LoRaWAN Soil Moisture & EC Sensor User Manual

Document Version: 1.3
Image Version: v1.0

Version	Description	Date
1.0	Release	2020-Apr-24
1.1	Add fix for rejoin issue on second packet (trouble shooting)	2020-May-30
1.2	Fix typo on v2.3.3, add measure volume info	2020-Sep-16
1.3	Add different hardware connection	2020-Nov-5

1. Introduction

1.1 What is LoRaWAN Soil Moisture & EC Sensor

The Dragino LSE01 is a **LoRaWAN Soil Moisture & EC Sensor** for IoT of Agriculture. It is designed to measure the soil moisture of saline-alkali soil and loamy soil. The soil sensor uses FDR method to calculate the soil moisture with the compensation from soil temperature and conductivity. It also has been calibrated in factory for Mineral soil type.

It detects **Soil Moisture**, **Soil Temperature** and **Soil Conductivity**, and uploads the value via wireless to LoRaWAN IoT Server.

The LoRa wireless technology used in LES01 allows device to send data and reach extremely long ranges at low data-rates. It provides ultra-long range spread spectrum communication and high interference immunity whilst minimizing current consumption.

LES01 is powered by **4000mA Li-SOCI2 battery**, It is designed for long term use up to 10 years.

Each LES01 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.

LSE01 in a LoRaWAN Network

1.2 Features

- ✧ LoRaWAN 1.0.3 Class A
- ✧ Ultra low power consumption
- ✧ Monitor Soil Moisture
- ✧ Monitor Soil Temperature
- ✧ Monitor Soil Conductivity
- ✧ Bands: CN470/EU433/KR920/US915/EU868/AS923/AU915/IN865
- ✧ AT Commands to change parameters
- ✧ Uplink on periodically
- ✧ Downlink to change configure
- ✧ IP66 Waterproof Enclosure
- ✧ 4000mAh Battery for long term use

1.3 Specification

Measure Volume: Base on the centra pin of the probe, a cylinder with 7cm diameter and 10cm height.

Parameter	Soil Moisture	Soil Conductivity	Soil Temperature
Range	0-100.00%	0-20000uS/cm (25℃)(0-20.0EC)	-40.00℃～85.00℃
Unit	V/V %,	uS/cm,	℃
Resolution	0.01%	1 uS/cm	0.01℃
Accuracy	±3% (0-53%) ±5% (>53%)	2%FS,	-10℃～50℃ :<0.3℃ All other: <0.6℃
Measure Method	FDR , with temperature &EC compensate	Conductivity , with temperature compensate	RTD, and calibrate

1.4 Applications

- ✧ Smart Agriculture

1.5 Firmware Change log

LSE01 v1.0:

- ➢ Release

2. Configure LSE01 to connect to LoRaWAN network

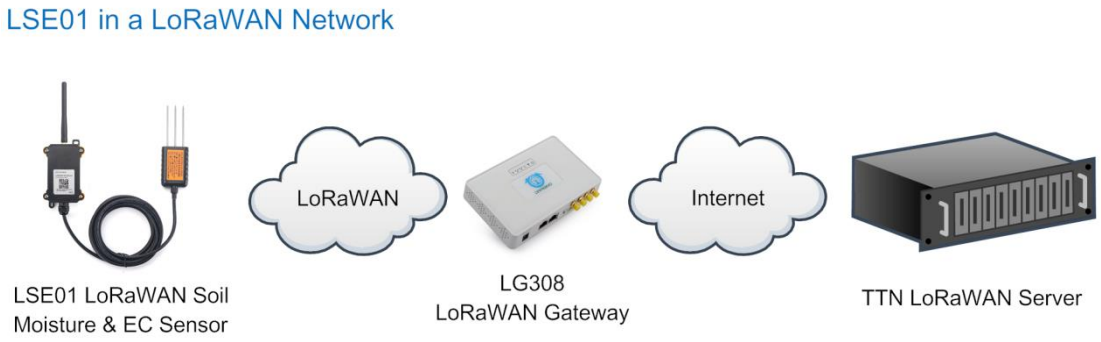
2.1 How it works

The LSE01 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 power on the LSE0150. It will automatically join the network via OTAA and start to send the sensor value

In case you can't set the OTAA keys in the LoRaWAN OTAA server, and you have to use the keys from the server, you can use AT Commands to set the keys in the LSE01.

2.2 Quick guide to connect to LoRaWAN server (OTAA)

Following is an example for how to join the TTN LoRaWAN Network. Below is the network structure; we use the LG308 as a LoRaWAN gateway in this example.

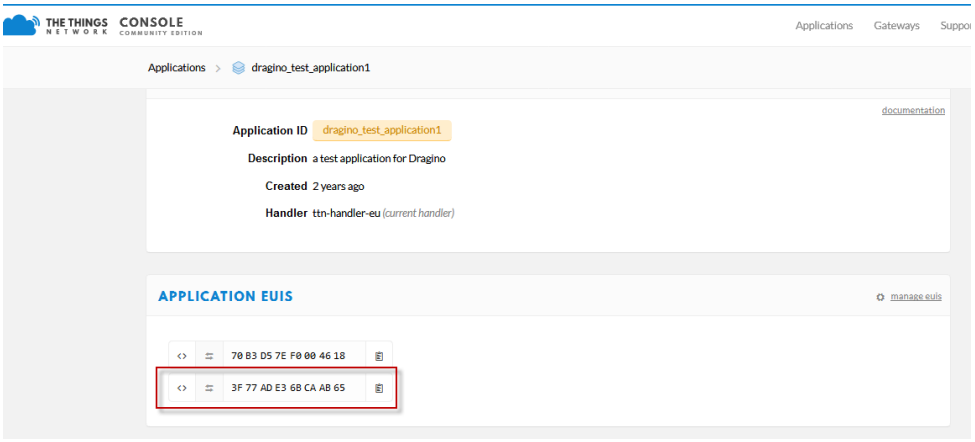


The LG308 is already set to connected to TTN network , so what we need to now is configure the TTN server.

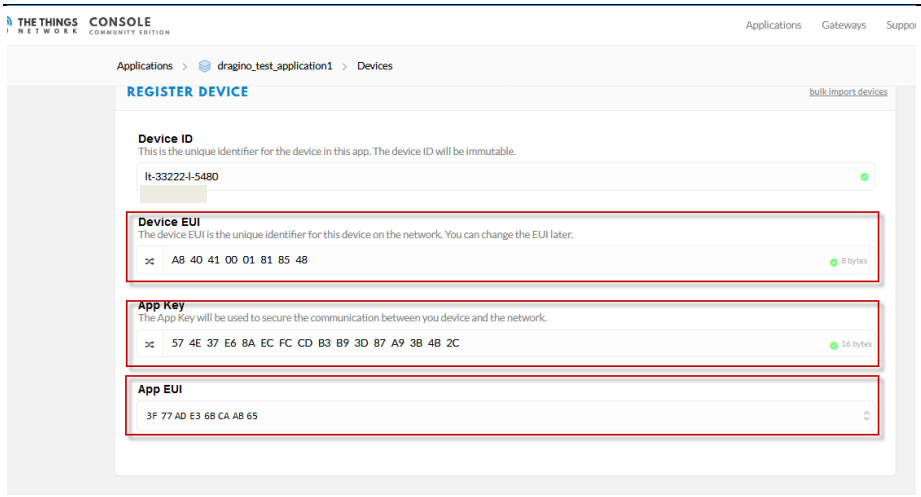
Step 1: Create a device in TTN with the OTAA keys from LSE01.
Each LSE01 is shipped with a sticker with the default device EUI as below:

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

Add APP EUI in the application



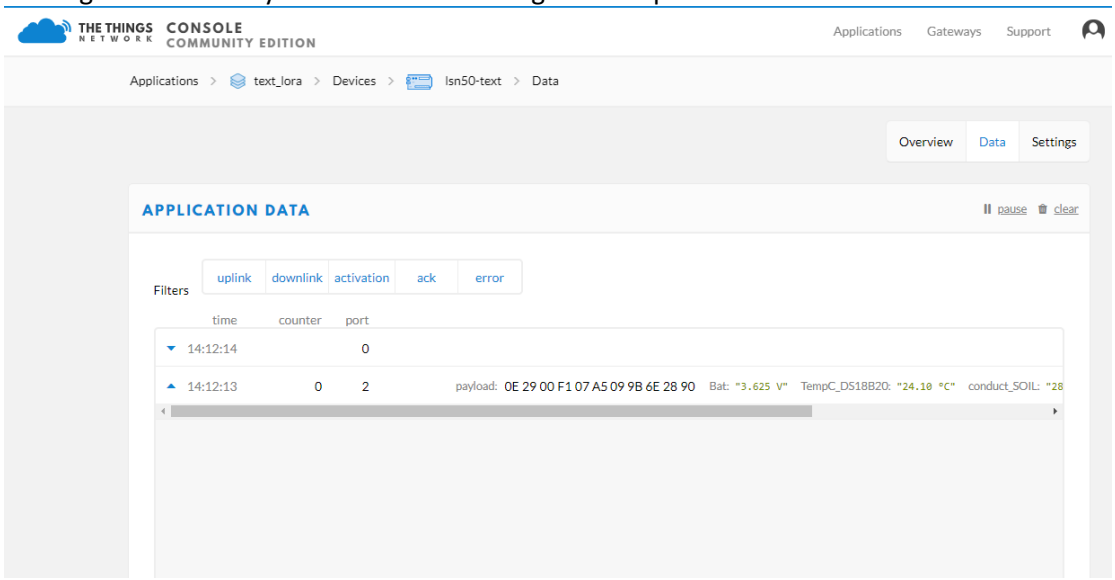
Add APP KEY and DEV EUI


THE THINGS NETWORK CONSOLE COMMUNITY EDITION
Applications
Gateways
Suppo
Applications > dragino_test_application1 > Devices
REGISTER DEVICE
bulk import devices
Device ID
This is the unique identifier for the device in this app. The device ID will be immutable.
lt-33222-l-5480
Device EUI
The device EUI is the unique identifier for this device on the network. You can change the EUI later.
A8 40 41 00 01 81 85 48
8 bytes
App Key
The App Key will be used to secure the communication between you device and the network.
57 4E 37 E6 8A EC FC CD B3 B9 3D 87 A9 3B 4B 2C
16 bytes
App EUI
3F 77 AD E3 6B CA AB 65

Step 2: Power on LSE01

Put a Jumper on JP2 to power on the device. (The Jumper must be in FLASH position).

Step 3: The LSE01 will auto join to the TTN network. After join success, it will start to upload messages to TTN and you can see the messages in the panel.

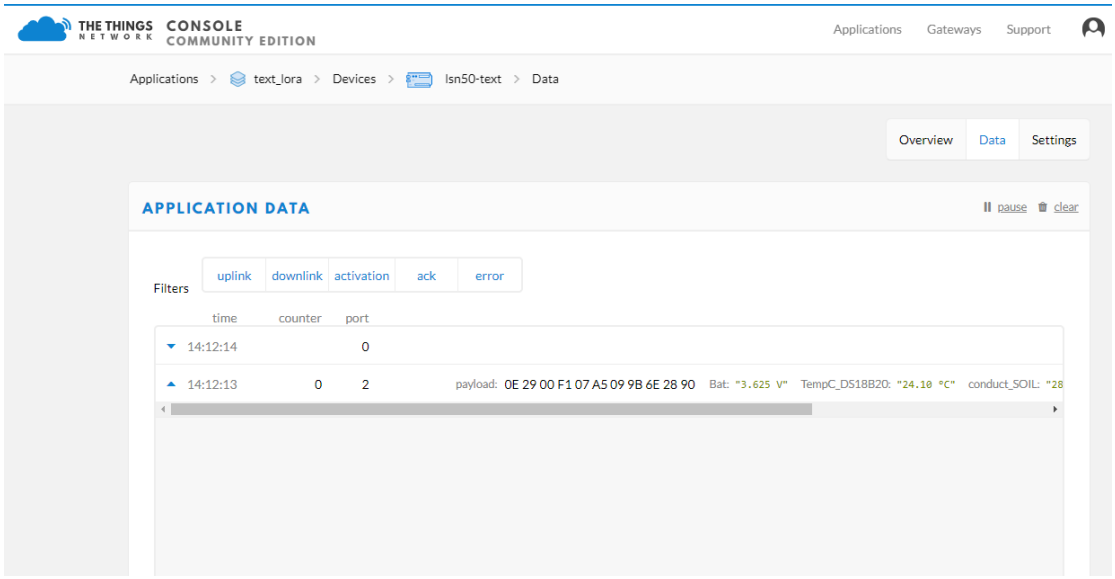


2.3 Uplink Payload

LSE01 will uplink payload via LoRaWAN with below payload format:

Uplink payload includes in total 11 bytes.

Size (bytes)	2	2	2	2	2	1
Value	BAT	Temperature (Reserve, Ignore now)	Soil Moisture	Soil Temperature	Soil Conductivity (EC)	Digital Interrupt (Optional)



2.3.1 Battery Info

Check the battery voltage for LSE01.
Ex1: 0x0B45 = 2885mV
Ex2: 0x0B49 = 2889mV

2.3.2 Soil Moisture

Get the moisture content of the soil. The value range of the register is 0-10000(Decimal), divide this value by 100 to get the percentage of moisture in the soil.
For example, if the data you get from the register is 0x05 0xDC, the moisture content in the soil is

05DC(H) = 1500(D) /100 = 15%.

2.3.3 Soil Temperature

Get the temperature in the soil. The value range of the register is -4000 - +800(Decimal), divide this value by 100 to get the temperature in the soil. For example, if the data you get from the register is 0x09 0xEC, the temperature content in the soil is
Example:

If payload is 0105H: ((0x0105 & 0x8000)>>15 === 0),temp = 0105(H)/100 = 2.61 °C
If payload is FF7EH: ((FF7E & 0x8000)>>15 ===1),temp = (FF7E(H)-FFFF(H))/100 = -1.29 °C

2.3.4 Soil Conductivity (EC)

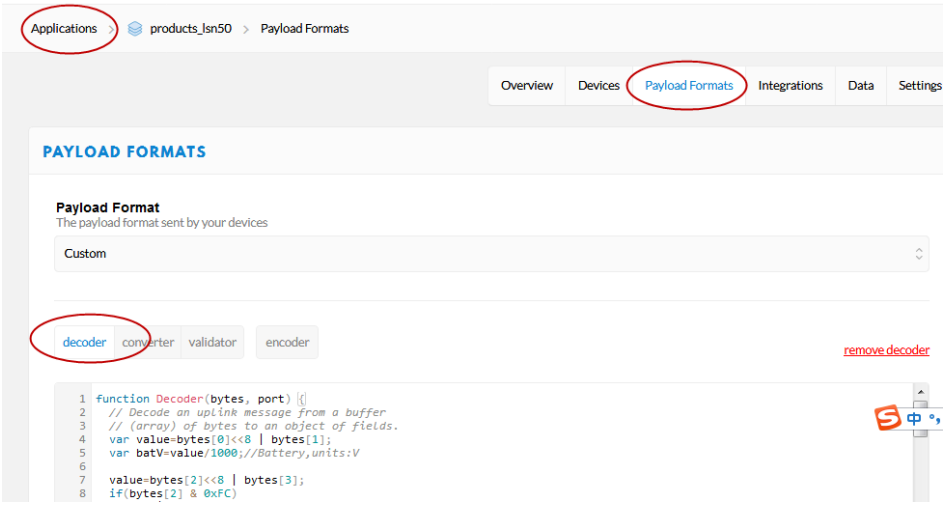
Obtain soluble salt concentration in soil or soluble ion concentration in liquid fertilizer or planting medium,. The value range of the register is 0 - 20000(Decimal)(Can be greater than 20000).

For example, if the data you get from the register is 0x00 0xC8, the soil conductivity is 00C8(H) = 200(D) = 200 uS/cm.

Generally, the EC value of irrigation water is less than 800uS / cm.

2.3.5 Decode payload in The Things Network

While using TTN network, you can add the payload format to decode the payload.



The payload decoder function for TTN is here:
LSE01 TTN Payload Decoder:
http://www.dragino.com/downloads/index.php?dir=LoRa_End_Node/LSE01/Payload_Decoder/

2.4 Downlink Payload

By default, LSE50 prints the downlink payload to console port.

Downlink Control Type	FPort	Type Code	Downlink payload size(bytes)
TDC (Transmit Time Interval)	Any	01	4
RESET	Any	04	2
AT+CFM	Any	05	4
INTMOD	Any	06	4

Examples

Set TDC

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

Payload: 01 00 00 1E TDC=30S

Payload: 01 00 00 3C TDC=60S

Reset

If payload = 0x04FF, it will reset the LSE01

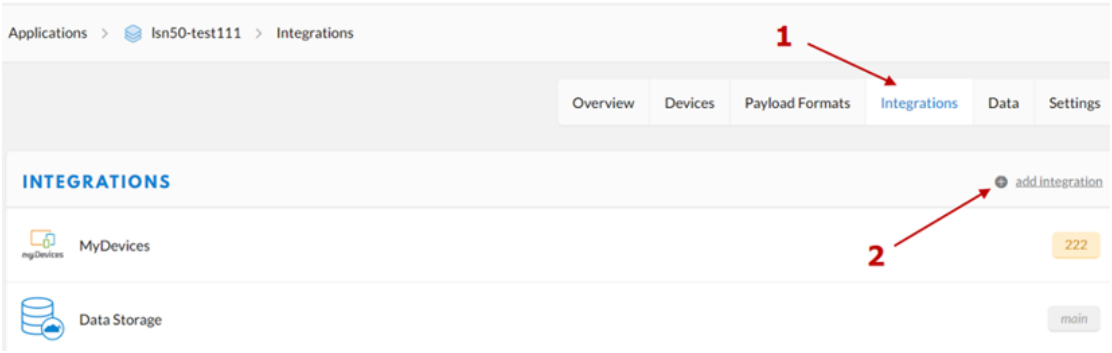
CFM

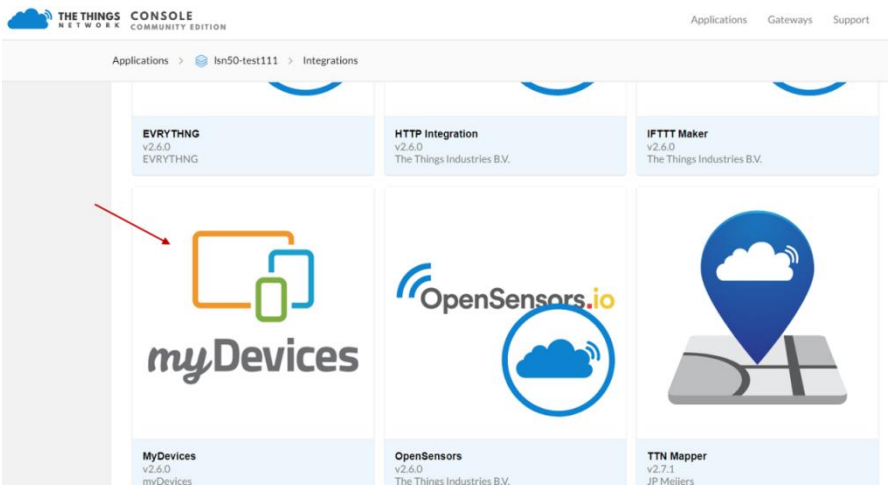
Downlink Payload: 05000001, Set AT+CFM=1 or 05000000 , set AT+CFM=0

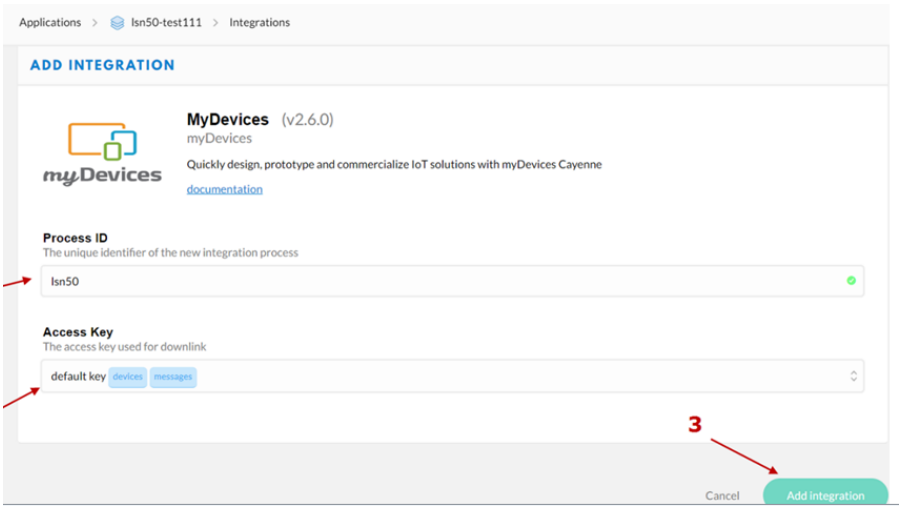
2.5 Show Data in Mydevices IoT Server

Mydevices provides a human friendly interface to show the sensor data, once we have data in TTN, we can use Mydevices to connect to TTN and see the data in Mydevices. Below are the steps:

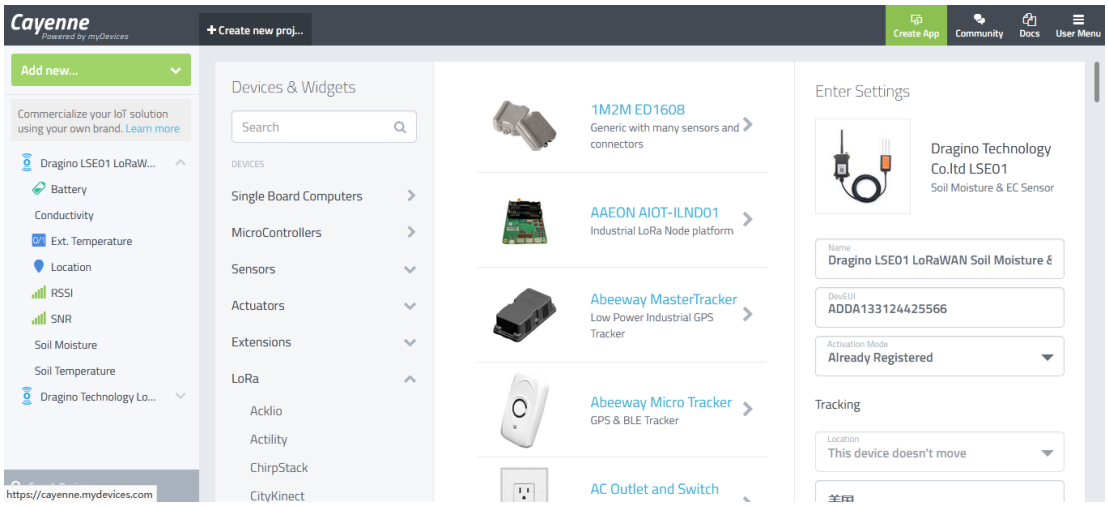
Step 1: Be sure that your device is programmed and properly connected to the network at this time.
Step 2: To configure the Application to forward data to Mydevices you will need to add integration. To add the Mydevices integration, perform the following steps:



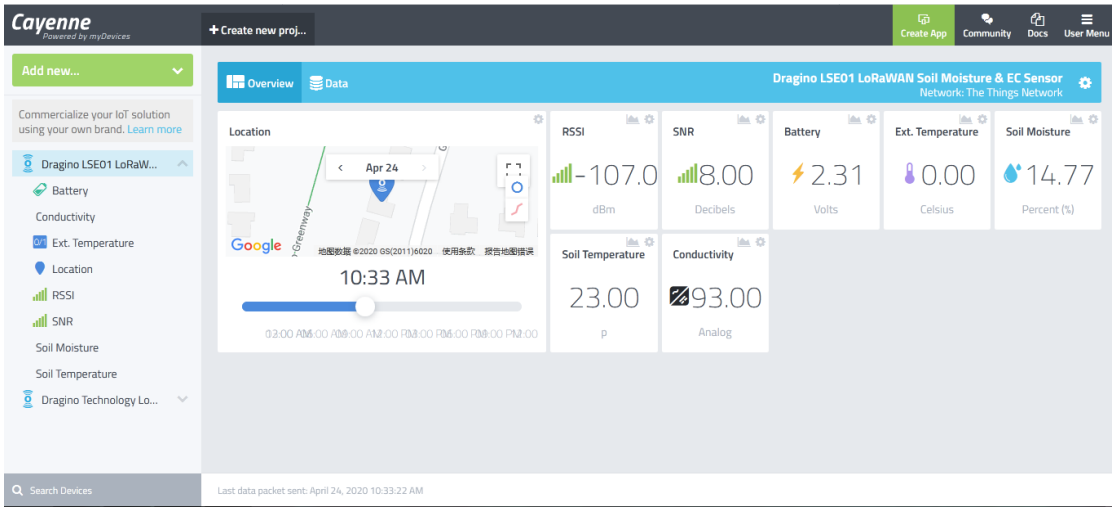




Step 3: Create an account or log in Mydevices.
Step 4: Search the LSE01 and add DevEUI.



After added, the sensor data arrive TTN, it will also arrive and show in Mydevices.



2.6 Frequency Plans

The LSE01 uses OTAA mode and below frequency plans by default. If user want to use it with different frequency plan, please refer the AT command sets.

2.6.1 EU863-870 (EU868)

Uplink:
868.1 - SF7BW125 to SF12BW125
868.3 - SF7BW125 to SF12BW125 and SF7BW250
868.5 - SF7BW125 to SF12BW125
867.1 - SF7BW125 to SF12BW125
867.3 - SF7BW125 to SF12BW125
867.5 - SF7BW125 to SF12BW125
867.7 - SF7BW125 to SF12BW125
867.9 - SF7BW125 to SF12BW125

868.8 - FSK

Downlink:
Uplink channels 1-9 (RX1)
869.525 - SF9BW125 (RX2 downlink only)

2.6.2 US902-928(US915)

Used in USA, Canada and South America. Default use CHE=2
Uplink:
903.9 - SF7BW125 to SF10BW125
904.1 - SF7BW125 to SF10BW125
904.3 - SF7BW125 to SF10BW125
904.5 - SF7BW125 to SF10BW125
904.7 - SF7BW125 to SF10BW125
904.9 - SF7BW125 to SF10BW125
905.1 - SF7BW125 to SF10BW125
905.3 - SF7BW125 to SF10BW125

Downlink:
923.3 - SF7BW500 to SF12BW500
923.9 - SF7BW500 to SF12BW500
924.5 - SF7BW500 to SF12BW500
925.1 - SF7BW500 to SF12BW500
925.7 - SF7BW500 to SF12BW500
926.3 - SF7BW500 to SF12BW500
926.9 - SF7BW500 to SF12BW500
927.5 - SF7BW500 to SF12BW500
923.3 - SF12BW500(RX2 downlink only)

2.6.3 CN470-510 (CN470)

Used in China, Default use CHE=1
Uplink:
486.3 - SF7BW125 to SF12BW125
486.5 - SF7BW125 to SF12BW125
486.7 - SF7BW125 to SF12BW125
486.9 - SF7BW125 to SF12BW125
487.1 - SF7BW125 to SF12BW125
487.3 - SF7BW125 to SF12BW125
487.5 - SF7BW125 to SF12BW125
487.7 - SF7BW125 to SF12BW125

Downlink:
506.7 - SF7BW125 to SF12BW125
506.9 - SF7BW125 to SF12BW125
507.1 - SF7BW125 to SF12BW125
507.3 - SF7BW125 to SF12BW125
507.5 - SF7BW125 to SF12BW125
507.7 - SF7BW125 to SF12BW125
507.9 - SF7BW125 to SF12BW125
508.1 - SF7BW125 to SF12BW125
505.3 - SF12BW125 (RX2 downlink only)

2.6.4 AU915-928(AU915)

Default use CHE=2

Uplink:

916.8 - SF7BW125 to SF12BW125
917.0 - SF7BW125 to SF12BW125
917.2 - SF7BW125 to SF12BW125
917.4 - SF7BW125 to SF12BW125
917.6 - SF7BW125 to SF12BW125
917.8 - SF7BW125 to SF12BW125
918.0 - SF7BW125 to SF12BW125
918.2 - SF7BW125 to SF12BW125

Downlink:

923.3 - SF7BW500 to SF12BW500
923.9 - SF7BW500 to SF12BW500
924.5 - SF7BW500 to SF12BW500
925.1 - SF7BW500 to SF12BW500
925.7 - SF7BW500 to SF12BW500
926.3 - SF7BW500 to SF12BW500
926.9 - SF7BW500 to SF12BW500
927.5 - SF7BW500 to SF12BW500
923.3 - SF12BW500(RX2 downlink only)

2.6.5 AS920-923 & AS923-925 (AS923)

Default Uplink channel:

923.2 - SF7BW125 to SF10BW125
923.4 - SF7BW125 to SF10BW125

Additional Uplink Channel:

(OTAA mode, channel added by JoinAccept message)

AS920~AS923 for Japan, Malaysia, Singapore:

922.2 - SF7BW125 to SF10BW125
922.4 - SF7BW125 to SF10BW125
922.6 - SF7BW125 to SF10BW125
922.8 - SF7BW125 to SF10BW125
923.0 - SF7BW125 to SF10BW125
922.0 - SF7BW125 to SF10BW125

AS923 ~ AS925 for Brunei, Cambodia, Hong Kong, Indonesia, Laos, Taiwan, Thailand, Vietnam:

923.6 - SF7BW125 to SF10BW125
923.8 - SF7BW125 to SF10BW125
924.0 - SF7BW125 to SF10BW125
924.2 - SF7BW125 to SF10BW125
924.4 - SF7BW125 to SF10BW125
924.6 - SF7BW125 to SF10BW125

Downlink:

Uplink channels 1-8 (RX1)
923.2 - SF10BW125 (RX2)

2.6.6 KR920-923 (KR920)

Default channel:
922.1 - SF7BW125 to SF12BW125
922.3 - SF7BW125 to SF12BW125
922.5 - SF7BW125 to SF12BW125

Uplink: (OTAA mode, channel added by JoinAccept message)
922.1 - SF7BW125 to SF12BW125
922.3 - SF7BW125 to SF12BW125
922.5 - SF7BW125 to SF12BW125
922.7 - SF7BW125 to SF12BW125
922.9 - SF7BW125 to SF12BW125
923.1 - SF7BW125 to SF12BW125
923.3 - SF7BW125 to SF12BW125

Downlink:
Uplink channels 1-7(RX1)
921.9 - SF12BW125 (RX2 downlink only; SF12BW125 might be changed to SF9BW125)

2.6.7 IN865-867 (IN865)

Uplink:
865.0625 - SF7BW125 to SF12BW125
865.4025 - SF7BW125 to SF12BW125
865.9850 - SF7BW125 to SF12BW125

Downlink:
Uplink channels 1-3 (RX1)
866.550 - SF10BW125 (RX2)

2.7 LED Indicator

The LSE01 has an internal LED which is to show the status of different state.

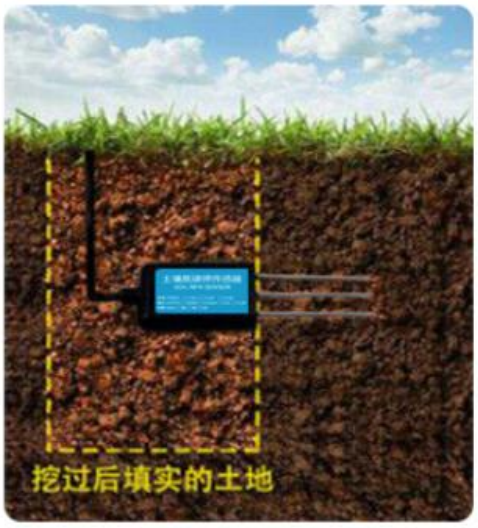
- Blink once when device power on.
- Solid ON for 5 seconds once device successful Join the network.
- Blink once when device transmit a packet.

2.8 Installation in Soil

Measurement the soil surface

Choose the proper measuring position. Avoid the probe to touch rocks or hard things. Split the surface soil according to the measured deep. Keep the measured as original density. Vertical insert the probe into the soil to be measured. Make sure not shake when inserting.

Dig a hole with diameter > 20CM.
Horizontal insert the probe to the soil and fill the hole for long term measurement.



2.9 Firmware Change Log

Firmware download link:
http://www.dragino.com/downloads/index.php?dir=LoRa_End_Node/LSE01/Firmware/

Firmware Upgrade Method:
http://wiki.dragino.com/index.php?title=Firmware_Upgrade_Instruction_for_STM32_base_products#Introduction

V1.0.
Release

2.10 Battery Analysis

2.10.1 Battery Type

The LSE01 battery is a combination of a 4000mAh Li/SOCI2 Battery and a Super Capacitor. The battery is non-rechargeable battery type with a low discharge rate (<2% per year). This type of battery is commonly used in IoT devices such as water meter.

The battery is designed to last for more than 5 years for the LSN50.

The battery related documents as below:

- Battery Dimension,
- Lithium-Thionyl Chloride Battery datasheet, Tech Spec
- Lithium-ion Battery-Capacitor datasheet, Tech Spec

2.10.2 Battery Note

The Li-SICO battery is designed for small current / long period application. It is not good to use a high current, short period transmit method. The recommended minimum period for use of this battery is 5 minutes. If you use a shorter period time to transmit LoRa, then the battery life may be decreased.

2.10.3 Replace the battery

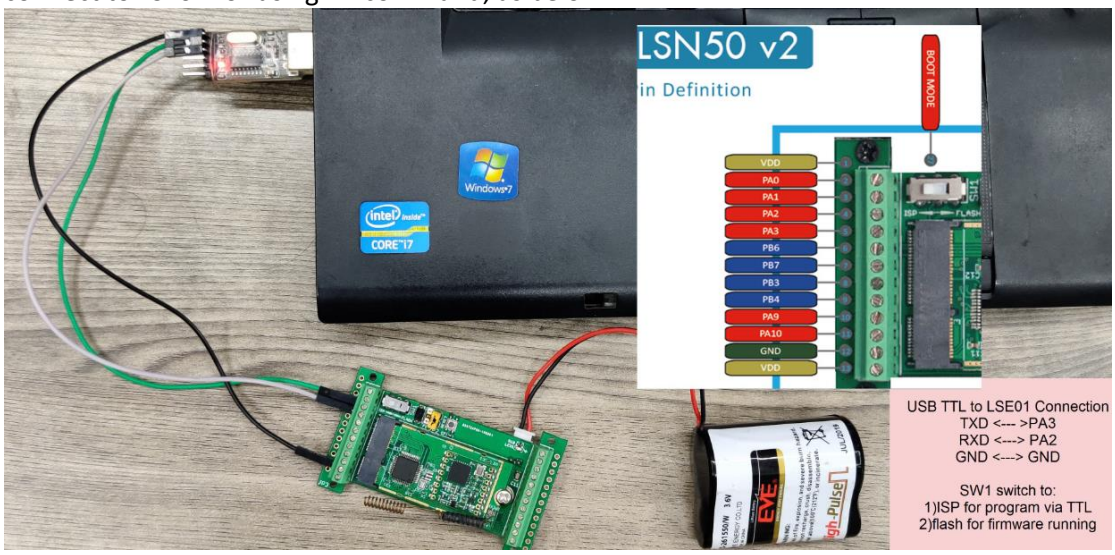
You can change the battery in the LSE01.The type of battery is not limited as long as the output is between 3v to 3.6v. On the main board, there is a diode (D1) between the battery and the main circuit. If you need to use a battery with less than 3.3v, please remove the D1 and shortcut the two pads of it so there won't be voltage drop between battery and main board.

The default battery pack of LSE01 includes a ER18505 plus super capacitor. If user can't find this pack locally, they can find ER18505 or equivalence, which will also work in most case. The SPC can enlarge the battery life for high frequency use (update period below 5 minutes)

3. Using the AT Commands

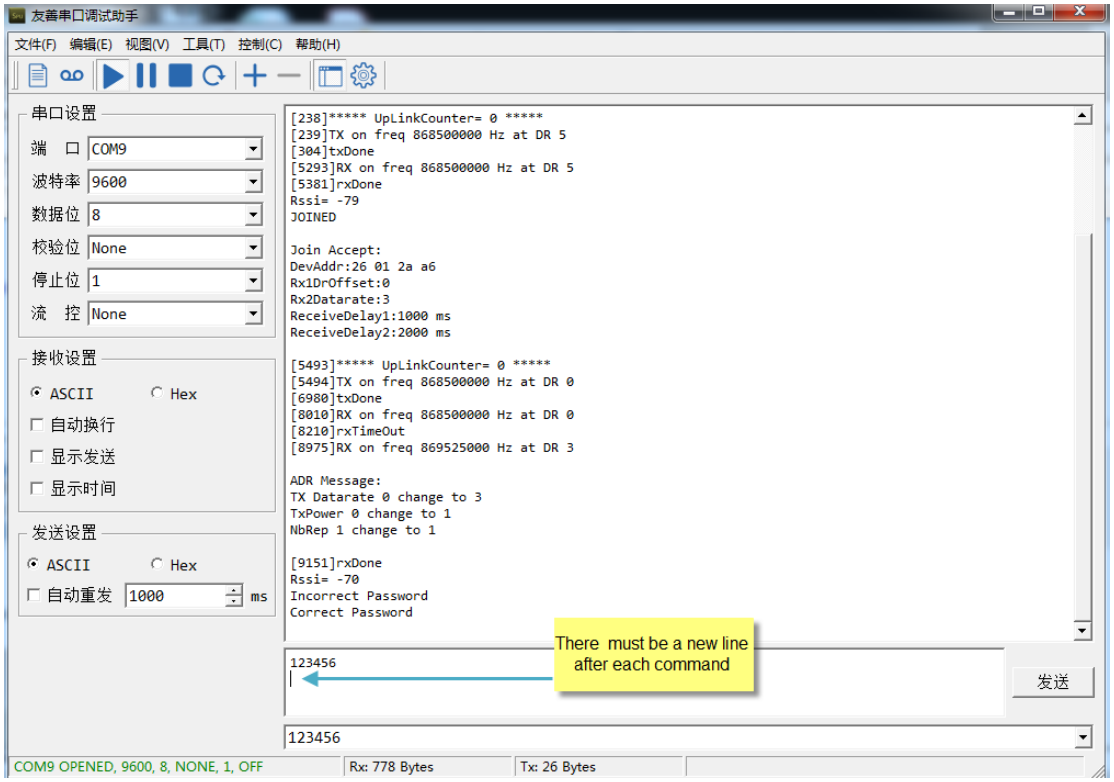
3.1 Access AT Commands

LSE01 supports AT Command set in the stock firmware. You can use a USB to TTL adapter to connect to LSE01 for using AT command, as below.



Or if you have below board, use below connection:

In the PC, you need to set the serial baud rate to **9600** to access the serial console for LSE01. LSE01 will output system info once power on as below:



Below are the available commands, a more detailed AT Command manual can be found at [AT Command Manual: http://www.dragino.com/downloads/index.php?dir=LoRa_End_Node/LSE01/](http://www.dragino.com/downloads/index.php?dir=LoRa_End_Node/LSE01/)

AT+<CMD>? : Help on <CMD>
AT+<CMD> : Run <CMD>
AT+<CMD>=<value> : Set the value
AT+<CMD>=? : Get the value

General Commands

AT : Attention
AT? : Short Help
ATZ : MCU Reset
AT+TDC : Application Data Transmission Interval

Keys, IDs and EUIs management

AT+APPEUI : Application EUI
AT+APPKEY : Application Key
AT+APPSKEY : Application Session Key
AT+DADDR : Device Address
AT+DEUI : Device EUI
AT+NWKID : Network ID (You can enter this command change only after successful network connection)
AT+NWKSKEY : Network Session Key Joining and sending date on LoRa network
AT+CFM : Confirm Mode
AT+CFS : Confirm Status
AT+JOIN : Join LoRa? Network
AT+NJM : LoRa? Network Join Mode
AT+NJS : LoRa? Network Join Status
AT+RECV : Print Last Received Data in Raw Format

AT+RECVB : Print Last Received Data in Binary Format
AT+SEND : Send Text Data
AT+SENB : Send Hexadecimal Data

LoRa Network Management

AT+ADR : Adaptive Rate
AT+CLASS : LoRa Class(Currently only support class A
AT+DCS : Duty Cycle Setting
AT+DR : Data Rate (Can Only be Modified after ADR=0)
AT+FCD : Frame Counter Downlink
AT+FCU : Frame Counter Uplink
AT+JN1DL : Join Accept Delay1
AT+JN2DL : Join Accept Delay2
AT+PNM : Public Network Mode
AT+RX1DL : Receive Delay1
AT+RX2DL : Receive Delay2
AT+RX2DR : Rx2 Window Data Rate
AT+RX2FQ : Rx2 Window Frequency
AT+TXP : Transmit Power

Information

AT+RSSI : RSSI of the Last Received Packet
AT+SNR : SNR of the Last Received Packet
AT+VER : Image Version and Frequency Band
AT+FDR : Factory Data Reset
AT+PORT : Application Port
AT+CHS : Get or Set Frequency (Unit: Hz) for Single Channel Mode
AT+CHE : Get or Set eight channels mode, Only for US915, AU915, CN470

4. FAQ

4.1 How to change the LoRa Frequency Bands/Region?

You can follow the instructions for how to upgrade image.
When downloading the images, choose the required image file for download.

How to set up LSE01 to work in 8 channel mode
By default, the frequency bands US915, AU915, CN470 work in 72 frequencies. Many gateways are 8 channel gateways, and in this case, the OTAA join time and uplink schedule is long and unpredictable while the end node is hopping in 72 frequencies.

You can configure the end node to work in 8 channel mode by using the AT+CHE command. The 500kHz channels are always included for OTAA.

For example, in **US915** band, the frequency table is as below. By default, the end node will use all channels (0~71) for OTAA Join process. After the OTAA Join, the end node will use these all channels (0~71) to send uplink packets.

CHE	US915 Uplink Channels(125KHz,4/5,Unit:MHz,CHS=0)								
0	ENABLE Channel 0-63								
1	902.3	902.5	902.7	902.9	903.1	903.3	903.5	903.7	Channel 0-7
2	903.9	904.1	904.3	904.5	904.7	904.9	905.1	905.3	Channel 8-15
3	905.5	905.7	905.9	906.1	906.3	906.5	906.7	906.9	Channel 16-23
4	907.1	907.3	907.5	907.7	907.9	908.1	908.3	908.5	Channel 24-31
5	908.7	908.9	909.1	909.3	909.5	909.7	909.9	910.1	Channel 32-39
6	910.3	910.5	910.7	910.9	911.1	911.3	911.5	911.7	Channel 40-47
7	911.9	912.1	912.3	912.5	912.7	912.9	913.1	913.3	Channel 48-55
8	913.5	913.7	913.9	914.1	914.3	914.5	914.7	914.9	Channel 56-63
Channels(500KHz,4/5,Unit:MHz,CHS=0)									
	903	904.6	906.2	907.8	909.4	911	912.6	914.2	Channel 64-71

When you use the TTN network, the US915 frequency bands use are:

- 903.9 - SF7BW125 to SF10BW125
- 904.1 - SF7BW125 to SF10BW125
- 904.3 - SF7BW125 to SF10BW125
- 904.5 - SF7BW125 to SF10BW125
- 904.7 - SF7BW125 to SF10BW125
- 904.9 - SF7BW125 to SF10BW125
- 905.1 - SF7BW125 to SF10BW125
- 905.3 - SF7BW125 to SF10BW125
- 904.6 - SF8BW500

Because the end node is now hopping in 72 frequency, it makes it difficult for the devices to Join the TTN network and uplink data. To solve this issue, you can access the device via the AT commands and run:

AT+CHE=2
ATZ

to set the end node to work in 8 channel mode. The device will work in Channel 8-15 & 64-71 for OTAA, and channel 8-15 for Uplink.

The **AU915** band is similar. Below are the AU915 Uplink Channels.

CHE	AU915 Uplink Channels(125KHz,4/5,Unit:MHz,CHS=0)								
0	ENABLE Channel 0-63								
1	915.2	915.4	915.6	915.8	916	916.2	916.4	916.6	Channel 0-7
2	916.8	917	917.2	917.4	917.6	917.8	918	918.2	Channel 8-15
3	918.4	918.6	918.8	919	919.2	919.4	919.6	919.8	Channel 16-23
4	920	920.2	920.4	920.6	920.8	921	921.2	921.4	Channel 24-31
5	921.6	921.8	922	922.2	922.4	922.6	922.8	923	Channel 32-39
6	923.2	923.4	923.6	923.8	924	924.2	924.4	924.6	Channel 40-47
7	924.8	925	925.2	925.4	925.6	925.8	926	926.2	Channel 48-55
8	926.4	926.6	926.8	927	927.2	927.4	927.6	927.8	Channel 56-63
Channels(500KHz,4/5,Unit:MHz,CHS=0)									
	915.9	917.5	919.1	920.7	922.3	923.9	925.5	927.1	Channel 64-71

5. Trouble Shooting

5.1 Why I can't join TTN in US915 / AU915 bands?

It is due to channel mapping. Please see the Eight Channel Mode section above for details.

5.2 AT Command input doesn't work

In the case if user can see the console output but can't type input to the device. Please check if you already include the **ENTER** while sending out the command. Some serial tool doesn't send **ENTER** while press the send key, user need to add ENTER in their string.

5.3 Device rejoin in at the second uplink packet.

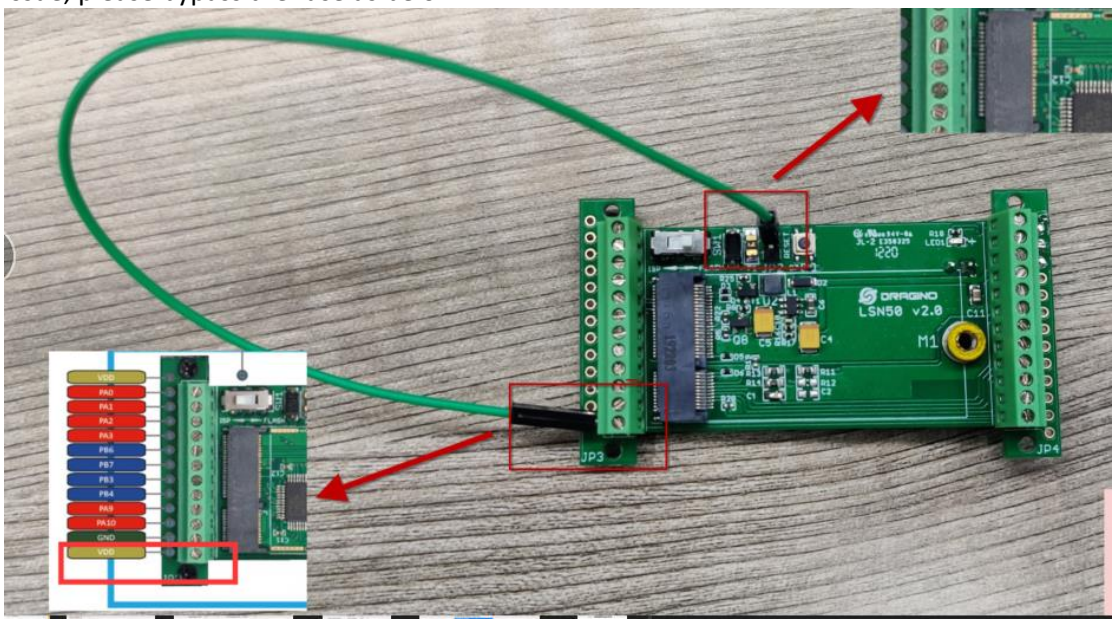
Issue describe as below:

Cause for this issue:

The fuse on LSE01 is not large enough, some of the soil probe require large current up to 5v 800mA, in a short pulse. When this happen, it cause the device reboot so user see rejoin.

Solution:

All new shipped LSE01 after 2020-May-30 will have this to fix. For the customer who see this issue, please bypass the fuse as below:



6. Order Info

Part Number: **LSE01-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

7. Packing Info

Package Includes:

- LSE01 LoRaWAN Soil Moisture & EC Sensor x 1

Dimension and weight:

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

8. 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.com