DEKRA Testing and Certification, S.A.U.
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c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

ENSAYOS Nº 51/LE147

Test report No:
NIE: 64461RRF.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	PCB Controller for Solar Tracking and Data Acquisition
(*) Trademark	DEEPTRACK
(*) Model and /or type reference	DBOARD
Other identification of the product	HW version: R3 SW version: 3.1.26.4 FCC ID: 2AVRXDBOARD31 IC ID: 26278-DBOARD31
(*) Features	LoRa/LoRaWAN EU868 and US915 communications, NFC tag, RS485
Applicant	DEEPTRACK S.L.U. Avda. De la Transición Española 32, Parque Empresarial Omega, Edificio A, 28108 Alcobendas, Madrid, Spain.
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)	José Carlos Luque RF Lab. Supervisor 74841983Y JOSE CARLOS LUQUE (C:A29507456) Firmado digitalmente por 74841983Y JOSE CARLOS LUQUE (C:A29507456) Fecha: 2020.09.29 10:27:57 +02'00'
Date of issue	2020-09-29
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.
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.
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 DBOARD is a device that allows remote control of motor and data acquisition for solar trackers in Photovoltaic Industry.

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 M/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
64461C/010	PCB Controller for Solar Tracking and Data Acquisition	DBOARD	--	2020/06/23

Sample M/01 has undergone the following test(s): All RADIATED tests indicated in Appendix A.

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

Control Nº	Description	Model	Serial Nº	Date of reception
64461C/011	PCB Controller for Solar Tracking and Data Acquisition	DBOARD	--	2020/06/23

Auxiliary elements used with the Sample M/02:

Control Nº	Description	Model	Serial Nº	Date of reception
64461C/002	Power Supply 24 Vdc	IFR26650	PVFB015751	2020/06/23

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

Test sample description

Ports…… :	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)
	RS485		☒	☐	☐
	RS485		☒	☐	☐
	SPI		☐	☐	☐
	DIOS		☐	☐	☐
			☐	☐	☐
			☐	☐	☐
Supplementary information to the ports……:					

Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 24 Vdc					
	☐	DC:					
Rated Power .....:	0.75W						
Clock frequencies .....:	32MHz						
Other parameters.....:							
Software version .....:	3.1.26.4						
Hardware version.....:	R3						
Dimensions in cm (W x H x D)....:	11.0x11.5x3.5						
Mounting position.....:	☐	Table top equipment					
	☐	Wall/Ceiling mounted equipment					
	☐	Floor standing equipment					
	☐	Hand-held equipment					
	☒	Other: Outdoor Field Environment					

Modules/parts .....:	Module/parts of test item	Type	Manufacturer

Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	MODBUS Inclinometer		RION
	LiFePO Battery		FBTECH

Documents as provided by the applicant.....:	Description	File name	Issue date

(3) Only for Medical Equipment

Identification of the client

DEEPTRACK S.L.U.

Avda. De la Transición Española 32, Parque Empresarial Omega, Edificio A, 28108 Alcobendas, Madrid, Spain.

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2020-07-21
Date (finish)	2020-08-24

Document history

Report number	Date	Description
64461RRF.001	2020-09-29	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: Javier Miguel Nadales and Miguel Manuel López.

Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
2.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2019/10	2021/10
3.	Digital Multimeter FLUKE 179	2019/09	2020/09

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
3.	Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2017/09	2020/09
4.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
5.	DC Power Supply, 30V/5A KEYSIGHT TECHNOLOGIES U8002A	N.A.	N.A.
6.	Digital Multimeter, FLUKE 175	2019/10	2020/10
7.	Horn Antenna 1-18GHz, HEWLETT PACKARD 11966E	2018/10	2021/10
8.	RF Pre-amplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2019/11	2020/11
9.	Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2019/10	2021/10

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	
FCC 15.247 (a)(1)(iii) / 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) / 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 (f) / RSS-247 5.3. (b)	Power spectral density for hybrid systems	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):

V nonimal:	24 Vdc
Type of power supply:	LiFePO Battery.

ANTENNA:

Type of Antenna:	Internal (Discrete Antenna Booster)
Maximum Declared Assembly Gain:	+4.5 dBi

TEST FREQUENCIES:

Low Channel:	902.3 MHz
Middle Channel:	908.5 MHz
High Channel:	914.9 MHz

The equipment can operate as a hybrid 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 DC supply voltage is applied using an external calibrated power supply.

RADIATED MEASUREMENTS

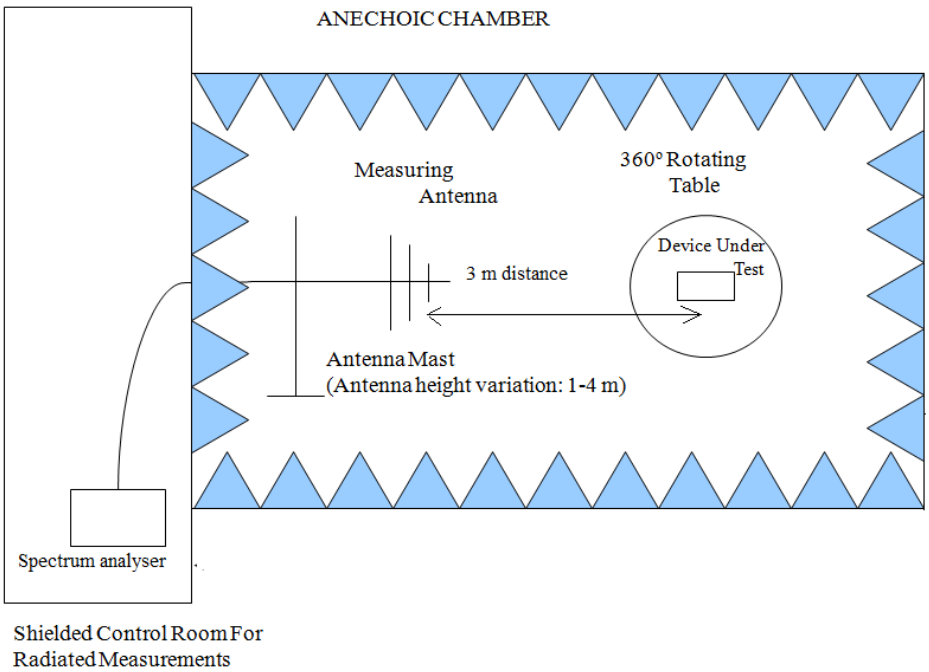
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz and 1 GHz-10 GHz Double ridge horn antenna) is situated at a distance of 3 m.

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.

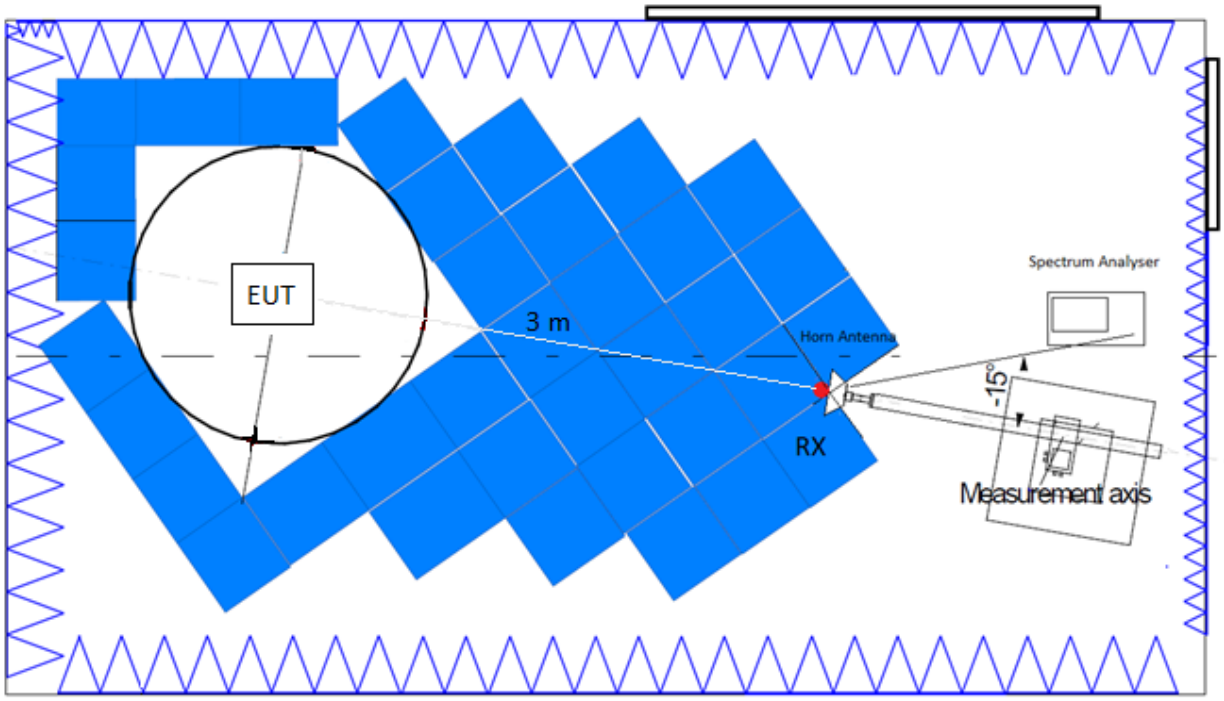
Measurements were made in both horizontal and vertical planes of polarization.

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

SPECIFICATION:

FCC §2.1049. Measurements required: Occupied bandwidth.

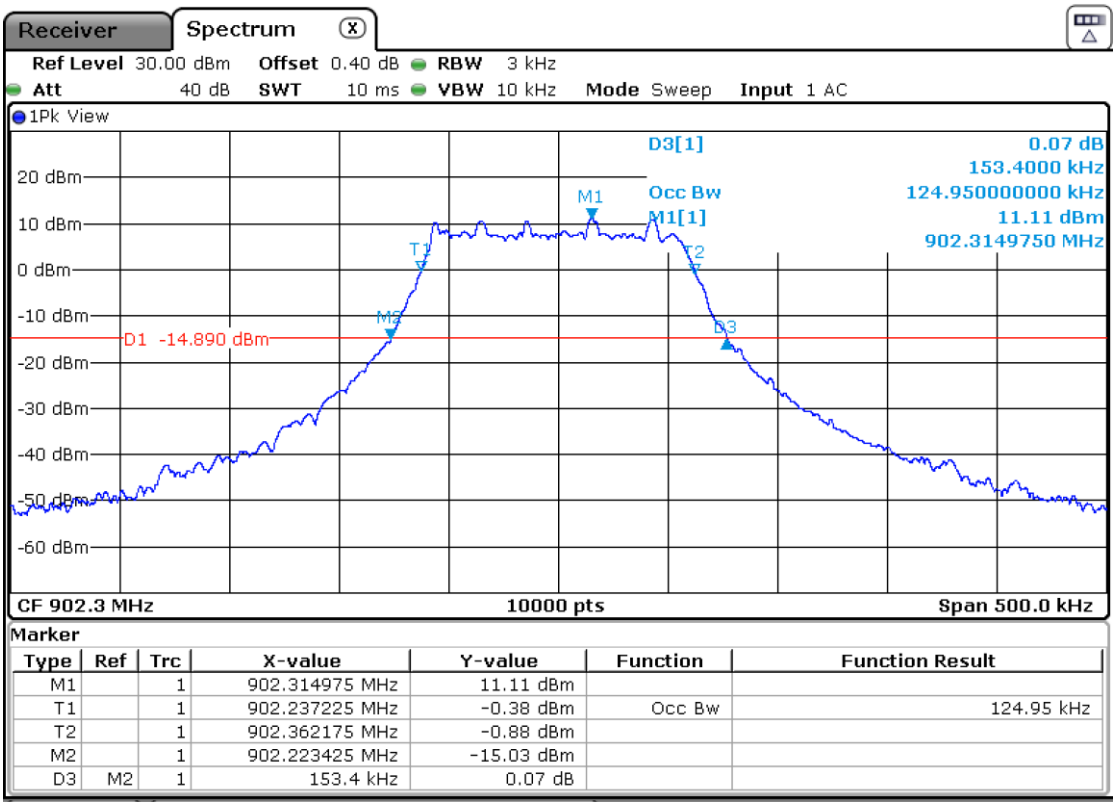
RSS-Gen Clause 6.7.

