RHF-DS01500 RHF76-052 LoRaWAN Module

V0.3

Document information

| Info | Content |
|----------|---|
| Keywords | Ai-Thinker, LoRaWAN, Module |
| Abstract | This document is a datasheet of RHF76-052 LoRaWAN module. |

RHF76-052 LoRaWAN Module

Low Power Small Size High integrated LoRaWAN Module

General description

RHF76-052 LoRaWAN Module is a low cost, low power and small size module, embedded with Semtech's LoRa propriety chip SX1276 and ST's ultralow power MCU STM32L051/052xx. The module designed by Ai-Thinker (Shenzhen) is targeted to application in sensor networking and others IOT device powered by battery which need low power consumption to extend the battery lifetime.

This datasheet will give some details of description of the module, including HW design info, performance validation, and application information.

Applications

The RHF76-052 LoRaWAN Module is designed for end device which need long range and low power consumption, such as metering, sensor networking, and others IOT application.

Key features

- Low power consumption: 1.45uA sleep current in WOR mode
- Low cost: SX1276 with cost-effective MCU; 2 layers layout
- Small size: 23mm X 28mm
- ♦ 33 pins SMT package
- Dual band: 434MHz/470MHz 868MHz/915MHz
- High performance: Dual Band: TXOP=20dBm@434MHz/470MHz TXOP=14dBm@868MHz/915MHz Single Band: TXOP=20dBm@868MHz/915MHz 160dB link budget, suitable for long range
 User-friendly interface
- User-friendly interface SPI; USART; I2C; USB;
 - ADC;
 - 10 more GPIOs
- ◆ LoRaWAN embedded

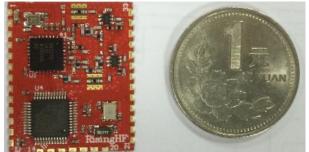


Figure 1 RHF76-052 Module Outline

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This product datasheet contains a detailed description of the RHF76-052 performance and functionality. Please consult with Ai-Thinker for the latest updates, Firmware or errata.

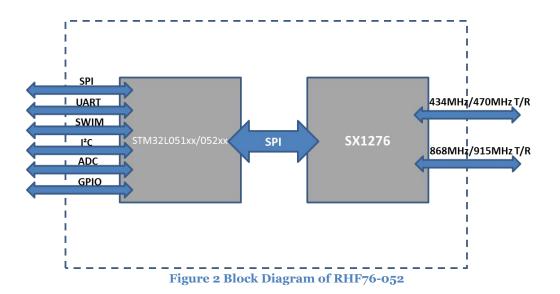
1. General description

The RHF76-052 incorporates SX1276 and STM32L052xx, and is well suited for node in the networking of IOT.

The module has two RF port, RFIO_LF and RFIO_HF. RFIO_LF covers low frequency band, i.e. 434MHz/470MHz. RFIO_HF covers high frequency band, i.e. 868MHz/915MHz.

Based on the powerful functions and performance of SX1276, the RHF76-052 could operates in both (G)FSK and LoRa. In LoRa mode, BW with 62.5kHz, 125kHz, 250kHz and 500kHz could be used.

And with the STM32L051xx/052xx MCU, the module could provide SPI, UART, I2C, ADC and some others GPIOs for customer to extend their application. Two wire interface (SWIM) is suggested to be used for programming.



1.1 Simplified Block Diagram

1.2 Pin description

| 1 | VCC | GND | 33 |
|----|--------------------------|-----------------|----|
| 2 | GND | RFIO_LF | 32 |
| 3 | PA8 | GND | 31 |
| 4 | PA9 | RFIO_HF | 30 |
| 5 | PA10 | GND | 29 |
| 6 | NSS | PA0 | 28 |
| 7 | SCK | NRST | 27 |
| 8 | MISO | PC13 | 26 |
| 9 | MOSI | SDA | 25 |
| 10 | USART_CTS | SCL | 24 |
| 11 | USART_RTS | USART_RX | 23 |
| 12 | SWDIO | USART_TX | 22 |
| 13 | SWCLK | PB5 | 21 |
| | PA15 PB3 PB4 NG | NC NC PA3 | |

Figure 3 Pin diagram

Table 1 Pin description

| Number | Name | Туре | Description |
|--------|------------|------|---|
| 1 | VCC | - | Supply voltage for the module |
| 2 | GND | - | Ground |
| 3 | PA8 | I/O | GPIO from MCU, PA8 |
| 4 | PA9 | I/O | GPIO from MCU, PA9 |
| 5 | PA10 | I/O | GPIO from MCU, PA10 |
| 6 | NSS | I/O | NSS of SPI1 from MCU; or GPIO from MCU, PB12 |
| 7 | SCK | I/O | SCK of SPI1 from MCU; or GPIO from MCU, PB13 |
| 8 | MISO | I/O | MISO of SPI1 from MCU; or GPIO from MCU, PB14 |
| 9 | MOSI | I/O | MOSI of SPI1 from MCU; or GPIO from MCU, PB15 |
| 10 | USART1_CTS | I/O | USART1_CTS from MCU; or GPIO from MCU, PA11 |
| 11 | USART1_RTS | I/O | USART1_RTS from MCU; or GPIO from MCU, PA12 |
| 12 | SWDIO | I/O | SWDIO of SWIM for program download |
| 13 | SWCLK | I/O | SWCLK of SWIM for program download |
| 14 | PA15 | I/O | GPIO from MCU, PA15 |
| 15 | PB3 | I/O | GPIO from MCU, PB3 |
| 16 | PB4 | I/O | GPIO from MCU, PB4 |
| 17 | NC | - | Connected to Ground |
| 18 | NC | - | Connected to Ground |
| 19 | NC | - | Connected to Ground |
| 20 | PA3/ADC3 | I/O | GPIO from MCU, PA3; or ADC3 input |
| 21 | PB5 | I/O | GPIO from MCU, PB5 |
| 22 | USART1_TX | I/O | USART1_TX from MCU; or GPIO from MCU, PB6 |

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| 23 | USART1_RX | I/O | USART1_RX from MCU; or GPIO from MCU, PB7 |
|----|------------|-----|--|
| 24 | I2C_SCL | I/O | SCL of I2C from MCU; or GPIO from MCU, PB8 |
| 25 | I2C_SDA | I/O | SDA of I2C from MCU; or GPIO from MCU, PB9 |
| 26 | PC13/Wkup2 | I/O | Wake up pin for MCU; or GPIO from MCU, PC13 |
| 27 | NRST | I | Reset trigger input for MCU |
| 28 | PA0/AD0 | I/O | GPIO from MCU, PA0; or ADC0 input |
| 29 | GND | - | Ground |
| 30 | RFIO_HF | - | RF input/output in high band, i.e. 868MHz/915MHz |
| 31 | GND | - | Ground |
| 32 | RFIO_LF | - | RF input/output in low band, i.e. 434MHz/470MHz |
| 33 | GND | - | Ground |

2. Electrical Characteristics

2.1 Absolute Maximum Ratings

Stresses above the values listed below may cause permanent device failure. Exposure to absolute maximum ratings for extended periods may affect device reliability. Table 2 Absolute Maximum Ratings

| Item | Description | min | max | unit |
|-------|----------------|------|------|------|
| VCCmr | Supply voltage | -0.3 | +3.9 | V |
| Tmr | Temperature | -55 | +115 | °C |
| Pmr | RF input level | - | +10 | dBm |

2.2 Operating Range

Table 3 Operating Range

| Item | Description | min | max | unit |
|-------|----------------|------|------|------|
| VCCop | Supply voltage | +1.8 | +3.6 | V |
| Тор | Temperature | -40 | +85 | °C |
| Рор | RF input level | - | +10 | dBm |

2.3 Module Specifications

Table 4 Module Specifications

| ITEMs | Parameter | Specifications | Unit |
|-----------|-----------|------------------------|------|
| Structure | Size | 23(W) X 28(L) X 2.6(H) | mm |
| Structure | Package | 33 pins, SMT | |

RHF76-052

| | power supply | 3.3V type | v | | |
|-------------------------------|-------------------|---|-----|--|--|
| | Sleep current | 1.45uA | uA | | |
| | Operation current | 120mA @20dBm in 434MHz/470MHz type | mA | | |
| | (Transmitter+MCU) | 45mA @14dBm in 868MHz/915MHz type | mA | | |
| | Operation current | 16mA @BW125kHz, 434MHz/470MHz type | mA | | |
| | (Receiver+MCU) | 15.5mA @BW125kHz, 868MHz/915MHz type | mA | | |
| Electrical Characteristics | Output power | 20dBm max @434MHz/470MHz | dBm | | |
| characteristics | | 14dBm max @868MHz/915MHz | dBm | | |
| | | -139dBm @SF12, BW125kHz, 434MHz/470MHz | dBm | | |
| | Sensitivity | -137dBm @SF12, BW125kHz, 868MHz/915MHz | dBm | | |
| | | <pre>darmonics (LE) <-42dBm below 1GHz</pre> | | | |
| | Harmonics (LF) | <-35dBm above 1GHz | dBm | | |
| | Harmonics (HF) | <-40dBm above 1GHz | dBm | | |
| | RFIO_LF | RF port for Low Band (434MHz/470MHz) | | | |
| | RFIO_HF | RF port for High Band (868MHz/915MHz) | | | |
| | SPI | 1 group of SPI, include 4 pins | | | |
| | USART | 1 group of USART, include 2pins | | | |
| Interface | USB | 1 group of USB, include 2 pins | | | |
| | 12C | 1 group of I2C, include 2 pins | | | |
| | ADC | 2 ADC Input, include 2 pins | | | |
| | GPIOs | 8 GPIOs more except the interface above | | | |
| | NRST | Manual reset pin input | | | |

3. Typical Performance Characteristics Measurement

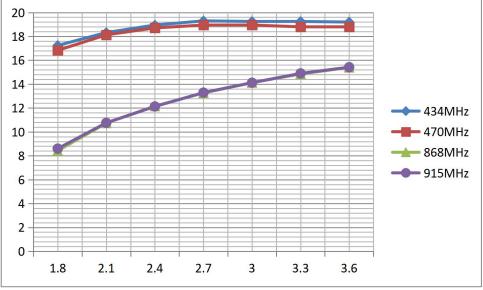
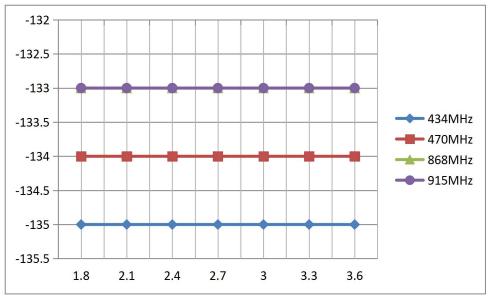
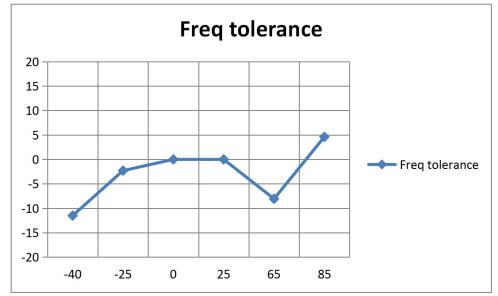


Figure 4 TXOP vs Supply voltage









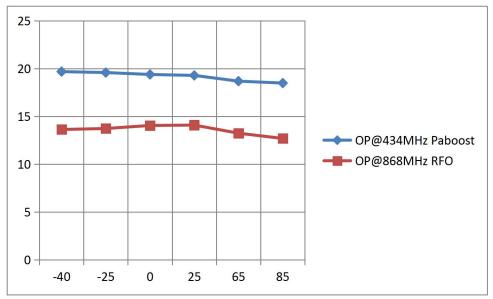
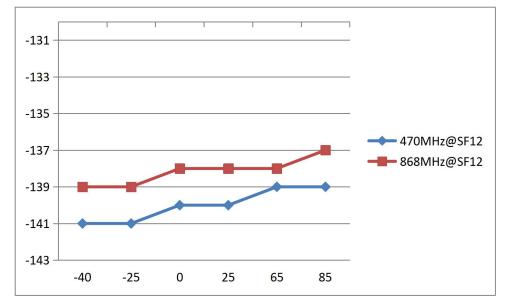


Figure 7 TXOP vs Temperature

RHF76-052

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| | nt Spect | | alyzer - Swep | | | | | r | | | | |
|----------------------------|----------|-------|--|------------|------------------------|-------------------------|---|-----------|--------------------------|----------|-----------------------------|---------------------------------|
| enter | r Fre | RF | 50 Ω | AC 0000 GH | Iz | | VSE:INT | Avg Typ | ALIGN AUTO e: Log-Pwr | TRAC | M Feb 27, 2015 | Frequency |
| 0 dB/di | | | 21.00 d | P IF | NO: Fast (Gain:Low | Trig: Free Atten: 40 | | | | TYI | PE WWWWWW ET N N N N N N | Auto Tur |
| 11.00 | | | | | | | | | | | | Center Fre 3.505000000 GH |
| 9.0 9.0 99.0 | | | ^ 2 | | | | | | | | | Start Fr 10.000000 M |
| 9.0 1 9.0 9.0 | | | 1999 (1999 (1996) (1996 (1996 (1996) | | a ist date | | ^{be} len en e | | u sliki İstikis d | | | Stop Fr 7.000000000 G |
| enter Res B | 3.50 | 05 GI | lz | ****** | | V 100 kHz | | | | Span 6 | .990 GHz 1001 pts) | CF St 699.000000 M Auto M |
| KR MOD | ETRC | SCL | | X 420.4 | 0 MHz | 19.09 di | | ICTION FU | NCTION WIDTH | FUNCTION | ON VALUE | <u>Auto</u> IV |
| 2 N 3 4 | 1 | f | | 1.296 1 | | -37.15 dE | | | | | | Freq Offs 0 |
| | | | | | | | | | | | | |
| 5 6 7 8 9 | | | | | | | | | | | | |
| 6 7 8 9 | | | | | | m | | | | | | |

Figure 9 Harmonics measurement @Frf=434MHz, TXOP=20dBm





| 🚺 Keysight Spectrum Analyzer | - Swept SA | | | | |
|--------------------------------------|--|---|---------------------------------|---|--|
| ©RF Center Freq 3.50 | | SENSE:INT | ALIGN AUTO Avg Type: Log-Pwr | 02:08:28 PM Feb 27, 2015 TRACE 1 2 3 4 5 6 TYPE WWWWW | Frequency |
| 10 dB/div Ref 21.0 | PNO: Fast C IFGain:Low | Atten: 40 dB | Mkr | 3 1.408 00 GHz -35.18 dBm | Auto Tune |
| Log 11.0 1.00 -9.00 | | | | | Center Freq 3.505000000 GHz |
| -19.0 -29.0 -39.0 | | | | | Start Freq 10.000000 MHz |
| -49.0 | a gent gan an a | ile han e della desta | | | Stop Freq 7.000000000 GHz |
| Center 3.505 GHz #Res BW 100 kHz | | / 100 kHz | | Span 6.990 GHz 42.9 ms (1001 pts) | CF Step 699.000000 MHz <u>Auto</u> Man |
| 1 N 1 f 2 N 1 f 3 N 1 f 4 5 | 471.34 MHz 946.66 MHz 1.408 00 GHz | 18.38 dBm -43.08 dBm -35.18 dBm | | | Freq Offset 0 Hz |
| 6 7 8 9 10 11 | | | | | |
| MSG | | | STATUS | s to the second | |

Harmonics measurement @Fri =470MHZ,

| 📜 Keysight Spect | rum Analyzer - Swej | pt SA | | | | |
|------------------|--------------------------|---------------------------------|-------------------------|---|---------------------------------|----------------------------|
| ×. | RF 50 Ω | AC | SENSE:INT | ALIGN AUTO | 01:29:57 PM Feb 27, 2015 | Frequency |
| Center Fre | ter Freq 3.505000000 GHz | | Trig: Free Run | Avg Type: Log-Pwr | TRACE 1 2 3 4 5 6 TYPE WWWWW | requeries |
| | | IFGain:Low | Atten: 30 dB | | DETNNNNN | |
| | | | | Mkr | 3 2.610 28 GHz | Auto Tune |
| 10 dB/div | Ref 17.00 d | Bm | | | -43.04 dBm | |
| Log | 11 | | | | | |
| 7.00 | | | | | | Center Free |
| -3.00 | | | | | | 3.505000000 GH: |
| -13.0 | | | | | | |
| -23.0 | | | | | | 1750 March 1870 |
| -33.0 | | ^2 | | | | Start Free |
| | | | 3 | | | 10.000000 MH; |
| -43.0 | | | | | | |
| -53.0 | فيعقدوا ودجارها | القاصية بالعالية السابية أرديان | L. L. H. H. LEL | and the local data in the second s | | Stop Free |
| -63.0 | | | - | | | 7.000000000 GH |
| -73.0 | | | | | | 7.00000000 GH. |
| | | فاستنابه والمسال | cittllaiselle a | Juck Gam | er egilismis lessit hat | |
| Center 3.50 | | | | | Span 6.990 GHz | CF Step |
| #Res BW 1 | 00 kHz | VBW | 100 kHz | Sweep 8 | 42.9 ms (1001 pts) | 699.000000 MHz Auto Mar |
| MKR MODE TRC | | × | | JNCTION FUNCTION WIDTH | FUNCTION VALUE | Auto Mai |
| 1 N 1 2 N 1 | f | 862.78 MHz 1.729 54 GHz | 14.55 dBm -40.07 dBm | | | |
| 3 N 1 | f | 2.610 28 GHz | -43.04 dBm | | | Freq Offse |
| 4 5 | | | 100 M 10.00 M | | | 0 H: |
| 6 | | | | | | c |
| 7 8 | - | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| < | | | | | · · · · | |
| MSG | | | | STATUS | 3 | H |
| | | | | | 1 | |

Figure 11 Harmonics measurement @Frf=868MHz, TXOP=14dBm





| 🚺 Keysight Spectrum Ar | nalyzer - Swept SA | | | | | | | d X |
|---------------------------|--|--|--|---|--|---|--------------------|--|
| ₩ Marker 4 3.65 | | | | ALIGN Avg Type: Log | | 6:12:30 PM Mar 1 TRACE 1 2 TYPE WW DET N N | 3456 Mar | ^{ker} (er Table |
| 10 dB/div Ref | 20.00 dBm | | | | Mkr4 3 | 8.658 78 -53.57 c | GHz on | Off |
| | | | | | | | [Of | |
| | | | | | | | Cou Marke On | |
| | | | en e | a hard a state of the least of | a an | n sus have a | N. | -50.1 |
| er 3.505 GHz BW 30 kHz | VB | ^ W 30 kHz | | Sweep | | 6.990 GHz (1001 pts) | | Ce #R |
| DDE TRC SCL N 1 f | × 918.70 MHz | Y 14.73 dBm | FUNCTION | FUNCTION WIDTH | | ION VALUE | | |
| N 1 F N 1 F N 1 F | 1.827 40 GHz 2.750 08 GHz 3.658 78 GHz | -49.94 dBm -48.75 dBm -53.57 dBm | | | 2 2 6 | | All Markers | 0.55 |
| | | | | | | | | on 5 6 7 7 8 0re 9 10 0f 2 11 |
| | | | | STATUS | 5 | | | MSG |

Figure 12 Harmonics measurement @Frf=915MHz, TXOP=14dBm

4. Application Information

4.1 Package Information

The RHF76-052 is available in a 33-lead SMD package as shown in Figure 5 below:

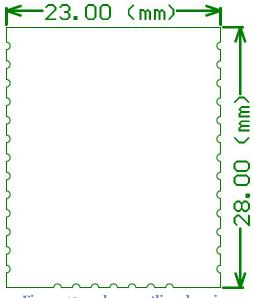
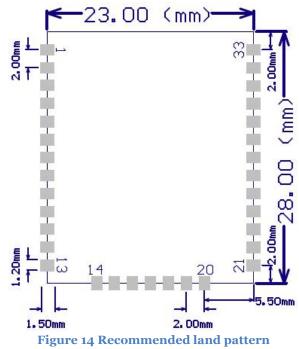


Figure 13 package outline drawing

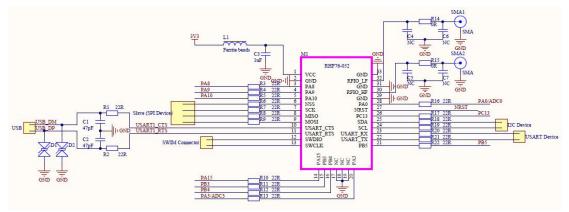
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Figure 6 show the recommended land pattern for layout.



4.2 Interface of Module

Except that several essential GPIOs and one group of SPI would be used for internal transceiver control, all others GPIOs and interface of the MCU would be connected to external pins of the module, which includes SPI, USART, I2C, USB and 10 GPIOs. And there are 2 ADC included in the 10 GPIOs. This is very useful and important for customer to extend their design with these abundant GPIOs and interfaces. For more details of interface, please refer to Table 1 Pin description and datasheet of STM32L051xx/STM32L052xx.



4.3 Reference design with RHF76-052 Module

Figure 15 Reference design with RHF76-052

5. Application in LoRaWAN

5.1 LoRaWAN/LoRaMAC

LoRaWAN networks typically are laid out in a star-of-stars topology in which gateways relay messages between end-devices and a central network server at the backend. Gateways are connected to the network server via standard IP connections while end devices use single-hop LoRa[™] or FSK communication to one or many gateways. All communication is generally bi-directional, although uplink communication from an end device to the network server is expected to be the predominant traffic.

