

FCC Test Firm Designation Number: FR0014
ISED Wireless Device Testing Laboratory CAB Number: FR0004

Matériel testé :
Equipment under test:

ST / X-NUCLEO-WB05KN1
(Trademark / Marketing name or product reference)

Demandeur de certification : **STMicroelectronics (Rousset) SAS**
Applicant for certification: 190 Avenue Celestin Coq
13106 – ROUSSET – France

Client : **STMicroelectronics**
Customer: 9-11, rue Pierre-Félix Delarue
72100 Le Mans, France

Numéro d'affaire : 110276
Work number :

Référence de la proposition : DV-810397
Proposal number:

Date de l'essai : Du 7 au 12 juin 2024
Date of test: June 7th to 12th, 2024

Objectif des essais : EMC qualification accordingly to following standards:
Test purpose: - CFR 47, FCC Part 15, Subpart C
(Chapter 15.247 - Operation within the bands 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz)s
- Industry Canada RSS-247, Issue 3
(Digital Transmission Systems Operating in the Bands 902–928 MHz)
Measurement standards:
ANSI C63.10 (2013)

Lieu du test: SMEE, 385 Rue René Rambaud
Test location: 38500 VOIRON - France

Test réalisé par : Chemseddine KERMICHE
Test realized by:

Conclusion : L'équipement satisfait aux prescriptions et essais des normes citées en référence.
Conclusion: The appliance complies with requirements and tests of above mentioned standards.

Ed.	Date	Modifications Pages	Written by: Visa	Approved by: Visa
1	September 5 th , 2024	Initial Edition	Chemseddine KERMICHE Test operator 	Laurent CHAPUS Technical Manager

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1. Normatives References

FCC qualification according to:		
Standards	Applied	Title
ANSI C63.10 (2013)	X	American National Standard for Testing Unlicensed Wireless Devices
CFR47, Part 15 (June 2024)	X	Telecommunication – Federal Communication Commission – Radio frequency devices, Sections 15.207 / 15.209 / 15.247

ISED qualification according to:		
Standards	Applied	Title
RSS-Gen (Issue 5/2018, amendments 2019 and 2021)	X	General Requirements and Information for the Certification of Radio Apparatus
RSS-247 (Issue 3/2023)	X	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Note: Following guidance are used

- DTS Measurement Guidance 558074 D01 v05r02
- Determining ERP and EIRP Guidance 412172 D01 v01r01

Deviation from standard: None.

2. Test synthesis

TEST	Paragraph number FCC Part 15 / ISED ICES & RSS	Spec. FCC Part 15 / ISED ICES & RSS	RESULTS (comments)
Conducted emissions test	15.207 (a) RSS-Gen § 8.8	Table 15.107 (a) / 15.207 (a) Table 4 / RSS-Gen	PASS
6dB Bandwidth	15.247 (a) (2) RSS-247 § 5.2 (a)	At least 500kHz	PASS
Maximum Peak Output Power	15.247 (b) (3) & (4) RSS-247 § 5.4 (d)	1W max / 30dBm (Conducted) 4W max / 36dBm (EIRP)	PASS
Maximum Power Spectral Density	15.247 (e) RSS-247 § 5.2 (b)	8dBm in a 3kHz band segment	PASS
Unwanted emissions into Non Restricted Frequency Bands	15.247 (d) / RSS-247 § 5.5	-20dBc in any 100kHz outside frequency band.	PASS
Unwanted emissions into Restricted Frequency Bands	15.209 (a) / 15.247 (d) / 15.205 (a) RSS-GEN §8.9, § 8.10 / RSS-247 § 5.5	<u>Measure at 300m</u> 9-490kHz: 2400µV/m/F(kHz) 6.370µA/m/F (kHz) <u>Measure at 30m</u> 0.490-1.705: 24000µV/m/F(kHz) 63.70µA/m/F (kHz) 1.705-30MHz: 30µV/m 0.08µA/m <u>Measure at 3m</u> 30MHz-88MHz : 40 dBµV/m 88MHz-216MHz : 43.5 dBµV/m 216MHz-960MHz : 46.0 dBµV/m Above 960MHz : 54.0 dBµV/m	PASS
Occupied Bandwidth	RSS-GEN § 6.7	BW at 99%	PASS
Antenna requirement	FCC 15.203 RSS-GEN § 6.8		PASS

- General conclusion:**

Measures and tests performed on the sample of the product *ST / X-NUCLEO-WB05KN1*, in configuration and description presented in this test report, show compliance with standards FCC CFR 47, PART 15, Subpart C and ISED RSS-Gen & RSS-247.

3. Equipment Under Test (EUT)

**Nom /
Identification**

ST / X-NUCLEO-WB05KN1
(Trademark / Marketing name or product reference)

Note: The X-NUCLEO-WB05KN1 is made of two different boards:
MB2160-WB05N-B01 / SN: C242200594
MB2032-WB05N-B01 / SN: C242200594
The X-NUCLEO-WB05KN1 is set on a MB1549-U575ZIQ-C03 / SN: A235001098
(Supporting board)

FCC ID:
IC:
Model / HVIN:
Product name / PMN:
FVIN:
Modular approval:

YCP-MB203202
8976A-MB203202
X-NUCLEO-WB05KN1
X-NUCLEO-WB05KN1
V1.5.1
No

**Alimentation /
Power supply**

5V DC from Laptop USB-Port. (USB port)

**Auxiliaires /
Auxiliaries**

Laptop ASUS, model ASUS VIVABOOK for equipment programming only.

**Entrées-Sorties /
Input / Output**

Connecteur / Connector	Câbles pour essai / Cables for test	Blindé / Shielded	Prévu pour >3m / Intended for >3m
USB Micro-C (STLINK+power)	1.0m	Yes	No
USB-Type C	1.0m	Yes	<3m

**Mode de fonctionnement /
Running mode**

The MB2032B board is placed on a MB1549. The EUT is linked to a laptop through a USB-C cable. The tested sample is able to:
- Transmit a carrier frequency on low, middle and high channels (Bluetooth Low Energy).

**Programme de test /
Test program /**

BlueNRG GUI v4.3.1 ALPHA

**Fréquence max interne EST /
Max internal EUT frequency**

2.480GHz for RF data transmission.

**Information sur l'équipement /
Equipment information**

Declaration of the applicant:
- Frequency band: 2400 to 2483.5 MHz (Tx & Rx, Wideband Data Transmission systems)
- BLE Power Setting: Power is set at High power 31 (Max setting)
- Duty cycle: 85%
- Modulation: Bluetooth Low Energy GFSK (1Mbps, 2Mbps) for DTS
- BLE version 5.4
- Antenna type: Printed PCB (Max antenna gain 1.95dBi)
- Powered by 5V DC from external power supply
- Equipment intended for use as a mobile device
- Equipment designed for continuous operation

**Dimensions de l'EST /
Dimensions of EUT**

132.5mm x 70 x 32 (PCB)

All Information above is declared by the customer / applicant and are under his responsibility.

4. Test conditions

Power supply voltage:
Equipment under test: 5V DC from Laptop USB-Port
Auxiliaries: 120V/60Hz

5. Modifications of the EUT

None.

6. Special accessory

None.

7. Measurement Uncertainty

Test Description	Expanded uncertainty
Conducted emissions test (150k-30MHz, AC mains)	± 3.5dB
Radiated emission test (9kHz-30MHz, electric field)	± 4.0dB
Radiated emission test (30-200MHz, SAC 3m)	± 5.6dB
Radiated emission test (200-1000MHz, SAC 3m)	± 5.3dB
Radiated emission test (1-18GHz, FAC 3m)	± 5.6dB
Radiated emission test (18-40GHz, FAC 3m)	± 5.6dB
Conducted RF output power at antenna port	± 1.6dB
Radiated RF output power (Peak, Power density)	± 5.6dB
DTS Bandwidth, 99% OBW	±4%
Temperature	± 1°C
Time and duty cycle calculation	±1%
AC and DC voltage	±1%

Note: Expanded uncertainty at 95% confidence (k=2)

8. Field Strength Calculation

The field strength (level) is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation is as follow:

$$FS = RA + AF + CF - AG$$

Where FS = Field Strength (Level)

RA = Receiver Amplitude (Meter Reading)

AF = Antenna Factor

CF = Cable Factor

AG = Amplifier Gain

Margin value = Emission level – Limit value

Example:

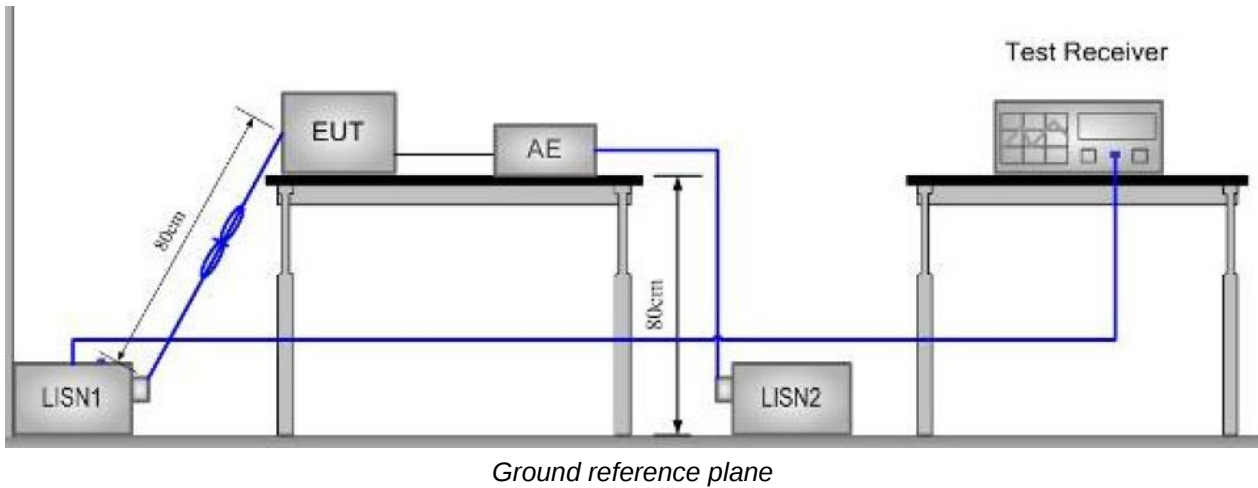
RA: 14.0dBμV / AF: 16.5 dBm⁻¹ / CF: 3.5dB / AG: 15dB

→ Total factor: 5dBm⁻¹

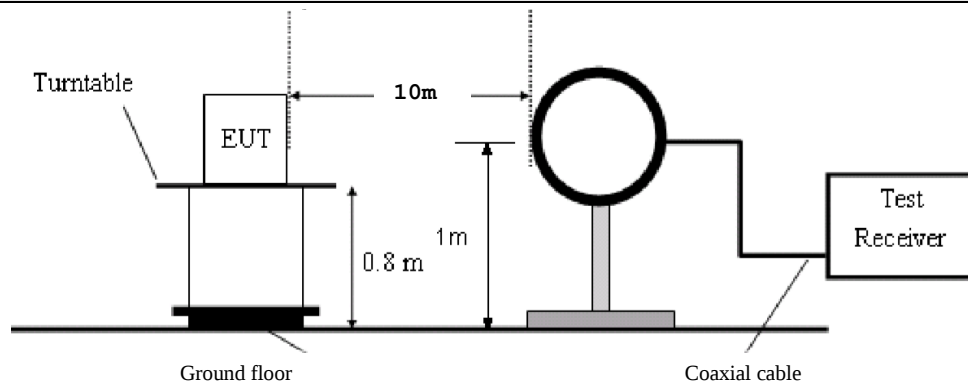
→ Field level: 19.0dBμV/m (-21.0dB for margin if limit is 40dBμV/m)

