DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
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C.I.F. A29 507 456

DEKRA

ilac-MRA ENAC ENSAYOS Nº 51/LE147

Test report No:
NIE: 59563RRF.002A1

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	Communication system module for Personal Protections Equipment (PPE) including BT, Proprietary wireless intercom communications and Level Dependent protection.
Trademark	Pro1
Model and /or type reference	Pro1
Other identification of the product	HW version: 1.0. SW version: 1.0. FCC ID:Q95ER24 IC: 4668A-ER24
Features	BT 4.2 and 2.4GHz Proprietary wireless intercom.
Applicant	CARDO SYSTEMS LTD 811 E. Plano Parkway, suite 110A. Plano TX. 75074, USA
Test method requested, standard	USA FCC Part 15.247 10-1-18 Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 10-1-18 Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 5 (April 2018). 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)	A. Llamas RF Lab. Manager Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ Fecha: 2019.07.12 13:55:05 +02'00'

Date of issue	2019-07-10
Report template No	FDT08_21

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Competences and guarantees

DEKRA Testing and Certification 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 has a calibration and maintenance program for its measurement equipment.

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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 sample consists of a PCB based module that can be integrated into Personal Protections Equipment (PPE). The module got 2 radios – BT 4.2 Radio and 2.4GHz Proprietary wireless intercom communications radio. Module can also support aux Audio input of 2 way radio. Module can also support Level Dependent electronics supporting EN352-4. BT RF power is up to 8dBm. 2.4GHz Proprietary wireless intercom communications radio is up to 20dBm. Module support connector to External 2.4GHz antenna.

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	Reception
59563B/001	Communication system Module	Pro1	--	2019/01/21
59563B/002	Test Board	--	--	2019/01/21
59563B/003	Antenna	--	--	2019/01/21
59563B/016	Li-ion Battery	--	--	2019/01/21

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

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

Control Nº	Description	Model	Serial Nº	Reception
59563B/006	Communication system Module	Pro1	--	2019/01/21
59563B/007	Test Board	--	--	2019/01/21
59563B/016	Li-ion Battery	--	--	2019/01/21

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

- Sample S/03 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Reception
59563B/008	Test Board	--	--	2019/01/21
59563B/009	Antenna	--	--	2019/01/21
59563B/016	Li-ion Battery	--	--	2019/01/21
59563B/004	Communication system Module	Pro1	--	2019/01/21
59563B/011	USB Cable	--	--	2019/01/21

Sample S/03 has undergone the following test(s): All Radiated tests indicated in Appendix C.

- Sample S/04 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Reception
59563B/008	Test Board	--	--	2019/01/21
59563B/016	Li-ion Battery	--	--	2019/01/21
59563B/046	Communication system Module	Pro1	--	2019/06/05
59563B/011	USB Cable	--	--	2019/01/21

Sample S/04 has undergone the following test(s): All conducted tests indicated in Appendix C.

Test sample description

Ports…… :	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
Supplementary information to the ports…… :					

Rated power supply .....:	Voltage and Frequency		Reference poles			
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 2.4V to 4.2V 1Amp					
	☐	DC:					
Rated Power .....:	1W						
Clock frequencies .....:	26MHz, 12MHz, 16MHz, 8MHz, 40MHz, 32KHz						

Other parameters.....:			
Software version .....:	1.0		
Hardware version.....:	1.0		
Dimensions in cm (W x H x D)....:	45x50mm		
Mounting position.....:	☐	Table top equipment	
	☐	Wall/Ceiling mounted equipment	
	☐	Floor standing equipment	
	☐	Hand-held equipment	
	☒	Other: PCB module inside Earmuff or Hand Held equipment	
Modules/parts .....:	Module/parts of test item	Type	Manufacturer
	Pro1 PCB	PCB	Cardo
Accessories (not part of the test item).....:	Description	Type	Manufacturer
	EVB PCB	PCB	Cardo
	Power PCB	PCB	Cardo
Documents as provided by the applicant.....:	Description	File name	Issue date

Identification of the client

CARDO SYSTEMS LTD
811 E. Plano Parkway, suite 110A. Plano TX. 75074, USA

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2019-01-31
Date (finish)	2019-06-06

Document history

Report number	Date	Description
59563RRF.002	2019-06-11	First reléase
59563RRF.002A1	2019-07-10	The antenna gain for Bluetooth EDR and Bluetooth Low Energy is updated to new value. The new value is 2dBi and not -2dBi.

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. = 35 %

Remarks and comments

The tests have been performed by the technical personnel: Francisco José Alcaide, Carolina Postigo, Ignacio Cabra, Juan Carlos Fuentes, José Manuel Jiménez González, Jaime Barranquero and Miguel Ángel Torres.

