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Template : March 5th, 2024

TEST REPORT

N°: **21806588-799393-A(FILE#8175439)** Version: **01**

Subject	**Radio spectrum tests according to the standards: FCC CFR 47 Part 15.247 & ANSI C63.10 RSS-247 & RSS-Gen**
Issued to	**EWATTCH** 13 Rue Maurice Jeandon 88100 – SAINT-DIE-DES-VOSGES FRANCE
Apparatus under test	
Product	**SQUID PRO LoRaWAN**
Trade mark	**EWATTCH**
Manufacturer	**EWATTCH**
Model under test	**SQUID-PRO**
Serial number	**70B3D5475012134E**
FCCID	**2BBDC-SQUID-PRO-01**
IC	**31217-SQUIDPRO01**
Conclusion	See Test Program chapter
Test date	April 04, 2024 to April 11, 2024
Test location	LCIE Grenoble
FCC Test site	FR0008 - 918017 (MOI)
ISED Test site	6500A (MOI)
Sample receipt date	April 01, 2024
Composition of document	58 pages
Document issued on	April 29, 2024

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PUBLICATION HISTORY

Version	Date	Author	Modification
01	April 29, 2024	Akram HAKKARI	Creation of the document

Each new edition of this test report replaces and cancels the previous edition. The control of the old editions of report is under responsibility of client.

SUMMARY

1. TEST PROGRAM

References

- **47 CFR Part 15.247 (2023)**
- **RSS 247 Issue 3**
- **RSS Gen Issue 5**
- **KDB 558074 D01 DTS Meas Guidance v05r02**
- **KDB 662911 D01 Multiple Transmitter Output v02r01**
- **ANSI C63.10 (2013)**

Radio requirement:

Clause - Test Description		Test result - Comments
Occupied Bandwidth	***ISED***	**PASS**
6dB Bandwidth	***FCC & ISED***	**PASS**
Maximum Conducted Output Power	***FCC & ISED***	**PASS**
Power Spectral Density	***FCC & ISED***	**PASS**
Unwanted Emissions in Non-Restricted Frequency Bands	***FCC & ISED***	**PASS**
Unwanted Emissions in Restricted Frequency Bands	***FCC & ISED***	**PASS**
Receiver Radiated Emissions	***ISED***	**PASS(2)**
This table is a summary of test report, see conclusion of each clause of this test report for detail.		

(1) Limited program
(2) Testing covered the receive mode, and receiver spurious emissions are considered to be the same as transmitter.

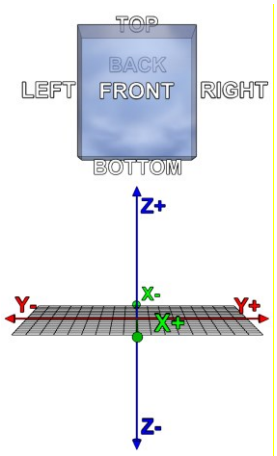
PASS: EUT complies with standard's requirement
FAIL: EUT does not comply with standard's requirement
NA: Not Applicable
NP: Test Not Performed

2. EQUIPMENT UNDER TEST: CONFIGURATION (DECLARED BY PROVIDER)

2.1. HARDWARE IDENTIFICATION (EUT AND AUXILIARIES):

Equipment under test (EUT):

Model under test:	**SQUID-PRO**
Serial Number:	**70B3D5475012134E**



Dimensions:	103,5 x 87,8 x 62 mm (Length x Width x Height)
Type:	Panel / Rack / Cabinet (considered like table-top)

Power supply:

Name	Type	Rating	Reference / Sn	Comments
Supply1	DC	24 VDC	-	-

NC: Not communicated by provider

Inputs/outputs - Cable:

Access	Type	Length used (m)	Declared <3m	Shielded	Comments
Supply1	24 VDC	3	No	No	-
Access1	Sensor connector	2	Yes	No	-
Access2	Sensor connector	2	Yes	No	-
Access3	Sensor connector	2	Yes	No	-
Access4	Sensor connector	2	Yes	No	-
Access5	Sensor connector	2	Yes	No	-
Access6	Sensor connector	2	Yes	No	-
Access7	Sensor connector	2	Yes	No	-
Access8	Sensor connector	2	Yes	No	-
Access9	Sensor connector	2	Yes	No	-
Access10	Sensor connector	2	Yes	No	-
Access11	Sensor connector	2	Yes	No	-
Access12	Sensor connector	2	Yes	No	-
Access13	USB	1	Yes	Yes	Accessible only for testing
Access14	Connector (three-phase)	3	Yes	No	-

NC: Not communicated by provider

Auxiliary equipment used during test:

Type	Reference	Sn	Comments
Laptop	Lenovo Thinkpad	-	-

NC: Not communicated by provider

Equipment information (declaration of provider):

DTS:	LoraWAN
Chipset / RF Module	SX1262
Frequency band:	[902-928] MHz
Spectrum Modulation:	Chirp Spread Spectrum
Number of Channel:	8
Spacing channel:	1.6MHz (500kHz BW)
Channel bandwidth:	500kHz
Antenna Type:	External with connector
Antenna connector:	Permanent external
Antenna requirements §15.203	The transmitter uses an integral antenna and it permanently connected
Transmit chains:	1
Receiver chains	1

CHANNEL PLAN – 500kHz channels uplink	
Channel	**Frequency (MHz)**
Cmin: 64	**903.0**
65	904.6
66	906.2
67	907.8
Cmid: 68	**909.4**
69	911.0
70	912.6
Cmax: 71	**914.2**

DATA RATE			
Available	**Bandwidth**	**Modulation Type**	**Worst Case Modulation**
☐	125kHz	CSS	☐
☑	500kHz	CSS	☑

Antenna Characteristic			
Antenna reference	Gain (dBi)	Frequency Band (MHz)	Impedance(Ω)
CW-WZ-0136	3	902-928	50

Hardware information				
Highest internal frequency (PLL, Quartz, Clock, Microprocessor…):		**$F_{Highest}$:**	**96**	**MHz**
Firmware (if applicable):		**V:**	1.6	
Software (if applicable):		**V:**	EWATTCH Product configurator	
Equipment intended:	Fixed			
Type of equipment:	Stand-alone			
Equipment sample:	Production model			
Duty cycle:	Continuous operation			
Operating temperature range:	T_{min}:	5 °C		
	T_{nom}:	20°C		
	T_{max}:	65 °C		
Operating voltage:	V_{min} (85% Vnom):	21 VDC		
	V_{nom}:	24 VDC		
	V_{max} (115% Vnom):	26 VDC		

NC: Not communicated by provider

2.2. RUNNING MODE

Test mode	Description of test mode
Test mode 1	Permanent emission with modulation on a fixed channel in the data rate that produced the highest power.
Test mode 2	Permanent reception

All tests are done with OutputPower = 8dBm

Test	Running mode
Occupied Bandwidth	Test mode 1
6dB Bandwidth	Test mode 1
Maximum Conducted Output Power	Test mode 1
Power Spectral Density	Test mode 1
Conducted Spurious Emission at the Band Edge	Test mode 1
Unwanted Emissions in Non-Restricted Frequency Bands	Test mode 1
Unwanted Emissions in Restricted Frequency Bands	Test mode 1
Receiver Radiated Emissions	Test mode 2 (1)

(1) Testing covered the receive mode, and receiver spurious emissions are considered to be the same as transmitter.

2.3. EQUIPMENT LABELLING

Label


2.4. EQUIPMENT MODIFICATIONS DURING THE TESTS

None

2.5. FIELD STRENGTH CALCULATION

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

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

Where:
FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Factor
AG = Amplifier Gain

Example:
Assume a receiver reading of 52.5dBµV is obtained. The antenna factor of 7.4 and a cable factor of 1.1 are added. The amplifier gain of 29dB is subtracted, giving a field strength of 32 dBµV/m.
FS = 52.5 + 7.4 + 1.1 – 29 = 32 dBµV/m
The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.
Level in µV/m = Common Antilogarithm [(32dBµV/m)/20] = 39.8 µV/m.

2.6. TEST DISTANCE EXTRAPOLATION – FCC/ISED

The field strength is extrapolated to the new measurement distance using formula from FCC Part15.31 (f) and §6.5-6.6 RSS-GEN:

Below 30MHz,

$$FS_{\text{limit}} = FS_{\max} - 40\log\left(\frac{d_{\text{limit}}}{d_{\text{measure}}}\right)$$

Above 30MHz,

$$FS_{\text{limit}} = FS_{\max} - 20\log\left(\frac{d_{\text{limit}}}{d_{\text{measure}}}\right)$$

Where:
FS_{limit} is the calculation of field strength at the limit distance, expressed in dBµV/m
FS_{max} is the measured field strength, expressed in dBµV/m
$d_{measure}$ is the distance of the measurement point from the EUT
d_{limit} is the reference limit distance

2.7. CALIBRATION DATE

The calibration intervals are extended at 12+2 months. This extended interval is based on the fact that there is sufficient calibration data to statistically establish a trend or based on experience of use of the test equipment to assure good measurement results for a longer period.

2.8. METHOD TO DETERMINATE THE SPURIOUS RADIATED EMISSION

The Normalized Site Attenuation (NSA) is added to the maximum values observed during the azimuth search in order to obtain the spurious radiated emission. For spurious above -6dB from the limit found with the NSA, the Substitution Method is applied.
The substitution antenna replaces the equipment under test (EUT) for Effective Radiated Power (ERP) or Effective Isotropically Radiated Power (EIRP) measurement following the standard. Power is measured for a high level and calculated for the same level of radiated field strength obtained on the measuring antenna and EUT.

3. DUTY CYCLE

3.1. *TEST CONDITIONS*

Date of test	:	April 08, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	32
Ambient temperature (°C)	:	21

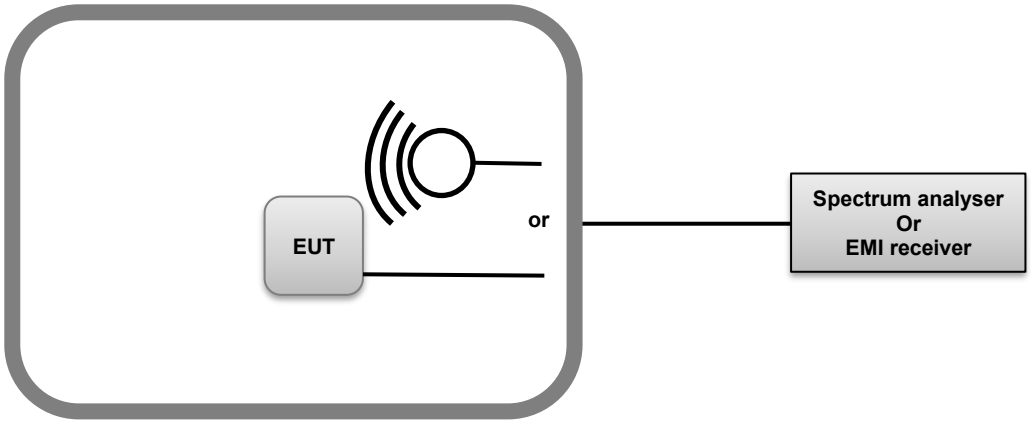
3.2. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the center frequency of the spectrum analyzer is set to the fundamental frequency.
The captured power is measured and recorded.

Test Procedure:
ANSI C63.10 § 11.6

- Zero-span mode
- RBW ≥ OBW if possible; otherwise, set RBW to the largest available value
- VBW ≥ RBW
- Detector = Peak
- Trace mode = Max Hold.
- Sweep time > 3 * Period time anticipated
- Sweep = Single
- Trigger Video



Test setup of Duty Cycle

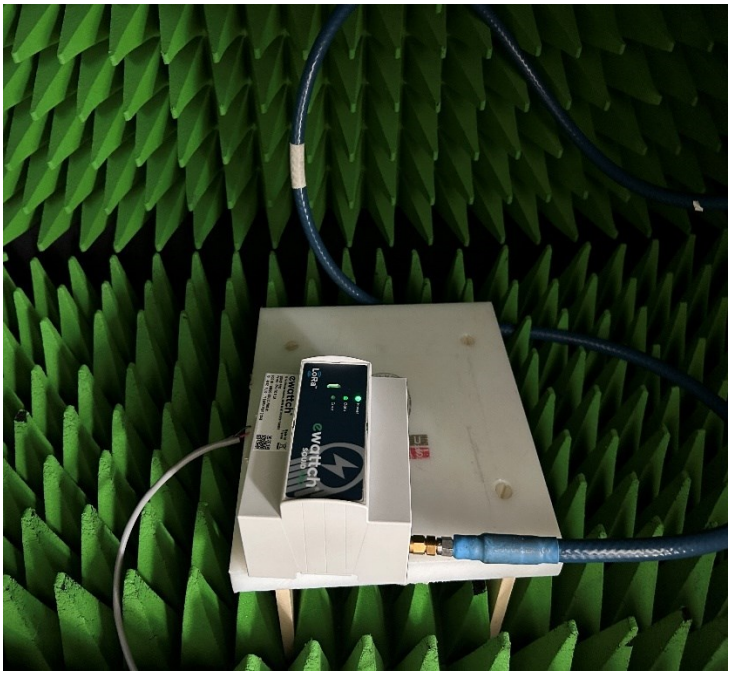


Photo of Duty Cycle

3.3. *LIMIT*

None

3.4. TEST EQUIPMENT LIST

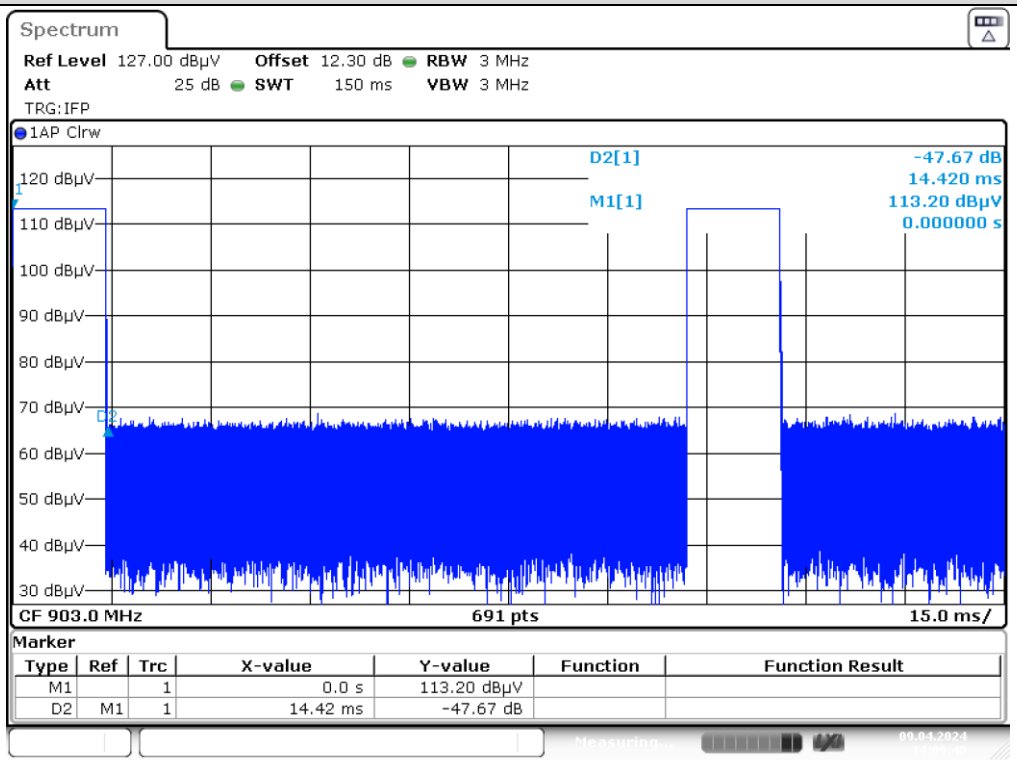
TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

