seeed studio

Wio-E5-LE Wireless Module

LoRa Wireless Module - Powered by STM32WLE5

Datasheet

V1.0

Content

1 Introduction

Wio-E5-LE Wireless Module is a low-cost, ultra-low power, ultra-small size LoRaWAN® module designed by Seeed Technology Co., Ltd. The module uses ST system on chip STM32WLE5JC, integrated high-performance LoRa® SX126X IP and ultra-low power Consumption of MCU. The target application of this module is wireless sensor networks and other Internet of Things devices, especially battery-powered low power consumption and long- distance occasions.

This specification mainly describes the hardware information, hardware performance and application information of the module.

Wio-E5-LE Wireless LoRaWAN® Module is mainly suitable for long-distance, ultra-low-power applications such as wireless meter reading, sensor networks, and other low-power wide-area IoT scenarios.

1.1 Feature

- ➢ Low power consumption: as low as 2.1uA sleep current (WOR mode)
- ➢ low cost:
- ➢ Small size: 12mm X 12mm * 2.5mm 28 pins SMT
- ➢ High performance:
  Wio-E5-LE
  - ✓ TXOP=14dBm@868MHz
  LoRa-E5-HF
  - ✓ TXOP=22dBm@915MHz
- ➢ -136.5dBm sensitivity for SF12 with 125KHz BW
- ➢ 158dB link budget, suitable for long distance

- ➢ interface
  - ✓ USART
  - ✓ I2C
  - ✓ ADC
  - ✓ SWD
- ➢ Embedded LoRaWAN® protocol, AT command, support global LoRaWAN® frequency plan
  - ✓ EU868
  - ✓ US915 and US915 Hybrid
  - ✓ AU915
  - ✓ AS923
  - ✓ KR920
  - ✓ IN865

This product specification includes a detailed description of the Wio-E5-LE Wireless Module's performance and functions. For the latest firmware, product updates or errata, please contact Seeedstudio.

2 Description

Wio-E5-LE Wireless Module is embedded with high-performance STM32WLE5JC, which is very suitable for the design of various IoT nodes.

Based on the development of the multi-mode high-performance SX126X chip, the Wio-E5-LE Wireless Module supports (G) FSK mode and LoRa®. 62.5kHz, 125kHz, 250kHz and 500kHz bandwidth can be used in LoRa® mode. Based on the powerful functions and rich peripherals of STM32WLE5JC, the module provides UART, I2C, SPI, ADC and GPIOs for users to choose according to the application. If you need to upgrade the built-in AT command firmware, please use the two-wire interface (UART) to complete the programming based on the boot mode; and customers can develop the software based on the internal MCU of the module to complete the program erasure and programming through SWD.

Wio-E5-LE Wireless Module currently contains two sub-models, Wio-E5-LE Wireless Module (Single-core STM32WLE5JC intergrated with SX126X IP), Wio-E5-LE Wireless Module supports 14dBm @ HF band (868 MHz);LoRa-E5-HF (Single-core STM32WLE5JC intergrated with SX126X IP), LoRa-E5-HF supports 22dBm @ HF band (915 MHz).
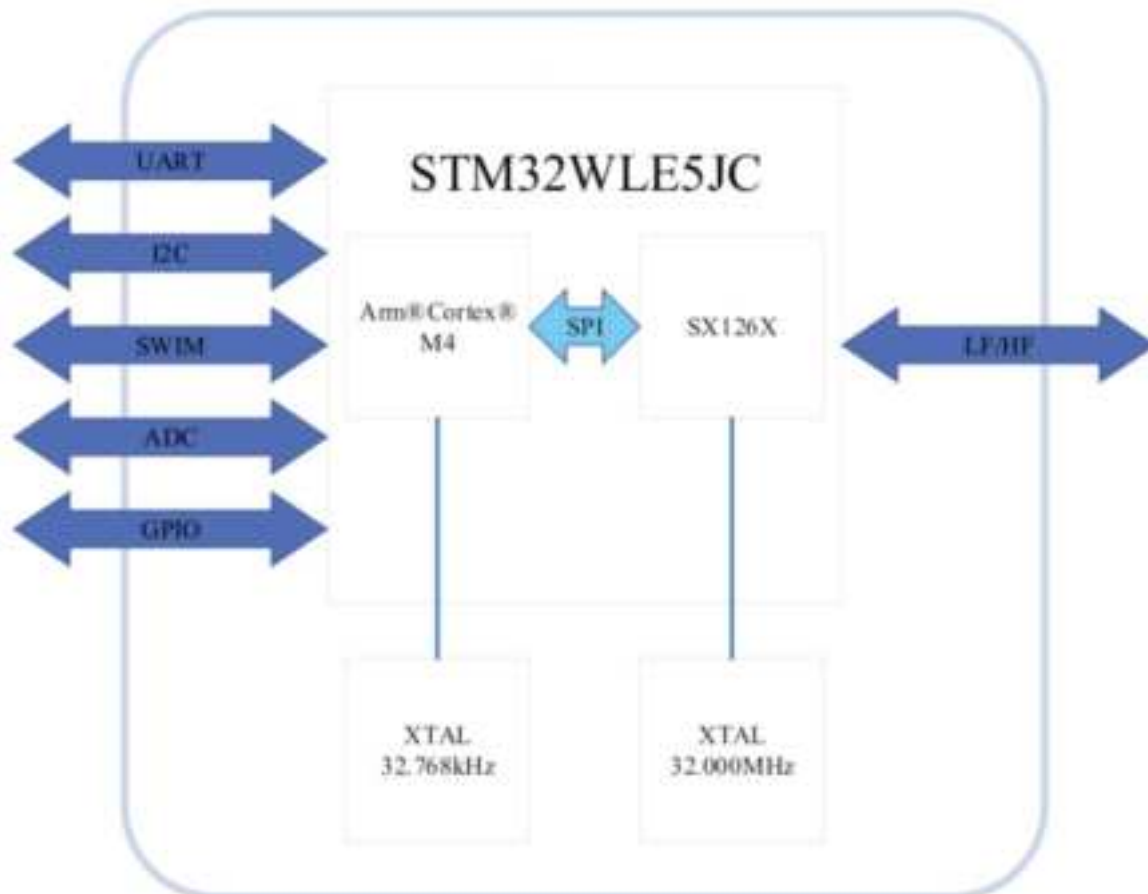

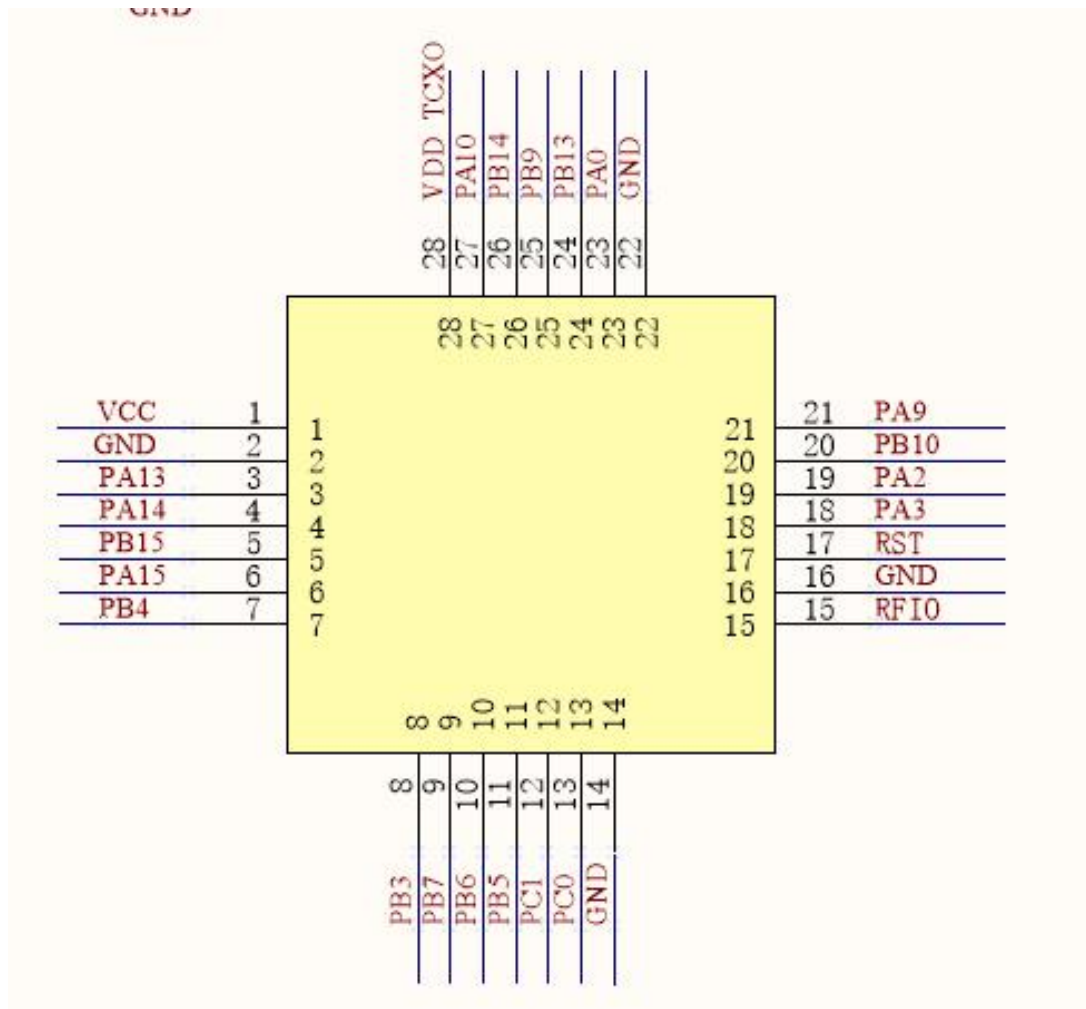**Figure 1   Wio-E5-LE Wireless Module Schematic diagram**

seeed studio

2.1 Pin definition

Figure 2 Wio-E5-LE Wireless Module Pin arrangement

seeed studio

Table 1 Wio-E5-LE Wireless Module pin out

Number	Name	Type	Description
1	VCC	-	Supply voltage for the module
2	GND	-	Ground
3	PA13	I	SWDIO of SWIM for program download
4	PA14	I/O	SWCLK of SWIM for program download
5	PB15	I/O	SCL of I2C2 from MCU
6	PA15	I/O	SDA of I2C2 from MCU
7	PB4	I/O	MCU GPIO
8	PB3	I/O	MCU GPIO
9	PB7	I/O	UART1_RX from MCU
10	PB6	I/O	UART1_TX from MCU
11	PB5	I/O	MCU GPIO
12	PC1	I/O	MCU GPIO ；LPUART1_TX from MCU
13	PC0	I/O	MCU GPIO ；LPUART1_RX from MCU
14	GND	-	Ground
15	RFIO	I/O	RF input/output
16	GND	-	Ground
17	RST	I/O	Reset trigger input for MCU
18	PA3	I/O	MCU GPIO；USART2_RX from MCU
19	PA2	I/O	MCU GPIO；USART2_TX from MCU
20	PB10	I/O	MCU GPIO
21	PA9	I/O	MCU GPIO
22	GND	-	Ground
23	PA0	I/O	MCU GPIO
24	PB13	I/O	SPI2_SCK from MCU; Boot pin(Active low)
25	PB9	I/O	SPI2_NSS from MCU
26	PB14	I/O	SPI2_MISO from MCU
27	PA10	I/O	SPI2_MOSI from MCU
28	PB0	I/O	Unavailable；Suspended treatment

3 Electrical characteristics

3.1 Extreme working conditions

Reaching or exceeding the maximum ratings listed in the table below can cause equipment damage.

Table 2 Absolute Maximum Ratings

Item	Description	min	max	unit

VCCmr	Supply voltage	-0.3	+3.9	V
Tmr	Ambient temperature	-40	+85	℃
Pmr	RF input power	-	+10	dBm

Note: Stresses exceeding the absolute ratings may cause permanent damage. Functional operation is not guaranteed under these conditions. Extended exposure to absolute ratings may adversely affect reliability.

3.2 Normal working conditions

Table 3 Recommended Operating Conditions

Item	Description	min	max	unit
VCCop	Supply voltage	+1.8	+3.6	V
Top	Ambient temperature	-40	+85	℃
Pop	RF input power	-	+10	dBm

Table 4 Wio-E5-LE Wireless Module 868MHz Currents of varying power levels

Tx Power(dBm)	1	2	3	4	5	6	7
Current(mA)	12.41	13.11	13.84	14.48	15.33	16.29	17.16
Output Power(dBm)	1.161	2.159	3.069	3.863	4.895	6.025	7.014

Tx Power(dBm)	8	9	10	11	12	13	14
Current(mA)	18	19.21	20.36	21.65	22.93	24.5	26.22
Output Power(dBm)	7.88	8.954	9.878	10.814	11.642	12.545	13.461

3.3 Module specifications

Table 5 Wio-E5-LE Wireless Module features

ITEMs	Parameter	Specifications				Unit
Structure	Size	12(W) X 12(L) X 2.5(H)				mm
	Package	28 pins, SMT				
Electrical Characteristics	power supply	3.3V type				V
	Sleep current	2.1uA (WDT on);				uA
	Operation current (Transmitter+MCU)	26mA @14dBm in 868MHz type				mA
	Operation current (Receiver+MCU)	6.7mA @BW125kHz, 868MHz type				mA
	Output power	14dBm max @868MHz				dBm
	Sensitivity	@SF12, BW125kHz				dBm
		Fr(MHz)	min	type	max	
		868	-	-135	-137	
	Harmonics	<-36dBm below 1GHz				dBm
		<-40dBm above 1GHz				dBm
Interface	RFIO	RF port				
	UART	3 group of UART, include 2pins				
	I2C	1 group of I2C, include 2 pins				
	ADC	1 ADC Input, include 1pins,12-bit 1Msps				
	NRST	Manual reset pin input				
	SPI	1 group of SPI, include 4 pins				

4 Typical RF performance test

4.1 Wio-E5-LE Wireless Module Performance Testing
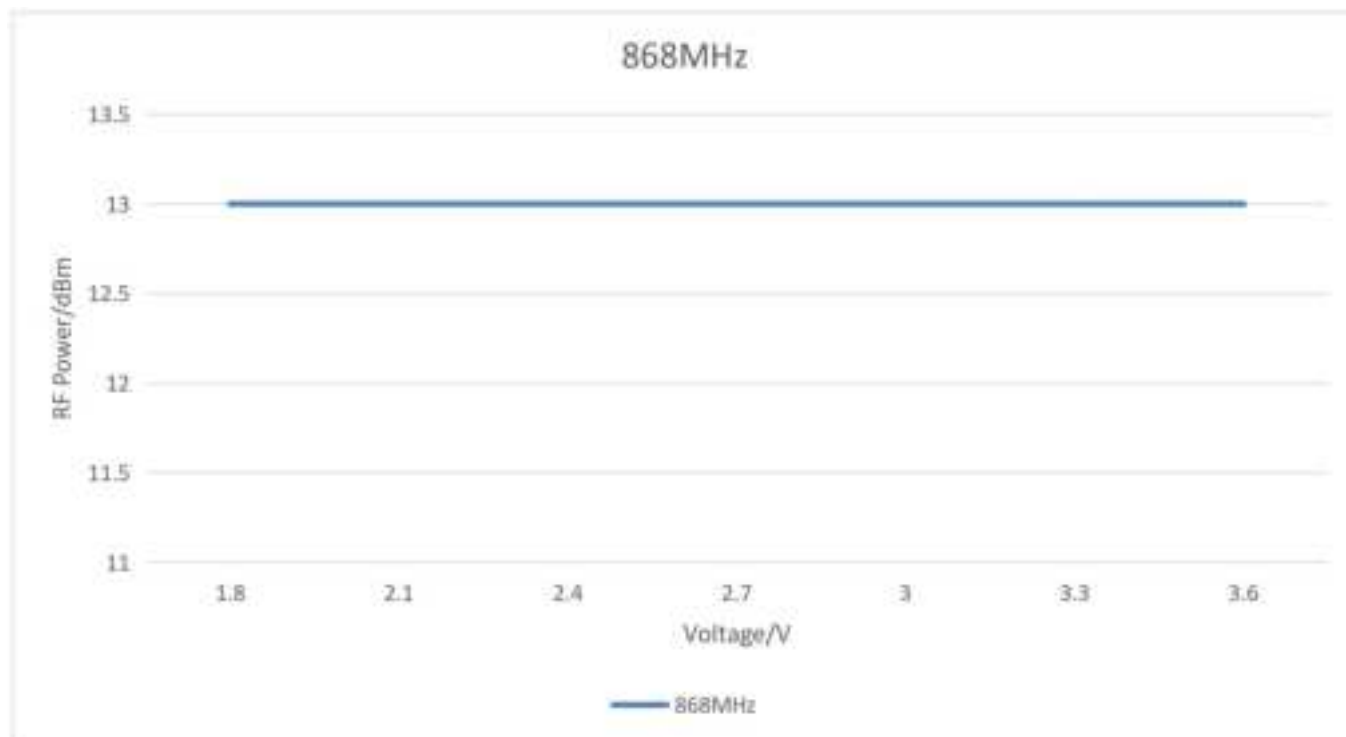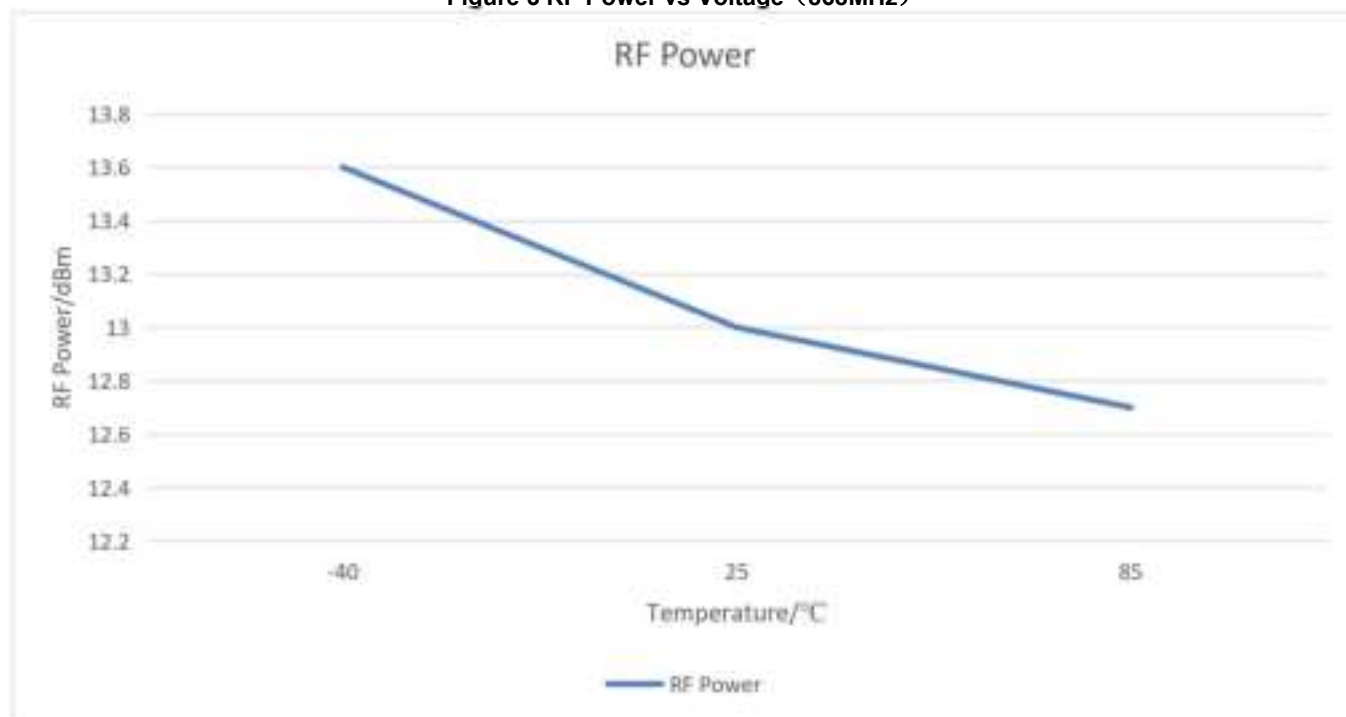

Figure 3 RF Power vs Voltage（868MHz）
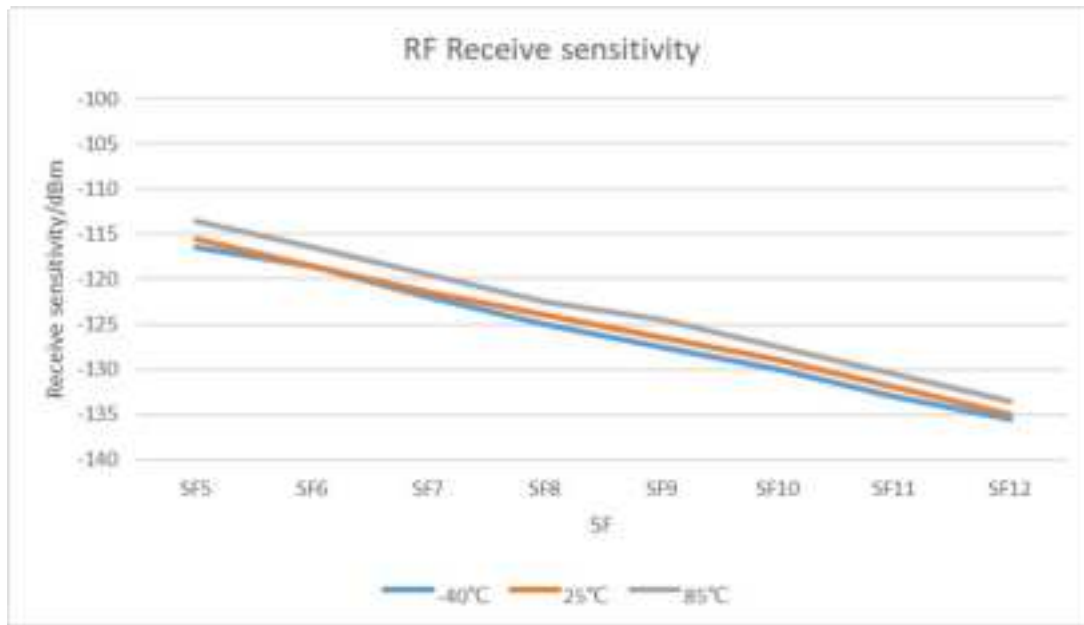

Figure 4 RF Power VS Temperature（868MHz）

Figure 5 RF Receiver Sensitivity VS Temperature（868MHz）

5 Application information

5.1 Package information

Unless specified dimension tolerance, the Dimension below will be with tolerance ±0.1mm, all the dimension unit is mm.

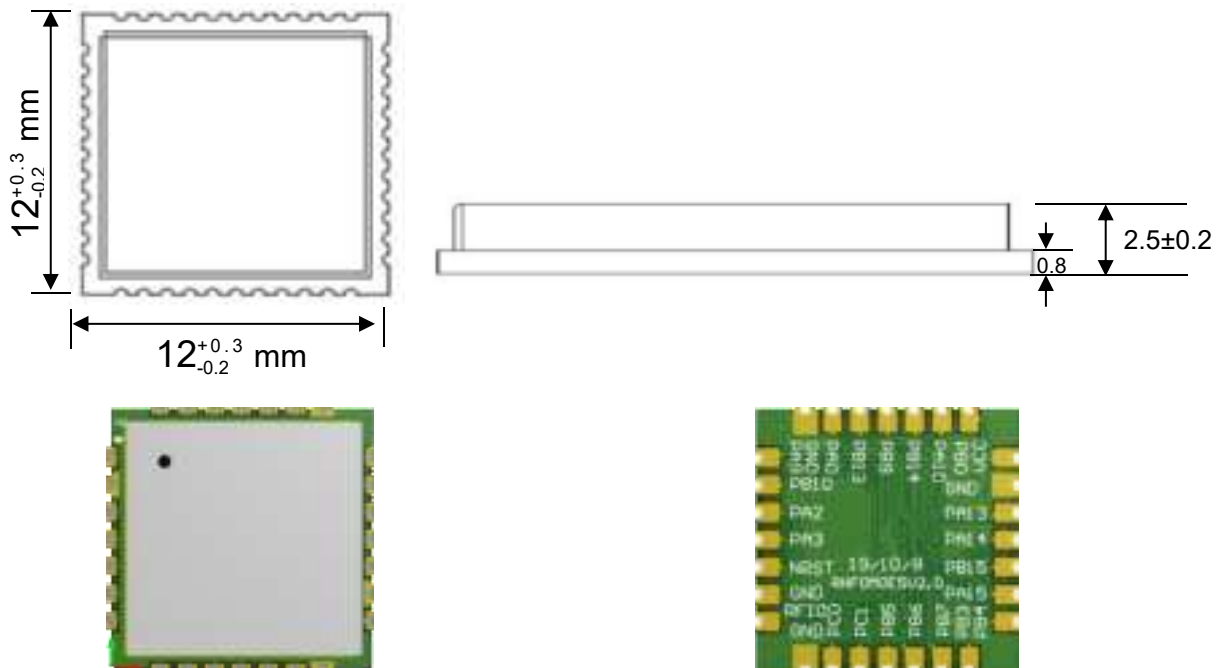Wio-E5-LE Wireless Module has a 28-pin SMD package:

Figure 6 Wio-E5-LE Wireless Module appearance

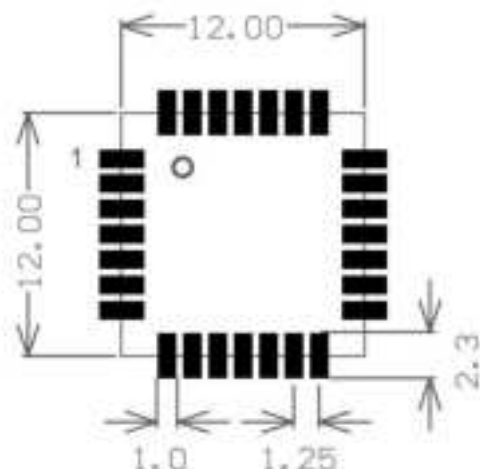The following figure shows the recommended Layout package dimensions.

Figure 7 PCB footprint

5.2 External interface of the module

In addition to several necessary GPIO ports and a set of SPI ports used for internal RF transceiver control, other GPIOs of the MCU have been derived, including UART (for AT commands), I2C, ADC, etc. For customers who want to develop software or expand peripherals on the MCU of the module, these rich GPIO interfaces can satisfy most application requirements.

5.3 Reference design based on Wio-E5-LE Wireless Module

Wio-E5-LE Wireless Module embeds the global LoRaWAN® protocol and AT instruction set. This will make the design of LoRaWAN® nodes based on this module very easy. The following is a typical reference design that uses Wio-E5-LE Wireless Module to quickly start a LoRaWAN® application. Just connect UART and NRST to the host MCU and send AT commands.

In addition,Pin24 grounding of the module will force the module to enter Boot upgrade mode.

Note: The 28-pin PB0 must be left floating and not allowed to be pulled up or grounded.

For the RF antenna part, there are no specific values available. Furthermore, you will need to conduct tests based on parameters such as circuit board thickness or other relevant factors to determine the resistance value of the required resistor to be used.

Figure 8 Reference design based on Wio-E5-LE Wireless Module
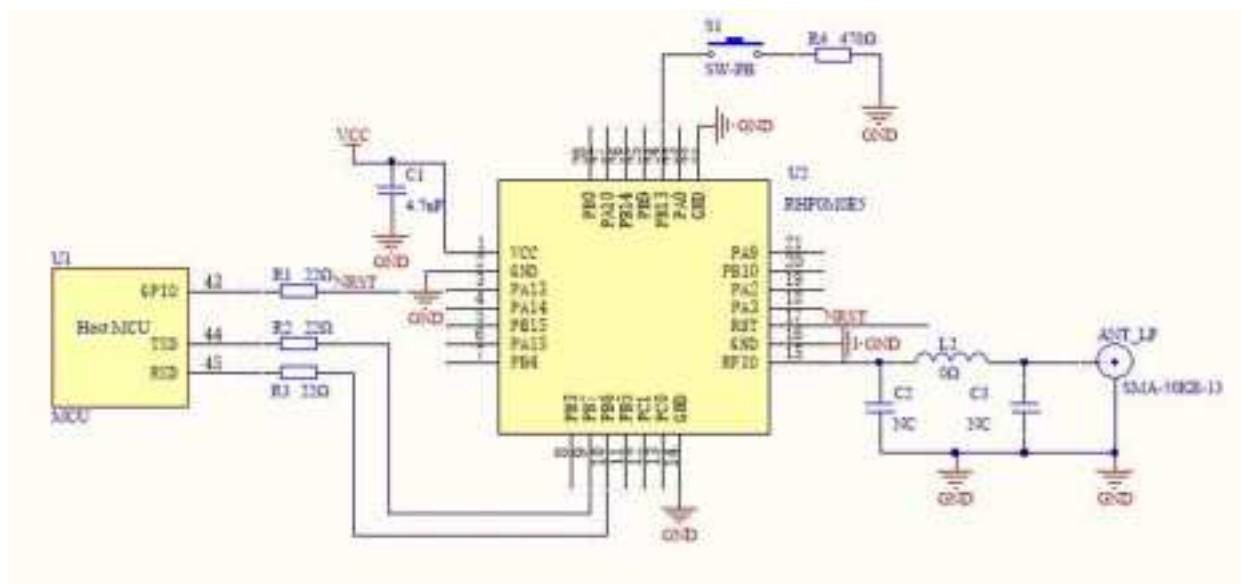
6 LoRaWAN® application information

6.1 LoRaWAN® application

The topology of the LoRaWAN® network is a star network, and the gateway acts as a relay between nodes and network servers. The gateway is connected to the network server through a standard IP link, and the node device uses LoRa® or FSK to communicate with one or more gateways. Communication is bidirectional, although it is mainly upstream communication from the node to the network server.

The communication between the node and the gateway uses different frequencies and rates. The choice of rate is a compromise between power consumption and distance, and different rates do not interfere with each other. According to different spreading factors and bandwidths, the rate of LoRa® can be from 300bps to 50Kbps. In order to maximize battery life and network capacity, the network server manages the node's rate and output power through rate adaptation (ADR).

The node device may transmit on a random channel at any time and at any rate, as long as the following conditions are met:

    1) The channel currently used by the node is pseudo-random. This makes the system more resistant to interference

    2) The maximum transmission time (dwell time of the channel) and duty cycle of the node depends on the frequency band used and local regulations

Wio-E5-LE Wireless Module integrates ST ultra-low power IC STM32WLE5JC. The current is only 2.1uA in sleep mode, this module is very suitable for various applications of LoRaWAN®.

6.2 Design LoRaWAN® wireless sensor based on Wio-E5-LE Wireless Module

Wio-E5-LE Wireless Module is an AT instruction set that encapsulates the global LoRaWAN® standard protocol. The customer only needs a very simple MCU as the main control, and can control the Wio-E5-LE Wireless Module through the serial port, thereby easily implementing the LoRaWAN® protocol. This helps customers quickly bring sensor products to the LoRaWAN® market.
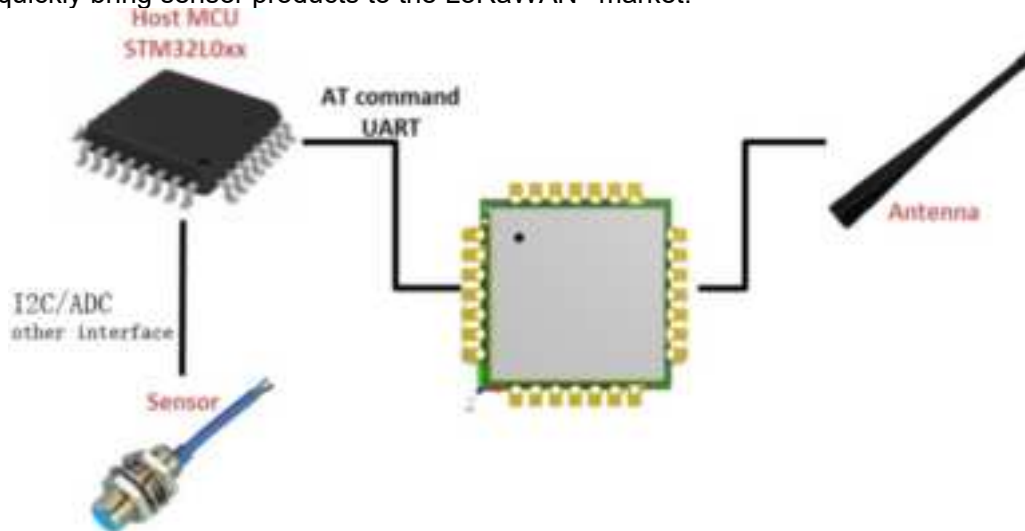

Figure 9 Design of LoRaWAN® wireless sensor based on Wio-E5-LE Wireless Module

7 Ordering information

Technical Support:sensecap@seeed.cc

Sales:iot@seeed.cc

Table 6 Ordering Information

SKU	Name	Model
114993120	Wio-E5-LE Wireless Module (Bulk)	Wio-E5-LE-HF
114993121	Wio-E5-LE Wireless Module (Tape Reel)	Wio-E5-LE-HF
317990687	Wio-E5 Wireless Module (Bulk)	Wio-E5-HF
317990829	Wio-E5 Wireless Module (Tape Reel)	Wio-E5-HF

8 ODM & OEM Services

With decades of ODM & OEM experience, our engineers and product experts are proficient in delivering customization service for popular open-source hardware platforms – NVIDIA® Jetson™, Raspberry Pi ®, Beagleboard ®,and more. Use the Wio-E5-LE module to create industrial-grade sensors or development boards for rapid AIoT implementation.

We're dedicated to supporting you and streamlining your idea-to-product journey. We are ready to bring your product concept to the market with Seeed Studio's industrial capabilities from design, manufacturing, testing, certification, global distribution, and marketplace. To design with the Wio-E5-LE Wireless Module module, please contact iot@seeed.cc.

9 Reversion

V1.0 2023-05-17   First release

seeed studio

Declaration of Conformity

Hereby, Seeed Technology Co., Ltd. declares that the radio equipment type Wio-E5-LE-HF of Wio-E5-LE Wireless Module is in compliance with Directive 2014/53/EU and this product is allowed to be used in all EU member states. The full text of the EU declaration of conformity is available at the following internet address: www.seeedstudio.com

Manufacturer information:
Company name: Seeed Technology Co., Ltd.
Address：9F, G3 Building, TCL International E City, Zhongshanyuan Road, Nanshan District, Shenzhen 518055, China

Operation frequency (Max power)
Lora: 863MHz-870MHz (13.1dBm)

RF exposure statement
RF exposure information: The Maximum Permissible Exposure (MPE) level has been calculated based on a distance of d=20 cm between the device and the human body. To maintain compliance with RF exposure requirement, use product that maintain a 20cm distance between the device and human body.

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.

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: **Z4T-WIO-E5-LE**". 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

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: Z4T-WIO-E5-LE.

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: Z4T-WIO-E5-LE"

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.