

FCC Test Firm Designation Number: FR0014
Industry Canada Test Firm Number: Site# 9545A-1 / 9545A-2

Matériel testé :
Equipment under test:

SORHEA / PIRAMID CONNECT (PIRAMID XL3)
(Trademark / Marketing name or product reference)

Client / Demandeur:
Customer / Applicant : **SORHEA**
M. Aymeric CARADEC
1, rue du Dauphiné
69120 Vaulx-En-Velin - France

Fabricant :
Manufacturer: **SORHEA**
1, rue du Dauphiné
69120 Vaulx-En-Velin - France

Numéro d'affaire :
Work number : 12407

Référence de la proposition :
Proposal number: 032018-22954

Date de l'essai :
Date of test: 8 octobre 2018
October 8th, 2018

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 2400-2483.5 MHz)

Lieu du test:
Test location: SMEE, Rue de Taille
38500 VOIRON - France

Test réalisé par :
Test realized by: Laurent CHAPUS

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

Ed.	Date	Modifications Pages	Written by : Visa	Approved by: Visa
1	January 30 th , 2019	Initial Edition	Laurent Chapus	Régis ANCEL

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COORDONNEES

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1. Normatives References

FCC qualification according to:		
Standards	Applied	Title
ANSI C63.4 (2014)	X	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
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
ICES-003 (Issue 6/2016)	X	Information Technology Equipment (ITE) – Limits and methods of measurement
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 v05
- Determining ERP and EIRP Guidance 412172 D01 v01r01

Deviation from standard: None

2. Test synthesis

TEST	Paragraph number FCC Part 15 / IC RSS-247 / RSS-GEN	Spec. FCC Part 15 / IC RSS-247 / RSS-GEN	RESULTS (comments)
Conducted emissions test	15.207 (a) RSS-Gen § 8.8	Table 15.107 (a) Table 4 / RSS-Gen	PASS
Radiated emission test	15.209 (a) ICES-003	Table 15.209 (a) Table 5 , § 6.2	PASS
6dB Bandwidth	15.247 (a) (2) RSS-247 § 5.2 (a)	At least 500kHz	PASS
Maximum Peak Output Power	15.247 (b) (3) 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 § 7.1, §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	PASS
Occupied Bandwidth	RSS-GEN § 6.7	BW at 99%	PASS

- General conclusion:**

Measures and tests performed on the sample of the product **SORHEA PIRAMID CONNECT (PIRAMID XL3)** , in configuration and description presented in this test report, show compliance with standards FCC CFR 47, PART 15, Subpart C and ISSED RSS-Gen & RSS-247.

3. Equipment Under Test (EUT)

Nom /
Identification

PIRAMID CONNECT (PIRAMID XL3)

Sn: CEM2

FCC ID:
IC:
Model:

FCC ID: QVA-PIRCONNECT
IC: 11664A-PIRCONNECT
HVIN: PIRAMID XL3

Alimentation /
Power supply

12V DC from external power supply

AC/DC power adapter used for test: Dong Guan City GangQi Electronic Co
Model:GQ15-120100-AG
Input:100-240 V -50/60 Hz 0.5Amax
Output:12V/1.0A (1m cable)

Auxiliaires /
Auxiliaries

None

Entrées-Sorties /
Input / Output

	Câbles pour essai / Cables for test	Blindé / Shielded	Prévu pour >3m / Intended for >3m
DC input cable (12V)	2 wires / 1m	No	Yes
Relay outputs (C/NC/NO)	6 wires / 1m	No	Yes

Version programme /
Firmware version

NC

Mode de fonctionnement /
Running mode

The tested sample is able to:

- Transmit a carrier frequency on low, middle and high channels (Bluetooth Low Energy)
- The microwave radar carrier frequency is always ON during testing (10.531GHz)

Programme de test /
Test program /

None

Fréquence max interne EST /
Max internal EUT frequency

50MHz (Except RF frequency)

Information sur l'équipement /
Equipment information

- ISM Frequency band: 2400 to 2483.5 MHz (Tx & Rx, Wideband Data Transmission systems)
- BLE Power Setting: Power is set at its maximum rated output power (+3dBm)
- Modulation: Bluetooth Low Energy
- Antenna type: Integral (PCB trace, peak gain 0dBi)
- Powered by 12V DC from external power supply
- Equipment intended for use as a fixed station
- Equipment designed for continuous operation

4. Test conditions

Power supply voltage:

12V DC

Equipment under test:

230V/50Hz (Radiated emission)

Auxiliaries:

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

8. Field Strength Calculation

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

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

Where FS = Field Strength (Level)

RA = Receiver Amplitude (Meter Reading)

AF = Antenna Factor

CF = Cable Factor

AG = Amplifier Gain

Margin value = Emission level – Limit value

Example:

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

→ Total factor: 5dBm⁻¹

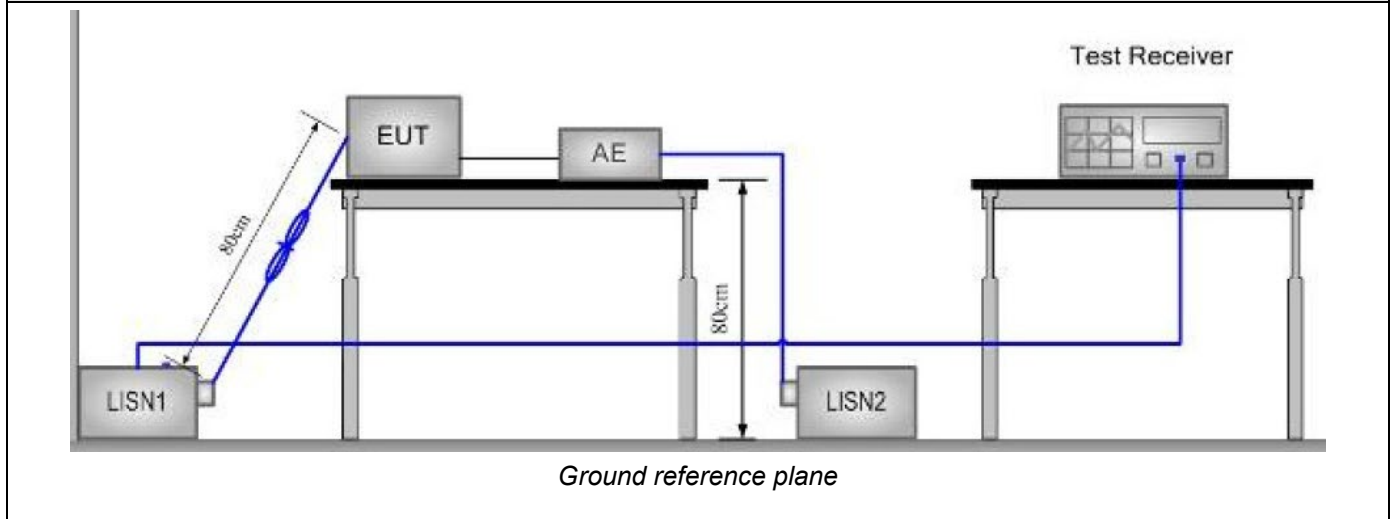
→ Field level: 19.0dBμV/m (-21.0dB for margin if limit is 40dBμV/m)

9. 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		22°C ± 2
Relative Humidity		25 to 70 %		56% ± 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) Power adapter
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: October 8 th , 2018. Tested by L. CHAPUS Power supply voltage: 12V from power adapter (AC mains 110V/60Hz)				

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Attenuator / limiter	SMEE	ATT#2	ATT-171-010	2018/6	2019/6
Cable RF	Div	1m	CAB-101-021	2018/4	2019/4
LISN (50Ω / 50µH) (Meas.)	AFJ	LS16C	RSI-101-001	2017/6	2019/6
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2017/5	2019/5
EMC Software	NEXIO	BAT EMC V3.8	SOF-101-001	-	-
AC power supply	PACIFIC POWER	AMX-125	ALI-101-002	-	-