3.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

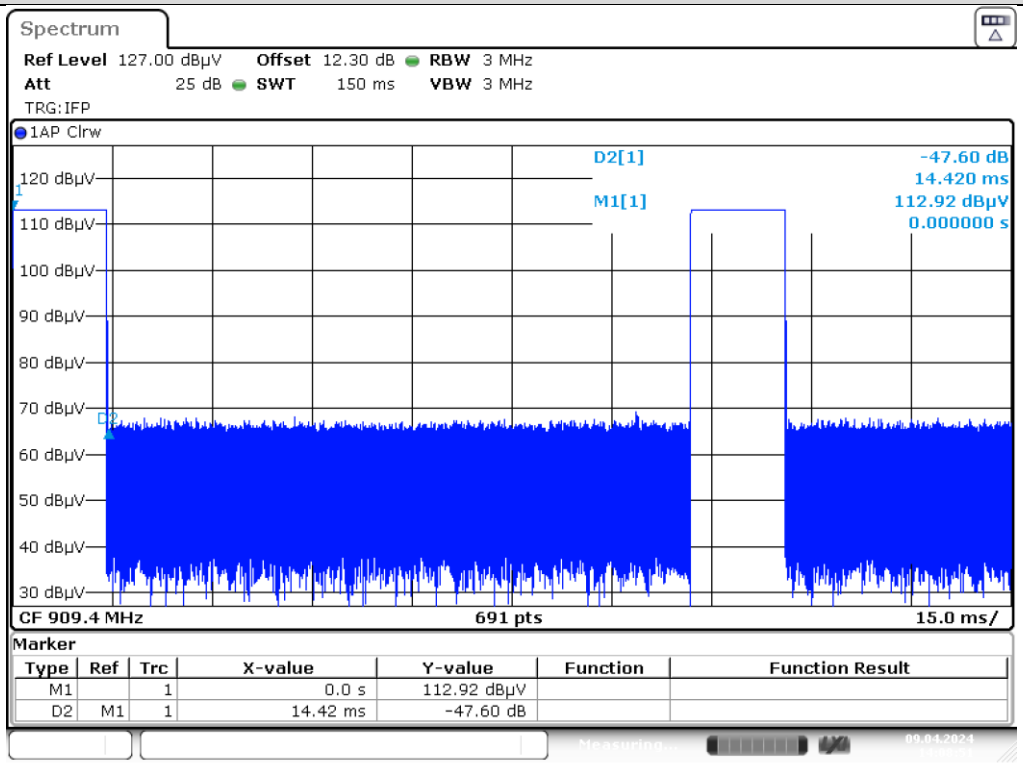
3.6. *RESULTS*

Duty Cycle
Cmin
LoraWAN - 500kHz



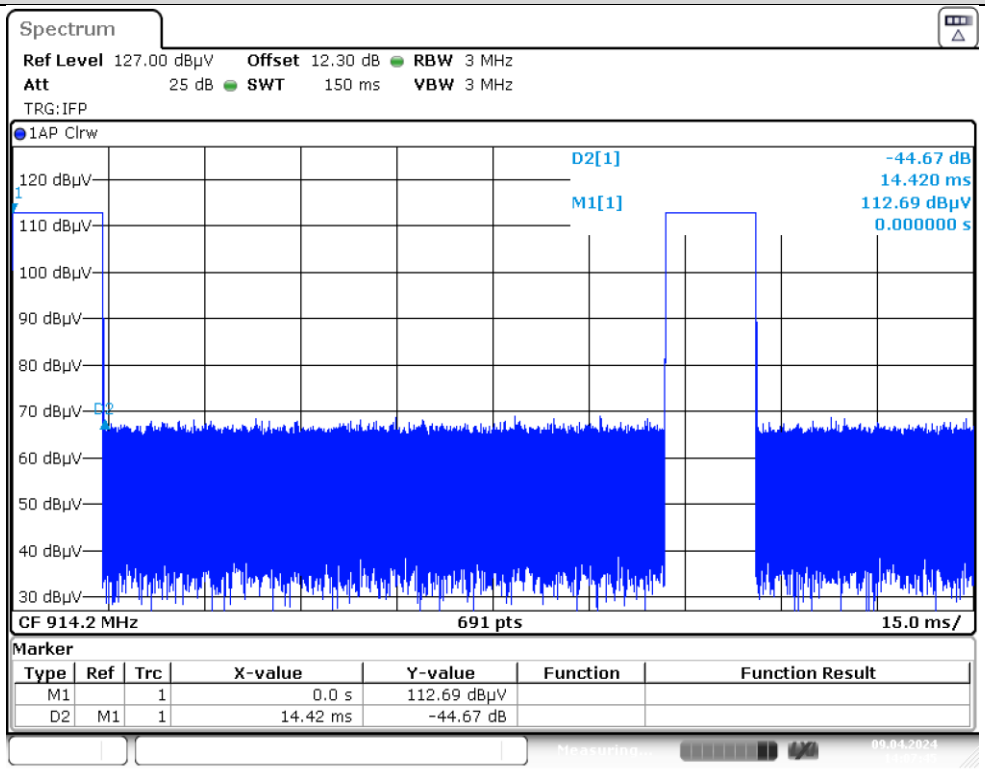
Test Period (ms)	Total Time ON (ms)	Duty Cycle (%)	Duty Cycle Factor (dB)
150	14.42 x 2 = 28.84	19.2	7.16
*Duty Cycle (%) = (Total Time ON / Test Period) * 100*		*Duty Factor (dB) = 10*log(100 / Duty Cycle(%))*	

Duty Cycle
Cmid
LoraWAN - 500kHz



Test Period (ms)	Total Time ON (ms)	Duty Cycle (%)	Duty Cycle Factor (dB)
150	14.42 x 2 = 28.84	19.2	7.16
*Duty Cycle (%) = (Total Time ON / Test Period) * 100*		*Duty Factor (dB) = 10*log(100 / Duty Cycle(%))*	

Duty Cycle
Cmax
LoraWAN - 500kHz



Test Period (ms)	Total Time ON (ms)	Duty Cycle (%)	Duty Cycle Factor (dB)
150	14.42 x 2 = 28.84	19.2	7.16
*Duty Cycle (%) = (Total Time ON / Test Period) * 100*		*Duty Factor (dB) = 10*log(100 / Duty Cycle(%))*	

3.1. CONCLUSION

Duty Cycle measurement performed on the sample of the product SQUID-PRO, Sn: 70B3D5475012134E, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247 limits**.

OCCUPIED BANDWIDTH

3.2. *TEST CONDITIONS*

Date of test	:	April 08, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	33
Ambient temperature (°C)	:	21

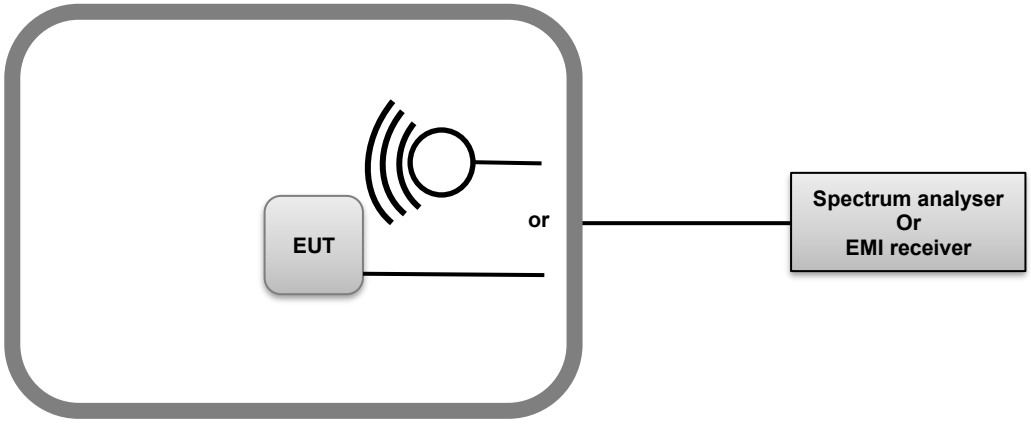
3.3. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the center frequency of the spectrum analyzer is set to the fundamental frequency. The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Test Procedure:
ANSI C63.10 § 6.9.2 and RSS-Gen Issue 5 § 6.7

- RBW used in the range of 1% to 5% of the anticipated emission bandwidth
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = Max Hold.
- Sweep = Auto couple.
- Allow the trace to stabilize.
- OBW 99% function of spectrum analyzer used



Test setup of Occupied Bandwidth

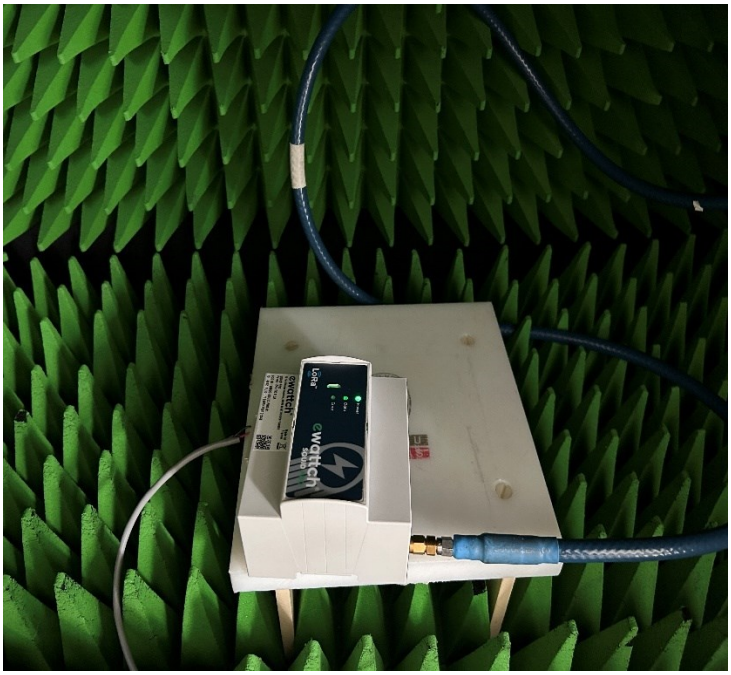


Photo of Occupied bandwidth

3.4. *LIMIT*

None

3.5. TEST EQUIPMENT LIST

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

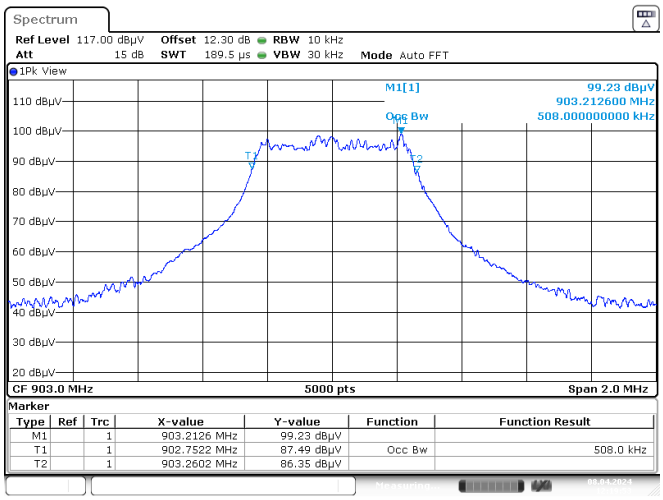
3.6. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

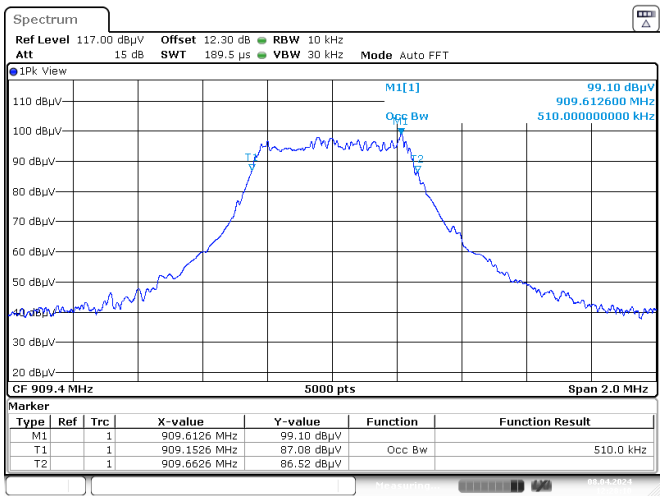
3.7. *RESULTS*

Occupied Bandwidth

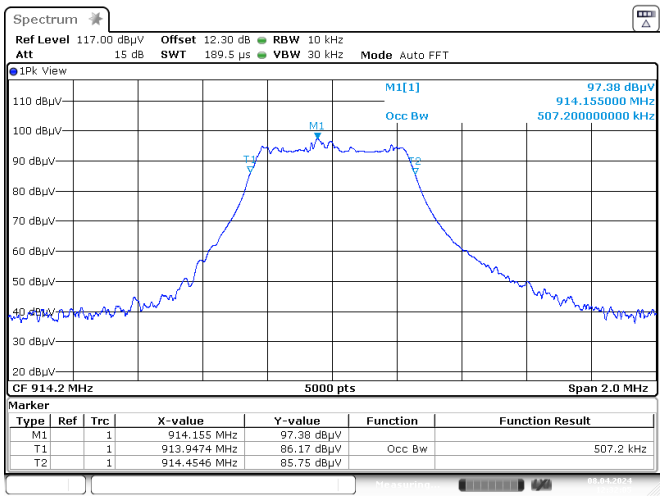
Cmin



Cmid



Cmax



Configuration: LoraWAN - 500kHz

Channel	Occupied Bandwidth (KHz)
Cmin	508
Cmid	510
Cmax	507.2

3.8. *CONCLUSION*

Occupied Channel Bandwidth measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **RSS-GEN** limits.