Used instrumentation:

Conducted Measurements:

		Last Calibration	Due Calibration
1.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2017/07	2019/07
2.	DC Power Supply 40V/40A Rohde & Schwarz NGPE40	2018/02	2021/02
3.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2018/02	2020/02

Radiated Measurements:

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
3.	Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2017/09	2020/09
4.	RF Pre-amplifier 40 dB, 10 MHz - 6 GHz BONN ELEKTRONIK BLNA 0160-01N	2019/02	2020/08
5.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2018/02	2020/02
6.	RF Pre-amplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2019/04	2020/04
7.	Broadband Horn antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
8.	Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2018/02	2020/02
9.	RF Pre-amplifier, G>48dB, 18-40GHz NARDA JS44-18004000-33-8P	2018/02	2020/02
10.	Broadband Horn antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2016/11	2019/11
11.	Broadband Horn antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2018/07	2021/07
12.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
13.	BiconicalLog antenna ETS LINDGREN 3142E	2017/09	2020/09
14.	Multi Device Controller MESSTECHNIK DAV-RR	N.A.	N.A.
15.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2018/01	2021/01
16.	Spectrum analyser Rohde & Schwarz FSV40	2018/02	2020/02
17.	RF pre-amplifier 30-6 GHz Bonn Elektronik BLMA 0160-01N	2019/02	2020/08

Testing verdicts

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

Summary

1. Bluetooth EDR

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

2. Bluetooth Low Energy

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

3. Proprietary Protocol Intercom

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

Appendix A: Test results. Bluetooth EDR (GFSK, Pi/4 DQPSK, 8DPSK)

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FCC Section 15.247 Subclause (a)(1)(iii) / RSS-247 Clause 5.1 (d) Time of occupancy (Dwell Time).....26

FCC Section 15.247 Subclause (b) / RSS-247 Clause 5.4 (b) Maximum peak output power and antenna gain 32

FCC Section 15.247 Subclause (d) / RSS-247 Clause 5.5. Band-edge emissions compliance (Transmitter) (conducted) 38

FCC Section 15.247 Subclause (d) / RSS-247 Clause 5.5. Emission limitations radiated. (Transmitter) 45

TEST CONDITIONS

POWER SUPPLY (V):

V nonimal:	3.7 Vdc
Type of Power Supply:	Battery Li Ion.
Type of Antenna:	Internal.
Maximum Declared Antenna Gain:	+2 dBi

TEST FREQUENCIES:

Lowest channel: 2402 MHz

Middle channel: 2441 MHz

Highest channel: 2480 MHz

The EUT was tested in the following operating mode(s):

- The sample was used to configure the EUT to continuously transmit at maximum power in all channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) as required.
- The sample was used to configure the EUT to continuously transmit at maximum power in hopping mode on on all channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) as required.

CONDUCTED MEASUREMENTS:

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

RADIATED MEASUREMENTS:

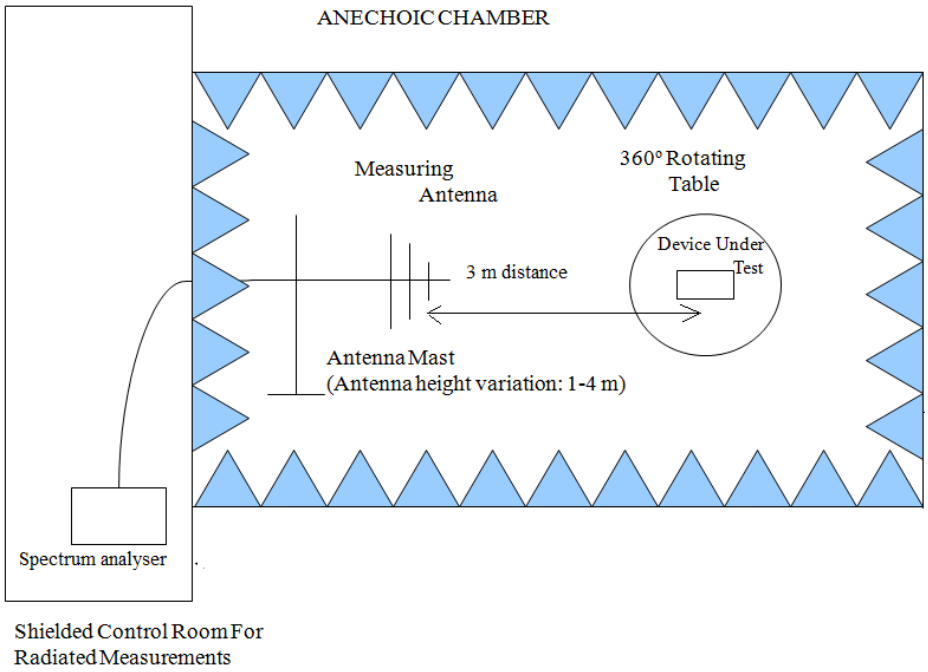
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz) is situated at a distance of 3 m and at a distance of 1m for the frequency range 1 GHz-26 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

For radiated emissions in the range 1 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

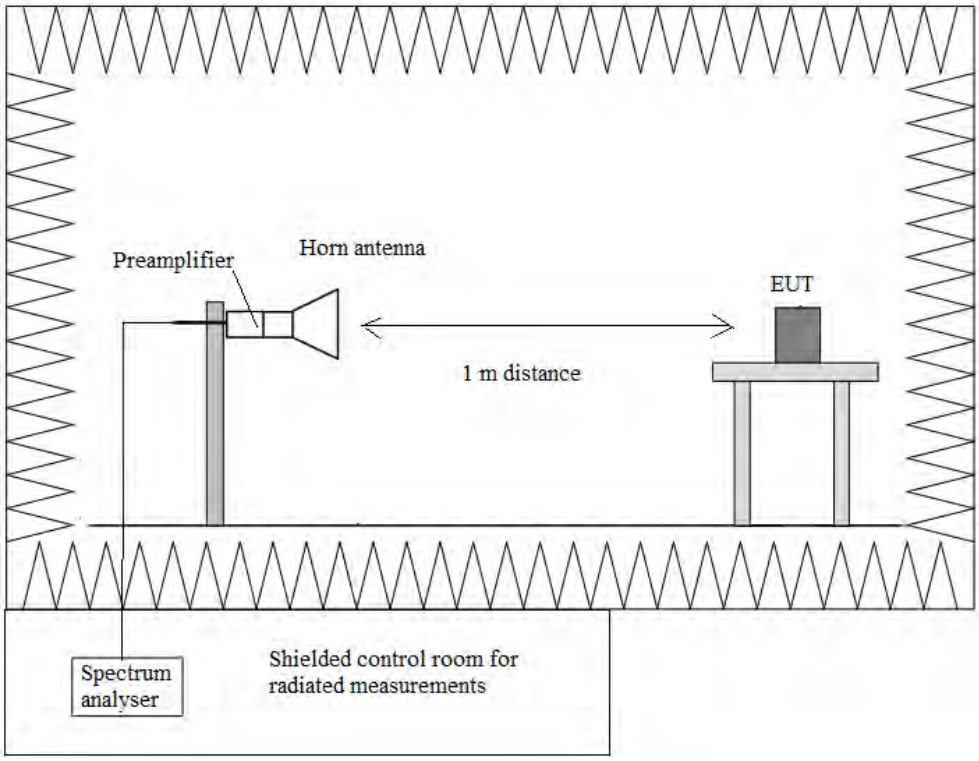
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find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

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

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup f > 1 GHz:



FCC Section 15.247 Subclause (a) (1) / RSS-247 Clause 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. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

RESULTS:

- **GFSK**

	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (kHz)	945	951	942
99% Bandwidth (kHz)	867	870	870
Measurement uncertainty (kHz)	<±0.35		

- **Pi/4 DQPSK**

	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (kHz)	1235	1263.8	1239.7
99% Bandwidth (kHz)	1188	1203	1197
Measurement uncertainty (kHz)	<±0.35		

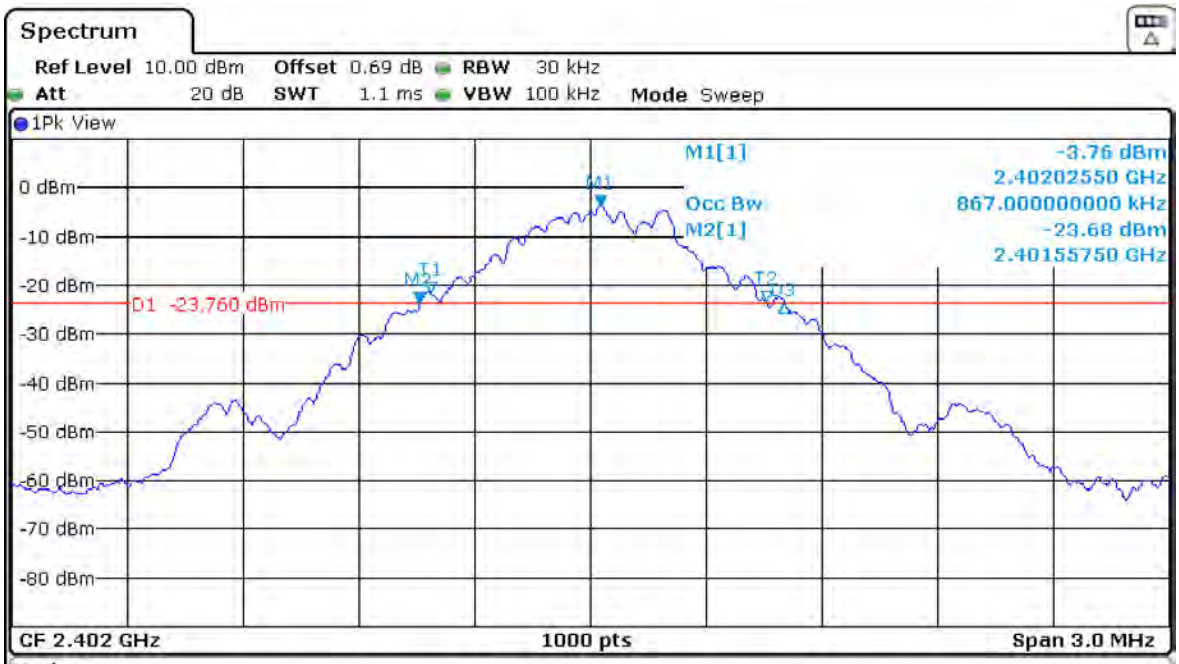
- **8DPSK**

	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
20 dB Spectrum Bandwidth (kHz)	1253	1252.3	1254.7
99% Bandwidth (kHz)	1164	1170	1173
Measurement uncertainty (kHz)	<±0.35		

