



NSE01 NB-IoT Sensor Node User Manual

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Version	Description	Date
1.0.0	Release	2021-May-19

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1. Introduction

1.1 What is NSE01 Soil Moisture & EC Sensor

Dragino NSE01 is an **NB-IOT soil moisture & EC** sensor for agricultural IoT. Used to measure the soil moisture of saline-alkali soil and loam. The soil sensor uses the FDR method to calculate soil moisture and compensates it with soil temperature and electrical conductivity. It has also been calibrated for mineral soil types at the factory.

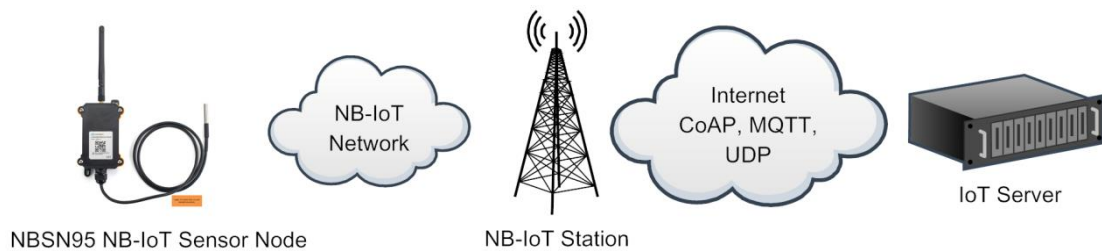
It can detect **Soil Moisture**, **Soil Temperature** and **Soil Conductivity**, and upload its value to the server wirelessly.

The wireless technology used in NSE01 allows the device to send data at a low data rate and reach ultra-long distances, providing ultra-long-distance spread spectrum Communication.

NSE01 are powered by **8500mAh Li-SOCI2 batteries**, which can be used for up to 5 years.



NBSN95 in a NB-IoT Network



1.2 Specifications

Common DC Characteristics:

- Supply Voltage: 2.1v ~ 3.6v
- Operating Temperature: -40 ~ 85°C

NB-IoT Spec:

- - B1 @H-FDD: 2100MHz
- - B3 @H-FDD: 1800MHz
- - B8 @H-FDD: 900MHz
- - B5 @H-FDD: 850MHz
- - B20 @H-FDD: 800MHz
- - B28 @H-FDD: 700MHz

Probe Specification:

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

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

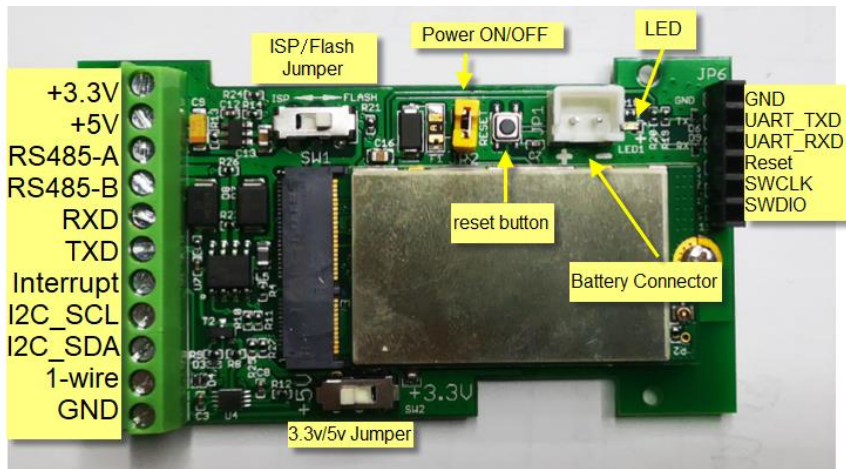
1.3 Features

- NB-IoT Bands: B1/B3/B8/B5/B20/B28 @H-FDD
- Monitor Soil Moisture
- Monitor Soil Temperature
- Monitor Soil Conductivity
- AT Commands to change parameters
- Uplink on periodically
- Downlink to change configure
- IP66 Waterproof Enclosure
- Ultra-Low Power consumption
- AT Commands to change parameters
- Micro SIM card slot for NB-IoT SIM
- 8500mAh Battery for long term use

1.4 Applications

- Smart Agriculture

1.5 Pin Definitions

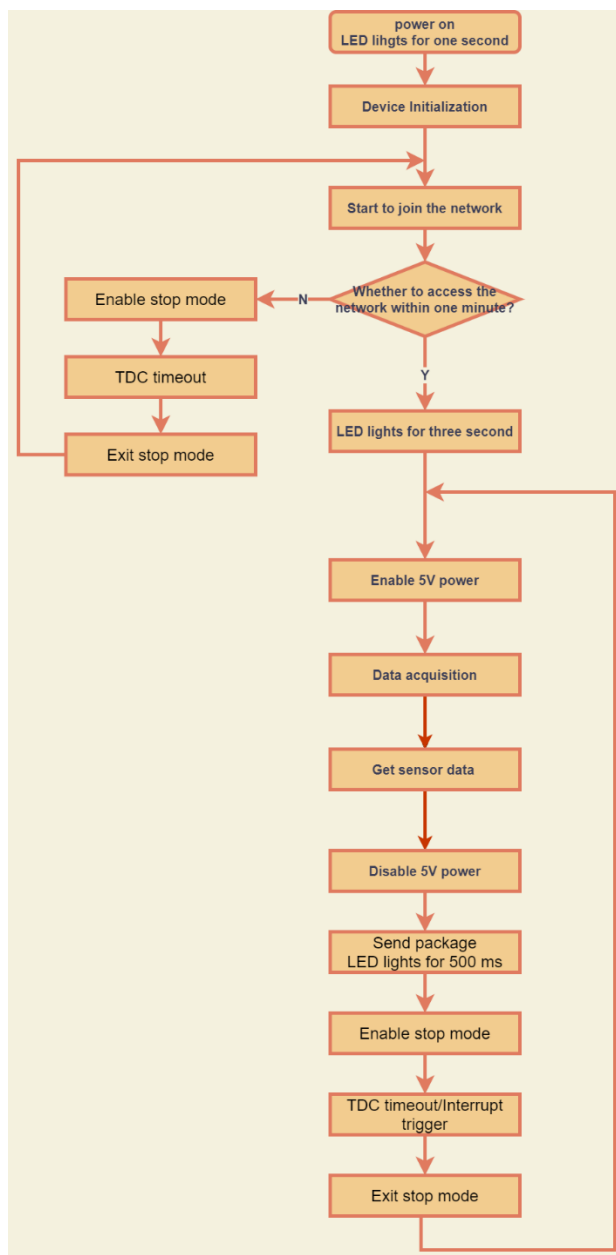


2. Use NSE01 to communicate with IoT Server

2.1 How it works

The NSE01 is equipped with a NB-IoT module, the pre-loaded firmware in NSE01 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 NSE01.

