TEST REPORT

ETSI EN 300 328 V2.0.20 (2016-03)

Product	:	GEOMETRIC WIRELESS SPEAKER
Model Name	:	P326.24X
Brand	:	N/A
Report No.	:	PTCHX04161100303E-EM01

Prepared for

Prepared by

DongGuan Precise Testing Service Co.,Ltd.

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TEST RESULT CERTIFICATION

Applicant's name	:	
Address	:	
Manufacture's name	:	
Address	:	
Product name	:	GEOMETRIC WIRELESS SPEAKER
Model name	:	P326.24X
Brand Name		N/A

This device described above has been tested by PTC, and the test results show that the equipment under test (EUT) is in compliance with the RED 2014/53/EU Directive Art.3.2 requirements. And it is applicable only to the tested sample identified in the report.

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Date of Test

Date (s) of performance of tests :	Nov.02, 2016 ~ Nov.03, 2016
Date of Issue:	Nov.04, 2016
Test Result:	**Pass**

Tested By:

August Qiu

August Qiu / Engineer

Approved & Authorized Signer

PRECISE TESTING & CERTIFICATION ... APPROVED ... DONGGUAN ... CO.,LTD

Chris Du /Manager

Contents

1 Test Summary

ETSI EN 300 328				
Clause	Test Item	Limit	Frequency Range(Mhz)	Applicable (Yes/No)
TRANSMITTER PARAMETERS				
4.3.1.2	RF output power	20 dBm		Y
4.3.1.3	Duty Cycle, Tx-sequence, Tx-gap	5 ms		N(<10dBm)
4.3.1.4	Accumulated Transmit time, Frequency Occupation & Hopping Sequence	400 ms		Y
4.3.1.5	Hopping Frequency Separation	>100K		Y
4.3.1.6	Medium Utilisation (MU) factor	--	2400-2483.5	N(<10dBm)
4.3.1.7	Adaptivity (Adaptive Frequency Hopping)	--		N(<10dBm)
4.3.1.8	Occupied Channel Bandwidth	(clause 4.3.1.8.2)		Y
4.3.1.9	Transmitter unwanted emissions in the OOB domain	Clause 4.3.1.9.2		Y
4.3.1.10	Transmitter unwanted emissions in the spurious domain	Clause 4.3.1.10.2		Y
4.3.1.11	Receiver Spurious emissions (conducted)	-57dBm	30-1000	N
		-47dBm	1000-12750	
	Receiver Spurious emissions (radiated)	-57dBm	30-1000	Y
		-47dBm	1000-12750	Y
4.3.1.12	Receiver Blocking	--	2400-2483.5	N(<10dBm)
4.3.1.13	Geo-location capability	--	--	N

Remark:

N/A: Not Applicable

2 General Information

2.1 General Description of E.U.T.

Product Name	:	GEOMETRIC WIRELESS SPEAKER
Brand Name	:	N/A
Model Name	:	P326.24X
Model Description	:	N/A
Bluetooth Version	:	V3.0
Operating frequency	:	2402-2480MHz, 79 channels
Antenna installation:	:	Integrated Antenna
Antenna Gain:	:	0 dBi
Type of Modulation	:	BT(1Mbps): GFSK BT EDR(2Mbps): π/4-DQPSK BT EDR(3Mbps): 8-DPSK
Power supply	:	DC 5V by adapter/DC 3.7V from battery

a) The type of modulation used by the equipment:

■FHSS

□other forms of modulation

b) In case of FHSS modulation:

•In case of non-Adaptive Frequency Hopping equipment:

The number of Hopping Frequencies:

•In case of Adaptive Frequency Hopping Equipment:

The maximum number of Hopping Frequencies: 79

The minimum number of Hopping Frequencies: 79

The Dwell Time:

The Minimum Channel Occupation Time:

c) Adaptive / non-adaptive equipment:

□non-adaptive Equipment

■adaptive Equipment without the possibility to switch to a non-adaptive mode

□adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The Channel Occupancy Time implemented by the equipment:

□The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:

□The equipment is Frame Based equipment

□The equipment is Load Based equipment

■The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: .... µs

The value q as referred to in clause 4.3.2.5.2.2.2 ....

□The equipment has implemented an non-LBT based DAA mechanism

□The equipment can operate in more than one adaptive mode

e) In case of non-adaptive Equipment:

The maximum RF Output Power (e.i.r.p.): -6.55dBm

The maximum (corresponding) Duty Cycle: 45%

Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

f) The worst case operational mode for each of the following tests:

- RF Output Power

  GFSK

- Dwell time, Minimum Frequency Occupation & Hopping Sequence

  GFSK

- Hopping Frequency Separation

  GFSK

- Occupied Channel Bandwidth

GFSK

- Transmitter unwanted emissions in the OOB domain

  GFSK

- Transmitter unwanted emissions in the spurious domain

  GFSK

- Receiver spurious emissions

  GFSK

g) The different transmit operating modes (tick all that apply):

■Operating mode 1: Single Antenna Equipment

■Equipment with only 1 antenna

□Equipment with 2 diversity antennas but only 1 antenna active at any moment in time

□Smart Antenna Systems with 2 or more antennas, but operating in a (legacy) mode where only 1 antenna is used. (BT mode in smart antenna systems)

□Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming

□Single spatial stream / Standard throughput / (BT mode)

□High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1

□High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 2

NOTE: Add more lines if more channel bandwidths are supported.

□Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

□Single spatial stream / Standard throughput (BT mode)

□High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1

□High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 2

NOTE: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

- The number of Receive chains: ....
- The number of Transmit chains: ....

□symmetrical power distribution

□asymmetrical power distribution

In case of beam forming, the maximum beam forming gain: ....

NOTE: Beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

• Operating Frequency Range 1: 2402 MHz to 2480 MHz

• Operating Frequency Range 2:

NOTE: Add more lines if more Frequency Ranges are supported.

j) Occupied Channel Bandwidth(s):

Occupied Channel Bandwidth : 0.762MHz

Occupied Channel Bandwidth : 1.152MHz

NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

■Stand-alone

□Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

□Plug-in radio device (Equipment intended for a variety of host systems)

Other ....

l) The extreme operating conditions that apply to the equipment:

Operating temperature range: -20° C to 55° C

Operating voltage range: 3.7V ■DC

□Details provided are for the:
■stand-alone equipment

□combined (or host) equipment

□test jig

m) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:

• Antenna Type

■Integral Antenna

Antenna Gain: 0 dBi

If applicable, additional beamforming gain (excluding basic antenna gain): .... dB

□Temporary RF connector provided

□No temporary RF connector provided

□Dedicated Antennas (equipment with antenna connector)

□Single power level with corresponding antenna(s)

□Multiple power settings and corresponding antenna(s)

Number of different Power Levels: ....

Power Level 1: .... dBm

Power Level 2: .... dBm

Power Level 3: .... dBm

NOTE 1: Add more lines in case the equipment has more power levels.

NOTE 2: These power levels are conducted power levels (at antenna connector).

• For each of the Power Levels, provide the intended antenna assemblies, their, corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable

Power Level 1: .... dBm
Number of antenna assemblies provided for this power level: ....

Assembly #	Gain (dBi)	e.i.r.p.(dBm)	Part number or model name
1	0	-6.55	
2			
3			

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

Power Level 2: .... dBm

Number of antenna assemblies provided for this power level: ....

Assembly #	Gain (dBi)	e.i.r.p.(dBm)	Part number or model name
1			
2			
3			

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

Power Level 3: .... dBm

Number of antenna assemblies provided for this power level: ....

Assembly #	Gain (dBi)	e.i.r.p.(dBm)	Part number or model name
1			
2			
3			

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

n) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:

Details provided are for the: ■stand-alone equipment

□combined (or host) equipment

□test jig Supply Voltage

□AC mains State AC voltage 100-240 V

■DC State DC voltage :3.7V

In case of DC, indicate the type of power source

□Internal Power Supply
□External Power Supply or AC/DC adapter

□Battery:

□Other: ....

o) Describe the test modes available which can facilitate testing:

N/A

p) The equipment type (e.g. Bluetooth®, IEEE 802.11™ [i.3], proprietary, etc.):

BT

2.1.3 Channel List

BT 3.0							
Channel No.	**Frequency (MHz)**	**Channel No.**	**Frequency (MHz)**	**Channel No.**	**Frequency (MHz)**	**Channel No.**	**Frequency (MHz)**
0	2402	20	2422	40	2442	60	2462
1	2403	21	2423	41	2443	61	2463
2	2404	22	2424	42	2444	62	2464
3	2405	23	2425	43	2445	63	2465
4	2406	24	2426	44	2446	64	2466
5	2407	25	2427	45	2447	65	2467
6	2408	26	2428	46	2448	66	2468
7	2409	27	2429	47	2449	67	2469
8	2410	28	2430	48	2450	68	2470
9	2411	29	2431	49	2451	69	2471
10	2412	30	2432	50	2452	70	2472
11	2413	31	2433	51	2453	71	2473
12	2414	32	2434	52	2454	72	2474
13	2415	33	2435	53	2455	73	2475
14	2416	34	2436	54	2456	74	2476
15	2417	35	2437	55	2457	75	2477
16	2418	36	2438	56	2458	76	2478
17	2419	37	2439	57	2459	77	2479
18	2420	38	2440	58	2460	78	2480
19	2421	39	2441	59	2461	-	-

3 Equipment During Test

3.1 Equipments List

RF Conducted Test							
Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until	Calibration period
1	EMC Analyzer (9k~26.5GHz)	Agilent	E4407B	MY45109572	July 15, 2016	July 14, 2017	1 year
2	Signal Analyzer	Agilent	N9020A	MY49100060	July 15, 2016	July 14, 2017	1 year
3	USB Wideband Power Sensor	Keysight	U2021XA	SG5440003	July 15, 2016	July 14, 2017	1 year
Spurious Emissions							
Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until	Calibration period
1	EMI Test Receiver	Rohde&Schwarz	ESCI	101417	July 15, 2016	July 14, 2017	1 year
2	Trilog Broadband Antenna	SCHWARZBECK	VULB9160	9160-3355	July 15, 2016	July 14, 2017	1 year
3	Amplifier	EM	EM-30180	060538	July 15, 2016	July 14, 2017	1 year
4	Horn Antenna	SCHWARZBECK	BBHA9120D	9120D-1246	July 15, 2016	July 14, 2017	1 year
5	Bilog Antenna	TESEQ	CBL6111D	34678	July 15, 2016	July 14, 2017	1 year

3.2 Measurement Uncertainty

Parameter	**Uncertainty**
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±1.5dB
Power Spectral Density, conducted	±3dB
Unwanted Emissions, conducted	±3dB
All emissions, radiated	±6dB
Time	±2%
Duty Cycle	±2%
Temperature	±1°C
Humidity	±5%
DC and low frequency voltages	±3%
Conduction disturbance(150kHz~30MHz)	±3.26dB
Radiated Emission(30MHz~1GHz)	±4.76dB
Radiated Emission(1GHz~25GHz)	±5.39dB

4 RF Requirements

1. Normal Test Conditions:

Ambient Condition: , 21°C

2. Extreme Test Conditions:

Extreme Temperature: -20°C to +55°C;

For tests at extreme temperatures, measurements shall be made over the extremes of the operating temperature range as declared by the manufacturer.
Extreme Power Source Voltages:3.7VDC

For tests at extreme voltages, measurements shall be made over the extremes of the power source voltage range as declared by the manufacturer.

Test Conditions	Normal	LTLV	LTHV	HTHV	HTLV
Temperature (℃)	20	-20	-20	55	55
Voltage (V)	3.7	3.4	4.2	4.2	3.4

3. Test Mode

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

Modulation	Test mode	Low channel	Middle channel	High channel
GFSK	Transmitting	2402MHz	2441MHz	2480MHz
GFSK	Receiving	2402MHz	2441MHz	2480MHz
Pi/4DQPSK	Transmitting	2402MHz	2441MHz	2480MHz
Pi/4DQPSK	Receiving	2402MHz	2441MHz	2480MHz
8DPSK	Transmitting	2402MHz	2441MHz	2480MHz
8DPSK	Receiving	2402MHz	2441MHz	2480MHz

4.1 RF Output power

4.1.1 Definition

The RF output power is defined as the mean equivalent isotropically radiated power (e.i.r.p.) of the equipment during a transmission burst.

4.1.2 Limit

FHSS:

The maximum RF output power for adaptive Frequency Hopping equipment shall be equal to or less than 20 dBm. The maximum RF output power for non-adaptive Frequency Hopping equipment shall be declared by the supplier. See clause 5.3.1 m). The maximum RF output power for this equipment shall be equal to or less than the value declared by the supplier. This declared value shall be equal to or less than 20 dBm. This limit shall apply for any combination of power level and intended antenna assembly.

Other than FHSS:

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.

4.1.3 EUT Operation Condition

The EUT was programmed to be in continuously transmitting mode.

