UM02103

RHF0M083 User Manual

V1.0

Document information

Info	Content
Keywords	*LoRa-2.4G, AT Command, Relay, Slave, Master*
Abstract	This document defines relay AT command format used by RisingHF LoRa-2.4G module

Content

1 Introduction

LoRa-2.4G relay designed by RisingHF follows LoRa-2.4G relay specification and add customized features like buffer mode (LoRa-2.4G application payload decrypted) and reserved replay mode. The LoRa-2.4G relay or relay mentioned in this documentation stands for RisingHF relay.
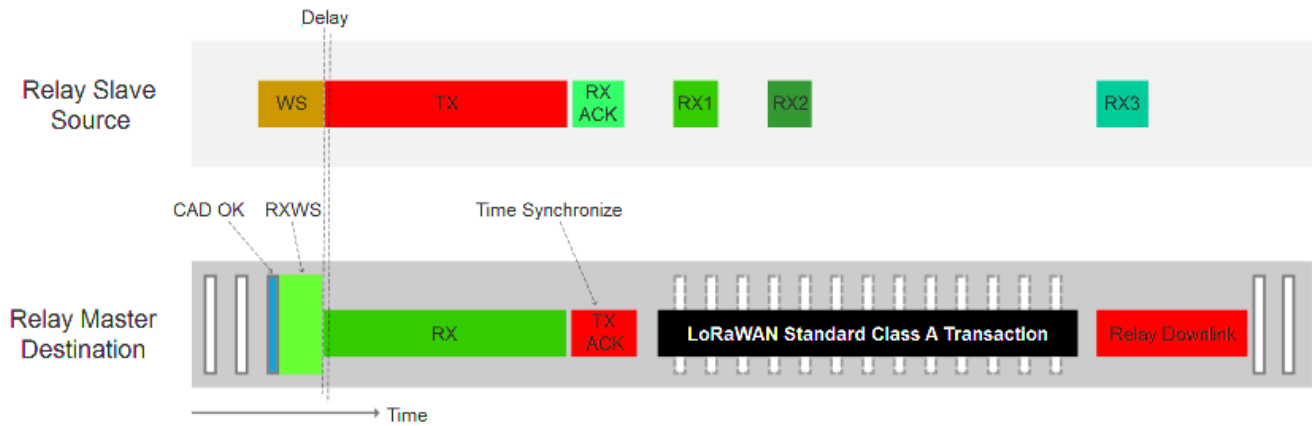

Figure 1 LoRa-2.4G Relay Timing

LoRa-2.4G relay is defined to two roles, the slave and the master. During relay communication slave first send wake-up sequence (WS) to wake-up master and let master receive the WS packet, the wake-up sequence contains the following standard LoRa-2.4G uplink RF configuration (DR / CH). When finished WS packet receiving, master switch to uplink receiving mode to receive slave uplink with correct channel and data rate. To do it this way, slave can communicate with relay and gateway together at the same time. If uplink is successfully received, master sends on ACK to slave, slave knows uplink delivered successfully if ACK packet received, the ACK packet also contains a time synchronize information, to let slave sync it time with master to predict master's CAD window and send shorter wake-up sequence, and thus save power.

At the same time, slave keeps LoRa-2.4G Class A RX1 and RX2. The additional RX3 window is for relay downlink communication.

Refer to LoRa-2.4G timing diagram for details.

2 Get Started

2.1 Preparation

➢ USB to TTL Serial tool x 2pcs
➢ RHF0M083 x 2pcs
➢ PC
➢ Serial Terminal tool (SSCOM, PUTTY, TERATERM, etc.)

RHF0M083 must be at v5.x.x firmware. If it is not, upgrade first.

2.2 Relay Communication (Manual Key Mode)

Before relay communication, user should select one device as master and another as slave.
1. Configure Slave
   a) **AT+DR=LR24**; (Or any other available band as wishes)
   b) **AT+RELAY=SLAVE**; Set device to slave mode
   c) **AT+MODE=ABP**
   d) **AT+ID**; Get slave DEVADDR
2. Configure Master
   a) **AT+DR=LR24**; (Use the same configuration as slave)
   b) **AT+RELAY=WL,ADD,devaddr,nwkskey,appskey,relayskey** (use slave's DEVADDR/NWKSKEY/APPSKEY/RELAYSKEY)
   c) **AT+RELAY=MASTER**; Set device to master mode
3. Slave send packet **AT+MSG=xxxxxxx**
4. Master receive packet by polling **AT+RELAY=PL**

Enable low power mode by sending AT+LOWPOWER=AUTOON to both master and slave, after low power mode enabled, user should send four 0xFF wake up prefixes at each AT command.

2.3 Relay Communication (Auto Key Mode)

Before relay communication, user should select one device as master and another as slave.
1. Configure Slave
   a) **AT+DR=LR24**; (Or any other available band as wishes)
   b) **AT+RELAY=SLAVE**; Set device to slave mode
   c) **AT+MODE=ABP**
   d) **AT+ID**; Get slave DEVADDR
   e) **AT+KEY=AUTO**
2. Configure Master
   a) **AT+DR=LR24**; (Use the same configuration as slave)
   b) Register device address to master whitelist
      i. **AT+RELAY=WL,ADD,devaddr** specify a single DevAddr
      ii. **AT+RELAY=WL,devaddr_min,devaddr_max** specify device address range
   c) **AT+RELAY=MASTER**; Set device to master mode
3. Slave send packet **AT+MSG=xxxxxxx**

4. Master receive packet by polling **AT+RELAY=PL**

Above communication use default RootKey, if user need to specify a new RootKey use "**AT+KEY=RO OTKEY, aeskey**" command to overwrite default one.

3 Advanced Application Guide

3.1 Slave LoRa-2.4G Communication

To simplify LoRa-2.4G relay design and increase communication system stability. The Relay implementation make trade-off on connectivity switch between relay and gateway challenge. Once configured relay slave will always try to communicate with Relay and let application user to decide which connectivity it should use (Configure through AT command).

AT + MSG / CMSG / MSGHEX / CMSGHEX are still available for packet transmitting. Relay slave LoRa-2.4G transaction will take longer time to finish. Maximum timeout to be defined

3.2 Master LoRa-2.4G Communication

Relay master LoRa-2.4G communication will keep the same as standard LoRa-2.4G AT modem. AT + MSG / CMSG / MSGHEX / CMSGHEX are still available for relay master mode.

3.3 Relay Buffer Mode Limitation

➢ Relay Buffer Mode never supports uplink frame counter which is larger than 0x3FFFFFF (67108863), it is equal to about 21 years' time device transmitting at 10 seconds period
➢ If two master devices work closely, make sure the masters are isolated either by wake-up channel, RootKeys (Key Auto mode), or register device to different master (manual mode). In a word, whitelist or wake-up channel of the two masters must be carefully designed.
➢ Relay Buffer Mode master doesn't send ACK to slave device
➢ Relay Buffer Mode doesn't support ADR
➢ Relay Buffer Mode supports only ABP communication

3.4 Key Mode

3.4.1 Automatic Session Key Workflow

1. Relay Slave set DevAddr / RootKey and enable auto key mode
2. Relay Master set root key
3. Relay Master set DevAddr range
4. Relay Master and Slave communication without specify any session key

3.4.2 Manually Bind Slave and Master Workflow

1. Relay Slave set DevAddr / NwkSKey / AppSKey / RelaySKey (nothing special, no need algorithm)
2. Relay Master set single DevAddr (DevAddr / NwkSKey / AppSKey / RelaySKey needed)
3. Relay Master and Slave communication

Master supports two workflows at the same time.

3.5 Relay Channel Configuration Guidance

LoRa receiver is very sensitive and can restore signal under noise floor. This characteristic brings trouble when scanning CAD on two channel. If the signal is strong and channel space are not far enough, master is possible to be woken-up on the wrong channel, and lead to communication error. This CAD error wake-up test aims to get a guideline about how to select channel space.

Spread Factor and Band Width	Recommended channel space
SF12 / 812.5KHz	>= 5MHz

3.6 Relay Master Database

Relay master integrates a small footprint database to save slave information (whitelist and blacklist) in non-volatile area. The data base will be kept at each firmware upgrade without any notification, user can use AT+RELAY=WL / BL command to write and read the database.

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.
(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
NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

        This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

ORIGINAL EQUIPMENT MANUFACTURER (OEM) NOTES
        ☐ The OEM must certify the final end product to comply with unintentional radiators before declaring compliance of the final product to Part 15 of the FCC rules and regulations. Integrationinto devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change.
          The OEM must comply with the FCC labeling requirements. If the module's label is not visible when installed, then an additional permanent label must be applied on the outside of the finished product which states:
        "Contains transmitter module FCC ID: 2AJUZ0M083. Additionally, the following statement should be included on the label and in the final product's user manual: "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 interferences, and
        (2) this device must accept any interference received, including interference that may cause undesired operation."
        The module is limited to installation in mobile or fixed applications. Separate approval is required for all other operating configurations, including portable configuration with respect to Part 2.1093 and different antenna configurations.
Professional installation:
This module need to be installed under professional guidance, if there is any questions, please contact us.

Antenna information：Gain: 2.0dBi; Type: Dipole antenna; Impedance: 50 Ω

The module can work on the host device, it means the driver is matched, different host devices have the different drives.

The host manufacturer can not get the module drive authorization to remain compliant, until the host device compliance with the requirements.

Note: The module has the antenna schematics, so the host device just provide the antenna connector for this device. The antenna port and connector is designed by OEM, it need to compliance with the 15.203 requirement, and it is not designed for use with high-gain directional antennas.

A module or modules can only be used without additional authorizations if they have been tested and granted under the same intended end-use operational conditions, including simultaneous transmission operations.

When they have not been tested and granted in this manner, additional testing and/or FCC application filing may be required. The most straightforward approach to address additional testing conditions is to have the grantee responsible for the certification of at least one of the modules submit a permissive change application.

When having a module grantee file a permissive change is not practical or feasible, the following guidance provides some additional options for host manufacturers. Integrations using modules where additional testing and/or FCC application filing(s) may be required are: (A) a module used in devices requiring additional RF exposure compliance information (e.g., MPE evaluation or SAR testing); (B) limited and/or split modules not meeting all of the module requirements; and (C) simultaneous transmissions for independent collocated transmitters not previously granted together.

This Module is full modular approval, it is limited to OEM installation ONLY.

Integration into devices that are directly or indirectly connected to AC lines must add with Class II Permissive Change. (OEM) Integrator has to assure compliance of the entire end product incllud the integrated Module.

Additional measurements (15B) and/or equipment authorizations (e.g Verification) may need to be addressed depending on co-location or simultaneous transmission issues if applicable. (OEM) Integrator is reminded to assure that these installation instructions will not be made available to the end user of the final host device.

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