Test Report

Verified code: 555348

Report No.: E20221228512201-2

Customer:	Shenzhen Bipu Technology Co., Ltd.
Address:	Building 2, Floor 2, Wenkeng Industrial Area, Dafa Road No.24, Bantian, Long Gang District, Shenzhen, China
Sample Name:	Mechanical Keyboard
Sample Model:	PKKE221
Receive Sample Date:	Dec.30,2022
Test Date:	Jan.05,2023 ~ Apr.10,2023
Reference Document:	CFR 47, FCC Part 15 Subpart C RADIO FREQUENCY DEVICES:Subpart C—Intentional Radiators
Test Result:	Pass

Prepared by: Huang Lifang Reviewed by: Liu Haoming Approved by: Zhao Zehan

GRG METROLOGY & TEST GROUP CO., LTD.

Issued Date: 2023-05-12

GRG METROLOGY & TEST GROUP CO., LTD.
Address: No.163, Pingyun Road, West of Huangpu Avenue, Guangzhou, Guangdong, China
Tel：（+86）400-602-0999 FAX：（+86）020-38698685 Web：http://www.grgtest.com

Statement

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2. The sample information is provided by the client and responsible for its authenticity; The content of the report is only valid for the samples sent this time.

3. When there are reports in both Chinese and English, the Chinese version will prevail when the language problems are inconsistent.

4. If there is any objection concerning the report, please inform us within 15 days from the date of receiving the report.

5. Without the agreement of the laboratory, the client is not authorized to use the test results for unapproved propaganda.

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REPORT ISSUED HISTORY

Report Version	Report No.	Description	Compile Date
1.0	E20221228512201-2	Original Issue	2023-04-17

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1. TEST RESULT SUMMARY

FCC 47 CFR Part 15 Subpart C 15.247,ANSI C63.10-2013 KDB 558074 D01 15.247 measurement guidance v05r02			
Standard	**Item**	**Limit / Severity**	**Result**
FCC 47 CFR Part 15 Subpart C (15.247)	Antenna Requirement	Section 15.203	PASS
	20dB Bandwidth	Section 15.247(a)(1)	PASS
	Carrier Frequencies Separated	Section 15.247(a)(1)	PASS
	Hopping Channel Number	Section 15.247(a)(1)(iii)	PASS
	Dwell Time	Section 15.247(a)(1)(iii)	PASS
	Maximum Peak Output Power	Section 15.247(b)(1)	PASS
	Conducted Emission	Section 15.207	PASS
	Conducted band edges and Spurious Emission	Section 15.209 &15.247(d)	PASS
	Radiated Spurious Emission	Section 15.209 &15.247(d)	PASS
	Restricted bands of operation	Section 15.247 (d) &15.205	PASS

Note: The EUT antenna is FPC antenna. Max Antenna gain is 1.53dBi .Which accordance 15.203.is considered sufficient to comply with the provisions of this section.

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2. GENERAL DESCRIPTION OF EUT

2.1 APPLICANT

Name:	Shenzhen Bipu Technology Co., Ltd.
Address:	Building 2, Floor 2, Wenkeng Industrial Area, Dafa Road No.24, Bantian, Long Gang District, Shenzhen, China

2.2 MANUFACTURER

Name:	Shenzhen Bipu Technology Co., Ltd.
Address:	Building 2, Floor 2, Wenkeng Industrial Area, Dafa Road No.24, Bantian, Long Gang District, Shenzhen, China

2.3 FACTORY

Name:	Dongguan Jieguan Industrial Technology Co., Ltd.
Address:	Room 301,No.1 Building,No.5, xifa Road,Lin Village,Tangxia Town,Dongguan City,Guangdong Province.

2.4 BASIC DESCRIPTION OF EQUIPMENT UNDER TEST

Equipment:	Mechanical Keyboard
Model No.:	PKKE221
Adding Model:	/
Trade Name:	Keychron
FCC ID:	2ASF4-PKKE221
Power supply:	DC 3.87V power supplied by battery DC 5V power supplied by notebook
Battery Specification:	Name:Rechargeable Li-ion Polymer Battery Model:BLP959 Nominal Voltage:3.87Vdc Rated Capacity:4880mAh/18.88Wh Typical Capacity:5000mAh/19.35Wh
Frequency Range:	2402MHz~2480MHz
Transmit Power:	GFSK:-3.04dBm
Type of Modulation:	GFSK for 1Mbps
Antenna Specification:	1.53dBi

Temperature Range: -10℃~+50℃

Hardware Version: V2.6

Software Version: V1.02

Sample No: E20221228512201-0004,E20221228512201-0009

Note: /

2.5 TEST OPERATION MODE

Mode No.	Description of the modes
1	Bluetooth(BT) fixed frequency transmitting

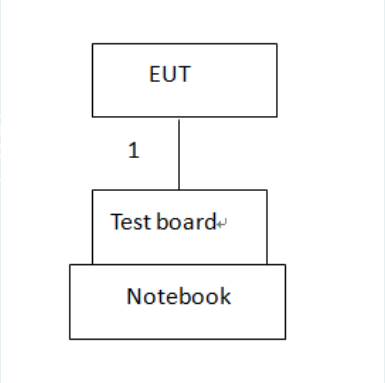
2.6 LOCAL SUPPORTIVE

Name of equipment	Manufacturer	Model	Serial number	Note
Notebook	DELL	Latitude 3400	8RZFJW2	/
Test board	/	/	/	/

No.	Cable Type	Qty.	Shielded Type	Ferrite Core(Qty.)	Length
1	USB cable	1	No	0	1.0m

2.7 CONFIGURATION OF SYSTEM UNDER TEST

For Conducted Emission, 20dB bandwidth, Carrier Frequencies Separated, Hopping Channel Number , Dwell Time ,Maximum Peak Output Power, Conducted band edges and Spurious Emission measurement



For Radiated Spurious Emission, Restricted bands of operation

Test software:

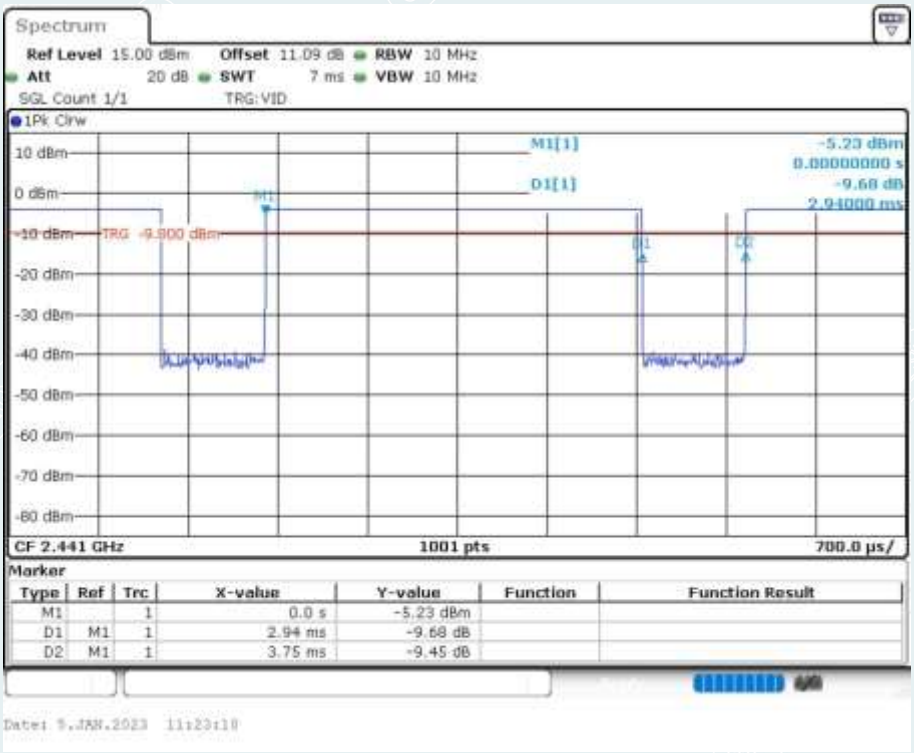
Software version	Test level
Bluetool	default

2.8 DUTY CYCLE

EUT Name	Mechanical Keyboard	Model	PKKE221
Environmental Conditions	23.6℃/55%RH/101.0kPa	Test Voltage	DC 3.87V
Tested By	Qin Tingting	Tested Date	2023-01-05

TestMode	Antenna	Frequency [MHz]	ON Time [ms]	Period [ms]	DC [%]	T [s]
DH5	Ant1	2441	2.94	3.75	78.40	0.00294

DH5_2441MHz



3. LABORATORY AND ACCREDITATIONS

3.1 LABORATORY

The tests & measurements refer to this report were performed by Shenzhen EMC Laboratory of GRG METROLOGY & TEST GROUP CO., LTD.

Add	:	No.1301 Guanguang Road Xinlan Community, Guanlan Street, Longhua District Shenzhen, 518110, People's Republic of China
P.C.	:	518110
Tel	:	0755-61180008
Fax	:	0755-61180008

3.2 ACCREDITATIONS

Our laboratories are accredited and approved by the following approval agencies according to GB/T 27025(ISO/IEC 17025:2017)

USA	A2LA(Certificate #2861.01)

The measuring facility of laboratories has been authorized or registered by the following approval agencies.

Canada	ISED (Company Number: 24897，CAB identifier:CN0069)
USA	FCC (Registration Number: 759402，Designation Number:CN1198)

Copies of granted accreditation certificates are available for downloading from our web site, http://www.grgtest.com

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4. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement		Frequency	Uncertainty
Radiated Emission	Horizontal	9kHz～30MHz	5.1dB[1)]
		30MHz～200MHz	4.5dB[1)]
		200MHz～1000MHz	4.4dB[1)]
		1GHz～18GHz	5.6dB[1)]
		18GHz～26.5GHz	3.7dB[1)]
	Vertical	9kHz～30MHz	5.1dB[1)]
		30MHz～200MHz	4.4dB[1)]
		200MHz～1000MHz	4.5dB[1)]
		1GHz～18GHz	5.6dB[1)]
		18GHz～26.5GHz	3.7dB[1)]
Conduction Emission		150kHz～30MHz	3.40dB[1)]

Measurement	Uncertainty
RF frequency	6.0×10^{-6}
RF power conducted	0.78dB
Occupied channel bandwidth	0.4dB
Unwanted emission, conducted	0.68dB
Humidity	6%
Temperature	2℃

Note:

[1)] This uncertainty represents an expanded uncertainty expressed at approximately the 95%.

This uncertainty represents an expanded uncertainty factor of *k*=2.

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5. LIST OF USED TEST EQUIPMENT AT GRGT

Name of Equipment	Manufacturer	Model	Serial Number	Calibration Due
Conducted Emissions				
EMI TEST RECEIVER	R&S	ESCI	100783	2023-08-28
LISN(EUT)	R&S	ENV216	101543	2023-09-13
Test S/W	EZ	CCS-3A1-CE		
Hopping Channel Number				
Spectrum Analyzer	R&S	FSV30	104381	2023-11-17
Dwell Time				
Spectrum Analyzer	R&S	FSV30	104381	2023-11-17
Radiated Spurious Emission&Restricted bands of operation				
Test S/W	EZ	CCS-03A1		
Test Receiver	R&S	ESR7	102444	2023-09-02
Preamplifier	EMEC	EM330	I00426	2024-02-06
Bi-log Antenna	TESEQ	CBL6143A	26039	2024-10-23
Loop Antenna	TESEQ	HLA6121	52599	2024-02-03
Spectrum Analyzer	KEYSIGHT	N9010A	MY52221469	2023-06-29
Horn Antenna	Schwarzbeck	BBHA9120D	02143	2023-10-15
Board-Band Horn Antenna	Schwarzbeck	BBHA 9170	BBHA 9170-497	2023-10-14
Amplifier	Tonscend	TAP01018048	AP20E8060075	2023-05-05
Amplifier	Tonscend	TAP184050	AP20E806071	2023-05-05
Amplifier	SHIRONG ELECTRONIC	DLNA-1G18G-G40	20200928005	2023-05-08
Test S/W	Tonscend	JS36-RE/2.5.1.5		
20 dB Bandwidth				
Spectrum Analyzer	R&S	FSV30	104381	2023-11-17
Maximum Peak Output Power				
Pulse power sensor	Anritsu	MA2411B	1126150	2023-03-01
Power meter	Anritsu	ML2495A	1204003	2023-02-28
Conducted band edges and Spurious Emission				
Spectrum Analyzer	R&S	FSV30	104381	2023-11-17
Carrier Frequencies Separated				
Spectrum Analyzer	R&S	FSV30	104381	2023-11-17

Note: The calibration interval of the above test instruments is 12 months except Bi-log Antenna, The calibration interval of the Bi-log Antenna is 24 months.

6. E.U.T. TEST CONDITIONS

Type of antenna: FPC

Test frequencies: According to the 15.31(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and. if required. reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top 1 near middle and 1 near bottom

EUT channels and frequencies list:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	**2402**	14	2416	28	2430
1	2403	15	2417	29	2431
2	2404	16	2418	30	2432
3	2405	17	2419	31	2433
4	2406	18	2420	32	2434
5	2407	19	2421	33	2435
6	2408	20	2422	34	2436
7	2409	21	2423	35	2437
8	2410	22	2424	36	2438
9	2411	23	2425	37	2439
10	2412	24	2426	38	2440
11	2413	25	2427	39	**2441**
12	2414	26	2428	40	2442
13	2415	27	2429	41	2443

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
42	2444	55	2457	68	2470
43	2445	56	2458	69	2471
44	2446	57	2459	70	2472
45	2447	58	2460	71	2473
46	2448	59	2461	72	2474
47	2449	60	2462	73	2475
48	2450	61	2463	74	2476
49	2451	62	2464	75	2477
50	2452	63	2465	76	2478
51	2453	64	2466	77	2479
52	2454	65	2467	78	**2480**
53	2455	66	2468		
54	2456	67	2469		

Test frequency is the lowest channel: 0 frequency(2402MHz), middle channel: 39 frequency (2441MHz) and highest channel: 78 frequency(2480MHz)

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7. 20dB BANDWIDTH

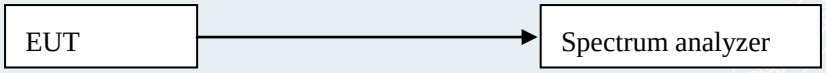
7.1 LIMITS

Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

7.2 TEST PROCEDURES

1) Remove the antenna from the EUT, and then connect a low loss RF cable from antenna port to the spectrum analyzer.
2) Set the spectrum analyzer as RBW=30 kHz, VBW=100 kHz, Span=3MHz, Sweep = auto. Allow the trace to stabilize, record 20dB bandwidth value
3) Repeat until all the test channels are investigated.