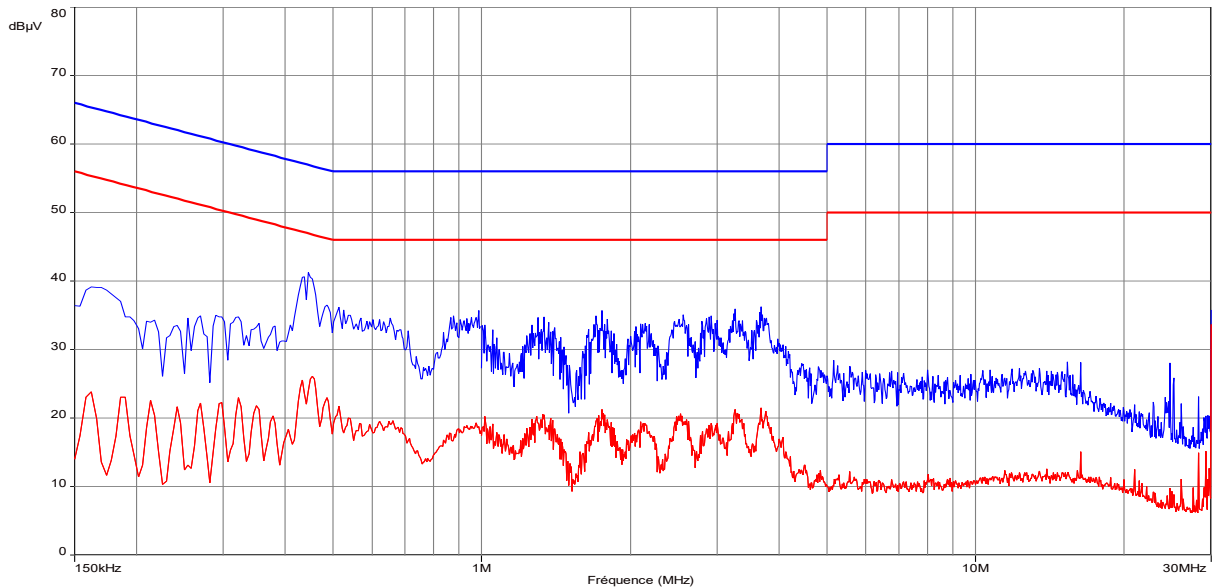
Test Setup for conducted emission



Tabulated Results for Mains Terminal Disturbance Voltage on AC port

FREQ (MHz)	Meas. PK (dBμV)	Meas. QP (dBμV)	LIMIT QP (dBμV)	Margin QP (dB)	Mes. AV (dBμV)	LIMIT AV (dBμV)	Margin AV (dB)	Line
Levels are at least 20dB below limits								L1 / N
Frequency band investigated:		150kHz-30MHz						
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: $\text{Meas.} = \text{RA} + \text{CF} + \text{ATT}_{\text{TRAN}} + \text{ATT}_{\text{LISN}}$ Where Meas. = Level (dBμV) RA = Receiver Amplitude CF = Cable Factor ATT_{TRAN} = Transient suppressor attenuation ATT_{LISN} = LISN attenuation Margin value = Emission level – Limit value (A negative margin shows compliance to limit)						

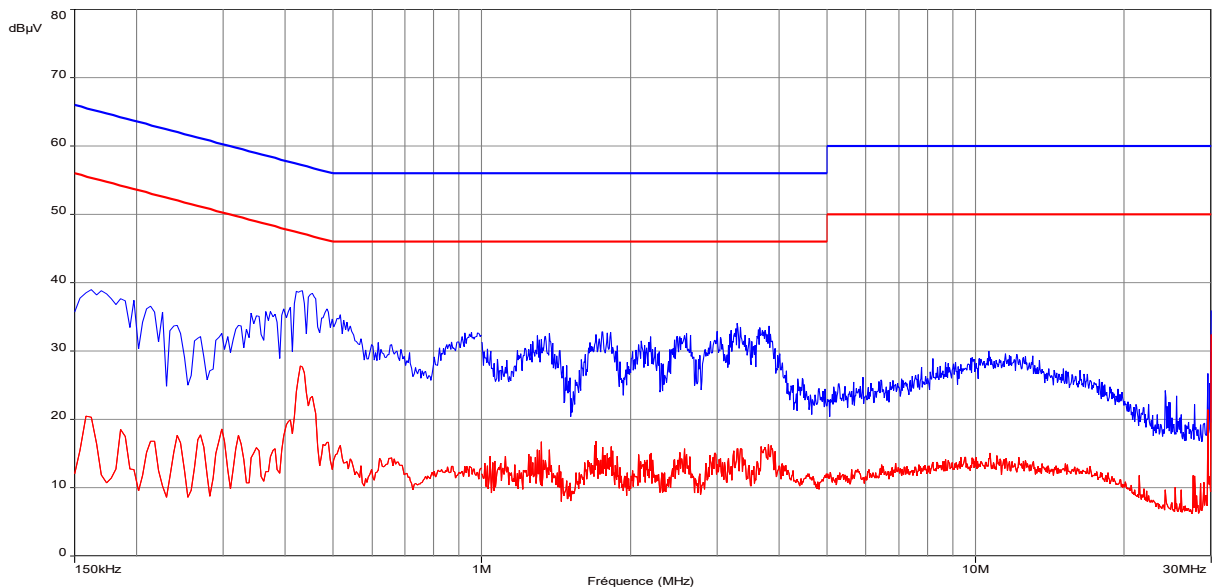
Graphical representation of Conducted Disturbance Measurement (Peak and Average detection) AC port, Line L1 – Power adapter



----: Peak

----: Average

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



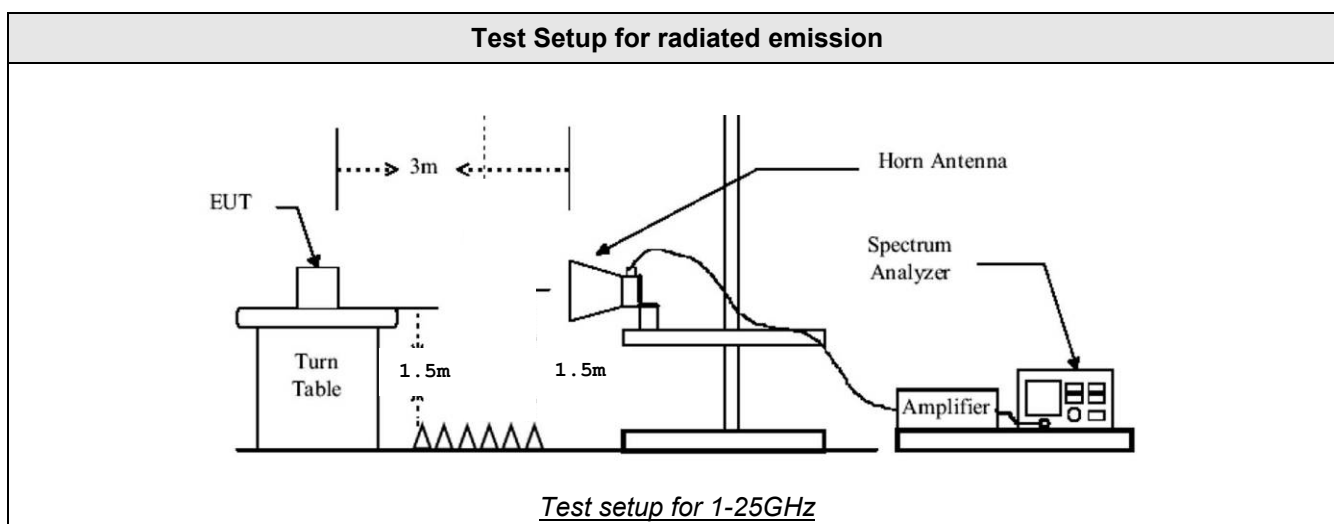
----: Peak

----: Average

10. 6dB Bandwidth

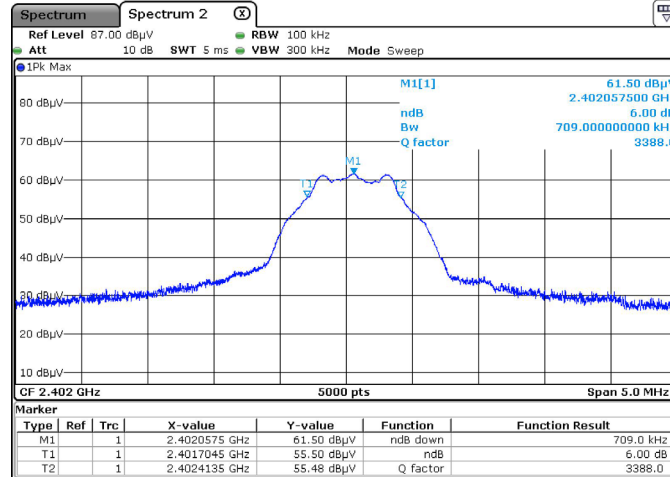
TEST: 6dB Bandwidth		Verdict	
<u>Method:</u> The setup is in an anechoic chamber. The spectrum analyzer is connected to the measuring antenna. A radiated measurement is performed. The RBW is 100kHz, with VBW ≥ 3 x RBW. The SPAN is wide enough to capture all products of the modulation process. A MaxHold 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		22°C ± 2
Relative Humidity	25 to 70 %		56% ± 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: October 8 th , 2018. Tested by L. CHAPUS			

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	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2017/5	2019/5

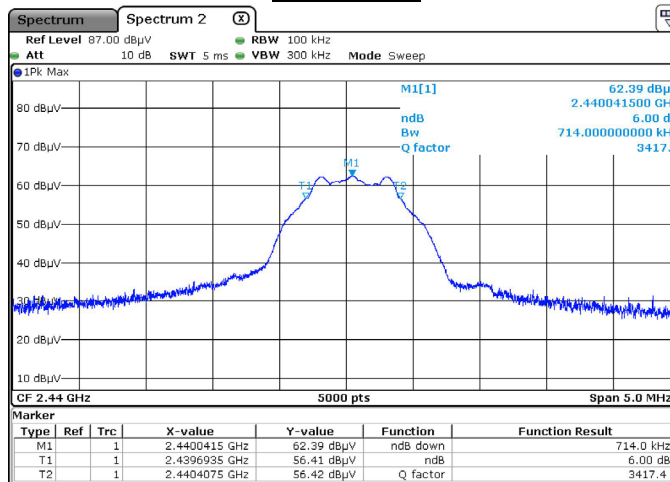


Tabulated Results for Occupied Bandwidth		
Frequency (MHz)	6dB Bandwidth (kHz)	Result
2402.0	709.0	Pass
2440.0	714.0	Pass
2480.0	717.0	Pass