4. 6DB BANDWIDTH

4.1. *TEST CONDITIONS*

Date of test	:	April 08, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	32
Ambient temperature (°C)	:	21

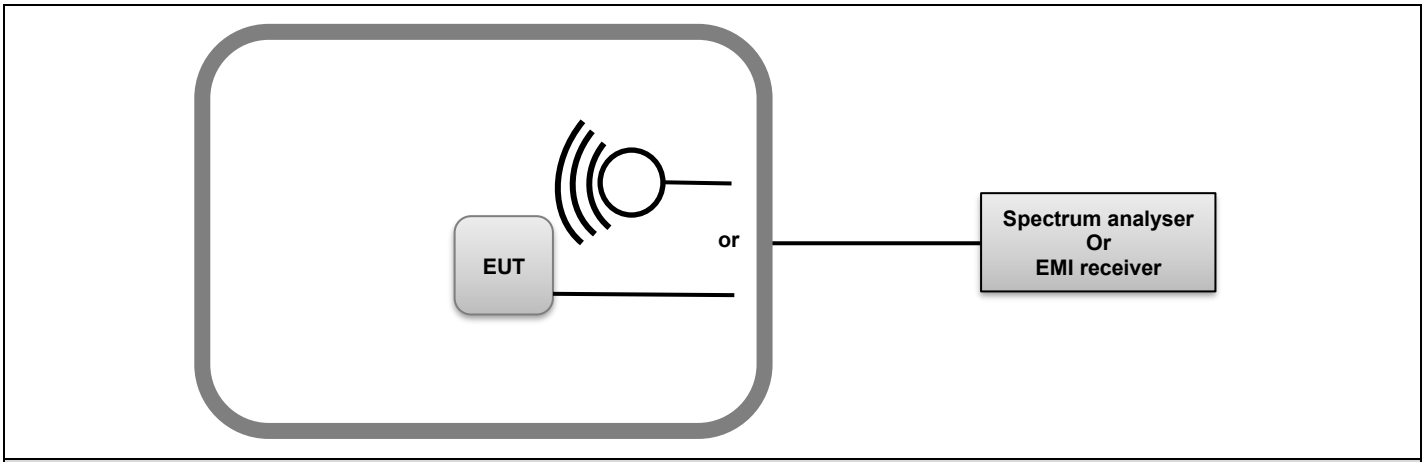
4.2. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the center frequency of the spectrum analyzer is set to the fundamental frequency. The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Test Procedure:
KDB 558074 D01 DTS Meas Guidance v05r02 § 8.2

- Set resolution bandwidth (RBW) = 100kHz.
- Set the video bandwidth (VBW) ≥ 3 x RBW.
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission. Compare the resultant bandwidth with the RBW setting of the analyzer.



Test setup of 6dB Bandwidth

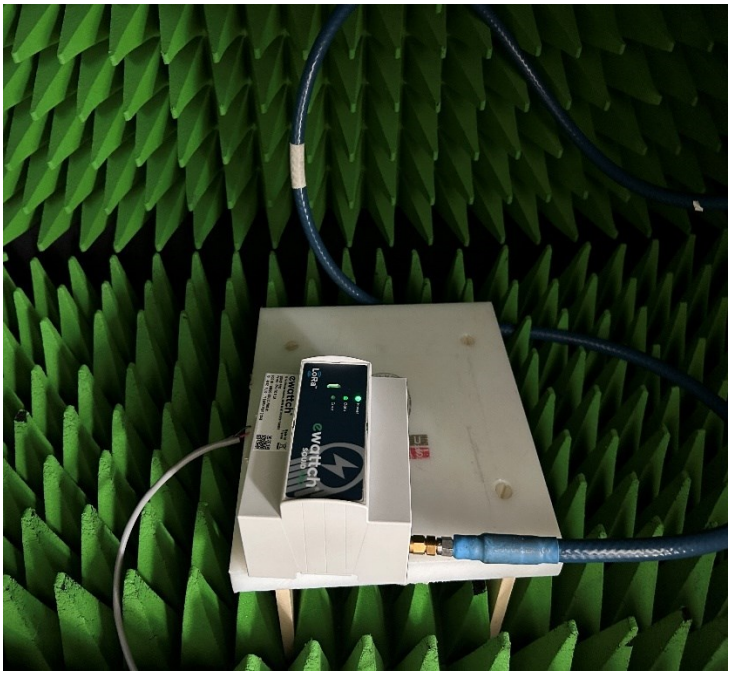


Photo of 6dB bandwidth

4.3. *LIMIT*

Frequency range	6dB bandwidth
902-928MHz 2400MHz to 2483.5MHz 5725-5850 MHz	≥500kHz

4.4. TEST EQUIPMENT LIST

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

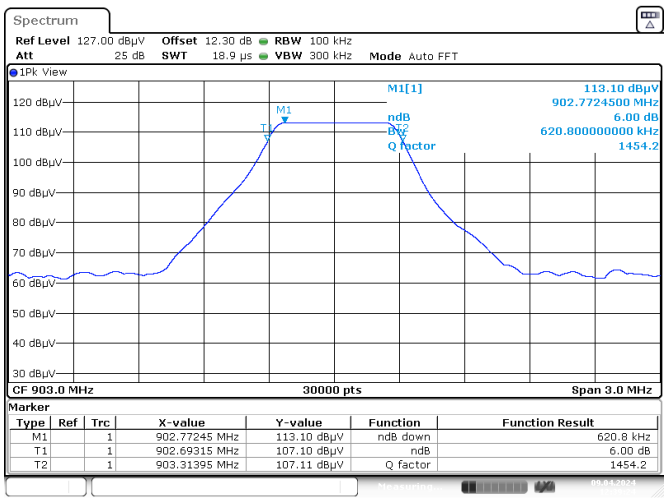
4.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

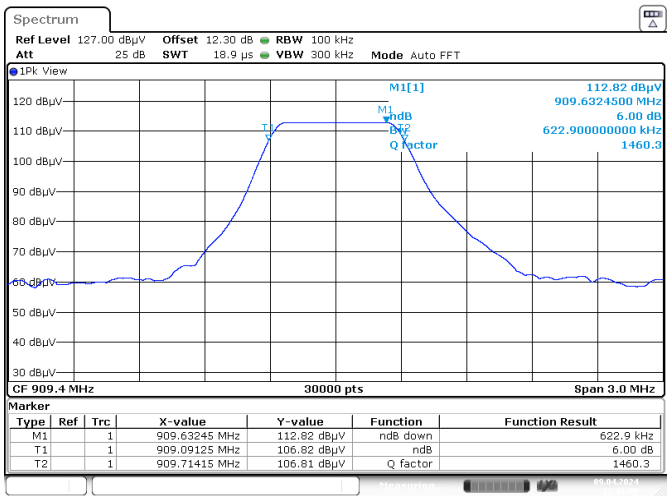
4.6. *RESULTS*

6dB Bandwidth

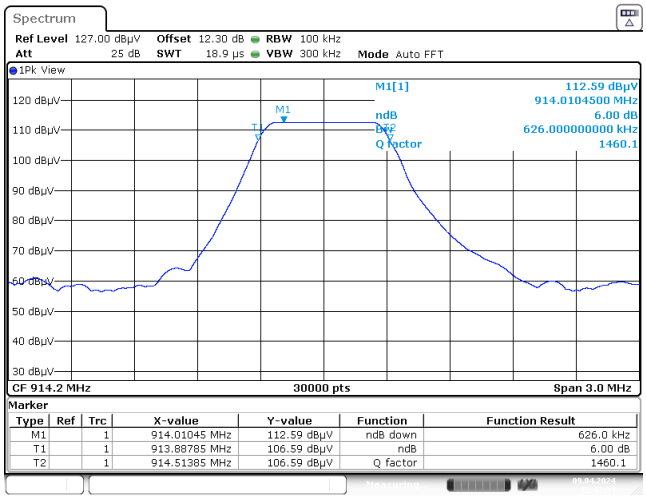
Cmin



Cmid



Cmax



Configuration: Choisissez

Channel	6dB Bandwidth (MHz)	Limit (MHz)
Cmin	0.62	**> 0.5**
Cmid	0.622	**> 0.5**
Cmax	0.626	**> 0.5**

4.7. *CONCLUSION*

6dB Bandwidth measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247** limits.

5. MAXIMUM CONDUCTED OUTPUT POWER

5.1. *TEST CONDITIONS*

Date of test	:	April 09, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	32
Ambient temperature (°C)	:	21

5.2. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the center frequency of the spectrum analyzer is set to the fundamental frequency. The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Test Procedure used: KDB 558074 D01 DTS Meas Guidance v05r02 § 8.3.1.1

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.3.1.1

This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.

- Set the RBW ≥ DTS bandwidth.
- Set VBW ≥ 3 x RBW.
- Set span ≥ 3 x RBW
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use peak marker function to determine the peak amplitude level.

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.3.1.2

This procedure may be used when the maximum available RBW of the measurement instrument is less than the DTS bandwidth.

- Set the RBW = 1 MHz.
- Set the VBW ≥ 3 x RBW
- Set the span ≥ 1.5 x DTS bandwidth.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the instrument's band/channel power measurement function with the band limits set equal to the DTS bandwidth edges

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.3.2.2(Method AVGSA-1)

Subclause 11.9.2.2 of ANSI C63.10 is applicable, Method AVGSA-1 uses trace averaging with the EUT transmitting at full power throughout each sweep.

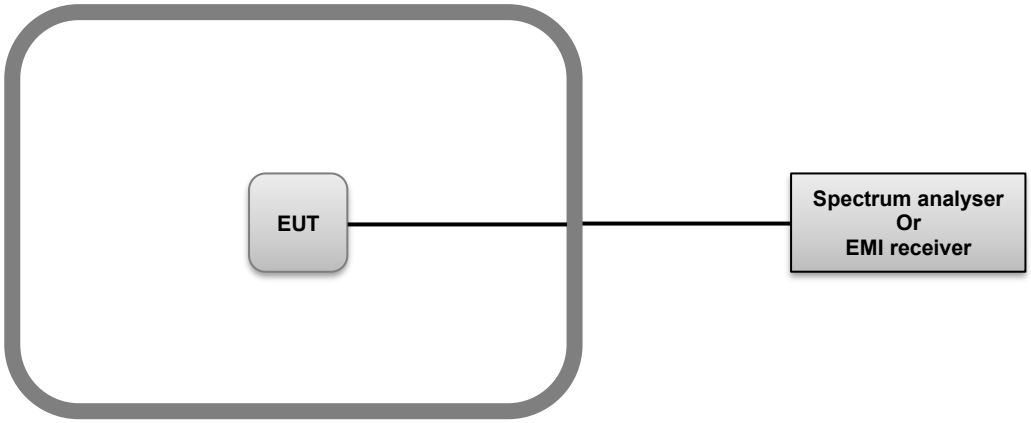
- a) Set span to at least 1.5 times the OBW.
- b) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- c) Set VBW ≥ [3 × RBW].
- d) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- e) Sweep time = auto.
- f) Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
- g) If transmit duty cycle < 98%, use a sweep trigger with the level set to enable triggering only on full power pulses. The transmitter shall operate at the maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no OFF intervals) or at duty cycle ≥ 98%, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run."
- h) Trace average at least 100 traces in power averaging (rms) mode.
- i) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function, with band limits set equal to the OBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.3.2.2(Method AVGSA-2)

Subclause 11.9.2.2 of ANSI C63.10 is applicable.

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

- a) Measure the duty cycle D of the transmitter output signal as described in 11.6.
- b) Set span to at least 1.5 times the OBW.
- c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.
- d) Set VBW ≥ [3 × RBW].
- e) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)
- f) Sweep time = auto.
- g) Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.
- h) Do not use sweep triggering. Allow the sweep to "free run."
- i) Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.
- j) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.
- k) Add [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add [10 log (1/0.25)] = 6 dB if the duty cycle is 25%.



Test setup of Maximum Conducted Output Power

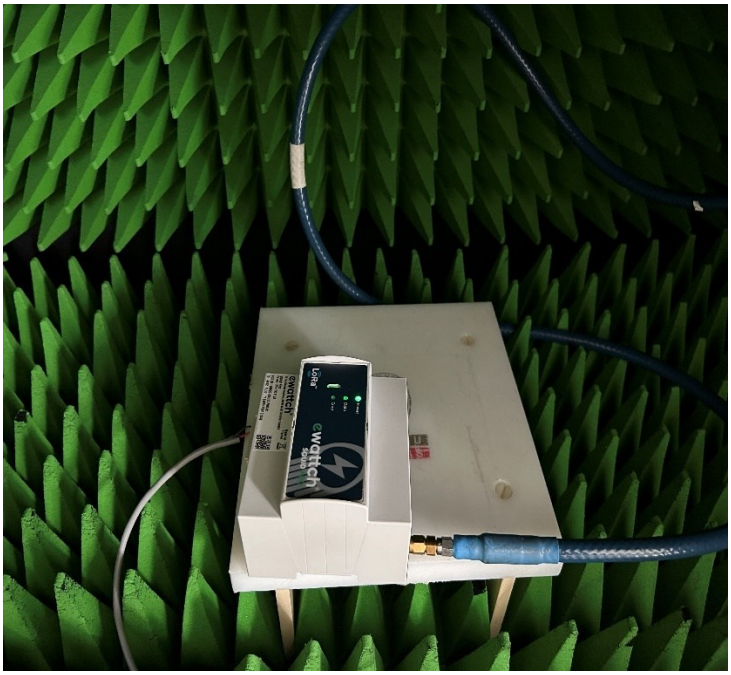


Photo of Maximum Conducted Output Power

5.3. *LIMIT*

Frequency range	Maximum Conducted Output Power
902-928MHz 2400MHz to 2483.5MHz 5725-5850 MHz	≤30dBm*

*Remark: Limits are reduced by G-6dBi if Overall Antenna Gain above 6dBi

5.4. *TEST EQUIPMENT LIST*

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

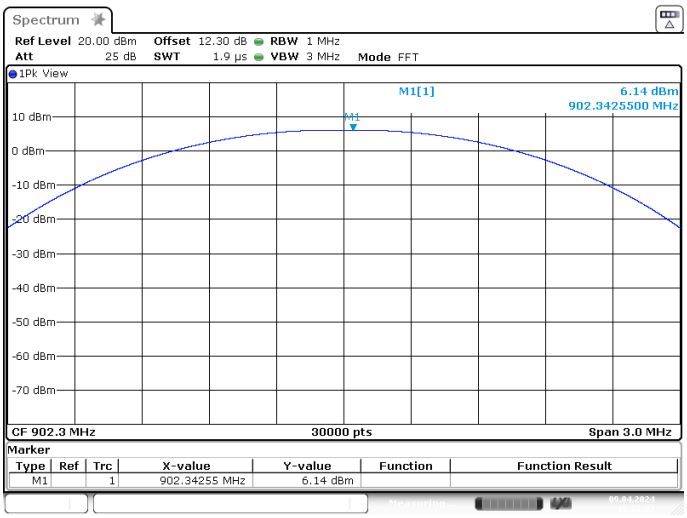
5.5. *DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION*

None

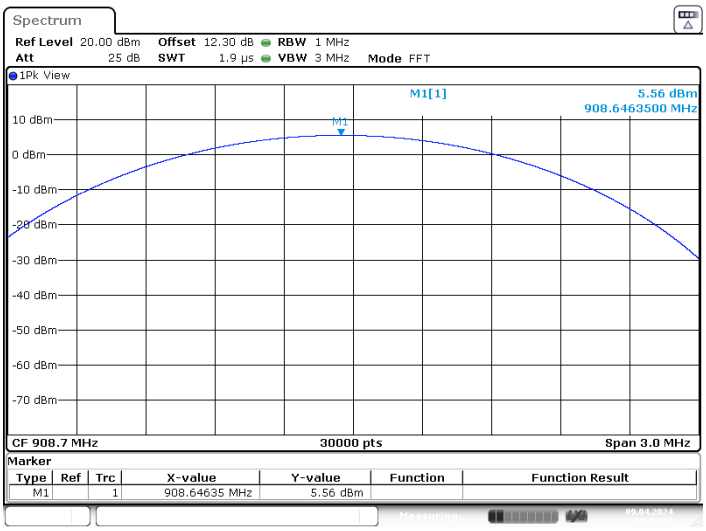
5.6. RESULTS

Maximum Conducted Output Power

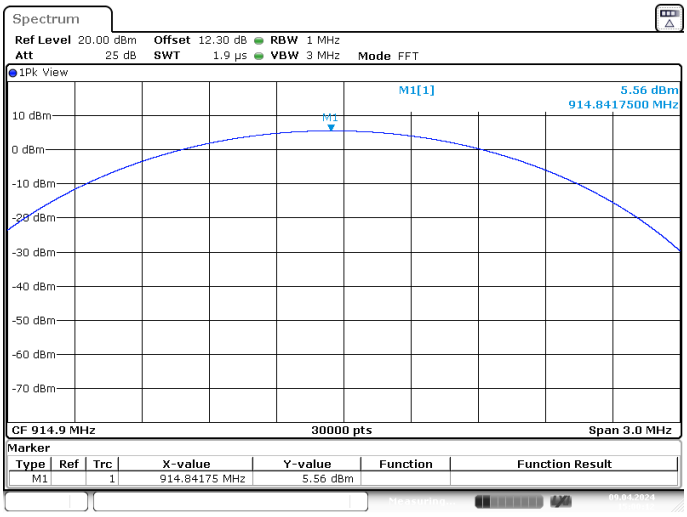
Cmin



Cmid



Cmax



Configuration: LoraWAN - 500kHz

Channel	Offset Cable+Att (dB)	Antenna Gain (dBi)	Conducted Power (dBm)	Limit (dBm)
Cmin	12.3	3	6.14	**30**
Cmid	12.3	3	5.56	**30**
Cmax	12.3	3	5.56	**30**

5.7. CONCLUSION

Maximum Output Conducted Power measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247** limits.

6. POWER SPECTRAL DENSITY

6.1. *TEST CONDITIONS*

Date of test	:	April 09, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	32
Ambient temperature (°C)	:	21

6.2. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the center frequency of the spectrum analyzer is set to the fundamental frequency. The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Test Procedure used: KDB 558074 D01 DTS Meas Guidance v05r02 § 8.4 (Method PKPSD)

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.4 (Method PKPSD)

Subclause 11.10 of ANSI C63.10 is applicable

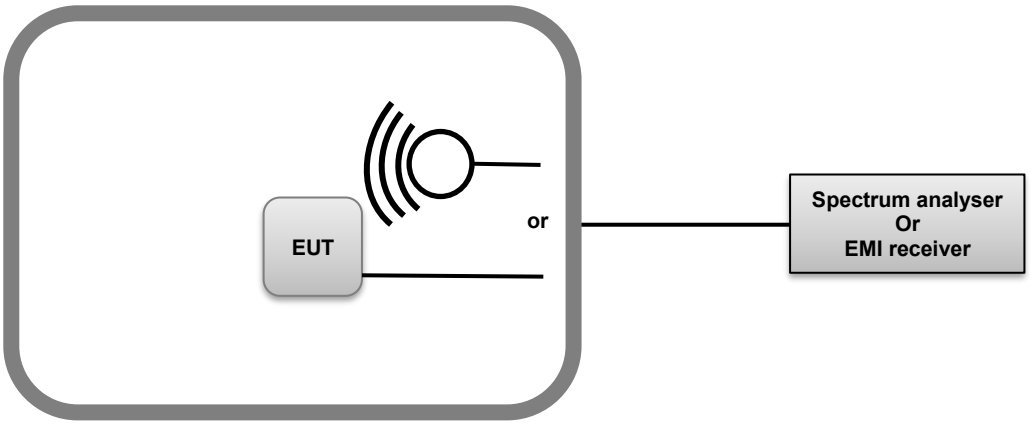
- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: 3 kHz.
- Set the VBW ≥ 3 x RBW.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

KDB 558074 D01 DTS Meas Guidance v05r02 § 8.4 (Method AVGPSD-1)

Subclause 11.10 of ANSI C63.10 is applicable

Method AVGPSD-1 uses trace averaging with EUT transmitting at full power throughout each sweep. The following procedure may be used when the maximum (average) conducted output power was used to determine compliance to the fundamental output power limit. This is the baseline method for determining the maximum (average) conducted PSD level. If the instrument has a power averaging (rms) detector, then it must be used; otherwise, use the sample detector. The EUT must be configured to transmit continuously (D ≥ 98%), or else sweep triggering/signal gating must be implemented to ensure that measurements are made only when the EUT is transmitting at its maximum power control level (no transmitter OFF time to be considered):

- a) Set instrument center frequency to DTS channel center frequency.
- b) Set span to at least 1.5 times the OBW.
- c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
- d) Set VBW ≥ [3 × RBW].
- e) Detector = power averaging (rms) or sample detector (when rms not available).
- f) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].
- g) Sweep time = auto couple.
- h) Employ trace averaging (rms) mode over a minimum of 100 traces.
- i) Use the peak marker function to determine the maximum amplitude level.
- j) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).



Test setup of Power Spectral Density

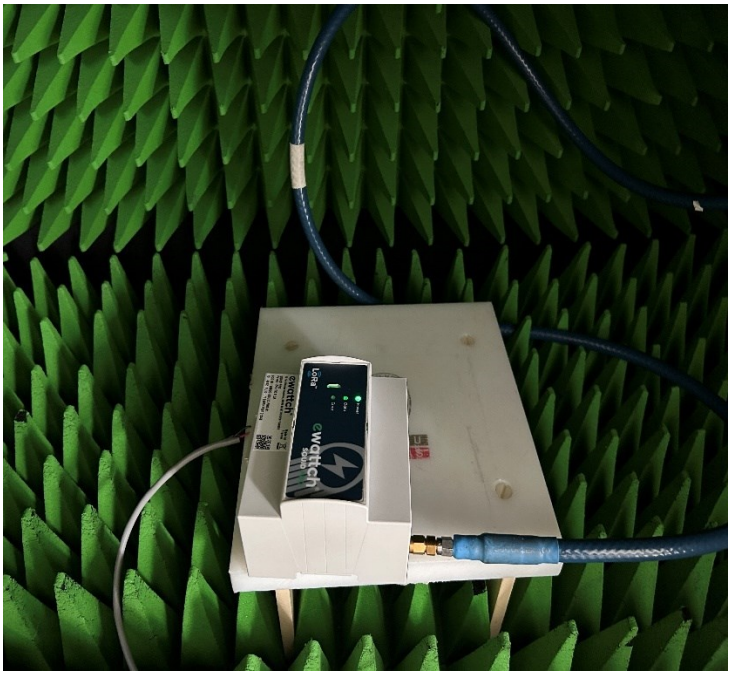


Photo of Power Spectral Density

6.3. *LIMIT*

Frequency range	Power Spectral Density
902-928MHz 2400MHz to 2483.5MHz 5725-5850 MHz	≤8dBm / 3kHz *

*Remark: Limits are reduced by G-6dBi if Overall Antenna Gain above 6dBi

6.4. TEST EQUIPMENT LIST

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

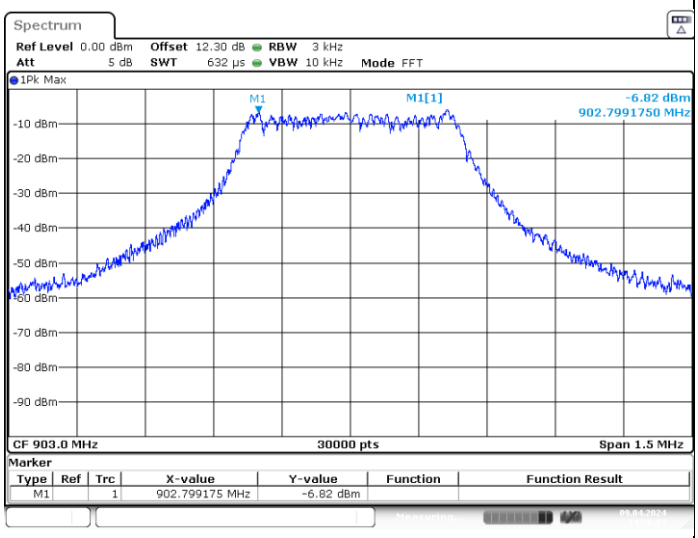
6.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

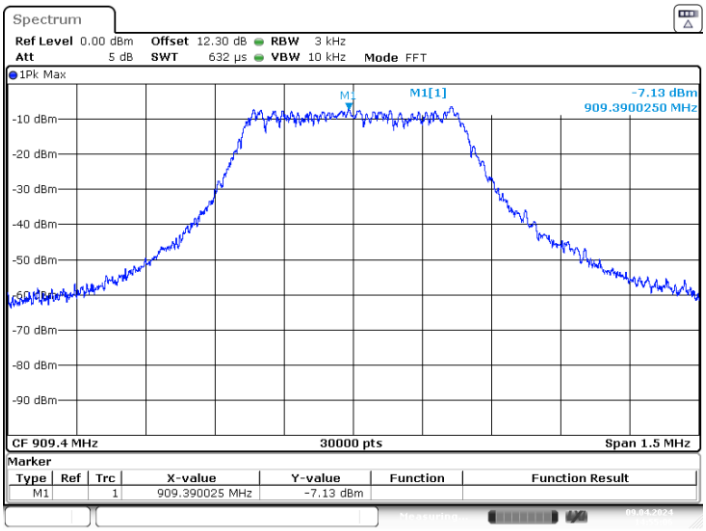
6.6. RESULTS

Power Spectral Density

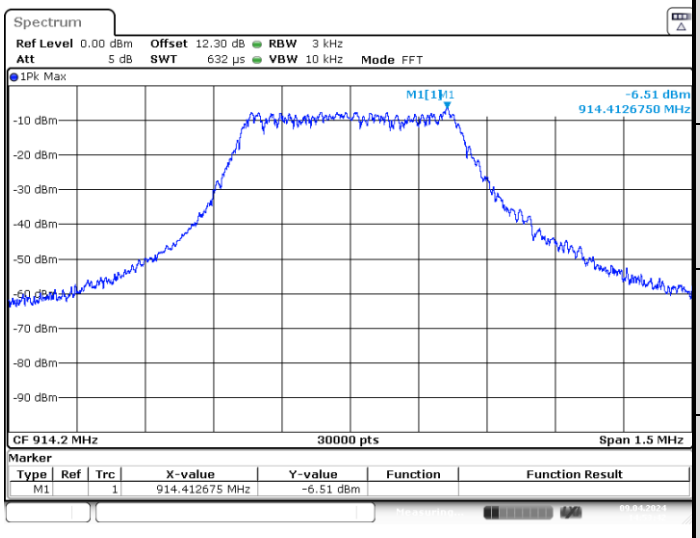
Cmin



Cmid



Cmax



Configuration: LoraWAN - 500kHz

Channel	Offset Cable+Att (dB)	Antenna Gain (dBi)	Power Spectral Density (dBm)	Limit (dBm)
Cmin	12.3	3	-6.82	**≤ 8**
Cmid	12.3	3	-7.13	**≤ 8**
Cmax	12.3	3	-6.51	**≤ 8**

6.7. CONCLUSION

Power Spectral Density measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247** limits.

7. UNWANTED EMISSIONS IN NON-RESTRICTED FREQUENCY BANDS

7.1. *TEST CONDITIONS*

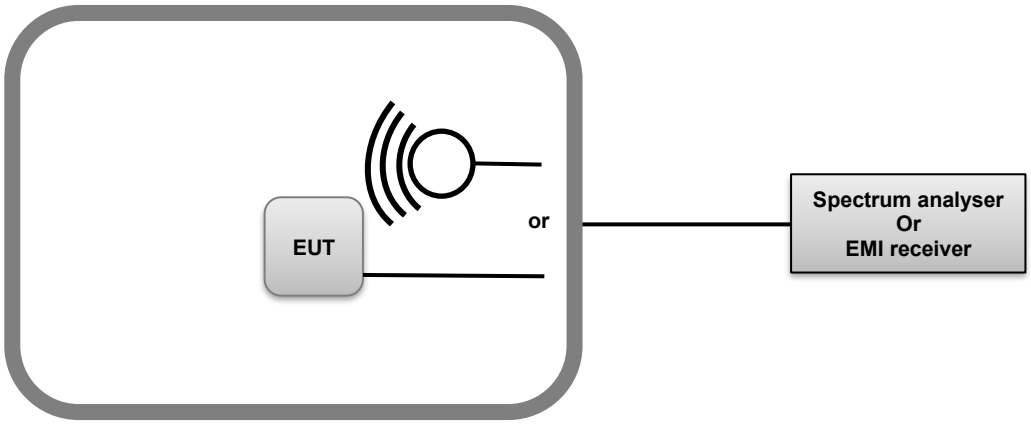
Date of test	:	April 09, 2024
Test performed by	:	Akram HAKKARI
Relative humidity (%)	:	33
Ambient temperature (°C)	:	22

7.2. *TEST SETUP*

The Equipment Under Test is installed in an anechoic chamber.
Measurement is performed with a spectrum analyzer in conducted method.

The EUT is turned ON, the captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Test Procedure:
KDB 558074 D01 DTS Meas Guidance v05r02 § 8.5



Test setup of Unwanted emissions in non-restricted frequency bands

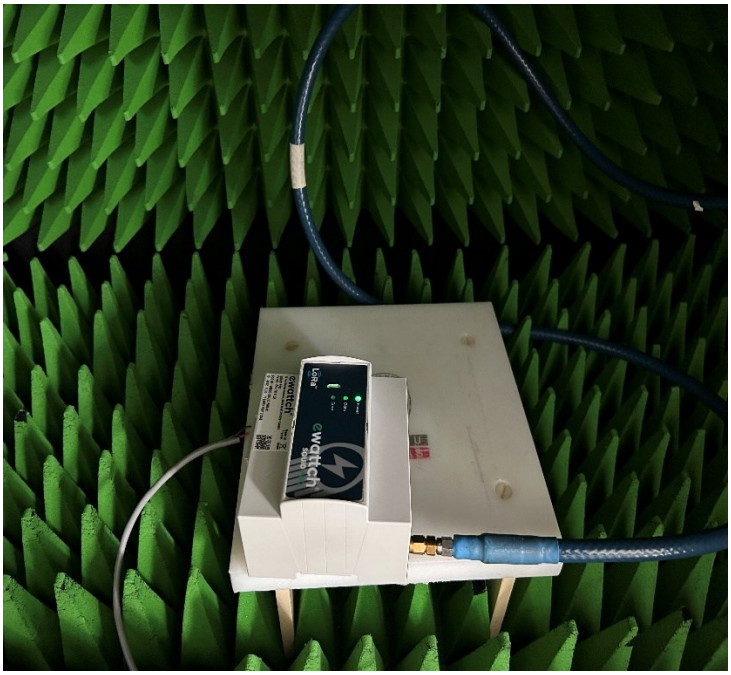


Photo of Unwanted emissions in non-restricted frequency bands

7.3. *LIMIT*

All Spurious Emissions must be at least 20dB below the Fundamental Radiator Level at the Band Edge of operating frequency band and in non-restricted bands.

