Test Report

Applicant's Name.....:	Shenzhen SaiFeng Electronic Technology Co., Ltd
Address.....:	Community, Ban Tin Street, LonggangDistrict, Shenzhen City, China
Manufacturer's Name.....:	Shenzhen SaiFeng Electronic Technology Co., Ltd
Address.....:	Community, Ban Tin Street, LonggangDistrict, Shenzhen City, China

Product Description

Product Name.....:	TWS True Wireless Earbuds
Model Name.....:	SE60, SE-ONE, TWS-SE
Trademark.....:	/
Model difference.....:	SE60 is tested model, other models are derivative models .The models are identical in circuit, only different on the model names , size and shape and color. So the test data of SE60 can represent the remaining models.
Ratings.....:	Input: 5 V⎓1 A or DC 3.7 V power by battery
Standards.....:	**ETSI EN 300 328 V2.2.2 (2019-07)**
Report Version.....:	B01

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Date of Test	Nov. 27, 2024
Date (s) of Performance of Tests :	Nov. 27, 2024 to Dec. 04, 2024
Date of Issue :	Dec. 04, 2024
Test Result :	Pass

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(Wanna)

Reviewed by : Chopin Xiao
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Approved by : Approved
(Kind Yang)
Shenzhen Promise Test Technology Co., Ltd.

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1. Revision History

Report Version	Revise Time	Issued Date	Valid Version	Notes
V1.0	/	Dec. 04, 2024	Valid	Original Report

2. Test Summary

The Product has been tested according to the following specifications:

Standard	ETSI EN 300 328 V2.2.2		
Test Item	**Test Requirement**	**Test Method**	**Results**
Transmitter Parameters			
RF Output Power	Clause 4.3.1.2	Clause 5.4.2	PASS
Power Spectral Density	Clause 4.3.2.3	Clause 5.4.3	N/A[1]
Duty cycle, Tx-Sequence, Tx-gap	Clause 4.3.1.3	Clause 5.4.2	N/A[2]
Accumulated Transmit time, Frequency Occupation & Hopping Sequence	Clause 4.3.1.4	Clause 5.4.4	PASS
Hopping Frequency Separation	Clause 4.3.1.5	Clause 5.4.5	PASS
Medium Utilization	Clause 4.3.1.6	Clause 5.4.2	N/A[2]
Adaptivity	Clause 4.3.1.7	Clause 5.4.6	N/A[3]
Occupied Channel Bandwidth	Clause 4.3.1.8	Clause 5.4.7	PASS
Transmitter unwanted emissions in the OOB domain	Clause 4.3.1.9	Clause 5.4.8	PASS
Transmitter unwanted emissions in the spurious domain	Clause 4.3.1.10	Clause 5.4.9	PASS
Receiver Parameters			
Receiver spurious emissions	Clause 4.3.1.11	Clause 5.4.10	PASS
Receiver Blocking	Clause 4.3.1.12	Clause 5.4.11	PASS
Geo-location capability	Clause 4.3.1.13	Clause 5.4.12	N/A[4]
Remark: N/A[1]: Only for equipment using wide band modulations other than FHSS N/A[2]: Only for non-Adaptive equipment. N/A[3]:The maximum output power of EUT less than 10dBm, so not applicable N/A[4]: Only for equipment with geo-location capability Tx: In this whole report Tx (or tx) means Transmitter. Rx: In this whole report Rx (or rx) means Receiver. RF: In this whole report RF means Radiated Frequency. CH:In this whole report CH means channel.			

3. Product Information And Test Setup

3.1. Product Information

EUT Name	:	TWS True Wireless Earbuds
Test Model No.	:	SE60
Power supply	:	Input: 5 V⎓1 A or DC 3.7 V power by battery
Operation frequency	:	2402MHz-2480MHz, 79 Channels
Modulation	:	GFSK, π/4DQPSK,8DPSK
Antenna Type	:	PCB Antenna
Antenna Gain	:	0dBi
Hardware Version	:	V1.0
Software Version	:	V1.0

3.2. Test Setup Configuration

See test photographs attached in EUT TEST SETUP PHOTOGRAPHS for the actual connections between Product and support equipment.

3.3. Support Equipment

Item	Equipment	Mfr/Brand	Model/Type No.	Series No.	Note

Notes:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer’s requirements and conditions for the intended use.

3.4. Channel List

CH	Frequency (MHz)	CH	Frequency (MHz)	CH	Frequency (MHz)	CH	Frequency (MHz)
0	2402	1	2403	2	2404	3	2405
4	2406	5	2407	6	2408	7	2409
8	2410	9	2411	10	2412	11	2413
12	2414	13	2415	14	2416	15	2417
16	2418	17	2419	18	2420	19	2421
20	2422	21	2423	22	2424	23	2425
24	2426	25	2427	26	2428	27	2429
28	2430	29	2431	30	2432	31	2433
32	2434	33	2435	34	2436	35	2437
36	2438	37	2439	38	2440	39	2441
40	2442	41	2443	42	2444	43	2445
44	2446	45	2447	46	2448	47	2449
48	2450	49	2451	50	2452	51	2453
52	2454	53	2455	54	2456	55	2457
56	2458	57	2459	58	2460	59	2461
60	2462	61	2463	62	2464	63	2465
64	2466	65	2467	66	2468	67	2469
68	2470	69	2471	70	2472	71	2473
72	2474	73	2475	74	2476	75	2477
76	2478	77	2479	78	2480	79	/

3.5. Test Mode

All test mode(s) and condition(s) mentioned were considered and evaluated respectively by performing full tests, the worst data were recorded and reported.

Test mode	Low channel	Middle channel	High channel
Transmitting (GFSK, π/4DQPSK, 8DPSK)	2402MHz	2441MHz	2480MHz
Receiving (GFSK, π/4DQPSK, 8DPSK)	2402MHz	2441MHz	2480MHz

3.6. Test Environment

Humidity(%):	54.2
Atmospheric Pressure(kPa):	101.4
Normal Temperature(℃)	23.5
Low Temperature(℃)	-10
High Temperature(℃)	50

4. Test Facility And Test Instrument Used

4.1. Test Facility

Shenzhen Promise Test Technology Co., Ltd.

103, Building 1, Yibaolai Industrial City, Qiaotou Community, Fuhai Street, Bao'an District, Shenzhen, Guangdong, China

4.2. Test Instrument Used

Equipment	Manufacturer	Model	Serial No.	Last Cal.	Next Cal.
Receiver	R&S	ESCI	100874	May 10, 2024	May 09, 2025
Loop antenna	EMCI	LAP600	272	May 10, 2024	May 09, 2025
Amplifier	Schwarzbeck	BBV 9743 B	00378	May 10, 2024	May 09, 2025
Amplifier	Schwarzbeck	BBV 9718 B	N/A	May 10, 2024	May 09, 2025
Bilog Antenna	Schwarzbeck	VULB9162	00498	May 28, 2024	May 27, 2025
Horn Antenna	Schwarzbeck	BBHA9120D	02623	May 16, 2024	May 15, 2025
Horn Antenna	A.H.SYSTEMS	SAS574	588	May 10, 2024	May 09, 2025
Amplifier	AEROFLEX	100KHz-40GHz	097	May 10, 2024	May 09, 2025
Spectrum Analyzer	R&S	FSV40	101413	May 10, 2024	May 09, 2025
CDN	Schwarzbeck	CDN M2+M3-16A	210313	May 10, 2024	May 09, 2025
966 Anechoic Chamber	EMToni	9m6m6m	N/A	Nov. 25, 2021	Nov. 24, 2024
Spectrum Analyzer	KEYSIGHT	N9020A	MY53420208	May 10, 2024	May 09, 2025
WIDBAND RADIO COMMUNICATION TESTER	R&S	CMW500	109863	May 10, 2024	May 09, 2025
Single Generator	Agilent	N5182A	MY48180575	May 10, 2024	May 09, 2025
Power Sensor	MWRFtest	MW100-RFCB	N/A	May 10, 2024	May 09, 2025
Single Generator	R&S	SMB100A	N/A	May 10, 2024	May 09, 2025
Power Amplifier Shielding Room	EMToni	2m3m3m	N/A	Nov. 25, 2021	Nov. 24, 2024

4.3. MAXIMUM MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

No.	Item	Uncertainty
1	AC Conducted Emission Test	±1.38dB
2	3m camber Radiated spurious emission(9KHz-30MHz)	U=1.6dB
3	3m camber Radiated spurious emission(30MHz-1GHz)	U=4.6dB
4	3m chamber Radiated spurious emission(1GHz-18GHz)	U=4.3dB
5	3m chamber Radiated spurious emission(18GHz-40GHz)	U=5.0dB
6	Conducted Adjacent channel power	U=1.38dB
7	Conducted output power uncertainty Above 1G	U=1.576dB
8	Conducted output power uncertainty below 1G	U=1.28dB
9	humidity uncertainty	U=5.3%
10	Temperature uncertainty	U=0.59℃

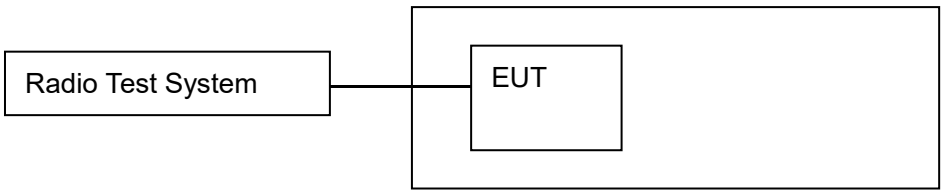
Decision Rule

☒ Uncertainty is not included

☐ Uncertainty is included

5. RF Output Power

5.1. Block Diagram Of Test Setup



5.2. Limit

For adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be 20 dBm.

The maximum RF output power for non-adaptive equipment shall be declared by the supplier and shall not exceed 20 dBm. See clause 5.3.1 m). For non-adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be equal to or less than the value declared by the supplier.

This limit shall apply for any combination of power level and intended antenna assembly.

Limit
20dBm

5.3. Test procedure

Step 1:

• Use a fast power sensor suitable for 2.4 GHz and capable of minimum 1 MS/s.

• Use the following settings:

- Sample speed 1 MS/s or faster.

- The samples shall represent the RMS power of the signal.

- Measurement duration: For non-adaptive equipment: equal to the observation period defined in clause 4.3.1.3.2 or clause 4.3.2.4.2. For adaptive equipment, the measurement duration shall be long enough to ensure a minimum number of bursts (at least 10) are captured.

NOTE 1: For adaptive equipment, to increase the measurement accuracy, a higher number of bursts may be used.

Step 2:

• For conducted measurements on devices with one transmit chain:

- Connect the power sensor to the transmit port, sample the transmit signal and store the raw data. Use these stored samples in all following steps.

• For conducted measurements on devices with multiple transmit chains:

- Connect one power sensor to each transmit port for a synchronous measurement on all transmit ports.

- Trigger the power sensors so that they start sampling at the same time. Make sure the time difference between the samples of all sensors is less than 500 ns.
- For each individual sampling point (time domain), sum the coincident power samples of all ports and store them. Use these summed samples in all following steps.

Step 3:

• Find the start and stop times of each burst in the stored measurement samples.

The start and stop times are defined as the points where the power is at least 30 dB below the highest value of the stored samples in step 2.

NOTE 2: In case of insufficient dynamic range, the value of 30 dB may need to be reduced appropriately.

Step 4:

• Between the start and stop times of each individual burst calculate the RMS power over the burst using the formula below. Save these P_{burst} values, as well as the start and stop times for each burst.

$$P_{burst} = \frac{1}{k}\sum_{n=1}^{k} P_{sample}(n)$$

with 'k' being the total number of samples and 'n' the actual sample number

Step 5:

• The highest of all P_{burst} values (value "A" in dBm) will be used for maximum e.i.r.p. calculations.

Step 6:

• Add the (stated) antenna assembly gain "G" in dBi of the individual antenna.

• If applicable, add the additional beamforming gain "Y" in dB.

• If more than one antenna assembly is intended for this power setting, the maximum overall antenna gain (G or G + Y) shall be used.

• The RF Output Power (P) shall be calculated using the formula below:

P = A + G + Y

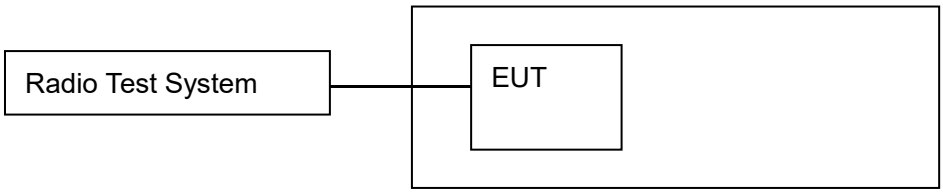
• This value, which shall comply with the limit given in clause 4.3.1.2.3 or clause 4.3.2.2.3, shall be recorded in the test report.

