

TEST REPORT

FCC BT LE Test for SLEEPade
Certification

APPLICANT
BrainU Co.,Ltd.

REPORT NO.
HCT-RF-2306-FC004

DATE OF ISSUE
June 29, 2023

Tested by
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TEST REPORT

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SLEEPade

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Additional Model

-

Applicant

BrainU Co.,Ltd.

3F, 7, Yatap-ro 105beongil, Bundang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

**Eut Type
Model Name**

Sleep Monitoring System
SLEEPade

FCC ID

2BBOF-SLEEPADE

Max. RF Output Power

-7.225 dBm (0.19 mW)

Modulation type

GFSK

FCC Classification

Digital Transmission System(DTS)

FCC Rule Part(s)

Part 15.247

The result shown in this test report refer only to the sample(s) tested unless otherwise stated.

This test results were applied only to the test methods required by the standard.

REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	June 29, 2023	Initial Release

Engineering Statement:

The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules under normal use and maintenance.

Test Report Statement:

The above Test Report is not related to the accredited test result by (KS Q) ISO/IEC 17025 and KOLAS(Korea Laboratory Accreditation Scheme) / A2LA(American Association for Laboratory Accreditation), which signed the ILAC-MRA.

If this report is required to confirmation of authenticity, please contact to www.hct.co.kr

CONTENTS

1. EUT DESCRIPTION	5
2. TEST METHODOLOGY	6
EUT CONFIGURATION	6
EUT EXERCISE	6
GENERAL TEST PROCEDURES	6
DESCRIPTION OF TEST MODES	7
3. INSTRUMENT CALIBRATION	7
4. FACILITIES AND ACCREDITATIONS	7
FACILITIES	7
EQUIPMENT	7
5. ANTENNA REQUIREMENTS	8
6. MEASUREMENT UNCERTAINTY	8
7. DESCRIPTION OF TESTS	9
8. SUMMARY TEST OF RESULTS	23
9. TEST RESULT	24
9.1 DUTY CYCLE	24
9.2 6 dB BANDWIDTH	25
9.3 OUTPUT POWER	30
9.4 POWER SPECTRAL DENSITY	31
9.5 BAND EDGE/ CONDUCTED SPURIOUS EMISSIONS	36
9.6 RADIATED SPURIOUS EMISSIONS	39
9.7 RADIATED RESTRICTED BAND EDGES	43
10. LIST OF TEST EQUIPMENT	45
11. ANNEX A_ TEST SETUP PHOTO	47

1. EUT DESCRIPTION

Model	SLEEPade	
Additional Model	-	
EUT Type	Sleep Monitoring System	
Power Supply	DC 3.70 V	
Frequency Range	2 402 MHz – 2 480 MHz	
Max. RF Output Power	Peak	2 MBit/s : -7.225 dBm (0.19 mW)
	Average	2 MBit/s : -7.42 dBm (0.18 mW)
Modulation Type	GFSK	
Bluetooth Version	5.0	
Number of Channels	40 Channels	
Antenna Specification	Antenna type: Externall(Multilayer Chip Antenna) Peak Gain : 2.3 dBi	
Date(s) of Tests	June 09, 2023 ~ June 27, 2023	
EUT Serial Number	Conduction : SLA01 00012 23 B Radiation : SLA01 00011 23 B	

2. TEST METHODOLOGY

FCC KDB 558074 D01 15.247 Meas Guidance v05r02 dated April 02, 2019 entitled “guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices and the measurement procedure described in ANSI C63.10 (Version : 2013) ‘the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices’.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30 MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1 GHz. Above 1 GHz with 1.5 m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013)

DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.

Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

4. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil,

Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA.

The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032).

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements. Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR § 15.203:

“An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.”

- (1) The antennas of this E.U.T are permanently attached.
- (2) The E.U.T Complies with the requirement of § 15.203

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicate a 95 % level of confidence.

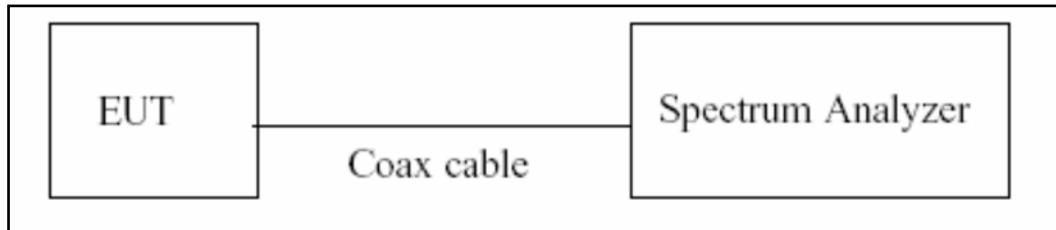
The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.90 (Confidence level about 95 %, $k=2$)
Radiated Disturbance (9 kHz ~ 30 MHz)	4.14 (Confidence level about 95 %, $k=2$)
Radiated Disturbance (30 MHz ~ 1 GHz)	5.82 (Confidence level about 95 %, $k=2$)
Radiated Disturbance (1 GHz ~ 18 GHz)	5.74 (Confidence level about 95 %, $k=2$)
Radiated Disturbance (18 GHz ~ 40 GHz)	5.76 (Confidence level about 95 %, $k=2$)
Radiated Disturbance (Above 40 GHz)	5.52 (Confidence level about 95 %, $k=2$)

7. DESCRIPTION OF TESTS

7.1. Duty Cycle

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to the zero-span measurement method, 6.0)b) in KDB 558074 v05r02.

The largest available value of RBW is 8 MHz and VBW is 50 MHz.

The zero-span method of measuring duty cycle shall not be used if $T \leq 6.25$ microseconds. $(50/6.25 = 8)$

The zero-span method was used because all measured T data are > 6.25 microseconds and both RBW and VBW are $> 50/T$.

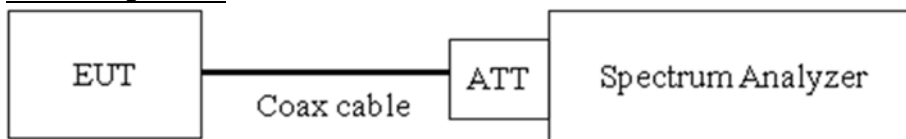
1. RBW = 8 MHz (the largest available value)
2. VBW = 8 MHz ($\geq$ RBW)
3. SPAN = 0 Hz
4. Detector = Peak
5. Number of points in sweep > 100
6. Trace mode = Clear write
7. Measure T_{total} and T_{on}
8. Calculate Duty Cycle = T_{on}/T_{total} and Duty Cycle Factor = $10\log(1/\text{Duty Cycle})$

7.2. 6 dB Bandwidth

Limit

The minimum permissible 6 dB bandwidth is 500 kHz.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

The Spectrum Analyzer is set to (Procedure 8.2 in KDB 558074 v05r02,
Procedure 11.8.1 in ANSI 63.10-2013)

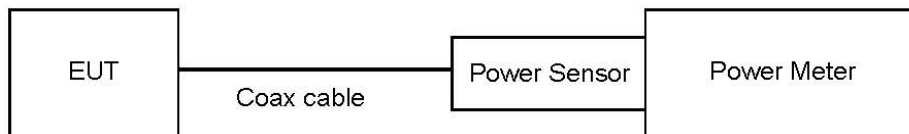
- 1) RBW = 100 kHz
- 2) VBW $\geq 3 \times$ RBW
- 3) Detector = Peak
- 4) Trace mode = Max hold
- 5) Sweep = auto couple
- 6) Allow the trace to stabilize
- 7) We tested 6 dB bandwidth using the automatic bandwidth measurement capability of a spectrum analyzer. X dB is set 6 dB.

7.3. Output Power

Limit

The maximum permissible conducted output power is 1 Watt.

Test Configuration



Test Procedure

The transmitter output is connected to the Power Meter.

- Peak Power (Procedure 11.9.1.3 in ANSI 63.10-2013)
: Measure the peak power of the transmitter.
- Average Power (Procedure 8.3.2.3 in KDB 558074 v05r02, Procedure 11.9.2.3 in ANSI 63.10-2013)
 - 1) Measure the duty cycle.
 - 2) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.
 - 3) Add $10 \log(1/x)$, where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times.

Sample Calculation

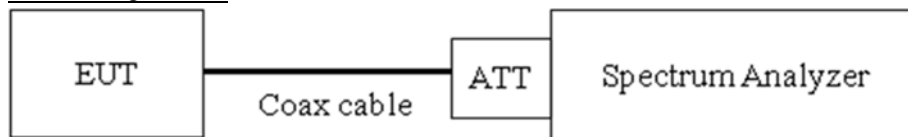
- Conducted Output Power(Peak) = Measured Level + ATT loss + Cable loss
- Conducted Output Power(Average) = Measured Level + ATT loss + Cable loss + Duty Cycle Factor

7.4. Power Spectral Density

Limit

The transmitter power density average over 1-second interval shall not be greater than 8 dBm in any 3 kHz BW.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to Procedure 8.4 in KDB 558074 v05r02, Procedure 11.10 in ANSI 63.10-2013.

The spectrum analyzer is set to :

- 1) Set analyzer center frequency to DTS channel center frequency.
- 2) Set span to at least 1.5 times the OBW.
- 3) $RBW = 3 \text{ kHz} \leq RBW \leq 100 \text{ kHz}$.
- 4) $VBW \geq 3 \times RBW$.
- 5) Sweep = auto couple
- 6) Detector = Peak
- 7) Trace mode = Max hold
- 8) Allow trace to fully stabilize.
- 9) Use the peak marker function to determine the maximum amplitude level.
- 10) Use the peak marker function to determine the maximum amplitude level within the RBW.

If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

Sample Calculation

- Power Spectral Density = Measured Level + ATT loss + Cable loss

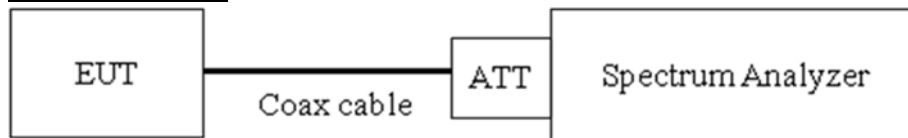
7.5. Conducted Band Edge(Out of Band Emissions) & Conducted Spurious Emissions

Limit

The maximum conducted (Peak) output power was used to demonstrate compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz.

[Conducted > 20 dBc]

Test Configuration



Test Procedure

The transmitter output is connected to the spectrum analyzer.

(Procedure 8.5 in KDB 558074 v05r02, Procedure 11.11 in ANSI 63.10-2013)

- 1) RBW = 100 kHz
- 2) VBW $\geq 3 \times$ RBW
- 3) Set span to encompass the spectrum to be examined
- 4) Detector = Peak
- 5) Trace Mode = Max hold
- 6) Sweep time = auto couple
- 7) Ensure that the number of measurement points $\geq 2 \times$ Span/VBW
- 8) Allow trace to fully stabilize.
- 9) Use peak marker function to determine the maximum amplitude level.

