

RHF76-052

How To Use Ai-Thinker's LoRaWAN Modem

V0.1

Document information

Info	Content
Keywords	<i>LoRaWAN, IoT, Point to Point, Custom, full-duplex RHF76-052</i>
Abstract	This document shows customer how to use LoRaWAN Modem

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1 Preface

This document shows user how to make quick test with LoRaWAN modem, include how to configure the modem, detailed explanation of key parameters, how to add node to server, how to add device to server etc.

2 Requirements

There are 1 kinds of LoRaWAN modem in Ai-Thinker's product family now, which all are based on the Ai-Thinker's **RHF76-052** module and supports the same AT commands set.

RHF76-052 — UART AT command, UART bootloader

In addition to the modem, a Host PC or MCU is needed to send the AT command to control the modem.

Consider to firmware upgrade, user will need an extra open source tool ExtraPutty. Please contact to our postsale engineer.

UART configuration: "9600, 8, n 1" (8 bits data, no parity, 1 stop bit)

3 Quick Start

Thanks to the high performance in both LoRaWAN network and Point to Point application, Ai-Thinker's LoRa modem is very suitable for long range long battery life application. Customer could use it to join a existed LoRaWAN network with ABP or OTAA mode, or just use it to achieve point to point application.

- 1) To participate in a LoRaWAN network, each end-device has to be personalized and activated. Activation of an end-device can be achieved in two ways, either via **Over-The-Air Activation (OTAA)** when an end-device is deployed or reset, or via **Activation By Personalization (ABP)** in which the two steps of end-device personalization and activation are done as one step.
- 2) To achieve Point to Point application, the device should be configured to TEST mode first by AT command. You can use two modems to communicate with each other, or you could use Ai-Thinker's modem to communicate with others LoRa device.

Refer the table below about relationship of key, ID, EUI and mode:

Mode	ID/EUI	Key
ABP	DevAddr	NwkSKey, AppSKey
OTAA	AppEUI, DevEUI	AppKey

Table 3-1 ABP and OTAA mode ID/EUI/Key

3.1 ABP mode

With ABP mode, the NwkSKey and AppSKey are needed to be known in advance. Please check these two keys with the server.

Please follow up the command list below when power up the device in the first time:

```
AT+RESET //AT command to modem from HOST// //Reset the modem when power up//
+RESET: OK
```

LoRaWAN AT Modem

```
+VER: 1.9.1 // Message return back to HOST follow AT command //
AT //Sent command "AT" to double check the interface between HOST and SLAVE//
+AT: OK
AT+ID //Check ID of the device//
+ID: DevAddr, 01:72:f4:d2
```

```

+ID: DevEui, 47:36:54:9f:00:2e:00:55
+ID: AppEui, 52:69:73:69:6e:67:48:46
AT+ID=DevAddr,"01 02 03 04" //Set the new DevAddr//
+ID: DevAddr, 01:02:03:04
AT+DR=EU868 //Configure to LoRaWAN EU band, there are EU868, US915 and custom data rate scheme//
+DR: EU868
AT+CH=0,868.1,DR0,DR5 //Set Channel 0 to 868.1MHz, date rate from DR0 to DR5//
+CH: 0,868100000,DR0:DR5
AT+CH=1,868.3,DR0,DR5 //Set Channel 1 to 868.3MHz, date rate from DR0 to DR5//
+CH: 0,868300000,DR0:DR5
... //16 channels could be configured totally, from 0 to 15, please check the maximum channels the gateway can support//
AT+RXWIN2=869.525,DR3//Set the parameters of RXWIN2. Please check the RXWIN2 with server, wrong RXWIN2 will
cause downlink lost//
// You can also use SF and Bandwidth to configure RXWIN2. For example, AT+RXWIN2=434.9,SF9,250 //
+RXWIN2: 869525000,DR3
AT+DR=DR0 //Set the default date rate of the device//
+DR: DR0
AT+POWER=14 //Set default output power to 14dBm(1)//
+POWER: 14
AT+ADR=ON //Set ADR ON, you could also set to OFF//
+ADR: ON
AT+KEY=NwkSKey,"2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C" //Use the NwkSKey used in your network
instead//
+KEY: NWKSKEY 2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C
AT+KEY=AppSKey,"2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C" //Use the AppSKey used in your network
instead//
+KEY: APPSKEY 2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C
AT+CLASS=A //set to Class A mode//
+CLASS: A
AT+CMGHEX="00 ff 22 33 5f 88 01 98 ad ac 46 12 be 43 54 43 35 45 33 45 44 35 33 54 5 43" //Now you can
send message to Gateway. 4 kinds of command could be used to transmit: AT+MSG, AT+CMMSG, AT+MSGHEX,
AT+CMGHEX//
+CMGHEX: Start LoRaWAN transaction
+CMGHEX: TX "00 FF 22 33 5F 88 01 98 AD AC 46 12 BE 43 54 43 35 45 33 45 44 35 33 54 05 43"
+CMGHEX: Wait ACK
+CMGHEX: ACK Received
+CMGHEX: PORT: 12; RX: "11 22 33 44 55 66 77 88 99 00"
+CMGHEX: RXWIN1, RSSI -82, SNR 10.25
+CMGHEX: Done

```

Note:

(1) For Ai-Thinker's modem with part number RHF76-052, RHF76-052AN and RHF3M076, the output power is 20dBm max @434MHz/470MHz, 14dBm max @868MHz/915MHz. If you have different requirements, please contact support@Ai-Thinker.com

3.2 OTAA mode

With OTAA mode, AppKey and AppEui are needed. You should check the AppKey and AppEui with the server first.

Please follow up the step below when power up the device in the first time:

```
AT+RESET //AT command to modem from HOST// //Reset the modem when power up//
+RESET: OK
```

LoRaWAN AT Modem

```
+VER: 1.9.1 // Message return back to HOST follow AT command //
```

```
AT //Sent command "AT" to double check the interface between HOST and SLAVE//
```

```
+AT: OK
```

```
AT+ID //Check ID of the device//
```

```
+ID: DevAddr, 01:72:f4:d2
```

```
+ID: DevEui, 47:36:54:9f:00:2e:00:55
```

```
+ID: AppEui, 52:69:73:69:6e:67:48:46
```

```
AT+ID=DevEui,"47 36 54 9f 00 2e 00 55" //Set the new DevEui//
```

```
+ID: DevEui, 47:36:54:9f:00:2e:00:55
```

```
AT+ID=AppEui,"52 69 73 69 6e 67 48 46" //Set the new AppEui//
```

```
+ID: AppEui, 52:69:73:69:6e:67:48:46
```

```
AT+DR=EU868 //Configure to LoRaWAN EU band, there are EU868, US915 and custom data rate scheme//
```

```
+DR: EU868
```

```
AT+CH=0,868.1,DR0,DR5 //Set Channel 0 to 868.1MHz, date rate from DR0 to DR5//
```

```
+CH: 0,868100000,DR0:DR5
```

```
AT+CH=1,868.3,DR0,DR5 //Set Channel 1 to 868.3MHz, date rate from DR0 to DR5//
```

```
+CH: 0,868300000,DR0:DR5
```

```
... //16 channels could be configured totally, from 0 to 15, please check the maximum channels the gateway can support//
```

```
AT+RXWIN2=869.525,DR3//Set the parameters of RXWIN2. Please check the RXWIN2 with server, wrong RXWIN2 will cause downlink lost//
```

```
// You can also use SF and Bandwidth to configure RXWIN2. For example, AT+RXWIN2=434.9,SF9,250 //
```

```
+RXWIN2: 869525000,DR3
```

```
AT+DR=DR0 //Set the default date rate of the device//
```

```
+DR: DR0
```

```
AT+POWER=14 //Set default output power to 14dBm//
```

```
+POWER: 14
```

```
AT+ADR=ON //Set ADR ON, you could also set to OFF//
```

```
+ADR: ON
```

```
AT+KEY=AppKey,"2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C" //Use the AppKey used in your network instead//
```

```
+KEY: APPKEY 2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C
```

```
AT+CLASS=A //set to Class A mode//
```

```
+CLASS: A
```

```
AT+Join //Join command//
```

```
+JOIN: Starting
```

```
+JOIN: NORMAL, count 1, 0s, 0s
```

```
+JOIN: Network joined
```

```
+JOIN: NetID 000024 DevAddr 48:00:00:01
```

```
+JOIN: Done
```

```
AT+CMSSGHEX="00 ff 22 33 5f 88 01 98 ad ac 46 12 be 43 54 43 35 45 33 45 44 35 33 54 5 43" //Now you can send message to Gateway. 4 kinds of command could be used to transmit: AT+MSG, AT+CMSSG, AT+MSGHEX, AT+CMSSGHEX//
```

```
AT+CMSSGHEX//
```

```
+CMSSGHEX: Start LoRaWAN transaction
```

```
+CMSSGHEX: TX "00 FF 22 33 5F 88 01 98 AD AC 46 12 BE 43 54 43 35 45 33 45 44 35 33 54 05 43"
```

```
+CMSSGHEX: Wait ACK
```

```
+CMSSGHEX: ACK Received
```

```
+CMSSGHEX: PORT: 12; RX: "11 22 33 44 55 66 77 88 99 00"
```

```
+MSGHEX: RXWIN1, RSSI -82, SNR 10.25
+MSGHEX: Done
```

3.3 Application with Custom data rate

Except that EU868 and US915 data rate scheme, Ai-Thinker modem also support custom data rate scheme. This need customer know deeply in LoRa and LoRaWAN before define a custom data rate scheme.

For example,

```
AT+DR=custom
```

```
+DR: CUSTOM
```

```
AT+DR=Scheme
```

```
+DR: CUSTOM
```

```
+DR: CUSTOM DR0 RFU
```

```
+DR: CUSTOM DR1 RFU
```

```
+DR: CUSTOM DR2 RFU
```

```
+DR: CUSTOM DR3 RFU
```

```
+DR: CUSTOM DR4 RFU
```

```
+DR: CUSTOM DR5 RFU
```

```
+DR: CUSTOM DR6 RFU
```

```
+DR: CUSTOM DR7 RFU
```

```
+DR: CUSTOM DR8 RFU
```

```
+DR: CUSTOM DR9 RFU
```

```
+DR: CUSTOM DR10 RFU
```

```
+DR: CUSTOM DR11 RFU
```

```
+DR: CUSTOM DR12 RFU
```

```
+DR: CUSTOM DR13 RFU
```

```
+DR: CUSTOM DR14 RFU
```

```
+DR: CUSTOM DR15 RFU
```

```
AT+DR=Custom,DR0,SF10,125
```

```
+DR: CUSTOM DR0 SF10 BW125K
```

```
AT+DR=Custom,DR1,SF9,125
```

```
+DR: CUSTOM DR1 SF9 BW125K
```

```
AT+DR=Custom,DR2,SF8,125
```

```
+DR: CUSTOM DR2 SF8 BW125K
```

```
AT+DR=Custom,DR3,SF7,125
```

```
+DR: CUSTOM DR3 SF7 BW125K
```

```
AT+DR=Custom,DR4,SF7,500
```

```
+DR: CUSTOM DR4 SF7 BW500K
```

//Here we define DR0 to DR4 totally 5 kinds of data rate different from LoRaWAN definition. Note that both GW and Node should follow this rule when in custom data rate definition//

```
AT+DR=Scheme //Check the data rate scheme again//
```

```
+DR: CUSTOM
```

```
+DR: CUSTOM DR0 SF10 BW125K
```

```
+DR: CUSTOM DR1 SF9 BW125K
```

```
+DR: CUSTOM DR2 SF8 BW125K
```

```
+DR: CUSTOM DR3 SF7 BW125K
```

```
+DR: CUSTOM DR4 SF7 BW500K
```

```
+DR: CUSTOM DR5 RFU
```

```
+DR: CUSTOM DR6 RFU
```

```
+DR: CUSTOM DR7 RFU
```

```
+DR: CUSTOM DR8 RFU
```

```
+DR: CUSTOM DR9 RFU
```

```
+DR: CUSTOM DR10 RFU
```

```
+DR: CUSTOM DR11 RFU
```



```
+DR: CUSTOM DR12 RFU
+DR: CUSTOM DR13 RFU
+DR: CUSTOM DR14 RFU
+DR: CUSTOM DR15 RFU
```

3.4 Application with Full-duplex gateway

A gateway support full-duplex, which means that there is a frequency shift for downlink and uplink of gateway. With AT+RXWIN1 and AT+RXWIN2 command, Ai-Thinker modem could achieve this easily to support full-duplex gateway. In default, the frequency shift in RXWIN1 is off, that the downlink use the same frequency as the uplink in RXWIN1. If you want to shift a frequency offset, then use "AT+RXWIN1=ON" to set to ON.

For example, uplink use 8 channels: 471.5MHz, 471.7MHz, 471.9MHz, 472.1MHz, 472.3MHz, 472.5MHz, 472.7MHz and 472.9MHz; downlink use another 8 channels with a fixed shift frequency, 10MHz for example, i.e. 481.5MHz, 481.7MHz, 481.9MHz, 482.1MHz, 482.3MHz, 482.5MHz, 482.7MHz and 482.9MHz. You can configure the modem like below:

```
AT+CH=0,471.5,DR0,DR5 //Set the uplink channel and data rate//
+CH: 0,471500000,DR0:DR5
AT+CH=1,471.7,DR0,DR5
+CH: 1,471700000,DR0:DR5
AT+CH=2,471.9,DR0,DR5
+CH: 2,471900000,DR0:DR5
AT+CH=3,472.1,DR0,DR5
+CH: 3,472100000,DR0:DR5
AT+CH=4,472.3,DR0,DR5
+CH: 4,472300000,DR0:DR5
AT+CH=5,472.5,DR0,DR5
+CH: 5,472500000,DR0:DR5
AT+CH=6,472.7,DR0,DR5
+CH: 6,472700000,DR0:DR5
AT+CH=7,472.9,DR0,DR5
+CH: 7,472900000,DR0:DR5
```

```
AT+RXWIN1=ON //Enable the RXWIN1 configuration command//
+RXWIN1: ON
AT+RXWIN1=0,481.5 //set downlink frequency channel in RXWIN1 to achieve full-duplex of the gateway//
+RXWIN1 0,481500000
AT+RXWIN1=1,481.7
+RXWIN1 1,481700000
AT+RXWIN1=2,481.9
+RXWIN1 2,481900000
AT+RXWIN1=3,482.1
+RXWIN1 3,482100000
AT+RXWIN1=4,482.3
+RXWIN1 4,482300000
AT+RXWIN1=5,482.5
+RXWIN1 5,482500000
AT+RXWIN1=6,482.7
+RXWIN1 6,482700000
```

```
AT+RXWIN1=7,482.9
+RXWIN1 7,48290000
```

//Now the modem could support the full-duplex gateway with the RXWIN1 with shift frequency channel//

3.5 Downlink

LoRaWAN modem is bidirectional device, so downlink could be received if server transmits. In LoRaWAN Class A mode, two receive windows will be opened to receive downlink from server, however LoRaWAN Class C device could receive downlink from server at almost any time. Following example shows how modem reports received downlink message.

Example: (CMSG)

```
+CMSG: Start LoRaWAN transaction
+CMSG: TX "Ai-Thinker"
+CMSG: Wait ACK
+CMSG: ACK Received
+CMSG: PORT: 5; RX: "14 54 54"
+CMSG: RXWIN2, RSSI -88, SNR 13.5
+CMSG: Done
```

Example: (Class C)

```
+CMSG: ACK Received
+CMSG: PORT: 5; RX: "14 54 54"
+CMSG: RXWIN2, RSSI -88, SNR 13.5
```

Class C downlink will use last message command (MSG/CMSG/MSGHEX/CMSGHEX) as its prompt symbol. Could be any of below cases.

```
+MSG: PORT: 5; RX: "14 54 54"
+CMSG: PORT: 5; RX: "14 54 54"
+MSGHEX: PORT: 5; RX: "14 54 54"
+CMSGHEX: PORT: 5; RX: "14 54 54"
```

3.6 Point to Point communication with LoRa

Ai-Thinker's modem not only supports the LoRaWAN stack, but also could be as normal LoRa transceiver controlled via AT command.

a) As Transmitter

```
AT+RESET //AT command to modem from HOST// //Reset the modem when power up//
+RESET: OK
```

LoRaWAN AT Modem

```
+VER: 1.9.1 // Message return back to HOST follow AT command //
```

```
AT //Send command "AT" to double check the interface between HOST and SLAVE//
```

```
+AT: OK
```

```
AT+Mode=Test//Set to test mode first//
```

```
+MODE: TEST
```

```
AT+TEST=RFCFG,472.3,8,250,8,8,20 //Configure the modem,like Freq, SF, BW, Preamble length, TX output power//
+TEST=RFCFG,472.3,8,250,8,8,20
AT+TEST=TXLRPKT(2),"00 00 01 00 00 AF 80 07 02 00 00 39"//You could now transmit packet now//
+TEST: TXLRPKT "00 00 01 00 00 AF 80 07 02 00 00 39 "
+TEST: TX DONE
```

Note:

(2) There are two kinds of commands for packet transmit: AT+TEST=TXLRPKT used to transmit packets in HEX format; AT+TEST=TXLRSTR used to transmit packets in string.

b) As Receiver

```
AT+RESET //AT command to modem from HOST// //Reset the modem when power up//
+RESET: OK
```

