PS01509

LoRaWAN AT Command Specification

V3.1

Document information

Info	Content
Keywords	*LoRaWAN, AT Command, UART, USB*
Abstract	This document defines AT command format used by RisingHF LoRaWAN module

WARNING:

This document is only for RHF76-052AM module with version higher than 2.0.0, others please refer to PS01509-V2.4

Content

Tables

1 Introduction

RisingHF™ LoRaWAN™ modem is LoRaWAN compatible device, which supports flexible LoRaWAN communication. This document is intended to describe a command interface implementation of LoRaWAN Class A/C protocol. LoRaWAN protocol is available from LoRa Alliance, it is recommended to review LoRaWAN specification before using LoRaWAN modem.

1.1 Feature

- Maximum configurable 72 channels
- Maximum 255 bytes frame
- User configuration nonvolatile
- Support LoRaWAN R1.0.1 data rate schemes: EU434/EU868/US915/ AU920/US915HYBRID
- Customized data rate scheme
- LoRaWAN Class A/C
- Numerous test commands (LoRa P2P, Class C downlink, Continuous Wave etc.)
- Flexible hexadecimal string parser
- Ultra-low power (1.4uA@3.3V)[1], intelligent auto low power mode
- Case insensitive commands
- Flexible RXWIN2 configuration interface
- Configurable RXWIN1 channel frequency
- Possibility to enable full-duplex LoRaWAN system
- 256 bytes EEPROM to save user data
- RTC time and supply voltage measurement

1.2 Related Products

Part Number	Bootloader	Interface
RHF76-052AM	UART	UART

Table 1-1 Related products list

[1] UART interface modem only

2 Preface

2.1 Conventions

- Command is case insensitive;
- All commands have response;
- Command length never exceeds total 528 characters;
- One valid AT Command must end with '\n', "\r\n" is also valid;
- If command timeout feature is enabled, end '\n' will not be mandatory;
- <LF> means the newline character. <CR> means carriage return;
- UART[2] configuration "9600, 8, n 1" (8 bits data, no parity, 1 stop bit);

2.2 Symbols

- = --> Set value for command
- ? --> Query
- : --> Start a list input parameter
- + --> Prefix of command
- , --> Separator of parameters
- Space --> Empty character, could be used to format command

NOTE: You could use quote sign < " > to force input parameter with space, such as <AT+MSGHEX="AA BB CC DD EE">, then "AA BB CC DD EE" is treated as one parameter. But if you input command <AT+MSGHEX=AA BB CC DD EE>, "AA BB CC DD EE" will treated as 5 parameters, AT+MSGHEX returns error.

2.3 Format

All commands in this document are end with <CR><LF>. In order to facilitate the description, all <CR><LF> is intentionally omitted in this document.

2.3.1 Query

Use query command to check LoRaWAN modem configuration, such as channel configuration, ADR status, TX power, etc.

```
AT+COMMAND
AT+COMMAND?
AT+COMMAND=?
```

NOTE: Query format is available with every LoRaWAN supported command

2.3.2 Configure / Control

Uses configure/control command to set new configuration or control transaction.

```
AT+COMMAND=DATA
```

2.3.3 Return

Return data is in format like "+CMD: RETURN DATA"

```
+COMMAND: "RETURN DATA"
```

[2] ***RHF76-052AM*** *supports UART interface*
RHF3M076 *supports USB CDC interface of which UART configuration is unconcerned*

2.4 Error

Code	Comment
-1	The number of parameters is invalid
-2	The content of the parameter is invalid
-3	API function returns error when user parameter is passed to it
-4	LoRaWAN modem can't save parameter to EEPROM
-5	The command is disabled currently
-6	Unknown error occurs
-7	There is not enough HEAP to execute user operation
-10	Command unknown
-11	Command is in wrong format
-12	Command is unavailable in current mode (Check with "AT+MODE")
-20	Too many parameters. LoRaWAN modem support max 15 parameters
-21	Length of command is too long (exceed 528 bytes)
-22	Receive end symbol timeout, command must end with <LF>
-23	Invalid character received
-24	Either -21, -22 or -23

Table 2-1 Error code list

This error code list applies to all LoRaWAN supported command. User could refer to this list to know what is happening to LoRaWAN modem, when gets errors.

2.5 EEPROM

Items below will be synchronized to EEPROM of LoRaWAN modem once changed successfully, this makes LoRaWAN modem memorized, user doesn't need to reconfigure parameter after repower, LoRaWAN modem helps to keep it. If user wants to go back factory default configuration, refer to 3.21 FDEFAULT.

Item
Channel frequency, datarate range (up to 16 channels)
Datarate
TX power
ADR
RX Window2 frequency/datarate
RX Window1 frequency
Keys(NwkSkey, AppSkey, AppKey)
ID(DevAddr, DevEUI, AppEui)
Port
Unconfirmed message repetition
Confirmed message retry
Mode[3]
LWABP/LWOTAA
Customize data rate scheme
Delay(RX1, RX2, JRX1, JRX2)
Multicast parameters (MC_DevAddr, MC_ NwkSkey, MC_ AppSkey)

Table 2-2 Memorized configuration

[3] Test mode is not stored; a reset during test mode makes modem switch back to previous mode.

2.6 Payload Length Limitation

Repeater mode is not supported.

2.6.1 EU868/EU434

Data Rate	PHYPayload	MacPayload	FRMPayload
0	64	59	51
1	64	59	51
2	64	59	51
3	128	123	115
4	255	250	242
5	255	250	242
6	255	250	242
7	255	250	242
8:15	-	-	-

Table 2-3 EU868/EU434 Payload Length Limitation

2.6.2 US915/AU920

Data Rate	PHYPayload	MacPayload	FRMPayload
0	24	19	11
1	66	61	53
2	139	134	126
3	255	250	242
4	255	250	242
5-7	-	-	-
8	66	61	53
9	142	137	129
10	255	250	242
11	255	250	242
12	255	250	242
13	255	250	242
14:15	-	-	-

Table 2-4 US915/AU920 Payload Length Limitation

2.6.1 Customized Band Data Rate Scheme

Payload length depends on the current using spread factor and band width. Table below shows the relationship between “Spread Factor”, “Band Width”, “PHYPayload” and “MacPayload”.

Spread Factor	Band Width	PHYPayload	MacPayload	FRMPayload
SF12	**125KHz**	64	59	51
SF11	**125KHz**	64	59	51
SF10	**125KHz**	64	59	51
SF9	**125KHz**	128	123	115
SF8	**125KHz**	255	250	242
SF7	**125KHz**	255	250	242
SF12	**250KHz**	128	123	115
SF11	**250KHz**	255	250	242
SF10	**250KHz**	255	250	242
SF9	**250KHz**	255	250	242

SF8	**250KHz**	255	250	242
SF7	**250KHz**	255	250	242
SF12	**500KHz**	255	250	242
SF11	**500KHz**	255	250	242
SF10	**500KHz**	255	250	242
SF9	**500KHz**	255	250	242
SF8	**500KHz**	255	250	242
SF7	**500KHz**	255	250	242
FSK:50Kbps		255	250	242

Table 2-5 Customized Data Rate Payload length limitation

2.1 Data Rate Scheme

2.1.1 EU868/EU434

LoRaWAN Data Rate	Configuration	Indicative physical bit rate [bit/s]
DR0	LoRa SF12/125KHz	250
DR1	LoRa SF11/125KHz	440
DR2	LoRa SF10/125KHz	980
DR3	LoRa SF9/125KHz	1760
DR4	LoRa SF8/125KHz	3125
DR5	LoRa SF7/125KHz	5470
DR6	LoRa SF7/250KHz	11000
DR7	FSK:50kbps	50000
DR8-DR15	RFU	RFU

Table 2-6 LoRaWAN EU868/EU434 Data Rate Scheme

2.1.2 US915/AU920

LoRaWAN Data Rate	Configuration	Indicative physical bit rate [bit/s]
DR0	LoRa SF10/125KHz	980
DR1	LoRa SF9/125KHz	1760
DR2	LoRa SF8/125KHz	3125
DR3	LoRa SF7/125KHz	5470
DR4	LoRa SF8/500KHz	12500
DR5-DR7	RFU	RFU
DR8	LoRa SF12/500KHz	980
DR9	LoRa SF11/500KHz	1760
DR10	LoRa SF10/500KHz	3900
DR11	LoRa SF9/500KHz	7000
DR12	LoRa SF8/500KHz	12500
DR13	LoRa SF7/500KHz	21900
DR14-DR15	RFU	RFU

Table 2-7 LoRaWAN US915/AU920 Data Rate Scheme

2.1.3 Custom Band

According to the application that customer needs, in some cases user may need define a new data rate scheme. Refer to DR chapter to know more details.

2.2 Output Power Encoding

TXPower is defined in LoRaWAN specification Mac command LinkADRReq chapter.

2.2.1 EU868

TXPower	Output Power (dBm)
0	20
1	14
2	11
3	8
4	5
5	2
6-15	RFU

Table 2-8 EU868 TxPower Definition

2.2.2 EU434

TXPower	Output Power (dBm)
0	10
1	7
2	4
3	1
4	-2
5	-5
6-15	RFU

Table 2-9 EU434 TxPower Definition

2.2.1 US915/AU920

Formula:

```
30 - 2*TXpower (dBm)
```

TXPower	Output Power (dBm)
0	30
1	28
2	26
3	24
4	22
5	20
6	18
7	16
8	14
9	12
10	10
11:15	RFU

Table 2-10 US915/AU920 TxPower Definition

2.2.2 Custom Band

TXPower	Output Power (dBm)
0	20
1	19

2	17
3	16
4	14
5	13
6	12
7	10
8	7
9	5
10	2
11	0
12	-2
13:15	RFU

Table 2-11 Custom Band TxPower Definition

2.3 RX1DROffset Limitation

2.3.1 EU868/EU434

Uplink DR \ RX1DROffset	0	1	2	3	4	5
DR0	DR0	DR0	DR0	DR0	DR0	DR0
DR1	DR1	DR0	DR0	DR0	DR0	DR0
DR2	DR2	DR1	DR0	DR0	DR0	DR0
DR3	DR3	DR2	DR1	DR0	DR0	DR0
DR4	DR4	DR3	DR2	DR1	DR0	DR0
DR5	DR5	DR4	DR3	DR2	DR1	DR0
DR6	DR6	DR5	DR4	DR3	DR2	DR1
DR7	DR7	DR6	DR5	DR4	DR3	DR2

Table 2-12 EU868/EU434 RX Window 1 Data Rate Definition

2.3.2 US915/AU920

Uplink DR \ RX1DROffset	0	1	2	3
DR0	DR10	DR9	DR8	DR8
DR1	DR11	DR10	DR0	DR8
DR2	DR12	DR11	DR0	DR9
DR3	DR13	DR12	DR1	DR10
DR4	DR13	DR13	DR2	DR11

Table 2-13 US915/AU920 RX Window 1 Data Rate Definition

2.3.3 Custom

Custom data rate scheme will ignore RX1DROffset value. Each uplink data rate uses a fixed map downlink data rate, available DLDRx value ranges from DR0 to DR15. If DLDR is not specified, DRn will be mapped to itself.

Uplink DR \ RX1DROffset	x
DR0	DLDR0
DR1	DLDR1

DR2	DLDR2
DR3	DLDR3
DR4	DLDR4
DR5	DLDR5
DR6	DLDR6
DR7	DLDR7
DR8	DLDR8
DR9	DLDR9
DR10	DLDR10
DR11	DLDR11
DR12	DLDR12
DR13	DLDR13
DR14	DLDR14
DR15	DLDR15

Table 2-14 Custom Band RX Window 1 Data Rate Definition

Furthermore, user could use custom data rate scheme to emulate EU868 or US915 data rate scheme to create below map between uplink and downlink.

EU868

RX1DROffset / Uplink DR	x
DR0	DR0
DR1	DR1
DR2	DR2
DR3	DR3
DR4	DR4
DR5	DR5
DR6	DR6
DR7	DR7
DR8:DR15	No Use

Table 2-15 Custom Band Emulate EU868 RX Window 1 Data Rate

US915:

RX1DROffset / Uplink DR	x
DR0	DR10
DR1	DR11
DR2	DR12
DR3	DR13
DR4	DR13
DR5:DR15	No Use

Table 2-16 Custom Band Emulate US915 RX Window 1 Data Rate

2.4 Band Specific Limitation

2.4.1 US915/AU920 Limitation

Under these modes, up to 72 channels could be enabled. All these channels are not configurable with the default channels according to the definition of LoRaWAN 1.0.1. This means below commands will be invalid:

```
AT+CH=CHx, FREQEUNCY, [DR_MIN], [DR_MAX]
AT+RXWIN=CHx, FREQEUNCY
```

When switching data rate scheme, RXWIN2 must be reconfigured manually. It may cause packet lost if not.

2.4.2 EU868 Duty Cycle Limitation

Only EU868 band need enable duty cycle limitation to comply with ETSI [EN300.220] standard. Band and limitation is defined as below. Other bands rather than EU868 no need duty cycle limitation.

Band Index	Frequencies(MHz)	Maximum Power	Duty Cycle	Band Width
g	865.00 ~ 868.00	14dBm	1%	3MHz
g1	868.00 ~ 868.60	14dBm	1%	600KHz
g2	868.70 ~ 869.20	14dBm	0.1%	500KHz
g3	869.40 ~ 869.65	27dBm	10%	250KHz
g4	869.70 ~ 867.00	14dBm	1%	300KHz

Table 2-17 ETSI EU868 Regulation

3 Commands

Command	Description
AT	Test command
HELP	Print command list
FDEFAULT	Factory data reset
RESET	Software reset
DFU	Force bootloader to enter dfu mode
LOWPOWER	Enter sleep mode
VER	Version[Major.Minor.Patch]
MSG	LoRaWAN unconfirmed data
MSGHEX	LoRaWAN unconfirmed data in hex
CMSG	LoRaWAN confirmed data
CMSGHEX	LoRaWAN confirmed data in hex
PMSG	LoRaWAN proprietary
PMSGHEX	LoRaWAN proprietary in hex
CH	LoRaWAN channel frequency
DR	LoRaWAN datarate
ADR	LoRaWAN ADR control
REPT	Unconfirmed message repetition
RETRY	Confirmed message retry
POWER	LoRaWAN TX power
RXWIN2	LoRaWAN RX window2
RXWIN1	Customized RXWIN1 frequency
PORT	LoRaWAN communication port
MODE	LWABP, LWOTAA, TEST
ID	LoRaWAN DevAddr/DevEui/AppEui
KEY	Set NWKSKEY/APPSKEY/APPKEY
CLASS	Choose LoRaWAN modem class(A/B/C)
JOIN	LoRaWAN OTAA JOIN
LW	LoRaWAN misc configuration (CDR, ULDL, NET, DC, MC, THLD)
TEST	Send test serious command
UART	UART configure
REG	Control RF Chip
DELAY	RX window delay
VDD	Get VDD
RTC	RTC time get/set
EEPROM	Write/Read EEPROM

Table 3-1 Command List

3.1 AT

Use to test if connection of module is OK. This is a dummy command just like other common "AT modules"

Format:

```
AT
AT?
```

Return:

```
+AT: OK
```

3.2 VER

Check firmware version. Versioning rule refers to Semantic Versioning 2.0.0.

Format:

```
AT+VER=?
AT+VER?
AT+VER
```

Return:

```
+VER: $MAJOR.$MINOR.$PATCH
+VER: 2.x.x
```

3.3 ID

Use to check the ID of the LoRaWAN module, or change the ID. ID is treated as big endian numbers.

