DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
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C.I.F. A29507456

ISED CABid: ES1909

Test report No:
NIE: 66594RRF.002A1

Test Report
USA FCC Part 15.247, 15.209
CANADA RSS-247, RSS-Gen

(*) Identification of item tested	Sigfox certified system-in-package (SiP) module
(*) Trademark	HT Micron
(*) Model and /or type reference	HTSXMO32L-22
Other identification of the product	HW version: V2.2 SW version: V2.8.1 FCC ID: 2A7ZW-HTSXMO32L
(*) Features	Sigfox communication and regular MCU GPIOs, ADCs, USART
Applicant	HT Micron Semicondutores Avenida Unisinos 1550, Cristo Rei, São Leopoldo-RS, Brazil ZIP code: 93022-750
Test method requested, standard	USA FCC Part 15.247 (10-1-19 Edition): Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 (10-1-19 Edition): Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5, Amendment 1, March 2019 Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05r02 dated April 2, 2019. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Jose Manuel Gómez EMC Consumer & RF Lab. Manager Firmado digitalmente por 53680346W JOSE MANUEL GOMEZ (C:A29507456)
Date of issue	2023-07-12
Report template No	FDT08_24 (*) "Data provided by the client"

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Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC – Entidad Nacional de Acreditación) to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that includes testing performed in this test report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory with appropriate scope of accreditation that includes testing performed in this test report

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report, and it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

DEKRA Testing and Certification S.A.U. is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification S.A.U.
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Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").

2. The sample of the model HTSXMO32L-22 is a system-in-package module that contains an MCU, a Sigfox radio transceiver, a crystal oscillator and a power amplifier.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: the client.

- Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
66594C/002	SMA cable	---	---	2021/01/20
66594C/005	Sigfox module	HTSXMO32L-22	---	2021/01/20

Sample S/01 has undergone the following test(s): The Conducted tests indicated in the Appendix A.

- Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
66594C/002	SMA cable	---	---	2021/01/20
66594C/004	Antenna	---	---	2021/01/20
66594C/005	Sigfox module	HTSXMO32L-22	---	2021/01/20

Sample S/02 has undergone the following test(s): The Radiated tests indicated in the Appendix A.

Test sample description

Ports…… :	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)
	DC supply via USB	1	☒	☐	☐
	Header pins	0.15	☒	☐	☐
	SMA RF out	0.5	☒	☐	☐
Supplementary information to the ports…… :	-				

Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: USB port on computer					
	☐	DC:					

Rated Power .....:	0.66-1W only during transmission
Clock frequencies.....:	MCU maximum clock is 32MHz, S2LP clock reference is 50MHz crystal oscillator
Other parameters .....:	-
Software version .....:	V2.8.1
Hardware version .....:	V2.2

Dimensions in cm (W x H x D) ....:	-			
Mounting position .....:	☒	Table top equipment		
	☐	Wall/Ceiling mounted equipment		
	☐	Floor standing equipment		
	☐	Hand-held equipment		
	☐	Other:		
Modules/parts.....:	Module/parts of test item		Type	Manufacturer
	HTSXMO32L-22		System-in-package	HT Micron
Accessories (not part of the test item) .....:	Description		Type	Manufacturer
	-			
	-			
Documents as provided by the applicant.....:	Description		File name	Issue date
	Device operating instructions			

(3) Only for Medical Equipment

Identification of the client

HT Micron Semicondutores

Avenida Unisinos 1550, Cristo Rei, São Leopoldo-RS, Brazil

ZIP code: 93022-750

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-04-05
Date (finish)	2021-06-21

Document history

Report number	Date	Description
66594RRF.002	2022-10-26	First release
66594RRF.002A1	2023-07-12	First modification. **Antenna gain**: Correction in antenna gain in all the report. Previous version considered an incorrect antenna gain (5dBi). The real antenna gain is 2.2dBi. The report has been corrected with this new value. **Modulation**: the modulation used during the test (DBPSK 600 bps) is specified in this report. **Carrier frequency separation:** this test has been repeated with 20000 points of resolution to show compliance: >25kHz. This report cancels and replaces the previous 66594RRF.002.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the semianechoic chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Jaime Barranquero, Daniel Mejías and Antonio Manuel Sánchez.

Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
2.	SPECTRUM ANALYZER 9kHz-6GHz ROHDE AND SCHWARZ FSL6	2021/04	2023/04
3.	EMI TEST RECEIVER 2Hz-44GHz ROHDE AND SCHWARZ ESW44	2019/10	2021/10

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ALBATROSS P29419	N.A.	N.A.
2.	SHIELDED ROOM ALBATROSS P29419	N.A.	N.A.
3.	ULTRALOG ANTENNA 30MHz-6GHz ROHDE AND SCHWARZ HL562E_UPG	2019/10	2022/10
4.	HORN ANTENNA 1-18GHz SCHWARZBECK MESS- ELEKTRONIK BBHA 9120D	2019/11	2022/11
5.	PREAMPLIFIER 30dB 500MHz-18GHz SCHWARZBECK BBV 9718 C	2021/02	2022/02
6.	EMI TEST RECEIVER 2Hz-44GHz ROHDE AND SCHWARZ ESW44	2019/10	2021/10

Testing verdicts

Not applicable:	N/A
Pass:	P
Fail:	F
Not measured:	N/M

Summary

1. Sigfox 900 MHz

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
FCC 15.247 (a)(1) / RSS-247 5.1 (b)	20 dB Bandwidth and Carrier frequency separation	P	
FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c)	Number of hopping channels	P	
FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c)	Time of occupancy (Dwell Time)	P	
FCC 15.247 (b)(2) / RSS-247 5.4 (a)	Maximum peak output power and antenna gain	P	
FCC 15.247 (d) / RSS-247 5.5	Band-edge compliance of conducted emissions (Transmitter)	P	
FCC 15.247 (d) / RSS-247 5.5	Emission limitations radiated (Transmitter)	P	
Supplementary information and remarks: None.			

Appendix A: Test results

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TEST CONDITIONS

POWER SUPPLY:

V nonimal: 5 Vdc

Type of Power Supply: USB powered

ANTENNA:

Type of Antenna: Monopole

Maximum Declared Assembly Gain: +2.2 dBi

TEST FREQUENCIES:

Conducted Tests:

Low Channel: 902.1375 MHz

Middle Channel: 903.3875 MHz

High Channel: 904.6625 MHz

Radiated Tests:

Low Channel: 902.1375 MHz

Middle Channel: 903.3875 MHz

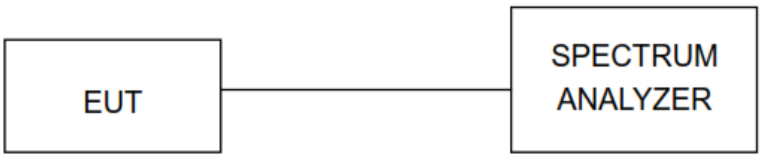
High Channel: 904.6625 MHz

MODULATION: DBPSK 600 bps.

- The equipment operates as a frequency hopping system using 54 hopping channels.

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and connected to the spectrum analyser using a low-loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.



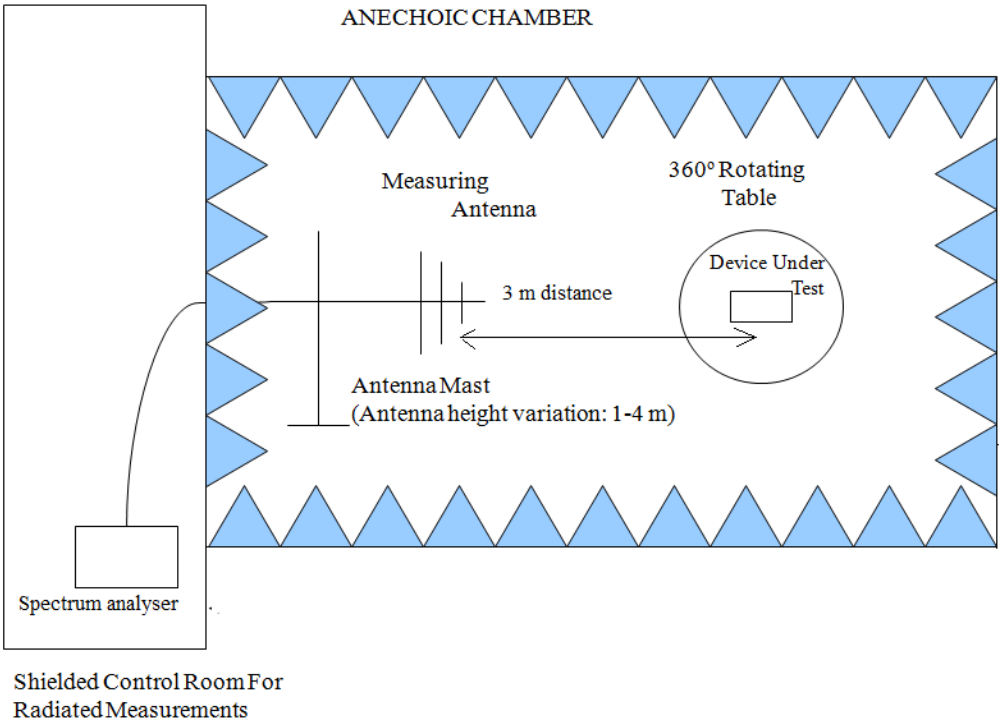
RADIATED MEASUREMENTS

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range 30 MHz to 1000 MHz and Double ridge horn antenna for the range 1 GHz to 10 GHz) is situated at a distance of 3 m.

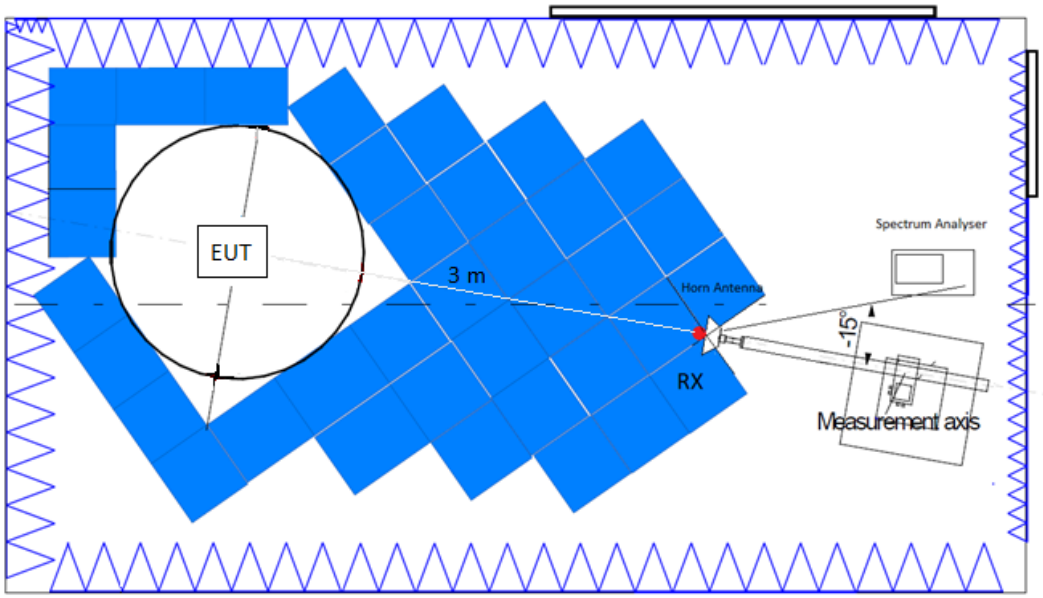
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission. Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth/video bandwidth of 100 kHz/300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 10 GHz:



Occupied Bandwidth

SPECIFICATION:

FCC §2.1049. Measurements required: Occupied bandwidth.

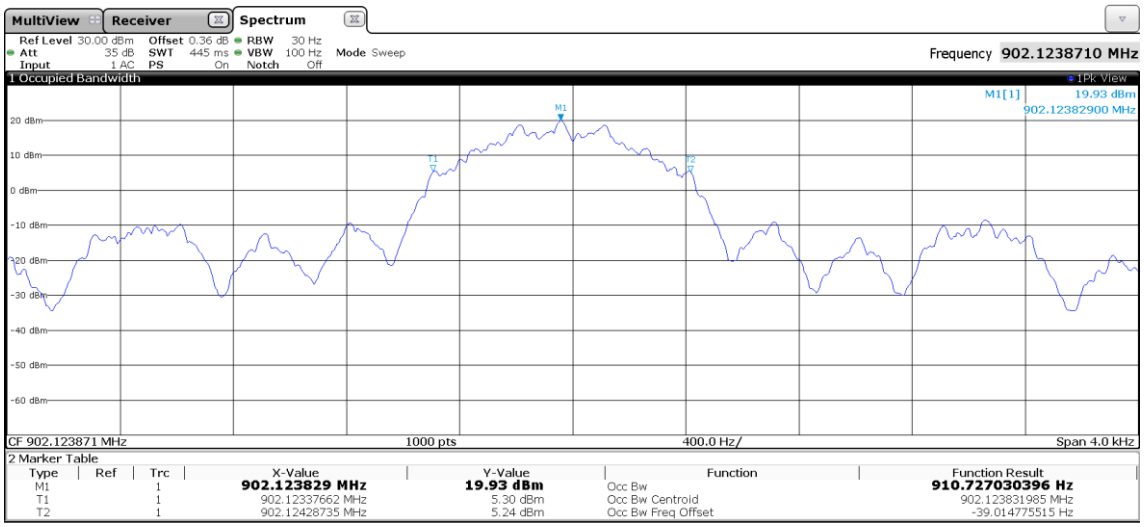
RSS-Gen Clause 6.7. Occupied bandwidth (or 99% emission bandwidth)

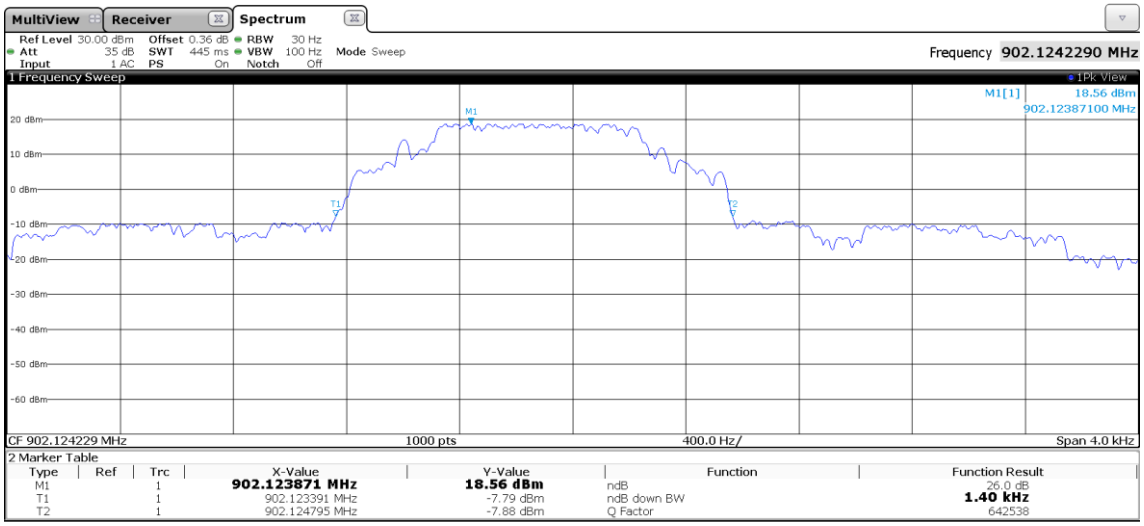
RESULTS:

	Low Channel	Middle Channel	High Channel
99% Bandwidth (kHz)	0.910727	0.939366	0.937554
-26 dBc Bandwidth (kHz)	1.40	1.09	1.06
Measurement uncertainty (kHz)	<± 0.87		

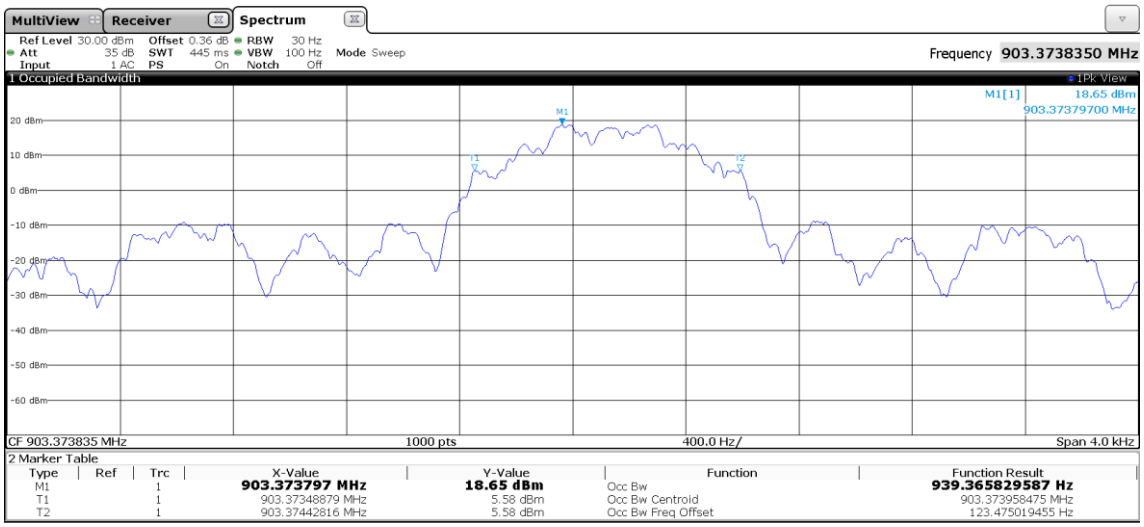
Verdict: PASS

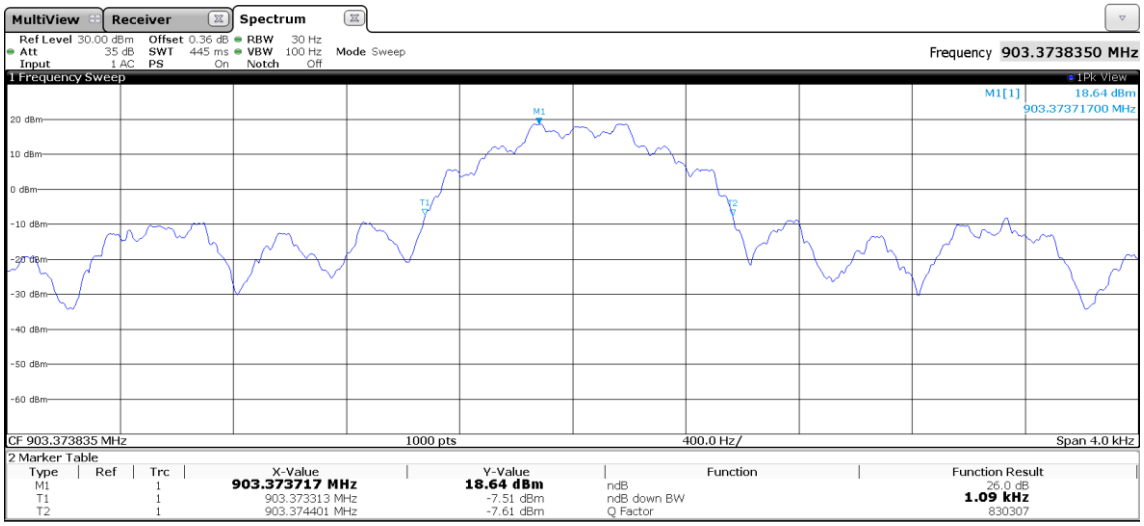
Low Channel:


MultiView
Receiver
Spectrum
Ref Level 30.00 dBm Offset 0.36 dB RBW 30 Hz
Att 35 dB SWT 445 ms VBW 100 Hz Mode Sweep
Input 1 AC PS On Notch Off
Frequency 902.1238710 MHz
1 Occupied Bandwidth
1Pk View
M1[1] 19.93 dBm
902.12382900 MHz
CF 902.123871 MHz
1000 pts
400.0 Hz/
Span 4.0 kHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 902.123829 MHz 19.93 dBm Occ Bw 910.727030396 Hz
T1 1 902.12337662 MHz 5.30 dBm Occ Bw Centroid 902.123831985 MHz
T2 1 902.12428735 MHz 5.24 dBm Occ Bw Freq Offset -39.014775515 Hz

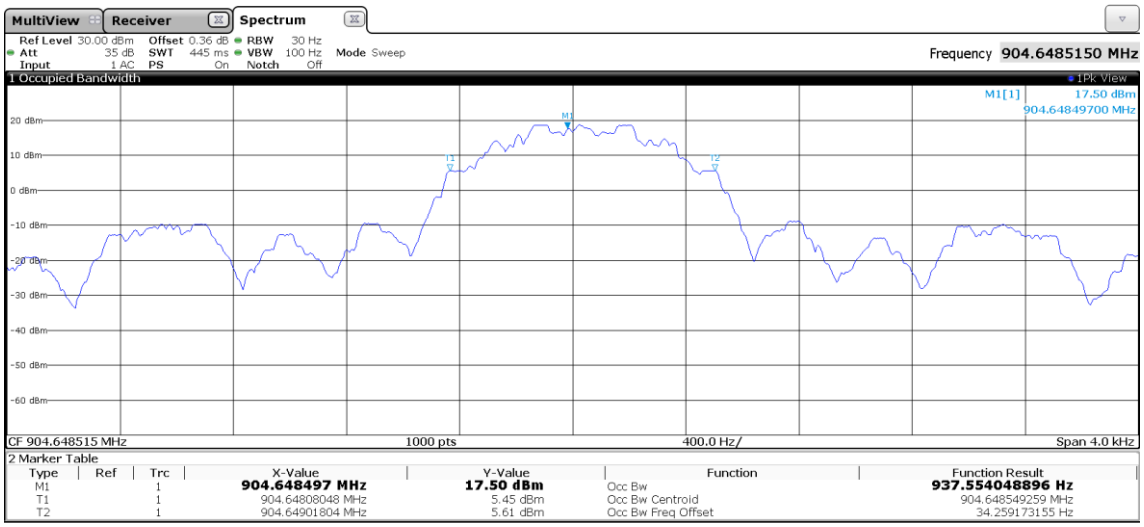

MultiView
Receiver
Spectrum
Ref Level 30.00 dBm Offset 0.36 dB RBW 30 Hz
Att 35 dB SWT 445 ms VBW 100 Hz Mode Sweep
Input 1 AC PS On Notch Off
Frequency 902.1242290 MHz
1 Frequency Sweep
1Pk View
M1[1] 18.56 dBm
902.12387100 MHz
CF 902.124229 MHz
1000 pts
400.0 Hz/
Span 4.0 kHz
2 Marker Table
Type Ref Trc X-Value Y-Value Function Function Result
M1 1 902.123871 MHz 18.56 dBm ndB 26.0 dB
T1 1 902.123391 MHz -7.79 dBm ndB down BW 1.40 kHz
T2 1 902.124795 MHz -7.88 dBm Q Factor 642538

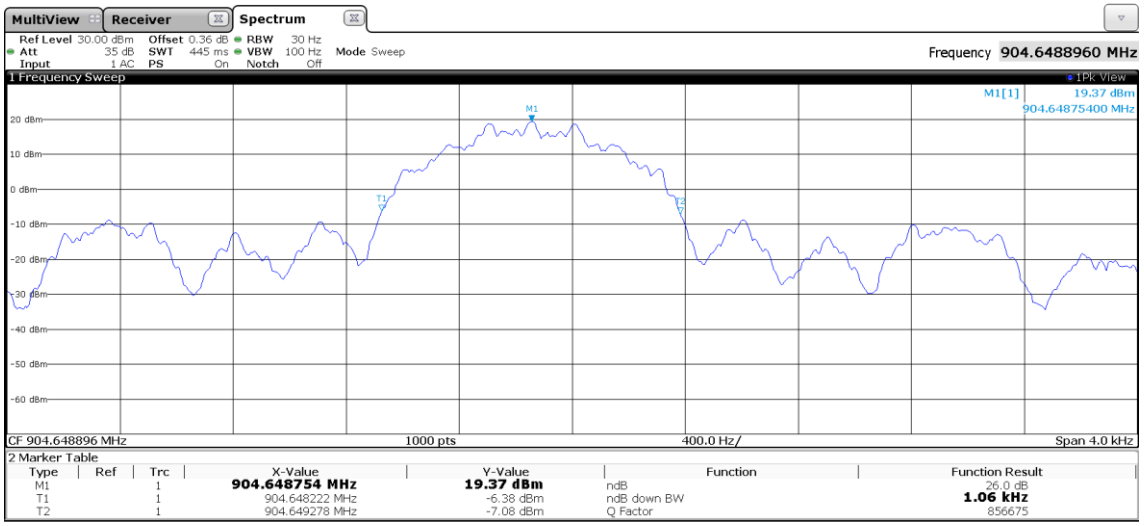
Middle Channel:





High Channel:





FCC 15.247 (a) (1) / RSS-247 5.1 (b) 20 dB Bandwidth and Carrier frequency separation

SPECIFICATION:

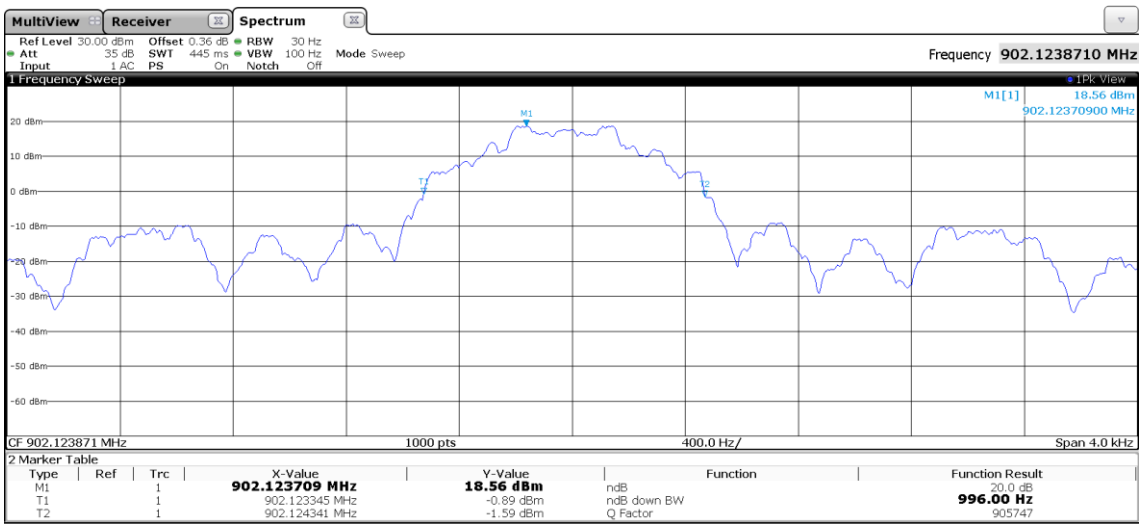
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

RESULTS:

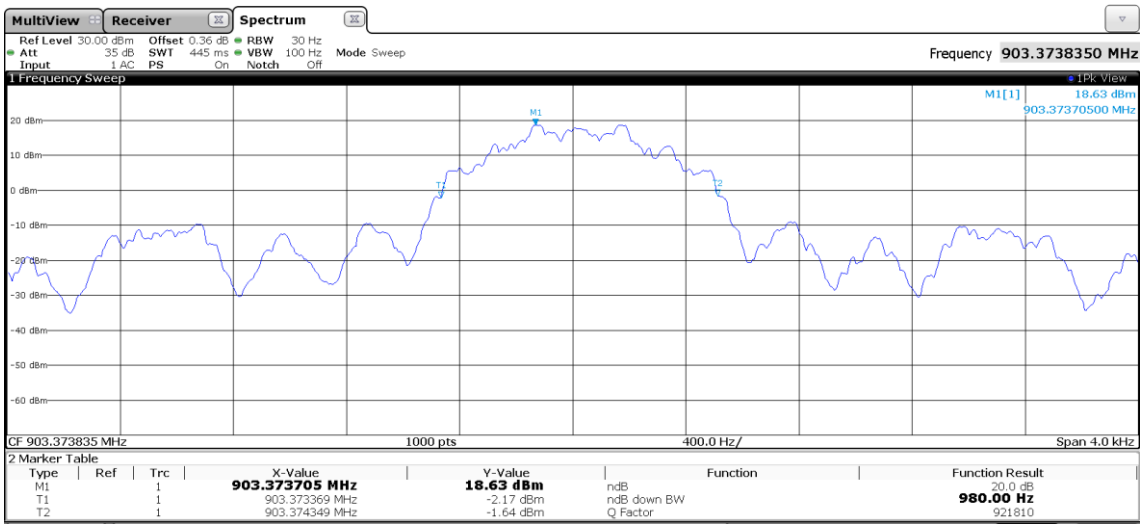
	Low Channel	Middle Channel	High Channel
20 dB Spectrum bandwidth (kHz)	0.996	0.980	0.964
Measurement uncertainty (kHz)	<± 0.87		

Verdict: PASS

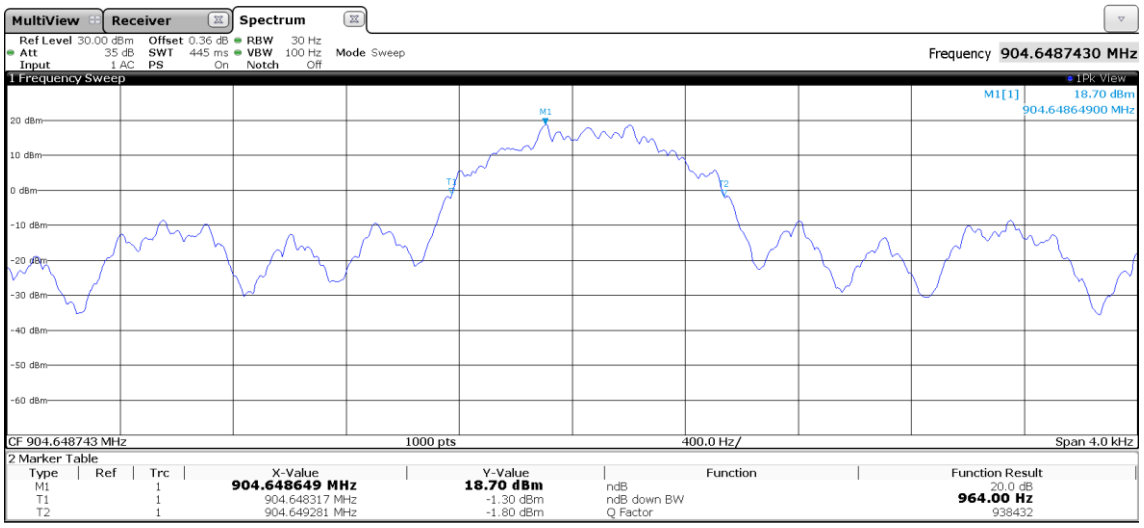
Low Channel:



Middle Channel:

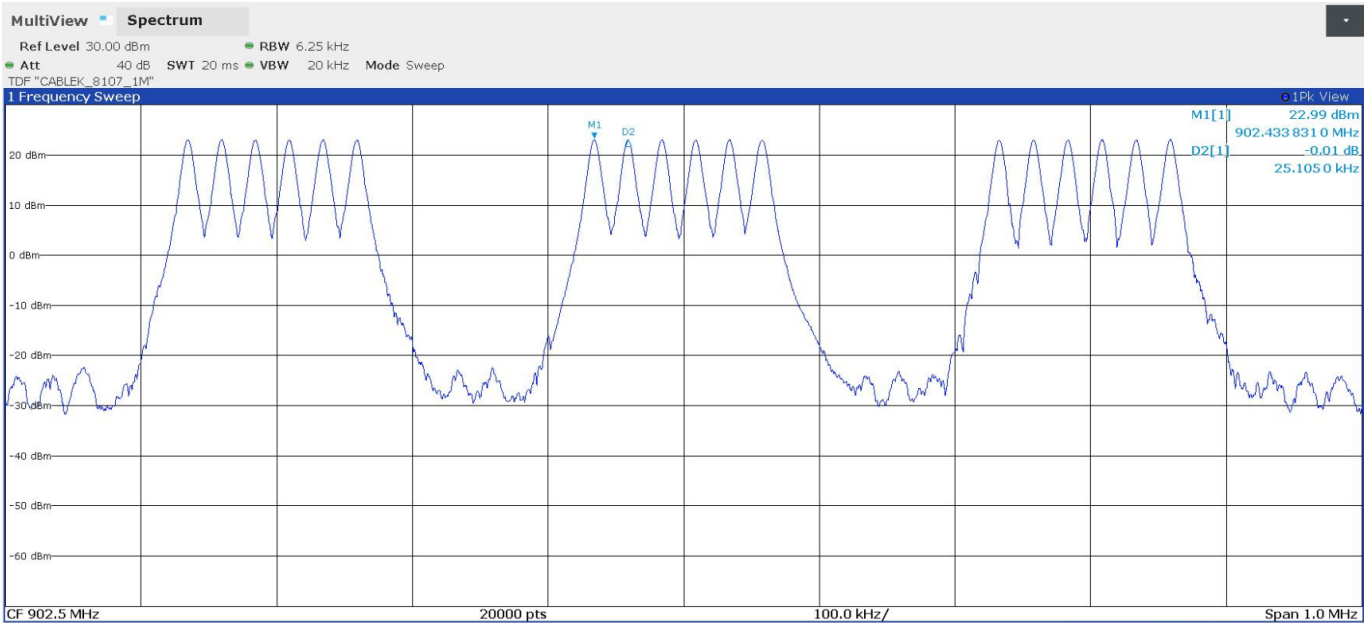


High Channel:



Carrier frequency separation

25.105 kHz



The hopping carrier frequencies are separated by a minimum of the 20 dB bandwidth of the hopping channel.

Verdict: PASS

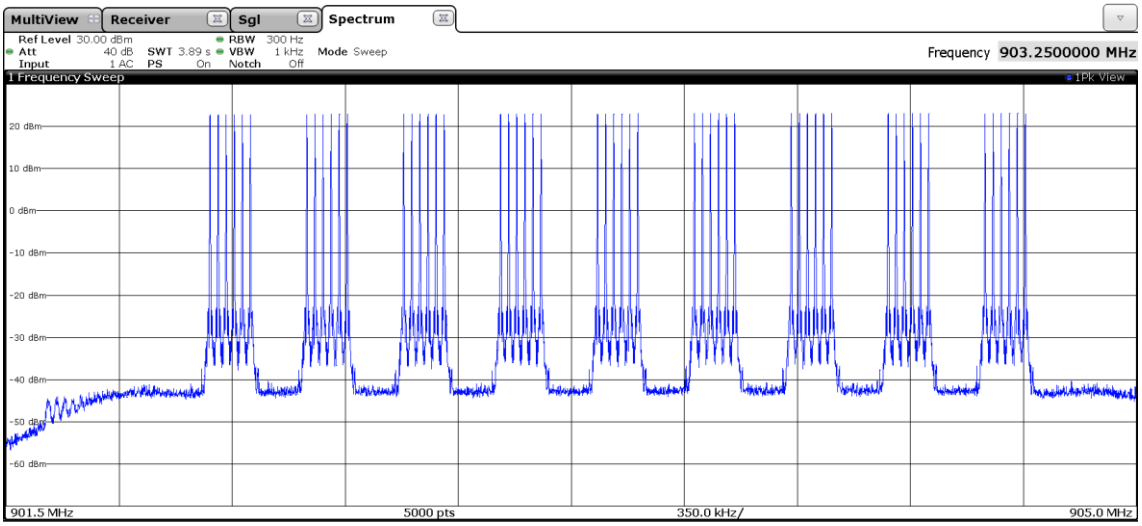
FCC 15.247 (a)(1)(i) / RSS-247 5.1 Number of hopping channels

SPECIFICATION:

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

RESULTS:

The equipment operates as a frequency hopping system. The maximum number of hopping channels is 54 (see next plot).



Number of hopping frequencies: 54

Verdict: PASS

FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c) Time of occupancy (Dwell Time)

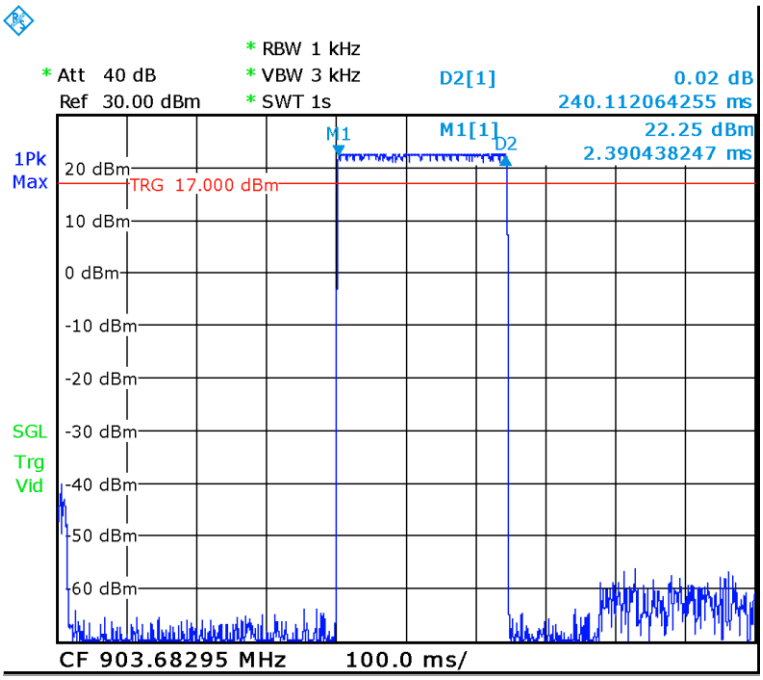
SPECIFICATION:

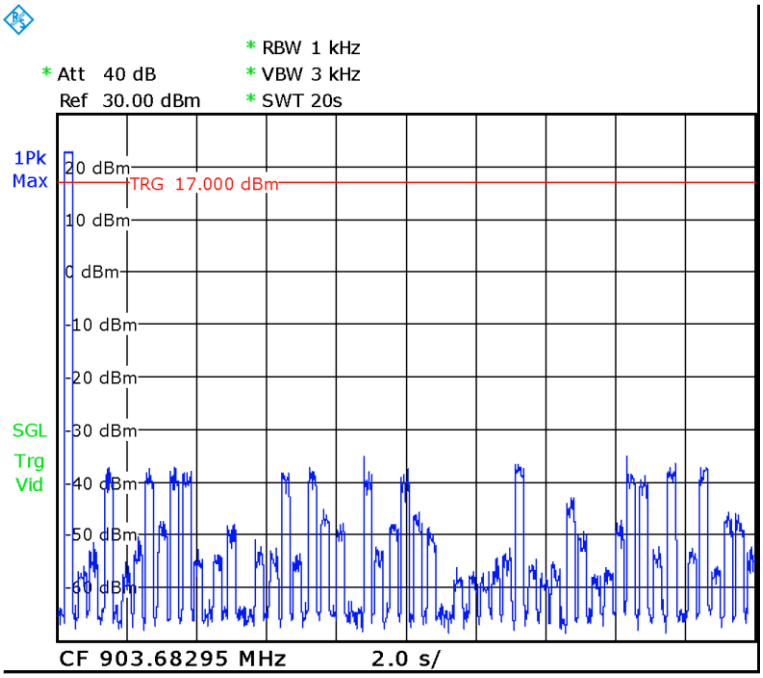
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

RESULTS:

OPERATION AS A FREQUENCY HOPPING SYSTEM USING 54 HOPPING CHANNELS.

- TX time per hop: 240.112 ms (see next plots)
- Number of hops over a period of 20 s: 1 (see next plots)





- **Average Time of Occupancy** = 240.112 ms x 1 hops = 240.112 ms per 20 s.

  Average Time of Occupancy is < 0.4 s within a 20 second period.

Measurement uncertainty (ms)	<±11.578

Verdict: PASS

FCC 15.247 (b)(2) / RSS-247 5.4 (a) Maximum output power and antenna gain

SPECIFICATION:

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels. Hybrid systems shall comply with the 1 W limit.

Additionally for RSS-247:

For FHSs operating in the band 902-928 MHz, the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

RESULTS:

The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power.

Maximum Declared Antenna Gain: +2.2 dBi

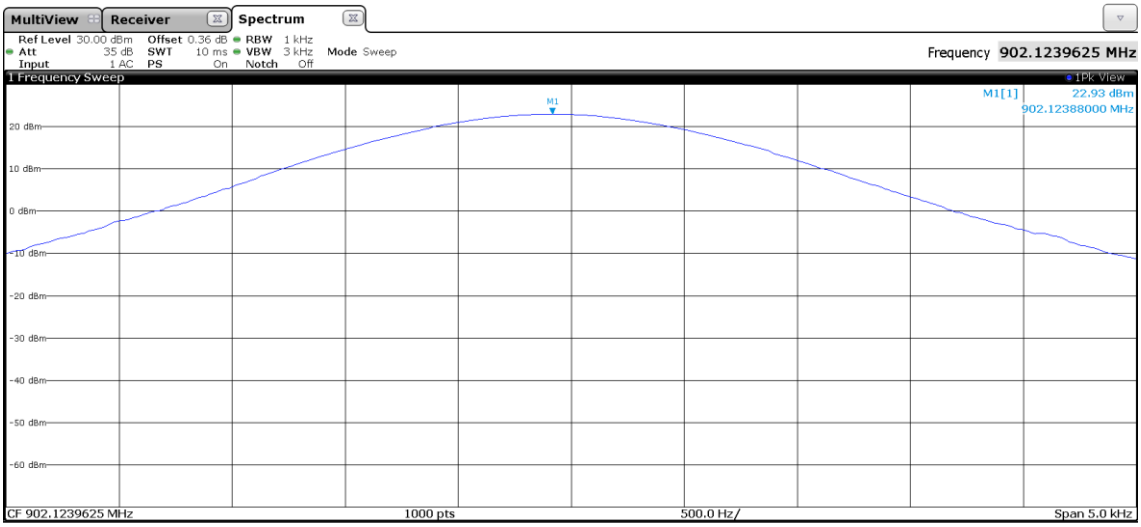
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

	Low Channel	Middle Channel	High Channel
Maximum Peak Conducted Power (dBm)	22.93	22.98	23.04
Maximum EIRP Peak Conducted Power (dBm)	25.13	25.18	25.24
Measurement uncertainty (dB)	<±1.845		

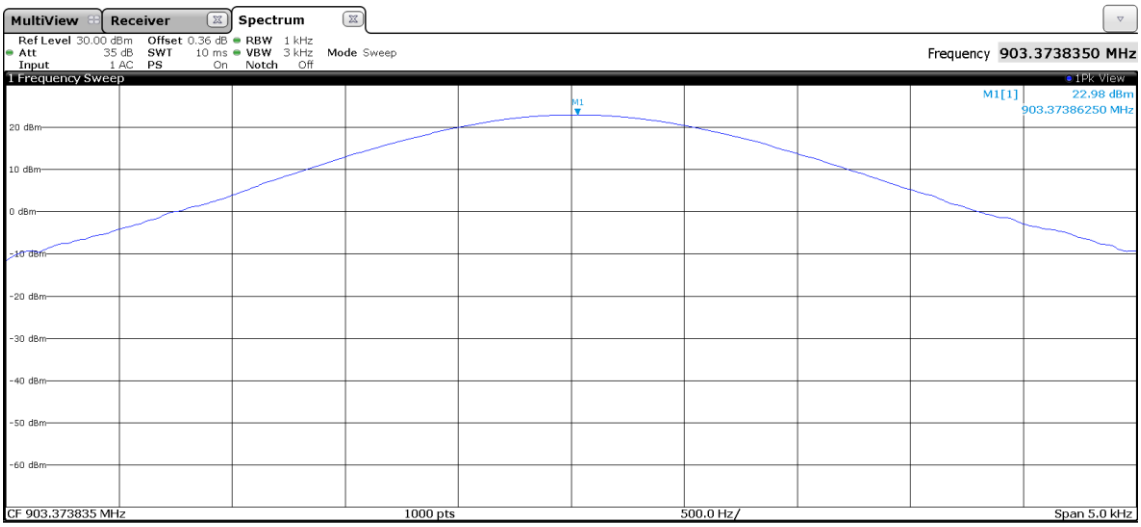
Verdict: PASS

Maximum Peak Output Power:

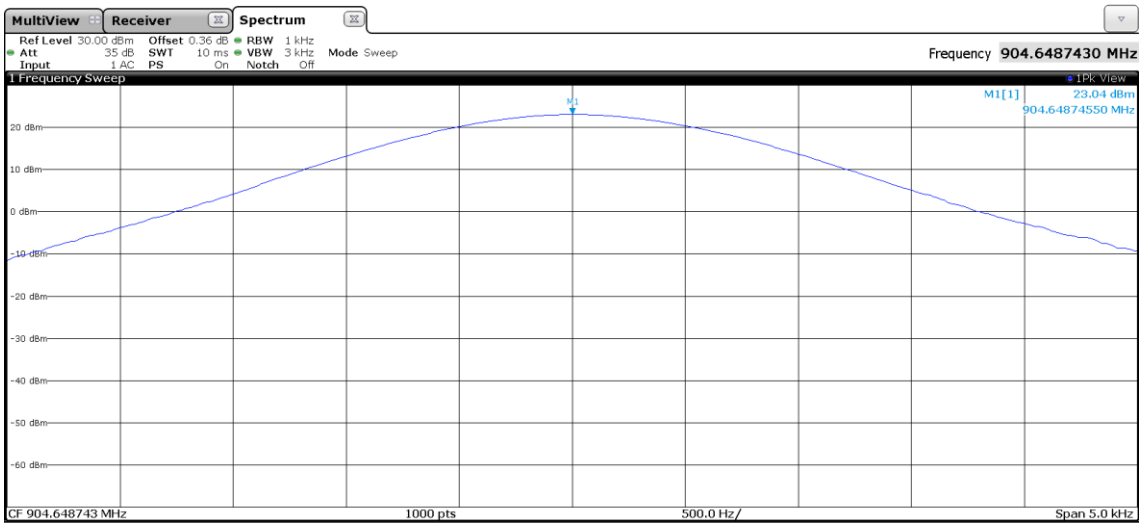
Low Channel:



Middle Channel:



High Channel:



FCC 15.247 (d) / RSS-247 5.5 Band-edge compliance of conducted emissions (Transmitter)

SPECIFICATION:

In any 100 kHz bandwidth outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

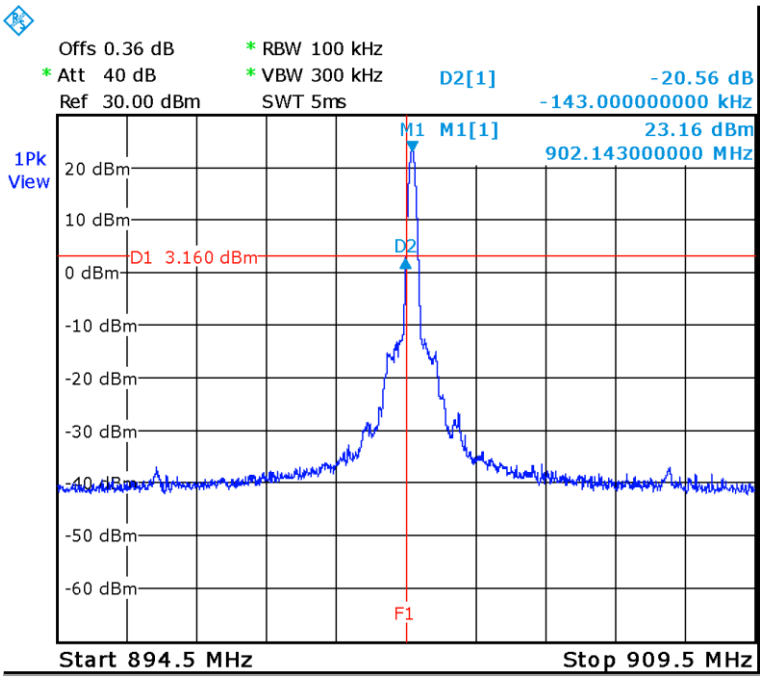
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

RESULTS:

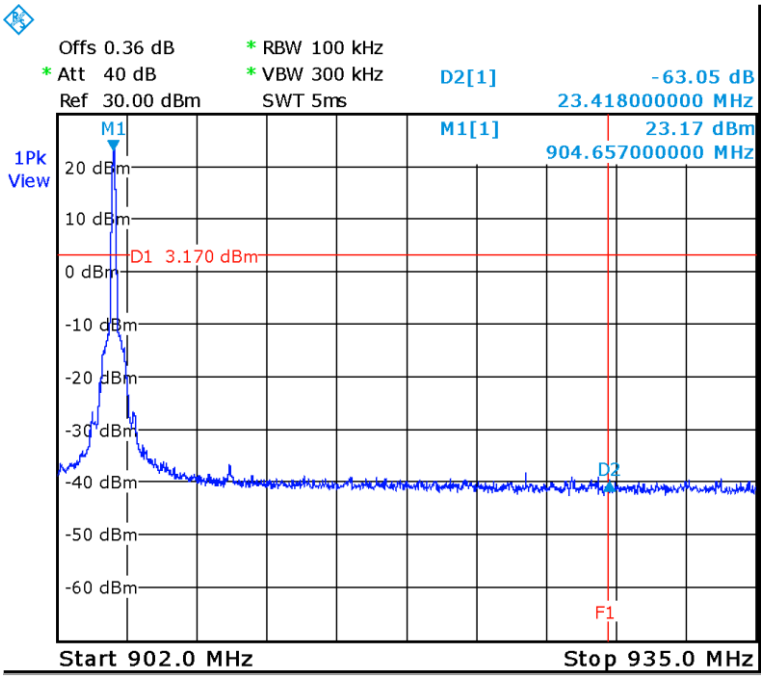
The attenuation of highest emissions at the band edge is more than 20 dB respect to the highest level of the desired power.

- HOPPING OFF

  - Low Frequency Section:



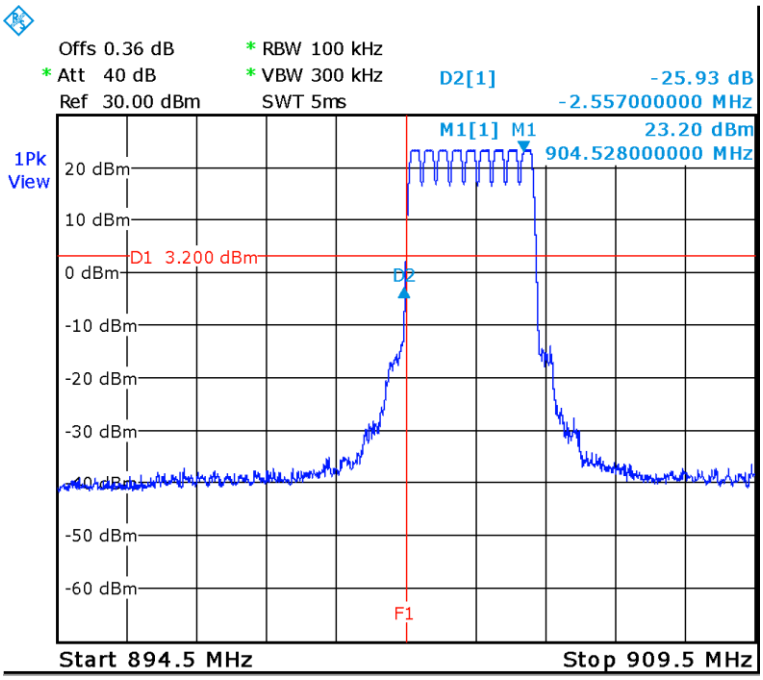
- High Frequency Section:



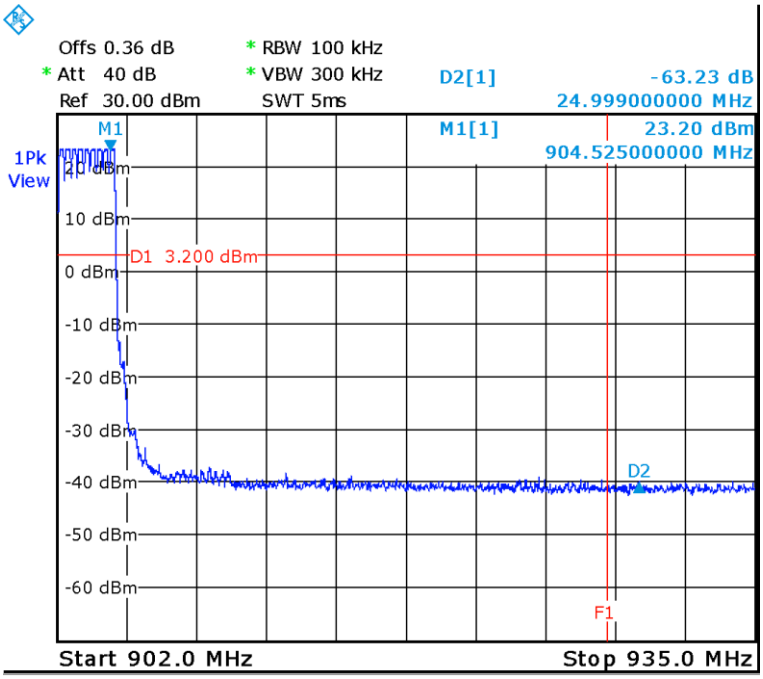
Verdict: PASS

- HOPPING ON:

  - Low Frequency Section:



- High Frequency Section:



Verdict: PASS

Measurement uncertainty (dB)	<±2.997

FCC 15.247 (d) / RSS-247 5.5 Emission limitations radiated (Transmitter)

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)/RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009 - 0.490	2400/F(kHz)	-	300
0.490 - 1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit specified when measuring with peak detector function, corresponding to 20 dB above the indicated values in the table.

RSS-247

Attenuation below the general field strength limits specified in RSS-Gen is not required.

RESULTS:

The situation and orientation of the equipment under test was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

Measurements were made in both horizontal and vertical planes of polarization.

All tests were performed in a semi-anechoic chamber at a distance of 3 m for the frequency range 30 MHz-10 GHz.

The field strength is calculated by adding a correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

RADIATED

Frequency range 30 MHz - 1 GHz:

The spurious frequencies do not depend on the operating channel.

Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
42.998	22.00	V	Quasi-Peak	<± 5.15
70.203	31.65	V		
71.516	30.64	V		
154.354	26.05	H		
166.722	30.35	H		
172.299	30.24	H		

Frequency range 1 - 10 GHz:

The results in the next tables show the maximum measured levels in the range 1-10 GHz (see next plots).

Spurious frequencies with peak levels above the average limit (54 dBµV/m at 3 m) are measured with average detector to check compliance with the average limit.

- Low Channel. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.8043 (*)	59.89	H	Peak	≤±4.28
3.6085	39.34	H	Peak	
4.5105	49.42	H	Peak	
6.3150 (*)	43.56	V	Peak	

(*) This Spurious Frequency is outside the restricted bands as defined in §15.205(a). The measured maximum carrier level at 3 m was 121.89 dBµV/m (Peak) so the spurious level is more than 20 dB below the carrier level.

- Middle Channel. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.8067 (*)	59.83	H	Peak	≤±4.28
3.6133	42.05	H	Peak	
4.5168	48.05	V	Peak	
5.4200	45.13	V	Peak	
6.3238 (*)	48.86	H	Peak	
7.2273 (*)	48.39	H	Peak	

(*) This Spurious Frequency is outside the restricted bands as defined in §15.205(a). The measured maximum carrier level at 3 m was 122.89 dBµV/m (Peak) so the spurious level is more than 20 dB below the carrier level.

- High Channel. Spurious frequencies closest to the limit:

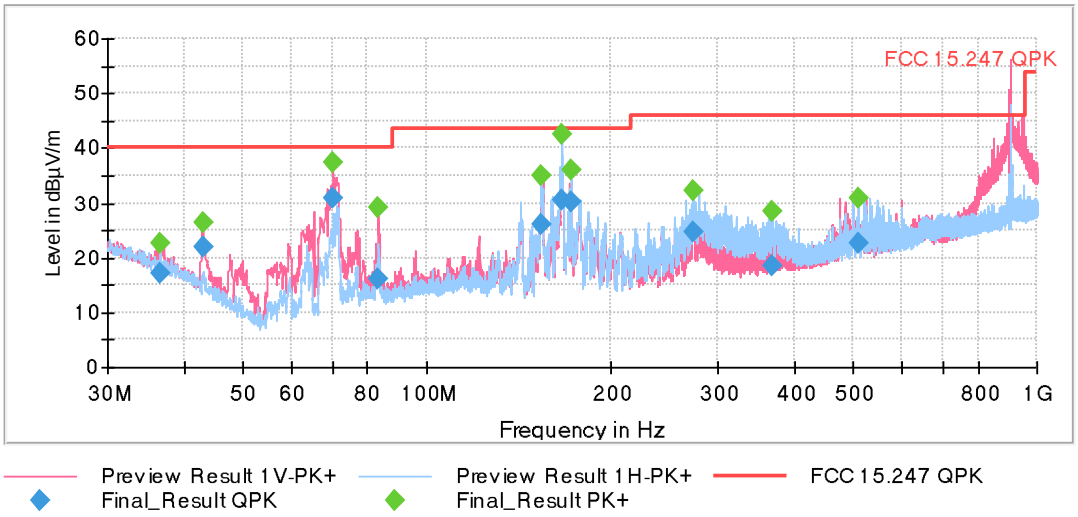
Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.8093 (*)	61.02	V	Peak	≤±4.28
3.6188	42.65	H	Peak	
4.5233	48.02	V	Peak	
5.4278	44.93	V	Peak	
6.3325 (*)	50.93	V	Peak	
7.2373 (*)	47.94	H	Peak	
8.1420	44.73	V	Peak	

(*) This Spurious Frequency is outside the restricted bands as defined in §15.205(a). The measured maximum carrier level at 3 m was 123.16 dBµV/m (Peak) so the spurious level is more than 20 dB below the carrier level.

Verdict: PASS

FREQUENCY RANGE 30 MHz – 1 GHz:

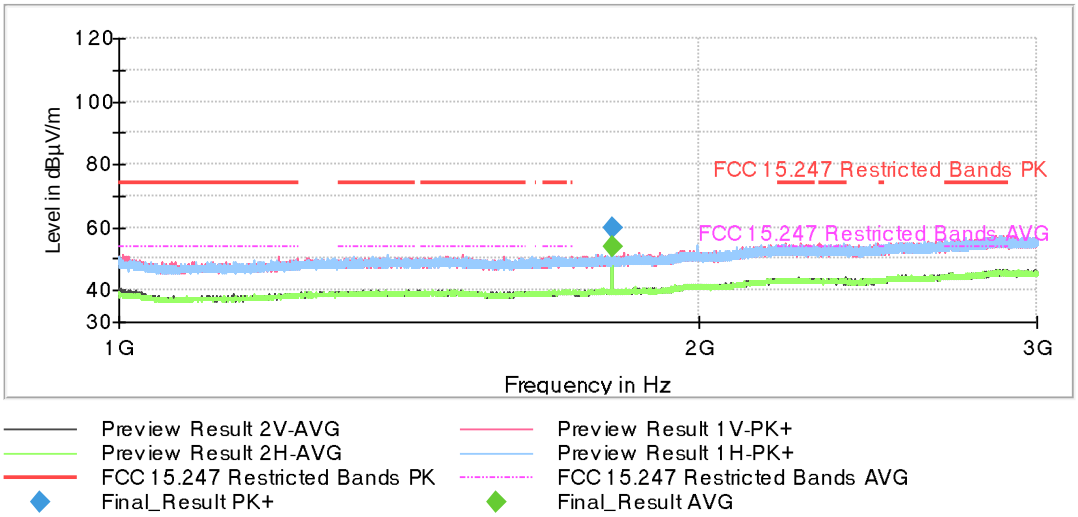
This plot is valid for all channels.



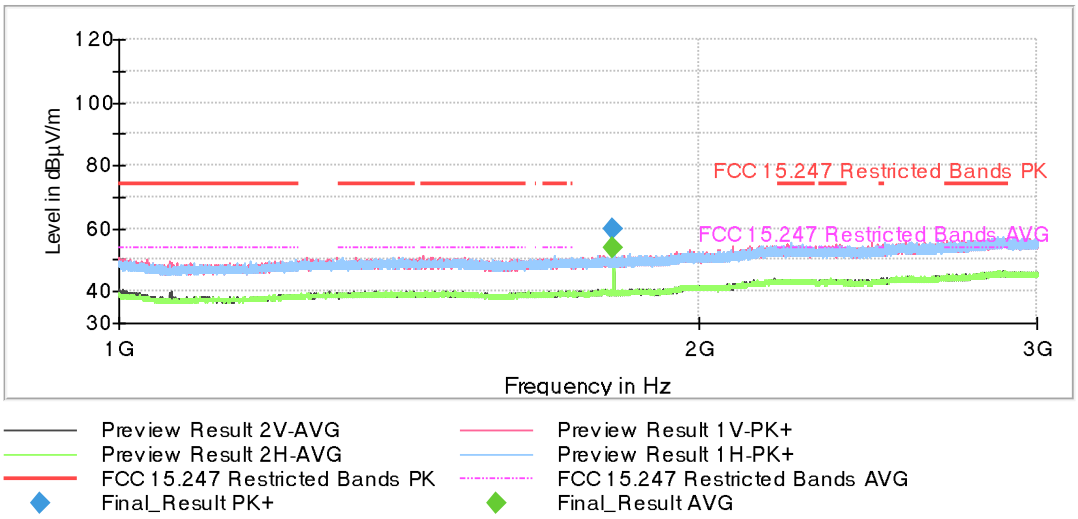
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 GHz – 3 GHz:

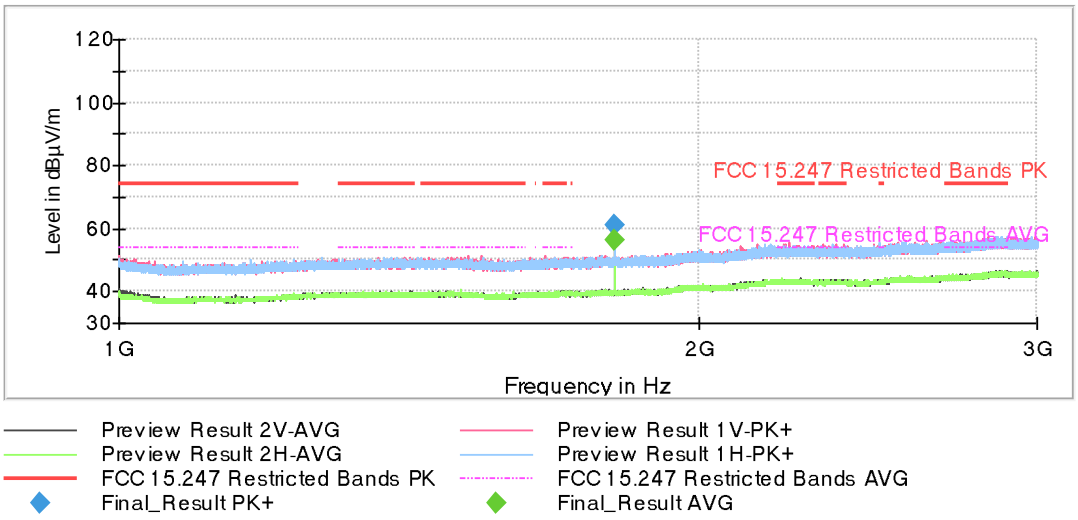
- Low Channel:



- Middle Channel:

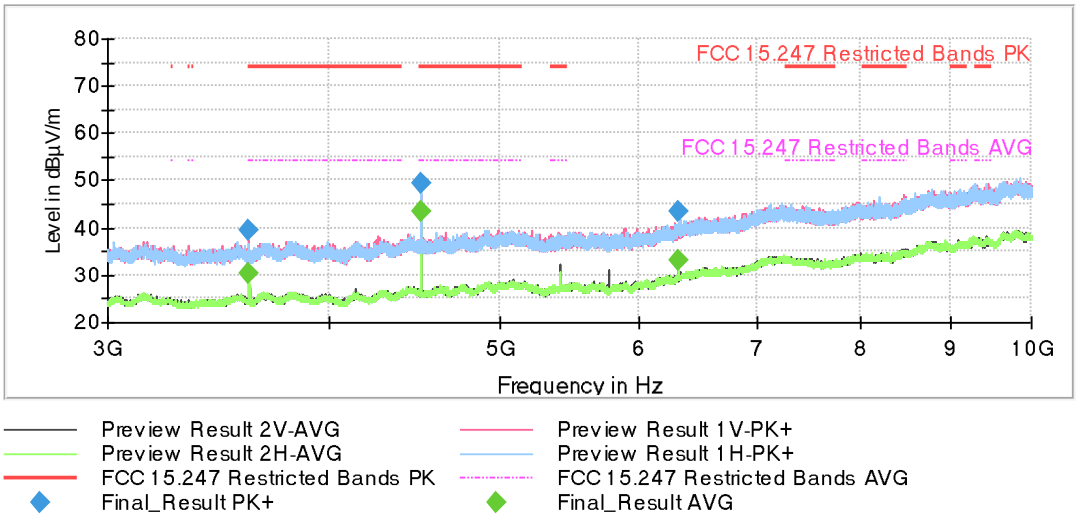


- High Channel:

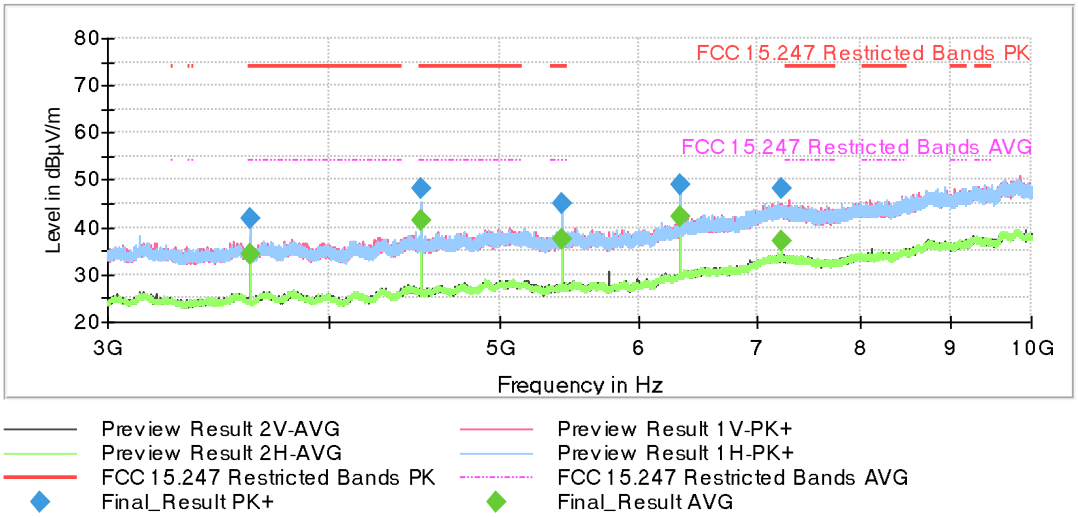
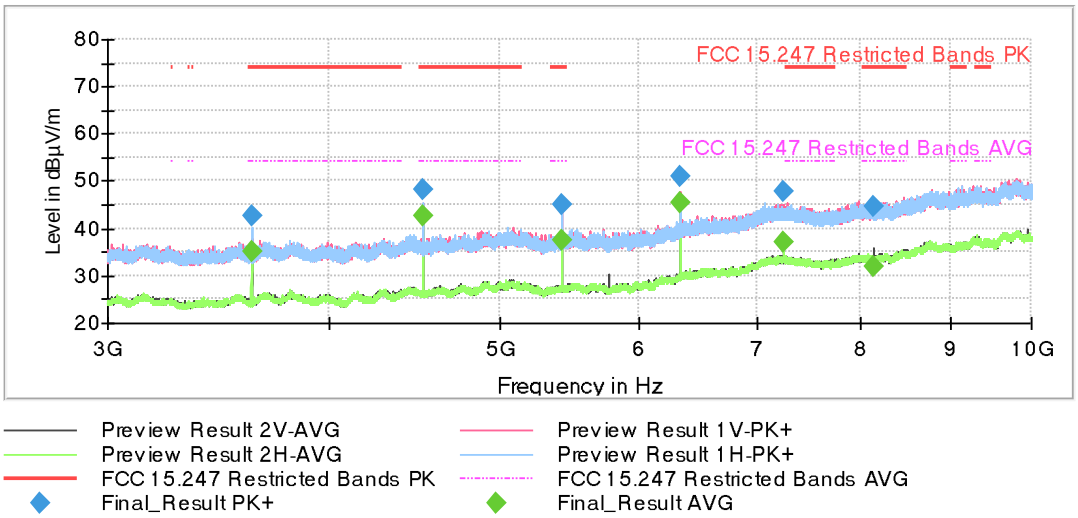


FREQUENCY RANGE 3 GHz – 10 GHz:

- Low Channel:



- Middle Channel:



- High Channel: