INTRODUCTION

Key features:

- Low power consumption: as low as 2uA sleep current (WOR mode)
- Small size: 28mm X 23mm X 2.8mm 33 pins SMT
- High performance:

  High transmit power: :

  - TXOP=22dBm@470MHz
  - TXOP=22dBm@868/915MHz
  - TXOP=13dBm@2400MHz

  High receiving sensitivity:

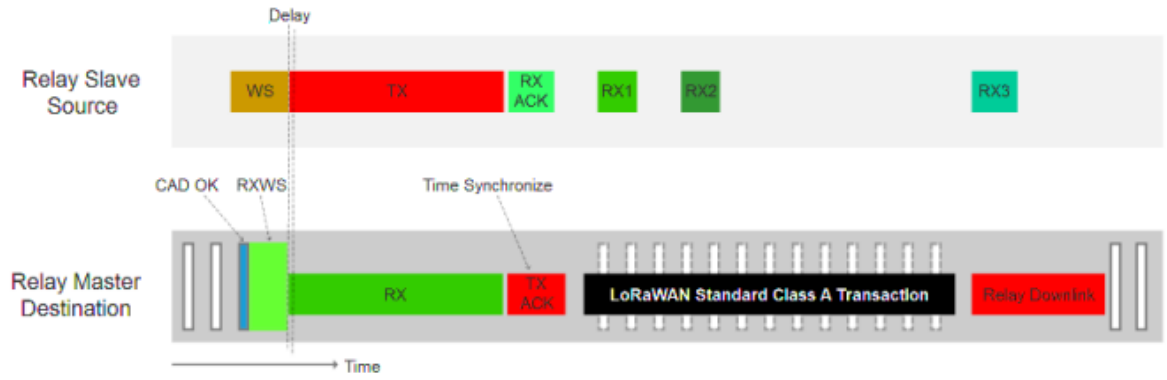
  - 470MHz:-134 dBm sensitivity for SF12 with 125KHz BW
  - 868MHz:-132 dBm sensitivity for SF12 with 125KHz BW
  - 2400MHz:-130 dBm sensitivity for SF12 with 125KHz BW
- Interface
  - SPI
  - USART
  - I2C
  - ADC
  - GPIO
  - SWD
- Embedded LoRaWAN® protocol, AT command, support global LoRaWAN® frequency plan
  - EU868
  - US915 and US915 Hybrid
  - CN779
  - AU915
  - CN470 and CN470 Prequet
  - AS923
  - KR920
  - IN865

Application:

- LoRaWAN® node
- Home automation applications
- Smart security
- Low-power wireless sensor network
- 2.4GHz remote application

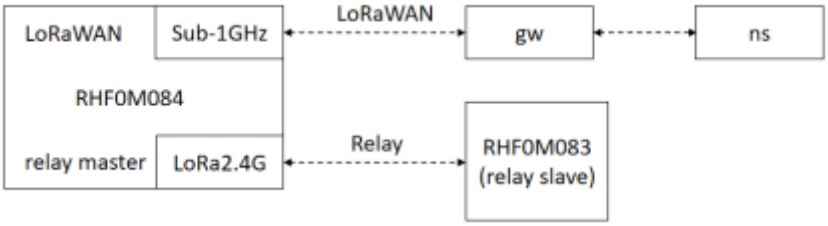
Function Description

LoRaWAN Relay is a new defined LoRa Alliance specification, due to August 2019 official specification is still in preliminary stage. LoRaWAN relay designed by RisingHF follows LoRaWAN relay specification and add customized features like buffer mode (LoRaWAN application payload decrypted) and reserved replay mode. The LoRaWAN relay or relay mentioned in this documentation stands for RisingHF relay.



LoRaWAN 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 LoRaWAN 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 LoRaWAN Class A RX1 and RX2, which can be compatible with standard LoRaWAN 100%. The additional RX3 window is for relay downlink communication. Refer to LoRaWAN timing diagram for details.



The RHF0M084 supports SUB-1GHz and LORA2.4G. Its communication model is shown in the figure below, and the RHF0M083 acts as a relay slave, and the RHF0M084 is simultaneously as a relay master and a LoRaWAN node.

Get Started

Preparation

- USB to TTL Serial tool x 2pcs
- RHF0M083 x 1pcs RHF0M084 x 1pcs LoRaWAN Gateway (maybe US915 Band)
- PC
- Serial Terminal tool (SSCOM, PUTTY, TERATERM, etc.)

Relay Communication (Manual Key Mode)

Before relay communication, user should select one device as master and another as slave.

- Configure Slave (RHF0M083)
    - **AT+DR=LR24** Or any other available band as wishes

    - **AT+RELAY=SLAVE** Set device to slave mode
    - **AT+MODE=ABP**
    - **AT+ID**; Get slave DEVADDR
- Configure Master(RHF0M084)
    - **AT+DR=US915** Frequency segment for setting LoRaWAN
    - **AT+RELAY=WL,ADD,devaddr,nwkskey,appskey,relayskey** (use slave's DEVADDR/NWKSKEY/APPSKEY/RELAYSKEY)
    - **AT+RELAY=MASTER**; Set device to master mode,not support slave mode
- Slave send packet
    - **AT+MSG=xxxxxxx**
- 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.

Relay Communication(Auto Key Mode)

Before relay communication, user should select 084 device as master and 083 as slave.

- Configure Slave
    - **AT+DR=LR24** (Or any other available band as wishes)
    - **AT+RELAY=SLAVE** Set device to slave mode
    - **AT+MODE=ABP**
    - **AT+ID** Get slave DEVADDR
    - **AT+KEY=AUTO**
- Configure Master
    - **AT+DR=US915** (Frequency segment for setting LoRaWAN)
    - Register device address to master whitelist
        - **AT+RELAY=WL,ADD,devaddr** specify a single DevAddr
        - **AT+RELAY=WL,devaddr_min,devaddr_max** specify device address range
        - **AT+RELAY=MASTER** Set device to master mode
    - Slave send packet
        - **AT+MSG = xxxxxxx**
    - Master receive packet by polling
        - **AT+RELAY = PL**

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

LoRaWAN Communication

LoRaWAN communication can be performed at the same time as Relay,

- Configure RHF0M084
  - **AT+DR=US915** (If you set it before, you don't need to reset it.)
  - **AT+CH = NUM , 0-7** (Set the range of subnets, and the range supported by the gateway)
  - **AT+MODE= OTAA**
  - **AT+ID** Get master Deveui ,Appeui
  - **Use this ID to register nodes on NS**
- Join
  - **AT+JOIN**
- RHF0M084 send MSG or CMSG
  - **AT+CMSG = 11111111** , **AT+MSG = 22222222222**
- RHF0M083 send MSG to RHF0M084 ,and RHF0M084 receive packet by polling
  - **AT+RELAY=PL**

Advanced Application Guide

Slave LoRaWAN Communication

To simplify LoRaWAN 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 LoRaWAN transaction will take longer time to finish. Maximum timeout to be defined

Master LoRaWAN Communication

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

Relay Buffer Mode Limitation

- Relay Buffer Mode never supports uplink frame counter which is larger than 0x3FFFFF (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

Key Mode

Automatic Session Key Workflow

- Relay Slave set DevAddr / RootKey and enable auto key mode
- Relay Master set root key
- Relay Master set DevAddr range
- Relay Master and Slave communication without specify any session key

Manually Bind Slave and Master Workflow

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

Master supports two workflows at the same time.

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

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.

Contact

Please contact with sales@risinghf.com for detailed information.

Conformity

FCC regulatory conformance :
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.

FCC Radiation Exposure Statement:
This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

- English: "
This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and
(2) this device must accept any interference, including interference thatmay cause undesired operation of the device."
- French:"
Le présent appareil est conforme aux CNR d'Industrie Canada applicables
aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
(1) l'appareil nedoit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique
subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

ORIGINAL EQUIPMENT MANUFACTURER (OEM) NOTES

The OEM must certify the final end product to comply with unintentional radiators (FCC Sections 15.107 and 15.109) before declaring compliance of the final product to Part 15 of the FCC rules and regulations. Integration into 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: **2AJUZ0M084**". 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.

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 include 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

IC labeling requirement for the final end product:

The final end product must be labeled in a visible area with the following “Contains IC: 22005-0M084”

The Host Marketing Name (HMN) must be indicated at any location on the exterior of the host product or product packaging or product literature, which shall be available with the host product or online.

This radio transmitter [IC: 22005-0M084] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Frequency range	Manufacturer	Peak gain	Impedance	Antenna type
902.3-914.9MHz	RisingHF	1.0dBi	50 Ω	Dipole Antenna
923.3-927.5MHz	RisingHF	1.0dBi	50 Ω	Dipole Antenna
2405-2480MHz	RisingHF	1.8dBi	50 Ω	Dipole Antenna

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.3

Explanation: This module meets the requirements of FCC part 15C(15.247).

2.3 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The EUT has a Dipole Antenna, and the antenna use a permanently attached antenna which is not replaceable.

2.4 Limited module procedures

If a modular transmitter is approved as a "limited module," then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.

A limited module manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/ data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This limited module procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is not a limited module.

2.5 Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects:
layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.
a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna);
b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);
c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;
d) Appropriate parts by manufacturer and specifications;
e) Test procedures for design verification; and
f) Production test procedures for ensuring compliance.
The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.
Explanation: Yes, The module with trace antenna designs, and This manual has been shown the layout of trace design, antenna, connectors, and isolation requirements.

2.6 RF exposure considerations

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person’s body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).
Explanation: This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment, This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body." This module is designed to comply with the FCC statement, FCC ID is: 2AJUZ0M084.

2.7 Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an “omni-directional antenna” is not considered to be a specific “antenna type”)).

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.

Explanation: The EUT has a Dipole Antenna, and the antenna use a permanently attached antenna which is unique.

2.8 Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules. This includes advising host product manufacturers that they need to provide a physical or e-label stating “Contains FCC ID” with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.

Explanation: The host system using this module, should have label in a visible area indicated the following texts: “Contains FCC ID: 2AJUZ0M084, Contains IC: 22005-0M084”

2.9 Information on test modes and additional testing requirements5

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer’s determination that a module as installed in a host complies with FCC requirements.

Explanation: Top band can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

2.10 Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that the modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: 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.