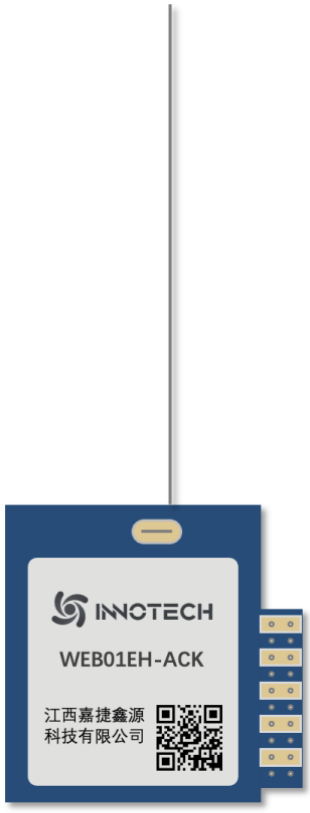
WBE01EH ACK

Datasheet

V1.2

2022-04-02

INNOTECH Alexa Connect Kit (ACK)模组



Revision History

Date	Version	Release notes
2021-7-23	V1.0	First release
2021-8-5	V1.1	Update RF Characteristics
2022-04-02	V1.2	Delete chapter 8 packaging

Contents

1. MODULE OVERVIEW

1.1 Features

MCU

- 32-bit RISC-V single-core processor up to 160 MHz
- 400KB of SRAM
- 384KB of ROM
- 8KB SRAM in RTC

Wi-Fi

- IEEE 802.11b/g/n
- Supports 20 MHz, 40 MHz bandwidth in 2.4 GHz band
- 1T1R mode with data rate up to 150 Mbps
- Wi-Fi Multimedia (WMM)
- TX/RX A-MPDU, RX A-MSDU

Bluetooth®

- Bluetooth LE: Bluetooth 5, Bluetooth mesh
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2

Hardware

- Interfaces: 1 × UART (Connection to the host), 1 × I^2C, 5 × PWMs, 1 × ADC
- 40 MHz crystal oscillator
- 4 MB Embedded Flash
- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating temperature range: –40 ~ 105 °C
- Dimensions: 18.5 × 18.5 mm

Certification

- Bluetooth certification: BQB
- RF certification:
  – FCC
  – IC
  – RCM
  – CE-RED
- Green certification: REACH/RoHS

1.2 Description

The WBE01EH is a module that is based on ESP32-C3FH4. It provides complete Wi-Fi and Bluetooth® functionalities with embedded 32-bit RISC-V single-core processor. The module integrates a 4 MB embedded flash.

At the core of this module is the ESP32 chip, which is a single 2.4 GHz Wi-Fi and Bluetooth combo chip. WBE01EH integrates all peripheral components seamlessly, including a crystal oscillator, flash, filter capacitors and RF matching links in one single package. It is ultra-small in size, with a metal pin antenna, robust performance, and low energy consumption.

WBE01EH is a module for Alexa Connect Kit (ACK), a managed service that makes it easy to integrate Alexa into your products. With WBE01EH and its default firmware, you can connect your devices or system to Alexa and the Internet without worrying about managing cloud services, writing an Alexa Skill, or developing complex networking and security firmware.

1.3 Application:

- LED Light Bulbs

2. BLOCK DIAGRAM

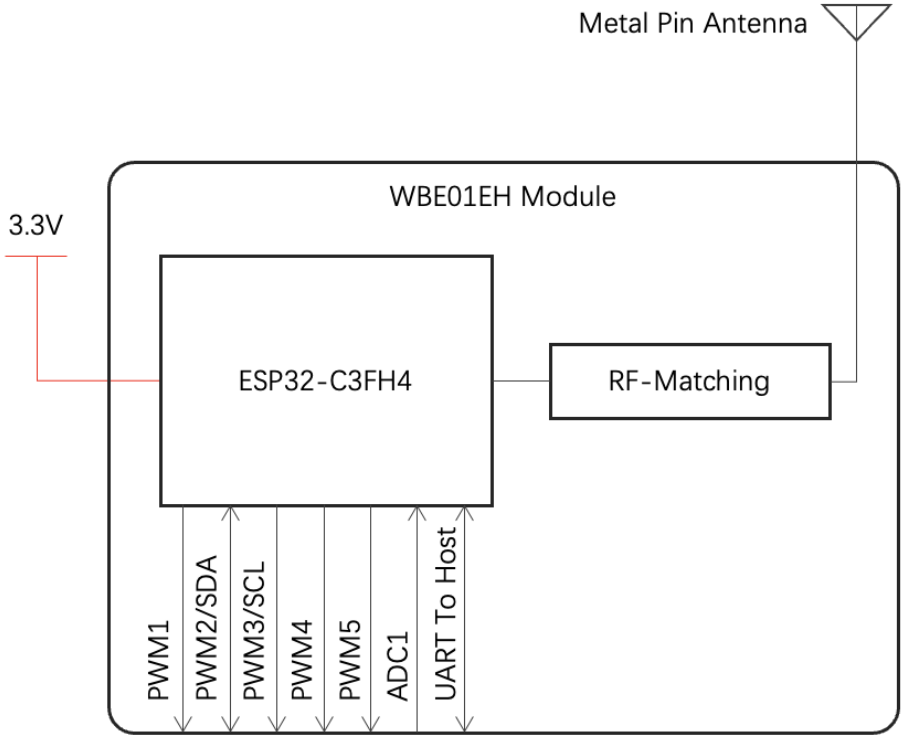
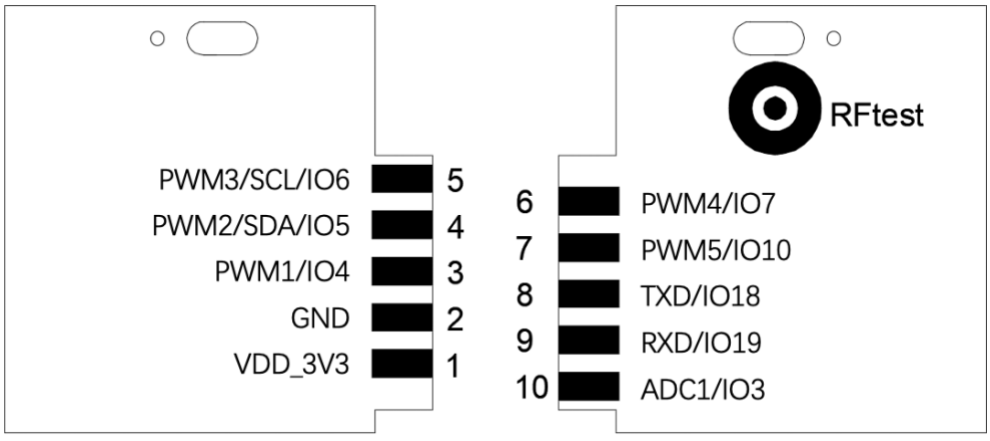


Figure 1: WBE01EH Block Diagram

3. PIN DEFINITIONS

3.1 Pin Layout



Top view Bottom view

Figure 2: Pin Layout of WBE01EH

3.2 Pin Description

Table 1: Pin Definitions

Name	No.	Type	Function
VDD_3V3	1	P	Power supply (3.0-3.6V)
GND	2	P	Ground
PWM1	3	I/O	PWM output1, GPIO4
PWM2/SDA	4	I/O	PWM output2, GPIO5 I2C data line
PWM3/SCL	5	I/O	PWM Output3, GPIO6 I2C clock line
PWM4	6	I/O	PWM Output4, GPIO7
PWM5	7	I/O	PWM Output5, GPIO10
TXD	8	I/O	UART TX, connect to host RX, GPIO18
RXD	9	I/O	UART RX, connect to host TX, GPIO19
ADC1	10	I/O	ADC input, GPIO3

4. ELECTRICAL CHARACTERISTICS

4.1 Absolute Maximum Ratings

Stresses beyond the absolute maximum ratings listed in the table below may cause permanent damage to the device. These are stress ratings only, and do not refer to the functional operation of the device that the recommended operating conditions.

Table 2: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDD_3V3	Power supply voltage	-0.3	3.6	V
T_{store}	Storage temperature	-40	105	℃

4.2 Recommended Operating Conditions

Table 3: Recommended Operating Conditions

Symbol	Parameter	Min	Type	Max	Unit
VDD_3V3	Power supply voltage	3.0	3.3	3.6	V
I_{VDD}	Current delivered by external power supply	0.5	--	--	A
T_A	Operating temperature	-40	--	105	℃
Humidity	Humidity condition	--	--	85	%RH

4.3 DC Characteristics (3.3V, 25℃)

Table 4: DC Characteristics (3.3V, 25℃)

Symbol	Parameter	Min	Type	Max	Unit
C_{IN}	Pin capacitance	-	2	-	pF
V_{IN}	High-level input voltage	0.75*VDD	-	VDD+0.3	V
V_{IL}	Low-level input voltage	-0.3	-	0.25*VDD	V
I_{IH}	Hight-level input current	-	-	50	nA
I_{IL}	Low-level input current	-	-	50	nA
V_{OH}	High-level output voltage	0.8VDD	-	-	V
V_{OL}	Low-level output voltage	-	-	0.1*VDD	V
I_{OH}	High-level source current (VDD =3.3V, V_{OH}≥2.64V, PAD_DRIVER = 3)	-	40	-	mA
I_{OL}	Low-level sink current (VDD = 3.3V, VOL = 0.495V, PAD_DRIVER = 3)	-	28	-	mA
R_{PU}	Resistance of internal pull-up resistor	-	45	-	kΩ
R_{PD}	Resistance of internal pull-down resistor	-	45	-	kΩ
V_{IL_nRST}	Low-level input voltage of CHIP_PU to power off the chip	–0.3	-	0.25 × VDD	V

4.4 Current Consumption Characteristics

With the use of advanced power-management technologies, ESP32 can switch between different modes.

Table 5: Current Consumption Characteristics

Work mode	Description		Peak(mA)
Active (RF working)	TX	802.11b, 20 MHz, 1 Mbps, @21 dBm	350 pending
		802.11g, 20 MHz, 54 Mbps, @19 dBm	295 pending
		802.11n, 20 MHz, MCS7, @18.5 dBm	290 pending
		802.11n, 40 MHz, MCS7, @18.5 dBm	290 pending
	RX	802.11b/g/n, HT20	82 pending
		802.11n, HT40	84 pending

Note:

- The current consumption measurements are taken with a 3.3 V supply at 25 °C of ambient temperature at the RF port. All transmitters' measurements are based on a 100% duty cycle.
- The current consumption figures for in RX mode are for cases when the peripherals are disabled and the CPU idle.

Table 6: Current Consumption De on Work Modes

Work mode	Description		Current consumption (Type)	Unit
Modem-sleep	The CPU is Powered on	160 MHz	20	mA
		80 MHz	15	mA
Light-sleep	-		130	µA
Deep-sleep	RTC timer + RTC memory		5	µA
Power off	CHIP_PU is set to low level, the chip is powered off.		1	µA

Note:

- The current consumption figures in Modem-sleep mode are for cases where the CPU is powered on and the cache idle.
- When Wi-Fi is enabled, the chip switches between Active and Modem-sleep modes. Therefore, current consumption changes accordingly.

- In practice, software can adjust CPU's frequency according to CPU load to reduce current consumption.

4.5 Wi-Fi Characteristics

4.5.1 Wi-Fi RF Standards

Table 7: Wi-Fi RF Standards

Name		Description
Center frequency range of operating channel		2412 ~ 2484 MHz
Wi-Fi wireless standard		IEEE 802.11b/g/n
Data rate	20 MHz	11b: 1, 2, 5.5 and 11 Mbps 11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps 11n: MCS0-7, 72.2 Mbps (Max)
	40 MHz	11n: MCS0-7, 150 Mbps (Max)
Antenna type		Metal pin antenna

Note:
- Device should operate in the center frequency range allocated by regional regulatory authorities. Target center frequency range is configurable by software.

4.5.2 Wi-Fi Transmitter Characteristics

Table 8: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

Parameter	Rate	Type	Unit
TX Power	11b, 1 Mbps	20.5	dBm
	11b, 11 Mbps	20.5	
	11g, 6 Mbps	20.0	
	11g, 54 Mbps	18.0	
	11n, HT20, MCS0	19.0	
	11n, HT20, MCS7	17.5	
	11n, HT40, MCS0	18.5	
	11n, HT40, MCS7	17.0	

Note:
- Target TX power is configurable based on device or certification requirements.

4.5.3 Wi-Fi Receiver Characteristics

Table 9: Wi-Fi Receiver Characteristics

Parameter	Rate	Type	Unit
RX Sensitivity	1 Mbps	-97.6	dBm
	2 Mbps	-96.0	
	5.5 Mbps	-93.0	
	11 Mbps	-88.4	

