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

Matériel testé : *Equipment under test*:	**SORHEA / SORADIO** *(Trademark / Marketing name or product reference)* *(BLE radio communication link)*

Demandeur de certification :
Applicant for certification:
SORHEA
1, rue du Dauphiné
69120 Vaulx en Velin - France

Client :
Customer:
SORHEA
1, rue du Dauphiné
69120 Vaulx en Velin – France

Numéro d'affaire :
Work number :
13647

Référence de la proposition :
Proposal number:
062020-24121

Date de l'essai :
Date of test:
Du 27 janvier au 19 avril 2021
January 27th to April 19th, 2021

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)
- Industry Canada RSS-247, Issue 2
(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:
Laurent CHAPUS

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 2	April 23rd, 2021 June 23rd, 2021	Initial Edition TCB review ATCB027055 file	Laurent CHAPUS *Technical Manager* Signature numérique de CHAPUS L.	Regis ANCEL *General Manager* Signature numérique de Ancel Régis

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 (April 2021)	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 (Issue2/2017)	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**

- **General conclusion:**

Measures and tests performed on the sample of the product *SORHEA / SORADIO*, 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*	**SORHEA / SORADIO** *(Trademark / Marketing name or product reference)*	Sn: 0003611

FCC ID: QVA-SORADIO
IC: 11664A-SORADIO
Model / HVIN: SORADIO

Alimentation / *Power supply*: 12V DC from external power supply

Auxiliaires / *Auxiliaries*: Laptop ASUS, model F200M for equipment programming only.

Entrées-Sorties / *Input / Output*

	Câbles pour essai / *Cables for test*	Blindé / *Shielded*	Prévu pour >3m / *Intended for >3m*
Power input (12V DC)	1.5m (2 wires)	No	No

Mode de fonctionnement / *Running mode*:
The tested sample is able to:
- Transmit a carrier frequency on low, middle and high channels (Bluetooth Low Energy)

Programme de test / *Test program*:
Use only for board programming:
ProgramLoaderMiniprog3.exe

Logiciel embarqué de test / *Test firmware*:
BLE Mode: ble_modulated_carrier_0db_24xx.hex (xx is channel 2402, 2440 or 2480)
(0dBm output power, date rate 1Mbps)

Fréquence max interne EST / *Max internal EUT frequency*: 26MHz (Except intentional RF)

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 0dBm
- Modulation: Bluetooth Low Energy (1Mbps)
- Modulation: GFSK
- Number of channels 40 spaced by 2MHz from 2042 to 2480MHz
- Antenna type: Integral (PCB trace, peak gain 0dBi)
- Powered by 12V 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*: 65mm x 75 x 13 (PCB)

4. Test conditions

Power supply voltage:
Equipment under test: 12V DC
Auxiliaries: 230V/50Hz (Radiated emission)
110V/60Hz (Conducted emission)

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)

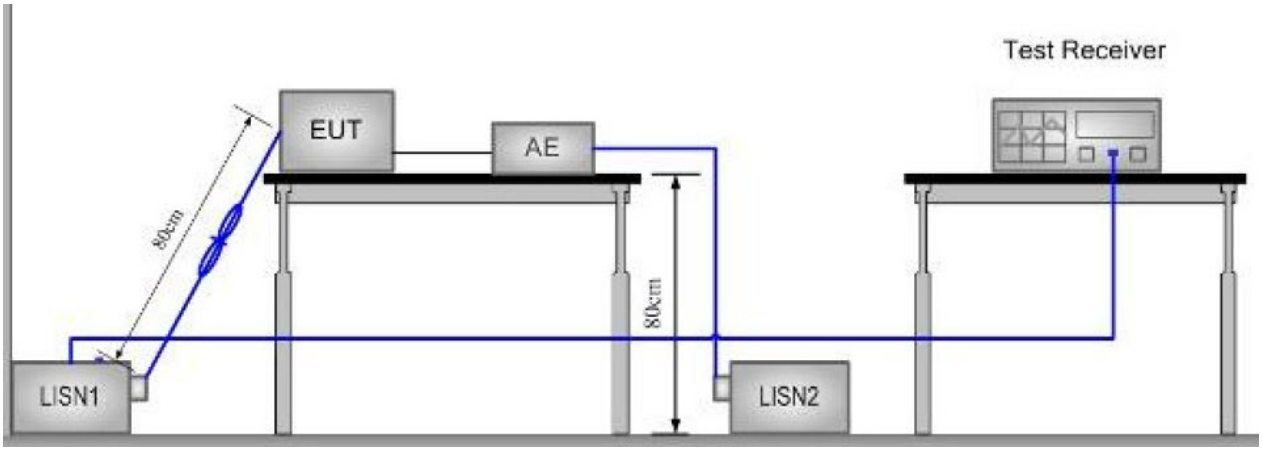
8. Field Strength Calculation

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)