Verdict: PASS

- **GFSK – Bandwidths**

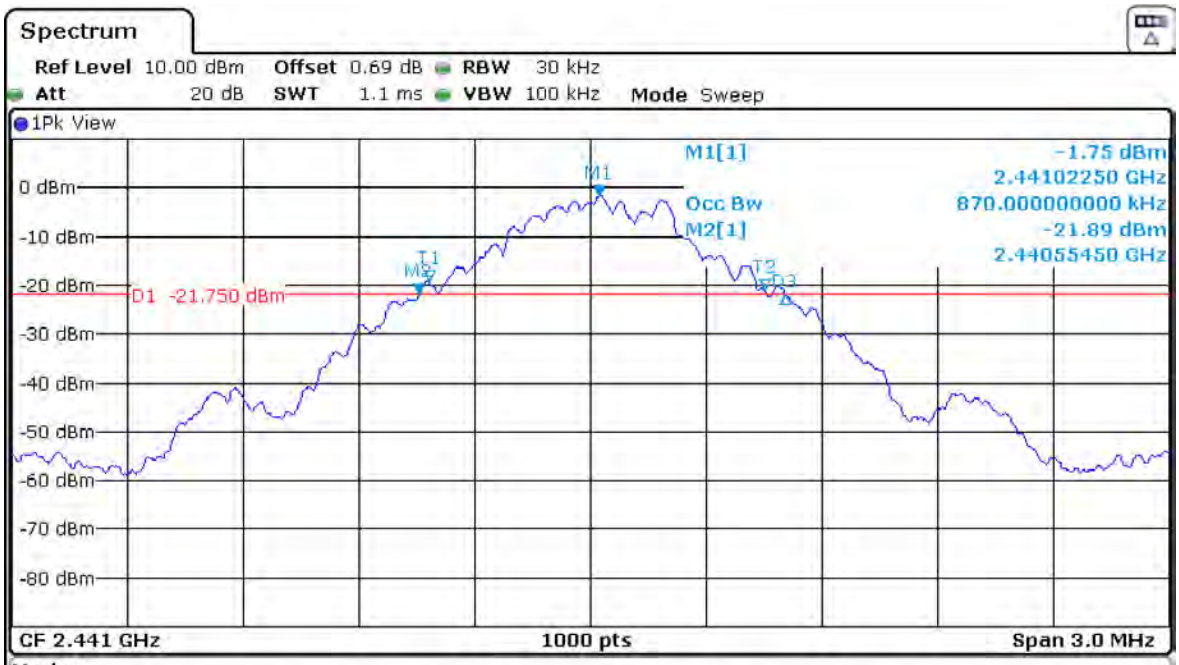
- Low Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4020255 GHz	-3.76 dBm		
T1		1	2.4015875 GHz	-21.65 dBm	Occ Bw	867.0 kHz
T2		1	2.4024545 GHz	-23.20 dBm		
M2		1	2.4015575 GHz	-23.68 dBm		
D3	M2	1	945.0 kHz	0.18 dB		

- Middle Channel:



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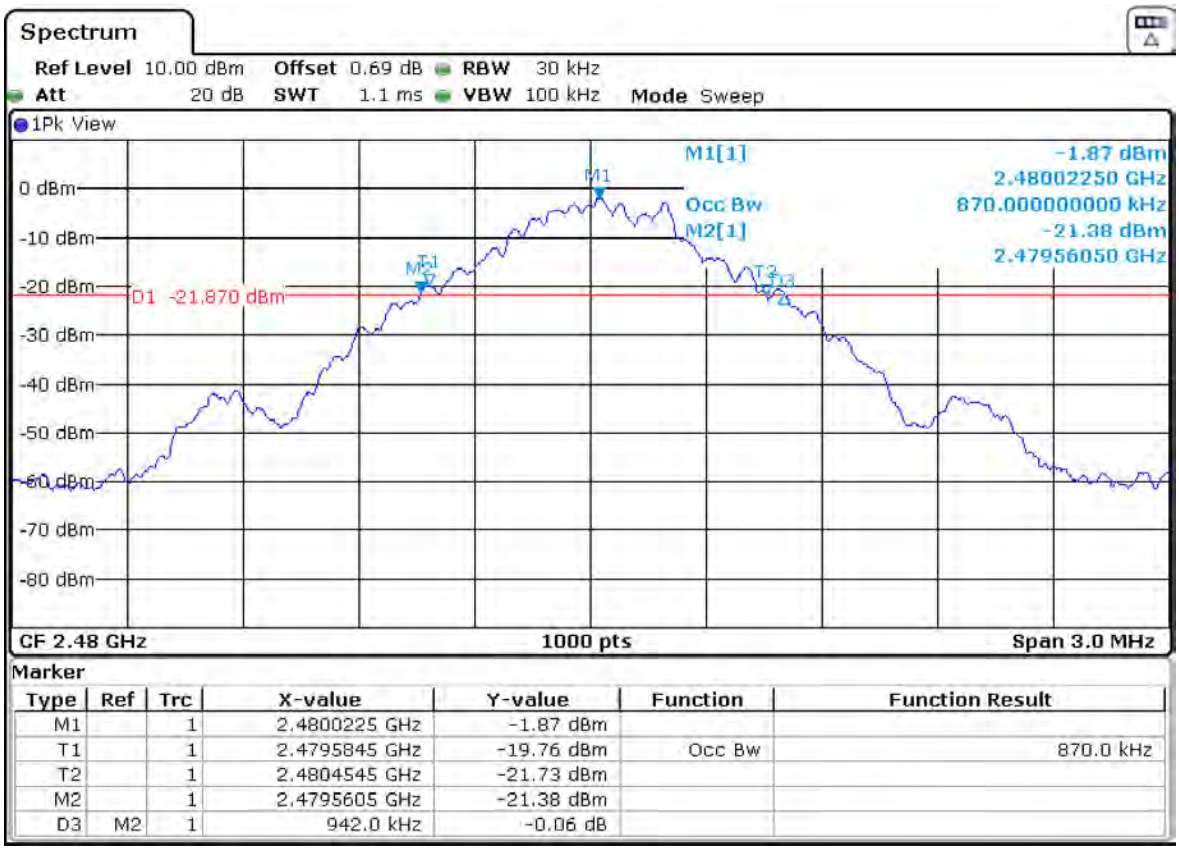
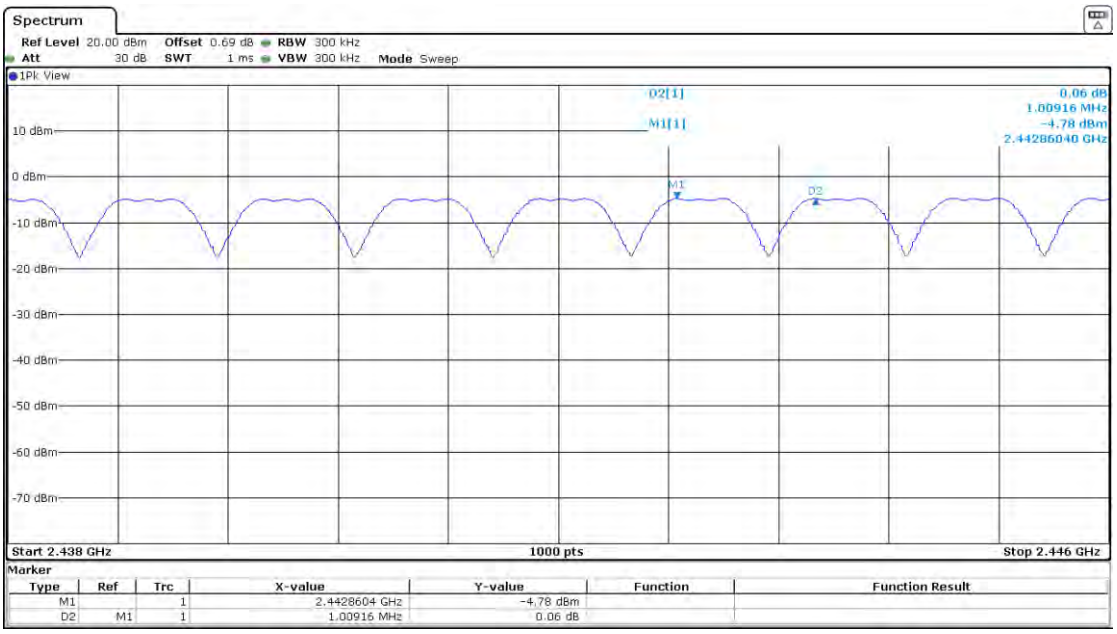
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4410225 GHz	-1.75 dBm		
T1		1	2.4405815 GHz	-19.21 dBm	Occ Bw	870.0 kHz
T2		1	2.4414515 GHz	-21.07 dBm		
M2		1	2.4405545 GHz	-21.89 dBm		
D3	M2	1	951.0 kHz	0.17 dB		