Read ID Format:

```
AT+ID                    // Read all, DevAddr(ABP), DevEui(OTAA), AppEui(OTAA)
AT+ID?                   // Read all
AT+ID=?                  // Read all
AT+ID=DevAddr            // Read DevAddr
AT+ID=DevEui             // Read DevEui
AT+ID=AppEui             // Read AppEui
AT+ID=DevAddr, "new devaddr"          // Set new DevAddr
AT+ID=DevEui, "new deveui"            // Set new DevEui
AT+ID=AppEui, "new appeui"            // Set new AppEui
```

Return:

```
+ID: DevAddr, xx:xx:xx:xx
+ID: DevEui[4], xx:xx:xx:xx:xx:xx:xx:xx
+ID: AppEui[5], xx:xx:xx:xx:xx:xx:xx:xx
```

Change end device address (**DEVADDR**)

```
AT+ID=DevAddr, “4 bytes length hex identifier”
eg: AT+ID=DevAddr, "01234567"
eg: AT+ID=DEVADDR, "01 23 45 67"
```

[4] DevEui which is supplied by RisingHF are derived from STM32's UUID, these EUIs are RisingHF unique is not standard IEEE EUI-64, , it is recommended to apply and use IEEE-EUI64.

[5] Default AppEui is **52:69:73:69:6E:67:48:46**

Return:

```
+ID: DevAddr, 01:23:45:67
```

Change device extended unique identifier (**DEVEUI**)

```
AT+ID= DevEui, “8 bytes length hex identifier (64bit)”
eg: AT+ID=DevEui, "0123456789ABCDEF"
eg: AT+ID=DEVEUI, "01 23 45 67 89 AB CD EF"
```

Return:

```
+ID: DevEui, 01:23:45:67:89:AB:CD:EF
```

Change device extended unique identifier (**APPEUI**)

```
AT+ID= AppEui, “8 bytes length hex identifier (64bit)”
eg: AT+ID=AppEui, "0123456789ABCDEF"
eg: AT+ID=APPEUI, "01 23 45 67 89 AB CD EF"
```

Return:

```
+ID: AppEui, 01:23:45:67:89:AB:CD:EF
```

3.4 RESET

Use to reset the module. If module returns error, then reset function is invalid.

Format:

```
AT+RESET
```

Return:

```
+RESET: OK
+RESET: ERROR(-5)            // USB interface device returns error
```

Note: This command is unavailable if the LoRaWAN modem is USB interface device

3.5 MSG

Use to send string format frame which is no need to be confirmed by the server.

Format:

```
AT+MSG="Data to send"
```

Return:

```
+MSG: Start LoRaWAN transaction
+MSG: TX "xxxxxx"
+MSG: Done
```

Example: *(Normal)*

```
+MSG: Start LoRaWAN transaction
+MSG: TX "RisingHF"
+MSG: Done
```

Example: *(Downlink message, RX payload is in hex format)*

```
+MSG: Start LoRaWAN transaction
+MSG: TX "RisingHF"
+MSG: PORT: 8; RX: "12 34 56 78"
+MSG: RXWIN2[6], RSSI -106, SNR 4
```

[6] RXWIN2: Message is received during RX Window2; RXWIN1: RX Window1; RXWIN0: Class C Extra RXWIN2.

```
+MSG: Done
```

Example: *(MAC command received)*

```
+MSG: Start LoRaWAN transaction
+MSG: TX "RisingHF"
+MSG: MACCMD: "03 51 07 00 61"
+MSG: RXWIN2, RSSI -88, SNR 13.75
+MSG: Done
```

3.5.1 LinkCheckReq

AT+MSG could be used to send LinkCheckReq mac command to check Link status between modem and server.

```
AT+MSG
+MSG: Start
+MSG: TX ""
+MSG: LoRaWAN modem is busy
+MSG: MACCMD: "02 0A 03"
+MSG: RXWIN1, RSSI -93, SNR 6.25
+MSG: Done
```

From example above, server send back “02 0A 03” to modem, it is in the format of below table

LinkCheckReq	Margin	GwCnt
02	0A	03

The demodulation margin (Margin) is an 8-bit unsigned integer in the range of 0..254 indicating the link margin in dB of the last successfully received LinkCheckReq command.
A value of “0” means that the frame was received at the demodulation floor (0 dB or no margin) while a value of “20”, for example, means that the frame reached the gateway 20 dB above the demodulation floor. Value “255” is reserved. The gateway count (GwCnt) is the number of gateways that successfully received the last LinkCheckReq command.

Note: several mac commands could be received

3.6 CMSG

Use to send string format frame which must be confirmed by the server.
Format:

```
AT+CMSG="Data to send"
```

Return: *(NACK)*

```
+CMSG: Start LoRaWAN transaction
+CMSG: TX "RisingHF"
+CMSG: Wait ACK
+CMSG: Done
```

Return: *(ACK Received)*

```
+CMSG: Start LoRaWAN transaction
+CMSG: TX "RisingHF"
+CMSG: Wait ACK
+CMSG: ACK Received
+CMSG: RXWIN2, RSSI -88, SNR 13.75
```

```
+CMSG: Done
```

Return: *(ACK with Payload received)*

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

3.7 MSGHEX

Use to send hex format frame which is no need to be confirmed by the server.

Format:

```
AT+MSGHEX="xx xx xx xx"
eg: AT+MSGHEX="11 22 33 AA BB FF"
```

Return:

```
+MSGHEX: Start LoRaWAN transaction
+MSGHEX: TX "xxxxxx"
+MSGHEX: Done
```

For detailed examples, please refer to MSG. MSG and MSGHEX are the same command except payload format.

3.8 CMSGHEX

Use to send hex format frame which must be confirmed by the server.

Format:

```
AT+CMSGHEX="Data to send"
eg: AT+CMSGHEX="11 22 33 AA BB FF"
```

Return:

```
+CMSGHEX: Start LoRaWAN transaction
+CMSGHEX: TX "xxxxxx"
+CMSGHEX: Wait ACK
+CMSGHEX: Done
```

For detailed examples, please refer to CMSG. CMSG and CMSGHEX are the same command except payload format.

3.9 PMSG

Use to send string format LoRaWAN proprietary frames.

Format:

```
AT+PMSG="Data to send"
eg: AT+PMSG="This is a string"
```

Return:

```
+PMSG: Start LoRaWAN transaction
+PMSG: TX "This is a string"
+PMSG: Done
```

3.10 PMSGHEX

Use to send hex format LoRaWAN proprietary frames.

Format:

```
AT+PMSGHEX="Data to send"
eg: AT+PMSGHEX="AB CD"
```

Return:

```
+PMSGHEX: Start LoRaWAN transaction
+PMSGHEX: TX "AB CD"
+PMSGHEX: Done
```

3.11 PORT

Set PORT number which will be used by MSG/CMSG/MSGHEX/CMSGHEX command to send message, port number should range from 1 to 255. User should refer to LoRaWAN specification to choose port.

Format:

```
AT+PORT="port"                    // "port" should be 1~255
eg: AT+PORT=8                     // Set port to 8
eg: AT+PORT=?                     // Check current port
```

Return:

```
+PORT: 8                          // PORT query/set return
```

3.12 ADR

Set ADR function of LoRaWAN module.

Format:

```
AT+ADR="New state"
eg: AT+ADR=ON                     // Enable ADR function
AT+ADR=OFF                        // Disable ADR function
AT+ADR=?                          // Check current ADR configuration
```

Return:

```
+ADR: ON                          // ADR query/set return
```

3.13 DR

Use LoRaWAN defined DRx to set datarate of LoRaWAN AT modem. Refer to Table 2-6 LoRaWAN EU868/EU434 Data Rate Scheme and Table 2-7 LoRaWAN US915/AU920 Data Rate Scheme about the detailed definition of LoRaWAN data rate.

Format:

```
AT+DR="DRx"                       // "DRx" should range 0~15
eg: AT+DR=0
eg: AT+DR=5
eg: AT+DR=DR0
eg: AT+DR=DR5
eg: AT+DR=?                       // Check current selected DataRate
```

Return:

```
+DR: DR0
+DR: US915 DR0  SF10 BW125K
```

Return: *(ADR is functional)*

```
+DR: DR0 (ADR DR3)
+DR: US915 DR3  SF7  BW125K
+DR: US915 DR0  SF10 BW125K
```

3.13.1 Datarate Scheme

LoRaWAN R1.0 defines 2 kinds of datarate scheme: EU868 (or EU868-like) and US915 (or AU920). RisingHF LoRaWAN modem supports both this 2 kinds of datarate.

