

**SMEE**

SOCIÉTÉ MODERNE D'ÉTUDES ÉLECTRONIQUES

## Rapport d'essais / Test Report

N° : 13338-FCC-IC-1

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

Matériel testé :  
*Equipment under test:*

**IOTIZE / TnLFIW10**  
(Trademark / Marketing name or product reference)  
**(BLE communication media)**

Client / Demandeur:  
*Customer / Applicant:*

**IOTIZE**  
960 chemin de la Croix Verte  
38330 Montbonnot - FRANCE

Rapport délivré à :  
*Issued to:*

**IOTIZE**  
960 chemin de la Croix Verte  
38330 Montbonnot - FRANCE

Numéro d'affaire :  
*Work number:*

13338

Référence de la proposition : 102019-23819  
*Proposal number:*

Date de l'essai : 14 novembre 2019  
*Date of test:*  
November 14<sup>th</sup>, 2019

Objectif des essais :  
*Test purpose:*

EMC qualification according 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*)
- ISED ICES-003 Issue 6 & RSS-247, Issue 2 (*Digital Transmission Systems Operating in the Bands 2400-2483.5 MHz*)

Measurement standards : ANSI C63.10 (2013)

Lieu du test:  
*Test location:*

SMEE, Rue de Taille  
38500 VOIRON - France

Test réalisé par : Laurent CHAPUS  
*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	March 25 <sup>th</sup> , 2020	Initial Edition	Laurent CHAPUS Technical Manager	Regis ANCEL General 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	X	Telecommunication – Federal Communication Commission – Radio frequency devices, Sections 15.109 / 15.209 / 15.247

ISED qualification according to:		
Standards	Applied	Title
RSS-Gen (Issue 5/2018)	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)
<b>Conducted emissions test</b>	15.207 (a) RSS-Gen § 8.8	Table 15.207 Table 4 / RSS-Gen	<b>PASS</b>
<b>Radiated emission test</b>	15.109 (a) / 15.209 (a) RSS-Gen § 8.9	Table 15.109 (a) / 15.209 (a) Table 5 & 6 / RSS-Gen	<b>PASS</b>
<b>6dB Bandwidth</b>	15.247 (a) (2) RSS-247 § 5.2 (a)	At least 500kHz	<b>PASS</b>
<b>Maximum Peak Output Power</b>	15.247 (b) (3) & (4) RSS-247 § 5.4 (d)	1W max / 30dBm (Conducted) 4W max / 36dBm (EIRP)	<b>PASS</b>
<b>Maximum Power Spectral Density</b>	15.247 (e) RSS-247 § 5.2 (b)	8dBm in a 3kHz band segment	<b>PASS</b>
<b>Unwanted emissions into Non Restricted Frequency Bands</b>	15.247 (d) / RSS-247 § 5.5	-20dBc in any 100kHz outside frequency band.	<b>PASS</b>
<b>Unwanted emissions into Restricted Frequency Bands</b>	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) Measure at 30m 0.490-1.705: 24000µV/m/F(kHz) 1.705-30MHz: 30µV/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	<b>PASS</b>
<b>Occupied Bandwidth</b>	RSS-GEN § 6.7	BW at 99%	<b>PASS</b>

- General conclusion:**

Measures and tests performed on the sample of the product *OTIZE / TnLFIW10*, 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**

**IOTIZE / TnLFIW10**  
*(Trademark / Marketing name or product reference)*  
**(BLE communication media)**

Sn: IoTize004100000010

**FCC ID:**

2APCX-TNLFIW10

**IC:**

23741-TNLFIW10

**Model / HVIN:**

TnLFIR10

**Alimentation /  
Power supply**

Module is powered by 3.3V DC from the MCU target board  
(Nominal voltage range is 2.3V to 3.6V)

**Auxiliaires /  
Auxiliaries**

- Laptop ASUS, model F200M with its power supply unit
- Serial communication board (FTDI232)
- TapNPass expansion board

**Entrées-Sorties /  
Input / Output**

	Câbles pour essai / Cables for test	Blindé / Shielded	Prévu pour >3m / Intended for >3m
Debug connector (J1/J3)	None	No	No
P1 extension connector	Direct plugin	-	-
Auxiliary ports: - USB (Target board, COM port + DC)	1m	Yes	No

**Version programme embarqué /  
Firmware version**

ESP32\_RF\_TEST\_BIN\_V1.3.9

**Mode de fonctionnement /  
Running mode**

The tested sample is able to:

- Transmit a modulated carrier frequency on low, middle and high channels (Bluetooth Low Energy)

The module is plugged onto the expansion board.

The serial communication wire is only used for board programming.

**Programme de test /  
Test program /**

EspRFtestTool running on the PC.

**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 the maximum
- Modulation: Bluetooth Low Energy (1Mbps)
- Antenna type: CMS chip antenna (Peak antenna gain is 0.5dBi)
- Equipment intended for use as a mobile station
- Equipment designed for continuous operation

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

Module: 28 x 38 x 3 mm

### 4. Test conditions

**Power supply voltage:**

Equipment under test:

Auxiliaries (AC mains):

3.3V for RF module

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 (30-300MHz, OATS)	± 5.6dB
Radiated emission test (300-1000MHz, OATS)	± 5.3dB
Radiated emission test (1-40GHz, OATS / FAC)	± 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: 14.0dB $\mu$ V / AF: 16.5 dBm $^{-1}$  / CF: 3.5dB / AG: 15dB

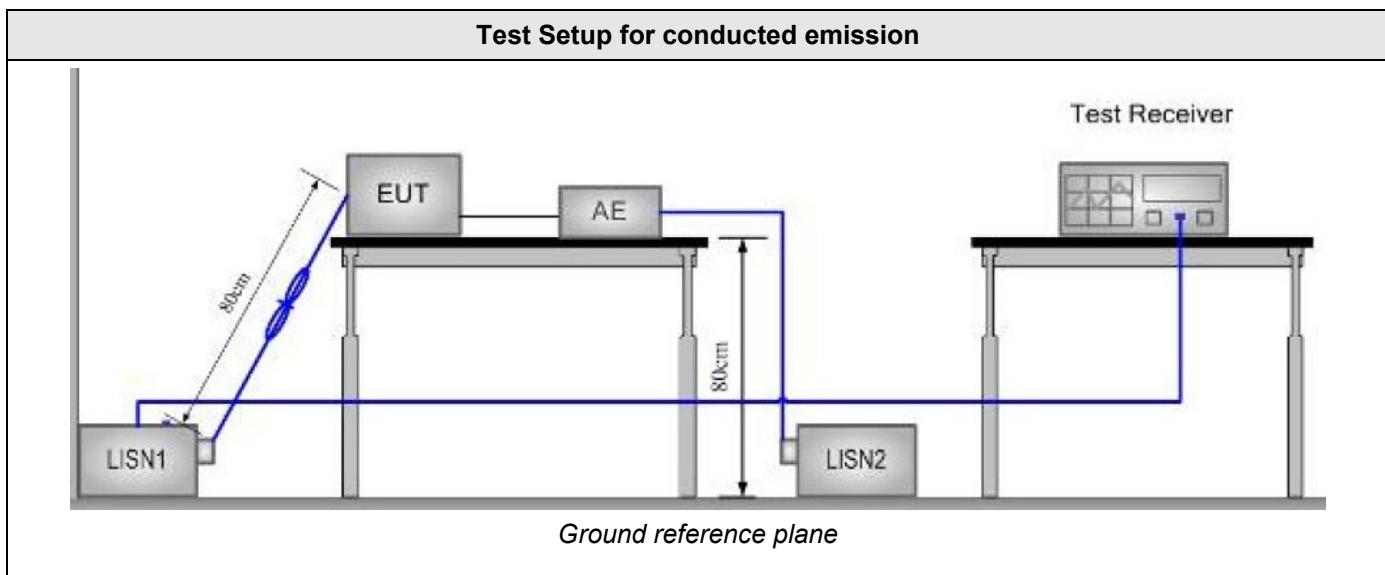
→ Total factor: 5dBm $^{-1}$

→ Field level: 19.0dB $\mu$ V/m (-21.0dB for margin if limit is 40dB $\mu$ V/m)

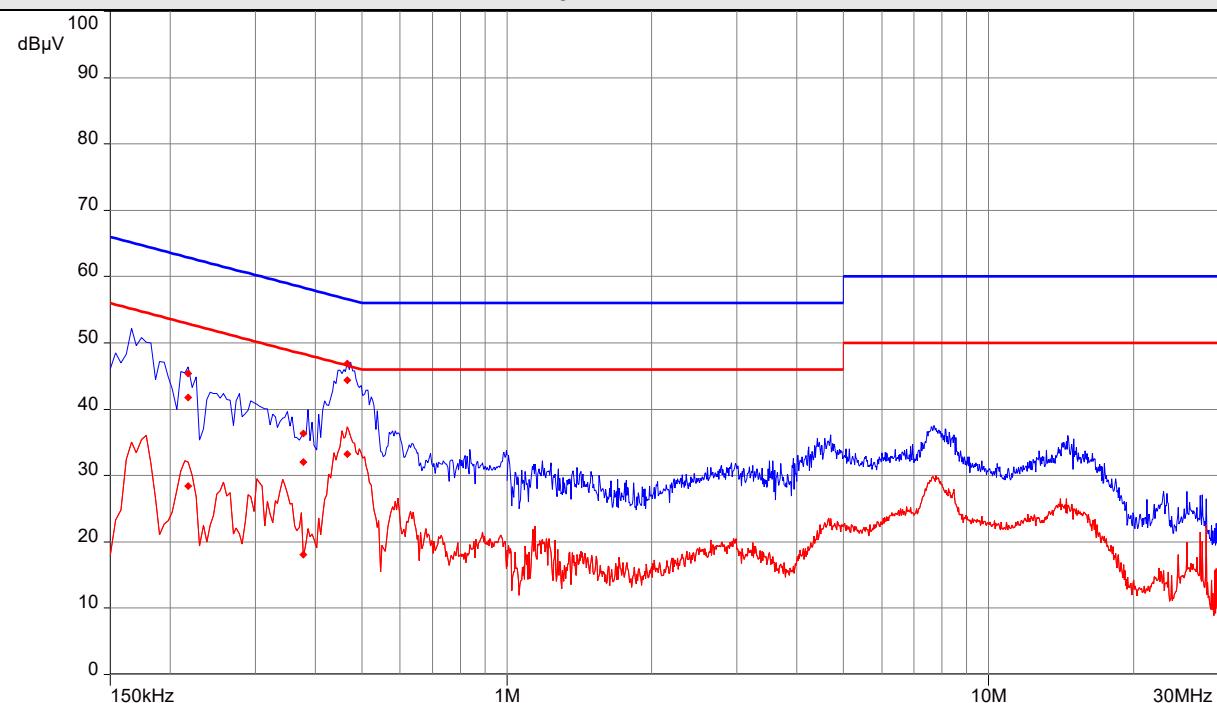
## 9. Conducted Emission Measurement (150kHz-30MHz)