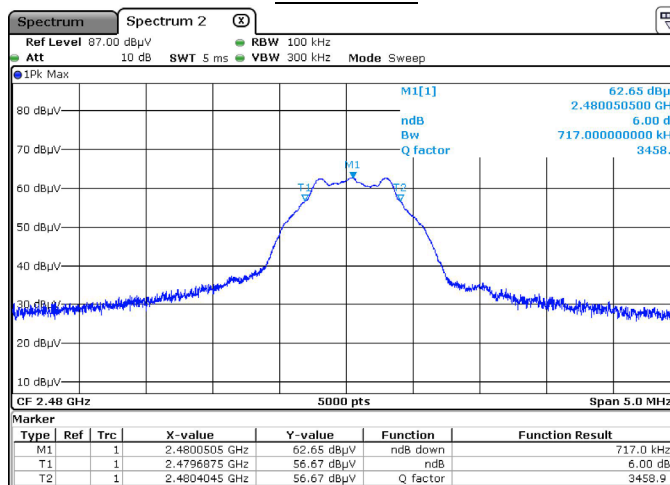
Graphical representation of 6dB Bandwidth



Low channel



Mid channel



High channel

Frequency band investigated: 2400MHz to 2483.5MHz

RBW : 100kHz

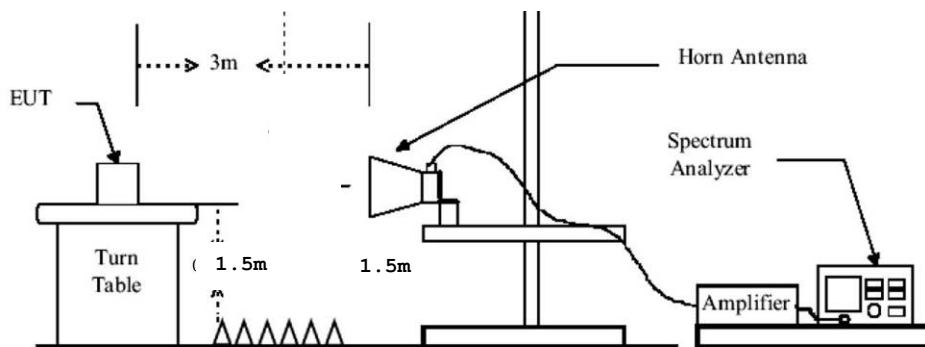
Measurement detector : Peak

11. 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 (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.			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 %	56% ± 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: October 8 th , 2018. Tested by L. CHAPUS			

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	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2017/5	2019/5

Test Setup for radiated emission



Test setup for 1-25GHz

Tabulated Results for Maximum peak output power (Radiated measurement)

FREQ (MHz)	Field Strength 3m (dBμV/m)	Calculated EIRP (dBm)	Limit (dBm)	Result
2402	96.7	1.5	36.0	Pass
2441	96.8	1.6	36.0	Pass
2480	96.8	1.6	36.0	Pass
RBW:		1MHz		
Measurement distance:		3m		
Limit:		FCC Part 15.247 / RSS-247		
Final measurement detector:		Peak		
RESULT:		PASS		
Note:		(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: $FS = RA + AF + CF - AG$ Where FS = Field Strength RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain Total factor (dB) is AF + CF – AG Margin value = Emission level – Limit value (2): EIRP is calculated using the following equation: $EIRP = E + 20 \times \log(D) - 104.8 - GR$ 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)		

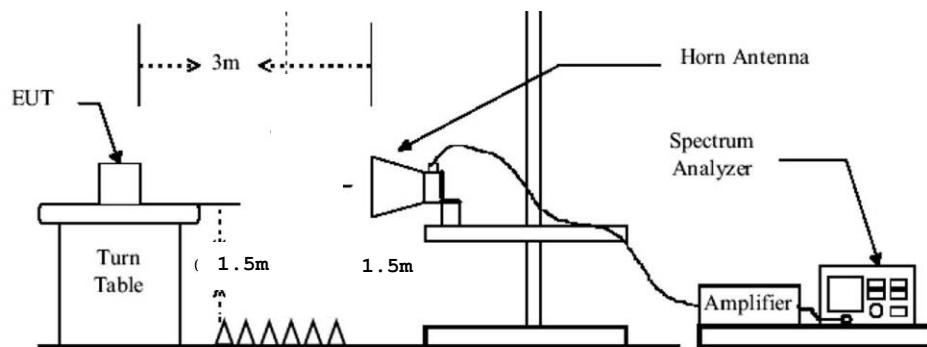
Tabulated Results for Maximum peak output power (Conducted)			
FREQ	Conducted power	Limit	Result
(MHz)	(dBm)	(dBm)	
2402	1.5	30.0	Pass
2440	1.6	30.0	Pass
2480	1.6	30.0	Pass
RBW:		1MHz	
Limit:		FCC Part 15.247 / IC RSS-247	
Final measurement detector:		Peak	
RESULT:		PASS	
Note:		(1): Maximum conducted Peak output power is calculated as follow: $P_c = EIRP - G$ Where P_c = Conducted power dBm $EIRP$ = Equivalent Isotropic Radiated Power in dBm G = Antenna gain in dBi (0dBi, as declared by the manufacturer)	

12. Maximum Power Spectral Density Level in the fundamental emission

TEST: Maximum Peak Power Spectral Density			Verdict
<u>Method:</u> 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.			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 %	56% ± 5	
Limits – FCC Part 15.247 (e) / RSS-247 §5.2 (b)			
Frequency (MHz)	Level (Detector)	Limit	
2441.75	8 dBm/3kHz (Pk)	Pass	
Supplementary information: Test location: SMEE. Test date: October 8 th , 2018. Tested by L. CHAPUS			

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	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2017/5	2019/5

Test Setup for radiated emission



Test setup for 1-25GHz

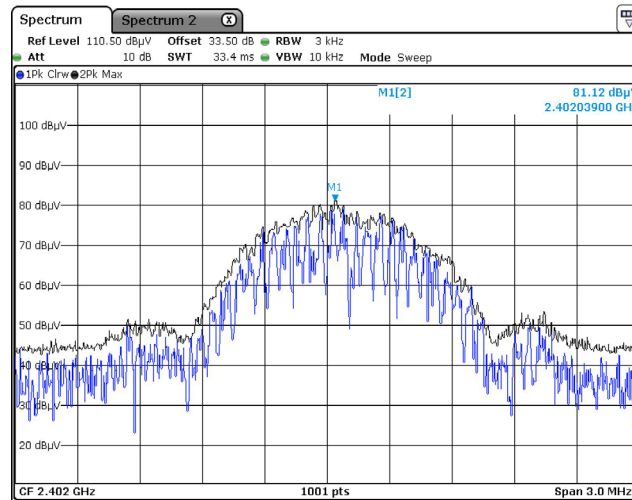
Tabulated Results for Maximum Spectral Density (Radiated measurement)

FREQ	Field Strength 3m	Calculated Radiated PSD (EIRP)	Limit	Result
(MHz)	(dBμV/m)	(dBm)	(dBm)	
2402	81.1	-14.0	-	-
2440	81.9	-13.3	-	-
2480	82.3	-12.9	-	-
RBW:		3kHz		
Measurement distance:		3m		
Limit:		FCC Part 15.247 / RSS-247		
Final measurement detector:		Peak		
Note:		(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: $FS = RA + AF + CF - AG$ Where FS = Field Strength RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain Total factor (dB) is AF + CF – AG Margin value = Emission level – Limit value (2): EIRP/PSD is calculated using the following equation: $EIRP = E + 20 \times \log(D) - 104.8 - GR$ 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)		

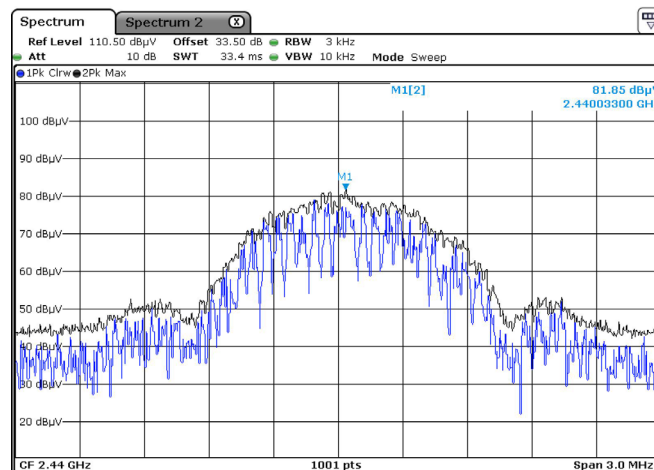
Tabulated Results for Maximum Conducted Power Spectral Density

Frequency (MHz)	PSD (dBm/3kHz)	Limit	Result
2402.0	-14.0	8dBm/3kHz	Pass
2441.0	-13.3	8dBm/3kHz	Pass
2480.0	-12.9	8dBm/3kHz	Pass
RBW:		3kHz	
Limit:		FCC Part 15.247 / RSS-247	
Final measurement detector:		Peak	
RESULT:		PASS	
Note:		(1): Maximum conducted power spectral density is calculated as follow: $P_{SD} = EIRP - G$ Where P_{SD} = Conducted power spectral density $EIRP$ = Equivalent Isotropic Radiated Power in dBm G = Antenna gain in dBi (0dBi, as declared by the manufacturer)	

Graphical representation for Maximum Power Spectral Density

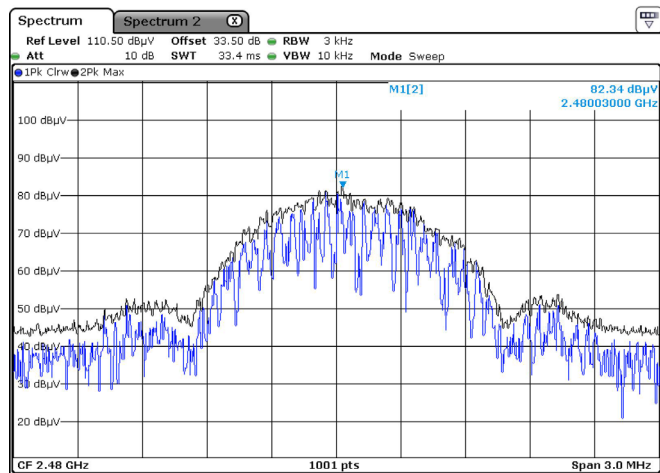


Low channel



Mid channel

Graphical representation for Maximum Power Spectral Density



High channel

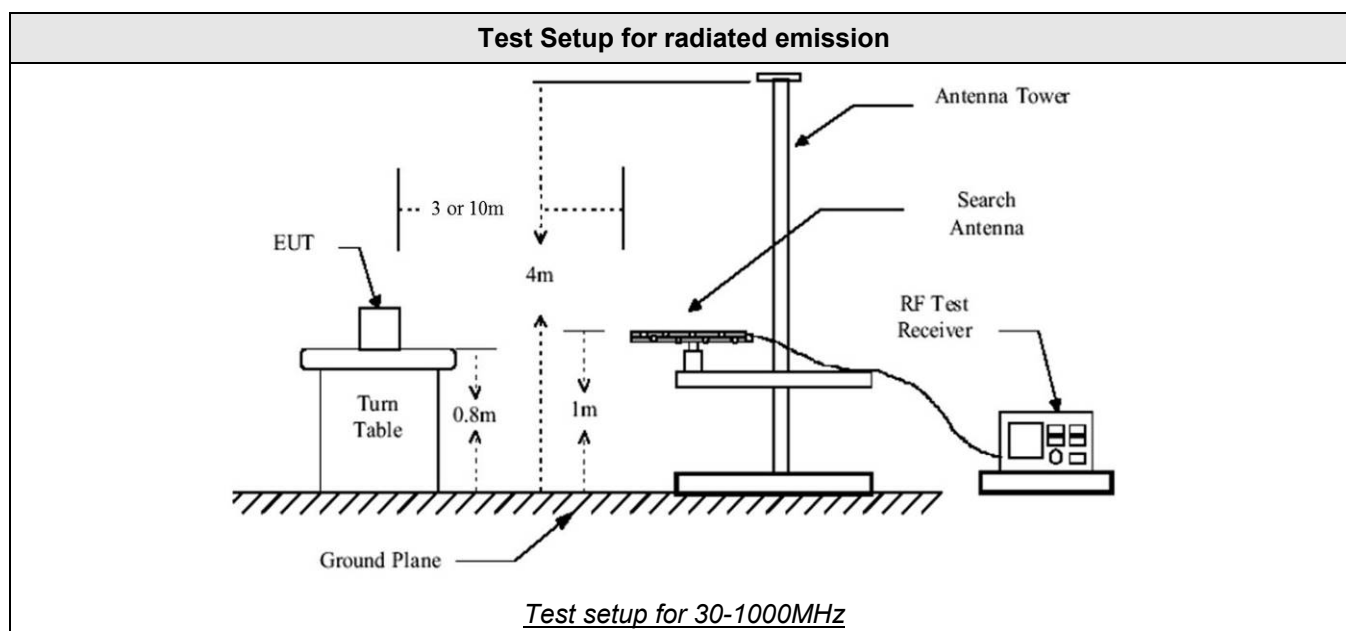
RBW:	3kHz
Limit:	FCC Part 15.247 / RSS-247
RESULT:	PASS

13. Unwanted emissions in Non-Restricted Frequency bands

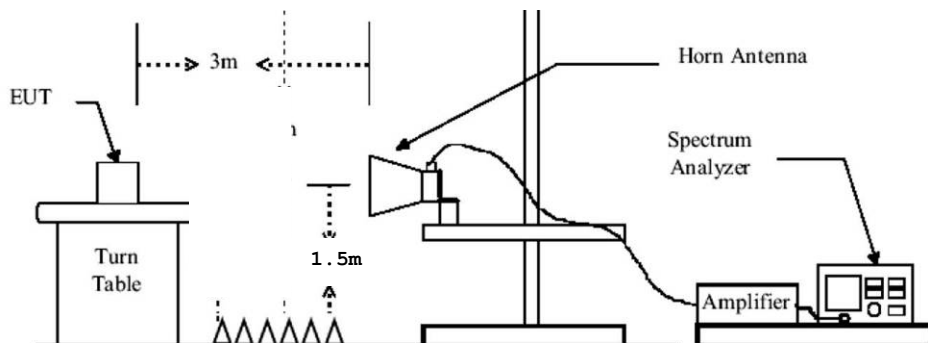
TEST: Unwanted emissions in Non-Restricted Frequency Bands			Verdict
<u>Method:</u> Measurements were performed on a 3-meter Open Area Test Site (OATS) for frequency below 1GHz. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. Final measurements (Peak) were then performed by rotating the EUT on 360° and adjusting the receive antenna height from 1 to 4 m 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. 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). 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.			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 %	56% ± 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	
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: October 8th, 2018. Tested by L. CHAPUS			

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Log-periodic antenna	TDK	PLP3003	ANT-101-001	2017/5	2019/5
Biconnic antenna	COM-POWER	AB- 900	ANT-101-003	2017/5	2019/5
Loop antenna	EMCO	6502	ANT-101-009	2017/8	2019/8
BiConiLog antenna	EMCO	3142B	ANT-101-010	2017/7	2019/7
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	2017/5	2019/5
RF cable	Div	OATS/25m	CAB-101-017	2018/4	2019/4
RF cable	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-026	2018/4	2019/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-029	2018/4	2019/4

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2017/5	2019/5
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-035	2017/5	2019/5
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Antenna mast	Innco- Systems	MA4000EP	MAT-101-001	-	-
Turntable	Innco- Systems	DS1200S	PLA-101-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-001		
Pre-amplifier	PE	1524	PRE-101-002	2018/4	2019/4
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2017/12	2019/12
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-003	2017/5	2019/5
OATS	Div	10m	SIT-101-001	2017/7	2020/7
EMC Software	NEXIO	BAT EMC V3.8	SOF-101-001	-	-



Test Setup for radiated emission



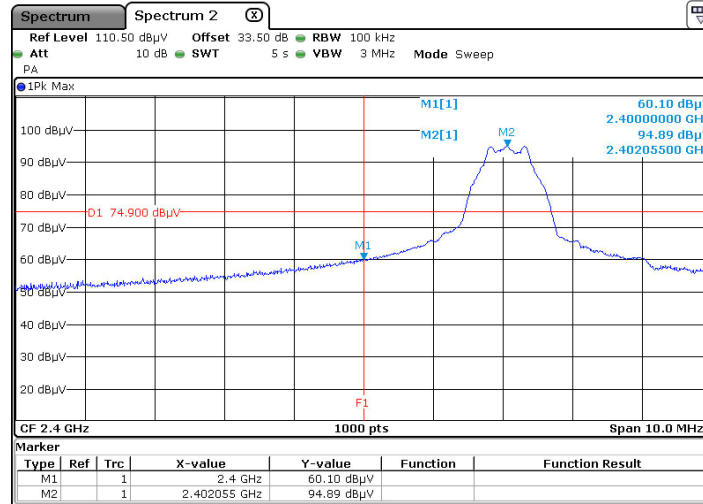
Test setup for 1-25GHz

Tabulated Results for Peak Output Power Reference level

FREQ (MHz)	Field Strength 3m (dB μ V/m)
2402.0	94.9
2440.0	95.0
2480.0	95.0
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 74.9 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)
2399.942	60.1	74.9	-14.8	Pass
7206.000	57.4	74.9	-17.5	Pass
RBW:		100kHz		
Measurement distance:		3m		
Limit:		15.247 / RSS-247		
Final measurement detector:		Peak		
RESULT:		PASS		
Note:		(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: $FS = RA + AF + CF - AG$ Where FS = Field Strength RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain Total factor (dB) is $AF + CF - AG$ Margin value = Emission level – Limit value (2): Peak pre-scans not performed at 3-meters distance are corrected as follow: $M@3m = M@D_m + 20 \times \log(D_m / 3m)$ Where D is the measurement distance in meter (3): All frequencies not specified have margin < -10dB (4): Worst case between charge mode and normal used mode (5): 3-axis measurement performed for device under test.		

