

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

Matériel testé :
Equipment under test:

ST / STM32WL5MOCH
(Trademark / Marketing name or product reference)

Demandeur de certification : **ST Microelectronics Rousset SAS**
Applicant for certification: 190, rue Célestin Coq
13106 ROUSSET Cedex – France

Client : **ST Microelectronics**
Customer: 9-11 rue Pierre Félix Delarue
72100 Le Mans – France

Numéro d'affaire : 15100
Work number :

Référence de la proposition : 012022-25243-1
Proposal number:

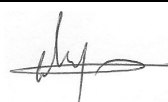
Date de l'essai : 22 mai 2023 au 7 Juillet 2023
Date of test: May 22nd to July 7th, 2023

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

Lieu du test: SMEE - 385 rue René Rambaud, ZA le Parvis 2
Test location: 38500 VOIRON - France

Test réalisé par : Chemseddine KERMICHE
Test realized by:

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

Ed.	Date	Modifications Pages /	Written by : Visa	Approved by: Visa
1	January 9, 2024	Initial Edition	Chemseddine KERMICHE Test operator 	Laurent Chapus Technical Manager 

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SMEE
385, Rue René Rambaud, ZA Le Parvis 2
38500 VOIRON - France

TEL : 04 76 65 76 50
FAX : 04 76 66 18 30

SAS au capital de 50 000 € / RC Grenoble B534 796 453 / SIRET 534 796 453 00015 / code APE 7490B / n° TVA : FR 59 534 796 453

Contents

1. NORMATIVES REFERENCES	3
2. TEST SYNTHESIS.....	4
3. EQUIPMENT UNDER TEST (EUT)	5
4. TEST CONDITIONS.....	7
5. MODIFICATIONS OF THE EUT	7
6. SPECIAL ACCESSORY	7
7. MEASUREMENT UNCERTAINTY	7
8. FIELD STRENGTH CALCULATION.....	7
9. TEST SETUP DIAGRAM.....	8
10. TEST EQUIPMENT LIST	10
11. CONDUCTED EMISSION MEASUREMENT (150KHZ-30MHZ)	11
12. 20DB BANDWIDTH AND CHANNEL SEPARATION	14
13. NUMBER OF HOPPING CHANNELS.....	17
14. AVERAGE TIME OF OCCUPANCY	18
15. FUNDAMENTAL EMISSION OUTPUT POWER.....	19
16. UNWANTED SPURIOUS EMISSIONS (CONDUCTED EMISSIONS).....	21
17. UNWANTED EMISSIONS IN NON-RESTRICTED FREQUENCY BANDS (RADIATED EMISSIONS)	24
18. UNWANTED EMISSIONS IN RESTRICTED FREQUENCY BANDS	26
19. OCCUPIED BANDWIDTH (99%)	39

1. Normatives References

FCC qualification according to:		
Standards	Applied	Title
ANSI C63.10 (2013)	X	American National Standard for Testing Unlicensed Wireless Devices
CFR47, Part 15 (June 2023)	X	Telecommunication – Federal Communication Commission – Radio frequency devices, Sections 15.205 / 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 (Issue3/2023)	X	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Note: Following guidance are used

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

Deviation from standard: None.

2. Test synthesis

Requirement for FHSS systems

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 15.207 (a) Table 4 / RSS-Gen	PASS
20dB Bandwidth	15.247 (a) (1) RSS-247 § 5.1	250kHz < BW _{20dB} < 500kHz	PASS
Hopping channel separation	15.247 (a) (1) / RSS-247 5.1 a) b)	<u>Minimum separation</u> 25kHz or the 20dB bandwidth whichever is greater	PASS
Number of hopping frequencies	15.247 (a) (1) / RSS-247 5.1 c)	Minimum 25 channels shall be used. (20dB BW > 250kHz)	PASS
Time of occupancy	15.247 (f) / RSS-247 5.3 a)	Maximum 400ms per channel within 10s	PASS
Maximum Peak Output Power & EIRP	15.247 (b) (3) RSS-247 § 5.4 (d)	0.25W max / 24dBm (Conducted) 1W max / 30dBm (EIRP)	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	<u>Measure at 300m</u> 9-490kHz: 2400µV/m/F(kHz) 6.370µA/m/F (kHz) <u>Measure at 30m</u> 0.490-1.705: 24000µV/m/F(kHz) 63.70µA/m/F (kHz) 1.705-30MHz: 30µV/m 0.08µA/m <u>Measure at 3m</u> 30MHz-88MHz : 40 dBµV/m 88MHz-216MHz : 43.5 dBµV/m 216MHz-960MHz : 46.0 dBµV/m Above 960MHz : 54.0 dBµV/m	PASS
Occupied Bandwidth	RSS-GEN § 6.7	BW at 99%	PASS
Antenna requirement	FCC 15.203 RSS-GEN § 6.8		PASS

• General conclusion:

Measures and tests performed on the sample of the product STM32WL5MOCH, in configuration and description presented in this test report, show compliance with standards FCC CFR 47, PART 15, Subpart C and RSS-Gen & RSS-247.

3. Equipment Under Test (EUT)

Nom /
Identification

ST / STM32WL5MOCH
(Trademark / Marketing name or product reference)

Note

The STM32WL5MOCH module is set on the MB1779 card. (B-WL5M-SUBG1 connectivity expansion board)
MB1779-HIGH-BAND-B0

FCC ID:

FCC ID: YCP-32WL5MOCH01

IC:

IC: 8976A-32WL5MOCH01

Product name / PMN:

STM32WL5MOCH

Model / HVIN:

32WL5MOCH6 / 32WL5MOCH6S

Différence de modèles /
Model differences

The STM32WLMOCH module can be delivered with or without the STSAFE option.
Ordering information:
- STM32WL5MOCH: Without STSAFE (HVIN: 32WL5MOCH6)
- STM32WL5MOCH6S : With STSAFE (HVIN: 32WL5MOCH6S)

Carte testée /
Tested Board

	SN	Cond. emission test	20dB Bandwidth Channel separation	Number of hopping channels / Average time of occupancy	Maximum Peak Output Power	Unwanted emissions into Non Restricted Frequency Bands	Unwanted emissions into Restricted Frequency Bands	Occupied Bandwidth
SW HP	C231200164	X	X	X	X	X	X	X
SW HP 6S	C231200210						X	
SB HP	C231200116						X	

Note:

SW HP: High power mode with DC switch configuration
SB HP: High power mode with solder bridge switch configuration
(Solder bridge replacing the DC switch)
6S: STSAFE option (STM32WL5MOCH6S)

Alimentation /
Power supply

Input 5V on the MB1779 board. (3.5V to 5V)

Auxiliaires /
Auxiliaries

Laptop ASUS, model F200M

Entrées-Sorties /
Input / Output

	Câbles pour essai / Cables for test	Blindé / Shielded	Prévu pour >3m / Intended for >3m
None	-	-	-

Mode de fonctionnement /
Running mode

Equipment running modes are:

The tested sample is able to set in following modes:

- Transmit a modulated carrier frequency on low, middle and high channels (902.5/913.5/924.5MHz)
- Normal hopping sequence from 902.5MHz to 924.5MHz

Version programme interne /
Firmware version

v1.0

Programme de test /
Test program /

PC test: serial command terminal

Setting command:

AT+TCONF=FREQUENCY:POWER:5:10:4/5:0:0:1:16:25000:2:3

AT+TTX=5000

Where: FREQUENCY = 902.5MHz, 913.5MHz, 924.5MHz

POWER = 22dBm (High Power)

**Informations
supplémentaires /
Additional informations**

Declaration of the applicant:

- Type of technology: Proprietary RF protocol
- Frequency transmission band: 902.5 to 924.5MHz.
- 45 channels used in FHSS mode
- Channel spacing for FHSS mode: 500kHz
- Power setting: 22dBm (High Power)
- Modulation: LORA with 250kHz nominal BW / SF10
- Equipment intended for use as a mobile station
- Equipment designed for continuous operation
- Antenna type: Dipole antenna with max gain 2dBi

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

122mm x 30 x 12 (Board)
Antenna length is 56.8mm

Note: The above information are declared by the manufacturer/customer and are under his responsibility.

4. Test conditions

Power supply voltage:

Equipment under test:

Auxiliaries:

3.7V DC (Battery) or 5V from external power supply (conducted emission)

120V/60Hz (AC mains for 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: Expanded uncertainty at 95% confidence (k=2)

8. Field Strength Calculation

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

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

Where FS = Field Strength (Level)

RA = Receiver Amplitude (Meter Reading)

AF = Antenna Factor

CF = Cable Factor

AG = Amplifier Gain

Margin value = Emission level – Limit value

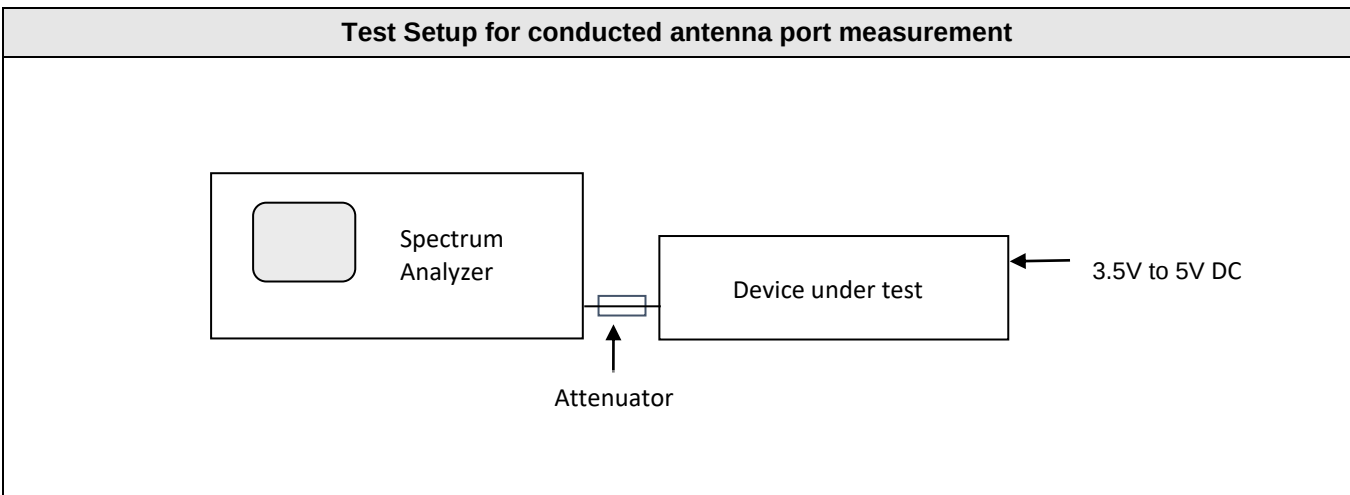
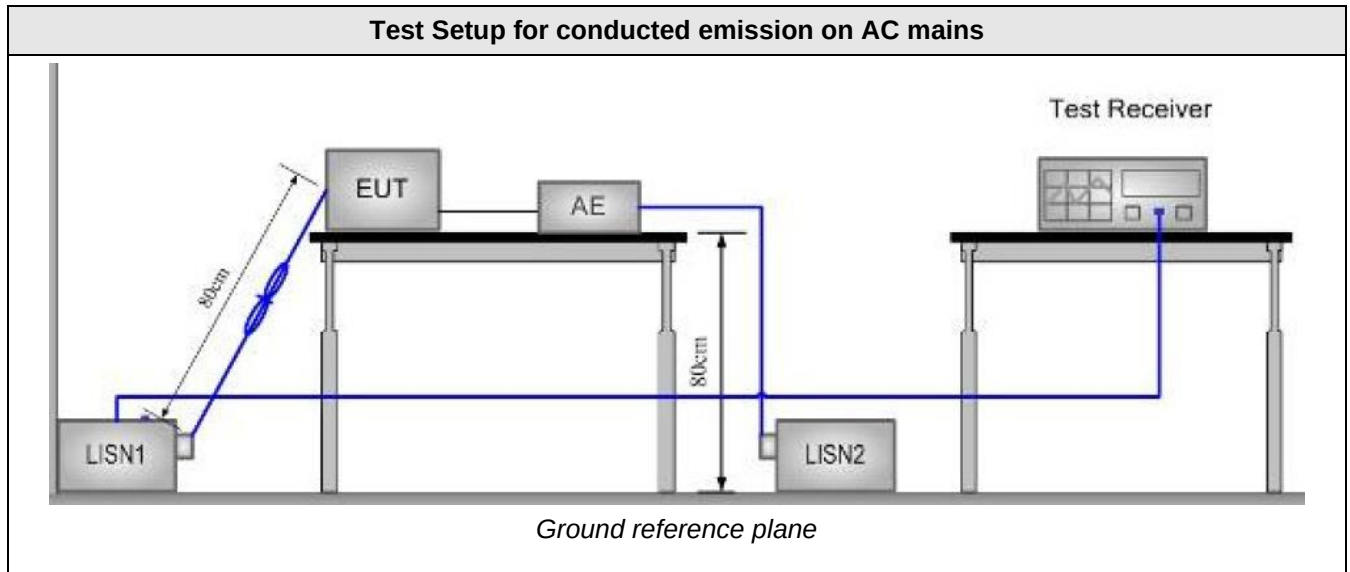
Example:

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

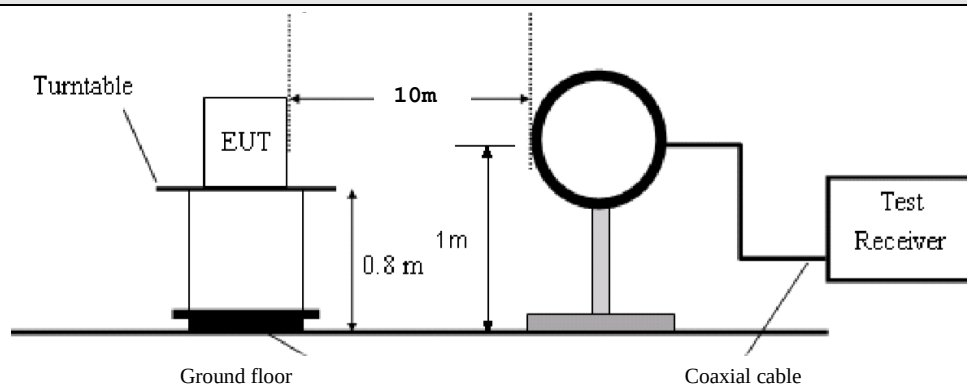
→ Total factor: 5dBm⁻¹

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

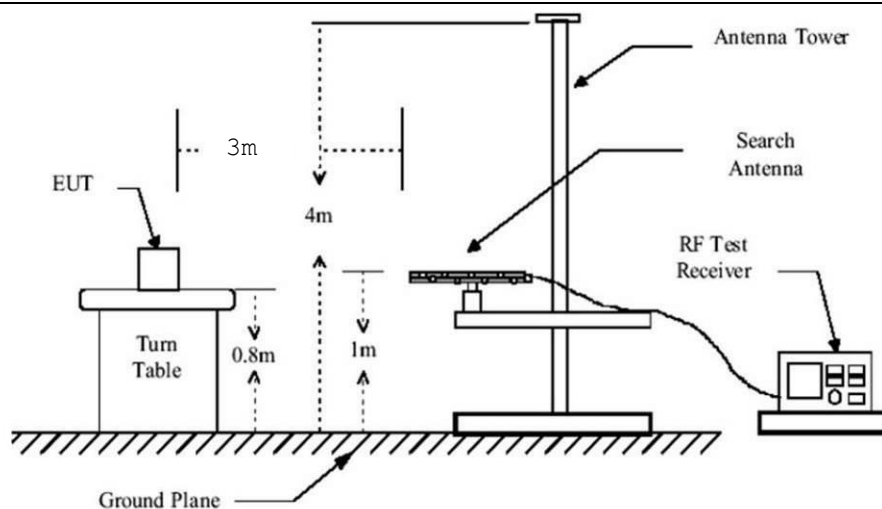
9. Test Setup Diagram



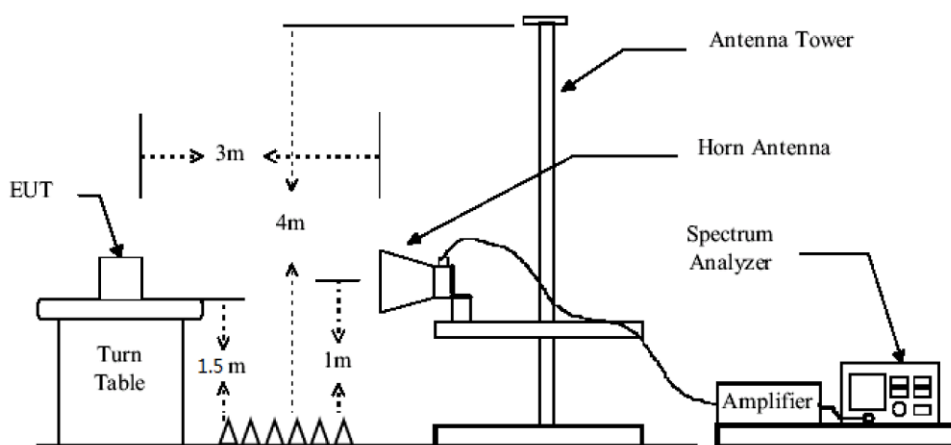
Test Setup for radiated emission



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



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



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

10. Test Equipment List

Test Equipment Used for conducted emission on AC mains					
Description	Manufacturer	Model	ID	Date Cal.	Nxt. Cal.
AC power supply	PACIFIC POWER	AMX-125	ALI-101-002	-	-
Attenuator / limiter	SMEE	ATT#2	ATT-171-010	2023/4	2024/4
Cable RF	RADIAL	RG58 / BNC	CAB-211-042	2023/4	2024/4
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2021/9	2023/11
LISN (50Ω / 50μH) (Meas.)	AFJ	LS16C	RSI-101-001	2021/7	2023/7
EMC Software	NEXIO	BAT EMC	SOF-101-001	-	-

Test Equipment Used for conducted antenna port measurement					
Description	Manufacturer	Model	ID	Date Cal.	Nxt. Cal.
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2021/9	2023/11
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2021/10	2023/10
RF Attenuator	Mini-Circuit	BW-N10W5+	ATT-171-008	2023/4	2024/4
EMC Software	NEXIO	BAT EMC	SOF-101-001	-	-

Test Equipment Used for radiated measurement					
Description	Manufacturer	Model	ID	Date Cal.	Nxt. Cal.
Log-periodic antenna	EMCO	3146	ANT-191-019	2021/7	2024/1
Biconnic antenna	COM-POWER	AB- 900A	ANT-201-021	2023/1	2025/1
Horn antenna	COM-POWER	AH-118	ANT-101-004	2021/7	2024/7
Loop antenna	EMCO	6502	ANT-101-009	2021/8	2023/8
Spectrum analyzer	Rohde&Schwarz	FSV40	ASP-171-004	2021/10	2023/10
RF cable	HUBER+SUHNER	SF126E / 2m	CAB-231-043	2023/4	2024/4
RF cable	HUBER+SUHNER	SF104E / 5.3m	CAB-231-044	2023/4	2024/4
RF cable	HUBER+SUHNER	SF126E / 7m	CAB-231-045	2023/4	2024/4
Semi anechoic room	COMTEST	218292	CAG-201-002	2022/4	2025/2
High-Pass filter	Wainwright Inst.	HK6-948-1200	FIL-141-004	2023/4	2024/4
Antenna mast	Innco- Systems	MA4640-XP-ET	MAT-201-002	-	-
Turntable	Innco- Systems	CT0800	PLA-141-001	-	-
Turntable	Innco- Systems	DS1500-S-1t	PLA-201-003	-	-
Pre-amplifier	COM-POWER	1-18GHz	PRE-221-005	2023/4	2024/4
Measuring receiver	Rohde&Schwarz	ESRP	REC-151-002	2021/9	2023/11
FS OATS	Div	10m	SIT-201-002	-	-
EMC Software	NEXIO	BAT EMC	SOF-101-001	-	-

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

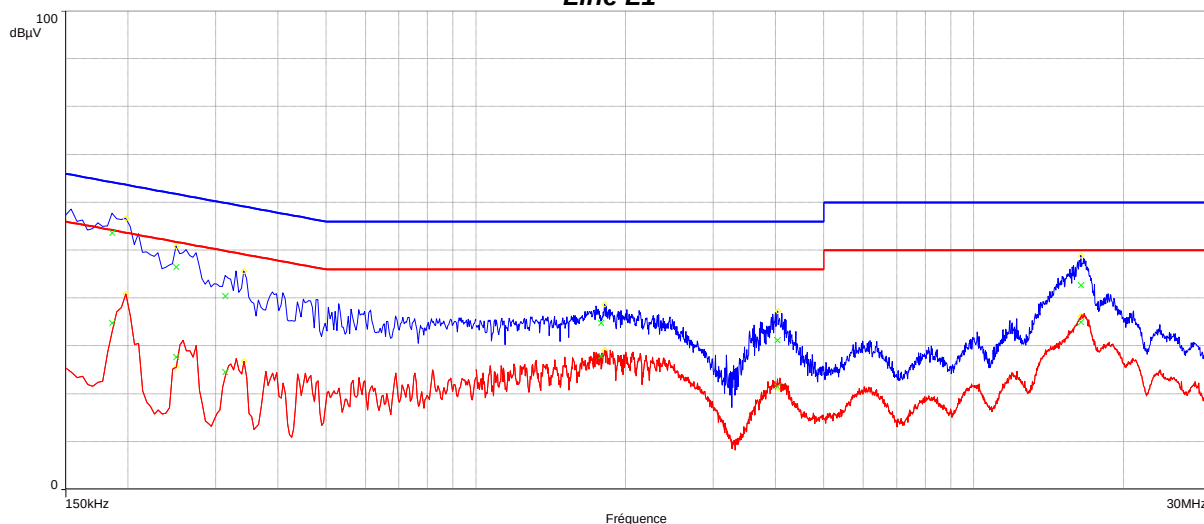
TEST: Limits for conducted disturbance 150kHz – 30MHz				Verdict
Method: The LISN is placed 0,8 m from the boundary of the unit under test and bonded to a ground reference plane. This distance was between the closest points of the AMN and the EUT. All other units of the EUT and associated equipment were 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		17 to 27°C	21°C ± 2	
Relative Humidity		25 to 65 %	51% ± 5	
Fully configured sample scanned over the following frequency range		Frequency range on each side of line	Measurement Point	
		150kHz to 30MHz	AC input port (120V)	
Limits				
Frequency (MHz)	Limit dB (µV)			
	Quasi-Peak	Result	Average	Result
0.15 – 0.50	66 \ 56	PASS	56 \ 46	PASS
0.50 - 5	56	PASS	46	PASS
5 – 30	60	PASS	50	PASS
Supplementary information: Test location: SMEE Test date: June 26 th , 2023 by C. KERMICHE. Power supply voltage: 5V DC via Port-USB and 120V AC 60Hz for the laptop.				

Tabulated Results for Mains Terminal Disturbance Voltage on AC port

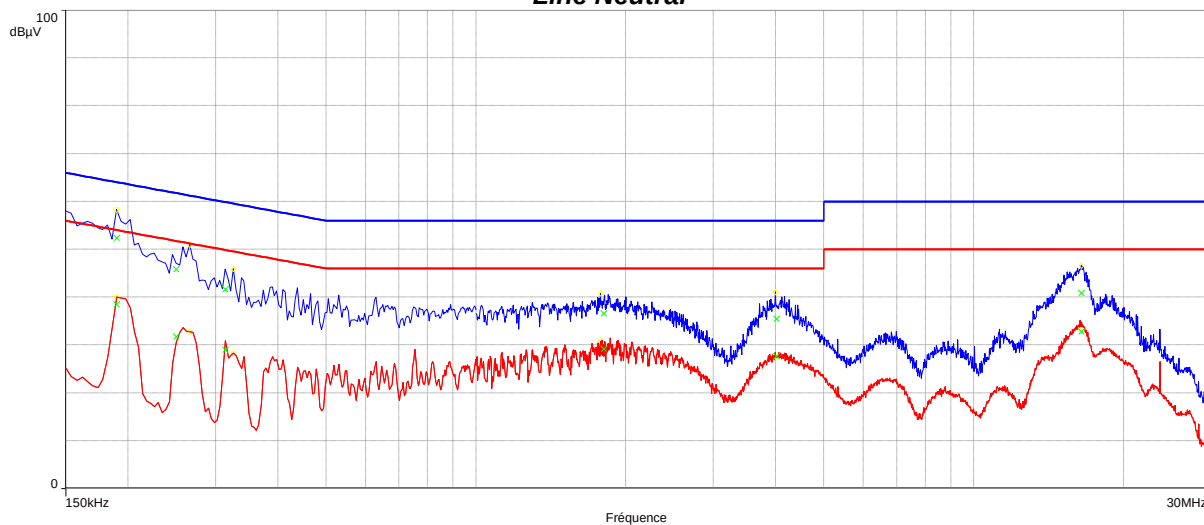
FREQ	Meas. PK	Mes. QP	LIMIT QP	Margin QP	Mes. AV	LIMIT AV	Margin AV	Line
(MHz)	(dBμV)	(dBμV)	(dBμV)	(dB)	(dBμV)	(dBμV)	(dB)	
0.187928	57.50	53.64	64.21	-10.57	34.76	54.21	-19.45	L1
0.25	50.85	46.45	61.76	-15.30	27.67	51.76	-24.09	L1
0.313259	45.58	40.44	59.86	-19.43	24.51	49.86	-25.36	L1
1.784909	38.76	34.77	56.00	-21.23	27.83	46.00	-18.17	L1
4.031583	37.11	31.15	56.00	-24.85	21.53	46.00	-24.47	L1
16.417453	48.57	42.66	60.00	-17.34	34.97	50.00	-15.03	L1
0.189566	58.14	52.38	64.04	-11.65	38.51	54.04	-15.52	N
0.25037	51.87	45.87	61.76	-15.89	31.72	51.76	-20.03	N
0.315146	48.54	41.61	59.86	-18.26	28.97	49.86	-20.89	N
1.807959	40.96	36.57	56.00	-19.43	29.17	46.00	-16.83	N
4.015369	41.01	35.42	56.00	-20.58	27.70	46.00	-18.30	N
16.463195	46.66	40.88	60.00	-19.12	32.81	50.00	-17.19	N
Frequency band investigated:		150kHz-30MHz						
RBW:		9kHz						
Voltage:		120V / 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						
Note:		Same results for all running modes / tested boards						

Graphical representation of Conducted Disturbance Measurement (Peak and Average detection) - AC port -

Line L1



Line Neutral



----: Peak

----: Average

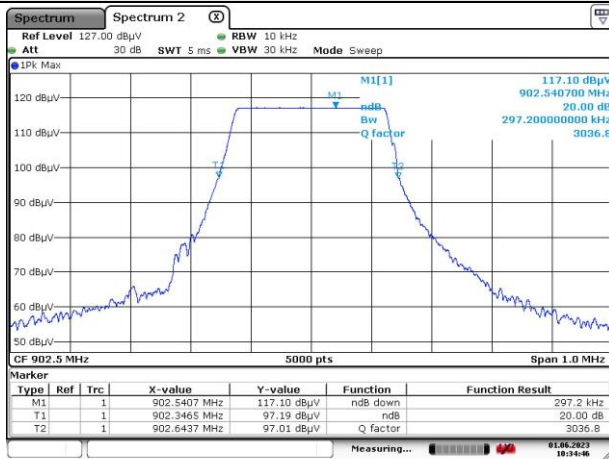
12. 20dB Bandwidth and Channel Separation

TEST: Hopping channel measurement (20dB BW and Separation)			Verdict
<u>Method:</u> The Equipment under test is connected to the spectrum analyzer with suitable mean. The SPAN is adapted to see the frequency band of operation. The spectrum analyzer RBW was 10kHz and VBW was 30kHz. The channel separation is measured with the hopping function enable on the EUT. <u>Limits:</u> Minimum separation between channels shall be 25kHz or the 20dB bandwidth, whichever is greater.			Pass
Laboratory Parameters:	Required prior to the test	During the test	
Ambient Temperature	17 to 27°C	21°C ± 2	
Relative Humidity	25 to 65 %	42% ± 5	
Supplementary information: Test location: SMEE Test date: June 1 st , 2023 by C. KERMICHE Power supply voltage: 3.7V			

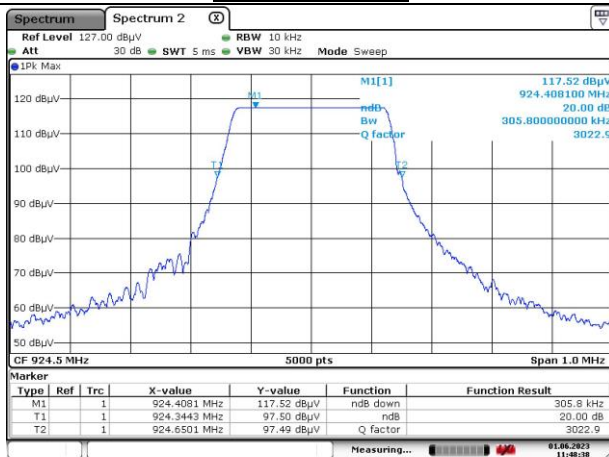
Tabulated Results for 20dB bandwidth			
Channel frequency	20dB Bandwidth	Limit for 20dB BW	Result
(MHz)	(kHz)	(kHz)	
902.5	297.2	250kHz < BW < 500kHz	PASS
913.5	301.0	250kHz < BW < 500kHz	PASS
924.5	305.8	250kHz < BW < 500kHz	PASS

Tabulated Results for Hopping Channel Separation				
Channel frequency	Adjacent channel separation	20dB Bandwidth	Minimum limit for channel separation	Result
(MHz)	(kHz)	(kHz)	(kHz)	
902.5	500.0	297.2	297.2	PASS
913.5		301.0	301.0	PASS
924.5		305.8	305.8	PASS

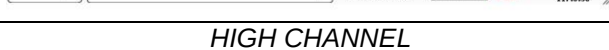
Graphical representation of 20dB Bandwidth



LOW CHANNEL

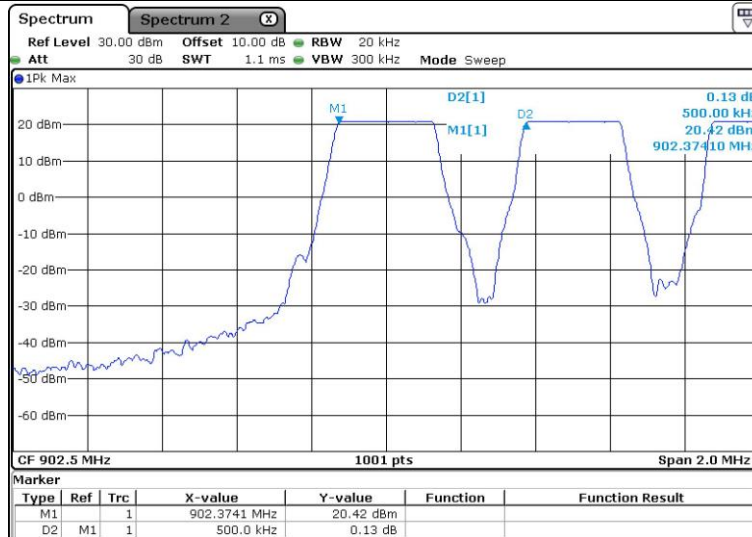


MID CHANNEL

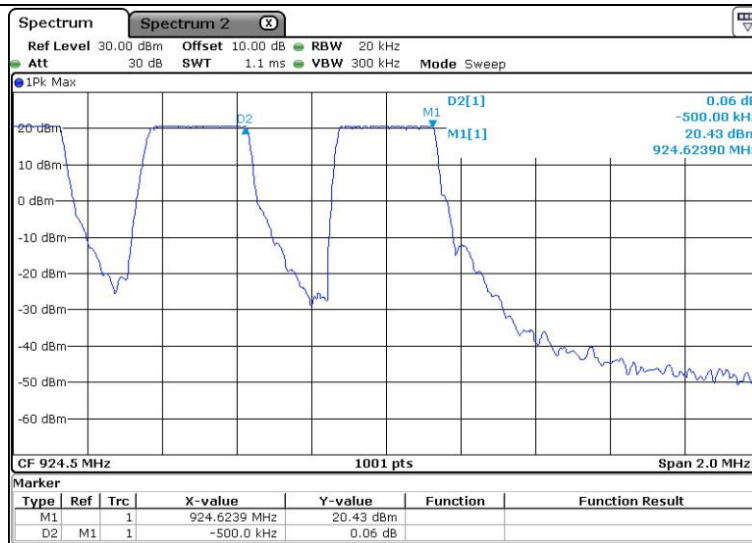


HIGH CHANNEL

Graphical representation of Hopping channel separation



Low channel

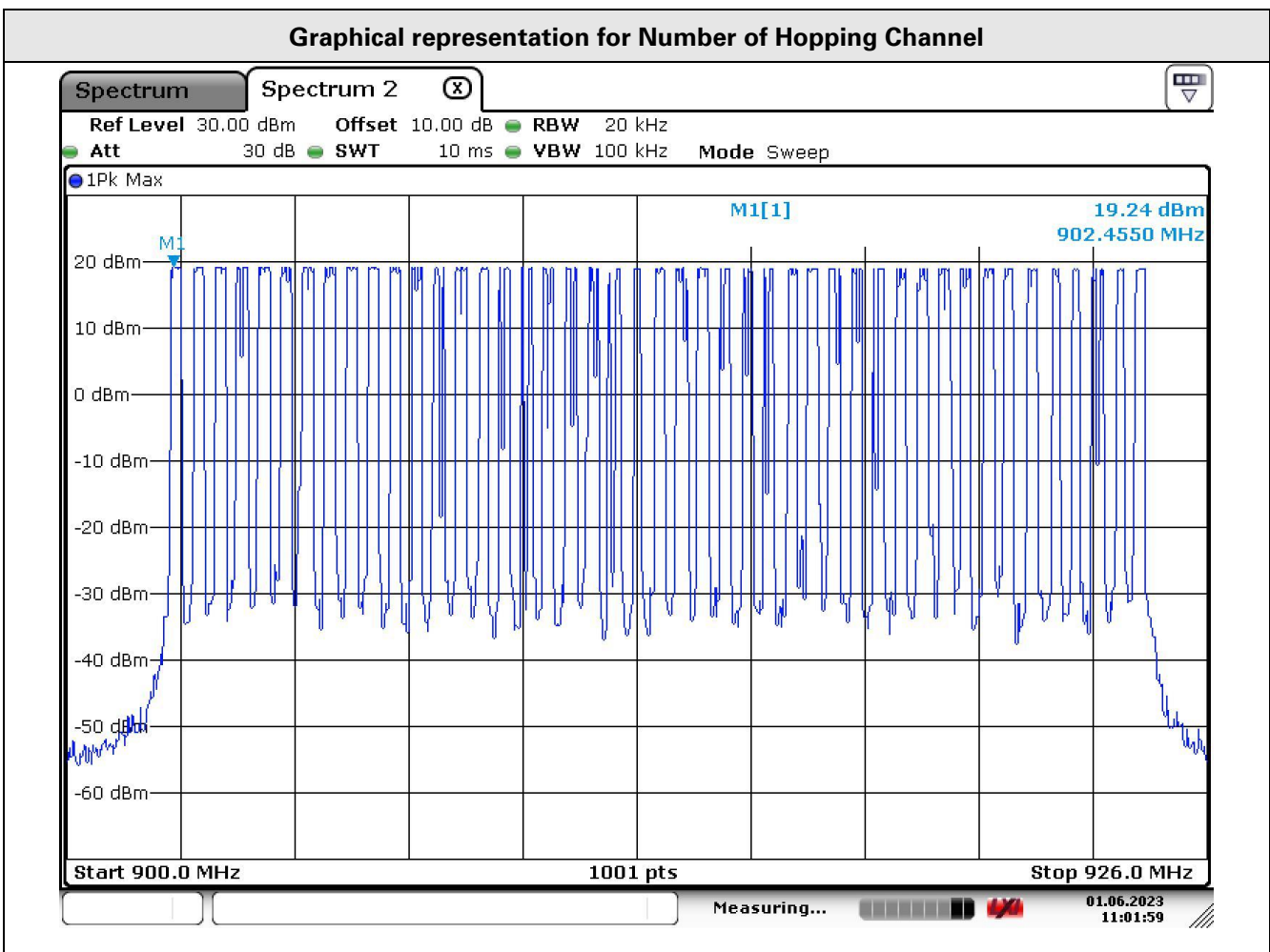


High channel

13. Number of hopping channels

TEST: Number of hopping channels			Verdict
Method: The Equipment under test is connected to the spectrum analyzer with suitable mean. The SPAN is adapted to see the frequency band of operation. The EUT has its hopping function enable. Limits: 25 channels			Pass
Laboratory Parameters:	Required prior to the test	During the test	
Ambient Temperature	17 to 27°C	21°C ± 2	
Relative Humidity	25 to 65 %	42% ± 5	
Supplementary information: Test location: SMEE Test date: June 1 st , 2023 by C. KERMICHE Power supply voltage: 3.7V			

Tabulated Results for Number of Hopping Channel		
Number of channels	Minimum number of channels	Result
45	25	PASS

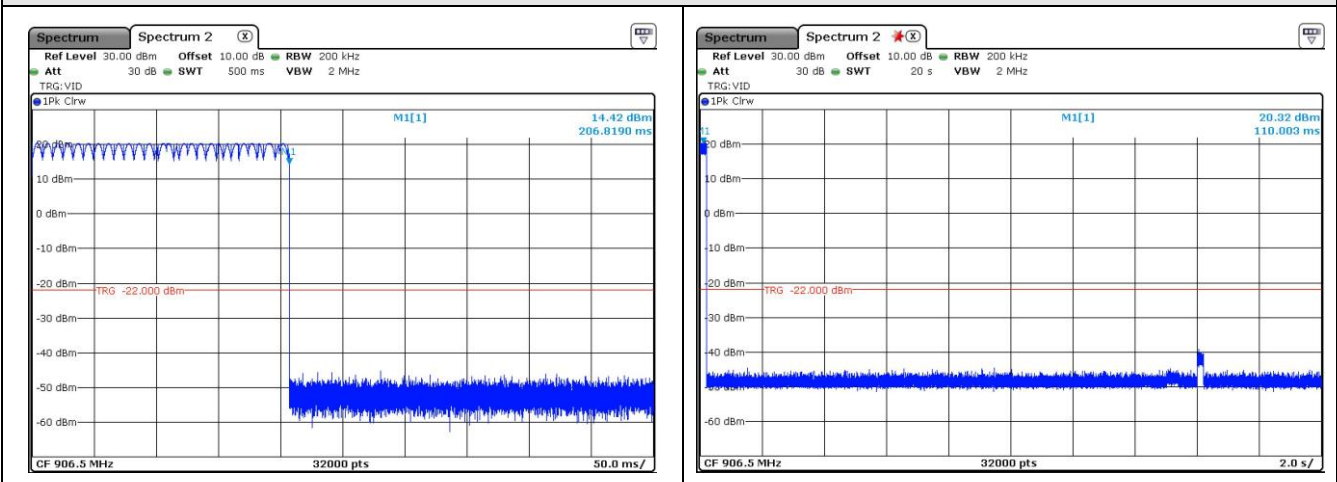


14. Average Time of occupancy

TEST: Time of occupancy			Verdict
<u>Method:</u> The Equipment under test is connected to the spectrum analyzer with suitable mean. The spectrum analyser is set to zero-span. The EUT has its hopping function enable. <u>Limits:</u> 400ms of transmission by channel on a period 10s. (45 channels used)			Pass
Laboratory Parameters:	Required prior to the test	During the test	
Ambient Temperature	17 to 27°C	24°C ± 2	
Relative Humidity	25 to 65 %	51% ± 5	
Supplementary information: Test location: SMEE Test date: July 7 th , 2023 by C. KERMICHE Power supply voltage: 3.7V			

Tabulated Results for Dwell time					
Modulation	Number of pulses per 10s period	Length of 1 pulse (ms)	Average Time of occupancy (ms)	Limit (ms)	Result
LORA	1	206.8	206.8	400ms	PASS
Additional information:					

Graphical representation for dwell time



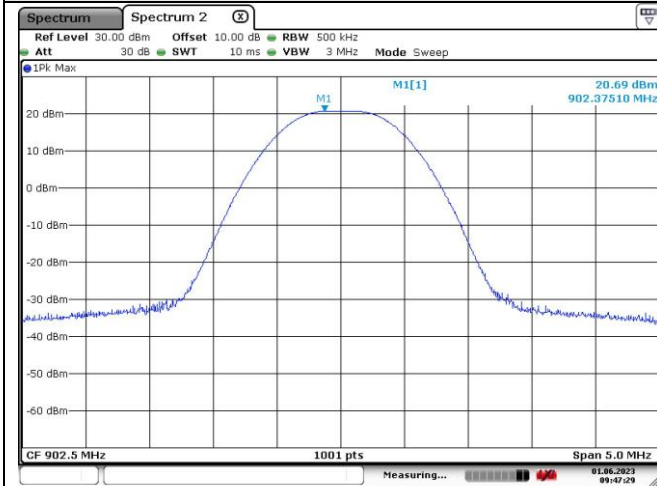
15. Fundamental emission output power

TEST: Maximum conducted output power			Verdict
Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the antenna port of the device under test. A conducted measurement is performed. The tested equipment is set to transmit operation with modulation on low, middle and high channels.			Pass
Laboratory Parameters:	Required prior to the test		During the test
Ambient Temperature	17 to 27°C		21°C ± 2
Relative Humidity	25 to 65 %		42% ± 5
Limits – FCC Part 15.247 (b) / RSS-247 §5.4			
Frequency (MHz)	Limits		
	Level	Results	
902.5 to 924.5	24 dBm (Conducted)	Pass	
	30 dBm (Radiated, EIRP)	Pass	
Supplementary information: Test location: SMEE Test date: June 1 st , 2023 by C. KERMICHE Power supply voltage: 3.7V			

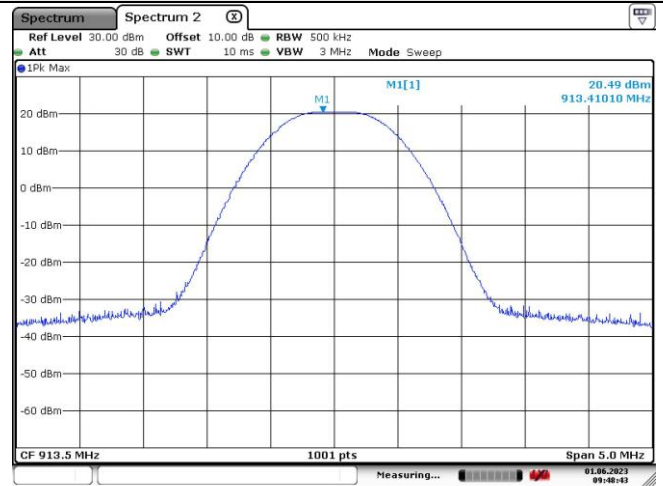
Tabulated Results for Maximum (Peak) output power (Conducted)					
FREQ (MHz)	Measured conducted power (dBm)	Duty cycle factor (dB)	Maximum output power (dBm)	Limit (dBm)	Result
902.5	20.7	-	20.7	24.0	Pass
913.5	20.5	-	20.5	24.0	Pass
924.5	20.4	-	20.4	24.0	Pass
RESULT:		PASS			
Note:		- Method used is ANSI C63.10 §7.8.5			

Tabulated Results for Maximum (Peak) output power (Radiated)					
FREQ (MHz)	Maximum output power Conducted (dBm)	Max Antenna Gain (dBi)	Maximum calculated output power (Radiated) (dBm)	Limit (dBm)	Result
902.5	20.7	2.0	22.7	30.0	Pass
913.5	20.5	2.0	22.5	30.0	Pass
924.5	20.4	2.0	22.4	30.0	Pass
RESULT:		PASS			

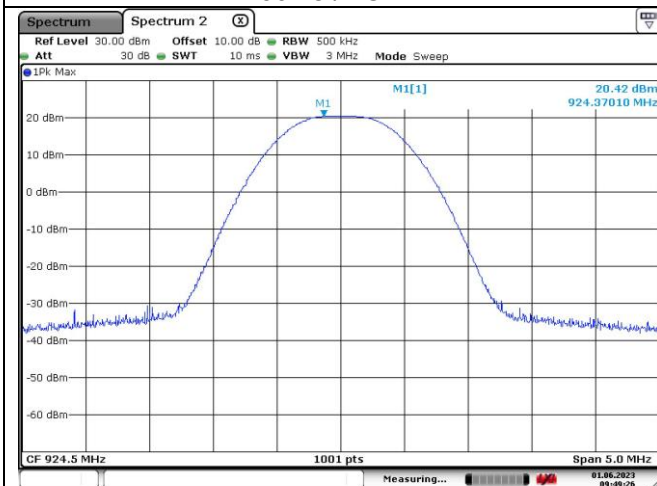
Graphical representation of Conducted output power



902.5 / LORA



913.5 / LORA

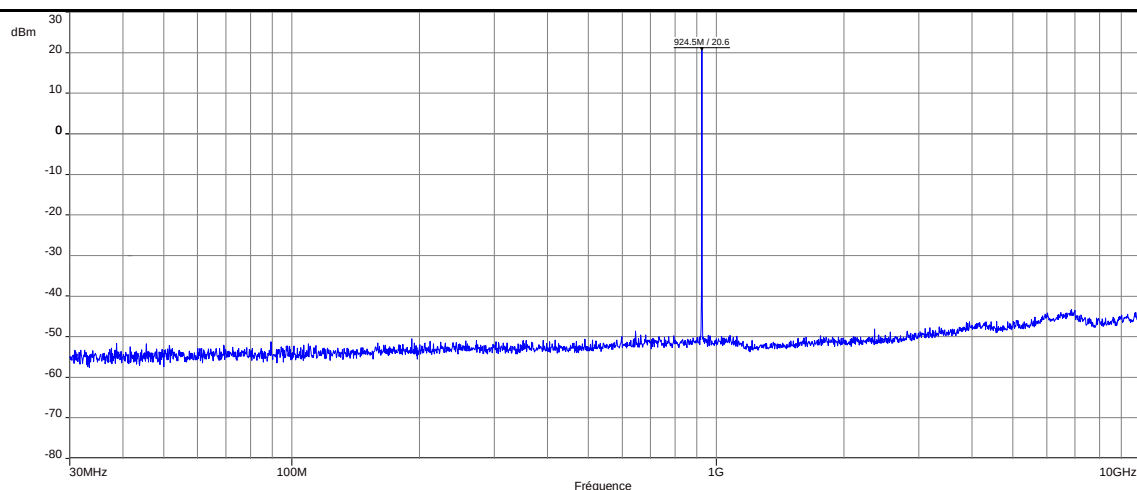
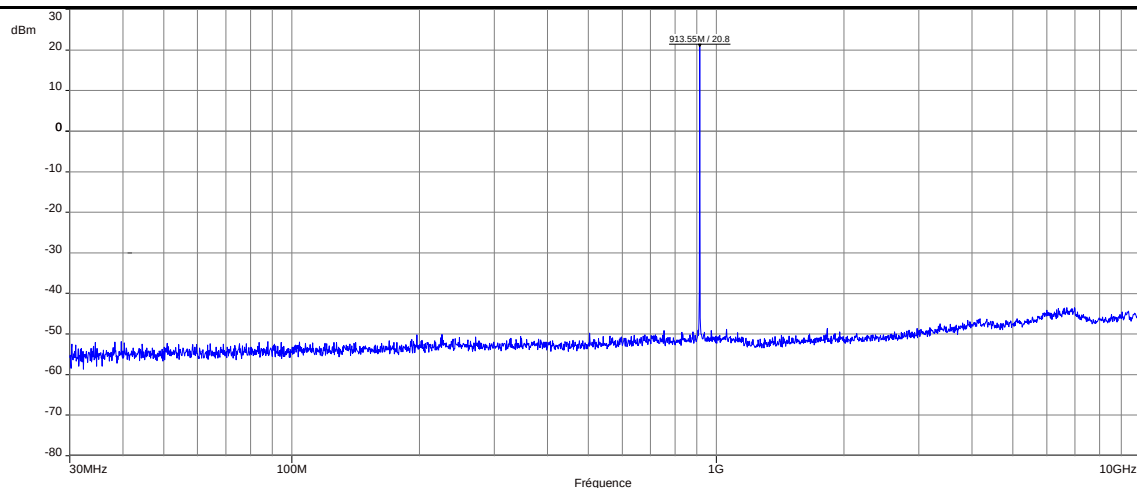
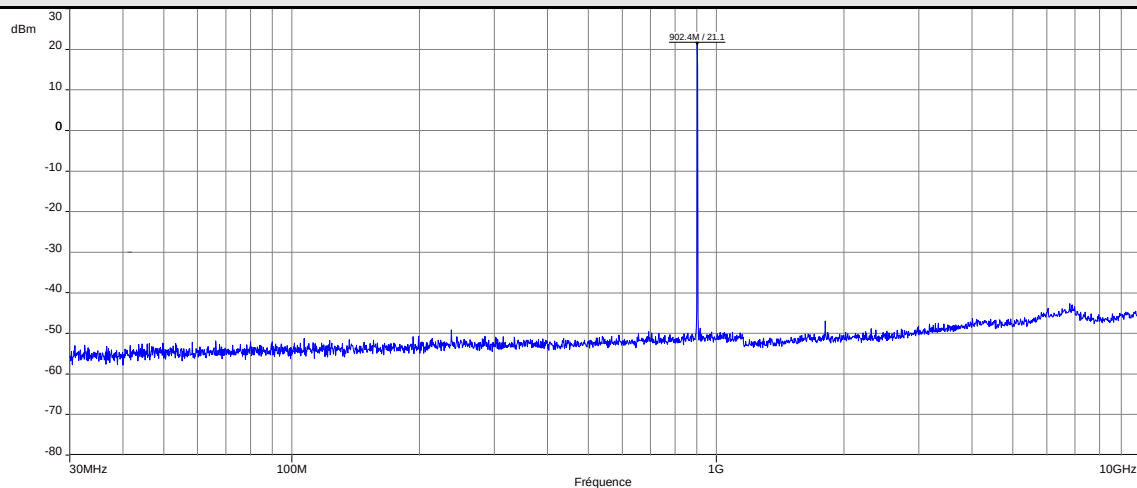


924.5 / LORA

16. Unwanted Spurious Emissions (Conducted emissions)

TEST: Conducted Spurious emissions			Verdict
Method: The setup is in an anechoic chamber. The spectrum analyzer is connected to the antenna port of the device under test. A conducted measurement is performed. 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	17 to 27°C		22°C ± 2
Relative Humidity	25 to 65 %		45% ± 5
Fully configured sample scanned over the following frequency range	Frequency range on each side of line		Measurement Point
	30MHz – 10GHz		Antenna port
Limits – FCC Part 15.247 (d) / RSS-247 § 5.5			
Frequency (MHz)	Limits (dBµV/m)		
	Detector / Analyser RBW	Limit	Results
30 to 10000	Pk / 100kHz	20dB below the maximum Peak level	Pass
Supplementary information: Test location: SMEE Test date: May 26 th , 2023 by C. KERMICHE Power supply voltage: 3.7V from external battery			

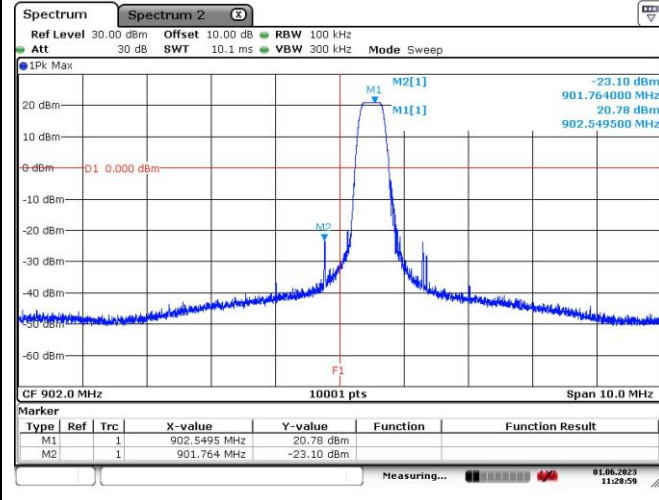
Graphical representation of Conducted Spurious emissions (LORA mode / Low, Mid and High channels)



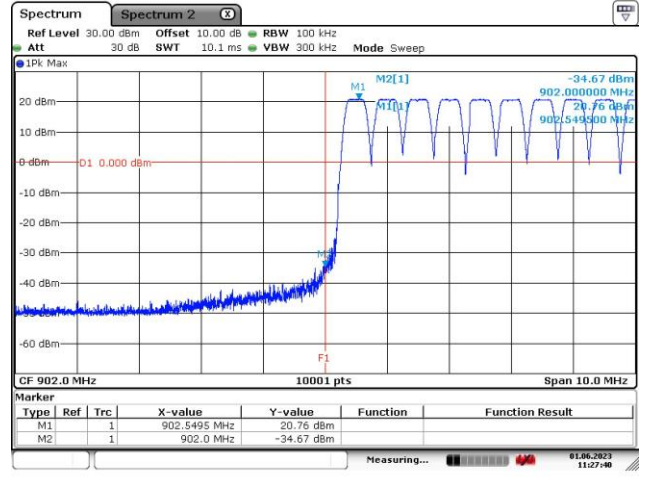
Frequency band investigated:	30MHz-10GHz
Unit :	dBm
RBW :	100kHz (Frequency step 50kHz)
Measurement detector:	Peak
Limit:	0.6 dBm

Graphical representation of Band-edge compliance (LOW)

LORA / Hopping Disable



LORA / Hopping Enabled



Unit : dBm

RBW : 100kHz

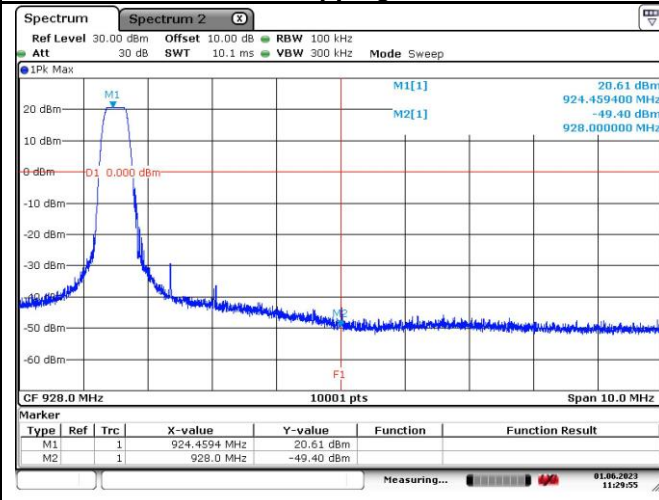
Measurement detector: Peak

Limit: 0.8 dBm

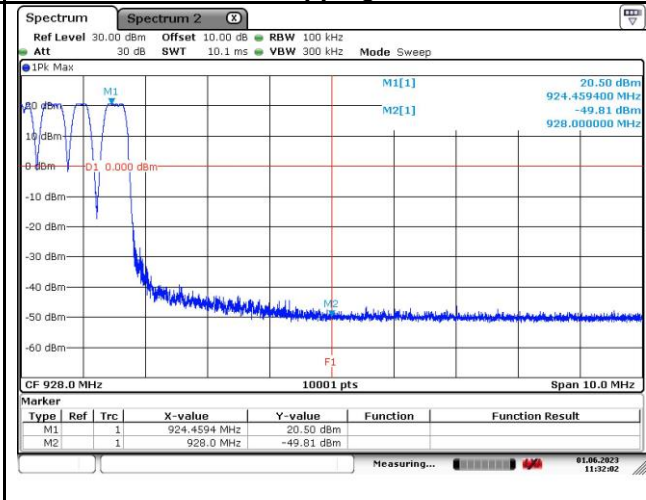
Note: F1 = 902MHz

Graphical representation of Band-edge compliance (High)

LORA / Hopping Disable



LORA / Hopping Enabled



Unit : dBm

RBW : 100kHz

Measurement detector: Peak

Limit: 0.5 dBm

Note: F1 = 928MHz

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

TEST: Unwanted emissions in Non-Restricted Frequency Bands			Verdict
Method: Measurements were made in a 3-meter Semi Anechoic Room (SAR) up to 1GHz and in a 3-meter Full Anechoic environment (SAR with floor absorbers) above 1GHz. The Semi Anechoic Room complies with CISPR16-1-4 / ANSI C63.4 requirements. Preliminary (peak) measurements were performed at an antenna to EUT separation distance of 3 meters. The EUT was rotated 360° about its azimuth with the receive antenna located at various heights in horizontal and vertical polarities. The pre-characterization graphs are obtained in PEAK detection. Final measurements (Peak, Quasi-peak, Average) were then performed by rotating the EUT 360° and adjusting the receive antenna height from 1 to 4 m. All frequencies were investigated in both horizontal and vertical antenna polarity, where applicable. 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	17 to 27°C	21°C ± 2	
Relative Humidity	25 to 65 %	42% ± 5	
Fully configured sample scanned over the following frequency range	Frequency range on each side of line	Measurement Point	
	30MHz – 10GHz	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 10000	Pk / 100kHz	20dB below the maximum Peak level	Pass
Supplementary information:			
Test location: SMEE			
Test date: May 26 th , 2023 by C. KERMICHE			
Power supply voltage: 3.7V			

Tabulated Results for Peak Output Radiated level	
FREQ (MHz)	Field Strength 3m (dBμV/m)
902.5	120.4
913.5	120.2
924.5	119.8
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 99.8 dBμV/m Peak for out-of-band frequencies in Non-Restricted bands (with a 100kHz RBW on the spectrum analyzer)

Tabulated Results for Unwanted emissions in Non-Restricted bands				
FREQ (MHz)	Field Strength 3m (dBμV/m)	Limit (dBμV/m)	Margin (dBμV/m)	Result (dBμV/m)
Levels are at least 10 dB below the -20dBc limit See pre-scan graphs in chapter 18.				
RBW:	100kHz			
Measurement distance:	3m			
Limit:	15.247 / RSS-247			
Final measurement detector:	Peak			
RESULT:	PASS			
Note:	3-axis measurement performed for device under test.			

18. 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	17 to 27°C	22°C ± 2
Relative Humidity	25 to 65 %	45% ± 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 – 10GHz	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: May 26th, 2023 by C. KERMICHE Power supply voltage: 3.7V		

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 / RSS-Gen clause 6.5) (M@30m = M@10m-19.1dB) Loop antenna used and rotated about its axis to maximize any emission.					

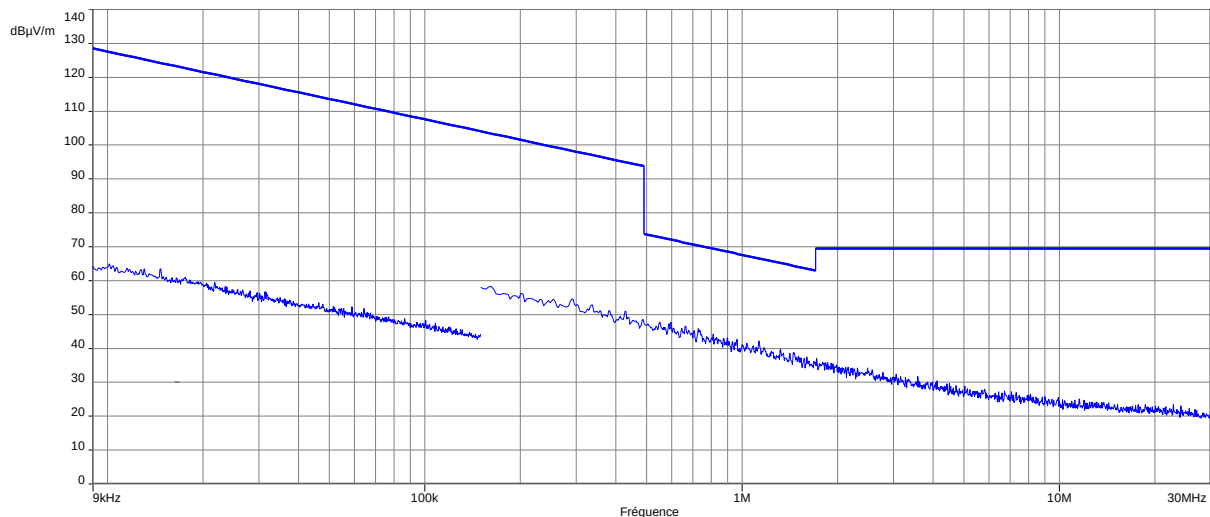
Tabulated Results for Unwanted emissions (30MHz-1GHz)										
FREQ	Meter reading	Meter reading	Total factor	Field level	Field level	Pol	Antenna height	Table angle	Limit	Margin
MHz	(QP) dBμV	(Pk) dBμV	dB	(QP) dBμV/m	(Pk) dBμV/m	H/V	cm	Degree	(QP) dBμV/m	dB
Levels are at least 10dB below limits										
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						

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

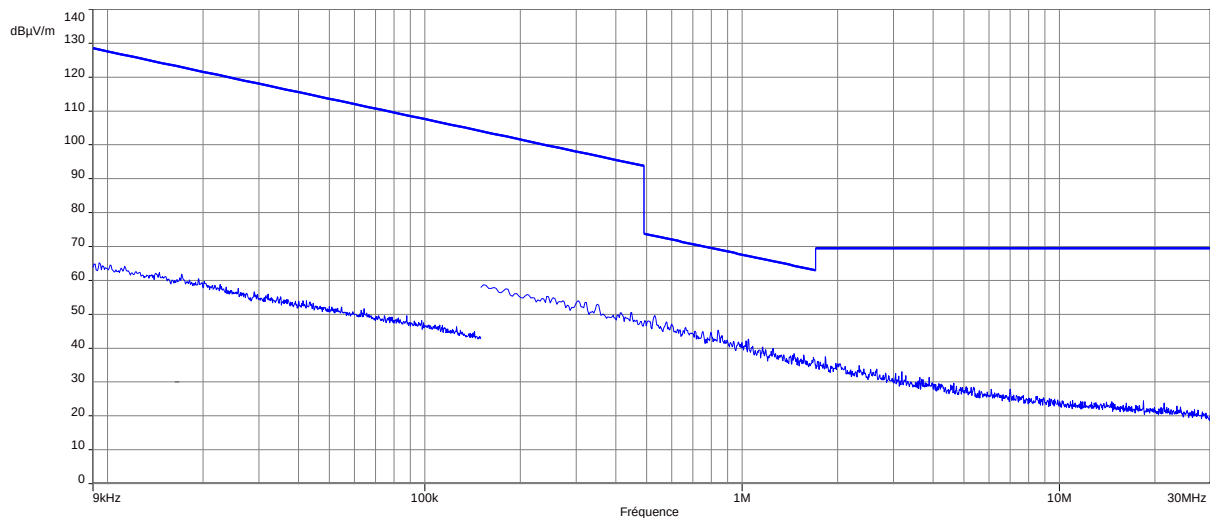
Board

SW HP: SN C231200164

Parallel



Perpendicular



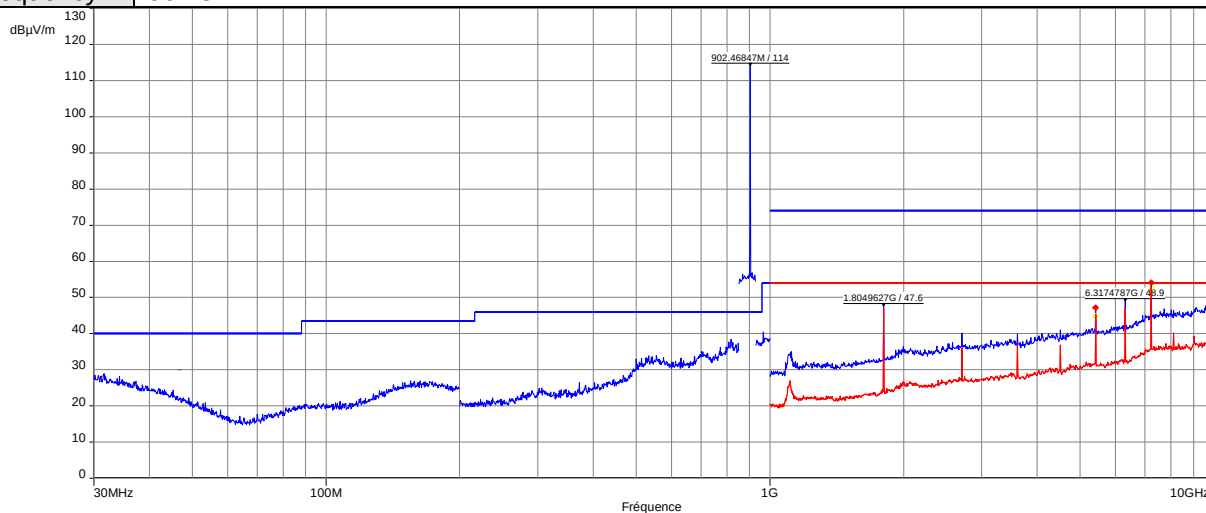
Frequency band investigated:	9kHz-30MHz
Unit :	dBμV/m
RBW :	200Hz (9kHz-150kHz) 9kHz (150kHz-30MHz)
Antenna polarization :	Parallel & Perpendicular to measurement axis.
Measurement detector:	Peak.
Notes:	Pre-scan graph only for identification purpose. Same result for all tested boards / running modes.

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

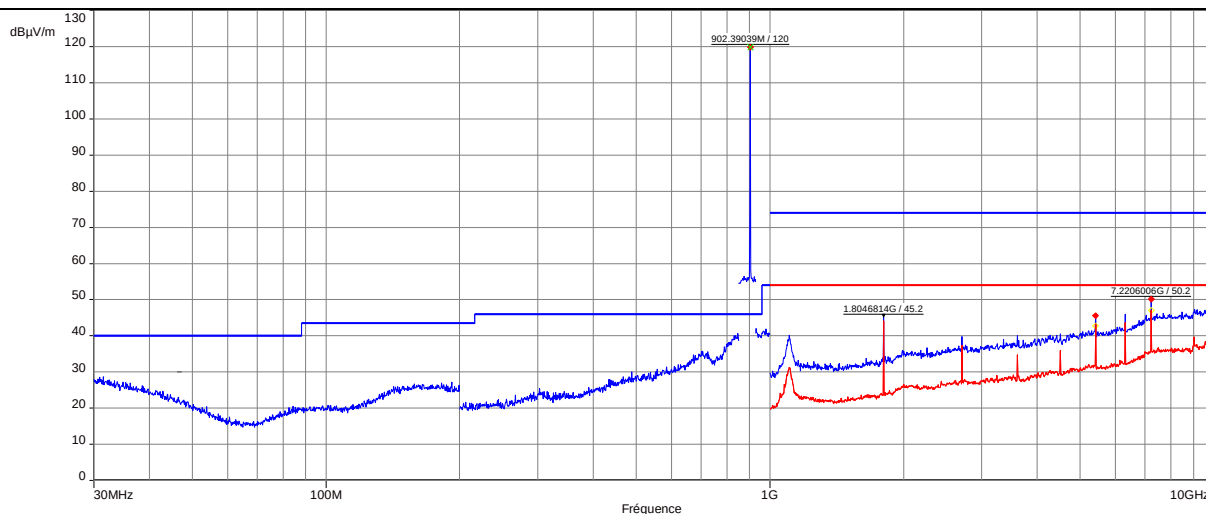
Board : SW HP: SN C231200164

Center frequency: 902.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



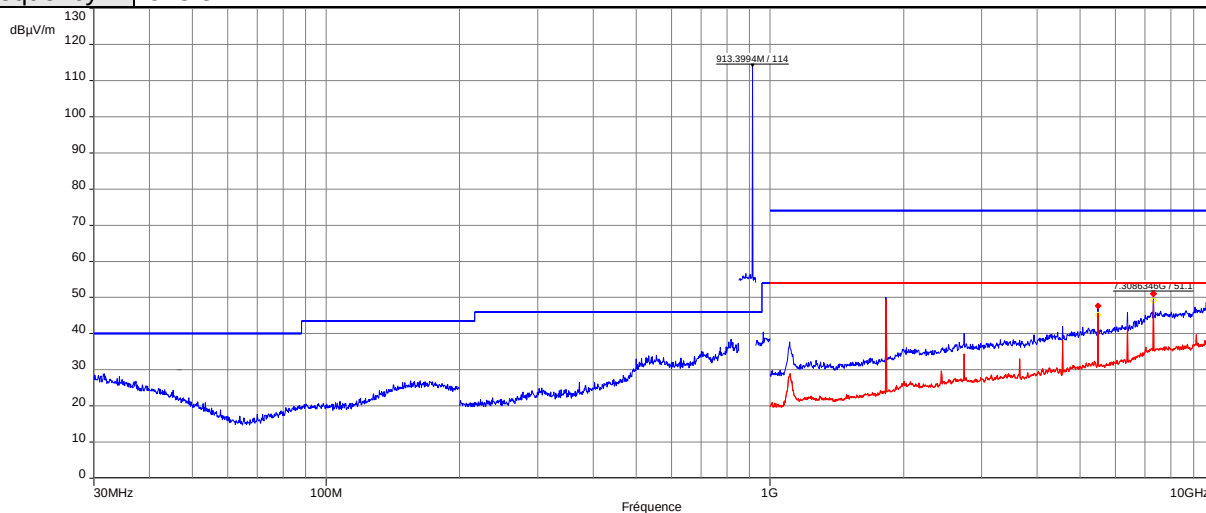
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV /m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
5414.67507	49.61	38.50	74.00	-24.39	54.00	-15.50	332.10	1.39	0.14	H	(1)
7219.44309	55.78	43.15	74.00	-18.22	54.00	-10.85	222.70	1.20	4.89	H	(1)
5414.55027	47.21	36.33	74.00	-26.79	54.00	-17.67	235.40	2.30	0.14	V	(1)
7219.92913	49.72	36.86	74.00	-24.28	54.00	-17.14	295.80	1.60	4.89	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

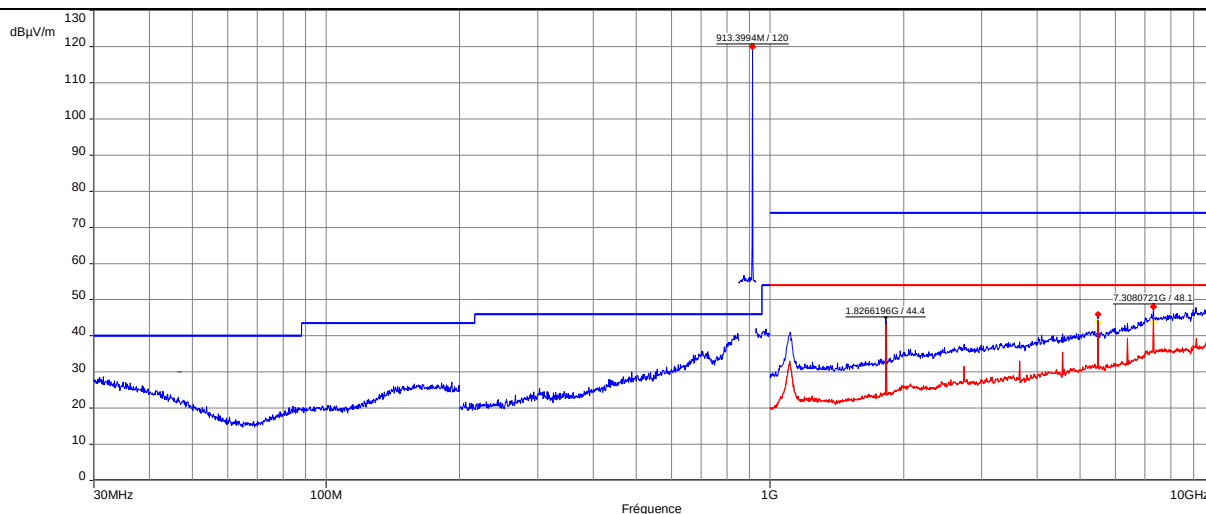
Board : SW HP: SN C231200164

Center frequency: 913.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



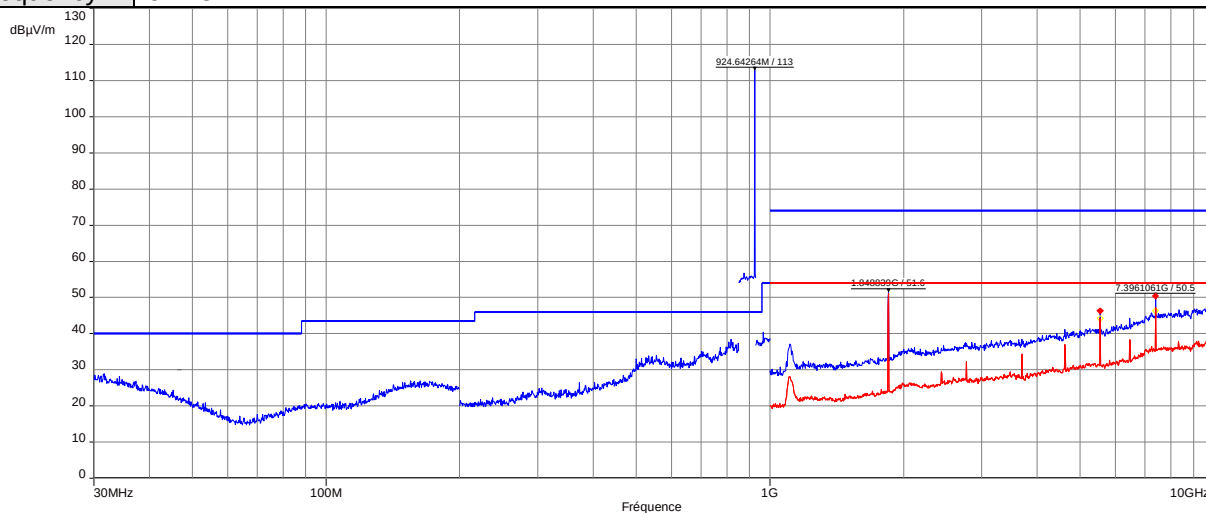
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV /m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
5480.58891	48.75	37.97	74.00	-25.25	54.00	-16.03	327.20	1.08	0.14	H	(1)
7308.33665	52.80	40.12	74.00	-21.20	54.00	-13.88	227.00	1.09	5.06	H	(1)
5480.3871	47.93	36.08	74.00	-26.07	54.00	-17.92	253.00	2.02	0.14	V	(1)
7307.10217	50.49	36.81	74.00	-23.51	54.00	-17.19	230.90	2.09	5.06	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

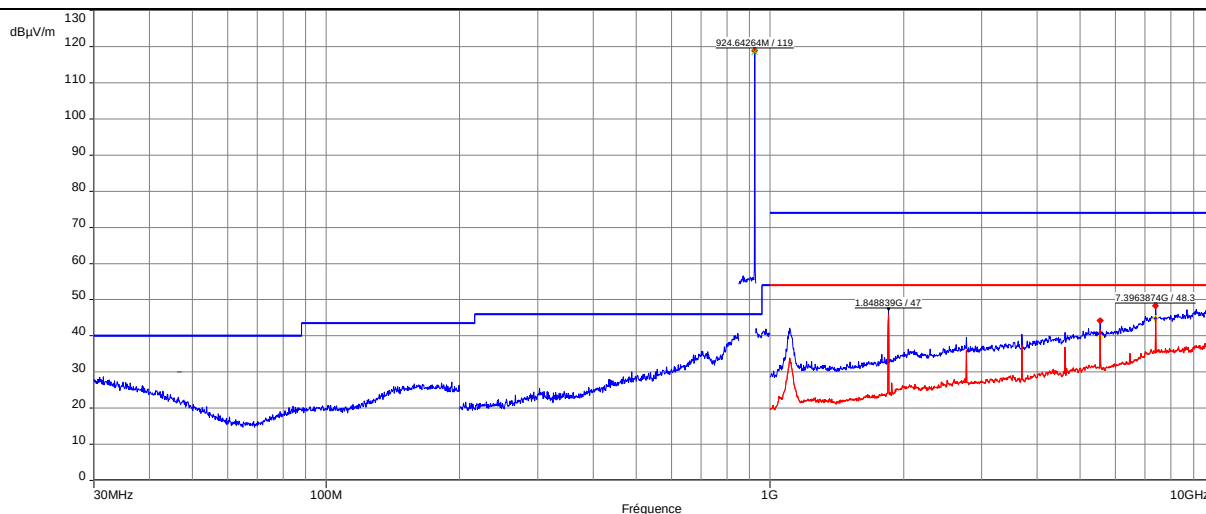
Board : SW HP: SN C231200164

Center frequency: 924.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



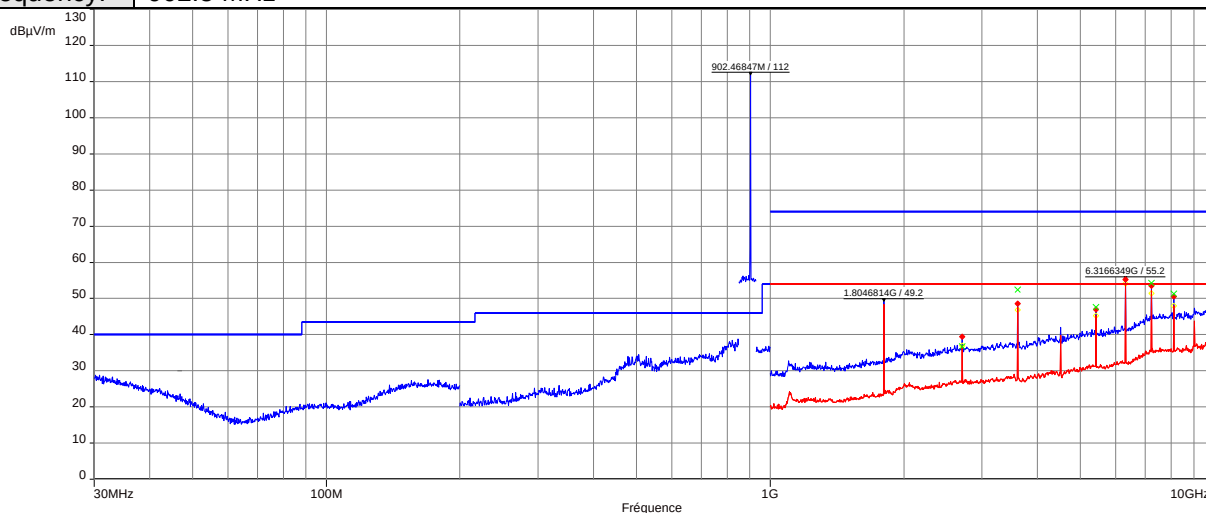
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV /m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
5547.27658	46.32	34.62	74.00	-27.68	54.00	-19.38	169.50	1.10	0.20	H	(1)
7396.46811	49.78	37.30	74.00	-24.22	54.00	-16.70	83.40	2.63	5.11	H	(1)
5547.535	45.11	32.67	74.00	-28.89	54.00	-21.33	322.80	2.31	0.20	V	(1)
7396.20439	49.41	36.01	74.00	-24.59	54.00	-17.99	212.30	1.47	5.10	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

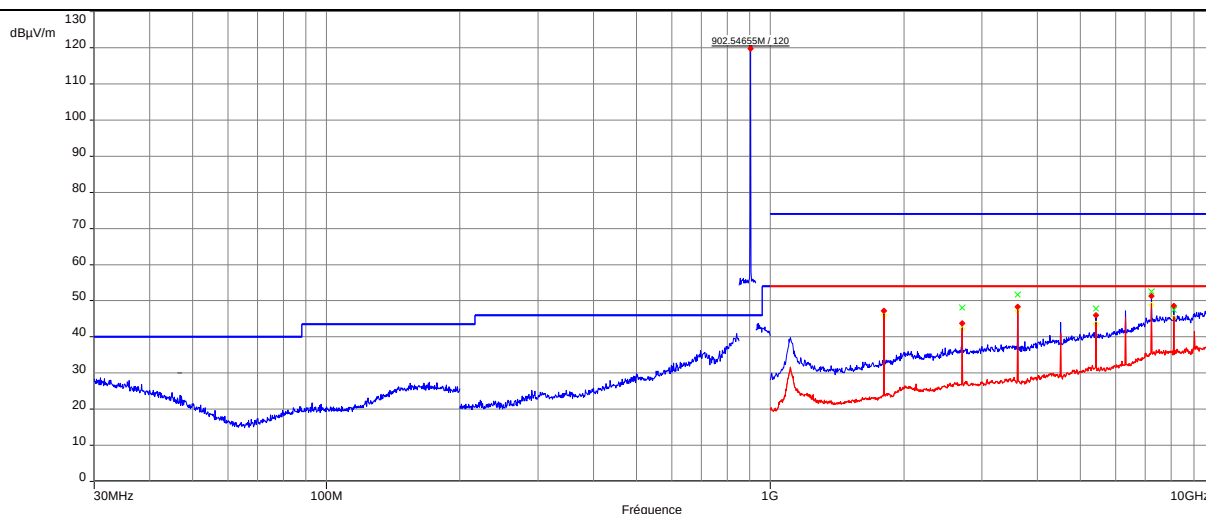
Board: SW HP 6S: SN C231200210

Center frequency: 902.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



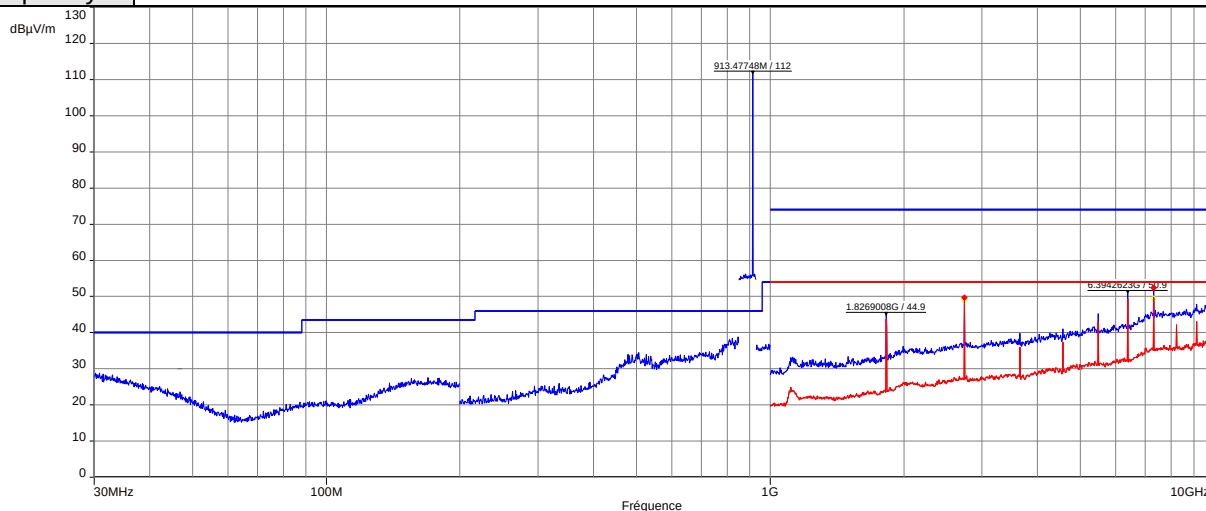
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV/m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
2705.83709	36.73	23.66	74.00	-37.27	54.00	-30.34	77.70	1.40	-6.72	H	(1)
3609.72583	52.40	30.90	74.00	-21.60	54.00	-23.10	128.70	2.72	-5.61	H	(1)
5414.92553	47.58	36.43	74.00	-26.42	54.00	-17.57	215.00	1.12	0.14	H	(1)
7220.86545	54.27	40.07	74.00	-19.73	54.00	-13.93	101.10	2.23	4.89	H	(1)
8123.14408	51.27	38.03	74.00	-22.73	54.00	-15.97	307.90	2.10	7.13	H	(1)
2707.69988	48.02	26.79	74.00	-25.98	54.00	-27.21	159.80	1.74	-6.71	V	(1)
3610.1026	51.70	32.83	74.00	-22.30	54.00	-21.17	359.50	1.09	-5.61	V	(1)
5414.45079	47.84	36.88	74.00	-26.16	54.00	-17.12	231.90	2.17	0.14	V	(1)
7219.3156	52.56	37.05	74.00	-21.44	54.00	-16.95	143.40	1.57	4.89	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

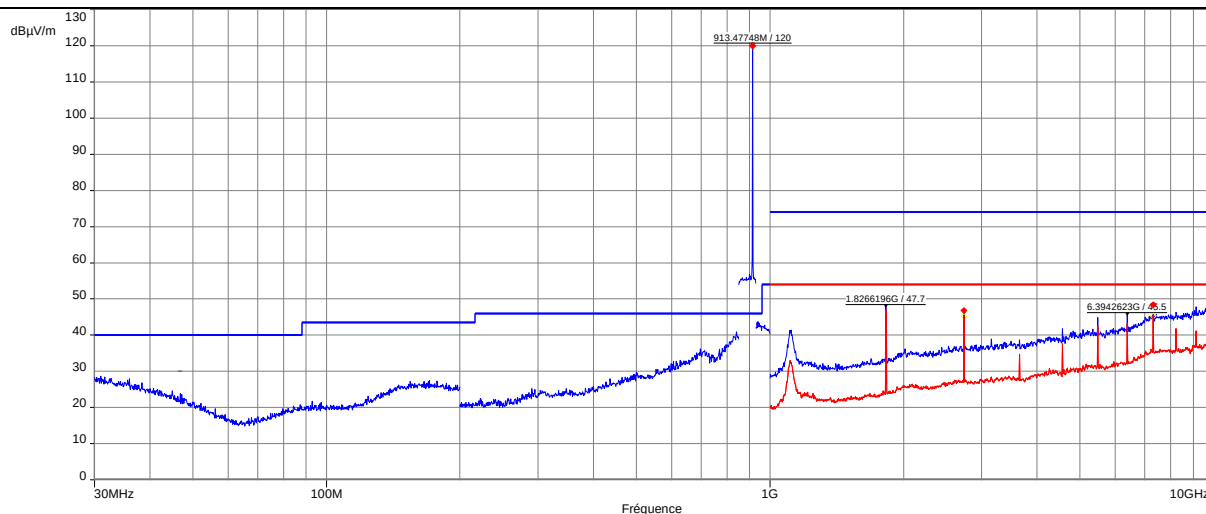
Board : SW HP 6S: SN C231200210

Center frequency: 913.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



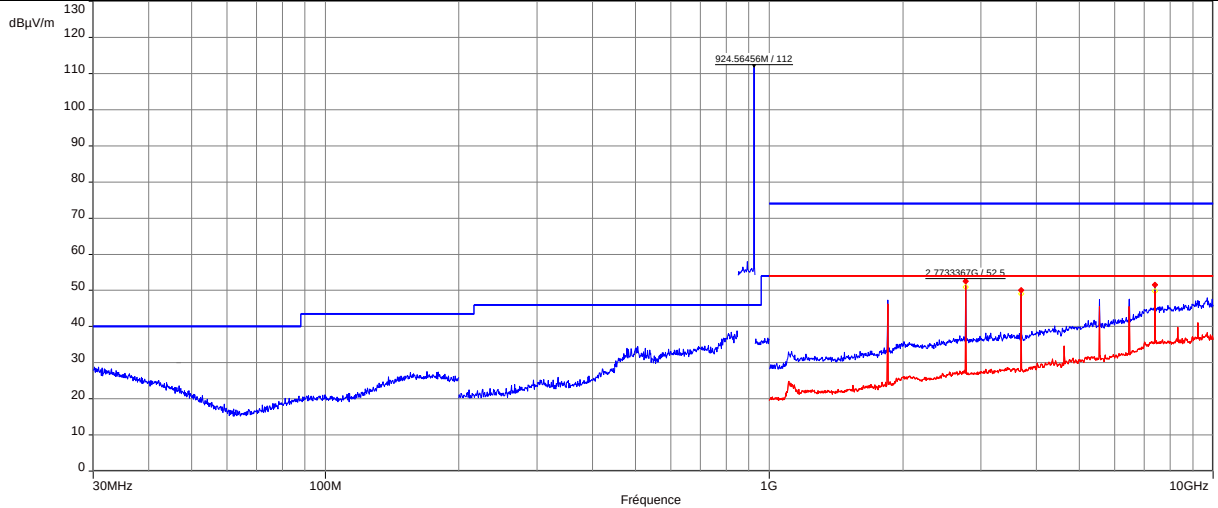
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV /m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
2740.50457	50.30	32.12	74.00	-23.70	54.00	-21.88	284.90	1.59	-6.72	H	(1)
7309.04902	53.32	38.69	74.00	-20.68	54.00	-15.31	235.70	1.90	5.06	H	(1)
2740.45581	45.83	34.65	74.00	-28.17	54.00	-19.35	344.60	1.09	-6.72	V	(1)
7308.69909	50.57	38.03	74.00	-23.43	54.00	-15.97	112.70	2.41	5.06	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

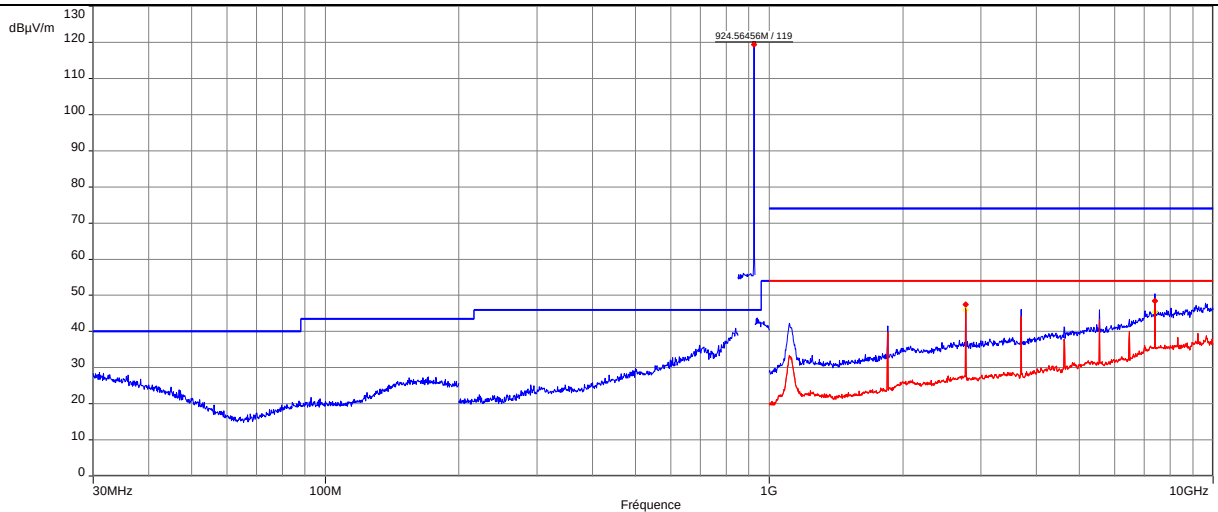
Board : SW HP 6S: SN C231200210

Center frequency: 924.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



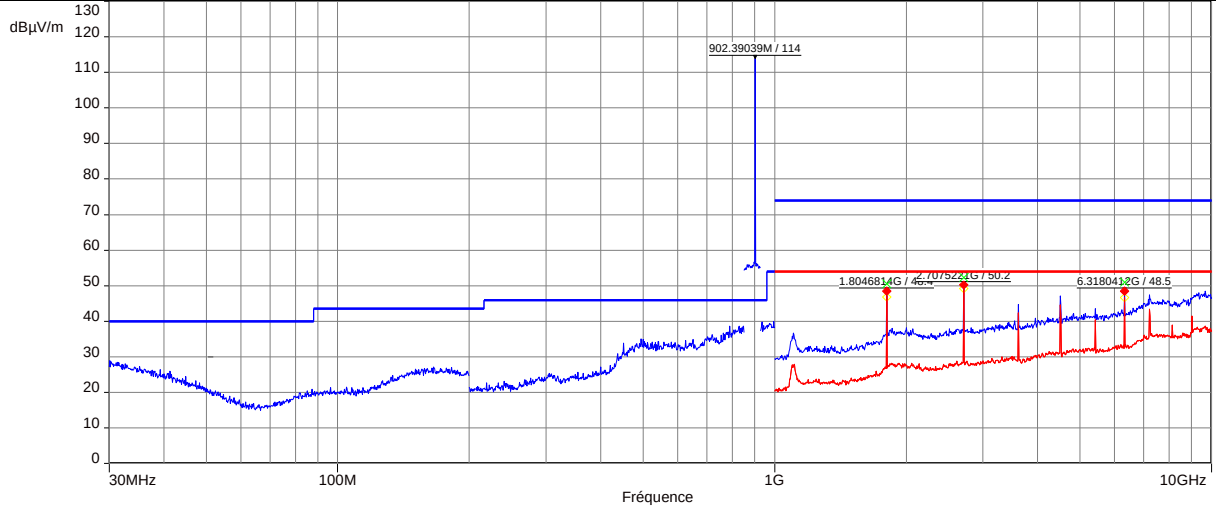
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV/m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
2773.89012	50.30	32.14	74.00	-23.70	54.00	-21.86	68.70	1.64	-6.76	H	(1)
3697.76048	43.81	25.45	74.00	-30.19	54.00	-28.55	177.10	1.27	-5.62	H	(1)
7396.35261	52.62	40.06	74.00	-21.38	54.00	-13.94	124.80	2.81	5.10	H	(1)
2773.47343	49.06	28.29	74.00	-24.94	54.00	-25.71	175.70	1.55	-6.76	V	(1)
7395.74566	52.43	39.94	74.00	-21.57	54.00	-14.06	107.20	1.60	5.10	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

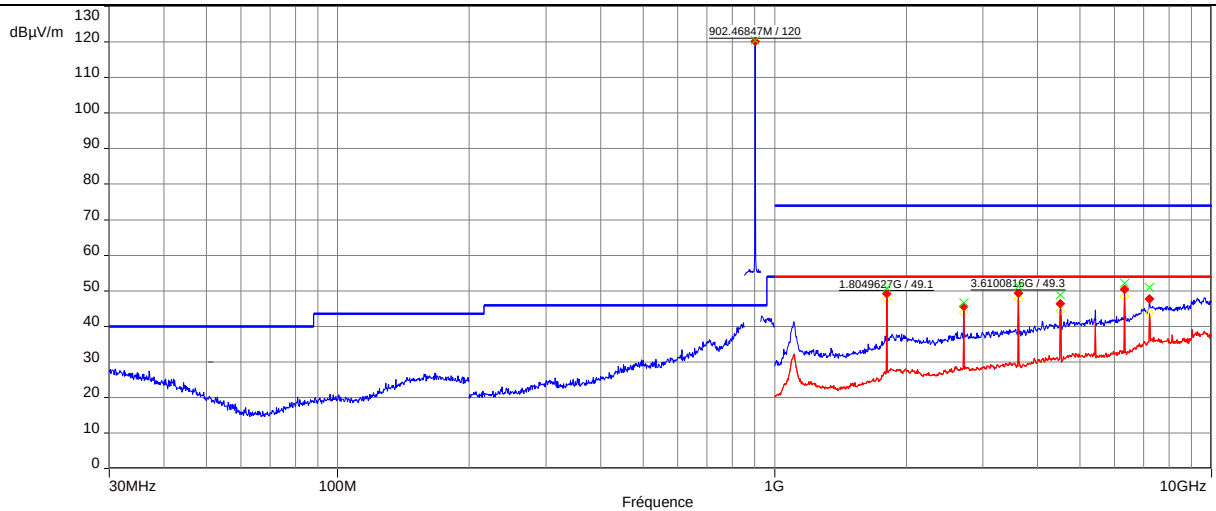
Board: SB HP: SN C231200116

Center frequency: 902.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



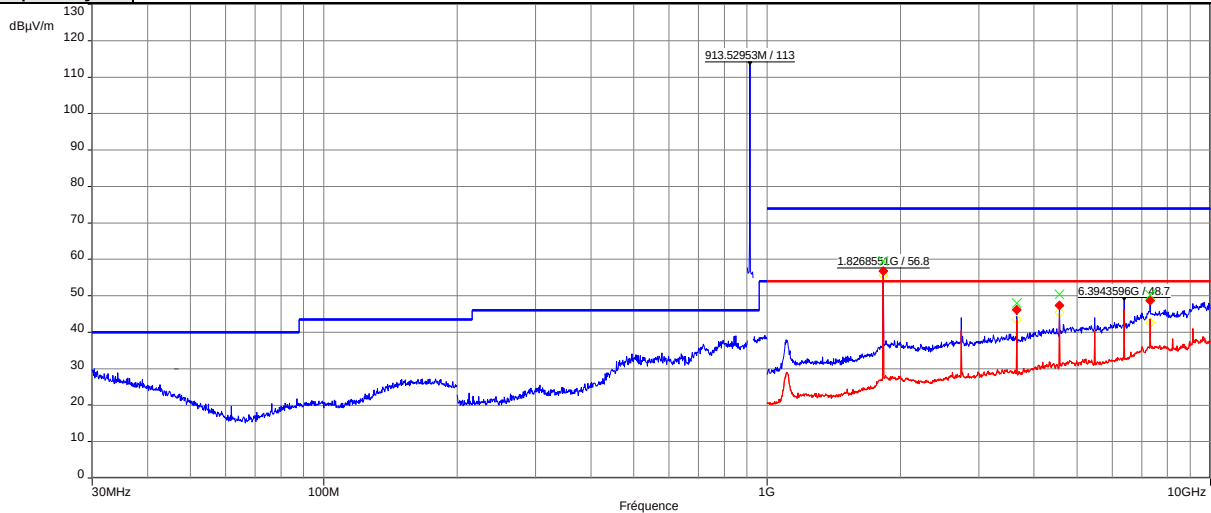
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV /m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
1804.96111	50.51	45.29	-	-	-	-	100.00	1.19	-6.54	H	(2)
2707.70899	52.31	46.52	74.00	-21.69	54.00	-7.48	248.90	1.09	-5.42	H	(1)
6317.15485	51.00	45.08	-	-	-	-	47.90	1.09	2.46	H	(2)
1804.86421	50.80	45.08	-	-	-	-	178.00	2.28	-6.54	V	(2)
2707.446	46.66	40.25	74.00	-27.34	54.00	-13.75	19.80	1.09	-5.43	V	(1)
3610.17706	51.31	34.32	74.00	-22.69	54.00	-19.68	348.10	2.08	-4.11	V	(1)
4512.62139	48.85	42.41	74.00	-25.15	54.00	-11.59	37.40	1.92	-1.13	V	(1)
6317.3101	52.12	44.72	-	-	-	-	112.80	1.09	2.46	V	(2)
7219.96231	50.97	41.18	74.00	-23.03	54.00	-12.82	263.70	1.09	5.97	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band. (2): Non-restricted band								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

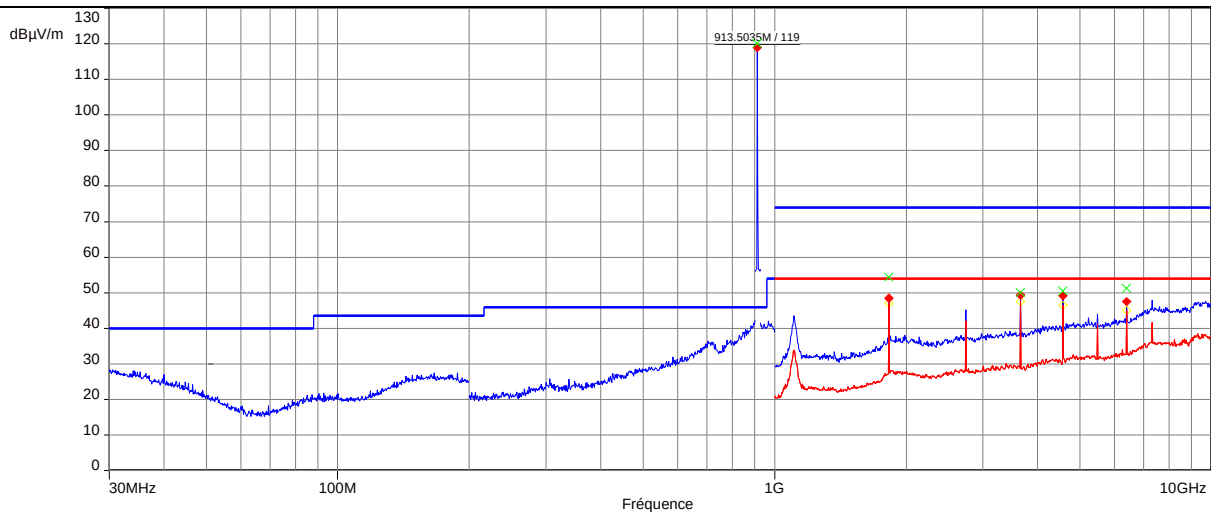
Board: SB HP: SN C231200116

Center frequency: 913.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



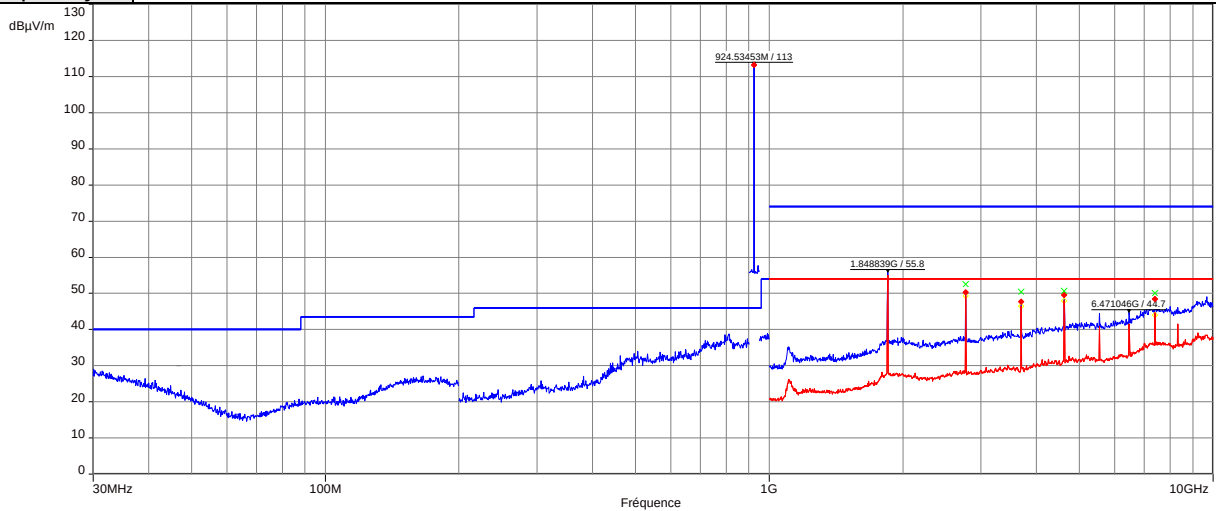
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV/m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
1826.99571	59.56	55.87	-	-	-	-	217.50	1.72	-6.09	H	(2)
3653.99711	48.01	41.60	74.00	-25.99	54.00	-12.40	292.50	2.86	-4.04	H	(1)
4567.52878	50.44	41.35	74.00	-23.56	54.00	-12.65	266.50	1.39	-0.95	H	(1)
7308.20088	50.24	40.53	74.00	-23.76	54.00	-13.47	125.70	2.37	6.06	H	(1)
1827.07279	54.47	50.31	-	-	-	-	258.50	2.90	-6.09	V	(2)
3653.76982	50.11	44.05	74.00	-23.89	54.00	-9.95	351.30	1.85	-4.04	V	(1)
4567.64771	50.62	43.54	74.00	-23.38	54.00	-10.46	38.60	2.39	-0.95	V	(1)
6394.00984	51.26	42.98	-	-	-	-	98.40	1.09	2.53	V	(2)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band. (2): Non-restricted band								

Graphical representation of Radiated Disturbance Measurement (Peak detection, Full Anechoic Chamber pre-scan, 30MHz-10GHz / 3m / Transmit mode / Worst position)

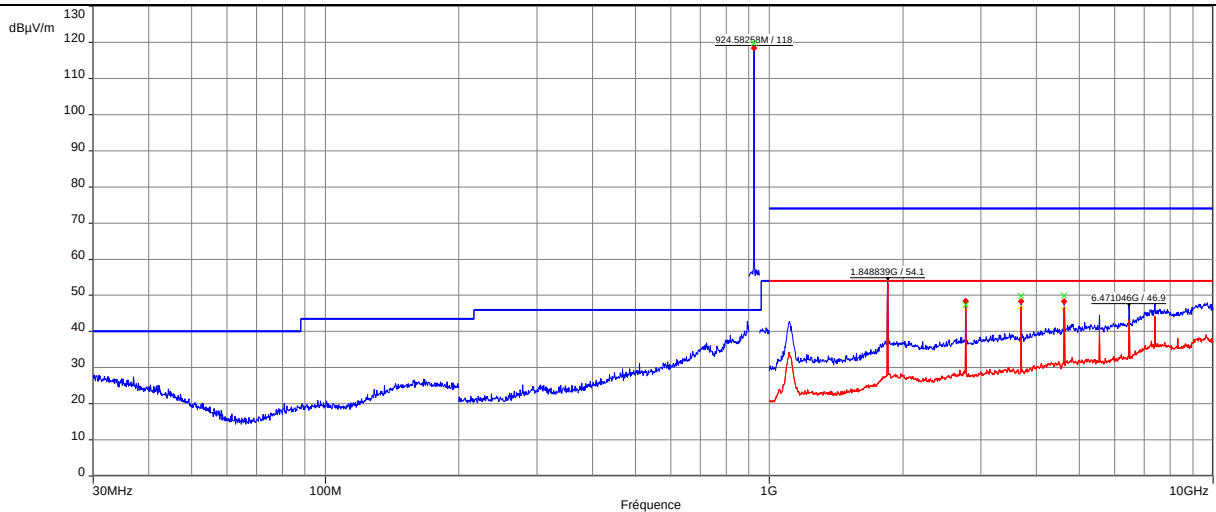
Board : SB HP: SN C231200116

Center frequency: 924.5 MHz

HORIZONTAL POLARIZATION



VERTICAL POLARIZATION



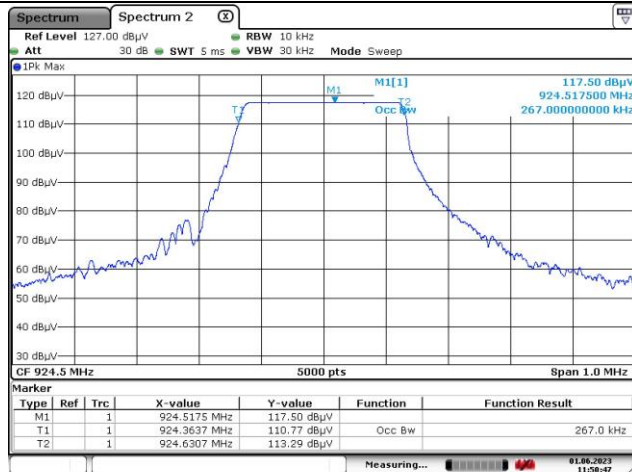
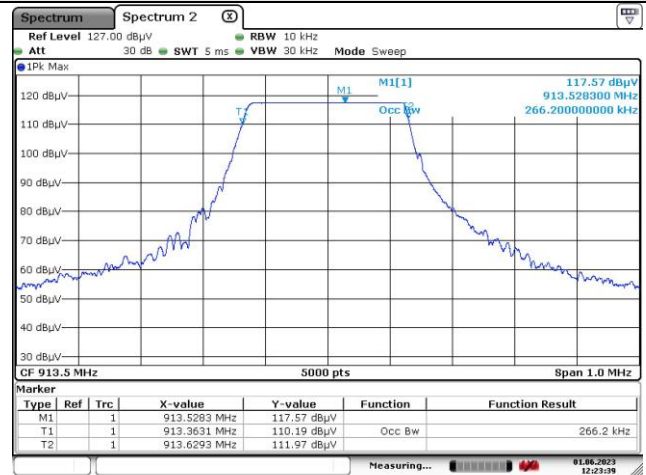
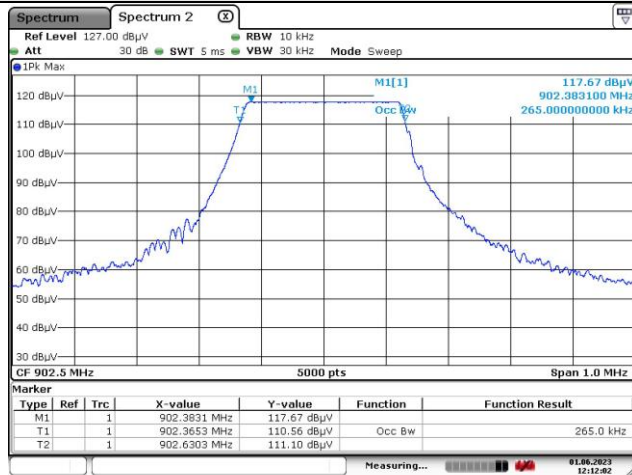
FREQ	Field level	Field level	Limit	Margin	Limit	Margin	Table angle	Ant height	Total factor	Pol	Note
MHz	(PK) dBμV/m	(AV) dBμV/m	(PK) dBμV/m	(PK) dB	(AV) dBμV/m	(AV) dB	Degree	m	dB		
2773.52591	52.52	38.64	74.00	-21.48	54.00	-15.36	273.00	1.86	-5.56	H	(1)
3698.38838	50.38	35.61	74.00	-23.62	54.00	-18.39	275.20	2.27	-4.12	H	(1)
4622.89159	50.66	38.64	74.00	-23.34	54.00	-15.36	274.50	1.09	-0.67	H	(1)
7396.24988	50.04	34.72	74.00	-23.96	54.00	-19.28	285.40	1.22	6.20	H	(1)
2773.67816	47.34	37.80	74.00	-26.66	54.00	-16.20	333.90	1.09	-5.56	V	(1)
3698.32129	49.75	35.62	74.00	-24.25	54.00	-18.38	354.30	1.09	-4.12	V	(1)
4622.15215	49.89	38.30	74.00	-24.11	54.00	-15.70	34.30	1.68	-0.67	V	(1)
RBW :			100kHz < 1GHz and 1MHz > 1GHz.								
Final measurement detector:			Quasi-Peak below 1GHz. Peak and CISPR Average above 1GHz.								
Note:			(1) Restricted band.								

19. Occupied bandwidth (99%)

TEST: Occupied bandwidth (99%) / RSS-GEN		Verdict
Method: The setup is in an anechoic chamber. The Equipment under test is connected to the spectrum analyzer with suitable mean. The RBW is set in the range of 1% to 5% of the occupied bandwidth, with VBW $\geq 3 \times$ RBW. The SPAN is wide enough to capture all products of the modulation process. A 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	17 to 27°C	21°C $\pm$ 2
Relative Humidity	25 to 65 %	42% $\pm$ 5
Supplementary information: Test location: SMEE Test date: June 1st, 2023 by C. KERMICHE Power supply voltage: 3.7V		

Tabulated Results for Occupied Bandwidth	
Frequency (MHz)	99% Occupied Bandwidth (kHz)
902.5	265.0
913.5	266.2
924.5	267.0

Graphical representation of Occupied Bandwidth



END OF TEST REPORT.