Check data rate scheme:

```
AT+DR=SCHEME       // Check current band
```

Return: *(US915)*

```
+DR: US915
+DR: US915 DR0  SF10 BW125K
+DR: US915 DR1  SF9  BW125K
+DR: US915 DR2  SF8  BW125K
+DR: US915 DR3  SF7  BW125K
+DR: US915 DR4  SF8  BW500K
+DR: US915 DR5  RFU
+DR: US915 DR6  RFU
+DR: US915 DR7  RFU
+DR: US915 DR8  SF12 BW500K
+DR: US915 DR9  SF11 BW500K
+DR: US915 DR10 SF10 BW500K
+DR: US915 DR11 SF9  BW500K
+DR: US915 DR12 SF8  BW500K
+DR: US915 DR13 SF7  BW500K
+DR: US915 DR14 RFU
+DR: US915 DR15 RFU
```

Return: *(EU868)*

```
+DR: EU868
+DR: EU868 DR0  SF12 BW125K
+DR: EU868 DR1  SF11 BW125K
+DR: EU868 DR2  SF10 BW125K
+DR: EU868 DR3  SF9  BW125K
+DR: EU868 DR4  SF8  BW125K
+DR: EU868 DR5  SF7  BW125K
+DR: EU868 DR6  SF7  BW250K
+DR: EU868 DR7  FSK  50kbps
+DR: EU868 DR8  RFU
+DR: EU868 DR9  RFU
+DR: EU868 DR10 RFU
+DR: EU868 DR11 RFU
```

```
+DR: EU868 DR12 RFU
+DR: EU868 DR13 RFU
+DR: EU868 DR14 RFU
+DR: EU868 DR15 RFU
```

Return: *(CUSTOM)*

```
+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
```

Choose data rate scheme

```
AT+DR=EU868        // LoRaWAN EU868 data rate scheme
AT+DR=US915        // LoRaWAN US915 data rate scheme
AT+DR=CUSTOM       // Customized data rate scheme
```

3.13.2 Customized Data Rate Scheme

In order to provide maximum flexibility to define data rate, this customized data rate scheme feature is added from firmware v1.8.0.

Define a new data rate:

```
AT+DR=CUSTOM, DRx, SFx, BW, [DRx (RXWin1)]
```

Note: [DRx (RXWin1)] is optional parameter, which could be used to specify an RXWin1 data rate for a predefined data rate. For example, "AT+DR=CUSTOM, DR0, SF10, 500, DR4" will map DR0 and DR4, this means when sending a message use DR0, RXWIN1 will set DR11 to receive downlink. This feature is useful when downlink output power is higher than uplink, in this situation, it is reasonable to use higher data rate and still keep uplink budget and downlink budget balance, and make whole network high efficient. If absent, RXWIN1 data rate will be set to the same as uplink data rate in default.

Set data rate to RFU (Reserve For Use)

```
AT+DR=CUSTOM, DRx, RFU
```

Example:

```
// Set DR0 to SF7 and BW125KHz
AT+DR=CUSTOM, DR0, SF7, 125
```

Return:

```
+DR: CUSTOM DR0  SF7  BW125K    //By default downlink DR is the same as uplink DR
```

Example:

```
// Set DR0 to SF9 and BW500KHz, and map DR0 (uplink) with DR11 (downlink).
AT+DR=CUSTOM, DR3, SF10, 500, DR4
```

Return:

```
+DR: CUSTOM DR3  SF10 BW500K DLDR4
```

Example:

```
// Set DR0 to FSK 50kpbs
AT+DR=CUSTOM,DR0,FSK
```

Return:

```
+DR: CUSTOM DR0  FSK  50kbps
```

Example:

```
// Set DR0 to FSK 50kpbs, and map DR0 with DR5,
// Note: [BW] parameter should be set to 0 or any other integer.
AT+DR=CUSTOM,DR0,FSK,0,DR5
```

Return:

```
+DR: CUSTOM DR0  FSK  50kbps
```

Example:

```
// Set DR0 to RFU
AT+DR=CUSTOM, DR0, RFU
```

Return:

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

Example:

```
// Check custom data rate scheme
AT+DR=CUSTOM
AT+DR=SCHEME
```

Return:

```
+DR: CUSTOM
+DR: CUSTOM DR0  SF7  BW125K
+DR: CUSTOM DR1  RFU
+DR: CUSTOM DR2  RFU
+DR: CUSTOM DR3  SF10 BW500K DLDR4
+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
```

Note: After changing the data rate scheme, user should run commands below to check if the data rate settings are valid, and make sure no RFU data rate is used.

AT+CH
AT+RXWIN2
AT+DR

3.14 CH

Set channel parameter of LoRaWAN modem, Set frequecy zero to disable one channel.
Format:

```
AT+CH="LCn", ["Freq"], ["DR_MIN"], ["DR_MAX"]
// Change the LCn channel frequency to "Freq"
// "Freq" is in MHz.
// Available DR_MIN/DR_MAX range DR0 ~ DR15
```

1. Change channel LC0 frequency to 433.3MHz, datarate DR0~DR5
   ```
   eg: AT+CH=0, 433.3, DR0, DR5
   ```

2. Change channel LC1 frequency to 433.5MHz, datarate DR0~DR2
   ```
   eg: AT+CH=1, 433.5, DR0, DR2
   ```

3. Disable channel LC2
   ```
   eg: AT+CH=2, 0
   ```

4. Change channel LC3 frequency to 433.7MHz, with default datarate DR0~DR5
   ```
   eg: AT+CH=?
   eg: AT+CH=3, 433.7
   // It is not recommended to use this command
   ```

5. Change channel LC0 frequency to 433.3MHz,DR7
   ```
   eg: AT+CH=0, 433.3, DR7
   ```

6. Change channel LC3 frequency to 433.7MHz, datarate DR0~DR5
   ```
   eg: AT+CH=3, 433.7, 0, 5
   ```

7. Change channel LC3 frequency to 433.7MHz, datarate DR7
   ```
   eg: AT+CH=3, 433.7, DR7
   ```

8. Check single channel frequency

```
eg: AT+CH=2
+CH: 2,868500000,DR0:DR5
```

Return:

```
+CH: 3,433700000,DR0:DR5
+CH: 3,433700000,DR1
```

Query Return Format:

```
+CH: TOTAL_CHANNEL_NUMBER; LCn,FREQn,DR_MINn,DR_MAXn; LCy,FREQy,DR_MINy,DR_MAXy; ...
LCz,FREQz,DR_MINz,DR_MAXz;
eg: +CH: 8; 0,433300000,DR0,DR5; 1,433500000,DR0,DR5; 2,433700000,DR0,DR5;
3,433900000,DR0,DR5; 4,434100000,DR0,DR5; 5,434300000,DR0,DR5; 6,434500000,DR0,DR5;
7,434700000,DR0,DR5;
```

3.15 POWER

Set TX power of LoRaWAN AT Module, valid power value 20, 14, 11, 8, 5, 2.

Format:

```
AT+POWER="Power value"                // Change LoRaWAN Tx Power
eg: AT+POWER=14                       // Change LoRaWAN AT module TX power to 14dBm
```

Return:

```
+POWER: 14
```

3.16 REPT

Unconfirmed message repeats times.

Format:

```
AT+REPT="Repeat Times"    //Repeat times" should range 1~15
eg: AT+REPT=2             //Repeat 2 times
```

Return:

```
+REPT: 2
```

3.17 RETRY

Confirmed message retry times. Valid range 0~254, if retry times is less than 2, only one message will be sent.

Format:

```
AT+RETRY="Retry Times"    //Retry times" should range 0~15
eg: AT+RETRY=3            //Retry 2 times (3-1), if no ack receive
```

Return:

```
+RETRY: 3
```

3.18 RXWIN2

Set second RX window frequency and Data Rate. This command will change RXWIN2 configuration, which may cause downlink lost, if configuration is wrong.

Format:

```
AT+RXWIN2=Frequency,DRx               // Set frequency and datarate
AT+RXWIN2=Frequency,SFx,BW            // Set RXWIN2 through SF and BW
```

```
AT+ RXWIN2=?                          // Query RX Window2 configuration
AT+ RXWIN2?                          // Query RX Window2 configuration
AT+ RXWIN2                            // Query RX Window2 configuration
eg: AT+RXWIN2=433.3,DR3               // Set RXWIN2 433.3MHz/DR3
eg: AT+RXWIN2=433.3,SF7,500           // Set RXWIN2 433.3MHz/SF7/BW500KHz
```

Return:

```
// General data rate
+RXWIN2: 433300000,DR5
// Customized RX Window2 data rate with spread factor and band width
+RXWIN2: 433000000,SF7,BW125K
```

From firmware 1.8.0, RXWIN2 command could support more flexible configuration. Both LoRaWAN defined data rate (combination of spread faction and band width) and LoRa defined spread factor and band width format are supported. User could set his RXWIN2 to any possible SF and BW scheme, which is a very useful function for LoRaWAN proof of concept.

3.19 RXWIN1

RXWIN1 command could be used to set customized RXWIN channel, each RXWIN channel maps to an uplink channel. When RXWIN1 is enabled, user need make sure every uplink channel has its own mapped RXWIN1 channel, or the modem may perform unexpected.

With this special RXWIN1 command, frequency shift between uplink and downlink becomes possible, then full-duplex is easy to achieve for the system if gateway supports.

a) Enable RXWIN1

```
AT+RXWIN1=ON
+RXWIN1: ON; 3; 0,868100000; 1,868300000; 2,868500000;
```

b) Disable RXWIN1

```
AT+RXWIN1=OFF
+RXWIN1: ON; 3; 0,868100000; 1,868300000; 2,868500000;
```

c) Set RXWIN1

```
AT+RXWIN1=CH,FREQ
```

CH is the channel number 0~71. FREQ is in MHz

```
eg: AT+RXWIN1=0,868.9
```

d) Query RXWIN1 channel

```
AT+RXWIN1=CH
```

CH is the channel number 0~71. FREQ is in Hz

```
eg: AT+RXWIN1=0,868100000
```

e) Check RXWIN1

```
AT+RXWIN1           // return normal or special case
// RXWIN1 is disabled
+RXWIN1: OFF; 3; 0,868100000; 1,868300000; 2,868500000;
// RXWIN1 is enabled
 +RXWIN1: ON; 3; 0,868100000; 1,868300000; 2,868500000;
```

AT+RXWIN1 and its subcommands always returns the channels which are enabled currently. If customized downlink channel is zero, then default downlink channels will be used.

3.20 KEY

Change LoRaWAN related AES-128 KEY. If wrong key is used, your LoRaWAN modem will be rejected by LoRaWAN server. Contact server administrator to know what key should use. All KEYs are unreadable for security, the one who forgets his KEY need rewrite with a new key.

Format:

Change network session key (NWKSKEY)

```
AT+KEY=NWKSKEY, “16 bytes length key”
eg: AT+KEY=NWKSKEY, "2B7E151628AED2A6ABF7158809CF4F3C"
eg: AT+KEY=NWKSKEY, "2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C"
```

Return:

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

Change application session key (APPSKEY)

```
AT+KEY=APPSKEY, “16 bytes length key”
eg: AT+KEY=APPSKEY, "2B7E151628AED2A6ABF7158809CF4F3C"
eg: AT+KEY= APPSKEY, "2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C"
```

Return:

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

Change application session key (APPKEY)

```
AT+KEY=APPKEY, “16 bytes length key”
eg: AT+KEY=APPKEY, "2B7E151628AED2A6ABF7158809CF4F3C"
    AT+KEY= APPKEY, "2B 7E 15 16 28 AE D2 A6 AB F7 15 88 09 CF 4F 3C"
```

Return:

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

3.21 FDEFAULT

Reset LoRaWAN AT modem to factory default configuration. Command “AT+FDEFAULT=RISINGHF” should be used to do the factory reset. Company name "RISINGHF" (case insensitive) is kept on purpose to avoid command to be triggered unexpectedly. After reset user could use “Query” format command to know which configuration is used.

Format:

```
AT+FDEFAULT=RISINGHF
```

Return:

```
+FDEFAULT: OK
```

Item	Value
Mode	LoRaWAN ABP
Channel	3 default channels 868.1MHz 868.3MHz 868.5MHz
Datarate Range	DR0 : DR5
Unconfirmed Message Repetition	1
Confirmed Message Retry	3
Port	8
Datarate	DR0
ADR	ON
Power	14dBm
RXWIN2	869.525MHz, DR3
RXWIN1 Delay	1s
RXWIN2 Delay	2s
JOIN ACCEPT RXWIN1 Delay	5s
JOIN ACCEPT RXWIN2 Delay	6s
Listen Before Talk Threshold	-90dBm
EU868 Duty Cycle Limitation	OFF
LoRaWAN Public Network	ON
NwkSKey	2B7E151628AED2A6ABF7158809CF4F3C
AppSKey	2B7E151628AED2A6ABF7158809CF4F3C
AppKey	2B7E151628AED2A6ABF7158809CF4F3C
AppEui	52:69:73:69:6e:67:48:46
Uplink Counter	1
Downlink Counter	0
Multicast	OFF
Customized RXWIN1	OFF

Table 3-2 Factory default configuration

NOTE: Customized modem may be precompiled to use a different factory default configuration. If any user has request, please contact RisingHF support@risinghf.com.

3.22 DFU

Use to enter DFU mode. If user need to enter DFU mode to update LoRaWAN modem firmware, then user should first send "AT+DFU=ON" command to enable firmware upgrade. Once DFU mode is on, user should repower LoRaWAN modem (unplug and plug back), after repowered LoRaWAN will enter

DFU mode, user could use DfuSe tool to update the firmware. If user want to exit DFU mode without upgrade, user just need to repower again, LoRaWAN modem will exit DFU mode automatically.

For UART bootloader, "AT+DFU=ON" command will make device enter bootloader mode automatically.

Format:

```
AT+DFU="New state"
eg: AT+DFU=ON            // Enable DFU function
eg: AT+DFU=OFF           // Disable DFU function
AT+DFU=?                 // Check if DFU is enabled configuration
```

Return:

```
+DFU: ON
+DFU: OFF
```

Example: (RHF76-052AM/RHF76-052AN)

```
+DFU: ON
+DFU: +DFU: Enter bootloader after reboot in 5s...
```

Example: (RHF3M076)

```
+DFU: ON                // Need manually repower RHF3M076 device
```

Note: DFU mode is risky. Before updating, user must make sure the firmware is supplied by RisingHF, a wrong firmware may brick LoRaWAN modem.

3.23 HELP

Return brief help information. Refer to Table 3-1 Command List.

Format:

```
AT+HELP=?
AT+HELP?
AT+HELP
```

Return:

```
+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)
       PMSG -- Proprietary
    PMSGHEX -- Proprietary (HEX)
         CH -- Set channel
        ADR -- ADR ON/OFF
```

```
    DR -- Set datarate
  REPT -- MSG/MSGHEX repetition
 RETRY -- CMSG/CMSGHEX retry
 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
    LW -- LoRaWAN misc conf
  TEST -- Test commands
  UART -- UART configure
   REG -- Control RF Chip
 DELAY -- RX window delay
   VDD -- Get VDD
   RTC -- RTC
```

3.24 MODE

Use to select work mode. LWABP[7], LWOTAA[8], TEST are supported. LoRaWAN modem can only work with one mode at a time. By default, LWABP is enabled, all test commands are unavailable, LoRaWAN will return error(-12) if it receives test command in non-test mode.

"AT+MODE" command will reset LoRaWAN stack when first enter LWABP/LWOTTA mode and reset LoRa chip when first enter test mode.

LWABP/LWOTAA mode status is remembered by LoRaWAN modem, each time LoRaWAN modem starts, it will enter previous working mode before reset or repower.

Format:

```
AT+MODE="New mode"
eg: AT+MODE=TEST                // Enter TEST mode
eg: AT+MODE=LWOTAA              // Enter TEST mode
eg: AT+MODE=LWABP               // Enter LWABP mode
```

Return

```
+MODE: LWABP                    // Enter LWABP mode successfully
+MODE: LWOTAA                   // Enter LWABP mode successfully
+MODE: TEST                     // Enter TEST mode successfully
```

3.25 JOIN

When OTAA mode is enabled, JOIN command could use to join a known network.

[7] *LWABP is short for LoRaWAN Activation By Personalization. Check < LoRaWAN™ Specification> for details*
[8] *LWOTAA is short for LoRaWAN Over-The-Air-Activation.*

Format:

```
AT+JOIN
AT+JOIN=FORCE
```

1. Join

```
eg: AT+JOIN                          // Send JOIN request
```

2. Disconnect with current network, force send one JOIN request

```
eg: AT+JOIN=FORCE
```

3. Returns
   a) Join successfully

```
+JOIN: Starting
+JOIN: NORMAL
+JOIN: NetID 000024 DevAddr 48:00:00:01
+JOIN: Done
```

   b) Join failed

```
+JOIN: Join failed
```

   c) Join process is ongoing

```
+JOIN: LoRaWAN modem is busy
```

3.26 CLASS

This command could enable LoRaWAN modem to work at different mode (Class A/B[9]/C). LoRaWAN modem works at class A mode when power on, user need manually switch mode to class B/C as needed.

Format:

```
eg: AT+CLASS=A                       // Enable Class A mode
eg: AT+CLASS=C                       // Enable Class C mode
```

Return

```
+CLASS: A                            // Enter LWABP mode successfully
```

3.27 DELAY

RX window delay configuration command. Supports configure RECEIVE_DELAY1, RECEIVE_DELAY2, JOIN_ACCEPT_DELAY1, JOIN_ACCEPT_DELAY2.

Command	Item	Comments
AT+DELAY=RX1, ms	RECEIVE_DELAY1	RX window 1 delay time
AT+DELAY=RX2, ms	RECEIVE_DELAY2	RX window 1 delay time
AT+DELAY=JRX1, ms	JOIN_ACCEPT_DELAY1	Join accept RX window 1 delay time
AT+DELAY=JRX2, ms	JOIN_ACCEPT_DELAY2	Join accept RX window 2 delay time

Table 3-3 LoRaWAN Delay Items

Format:

```
// Query delay settings
AT+DELAY
AT+DELAY?
```

[9] Class B is unavailable in current version

```
AT+DELAY=?

// Set delay
AT+DELAY=RX1, 1000    // Unit: ms
AT+DELAY=RX2, 2000
AT+DELAY=JRX1, 5000
AT+DELAY=JRX2, 6000
```

Return:

```
+DELAY RX1, 1000
+DELAY RX2, 2000
+DELAY JRX1, 5000
+DELAY JRX2, 6000
```

3.28 LW

LW commands is a collection of several LoRaWAN control commands. Include CDR, ULDL, DC, NET, MC, THLD.

3.28.1 CDR

CDR is for customized data rate control, this command could be used to specify the valid data rate range of uplink packet and downlink packet.

Format:

```
AT+LW=CDR, [ UL_DR_MIN, UL_DR_MAX, DL_DR_MIN, DL_DR_MAX ]
```

1. Check current datarate limitation

```
AT+LW=CDR
+LW: CDR, TXDR(0,7), RXDR(0,7)              //EU868
+LW: CDR, TXDR(0,4), RXDR(8,13)             //AU920
```

2. Set customized data rate limitation, this command is only valid when customized data rate mode is enabled

```
AT+DR=CUSTOM
AT+LW=CDR, 0,7,0,7
+LW: CDR, TXDR(0,7), RXDR(0,7)
```

3.28.2 ULDL

Set and read uplink and downlink counter.

Format:

```
AT+LW=ULDL, UL_COUNTER, DL_COUNTER
```

1. Read counter

```
AT+LW=ULDL
+LW: ULDL 1, 0
```

2. Set counter

```
AT+LW=ULDL, 5, 10
+LW: ULDL 5, 10
```

3.28.3 DC

EU868 Duty Cycle limitation and LoRaWAN Transmit Duty Cycle control interface. This option is mandatory to be set to on, when using in Europe to follow ETSI regulation. And this command could also be used to set a specify value for **MaxDCycle**, valid range 0 ~ 15. And the tansmit aggregated duty cycle is allowed by:

$$AggregatedDutyCylce = \frac{1}{2^{MaxDCycle}}$$

A value of 0 corresponds to “no duty cycle limitation” except the one set by the regional regulation.

MaxDCycle	$2^{MaxDCycle}$	Aggregated Duty Cycle
0	1	100.000%
1	2	50.000%
2	4	25.000%
3	8	12.500%
4	16	6.250%
5	32	3.125%
6	64	1.563%
7	128	0.781%
8	256	0.391%
9	512	0.195%
10	1024	0.098%
11	2048	0.049%
12	4096	0.024%
13	8192	0.012%
14	16384	0.006%
15	32768	0.003%

Table 3-4 Duty Cycle Control

Format:

```
AT+LW=DC, "ON/OFF"
AT+LW=DC, MaxDCycle
```

Return format:

```
+LW=DC, "ON/OFF", MaxDCycle
```

1. Check DC option

```
AT+LW=DC
+LW: DC, ON, 0            // EU868 Duty Cycle ON, MaxDCycle is 0
```

2. Set EU868 ETSI Duty Cycle on

```
AT+LW=DC, ON
+LW: DC, ON, 0            //
```

3. Set EU868 ETSI Duty Cycle off

```
AT+LW=DC, OFF
+LW: DC, OFF
```

4. Set LoRaWAN MaxDCycle

```
AT+LW=DC
+LW: DC, ON, 0     // EU868 Duty Cycle ON, MaxDCycle is 0
+LW: DC, OFF, 1    // EU868 Duty Cycle OFF or not in EU868 mode, MaxDCycle is 0
```

3.28.4 NET

This command is used to choose public LoRaWAN network or private network. Set ON to choose public network, set OFF to choose private network.

Format:

```
AT+LW=NET, "ON/OFF"
```

1. Check network type

```
AT+LW=NET
+LW: NET, ON
```

2. Set public network on

```
AT+LW=NET, ON
+LW: NET, ON
```

3. Set public network off

```
AT+LW=NET, OFF
+LW: NET, OFF
```

3.28.5 MC

MC command could enable an extra broadcast address for LoRaWAN modem. This command is useful when using Class C mode, to control a group of devices which has the same multi cast address at the same time to use a broadcast command.

Format:

```
AT+LW=MC,["ON/OFF"],["DEVADDR"],["NWKSKEY"],["APPSKEY"],["COUNTER"]
```

1. Check multi cast status

```
AT+LW=MC
+LW: MC, OFF, 00cf3e72, 0
```

2. Set MC parameters

```
AT+LW=MC,ON,"11223344","2B7E151628AED2A6ABF7158809CF4F3C","2B7E151628AED2A6ABF7158809CF4F3C",0
+LW: MC, ON, 11223344, 0
```

Default MC_NWKSKEY and MC_APPSKEY both are ***2B7E151628AED2A6ABF7158809CF4F3C***.

3.28.6 THLD

Listen before talk threshold control, available value -55 ~ -105 (dBm).

Format:

```
AT+LW=THLD, NEW_THLD
```

1. Check current threshold level

```
AT+LW=THLD
+LW: THLD, -90
```

2. Set new threshold

```
AT+LW=THLD, -85
+LW: THLD, -85
```

3.29 LOWPOWER[10]

Sleep command could be used to make modem enter sleep mode with ultra-low power consumption, check device datasheet to know detailed parameters. After device enters in sleep mode, host device could send any character to wakeup it, after this host should wait at least 5ms to send next commands, so that modem could get ready. A C code example is attached to show how to handle LOWPOWER mode.

During the LOWPOWER mode, level of UART RX pin must keep unchanged, any signal on UART RX pin will make modem exit LOWPOWER mode. When LOWPOWER mode is triggered, there are extra 30ms before modem really enter sleep mode, host device should use this time to de-initial its UART if it is needed.

It also supplies feature to set a lowpower alarm from 100ms to 129600000ms (36hrs).

Format:

```
eg: AT+LOWPOWER                    // Sleep until woke up by UART TX
eg: AT+LOWPOWER=1000[11]           // Sleep 1000ms until timeout
eg: AT+LOWPOWER=AUTOON             // Enter extremely low power mode
eg: AT+LOWPOWER=AUTOOFF            // Exit extremely low power mode
                                   // Query symbol is not available
```

Return

```
+LOWPOWER: SLEEP                  // Enter SLEEP mode successfully
U+LOWPOWER: WAKEUP                 // Modem is woke up.
```

Example:

```
AT+LOWPOWER=1000
U+LOWPOWER: WAKEUP
```

Note: Extra 0x55 will be sent to host mcu to perform a wakeup signal for it, LoRaWAN AT Modem will wait for 15ms before sending “+LOWPOWER: WAKEUP” frame , host MCU could use this 15ms to initialize then to receive the WAKEUP frame.

C example:

```
printf("AT+LOWPOWER\r\n");// Set low-power mode
// ...
// HOST do other operation.
// ...
printf("A");              // Send any character to wake-up the modem
DelayMs(5);               // Wait modem ready
printf("AT+ID\r\n");      // New operation
```

3.29.1 Low Power Auto Mode

AT+LOWPOWER=AUTOON command could be used to enable extremely low power mode. In this mode modem will enter deep sleep mode when it is idle. The idle status means no ongoing receiving commands, no ongoing LoRaWAN service needed. If this mode is enabled, when sending commands to modem, at least four 0xFFs need to be added to the start of each AT command. At the same time, each return message is also added with four 0xFFs. The host mcu parser should be able to handle these wakeup characters.

[10] RHF76-052AM (UART enabled) supports this feature, RHF3M076 (USB enabled) doesn't support sleep mode.

[11] Available after v1.9.5

.

Example to send AT+ID command with low power auto mode

0xFF	0xFF	0xFF	0xFF	'A'	'T'	'+'	'I'	'D'	'\r'	'\n'

Use AT+LOWPOWER=AUTOOFF command to turn off low power auto mode, four 0xFFs are also needed to add to the start of the command.

FF	FF	FF	FF	A	T	+	L	O	W	P	O	W	E	R	=	A	U	T	O	O	F	F	\r	\n
FF	FF	FF	FF	61	74	2B	6C	6F	77	70	6F	77	65	72	3D	61	75	74	6F	6F	66	66	0D	0A

Below hex string equals to the table above, send it to modem in hex format could also disable the low power auto on feature.

FFFFFFFF61742B6C6F77706F7765723D6175746F6F66660D0A

C example:

```
uint8_t buf[256];
printf("AT+LOWPOWER=AUTOON\r\n");// Set low-power auto on mode
// ...
// HOST do other operation.
// ...
buf[0] = 0xFF;
buf[1] = 0xFF;
buf[2] = 0xFF;
buf[3] = 0xFF;
sprintf(buf+4, "AT+MSG=\"string\"\r\n");
uart_putbuf(buf, strlen(buf+4)+4); // Send command to LoRaWAN modem
```

3.30 VDD

Get supply voltage, return value in unit 0.01V. Format:

AT+VDD

AT+VDD?

AT+VDD=?

Example:

AT+VDD

+VDD: 3.30V

3.31 RTC

Get real time from LoRaWAN modem. When modem is powered on, it always starts from 2000-01-01 00:00:00, user could set new time to modem to sync to the real time.

1. Check current time

   AT+RTC

   +RTC: 2000-01-01 01:00:28 // this means the modem has kept running for 1 hour

2. Set new time to "2016-06-14 18:16:11", this format is very critical, must keep the same format as "yyyy-MM-dd HH:mm:ss", year must starts with 20xx.

   AT+RTC="2016-06-14 18:16:11"

   +RTC: 2016-06-14 18:16:11

3.32 EEPROM

LoRaWAN Modem supports maximum 256 bytes to save user data. Format:

```
AT+EEPROM=ADDR
AT+EEPROM=ADDR,VAL
```

Return:

```
+EEPROM: ADDR, VAL
```

Both ADDR and VAL are in hex format. Valid range is 0x00 ~ 0xFF. Example:

```
AT+EEPROM=00, AB
+EEPROM: 00, AB
```

3.33 UART

3.33.1 TIMEOUT

LoRaWAN AT modem supports UART receive timeout feature, AT parser inside the modem start counts from first "AT" character is received, when counter overflows, a "Input timeout" event will be triggered. One message like below will be showed. Maximum timeout value is 300ms.

```
+INFO: Input timeout, start parse

AT+UART=TIMEOUT, 0              // Disable timeout feature
AT+UART=TIMEOUT, 1000           // Set timeout 1s feature
AT+UART=TIMEOUT                 // Get timeout value
```

3.34 TEST

TEST command is not like other command, it is a serious command, includes several sub-commands, refer to table below. With test mode, user could do RF performance test quickly without any knowledge of LoRa chip. Commands which are related to RF configuration is disabled in test mode.

Sub-Command	Comment
HELP	Print test command help information, make LoRa transceiver to standby mode
STOP	Set LoRaWAN Modem to TEST stop mode
TXCW	Transmit continuous wave
TXCLORA	Transmit continuous LoRa signal
RFCFG	Set RF configuration in TEST mode
RXLRPKT	Continuous receive pure LoRa packet, print once there is new packet received
TXLRPKT	Send one HEX format packet out
TXLRSTR	Send one string format packet
RSSI	Get RSSI value of specified channel
LWDL	Send LoRaWAN downlink packet, useful tool to test CLASS C device

Table 3-5 TEST mode sub-command list

3.34.1 Print Help Information

Format:

```
AT+TSET=HELP
```

Return:

```
+TEST: HELP
       STOP -- AT+TEST=STOP
       HELP -- AT+TSET=HELP
       TXCW -- AT+TEST=TXCW
    TXCLORA -- AT+TEST=TXCLORA
      RFCFG -- AT+TEST=RFCFG,[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]
```

"[ ]" means the parameter is omissible together with parameters behind it

3.34.2 Enter TEST mode

Before use any TEST command, LoRaWAN should work in test mode, or error code -12 will be reported.

Command:

```
AT+MODE=TEST
```

Return:

```
+MODE: TEST                 // LoRaWAN modem enter TEST mode successfully
```

3.34.3 Query RF configuration

First thing after enter TEST mode should be check RF configuration.

Command:

```
AT+TEST=?                    // Query test mode and RF configuration
```

Return Error:

```
+TEST: ERROR(-12)
```

When come with ERROR(-12), user could try "AT+MODE=?" to check if LoRaWAN modem is in TEST mode, if not user should enter test mode first.

Return STOP:

```
+TEST: STOP
+TEST: RFCFG F:433300000, SF12, BW125K, TXPR:8, RXPR:8, POW:14dBm
```

Return TXLRPKT:

```
+TEST: TXLRPKT
+TEST: RFCFG F:433300000, SF12, BW125K, TXPR:8, RXPR:8, POW:14dBm
```

Return RXLRPKT:

```
+TEST: RXLRPKT
+TEST: RFCFG F:433300000, SF12, BW125K, TXPR:8, RXPR:8, POW:14dBm
```

Return TXCW:

```
+TEST: TXCW
+TEST: RFCFG F:433300000, SF12, BW125K, TXPR:8, RXPR:8, POW:14dBm
```

3.34.4 Set RF Configuration

RFCFG supports set frequency, SF, band width, TX preamble, RX preamble and TX power settings.

TX and RX shares all configuration except "preamble length", user could choose different preamble length. For LoRa communication, it is strongly recommended to set RX preamble length longer than TX's. Bandwidth only supports 125KHz / 250KHz / 500KHz.

Depend on Semtech SX1276 (PA_BOOST/RFO) and design solution of RisingHF module, MAX output power of different band LoRaWAN modem could be different. Check below table about the details.

Device	Bootloader	Interface	LF Band[12]	HF Band[13]
RHF3M076	USB	USB	20dBm	14dBm
RHF76-052AM	UART	UART	20dBm	14dBm
RHF76-052AN	USB	UART	20dBm	14dBm

Table 3-6 MAX output power of HF and LF band

RHF3M076 is part number of RisingHF LoRaWAN modem.