5.4. Test Result

Modulation	Test conditions (Temperature)	EIRP (dBm)
		Hopping mode
GFSK	Normal	4.42
	Lower	4.43
	Upper	4.56
π/4DQPSK	Normal	1.25
	Lower	1.19
	Upper	1.4
8DPSK	Normal	1.13
	Lower	1.28
	Upper	1.43
Limit		≤100mW (20dBm)
Remark: P = A + G + Y, G=0dBi, Y=0		

6. Accumulated Transmit Time, Frequency Occupation, Hopping Sequence

6.1. Block Diagram Of Test Setup



6.2. Limit

Adaptive Frequency Hopping equipment shall be capable of operating over a minimum of 70 % of the band specified in clause 1.

The Accumulated Transmit Time on any hopping frequency shall not be greater than 400 ms within any observation period of 400 ms multiplied by the minimum number of hopping frequencies (N) that have to be used. In order for the equipment to comply with the Frequency Occupation requirement, it shall meet either of the following two options:

Option 1: Each hopping frequency of the hopping sequence shall be occupied at least once within a period not exceeding four times the product of the dwell time and the number of hopping frequencies in use.

Option 2: The occupation probability for each frequency shall be between ((1 / U) × 25 %) and 77 % where U is the number of hopping frequencies in use.

The hopping sequence(s) shall contain at least N hopping frequencies at all times, where N is 15 or 15 divided by the minimum Hopping Frequency Separation in MHz, whichever is the greater.

6.3. Test procedure

Step 1:

• The output of the transmitter shall be connected to a spectrum analyzer or equivalent.

• The analyzer shall be set as follows:

- Centre Frequency: Equal to the hopping frequency being investigated

- Frequency Span: 0 Hz

- RBW: ~ 50 % of the Occupied Channel Bandwidth

- VBW: ≥ RBW

- Detector Mode: RMS

- Sweep time: Equal to the applicable observation period (see clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2)

- Number of sweep points: 30 000

- Trace mode: Clear / Write

- Trigger: Free Run

Step 2:

• Save the trace data to a file for further analysis by a computing device using an appropriate software application or program.

Step 3:

• Identify the data points related to the frequency being investigated by applying a threshold.

The data points resulting from transmissions on the hopping frequency being investigated are assumed to have much higher levels compared to data points resulting from transmissions on adjacent hopping frequencies. If a clear determination between these transmissions is not possible, the RBW in step 1 shall be further reduced. In addition, a channel filter may be used.

• Count the number of data points identified as resulting from transmissions on the frequency being investigated and multiply this number by the time difference between two consecutive data points.

Step 4:

• The result in step 3 is the Accumulated Transmit Time which shall comply with the limit provided in clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2 and which shall be recorded in the test report.

Step 5:

NOTE 1: This step is only applicable for equipment implementing Option 1 in clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2 for complying with the Frequency Occupation requirement and the manufacturer decides to demonstrate compliance with this requirement via measurement.

• Make the following changes on the analyser and repeat step 2 and step 3.

Sweep time: 4 × Dwell Time × Actual number of hopping frequencies in use

The hopping frequencies occupied by the equipment without having transmissions during the dwell time (blacklisted frequencies) should be taken into account in the actual number of hopping frequencies in use. If this number cannot be determined (number of blacklisted frequencies unknown) it shall be assumed that the equipment uses the maximum possible number of hopping frequencies.

• The result shall be compared to the limit for the Frequency Occupation defined in clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2. The result of this comparison shall be recorded in the test report.

Step 6:

• Make the following changes on the analyzer:

- Start Frequency: 2 400 MHz

- Stop Frequency: 2 483,5 MHz

- RBW: ~ 50 % of the Occupied Channel Bandwidth (single hopping frequency)

- VBW: ≥ RBW

- Detector Mode: RMS

- Sweep time: 1 s

- Trace Mode: Max Hold

- Trigger: Free Run

NOTE 2: The above sweep time setting may result in long measuring times. To avoid such long measuring times, an FFT analyser could be used.

• Wait for the trace to stabilize. Identify the number of hopping frequencies used by the hopping sequence.

• The result shall be compared to the limit (value N) defined in clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2. This value shall be recorded in the test report.

For equipment with blacklisted frequencies, it might not be possible to verify the number of hopping frequencies in use. However they shall comply with the requirement for Accumulated Transmit Time and Frequency Occupation assuming the minimum number of hopping frequencies (N) defined in clause 4.3.1.4.3.1 or clause 4.3.1.4.3.2 is used.

Step 7:

• For adaptive equipment, using the lowest and highest -20 dB points from the total spectrum envelope obtained in step 6, it shall be verified whether the equipment uses 70 % of the band specified in clause 1. The result shall be recorded in the test report.

6.4. Test Result

Accumulated Transmit Time

Mode	Frequency (MHz)	Accumulated Transmit Time (ms)	Limit (ms)	Sweep Time (ms)	Burst Number	Verdict
1-DH5	2402	323.01	400	31600	111	Pass
1-DH5	2441	316.427	400	31600	109	Pass
1-DH5	2480	267.72	400	31600	92	Pass
2-DH5	2402	270.63	400	31600	93	Pass
2-DH5	2441	293.91	400	31600	101	Pass
2-DH5	2480	302.64	400	31600	104	Pass
3-DH5	2402	317.19	400	31600	109	Pass
3-DH5	2441	314.172	400	31600	108	Pass
3-DH5	2480	320.1	400	31600	110	Pass

Frequency Occupation

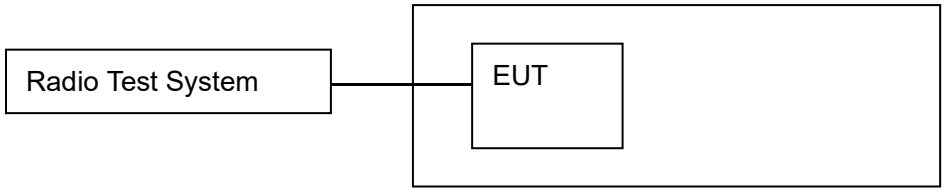
Mode	Frequency (MHz)	Burst Number	Limit	Sweep Time (ms)	Verdict
1-DH5	2402	4	1	919.56	Pass
1-DH5	2441	6	1	917.348	Pass
1-DH5	2480	1	1	919.56	Pass
2-DH5	2402	1	1	919.56	Pass
2-DH5	2441	2	1	919.56	Pass
2-DH5	2480	1	1	919.56	Pass
3-DH5	2402	5	1	919.56	Pass
3-DH5	2441	7	1	919.244	Pass
3-DH5	2480	3	1	919.56	Pass

Hopping sequence

Mode	Hopping Number	Limit	Band Allocation (%)	Limit Band Allocation (%)	Verdict
1-DH5	79	15	95.4	70	Pass
2-DH5	79	15	96	70	Pass
3-DH5	79	15	96	70	Pass

7. Hopping Frequency Separation

7.1. Block Diagram Of Test Setup



7.2. Limit

For Non-adaptive frequency hopping systems
The minimum Hopping Frequency Separation shall be equal to Occupied Channel Bandwidth (see clause 5.3.1.5.3) of a single hop, with a minimum separation of 100 kHz.
For Adaptive frequency hopping systems
The minimum Hopping Frequency Separation shall be 100 kHz.

7.3. Test procedure

The Hopping Frequency Separation as defined in clause 4.3.1.5 shall be measured and recorded using any of the following options. The selected option shall be stated in the test report.

Option 1

Step 1:

• The output of the transmitter shall be connected to a spectrum analyser or equivalent.

• The analyser shall be set as follows:

- Centre Frequency: Centre of the two adjacent hopping frequencies
- Frequency Span: Sufficient to see the complete power envelope of both hopping frequencies
- RBW: 1 % of the span
- VBW: 3 × RBW
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep time: 1 s

Step 2:

• Wait for the trace to stabilize.

• Use the marker function of the analyser to define the frequencies corresponding to the lower -20 dBr point and the upper -20 dBr point for both hopping frequencies F1 and F2. This will result in $F1_L$ and $F1_H$ for hopping frequency F1 and in $F2_L$ and $F2_H$ for hopping frequency F2. These values shall be recorded in the report.

Step 3:

• Calculate the centre frequencies $F1_C$ and $F2_C$ for both hopping frequencies using the formulas below. These values shall be recorded in the report.

$$F1_C = \frac{F1_L + F1_H}{2} \quad F2_C = \frac{F2_L + F2_H}{2}$$

• Calculate the -20 dBr channel bandwidth (BW_{CHAN}) using the formula below. This value shall be recorded in the report.

$$BW_{CHAN} = F1_H - F1_L$$

• Calculate the Hopping Frequency Separation (FHS) using the formula below. This value shall be recorded in the report.

$$F_{HS} = F2_C - F1_C$$

• Compare the measured Hopping Frequency Separation with the limit defined in clause 4.3.1.5.3. In addition, for non-Adaptive Frequency Hopping equipment, the Hopping Frequency Separation shall be equal to or greater than Occupied Channel Bandwidth as defined in clause 4.3.1.8 or:

$$F_{HS} \geq \text{Occupied Channel Bandwidth}$$

• See figure 4:

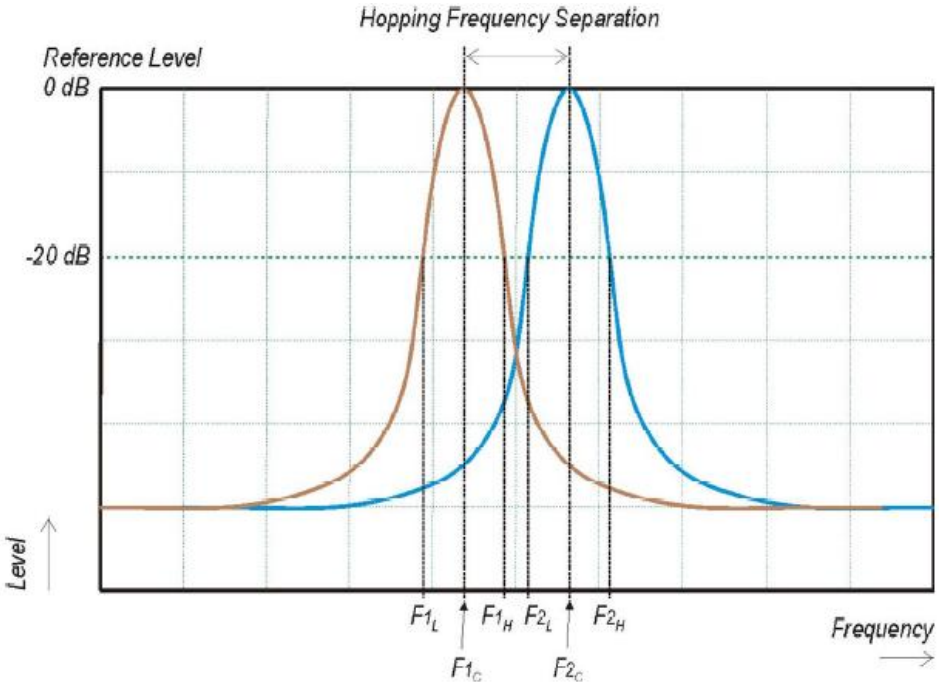


Figure 4: Hopping Frequency Separation

For adaptive equipment, in case of overlapping channels which will prevent the definition of the -20 dBr reference points $F1_H$ and $F2_L$, a higher reference level (e.g. -10 dBr or - 6 dBr) may be chosen to define the reference points $F1_L$; $F1_H$; $F2_L$ and $F2_H$.

Alternatively, special test software may be used to:

• force the UUT to hop or transmit on a single Hopping Frequency by which the -20 dBr reference

points can be measured separately for the two adjacent Hopping Frequencies; and/or

• force the UUT to operate without modulation by which the centre frequencies F1C and F2C can be measured directly.

The method used to measure the Hopping Frequency Separation shall be documented in the test report.