Graphical representation of Band-edge compliance (LOW)



Low bandedge compliance

Radiated Peak level is 60.1dBμV/m (limit 74.9dBμV/m)

F1 = 2400MHz

RESULT: PASS

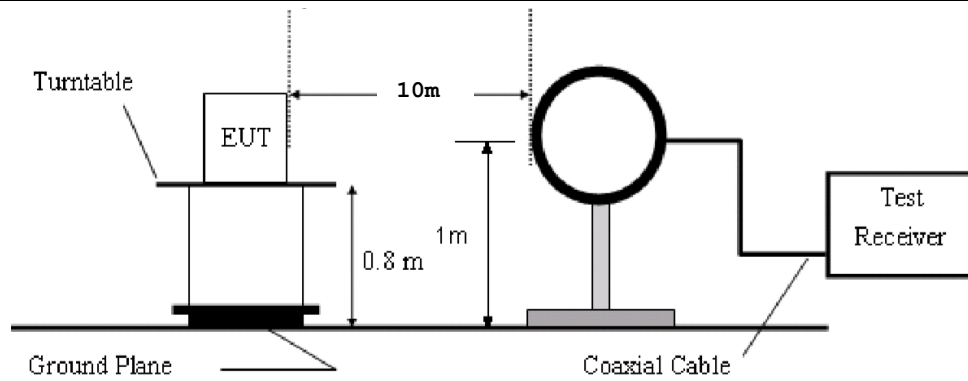
Note: radiated measurement (3m in FAC)

14. Unwanted emissions in Restricted Frequency bands

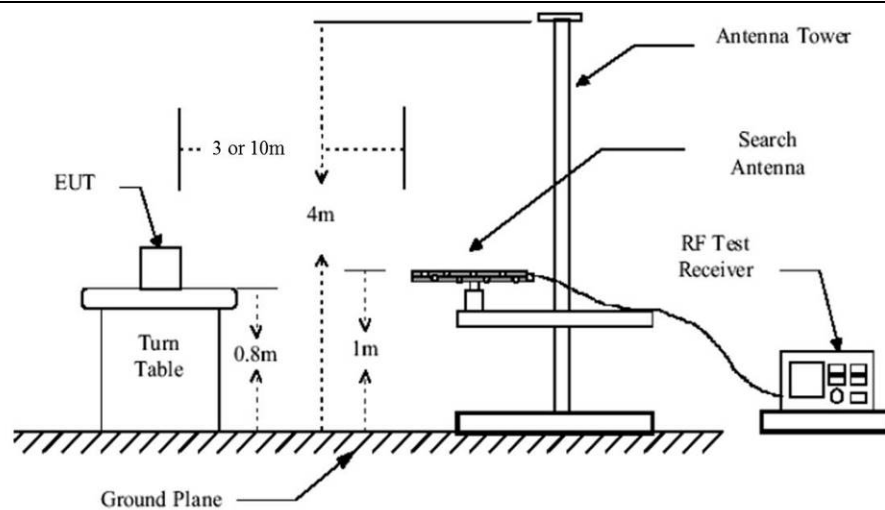
TEST: Unwanted emissions into Restricted Frequency Bands		Verdict
Method: Measurements were performed on a 3-meter Open Area Test Site (OATS) for frequency below 1GHz. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. Final measurements (Peak) were then performed by rotating the EUT on 360° and adjusting the receive antenna height from 1 to 4 m 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. 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). 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.		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 %	56% ± 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: October 8 th , 2018. Tested by L. CHAPUS		

Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Log-periodic antenna	TDK	PLP3003	ANT-101-001	2017/5	2019/5
Biconnic antenna	COM-POWER	AB- 900	ANT-101-003	2017/5	2019/5
Loop antenna	EMCO	6502	ANT-101-009	2017/8	2019/8
BiConiLog antenna	EMCO	3142B	ANT-101-010	2017/7	2019/7
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	2017/5	2019/5
RF cable	Div	OATS/25m	CAB-101-017	2018/4	2019/4
RF cable	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-026	2018/4	2019/4
RF cable	HUBER+SUHNER	RG214U	CAB-141-029	2018/4	2019/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
RF cable	HUBER+SUHNER	SF102 (K/2m)	CAB-171-034	2017/5	2019/5
RF cable	HUBER+SUHNER	SF102 (K/3m)	CAB-171-034	2017/5	2019/5
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Antenna mast	Innco- Systems	MA4000EP	MAT-101-001	-	-
Turntable	Innco- Systems	DS1200S	PLA-101-001	-	-
Turntable	Innco- Systems	CT0800	PLA-141-001		
Pre-amplifier	PE	1524	PRE-101-002	2018/4	2019/4
Pre-amplifier	SMEE	18-40GHz	PRE-171-004	2017/12	2018/12
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-003	2017/5	2019/5
OATS	Div	10m	SIT-101-001	2017/7	2020/7
EMC Software	NEXIO	BAT EMC V3.8	SOF-101-001	-	-

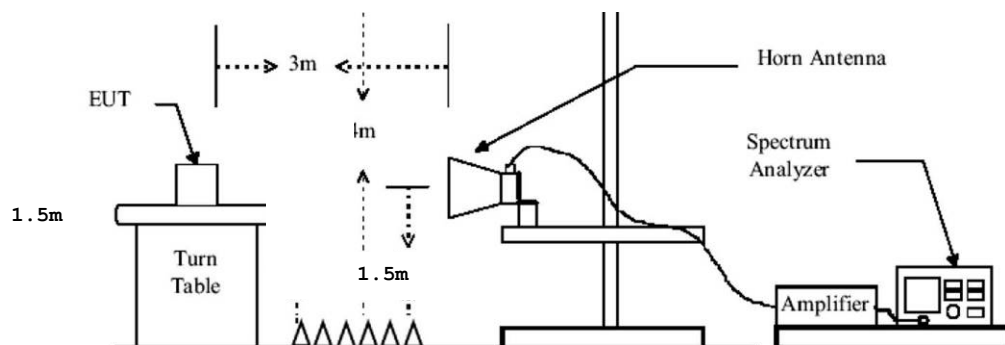
Test Setup for radiated emission



Test setup for 9k-30MHz



Test setup for 30-1000MHz



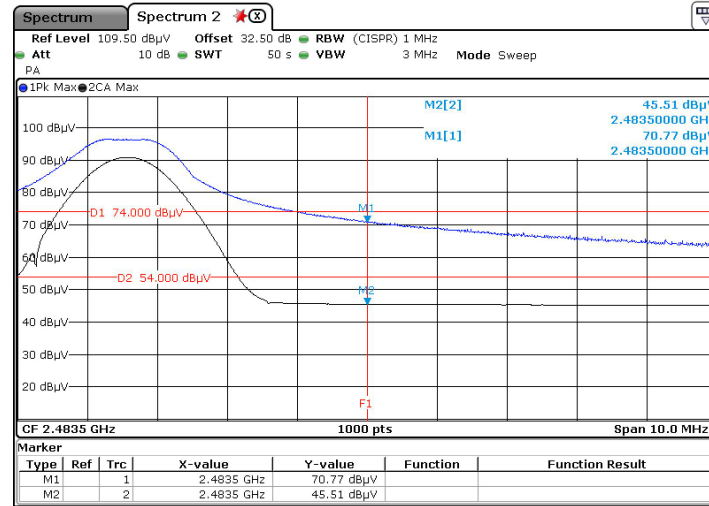
Test setup for 1-25GHz

Tabulated Results for Unwanted emissions (9kHz-30MHz)						
FREQ	RF field @ 30m	Limit @ 30m	Margin	Antenna angle	Table angle	Correc. Fact. (CF)
MHz	(QP) dBμV/m	(QP) dBμV/m	dB	Degree	Degree	dB
Margin < -10dB						
Supplementary information: Frequency list measured on the Open Area Test Site has been created with pre-scan results.						
Frequency band investigated:		9kHz-30MHz				
RBW:		200Hz (9kHz-150kHz)				
		9kHz (150kHz-30MHz)				
Measurement distance:		10m				
Limit:		FCC Part 15.205 - 15.209 / RSS-GEN				
Final measurement detector:		Peak / Quasi-Peak / Average				
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)				

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	Degré	(QP) dBμV/m	dB
319.800	22.5	26.7	17.9	40.4	44.6	V	100	150	46.0	-5.6
337.500	20.1	26.4	19.4	39.5	45.8	V	120	120	46.0	-6.5
Supplementary information: Frequency list measured on the Open Area Test Site 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								
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 RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain Total factor (dB) is AF + CF – AG Margin value = Emission level – Limit value								

Tabulated Results for Unwanted emissions (1GHz-25GHz)					
FREQ (MHz)	Field Strength 3m (dBμV/m)	Detector	Limit (dBμV/m)	Margin (dBμV/m)	Result
2483.5	70.8	Pk	74	-3.2	Pass
2483.5	45.5	Avg	54	-8.5	Pass
4804.0	58.6	Pk	74	-15.4	Pass
4804.0	47.3	Avg	54	-6.7	Pass
4882.0	59.7	Pk	74	-14.3	Pass
4882.0	48.1	Avg	54	-5.9	Pass
4960.0	59.9	Pk	74	-14.1	Pass
4960.0	48.8	Avg	54	-5.2	Pass
7323.0	57.4	Pk	74	-16.6	Pass
7323.0	45.9	Avg	54	-8.1	Pass
7440.0	58.1	Pk	74	-15.9	Pass
7440.0	46.3	Avg	54	-7.7	Pass
RBW / VBW		1MHz / 3MHz			
Measurement distance:		3m			
Limit:		FCC Part 15.205, 15.209, 15.247 / RSS-Gen, RSS-247			
Final measurement detector:		Peak / Average			
RESULT:		PASS			
Notes:		(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: $FS = RA + AF + CF - AG$ Where FS = Field Strength RA = Receiver Amplitude AF = Antenna Factor CF = Cable Factor AG = Amplifier Gain Total factor (dB) is $AF + CF - AG$ Margin value = Emission level – Limit value (2): Peak pre-scans not performed at 3-meters distance are corrected as follow: $M@3m = M@Dm + 20 \times \log (Dm / 3m)$ Where D is the measurement distance in meter (3): All frequencies not specified have margin < -10dB (for peak and average detector)			

Graphical representation of Band-edge compliance (HIGH)



High bandedge compliance

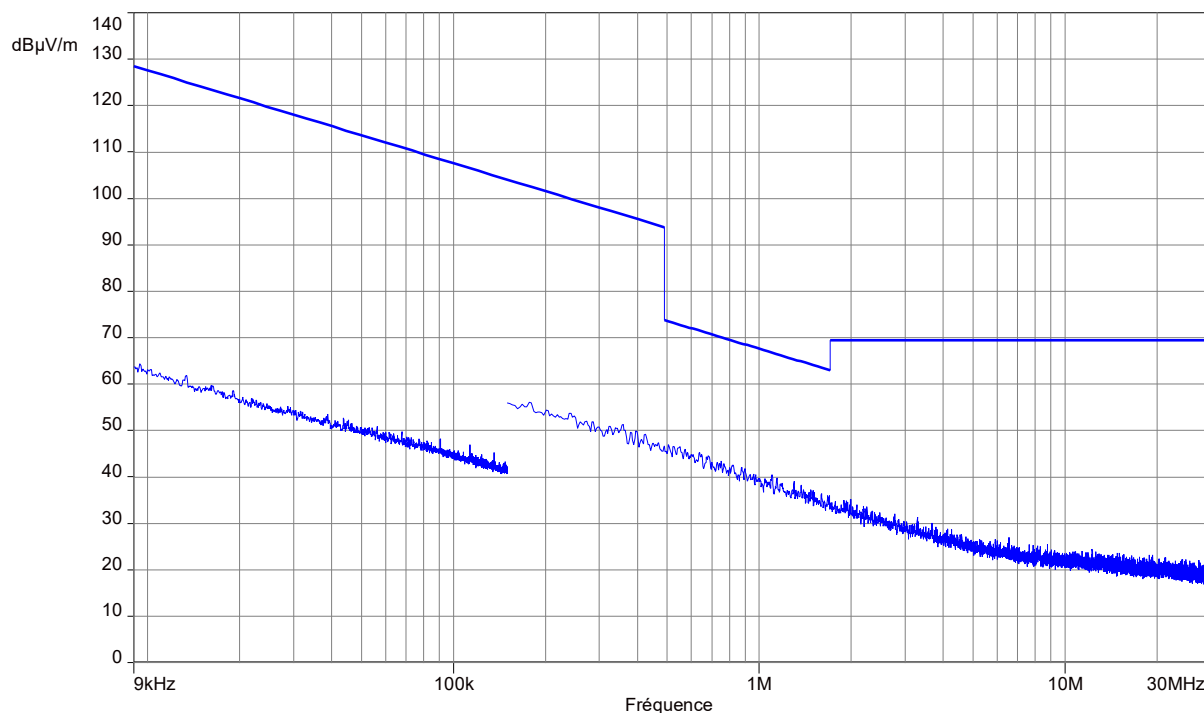
Radiated Peak level is 70.8dBμV/m (limit 74dBμV/m)

Radiated Average level is 45.5dBμV/m (limit 54dBμV/m, CISPR Average detector measurement)

RESULT: PASS

Note: radiated measurement

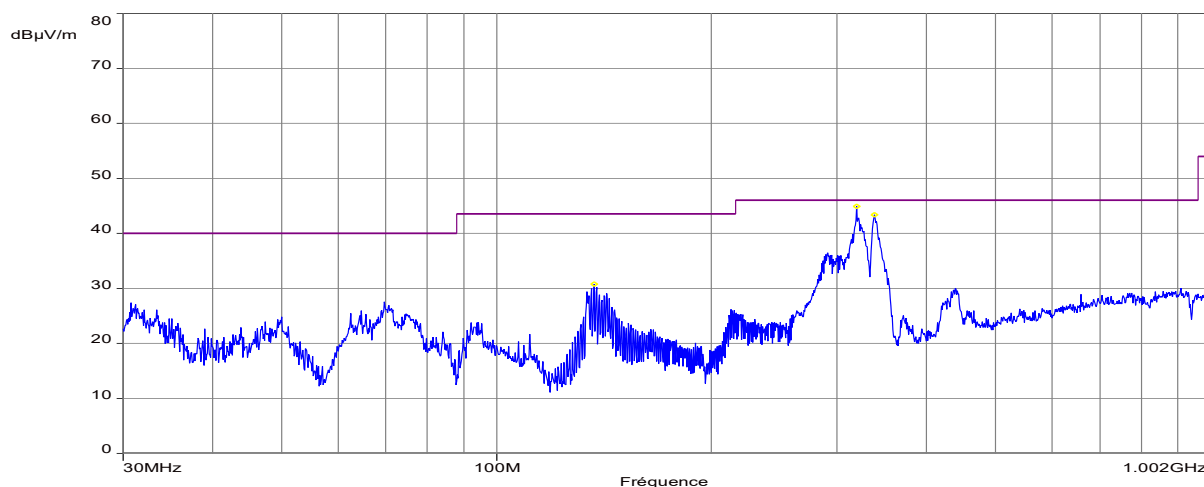
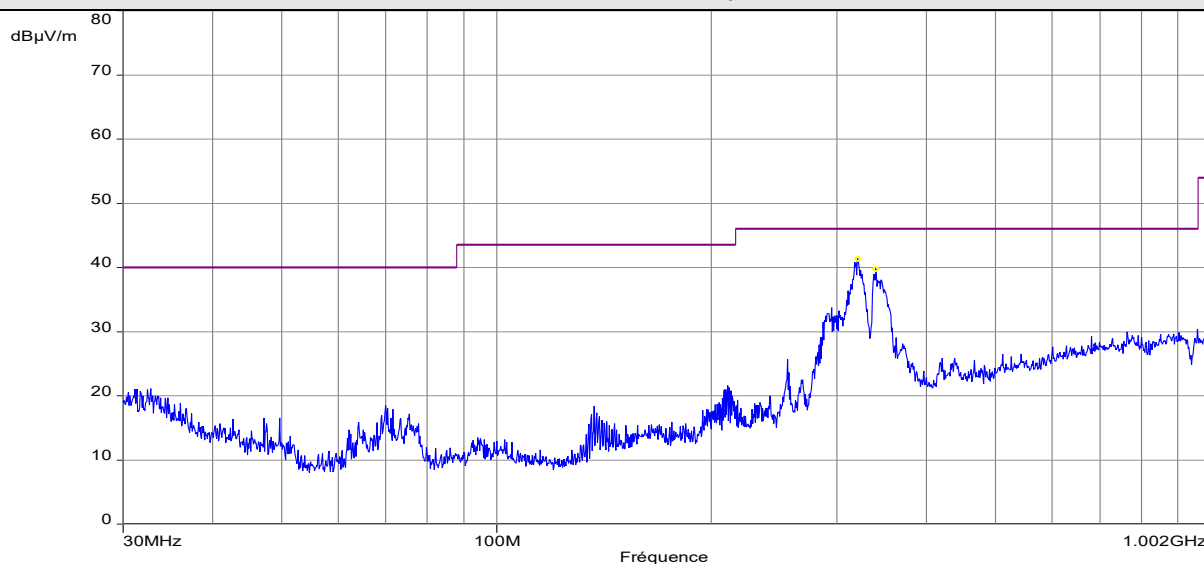
Graphical representation of Radiated Disturbance Measurement (Peak detection, Anechoic chamber pre-scan, 9kHz-30MHz / 3m / Parallel & Perpendicular antenna position / Transmit mode)



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)

