



LHT65 Temperature & Humidity Sensor User Manual

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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 %RH
- 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 Applications

LHT65 Temperature & Humidity sensor

- ✓ 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 100ms < time < 1s	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?

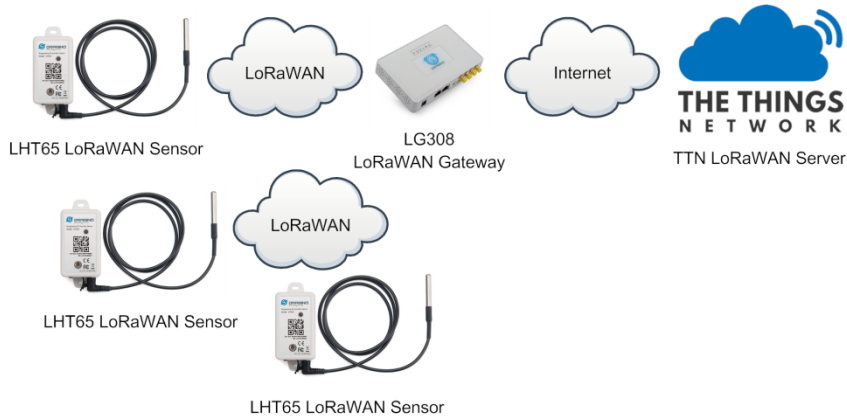
The LHT65 is configured as LoRaWAN OTAA Class A mode by default. Each LHT65 is shipped with a worldwide unique set of OTAA and ABP keys. To use LHT65 in a LoRaWAN network, user needs to input the OTAA or ABP keys in the network server. So LHT65 can join the LoRaWAN network and start to transmit sensor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

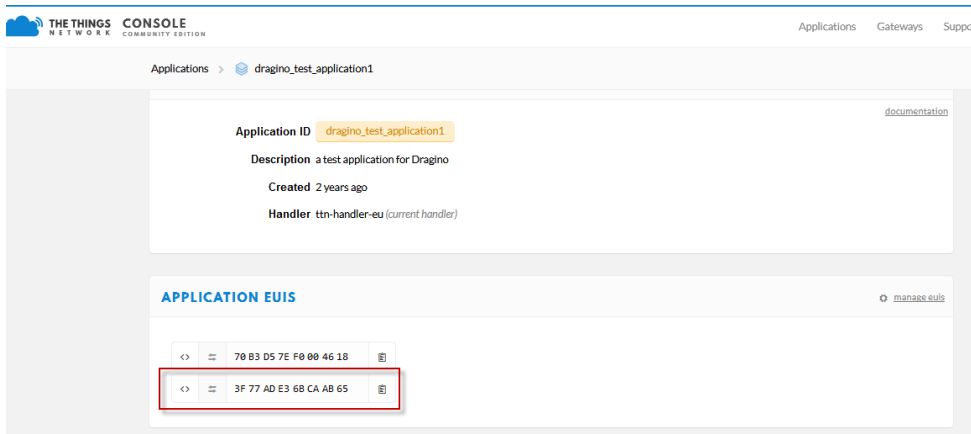
Step 1: Create a device in TTN with the OTAA keys from LHT65.

Each LHT65 is shipped with a sticker with the default device EUI as below:

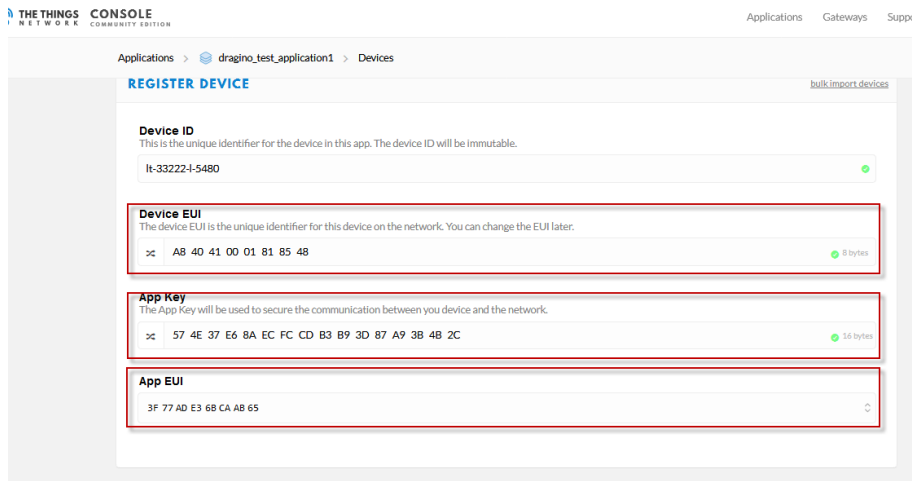


User can enter these keys in the LoRaWAN Server portal. Below is TTN screen shot:

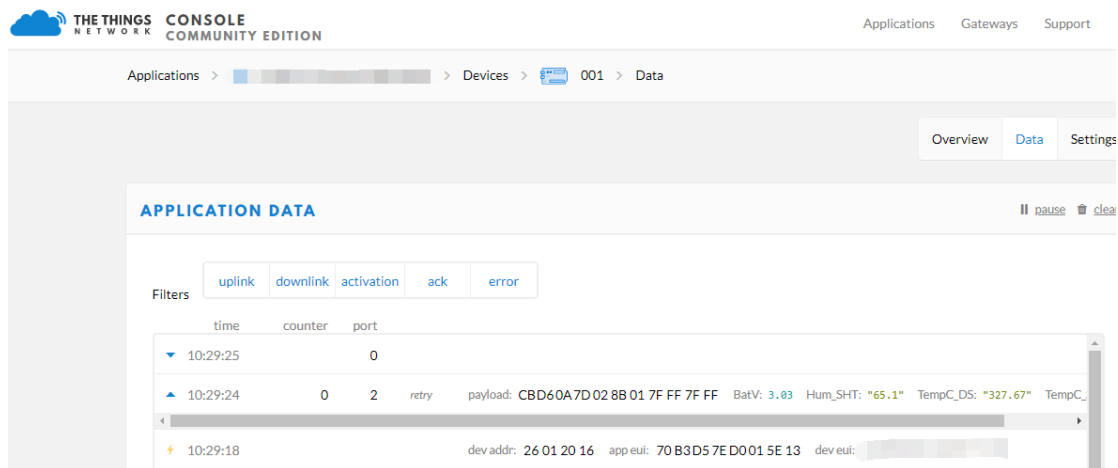
Add APP EUI in the application.



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.

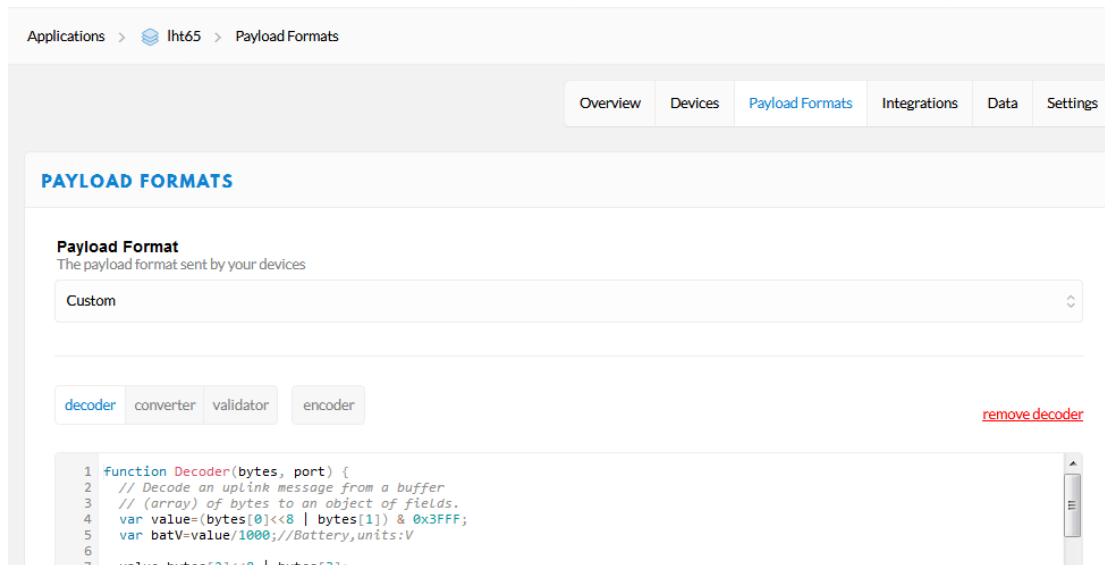
Size(bytes)	2	2	2	1	4
Value	BAT	Built-In Temperature	Built-in Humidity	Ext #	Ext value

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:°C

  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:°C

  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

APPLICATION DATA

Filters: uplink downlink activation ack error

time	counter	port	payload
▲ 08:38:57	375	2	CB F6 0B 0D 03 76 01 0A DD 7F FF

Check the battery voltage for LHT65.

Bat status=(0xCB F6 >> 14) & 0xFF = 11(B), very good

battery voltage = 0xCB F6 & 0x3FFF = 0x0B F6 = 3062mV

2.4.3 Built-in Temperature

APPLICATION DATA

Filters: uplink downlink activation ack error

time	counter	port	payload
▲ 08:38:57	375	2	CB F6 0B 0D 03 76 01 0A DD 7F FF

Temperature: $0x0B0D/100=28.29^{\circ}\text{C}$

▲ 10:02:54	1559	2	payload: CB BD F5 C6 02 2E 01 F5 4F 7F FF
------------	------	---	---

Temperature: $(0xF5C6-65536)/100=-26.18^{\circ}\text{C}$

2.4.4 Built-in Humidity

APPLICATION DATA

Filters: uplink downlink activation ack error

	time	counter	port	
▲	08:38:57	375	2	payload: CB F6 0B 0D 03 76 01 0ADD7F FF

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

APPLICATION DATA

Filters: uplink downlink activation ack error

	time	counter	port	
▲	08:38:57	375	2	payload: CB F6 0B 0D 03 76 01 0ADD7F FF

DS18B20 temp= $0x0ADD/100=27.81^{\circ}\text{C}$

The last 2 bytes of data are meaningless

▲	10:02:54	1559	2	payload: CBBD F5 C6 02 2E 01 F5 4F 7F FF
---	----------	------	---	--

DS18B20 temp= $(0xF54F-65536)/100=-27.37^{\circ}\text{C}$

The last 2 bytes of data are meaningless

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 minutes)
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:

DOWNLINK

Scheduling

replace first last

FPort

2

Confirmed

Payload

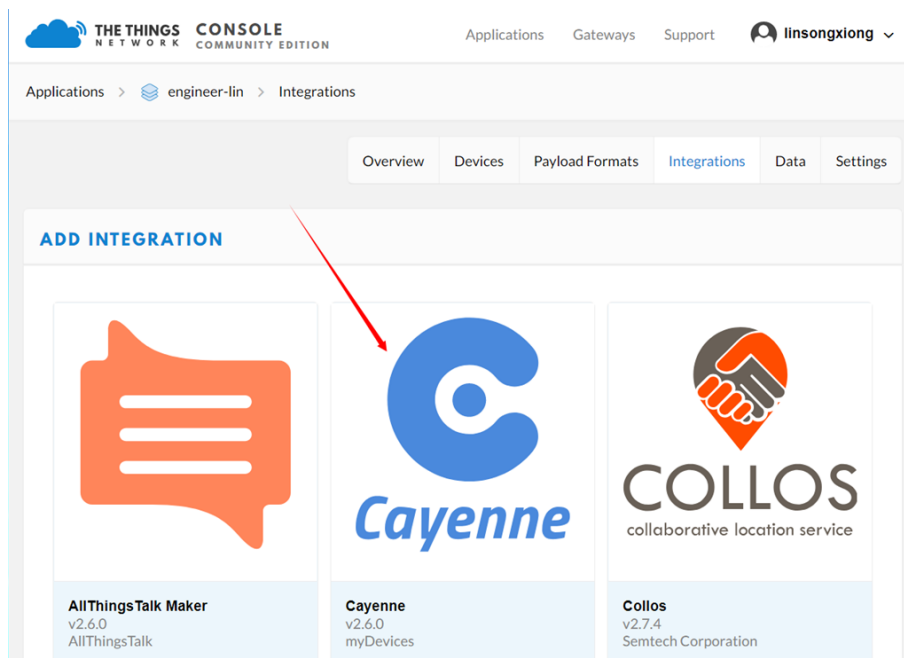
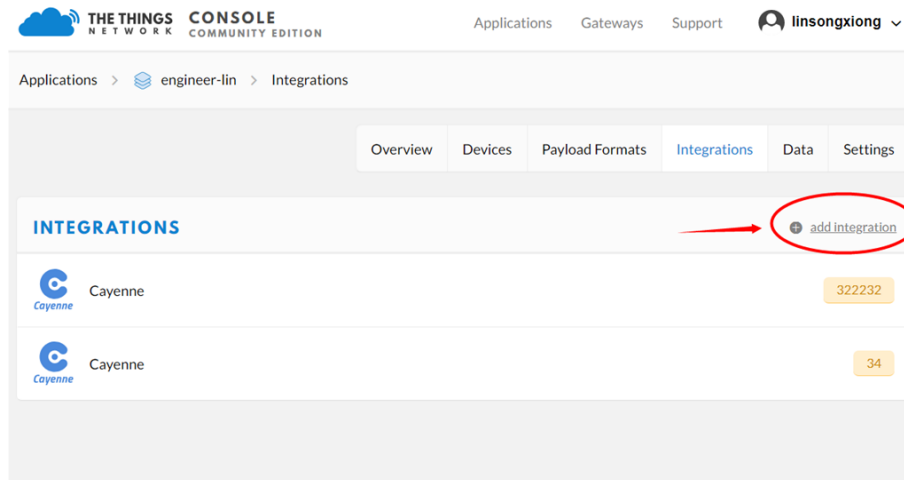
bytes fields 01 00 00 3C 4 bytes

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:



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:

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+PASSWORD: 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](#).

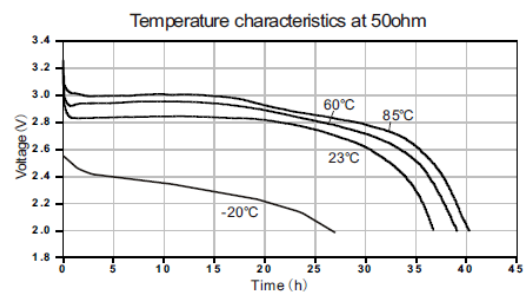
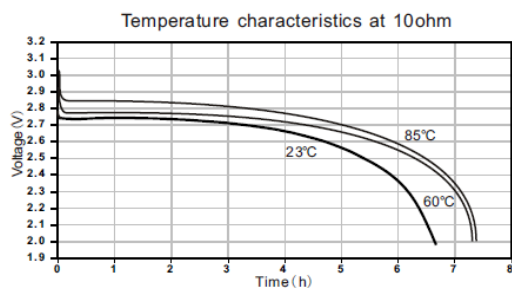
3.3 Battery Analyze

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:

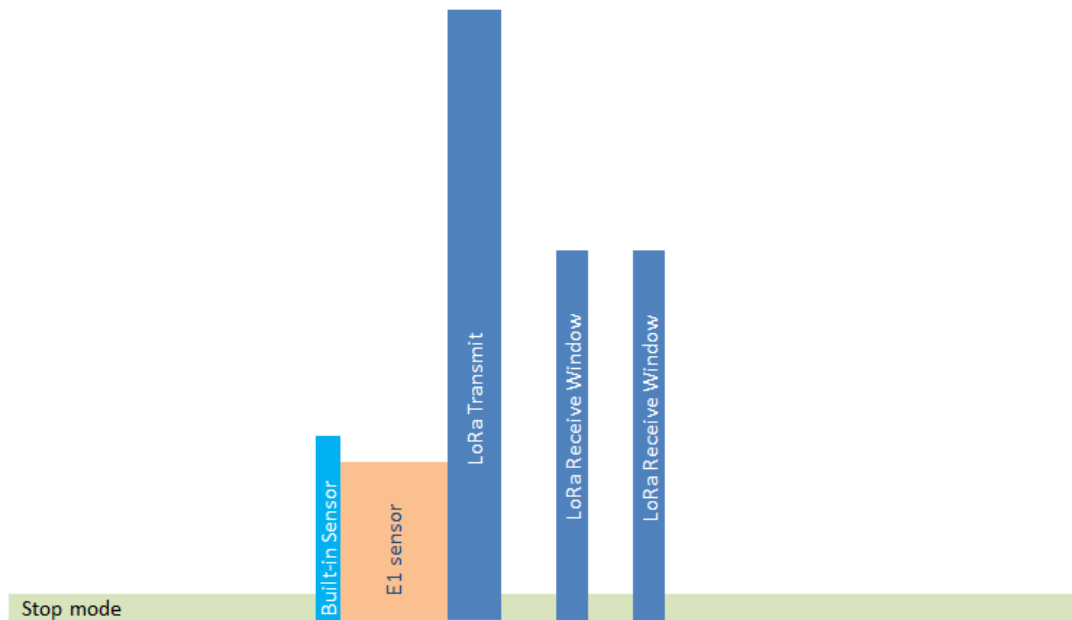
- ✓ LHT65: 2.45v ~ 3.6v
- ✓ ES-E1 Temperature Sensor : 2.35v ~ 5v

3.3.2 Power consumption Analyze

Below is the transmit power consumption of the system:

1. Deep Sleep (Stop mode):
 - a) LHT65 without sensor. $\sim 3\mu\text{A}$
 - b) With E1 sensor: $\sim 4\mu\text{A}$
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

Lower Power Case:

- ✓ Radio Parameter: SF7, 125kHz, 20dbm
- ✓ Transmit interval: 15 minutes.
- ✓ Payload :8 Bytes.

High Power Case:

- ✓ Radio Parameter: SF10, 125kHz, 20dbm
- ✓ Transmit interval: 15 minutes.
- ✓ Payload : 8 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	5	5	15	15		
Sampling	ms	870	870	870	870		
Transmit	ms	39.4	274.4	39.4	274.4		
Receive	ms	72	491.4	72	491.4		
Radio type		SF7_125K_20dB	SF10_125K_20dB	SF7_125K_20dB	SF10_125K_20dB		
# of bytes transmitted		8	8	8	8		
Total System Current							
Sleep	mA	0.01	0.01	0.005	0.005		
Sampling	mA	10	10	10	10		
Transmit	mA	133	133	133	133		
Receive	mA	18.8	18.8	18.8	18.8		
					Micro-Controller Active power (mA):		8
Power usage comparison							
Sleep	%	16.40%	5.22%	22.73%	7.64%	0.00%	0.00%
Sampling	%	47.56%	15.15%	43.95%	14.76%	0.00%	0.00%
Transmit	%	28.64%	63.54%	26.47%	61.93%	0.00%	0.00%
Receive	%	7.40%	16.09%	6.84%	15.68%	0.00%	0.00%
					Legend: Red > 100%, Green <= 100%		
Average current	mA	0.0607805	0.190406842	0.021969155	0.065362888	0	0
Design Goals							
System efficiency		90%	90%	90%	90%	90%	90%
Target battery life	yr	1	1	1	1	1	1
Required battery capacity	mAh	592.00	1854.56	213.98	636.63	0.00	0.00
Given battery capacity	mAh	2400	2400	2400	2400	2400	2400
Estimated battery life	yr	4.05	1.29	11.22	3.77	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
- $\pm 0.5^{\circ}\text{C}$ accuracy from -10°C to $+85^{\circ}\text{C}$
- $\pm 2^{\circ}\text{C}$ accuracy from -55°C to $+125^{\circ}\text{C}$
- Operating Range: $-40 \sim 125^{\circ}\text{C}$
- -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.

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:

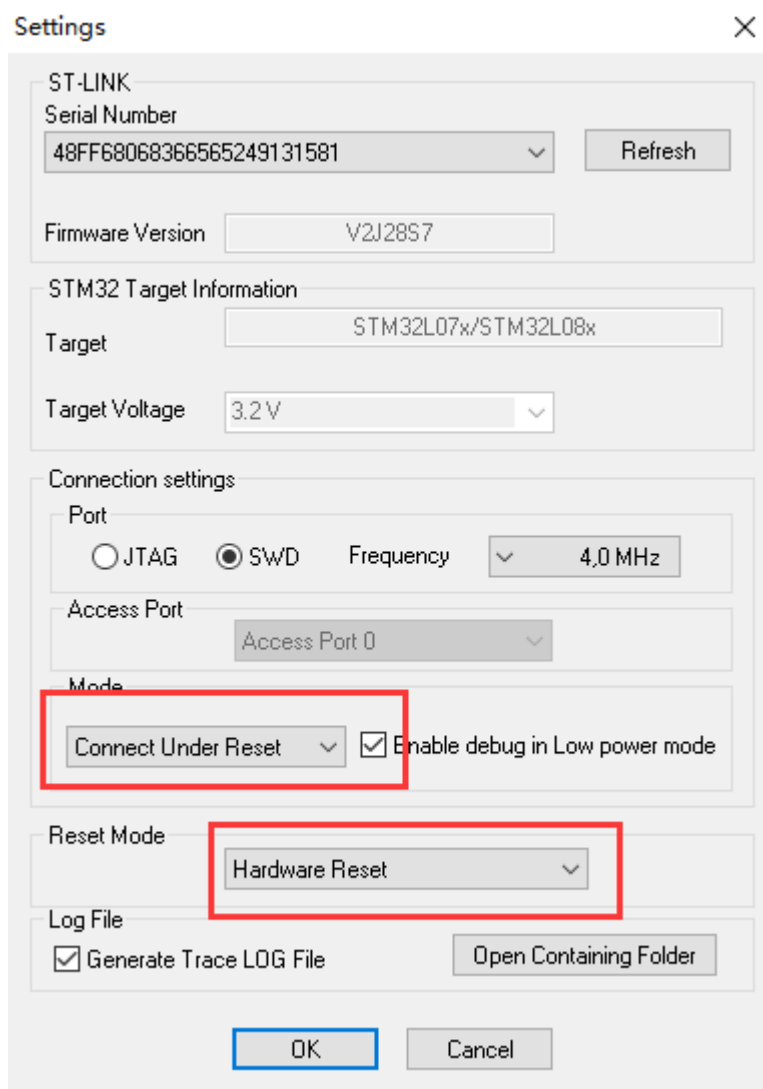
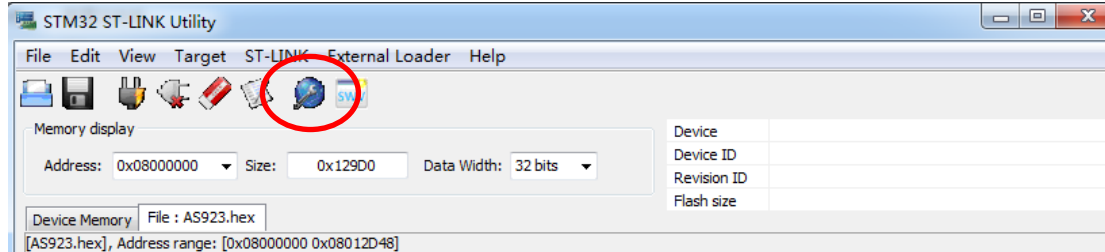
- ✓ ST-LINK v2 GND <--> Dupont black pin
- ✓ ST-LINK v2 SWCLK <--> Dupont green pin
- ✓ ST-LINK v2 RESET <--> Dupont red pin
- ✓ ST-LINK v2 SWDIO <--> Dupont white pin

Step1: Install [ST-LINK driver](#) first and then install [ST-LINK Utility](#)

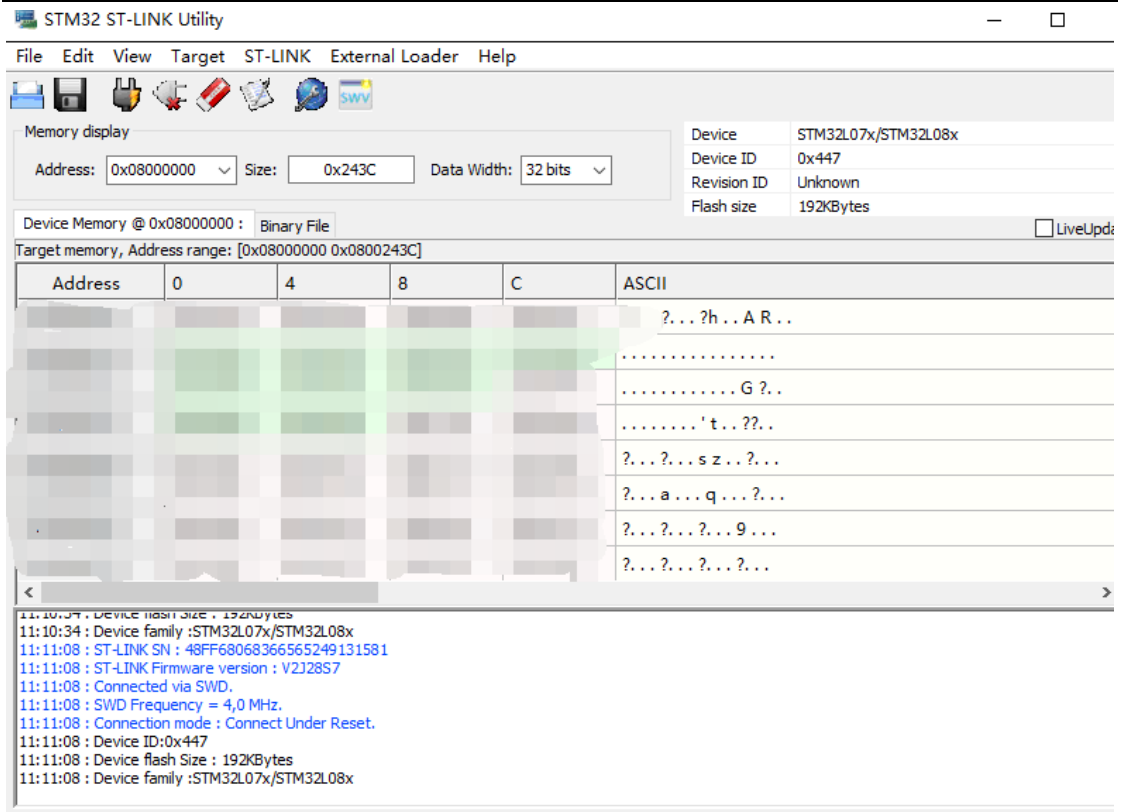
Step2: Download the LHT65 Image files.

<http://www.dragino.com/downloads/index.php?dir=LHT65/Firmware/>

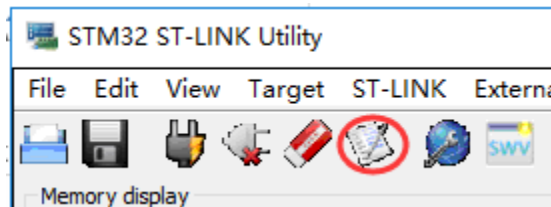
Step3: click the blue global “settings” button on ST-LINK.

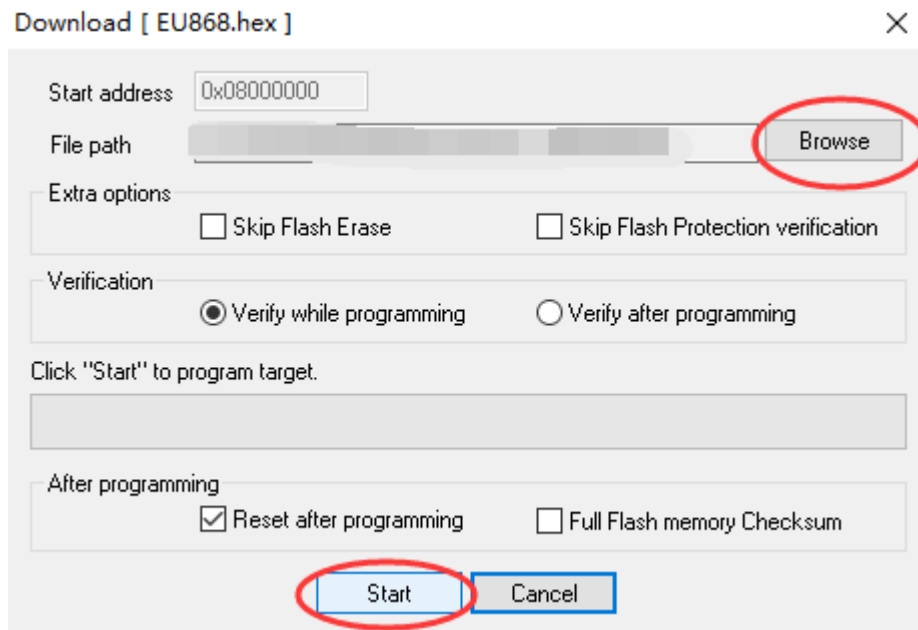


Click ok



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

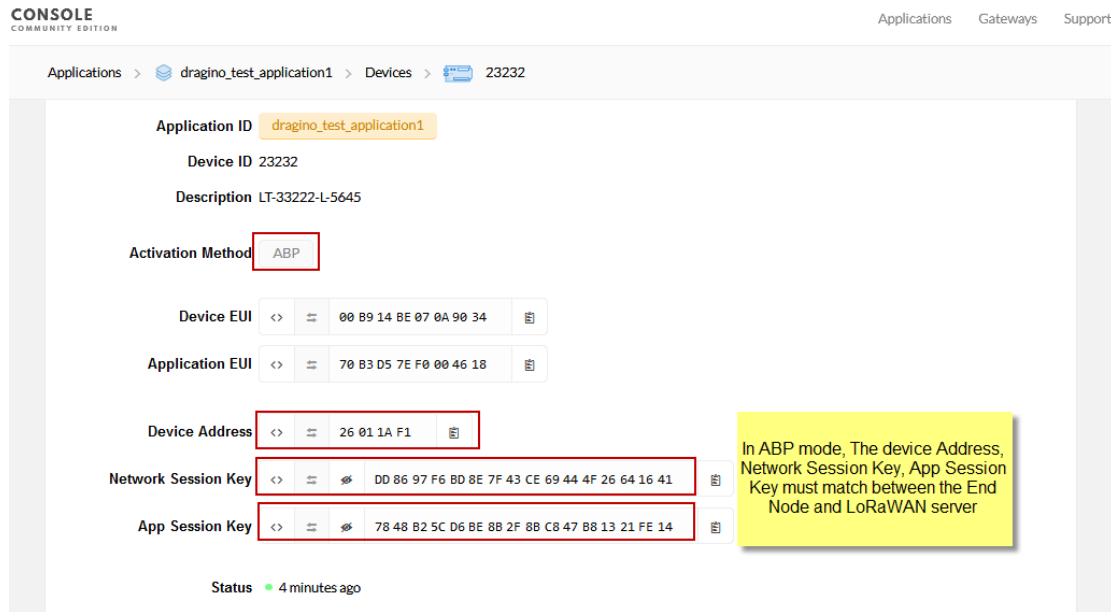
CHE	CN470 Uplink Channels(125KHz,4/5,Unit:MHz,CHS=0)								
0	ENABLE Channel 80-95								
1	486.3	486.5	486.7	486.9	487.1	487.3	487.5	487.7	Channel 80-87
2	487.9	488.1	488.3	488.5	488.7	488.9	489.1	489.3	Channel 88-95

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.

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.



The screenshot shows the TTN Console interface for configuring a device. The breadcrumb trail is: Applications > dragino_test_application1 > Devices > 23232. The configuration details are as follows:

- Application ID: dragino_test_application1
- Device ID: 23232
- Description: LT-33222-L-5645
- Activation Method: ABP
- Device EUI: 00 B9 14 BE 07 0A 90 34
- Application EUI: 70 B3 D5 7E F0 00 46 18
- Device Address: 26 01 1A F1
- Network Session Key: DD 86 97 F6 BD 8E 7F 43 CE 69 44 4F 26 64 16 41
- App Session Key: 78 48 B2 5C D6 BE 8B 2F 8B C8 47 B8 13 21 FE 14

A yellow callout box states: "In ABP mode, The device Address, Network Session Key, App Session Key must match between the End Node and LoRaWAN server".

Note: user just need to make sure above three keys match, User can change either in TTN or Device to make them 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
    
```

6. Trouble Shooting

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