Friendcom LoRaWAN End Node Module Product Manual

Version：V1.0

Applicability Table

Product
WSL05-A0

Copyright Statement

Note

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Content

1. Overview

1.1 Product introduction

The WSL05-A0 module is a low-power, high-performance LoRaWAN end node module that integrates the LoRaWAN™ protocol stack and complies with the LoRaWAN™ Specification 1.0.4 Class A\C application standard.

The WSL05-A0 module uses a serial port interface (UART) to exchange data with user device. It has significant features such as automatically connecting to the network and saving session context, making it convenient for users to quickly access the network and implement wireless data transmission.

The WSL05-A0 module supports secondary development functions and can write and run user code, allowing users to implement their own special applications without the need for an external MCU, saving users costs and providing lower power consumption.

1.2 Main features

Hardware features:

- Standard LoRaWAN communication protocol, supports CLASS A/C
- Supports multiple frequency bands, currently supports AS923\AU915\CN470\CN779\EU433\EU868\KR920\IN865\US915\RU864, etc., including multiple hardware versions
- Wide operating voltage range: 2.2~3.7V
- LoRa spread spectrum modulation technology, receiving sensitivity up to -138dBm (SF12)
- Supports a maximum output power of 22dBm, which can be adjusted arbitrarily within the range of 0~22dBm
- Sleep current as low as 1.5uA
- Average receive current as low as 4.8mA

Software features：

- Support users to switch frequency bands
- Support AT command mode and SerialNet mode
- Rich AT command set, supports remote AT commands
- Multiple sleep management modes, supports UART interface wake-up mode, automatically sleeps without user participation, and does not affect data transmission and reception during sleep
- Support battery power detection, optional automatic power reporting
- Support serial port upgrade and wireless upgrade
- Support user secondary development and provide UART, SPI, I2C, GPIO, AD and other interface function libraries
- Support data transmission between two nodes

2. Technical Specifications

2.1 Absolute Maximum Ratings

Table 2-1 Absolute maximum value table

Item	Symbol	Description	Min.	Typ.	Max.	Unit
Power supply voltage	VCCm	Provides the maximum limit voltage to the VCC pin	-0.3	-	3.9	V
Input voltage	VIOm	Maximum input voltage of GPIO port	-0.3	-	3.9	V
ESD features	HBM	Class 2 of ANSI/ESDA/JEDEC Standard JS-001-2014	-	-	2.0	KV

2.2 Radio frequency characteristics

The reference voltage for RF characteristic testing is VCC=3.3V and the temperature is 25°C.

Table 2-2 Radio frequency characteristics table

Item	Symbol	Description		Min.	Typ.	Max.	Unit
Frequency Range	Band	AS923			923		MHz
		AU915		915	-	928	MHz
		CN470		470	-	510	MHz
		CN779		779	-	787	MHz
		EU433		433.175	-	434.665	MHz
		EU868		863	-	870	MHz
		KR920		920	-	923	MHz
		IN865		865	-	867	MHz
		US915		902	-	928	MHz
		RU864		864	-	870	MHz
Data rate (LoRa)	DR	BW=125K，SF=12		-	250	-	bps
		BW=125K，SF=11		-	440	-	bps
		BW=125K，SF=10		-	980	-	bps
		BW=125K，SF=9		-	1.7	-	Kbps
		BW=125K，SF=8		-	3.1	-	Kbps
		BW=125K，SF=7		-	5.4	-	Kbps
Receiver sensitivity	RXS	470MHz	BW=125K，SF=7	-	-125	-	dBm
			BW=125K，SF=10	-	-132	-	dBm
			BW=125K，SF=12	-	-138	-	dBm
		868MHz	BW=125K，SF=7	-	-122	-	dBm
			BW=125K，SF=10	-	-131	-	dBm

			BW=125K，SF=12	-	-136	-	dBm

Table 2-2 Radio frequency characteristics table (continued)

Item	Symbol	Description		Min.	Typ.	Max.	Unit
Transmit power	TxPwr	470MHz	22dBm	-	21.8	-	dBm
			20dBm	-	19.8	-	dBm
			17dBm	-	17.5	-	dBm
			14dBm	-	14.2	-	dBm
			10dBm	-	10.5		dBm
		868MHz	22dBm	-	21.5	-	dBm
			20dBm	-	19.7	-	dBm
			17dBm	-	16.9	-	dBm
			14dBm	-	13.8	-	dBm
			10dBm	-	10.4	-	dBm
Frequency characteristics	Fs	Temperature range:：-40~85°C		-	15	30	ppm
Output impedance	Ro			-	50	-	Ω

2.3 Power supply characteristics

Table 2-3 Power supply characteristics table

Item	Symbol	Description		Min.	Typ.	Max.	Unit
Power supply voltage	VCC			2.2	3.3	3.7	V
Standby current	Istdy	In CLASS A mode, sleep mode SM=0, RF is turned off, and the module is waiting for serial port data.		-	0.65	-	mA
RX current	Irx	In CLASS C mode, sleep mode SM=1, average value when RF is in receiving state		-	4.6	-	mA
Sleep current	Islp	In CLASS A mode, sleep mode SM=1, the module is in full sleep state.		-	1.5	3.0	μA
TX current	Itx	470MHz	TxPwr=10dBm	-	13.5	-	mA
			TxPwr=14dBm	-	22.5/59	-	mA
			TxPwr=17dBm	-	71	-	mA
			TxPwr=20dBm	-	90	-	mA
			TxPwr=22dBm	-	110.5	-	mA
		868MHz	TxPwr=10dBm	-	17.5	-	mA

			TxPwr=14dBm	-	23.5/92	-	mA
			TxPwr=17dBm	-	98	-	mA
			TxPwr=20dBm	-	107.5	-	mA
			TxPwr=22dBm	-	120.0	-	mA

2.4 GPIO characteristics

Table 2-4 GPIO characteristics table

Item	Symbol	Description	Min.	Typ.	Max.	Unit
High level output voltage	VOH	VCC>=2.7V，$\|I_{IO}\|$=8.0mA	VCC-0.4	-	-	V
Low level output voltage	VOL	VCC>=2.7V，$\|I_{IO}\|$=8.0mA	-	-	0.4	V
High level input voltage	VIH		0.7 xVCC	-	VCC	V
Low level input voltage	VIL		0	-	0.3 xVCC	V
High level output current	IOH	Non-analog port	-	-	-10.0 （Note 1）	mA
Low level output current		Analog port	-	-	-0.1	mA
Pull-up resistor	IOL	Non-analog port	-	-	20.0 （Note 1）	mA
High level output voltage		Analog port	-	-	0.4	mA
Low level output voltage	PU	GPIO	25	40	55	kΩ

Note:

1. The total current cannot exceed the maximum value of 70mA.

2. The analog port does not support pull-up resistors. The I2C interface has a built-in 10k pull-up resistor and cannot be canceled.

2.5 Communication interface characteristics

Table 2-5 Communication interface characteristics table

Item	Symbol	Description	Min.	Typ.	Max.	Unit
UART interface baud rate	BR	-	1200	9600	115200	bps
UART interface baud rate	BRerr	Temperature range：-40~85°C	-	-	±5	%

accuracy						
SPI interface clock rate	SPIclk	-	-	-	24	MHz

2.6 General specifications

Table 2-6 General specifications table

Item	Symbol	Description	Min.	Typ.	Max.	Unit
Storage temperature	Tstg	Storage temperature range	-40	-	125	℃
Operating temperature	Top	Operating temperature range	-40	-	85	℃
Operating humidity	RHop	Operating humidity range	5	-	95	%
Dimensions	-		22(L)X14(W)X3.2(H)			mm

3. Hardware

3.1 Pin connection diagram

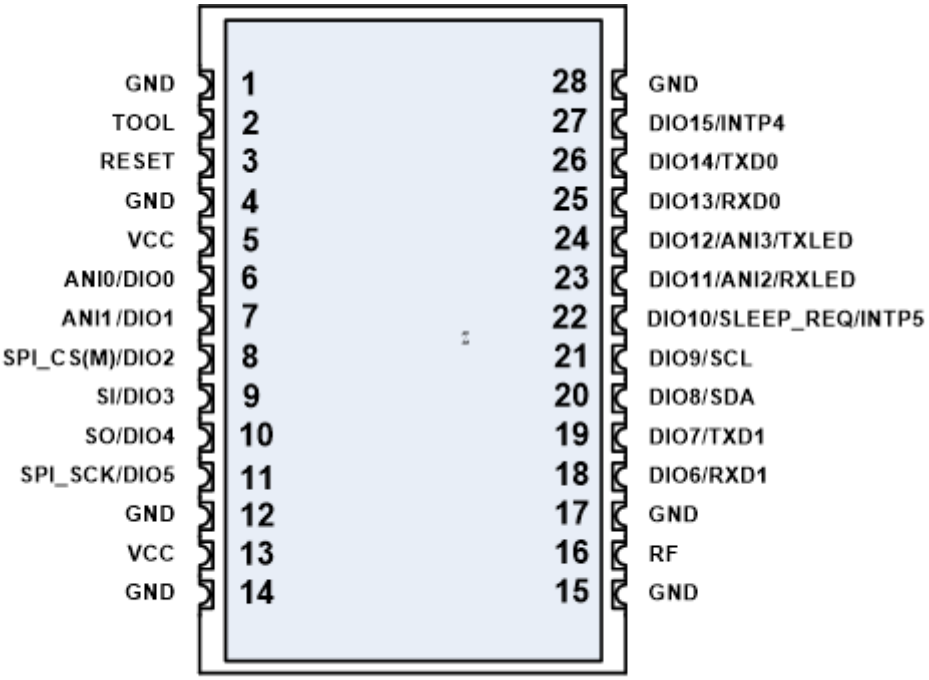

Figure 3-1 Module pin connection diagram

3.2 Pin description

Table 3-1 Module pin description

Pin No.	Name	Reuse function	Pull-up resistor	Description
1	**GND**	-	-	Power ground
2	**TOOL**	-	N	Program simulation, programming port SWDCLK
3	**RESET**	-	-	External reset signal, low level reset
4	**GND**	-	-	Power ground
5	**VCC**	-	-	Power VCC
6	**DIO0**	**SWDIO/ANI0**	N	General IO, analog channel 0, burning SWDIO
7	**DIO1**	**ANI1**	N	General IO, analog channel 1
8	**DIO2**	**SPI_CS(M)**	N	Used as CS pin in general IO and SPI master mode
9	**DIO3**	**SI**	N	General IO, SPI interface data input, special attention:
10	**DIO4**	**SO**	N	Used as output in main mode
11	**DIO5**	**SPI_SCK**	N	Used as input when in slave mode
12	**GND**	-	-	General IO, SPI interface data output, special attention:
13	**VCC**	-	-	Used as input in main mode
14	**GND**	-	-	Used as output when in slave mode
15	**GND**	-	-	Clock pin of general IO and SPI interface
16	**RF**	-	-	Power ground
17	**GND**	-	-	Power VCC
18	**DIO6**	**RXD1**	N	Power ground
19	**DIO7**	**TXD1**	N	Power ground
20	**DIO8**	**SDA**	Y	RF antenna port
21	**DIO9**	**SCL**	Y	Power ground
22	**DIO10**	**SLEEP_REQ/INTP5**	N	RXD pin of general IO and UART1 interface
23	**DIO11**	**ANI2\RXLED**	N	TXD pin of general IO and UART1 interface
24	**DIO12**	**ANI3\TXLED**	N	SDA pin of general IO and I2C interface
25	**DIO13**	**RXD0**	N	SCL pin of general IO and I2C interface
26	**DIO14**	**RXD1**	N	General IO, external interrupt input pin
27	**DIO15**	**INTP4**	N	General IO, analog channel 2, RF receiving LED indication
28	**GND**	-	-	General IO, analog channel 3, RF sending LED indication

3.3 Circuit design description

3.3.1 Power supply design

Special attention needs to be paid to the power supply design. In particular, poor design of the switching power supply will affect the RF performance of the module. It is recommended that the external power supply be an LDO type power supply or directly connected to the battery. In order to reduce noise, during PCB layout, connect 1.0μF and 47pF capacitors in parallel as close as possible to the VOUT pin on the PCB.

If a switching regulated power supply is used for power supply, it is recommended to use a switching power supply with a switching frequency of 500kHz or above, and the power supply voltage must be limited to below 250mV.

If conditions permit, it is recommended to add a 10μF decoupling capacitor to the VCC pin of the module. The capacitors can be connected in parallel. 47pF, 1.0μF and 10μF capacitors can be connected in parallel to filter out noise at multiple frequencies.

3.3.2 Circuit board design

It is recommended to make the VCC and GND traces as thick as possible to ensure that the module has sufficient current loop.

3.3.3 Recommended external pin connections

In order for the module to work properly, VCC and GND must be connected correctly, and the voltage between VCC and GND must be within the allowable range of the module.

The UART interface is a forced enable interface and may be forcibly enabled after the module is powered on or reset. If the UART interface is not used, it is recommended that the RXD0 pin be connected to a pull-up resistor and the TXD0 pin be left floating.

In order to ensure stable sleep current, the module configures the port as a pull-up input by default. For ports without pull-up resistors, ANI0 and ANI1 are configured as output 0, and ANI2 and ANI3 are configured as output 1. If you need to change the default configuration, you can change it through AT commands.