<b>TEST: Limits for conducted disturbance 150kHz – 30MHz</b>			<b>Verdict</b>		
<b>Method:</b> 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.			<b>Pass</b>		
<b>Laboratory Parameters:</b>		Required prior to the test	During the test		
Ambient Temperature		20 to 30 °C	23°C ± 2		
Relative Humidity		25 to 70 %	40% ± 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) Personal Computer		
<b>Limits</b>					
Frequency (MHz)	Limit dB (µV)				
	Quasi-Peak	Result	Average	Result	
0.15 – 0.50	66 \ 56	<b>PASS</b>	56 \ 46	<b>PASS</b>	
0.50 - 5	56	<b>PASS</b>	46	<b>PASS</b>	
5 – 30	60	<b>PASS</b>	50	<b>PASS</b>	
Supplementary information: Test location: SMEE Test date: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC (AC mains 110V/60Hz)					

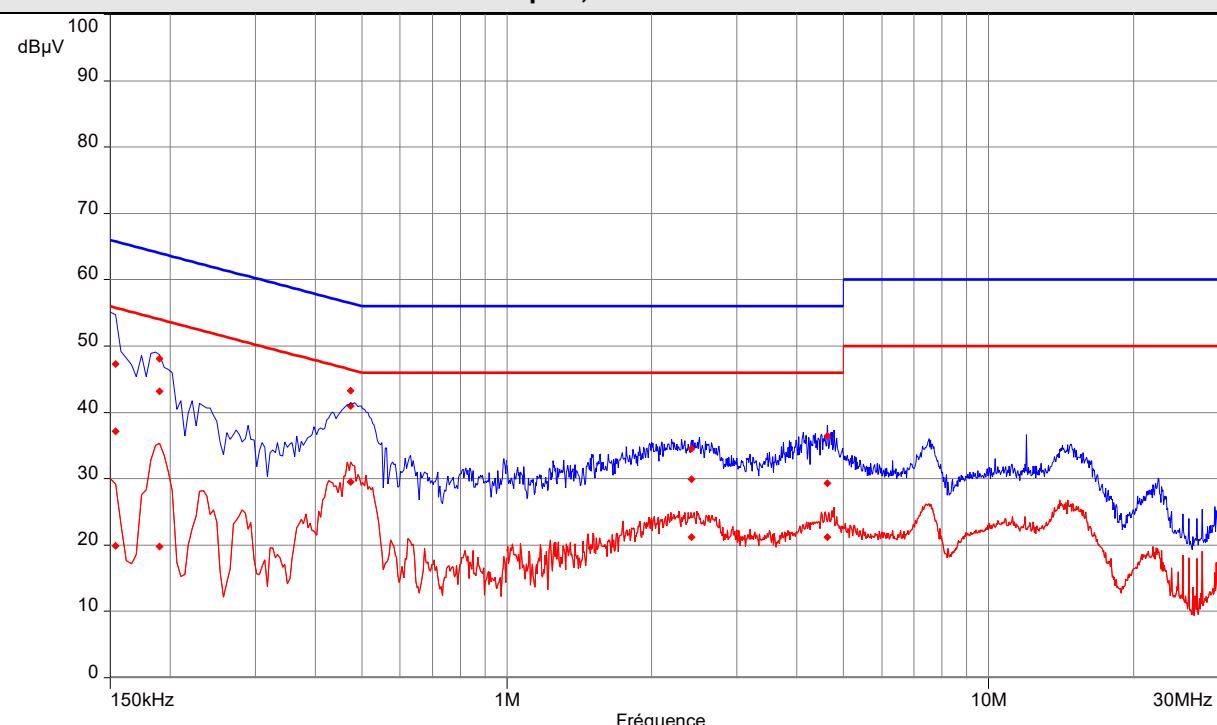
<b>Test Equipment Used</b>					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
AC power supply	PACIFIC POWER	AMX-125	ALI-101-002	-	-
Attenuator / limiter	SMEE	ATT#2	ATT-171-010	2019/6	2020/6
Cable RF	Div	1m	CAB-101-021	2019/4	2020/4
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9
LISN (50Ω / 50µH) (Meas.)	AFJ	LS16C	RSI-101-001	2019/6	2021/6
EMC Software	NEXIO	BAT EMC V3.18	SOF-101-001	-	-



Tabulated Results for Mains Terminal Disturbance Voltage on AC port								
<b>FREQ</b> (MHz)	<b>Meas. PK</b> (dB $\mu$ V)	<b>Mes. QP</b> (dB $\mu$ V)	<b>LIMIT QP</b> (dB $\mu$ V)	<b>Margin QP</b> (dB)	<b>Mes. AV</b> (dB $\mu$ V)	<b>LIMIT AV</b> (dB $\mu$ V)	<b>Margin AV</b> (dB)	<b>Line</b>
0.218	45.4	41.8	62.9	<b>-21.1</b>	28.5	52.9	<b>-24.4</b>	L1
0.378	36.4	32.0	58.3	<b>-26.3</b>	18.0	48.3	<b>-30.3</b>	L1
0.466	46.9	44.4	56.6	<b>-12.2</b>	33.2	46.6	<b>-13.4</b>	L1
0.154	47.3	37.2	65.8	<b>-28.6</b>	19.9	55.8	<b>-35.9</b>	N
0.19	48.1	43.2	64.0	<b>-20.9</b>	19.8	54.0	<b>-34.2</b>	N
0.474	43.3	41.0	56.4	<b>-15.4</b>	29.5	46.4	<b>-16.9</b>	N
2.42	34.6	29.9	56.0	<b>-26.1</b>	21.2	46.0	<b>-24.8</b>	N
4.624	36.4	29.4	56.0	<b>-26.7</b>	21.2	46.0	<b>-24.8</b>	N
<b>Frequency band investigated:</b>	150kHz-30MHz							
<b>RBW:</b>	9kHz							
<b>Voltage:</b>	110V / 60Hz							
<b>Limit:</b>	15.207 / RSS-GEN §8.8							
<b>Final measurement detector:</b>	Quasi-Peak and CISPR Average (AV)							
<b>RESULT:</b>	PASS							
<b>Measured value calculation:</b>	<p>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:</p> <p>Meas. = RA + CF + ATT<sub>TRAN</sub> + ATT<sub>LISN</sub></p> <p>Where Meas. = Level (dB<math>\mu</math>V)  RA = Receiver Amplitude  CF = Cable Factor  ATT<sub>TRAN</sub> = Transient suppressor attenuation  ATT<sub>LISN</sub> = LISN attenuation  Margin value = Emission level – Limit value</p>							

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


----: Peak      ----: Average

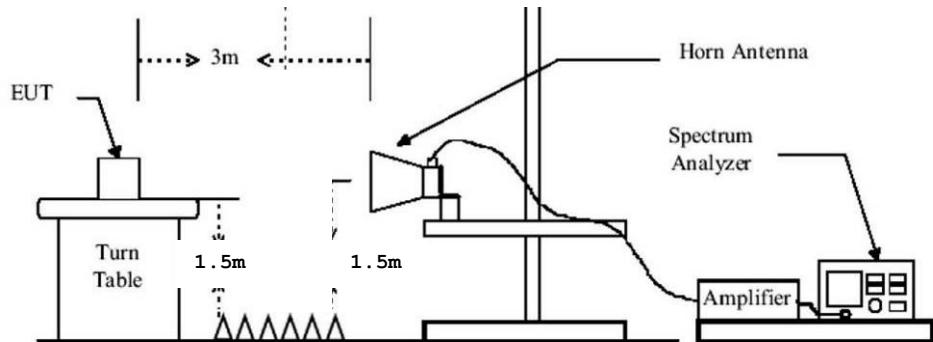
**Graphical representation of Conducted Disturbance Measurement (Peak and Average detection)  
AC port, Line Neutral**


----: Peak      ----: Average

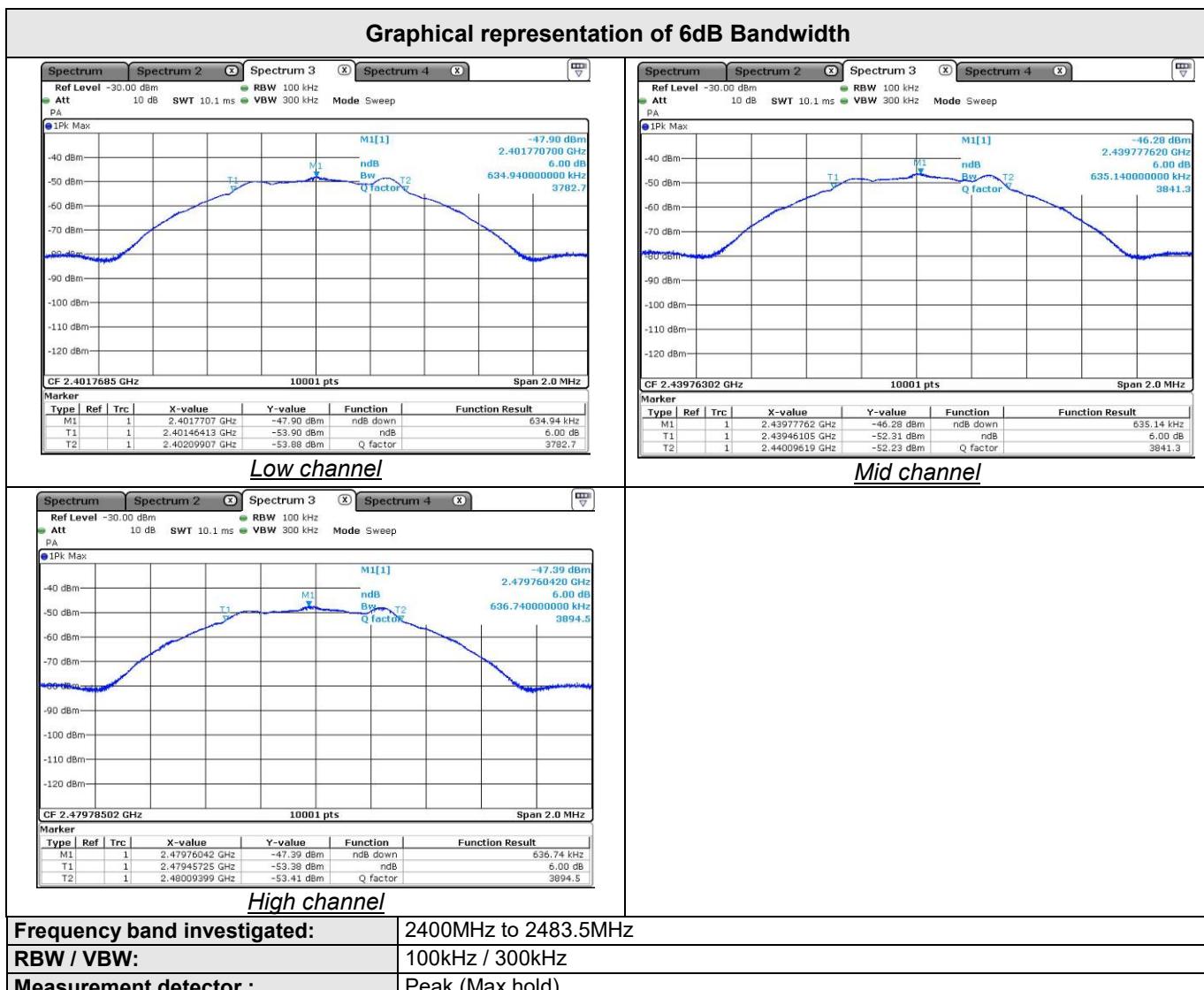
## 10. DTS Bandwidth

TEST: DTS Bandwidth			Verdict
<u>Method:</u> 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 $\geq 3 \times$ 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	23°C $\pm$ 2
Relative Humidity		25 to 70 %	40% $\pm$ 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: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC			