- High Channel:



Carrier frequency separation - GFSK

Carrier frequency separation: 1009.16 kHz

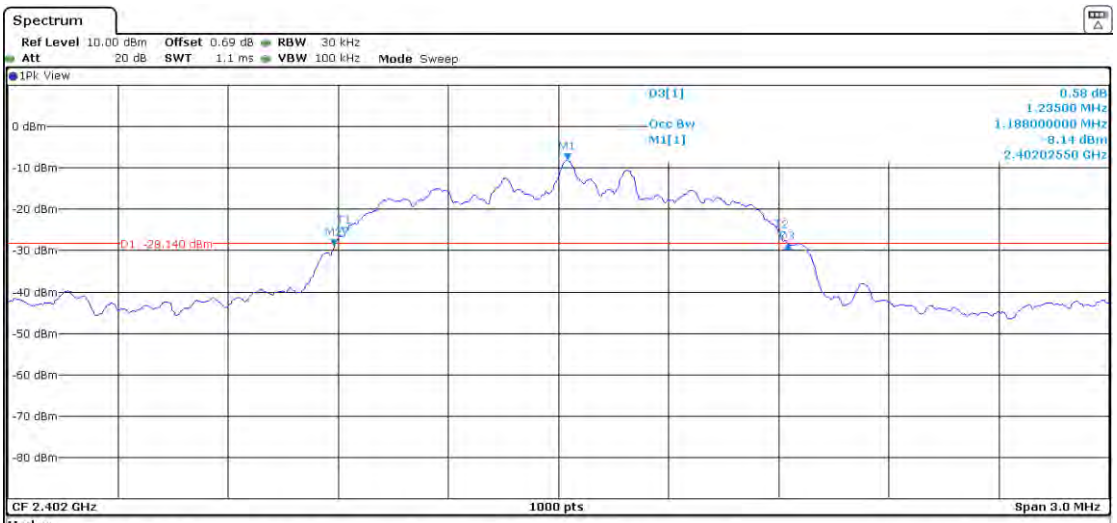


The hopping channel carrier frequencies are separated by a minimum of the two-thirds of the 20 dB bandwidth of the hopping channel.

