Rapport d'essais / *Test Report*

N° : **10151-FCC-ISED-1** Page 1 / 33

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

Matériel testé : *Equipment under test*:	**ST / NUCLEO-WB09KE** *(Trademark / Marketing name or product reference)*

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

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

Numéro d'affaire :
Work number :
10151

Référence de la proposition :
Proposal number:
DV-10204-2

Date de l'essai :
Date of test:
Du 14 au 15 mars 2024
March 14th to 15th,2024

Objectif des essais :
Test purpose:
EMC qualification accordingly to following standards:
- 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:
Test location:
SMEE, 385 Rue René Rambaud
38500 VOIRON - France

Test réalisé par :
Test realized by:
Chemseddine KERMICHE

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

Ed.	Date	Modifications / Pages	Written by: Visa	Approved by: Visa
1	May 21th, 2024	Initial Edition	Chemseddine KERMICHE *Test operator*	Laurent CHAPUS *Technical Manager*

COORDONNEES
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Contents

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 (March 24)	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	Measure at 300m 9-490kHz: 2400µV/m/F(kHz) 6.370µA/m/F (kHz) Measure at 30m 0.490-1.705: 24000µV/m/F(kHz) 63.70µA/m/F (kHz) 1.705-30MHz: 30µV/m 0.08µA/m Measure at 3m 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 Bandwidwth	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 / NUCLEO-WB09KE*, 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 / NUCLEO-WB09KE** *(Trademark / Marketing name or product reference)*	MB1801-NonUSB-D02 SN: C233900119 MB2023-WB09-B01 SN: C233300202

FCC ID:	YCP-MB203201
IC:	8976A-MB203201
Model / HVIN:	NUCLEO-WB09KE
Product name / PMN:	NUCLEO-WB09KE
FVIN:	V1.0.0
Modular approval:	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***

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

Mode de fonctionnement / ***Running mode*** : The MB2032B board is placed on a MB1801. 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*** : 71.6mm x 70 x 26 (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: Expended uncertainty at 95% confidence (k=2)

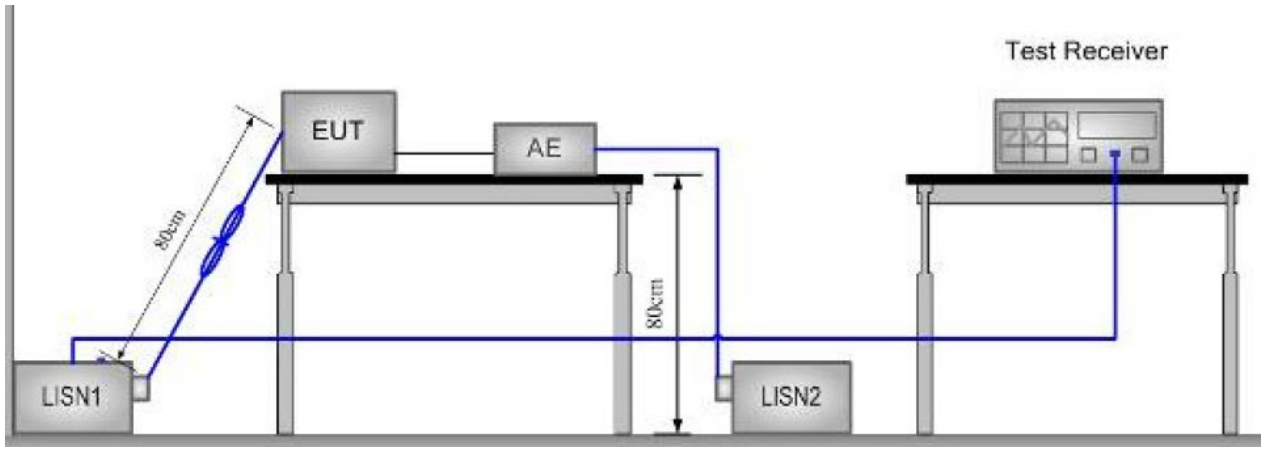
8. Field Strength Calculation

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)

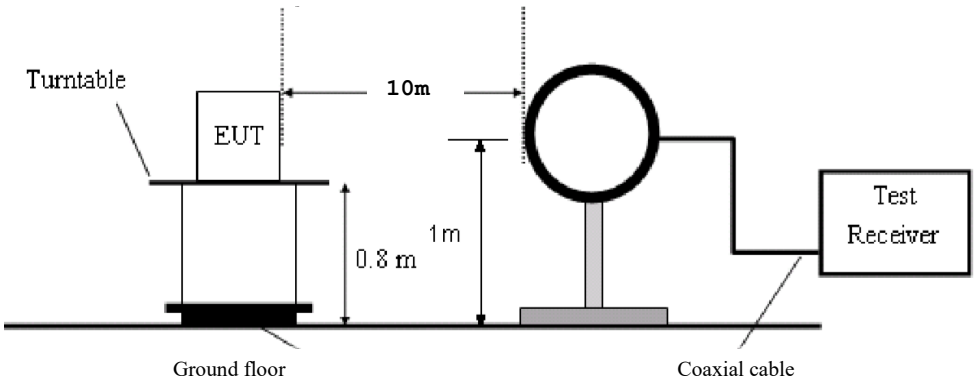
9. Test Setup Diagram

Test Setup for conducted emission



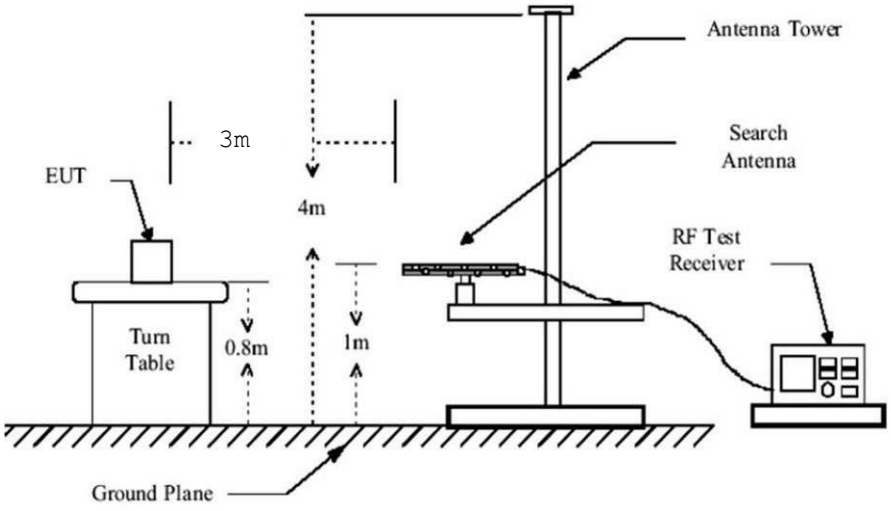
Ground reference plane

Test Setup for radiated emission

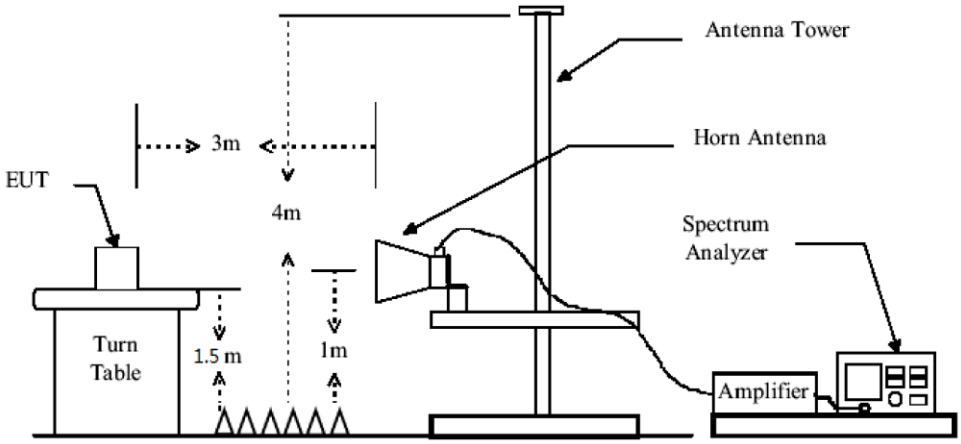


Test setup for 9k-30MHz (FS OATS)

Test Setup for radiated emission

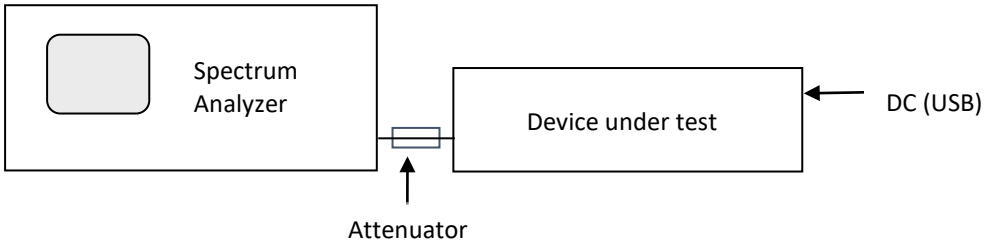


Test setup for 30-1000MHz (SAC 3m)