7.4. TEST EQUIPMENT LIST

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Attenuator 10dB	AEROFLEX	_	A7122267	10/23	10/25
DC Power Supply	RS PRO	RS3005P	A7042314		
Emission Cable (SMA 1m)	TELEDYNE	26GHz	A5329874	08/22	08/25
Full Anechoic Room	SIEPEL	_	D3044024		
Multimeter - CEM	FLUKE	87	A1240251	10/23	10/25
SMA 1.5m	SUCOFLEX	18GHz	A5329864	10/23	10/24
Thermo-hygrometer	TESTO	608-H1	B4204120	03/23	03/25
Spectrum analyzer	ROHDE & SCHWARZ	FSV 30	A4060051	02/24	02/26

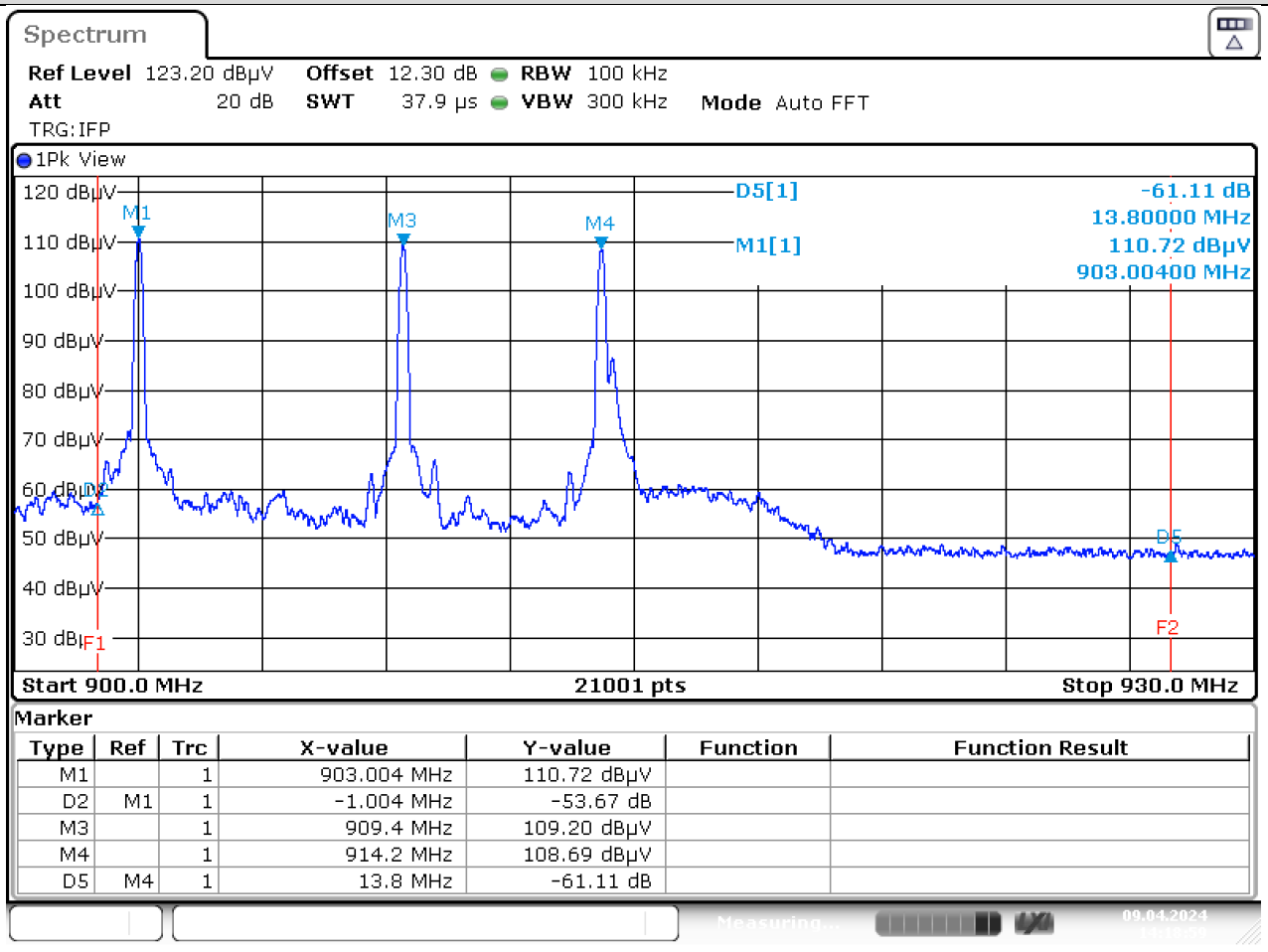
7.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

7.6. RESULTS

7.6.1. Operational frequency band

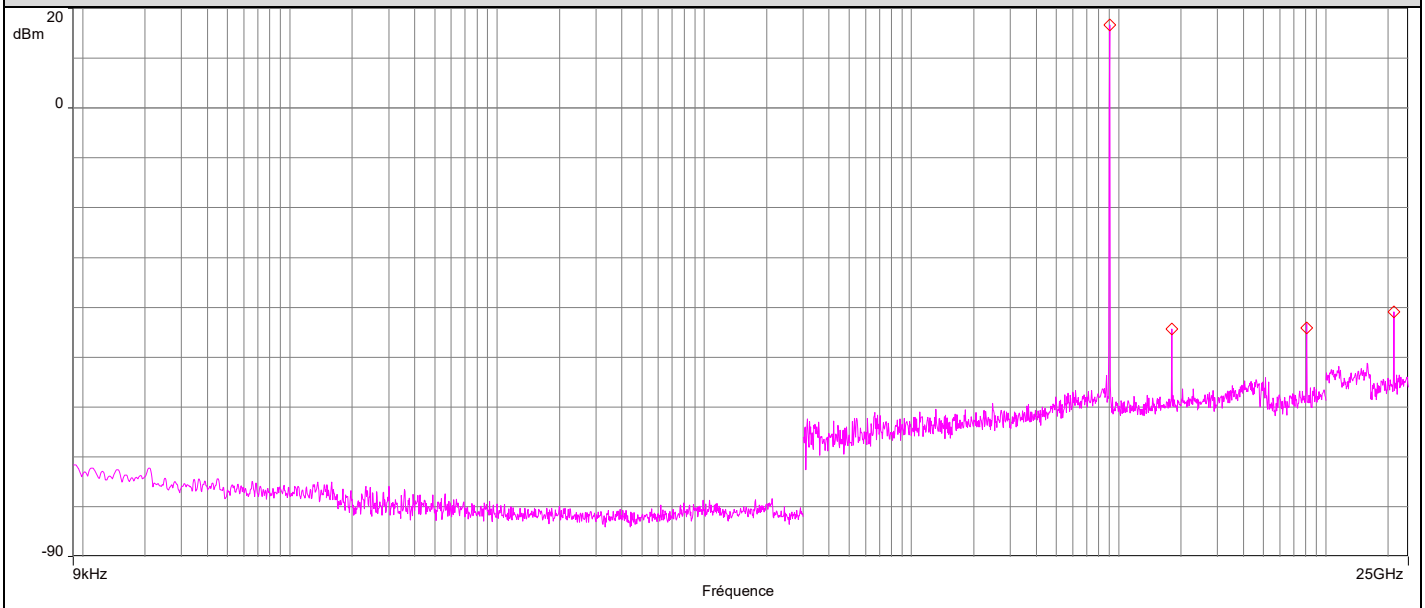
Unwanted emissions in non-restricted bands at the band edge
Configuration: LoraWAN - 500kHz
Cmin / Cmid / Cmax
Delta limit (dBc) determination
Tx1



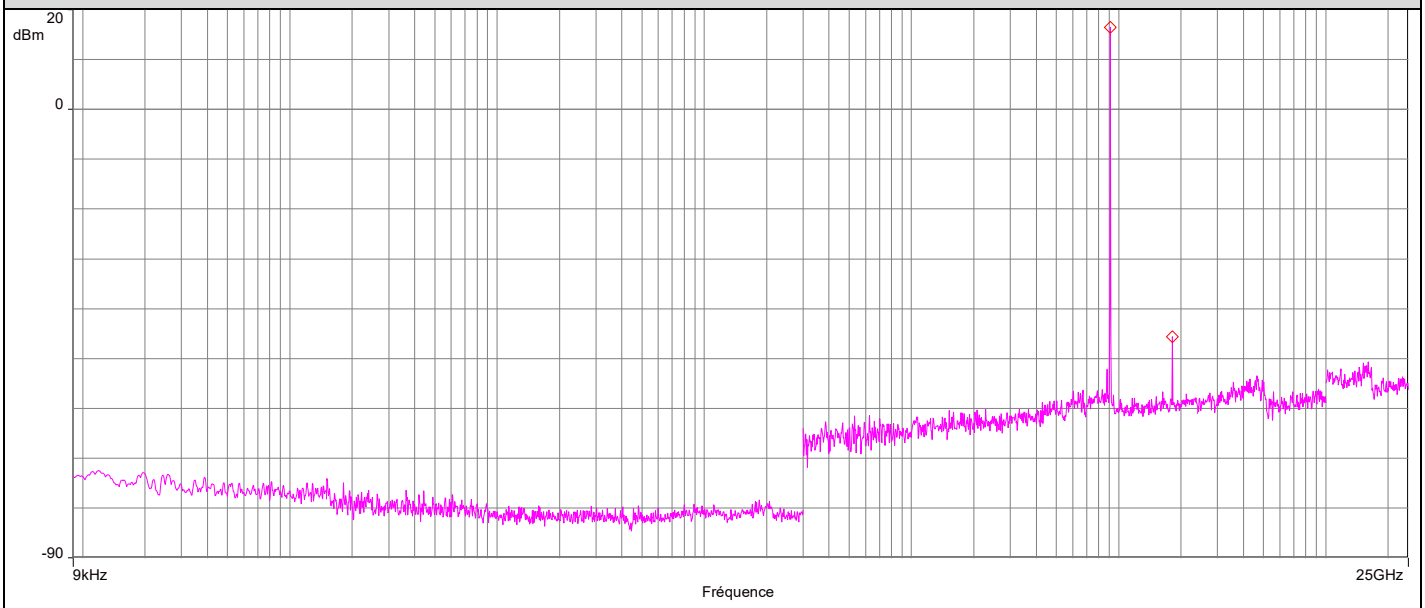
Frequency (MHz)	Level (dBc)	Limit (dBc)
C_{min}	-53.6	**-20**
C_{max}	-61.1	**-20**

7.6.2. Non restricted frequency bands

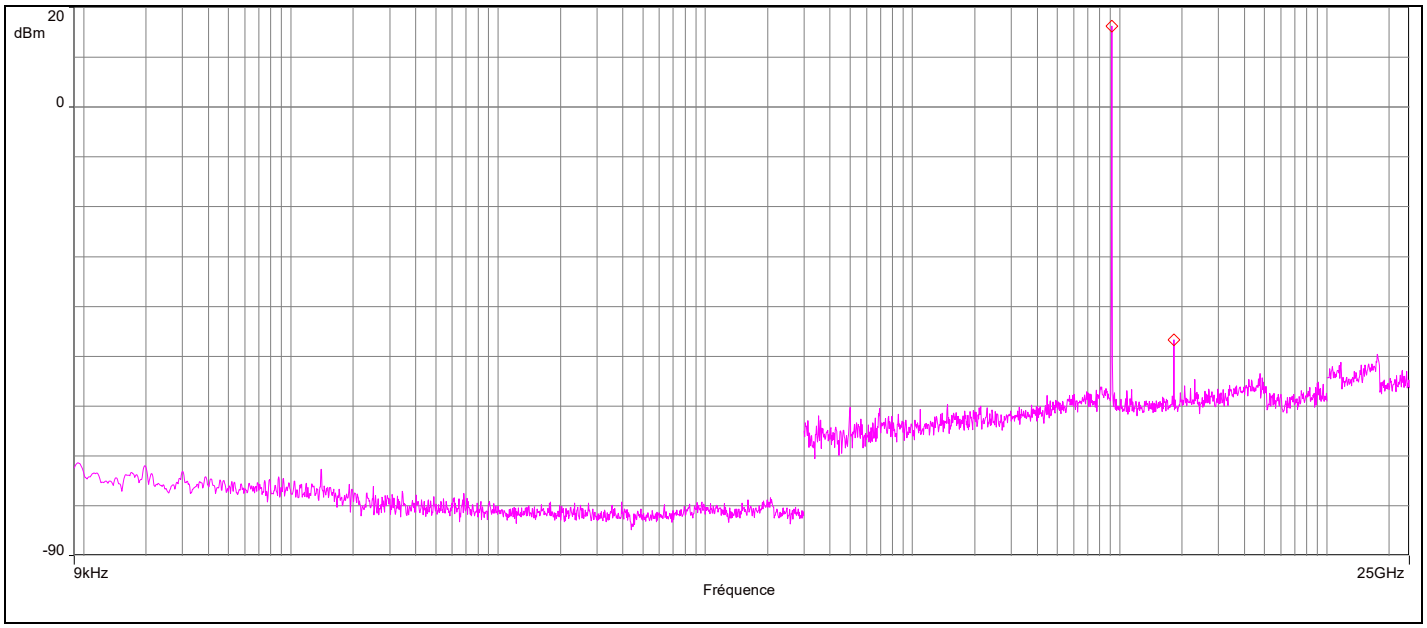
Unwanted emissions in non-restricted bands
Configuration: LoraWAN - 500kHz
Cmin



Cmid



Cmax



All spurious emissions are lower than 20 dB below the fundamental radiator level.

7.7. CONCLUSION

Unwanted emissions in non-restricted bands and at the band edge measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247** limits.

8. UNWANTED EMISSIONS IN RESTRICTED FREQUENCY BANDS

8.1. *TEST CONDITIONS*

Date of test : April 05, 2024
Test performed by : Akram HAKKARI
Relative humidity (%) : 33
Ambient temperature (°C) : 22

8.2. *TEST SETUP*

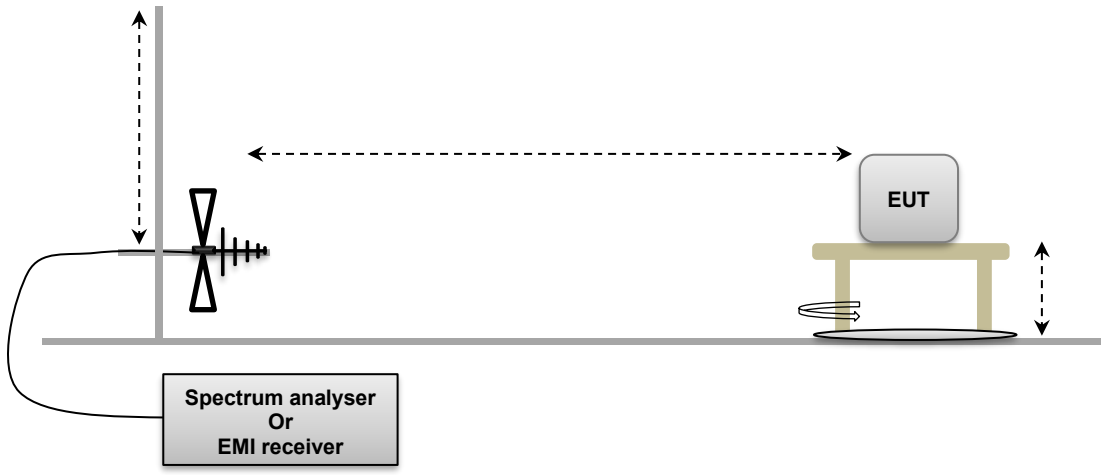
Test procedure:
ANSI C63.10 & FCC Part 15 subpart C

Following frequency ranges, test setup parameters are different and specified in this table:

Frequency range:	**9kHz to 30MHz**	
Test:	**Pre-Characterization**	**Qualification**
Antenna Polarization:	Parallel, Perpendicular and Ground parallel	
Antenna Height:	Centered on EUT (§6.6.5 ANSI C63-10)	1m
Antenna Type:	Loop	
RBW Filter:	200Hz below 150kHz / 9kHz above 150kHz	
Maximization:	Turntable rotation of 360 degrees range and all axis of EUT used in normal configuration	
EUT height:	1.5m	1.5m
Test site:	Full Anechoic Chamber	Open Aera Test Site
Distance EUT - Antenna:	3m	10m
Detector:	Peak	QPeak

Frequency range:	**30MHz to 1GHz**	
Test:	**Pre-Characterization**	**Qualification**
Antenna Polarization:	Horizontal and Vertical	
Antenna Height:	Centered on EUT (§6.6.5 ANSI C63-10)	Varied from 1m to 4m
Antenna Type:	Bi-Log	
RBW Filter:	120kHz	
Maximization:	Turntable rotation of 360 degrees range and all axis of EUT used in normal configuration	
EUT height:	1.5m	0.8m
Test site:	Full Anechoic Chamber	Open Aera Test Site
Distance EUT - Antenna:	3m	3m
Detector:	Peak	QPeak

Frequency range:	1GHz to 9.5GHz	
Test:	**Pre-Characterization**	**Qualification**
Antenna Polarization:	Horizontal and Vertical	
Antenna Height:	Centered on EUT (§6.6.5 ANSI C63-10)	Centered on EUT (§6.6.5 ANSI C63-10)
Antenna Type:	Horn	
RBW Filter:	1MHz	
Maximization:	Turntable rotation of 360 degrees range and all axis of EUT used in normal configuration	
EUT height:	1.5m	1.5m
Test site:	Full Anechoic Chamber	Full Anechoic Chamber
Distance EUT - Antenna:	3m	3m
Detector:	Peak & Average	Peak & Average



Test setup of Unwanted Emissions in Restricted Frequency Bands

Photo of Unwanted Emissions in Restricted Frequency Bands

8.3. *LIMIT*

Measure at 300m		
Frequency range	**Level**	**Detector**
9kHz-490kHz	67.6dBµV/m /F(kHz)	QPeak
Measure at 30m		
Frequency range	**Level**	**Detector**
490kHz-1.705MHz	87.6dBµV/m /F(kHz)	QPeak
1.705MHz-30MHz	29.5dBµV/m	QPeak
Measure at 10m		
Frequency range	**Level**	**Detector**
30MHz to 88MHz	29.5dBµV/m	QPeak
88MHz to 216MHz	33dBµV/m	QPeak
216MHz to 960MHz	35.5BµV/m	QPeak
960MHz to 1000MHz	43.5dBµV/m	QPeak
Above 1000MHz	63.5dBµV/m	Peak
	43.5dBµV/m	Average
Measure at 3m		
Frequency range	**Level**	**Detector**
30MHz to 88MHz	40dBµV/m	QPeak
88MHz to 216MHz	43.5dBµV/m	QPeak
216MHz to 960MHz	46BµV/m	QPeak
960MHz to 1000MHz	54dBµV/m	QPeak
Above 1000MHz	74dBµV/m	Peak
	54dBµV/m	Average

8.4. TEST EQUIPMENT LIST

TEST EQUIPMENT USED					
Description	**Manufacturer**	**Model**	**Identifier**	**Cal_Date**	**Cal_Due**
Amplifier 10MHz - 18GHz	LCIE SUD EST	_	A7102082	05/22	05/24
Antenna Bi-log	AH System	SAS-521-7	C2040180	05/23	05/25
Antenna horn 18GHz	EMCO	3115	C2042029	03/22	03/25
BAT EMC	NEXIO	v3.21.0.32	L1000115		
Cable 0.75m	-	18GHz	A5329900	08/22	08/24
Comb EMR HF	YORK	CGE01	A3169114		
CONTROLLER	INNCO	CO3000	D3044034		
Filter Matrice	LCIE SUD EST	Combined filters	A7484078	03/23	03/25
Rehausse Table C3	LCIE	_	F2000511		
Rehausse Table C3	LCIE	_	F2000507		
Semi-Anechoic chamber #3 (BF)	SIEPEL	_	D3044017_BF	04/22	04/25
Semi-Anechoic chamber #3 (VSWR)	SIEPEL	_	D3044017_VSWR	04/22	04/25
SMA Cable 18GHz 0.5m	TELEDYNE	18GHz	A5330059	02/23	02/24
SMA Cable 18GHz 0.5m	TELEDYNE	18GHz	A5330060	02/23	02/24
SMA Cable 18GHz 0.6m	TELEDYNE	18GHz	A5330055	02/23	02/24
SMA Cable 18GHz 3.5m	TELEDYNE	18GHz	A5330058	02/23	02/24
SMA Cable 18GHz 6m	TELEDYNE	18GHz	A5330057	02/23	02/24
Spectrum analyzer	ROHDE & SCHWARZ	FSU 26	A4060058	09/23	09/25
Table C3	LCIE	_	F2000461		
Thermo-hygrometer (PM1/2/3)	KIMO	HQ 210	B4206022	05/23	05/25
TILT	INNCO	TILT	D3044033		
Turntable chamber (Cage#3)	ETS Lingren	Model 2165	F2000371		
Turntable controller (Cage#3)	ETS Lingren	Model 2090	F2000444		
Antenna loop	ELECTRO-METRICS	EM-6879	C2040294	08/22	08/24
Antenna Mat (OATS)	ETS Lingren	2071-2	F2000392		
Biconic Antenna	EATON	94455-1	C2040234	05/23	05/25
Cable (OATS)	_	1GHz	A5329623	09/23	09/24
Emission Cable	MICRO-COAX	1GHz	A5329656	09/23	09/24
Emission Cable	RADIALEX		A5329061	07/23	07/24
Emission Cable	CABELTEL	6GHz	A5329069	02/24	02/25
OATS	_	_	F2000409	08/23	08/24
Rehausse Table C1/OATS	LCIE	_	F2000512		
Table C1/OATS	LCIE	_	F2000445		
Turntable (OATS)	ETS Lingren	Model 2187	F2000403		
Turntable / Mast controller (OATS)	ETS Lingren	Model 2066	F2000372		

8.1. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

8.2. RESULTS

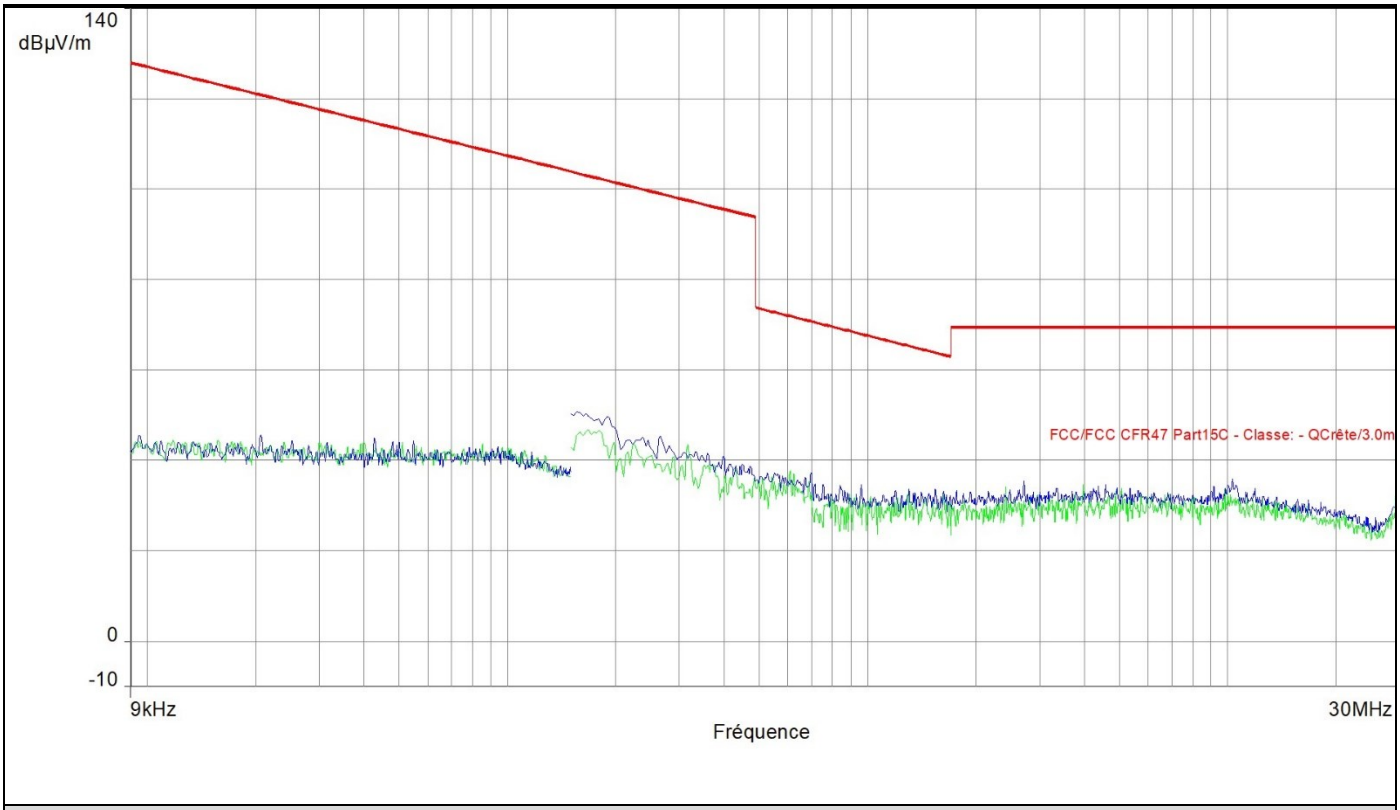
For all following measurements, worst case is presented with different configurations and modulations of EUT.

8.2.1. 9kHz to 30MHz

Graphs – Pre characterization:

Graph identifier		Polarization	Mode	Channel	EUT position	Comments
Emr#	1	0°/90°	TX	Cmin	Axis XY/Z	See the following results
Emr#	2	180°	TX	Cmin	Axis XY/Z	See the following results
Emr#	3	0°/90°	TX	Cmid	Axis XY/Z	See the following results
Emr#	4	180°	TX	Cmid	Axis XY/Z	See the following results
Emr#	5	0°/90°	TX	Cmax	Axis XY/Z	See the following results
Emr#	6	180°	TX	Cmax	Axis XY/Z	See the following results

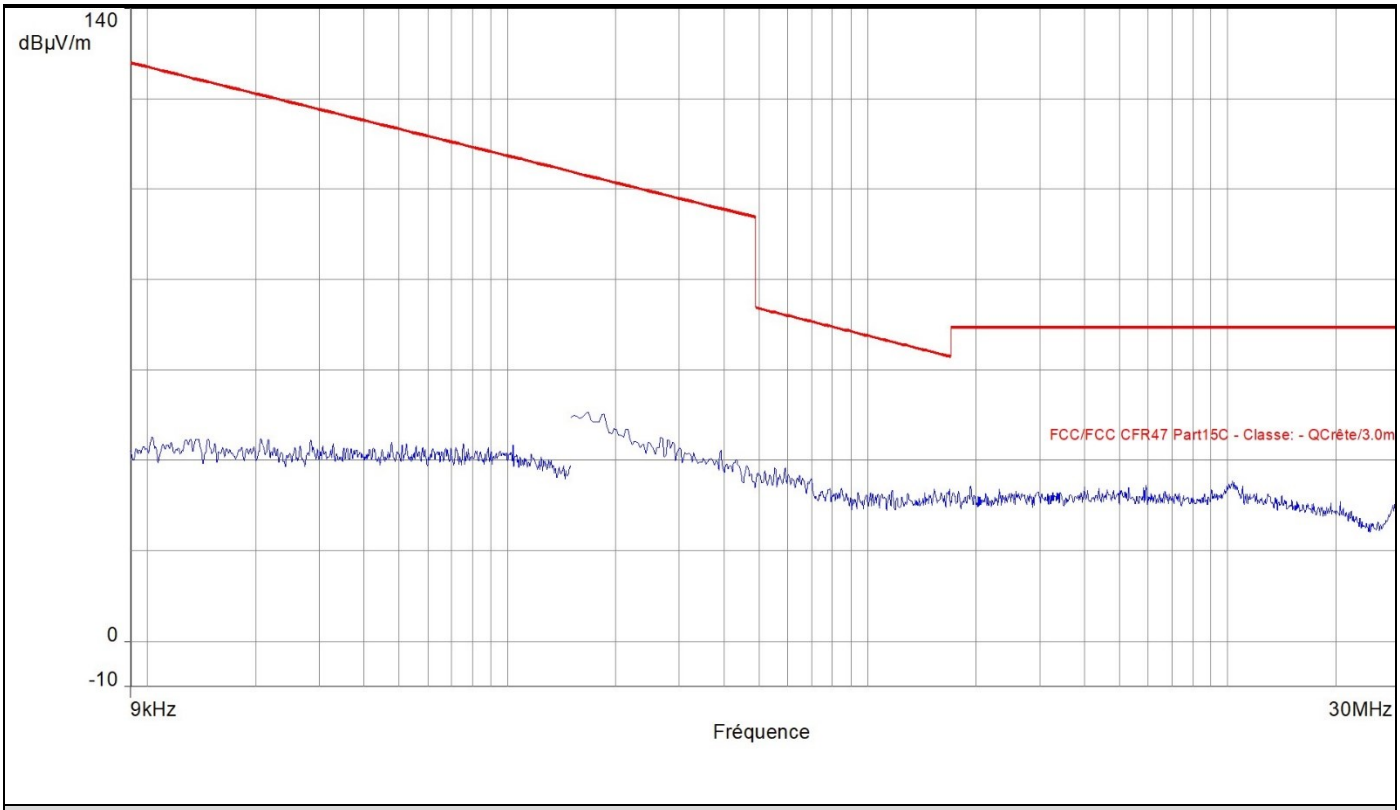
RADIATED EMISSIONS			
Graph name:	Emr#1	**Test configuration:**	
Limit:	FCC CFR47 Part15C	(0°/90°) - TX mode - Axis 0° (Worst case presented) 903MHz	
Class:			
Frequency range: [9kHz - 30MHz]			
Antenna polarization:		**RBW :**	200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :**	1kHz to 30kHz



Spurious emissions

No significative frequency observed

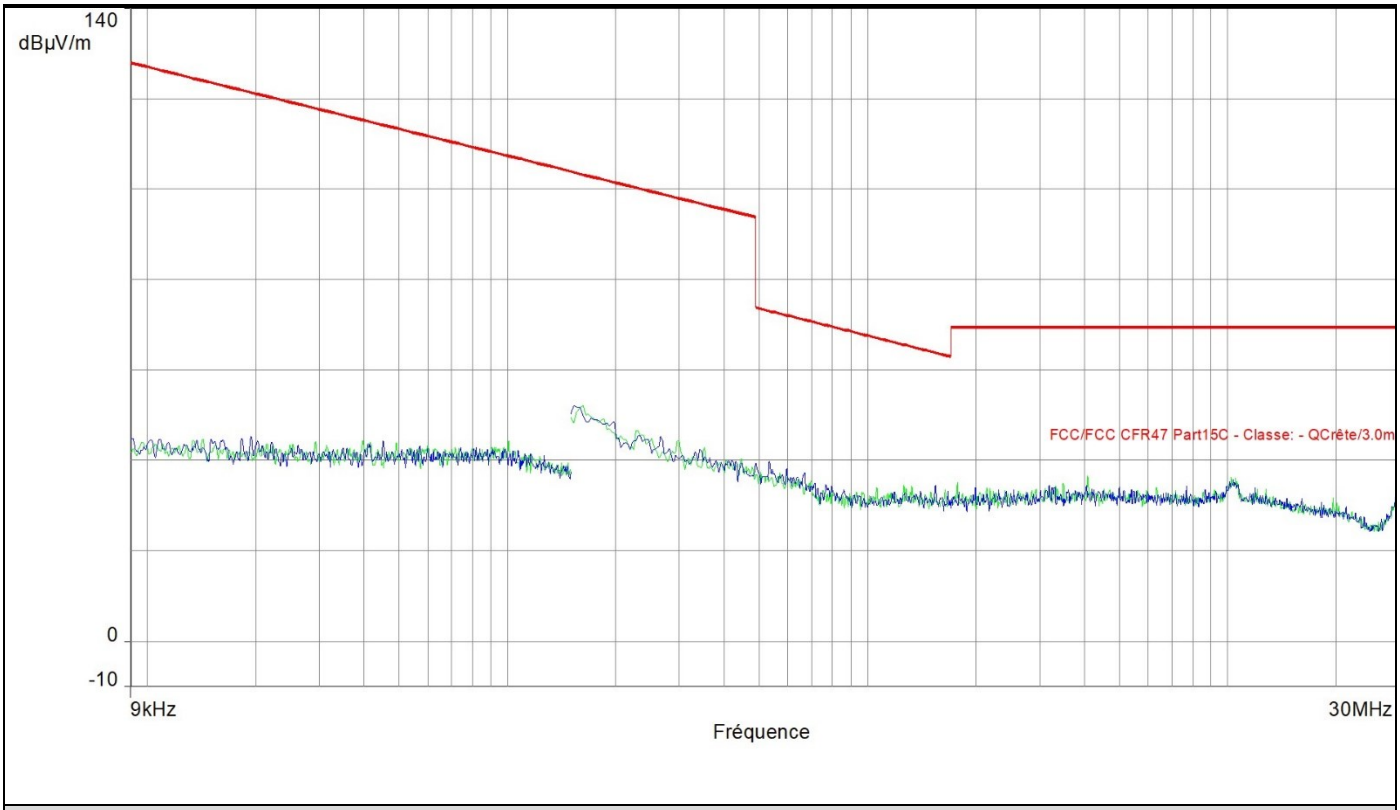
RADIATED EMISSIONS			
Graph name:	Emr#2	**Test configuration:**	
Limit:	FCC CFR47 Part15C	(180°) - TX mode - Axis 0° (Worst case presented) 903MHz	
Class:			
Frequency range: [9kHz - 30MHz]			
Antenna polarization:		**RBW :**	200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :**	1kHz to 30kHz



Spurious emissions

No significative frequency observed

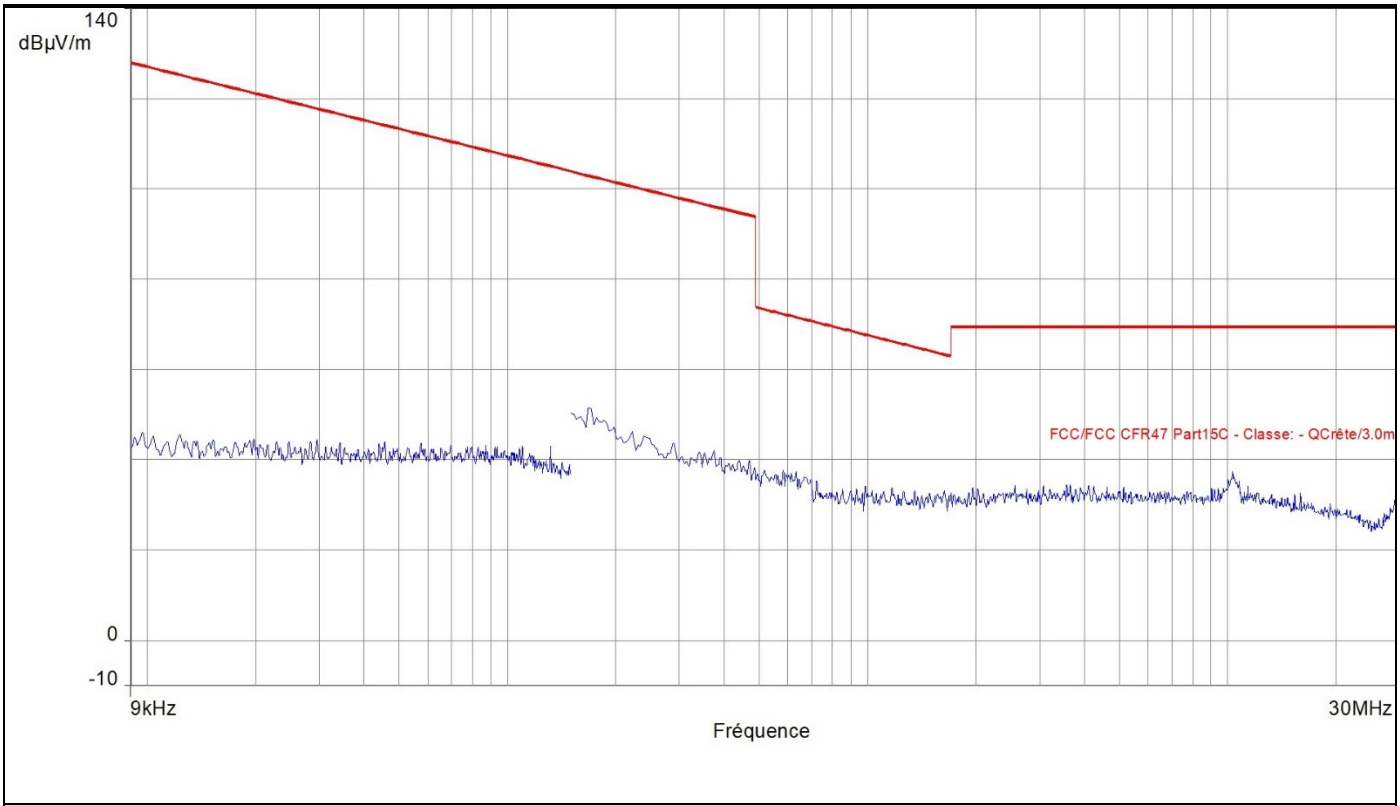
RADIATED EMISSIONS			
Graph name:	Emr#3	**Test configuration:**	
Limit:	FCC CFR47 Part15C	(0°/90°) - TX mode - Axis 0° (Worst case presented) 909.4MHz	
Class:			
Frequency range: [9kHz - 30MHz]			
Antenna polarization:		**RBW :**	200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :**	1kHz to 30kHz



Spurious emissions

No significative frequency observed

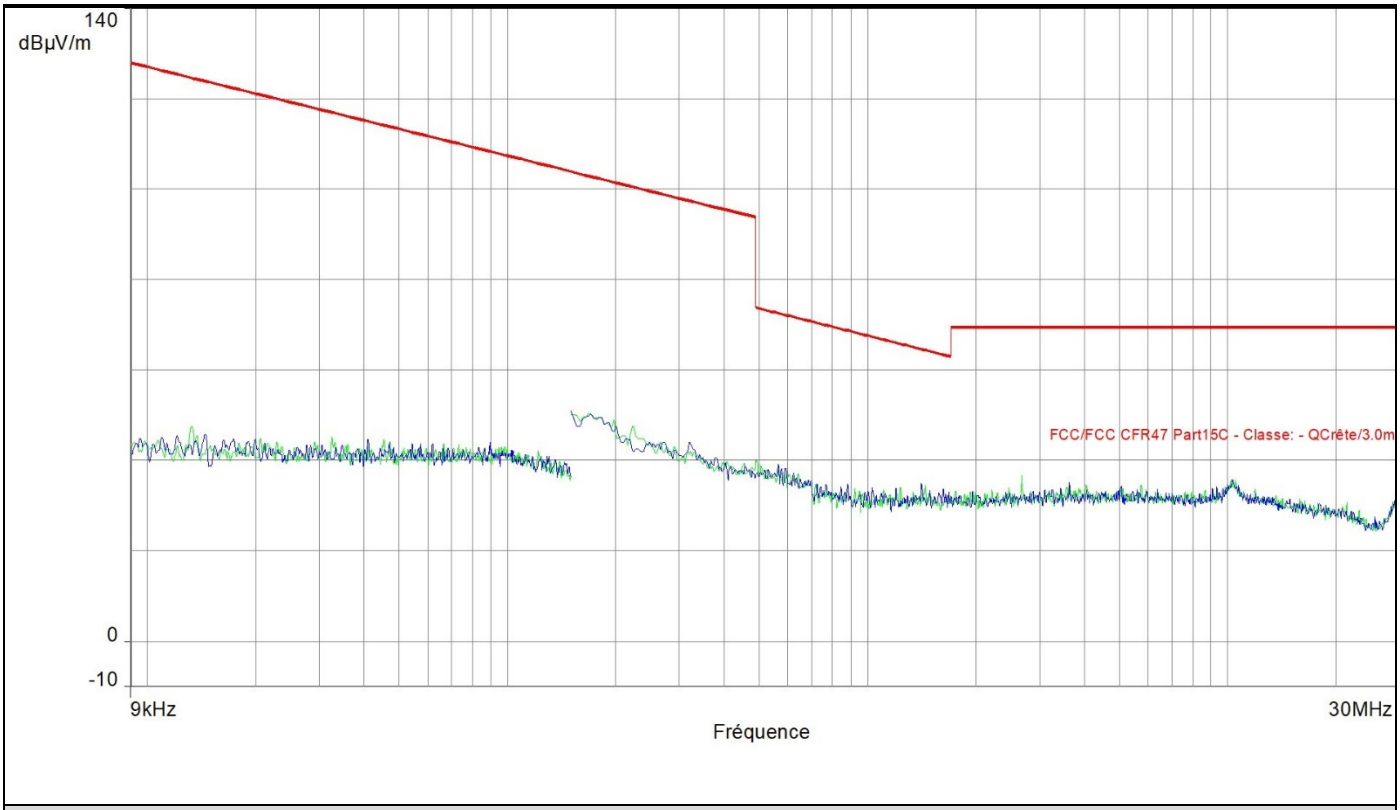
RADIATED EMISSIONS		
Graph name:	Emr#4	**Test configuration:**
Limit:	FCC CFR47 Part15C	(180°) - TX mode - Axis 0° (Worst case presented) 909.4MHz
Class:		
Frequency range: [9kHz - 30MHz]		
Antenna polarization:		**RBW :** 200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :** 1kHz to 30kHz



Spurious emissions

No significative frequency observed

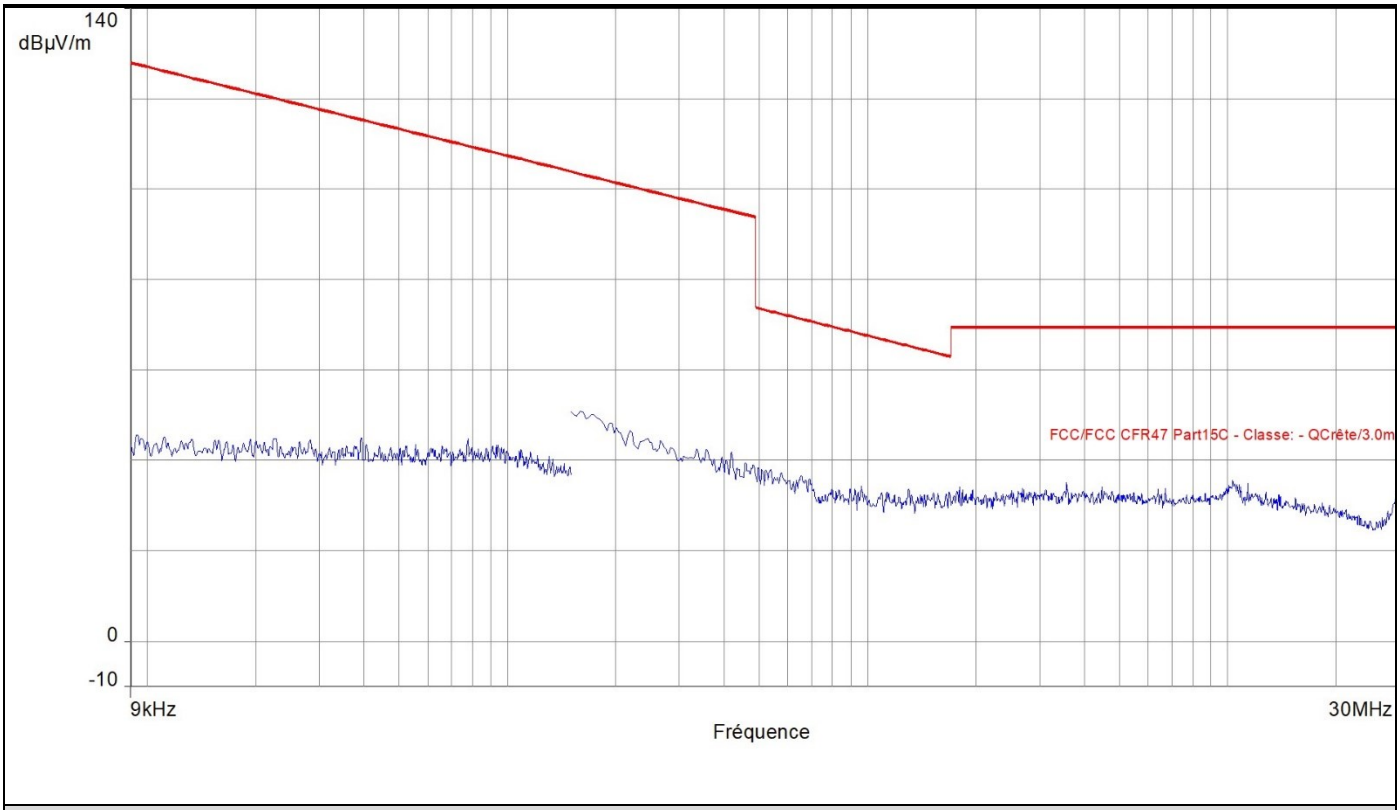
RADIATED EMISSIONS			
Graph name:	Emr#5	**Test configuration:**	
Limit:	FCC CFR47 Part15C	(0°/90°) - TX mode - Axis 0° (Worst case presented) 914.2MHz	
Class:			
Frequency range: [9kHz - 30MHz]			
Antenna polarization:		**RBW :**	200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :**	1kHz to 30kHz



Spurious emissions

No significative frequency observed

RADIATED EMISSIONS			
Graph name:	Emr#6	**Test configuration:**	
Limit:	FCC CFR47 Part15C	(180°) - TX mode - Axis 0° (Worst case presented) 914.2MHz	
Class:			
Frequency range: [9kHz - 30MHz]			
Antenna polarization:		**RBW :**	200Hz to 10kHz
Azimuth:	0° - 360°	**VBW :**	1kHz to 30kHz



Spurious emissions

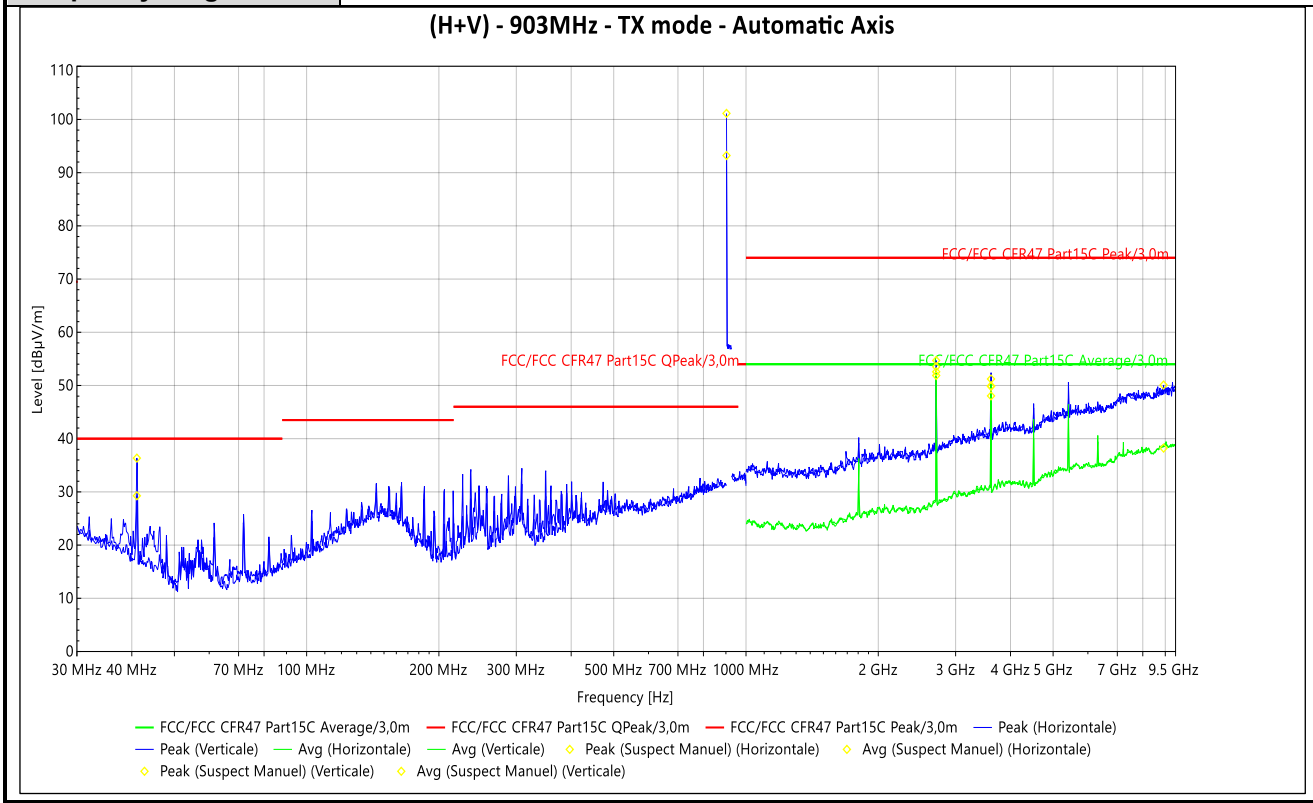
No significative frequency observed

8.2.2. 30MHz to 9.5GHz

Graphs – Pre characterization:

Graph identifier		Polarization	Mode	Channel	EUT position	Comments
Emr#	1	H/V	TX	Cmin	Axis XY/Z	See the following results
Emr#	2	H/V	TX	Cmid	Axis XY/Z	See the following results
Emr#	3	H/V	TX	Cmax	Axis XY/Z	See the following results

Radiated Emissions	
Graph name:	Emr#1
Frequency range:	30 MHz to 9,5 GHz

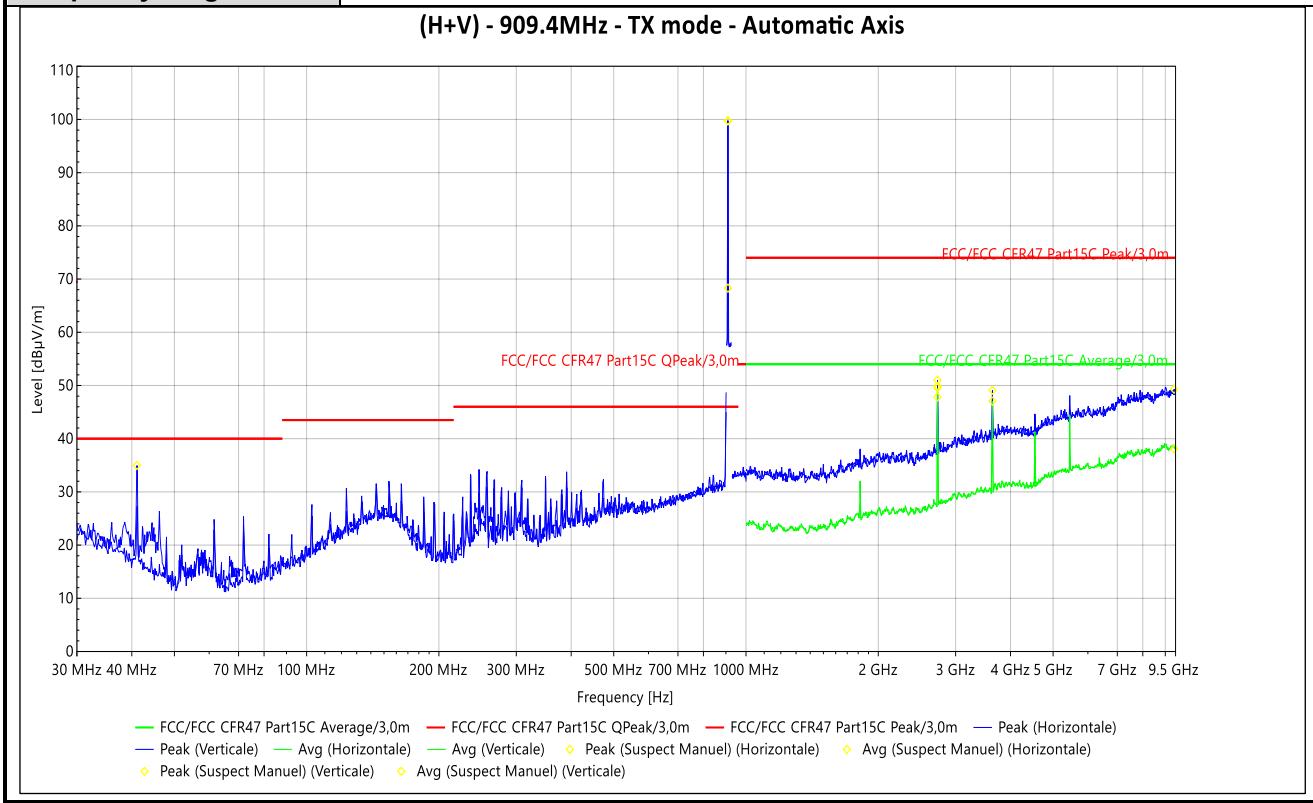


Pre-Characterization:

Frequency	PK Level (dBµV/m)	Lim.PK (dBµV/m)	Avg (dBµV/m)	Lim.Avg (dBµV/m)	Lim.QP (dBµV/m)	Angle (°)	Polar.	Correct. (dB)
902.936 MHz*	93.22					23	H	27.91
902.78 MHz*	101.14					113	V	27.91
41.0744 MHz	29.27				40.00	57	H	15.96
2.70935 GHz	53.52	74.00	51.88	54.00		321	H	-26.35
3.6112 GHz	49.92	74.00	48.04	54.00		261	H	-22.88
8.92115 GHz	50.08	74.00	38.23	54.00		68	H	-12.86
2.70935 GHz	54.69	74.00	52.57	54.00		353	V	-26.35
3.6112 GHz	51.22	74.00	49.84	54.00		263	V	-22.88
41.0744 MHz	36.35				40.00	282	V	15.96

*Carrier frequency
Significant frequency observed

Radiated Emissions	
Graph name:	Emr#2
Frequency range:	30 MHz to 9,5 GHz

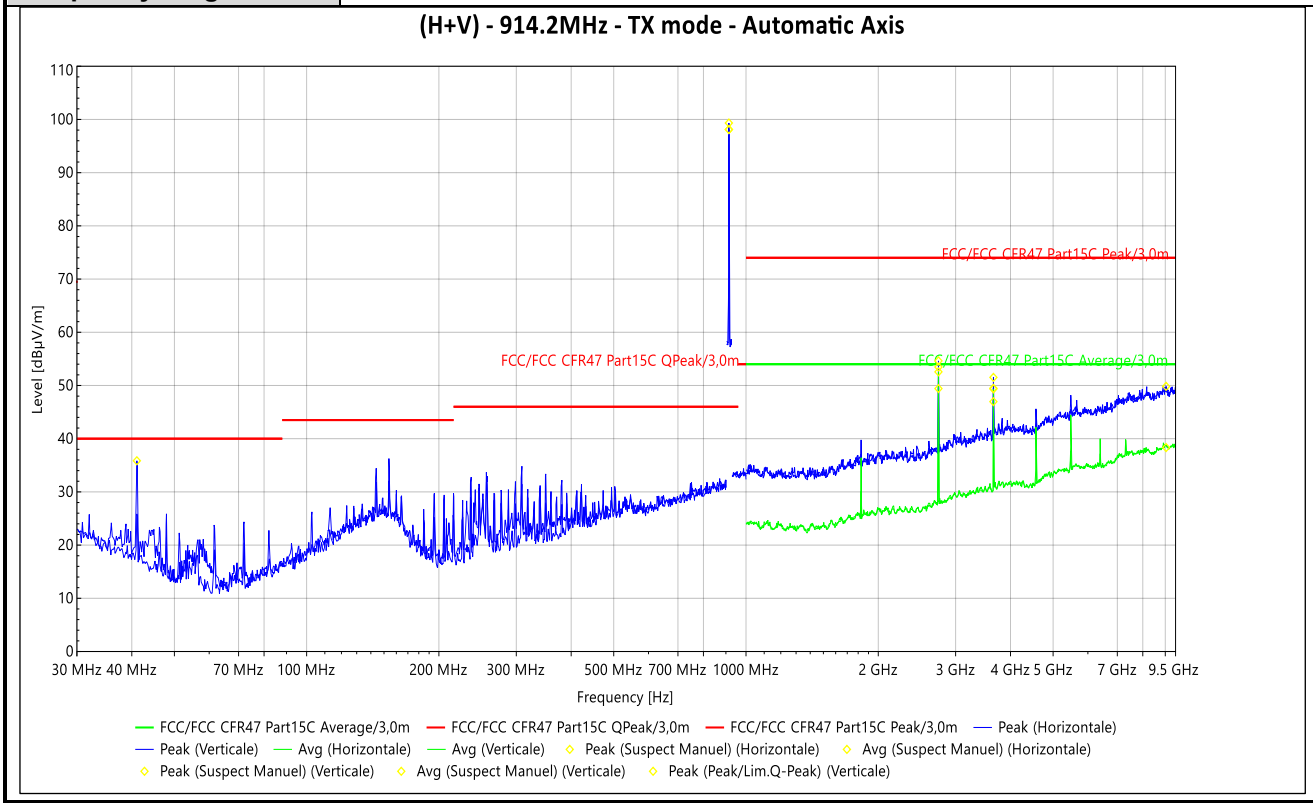


Pre-Characterization:

Frequency	PK Level (dBµV/m)	Lim.PK (dBµV/m)	Avg (dBµV/m)	Lim.Avg (dBµV/m)	Lim.QP (dBµV/m)	Angle (°)	Polar.	Correct. (dB)
909.488 MHz*	99.80					104	H	28.04
909.618 MHz*	68.29					106	H	28.04
909.384 MHz*	99.72					176	V	28.04
2.72805 GHz	50.99	74.00	49.55	54.00		232	H	-26.27
3.63755 GHz	49.11	74.00	47.06	54.00		321	H	-22.70
9.42435 GHz	49.30	74.00	38.08	54.00		187	H	-12.94
2.72805 GHz	49.82	74.00	47.85	54.00		249	V	-26.27
41.0744 MHz	34.96				40.00	244	V	15.96

*Carrier frequency
Significant frequency observed

Radiated Emissions	
Graph name:	Emr#3
Frequency range:	30 MHz to 9,5 GHz



Pre-Characterization:

Frequency	PK Level (dBµV/m)	Lim.PK (dBµV/m)	Avg (dBµV/m)	Lim.Avg (dBµV/m)	Lim.QP (dBµV/m)	Angle (°)	Polar.	Correct. (dB)	PK-Lim.QP (dB)	Angle (°)	Tilt (°)
914.168 MHz*	99.33					131	H	28.03			
914.194 MHz*	98.11					171	V	28.03			
914.194 MHz*	98.11						V	28.03	52.11	171	0.40
2.74165 GHz	54.62	74.00	52.56	54.00		203	H	-26.26			
3.6571 GHz	51.52	74.00	49.35	54.00		323	H	-22.59			
2.74165 GHz	53.47	74.00	49.42	54.00		350	V	-26.26			
3.65625 GHz	49.48	74.00	46.96	54.00		3	V	-22.59			
9.04015 GHz	49.83	74.00	38.33	54.00		46	V	-12.99			
41.0744 MHz	35.85				40.00	99	V	15.96			

*Carrier frequency
Significant frequency observed

Final measurement:

Test Frequency (MHz)	Meter Reading dB(µV)	Detector (Pk/QP/Av)	Transducer Factor (dB)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
41.0744	25.6	QP	13.8	39.4	40.0	**-0.6**

8.3. CONCLUSION

Unwanted emissions in non-restricted bands measurement performed on the sample of the product **SQUID-PRO**, Sn: **70B3D5475012134E**, in configuration and description presented in this test report, show levels **compliant** to the **47 CFR PART 15.247 & RSS 247** limits.

9. UNCERTAINTIES CHART

Kind of measurement	*Wide uncertainty laboratory*
Occupied Channel Bandwidth	±2.8 %
Humidity	±3.2 %
Power Spectral Density, Conducted	±1.7 dB
Radio frequency	±0.3 ppm
RF power, conducted	±1.2 dB
RF power, radiated (Full anechoic chamber above 1GHz)	±3.7 dB
RF power, radiated (Semi anechoic chamber & open test site)	±5.6 dB
Spurious emission, conducted	±2.3 dB
Spurious emission, radiated (Full anechoic chamber above 1GHz)	±3.8 dB
Spurious emission, radiated (Semi anechoic chamber & open test site)	±5.7 dB
Temperature	±0.75 °C
Time	±2.3 %
Voltage	±1.7 %

The uncertainty values calculated by the laboratory are lower than limit uncertainty values defined by the standard. The conformity of the sample is directly established by the applicable limit values. This table includes all uncertainties maximum feasible for testing in the laboratory, whether or not made in this report.