



ROOT_WLE_32 Datasheet V0.4

2025-10-21

Revision History

Version	Description	Date	Author
V0.1		2025-06-07	Lei.Yang
V0.2	The following content has been added: 8.8.Module Peripheral Circuit & Placement Guidelines 10.FCC warning	2025-07-03	Lei.Yang
V0.3	Change the datasheet to English	2025-07-21	Lei.Yang
V0.4	The following content has been updated: 10.FCC warning	2025-10-21	Lei.Yang
V0.5	The following content has been updated: 10. FCC warning 4. Radio Transceiver	2025-10-27	Lei.Yang

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1. Introduction

ROOT_WLE_32 is a low-power, highly integrated AIoT module featuring an MCU ESP32_C3FH4X chip, with integrated Bluetooth Low Energy (Bluetooth LE 5.0 & Bluetooth mesh) and 2.4G WiFi wireless communication. It includes 4MB Flash and several GPIOs.

ROOT_WLE_32 is an RTOS platform integrating all WiFi MAC and TCP/IP protocol libraries. Users can develop customized embedded WiFi products based on these resources

1.1 Key Features

- Including low-power MCU ESP32-C3FH4X. Can serve as an application processor.
- WiFi
 - Support IEEE 802.11b/g/n
 - Support 20MHz and 40MHz bandwidth on 2.4 GHz Freq.
 - Support 1T1R, Rate speed up to 150Mbps
 - Channel 1-14@2.4GHz (CH1-11 for US/CA, CH1-13 for EU/CN)
 - Support Security Modes WEP/WPA/WPA2/WPA2-PSK (AES)
- Bluetooth
 - Bluetooth LE: Bluetooth 5.0, Bluetooth mesh
 - 125Kbps, 500Kbps, 1Mbps, 2Mbps
 - WiFi and Bluetooth share the same antenna
 - TX Max Power 20dBm
- 32-bit RISC-V single-core processor, frequency up to 160MHz
- Supply Voltage: 3V - 3.6V
- Operating Temperature: -20°C - 85°C
- PCB Onboard Antenna
- peripheral device: 10 x GPIO, 1 x UART, 1 x I2C, 5 x ADC and 6 x PWM
- Support SmartConfig, including Android and IOS device

1.2 Applications

- Smart LED systems
- Smart home devices
- Smart low-power sensors
- Smart Building
- Smart socket
- Intelligent public transportation
- Industrial wireless control

2. Module interface

2.1 Appearance Dimensions

ROOT_WLE_32 has a total of 18 interfaces.

Pin configuration: 3 rows ($2 \times 8 + 1 \times 2$)

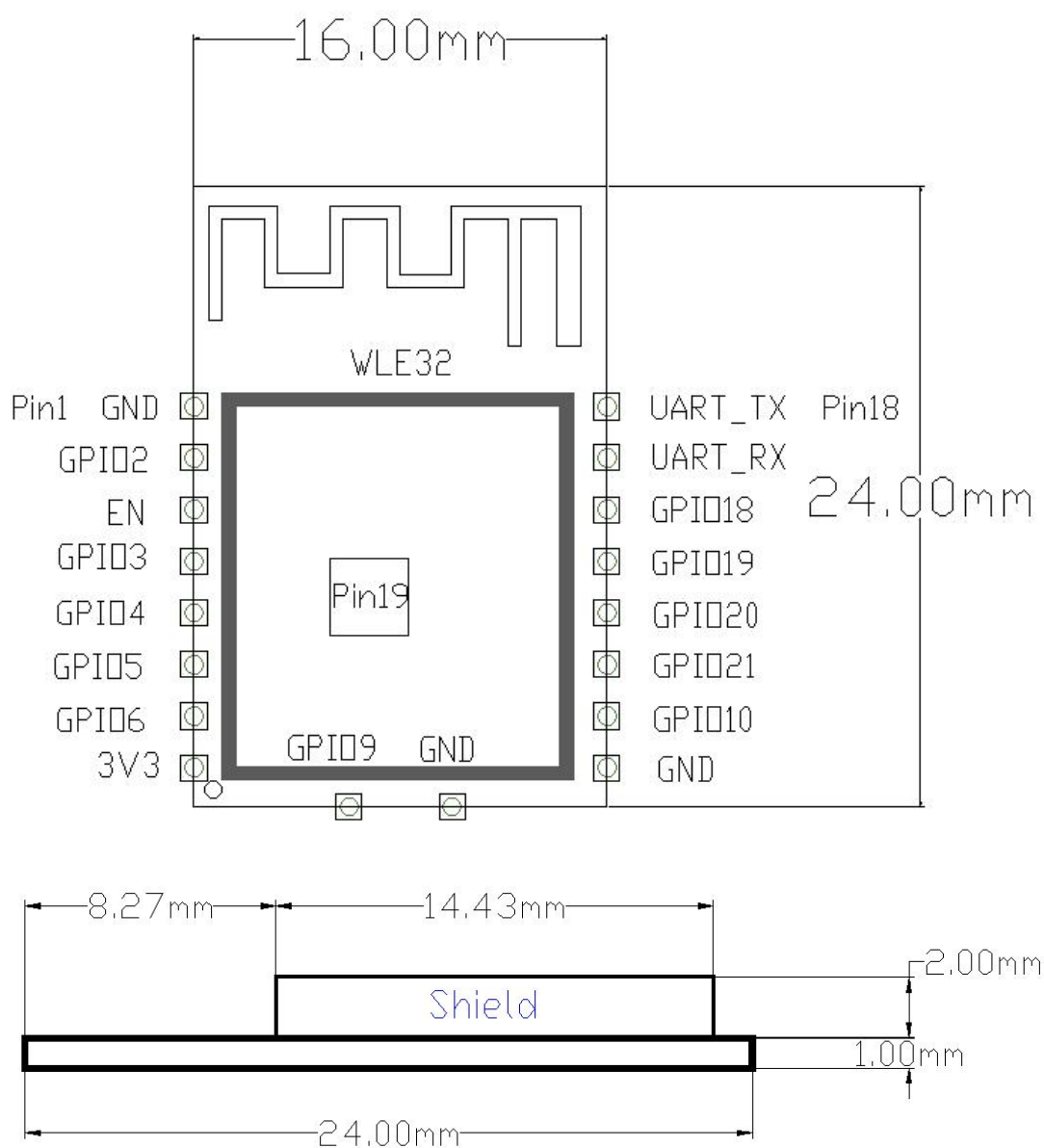
Pin width: 1mm

Vertical pitch: 2mm (between rows)

Horizontal pitch: 4mm (within rows)

Thermal pad (EPAD): Centrally located exposed pad for heatsinking.

ROOT_WLE_32 Dimensions: $16 \pm 0.35\text{mm}$ (W) $\times$ $24 \pm 0.35\text{mm}$ (L) $\times$ $3.2 \pm 0.15\text{mm}$ (H)。



2.2 Definition of pins

No.	Name	I/O	Functional Description
1	GND	GND	GND
2	GPIO2	I/O	GPIO2/PWM/ADC1_CH2/IC_pin6, internal up
3	EN	I	low level reset chip
4	GPIO3	I/O	GPIO2/PWM/ADC1_CH1/IC_pin8
5	GPIO4	I/O	GPIO4/PWM/ADC1_CH4/IC_pin9
6	GPIO5	I/O	GPIO5/PWM/IC_pin10
7	GPIO6	I/O	GPIO6/PWM/IC_pin12
8	3V3	Power	3.3VPower supply
9	GPIO9	I/O	GPIO9/PWM/IC_pin15, forbid down
10	GND	GND	GND
11	GND	GND	GND
12	GPIO10	I/O	GPIO10/PWM/IC_pin16
13	GPIO21	I/O	GPIO21/PWM/IC_pin28
14	GPIO20	I/O	GPIO20/PWM/IC_pin27
15	GPIO19	I/O	GPIO19/PWM/IC_pin26
16	GPIO18	I/O	GPIO18/PWM/IC_pin25
17	UART_RX	I/O	UART_RX/GPIO1/ADC1_CH1
18	UART_TX	I/O	UART_TX/GPIO0/ADC1_CH0
19	EPAD	GND	GND, EPAD

Note: I is input ,O is output.

3. Electrical parameters

3.1 Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
Ts (Storage temperature)		-40	105	℃
VDD (Power supply)		-0.3	3.6	V
ESD HBM	TAMB-25℃		2	KV

ESD CDMQF

TAMB=25°C

0.5

KV

3.2 Operating Conditions (3.3V 25°C)

Symbol	Description	Min.	Typ.	Max.	Unit
Ta	Operating temperature	-20		85	°C
VDD	Supply voltage normal mode	3.0	3.3	3.6	V
VIL	low-level input voltage	-0.3		0.25 x VDD	V
VIH	high-level input voltage	0.75 x VDD		VDD + 0.3	V
IIL	low-level input current			50	nA
IIH	high-level input current			50	nA
VOL ¹	low-level output voltage			0.1 x VDD	V
VOH ¹	high-level output voltage	0.8 x VDD			V
IOL	Low-Level Sink Current		28		mA
IOH	High-Level Source Current		40		mA
Cpad	Pin capacitance		2		pF

Note:

1 VOH and VOL is the test value under high resistance conditions for the load.

3.3 Radio Current Consumption (3.3V 25°C)

All emission data is measured based on a 100% duty cycle.

Parameter	Description	Tx_Power (dBm)	Typ (mA)
TX	802.11b 1Mbps	17.5	335
TX	802.11g 54Mbps	14.5	285
TX	802.11n20 MCS7	13.5	276
TX	802.11n40 MCS7	13.5	278
RX	802.11b, 11g, 11n20		84

RX	802.11n40	87
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3.4 Current Consumption

Mode	CPU Freq (MHz)	Parameter	Peripheral Clock Gating Enabled (mA)	外设时钟全开 ¹ (mA)
Modem-sleep ²³	160	CPU operation	23	28
		CPU idle	16	21
	80	CPU operation	17	22
		CPU idle	13	18

Note:

1 Actual peripheral current consumption varies with operating states.

2 In Modem-sleep mode, WiFi clock gating is activated

3 Flash access increases power consumption in Modem-sleep mode. At 80Mbit/s SPI 2-wire mode, flash adds 10mA.

4. Radio Transceiver

4.1 Transceiver characteristics

Parameter	Description
WiFi Frequency range	2412MHz~2462MHz
BLE Frequency range	2402MHz~2480MHz
WiFi	IEEE 802.11b/g/n
Bluetooth LE	Bluetooth 5.0, Bluetooth mesh
Rate	11b, 11g, 11n20, 11n40
Antenna	PCB Onboard Antenna, Gain 3.353dBi

4.2 WIFI TX Specification

Typ.			
Rate	Power	EVM	SPEC
802.11b 1Mbps	17.5dBm		

802.11b 11Mbps	17.5dBm		
802.11g 6Mbps	17dBm		
802.11g 54Mbps	14.5dBm	-28	-25
802.11n20 MCS0	16dBm		
802.11n20 MCS7	13.5dBm	-29	-27
802.11n40 MCS0	16dBm		
802.11n40 MCS7	13.5dBm	-28	-27

4.3 WIFI RX Specification

	Typ.
Rate	SEN SPEC
802.11b 1Mbps	-97dBm
802.11b 11Mbps	-87dBm
802.11g 6Mbps	-91dBm
802.11g 54Mbps	-75dBm
802.11n20 MCS0	-91dBm
802.11n20 MCS7	-72dBm
802.11n40 MCS0	-88dBm
802.11n40 MCS7	-69dBm

4.4 BLE TX Specification

Parameter	Min.	Typ.	Max.	Unit
1Mbps RF Output Power	-24	12	13	dBm
2Mbps RF Output Power	-24	9	10	dBm
125Kbps RF Output Power	-24	12	13	dBm
500Kbps RF Output Power	-24	12	13.5	dBm
Gain step		3		dB

4.5 BLE RX Specification

Rate	Min.	Typ.	Max.	Unit
1Mbps Sensitivity@30.8% PER		-97		dBm
2Mbps Sensitivity@30.8% PER		-93		dBm
125Kbps Sensitivity@30.8% PER		-105		dBm
500Kbps Sensitivity@30.8% PER		-100		dBm

5. Antenna characteristics

5.1 Antenna Type

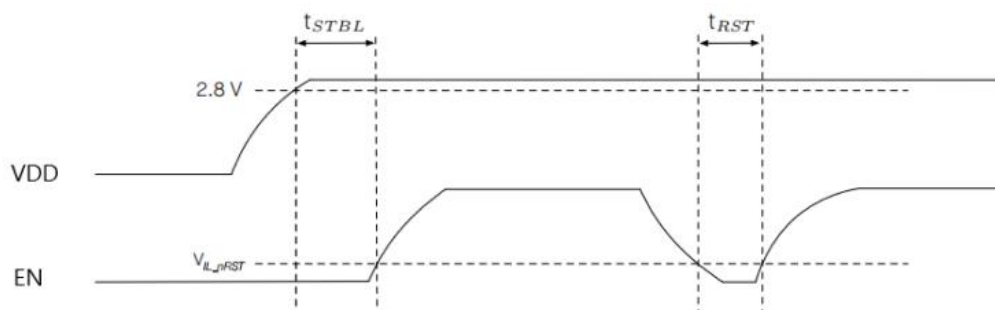
PCB Onboard Antenna, Gain 3.353dBi

5.2 Reduce antenna interference

Due to the use of PCB Onboard antennas in AIoT module, it is recommended that the distance between the module antenna and other metal components be at least 15mm to ensure optimal BLE performance.

