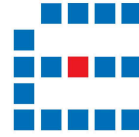


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SPH01-NB -- NB-IoT Soil pH Sensor User Manual

last modified by Xiaoling

on 2024/01/03 08:39

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1. Introduction

1.1 What is NB-IoT Soil pH Sensor

The Dragino SPH01-NB is a **NB-IoT Soil pH Sensor** for IoT of Agriculture. It is designed to measure the **soil PH and soil temperature**, so to send to the platform to analyze the soil acid or alkali level. The probe is IP68 waterproof.

SPH01-NB probe is made by Solid AgCl reference electrode and Pure metal pH sensitive electrode. It can detect **soil's pH** with high accuracy and stable value. The SPH01-NB probe can be buried into soil for long time use.

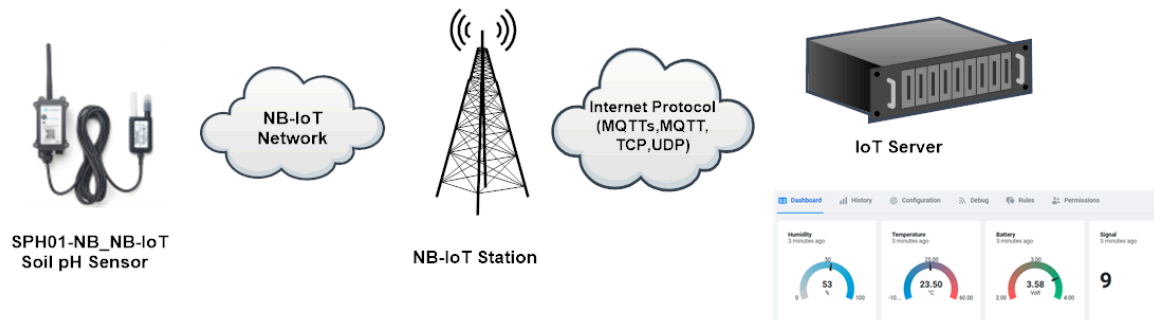
SPH01-NB supports different uplink methods including **MQTT, MQTTs, UDP & TCP** for different application requirement, and support uplinks to various IoT Servers.

SPH01-NB **supports BLE configure and OTA update** which make user easy to use.

SPH01-NB is powered by **8500mAh Li-SOCI2 battery**, it is designed for long-term use up to several years.

SPH01-NB has optional built-in SIM card and default IoT server connection version. Which makes it works with simple configuration.

SPH01-NB in a NB-IoT Network



1.2 Features

- NB-IoT Bands: B1/B2/B3/B4/B5/B8/B12/B13/B17/B18/B19/B20/B25/B28/B66/B70/B85 @H-FDD
- Ultra-low power consumption
- Monitor soil pH with temperature compensation.
- Monitor soil temperature
- Support pH calibration by end user
- Multiply Sampling and one uplink
- Support Bluetooth v5.1 remote configure and update firmware
- Uplink on periodically
- Downlink to change configure
- 8500mAh Battery for long term use
- Nano SIM card slot for NB-IoT SIM

1.3 Specification

Common DC Characteristics:

- Supply Voltage: 2.5v ~ 3.6v
- Operating Temperature: -40 ~ 85°C

Soil pH:

- Range: 3 ~ 10 pH
- Resolution: 0.01 pH
- Accuracy: $\pm 2\%$ under (0~50 °C, Accuracy will poor under 0 due to frozen)
- Temperature Compensation Range: 0 ~ 50°C
- IP68 Protection
- Length: 3.5 meters

Soil Temperature:

- Range -40°C ~ 85°C
- Resolution: 0.1°C
- Accuracy: $<\pm 0.5^\circ\text{C}$ (-10°C ~ 40°C), $<\pm 0.8^\circ\text{C}$ (others)

- IP68 Protection
- Length: 3.5 meters

NB-IoT Spec:

NB-IoT Module: BC660K-GL

Support Bands:

- B1 @H-FDD: 2100MHz
- B2 @H-FDD: 1900MHz
- B3 @H-FDD: 1800MHz
- B4 @H-FDD: 2100MHz
- B5 @H-FDD: 860MHz
- B8 @H-FDD: 900MHz
- B12 @H-FDD: 720MHz
- B13 @H-FDD: 740MHz
- B17 @H-FDD: 730MHz
- B18 @H-FDD: 870MHz
- B19 @H-FDD: 870MHz
- B20 @H-FDD: 790MHz
- B25 @H-FDD: 1900MHz
- B28 @H-FDD: 750MHz
- B66 @H-FDD: 2000MHz
- B70 @H-FDD: 2000MHz
- B85 @H-FDD: 700MHz

Battery:

- Li/SOCl₂ un-chargeable battery
- Capacity: 8500mAh
- Self Discharge: <1% / Year @ 25°C
- Max continuously current: 130mA
- Max boost current: 2A, 1 second

