

Dispositius LoRaWAN

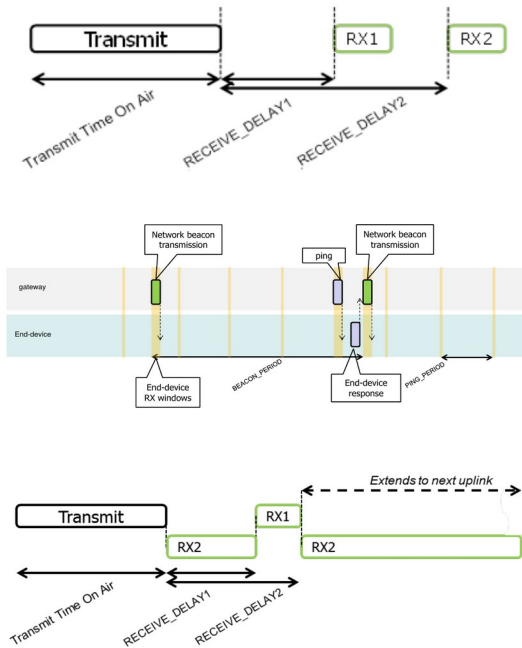
Teoria

Característiques d'un dispositiu LoRaWAN

Tipus de dispositius

Tres tipus de dispositius (*device classes*):

- **Classe A:** Tenen una comunicació bidireccional parcial, donat que només poden rebre dades de la Gateway quan han enviat prèviament un paquet. Aquesta classe és la que menys energia necessita, els dispositius estan normalment dormint. No són temps-real.
- **Classe B:** Aquesta classe de dispositius estan **sincronitzats** amb la Gateway corresponent de manera que poden rebre paquets de dades des de la Gateway a certs intervals pre-negociats (*beacons*) sense la necessitat d'haver enviat un paquet prèviament. No són temps-real, però són previsibles.
- **Classe C:** Els dispositius d'aquesta classe estan permanentment en disposició de rebre paquets des de la Gateway (sempre que no estigui enviant). Aquesta classe és la que més energia consumeix. Són temps-real.



Velocitat adaptativa (ADR)

Hi ha dues maneres d'arribar més lluny: cridar més o parlar més a poc a poc. Ambdues, però, consumeixen més energia. La xarxa s'autogestiona per optimitzar consum i congestió:

- Si ADR està activat, la xarxa ajusta el **SF** i **potència TX** del dispositiu:
 - Si bona cobertura → Disminueix SF (més ràpid, menys consum, menys rang)
 - Si mala cobertura → Augmenta SF (més lent, més consum, més rang)
- Millora el funcionament de la xarxa
 - Reduint el temps en aire → **menys col·lisions**
 - Reduint els dispositius que una passarel·la ha de gestionar → **més capacitat**

Pot haver-hi **situacions on no es recomana ADR**:

- Dispositius mòbils
- Dispositius amb entorn molt variable

Cicle de treball

El cicle de treball (**duty cycle**) màxim està regulat per l'ETSI (*European Telecommunications Standards Institute*). Aquest defineix per la banda 868 MHz:

- Ocupació de l'1% del temps
- 1% de 3600 segons → 36 segons per hora
- Mòduls ràdio fan càlcul automàtic i no permeten sobre-passar-lo

A sobre d'aquest, diferents xarxes poden imposar cicles més restrictius. TTN defineix una «política de joc net» (**Fair Access Policy**) que imposa:

- Enviar: 30 segons cada 24 hores (*uplink*)
- Rebre: 10 missatges cada 24 hores (*downlink*)

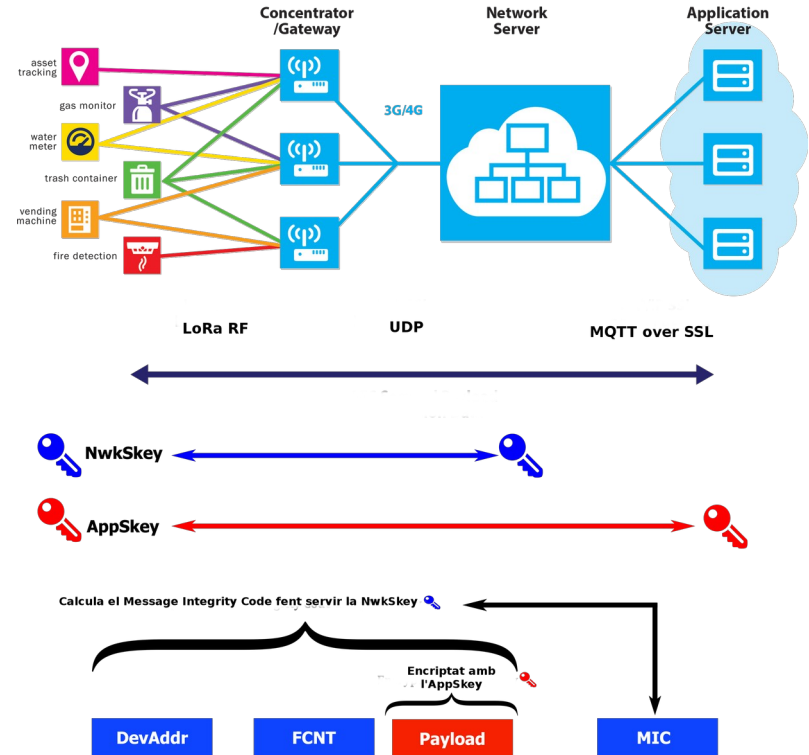
Seguretat

Les dades del sensor (**payload**) estan encriptades amb l'AppSkey (AES128).

El missatge està signat amb el MIC (**codi d'integritat del missatge**), que es calcula amb el *payload*, el *devaddr*, el *fcnt* i fent servir la NwkSkey.

La xarxa "no pot saber" què s'està enviant, només l'aplicació.

TTN permet descodificar el missatge en el *backend*, per tant es recomana fer servir un *handler* segur per connectar-se (MQTT sobre SSL).



Activació

Un dispositiu connectat a una xarxa LoRaWAN ha de emmagatzemar els següents valors:

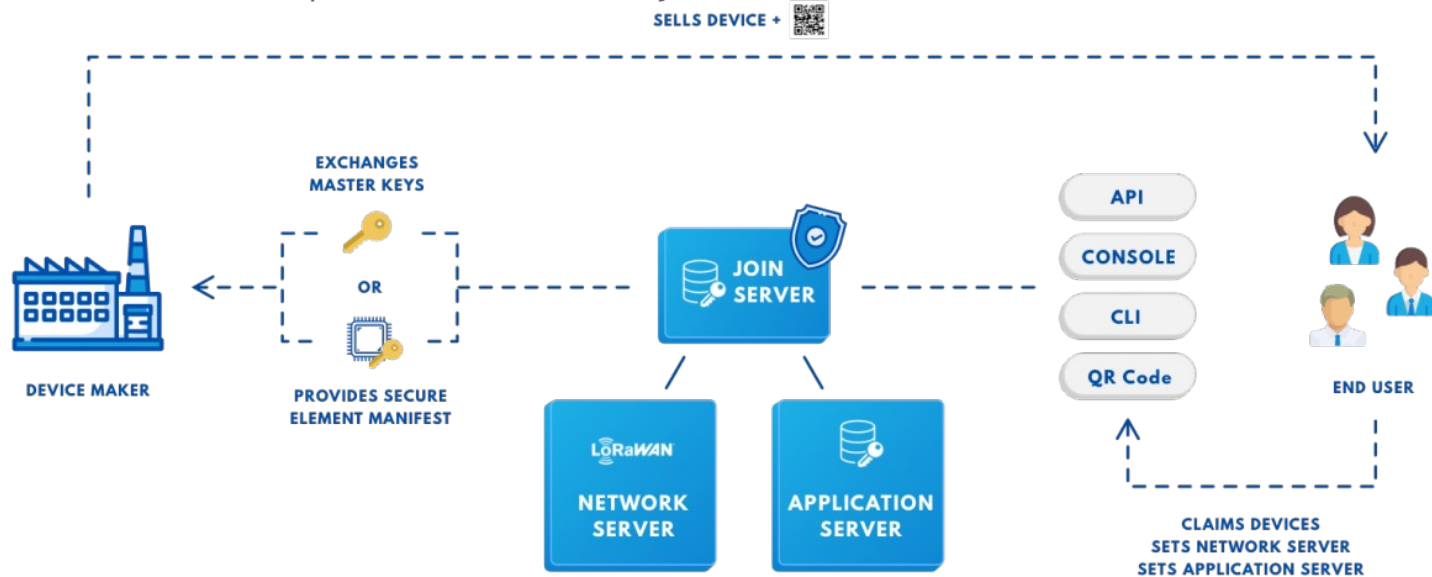
- DevAddr (una adreça)
- NwkSKey (clau de xarxa per la sessió)
- AppSKey (clau d'aplicació per la sessió)

LoRaWAN defineix dos mètodes per disposar d'aquestes dades:

- **ABP** (*Activation By Personalization*): Cada dispositiu porta les aquest valors (identificador i claus) pre-programades. En general és més insegur (les claus estan al dispositiu) però té l'avantatge que no cal negociació prèvia.
- **OTAA** (*Over The Air Activation*): Cal una negociació prèvia per cada sessió de connexió. És més segur i és el que normalment fan servir els dispositius comercials. Per realitzar aquesta negociació el dispositiu necessita:
 - DevEUI (identificador únic del dispositiu)
 - AppEUI o JoinEUI (identificador de l'aplicatiu en el qual el dispositiu està registrat)
 - AppKey (clau única de registre)

Activació (manifest file)

Alguns fabricants (com Microchip) comencen a proporcionar *manifest files* per poder registrar automàticament els teus dispositius a través d'un *Join Server*.



Components

Circuits integrats

Semtech fabrica *transceivers* (ràdios) per nodes: SX1276, SX1277, SX1278 i SX1279...

Aquestes ràdios estan preparades per diferents freqüències i *spreading factors* i orientades a diferents mercats.

TTN a Europa és comparable amb dispositius basats en SX1276 (137-1020Mhz i SF6-12, tot i que l'ús de SF6 està limitat).

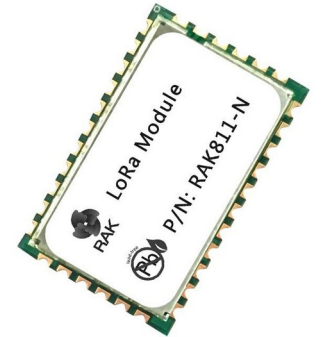
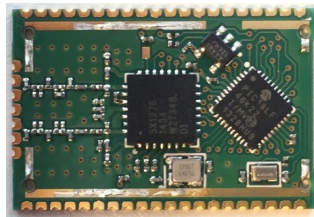
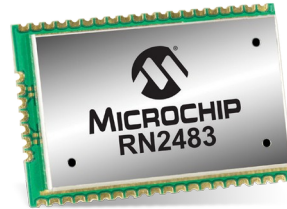
Semtech llicencia la fabricació a altres fabricants. De moment només HopeRF, Microchip i ST fabriquen xips.

Cada cop hi ha més i més xips i mòduls disponibles i és més i més fàcil integrar LoRa en un projecte.



Mòduls

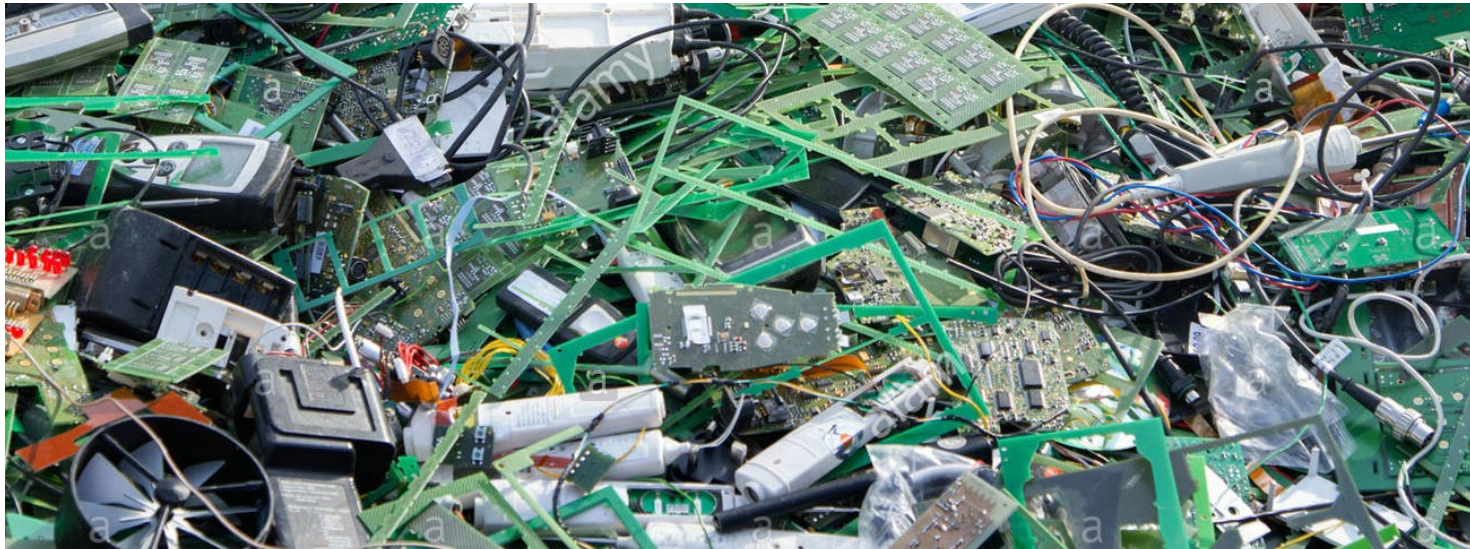
Una aproximació habitual a l'hora d'integrar LoRaWAN en un projecte és fer servir mòduls. Aquest mòduls inclouen un microcontrolador encarregat de la pila LoRaWAN i un xip LoRa per la transmissió i recepció. Habitualment implementen un protocol sèrie per interaccionar amb el controlador principal del producte.



Dispositius de desenvolupament

Plaques de desenvolupament

Més enllà de les plaques d'avaluació i desenvolupament dels fabricants (cares i orientades a un mercat molt professional) hi ha moltes opcions de plaques de desenvolupament pensades per proves de concepte i, algunes, per desplegaments petits.



The Things Uno

- Arduino Leonardo compatible board
- Microchip Atmel ATMEGA32U4
 - 8-bit AVR RISC-based
 - 32KB flash
 - 2.5KB SRAM
 - 1KB EEPROM
- Microchip RN2483 LoRaWAN
 - PIC-based
 - UART interface
- C-programable
- Arduino IDE compatible
- ~48€



Arduino MKR WAN 1300

- Arduino MKR family
- Microchip Atmel SAMD21G
 - Cortex M0+ 32bits
 - 48MHz
 - 256Kb flash
 - 32Kb SRAM
- Murata CMWX1ZZABZ LoRaWAN module
 - STM32-based
 - UART interface
- C-programable
- Arduino IDE compatible
- ~35€



BastWAN

- RAK4260
 - Microchip SAMR34 (ARM Cortex M0-
 - 48 MHz
 - 256Kb Flash
 - 32Kb RAM
- LoRa radio in module based on SX127X
- ATECC608A crypto chip
- C
- Arduino IDE compatible
- Designed by Electronic Cats a OSHW
- Manufactured by RAKwireless
- ~12€



WisBlock

- Modular prototyping, PoC, production ready platform
- LPWAN Module
 - Nordic nRF52840 (ARM Cortex M4F)
 - 64 MHz
 - 1MB flash
 - 256Kb RAM
- Several radios
 - Bluetooth LE
 - LoRa
- SX1272
 - SPI interface
- C
- Arduino IDE compatible
- ~30€ (base + LPWAN module)



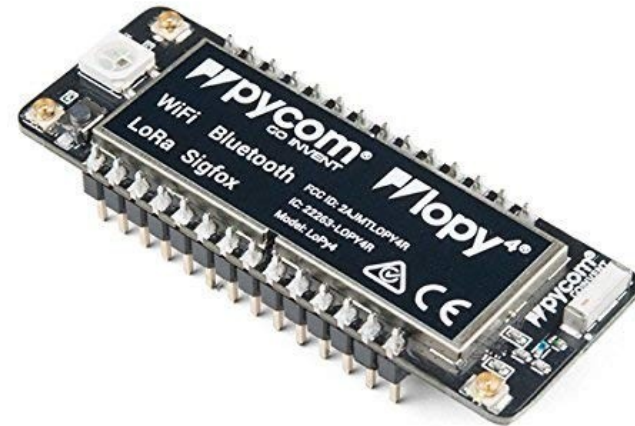
CubeCell

- ASR6052
 - ARM Cortex M0+
 - 48 MHz
 - 128Kb flash
 - 16Kb SRAM
- SX1276
 - SPI interface
- C
- Arduino IDE compatible
- ~12€



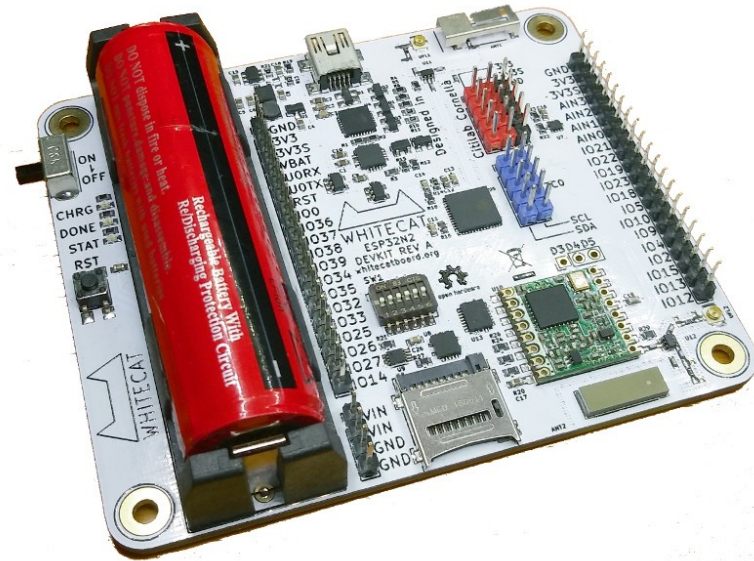
PyCom LoPy4

- Espressif ESP32 based
 - Xtensa dual-core 32-bit LX6
 - 240 MHz
 - 4MB external flash
 - 512Kb RAM
- Several radios
 - WiFi
 - Bluetooth LE
 - LoRa
 - Sigfox
- SX1276
 - SPI interface
- MicroPython programmable
- ~35€



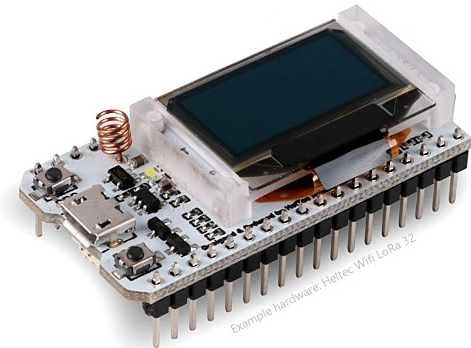
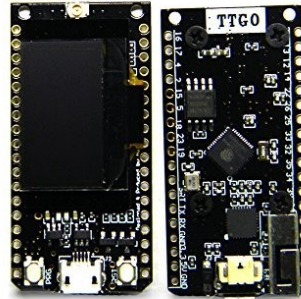
WhiteCatBoard N2

- Espressif ESP32 based
 - Xtensa dual-core 32-bit LX6
 - 240 MHz
 - 4MB external flash
 - 512Kb RAM
- Several radios
 - WiFi
 - Bluetooth LE
 - LoRa
- Integrates a HopeRF95 (SX1276)
 - SPI interface
- KM0 (designed at the Citilab Cornellà)
- Lua o Blockly
- ~40€



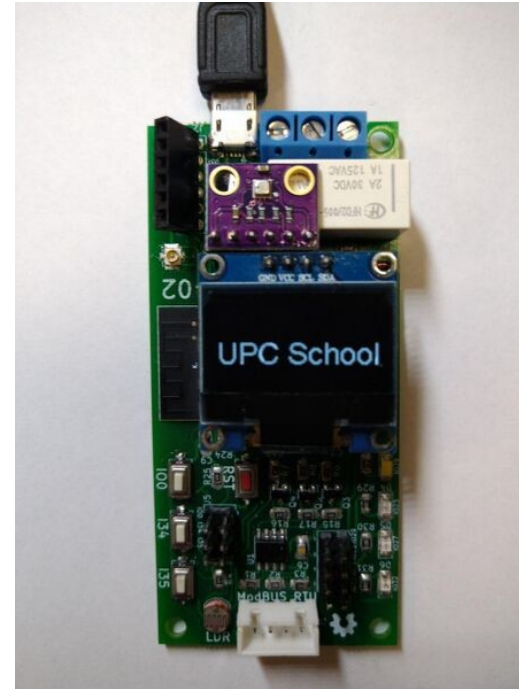
TTGO / HELTEC LoRa32

- Espressif ESP32 based
 - Xtensa dual-core 32-bit LX6
 - 240 MHz
 - 4MB external flash
 - 512Kb RAM
- Several radios
 - WiFi
 - Bluetooth LE
 - LoRa
- SX1276
 - SPI interface
- C
- Arduino IDE compatible
- ~12€



Kit IoT-02

- Espressif ESP32 based
 - Xtensa dual-core 32-bit LX6
 - 240 MHz
 - 4MB external flash
 - 512Kb RAM
- Several radios
 - WiFi
 - Bluetooth LE
 - LoRa
- SX1276
 - SPI interface
- 3 user buttons, 4 leds, LDR
- Latching relay
- I2C OLED
- I2C BME280
- MODBUS RTU
- C
- Arduino IDE compatible
- Micropython
- ~58€



Pràctica

Alta de dispositius OTAA

Alta OTAA (1)



THE THINGS STACK
Community Edition

- Overview
- Applications**
- Gateways
- Organizations

EU1 Community
No SLA applicable

Jordi Binefa

Curs TTNCat sobre TTSv3

Applications > Curs TTNCat sobre TTSv3

Overview

Curs TTNCat sobre TTSv3

ID: curs-tts-ttncat

No recent activity

0 End devices 1 Collaborator 0 API keys

End devices

Live data

Payload formatters

Integrations

Collaborators

API keys

General settings

General information

Application ID	<input type="text" value="curs-tts-ttncat"/>
Created at	Oct 17, 2022 15:31:28
Last updated at	Oct 17, 2022 15:31:28

Live data

See all activity

15:31:28	curs-tts-t...	Create application
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End devices (0)

Search

Import end devices

Add end device

Alta OTAA (2)



Applications > Curs TTNCat sobre TTSv3



Curs TTNCat sobre TTSv3

ID: curs-tts-ttnocat

No recent activity ⓘ

0 End devices 1 Collaborator 0 API keys

General information

Application ID

Created at Oct 17, 2022 15:31:28

Last updated at Oct 17, 2022 15:31:28

Live data

[See all activity →](#)

+ 15:31:28 curs-tts-t... Create application

Alta OTAA (3)



Applications > Curs TTNCat sobre TTSv3 > End devices

End devices (0)

Search

Import end devices

Add end device

ID

Name

DevEUI

JoinEUI

Last activity

Applications > Curs TTNCat sobre TTSv3 > End devices

No items found

Applications > Curs TTNCat sobre TTSv3 > End devices

Register end device

Does your end device have a QR code? Scan it to speed up onboarding.

Scan end device QR code [Learn more](#)

End device type

Input Method

- Select the end device in the LoRaWAN Device Repository
- Enter end device specifics manually

End device brand

Type to search...

Cannot find your exact end device? [Get help here](#) and try **enter end device specifics manually** option above.

Register end device

Does your end device have a QR code? Scan it to speed up onboarding.

Scan end device QR code [Learn more](#)

End device type

Input Method

- Select the end device in the LoRaWAN Device Repository
- Enter end device specifics manually

Frequency plan

Select...

LoRaWAN version

Select...

Regional Parameters version

Select...

To continue, please enter versions and frequency plan information

Alta OTAA (4)



Register end device

Does your end device have a QR code? Scan it to speed up onboarding.

 Scan end device QR code


[Learn more](#) 

End device type

Input Method

- Select the end device in the LoRaWAN Device Repository
- Enter end device specifics manually

Frequency plan *

Europe 863-870 MHz (SF9 for RX2 - recommended) | 

LoRaWAN version *

LoRaWAN Specification 1.0.2 | 

Regional Parameters version *

RP001 Regional Parameters 1.0.2 | 

[Show advanced activation, LoRaWAN class and cluster settings](#) 

- Enter end device specifics manually

Frequency plan *

Europe 863-870 MHz (SF9 for RX2 - recommended) | 

LoRaWAN version *

LoRaWAN Specification 1.0.2 | 

Regional Parameters version *

RP001 Regional Parameters 1.0.2 | 

[Show advanced activation, LoRaWAN class and cluster settings](#) 

Activation mode *

- Over the air activation (OTAA)
- Activation by personalization (ABP)
- Define multicast group (ABP & Multicast)

Additional LoRaWAN class capabilities

None (class A only) | 

Network defaults

- Use network's default MAC settings

Cluster settings

- Skip registration on Join Server

Alta OTAA (5)



[Show advanced activation, LoRaWAN class and cluster settings](#) ^

Activation mode ? *

- Over the air activation (OTAA)
- Activation by personalization (ABP)
- Define multicast group (ABP & Multicast)

Additional LoRaWAN class capabilities ?

None (class A only) | v

Network defaults ?

- Use network's default MAC settings

Cluster settings ?

- Skip registration on Join Server

Provisioning information

JoinEUI ? *

81 1A DE CA 75 00 00 01

Confirm

To continue, please enter the JoinEUI of the end device so we can determine onboarding options

Provisioning information

JoinEUI ? *

81 1A DE CA 75 00 00 01

Reset

This end device can be registered on the network

DevEUI ? *

70 B3 D5 7E D0 05 68 B7

Generate

1/50 used

AppKey ? *

56 3B EC E8 F1 94 65 9D 9F 94 7C 4E 40 69 FF 3E

Generate

End device ID ? *

ttncat-otaa-01

This value is automatically prefilled using the DevEUI

After registration

- View registered end device
- Register another end device of this type

Register end device

Alta OTAA (6)

Applications > Curs TTNCat sobre TTSv3 > End devices > ttncat-otaa-01



ttncat-otaa-01

ID: ttncat-otaa-01

↑ n/a ↓ n/a • No activity yet ⓘ

Overview Live data Messaging Location Payload formatters Claiming General settings

General information

End device ID	ttncat-otaa-01	📄
Frequency plan	Europe 863-870 MHz (SF9 for RX2 - recom...	📄
LoRaWAN version	LoRaWAN Specification 1.0.2	📄
Regional Parameters version	RP001 Regional Parameters 1.0.2	📄
Created at	Oct 17, 2022 15:40:18	

Activation information

AppEUI	81 1A DE CA 75 00 00 01	<> 📄
DevEUI	70 B3 D5 7E D0 05 68 B7	<> 📄
AppKey	📄 ⓘ

Session information

This device has not joined the network yet

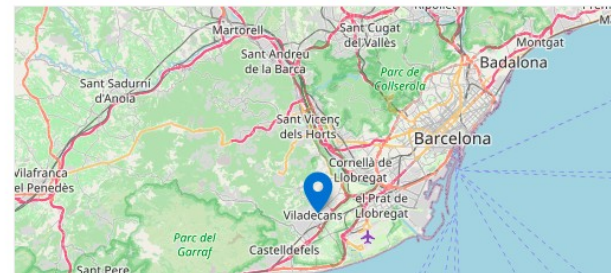
Live data

See all activity →

- ✎ 15:41:33 Update end device ["locations"]
- ➕ 15:40:18 Create end device

Location

Change location settings →



Alta OTAA (7)



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Curs TTNCat sobre TTSv3

- Overview
- End devices
- Live data

Applications > Curs TTNCat sobre TTSv3 > End devices

End devices (1)

ID	Name	DevEUI	JoinEUI	Last activity
ttncat-otaa-01		70 B3 D5 7E D0 05 68 B7	81 1A DE CA 75 00 00 01	Never

**Alta de dispositius
ABP**

Alta ABP (1)



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Curs TTNCat sobre TTSv3

- Overview
- End devices**
- Live data

Applications > Curs TTNCat sobre TTSv3 > End devices

End devices (1)

ID	Name	DevEUI	JoinEUI	Last activity
ttncat-otaa-01		70 B3 D5 7E D0 05 68 B7	81 1A DE CA 75 00 00 01	Never

Alta ABP (2)



Select the end device in the LoRaWAN Device repository

Enter end device specifics manually

Frequency plan [?] *

Europe 863-870 MHz (SF9 for RX2 - recommended) | v

LoRaWAN version [?] *

LoRaWAN Specification 1.0.2 | v

Regional Parameters version [?] *

RP001 Regional Parameters 1.0.2 | v

Show advanced activation, LoRaWAN class and cluster settings ^

Activation mode [?] *

Over the air activation (OTAA)

Activation by personalization (ABP)

Define multicast group (ABP & Multicast)

Additional LoRaWAN class capabilities [?]

None (class A only) | v

Network defaults [?]

Use network's default MAC settings

Cluster settings [?]

Activation by personalization (ABP)

Define multicast group (ABP & Multicast)

Additional LoRaWAN class capabilities [?]

None (class A only) | v

Network defaults [?]

Use network's default MAC settings

Cluster settings [?]

Skip registration on Join Server

Provisioning information

JoinEUI [?] *

81 1A DE CA 75 00 00 01 | Reset

This end device can be registered on the network

DevEUI [?]

70 B3 D5 7E D0 05 68 BA | Generate 2/50 used

Device address [?] *

26 0B 36 23 | Generate

AppSKey [?] *

CF 51 A9 83 50 E0 95 9D 9A 1F 48 93 58 81 56 5B | Generate

Alta ABP (3)



Provisioning information

JoinEUI [?](#) *

81 1A DE CA 75 00 00 01

Reset

This end device can be registered on the network

DevEUI [?](#)

70 B3 D5 7E D0 05 68 BA

[?](#) Generate

2/50 used

Device address [?](#) *

26 0B 36 23

[?](#) Generate

AppSKey [?](#) *

CF 51 A9 83 50 E0 95 9D 9A 1F 48 93 58 81 56 5B

[?](#) Generate

NwkSKey [?](#) *

55 8B 45 49 12 BA AA 15 BA 21 57 4A 3C E4 B3 74

[?](#) Generate

End device ID [?](#) *

ttncat-abp-01

This value is automatically prefilled using the DevEUI

After registration

- View registered end device
- Register another end device of this type

Alta ABP (4)

Applications > Curs TTNCat sobre TTSv3 > End devices > ttn-cat-abp-01



ttn-cat-abp-01

ID: ttn-cat-abp-01

↑ n/a ↓ n/a • No activity yet ⓘ

Overview Live data Messaging Location Payload formatters General settings

General information

End device ID	ttn-cat-abp-01	📄
Frequency plan	Europe 863-870 MHz (SF9 for RX2 - recom...	📄
LoRaWAN version	LoRaWAN Specification 1.0.2	📄
Regional Parameters version	RP001 Regional Parameters 1.0.2	📄
Created at	Oct 17, 2022 15:46:59	

Activation information

AppEUI	81 1A DE CA 75 00 00 01	<> 📄
DevEUI	70 B3 D5 7E D0 05 68 BA	<> 📄

Session information

Session start	Oct 17, 2022 15:46:59	
Device address	26 0B 36 23	<> 📄
Manufacturer	📄 🏠

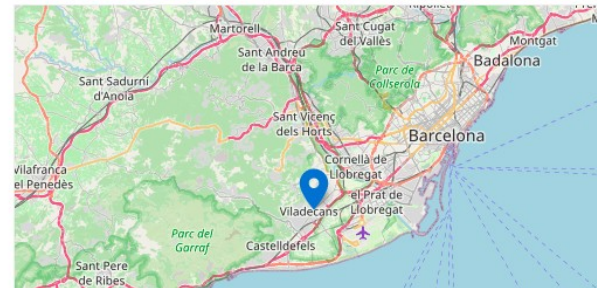
Live data

See all activity →

🔍 15:47:23	Update end device ["locations"]
+ 15:46:59	Create end device DevAddr: 26 0B 36 23 <> 📄

Location

Change location settings →



Alta ABP (5)

Applications > Curs TTNCat sobre TTSv3 > End devices > ttn-cat-abp-01 > General settings



ID: ttn-cat-abp-01

↑ n/a ↓ n/a • No activity yet ⓘ

Overview Live data Messaging Location Payload formatters General settings

Basic

Collapse

Description, cluster information and metadata

End device ID *

ttn-cat-abp-01

AppEUI ⓘ *

81 1A DE CA 75 00 00 01

DevEUI ⓘ *

70 B3 D5 7E D0 05 68 BA

End device name ⓘ

My new end device

End device description ⓘ

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

organization

Save changes

Delete end device

Network layer

Collapse

LoRaWAN network-layer settings, behavior and session

Frequency plan ⓘ *

Europe 863-870 MHz (SF9 for RX2 - recommended)

LoRaWAN version ⓘ *

LoRaWAN Specification 1.0.2

Regional Parameters version ⓘ *

RP001 Regional Parameters 1.0.2

LoRaWAN class capabilities ⓘ

Supports class B

Supports class C

Activation mode ⓘ *

Over the air activation (OTAA)

Activation by personalization (ABP)

Define multicast group (ABP & Multicast)

Device address ⓘ *

26 0B 36 23

Generate

Alta ABP (6)

Supports class C

Activation mode [ⓘ] *

- Over the air activation (OTAA)
- Activation by personalization (ABP)
- Define multicast group (ABP & Multicast)

Device address [ⓘ] *

26 0B 36 23

NwkSKey [ⓘ] *

••••••••••••••••••••••••••••••••

Session and MAC state reset [ⓘ]

Advanced MAC settings [^]

Frame counter width [ⓘ]

- 16 bit 32 bit

Rx1 delay [ⓘ]

1 sec

Desired Rx1 delay [ⓘ]

5 sec

Rx1 data rate offset [ⓘ]

0

Desired Rx1 data rate offset [ⓘ]

0

Resets frame counters [ⓘ]

[⚠] Resetting is insecure and makes your device susceptible for replay attacks

Rx2 data rate index [ⓘ]

0

Desired Rx2 data rate index [ⓘ]

3

Resets frame counters [ⓘ]

[⚠] Resetting is insecure and makes your device susceptible for replay attacks

Rx2 data rate index [ⓘ]

0

Desired Rx2 data rate index [ⓘ]

3

Rx2 frequency [ⓘ]

869,525 MHz

Desired Rx2 frequency [ⓘ]

869,525 MHz

Maximum duty cycle [ⓘ]

100%

Desired maximum duty cycle [ⓘ]

100%

Factory preset frequencies [ⓘ]

List of factory-preset frequencies. Note: order is respected.

Status count periodicity [ⓘ]

200 messages

Status time periodicity [ⓘ]

86400 seconds

Adaptive data rate (ADR) [ⓘ]

- Dynamic mode
- Static mode
- Disabled

ADR margin [ⓘ]

15 dB

Alta ABP (7)



eu1.cloud.thethings.network/console/applications/curs-tts-ttncat/devices

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EU1 Community No SLA applicable

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- Live data
- Payload formatters
- Integrations
- Collaborators
- API keys
- General settings

Applications > Curs TTNCat sobre TTSv3 > End devices

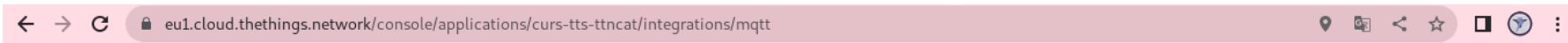
End devices (2) [Import end devices](#) [+ Add end device](#)

ID	Name	DevEUI	JoinEUI	Last activity
ttn-cat-abp-01		70 B3 D5 7E D0 05 68 BA	81 1A DE CA 75 00 00 01	Never
ttn-cat-otaa-01		70 B3 D5 7E D0 05 68 B7	81 1A DE CA 75 00 00 01	Never

Connectivitat

MQTT

Connectivitat MQTT (1)



Navigation bar with logos for THE THINGS NETWORK, THE THINGS STACK Community Edition, Overview, Applications, Gateways, Organizations, EU1 Community (No SLA applicable), and user profile (Jordi Binefa).

Left sidebar menu for 'Curs TTNCat sobre TTSv3' with options: Overview, End devices, Live data, Payload formatters, Integrations (selected), MQTT, Webhooks, Storage Integration, AWS IoT, and Azure IoT.

Applications > Curs TTNCat sobre TTSv3 > MQTT

MQTT

MQTT is a publish/subscribe messaging protocol designed for IoT. Every application on TTS automatically exposes an MQTT endpoint. In order to connect to the MQTT server you need to create a new API key, which will function as connection password. You can also use an existing API key, as long as it has the necessary rights granted.

Further resources

[MQTT server](#) | [Official MQTT website](#)

Connection information

MQTT server host

Public address:

Public TLS address:

Connection credentials

Username:

Connectivitat MQTT (2)



Applications > Curs TTNCat sobre TTSv3 > MQTT

MQTT

MQTT is a publish/subscribe messaging protocol designed for IoT. Every application on TTS automatically exposes an MQTT endpoint. In order to connect to the MQTT server you need to create a new API key, which will function as connection password. You can also use an existing API key, as long as it has the necessary rights granted.

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Connection information

MQTT server host

Public address



Public TLS address



Connection credentials

Username



Password

[Go to API keys](#)

Kit IoT-02

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