7.4. Test Result

Mode	Hopping Freq1 (MHz)	Hopping Freq2 (MHz)	HFS (MHz)	Limit (MHz)	Verdict
1-DH5	2402.007	2402.992	0.985	0.1	Pass
1-DH5	2441.016	2442.029	1.013	0.1	Pass
1-DH5	2479.013	2480	0.987	0.1	Pass
2-DH5	2401.95	2402.94	0.99	0.1	Pass
2-DH5	2440.972	2442.12	1.148	0.1	Pass
2-DH5	2478.814	2479.902	1.088	0.1	Pass
3-DH5	2401.838	2402.918	1.08	0.1	Pass
3-DH5	2441.013	2441.918	0.905	0.1	Pass
3-DH5	2479.016	2480.013	0.997	0.1	Pass

Test Graphs
HFS NVNT 1-DH5 2402MHz Ant1

HFS NVNT 1-DH5 2441MHz Ant1

HFS NVNT 1-DH5 2480MHz Ant1

HFS NVNT 2-DH5 2402MHz Ant1

HFS NVNT 2-DH5 2441MHz Ant1

HFS NVNT 2-DH5 2480MHz Ant1

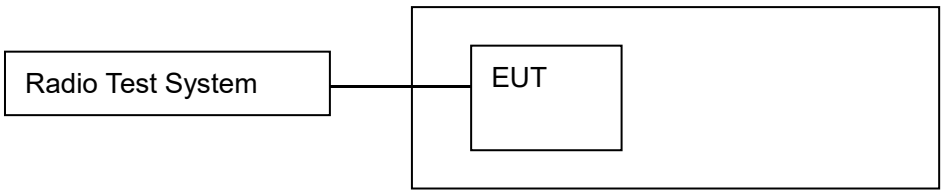
HFS NVNT 3-DH5 2402MHz Ant1

HFS NVNT 3-DH5 2441MHz Ant1

HFS NVNT 3-DH5 2480MHz Ant1

8. Occupied Channel Bandwidth

8.1. Block Diagram Of Test Setup



8.2. Limit

The Occupied Channel Bandwidth shall fall completely within the band given in 2.4GHz to 2.4835GHz.
In addition, for non-adaptive systems using wide band modulations other than FHSS and with e.i.r.p greater than 10 dBm, the occupied channel bandwidth shall be less than 20 MHz.

8.3. Test procedure

Step 1:

Connect the UUT to the spectrum analyser and use the following settings:

• Centre Frequency: The centre frequency of the channel under test

• Resolution BW: ~ 1 % of the span without going below 1 %

• Video BW: 3 × RBW

• Frequency Span: 2 × Nominal Channel Bandwidth

• Detector Mode: RMS

• Trace Mode: Max Hold

• Sweep time: 1 s

Step 2:

Wait for the trace to stabilize.

Find the peak value of the trace and place the analyser marker on this peak.

Step 3:

Use the 99 % bandwidth function of the spectrum analyser to measure the Occupied Channel Bandwidth of the UUT.

This value shall be recorded.

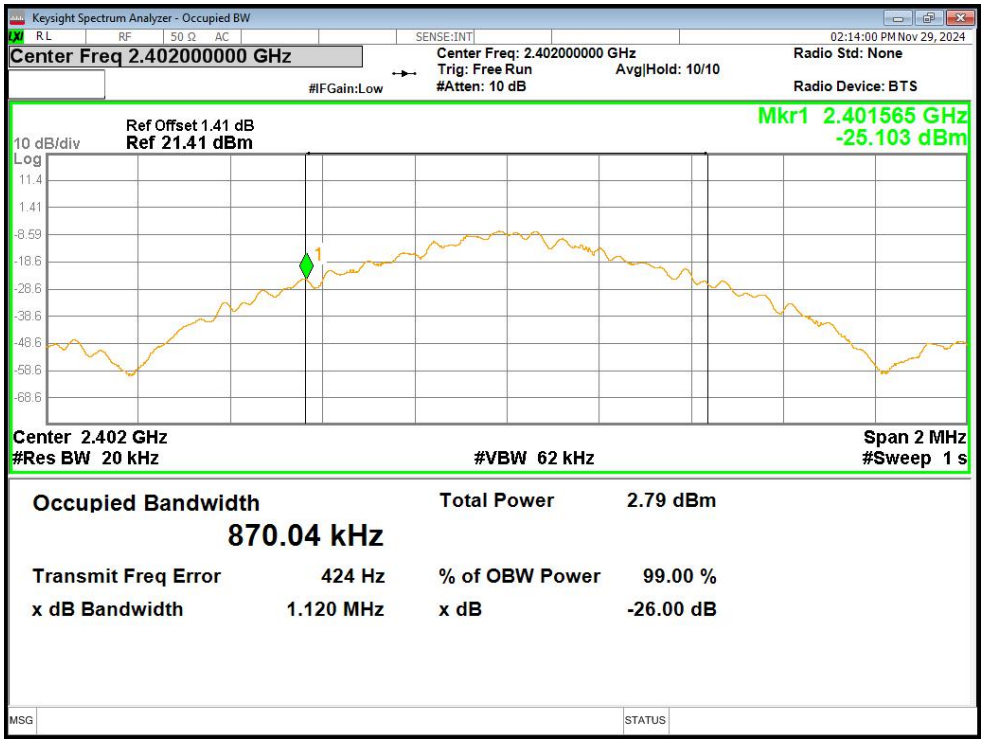
NOTE: Make sure that the power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals left and right from the power envelope being taken into account by this measurement.

8.4. Test Result

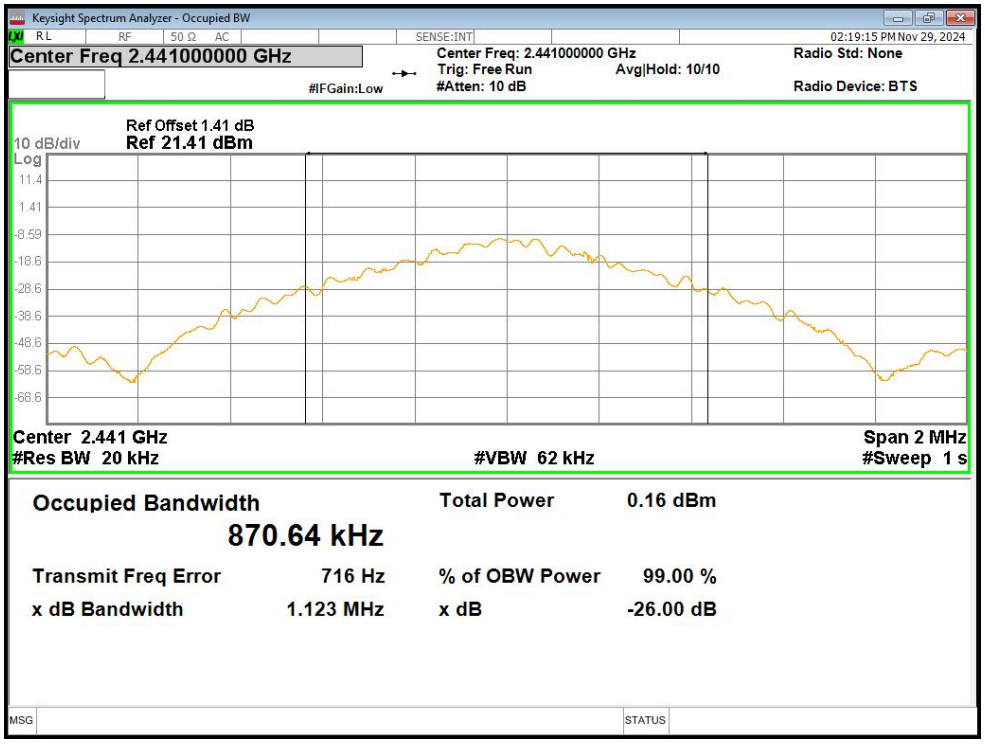
Modulation	Frequency (MHz)	Occupied Channel (MHz)	Frequency Range (MHz)	
π/4DQPSK	Low	0.87	2401.565	2402.435
	Middle	0.871	2440.565	2441.436
	High	0.87	2479.565	2480.435
GFSK	Low	1.186	2401.41	2402.596
	Middle	1.187	2440.41	2441.596
	High	1.186	2479.409	2480.596
8DPSK	Low	1.197	2401.403	2402.6
	Middle	1.197	2440.403	2441.6
	High	1.198	2479.403	2480.6