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

Test Setup for conducted antenna port measurement

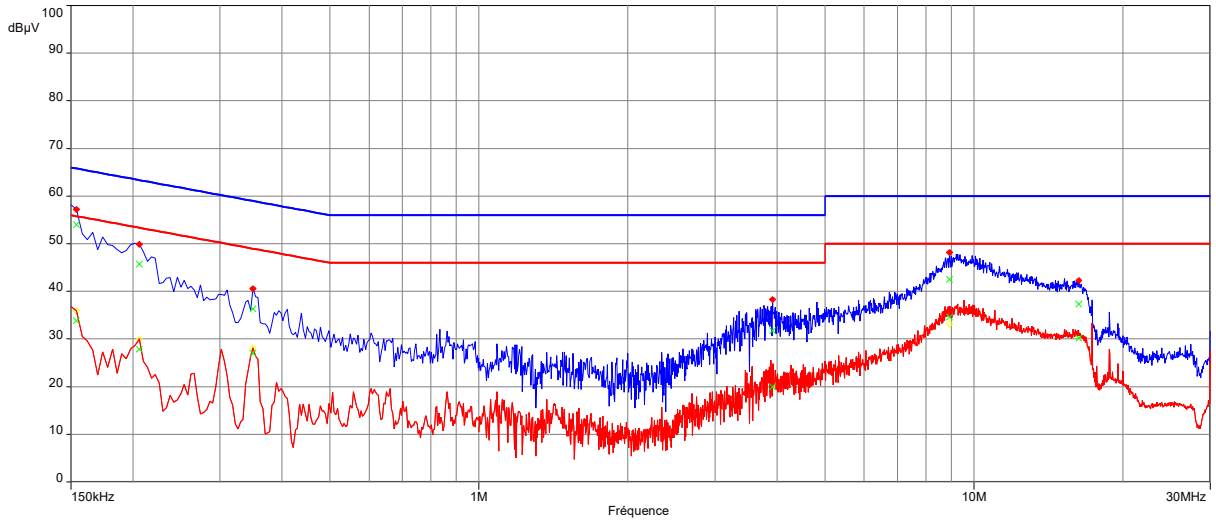


10. Conducted Emission Measurement (150 kHz-30MHz)

TEST: Limits for conducted disturbance 150kHz – 30MHz					**Verdict**
Method: 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		21°C ± 2	
Relative Humidity		25 - 65 %		48% ± 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: March 15th, 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	**Meas. PK**	**Mes. QP**	**LIMIT QP**	**Margin QP**	**Mes. AV**	**LIMIT AV**	**Margin AV**	Line
(MHz)	(dBµV)	(dBµV)	(dBµV)	(dB)	(dBµV)	(dBµV)	(dB)	
0.154	57.68	54.04	65.78	-11.74	33.80	55.78	-21.98	L1
0.206	50.44	45.73	63.37	-17.63	27.88	53.37	-25.48	L1
0.35	41.81	36.32	58.96	-22.64	26.97	48.96	-21.99	L1
3.916	38.54	31.77	56.00	-24.23	19.95	46.00	-26.05	L1
8.928	47.98	42.47	60.00	-17.53	34.61	50.00	-15.39	L1
16.296	42.50	37.32	60.00	-22.68	30.24	50.00	-19.76	L1
0.154	56.87	53.77	65.78	-12.01	35.30	55.78	-20.49	N
0.174	53.61	49.71	64.77	-15.05	31.83	54.77	-22.93	N
0.254	45.10	40.83	61.63	-20.80	29.17	51.63	-22.45	N
3.748	40.99	35.25	56.00	-20.75	19.92	46.00	-26.08	N
9.792	48.65	43.53	60.00	-16.47	35.71	50.00	-14.29	N
16.344	45.68	40.35	60.00	-19.65	34.21	50.00	-15.79	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: Meas. = RA + CF + ATT_{TRAN} + ATT_{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)					

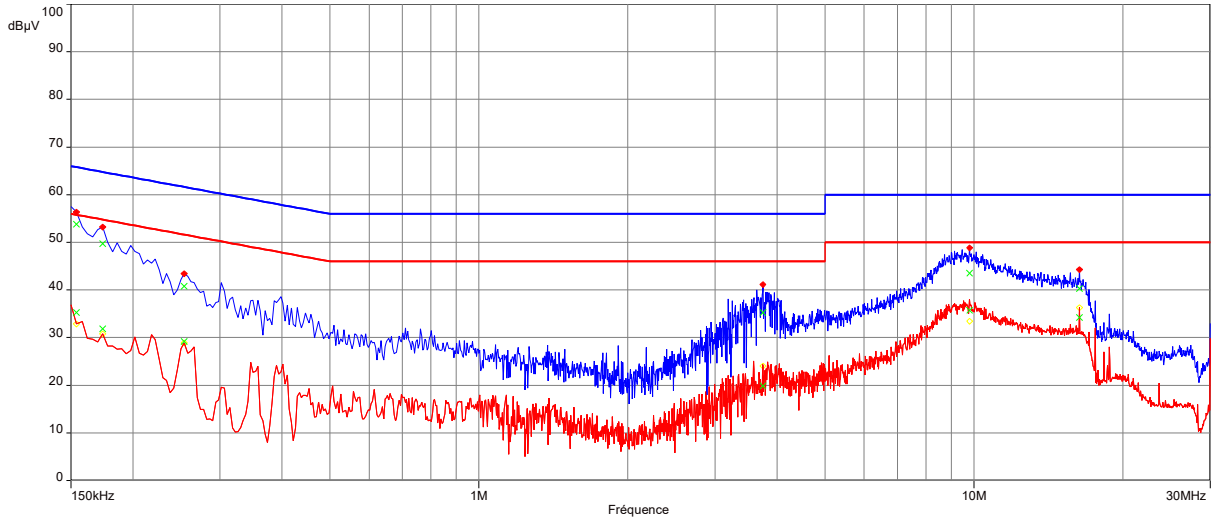
Graphical representation of Conducted Disturbance Measurement (Peak and Average detection)
AC port, Line L1



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



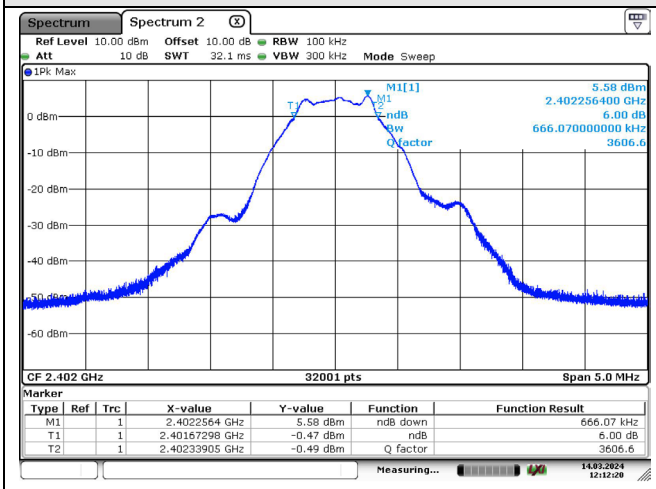
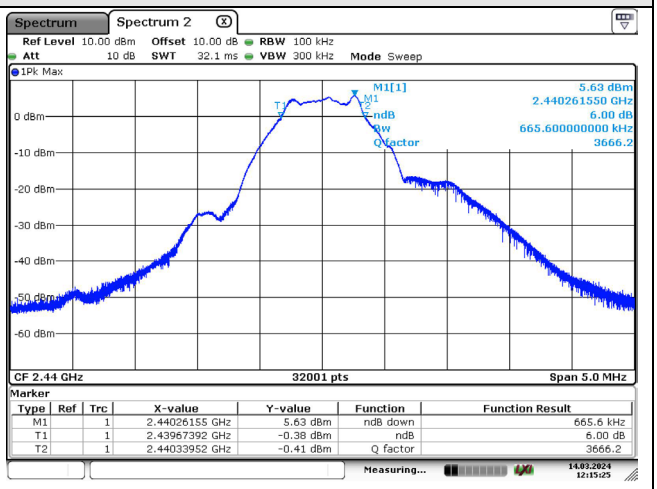
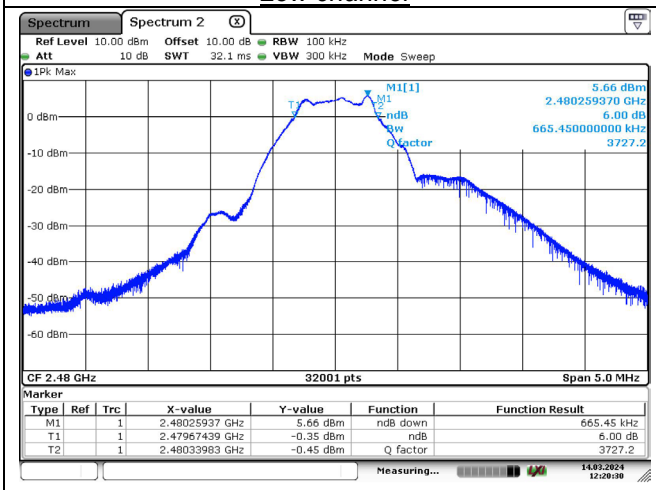
Note : Same result for all transmit modes on all channels.