The diagram below shows the working flow in default firmware of NSE01:



2.2 Configure the NSE01

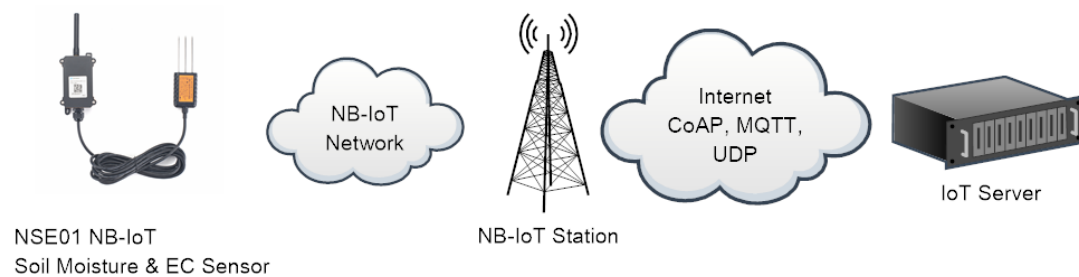
2.2.1 Test Requirement

To use NSE01 in your city, make sure meet below requirements:

- ✓ Your local operator has already distributed a NB-IoT Network there.
- ✓ The local NB-IoT network used the band that NSE01 supports.
- ✓ Your operator is able to distribute the data received in their NB-IoT network to your IoT server.

Below figure shows our testing structure. Here we have NB-IoT network coverage by China Mobile, the band they use is B8. The NSE01 will use CoAP(120.24.4.116:5683) or raw UDP(120.24.4.116:5601) or MQTT(120.24.4.116:1883) or TCP(120.24.4.116:5600) protocol to send data to the test server

NSE01 in a NB-IoT Network



2.2.2 Insert SIM card

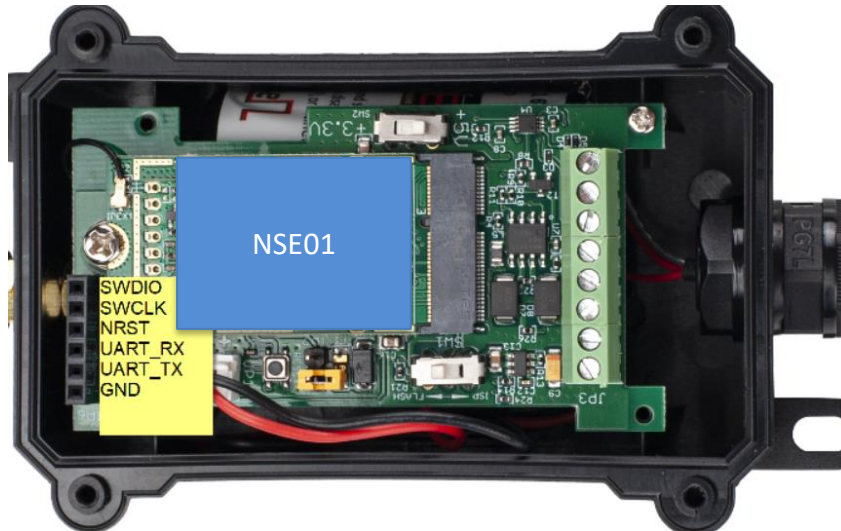
Insert the NB-IoT Card get from your provider.

User need to take out the NB-IoT module and insert the SIM card like below:



2.2.3 Connect USB – TTL to NSE01 to configure it

User need to configure NSE01 via serial port to set the **Server Address / Uplink Topic** to define where and how-to uplink packets. NSE01 support AT Commands, user can use a USB to TTL adapter to connect to NSE01 and use AT Commands to configure it, as below.



Connection:

USB TTL GND <----> GND

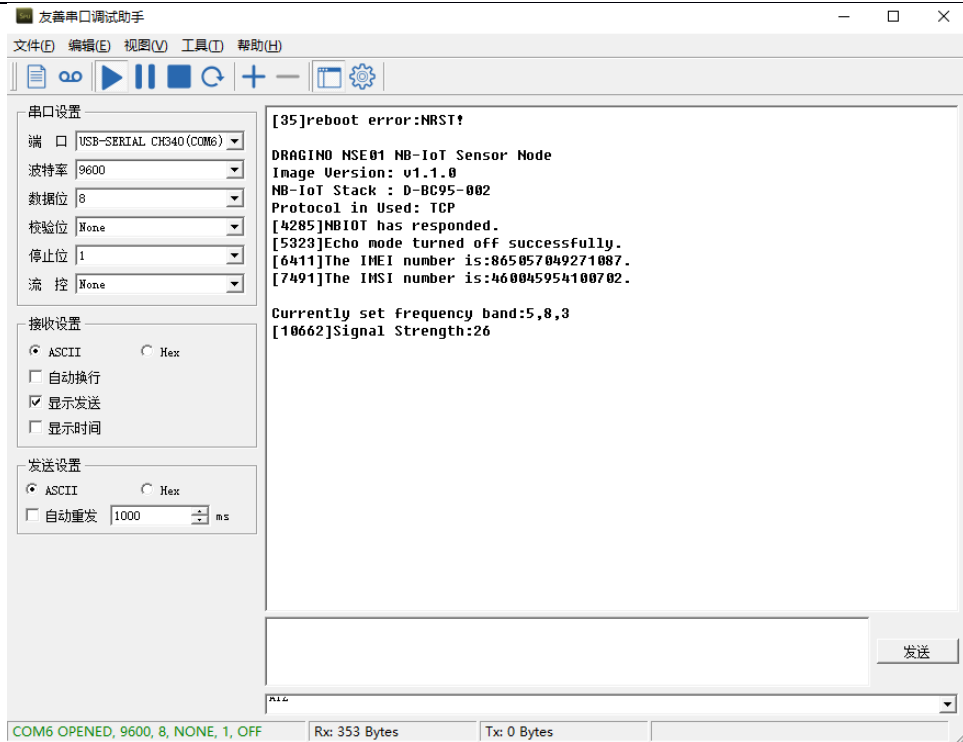
USB TTL TXD <----> UART_RXD

USB TTL RXD <----> UART_TXD

In the PC, use below serial tool settings:

- ✓ Baud: **9600**
- ✓ Data bits: **8**
- ✓ Stop bits: **1**
- ✓ Parity: **None**
- ✓ Flow Control: **None**

Make sure the switch is in FLASH position, then power on device by connecting the jumper on NSE01. NSE01 will output system info once power on as below, we can enter the **password: 12345678** to access AT Command input.