Test Graphs

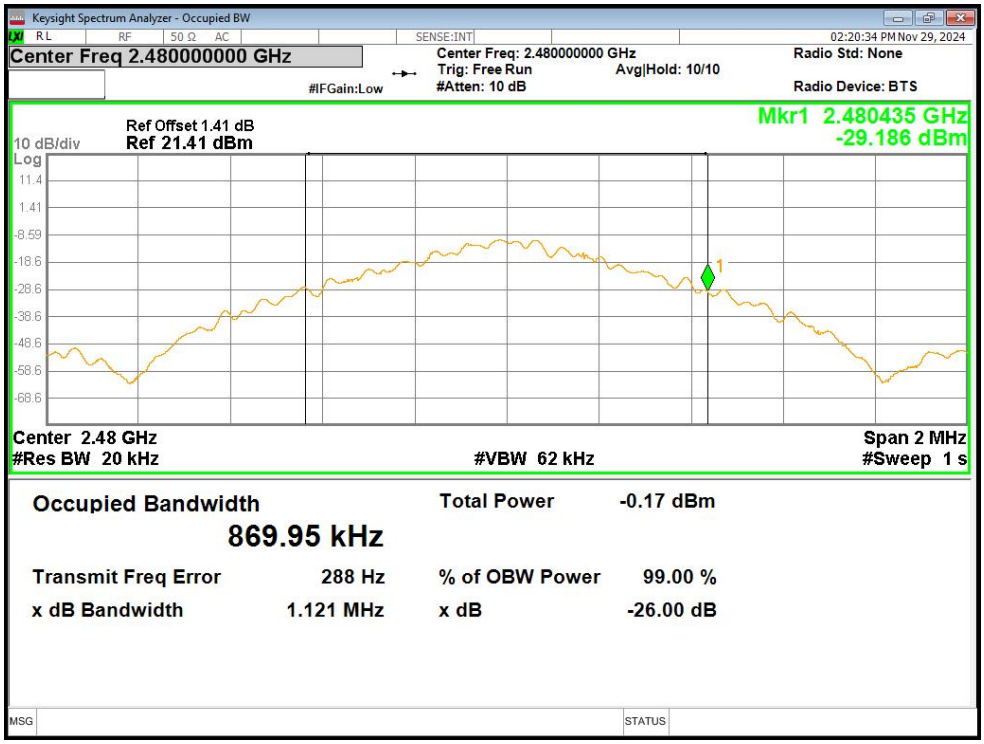
OBW NVNT 1-DH5 2402MHz Ant1



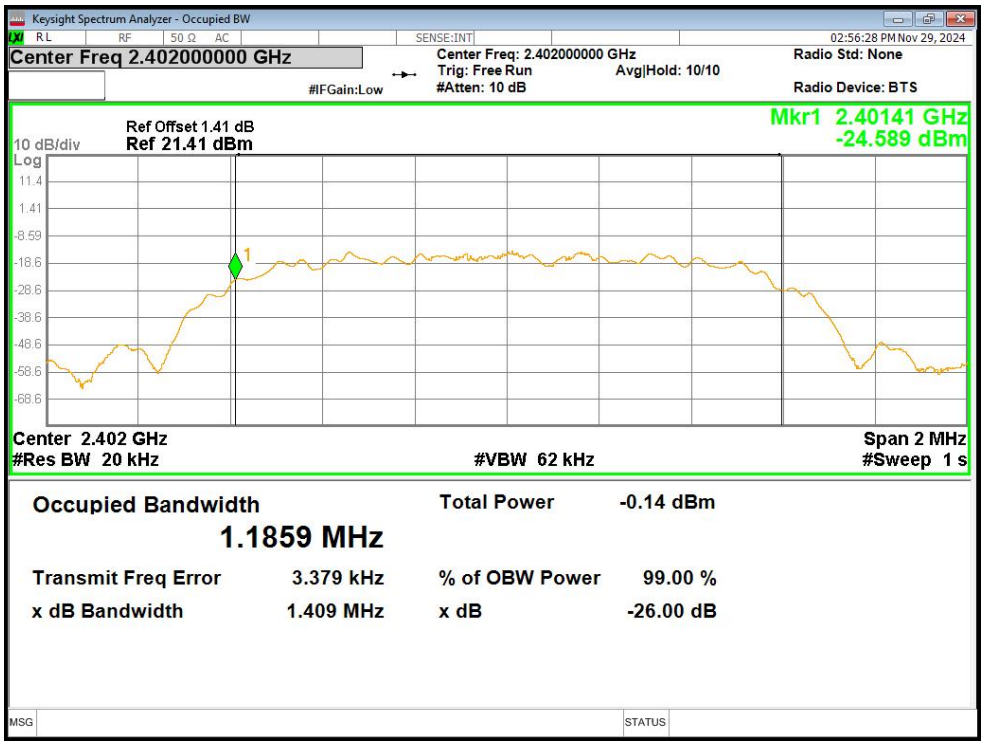
OBW NVNT 1-DH5 2441MHz Ant1



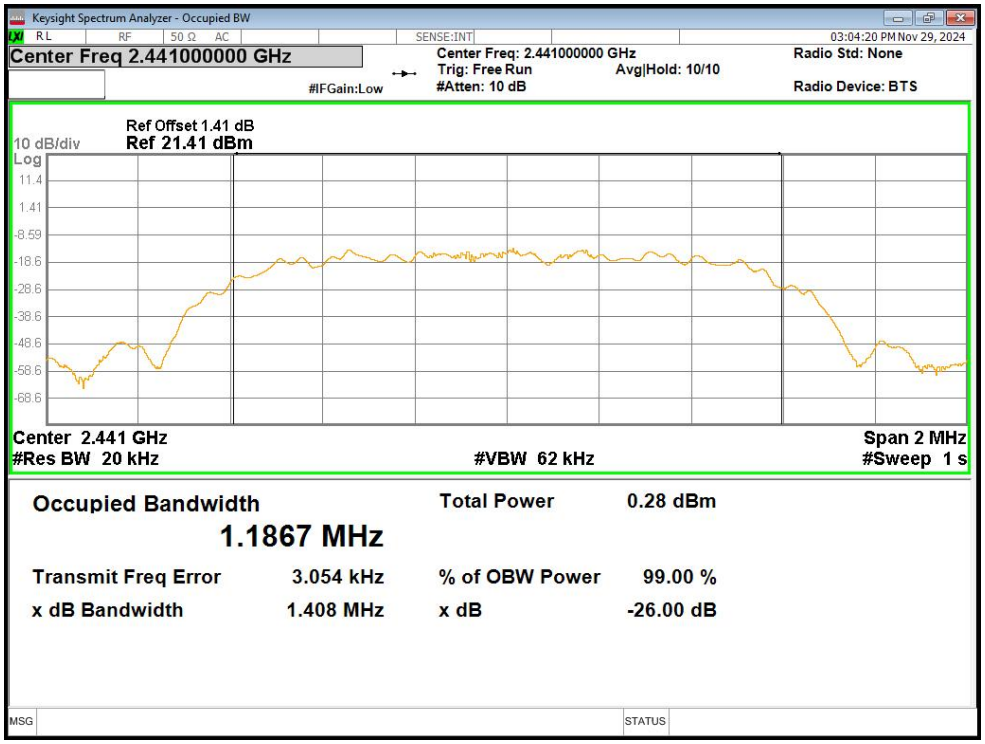
OBW NVNT 1-DH5 2480MHz Ant1



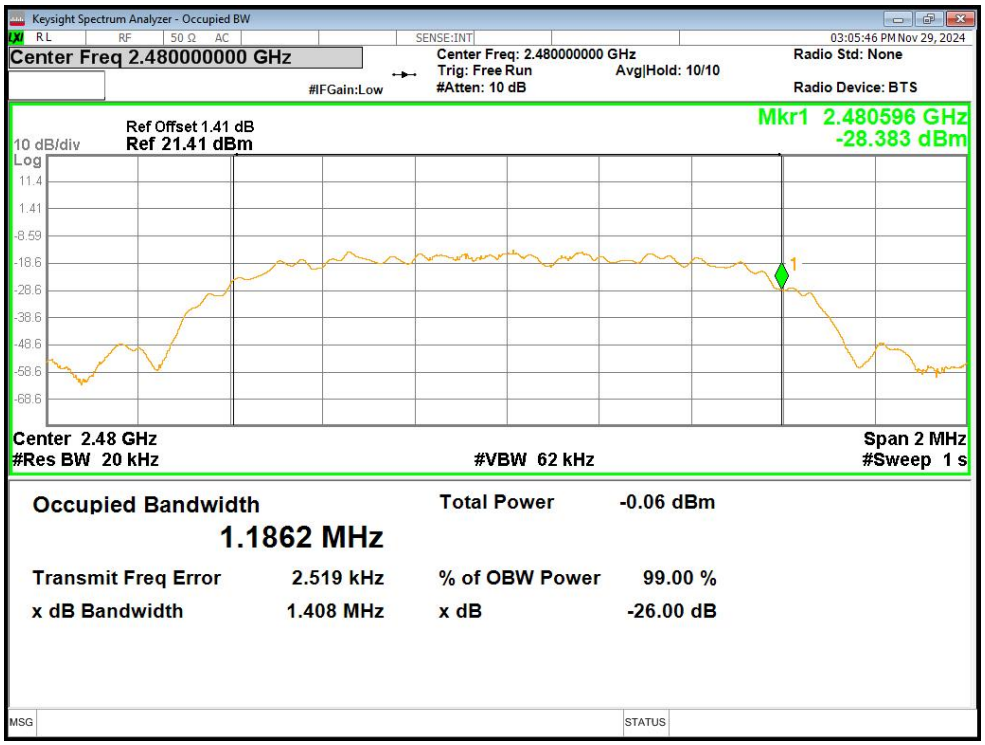
OBW NVNT 2-DH5 2402MHz Ant1



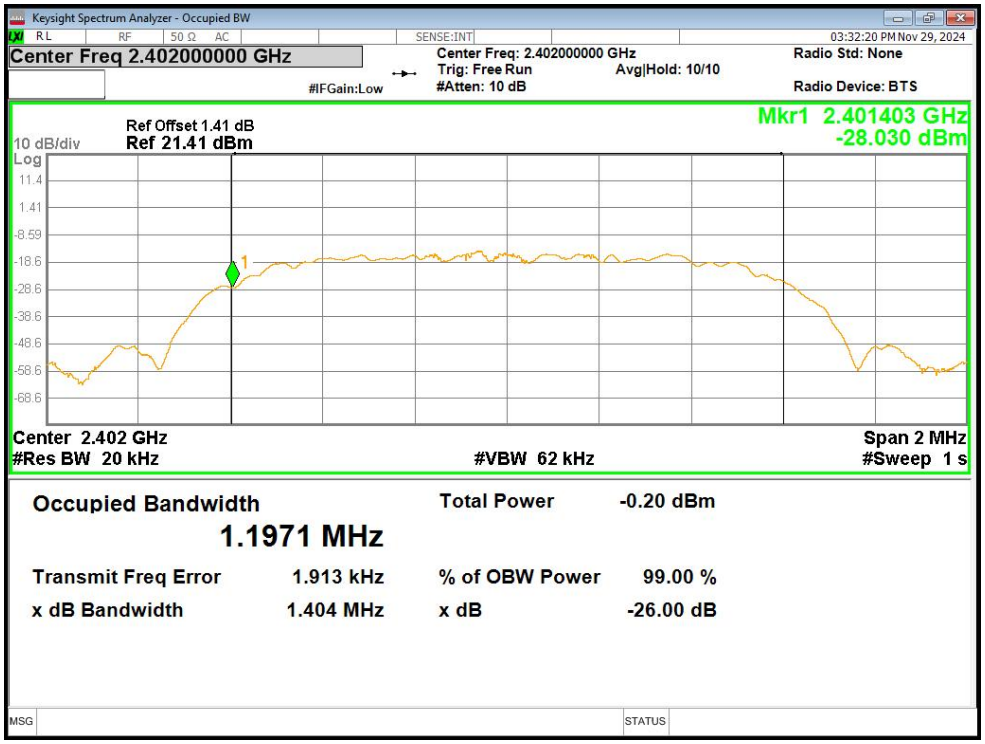
OBW NVNT 2-DH5 2441MHz Ant1



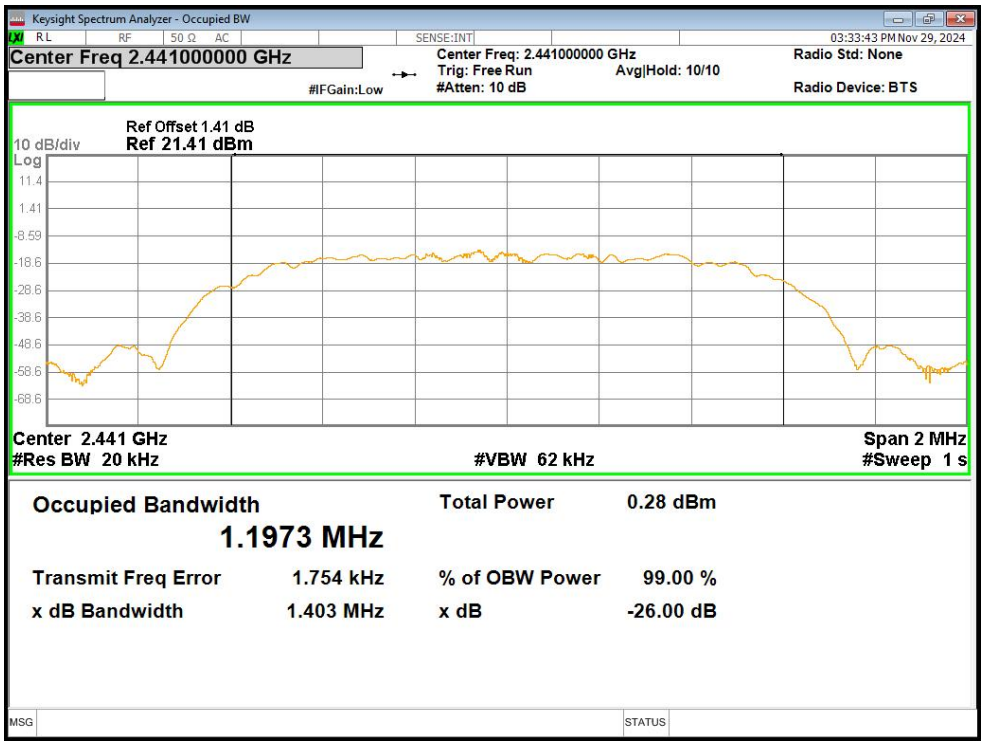
OBW NVNT 2-DH5 2480MHz Ant1



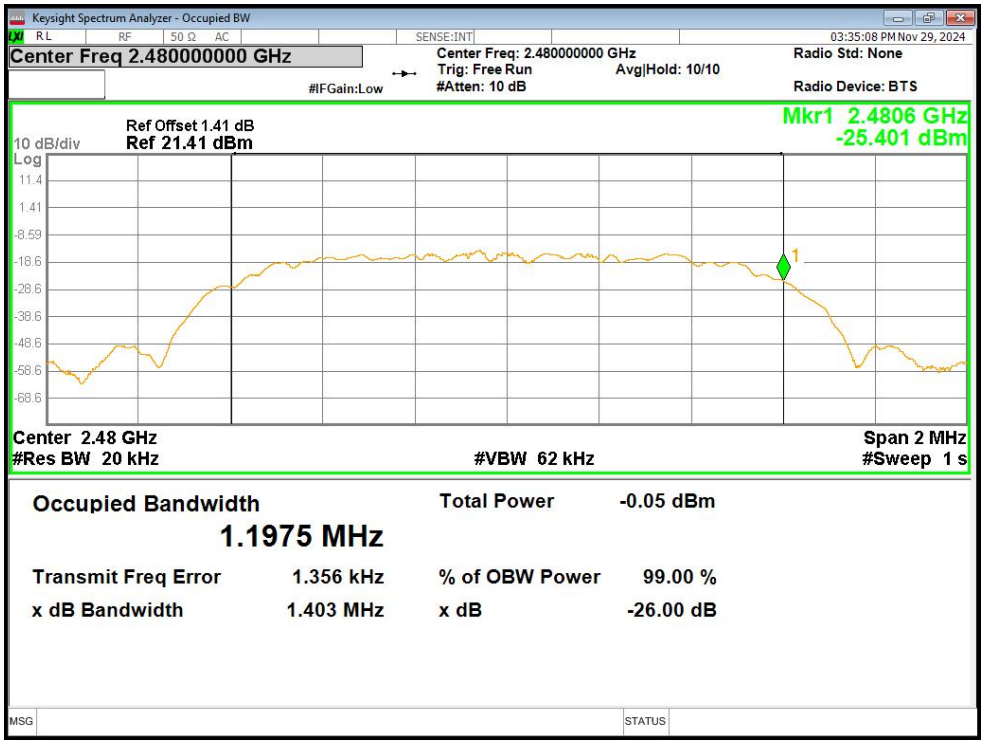
OBW NVNT 3-DH5 2402MHz Ant1



OBW NVNT 3-DH5 2441MHz Ant1

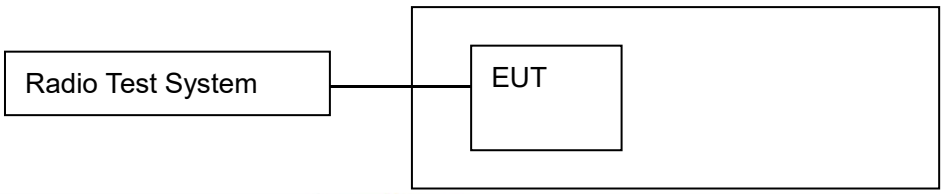


OBW NVNT 3-DH5 2480MHz Ant1



9. Transmitter Unwanted Emissions In The Out-of-band Domain

9.1. Block Diagram Of Test Setup



9.2. Limit

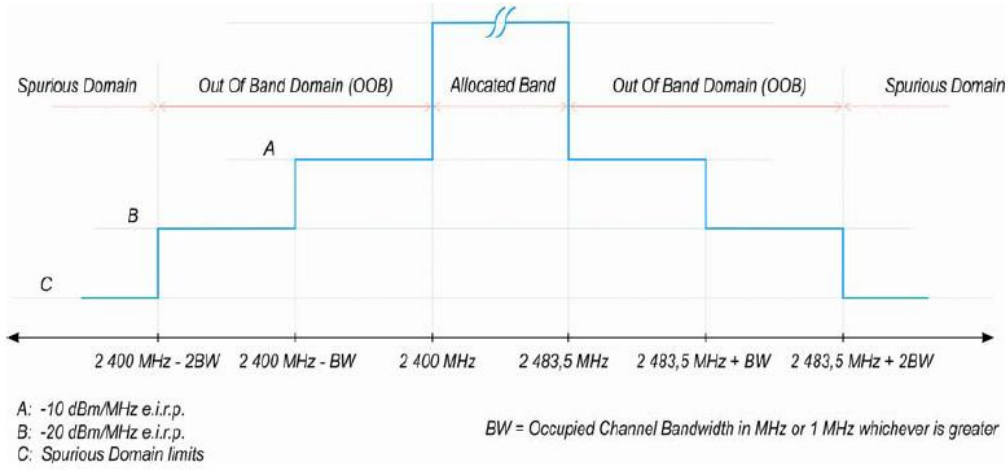


Figure 3: Transmit mask

9.3. Test procedure

The applicable mask is defined by the measurement results from the tests performed under clause 5.3.8 (Occupied Channel Bandwidth).

The test procedure is further as described under clause 5.3.9.2.1.

The Out-of-band emissions within the different horizontal segments of the mask provided in figures 1 and 3 shall be measured using the steps below. This method assumes the spectrum analyser is equipped with the Time Domain Power option.

Step 1:

• Connect the UUT to the spectrum analyser and use the following settings:

- Centre Frequency: 2 484 MHz

- Span: 0 Hz

- Resolution BW: 1 MHz

- Filter mode: Channel filter

- Video BW: 3 MHz

- Detector Mode: RMS

- Trace Mode: Max Hold

- Sweep Mode: Continuous

- Sweep Points: Sweep Time [s] / (1 µs) or 5 000 whichever is greater

- Trigger Mode: Video trigger

NOTE 1: In case video triggering is not possible, an external trigger source may be used.

- Sweep Time: > 120 % of the duration of the longest burst detected during the measurement of the RF Output Power

Step 2 (segment 2 483,5 MHz to 2 483,5 MHz + BW):

• Adjust the trigger level to select the transmissions with the highest power level.

• For frequency hopping equipment operating in a normal hopping mode, the different hops will result in signal bursts with different power levels. In this case the burst with the highest power level shall be selected.

• Set a window (start and stop lines) to match with the start and end of the burst and in which the RMS power shall be measured using the Time Domain Power function.

• Select RMS power to be measured within the selected window and note the result which is the RMS power within this 1 MHz segment (2 483,5 MHz to 2 484,5 MHz). Compare this value with the applicable limit provided by the mask.

• Increase the centre frequency in steps of 1 MHz and repeat this measurement for every 1 MHz segment within the range 2 483,5 MHz to 2 483,5 MHz + BW. The centre frequency of the last 1 MHz segment shall be set to 2 483,5 MHz + BW - 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 3 (segment 2 483,5 MHz + BW to 2 483,5 MHz + 2BW):

• Change the centre frequency of the analyser to 2 484 MHz + BW and perform the measurement for the first 1 MHz segment within range 2 483,5 MHz + BW to 2 483,5 MHz + 2BW. Increase the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 483,5 MHz + 2 BW - 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 4 (segment 2 400 MHz - BW to 2 400 MHz):

