CS01-LB -- LoRaWAN 4 Channels Current Sensor Converter User Manual

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1. Introduction

1.1 What is LoRaWAN 4 Channels Current Sensor Converter

The Dragino CS01-LB is a **LoRaWAN 4 Channels Current Sensor Converter**. It can convert the reading from current sensors and upload to IoT server via LoRaWAN Network.

CS01-LB can be used to **monitor the machine running status** and **analyze power consumption trends**.

The CS01-LB supports maximum 4 current sensors. The current sensors are detachable and can be replaced with different scales.

CS01-LB **supports BLE configure** and **wireless OTA update** which make user easy to use.

CS01-LB is powered by **8500mAh Li-SOCI2 battery,** it is designed for long-term use up to several years.

Each CS01-LB is pre-load with a set of unique keys for LoRaWAN registrations, register these keys to local LoRaWAN server and it will auto-connect after power on.

1.2 Features

- LoRaWAN 1.0.3 Class A
- Bands:CN470/EU433/KR920/US915/EU868/AS923/AU915/IN865
- Ultra-low power consumption
- Supports maximum 4 current sensors
- Support various current sensor Ratio: 50A, 100A etc.
- Monitor the machine running status
- Analyze power consumption trends
- Current Alarm
- Support Bluetooth v5.1 and LoRaWAN remote configure
- Support wireless OTA update firmware
- Uplink on periodically
- Downlink to change configure
- 8500mAh Li/SOCl2 Battery

1.3 Specification

Common DC Characteristics:

- Supply Voltage: Built-in Battery , 2.5v ~ 3.6v
- Operating Temperature: -40 ~ 85°C

LoRa Spec:

- Frequency Range, Band 1 (HF): 862 ~ 1020 Mhz
- Max +22 dBm constant RF output vs.
- RX sensitivity: down to -139 dBm.
- Excellent blocking immunity

Battery:

- Li/SOCI2 un-chargeable battery
- Capacity: 8500mAh
- Self-Discharge: <1% / Year @ 25°C
- Max continuously current: 130mA
- Max boost current: 2A, 1 second

Power Consumption

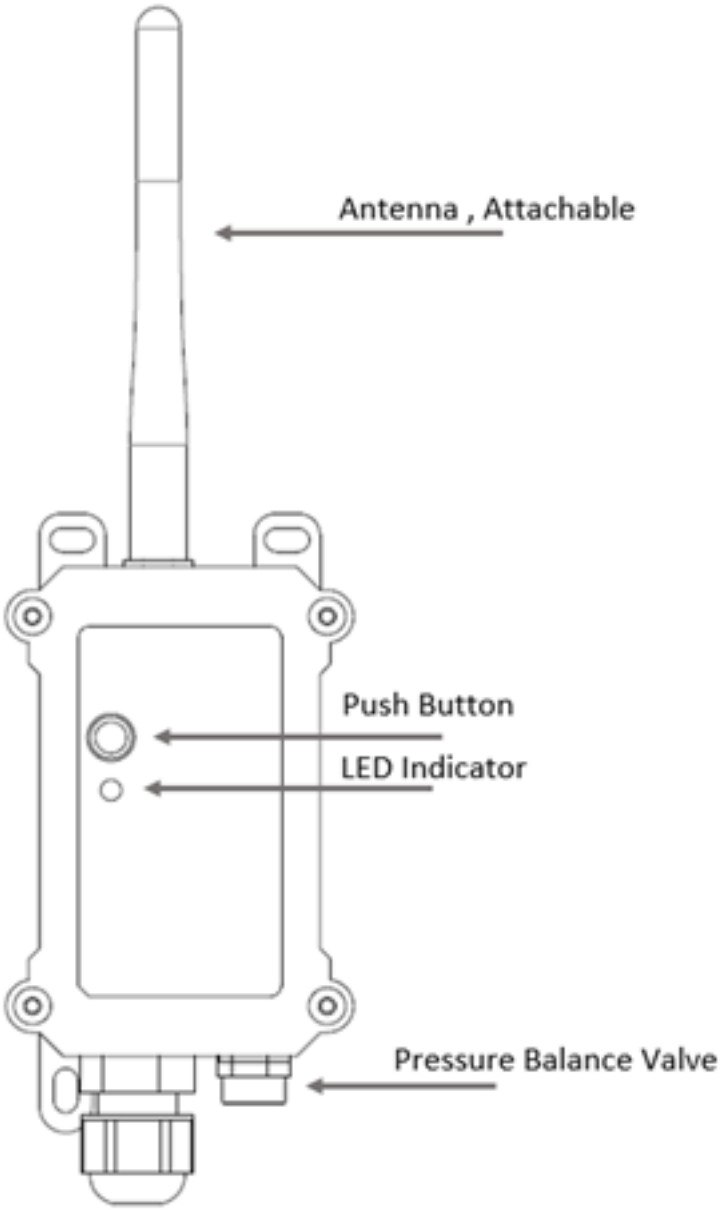
- Sleep Mode: 5uA @ 3.3v
- LoRa Transmit Mode: 125mA @ 20dBm, 82mA @ 14dBm

1.4 Sleep mode and working mode

Deep Sleep Mode: Sensor doesn't have any LoRaWAN activate. This mode is used for storage and shipping to save battery life.

Working Mode: In this mode, Sensor will work as LoRaWAN Sensor to Join LoRaWAN network and send out sensor data to server. Between each sampling/tx/rx periodically, sensor will be in IDLE mode, in IDLE mode, sensor has the same power consumption as Deep Sleep mode.

1.5 Button & LEDs



Behavior on ACT	Function	Action
Pressing ACT between 1s < time < 3s	Send an uplink	If sensor is already Joined to LoRaWAN network, sensor will send an uplink packet, **blue led** will blink once. Meanwhile, BLE module will be active and user can connect via BLE to configure device.
Pressing ACT for more than 3s	Active Device	**Green led** will fast blink 5 times, device will enter **OTA mode** for 3 seconds. And then start to JOIN LoRaWAN network. **Green led** will solidly turn on for 5 seconds after joined in network. Once sensor is active, BLE module will be active and user can connect via BLE to configure device, no matter if device join or not join LoRaWAN network.
Fast press ACT 5 times.	Deactivate Device	**Red led** will solid on for 5 seconds. Means device is in Deep Sleep Mode.