For other pins, it is recommended not to connect them to prevent misoperation.

3.3.4 Program burning port and reset pin

Program burning or simulation requires four pins: VCC, GND, TOOL, DIO0, and RESET. Users who need secondary development should pay attention to the reserved ports. TOOL corresponds to the SWDCLK function, and DIO0 corresponds to the SWDIO function.

4. Applications

The WSL05-A0 module (hereinafter referred to as the module) integrates the LoRaWAN™ protocol stack and uses a serial interface (UART) to interact with user host device for data and command. It can provide users with LoRaWAN network access and wireless data services conveniently and quickly.

In addition, the module allocates a section of program space for users and provides a full set of peripheral driver interfaces, allowing users to implement customized services without the need for external host devices. For detailed information on user secondary development, please contact our company.

The functional block diagram of the module is shown in the figure below.

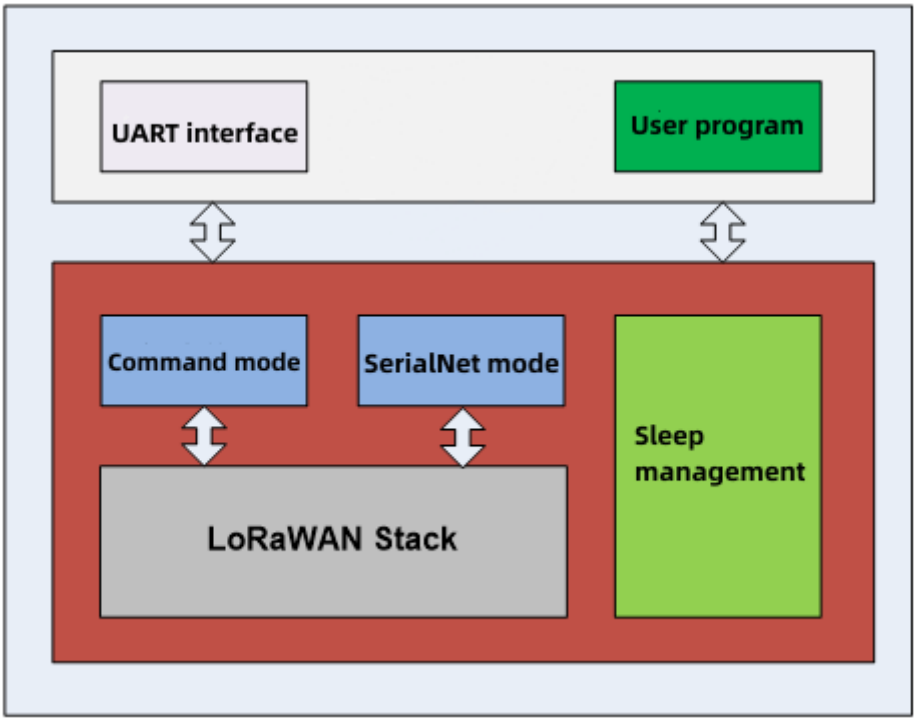

Figure 4-1 Module functional block diagram

4.1 Serial interface

The WSL05-A0 module is connected to external controllers and host devices through serial interfaces. It mainly supports the following interface methods:

- UART interface.

4.1.1 UART interface

The UART interface of the module is compatible with CMOS logic levels. The external controller and host device can be in the following two ways：

- Connect an external MCU with compatible logic voltage as the main controller and communicate with UART peripherals;
- Connect to PC through a logic level converter (such as USB to RS-232 adapter board).

An external controller with UART interface can be directly connected to the corresponding pin of the module, and its electrical connection relationship is as shown in the figure below:

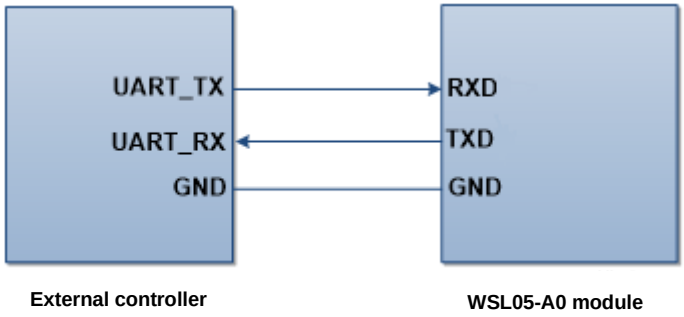

Figure 4-2 UART wiring diagram

Table 4-1 UART interface pin description

Pin number	Name	Description
26	TXD1	UART_TX pin, serial data output
25	RXD1	UART_RX pin, serial data input

Note: The module does not currently support RTS and CTS functions.

To ensure successful serial communication, the UART interfaces of the external controller and module need to be set in a compatible manner. Includes baud rate, start bit, data bits, parity and stop bits.

Each data byte consists of 1 start bit (active low level), 8 data bits (LSB), 0/1 parity bit, and 1/2 stop bit. Parity check is optional.

Before transmission, when the UART bus is idle, it is represented by a logic high level, the start bit is a logic low level, and the 8 data bits are sent first in low order. After the data is sent, the check bit (if it exists) is sent, and finally send a stop bit to complete a byte transfer.

Generally, transmission without parity is used to improve efficiency. The following figure uses N81 mode

as an example to illustrate the UART logic signal timing.

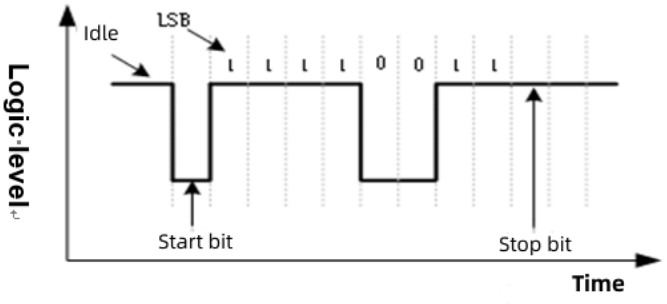

Figure 4-3 Serial communication timing diagram

The module's baud rate, parity, stop bits, etc. can be configured through AT commands. For detailed configuration methods, please refer to the AT command manual.

4.1.2 Serial port selection

By default, the UART interface is used as the communication interface with the user's external host. The UART interface is forcibly opened when the module is powered on or reset.

4.1.3 Serial buffer

The serial buffer contains a transmit buffer and a receive buffer, which are used to temporarily store serial interface data.

Serial receive buffer

After receiving the serial data (UART RXD0 pin data), the module stores the data in the serial receive buffer and waits for processing.

If the serial interface receives too much data and the module is unable to process the data in the receive buffer, causing the receive buffer to become full or overflow, the newly input data will be discarded.

Serial send buffer

When the module receives air data, the data is processed in frames and saved to the serial transmission buffer. If the serial interface uses the UART interface, the module outputs the data through the TXD0 pin.

If the module receives too much air data, the user fails to retrieve the data in time, causing the sending buffer to be full or overflow, the newly received data packets will be discarded.

4.2 Working mode

The module supports AT command mode and SerialNet mode. Different working modes process data

differently.

- AT command mode can only receive AT commands and can be used for data transmission, parameter configuration, status reading, etc.
- All data received in SerialNet mode is regarded as payload and is only used for data transmission.

4.2.1 AT command mode

By default, the module is in AT command mode. AT command mode can perform all operations on the module, including data transceiving, parameter configuration, status reading, etc.

After receiving a command, the module performs command parsing, execution, response and other processes.

The AT command format uses AT as the leading character and the carriage return (\r) as the end; the response command format starts and ends with the carriage return and line feed (\r\n). For a more detailed description of the AT command, please refer to the AT command manual.

Through the test command, you can identify whether the AT command mode is activated. Send command AT\r to the module, and the module responds \r\nOK\r\n, indicating that the module can accept the command, as shown in the following example：

```
AT
OK
```

Where, for the convenience of reading, this article hides \r (terminator) and \r\n (carriage return and line feed).

If the module does not respond, it means that the module cannot accept AT commands at this time. The possible reasons are as follows：

（1） Please check whether the line is correct;

（2） Please check whether the baud rate, parity, stop bits, etc. are configured correctly;

（3） The module runs in the external interrupt sleep wake-up mode and should be woken up first;

（4） The module is in SerialNet mode.

Switch to SerialNet mode

In AT command mode, you can switch to SerialNet mode by sending AT+ATMODE=1 command, as shown in the following example：

```
AT+ATMODE=1
```

```
OK
```

At this time, if you need the module to run in SerialNet mode after the next restart or reset, you can re-enter the AT command mode through the command sequence and execute the AT+SAVE command to save parameters. Example：

```
+++
OK
AT+SAVE
OK
```

4.2.2 SerialNet mode

In SerialNet mode, the module treats all data received by the serial port as payload data, organizes it into LoRaWAN packets, and then sends the data to the server. When receiving the data sent by the server, only the payload data is output to the serial port.

In SerialNet mode, necessary status information may not be provided, such as whether the transmission is successful, module status, signal strength, etc.

Command sequence（GT + “+++” + GT）

The command sequence is used in SerialNet mode to activate the module to enter AT command mode by sending a special character sequence. GT stands for guard time, which means that during this time, the serial port cannot have data activity. The command sequence, that is, the serial port executes the following process:

Idle for a period of time (1s), then send three "+" characters, and then idle for a period of time (1s).

Where, the guard time GT can be configured to other values through command, and the default is 1s.

After the module detects the command sequence, it returns an OK response. If there is no response, it may be due to the following reasons:

（1） Please check whether the line is correct;

（2） Please check whether the baud rate, parity, stop bits, etc. are configured correctly;

（3） The module runs in the external interrupt sleep wake-up mode and should be woken up first;

（4） The module is in AT command mode.

Switch to AT command mode

In the SerialNet mode, you can temporarily enter the AT command mode by sending a command

sequence. At this time, if no valid command is received within the command timeout time (default 10s), it will automatically return to the SerialNet mode; if you need to quickly return to the SerialNet mode, In transmission mode, AT+EXIT commands can be sent.

If you want to always be in AT command mode, you can send AT+ATMODE=0 to activate. If you need the module to run in AT command mode after the next restart or reset, you can execute the AT+SAVE command to save parameters. Example：

```
+++
AT+ATMODE=0
OK
AT+SAVE
OK
```

4.3 Activation method

In order to be able to access the LoRaWAN network, the module needs to be activated before use. The module supports two activation methods: OTAA and ABP. The activation methods of the two modes are different.

The activation mode can be selected through the +JOINMODE command. The default is OTAA mode.

4.3.1 OTAA mode

The OTAA mode is activated by sending a Join request frame to the server. If the server has registered the module information, it will respond to the Join acceptance frame and allow the module to access the network, and the activation is completed.

Activation process in OTAA mode：

（1） First register the module information on the server, that is: add OTAA devices, set DevEui, AppKey, frequency band and other parameters;

（2） DevEui is the address of the module, which can be obtained through the AT+DevEui? command;

（3） Configure the AppEui, AppKey and other parameters of the module;

（4） Set to OTAA activation mode;

（5） Delete the session context of the module and set the AutoJoin flag;

（6） Save parameters;

（7） After the configuration is completed, the Join operation can be automatically executed after the module is reset.

Example of activation configuration under OTAA module：

```
AT+DEVEUI=1122334455667788
OK
AT+APPEUI=1234567812345678
OK
AT+APPKEY=00112233445566778899AABBCCDDEEFF
OK
AT+JOINMODE=0
OK
AT+HOTS=1
OK
AT+SAVE
OK
AT+RESET
OK
```

4.3.2 ABP mode

ABP activation mode simulates activation operations by configuring the same session context directly on the server and module. ABP mode does not require sending a Join request to the server, thus simplifying the activation process.

Activation process in ABP mode：

（1） First register the module information on the server, that is: add ABP device, set DevAddr, NwkSKey, AppSKey, frequency band and other parameters;

（2） The DevAddr, NwkSKey, and AppSKey parameters of the configuration module are the same as those of the server;

（3） Set to ABP activation mode;

（4） Save parameters;

（5） After the configuration is completed, the module will be activated after reset (data can be sent to the server).

Example of activation configuration in ABP mode：

```
AT+DEVADDR=1
OK
AT+NWKSKEY=1234567890ABCDEF1234567890ABCDEF
OK
AT+APPSKEY=00112233445566778899AABBCCDDEEFF
OK
AT+JOINMODE=1
OK
AT+SAVE
OK
AT+RESET
OK
```

4.4 Join the network

In OTAA mode, to establish a connection between the module and the LoRaWAN server, a Join process is required. The module provides two network access request triggering modes：

- Automatic network access
- Manual network access

After the module is powered on or reset, it will decide whether to perform the Join process based on different configurations or conditions. It is recommended to set this parameter before activating the module.

Note: There is no Join process in ABP mode.

4.4.1 Automatic network access

The automatic network access function can automatically detect the connection status between the module and the server. When it is found that the module has not established a connection with the server, or the module determines that it has been disconnected from the server, it is a mechanism that can automatically trigger the Join process.

In OTAA mode, when automatic network access is enabled, the automatic Join process will be triggered when the module is in one of the following situations:

（1） When the module is powered on or reset (hot startup is enabled), the network access operation will be performed.

（2） When the network is disconnected, when performing a data transmission operation, the module will automatically trigger a Join operation. When the Join is successful, the module will automatically transmit data.

4.4.2 Manual network access

In manual mode, the user decides when to execute the Join process, and the module will not automatically trigger the Join process. In manual mode, when data is sent abnormally multiple times in a row, the network status should be checked. If it is not connected, a re-entry command should be executed.

Set as manual network access trigger module, operation example：

```
AT+JOIN=1
OK
```

4.5 Hot startup

The hot startup function is used to save the LoRaWAN session context. When the hot startup function is enabled, each time the Join is successful and uplink data is sent, the module automatically saves the session context parameters to the EEPROM. When the module is powered on or reset, the session context parameters will be directly retrieved from EEPROM without the need to repeat the Join operation.

The hot startup function can be enabled when applied to the following scenarios：

（1） For applications where the deployed network is relatively stable and the device may be powered off frequently；

（2） Or applications that want the module to be able to send data immediately after it is powered on again or reset.

Enable hot startup function, operation example：

```
AT+HOTS=1
OK
AT+SAVE
OK
```

If you need to update the session context, you can first delete the session context content and then restart the JOIN command, as shown in the following example：

```
AT+JOIN=0
OK
AT+JOIN=1
```

OK

4.6 Data services

Before using the module, network initialization, network activation and other operations are required before the data transmission service can be carried out. The figure below shows the operation process and data transmission flow chart of the module to facilitate user understanding.

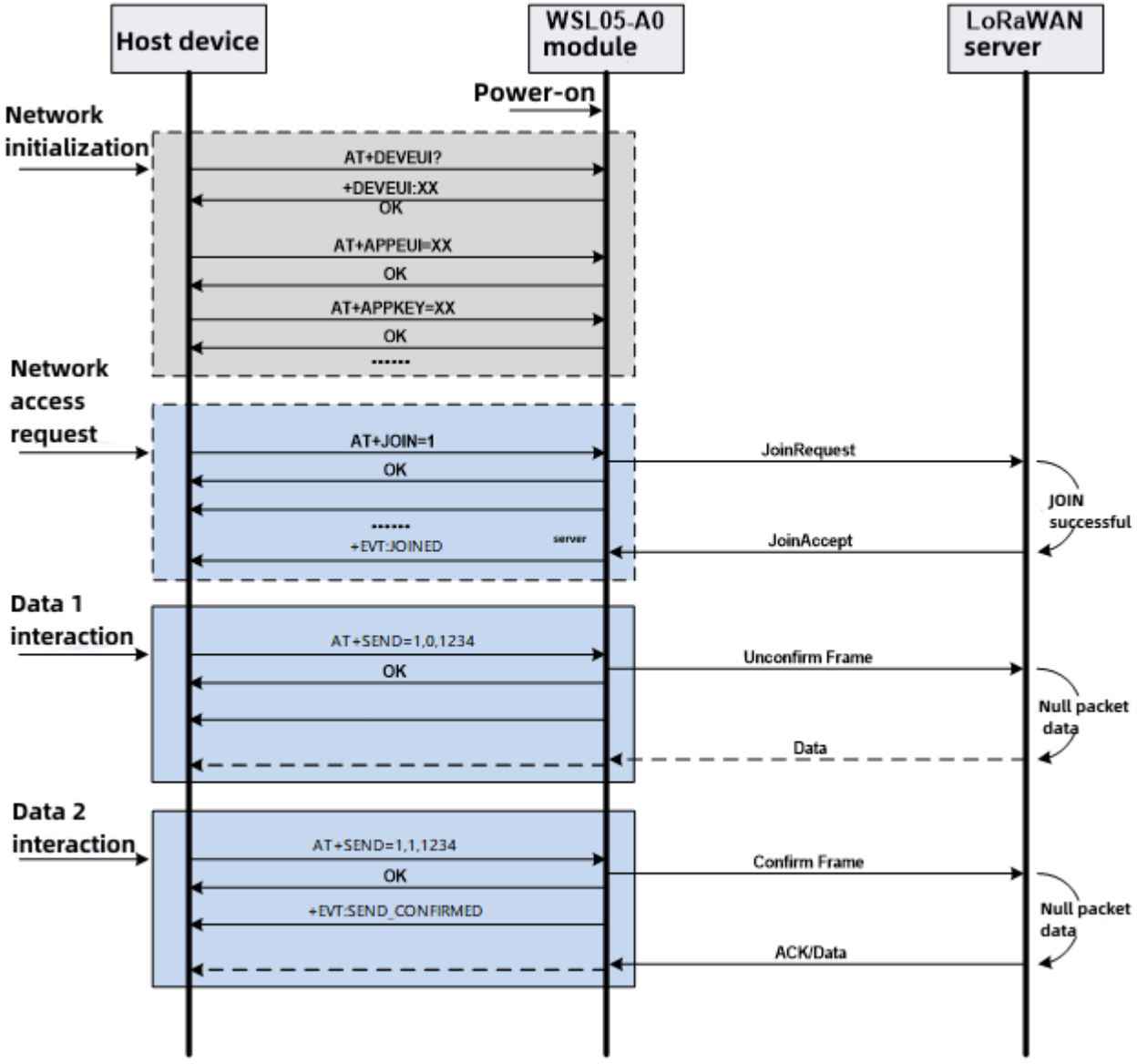

Figure 4-7 Data exchange flow chart

The network initialization process only needs to be set when the module is activated and connected to the network for the first time. The network access request process only needs to be executed when the network access mode is manually triggered and the hot startup function is canceled, otherwise the module

will be executed automatically.

Normally, after the module successfully connects to the network, it is always considered to be connected to the server. Only when the confirmed uplink data frame is sent and there is no response for a certain number of consecutive times, the module will be diagnosed as disconnected, and then the module will automatically trigger a network access request.

When the hot startup function is enabled, after the module successfully connects to the network, it will be in the connected state after being powered on.

4.6.1 Send parameter configuration

When transmitting data, some parameters may need to be adjusted according to different application scenarios, such as rate adaptation, transmit power, rate, duty cycle, application port, etc. Users should configure appropriate parameters according to their own application conditions.

- **Rate adaptation**

  The rate adaptation function is used by the server to adjust the transmit power and rate of the module to achieve optimal power-saving performance. Operation example:

  ```
  AT+ADR=1
  OK
  ```

After turning on rate adaptation, the server needs to collect module signal quality, which may increase additional network traffic. For fixed networks with stable signals, using fixed transmit power and rate may achieve better results.

- **Transmit power**

Configure the default transmit power through the +TXPWR command, and the module will give priority to using this default value to start transmitting data. The transmit power setting range is related to the frequency band. For a more detailed description, please refer to the LoRaWAN protocol.

For the CN470 frequency band, the power setting range is 0~7，corresponding to 20dBm,18dBm,16dBm…….

Example of setting power operation：

```
AT+TXPWR=0
OK
```

- **Data rate**

Configure the default data rate through the +DATARATE command, and the module will give priority to using this default value to start transmitting data. The rate setting range is related to the frequency band. For a more detailed description, please refer to the LoRaWAN protocol.

For the CN470 frequency band, the rate setting range is 0~5, corresponding to SF12~SF7 in order.

Example of setting rate operation：

```
AT+DATARATE=5
OK
```

- **Transmit duty cycle**

The transmit duty cycle is used to limit the frequency of data transmission. Unless it is required by regional regulations, this function can be used to limit the module's data transmission to prevent certain devices from occupying too much traffic resources.

Example of setting the sending duty cycle operation：

```
AT+TXDC=1
OK
```

Example of closing the sending duty cycle operation：

```
AT+TXDC=0
OK
```

- **Application port**

The application port is specific to the application. Ports are used to distinguish different application categories. The LoRaWAN server pushes frames of valid ports (1~199) to the application. Operation example：

```
AT+APPPORT=5
OK
```

4.6.2 Data transmission

The module supports two frame types: unconfirmed uplink data frame and confirmed uplink data frame. When using unconfirmed uplink data frames to transmit data, the server does not need to respond to ACK frames, which can effectively save traffic, but it cannot determine whether the data is successfully transmitted

When using a confirmed uplink data frame to transmit data, the server needs to respond to an ACK frame for each transmission. Although confirming the uplink data frame increases data traffic, the reliability of the data is effectively guaranteed.

Since the LoRaWAN network supports 8 uplink channels but only 1 downlink channel, under normal circumstances, as many unconfirmed uplink data frames as possible should be used to transmit data.

The module sends data through the +SENDSTR command. You can set the default frame type before sending data.

Example of setting frame type and number of transmissions：

```
AT+CONFIRM=0
OK
```

0 indicates unconfirmed uplink data frame, 1 indicates confirmed uplink data frame.

After setting, send data directly：

```
AT+SENDSTR=12345678
OK
```

Or, directly specify the application port and frame type. The specified application port and frame type are only valid for this transmission, as shown in the following example：

```
AT+SEND=1,1,12345678
OK
```

When the module sends data successfully, the returned status is：

```
OK
+EVT:SEND_CONFIRMED
+EVT:RX_1, PORT 0, DR 5, RSSI -115, SNR -2
```

When the module fails to send, the returned status is：

```
AT_ERROR/AT_NO_NET_JOINED 等
```

4.6.3 Data reception

According to the communication mechanism stipulated in the LoRaWAN protocol specification, the module delays RX1Delay after the uplink data frame, and then opens the receiving windows RX1 and RX2 in sequence to receive data, as shown in the following figure：

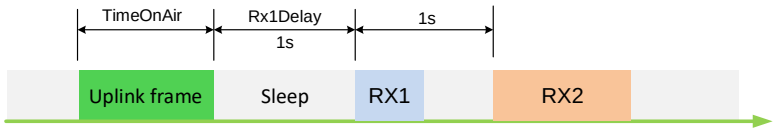

Figure 4-8 Schematic diagram of CLASS A device communication mechanism

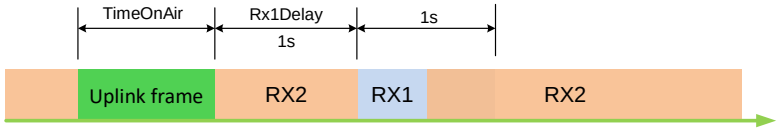

Figure 4-9 Schematic diagram of CLASS C device communication mechanism

When the module is used as a CLASS A device, usually the radio frequency is in a sleep state and cannot receive data at this time. It must first actively send uplink data once, then receive data during RX1 and RX2, and return to sleep state after the process is completed.

When the module is used as a CLASS C device, usually the radio frequency is in the RX2 state of the interface window to receive data.

When the module receives the downlink data, it will first store the data in the serial sending buffer. If the module works in AT command mode, the module will package the data into a receive data response frame and output it to the serial port.

The output format supports HEX and STR, as defined below：

+SEND:<Port>,<Confirm>,<Payload>
+SENDSTR:<Payload>

Where, the SEND command sends HEX format data and needs to bring the port and the confirmed frame type data. SENDSTR sends STR format and needs to configure the application port and the confirmed frame type in advance through the APPPORT and CONFIRM command.

Note: When the module works in SerialNet mode, the data received by the module is HEX payload data.

4.6.4 Maximum load length

The maximum payload sent is related to the rate. For details, please refer to the LoRaWAN protocol specification. When the transmission length is greater than the maximum payload, the module cannot perform the transmission operation.

In addition, the uplink data frame may carry MAC command information, and it cannot be sent according to the maximum packet length. In this case, the module will trigger the reporting of MAC commands first, and the data requested to be sent will be discarded.

4.7 Sleep mode

In order to support battery-powered applications, the module is designed with multiple power management modes to minimize system power consumption. When the sleep management function is enabled, the module can execute different sleep strategies according to different stages to ensure that the module runs in a deep sleep state as much as possible to obtain the best performance.

Set the sleep management mode through the sleep mode command. Operation example：

```
AT+SM=1
OK
AT+SAVE
OK
```

4.7.1 Normal mode（SM=0）

Normal mode means that the module does not perform any sleep and is running at full speed. At this time, the module is always waiting for serial port data. There is no need to execute the wake-up mechanism at this time, so the response time is the fastest, but the power consumption is relatively large.

4.7.2 UART wake-up mode（SM=1）

The UART wake-up mode uses the transition signal of the RXD pin to wake up the module. Therefore, before sending data, it is necessary to send a wake-up code to wake up the module. Only a one-byte wake-up code is needed to wake up the module.

Normally, the module remains in a deep sleep state. After being awakened, it starts receiving serial data and processing it. After processing, it returns to a deep sleep state.

In order to minimize power consumption, when the module detects that there is no data activity on the serial port, it will enter a deep sleep state. When there is still data being sent, the module will automatically wake up and process subsequent operations.

The wake-up code must comply with certain rules in order to wake up the module. The supported wake-up codes are: 0xFF, 0xFE, 0xFC, 0xF8, etc. Space characters can be used during testing.

4.7.3 Pin wake-up mode（SM=2）

The pin wake-up mode wakes up the module through the level change of the SLEEP_REQ pin. This mode

is suitable for the following situations：

- Pin wake-up

When the SLEEP_REQ pin is pulled low, if the module is already in an idle state (no data activity on the serial port), it will enter a deep sleep state, otherwise it will wait until it is idle before sleeping. If there is data service, it will automatically wake up for processing in the background.

When the SLEEP_REQ pin is pulled high, the module resumes full speed operation, which is equivalent to SM=0 mode.

4.7.4 Periodic wake-up mode（SM=3）

The periodic wake-up mode means that the module sleeps for a period of time, then wakes up for a period of time, and repeat the cycle. During sleep, the module cannot be woken up by external events, and the wake-up period is equivalent to SM=0 mode.

The periodic wake-up mode is not very applicable and can only be applied to applications with fixed periodic triggering reports.

For detailed command on setting the sleep time, please refer to the AT command manual.

4.7.5 Pin period wake-up mode（SM=4）

The pin period wake-up mode combines the two modes of pin wake-up and period wake-up. When the module is in sleep state, the SLEEP_REQ pin can be used to wake up the module in advance.

4.8 DIO function

The DIOx (x=0~15) port pins of the module can be configured as general-purpose IO functions or peripheral functions, and some pins can be used as signal indication functions. Configure the pin function through the +DIOx command, as shown in the following operation example：

```
AT+DIO0=1
OK
AT+SAVE
OK
```

4.8.1 DIOx configuration function

Table 4-4 DIOx configuration value table

DIOx =	Description
0	Disable the port, the module does not do anything with the DIO configured with this value
1	Main function, such as peripheral pins, including SPI, UART, I2C, etc.
2	Auxiliary function, currently used as ADC
3	Floating input
4	Pull-up input (not all DIO supports pull-up input)
5	Pull-down input (reserved, not supported yet)
6	Fixed output 0
7	Fixed output 1
8	Signal indication 0
9	Signal indication 1 (inverted phase of signal indication 0)

Note:

1. When configured as a general-purpose IO input (floating input, pull-up input), the port level status can be read through AT+RDIOx?.
2. When configured as an analog input, the port ADC value can be read through AT+ADCn?; or the port voltage value can be read through AT+ADCnV?, where n=0~3.
3. When configured as signal indication, it can be mapped to the corresponding DIO port such as RS485, sleep/wake status indication, send/receive LED indication, etc.

4.8.2 DIO pin mapping

Table 4-5 DIOx pin mapping relationship table

DIOx=	0	1	2	3	4	5	6	7	8	9
	Disable	Main function	Auxiliary function	Floating input	Pull-up input	Pull-down input	Fixed output	Fixed output	Signal indication 0/1	
DIO0	-	-	ANI0	FL	-	-	0	1	-	
DIO1	-	-	ANI1	FL	-	-	0	1	-	
DIO2	-	SPI_CS	-	FL	PU	-	0	1	-	
DIO3	-	SPI_MOSI(S)	-	FL	PU	-	0	1	-	
DIO4	-	SPI_MISO(S)	-	FL	PU	-	0	1	-	
DIO5	-	SPI_SCLK	-	FL	PU	-	0	1	-	
DIO6	-	RXD1	-	FL	PU	-	0	1	-	
DIO7	-	TXD1	-	FL	PU	-	0	1	-	
DIO8	-	SDA	-	FL	PU	-	0	1	-	
DIO9	-	SCL	-	FL	PU	-	0	1	-	

DIO10	-	SLEEP_REQ	-	FL	PU	-	0	1	-
DIO11	-	-	ANI2	FL	-	-	0	1	RXLED
DIO12	-	-	ANI3	FL	-	-	0	1	TXLED
DIO13	-	RXD0	-	FL	PU	-	0	1	-
DIO14	-	TXD0	-	FL	PU	-	0	1	-
DIO15	-	-		FL	PU		0	1	

Note:

1. The blue mark in the table indicates the default configuration value. In order to ensure that the sleep current is stable when the module is floating, the module configures most ports as pull-up inputs. For ports without pull-up resistors, they are configured as fixed output of 0 or 1;
2. SPI_CS indicates that the module acts as a host;
3. SDA and SCL have internal 10K pull-up resistors and cannot be disabled.

4.8.3 Signal indication

The module can output some special signals to adapt to different applications. When the conditions are met, the indication will be set (output 0/1). When the condition is eliminated, the indication will be cleared (output 1/0). As described in the following table.

Table 4-6 Definition of signal indication types

Name	Description
TXLED	TX Data Indication, generally connected to the TX LED indicator light
RXLED	RX Data Indication, generally connected to the RX LED indicator light

Note: The only difference between Signal Indication 0 and Signal Indication 1 is the inversion of the signal.

5 Typical applications

The module requires only four wires ---- VCC, GND, TXD0, and RXD0 ---- to form the minimal testing system. The diagram is as follows.

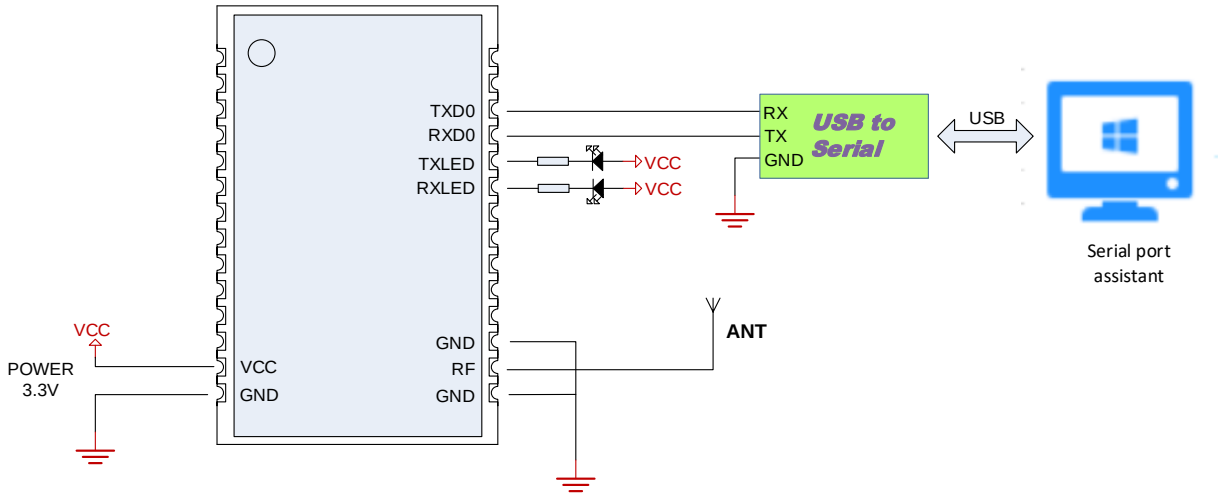

Figure 5-1 Schematic diagram of the minimum testing system

6 Dimensions

6.1 Overall dimensions (unit：mm）

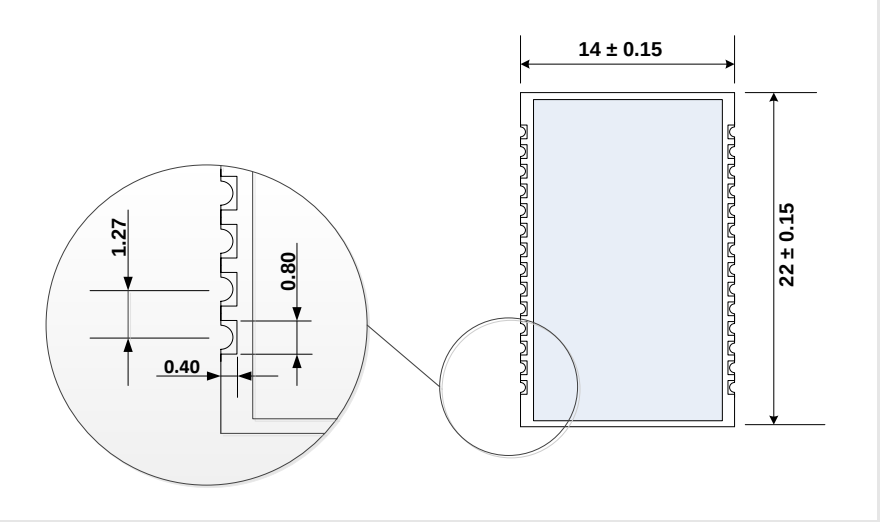

Figure 6-1 Module front view

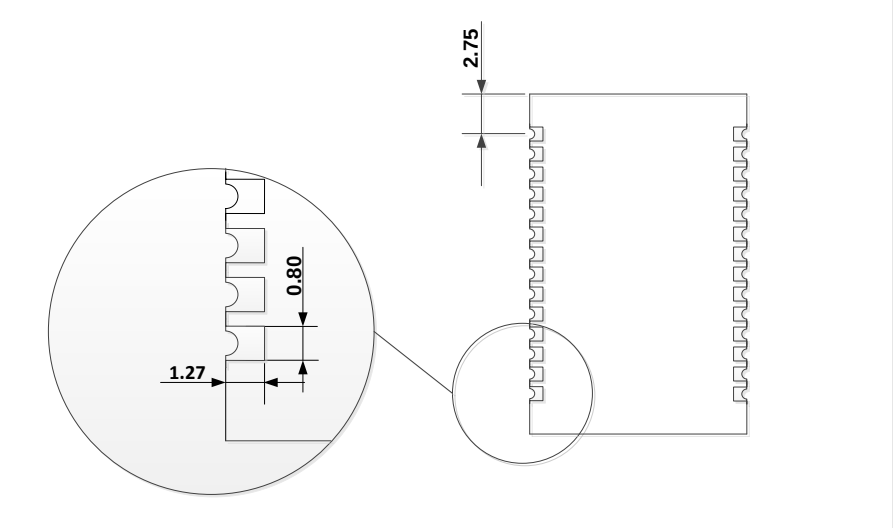

Figure 6-2 Module bottom view

Figure 6-3 Module side view

7.Warranty

Within 12 months from the date of self-delivery by the end user, and under the conditions that the user complies with the requirements specified in the user manual and the factory lead seal remains intact, our company is responsible for free repairs in case of quality issues. After the initial 12 months, our company ensures continued after-sales service.

Note: The terms of this clause are subject to the contractual agreement in the event of a contract.

Shenzhen Friendcom Technology Co., Ltd. Warranty Card

Product name		Model	
Product number		Grade	
Fault description			
End user		Post code	
Contact person		Contact number	

Address：3rd Floor, Building 6, Guangqian Industrial Park, 3rd Longzhu Road, Longguang Community, Taoyuan Street, Nanshan District, Shenzhen

Post code：518108

Tel：0755-86026600

Warranty Statement：

To better serve our users, our company provides a warranty card randomly enclosed with the product. Please keep it safe to enjoy the services we provide.

1) From the date of purchase, products that are operated normally without being disassembled or repaired are eligible for warranty service within one year.
2) The following situations are not covered by free repair services:
    a) Damage to the terminal caused by significant fluctuations in the power grid voltage.
    b) Terminal damage due to misuse or intentional actions.
    c) Terminal damage caused by excessive vibration during user transportation.
3) The software of this product is upgraded for free, and our company provides free training.
4) When the user does not possess a warranty card, charges may apply at the discretion of our

company.

5) If repair services are needed, please fill out the warranty card carefully and return it to our company.

FCC Statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

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

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
The modular can be installed or integrated in mobile or fix devices only. This modular cannot be installed in any portable device.
FCC Radiation Exposure Statement
This modular complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This modular must be installed and operated with a minimum distance of 20 cm between the radiator and user body.

KDB 996369 D03 statements

2.2 List of applicable FCC rules:
The module complies with FCC Part 15.247.
FCC ID: UU3FCWSL05 on User manual and on the external of the packaging.
2.3 Summarize the specific operational use conditions
2.4 Limited module procedures
The module is not a limited module.
2.5 Trace antenna designs
Not applicable
2.6 RF exposure considerations
This equipment complies with FCC's RF radiation exposure limits set forth for an uncontrolled environment.
The antenna(s) used for this transmitter must not be collocated or operating
in conjunction with any other antenna or transmitter.
2.7 Antennas
Antenna Type: Rod Antenna
Antenna gain: 4.5 dBi
Nominal Impedance:50Ω
Dimensions-mm:58
VSWR:≤2.0
2.8 Label and compliance information
The host system using this module, should have label in a visible area indicated the following texts:
"Contains Transmitter Module FCC ID: UU3FCWSL05 Or Contains FCC ID: UU3FCWSL05"
2.9 Information on test modes and additional testing requirements
When testing host product, the host manufacture should follow FCC KDB Publication 996369 D04 Module Integration Guide for testing the host products. The host manufacturer may operate their product during the measurements. In setting up the configurations, if the pairing and call box options for testing does not work, then the host product manufacturer should coordinate with the module manufacturer for access to test mode software.
The module has been certified for Potable applications. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter
2.10 Additional testing, Part 15 Subpart B disclaimer
The module without unintentional-radiator digital circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host shoule be evaluated by the FCC Subpart B.
2.11 Note EMI Considerations
host manufacture is recommended to use D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties
2.12 How to make changes
This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system. According to the KDB 996369 D02 Q&A Q12, that a host manufacture only needs to do an evaluation (i.e., no C2PC

required when no emission exceeds the limit of any individual device (including unintentional radiators) as a composite. The host manufacturer must fix any failure.