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	Pasternack	PE302-120	CAB-131-024	2019/4	2020/4
Anechoic chamber	COMTEST	214263	CAG-141-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-002	-	-
Measuring Receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9

**Test Setup for radiated emission**

Test setup for 1-25GHz
**Tabulated Results for Occupied Bandwidth**

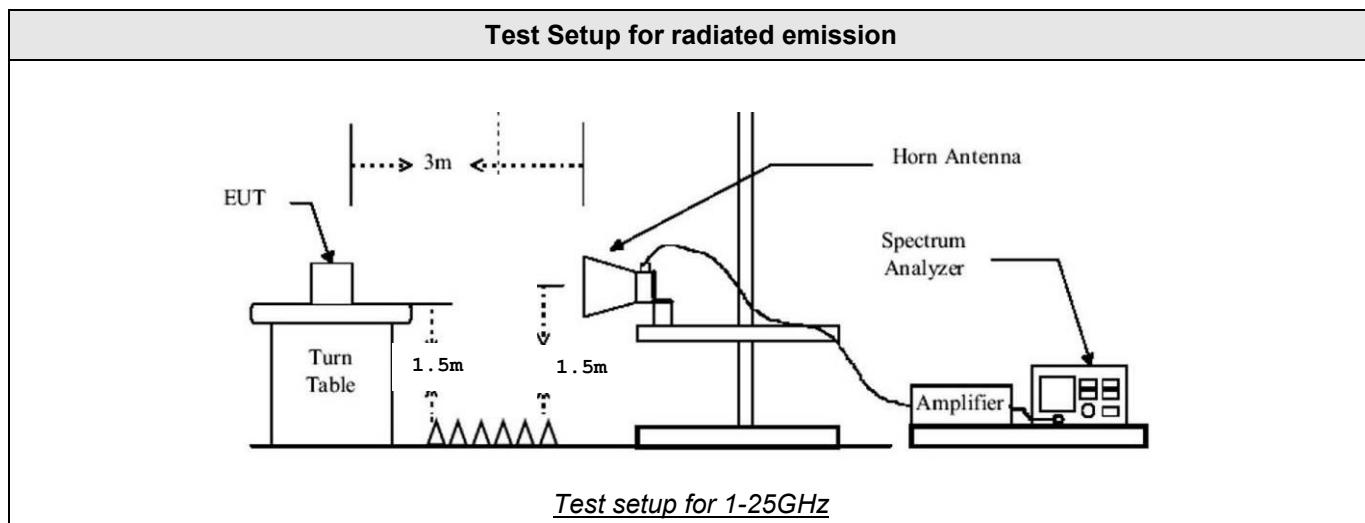
Frequency (MHz)	6dB Bandwidth (kHz)	Result
2402.0	634.94	Pass
2440.0	635.14	Pass
2480.0	636.74	Pass



## 11. Maximum Peak Output power

<b>TEST: Maximum peak conducted output power</b>			<b>Verdict</b>
Method: A radiated measurement is performed. The RBW is wide enough to capture the maximum amplitude level (1MHz). 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 Full Anechoic Chamber (FAC) that complies with ANSI C63.10. Maximum field strength (Peak) is performed by rotating the EUT 360°. 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, with a 60° rotation on each axis. (Clause 6.6.5 of ANSI C63.10). The tested equipment is set to transmit operation with modulation on low, mid and high channels.			<b>Pass</b>
Laboratory Parameters:			Required prior to the test
Ambient Temperature			20 to 30 °C
Relative Humidity			25 to 70 %
<b>Limits – FCC Part 15.247 (b) / RSS-247 §5.4 (d)</b>			
Frequency (MHz)		Limits (dB $\mu$ V/m)	
		Level / Detector	
2400 to 2483.5		36 dBm / Pk / 3m (Radiated)	
2400 to 2483.5		30 dBm / Pk (Conducted)	
Supplementary information: Test location: SMEE Test date: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC			

<b>Test Equipment Used</b>					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	Pasternack	PE302-120	CAB-131-024	2019/4	2020/4
Anechoic chamber	COMTEST	214263	CAG-141-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-002	-	-
Measuring Receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9



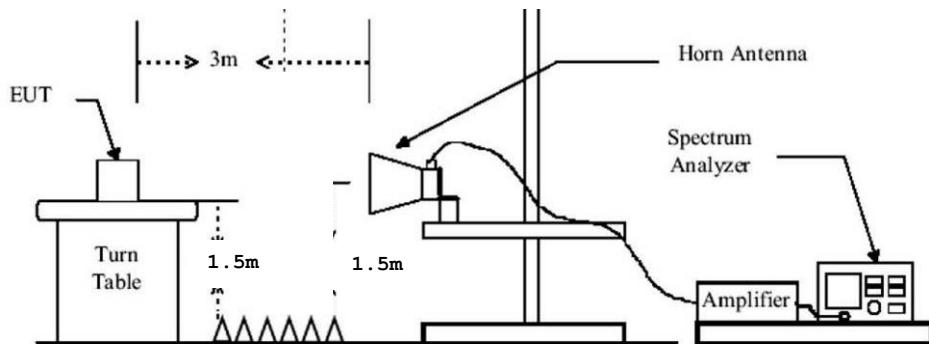
Tabulated Results for Maximum peak output power (Radiated measurement)				
FREQ (MHz)	Field Strength 3m (dB $\mu$ V/m)	Calculated EIRP (dBm)	Limit (dBm)	Result
2402	91.1	-4.1	36.0	Pass
2440	92.7	-2.5	36.0	Pass
2480	92.2	-3.0	36.0	Pass
<b>RBW:</b>	1MHz			
<b>Measurement distance:</b>	3m			
<b>Limit:</b>	FCC Part 15.247 / RSS-247			
<b>Final measurement detector:</b>	Peak			
<b>RESULT:</b>	PASS			
<b>Note:</b>	<p>(1): 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:</p> $FS = RA + AF + CF - AG$ <p>Where FS = Field Strength            RA = Receiver Amplitude            AF = Antenna Factor            CF = Cable Factor            AG = Amplifier Gain</p> <p>Total factor (dB) is AF + CF - AG            Margin value = Emission level - Limit value</p> <p>(2): EIRP is calculated using the following equation:</p> $EIRP = E + 20x\log(D) - 104.8 - GR$ <p>Where EIRP = Equivalent Isotropic Radiated Power in dBm            E = Electric field strength in dB<math>\mu</math>V/m            D = Measuring distance in meter            GR = Ground reflection in dB (0dB above 1GHz)</p>			

Tabulated Results for Maximum peak output power (Conducted)			
<b>FREQ</b> (MHz)	<b>Conducted power</b> (dBm)	<b>Limit</b> (dBm)	<b>Result</b>
2402	-4.6	30.0	<b>Pass</b>
2440	-3.0	30.0	<b>Pass</b>
2480	-3.5	30.0	<b>Pass</b>
<b>RBW:</b>	1MHz		
<b>Limit:</b>	FCC Part 15.247 / IC RSS-247		
<b>Final measurement detector:</b>	Peak		
<b>RESULT:</b>	PASS		
<b>Note:</b>	(1): Maximum conducted Peak output power is calculated as follow: $P_c = EIRP - G$ Where $P_c$ = Conducted power dBm $EIRP$ = Equivalent Isotropic Radiated Power in dBm $G$ = Antenna gain in dBi (0.5dBi, as declared by the manufacturer)		