9. Test Setup Diagram

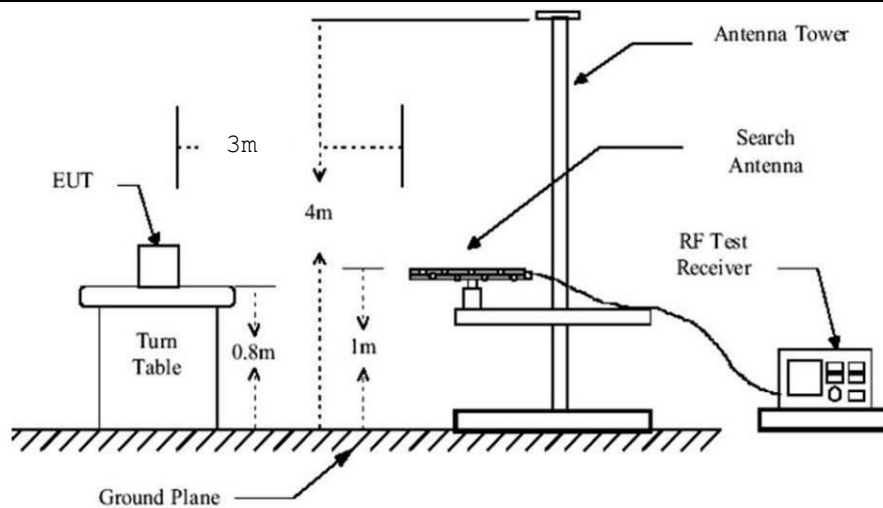
Test Setup for conducted emission



Test Setup for radiated emission

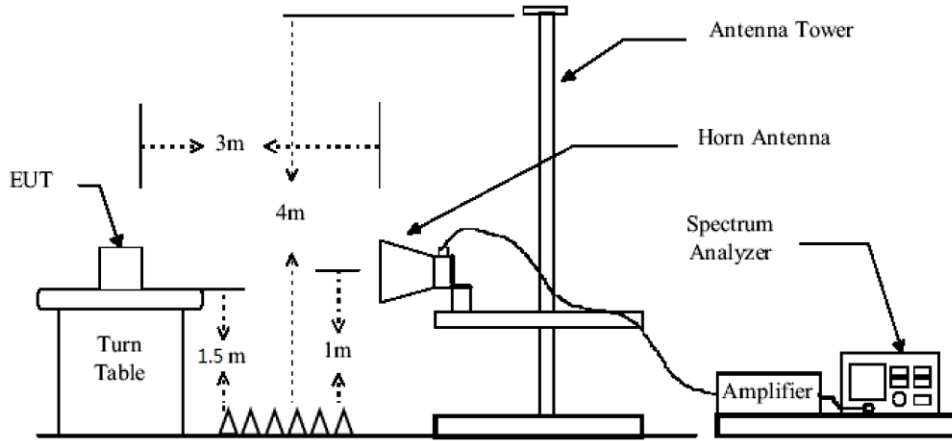


Test setup for 9k-30MHz (FS OATS)



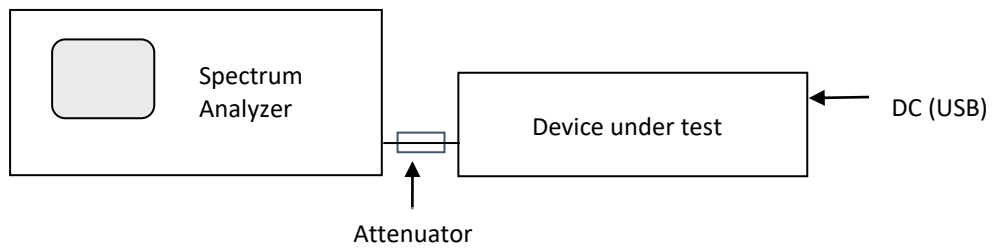
Test setup for 30-1000MHz (SAC 3m)

Test Setup for radiated emission



Test setup for 1-25GHz (SAC 3m, tilt antenna mast used)

Test Setup for conducted antenna port measurement



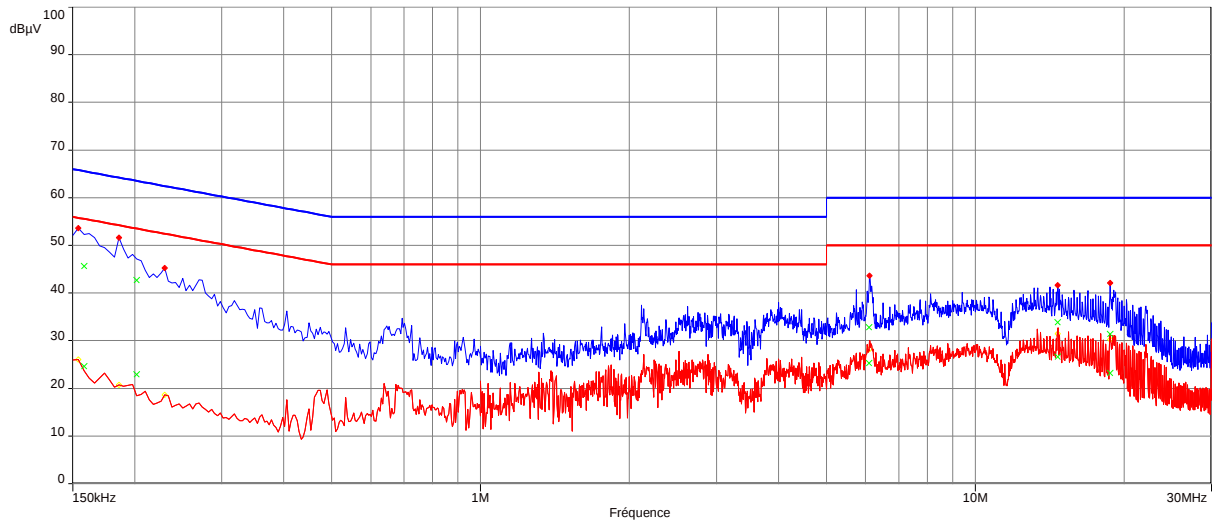
10. Conducted Emission Measurement (150 kHz-30MHz)

TEST: Limits for conducted disturbance 150kHz – 30MHz				Verdict
<u>Method:</u> The LISN is placed 0,8 m from the boundary of the unit under test and bonded to a ground reference plane. This distance was between the closest points of the AMN and the EUT. All other units of the EUT and associated equipment were at least 0,8 m from the AMN. All power was connected to the system through Artificial Mains Network (AMN). Conducted voltage measurements on lines were made at the output of the LISN. The EUT is 80cm above the ground reference plane and 40cm from the vertical ground plane. The AC power cable is 1m length.				Pass
Laboratory Parameters:		Required prior to the test		During the test
Ambient Temperature		17 - 27 °C		22°C ± 2
Relative Humidity		25 - 65 %		49% ± 5
Fully configured sample scanned over the following frequency range		Frequency range on each side of line		Measurement Point
		150kHz to 30MHz		AC input port (120V/60Hz)
Limits				
Frequency (MHz)	Limit dB (µV)			
	Quasi-Peak	Result	Average	Result
0.15 – 0.50	66 \ 56	PASS	56 \ 46	PASS
0.50 - 5	56	PASS	46	PASS
5 – 30	60	PASS	50	PASS
Supplementary information: Test location: SMEE. Test date: June 12 th , 2024 by C KERMICHE. Power supply voltage: 5V DC from USB-Port, powered with 120V 60Hz.				

Tabulated Results for Mains Terminal Disturbance Voltage on AC port

FREQ (MHz)	Meas. PK (dBμV)	Mes. QP (dBμV)	LIMIT QP (dBμV)	Margin QP (dB)	Mes. AV (dBμV)	LIMIT AV (dBμV)	Margin AV (dB)	Line
0.156391	56.24	45.62	65.57	-19.95	24.67	55.57	-30.90	L1
0.200043	50.70	42.65	63.53	-20.88	22.93	53.53	-30.60	L1
6.097673	37.75	32.78	60.00	-27.22	25.27	50.00	-24.73	L1
14.669025	41.58	33.86	60.00	-26.14	26.67	50.00	-23.33	L1
18.720012	39.95	31.39	60.00	-28.61	23.15	50.00	-26.85	L1
0.156391	56.24	45.62	65.57	-19.95	24.67	55.57	-30.90	L1
0.152822	56.84	48.00	65.78	-17.79	30.82	55.78	-24.96	N
0.168217	54.76	44.49	64.96	-20.47	28.00	54.96	-26.96	N
0.473097	44.45	41.75	56.44	-14.70	32.16	46.44	-14.28	N
0.478718	44.30	41.15	56.37	-15.22	31.39	46.37	-14.99	N
11.425331	49.37	46.24	60.00	-13.76	37.31	50.00	-12.69	N
12.307653	51.18	42.67	60.00	-17.33	34.63	50.00	-15.37	N
RBW:			9kHz					
Voltage:			120V/60Hz					
Limit:			FCC Part 15.207 / RSS-Gen: Issue 5, §8.8 Table 4					
Final measurement detector:			Quasi-Peak and CISPR Average (AV)					
RESULT:			PASS					
Measured value calculation:			The measured value (level) is calculated by adding the Cable Factor, the Transient suppressor attenuation and LISN attenuation from the receiver amplitude reading. The basic equation is as follow: $\text{Meas.} = \text{RA} + \text{CF} + \text{ATT}_{\text{TRAN}} + \text{ATT}_{\text{LISN}}$ Where Meas. = Level (dBμV) RA = Receiver Amplitude CF = Cable Factor ATT_{TRAN} = Transient suppressor attenuation ATT_{LISN} = LISN attenuation Margin value = Emission level – Limit value (A negative margin shows compliance to limit)					

Graphical representation of Conducted Disturbance Measurement (Peak and Average detection) AC port, Line L1

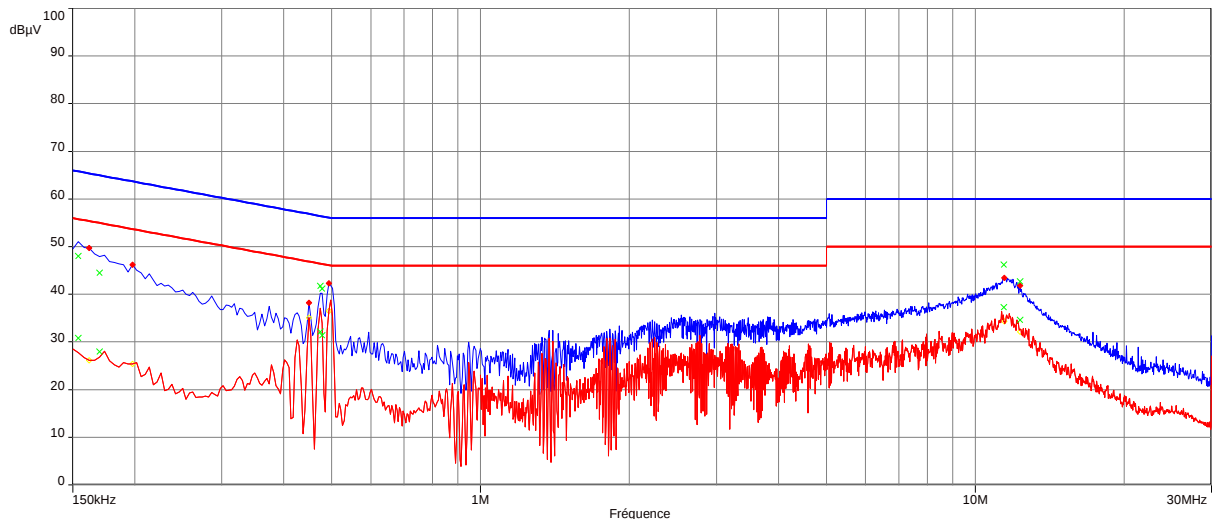


Note : Same result for all transmit modes on all channels.

~~~~~: Peak

~~~~~: Average

Graphical representation of Conducted Disturbance Measurement (Peak and Average detection) AC port, Line Neutral



