DEKRA Testing and Certification, S.A.U.
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C.I.F. A29507456

ENAC ENSAYOS Nº 51/LE147

Test report No:
NIE: 65307RRF.001

Test Report

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

Radio Frequency Devices. Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz.
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.
General Requirements and Information for the Certification of Radio Apparatus.

(*) Identification of item tested	Long-range wireless gateway: endpoint adapter and master concentrator
(*) Trademark	Carlo Gavazzi
(*) Model and /or type reference	UWPAM1US1L2X
Other identification of the product	HW version: 1 SW version: 2 FCC ID: Not provided IC ID: Not provided
(*) Features	USB, RS485, LoRaWan (both EU868 and US915 frequencies)
Applicant	CARLO GAVAZZI CONTROLS SPA Via Safforze, 8 , 32100 Belluno (BL) ITALY
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 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)	José Carlos Luque RF Lab. Supervisor 74841983Y JOSE CARLOS LUQUE (C:A29507456) Firmado digitalmente por 74841983Y JOSE CARLOS LUQUE (C:A29507456) Fecha: 2020.10.14 05:03:16 +02'00'
Date of issue	2020-10-14
Report template No	FDT08_22 (*) "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 include testing performed in this test report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory with appropriate scope of accreditation that include 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.
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4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

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 UWPAM1US1L2X consists of an electric-cabinet equipment that receives data from Carlo Gavazzi Meters (es. Carlo Gavazzi EM24) via RS485 and transmits them using LoRa modulation.

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
65307/005	Long-range wireless gateway	UWPAM1US1L2X	BU1770108011M	2020/07/14
65307/006	Antenna	--	--	2020/07/14

Sample S/01 has undergone the test(s): All RADIATED tests indicated in Appendix A and B.

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

Control Nº	Description	Model	Serial Nº	Date of reception
65307/005	Long-range wireless gateway	UWPAM1US1L2X	BU1770108011M	2020/07/14

Sample S/02 has undergone the following test(s): All CONDUCTED tests indicated in Appendix A and B.

Test sample description

Ports…… :	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)
	USB Micro B (shielded to internal mass)		☐	☒	☐
	RS485		☐	☐	☐
	Antenna connector (shielded to internal mass)		☒	☒	☐
Supplementary information to the ports……:	--				

Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☒	AC: 115-240 V ac 50/60 Hz +/-10%	☒	☐	☐	☒	☐
	☒	DC: 24V +/- 20%					
Rated Power .....:	DC: 1.3 W max. AC: 5.5 VA max.						
Clock frequencies .....:	Integrated micro: 32MHz clock. Transceiver 32.768KHz clock						

Other parameters.....:	-		
Software version .....:	2		
Hardware version.....:	1		
Dimensions in cm (W x H x D)....:	-		
Mounting position.....:	☒ Other: Electrical Cabinet		
Modules/parts .....:	Module/parts of test item	Type	Manufacturer
	Main module		Carlo Gavazzi
	Dipole Antenna		
	RS485 Cable		
	Power cable		
Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	-		
Documents as provided by the applicant.....:	Description	File name	Issue date
	UWPA-UWPM Datasheet	uwpa-uwpm_ds	4/12/2019

(3) Only for Medical Equipment

Identification of the client

CARLO GAVAZZI CONTROLS SPA

Via Safforze, 8, 32100 Belluno (BL) ITALY

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2020-08-27
Date (finish)	2020-09-03

Document history

Report number	Date	Description
65307RRF.001	2020-10-14	First release

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: José Manuel Jiménez, José Gabriel Pendón, Alfonso Gutiérrez and Pablo Redondo.

Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
2.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV 40	2019/09	2021/09
3.	AC Power Supply ELGAR CS-AC35(351SL)	2019/09	2022/09
4.	DC Power Supply 30V/5A AGILENT TECHNOLOGIES U8002A	N.A.	N.A.
5.	Digital Multimeter FLUKE 179	2020/06	2021/06

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2017/09	2020/09
3.	RF Pre-amplifier 40 dB 10MHz-6 GHz BONN ELEKTRONIK BLNA 0160-01N	2020/02	2021/02
4.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
5.	Broadband Horn Antenna 1-18 GHz HEWLETT PACKARD 11966E	2018/10	2021/10
6.	RF Pre-amplifier 30 dB 1-18 GHz BONN ELEKTRONIK BLMA 0118-3A	2020/09	2021/09
7.	Signal and spectrum analyzer ROHDE AND SCHWARZ FSV40	2019/10	2021/10
8.	AC Power Supply ELGAR CS-AC35(351SL)	2019/09	2022/09
9.	DC Power Supply 30V/5A KEYSIGHT TECHNOLOGIES U8002A	N.A.	N.A.
10.	Digital Multimeter FLUKE 175	2019/10	2020/10

Testing verdicts

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

Summary

1. LoRa 125 kHz

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	
15.247 (a)(1)(i) / RSS-247 5.1 (c)	Number of hopping channels	P	
FCC 15.247 (f) / RSS-247 5.3. (a)	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.			

2. LoRa 500 kHz

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		**Verdict**	**Remark**
FCC 15.247 (a)(2) / RSS-247 5.2. (a)	6 dB Bandwidth	P	
FCC 15.247 (b) / RSS-247 5.4. (d)	Maximum peak output power and antenna gain	P	
FCC 15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
FCC 15.247 (e) / RSS-247 5.2. (b)	Power spectral density	P	
FCC 15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
Supplementary information and remarks: None.			

Appendix A: Test results. LoRa 125 kHz

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TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 115 Vac.

Type of power supply: AC Voltage.

The power supply of 115 Vac was selected based on preliminary testing that identified this power supply corresponding to the worst case for emission limitations radiated in the frequency range 1 GHz – 3 GHz.

ANTENNA:

Type of Antenna: Dipole Antenna.

Maximum Declared Assembly Gain: +2.15 dBi

TEST FREQUENCIES:

Low Channel: 902.3 MHz

Middle Channel: 908.7 MHz

High Channel: 914.9 MHz

The equipment can operate as a frequency hopping system using 64 hopping channels.

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is 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.

The AC supply voltage is applied using an external calibrated power supply.

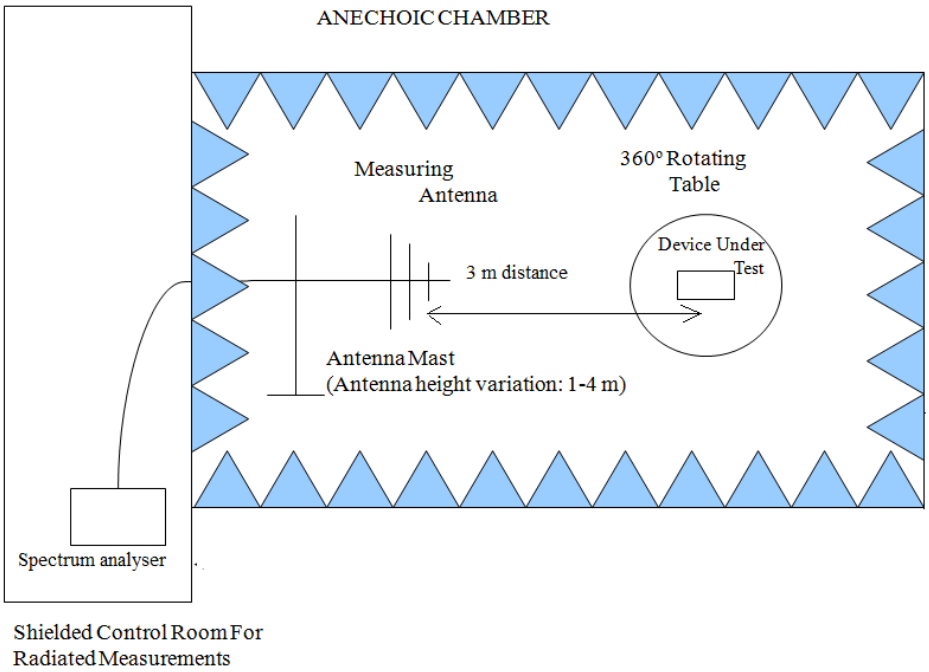
RADIATED MEASUREMENTS

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

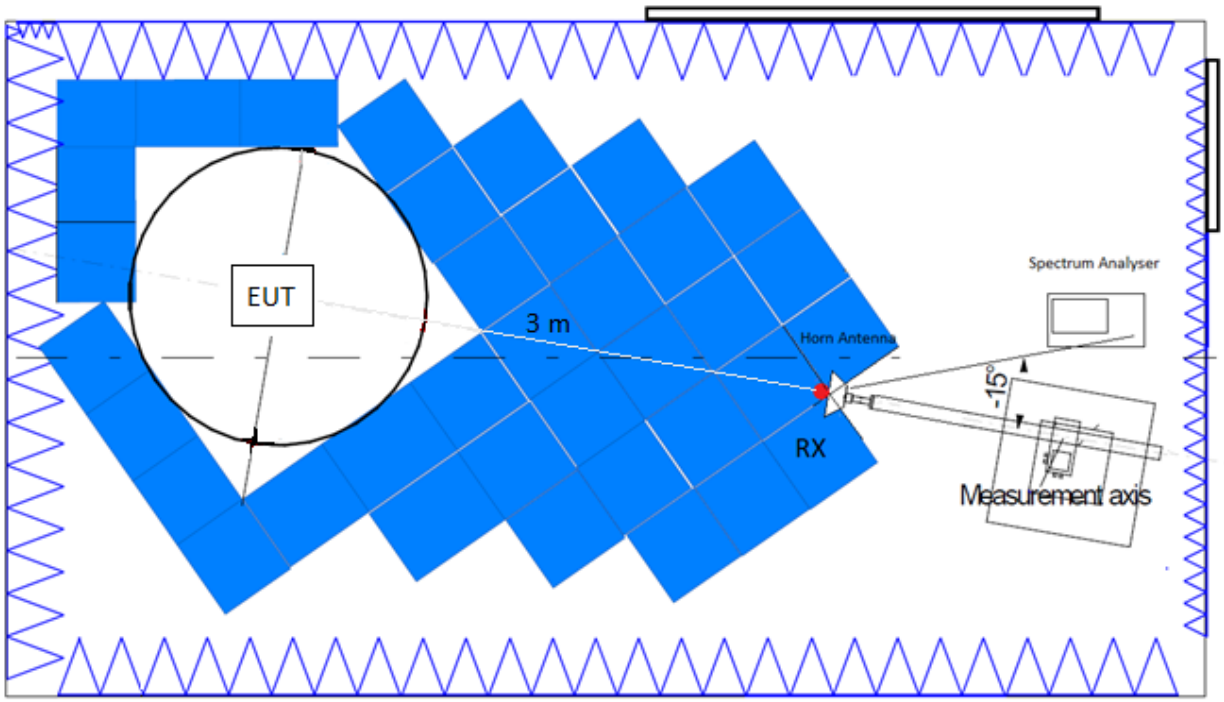
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find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

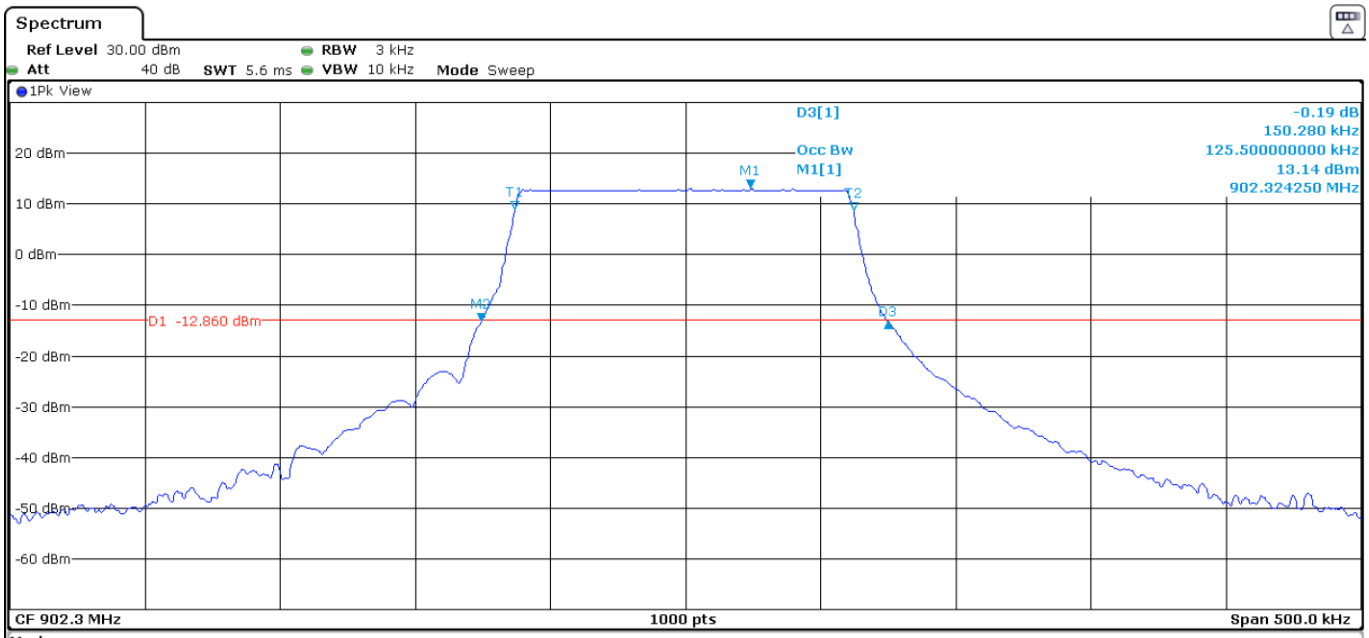
RSS-Gen Clause 6.7.

RESULTS:

	Lowest Channel 902.3 MHz	Middle Channel 908.7 MHz	Highest Channel 914.9 MHz
99% bandwidth (kHz)	125.50	125.50	126.00
-26 dBc bandwidth (kHz)	150.28	147.28	150.59
Measurement uncertainty (kHz)	<± 0.87		

Verdict: PASS

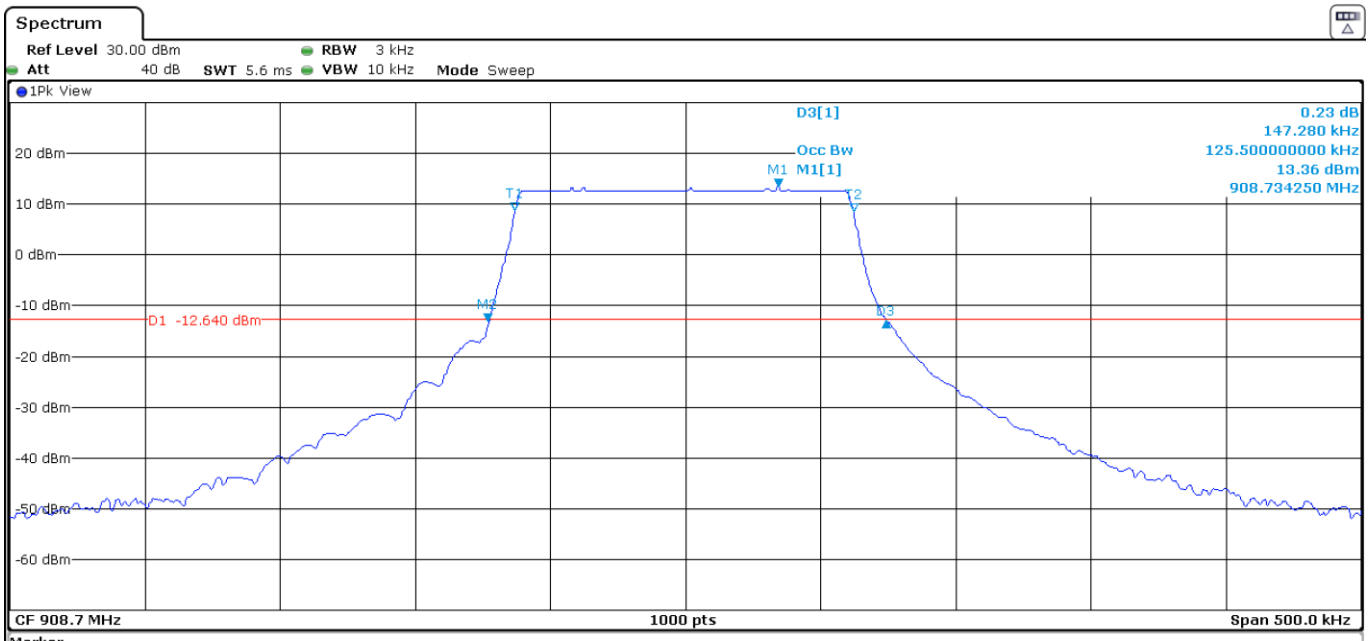
- Lowest Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	902.32425 MHz	13.14 dBm		
T1		1	902.23675 MHz	9.07 dBm	Occ Bw	125.5 kHz
T2		1	902.36225 MHz	8.69 dBm		
M2		1	902.22456 MHz	-12.87 dBm		
D3	M2	1	150.28 kHz	-0.19 dB		

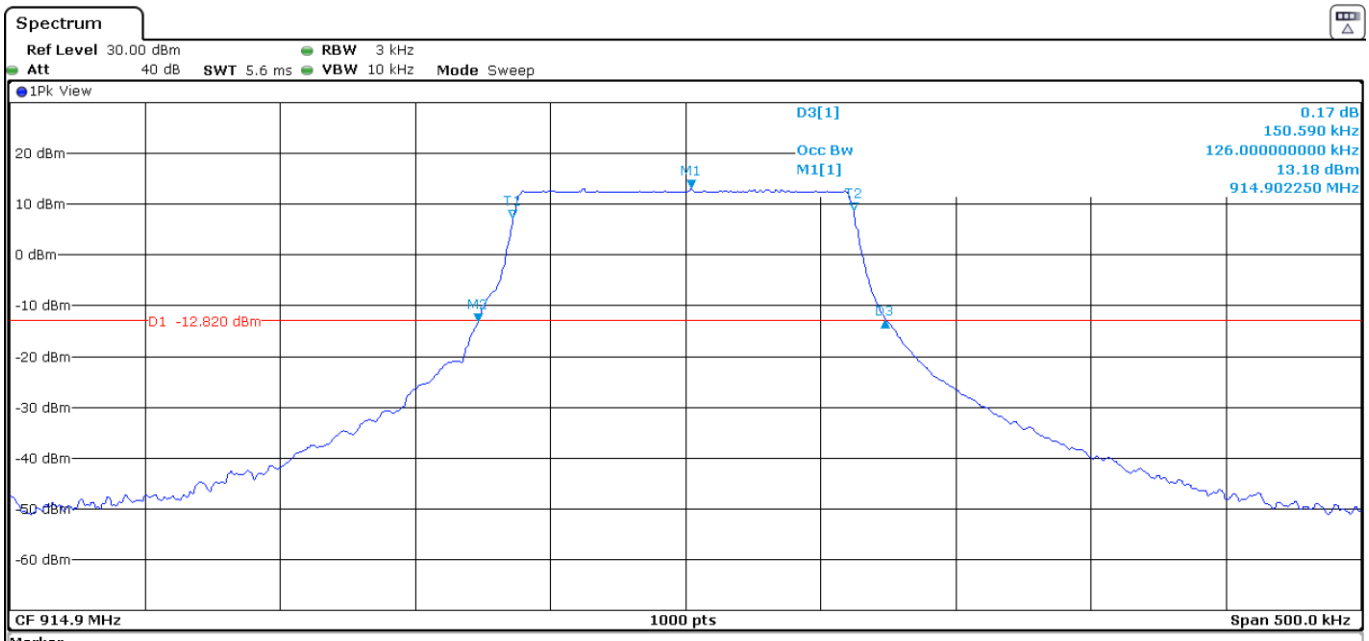
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	908.73425 MHz	13.36 dBm		
T1		1	908.63675 MHz	8.74 dBm	Occ Bw	125.5 kHz
T2		1	908.76225 MHz	8.63 dBm		
M2		1	908.627 MHz	-13.07 dBm		
D3	M2	1	147.28 kHz	0.23 dB		

- High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.90225 MHz	13.18 dBm		
T1		1	914.83625 MHz	7.23 dBm	Occ Bw	126.0 kHz
T2		1	914.96225 MHz	8.69 dBm		
M2		1	914.82341 MHz	-13.05 dBm		
D3	M2	1	150.59 kHz	0.17 dB		

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

SPECIFICATION:

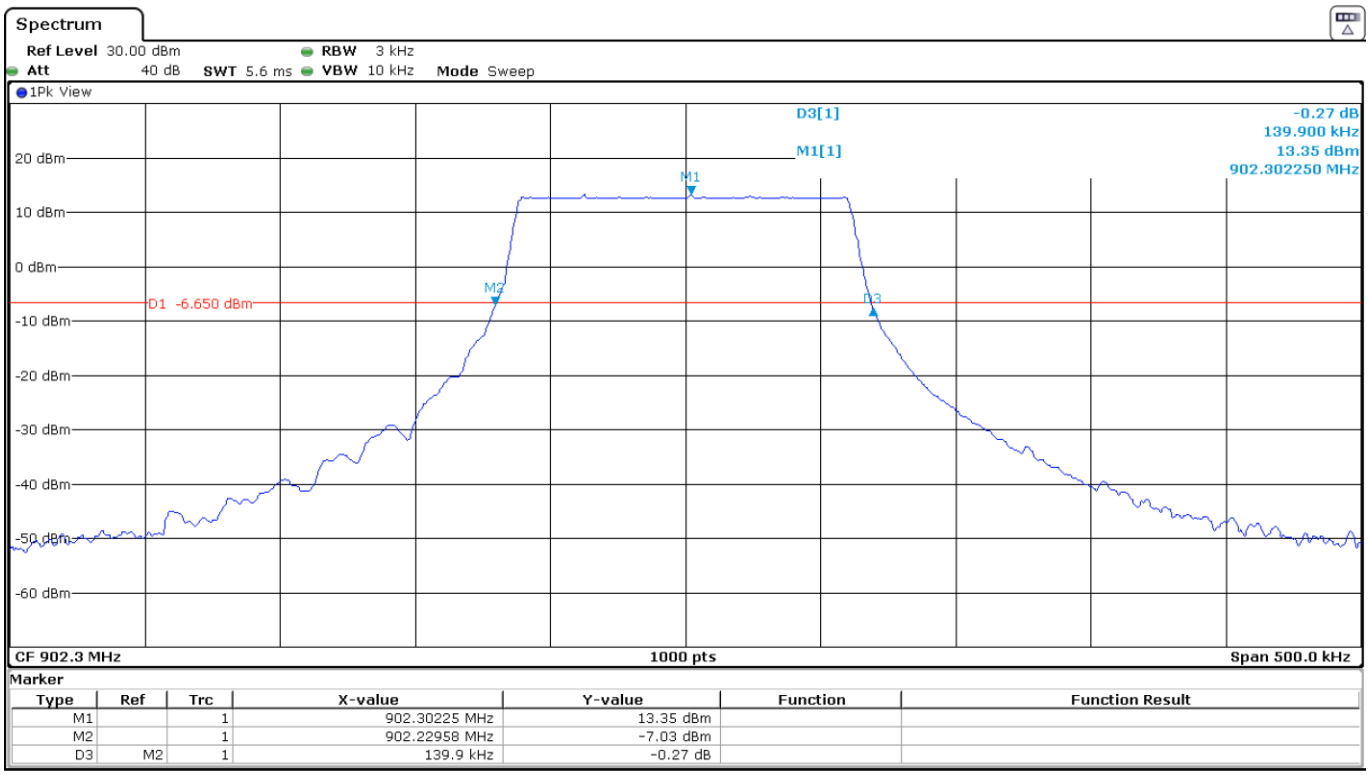
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