Communication between end-devices and gateways is spread out on different frequency channels and data rates. The selection of the data rate is a trade-off between communication range and message duration, communications with different data rates

do not interfere with each other. LoRa data rates range from 0.3 kbps to 50 kbps, with different Band Width and Spreading Factor. To maximize both battery life of the enddevices and overall network capacity, the LoRa network infrastructure can manage the data rate and RF output for each end-device individually by means of an adaptive data rate (ADR) scheme.

End-devices may transmit on any channel available at any time, using any available data rate, as long as the following rules are respected:

1) The end-device changes channel in a pseudo-random fashion for every transmission. The resulting frequency diversity makes the system more robust to interferences.

2) The end-device respects the maximum transmit duty cycle relative to the sub-band used and local regulations.

3) The end-device respects the maximum transmit duration (or dwell time) relative to the sub-band used and local regulations.

The RHF76-052 Module incorporates Semtech's LoRa Chip SX1276 and ST's ultra-low power MCU. With only 1.45uA sleep current in WOR mode, the module is really very suitable for LoRaWAN application.

5.2 RHF76-052 with LoRaWAN

The Figure 16 and Figure 17 below show the power consumption of the RHF76-052 module. The code is organized so that the MCU and all peripherals are in sleep mode most of the time.

In Figure 16, two RX windows will follow the TX window which is in accordance with LoRaWAN protocol. In the RX window1, the SF of the receiver would set to SF12 for example (should be same as the SF when transmit before).When there is no packet received in the RX window1, the RX window2 would occur. In the RX window2, the SF of the receiver would set to SF9.

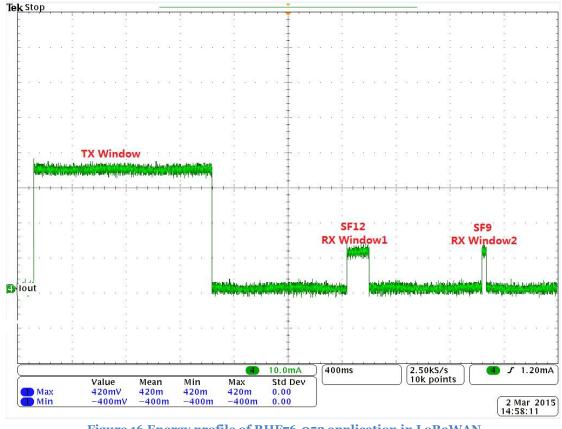


Figure 16 Energy profile of RHF76-052 application in LoRaWAN (No packet received from Server)

In Figure 17, the node receive the packet from server in the RX window1.

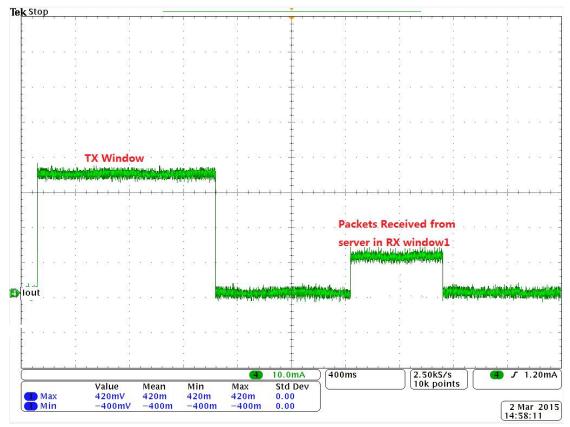


Figure 17 Energy profile of RHF76-052 application in LoRaWAN (A packet received from Server in RX window1)

6. Ordering information

Contact: <u>Support@Ai-Thinker.com</u>

| Part number | Band | Max OP@Low band (434MHz/470MHz) | Max OP@High band (868MHz/915MHz) | MCU | Description |
|-------------|-------------|---------------------------------------|--|---------------|-------------|
| RHF76-052A | dual band | 20dBm | 14dBm | STM32L052C8T6 | USB |
| RHF76-052C | Single Band | NC | 20dBm | STM32L052C8T6 | USB |
| RHF76-051A | dual band | 20dBm | 14dBm | STM32L051C8T6 | Without USB |
| RHF76-051C | Single Band | NC | 20dBm | STM32L051C8T6 | Without USB |

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