Note : Same result for all transmit modes on all channels.

~~~~~: Peak

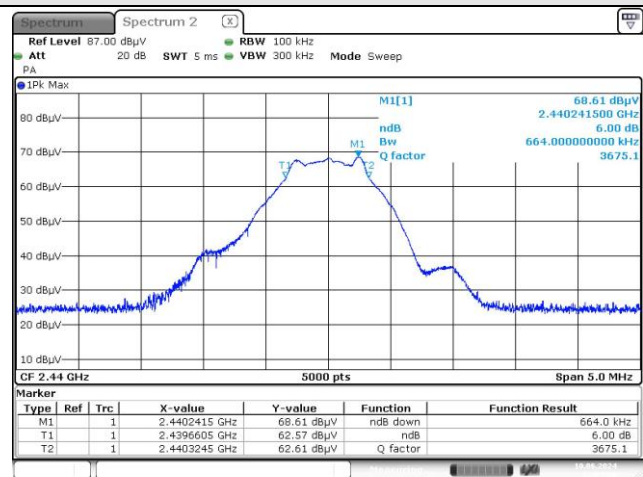
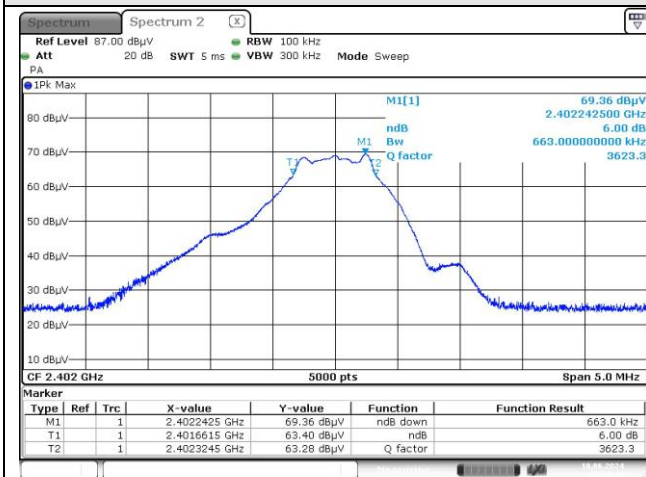
~~~~~: Average

11. DTS Bandwidth

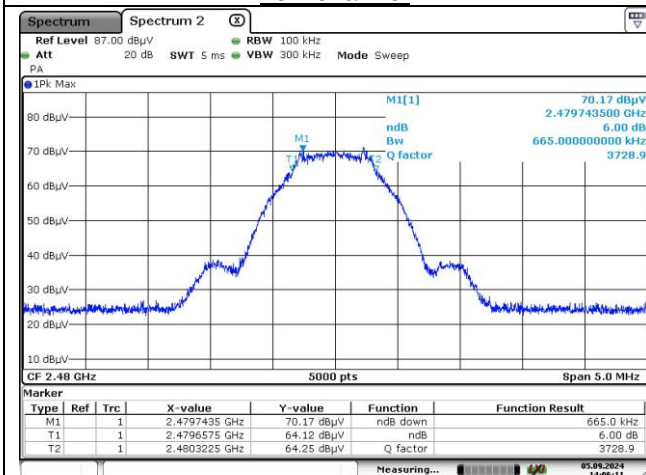
| TEST: DTS Bandwidth | | Verdict | |
|--|------------------------------------|-----------------|-----------------|
| <p>Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed.</p> <p>The RBW is 100kHz, with VBW ≥ 3 x RBW.</p> <p>The SPAN is wide enough to capture all products of the modulation process.</p> <p>A MaxHold Peak detector is used. Automatic function of the spectrum analyser is used.</p> <p>The tested equipment is set to transmit operation with modulation on low, mid and high channels.</p> | | Pass | |
| Laboratory Parameters: | Required prior to the test | | During the test |
| Ambient Temperature | 20 to 30 °C | | 21°C ± 2 |
| Relative Humidity | 25 to 70 % | | 48% ± 5 |
| Limits – FCC Part 15.247 (a) / RSS-247 §5.2 (a) | | | |
| Frequency (MHz) | Level for Bandwidth | Limit | |
| 2402.0 | 6dB below the maximum output power | At least 500kHz | |
| 2440.0 | | | |
| 2480.0 | | | |
| Supplementary information:
Test location: SMEE
Test date: June 10 th , 2024 by C KERMICHE.
Power supply voltage: 5V DC from USB-Port. | | | |

| Tabulated Results for Occupied Bandwidth | | |
|--|---------------|--------|
| Frequency (MHz) | 6dB Bandwidth | Result |
| BLE: 1MBps | | |
| 2402.0 | 663.0 kHz | Pass |
| 2440.0 | 664.0 kHz | Pass |
| 2480.0 | 665.0 kHz | Pass |
| BLE: 2MBps | | |
| 2402.0 | 1.146 MHz | Pass |
| 2440.0 | 1.256 MHz | Pass |
| 2480.0 | 1.150 MHz | Pass |

Graphical representation of 6dB Bandwidth / BLE: 1Mbps



Low channel

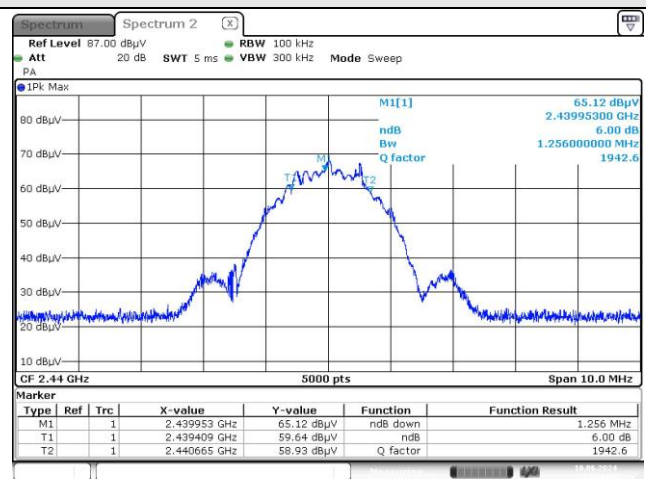
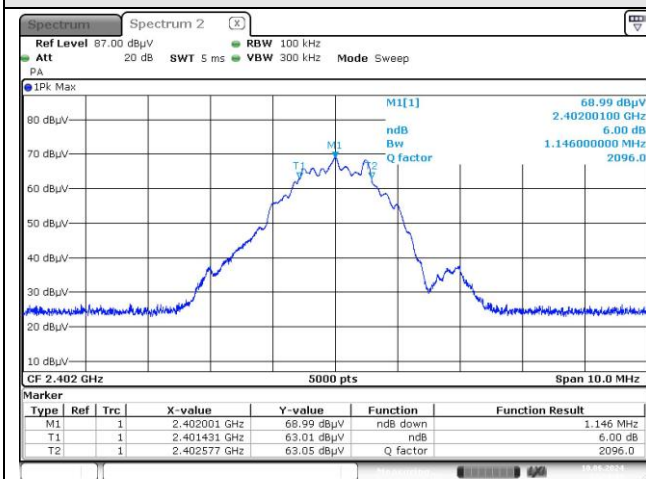


Mid channel

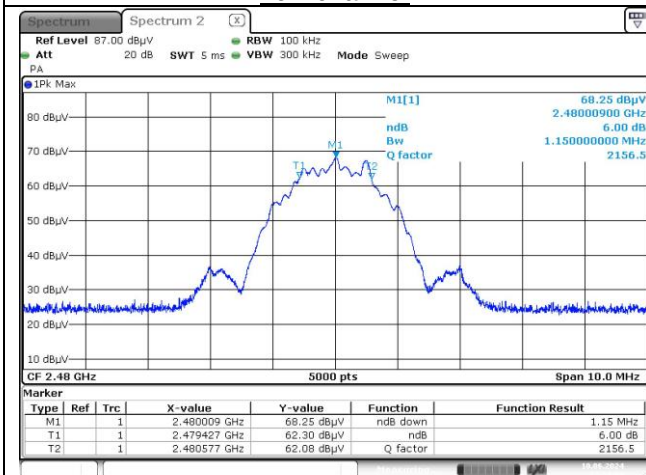
High channel

| | |
|------------------------------|----------------------|
| Frequency band investigated: | 2400MHz to 2483.5MHz |
| RBW : | 100kHz |
| Measurement detector : | Peak |

Graphical representation of 6dB Bandwidth / BLE: 2Mbps



Low channel



Mid channel

High channel

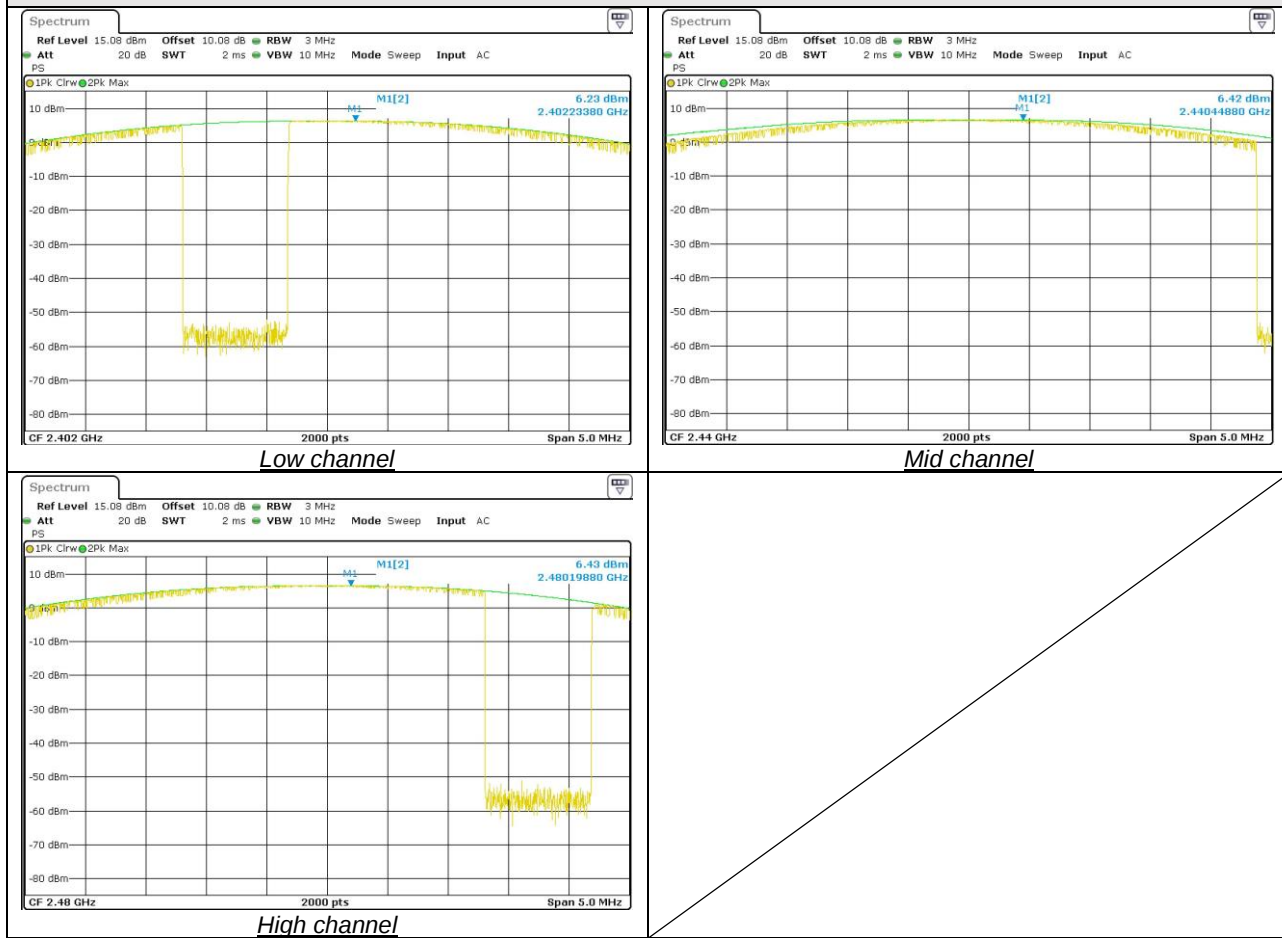
| | |
|------------------------------|----------------------|
| Frequency band investigated: | 2400MHz to 2483.5MHz |
| RBW : | 100kHz |
| Measurement detector : | Peak |

12. Maximum Peak Output power

| TEST: Maximum peak conducted output power | | | Verdict |
|--|-----------------------------|-----------------|---------|
| <p>Method: A conducted measurement is performed.
The RBW is wide enough to capture the maximum amplitude level.
The SPAN is wide enough to capture all products of the modulation process.
A MaxHold Peak detector is used.
Radiated field strength of RF Output Power is measured at 3m in a Semi Anechoic Chamber (SAC) that complies with ANSI C63.10 / ANSI C63.4.
Maximum field strength (Peak) is performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity
The tested equipment is set to transmit operation with modulation on low, mid and high channels.</p> | | | Pass |
| Laboratory Parameters: | Required prior to the test | During the test | |
| Ambient Temperature | 20 to 30 °C | 21°C ± 2 | |
| Relative Humidity | 25 to 70 % | 48% ± 5 | |
| Limits – FCC Part 15.247 (b) / RSS-247 §5.4 (d) | | | |
| Frequency (MHz) | Limits (dBµV/m) | | |
| | Level / Detector | Results | |
| 2400 to 2483.5 | 36 dBm / Pk / 3m (Radiated) | Pass | |
| 2400 to 2483.5 | 30 dBm / Pk (Conducted) | Pass | |
| Supplementary information:
Test location: SMEE
Test date: June 12 th , 2024 by C KERMICHE.
Power supply voltage: 5V DC from USB-Port. | | | |

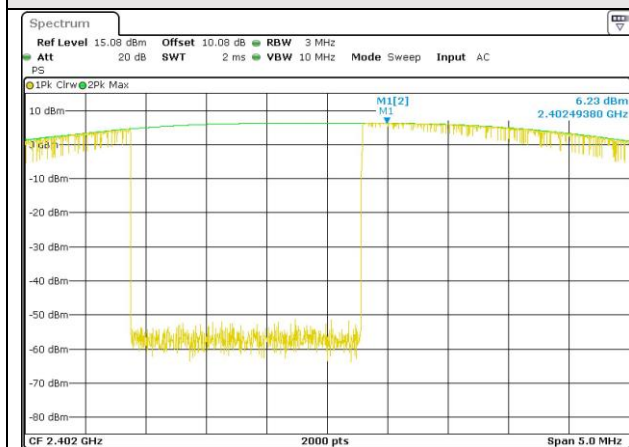
| Tabulated Results for Maximum peak output power (Conducted measurement) | | | | | | |
|---|-----------------|--------------|--|-----------------|----------------|--------|
| FREQ | Conducted power | Antenna Gain | Radiated power E.I.R.P | Conducted Limit | Radiated Limit | Result |
| (MHz) | (dBm) | (dBi) | (dBm) | (dBm) | (dBm) | |
| 1Mbps | | | | | | |
| 2402 | 7.0 | 1.95 | 8.95 | 30.0 | 36.0 | Pass |
| 2440 | 7.2 | 1.95 | 9.15 | 30.0 | 36.0 | Pass |
| 2480 | 7.2 | 1.95 | 9.15 | 30.0 | 36.0 | Pass |
| 2Mbps | | | | | | |
| 2402 | 7.0 | 1.95 | 8.95 | 30.0 | 36.0 | Pass |
| 2440 | 7.2 | 1.95 | 9.15 | 30.0 | 36.0 | Pass |
| 2480 | 7.2 | 1.95 | 9.15 | 30.0 | 36.0 | Pass |
| RBW: | | | 1MHz | | | |
| Limit: | | | FCC Part 15.247 / RSS-247 | | | |
| Final measurement detector: | | | Peak | | | |
| RESULT: | | | PASS | | | |
| Note: | | | EIRP is calculated using the following equation:
- EIRP = Conducted power (dBm) + Antenna Gain (dBi).
Where:
- Conducted power = Conducted measurement (dBm) + Cable loss.
- Cable loss = 0.8 dB
- Attenuator is 10 dB (The attenuator value has been added to the SA)
- Antenna gain = 1.95 dBi (declared by the manufacturer). | | | |

Graphical representation for Maximum Peak Output power (1Mbps)

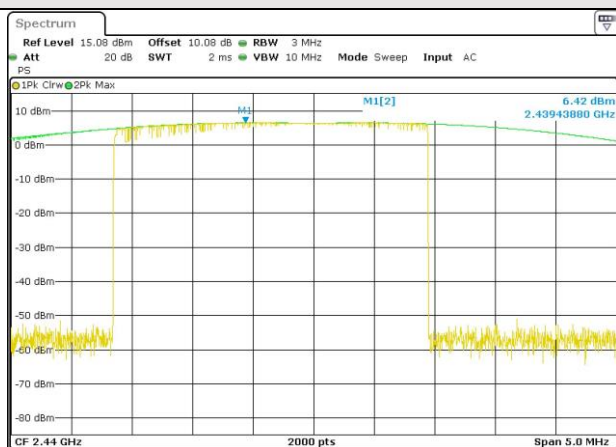


| | |
|--------------|--|
| Measurement: | Conducted measurement |
| Limit: | FCC Part 15.247 / RSS-247 |
| RBW: | 3MHz (RBW $\geq$ DTS bandwidth) |
| VBW: | 28MHz (VBW $\geq$ [3 $\times$ RBW]) |
| Span: | 10MHz (Set span $\geq$ [3 $\times$ RBW]) |

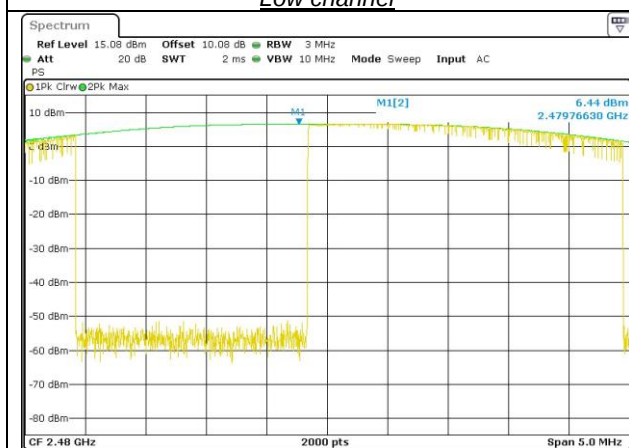
Graphical representation for Maximum Peak Output power (2Mbps)



Low channel



Mid channel



High channel

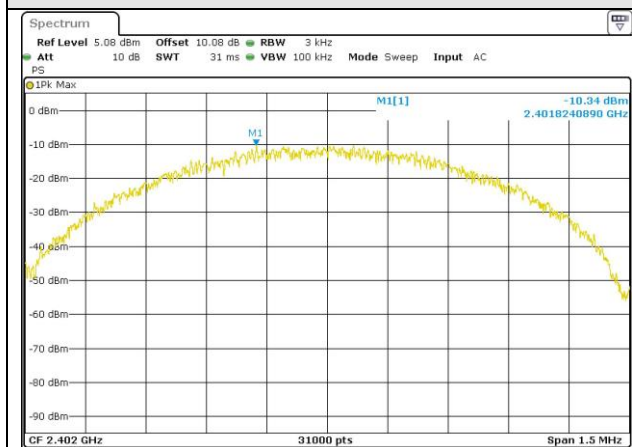
| | |
|--------------|--|
| Measurement: | Conducted measurement |
| Limit: | FCC Part 15.247 / RSS-247 |
| RBW: | 3MHz (RBW $\geq$ DTS bandwidth) |
| VBW: | 28MHz (VBW $\geq$ [3 $\times$ RBW]) |
| Span: | 10MHz (Set span $\geq$ [3 $\times$ RBW]) |

13. Maximum Power Spectral Density Level in the fundamental emission

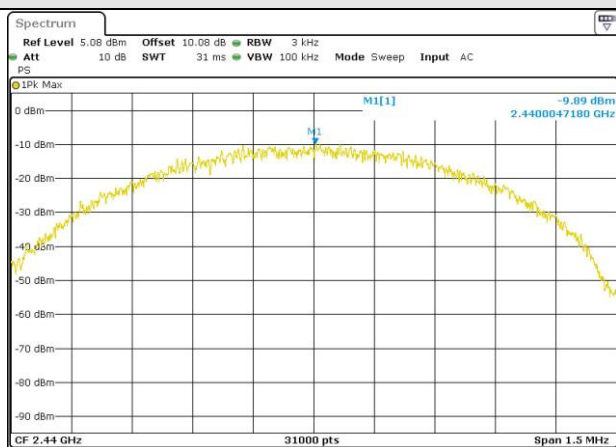
| TEST: Maximum Peak Power Spectral Density | | Verdict |
|---|----------------------------|-----------------|
| <p>Method: A conducted measurement is performed.
 The RBW is set at 3kHz.
 The SPAN is wide enough to capture all products of the modulation process.
 A MaxHold Peak detector is used.
 Radiated field strength of RF Output Power is measured at 3m in a Semi Anechoic Chamber (SAC) that complies with ANSI C63.10 / ANSI C63.4.
 Maximum field strength (Peak) is performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity
 The tested equipment is set to transmit operation with modulation on low, mid and high channels.</p> | | Pass |
| Laboratory Parameters: | Required prior to the test | During the test |
| Ambient Temperature | 20 to 30 °C | 21°C ± 2 |
| Relative Humidity | 25 to 70 % | 52% ± 5 |
| Limits – FCC Part 15.247 (e) / RSS-247 §5.2 (b) | | |
| Frequency (MHz) | Level (Detector) | Limit |
| 2402 / 2440 / 2480 | 8 dBm/3kHz (Pk) | Pass |
| <p>Supplementary information:
 Test location: SMEE
 Test date: June 12th, 2024 by C KERMICHE.
 Power supply voltage: 5V DC from USB-Port.</p> | | |

| Tabulated Results for Maximum Conducted Power Spectral Density | | | |
|--|---|-----------|--------|
| Frequency (MHz) | PSD (dBm/3kHz) | Limit | Result |
| BLE: 1Mbps | | | |
| 2402.0 | -9.5 | 8dBm/3kHz | Pass |
| 2441.0 | -9.0 | 8dBm/3kHz | Pass |
| 2480.0 | -9.1 | 8dBm/3kHz | Pass |
| BLE: 2Mbps | | | |
| 2402.0 | -11.1 | 8dBm/3kHz | Pass |
| 2441.0 | -11.3 | 8dBm/3kHz | Pass |
| 2480.0 | -11.2 | 8dBm/3kHz | Pass |
| RBW: | 3kHz | | |
| Limit: | FCC Part 15.247 / RSS-247 | | |
| Final measurement detector: | Peak | | |
| RESULT: | PASS | | |
| Note: | <p>PSD is calculated using the following equation:
 $PSD = PSD_{\text{Conducted measurement}} \text{ (dBm/3kHz)} + \text{Cable loss (dB)}$
 Where:
 - Attenuator is 10 dB (The attenuator value has been added to the SA)
 - Cable loss = 0.8 dB</p> | | |

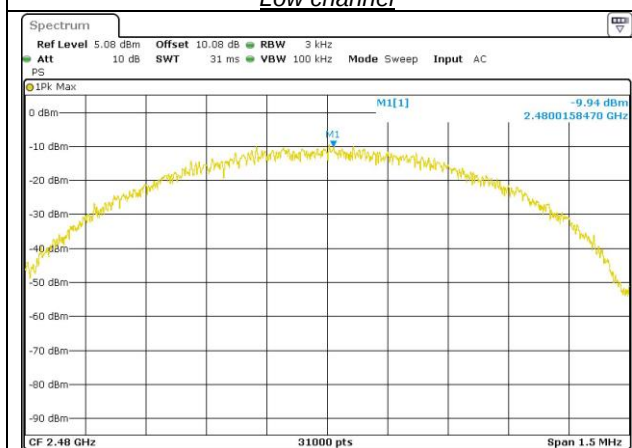
Graphical representation for Maximum Power Spectral Density / BLE: 1Mbps



Low channel



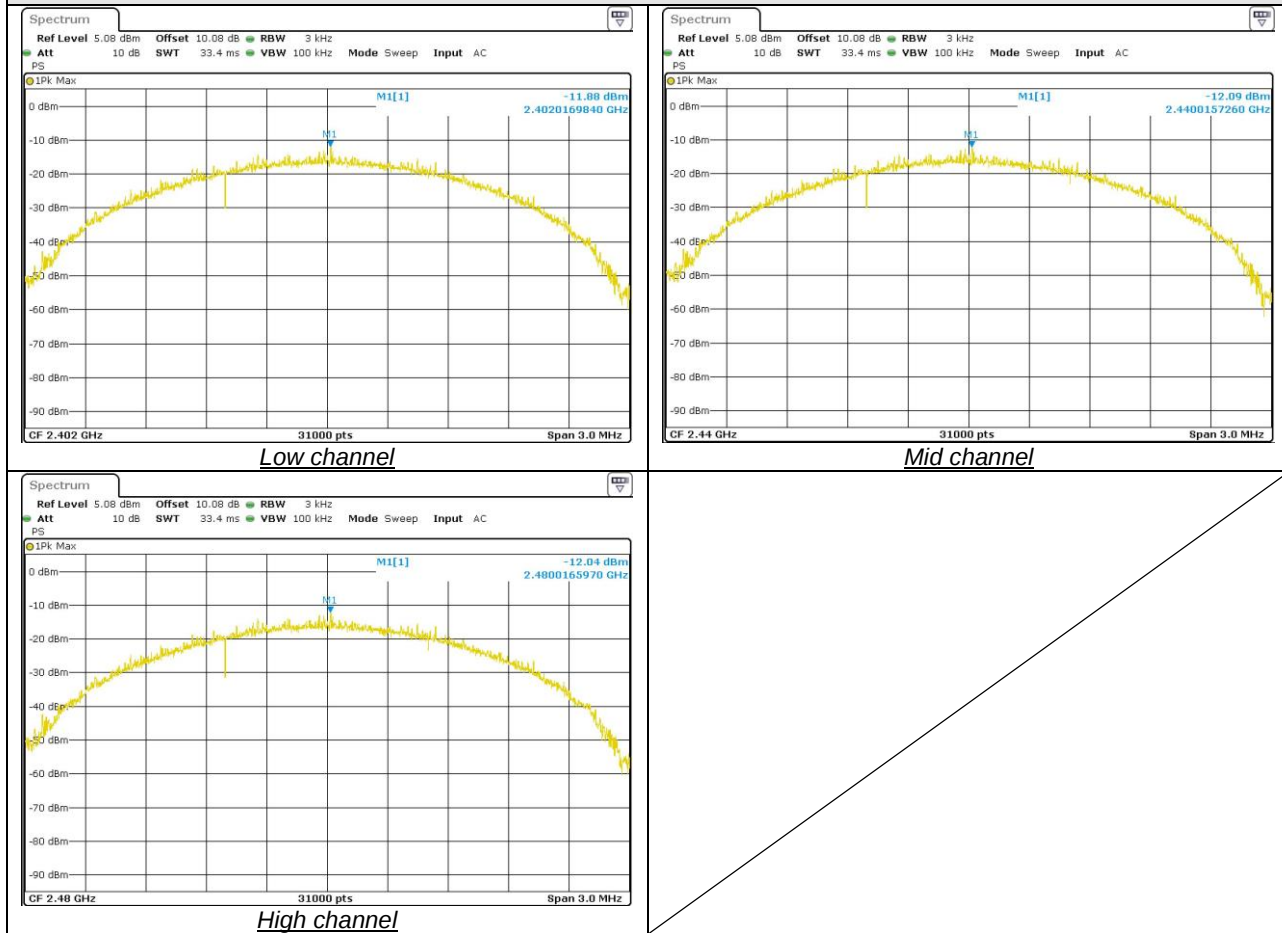
Mid channel



High channel

| | |
|--------------|---------------------------|
| Measurement: | Conducted measurement |
| RBW: | 3kHz |
| Limit: | FCC Part 15.247 / RSS-247 |
| RESULT: | PASS |

Graphical representation for Maximum Power Spectral Density / BLE: 2Mbps



| | |
|---------------------|---------------------------|
| Measurement: | Conducted measurement |
| RBW: | 3kHz |
| Limit: | FCC Part 15.247 / RSS-247 |
| RESULT: | PASS |

14. Unwanted emissions in Non-Restricted Frequency bands (Radiated emissions)

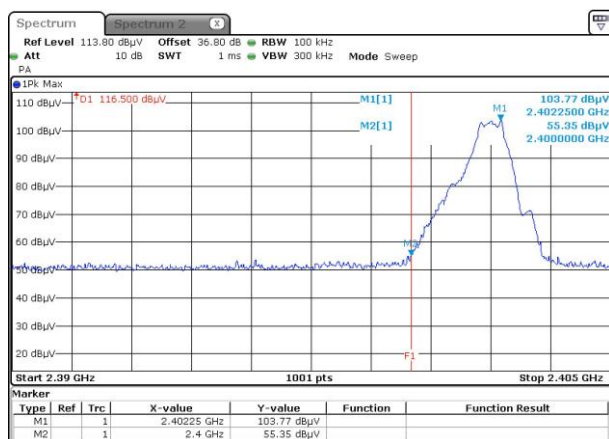
| TEST: Unwanted emissions in Non-Restricted Frequency Bands | | | Verdict |
|--|--------------------------------------|-----------------------------------|---------|
| <p><u>Method:</u> Measurements were made in a 3-meter Semi Anechoic Room (SAR) up to 1GHz and in a 3-meter Full Anechoic environment (SAR with floor absorbers) above 1GHz.</p> <p>The Semi Anechoic Room complies with CISPR16-1-4 / ANSI C63.4 requirements.</p> <p>Preliminary (peak) measurements were performed at an antenna to EUT separation distance of 3 meters.</p> <p>The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. The pre-characterization graphs are obtained in PEAK detection.</p> <p>Final measurements (Peak, Quasi-peak, Average) were then performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity, where applicable.</p> | | | Pass |
| Laboratory Parameters: | Required prior to the test | During the test | |
| Ambient Temperature | 20 to 30 °C | 21°C ± 2 | |
| Relative Humidity | 25 to 70 % | 49% ± 5 | |
| Fully configured sample scanned over the following frequency range | Frequency range on each side of line | Measurement Point | |
| | 30MHz – 25GHz | 3m measurement distance | |
| Limits – FCC Part 15.247 (d) / RSS-247 § 5.5 | | | |
| Frequency (MHz) | Limits (dBµV/m) | | |
| | Detector / Analyser RBW | Limit | Results |
| 30 to 25000 | Pk / 100kHz | 20dB below the maximum Peak level | Pass |
| Supplementary information:
Test location: SMEE
Test date: June 11 th , 2024 by C KERMICHE.
Power supply voltage: 5V DC from USB-Port. | | | |

| Tabulated Results for Peak Output Power Reference level | |
|---|--|
| FREQ
(MHz) | Field Strength 3m
(dBµV/m) |
| 2402.0 | 104.1 ⁽¹⁾ |
| 2440.0 | 103.8 ⁽¹⁾ |
| 2480.0 | 103.3 ⁽¹⁾ |
| RBW: | 100kHz |
| Measurement distance: | 3m |
| Limit: | Ref. level only – For 15.247 (d) / RSS-247 § 5.5 |
| Final measurement detector: | Peak |
| Note: | (1): Only for identification of limit in non-restricted band
Limit is 83.3 dBµV/m Peak for out-of-band frequencies in Non-Restricted bands (with a 100kHz RBW on the spectrum analyzer). |

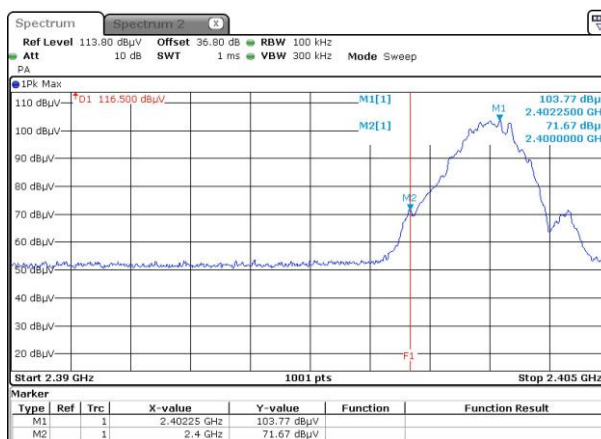
Tabulated Results for Unwanted emissions in Non-Restricted bands (30M-25GHz)

| FREQ
(MHz) | Field Strength 3m
(dBμV/m) | Limit
(dBμV/m) | Margin
(dBμV/m) | Result
(dBμV/m) |
|--|--|-------------------|--------------------|--------------------|
| All levels are at least 10dB below applicable limits | | | | |
| RBW: | 100kHz | | | |
| Measurement distance: | 3m | | | |
| Limit: | FCC 15.247 / RSS-247 | | | |
| Final measurement detector: | Peak | | | |
| RESULT: | PASS | | | |
| Note: | See band-edge measurement.
See pre-scan graphs in chapter 15. | | | |

Graphical representation of Band-edge compliance (LOW)



Low band edge compliance: BLE/1Mbps



Low band edge compliance: BLE/2Mbps

RESULT: PASS.

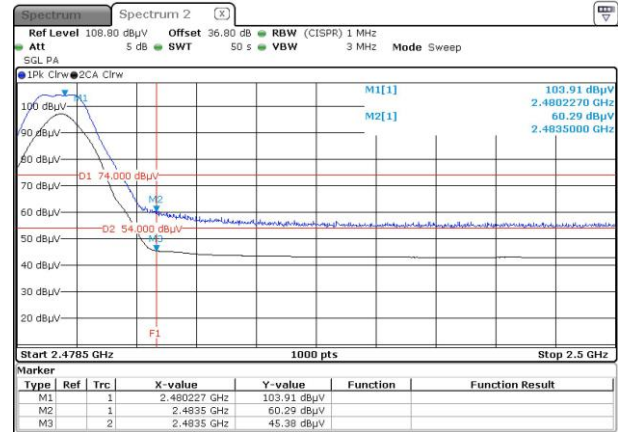
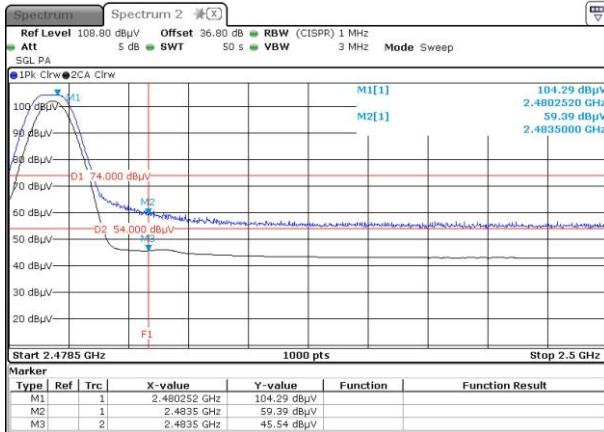
Note: Radiated measurement.

| FREQ
(MHz) | Field Strength
3m
(dBμV/m) | Limit
(dBμV/m) | Margin
(dBμV/m) | Result
(dBμV/m) |
|---------------|----------------------------------|-------------------|--------------------|--------------------|
| BLE: 1Mbps | | | | |
| 2400.00 | 55.4 | 83.3 | -27.9 | Pass |
| BLE: 2Mbps2 | | | | |
| 2400.00 | 71.7 | 83.3 | -11.6 | Pass |

15. Unwanted emissions in Restricted Frequency bands

| TEST: Unwanted emissions into Restricted Frequency Bands | | Verdict |
|---|---|---------------------------|
| <p>Method: Measurements were made in a 3-meter Semi Anechoic Room (SAR) for frequency 30MHz to 1GHz and in a 3-meter Full Anechoic environment (SAR with floor absorbers) above 1GHz. The Semi Anechoic Room complies with CISPR16-1-4 / ANSI C63.4 requirements. For frequency 9kHz to 30MHz, measurements are performed on a free-space open area test site at 10m distance.</p> <p>Preliminary (peak) measurements were performed at an antenna to EUT separation distance of 3 meter. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities.</p> <p>Final measurements (Peak, Quasi-peak, Average) were then performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity, where applicable.</p> | | Pass |
| Laboratory Parameters: | Required prior to the test | During the test |
| Ambient Temperature | 20 to 30 °C | 22°C ± 2 |
| Relative Humidity | 25 to 70 % | 52% ± 5 |
| Fully configured sample scanned over the following frequency range | Frequency range on each side of line | Measurement Point |
| | 9kHz – 30MHz | 10 m measurement distance |
| | 30MHz – 25GHz | 3 m measurement distance |
| Limits – FCC Part 15.205, 15.209 (a), 15.247 (d) / RSS-GEN §8.9, §8.10, RSS-247 §5.5 | | |
| Frequency (MHz) | Limits (dBµV/m) | |
| | Level / Detector / Distance | Results |
| 0.009 to 0.090 | 107.6 – 87.6 / AV / 10m
127.6 – 107.6 / PK / 10m | Pass |
| 0.090 to 0.110 | 87.6 – 85.9 / QP / 10m | Pass |
| 0.110 to 0.490 | 85.7 – 72.9 / AV / 10m
105.7 – 92.9 / PK / 10m | Pass |
| 0.490 to 1.705 | 52.9 – 42.1 / QP / 10m | Pass |
| 1.705 to 30 | 48.6 / QP / 10m | Pass |
| 30 to 88 | 40.0 / QP / 3m | Pass |
| 88 to 216 | 43.5 / QP / 3m | Pass |
| 216 to 960 | 46.0 / QP / 3m | Pass |
| 960-1000 | 54.0 / QP / 3m | Pass |
| Above 1GHz | 54.0 / AV / 3m
74.0 / PK / 3m | Pass |
| Supplementary information:
Test location: SMEE
Test date: June 7 th , 2024 by C KERMICHE.
Power supply voltage: 5V DC from USB-Port. | | |

Graphical representation of Band-edge compliance (HIGH)



High band edge compliance: BLE/1Mbps

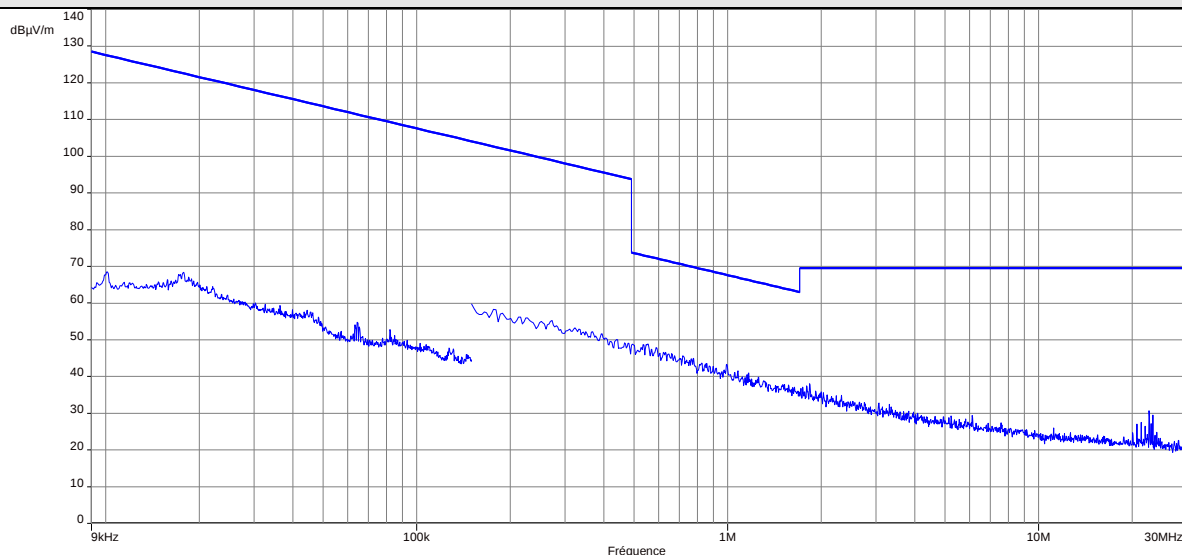
Radiated Peak level is 59.4 dBμV/m (limit 74dBμV/m).
Max radiated Average level is 45.5 dBμV/m (limit 54dBμV/m, CISPR Average detector measurement).

RESULT: PASS

High band edge compliance: BLE/2Mbps

Radiated Peak level is 60.3 dBμV/m (limit 74dBμV/m).
Max radiated Average level is 45.4 dBμV/m (limit 54dBμV/m, CISPR Average detector measurement).

Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 9kHz-30MHz / 3m / Parallel & Perpendicular antenna position / Transmit mode)



Notes: Pre-scan graph only for identification purpose. Same result for transmit mode on all channels.

Tabulated Results for Unwanted emissions (9kHz-490kHz)

| FREQ | RF field @ 300m | Limit @ 300m | Detector | Margin | Ant. angle | Table angle | Correc. Fact. (CF) |
|---|-----------------|--|--------------|--------|------------|-------------|--------------------|
| MHz | dBμV/m | dBμV/m | Pk / QP / AV | dB | Degree | Degree | dB |
| All levels are at least 20dB below applicable limits | | | | | | | |
| Supplementary information:
Frequency list measured has been created with pre-scan results. | | | | | | | |
| Frequency band investigated: | | 9kHz-490kHz | | | | | |
| RBW: | | 200Hz (9kHz-150kHz)
9kHz (150kHz-30MHz) | | | | | |
| Measurement distance: | | 10m | | | | | |
| Final measurement detector: | | Peak / Quasi-Peak / Average | | | | | |
| Limit: | | FCC Part 15.209 / RSS-Gen | | | | | |
| Note: | | CF: Correction factor = Antenna factor + Cable loss
(M@300m = M@10m-59.1dB)
Loop antenna used and rotated about its axis to maximize any emission. | | | | | |

Tabulated Results for Unwanted emissions (490kHz-30MHz)

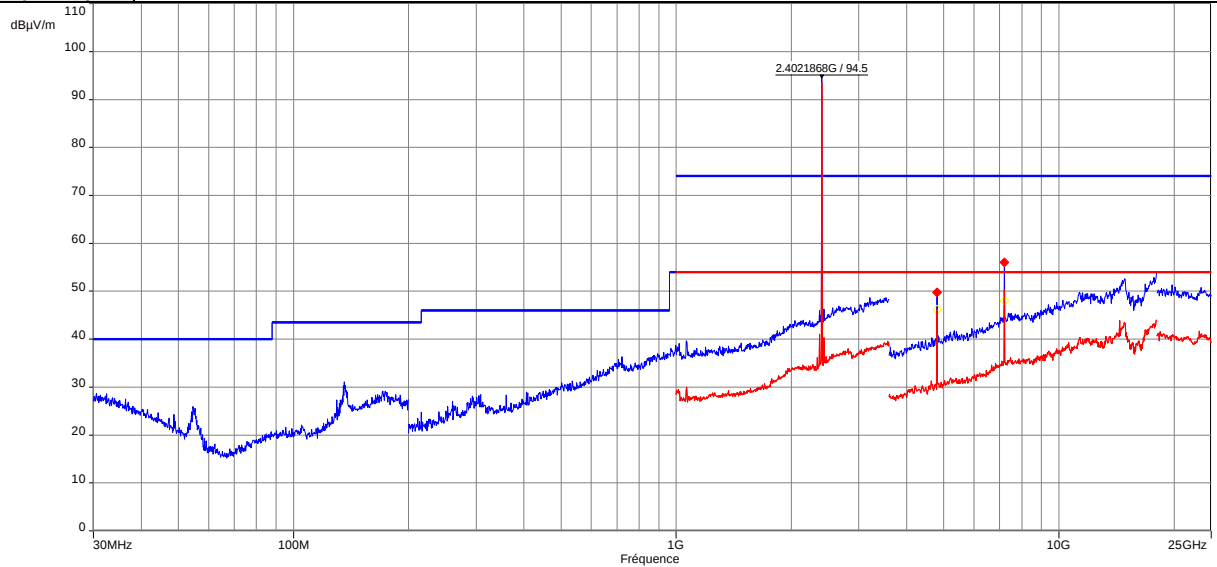
| FREQ | RF field @ 30m | Limit @ 30m | Detector | Margin | Ant. angle | Table angle | Correc. Fact. (CF) |
|---|----------------|---|----------|--------|------------|-------------|--------------------|
| MHz | dBμV/m | dBμV/m | Pk / QP | dB | Degree | Degree | dB |
| All levels are at least 20dB below applicable limits | | | | | | | |
| Supplementary information:
Frequency list measured has been created with pre-scan results. | | | | | | | |
| Frequency band investigated: | | 490kHz-30MHz | | | | | |
| RBW: | | 9kHz (150kHz-30MHz) | | | | | |
| Measurement distance: | | 10m | | | | | |
| Final measurement detector: | | Quasi-Peak | | | | | |
| Limit: | | FCC Part 15.209 / RSS-Gen | | | | | |
| Note: | | CF: Correction factor = Antenna factor + Cable loss
(M@30m = M@10m-19.1dB)
Loop antenna used and rotated about its axis to maximize any emission. | | | | | |

Graphical of Radiated Disturbance Measurement (Peak and Average Measurement, 30Mz-25GHz)

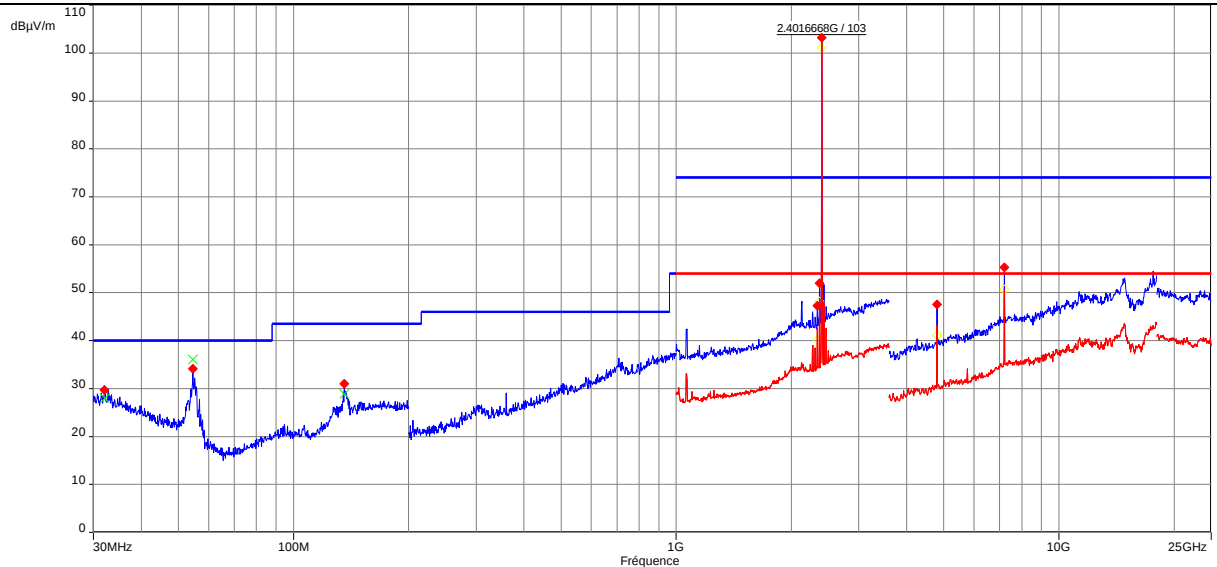
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2402 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



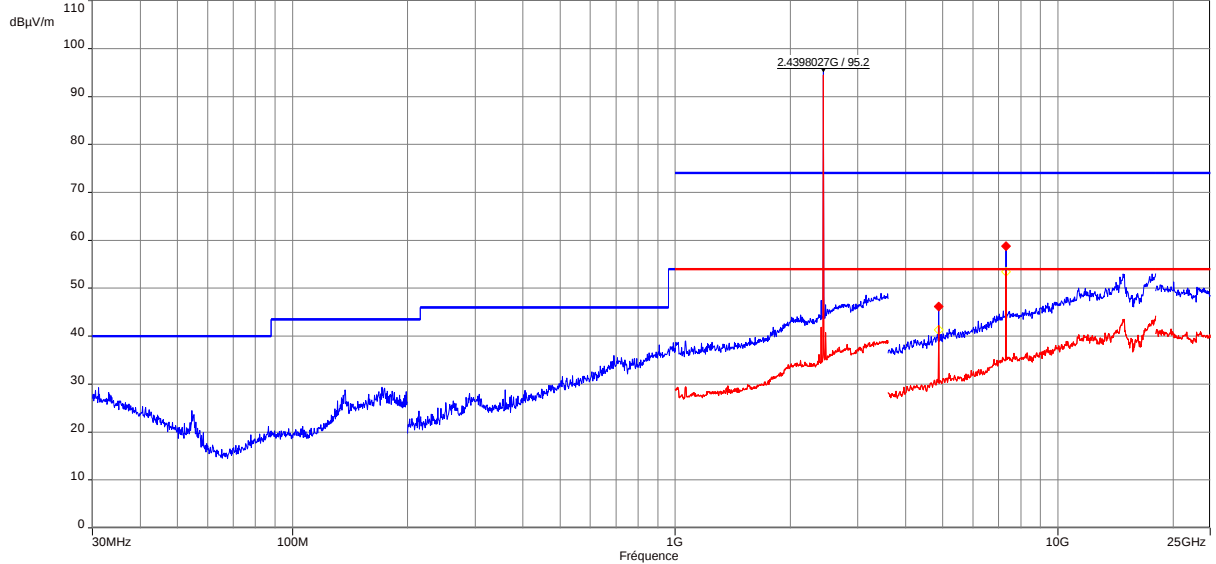
| FREQ (MHz) | Field Strength 3m PK (dBμV/m) | Field Strength 3m QP or AV (dBμV/m) | Limit PK (dBμV/m) | Margin Peak (dBμV/m) | Limit PQ or AV (dB) | Margin QP or AV (dBμV/m) | Table angle (°) | Ant height (m) | Total factor (dB) | Pol (H/V) | Detector & Limit QP |
|---------------------------|-------------------------------|-------------------------------------|--|----------------------|---------------------|--------------------------|-----------------|----------------|-------------------|-----------|---------------------|
| 4804.33951 | 50.19 | 41.79 | 74.00 | -23.81 | 54.00 | -12.21 | 203.80 | 1.84 | -0.37 | H | PK&AV |
| 7205.2 | 57.2 | 48.3 | 74.0 | -16.8 | 54.0 | -5.7 | 133.40 | 1.10 | 6.02 | H | PK&AV |
| 32.156023 | 28.01 | 23.50 | - | - | 40.00 | -16.50 | 198.90 | 1.00 | 18.29 | V | QP |
| 54.58159 | 36.04 | 30.15 | - | - | 40.00 | -9.85 | 126.60 | 1.00 | 10.19 | V | QP |
| 135.64306 | 28.91 | 24.50 | | | 43.50 | -19.00 | 126.20 | 1.00 | 14.65 | V | QP |
| 2338.3092 | 49.03 | 39.29 | 74.00 | -24.97 | 54.00 | -14.71 | 181.80 | 2.17 | 33.89 | V | PK&AV |
| 2369.7284 | 51.97 | 44.35 | 74.00 | -22.03 | 54.00 | -9.65 | 138.50 | 1.91 | 34.23 | V | PK&AV |
| 4803.85417 | 48.81 | 38.77 | 74.00 | -25.19 | 54.00 | -15.23 | 134.70 | 1.36 | -0.37 | V | PK&AV |
| 7205.28874 | 56.84 | 46.80 | 74.00 | -17.16 | 54.00 | -7.20 | 154.80 | 2.12 | 6.02 | V | PK&AV |
| Frequency and Limit band: | | | 30Mz-10GHz / FCC 15.209 / RSS-GEN. | | | | | | | | |
| RBW and Limit detector: | | | Below 1GHz: RBW= 120kHz, Quasi-Peak / above 1GHz: RBW= 1MHz, Peak and CISPR Average. | | | | | | | | |
| Results | | | PASS. | | | | | | | | |

Graphical of Radiated Disturbance Measurement (Peak and Average Measurement, 30MHz-25GHz)

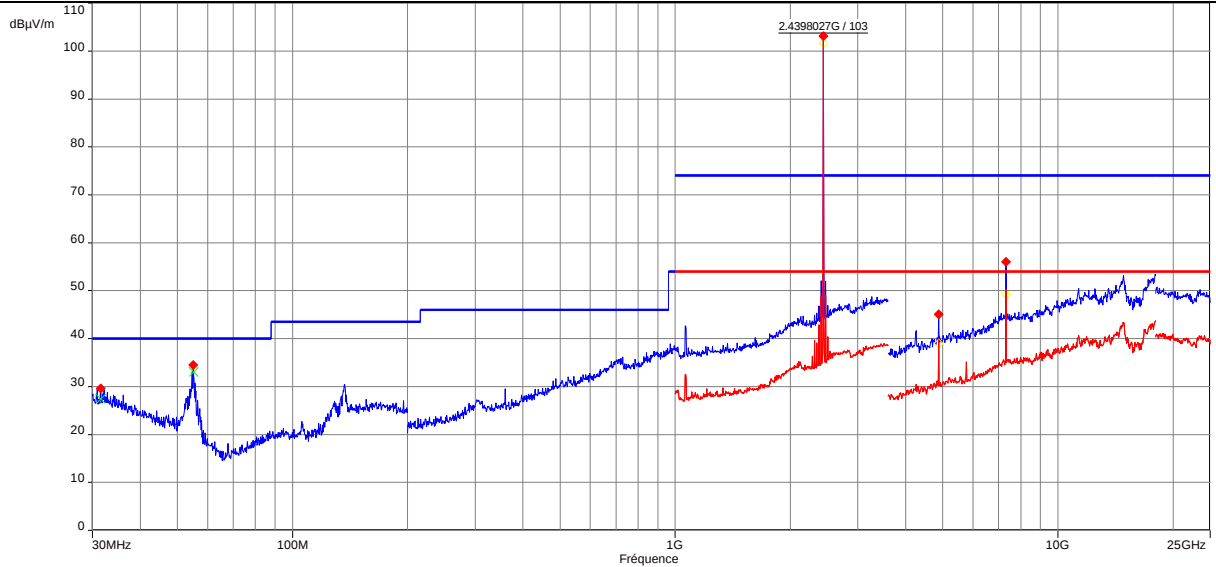
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2440 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



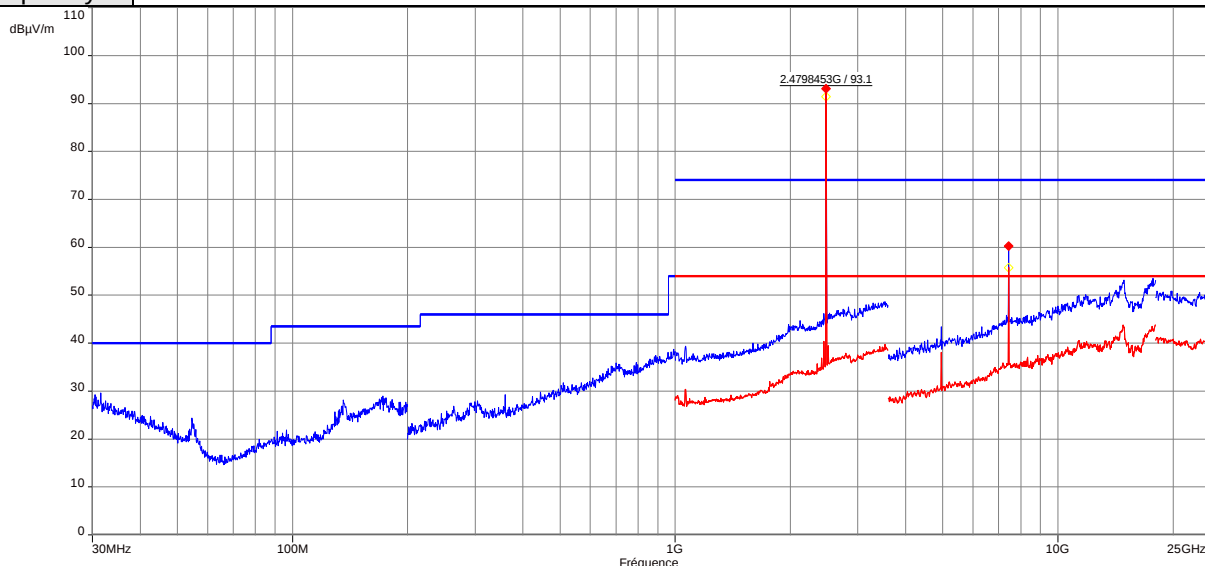
| FREQ (MHz) | Field Strength 3m PK (dBμV/m) | Field Strength 3m QP or AV (dBμV/m) | Limit PK (dBμV/m) | Margin Peak (dBμV/m) | Limit PQ or AV (dB) | Margin QP or AV (dBμV/m) | Table angle (°) | Ant height (m) | Total factor (dB) | Pol (H/V) | Detector & Limit QP |
|---------------------------|-------------------------------|-------------------------------------|--|----------------------|---------------------|--------------------------|-----------------|----------------|-------------------|-----------|---------------------|
| 4880.22304 | 48.25 | 38.88 | 74.00 | -25.75 | 54.00 | -15.12 | 201.00 | 1.86 | -0.27 | H | PK&AV |
| 7320.7593 | 59.50 | 50.85 | 74.00 | -14.50 | 54.00 | -3.15 | 122.60 | 1.09 | 6.03 | H | PK&AV |
| 31.525351 | 27.38 | 24.19 | - | - | 40.00 | -15.81 | 360.00 | 1.00 | 18.44 | V | QP |
| 55.224683 | 33.00 | 28.41 | - | - | 40.00 | -11.59 | 126.20 | 1.00 | 9.94 | V | QP |
| 4880.33452 | 46.65 | 36.20 | 74.00 | -27.35 | 54.00 | -17.80 | 121.80 | 1.43 | -0.27 | V | PK&AV |
| 7319.21311 | 56.77 | 47.81 | 74.00 | -17.23 | 54.00 | -6.19 | 143.50 | 2.06 | 6.02 | V | PK&AV |
| Frequency and Limit band: | | | 30Mz-10GHz / FCC 15.209 / RSS-GEN. | | | | | | | | |
| RBW and Limit detector: | | | Below 1GHz: RBW= 120kHz, Quasi-Peak / above 1GHz: RBW= 1MHz, Peak and CISPR Average. | | | | | | | | |
| Results | | | PASS. | | | | | | | | |
| Note: | | | Pre-scan graphic only for identification. | | | | | | | | |

Graphical of Radiated Disturbance Measurement (Peak and Average Measurement, 30Mz-25GHz)

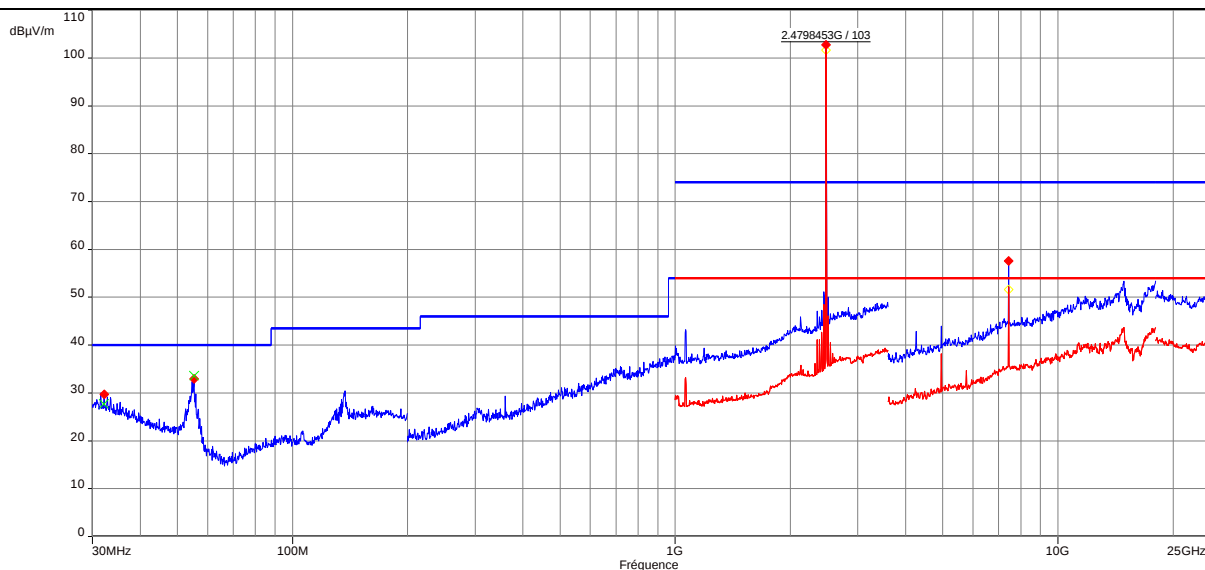
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2480 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



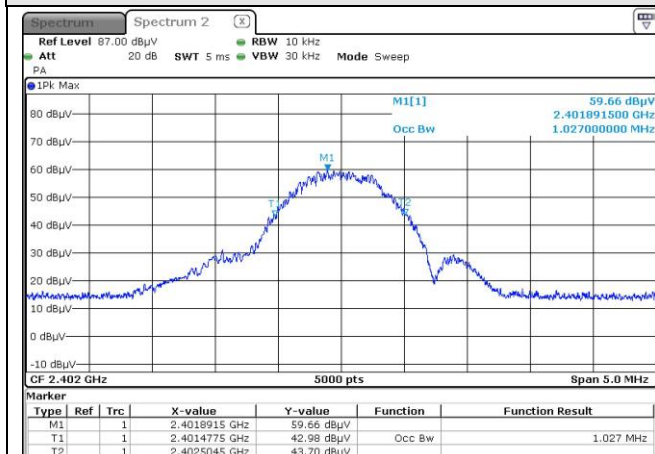
| FREQ (MHz) | Field Strength 3m PK (dBμV/m) | Field Strength 3m QP or AV (dBμV/m) | Limit PK (dBμV/m) | Margin Peak (dBμV/m) | Limit PQ or AV (dB) | Margin QP or AV (dBμV/m) | Table angle (°) | Ant height (m) | Total factor (dB) | Pol (H/V) | Detector & Limit QP |
|----------------------------------|-------------------------------|-------------------------------------|--|----------------------|---------------------|--------------------------|-----------------|----------------|-------------------|-----------|---------------------|
| 7440.6 | 61.0 | 53.1 | 74.0 | -13.0 | 54.0 | -0.9 | 126.9 | 1.09 | 6.60 | H | PK&AV |
| 32.167262 | 27.71 | 23.22 | - | - | 40.00 | -16.78 | 26.20 | 1.00 | 18.29 | H | QP |
| 55.244633 | 33.62 | 28.82 | - | - | 40.00 | -11.18 | 125.00 | 1.00 | 9.93 | V | QP |
| 7439.2265 | 58.13 | 48.31 | 74.00 | -15.87 | 54.00 | -5.69 | 139.10 | 1.95 | 6.60 | V | PK&AV |
| Frequency and Limit band: | | | 30Mz-10GHz / FCC 15.209 / RSS-GEN. | | | | | | | | |
| RBW and Limit detector: | | | Below 1GHz: RBW= 120kHz, Quasi-Peak / above 1GHz: RBW= 1MHz, Peak and CISPR Average. | | | | | | | | |
| Results | | | PASS. | | | | | | | | |
| Note: | | | Pre-scan graphic only for identification. | | | | | | | | |

16. Occupied bandwidth (99%)

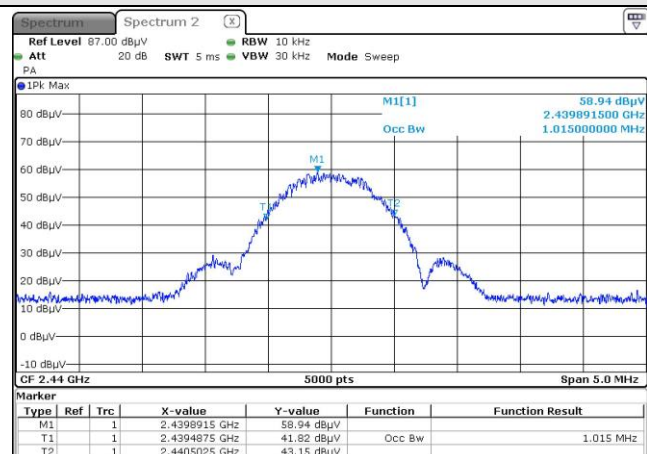
| TEST: Occupied bandwidth (99%) / RSS-GEN | | Verdict |
|--|----------------------------|-----------------|
| <p>Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed.</p> <p>The RBW is set in the range of 1% to 5% of the OBW, with VBW $\geq 3 \times$ RBW.</p> <p>The SPAN is wide enough to capture all products of the modulation process. (Between 1.5 to 5 times the OBW).</p> <p>A MaxHold Peak detector is used. Automatic function of the spectrum analyser is used.</p> <p>The tested equipment is set to transmit operation with modulation on low, mid and high channels.</p> | | Pass |
| Laboratory Parameters: | Required prior to the test | During the test |
| Ambient Temperature | 20 to 30 °C | 21°C $\pm$ 2 |
| Relative Humidity | 25 to 70 % | 38% $\pm$ 5 |
| <p>Supplementary information:</p> <p>Test location: SMEE</p> <p>Test date: June 10th, 2024 by C KERMICHE.</p> <p>Power supply voltage: 5V DC from USB-Port.</p> | | |

| Tabulated Results for 99% Occupied Bandwidth | |
|--|---------------------------------|
| Frequency
(MHz) | 99% Occupied Bandwidth
(MHz) |
| BLE: 1Mbps | |
| 2402.0 | 1.027 |
| 2440.0 | 1.015 |
| 2480.0 | 1.012 |
| BLE: 2Mbps | |
| 2402.0 | 2.054 |
| 2440.0 | 2.042 |
| 2480.0 | 2.046 |

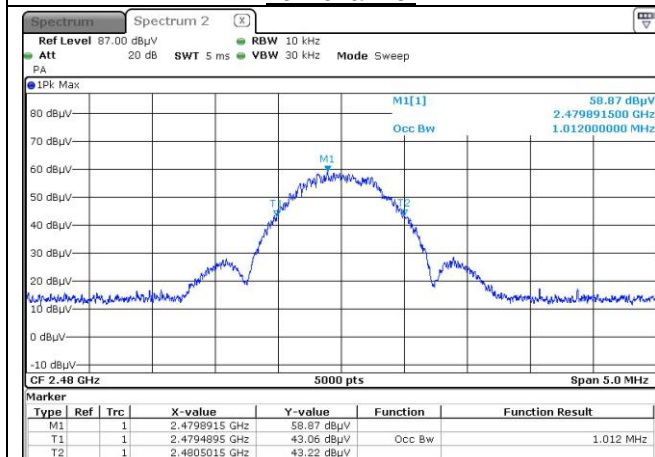
Graphical representation of 99% Occupied Bandwidth / BLE: 1Mbps



Low channel



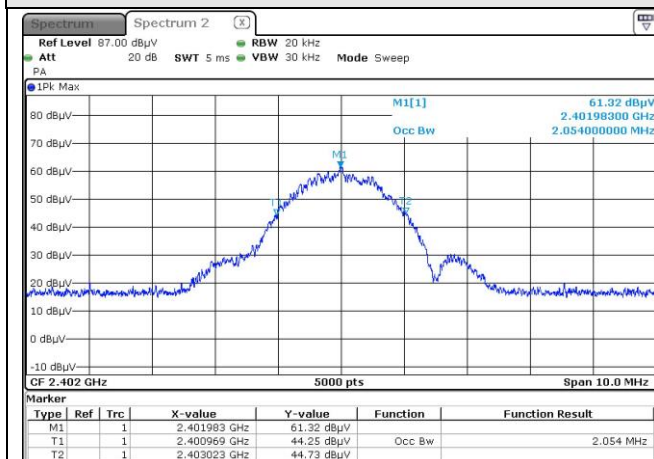
Mid channel



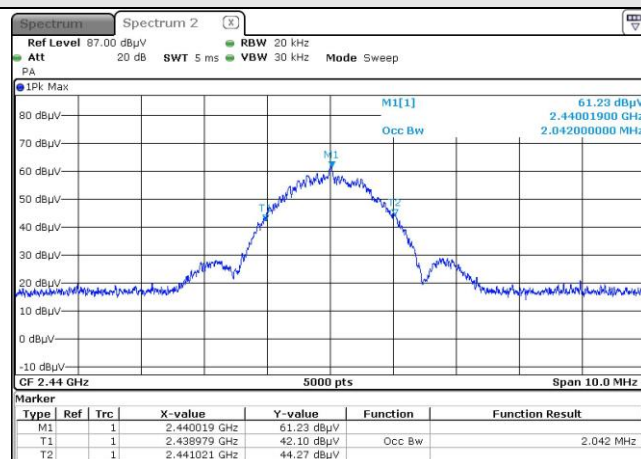
High channel

| | |
|------------------------------|--------------------|
| Frequency band investigated: | 2402MHz to 2480MHz |
| RBW : | 10kHz |
| Measurement detector: | Peak |

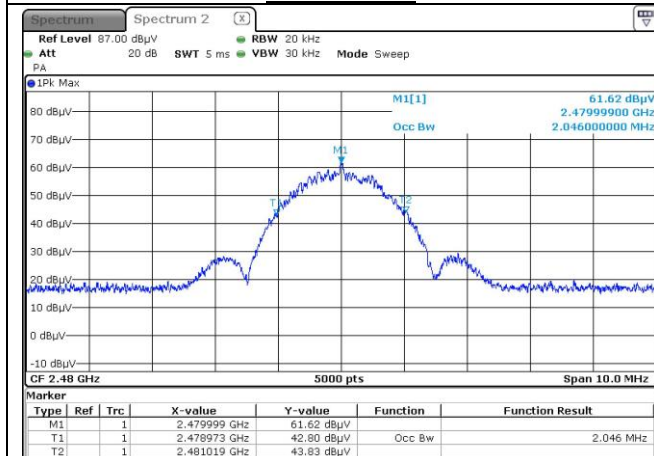
Graphical representation of 99% Occupied Bandwidth / BLE: 2Mbps



Low channel



Mid channel



High channel

| | |
|------------------------------|--------------------|
| Frequency band investigated: | 2402MHz to 2480MHz |
| RBW: | 10kHz |
| Measurement detector: | Peak |

17. Test Equipment List

| Test Equipment Used for conducted emission | | | | | |
|--|---------------|-----------------|-------------|-----------|----------|
| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
| AC power supply | PACIFIC POWER | AMX-125 | ALI-101-002 | 2023/8 | 2024/8 |
| Attenuator / limiter | SMEE | ATT#2 | ATT-171-010 | 2024/4 | 2025/4 |
| RF cable | RADIALL | RG58 / BNC / 5m | CAB-211-042 | 2024/4 | 2025/4 |
| Measuring receiver | Rohde&Schwarz | ESRP | REC-151-002 | 2021/12 | 2024/6 |
| LISN (50Ω / 50μH) | AFJ | LS16C | RSI-101-001 | 2023/7 | 2025/7 |
| EMC Software | NEXIO | BAT EMC | SOF-101-001 | - | - |

| Test Equipment Used for conducted antenna port measurement | | | | | |
|--|---------------|-----------|-------------|-----------|----------|
| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
| RF Attenuator | Mini-Circuit | BW-N10W5+ | ATT-171-008 | 2024/4 | 2025/4 |
| Spectrum analyzer | Rohde&Schwarz | FSV40 | ASP-171-004 | 2024/4 | 2026/10 |

| Test Equipment Used for radiated emission | | | | | |
|---|----------------|------------------|-------------|-----------|----------|
| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
| AC power supply | PACIFIC POWER | AMX-125 | ALI-101-002 | 2023/8 | 2024/8 |
| Horn antenna | COM-POWER | AH-118 | ANT-101-004 | 2021/7 | 2024/7 |
| Loop antenna | EMCO | 6502 | ANT-101-009 | 2023/9 | 2025/9 |
| Horn antenna | ETS-LINDGREN | 3116 | ANT-161-014 | 2024/4 | 2026/4 |
| Log-periodic antenna | EMCO | 3146 | ANT-191-019 | 2024/3 | 2026/3 |
| Biconnic antenna | COM-POWER | AB- 900A | ANT-201-021 | 2023/01 | 2025/1 |
| Spectrum analyzer | Rohde&Schwarz | FSV40 | ASP-171-004 | 2024/4 | 2026/10 |
| RF cable | Div | OATS/25m | CAB-101-017 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF102 (K/2m) | CAB-171-034 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF102 (K/3m) | CAB-171-035 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF104E (NN/1m) | CAB-231-049 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF126E (NN/2m) | CAB-231-043 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF104E (NN/5,3m) | CAB-231-044 | 2024/4 | 2025/4 |
| RF cable | HUBER+SUHNER | SF104E (NN/7m) | CAB-231-045 | 2024/4 | 2025/4 |
| Semi anechoic room | COMTEST | 218292 | CAG-201-002 | 2022/4 | 2025/4 |
| High-pass filter | RF-Lambda | RHPF23G03G18 | FIL-221-011 | 2024/4 | 2025/4 |
| Antenna mast SAC | Innco- Systems | MA4640-XP-ET | MAT-201-002 | - | - |
| Turntable SAC | Innco- Systems | DS1500-S-1t | PLA-201-003 | - | - |
| Pre-amplifier | SMEE | 18-40GHz | PRE-171-004 | 2024/4 | 2025/4 |

| Test Equipment Used for radiated emission | | | | | |
|---|---------------|---------|-------------|-----------|----------|
| Description | Manufacturer | Model | Identifier | Cal. Date | Cal. Due |
| Pre-amplifier | COM-POWER | 1-18GHz | PRE-221-005 | 2024/4 | 2025/4 |
| Measuring receiver | Rohde&Schwarz | ESRP | REC-151-002 | 2021/12 | 2024/6 |
| FS OATS | Div | 10m | SIT-201-002 | - | - |
| EMC Software | NEXIO | BAT EMC | SOF-101-001 | - | - |

END OF REPORT