Power Consumption

- STOP Mode: 10uA @ 3.3v
- Max transmit power: 350mA@3.3v

1.4 Applications

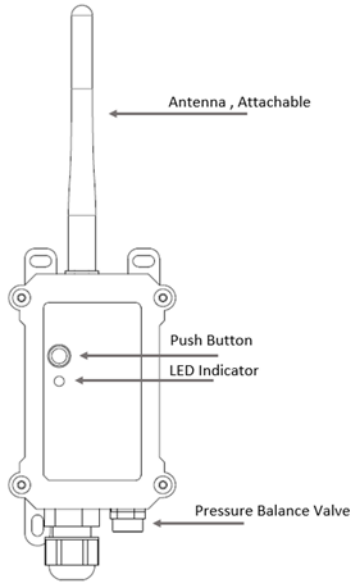
- Smart Agriculture

1.5 Sleep mode and working mode

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

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

1.6 Button & LEDs



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

Note: When the device is executing a program, the buttons may become invalid. It is best to press the buttons after the device has completed the program execution.

1.7 BLE connection

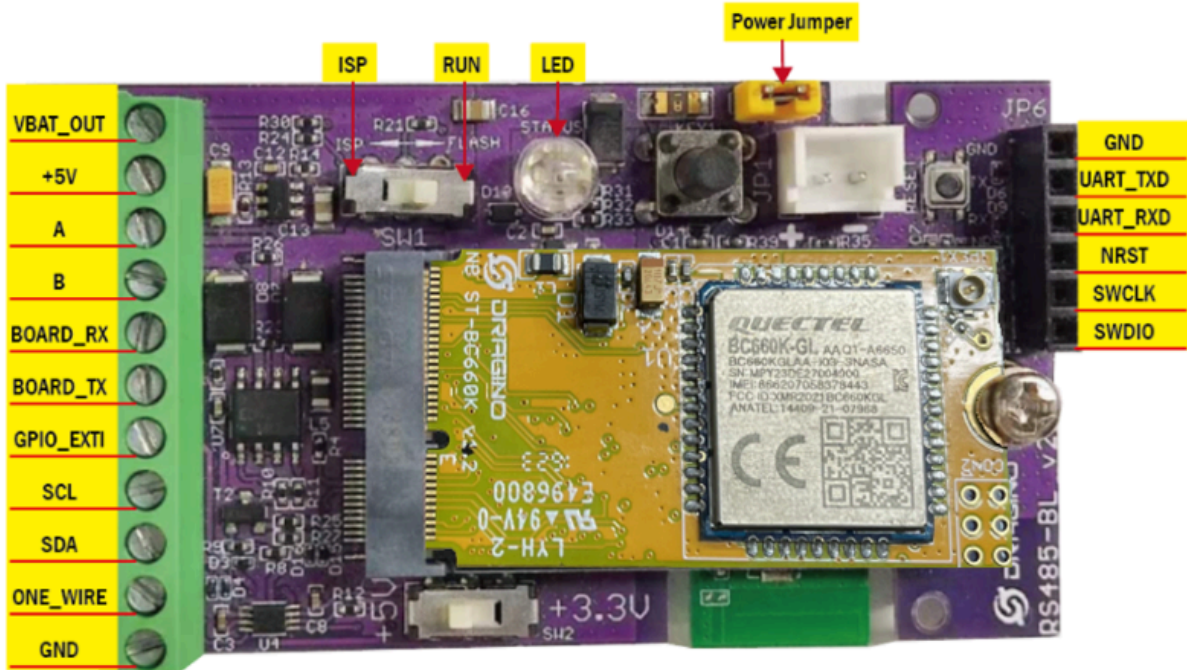
SPH01-NB support BLE remote configure and firmware update.

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

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

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

1.8 Pin Definitions , Switch & SIM Direction



1.8.1 Jumper JP2

Power on Device when put this jumper.

1.8.2 BOOT MODE / SW1

- 1) **ISP**: upgrade mode, device won't have any signal in this mode. but ready for upgrade firmware. LED won't work. Firmware won't run.
- 2) **Flash**: work mode, device starts to work and send out console output for further debug

1.8.3 Reset Button

Press to reboot the device.

1.8.4 SIM Card Direction

See this link. [How to insert SIM Card.](#)

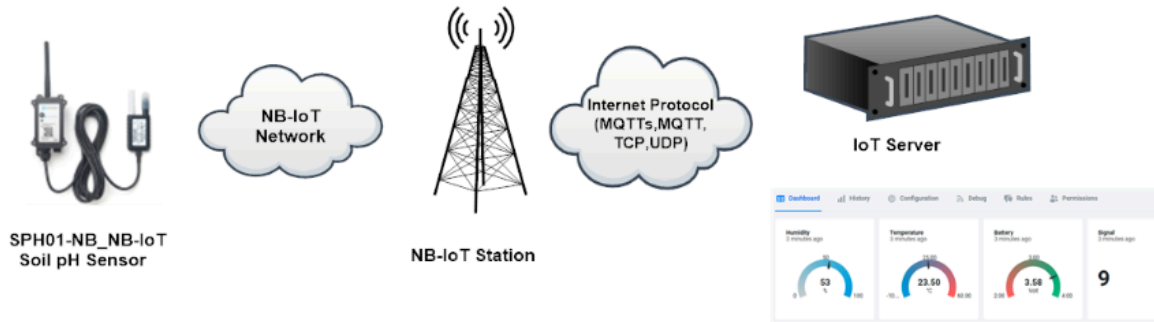
2. Use SPH01-NB to communicate with IoT Server

2.1 Send data to IoT server via NB-IoT network

The SPH01-NB is equipped with a NB-IoT module, the pre-loaded firmware in SPH01-NB will get environment data from sensors and send the value to local NB-IoT network via the NB-IoT module. The NB-IoT network will forward this value to IoT server via the protocol defined by SPH01-NB.

Below shows the network structure:

SPH01-NB in a NB-IoT Network



There are two version: **-GE** and **-1D** version of SPH01-NB.

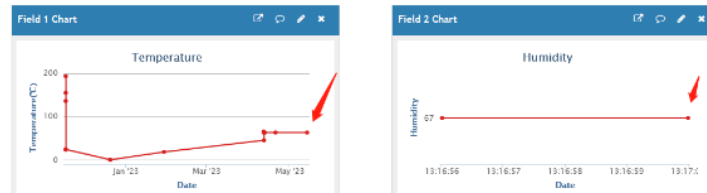
GE Version: This version doesn't include SIM card or point to any IoT server. User needs to use AT Commands to configure below two steps to set SPH01-NB send data to IoT server.

- Install NB-IoT SIM card and configure APN. See instruction of [Attach Network](#).
- Set up sensor to point to IoT Server. See instruction of [Configure to Connect Different Servers](#).

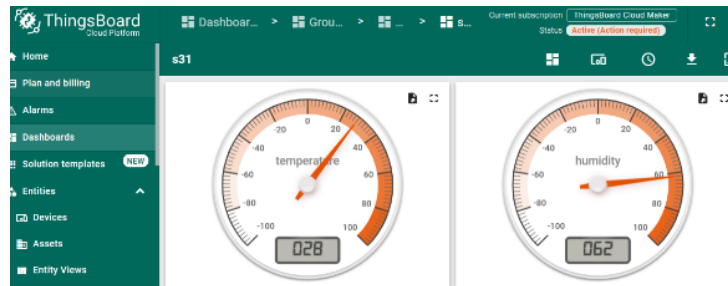
Below shows result of different server as a glance.

Servers	Dash Board	Comments
Node-Red		
DataCake		
Tago.IO		Raw Payload. Need Developer to design Dash Board
General UDP		Raw Payload. Need Developer to design Dash Board
General MQTT		Raw Payload. Need Developer to design Dash Board

[ThingSpeak](#)



[ThingsBoard](#)



1D Version: This version has 1NCE SIM card pre-installed and configure to send value to DataCake. User Just need to select the sensor type in DataCake and Activate SPH01-NB and user will be able to see data in DataCake. See here for [DataCake Config Instruction](#).

2.2 Payload Types

To meet different server requirement, SPH01-NB supports different payload type.

Includes:

- [General JSON format payload](#). (Type=5)
- [HEX format Payload](#). (Type=0)
- [ThingSpeak Format](#). (Type=1)
- [ThingsBoard Format](#). (Type=3)

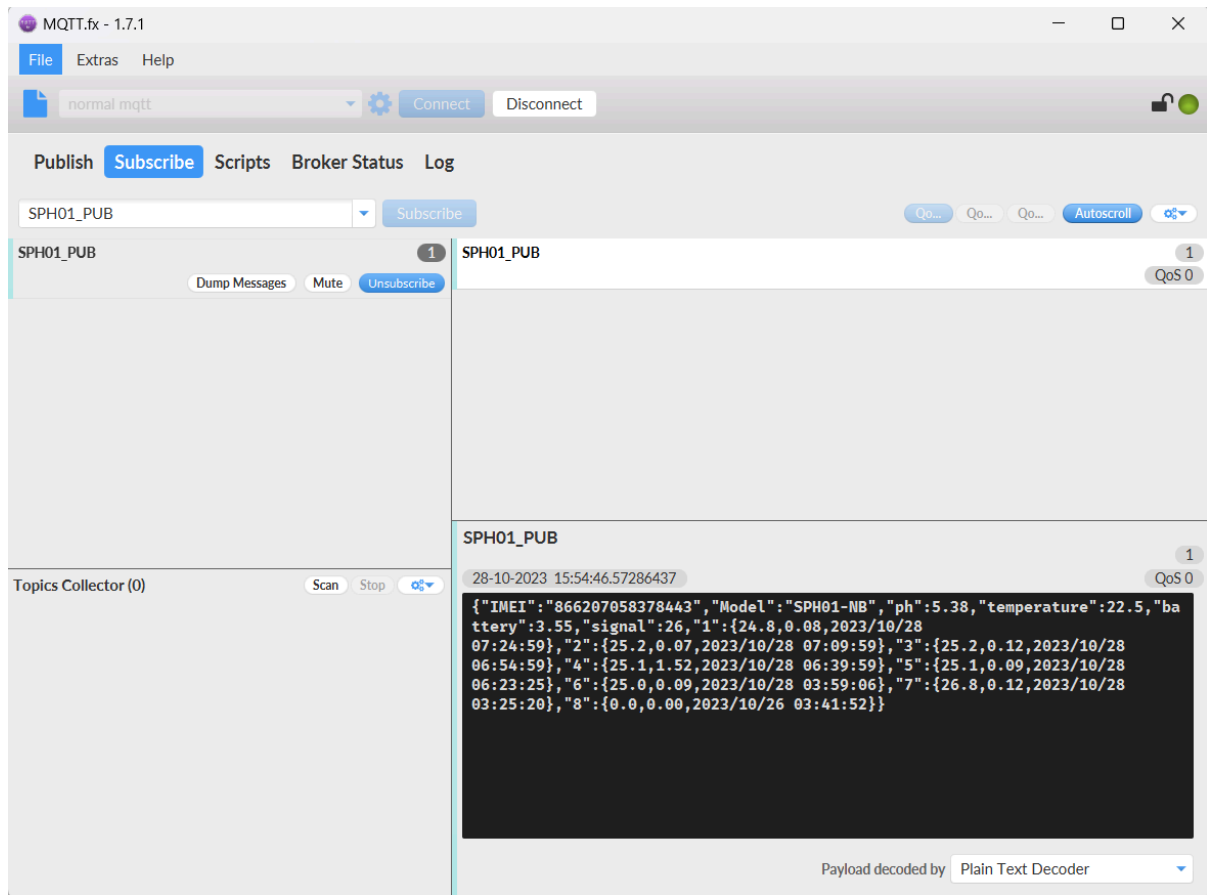
User can specify the payload type when choose the connection protocol. Example:

- AT+PRO=2,0** // Use UDP Connection & hex Payload
- AT+PRO=2,5** // Use UDP Connection & Json Payload
- AT+PRO=3,5** // Use MQTT Connection & Json Payload

2.2.1 General Json Format(Type=5)

This is the General Json Format. As below:

```
{
  "IMEI": "866207058378443",
  "Model": "SPH01-NB",
  "ph": 5.38,
  "temperature": 22.5,
  "battery": 3.55,
  "signal": 26,
  "1": {
    "24.8,0.08,2023/10/28 07:24:59"
  },
  "2": {
    "25.2,0.07,2023/10/28 07:09:59"
  },
  "3": {
    "25.2,0.12,2023/10/28 06:54:59"
  },
  "4": {
    "25.1,1.52,2023/10/28 06:39:59"
  },
  "5": {
    "25.1,0.09,2023/10/28 06:23:25"
  },
  "6": {
    "25.0,0.09,2023/10/28 03:59:06"
  },
  "7": {
    "26.8,0.12,2023/10/28 03:25:20"
  },
  "8": {
    "0.0,0.00,2023/10/26 03:41:52"
  }
}
```



Notice, from above payload:

- PH, Temperature, Battery & Signal are the value at uplink time.
- Json entry 1 ~ 8 are the last 1 ~ 8 sampling data as specify by **AT+NOUD=8** Command. Each entry includes (from left to right): PH, Temperature, Sampling time.

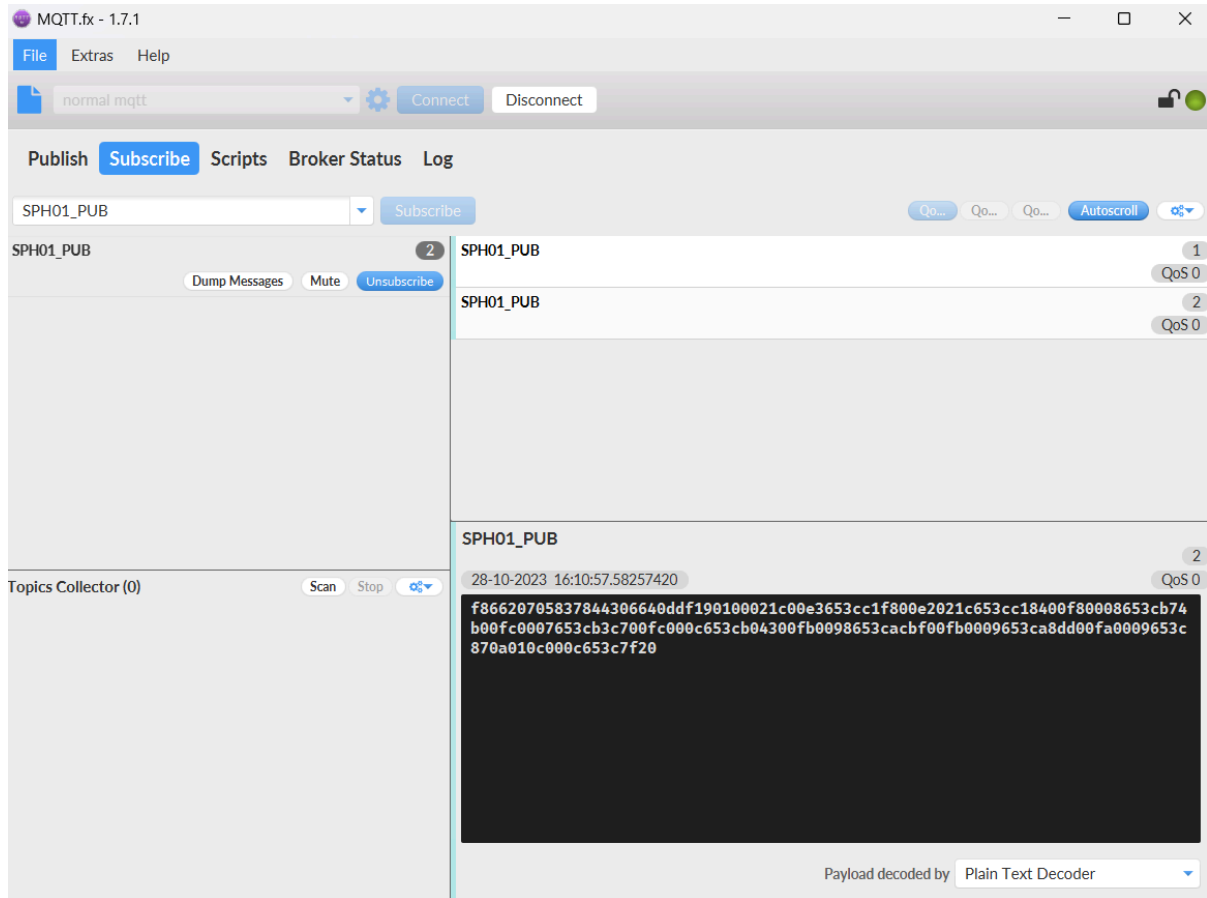
2.2.2 HEX format Payload(Type=0)

This is the HEX Format. As below:

f86620705837844306640ddf190100021c00e3653cc1f800e2021c653cc18400f80008653cb74b00fc0007653cb3c700fc000c653

HEX Format for SPH01-NB (AT+NOUD=8)										
f866207058386669 f+IMEI 8 Bytes			0664 Version	0db6 BAT	12 Singal	01 Mod	00 Interrupt 27 Bytes	0294 Soil PH	0107 Soil Temperature	64e6eeca Timestamp
0104 PH	0294 Temperature	64e6ec10 Timestamp 8 Bytes	0104029f64e6e88c last 2nd data 8 Bytes			0104029464e6e808 last 3rd data 8 Bytes			00ff029b64e6e184 last 4th data 8 Bytes	
0101029664e6de00 last 5th data 8 Bytes			0105029964e6da7c last 6th data 8 Bytes			0109027d64e6d6f8 last 7th data 8 Bytes			010b02a364e6d374 last 8th data 8 Bytes	

If we use the MQTT client to subscribe to this MQTT topic, we can see the following information when the NB sensor uplink data.



Version:

These bytes include the hardware and software version.

Higher byte: Specify Sensor Model: 0x06 for SPH01-NB

Lower byte: Specify the software version: 0x64=100, means firmware version 100

BAT (Battery Info):

Ex1: 0x0CC6 = 3270mV

Signal Strength:

NB-IoT Network signal Strength.

Ex1: 0x18 = 24

0 -113dBm or less

1 -111dBm

2...30 -109dBm... -53dBm

31 -51dBm or greater

99 Not known or not detectable

DS18B20 Temperature sensor

This is optional, user can connect external DS18B20 sensor to the +3.3v, 1-wire and GND pin . and this field will report temperature.

Example:

If payload is: 0105H: (0105 & FC00 == 0), temp = 0105H /10 = 26.1 degree

If payload is: FF3FH : (FF3F & FC00 == 1) , temp = (FF3FH - 65536)/10 = -19.3 degrees.

Soil pH

Range: 0 ~ 14 pH

Example:

0x02B7(H) = 695(D) = 6.95pH

Soil Temperature

Get Soil Temperature

Example:

If payload is: **0105H:** (0105 & FC00 == 0), temp = 0105H /10 = 26.1 degree

If payload is: **FF3FH** : (FF3F & FC00 == 1) , temp = (FF3FH - 65536)/10 = -19.3 degrees.

TimeStamp:

Unit TimeStamp Example: 64d49439(H) = 1691653177(D)

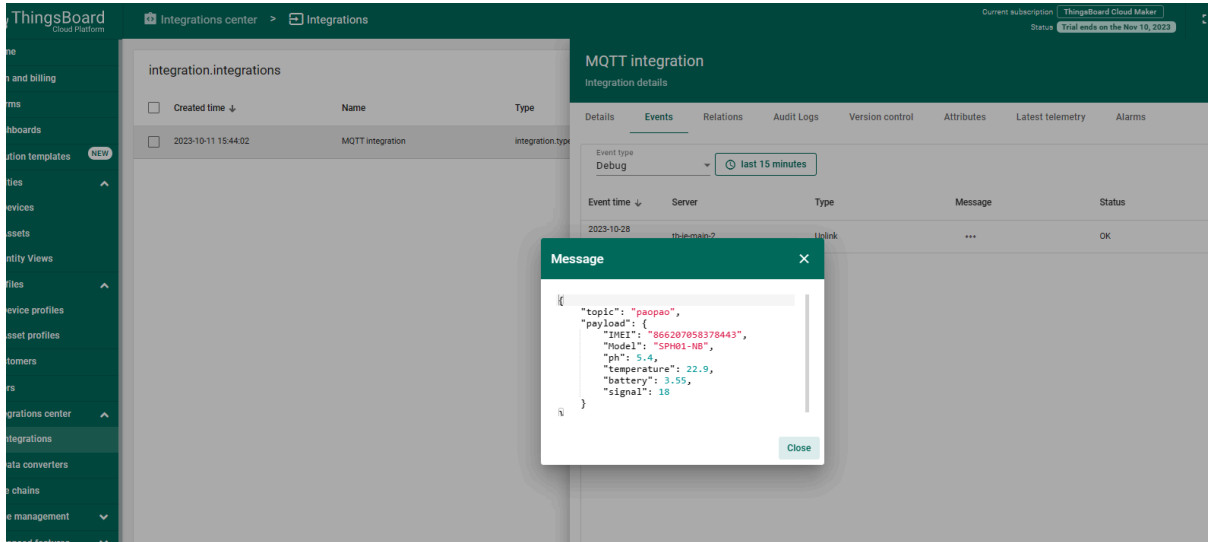
Put the decimal value into this link(<https://www.epochconverter.com>) to get the time.

2.2.3 ThingsBoard Payload(Type=3)

Type3 payload special design for ThingsBoard, it will also configure other default server to ThingsBoard.

```
{  
  "IMEI": "866207058378443",  
  "Model": "SPH01-NB",
```

```
"ph": 5.4,  
"temperature": 22.9,  
"battery": 3.55,  
"signal": 18  
}
```

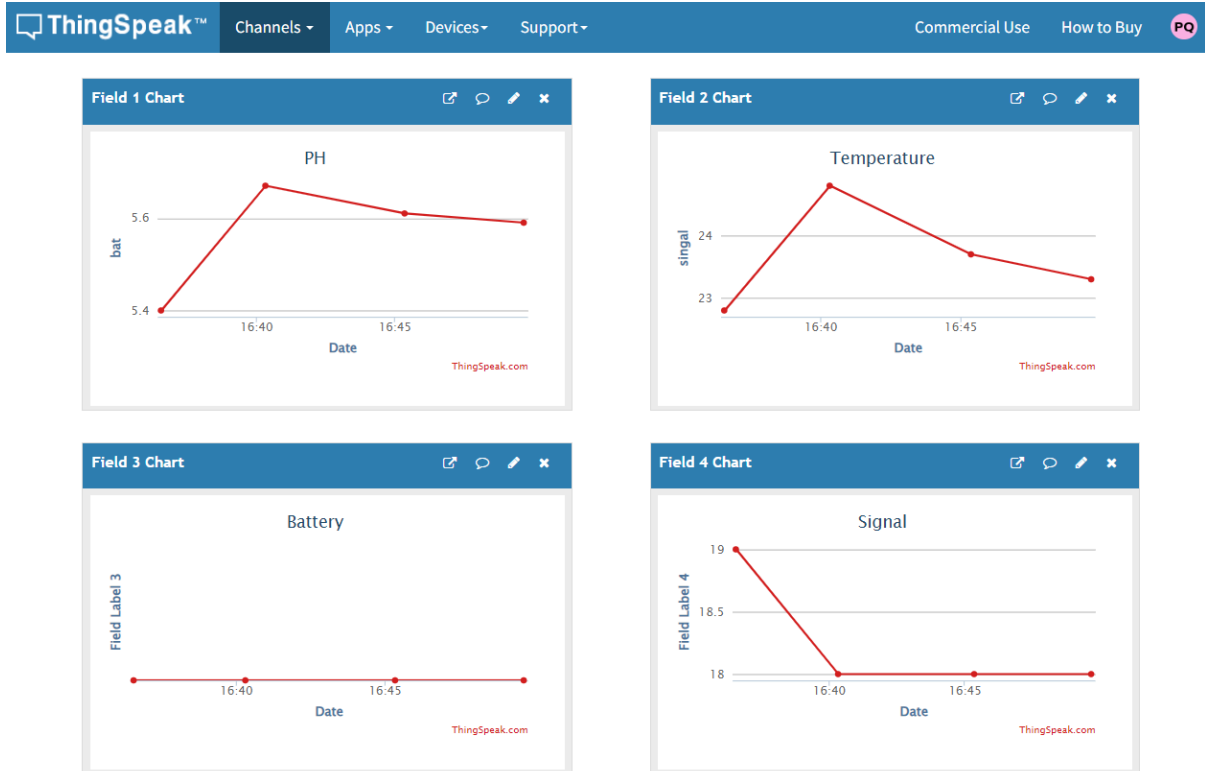


2.2.4 ThingSpeak Payload(Type=1)

This payload meets ThingSpeak platform requirement. It includes only four fields. Form 1~4 are: PH, Temperature, Battery & Signa. This payload type only valid for ThingSpeak Platform.

As below:

field1=PH value&field2=Temperature value&&field3=Battery value&field4=Signal value



2.3 Test Uplink and Change Update Interval

By default, Sensor will send uplinks **every 2 hours** & AT+NOUD=8

User can use below commands to change the **uplink interval**.

AT+TDC=600 // Set Update Interval to 600s

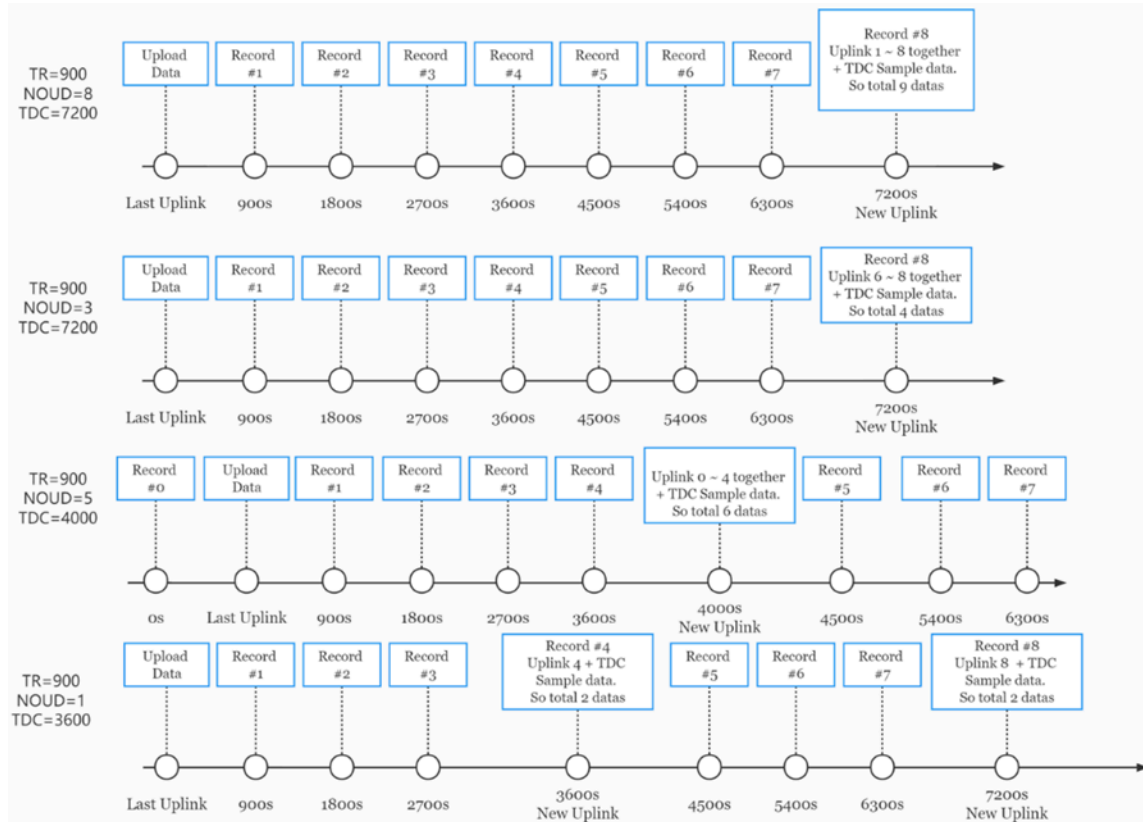
User can also push the button for more than 1 seconds to activate an uplink.

2.4 Multi-Samplings and One uplink

To save battery life, SPH01-NB will sample temperature & humidity data every 15 minutes and send one uplink every 2 hours. So each uplink it will include 8 stored data + 1 real-time data. They are defined by:

- **AT+TR=900** // The unit is seconds, and the default is to record data once every 900 seconds (15 minutes, the minimum can be set to 180 seconds)
- **AT+NOUD=8** // The device uploads 8 sets of recorded data by default. Up to 32 sets of record data can be uploaded.

The diagram below explains the relationship between TR, NOUD, and TDC more clearly:



2.5 Triggier an uplink by external interrupt

SPH01-NB has an external trigger interrupt function. Users can use the PB15 pin to trigger the upload of data packets.

AT command:

- **AT+INTMOD** // Set the trigger interrupt mode
- **AT+INTMOD=0** // Disable Interrupt
- **AT+INTMOD=1** // Trigger by rising and falling edge
- **AT+INTMOD=2** // Trigger by falling edge
- **AT+INTMOD=3** // Trigger by rising edge

2.6 Installation and Maintain

2.6.1 Before measurement

If the SPH01-NB has more than 7 days not use or just clean the pH probe. User should put the probe inside pure water for more than 24 hours for activation. If no put in water, user need to put inside soil for more than 24 hours to ensure the measurement accuracy.

2.6.2 Measurement

Measurement the soil surface:



Choose the proper measuring position. Split the surface soil according to the measured deep.

Put pure water, or rainwater to make the soil of measurement point to moist mud. Remove rocks or hard things.

Slowly insert the probe to the measure point. Don't use large force which will break the probe. Make sure not shake when inserting.

Put soil over the probe after insert. And start to measure.

Measurement inside soil:

Dig a hole with diameter > 20CM.

Insert the probe inside, method like measure the surface.

2.6.3 Maintain Probe

1. pH probe electrode is fragile and no strong. User must avoid strong force or hitting it.
2. After long time use (3~ 6 months). The probe electrode needs to be clean; user can use high grade sandpaper to polish it or put in 5% hydrochloric acid for several minutes. After the metal probe looks like new, user can use pure water to wash it.
3. Probe reference electrode is also no strong, need to avoid strong force or hitting.
4. User should keep reference electrode wet while not use.
5. Avoid the probes to touch oily matter. Which will cause issue in accuracy.
6. The probe is IP68 can be put in water.

2.7 Calibration

User can do calibration for the probe. It is limited to use below pH buffer solution to calibrate: 4.00, 6.86, 9.18. When calibration, user need to clean the electrode and put the probe in the pH buffer solution to wait the value stable (a new clean electrode might need max 24 hours to be stable).

After stable, user can use below command to calibrate.

pH buffer solution	AT Command to calibrate	Downlink Command	Read Cal Value
4.00	AT+PHCAL=4	0x13 04 Reply with Calibrate payload	AT+PHCAL=? Example 41,61,91
6.86	AT+PHCAL=6	0x13 06 Reply with Calibrate payload	AT+PHCAL=?
9.18	AT+PHCAL=9	0x13 09 Reply with Calibrate payload	AT+PHCAL=?
Factory Default	AT+PHCAL=15	0x13 15 Reply with Calibrate payload	AT+PHCAL=? Example 151

Calibration Payload

Size(bytes)	1	1	1	7	1
Value	PH4 Calibrate value	PH6.86 Calibrate value	PH9.18 Calibrate value	Reserve	Message Type Always 0x03

User can also send 0x14 downlink command to poll the current calibration payload.

Downlink Control Type	FPort	Type Code	Downlink payload size(bytes)
Get Calibration Version Info	Any	14	2

- Reply to the confirmation package: 14 01
- Reply to non-confirmed packet: 14 00

3. Configure SPH01-NB

3.1 Configure Methods

SPH01-NB supports below configure method:

- AT Command via Bluetooth Connection (**Recommended**): [BLE Configure Instruction](#).
- AT Command via UART Connection : See [UART Connection](#).

3.2 AT Commands Set

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
AT+CFG : Print all configurations
AT+CFGMOD : Working mode selection
AT+DEUI : Get or set the Device ID
AT+INTMOD : Set the trigger interrupt mode
AT+5VT : Set extend the time of 5V power
AT+PRO : Choose agreement
AT+RXDL : Extend the sending and receiving time
AT+DNSCFG : Get or Set DNS Server
AT+GETSENSORVALUE : Returns the current sensor measurement
AT+NOUD : Get or Set the number of data to be uploaded
AT+CDP : Read or Clear cached data
AT+SHTEMP: Get or Set alarm of temp
AT+SHHUM: Get or Set alarm of moisture
AT+SERVADDR : Server Address

UDP Management

AT+CFM : Upload confirmation mode (only valid for UDP)

MQTT Management

AT+CLIENT : Get or Set MQTT client
AT+UNAME : Get or Set MQTT Username
AT+PWD : Get or Set MQTT password
AT+PUBTOPIC : Get or Set MQTT publish topic
AT+SUBTOPIC : Get or Set MQTT subscription topic

Information

AT+FDR : Factory Data Reset
AT+PASSWORD : Serial Access Password
AT+LDATA : Get the last upload data
AT+CDP : Read or Clear cached data

4. Battery & Power Consumption

SPH01-NB use ER26500 + SPC1520 battery pack. See below link for detail information about the battery info and how to replace.

[Battery Info & Power Consumption Analyze](#) .

5. Firmware update

User can change device firmware to::

- Update with new features.
- Fix bugs.

Firmware and changelog can be downloaded from : [Firmware download link](#)

Methods to Update Firmware:

- (Recommended way) OTA firmware update via BLE: [Instruction](#).
- Update through UART TTL interface : [Instruction](#).

6. FAQ

6.1 How can I access t BC660K-GL AT Commands?

User can access to BC660K-GL directly and send AT Commands.

[See BC660K-GL AT Command set](#)

7. Order Info

Part Number: **SPH01-NB-XX**

XX:

- **GE:** General version (Exclude SIM card)
- **1D:** with 1NCE* 10 years 500MB SIM card and Pre-configure to DataCake server

1NCE SIM Card NB-IoT network coverage: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Latvia, Malta, Netherlands, Norway, Puerto Rico, Russia, Slovak , Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan, USA, US Virgin Islands

8. Packing Info

Package Includes:

- SPH01-NB NB-IoT Soil pH Sensor x 1
- External antenna x 1

Dimension and weight:

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

9. Support

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