• Change the centre frequency of the analyser to 2 399,5 MHz and perform the measurement for the first 1 MHz segment within range 2 400 MHz - BW to 2 400 MHz Reduce the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 400 MHz - BW + 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 5 (segment 2 400 MHz - 2BW to 2 400 MHz - BW):

• Change the centre frequency of the analyser to 2 399,5 MHz - BW and perform the measurement for the first 1 MHz segment within range 2 400 MHz - 2BW to 2 400 MHz - BW. Reduce the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 400 MHz - 2BW + 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 6:

• In case of conducted measurements on equipment with a single transmit chain, the declared antenna assembly gain "G" in dBi shall be added to the results for each of the 1 MHz segments and compared with the limits

provided by the mask given in figure 1 or figure 3. If more than one antenna assembly is intended for this power setting, the antenna with the highest gain shall be considered.

• In case of conducted measurements on smart antenna systems (equipment with multiple transmit chains), the measurements need to be repeated for each of the active transmit chains. The declared antenna assembly gain "G" in dBi for a single antenna shall be added to these results. If more than one antenna assembly is intended for this power setting, the antenna with the highest gain shall be considered. Comparison with the applicable limits shall be done using any of the options given below:

- Option 1: the results for each of the transmit chains for the corresponding 1 MHz segments shall be added. The additional beamforming gain "Y" in dB shall be added as well and the resulting values compared with the limits provided by the mask given in figure 1 or figure 3.

- Option 2: the limits provided by the mask given in figure 1 or figure 3 shall be reduced by

10 × log10(Ach) and the additional beamforming gain "Y" in dB. The results for each of the transmit chains shall be individually compared with these reduced limits.

NOTE 2: Ach refers to the number of active transmit chains.

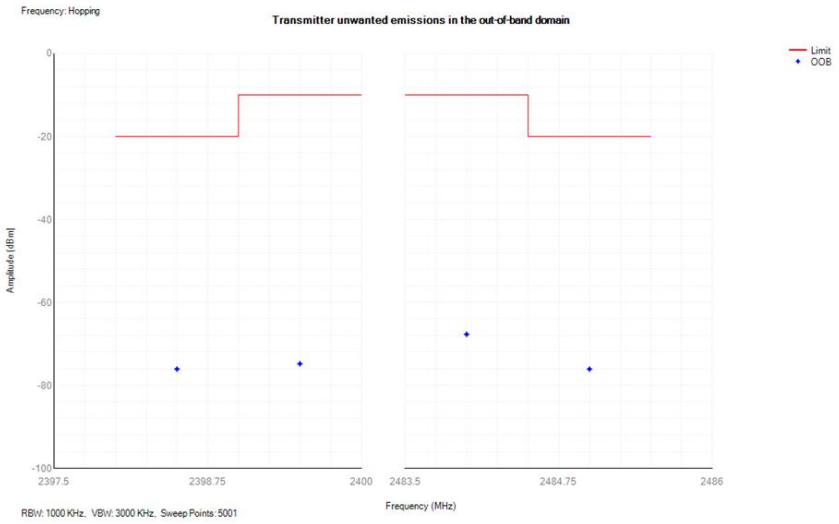
It shall be recorded whether the equipment complies with the mask provided in figure 1 or figure 3.

9.4. Test Result

Modulation : GFSK (the worst data)

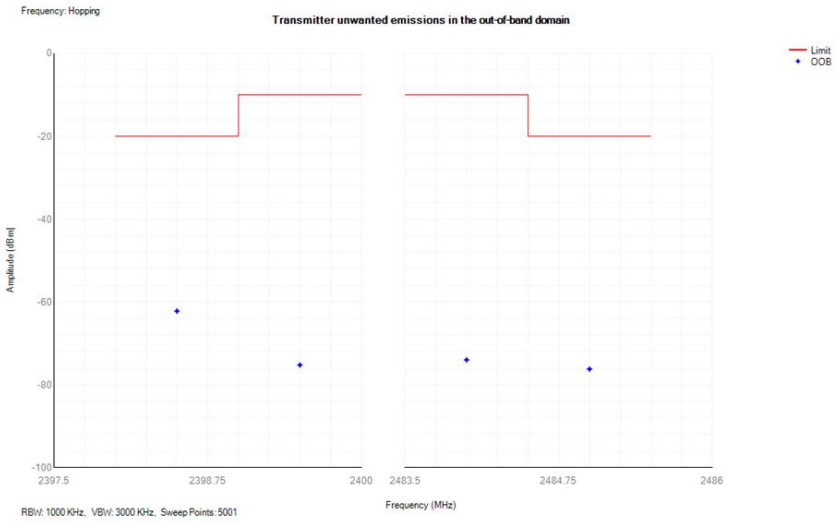
CH Low (Normal Temp)

Test Freq (MHz)	Antenna	Freq(MHz)	Level	Limit
2402	Antenna 1	2399.5	-74.78	-10
2402	Antenna 1	2398.5	-76.06	-20



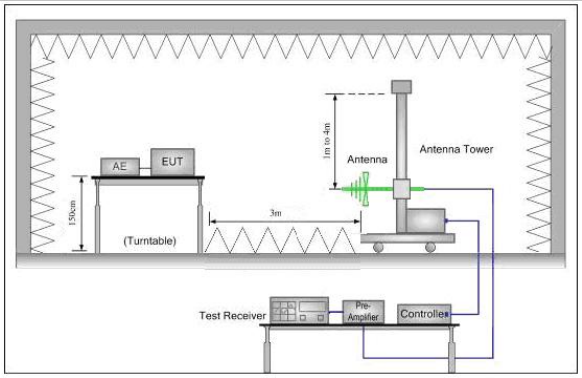
CH High (Normal Temp)

Test Freq (MHz)	Antenna	Freq(MHz)	Level	Limit
2480	Antenna 1	2484	-67.67	-10
2480	Antenna 1	2485	-76.06	-20

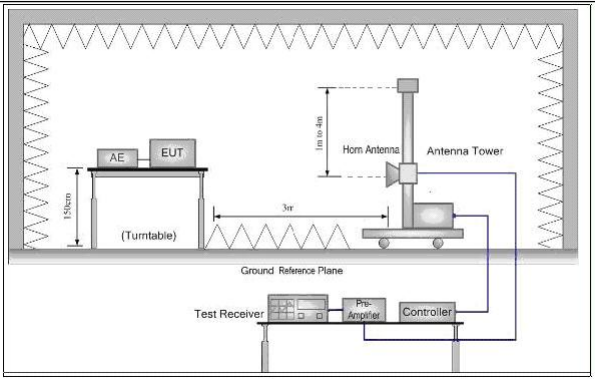


10. Transmitter Unwanted Emissions In The Spurious Domain

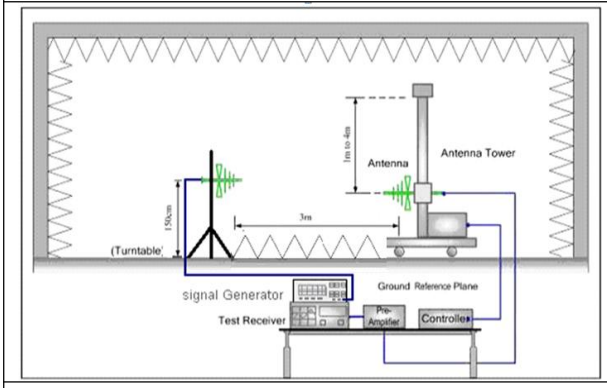
10.1. Block Diagram Of Test Setup



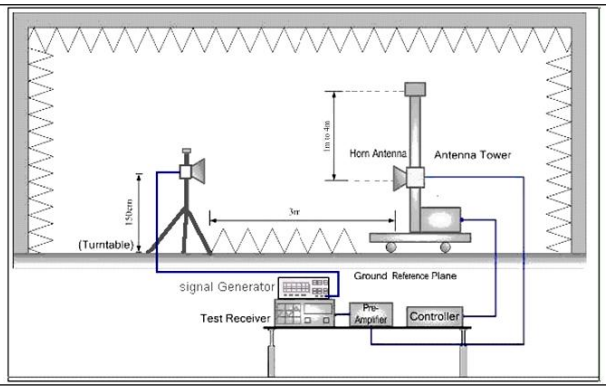
Below 1GHz



Above 1GHz



Below 1GHz



Above 1GHz

10.2. Limits

Frequency range	Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p. (> 1 GHz)	RBW/VBW
30 MHz to 47 MHz	-36 dBm	100 kHz/300KHz
47 MHz to 74 MHz	-54 dBm	100 kHz/300KHz
74 MHz to 87,5 MHz	-36 dBm	100 kHz/300KHz
87,5 MHz to 118 MHz	-54 dBm	100 kHz/300KHz
118 MHz to 174 MHz	-36 dBm	100 kHz/300KHz
174 MHz to 230 MHz	-54 dBm	100 kHz/300KHz
230 MHz to 470 MHz	-36 dBm	100 kHz/300KHz
470 MHz to 694 MHz	-54 dBm	100 kHz/300KHz
694 MHz to 1 GHz	-36 dBm	100 kHz/300KHz
1 GHz to 12,75 GHz	-30 dBm	1 MHz/3MHz

10.3. Test Procedure

30MHz ~ 1GHz:

a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.

