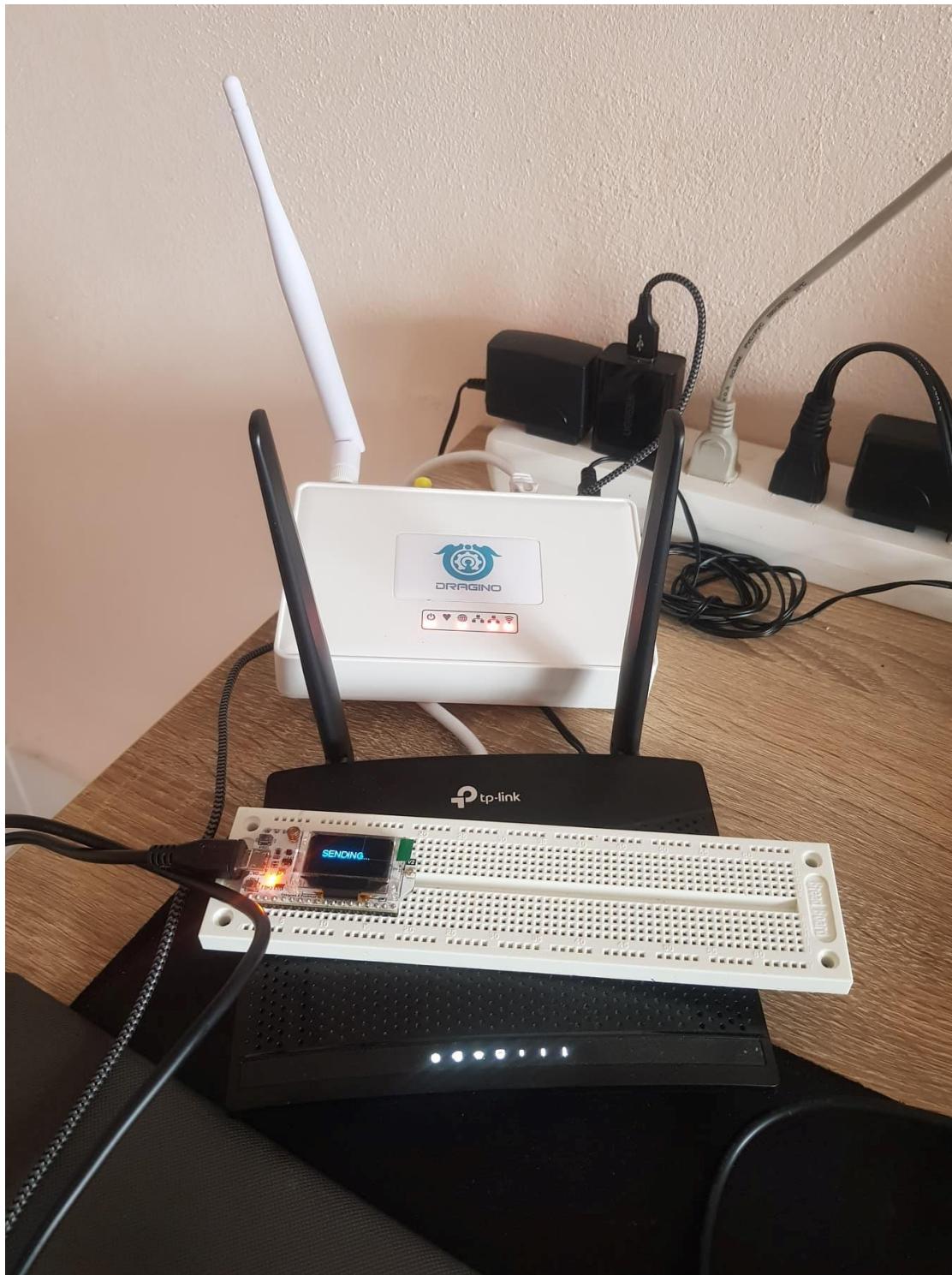


คู่มือการใช้งาน Chirp Stack Lora WAN® Network Server



ติดตั้ง Chirp Stack Lora WAN® Network Server บน PI 4B

ก่อนอื่นให้ติดตั้ง Noob หรือ Raspbian ให้เรียบร้อยแล้วใช้คำสั่งดังนี้

```
sudo apt updatesudo apt upgradegit clone
https://github.com/m2mlorawan/ChirpStack\_on\_Raspbiancd
ChirpStack_on_Raspbian/chmod +x install.shsudo
./install.shsudo reboot
```

หลังจาก Pi บูทเสร็จ เรียกใช้งานด้วย Port 8080

<http://<PI IP>:8080>

และใช้ User admin และ Password admin

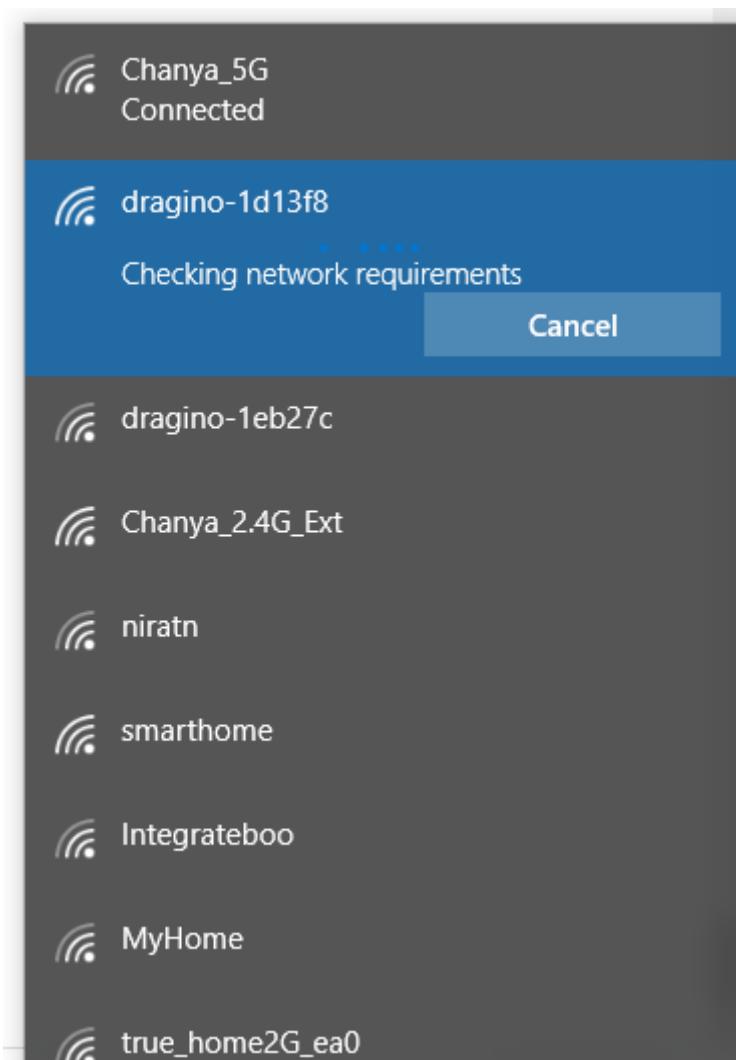
Name	Server
ns	localhost:8000

แก้ค่าใน LoRaWAN® gateway

ให้แก่ที่ Gateway โดยให้เข้าไปที่ IP ของ LoRaWAN® Network Server ที่เราสร้างขึ้น
ตัวอย่าง เช่น ถ้าใช้ Dragino LG308-AS923-EC25 ตามรูป



ให้ Connect gateway ด้วย WIFI เลือก Hotspot ที่ขึ้นด้วย Dragino



เข้ามายังต่อตัวโดยรหัสผ่าน dragino+dragino เปิดเว็บที่หน้า 10.130.1.1 เข้าด้วย ยูสเซอร์และรหัสผ่าน admin/admin

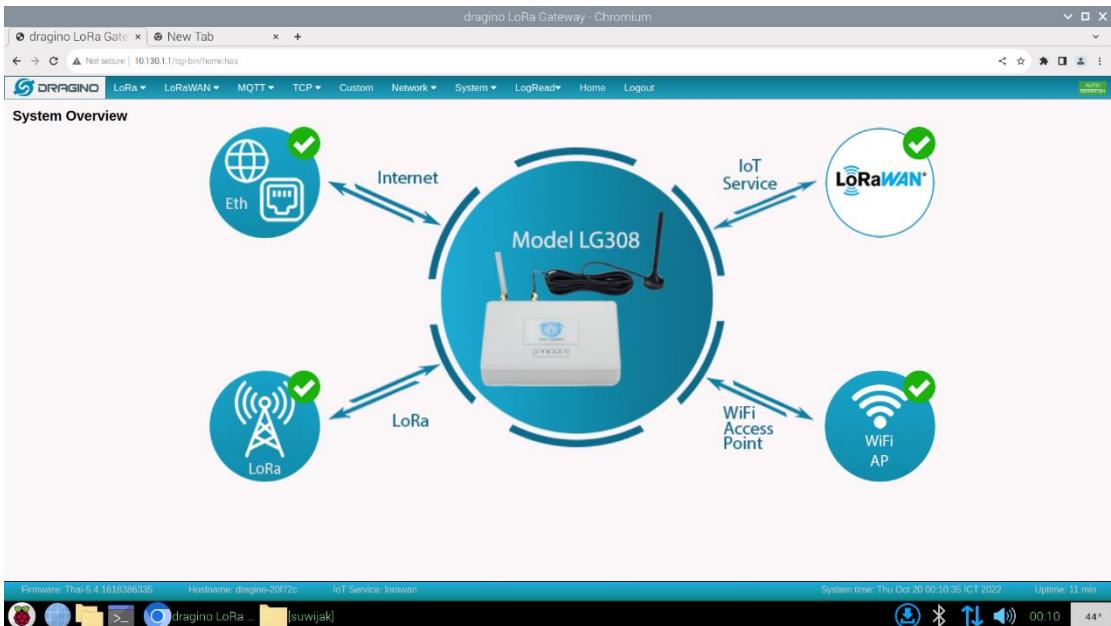
① 10.130.1.1/cgi-bin/home.has

ลงชื่อเข้าใช้

http://10.130.1.1
การเข้ามายังต่อตัวโดยยูสเซอร์และรหัสผ่าน

ชื่อยูสเซอร์	admin
รหัสผ่าน	*****

การทำงาน Gateway



Gateway Dragino Home หน้านี้เป็นหน้าที่บอกการทำงานของ Gateway ว่าทำงานยังไง และ เชื่อมต่ออะไรบ้าง

Firmware: THi-5.4.1613306335 Hostname: dragino-20f72c IoT Service: lorawan System time: Thu Oct 20 00:18:35 ICT 2022 Uptime: 11 min

dragino LoRa Gate x | +

Not secure | 10.130.1.1/cgi-bin/home.cgi

dragino LoRa Gateway - Chromium

LoRaWAN Configuration

General Settings

Email: topstop0023@hotmail.co.th
Gateway ID: a8404120f72c4150

Primary LoRaWAN Server

Service Provider: Custom / Private LoRaWAN
Uplink Port: 1700
Downlink Port: 1700
Server Address: 10.130.1.238

Packet Filter

Fport Filter: 0 DevAddr Filter: 0

Current Mode: LoRaWAN Semtech UDP

Save&Apply | Cancel

Gateway Dragino Setup เป็นหน้าการตั้งค่าอีเมล และ Password ID ของ Gateway

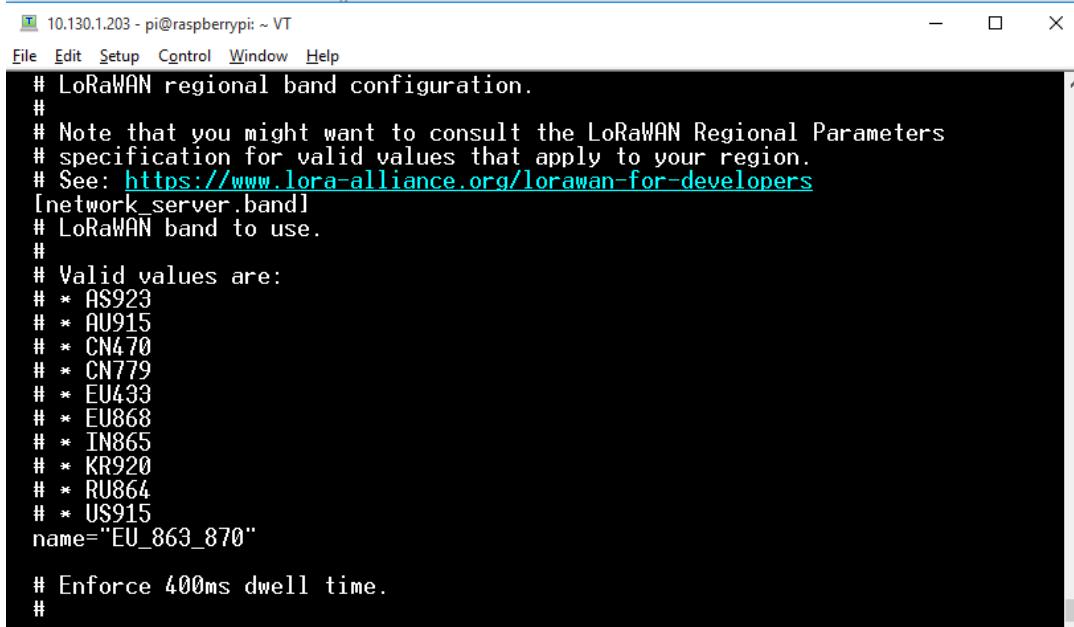
The screenshot shows the ChirpStack web interface for managing network-servers. On the left, there's a sidebar with options like Network-servers, Gateway-profiles, Organizations, All users, API keys, and a dropdown for 'chirpstack'. The main area is titled 'Network-servers / ns (EU868 @ 3.9.0)'. It has three tabs: GENERAL (selected), GATEWAY DISCOVERY, and TLS CERTIFICATES. Under GENERAL, there are two fields: 'Network-server name *' with the value 'ns' and 'Network-server server *' with the value 'localhost:8000'. A red circle surrounds the network-server name, and two red arrows point to the 'ns' and 'localhost:8000' fields respectively. At the bottom right of the main area is a blue 'UPDATE NETWORK-SERVER' button.

ความถี่ของสัญญาณ

Script ที่ติดตั้งวิธีที่กล่าวข้างต้น จะติดตั้งค่าความถี่ Default ของ network-server เป็น EU868 โดยสังเกตุจาก NS ของเรา Default จะมี (EU868 @ 3.9.0) ต่อท้าย ซึ่งจะมีปัญหากับเราตอน Downlink ซึ่งหากมี Node แบบ OTAA ติดต่อเข้ามา จังหวะ Downlink ตัว Hardware ของ Lora WAN Gateway จะถูกสั่งให้ปรับความถี่กลับไปที่ช่อง 868 ซึ่งตัว Lora WAN Gateway จะไม่ยอมอนุญาติตามที่ chirp stack-network-server ร้องขอ แต่จะรายงาน Error กลับมาที่ Network Server ทำให้การ Downlink ทั้งหมดทำไม่สำเร็จ ดูว่า Config ที่ใช้อยู่ปัจจุบันของ chirp stack-network-server มีค่าอะไรบ้าง โดยใช้คำสั่ง

chirp stack-network-server configfile

จะเห็นว่ามีการตั้งค่าเป็น name="EU_868_870"



```

10.130.1.203 - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
# LoRaWAN regional band configuration.
#
# Note that you might want to consult the LoRaWAN Regional Parameters
# specification for valid values that apply to your region.
# See: https://www.lora-alliance.org/lorawan-for-developers
[network_server.band]
# LoRaWAN band to use.
#
# Valid values are:
# * AS923
# * AU915
# * CN470
# * CN779
# * EU433
# * EU868
# * IN865
# * KR920
# * RU864
# * US915
name="EU_863_870"

# Enforce 400ms dwell time.
#

```

แก้ไขความถี่

ก่อนอื่น เข้าสิทธิ System Admin ก่อนโดยใช้คำสั่ง คำสั่งหนึ่งดังนี้

sudo -i หรือ sudo su หรือ sudo -s

เปลี่ยน Dir ให้งานเป็น /etc/chirp stack-network-server

cd /etc/chirp stack-network-server

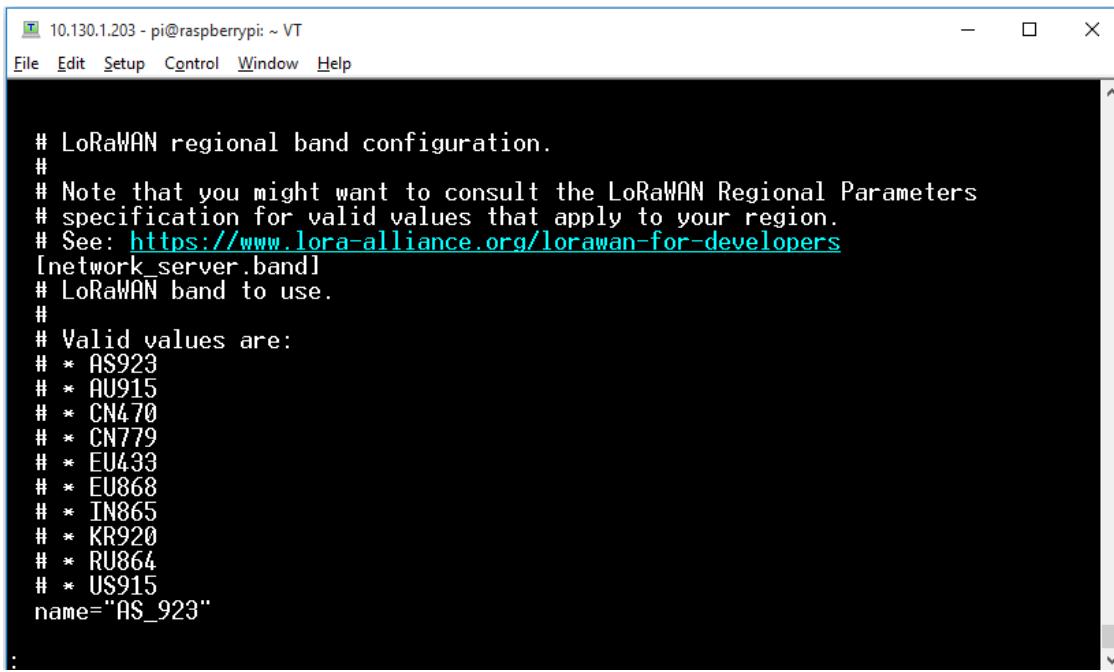
Backup ไฟล์เดิมไว้ก่อน โดยใช้คำสั่ง

cp chirp stack-network-server.toml chirp stack-network-server.toml.BAK

ให้ Copy ไฟล์ AS_923 ไปแทน

cp chirpstack-network-server.as_923.toml chirp stack-network-server.toml

ลองเช็คอ่านค่า config อีกครั้งจะเห็นว่า name="AS_923"



```
# LoRaWAN regional band configuration.
#
# Note that you might want to consult the LoRaWAN Regional Parameters
# specification for valid values that apply to your region.
# See: https://www.lora-alliance.org/lorawan-for-developers
[network_server.band]
# LoRaWAN band to use.
#
# Valid values are:
# * AS923
# * AU915
# * CN470
# * CN779
# * EU433
# * EU868
# * IN865
# * KR920
# * RU864
# * US915
name="AS_923"
```

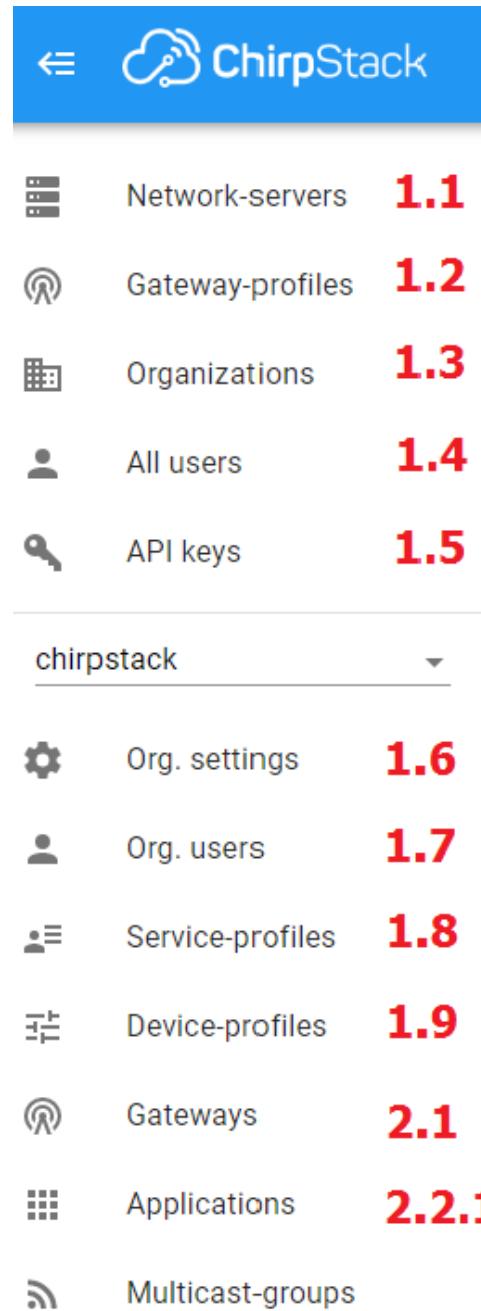
แก้ไขความถี่เป็น AS_923

Restart chirp stack-network-server ใหม่โดย

sudo systemctl restart chirp stack-network-server

ใช้งาน Chirp Stack Lora WAN® Network Server บน PI 4B

การใช้งานจะเริ่มต้นจากเมนูข้างซ้ายของจอภาพ จากบนลงล่าง หลังล็อกอินเสร็จจะมีเมนูด้านซ้ายดังนี้
บทความนี้จะแนะนำให้เรียงแต่ละเมนูตามหัวข้อสีแดงในภาพ



เมนูภายใน chirp stack ก็จะมี ปุ่ม Network-servers, Gateway-profiles, Organizations, allusers, API keys, Org. Settings, Org.Users, Service-Profiles ,Device-Profiles, Gateways, Applications, Multicast-groups

Network-servers

Name	Server
ns	localhost:8000

Rows per page: 10

เมนู Network-server หน้านี้จะบอก ชื่อของ Network และ ID ของ Server Network

Network-servers / ns (EU868 @ 3.9.0)

GENERAL

Network-server name: ns

A name to identify the network-server.

Network-server server: localhost:8000

The hostname:port of the network-server, e.g. 'localhost:8000'.

DELETE

UPDATE NETWORK-SERVER

หน้านี้จะบอกถึงว่ามีการตั้งค่า ns ไว้แล้วเป็น localhost:8000

Gateway-profiles

Important: Gateway profiles are deprecated and will be removed in the next major release.

Name	Network-server
gateway_profile	ns

หน้านี้จะบอกรหัสชื่อของ Gateway-profile และชื่อของ Network server

Gateway-profiles / gateway_profile

Name *
gateway_profile

Enabled channels *
0, 1, 2

[ADD EXTRA CHANNEL](#) [UPDATE GATEWAY-PROFILE](#)

มีการตั้งค่า gateway profile ไว้แล้ว เชื่อมเข้ากับ Network Server ชื่อ NS

ChirpStack

Search organization, application, gateway or device

Network-servers
Gateway-profiles
Organizations
All users
API keys

chirpstack

Org. settings
Org. users

Organizations

Name	Display name	Can have gateways
chirpstack	ChirpStack	<input checked="" type="checkbox"/>

Rows per page: 10 1-1 of 1

หน้าของเมนู Organization จะบอกชื่อของ Organization และชื่อ display ของ Organization ชื่อ chirp Stack

ChirpStack

Search organization, application, gateway or device

Network-servers
Gateway-profiles
Organizations
All users
API keys

chirpstack

Org. settings
Org. users
Service-profiles
Device-profiles

Organizations / chirpstack

DELETE

Organization name *
chirpstack

The name may only contain words, numbers and dashes.

Display name *
ChirpStack

Gateways
 Organization can have gateways

When checked, it means that organization administrators are able to add their own gateways to the network. Note that the usage of the gateways is not limited to this organization.

UPDATE ORGANIZATION

หน้านี้จะเป็นหน้าของเมนู Org. settings ตั้งไว้แล้วตามรูป

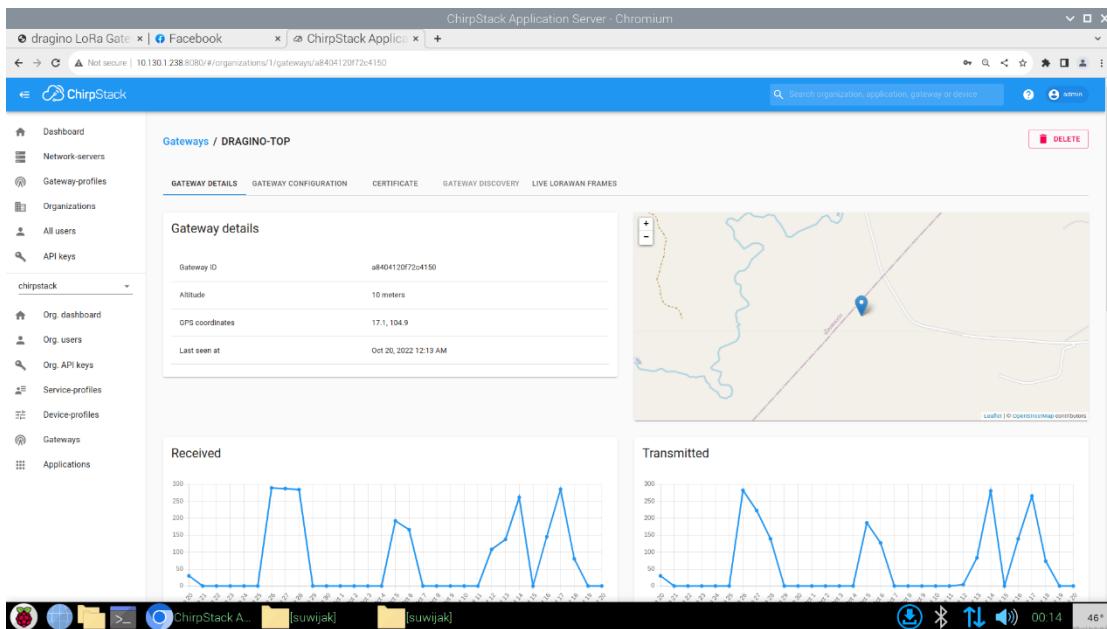
ID	Username	Admin
1	admin	<input checked="" type="checkbox"/>

หน้านี้จะเป็นหน้าของเมนู Org. users จะมี Username ชื่อ admin และมี ID คือ 1

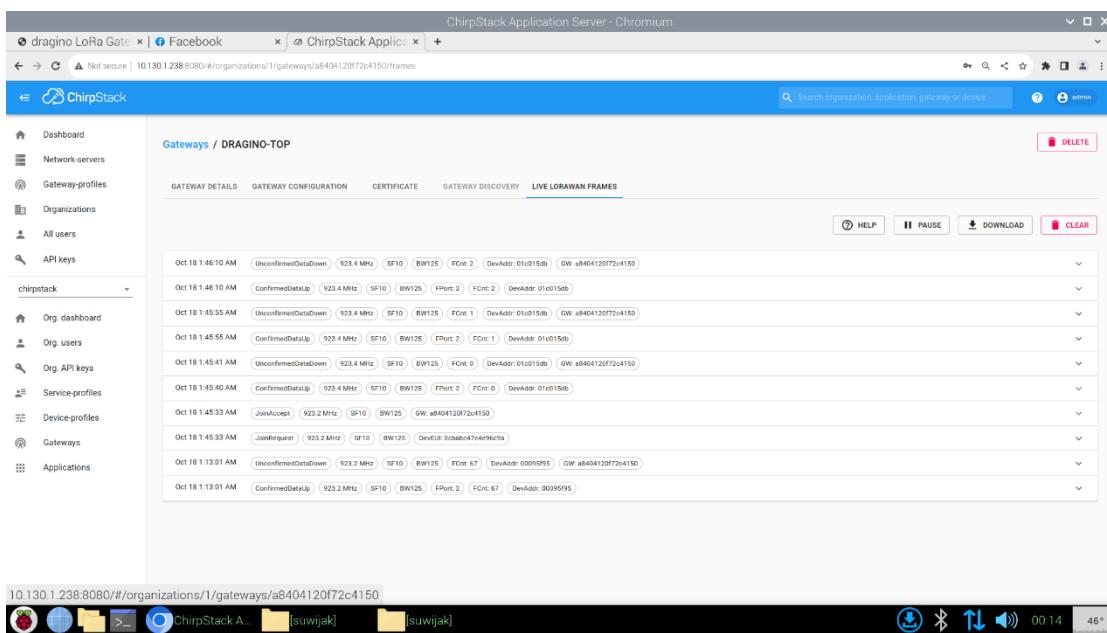
Last seen	Name	Gateway ID	Network server	Gateway activity (30d)
a few seconds ago	DRAGINO-TOP	a8404120f72c4150	ns	
Never	rak_gateway	0000000000000000	ns	

หน้านี้จะเป็นหน้าของ Gateway Menu หน้านี้จะบอก ว่า Gateway Menu มีอะไรบ้าง

LORAWAN GUIDE BY SUWIJAK



หน้านี้จะบอกรายละเอียดของ Gateway ที่จะบอกรายการ received และรายการ Transmitted



หน้านี้จะบอกรายละเอียดของข้อมูลที่ส่งผ่าน Gateway

LORAWAN GUIDE BY SUWIJAK

The screenshot shows the ChirpStack Application Server interface in a Chromium browser window. The URL is 10.130.1.238:8080/#/organizations/1/applications. The left sidebar has a 'chirpstack' section with 'Applications' selected. The main area is titled 'Applications' and lists two entries:

ID	Name	Service-profile	Description
1	app	service-profile	app
2	heltec-bike1	heltec	123132

At the bottom, there are navigation links for 'Rows per page: 10', '1 of 2', and 'Next >'. The status bar at the bottom shows the IP address 10.130.1.238:8080, the ChirpStack logo, and the user 'suwijak'.

หน้านี้จะเป็นหน้า Application Menu ที่จะบอกรายชื่อ Application profile

The screenshot shows the ChirpStack Application Server interface in a Chromium browser window. The URL is 10.130.1.238:8080/#/organizations/1/applications/2. The left sidebar has a 'chirpstack' section with 'Applications / heltec-bike1' selected. The main area is titled 'Devices' and lists one device entry:

Last seen	Device name	Device EUI	Device profile	Link margin	Battery
a few seconds ago	heltec-bike1	0cbabc47c4e96c9a	device_profile_etaa	n/a	n/a

At the bottom, there are navigation links for 'Rows per page: 10', '1 of 1', and 'Next >'. The status bar at the bottom shows the IP address 10.130.1.238:8080, the ChirpStack logo, and the user 'suwijak'.

หน้านี้จะบอกรายชื่อ Device ที่จะแสดงใน Application

LORAWAN GUIDE BY SUWIJAK

.dragino LoRa G... ChirpStack Appli... Node-RED : 10.0.0.10

Not secure | 10.130.1.238:8080/#/organizations/1/applications/2/devices/0cab07cf4095ca

ดูเพิ่ม ChirpStack dragino ใช้งาน ChirpStack MQTT au... TLS -> C... ssl - Mos... MQTT - C... MQTT W...

ChirpStack

Dashboard Network-servers Gateway profiles Organizations All users API keys chirpstack Org. dashboard Org. users Org. API keys Service-profiles Device-profiles Gateways Applications

Applications / Bike-keep / Devices / Bike-keep

DETAILS CONFIGURATION KEYS (OTAA) ACTIVATION DEVICE DATA LORAWAN FRAMES

DELETE

Details

Name	Bike-keep1
Description	lorawan-bike1
Device profile	device_profile_otaa
Multicast groups	

Status

Last seen at	Oct 31, 2022 2:51 PM
State	enabled

Received

Errors

SNR

RSSI

ChirpStack Application Server - Chromium

suwijak@raspberrypi: ~ suwijak

12:33 45°

หน้านี้จะแสดงข้อมูล Device Detail

The screenshot shows the ChirpStack Application Server interface. The top navigation bar includes tabs for 'dragino LoRa Go', 'ChirpStack Appli', 'Node-RED: 10.0.0.1', and a search bar. Below the header, a breadcrumb trail shows the path: 'dragino LoRa... ChirpStack... dragino LoRa... ใช้งาน Chir... ก้าวติดต่อ... Notes for... MQTT au... TLS -> C... ssl - Mos... MQTT - C... MQTT W...'. The main content area displays a list of devices under 'Applications / Bike-keep / Devices / Bike-keep'. Each device entry includes fields for 'DETAILS', 'CONFIGURATION', 'KEYS (OTAA)', 'ACTIVATION', 'DEVICE DATA' (which is currently selected), and 'LORAWAN FRAMES'. The 'DEVICE DATA' section shows two entries for the device, both with status 'up'. The first entry has parameters: 923.4 MHz, SF10, BW125, FCnt: 164, FPort: 2, Confirmed. The second entry has parameters: 923.2 MHz, SF10, BW125, FCnt: 163, FPort: 2, Confirmed. To the right of these entries are buttons for 'HELP', 'PAUSE', 'DOWNLOAD', and 'CLEAR'. On the left sidebar, there are links for 'Dashboard', 'Network-servers', 'Gateway-profiles', 'Organizations', 'All users', 'API keys', and a dropdown for 'chirpstack' which lists 'Org. dashboard', 'Org. users', 'Org. API keys', 'Service-profiles', 'Device-profiles', 'Gateways', and 'Applications'. The bottom of the screen shows the Windows taskbar with icons for File Explorer, Task View, and Start, along with the ChirpStack Application Server icon and the user 'suwijak@ras...'. The system tray shows battery level at 49% and the date/time as 12:34.

หน้านี้จะโชว์ข้อมูลของ Device Data

The screenshot shows the ChirpStack web interface. On the left, a sidebar menu is visible with various options like Network-servers, Gateway-profiles, Organizations, All users, API keys, and a dropdown for 'chirpstack'. The main content area is titled 'Organizations / chirpstack'. It contains fields for 'Organization name*' (set to 'chirpstack') and 'Display name*' (set to 'ChirpStack'). A checkbox labeled 'Organization can have gateways' is checked. Below these fields is a note: 'When checked, it means that organization administrators are able to add their own gateways to the network. Note that the usage of the gateways is not limited to this organization.' At the bottom right of the form is a blue 'UPDATE ORGANIZATION' button.

หน้านี้จะบอกการตั้งค่า Organization ไว้แล้วข้อ chirp stack

The screenshot shows the ChirpStack web interface. On the left, a sidebar menu is visible with various options like Network-servers, Gateway-profiles, Organizations, All users, API keys, and a dropdown for 'chirpstack'. The main content area is titled 'Users'. It displays a table with columns 'Username', 'Active', and 'Admin'. There is one row shown with 'admin' in the 'Username' column, which is highlighted with a red arrow. To the right of the table, there are buttons for 'Rows per page: 10' and '1-11'. At the bottom right of the table is a blue 'UPDATE' button.

หน้านี้จะเป็นหน้าเมนู All users ที่บอกรหัส Username ชื่อ admin

ChirpStack Admin UI - Users / admin

Username * admin

E-mail address *

Optional note

Optional note, e.g. a phone number, address, comment...

Permissions

Is active

Is global admin

UPDATE USER

หน้านี้จะบอกว่ามีการตั้งเพิ่มค่าในเมนู All users ไว้แล้วซึ่งเป็น User : admin

ChirpStack Admin UI - Global API keys

+ CREATE

ID	Name

Rows per page: 10 0-0 of 0 < >

ยังไม่ได้มีการตั้งค่าใดๆ เราสามารถสร้าง API KEY โดยคลิก Create มุมขวาบน บทความนี้เรายังไม่ได้ใช้ค่านี้

Organization users / admin

Username: admin

An user without additional permissions will be able to see all resources under this organization and will be able to send and receive device payloads.

User is organization admin ←

An organization admin user is able to add `join request` resources part of the organization.

UPDATE USER

หน้านี้จะบอกว่ามีการตั้งค่าไว้แล้วคือ หน้า Organization users ชื่อ admin

Service-profiles

Name
service-profile ←

Rows per page: 10 1-1 of 1 < >

หน้านี้จะบอกถึงเมนู Service profile ที่มี Username ชื่อ Service profile

LORAWAN GUIDE BY SUWIJAK

ChirpStack Application Server - Chromium

dragino LoRa Gate Facebook ChirpStack Application Server

Not secure | 10.130.1.238:8080/#/organizations/1/service-profiles/993405dc-7299-42f5-b151-23ef96d7b255

ChirpStack

Service-profiles / heltec

Service-profile name * heltec

Add gateway meta data

GW metadata (RSSI, SNR, GW geoloc., etc.) are added to the packet sent to the application-server.

Enable network geolocation

When enabled, the network-server will try to resolve the location of the devices under this service profile. Please note that you need to have gateways supporting the fine-timestamp feature and that the network-server needs to be configured in order to provide geolocation support.

Device-status request frequency 0

Frequency to initiate an End-Device status request (request/day). Set to 0 to disable.

Minimum allowed data-rate * 10

Minimum allowed data rate. Used for ADR.

Maximum allowed data-rate * 10

Maximum allowed data rate. Used for ADR.

Private gateways

Gateways under this service-profile are private. This means that these gateways can only be used by devices under the same service-profile.

UPDATE SERVICE PROFILE

Org. dashboard Org. users Org. API keys Service-profiles Device-profiles Gateways Applications

ChirpStack A [suwijak]

00:12 45°

ChirpStack Application Server - Chromium

dragino LoRa Gate Facebook ChirpStack Application Server

Not secure | 10.130.1.238:8080/#/organizations/1/device-profiles

ChirpStack

Device-profiles

+ CREATE

Name	Network Server
device_profile_abp	ns
device_profile_oiaa	ns

Rows per page: 10 1-2 of 2 < >

10.130.1.238:8080/#/organizations/1/device-profiles

ChirpStack A [suwijak] 00:12 45°

LORAWAN GUIDE BY SUWIJAK

ChirpStack Application Server - Chromium

dragino LoRa Gate | Facebook | ChirpStack Application Server

Not secure | 10.130.1.238:8080/#/organizations/1/device-profiles/9e89a1f2-fbf-46fa-840d-73f238053b0d

ChirpStack

Device-profiles / device_profile_otaas

GENERAL JOIN (OTAA / ABP) CLASS-B CLASS-C CODEC TAGS

Device profile name * device_profile_otaas

LoRaWAN MAC version * 1.0.2

LoRaWAN Regional Parameters revision * A

ADR algorithm * Default ADR algorithm (LoRa only)

Max EIRP * 0

Uplink interval (seconds) * 86400

UPDATE DEVICE-PROFILE

ChirpStack A [suwijak] [suwijak]

00:13 44°

ChirpStack Application Server - Chromium

dragino LoRa Gate | Facebook | ChirpStack Application Server

Not secure | 10.130.1.238:8080/#/organizations/1/device-profiles/9e89a1f2-fbf-46fa-840d-73f238053b0d

ChirpStack

Device-profiles / device_profile_otaas

GENERAL JOIN (OTAA / ABP) CLASS-B CLASS-C CODEC TAGS

Device supports Class-B

Class-B confirmed downlink timeout * 30

Class-B timeout (in seconds) for confirmed downlink transmissions.

Class-B ping slot periodicity * every 4 seconds

Class-B ping-slot periodicity

Class-B ping-slot data-rate * 5

Class-B ping-slot frequency (Hz) * 1

UPDATE DEVICE-PROFILE

ChirpStack A [suwijak] [suwijak]

00:13 46°

LORAWAN GUIDE BY SUWIJAK

dragino LoRa Gate | Facebook | ChirpStack Application Server - Chromium

Not secure | 10.130.1.238:8080/#/organizations/1/device-profiles/%e0%a1f2fbf46fa840d73f238053bd

ChirpStack

Device-profiles / device_profile_ota

Dashboard Network-servers Gateway-profiles Organizations All users API keys chirpstack

GENERAL JOIN (OTAA / ABP) CLASS-B CLASS-C CODEC TAGS

Device supports Class-C

Select this option when the device will operate as Class-C device immediately after activation. In case it sends a DeviceModeInd mac-command when it changes to Class-C, do not select this option.

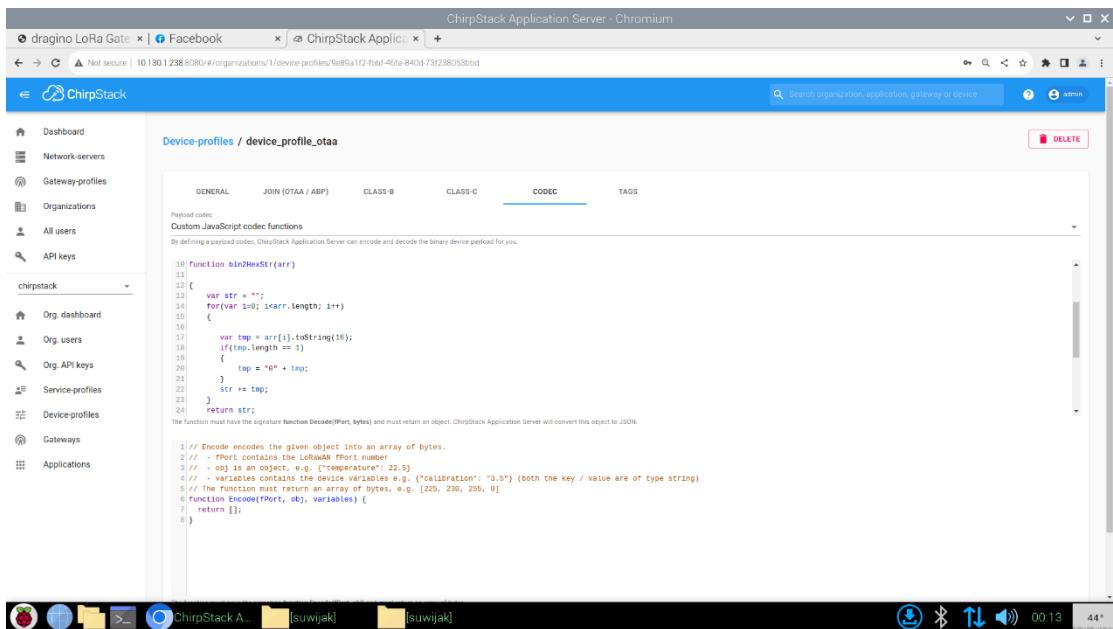
Class-C confirmed downlink timeout *

60

Class C timeout (in seconds) for confirmed downlink transmissions.

UPDATE DEVICE PROFILE

LORAWAN GUIDE BY SUWIJAK



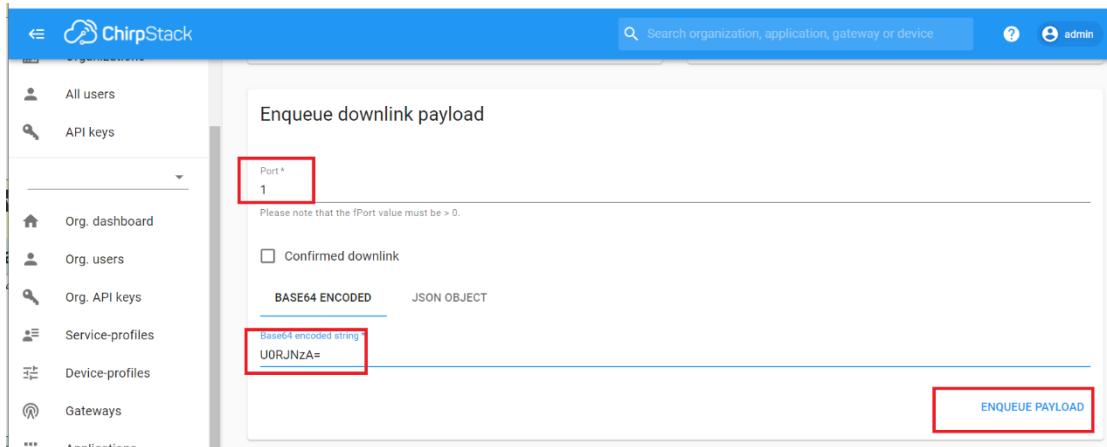
Downlink guideline.

Details	Configuration	Keys (OTAA)	Activation	Device Data	Lorawan Frames
Name: Sens3					
Description: sensor 3					
Device-profile: DEVPROF-AS923					
Multicast groups:					

Figure 1 shows that you go to Application -> AppB (I created myself) -> Devices -> Sens3 (I created myself) -> DETAILS

Then you scroll down

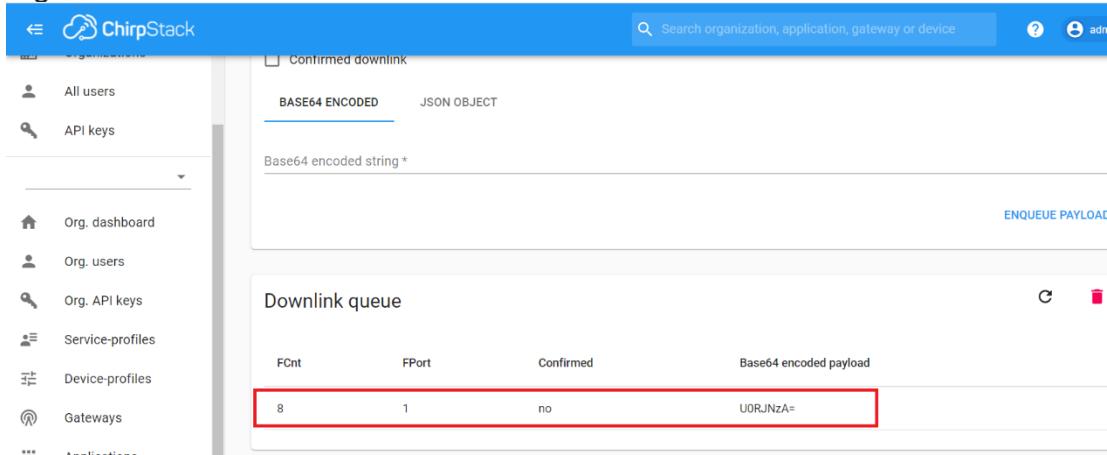
Figure 2



When you scroll down to Enqueue downlink payload, you key in the port number. This port number you will see it when your node sends data over to you application server. Key in the same port number of the node you want to send downlink data to.

Then key in the Base64 value. The base64 value you can obtain by converting it at asciitohex.com (as shown in Figure 3 below) (I guess you know that also. Or you can go to any site that can help you to convert.

Figure 3



As can be seen in Figure 3, I am, actually, sending SDI70 downlink value to the node. After conversion, I get U0RJNzA=. Key in this value to the BASE64 ENCODED column. Actually, I don't know what to key in to the JSON OBJECT column. Do know what to key in? I just leave it blank.

Then you click on the ENQUEUE PAYLOAD.

Once you have clicked it, if successful, you will see what is shown in Figure 4 below.

Figure 4



Once it is successfully sent over to the node, when you click on the refresh icon (next to the red bin icon) the data will disappear. That's OK.

Figure 5

The screenshot shows a terminal window titled 'Tera Term - [disconnected] VT'. The terminal displays the following text:

```

Tera Term - [disconnected] VT
File Edit Setup Control Window Help
Payload: 5344493730send data interv 70s
*****
Transmission Success
*****
Sensor Value: 93 Hz
Tx Sensor Data Sent
*** Received DL Data ***
Frame Received at port 1
Frame Length - 6 Ascii value for "SDI70"
Address -
Payload: 5344493730send data interv 70s
*****
Transmission Success
*****
Sensor Value: 95 Hz
Tx Sensor Data Sent
Transmission Success
*****
Sensor Value: 96 Hz
Tx Sensor Data Sent
Transmission Success
*****

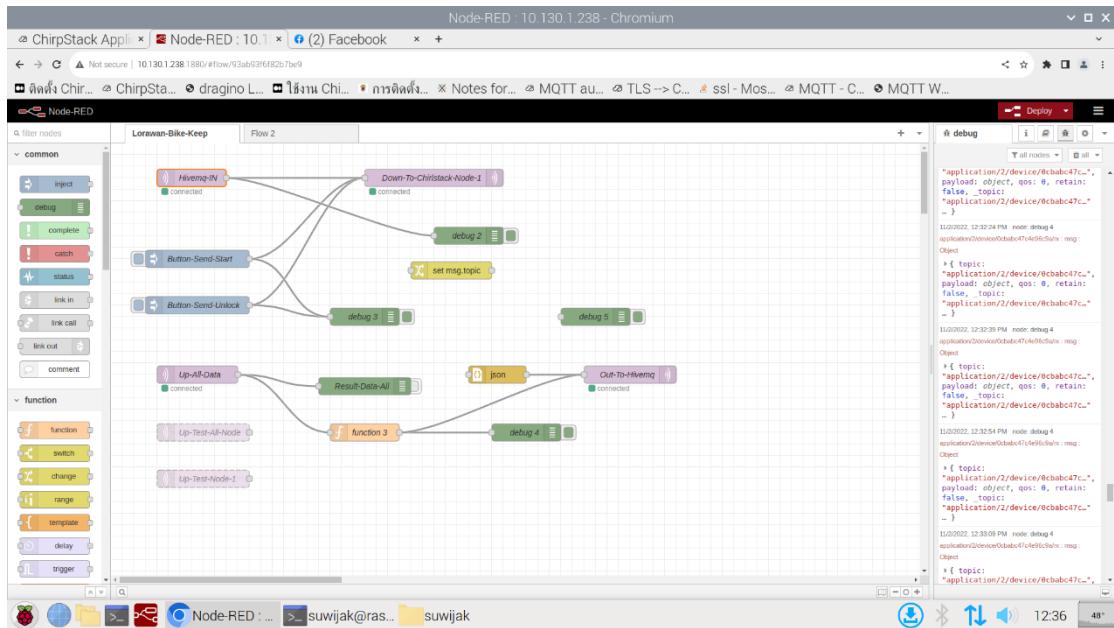
```

A white arrow points from the text 'Ascii value for "SDI70"' to the payload '5344493730' in the second frame received at port 1.

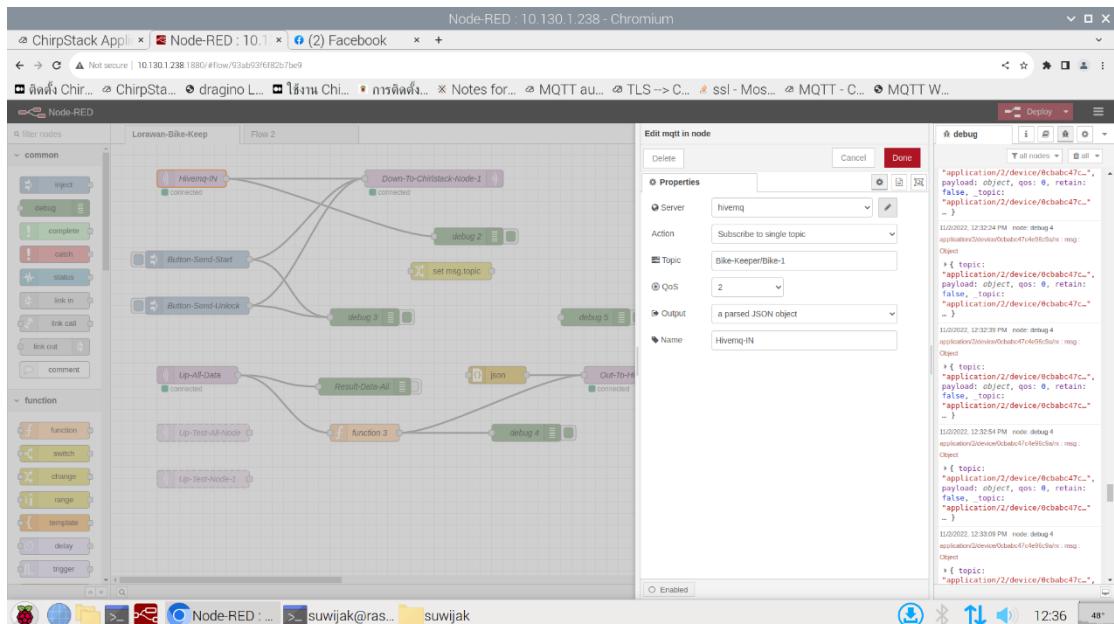
Figure 5 shows the output (I use printf) at my node's part. As you can see, after I have send Sensor Value of 93 Hz over to the application server, I get the downlink data from the application server (5344493730). This string of number (5344493730) is the ASCII value of SDI70 (S - 0x53, D - 0x44, I - 0x49, 7 - 0x37, 0 - 0x30), which is sent by the application server just now.

As you can see, it's quite a lot of job to be done. For a non-programmer, I don't think they want to do that. That's why I am thinking of creating a button for the user to send downlink data over to the node.

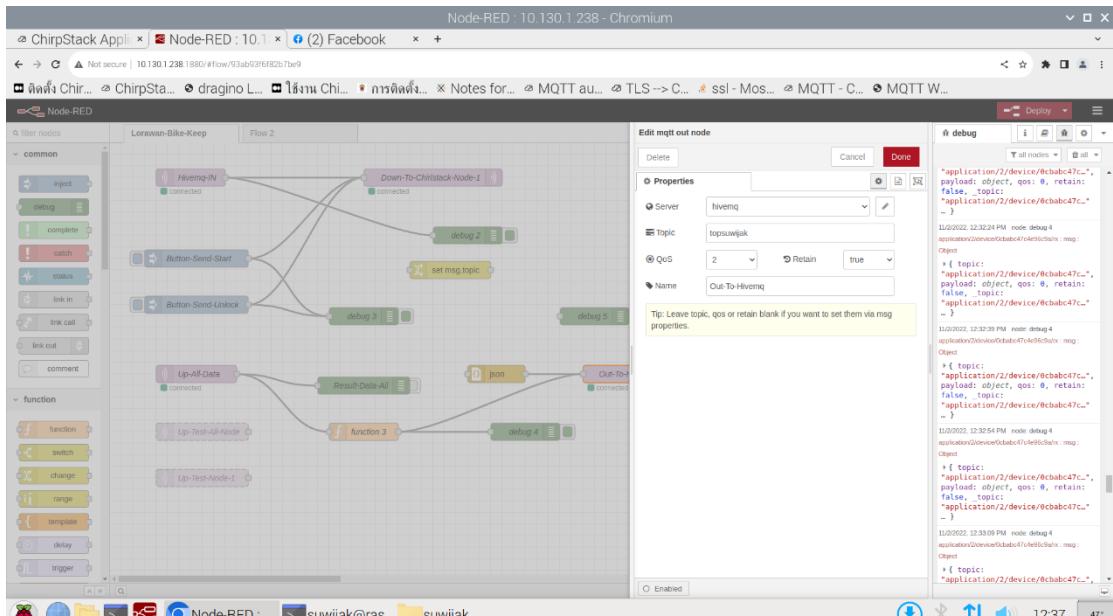
การทำงานของ Node-red



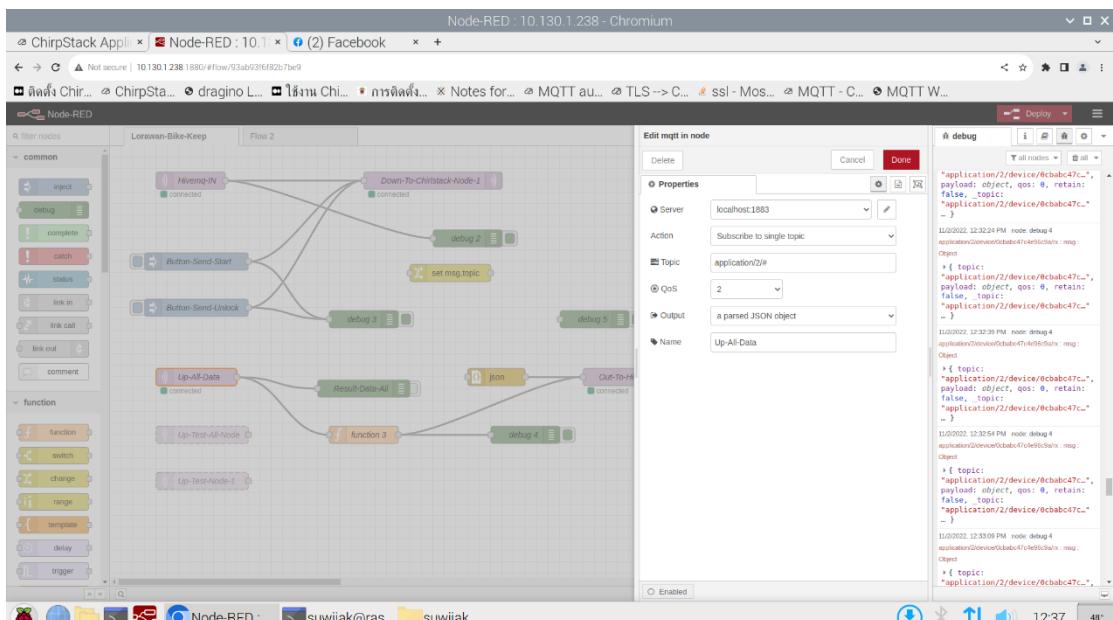
หน้านี้จะเป็นหน้าของ Node-red ที่จะบอกว่า Node-red เชื่อมไปไหนบ้างทำงานยังไงบ้าง



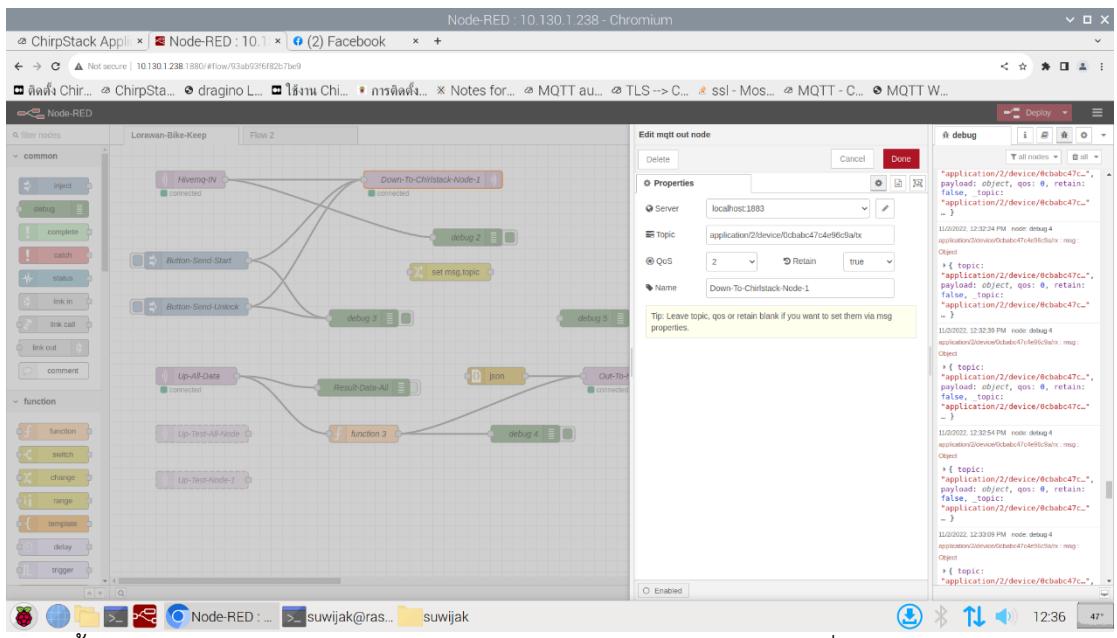
หน้านี้จะบอกว่า Node-red input from Hivemq คือการที่ Node-red เชื่อมต่อหรือ input ไปยัง Hivemq



หน้านี้จะแสดงให้เห็นว่า Node-red Output from Hivemq คือการที่ Node-red ทำการ Output หรือออกจาก Hivemq



หน้านี้จะแสดงหน้า Node-red Get data จาก Chirp stack คือ Node-red รับค่าข้อมูลมาจากการ Data และจาก Chirp stack



หน้านี้จะแสดงให้เห็นว่า Node-red send data ไป Chirp stack คือการที่ Node-red data ส่งข้อ
มูลไปยัง chirp stack

LORAWAN GUIDE BY SUWIJAK

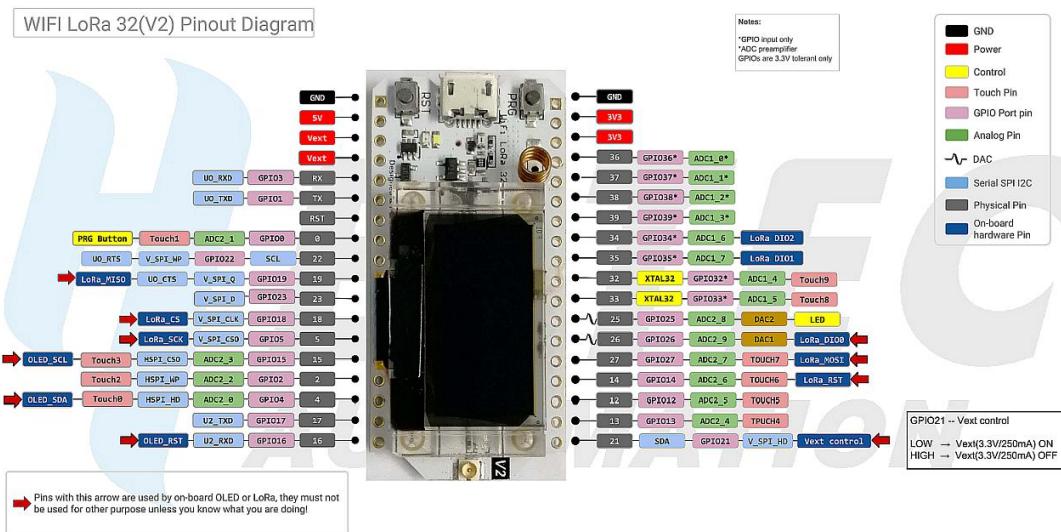
การทำงานของ MQTT

```
File Edit Tabs Help
[suwijak@raspberrypi: ~] $ sudo service mosquitto stop
[suwijak@raspberrypi: ~] $ mosquitto -v
1667392683: mosquitto version 2.0.11 starting
1667392683: Using default config.
1667392683: Starting in local only mode. Connections will only be possible from clients running on this machine.
1667392683: Create a configuration file which defines a listener to allow remote access.
1667392683: For more details see https://mosquitto.org/documentation/authentication-methods/
1667392683: Opening ipv4 listen socket on port 1883.
1667392683: Opening ipv6 listen socket on port 1883.
1667392683: New client connection from 127.0.0.1:55930 on port 1883.
1667392684: New client connected from 127.0.0.1:55930 as auto-E3F36EDF-1672-5482-E096-C93EAD934980 (p2, c1, k30).
1667392684: No will message specified.
1667392684: Sending CONNACK to auto-E3F36EDF-1672-5482-E096-C93EAD934980 (0, 0)
1667392684: New connection from ::1:35380 on port 1883.
1667392684: New client connected from ::1:35380 on port 1883.
1667392684: No will message specified.
1667392684: New client connected from ::1:35380 as auto-D37E11A1-DE72-BBD5-2E13-9A601B95D060 (p2, c1, k30).
1667392684: No will message specified.
1667392684: Sending CONNACK to auto-D37E11A1-DE72-BBD5-2E13-9A601B95D060 (0, 0)
1667392684: New client connected from ::1:35394 on port 1883.
1667392684: No will message specified.
1667392684: Received SUBSCRIBE from auto-D37E11A1-DE72-BBD5-2E13-9A601B95D060
1667392684: Sending CONNACK to auto-E3F36EDF-1672-5482-E096-C93EAD934980 (0, 0)
1667392684: Received SUBSCRIBE from auto-D37E11A1-DE72-BBD5-2E13-9A601B95D060
1667392684: application/+device/+tx (QoS 0)
1667392684: auto-D37E11A1-DE72-BBD5-2E13-9A601B95D066 0 application/+device/+tx
1667392684: Sending SUBACK to auto-D37E11A1-DE72-BBD5-2E13-9A601B95D069
1667392684: Received SUBSCRIBE from auto-10F1A685-7264-1B51-6A6B-8A96EEC78002
1667392684: gateway/+event/+ (QoS 0)
1667392684: auto-10F1A685-7264-1B51-6A6B-8A96EEC78002 0 gateway/+event/+
1667392684: Sending SUBACK to auto-10F1A685-7264-1B51-6A6B-8A96EEC78002
1667392684: Received SUBSCRIBE from auto-E3F36EDF-1672-5482-E096-C93EAD934980
1667392684: gateway/a8a04120f72c4150/command/# (QoS 0)
1667392684: auto-E3F36EDF-1672-5482-E096-C93EAD934980 0 gateway/a8a04120f72c4150/command/# (QoS 0)
1667392684: Sending SUBACK to auto-E3F36EDF-1672-5482-E096-C93EAD934980
1667392684: Received PUBLISH From auto-E3F36EDF-1672-5482-E096-C93EAD934980 (d0, q0, r1, m0, 'gateway/a8a04120f72c4150/state/conn', ... (12 bytes))
1667392687: Received PUBLISH From auto-E3F36EDF-1672-5482-E096-C93EAD934980 (d0, q0, r0, m0, 'gateway/a8a04120f72c4150/event/up', ... (120 bytes))
1667392687: Sending PUBLISH to auto-10F1A685-7264-1B51-6A6B-8A96EEC78002 (d0, q0, r0, m0, 'gateway/a8a04120f72c4150/event/up', ... (120 bytes))
1667392688: Received PUBLISH From auto-D37E11A1-DE72-BBD5-2E13-9A601B95D060 (d0, q0, r0, m0, 'application/2/device/0cababc47c4e96c9a/error', ... (194 bytes))
```

หน้านี้จะแสดงการใช้งาน MQTT

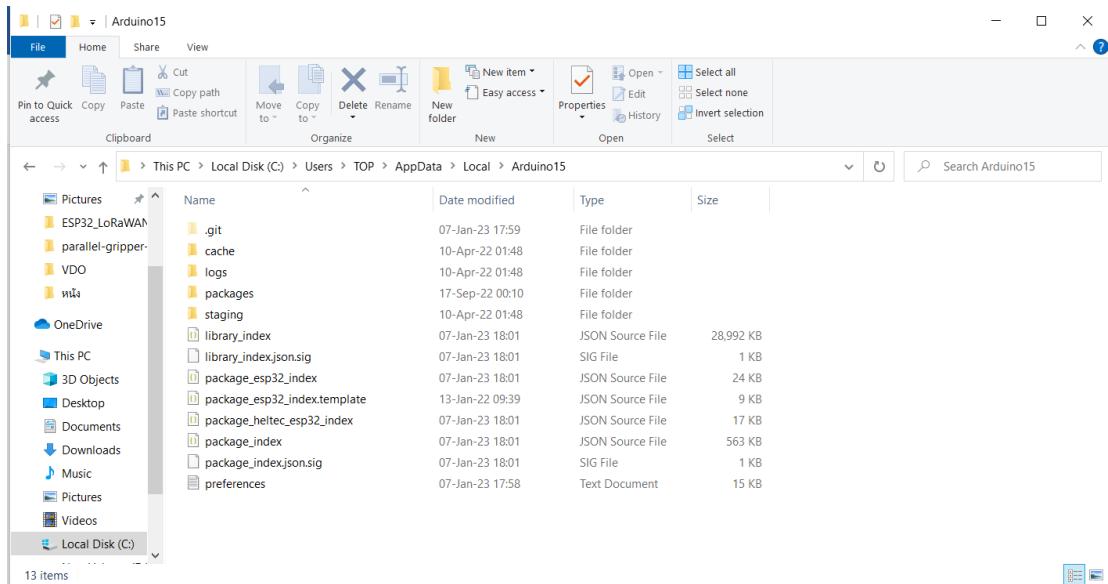
หน้านี้จะแสดงข้อมูล จาก Application ID คือการส่งข้อมูลจาก Application many MQTT

การทำงานของ Arduino

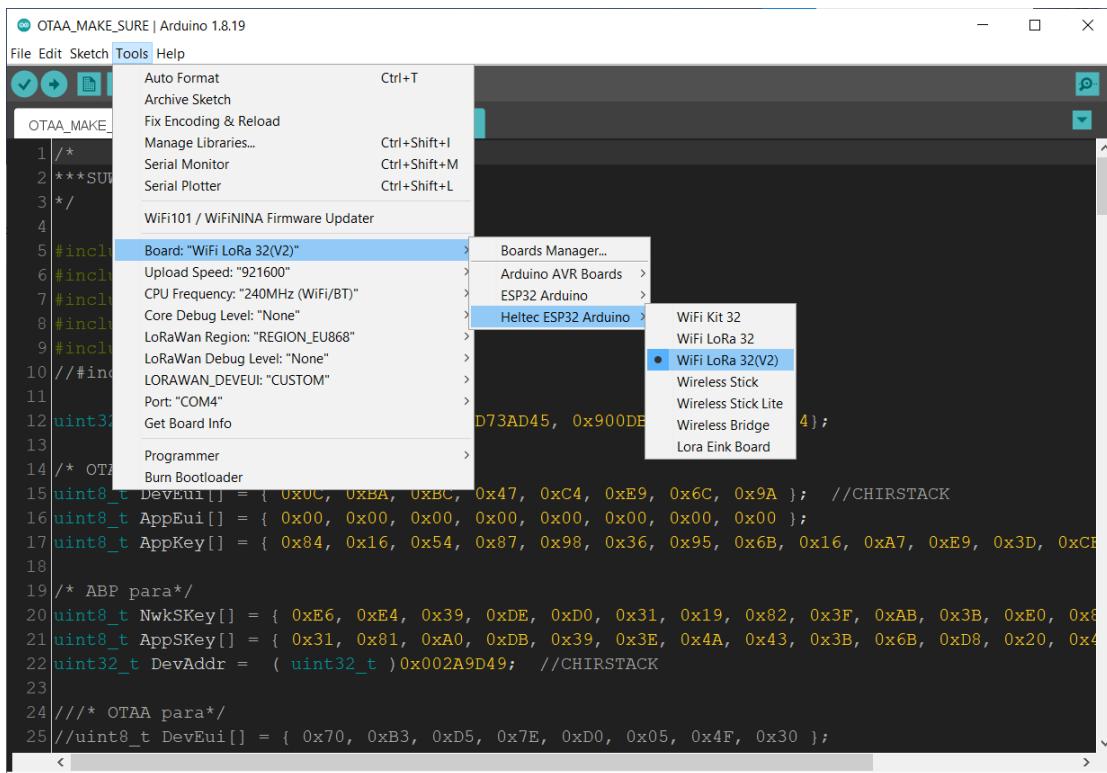


ติดตั้ง ข้อมูลของ Board heltec + libraries ใน โฟลเดอร์ C:\Users\ชื่อของuserที่ใช้\AppData\Local\Arduino15

<https://github.com/suwijak0023/Arduino15>



LORAWAN GUIDE BY SUWIJAK



The screenshot shows the Serial Monitor window with the port set to "COM4". The window displays a log of communication between the Node and a gateway. The log includes timestamped messages such as "DIOU:RX Done", "RX on freq 923200000 Hz at DR 2", "receive data: rssi = -118, snr = 2, datarate = 2", and "DIOO:RX Done". It also shows a transmission message "TX on freq 923200000 Hz at DR 2" and a status message "Status : START DEVICE 1". The log continues with various receive and transmit events, including "RX on freq 923200000 Hz at DR 2" and "RX on freq 923200000 Hz at DR 2" with different parameters like rssi = -117, snr = 4, datarate = 2.

```
18:49:52.274 -> DIOU:RX Done
18:49:52.274 -> RX on freq 923200000 Hz at DR 2
18:49:52.274 -> receive data: rssi = -118, snr = 2, datarate = 2
18:49:56.015 -> DIOO:RX Done
18:49:56.015 -> RX on freq 923200000 Hz at DR 2
18:49:56.015 -> receive data: rssi = -116, snr = 3, datarate = 2
18:49:56.015 -> +REV DATA:RXWIN2,RXSIZE 7,PORT 10
18:49:56.015 -> +REV DATA:data:83
18:49:56.015 -> Status : START DEVICE 1
18:49:56.015 ->
18:49:56.015 -> 1:Data InPut : StartD1
18:49:56.015 ->
18:50:05.538 -> confirmed uplink sending ...
18:50:05.584 -> TX on freq 923200000 Hz at DR 2
18:50:06.000 -> DIOO:TX Done
18:50:06.000 -> RX on freq 923200000 Hz at DR 2
18:50:07.019 -> RX on freq 923200000 Hz at DR 2
18:50:07.342 -> DIOO:RX Done
18:50:07.342 -> RX on freq 923200000 Hz at DR 2
18:50:07.342 -> receive data: rssi = -117, snr = 4, datarate = 2
18:50:11.133 -> DIOO:RX Done
18:50:11.133 -> RX on freq 923200000 Hz at DR 2
18:50:11.133 -> receive data: rssi = -119, snr = 1, datarate = 2
18:50:11.133 -> +REV DATA:RXWIN2,RXSIZE 4,PORT 10
18:50:11.133 -> +REV DATA:data:76
18:50:11.133 -> Status : UNLOCK DEVICE 1
18:50:11.133 -> 2:Data InPut : LOCK
18:50:11.133 ->
```

หน้านี้จะแสดงการรับข้อมูลจาก MQTT และจะสั่งการทำงานของ Node

LORAWAN GUIDE BY SUWIJAK

```

// OMA-MAKE-SURE - downlinking | Arduino 1.8.19
File Edit Sketch Tools Help
GTA-MAKE-SURE sketch main.ino
1 #include <LoRa.h>
2 #define LEDPin 29
3 #define LockPin 36
4 void appEvent_t_data()
5 {
6     lora.println("data:Downlink", _data);
7     switch (_data)
8     {
9         case 0:
10        {
11             pinMode(LEDPin, OUTPUT);
12             digitalWrite(LEDPin, HIGH);
13             pinMode(LockPin, INPUT);
14             digitalWrite(LockPin, HIGH);
15             Serial.println("status : START DEVICE 1");
16             break;
17         }
18         case 16:
19        {
20             pinMode(LEDPin, INPUT);
21             digitalWrite(LEDPin, LOW);
22             pinMode(LockPin, INPUT);
23             digitalWrite(LockPin, LOW);
24             Serial.print("Status : UNLOCK DEVICE 1 ");
25             break;
26         }
27     }
28 }
29
30 Done Sketch
31 invalid library found in C:\Users\YON\AppData\Local\Arduino15\packages\Heltec\esp32\hardware\esp32\0.0.0\libraries\c\SSU32 Azurelor Arduino: no headers files (.h) found in C:\Users\YON\AppData\Local\Arduino15\packag
32
33 Updates available for some of your boards and libraries | Boards | Libraries |

```

หน้านี้จะแสดงหน้าของ Down link รับข้อมูลจาก Server และได้ตั้งเงื่อนไขแบบ Switch case

```

// OMA-MAKE-SURE - downlinking | Arduino 1.8.19
File Edit Sketch Tools Help
GTA-MAKE-SURE sketch main.ino
1 #include <LoRa.h>
2 String LoRa_data;
3 nuint_t num = 0;
4 bool LoRaDownLink = false;
5 uint32_t LoRaDownLinkTime;
6
7 void downlinkHandleData(mcpsIndication_t *mcpsIndication)
8 {
9     LoRa_data = "";
10    lora.readData((mcpsIndication->RxDataSize), mcpsIndication->RxData[0], mcpsIndication->RxData[1], mcpsIndication->RxData[2], mcpsIndication->RxData[3]);
11    lora.println("data:DOWN");
12    app_mcpsIndication->Buff[0];
13    for (nuint_t i = 0; i < mcpsIndication->BufferSize; i++)
14    {
15        // Serial.print("SubArrn", mcpsIndication->Buff[i]);
16        LoRa_data = LoRa_data + (String)(char)mcpsIndication->Buff[i];
17    }
18    lora.println("\r\n");
19
20    LoRaDownLink = true;
21    LoRaDownLinkTime = millis();
22    num++;
23    Serial.println();
24    Serial.print(num);
25    Serial.print(":");
26    Serial.print("Data: ");
27    Serial.print(LoRa_data);
28    Serial.print("\r\n");
29
30 }
31
32 Done Sketch
33 invalid library found in C:\Users\YON\AppData\Local\Arduino15\packages\Heltec\esp32\hardware\esp32\0.0.0\libraries\c\SSU32 Azurelor Arduino: no headers files (.h) found in C:\Users\YON\AppData\Local\Arduino15\packag
34
35 Updates available for some of your boards and libraries | Boards | Libraries |

```

หน้านี้จะแสดงหน้าของ Down link รับข้อมูลจาก Server และทำการแปลงข้อมูลให้เป็น string

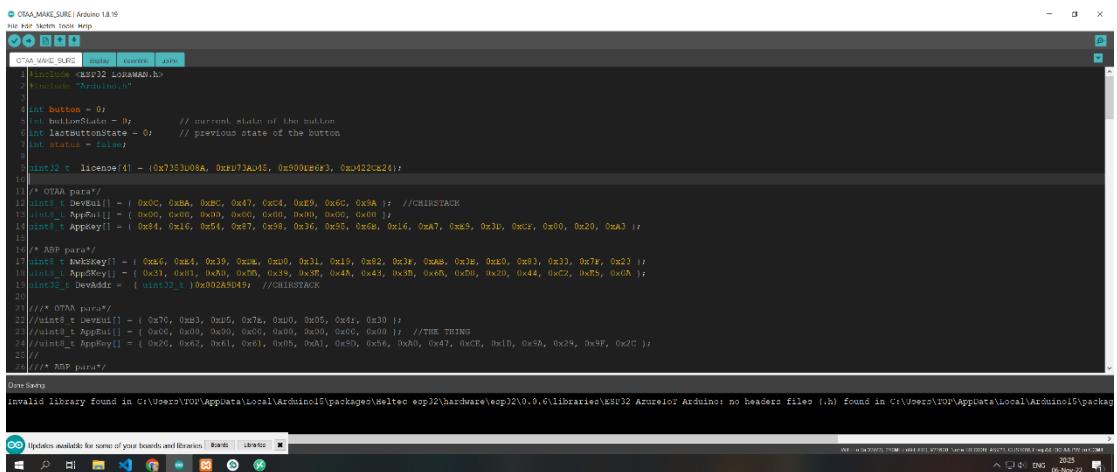
```

// OMA-MAKE-SURE - uplinking | Arduino 1.8.19
File Edit Sketch Tools Help
GTA-MAKE-SURE sketch main.ino
1 //MCU1000 bdc10804
2
3 static void prepareTxFrame( nuint_t port )
4 {
5     appDataSize = 8; //AppDataSize max value is 64 ( src/Commissioning.h > 128 )
6     appData[0] = 0x74;
7     appData[1] = 0x74;
8     appData[2] = 0x65;
9     appData[3] = 0x65;
10    appData[4] = 0x73;
11    appData[5] = 0x73;
12    appData[6] = 0x76;
13
14    static void Txup_Send_Button_On( nuint_t port )
15    {
16        appDataSize = 10 //AppDataSize max value is 64 ( src/Commissioning.h > 128 )
17        appData[0] = 0x42;
18        appData[1] = 0x54;
19        appData[2] = 0x54;
20        appData[3] = 0x41;
21        appData[4] = 0x68;
22        appData[5] = 0x76;
23        appData[6] = 0x6F;
24        appData[7] = 0x6F;
25        appData[8] = 0x4F;
26        appData[9] = 0x6F;
27
28 // TXDATA TO HEX ONLY NOT CURRENT NUMBER TO HEX
29
30 }
31
32 Done Sketch
33 invalid library found in C:\Users\YON\AppData\Local\Arduino15\packages\Heltec\esp32\hardware\esp32\0.0.0\libraries\c\SSU32 Azurelor Arduino: no headers files (.h) found in C:\Users\YON\AppData\Local\Arduino15\packag
34
35 Updates available for some of your boards and libraries | Boards | Libraries |

```

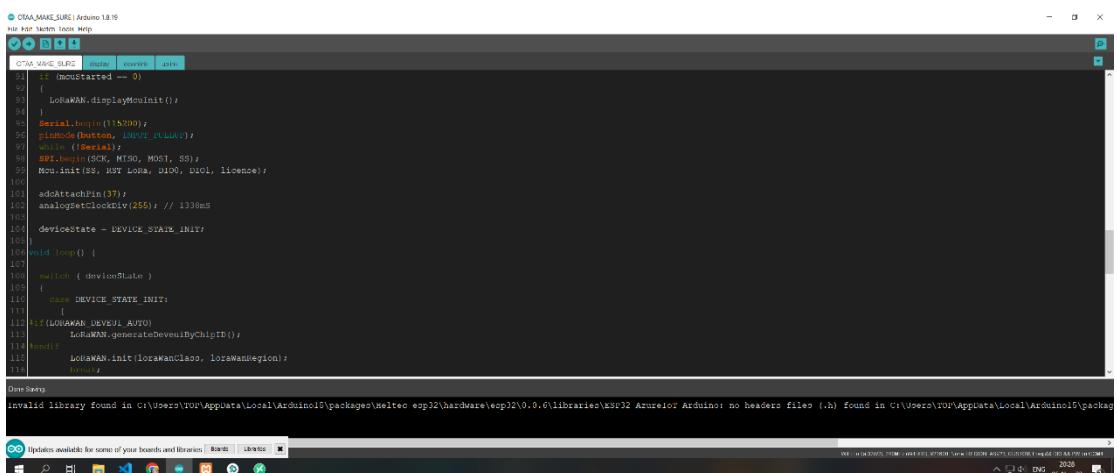
หน้านี้จะแสดงหน้าของหน้า Up link ข้อมูลไป Server โดยทำการแปลงข้อมูลให้เป็นรูปแบบ Hex

LORAWAN GUIDE BY SUWIJAK



```
/* OTAA para/
uint8_t DevEui[] = { 0x0C, 0x0A, 0x0C, 0x07, 0xC4, 0x9, 0x0C, 0xA }; //CHIRPSTACK
uint8_t AppKey[] = { 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00 }; //THE THING
uint8_t Appkey[] = { 0x94, 0x16, 0x0f, 0x07, 0x98, 0x36, 0x0e, 0x16, 0x07, 0x09, 0x04, 0x00, 0x20, 0x03 }; //CHIRPSTACK
// APP para/
uint8_t NwkSKey[] = { 0x06, 0x01, 0x05, 0x00, 0x31, 0x01, 0x02, 0x03, 0x0A, 0x0E, 0x00, 0x03, 0x03, 0x7, 0x21 }; //CHIRPSTACK
uint8_t AppSKey[] = { 0x31, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00 }; //THE THING
//uint8_t AppKey[] = { 0x26, 0x02, 0x01, 0x05, 0x01, 0x50, 0x56, 0x00, 0x47, 0xCE, 0x10, 0x5A, 0x24, 0x5F, 0x2C }; //CHIRPSTACK
//*/
// Device Parameters
#define DEV_EUI {0x0C, 0x0A, 0x0C, 0x07, 0xC4, 0x9, 0x0C, 0xA}
#define APP_KEY {0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
#define APP_SKEY {0x06, 0x01, 0x05, 0x00, 0x31, 0x01, 0x02, 0x03, 0x0A, 0x0E, 0x00, 0x03, 0x03, 0x7, 0x21}
#define NWKSKEY {0x31, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
#define APPSKEY {0x26, 0x02, 0x01, 0x05, 0x01, 0x50, 0x56, 0x00, 0x47, 0xCE, 0x10, 0x5A, 0x24, 0x5F, 0x2C}
```

หน้านี้จะแสดงหน้าของ DevEui,AppKey ของ OTAA และ Activation ของ ABP



```
if (!moustarted == 0)
{
    LoRaWAN.displayMouinit();
}

Serial.begin(115200);
pinMode(button, INPUT_PULLUP);
while (!Serial);
SPI.begin(SCK, MISO, MOSI, SS);
MouInit(SS, RST, LORA, DIO0, DIO1, license);

attachInterrupt(37);
analogSetClockDiv(255); // 133ms
deviceState = DEVICE_STATE_INIT;
loop();

void loop()
{
    mouInit();
    if (deviceState == DEVICE_STATE_INIT)
    {
        LoRaWAN.devEui();
        LoRaWAN.generateDevEuiByChipID();
        LoRaWAN.init(lorawanLaco, lorawanRegion);
    }
}

// Device Parameters
#define DEV_EUI {0x0C, 0x0A, 0x0C, 0x07, 0xC4, 0x9, 0x0C, 0xA}
#define APP_KEY {0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
#define APP_SKEY {0x06, 0x01, 0x05, 0x00, 0x31, 0x01, 0x02, 0x03, 0x0A, 0x0E, 0x00, 0x03, 0x03, 0x7, 0x21}
#define NWKSKEY {0x31, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
#define APPSKEY {0x26, 0x02, 0x01, 0x05, 0x01, 0x50, 0x56, 0x00, 0x47, 0xCE, 0x10, 0x5A, 0x24, 0x5F, 0x2C}
```

หน้านี้จะเป็นการ Setup หรือการตั้งค่าข้อมูล

LORAWAN GUIDE BY SUWIJAK

```
OSA-JANKEURU: Arduino 1.8.19
no file selected from menu

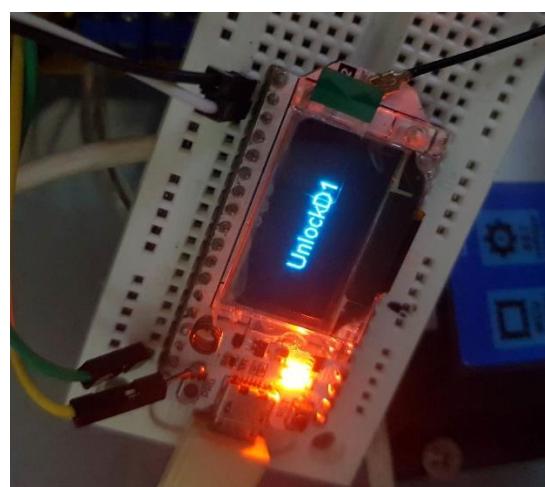
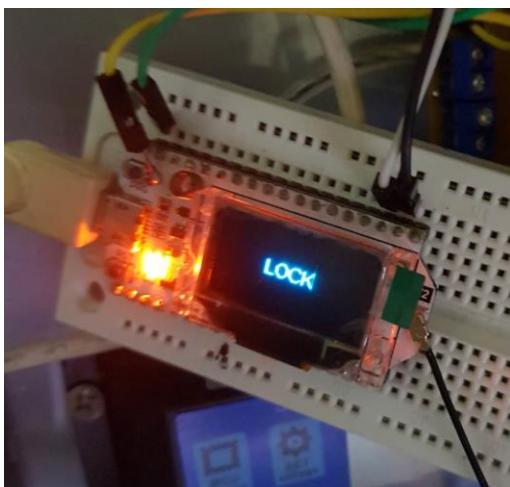
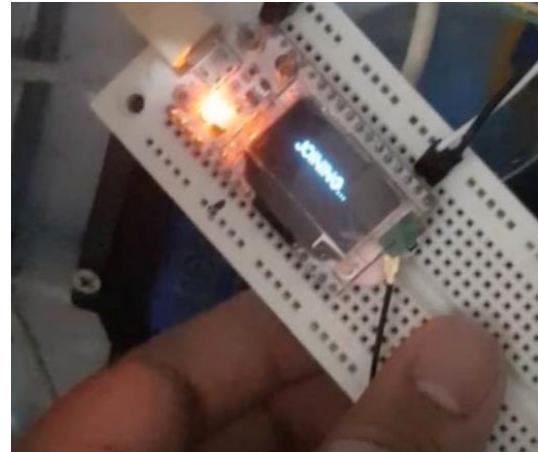
G704_WAVE_SLEUTH: display, assets, ideHelp

147
148     case DEVICE_STATE_JOINING:
149     {
150         WiFiManager.join();
151         WiFiManager.displayJoining();
152         break;
153     }
154     case DEVICE_STATE_SENDING:
155     {
156         WiFiManager.displaySending();
157         //    prepareTxFrame( appPort );
158         //    TXUP Send Button On( appPort );
159         if (digitalRead(button) == LOW)
160         {
161             status = !status;
162             Serial.println(status);
163             //    digitalWrite(red, status);
164         }
165     }
166     while (digitalRead(button) == LOW);
167     delay(50);
168     if (status == 1)
169     {
170         //    TXUP SetParameter( appPort );
171         //    TXUP SetParameterName( appPort );
172         TXUP_Send_Button_On( appPort );
173         displayInfo();
174         delay(50);
175     }
176 }

AppTerminated

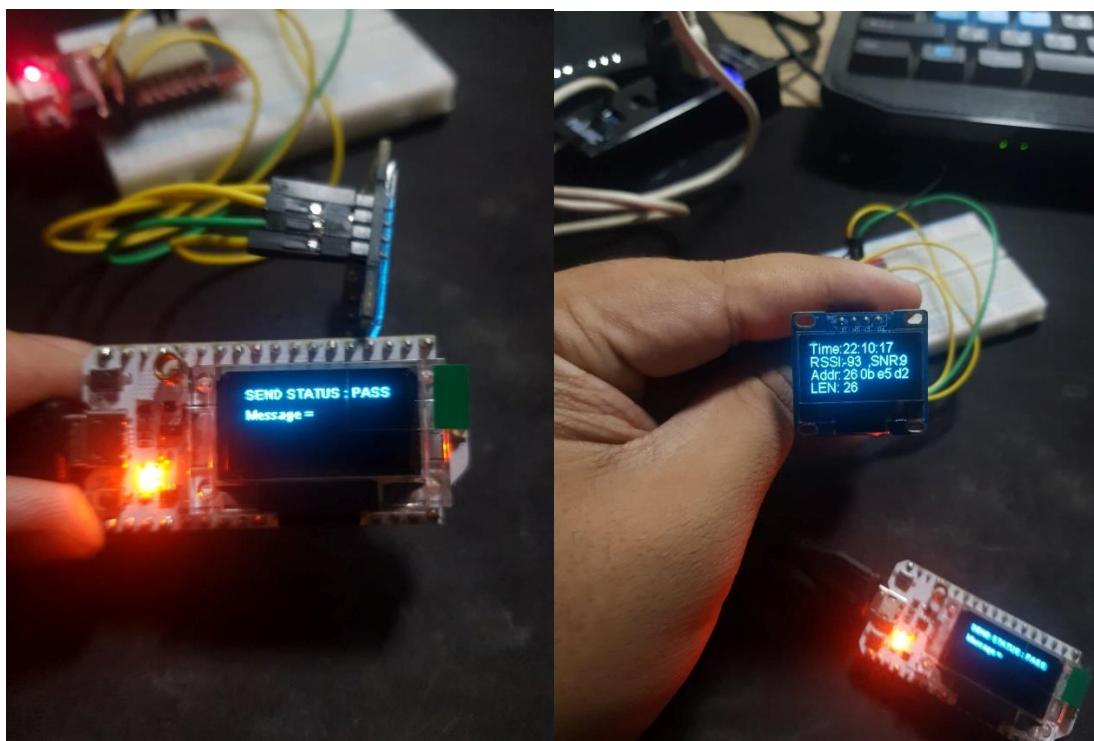
invalid library found in C:\Users\JON\AppData\Local\Arduino15\packages\Heltec\esp32\hardware\esp32\0.0.0\libraries\ESP32_AzureIoT_Arduino: no headers file (.h) found in C:\Users\JON\AppData\Local\Arduino15\packag
```

หน้านี้จะแสดงหน้า loop



หน้านี้แสดงการรับข้อมูลที่ได้ Server มากยัง Node ปลายทาง

NODE TO NODE



หน้านี้แสดงถึงการส่งข้อมูลระหว่าง Node หา Node ด้วยกันโดยจะมีฝั่งส่งและรับ

SC GATEWAY HELTEC

กรณีใช้ Esp32 เป็น Gateway

ESP Gateway Config

Version: V.5.3.3.H; 180825a

ESP alive since Saturday 13-8-2022 14:55:20, Uptime: 0-00:54:52

Current time Saturday 13-8-2022 15:50:00

[Documentation](#) [Basic Mode](#) [Log Files](#)

Package Statistics

Counter	C 0	C 1	C 2	Pkgs	Pkgs/hr
Packages Downlink				0	
Packages Uplink Total				8	8
Packages Uplink OK				8	
SF7 rcvd	6	1	1	8	100 %
SF8 rcvd	0	0	0	0	0 %
SF9 rcvd	0	0	0	0	0 %
SF10 rcvd	0	0	0	0	0 %
SF11 rcvd	0	0	0	0	0 %
SF12 rcvd	0	0	0	0	0 %

Message History

Time	Node	C	Freq	SF	pRSSI
Saturday 13-8-2022 15:45:17	26 0d 26 15	2	923600000	7	-71
Saturday 13-8-2022 15:30:26	26 0d 26 15	0	923200000	7	-73
Saturday 13-8-2022 15:29:59	26 0d 26 15	0	923200000	7	-75
Saturday 13-8-2022 15:28:14	26 0d 26 15	0	923200000	7	-72
Saturday 13-8-2022 15:25:52	26 0d 93 bc	0	923200000	7	-75
Saturday 13-8-2022 15:09:09	26 0d 26 15	0	923200000	7	-73
Saturday 13-8-2022 15:01:31	26 0d 26 15	1	923400000	7	-71
Saturday 13-8-2022 14:57:57	26 0d 26 15	0	923200000	7	-70

Gateway Settings

Setting	Value	Set
CAD	ON	ON OFF
HOP	ON	ON OFF
SF Setting	AUTO	
Channel	AUTO	
Debug level	1	- +
Debug pattern	SCN CAD RX TX PRE MAI GUI RDIO	
Usb Debug	1	
WWW Refresh	ON	ON OFF
Update Firmware		UPDATE
Format SPIFFS		FORMAT
Statistics	0	RESET
Boots and Resets	17	RESET

WiFi Config

Parameter	Value
WiFi host	esp32-e282c4
WiFi SSID	SANGTONG 2.4G
IP Address	192.168.1.142
IP Gateway	192.168.1.1
NTP Server	nl.pool.ntp.org
LoRa Router	au1.cloud.thethings.network
LoRa Router IP	13.55.29.193

System Status

Parameter	Value	Set
Gateway ID	2462abFFFFe282c4	
Free heap	942040	

ជំនួយ

ชื่อ – นามสกุล
อีเมล
การศึกษา

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หลักสูตรวิศวกรรมคอมพิวเตอร์
มหาวิทยาลัยเกษตรศาสตร์ วิทยาเขตเฉลิม
พระเกียรติจังหวัดสกลนคร

Link ข้อมูลและวิดีโอที่เกี่ยวข้อง (อ้างอิง)

Github ของผู้จัดทำ

<https://github.com/suwijak0023/Lorawan-libraries-Code-Esp32>

Board libraries

<https://github.com/suwijak0023/Arduino15>

Chirstack Setup

<https://www.youtube.com/watch?v=FnTP7t47DlI&list=PL9FegcZTeB9LRLnXtN6OMkVSZYgHdlmOr>

MQTT LORA CHIRSTACK

<https://www.youtube.com/watch?v=J4LITgZljPE>

ESP32 LoRaWan Gateway + LoRa Node

<https://meetjoeblog.com/2018/04/29/esp32-lorawan-gateway/>

LoRaWAN node วัดอุณหภูมิและความชื้น ด้วย Heltec ESP32 Wifi LoRa Oled V.2 ใช้ได้ กับ TheThings หรือ Helium

<https://khunsomsak.medium.com/%E0%B8%97%E0%B8%B3-lorawan-node-%E0%B8%A7%E0%B8%B1%E0%B8%94%E0%B8%AD%E0%B8%B8%E0%B8%93%E0%B8%AB%E0%B8%A0%E0%B8%B9%E0%B8%A1%E0%B8%B4%E0%B9%81%E0%B8%A5%E0%B8%B0%E0%B8%84%E0%B8%A7%E0%B8%B2%E0%B8%A1%E0%B8%8A%E0%B9%89%E0%B8%99-%E0%B8%94%E0%B9%89%E0%B8%A7%E0%B8%A2-heltec-esp32-wifi-lora-oled-v-2-836fabd400b1>

[LoRaWAN] ทดสอบสร้าง Server รับข้อมูลจาก End-node [ต่อ]

<https://iamteam.me/lorawan-%E0%B8%97%E0%B8%94%E0%B8%AA%E0%B8%AD%E0%B8%9A%E0%B8%>

[AA%E0%B8%A3%E0%B9%89%E0%B8%B2%E0%B8%87-server-%E0%B8%A3%E0%B8%B1%E0%B8%9A%E0%B8%82%E0%B9%89%E0%B8%A
D%E0%B8%A1%E0%B8%B9%E0%B8%A5%E0%B8%88%E0%B8%B2%E0%B8%
81-end-node-%E0%B8%95%E0%B9%88%E0%B8%AD-75e9484c2df8](#)

End node and gateway connection

<https://www.thethingsnetwork.org/forum/t/end-node-and-gateway-connection/47147/3>

ESP8266 / ESP32 & Mesh Network ตอนที่ 4: Painlessmesh Bridge with LoRa

<https://meetjoeblog.com/2018/04/25/esp8266-esp32-painlessmesh-bridge-with-lora-ep4/>

<https://www.thethingsnetwork.org/forum/t/how-do-i-send-data-from-my-gateway-to-node/17912/3>

<https://how2electronics.com/esp32-lora-thingspeak-gateway-sensor-node/>

<https://www.sparkfun.com/products/18074>

<https://electropeak.com/learn/the-beginners-guide-to-display-text-image-animation-on-oled-display-by-arduino/>

<a href="http://lorawan.lnwshop.com/product/75/heltec-esp32-wifi-lora-oled-v-2-%E0%B9%80%E0%B8%AA%E0%B8%B2%E0%B8%81%E0%B8%A5%E0%B8%A
1%E0%B8%9A%E0%B8%B1%E0%B8%94%E0%B8%81%E0%B8%A3%E0%B8%
B5%E0%B8%82%E0%B8%B2%E0%B9%84%E0%B8%A7%E0%B9%89%E0%B
9%81%E0%B8%A5%E0%B9%89%E0%B8%A7

https://wiki.octoate.de/doku.php/thethingsnetwork:esp32_mit_868_mhz_lora_modul

<https://circuitdigest.com/microcontroller-projects/esp32-lora-communication-with-the-things-network>

<http://10.130.1.1/cgi-bin/lorawan.has>

<https://robotzero.one/heltec-lora32-lorawan-node/>

<http://wiki.dragino.com/xwiki/bin/view/Main/LoRaWAN%20Communication%20Debug/>

<https://how2electronics.com/esp32-lora-sx1278-76-transmitter-receiver/>

<https://www.youtube.com/watch?v=eZhDvsJzwwI>

<https://www.youtube.com/watch?v=0HYzXdOxnEE>

<https://www.youtube.com/watch?v=VXNfNDcFU2c>

<https://www.youtube.com/watch?v=k5-1o8WifQM>

<https://www.youtube.com/watch?v=lZXiaMFYwfw>

<https://iamteam.me lorawan-%E0%B8%97%E0%B8%94%E0%B8%AA%E0%B8%AD%E0%B8%9A%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%AA%E0%B9%88%E0%B8%87%E0%B8%82%E0%B9%89%E0%B8%AD%E0%B8%A1%E0%B8%B9%E0%B8%A5%E0%B8%88%E0%B8%B2%E0%B8%81-server-%E0%B9%84%E0%B8%9B%E0%B8%A2%E0%B8%B1%E0%B8%87-end-node-downlink-491f59c20f2e>

https://www.youtube.com/watch?v=_XkVR-XiHkw

https://docs.heltec.cn/#/en/products/lora/lora_node/heltec_lora_node_list

https://docs.heltec.cn/general/how_to_config_raspberry_pi.html

<http://wiki.dragino.com/xwiki/bin/view/Main/Notes%20for%20ChirpStack/>

<https://forums.raspberrypi.com/viewtopic.php?t=259977>

<https://thingsboard.io/docs/user-guide/integrations/chirpstack/>

<https://www.youtube.com/watch?v=E-DjCbFyR7U>

<https://www.hackster.io/sidikalamin/full-stack-rpi-chirpstack-lorawan-environment-dashboard-f51bd0>

<https://sidik.my/gabungan-node-lorawan-gateway-bridge-network-server-application-server-mqtt-node-red-influxdb-grafana/>

https://www.youtube.com/watch?v=jp_2gwBrOc8

<https://easyelectronicsproject.com/arduino/lora-arduino-control-relay/>

https://www.youtube.com/watch?v=jp_2gwBrOc8

<https://www.youtube.com/watch?v=RqNntBJXyOo>

https://www.youtube.com/watch?v=U_OUIGAtjM

<https://www.youtube.com/watch?v=yqapqKijVO4&t=78s>

<https://www.instructables.com/Add-a-Sensor-to-LoraExample-DHT-22/>

<https://github.com/ucwlabs/iot-monitoring-ttn/blob/master/lora-sensor-node-dht/lora-sensor-node-dht.ino>

<https://www.youtube.com/watch?v=llFwNOlhwck>

<https://www.instructables.com/Intelligent-Street-Light-Using-LoRa/>

<https://www.youtube.com/watch?v=jPy7YJcAmx4>

<https://tutorial.cytron.io/2021/12/13/sending-data-from-node-to-the-things-stack/>

<https://www.youtube.com/watch?v=fFEVU1oJLqk>

<https://www.youtube.com/watch?v=q5Wj-EZM4Bg>

<https://tommydesrochers.com/controlez-votre-esp32-a-partir-dune-page-web-version-facile-esp32-ep3/>

<https://randomnerdtutorials.com/cloud-weather-station-esp32-esp8266/>