1.6 BLE connection

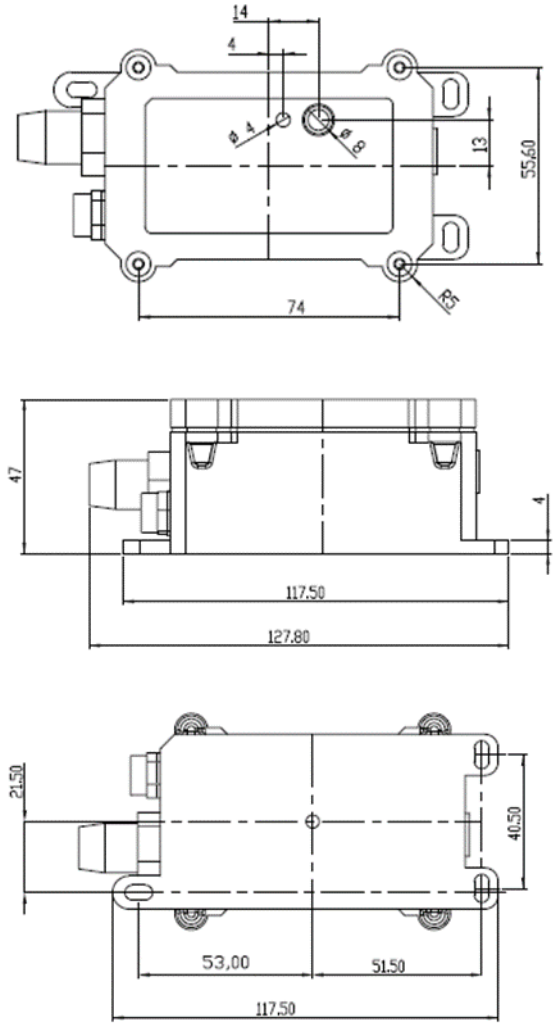
CS01-LB supports BLE remote configure.

BLE can be used to configure the parameter of sensor or see the console output from sensor. BLE will be only activate on below case:

- Press button to send an uplink
- Press button to active device.
- Device Power on or reset.

If there is no activity connection on BLE in 60 seconds, sensor will shut down BLE module to enter low power mode.

1.8 Mechanical



1.9 Current Sensor Spec

The current sensor list below is not ship with CS01-LB, user need to order seperately:

Model	Photo	Specification
SCT013G-D-100		* Split core current transformer * Spec: 100A/50mA * φ16mm Aperture * Material of core: Ferrite

2. Configure CS01-LB to connect to LoRaWAN network

2.1 How it works

The CS01-LB is configured as **LoRaWAN OTAA Class A** mode by default. It has OTAA keys to join LoRaWAN network. To connect a local LoRaWAN network, you need to input the OTAA keys in the LoRaWAN IoT server and press the button to activate the CS01-LB. It will automatically join the network via OTAA and start to send the sensor value. The default uplink interval is 20 minutes.

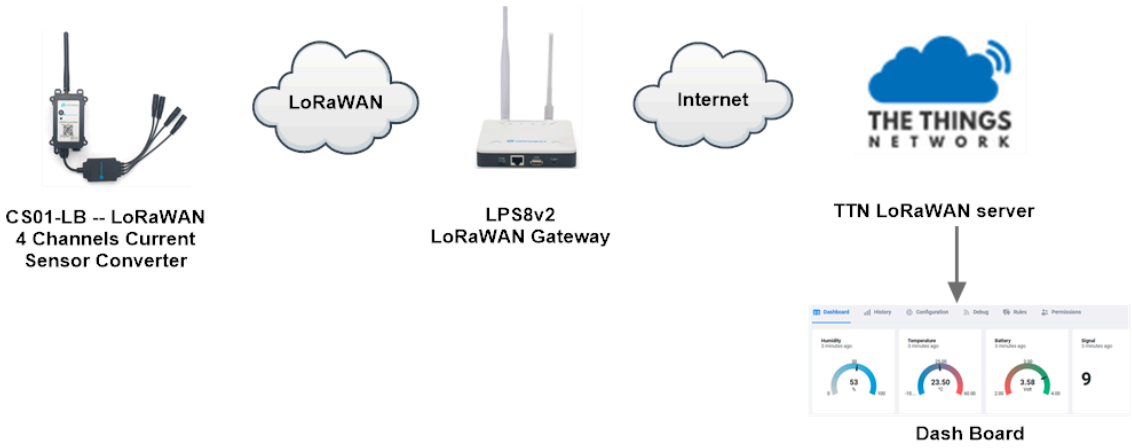
Notice: CS01-LB doesn't include current sensor. User needs to get the current sensor separately and attach to CS01-LB for measuring.

2.2 Quick guide to connect to LoRaWAN server (OTAA)

Following is an example for how to join the TTN v3 LoRaWAN Network. Below is the network structure; we use the LPS8v2 as a LoRaWAN gateway in this example.