RESULTS:

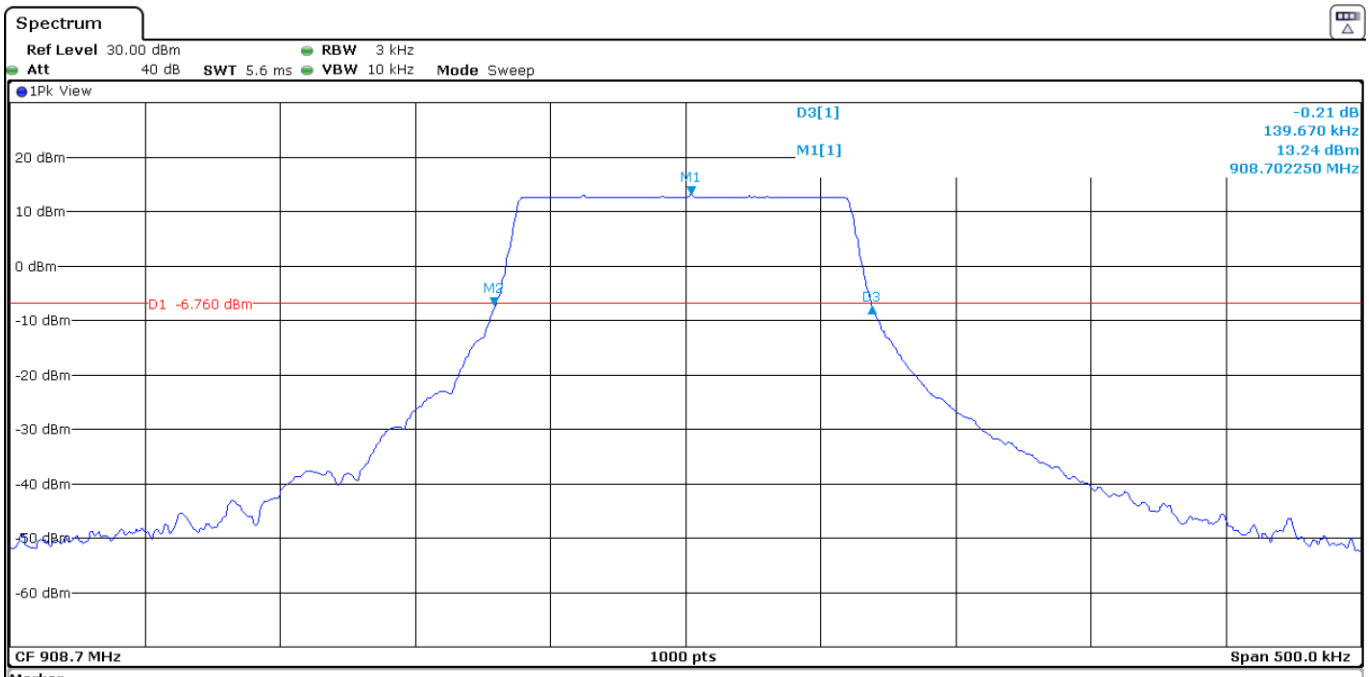
	Lowest Channel 902.3 MHz	Middle Channel 908.7 MHz	Highest Channel 914.9 MHz
20 dB Spectrum bandwidth (kHz)	139.90	139.67	139.86
Measurement uncertainty (kHz)	<± 0.87		

Verdict: PASS

- Lowest Channel:



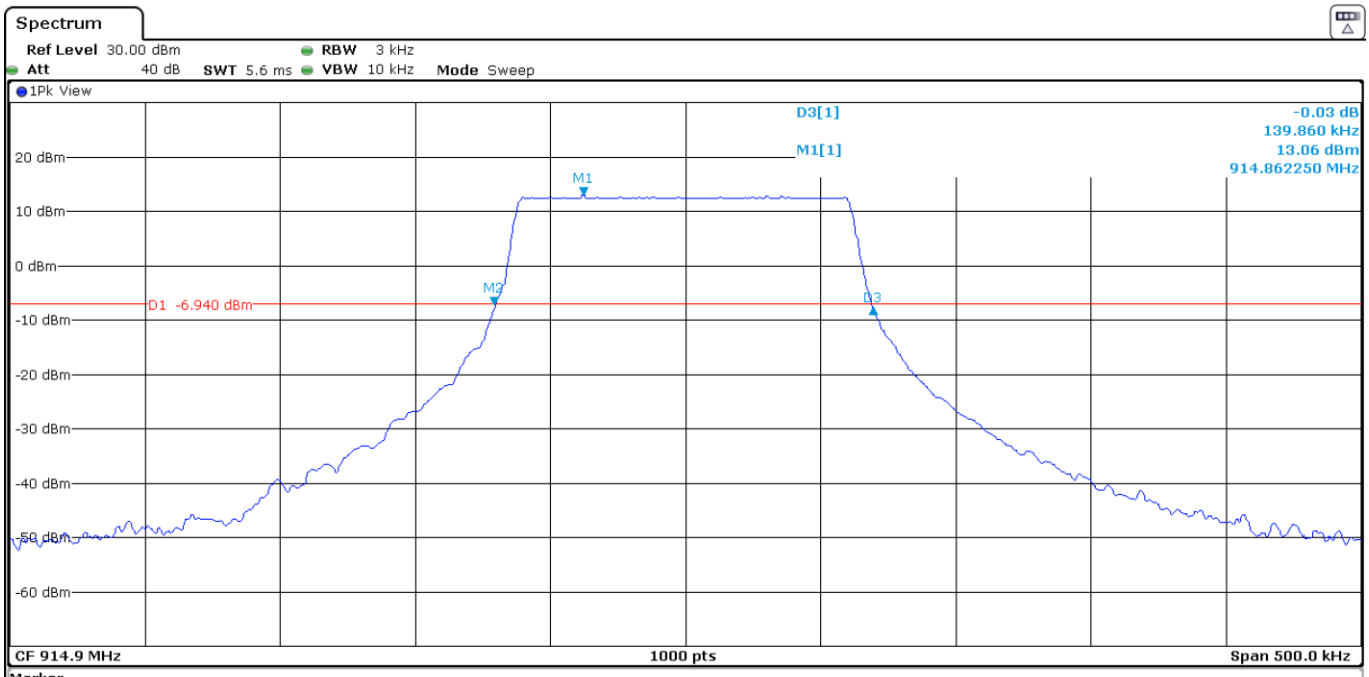
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	908.70225 MHz	13.24 dBm		
M2		1	908.62955 MHz	-7.16 dBm		
D3	M2	1	139.67 kHz	-0.21 dB		

- Highest Channel:



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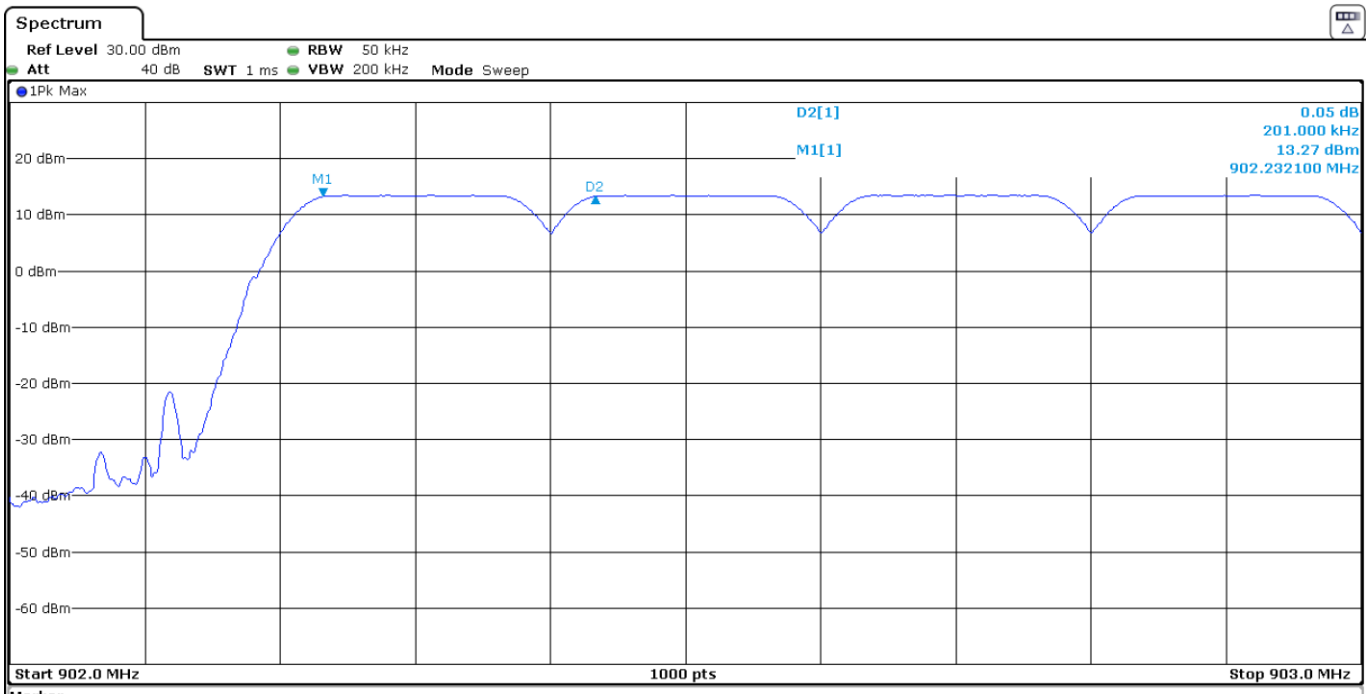
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.86225 MHz	13.06 dBm		
M2		1	914.82952 MHz	-7.31 dBm		
D3	M2	1	139.86 kHz	-0.03 dB		

Carrier frequency separation

201 kHz



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	902.2321 MHz	13.27 dBm		
D2	M1	1	201.0 kHz	0.05 dB		

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

Verdict: PASS

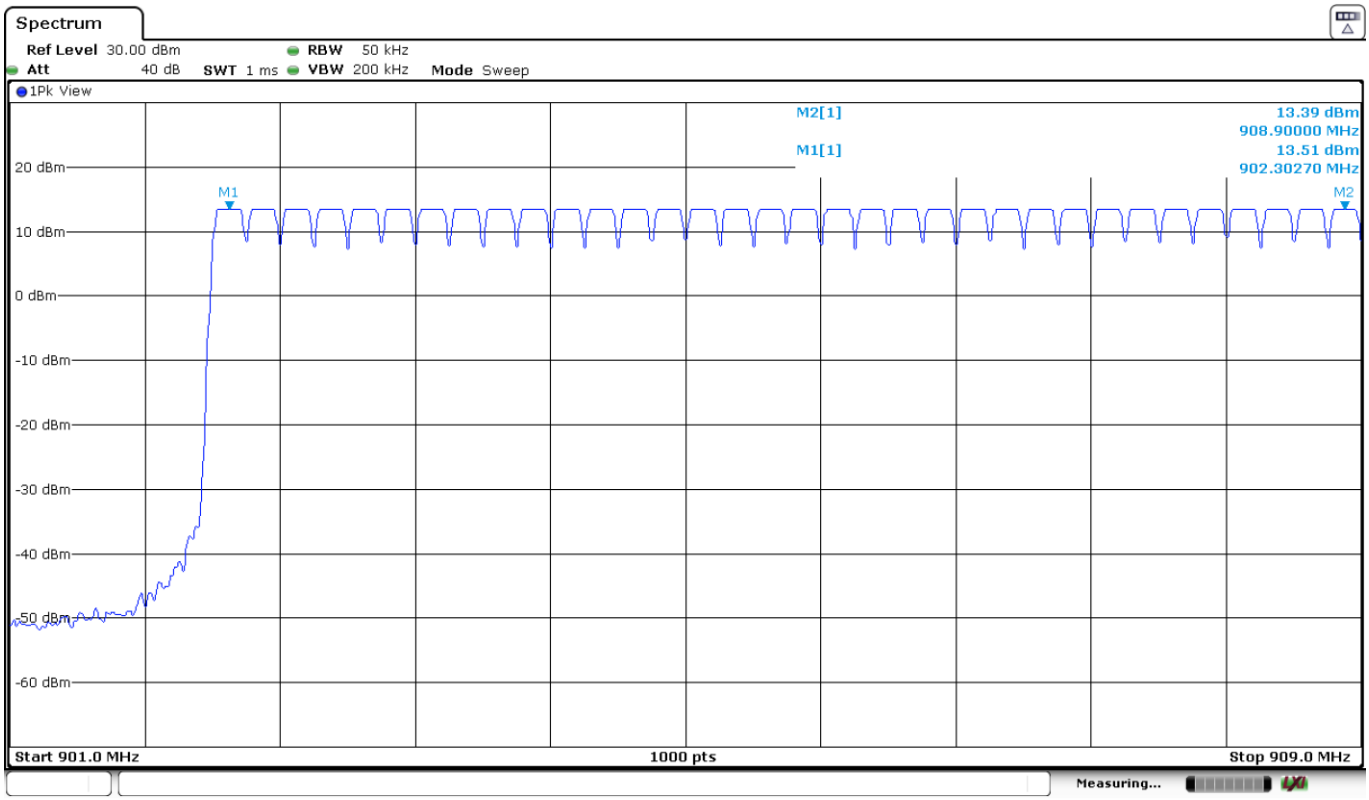
FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c) Number of hopping channels

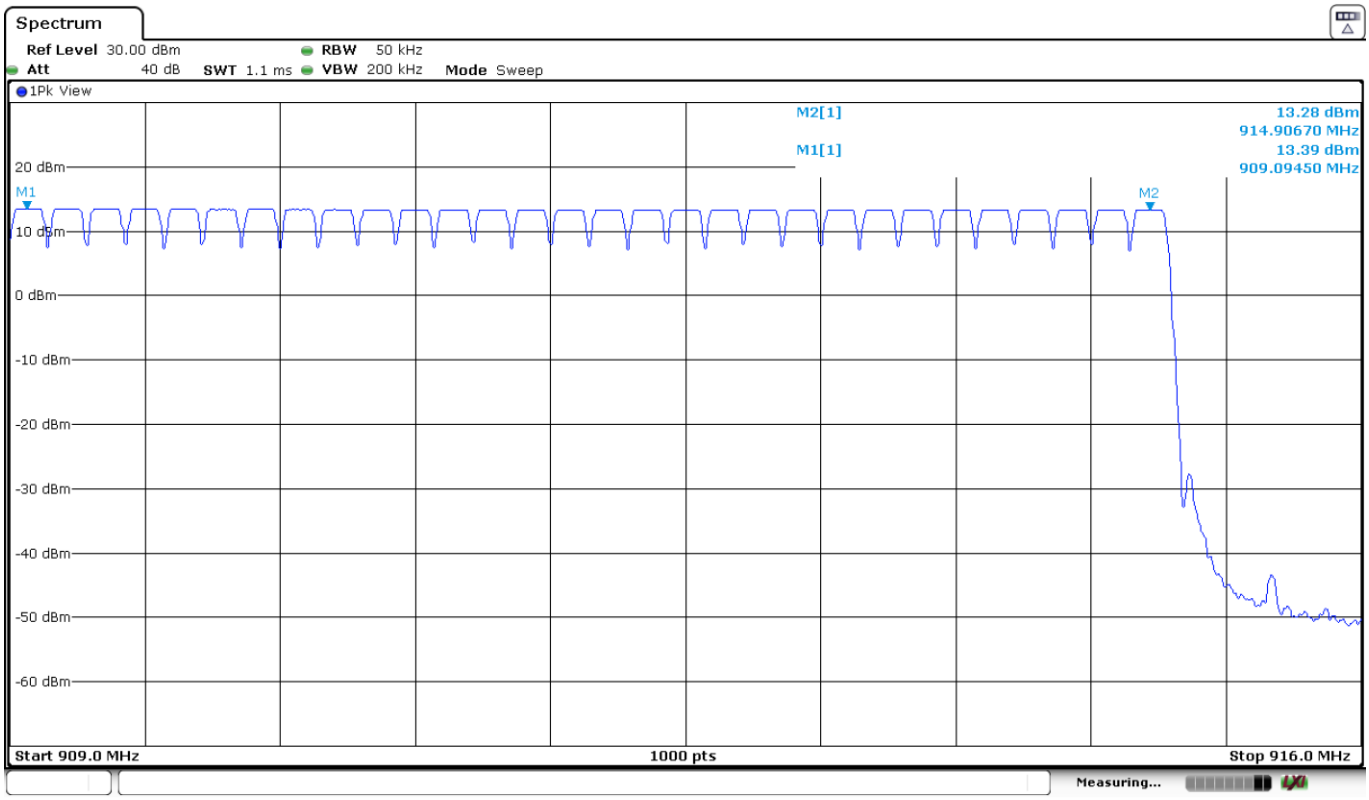
SPECIFICATION:

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 number of hopping channels is 64.





Total number of hopping channels: 64

Verdict: PASS

FCC 15.247 (f) / RSS-247 5.3. (a) Time of occupancy (Dwell Time)

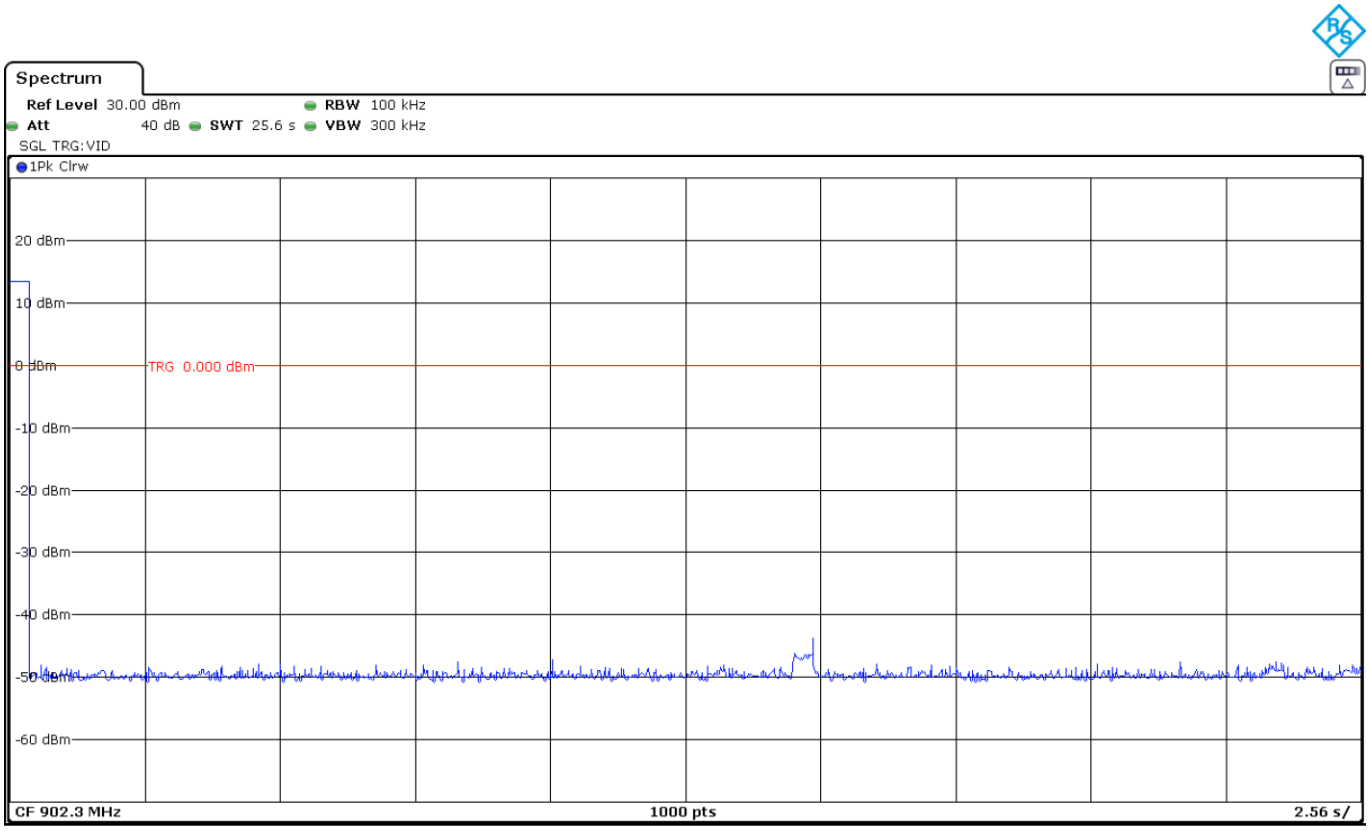
SPECIFICATION:

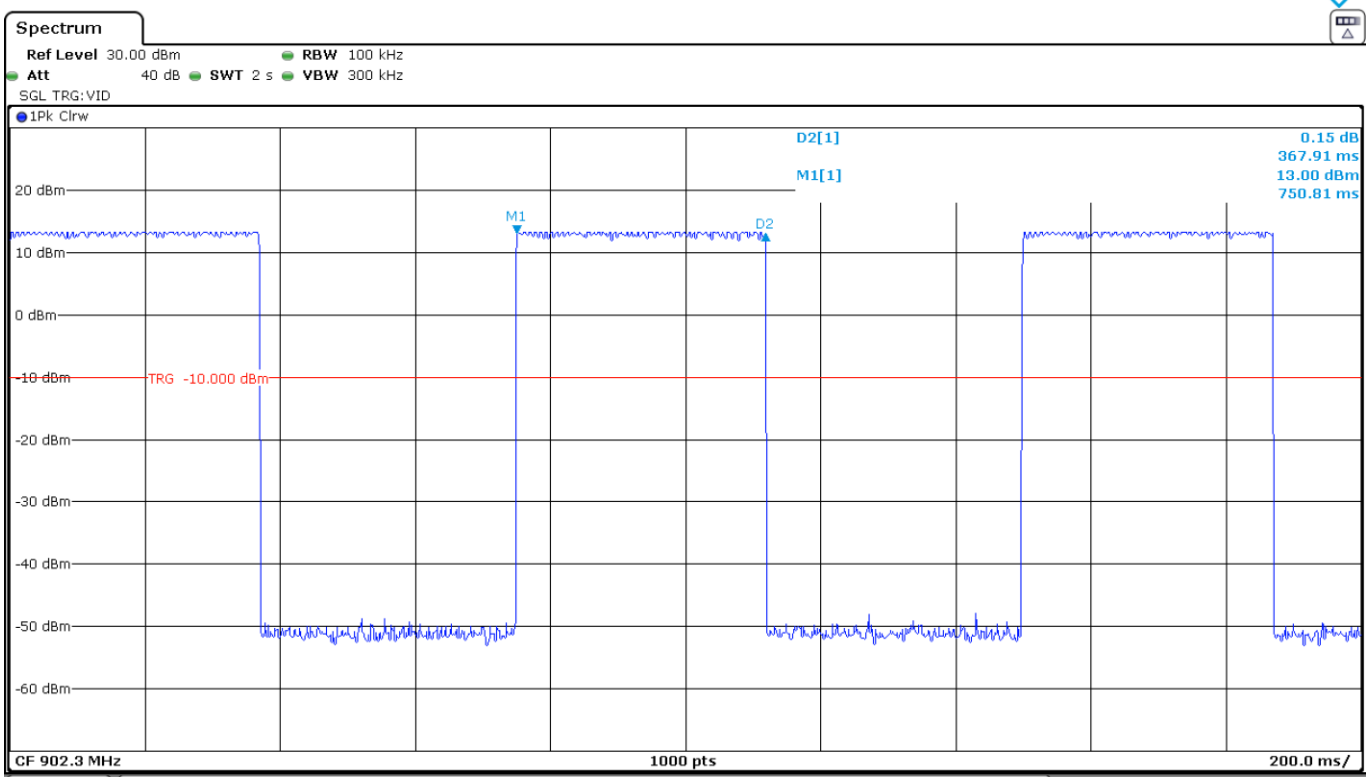
For the purposes of this section, frequency hopping systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

RESULTS:

1. OPERATION AS FREQUENCY HOPPING SYSTEM USING 64 HOPPING CHANNELS:

- TX time per hop: 367.91 ms (see next plots)
- Number of hops over a period of s: 1 (see next plots)





- **Average Time of Occupancy** = 367.91 ms x 1 hops = 367.91 ms per 25.6 s.

