Ultra-Low-Power Sub-1 GHz Wireless Module and Protocol

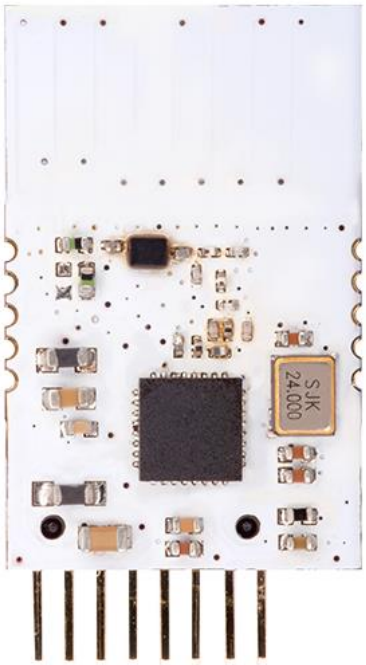
Version 2.0

Shenzhen RF-star Technology Co., Ltd.

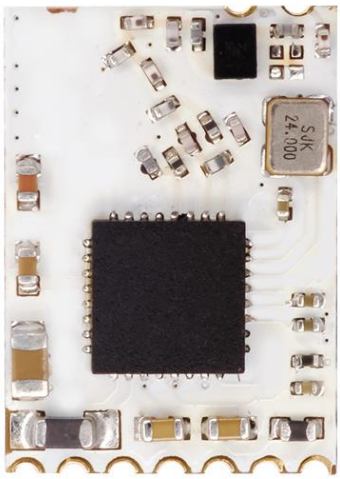
Sep. 14th, 2020

RF-SM-1077B1

RF-SM-1077B2



RF-SM-1044B1



RF-SM-1044B2

RF-SM-1044B4

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1 Device Overview

1.1 Overview

RF-star Sub-1 GHz modules are based on TI CC1310, which combines a flexible, very low-power RF transceiver with a powerful 48 MHz ARM® Cortex®-M3 microcontroller supporting multiple physical layers and RF standards and a dedicated radio controller Cortex®-M0 handling RF protocol commands that are stored in ROM or RAM. RF-star Sub-1G modules all integrate a 24.0 MHz crystal, an antenna matching which make the module low cost, low power consumption and long wireless communication in Sub-1 GHz.

The design purpose of those modules is to handle low power consumption and high wireless communication distance requirements. It can be widely used in various electronic devices with this demand, such as instrumentation, logistics tracking, health care, building automation, motion measurement, and automobiles electronics, leisure toys, agricultural monitoring, etc. Users can use this module to integrate existing solutions or products with the shortest development cycle, occupy the market at the fastest speed, and at the same time inject new technical force into the development of the enterprise.

CC1310F128RGZ (7 mm × 7 mm) chip are integrated in RF-SM-1077B1 and RF-SM-1077B2 with 30 GPIOs. CC1310F128RSM (4 mm × 4 mm) chip are integrated in RF-SM-1044B1, RF-SM-1044B2 and RF-SM-1044B4 with 8 GPIOs, 7 GPIOs and 12 GPIOs separately. In which, RF-SM-1077B1, RF-SM-1044B1, RF-SM-1044B2 and RF-SM-1044B4 supports 868 MHz and 915 MHz, while RF-SM-1077B2 supports 433 MHz and 470 MHz.

RF-star Sub-1 GHz modules are flashed transparent transmission firmware with AT commands by default. The default values are as follows: 115200 baud rate, 8 data bit, no parity check bit,1 stop bit, 433 MHz operating frequency, 15 dBm TX power and 50 Kbps of MAC rate. When the module starts to work, the serial port will print “Application Start\r\n”, and start transparent transmission mode by default, serial port will transmit all the data except “+++”, please refer to the AT command in detail.

1.2 Working Mode

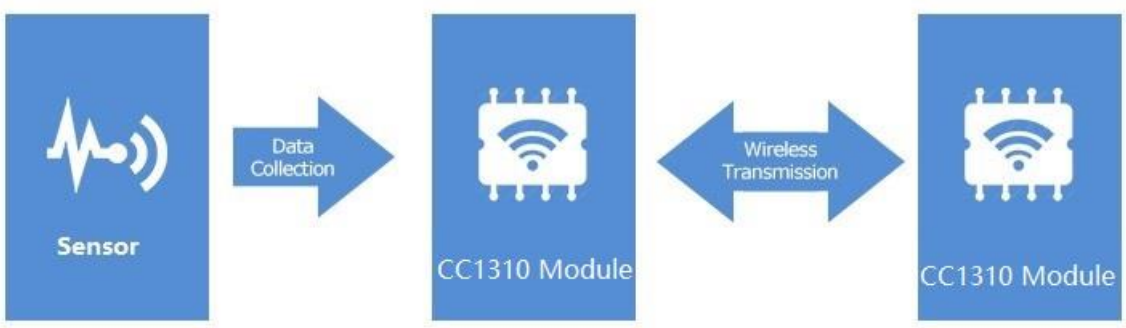


Figure 1. Working Mode Diagram

2 Package and Pin Assignment

2.1 RF-SM-1077B1 and RF-SM-1077B2

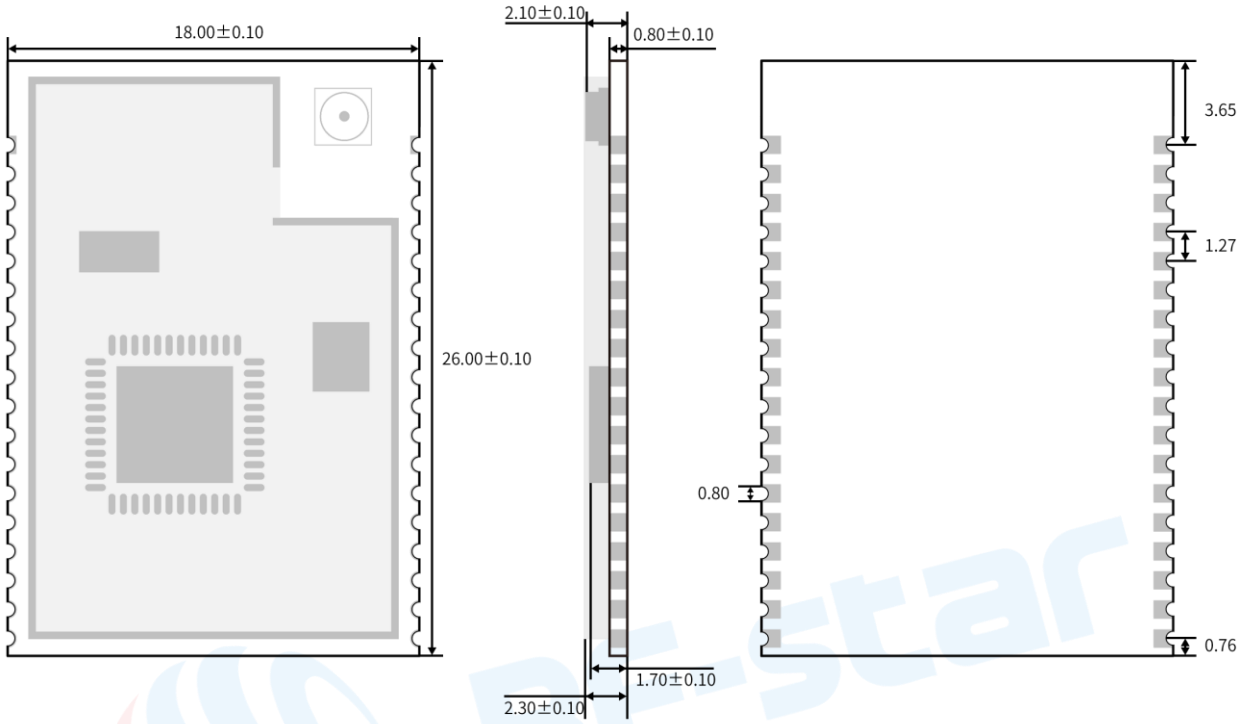


Figure 2. Recommended PCB Footprint of RF-SM-1077B1 and RF-SM-1077B2 (mm)