Verdict: PASS

- **Pi/4 DQPSK – Bandwidths**

- Low Channel:



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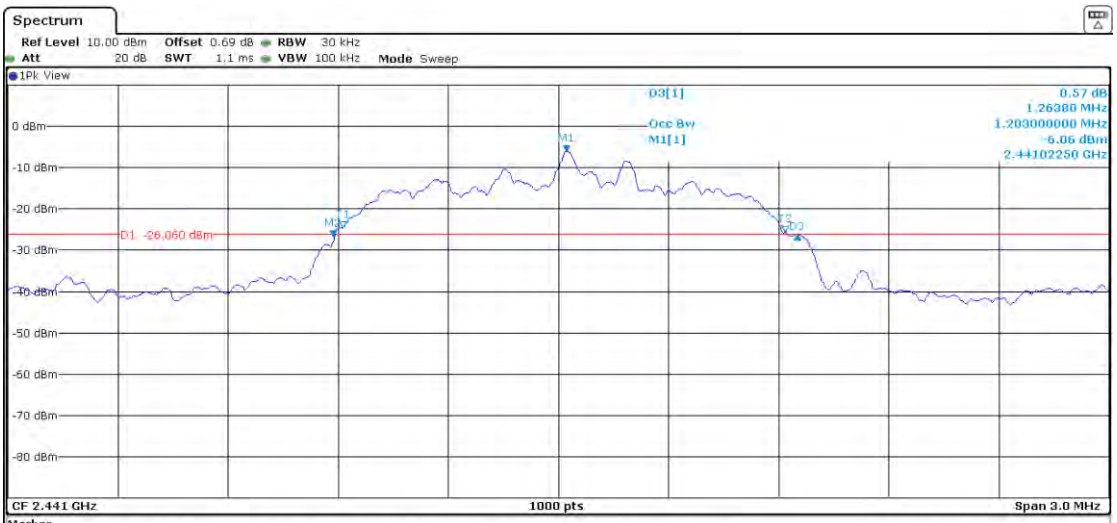
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4020255 GHz	-8.14 dBm		
T1		1	2.4014195 GHz	-25.96 dBm	Occ Bw	1.188 MHz
T2		1	2.4026075 GHz	-26.86 dBm		
M2		1	2.4013894 GHz	-28.80 dBm		
D3	M2	1	1.235 MHz	0.58 dB		

- Middle Channel:



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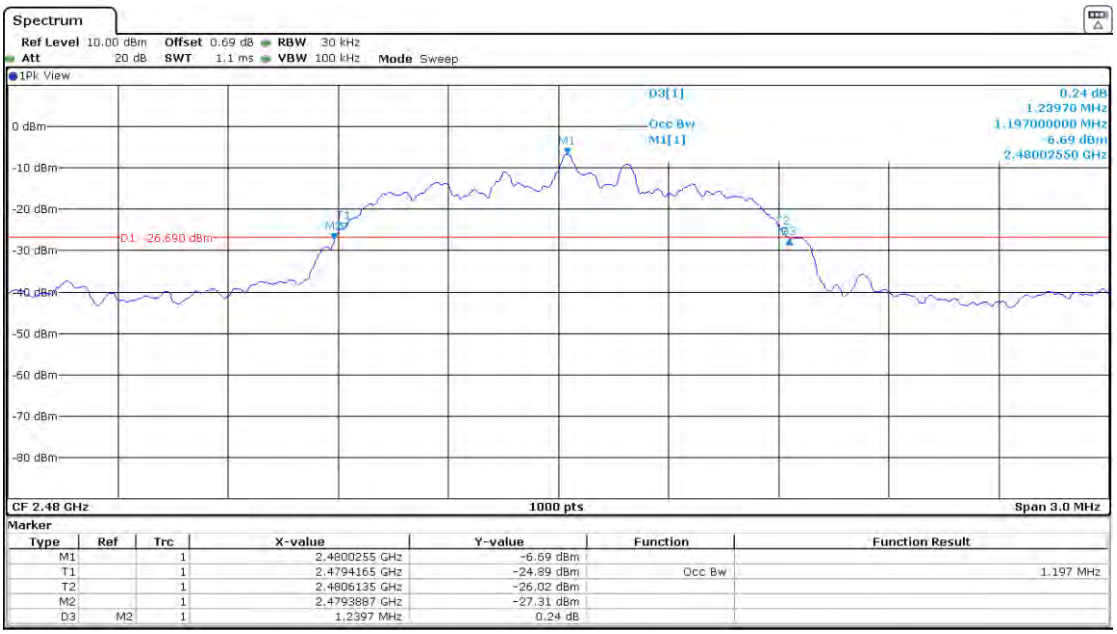
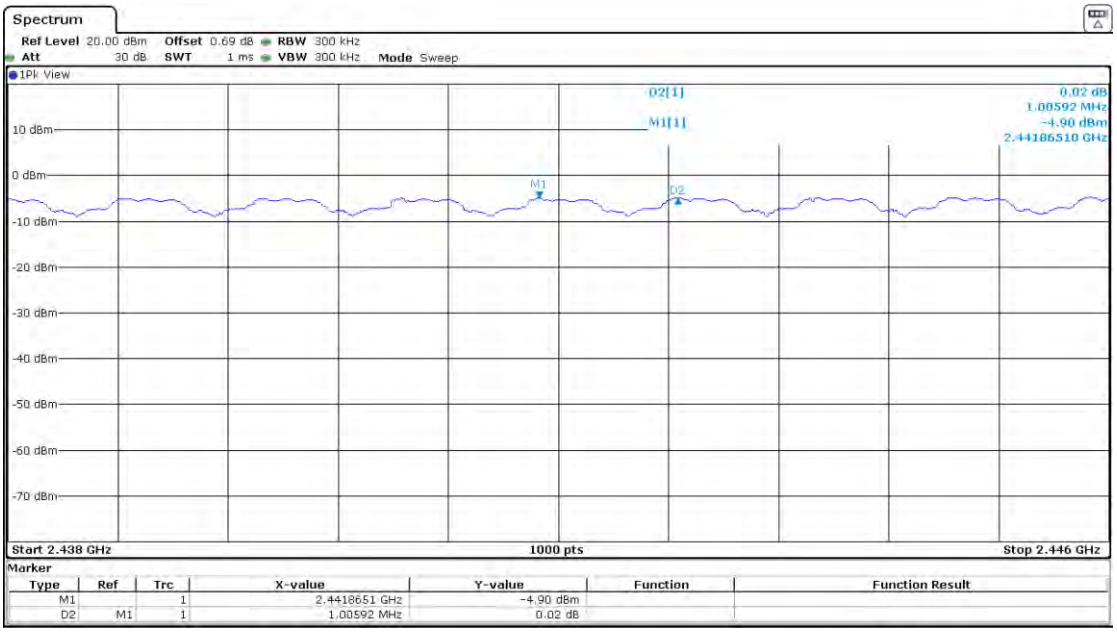
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4410225 GHz	-6.06 dBm		
T1		1	2.4404135 GHz	-24.62 dBm	Occ Bw	1.203 MHz
T2		1	2.4416165 GHz	-25.77 dBm		
M2		1	2.4403881 GHz	-26.73 dBm		
D3	M2	1	1.2638 MHz	0.57 dB		