RESULTS:

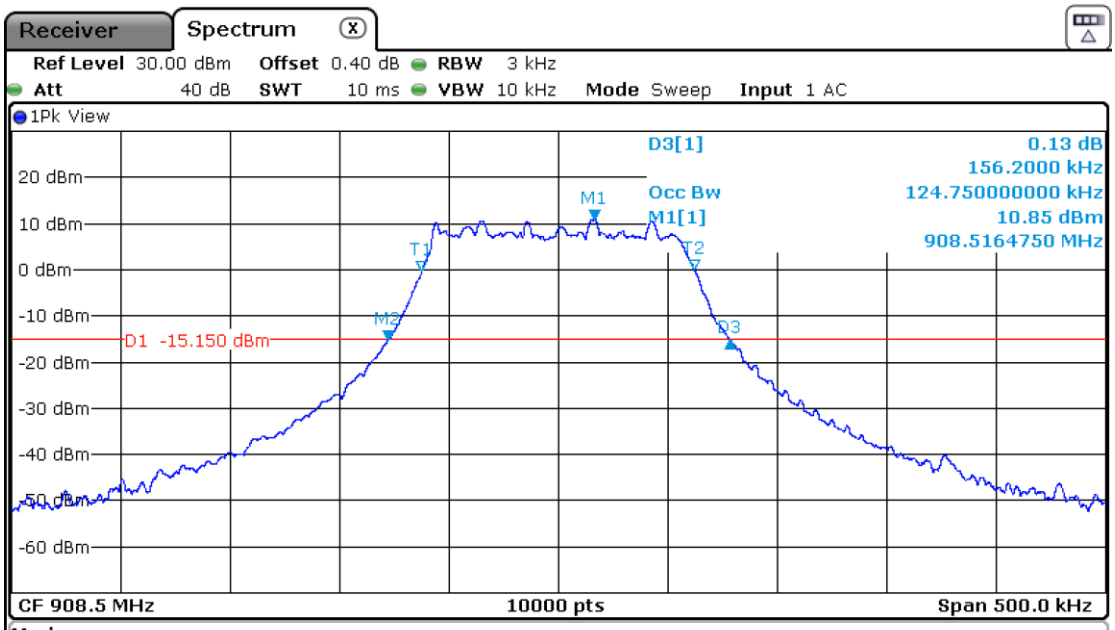
	Lowest Channel 902.3 MHz	Middle Channel 908.5 MHz	Highest Channel 914.9 MHz
99% bandwidth (kHz)	124.95	124.75	125
-26 dBc bandwidth (kHz)	153.4	156.2	154.55
Measurement uncertainty (kHz)	<± 0.52		

Verdict: PASS

Lowest Channel:



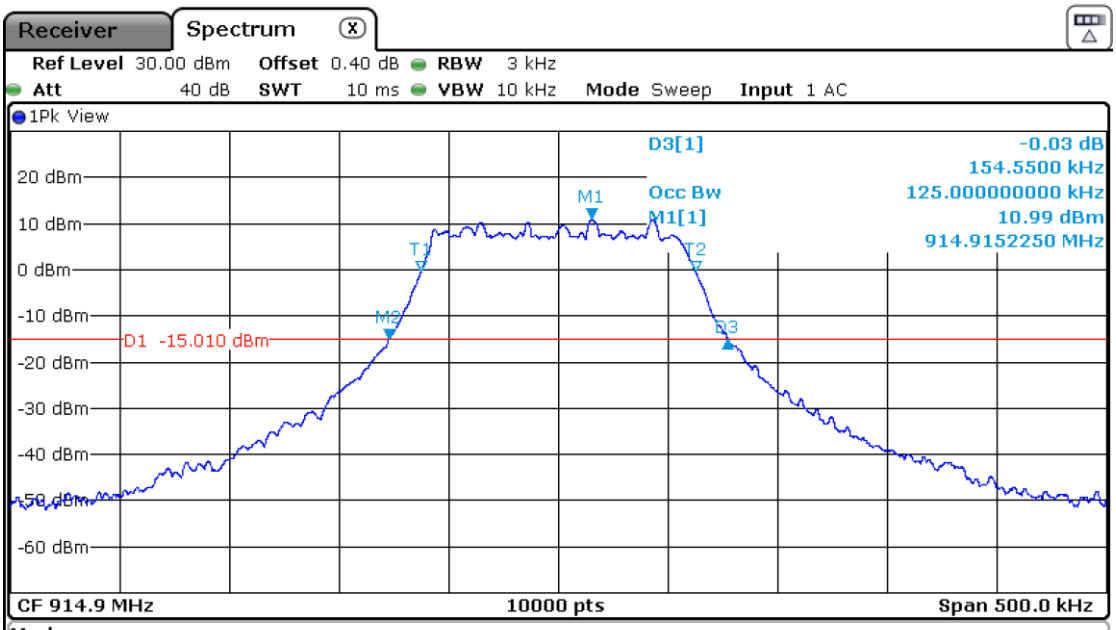
Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	908.516475 MHz	10.85 dBm		
T1		1	908.437525 MHz	-0.36 dBm	Occ Bw	124.75 kHz
T2		1	908.562275 MHz	-0.18 dBm		
M2		1	908.422025 MHz	-15.30 dBm		
D3	M2	1	156.2 kHz	0.13 dB		

High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.915225 MHz	10.99 dBm		
T1		1	914.837425 MHz	-0.33 dBm	Occ Bw	125.0 kHz
T2		1	914.962425 MHz	-0.34 dBm		
M2		1	914.822525 MHz	-15.04 dBm		
D3	M2	1	154.55 kHz	-0.03 dB		

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

SPECIFICATION:

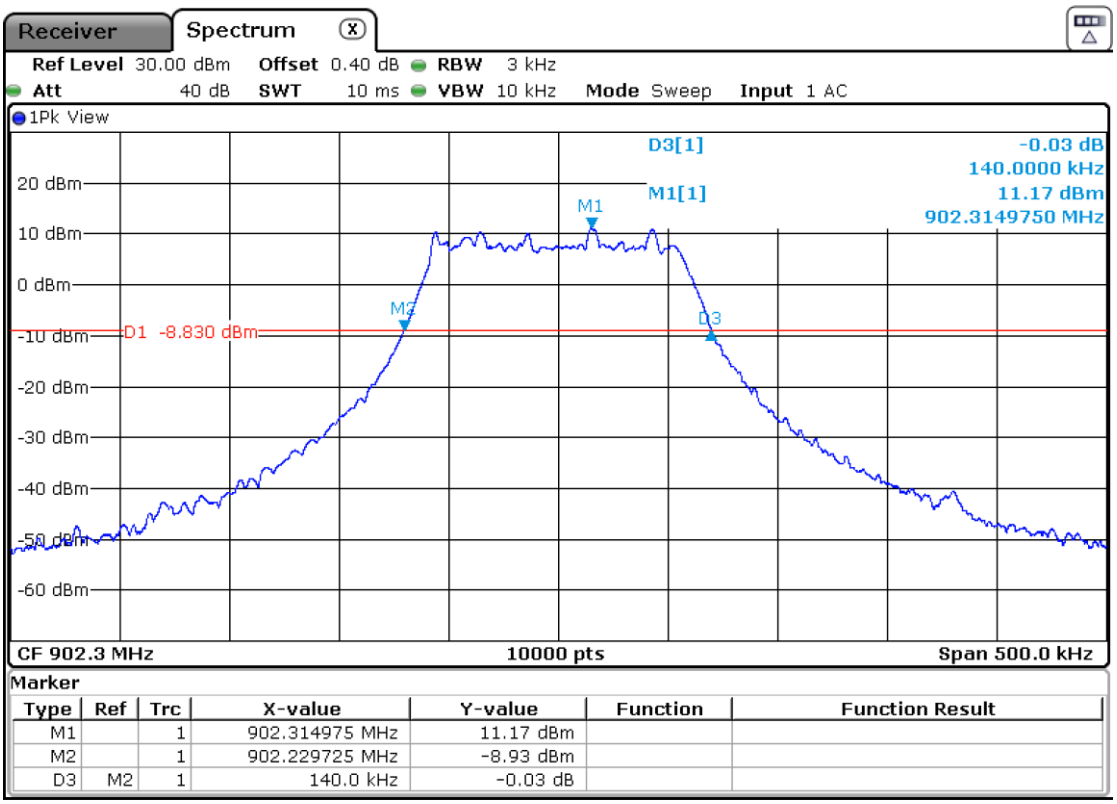
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

RESULTS:

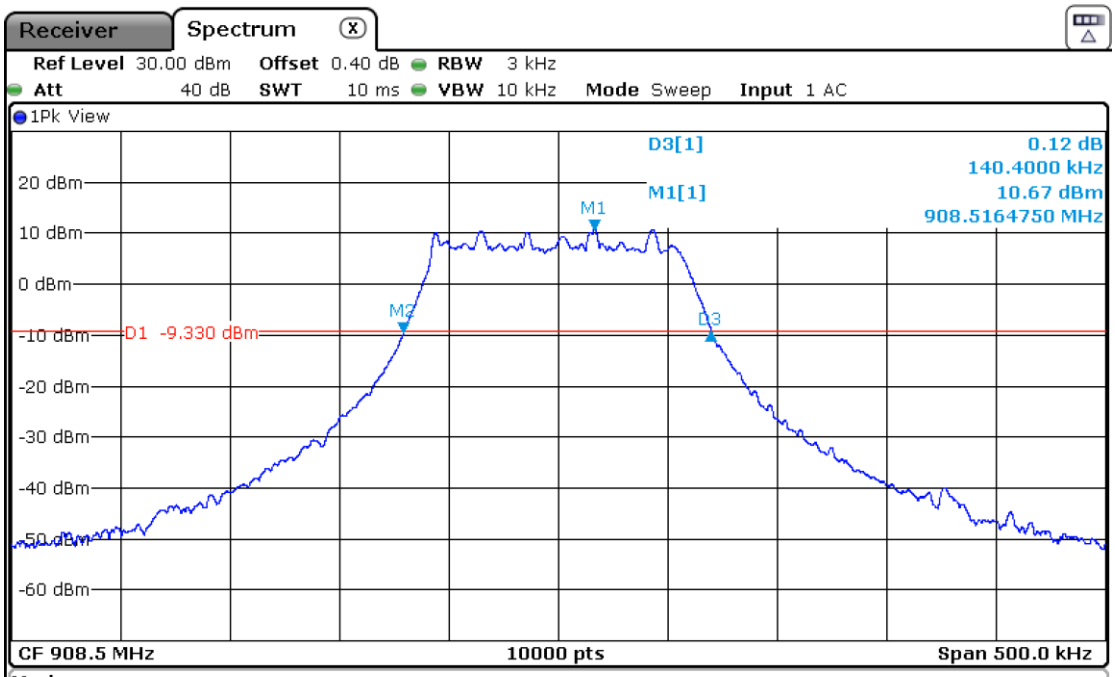
	Lowest Channel 902.3 MHz	Middle Channel 908.5 MHz	Highest Channel 914.9 MHz
20 dB Spectrum bandwidth (kHz)	140	140.4	140.65
Measurement uncertainty (kHz)	<± 0.52		

Verdict: PASS

Lowest Channel:



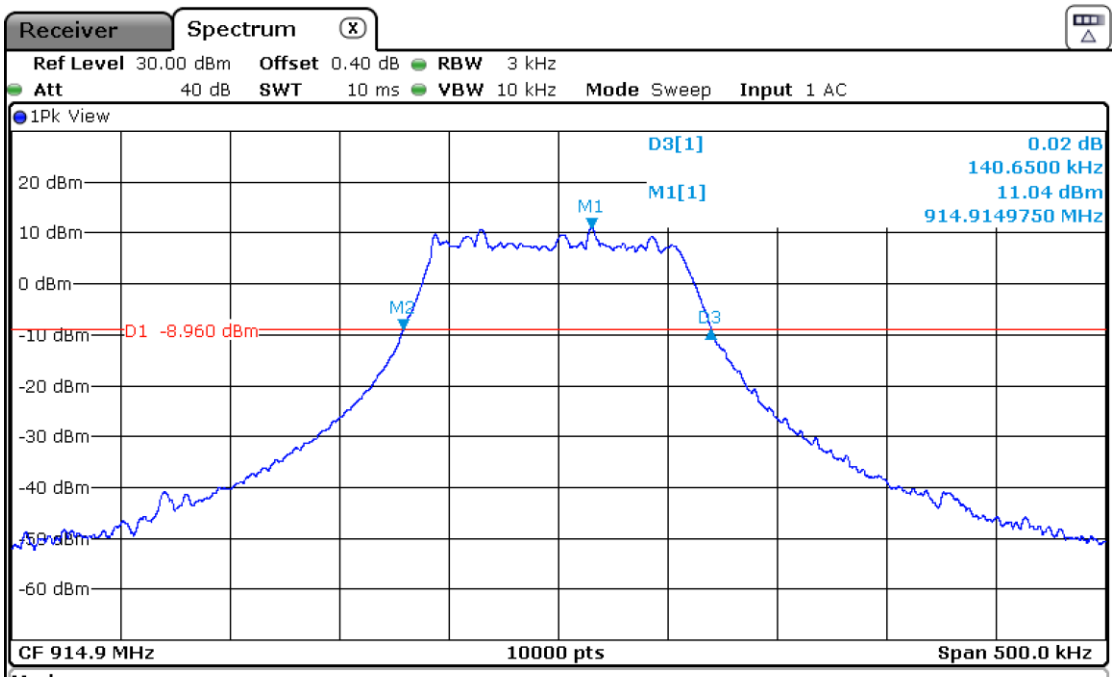
Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	908.516475 MHz	10.67 dBm		
M2		1	908.429425 MHz	-9.40 dBm		
D3	M2	1	140.4 kHz	0.12 dB		

Highest Channel:

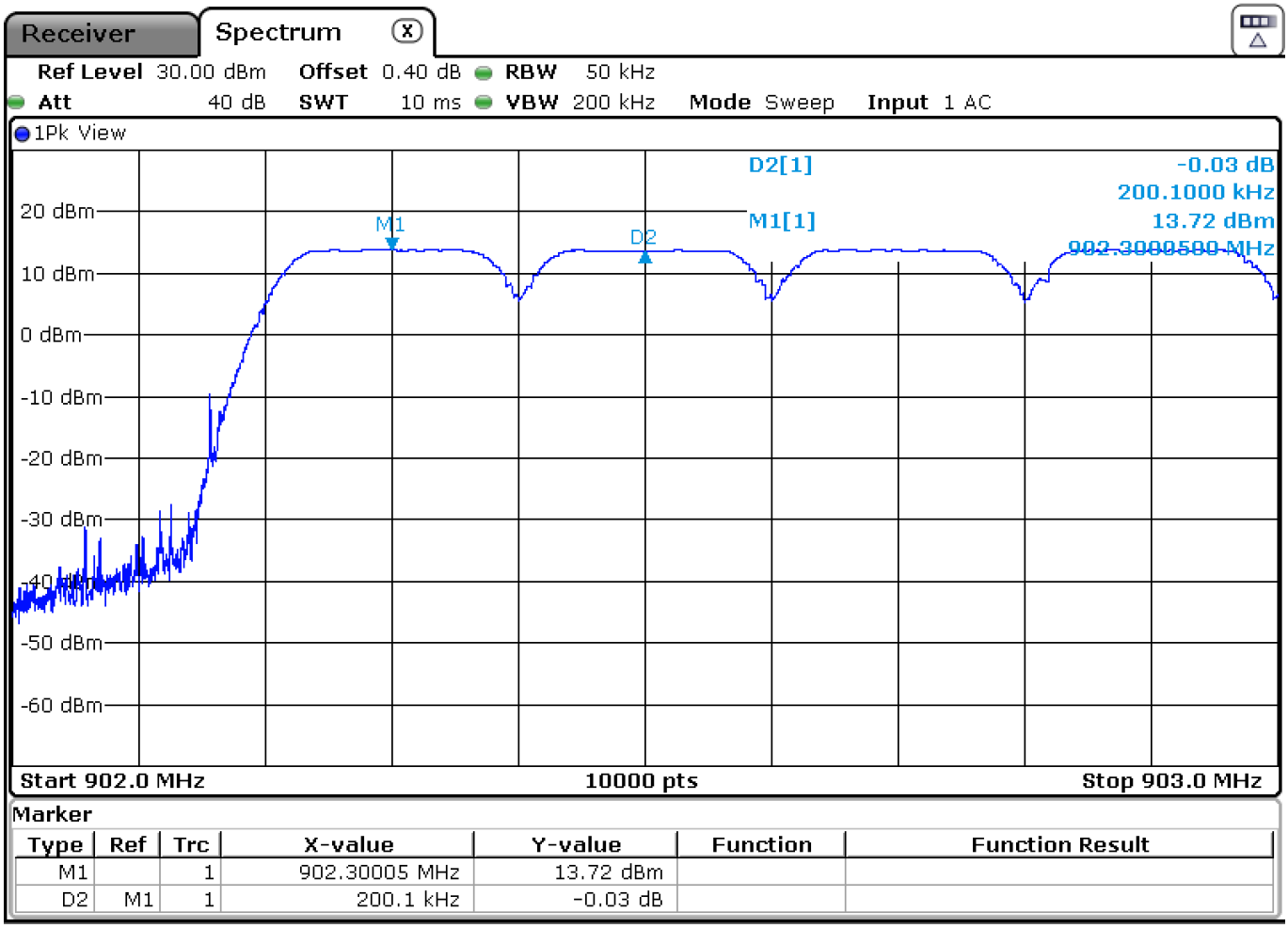


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.914975 MHz	11.04 dBm		
M2		1	914.829025 MHz	-8.99 dBm		
D3	M2	1	140.65 kHz	0.02 dB		

Carrier frequency separation

200.1 kHz



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

Verdict: PASS

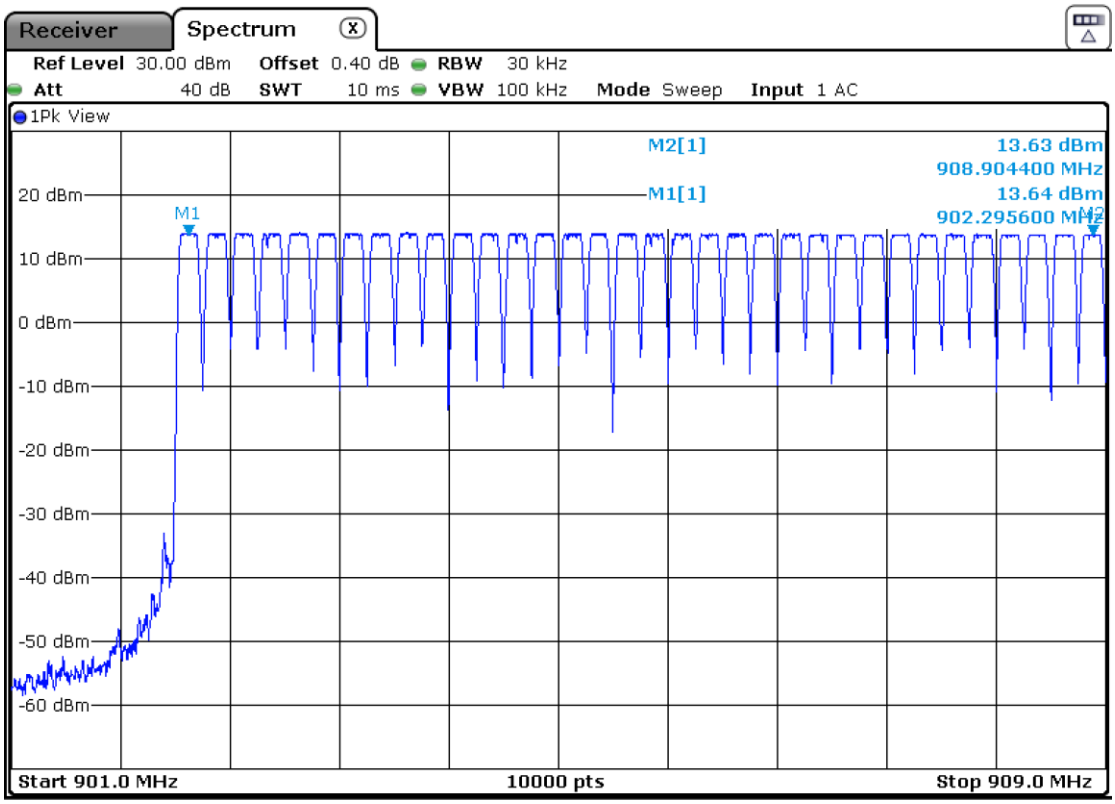
FCC 15.247 (a) (1) (iii) / RSS-247 5.1. (c) Number of hopping channels