Measurements are made over the 30 MHz to 25 GHz range with the transmitter set to the lowest, middle, and highest channels.

Factors for frequency

Freq(MHz)	Factor(dB)
30	10.95
100	11.01
200	11.03
300	11.04
400	11.05
500	11.04
600	11.03
700	11.09
800	11.10
900	11.08
1 000	11.11
2 000	11.25
2 400	11.36
2 412	11.60
2 437	11.60
2 462	11.60
2 500	11.76
3 000	11.89
4 000	12.24
5 000	12.42
5 700	12.87
5 800	12.87
6 000	12.98
7 000	13.07
8 000	13.19
9 000	13.24
10 000	13.38
11 000	13.43
12 000	13.49
13 000	13.66
14 000	13.96
15 000	14.12
16 000	14.15
17 000	14.05
18 000	14.08
19 000	13.97
20 000	14.23
21 000	14.67
22 000	14.49
23 000	14.62
24 000	14.60
25 000	14.92

Note : 1. 2400 ~ 2500 MHz is fundamental frequency range.

2. Factor = Attenuator loss + Cable loss

7.6. Radiated Test

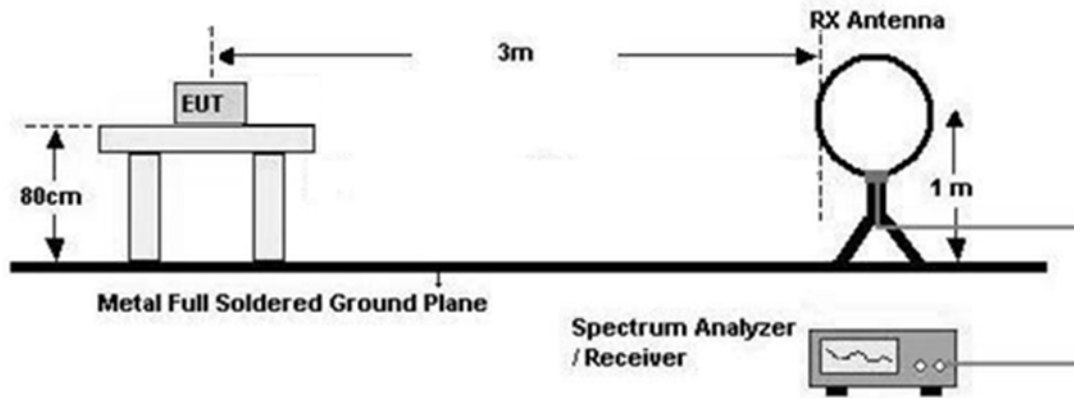
Limit

FCC

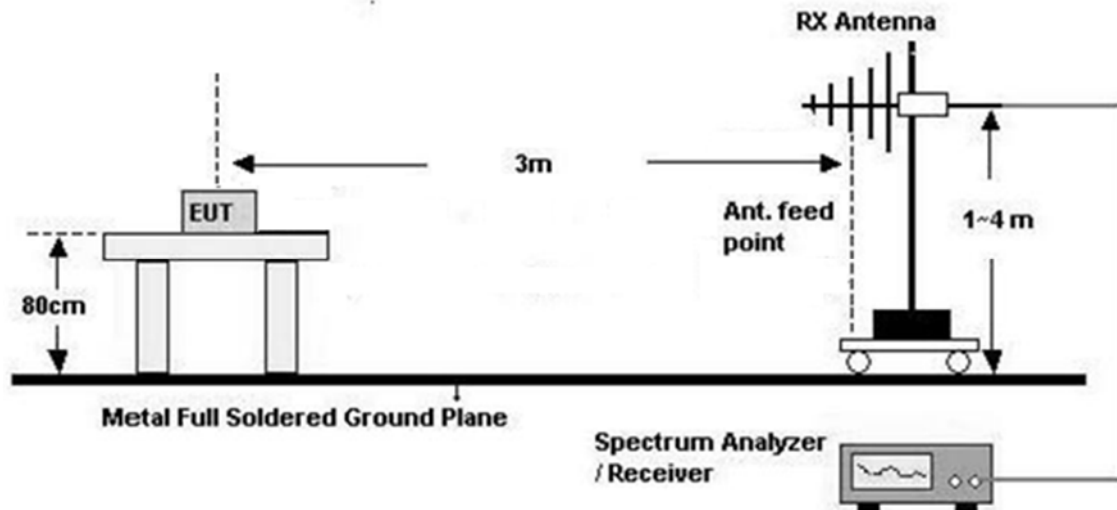
Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$)	Measurement Distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Test Configuration

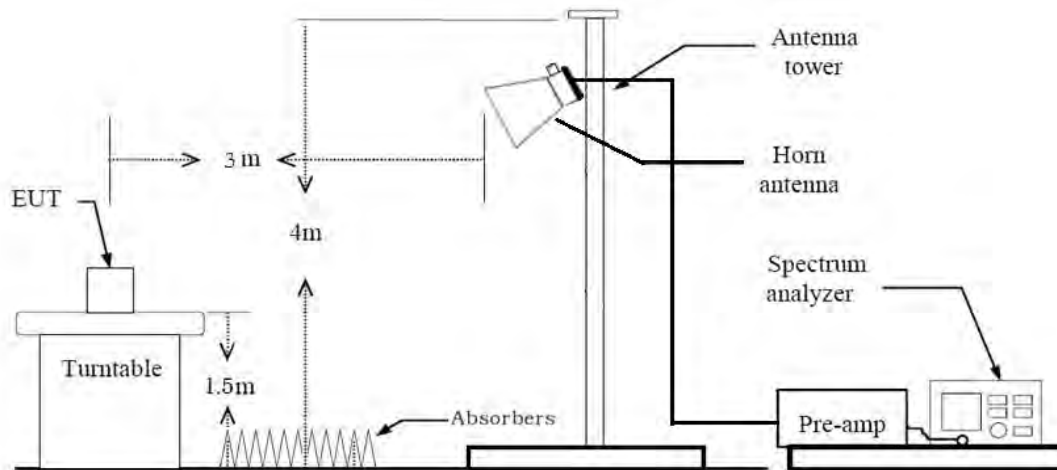
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions(Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3 m from the EUT
3. The EUT is placed on a turntable, which is 0.8 m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization and Parallel to the ground plane in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor(0.009 MHz – 0.490 MHz) = $40\log(3\text{ m}/300\text{ m}) = -80\text{ dB}$
Measurement Distance : 3 m
7. Distance Correction Factor(0.490 MHz – 30 MHz) = $40\log(3\text{ m}/30\text{ m}) = -40\text{ dB}$
Measurement Distance : 3 m
8. Spectrum Setting
 - Frequency Range = 9 kHz ~ 30 MHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 9 kHz
 - VBW $\geq 3 \times$ RBW
9. Total = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)
10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

KDB 414788 OFS and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

Test Procedure of Radiated spurious emissions(Below 1 GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8 m above ground plane.
3. The Hybrid antenna was placed at a location 3 m from the EUT, which is varied from 1 m to 4 m to find out the highest emissions.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

6. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Peak
- Trace = Maxhold
- RBW = 100 kHz
- VBW $\geq$ 3 x RBW

(2) Measurement Type(Quasi-peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Quasi-Peak
- RBW = 120 kHz

※In general, (1) is used mainly

7. Total = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L)

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

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range 1 GHz – 10th Harmonics
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq$ 3 x RBW
 - (2) Measurement Type(Average):
 - Duty cycle < 98%, duty cycle variations are less than $\pm 2\%$
 - Measured Frequency Range : 1 GHz – 25 GHz
 - Detector = RMS
 - Averaging type = power (*i.e.*, RMS)
 - RBW = 1 MHz
 - VBW $\geq$ 3 x RBW
 - Sweep time = auto.
9. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
10. Distance extrapolation factor = $20\log(\text{test distance} / \text{specific distance})$ (dB)
11. Total (Measurement Type : Peak)
 - = Peak Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)
- Total (Measurement Type : Average)
 - = Average Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)
- The duty cycle factor was the maximum supported by the protocol , then we measured average with no correction.

Test Procedure of Radiated Restricted Band Edge

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 1 GHz – 10th Harmonics
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq$ 3 x RBW
 - (2) Measurement Type(Average):
 - Duty cycle < 98%, duty cycle variations are less than $\pm 2\%$
 - Measured Frequency Range : 1 GHz – 10th Harmonics
 - Detector = RMS
 - Averaging type = power (*i.e.*, RMS)
 - RBW = 1 MHz
 - VBW $\geq$ 3 x RBW
 - Sweep time = auto.
 - Trace mode = average (at least 100 traces).
8. Distance extrapolation factor = $20\log$ (test distance / specific distance) (dB)
9. Total(Measurement Type : Peak)
 - = Peak Measured Value
 Total(Measurement Type : Average)
 - = Average Measured Value
 - We apply to the offset in the range 1 GHz - 18 GHz.
 - The offset is Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F).
10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

7.7. AC Power line Conducted Emissions

Limit

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dB μ V)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56 ^(a)	56 to 46 ^(a)
0.50 to 5	56	46
5 to 30	60	50

^(a)Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.

Sample Calculation

Quasi-peak(Final Result) = Measured Level + Correction Factor

7.8. Worst case configuration and mode

Radiated Test

1. All modes of operation were investigated and the worst case configuration results are reported.
 - Mode : Stand alone
 - Worstcase : Stand alone
2. EUT Axis:
 - Radiated Spurious Emissions : X
 - Radiated Restricted Band Edge : X
3. All packet length of operation were investigated and the test results are worst case in lowest packet length.
(Worst case : 37 Byte)
4. All position of loop antenna were investigated and the test result is a no critical peak found at all positions.
 - Position : Horizontal, Vertical, Parallel to the ground plane

AC Power line Conducted Emissions

1. We don't perform powerline conducted emission test. Because this EUT is used DC.

Conducted test

1. The EUT was configured with packet length of highest power.

8. SUMMARY TEST OF RESULTS

FCC Part

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
6 dB Bandwidth	§ 15.247(a)(2)	> 500 kHz	Conducted	PASS
Conducted Maximum Output Power	§ 15.247(b)(3)	< 1 Watt		PASS
Power Spectral Density	§ 15.247(e)	< 8 dBm / 3 kHz Band		PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	Conducted > 20 dBc		PASS
AC Power line Conducted Emissions	§ 15.207	cf. Section 7.7		N/A (#Note1)
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	cf. Section 7.6	Radiated	PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	cf. Section 7.6		PASS

#Note1 : Not Tested

9. TEST RESULT

9.1 DUTY CYCLE

Data rate (Bit/s)	Packet length (Byte)	T _{on} (ms)	T _{total} (ms)	Duty Cycle	Duty Cycle Factor (dB)
2M	37	-	-	-	-
2M	255	-	-	-	-

Note:

1. Duty Cycle Factor = $10\log(1/\text{Duty Cycle})$. where, Duty Cycle = T_{on} / T_{total}
2. Test was performed with continuous Tx.



9.2 6 dB BANDWIDTH

Mode (Bit/s)	Channel	6 dB Bandwidth (kHz)	Limit (kHz)
2M 37 Byte	0	1 371	> 500
	19	1 379	
	39	1 391	
2M 255 Byte	0	1 366	> 500
	19	1 380	
	39	1 387	

2M Bit/s(37 Byte) Test Plots

6 dB Bandwidth plot (Low-CH 0)



6 dB Bandwidth plot (Mid-CH 19)



6 dB Bandwidth plot (High-CH 39)



2M Bit/s(255 Byte) Test Plots

6 dB Bandwidth plot (Low-CH 0)



6 dB Bandwidth plot (Mid-CH 19)



6 dB Bandwidth plot (High-CH 39)



9.3 OUTPUT POWER

Peak Power

Data rate	Packet length	LE Mode		Measured Power(dBm)	Limit (dBm)
(Bit/s)	(Byte)	Frequency [MHz]	Channel		
2M	37	2 402	0	-7.847	30
		2 440	19	-7.607	
		2 480	39	-7.225	
	255	2 402	0	-8.015	
		2 440	19	-7.773	
		2 480	39	-7.310	

Average Power

Data rate	Packet length	LE Mode		Measured Power(dBm)	Limit (dBm)
(Bit/s)	(Byte)	Frequency [MHz]	Channel		
2M	37	2 402	0	-8.01	30
		2 440	19	-7.73	
		2 480	39	-7.42	
	255	2 402	0	-8.19	
		2 440	19	-7.93	
		2 480	39	-7.49	

9.4 POWER SPECTRAL DENSITY

Frequency (MHz)	Channel No.	Mode (Bit/s)	Test Result	
			Measured Power(dBm)	Limit (dBm/3 kHz)
2 402	0	2M Bit/s 37 Byte	-10.755	8
2 440	19		-10.606	
2 480	39		-10.372	
2 402	0	2M Bit/s 255 Byte	-10.994	
2 440	19		-10.867	
2 480	39		-10.473	

Note :

1. The PSD measured results in plot is already including the actual values of loss for the attenuator and cable combination.

2M Bit/s (37 Byte) Test Plots

Power Spectral Density (Low-CH 0)



Power Spectral Density (Mid-CH 19)



Power Spectral Density (High-CH 39)



2M Bit/s (255 Byte) Test Plots

Power Spectral Density (Low-CH 0)



Power Spectral Density (Mid-CH 19)



Power Spectral Density (High-CH 39)



9.5 BAND EDGE/ CONDUCTED SPURIOUS EMISSIONS

Test Result : please refer to the plot below.

In order to simplify the report, attached plots were only the worst case channel and data rate.

[BAND EDGE]

Frequency (MHz)	Mode	Channel No.	Position	Test Result	
				Measured Level (dB)	Limit (dBc)
2 402	2M Bit/s 37 Byte	0	Lower	32.660	20
2 480		39	Upper	53.968	20
2 402	2M Bit/s 255 Byte	0	Lower	32.737	20
2 480		39	Upper	54.030	20

2M Bit/s (37 Byte) Test Plots -BandEdge

Low-CH 0



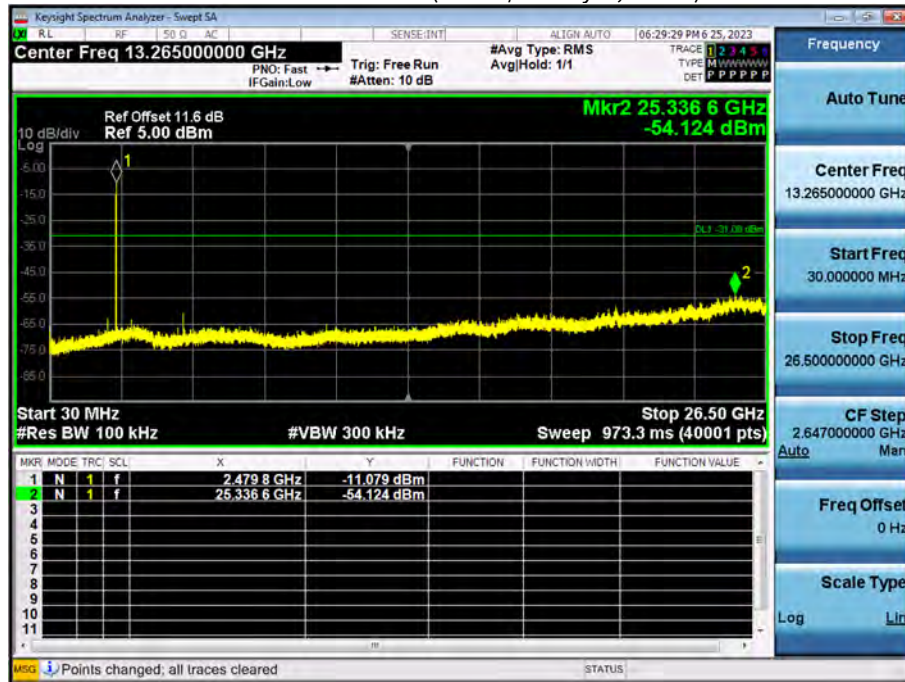
High-CH 39



[CONDUCTED SPURIOUS EMISSIONS]

▣ Test Plots

30 MHz ~ 26.5 GHz (2M Bit/s 37 Byte, CH 39)



Note :

Limit : -31.08 dBm

9.6 RADIATED SPURIOUS EMISSIONS

Frequency Range : 9 kHz – 30MHz

Frequency	Measured Value	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBμV/m	dB/m	dB	(H/V)	dBμV/m	dBμV/m	dB
No Critical peaks found							

Note:

1. The Measured Level of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
2. Distance extrapolation factor = $40\log(\text{specific distance} / \text{test distance})$ (dB)
3. Limit line = specific Limits (dBμV) + Distance extrapolation factor

Frequency Range : Below 1 GHz

Frequency	Measured Value	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBμV/m	dB/m	dB	(H/V)	dBμV/m	dBμV/m	dB
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.

Frequency Range : Above 1 GHz

Mode : 2M Bit/s (37 Byte)

Operation Mode: CH Low

Frequency	Measured Value	Duty Cycle Factor	AF+CL+DF-AG	Ant. Pol.	Total	Limit	Margin	Measurement Type
[MHz]	[dBμV]	[dB]	[dB/m]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]	
4 804	52.62	0.00	2.51	V	55.13	73.98	18.85	PK
4 804	48.11	0.00	2.51	V	50.62	53.98	3.36	AV
7 206	41.68	0.00	9.10	V	50.78	73.98	23.20	PK
7 206	30.08	0.00	9.10	V	39.18	53.98	14.80	AV
4 804	52.81	0.00	2.51	H	55.32	73.98	18.66	PK
4 804	48.13	0.00	2.51	H	50.64	53.98	3.34	AV
7 206	41.99	0.00	9.10	H	51.09	73.98	22.89	PK
7 206	30.10	0.00	9.10	H	39.20	53.98	14.78	AV

Operation Mode: CH Mid

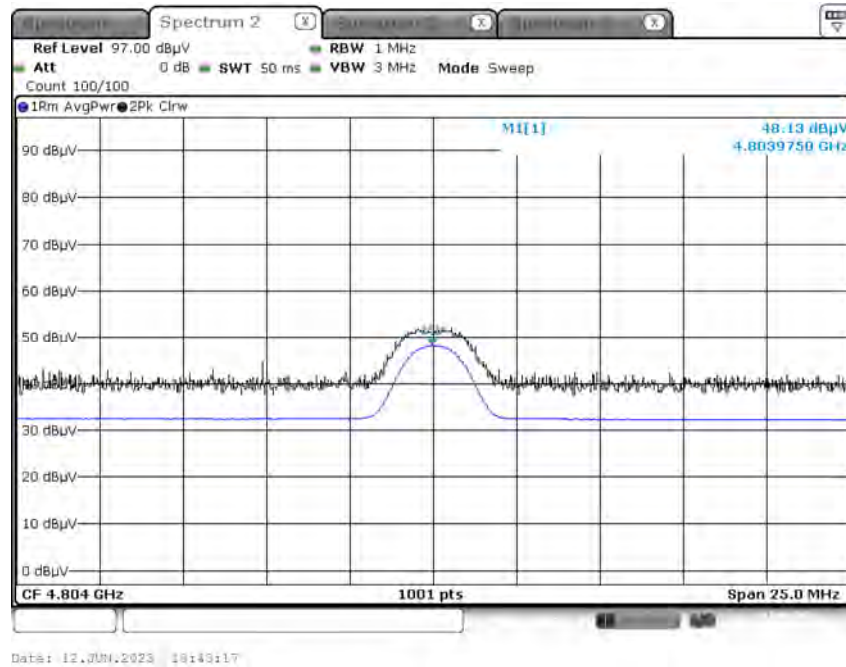
Frequency	Measured Value	Duty Cycle Factor	AF+CL+DF-AG	Ant. Pol.	Total	Limit	Margin	Measurement Type
[MHz]	[dBμV]	[dB]	[dB/m]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]	
4 880	51.38	0.00	2.92	V	54.30	73.98	19.68	PK
4 880	46.75	0.00	2.92	V	49.67	53.98	4.31	AV
7 320	41.69	0.00	9.42	V	51.11	73.98	22.87	PK
7 320	30.45	0.00	9.42	V	39.87	53.98	14.11	AV
4 880	51.55	0.00	2.92	H	54.47	73.98	19.51	PK
4 880	46.81	0.00	2.92	H	49.73	53.98	4.25	AV
7 320	42.04	0.00	9.42	H	51.46	73.98	22.52	PK
7 320	30.60	0.00	9.42	H	40.02	53.98	13.96	AV

Operation Mode: CH High

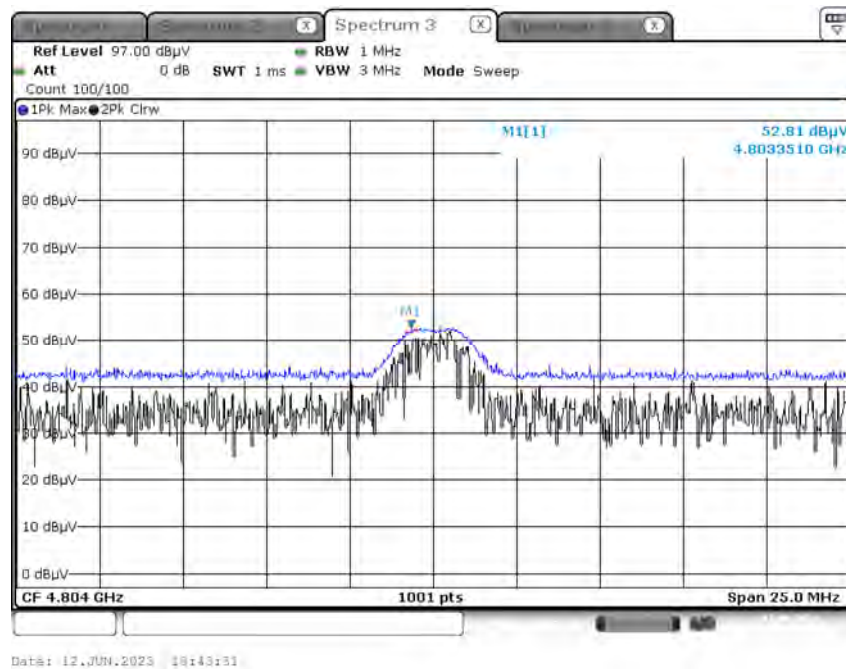
Frequency	Measured Value	Duty Cycle Factor	AF+CL+DF-AG	Ant. Pol.	Total	Limit	Margin	Measurement Type
[MHz]	[dBμV]	[dB]	[dB/m]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]	
4 960	50.66	0.00	2.00	V	52.66	73.98	21.32	PK
4 960	46.02	0.00	2.00	V	48.02	53.98	5.96	AV
7 440	41.30	0.00	9.99	V	51.29	73.98	22.69	PK
7 440	29.46	0.00	9.99	V	39.45	53.98	14.53	AV
4 960	50.89	0.00	2.00	H	52.89	73.98	21.09	PK
4 960	46.16	0.00	2.00	H	48.16	53.98	5.82	AV
7 440	41.63	0.00	9.99	H	51.62	73.98	22.36	PK
7 440	29.57	0.00	9.99	H	39.56	53.98	14.42	AV

2M Bit/s 37 Byte Test Plots

Radiated Spurious Emissions plot – Average Result (Ch.0 2nd Harmonic, H)



Radiated Spurious Emissions plot – Peak Result (Ch.0 2nd Harmonic, H)



Note:

Plot of worst case are only reported.

9.7 RADIATED RESTRICTED BAND EDGES

Mode : 2 MBit/s (37 Byte)

Operating Frequency

2402 MHz & 2480 MHz

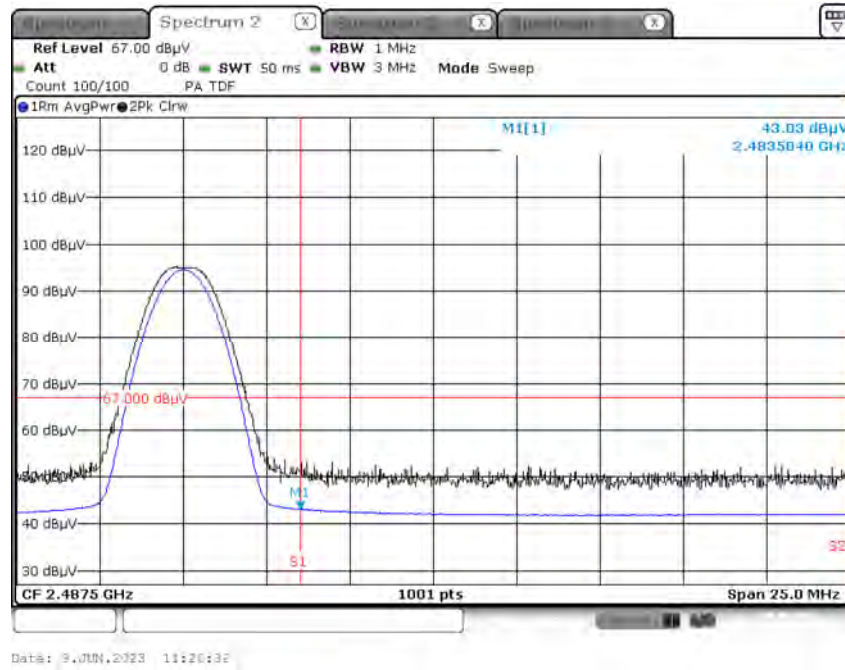
Channel No.

0 & 39

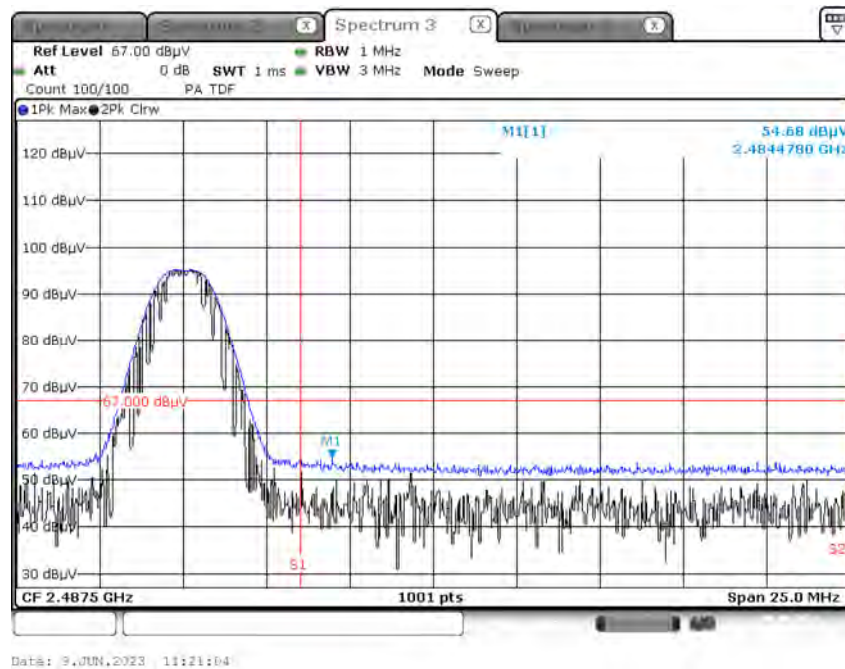
Frequency	Measured Value	Duty Cycle Factor	Ant. Pol.	Total	Limit	Margin	Measurement Type
[MHz]	[dBμV]	[dB]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]	
2 390.0	54.06	0.00	H	54.06	73.98	19.92	PK
2 390.0	41.71	0.00	H	41.71	53.98	12.27	AV
2 390.0	54.05	0.00	V	54.05	73.98	19.93	PK
2 390.0	41.60	0.00	V	41.60	53.98	12.38	AV
2 483.5	54.68	0.00	H	54.68	73.98	19.30	PK
2 483.5	43.03	0.00	H	43.03	53.98	10.95	AV
2 483.5	54.39	0.00	V	54.39	73.98	19.59	PK
2 483.5	42.66	0.00	V	42.66	53.98	11.32	AV

2M Bit/s (37 Byte) Test Plots

Radiated Restricted Band Edges plot – Average Result (Ch.39, H)



Radiated Restricted Band Edges plot – Peak Result (Ch.39, H)



Note:

Plot of worst case are only reported.

10. LIST OF TEST EQUIPMENT

Conducted Test

Equipment	Model	Manufacturer	Serial No.	Due to Calibration	Calibration Interval
LISN	ENV216	Rohde & Schwarz	102245	08/22/2023	Annual
EMI Test Receiver	ESR	Rohde & Schwarz	101910	05/26/2024	Annual
Temperature Chamber	SU-642	ESPEC	93008124	02/22/2024	Annual
Signal Analyzer	N9030A	Keysight	MY55410508	09/06/2023	Annual
Power Meter	N1911A	Agilent	MY45100523	03/06/2024	Annual
Power Sensor	N1921A	Agilent	MY57820067	03/06/2024	Annual
Directional Coupler	87300B	Agilent	3116A03621	11/02/2023	Annual
Power Splitter	11667B	Hewlett Packard	10545	02/06/2024	Annual
DC Power Supply	E3632A	Agilent	KR75305528	01/03/2024	Annual
Attenuator(10 dB)(DC-26.5 GHz)	8493C-010	Agilent	08285	06/02/2024	Annual
Attenuator(30 dB)(DC-26.5 GHz)	8493C-030	Agilent	77640	06/12/2024	Annual
Software	EMC32	Rohde & Schwarz	N/A	N/A	N/A
FCC WLAN&BT&BLE Conducted Test Software v3.0	N/A	HCT CO., LTD.	N/A	N/A	N/A
Bluetooth Tester	CBT	Rohde & Schwarz	100808	02/16/2024	Annual

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

Radiated Test

Equipment	Model	Manufacturer	Serial No.	Due to Calibration	Calibration Interval
Controller(Antenna mast)	CO3000	Innco system	CO3000-4p	N/A	N/A
Antenna Position Tower	MA4640/800-XP-EP	Innco system	N/A	N/A	N/A
Controller	EM2090	Emco	060520	N/A	N/A
Turn Table	N/A	Ets	N/A	N/A	N/A
Loop Antenna	FMZB 1513	Rohde & Schwarz	1513-333	03/17/2024	Biennial
Hybrid Antenna	VULB 9168	Schwarzbeck	9168-0895	08/16/2024	Biennial
Horn Antenna	BBHA 9120D	Schwarzbeck	9120D-1191	11/18/2023	Biennial
Horn Antenna(15 GHz ~ 40 GHz)	BBHA9170	Schwarzbeck	BBHA9170124	03/28/2025	Biennial
Amp & Filter Bank Switch Controller	FBSM-01A	TNM system	0	N/A	N/A
Band Reject Filter	WRCJV2400/2483.5-2370/2520-60/12SS	Wainwright Instruments	2	01/05/2024	Annual
Band Reject Filter	WRCJV12-4900-5100-5900-6100-50SS	Wainwright Instruments	5	06/12/2024	Annual
Band Reject Filter	WRCJV12-4900-5100-5900-6100-50SS	Wainwright Instruments	6	06/12/2024	Annual
Band Reject Filter	WRCJV5100/5850-40/50-8EEK	Wainwright Instruments	1	02/09/2024	Annual
RF Switching System	FBSR-03A (3G HPF+LNA)	T&M SYSTEM	S3L1	12/05/2023	Annual
RF Switching System	FBSR-03A (10dB ATT+LNA)	T&M SYSTEM	S3L2	12/05/2023	Annual
RF Switching System	FBSR-03A (7G HPF+LNA)	T&M SYSTEM	S3L3	12/05/2023	Annual
RF Switching System	FBSR-03A (3dB ATT+LNA)	T&M SYSTEM	S3L4	12/05/2023	Annual
Power Amplifier	CBL18265035	CERNEX	22966	12/01/2023	Annual
Power Amplifier	CBL26405040	CERNEX	25956	03/02/2024	Annual
Bluetooth Tester	TC-3000C	TESCOM	3000C000175	03/28/2024	Annual
Spectrum Analyzer	FSP (9 kHz ~ 30 GHz)	Rohde & Schwarz	836650/016	09/06/2023	Annual
Spectrum Analyzer	FSVA40 (10 Hz ~ 40 GHz)	Rohde & Schwarz	101502	03/17/2024	Annual

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.
3. Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5(Version : 2017).

11. ANNEX A_ TEST SETUP PHOTO

Please refer to test setup photo file no. as follows;

No.	Description
1	HCT-RF-2306-FC004-P