Note: the valid AT Commands can be found at:

<http://www.dragino.com/downloads/index.php?dir=NB-IoT/NSE01/>

2.2.4 Use CoAP protocol to uplink data

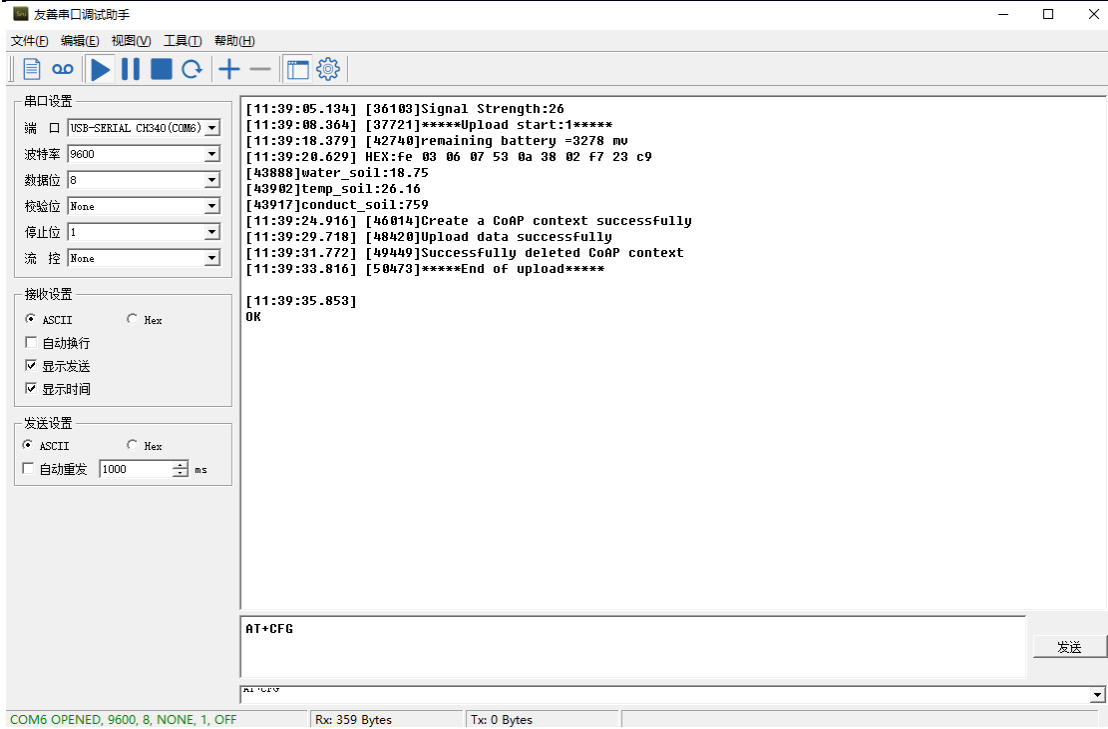
Note: if you don't have CoAP server, you can refer this link to set up one:

http://wiki.dragino.com/index.php?title=Set_up_CoAP_Server

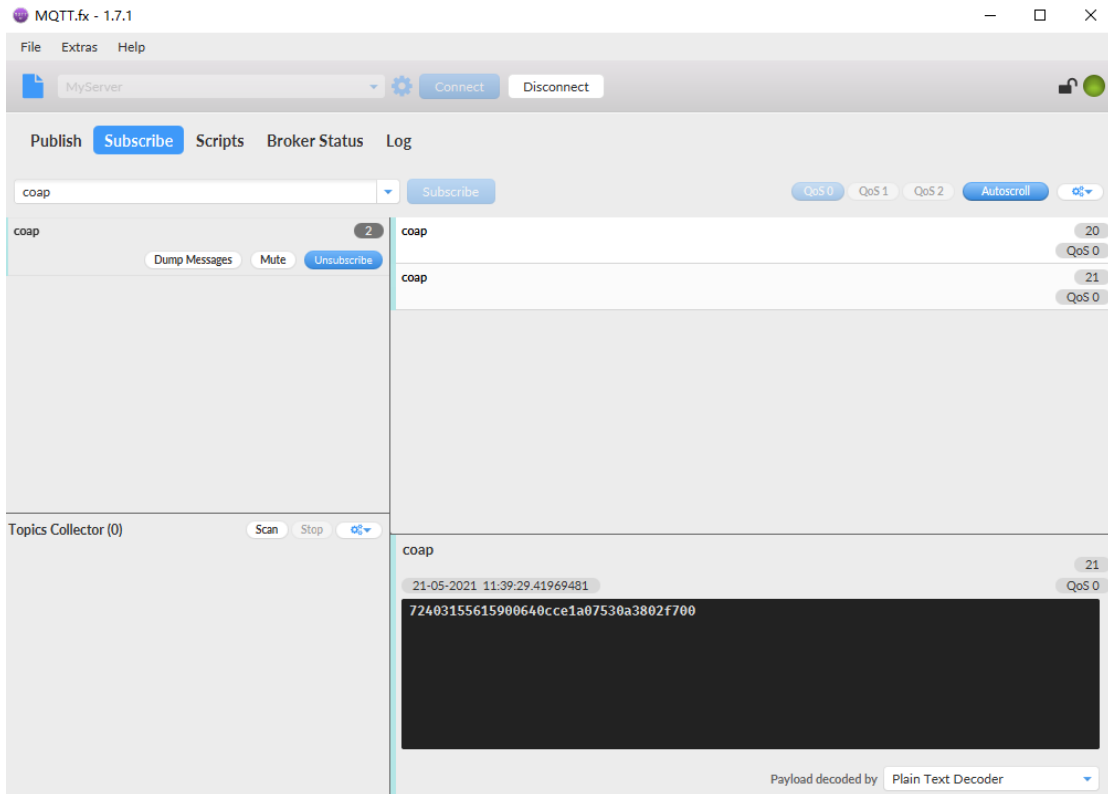
Use below commands:

- **AT+PRO=1** // Set to use CoAP protocol to uplink
- **AT+SERVADDR=120.24.4.116,5683** // to set CoAP server address and port
- **AT+URI=5,11,"mqtt",11,"coap",12,"0",15,"c=text1",23,"0"** //Set COAP resource path

For parameter description, please refer to AT command set



After configure the server address and **reset the device** (via AT+ATZ), NSE01 will start to uplink sensor values to CoAP server.

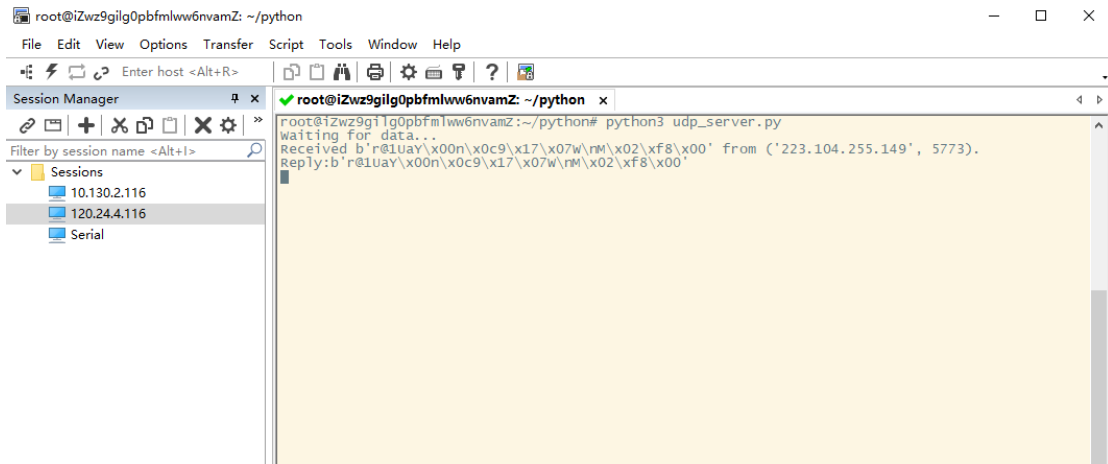
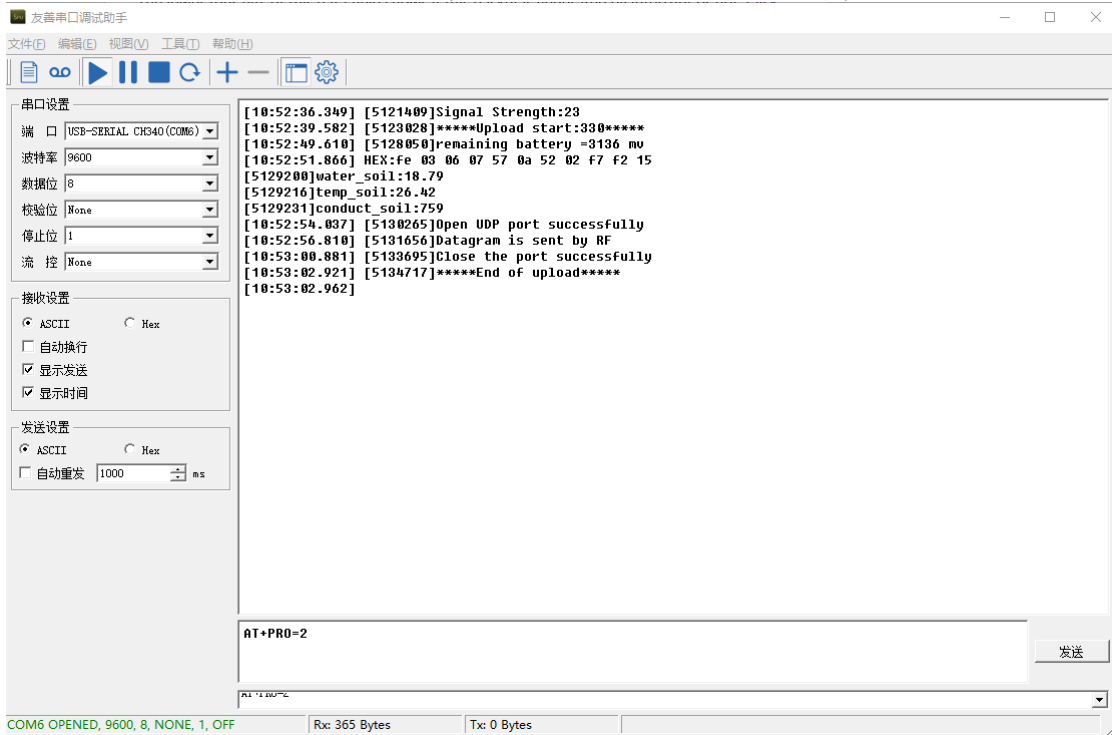


2.2.5 Use UDP protocol to uplink data(Default protocol)

This feature is supported since firmware version v1.0.1

- **AT+PRO=2** // Set to use UDP protocol to uplink
- **AT+SERVADDR=120.24.4.116,5601** // to set UDP server address and port

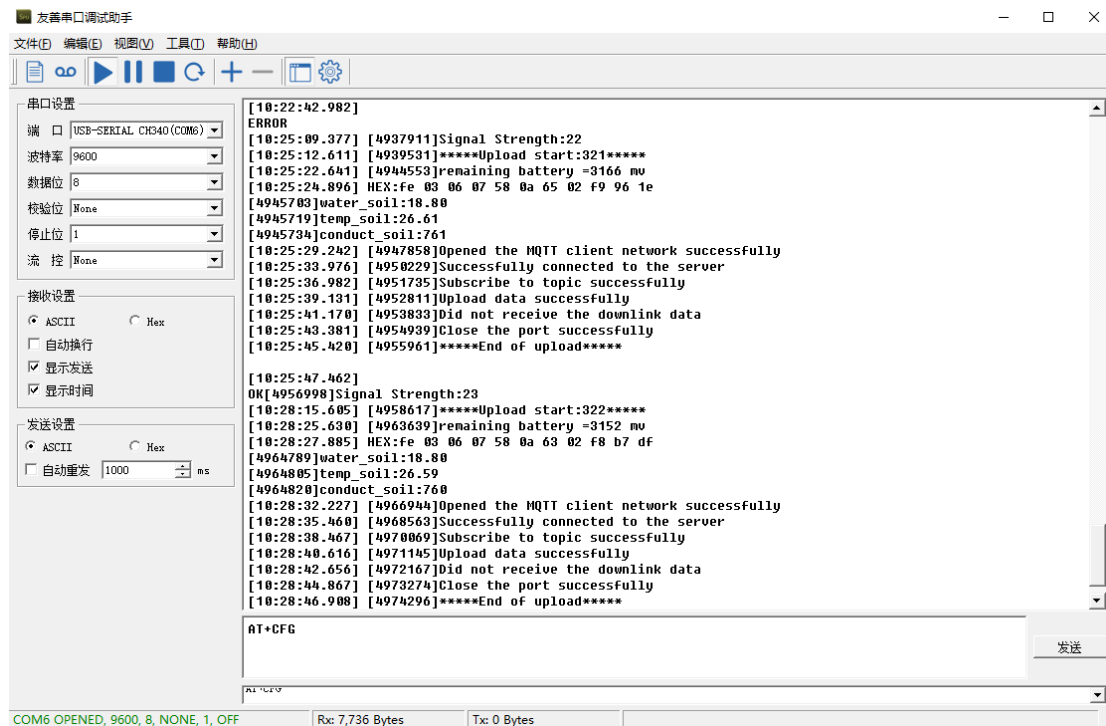
➤ **AT+CFM=1** //If the server does not respond, this command is unnecessary



2.2.6 Use MQTT protocol to uplink data

This feature is supported since firmware version v110

- **AT+PRO=3** //Set to use MQTT protocol to uplink
- **AT+SERVADDR=120.24.4.116,1883** //Set MQTT server address and port
- **AT+CLIENT=CLIENT** //Set up the CLIENT of MQTT
- **AT+UNAME=UNAME** //Set the username of MQTT
- **AT+PWD=PWD** //Set the password of MQTT
- **AT+PUBTOPIC=NSE01_PUB** //Set the sending topic of MQTT
- **AT+SUBTOPIC=NSE01_SUB** //Set the subscription topic of MQTT



The screenshot shows a serial terminal window titled "友善串口调试助手" (Friendly Serial Port Debug Assistant). The interface includes settings for the serial port (USB-SERIAL CH340 (COM6)), baud rate (9600), data bits (8), parity (None), stop bits (1), and flow control (None). It also has sections for reception settings (ASCII selected, auto-switching, display send, display time) and transmission settings (ASCII selected, auto-retransmit at 1000ms).

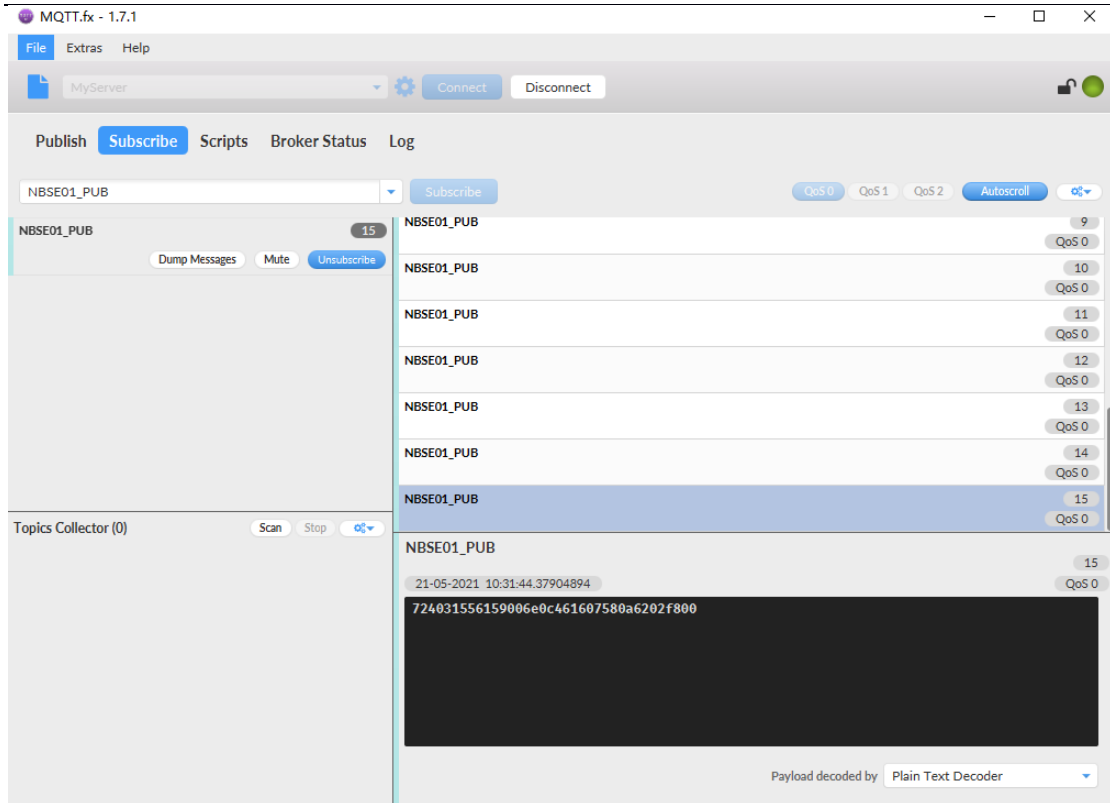
The main terminal area displays the following log output:

```
[10:22:42.982]
ERROR
[10:25:09.377] [4937911]Signal Strength:22
[10:25:12.611] [4939531]*****Upload start:321*****
[10:25:22.641] [4944553]remaining battery =3166 mv
[10:25:24.896] HEX:Fe 03 06 07 58 0a 65 02 f9 96 1e
[4945703]water_soil:18.80
[4945719]temp_soil:26.61
[4945734]conduct_soil:761
[10:25:29.242] [4947858]Opened the MQTT client network successfully
[10:25:33.976] [4950229]Successfully connected to the server
[10:25:36.982] [4951735]Subscribe to topic successfully
[10:25:39.131] [4952811]Upload data successfully
[10:25:41.170] [4953833]Did not receive the downlink data
[10:25:43.381] [4954939]Close the port successfully
[10:25:45.420] [4955961]*****End of upload*****

[10:25:47.462]
OK[4956998]Signal Strength:23
[10:28:15.605] [4958617]*****Upload start:322*****
[10:28:25.630] [4963639]remaining battery =3152 mv
[10:28:27.885] HEX:Fe 03 06 07 58 0a 63 02 f8 b7 df
[4964789]water_soil:18.80
[4964805]temp_soil:26.59
[4964820]conduct_soil:760
[10:28:32.227] [4966944]Opened the MQTT client network successfully
[10:28:35.460] [4968563]Successfully connected to the server
[10:28:38.467] [4970069]Subscribe to topic successfully
[10:28:40.616] [4971145]Upload data successfully
[10:28:42.656] [4972167]Did not receive the downlink data
[10:28:44.867] [4973274]Close the port successfully
[10:28:46.908] [4974296]*****End of upload*****

AT+CFG
```

At the bottom of the window, a status bar shows: "COM6 OPENED, 9600, 8, NONE, 1, OFF", "Rx: 7,736 Bytes", and "Tx: 0 Bytes".

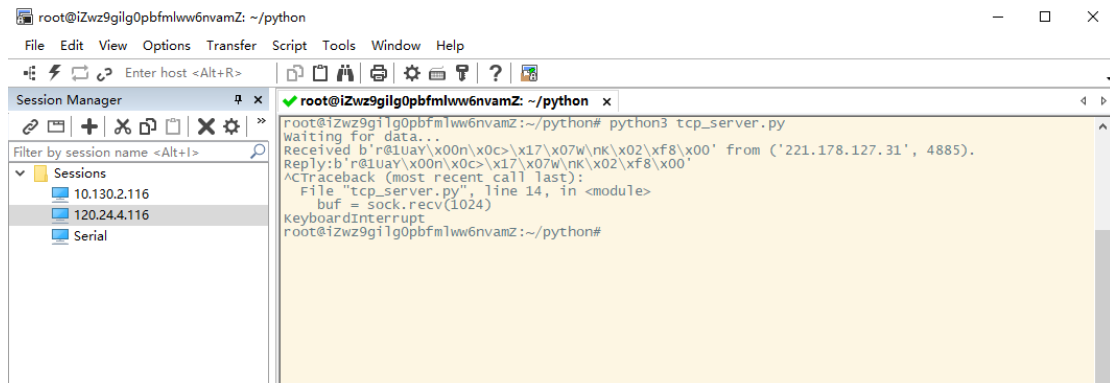
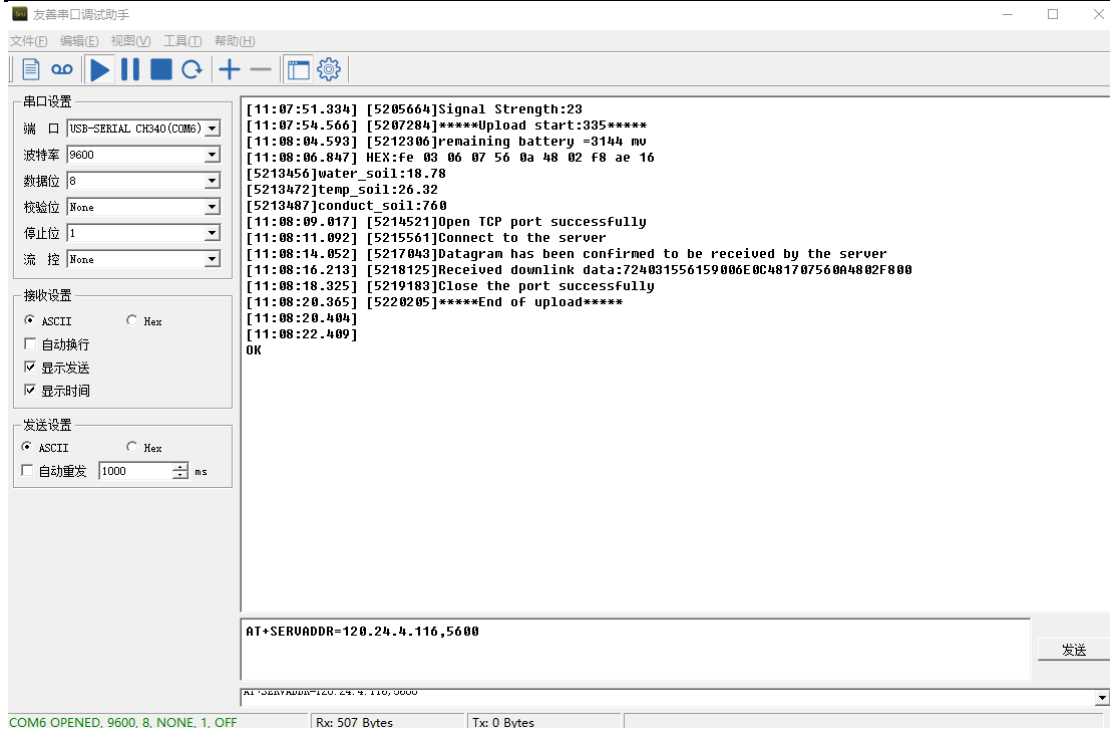


MQTT protocol has a much higher power consumption compare vs UDP / CoAP protocol. Please check the power analyze document and adjust the uplink period to a suitable interval.

2.2.7 Use TCP protocol to uplink data

This feature is supported since firmware version v110

- **AT+PRO=4** // Set to use TCP protocol to uplink
- **AT+SERVADDR=120.24.4.116,5600** // to set TCP server address and port



2.2.8 Change Update Interval

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

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

NOTE:

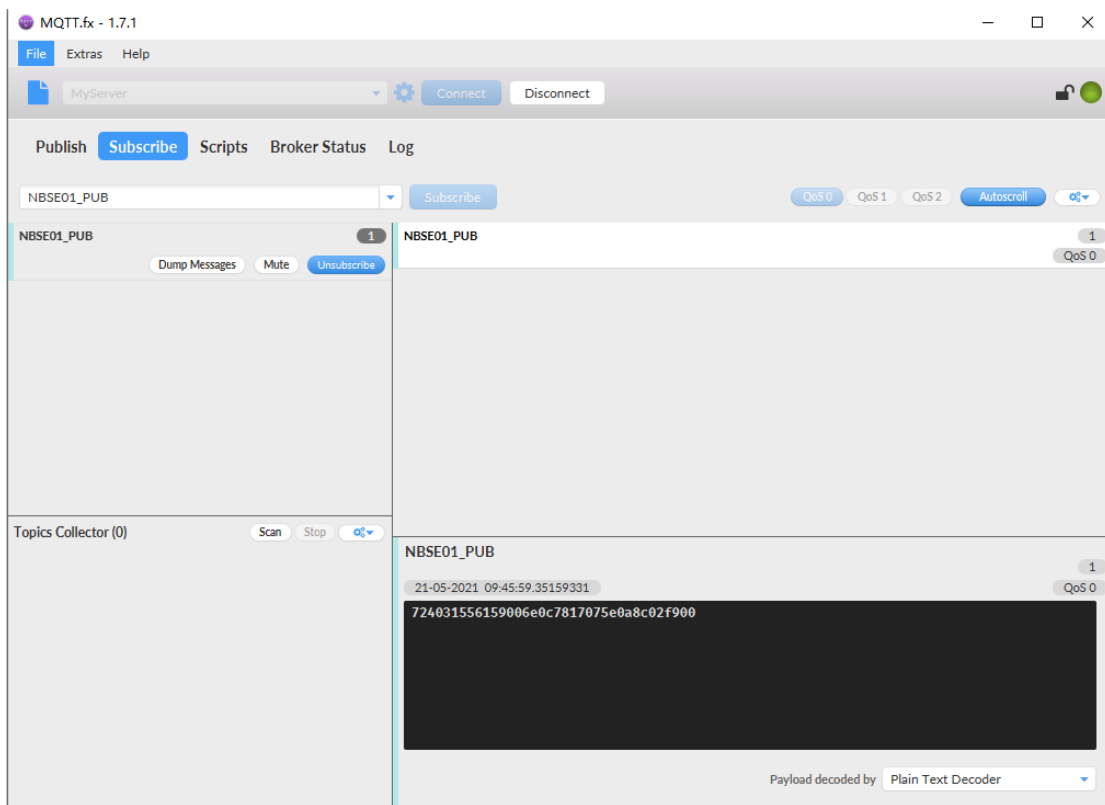
- By default, the device will send an uplink message every 1 hour.

2.3 Uplink Payload

In this mode, uplink payload includes in total 18 bytes

Size (bytes)	6	2	2	1	2	2	2	1
Value	Device ID	Ver	BAT	Signal Strength	Soil Moisture	Soil Temperature	Soil Conductivity(EC)	Interrupt

If we use the MQTT client to subscribe to this MQTT topic, we can see the following information when the NSE01 uplink data.



The payload is ASCII string, representative same HEX: 0x72403155615900640c7817075e0a8c02f900 where:

- Device ID: 0x 724031556159 = 724031556159
- Version: 0x0064=100=1.0.0
- BAT: 0x0c78 = 3192 mV = 3.192V
- Singal: 0x17 = 23
- Soil Moisture: 0x075e= 1886 = 18.86 %
- Soil Temperature:0x0a8c =2700=27 ° C
- Soil Conductivity(EC) = 0x02f9 =761 uS /cm
- Interrupt: 0x00 = 0

2.4 Payload Explanation and Sensor Interface

2.4.1 Device ID

By default, the Device ID equal to the last 6 bytes of IMEI.

User can use AT+DEUI to set Device ID

Example:

```
AT+DEUI=A84041F15612
```

The DeviceID is stored in a none-erase area, Upgrade the firmware or run AT+FDR won't erase Device ID.

2.4.2 Version Info

Specify the software version: 0x64=100, means firmware version 1.00.

For example: 0x00 64 : this device is NSE01 with firmware version 1.0.0.

2.4.3 Battery Info

Ex1: 0x0B45 = 2885mV

Ex2: 0x0B49 = 2889mV

2.4.4 Signal Strength

NB-IoT Network signal Strength.

Ex1: 0x1d = 29

0 -113dBm or less

1 -111dBm

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

31 -51dBm or greater

99 Not known or not detectable

2.4.5 Soil Moisture

Get the moisture content of the soil. The value range of the register is 0-10000(Decimal), divide this value by 100 to get the percentage of moisture in the soil.

For example, if the data you get from the register is 0x05 0xDC, the moisture content in the soil is

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

2.4.6 Soil Temperature

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

Example:

If payload is 0105H: $((0x0105 \& 0x8000) \gg 15 \text{ === } 0)$, temp = $0105(H)/100 = 2.61 \text{ }^\circ\text{C}$

If payload is FF7EH: $((FF7E \& 0x8000) \gg 15 \text{ === } 1)$, temp = $(FF7E(H) - FFFF(H))/100 = -1.29 \text{ }^\circ\text{C}$

2.4.7 Soil Conductivity(EC)

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

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

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

2.4.8 Digital Interrupt

Digital Interrupt refers to pin **GPIO_EXTI**, and there are different trigger methods. When there is a trigger, the NSE01 will send a packet to the server.

The command is:

AT+INTMOD=3 //(more info about INMOD please refer [AT Command Manual](#)).

The lower four bits of this data field shows if this packet is generated by interrupt or not. Click here for the hardware and software set up.

Example:

0x(00): Normal uplink packet.

0x(01): Interrupt Uplink Packet.

2.4.9 +5V Output

NSE01 will enable +5V output before all sampling and disable the +5v after all sampling.

The 5V output time can be controlled by AT Command.

AT+5VT=1000

Means set 5V valid time to have 1000ms. So the real 5V output will actually have 1000ms + sampling time for other sensors.

2.5 Downlink Payload

By default, NSE01 prints the downlink payload to console port.

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

Examples

Set TDC

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

Payload: 01 00 00 1E TDC=30S

Payload: 01 00 00 3C TDC=60S

Reset

If payload = 0x04FF, it will reset the NSE01

INTMOD

2.6 LED Indicator

The NSE01 has an internal LED which is to show the status of different state.

- When power on, NSE01 will detect if sensor probe is connected, if probe detected, LED will blink four times. (no blinks in this step is no probe)
- Then the LED will be on for 1 second means device is boot normally.
- After NSE01 join NB-IoT network. The LED will be ON for 3 seconds.
- For each uplink probe, LED will be on for 500ms.

2.7 Installation in Soil

Measurement the soil surface



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

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



2.8 Firmware Change Log

Download URL & Firmware Change log

www.dragino.com/downloads/index.php?dir=NB-IoT/NSE01/Firmware/

Upgrade Instruction: [Upgrade Firmware](#)

2.9 Battery Analysis

2.9.1 Battery Type

The NSE01 battery is a combination of an 8500mAh Li/SOCI2 Battery and a Super Capacitor. The battery is none-rechargeable battery type with a low discharge rate (<2% per year). This type of battery is commonly used in IoT devices such as water meter.

The battery is designed to last for several years depends on the actually use environment and update interval.

The battery related documents as below:

- [Battery Dimension](#),
- [Lithium-Thionyl Chloride Battery](#) datasheet
- [Lithium-ion Battery-Capacitor](#) datasheet,



2.9.2 Power consumption Analyze

Dragino battery powered product are all runs in Low Power mode. We have an update battery calculator which base on the measurement of the real device. User can use this calculator to check the battery life and calculate the battery life if want to use different transmit interval.

Instruction to use as below:

Step 1: Downlink the up-to-date DRAGINO_Battery_Life_Prediction_Table.xlsx from:

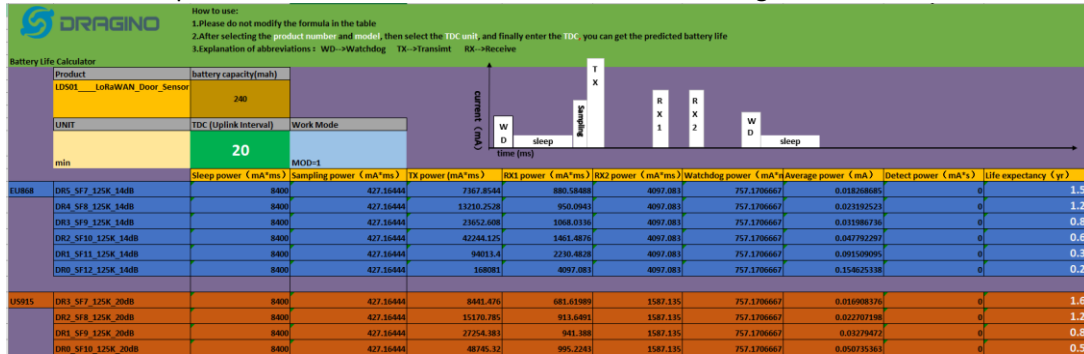
https://www.dragino.com/downloads/index.php?dir=LoRa_End_Node/Battery_Analyze/

Step 2: Open it and choose

- Product Model

- Uplink Interval
- Working Mode

And the Life expectation in difference case will be shown on the right.



2.9.3 Battery Note

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

2.9.4 Replace the battery

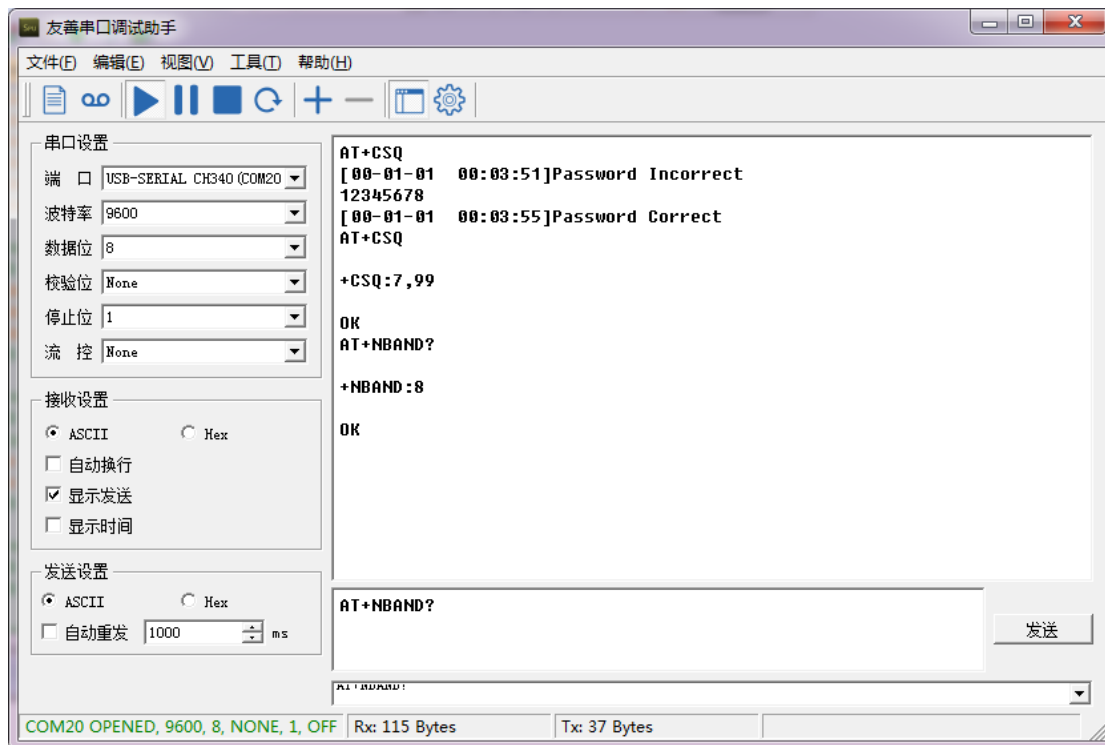
The default battery pack of NDDS75 includes a ER26500 plus super capacitor. If user can't find this pack locally, they can find ER26500 or equivalence without the SPC1520 capacitor, which will also work in most case. The SPC can enlarge the battery life for high frequency use (update period below 5 minutes)

3. Access NB-IoT Module

Users can directly access the AT command set of the NB-IoT module.

The AT Command set can refer the BC35-G NB-IoT Module AT Command:

https://www.dragino.com/downloads/index.php?dir=datasheet/other_vendors/BC35-G/



4. Using the AT Commands

4.1 Access AT Commands

See this link for detail:

<http://www.dragino.com/downloads/index.php?dir=NB-IoT/NSE01/>

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+INTMOD : Set the trigger interrupt mode
AT+5VT : Set extend the time of 5V power
AT+PRO : Choose agreement
AT+WEIGRE : Get weight or set weight to 0
AT+WEIGAP : Get or Set the GapValue of weight
AT+RXDL : Extend the sending and receiving time
AT+CNTFAC : Get or set counting parameters
AT+SERVADDR : Server Address

COAP Management

AT+URI : Resource parameters

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

5. FAQ

5.1 How to Upgrade Firmware

User can upgrade the firmware for 1) bug fix, 2) new feature release.

Please see this link for how to upgrade:

[http://wiki.dragino.com/index.php?title=Firmware Upgrade Instruction for STM32 base products#Hardware Upgrade Method Support List](http://wiki.dragino.com/index.php?title=Firmware_Upgrade_Instruction_for_STM32_base_products#Hardware_Upgrade_Method_Support_List)

Notice, NSE01 and LSE01 share the same mother board. They use the same connection and method to update.

6. Trouble Shooting

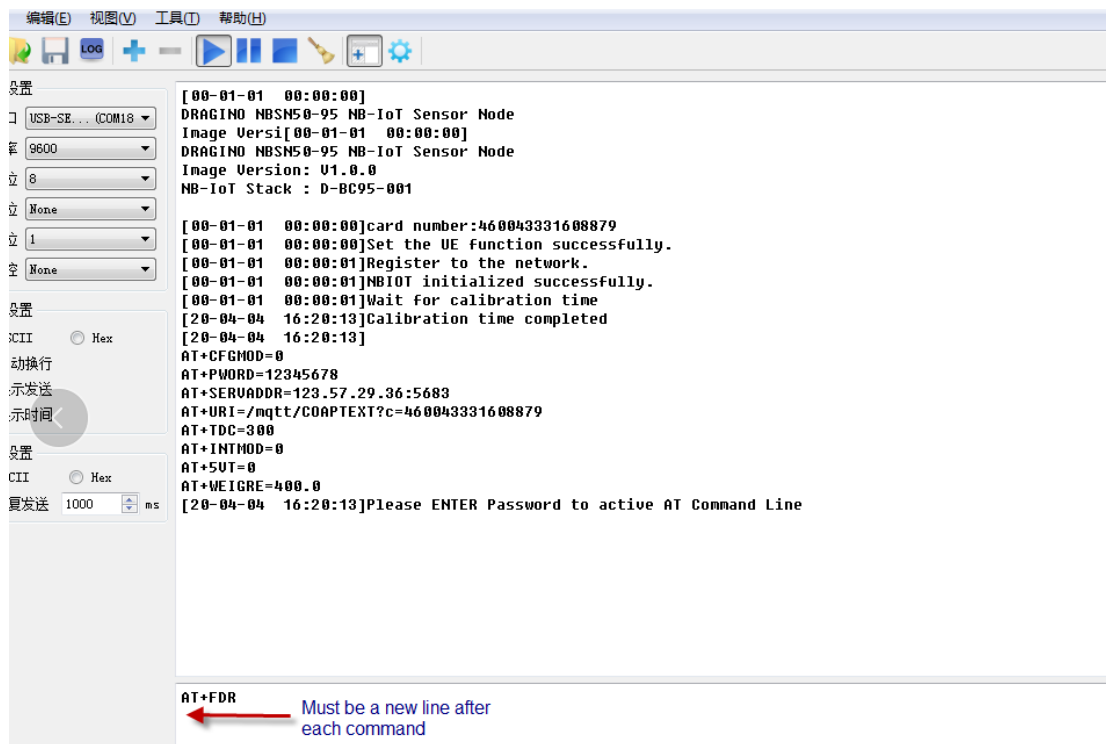
6.1 Connection problem when uploading firmware.

Please see:

http://wiki.dragino.com/index.php?title=Firmware_Upgrade_Trouble_Shooting#UART_upgrade_trouble_shooting

6.2 AT Command input doesn't work

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



7. Order Info

Part Number: **NSE01**

8. Packing Info

Package Includes:

- NSE01 NB-IoT Sensor Node x 1
- External antenna x 1

Dimension and weight:

- Size: 195 x 125 x 55 mm
- Weight: 420g

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