SPECIFICATION:

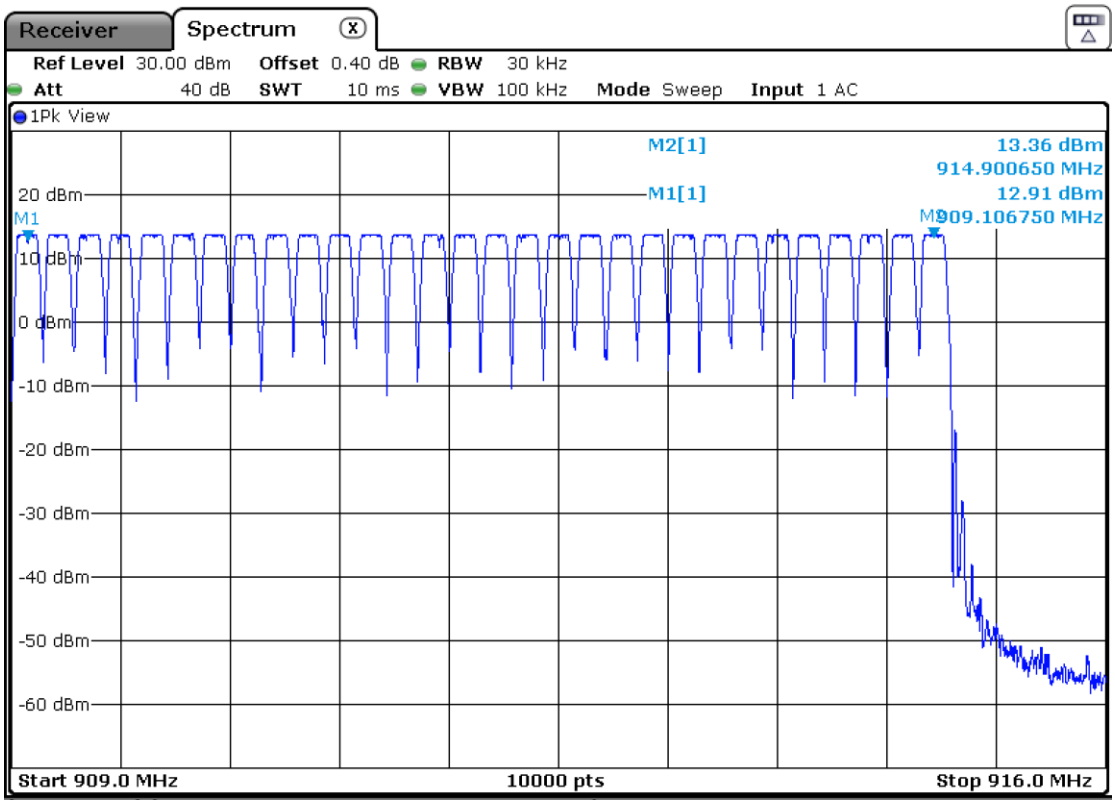
For frequency hopping systems operating in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the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

RESULTS:

The maximum number of hopping channels is 64 when the equipment operates as a frequency hopping system (see next plots).



Number of hopping frequencies: 34



Number of hopping frequencies: 34

Verdict: PASS

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

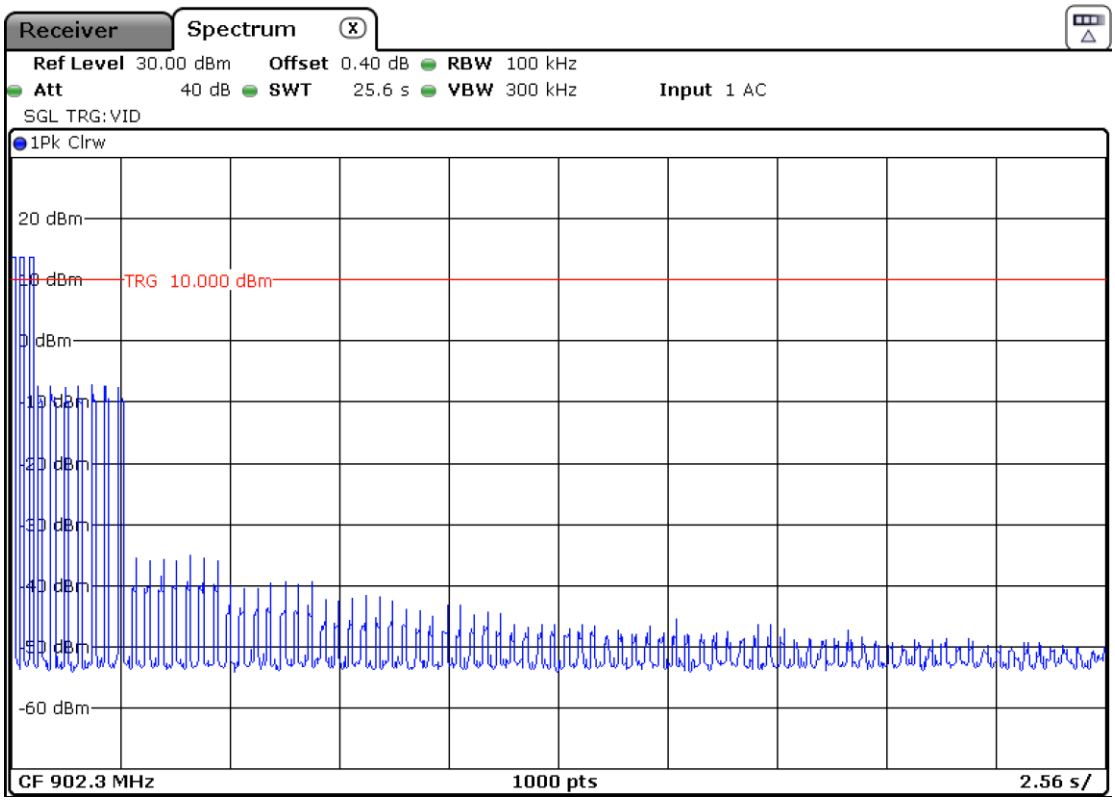
SPECIFICATION:

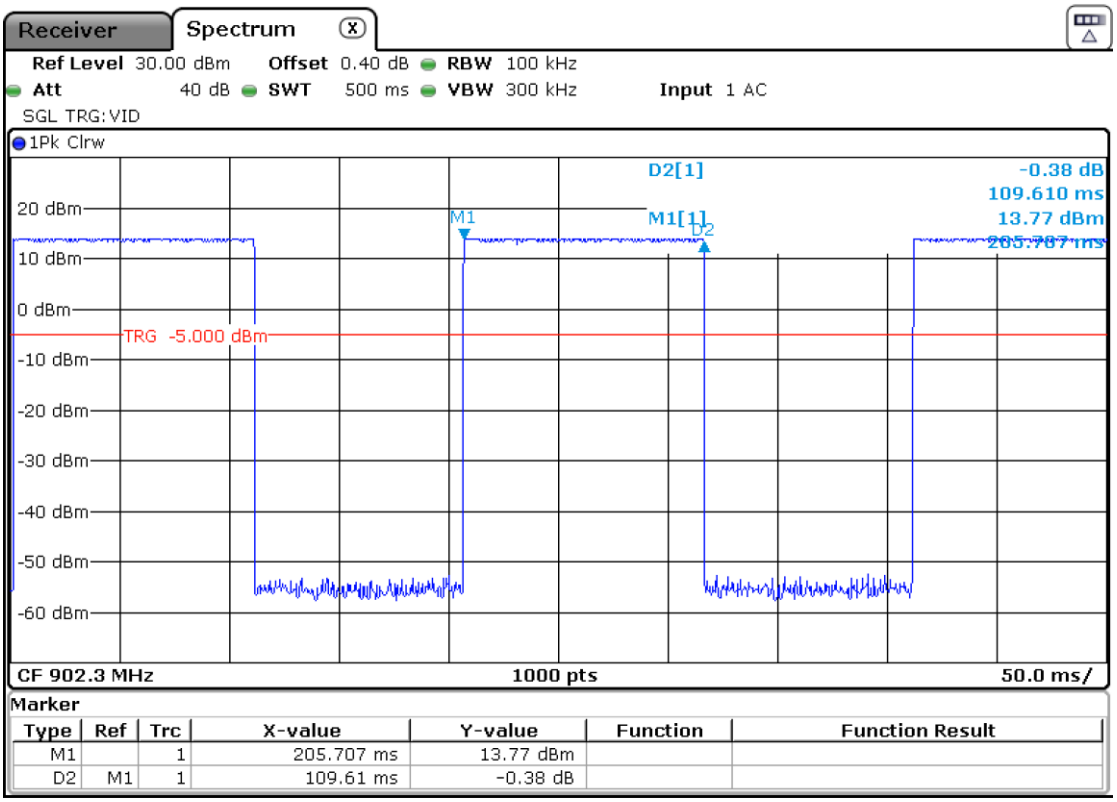
For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy 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: 109.61 ms (see next plots)
- Number of hops over a period of 25.6 s: 3 (see next plots)





- **Average Time of Occupancy** = 109.61 ms x 3 hops = 328.83 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)	<±1.02

Verdict: PASS

FCC 15.247 (b) / 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 maximum conducted (average) output power was measured using the method AVGSA-1 (trace averaging across on and off times of the EUT transmissions) according to point 11.9.2.2.2 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: +4.5 dBi

