Test Report

Applicant	Espressif Systems (Shanghai) Co.,Ltd.
Product	Wi-Fi & Bluetooth Internet of Things
Model	ESP32-PICO-V3-ZERO
Report No.	R2006A0382-R4
Issue Date	July 15, 2020

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **Article 2 Paragraph 1 Item 19, MIC notification. No.88 of 2004, Annex 43**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Performed by: Peng Tao   *Approved by: Kai Xu*

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Summary of measurement results

Number	Summary of measurements of results	Verdict
1	Frequency Error Measurement	PASS
2	Occupied Bandwidth Measurement	PASS
3	Spread Bandwidth and Spread Factor Measurement	PASS
4	Antenna Power (Conducted) Measurement	PASS
5	Unwanted Emission Strength Measurement	PASS
6	Secondarily Emitted Radio Wave Strength Measurement	PASS
7	Carrier Sense Measurement	PASS
8	Radio Interference Prevention Capability Measurement	PASS
9	Construction Protection Confirmation Method	PASS
Date of Testing: June 24, 2020 ~ July 7, 2020		
Note: NA = Not applicable. All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.		

1. Test Laboratory

1.1. Notes of the Test Report

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1.2. Testing Location

Company:	TA Technology (Shanghai) Co., Ltd.
Address:	No.145, Jintang Rd, Tangzhen Industry Park, Pudong
City:	Shanghai
Post code:	201201
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E-mail:	xukai@ta-shanghai.com

2. General Description of Equipment under Test

2.1. Applicant and Manufacturer Information

Applicant	Espressif Systems (Shanghai) Co.,Ltd.
Applicant address	Suite 204, Block 2, 690 Bibo Road, Zhang Jiang Hi-Tech Park, Shanghai, China
Manufacturer	Espressif Systems (Shanghai) Co.,Ltd.
Manufacturer address	Suite 204, Block 2, 690 Bibo Road, Zhang Jiang Hi-Tech Park, Shanghai, China

2.2. General Information

EUT Description		
Model	ESP32-PICO-V3-ZERO	
SN:	1#	
Hardware Version	V1.2	
Software Version	V1.1.3.0	
Antenna Type	PCB Antenna	
Antenna Gain	Frequency(MHz)	Gain (dBi)
	2402	3.00
	2440	2.85
	2480	2.90
Device operating configurations		
Test Mode:	Bluetooth (Low Energy);	
Operating Frequency Range(s)	2402MHz ~ 2480MHz	
Test Modulation:	Bluetooth v4.2 LE: GFSK	
Test Frequency Range(s)	Bluetooth (Low Energy):2402MHz ~ 2480MHz	
Rate Voltage	3.3V	
Extreme Voltage	3V to 3.6V	
Note: The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.		

3. Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

Article 2 Paragraph 1 Item 19
MIC notification. No.88 of 2004, Annex 43

4. Test Configuration

For all the test items，an engineering test program installed in notebook was used to make the EUT continuously transmit/receive.

5. Test Case Results

5.1. Frequency Error Measurement

Methods of Measurement

Spectrum Analyzer Setting
SPAN: 300 kHz
RBW: 1 kHz
VBW: 30 kHz
Sweep Time: AUTO (Minimum time to ensure measurement accuracy.)
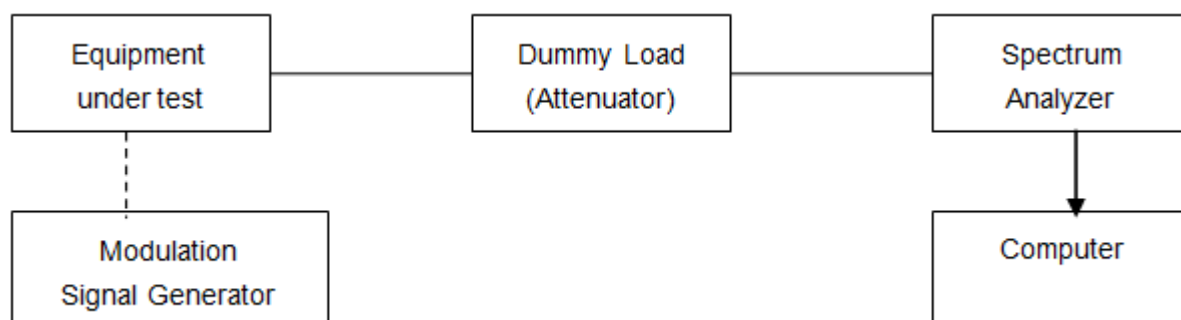Data Points: 401 points or more
Sweep Mode: Single Sweep
Detection Mode: Positive Peak
Storage Mode: Normal
Y-axis Scale: 10 dB/Div.
Reference Level: Enough level for maximum dynamic range

Test Setup

Limits

Frequency Tolerance ≤ 50 ppm.