- High Channel:



Carrier frequency separation - Pi/4 DQPSK

Carrier frequency separation: 1005.92 kHz

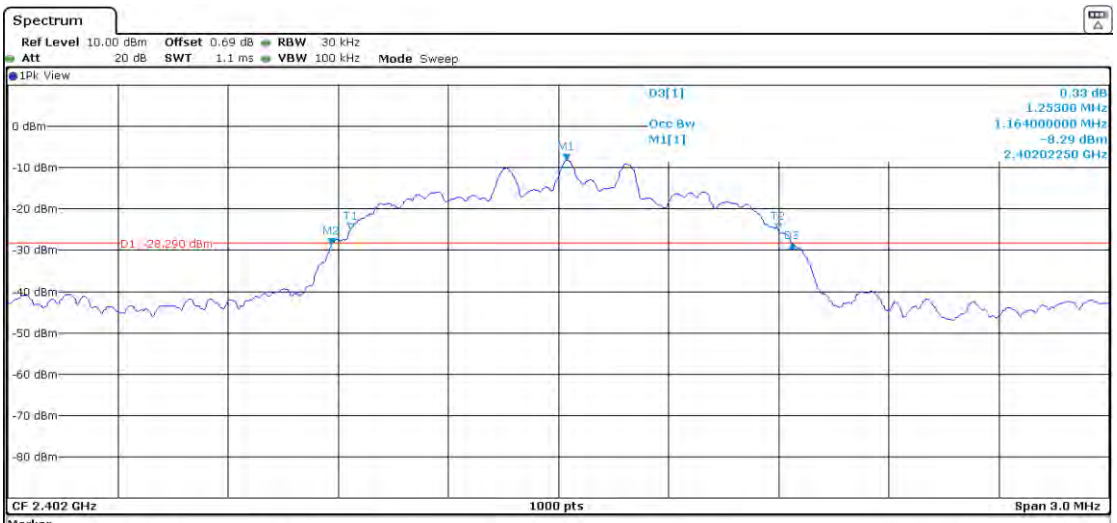


The hopping channel carrier frequencies are separated by a minimum of the two-thirds of the 20 dB bandwidth of the hopping channel.

Verdict: PASS

- **8DPSK – Bandwidths**

- Low Channel:



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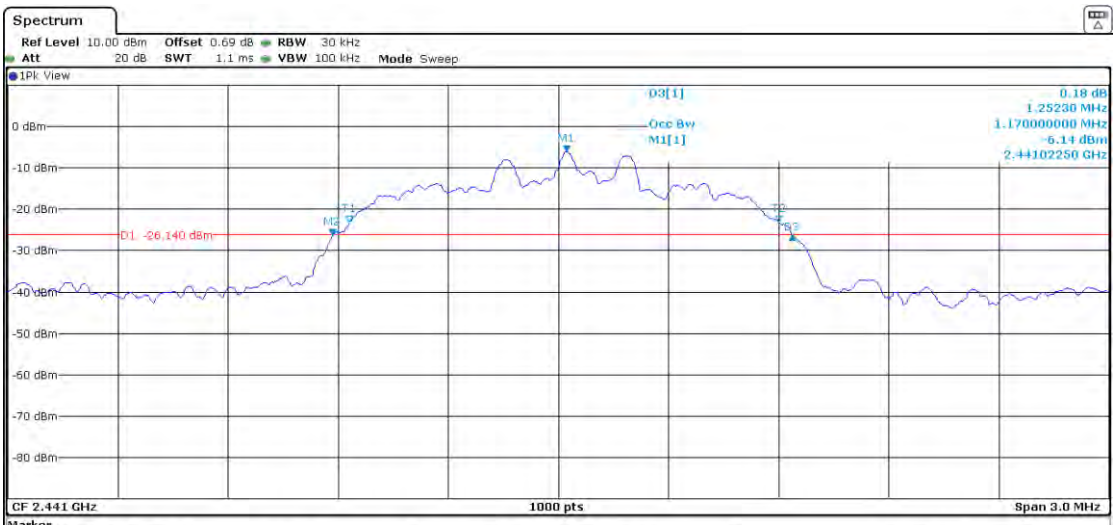
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4020225 GHz	-8.29 dBm		
T1		1	2.4014345 GHz	-24.97 dBm	Occ Bw	1.164 MHz
T2		1	2.4025985 GHz	-25.02 dBm		
M2		1	2.4013834 GHz	-28.63 dBm		
D3	M2	1	1.253 MHz	0.33 dB		