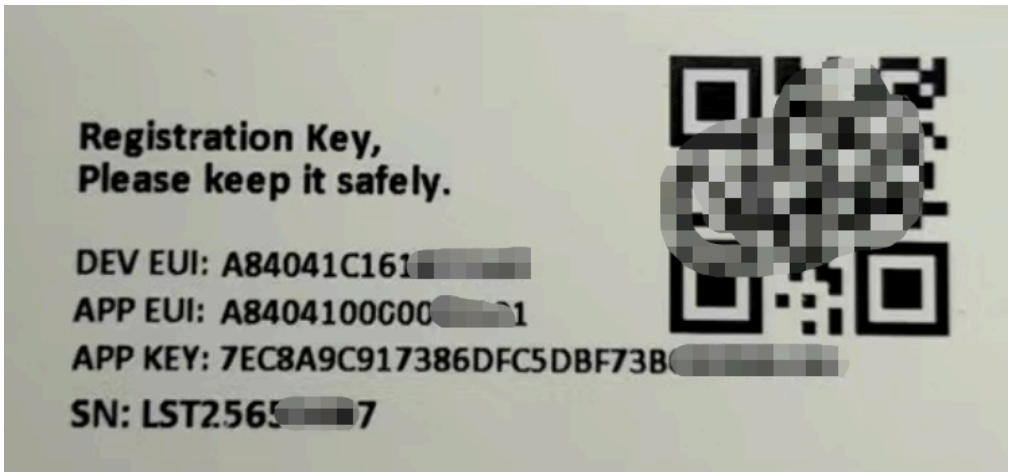
The LPS8V2 is already set to connected to TTN network , so what we need to now is configure the TTN server.

CS01-LB in a LoRaWAN Network



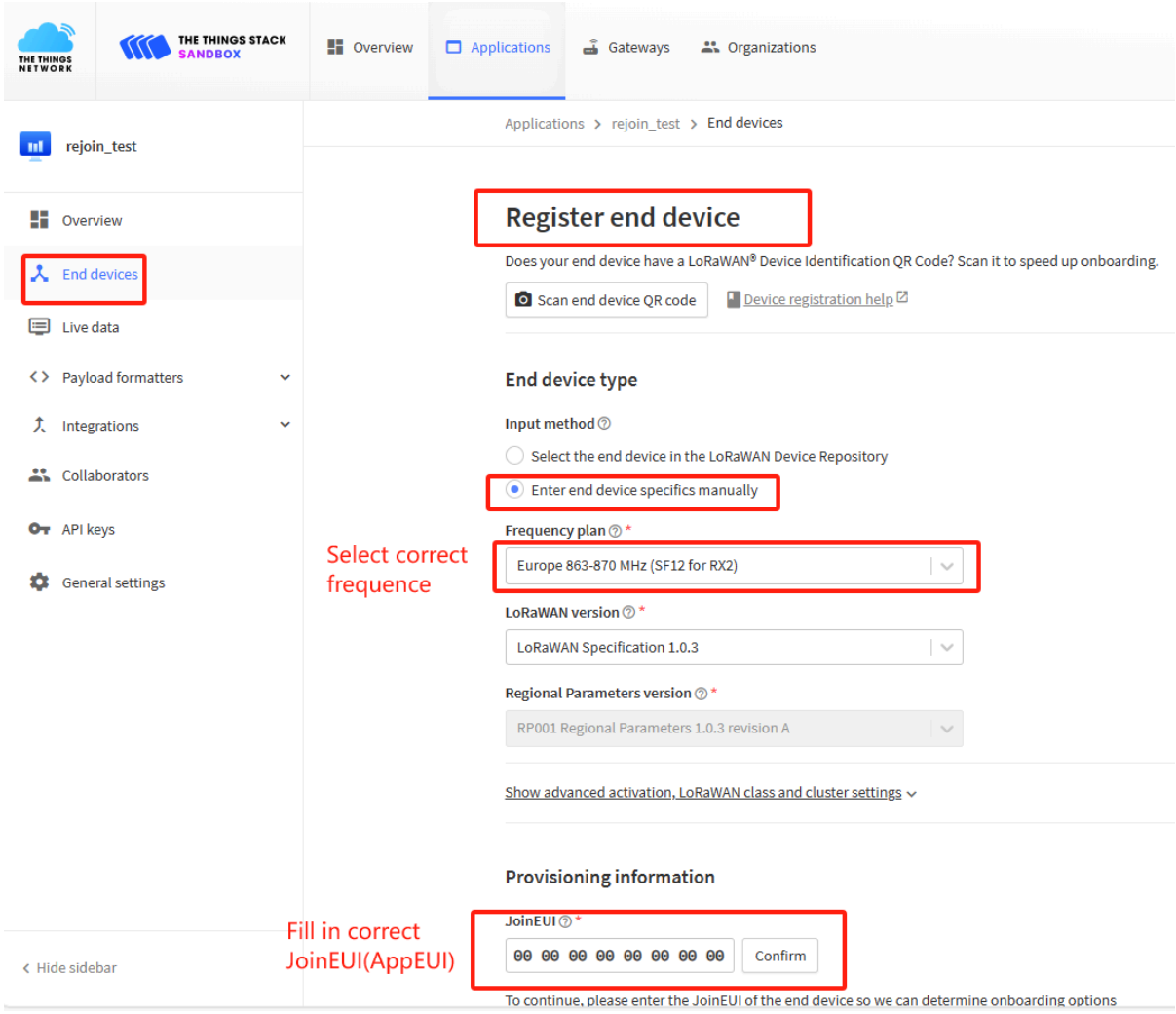
Step 1: Create a device in TTN with the OTAA keys from CS01-LB.

Each CS01-LB is shipped with a sticker with the default device EUI as below:

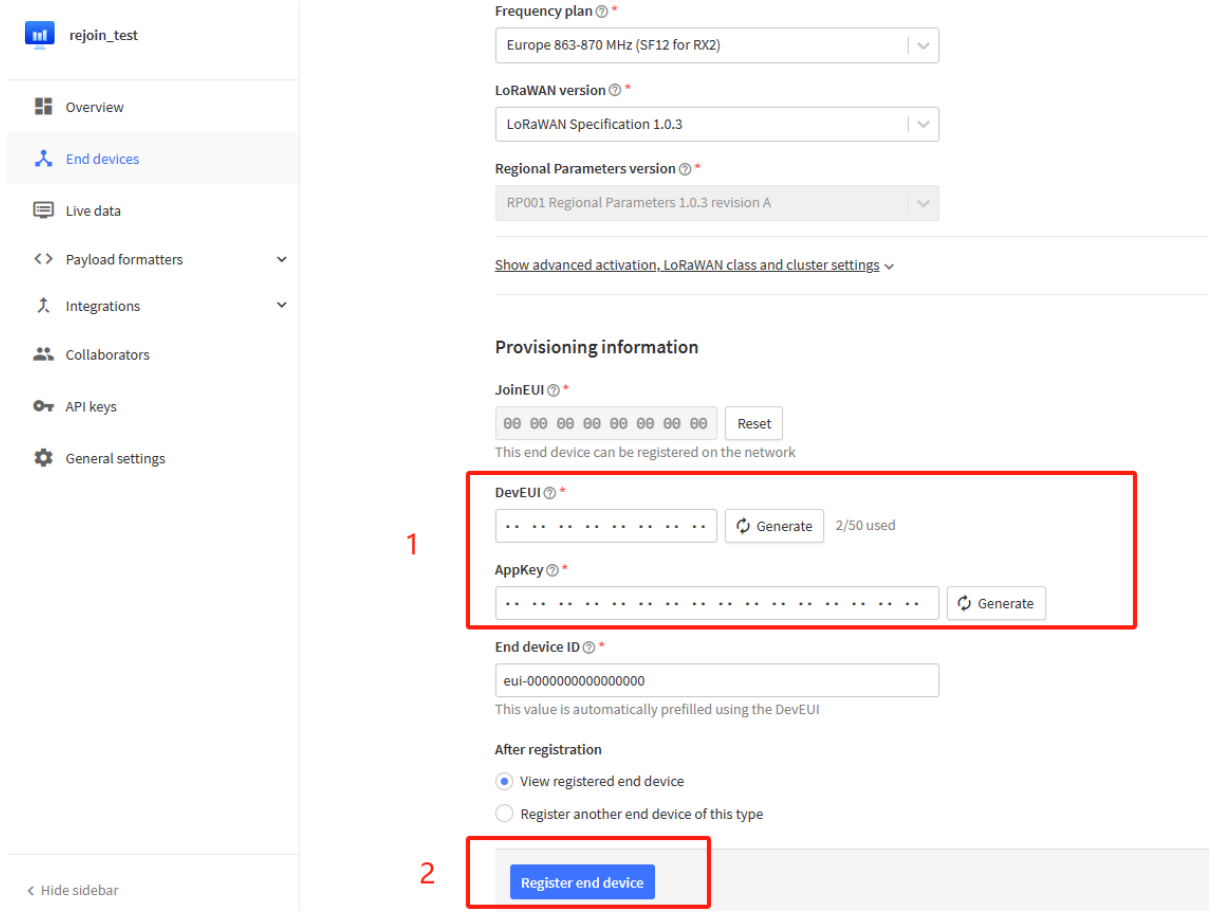


You can enter this key in the LoRaWAN Server portal. Below is TTN screen shot:

Register the device



Add DevEUI and AppKey



Step 2: Activate on CS01-LB

Press the button for 5 seconds to activate the CS01-LB.

Green led will fast blink 5 times, device will enter **OTA mode** for 3 seconds. And then start to JOIN LoRaWAN network. **Green led** will solidly turn on for 5 seconds after joined in network.

After join success, it will start to upload messages to TTN and you can see the messages in the panel.

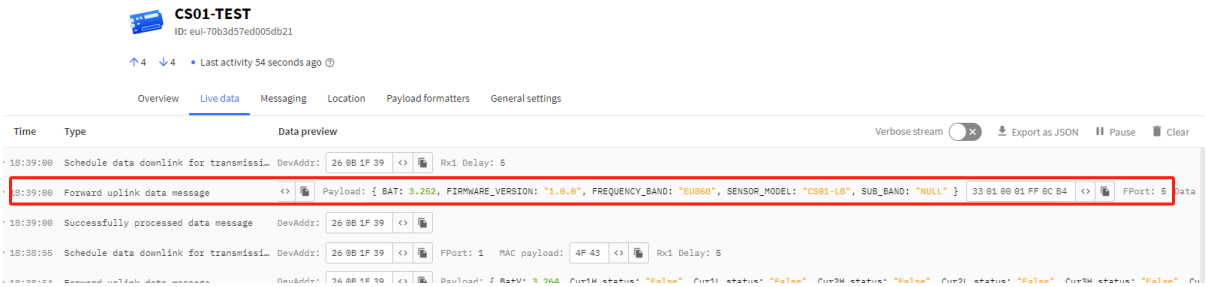
2.3 Device Status, FPORT=5

Users can use the downlink command(**0x26 01**) to ask CS01-LB to send device configure detail, include device configure status. CS01-LB will uplink a payload via FPort=5 to server.

The Payload format is as below.

Device Status (FPORT=5)					
Size (bytes)	**1**	**2**	**1**	**1**	**2**
Value	Sensor Model	Firmware Version	Frequency Band	Sub-band	BAT

Example parse in TTNv3.



Sensor Model: For CS01-LB, this value is 0x0A

Firmware Version: 0x0100, Means: v1.0.0 version

Frequency Band:

0x01: EU868

0x02: US915

0x03: IN865

0x04: AU915

0x05: KZ865

0x06: RU864

0x07: AS923

0x08: AS923-1

0x09: AS923-2

0x0a: AS923-3

0x0b: CN470

0x0c: EU433

0x0d: KR920

0x0e: MA869

Sub-Band:

AU915 and US915:value 0x00 ~ 0x08

CN470: value 0x0B ~ 0x0C

Other Bands: Always 0x00

Battery Info:

Check the battery voltage.

Ex1: 0x0B45 = 2885mV

Ex2: 0x0B49 = 2889mV

2.4 Working Mode & Uplink Payload

2.4.1 MOD=1(General acquisition mode), FPORT=2

Default mode. Each TDC time sends real-time collected current clamp values. If the threshold alarm function is enabled (**AT+CALARM** only takes effect at MOD=1), an alarm is generated if the limit is exceeded.

Uplink packets use FPORT=2.

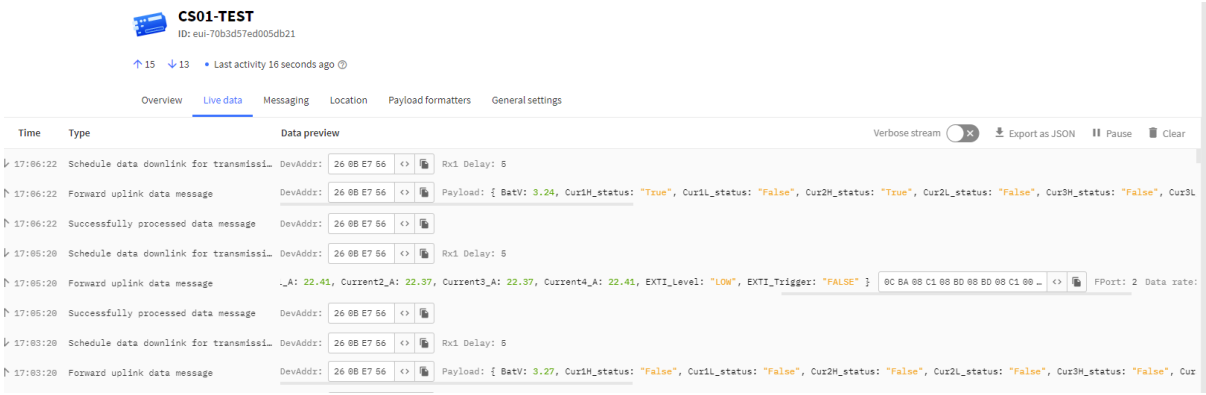
Size(bytes)	2	2	2	2	2	1
Value	Battery Info&Interrupt flag & Interrupt Level	Current channel 1	Current channel 2	Current channel 3	Current channel 4	Alarm

Alarm_status is a combination for Cur1L_status, Cur1H_status, Cur2L_status, Cur2H_status, Cur3L_status, Cur3H_status, Cur4L_status and Cur4H_status.

Totally 1bytes as below:

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1
Cur1L	Cur1H	Cur2L	Cur2H	Cur3L	Cur3H	Cur4L

Example parse in TTNv3.



Battery Info

Check the battery voltage for LDS12-LB/LS.

Ex1: 0x0B45&0x3FFF = 2885mV

Ex2: 0x0B49&0x3FFF = 2889mV

Interrupt Flag & Interrupt Level

This data field shows if this packet is generated by interrupt or not. Click here for the hardware and software set up.

Note: The Internet Pin is a separate pin in the screw terminal. See pin mapping of GPIO_EXTI .

Example:

If byte[0]&0x80>>15=0x00 : Normal uplink packet.

If byte[0]&0x80>>15=0x01 : Interrupt Uplink Packet.

If byte[0]&0x40>>14=0x00 : Interrupt pin low level.

If byte[0]&0x40>>14=0x01 : Interrupt pin high level.

Current channel 1:

Channel 1 for measuring AC current. Resolution 0.01A.

Ext: 0x03e8 =1000/100=10.00A

Cur1L_status:

When setting a current threshold alarm, this flag is True when it is lower than the set threshold, otherwise it is False.

Cur1H_status:

When setting a current threshold alarm, this flag is True when it is higher than the set threshold, otherwise it is False.

Current channel 2, Current channel 3, Current channel 4 are the same as Current channel 1.

2.4.2 MOD=2(Continuous acquisition mode), FPORT=7

Continuous collection mode**(AT+MOD=2,aa,bb)**, record the number of data groups according to the detection interval, and report after collection. This mode has high power consumption. External power supply is recommended.

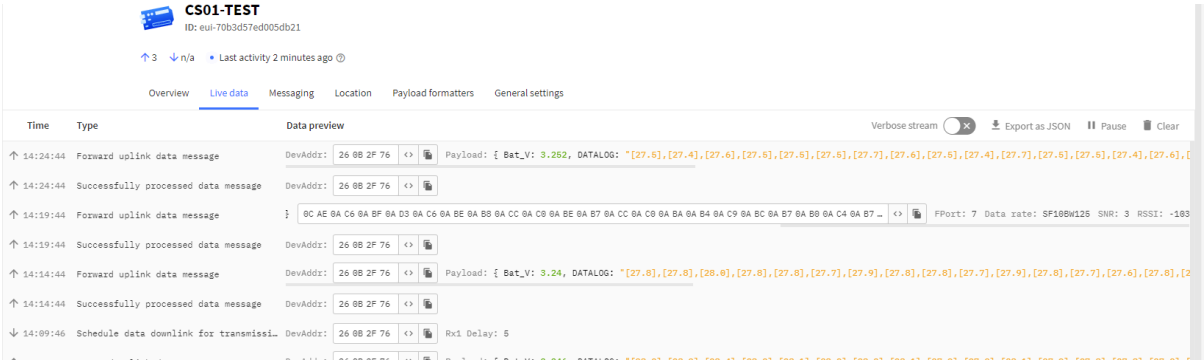
Uplink packets use FPORT=7.

Size(bytes)	2	n
Value	BAT	Current value, each 8 bytes is a set of current values(The maximum is 30 groups).

Multiple sets of data collected are displayed in this `form:`

[Current channel 1 value1], [Current channel 2 value1], [Current channel 3 value1], [Current channel 4 value1], [Current channel 1 value2], [Current channel 2 value2], [Current channel 3 value2], [Current channel 4 value2]... [current value n/8]

Example parse in TTNv3.



2.5 Payload Decoder file

In TTN, use can add a custom payload so it shows friendly reading

In the page **Applications --> Payload Formats --> Custom --> decoder** to add the decoder from:

https://github.com/dragino/dragino-end-node-decoder/tree/main/

2.6 Datalog Feature

Datalog Feature is to ensure IoT Server can get all sampling data from Sensor even if the LoRaWAN network is down. For each sampling, CS01-LB will store the reading for future retrieving purposes.

2.6.1 Ways to get datalog via LoRaWAN

Set PNACKMD=1, CS01-LB will wait for ACK for every uplink, when there is no LoRaWAN network, CS01-LB will mark these records with non-ack messages and store the sensor data, and it will send all messages (10s interval) after the network recovery.

- a) CS01-LB will do an ACK check for data records sending to make sure every data arrive server.
- b) CS01-LB will send data in **CONFIRMED Mode** when PNACKMD=1, but CS01-LB won't re-transmit the packet if it doesn't get ACK, it will just mark it as a NONE-ACK message. In a future uplink if CS01-LB gets a ACK, CS01-LB will consider there is a network connection and resend all NONE-ACK messages.

2.6.2 Unix TimeStamp

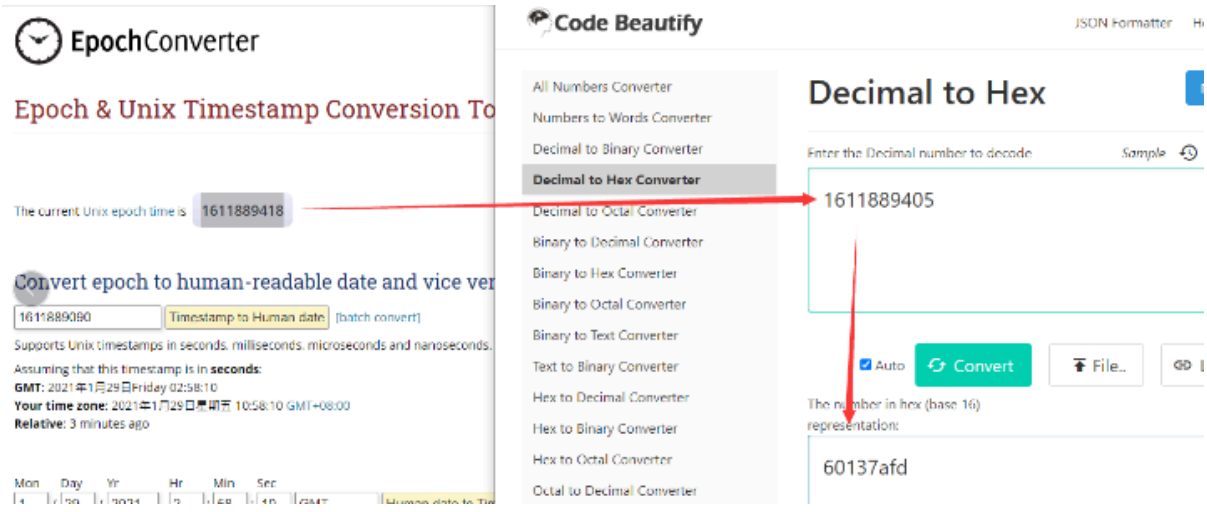
CS01-LB uses Unix TimeStamp format based on

Size (bytes)	4	1
DeviceTimeAns Payload	32-bit unsigned integer : Seconds since epoch*	8bits unsigned integer: fractional-second in ½^8 second steps

Figure 10 : DeviceTimeAns payload format

User can get this time from link: https://www.epochconverter.com/ :

Below is the converter example



So, we can use AT+TIMESTAMP=1611889405 or downlink 3060137afd00 to set the current time 2021 – Jan -- 29 Friday 03:03:25

2.6.3 Set Device Time

User need to set **SYNCMOD=1** to enable sync time via MAC command.

Once CS01-LB Joined LoRaWAN network, it will send the MAC command (DeviceTimeReq) and the server will reply with (DeviceTimeAns) to send the current time to CS01-LB. If CS01-LB fails to get the time from the server, CS01-LB will use the internal time and wait for next time request (AT+SYNCTDC to set the time request period, default is 10 days).

Note: LoRaWAN Server need to support LoRaWAN v1.0.3(MAC v1.0.3) or higher to support this MAC command feature, Chirpstack,TTN V3 v3 and loriot support but TTN V3 v2 doesn't support. If server doesn't support this command, it will through away uplink packet with this command, so user will lose the packet with time request for TTN V3 v2 if SYNCMOD=1.

2.6.4 Datalog Uplink payload (FPORT=3)

The Datalog uplinks will use below payload format.

Retrieval data payload:

Size(bytes)	1	2	2	2	4
Value	Interrupt flag & Interrupt_level	Current1	Current2	Current3	Unix TimeStamp

Interrupt flag & Interrupt level :

Size(bit)	bit7	bit6	[bit5:bit2]	bit1	bit0
Value	NO ACK message	Poll Message Flag	Reserve	interrupt level	interrupt flag

No ACK Message: 1: This message means this payload is fromn Uplink Message which doesn't get ACK from the server before (for **PNACKMD=1** feature)

Poll Message Flag: 1: This message is a poll message reply.

- Poll Message Flag is set to 1.
- Each data entry is 11 bytes, to save airtime and battery, devices will send max bytes according to the current DR and Frequency bands.

For example, in US915 band, the max payload for different DR is:

a) DR0: max is 11 bytes so one entry of data

b) DR1: max is 53 bytes so devices will upload 4 entries of data (total 44 bytes)

c) DR2: total payload includes 11 entries of data

d) DR3: total payload includes 22 entries of data.

If devise doesn't have any data in the polling time. Device will uplink 11 bytes of 0

Example:

If CS01-LB has below data inside Flash:

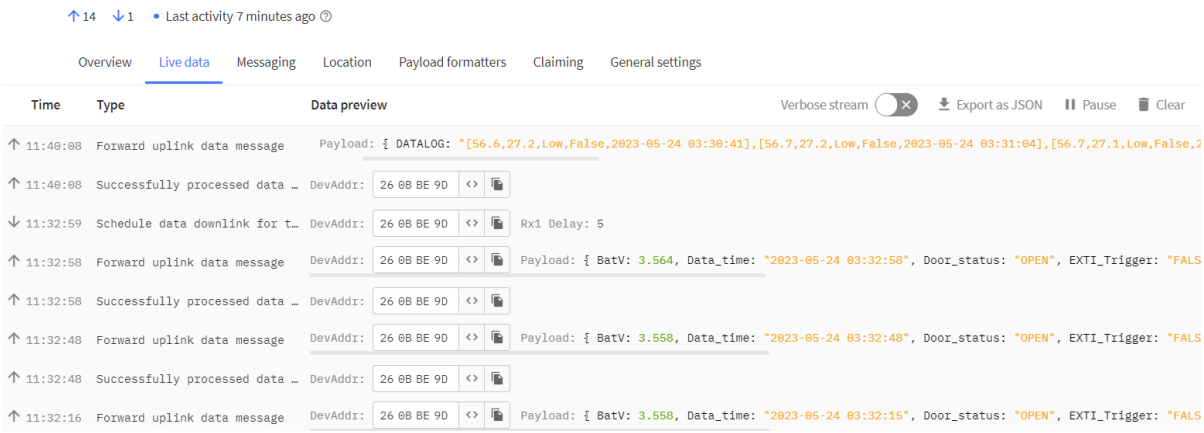
```
Stop Tx events when read sensor data
8031080 2023/5/24 03:30:41 3558 temp=27.2 hum=56.6 level:low status:false
8031090 2023/5/24 03:31:04 3564 temp=27.2 hum=56.7 level:low status:false
80310A0 2023/5/24 03:31:16 3564 temp=27.1 hum=56.7 level:low status:false
80310B0 2023/5/24 03:31:36 3564 temp=27.1 hum=57.0 level:low status:false
80310C0 2023/5/24 03:32:06 3558 temp=27.1 hum=57.2 level:low status:false

80310D0 2023/5/24 03:32:15 3558 temp=27.0 hum=57.3 level:low status:false
80310E0 2023/5/24 03:32:48 3558 temp=27.0 hum=57.5 level:low status:false
80310F0 2023/5/24 03:32:58 3564 temp=27.0 hum=57.6 level:low status:false
Start Tx events

OK
```

If user sends below downlink command: 31646D84E1646D856C05

Where : Start time: 646D84E1 = time 23/5/24 03:30:41

Stop time: 646D856C= time 23/5/24 03:33:00

CS01-LB will uplink this payload.



00 00 02 36 01 10 40 64 6D 84 E1 00 00 02 37 01 10 40 64 6D 84 F8 00 00 02 37 01 0F 40 64 6D 85 04 00 00 02 3A 01 0F 40 64 6D 85 18 00 00 02 3C 01 0F 40 64 6D 85 36 00 00 02 3D 01 0E 40 64 6D 85 3F 00 00 02 3F 01 0E 40 64 6D 85 60 00 00 02 40 01 0E 40 64 6D 85 6A

Where the first 11 bytes is for the first entry:

00 00 02 36 01 10 40 64 6D 84 E1

Hum=0x0236/10=56.6

Temp=0x0110/10=27.2

poll message flag & Alarm Flag & Level of PA8=0x40,means reply data,sampling uplink message,the PA8 is low level.

Unix time is 0x646D84E1=1684899041s=23/5/24 03:30:41

2.7 Frequency Plans

The CS01-LB uses OTAA mode and below frequency plans by default. Each frequency band use different firmware, user update the firmware to the corresponding band for their country.

http://wiki.dragino.com/xwiki/bin/view/Main/End%20Device%20Frequency%20Band/

2.8 Firmware Change Log

Firmware download link: https://www.dropbox.com/scl/fo/cnnyz4ynebs3am96jvtv0/h?rlkey=4no594ssi0nzt2lc3irbkid9b&dl=0

3. Configure CS01-LB

3.1 Configure Methods

CS01-LB supports below configure method:

- AT Command via Bluetooth Connection (**Recommended**): BLE Configure Instruction.
- AT Command via UART Connection : See UART Connection.
- LoRaWAN Downlink. Instruction for different platforms: See IoT LoRaWAN Server section.

3.2 General Commands

These commands are to configure:

- General system settings like: uplink interval.
- LoRaWAN protocol & radio related command.

They are same for all Dragino Devices which support DLWS-005 LoRaWAN Stack. These commands can be found on the wiki:

http://wiki.dragino.com/xwiki/bin/view/Main/End%20Device%20AT%20Commands%20and%20Downlink%20Command/

3.3 Commands special design for CS01-LB

These commands only valid for CS01-LB, as below:

3.3.1 Set Transmit Interval Time

Feature: Change LoRaWAN End Node Transmit Interval.

AT Command: AT+TDC

Command Example	Function	Response
AT+TDC=?	Show current transmit Interval	30000 OK the interval is 30000ms = 30s
AT+TDC=60000	Set Transmit Interval	OK Set transmit interval to 60000ms = 60 seconds

Downlink Command: 0x01

Format: Command Code (0x01) followed by 3 bytes time value.

If the downlink payload=0100003C, it means set the END Node's Transmit Interval to 0x00003C=60(S), while type code is 01.

- Example 1: Downlink Payload: 0100001E // Set Transmit Interval (TDC) = 30 seconds
- Example 2: Downlink Payload: 0100003C // Set Transmit Interval (TDC) = 60 seconds

3.3.2 Get Device Status

Send a LoRaWAN downlink to ask device send Alarm settings.

Downlink Payload: 0x26 01

Sensor will upload Device Status via FPORT=5. See payload section for detail.

3.3.3 Set Alarm Interval

The shortest time of two Alarm packet. (unit: min)

- **AT Command:**

AT+ATDC=30 // The shortest interval of two Alarm packets is 30 minutes, Means is there is an alarm packet uplink, there won't be another one in the next 30 minutes.