7.3 TEST SETUP



7.4 TEST RESULTS

Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date: 2023-01-05

Test mode	Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
DH5	Lowest	2402	1041
	Middle	2441	1044
	Highest	2480	1041

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Result plot as follows:

DH5

LowestChannel

Middle Channel

Highest Channel

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8. CARRIER FREQUENCIES SEPARATED

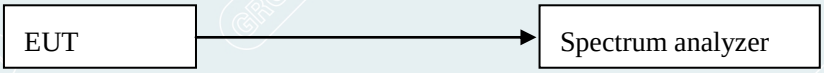
8.1 LIMITS

1) Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

8.2 TEST PROCEDURES

1) Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
2) Set center frequency of spectrum analyzer = middle of hopping channel.
3) Set the spectrum analyzer as RBW=100kHz, VBW=300kHz, Adjust Span to 2MHz, Sweep = auto
4) Use the marker-delta function to mark hopping channel carrier frequencies and record the channel separation.

8.3 TEST SETUP



8.4 TEST RESULTS

Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date: 2023-01-05

DH5

Channel Separation (MHz)	Two-thirds of the 20 dB Bandwidth (kHz)	Channel Separation Limit	Result
0.997	696	> Two-thirds of the 20 dB Bandwidth	Pass

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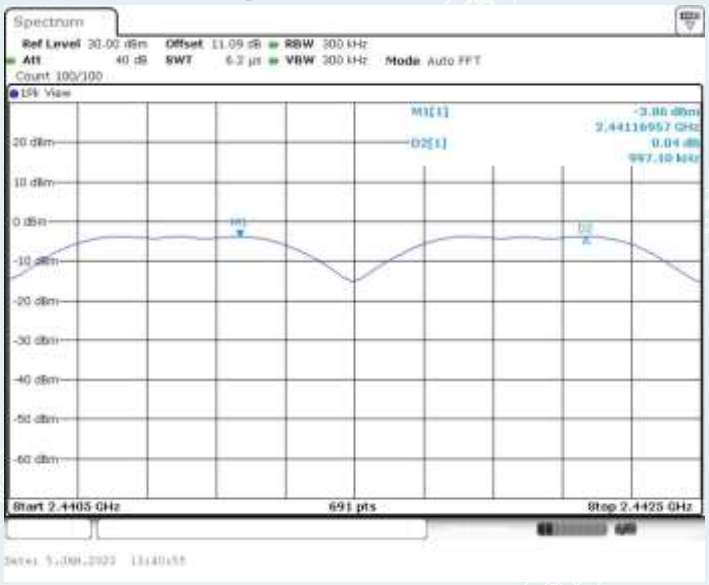
Result plot as follows:

DH5

Measurement of Channel Separation



Test result: The unit does meet the FCC requirements.

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9. HOPPING CHANNEL NUMBER

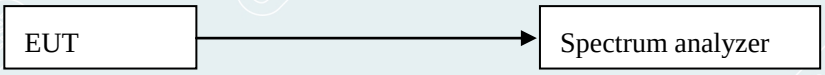
9.1 LIMITS

Regulation 15.247 (a) (1)(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

9.2 TEST PROCEDURES

1) Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
2) Set the spectrum analyzer as RBW=100kHz, VBW=300kHz.
3) Set the spectrum analyzer: start frequency = 2400MHz. stop frequency = 2483.5MHz. Submit the test result graph.

9.3 TEST SETUP



9.4 TEST RESULTS

Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date: 2023-01-05

Type of Modulation	Result (No. of CH)	Limit (No. of CH)	Result
GFSK	79	≥15	PASS

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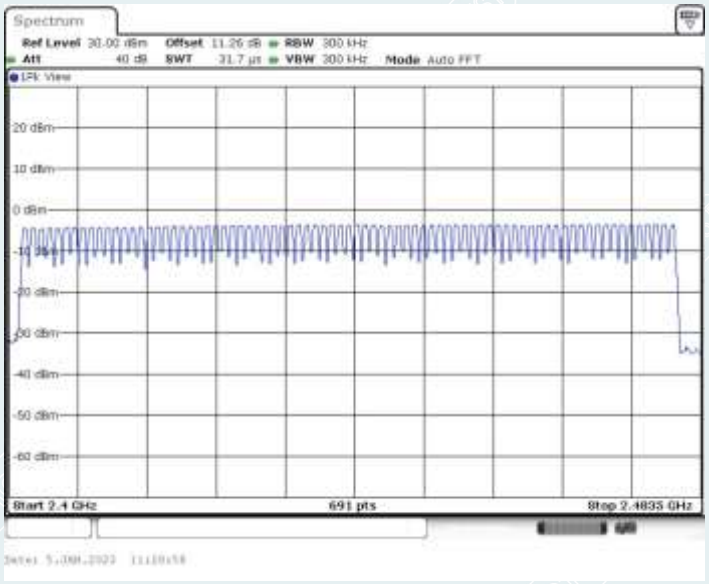
GFSK

2.400 GHz – 2.4835 GHz



Test result: The unit does meet the FCC requirements.

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10. DWELL TIME

10.1 LIMITS

Regulation 15.247(a)(1)(iii) Frequency hopping systems in the 2400-2483.5MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

10.2 TEST PROCEDURES

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2) Set spectrum analyzer span = 0. centered on a hopping channel;
3) Set RBW = 1MHz and VBW = 3MHz.Sweep = as necessary to capture the entire dwell time per hopping channel. Detector Function = Peak. Trace = Max hold;
4) Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g.. data rate. modulation format. etc.). Repeat this test for each variation.
5) DH1 Packet permit maximum 1600 / 79 /2 = 10.12 hops per second in each channel (1 time slot TX, 1 time slot RX).So, the dwell time is the time duration of the pulse times 10.12 x 31.6 = 320 within 31.6 seconds
6) DH3 Packet permit maximum 1600 / 79 / 4 = 5.06 hops per second in each channel (3 time slotsTX, 1 time slot RX).So, the dwell time is the time duration of the pulse times 5.06 x 31.6 = 160 within 31.6 seconds
7) DH5 Packet permit maximum 1600/ 79 / 6 = 3.37 hops per second in each channel (5 time slotsTX, 1 time slot RX).So, the dwell time is the time duration of the pulse times 3.37 x 31.6 = 106.6 within 31.6 seconds

10.3 TEST SETUP

10.4 TEST RESULTS

Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date:2023-01-05

The test period: T= 0.4 Second/Channel x 79 Channel = 31.6 s

GFSK: Middle Channel (2.441GHz)

DH1	time slot=	0.436	(ms)*	(1600/(2*79))	*	31.6	=	140	ms
DH3	time slot=	1.680	(ms)*	(1600/(4*79))	*	31.6	=	268.8	ms
DH5	time slot=	2.920	(ms)*	(1600/(6*79))	*	31.6	=	311.47	ms

The results are not greater than 0.4 seconds.
The unit does meet the requirements.

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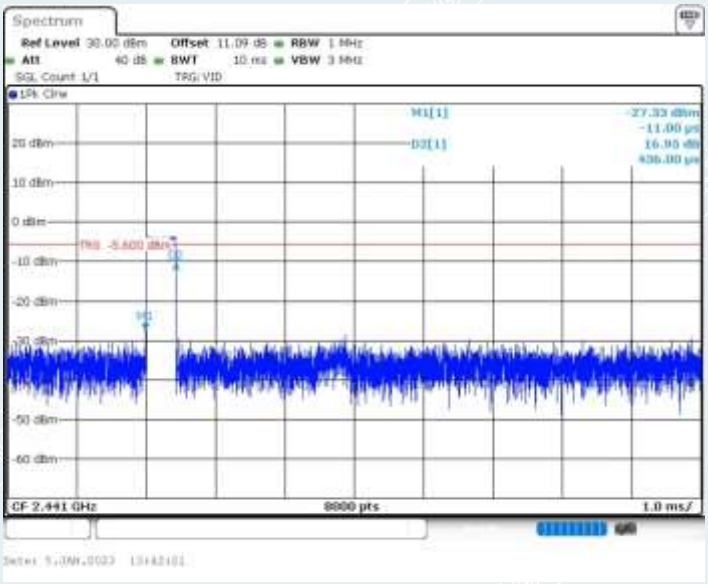
Please refer the graph as below:

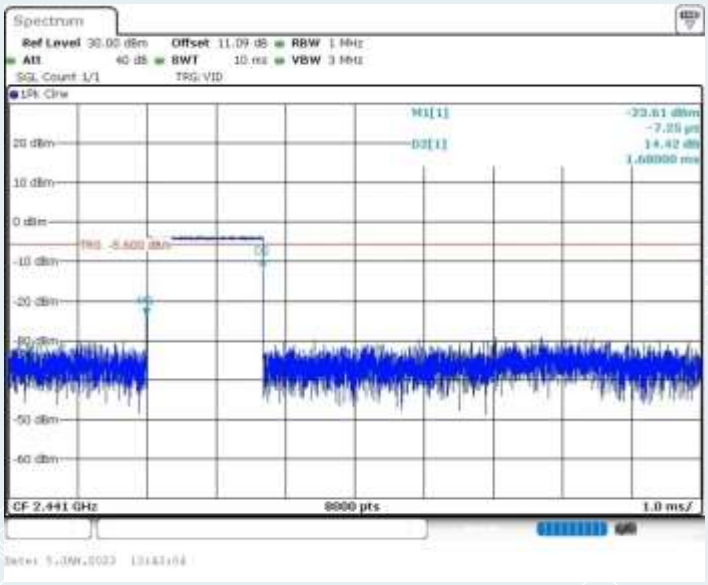
GFSK

Middle Frequency (2.441GHz)

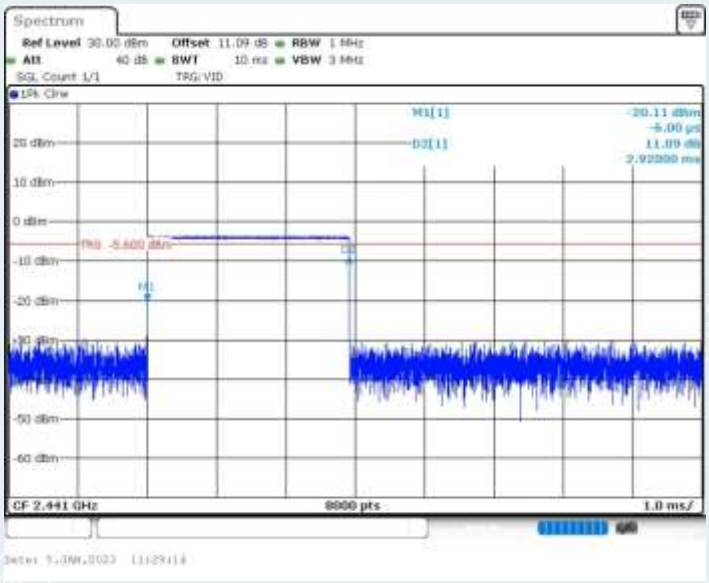
DH1



DH3



DH5



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11. CONDUCTED EMISSION MEASUREMENT

11.1 LIMITS

Frequency range	Limits (dBμV)	
	Quasi-peak	Average
150kHz～0.5MHz	66～56	56～46
0.5MHz～5MHz	56	46
5MHz～30MHz	60	50

11.2 TEST PROCEDURES

Procedure of Preliminary Test

For measurement of the disturbance voltage the equipment under test (EUT) is connected to the power supply mains and any other extended network via one or more artificial network(s). An EUT, whether intended to be grounded or not, and which is to be used on a table is configured as follows:

– Either the bottom or the rear of the EUT shall be at a controlled distance of 40 cm from a reference ground plane. This ground plane is normally the wall or floor of a shielded room. It may also be a grounded metal plane of at least 2 m by 2 m. This is physically accomplished as follows:

1) Place the EUT on a table of non-conducting material which is at least 80 cm high. Place the EUT so that it is 40 cm from the wall of the shielded room, or

2) place the EUT on a table of non-conducting material which is 40 cm high so that the bottom of the EUT is 40 cm above the ground plane;

– All other conductive surfaces of the EUT shall be at least 80 cm from the reference ground plane;

– The EUT are placed on the floor that one side of the housings is 40 cm from the vertical reference ground plane and other metallic parts;

– Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 cm to 40 cm long, hanging approximately in the middle between the ground plane and the table.

– I/O cables that are connected to a peripheral shall be bundled in the centre. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1 m.

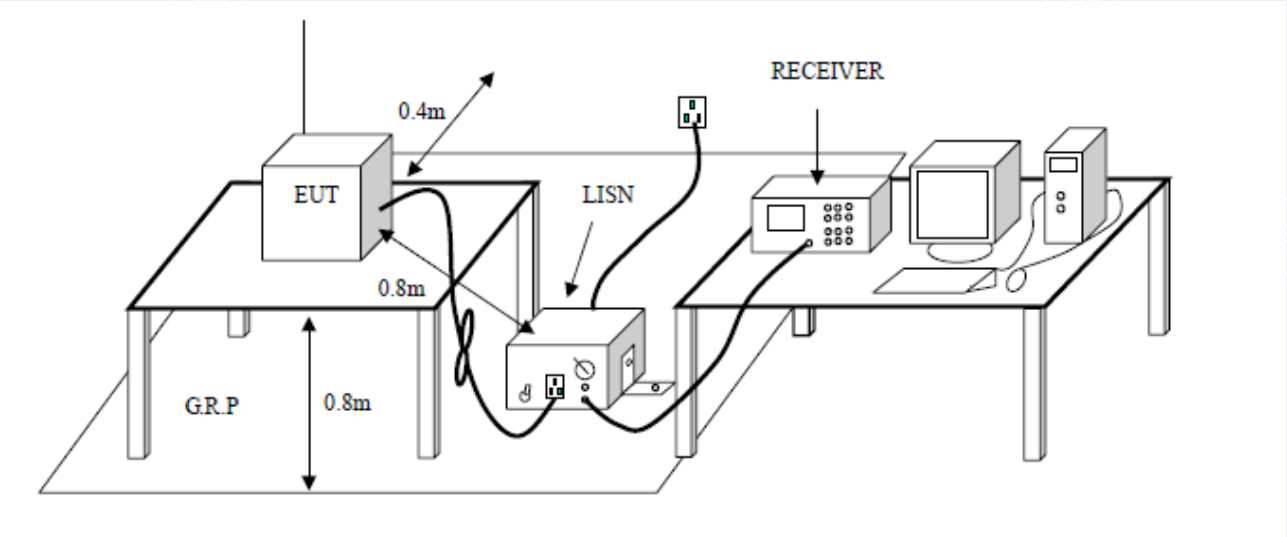
The test mode(s) described in Item 2.5 were scanned during the preliminary test. After the preliminary scan, we found the test mode described in Item 2.5 producing the highest emission level.The EUT configuration and cable configuration of the above highest emission levels were recorded for reference of the final test.

Procedure of Final Test

EUT and support equipment were set up on the test bench as per the configuration with highest emission level in the preliminary test. A scan was taken on both power lines, recording at least the six highest emissions.

Emission frequency and amplitude were recorded into a computer in which correction factors were used to calculate the emission level and compare reading to the applicable limit. The test data of the worst-case condition(s) was recorded.

11.3 TEST SETUP



11.4 DATA SAMPLE

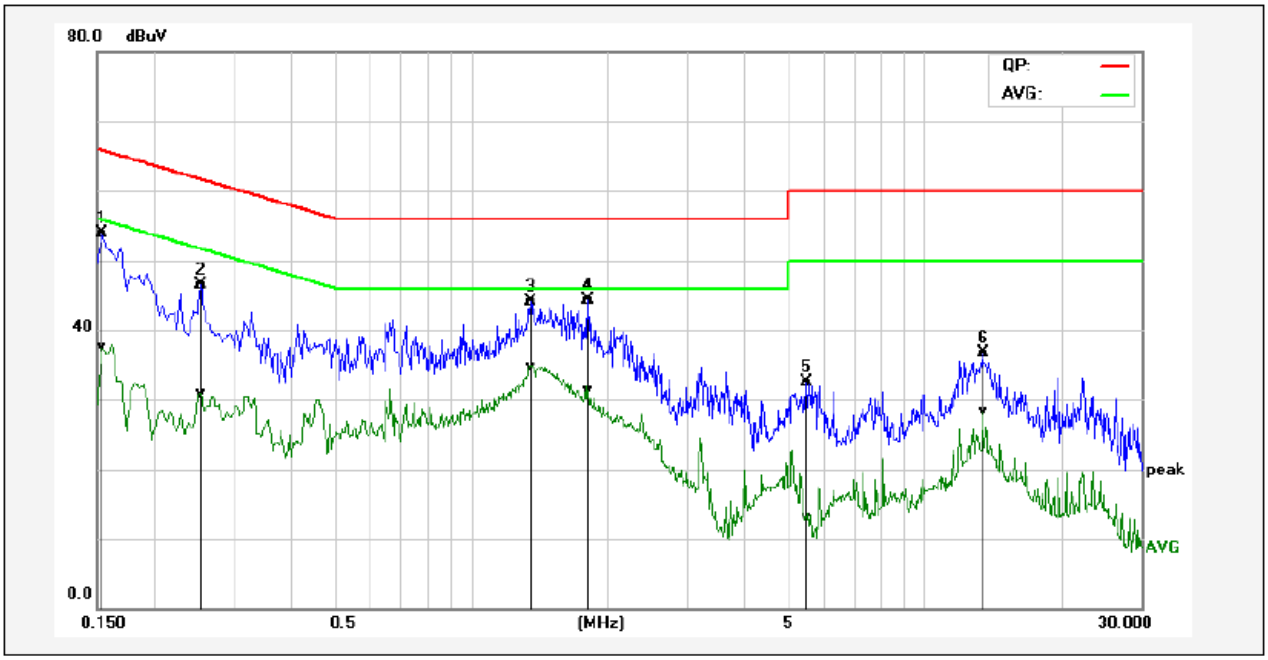
Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
X.XXXX	32.69	25.65	11.52	44.21	37.17	65.78	55.79	-21.57	-18.62	Pass

Factor = Insertion loss of LISN + Cable Loss
Result = Quasi-peak Reading/ Average Reading + Factor
Limit = Limit stated in standard
Margin = Result (dBuV) – Limit (dBuV)

11.5 TEST RESULTS

EUT Name	Mechanical Keyboard	Model	PKKE221
Environmental Conditions	23.1℃/52%RH/101.0kPa	Test Mode	DH5 2480MHz
Tested By	Wang Xinyuan	Line	L
Tested Date	2023-01-10	Test Voltage	AC 120V/60Hz

(The chart below shows the highest readings taken from the final data.)



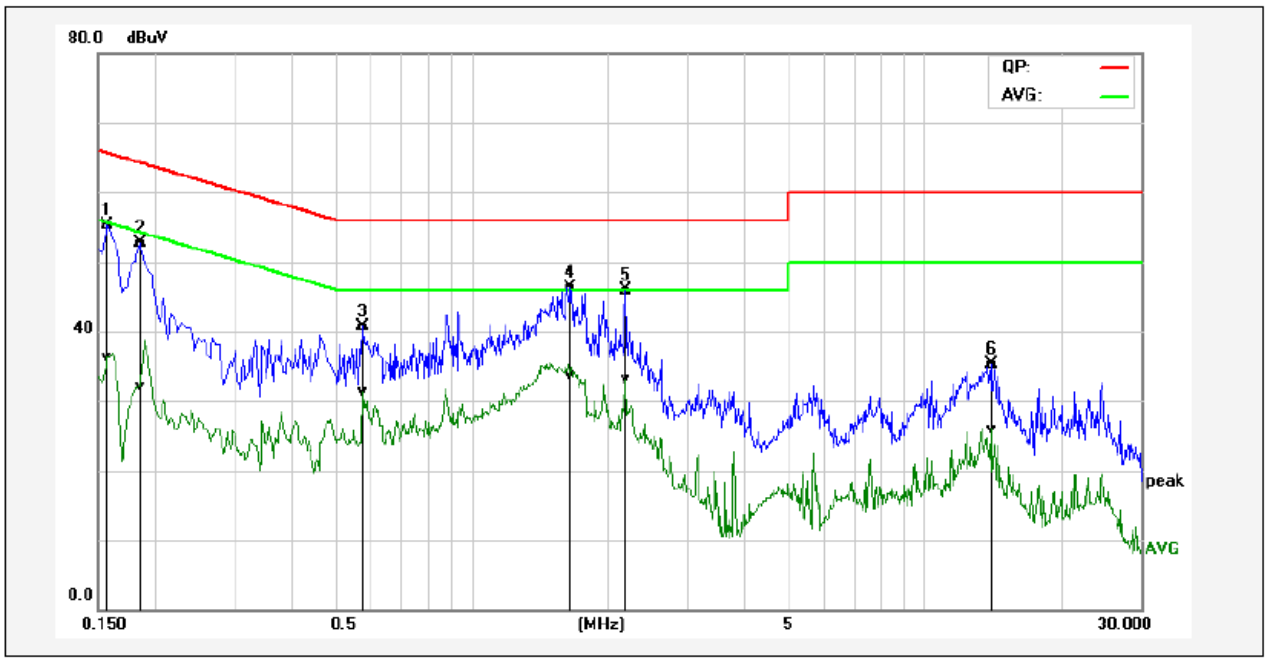
No.	Frequency (MHz)	QuasiPeak reading (dBuV)	Average reading (dBuV)	Correction factor (dB)	QuasiPeak result (dBuV)	Average result (dBuV)	QuasiPeak limit (dBuV)	Average limit (dBuV)	QuasiPeak margin (dB)	Average margin (dB)	Remark
1	0.1539	44.26	27.99	9.61	53.87	37.60	65.78	55.79	-11.91	-18.19	Pass
2	0.2540	36.90	21.25	9.61	46.51	30.86	61.62	51.63	-15.11	-20.77	Pass
3*	1.3580	34.52	25.17	9.63	44.15	34.80	56.00	46.00	-11.85	-11.20	Pass
4	1.8180	34.61	21.57	9.65	44.26	31.22	56.00	46.00	-11.74	-14.78	Pass
5	5.4860	22.70	3.37	9.71	32.41	13.08	60.00	50.00	-27.59	-36.92	Pass
6	13.4340	27.00	18.53	9.79	36.79	28.32	60.00	50.00	-23.21	-21.68	Pass

REMARKS: *L = Live Line*

Pre-scan all mode and recorded the worst case results in this report (TX-highest Channel)

EUT Name	Mechanical Keyboard	Model	PKKE221
Environmental Conditions	23.1℃/52%RH/101.0kPa	Test Mode	DH5 2480MHz
Tested By	Wang Xinyuan	Line	N
Tested Date	2023-01-10	Test Voltage	AC 120V/60Hz

(The chart below shows the highest readings taken from the final data.)



No.	Frequency (MHz)	QuasiPeak reading (dBuV)	Average reading (dBuV)	Correction factor (dB)	QuasiPeak result (dBuV)	Average result (dBuV)	QuasiPeak limit (dBuV)	Average limit (dBuV)	QuasiPeak margin (dB)	Average margin (dB)	Remark
1	0.1580	45.79	26.65	9.60	55.39	36.25	65.56	55.57	-10.17	-19.32	Pass
2	0.1860	43.12	22.57	9.60	52.72	32.17	64.21	54.21	-11.49	-22.04	Pass
3	0.5780	31.07	21.69	9.60	40.67	31.29	56.00	46.00	-15.33	-14.71	Pass
4*	1.6580	36.74	24.03	9.64	46.38	33.67	56.00	46.00	-9.62	-12.33	Pass
5	2.1900	36.24	23.41	9.64	45.88	33.05	56.00	46.00	-10.12	-12.95	Pass
6	14.0060	25.40	16.14	9.86	35.26	26.00	60.00	50.00	-24.74	-24.00	Pass

REMARKS: *N = Neutral Line.*

Pre-scan all mode and recorded the worst case results in this report (TX-highest Channel)

12. MAXIMUM PEAK OUTPUT POWER

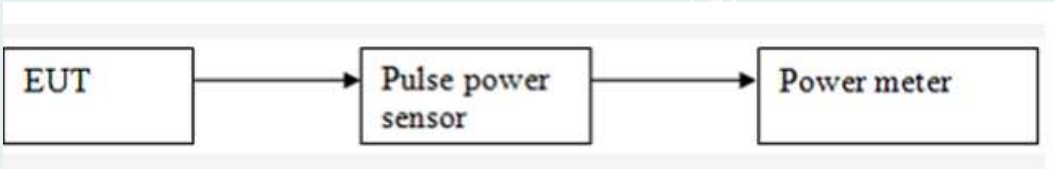
12.1 LIMITS

Regulation 15.247 (b)(1)For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

12.2 TEST PROCEDURES

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the power meter and enable the EUT transmit continuously.
2) Keep the EUT in transmitting at lowest, middle and highest channel individually. Record the max value.

12.3 TEST SETUP



---------- **The following blanks** ----------

12.4 TEST RESULTS

Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date: 2023-01-05

DH5

Test Channel	Fundamental Frequency (GHz)	Max Output Power(dBm)	Limit (dBm)	Peak/ Average	Pass/Fail
Lowest	2.402	-3.51	20.97	Peak	Pass
Middle	2.441	-3.27			Pass
Highest	2.480	-3.04			Pass

Test result: The unit does meet the FCC requirements.

---------- The following blanks ----------

13. CONDUCTED BAND EDGES AND SPURIOUS EMISSIONS

13.1 LIMITS

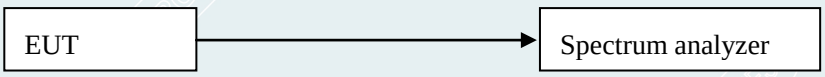
In any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB.

13.2 TEST PROCEDURES

Test procedures follow KDB 558074 D01 DTS Measurement Guidance v05r02.

1) Remove the antenna from the EUT and then connect a low attenuation cable from the antenna port to the spectrum.
2) Set the spectrum analyzer: RBW =100kHz; VBW =300kHz, Frequency range = 30MHz to 26.5GHz; Sweep = auto; Detector Function = Peak. Trace = Max, hold.
3) Measure and record the results in the test report.
4) The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

13.3 TEST SETUP



13.4 TEST RESULTS

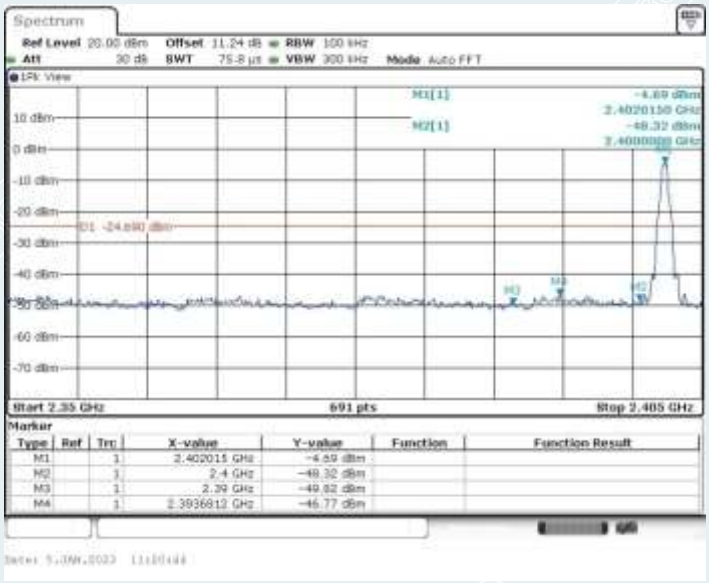
Environment: 23.6℃/55%RH/101.0kPa Voltage:DC 3.87V
Tested By:Qin Tingting Date: 2023-01-05

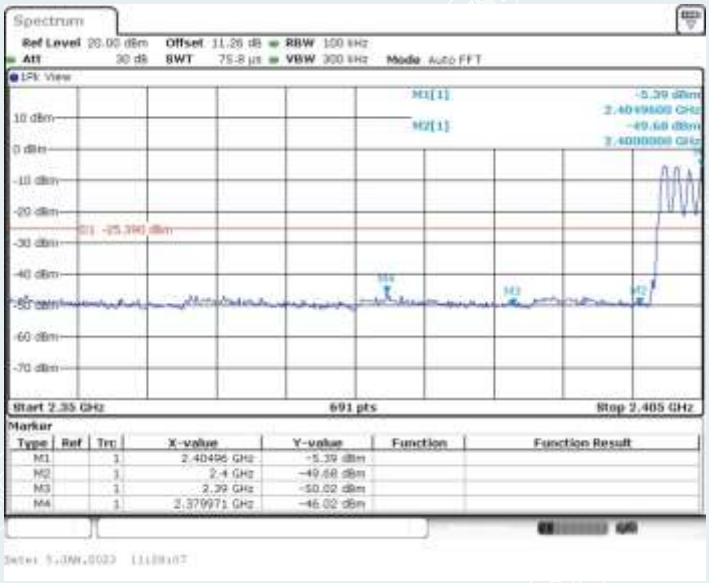
Test result plot as follows:

Band Edges

DH5

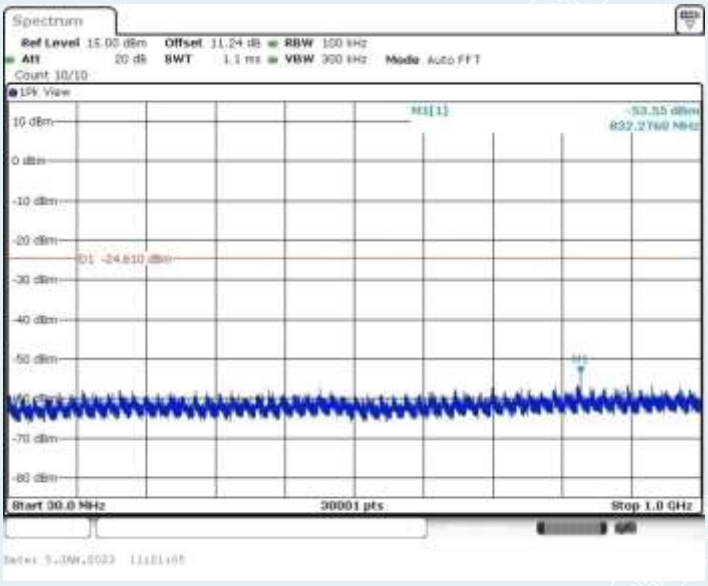
CH Low (2.35GHz ~2.405GHz)

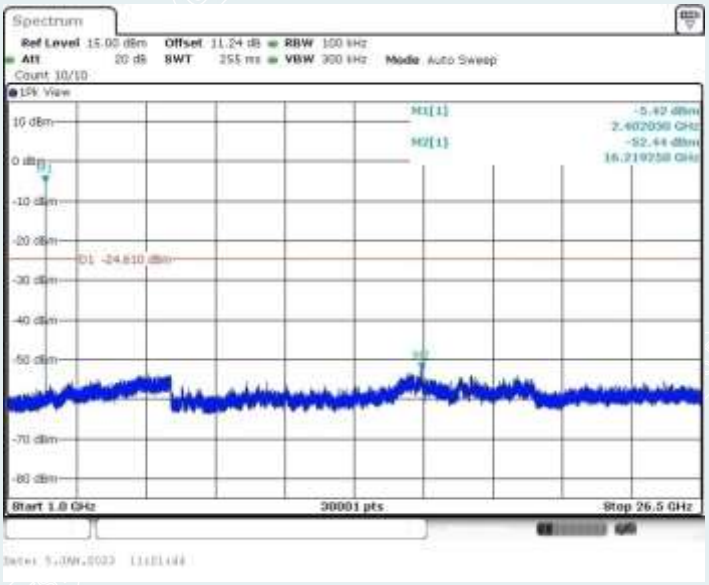




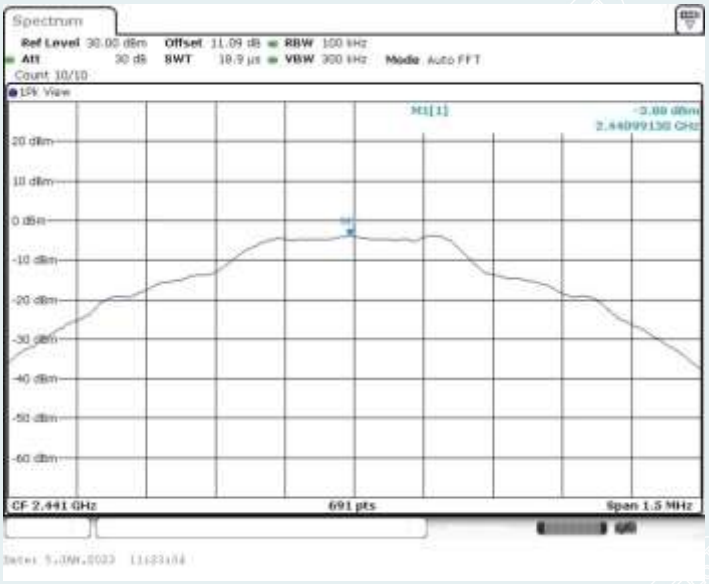
CH High (2.47GHz ~ 2.55GHz)

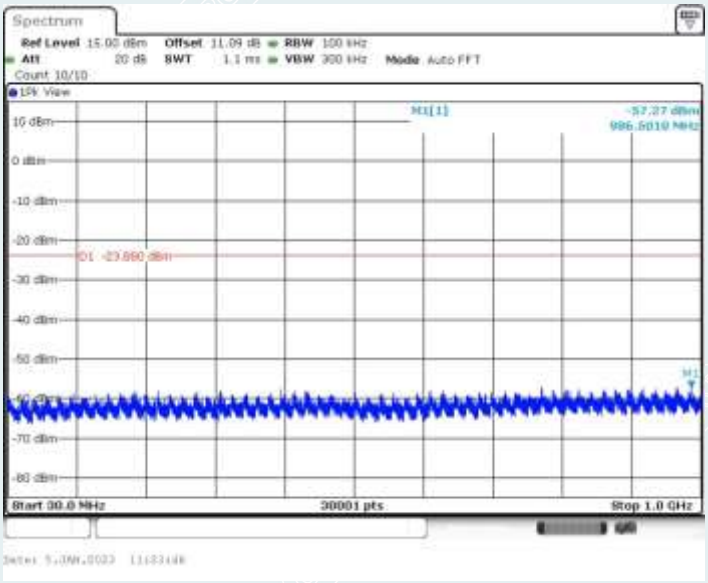
Spurious Emissions
DH5
CH Low

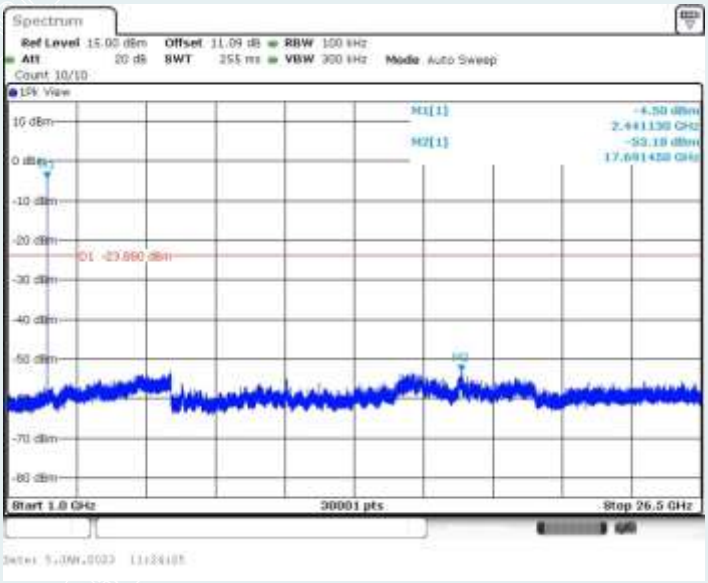



Spectrum
Ref Level 15.00 dBm Offset 11.24 dB RBW 100 kHz
Att 20 dB SWT 255 ms VBW 300 kHz Mode Auto Sweep
Count 10/10
1Pk View
M1[1] -5.42 dBm
2.402050 GHz
M2[1] -52.44 dBm
16.219250 GHz
D1 -24.610 dBm
Start 1.0 GHz 30001 pts Stop 26.5 GHz

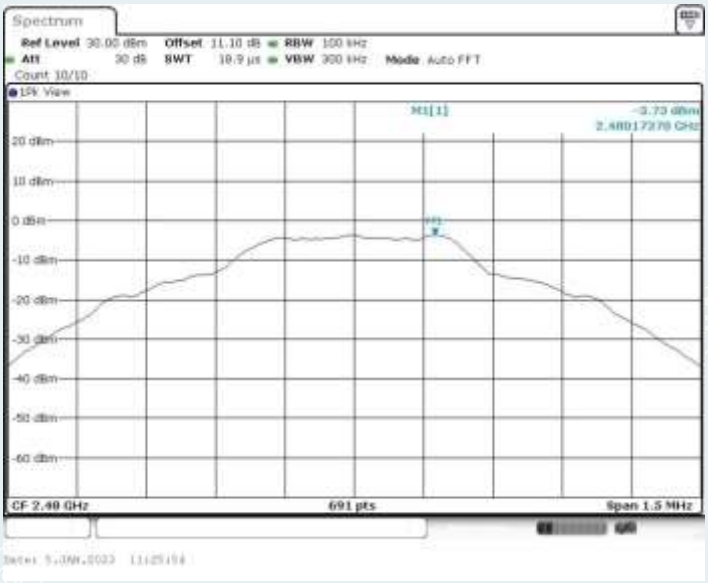
CH Mid

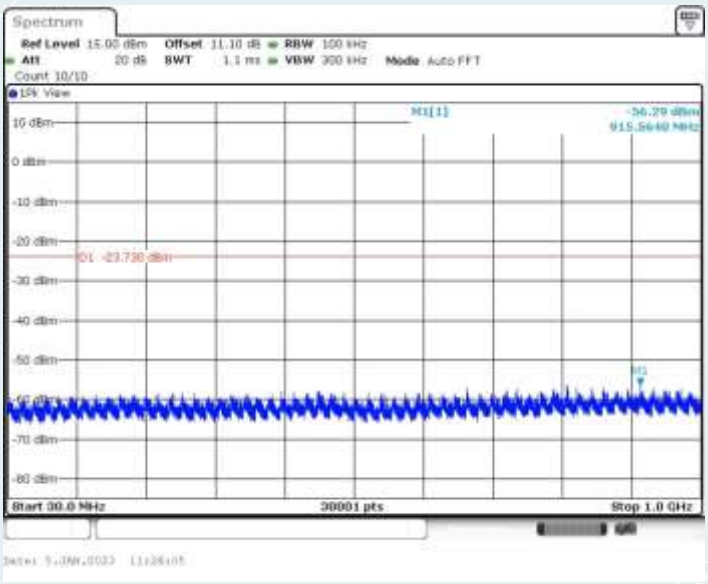

Spectrum
Ref Level 30.00 dBm Offset 11.09 dB RBW 100 kHz
Att 30 dB SWT 18.9 µs VBW 300 kHz Mode Auto FFT
Count 10/10
1Pk View
M1[1] -3.88 dBm
2.440999130 GHz
CF 2.441 GHz 691 pts Span 1.5 MHz

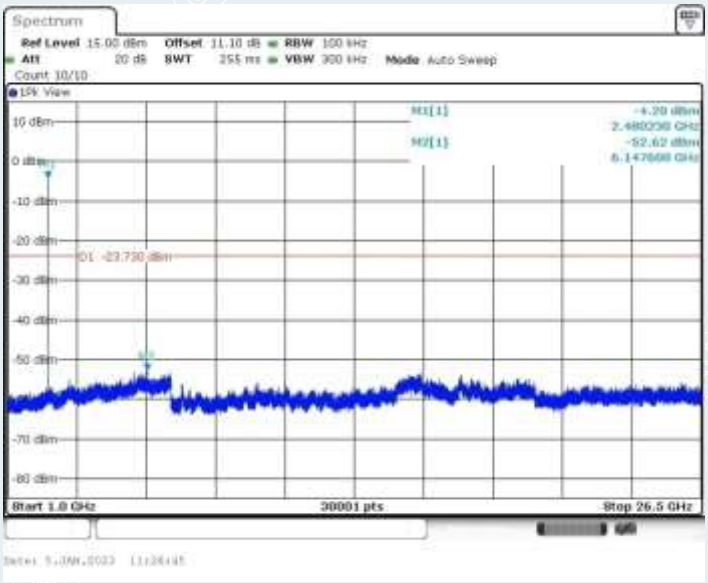

Spectrum
Ref Level 15.00 dBm Offset 11.09 dB RBW 100 kHz
Att 20 dB SWT 1.1 ms VBW 300 kHz Mode Auto FFT
Count 10/10
1Pk View
M1[1] -57.27 dBm
986.5010 MHz
D1 -23.890 dBm
Start 30.0 MHz 30001 pts Stop 1.0 GHz


Spectrum
Ref Level 15.00 dBm Offset 11.09 dB RBW 100 kHz
Att 20 dB SWT 255 ms VBW 300 kHz Mode Auto Sweep
Count 10/10
1Pk View
M1[1] -4.50 dBm
2.441130 GHz
M2[1] -53.18 dBm
17.691450 GHz
D1 -23.890 dBm
Start 1.0 GHz 30001 pts Stop 26.5 GHz

CH High


Spectrum
Ref Level 30.00 dBm Offset 11.10 dB RBW 100 kHz
Att 30 dB SWT 10.9 µs VBW 300 kHz Mode Auto FFT
Count 10/10
1Pk View
M1[1] -3.73 dBm
2.48017270 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
CF 2.48 GHz 691 pts Span 1.5 MHz


Spectrum
Ref Level 15.00 dBm Offset 11.10 dB RBW 100 kHz
Att 20 dB SWT 1.1 ms VBW 300 kHz Mode Auto FFT
Count 10/10
1Pk View
M1[1] -56.29 dBm
915.5640 MHz
10 dBm
0 dBm
-10 dBm
-20 dBm
D1 -23.730 dBm
-30 dBm
-40 dBm
-50 dBm
-70 dBm
-80 dBm
Start 30.0 MHz 30001 pts Stop 1.0 GHz



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14. RADIATED SPURIOUS EMISSIONS

14.1 LIMITS

In any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB. Attenuation below the general limits specified in §15.209(a) is not required.

Frequency (MHz)	Quasi-peak(μV/m)	Measurement distance(m)	Quasi-peak(dBμV/m)@distance 3m
0.009-0.490	2400/F(kHz)	300	128.5~93.8
0.490-1.705	24000/F(kHz)	30	73.8~63
1.705-30.0	30	30	69.5
30 ~ 88	100	3	40
88~216	150	3	43.5
216 ~ 960	200	3	46
Above 960	500	3	54

NOTE:

(1) The emission limits for the ranges 9-90kHz and 110-490kHz are based on measurements employing a linear average detector.

(2) The lower limit shall apply at the transition frequencies.

(3) Above 18GHz test distance is 1m, so the Peak Limit=74+20*log(3/1)=83.54 (dBμV/m). The Avg Limit=54+20*log(3/1)=63.54 (dBμV/m).

14.2 TEST PROCEDURES

1) Sequence of testing 9kHz to 30MHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground.

--- Set the EUT transmit continuously with maximum output power.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Pre measurement:

--- The turntable rotates from 0 °to 360 °.

--- The antenna height is 1.0 meter.

--- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

--- Identified emissions during the pre measurement the software maximizes by rotating the turntable position (0 °to 360 °) and by rotating the elevation axes (0 °to 360 °).

--- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QP detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the pre measurement and the limit will be stored.

2) Sequence of testing 30MHz to 1GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Set the EUT transmit continuously with maximum output power.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Pre measurement:

--- The turntable rotates from 0 °to 360 °.

--- The antenna is polarized vertical and horizontal.

--- The antenna height changes from 1 to 4 meter.

--- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable rotates from 0 °to 360 °and antenna movement between 1 and 4 meter.

--- The final measurement will be done with QP detector with an EMI receiver.

--- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

3) Sequence of testing 1GHz to 18GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Set the EUT transmit continuously with maximum output power.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Pre measurement:

--- The turntable rotates from 0 °to 360 °.

--- The antenna is polarized vertical and horizontal.

--- The antenna height scan range is 1 meter to 4 meter.

--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable rotates from 0 °to 360 °and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.

--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.
--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the pre measurement with marked maximum final measurements and the limit will be stored.

4) Sequence of testing above 18GHz
Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Set the EUT transmit continuously with maximum output power.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 1 meter.

--- The EUT was set into operation.

Pre measurement:

--- The antenna is moved spherical over the EUT in different polarisations of the antenna.

Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.
--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

NOTE:
(a).The frequency from 9kHz to 150kHz, Set RBW=300Hz(for Peak&AVG), RBW=300Hz(for Peak&AVG). the frequency from 150kHz to 30MHz, Set RBW=9kHz, RBW=9kHz, (for QP Detector).

(b).The frequency from 30MHz to 1GHz, Set RBW=120kHz, RBW=300kHz, (for QP Detector).
(c).The frequency above 1GHz, for Peak detector: Set RBW=1MHz, RBW=3MHz.
(d).The frequency above 1GHz, for Avg detector: Set RBW=1MHz, if the EUT is configured to transmit with duty cycle ≥98%， set VBW≤RBW/100 (i.e.,10kHz) but not less than 10 Hz. if the EUT duty cycle is ＜98%， set VBW≥1/T, Where T is defined in section 2.8.

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14.3 TEST SETUP

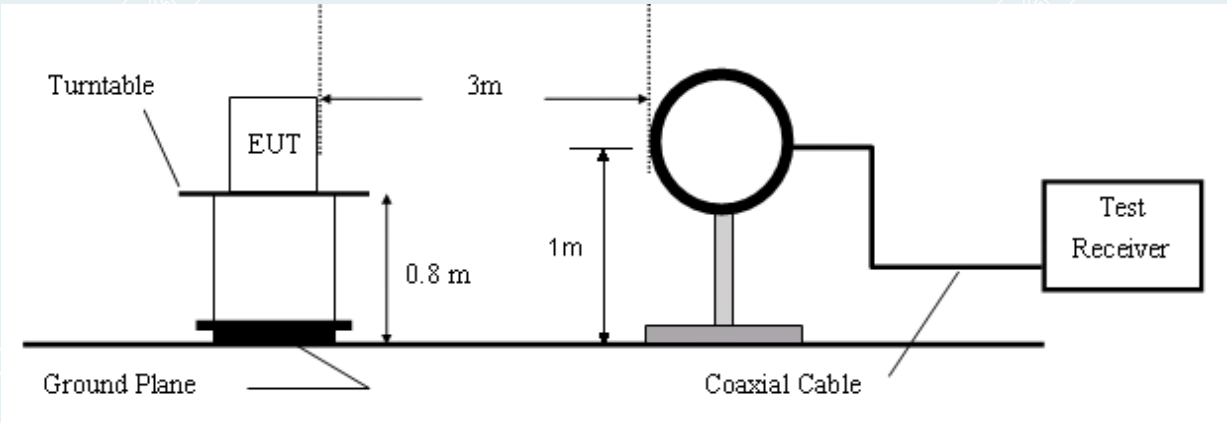


Figure 1. 9kHz to 30MHz radiated emissions test configuration

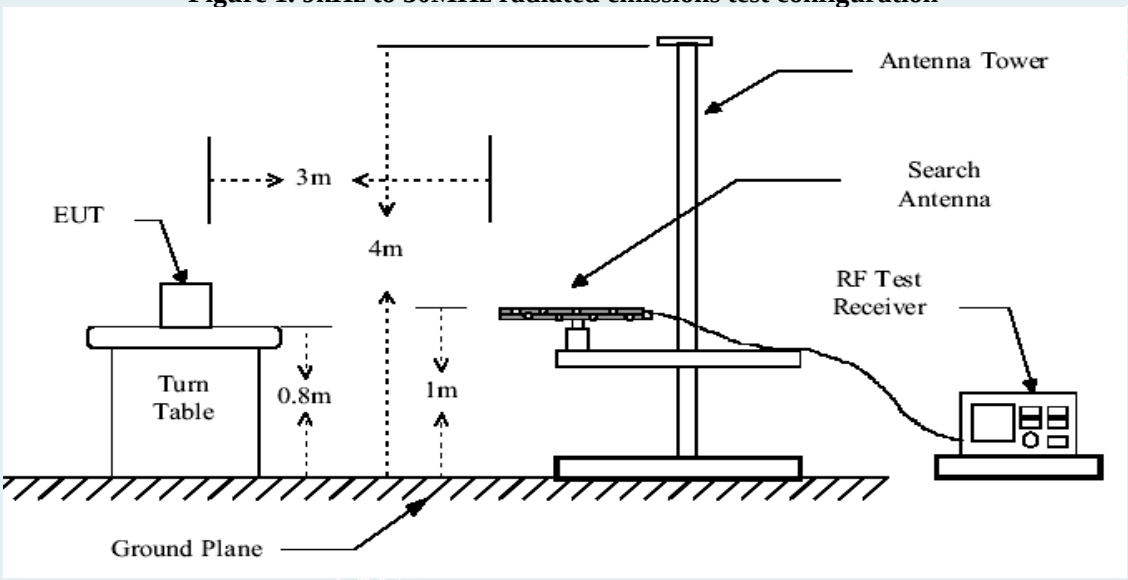


Figure 2. 30MHz to 1GHz radiated emissions test configuration

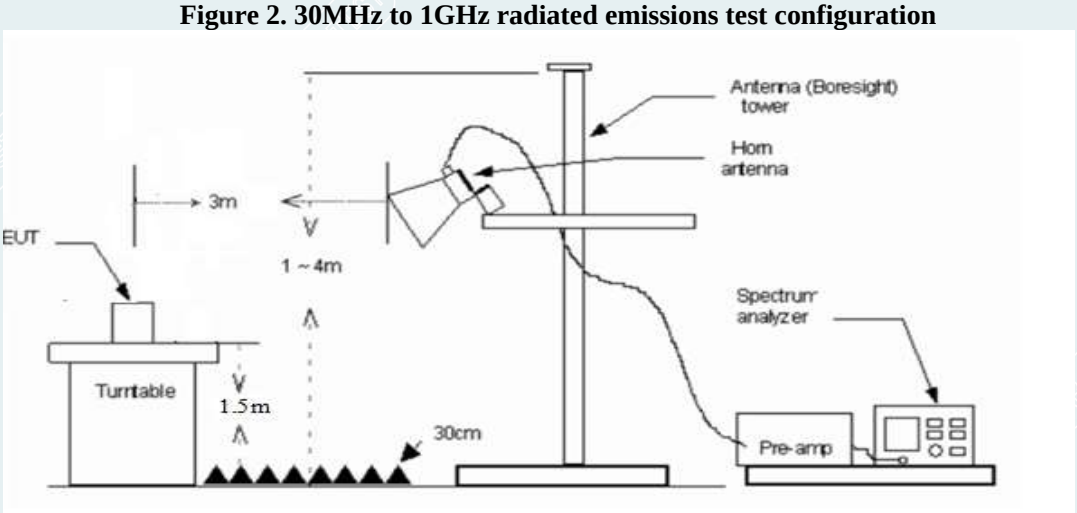


Figure 3. 1GHz to 18GHz radiated emissions test configuration

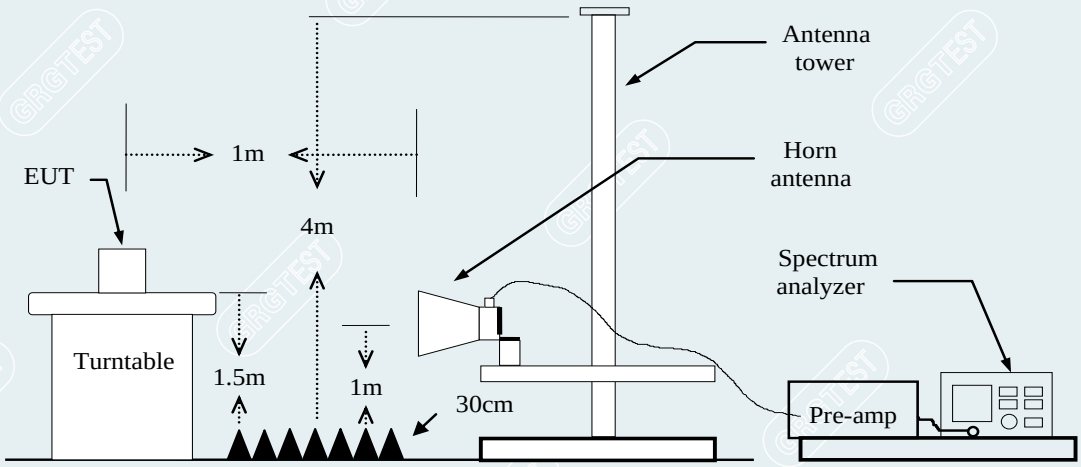


Figure 4. 18GHz to 26.5GHz radiated emissions test configuration

14.4 DATA SAMPLE

30MHz to 1GHz

No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Pole
xxx	xxx	37.06	-15.48	21.58	40.00	-18.42	QP	Vertical

1GHz-18GHz

No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Pole
xxx	xxx	65.45	-11.12	54.33	74.00	-19.67	peak	Vertical
xxx	xxx	63.00	-11.12	51.88	54.00	-2.12	AVG	Vertical

Above 18GHz

No.	Frequency (MHz)	Reading (dBuV/m)	Factor (dB)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Pole
xxx	xxx	68.86	57.66	-11.20	83.54	25.88	peak	Vertical
xxx	xxx	68.89	-11.20	57.69	63.54	5.85	AVG	Vertical

Frequency (MHz) = Emission frequency in MHz

Ant.Pol. (H/V) = Antenna polarization

Reading (dBuV) = Uncorrected Analyzer / Receiver reading

Correction Factor (dB/m) = Antenna factor + Cable loss – Amplifier gain

Result (dBuV/m) = Reading (dBuV) + Correction Factor (dB/m)

Limit (dBuV/m) = Limit stated in standard

Margin (dB) = Remark Result (dBuV/m) – Limit (dBuV/m)

Peak = Peak Reading

QP = Quasi-peak Reading

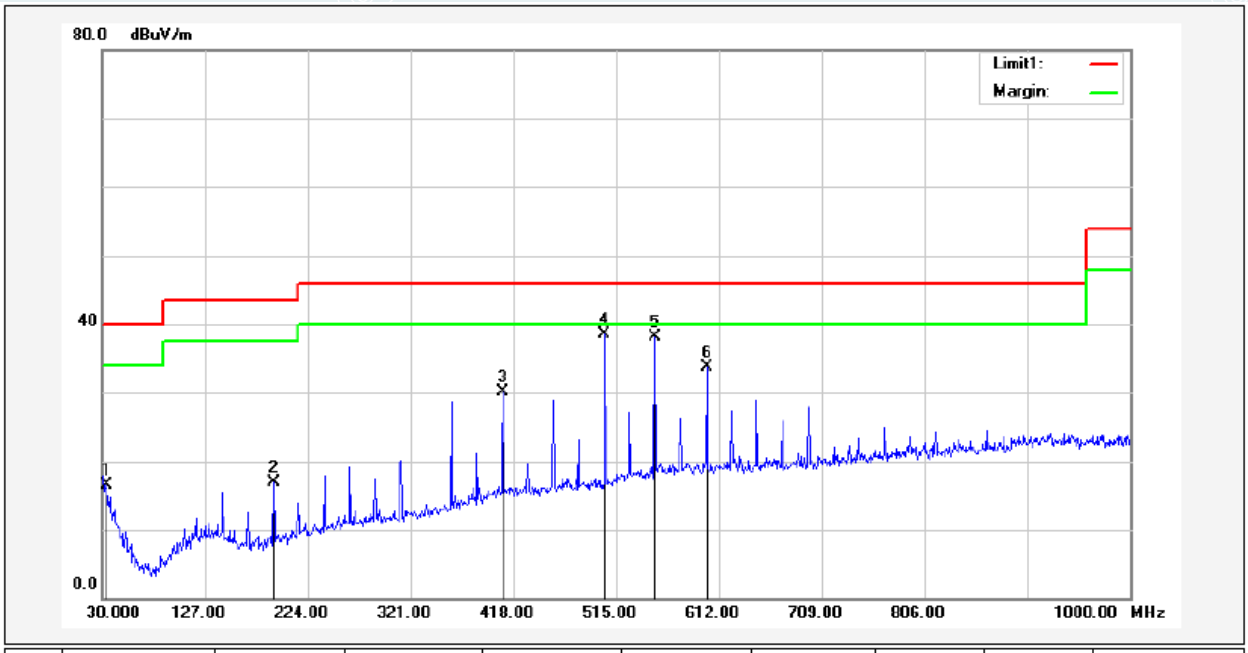
AVG = Average Reading

14.5 TEST RESULTS

Below 1GHz

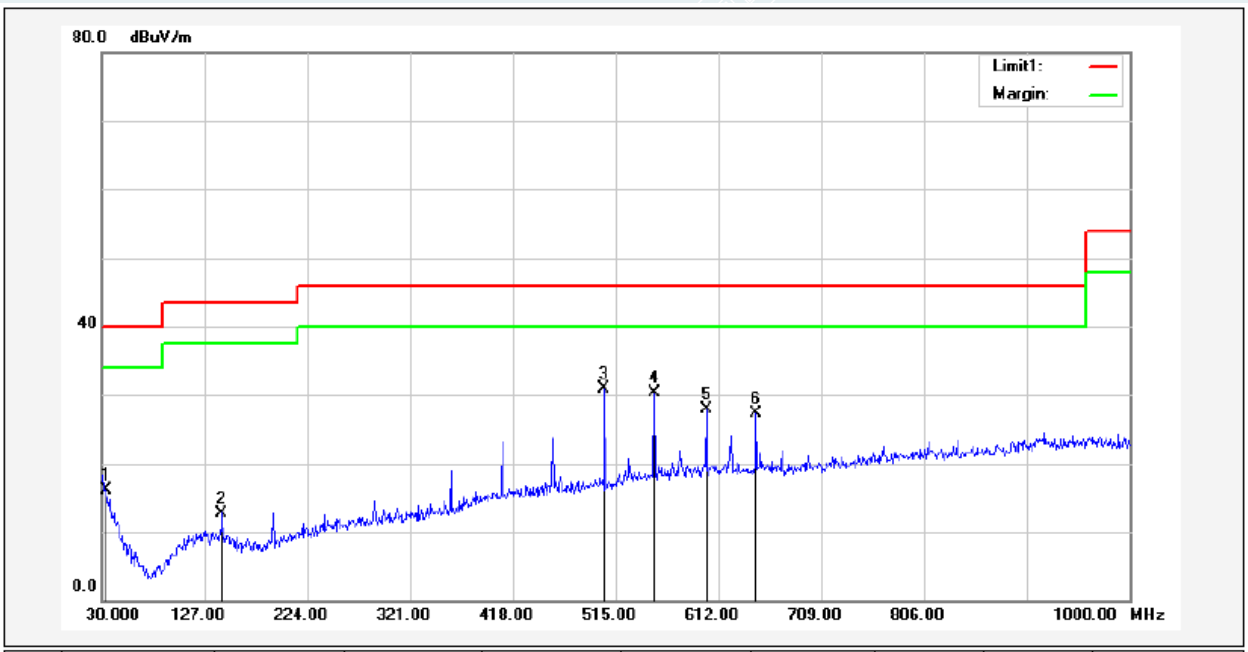
The chart below shows the highest readings taken from the final data.

Mode: DH5
Highest Frequency (2480MHz) Date: 2023-04-10
Environment: 22.6℃/51%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Wang Xinyuan Probe : Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Correction factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Degree (deg.)	Height (cm)	Detector type
1	34.8500	35.42	-18.99	16.43	40.00	-23.57	10	100	QP
2	191.9900	44.01	-27.03	16.98	43.50	-26.52	112	100	QP
3	408.3000	49.81	-19.80	30.01	46.00	-15.99	252	100	QP
4*	504.3300	56.48	-18.06	38.42	46.00	-7.58	56	200	QP
5	551.8600	54.67	-16.49	38.18	46.00	-7.82	56	200	QP
6	600.3600	49.84	-16.12	33.72	46.00	-12.28	49	200	QP

Mode: DH5
Highest Frequency (2480MHz) Date: 2023-04-10
Environment: 22.6℃/51%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Wang Xinyuan Probe : Vertical



No.	Frequency (MHz)	Reading (dBuV)	Correction factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Degree (deg.)	Height (cm)	Detector type
1	33.8800	34.69	-18.52	16.17	40.00	-23.83	360	399	QP
2	143.4900	38.95	-26.15	12.80	43.50	-30.70	358	400	QP
3*	504.3300	48.95	-18.06	30.89	46.00	-15.11	353	200	QP
4	551.8600	46.78	-16.49	30.29	46.00	-15.71	360	105	QP
5	600.3600	43.98	-16.12	27.86	46.00	-18.14	19	100	QP
6	647.8900	43.11	-15.84	27.27	46.00	-18.73	5	100	QP

Remark:

1 No emission found between lowest internal used/generated frequency to 30MHz.
2 Pre-scan all mode and recorded the worst case results in this report (TX-Highest Channel(DH5))
3 Measuring frequencies from 9kHz to the 1GHz.
4 Radiated emissions measured in frequency range from 30MHz to 1GHz were made with an instrument using Peak/Quasi-peak detector mode.
5 Data of measurement within this frequency range shown " --- " in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.
6 The IF bandwidth of SPA between 30MHz to 1GHz was 120kHz.

Above 1GHz to 18GHz

Mode: DH5
Lowest Frequency (2402MHz) Date: 2023-02-16
Environment: 25.0℃/60%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Zhang Zishan

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1120.015	70.96	45.66	-25.30	74.00	28.34	100	228	Horizontal
2	1994.1243	65.49	44.32	-21.17	74.00	29.68	100	228	Horizontal
3	2498.9374	61.68	43.01	-18.67	74.00	30.99	100	238	Horizontal
4	2998.7498	62.42	45.28	-17.14	74.00	28.72	200	189	Horizontal
5	3266.2833	60.88	44.45	-16.43	74.00	29.55	100	260	Horizontal
6	10499.0624	47.44	53.01	5.57	74.00	20.99	200	191	Horizontal

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	10499.0624	5.57	42.15	47.72	54.00	6.28	200	191	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1118.0148	69.69	46.84	-22.85	74.00	27.16	200	226	Vertical
2	2653.2067	62.05	44.24	-17.81	74.00	29.76	100	276	Vertical
3	4254.5318	59.23	44.93	-14.30	74.00	29.07	100	279	Vertical
4	4803.9755	58.67	45.78	-12.89	74.00	28.22	200	172	Vertical
5	6396.0495	57.00	49.87	-7.13	74.00	24.13	100	259	Vertical
6	10699.7125	46.74	52.34	5.60	74.00	21.66	200	319	Vertical

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	6367.0773	-7.13	49.42	42.29	54.00	11.71	100	242.9	Vertical
2	10699.7125	5.60	42.14	47.74	54.00	6.26	200	319	Vertical

Mode: DH5
Middle Frequency (2441MHz) Date: 2023-02-16
Environment: 25.0℃/60%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Zhang Zishan

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1119.2649	70.61	45.30	-25.31	74.00	28.70	100	219	Horizontal
2	1995.6245	67.16	45.98	-21.18	74.00	28.02	100	248	Horizontal
3	2848.9811	64.63	48.33	-16.30	74.00	25.67	100	189	Horizontal
4	3266.2833	62.70	46.27	-16.43	74.00	27.73	100	251	Horizontal
5	10465.3082	47.09	52.89	5.80	74.00	21.11	100	65	Horizontal
6	17713.0891	43.97	52.64	8.67	74.00	21.36	100	319	Horizontal

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2843.7862	-16.30	45.70	29.40	54.00	24.60	183	274.8	Horizontal
2	10465.3082	5.80	42.12	47.92	54.00	6.08	100	65	Horizontal
3	17713.0891	8.67	39.14	47.81	54.00	6.19	100	319	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1118.2648	68.71	45.85	-22.86	74.00	28.15	200	217	Vertical
2	1993.1241	64.98	44.29	-20.69	74.00	29.71	200	208	Vertical
3	2593.9492	61.25	42.86	-18.39	74.00	31.14	100	51	Vertical
4	4880.8601	56.81	45.28	-11.53	74.00	28.72	200	171	Vertical
5	6414.8018	58.79	51.73	-7.06	74.00	22.27	100	251	Vertical
6	10465.3082	46.23	52.24	6.01	74.00	21.76	100	280	Vertical

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	6401.6198	-7.06	50.44	43.38	54.00	10.62	100	242.4	Vertical
2	10465.3082	6.01	41.14	47.15	54.00	6.85	100	280	Vertical

Mode: DH5
Highest Frequency (2480MHz)
Environment: 25.0℃/60%RH/101.0kPa
Test Engineer: Zhang Zishan

Date: 2023-02-16
Test Voltage: DC 3.87V

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1121.0151	71.18	45.89	-25.29	74.00	28.11	100	226	Horizontal
2	1194.7743	71.89	47.86	-24.03	74.00	26.14	100	246	Horizontal
3	1997.8747	63.51	42.34	-21.17	74.00	31.66	100	266	Horizontal
4	2845.9807	60.42	44.04	-16.38	74.00	29.96	100	140	Horizontal
5	4940.8676	55.21	43.76	-11.45	74.00	30.24	200	113	Horizontal
6	9859.6075	48.12	52.50	4.38	74.00	21.50	100	316	Horizontal

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	9859.6075	4.38	42.15	46.53	54.00	7.47	100	316	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	1065.0081	69.32	46.54	-22.78	74.00	27.46	200	186	Vertical
2	1119.5149	68.85	45.94	-22.91	74.00	28.06	200	234	Vertical
3	1793.8492	66.38	44.04	-22.34	74.00	29.96	100	63	Vertical
4	3189.3987	59.82	43.32	-16.50	74.00	30.68	100	94	Vertical
5	6379.1724	60.11	53.00	-7.11	74.00	21.00	100	241	Vertical
6	9801.4752	48.32	52.78	4.46	74.00	21.22	100	75	Vertical

AV Final Data List									
NO.	Freq. [MHz]	Factor [dB]	AV Reading [dBμV/m]	AV Value [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Height [cm]	Angle [°]	Polarity
1	6388.5885	-7.11	52.01	44.90	54.00	9.10	101	241.8	Vertical
2	9801.4752	4.46	42.21	46.67	54.00	7.33	100	75	Vertical

Remark:

1 Measuring frequencies from 1 GHz to 18GHz harmonic of highest fundamental frequency.

2 Measurements above show only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin>20dB from the applicable limit) and considered that's already beyond the background noise floor.

3 Radiated emissions measured in frequency above 1000MHz were made with an instrument using Peak detector mode and average detector mode of the emission shown in Actual FS column.

4 Spectrum setting:
a. Peak Setting 1GHz–26.5GHz, RBW = 1MHz, VBW = 1MHz, Sweep time = auto.
b. AV Setting 1GHz–26.5GHz, Set RBW=1MHz, if the EUT is configured to transmit with duty cycle ≥98%，set VBW≤RBW/100 (i.e.,10kHz) but not less than 10 Hz. if the EUT duty cycle is ＜98%，set VBW≥1/T, Where T is defined in section 2.8.

Test result: The unit does meet the requirements.

---------- The following blanks ----------

18GHz to 26.5GHz

According to C63.10, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement, so AV emission value did not show in below table if the peak value complies with average limit.

Mode: DH5
Lowest Frequency (2402MHz) Date: 2023-01-31
Environment: 20.3℃/45%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Zhang Zishan

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	18436.05	53.13	40.86	-12.27	83.54	42.68	100	18	Horizontal
2	19803.7	53.69	42.51	-11.18	83.54	41.03	200	328	Horizontal
3	20847.925	51.12	40.92	-10.20	83.54	42.62	100	233	Horizontal
4	21708.55	51.32	41.56	-9.76	83.54	41.98	100	18	Horizontal
5	22998	49.59	40.95	-8.64	83.54	42.59	200	247	Horizontal
6	25370.35	47.59	40.34	-7.25	83.54	43.20	100	312	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	18750.975	53.05	41.11	-11.94	83.54	42.43	200	30	Vertical
2	19803.7	53.66	42.58	-11.08	83.54	40.96	100	15	Vertical
3	21313.3	51.03	41.15	-9.88	83.54	42.39	100	109	Vertical
4	23373.7	49.76	41.14	-8.62	83.54	42.40	200	15	Vertical
5	25062.65	49.03	41.90	-7.13	83.54	41.64	100	92	Vertical
6	26357.2	47.17	40.08	-7.09	83.54	43.46	100	92	Vertical

Mode: DH5
Middle Frequency (2441MHz) Date: 2023-01-31
Environment: 20.3℃/45%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Zhang Zishan

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	19795.625	54.38	43.19	-11.19	83.54	40.35	100	346	Horizontal
2	20709.375	51.88	41.56	-10.32	83.54	41.98	200	282	Horizontal
3	22785.075	50.24	41.49	-8.75	83.54	42.05	200	251	Horizontal
4	24571.35	49.10	41.39	-7.71	83.54	42.15	100	94	Horizontal
5	25262.825	47.71	40.56	-7.15	83.54	42.98	100	189	Horizontal
6	26276.45	46.80	39.40	-7.40	83.54	44.14	100	127	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	18702.1	53.13	41.15	-11.98	83.54	42.39	100	172	Vertical
2	19795.625	54.65	43.56	-11.09	83.54	39.98	200	358	Vertical
3	20547.45	51.49	41.16	-10.33	83.54	42.38	100	282	Vertical
4	24328.25	48.91	40.92	-7.99	83.54	42.62	100	282	Vertical
5	25549.275	47.96	40.54	-7.42	83.54	43.00	100	265	Vertical
6	26342.75	47.68	40.55	-7.13	83.54	42.99	100	235	Vertical

Mode: DH5
Highest Frequency (2480MHz) Date: 2023-01-31
Environment: 20.3℃/45%RH/101.0kPa Test Voltage: DC 3.87V
Test Engineer: Zhang Zishan

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	18863.6	52.76	40.87	-11.89	83.54	42.67	100	189	Horizontal
2	19803.7	55.11	43.93	-11.18	83.54	39.61	200	16	Horizontal
3	20822	51.05	40.83	-10.22	83.54	42.71	100	266	Horizontal
4	21915.95	50.05	40.28	-9.77	83.54	43.26	100	111	Horizontal
5	25406.9	47.61	40.32	-7.29	83.54	43.22	100	189	Horizontal
6	26368.25	46.44	39.23	-7.21	83.54	44.31	100	189	Horizontal

Suspected Data List									
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	19065.9	53.77	42.02	-11.75	83.54	41.52	200	2	Vertical
2	19795.625	54.30	43.21	-11.09	83.54	40.33	100	345	Vertical
3	21990.325	50.74	41.07	-9.67	83.54	42.47	100	127	Vertical
4	23900.7	48.76	40.34	-8.42	83.54	43.20	200	188	Vertical
5	25259.85	47.89	40.84	-7.05	83.54	42.70	100	111	Vertical
6	26201.225	47.12	39.64	-7.48	83.54	43.90	100	111	Vertical

15. RESTRICTED BANDS OF OPERATION

15.1 LIMITS

Section 15.247(d) In addition, Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

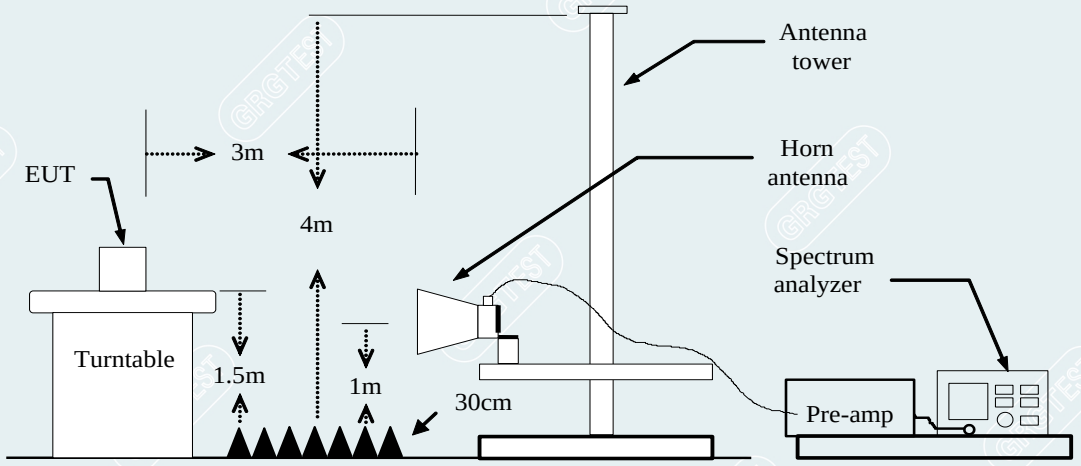
MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2655 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	
13.36 - 13.41			

Frequency (MHz)	Quasi-peak(μV/m)	Measurement distance(m)	Quasi-peak(dBμV/m)@distance 3m
0.009-0.490	2400/F(kHz)	300	128.5~93.8
0.490-1.705	24000/F(kHz)	30	73.8~63
1.705-30.0	30	30	69.5
30 ~ 88	100	3	40
88~216	150	3	43.5
216 ~ 960	200	3	46
Above 960	500	3	54

15.2 TEST PROCEDURES

1) The EUT is placed on a turntable, which is 1.5m above the ground plane.
2) The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3) EUT is set 3m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emission.
4) Set the spectrum analyzer in the following setting in order to capture the lower and upper band-edges of the emission:
   a) PEAK: RBW=1MHz / VBW=1MHz / Sweep=AUTO.
   b) AVERAGE: RBW=1MHz / VBW=1/T / Sweep=AUTO.Where T is defined in section 2.8.
5) Repeat the procedures until all the PEAK and AVERAGE versus polarization are measured.

15.3 TEST SETUP



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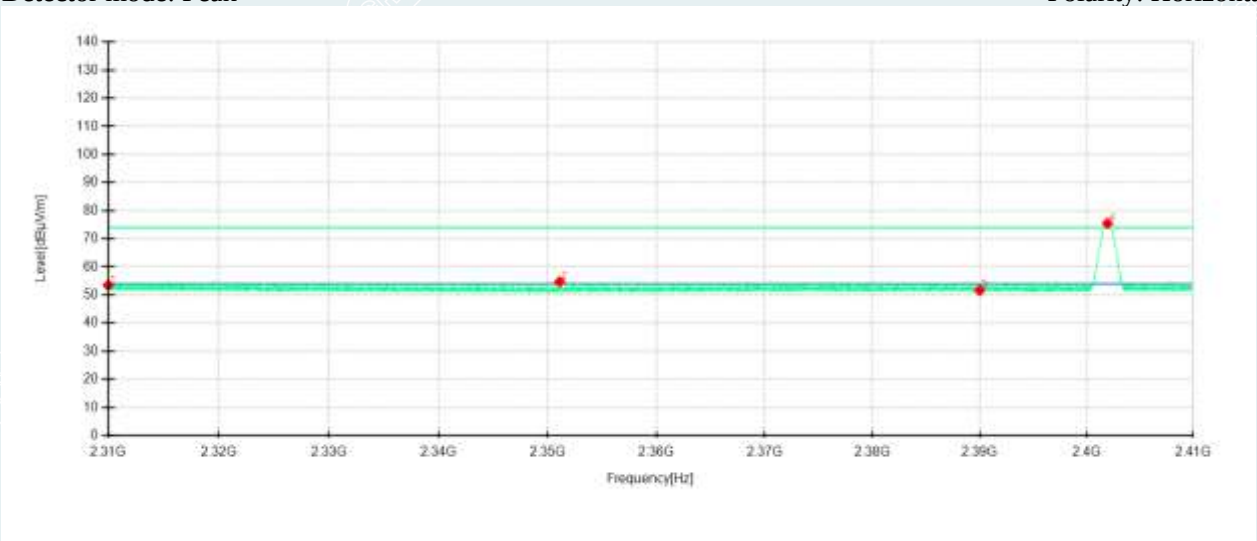
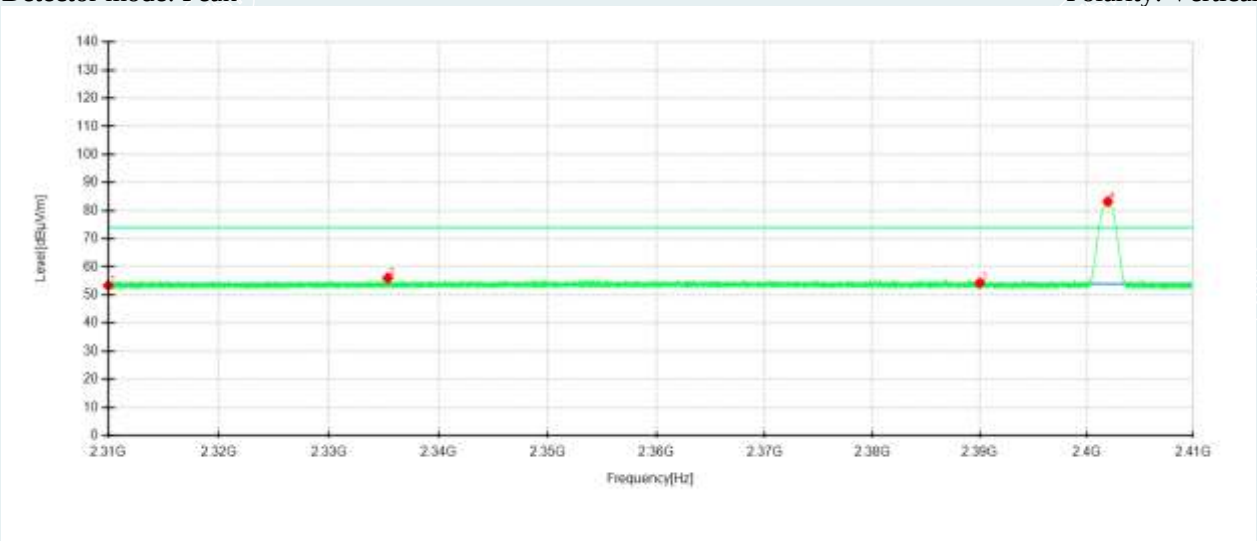
15.4 TEST RESULTS

DH5
Lowest Channel
Frequency 2402MHz
Environment: 25.3℃/54%RH/101.0kPa Test Voltage: DC 3.87V
Tested By: Chen Xiaocong Date: 2023-02-16
Detector mode: Peak Polarity: Horizontal



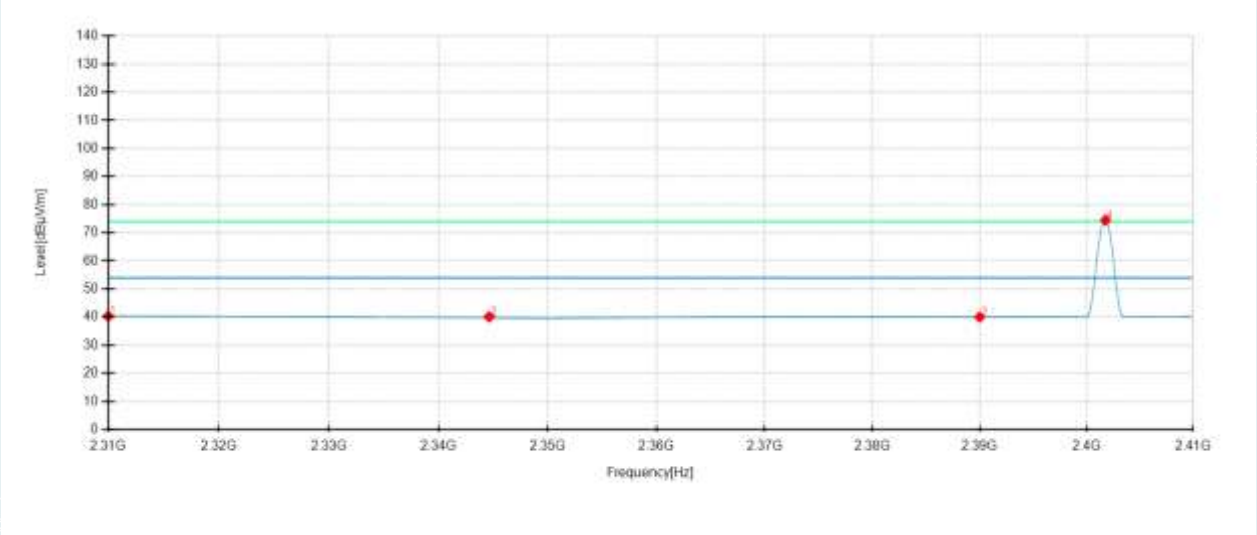
Detector mode: Peak Polarity: Vertical



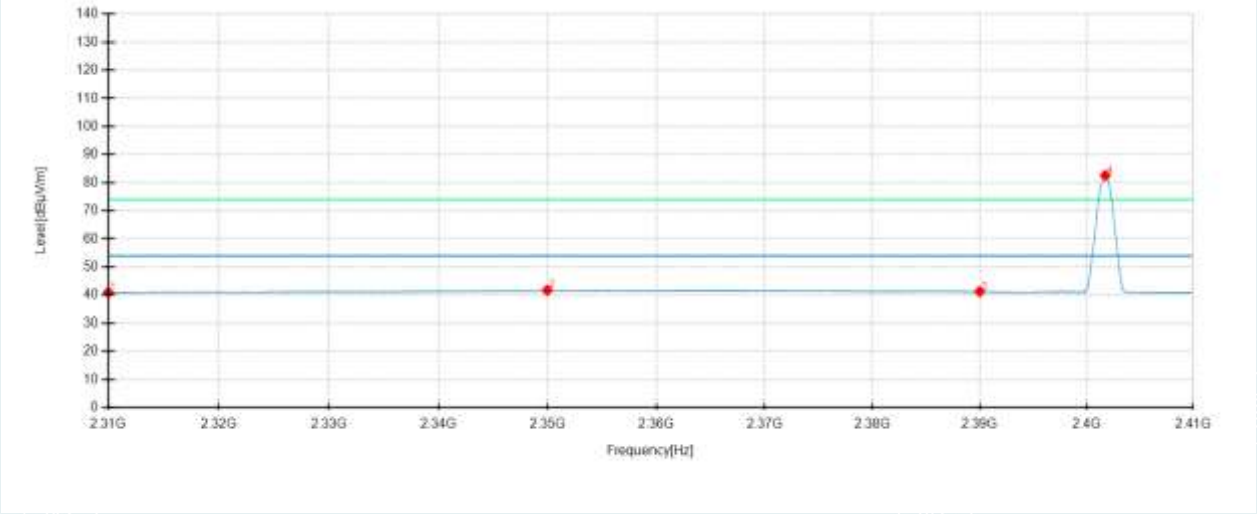
No.	Frequency MHz	Reading dBµV/m	Level dBµV/m	Factor dB	Limit dBuV/m	Margin dB	Height cm	Angle °	Pole	Remark
1	2310	44.11	53.46	9.35	74.00	20.54	200	157	Horizontal	/
2	2351.0961	46.14	54.67	8.53	74.00	19.33	100	311	Horizontal	/
3	2390	42.61	51.54	8.93	74.00	22.46	100	300	Horizontal	/
4	2401.9728	66.41	75.45	9.04	74.00	-1.45	200	224	Horizontal	No limit
1	2310	43.40	53.33	9.93	74.00	20.67	100	182	Vertical	/
2	2335.3684	45.89	56.00	10.11	74.00	18.00	100	248	Vertical	/
3	2390	44.15	54.22	10.07	74.00	19.78	200	23	Vertical	/
4	2401.9928	73.22	83.21	9.99	74.00	-9.21	100	193	Vertical	No limit

---------- The following blanks ----------

Lowest Channel
Frequency 2402MHz
Environment: 25.3℃/54%RH/101.0kPa Test Voltage: DC 3.87V
Tested By: Chen Xiaocong Date: 2023-02-16
Detector mode: Average Polarity: Horizontal



Detector mode: Average Polarity: Vertical



No.	Frequency MHz	Reading dBµV/m	Level dBµV/m	Factor dB	Limit dBuV/m	Margin dB	Height cm	Angle °	Pole	Remark
1	2310	30.94	40.29	9.35	54.00	13.71	200	346	Horizontal	/
2	2344.629	31.45	40.08	8.63	54.00	13.92	100	266	Horizontal	/
3	2390	31.05	39.98	8.93	54.00	14.02	200	126	Horizontal	/
4	2401.7728	65.45	74.48	9.03	54.00	-20.48	200	237	Horizontal	No limit
1	2310	30.96	40.89	9.93	54.00	13.11	200	66	Vertical	/
2	2349.956	31.42	41.64	10.22	54.00	12.36	200	210	Vertical	/
3	2390	31.18	41.25	10.07	54.00	12.75	100	213	Vertical	/
4	2401.7595	72.57	82.57	10.00	54.00	-28.57	100	181	Vertical	No limit

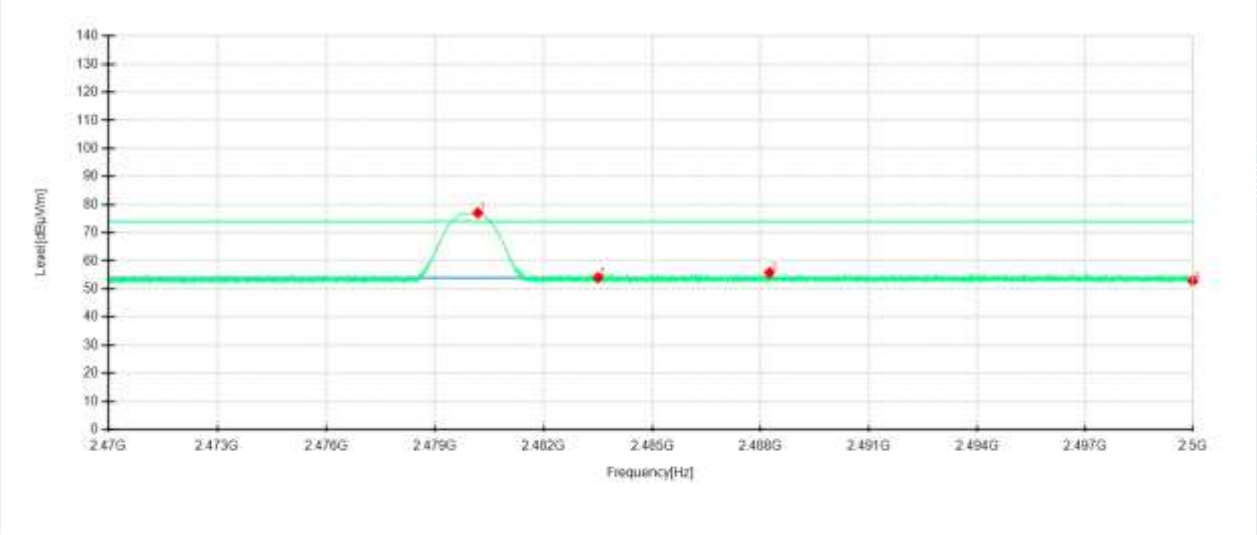
Highest Channel

Frequency 2480MHz

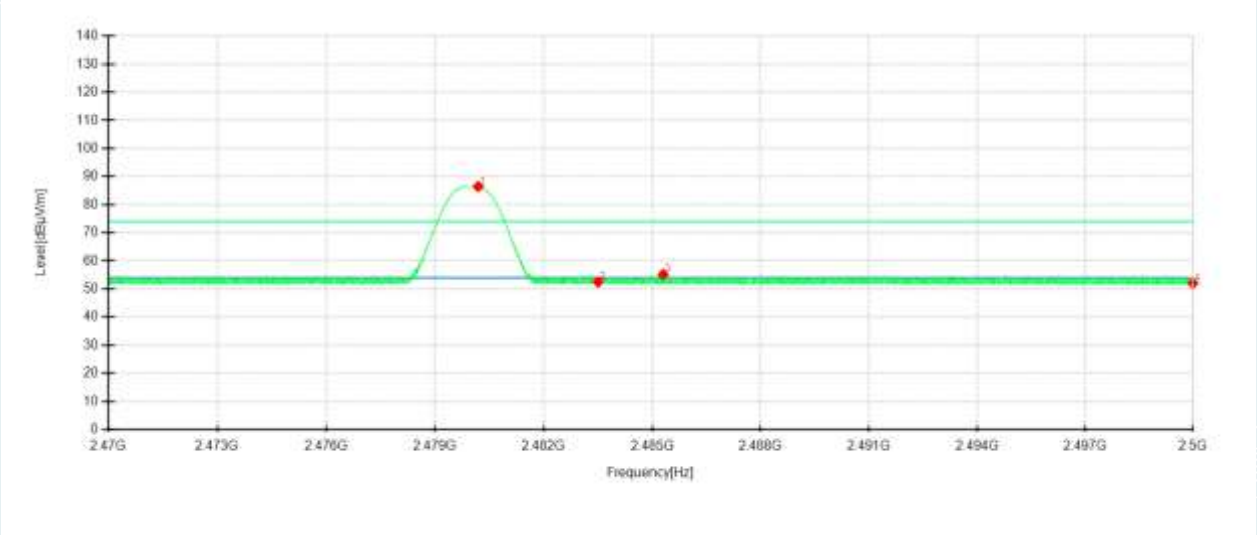
Environment: 25.3℃/54%RH/101.0kPa Test Voltage: DC 3.87V

Tested By: Chen Xiaocong Date: 2023-02-16

Detector mode: Peak Polarity: Horizontal



Detector mode: Peak Polarity: Vertical



No.	Frequency MHz	Reading dBµV/m	Level dBµV/m	Factor dB	Limit dBuV/m	Margin dB	Height cm	Angle °	Pole	Remark
1	2480.1807	67.20	77.05	9.85	74.00	-3.05	200	299	Horizontal	No limit
2	2483.5	44.06	53.98	9.92	74.00	20.02	100	81	Horizontal	/
3	2488.2432	45.76	55.77	10.01	74.00	18.23	200	200	Horizontal	/
4	2500	42.58	52.83	10.25	74.00	21.17	100	224	Horizontal	/
1	2480.1907	77.19	86.46	9.27	74.00	-12.46	200	181	Vertical	No limit
2	2483.5	43.17	52.45	9.28	74.00	21.55	200	336	Vertical	/
3	2485.303	45.86	55.15	9.29	74.00	18.85	200	82	Vertical	/
4	2500	42.64	51.99	9.35	74.00	22.01	200	137	Vertical	/

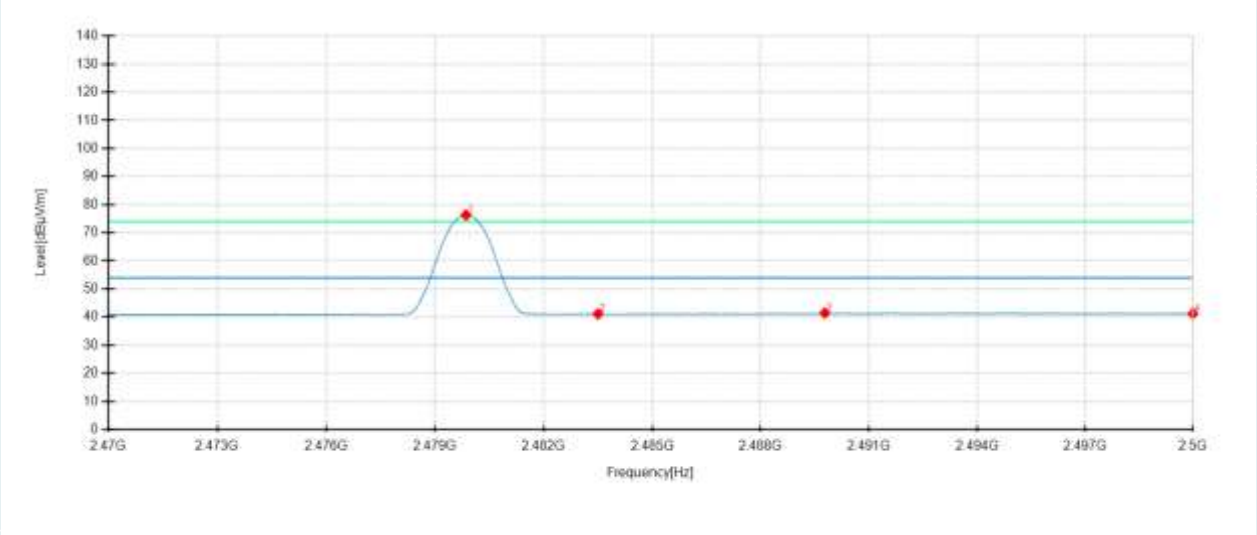
Highest Channel

Frequency 2480MHz

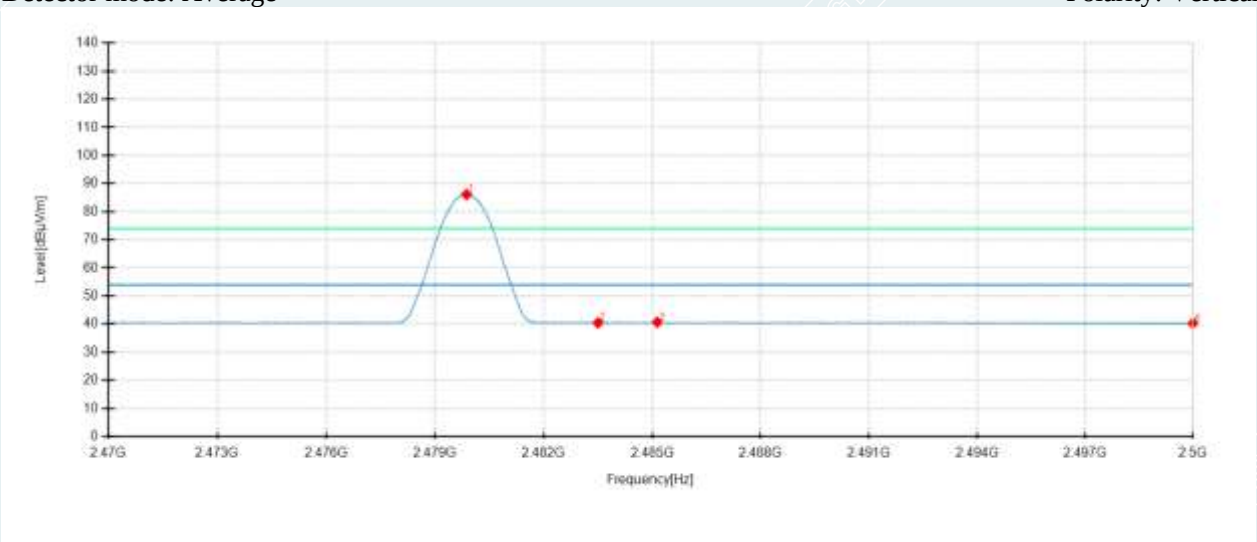
Environment: 25.3℃/54%RH/101.0kPa Test Voltage: DC 3.87V

Tested By: Chen Xiaocong Date: 2023-02-16

Detector mode: Average Polarity: Horizontal



Detector mode: Average Polarity: Vertical



No.	Frequency MHz	Reading dBμV/m	Level dBμV/m	Factor dB	Limit dBuV/m	Margin dB	Height cm	Angle °	Pole	Remark
1	2479.8567	66.48	76.33	9.85	54.00	-22.33	200	300	Horizontal	No limit
2	2483.5	31.17	41.09	9.92	54.00	12.91	200	255	Horizontal	/
3	2489.7773	31.39	41.44	10.05	54.00	12.56	200	23	Horizontal	/
4	2500	30.92	41.17	10.25	54.00	12.83	100	204	Horizontal	/
1	2479.8707	76.86	86.13	9.27	54.00	-32.13	200	184	Vertical	No limit
2	2483.5	31.15	40.43	9.28	54.00	13.57	200	338	Vertical	/
3	2485.139	31.36	40.65	9.29	54.00	13.35	100	299	Vertical	/
4	2500	30.93	40.28	9.35	54.00	13.72	100	333	Vertical	/

Remark:

1) Max field strength in 3m distance. No any other emission which falls in restricted bands can be detected and be reported.

---------- The following blanks ----------

APPENDIX A. PHOTOGRAPH OF THE TEST CONNECTION DIAGRAM

Please refer to the attached document E20221228512201-7-Test photo.

APPENDIX B. PHOTOGRAPH OF THE EUT

Please refer to the attached document E20221228512201-8-EUT photo.

---------- End of Report ----------