



# Insertion Temperature Sensor

Featuring LoRaWAN®

TS101

User Guide



## Safety Precautions

Milesight will not shoulder responsibility for any loss or damage resulting from not following the instructions of this operating guide.

- ❖ The probe has a sharp point. Please be careful and keep the edges and points away from human body.
- ❖ The device must not be disassembled or remodeled in any way.
- ❖ To ensure the security of your device, please change the device password during the initial configuration. The default password is 123456.
- ❖ Do not place the device close to objects with naked flames.
- ❖ Do not place the device where the temperature is below/above the operating range.
- ❖ Make sure electronic components do not drop out of the enclosure while opening.
- ❖ When installing the battery, please install it accurately, and do not install the inverse or wrong model.
- ❖ The device must never be subjected to shocks or impacts.

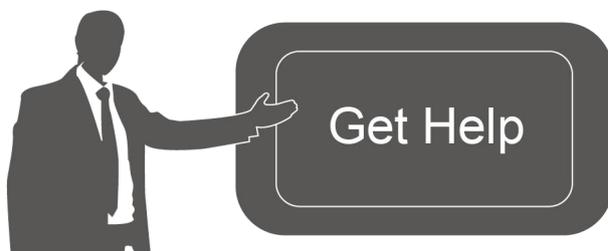
## Declaration of Conformity

TS101 conforms with the essential requirements and other relevant provisions of the CE, FCC, and RoHS.



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For assistance, please contact

Milesight technical support:

Email: [iot.support@milesight.com](mailto:iot.support@milesight.com)

Support Portal: [support.milesight-iot.com](http://support.milesight-iot.com)

Tel: 86-592-5085280

Fax: 86-592-5023065

Address: Building C09, Software Park III,  
Xiamen 361024, China

## Revision History

Date	Doc Version	Description
April 10, 2023	V 1.0	Initial version
Feb. 20, 2024	V 1.1	Add temperature calibration downlink command

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# 1. Product Introduction

## 1.1 Overview

Milesight TS101 is an all-in-one insertion temperature sensor with an integrated transmitter. It is equipped with an advanced measuring unit that provides a wide temperature measuring range.

With IP67 and IK10 ratings, the exquisite TS101 sensor is suitable for monitoring the inner temperature of Tobacco or grain stacks. It can also be applied in other warehousing scenarios which require inner temperature detection with high efficiency.

TS101 is compatible with Milesight LoRaWAN® gateway and mainstream LoRaWAN® network servers. With this low power consumption technology, TS101 can work for up to 10 years with a 4,000mAh battery. Combining with Milesight LoRaWAN® gateway and Milesight IoT solution, users can manage all data remotely and visually.

## 1.2 Features

- Equipped with highly accurate and stable DS18B20 temperature sensor chip with high resolution
- Adopt food-grade stainless-steel probe and shell material for efficient and safe detection
- Store up to 1200 sets of data locally and support data retrievability and retransmission
- IP67 and IK10 rated and phosphine corrosion-resistant for harsh environment
- Built-in 4000mAh replaceable battery and works for up to 10 years without replacement
- Integrated and compact design for wireless deployment
- Built-in NFC for easy configuration
- Compliant with standard LoRaWAN® gateway and network servers
- Quick and easy management with Milesight IoT Cloud solution

# 2. Hardware Introduction

## 2.1 Packing List

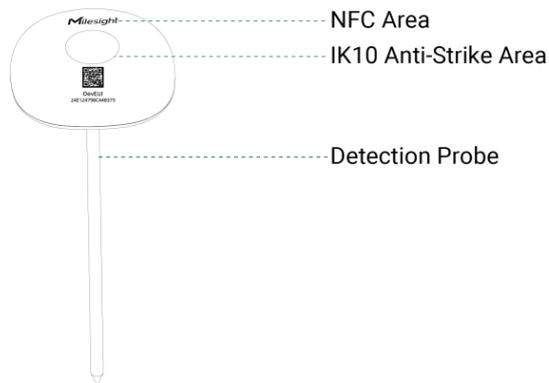


1 × TS101 Device    1 × Quick Start Guide    1 × Warranty Card

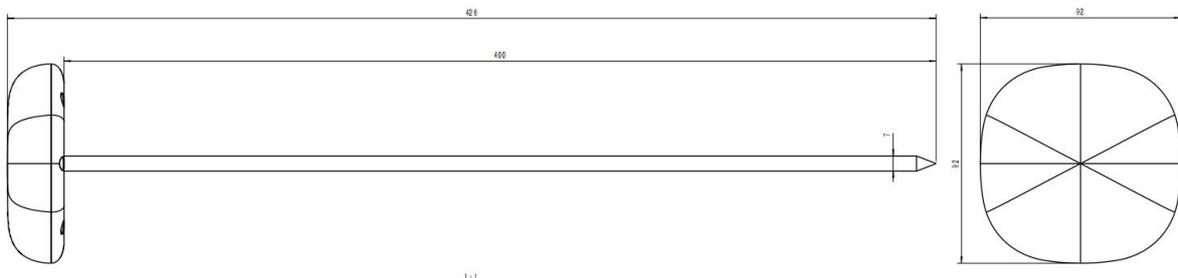


**If any of the above items is missing or damaged, please contact your sales representative.**

## 2.2 Hardware Overview



## 2.3 Dimensions (mm)



## 2.4 Reset Button & LED Patterns

TS101 sensor equips with a reset button and a LED indicator inside the device, please remove the cover for emergency reset or reboot. Usually, users can use NFC to complete all steps.

Function	Action	LED Indicator
Power On	Press and hold the button for more than 3 seconds.	Off → On
Power Off	Press and hold the button for more than 3 seconds.	On → Off
Reset to Factory Default	Press and hold the button for more than 10 seconds.	Blinks quickly
Check On/Off Status	Quickly press the reset button.	Light On: Device is On.
		Light Off: Device is Off.

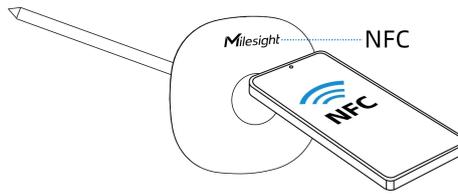
## 3. Operation Guide

### 3.1 NFC Configuration

TS101 can be configured via NFC.

1. Download and install "Milesight ToolBox" App from Google Play or App Store.

2. Enable NFC on the smartphone and open “Milesight ToolBox” App.
3. Attach the smartphone with the NFC area to the device to read the basic information.



4. Basic information and settings of devices will be shown on ToolBox if it's recognized successfully. You can read and write the device by tapping the button on the App. Password validation is required when configuring devices via an unused phone to ensure security. The default password is **123456**.

Status	Setting	Maintenance
SN	6732D07453450005	
Model	TS101-868M	
Device EUI	24E124732D074534	
Firmware Version		V1.1
Hardware Version		V1.0
Device Status	ON	<input checked="" type="checkbox"/>

**Note:**

- 1) Ensure the location of the smartphone NFC area and it's recommended to take off the phone case.
- 2) If the smartphone fails to read/write configurations via NFC, move it away and try again later.

## 3.2 LoRaWAN Settings

LoRaWAN settings is used for configuring the transmission parameters in LoRaWAN® network.

Device EUI

24E124732D074534

\* APP EUI

24e124c0002a0001

\* Application Port

 85 

Join Type

OTAA

\* Application Key

\*\*\*\*\*

LoRaWAN Version

V1.0.3

Work Mode

Class A

RX2 Data Rate

DR0 (SF12, 125 kHz)

RX2 Frequency

869525000

Confirmed Mode [i](#)

Rejoin Mode

Set the number of detection signals sent [i](#)

32

ADR Mode [i](#)Spreading Factor [i](#)

SF10-DR2

TXPower

TXPower0-16 dBm

Parameters

Description

Device EUI	The device's unique ID can also be found on the label.
App EUI	The default App EUI is 24E124C0002A0001.
Application Port	The port used for sending and receiving data, the default port is 85.
Join Type	OTAA and ABP modes are available.
Application Key	Appkey for OTAA mode, default is 5572404C696E6B4C6F52613230313823.
Device Address	DevAddr for ABP mode, default is the 5 <sup>th</sup> to 12 <sup>th</sup> digits of SN.
Network Session Key	Nwkskey for ABP mode, default is 5572404C696E6B4C6F52613230313823.
Application Session Key	Appskey for ABP mode, default is 5572404C696E6B4C6F52613230313823.
LoRaWAN Version	V1.0.2 and V1.0.3 are available.
Work Mode	It's fixed as Class A.
RX2 Data Rate	RX2 data rate to receive downlinks.
RX2 Frequency	RX2 frequency to receive downlinks. Unit: Hz
Supported Frequency	<p>Enable or disable the frequency to send uplinks. If frequency is one of CN470/AU915/US915, enter the index of the channel that you want to enable in the input box, making them separated by commas.</p> <p><b>Examples:</b></p> <p>1, 40: Enabling Channel 1 and Channel 40</p> <p>1-40: Enabling Channel 1 to Channel 40</p> <p>1-40, 60: Enabling Channel 1 to Channel 40 and Channel 60</p> <p>All: Enabling all channels</p> <p>Null: Indicate that all channels are disabled</p>

	<p>Channel Mode</p> <p>Standard-Channel</p> <p>Enable Channel Index ⓘ</p> <p>0-71</p> <table border="1"> <thead> <tr> <th>Index</th> <th>Frequency/MHz ⓘ</th> </tr> </thead> <tbody> <tr> <td>0 - 15</td> <td>902.3 - 905.3</td> </tr> <tr> <td>16 - 31</td> <td>905.5 - 908.5</td> </tr> <tr> <td>32 - 47</td> <td>908.7 - 911.7</td> </tr> <tr> <td>48 - 63</td> <td>911.9 - 914.9</td> </tr> <tr> <td>64 - 71</td> <td>903 - 914.2</td> </tr> </tbody> </table>	Index	Frequency/MHz ⓘ	0 - 15	902.3 - 905.3	16 - 31	905.5 - 908.5	32 - 47	908.7 - 911.7	48 - 63	911.9 - 914.9	64 - 71	903 - 914.2
Index	Frequency/MHz ⓘ												
0 - 15	902.3 - 905.3												
16 - 31	905.5 - 908.5												
32 - 47	908.7 - 911.7												
48 - 63	911.9 - 914.9												
64 - 71	903 - 914.2												
Spread Factor	If ADR is disabled, the device will send data via this spread factor.												
Confirmed Mode	If the device does not receive an ACK packet from the network server, it will resend data once.												
Rejoin Mode	<p>Reporting interval <math>\leq</math> 35 mins: the device will send a specific number of LinkCheckReq MAC packets to the network server every reporting interval or every double reporting interval to validate connectivity; If there is no response, the device will re-join the network.</p> <p>Reporting interval <math>&gt;</math> 35 mins: the device will send a specific number of LinkCheckReq MAC packets to the network server every reporting interval to validate connectivity; If there is no response, the device will re-join the network.</p>												
Set the number of packets sent	When rejoin mode is enabled, set the number of LinkCheckReq packets sent.												
ADR Mode	Allow the network server to adjust datarate of the device. This only works with Standard Channel Mode.												
Tx Power	Transmit power of the device.												

**Note:**

- 1) Please contact sales for the device EUI list if there are many units.
- 2) Please contact sales if you need random App keys before purchase.
- 3) Select OTAA mode if you use Milesight IoT Cloud to manage devices.
- 4) Only OTAA mode supports rejoin mode.

### 3.3 Time Synchronization

- **ToolBox App Sync**

Go to **Device > Status** of ToolBox App to click **Sync** to sync the time.

Hardware Version	V1.0
Device Status	ON <input checked="" type="checkbox"/>
Join Status	Activated
RSSI/SNR	-55/9
Device Time	2023-04-10 09:34 <span style="border: 1px solid red; padding: 2px;">Sync</span>

- **Network Server Sync:**

Change device LoRaWAN® Version as 1.0.3, the device will ask the network server for the time everytime it joins the network.

**Note:**

- 1) This function is only applicable to network server using LoRaWAN® 1.0.3 or 1.1 version.
- 2) Network server will sync the time which timezone is UTC+0 by default. It's suggested to sync the timezone via ToolBox App to change the timezone.

### 3.4 Basic Settings

Go to **Device > Setting > General Settings** to change the reporting interval, etc.

Temperature Unit ⓘ

Reporting Interval  60  min

Data Storage ⓘ

Data Retransmission ⓘ

Change Password

Parameters	Description
Reporting Interval	Reporting interval of transmitting data to the network server. Range: 1~1080min; Default: 60min
Temperature Unit	Change the temperature unit displayed on the ToolBox. <b>Note:</b> 1) The temperature unit in the reporting package is fixed as °C. 2) Please modify the threshold settings if the unit is changed.

<u>Data Storage</u>	Disable or enable reporting data storage locally.
<u>Data Retransmission</u>	Disable or enable data retransmission.
Change Password	Change the password for ToolBox app to write this device.

## 3.5 Advanced Settings

### 3.5.1 Calibration Settings

ToolBox supports temperature calibration. Go to **Device > Setting > Calibration Settings** to type the calibration value and save, the device will add the calibration to raw value.

Temperature

**Numerical Calibration**

Current Value: 26 °C

Calibration Value

°C

Final Value: 25 °C

### 3.5.2 Threshold Settings

Go to **Device > Setting > Threshold Settings** to enable the threshold settings and input the threshold. TS101 sensor will upload the current data once instantly when the temperature threshold is triggered. Note that when you change the temperature unit, please re-configure the threshold.

Temperature

Over / °C

Below / °C

Temperature mutation value over / °C

Collecting Interval  10  min

Parameters	Description
Temperature Threshold	When the temperature is over or below the threshold value, the

	device will report an alarm packet.
Temperature Mutation Value	When the temperature mutation value is over the threshold value, the device will report an alarm packet. <b>Temperature Mutation Value</b> =  Current temperature - Last temperature .
Collecting Interval	Collecting interval for detecting the temperature. Default: 10min; Range: 1~1080min

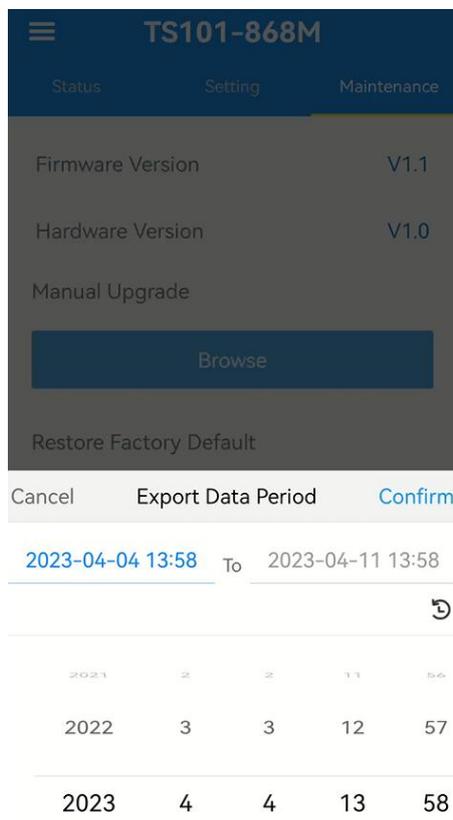
### 3.5.3 Data Storage

TS101 sensor supports storing more than 1,200 data records locally and export data via ToolBox App. The device will record the data according to reporting interval even not joining to network.

1. Go to **Device > Setting > General Settings** of ToolBox App to enable data storage feature.



2. Go to **Device > Maintenance** of ToolBox App, click **Export**, then select the data time period and click **Confirm** to export data. The maximum export data period on ToolBox App is 14 days.



3. Click **Data Cleaning** to clear all stored data inside the device.

## Export Historical Data



### 3.5.4 Data Retransmission

TS101 sensor supports data retransmission to ensure the network server can get all data even if network is down for some times. There are two ways to get the lost data:

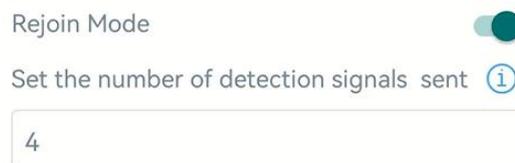
- Network server sends downlink commands to enquire the historical data for specifying time range, refer to section [Historical Data Enquiry](#).
- When network is down if no response from LinkCheckReq MAC packets for a period of time, the device will record the network disconnected time and re-transmit the lost data after device re-connects the network.

Here are the steps for retransmission:

1. Refer to [Time Synchronization](#) to sync the device time.
2. Go to **Device > Setting > General Settings** to enable data storage and data retransmission feature.



3. Go to **Device > Setting > LoRaWAN Settings** to enable rejoin mode and set the number of packet sent. For example, the device will send LinkCheckReq MAC packets to the network server regularly to check any network disconnection; if there is no response for 4 +1 times, the join status will change to de-activate and the device will record a data lost time point (the time it reconnected to the network).



4. After the network connected back, the device will send the lost data from the point in time when the data was lost according to the reporting interval.

**Note:**

- 1) If the device is reboot or re-powered when data retransmission is not completed, the device will re-send all retransmission data again after device is reconnected to the network.
- 2) If the network is disconnected again during data retransmission, it will only send the latest disconnection data.
- 3) The retransmission data format is started with "20ce", please refer to section [Historical Data Enquiry](#).
- 4) Data retransmission will increase the uplinks and shorten the battery life.

## 3.6 Maintenance

### 3.6.1 Upgrade

1. Download firmware from Milesight website to your smartphone.
2. Open Toolbox App, go to **Device > Maintenance** and click **Browse** to import firmware and upgrade the device.

**Note:**

- 1) Operation on ToolBox is not supported during a firmware upgrade.
- 2) Only the Android version of ToolBox supports the upgrade feature.

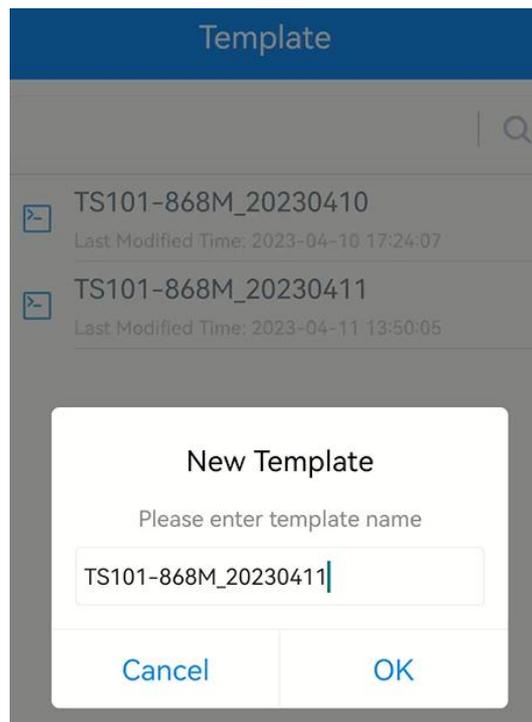
Status	Setting	Maintenance
SN	6732D07453450005	
Model	TS101-868M	
Firmware Version	V1.1	
Hardware Version	V1.0	
Manual Upgrade		
Browse		

### 3.6.2 Backup

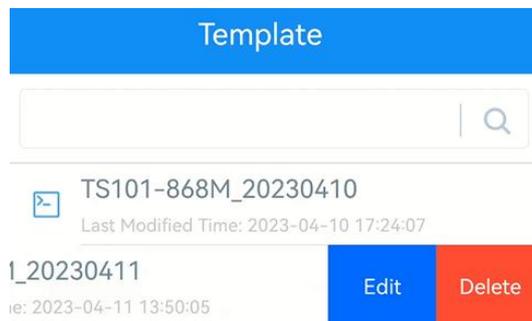
TS101 supports configure backup for easy and quick device configuration in bulk. Backup is allowed only for devices with the same model and LoRaWAN® frequency band.

1. Go to **Template** page on the App and save the current settings as a template. You can also edit the template file.
2. Select one template file saved in the smartphone and click **Write**, then attach the smartphone

to another device to write the configuration.



**Note:** Slide the template item left to edit or delete the template. Click the template to edit the configurations.



### 3.6.3 Reset to Factory Default

Please select one of the following methods to reset the device:

**Via Hardware:** Hold on the power button (internal) for more than 10s.

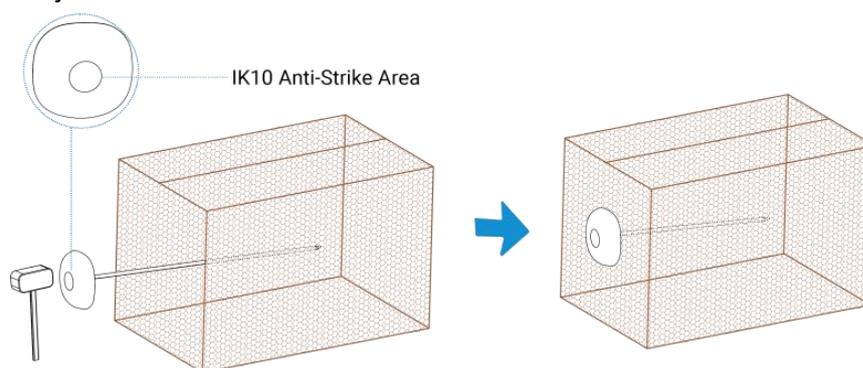
**Via ToolBox App:** Go to **Device > Maintenance** to click **Reset**, then attach the smartphone with NFC area to the device to complete the reset.

Status	Setting	Maintenance
SN	6732D07453450005	
Model	TS101-868M	
Firmware Version	V1.1	
Hardware Version	V1.0	
Manual Upgrade		
Browse		
Restore Factory Default		
Reset		

## 4. Installation

Insert the probe into the measured object directly.

**Note:** If the density of the measured object is too high to insert the probe directly (such as haystack), please use rubber hammer to strike the anti-strike area of TS101 until the probe is completely inserted into the measured object.



## 5. Communication Protocol

All data are based on the following format (HEX), the Data field should follow little-endian:

Channel1	Type1	Data1	Channel2	Type2	Data2	Channel 3	...
----------	-------	-------	----------	-------	-------	-----------	-----

1 Byte	1 Byte	N Bytes	1 Byte	1 Byte	M Bytes	1 Byte	...
--------	--------	---------	--------	--------	---------	--------	-----

For decoder examples please find files on <https://github.com/Milesight-IoT/SensorDecoders>.

## 5.1 Basic Information

TS101 reports basic information about the sensor every time it joins the network.

Channel	Type	Description
ff	01(Protocol Version)	01=>V1
	09 (Hardware Version)	01 40 => V1.4
	0a (Software Version)	01 14 => V1.14
	0b (Power On)	Device is on
	0f (Device Type)	00: Class A, 01: Class B, 02: Class C
	16 (Device SN)	16 digits

Example:

ff0bff ff0101 ff166732d07453450005 ff090100 ff0a0101 ff0f00					
Channel	Type	Value	Channel	Type	Value
ff	0b (Power On)	ff (Reserved)	ff	01 (Protocol Version)	01 (V1)
Channel	Type	Value	Channel	Type	Value
ff	16 (Device SN)	6732d07453 450005	ff	09 (Hardware version)	0100 (V1.0)
Channel	Type	Value	Channel	Type	Value
ff	0a (Software version)	0101 (V1.1)	ff	0f (Device Type)	00 (Class A)

## 5.2 Sensor Data

Item	Channel	Type	Description
Battery Level	01	75	UINT8, Unit: %
Temperature	03	67	INT16/10, Unit: °C, Resolution: 0.1°C
Threshold Alarm	83	67	3 Bytes, Temperature(2B) + 01 Temperature: INT16/10, Unit: °C
Mutation Threshold Alarm	93	d7	5 Bytes, Temperature(2B) + Mutation Value(2B) + 02 Temperature: INT16/10, Unit: °C Mutation Value: INT16/100, Unit: °C

Example:

1. Periodic Packet: report according to reporting interval (60 min by default).

017564 0367f900					
Channel	Type	Value	Channel	Type	Value
01	75 (Battery)	64 => 100%	03	67 (Temperature)	f9 00 => 00 f9 =>249/10=24.9°C

2. Temperature Threshold Alarm Packet

83675201 01		
Channel	Type	Value
83	67 (Temperature)	52 01 => 01 52 => 338/10 = 33.8°C 01 => Temperature Alarm

3. Temperature Mutation Alarm Packet

93d74e01 c602 02		
Channel	Type	Value
93	d7 (Temperature Mutation Threshold)	Temperature: 4e 01 => 01 4e => 334/10 = 33.4°C Mutation Value: c6 02 => 02 c6 => 710/10=7.1°C 02 => Mutation Alarm

## 5.3 Downlink Commands

TS101 supports downlink commands to configure the device. The application port is 85 by default.

Item	Channel	Type	Description
Reboot	ff	10	ff (Reserved)
Reporting Interval		03	2 Bytes, unit: s
Collecting Interval		02	2 Bytes, unit: s
Threshold Alarm	ff	06	9 Bytes, CTRL(1B)+Min(2B)+Max(2B)+00000000(4B)  CTRL: Bit2~Bit0: 000=disable 001=below 010=above 011=within

		100=below or above Bit5~Bit3: ID 001=Temperature Threshold 010=Temperature Mutation Threshold Bit6: 0=disable the Alarm Threshold 1=enable the Alarm Threshold Bit7: Reserved
Temperature Calibration	ab	Byte 1: 00-disable, 01-enable Byte 2-3: calibration value, INT16/10, unit: °C
UTC Time Zone	17	INT16/10
Data Storage	68	00: disable, 01: enable
Data Retransmission	69	00: disable, 01: enable
Data Retransmission Interval	6a	3 Bytes Byte 1: 00 Byte 2-3: interval time, unit:s range: 30~1200s (600s by default)

**Example:**

1. Set reporting interval as 20 minutes.

ff03b004		
Channel	Type	Value
ff	03 (Set Reporting Interval)	b0 04 => 04 b0 = 1200s = 20 minutes

2. Reboot the device.

ff10ff		
Channel	Type	Value
ff	10 (Reboot)	ff (Reserved)

3. Enable temperature threshold and configure the alarm when the temperature exceeds 30°C.

ff06 ca 0000 2c01 00000000		
Channel	Type	Value
ff	06 (Set Threshold Alarm)	CTRL: ca =11 001 010 010 = above 001 = Temperature Threshold 1 = enable the Threshold Alarm Max: 2c 01 => 01 2c => 300*0.1 = 30°C

4. Disable mutation threshold and configure the alarm when the mutation value exceeds 5°C.

ff06 10 0000 3200 00000000		
Channel	Type	Value
ff	06(Set Threshold Alarm)	CTRL: 10 = 00 010 000 010 = Temperature Mutation Threshold 0 = disable the Threshold Alarm Max: 32 00 => 00 32 => 50*0.1 = 5°C

5. Enable temperature calibration and set calibration value.

ffab01fdff		
Channel	Type	Value
ff	ab (Temperature Calibration)	01=Enable fdff=>fffd=-3/10=-0.3 °C

6. Set the time zone.

ff17ecff		
Channel	Type	Value
ff	17	ec ff => ff ec = -20/10=-2 the time zone is UTC-2

## 5.4 Historical Data Enquiry

TS101 supports sending downlink commands to enquire historical data for specified time point or time range. Before that, ensure **the device time is correct and data storage feature was enabled to store the data.**

**Command format:**

Channel	Type	Description
fd	6b (Enquire data in time point)	4 Bytes, unix timestamp
fd	6c (Enquire data in time range)	Start time (4 bytes) + End time (4 bytes), Unix timestamp
fd	6d (Stop query data report)	ff
ff	6a (Report Interval)	3 Bytes, Byte 1: 01 Byte 2: interval time, unit: s, range: 30~1200s (60s by default)

**Reply format:**

Channel	Type	Description
fc	6b/6c	00: data enquiry success

		01: time point or time range invalid 02: no data in this time or time range
20	ce (Historical Data)	Data time stamp (4 Bytes) + Data Contents (Mutable)

**Note:**

1. The device only uploads no more than 300 data records per range enquiry.
2. When enquiring the data in time point, it will upload the data which is the closest to the search point within the reporting interval range. For example, if the device's reporting interval is 10 minutes and users send command to search for 17:00's data, if the device find there is data stored in 17:00, it will upload these data. If not, it will search for data between 16:50 to 17:10 and upload the data which is the closest to 17:00.

**Example:**

1. Enquire historical data between 2023/3/29 15:05:00 to 2023-3-29 15:30:00.

fd6c 1ce32364 f8e82364		
Channel	Type	Value
fd	6c (Enquire data in time range)	Start time: 1ce32364=> 6423e31c = 1680073500s =2023/3/29 15:05:00 End time: f8e82364 => 6423e8f8 = 1680075000s =2023-3-29 15:30:00

Reply:

fc6c00		
Channel	Type	Value
fc	6c (Enquire data in time range)	00: data enquiry success

20ce 23e42364 0401			
Channel	Type	Time Stamp	Value
20	ce (Historical Data)	23e42364 => 6423e423 => 1680073763s = 2023-3-29 15:09:23	Temperature: 04 01=>01 04 =26°C

**-END-**