4.1.4 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 transmits 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:

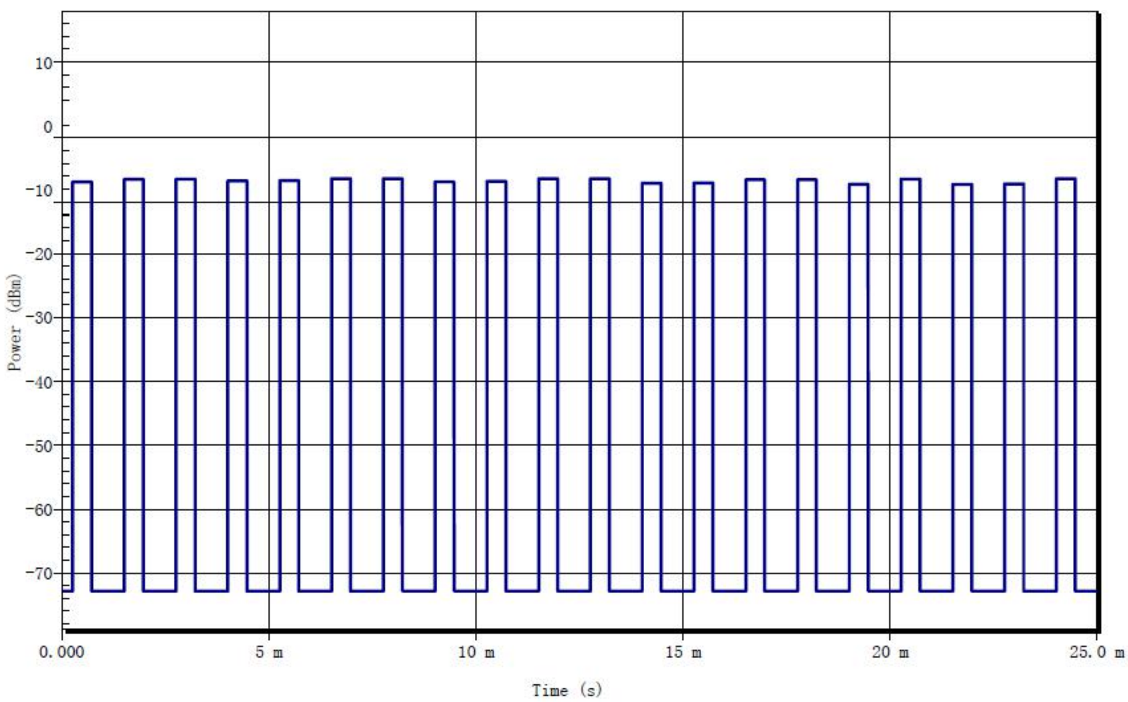
P = A + G + Y

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.

4.1.5 Measurement Record

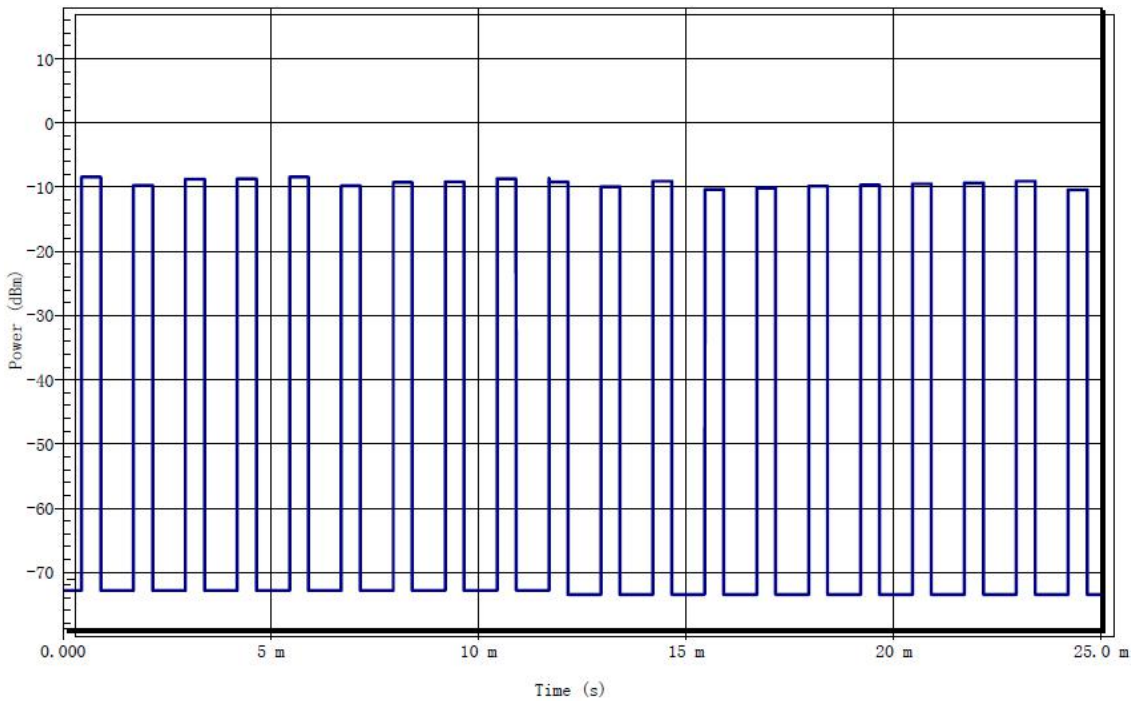
Modulation		GFSK				
Test conditions		Normal	Extreme			
			LTLV	LTHV	HTLV	HTHV
EIRP (dBm)	Hopping	-6.60	-6.63	-6.55	-6.64	-6.62
	Max. output power	-6.55				
Limits		20dBm (-10dBW)				
Burst plot		> 10				
T/on		0.25ms				
T/Off		1ms				
Result		**Complies**				

GFSK HOPPING



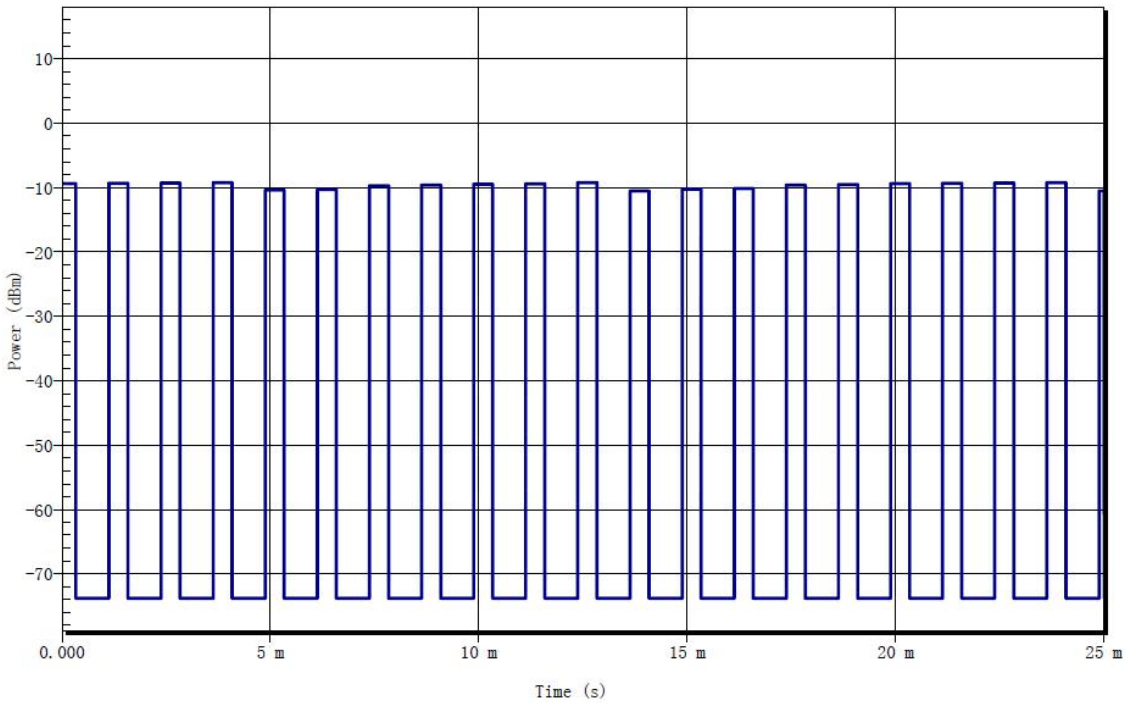
Modulation		π/4-DQPSK				
Test conditions		Normal	Extreme			
			LTLV	LTHV	HTLV	HTHV
EIRP (dBm)	Hopping	-7.90	-7.93	-7.84	-7.93	-7.89
	Max. output power	-7.84				
Limit		≤100mW (20dBm)				
Burst plot		> 10				
T/on		0.25ms				
T/Off		1ms				
Result		**Complies**				

Π/4QPSK HOPPING



Modulation		8-DPSK				
Test conditions		Normal	Extreme			
			LTLV	LTHV	HTLV	HTHV
EIRP (dBm)	Hopping	-8.10	-8.13	-8.03	-8.13	-8.11
	Max. output power	-8.03				
Limit		≤100mW (20dBm)				
Burst plot		> 10				
T/on		0.25ms				
T/Off		1ms				
Result		**Complies**				

8DPSK HOPPING



4.2 Accumulated Transmit Time, Frequency Occupation and Hopping Sequence

4.2.1 Definition

The Accumulated Transmit Time is the time that a particular hopping frequency would be occupied by the transmitterduring a singlehop. The equipment itself is not required to transmit on this hopping frequency during theAccumulated Transmit Time.

The Frequency Occupation Time is the minimum time each hopping frequency shall beoccupied within agiven period.

The Hopping Sequence of a Frequency Hopping system is the unrepeated pattern of the hoppingfrequencies used bythe equipment.

4.2.2 Limit

Adaptive Frequency Hopping systems shall be capable of operating over a minimum of 70 % of theband specified inclause 1.

The maximum accumulated dwell time on any hopping frequency shall be 400 ms within any period of400 msmultiplied by the minimum number of hopping frequencies (N) that have to be used.

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.

The Minimum Frequency Occupation Time shall be equal to one dwell time within a period not exceeding four times the product of the dwell time per hop and the number of hopping frequencies inuse.

4.2.3 EUT Operation Condition

The equipment shall be configured to operate at its maximum Dwell Time and maximum Duty Cycle.

4.2.4 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 hoppingsequence.

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 inclause 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 obtainedin 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.

4.2.5 Measurement Record

GFSK

Dwell Time: N/A for Modulation Technology other than FHSS

Data Packet	Frequency	Pulse Duration	Dwell Time	Limits
		(ms)	(s)	(ms)
DH1	2441	0.390	0.118	400
DH3	2441	1.650	0.262	400
DH5	2441	2.900	0.307	400

Minimum Frequency Occupation Time Result:
N/A for Modulation Technology other than FHSS

Mode	Channel	Minimum Frequency occupation Time(ms)
DH1	2441	346.35
DH3	2441	1197.75
DH5	2441	2389.43

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

Hopping sequence: N/A for Modulation Technology other than FHSS

20dB BW(MHz)	Limit	CH Limit
79.60		
Hopping Sequence(%)	>70%	>15
95.32%		

Remark:

1. For adaptive systems, using the lowest and highest -20 dB points from the total spectrum envelope, it shall be verified whether the system uses 70 % of the band specified.

2. Hopping Sequence(%) = (20dB BW/83.5)*100

8DPSK

Dwell Time: N/A for Modulation Technology other than FHSS

Data Packet	Frequency	Pulse Duration	Dwell Time	Limits
		(ms)	(s)	(ms)
3DH1	2441	0.380	0.122	400
3DH3	2441	1.630	0.262	400
3DH5	2441	2.890	0.307	400

Minimum Frequency Occupation Time Result:

N/A for Modulation Technology other than FHSS

Mode	Channel	Minimum Frequency occupation Time(ms)
3DH1	2441	346.35
3DH3	2441	1197.75
3DH5	2441	2389.43

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

Hopping sequence: N/A for Modulation Technology other than FHSS

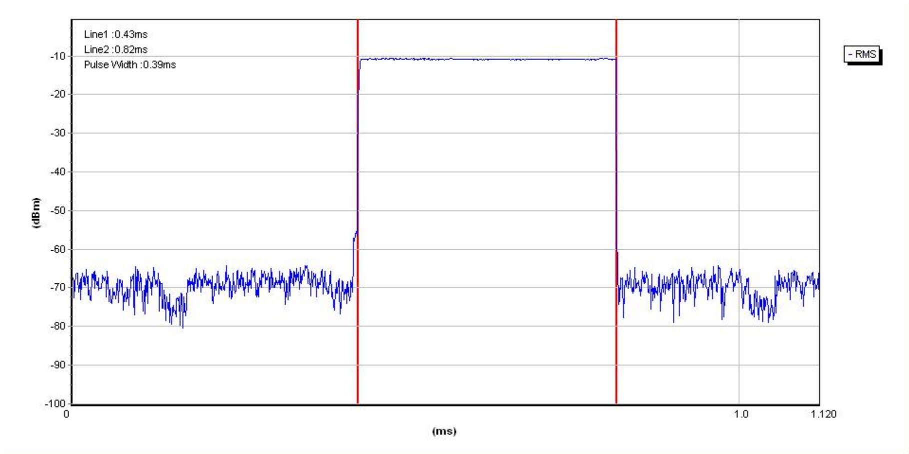
20dB BW(MHz)	Limit	CH Limit
79.61		
Hopping Sequence(%)	>70%	>15
95.31%		

Remark:

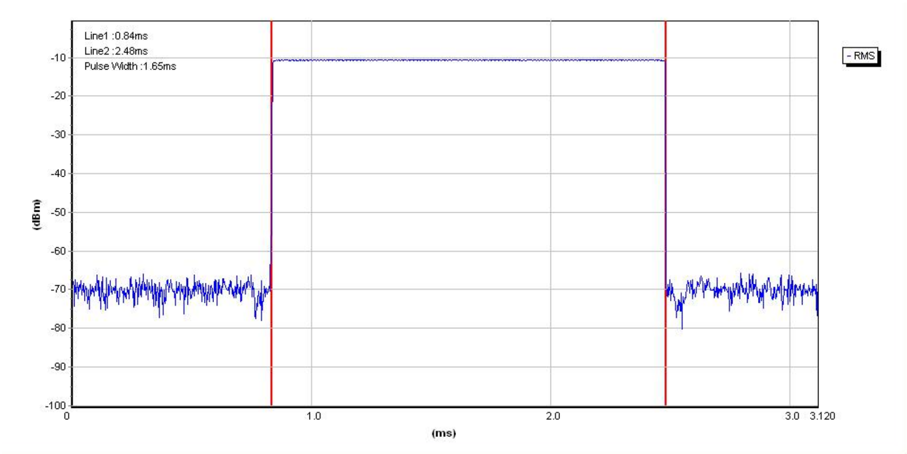
1. For adaptive systems, using the lowest and highest -20 dB points from the total spectrum envelope, it shall be verified whether the system uses 70 % of the band specified.
2. Hopping Sequence(%) = (20dB BW/83.5)*100