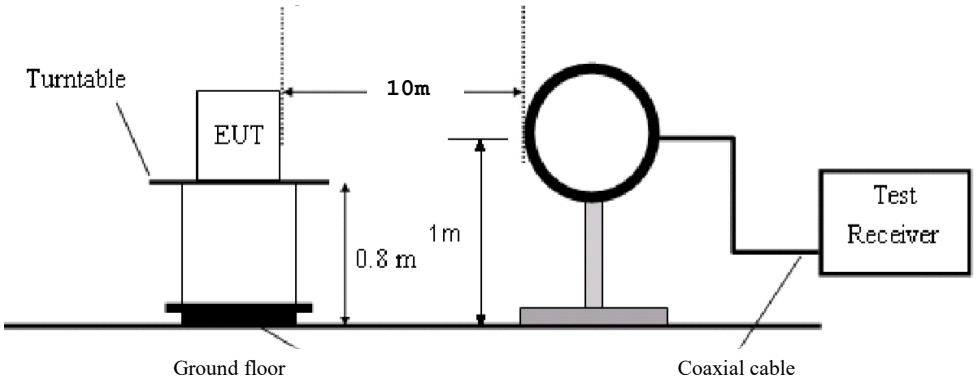
9. Test Setup Diagram

Test Setup for conducted emission



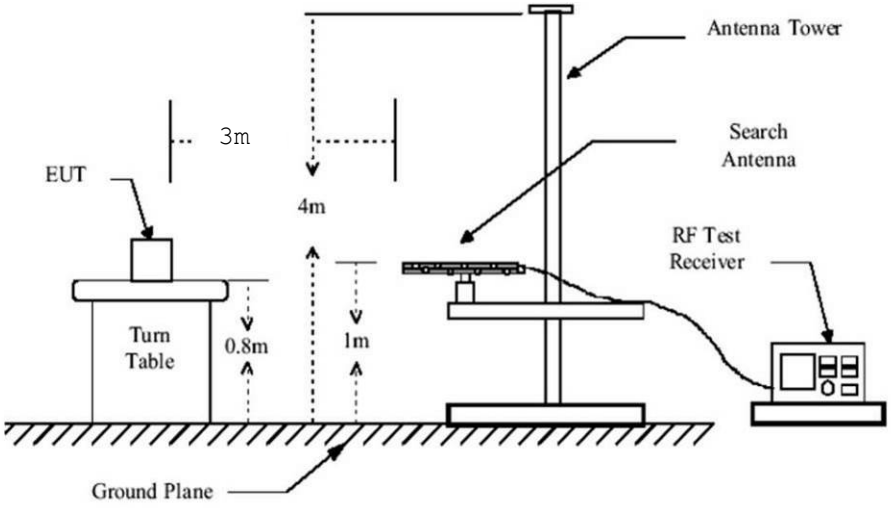
Ground reference plane

Test Setup for radiated emission

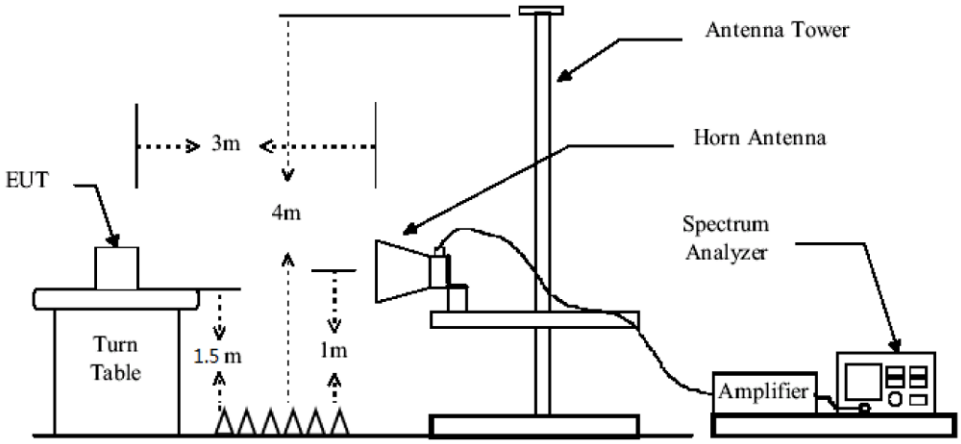


Test setup for 9k-30MHz (FS OATS)

Test Setup for radiated emission



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



Test setup for 1-10GHz (SAC 3m, tilt antenna mast used)

10. Conducted Emission Measurement (150kHz-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	20 to 30 °C	21°C ± 2
Relative Humidity	25 to 70 %	30% ± 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 (110V)

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**

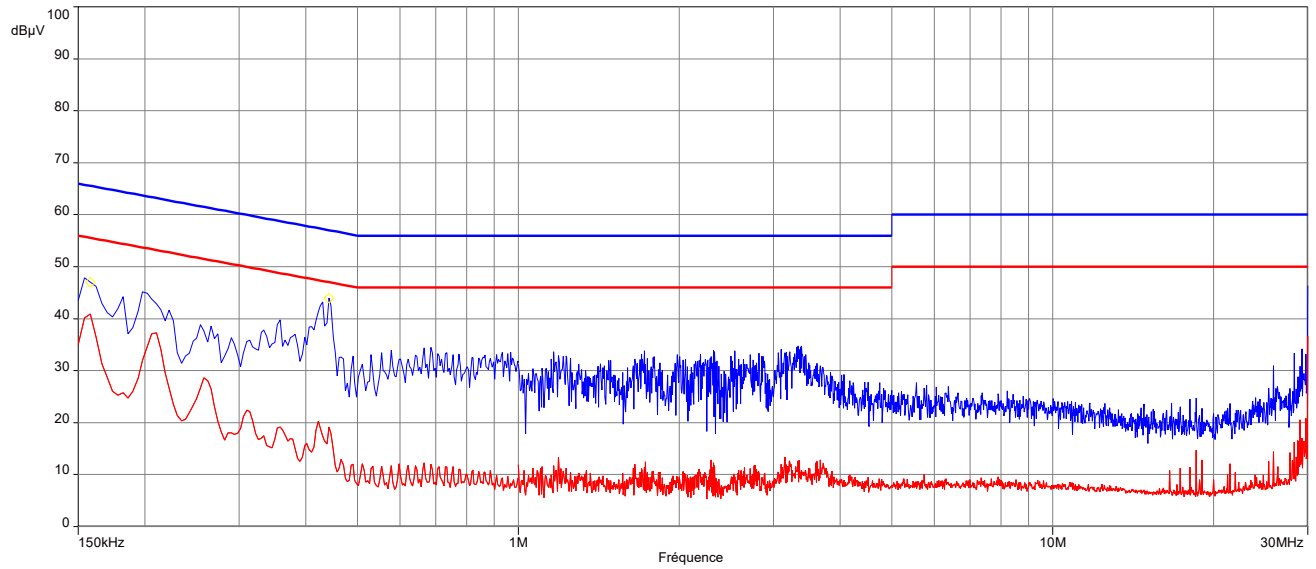
Supplementary information:
Test location: SMEE
Test date: January 26, 2021. Tested by L. CHAPUS
Power supply voltage: AC mains 110V/60Hz

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)	
0.158	48.4	42.2	65.6	-23.4	37.7	55.6	-17.9	L1
0.442	43.8	38.8	57.0	-18.2	19.4	47.0	-27.7	L1
0.154	48.9	42.4	65.8	-23.4	38.7	55.8	-17.1	N
0.426	44.7	38.3	57.3	-19.1	19.9	47.3	-27.5	N

RBW:	9kHz
Voltage:	110V/60Hz
Limit:	FCC Part 15.209 a) / 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)

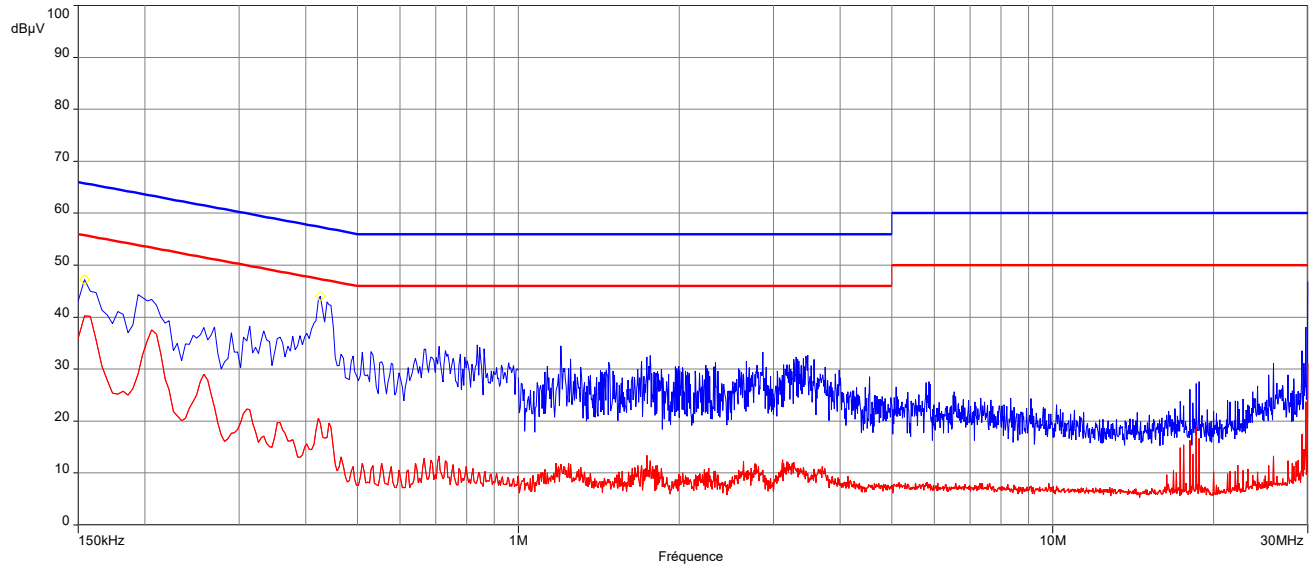
Graphical representation of Conducted Disturbance Measurement (Peak and Average detection)
AC port, Line L1



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.

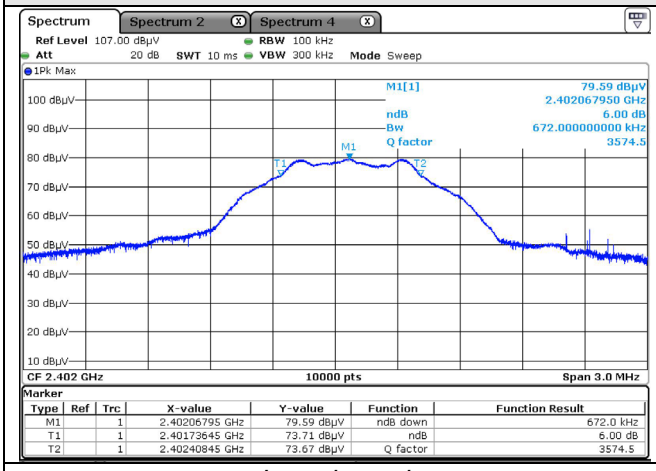
----: Peak	----: Average	

11. DTS Bandwidth

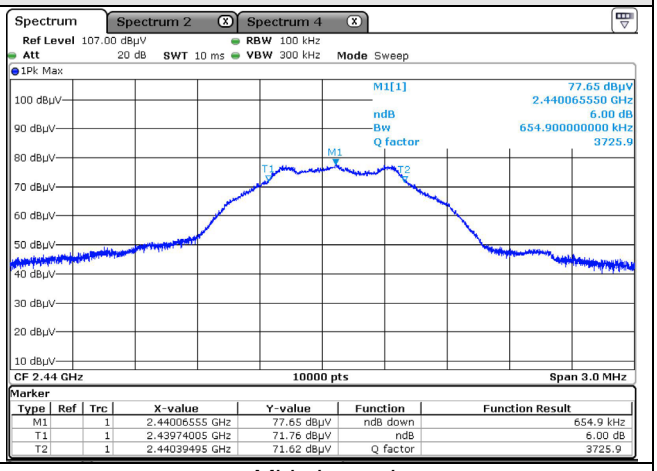
TEST: DTS Bandwidth		**Verdict**
Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed. The RBW is 100kHz, with VBW ≥ 3 x RBW. The SPAN is wide enough to capture all products of the modulation process. A MaxHold Peak 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 %	30% ± 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: January 27th, 2021. Tested by L. CHAPUS		

Tabulated Results for Occupied Bandwidth		
Frequency (MHz)	**6dB Bandwidth** (kHz)	**Result**
2402.0	672.0	**Pass**
2440.0	654.9	**Pass**
2480.0	697.8	**Pass**

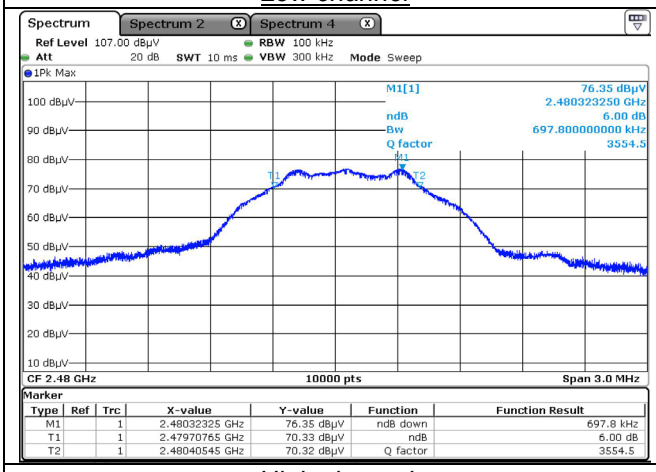
Graphical representation of 6dB Bandwidth



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. Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength. 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	22°C ± 2
Relative Humidity	25 to 70 %	33% ± 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: April 19th, 2021. Tested by L. CHAPUS

Tabulated Results for Maximum peak output power (Radiated measurement)				
FREQ	**Field Strength 3m**	**Calculed EIRP**	**Limit**	**Result**
(MHz)	(dBµV/m)	(dBm)	(dBm)	
2402	90.5	-4.8	36.0	**Pass**
2440	90.2	-5.1	36.0	**Pass**
2480	89.9	-5.4	36.0	**Pass**

RBW:	1MHz
Measurement distance:	3m
Limit:	FCC Part 15.247 / RSS-247
Final measurement detector:	Peak
RESULT:	PASS
Note:	EIRP is calculated using the following equation: EIRP = E + 20xlog (D) – 104.8 – GR Where EIRP = Equivalent Isotropic Radiated Power in dBm E = Electric field strength in dBµV/m D = Measuring distance in meter GR = Ground reflection in dB (0dB above 1GHz)