Test Results

Test Mode	Test Frequency (MHz)	Reading Frequency (MHz)		Frequency Tolerance (ppm)	Limit (ppm)	Result
		FL (MHz)	FH (MHz)			
Bluetooth (Low Energy)	2402	2401.56	2402.38	-12.91	≤ 50	Pass
	2440	2439.56	2440.38	-12.30	≤ 50	Pass
	2480	2479.55	2480.38	-13.71	≤ 50	Pass

5.2. Occupied Bandwidth Measurement

Ambient condition

Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Method of Measurement

Spectrum Analyzer Setting
SPAN: 40 MHz(BW=20) or 80 MHz(BW=40) or 160 MHz(BW=80) or 320 MHz(BW=160)
RBW: 10 kHz
VBW: 10 kHz
Sweep Time: AUTO (Minimum time to ensure measurement accuracy.)
Data Points: 401 points or more
Indication mode: Max hold
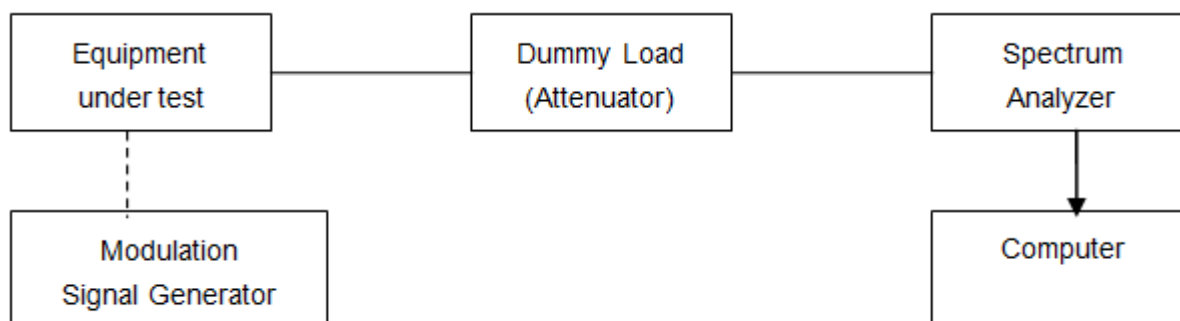Detection Mode: Positive Peak
Storage Mode: Normal
Y-axis Scale: 10 dB/Div.
Reference Level: Enough level for maximum dynamic range

Test Setup

Limits

Occupied Bandwidth ≤ 26 MHz.

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 936 Hz.

Test Results

Network Standards	Carrier frequency (MHz)	99% bandwidth (MHz)	Limit (MHz)	Result
Bluetooth (Low Energy)	2402	1.012	≤26	Pass
	2440	1.012	≤26	Pass
	2480	1.014	≤26	Pass

BLE Carrier frequency (MHz): 2402

Occupied Bandwidth		Total Power	10.9 dBm
1.0121 MHz			
Transmit Freq Error	-26.378 kHz	% of OBW Power	99.00 %
x dB Bandwidth	1.269 MHz	x dB	-26.00 dB

BLE Carrier frequency (MHz): 2440

Occupied Bandwidth		Total Power	11.3 dBm
1.0122 MHz			
Transmit Freq Error	-27.822 kHz	% of OBW Power	99.00 %
x dB Bandwidth	1.268 MHz	x dB	-26.00 dB

BLE Carrier frequency (MHz): 2480

Occupied Bandwidth		Total Power	11.0 dBm
1.0138 MHz			
Transmit Freq Error	-28.269 kHz	% of OBW Power	99.00 %
x dB Bandwidth	1.269 MHz	x dB	-26.00 dB

5.3. Spread Bandwidth and Spread Factor Measurement

Ambient condition

Temperature	Relative humidity	Pressure
23°C ~25°C	45%~50%	101.5kPa

Method of Measurement

Spectrum Analyzer Setting
SPAN: 40 MHz(BW=20) or 80 MHz(BW=40) or 160 MHz(BW=80) or 320 MHz(BW=160)
RBW: 300 kHz
VBW: 300 kHz
Sweep Time: AUTO (Minimum time to ensure measurement accuracy.)
Data Points: 401 points or more
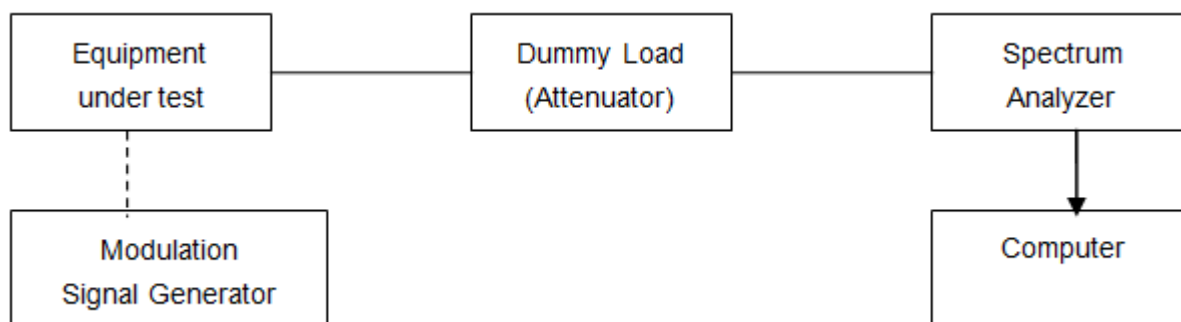Indication mode: Max hold
Detection Mode: Positive Peak
Storage Mode: Normal
Y-axis Scale: 10 dB/Div.
Reference Level: Enough level for maximum dynamic range

Test Setup

Limits

FHSS: Spread Bandwidth ≥ 0.5 MHz.
FHSS: Spread Factor ≥ 5

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 936 Hz.

Test Results

Test Mode	Test Frequency (MHz)	90% SBW (MHz)	SBW Limit (MHz)	Result
Bluetooth (Low Energy)	2402	0.659	≥0.5	Pass
	2440	0.659	≥0.5	Pass
	2480	0.659	≥0.5	Pass

BLE Carrier frequency (MHz): 2402

Occupied Bandwidth	Total Power	10.9 dBm
658.73 kHz		
Transmit Freq Error -37.012 kHz	% of OBW Power	90.00 %
x dB Bandwidth 1.269 MHz	x dB	-26.00 dB

BLE Carrier frequency (MHz): 2440

Occupied Bandwidth	Total Power	11.3 dBm
658.78 kHz		
Transmit Freq Error -37.312 kHz	% of OBW Power	90.00 %
x dB Bandwidth 1.266 MHz	x dB	-26.00 dB

BLE Carrier frequency (MHz): 2480

Occupied Bandwidth	Total Power	11.0 dBm
658.99 kHz		
Transmit Freq Error -37.801 kHz	% of OBW Power	90.00 %
x dB Bandwidth 1.268 MHz	x dB	-26.00 dB

5.4. Antenna Power (Conducted) Measurement

Ambient condition

Temperature	Relative humidity	Pressure
23°C ~ 25°C	45% ~ 50%	101.5kPa

Methods of Measurement

Spectrum Analyzer Setting
Mode: Channel power
SPAN: 40 MHz(BW=20) or 40 MHz(BW=80) or 80 MHz(BW=160) or 80 MHz(BW=160)
RBW: 30 kHz
VBW: 300 kHz
Sweep Time: AUTO (Minimum time to ensure measurement accuracy.)
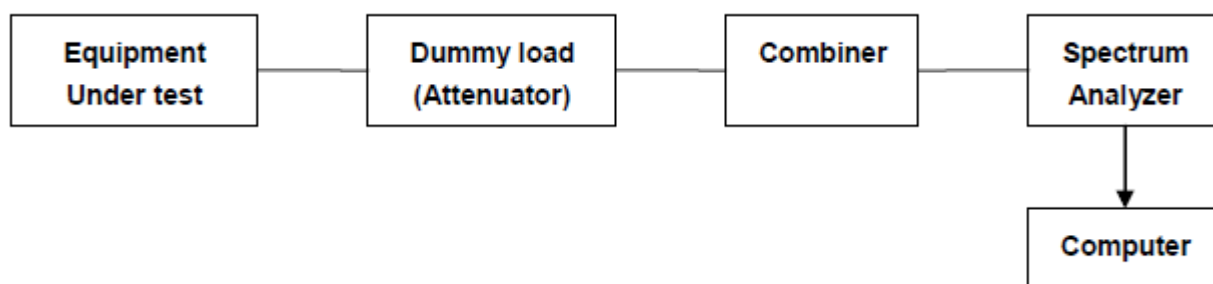Data Points: 401 points or more
Indication mode: Max hold
Detection Mode: Positive Peak
Storage Mode: Normal
Y-axis Scale: 10 dB/Div.
Reference Level: Enough level for maximum dynamic range.

Test Setup

Limits
RF Output Power ≤ 10 mW/MHz; EIRP Limit ≤ 12.14 dBm/MHz.
RF Output Power Tolerance ≤ 20 % ~ -80 %

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 2, U= 0.44 dB.

Test Results：

Mode	T_{on} (ms)	$T_{(on+off)}$ (ms)	Duty cycle	Duty cycle correction Factor (dB)
Bluetooth (Low Energy)	2.08	2.496	0.83	0.79

Test Mode	Test Frequency (MHz)	Antenna Power (dBm/MHz)	Total Power Density (mW/MHz)	Limit (mW/MHz)	Result
Bluetooth (Low Energy)	2402	5.45	3.51	10	Pass
	2440	5.90	3.89	10	Pass
	2480	5.69	3.71	10	Pass

Test Mode	Carrier Frequency (MHz)	EIRP (dBm/MHz)	Limit(dBm/MHz)	Conclusion
Bluetooth (Low Energy)	2402	8.45	12.14	PASS
	2440	8.75	12.14	PASS
	2480	8.59	12.14	PASS
Note: 1. EIRP = Antenna Power + Antenna Gain				

5.5. Unwanted Emission Strength Measurement

Ambient condition

Temperature	Relative humidity	Pressure
25°C	50%	101.5kPa

Method of Measurement

Step-1 (Search Mode)

Spectrum Analyzer Setting

SPAN: Measuring Frequency Range (Refer to the 4.7 of the page 18)

RBW: 1 MHz

VBW: Same as RBW

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)

Data Points: 401 points or more

Sweep Mode: Single Sweep

Detection Mode: Positive Peak

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range

Step-2 (Measuring Mode *Normal)

Spectrum Analyzer Setting

Center Frequency: Searched Frequency

SPAN: 1 MHz – 10 MHz (The SPAN that keeps accuracy of the frequency.)

RBW: 1 MHz

VBW: Same as RBW

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)

Data Points: 401 points or more

Sweep Mode: Single Sweep

Detection Mode: Positive Peak

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range

Step-3 (Measuring Mode *Zero Span)

Spectrum Analyzer Setting

Center Frequency: Searched Frequency

SPAN: 0 Hz (ZERO SPAN)

RBW: 1 MHz

VBW: Same as RBW

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)

Data Points: 401 points or more

Sweep Mode: Single Sweep

Detection Mode: Sample

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range
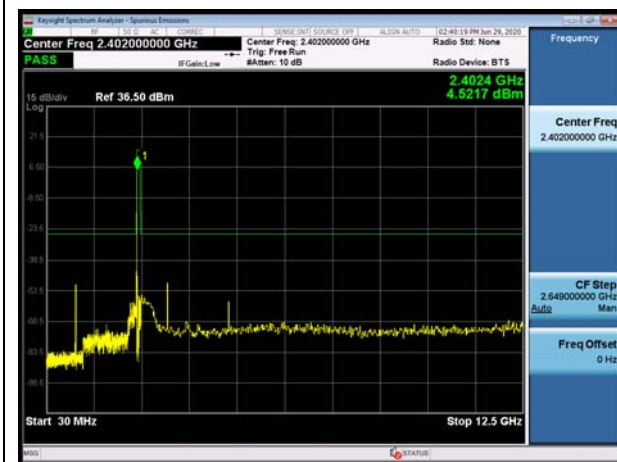
Test Setup
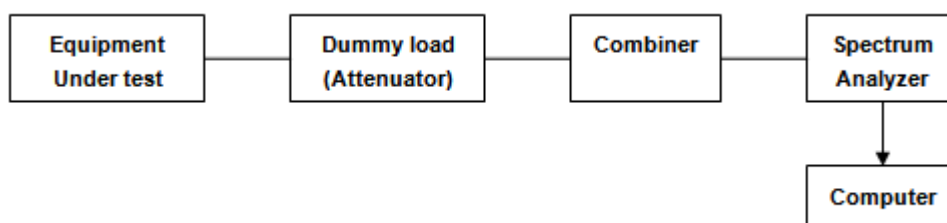
Limit

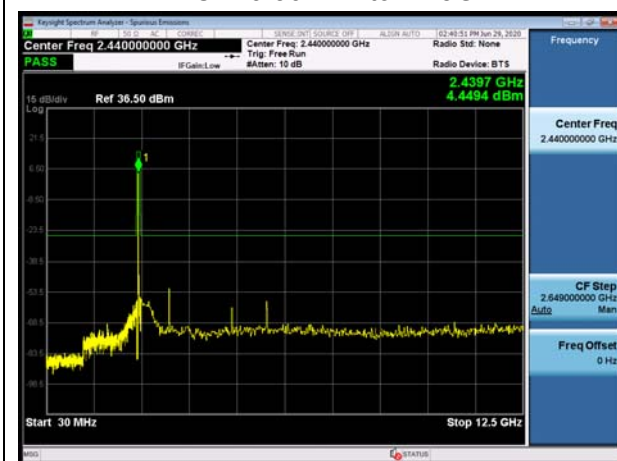| Frequency Range	Limits(μ W/MHz)
30MHz - 2387 MHz	2.5
2387MHz - 2400MHz	25
2483.5MHz - 2496.5MHz	2.5
2496.5MHz - 12.5GHz	25

Test Results

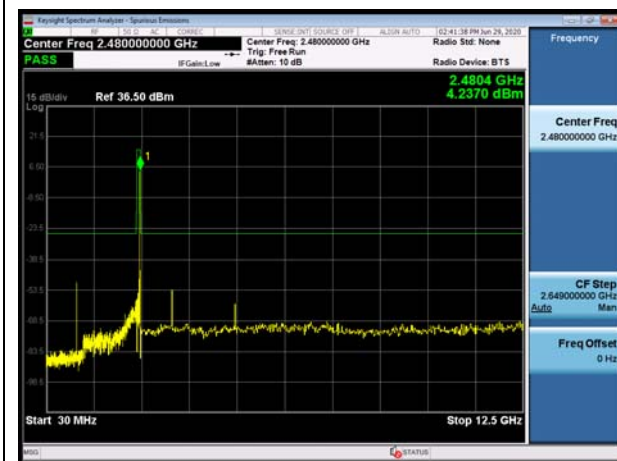The signal beyond the limit is carrier

BLE CH0 30MHz to 12.5GHz

BLE CH19 30MHz to 12.5GHz

BLE CH39 30MHz to 12.5GHz

5.6. Secondarily Emitted Radio Wave Strength Measurement

Ambient condition

Temperature	Relative humidity	Pressure
25°C	50%	101.5kPa

Method of Measurement

Step-1 (Search Mode)

Spectrum Analyzer Setting

SPAN: Measuring Frequency Range (Refer to the 4.7 of the page 18)

RBW: 1 MHz (frequency range; 1 GHz over), 100 kHz (frequency range; 30 MHz to 1 GHz)

VBW: Same as RBW (1 MHz or 100 kHz)

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)

Data Points: 401 points or more

Sweep Mode: Single Sweep

Detection Mode: Positive Peak

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range

Step-2 (Measuring Mode *Normal)

Spectrum Analyzer Setting

Center Frequency: Searched Frequency

SPAN: 1 MHz – 10 MHz (The SPAN that keeps accuracy of the frequency.)

RBW: 1 MHz (frequency range; 1 GHz over), 100 kHz (frequency range; 30 MHz to 1 GHz)

VBW: Same as RBW (1 MHz or 100 kHz)

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)

Data Points: 401 points or more

Sweep Mode: Single Sweep

Detection Mode: Positive Peak

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range

Step-3 (Measuring Mode *Zero Span)

Spectrum Analyzer Setting

Center Frequency: Searched Frequency SPAN: 0 Hz (ZERO SPAN)

RBW: 1 MHz (frequency range; 1 GHz over), 100 kHz (frequency range; 30 MHz to 1 GHz)

VBW: Same as RBW (1 MHz or 100 kHz)

Sweep Time: AUTO (Minimum time to ensure measurement accuracy.

*In case of burst wave, one burst shall be included per data point)
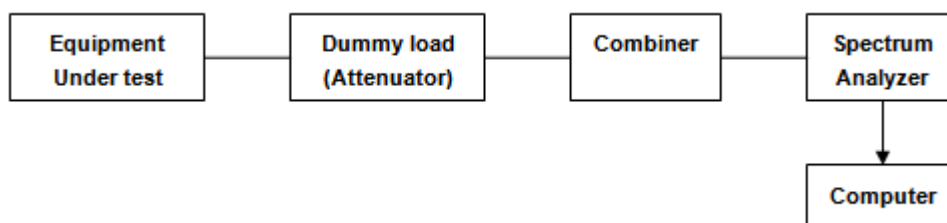
Data Points: 401 points or more

Sweep Mode: Single Sweep

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Detection Mode: Sample

Y-axis Scale: 10 dB/Div.

Reference Level: Enough level for maximum dynamic range

Test Setup

```
┌──────────────┐   ┌──────────────┐   ┌──────────┐   ┌──────────────┐
│  Equipment   │──▶│  Dummy load  │──▶│ Combiner │──▶│   Spectrum   │
│  Under test  │   │ (Attenuator) │   │          │   │   Analyzer   │
└──────────────┘   └──────────────┘   └──────────┘   └──────────────┘
                                                             │
                                                             ▼
                                                      ┌──────────────┐
                                                      │   Computer   │
                                                      └──────────────┘
```
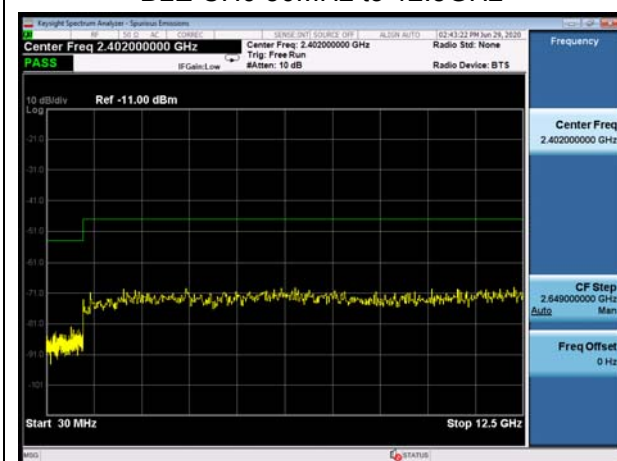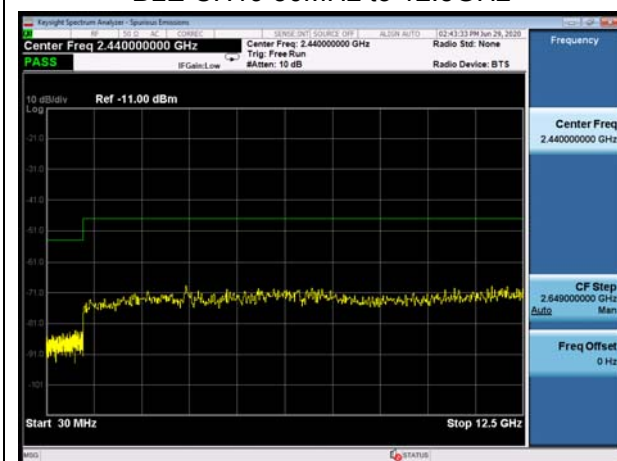
Limit

Frequency Range	Limits(nW)
Under 1 GHz	≤ 4
1GHz-12.5GHz	≤ 20

Test Results

BLE CH0 30MHz to 12.5GHz

BLE CH19 30MHz to 12.5GHz

BLE CH39 30MHz to 12.5GHz
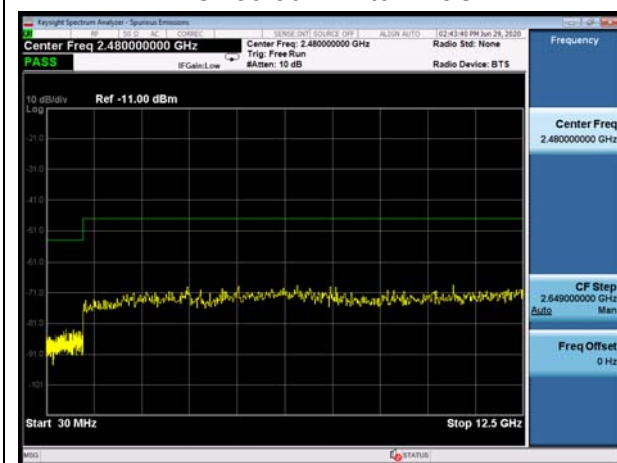
5.7. Carrier Sense Measurement

Ambient condition

Temperature	Relative humidity	Pressure
25°C	50%	101.5kPa

Method of Measurement

Set the spectrum analyzer as follow:

Resolution bandwidth:	1 MHz
Video bandwidth:	1 MHz
Sweep Time:	AUTO (Minimum time to ensure measurement accuracy.)
Sweep mode:	Continuous Sweep
Detection mode:	Positive peak
Storage Mode:	Normal
Y-axis scale:	10 dB/Div
Trigger:	Free Run

Test Setup

Carry out the test by Equipment under Test only (Necessary a Test Mode)
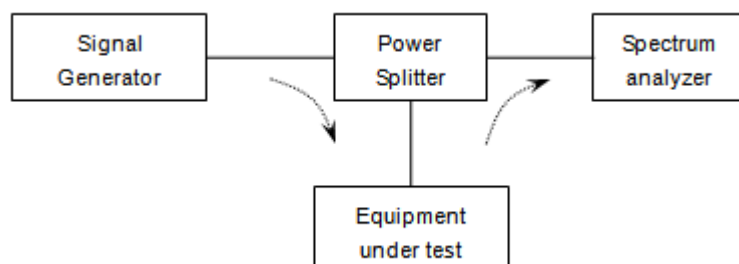
Carry out the test by using a companion equipment (Necessary actual communication)
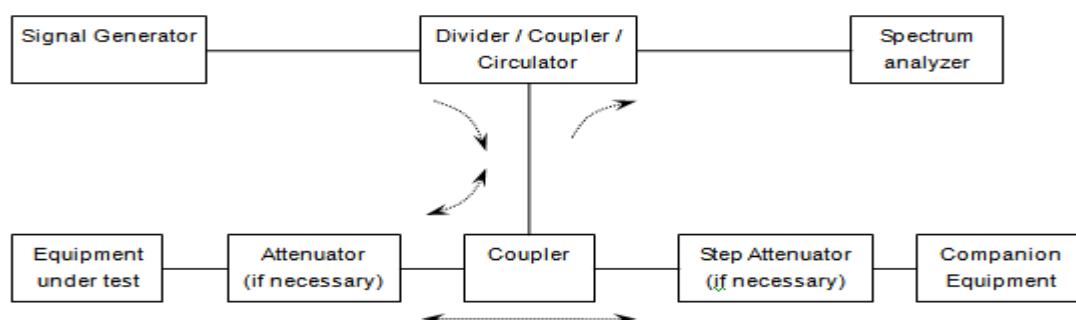
Limit

During outputting Carrier Wave by Signal Generator, check the EUT does not transmit any waves (include the Beacon)

Test Results

Test Mode	Test Frequency (MHz)	Carrier Sense	Result
Bluetooth (Low Energy)	2402	GOOD	Pass
	2440	GOOD	Pass
	2480	GOOD	Pass

5.8. Radio Interference Prevention Capability Measurement

Ambient condition

Temperature	Relative humidity	Pressure
25°C	50%	101.5kPa

Method of Measurement

1. In the case that the EUT has the function of automatically transmitting the identification code:

a. Transmit the predetermined identification codes form EUT.

b. Check the transmitted identification codes with the demodulator.

2. In the case of receiving the identification code:

a. Transmit the predetermined identification codes form the counterpart.

b. Check if communication is normal.

c. Transmit the signals other than predetermined ID codes form the counterpart.

d. check if the EUT stops the transmission, or if it displays that identification codes are different from the predetermined ones.

Test Setup
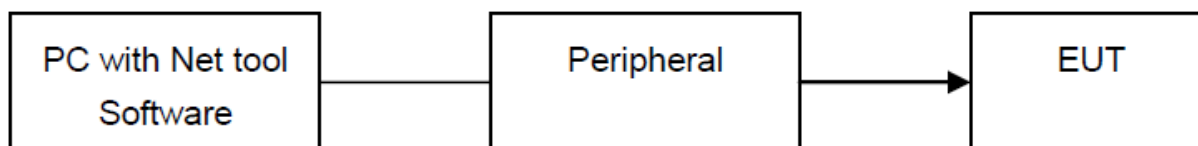
Limit

Identification code $\geq$ 48 bits

Test Results

Test Mode	Test Frequency (MHz)	Identification code	Result
Bluetooth (Low Energy)	2402	48	Pass
	2440	48	Pass
	2480	48	Pass

MAC Address:

#1：50:02:91:86:fe:5c

#2：50:02:91:86:dd:44

5.9. Construction Protection Confirmation Method

Ambient condition

| Temperature	Relative humidity	Pressure
25°C	50%	101.5kPa

Limit

The high-frequency section and modulation section of the radio equipment except for the antenna system shall not be capable of being opened easily.

Test Results:

Protected Method	RF chip is sealed
Description	This RF chip is sealed with a metal shield that is soldered down, If end user intends to open it, this product will be damaged and no longer be used
Photo	
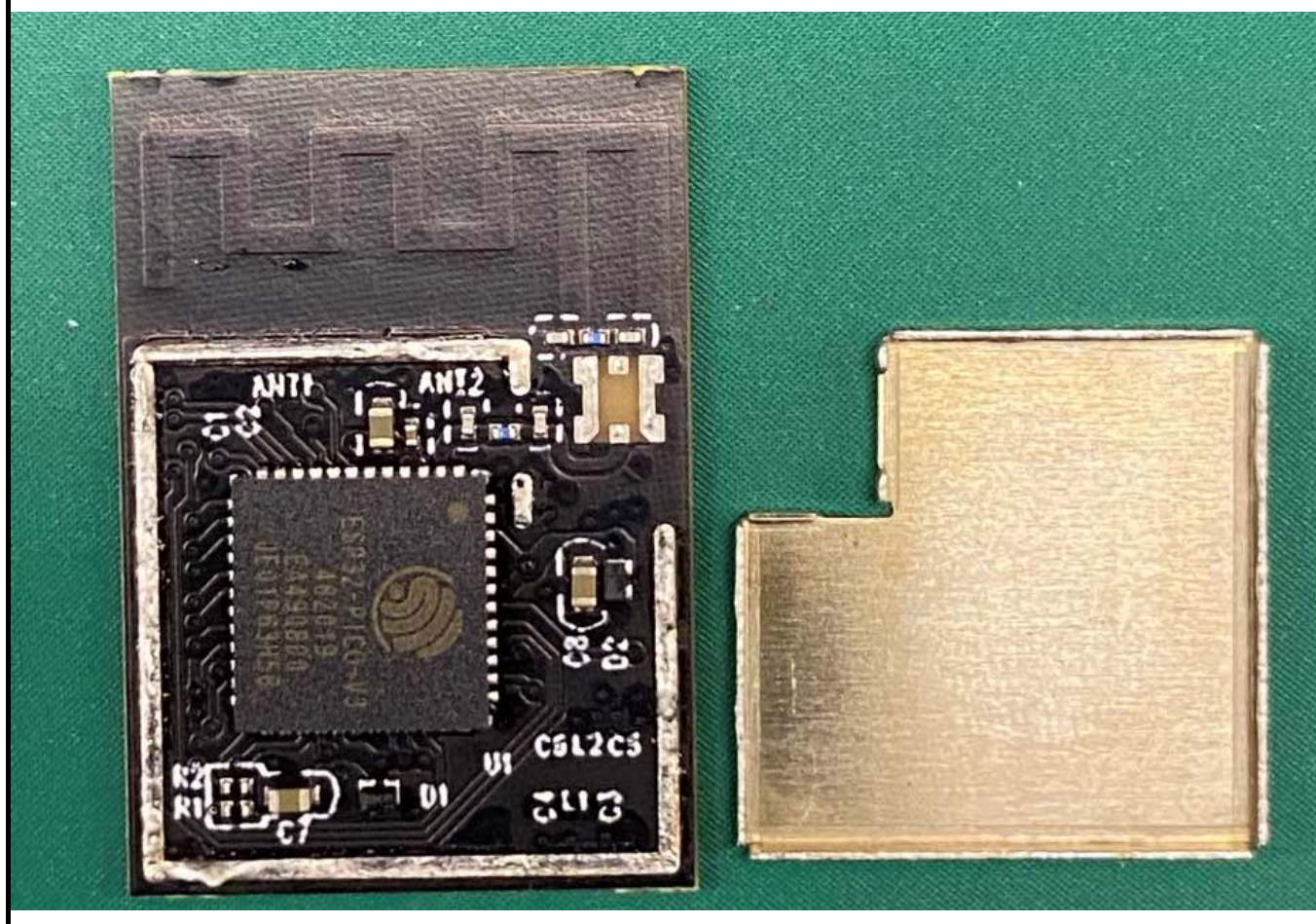
6. Uncertainty Measurement

Parameter	Uncertainty
RF Output Power	$\pm$1.25dB
Frequency Error Measurement	$\pm$2.5x10^{-7}
Occupied Bandwidth and Spread-spectrum Bandwidth / Factor	$\pm$4.54%
Unwanted Emission Strength Measurement	$\pm$1.23dB
Secondarily Emitted Radio Wave Strength	$\pm$1.12 dB
Carrier Sense	$\pm$1.55 dB

7. Main Test Instruments

Name	Manufacturer	Type	Serial Number	Calibration Date	Valid Period
Spectrum Analyzer	Agilent	N9020A	MY52330084	2020-05-18	2021-05-17
Power Meter	R&S	NRP2	104306	2020-05-18	2021-05-17
Power Sensor	R&S	NRP-Z21	104799	2020-05-18	2021-05-17
Signal Generator	Agilent	N5182B	MY51350303	2020-05-18	2021-05-17
DC Power Supply	GW Instek	GPS-3030D	GEP882653	2020-05-18	2022-05-17

******END OF REPORT ******