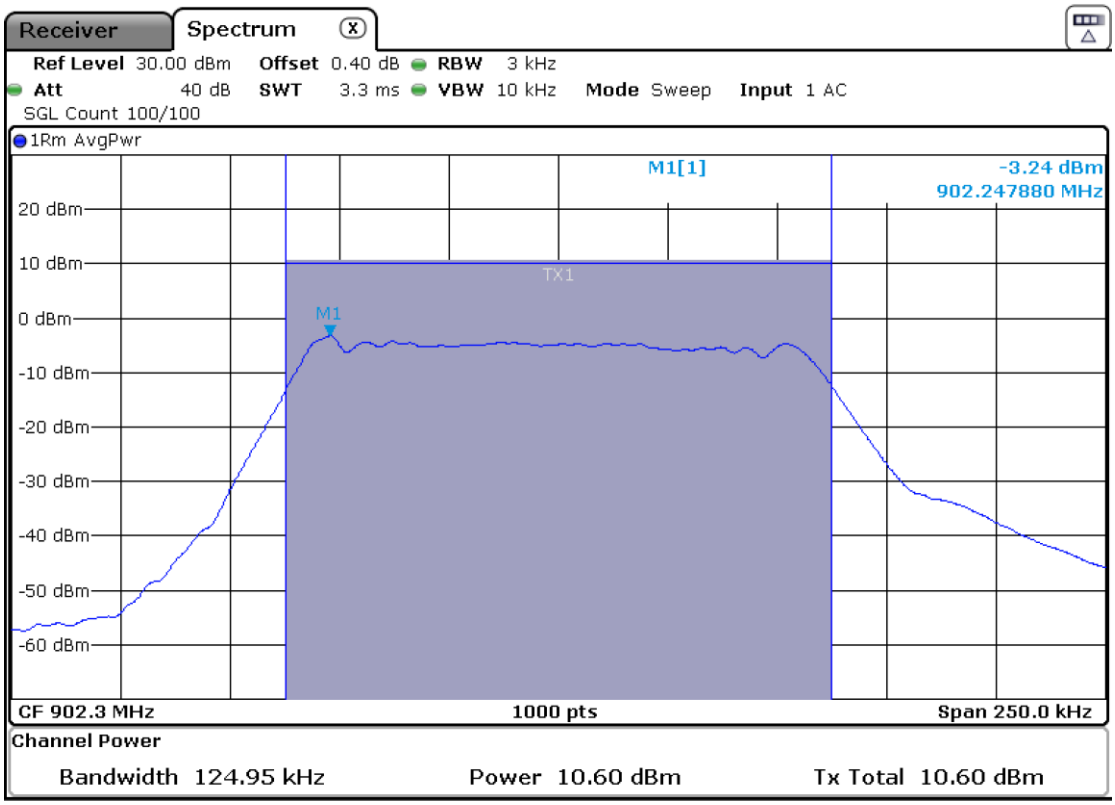
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

	Lowest Channel 902.3 MHz	Middle Channel 908.5 MHz	Highest Channel 914.9 MHz
Maximum Average Conducted Power (dBm)	10.6	11.58	10.81
Duty Cycle Correction (dB)	2.692		
Max. conducted power corrected (dBm)	13.29	14.27	13.50
Maximum EIRP Power with Duty Cycle Correction (dBm)	17.79	18.77	18.00
Measurement uncertainty (dB)	<±2.57		

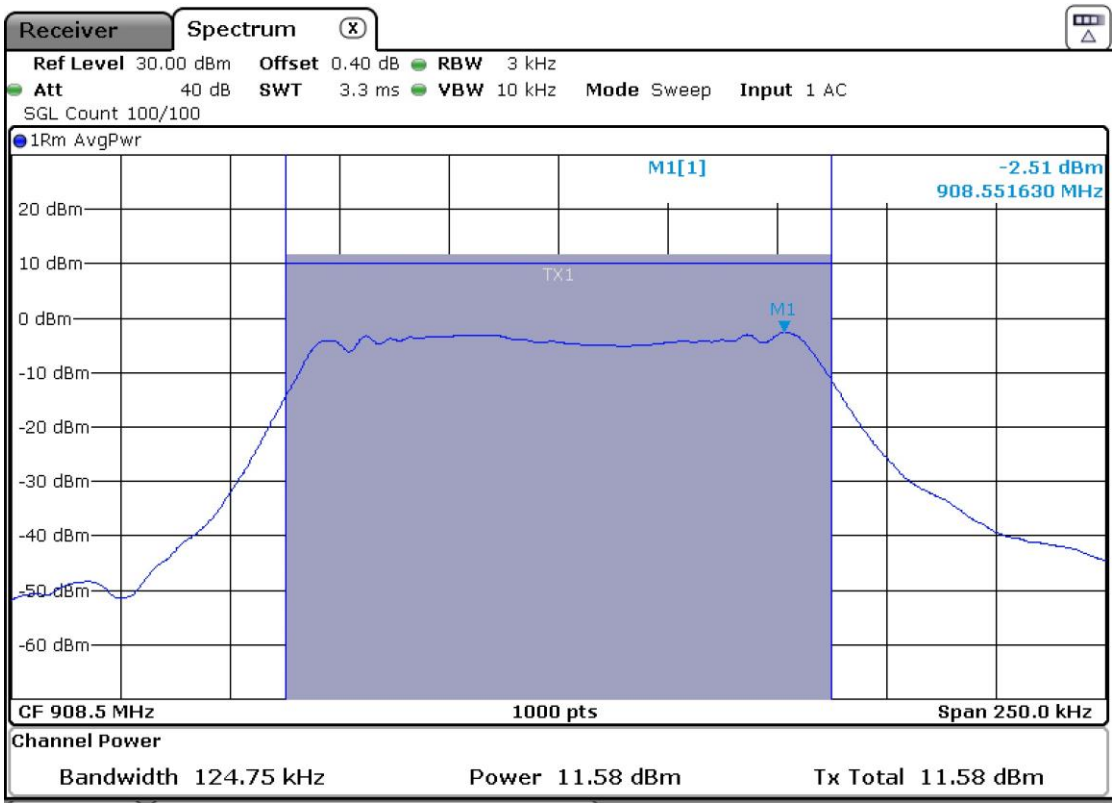
Verdict: PASS

Maximum Average Output Power:

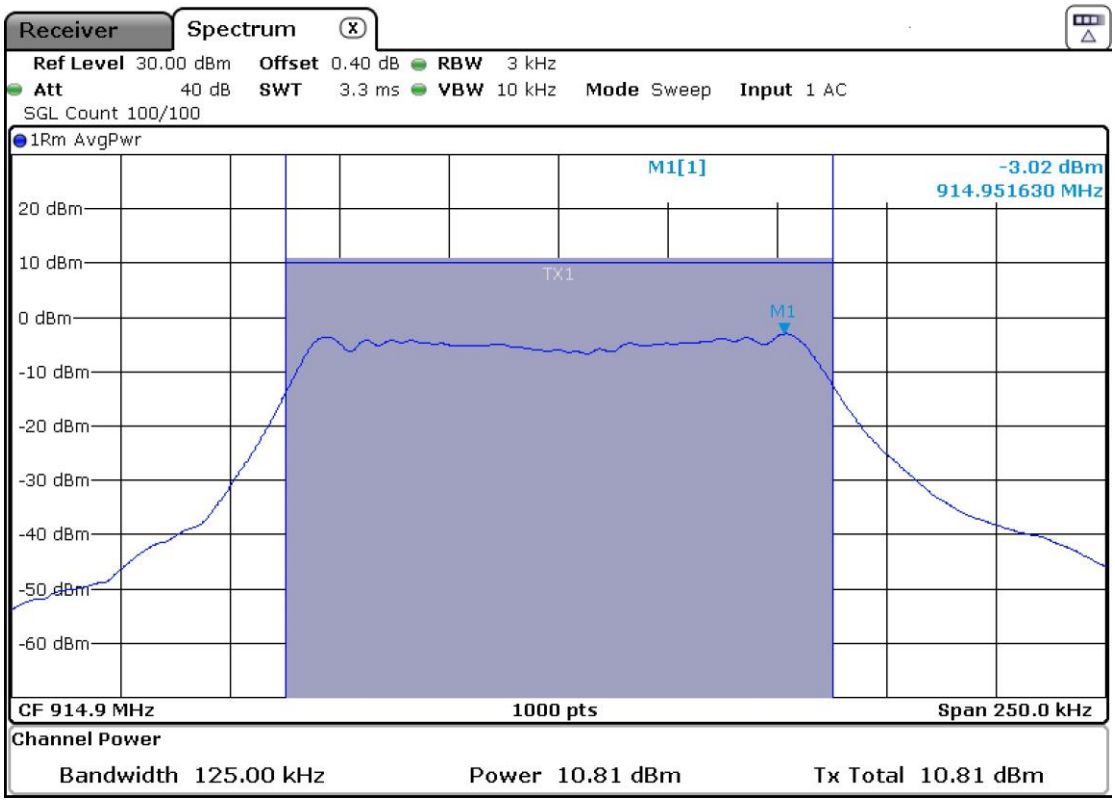
Lowest Channel:



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.

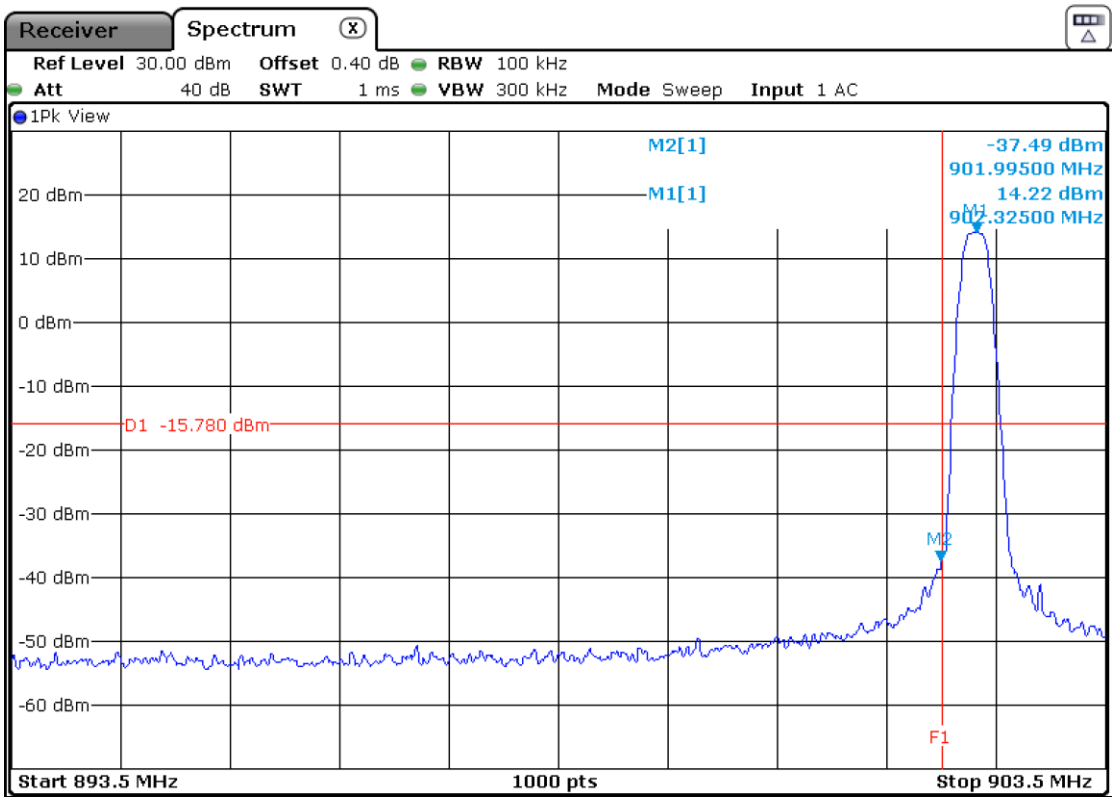
If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

RESULTS:

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

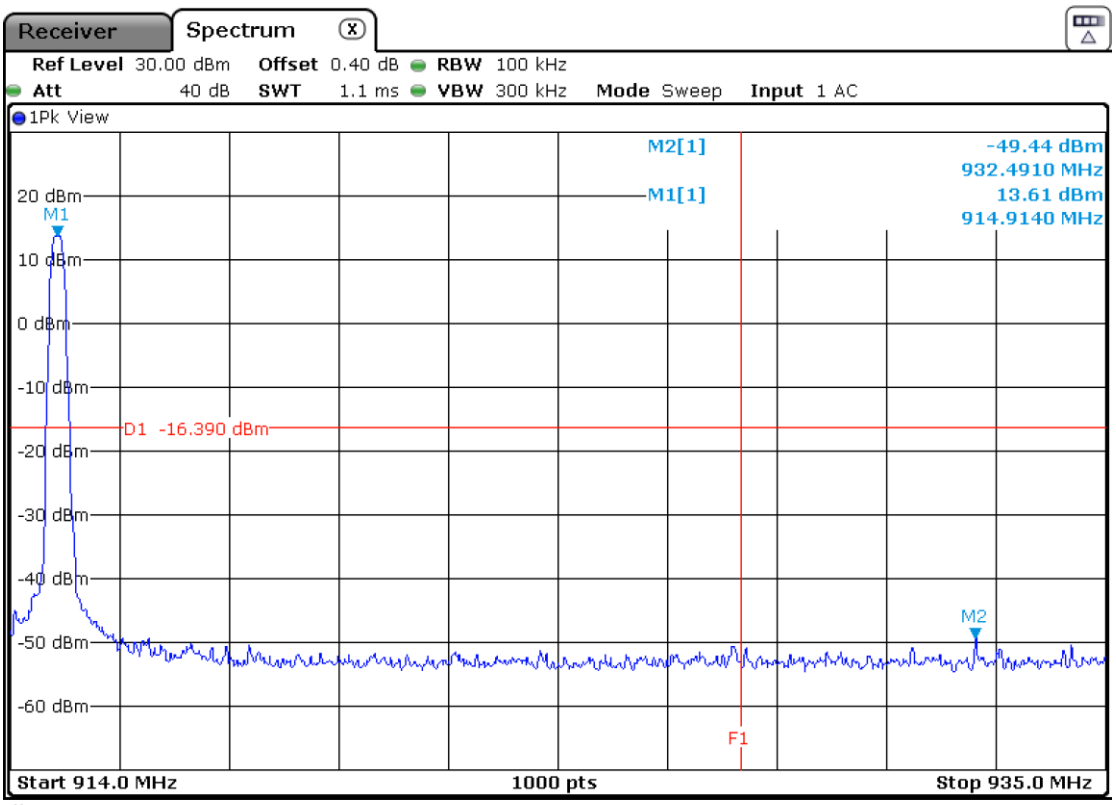
- HOPPING OFF:

  - LOW FREQUENCY SECTION:



Verdict: PASS

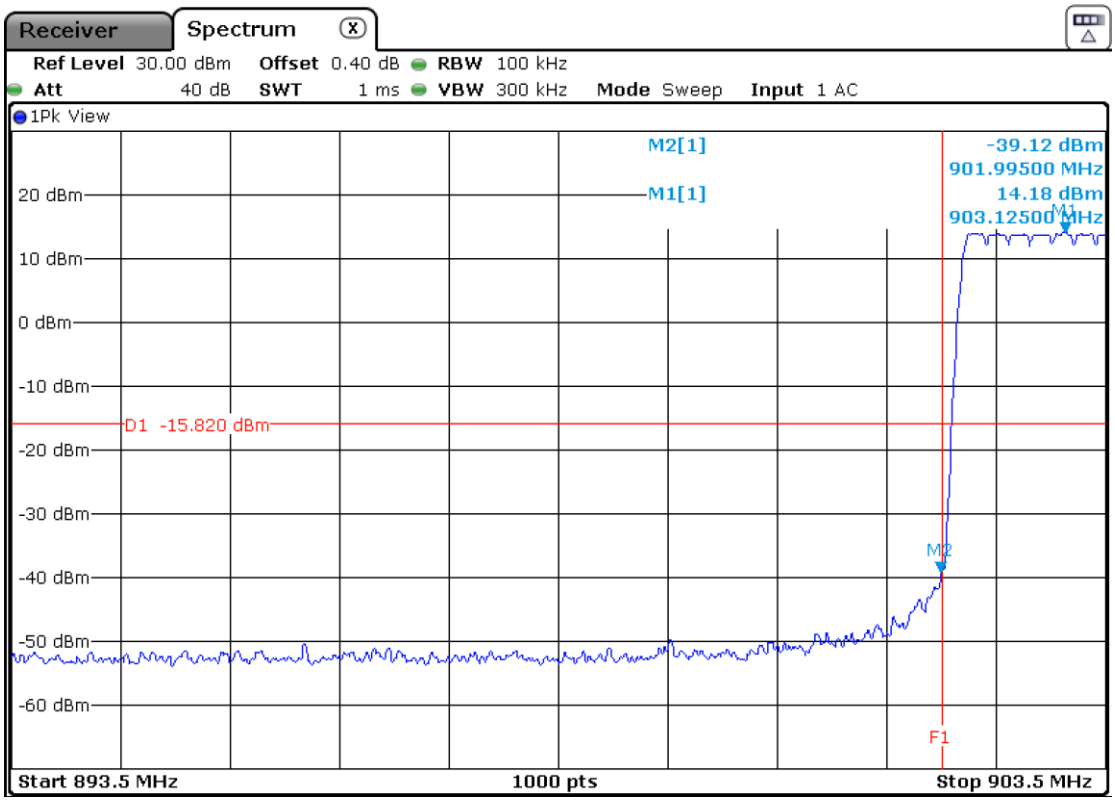
- HIGH FREQUENCY SECTION:



Verdict: PASS

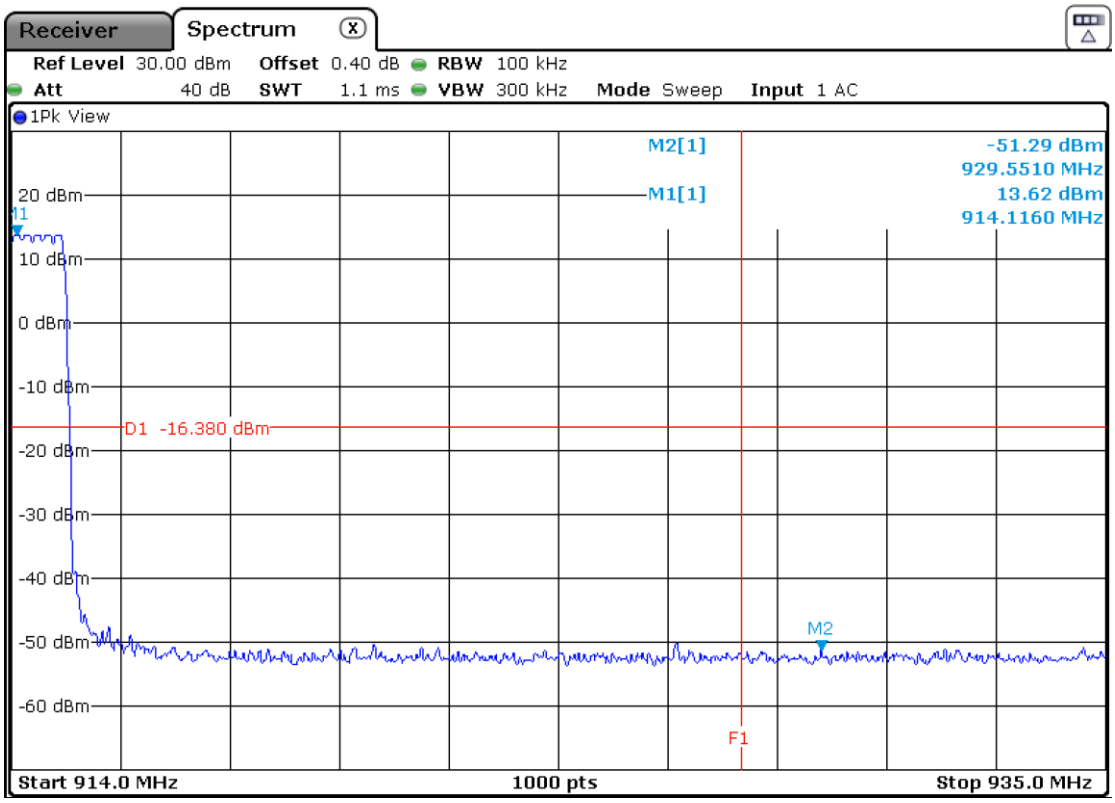
- HOPPING ON:

  - LOW FREQUENCY SECTION:



Verdict: PASS

- HIGH FREQUENCY SECTION:



Verdict: PASS

Measurement uncertainty (dB)	<±2.57

FCC 15.247 (f) / RSS-247 5.3. (b) Power spectral density for hybrid systems

SPECIFICATION:

For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.

The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

RESULTS:

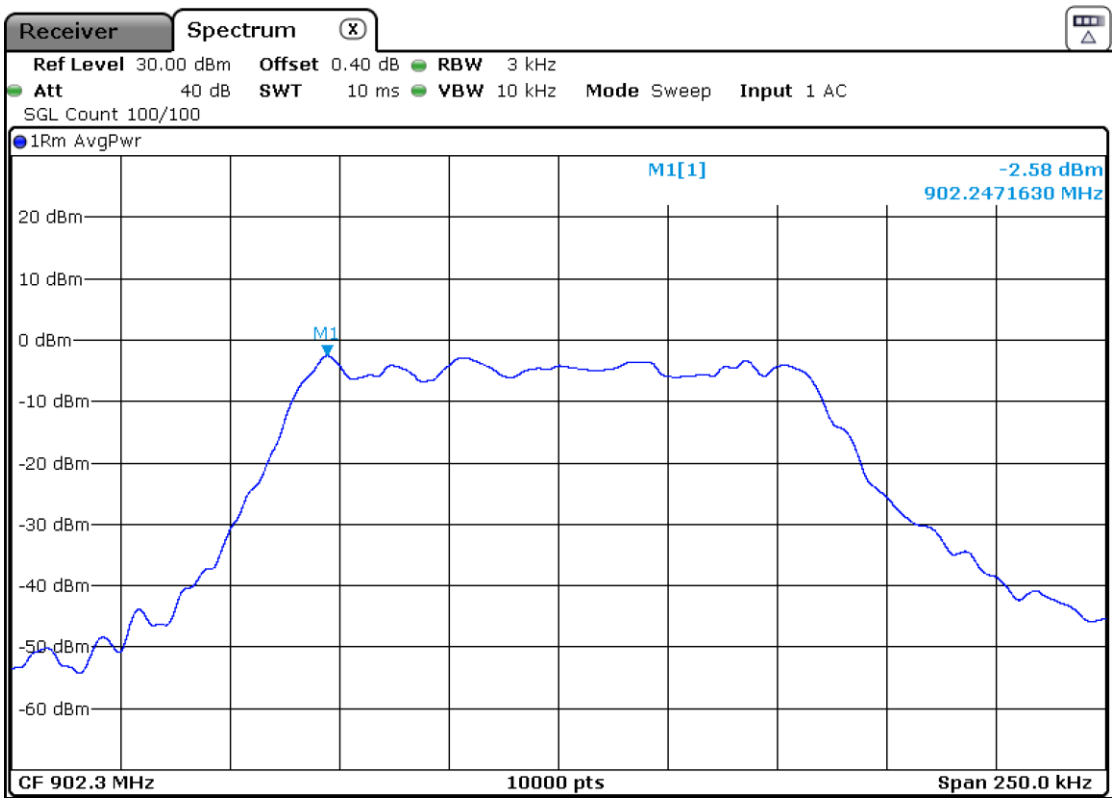
The maximum power spectral density level was measured using the method AVGPSD-1 according to point 11.10.3 of ANSI C.63.10-2013.