Tabulated Results for Maximum peak output power (Conducted)			
FREQ	**Conducted power**	**Limit**	**Result**
(MHz)	(dBm)	(dBm)	
2402	-4.8	30.0	**Pass**
2440	-5.1	30.0	**Pass**
2480	-5.4	30.0	**Pass**
RBW:	1MHz		
Limit:	FCC Part 15.247 / IC RSS-247		
Final measurement detector:	Peak		
RESULT:	PASS		
Note:	(1): Maximum conducted Peak output power is calculated as follow: Pc = EIRP – G Where Pc = Conducted power dBm EIRP = Equivalent Isotropic Radiated Power in dBm G = Antenna gain in dBi (0dBi, as declared by the manufacturer)		

13. Maximum Power Spectral Density Level in the fundamental emission

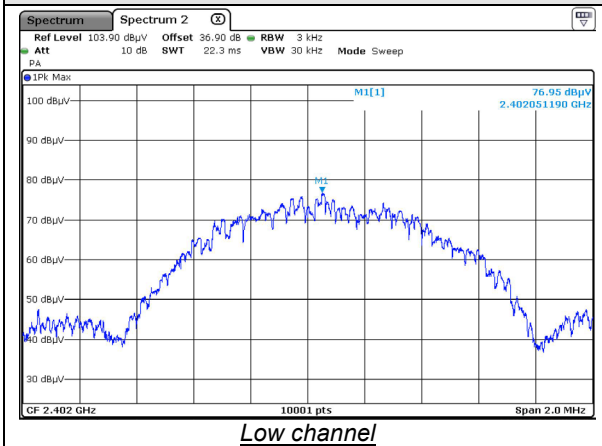
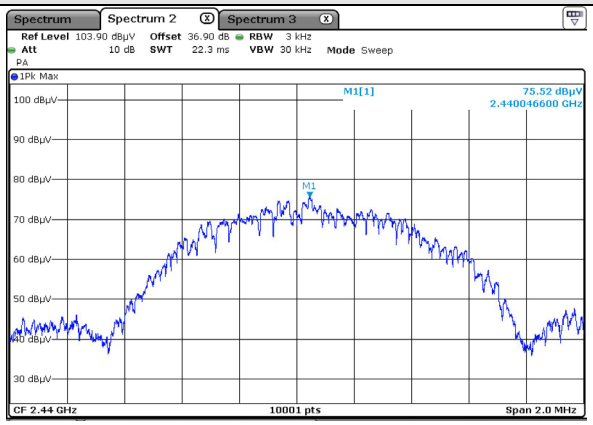
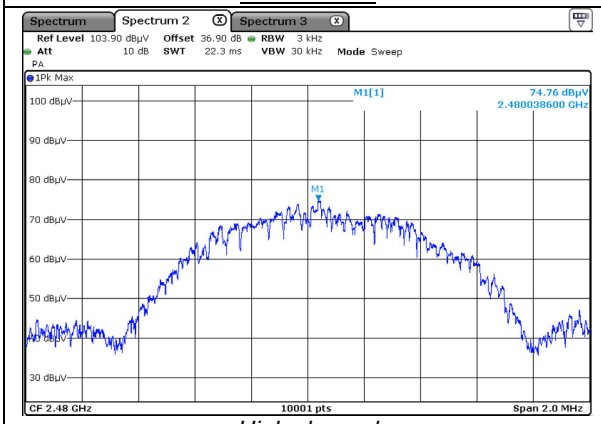
TEST: Maximum Peak Power Spectral Density			**Verdict**
Method: A radiated measurement is performed. The RBW is set at 3kHz. The SPAN is wide enough to capture all products of the modulation process. A MaxHold Peak detector is used. Radiated field strength of RF Output Power is measured at 3m in a Semi 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. Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength. 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	22°C ± 2	
Relative Humidity	25 to 70 %	33% ± 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: April 19th, 2021. Tested by L. CHAPUS			

Tabulated Results for Maximum Spectral Density (Radiated measurement)				
FREQ	**Field Strength 3m**	**Calculated Radiated PSD (EIRP)**	**Limit**	**Result**
(MHz)	(dBµV/m)	(dBm)	(dBm)	
2402	77.0	-18.3	-	-
2440	75.5	-19.8	-	-
2480	74.8	-20.5	-	-

RBW:	3kHz
Measurement distance:	3m
Limit:	FCC Part 15.247 / RSS-247
Final measurement detector:	Peak
Note:	EIRP/PSD is calculated using the following equation: EIRP = E + 20xlog (D) – 104.8 – GR Where EIRP = Equivalent Isotropic Radiated Power in dBm E = Electric field strength in dBµV/m D = Measuring distance in meter GR = Ground reflection in dB (0dB above 1GHz)

Tabulated Results for Maximum Conducted Power Spectral Density			
Frequency (MHz)	**PSD (dBm/3kHz)**	**Limit**	**Result**
2402.0	-18.3	8dBm/3kHz	**Pass**
2441.0	-19.8	8dBm/3kHz	**Pass**
2480.0	-20.5	8dBm/3kHz	**Pass**

RBW:	3kHz
Limit:	FCC Part 15.247 / RSS-247
Final measurement detector:	Peak
RESULT:	PASS
Note:	Maximum conducted power spectral density is calculated as follow: $P_{SD} = P_{SD\text{-}EIRP} - G$ Where P_{SD} = Conducted power spectral density $P_{SD\text{-}EIRP}$ = Equivalent Isotropic Radiated PSD in dBm G = Antenna gain in dBi (0dBi, as declared by the manufacturer)

Graphical representation for Maximum Power Spectral Density	
 *Low channel*	 *Mid channel*
 *High channel*	

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

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

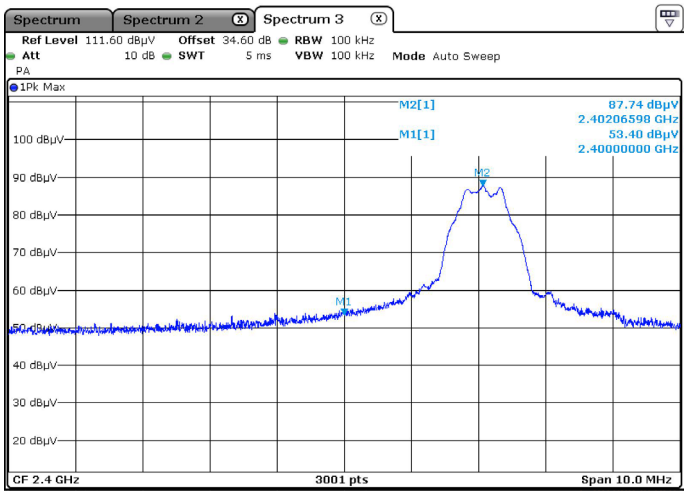
TEST: Unwanted emissions in Non-Restricted Frequency Bands			**Verdict**
Method: Measurements were made in a 3-meter Semi Anechoic Room (SAR) up to 1GHz and in a 3-meter Full Anechoic environment (SAR with floor absorbers) above 1GHz. The Semi Anechoic Room complies with CISPR16-1-4 / ANSI C63.4 requirements. Preliminary (peak) measurements were performed at an antenna to EUT separation distance of 3 meter. 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. Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength.			**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 %		33% ± 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: April 19th, 2021. Tested by L. CHAPUS Note: Tests are performed with only BLE radiating source. Test with both BLE and LORA sources transmitting simultaneously does not show additional spurious emission.			

Tabulated Results for Peak Output Power Reference level	
FREQ	**Field Strength 3m**
(MHz)	(dBµV/m)
2402.0	88.2 (1)
2440.0	88.0 (1)
2480.0	88.5 (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 **68 dBµV/m** Peak for out-of-band frequencies in Non-Restricted bands (with a 100kHz RBW on the spectrum analyser)

Tabulated Results for Unwanted emissions in Non-Restricted bands				
FREQ (MHz)	**Field Strength 3m** (dBµV/m)	**Limit** (dBµV/m)	**Margin** (dBµV/m)	**Result** (dBµV/m)
2400.00	53.4	68.0	**-14.6**	**Pass**

RBW:	100kHz
Measurement distance:	3m
Limit:	FCC 15.247 / RSS-247
Final measurement detector:	Peak
RESULT:	PASS
Note:	See band-edge measurement

Graphical representation of Band-edge compliance (LOW)



Low bandedge compliance

Radiated Peak level is 53.4dBµV/m (limit 68.0dBµV/m)
F1 = 2400MHz
RESULT: PASS
Note: Radiated measurement.

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. Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength.			**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 %	33% ± 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: April 19th, 2021. Tested by L. CHAPUS Note: Tests are performed with only BLE radiating source. Test with both BLE and LORA sources transmitting simultaneously does not show additional spurious emission.			

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 *1: Measure have been done at 10m distance and corrected according to requirements of 15.209.e / RSS-Gen clause 6.5) (M@300m = M@10m-59.1dB) Loop antenna used and rotated about its axis to maximize any emission.						

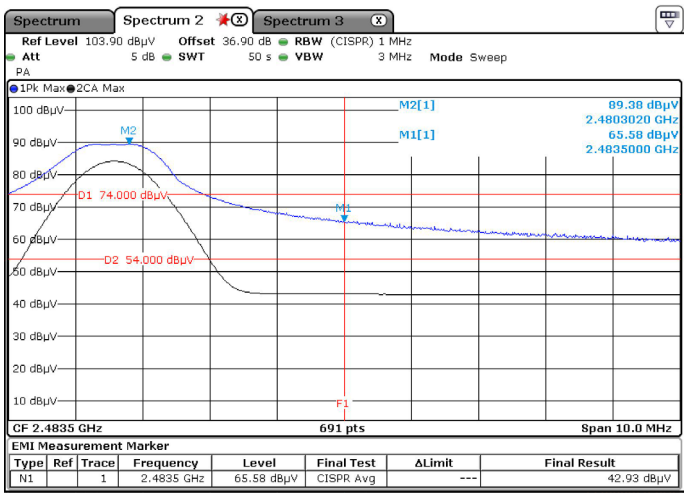
Tabulated Results for Unwanted emissions (490kHz-30MHz)							
FREQ	**RF field @ 30m**	**Limit @ 30m**	**Detector**	**Margin**	**Ant. angle**	**Table angle**	**Correc. Fact. (CF)**
MHz	dBµV/m	dBµV/m	Pk / QP	dB	Degree	Degree	dB
All levels are at least 20dB below applicable limits							
Supplementary 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 *1: Measure have been done at 10m distance and corrected according to requirements of 15.209.e) (M@30m = M@10m-19.1dB) Loop antenna used and rotated about its axis to maximize any emission.						

Tabulated Results for Unwanted emissions (30MHz-1GHz)										
FREQ	**Meter reading**	**Meter reading**	**Total factor**	**Field level**	**Field level**	**Pol**	**Antenna height**	**Table angle**	**Limit**	**Margin**
MHz	(QP) dBµV	(Pk) dBµV	dB	(QP) dBµV/m	(Pk) dBµV/m		cm	Degree	(QP) dBµV/m	dB
Levels are at least 10dB below limits										
Supplementary information: Frequency list has been created with pre-scan results.										

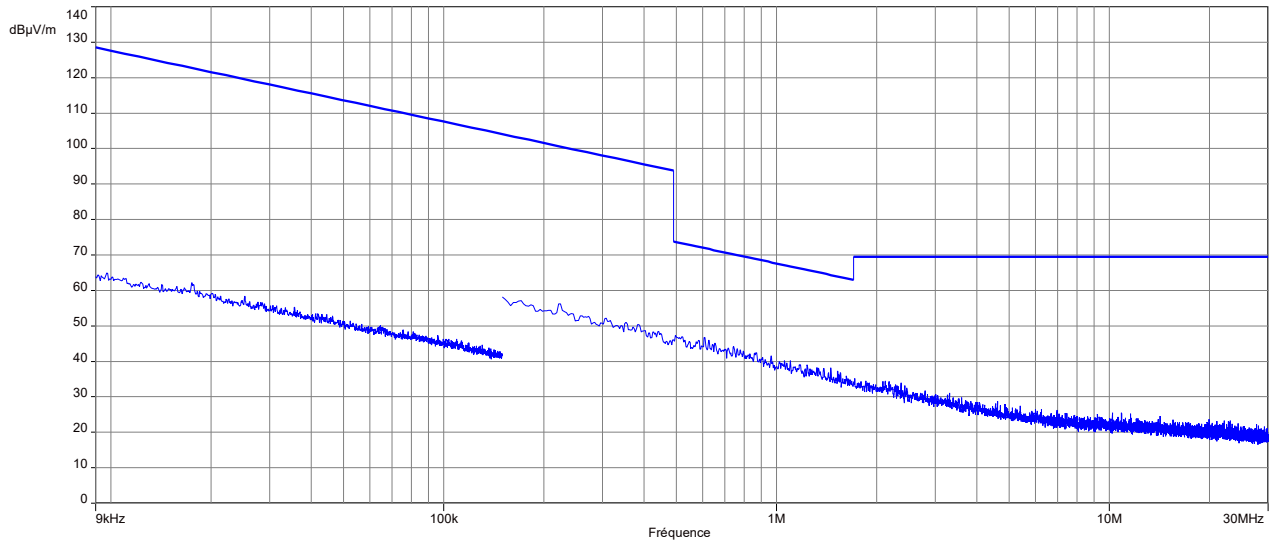
Frequency band investigated:	30MHz-1GHz
RBW:	120kHz
Measurement distance:	3m
Limit:	FCC Part 15.205 - 15.209 / RSS-GEN
Final measurement detector:	Quasi-Peak
RESULT:	PASS

Tabulated Results for Unwanted emissions (1GHz-25GHz)										
FREQ	**Field level**	**Field level**	**Limit**	**Margin**	**Limit**	**Margin**	**Table angle**	**Ant height**	**Total factor**	**Pol**
MHz	(PK) dBµV/m	(AV) dBµV/m	(PK) dBµV/m	(PK) dB	(AV) dBµV/m	(AV) dB	Degree	m	dB	
Low channel										
4803.6	56.4	50.2	74.0	-17.6	54.0	-3.8	360.0	1.5	24.6	H
7205.4	62.0	50.6	74.0	-12.1	54.0	-3.4	324.9	1.1	30.9	H
Middle channel										
4880.7	56.1	51.2	74.0	-17.9	54.0	-2.8	20.4	1.1	24.6	H
7320.9	62.9	50.8	74.0	-11.1	54.0	-3.2	318.1	1.1	30.9	H
High channel										
4959.6	57.0	52.7	74.0	-17.0	54.0	-1.3	66.7	1.1	25.0	H
7439.6	63.2	51.3	74.0	-10.8	54.0	-2.7	312.0	1.1	31.3	H
Supplementary information: Frequency list has been created with pre-scan results.										

RBW	1MHz
Measurement distance:	3m
Limit:	FCC Part 15.205, 15.209, 15.247 / RSS-Gen, RSS-247
Final measurement detector:	Peak / CISPR Average
RESULT:	PASS

Graphical representation of Band-edge compliance (HIGH)
 *High bandedge compliance*
Radiated Peak level is 65.6dBµV/m at 2483.5MHz (limit 74dBµV/m) Max radiated Average level is 42.9dBµV/m (limit 54dBµV/m, CISPR Average detector measurement) RESULT: PASS Note: Radiated measurement

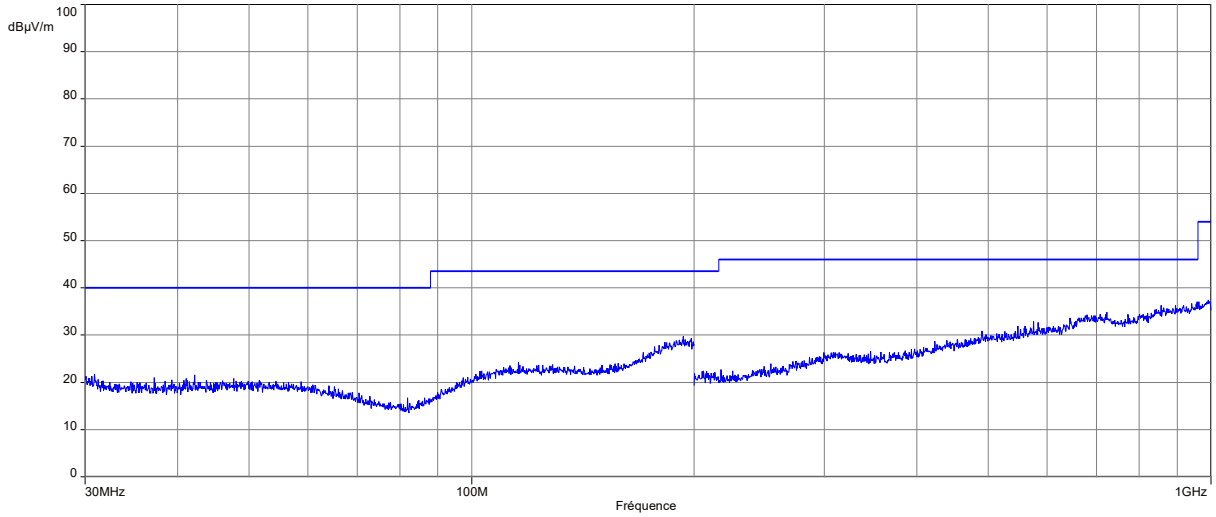
Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 9kHz-30MHz / 3m / Parallel & Perpendicular antenna position / Transmit mode)

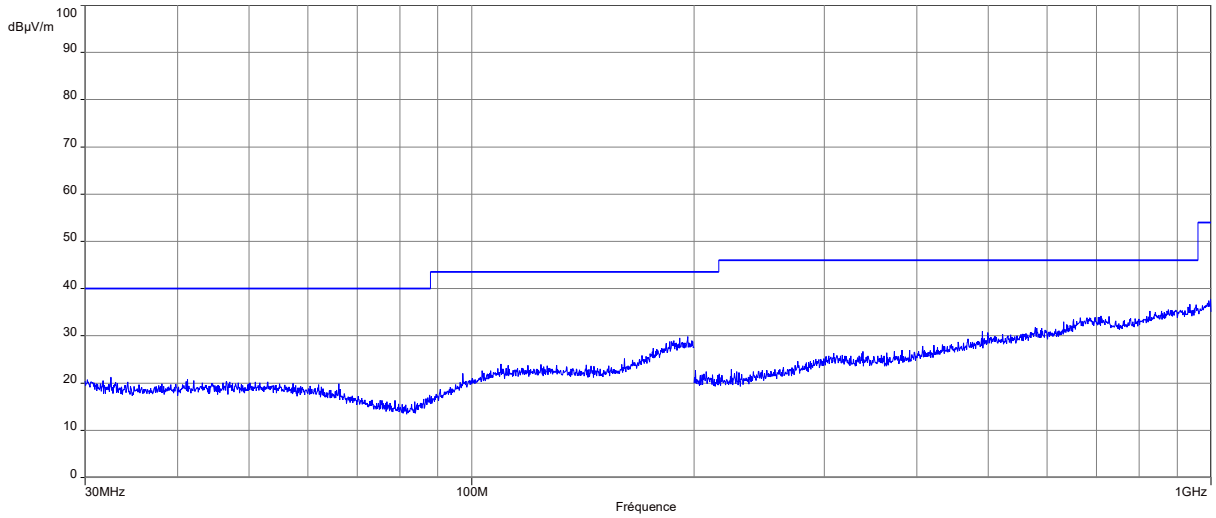


Notes: Pre-scan graph only for identification purpose.
Same result for transmit mode on all channels.

Frequency band investigated:	9kHz-30MHz
Unit :	dBµV/m
RBW :	200Hz (9kHz-150kHz) 9kHz (150kHz-30MHz)
Antenna polarization :	Parallel & Perpendicular to measurement axis
Measurement detector:	Peak

Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 30MHz-1GHz / 3m / Horizontal & Vertical/ Transmit mode)





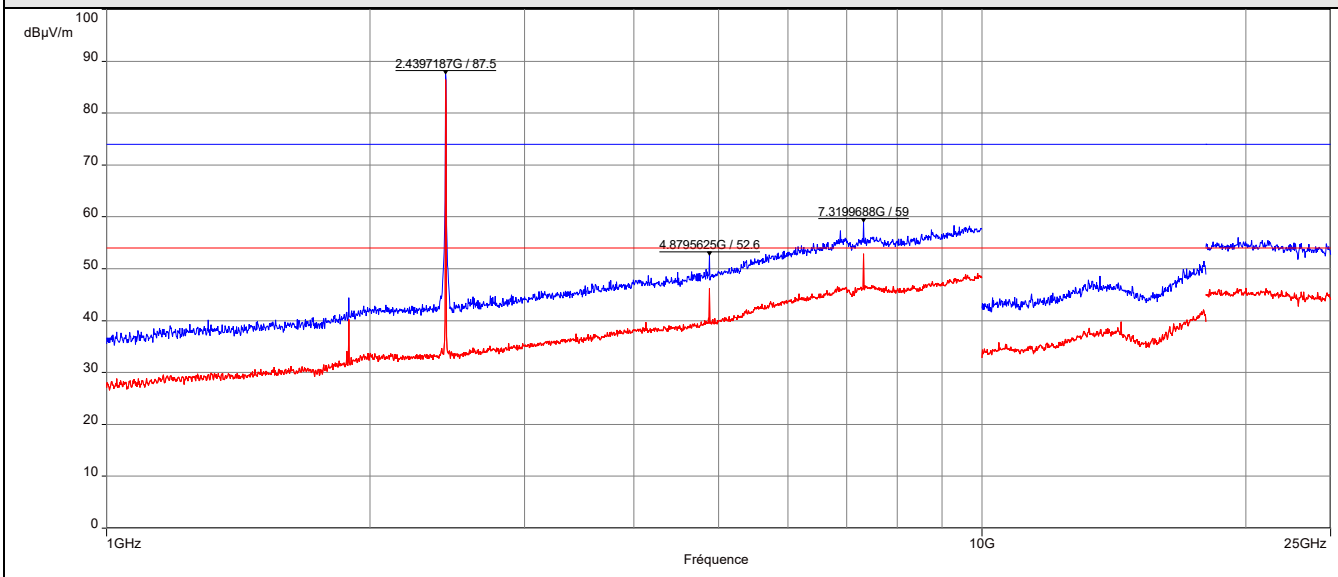
Note: Pre-scan graph only for identification purpose.
Same result for transmit mode on all channels

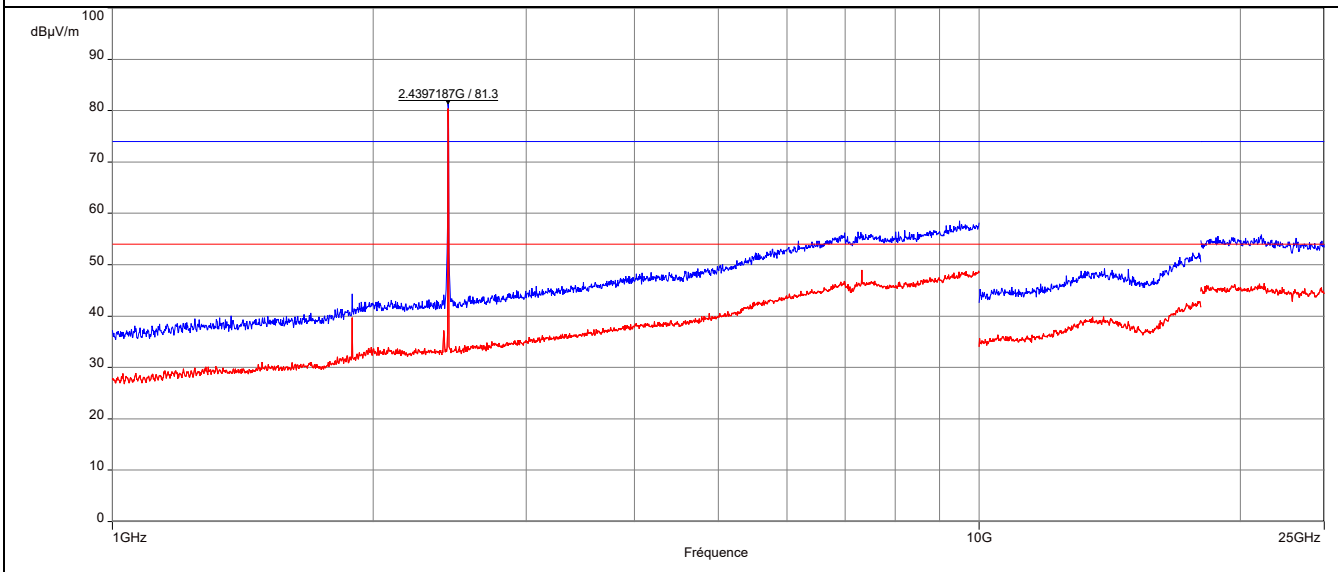
Frequency band investigated:	30MHz-1GHz
Unit :	dBµV/m
RBW :	100kHz
Antenna polarization :	Horizontal & Vertical
Voltage:	12V DC
Limit:	FCC 15.209 / RSS-GEN
Measurement detector:	Peak

PEAK LIST FROM PRE-SCAN

Frequency (MHz)	Peak Level (dBµV/m)	Angle (°)	Limit (dBµV/m)	Polarization	Comments
None					

Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 1GHz-18GHz / 3m / Horizontal & Vertical/ Transmit mode) – Mid channel





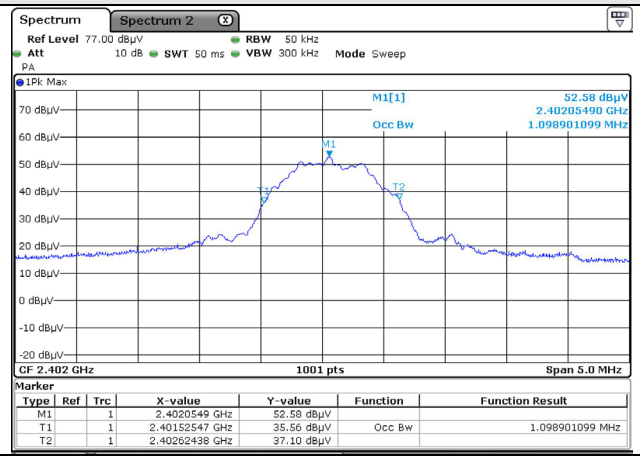
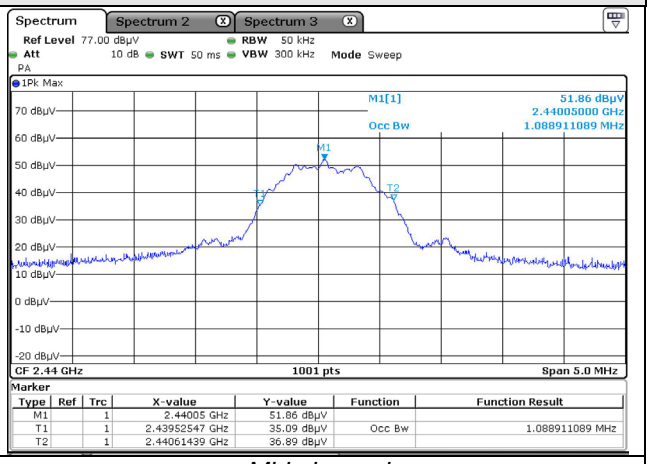
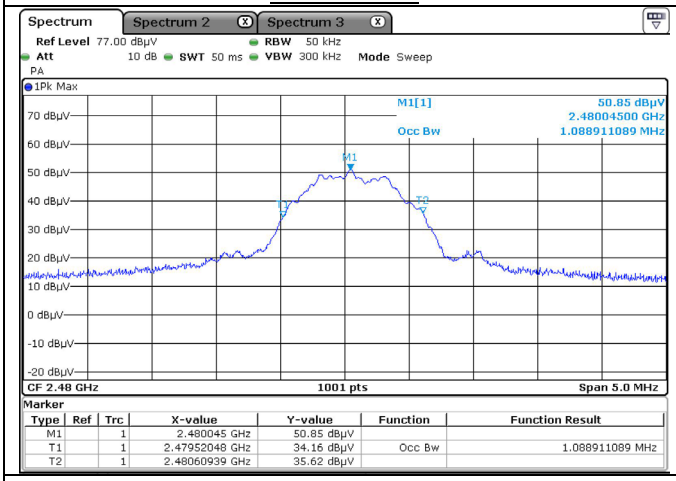
------ : Peak measure	------ : Average measure
Frequency band investigated:	1GHz-25GHz
Unit :	dBµV/m
RBW :	1MHz
Antenna polarization :	Horizontal & Vertical
Voltage:	12V
Limit:	FCC 15.247 / RSS-247
Measurement detector:	Peak / Average
Note :	Pre-scan graph only for identification purpose.

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	22°C ± 2
Relative Humidity	25 to 70 %	33% ± 5

Supplementary information:
Test location: SMEE
Test date: January 26, 2021. Tested by L. CHAPUS

Tabulated Results for Occupied Bandwidth	
Frequency (MHz)	**99% Occupied Bandwidth** (MHz)
2402.0	1.079
2440.0	1.084
2480.0	1.088

Graphical representation of Occupied Bandwidth	
	
Low channel	*Mid channel*
	
High channel	

Frequency band investigated:	2402MHz to 2480MHz
RBW :	100kHz
Measurement detector:	Peak

17. Test Equipment List

Test Equipment Used for conducted emission on AC mains					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
AC power supply	PACIFIC POWER	AMX-125	ALI-101-002	-	-
Attenuator / limiter	SMEE	ATT#2	ATT-171-010	2021/3	2022/3
Cable RF	Div	1m	CAB-101-021	2021/3	2022/3
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9
LISN (50Ω / 50µH) (Meas.)	AFJ	LS16C	RSI-101-001	2019/6	2021/6
LISN (50Ω / 50µH) (Aux.)	AFJ	LS16C	RSI-111-002	2019/6	2021/6
EMC Software	NEXIO	BAT EMC V3.18	SOF-101-001	-	-

Test Equipment Used for radiated emission					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Biconnic antenna	COM-POWER	AB- 900	ANT-101-003	2019/6	2021/6
Horn antenna	COM-POWER	AH-118	ANT-101-004	2018/10	2021/10
Loop antenna	EMCO	6502	ANT-101-009	2019/8	2021/8
Horn antenna	ETS-LINDGREN	3116	ANT-161-014	2017/12	2022/12
Log-periodic antenna	EMCO	3146	ANT-191-019	2019/6	2021/6
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2019/8	2021/8
RF cable	Div	OATS/25m	CAB-101-017	2021/3	2022/3
RF cable	Pasternack RF	PE302-120	CAB-131-023	2021/3	2022/3
RF cable	HUBER+SUHNER	SF102 (KN6m)	CAB-171-033	2021/3	2022/3
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2021/3	2022/3
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-035	2021/3	2022/3
RF cable	TMS	LMR-400 / 9m	CAB-201-039	2021/3	2022/3
Semi anechoic room	COMTEST	218292	CAG-201-002	2021/2	2022/2
High-Pass filter	Mini-circuit	VHF-3100+	FIL-151-006	2021/3	2022/3
Antenna mast SAC	Innco- Systems	MA4640-XP-ET	MAT-201-002	-	-
Turntable	Innco- Systems	CT0800	PLA-141-002	-	-
Turntable SAC	Innco- Systems	DS1500-S-1t	PLA-201-003	-	-
Pre-amplifier	PE	1524	PRE-101-002	2021/3	2022/3
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2017/12	2019/12
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9
FS OATS	Div	10m	SIT-201-002	-	-
EMC Software	NEXIO	BAT EMC V3.18	SOF-101-001	-	-