GFSK

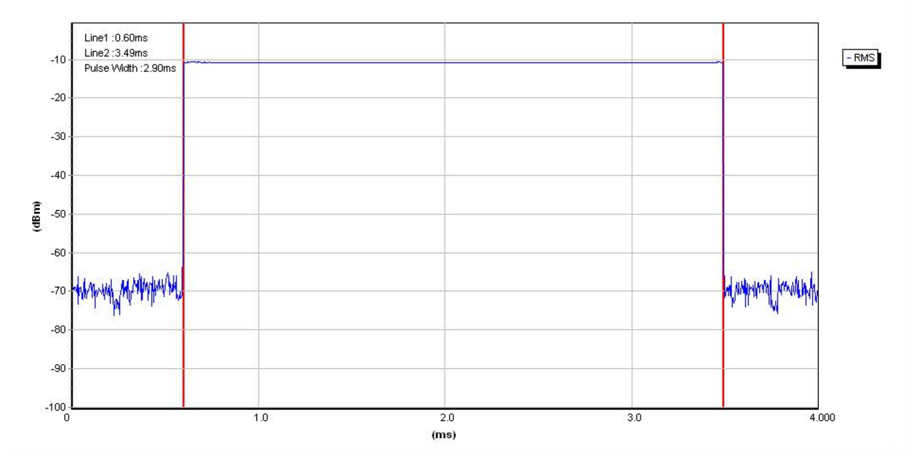
DH1



DH3

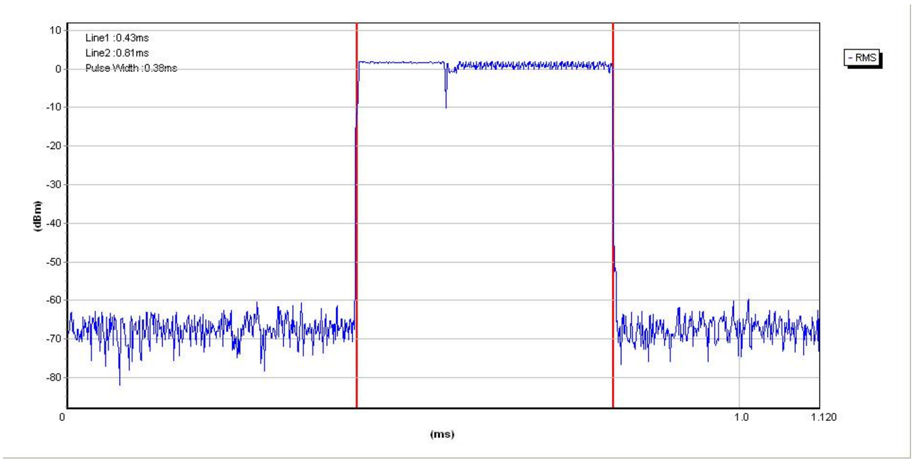


DH5

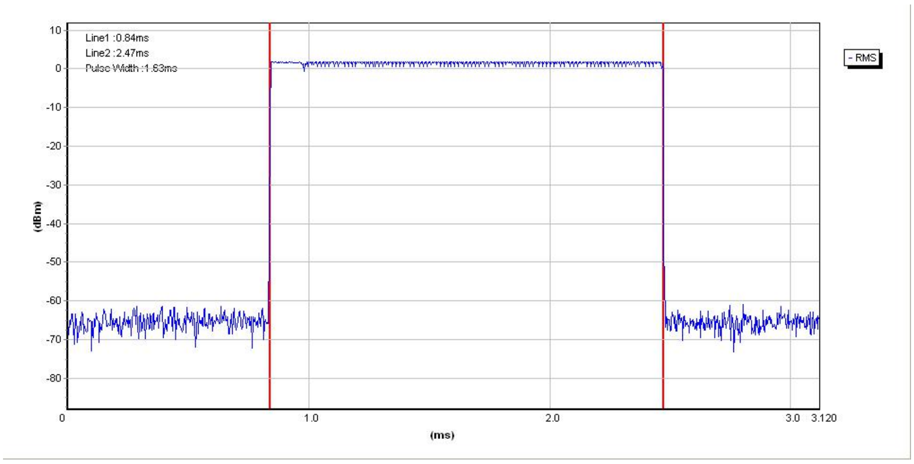


8DPSK

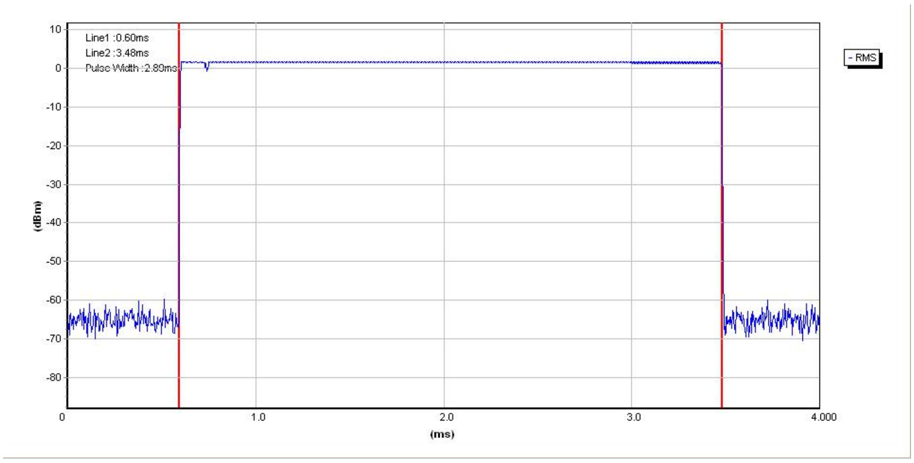
3DH1



3DH3



3DH5



4.3 Hopping Frequency Separation

4.3.1 Definition:

The Hopping Frequency Separation is the frequency separation between 2 adjacent hopping frequencies.

4.3.2 Limit

For adaptive Frequency Hopping equipment, the minimum Hopping Frequency Separation shall be 100 kHz

4.3.3 EUT Operation Condition

The EUT was programmed to be in hopping on mode.

4.3.4 Test Procedure

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 F1L and F1H for hopping frequency F1 and in F2L and F2H for hopping frequency F2. These values shall be recorded in the report.

Step 3:

Calculate the centre frequencies F1C and F2C for both hopping frequencies using the formulas below. Thesevalues 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 (BWCHAN) using the formula below. This value shall be recorded inthe report.

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

Calculate the Hopping Frequency Separation (F_{HS}) using the formula below. This value shall be recorded inthe 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 orgreater than the -20 dBr channel bandwidth or:

$$F_{HS} \geq BW_{CHAN}$$

See figure 4:

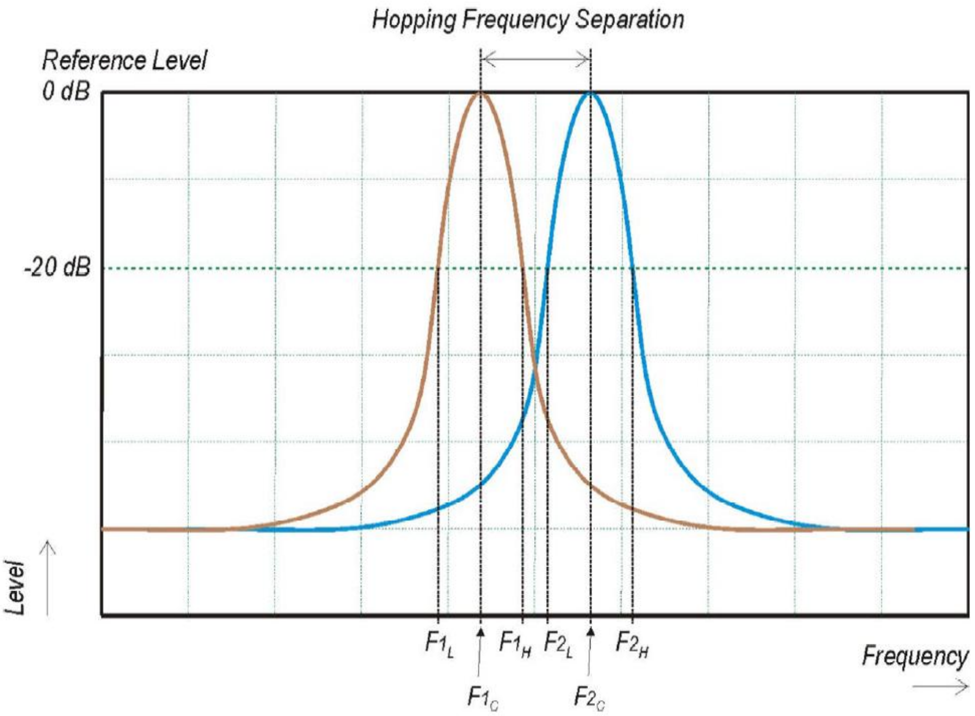


Figure 4: Hopping Frequency Separation

For adaptive equipment, in case of overlapping channels which will prevent the definition ofthe -20 dBr reference points F1H and F2L, a higher reference level (e.g. -10 dBr or - 6 dBr) may be chosen to define the reference points F1L; F1H; F2L and F2H.

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 bemeasured separately for the two adjacent Hopping Frequencies; and/or

Force the UUT to operate without modulation by which the centre frequencies $F1_C$ and $F2_C$ can be measureddirectly.

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

Option 2

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

NOTE: Depending on the nature of the signal (modulation), it might be required to use a much longer sweeptime, e.g. in case switching transients are present in the signals to be investigated.

Step 2:

Wait for the trace to stabilize.

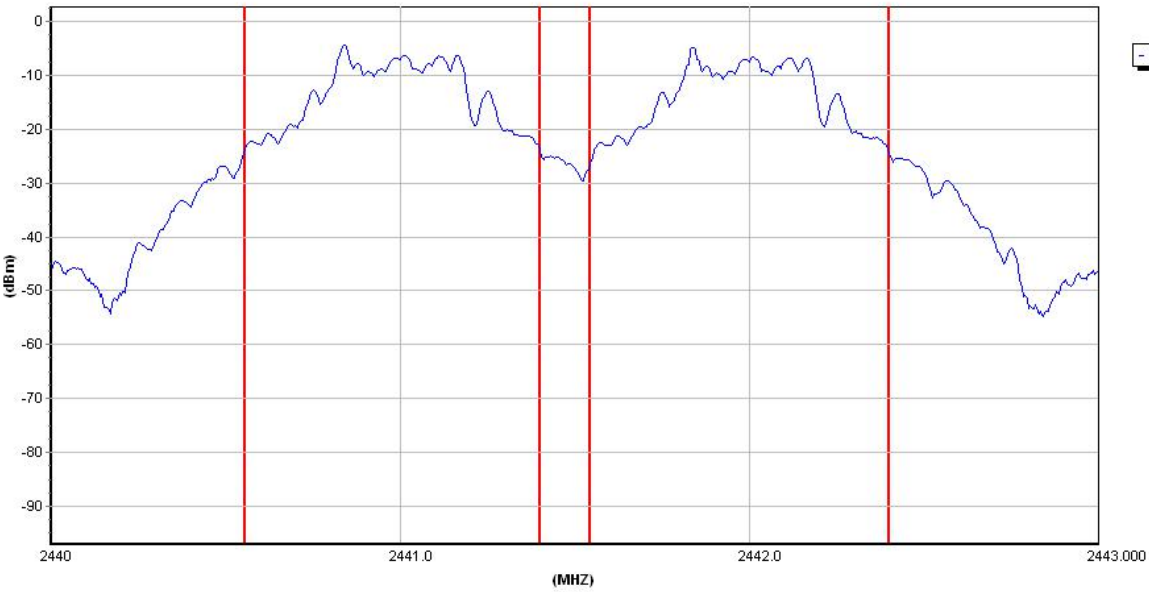
Use the marker-delta function to determine the Hopping Frequency Separation between the centres of the twoadjacent hopping frequencies (e.g. by indentifying peaks or notches at the centre of the power envelope for thetwo adjacent signals). This value shall be compared with the limits defined in clause 4.3.1.5.3 and shall be recorded in the test report.

4.3.5 Measurement Record

Please refer to the below photos for more details

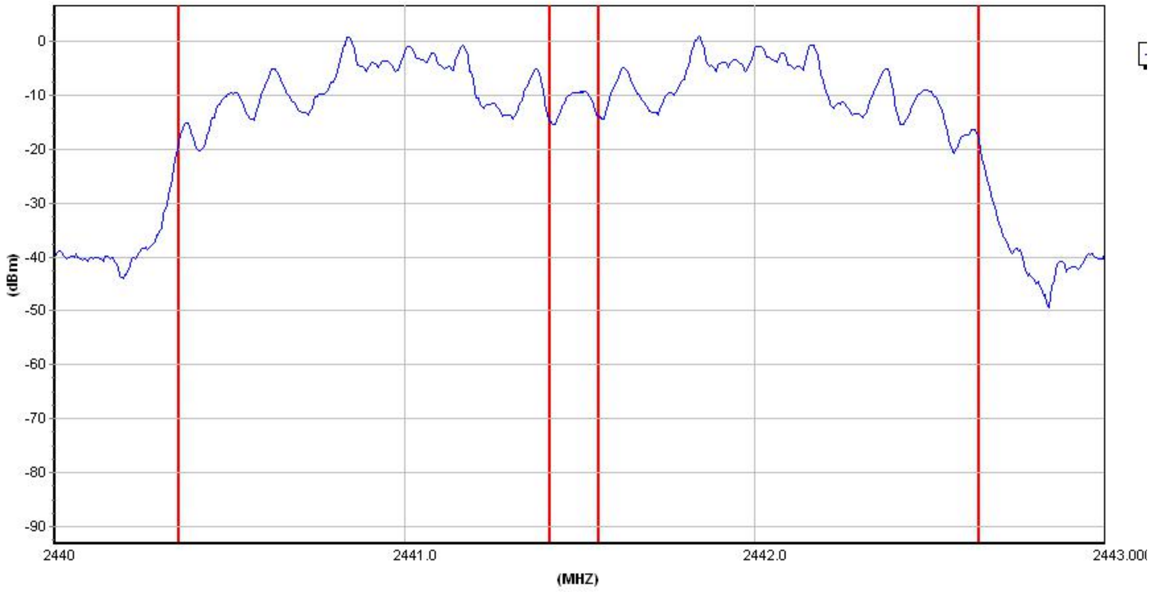
Frequency	Ch. Separation (MHz)	Limit (kHz)	Result
2402.000MHz	1.02	>100	**Complies**
2441.000MHz	1.02	>100	**Complies**
2480.000 MHz	1.02	>100	**Complies**

1Mbps-CH39



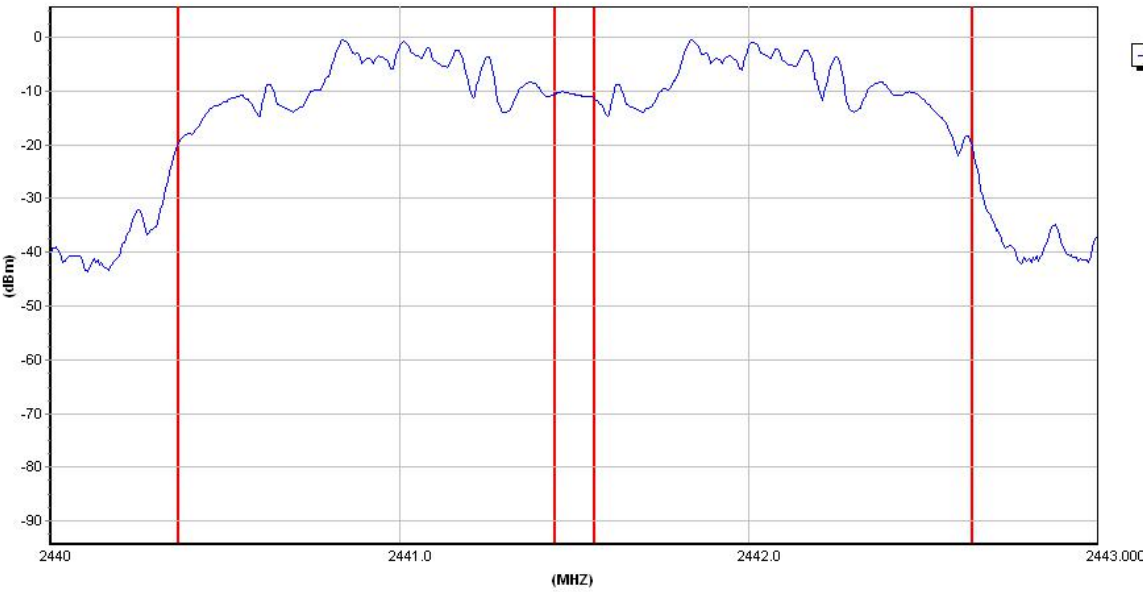
Frequency	Ch. Separation (MHz)	Limit (kHz)	Result
2402.000MHz	1.02	>100	**Complies**
2441.000MHz	1.02	>100	**Complies**
2480.000 MHz	1.02	>100	**Complies**

2Mbps-CH39



Frequency	Ch. Separation (MHz)	Limit (kHz)	Result
2402.000MHz	1.02	>100	**Complies**
2441.000MHz	1.02	>100	**Complies**
2480.000 MHz	1.02	>100	**Complies**

3Mbps-CH39



4.4 Adaptivity (Adaptive Frequency Hopping)

4.4.1 Definition

This requirement does not apply to non-adaptive equipment or adaptive equipment operating in a non-adaptive mode providing the equipment complies with the requirements and/or restrictions applicable to non-adaptive equipment.

In addition, this requirement does not apply for equipment with a maximum declared RF Output power level of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBme.i.r.p.

Adaptive equipment using modulations other than FHSS is allowed to operate in a non-adaptive mode providing itcomplies with the requirements applicable to non-adaptive equipment.

An adaptive equipment using modulations other than FHSS is equipment that uses a mechanism by which it can adaptto its radio environment by identifying other transmissions present within its Occupied Channel Bandwidth.

Adaptive equipment using modulations other than FHSS shall implement either of the Detect and Avoid mechanisms provided in clause 4.3.2.6.2 or clause 4.3.2.6.3.

Adaptive equipment is allowed to switch dynamically between different adaptive modes.

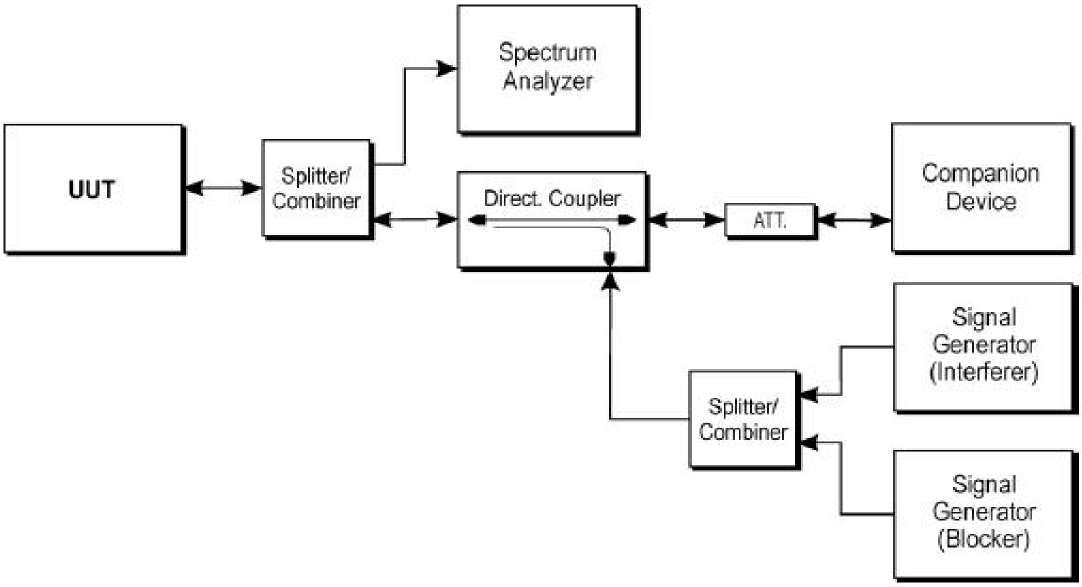
4.4.2 Limit

If implemented, Short Control Signaling Transmissions of adaptive equipment using wide band modulations other than FHSS shall have a maximum TxOn / (TxOn + TxOff) ratio of 10 % within any observation period of 50 ms.

4.4.3 EUT Operation Condition

The EUT was programmed to be in hopping on mode.

4.4.4Test Procedure



4.4.5Measurement Record

The EIRP is less than 10dBm, so the test is not applicable

4.5 Occupied Channel Bandwidth

4.5.1Definition

The Occupied Channel Bandwidth is the bandwidth that contains 99 % of the power of the signal.

4.5.2Limit

The Occupied Channel Bandwidth for each hopping frequency shall fall completely within the band given in clause 1.

For non-adaptive Frequency Hopping equipment with e.i.r.p greater than 10 dBm, the Occupied Channel Bandwidth forevery occupied hopping frequency shall be equal to or less than the value declared by the supplier. This declared valueshall not be greater than 5 MHz.

4.5.3EUT Operation Condition

The EUT was programmed to be in continuously transmitting mode.

4.5.4Test 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 for frequency hopping equipment: Lowest frequency separation that is used within the hopping sequence

Frequency Span for other types of equipment: 2 × Nominal Channel Bandwidth (e.g. 40 MHz for a 20 MHz channel)

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.

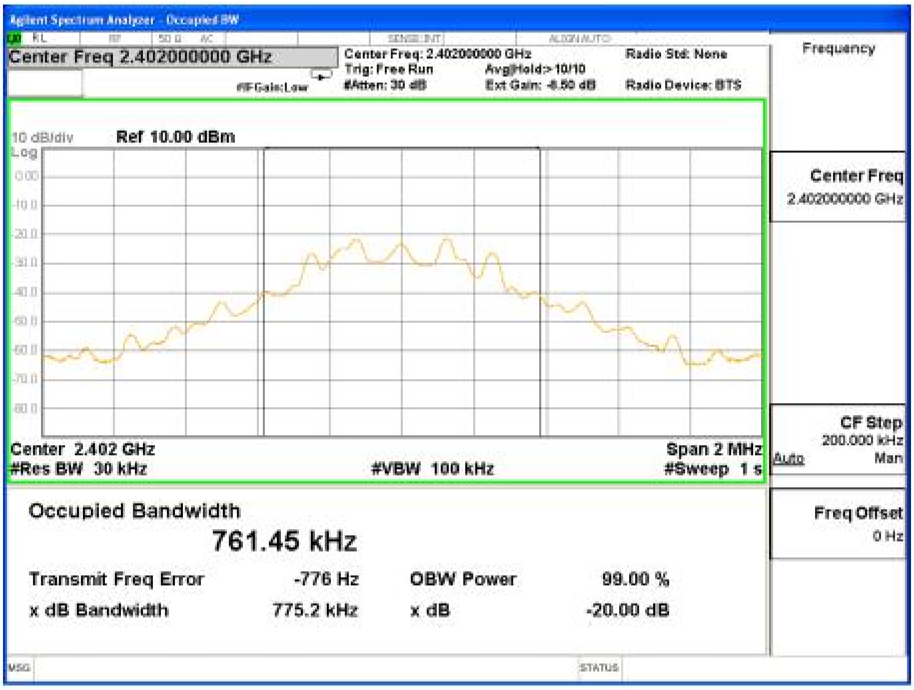
4.5.5Measurement Record

OCCUPIED CHANNEL BANDWIDTH				
Test mode	CH	Frequency MHz	Bandwidth MHz	Limit MHz
GFSK	CH00	2402	0.761	>2400.0 <2483.5
	CH78	2480	0.762	
Π/4QPSK	CH00	2402	1.146	
	CH78	2480	1.150	
8DPSK	CH00	2402	1.152	
	CH78	2480	1.148	
Test Result	PASS			

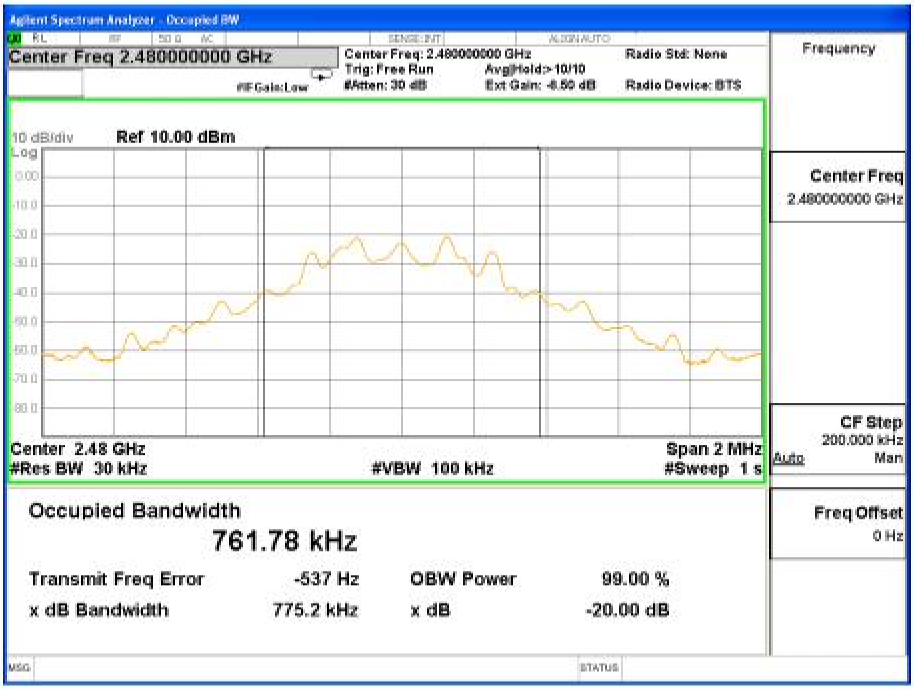
Note: FL is the lowest frequency of the 99% occupied bandwidth of power envelope.

FL is the lowest frequency of the 99% occupied bandwidth of power envelope.