Above 1GHz:

a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.

10.4. Test Results

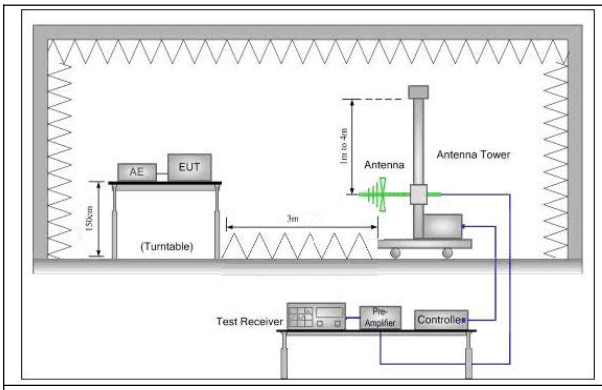
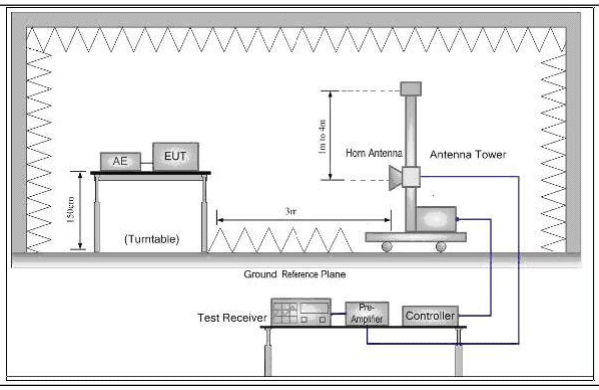
Frequency	Antenna Polar	Receiver Reading	Limit	Margin	Result
(MHz)	(H/V)	(dBm)	(dBm)	(dB)	
GFSK low channel					PASS
835.9	H	-52.07	-36	-16.07	
835.9	V	-53.52	-36	-17.52	
4824	H	-52.17	-30	-22.17	
4824	V	-52.2	-30	-22.2	
7236	H	-49.72	-30	-19.72	
7236	V	-51.35	-30	-21.35	
GFSK High channel					
841.18	H	-50.18	-36	-14.18	
841.18	V	-55.14	-36	-19.14	
4944	H	-49.13	-30	-19.13	
4944	V	-51.8	-30	-21.8	
7416	H	-55.59	-30	-25.59	
7416	V	-55.97	-30	-25.97	

Remark:

Margin = Receiver Reading - Limit.

11. Receiver Spurious Emissions

11.1. lock Diagram Of Test Setup

<table>
<tr><td> 
</td><td> 
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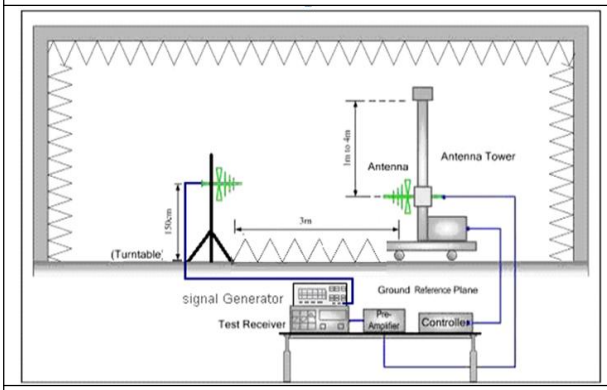
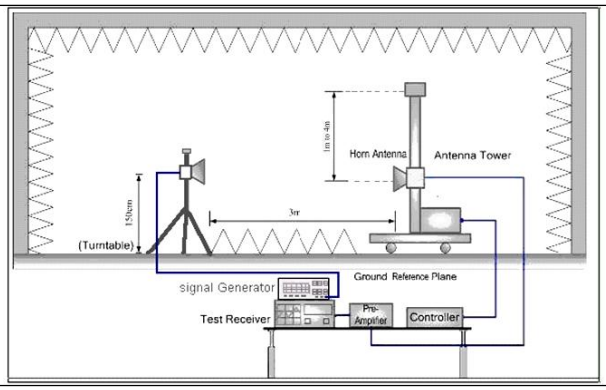
<tr><td>Below 1GHz</td><td>Above 1GHz</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Below 1GHz</td><td>Above 1GHz</td></tr>
</table>

11.2. Limits

Frequency(MHz)	Limit
30-1000	-57dBm
1000-12750	-47dBm

11.3. Test Procedure

30MHz ~ 1GHz:

a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to

find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.

Above 1GHz:

a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value

11.4. Test Results

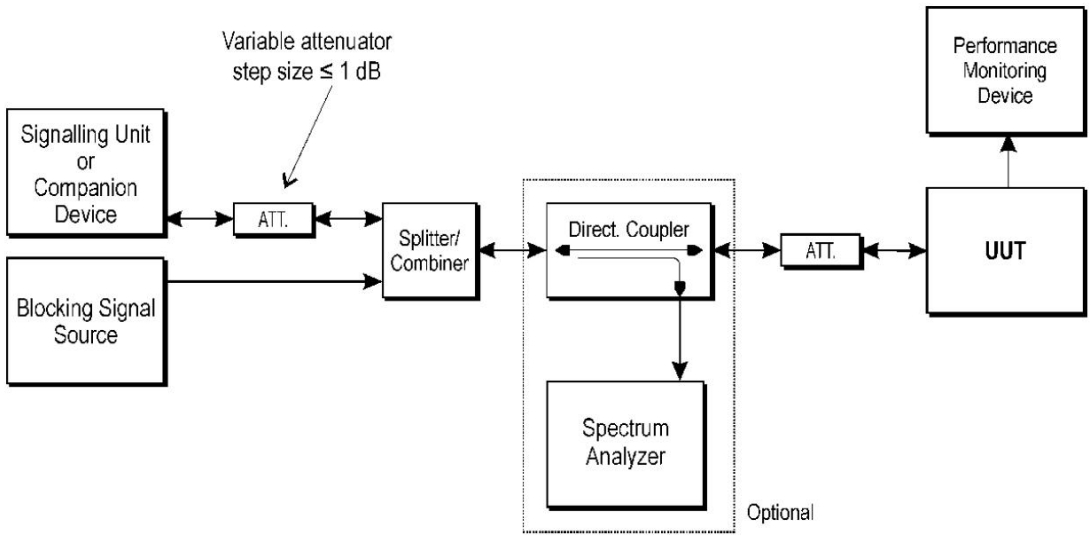
Frequency	Antenna Polar	Receiver Reading	Limit	Margin	Result
(MHz)	(H/V)	(dBm)	(dBm)	(dB)	
GFSK low channel					PASS
318.82	H	-59.82	-57	-2.82	
318.82	V	-60.85	-57	-3.85	
1617.48	H	-65.94	-47	-18.94	
1617.48	V	-57.04	-47	-10.04	
2131.89	H	-54.23	-47	-7.23	
2131.89	V	-57.74	-47	-10.74	
GFSK High channel					
420.41	H	-64.78	-57	-7.78	
420.41	V	-63.73	-57	-6.73	
2124.35	H	-61.93	-47	-14.93	
2124.35	V	-51.75	-47	-4.75	
2112.98	H	-55.86	-47	-8.86	
2112.98	V	-52.15	-47	-5.15	

Remark:

Margin = Receiver Reading - Limit.

12. Receiver Blocking

12.1. Block Diagram Of Test Setup



12.2. Limit

Table 6: Receiver Blocking parameters for Receiver Category 1 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 4)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 4)	Type of blocking signal
(-133 dBm + 10 × $\log_{10}$(OCBW)) or -68 dBm whichever is less (see note 2)	2 380 2 504	-34	CW
(-139 dBm + 10 × $\log_{10}$(OCBW)) or -74 dBm whichever is less (see note 3)	2 300 2 330 2 360 2 524 2 584 2 674		

NOTE 1: OCBW is in Hz.
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 20 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 4: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

Table 7: Receiver Blocking parameters receiver Category 2 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW
NOTE 1: OCBW is in Hz. NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal. NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.			

Table 8: Receiver Blocking parameters receiver Category 3 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW
NOTE 1: OCBW is in Hz. NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative the test may be performed using a wanted signal up to P_{min} + 30 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal. NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.			

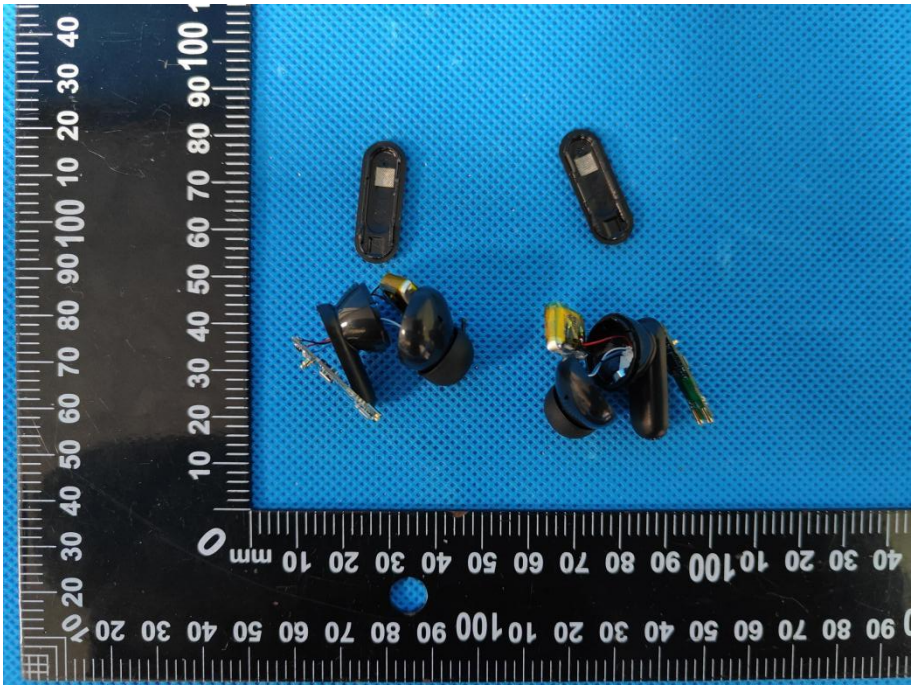
12.3. Test procedure

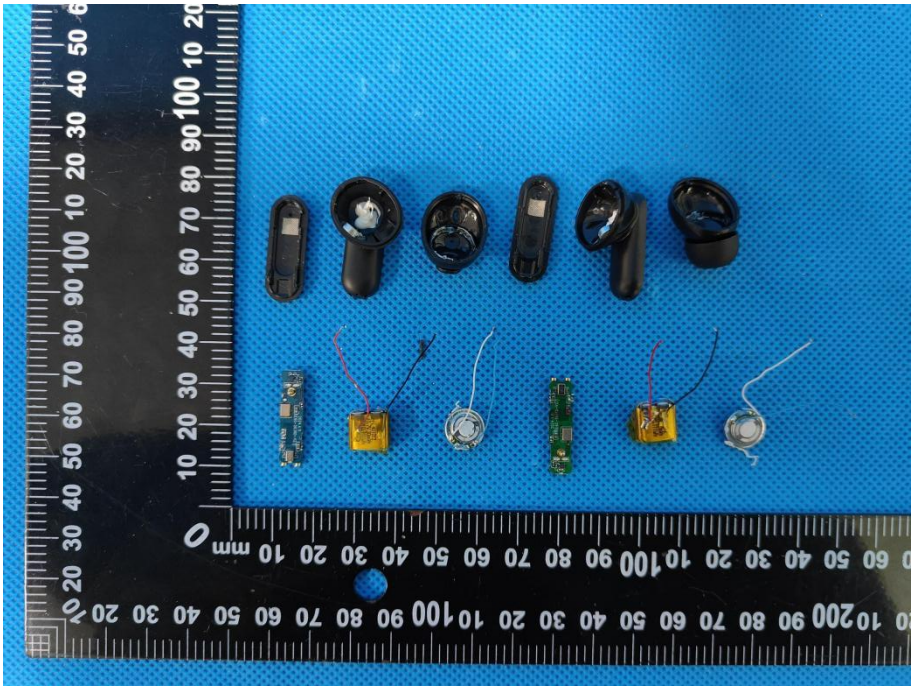
Refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.11.2.

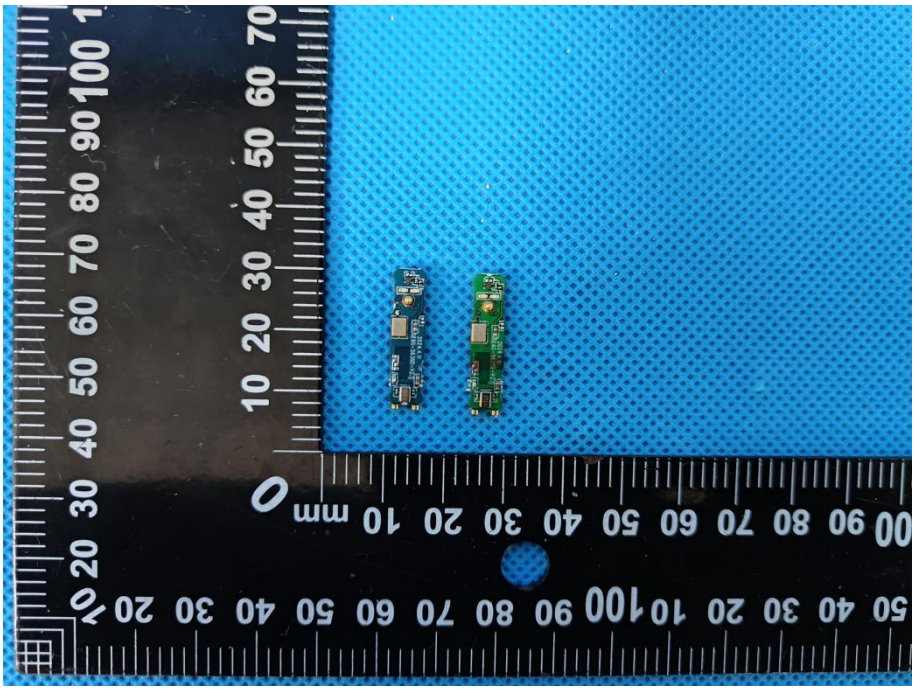
12.4. Test Result

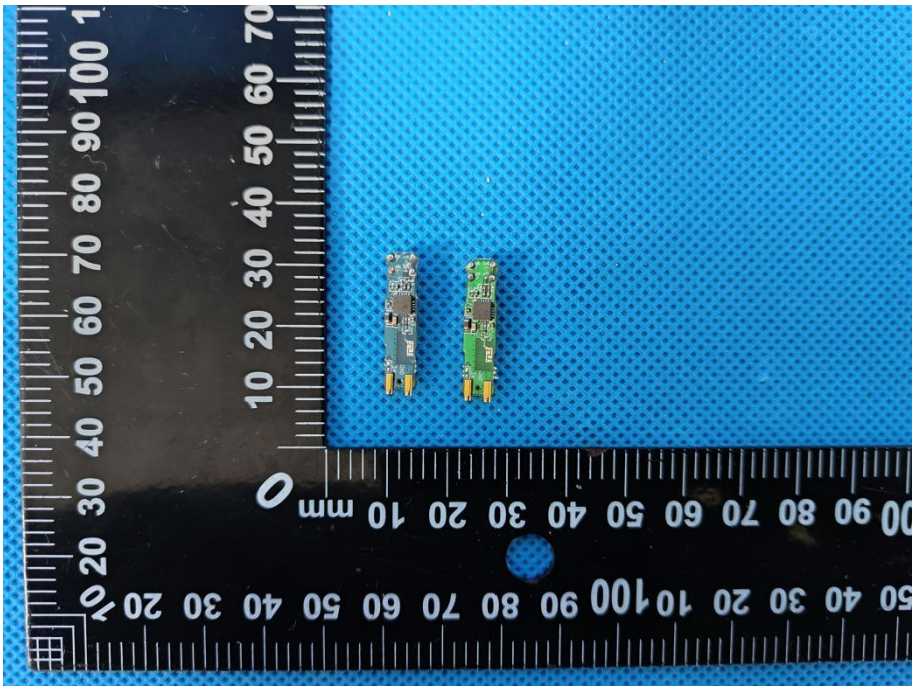
Receiver Category 2					
Mode Hopping	Wanted Power(dBm)	Blocking Frequency(MHz)	Blocking Power(dB)	Type of Blocking Signal	Performance Criteria
GFSK	-65.33	2380	-34	CW	Compliance
GFSK	-65.33	2504	-34	CW	Compliance
GFSK	-65.33	2300	-34	CW	Compliance
GFSK	-65.33	2584	-34	CW	Compliance
π/4DQPSK	-62.45	2380	-34	CW	Compliance
π/4DQPSK	-62.45	2504	-34	CW	Compliance
π/4DQPSK	-62.45	2300	-34	CW	Compliance
π/4DQPSK	-62.45	2584	-34	CW	Compliance
8DPSK	-53.82	2380	-34	CW	Compliance
8DPSK	-53.82	2504	-34	CW	Compliance
8DPSK	-53.82	2300	-34	CW	Compliance
8DPSK	-53.82	2584	-34	CW	Compliance