- **Downlink Payload:**

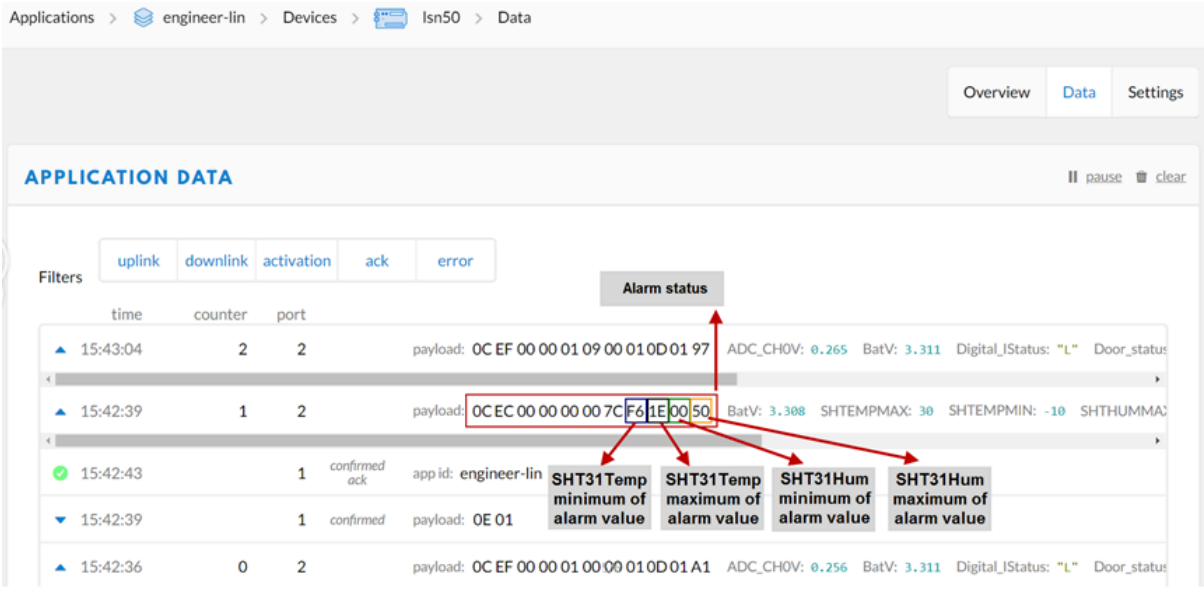
0x(0D 00 1E) **--->** Set AT+ATDC=0x 00 1E = 30 minutes

3.3.4 Get Alarm settings

Send a LoRaWAN downlink to ask device send Alarm settings.

- **Downlink Payload:** 0x0E 01

Example:



Explain:

- Alarm & MOD bit is 0x7C, 0x7C >> 2 = 0x31: Means this message is the Alarm settings message.

3.3.5 Set Interrupt Mode

Feature, Set Interrupt mode for PA8 of pin.

When AT+INTMOD=0 is set, PA8 is used as a digital input port.

AT Command: AT+INTMOD

Command Example	Function	Response
AT+INTMOD=?	Show current interrupt mode	0 OK the mode is 0 =Disable Interrupt
AT+INTMOD=2	Set Transmit Interval 0. (Disable Interrupt), 1. (Trigger by rising and falling edge) 2. (Trigger by falling edge) 3. (Trigger by rising edge)	OK

Downlink Command: 0x06

Format: Command Code (0x06) followed by 3 bytes.

This means that the interrupt mode of the end node is set to 0x000003=3 (rising edge trigger), and the type code is 06.

- Example 1: Downlink Payload: 06000000 // Turn off interrupt mode
- Example 2: Downlink Payload: 06000003 // Set the interrupt mode to rising edge trigger

3.3.6 Set Power Output Duration

Control the output duration 5V . Before each sampling, device will

1. first enable the power output to external sensor,

2. keep it on as per duration, read sensor value and construct uplink payload

3. final, close the power output.

AT Command: AT+5VT

Command Example	Function	Response
AT+5VT=?	Show 5V open time.	0 (default) OK
AT+5VT=1000	Close after a delay of 1000 milliseconds.	OK

Downlink Command: 0x07

Format: Command Code (0x07) followed by 2 bytes.

The first and second bytes are the time to turn on.

- Example 1: Downlink Payload: 070000 **--->** AT+5VT=0
- Example 2: Downlink Payload: 0701F4 **--->** AT+5VT=500

4. Battery & Power Consumption

CS01-LB use ER26500 + SPC1520 battery pack. See below link for detail information about the battery info and how to replace.

Battery Info & Power Consumption Analyze .

5. OTA Firmware update

User can change firmware CS01-LB to:

- Change Frequency band/ region.
- Update with new features.
- Fix bugs.

Firmware and changelog can be downloaded from : **Firmware download link**

Methods to Update Firmware:

- (Recommanded way) OTA firmware update via wireless : **http://wiki.dragino.com/xwiki/bin/view/Main/Firmware%20OTA%20Update%20for%20Sensors/**
- Update through UART TTL interface : **Instruction**.

6. FAQ

7. Order Info

Part Number: **CS01-LB-XX**

XX: The default frequency band

- **AS923**: LoRaWAN AS923 band
- **AU915**: LoRaWAN AU915 band
- **EU433**: LoRaWAN EU433 band
- **EU868**: LoRaWAN EU868 band
- **KR920**: LoRaWAN KR920 band
- **US915**: LoRaWAN US915 band

- **IN865**: LoRaWAN IN865 band
- **CN470**: LoRaWAN CN470 band

8. Packing Info

Package Includes:

- CS01-LB LoRaWAN 4 Channels Current Sensor Converter

Dimension and weight:

- Device Size: cm
- Device Weight: g
- Package Size / pcs : cm
- Weight / pcs : g

9. Support

- Support is provided Monday to Friday, from 09:00 to 18:00 GMT+8. Due to different timezones we cannot offer live support. However, your questions will be answered as soon as possible in the before-mentioned schedule.
- Provide as much information as possible regarding your enquiry (product models, accurately describe your problem and steps to replicate it etc) and send a mail to Support@dragino.cc.