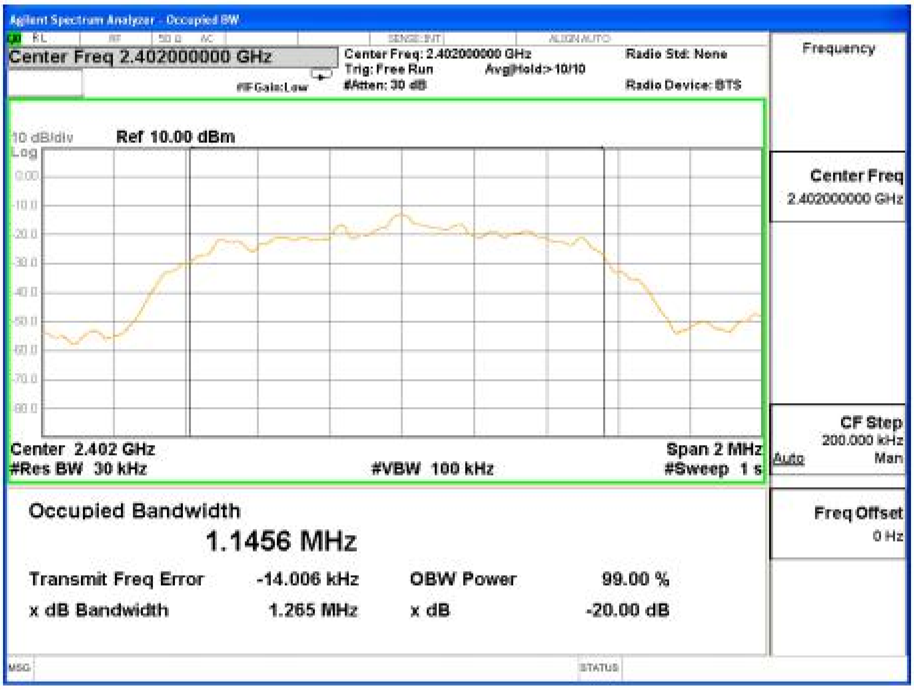
1Mbps CH00



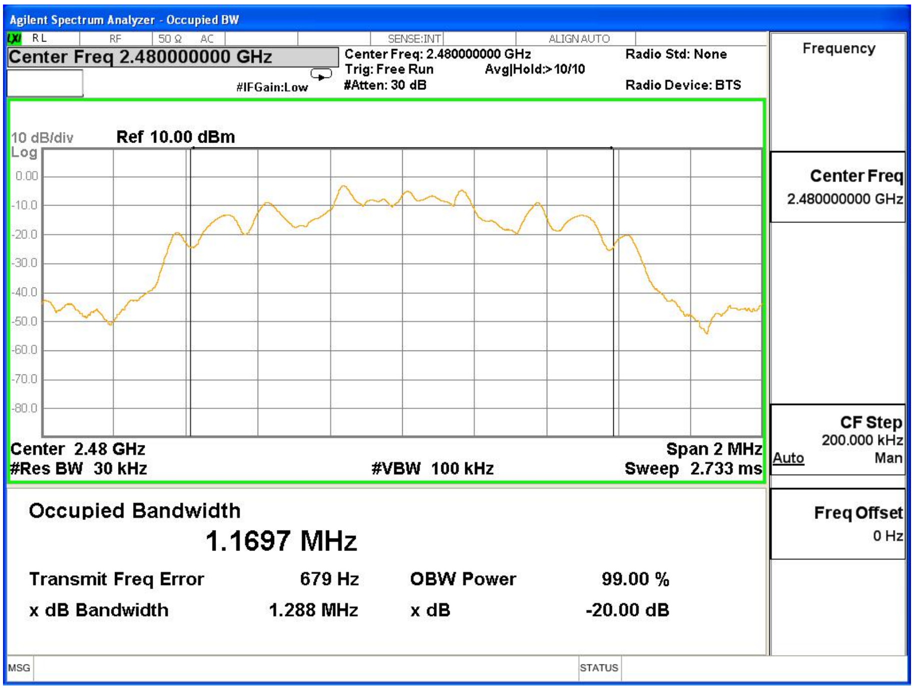
1Mbps CH78



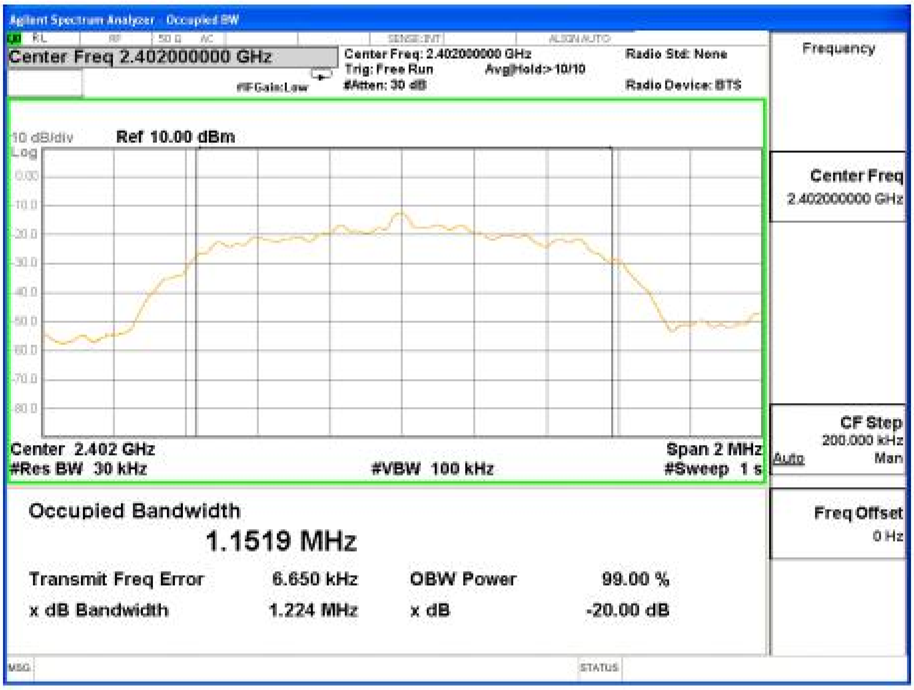
2Mbps CH00



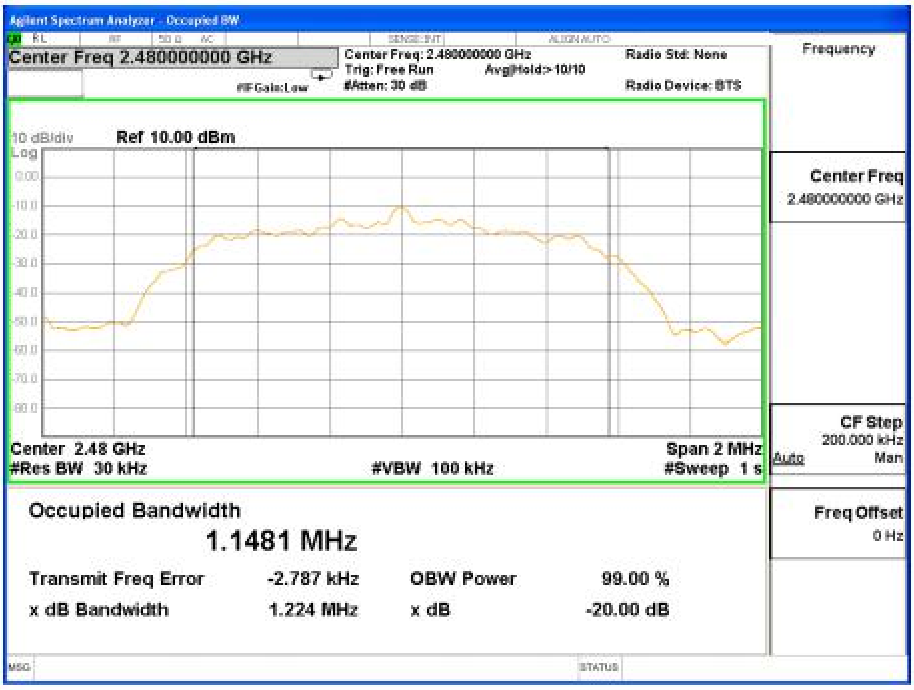
2Mbps CH78



3Mbps CH00



3Mbps CH78



4.6 Transmitter unwanted emissions in the out-of-band domain

4.6.1Definition

Transmitter unwanted emissions in the out-of-band domain are emissions when the equipment is in Transmit mode, onfrequencies immediately outside the necessary bandwidth which results from the modulation process, but excludingspurious.

4.6.2Limit

The transmitter unwanted emissions in the out-of-band domain but outside the allocated band, shall not exceed thevalues provided by the mask in figure 1.

NOTE: Within the 2 400 MHz to 2 483,5 MHz band, the Out-of-band emissions are fulfilled by compliance withthe Occupied Channel Bandwidth requirement in clause 4.3.1.7.

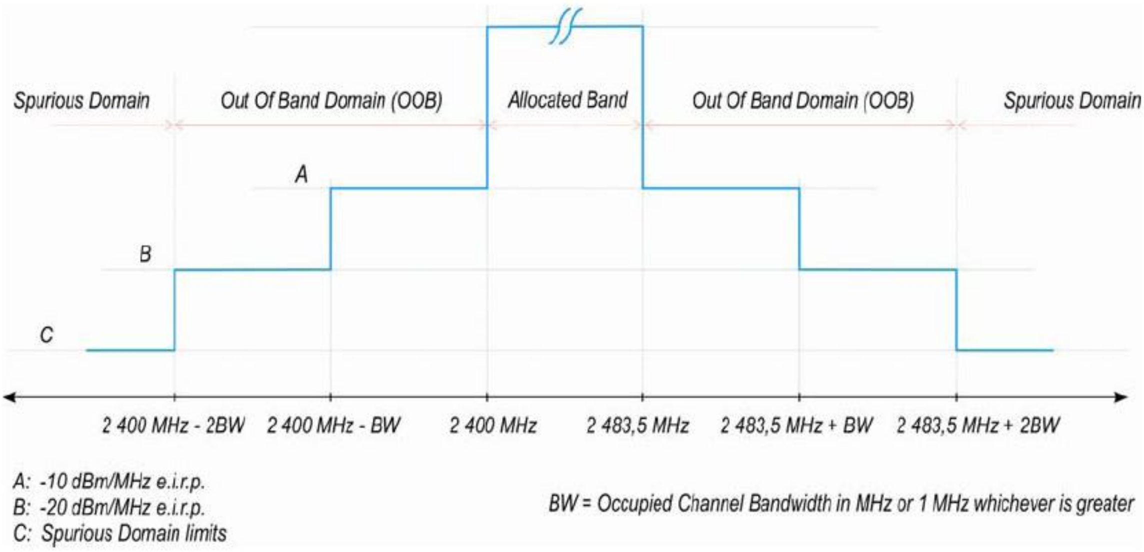


Figure 1: Transmit mask

4.6.3EUT Operation Condition

The EUT was programmed to be in continuously transmitting mode.

4.6.4Test Procedure

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

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 signalbursts 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 withinthe 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 repeats the measurements to cover this whole range. The centre frequency of the last 1 MHzsegment shall be set to 2 483,5 MHz + 2 BW - 0,5 MHz (which means this may partly overlap with theprevious 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 MHzsegment within range 2 400 MHz - BW to 2 400 MHz Reduce the centre frequency in 1 MHz steps and repeatthe 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 MHzsteps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segmentshall be set to 2 400 MHz - 2BW + 0,5 MHz (which means this may partly overlap with the previous 1 MHzsegment).

Step 6:

In case of conducted measurements on equipment with a single transmit chain, the declared antenna assemblygain "G" in dBi shall be added to the results for each of the 1 MHz segments and compared with the limitsprovided by the mask given in figure 1 or figure 3. If more than one antenna assembly is intended for thispower setting, the antenna with the highest gain shall be considered.

In case of conducted measurements on smart antenna systems (equipment with multiple transmit chains), themeasurements 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 intendedfor this power setting, the antenna with the highest gain shall be considered. Comparison with the applicablelimits shall be done using any of the options given below:

4.6.5Measurement Record

Condition: Normal

GFSK

		Low		High	
Test Condition		OOB EMISSION(MHz)		OOB EMISSION(MHz)	
		Segment A	Segment B	Segment A	Segment B
		maximum power	maximum power	maximum power	maximum power
		dBm/MHz)	dBm/MHz)	dBm/MHz)	dBm/MHz)
Tnom ℃	Vnom(v)	-56.01	-59.02	-60.01	-61.31
Limit (dBm)		-10.00	-20.00	-10.00	-20.00
PASS/FAIL		PASS	PASS	PASS	PASS

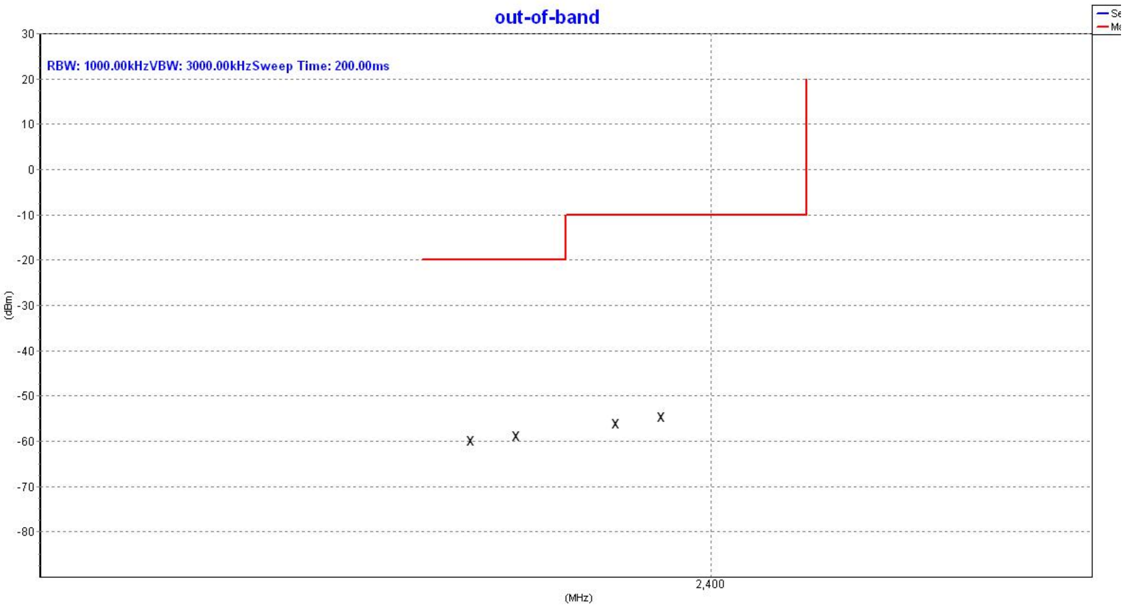
Π/4-QPSK

		Low		High	
Test Condition		OOB EMISSION(MHz)		OOB EMISSION(MHz)	
		Segment A	Segment B	Segment A	Segment B
		maximum power	maximum power	maximum power	maximum power
		dBm/MHz)	dBm/MHz)	dBm/MHz)	dBm/MHz)
Tnom ℃	Vnom(v)	-49.22	-58.03	-53.05	-59.02
Limit (dBm)		-10.00	-20.00	-10.00	-20.00
PASS/FAIL		PASS	PASS	PASS	PASS

