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TEST REPORT

FCC/ISED LoRa Test for LORU Certification

APPLICANT Mueller Systems, LLC

REPORT NO. HCT-RF-2312-FI012-R1

DATE OF ISSUE January 25, 2024

> **Tested by** Kyung Jun Woo



Technical Manager Jong Seok Lee Aij

Accredited by KOLAS, Republic of KOREA

HCT CO., LTD. Bongjai Huh BongJai Huh / CEO

F-TP22-03(Rev.05)

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T E S T R E P O R T	REPORT NO. HCT-RF-2312-FI012-R1 DATE OF ISSUE January 25, 2024
Applicant	Mueller Systems, LLC 1200 Abernathy Road, NE, Suite 1200. Atlanta, GA, USA, 30328
Eut Type Model Name	Water Meter Universal Node (LoRa) LORU
FCC ID IC	SM6-LORU 9235A-LORU
RF Peak Output Power	8.229 dBm (6.65 mW)
FCC Classification	FCC Part 15 Spread Spectrum Transmitter (DSS)
FCC Rule Part(s)	Part 15.247
ISED Rule Part(s)	RSS-247 Issue 3 (August 2023) RSS-Gen Issue 5_Amendment 2 (February 2021)
Location of Test	 Permanent Testing Lab On Site Testing (Address: 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi- do, Republic of Korea)

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REVISION HISTORY

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

Revision No.	Date of Issue	Description
0	December 27, 2023	Initial Release
1	January 25, 2024	Revised the Page 6.

Notice

Content

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 / ISED Rules under normal use and maintenance.

The results shown in this test report only apply to the sample(s), as received, provided by the applicant, unless otherwise stated.

The test results have only been applied with the test methods required by the standard(s).

When confirmation of authenticity of this test report is required, please contact www.hct.co.kr

This test report provides test result(s) under the scope accredited by the Korea Laboratory Accreditation Scheme (KOLAS), which signed the ILAC-MRA. (KOLAS (KS Q ISO/IEC 17025) Accreditation No. KT197)



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1. EUT DESCRIPTION

Model	LORU
Additional Model	-
ЕИТ Туре	Water Meter Universal Node (LoRa)
Battery Capacity	19 000 mAh
Rated Voltage (V)	3.60 V
Frequency Range	902 MHz – 928 MHz (TX 125 kHz : 902.3 ~ 914.9) – FHSS/DTS Signal (RX 500 kHz : 923.3 ~ 927.5) – DTS Signal
Max. RF Output Power	8.229 dBm (6.65 mW)
Modulation Type	CSS
Number of Channels (125 kHz)	64 Channels uplink 8 Channels downlink
Antenna Specification	Antenna type: PCB Antenna Peak Gain : 0.95 dBi
Date(s) of Tests	December 08, 2023 ~ December 27, 2023
PMN (Product Marketing Number)	Water Meter Universal Node (LoRa)
HVIN (Hardware Version Identification Number)	LORU
FVIN (Firmware Version Identification Number)	1.0
HMN (Host Marketing Name)	N/A
EUT serial numbers	Conducted : 180A58FC Radiated : C7D912E5

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2. Requirements for Hybrid System transmitter(15.247)

This LoRa module has been tested by a LoRa Qualification Lab, and we confirm the following:

1) This system is hopping pseudo-randomly.

2) Each frequency is used equally on the average by each transmitter.

3) The receiver shifts frequencies in synchronization with the transmitted signals.

4) In Hybrid mode, FHSS operates only during the transmission of the signal, and not while receiving the signal.

• 15.247(f), RSS-247 5.3 : hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.

• 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.

• 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

• RSS-247 5.1 (a): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.



3. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device (ANSI C63.10-2013, KDB 558074) is used in the measurement of the test device.

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. / RSS-Gen issue 5, RSS-247 issue 3.

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.

4. 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).

5. 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 March 31, 2022 (CAB identifier: KR0032).

For ISED, test facility was accepted dated April 06, 2022 (CAB identifier: 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."



6. 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

According to RSS-GEN(Issue 5) Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.





7. 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 %, <i>k</i> =2)
Radiated Disturbance (9 kHz ~ 30 MHz)	4.14 (Confidence level about 95 %, <i>k</i> =2)
Radiated Disturbance (30 MHz ~ 1 GHz)	5.82 (Confidence level about 95 %, <i>k</i> =2)
Radiated Disturbance (1 GHz ~ 18 GHz)	5.74 (Confidence level about 95 %, <i>k</i> =2)
Radiated Disturbance (18 GHz ~ 40 GHz)	5.76 (Confidence level about 95 %, <i>k</i> =2)
Radiated Disturbance (Above 40 GHz)	5.52 (Confidence level about 95 %, <i>k</i> =2)





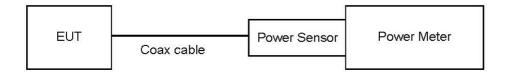
8. DESCRIPTION OF TESTS

8.1. Conducted Maximum Peak Output Power

Limit

The maximum permissible conducted output power is 1 Watt.

Test Configuration



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.

Sample Calculation

Conducted Output Power(Peak) = Measured Value + ATT loss + Cable loss

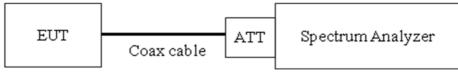


8.2. Power Spectral Density

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 kHz \leq RBW \leq 100 kHz.
- 4) VBW \geq 3 x 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.
- 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

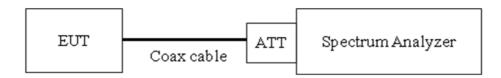


8.3. Conducted Band Edge(Out of Band Emissions)

Limit

According to § 15.247(d), in any 100 kHz 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 20 dB below that in the 100 kHz 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.

Test Configuration



Test Procedure

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

- Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
- 2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
- 3) Attenuation: Auto (at least 10 dB preferred).
- 4) Sweep time: Coupled.
- 5) RBW: 100 kHz
- 6) VBW: 300 kHz
- 7) Detector: Peak
- 8) Trace: Max hold

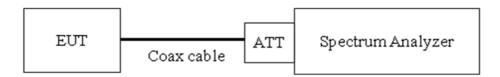


8.4. Frequency Separation & 20 dB Bandwidth

Limit

According to § 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Configuration



Test Procedure(Frequency Separation)

The Channel Separation test is performed with hopping on. And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013 & Procedure 10(b)(6)(iii) in KDB 558074 v05r02)

- 1) Span: Wide enough to capture the peaks of two adjacent channels
- 2) RBW: Start with the RBW set to approximately 30 % of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.
- 8) Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.





Test Procedure (20 dB Bandwidth)

And the 20 dB Bandwidth test is performed with hopping off.

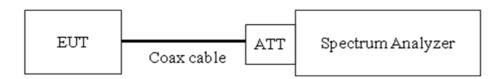
The Spectrum Analyzer is set to (6.9.2 in ANSI 63.10-2013)

- 1) Span: Set between two times and five times the OBW
- 2) RBW: 1 % to 5 % of the OBW.
- 3) VBW \geq 3 x RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.



8.5. Number of Hopping Frequencies

Test Configuration

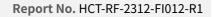


Test Procedure

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013 & Procedure 10(b)(4) in KDB 558074 v05r02)

- 1) Span: the frequency band of operation
- 2) RBW: To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) Allow the trace to stabilize.



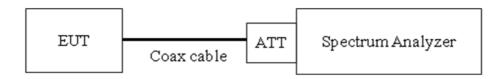


8.6. Time of Occupancy

Limit

According to § 15.247(f), The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

Test Configuration



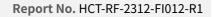
Test Procedure

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013 & Procedure 10(b)(6)(iv) in KDB 558074 v05r02)

- 1) Span: Zero span, centered on a hopping channel
- 2) RBW shall be \leq channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
- 3) Sweep = as necessary to capture the entire dwell time per hopping channel
- 4) Detector: Peak
- 5) Trace: Max hold

The marker-delta function was used to determine the dwell time.

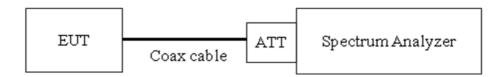




8.7. Conducted Spurious Emissions

Limit Conducted > 20 dBc

Test Configuration



Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

- 1) Span: 30 MHz to 10 times the operating frequency in GHz.
- 2) RBW: 100 kHz
- 3) VBW: 300 kHz
- 4) Sweep: Coupled
- 5) Detector: Peak

Measurements are made over the 30 MHz to 10 GHz range with the transmitter set to the lowest, middle, and highest channels.

This test is performed with hopping off.



Factors for frequency

Freq(MHz)	Factor(dB)
30	20.10
100	20.15
200	20.19
300	20.24
400	20.30
500	20.30
600	20.31
700	20.32
800	20.33
900	20.35
902	20.35
928	20.35
1 000	20.40
2 000	20.65
2 400	20.74
2 500	20.74
3 000	20.89
4 000	21.13
5 000	21.65
5 700	21.74
5 800	21.74
6 000	21.83
7 000	21.96
8 000	21.96
9 000	22.04
10 000	22.14
11 000	22.23
12 000	22.32
13 000	22.33
14 000	22.36
15 000	22.46
16 000	22.54
17 000	22.75
18 000	22.88
19 000	22.80
20 000	22.47
21 000	22.60
22 000	22.59
23 000	22.60
24 000	22.61
25 000	22.71

Note :

1. 902 ~ 928 MHz is fundamental frequency range.

2. Factor = Cable loss + Attenuator



8.8. Radiated Test

<u>Limit</u>

FCC

Frequency (MHz)	Field Strength (<u>µV</u> /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

ISED

Frequency (MHz)	Field Strength (<u>µ</u> A/m)	Measurement Distance (m)
0.009 - 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30

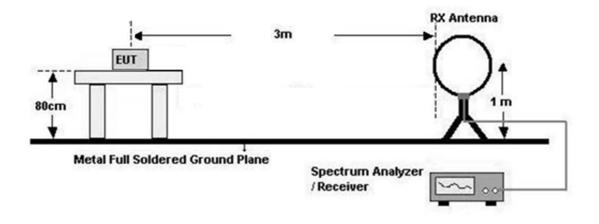
FCC&ISED

Frequency (MHz)	Field Strength (<u>µ</u> V/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

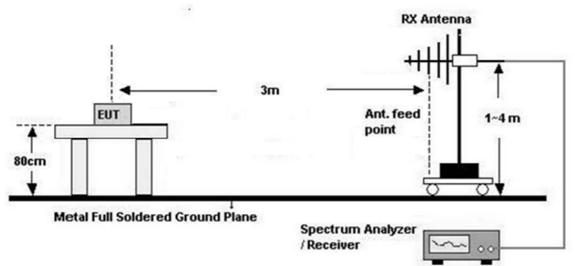


Test Configuration

Below 30 MHz

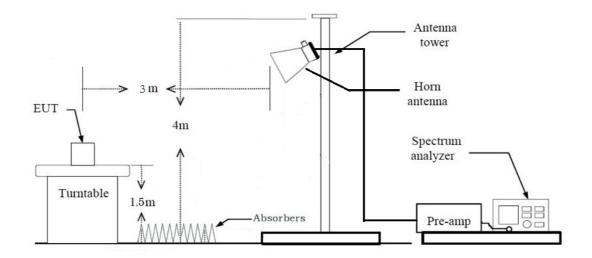


30 MHz - 1 GHz





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) = 40log(3 m/300 m) = 80 dB Measurement Distance : 3 m
- 7. Distance Correction Factor (0.490 MHz – 30 MHz) = 40log(3 m/30 m) = - 40 dB Measurement Distance : 3 m
- 8. Spectrum Setting
 - Frequency Range = 9 kHz ~ 30 MHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 9 kHz
 - VBW \geq 3 x RBW

9. Total = Measured Level + 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 Level + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)
- 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):
 - We performed using a reduced video BW method was done with the analyzer in linear mode
 - Measured Frequency Range 1 GHz 10th Harmonics
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq 1/\tau$ Hz, where τ = pulse width in seconds
 - #The actual setting value of VBW = 1 kHz

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 = 20log (test distance / specific distance) (dB)
- 11. Total(Measurement Type : Peak
 - = Peak Measured Value
 - Total(Measurement Type : Average)
 - = Average Measured Value
 - We apply to the offset in range 1 GHz 18 GHz
 - The offset = Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F) Amp.Gain(A.G)



8.9. 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 μH/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dBµV)		
	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



8.10. Receiver Spurious Emissions

Limit

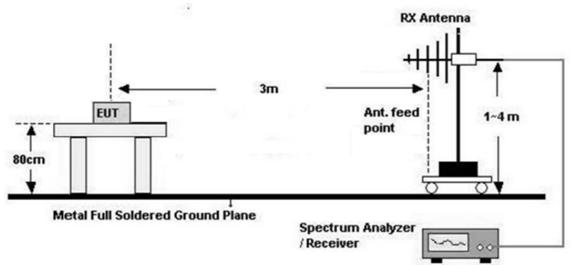
Frequency (MHz)	Field Strength (μV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

Measurements for compliance with the limits in table may be performed at distances other than 3 metres.

Test Configuration

30 MHz - 1 GHz







Test Procedure of Receiver Spurious Emissions (Below 1GHz)

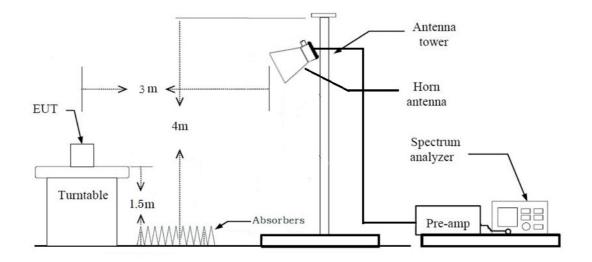
- 1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
- 2. The EUT is placed on a turntable, which is 0.8 m above ground plane.
- 3. The Hybrid antenna was placed at a location 3 m from the EUT, which is varied from 1 m to 4 m to find out the highest emissions.
- 4. We have 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
- 7. Total = Measured Level + Antenna Factor(A.F) + Cable Loss(C.L)



Above 1 GHz



Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.

2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

- 4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
- 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 25 GHz
 - 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.
- 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.

9. Total = Measured Level + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(A.G) + Distance Factor(D.F)





8.11. 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

2. EUT Axis

- Radiated Spurious Emissions : X

3. All data rate of operation were investigated and the test results are worst case of each mode.

- 125 kHz (SF 7, 8, 9, 10)

- Worst case : 125 kHz SF 10

4. All Packet length of operation were investigated and the test results are worst case of each mode.

- 125k SF 7, 8, 9 (1 to 36)
- 125k SF 10 (1 to 24)
- Worst case : Packet length 24

5. 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 EUT is used DC.

Conducted test

1. All modes of operation were investigated and the worst case configuration results are reported.

- Mode : 125kHz (SF 7, 8, 9, 10)
- Worst case : 125 kHz SF7, 10
- 2. All Packet length of operation were investigated and the test results are worst case of each mode.
 - 125k SF 7, 8, 9 (1 to 36)
 - 125k SF 10 (1 to 24)
 - Worst case : Packet length 1 & 36 (SF7), 1 & 24 (SF10)



Test Description	FCC Part Section(s)	ISED Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§ 15.247(a)(1)(i)	RSS-247, 5.1 c)	< 250 kHz		PASS
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A		N/A
Conducted Maximum Peak Output Power	§ 15.247(b)(3)	RSS-247, 5.4 a)	< 1 W		PASS
Power Spectral Density	§ 15.247(f)	RSS-247, 5.3 b)	< 8 dBm / 3 kHz Band		PASS
Carrier Frequency Separation	§ 15.247(a)(1)	RSS-247, 5.1 b)	> 25 kHz or > 20 dB BW of hopping channel, whichever is greater.		PASS
Number of Hopping Frequencies	-	-	-	Conducted	N/A
Time of Occupancy	§ 15.247(f)	RSS-247, 5.3 a)	< 400 ms (0.4xNumber of Hopping Frequencies)		PASS
Conducted Spurious Emissions	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions	-	PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§ 15.207(a)	RSS-GEN, 8.8	cf. Section 8.9		N/A (Note.1)
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9	cf. Section 8.8		PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9 RSS-GEN, 8.10	cf. Section 8.8	Radiated	PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7	cf. Section 8.10		PASS

9. SUMMARY OF TEST RESULTS

Note:

1. Not Tested



10. TEST RESULT

10.1 PEAK POWER

-SF7

Channel	Frequency (MHz)	Output Power (Length 1)		Output Power (Length 36)		Limit	Result
		(dBm)	(mW)	(dBm)	(mW)	(mW)	
0	902.3	8.127	6.50	8.131	6.50		Pass
31	908.5	8.183	6.58	8.173	6.57	1000	Pass
63	914.9	8.208	6.62	8.214	6.63		Pass

-SF8

Channel	Frequency (MHz)	Output Power (Length 1)		Output Power (Length 36)		Limit	Result
		(dBm)	(mW)	(dBm)	(mW)	(mW)	
0	902.3	8.122	6.49	8.125	6.49		Pass
31	908.5	8.177	6.57	8.182	6.58	1000	Pass
63	914.9	8.209	6.62	8.211	6.62		Pass



-SF9

Channel	Frequency (MHz)	Output Power (Lentgh 1)		Output Power (Lentgh 36)		Limit	Result
		(dBm)	(mW)	(dBm)	(mW)	(mW)	
0	902.3	8.124	6.49	8.126	6.50		Pass
31	908.5	8.179	6.58	8.171	6.56	1000	Pass
63	914.9	8.216	6.63	8.204	6.61		Pass

-SF10

Channel	Frequency (MHz)	Output Power (Lentgh 1)		Output Power (Lentgh 24)		Limit	Result
		(dBm)	(mW)	(dBm)	(mW)	(mW)	
0	902.3	8.141	6.52	8.168	6.56		Pass
31	908.5	8.191	6.59	8.194	6.60	1000	Pass
63	914.9	8.217	6.63	8.229	6.65		Pass



10.2 POWER SPECTRAL DENSITY

Note:

1. In order to simplify the report, The table was recorded at the highest power.

Channel	Frequency	PSD (Lengh 1)	PSD (Lengh 24)	Limit	Result	
	(MHz)	(dBm / 3 kHz)	(dBm/ 3 kHz)	(dBm/ 3 kHz)		
0	902.3	7.738	7.424		Pass	
31	908.5	7.762	7.457	8	Pass	
63	914.9	7.852	7.484		Pass	

-SF10-



Test Plots

Note:

In order to simplify the report, Attached Plots were only the worst case. Worst case : SF 10_Length 1, 24



Power Spectral Density (SF10_Packet Length 1_Channel 0)

Power Spectral Density (SF10_Packet Lenth 1_Channel 31)

Keysight Spectrum Analyzer - Swept S			1		
RL RF 50Ω A Center Freq 908.50000	O MHz	SENSE:INT	ALIGN AUTO #Avg Type: RMS	06:01:21 PM 12 20, 2023 TRACE 1 2 3 4 5 6	Frequency
	PNO: Close +++ IFGain:Low	Trig: Free Run Atten: 10 dB	Avg Hold: 1/1		
Ref Offset 20.35			Mkr1 S	08.435 32 MHz 7.762 dBm	Auto Tune
10.4					Center Fred 908.500000 MHz
9.65					Start Fred 908.390000 MH;
19.7				<u>\</u>	
29.7					Stop Fred 908.610000 MH;
39.7					CF Step
49.7					22.000 kH <u>Auto</u> Mar
59.7					Freq Offse
59.7					0 H:
					Scale Type
enter 908.5000 MHz Res BW 3.0 kHz	#VBW	9.1 kHz	Sweep 7	Span 220.0 kHz .467 ms (1001 pts)	Log <u>Lir</u>
ISG			STATUS	5	



	ectrum Analyzer - Swept SA					
X RL Center F	RF 50 Ω AC req 914.900000 M		SENSE:INT	ALIGN AUTO #Avg Type: RMS	06:02:31 PM 12 20, 2023 TRACE 1 2 3 4 5 6 TYPE M	Frequency
		PNO: Close ++ IFGain:Low	Trig: Free Run Atten: 10 dB	Avg Hold: 1/1	DET	
10 dB/div Log	Ref Offset 20.35 dB Ref 20.35 dBm			Mkr1 S	014.838 40 MHz 7.852 dBm	Auto Tune
10.4						Center Fred 914.900000 MH:
9.65						Start Free 914.790000 MH
29.7	\sim					Stop Fre 915.010000 MH
39.7						CF Ste 22.000 kH <u>Auto</u> Ma
59.7						Freq Offse 0 H
69.7						Scale Typ
Center 91 Res BW	4.9000 MHz 3.0 kHz	#VBW	9.1 kHz	Sweep 7	Span 220.0 kHz .467 ms (1001 pts)	Log <u>Li</u> i
ISG				STATUS	6	

Power Spectral Density (SF10_Packet Lenth 1_Channel 63)

Power Spectral Density (SF10_Packet Lenth 24_Channel 0)





Keysight Spe	ectrum Analyzer - Swept SA RF 50 Ω AC					
	req 908.500000 I	MHz PNO: Close ↔	Trig: Free Run	ALIGN AUTO #Avg Type: RMS Avg Hold: 1/1	06:00:01 PM 12 20, 2023 TRACE 1 2 3 4 5 6 TYPE M	Frequency
0 dB/div	Ref Offset 20.35 dB Ref 20.35 dBm	IFGain:Low	Atten: 10 dB	Mkr1 s	008.504 62 MHz 7.457 dBm	Auto Tun
10.4						Center Fre 908.500000 MH
350						Start Fre 908.390000 M⊢
29.7	~~					Stop Fre 908.610000 MH
39.7						CF Ste 22.000 k⊢ <u>Auto</u> Ma
19.7 <u> </u>						Freq Offse 0 ⊢
i9.7						Scale Typ
enter 90 Res BW	8.5000 MHz 3.0 kHz	#VBW	9.1 kHz	Sweep 7	Span 220.0 kHz .467 ms (1001 pts)	Log <u>Li</u>
s <mark>g</mark>				STATUS	5	

Power Spectral Density (SF10_Packet Lenth 24_Channel 31)

Power Spectral Density (SF10_Packet Lenth 24_Channel 63)



The report shall not be (partly) reproduced except in full without approval of the laboratory.



10.3 BAND EDGES

- Without hopping

Frequency		Destition	SF7	Limit	Margin	
(MHz)	Channel	Position	(dB)	(dBc)	(dBc)	Result
902.3	0	Lower	30.739	20	10.739	Pass
914.9	63	Upper	60.551	20	40.551	Pass
Frequency			SF10	Limit	Margin	
(MHz)	Channel	Position	(dB)	(dBc)	(dBc)	Result
902.3	0	Lower	30.699	20	10.699	Pass
914.9	63	Upper			40.260	Pass

- With hopping

Frequency	Channel	Position	SF7	Limit	Margin	Desult	
(MHz)	Channel	POSICION	(dB)	(dBc)	(dBc)	Result	
902.3	0	Lower	32.032	20	12.032	Pass	
914.9	63	Upper	59.360	20	39.360	Pass	

Frequency	Channel	Position	SF10	Limit	Margin	Decult
(MHz)	Channel	POSICION	(dB)	(dBc)	(dBc)	Result
902.3	0	Lower	32.146	20	12.146	Pass
914.9	63	Upper	59.697	20	39.697	Pass



Test Plots

Without Hopping (SF7)



Upper Band Edge (Channel 63)





With Hopping (SF7)



Lower Band Edge (Channel 0)

Upper Band Edge (Channel 63)





Without Hopping (SF10)



Upper Band Edge (Channel 63)





With Hopping (SF10)



Upper Band Edge (Channel 63)





10.4 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99 % BW)

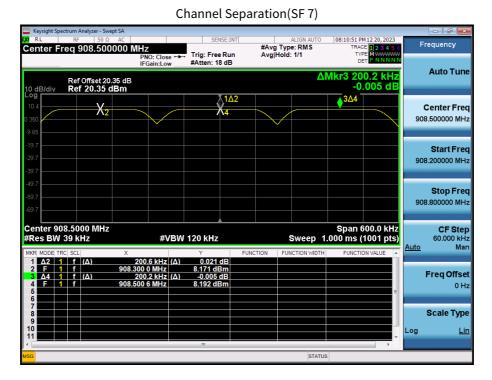
	Channel Separation (kHz)		20 dB	Limit				
SF7	SF10	Channel	SF 7	Limit (kHz)	SF 10	Limit (kHz)	(kHz)	Result
		0	149.2		139.1		>25 or > 20 dB BW of	
200.2	200.0	31	148.6 149.2	149.2	138.4	139.1	hopping channel,	Pass
		63	147.4		138.8		Whichever is greater	

Occupied Bandwidth (99 % BW)

	99 % BW (kHz)								
	SF	Channel 0	Channel 31	Channel 63					
Channel	SF7	127.78	127.25	127.01					
	SF10	126.61	126.02	126.17					



Test Plots

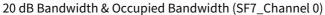


Channel Separation(SF 10)

Center Freq 908.500000 MHz Trig: Free Run #Avg Type: RMS Trig: Free Run #Avg Type: RMS Trig: Free Run #Avg Type: RMS Trig: Free Run Avg Hold: 1/1 Auto Tun 0.00 dB 1/1		ectrum Analyzer - Swej	pt SA						
IFGainLow #Atten: 18 dB Det latitude In dB/div Ref Offset 20.35 dB Auto Tun In dB/div Ref 20.35 dB 0.000 dB In dB/div Y2 In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day In day <td< td=""><td>Center F</td><td></td><td>000 MHz</td><td></td><td>#Avg T</td><td>Type: RMS</td><td>TRACE TYPE</td><td>23456</td><td>Frequency</td></td<>	Center F		000 MHz		#Avg T	Type: RMS	TRACE TYPE	23456	Frequency
MA X2 A Center Pression 965 2 4 4 5 908.50000 MH 967 398 398 309 Stop Free 908.50000 MH2 Stop Free 908.50000 MH2 Stop Free 908.50000 MH2 Stop Free 908.500.00 MH2 Stop Free	10 dB/div		IFGain:Low	#Atten: 18 dB		Δ	Mkr3 200.	2 kHz	Auto Tune
297 398 398 398 398 398 398 408 400 100 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 1000 10		χ			<u>2</u>		<u></u> 3∆4		Center Fred 908.500000 MH
597	-29.7								Start Fre 908.200000 MH
#Res BW 39 kHz #VBW 120 kHz Sweep 1.000 ms (1001 pts) Auto 60.000 kH MMR_MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE Mathematical Science Function width Function value Mathematical Science Mathematical Science Mathematical Science Science Function value Function width Function value Functi	-59.7								
1 Δ2 1 f (Δ) 200.0 HHz (Δ) 0.016 dB 2 F 1 f 908.300 0 HHz 8.106 dBm Freq Offset 3 Δ4 1 f (Δ) 200.2 KHz (Δ) 0.000 dB 4 F 1 f 908.500 0 MHz 8.123 dBm Freq Offset 6 I I 908.500 0 MHz 8.123 dBm Image: Constraint of the set of the	#Res BW	39 kHz			FUNCTION		.000 ms (10	01 pts)	60.000 kH
9 10 10 10 10 10 10 10 10 10 10 10 10 10	1 Δ2 1 2 F 1 3 Δ4 1 4 F 1 5 5	f (Δ) f	200.0 kHz(908.300 0 MHz 200.2 kHz(Δ) 0.016 dB 8.106 dBm Δ) 0.000 dB	PUNCTION		-runc non v		Freq Offse 0 H
	9								Scale Type
				m		STATUS		•	







20 dB Bandwidth & Occupied Bandwidth (SF7_Channel 31)







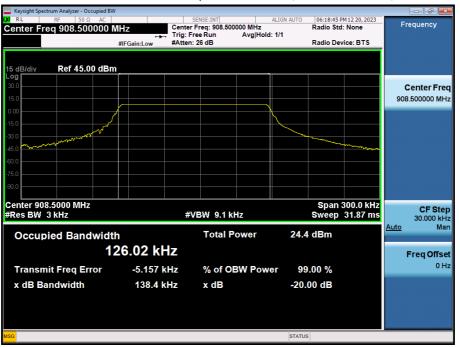
20 dB Bandwidth & Occupied Bandwidth (SF7_Channel 63)





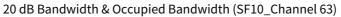
20 dB Bandwidth & Occupied Bandwidth (SF10_Channel 0)

20 dB Bandwidth & Occupied Bandwidth (SF10_Channel 31)





Keysight Spectrum Analyzer - Occupied B	W				
Image: RL RF 50 Ω AC Center Freq 914.900000 914.900000 AC	MHz	SENSE:INT Center Freq: 914.900	ALIGN AUTO	06:20:05 PM 12 20, 2023 Radio Std: None	Frequency
001101 1100 014.000000	#IFGain:Low	Trig: Free Run #Atten: 26 dB	Avg Hold: 1/1	Radio Device: BTS	
	#IFGaIn:Low	#Atten: 20 dB		Radio Device: D13	
15 dB/div Ref 45.00 dB	~				
30.0					Center Freq
15.0					914.900000 MHz
0.00			\vdash		
-15.0			- Van		
-30.0					
-45.0					
-60.0					
-75.0					
-90.0					
Center 914.9000 MHz				Span 300.0 kHz	
#Res BW 3 kHz		#VBW 9.1 kl	Hz	Sweep 31.87 ms	
					Auto Man
Occupied Bandwid	th	Total P	ower 24.	4 dBm	
1	26.17 kH	Iz			Freq Offset
Transmit Freg Error	-5.262 k		3W Power 9	9.00 %	0 Hz
· · · · ·					
x dB Bandwidth	138.8 k	Hz x dB	-20	.00 dB	
MSG			STATI	JS	







10.5 NUMBER OF HOPPING FREQUENCY

Result (No. of CH)	Limit
64	-

Test Plots







10.6 TIME OF OCCUPANCY (DWELL TIME)

Note :

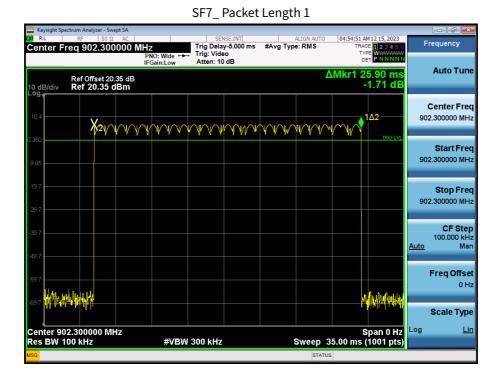
Time Period = 0.4s x 64(The number of Hopping Frequencies)

= 25.6 s

Spreading	Length	Dwell Time	Hops in 25.6s	The average time of	Limit
Factor	Length	(ms)	Hops III 25.65	occupancy (ms)	(ms)
667	1	25.90	6	155.40	
SF7	36	77.10	4	308.40	
CE0	1	51.68	5	258.40	
SF8	36	143.70	1	143.70	400
650	1	103.50	3	310.50	400
SF9	36	267.30	1	267.30	
6510	1	206.80	1	206.80	
SF10	24	370.40	1	370.40	



Test Plots



SF7_ Packet Length 36

Keysight Spectrum Analyzer - Swept SA				
x/ RL RF 50Ω AC Center Freq 902.300000 N	BACK SENSE:INT HZ PNO: Wide ↔ Trig: Video FGain:Low Atten: 10 dB	ALIGN AUTO	04:55:49 AM 12 15, 2023 TRACE 1 2 3 4 5 6 TYPE WWWWWW DET P NNNNN	Frequency
Ref Offset 20.35 dB 10 dB/div Ref 20.35 dBm	- Guinzon	l	∆Mkr1 77.10 ms -0.47 dB	Auto Tune
10.4		TY WYYYYYYYYYYY		Center Fred 902.300000 MH;
9.65				Start Free 902.300000 MH
-19.7				Stop Fre 902.300000 MH
49.7				CF Ste 100.000 kH <u>Auto</u> Ma
69.7			Mathan Martin	Freq Offse 0 H
Center 902.300000 MHz Res BW 100 kHz	#VBW 300 kHz	Sween	Span 0 Hz 100.0 ms (1001 pts)	Scale Type
<mark>ISG</mark>		STATU		



	ectrum Analyzer - Swept SA					- 7
Center F	RF 50 Ω AC req 902.30000		SENSE:INT Trig Delay-10.00 ms	#Avg Type: RMS	04:57:09 AM 12 15, 2023 TRACE 1 2 3 4 5 6	Frequency
		PNO: Wide ↔ IFGain:Low	Trig: Video Atten: 10 dB	A	DET P NNNNN	Auto Tune
10 dB/div Log	Ref Offset 20.35 d Ref 20.35 dBm				-4.41 dB	
36						Center Freq
10.4	Xanana				142	902.300000 MHz
0.350	1 72 Y V V	ŶŶŶŶŶŶŶ		, M . N M M M M	TRIG LVL	
						Start Freq 902.300000 MHz
-9.65						902.300000 MHz
-19.7						Stop Freq
						902.300000 MHz
-29.7						
-39.7						CF Step 100.000 kHz
(0.7						<u>Auto</u> Man
-49.7						
-59.7						Freq Offset 0 Hz
-69.7 MM	himunha				helphaland and an annual and	
-09.7						Scale Type
Center 90	02.300000 MHz				Span 0 Hz	Log <u>Lin</u>
Res BW 1		#VBW	300 kHz	Sweep 7	5.00 ms (1001 pts)	
MSG				STATUS		

SF8_ Packet Length 1

SF8_Packet Length 36

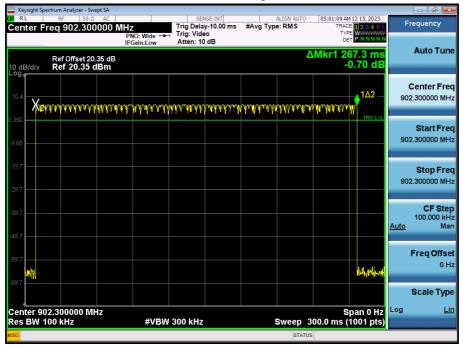
	ectrum Analyzer - Swept S					
enter F	RF 50 Ω A req 902.30000		SENSE:INT Trig Delay-10.00 ms Trig: Video Atten: 10 dB	ALIGN AUTO #Avg Type: RMS	04:58:46 AM 12 15, 2023 TRACE 1 2 3 4 5 6 TYPE WWWWW DET P N N N N N	Frequency
0 dB/div	Ref Offset 20.35 Ref 20.35 dBr	dB	Allen: To ub	L	Mkr1 143.7 ms -0.01 dB	Auto Tun
.og	(proposition	hukaa khuhana ka	N VATAVA VATAA	ektatukan kana kana kana kana kana kana kana	1∆2 ₩₩₩¥¥¥¥	Center Fre 902.300000 M⊦
350 9.65						Start Fre 902.300000 MH
9.7						Stop Fre 902.300000 Mi
9.7						CF Ste 100.000 k <u>Auto</u> M
9.7 9.7 ui(\rr/					Manalanda	Freq Offs 01
	02.300000 MHz 100 kHz	#VBW	300 kHz	Sweep 1	Span 0 Hz 70.0 ms (1001 pts)	Scale Typ Log <u>L</u>
G				STATU		



		Analyzer - Swe									_	- 6 💌
Center	R Fred	F 50 Ω 902.300	AC 000 MH	7		y-10.00 ms	#Avg Typ	ALIGN AUTO e: RMS		M1215,2023	F	requency
		0021000	F	PNO: Wide ↔ FGain:Low	. Trig: Vide Atten: 10				TY			
				Gam.cow	,				AMkr1 1	03.5 ms		Auto Tune
10 dB/div		f Offset 20. f 20.35 d							-	4.58 dB		
Log												Center Freq
10.4												2.300000 MHz
	X2V			$\gamma \gamma \gamma \gamma \gamma$	WWW	Y W W	WYWY		Δ2			
0.350										TRIG LVL		Start Freq
											90	2.300000 MHz
-9.65												
-19.7												Oton Eron
											903	Stop Freq 2.300000 MHz
-29.7												2.000000 1111 12
												CF Step
-39.7												100.000 kHz
-49.7											<u>Auto</u>	Man
-59.7												Freq Offset 0 Hz
ply dry	W.							d,	WALLANN	phillipping		0112
-69.7												Scale Type
		00000 MH	z		000 111				450.0	ipan 0 Hz	Log	<u>Lin</u>
Res BW	100 1	KHZ		#VBW	300 kHz				150.0 ms	1001 pts)		
MSG								STAT	05			

SF9_Packet Length 1

SF9_ Packet Length 36





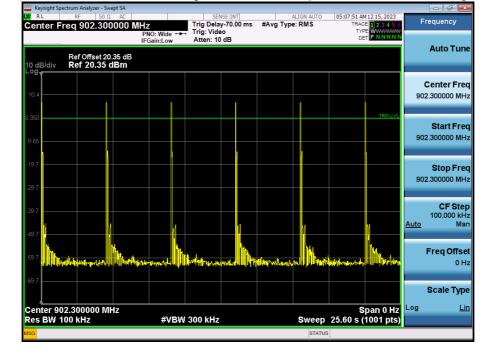
	pectrum Analyzer - Swept										
Center	RF 50 Ω Freq 902.3000			Trig Dela	vse:INT y-10.00 ms	#Avg Typ	ALIGN AUTO e: RMS	TRAC	112 15, 2023 E 1 2 3 4 5 6	F	requency
10 dB/div	Ref Offset 20.3 Ref 20.35 dE	PNO IFGa 5 dB): Wide ↔ iin:Low	Trig: Vide Atten: 10			Δ	Mkr1 2	06.8 ms 0.34 dB		Auto Tune
	21//////	$\gamma\gamma\gamma\gamma$	$\gamma \gamma \gamma$	$\sim \sim$			m				Center Freq 2.300000 MHz
-9.65										90:	Start Freq 2.300000 MHz
-19.7										90	Stop Freq 2.300000 MHz
-39.7										<u>Auto</u>	CF Step 100.000 kHz Man
-59.7								AMA	rtonalati		Freq Offset 0 Hz
	02.300000 MHz	2						s	pan 0 Hz	Log	Scale Type Lin
Res BW			#VBW	300 kHz			Sweep 2	50.0 ms (1001 pts)		
							514103				

SF10	Packet	Length	1
··			_

SF10_Packet Length 24

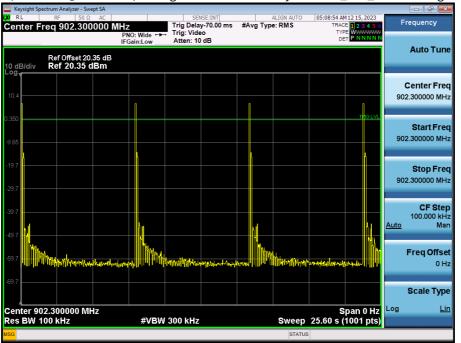
	déo 10 dB	g Type: RMS	05:03:44 AM12 15,2023 TRACE 2 3 4 3 2 3 TRACE 2 3 4 3 2 3 TPPE WWWWWW DET P NNNNN 1kr1 370.4 ms -3.95 dB	Frequency Auto Tur Center Fre 902.300000 Mi Start Fre 902.300000 Mi
Y Y W Y W Y W Y	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		-3.95 dB	Center Fre 902.300000 Mi Start Fre
Y WYYY Y Y WYY	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			902.300000 Mł Start Fre
				Stop Fr 902.300000 Mi
				CF Sto 100.000 k Auto M
			unvorloply.	Freq Offs 0
		Swoon 420	opunonz	Scale Typ
			#VBW 300 kHz Sweep 42	۲۰۰۵ (۱۹۵۵) Span 0 Hz #VBW 300 kHz Sweep 420.0 ms (1001 pts)



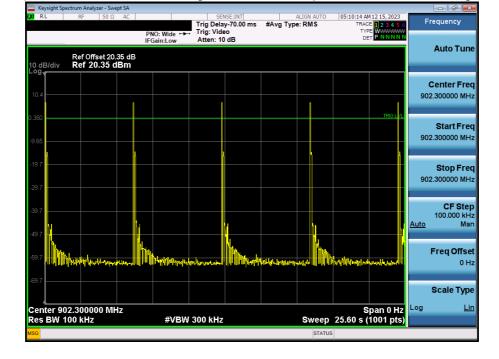


Hops / channel @ 25.6s = 6 (The highest emission is only relevant_SF7_ Packet Length 1)



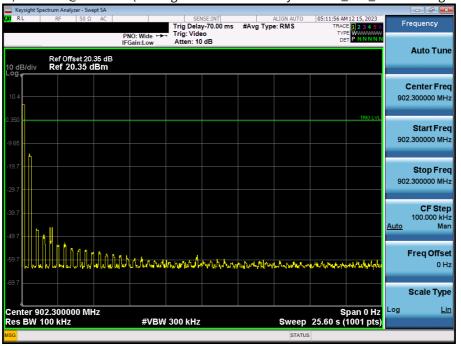




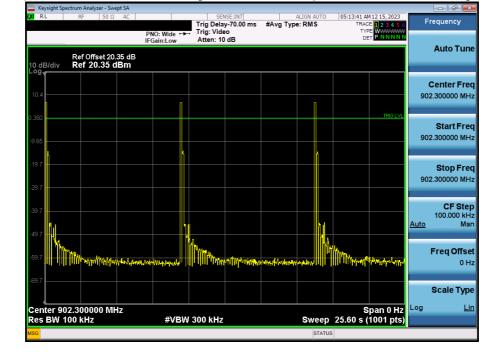


Hops / channel @ 25.6s = 5 (The highest emission is only relevant_SF8_ Packet Length 1)



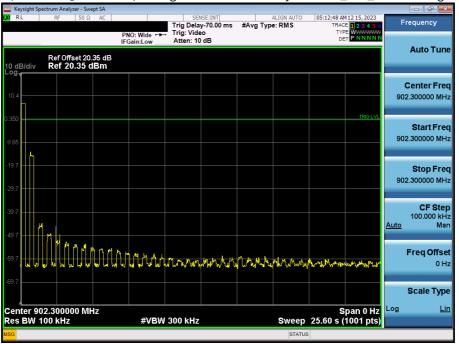






Hops / channel @ 25.6s = 3 (The highest emission is only relevant_SF9_ Packet Length 1)



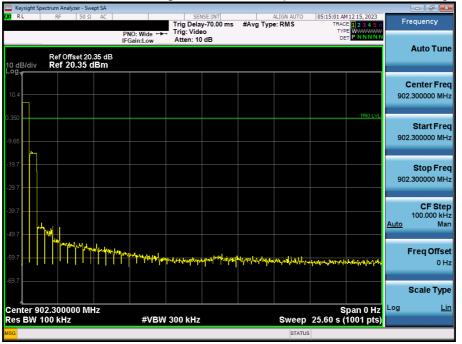




				PNO: Wide ↔ IFGain:Low	Trig Delay Trig: Video Atten: 10	b	#Avg Ty	pe:RMS	TYP	E 1 2 3 4 5 6 E WWWWWW T P N N N N N		requency
10 dB/di	Re V R e	ef Offset ef 20.3:	20.35 dB 5 dBm									Auto Tui
- ^{og}												Center Fr
10.4											90:	2.300000 M
.350										TRIG LVL		Start Fr
9.65											90:	2.300000 M
19.7												Stop Fr
29.7											90:	2.300000 M
39.7												CF St
	M										<u>Auto</u>	100.000 k M
49.7		nNa										Freq Offs
59.7	ฟิกิพ	w pl w h		nhanna	whichwas	แหม่ให้เส	hitran	a matter and	with have	www.thy		0
69.7												Scale Ty
`enter	002.2	00000	MHZ							pan 0 Hz	Log	Jealery
	902.3 V 100		WINZ	#VBV	V 300 kHz			Sweep	25.60 s (1001 pts)		
ISG								STATUS	5			

Hops / channel @ 25.6s = 1 (The highest emission is only relevant_SF10_ Packet Length 1)







10.7 SPURIOUS EMISSIONS

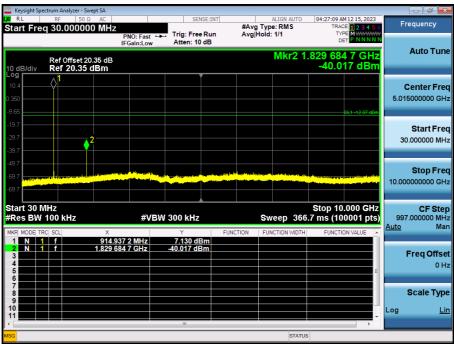
10.7.1 CONDUCTED SPURIOUS EMISSIONS

Note:

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

Worst case Mode : Channel 0_SF10_Length 24

Test Plots



30 MHz ~ 10 GHz

Note :

Limit : -12.87 dBm



10.7.2 RADIATED SPURIOUS EMISSIONS

Frequency Range : 9 kHz – 30 MHz

Frequency	Measured Level	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 = 40log (specific distance / test distance) (dB)
- 3. Limit line = specific Limits ($dB\mu V$) + Distance extrapolation factor

Frequency	Measured Level	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									

Frequency Range : Below 1 GHz

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

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 706.90	51.13	Н	51.13	73.98	22.85	PK
2 706.90	37.70	Н	37.70	53.98	16.28	AV
3 609.20	43.32	Н	43.32	73.98	30.66	PK
3 609.20	30.09	Н	30.09	53.98	23.89	AV
4 511.50	46.12	Н	46.12	73.98	27.86	РК
4 511.50	32.30	Н	32.30	53.98	21.68	AV
5 413.80	47.20	Н	47.20	73.98	26.78	РК
5 413.80	33.88	Н	33.88	53.98	20.10	AV
8 120.70	51.77	Н	51.77	73.98	22.21	PK
8 120.70	38.12	Н	38.12	53.98	15.86	AV
9 023.00	52.35	Н	52.35	73.98	21.63	PK
9 023.00	38.88	Н	38.88	53.98	15.10	AV

Channel : 0(902.3 MHz)

Note :



Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 706.90	51.08	V	51.08	73.98	22.90	PK
2 706.90	37.68	V	37.68	53.98	16.30	AV
3 609.20	43.22	V	43.22	73.98	30.76	PK
3 609.20	30.02	V	30.02	53.98	23.96	AV
4 511.50	46.05	V	46.05	73.98	27.93	РК
4 511.50	32.18	V	32.18	53.98	21.80	AV
5 413.80	46.92	V	46.92	73.98	27.06	РК
5 413.80	33.79	V	33.79	53.98	20.19	AV
8 120.70	51.75	V	51.75	73.98	22.23	PK
8 120.70	38.02	V	38.02	53.98	15.96	AV
9 023.00	52.28	V	52.28	73.98	21.70	PK
9 023.00	38.40	V	38.40	53.98	15.58	AV

Channel: 0(902.3 MHz)

Note :



Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 725.50	50.64	Н	50.64	73.98	23.34	PK
2 725.50	37.72	Н	37.72	53.98	16.26	AV
3 634.00	44.59	Н	44.59	73.98	29.39	PK
3 634.00	30.74	Н	30.74	53.98	23.24	AV
4 542.50	45.99	Н	45.99	73.98	27.99	PK
4 542.50	32.43	Н	32.43	53.98	21.55	AV
5 451.00	47.26	Н	47.26	73.98	26.72	РК
5 451.00	33.40	Н	33.40	53.98	20.58	AV
7 268.00	51.49	Н	51.49	73.98	22.49	РК
7 268.00	37.33	Н	37.33	53.98	16.65	AV
8 176.50	52.49	Н	52.49	73.98	21.49	PK
8 176.50	38.77	Н	38.77	53.98	15.21	AV
9 085.00	52.65	Н	52.65	73.98	21.33	PK
9 085.00	39.48	Н	39.48	53.98	14.50	AV

Channel : 31(908.5 MHz)

Note :



Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 725.50	50.97	V	50.97	73.98	23.01	PK
2 725.50	37.79	V	37.79	53.98	16.19	AV
3 634.00	44.27	V	44.27	73.98	29.71	PK
3 634.00	30.62	V	30.62	53.98	23.36	AV
4 542.50	45.61	V	45.61	73.98	28.37	PK
4 542.50	32.38	V	32.38	53.98	21.60	AV
5 451.00	47.12	V	47.12	73.98	26.86	PK
5 451.00	33.30	V	33.30	53.98	20.68	AV
7 268.00	51.32	V	51.32	73.98	22.66	PK
7 268.00	37.28	V	37.28	53.98	16.70	AV
8 176.50	51.97	V	51.97	73.98	22.01	PK
8 176.50	33.56	V	33.56	53.98	20.42	AV
9 085.00	52.44	V	52.44	73.98	21.54	PK
9 085.00	39.27	V	39.27	53.98	14.71	AV

Channel : 31(908.5 MHz)

Note :



Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 744.70	51.49	Н	51.49	73.98	22.49	РК
2 744.70	38.31	Н	38.31	53.98	15.67	AV
3 659.60	44.30	Н	44.30	73.98	29.68	PK
3 659.60	30.99	Н	30.99	53.98	22.99	AV
4 574.50	45.67	Н	45.67	73.98	28.31	РК
4 574.50	32.20	Н	32.20	53.98	21.78	AV
7 319.20	51.99	Н	51.99	73.98	21.99	РК
7 319.20	38.29	Н	38.29	53.98	15.69	AV
8 234.10	51.56	Н	51.56	73.98	22.42	PK
8 234.10	39.31	Н	39.31	53.98	14.67	AV
9 149.00	53.81	Н	53.81	73.98	20.17	РК
9 149.00	40.22	Н	40.22	53.98	13.76	AV

Channel : 63(914.9 MHz)

Note :



Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 744.70	51.36	V	51.36	73.98	22.62	PK
2 744.70	38.28	V	38.28	53.98	15.70	AV
3 659.60	44.21	V	44.21	73.98	29.77	PK
3 659.60	30.87	V	30.87	53.98	23.11	AV
4 574.50	45.51	V	45.51	73.98	28.47	PK
4 574.50	32.18	V	32.18	53.98	21.80	AV
7 319.20	51.57	V	51.57	73.98	22.41	PK
7 319.20	38.21	V	38.21	53.98	15.77	AV
8 234.10	51.42	V	51.42	73.98	22.56	РК
8 234.10	39.28	V	39.28	53.98	14.70	AV
9 149.00	53.77	V	53.77	73.98	20.21	РК
9 149.00	40.21	V	40.21	53.98	13.77	AV

Channel : 63(914.9 MHz)

Note :



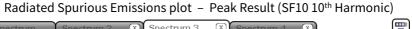
RESULT PLOTS

Note:

In order to simplify the report, Only the worst case plots were attached.

Radiated S	Spurious Emi	ssions plot –	Average Resu	lt (SF10 10) th Harmonic)
Spectrum	Spectrum 2	Spectrum 3	Spectrum	4 🗴	
RefLevel 97.0 Att		● RBW 1MHz ns ● VBW 1kHz I	Mode Sweep		
Count 100/100	TDF		indue oncop		
●1Pk Max●2Pk C	Irw		M1[1]		40.22 dBµV
90 dBµV					9.14840530 GHz
80 dBµV					
70 dBµV					
60 dBµV					
50 dBµV		M1			
40 dBuX				-	
30 dBµV					
20 dBµV					
10 dBµV					
0 dBµV					
CF 9.149 GHz		2001	pts		Span 10.0 MHz
			Measuring		06:59:38

Date: 18.DEC.2023 06:59:38



Spectrum	Spectrum 2 (x) Spectrum 3	Ľ s	pectrum 4	1 (X)		$\overline{\nabla}$
Ref Level 97.00		RBW 1 MHz	_				
Att		• VBW 3 MHz M	ode Sweep)			
Count 100/100	TDF						
●1Pk Max●2Pk Clr	W						
			M	1[1]		5	3.81 dBµV
90 dBµV						9.151	20890 GHz
80 dBµV							
70 dBµV							
, o dop.							
60 dBµV							
ου αθμν					M1		
والمراجعة والمتحد والمتحد والمراجع	the current of the second second		والمتعادية المتحديد	and the second second second	and a barry	al al state and a state	-
190-8800 Աեփիեստի Միլլ մերի, Ա	ورجيجاة الالبانية الشالية ألبر والبأ الألمادي		ak 1 . ה או וו ונג. האו האו	ետեսիների	بلارين الأردينيان	datation and a same	and in the little base
a na shi k a ka shi ka				14 M W W			AN MARKAN
140'ШвЩV : - 1 - 1 - 1	<u>, , , , , , , , , , , , , , , , , , , </u>			ble. Hee.	1		and the street
			1				
30 dBµV							
20 dBµV							
10 dBµV							
10 00p.							
o douve							
							10.0111
CF 9.149 GHz		2001	pts		_	Span	10.0 MHz
			Mea	suring		4/4	06:59:53

Date: 18.DEC.2023 06:59:54





10.8 RECEIVER SPURIOUS EMISSIONS

Frequency Range : Below 1 GHz

Frequency	Measured Level	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

Frequency	Measured Level	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							





11. LIST OF TEST EQUIPMENT

Conducted Test

Equipment	Model	Manufacturer	Serial No.	Due to Calibration	Calibration Interval
LISN	ENV216	Rohde & Schwarz	102245	08/02/2024	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	09/04/2024	Annual
Power Meter	N1911A	Agilent	MY45100523	03/06/2024	Annual
Power Sensor	N1921A	Agilent	MY57820067	03/06/2024	Annual
Directional Coupler	87300B	Agilent	3116A03621	10/30/2024	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(20 dB)	18N-20dB	Rohde & Schwarz	8	03/08/2024	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	S3AM	08/03/2025	Biennial
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	11/07/2025	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	11/17/2024	Annual
RF Switching System	FBSR-03A (10dB ATT+LNA)	T&M SYSTEM	S3L2	11/17/2024	Annual
RF Switching System	FBSR-03A (7G HPF+LNA)	T&M SYSTEM	S3L3	11/17/2024	Annual
RF Switching System	FBSR-03A (3dB ATT+LNA)	T&M SYSTEM	S3L4	11/17/2024	Annual
Power Amplifier	CBL18265035	CERNEX	22966	11/17/2024	Annual
Power Amplifier	CBL26405040	CERNEX	25956	03/02/2024	Annual
Bluetooth Tester	TC-3000C	TESCOM	3000C000175	03/28/2024	Annual
Spectrum Analyzer	FSVA40 (10 Hz ~ 40 GHz)	Rohde & Schwarz	101502	03/17/2024	Annual
Spectrum Analyzer	FSV40 (10 Hz ~ 40 GHz)	Rohde & Schwarz	100900	12/06/2024	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).



12. ANNEX A_TEST SETUP PHOTO

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

No.	Description
1	HCT-RF-2312-FI012-P