LoRaWAN AT Modem

```
+VER: 1.9.1 // Message return back to HOST follow AT command //
AT //Send command "AT" to double check the interface between HOST and SLAVE//
+AT: OK
AT+Mode=Test//Set to test mode first//
+MODE: TEST
AT+TEST=RFCFG,472.3,8,250,8,8,20(3)(4) //Configure the modem,like Freq, SF, BW, Preamble length//
+TEST=RFCFG,472.3,8,250,8,8,20
AT+TEST=RXLRPKT //Set to LoRa Rx continues mode//
+TEST: RXLRPKT
+TEST: LEN:12, RSSI:-101, SNR:6
+TEST: RX "00 00 01 00 00 AF 80 07 02 00 00 39"//Return the message in HEX if receive a packet//
```

Note:

(3) Preamble length of RX should be equal to or bigger than TX
 (4) When SF11 and SF12, the low data optimization would be ON for both TX and RX; others would be OFF.

3.7 Others important commands

3.7.1 Select CLASS of LoRaWAN

```
AT+CLASS=A // Enable Class A mode, this is the default configuration when power on in the first
time
+CLASS: A
AT+CLASS=C // Enable Class C mode//
+CLASS: C
```

Note: After Class C mode is enabled, at least one message needs to be transmitted to make LoRaWAN stack open extra RX window (RXWIN2)!!!

3.7.2 Set to SLEEP mode

```
AT+LOWPOWER //Set to Sleep mode//
+LOWPOWER: SLEEP

AT //Wake up when in Sleep mode//(5)
```

+LOWPOWER: WAKEUP

Note:

(5) Any AT command could wake up the device. So when you want to operate the device, use "AT" command as the first one to wake up. Then followed with the real operation command.

3.7.3 Get Help from Modem

a) Get Help in normal mode (ABP or OTAA mode)

AT+HELP //Get Help list//

+HELP: OK

AT -- AT Ping
HELP -- Print command List
FDEFAULT -- Factory data reset
RESET -- Software reset
DFU -- Bootloader mode
LOWPOWER -- Enter sleep mode
VER -- Version
MSG -- Unconfirmed
MSGHEX -- Unconfirmed (HEX)
CMSG -- Confirmed
CMSGHEX -- Confirmed (HEX)
CH -- Set channel
ADR -- ADR ON/OFF
DR -- Set datarate
REPT -- MSG/MSGHEX repetition
POWER -- TX power
RXWIN1 -- RX window1
RXWIN2 -- RX window2
PORT -- TX port
MODE -- LWABP/LWOTAA/TEST
ID -- DevAddr/DevEui/AppEui
KEY -- NWKSKEY/APPSKEY/APPKEY
CLASS -- Class(A/B/C)
JOIN -- OTAA Join request
TEST -- Test commands
UART -- UART configure
DELAY -- RX window delay

b) Get help in Test mode

AT+MODE=TEST //Set to TEST mode first//

+MODE: TEST

AT+TEST=HELP //Get HELP list in TEST mode//

+TEST: HELP

STOP -- AT+TEST=STOP
HELP -- AT+TSET=HELP
TXCW -- AT+TEST=TXCW
TXCLORA -- AT+TEST=TXCLORA
RF CFG -- AT+TEST=RF CFG, [F], [SF], [BW], [TXPR], [RXPR], [POW]
RXLRPKT -- AT+TEST=RXLRPKT
TXLRPKT -- AT+TEST=TXLRPKT, "HEX"

```
TXLRSTR -- AT+TEST=TXLRSTR, "TEXT"  
RSSI -- AT+TEST=RSSI, F, [CNT]  
LWDL -- AT+TEST=LWDL, TYPE, DevAddr, "HEX", [FCNT], [FPORT], [FCTRL]
```

3.7.4 Set to factory default configuration

```
AT+FDefault=Ai-Thinker //Reset LoRaWAN AT modem to factory default configuration.//  
+FDEFAULT: OK
```

Note: This command would reset all the configurations to factory default, like frequency channel, data rate, output power and so on.

3.7.5 Firmware upgrade

Ai-Thinker's modem use a tool called ExtraPuTTY to upgrade the firmware ,with the baud rate 115200bps. There are two ways to access into firmware upgrade mode.

1st, Hardware trigger way

Keep "**LOW**" for **pin14** of RHF76-052 module (GPIO_PA15) when power on the device. The two LEDs (connected to **pin16** GPIO_PB4 and **pin21** GPIO_PB5 of the module) would blink means boot loader is ready to upgrade FW.

2nd, Software trigger way

```
AT+DFU=on //Set to DFU mode//
```

The two LEDs (connected to pin16 GPIO_PB4 and **pin21** GPIO_PB5 of the module) would blink means boot loader is ready to upgrade FW.

Revision

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+ Initial

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