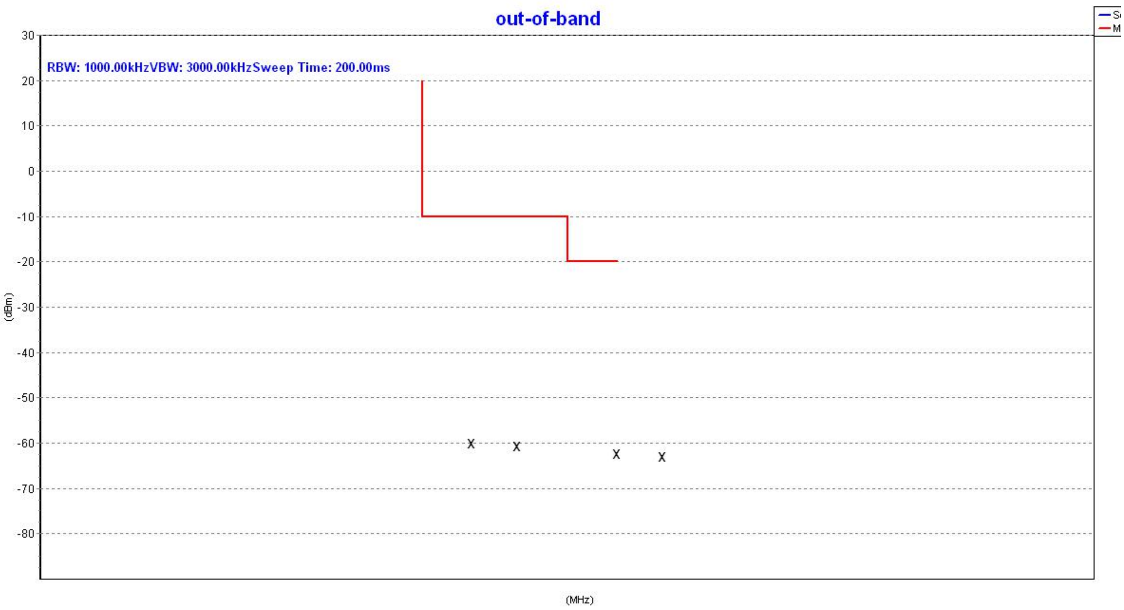
8DPSK

		Low		High	
Test Condition		OOB EMISSION(MHz)		OOB EMISSION(MHz)	
		Segment A	Segment B	Segment A	Segment B
		maximum power	maximum power	maximum power	maximum power
		dBm/MHz)	dBm/MHz)	dBm/MHz)	dBm/MHz)
Tnom ℃	Vnom(v)	-48.90	-57.85	-53.26	-59.30
Limit (dBm)		-10.00	-20.00	-10.00	-20.00
PASS/FAIL		PASS	PASS	PASS	PASS

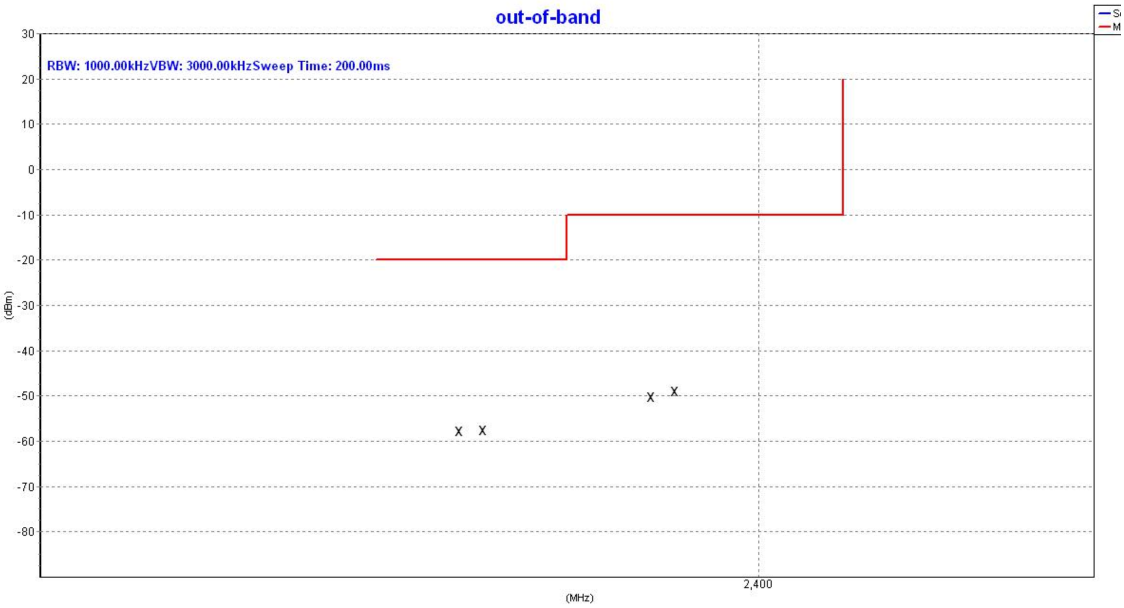
1M Low



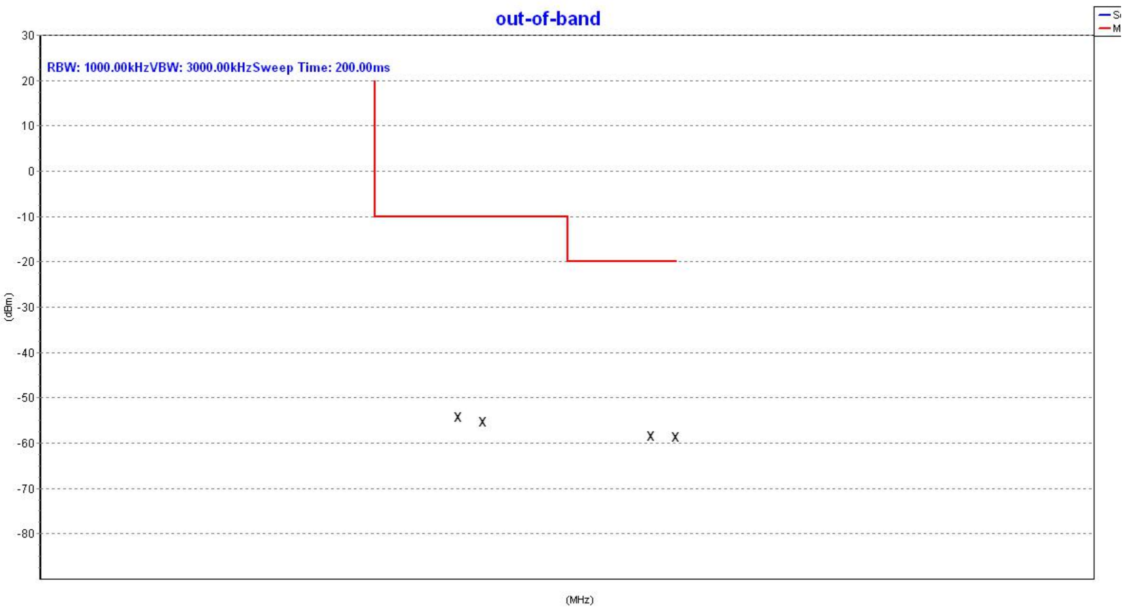
1M High



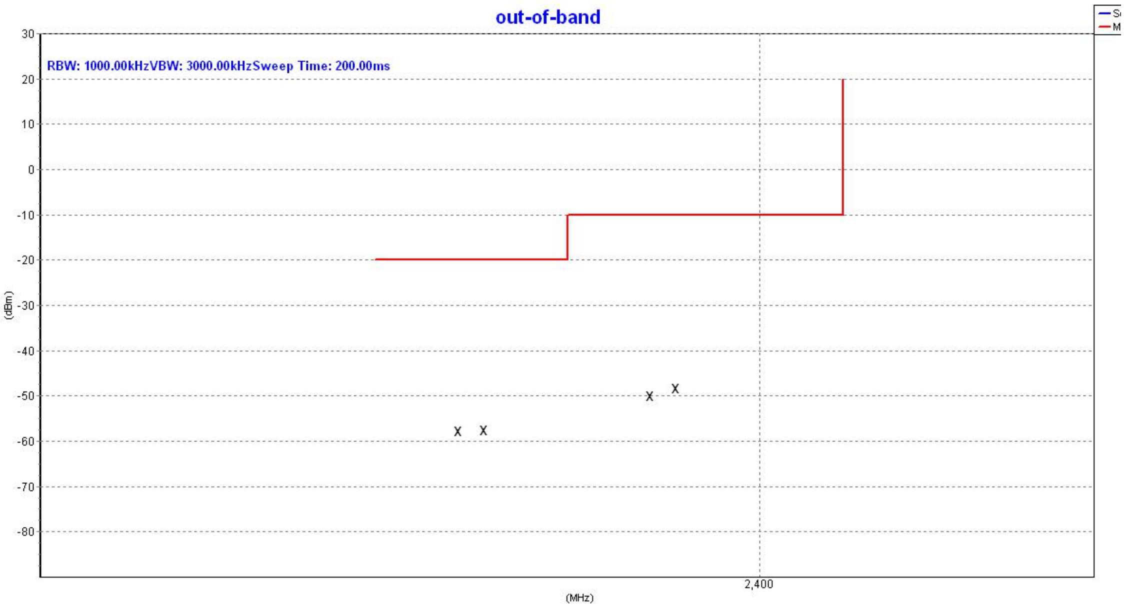
2M Low



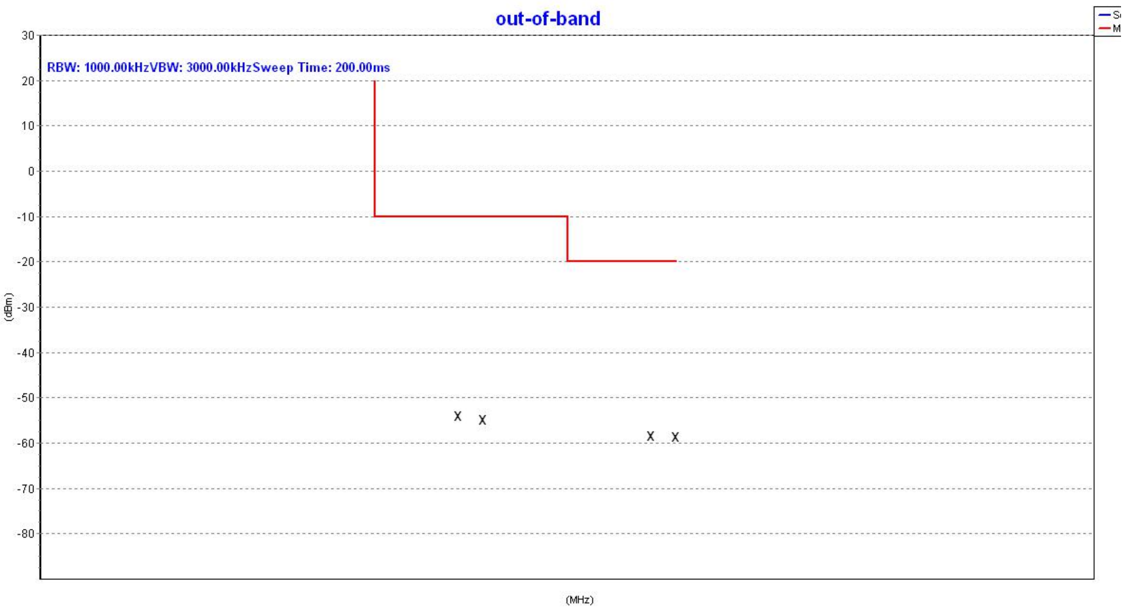
2M High



3M Low



3M High



4.7 Transmitter unwanted emissions in the spurious domain

4.7.1Definition

Transmitter unwanted emissions in the spurious domain are emissions outside the allocated band and outside theout-of-band domain as indicated in figure 1 when the equipment is in Transmit mode.

4.7.2Limit

Table 1: Transmitter limits for spurious emissions

Frequency range	Maximum power e.r.p. (≤1 GHz) e.i.r.p. (> 1 GHz)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87.5 MHz	-36 dBm	100 kHz
87.5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 862 MHz	-54 dBm	100 kHz
862 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12.75 GHz	-30 dBm	1 MHz

4.7.3EUT Operation Condition

The EUT was programmed to be in continuously transmitting mode.

4.7.4Test Procedure

Please refer to refer to ETSI EN 300 328 (V1.9.1) clause 4.3.1.10&5.3.10. The following table is the setting of the Spectrum Analyzer

Spectrum Analyzer	Setting	
Frequency Start to Stop	30 MHz to 1 000 MHz	1000 MHz to 12750MHz
RB/VB	100 kHz / 300 kHz	1 MHz / 3 MHz
Filter type:	3 dB (Gaussian)	3 dB (Gaussian)
Detector mode	Peak	Peak
Trace Mode	Max Hold	Max Hold
Sweep Points	≥ 19 400 (Set as 21 000)	≥ 23 500 (Set as 25 000)

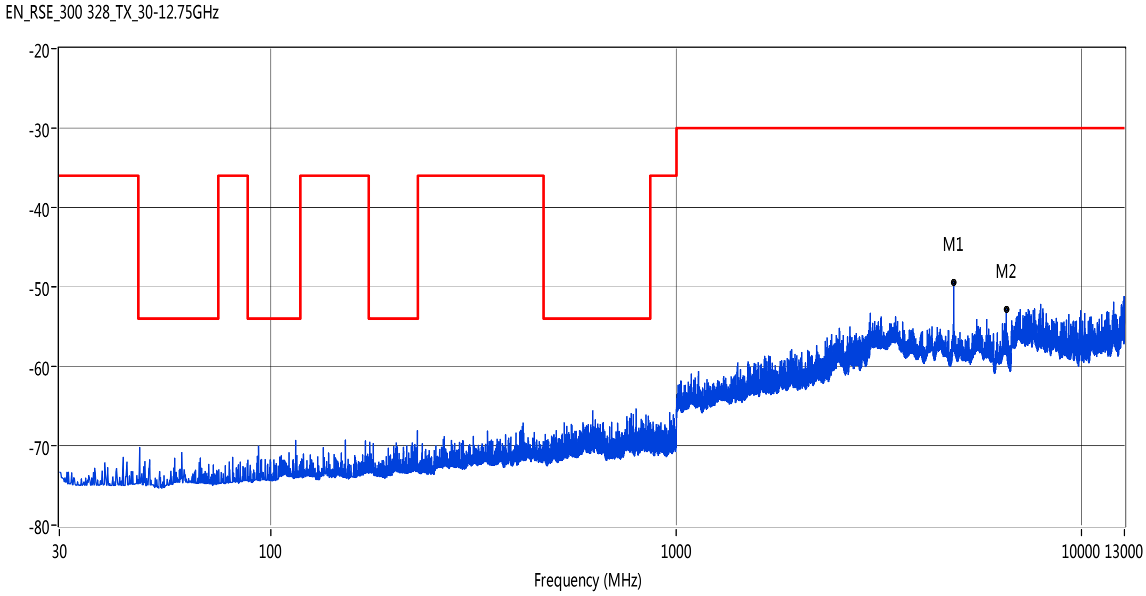
1. The EUT was placed on the top of the turntable in open test site area.
2. The test shall be made in the transmitting mode. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. This measurement shall be repeated with the transmitter in standby mode where applicable.
4. For 30~1000MHz spurious emissions measurement, the broad band bi-log receiving antenna was placed 3 meters far away from the turntable.
5. The broadband receiving antenna was fixed on the same height with the EUT to find each suspected emissions of both horizontal and vertical polarization. Each recorded suspected value is indicated as Read Level (Raw).
6. Replace the EUT by standard antenna and feed the RF port by signal generator.
7. Adjust the frequency of the signal generator to the suspected emission and slightly rotate the turntable to locate the position with maximum reading.
8. Adjust the power level of the signal generator to reach the same reading with Read Level (Raw).
9. The level of the spurious emission is the power level of (8) plus the gain of the standard antenna in dBi and minus the loss of the cable used between the signal generator and the standard antenna.
10. If the level calculated in (9) is higher than limit by more than 6dB, then lower the RBW of the spectrum analyzer to 30KHz. If the level of this emission does not change by more than 2dB, then it is taken as narrowband emission, otherwise, wideband emission.
11. The measurement shall be repeated at the lowest and the highest channel of the stated frequency range.
12. EUT Orthogonal Axis:

    “X” - denotes Laid on Table; ”Y” - denotes Vertical Stand; ”Z” - denotes Side Stand.

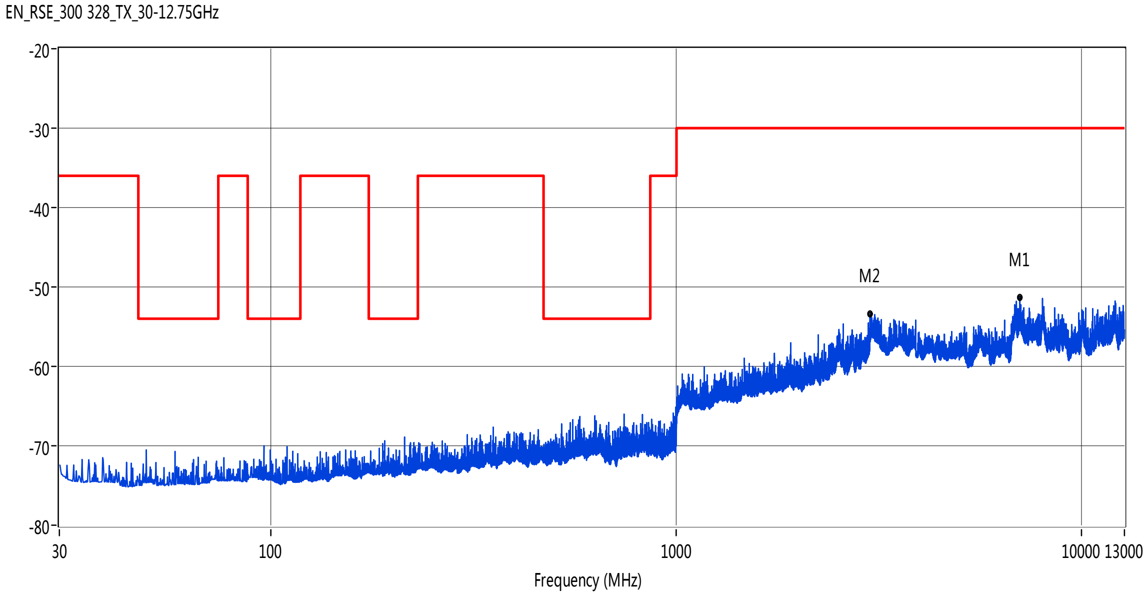
4.7.5Measurement Record

TX GFSK/2402MHz

Horizontal



Vertical



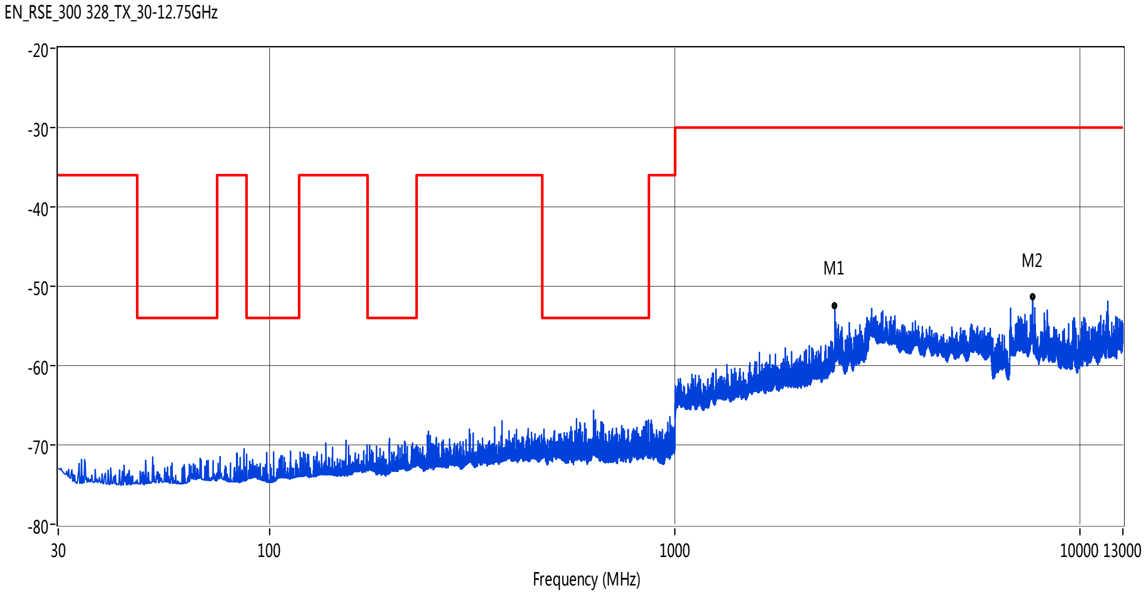
Remark:

1. The emission behaviour belongs to narrowband spurious emission.

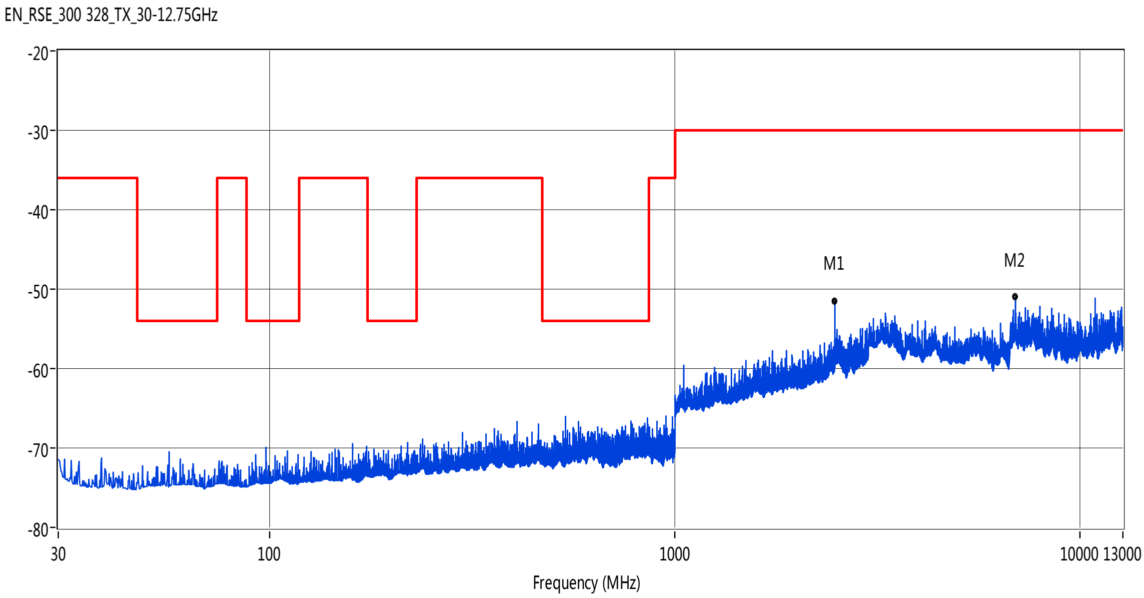
2. The all data rate modes had been test, but only worse test data was recorded in the test report.

TX GFSK/2480MHz

Horizontal



Vertical



Remark:

1. The emission behaviour belongs to narrowband spurious emission.

2. The all data rate modes had been test, but only worse test data was recorded in the test report.

4.8 Receiver spurious emissions

4.8.1Definition

Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode.

4.8.2Limit

Table 2: Spurious emission limits for receivers

Frequency range	Maximum power e.r.p. (≤1 GHz) e.i.r.p. (> 1 GHz)	Measurement bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHz	-47 dBm	1 MHz

4.8.3EUT Operation Condition

The EUT was programmed to be in continuously transmitting mode.

4.8.4Test Procedure

Please refer to refer to ETSI EN 300 328 (V1.9.1) clause 4.3.1.11&5.3.11.
The following table is the setting of the Spectrum Analyzer.

Spectrum Analyzer	Setting	
Frequency Start to Stop	30 MHz to 1 000 MHz	1000 MHz to 12750MHz
RB/VB	100 kHz / 300 kHz	1 MHz / 3 MHz
Filter type:	3 dB (Gaussian)	3 dB (Gaussian)
Detector mode	Peak	Peak
Trace Mode	Max Hold	Max Hold
Sweep Points	≥ 19 400 (Set as 21 000)	≥ 23 500 (Set as 25 000)

1. The EUT was placed on the top of the turntable in open test site area.
2. The test shall be made in the transmitting mode. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. This measurement shall be repeated with the transmitter in standby mode where applicable.
4. For 30~1000MHz spurious emissions measurement, the broad band bi-log receiving antenna was placed 3 meters far away from the turntable.
5. The broadband receiving antenna was fixed on the same height with the EUT to find each suspected emissions of both horizontal and vertical polarization. Each recorded suspected value is indicated as Read Level (Raw).
6. Replace the EUT by standard antenna and feed the RF port by signal generator.
7. Adjust the frequency of the signal generator to the suspected emission and slightly rotate the turntable to locate the position with maximum reading.
8. Adjust the power level of the signal generator to reach the same reading with Read Level (Raw).
9. The level of the spurious emission is the power level of (8) plus the gain of the standard antenna in dBi and minus the loss of the cable used between the signal generator and the standard antenna.
10. If the level calculated in (9) is higher than limit by more than 6dB, then lower the RBW of the spectrum analyzer to 30KHz. If the level of this emission does not change by more than 2dB, then it is taken as narrowband emission, otherwise, wideband emission.
11. The measurement shall be repeated at the lowest and the highest channel of the stated frequency range.
12. EUT Orthogonal Axis:

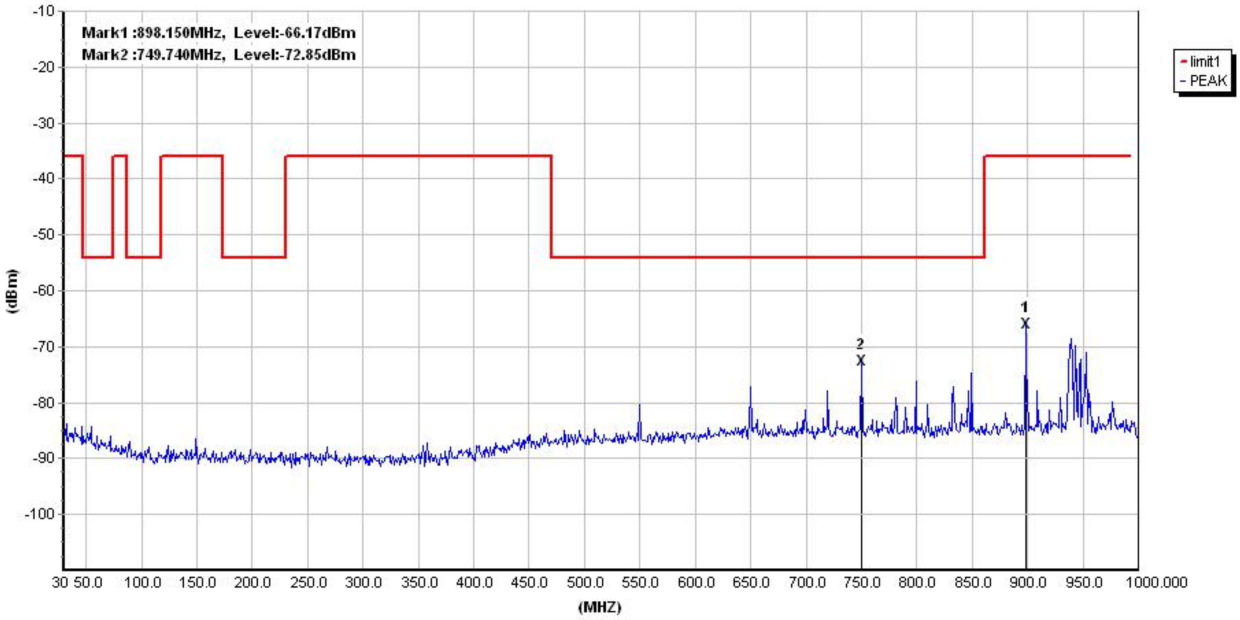
    “X” - denotes Laid on Table; ”Y” - denotes Vertical Stand; ”Z” - denotes Side Stand.