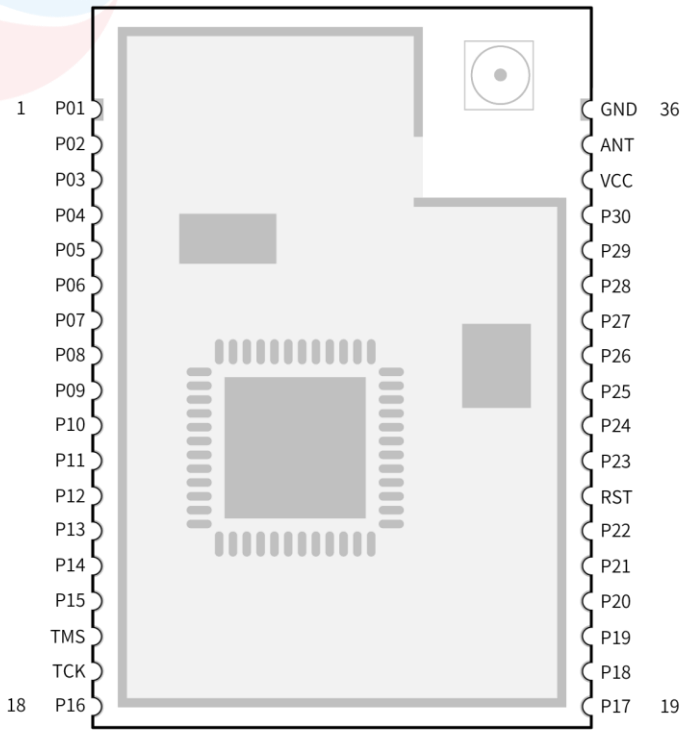


Figure 3. Pin Diagram of RF-SM-1077B1 and RF-SM-1077B2

Table 1. Pin Functions of RF-SM-1077B1 and RF-SM-1077B2

Pin	Name	Chip Pin	Pin Type	Description
1	P01	DIO_1	Digital I/O	GPIO, Sensor Controller
2	P02	DIO_2	Digital I/O	RX (GPIO, Sensor Controller)
3	P03	DIO_3	Digital I/O	TX (GPIO, Sensor Controller)
4	P04	DIO_4	Digital I/O	GPIO, Sensor Controller
5	P05	DIO_5	Digital I/O	GPIO, Sensor Controller
6	P06	DIO_6	Digital I/O	GPIO, Sensor Controller
7	P07	DIO_7	Digital I/O	GPIO, Sensor Controller
8	P08	DIO_8	Digital I/O	GPIO
9	P09	DIO_9	Digital I/O	GPIO
10	P10	DIO_10	Digital I/O	GPIO
11	P11	DIO_11	Digital I/O	GPIO
12	P12	DIO_12	Digital I/O	GPIO
13	P13	DIO_13	Digital I/O	GPIO
14	P14	DIO_14	Digital I/O	GPIO
15	P15	DIO_15	Digital I/O	GPIO
16	TMS	JTAG_TMSC	-	JTAG TMS
17	TCK	JTAG_TCKC	-	JTAG TCK
18	P16	DIO_16	Digital I/O	JTAG TDO
19	P17	DIO_17	Digital I/O	JTAG TDI
20	P18	DIO_18	Digital I/O	GPIO
21	P19	DIO_19	Digital I/O	GPIO
22	P20	DIO_20	Digital I/O	GPIO
23	P21	DIO_21	Digital I/O	GPIO
24	P22	DIO_22	Digital I/O	GPIO
25	RESET	RESET_N	-	Reset, active low. No internal pullup.
26	P23/ADC0	DIO_23	Digital or analog I/O	GPIO, Sensor Controller, analog

27	P24/ADC1	DIO_24	Digital or analog I/O	GPIO, Sensor Controller, analog
28	P25	DIO_25	Digital or analog I/O	GPIO, Sensor Controller, analog
29	P26	DIO_26	Digital or analog I/O	GPIO, Sensor Controller, analog
30	P27	DIO_27	Digital or analog I/O	GPIO, Sensor Controller, analog
31	P28	DIO_28	Digital or analog I/O	GPIO, Sensor Controller, analog
32	P29	DIO_29	Digital or analog I/O	GPIO, Sensor Controller, analog
33	P30	DIO_30	Digital or analog I/O	GPIO, Sensor Controller, analog
34	VCC	VCC	-	1.8 V ~ 3.6 V, recommended to 3.3 V
35	ANT	-	-	External antenna pin
36	GND	GND	-	Ground

2.2 RF-SM-1044B1

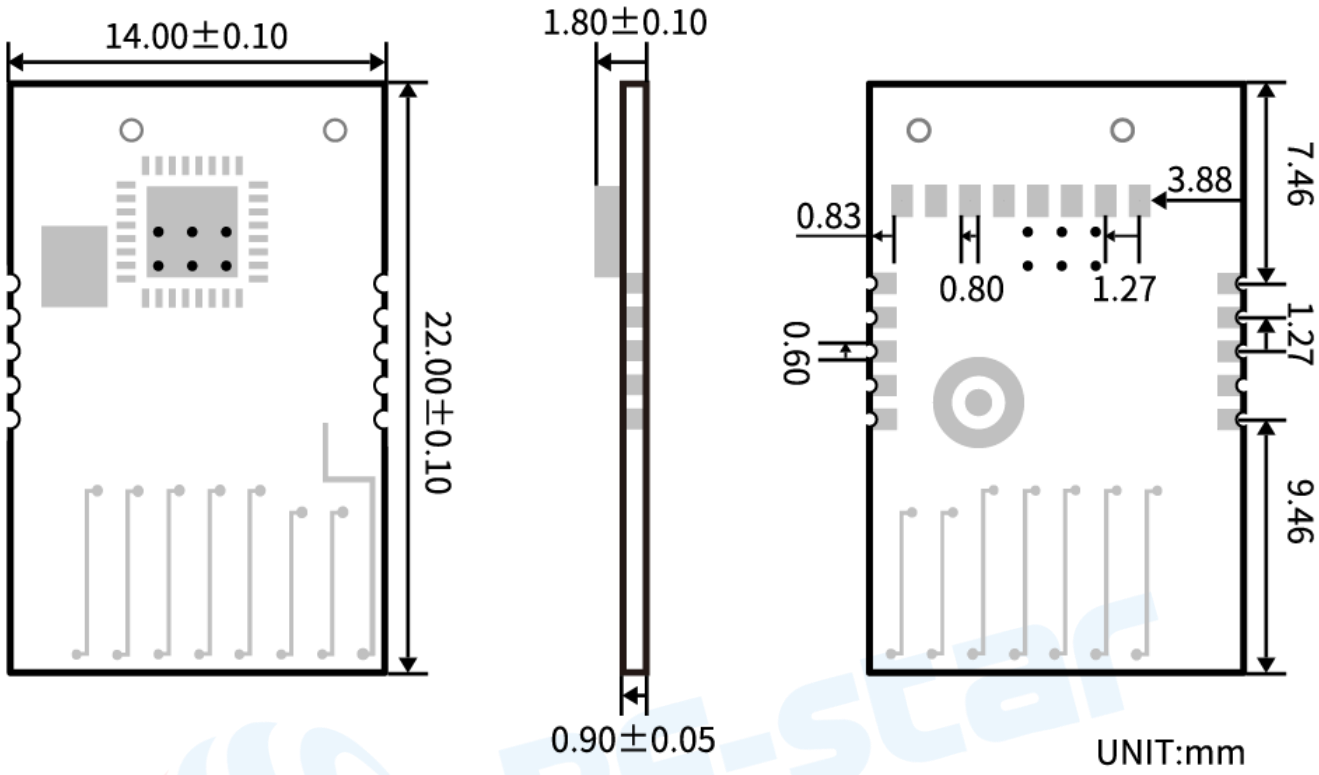
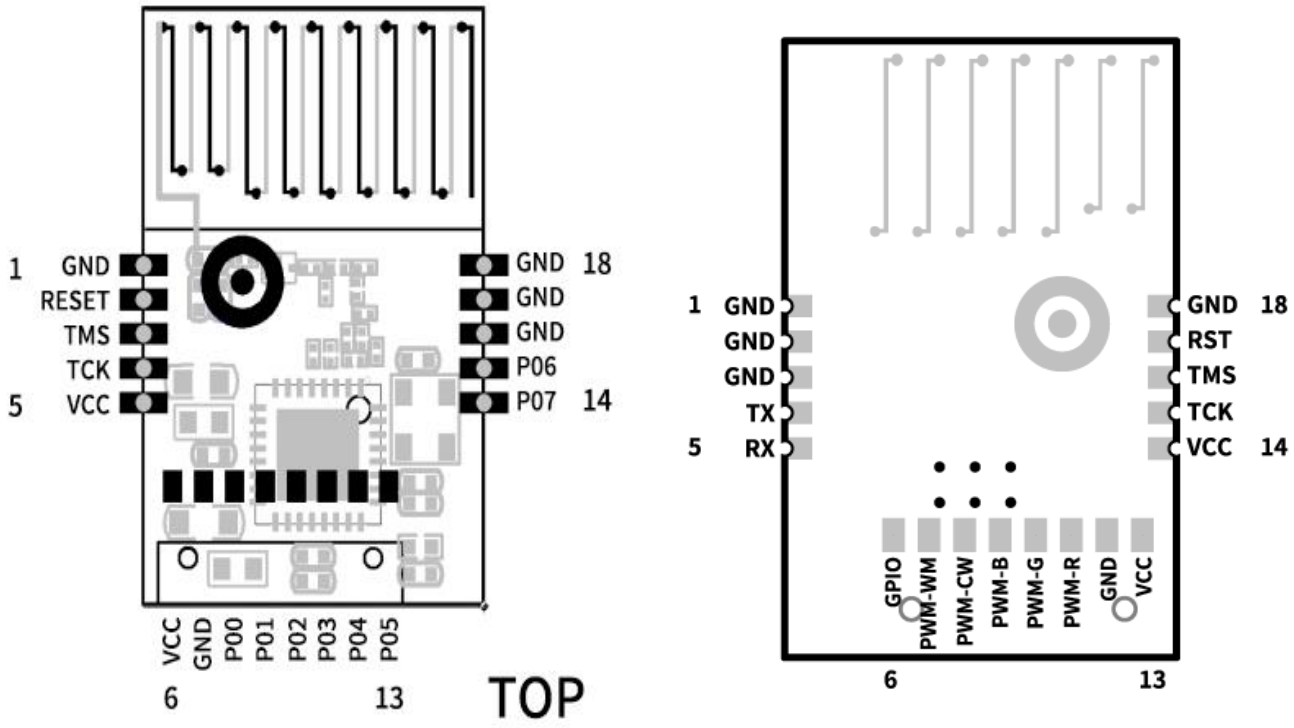


Figure 4. Recommended PCB Footprint of RF-SM-1044B1 (mm)



Top View

Bottom View

Figure 5. Pin Diagram of RF-SM-1044B1

Table 2. Pin Functions of RF-SM-1044B1

Pin	Name	Chip Pin	Pin Type	Description
1	GND	GND	GND	Ground
2	RST	RESET_N	RST	Reset, active low
3	TMS	JTAG_TMSC	-	JTAG TMSC
4	TCK	JTAG_TCKC	-	JTAG TCKC
5	VCC	VCC	-	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V
6	VCC	VCC	-	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V
7	GND	GND	GND	Ground
8	P00	DIO_0	GPIO	GPIO, Sensor Controller
9	P01	DIO_1	GPIO	GPIO, Sensor Controller
10	P02	DIO_2	GPIO	RX (GPIO, Sensor Controller)
11	P03	DIO_3	GPIO	TX (GPIO, Sensor Controller)
12	P04	DIO_4	GPIO	GPIO, Sensor Controller
13	P05	DIO_5	GPIO	GPIO, Sensor Controller
14	P07	DIO_7	GPIO	GPIO, Sensor Controller
15	P06	DIO_6	GPIO	GPIO, Sensor Controller
16	GND	GND	GND	Ground
17	GND	GND	GND	Ground
18	GND	GND	GND	Ground

2.3 RF-SM-1044B2

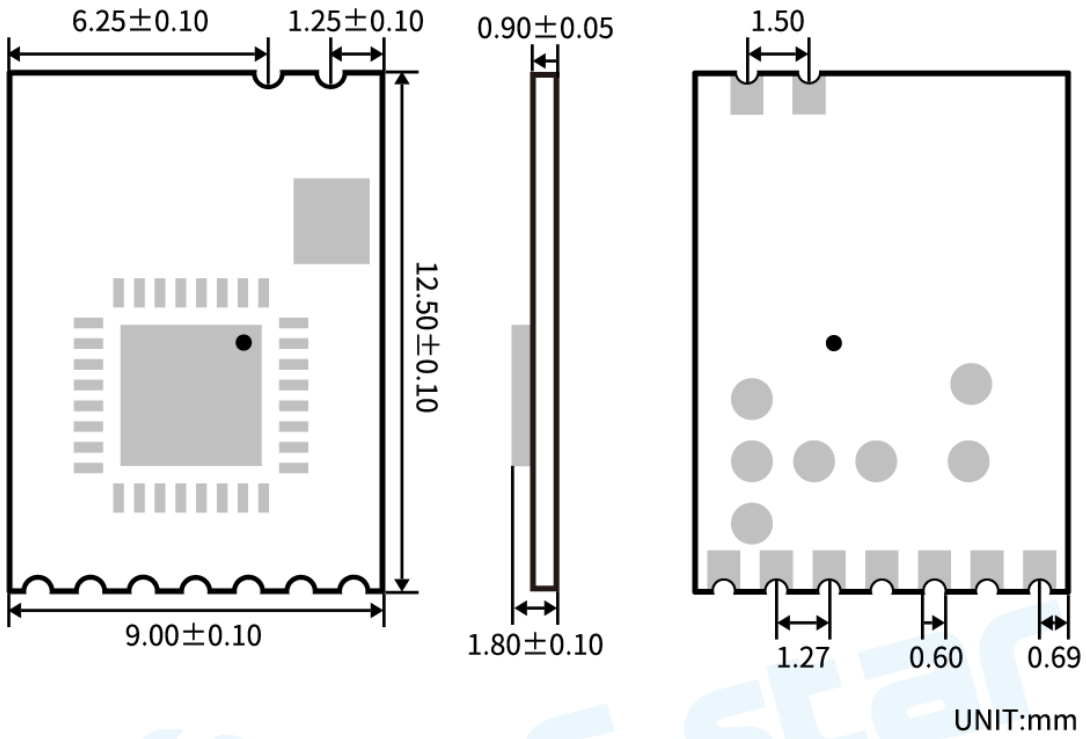


Figure 6. Recommended PCB Footprint of RF-SM-1044B2 (mm)

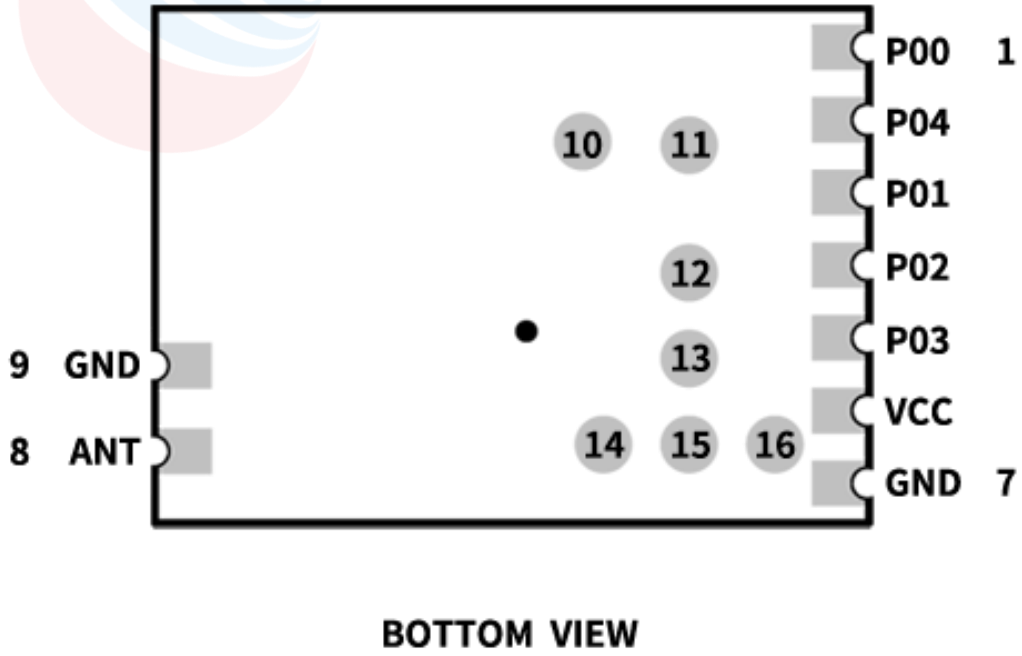


Figure 7. Pin Diagram of RF-SM-1044B2

Table 3. Pin Functions of RF-SM-1044B2

Pin	Name	Chip Pin	Pin Type	Description
1	P00	DIO_0	GPIO	GPIO, Sensor Controller
2	P04	DIO_4	GPIO	GPIO, Sensor Controller
3	P01	DIO_1	GPIO	GPIO, Sensor Controller
4	P02	DIO_2	GPIO	RX (GPIO, Sensor Controller)
5	P03	DIO_3	GPIO	TX (GPIO, Sensor Controller)
6	VCC	VCC	VCC	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V
7	GND	GND	GND	Ground
8	ANT	RF	RF	Antenna pin
9	GND	GND	GND	Ground
10	TMS	TMS	TMS	JTAG TMS
11	TCK	TCK	TCK	JTAG TCK
12	RST	RST	RST	Reset, active low.
13	P06	DIO_6	GPIO	GPIO, Sensor Controller
14	GND	GND	GND	Ground
15	P07	DIO_7	GPIO	GPIO, Sensor Controller
16	VCC	VCC	VCC	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V

2.4 RF-SM-1044B4

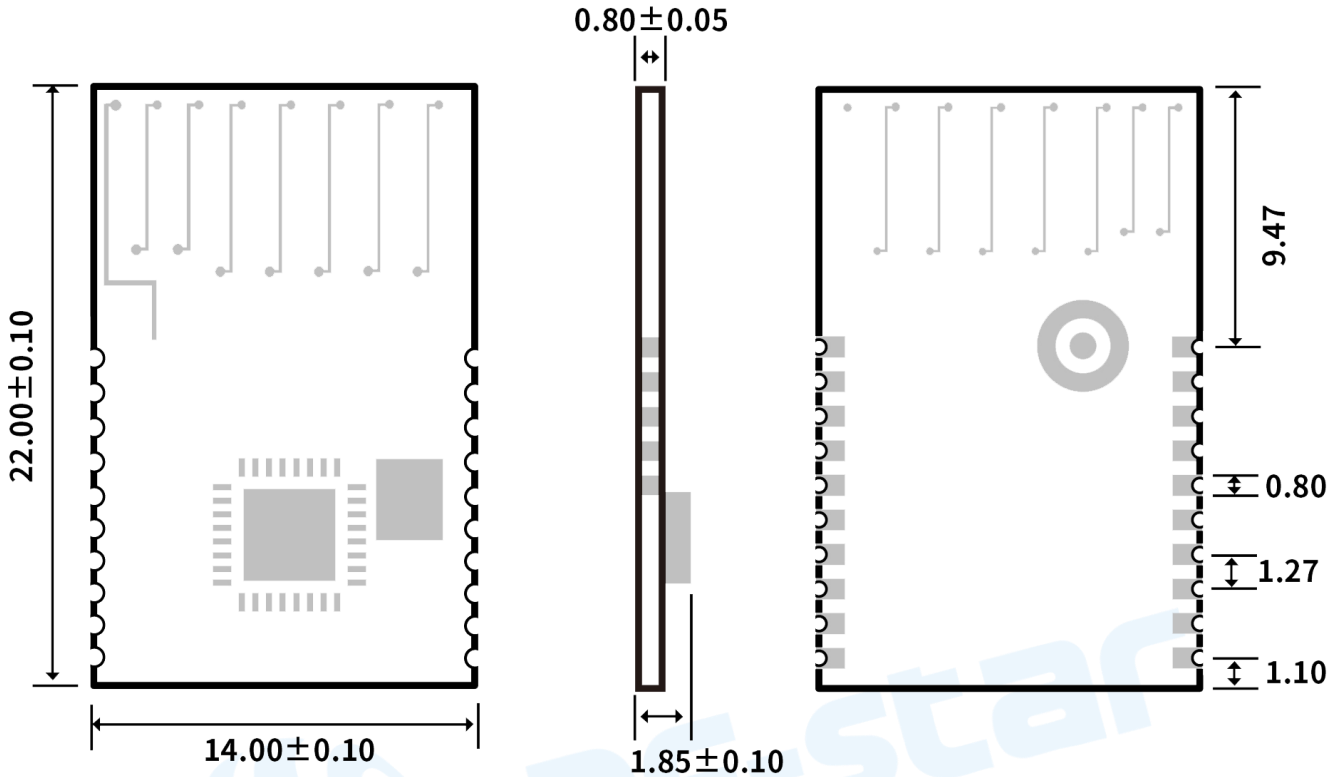


Figure 8. Recommended PCB Footprint of RF-SM-1044B4 (mm)

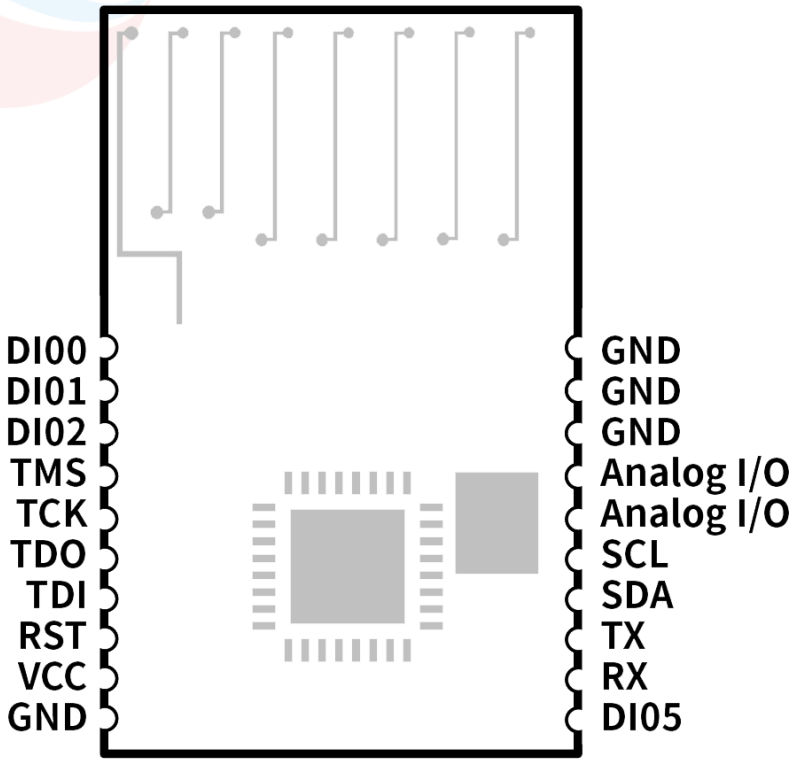


Figure 9. Pin Diagram of RF-SM-1044B2

Table 4. Pin Functions of RF-SM-1044B4

Pin	Name	Chip Pin	Pin Type	Description
1	DIO0	DIO_0	GPIO	GPIO, Sensor Controller
2	DIO1	DIO_1	GPIO	GPIO, Sensor Controller
3	DIO2	DIO_2	GPIO	GPIO, Sensor Controller
4	TMS	TMS	-	Debug pin
5	TCK	TCK	-	Debug pin
6	DIO3 / TDO	DIO_3	GPIO	Debug pin
7	DIO4 / TDI	DIO_4	GPIO	Debug pin
8	RST	Reset	Reset	Reset pin, active low.
9	VCC	VCC	VCC	Power supply 1.8 V ~ 3.8 V, Recommend 3.3 V
10	GND	GND	GND	Ground
11	DIO5	DIO_5	GPIO	GPIO, Sensor Controller
12	DIO6 / RX	DIO_6	GPIO	RX (GPIO, Sensor Controller)
13	DIO7 / TX	DIO_7	GPIO	TX (GPIO, Sensor Controller)
14	DIO8 / SDA	DIO_8	GPIO	GPIO, Sensor Controller
15	DIO9 / SCL	DIO_9	GPIO	GPIO, Sensor Controller
16	Analog I/O	X32_Q1	GPIO	GPIO, Sensor Controller
17	Analog I/O	X32_Q2	GPIO	GPIO, Sensor Controller
18	GND	GND	GND	Ground
19	GND	GND	GND	Ground
20	GND	GND	GND	Ground

3 Functions

3.1 Transparent Transmission

Transparent transmission mode is that the data is transmitted to a remote device.

The function is realized under the following conditions:

1. Two or more devices are in the same frequency.

2. The address of the devices are allowed to connect each other.

Users can define the channel of each device according to the condition, and only the devices which are in the same frequency and the same channels can communicate. The device channel can be defined by AT command, please kindly refer to the chapter of “AT Command”.

Transparent transmission rate: The device communicates through RF under IEEE 802.15.4g standard with three transmission rates: **625 bps, 50 Kbps, 200 Kbps**.

Data confirmation process mechanism is contained in transparent transmission. The mechanism contains timeout of receiving confirmation packet. This protocol defines the values of timeout period in different mode: 15 ms for 200 Kbps, 35 ms for 50 Kbps, 500 ms for 625 bps. At the same time, the packet sizes are regulated according to the different modes: 128 bytes for 200 Kbps and 50 Kbps data rate mode (the serial number size of the packet contains 2 bytes, so the actual packet size is no more than 126 bytes), and 30 bytes for 625 bps data rate mode (the serial number size of the packet contains 2 bytes, so the actual packet is no more than 28 bytes). When the packet size is over the defined maximum packet size, the default processing mechanism is only sending packets with the same defined packet size, and the extra data will be discarded directly.

Transparent transmission mechanism: The device starts transparent transmission mode by default after power on, that is, the data which received from the serial port will be transmitted. **"+++"** string is the startup command of AT command mode, transparent transmission mode will be disabled when serial port receives this command, and then the module enters AT command mode (please refer to “AT command” for details). The module will enter transparent transmission mode after exiting AT command mode.

This module is designed for long distance transmission and lower data transmitting rate, transparent transmission mode is recommended when lower requirement on low transmission rate.

3.2 Sensor Data Acquisition

CC1310 integrates a Sensor Controller, which supports data collection under low power mode. RTC provides work clock for Sensor Controller, e.g. Sensor Controller executes operation every 100 ms when RTC clock settled in 100 ms, after the operation executed. Sensor Controller will enter low power consumption mode automatically. Application layer can control the data collection frequency of sensor through RTC. Sensor Controller controls 7 digital I/Os (DIO1 ~ DIO7), 8 digital /analog I/Os (DIO23 ~ DIO30), and these I/Os can be configured as SPI, I^2C, ADC etc.

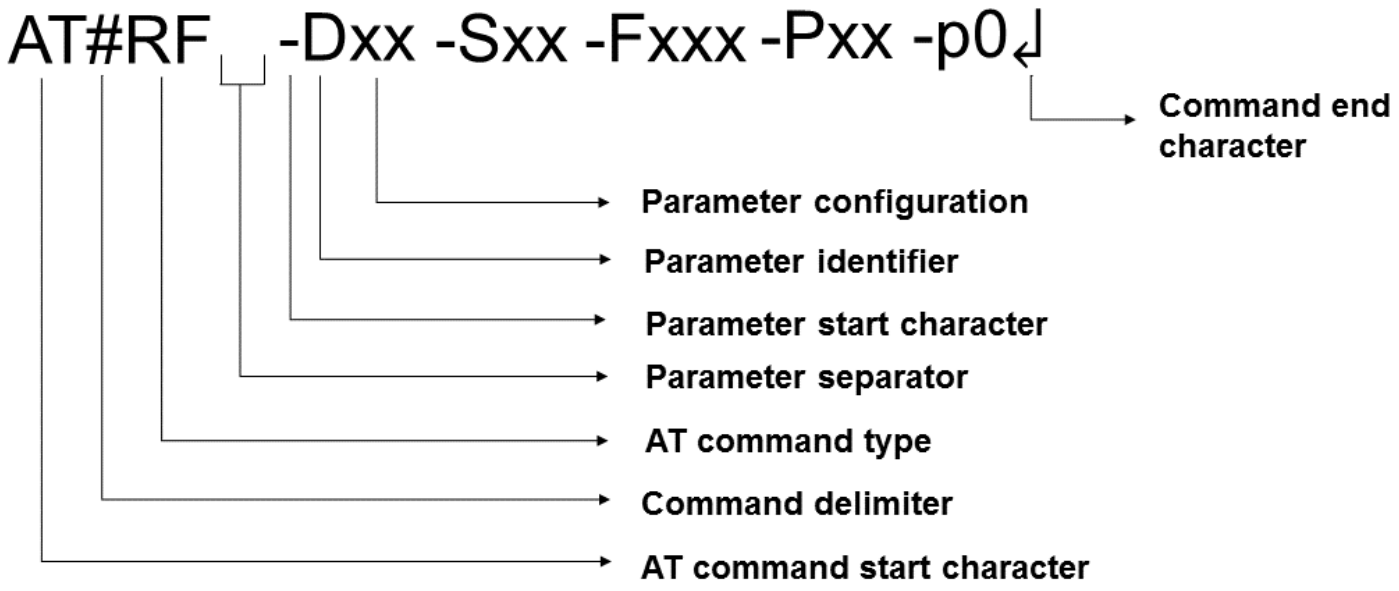
This protocol is configured with AD voltage acquisition function by default. This function enables two ADC channels (channel 0 is DIO23, channel 1 is DIO24). AD voltage acquisition range is 0 V~ 3.8 V. Sensor Controller control RTC to provide the clock for AD acquisition, and collect data once every second by default. Users can control the enable and disable of AD voltage collection through AT commands (please refer to “AT command” for details).

4 AT Command

The string which starts with "AT#" will be parsed and executed as an AT command, and the AT command will be returned from the serial port as it is. Then the execution result will be output. "OK↲" means successful operation, "ERROR↲" means error operation, and "FAIL↲" means failed operation.

5.1 AT Command Format

AT command format: "AT#EXIT" + "↲". The letters in AT commands are not case-sensitive unless otherwise specified. The specific format is as follows:



AT command start character: All AT commands must start with "AT" characters, which is not case-sensitive.

Command delimiter: The separator of "AT" start character and the command type is fixed as "#" character.

AT command type: AT command type, such as "RF", "UART", which is not case-sensitive.

Parameter separator: Parameter separator is used to separate the command type and configuration parameters or separate multiple configuration parameters, which is fixed as a space bar.

Parameter start character: The configuration parameter start character indicates the start character of the configuration parameter, which is fixed as "-".

Parameter identifier: Parameter identifier indicates the meaning of the configuration parameter. The different configuration parameters of the identifier will be different, which is not case-sensitive. Please refer to “AT Command” for details.

Parameter configuration: Different configuration parameters have different range of values, please refer to t“AT Command” for details.

Command end character: AT Command terminator is used to indicate that the command ends, which is fixed as carriage return linefeed “↲”(\r\n).

4.2 AT Commands

Start / Exit AT Command Mode

"+++": Start AT command mode.

Enter the command into serial port means that the device will enter AT command mode. When the serial port prints "OK↲", which means start the AT command mode successfully. Then the data received from the serial port will be regarded as AT command.

"AT#EXIT↲": Exit AT command mode.

Enter the command into serial port means that the device will exit AT command mode and then enter transparent transmission mode. When the serial port prints "OK↲", which means exit AT command mode successfully. Then the data except "+++" received from the serial port will be transmitted as transparent data.

Parameter Query / Configuration

"AT#UART?↲": Query parameter.

Enter the command into the serial port. When the serial port prints "OK↲" which means successful operation, in the meanwhile, the device parameters will be returned. If “Bps:xxxx Dat:x Par:x Stp:x” is returned, the parameters refer to the following:

“-Bps” is the baud rate.

“-Dat” is the data bit.

“-Par” is the parity bit.

“-Stp” is the stop bit.

If the command format is incorrect, the serial port will return "ERROR↲".

"AT#UART -Bxxxx -Dx -Px -Sx↲": Configure parameter.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In this command, “-Bps” is the baud rate, “-Dat” is the data bit, “-Par” is the parity bit, “-Stp” is the stop bit. If the instruction format is incorrect, the serial port will return "ERROR↲".

The command will take effect after restart.

Default configuration: 115200 baud rate, 8 data bit, no parity bit, 1 stop bit.

RF Parameter Query / Configuration

"AT#RF?↲": Query RF parameters.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, the RF output power of the device will be returned. If "Desxxx Src:xx Frq:xx PWr:xx Rat:xx↲" is returned, the parameters refer to the following:

“-Des” means the set transmitter address.

“Src” means the set receiver address.

“Frq” means the set frequency of the transmitter and receiver.

“Pwr” means the set Tx power of the transmitter.

“Rat” means the set MAC rate.

If the command format is incorrect, the serial port will return "ERROR↲".

"AT#RF -Dxx -Sxx -Fxxx -Pxx -Rxx↲": Configure RF parameters.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation.

“D” means the set transmitter address, and the address length is 8 bits (0xxx ~ 0xFF in hex).

“S” means the set receiver address, and the address length is 8 bits (0xxx ~ 0xFF in hex).

“F” means the frequency of the transmitter and receiver to be set, and the supporting frequency are **433 MHz, 470 MHz, 500 MHz, 868 MHz, 915 MHz and 920 MHz**.

“P” means the Tx power of the transmitter, and the supporting parameter is any one character among -10 dBm ~ 14 dBm (433 MHz, 470 MHz and 500 MHz supports -10 dBm ~ 15 Bm).

“R” means the set rate of the lower layer, the supporting parameter range is 625 bps, 50 Kbps and 200 Kbps.

The command will take effect after restart.

If the command format is incorrect, the serial port will return "ERROR↲".

Default configuration: transmitter address: 0xAA, receiver address: 0xAA, Frequency: 433 MHz, Tx power: 15 dBm, MAC rate: 50 Kbps.

Enable / Disable AD Voltage Acquisition

"AT#ADC -E↲": Enable AD voltage acquisition.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. The voltage acquisition function of ADC channel 0 and channel 1, and the serial port will print data in ADC channel 0 and channel 1 every second, otherwise, the function is failed to enable. AD voltage acquisition supports 0 V ~ 3.8 V, and the serial port return value is the integer from 0 mV to 3800 mV.

"AT#ADC -D↲": Disable AD voltage acquisition.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation.

Software Version Query

"AT#SVER↲": Query module software version.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, the software version number will be returned. If "V1.0.0↲" is returned, it means the version number is V1.0.0,

Module Restart

"AT#RESTART↲": Restart module.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, the device will be automatically restarted after 100 ms. After restart is done, the serial port prints "Application Start↲". If users want to enter the AT command mode again, "+++" need to be sent, please refer to "AT command" for details.

Module Reset

"AT#RESET↲": Reset module.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, all the parameters of the device are restored to the factory settings when the device starts next time.

Channel Query / Configuration

"AT#CHN?↲": Query channel.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, the channel of this device will be returned. If "AT#CHN 0↲" is returned, it means the channel 0.

If the command format is incorrect, the serial port will return "ERROR↲".

"AT#CHN-Cx↲": Configure channel.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the command, "-C" means the RF channel.

The command will take effect after restart.

If the command format is incorrect, the serial port will return "ERROR↲".

Default configuration: channel 0.

Received RSSI Query

"AT#RSSI?↲": Query received RSSI.

Enter the command into serial port. When the serial port prints "OK↲", which means successful operation. In the meanwhile, the received signal strength indicator value of the device for the last time will be returned. If "AT#RSSI-Rx↲" is returned, where "-Rx" means the RSSI.

If the command format is incorrect, the serial port will return "ERROR↲".

If the command is entered when the device have no data received, the default return value is 255.

AT Command Table

Table 5. AT Command Table

AT command	Parameters	Description
+++	-	"+++": Start AT command mode. "OK↲": successful operation. "ERROR↲": error operation. "FAIL↲": failed operation.
AT#EXIT	-	"AT#EXIT↲": Exit AT command mode. "OK↲": successful operation. "ERROR↲": error operation. "FAIL↲": failed operation.
AT#UART	-B: Baud rate (115200 bps) -D: Data bit (8 by default) -P: Parity bit (0 by default) -S: Stop bit (1 by default)	"AT#UART?↲": Query parameters. "OK↲": successful operation, and all parameters will be print, such as Bps:xxxx Dat:x Par:x Stp:x". "ERROR↲": error operation. "FAIL↲": failed operation. "AT#UART-B11520-D8-P0-S1↲": Configure parameters. Baud rate: 115200 bps, 38400 bps, 57600 bps, 14400 bps, 9600 bps, 4800 bps.

		Data bit: 8, 7, 6, 5. Parity bit: 0 and 1. Stop bit: 0 and 1. "OK↲": successful operation. “ERROR↲”: error operation. "FAIL↲": failed operation. Note: This command will take effect after restart.
AT#RF	“-D: the transmitter address (0xAA by default) “-S”: the receiver address, which means only receive data from this address (0xAA by default) “F”: frequency (433 MHz by default) “P”: Tx power (15 dBm by default) “R”: MAC rate, (50 Kbps by default)	"AT#RF?↲": Query RF parameters. "OK↲": successful operation, and all parameters will be returned. “ERROR↲”: error operation. "FAIL↲": failed operation. "AT#RF -DAA -SAA -F433 -P15 -R50↲": Configure RF parameters. “D” means the set transmitter address, and the address length is 8 bits (0xxx ~ 0xFF in hex). “S” means the set receiver address, and the address length is 8 bits (0xxx ~ 0xFF in hex). “F” means the frequency of the transmitter and receiver to be set, and the supporting frequency are **433 MHz, 470 MHz, 500 MHz, 868 MHz, 915 MHz and 920 MHz**. “P” means the Tx power of the transmitter, and the supporting parameter is any one character among -10 dBm ~ 14 dBm (433 MHz, 470 MHz and 500 MHz supports -10 dBm ~ 15 Bm). “R” means the set rate of the lower layer, the supporting parameter range is 625 bps, 50 Kbps and 200 Kbps. "OK↲": successful operation. “ERROR↲”: error operation. "FAIL↲": failed operation. Note: This command will take effect after restart.
AT#ADC	-E: Enable data acquisition of ADC channel 0 and channel 1. -D: Disable data acquisition of ADC	"AT#ADC -E↲": Enable data acquisition of ADC channel 0, 1. "OK↲": successful operation, and the serial port will print data values of ADC channel 0,1 every second (voltage acquisition range support 0 V ~ 3.8 V). “ERROR↲”: error operation.

	channel 0 and channel 1.	"FAIL↲": failed operation. "AT#ADC -D↲": Disable data acquisition of ADC channel 0,1. "OK↲": successful operation. "ERROR↲": error operation. "FAIL↲": failed operation.
AT#SVER	-	"AT#VER↲": Query module software version. "OK↲": successful operation, and the version will be returned, such as V1.0.0. "ERROR↲": error operation. "FAIL↲": failed operation.
AT#RESTART	-	"AT#RESTART↲": Module restart. "OK↲": successful operation, and the version will be returned, such as V1.0.0. "ERROR↲": error operation. "FAIL↲": failed operation.
AT#RESET	-	"AT#RESET↲": Module reset. T "OK↲": successful operation, and all the parameters of the device are restored to the factory settings in next time when the device starts to work. "ERROR↲": error operation. "FAIL↲": failed operation. Note: This command will take effect after restart.
AT#CHN	-C: RF channel, supporting Channel 0 ~ 6	"AT#CHN?↲": Query RF channel. "OK↲": successful operation, and the RF channel parameter will be returned. "ERROR↲": error operation. "FAIL↲": failed operation. "AT#CHN -C1↲": Configure RF channel. "OK↲": successful operation. "ERROR↲": error operation. "FAIL↲": failed operation. Note: This command will take effect after restart.
AT#RSSI	-	"AT#RSSI?↲": Query RSSI for the last time transmitting and receiving.

		"OK↲": successful operation. “ERROR↲”: error operation. "FAIL↲": failed operation.

Note:

AT Command with “” is the completed one.

5 Application, Implementation, and Layout

5.1 Antenna

RF-SM-1077B1 and RF-SM-1077B2 are integrated the IPEX version 1 antenna seat, the specification of antenna seat is as follow:

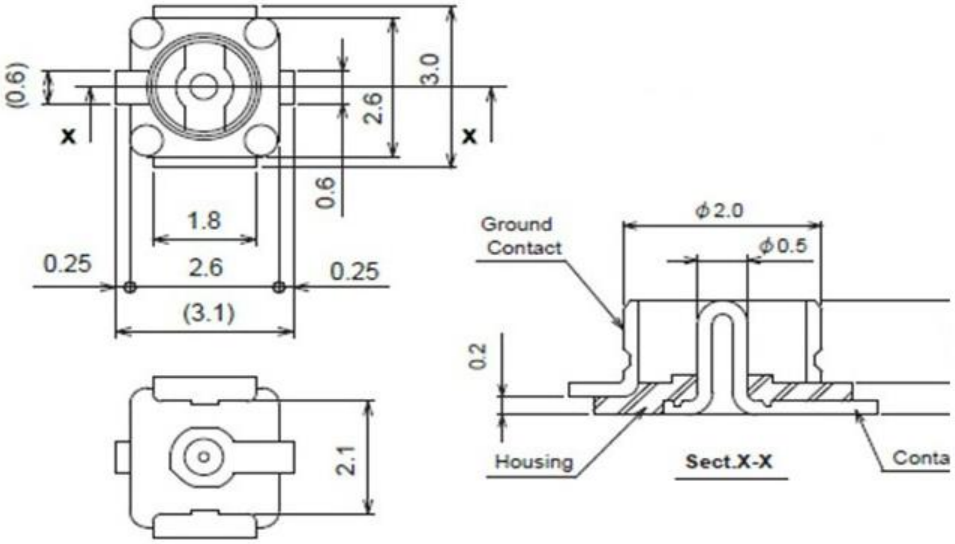


Figure 10. Specification of Antenna Seat

The specification of IPEX wire end is as follow:

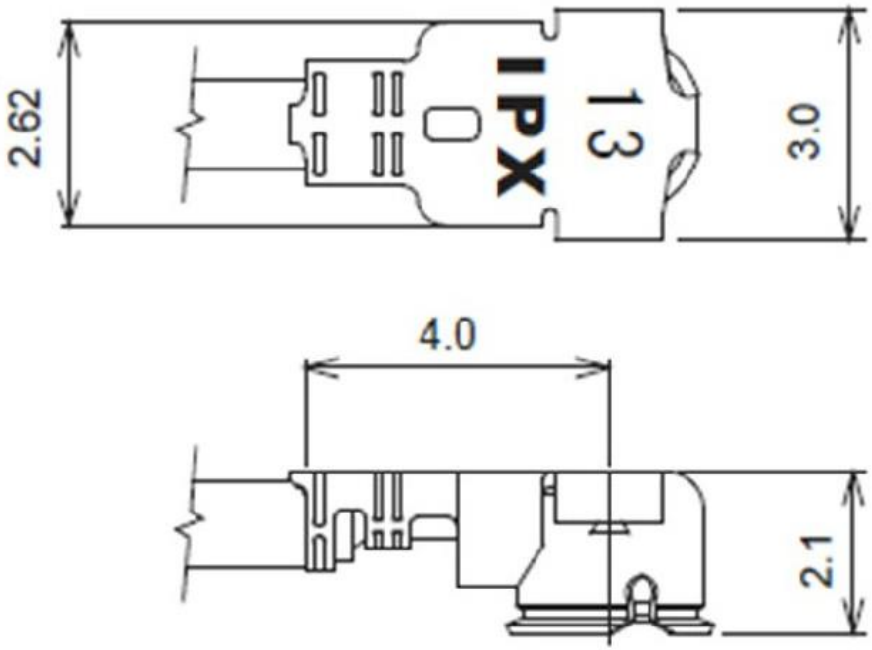


Figure 11. Specification of IPEX Wire

5.2 Basic Operation of Hardware Design

1. It is recommended to offer the module with a DC stabilized power supply, a tiny power supply ripple coefficient and the reliable ground. Please pay attention to the correct connection between the positive and negative poles of the power supply. Otherwise, the reverse connection may cause permanent damage to the module;
2. Please ensure the supply voltage is between the recommended values. The module will be permanently damaged if the voltage exceeds the maximum value. Please ensure the stable power supply and no frequently fluctuated voltage.
3. When designing the power supply circuit for the module, it is recommended to reserve more than 30% of the margin, which is beneficial to the long-term stable operation of the whole machine. The module should be far away from the power electromagnetic, transformer, high-frequency wiring and other parts with large electromagnetic interference.
4. The bottom of module should avoid high-frequency digital routing, high-frequency analog routing and power routing. If it has to route the wire on the bottom of module, for example, it is assumed that the module is soldered to the Top Layer, the copper must be spread on the connection part of the top layer and the module, and be close to the digital part of module and routed in the Bottom Layer (all copper is well grounded).
5. Assuming that the module is soldered or placed in the Top Layer, it is also wrong to randomly route the Bottom Layer or other layers, which will affect the spurs and receiving sensitivity of the module to some degrees;
6. Assuming that there are devices with large electromagnetic interference around the module, which will greatly affect the module performance. It is recommended to stay away from the module according to the strength of the interference. If circumstances permit, appropriate isolation and shielding can be done.
7. Assuming that there are routings of large electromagnetic interference around the module (high-frequency digital, high-frequency analog, power routings), which will also greatly affect the module performance. It is recommended to stay away from the module according to the strength of the interference. If circumstances permit, appropriate isolation and shielding can be done.
8. It is recommended to stay away from the devices whose TTL protocol is the same 433 MHz physical layer.
9. The antenna installation structure has a great influence on the module performance. It is necessary to ensure the antenna is exposed and preferably vertically upward. When the module is installed inside of the case, a high-quality antenna extension wire can be used to extend the antenna to the outside of the case.
10. The antenna must not be installed inside the metal case, which will cause the transmission distance to be greatly weakened.

5.3 Trouble Shooting

5.3.1 Unsatisfactory Transmission Distance

1. When there is a linear communication obstacle, the communication distance will be correspondingly weakened. Temperature, humidity, and co-channel interference will lead to an increase in communication packet loss rate. The

performances of ground absorption and reflection of radio waves will be poor, when the module is tested close to the ground.

2. Seawater has a strong ability to absorb radio waves, so the test results by seaside are poor.
3. The signal attenuation will be very obvious, if there is a metal near the antenna or the module is placed inside of the metal shell.
4. The incorrect power register set or the high data rate in an open air may shorten the communication distance. The higher the data rate, the closer the distance.
5. The low voltage of the power supply is lower than the recommended value at ambient temperature, and the lower the voltage, the smaller the power is.
6. The unmatchable antennas and module or the poor quality of antenna will affect the communication distance.

5.3.2 Vulnerable Module

1. Please ensure the supply voltage is between the recommended values. The module will be permanently damaged if the voltage exceeds the maximum value. Please ensure the stable power supply and no frequently fluctuated voltage.
2. Please ensure the anti-static installation and the electrostatic sensitivity of high-frequency devices.
3. Due to some humidity sensitive components, please ensure the suitable humidity during installation and application. If there is no special demand, it is not recommended to use at too high or too low temperature.

5.3.3 High Bit Error Rate

1. There are co-channel signal interferences nearby. It is recommended to be away from the interference sources or modify the frequency and channel to avoid interferences.
2. The unsatisfactory power supply may also cause garbled. It is necessary to ensure the power supply reliability.
3. If the extension wire or feeder wire is of poor quality or too long, the bit error rate will be high.

5.4 Electrostatics Discharge Warnings

The module will be damaged for the discharge of static. RF-star suggest that all modules should follow the 3 precautions below:

1. According to the anti-static measures, bare hands are not allowed to touch modules.
2. Modules must be placed in anti- static areas.
3. Take the anti-static circuitry (when inputting HV or VHF) into consideration in product design.
   Static may result in the degradation in performance of module, even causing the failure.

5.5 Soldering and Reflow Condition

1. Heating method: Conventional Convection or IR/convection.

2. Solder paste composition: Sn96.5 / Ag3.0 / Cu0.5
3. Allowable reflow soldering times: 2 times based on the following reflow soldering profile.
4. Temperature profile: Reflow soldering shall be done according to the following temperature profile.
5. Peak temperature: 245 ℃.

Table 6. Temperature Table of Soldering and Reflow

Profile Feature	Sn-Pb Assembly	Pb-Free Assembly
Solder Paste	Sn63 / Pb37	Sn96.5 / Ag3.0 / Cu0.5
Min. Preheating Temperature (T_{min})	100 ℃	150 ℃
Max. Preheating Temperature (T_{max})	150 ℃	200 ℃
Preheating Time (T_{min} to T_{max}) (t_1)	60 s ~ 120 s	60 s ~ 120 s
Average Ascend Rate (T_{max} to T_P)	Max. 3 ℃/s	Max. 3 ℃/s
Liquid Temperature (T_L)	183 ℃	217 ℃
Time above Liquidus (t_L)	60 s ~ 90 s	30 s ~ 90 s
Peak Temperature (T_p)	220 ℃ ~ 235 ℃	230 ℃ ~ 250 ℃
Average Descend Rate (T_p to T_{max})	Max. 6 ℃/s	Max. 6 ℃/s
Time from 25 ℃ to Peak Temperature (t_2)	Max. 6 minutes	Max. 8 minutes
Time of Soldering Zone (t_P)	20±10 s	20±10 s

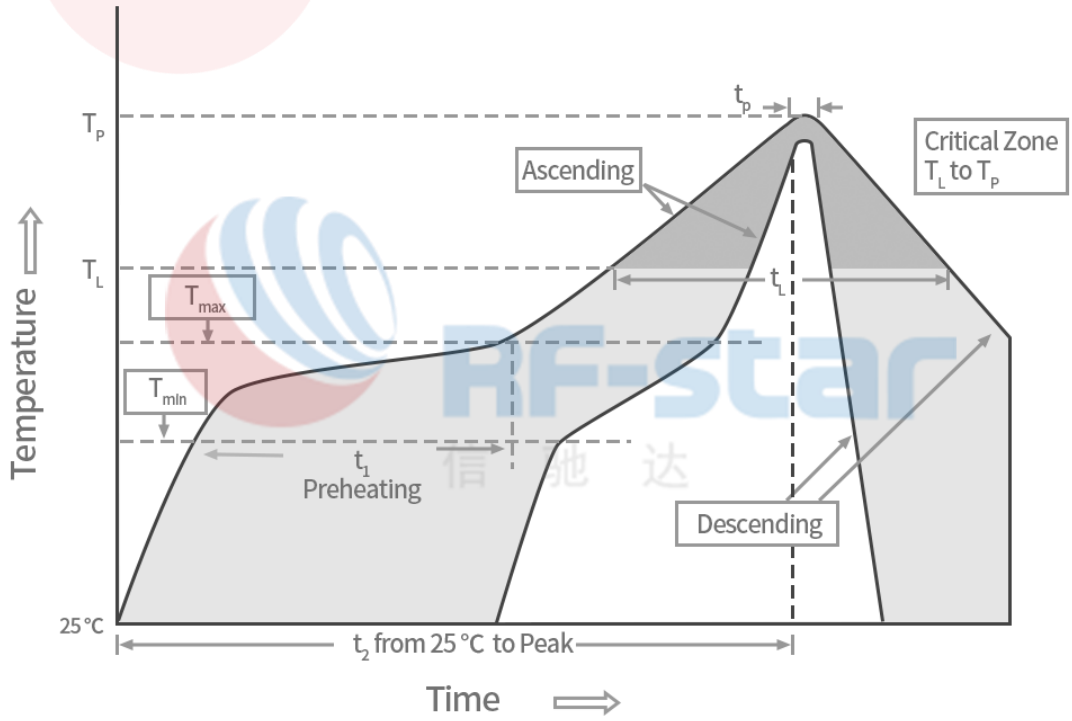


Figure 12. Recommended Reflow for Lead Free Solder

5.6 Optional Packaging

Figure 13. Optional Packaging Mode

Note: Default tray packaging.

6 Revision History

Date	Version No.	Description	Author
2017.10.19	V1.0	The initial version is released.	Levi
2018.03.12	V2.0	Add commands.	Levi
2018.01.24	V2.0	Add inquiry MAC address function.	Levi
2018.08.02	V2.0	Update company address.	Aroo Wang
2020.09.14	V2.0	Modify the parameters.	Sunny Li

Note:

1. The document will be optimized and updated from time to time. Before using this document, please make sure it is the latest version.
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