	Lowest Channel 902.3 MHz	Middle Channel 908.5 MHz	Highest Channel 914.9 MHz
Average Power Spectral Density (dBm)	-2.58	-2.17	-2.85
Duty Cycle (dB)	2.692		
Average Power Spectral Density with Duty Cycle Correction (dBm)	0.112	0.522	-0.158
Measurement uncertainty (dB)	<±2.57		

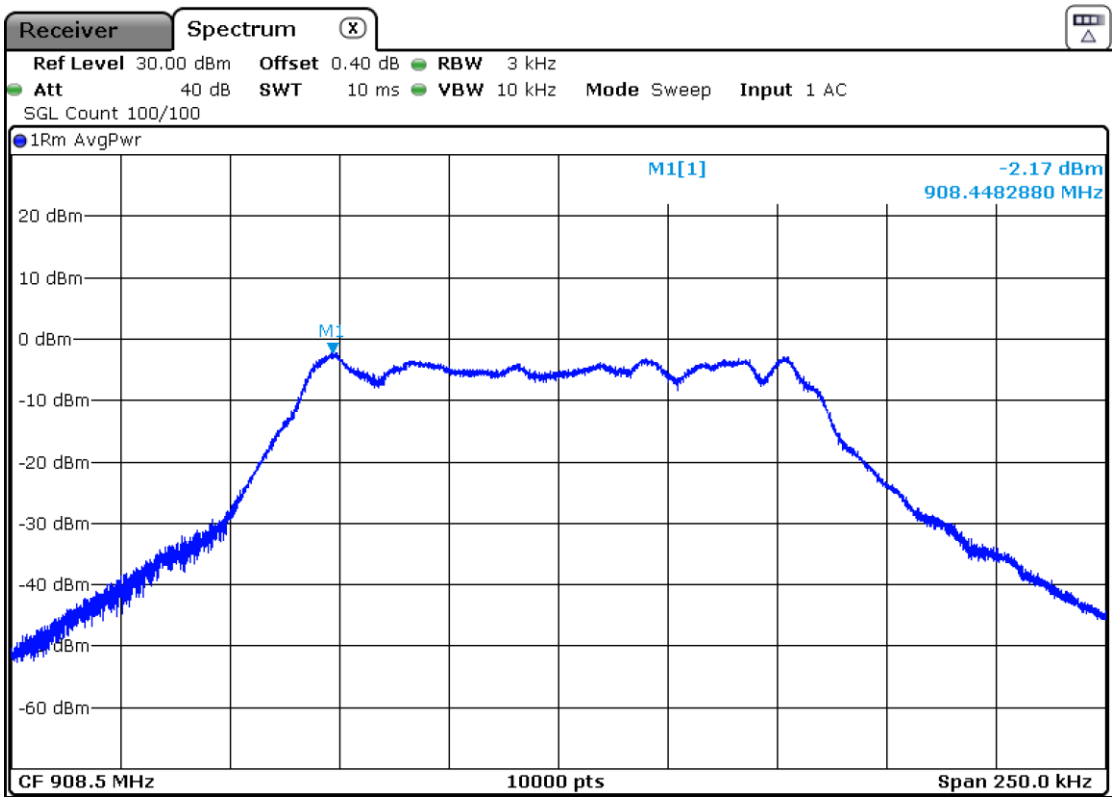
Verdict: PASS

Power Spectral Density:

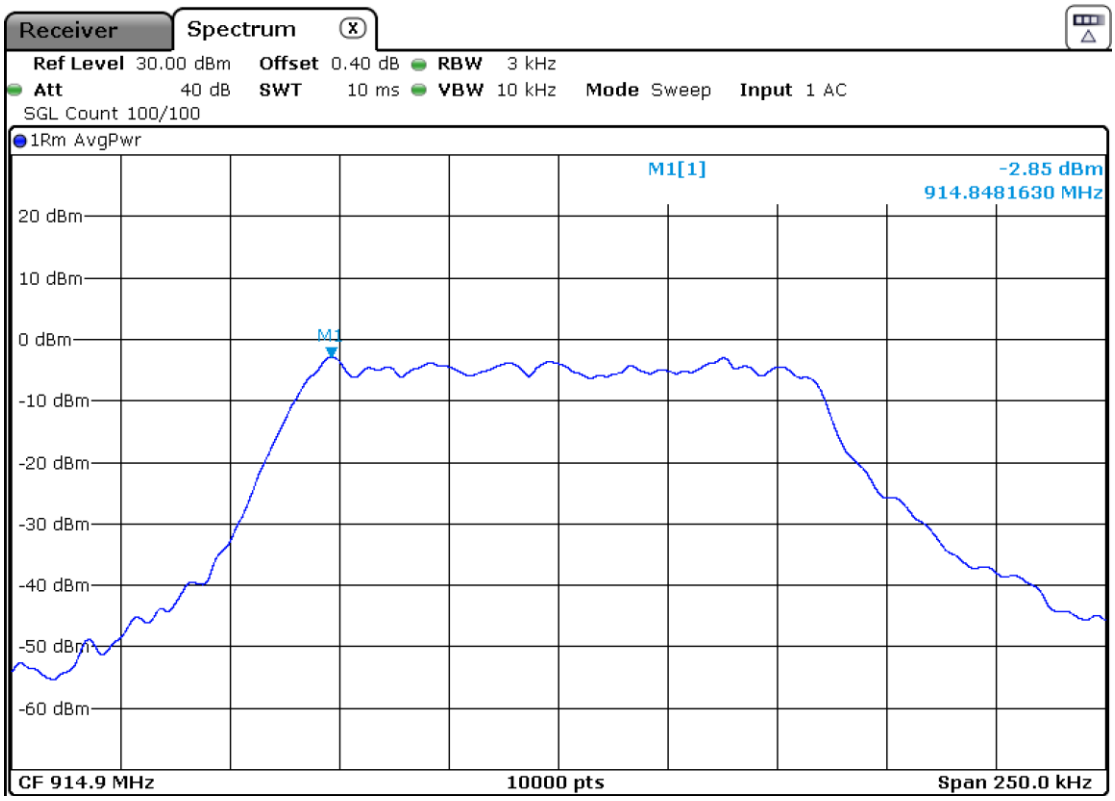
Lowest Channel:



Middle Channel:



Highest 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 §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.

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)
700.9975	26.58	H	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.

- LOW CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.6	40.02	H	Peak	<± 5.13
1.804266667	40.42	H	Peak	<± 5.13
5.41325	44.73	H	Peak	<± 5.13
8.1205	51.05	H	Peak	<± 5.13

- MIDDLE CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.5999333	40.37	H	Peak	<± 5.13
1.81686667	45.57	H	Peak	<± 5.13
5.451	45.96	H	Peak	<± 5.13
8.17675	49.79	H	Peak	<± 5.13

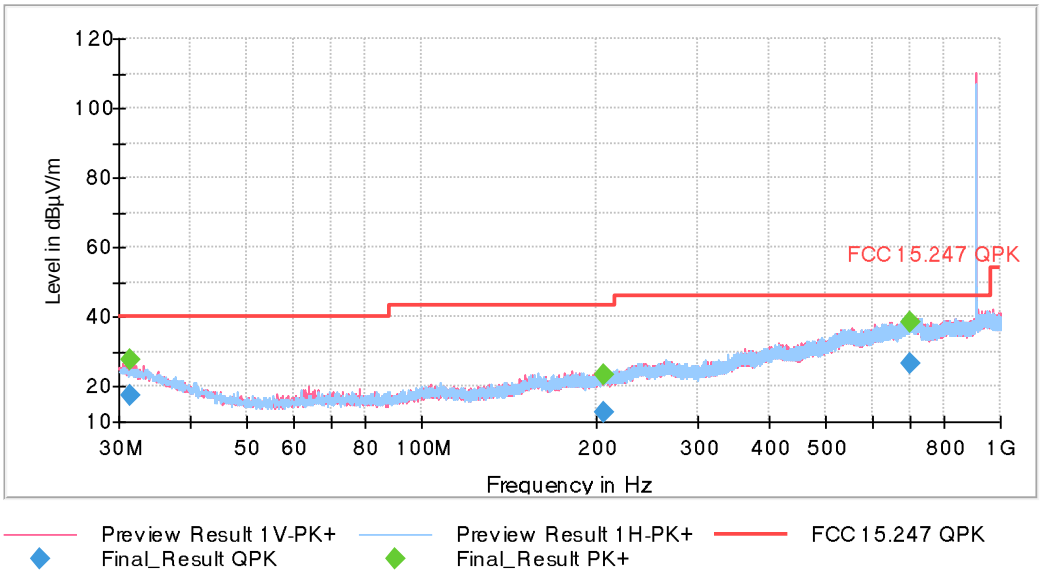
- HIGH CHANNEL. Spurious frequencies closest to the limit:

Spurious Frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
1.6001333	40.23	H	Peak	<± 5.13
1.8297333	45.56	H	Peak	<± 5.13
5.48925	45.51	H	Peak	<± 5.13
8.23375	48.37	H	Peak	<± 5.13

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

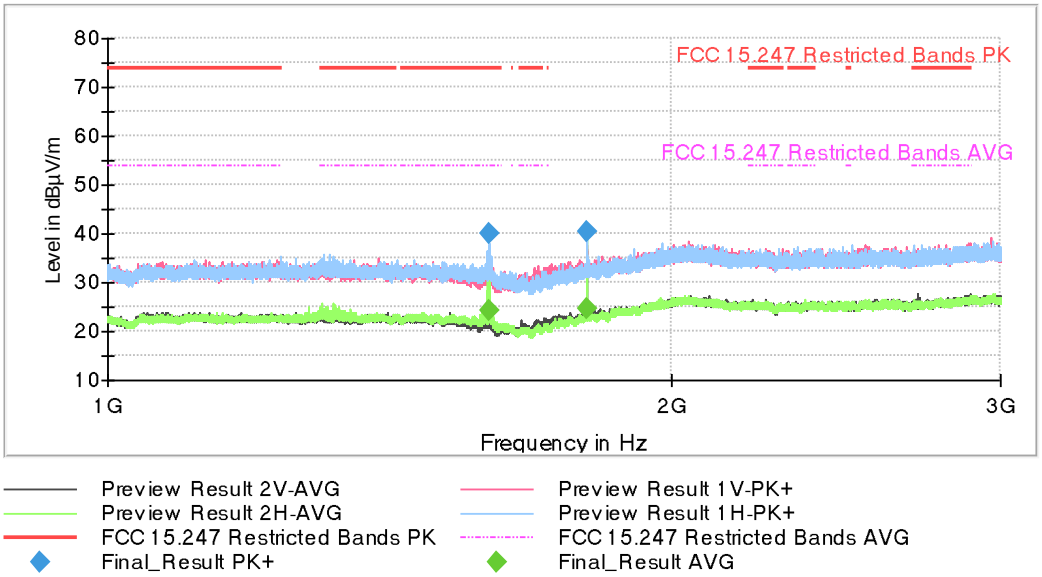
This plot is valid for the Low and High Channels.