6. Power-On Sequence

6.1 Power-On Sequence

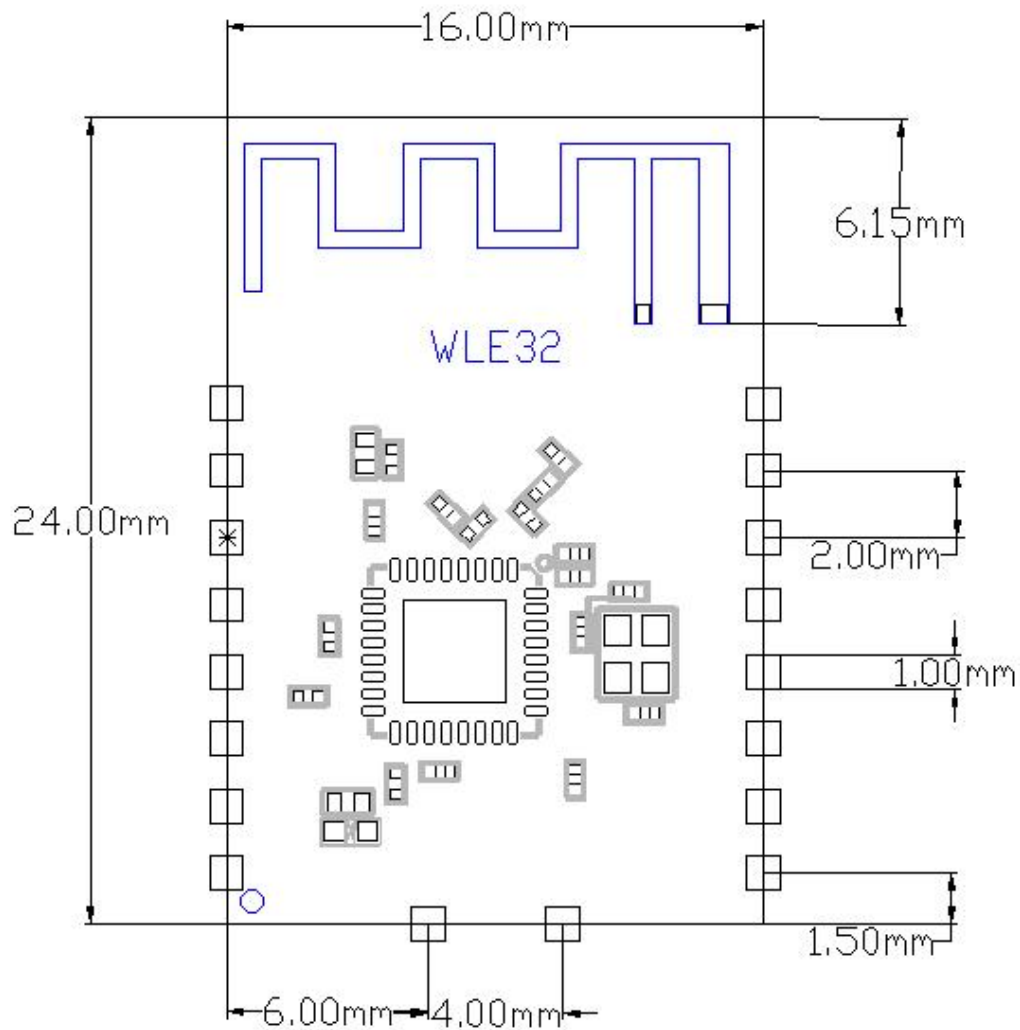


Parameter	Description	Min(us)
t_{STBL}	VDD stabilization time before EN assertion	50
t_{RST}	Chip reset time: EN pin deassertion below $0.25 \times VDD(\max)$	50

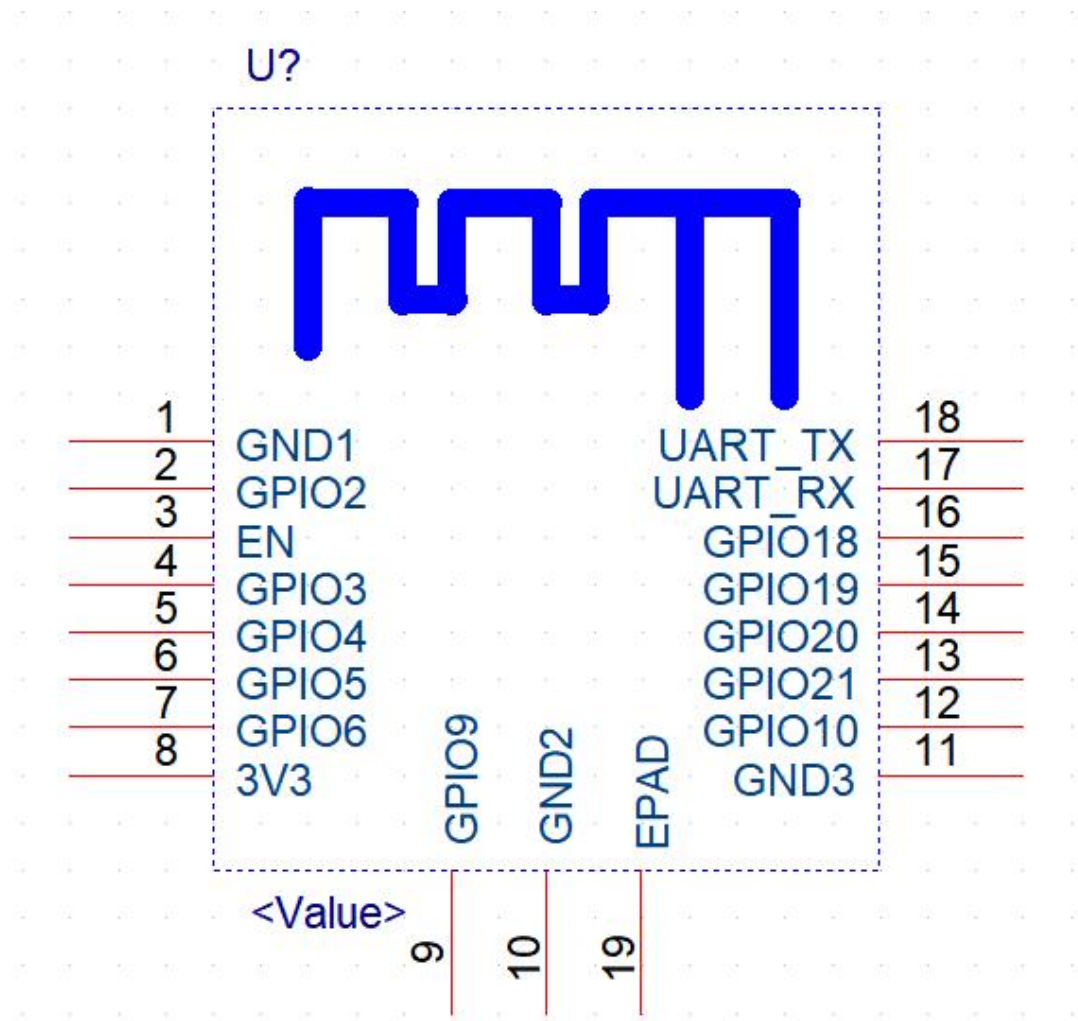
7. Package information and production guidance

7.1 PCB Size

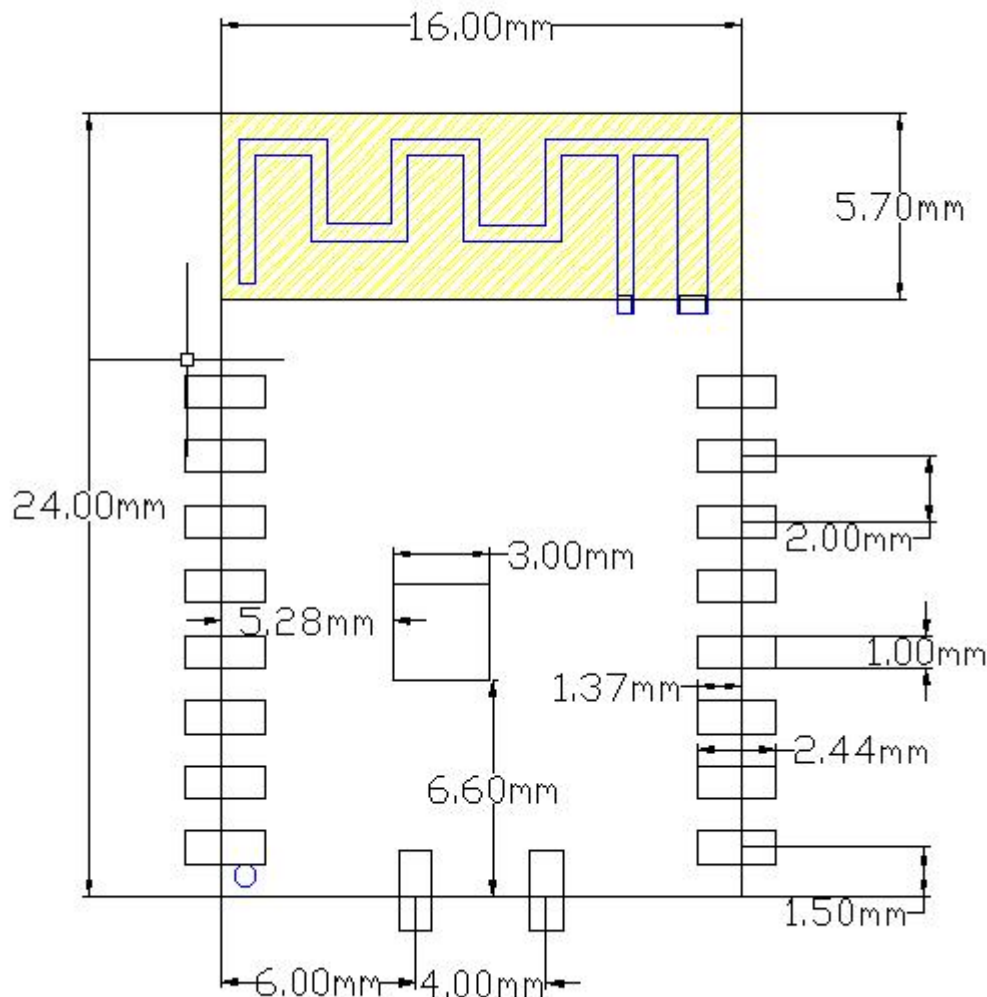
ROOT_WLE_32 PCB Size: $16\pm0.35\text{mm(W)}\times24\pm0.35\text{mm(L)}\times1.0\pm0.1\text{mm(H)}$ 。



7.2 Schematic Symbol



7.3 Recommended module package design dimensions



Copper paving is prohibited in the yellow area of the above picture

7.4 Production Guide

1. Modules should be mounted using SMT equipment. After opening the packaging, complete soldering within 24 hours.

Unused modules must be stored in a dry cabinet with $\leq 10\%$ RH or resealed in vacuum packaging with exposure time recorded. Total exposure time must not exceed 168 hours.

Required SMT Equipment:

- Pick-and-place machine
- SPI
- Reflow oven
- Profile thermometer

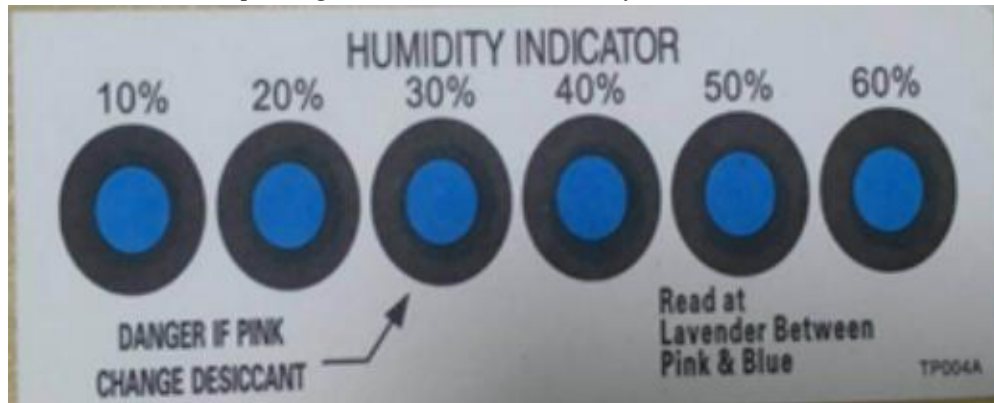
- AOI

Baking Equipment:

- Cabinet oven
- ESD-safe high-temperature trays
- ESD-safe high-temperature gloves

2. Module Storage Conditions:

- Moisture barrier bags must be stored at $<40^{\circ}\text{C}$ and $<90\%$ RH.
- Shelf life of dry-packed products: 12 months from sealing date.
- Each sealed package contains a humidity indicator card.



3. Baking Requirements for Moisture Exposure

Baking is required if:

- Vacuum packaging is damaged before opening.
- No humidity indicator card is found inside.
- Humidity indicator card shows $\geq 10\%$ (pink zone).
- Total exposure time exceeds 168 hours.
- Exceeds 12 months from initial sealing date.

4. Baking parameters:

- Baking Temperature:

Reel packaging: 40°C , $\leq 5\%$ RH

Tray packaging: 125°C , $\leq 5\%$ RH (Use high-temperature trays, not blister trays)

- Baking Duration:

Reel packaging: 168 hours

Tray packaging: 12 hours

- Over-Temperature Alarm Setting:

Reel packaging: 50°C

Tray packaging: 135°C

- Cool naturally to $\leq 36^{\circ}\text{C}$ before production.
- Rebake if re-exposed for >168 hours after initial baking.
- Wave soldering is not recommended for modules exposed >168 hours without baking. As MSL-3 moisture-sensitive devices, prolonged exposure likely causes moisture absorption. High-temperature soldering may lead to device failure or poor solder joints.

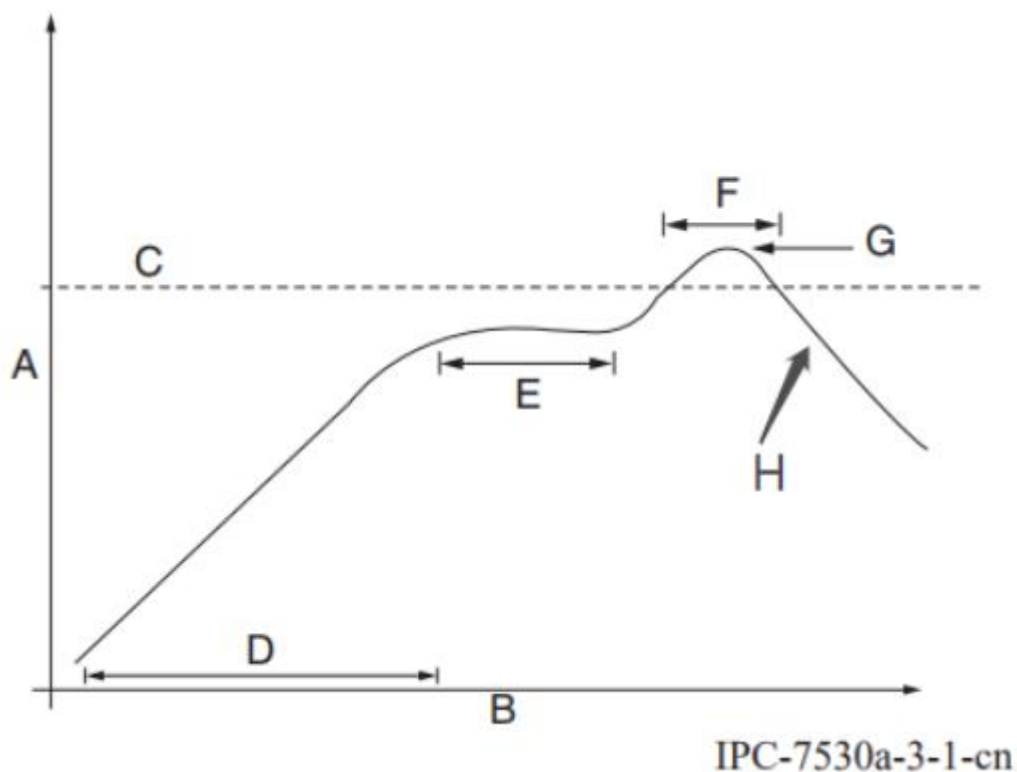
5. ESD safeguards must be implemented throughout production

6. Quality Assurance Recommendations

Use SPI and AOI to monitor solder paste printing and component placement

7.5 Recommended furnace temperature curve

Please set the temperature according to the reflow soldering curve, with a peak temperature of 245 °C. The reflow soldering temperature curve is shown in the following figure:



A: Temperature axis

B: Time axis

C: Alloy liquidus: 217 - 220° C

D: Ramp-up rate: 1 - 3° C/s

E: Soak zone: 60 - 120s at 150 - 200° C

F: Time above liquidus: 50 - 70s

G: Peak temperature: 235 - 245° C

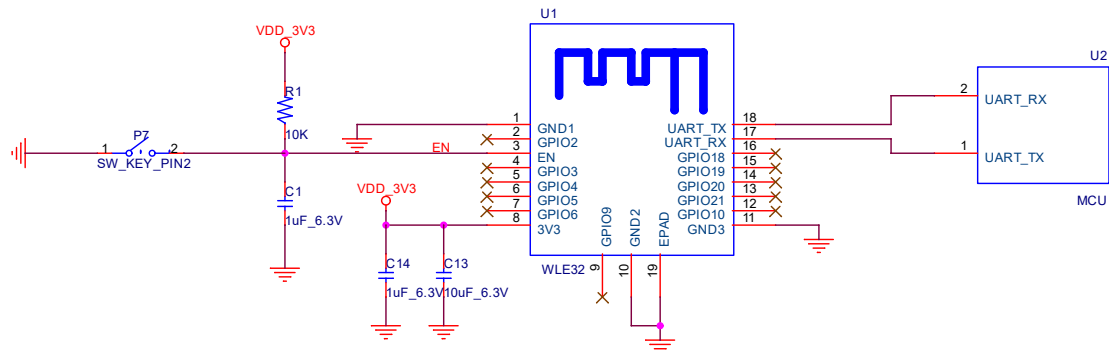
H: Ramp-down rate: 1 - 4° C/s

Note: The recommended curve above is based on SAC305 alloy solder paste as an example. For other alloy solder pastes, please follow the recommended furnace temperature curve settings in the solder paste specification book.

8. Module Peripheral Circuit & Placement

Guidelines

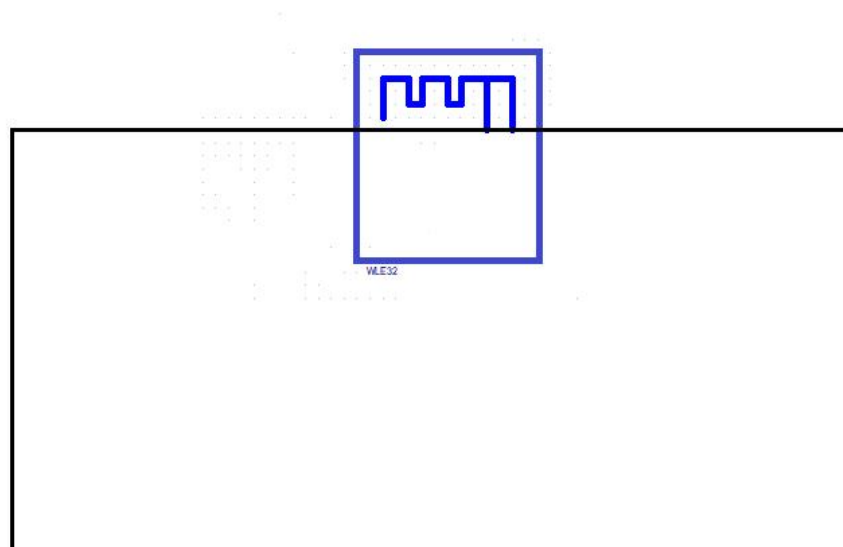
8.1 Peripheral Circuit Recommendations



1. Use 10kΩ pull-up + 1μF pull-down on EN pin for RC delay to ensure stable power-up.
2. Place 10μF+ 1μF capacitors on power supply pins.
3. EPAD may be left unconnected. Soldering to PCB GND improves thermal performance. Control solder paste volume to prevent excessive standoff height affecting pin contact.

8.2 Module Placement Guidelines

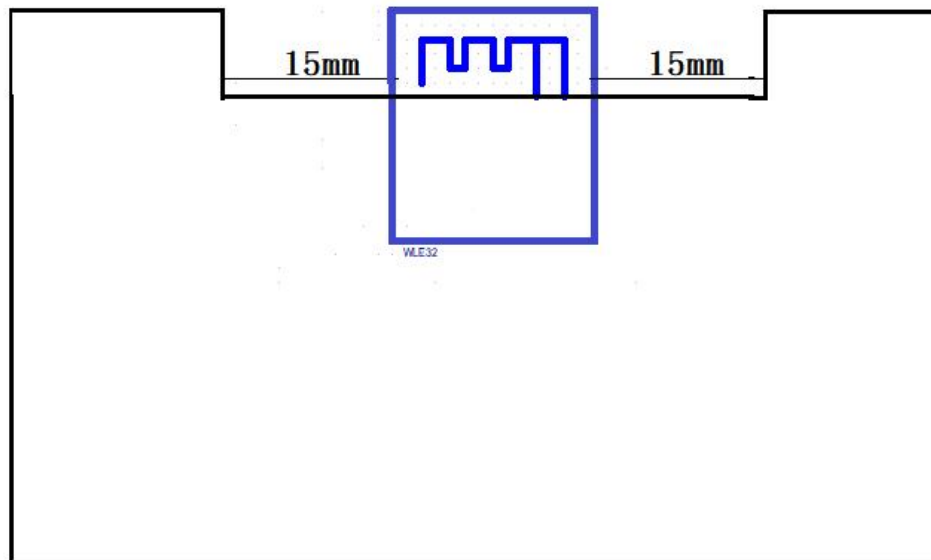
Extend antenna section beyond PCB edge to minimize ground plane interference.



If antenna cannot extend beyond board:

Maintain $\geq 15\text{mm}$ keepout area (no copper pours, traces, or components).

Remove ground planes under antenna area on opposite PCB layers.



9. Packaging information

10. FCC/ISED Statements

(OEM) Integrator has to assure compliance of the entire end-product incl. the integrated RF Module. For 15 B (§15.107 and if applicable §15.109) compliance, the host manufacturer is required to show compliance with 15 while the module is installed and operating.

Antenna Designation: PCB Antenna

Antenna Gain: 3.353dBi

Furthermore the module should be transmitting and the evaluation should confirm that the module's intentional emissions (15C) are compliant (fundamental / out-of-band). Finally the integrator has to apply the appropriate equipment authorization (e.g. Verification) for the new host device per definition in §15.101.

Integrator is reminded to assure that these installation instructions will not be made available to the end-user of the final host device.

The final host device, into which this RF Module is integrated" has to be labeled with an auxiliary label stating the FCC ID of the RF Module, such as "Contains FCC ID: 2BENK-WLE32

"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, and
- (2) this device must accept any interference received, including interference that may cause undesired operation."

"Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment."

the Integrator will be responsible to satisfy SAR/ RF Exposure requirements, when the module is integrated into the host device.

RF Exposure Warning Statements:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This equipment shall be installed and operated with minimum distance 20cm between the radiator & body.

Antennas

PCB antenna; 3.353dBi; 2400-2500MHz

The final host device, into which this RF Module is integrated" has to be labeled with an auxiliary label stating the ISED of the RF Module, Contains IC: 31919-WLE32

Le périphérique hôte final, dans lequel ce module RF est intégré "doit être étiqueté avec une étiquette auxiliaire indiquant le ISED du module RF, Contient IC: 31919-WLE32

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference.
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

- (1) L'appareil ne doit pas produire de brouillage;
- (2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Radio Frequency Exposure Statement for ISED



The device has been evaluated to meet general RF exposure requirements. The device can be used in mobile exposure conditions. The min separation distance is 20cm.

Déclaration d'exposition aux radiofréquences pour ISED

L'appareil a été évalué pour répondre aux exigences générales en matière d'exposition aux RF. L'appareil peut être utilisé dans des conditions d'exposition mobiles. La distance de séparation minimale est de 20 cm.

Module statement

The single-modular transmitter is a self-contained, physically delineated, component for which compliance can be demonstrated independent of the host operating conditions, and which complies with all eight requirements of § 15.212(a)(1) as summarized below.

- 1) The radio elements have the radio frequency circuitry shielded.
- 2) The module has buffered modulation/data inputs to ensure that the device will comply with Part 15 requirements with any type of input signal.
- 3) The module contains power supply regulation on the module.
- 4) The module contains a permanently attached antenna.
- 5) The module demonstrates compliance in a stand-alone configuration.
- 6) The module is labeled with its permanently affixed FCC ID label.
- 7) The module complies with all specific rules applicable to the transmitter, including all the conditions provided in the integration instructions by the grantee.
- 8) The module complies with RF exposure requirements.

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

Co-location Warning:

This equipment could not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with the FCC multi-transmitter product procedures.