Format:

"[ ]" means the parameter is omissible together with parameters after it

[12] LF Band: Frequency is less than 525MHz

[13] HF Band: Frequency is larger than 525MHz

```
AT+TEST=RFCFG,[FREQUENCY],[SF],[BANDWIDTH],[TX PR],[RX PR],[TX POWER]

// TX Configuration/868MHz/SF9/BW125KHz/TXPREAMBEL 12/RXPREAMBEL 15/14dBm
eg: AT+TEST=RFCFG,866,SF12,125,12,15,14
```

Return:

```
+TEST: RFCFG F:866000000,SF12,BW125K,TXPR:12,RXPR:15,POW:14dBm
```

3.34.5 TX LoRa Packet

After enter test mode, user could send LoRa packet through "AT+TEST=TXLRPKT" sub-command. The command format is like below:

```
AT+TEST=TXLRPKT, "HEX STRING"
```

Command sequence to send LoRa packet:

```
// Set test mode
AT+MODE=TEST
// Query test mode, check RF configuration
AT+TEST=?
// Set RF Configuration
AT+TEST=RFCFG,[FREQUENCY],[SF],[BANDWIDTH],[TX PR],[RX PR],[TX POWER]
// Send HEX format packet
AT+TEST=TXLRPKT, "HEX String"
eg:AT+TEST=TXLRPKT, "00 AA 11 BB 22 CC"
// Send TEXT format packet
AT+TEST=TXLRSTR, "TEXT"
eg:AT+TEST=TXLRSTR, "LoRaWAN Modem"
```

Return:

```
+TEST: TXLRPKT “00 11 22 33 44”
+TEST: TXLRSTR "LoRaWAN Modem"
+TEST: TX DONE
```

3.34.6 RX LoRa Packet

After enter test mode, user could enter LoRa packet continuous RX mode through RXLRPKT sub-command. Like below:

```
AT+TEST=RXLRPKT
```

Command sequence to receive LoRa packet:

```
// Set test mode
AT+MODE=TEST
// Query test mode, check RF configuration
AT+TEST=?
// Set RF Configuration
AT+TEST=RFCFG,[FREQUENCY],[SF],[BANDWIDTH],[TX PR],[RX PR],[TX POWER]
// Enter RX continuous mode
AT+TEST=RXLRPKT
```

Return:

```
+TEST: LEN:250, RSSI:-106, SNR:10
+TEST: RX 00 11 22 33 44
```

3.34.7 TX Continuous Wave

Before enable TXCW function, right frequency and TX power should be set. Format:

```
AT+TEST=TXCW
```

Return:

```
+TEST: TXCW
```

3.34.8 TX Continuous LoRa

Before enable TXCLORA function, right frequency and TX power should be set. Format:

```
AT+TEST= TXCLORA
```

Return:

```
+TEST: TXCLORA
```

3.34.9 RSSI

Read RSSI from a specified channel. Format:

```
AT+TEST = RSSI, frequency(MHz), [times]
```

Return:

```
+TEST: RSSI, frequency
+TEST: RSSI 0, RSSI0; 1, RSSI1; ... n, RSSIn;
...
+TEST: RSSI n+1, RSSI0; n+2, RSSI1; ..., ...
...
+TEST: RSSI, AVG average, MAX maximum, MIN minimum
```

3.34.10 LWDL

LWDL command is designed to test LoRaWAN modem CLASS C function. Use this command, user can easily send data to a working LoRaWAN Class C device.

```
AT+TEST = LWDL, TYPE, "DevAddr", "HEX STRING", [FCNT], [FPORT], [FCTRL]
```

Return:

```
AT+TEST=LWDL,MSG,"009291ad","14 54 54 88 08 93 122 35", 1, 5, 00
+TEST: LWDL "A0 AD 91 92 00 00 01 00 05 13 4D 37 EA 53 E3 02 3A 9F 01 25 D2 34"
+TEST: LORAWAN DOWNLINK TX DONE
```

3.35 REG

REG command could be used to control LoRa SX1276 register directly. In theory, user could use this command to do any operation, TX packet, RX packet, TXCW, even user could use this command to develop PC GUI tool to play with LoRa.

3.35.1 Dump All Registers

This command dump LoRa chip SX1276 registers (0x00-0x7F), 0x00 address value has no meaning. Format:

```
AT+REG=?<CR><LF>
```

Return:

```
+REG: OK
    00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
00: 00 88 1A 0B 00 52 D8 80 00 4F 09 2B 03 22 80 00
10: 00 1F 00 00 00 00 00 00 00 00 00 00 72 97 FF
20: 00 50 01 FF 00 00 04 00 00 00 00 00 00 50 14 40
30: 00 C3 05 27 1C 0A 03 0A 42 12 40 1D 00 A1 00 00
40: 00 00 12 24 2D 00 03 00 04 23 00 09 05 84 32 2B
50: 14 00 00 10 00 00 00 0F E0 00 0C 00 07 00 5C 78
60: 00 19 0C 4B CC 0D 81 20 04 47 AF 3F B4 00 D9 0B
70: D0 01 12 00 00 00 00 00 00 00 00 00 00 00 00 00
```

3.35.2 Read

Read register value with address.

Format:

```
AT+REG="HEX ADDRESS"<CR><LF>
eg: AT+REG=01<CR><LF>
```

Return:

```
+REG: Reg 0x01 Value 0x88
```

3.35.3 Write

Write register value to address.

Format:

```
AT+REG="HEX ADDRESS", "HEX VALUE"<CR><LF>
eg: AT+REG=01, 0x80<CR><LF>
```

Return:

```
+REG: Write Value 0x80 to Reg 0x01
```

3.35.4 Read FIFO

Format:

```
AT+REG=RFIFO, BYTES<CR><LF>
eg: AT+REG=RFIFO, 6<CR><LF>
```

Return:

```
+TEST: RFIFO 00 00 0B 9F 04 05
```

3.35.5 Write FIFO

Format:

```
AT+REG = "WFIFO", "HEX DATA"
AT+REG = "WFIFO", "10 20 30 40 55"
```

Return:

```
+TEST: WFIFO 10 20 30 40 55
```

Revision

V3.1 2016-06-30
+ Sync to FW v2.0.4
+ Add LinkCheckReq

V3.0 2016-06-26
+ Sync to FW v2.0.2
+ Support sending LoRaWAN proprietary frame
+ RETRY command to set confirmed message retry times
+ RXWIN1 is updated
+ JOIN command is simplified
+ Multi cast feature
+ LW command to change LBT threshold configuration
+ LOWPOWER command alarm feature, add timer to sleep mode
+ RTC yyyy-MM-dd HH:mm:ss
+ VDD command to read supply voltage
+ REG command to control SX1276 RF chip register directly (Merge PS01510)
+ EEPROM command

V2.4 2015-12-03
+ Sync to FW v1.9.1

V2.3 2015-11-26
+ Maximum payload size 255 bytes
+ Add AT+DELAY command
+ AT+DR=CUSTOM command FSK support

V2.1 2015-11-24
+ Fix typo
+ Remove all tedious <CR><LF>

V2.0 2015-11-18
+ Add RXWIN1 command
+ Add RXWIN2 SF and BW format command
+ Add AT+TEST=RFCFG command
+ Update DR, supports customized data rate scheme
+ Update doc for LoRaWAN mode firmware V1.8.0

V1.6 2015-09-11
+ AT+DR=BAND, AT+TEST=RSSI
+ Update doc for LoRaWAN mode firmware V1.6.8

V1.5 2015-09-04

+ Add "LOWPOWER" command to enable LowPower Mode
+ Add commands CH, PORT, JOIN, UART
+ Update ID, DR, TEST,
+ Update doc for LoRaWAN mode firmware V1.6.0

V1.2 2015-06-04

+ Add "CLASS" command to enable LoRaWAN Class C
+ Update doc for LoRaWAN mode firmware V1.2.6

V1.1 2015-05-14

+ Update "2.4 Error"
+ Fix typo
+ Add content about LoRaWAN output power
+ Update doc for LoRaWAN mode firmware V1.2.4

V1.0 2015-05-09

+ Use new template
+ Doc is for LoRaWAN mode firmware V1.1.0

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