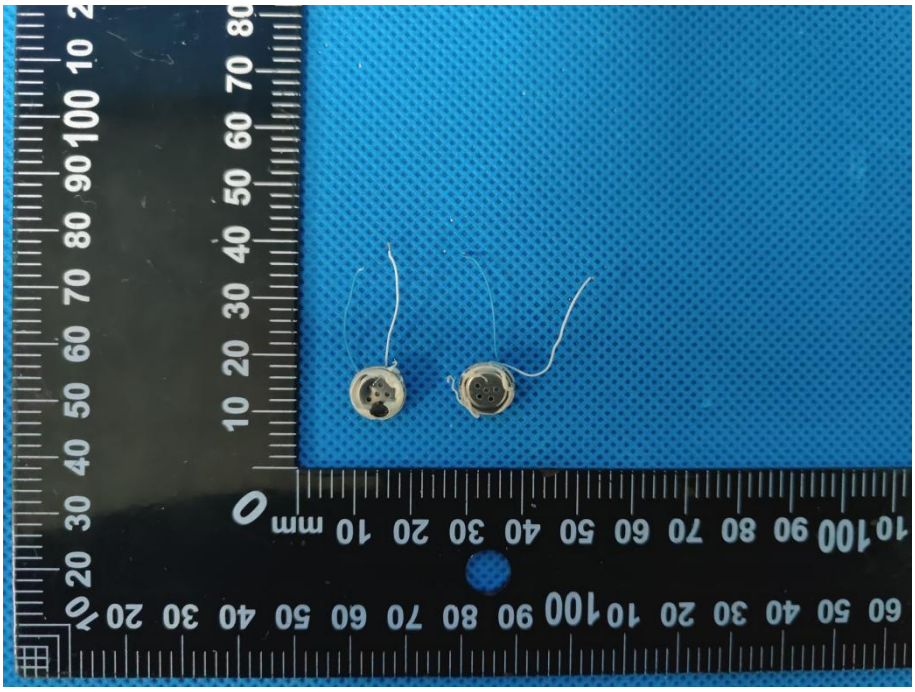
13. EUT Photographs

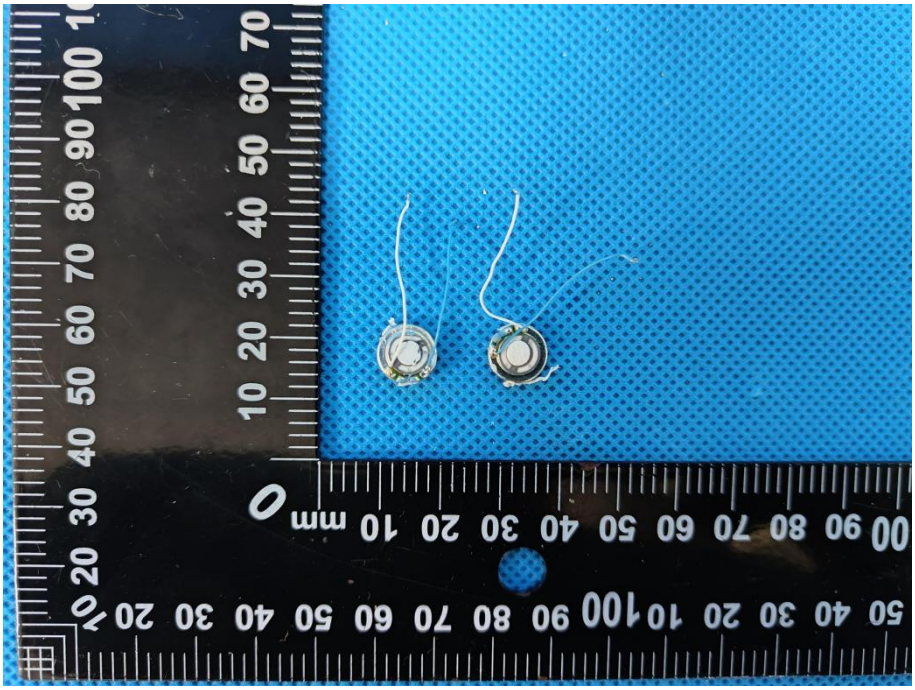


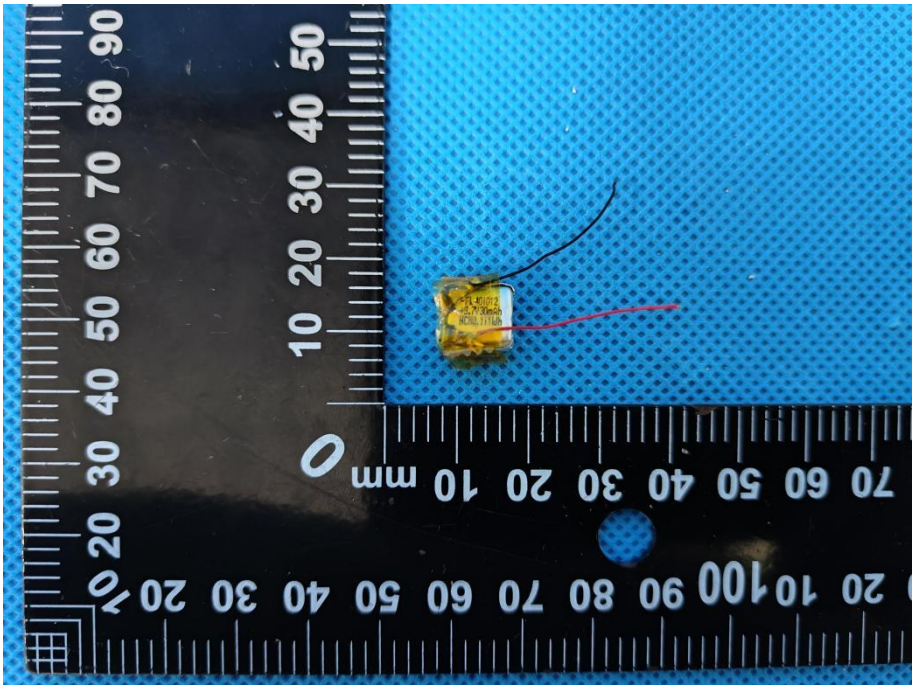


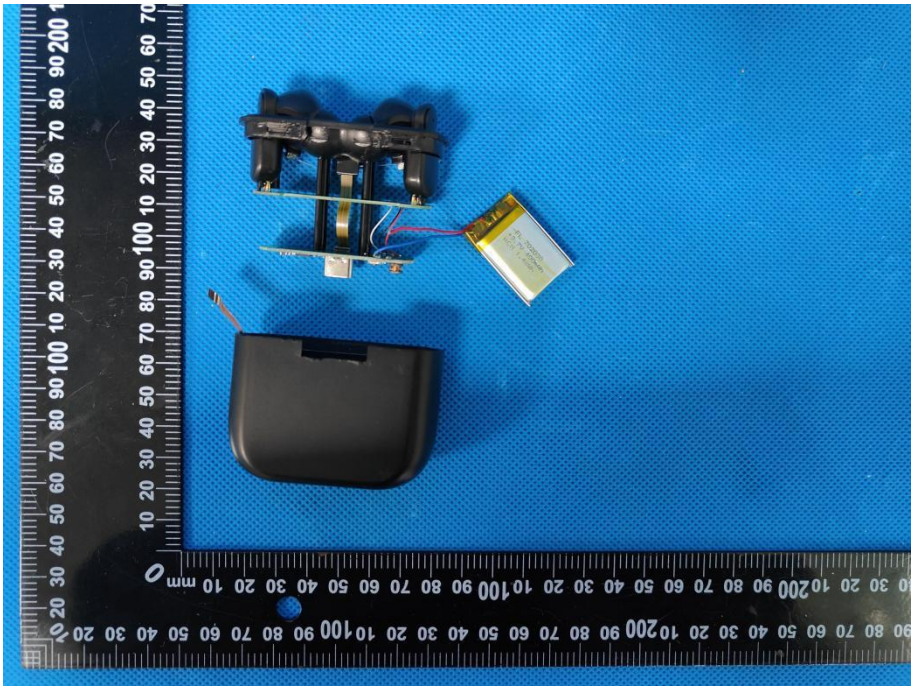


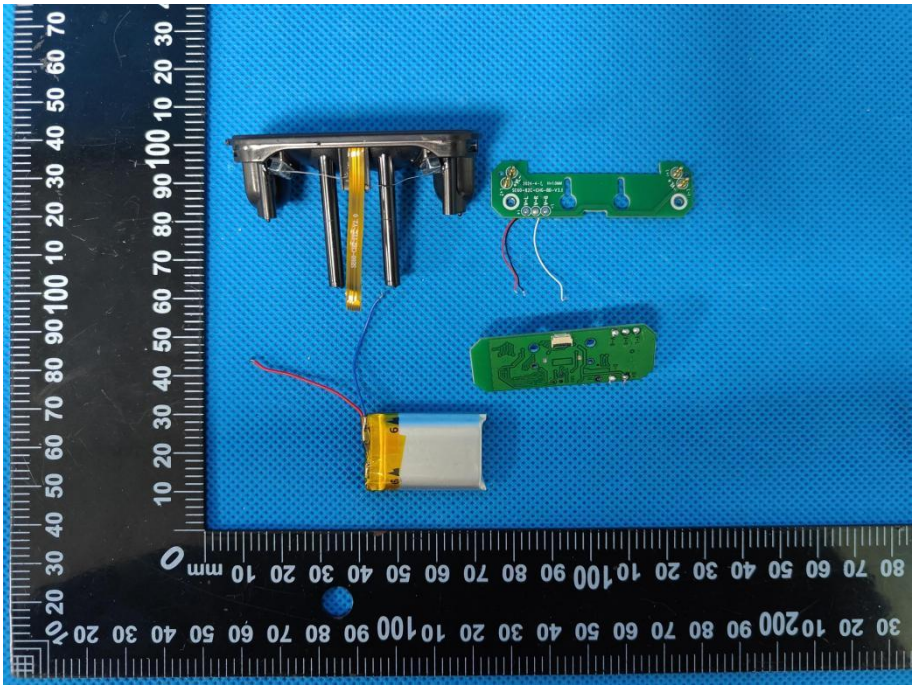


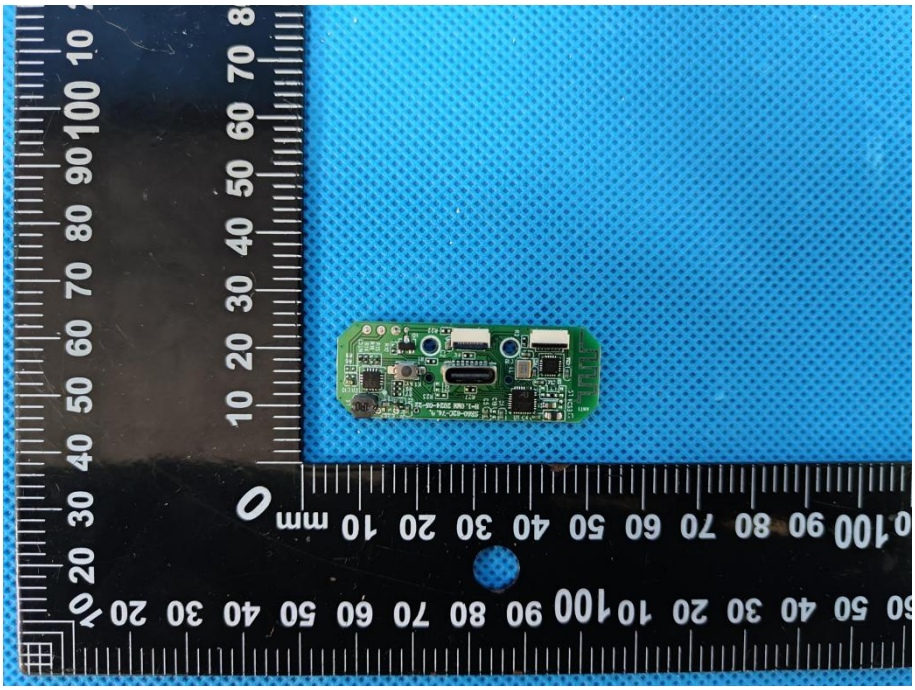


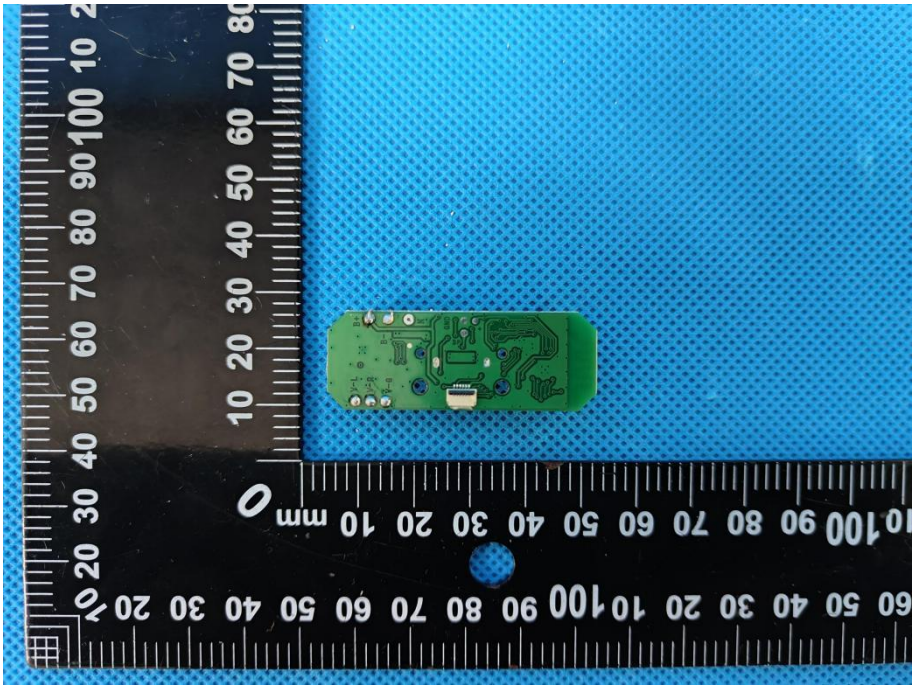


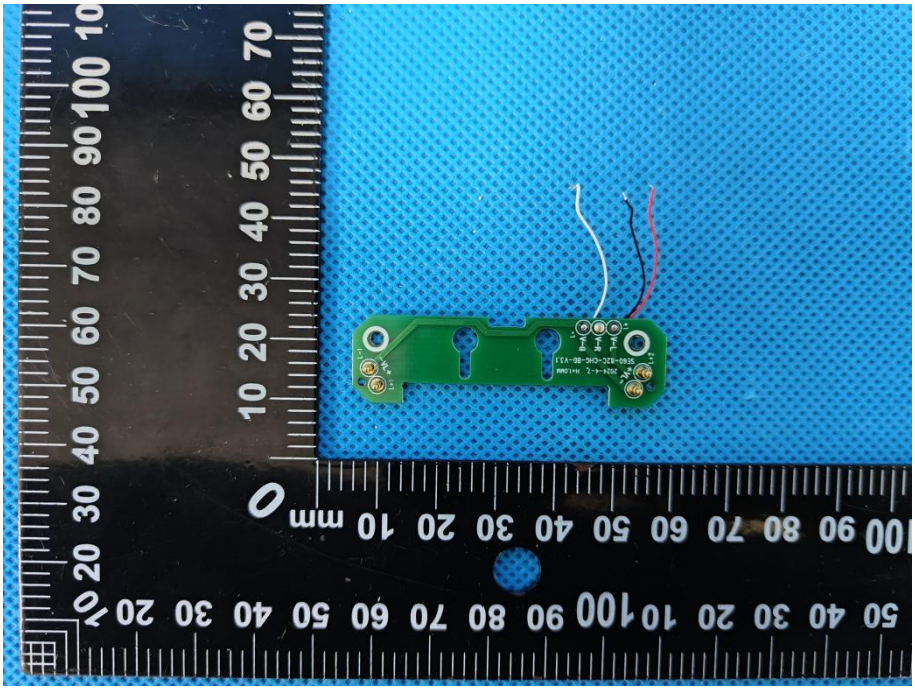


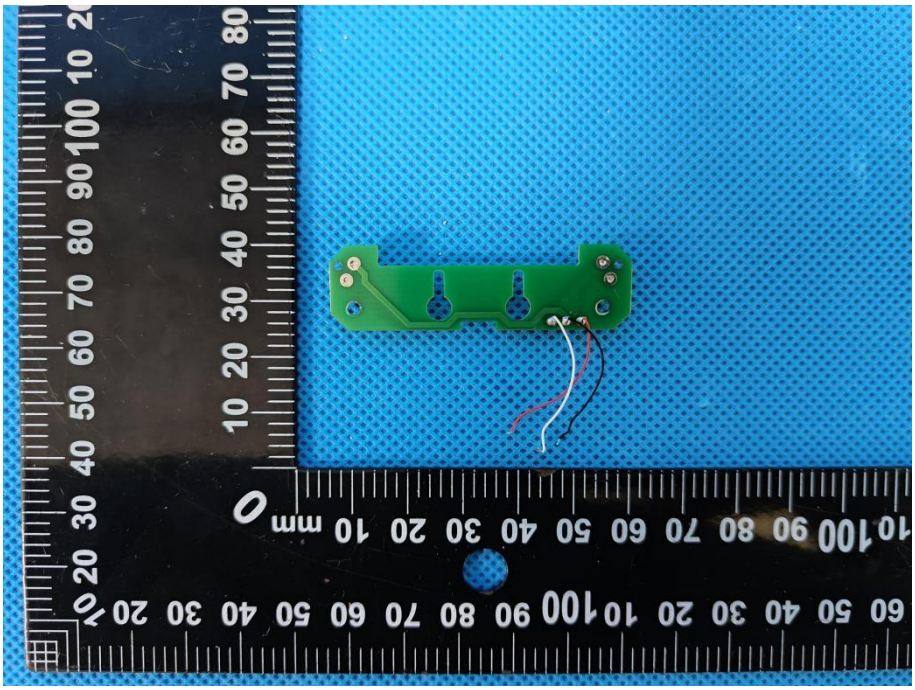


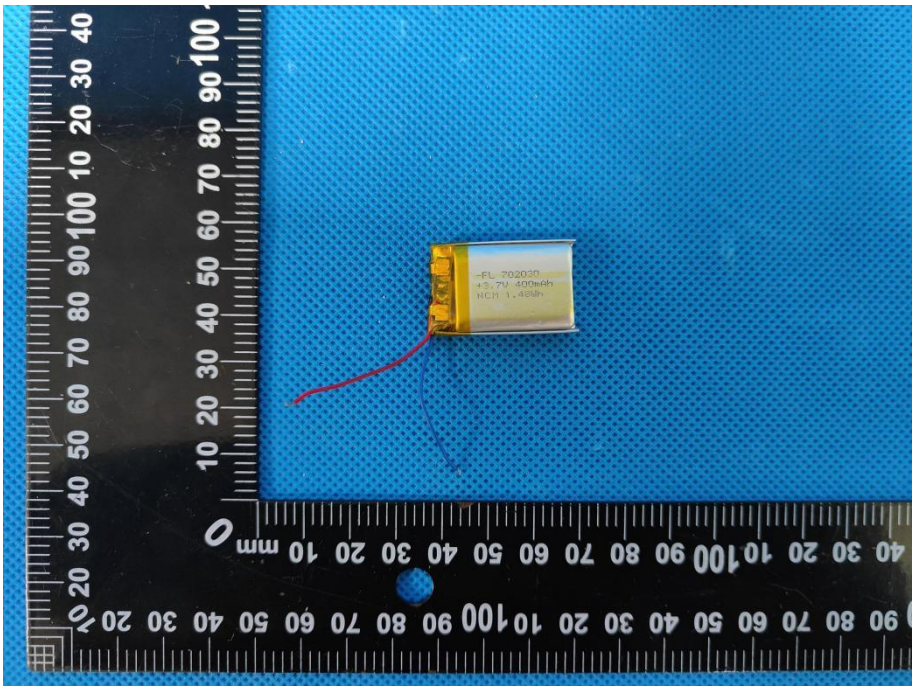












End of report