AQS01-L -- LoRaWAN Indoor CO2 Sensor User Manual

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Table of Contents:

1. Introduction

1.1 What is AQS01-L LoRaWAN Indoor CO2 Sensor

The Dragino AQS01-L is an **Indoor LoRaWAN Air Quality Sensor** for the Internet of Things solution. It is designed to measure the surrounding environment para **Humidity and Air pressure**, and then upload to IoT server via LoRaWAN wireless protocol.

AQS01-L is powered by a **ER18505 4000mAh battery**. The battery can last more than 2 years and is easy to change.

AQS01-L **supports BLE configure** and **wireless OTA update** which make user easy to use.

AQS01-L supports **CO2 Alarm and Temperature Alarm* features**, users can get an alarm for instant notice.

AQS01-L supports **Datalog feature**, User can retrieve the sensor data from LoRaWAN commands.

Note*: CO2 Alarm and temperature Alarm will decrease a lot the battery life.

1.2 Features

- LoRaWAN 1.0.3 Class A
- Monitor CO2/Temperature/Relative Humidity/Pressure
- Support CO2 alarm
- Support Datalog Feature
- Bands: CN470/EU433/KR920/US915/EU868/AS923/AU915/IN865
- Support Bluetooth v5.1 and LoRaWAN remote configure
- Support wireless OTA update firmware
- Uplink on periodically
- Downlink to change configure
- 4000mAh batteries powered

1.3 Specification

Common DC Characteristics:

- Supply Voltage: built in 4000mAh Li-SOCI2 battery , 2.5v ~ 3.6v
- Operating Temperature: -20 ~ 65°C

CO2 Sensor:

- Target gas: Carbon dioxide(CO2)
- Operating principle: Non-dispersiveinfrared(NDIR)
- Operating range: 0-50°C, 0-85% RH(non-condensing)
- Measurement range: 400ppm to 5000 ppm (extended range up to 10000 ppm)
- Accuracy: Typ ±(50 ppm +3% of reading)
- Pressure Compensation

Temperature Sensor:

- Range: -20 ~ 65 °C
- Accuracy: Typ ±1.0@ 0-65 °C
- Resolution: 0.01°C

Humidity Sensor:

- Range: 0 ~ 99.9% RH
- Accurancy: ± 3%RH (20 ~ 80%RH)
- Resolution: 0.008% RH
- Long term stability: 0.5 %RH/yr

Air Pressure:

- Range: 300~1100hPa
- Accuracy: ± 1.0 hPa (0-65 °C)
- Resolution: 0.18Pa
- Long term stability: ±1.0 hPa/yr

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: 4000mAh
- Self-Discharge: <1% / Year @ 25°C

Power Consumption

- Sleep Mode: 6uA @ 3.3v
- LoRa Transmit Mode: 125mA @ 20dBm, 82mA @ 14dBm

1.4 Applications

- Smart Building
- Industrial Monitoring and Control

1.5 Sleep mode and working mode

Deep Sleep Mode: Sensor doesn't have any LoRaWAN activity. 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 p sensor has the same power consumption as Deep Sleep mode.

1.6 BLE connection

AQS01-L supports BLE remote configure.

BLE can be used to configure the parameter of AQS01-L or see the console output from AQS01-L. BLE will be only activate on below case:

- Press button to send an uplink.
- Press button to active AQS01-L.
- Device Power on or reset.

If there is no activity connection on BLE in 60 seconds, AQS01-L will shut down BLE module to enter low power mode.

2. Configure AQS01-L to connect to LoRaWAN network

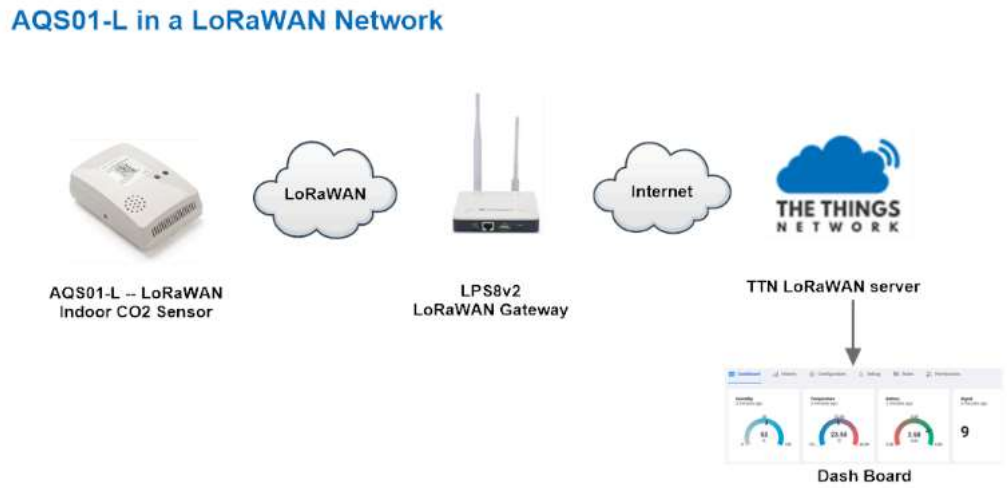
2.1 How it works

The AQS01-L 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 ne press the button to activate the AQS01-L. It will automatically join the network via OTAA and start to send the sensor value. The default uplink interval is 20 minute

2.2 Quick guide to connect to LoRaWAN server (OTAA)

Following is an example for how to join the TTN v3 LoRaWAN Network (https://console.cloud.thethings.network/) . Below is the network structure; we use the LP gateway/item/228-lps8v2.html) as a LoRaWAN gateway in this example.

The LPS8V2 is already set to connected to TTN network (https://console.cloud.thethings.network/) , so what we need to now is configure the TTN server.

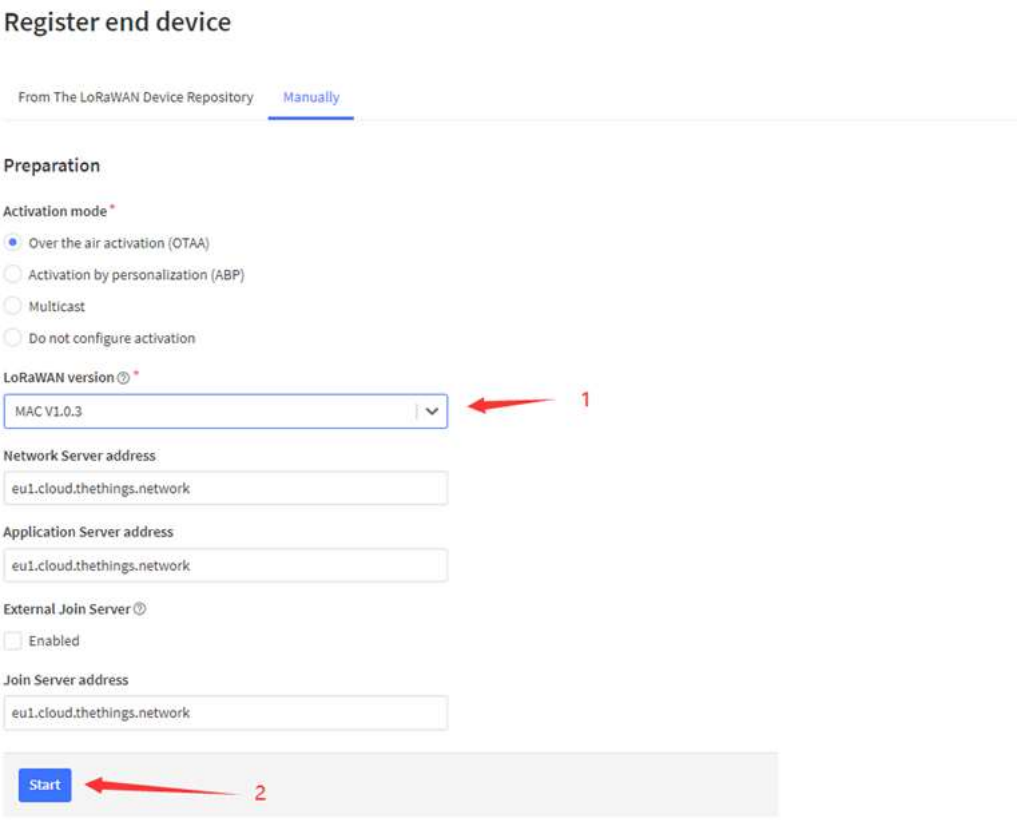


Step 1: Create a device in TTN with the OTAA keys from AQS01-L.

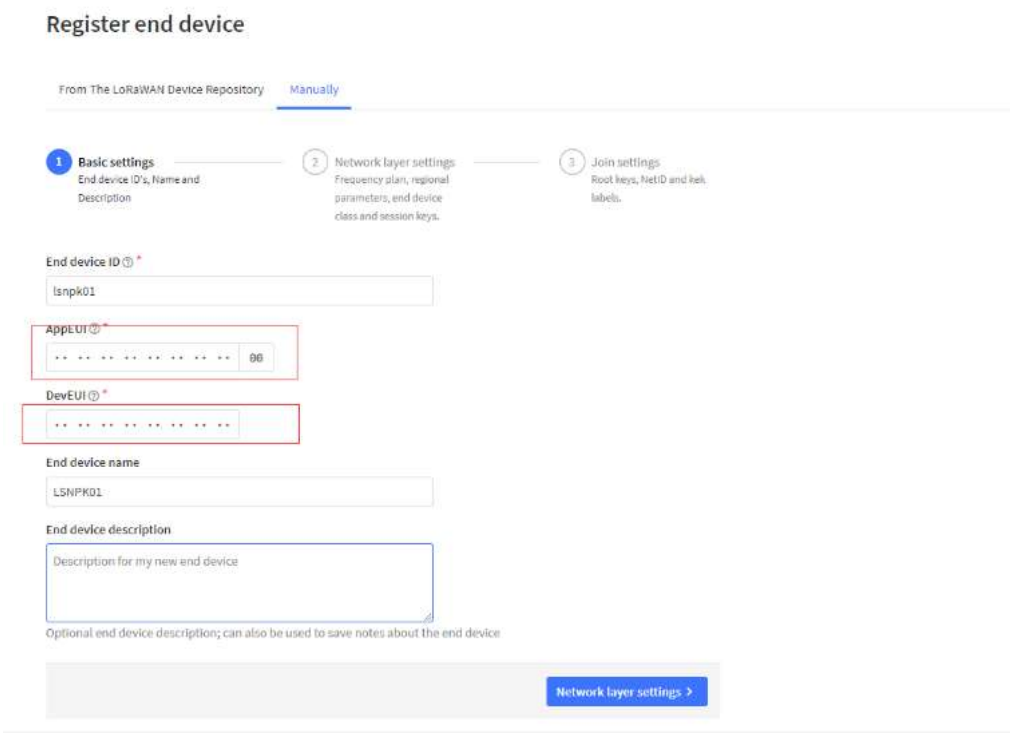
Each AQS01-L is shipped with a sticker with the default device EUI as below:

You can input these keys in the LoRaWAN Server portal. Below is TTN screen shot:

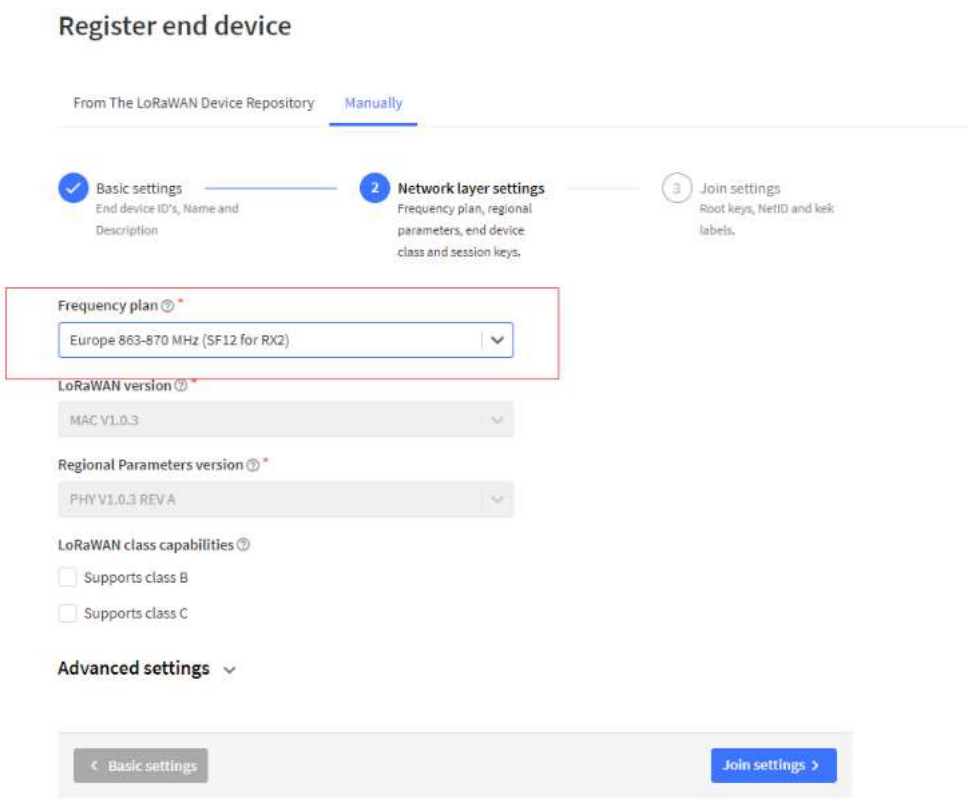
Register the device



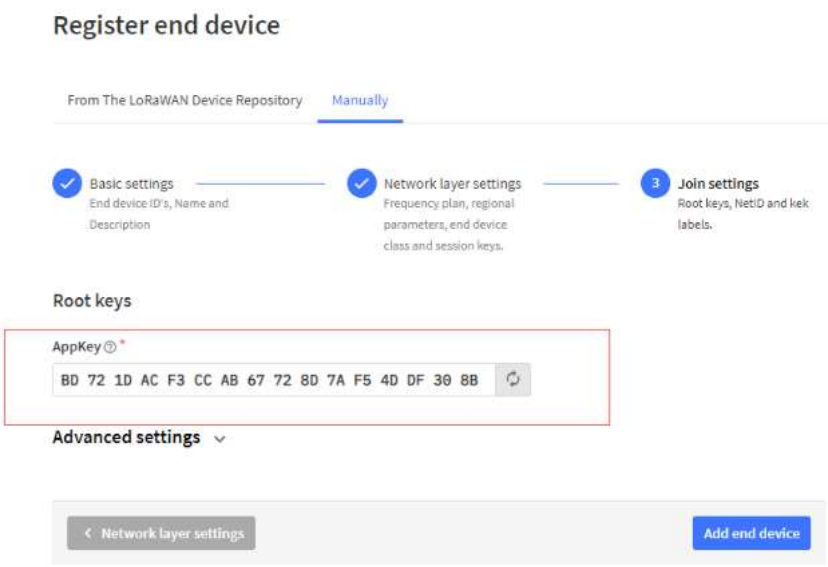
Add APP EUI and DEV EUI



Add APP EUI in the application



Add APP KEY



Step 2: Activate on AQS01-L

Press the button for 5 seconds to activate the AQS01-L.

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 second

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

2.3 Uplink Payload

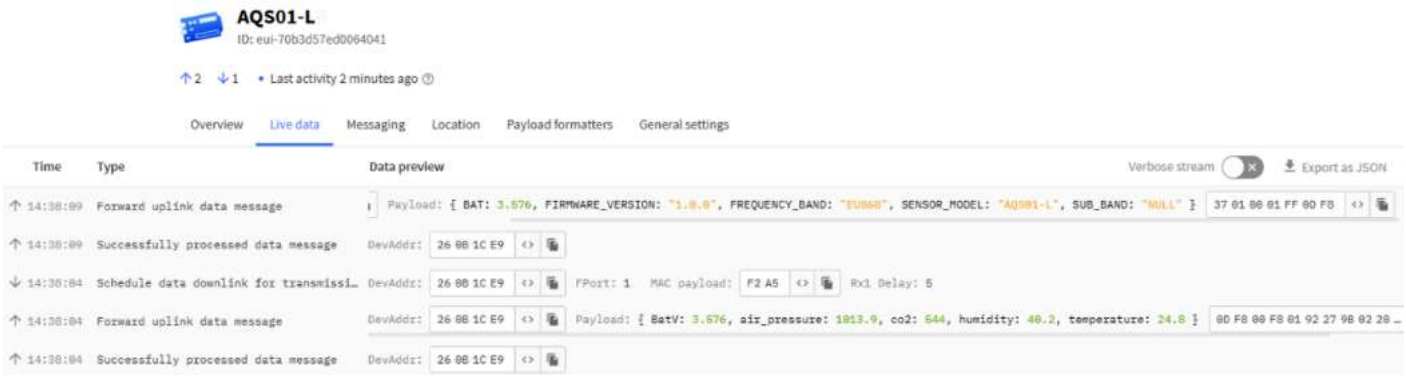
2.3.1 Device Status, FPORT=5

Users can use the downlink command(**0x26 01**) to ask AQS01-L to send device configure detail, include device configure status. AQS01-L will uplink a payload via F

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 AQS01-L, this value is 0x37

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

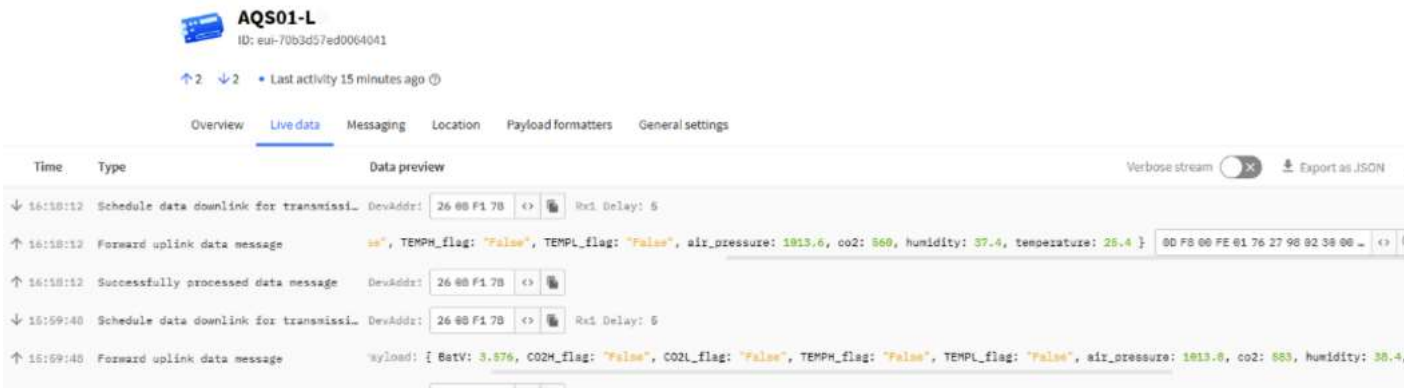
2.3.2 Sensor Data. FPORT=2

Sensor Data is uplink via FPORT=2

Size(bytes)	**2**	**2**	**2**	**2**	**2**	**1**
Value	Battery	Temperature	Humidity	Pressure	CO2	Alarm flag

Alarm flag:

Size(bit)	**[bit7:bit4]**	**bit3**	**bit2**	**bit1**	**bit0**
Value	Reserve	TEMPL_ flag	TEMPH_ flag	CO2L_ flag	CO2H_ flag



Battery

Sensor Battery Level.

Ex1: 0x0B45 = 2885mV

Ex2: 0x0B49 = 2889mV

Temperature

Example:

If payload is: 0105H: (0105 & 8000 == 0), temp = 0105H /10 = 26.1 degree

If payload is: FF3FH : (FF3F & 8000 == 1) , temp = (FF3FH - 65536)/10 = -19.3 degrees.

(FF3F & 8000: Judge whether the highest bit is 1, when the highest bit is 1, it is negative)

Humidity

Read:0x(018F)=399 Value: 399 / 10=39.9, So 39.9%

Pressure

Example:

If payload is: 279BH, Pressure = 279BH /10 = 1013.9 hPa

CO2

Example:

If payload is: 01FDH, CO2 = 01FDH= 509ppm

Alarm flag

TEMPH_flag: When it is True, the actual temperature exceeds the set alarm temperature.

TEMPL_flag: When it is True, the actual temperature lower than the set alarm temperature.

CO2H_flag: When it is True, the actual CO2 concentration exceeds the set alarm CO2 concentration.

CO2L_flag: When it is True, the actual CO2 concentration lower than the set alarm CO2 concentration.

Example:

AT+TEMPALARM=25,60 ------> temperature: 23.1, TEMPH_flag: "False", TEMPL_flag: "True"

AT+CO2ALARM=400,2000 ------> co2: 2368, CO2H_flag:"True", CO2L_flag:"False"

2.4 Payload Decoder file

In TTN, user 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 (https://github.com/dragino/dragino-end-node-decoder/tree/main/AQS01-L)

2.5 Datalog Feature

Datalog Feature is to ensure IoT Server can get all sampling data from AQS01-L even if the LoRaWAN network is down. For each sampling, AQS01-L will store the r

2.5.1 Ways to get datalog via LoRaWAN

Set PNACKMD=1, AQS01-L will wait for ACK for every uplink, when there is no LoRaWAN network,AQS01-L will mark these records with non-ack messages and stor
interval) after the network recovery.

- a) AQS01-L will do an ACK check for data records sending to make sure every data arrive server.
- b) AQS01-L will send data in **CONFIRMED Mode** when PNACKMD=1, but AQS01-L won't re-transmit the packet if it doesn't get ACK, it will just mark it as a NC
  AQS01-L will consider there is a network connection and resend all NONE-ACK messages.

2.5.2 Unix TimeStamp

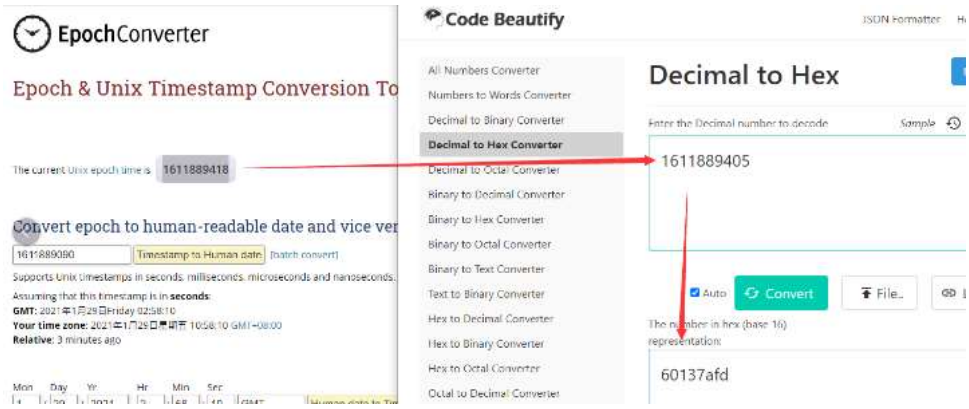
AQS01-L uses Unix TimeStamp format based on

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/ (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

2.5.3 Set Device Time

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

Once AQS01-L Joined LoRaWAN network, it will send the MAC command (DeviceTimeReq) and the server will reply with (DeviceTimeAns) to send the current time t server, AQS01-L 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 and loriot sup support this command, it will through away uplink packet with this command, so user will lose the packet with time request for TTN v2 if SYNCMOD=1

2.5.4 Datalog Uplink payload (FPORT=3)

The Datalog uplinks will use below payload format.

Retrieval data payload:

Size(bytes)	**2**	**2**	**2**	**1**	**4**
Value	CO2	Humidity	Temperature	Poll message flag	Unix Time Stamp

Poll message flag :

Bits	7	6	[5:0]
mean	No ACK Message	Poll Message Flag	Reserved

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 AQS01-L has below data inside Flash:

```
Stop Tx events when read sensor data
0001 2024/1/11 16:02:54 3744 temp:24.1 hum:42.0 pres:1013.8 co2:484
0002 2024/1/11 16:03:27 3750 temp:24.1 hum:42.1 pres:1013.7 co2:462
0003 2024/1/11 16:04:26 3750 temp:24.1 hum:42.0 pres:1013.7 co2:452
0004 1970/1/1 00:00:11 3756 temp:24.3 hum:45.2 pres:1013.8 co2:994
0005 2024/1/11 16:12:50 3756 temp:24.2 hum:43.5 pres:1013.9 co2:748
0006 2024/1/11 16:14:44 3762 temp:24.3 hum:43.3 pres:1013.9 co2:752
0007 2024/1/11 16:15:47 3762 temp:24.2 hum:42.9 pres:1014.0 co2:568
0008 2024/1/11 16:18:30 3762 temp:24.2 hum:44.4 pres:1013.9 co2:747
0009 2024/1/11 16:22:43 3768 temp:24.1 hum:44.1 pres:1013.9 co2:983
0010 1970/1/1 00:01:18 3768 temp:25.0 hum:43.7 pres:1013.9 co2:713
Start Tx events

OK
```

If user sends below downlink command: 3165A010F865A015E405

Where : Start time: 65A010F8 = time 24/1/11 16:02:00

Stop time: 65A015E4 = time 24/1/11 16:23:00

AQS01-L will uplink this payload.

01E401A400F14065A0112E01CE01A500F14065A0114F01C401A400F14065A0118A02EC01B300F24065A0138202F001B100F34065A013F4023801AD00F24065A014

Where the first 11 bytes is for the first entry: 01 E4 01 A4 00 F1 40 65 A0 11 2E

- **CO2**=0x01E4=484 ppm
- **Hum**=0x01A4/10=42 %
- **Temp**=0x00F1/10=24.1 ℃
- **poll message flag** =0x40,means reply data,sampling uplink message.
- **Unix time** is 0x65A0112E=1704888040s=24/1/11 16:02:54

2.6 Frequency Plans

The AQS01-L uses OTAA mode and below frequency plans by default. Each frequency band use different firmware, user update the firmware to the corresponding

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

2.7 Firmware Change Log

Firmware download link: https://www.dropbox.com/scl/fo/o5v6j7qewlks12eso98kl/h?rlkey=v1ian3hmva65924j4h4n0yfz8&dl=0 (https://www.dropbox.com/scl/fo
rlkey=v1ian3hmva65924j4h4n0yfz8&dl=0)

3. Configure AQS01-L

3.1 Configure Methods

AQS01-L supports below configure method:

- AT Command via Bluetooth Connection (**Recommended**): BLE Configure Instruction (http://wiki.dragino.com/xwiki/bin/view/Main/BLE%20Bluetooth%20Rer
- AT Command via UART Connection : See UART Connection (http://wiki.dragino.com/xwiki/bin/view/Main/UART%20Access%20for%20LoRa%20ST%20v4%20b
  Lmotherboard) .
- LoRaWAN Downlink. Instruction for different platforms: See IoT LoRaWAN Server (http://wiki.dragino.com/xwiki/bin/view/Main/) 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/
(http://wiki.dragino.com/xwiki/bin/view/Main/End%20Device%20AT%20Commands%20and%20Downlink%20Command/)

3.3 Commands special design for AQS01-L

These commands only valid for AQS01-L, 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 Temperature Alarm Threshold

- **AT Command:**

AT+TEMPALARM=min,max (Among them, 100 is an invalid value, which means not set)

- When min=100, and max≠100, Alarm higher than max
- When min≠100, and max=100, Alarm lower than min
- When min≠100 and max≠100, Alarm higher than max or lower than min

Example:

AT+TEMPALARM=100,30 // Alarm when temperature higher than 30.

- **Downlink Payload:**

0x(0C 01 64 1E) // Set AT+TEMPALARM=100,30

(note: 3rd byte= 0x64 for low limit(not set), 4th byte = 0x1E for high limit: 30)

3.3.4 Set CO2 Alarm Threshold

- **AT Command:**

AT+CO2ALARM=min,max (Among them, 0 is an invalid value, which means not set)

- When min=0, and max≠0, Alarm higher than max
- When min≠0, and max=0, Alarm lower than min
- When min≠0 and max≠0, Alarm higher than max or lower than min

Example:

AT+CO2ALARM=400,0 // Alarm when humidity lower than 400.

- **Downlink Payload:**

0x(0C 02 01 90 00 00) // Set AT+CO2ALARM=400,0

(note: 3rd byte+4rd byte= 0x0190 for low limit (400ppm), 5th byte+6rd byte = 0x00 for high limit (not set))

3.3.5 Set Alarm Interval

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

- **AT Command:**

AT+ATDC=20 // The shortest interval of two Alarm packets is 20 minutes, Means if there is an alarm packet uplink, there won't be another one in the next 20 m

- **Downlink Payload:**

0x(0D 14) **--->** Set AT+ATDC=0x 14 = 20 minutes

3.3.6 Set Time Sync Mode

Feature: Enable/Disable Sync system time via LoRaWAN MAC Command (DeviceTimeReq), LoRaWAN server must support v1.0.3 protocol to reply to this commanc

SYNCMOD is set to 1 by default. If user wants to set a different time from the LoRaWAN server, the user needs to set this to 0.

AT Command:

Command Example	Function	Response
AT+SYNCMOD=1	Enable Sync system time via LoRaWAN MAC Command (DeviceTimeReq) The default is zero time zone.	OK
AT+SYNCMOD=1,8	Enable Sync system time via LoRaWAN MAC Command (DeviceTimeReq) Set to East eight time zone.	OK
AT+SYNCMOD=1,-12	Enable Sync system time via LoRaWAN MAC Command (DeviceTimeReq) Set to West Twelve Time Zone.	OK

Downlink Command:

0x28 01 // Same As AT+SYNCMOD=1

0x28 01 08 // Same As AT+SYNCMOD=1,8

0x28 01 F4 // Same As AT+SYNCMOD=1,-12

0x28 00 // Same As AT+SYNCMOD=0

3.3.7 Request the server to send an ACK

AT Command: AT+PNACKMD

Command Example	Function	Response
AT+PNACKMD=1	If the node uploads the ACK as confirm, it will request the server to send an ACK. If the server ack is not received, the node will upload the packets that have not received the ACK the next time it receives the ACK	1 OK
AT+PNACKMD=0	off request the server to send an ACK	0 OK

Downlink Command: 0x34

0X34 01 //Same As AT+PNACKMD=1

0x34 00 //Same As AT+PNACKMD=0

4. Battery & Power Consumption

4.1 Battery Life

In a normal 20 minutes uplink situation , the battery life can last from 2 ~ 8 years depends on signal environment. The Alarm feature will reduce the battery life a l

See below link for detail information about the battery life calculation.

Battery Info & Power Consumption Analyze (http://wiki.dragino.com/xwiki/bin/view/Main/How%20to%20calculate%20the%20battery%20life%20of%20Dragino

4.2 Replace Battery

AQS01-L uses an ER18505 battery. If the battery is running out, User can purchase an ER18505 battery and replace. Make sure don't mess the + & - position.

5. OTA Firmware update

User can change firmware AQS01-L to:

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

Firmware and changelog can be downloaded from : **Firmware download link (https://www.dropbox.com/scl/fo/o5v6j7qewlks12eso98kl/h?rlkey=v1ian3hmv**

Methods to Update Firmware:

- (Recommanded way) OTA firmware update via wireless : **http://wiki.dragino.com/xwiki/bin/view/Main/Firmware%20OTA%20Update%20for%20Senso (http://wiki.dragino.com/xwiki/bin/view/Main/Firmware%20OTA%20Update%20for%20Sensors/)**
- Update through UART TTL interface : **Instruction (http://wiki.dragino.com/xwiki/bin/view/Main/UART%20Access%20for%20LoRa%20ST%20v4%20ba Lmotherboard)** .

6. FAQ

6.1 Do i need to calibrate the CO2 reading of AQS01-L?

The Operating principle for CO2 measurement used in AQS01-L is Non-dispersive infrared (NDIR). There is no need Calibration for this method.

7. Order Info

Part Number: **AQS01-L-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:

- AQS01-L LoRaWAN Indoor CO2 Sensor

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 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 (mailto:Support@dragino.cc) .