^^^^: Peak	^^^^: Average

11. DTS Bandwidth

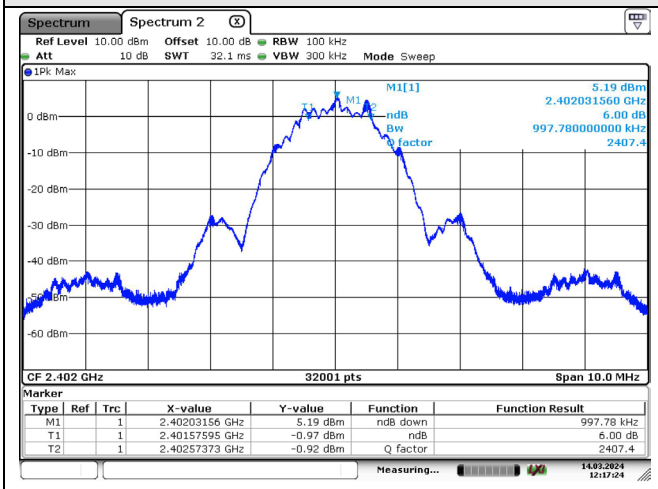
TEST: DTS Bandwidth		**Verdict**
Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed. The RBW is 100kHz, with VBW ≥ 3 x RBW. The SPAN is wide enough to capture all products of the modulation process. A MaxHold Peak detector is used. Automatic function of the spectrum analyser is used. The tested equipment is set to transmit operation with modulation on low, mid and high channels.		**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 %	42% ± 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: March 14th, 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	666.07 kHz	**Pass**
2440.0	665.6 kHz	**Pass**
2480.0	665.45 kHz	**Pass**
BLE: 2MBps		
2402.0	997.78 kHz	**Pass**
2440.0	1.01372 MHz	**Pass**
2480.0	993.41 kHz	**Pass**

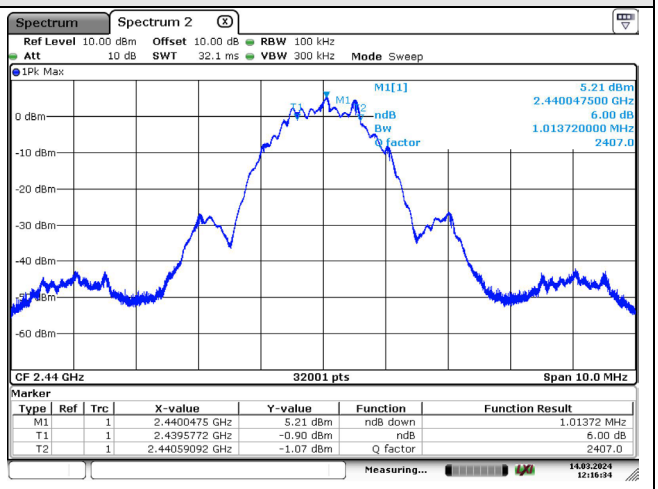
Graphical representation of 6dB Bandwidth / BLE: 1Mbps	
	
Low channel	*Mid channel*
	
High channel	

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

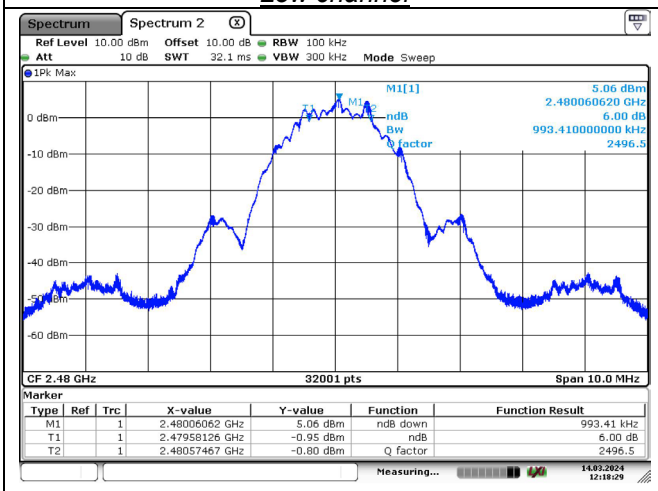
Graphical representation of 6dB Bandwidth / BLE: 2Mbps



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**
Method: A radiated 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.			**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 %	42% ± 5	

Limits – FCC Part 15.247 (b) / RSS-247 §5.4 (d)

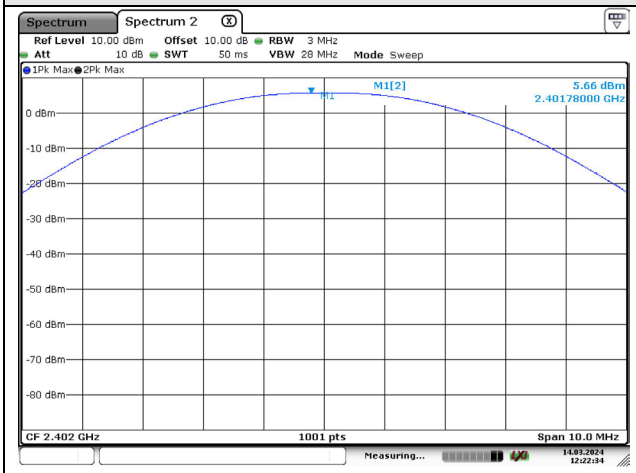
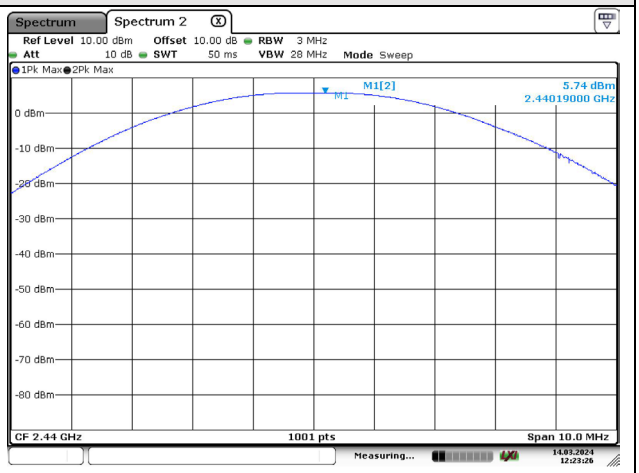
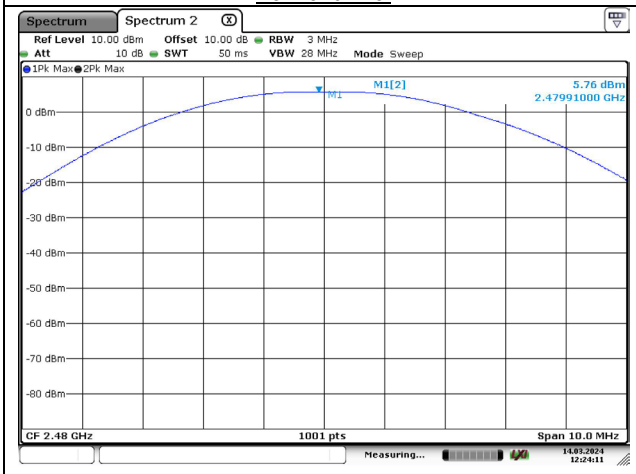
Frequency (MHz)	Limits (dBµV/m)	
	Level / Detector	Results
2400 to 2483.5	36 dBm / Pk / 3m (Radiated)	**Pass**
2400 to 2483.5	30 dBm / Pk (Conducted)	**Pass**

Supplementary information:
Test location: SMEE
Test date: March 14th, 2024 by C KERMICHE.
Power supply voltage: 5V DC from USB-Port.

Tabulated Results for Maximum peak output power (Conducted & Radiated measurement)

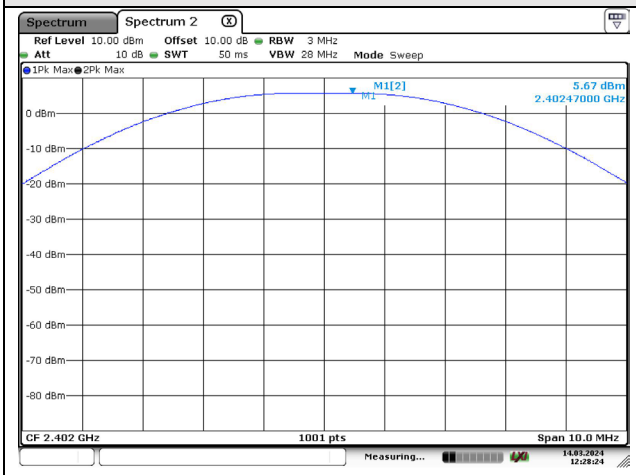
FREQ	**Conducted power**	**Antenna Gain**	**Radiated power E.I.R.P**	**Conducted Limit**	**Radiated Limit**	**Result**
(MHz)	(dBm)	(dBi)	(dBm)	(dBm)	(dBm)	
1Mbps						
2402	**6.5**	1.95	**8.5**	30.0	36.0	**Pass**
2440	**6.5**	1.95	**8.5**	30.0	36.0	**Pass**
2480	**6.6**	1.95	**8.6**	30.0	36.0	**Pass**
2Mbps						
2402	**6.5**	1.95	**8.5**	30.0	36.0	**Pass**
2440	**6.5**	1.95	**8.5**	30.0	36.0	**Pass**
2480	**6.6**	1.95	**8.6**	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 attenuation (dB). - Antenna gain = 1.95 dBi (declared by the manufacturer). - Cable attenuation = 0.8 dB

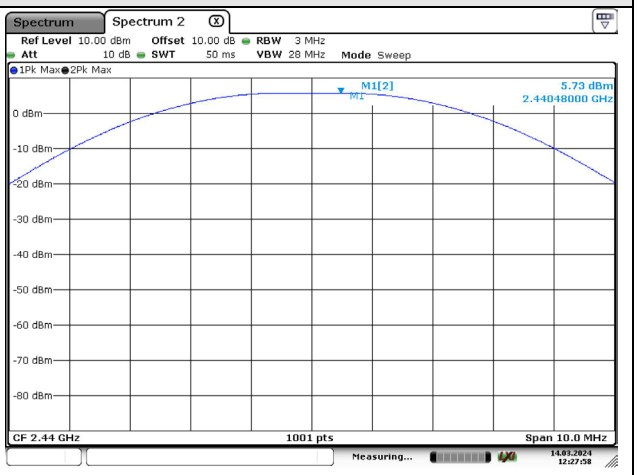
Graphical representation for Maximum Peak Output power (1Mbps)	
 *Low channel*	 *Mid channel*
 *High channel*	

Measurement:	Conducted measurement
Limit:	FCC Part 15.247 / RSS-247
RBW:	3MHz (RBW ≥ DTS bandwidth)
VBW:	28MHz (VBW ≥ [3 × RBW])
Span:	10MHz (Set span ≥ [3 × RBW])

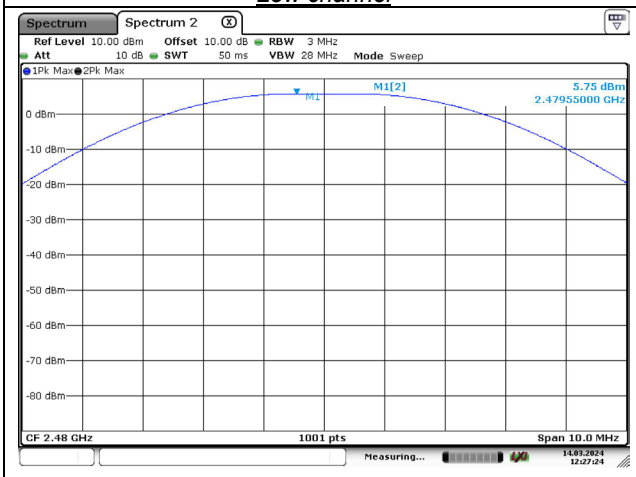
Graphical representation for Maximum Peak Output power (2Mbps)



Low channel



Mid channel



High channel

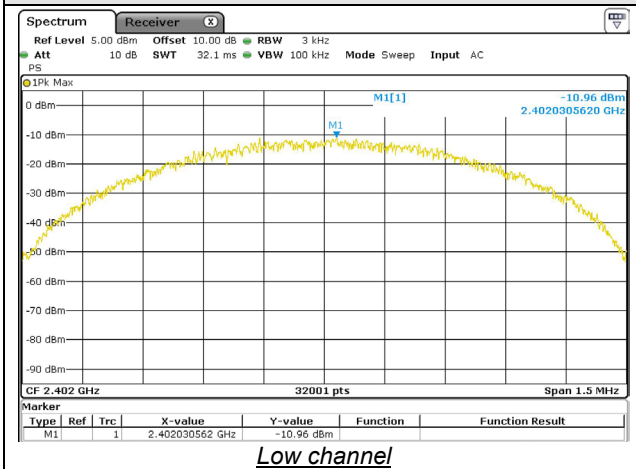
Measurement:	Conducted measurement
Limit:	FCC Part 15.247 / RSS-247
RBW:	3MHz (RBW ≥ DTS bandwidth)
VBW:	28MHz (VBW ≥ [3 × RBW])
Span:	10MHz (Set span ≥ [3 × RBW])

13. Maximum Power Spectral Density Level in the fundamental emission

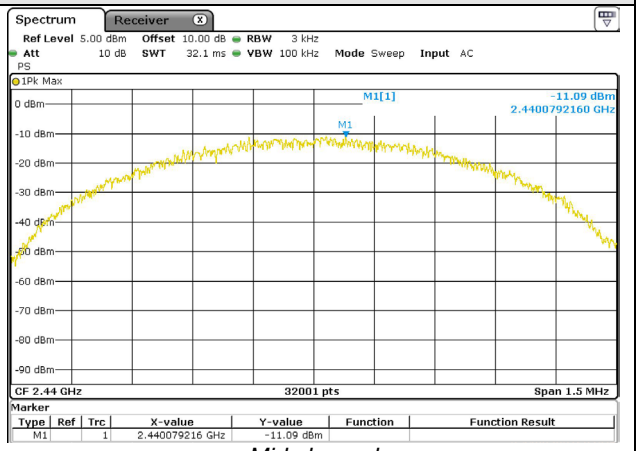
TEST: Maximum Peak Power Spectral Density			**Verdict**
Method: A radiated measurement is performed. The RBW is set at 3kHz. The SPAN is wide enough to capture all products of the modulation process. A MaxHold Peak detector is used. Radiated field strength of RF Output Power is measured at 3m in a Semi 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.			**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 %	42% ± 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**	
Supplementary information: Test location: SMEE Test date: March 14th, 2024 by C KERMICHE. Power supply voltage: 5V DC from USB-Port.			

Tabulated Results for Maximum Conducted Power Spectral Density			
Frequency (MHz)	**PSD (dBm/3kHz)**	**Limit**	**Result**
BLE: 1Mbps			
2402.0	-10.2	8dBm/3kHz	**Pass**
2441.0	-10.3	8dBm/3kHz	**Pass**
2480.0	-10.2	8dBm/3kHz	**Pass**
BLE: 2Mbps			
2402.0	-12.5	8dBm/3kHz	**Pass**
2441.0	-12.9	8dBm/3kHz	**Pass**
2480.0	-12.5	8dBm/3kHz	**Pass**
RBW:	3kHz		
Limit:	FCC Part 15.247 / RSS-247		
Final measurement detector:	Peak		
RESULT:	PASS		
Note:	PSD is calculated using the following equation: PSD = PSD $_{\text{Conducted measurement}}$ (dBm/3kHz) + Cable attenuation (dB) Where: - Cable attenuation = 0.8 dB		

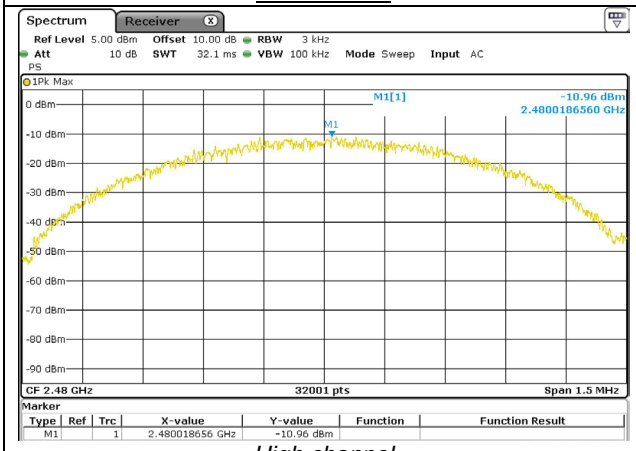
Graphical representation for Maximum Power Spectral Density / BLE: 1Mbps



Low channel



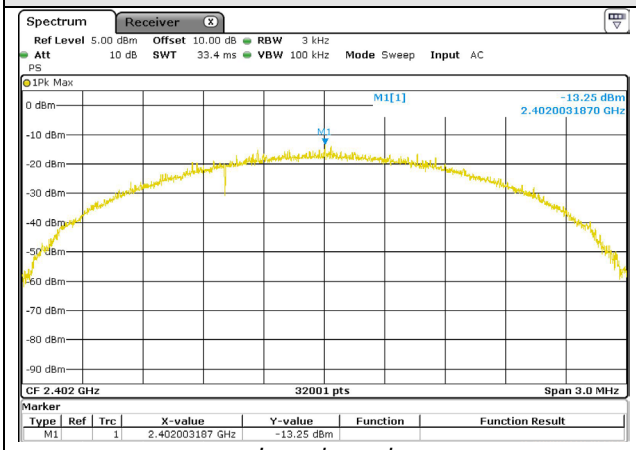
Mid channel



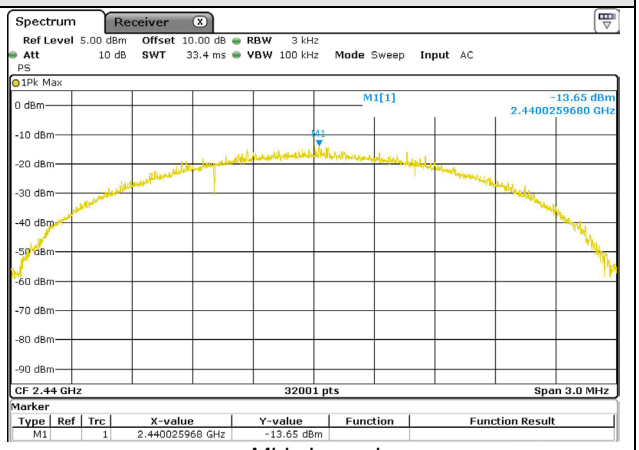
High channel

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

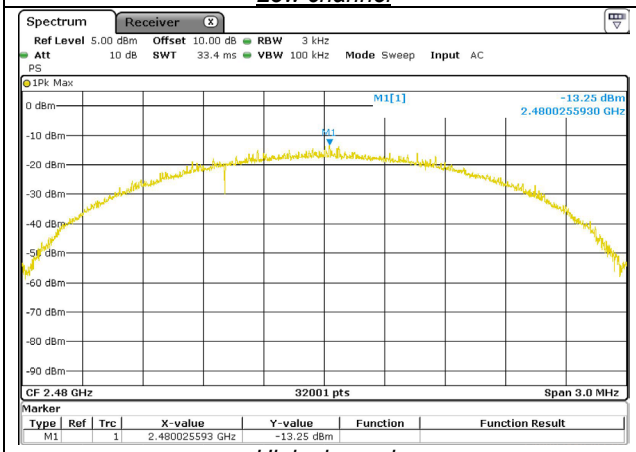
Graphical representation for Maximum Power Spectral Density / BLE: 2Mbps



Low channel



Mid channel



High channel

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

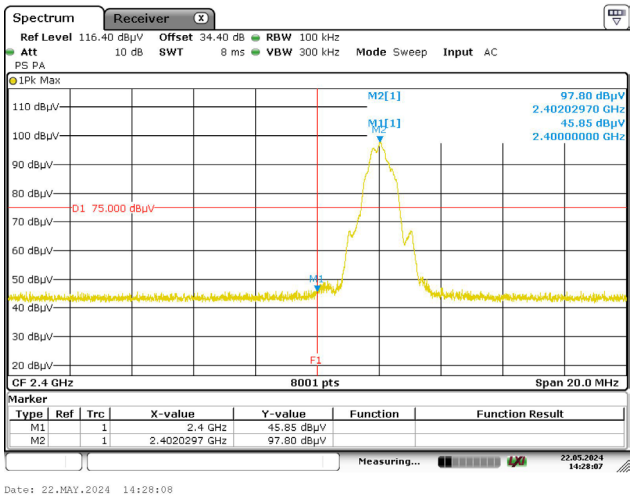
14. Unwanted emissions in Non-Restricted Frequency bands (Radiated emissions)

TEST: Unwanted emissions in Non-Restricted Frequency Bands			**Verdict**
Method: 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. The Semi Anechoic Room complies with CISPR16-1-4 / ANSI C63.4 requirements. Preliminary (peak) measurements were performed at an antenna to EUT separation distance of 3 meters. 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. 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.			**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 %		45% ± 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: March 15th, 2024 by C KERMICHE. Power supply voltage: 5V DC from USB-Port.			

Tabulated Results for Peak Output Power Reference level	
FREQ	**Field Strength 3m**
(MHz)	(dBµV/m)
2402.0	101.4 (1)
2440.0	100.8 (1)
2480.0	100.8 (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 **80.8 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)



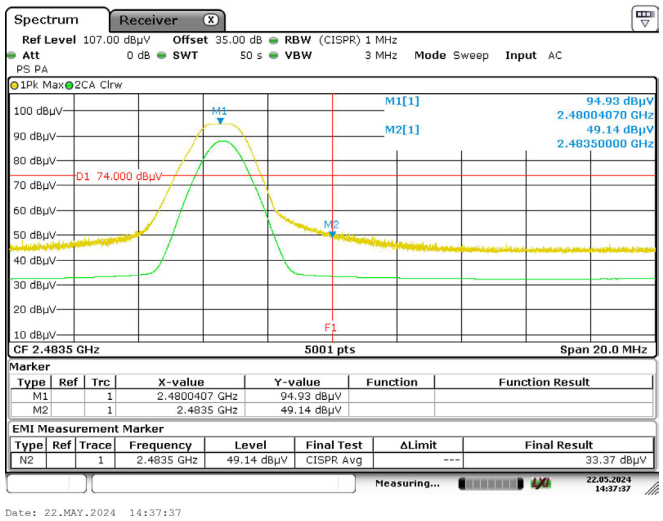
Low band edge compliance: BLE/1Mbps

RESULT: PASS.
Note: Radiated measurement.

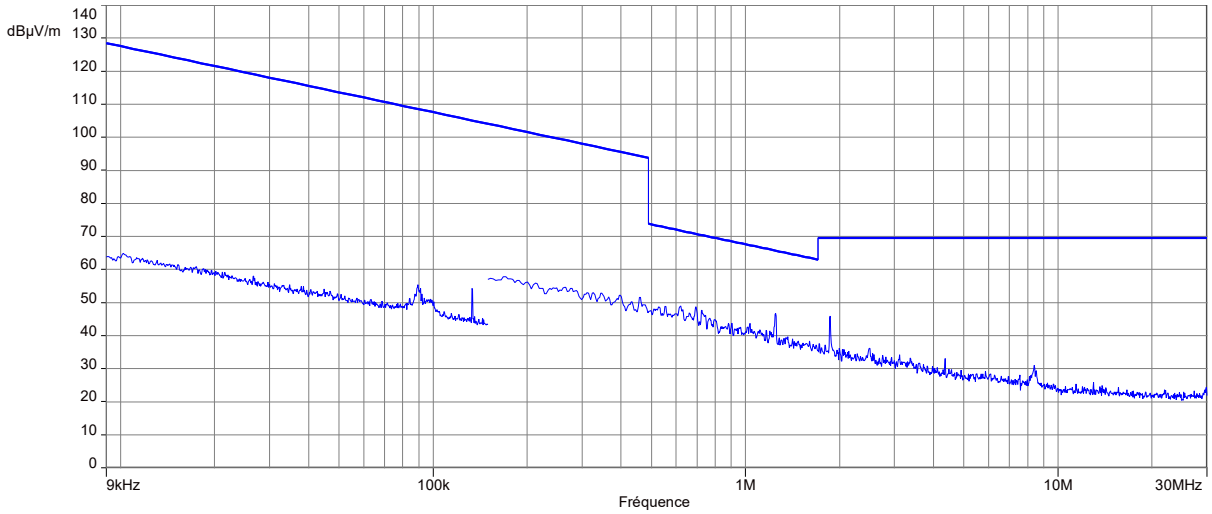
FREQ (MHz)	**Field Strength 3m** (dBµV/m)	**Limit** (dBµV/m)	**Margin** (dBµV/m)	**Result** (dBµV/m)
BLE: 1Mbps				
2400.00	52.7	80.4	**-27.7**	**Pass**
BLE: 2Mbps2				
2400.00	69.4	80.4	**-11.0**	**Pass**

15. Unwanted emissions in Restricted Frequency bands

TEST: Unwanted emissions into Restricted Frequency Bands			**Verdict**
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. 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. 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.			**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 %	42% ± 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: March 14th, 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	High band edge compliance: BLE/2Mbps
Radiated Peak level is 63.3 dBµV/m (limit 74dBµV/m). Max radiated Average level is 51.8 dBµV/m (limit 54dBµV/m, CISPR Average detector measurement).	Radiated Peak level is 63.2 dBµV/m (limit 74dBµV/m). Max radiated Average level is 50.0 dBµV/m (limit 54dBµV/m, CISPR Average detector measurement).
RESULT: PASS	

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.						

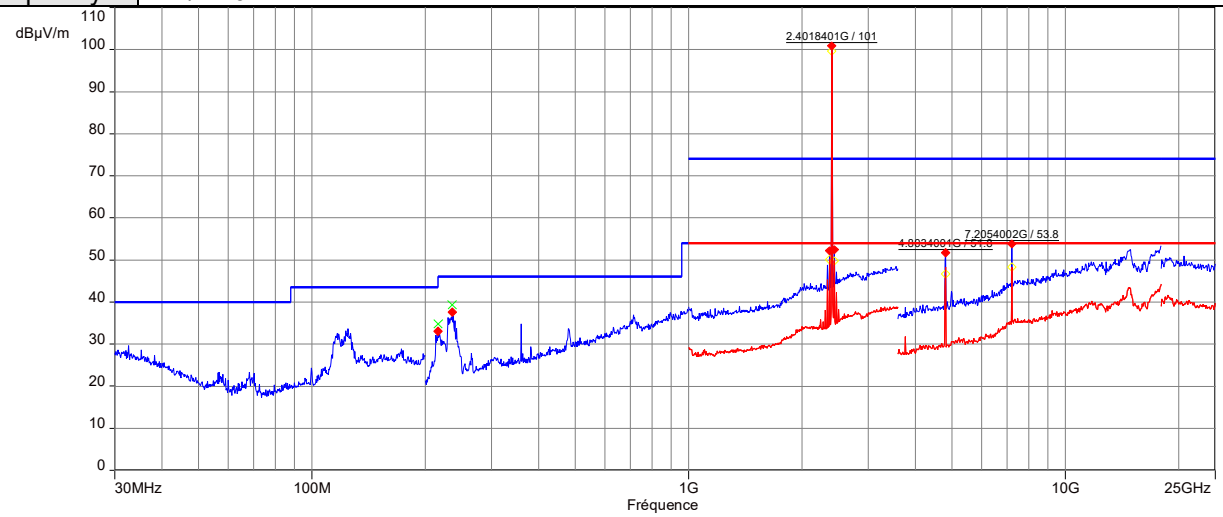
Tabulated Results for Unwanted emissions (490kHz-30MHz)							
FREQ	**RF field @ 30m**	**Limit @ 30m**	**Detector**	**Margin**	**Ant. angle**	**Table angle**	**Correc. Fact. (CF)**
MHz	dBµV/m	dBµV/m	Pk / QP	dB	Degree	Degree	dB
All levels are at least 20dB below applicable limits							
Supplementary 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)

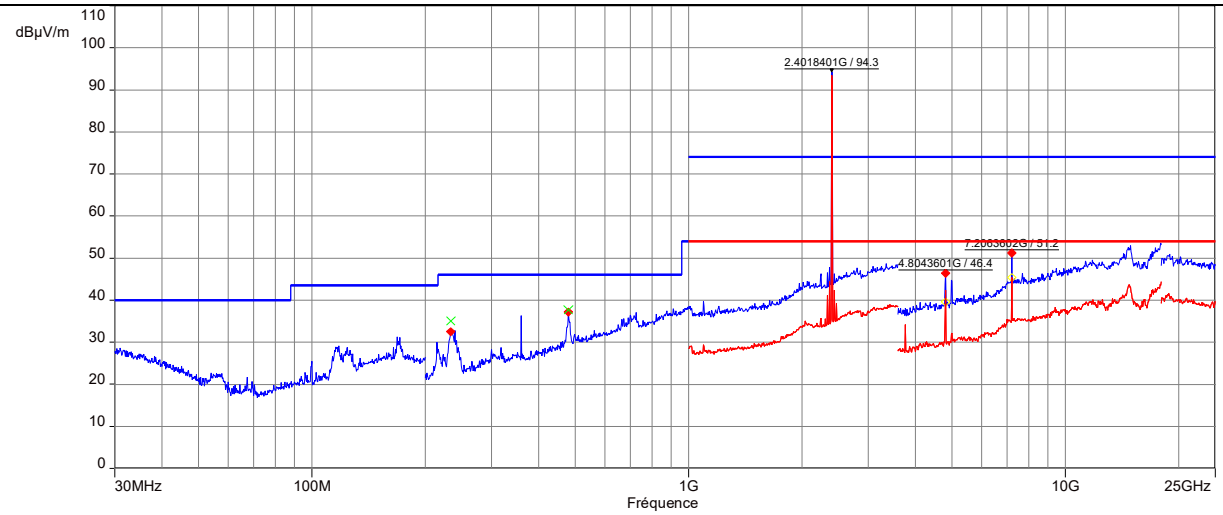
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2402 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



Pre-scan graph only for identification purpose.

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 QP or AV (dB)	Margin QP or AV (dBµV/m)	Table angle (°)	Ant height (m)	Total factor (dB)	Pol (H/V)	Detector & Limit QP
216.001553	34.86	27.70	-	-	46.00	-18.30	179.70	1.50	12.46	H	QP
235.892173	39.32	32.36	-	-	46.00	-13.64	148.10	1.00	12.74	H	QP
2369.71667	54.49	47.67	74.00	-19.51	54.00	-6.33	227.10	1.85	33.69	H	PK&AV
2433.7902	49.72	40.65	74.00	-24.28	54.00	-13.35	190.90	1.88	34.07	H	PK&AV
4803.64408	52.59	45.07	74.00	-21.41	54.00	-8.93	16.80	1.09	-1.40	H	PK&AV
7206.8366	54.67	44.41	74.00	-19.33	54.00	-9.59	206.10	1.56	5.06	H	PK&AV
233.921667	35.04	30.12	-	-	46.00	-15.88	287.00	1.00	12.67	V	QP
480.00772	37.69	34.94	-	-	46.00	-11.06	211.10	1.00	19.70	V	QP
4804.46661	47.70	39.31	74.00	-26.30	54.00	-14.69	303.80	2.94	-1.41	V	PK&AV
7206.6912	52.04	41.70	74.00	-21.96	54.00	-12.30	223.70	1.76	5.06	V	PK&AV

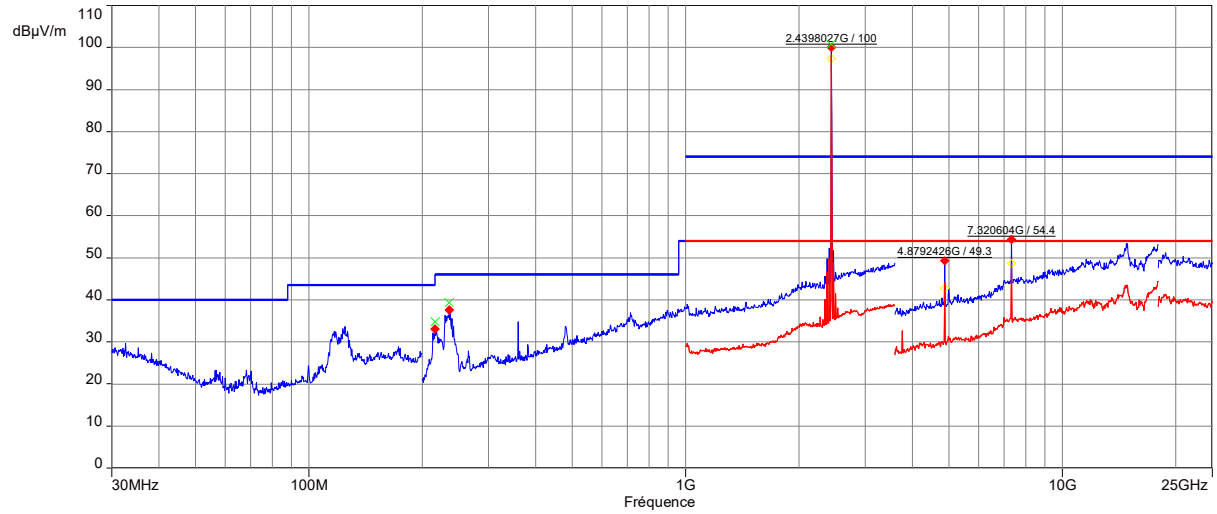
Frequency and Limit band:	30Mz-10GHz / FCC 15.209 / RSS-GEN
RBW and Limit detector:	Below 1GHz: RBW= 100kHz, Quasi-Peak Limit / above 1GHz: RBW= 1MHz, Peak and CISPR Average Limit
Results	PASS

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

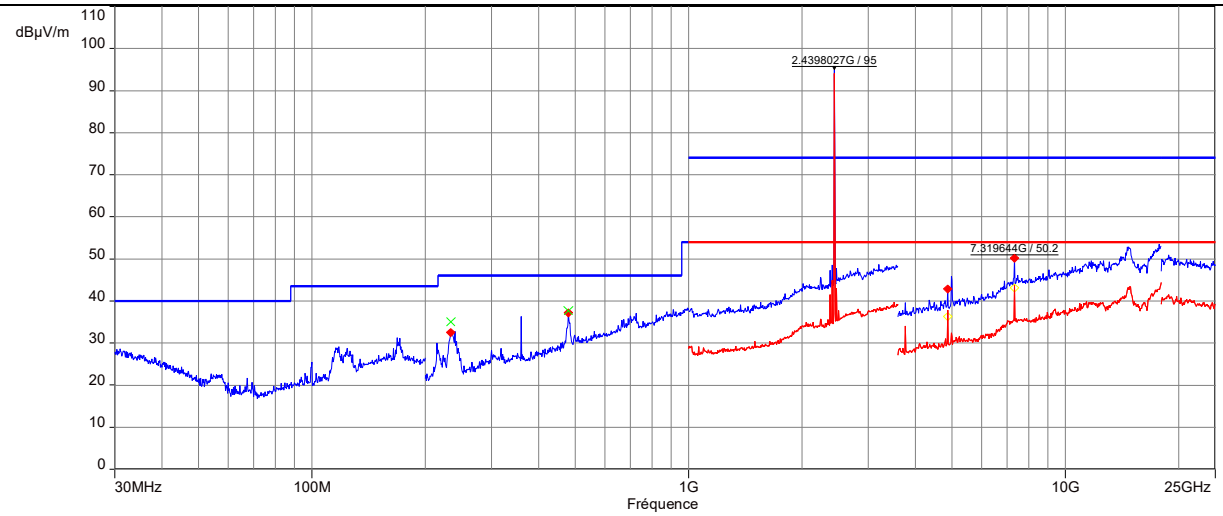
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2440 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



Pre-scan graph only for identification purpose.

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 QP or AV** (dB)	**Margin QP or AV** (dBµV/m)	**Table angle** (°)	**Ant height** (m)	**Total factor** (dB)	**Pol** (H/V)	**Detector & Limit** QP
216.001553	34.86	27.70	-	-	46.00	-18.30	179.70	1.50	12.46	H	QP
235.892173	39.32	32.36	-	-	46.00	-13.64	148.10	1.00	12.74	H	QP
4879.4706	50.41	41.69	74.00	-23.59	54.00	-12.31	30.80	1.09	-1.35	H	PK&AV
7320.71695	55.50	46.55	74.00	-18.50	54.00	-7.45	0.40	1.73	5.25	H	PK&AV
233.921667	35.04	30.12	-	-	46.00	-15.88	287.00	1.00	12.67	V	QP
480.00772	37.69	34.94	-	-	46.00	-11.06	211.10	1.00	19.70	V	QP
4880.5465	44.55	33.63	74.00	-29.45	54.00	-20.37	353.10	1.09	-1.34	V	PK&AV
7319.38099	53.16	42.75	74.00	-20.84	54.00	-11.25	223.30	1.40	5.25	V	PK&AV

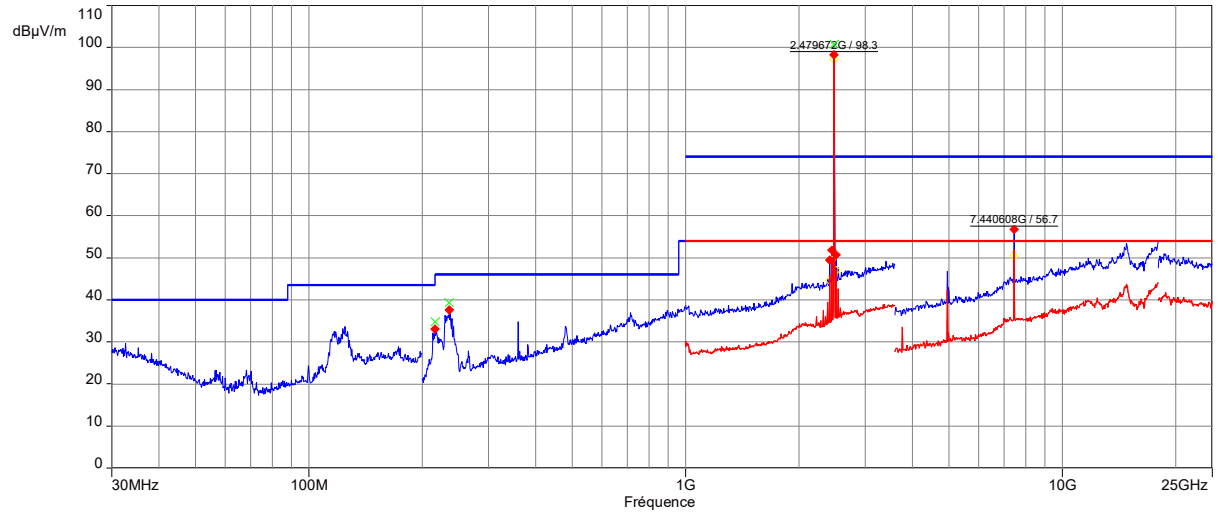
Frequency and Limit band:	30Mz-10GHz / FCC 15.209 / RSS-GEN
RBW and Limit detector:	Below 1GHz: RBW= 100kHz, Quasi-Peak Limit / above 1GHz: RBW= 1MHz, Peak and CISPR Average Limit
Results	PASS

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

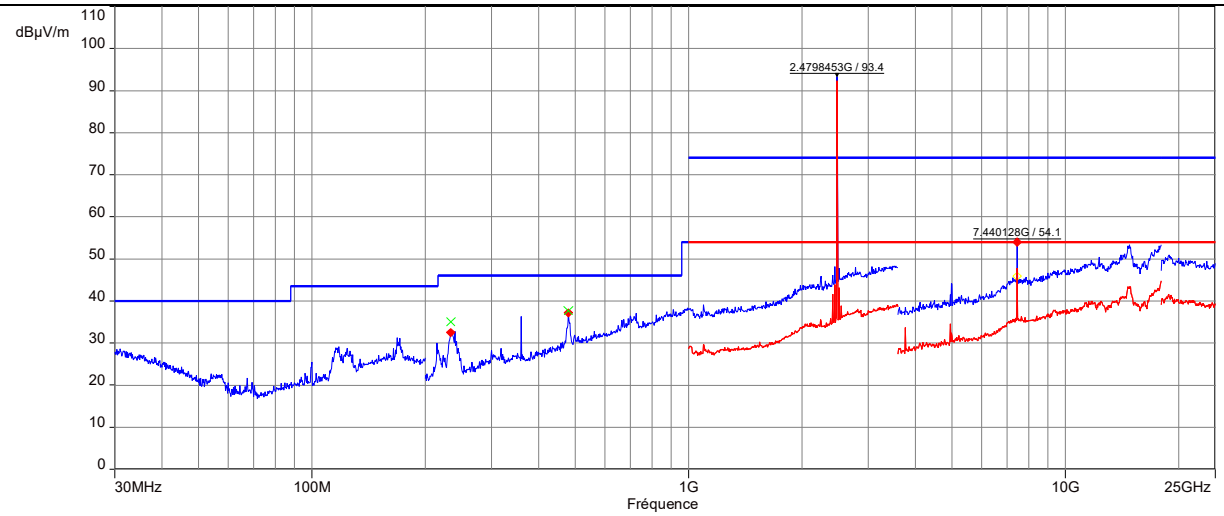
Worst case for both 1Mbps or 2Mbps test modes

Center frequency: Tx / 2480 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



Pre-scan graph only for identification purpose.

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 QP or AV** (dB)	**Margin QP or AV** (dBµV/m)	**Table angle** (°)	**Ant height** (m)	**Total factor** (dB)	**Pol** (H/V)	**Detector & Limit** QP
216.001553	34.86	27.70	-	-	46.00	-18.30	179.70	1.50	12.46	H	QP
235.892173	39.32	32.36	-	-	46.00	-13.64	148.10	1.00	12.74	H	QP
2415.88237	51.44	44.40	74.00	-22.56	54.00	-9.60	208.60	1.56	33.96	H	PK&AV
2447.92287	49.46	40.98	74.00	-24.54	54.00	-13.02	190.10	1.86	34.21	H	PK&AV
2511.75317	49.41	38.70	74.00	-24.59	54.00	-15.30	191.10	1.00	34.69	H	PK&AV
7440.61202	57.09	48.07	74.00	-16.91	54.00	-5.93	225.80	2.02	5.44	H	PK&AV
233.921667	35.04	30.12	-	-	46.00	-15.88	287.00	1.00	12.67	V	QP
480.00772	37.69	34.94	-	-	46.00	-11.06	211.10	1.00	19.70	V	QP
7439.21905	52.69	42.87	74.00	-21.31	54.00	-11.13	227.40	1.10	5.44	V	PK&AV

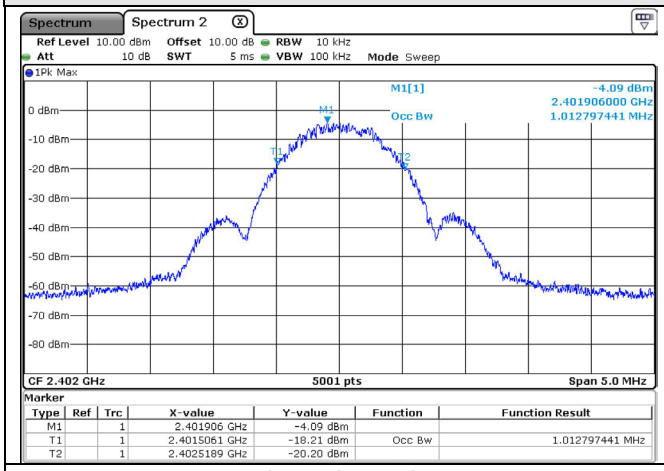
Frequency and Limit band:	30Mz-10GHz / FCC 15.209 / RSS-GEN
RBW and Limit detector:	Below 1GHz: RBW= 100kHz, Quasi-Peak Limit / above 1GHz: RBW= 1MHz, Peak and CISPR Average Limit
Results	PASS

16. Occupied bandwidth (99%)

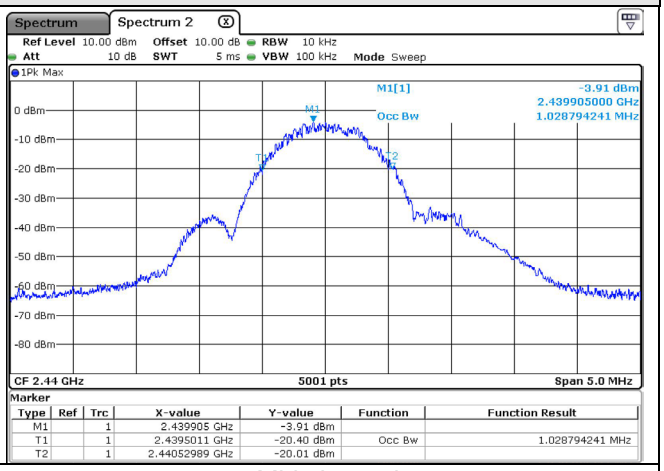
TEST: Occupied bandwidth (99%) / RSS-GEN		**Verdict**
Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed. The RBW is set in the range of 1% to 5% of the OBW, with VBW ≥ 3 x RBW. The SPAN is wide enough to capture all products of the modulation process. (Between 1.5 to 5 times the OBW). A MaxHold Peak detector is used. Automatic function of the spectrum analyser is used. The tested equipment is set to transmit operation with modulation on low, mid and high channels.		**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 %	42% ± 5
Supplementary information: Test location: SMEE Test date: March 14th, 2024 by C KERMICHE. Power supply voltage: 5V DC from USB-Port.		

Tabulated Results for 99% Occupied Bandwidth	
Frequency (MHz)	**99% Occupied Bandwidth** (MHz)
BLE: 1Mbps	
2402.0	1.013
2440.0	1.029
2480.0	1.030
BLE: 2Mbps	
2402.0	2.044
2440.0	2.056
2480.0	2.068

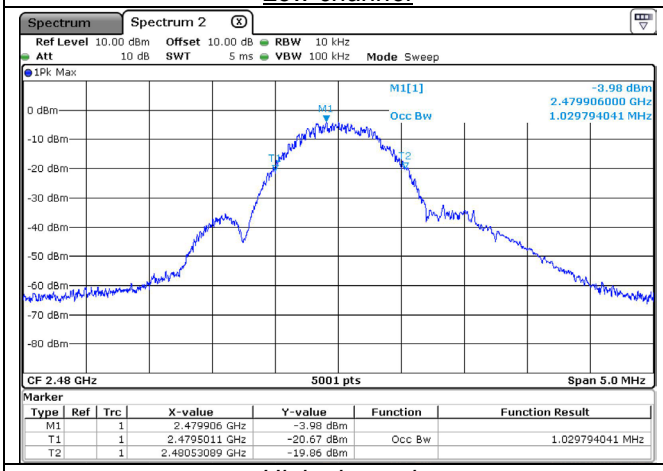
Graphical representation of 99% Occupied Bandwidth / BLE: 1Mbps



Low channel

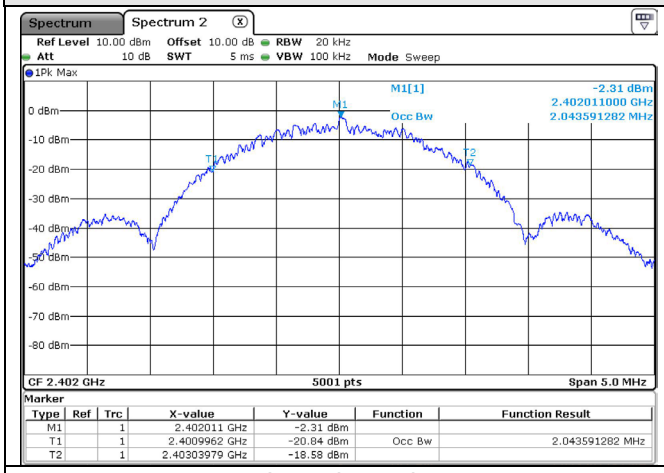
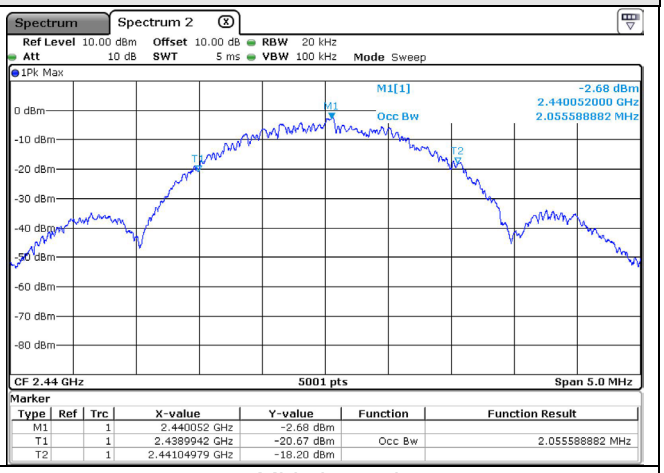
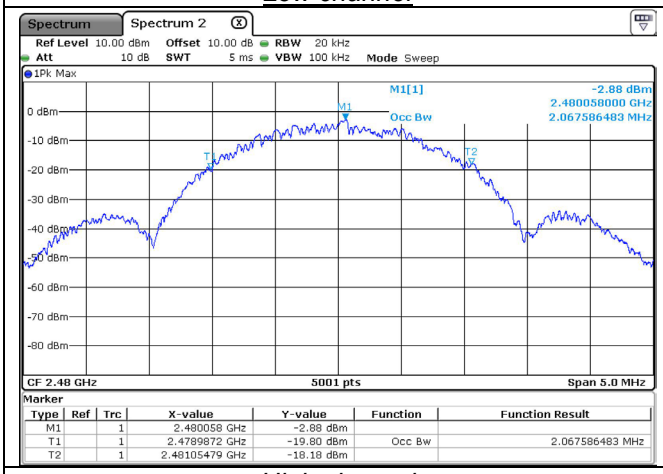


Mid channel



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	2023/4	2024/4
RF cable	RADIALL	RG58 / BNC / 5m	CAB-211-042	2023/4	2024/4
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	2023/4	2024/4
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2021/10	2024/4
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2021/12	2024/6

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	2021/7	2024/7
Log-periodic antenna	EMCO	3146	ANT-191-019	2024/3	2026/9
Biconnic antenna	COM-POWER	AB- 900A	ANT-201-021	2023/01	2025/1
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2021/10	2024/4
RF cable	Div	OATS/25m	CAB-101-017	2023/4	2024/4
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2023/4	2024/4
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-035	2023/4	2024/4
RF cable	RADIALL	R286301073	CAB-201-036	2023/4	2024/4
RF cable	HUBER+SUHNER	SF126E (NN/2m)	CAB-231-043	2023/4	2024/4
RF cable	HUBER+SUHNER	SF104E (NN/5,3m)	CAB-231-044	2023/4	2024/4
RF cable	HUBER+SUHNER	SF104E (NN/7m)	CAB-231-045	2023/4	2024/4
Semi anechoic room	COMTEST	218292	CAG-201-002	2022/4	2025/4
High-pass filter	RF-Lambda	RHPF23G03G18	FIL-221-011	2023/4	2024/4
Antenna mast SAC	Innco- Systems	MA4640-XP-ET	MAT-201-002	-	-

Test Equipment Used for radiated emission					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Turntable SAC	Innco- Systems	DS1500-S-1t	PLA-201-003	-	-
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2023/4	2024/4
Pre-amplifier	COM-POWER	1-18GHz	PRE-221-005	2023/4	2024/4
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