=*/ S

static char recv_buf[512];
static bool is_exist = false;

static int at_send_check_response(char *p_ack, int time
{
    int ch = 0;
    int index = 0;
    int startMillis = 0;
    va_list args;
    memset(recv_buf, 0, sizeof(recv_buf));
    va_start(args, p_cmd);
    Serial1.printf(p_cmd, args);
    Serial.printf(p_cmd, args);
    va_end(args);
    delay(200);
    startMillis = millis();

    if (p_ack == NULL)
    {
        return 0;
    }

    do
    {
        while (Serial1.available() > 0)
        {
            ch = Serial1.read();
            recv_buf[index++] = ch;
            Serial.print((char)ch);
            delay(2);
        }

        if (strstr(recv_buf, p_ack) != NULL)
        {
            return 1;
        }

    } while (millis() - startMillis < timeout_ms);
    return 0;
}

static int recv_prase(void)
{
    char ch;
    int index = 0;
    memset(recv_buf, 0, sizeof(recv_buf));
    while (Serial1.available() > 0)
    {
        ch = Serial1.read();
        recv_buf[index++] = ch;
        Serial.print((char)ch);
        delay(2);
    }

    if (index)
    {
        char *p_start = NULL;
        char data[32] = {
            0,
        };
        int rssi = 0;
        int snr = 0;

        p_start = strstr(recv_buf, "+TEST: RX \"5345454
        if (p_start)
        {
            p_start = strstr(recv_buf, "5345454544");
            if (p_start && (1 == sscanf(p_start, "53454
            {
                data[4] = 0;
                u8x8.setCursor(0, 4);
                u8x8.print("               ");
                u8x8.setCursor(2, 4);
                u8x8.print("RX: 0x");
                u8x8.print(data);
                Serial.print(data);
                Serial.print("\r\n");
            }

            p_start = strstr(recv_buf, "RSSI:");
            if (p_start && (1 == sscanf(p_start, "RSSI:
            {
                u8x8.setCursor(0, 6);
                u8x8.print("                ");
                u8x8.setCursor(2, 6);
                u8x8.print("rssi:");
                u8x8.print(rssi);
            }
            p_start = strstr(recv_buf, "SNR:");
            if (p_start && (1 == sscanf(p_start, "SNR:%
            {
                u8x8.setCursor(0, 7);
                u8x8.print("                ");
                u8x8.setCursor(2, 7);
                u8x8.print("snr :");
                u8x8.print(snr);
            }
            return 1;
        }
    }
    return 0;
}

static int node_recv(uint32_t timeout_ms)
{
    at_send_check_response("+TEST: RXLRPKT", 1000, "AT+
    int startMillis = millis();
    do
    {
        if (recv_prase())
        {
            return 1;
        }
    } while (millis() - startMillis < timeout_ms);
    return 0;
}

static int node_send(void)
```

```
{
    static uint16_t count = 0;
    int ret = 0;
    char data[32];
    char cmd[128];

    memset(data, 0, sizeof(data));
    sprintf(data, "%04X", count);
    sprintf(cmd, "AT+TEST=TXLRPKT,\"5345454544%s\"\r\n"

    u8x8.setCursor(0, 3);
    u8x8.print("                ");
    u8x8.setCursor(2, 3);
    u8x8.print("TX: 0x");
    u8x8.print(data);

    ret = at_send_check_response("TX DONE", 2000, cmd);
    if (ret == 1)
    {

        count++;
        Serial.print("Sent successfully!\r\n");
    }
    else
    {
        Serial.print("Send failed!\r\n");
    }
    return ret;
}

static void node_recv_then_send(uint32_t timeout)
{
    int ret = 0;
    ret = node_recv(timeout);
    delay(100);
    if (!ret)
    {
        Serial.print("\r\n");
        return;
    }
    node_send();
    Serial.print("\r\n");
}

static void node_send_then_recv(uint32_t timeout)
{
    int ret = 0;
    ret = node_send();
    if (!ret)
    {
        Serial.print("\r\n");
        return;
    }
    if (!node_recv(timeout))
    {
        Serial.print("recv timeout!\r\n");
    }
    Serial.print("\r\n");
}

void setup(void)
{

    u8x8.begin();
    u8x8.setFlipMode(1);
    u8x8.setFont(u8x8_font_chroma48medium8_r);

    Serial.begin(115200);
    // while (!Serial);

    Serial1.begin(9600);
    Serial.print("ping pong communication!\r\n");
    u8x8.setCursor(0, 0);

    if (at_send_check_response("+AT: OK", 100, "AT\r\n"
    {
        is_exist = true;
        at_send_check_response("+MODE: TEST", 1000, "AT
        at_send_check_response("+TEST: RFCFG", 1000, "A
        delay(200);
#ifdef NODE_SLAVE
        u8x8.setCursor(5, 0);
        u8x8.print("slave");
#else
        u8x8.setCursor(5, 0);
        u8x8.print("master");
#endif
    }
    else
    {
        is_exist = false;
        Serial.print("No E5 module found.\r\n");
        u8x8.setCursor(0, 1);
        u8x8.print("unfound E5 !");
    }
}

void loop(void)
{
    if (is_exist)
    {
#ifdef NODE_SLAVE
        node_recv_then_send(2000);
#else
        node_send_then_recv(2000);
        delay(3000);
#endif
    }
}
```

Review Results



Resources

Datasheet:

- Grove LoRa-E5 v1.0.brd [http://files.seeedstudio.com/products/113020091/Grove%20-%20LoRa%20-E5%20v1.0.brd]
- Grove LoRa-E5 v1.0.pdf [https://files.seeedstudio.com/products/113020091/Grove%20-%20LoRa%20-E5%20v1.0.pdf]
- Grove LoRa-E5 v1.0.sch [http://files.seeedstudio.com/products/113020091/Grove%20-%20LoRa%20-E5%20v1.0.sch]

- LoRa-E5 datasheet and specifications [https://files.seeedstudio.com/products/317990687/res/LoRa-E5%20module%20datasheet_V1.0.pdf]
- LoRa-E5 AT Command Specification [https://files.seeedstudio.com/products/317990687/res/LoRa-E5%20AT%20Command%20Specification_V1.0%20.pdf]
- STM32WLE5JC Datasheet [https://files.seeedstudio.com/products/317990687/res/STM32WLE5JC%20Datasheet.pdf]

Certifications:

- LoRa-E5-HF Certification CE-VOC-RED [https://files.seeedstudio.com/products/317990687/res/LoRa-E5-HF%20Certification%20CE-VOC-RED.pdf]
- LoRa-E5-HF FCC Certification -DSS [https://files.seeedstudio.com/products/317990687/res/LoRa-E5-HF%20FCC%20Certification%20-DSS.pdf]
- LoRa-E5-HF FCC Certification -DTS [https://files.seeedstudio.com/products/317990687/res/LoRa-E5-HF%20FCC%20Certification%20-DTS.pdf]

Relevant SDK:

- STM32Cube MCU Package for STM32WL series [https://my.st.com/content/my_st_com/en/products/embedded-software/mcu-mpu-embedded-software/stm32-embedded-software/stm32cube-mcu-mpu-packages/stm32cubewl.license=1608693595598.product=STM32CubeWL.version=1.0.0.html#overview]

Tech Support

Please submit any technical issue into our forum [http://forum.seeedstudio.com/].