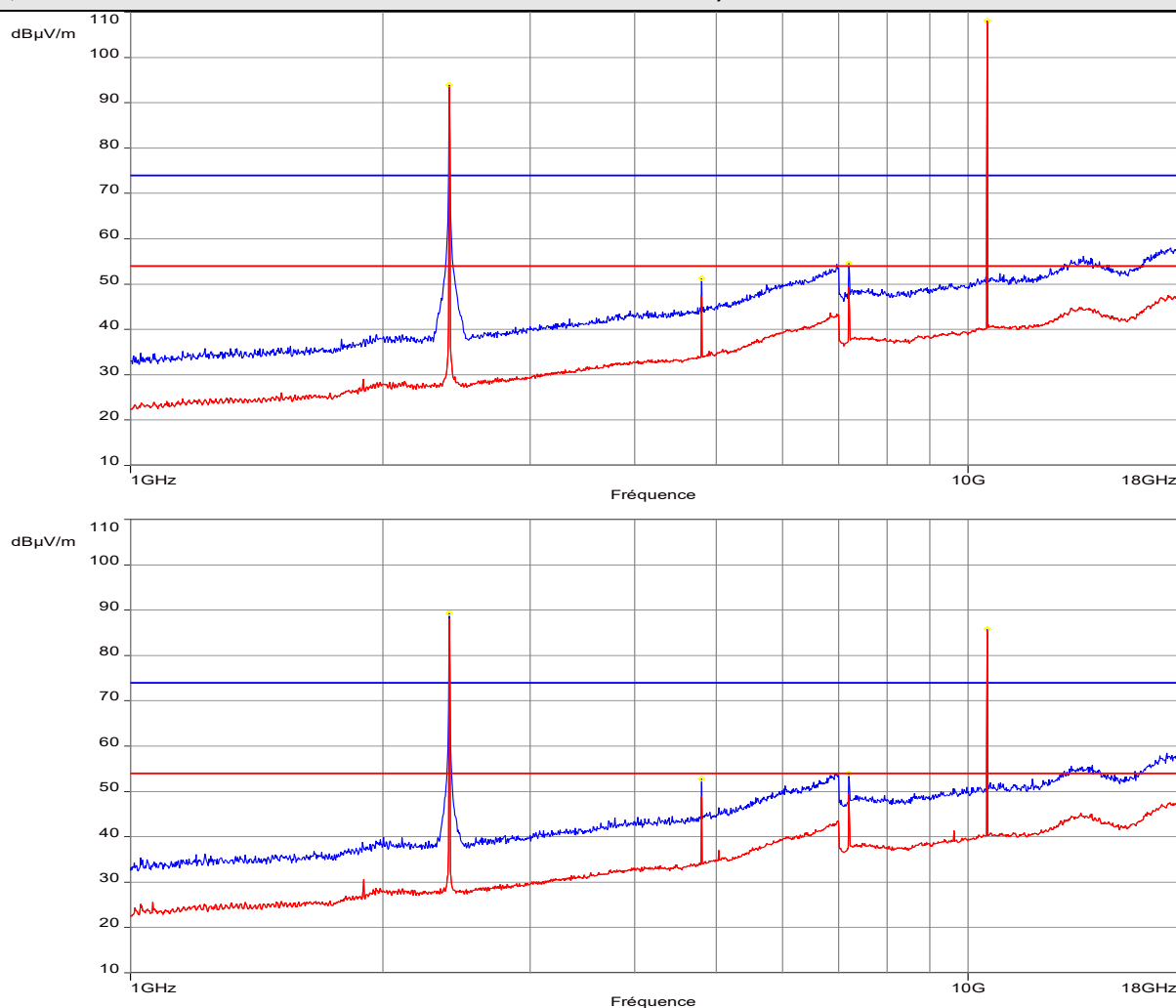


Note: Pre-scan graph only for identification purpose.

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
321.062	41.39	130.6	46.0	H	
339.592	39.79	115.2	46.0	H	
136.954	30.79	195.6	46.0	V	
319.452	44.87	149	46.0	V	
338.346	43.35	116.9	46.0	V	

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



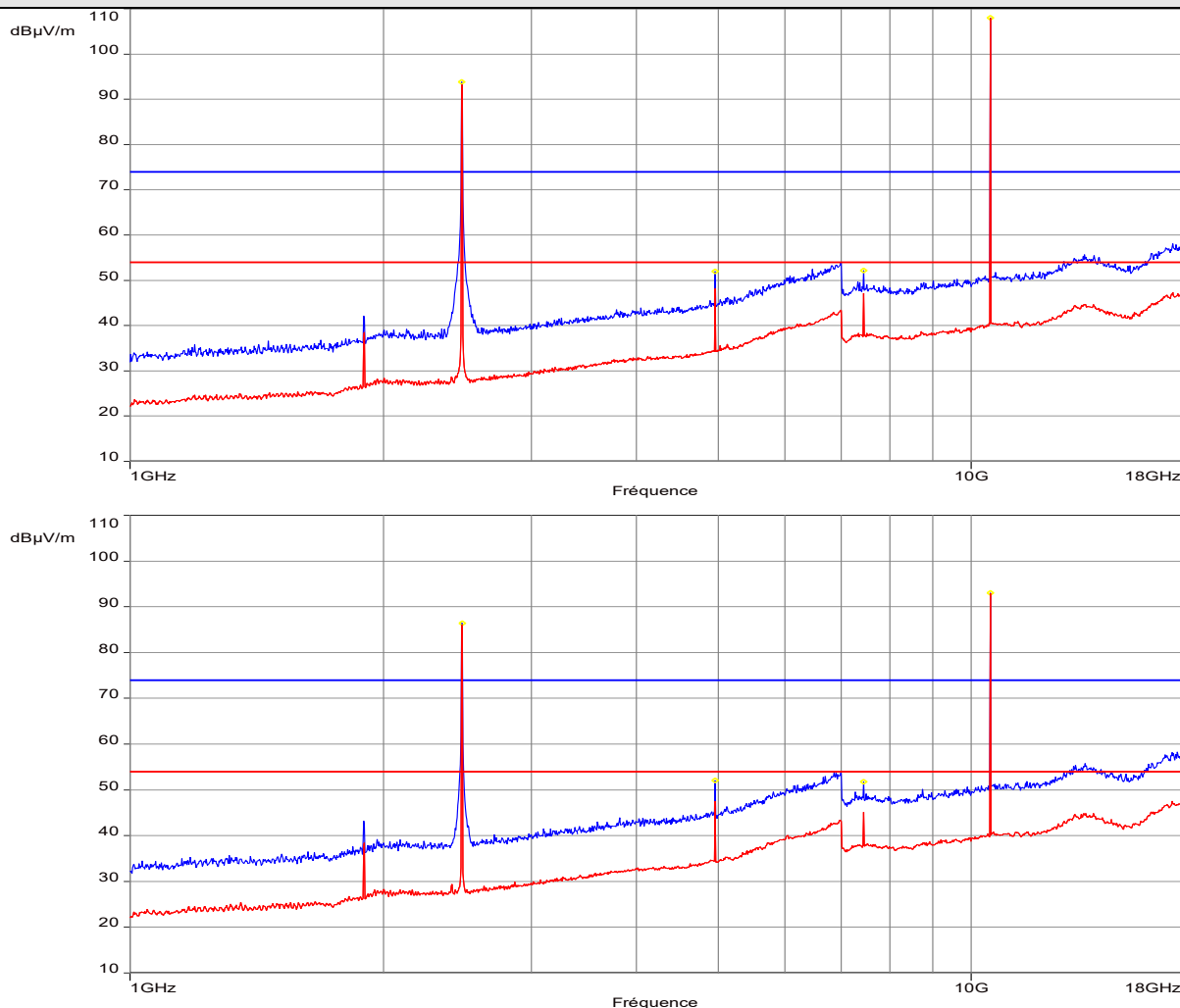
Note: Pre-scan graph only for identification purpose.

----- : Peak measure	----- : Average measure
Frequency band investigated:	1GHz-18GHz
Unit :	dBμV/m
RBW :	1MHz
Antenna polarization :	Horizontal & Vertical
Voltage:	12V
Limit:	FCC 15.247 / RSS-247
Measurement detector:	Peak / Average

PEAK LIST FROM PRE-SCAN

Frequency (MHz)	Peak Level (dBμV/m)	Angle (°)	Limit (dBμV/m)	Polarization	Comments
2401.79	93.98	191.9	74.0	H	RF / BLE carrier
4804.61	51.23	149.8	74.0	H	
7206.88	54.58	101.9	74.0	H	
10531.3	108.07	2.8	74.0	H	RF / MW radar carrier
2402.39	89.36	224.9	74.0	V	RF / BLE carrier
4803.58	52.74	68.3	74.0	V	
7206.67	53.98	163.2	74.0	V	
10531.5	85.81	16.4	74.0	V	RF / MW radar carrier

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



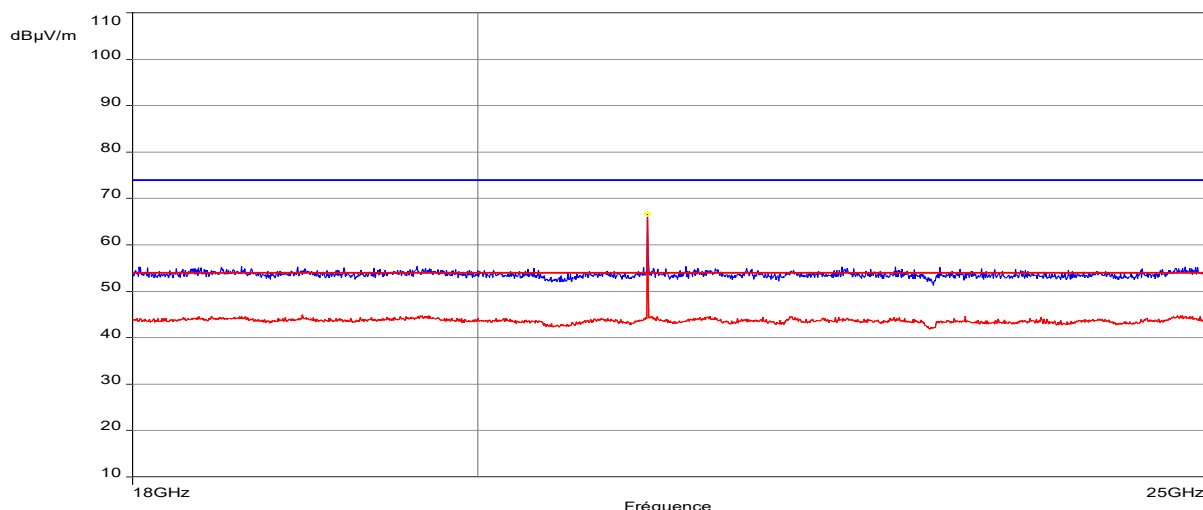
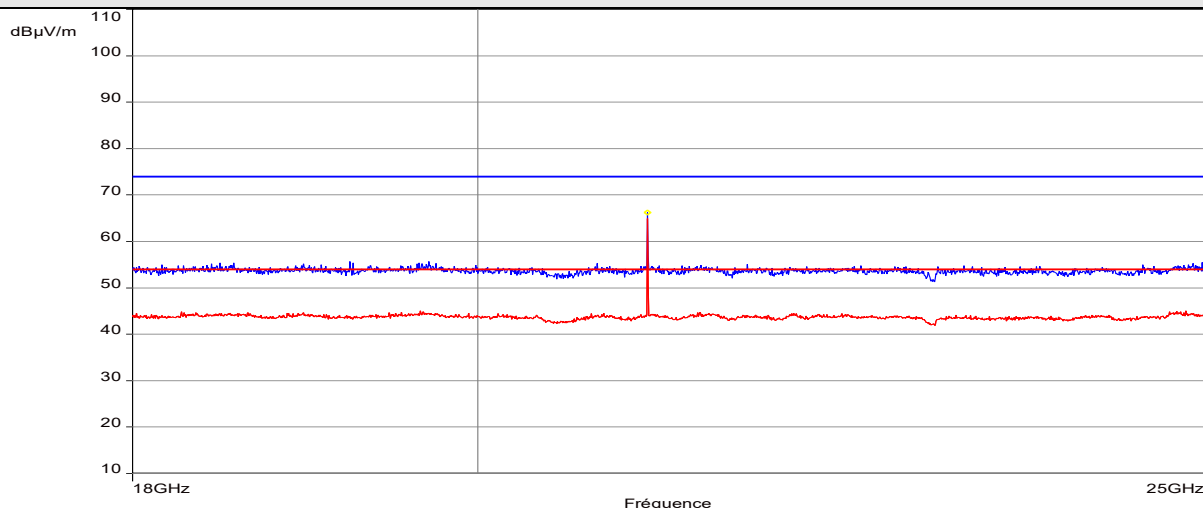
Note: Pre-scan graph only for identification purpose.

----- : Peak measure	----- : Average measure
Frequency band investigated:	1GHz-18GHz
Unit :	dBμV/m
RBW :	1MHz
Antenna polarization :	Horizontal & Vertical
Voltage:	12V
Limit:	FCC 15.247 / RSS-247
Measurement detector:	Peak / Average

PEAK LIST FROM PRE-SCAN

Frequency (MHz)	Peak Level (dBμV/m)	Angle (°)	Limit (dBμV/m)	Polarization	Comments
2479.8	93.89	20.6	74.0	H	RF / BLE carrier
4959.5	51.98	210.7	74.0	H	
7439.33	52.21	105.6	74.0	H	
10531.3	107.98	16.2	74.0	H	RF / MW radar carrier
2479.8	87.46	96.7	74.0	V	RF / BLE carrier
4959.3	54.6	82.8	74.0	V	
7440.56	51.96	25.2	74.0	V	
10531.3	81.73	96.2	74.0	V	RF / MW radar carrier

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



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
Frequency band investigated:	18GHz-25GHz
Unit :	dBμV/m
RBW :	1MHz
Antenna polarization :	Horizontal & Vertical
Voltage:	12V
Limit:	FCC 15.247 / RSS-247
Measurement detector:	Peak / Average

PEAK LIST FROM PRE-SCAN

Frequency (MHz)	Peak Level (dBμV/m)	Angle (°)	Limit (dBμV/m)	Polarization	Comments
21062.8	66.25	311.3	77.5 (*)	H	RF / MW radar harmonic
21062.8	66.59	47.3	77.5 (*)	V	RF / MW radar harmonic

(*): FCC 15.245 / RSS-210, F.1 limits

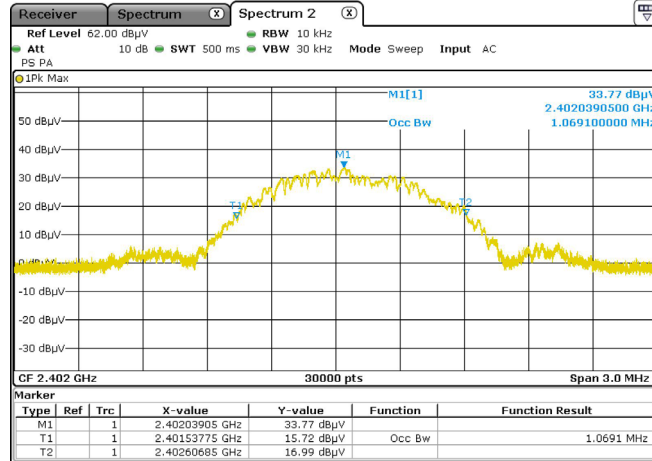
15. Occupied bandwidth (99%)

TEST: Occupied bandwidth (99%) / RSS-GEN			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 set in the range of 1% to 5% of the occupied bandwidth, with VBW ≥ 3 x RBW. The SPAN is wide enough to capture all products of the modulation process. A MaxHold Peak detector is used. Measure is performed with OBW 99% function of the spectrum analyser. 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 %	56% ± 5	
Supplementary information: Test location: SMEE. Test date: October 8 th , 2018. Tested by L. CHAPUS			

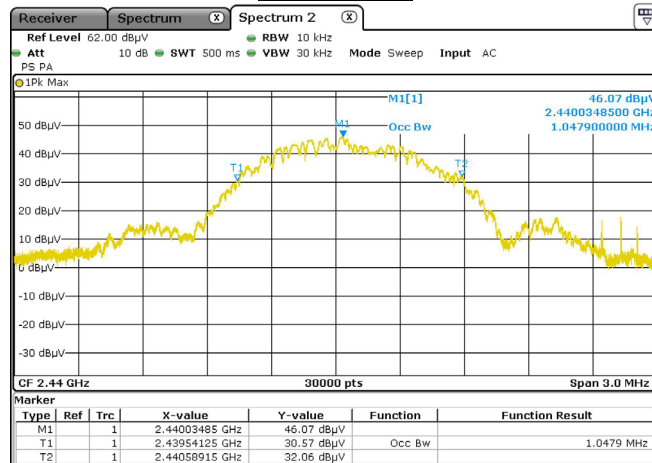
Test Equipment Used					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Horn antenna	ETS-LINDGREN	3115	ANT-141-013	2018/10	2021/10
RF cable	Pasternack RF	PE302-120	CAB-131-024	2018/4	2019/4
RF cable	HUBER+SUHNER	SF104	CAB-141-030	2018/4	2019/4
Anechoic chamber	COMTEST	214263	CAG-141-001	2017/6	2020/6
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-003	2017/5	2019/5

Tabulated Results for Occupied Bandwidth	
Frequency (MHz)	99% Occupied Bandwidth (MHz)
2402.0	1.0691
2440.0	1.0479
2480.0	1.0506

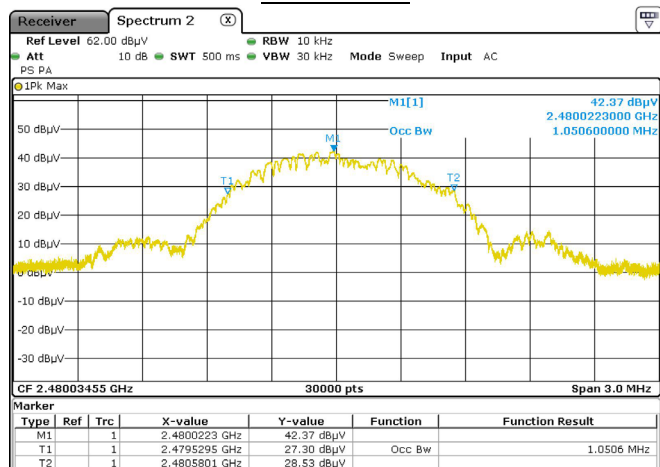
Graphical representation of Occupied Bandwidth



Low Channel



Mid Channel



High Channel

Frequency band investigated: 2400MHz to 2483.5MHz

RBW : 10kHz

Measurement detector: Peak