4.8.5Test Result

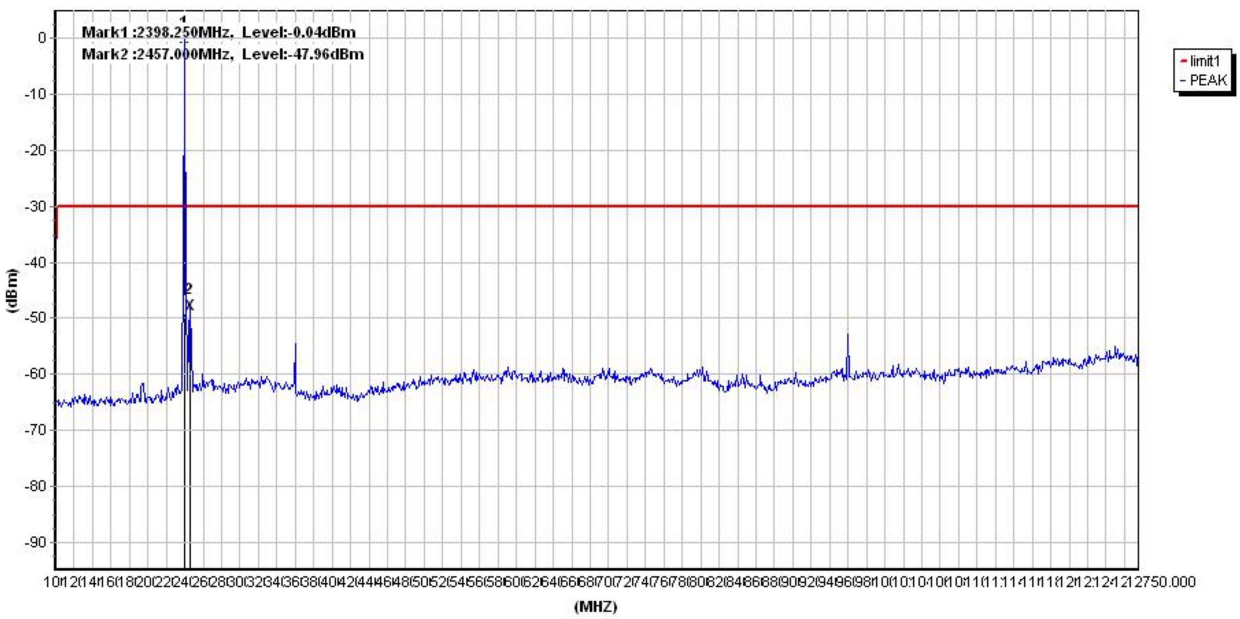
1. The emission behaviour belongs to narrowband spurious emission.

2. The all data rate modes had been test, but only worse test data was recorded in the test report.

Horizontal



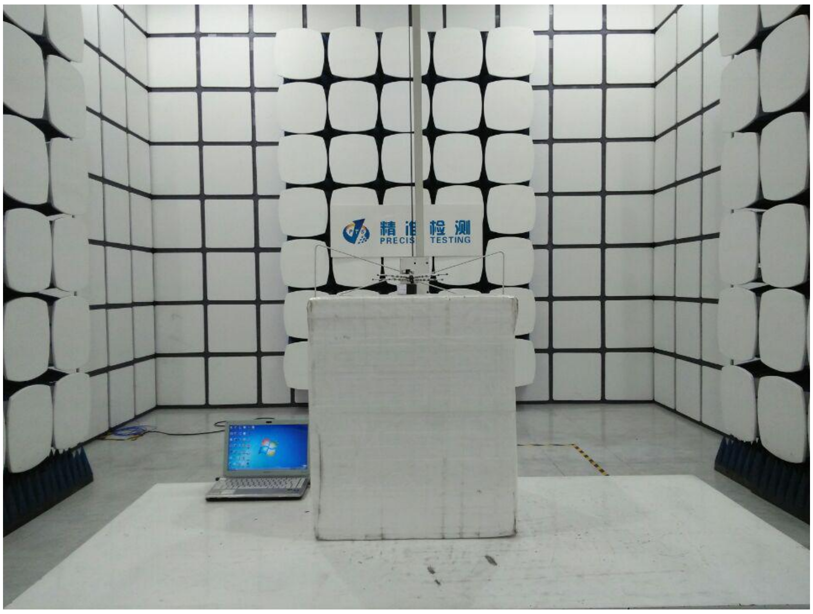
Vertical



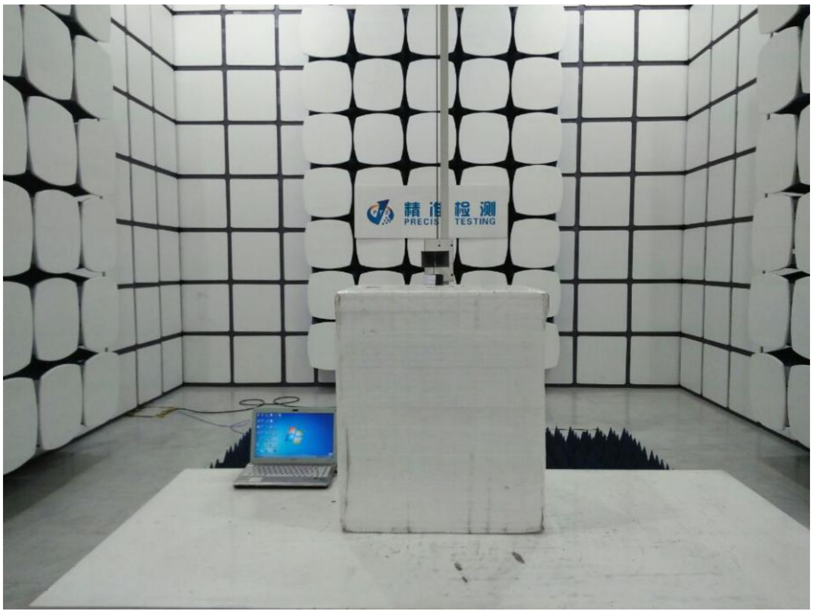
5 Test Setup

Spurious Emissions

30-1000MHz



Above 1GHz



6 EUT Photos

Photo 1

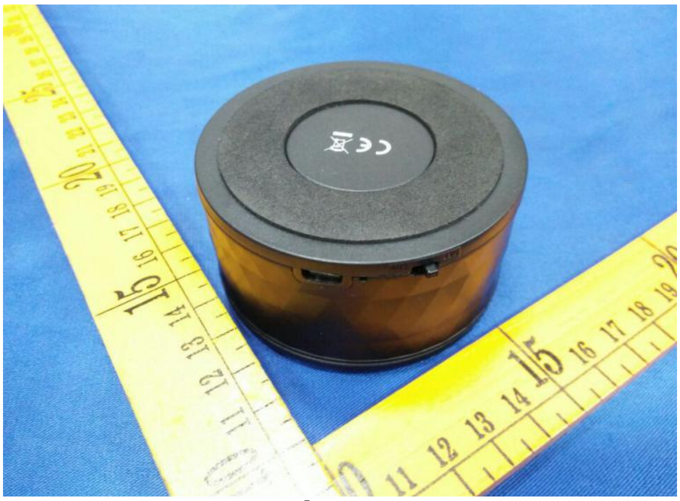


Photo 2

Photo 3

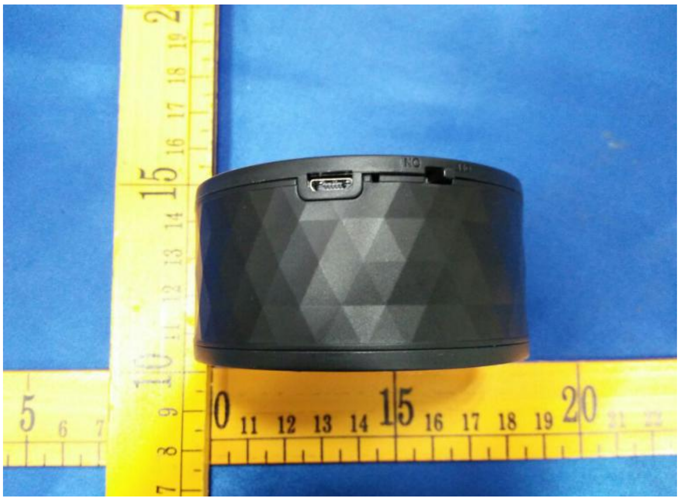


Photo 4

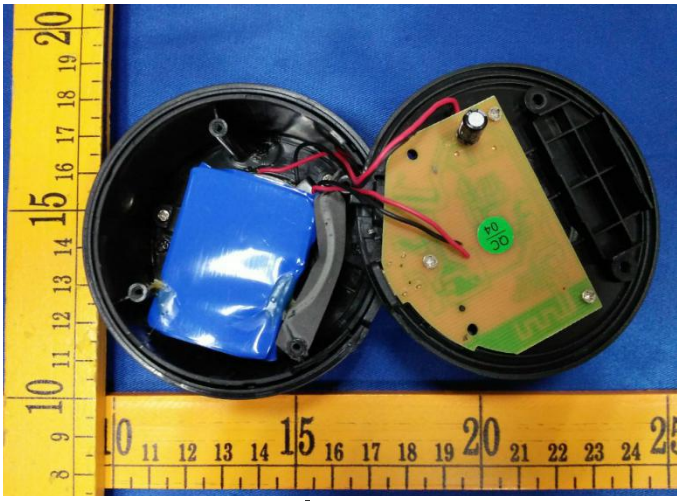


Photo 5

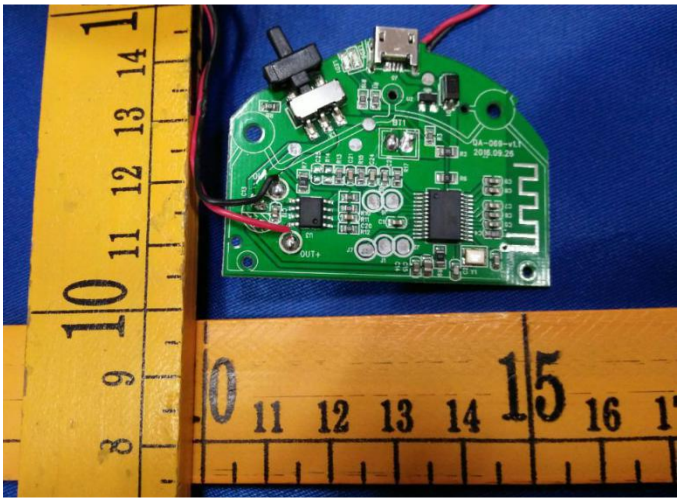


Photo 6

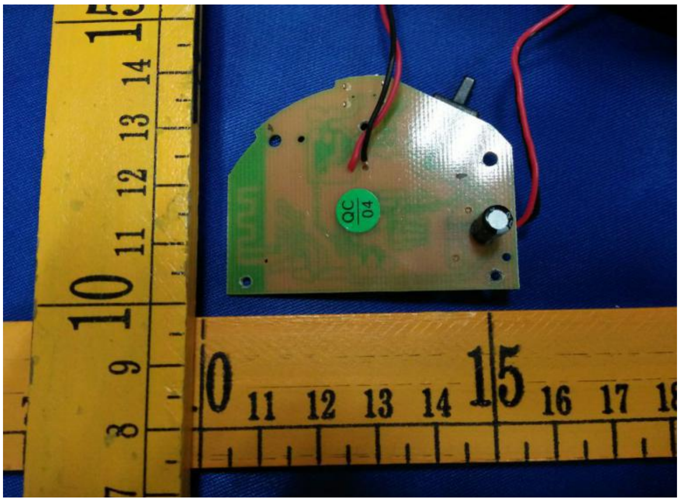
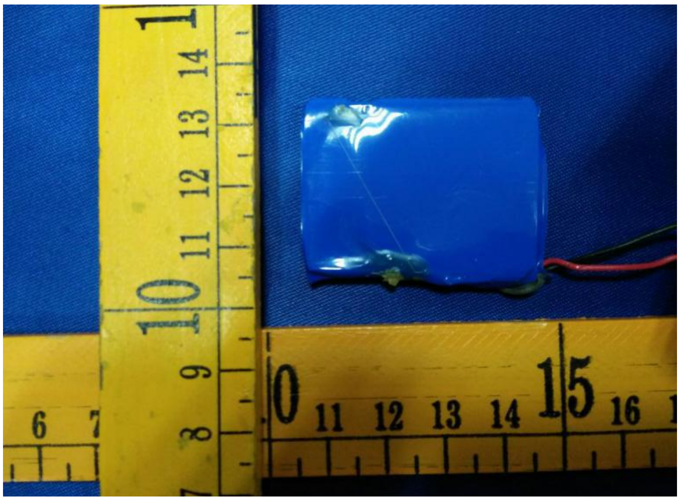


Photo 7



******THE END REPORT******