Test Report

Test Report No.: CQC-IVTS-2024-0269-E1

Product Name	SwingCube
Model Number	S2020
Applicant	SwingCube LLC
Approval Types	FCC ID: 2BK3Z-S2020

CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd.

National Quality Inspection and Testing Center for Internet of Vehicles Products

TEST REPORT DECLARATION

Equipment under Test	:	**SwingCube**
Test Model	:	S2020
Listed Models	:	-/-
Applicant	:	**SwingCube LLC**
Address	:	6796 Monticello Ln, Dublin, Ohio 43016
Manufacturer	:	**Shanghai Ivluan Technology Co.,Ltd**
Address	:	701, Buiding 5, No.518, Xinzhuan Road,Songjiang District,Shanghai

The EUT described above is tested by CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd. to determine the maximum emissions from the EUT. CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd. is assumed full responsibility for the accuracy of the test results.

Project Engineer:	王炎坤 (Yankun Wang 王炎坤)	Date: 2024-12-18
Checked by:	李昊昊 (Haohao Li 李昊昊)	Date: 2024-12-18
Approved by:	Wenliang Li (Wenliang Li 李文亮)	Date: 2024-12-18

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1. TEST STANDARDS

The tests were performed according to following standards: The equipment under test (EUT) has been tested at CQC-IVTS's (own or subcontracted) laboratories according to the leading reference documents giving table below:

No	Identify	Document Title	Version/Date
1	FCC Part 15 C § 15.249	Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHZ, and 24.0–24.25 GHz.	5/16/2023
2	ANSI C63.10	American National Standard ofProcedures for Compliance Testingof Unlicensed Wireless Devices	10 September 2020

2. SUMMARY

2.1. General Remarks

Date of receipt of test sample	:	August 15, 2024
Testing commenced on	:	August 15, 2024
Testing concluded on	:	September 10, 2024

2.2. Product Description*

Product Name:	SwingCube
Trade Mark	-/-
Model/Type reference:	S2020
List Model:	-/-
FCC ID:	2BK3Z-S2020
Hardware Version:	G810MB_V0.3
Software Version:	fw_1.5
Frequency range:	24.00 – 24.25 GHz
Nominal Frequency:	Low Channel: 24.011 GHz; Middle Channel: 24.131 GHz; High Channel: 24.248 GHz;
Number of Channels:	80
Modulation Type:	No modulation (CW only)
Antenna:	Integrated patch antenna
Antenna Gain:	15.79 dBi
Power Supply:	DC 3.8V from the battery
IC Classification:	Motion sensor device
Emission Designator:	N0N

*: declared by the applicant. CQC-IVTS not responsible for accuary.

2.3. EUT Operation Mode*

EUT operating mode no	Description of operating modes	Additional information
op. 1	Continuously transmitting and receiving mode	Carrier modulation (normal mode). 24.011 GHz, a continuous wave with 100% duty cycle
op. 2	Continuously transmitting and receiving mode	Carrier modulation (normal mode). 24.131 GHz, a continuous wave with 100% duty cycle
op. 3	Continuously transmitting and receiving mode	Carrier modulation (normal mode). 24.248 GHz, a continuous wave with 100% duty cycle
op. 4	Continuously transmitting and receiving mode	FMCW modulation (normal mode). 24.011 – 24.248 GHz, a continuous wave with 100% duty cycle

*: declared by the applicant

2.4. Modifications

No modifications were implemented to meet testing criteria

2.5. Test Item (Equipment Under Test) Description*

Short designation	EUT Name	EUT Description	Serial number	Hardware status	Software status
EUT A	S2020	SwingCube	-/-	G810MB_V0.3	fw_1.5

*: declared by the applicant.

2.6. Auxiliary Equipment (AE) Description*

AE short designation	EUT Name (if available)	EUT Description	Serial number (if available)	Software (if used)
AE1	Power Adapter	HW-050200C01	-/-	-/-
-/-	-/-	-/-	-/-	-/-

*: Provided by test labs.

2.7. Test Item Set-ups Description

set. 1	EUT A	EUT operating mode 1
set. 2	EUT A	EUT operating mode 2
set. 3	EUT A	EUT operating mode 3
set. 4	EUT A	EUT operating mode 4

2.8. Test Conditions*

Temperature, [°C]		Voltage, [V]	
T_{nom}	25.0	V_{nom}	AC 120.0 V
T_{min}	-10.0	V_{min}	AC 132.0 V
T_{max}	50.0	V_{max}	AC 108.0 V

*: declared by the applicant

2.9. Additional Information

Test items differences	None
Additional application considerations to test a component or sub-assembly	N/A

2.10. Test Channel

Test Channel	Frequency [MHz]	Test Channel	Frequency [MHz]
Low	24011.00	Middle	24131.00
High	24248.00		

2.11. Test Location

Location 1

Company:	CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd.
Address:	Building G5, TCL International E City, Xili Street, Nanshan District, Shenzhen, China
Post code:	518112
Contact Person:	Wenliang Li
Telephone:	+86-755-8618 9654
e-Mail:	liwenliang@cqc.com.cn

2.12. Abnormalities from Standard Conditions

None

2.13. Possible verdicts of the results

Test sample meets the requirements	P (PASS) ± the measured value is below the acceptance limit, AL = TL
Test sample does not meet the requirements	F (FAIL) ± the measured value is above the acceptance limit, AL = TL
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

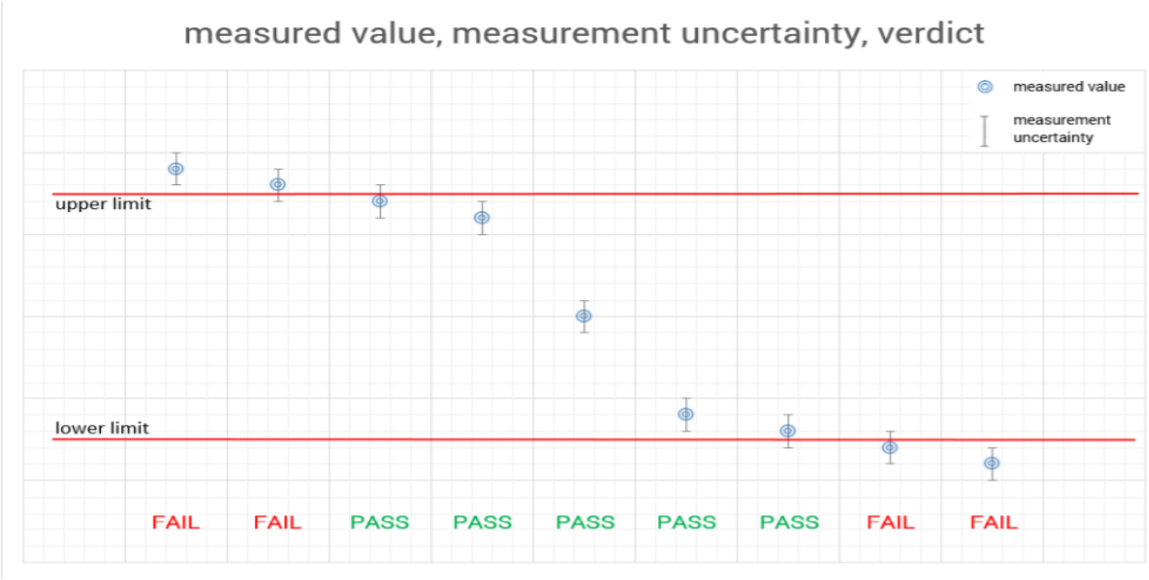
2.14. Formula for determination of correction values (E_c)

$E_C = E_R + AF + C_L + D_F - G_A$ (1)
$M = L_T - E_C$ (2)

E_C = Electrical field ± corrected value
E_R = Receiver reading
M = Margin
L_T = Limit
AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
G_A = Gain of pre-amplifier (if used)
All units are dB-units, positive margin means value is below limit.

2.15. Reporting Statements of Conformity – Decision Rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed. The measurement uncertainty is mentioned in this test report, see chapter 9, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



2.16. Radiated Emission Measurement Distance

The measurement antenna is in the far field of the EUT per formula $2D^2/\lambda$, where D is the larger between the dimension of the measurement antenna and the transmitting antenna of the EUT. In this case, “D” is the largest dimension of the measurement antenna. The EUT is manipulated through all orthogonal planes representative of its typical use and for both polarities of the measurement antenna in order to achieve the highest signal level. The worst-case position found was used for all radiated testing.

Frequency Range [GHz]	Wavelength [centimetres]	Far Field Distance [meters]	Measurement Distance [meters]
18 – 40	0.750	0.65	1.00
40 – 60	0.522	0.97	1.00
60 – 90	0.322	0.69	1.00
90 – 140	0.210	0.52	1.00
140 – 220	0.148	0.37	1.00
220 – 325	0.101	0.24	1.00

3. TEST ENVIRONMENT

3.1. Address of the test laboratory

CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd.
Building G5, TCL International E City, Xili Street, Nanshan District, Shenzhen, China
CQC-IVTS A2LA Certification Number: 6645.01;
FCC Designation Number: CN1329
ISED test lab CAB identifier: CN0134

3.2. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Normal Temperature:	25°C
Lative Humidity	55 %
Air Pressure	989 hPa

3.3. Test Description

Test Specification Clause	Test Case	Temperature Condition	Power Supply	PASS	FAIL	NA	NP	Results
FCC Part 15C § 15.249 (a)	Field strength of emissions (wanted signal)	Nominal	Nominal	☒	☐	☐	☐	
§ 15.249 (a)	Occupied bandwidth (20dB)	Nominal	Nominal	☒	☐	☐	☐	
§2.1049	Occupied bandwidth (99%)	Nominal	Nominal	☒	☐	☐	☐	
§15.209(a) §15.249(a) (d)	Field strength of emissions (spurious & harmonics)	Nominal	Nominal	☒	☐	☐	☐	

Remark:1. NA means “not applicable”; NP means Not Performed;
2.The measurement uncertainty is not included in the test result.

3.4. Statement of The Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to TR-100028-01” Electromagnetic compatibility and Radio spectrum Matters (ERM);Uncertainties in the measurement of mobile radio equipment characteristics; Part 1” and TR-100028-02 “Electromagnetic compatibility and Radio spectrum Matters (ERM);Uncertainties in the measurement of mobile radio equipment characteristics; Part 2 “ and is documented in the CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd..quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for CQC Internet of Vehicles Technical Service (Shenzhen) Co., Ltd.:

Test	Range	Measurement Uncertainty	Notes
Radiated Emission	30~1000MHz	4.90 dB	(1)
Radiated Emission	1~6GHz	4.20 dB	(1)
Radiated Emission	6~18GHz	4.50 dB	(1)
Radiated Emission	18-40GHz	5.42 dB	(1)
Radiated Emission	Above 40 GHz	5.50 dB	(1)
Conducted Disturbance	0.15~30MHz	3.30 dB	(1)

(1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

3.5. Equipments Used during the Test

Radiated Emission						
Item	Test Equipment	Manufacturer	Model No.	Equipment No.	Last Cal.	Cal.Due
1	EMI Test Receiver	R&S	ESW26	103003	2024/06/18	2025/06/17
2	Spectrum Analyzer	R&S	FSW43	10182	2024/05/14	2025/05/13
3	Ultra-Broadband Antenna	Schwarzbeck	VULB9168	1291	2024/08/01	2027/07/31
4	Horn Antenna	ETS- Lindgren	3117	102732	2024/08/01	2027/07/31
5	Amplifier	R&S	SCU01F	100369	2024/05/14	2025/05/13
6	Amplifier	R&S	SCU18F	100868	2024/05/14	2025/05/13
7	Amplifier	R&S	SCU26F	100781	2024/05/14	2025/05/13
8	Amplifier	R&S	SCU40F	102713	2024/05/14	2025/05/13
8	Horn Antenna	A-INFO	LB-180500H-2.4F	2110081000089	2024/08/03	2027/08/02
9	EMI Test Software	R&S	EMC32	N/A	N/A	N/A
10	TC-RX50	Tonscond	Receive Unit	1544	N/A	N/A
11	TC-RX75	Tonscond	Receive Unit	1545	N/A	N/A
12	TC-RX110	Tonscond	Receive Unit	1546	N/A	N/A
13	TC-RX170	Tonscond	Receive Unit	1547	N/A	N/A
14	TC-RX240	Tonscond	Receive Unit	1548	N/A	N/A
15	TC-RX40	Tonscond	Receive Unit	1543	N/A	N/A
16	Antenna Mast	Maturo	BAM4.0	N/A	N/A	N/A
17	Turntable	Maturo	TT3.5	N/A	N/A	N/A
18	Loop Antenna	R&S	HFH2-Z2E	101066	2024/08/03	2027/08/02

Conducted Emission						
Item	Test Equipment	Manufacturer	Model No.	Equipment No.	Last Cal.	Cal.Due
1	EMI Test Receiver	R&S	ESW26	103003	2024/06/18	2025/06/17
2	Artificial Mains	Schwarzbeck	NNBM8124-200N	05754	2024/06/18	2025/06/17
3	Artificial Mains	Schwarzbeck	NNBM8124-200N	05755	2024/06/18	2025/06/17
4	EMCTest Software	R&S	EMC32	N/A	N/A	N/A
5	Pusle Limiter	Schwarzbeck	VTSD9561FN	00871	2024/06/18	2025/06/17

4. TEST CONDITIONS AND RESULTS

4.1. Field Strength of Emissions

4.1.1. LIMITS

(a) According to § 15.249(a) and RSS-210 B.10 (a): Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902 – 928	50	500
2400 – 2482.5	50	500
5725 – 5875	50	500
24000 – 24250	250	2500

(b) According to § 15.249(c) and RSS-210 B.10 (a):Field strength limits are specified at a distance of 3 meters.:

(c) According to § 15.249(d): Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation.

(d) According to RSS-210 B.10 (b): Emissions radiated outside of the specified frequency bands, except for harmonic emissions, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is less stringent.

(e) According to § 15.249(b): Fixed, point-to-point operation as referred to in this paragraph shall be limited to systems employing a fixed transmitter transmitting to a fixed remote location. Point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information are not allowed. Fixed, point-to-point operation is permitted in the 24.05–24.25 GHz band subject to the following conditions:

(1) The field strength of emissions in this band shall not exceed 2500 millivolts/meter.

(2) The frequency tolerance of the carrier signal shall be maintained within ±0.001% of the operating frequency over a temperature variation of −20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

(3) Antenna gain must be at least 33 dBi. Alternatively, the main lobe beamwidth must not exceed 3.5 degrees. The beamwidth limit shall apply to both the azimuth and elevation planes. At antenna gains over 33 dBi or beamwidths narrower than 3.5 degrees, power must be reduced to ensure that the field strength does not exceed 2500 millivolts/meter.

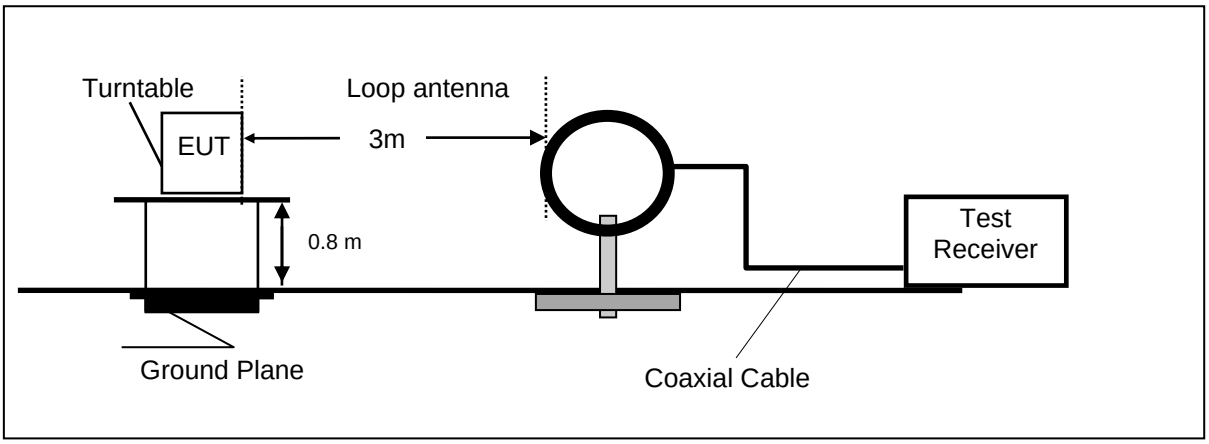
Frequency (MHz)	**Distance (Meters)**	**Radiated (dBμV/m)**	**Radiated (μV/m)**
0.009-0.49	3	20log(2400/F(KHz))+40log(300/3)	2400/F(KHz)
0.49-1.705	3	20log(24000/F(KHz))+ 40log(30/3)	24000/F(KHz)
1.705-30	3	20log(30)+ 40log(30/3)	30
30-88	3	40.0	100
88-216	3	43.5	150
216-960	3	46.0	200
Above 960	3	54.0	500

(1) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209 and RSS-Gen, whichever is the lesser attenuation.

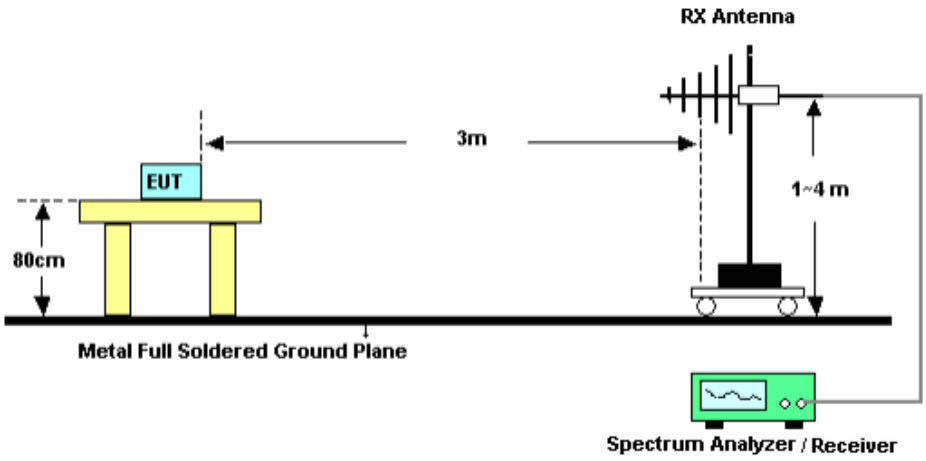
(2) The emission limits shown above are based on measurement instrumentation employing an average detector. The provisions in § 15.35 and RSS-Gen for limiting peak emissions apply.

4.1.2. TEST CONFIGURATION

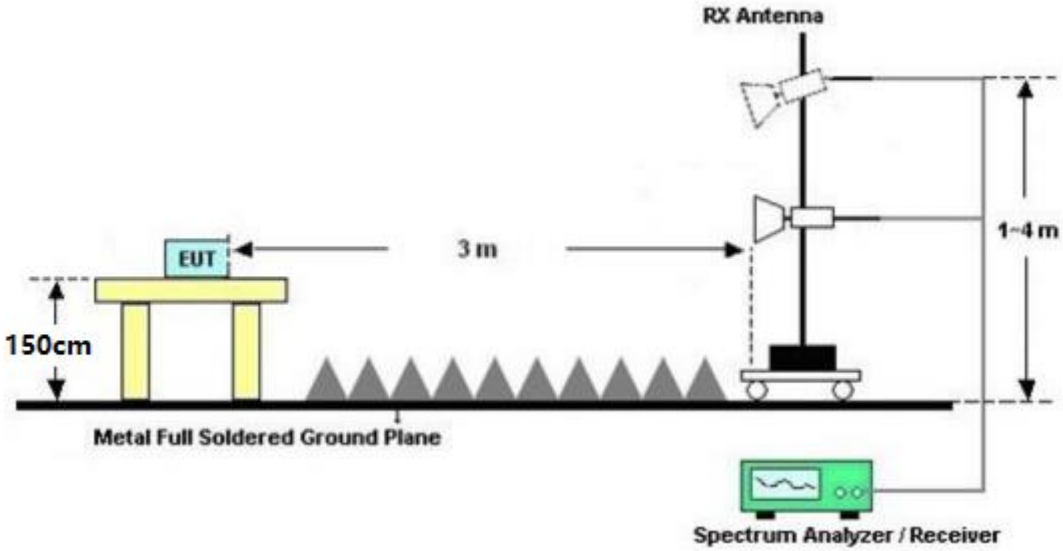
(a) Frequency range 9 KHz – 30MHz



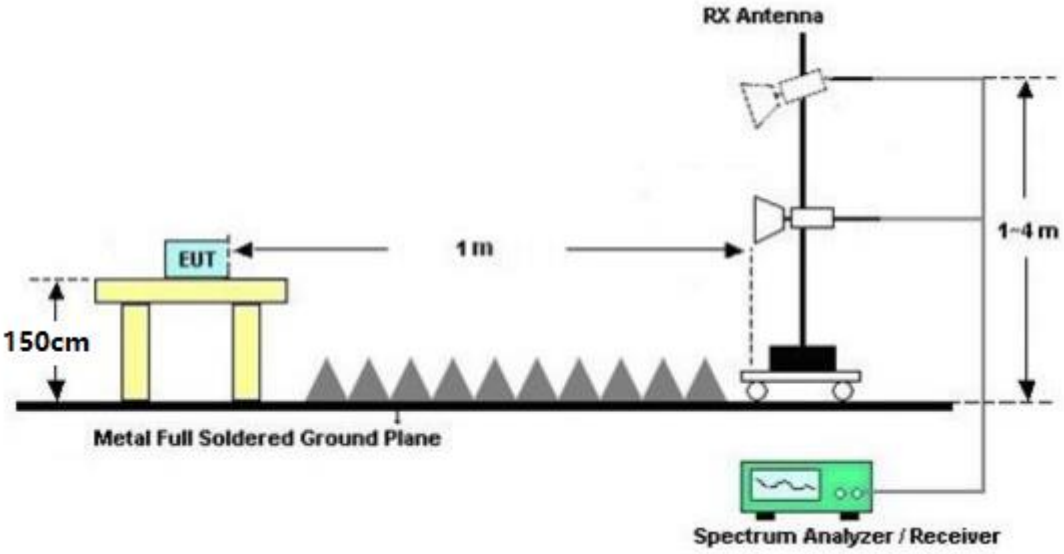
(b) Radiated emission test set-up, frequency range: 30 - 1000MHz



(c) Radiated emission test set-up, frequency range 1GHz – 18 GHz



(d) Radiated emission test set-up, frequency range above 18GHz



4.1.3. TEST PROCEDURE

4.1.3.1 Sequence of testing radiated spurious 9 KHz to 30 MHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 3m (see ANSI C63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0 degree to 360 degree.
- The antenna height is 1m.
- Set RBW = 200 Hz / VBW = 1 KHz, sweep time: Auto
- At each turntable position the anzlyer sweeps with position-peak detector to find the maximum of all emissions.

Final measurement

- Identified emissions during the premeaurement are maximized by the software by rotating the turntable from 0 degree to 360 degree.
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, conrrection factor, margin to the limit and limit will be recorded. A plot with the graph of the measurement and the limit is stored.

4.1.3.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 0.8 m height is used, which is placed on the ground plance.
- If the EUT is a floor standing device, it is placed directly on the ground plane.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 3m (see ANSI C63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0 degree to 360 degree.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set RBW = 120 KHz / VBW = 1 MHz, sweep time: Auto
- At each turntable position the anzlyer sweeps with position-peak detector to find the maximum of all emissions.

Final measurement

- The final neasurement is perormed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, conrrection factor, margin to the limit and limit will be recorded. A plot with the graph of the measurement and the limit is stored.

4.1.3.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turntable.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 3m (see ANSI C63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0 degree to 360 degree.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Peak for Peak, RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Average for Average.
- At each turntable position the anzlyer sweeps with position-peak detector to find the maximum of all emissions.

Final measurement

- The final neasurement us perormed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable and antenna height between 1 and 4 m.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the height emissions with Peak and Average detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, conrrection factor, margin to the limit and limit will be recorded. A plot with the graph of the measurement and the limit is stored.

4.1.3.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turntable.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 1m (see ANSI C63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0 degree to 360 degree.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Peak for Peak, RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Average for Average.
- At each turntable position the anzlyer sweeps with position-peak detector to find the maximum of all emissions.

Final measurement

- The final neasurement is perormed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable and antenna height between 1 and 4 m.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the height emissions with Peak and RMS detector (as described in ANSI C 63.4).
- All final levels should consider distance conversion factor as format: Final values (3 m) = Measurement values (1 m) + Distance conversion factor
  Distance conversion factor = 20 x Log_{10} (d/3), where d = measurement distance in m
  - Distance conversion factor = 20 x Log_{10} (1/3) = -9.54 [dB]
- Final levels, frequency, measuring time, bandwidth, turntable position, conrrection factor, margin to the limit and limit will be recorded. A plot with the graph of the measurement and the limit is stored.

4.1.3.5 Sequence of testing radiated spurious above 40 GHz with external mixers

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turntable.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 1m (see ANSI C63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0 degree to 360 degree.
- The antenna with external mixer is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Peak for Peak, RBW = 1 MHz / VBW = 3 MHz, sweep time: Auto, detector: Average for Average.
- At each turntable position the anzlyer sweeps with position-peak detector to find the maximum of all emissions.

Final measurement

- The final neasurement is perormed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable and antenna height between 1 and 4 m.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the height emissions with Peak and RMS detector (as described in ANSI C 63.4).
- All final levels should consider distance conversion factor as format: Final values (3 m) = Measurement values (1 m) + Distance conversion factor
  Distance conversion factor = 20 x Log_{10} (d/3), where d = measurement distance in m
  - Distance conversion factor = 20 x Log_{10} (1/3) = -9.54 [dB]
- Final levels, frequency, measuring time, bandwidth, turntable position, conrrection factor, margin to the limit and limit will be recorded. A plot with the graph of the measurement and the limit is stored.

4.1.4. FIELD STRENGTH CALCULATION

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS (dBuV/m) = RA (dBuV) + AF (dB/m) + CL (dB) – AG (dB)

Where FS = Field Strength	CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude	AG = Amplifier Gain
AF = Antenna Factor	

4.1.5. TEST RESULTS

EIRP measurements were ensured to be taken in the Far-Field test distance are shown in Section 2.15.

Sample Calculations

Calculating Field Strength from substitution power:

$$E(dBuV/m) = 126.8 - 20\log(\lambda) + P - G$$

Where;
E is the field strength of the emission at the measurement distance, in dBuV/m
P is the power measured at the output of the test antenna, in dBm; where P includes all applicable instrument correction factors up to the connections to the test antenna.
λ is the wavelength of the emission under investigation [300 / f_{MHz}], in m.
G is the gain of the test antenna, in dBi.

Calculating EIRP from Field Strength;

$$EIRP_{[dBm]} = E_{measurement} + 20\log(D_{measured}) - 104.7$$

Where;
EIRP is the equivalent isotropic radiated power in dBm
$E_{measured}$ is the field strength of the emission at the measurement distance, in dBuV/m
$D_{measured}$ is the measurement distance in meters.

74 dBuV/m @ 3m measurement distance = -21.250 dBm @ 1m measurement distance
54 dBuV/m @ 3m measurement distance = -41.250 dBm @ 1m measurement distance
Harmonics level 2500 uV/m @ 3m measurement distance = 67.96 dBuV/m @ 3m measurement distance = -27.27 dBm @ 1m measurement distance
87.96 dBuV/m @ 3m measurement distance = -7.27 dBm @ 1m measurement distance

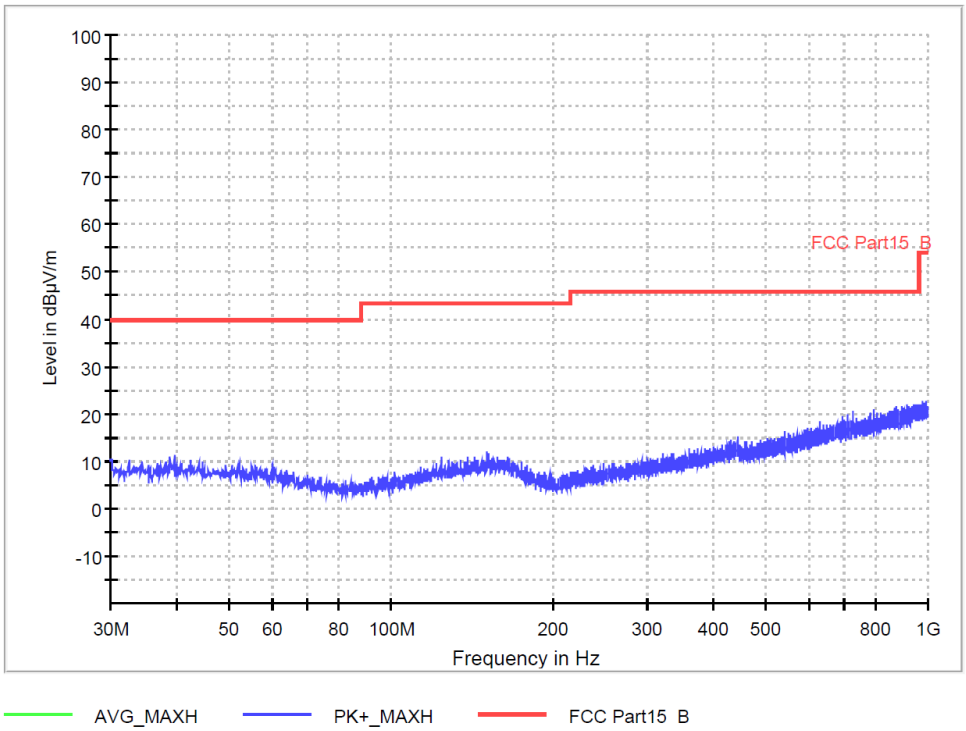
PASS

Remark:

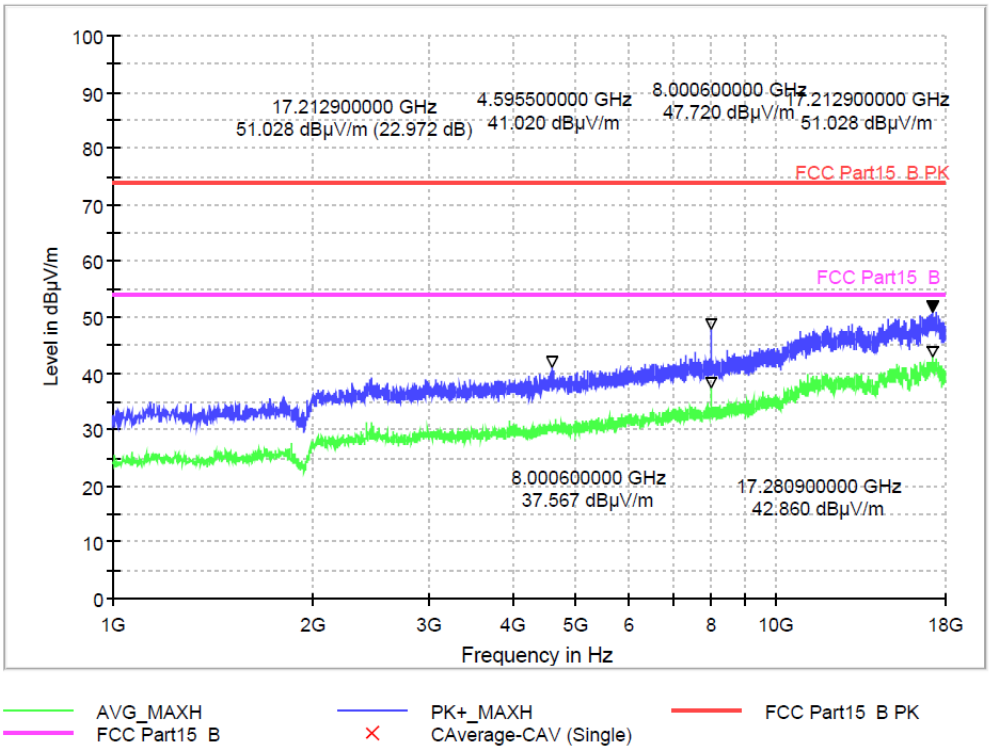
1. Not recorded values after pre-test below 30 MHz (9 KHz – 30 MHz), values at least 20 dB below limit.
2. Measured all channels from 30 MHz – 18 GHz, only recorded worst case at high channel.

Test Condictions	Test Channel	Nominal Frequency [MHz]	EUT/Antenna Orientation	Maximum Field Strength [dBuV/m @ 3m]				Test Results
				Peak	Peak Limit	Average	Average Limit	
T_{nom} / V_{nom}	Low	24011.00	X/H&V	92.63	127.96	92.31	107.96	PASS
T_{nom} / V_{nom}	Middle	24131.00	X/H&V	90.59	127.96	90.18	107.96	PASS
T_{nom} / V_{nom}	High	24248.00	X/H&V	87.56	127.96	87.12	107.96	PASS

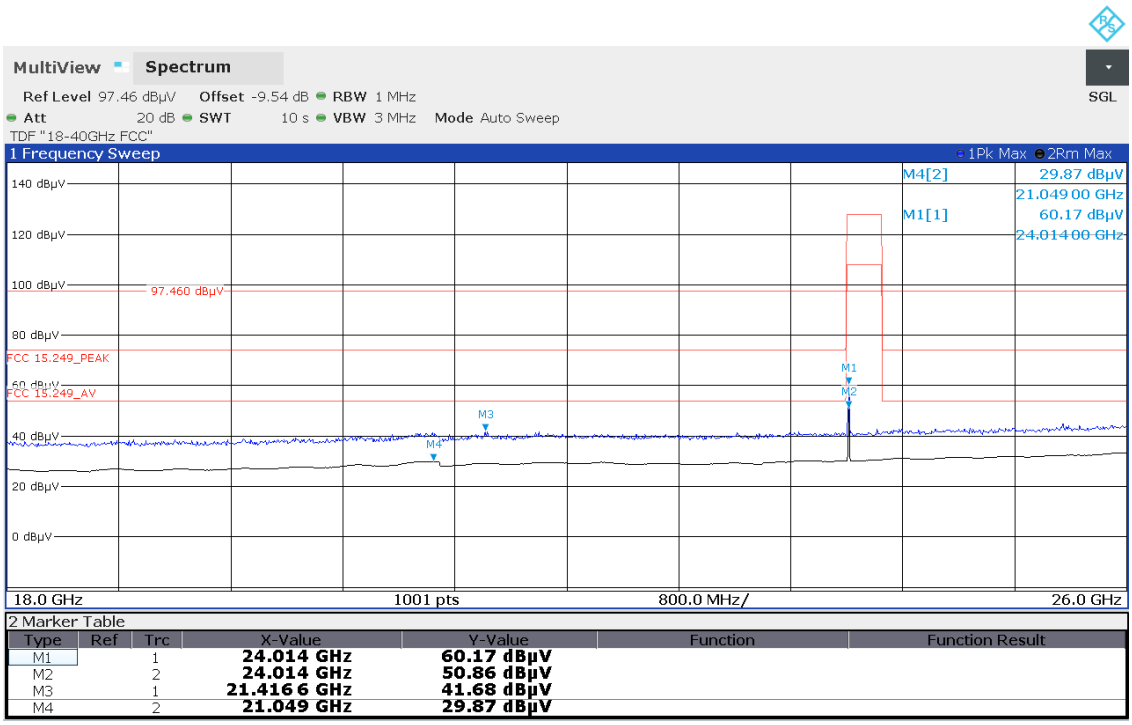
Plots No. 1: 30 MHz to 1 GHz, Horizontal / Vertical Polarization _ High Channel



Plots No. 2: 1 GHz to 18 GHz, Horizontal / Vertical Polarization _ High Channel



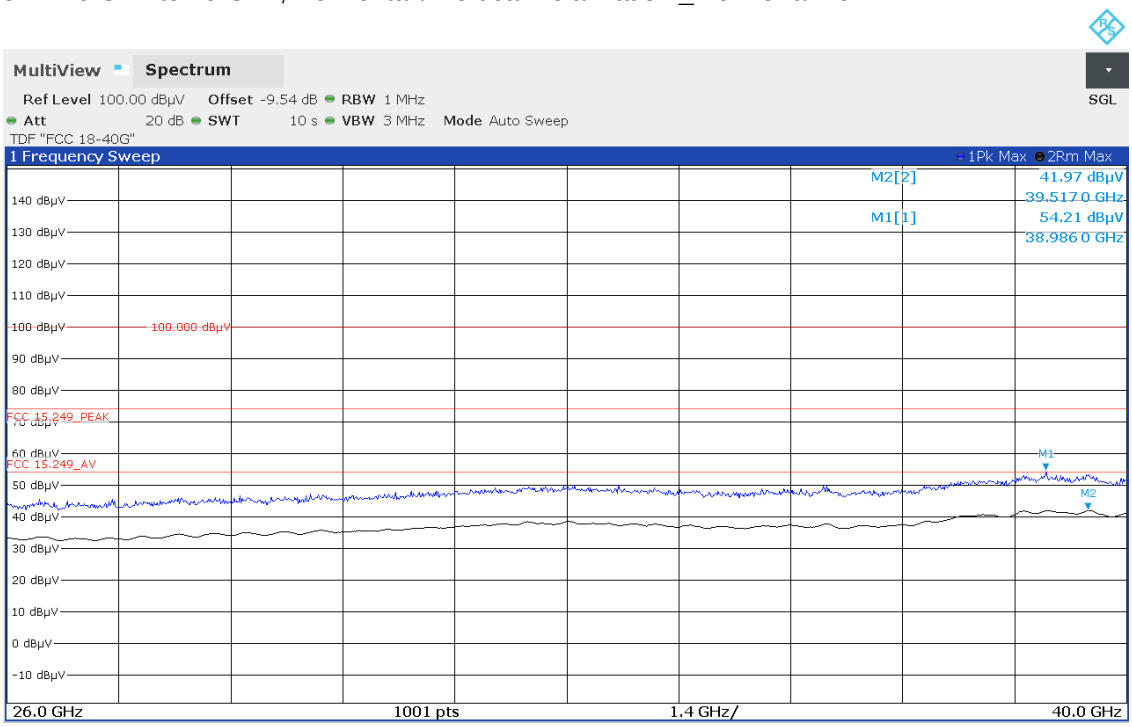
Plots No. 3: 18 GHz to 26 GHz, Horizontal / Vertical Polarization _ Low Channel



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	24.014 GHz	60.17 dBµV		
M2		2	24.014 GHz	50.86 dBµV		
M3		1	21.416 6 GHz	41.68 dBµV		
M4		2	21.049 GHz	29.87 dBµV		

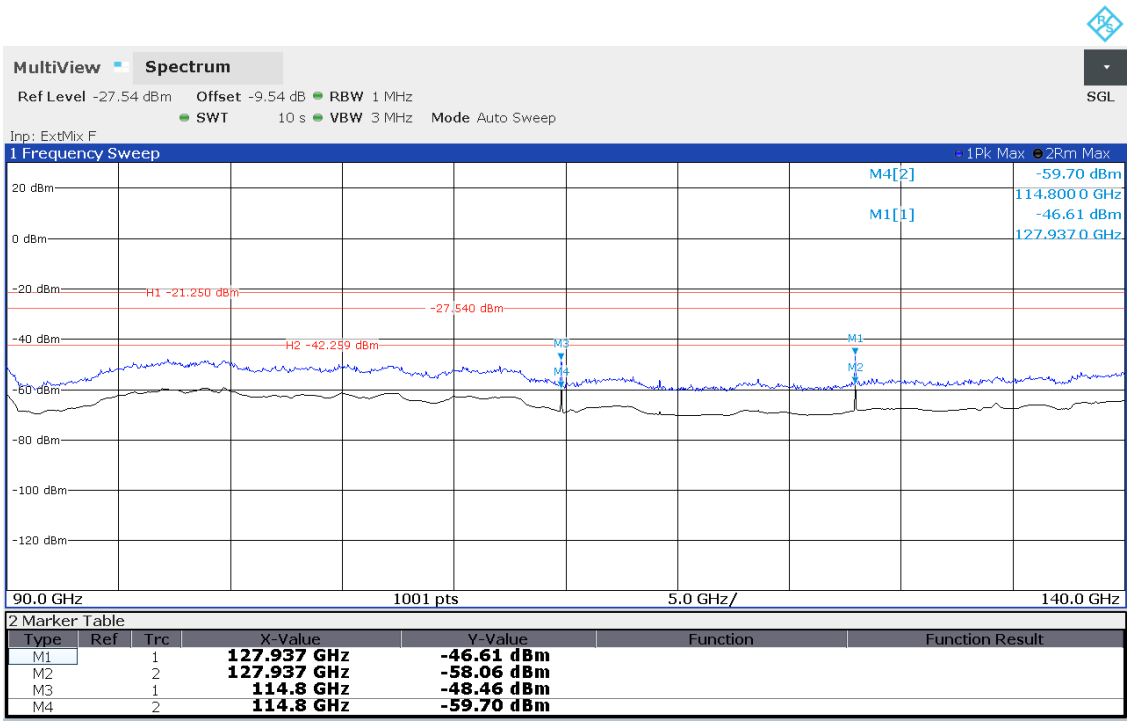
Plots No. 4: 26 GHz to 40 GHz, Horizontal / Vertical Polarization _ Low Channel



Plots No. 5: 40 GHz to 60 GHz, Horizontal / Vertical Polarization_ Low Channel

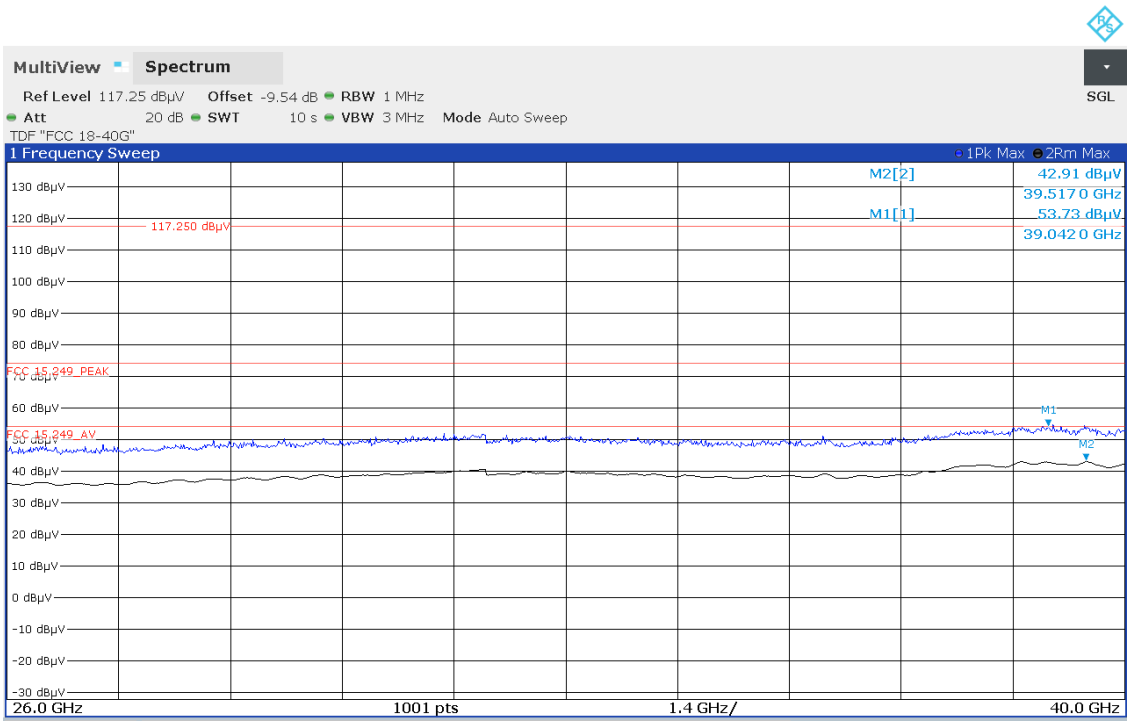
Plots No. 6: 60 GHz to 90 GHz, Horizontal / Vertical Polarization _ Low Channel

Plots No. 7: 90 GHz to 140 GHz, Horizontal / Vertical Polarization _ Low Channel

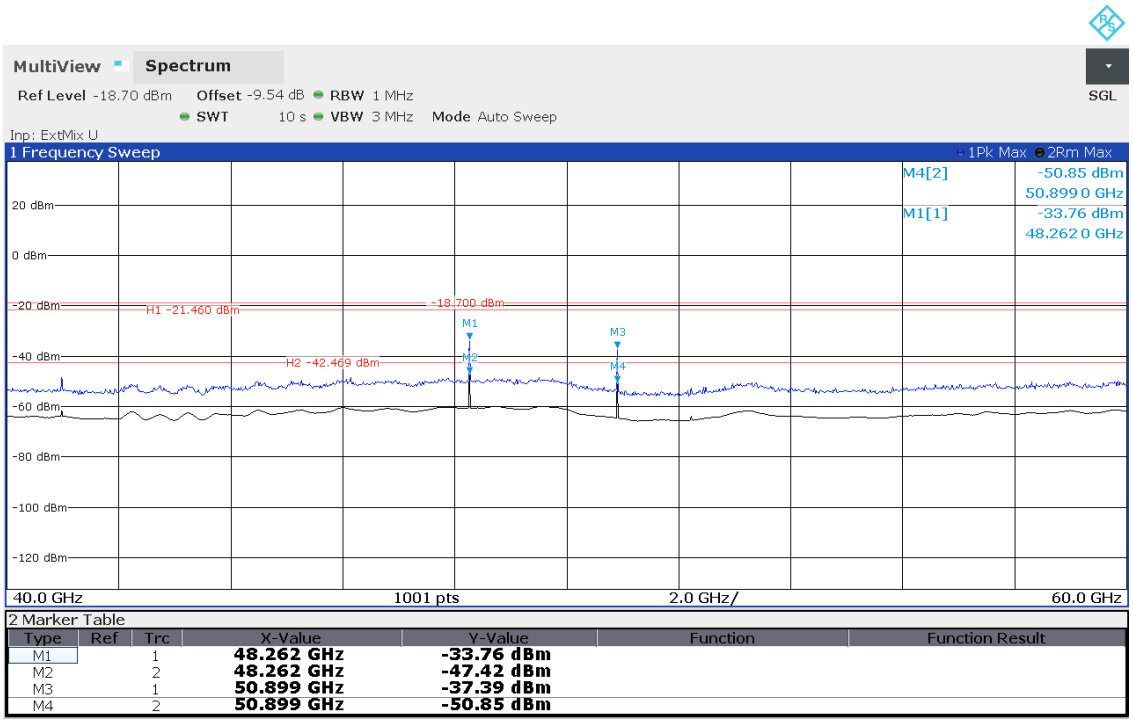


Plots No. 8: 18 GHz to 26 GHz, Horizontal / Vertical Polarization _ Middle Channel

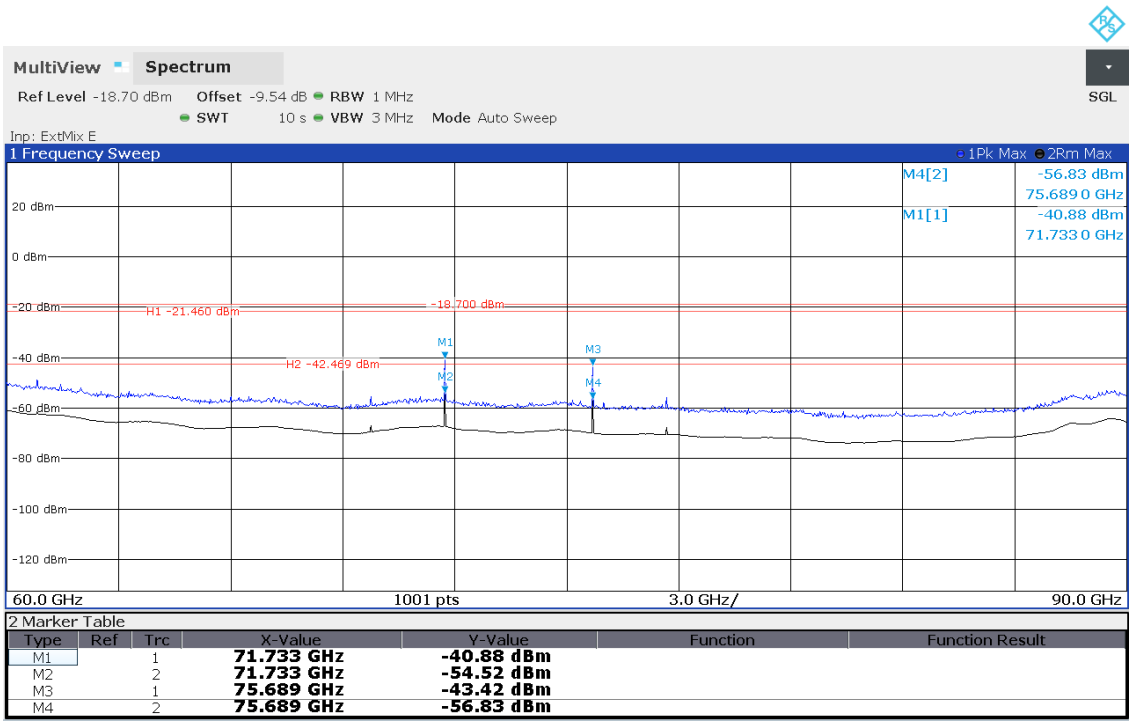
Plots No. 9: 26 GHz to 40 GHz, Horizontal / Vertical Polarization _ Middle Channel



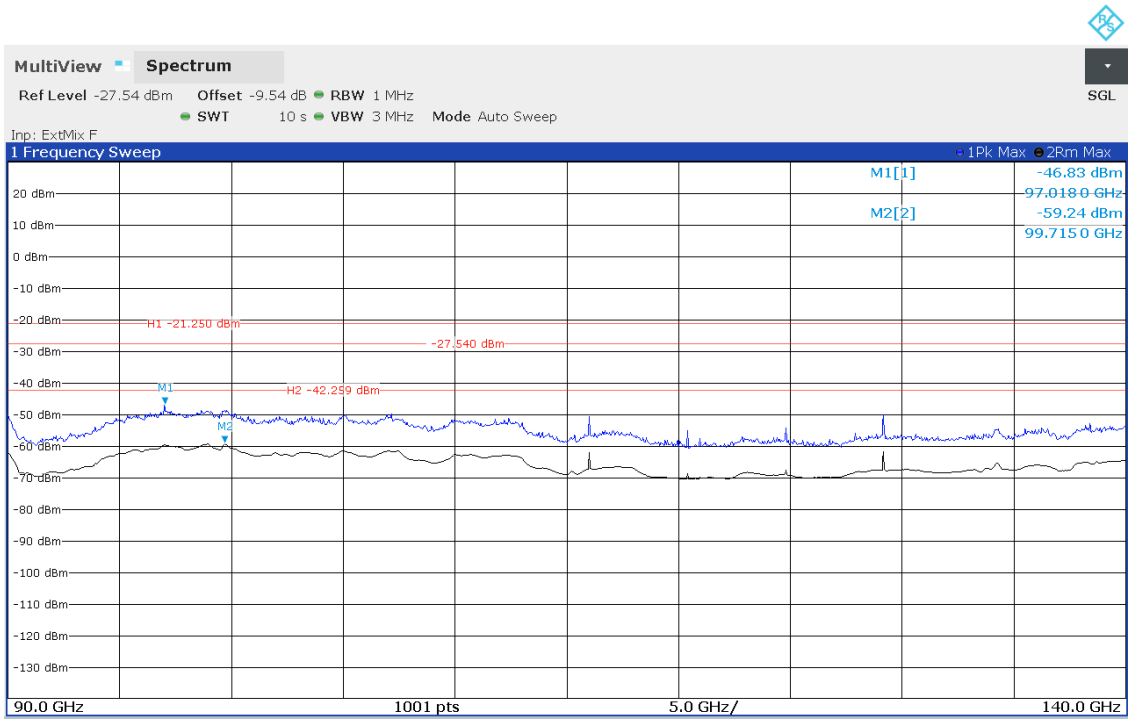
Plots No. 10: 40 GHz to 60 GHz, Horizontal / Vertical Polarization _ Middle Channel



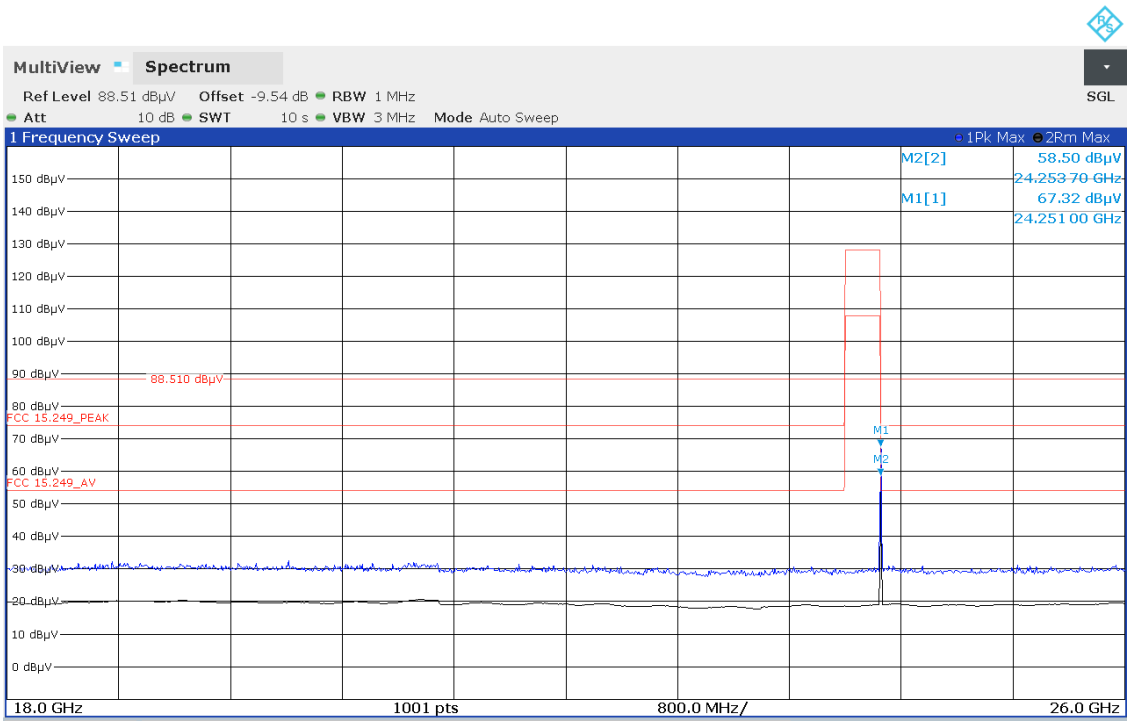
Plots No. 11: 60 GHz to 90 GHz, Horizontal / Vertical Polarization _ Middle Channel



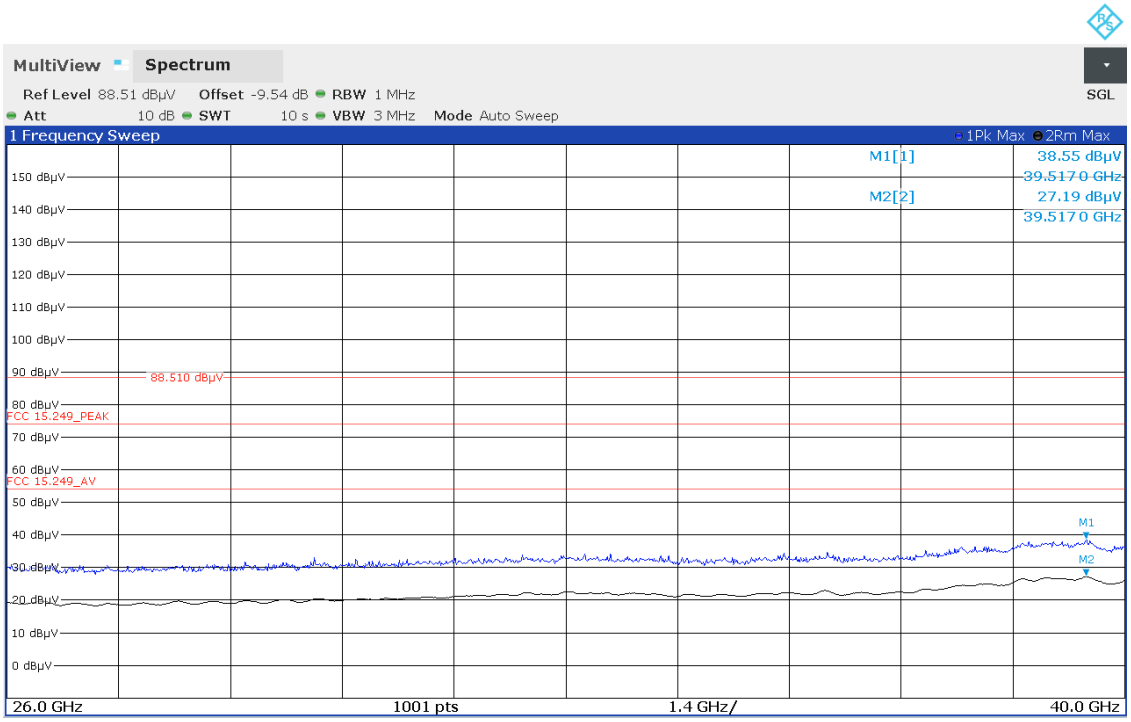
Plots No. 12: 90 GHz to 140 GHz, Horizontal / Vertical Polarization_ Middle Channel



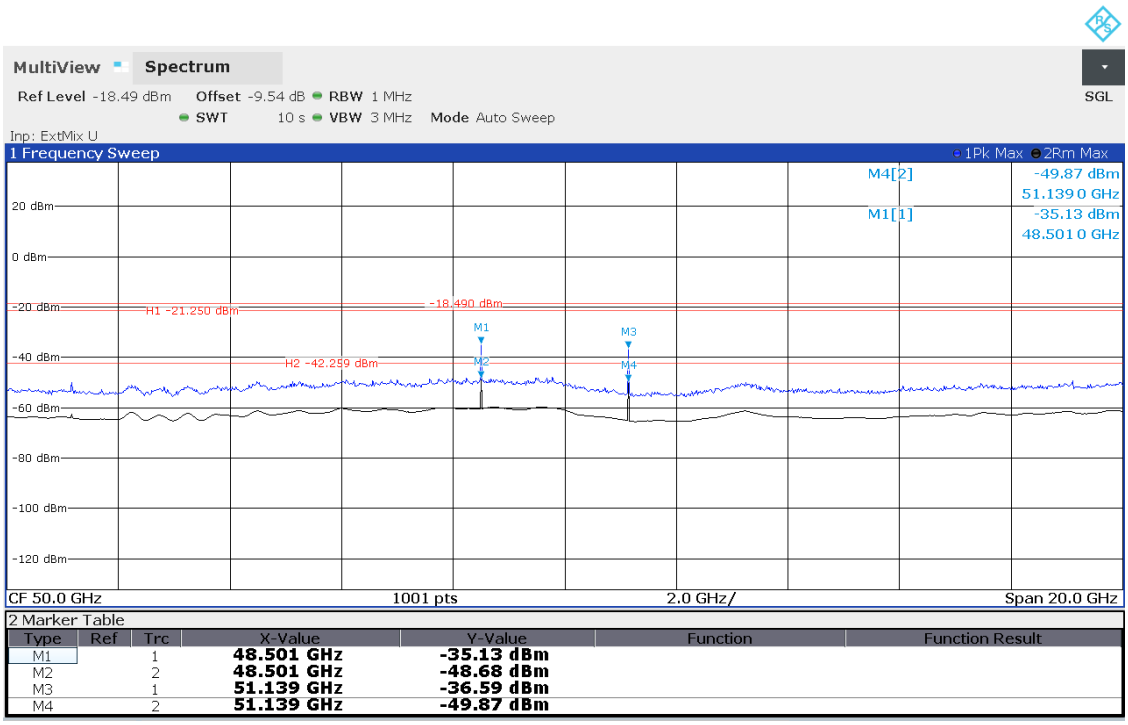
Plots No. 13: 18 GHz to 26 GHz, Horizontal / Vertical Polarization _ High Channel



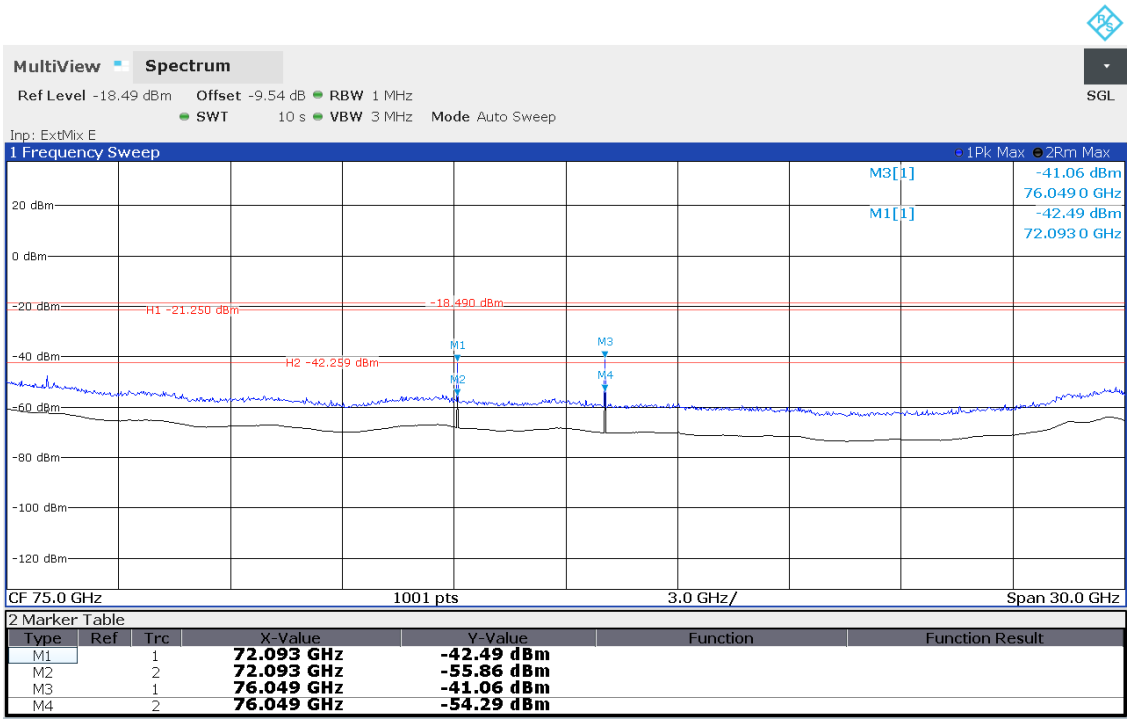
Plots No. 14: 26 GHz to 40 GHz, Horizontal / Vertical Polarization _ High Channel



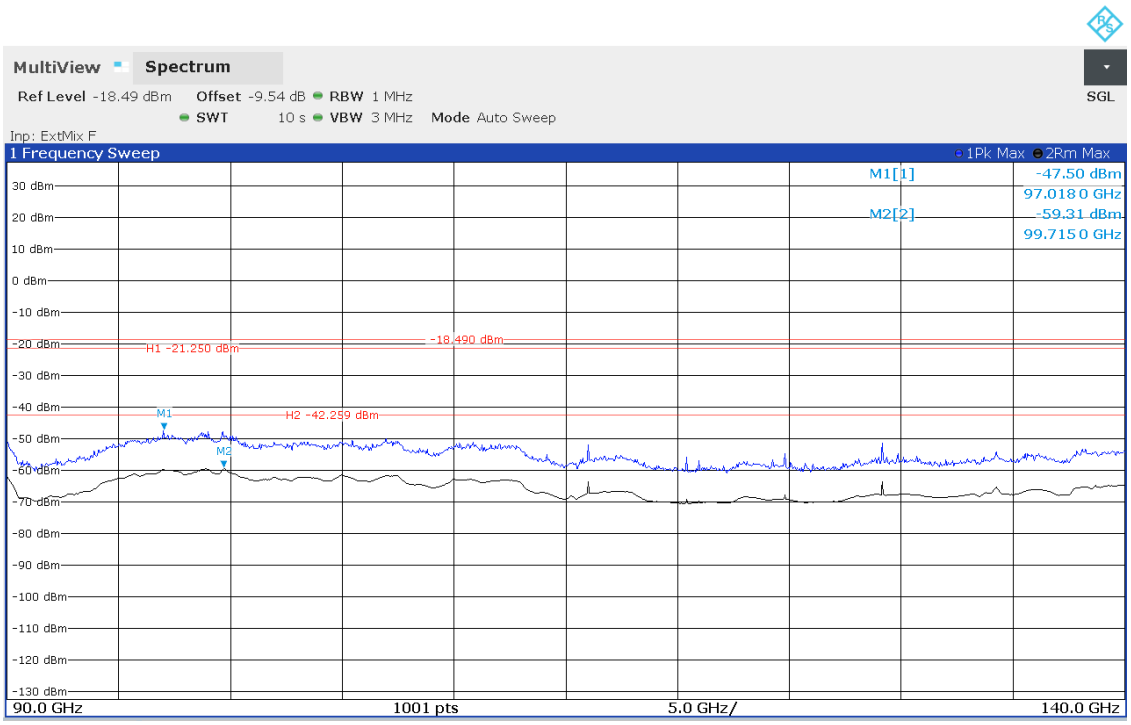
Plots No. 15: 40 GHz to 60 GHz, Horizontal / Vertical Polarization _ High Channel



Plots No. 16: 60 GHz to 90 GHz, Horizontal / Vertical Polarization _ High Channel



Plots No. 17: 90 GHz to 140 GHz, Horizontal / Vertical Polarization _ High Channel



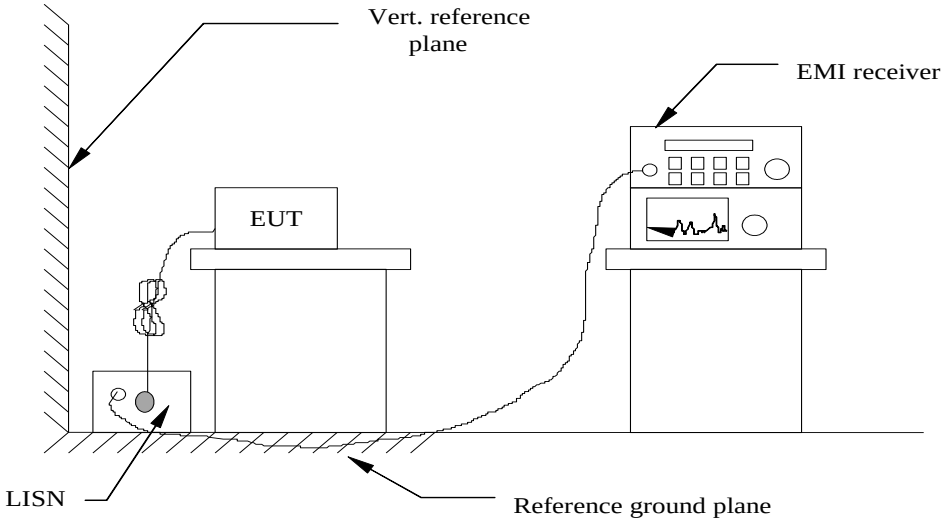
4.2. AC Conducted Emission

4.2.1. LIMITS OF DISTURBANCE

According to RSS Gen 8.8 and § 15.207(a) Line Conducted Emission Limits is as following:

Frequency range (MHz)	Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50
* Decreases with the logarithm of the frequency.		

4.2.2. TEST CONFIGURATION



4.2.3. TEST PROCEDURE

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10-2013.
2. Support equipment, if needed, was placed as per ANSI C63.10-2013
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10-2013
4. The EUT received DC 12V power from adapter, the adapter received AC120V/60Hz and AC 240V/60Hz power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
5. All support equipment received AC power from a second LISN, if any.
6. The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50-ohm load; the second scan had Line 1 connected to a 50-ohm load and Line 2 connected to the Analyzer / Receiver.
7. Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.
8. During the above scans, the emissions were maximized by cable manipulation.

4.2.4. DISTURBANCE CALCULATION

The AC mains conducted disturbance is calculated by adding the 10dB Pulse Limiter and Cable Factor and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

CD (dBuV) = RA (dBuV) + PL (dB) + CL (dB)

Where CD = Conducted Disturbance	CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude	PL = 10 dB Pulse Limiter Factor

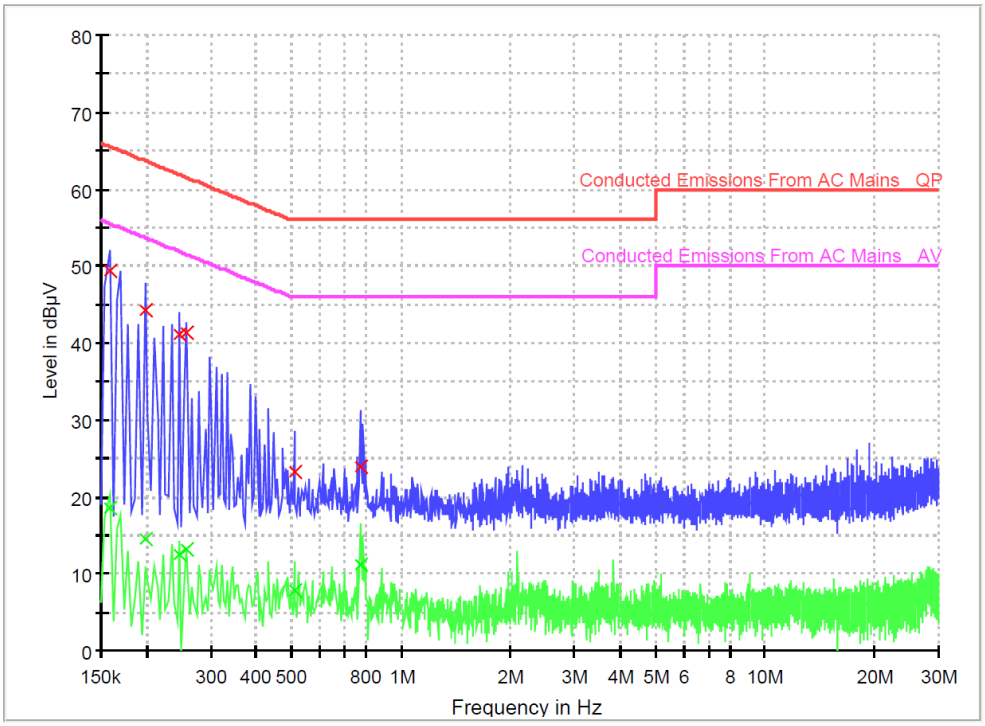
4.2.5. TEST RESULTS

PASS

Remark:

1. *Measured both AC 120V/60Hz and AC 230V/50Hz, recorded worst case at AC 120V/60Hz.*
2. *Measured all channels and recorded worst case at high channel.*

Plots No. 18: AC Mains Conducted Emission _ AC 120V/60Hz _ High Channel _ Line



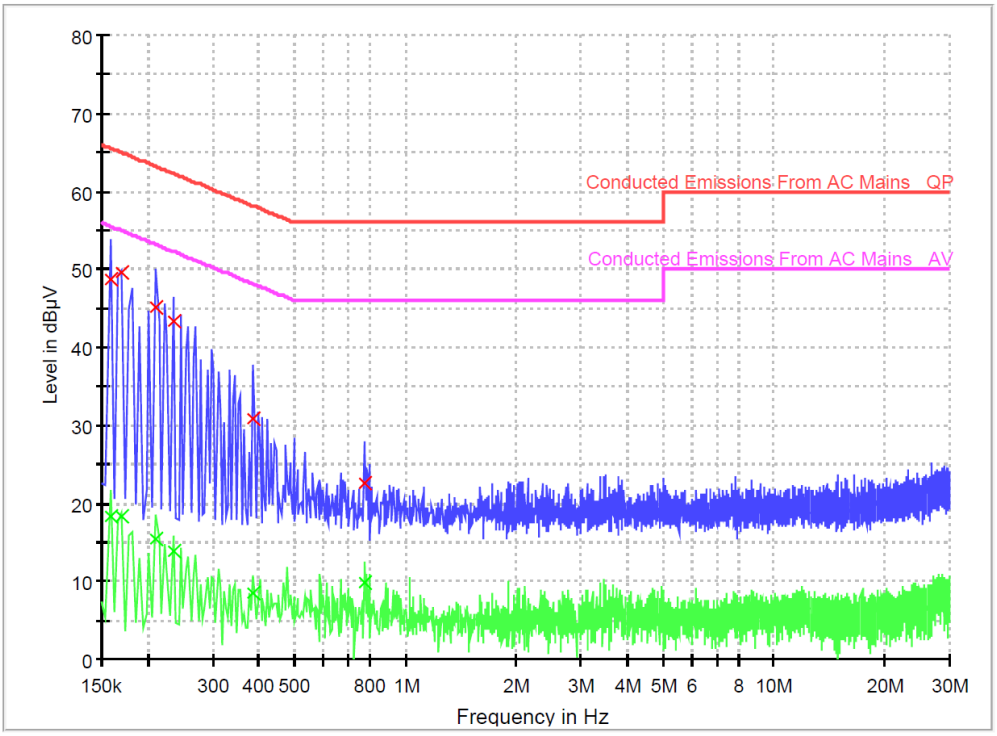
Limit and Margin

Frequency (MHz)	MaxPeak (dBµV)	QuasiPeak (dBµV)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.158	---	49.3	18.6	1000.0	9.000	LOCAL	OFF	9.6
0.198	---	44.3	14.5	1000.0	9.000	LOCAL	OFF	9.7
0.246	---	41.0	12.6	1000.0	9.000	LOCAL	OFF	9.7
0.258	---	41.3	13.1	1000.0	9.000	LOCAL	OFF	9.7
0.510	---	23.3	7.8	1000.0	9.000	LOCAL	OFF	9.8
0.774	---	23.9	11.3	1000.0	9.000	LOCAL	OFF	9.8

(continuation of the "Limit and Margin" table from column 14 ...)

Frequency (MHz)	Margin - QPK (dB)	Limit - QPK (dBµV)	Margin - AVG (dB)	Limit - AVG (dBµV)	Comment
0.158	16.2	65.6	47.0	65.6	
0.198	19.4	63.7	49.2	63.7	
0.246	20.9	61.9	49.3	61.9	
0.258	20.2	61.5	48.4	61.5	
0.510	32.7	56.0	48.2	56.0	
0.774	32.1	56.0	44.7	56.0	

Plots No. 19: AC Mains Conducted Emission _ AC 120V/60Hz _ High Channel _ Neutral



Limit and Margin

Frequency (MHz)	MaxPeak (dBµV)	QuasiPeak (dBµV)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.158	---	48.8	18.2	1000.0	9.000	LOCAL	OFF	9.6
0.170	---	49.5	18.3	1000.0	9.000	LOCAL	OFF	9.6
0.210	---	45.1	15.4	1000.0	9.000	LOCAL	OFF	9.7
0.234	---	43.3	13.9	1000.0	9.000	LOCAL	OFF	9.7
0.386	---	30.8	8.5	1000.0	9.000	LOCAL	OFF	9.7
0.774	---	22.6	9.8	1000.0	9.000	LOCAL	OFF	9.8

(continuation of the "Limit and Margin" table from column 14 ...)

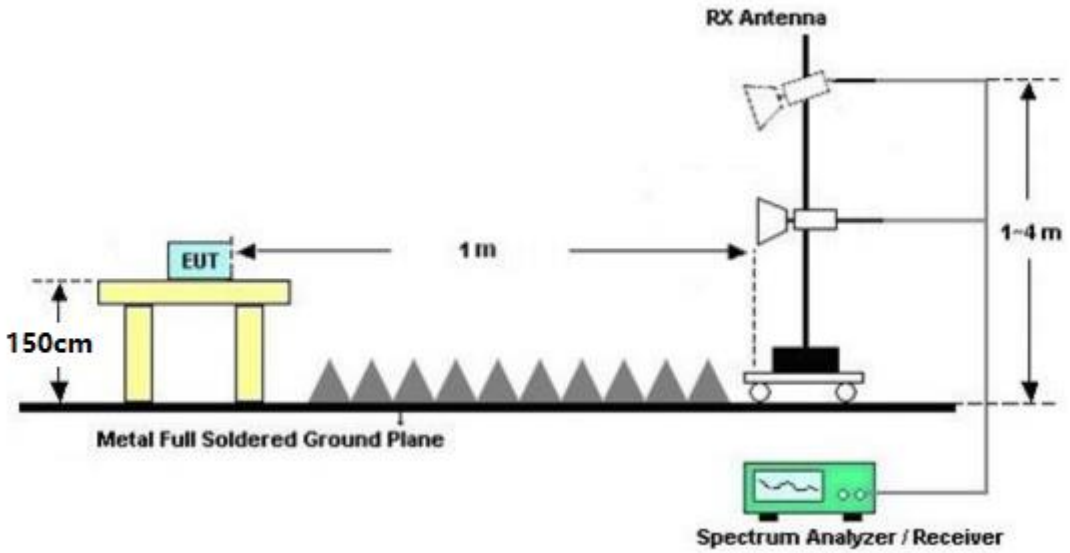
Frequency (MHz)	Margin - QPK (dB)	Limit - QPK (dBµV)	Margin - AVG (dB)	Limit - AVG (dBµV)	Comment
0.158	16.8	65.6	37.3	55.6	
0.170	15.5	65.0	36.7	55.0	
0.210	18.1	63.2	37.8	53.2	
0.234	19.0	62.3	38.4	52.3	
0.386	27.3	58.1	39.6	48.1	
0.774	33.4	56.0	36.3	46.0	

4.3 Occupied Bandwidth (99% Bandwidth)

4.3.1 LIMITS

The occupied bandwidth is defined as the 99% bandwidth.
According to § 2.1049 and RSS-Gen section 6.7: The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

4.3.2 TEST CONFIGURATION



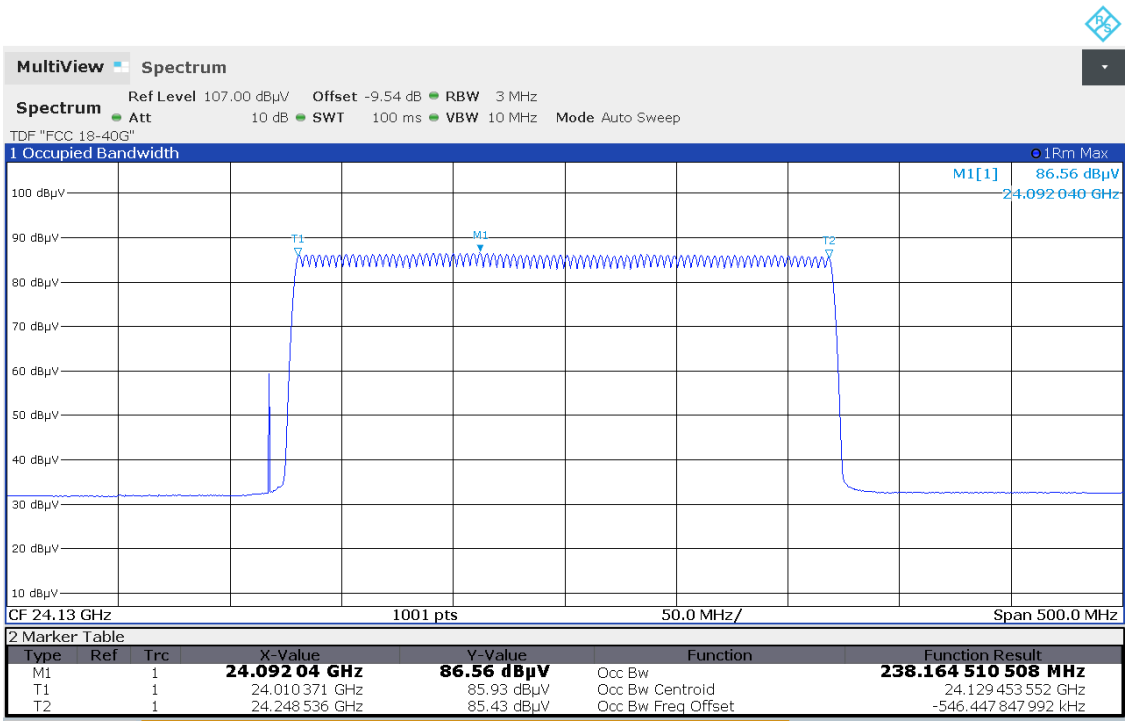
4.3.3 TEST PROCEDURE

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turntable.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 1m (see ANSI C63.4) – see test details.
- EUT is set into operation.
- The turntable rotates from 0 degree to 360 degree.
- The antenna with external mixer is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set the resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

4.3.4 TEST RESULTS

Test Condictions	Nominal Frequency [MHz]	EUT/Antenna Orientation	Occupied Bandwidth (99%) [MHz]	Test Results
T_{nom} / V_{nom}	24011.00-24248.00	X/H&V	0.43660	PASS

Plots No. 20: 99% Occupied Bandwidth, Horizontal / Vertical Polarization



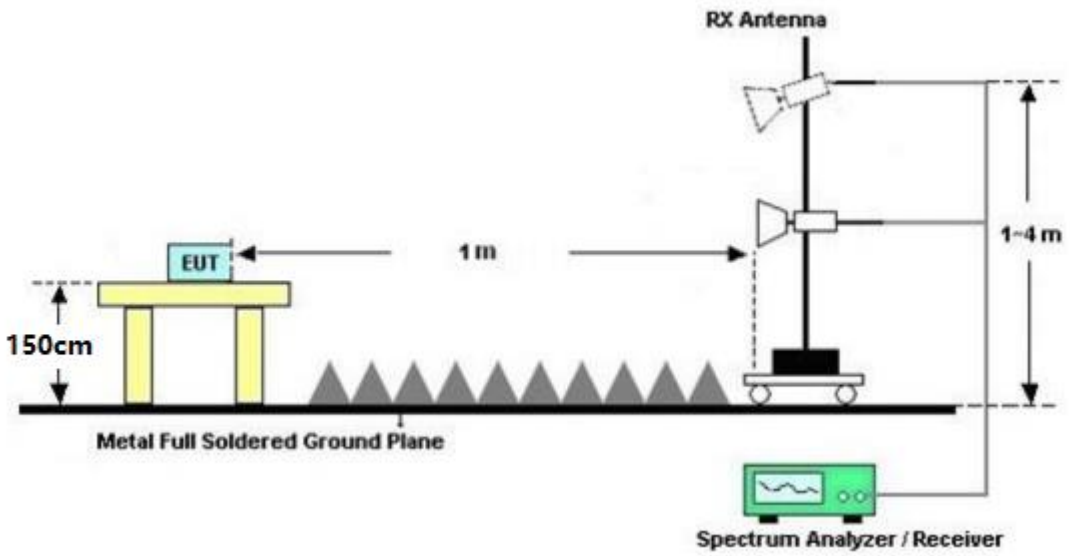
Notes: The RBW was set to 1.26% of OBW. (3 MHz / 238.164 MHz) x 100% = 1.26%

4.4 20dB Bandwidth

4.4.1 LIMITS

According to § 15.215 (c): Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

4.4.2 TEST CONFIGURATION



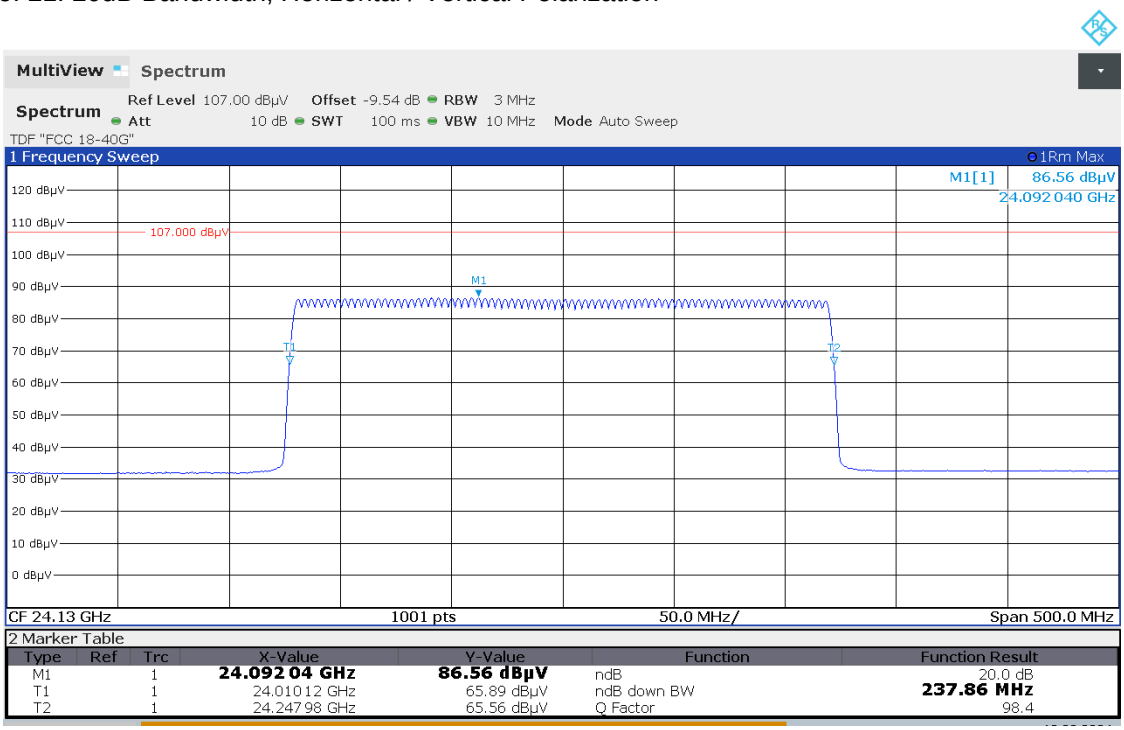
4.4.3 TEST PROCEDURE

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer
- If the EUT is a tabletop system, 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turntable.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measuremet distance is 1m (see ANSI C63.4) – see test details.
- EUT is set into operation.
- The turntable rotates from 0 degree to 360 degree.
- The antenna with external mixer is polarized vertical and horizontal.
- The antenna height changes from 1m to 4m.
- Set the resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

4.4.4 TEST RESULTS

Test Condictions	Nominal Frequency [MHz]	EUT/Antenna Orientation	20dB Bandwidth					Test Results
			F_L [GHz]	F_L Limit [GHz]	F_H [GHz]	F_H Limit [GHz]	20dB Bandwidth [MHz]	
T_{nom} / V_{nom}	24011.00-24248.00	X/H&V	24.01012	24.00	24.24798	24.25	237.86	PASS

Plots No. 21: 20dB Bandwidth, Horizontal / Vertical Polarization



Notes: The 20 dB bandwidth of the emission is contained within the frequency band.

4.5 Antenna Requirement

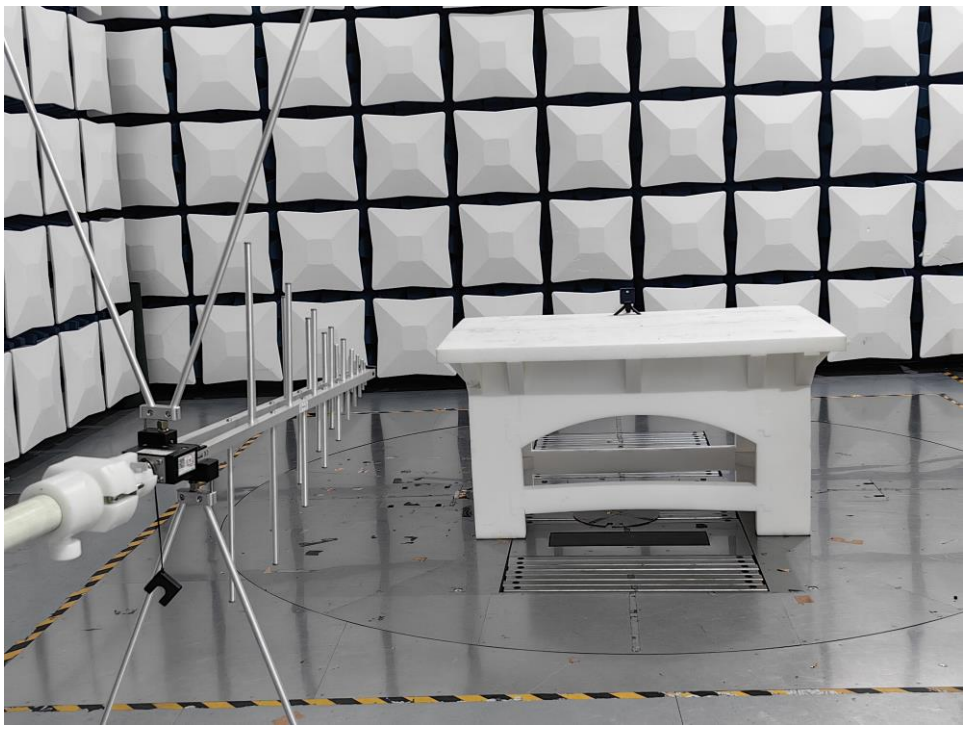
4.5.1 REQUIREMENT

According to § 15.203 and RSS-Gen: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited

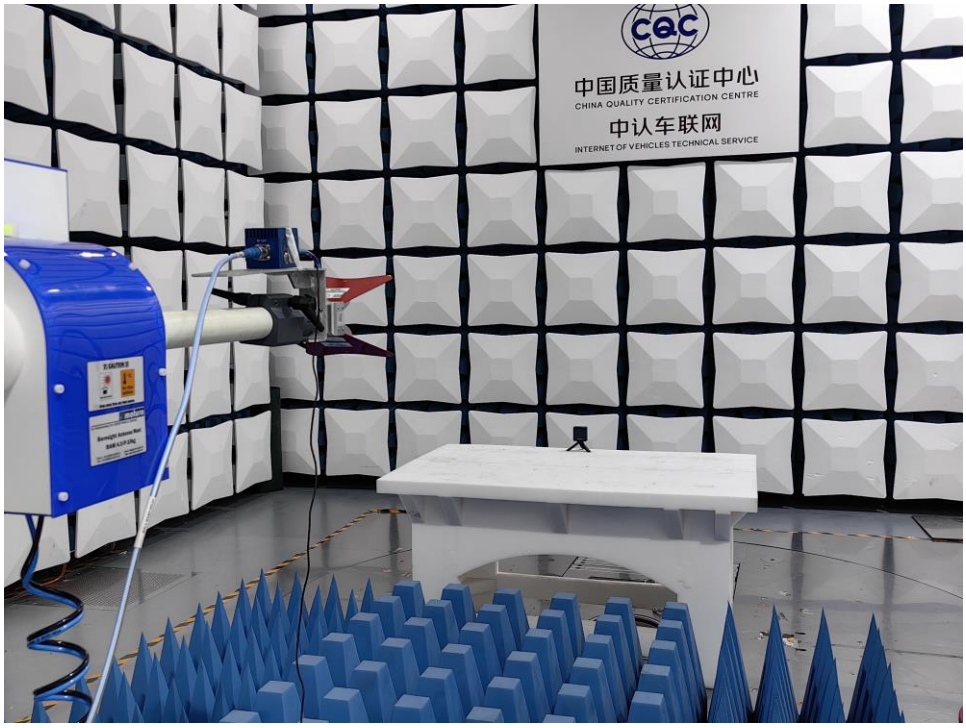
4.5.2 VERDICT

The EUT has an internal antenna which is not user accessible. Hence it compliances with the antenna requirements.

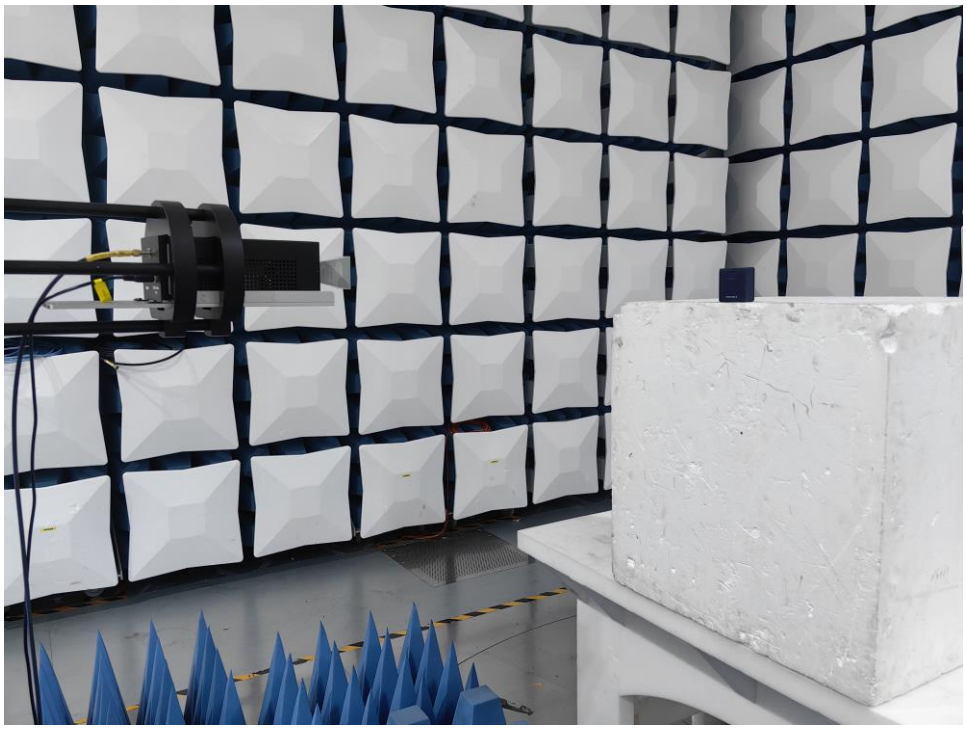
5. Test Set-up Photos of the EUT



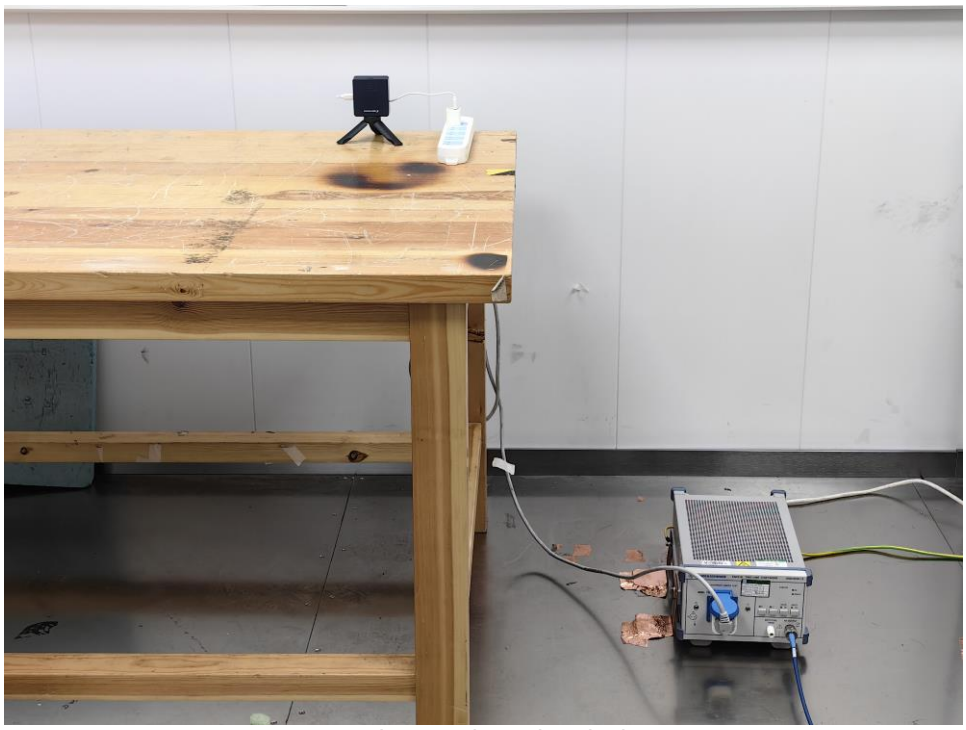
Radiated Emission (30 MHz – 1 GHz)



Radiated Emission (1 GHz – 18 GHz)



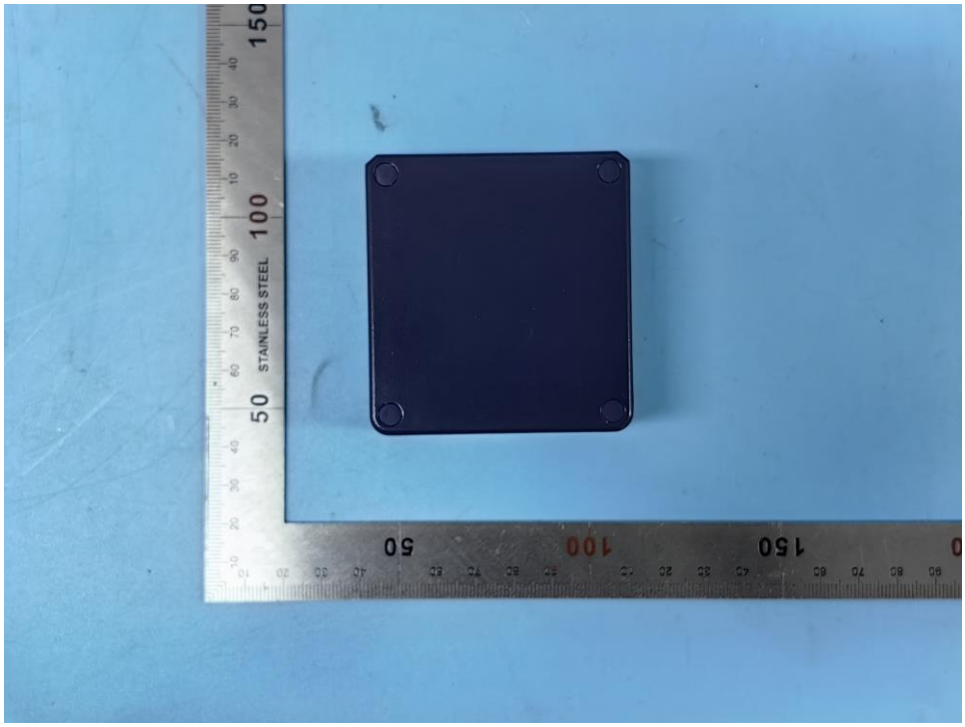
Radiated Emission (Above 18 GHz)

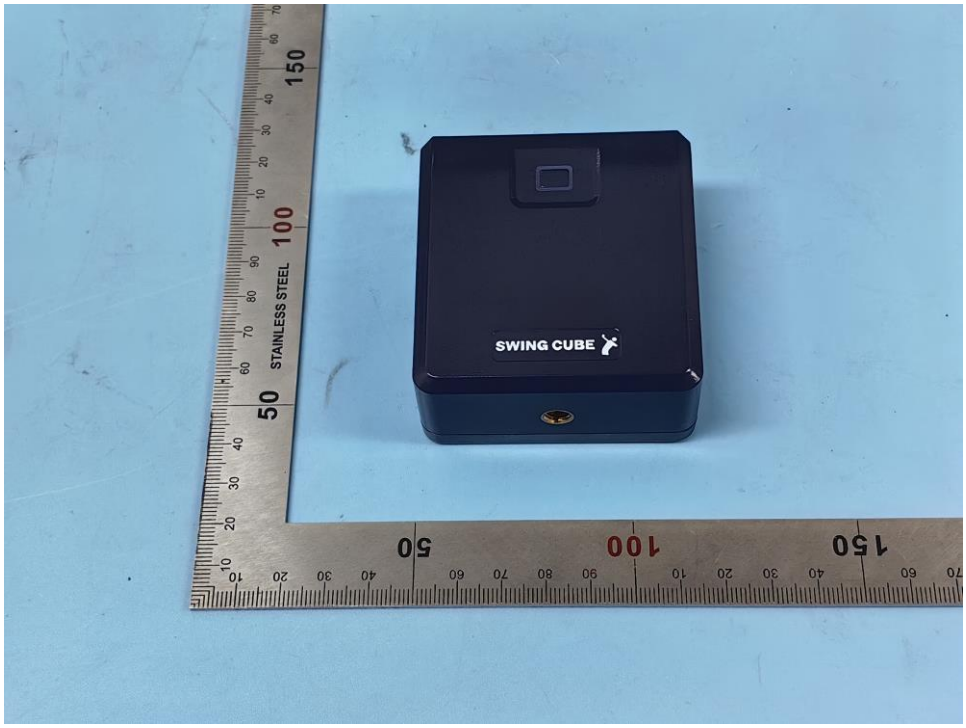


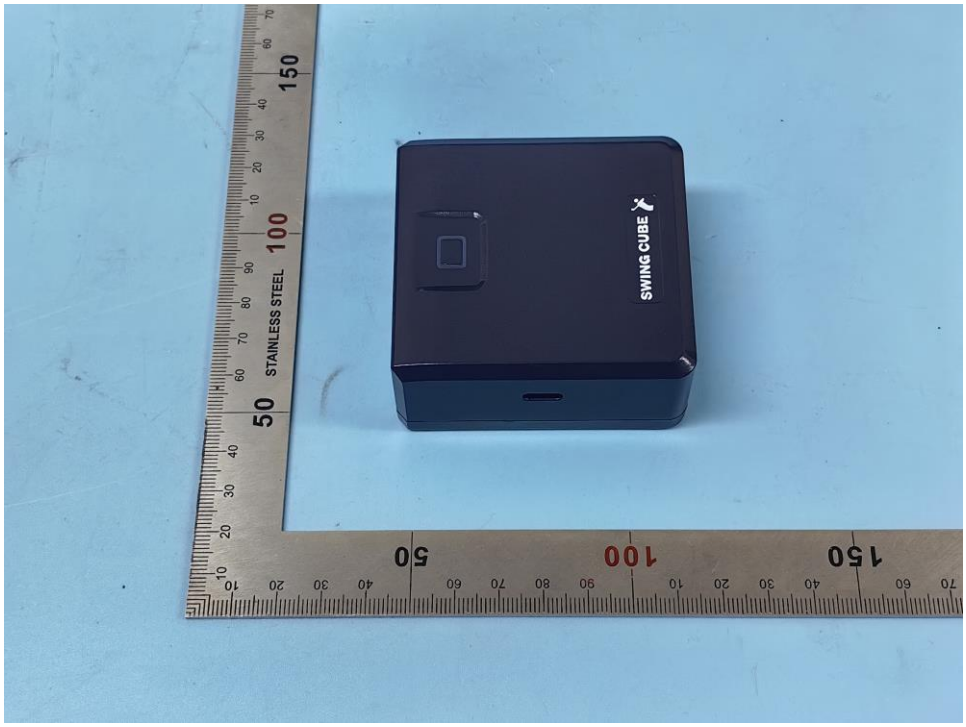
AC mains conducted emissions

6. External and Internal Photos of the EUT

External Photos



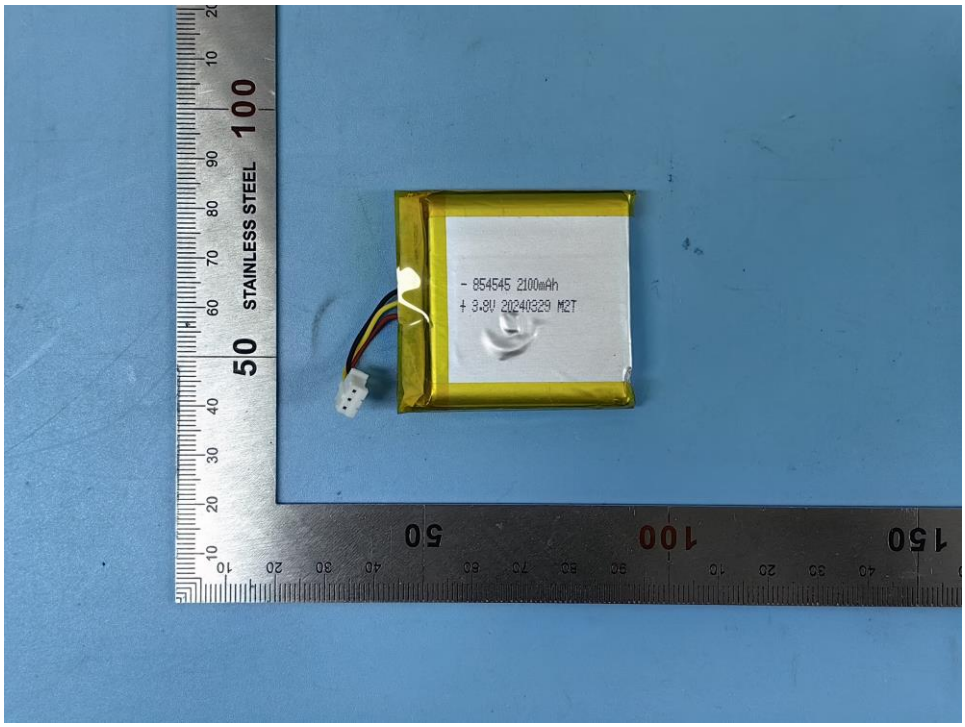

SWING CUBE
STAINLESS STEEL

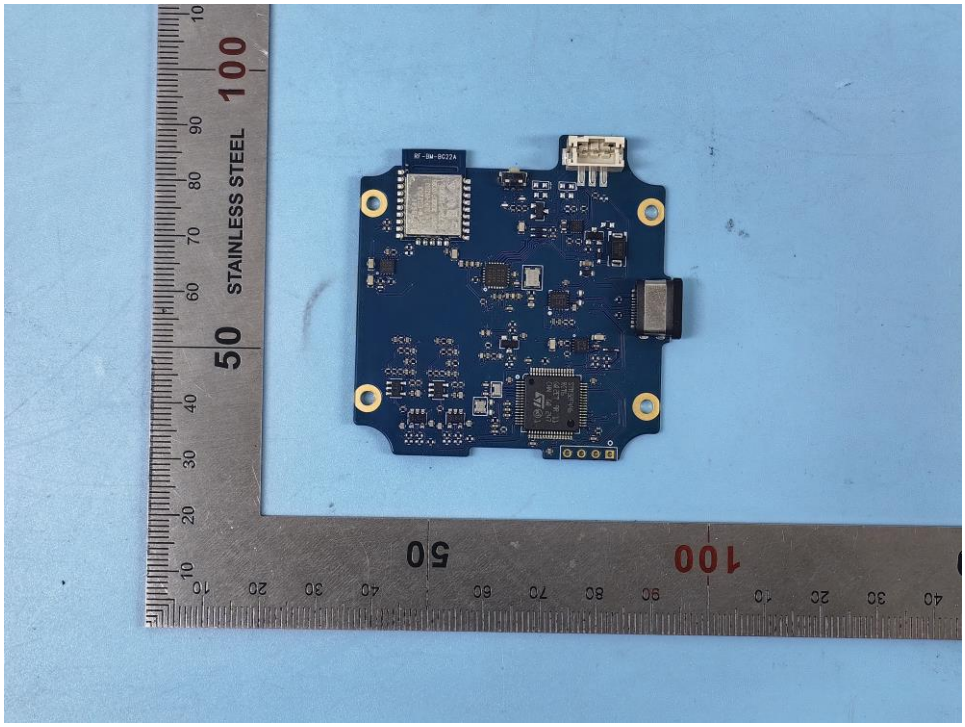

SWING CUBE
STAINLESS STEEL

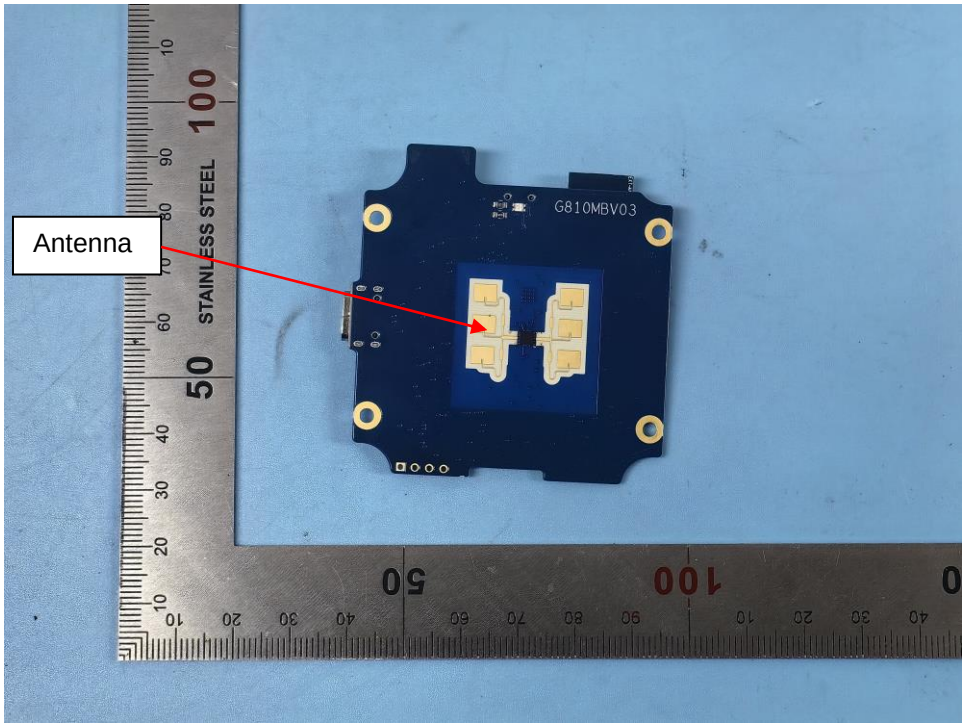
SWING CUBE
STAINLESS STEEL

SWING CUBE
STAINLESS STEEL

Internal Photos






Antenna
G810MBV03
STAINLESS STEEL

Revision History

Revision	Issue Date	Revisions	Revised By
1.0	2024-12-18	Original Issue	Wenliang Li

********** End of Report **********

DECLARATION

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test result without the written permission of the test laboratory.
If you have any questions on this report, please contact us within 15 days after issue this report.

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