  Average Time of Occupancy is <0.4 s per time period in seconds equal to the number of hopping frequencies employed (64) multiplied by 0.4.

Measurement uncertainty (ms)	<± 11.58

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.
For frequency hopping 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 maximum conducted output power was measured using the method AVGSA-2 according to point 11.9.2.2.4 of ANSI C.63.10-2013.

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

Maximum Declared Antenna Gain: +2.15 dBi

Duty cycle correction: +3.05 dB

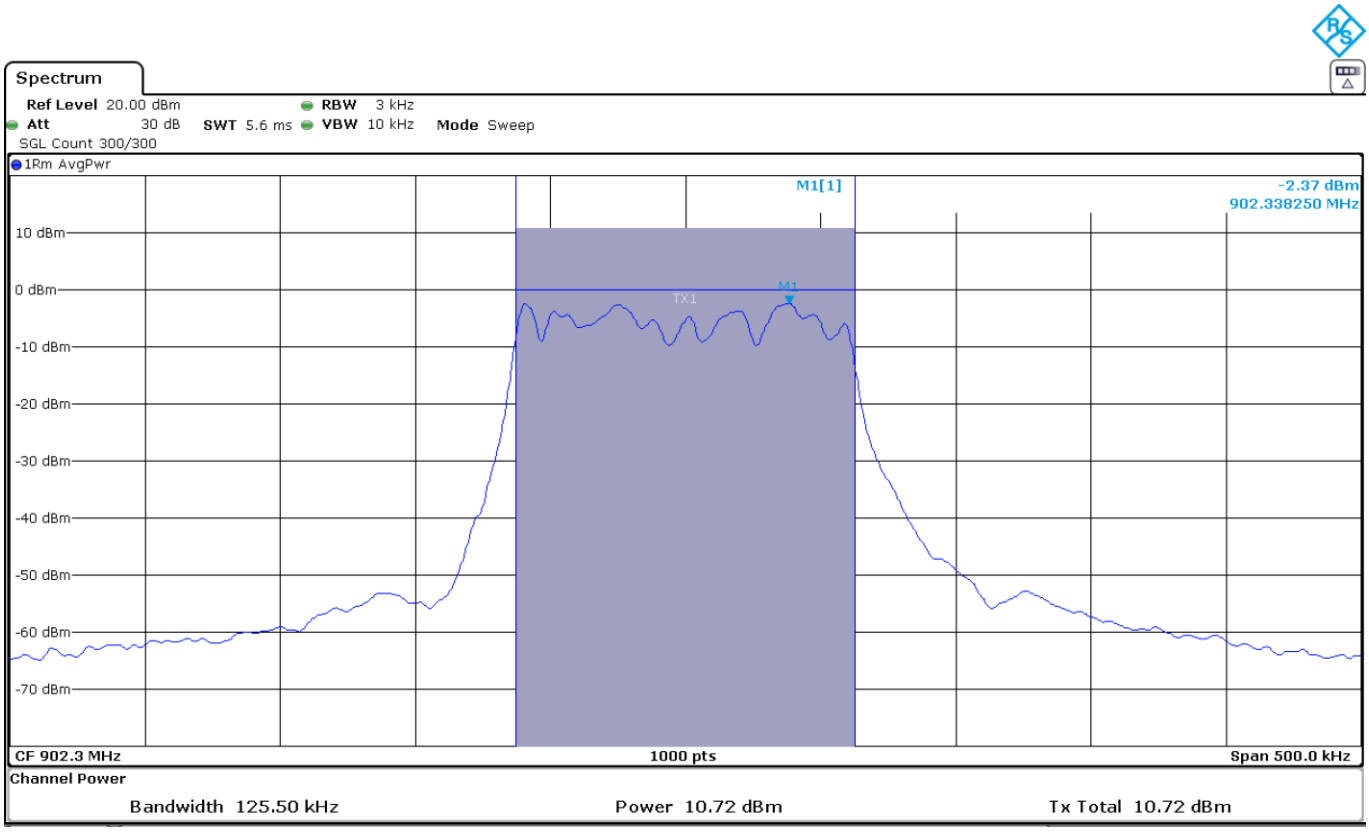
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

	Lowest Channel 902.3 MHz	Middle Channel 908.7 MHz	Highest Channel 914.9 MHz
Maximum conducted power (dBm)	10.72	10.38	10.42
Maximum conducted power with Duty Cycle correction (dBm)	13.77	13.43	13.47
Maximum E.I.R.P. power (dBm)	15.92	15.58	15.62
Measurement uncertainty (dB)	<±2.57		

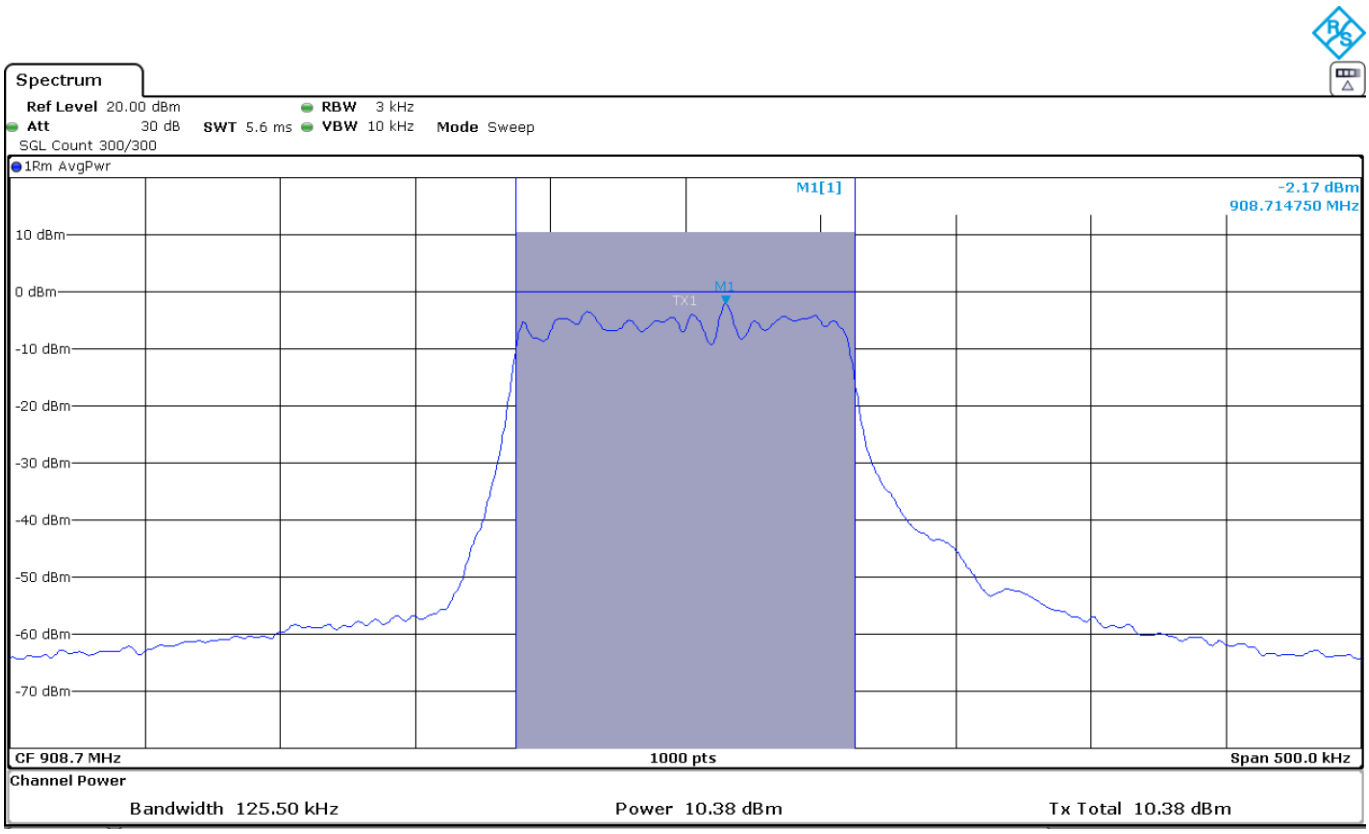
Verdict: PASS

Maximum Output Power:

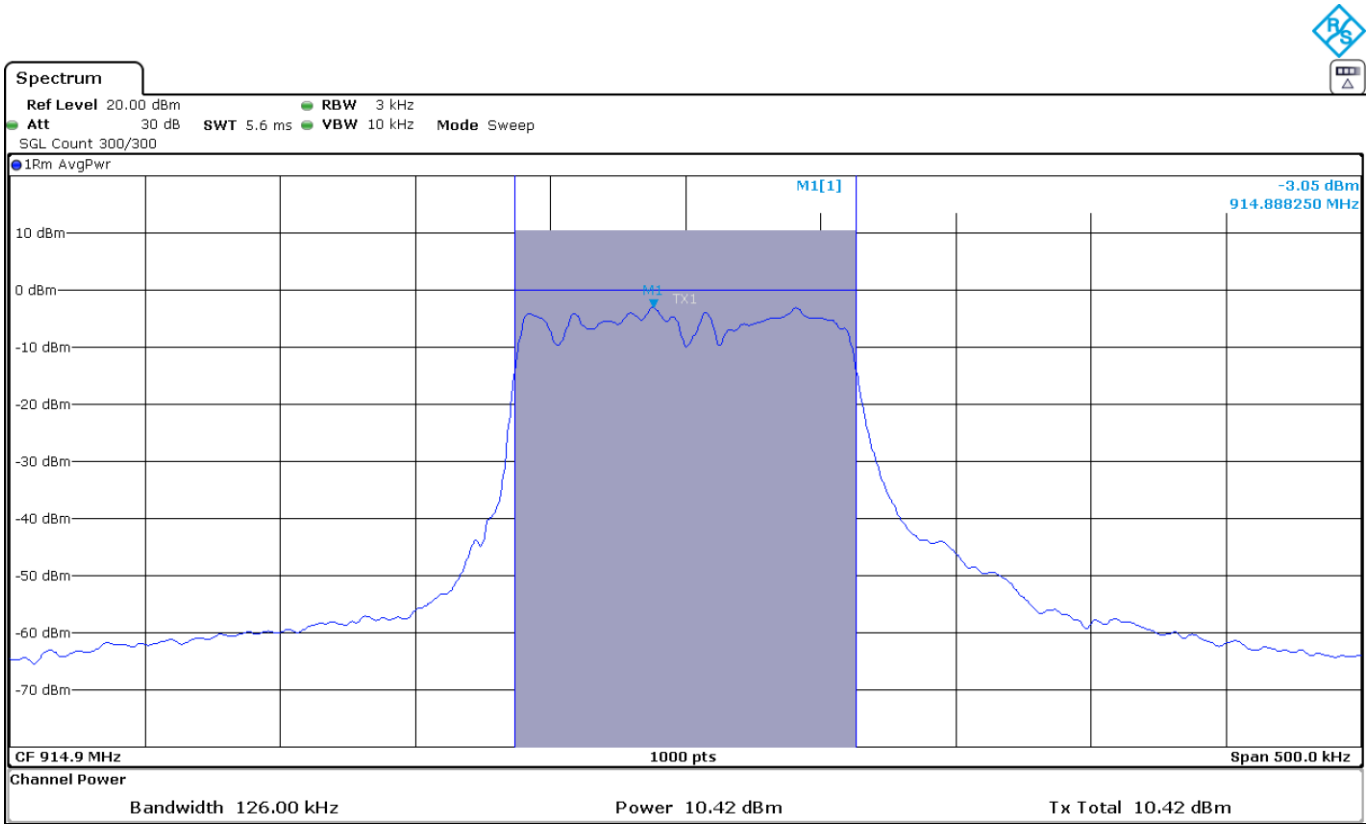
- Lowest Channel:



- Middle Channel:



- Highest Channel:



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

SPECIFICATION:

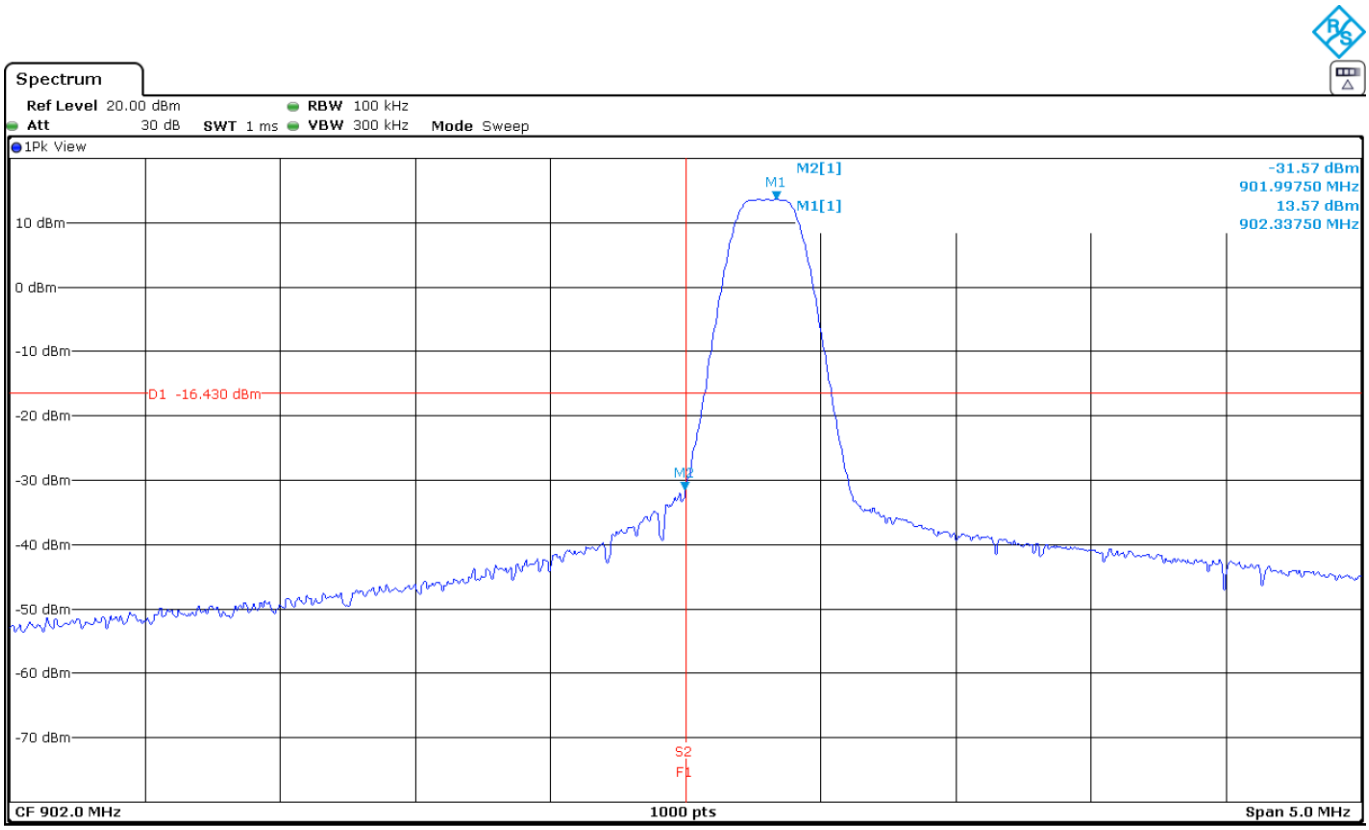
In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, 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.

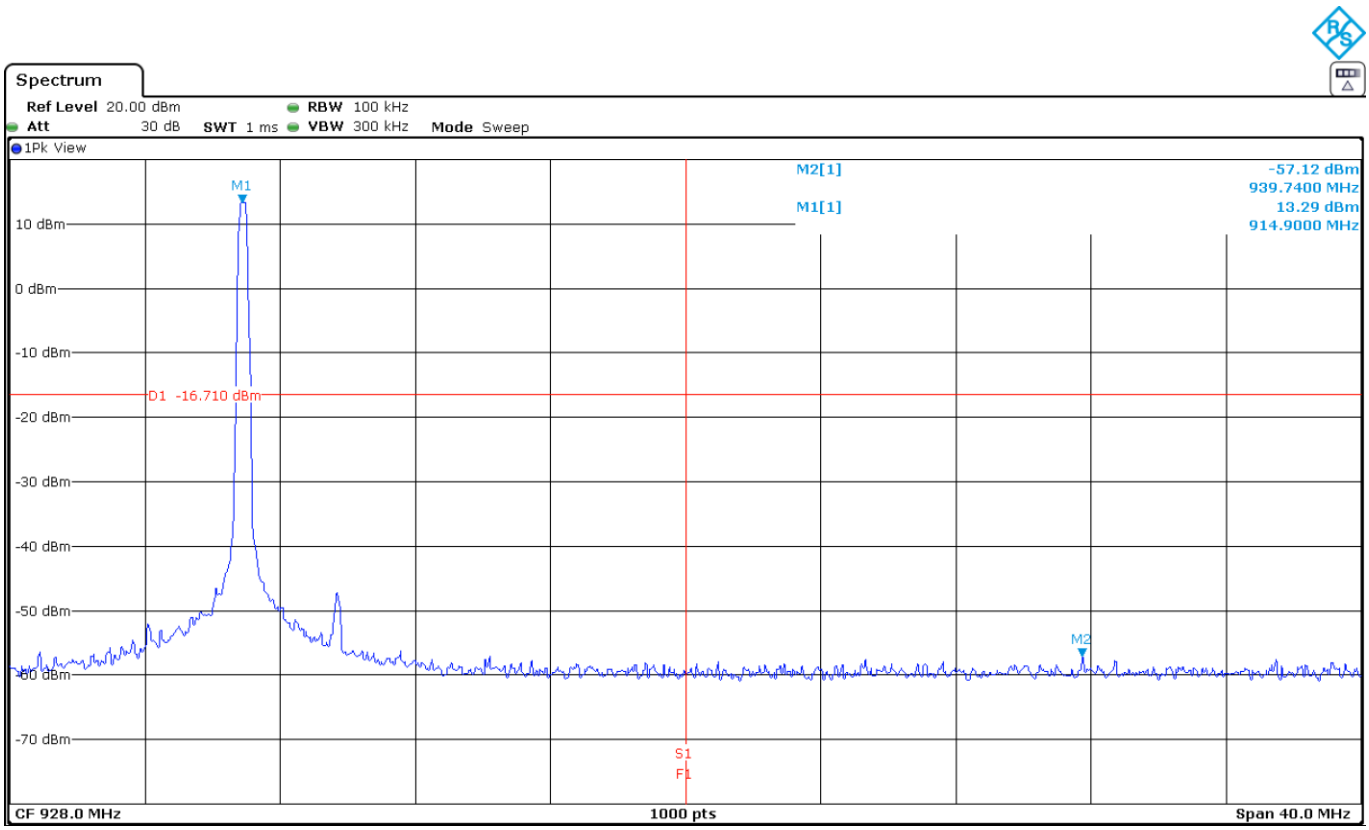
RESULTS:

The attenuation of highest emissions at the band-edge is more than 30 dB respect to the highest level of the desired power.

- HOPPING OFF:
    - LOW FREQUENCY SECTION:

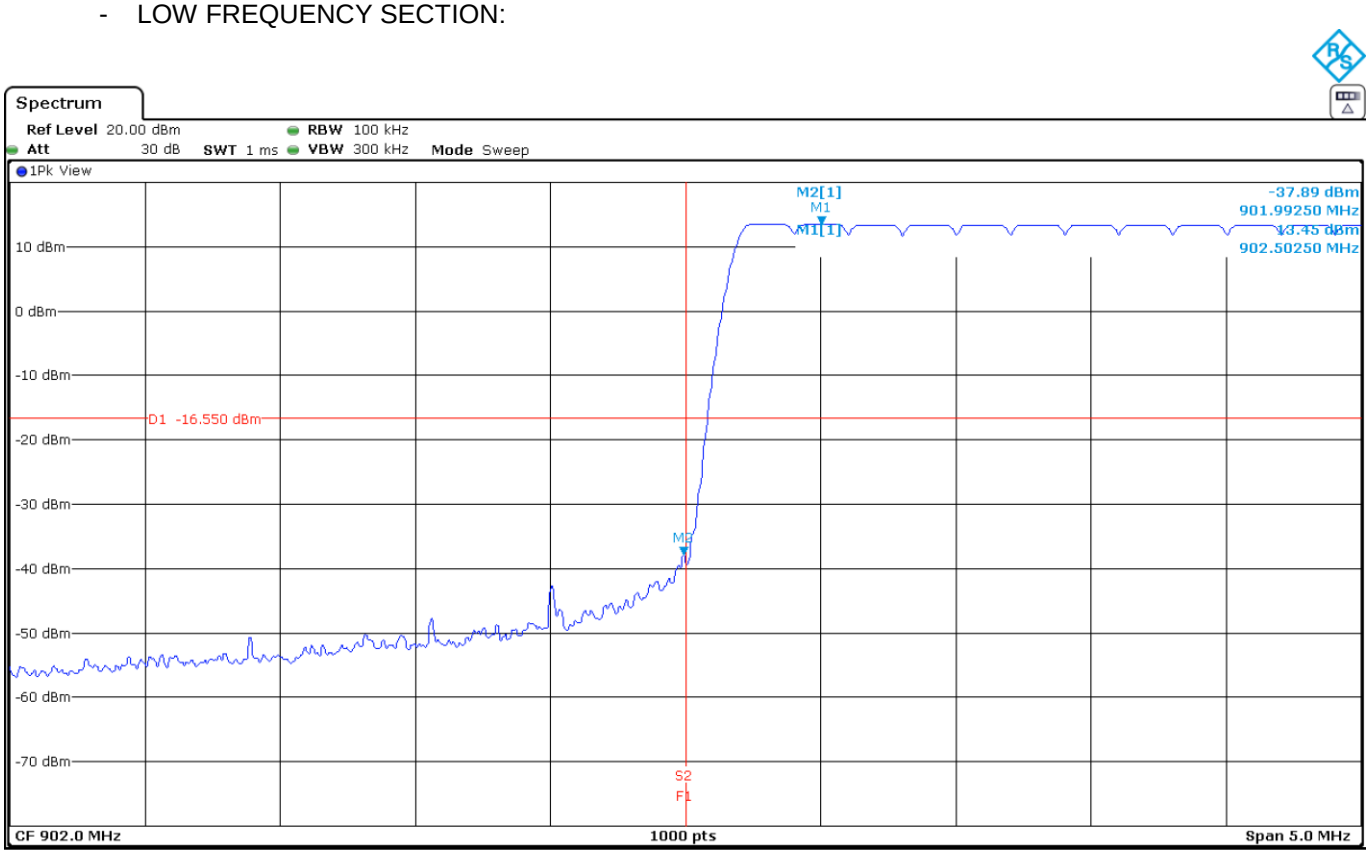


- HIGH FREQUENCY SECTION:

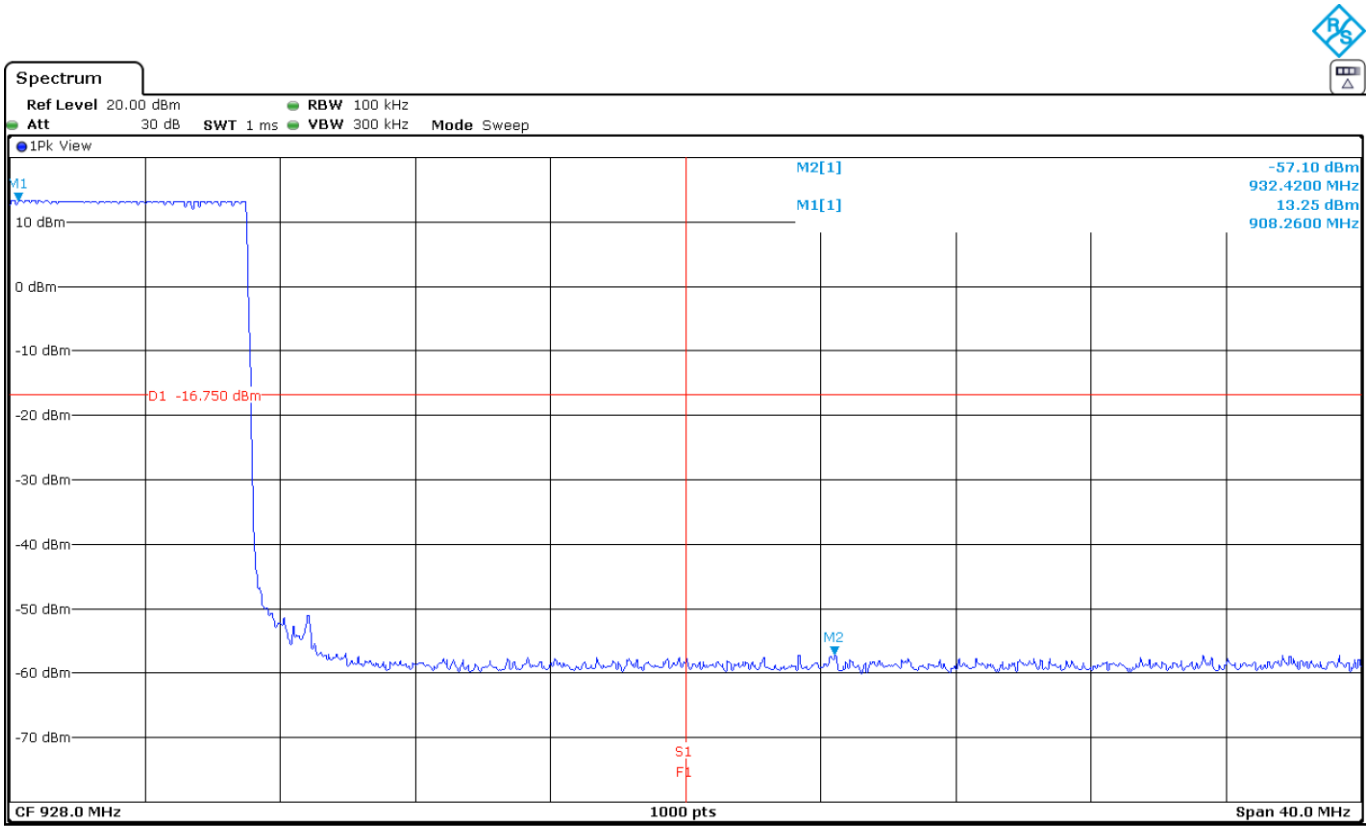


- HOPPING ON:

  - LOW FREQUENCY SECTION:



- HIGH FREQUENCY SECTION:



Verdict: PASS

Measurement uncertainty (dB) <±2.57

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
960 - 10000	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 corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RSS-247. Attenuation below the general field strength limits specified in RSS-Gen is not required.

RESULTS:

The situation and orientation 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 correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Frequency range 30 MHz - 1 GHz:

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
428.573	31.26	V	Quasi peak	<± 5.08
441.377	32.48	V	Quasi peak	<± 5.08
454.035	32.80	V	Quasi peak	<± 5.08
466.597	32.31	V	Quasi peak	<± 5.08

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
428.379	30.94	V	Quasi peak	<± 5.08
439.728	33.15	V	Quasi peak	<± 5.08
459.516	30.40	V	Quasi peak	<± 5.08

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
452.871	32.17	V	Quasi peak	<± 5.08
459.855	32.85	V	Quasi peak	<± 5.08

Frequency range 1 - 10 GHz:

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

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

Duty cycle correction: +3.05 dB

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.804333	60.92	60.92	V	Peak	<± 5.13
	32.48	35.53		Average	
2.707067	52.59	52.59	V	Peak	<± 5.13
3.609000	41.87	41.87	V	Peak	<± 5.13
4.511250	43.81	43.81	V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.817400	66.01	66.01	V	Peak	<± 5.13
	37.70	40.75		Average	
2.725867	57.68	57.68	V	Peak	<± 5.13
	38.72	41.77		Average	
3.634500	43.88	43.88	V	Peak	<± 5.13
4.543500	44.46	44.46	V	Peak	<± 5.13
8.175750	46.41	46.41	V	Peak	<± 5.13

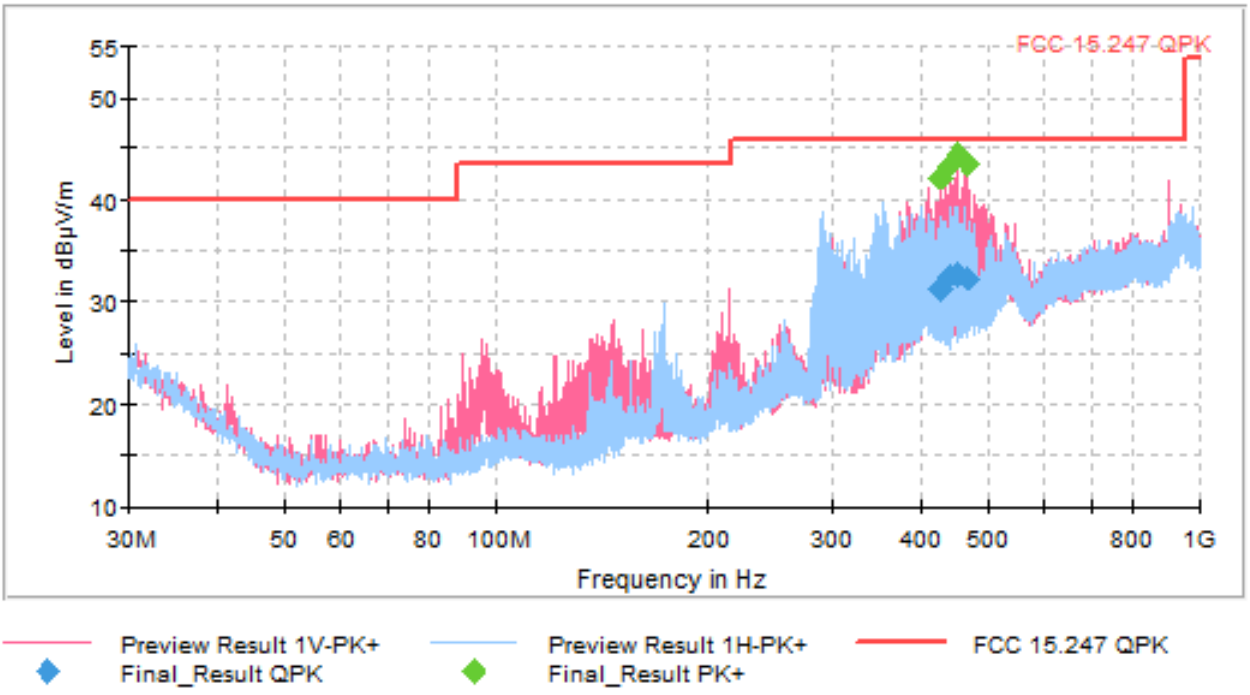
- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.829933	66.02	66.02	V	Peak	<± 5.13
	41.04	44.09		Average	
2.744600	59.98	59.98	V	Peak	<± 5.13
	40.03	43.08		Average	
3.659250	43.78	43.78	V	Peak	<± 5.13
4.574750	44.10	44.10	V	Peak	<± 5.13
6.404000	48.69	48.69	V	Peak	<± 5.13
8.234000	48.48	48.48	V	Peak	<± 5.13

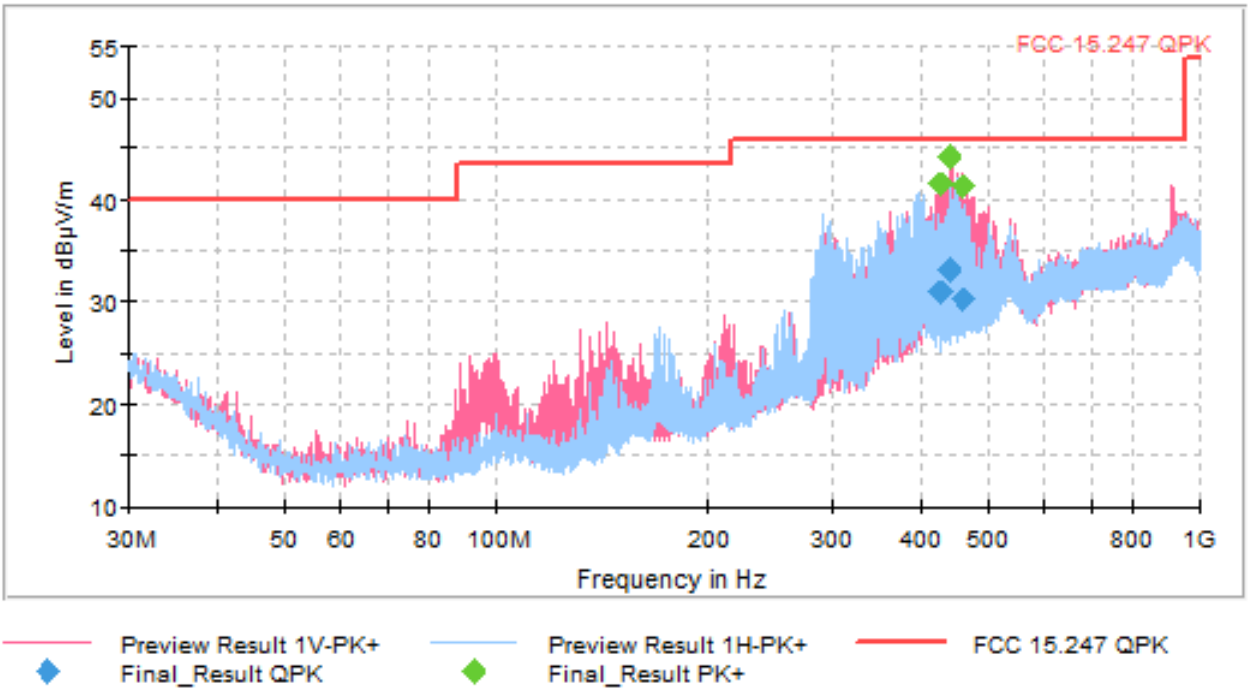
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

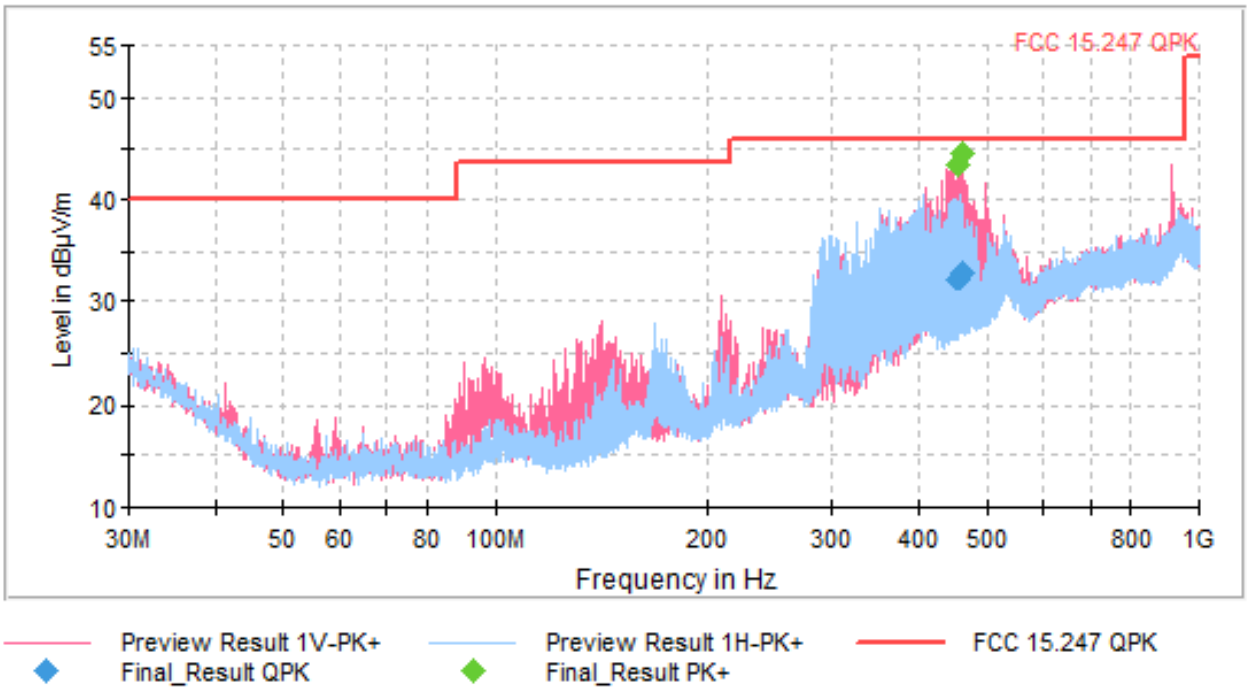
- Low Channel:



- Middle Channel:

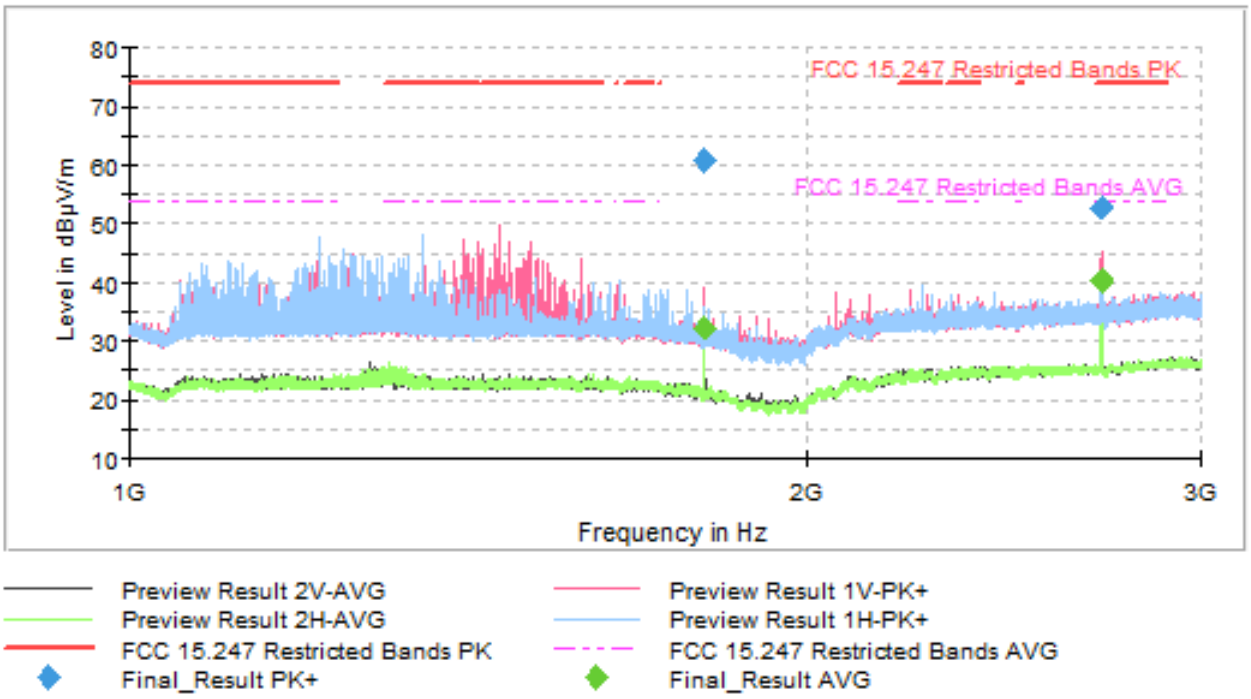


- High Channel

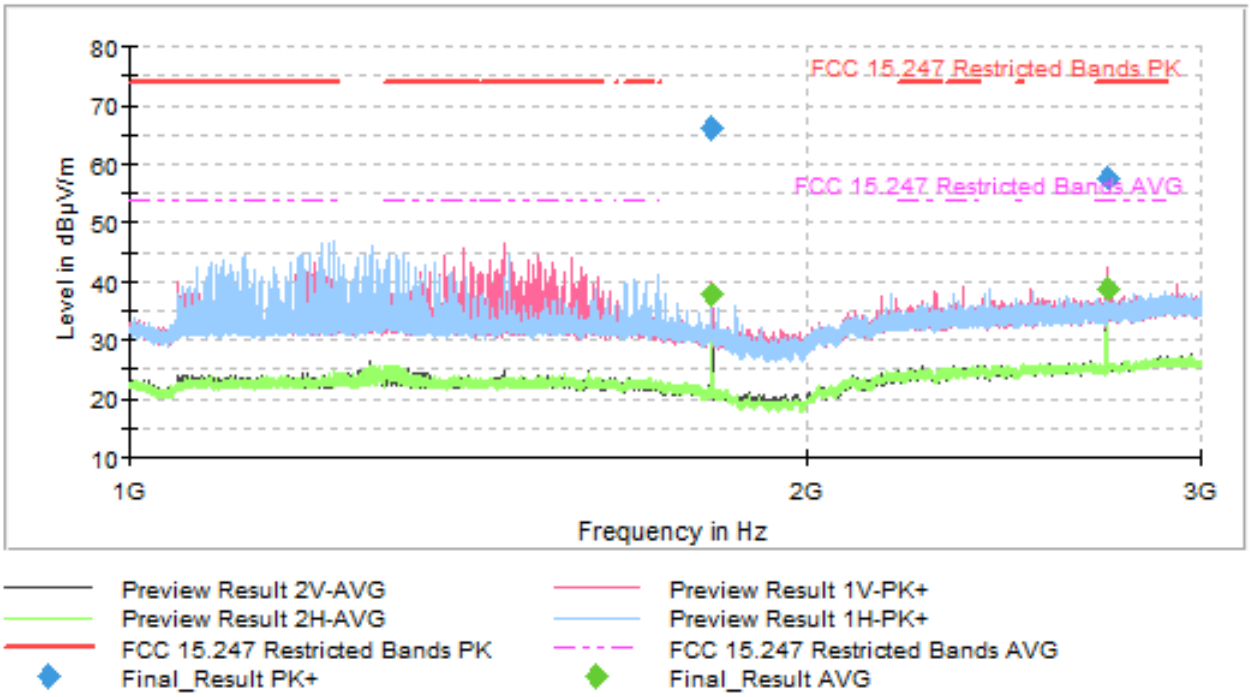


FREQUENCY RANGE 1 - 3 GHz:

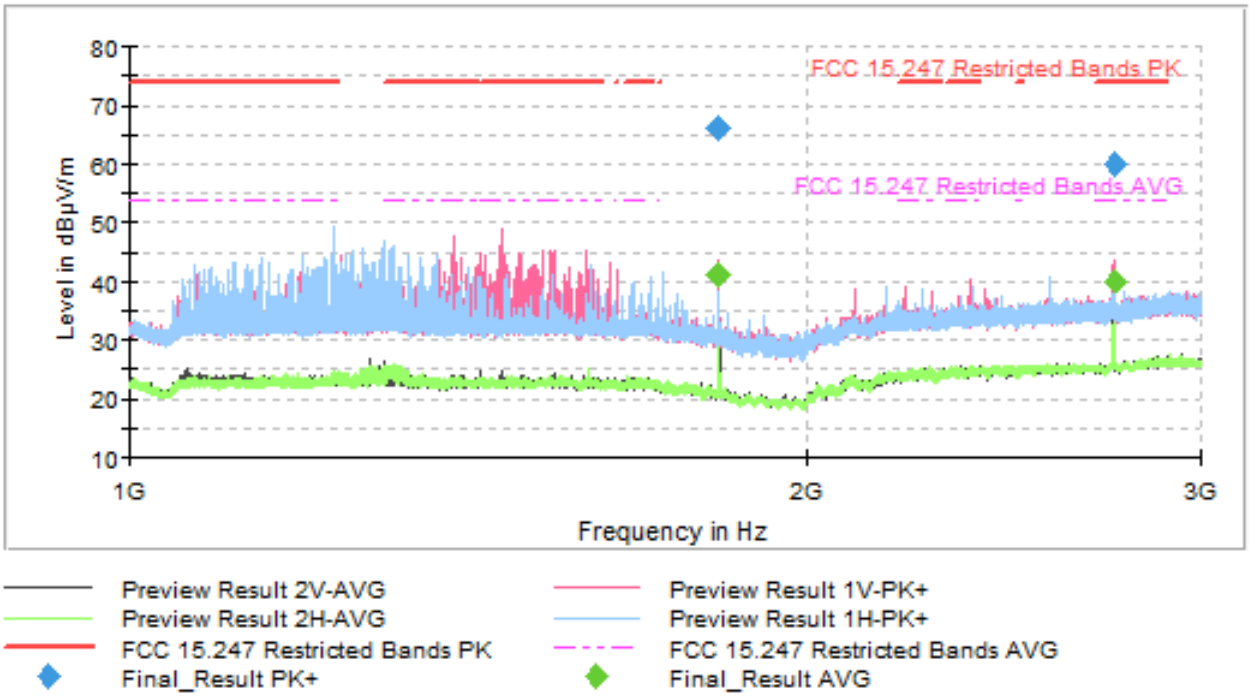
- Low Channel:



- Middle Channel:

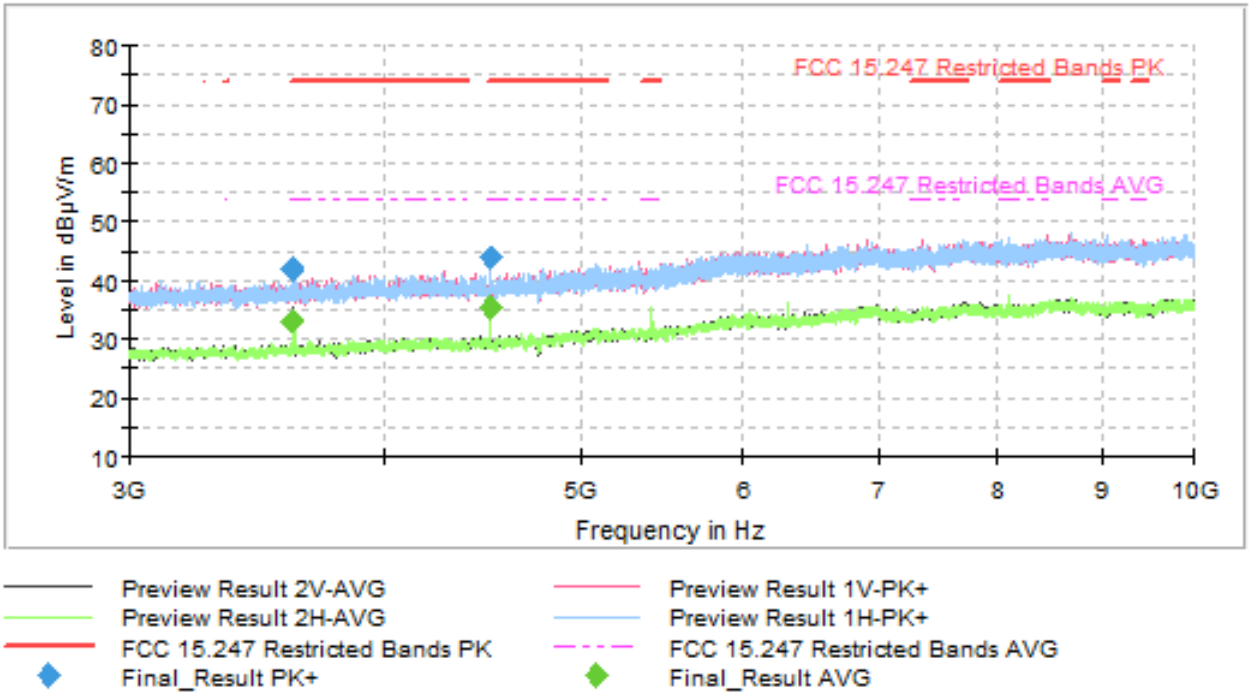


- High Channel:

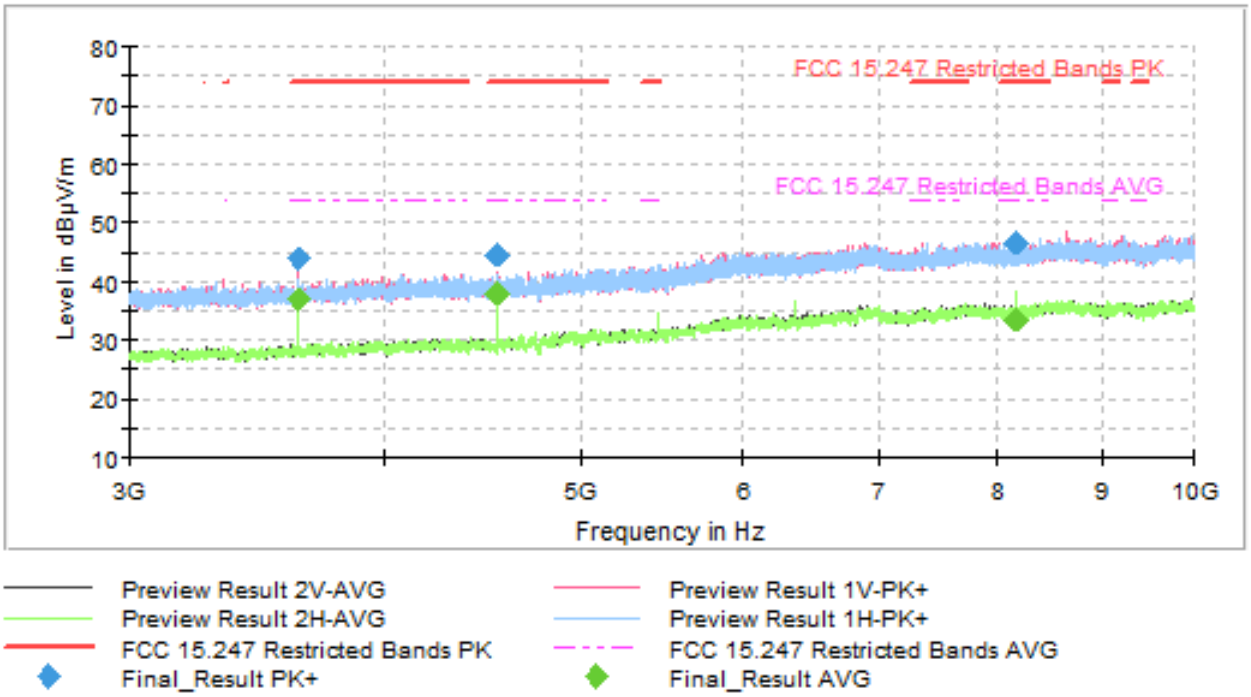


FREQUENCY RANGE 3 - 10 GHz:

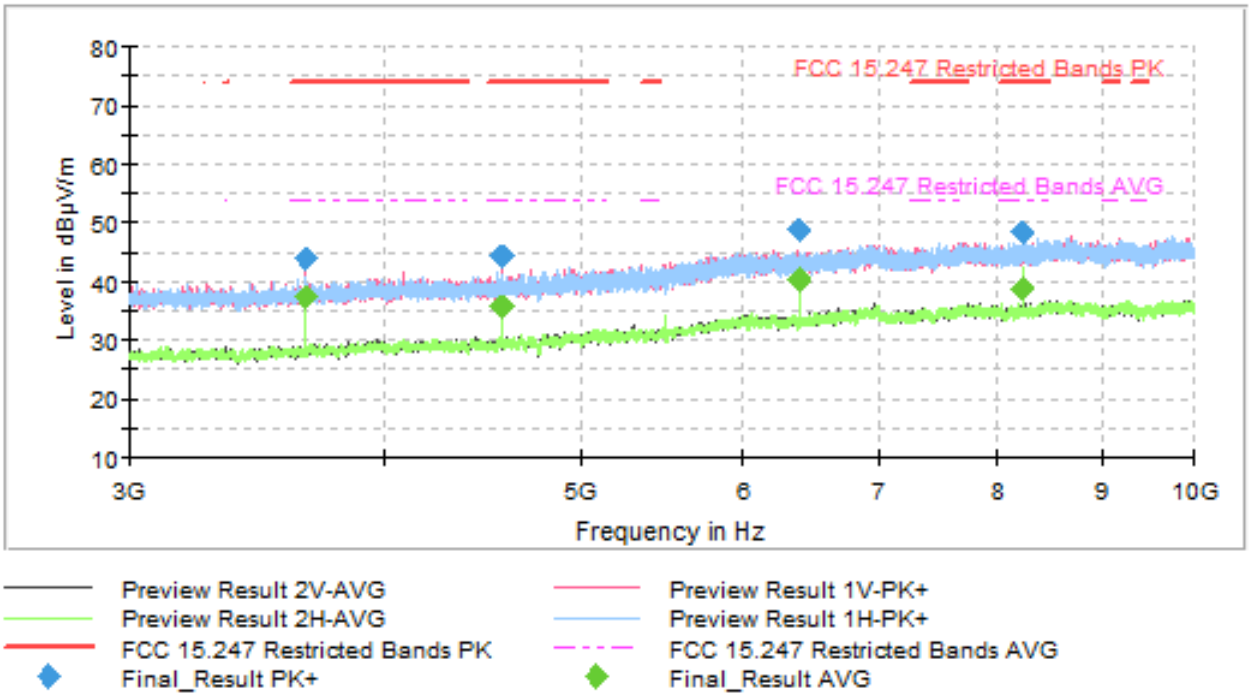
- Low Channel:



- Middle Channel:



- High Channel:



Appendix B: Test results. LoRa 500 kHz

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FCC 15.247 (d) / RSS-247 5.5. Emission limitations radiated (Transmitter) 52

TEST CONDITIONS

POWER SUPPLY (V):

Vnominal:	24 Vdc.
Type of Power Supply:	External power supply.

The power supply of 24 Vdc was selected based on preliminary testing that identified this power supply corresponding to the worst case for emission limitations radiated in the frequency range 1 GHz – 3 GHz.

ANTENNA:

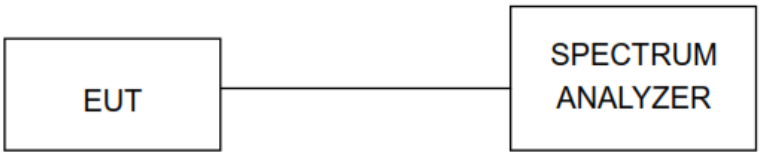
Type of Antenna:	Dipole Antenna.
Maximum Declared Antenna Gain:	+2.15 dBi

TEST FREQUENCIES:

Low Channel:	903.00 MHz
Middle Channel:	909.45 MHz
High Channel:	914.20 MHz

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is 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.



The DC supply voltage is applied using an external power supply.

RADIATED MEASUREMENTS

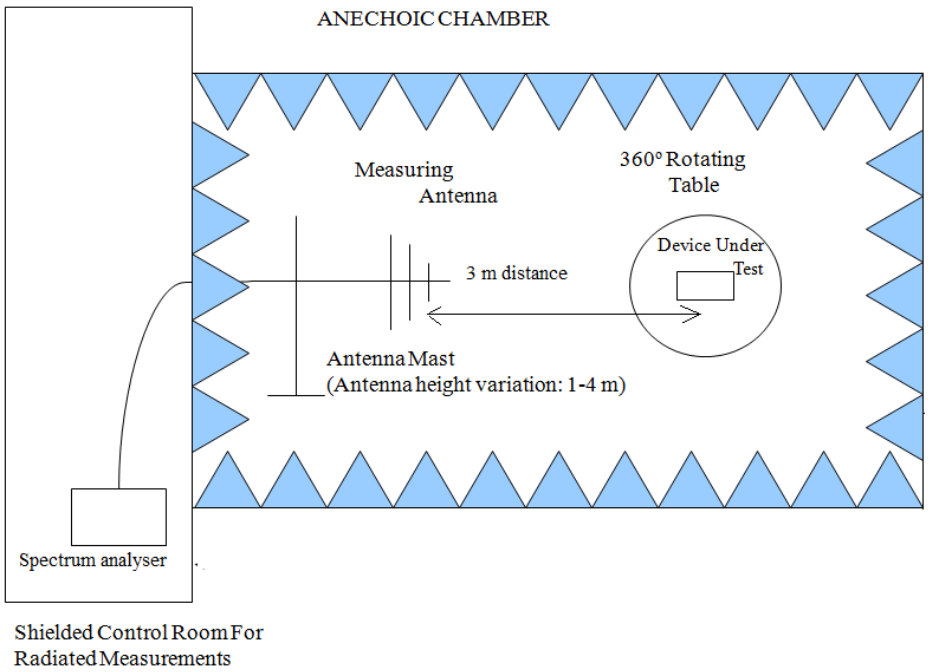
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz and 1 GHz-10 GHz Double ridge horn antenna) is situated at a distance of 3 m.

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.

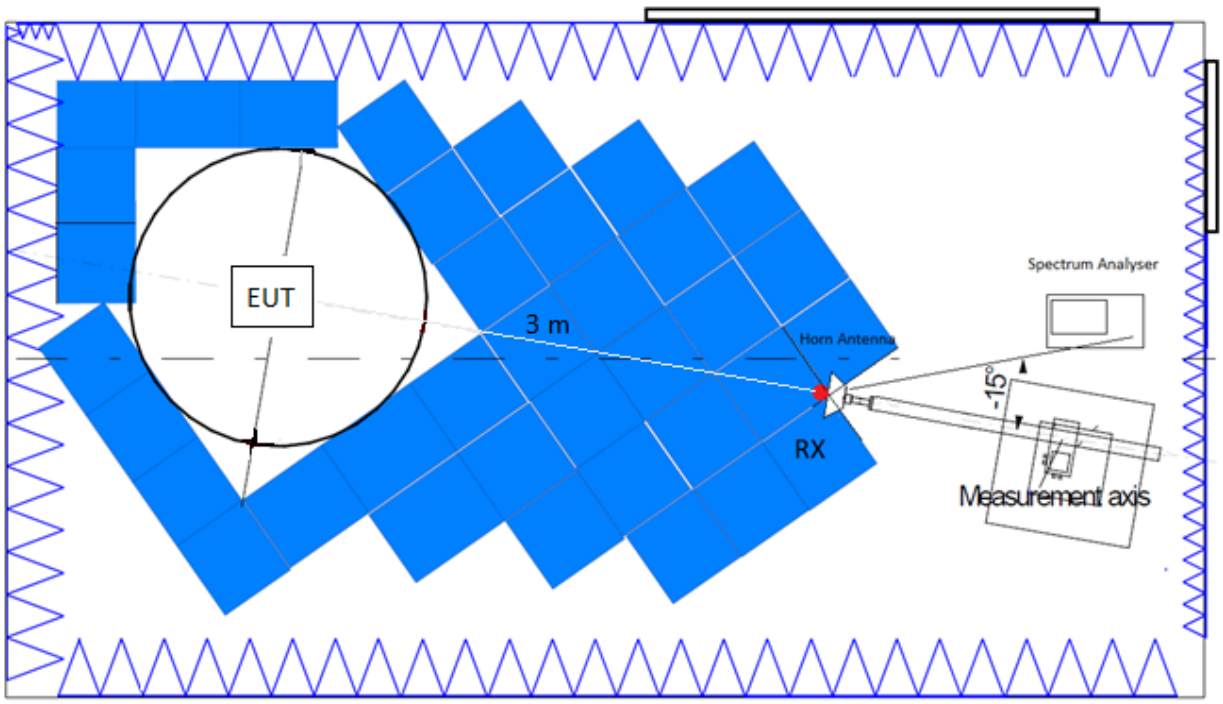
Measurements were made in both horizontal and vertical planes of polarization.

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

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 10 GHz:

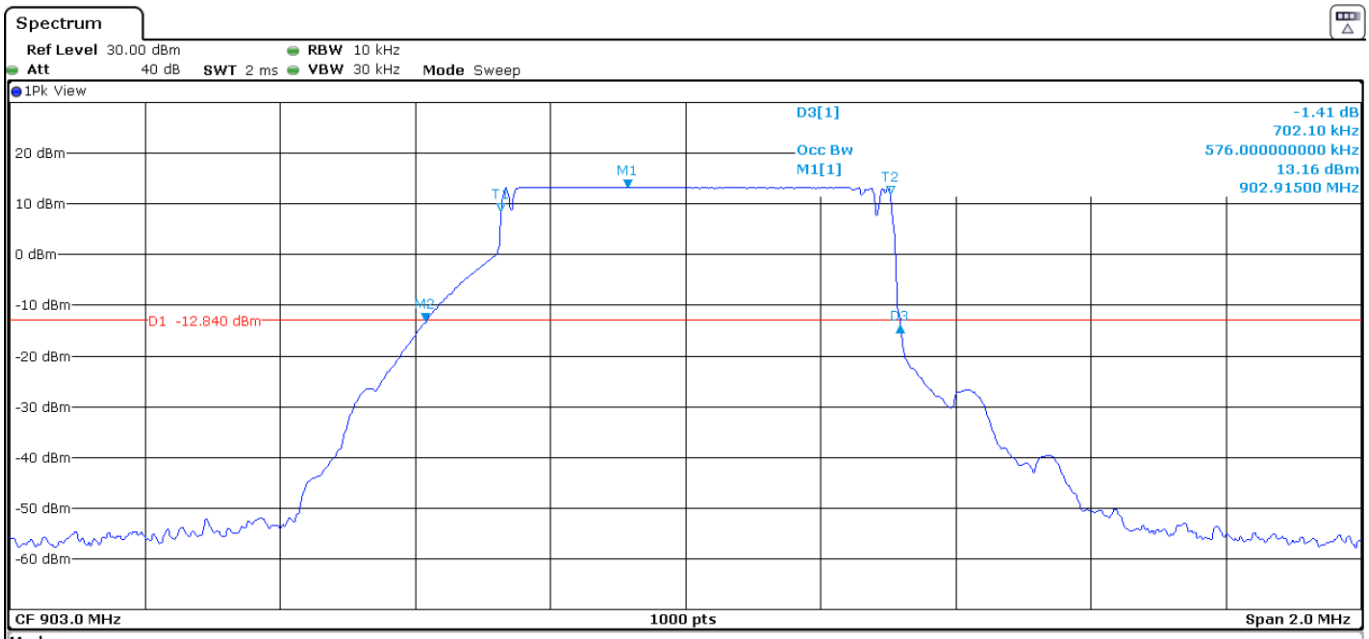


Occupied Bandwidth

RESULTS:

	Low Channel 903.00 MHz	Middle Channel 909.45 MHz	High Channel 914.20 MHz
99% bandwidth (MHz)	0.576	0.618	0.548
Measurement uncertainty (kHz)	<± 2.31		

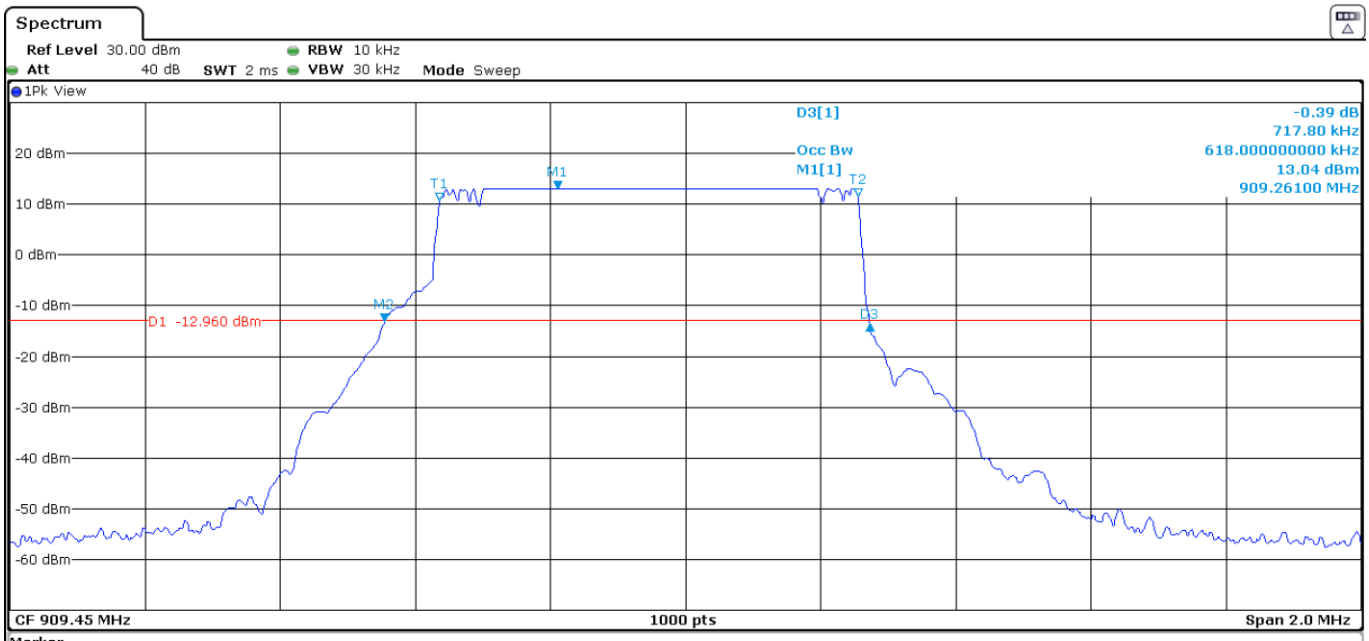
- Low Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	902.915 MHz	13.16 dBm		
T1		1	902.727 MHz	8.58 dBm	Occ Bw	576.0 kHz
T2		1	903.303 MHz	12.00 dBm		
M2		1	902.6162 MHz	-13.03 dBm		
D3	M2	1	702.1 kHz	-1.41 dB		

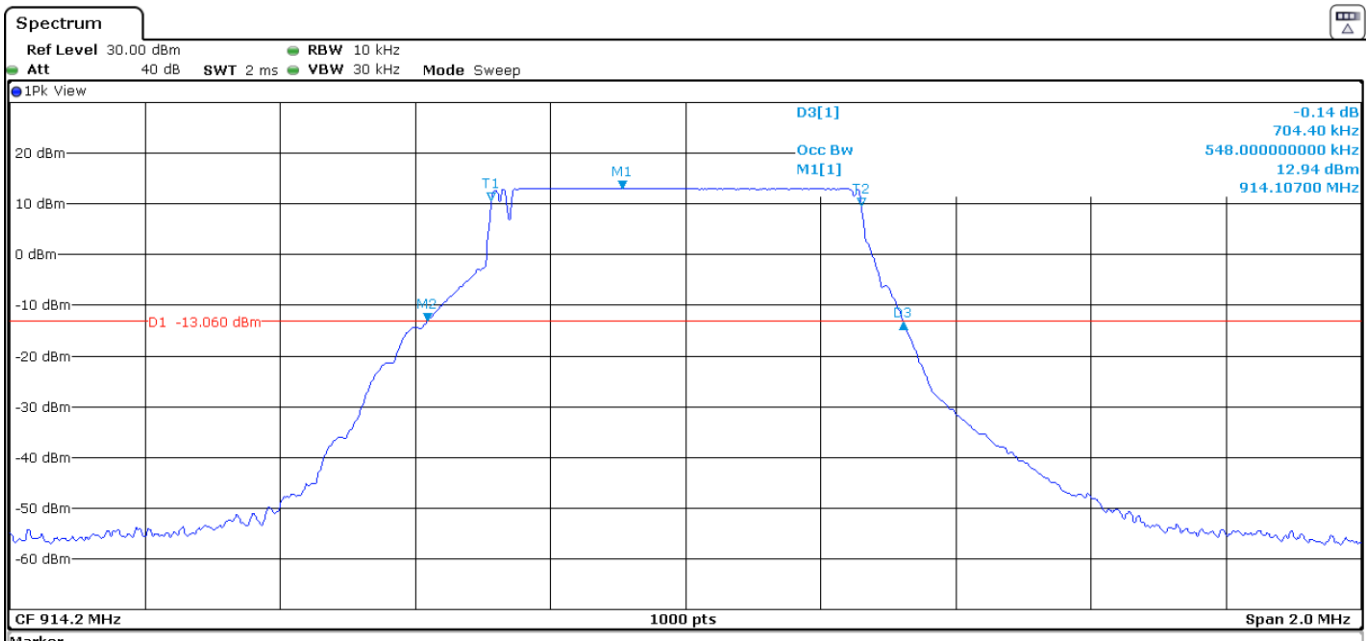
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	909.261 MHz	13.04 dBm		
T1		1	909.087 MHz	10.62 dBm	Occ Bw	618.0 kHz
T2		1	909.705 MHz	11.58 dBm		
M2		1	909.0052 MHz	-13.18 dBm		
D3	M2	1	717.8 kHz	-0.39 dB		

- High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.107 MHz	12.94 dBm		
T1		1	913.913 MHz	10.67 dBm	Occ Bw	548.0 kHz
T2		1	914.461 MHz	9.61 dBm		
M2		1	913.8187 MHz	-13.07 dBm		
D3	M2	1	704.4 kHz	-0.14 dB		

FCC 15.247 (a)(2) / RSS-247 5.2. (a) 6 dB Bandwidth

SPECIFICATION:

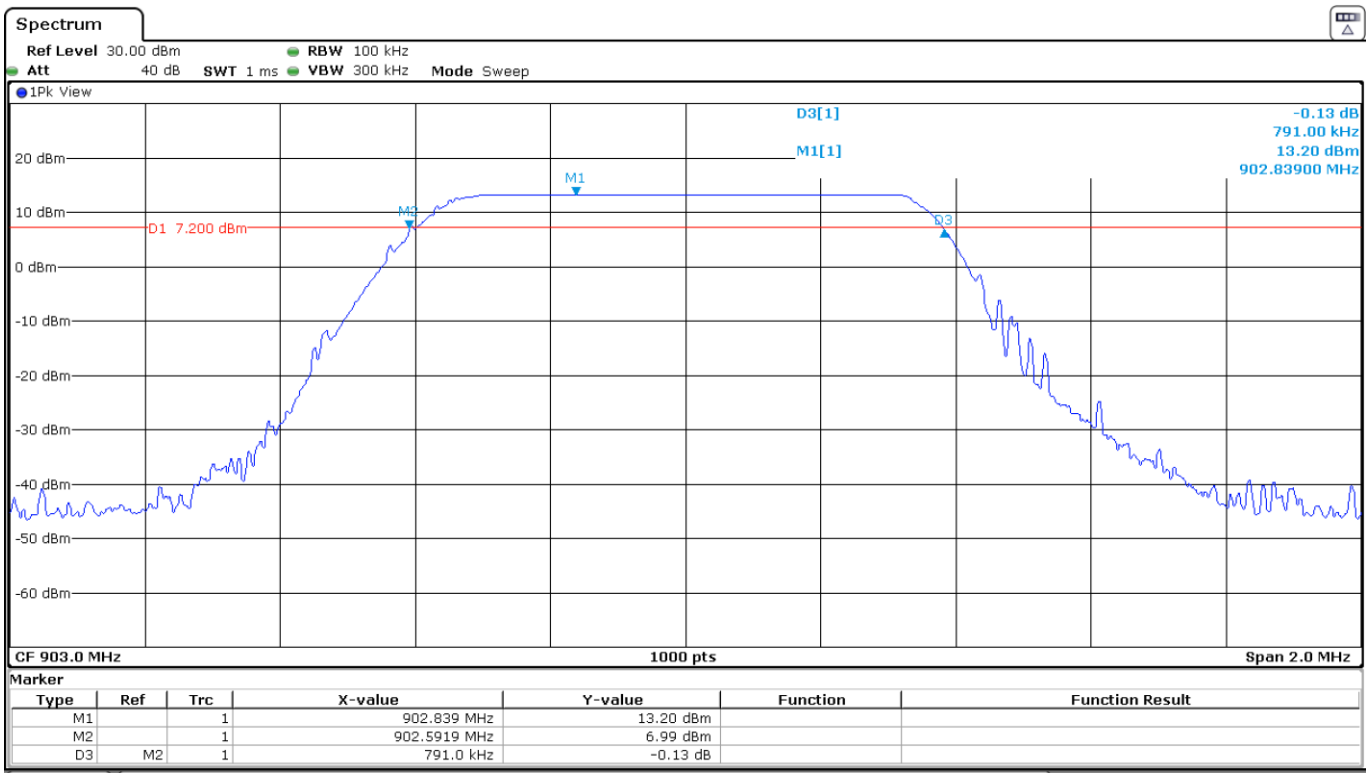
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS:

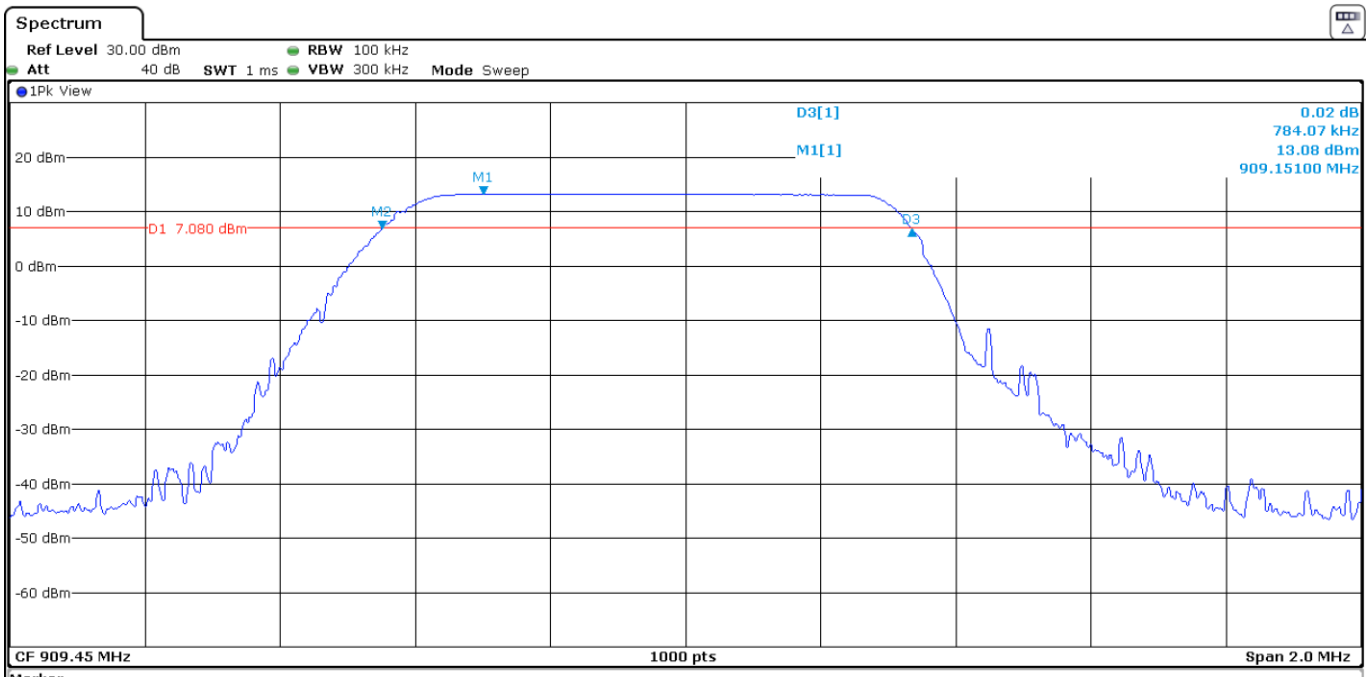
	Low Channel 903.00 MHz	Middle Channel 909.45 MHz	High Channel 914.20 MHz
6 dB Spectrum bandwidth (kHz)	791.00	784.07	788.98
Measurement uncertainty (kHz)	<±12.41		

Verdict: PASS

- Low Channel:



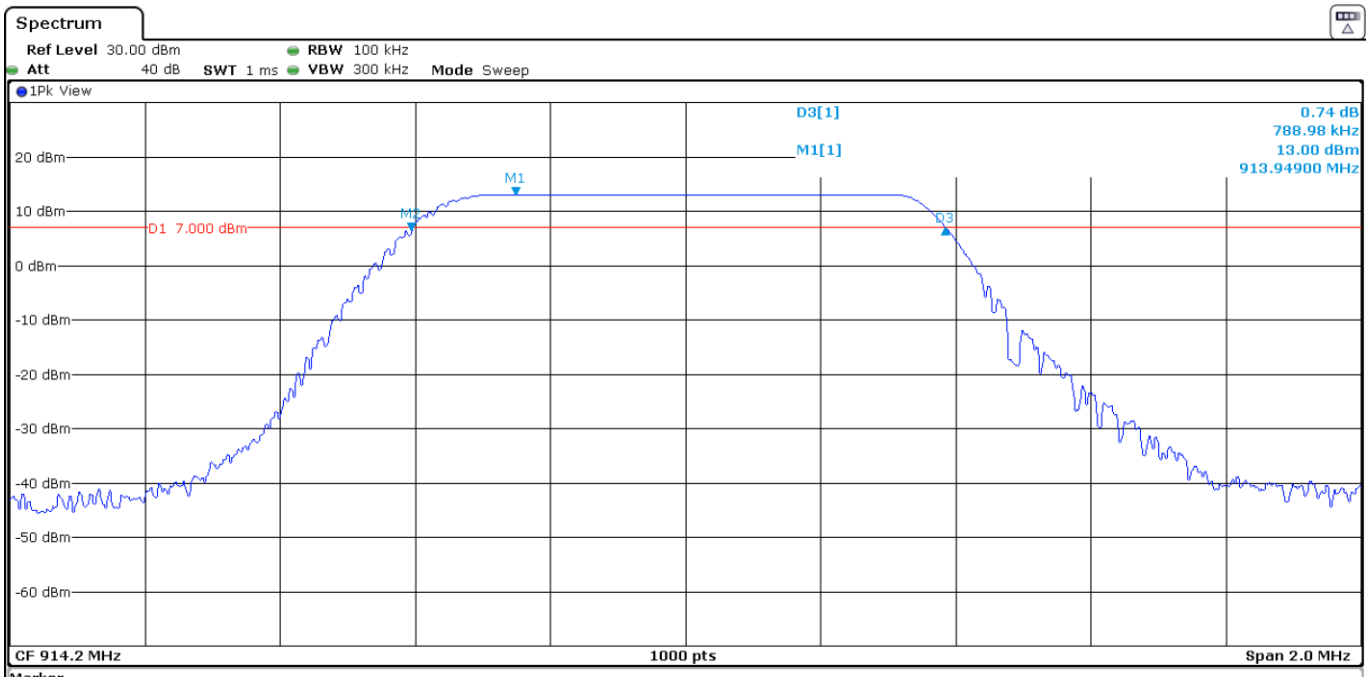
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	909.151 MHz	13.08 dBm		
M2		1	909.0014 MHz	6.76 dBm		
D3	M2	1	784.07 kHz	0.02 dB		

- High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	913.949 MHz	13.00 dBm		
M2		1	913.7952 MHz	6.23 dBm		
D3	M2	1	788.98 kHz	0.74 dB		

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

SPECIFICATION:

For systems using digital modulation in the 902-928 MHz band: 1 watt (30 dBm).
The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

RESULTS:

The maximum conducted output power level in the fundamental emission was measured using the method according to point 11.9.2.2.4 “AVGSA-2” of ANSI C.63.10-2013.

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

Maximum Declared Antenna Gain: +2.15 dBi

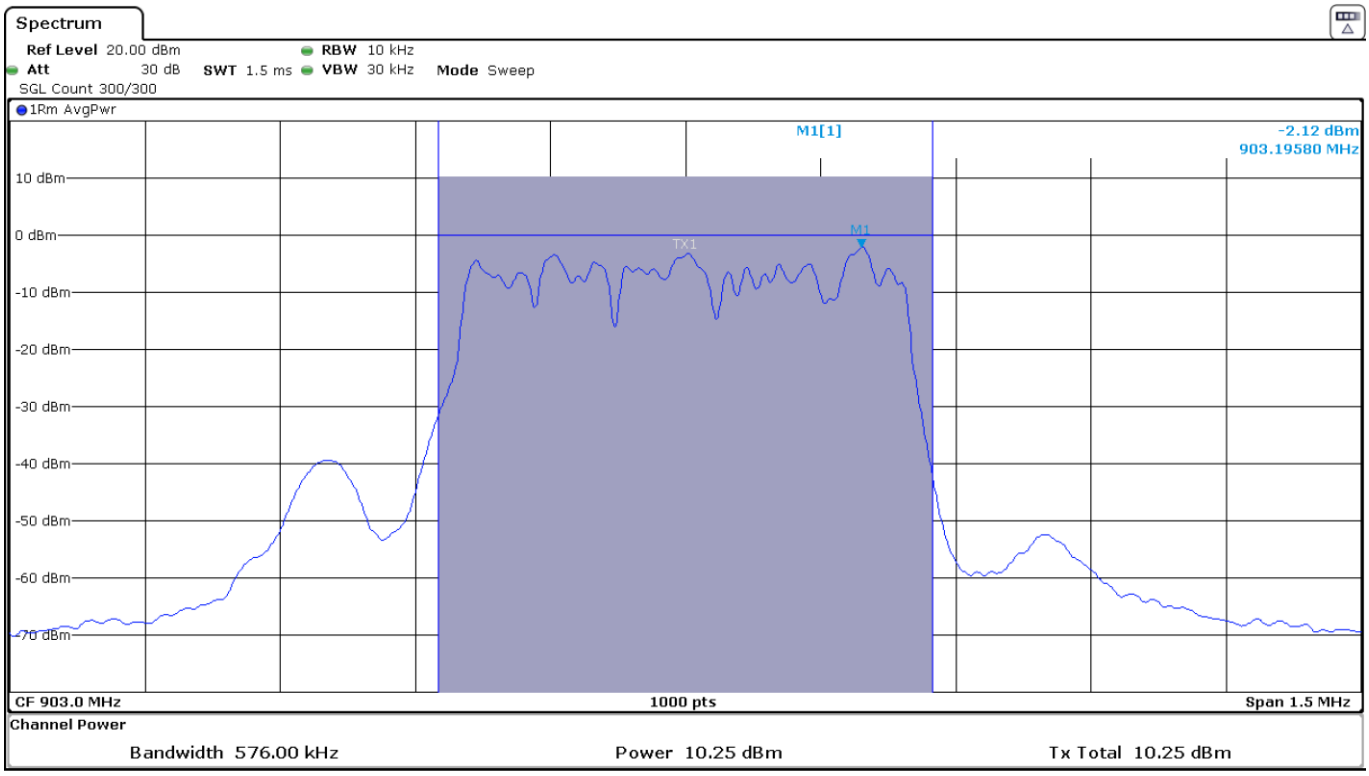
Duty cycle correction: +3.32 dB

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.

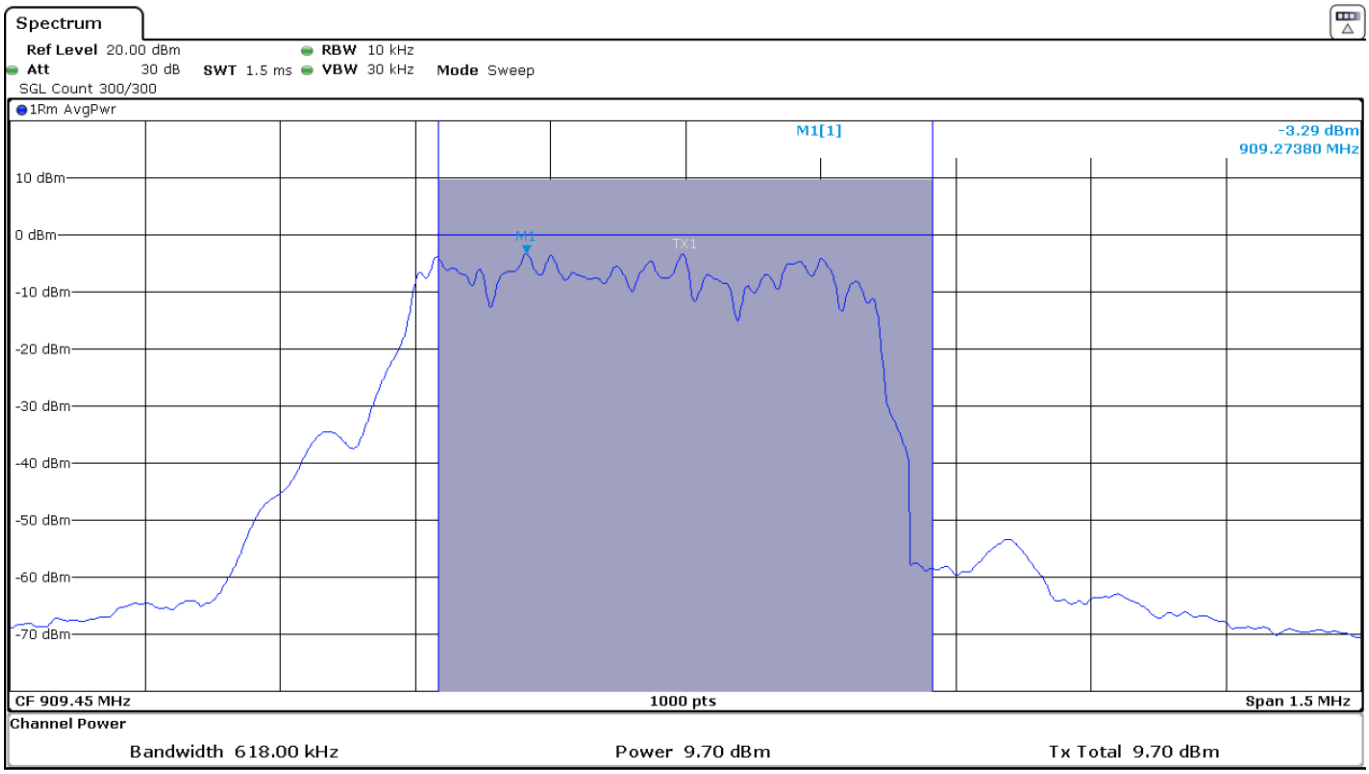
	Low Channel 903.00 MHz	Middle Channel 909.45 MHz	High Channel 914.20 MHz
Maximum Conducted Power (dBm)	10.25	9.70	9.76
Maximum conducted power with Duty Cycle correction (dBm)	13.57	13.02	13.08
Maximum E.I.R.P. Power (dBm)	15.72	15.17	15.23
Measurement uncertainty (dB)	<±2.57		

Verdict: PASS

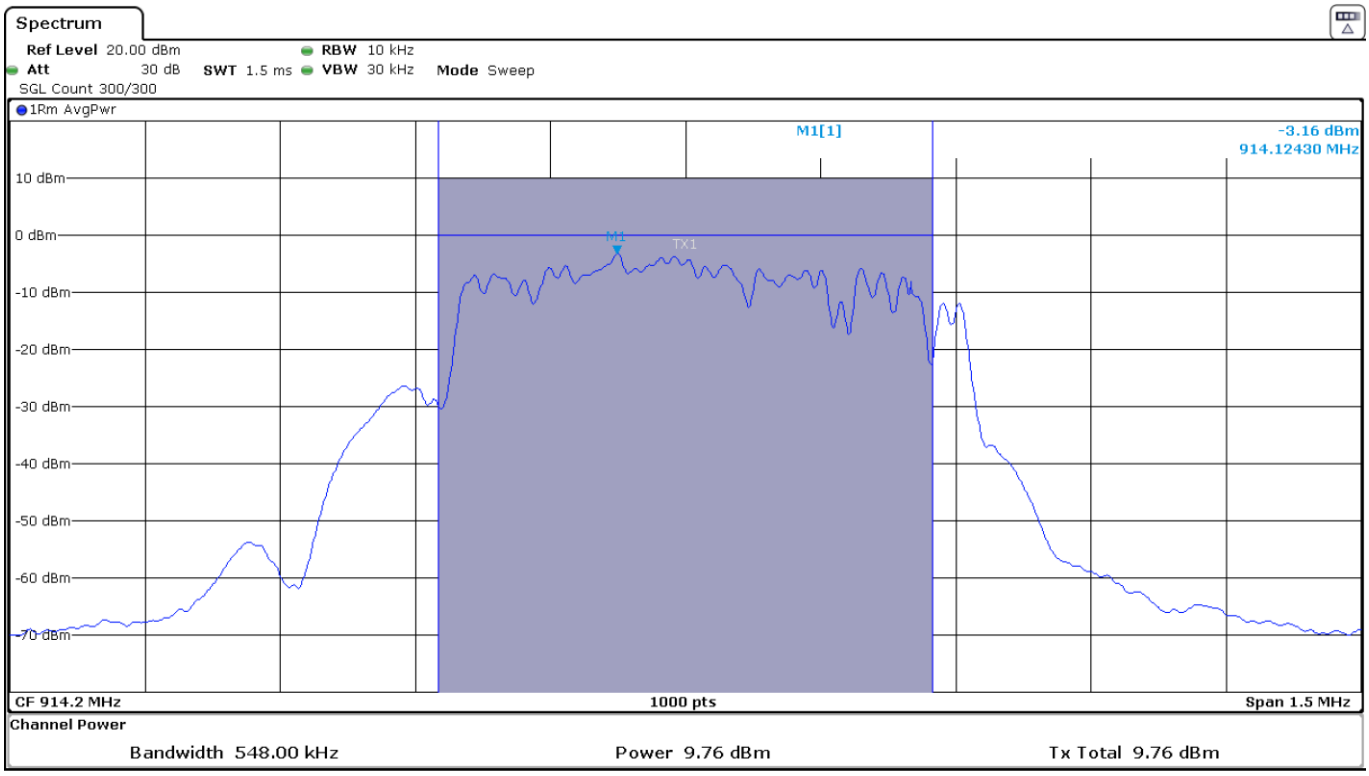
- Low Channel:



- Middle Channel:



- High Channel:



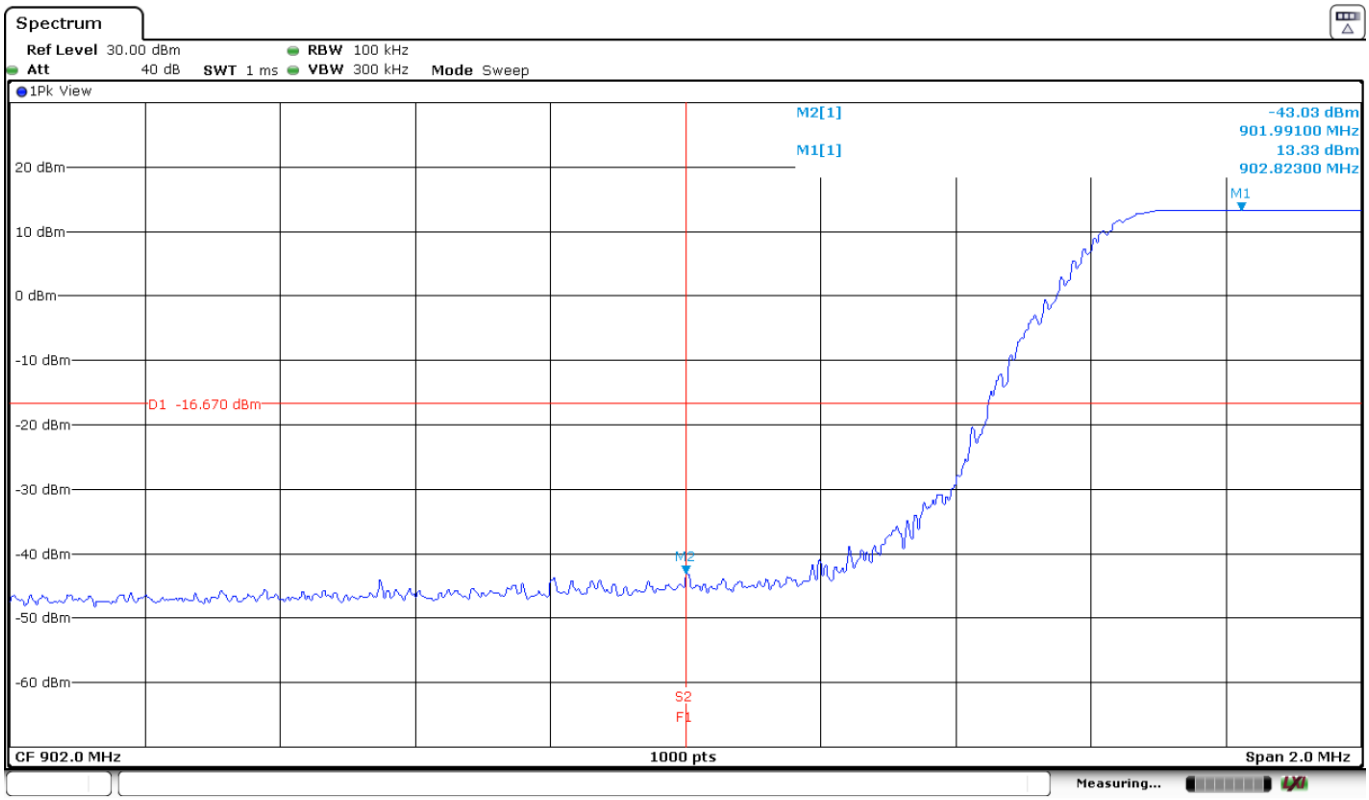
FCC 15.247 (d) / RSS-247 5.5. Band-edge emissions compliance (Transmitter)

SPECIFICATION:

In any 100 kHz bandwidths 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:

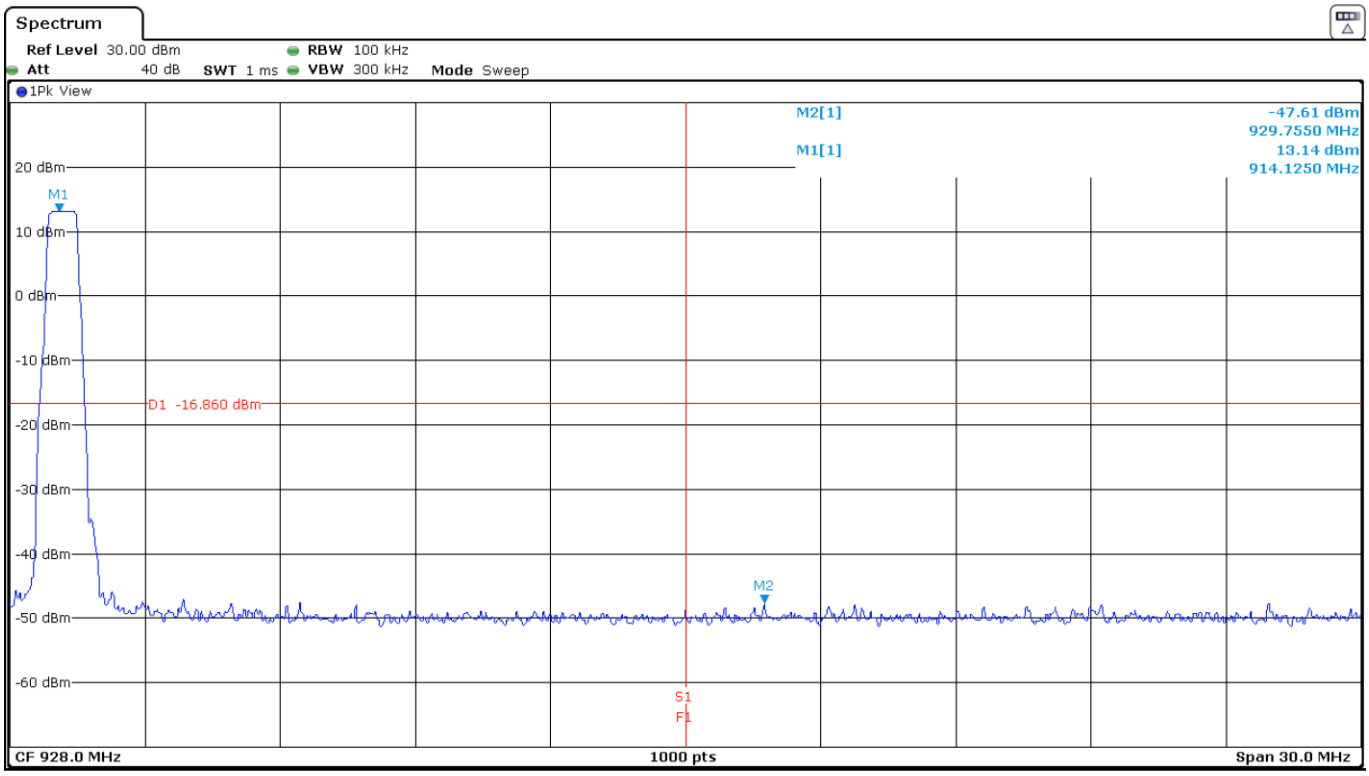
- Low Channel:



Measurement uncertainty (dB) <±2.57

Verdict: PASS

- High Channel:



Measurement uncertainty (dB) <±2.57

Verdict: PASS

FCC 15.247 (e) / RSS-247 5.2. (b) Power spectral density

SPECIFICATION:

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RESULTS:

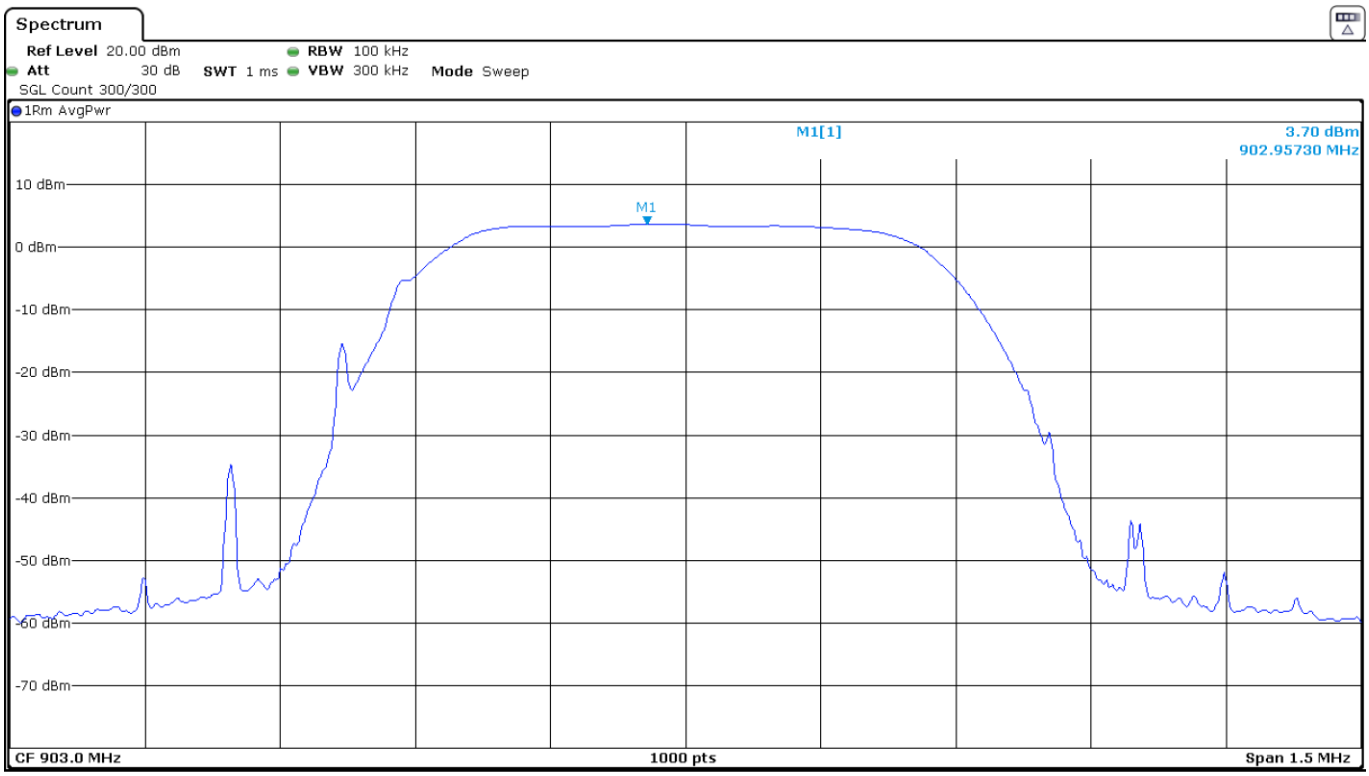
The maximum power spectral density level in the fundamental emission was measured using the method according to point 11.10.5." Method AVGPSD-2" of ANSI C.63.10-2013.

Duty cycle correction: +3.32 dB

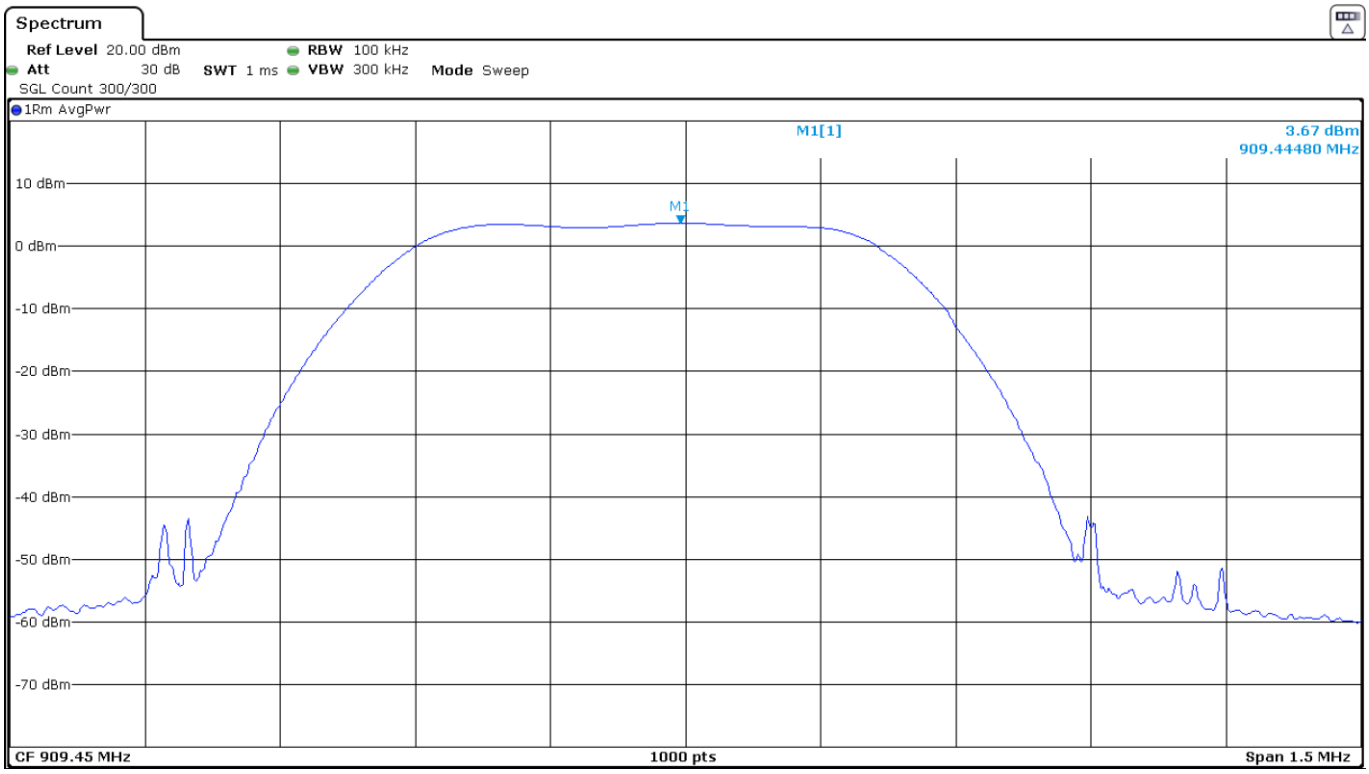
	Low Channel 903.00 MHz	Middle Channel 909.45 MHz	High Channel 914.20 MHz
Power Spectral Density (dBm)	3.70	3.67	3.55
Power Spectral Density with Duty Cycle correction (dBm)	7.02	6.99	6.87
Measurement uncertainty (dB)	<±2.57		

Verdict: PASS

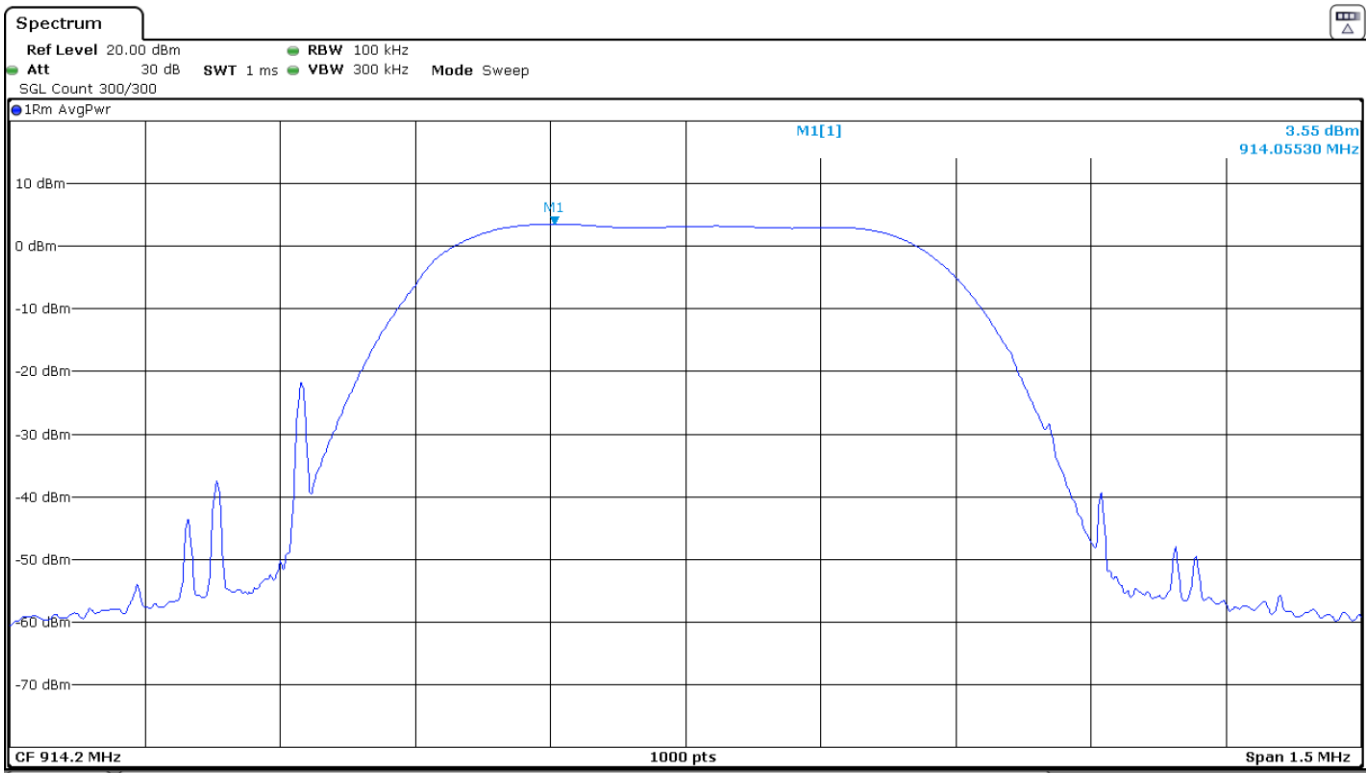
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 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
960 - 10000	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 corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RSS-247: Attenuation below the general field strength limits specified in RSS-Gen is not required.

RESULTS:

The situation and orientation 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 correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

Frequency range 30 MHz - 1 GHz:

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
430.270	27.11	V	Quasi peak	<± 5.08
444.820	28.72	V	Quasi peak	<± 5.08
470.865	27.13	V	Quasi peak	<± 5.08

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
451.077	28.23	V	Quasi peak	<± 5.08
846.643	30.44	V	Quasi peak	<± 5.08

- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (MHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
442.298	28.22	V	Quasi peak	<± 5.08
452.629	28.68	V	Quasi peak	<± 5.08

Frequency range 1 - 10 GHz:

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

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

Duty cycle correction: +3.32 dB

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
2.708867	48.79	V	Peak	<± 5.13
3.612500	42.26	V	Peak	<± 5.13
4.516250	45.02	V	Peak	<± 5.13
8.128250	47.87	V	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
2.728400	45.80	V	Peak	<± 5.13
3.636750	44.45	V	Peak	<± 5.13
6.367000	44.99	H	Peak	<± 5.13
8.184000	50.89	H	Peak	<± 5.13

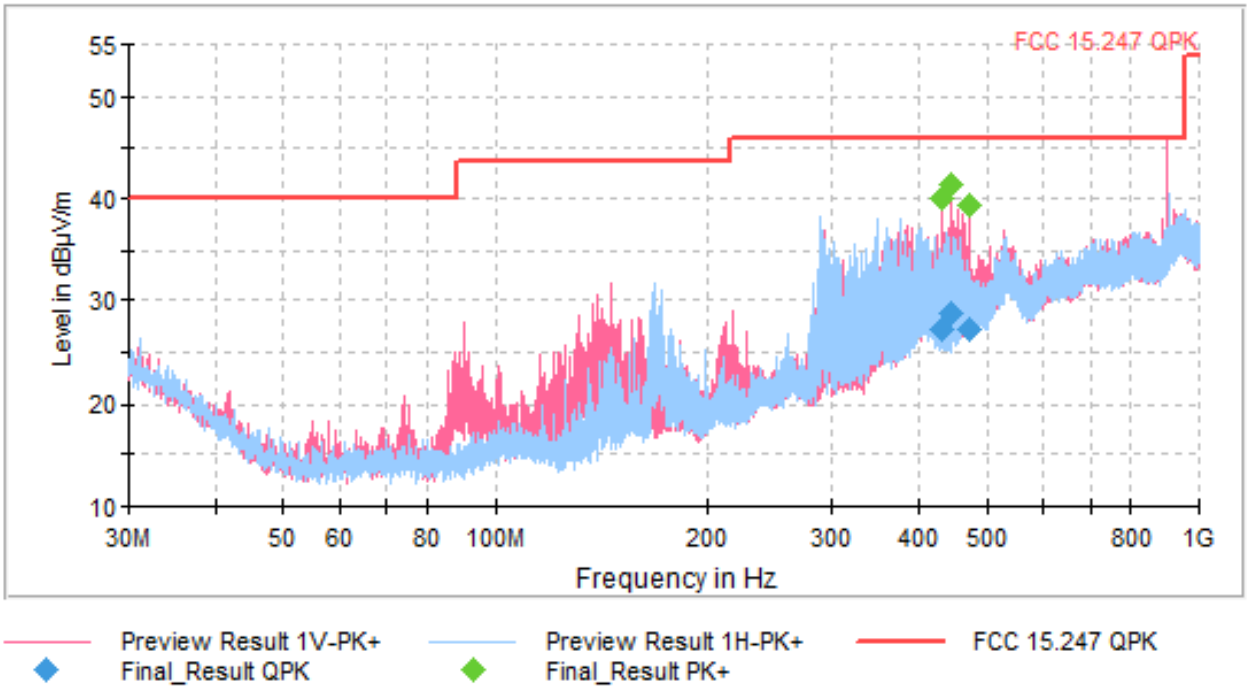
- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious frequency (GHz)	Emission Level (dBµV/m)	Corrected Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.828667	46.45	46.45	H	Peak	<± 5.13
2.742000	60.54	60.54	V	Peak	<± 5.13
	38.67	41.99		Average	
3.656500	43.75	43.75	H	Peak	<± 5.13
6.400250	47.98	47.98	H	Peak	<± 5.13
8.227750	49.00	49.00	V	Peak	<± 5.13

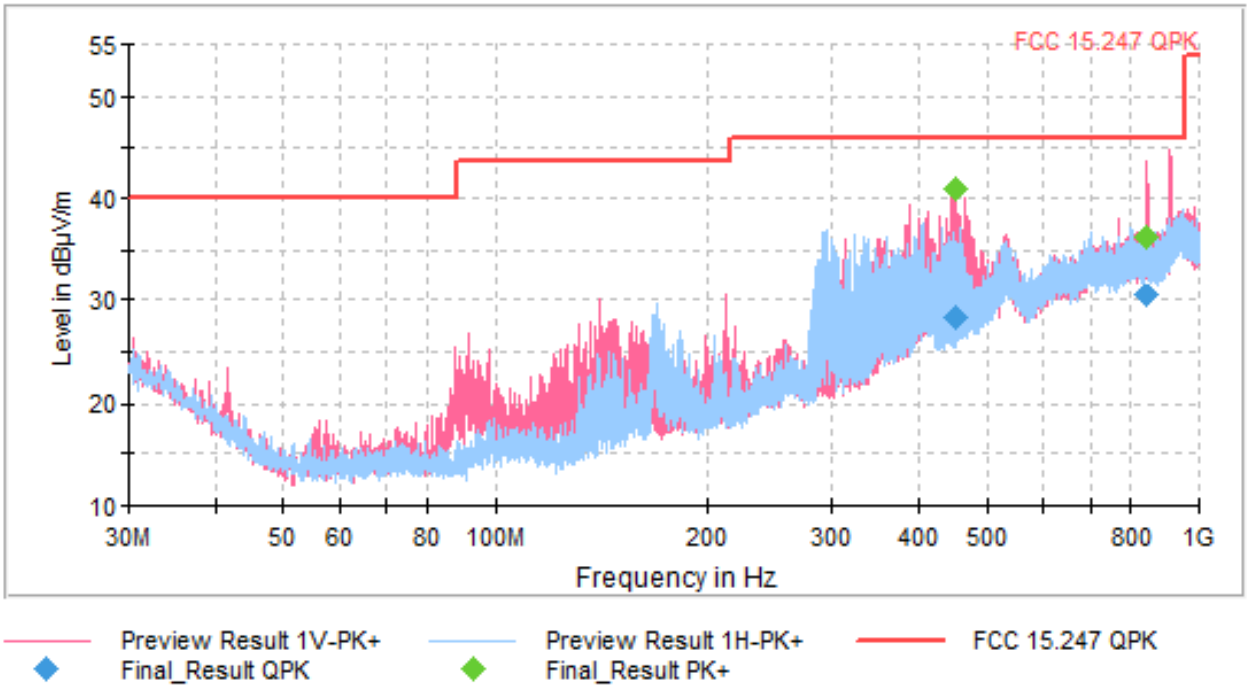
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

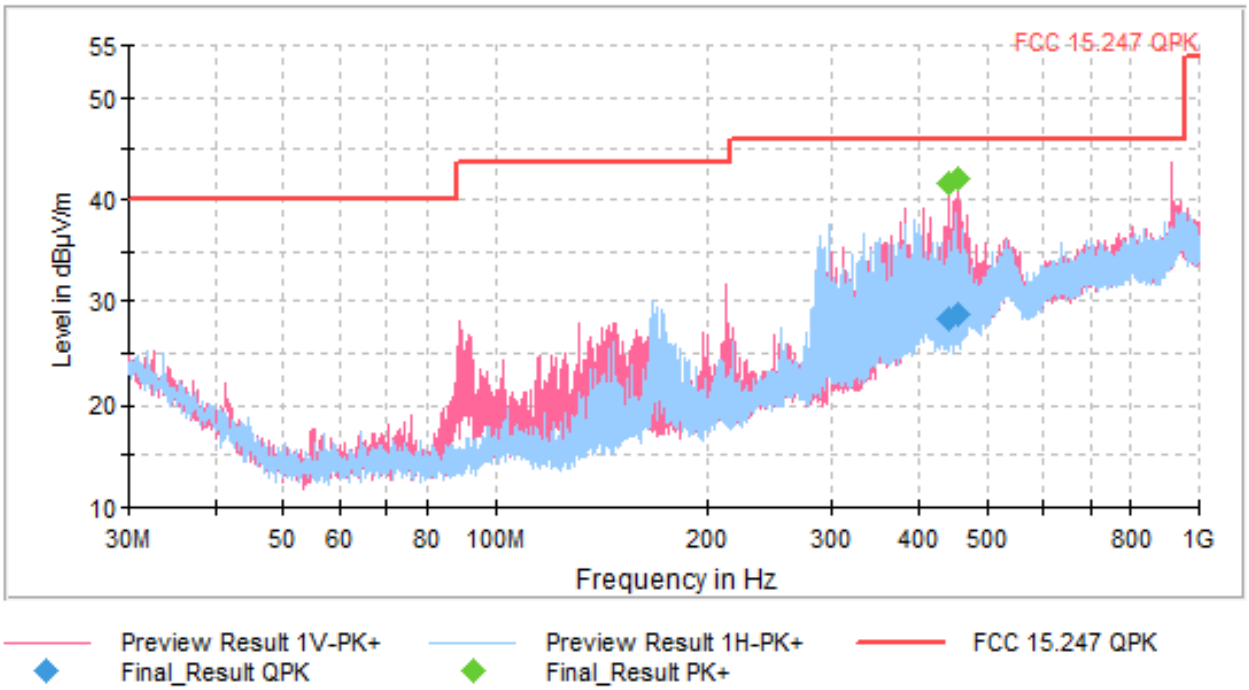
- Low Channel:



- Middle Channel:

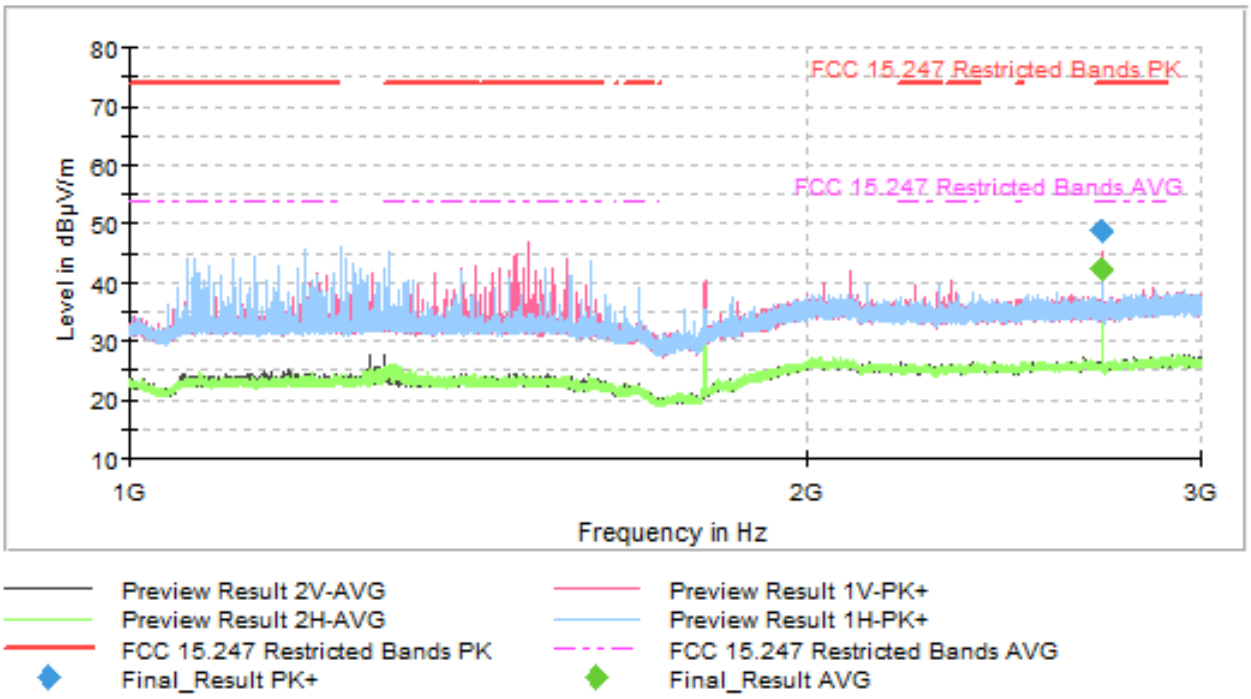


- High Channel:

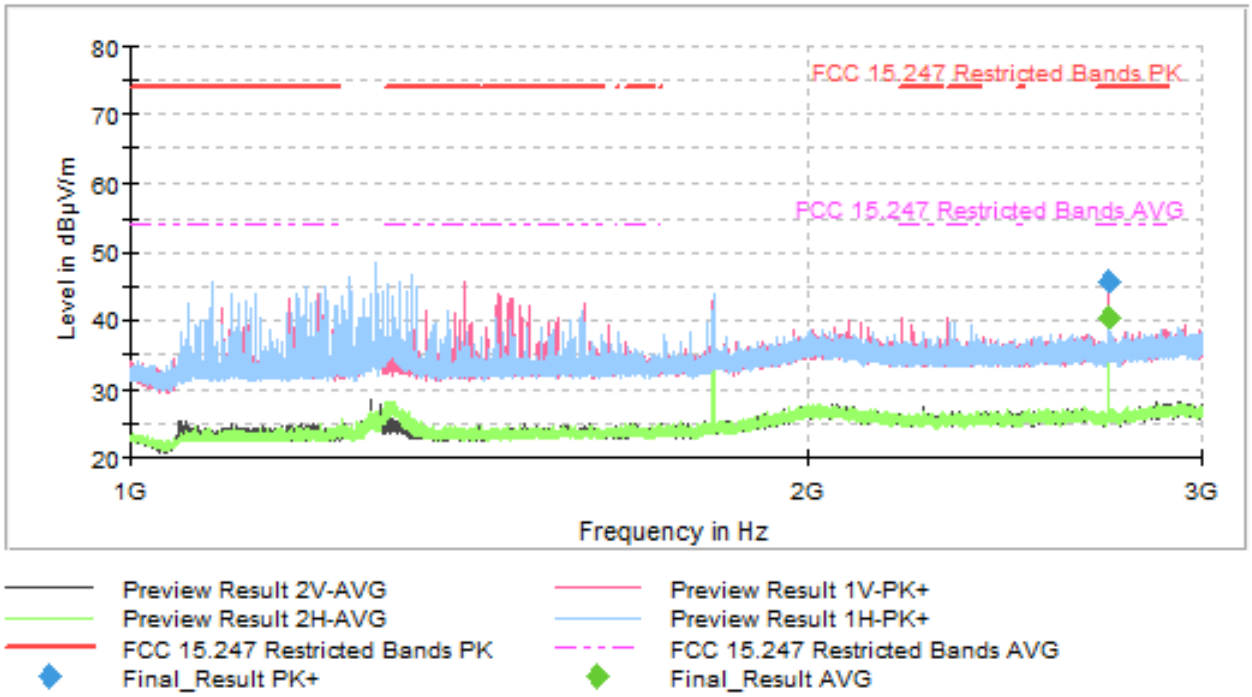


FREQUENCY RANGE 1 - 3 GHz:

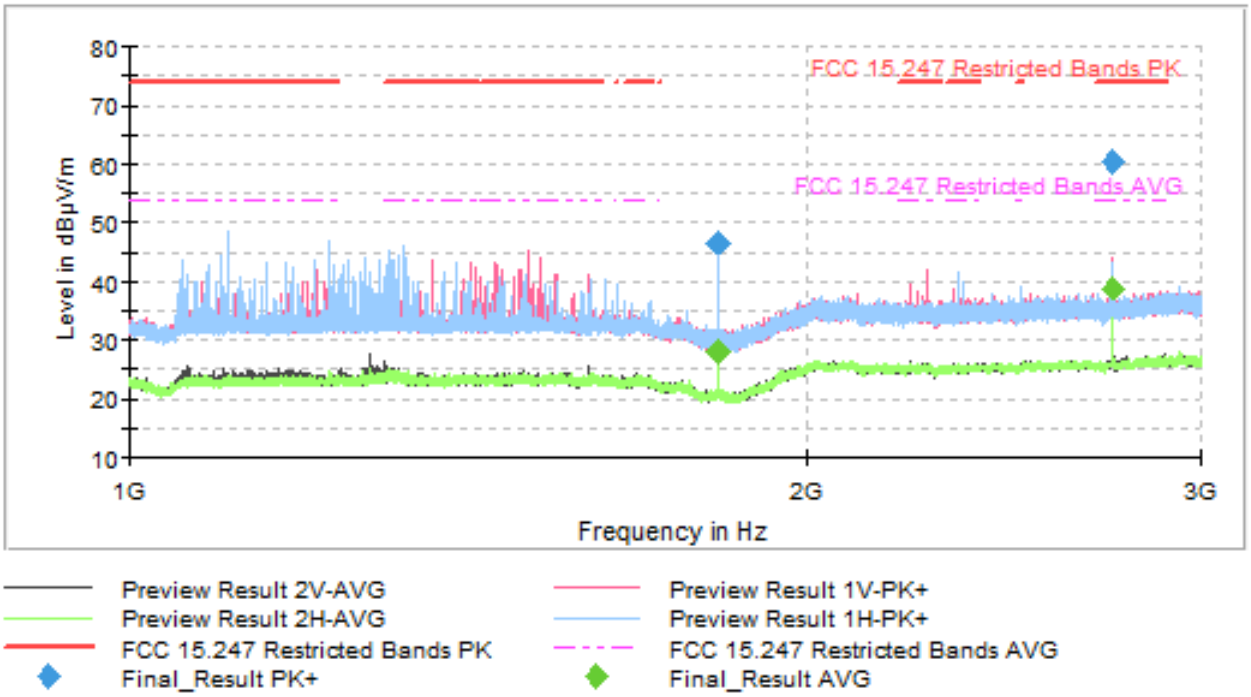
- Low Channel:



- Middle Channel:

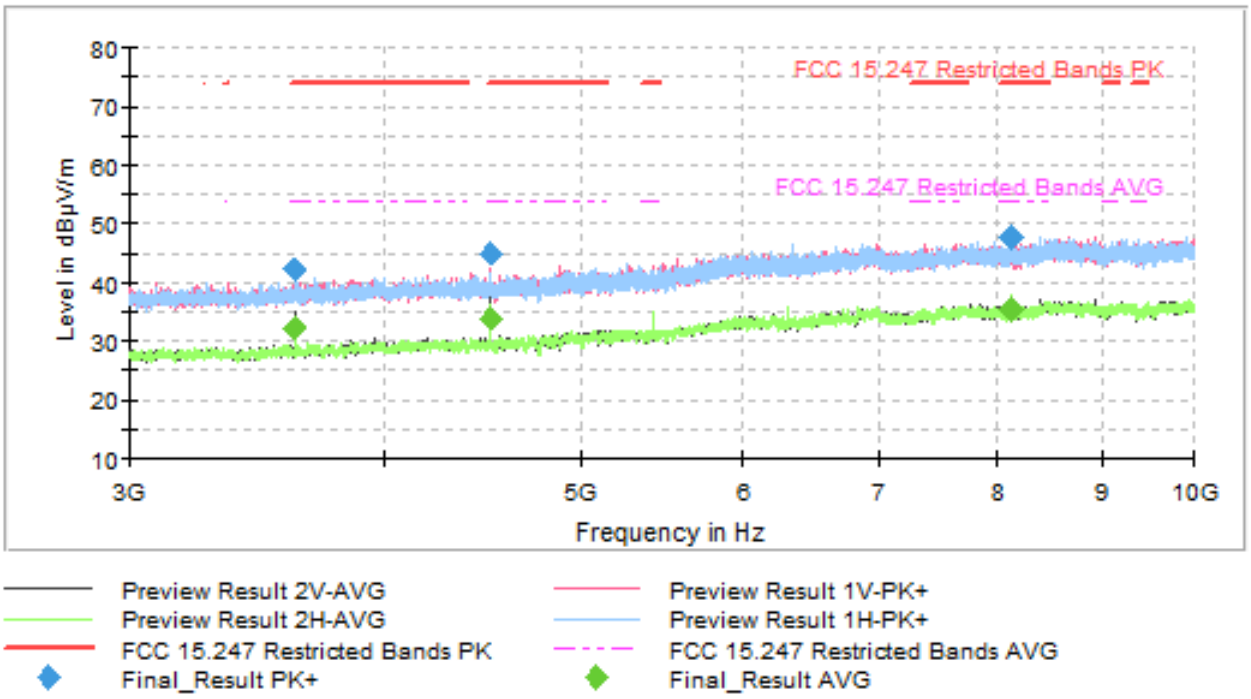


- High Channel:

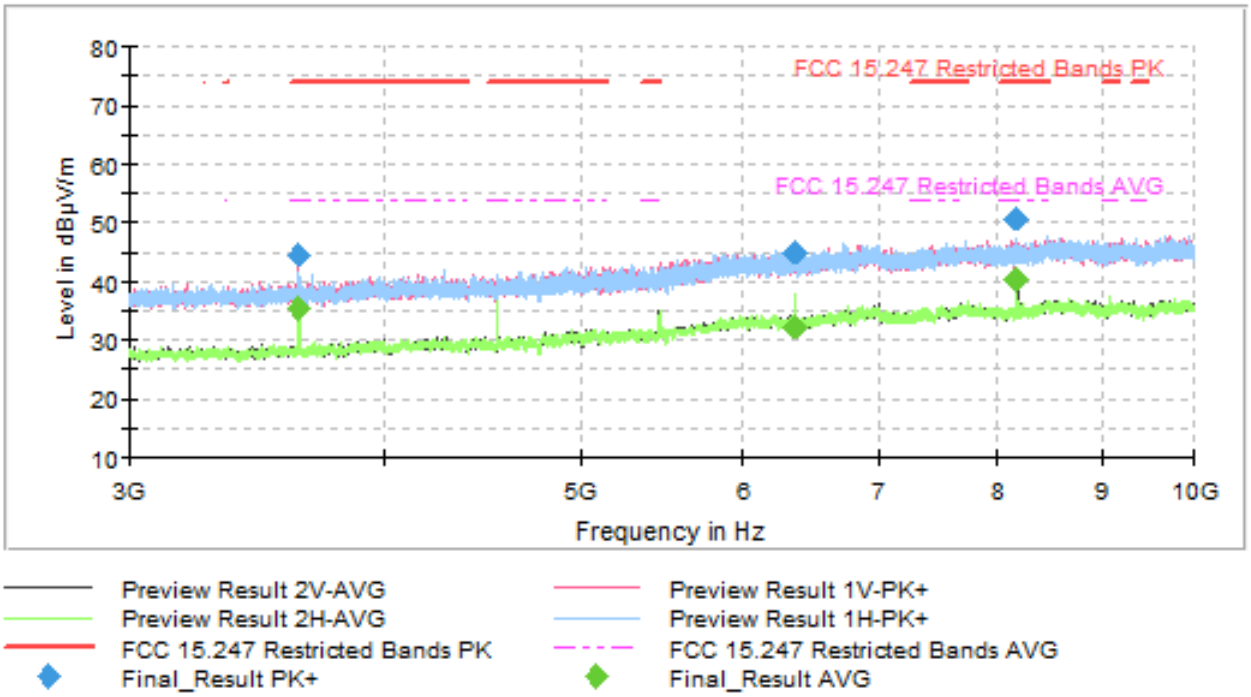


FREQUENCY RANGE 3 - 10 GHz:

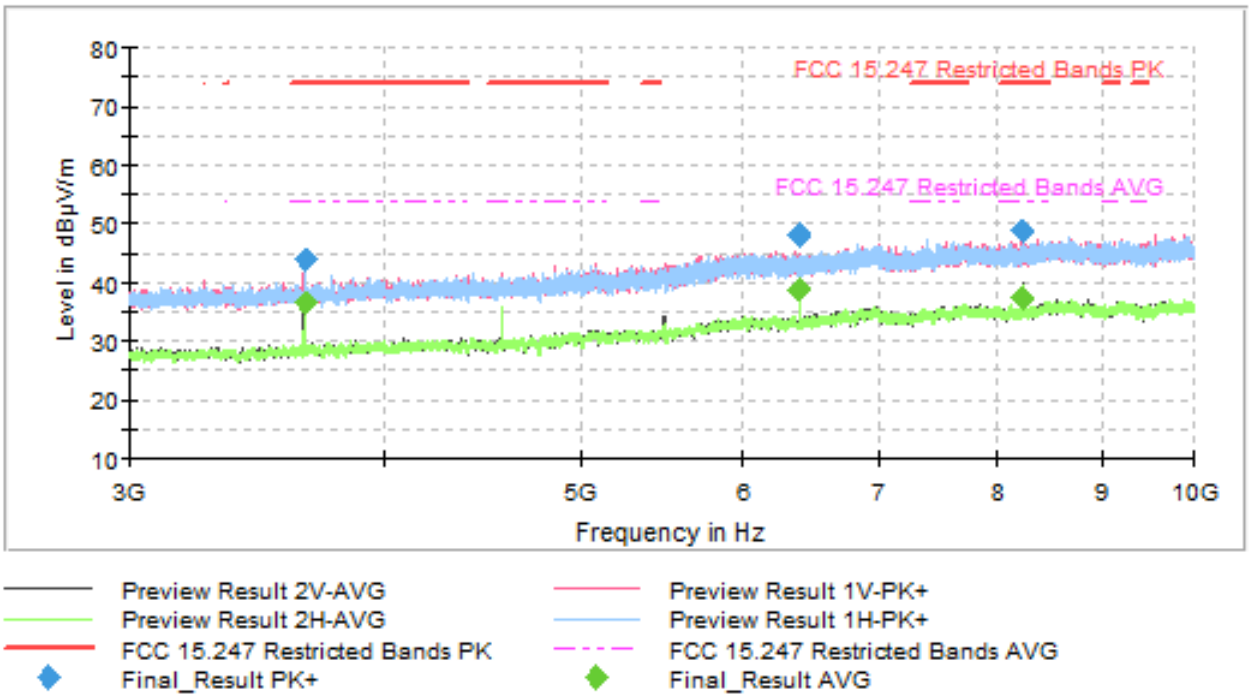
- Low Channel:



- Middle Channel:



- High Channel:


FCC 15.247 Restricted Bands PK
FCC 15.247 Restricted Bands AVG
Level in dBµV/m
80
70
60
50
40
30
20
10
3G
5G
6
7
8
9
10G
Frequency in Hz
Preview Result 2V-AVG
Preview Result 2H-AVG
FCC 15.247 Restricted Bands PK
Final_Result PK+
Preview Result 1V-PK+
Preview Result 1H-PK+
FCC 15.247 Restricted Bands AVG
Final_Result AVG