Parameter	Rate	Type	Unit
	6 Mbps	-92.6	
	9 Mbps	-91.8	
	12 Mbps	-90.0	
	18 Mbps	-88.0	
	24 Mbps	-85.0	
	36 Mbps	-81.0	
	48 Mbps	-77.0	
	54 Mbps	-76.0	
	11n, HT20, MCS0	-92.6	
	11n, HT20, MCS1	-90.0	
	11n, HT20, MCS2	-88.0	
	11n, HT20, MCS3	-84.4	
	11n, HT20, MCS4	-81.0	
	11n, HT20, MCS5	-77.0	
	11n, HT20, MCS6	-75.6	
	11n, HT20, MCS7	-74.2	
	11n, HT40, MCS0	-90.0	
	11n, HT40, MCS1	-87.0	
	11n, HT40, MCS2	-84.8	
	11n, HT40, MCS3	-81.8	
	11n, HT40, MCS4	-78.0	
	11n, HT40, MCS5	-74.0	
	11n, HT40, MCS6	-72.6	
	11n, HT40, MCS7	-71.2	
RX Maximum Input Level	11b, 1 Mbps	5	dBm
	11b, 11 Mbps	5	
	11g, 6 Mbps	5	
	11g, 54 Mbps	0	
	11n, HT20, MCS0	5	
	11n, HT20, MCS7	0	
	11n, HT40, MCS0	5	
	11n, HT40, MCS7	0	
Adjacent Channel Rejection	11b, 1 Mbps	35	dB
	11b, 11 Mbps	35	
	11b, 6 Mbps	31	
	11g, 54 Mbps	14	
	11n, HT20, MCS0	31	
	11n, HT20, MCS7	13	
	11n, HT40, MCS0	19	
	11n, HT40, MCS7	8	

4.6 Bluetooth LE Characteristics

4.6.1 Bluetooth LE Receiver Characteristics

Table 10: Bluetooth Receiver Characteristics – Bluetooth LE 1 Mbps

Parameter	Conditions	Min	Type	Max	Unit
Sensitivity @30.8% BER	-	-	-96	-	dBm
Maximum received signal @30.8% BER	-	-	10	-	dBm
Co-channel C/I	-	-	8	-	dB
Adjacent channel selectivity C/I	F=F0 + 1 MHz	-	-4	-	dB
	F=F0 - 1 MHz	-	-3	-	dB
	F=F0 + 2 MHz	-	-32	-	dB
	F=F0 - 2 MHz	-	-36	-	dB
	F ⩾ F0 + 3 MHz(1)	-	-	-	dB
	F ⩽ F0 - 3 MHz	-	-39	-	dB
Image frequency	-	-	-29	-	dB
Adjacent channel to image frequency	F=Fimage +1MHz	-	-38	-	dB
	F=Fimage –1MHz	-	-34	-	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	-	-9	-	dBm
	2000 MHz ~ 2400 MHz	-	-18	-	dBm
	2500 MHz ~ 3000 MHz	-	-16	-	dBm
	3000 MHz ~ 12.5 GHz	-	-6	-	dBm
Intermodulation	-	-	-44	-	dBm

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} -1 MHz.

Table 11: Bluetooth Receiver Characteristics – Bluetooth LE 2 Mbps

Parameter	Conditions	Min	Type	Max	Unit
Sensitivity @30.8% BER	-	-	-93	-	dBm
Maximum received signal @30.8% BER	-	-	0	-	dBm
Co-channel C/I	-	-	10	-	dB
Adjacent channel selectivity C/I	F=F0 + 2 MHz	-	-7	-	dB
	F=F0 – 2 MHz	-	-7	-	dB
	F=F0 + 4 MHz	-	-	-	dB
	F=F0 – 4 MHz	-	-34	-	dB
	F ⩾ F0 +6 MHz(1)	-	-39	-	dB
	F ⩽ F0 -6 MHz	-	-39	-	dB
Image frequency	-	-	-27	-	dB
Adjacent channel to image frequency	F=Fimage +2MHz	-	-39	-	dB
	F=Fimage –2MHz	-	-	-	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	-	-17	-	dBm
	2000 MHz ~ 2400 MHz	-	-19	-	dBm
	2500 MHz ~ 3000 MHz	-	-16	-	dBm
	3000 MHz ~ 12.5 GHz	-	-22	-	dBm
Intermodulation	-	-	-40	-	dBm

[1] Refer to the value of Image frequency

[2] Refer to the value of Adjacent channel to image frequency when F = F0 + 2 MHz.

Table 12: Bluetooth Receiver Characteristics – Bluetooth LE 125 Kbps

Parameter	Conditions	Min	Type	Max	Unit
Sensitivity @30.8% BER	-	-	-104	-	dBm
Maximum received signal @30.8% BER	-	-	10	-	dBm
Co-channel C/I	-	-	2	-	dB
Adjacent channel selectivity C/I	F=F0 + 1 MHz	-	-6	-	dB
	F=F0 – 1 MHz	-	-5	-	dB
	F=F0 + 2 MHz	-	-40	-	dB
	F=F0 – 2 MHz	-	-42	-	dB
	F ⩾ F0 +3 MHz[(1)]	-	-	-	dB
	F ⩽ F0 -3 MHz	-	-46	-	dB
Image frequency	-	-	-34	-	dB
Adjacent channel to image frequency	F=Fimage +1 MHz	-	-44	-	dB
	F=Fimage –1 MHz	-	-37	-	dB

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz

Table 13: Bluetooth Receiver Characteristics – Bluetooth LE 500 Kbps

Parameter	Conditions	Min	Type	Max	Unit
Sensitivity @30.8% BER	-	-	-99	-	dBm
Maximum received signal @30.8% BER	-	-	10	-	dBm
Co-channel C/I	-	-	3	-	dB
Adjacent channel selectivity C/I	F=F0 + 1 MHz	-	-5	-	dB
	F=F0 – 1 MHz	-	-7	-	dB
	F=F0 + 2 MHz	-	-39	-	dB
	F=F0 – 2 MHz	-	-40	-	dB
	F ⩾ F0 +3 MHz[(1)]	-	-	-	dB
	F ⩽ F0 -3 MHz	-	-40	-	dB
Image frequency	-	-	-34	-	dB
Adjacent channel to image frequency	F=Fimage +1 MHz	-	-43	-	dB
	F=Fimage –1 MHz	-	-38	-	dB

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz

4.6.2 Bluetooth LE Transmitter Characteristics

Table 14: Bluetooth LE Transmitter Characteristics – General

Parameter	Min	Type	Max	Unit
RF transmit power	-	0	-	dBm
Gain control step	-	3	-	dB
RF power control range	-27	-	18	dBm

Table 15: Bluetooth Transmitter Characteristics – Bluetooth LE 1 Mbps

Parameter	Conditions	Min	Type	Max	Unit
In-band emissions	F = F0 ± 2 MHz	-	-37.62	-	dBm
	F = F0 ± 3 MHz	-	-41.95	-	dB
	F = F0 ± > 3 MHz	-	-44.48	-	dBm
Modulation characteristics	$\Delta f1_{avg}$	-	245.00	-	KHz
	$\Delta f2_{max}$	-	208.00	-	KHz
	$\Delta f2_{avg}/\Delta f1_{avg}$	-	0.93	-	-
Carrier frequency offset	-	-	-9.00	-	KHz
Carrier frequency drift	$\lvert f0 - fn \rvert_{n=2, 3, 4, ..k}$	-	1.17	-	kHz
	$\lvert f1 - f0 \rvert$	-	0.30	-	KHz
	$\lvert fn - fn-5 \rvert_{n=6, 7, 8, ..k}$	-	4.90	-	kHz

Table 16: Bluetooth Transmitter Characteristics – Bluetooth LE 2 Mbps

Parameter	Conditions	Min	Type	Max	Unit
In-band emissions	F = F0 ± 4 MHz	-	-43.55	-	dBm
	F = F0 ± 5 MHz	-	-45.26	-	dB
	F = F0 ± > 5 MHz	-	-47.00	-	dBm
Modulation characteristics	$\Delta f1_{avg}$	-	497.00	-	KHz
	$\Delta f2_{max}$	-	398.00	-	KHz
	$\Delta f2_{avg}/\Delta f1_{avg}$	-	0.95	-	-
Carrier frequency offset	-	-	-9.00	-	KHz
Carrier frequency drift	$\lvert f0 - fn \rvert_{n=2, 3, 4, ..k}$	-	0.46	-	kHz
	$\lvert f1 - f0 \rvert$	-	0.70	-	KHz
	$\lvert fn - fn-5 \rvert_{n=6, 7, 8, ..k}$	-	6.80	-	kHz

Table 17: Bluetooth Transmitter Characteristics – Bluetooth LE 125 Kbps

Parameter	Conditions	Min	Type	Max	Unit
In-band emissions	F = F0 ± 2 MHz	-	-37.90	-	dBm
	F = F0 ± 3 MHz	-	-41.00	-	dB
	F = F0 ± > 3 MHz	-	-42.50	-	dBm
Modulation characteristics	$\Delta f1_{avg}$	-	252.00	-	KHz
	$\Delta f1_{max}$	-	200.00	-	KHz
Carrier frequency offset	-	-	-13.70	-	KHz
Carrier frequency drift	$\lvert f0 - fn \rvert_{n=2, 3, 4, ..k}$	-	1.52	-	kHz
	$\lvert f1 - f3 \rvert$	-	0.65	-	KHz
	$\lvert fn - fn-3 \rvert_{n=7, 8, 9, ..k}$	-	0.70	-	kHz

Table 18: Bluetooth Transmitter Characteristics – Bluetooth LE 500 Kbps

Parameter	Conditions	Min	Type	Max	Unit
In-band emissions	F = F0 ± 2 MHz	-	-37.90	-	dBm
	F = F0 ± 3 MHz	-	-41.30	-	dB
	F = F0 ± > 3 MHz	-	-42.80	-	dBm
Modulation characteristics	$\Delta f1_{avg}$	-	220.00	-	KHz
	$\Delta f1_{max}$	-	205.00	-	KHz
Carrier frequency offset	-	-	-11.90	-	KHz
Carrier frequency drift	$\lvert f0 - fn \rvert_{n=2, 3, 4, ..k}$	-	1.37	-	kHz
	|f1 – f3|	-	1.09	-	KHz
	$\lvert fn - fn-3 \rvert_{n=7, 8, 9, ..k}$	-	0.51	-	kHz

5. MODULE SCHEMATICS

This is the reference design of the module.

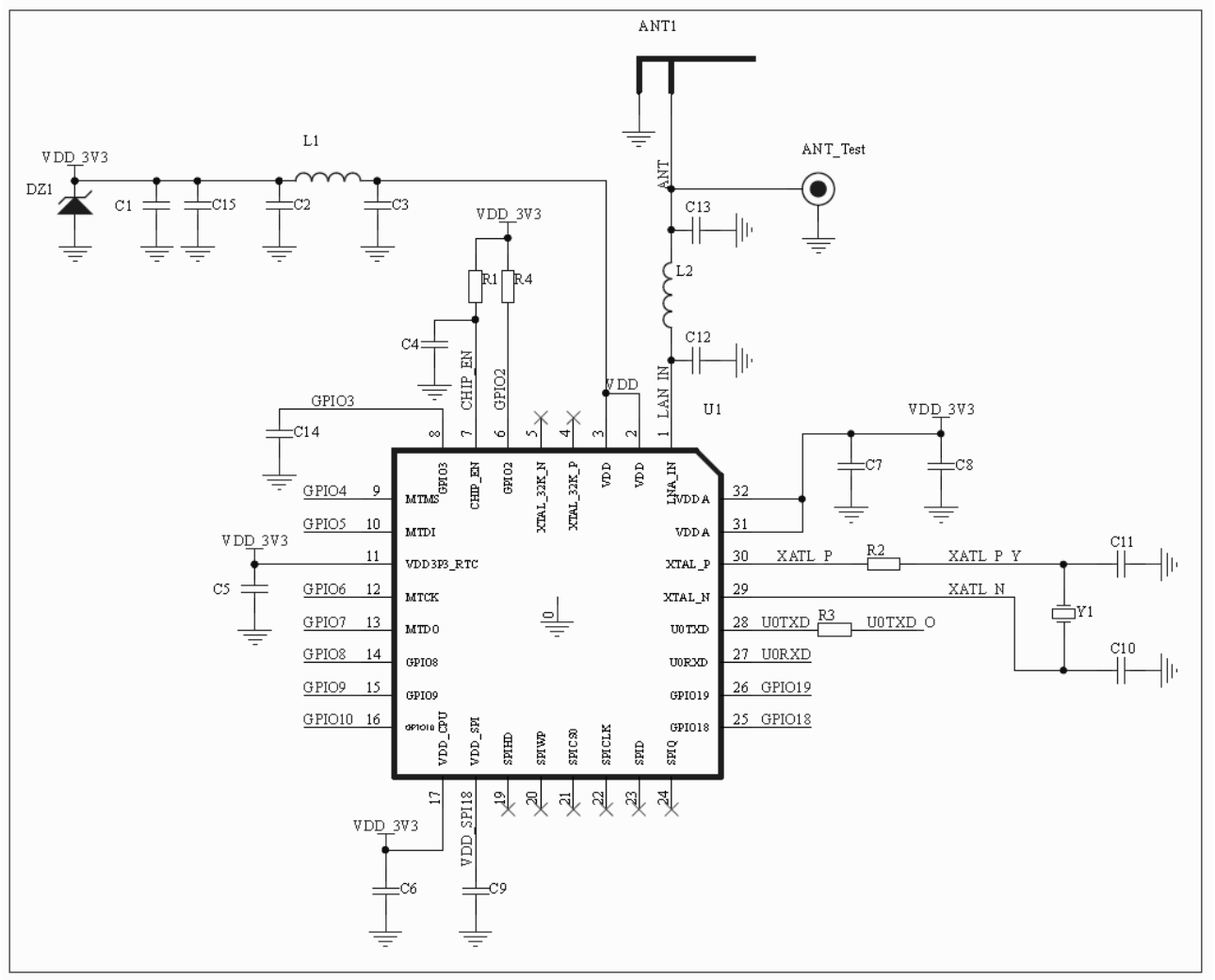


Figure 3: WBE01HE Module Schematics

6. PHYSICAL DIMENSIONS AND PCB LAND PATTERN

6.1 Physical Dimensions

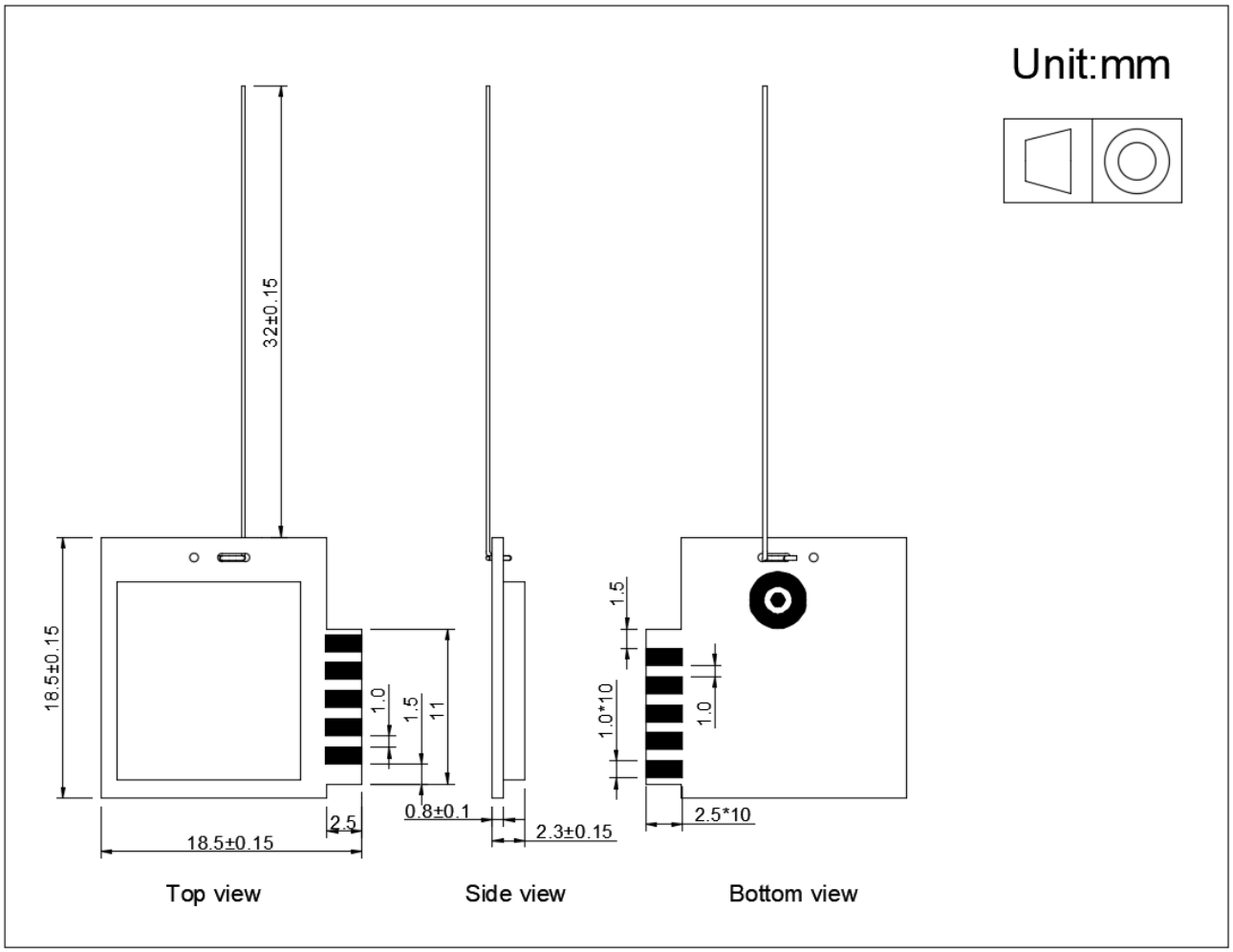


Figure 4: Physical Dimensions

6.2 Recommended PCB Land Pattern

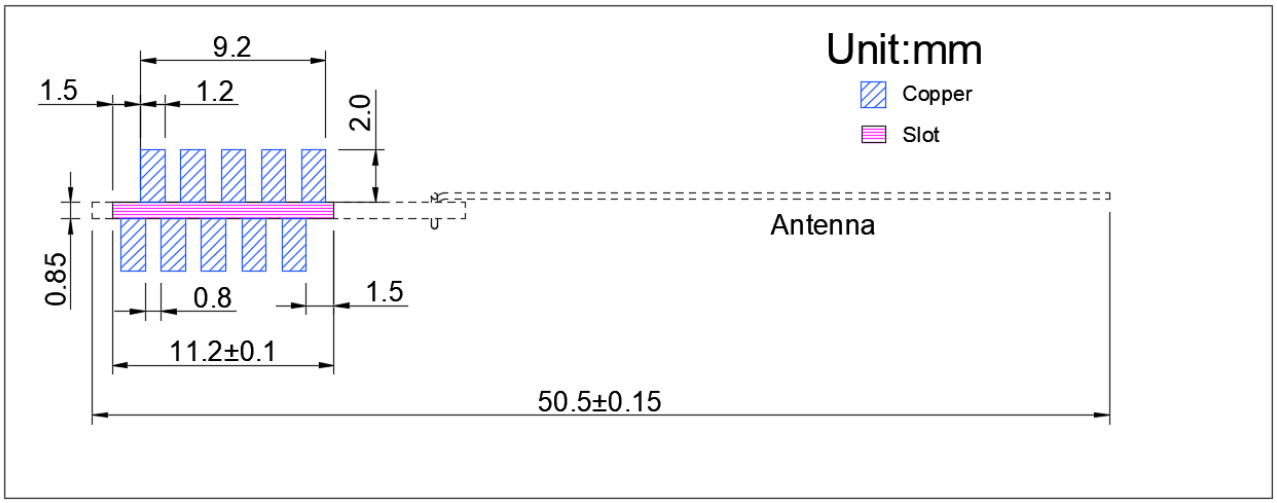


Figure 5: Recommended PCB Land Pattern

7. PRODUCT HANDING

7.1 Storage Condition

The products sealed in Moisture Barrier Bag (MBB) should be stored in a noncondensing atmospheric environment of < 40 °C/90% RH.

The module is rated at moisture sensitivity level (MSL) 3.

After unpacking, the module must be soldered within 168 hours with factory conditions 25±5 °C and 60% RH. The module needs to be baked if the above conditions are not met.

7.2 ESD

- Human body model (HBM): 2000 V
- Charged-device model (CDM): 500 V
- Air discharge: 6000 V
- Contact discharge: 4000 V

7.3 DIP Type Product Pass Wave Solder Graph

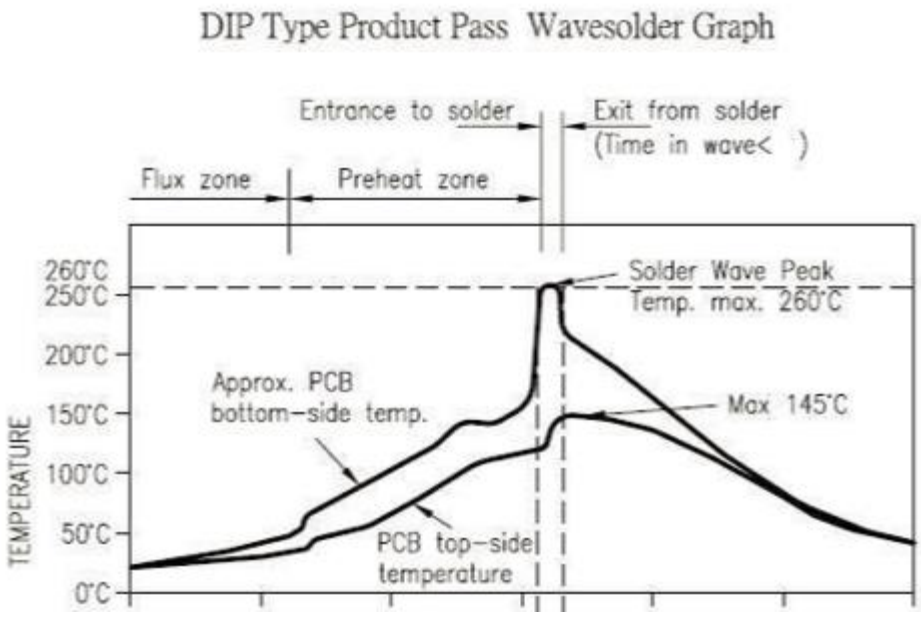


Figure 6: DIP Type Product Pass Wave Solder Graph

Table 19: Bluetooth Transmitter Characteristics – Bluetooth LE 500 Kbps

Suggestions for wave soldering furnace temperature curve		Manual soldering temperature recommendations	
pre-heat temperature	80-130℃	Welding temperature	360℃±20℃
Preheat time	75-100S	Welding time	< 3S/point
Peak contact time	3-5S	N/A	N/A
Tin tank temperature	260±5℃	N/A	N/A
Ramp rate	≤2℃/S	N/A	N/A
Cooling slope	≤6℃/S	N/A	N/A

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