## 12. Maximum Power Spectral Density Level in the fundamental emission

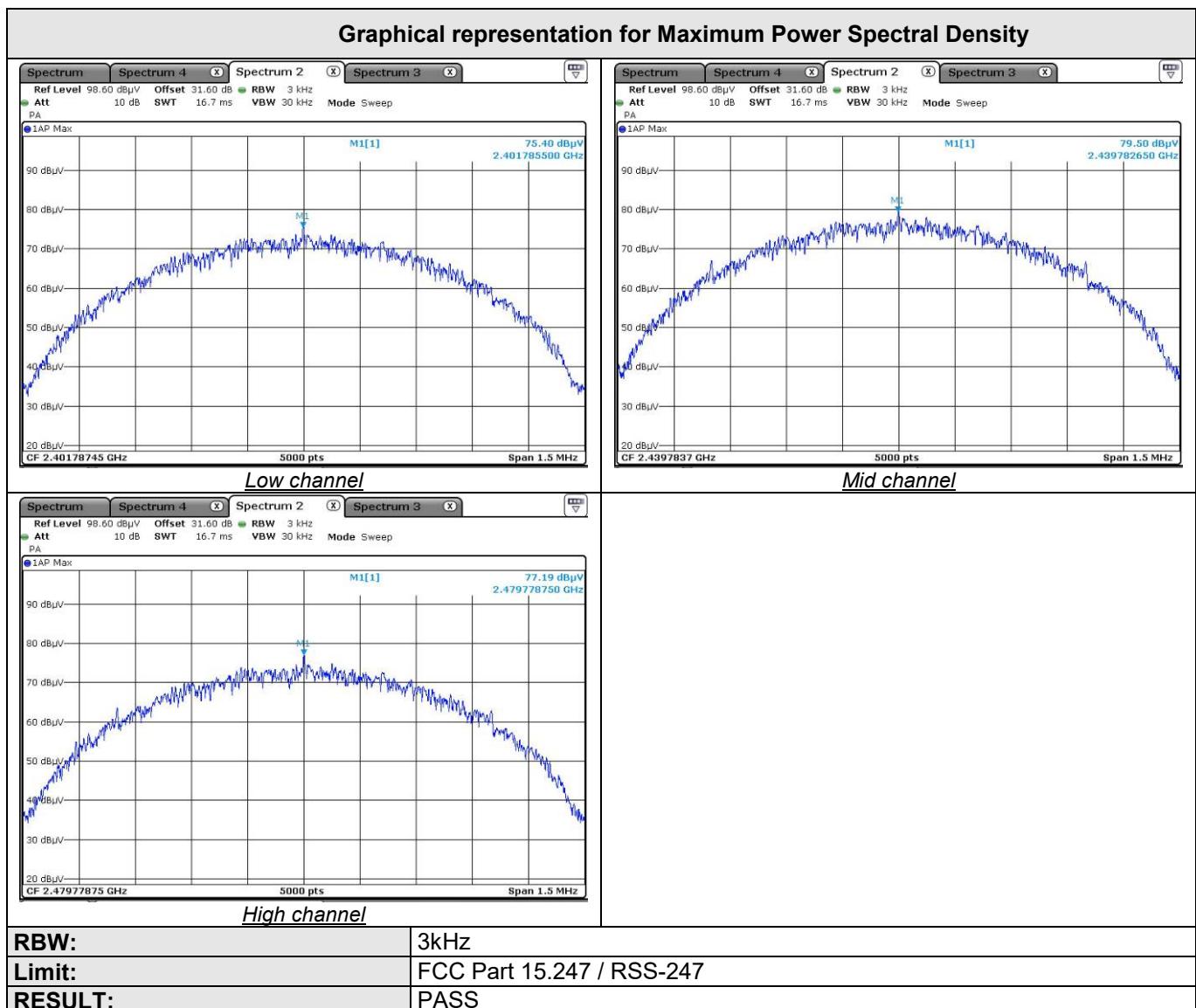
<b>TEST: Maximum Peak Power Spectral Density</b>		<b>Verdict</b>
Method: A radiated measurement is performed. The SPAN is wide enough to capture all products of the modulation process. Radiated field strength of RF Output Power is measured at 3m in a Full Anechoic Chamber (FAC) that complies with ANSI C63.10. Maximum field strength is performed by rotating the EUT 360°. 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, with a 60° rotation on each axis. (Clause 6.6.5 of ANSI C63.10). The tested equipment is set to transmit operation with modulation on low, mid and high channels.		<b>Pass</b>
Laboratory Parameters:	Required prior to the test	During the test
Ambient Temperature	20 to 30 °C	23°C ± 2
Relative Humidity	25 to 70 %	40% ± 5
<b>Limits – FCC Part 15.247 (e) / RSS-247 §5.2 (b)</b>		
Frequency (MHz)	Level (Detector)	Limit
2402	8 dBm/3kHz (Pk)	<b>Pass</b>
2440	8 dBm/3kHz (Pk)	<b>Pass</b>
2480	8 dBm/3kHz (Pk)	<b>Pass</b>
Supplementary information: Test location: SMEE Test date: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC		

<b>Test Equipment Used</b>					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	Pasternack	PE302-120	CAB-131-024	2019/4	2020/4
Anechoic chamber	COMTEST	214263	CAG-141-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-002	-	-
Measuring Receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9

**Test Setup for radiated emission**

Test setup for 1-25GHz
**Tabulated Results for Maximum Spectral Density (Radiated measurement)**

FREQ (MHz)	Field Strength 3m (dB $\mu$ V/m)	Calculated Radiated PSD (EIRP) (dBm)	Limit (dBm)	Result
2402	75.4	-19.8	-	-
2440	79.5	-15.7	-	-
2480	77.2	-18.0	-	-
<b>RBW:</b>	3kHz			
<b>Measurement distance:</b>	3m			
<b>Limit:</b>	FCC Part 15.247 / RSS-247			
<b>Final measurement detector:</b>	Peak			
<b>Note:</b>	<p>(1): 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:</p> $FS = RA + AF + CF - AG$ <p>Where FS = Field Strength RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain</p> <p>Total factor (dB) is AF + CF - AG</p> <p>Margin value = Emission level - Limit value</p> <p>(2): EIRP/PSD is calculated using the following equation:</p> $EIRP = E + 20\log(D) - 104.8 - GR$ <p>Where EIRP = Equivalent Isotropic Radiated Power in dBm E = Electric field strength in dB<math>\mu</math>V/m D = Measuring distance in meter GR = Ground reflection in dB (0dB above 1GHz)</p>			

Tabulated Results for Maximum Conducted Power Spectral Density			
Frequency (MHz)	PSD (dBm/3kHz)	Limit	Result
2402.0	-20.3	8dBm/3kHz	<b>Pass</b>
2440.0	-16.2	8dBm/3kHz	<b>Pass</b>
2480.0	-18.5	8dBm/3kHz	<b>Pass</b>
<b>RBW:</b>	3kHz		
<b>Limit:</b>	FCC Part 15.247 / RSS-247		
<b>Final measurement detector:</b>	Peak		
<b>RESULT:</b>	PASS		
<b>Note:</b>	(1): Maximum conducted power spectral density is calculated as follow: $P_{SD} = P_{SD-EIRP} - G$ Where $P_{SD}$ = Conducted power spectral density $P_{SD-EIRP}$ = Equivalent Isotropic Radiated PSD in dBm $G$ = Antenna gain in dBi (0.5dBi, as declared by the manufacturer)		

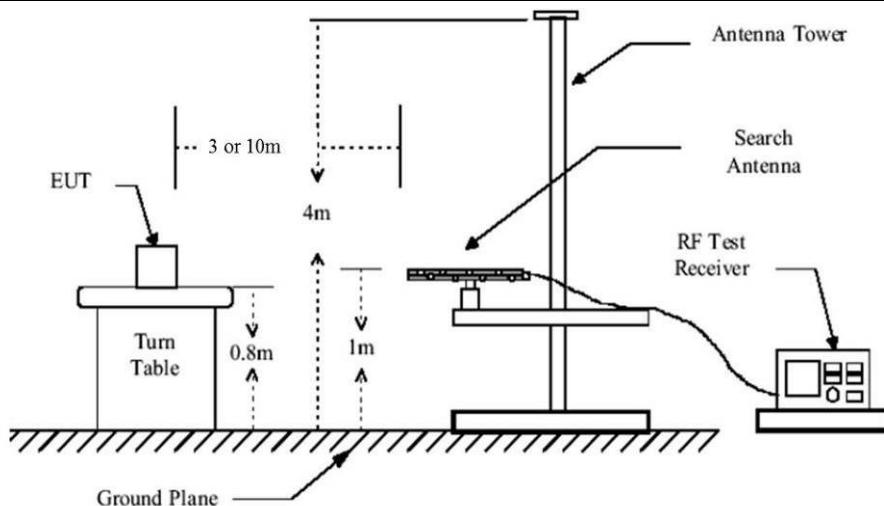


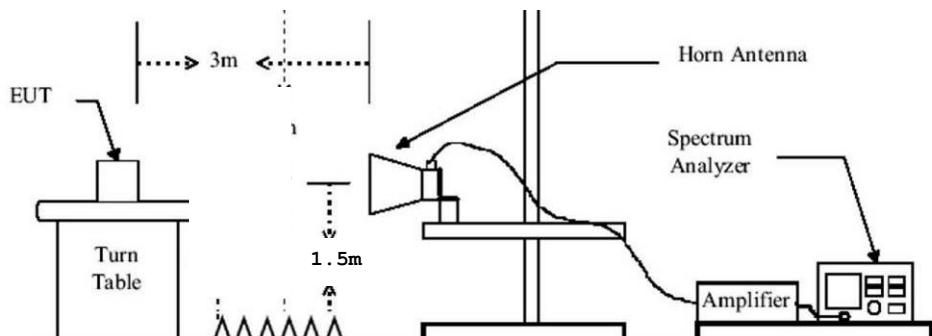
### 13. Unwanted emissions in Non-Restricted Frequency bands

TEST: Unwanted emissions in Non-Restricted Frequency Bands			Verdict
<p><b>Method:</b> Measurements were performed on a 3-meter Open Area Test Site (OATS) for frequency below 1GHz. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. Final measurements (Peak) were then performed by rotating the EUT on 360° and adjusting the receive antenna height from 1 to 4 m</p> <p>For frequency above 1GHz, final measurements were made at 3m in a Full Anechoic Chamber (FAC) that complies with ANSI C63.10. 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 in horizontal and vertical polarities.</p> <p>Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength, with 60° rotation on each axis. (Clause 6.6.5 of ANSI C63.10).</p> <p>A pre-scan frequency identification of the EUT has been performed in full anechoic chamber. The measured radiated field of the EUT is performed (or corrected) at 3-meters of distance. Antenna is 1.25-meters high. The pre-characterization graphs are obtained in PEAK detection with 360° continuous rotation of the device under test.</p>			Pass
Laboratory Parameters:		Required prior to the test	During the test
Ambient Temperature		20 to 30 °C	23°C ± 2
Relative Humidity		25 to 70 %	40% ± 5
Fully configured sample scanned over the following frequency range	Frequency range on each side of line		Measurement Point
	30MHz – 25GHz		3 m measurement distance
<b>Limits – FCC Part 15.247 (d) / RSS-247 § 5.5</b>			
Frequency (MHz)	Limits (dB $\mu$ V/m)		
	Detector / Analyser RBW	Limit	Results
30 to 25000	Pk / 100kHz	20dB below the maximum Peak level	Pass
Supplementary information: Test location: SMEC Test date: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC			

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Log-periodic antenna	EMCO	3146	ANT-191-019	2019/6	2021/6
Biconic antenna	COM-POWER	AB-900	ANT-101-003	2019/6	2021/6
BiConiLog antenna	EMCO	3142B	ANT-101-010	2019/8	2021/8
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
Horn antenna	ETS-LINDGREN	3116	ANT-161-014	2017/12	2022/12
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2019/8	2021/8
RF cable	Div	OATS/25m	CAB-101-017	2019/4	2020/4
RF cable	Pasternack RF	PE302-120	CAB-131-024	2019/4	2020/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-026	2019/4	2020/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-029	2019/4	2020/4

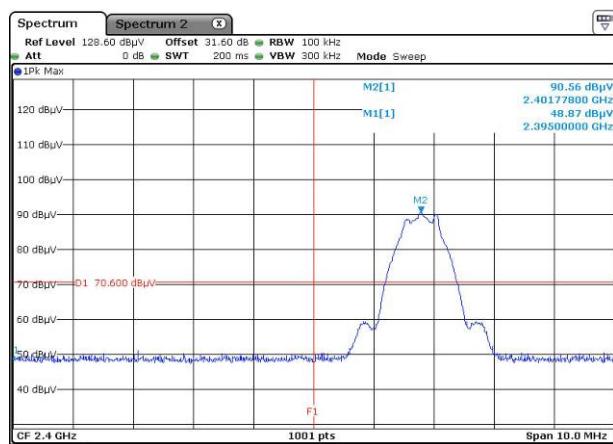
Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2019/4	2020/4
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-034	2019/4	2020/4
Pre-amplifier	Pasternack RF	PE1524	PRE-101-002	2019/6	2020/6
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2017/12	2019/12
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
OATS	Div	10m	SIT-101-001	2017/7	2020/7
Antenna mast	Innco- Systems	MA4000EP	MAT-101-001	-	-
Turntable	Innco- Systems	DS1200S	PLA-101-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring Rec	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9
EMC Software	NEXIO	BAT EMC V3.9	SOF-101-001	-	-

**Test Setup for radiated emission**

Test setup for 30-1000MHz

**Test Setup for radiated emission**

*Test setup for 1-25GHz*
**Tabulated Results for Peak Output Power Reference level**

<b>FREQ</b> (MHz)	<b>Field Strength 3m</b> (dB $\mu$ V/m)
2402.0	90.6
2440.0	92.1
2480.0	91.4
<b>RBW:</b>	100kHz
<b>Measurement distance:</b>	3m
<b>Limit:</b>	Ref. level only – For 15.247 (d) / RSS-247 § 5.5
<b>Final measurement detector:</b>	Peak
<b>Note:</b>	(1): Only for identification of limit in non-restricted band Limit is <b>70.6 dB<math>\mu</math>V/m</b> Peak for out-of-band frequencies in Non-Restricted bands (with a 100kHz RBW on the spectrum analyser)

<b>Tabulated Results for Unwanted emissions in Non-Restricted bands</b>				
<b>FREQ (MHz)</b>	<b>Field Strength 3m (dB<math>\mu</math>V/m)</b>	<b>Limit (dB<math>\mu</math>V/m)</b>	<b>Margin (dB<math>\mu</math>V/m)</b>	<b>Result (dB<math>\mu</math>V/m)</b>
2400.0	50.0	70.6	<b>-20.6</b>	<b>Pass</b>
<b>RBW:</b>	100kHz			
<b>Measurement distance:</b>	3m			
<b>Limit:</b>	FCC 15.247 / RSS-247			
<b>Final measurement detector:</b>	Peak			
<b>RESULT:</b>	PASS			
<b>Note:</b>	(1): All frequencies not specified have margin < -10dB or are below general limits. (See curves in §14) (2): Worst case between charge mode and normal used mode (3): 3-axis measurement performed for device under test.			

**Graphical representation of Band-edge compliance (LOW)**

Low bandedge compliance

Radiated Peak level is below 50dB $\mu$ V/m (limit 70.6dB $\mu$ V/m)

F1 = 2400MHz

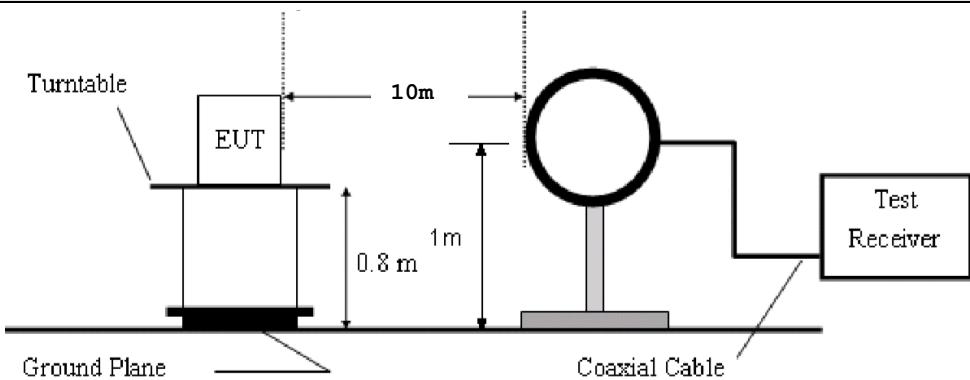
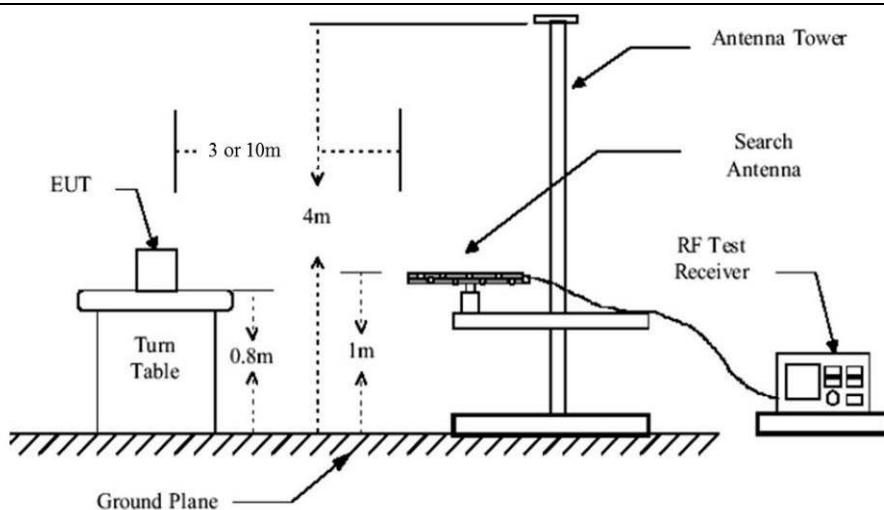
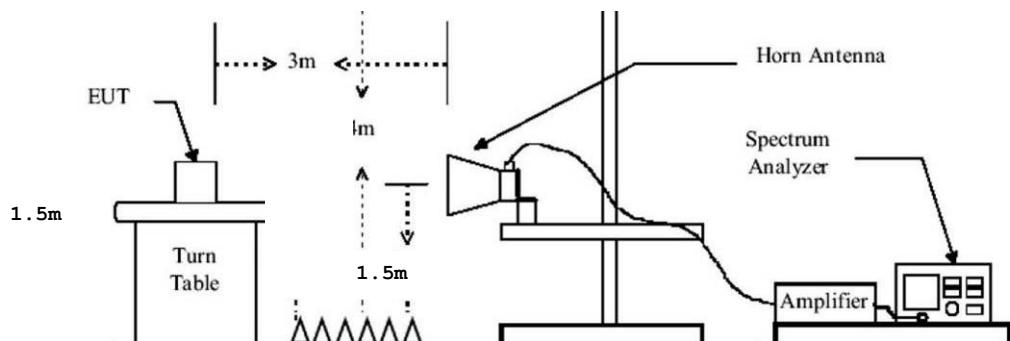
RESULT: PASS

Note: radiated measurement (3m in FAC)

## 14. Unwanted emissions in Restricted Frequency bands

<b>TEST: Unwanted emissions into Restricted Frequency Bands</b>		<b>Verdict</b>
<p><u>Method:</u> Measurements were performed on a 3-meter Open Area Test Site (OATS) for frequency below 1GHz. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. Final measurements (Peak) were then performed by rotating the EUT on 360° and adjusting the receive antenna height from 1 to 4 m</p> <p>For frequency above 1GHz, final measurements were made at 3m in a Full Anechoic Chamber (FAC) that complies with ANSI C63.10. 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 in horizontal and vertical polarities.</p> <p>Three orthogonal axis measurements on EUT are performed to obtain the maximum peak field strength, with 60° rotation on each axis.(Clause 6.6.5 of ANSI C63.10).</p> <p>A pre-scan frequency identification of the EUT has been performed in full anechoic chamber. The measured radiated field of the EUT is performed (or corrected) at 3-meters of distance. Antenna is 1.25-meters high. The pre-characterization graphs are obtained in PEAK detection with 360° continuous rotation of the device under test.</p>		<b>Pass</b>
Laboratory Parameters:	Required prior to the test	During the test
Ambient Temperature	20 to 30 °C	23°C ± 2
Relative Humidity	25 to 70 %	40% ± 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
<b>Limits – FCC Part 15.205, 15.209 (a), 15.247 (d) / RSS-GEN §8.9, §8.10, RSS-247 §5.5</b>		
Frequency (MHz)	Limits (dB $\mu$ V/m)	
	Level / Detector / Distance	Results
0.009 to 0.090	107.6 – 87.6 / AV / 10m 127.6 – 107.6 / PK / 10m	<b>Pass</b>
0.090 to 0.110	87.6 – 85.9 / QP / 10m	<b>Pass</b>
0.110 to 0.490	85.7 – 72.9 / AV / 10m 105.7 – 92.9 / PK / 10m	<b>Pass</b>
0.490 to 1.705	52.9 – 42.1 / QP / 10m	<b>Pass</b>
1.705 to 30	48.6 / QP / 10m	<b>Pass</b>
30 to 88	40.0 / QP / 3m	<b>Pass</b>
88 to 216	43.5 / QP / 3m	<b>Pass</b>
216 to 960	46.0 / QP / 3m	<b>Pass</b>
960-1000	54.0 / QP / 3m	<b>Pass</b>
Above 1GHz	54.0 / AV / 3m 74.0 / PK / 3m	<b>Pass</b>
Supplementary information: Test location: SMEC Test date: November 14th, 2019. Tested by L. CHAPUS Power supply voltage: 3.3V (Module) from PC		

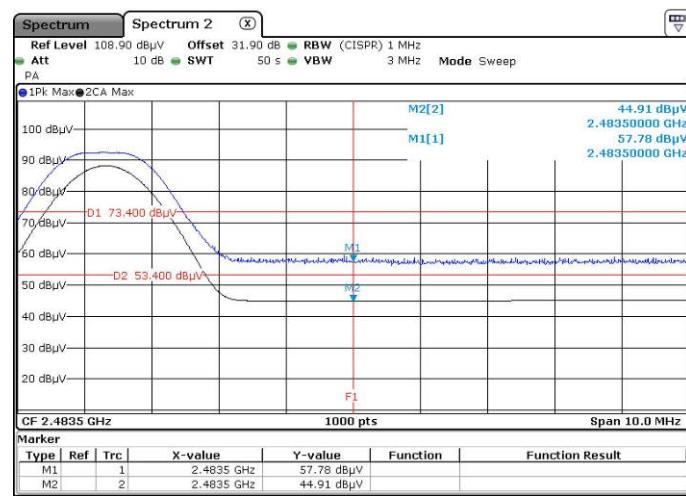
Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Log-periodic antenna	EMCO	3146	ANT-191-019	2019/6	2021/6
Biconic antenna	COM-POWER	AB- 900	ANT-101-003	2019/6	2021/6
Loop antenna	EMCO	6502	ANT-101-009	2019/8	2021/8
BiConiLog antenna	EMCO	3142B	ANT-101-010	2019/8	2021/8
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
Horn antenna	ETS-LINDGREN	3116	ANT-161-014	2017/12	2022/12
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2019/8	2021/8
RF cable	Div	OATS/25m	CAB-101-017	2019/4	2020/4
RF cable	Pasternack RF	PE302-120	CAB-131-024	2019/4	2020/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-026	2019/4	2020/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-029	2019/4	2020/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2019/4	2020/4
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-034	2019/4	2020/4
Pre-amplifier	Pasternack RF	PE1524	PRE-101-002	2019/6	2020/6
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2017/12	2019/12
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
OATS	Div	10m	SIT-101-001	2017/7	2020/7
Antenna mast	Innco- Systems	MA4000EP	MAT-101-001	-	-
Turntable	Innco- Systems	DS1200S	PLA-101-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring Rec	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9
EMC Software	NEXIO	BAT EMC V3.9	SOF-101-001	-	-

**Test Setup for radiated emission**

Test setup for 9k-30MHz

Test setup for 30-1000MHz

Test setup for 1-25GHz

Tabulated Results for Unwanted emissions (9kHz-30MHz)						
FREQ	RF field @ 30m	Limit @ 30m	Margin	Antenna angle	Table angle	Correc. Fact. (CF)
MHz	(QP) dB $\mu$ V/m	(QP) dB $\mu$ V/m	dB	Degree	Degree	dB
Levels are at least 10dB below limits						
Supplementary information:						
Frequency list measured on the Open Area Test Site has been created with pre-scan results.						
<b>Frequency band investigated:</b>		9kHz-30MHz				
<b>RBW:</b>		200Hz (9kHz-150kHz) 9kHz (150kHz-30MHz)				
<b>Measurement distance:</b>		10m				
<b>Limit:</b>		FCC Part 15.205 - 15.209 / RSS-GEN				
<b>Final measurement detector:</b>		Peak / Quasi-Peak / Average				
<b>Note:</b>		CF: Correction factor = Antenna factor + Cable loss Measure have been done at 10m distance and corrected according to requirements of 15.209.e) (M@30m = M@10m-19.1dB)				

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) dB $\mu$ V	(Pk) dB $\mu$ V	dB	(QP) dB $\mu$ V/m	(Pk) dB $\mu$ V/m		cm	Degré	(QP) dB $\mu$ V/m	dB
Levels are at least 10dB below limits										
Supplementary information:										
Frequency list measured on the Open Area Test Site has been created with pre-scan results.										
<b>Frequency band investigated:</b>		30MHz-1GHz								
<b>RBW:</b>		120kHz								
<b>Measurement distance:</b>		3m								
<b>Limit:</b>		FCC Part 15.205 - 15.209 / RSS-GEN								
<b>Final measurement detector:</b>		Quasi-Peak								
<b>RESULT:</b>		PASS								
<b>Note:</b>		(1): All frequencies not specified have margin < -10dB (for peak and average detector)								

Tabulated Results for Unwanted emissions (1GHz-25GHz)					
FREQ (MHz)	Field Strength 3m (dB $\mu$ V/m)	Detector	Limit (dB $\mu$ V/m)	Margin (dB $\mu$ V/m)	Result
2483.5	60.0	Pk	74	-14.0	<b>Pass</b>
2483.5	44.9	Avg	54	-9.1	<b>Pass</b>
3202.5	49.0	Pk	74	-25.0	<b>Pass</b>
3202.5	44.1	Avg	54	-9.9	<b>Pass</b>
3305.5	46.9	Pk	74	-27.1	<b>Pass</b>
3305.5	44.0	Avg	54	-10.0	<b>Pass</b>
4804.0	51.4	Pk	74	-22.6	<b>Pass</b>
4804.0	48.2	Avg	54	-5.8	<b>Pass</b>
4882.0	50.3	Pk	74	-23.7	<b>Pass</b>
4882.0	47.9	Avg	54	-6.1	<b>Pass</b>
4960.0	50.0	Pk	74	-24.0	<b>Pass</b>
4960.0	47.1	Avg	54	-6.9	<b>Pass</b>
<b>RBW:</b>	1MHz				
<b>Measurement distance:</b>	3m				
<b>Limit:</b>	FCC Part 15.205, 15.209, 15.247 / RSS-Gen, RSS-247				
<b>Final measurement detector:</b>	Peak / CISPR Average				
<b>RESULT:</b>	PASS				
<b>Notes:</b>	(1): All frequencies not specified have margin < -10dB (for peak and average detector)				

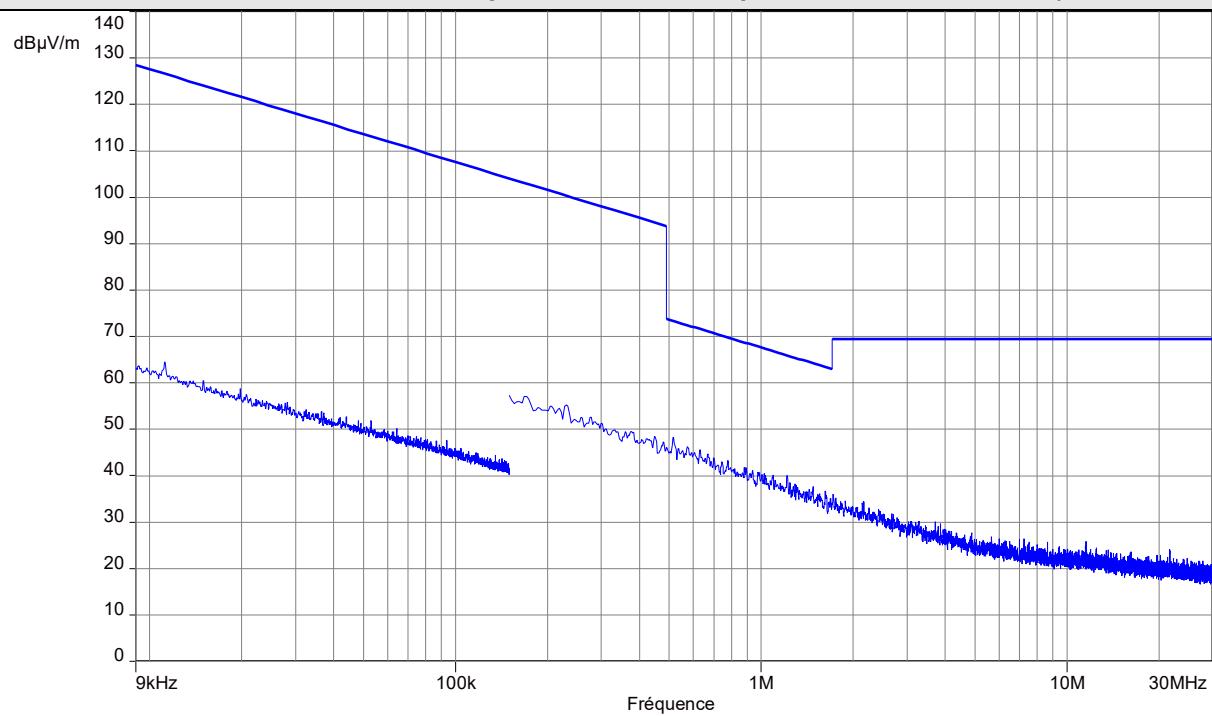
**Graphical representation of Band-edge compliance (HIGH)**

High bandedge compliance

Radiated Peak level is below 60dB $\mu$ V/m for frequency above 2483.5MHz (limit 74dB $\mu$ V/m)

Radiated Average level is 44.9dB $\mu$ V/m (limit 54dB $\mu$ V/m, CISPR Average detector measurement)

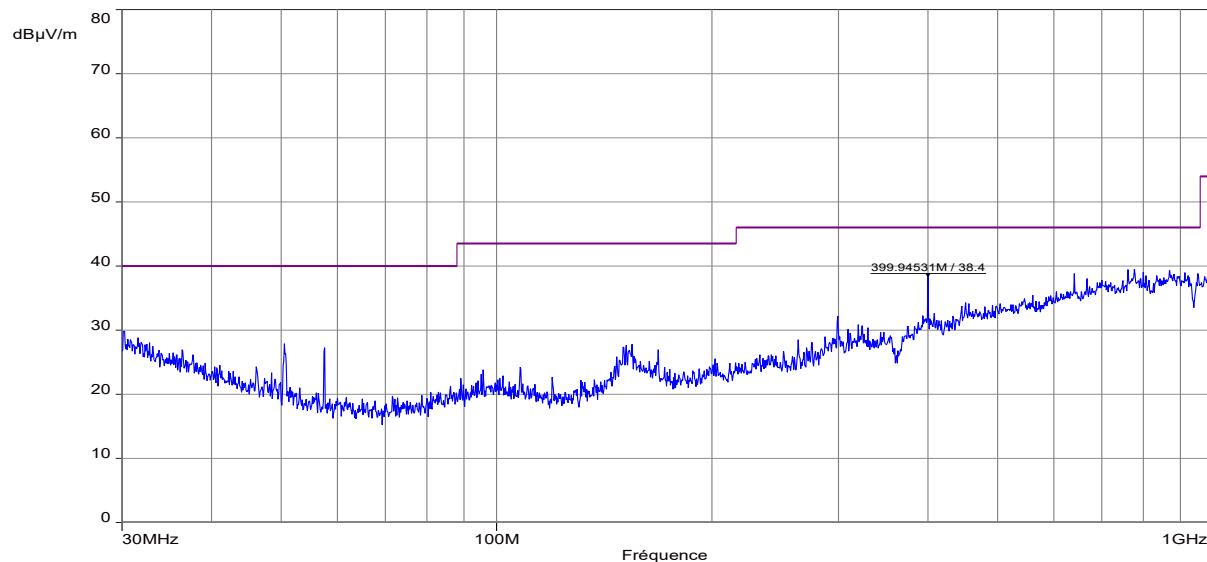
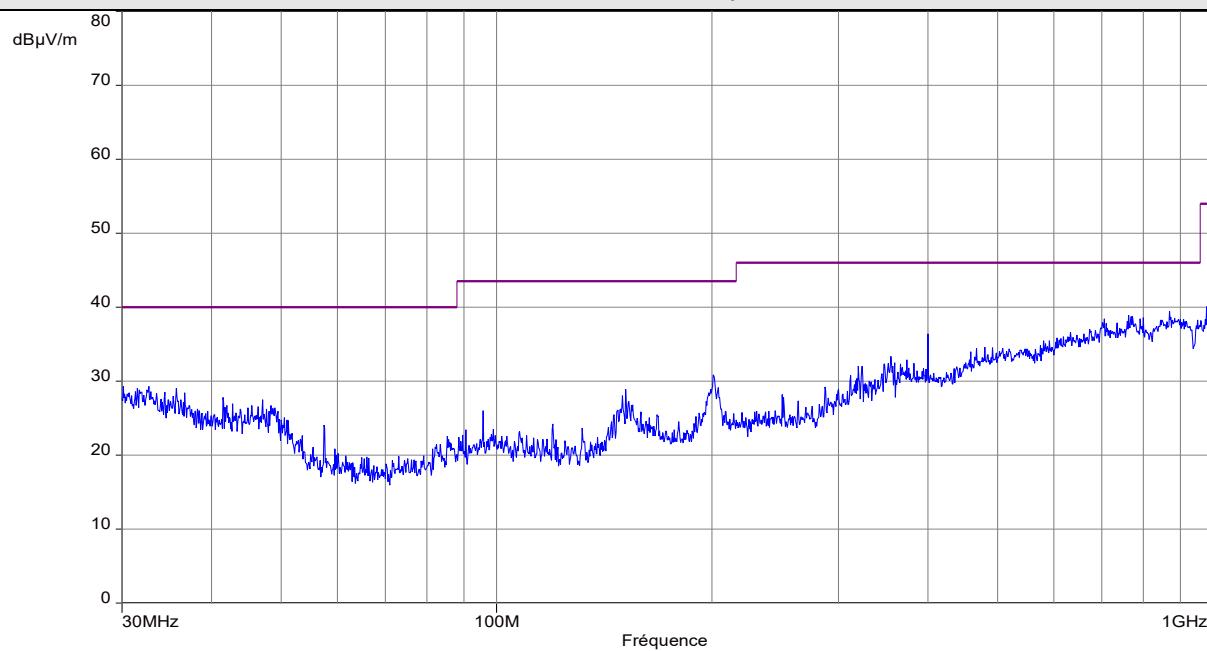
RESULT: PASS

Note: Radiated measurement (FAC/3m)

**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.

<b>Frequency band investigated:</b>	9kHz-30MHz
<b>Unit :</b>	dB $\mu$ V/m
<b>RBW :</b>	200Hz (9kHz-150kHz) 9kHz (150kHz-30MHz)
<b>Antenna polarization :</b>	Parallel & Perpendicular to measurement axis
<b>Measurement detector:</b>	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

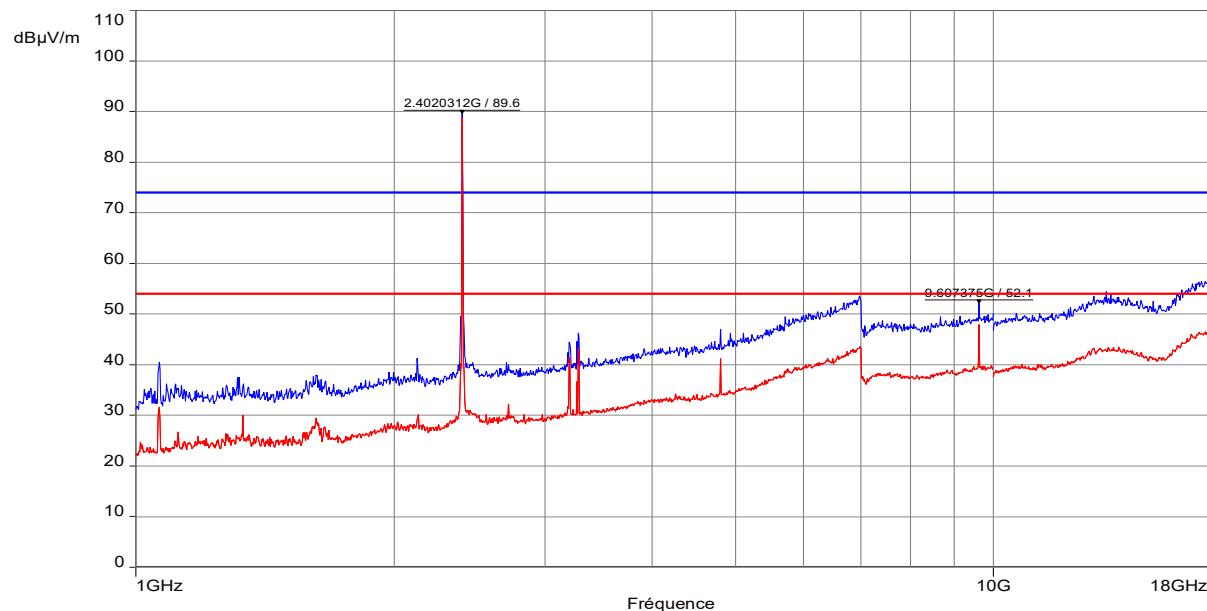
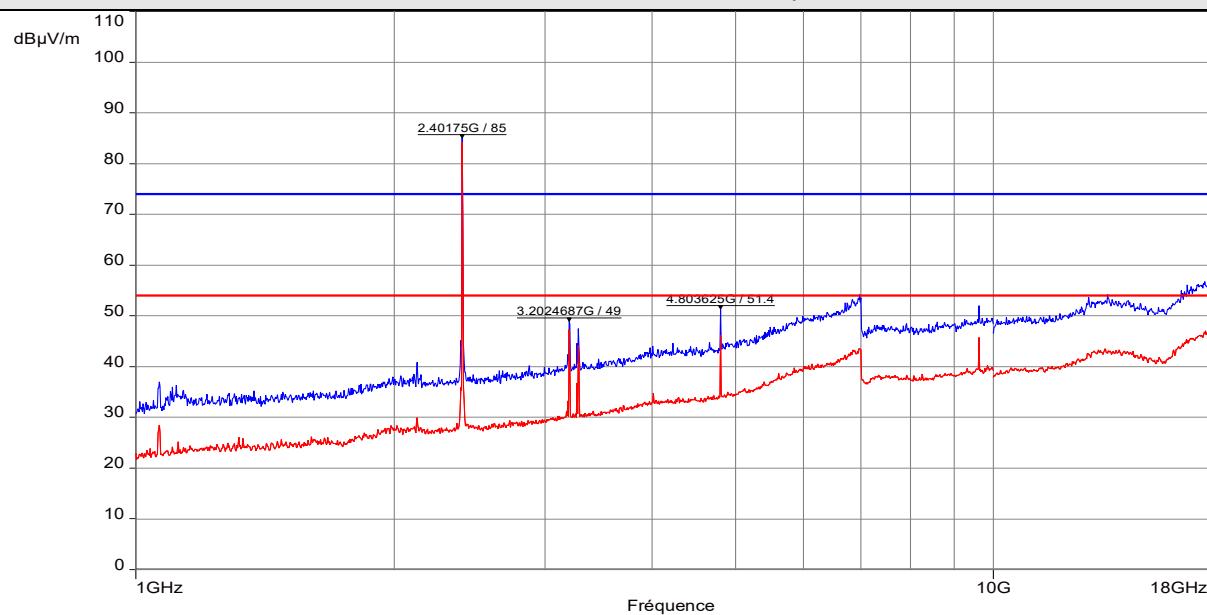
**RBW :** 100kHz

**Antenna polarization :** Horizontal & Vertical

**Measurement detector:** Peak

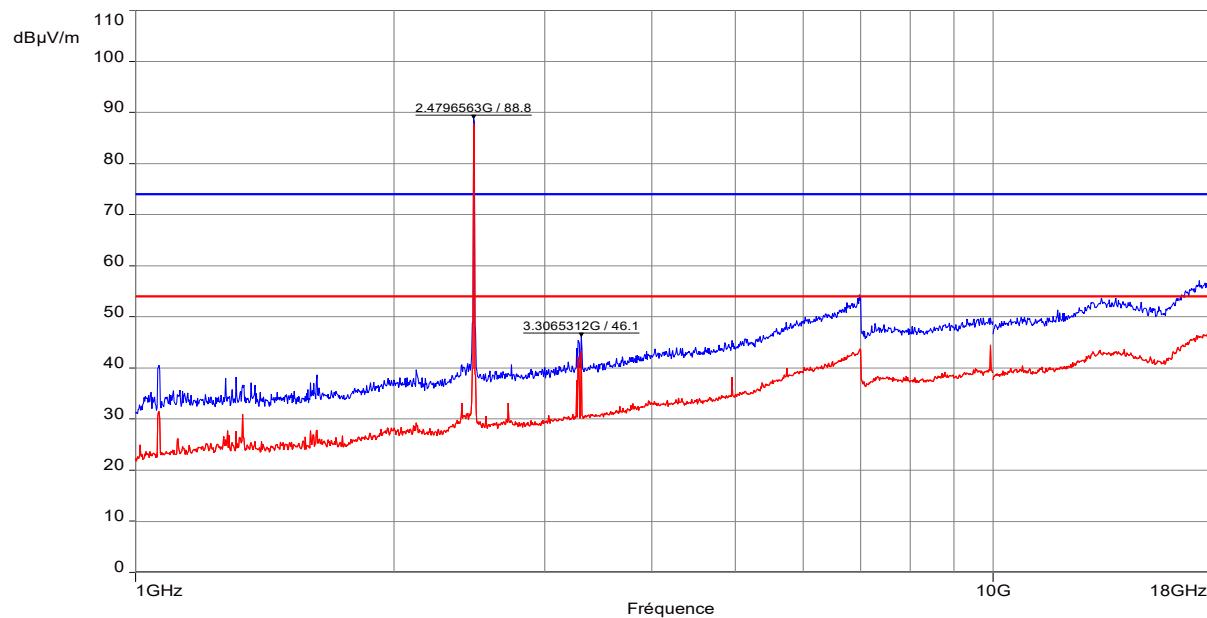
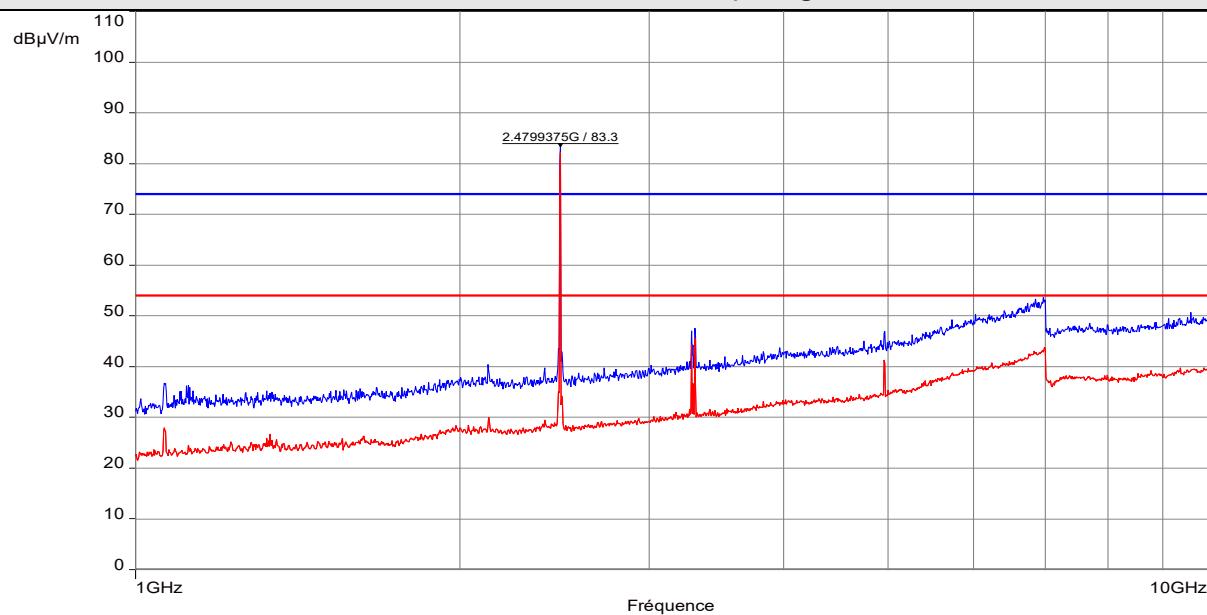
**PEAK LIST FROM PRE-SCAN**

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) – Low channel**


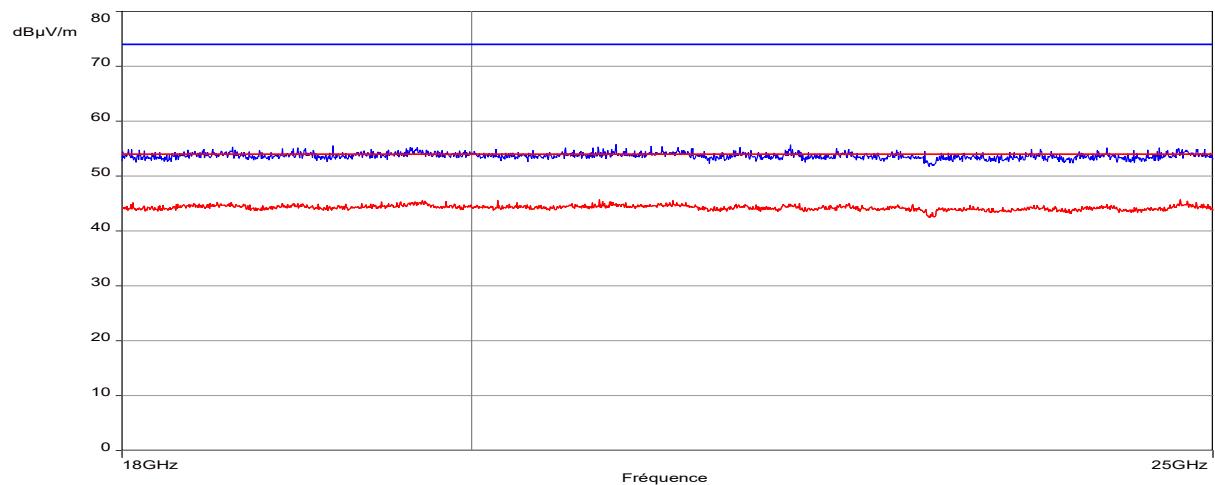
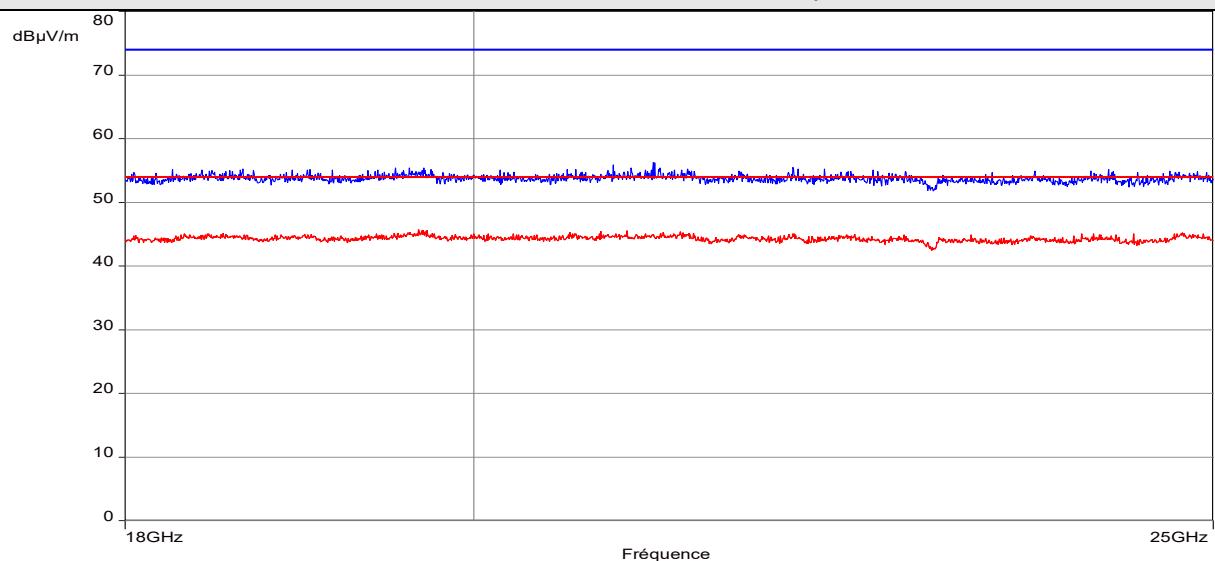
Note: Pre-scan graph only for identification purpose. Worst case position shown.

----- : Peak measure	----- : Average measure
<b>Frequency band investigated:</b>	1GHz-18GHz
<b>Unit :</b>	dBμV/m
<b>RBW :</b>	1MHz
<b>Antenna polarization :</b>	Horizontal & Vertical
<b>Measurement detector:</b>	Peak / Average

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


Note: Pre-scan graph only for identification purpose. Worst case position shown.

----- : Peak measure	----- : Average measure
<b>Frequency band investigated:</b>	1GHz-18GHz
<b>Unit :</b>	dB $\mu$ V/m
<b>RBW :</b>	1MHz
<b>Antenna polarization :</b>	Horizontal & Vertical
<b>Measurement detector:</b>	Peak / Average

**Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 18GHz-25GHz / 3m / Horizontal & Vertical/ Transmit mode)**


Note: Pre-scan graph only for identification purpose. Pre-scan performed at 1m.  
 Same result for transmit mode on all channels.

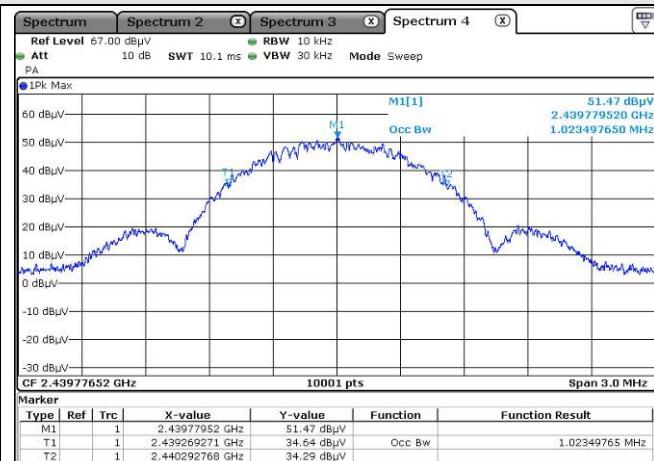
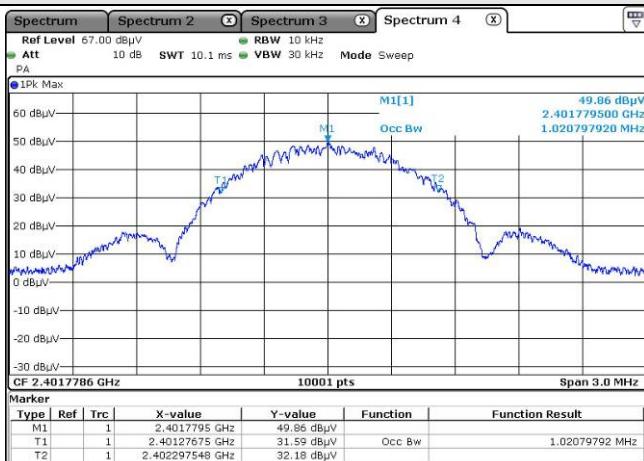
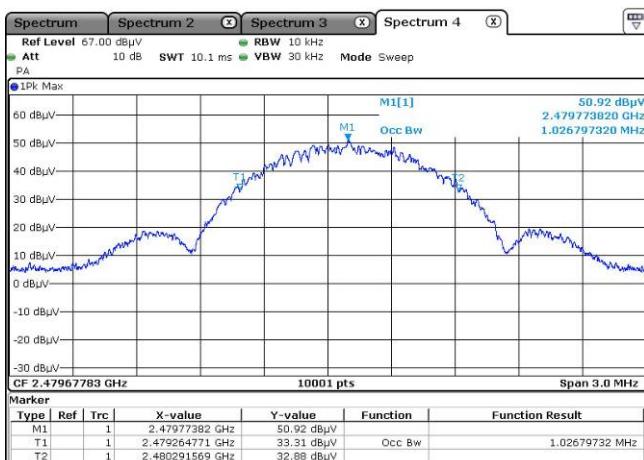
----- : Peak measure	----- : Average measure
<b>Frequency band investigated:</b>	18GHz-25GHz
<b>Unit :</b>	dBμV/m
<b>RBW :</b>	1MHz
<b>Antenna polarization :</b>	Horizontal & Vertical
<b>Measurement detector:</b>	Peak / Average

## 15. Occupied bandwidth (99%)

TEST: Occupied bandwidth (99%) / RSS-GEN			Verdict									
<p><u>Method:</u> 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 occupied bandwidth, with <math>VBW \geq 3 \times RBW</math>.</p> <p>The SPAN is wide enough to capture all products of the modulation process.</p> <p>A MaxHold Peak detector is used.</p> <p>Measure is performed with OBW 99% function of the spectrum analyser.</p> <p>The tested equipment is set to transmit operation with modulation on low, mid and high channels.</p>												
<p>Laboratory Parameters:</p> <table> <tr> <td>Laboratory Parameters:</td> <td>Required prior to the test</td> <td>During the test</td> </tr> <tr> <td>Ambient Temperature</td> <td>20 to 30 °C</td> <td>23°C ± 2</td> </tr> <tr> <td>Relative Humidity</td> <td>25 to 70 %</td> <td>40% ± 5</td> </tr> </table>			Laboratory Parameters:	Required prior to the test	During the test	Ambient Temperature	20 to 30 °C	23°C ± 2	Relative Humidity	25 to 70 %	40% ± 5	Pass
Laboratory Parameters:	Required prior to the test	During the test										
Ambient Temperature	20 to 30 °C	23°C ± 2										
Relative Humidity	25 to 70 %	40% ± 5										
<p>Supplementary information:</p> <p>Test location: SMEE</p> <p>Test date: November 14th, 2019. Tested by L. CHAPUS</p> <p>Power supply voltage: 3.3V (Module) from PC</p>												

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2019/4	2020/4
RF cable	Pasternack	PE302-120	CAB-131-024	2019/4	2020/4
Anechoic chamber	COMTEST	214263	CAG-141-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-002	-	-
Measuring Receiver	Rohde&Schwarz	ESRP	REC-151-002	2019/9	2021/9

Tabulated Results for Occupied Bandwidth	
Frequency (MHz)	99% Occupied Bandwidth (MHz)
2402.0	1.021
2440.0	1.023
2480.0	1.027

**Graphical representation of Occupied Bandwidth**

**Low Channel**
**Mid Channel**

**High Channel**
**Frequency band investigated:** 2400MHz to 2483.5MHz

**RBW / VBW :** 10kHz / 30kHz

**Measurement detector:** Peak