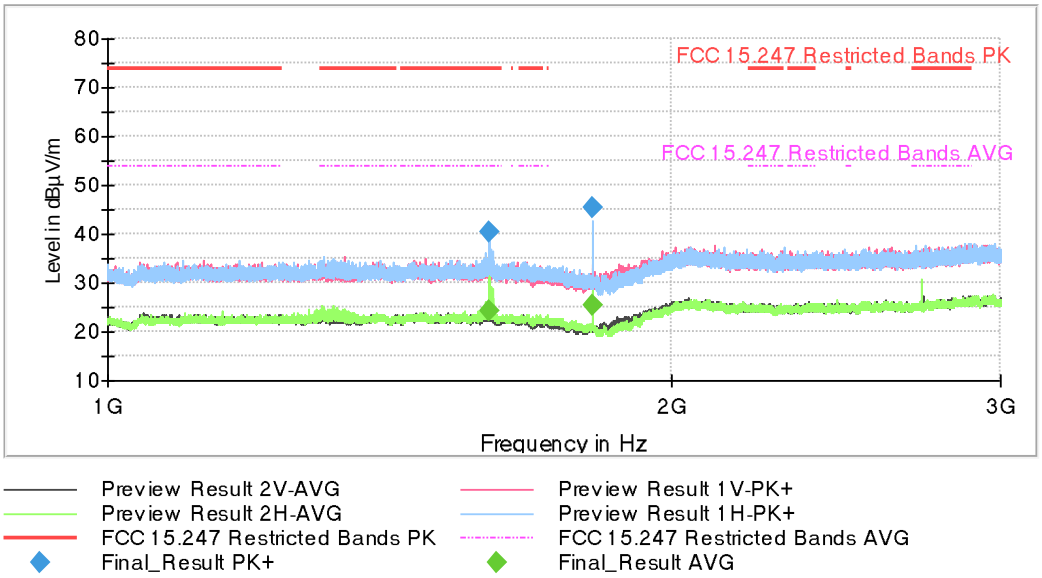
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 - 3 GHz:

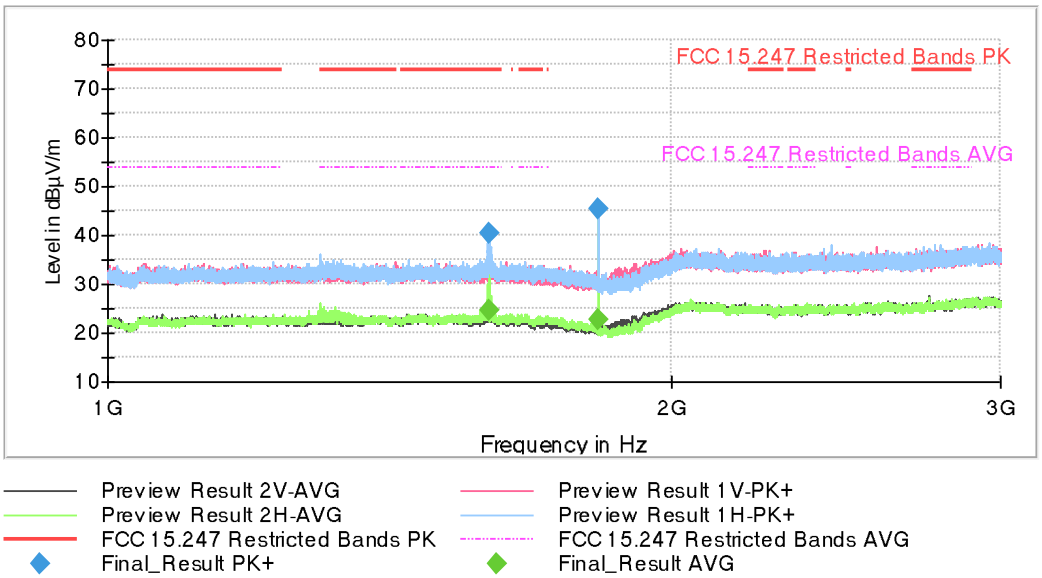
- Low Channel:



- Middle Channel:

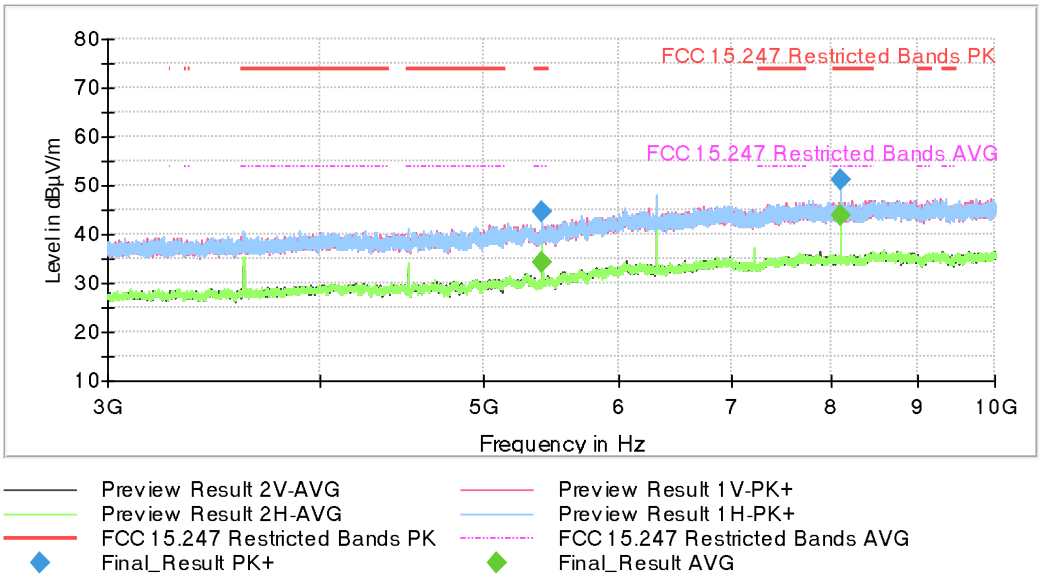


- High Channel:

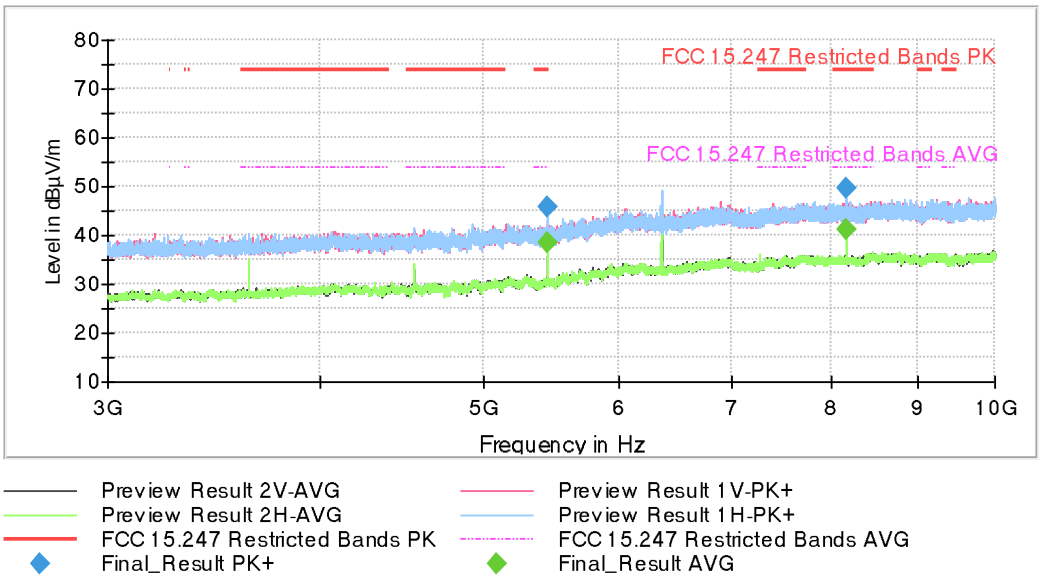
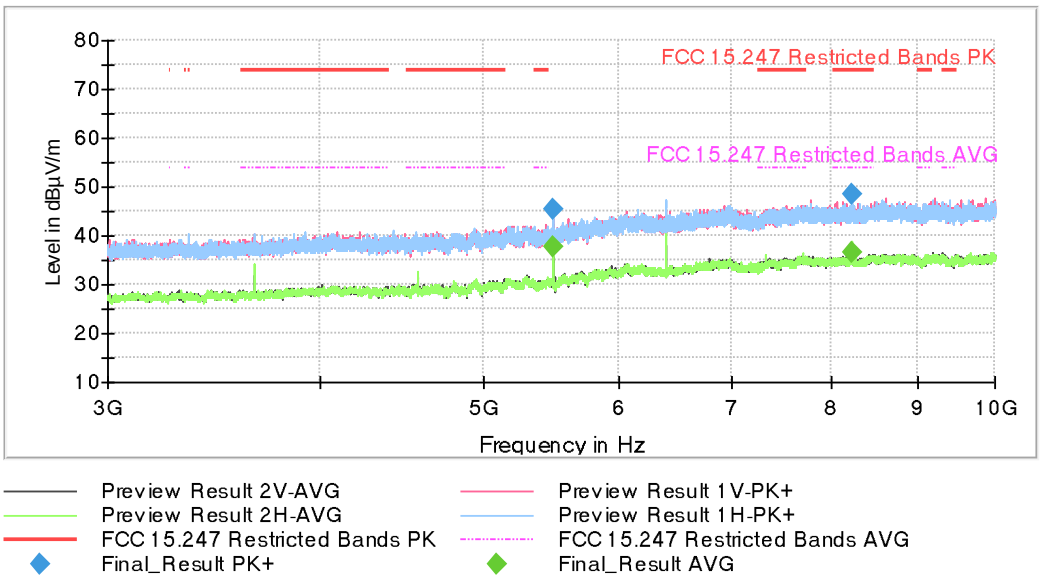


FREQUENCY RANGE 3 - 10 GHz:

- Low Channel:



- Middle Channel:



- High Channel: