LHT65 Temperature & Humidity Sensor User Manual

Document Version: 1.1

Image Version: v1.3

Version	Description	Date
0.9	Draft	2019-May-14
1.0	Release	2019-Jun-15
1.1	Modify activation process, Add TTN Payload Decode	2019-Aug-28
1.2	Fix ACT typo, Add cayenne photo. Battery Analyze. Add notice for single channel use.	

1. Introduction

1.1 What is LHT65 Temperature & Humidity Sensor

The Dragino LHT65 Temperature & Humidity sensor is a Long Range LoRaWAN Sensor. It includes a **built-in SHT20 Temperature & Humidity sensor** and has an external sensor connector to connect to external sensors such as **Temperature Sensor, Soil Moisture Sensor, Tilting Sensor etc** .

The LHT65 allows users to send data and reach extremely long ranges. It provides ultra-long range spread spectrum communication and high interference immunity whilst minimizing current consumption. It targets professional wireless sensor network applications such as irrigation systems, smart metering, smart cities, building automation, and so on.

LHT65 has a built-in 2400mAh non-chargeable battery which can be used for more than 10 years*.

LHT65 is full compatible with LoRaWAN v1.0.2 protocol, it can work with standard LoRaWAN gateway.

LHT65 has 3200 data records with datetime which can be retrieved with datetime for further analyze.

*The actually battery life depends how often to send data, please see battery analyzer chapter.

1.2 Features

- ✓ Wall mountable
- ✓ LoRaWAN Class A protocol
- ✓ Frequency Bands: CN470/EU433/KR920/US915/EU868/AS923/AU915
- ✓ AT Commands to change parameters
- ✓ Remote configure parameters via LoRaWAN Downlink
- ✓ Firmware upgradable via program port
- ✓ Built-in 2400mAh battery for more than 10 year use.
- ✓ Built-in Temperature & Humidity sensor
- ✓ Optional External Sensors
- ✓ Tri-color LED to indicate status
- ✓ 3200 set sensor record with time stamp

1.3 Specifications

Built-in Temperature Sensor:

- ➢ Resolution: 0.01 °C
- ➢ Accuracy Tolerance : Typ ±0.3 °C
- ➢ Long Term Drift: < 0.02 °C/yr
- ➢ Operating Range: -40 ~ 125 °C

Built-in Humidity Sensor:

- ➢ Resolution: 0.04 %RH
- ➢ Accuracy Tolerance : Typ ±3 %PH
- ➢ Long Term Drift: < 0.02 °C/yr
- ➢ Operating Range: 0 ~ 100 °C

External Temperature Sensor – E1:

- ➢ Resolution: 0.0625 °C
- ➢ ±0.5°C accuracy from -10°C to +85°C
- ➢ ±2°C accuracy from -55°C to +125°C
- ➢ Operating Range: -55 °C ~ 125 °C

1.4 Power Consumption

LHT65 (without external sensor): Idle: 3uA. Transmit: max 130mA.

LHT65 + E1 Sensor: Idle: 4uA, Transmit: max 130mA.

1.5 Storage & Operation Temperature

-40°C to +85°C

1.6 Applications

- ✓ Smart Buildings & Home Automation
- ✓ Logistics and Supply Chain Management
- ✓ Smart Metering
- ✓ Smart Agriculture
- ✓ Smart Cities
- ✓ Smart Factory

2. Operation Mode

2.1 How to activate LHT65?

The LHT65 has two working modes:

- ✓ Deep Sleep Mode: LHT-65 doesn't have any LoRaWAN activate. This mode is used for storage and shipping to save battery life.
- ✓ Working Mode: In this mode, LHT65 will works as LoRaWAN Sensor mode to Join LoRaWAN network and send out the sensor data to server. Between each sampling/tx/rx periodically, LHT65 will be in STOP mode (IDLE mode), in STOP mode, device has the same power consumption as Deep Sleep mode.

The LHT65 is set in deep sleep mode by default; The ACT button on the bottom of device is used to switch to different modes:

Behavior on ACT	Function	Action
Pressing ACT between 1s < time < 3s	Test uplink status	If LHT65 is already Joined to LoRaWAN network, LHT65 will send an uplink packet, if LHT65 has external sensor connected, blue led will blink once. If LHT65 has not external sensor, red led will blink once.
Pressing ACT for more than 3s	Active Device	green led will fast blink 5 times, device will enter working mode and start to JOIN LoRaWAN network. green led will solid turn on for 5 seconds after joined in network.
Fast press ACT 5 times.	Deactivate Device	red led will solid on for 5 seconds. Means LHT65 are in Deep Sleep Mode.

2.2 How it works?

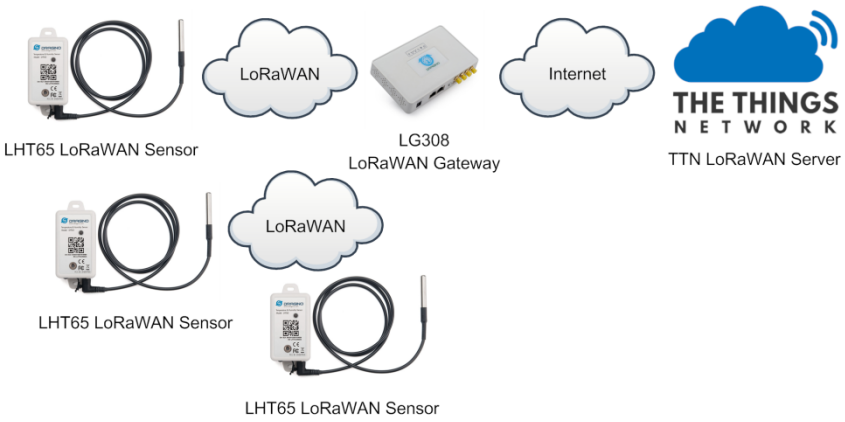
The LHT65 is configured as LoRaWAN OTAA Class A mode by default. Each LHT65 is shipped with a worldwide unique set of OTAA and ABP keys. To use LHT65 in a LoRaWAN network, user needs to input the OTAA or ABP keys in the network server. So LHT65 can join the LoRaWAN network and start to transmit sensor data. The default period for each uplink is 10 minutes.

In case user can't set the OTAA keys in the network server and has to use the existing keys from server. User can use AT Command to set the keys in LHT65.

2.3 Example to join LoRaWAN network

This section shows an example for how to join the TTN LoRaWAN IoT server. Use with other LoRaWAN IoT server is of similar procedure.

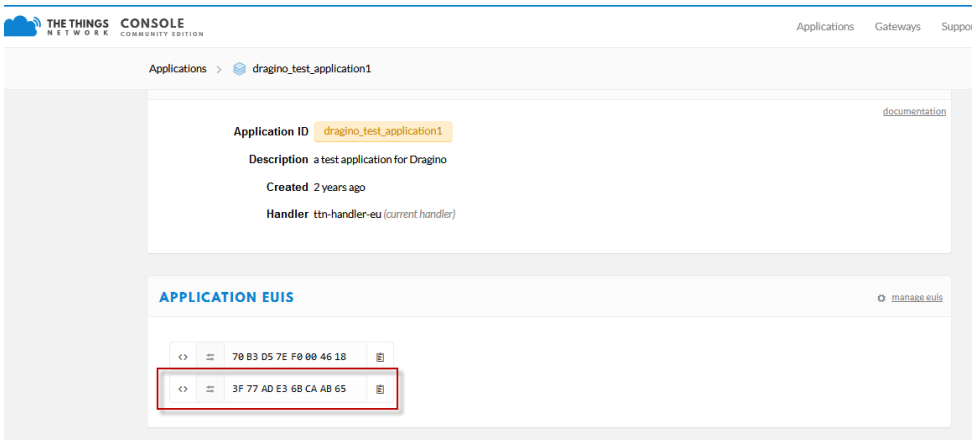
LHT65 in a LoRaWAN Network



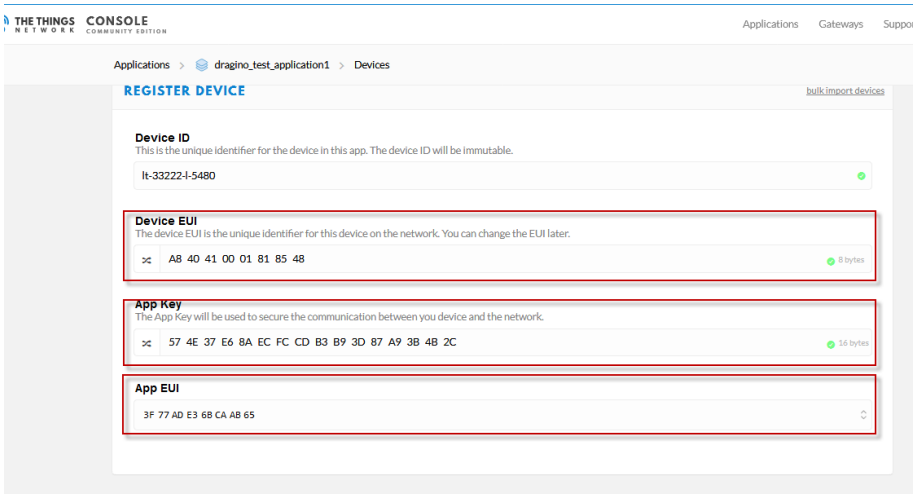
Assume the LG308 is already set to connect to TTN network . We need to add the LHT65 device in TTN:

Step 1: Create a device in TTN with the OTAA keys from LHT65.
Each LHT65 is shipped with a sticker with the default device EUI as below:

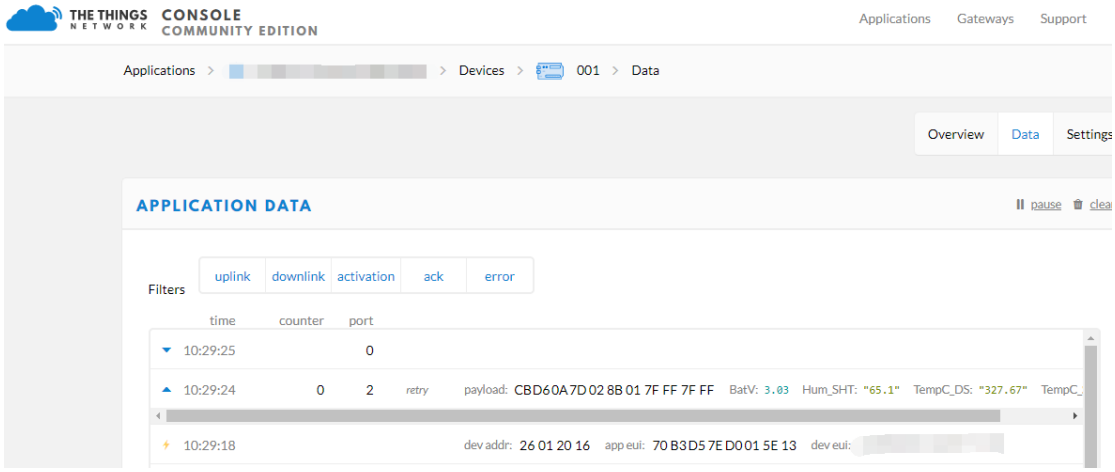
User can enter these keys in the LoRaWAN Server portal. Below is TTN screen shot:
Add APP EUI in the application.



Add APP KEY and DEV EUI



Step 2: Use ACT button to activate LHT65 and it will auto join to the TTN network. After join success, it will start to upload sensor data to TTN and user can see in the panel.



2.4 Uplink Payload

The uplink payload includes totally 11 bytes. Uplink packets use FPORT=2 and every 10 minutes send one uplink by default.

After each uplink, the BLUE LED will blink once.

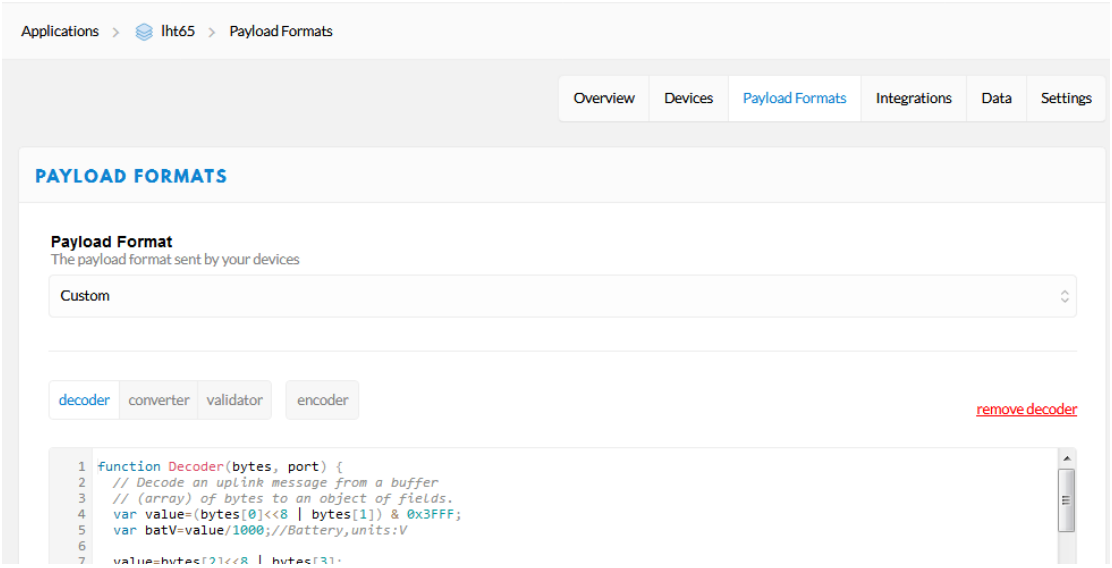
Size(bytes)	**2**	**2**	**2**	**1**	**4**
Value	BAT	Built-In Temperature	Built-in Humidity	Ext #	Ext value

First 6 bytes: has fix meanings for every device.

The 7th byte (EXT #): defines the external sensor model.

The 8th ~ 11th byte: the value for external sensor value. The definition is based on external sensor type. (If EXT=0, there won't be these four bytes.)

2.4.1 Decoder in TTN



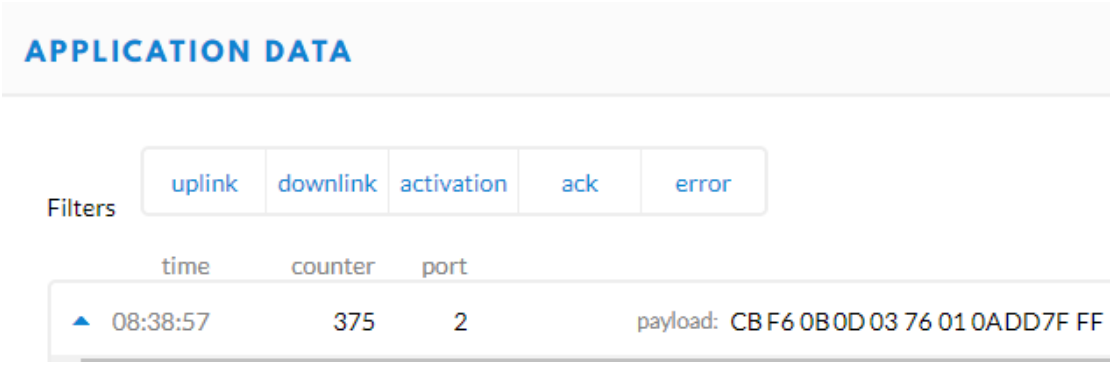

```
function Decoder(bytes, port) {
  // Decode an uplink message from a buffer
  // (array) of bytes to an object of fields.
  var value=(bytes[0]<<8 | bytes[1]) & 0x3FFF;
  var batV=value/1000;//Battery,units:V

  value=bytes[2]<<8 | bytes[3];
  if(bytes[2] & 0x80)
  {value |= 0xFFFF0000;}
   var temp_SHT=(value/100).toFixed(2);//SHT20,temperature,units:℃

   value=bytes[4]<<8 | bytes[5];
   var hum_SHT=(value/10).toFixed(1);//SHT20,Humidity,units:%

   value=bytes[7]<<8 | bytes[8];
  if(bytes[7] & 0x80)
  {value |= 0xFFFF0000;}
   var temp_ds=(value/100).toFixed(2);//DS18B20,temperature,units:℃

  return {
        BatV:batV,
        TempC_DS:temp_ds,
        TempC_SHT:temp_SHT,
        Hum_SHT:hum_SHT
  };
```

}

2.4.2 BAT-Battery Info

These two bytes of BAT include the battery state and the actually voltage

Bit(bit)	2	14
Value	BAT Status 00(b): Ultra Low (BAT <= 2.50v) 01(b): Low (2.50v <=BAT <= 2.55v) 10(b): OK (2.55v <= BAT <=2.65v) 11(b): Good (BAT >= 2.65v)	Actually BAT level

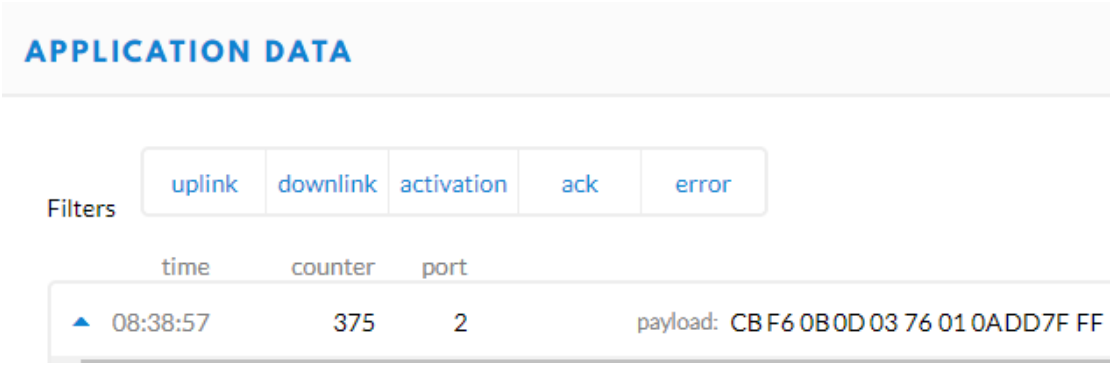


Check the battery voltage for LHT65.

Bat status=(0xCBF6>>14)&0xFF=11(B)，very good

battery voltage =0xCBF6&0x3FFF=0x0BF6=3062mV

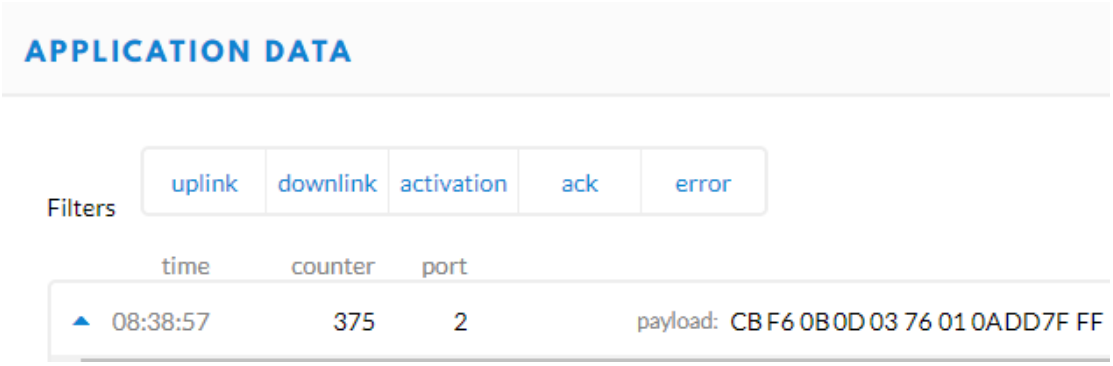
2.4.3 Built-in Temperature



Temperature: 0x0B0D/100=28.29℃

Temperature: (0xF5C6-65536)/100=-26.18℃

2.4.4 Built-in Humidity



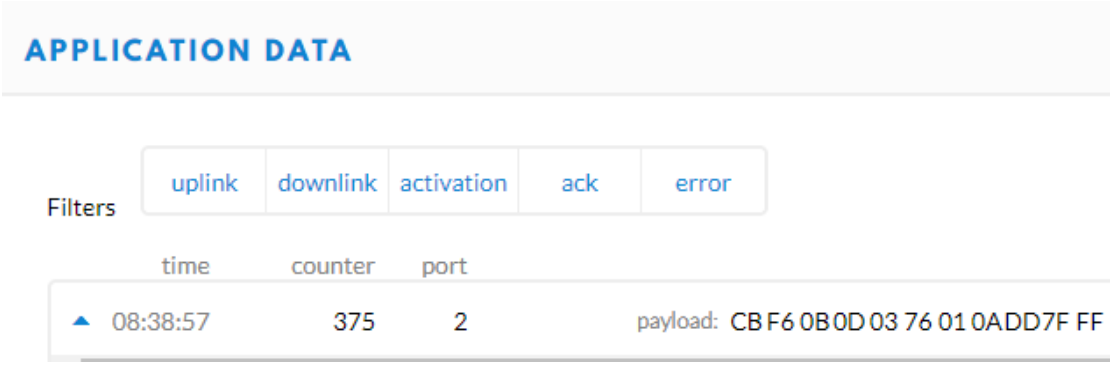
Humidity: 0x0376/10=88.6%

2.4.5 Ext

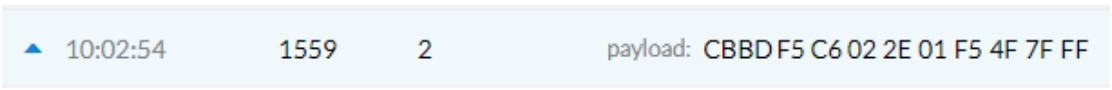
Bytes for External Sensor:

EXT # Value	External Sensor Type
0x01	Sensor E1, Temperature Sensor(DS18B20)

2.4.6 Ext value



DS18B20 temp=0x0ADD/100=27.81℃
The last 2 bytes of data are meaningless



DS18B20 temp= (0xF54F-65536)/100=-27.37℃
The last 2 bytes of data are meaningless

If the external sensor is 0x01, and there is no DS18B20 connected. The temperature will be set to 7FFF which is 327.67℃

2.5 Downlink Payload

After each success downlink, the PURPLE LED will blink once.

Downlink Command	FPort	Header	Downlink payload format
TDC (Transmit Time Interval)	Any	01	Total bytes: 4. Unit: Second Example: 0x01000258: Set AT+TDC=0x258=600S Recommend: higher than 0x12C (5 minuntes)
RESET	Any	04	Total bytes: 2 Example: 0x04FF, reset device
AT+CFM (Set Confirm status)	Any	05	Total bytes: 2 Example: 0x0501: AT+CFM=1, 0x0500: AT+CFM=0
AT+CHE	Any	07	Total bytes: 2 Example: 0x0702: AT+CHE=2
AT+DATE (Set time)	Any	A1	Total bytes: 7 Example: 0xA1190530162158: Set RTC time to 2019-5-30: 16:21:58
AT+EXT	Any	A2	Total bytes: 2 Example: 0xA201: Set external sensor type to E1
AT+CLRDTA (Clear Storage)	Any	A3	Total bytes: 2 Example: 0xA301: Clear data storage
AT+RTP (Set Record Time Period)	Any	A4	Total bytes: 3 unit: minutes Example: 0xA4000A: Set record time period to 10 minutes

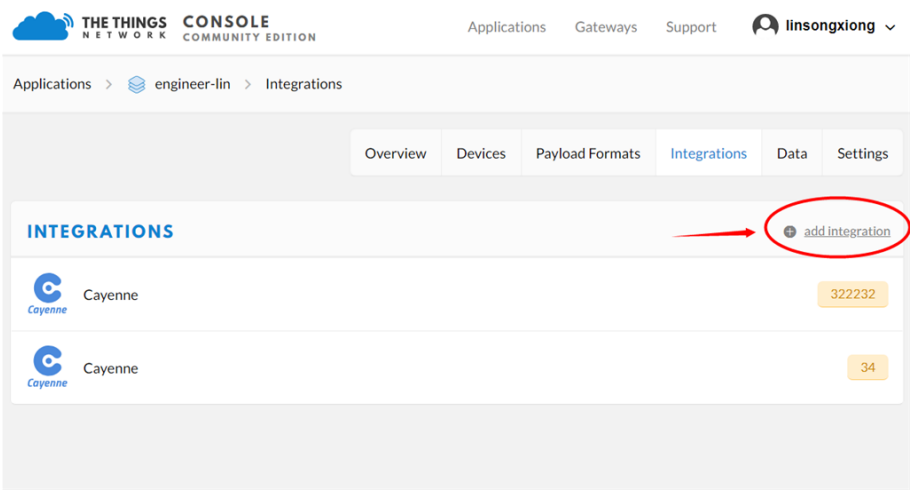
Example Downlink payload setting in TTN:

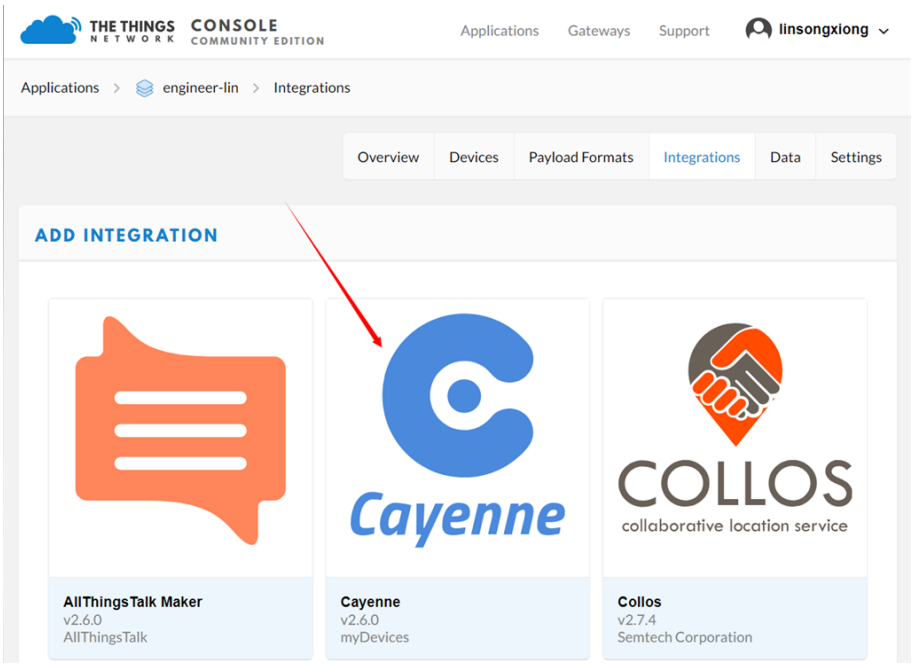
2.6 Show data on Cayenne

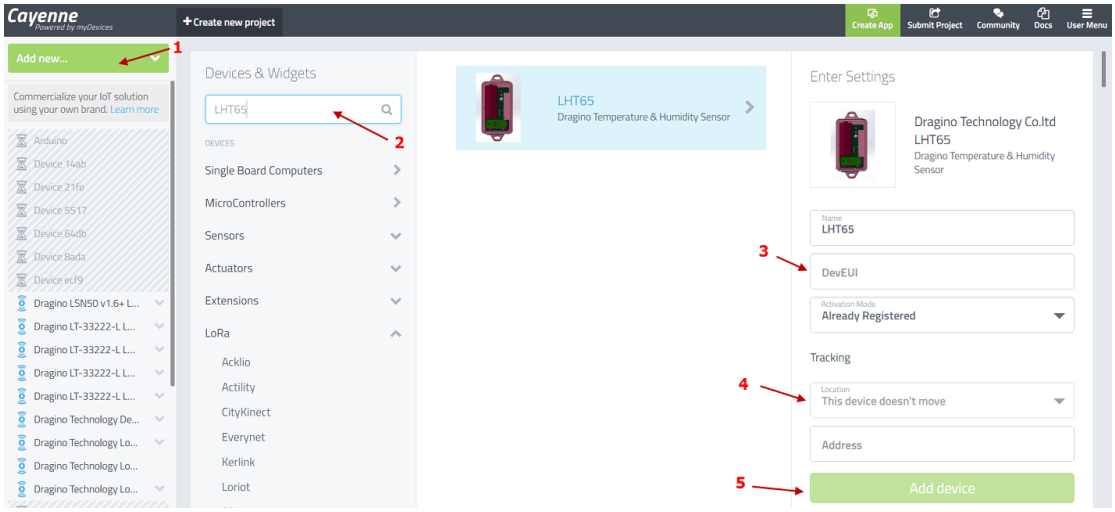
Cayenne provides a human friendly interface to show the sensor data, once we have data in TTN, we can use Cayenne to connect to TTN and see the data in Cayenne. Below are the steps:

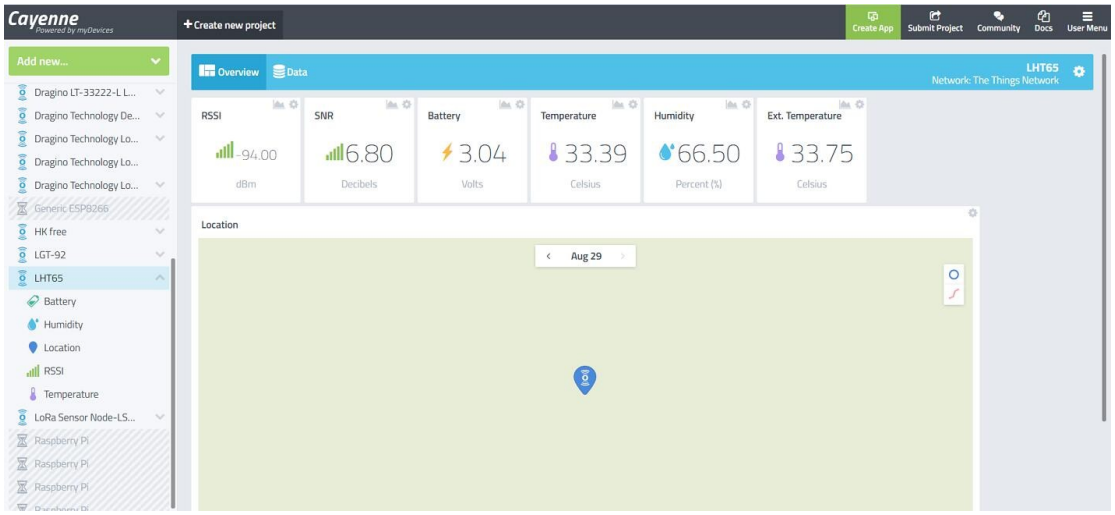
Step 1: Be sure that your device is programmed and properly connected to the network at this time.

Step 2: To configure your Application to forward data to Cayenne you will need to add an Integration. To add the Cayenne integration, perform the following steps:






Cayenne
Powered by myDevices
+ Create new project
Create App
Submit Project
Community
Docs
User Menu
Add new...
1
Commercialize your IoT solution using your own brand. Learn more
Devices & Widgets
LHT65
2
DEVICES
Single Board Computers
MicroControllers
Sensors
Actuators
Extensions
LoRa
Acklio
Actility
CityKinect
Everynet
Kerlink
Loriot
LHT65
Dragino Temperature & Humidity Sensor
Enter Settings
Dragino Technology Co.ltd
LHT65
Dragino Temperature & Humidity Sensor
Name
LHT65
3
DevEUI
Activation Mode
Already Registered
Tracking
4
Location
This device doesn't move
Address
5
Add device


Cayenne
Powered by myDevices
+ Create new project
Create App
Submit Project
Community
Docs
User Menu
Add new...
Overview
Data
LHT65
Network: The Things Network
RSSI
-94.00
dBm
SNR
6.80
Decibels
Battery
3.04
Volts
Temperature
33.39
Celsius
Humidity
66.50
Percent (%)
Ext. Temperature
33.75
Celsius
Location
Aug 29
HK free
LGT-92
LHT65
Battery
Humidity
Location
RSSI
Temperature
LoRa Sensor Node-LS...

2.7 Read stored sensor data

LHT65 provides 3200 set local data storage feature, user can use AT Commands to retrieve these data for further analyze.

By default, LHT65 stores one set of data every 5 minutes. LHT65 has reversed 400 sectors for storage; each sector can store 8 sets data so total 3200 sets of data can be stored. LHT65 use circle storage method, means the storage position reach the 400th sector, it will go back and erase the 1st sector and store from this position.

Below are the AT Commands used to operate these data:

AT+PDTA=start,stop: Print the sector from start to stop.. Example:

AT+PDTA=1,1 will print the first sector (8 set of data)

```
Stop Tx and RTP events when read sensor data
8019500 19/6/3 16:47 1 2987 sht_temp=28.31 sht_hum=53.6 ds_temp=27.50
8019510 19/6/3 16:48 1 2989 sht_temp=28.38 sht_hum=54.0 ds_temp=27.50
8019520 19/6/3 16:49 1 2987 sht_temp=28.46 sht_hum=55.0 ds_temp=27.62
8019530
8019540
8019550
8019560
8019570
Start Tx and RTP events
OK
```

Explain of the format:

- ✓ 8019500 is the flash address.
- ✓ 19/6/3 16:47 is the time
- ✓ 1 after time means the external sensor type.
- ✓ 2987 : battery voltage
- ✓ sht_temp and sht_hum are the built in sensor temperature and humidity.
- ✓ ds_temp is the external sensor value.

AT+PLDTA: will print the most recent few sets of data. Example:

AT+PLDTA=10 will print the latest 10 sets data

```
Stop Tx and RTP events when read sensor data
1 19/6/25 10:39 1 3023 sht_temp=26.82 sht_hum=62.4 ds_temp=327.67
2 19/6/25 10:44 1 3025 sht_temp=26.77 sht_hum=62.7 ds_temp=327.67
3 19/6/25 10:51 1 3019 sht_temp=27.57 sht_hum=62.0 ds_temp=327.67
4 19/6/25 10:56 1 3019 sht_temp=27.90 sht_hum=60.1 ds_temp=327.67
5 19/6/25 11:01 1 3021 sht_temp=27.86 sht_hum=59.9 ds_temp=327.67

6 19/6/25 11:06 1 3019 sht_temp=28.06 sht_hum=61.2 ds_temp=327.67
7 19/6/25 13:40 1 3012 sht_temp=28.09 sht_hum=74.2 ds_temp=327.67
8 19/6/25 13:45 1 3014 sht_temp=27.48 sht_hum=68.9 ds_temp=327.67
9 19/6/25 13:50 1 3016 sht_temp=28.30 sht_hum=80.6 ds_temp=327.67
10 19/6/25 14:06 1 3012 sht_temp=28.67 sht_hum=73.2 ds_temp=327.67
Start Tx and RTP events
OK
```

AT+CLRDTA: Clear the storage, record position back to 1st.

AT+RTP: Set record time period, default value 5 minute (AT+RTP=5). If RTP is set to 0, LHT65 will disable the record feature (RTP can be set by downlink command)

AT+DATE=19 05 30 16 21 58 set current time to 2019-5-30 16:21:58， AT+DATE=? to check the current time. System time error is ±2 min per month. This time can be configure via downlink command.

2.8 Frequency Plans

The LHT65 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.

2.8.1 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)

2.8.2 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)

2.8.3 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)

2.8.4 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)

2.8.5 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)

2.8.6 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)

2.8.7 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)

2.9 LED Indicator

The LHT65 has a triple color LED which for easy showing different stage .

While user press ACT button, the LED will work as per LED status with ACT button.

In a normal working state:

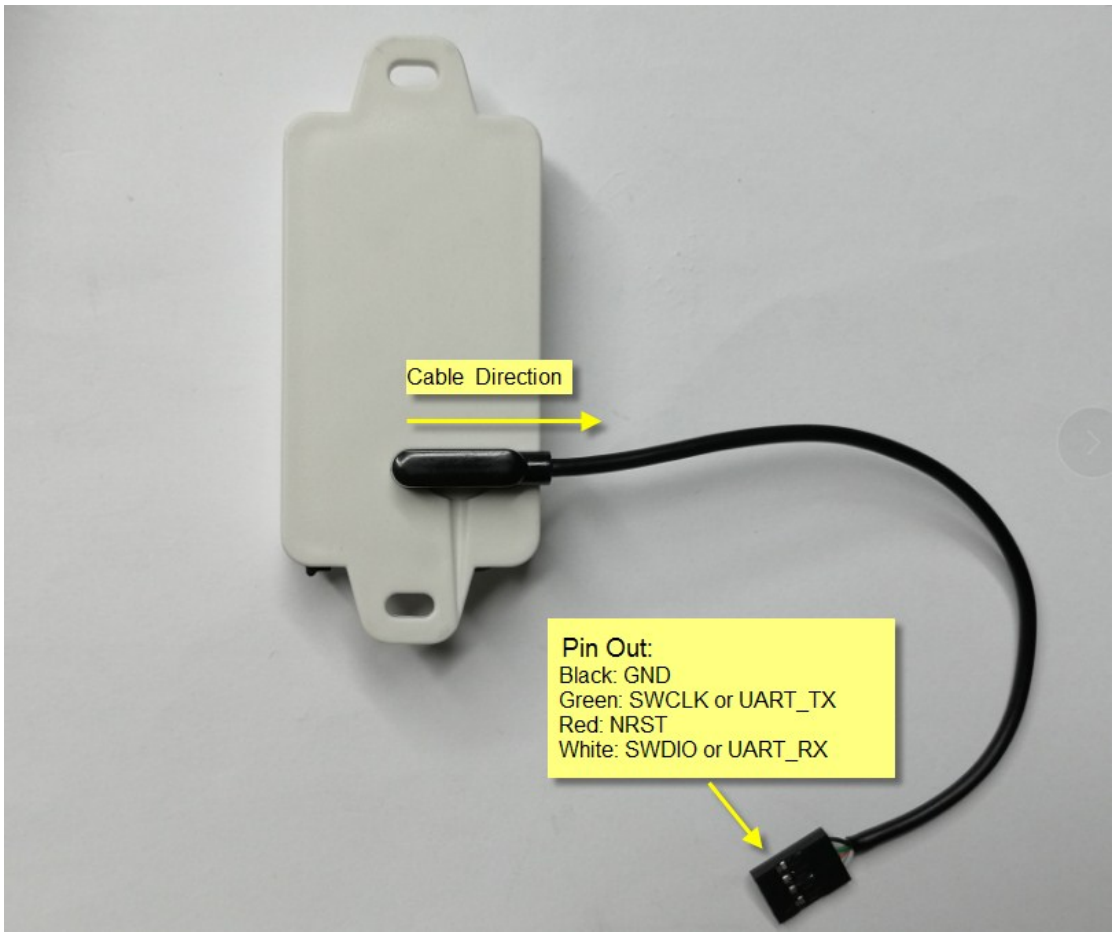
✓ For each uplink, the BLUE LED will blink once.

✓ For each success downlink, the PURPLE LED will blink once

3. Use AT Command

3.1 Access AT Command

LHT65 supports AT Command set. User can use a USB to TTL adapter plus the Program Cable to connect to LHT65 for using AT command, as below.

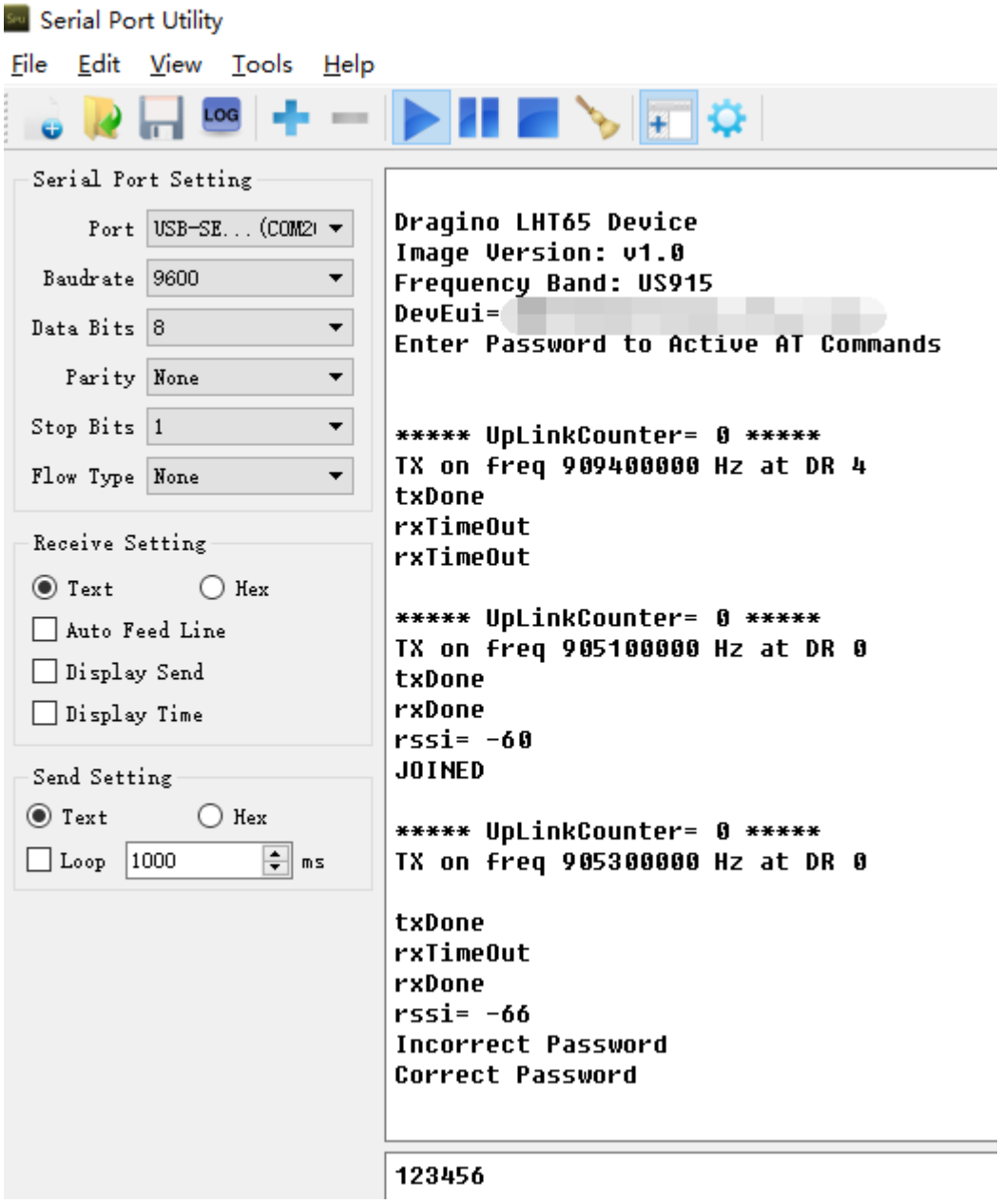


Connection:

- ✓ USB to TTL GND <--> Dupont black pin
- ✓ USB to TTL RXD <--> Dupont green pin
- ✓ USB to TTL TXD <--> Dupont white pin

In PC, User needs to set **serial tool**(such as putty, SecureCRT) baud rate to **9600** to access to access serial console for LHT65. The AT commands are disable by default and need to enter password (default:**123456**) to active it. Timeout to input AT Command is 5 min, after 5 minute, user need to input password again. User can use AT+DISAT command to disable AT command before timeout.

Input password and ATZ to activate LHT65,As shown below:



Below are the available commands, a more detail AT Command manual can be found at AT Command Manual

AT+<CMD>? : Help on <CMD>

AT+<CMD> : Run <CMD>

AT+<CMD>=<value> : Set the value

AT+<CMD>=? : Get the value

ATZ: Trig a reset of the MCU

AT+FDR: Reset Parameters to Factory Default, Keys Reserve

AT+DEUI: Get or Set the Device EUI

AT+DADDR: Get or Set the Device Address

AT+APPKEY: Get or Set the Application Key
AT+NWKSKEY: Get or Set the Network Session Key
AT+APPSKEY: Get or Set the Application Session Key
AT+APPEUI: Get or Set the Application EUI
AT+ADR: Get or Set the Adaptive Data Rate setting. (0: off, 1: on)
AT+TXP: Get or Set the Transmit Power (0-5, MAX:0, MIN:5, according to LoRaWAN Spec)
AT+DR: Get or Set the Data Rate. (0-7 corresponding to DR_X)
AT+DCS: Get or Set the ETSI Duty Cycle setting - 0=disable, 1=enable - Only for testing
AT+PNM: Get or Set the public network mode. (0: off, 1: on)
AT+RX2FQ: Get or Set the Rx2 window frequency
AT+RX2DR: Get or Set the Rx2 window data rate (0-7 corresponding to DR_X)
AT+RX1DL: Get or Set the delay between the end of the Tx and the Rx Window 1 in ms
AT+RX2DL: Get or Set the delay between the end of the Tx and the Rx Window 2 in ms
AT+JN1DL: Get or Set the Join Accept Delay between the end of the Tx and the Join Rx Window 1 in ms
AT+JN2DL: Get or Set the Join Accept Delay between the end of the Tx and the Join Rx Window 2 in ms
AT+NJM: Get or Set the Network Join Mode. (0: ABP, 1: OTAA)
AT+NWKID: Get or Set the Network ID
AT+FCU: Get or Set the Frame Counter Uplink
AT+FCD: Get or Set the Frame Counter Downlink
AT+CLASS: Get or Set the Device Class
AT+JOIN: Join network
AT+NJS: Get the join status
AT+SENDB: Send hexadecimal data along with the application port
AT+SEND: Send text data along with the application port
AT+RECVB: Print last received data in binary format (with hexadecimal values)
AT+RECV: Print last received data in raw format
AT+VER: Get current image version and Frequency Band
AT+CFM: Get or Set the confirmation mode (0-1)
AT+CFS: Get confirmation status of the last AT+SEND (0-1)
AT+SNR: Get the SNR of the last received packet
AT+RSSI: Get the RSSI of the last received packet
AT+TDC: Get or set the application data transmission interval in ms
AT+PORT: Get or set the application port
AT+DISAT: Disable AT commands
AT+PWORD: Set password, max 9 digits
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
AT+DATE: Get or Set real time
AT+PDTA: Print the sector data from start page to stop page
AT+PLDTA: Print the last few sets of data

AT+CLRDTA: Clear the storage, record position back to 1st

AT+SLEEP: Set sleep mode

AT+EXT: Get or Set external sensor model

AT+RTP: Get or Set record time period in min

AT+CFG: Print all configurations

3.2 Common AT Command Sequence

3.2.1 Multi-channel ABP mode (Use with SX1301/LG308)

If device has not joined network yet:

123456

AT+FDR

123456

AT+NJM=0

ATZ

If device already joined network:

AT+NJM=0

ATZ

3.2.2 Single-channel ABP mode (Use with LG01/LG02)

Please refer this link: How to Set Single Channel Mode.

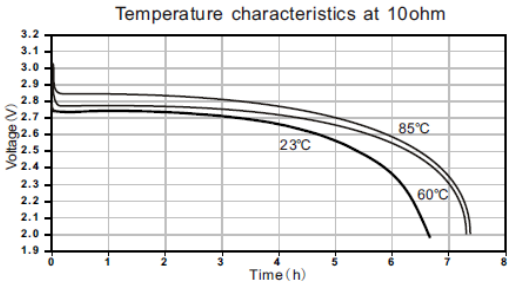
3.3 Battery Analyze

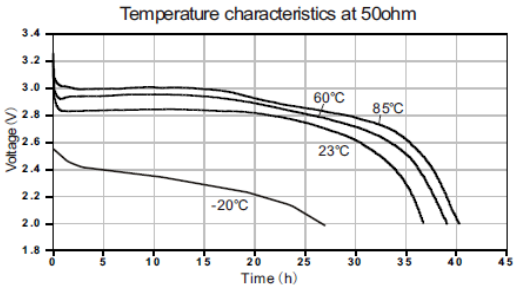
3.3.1 Battery Type

LHT-65 is equipped with a 2400mAH Li-MnO2 battery. The battery is un-rechargeable battery with low discharge rate targeting for 8~10 years use. This type of battery is commonly used in IoT target for long term running, such as water meter.

The discharge curve is not linear so can't simply use percentage to show the battery level. Below is the battery performance.

Performance





Minimum Working Voltage for the LHT65:

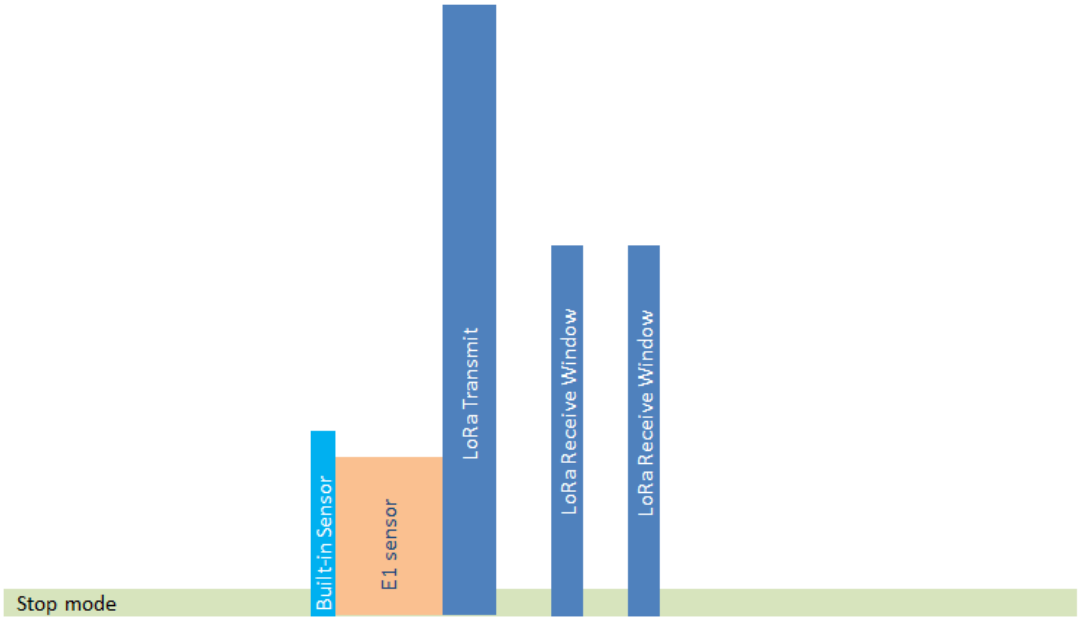
- ✓ LHT65: 2.45v ~ 3.6v
- ✓ ES-E1 Temperature Sensor : 2.35v ~ 5v

3.3.2 Power consumption Analyze

Below is the transmit power consumption of the system:

1. Deep Sleep (Stop mode):
   a) LHT65 without sensor. ~ 3uA
   b) With E1 sensor: ~ 4uA
2. Sampling current while reading E1.
   ✓ Built-in sensor sampling time: 120ms. 2mA
   ✓ E1 sensor sampling time: 750ms, current: 1.5mA
   ✓ Above power should add 8mA CPU power in working mode.
3. LoRaWAN transmit and receive time consumption. The LoRa TX / RX time and power can be found in the LoRa calculator tool.

In a typical LoRaWAN data transmit. The energy profile is as below:



LHT65 Energy Profile in one period

In LoRaWAN protocol, the device will transfer in different LoRa Radio, and have different energy profile in LoRa part. We can calculate the battery life in two case:

1) Lower power LoRa radio. Device has a good signal to gateway
2) Higher power LoRa radio. Device has a poor signal to gateway

Scenario-A, Lower Power Case (Good signal quality in **EU868** band)

✓ Radio Parameter: SF7, 125kHz, 14dbm
✓ Transmit interval: 15 minutes.
✓ Payload : 11 Bytes.

Scenario-B, High Power Case: (Poor signal quality in **EU868** band)

- ✓ Radio Parameter: SF12, 125kHz, 14dbm
- ✓ Transmit interval: 15 minutes.
- ✓ Payload : 11 Bytes.

Scenario-C, Low Power Case: (Good signal quality in **US915** band)

- ✓ Radio Parameter: SF7, 125kHz, 20dbm
- ✓ Transmit interval: 15 minutes.
- ✓ Payload : 11 Bytes.

Scenario-D, High Power Case: (Poor signal quality in **US915** band)

- ✓ Radio Parameter: SF10, 125kHz, 20dbm
- ✓ Transmit interval: 15 minutes.
- ✓ Payload : 11 Bytes.

To simplify the calculation, we can:

- ✓ Combine built-in sensor and E1 sampling energy together to **870ms@2ma**
- ✓ Combine two RX windows together.

There is a power consumption tool for easy analyze. And below is the analyze result.

Scenarios		A	B	C	D	E	F
Time	Units	Scenario_A	Scenario_B	Scenario_C	Scenario_D	Scenario_E	Scenario_F
Sleep	min	15	15	15	15		
Sampling	ms	870	870	870	870		
Transmit	ms	39.4	1097.7	39.4	274.4		
Receive	ms	100	2179	100	548		
Radio type		SF7_125K_14dB	SF12_125K_14dB	SF7_125K_20dB	SF10_125K_20dB		
Payload Bytes		11	11	11	11		
Total System Current							
Sleep	mA	0.005	0.005	0.005	0.005		
Sampling	mA	0.64	0.64	0.64	10		
Transmit	mA	52	52	133	133		
Receive	mA	18.8	18.8	18.8	18.8		
					Micro-Controller Active power (mA):		8
Power usage comparison							
Sleep	%	50.08%	4.36%	36.95%	7.50%	0.00%	0.00%
Sampling	%	6.20%	0.54%	4.57%	14.50%	0.00%	0.00%
Transmit	%	22.80%	55.36%	43.03%	60.83%	0.00%	0.00%
Receive	%	20.92%	39.73%	15.44%	17.17%	0.00%	0.00%
					Legend: Red > 100%, Green <= 100%		

Design Goals							
System efficiency		90%	90%	90%	90%	90%	90%
Target battery life	yr	1	1	1	1	1	1
Required battery capac	mAh	**97.14**	**1110.68**	**131.63**	**648.09**	**0.00**	**0.00**
or							
Given battery capacity	mAh	2400	2400	2400	2400	2400	2400
Estimated battery life	yr	**24.71**	**2.16**	**18.23**	**3.70**	**0.00**	**0.00**

Ignore the 11 year, because the battery has a max 2% discharge per year.

4. Sensors & Accessories

4.1 E1 Temperature Sensor

With DS18B20 Temperature sensor with 1 meter cable long

- Resolution: 0.0625 °C
- ±0.5°C accuracy from -10°C to +85°C
- ±2°C accuracy from -55°C to +125°C
- Operating Range: -40 ~ 125 °C
- -55°C to 125°C
- Working voltage 2.35v ~ 5v

5. FAQ

5.1 How to upgrade the firmware?

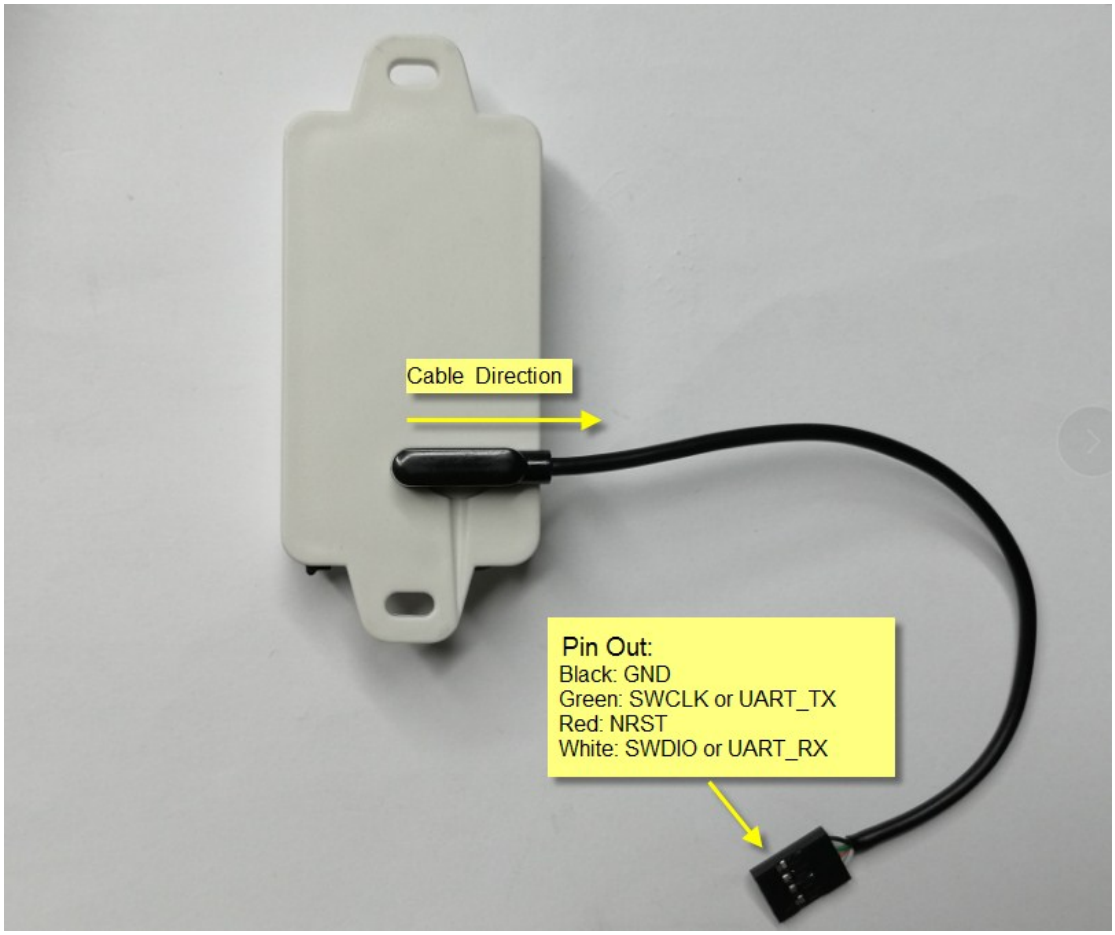
The LHT65 is shipped with a program cable, which is used to upload image to LHT65 for:

- ✓ Support new features
- ✓ For bug fix
- ✓ Change LoRaWAN bands.

Video Instruction is here: https://youtu.be/0xpSWTCuDGQ

The latest firmware and changelog can be found at below link:
http://www.dragino.com/downloads/index.php?dir=LHT65/Firmware/

Below shows the hardware connection for how to upload an image to the LHT65:



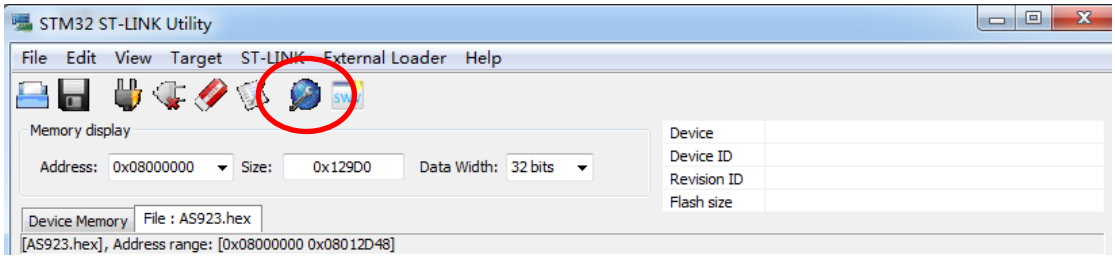
Connection:

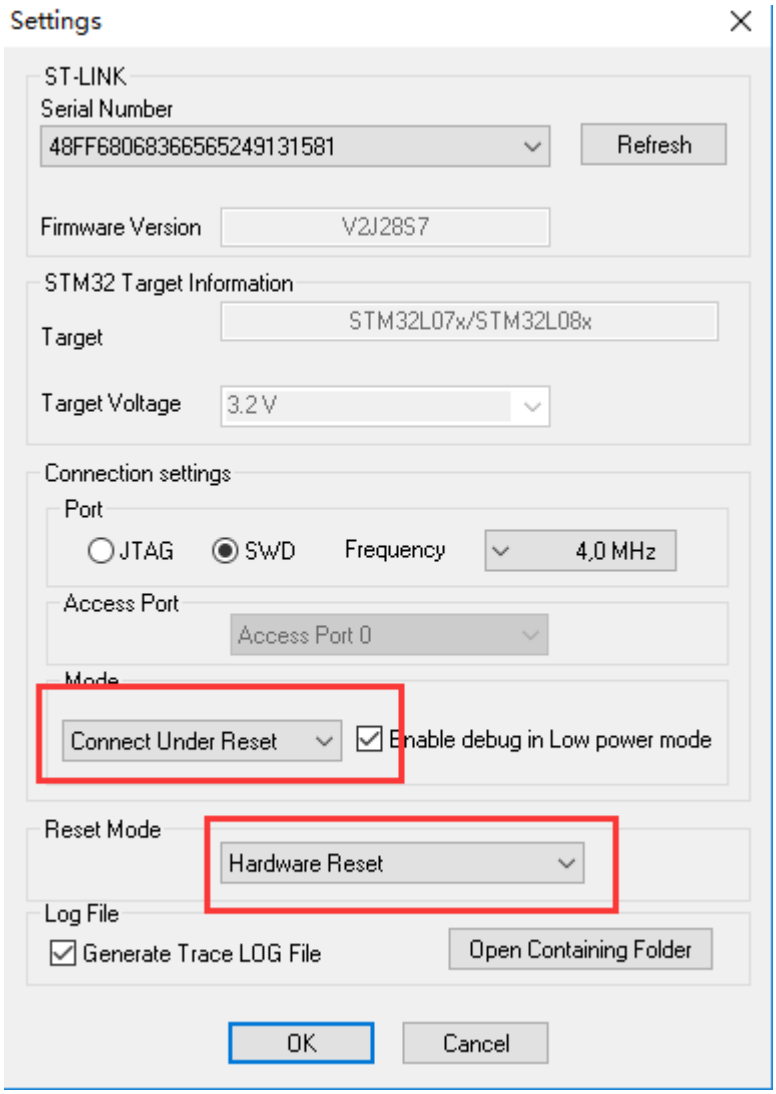
- ✓ ST-LINK v2 GND <--> Dupont black pin
- ✓ ST-LINK v2 SWCLK <--> Dupont green pin
- ✓ ST-LINK v2 RESET <--> Dupont red pin
- ✓ ST-LINK v2 SWDIO <--> Dupont white pin

Step1: Install ST-LINK driver first and then install ST-LINK Utility

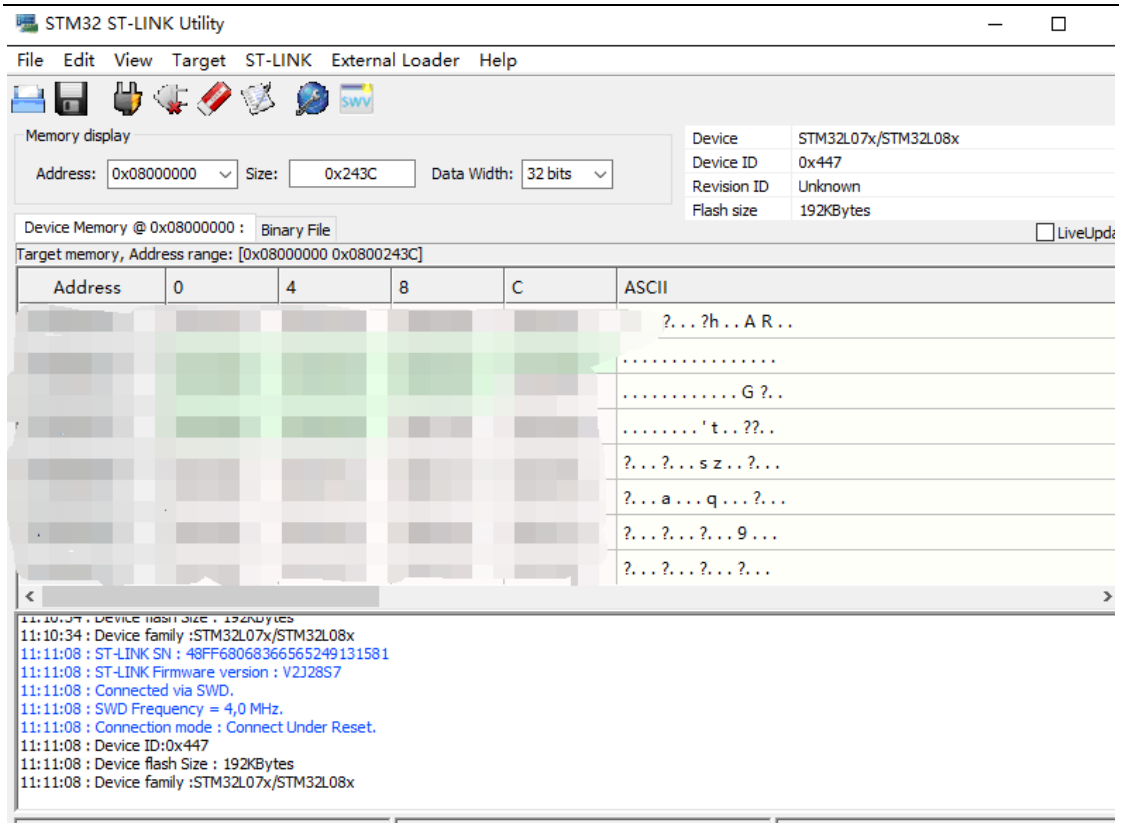
Step2: Download the LHT65 Image files.
http://www.dragino.com/downloads/index.php?dir=LHT65/Firmware/

Step3: click the blue global "**settings**" button on ST-LINK.

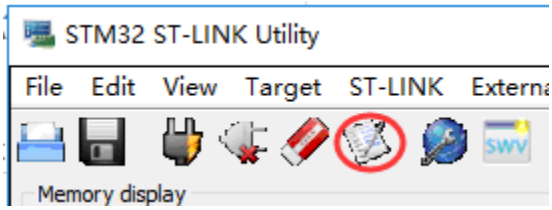


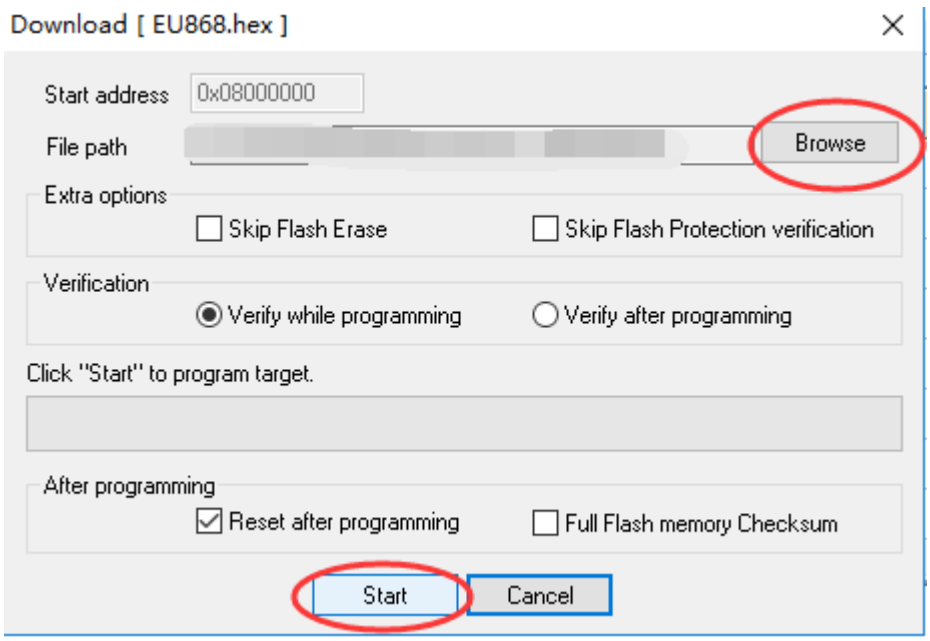


Click ok



Step4: The led on the ST-LINK adapter will now blinking, click program verify button to select the image to be upgraded.





Step5: Click the start button to download the image to LHT65.

*If you change different LoRa Frequency Bands/Region, you need using AT+FDR command to restore factory data after program success

5.2 How to change the LoRa Frequency Bands/Region?

User can follow the introduction for how to upgrade image. When download the images, choose the required image file for download.

5.3 How to choose the right frequency band set for US915, AU915, CN470 bands?

The frequency bands US915, AU915, CN470 total has 72 frequencies. As specify in LoRaWAN 1.0.3 Regional Parameters.xlsx

The LHT65 choose CHE=2 by default(US915/AU915). If user has issue to join the LoRaWAN network, please check if the frequency band matches the LoRaWAN network settings. If not, properly need to use AT+CHE command to change.

User can configure the LT to work in 8 channel models by using the AT+CHE command. For example, in US band, the table is as below. If we run AT+CHE=2. The device will work in Channel 8-15

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

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

CHE	CN470 Uplink Channels(125KHz,4/5,Unit:MHz,CHS=0)								
0	ENABLE Channel 80-95								
1	486.3	486.5	486.7	486.9	487.1	487.3	487.5	487.7	Channel 80-87
2	487.9	488.1	488.3	488.5	488.7	488.9	489.1	489.3	Channel 88-95

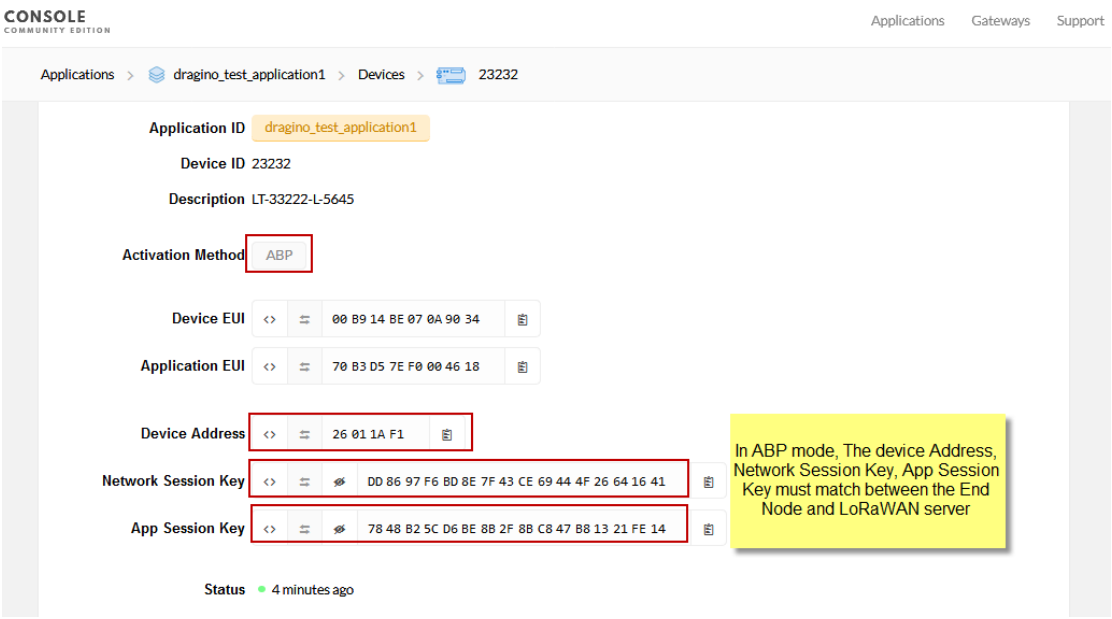
5.4 How to set up LHT65 to work with Single Channel Gateway such as LG01/LG02?

In this case, users need to set LHT65 to work in ABP mode & transmit in only one frequency.

Assume we have a LG02 working in the frequency 868400000 now, below is the step.

Note: EU868 firmware can't set to Single Frequency, to use single frequency in EU, user can first upgrade the firmware to IN865 and set it to work in Single Frequency.

Step1: Log in TTN, Create an ABP device in the application and input the network session key (NETSKEY), app session key (APPSKEY) from the device.



Note: user just need to make sure above three keys match, User can change either in TTN or Device to make then match. In TTN, NETSKEY and APPSKEY can be configured by user in setting page, but Device Addr is generated by TTN.

Step2: Run AT Command to make LHT65 work in Single frequency & ABP mode. Below is the AT commands:

123456 Enter Password to have AT access.

AT+FDR Reset Parameters to Factory Default, Keys Reserve

123456 Enter Password to have AT access.

AT+NJM=0 Set to ABP mode

AT+ADR=0 Set the Adaptive Data Rate Off

AT+DR=5 Set Data Rate (Set AT+DR=3 for 915 band)

AT+TDC=60000 Set transmit interval to 60 seconds

AT+CHS=868400000 Set transmit frequency to 868.4Mhz

AT+DADDR=26 01 1A F1 Set Device Address to 26 01 1A F1

ATZ Reset MCU

7. Order Info

Part Number: **LHT65-XX-YY**

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

YY:

- ✓ **00**: no external sensor
- ✓ **E1**: with model E1, temperature sensor (Default version)

External sensor can be ordered separately by using the sensor model + ES as prefix:

Part Number: **ES-YY**

Example: ES-E1

8. Packing Info

Package Includes:

- ✓ LHT65 Temperature & Humidity Sensor x 1
- ✓ Program cable x 1
- ✓ Optional external sensor

Dimension and weight:

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

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.com

10. FCC Warning

This device complies with part 15 of the FCC Rules.Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) this device must accept any interference received,including interference that may cause undesired operation

2. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
NOTE:
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.
This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
Reorient or relocate the receiving antenna.
Increase the separation between the equipment and receiver.
Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement
This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with Minimum distances 20cm between the radiator include antenna & your body.