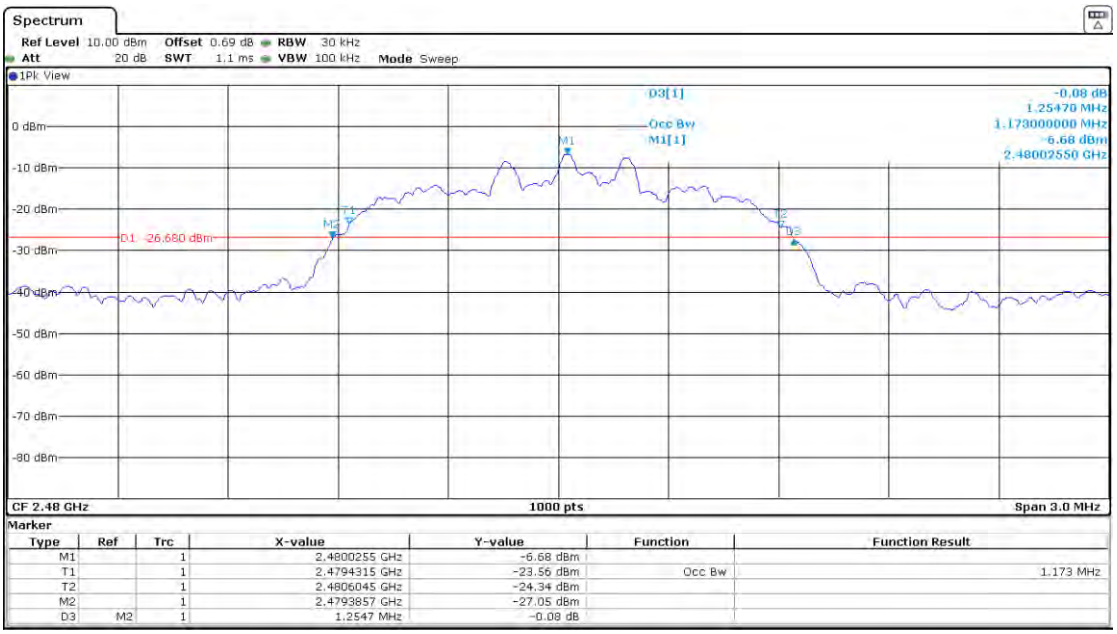
- Middle Channel:



Marker

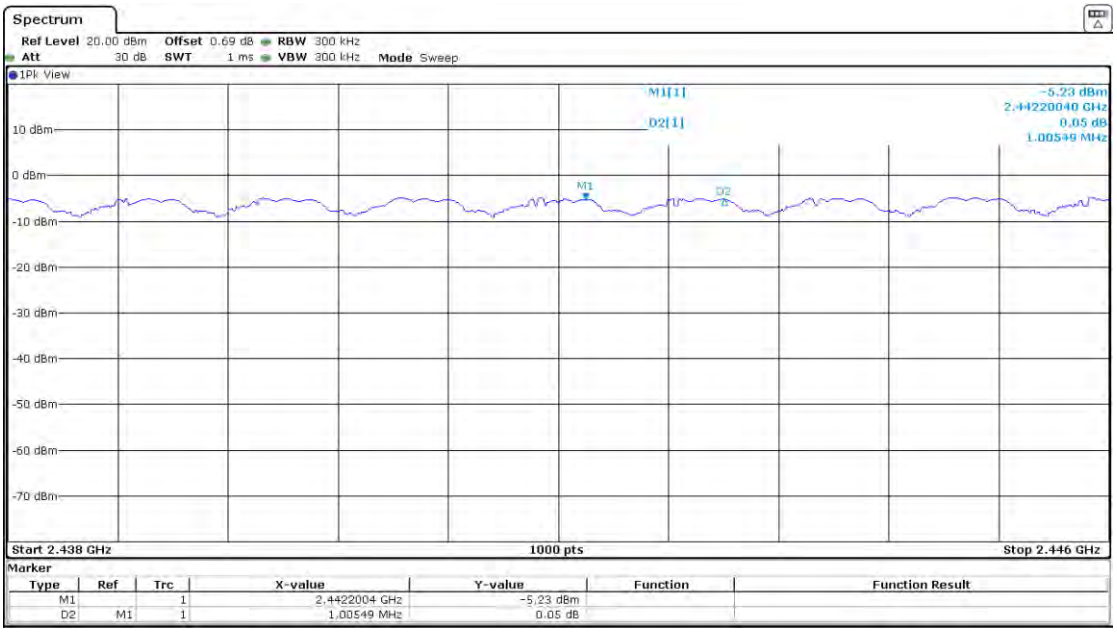
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4410225 GHz	-6.14 dBm		
T1		1	2.4404315 GHz	-23.11 dBm	Occ Bw	1.17 MHz
T2		1	2.4416015 GHz	-23.14 dBm		
M2		1	2.4403851 GHz	-26.33 dBm		
D3	M2	1	1.2523 MHz	0.18 dB		

- High Channel:



Carrier frequency separation - 8DPSK

Carrier frequency separation: 1005.49 kHz



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

Verdict: PASS

FCC Section 15.247 Subclause (a)(1)(iii) / RSS-247 Clause 5.1 (d) Number of hopping channels.

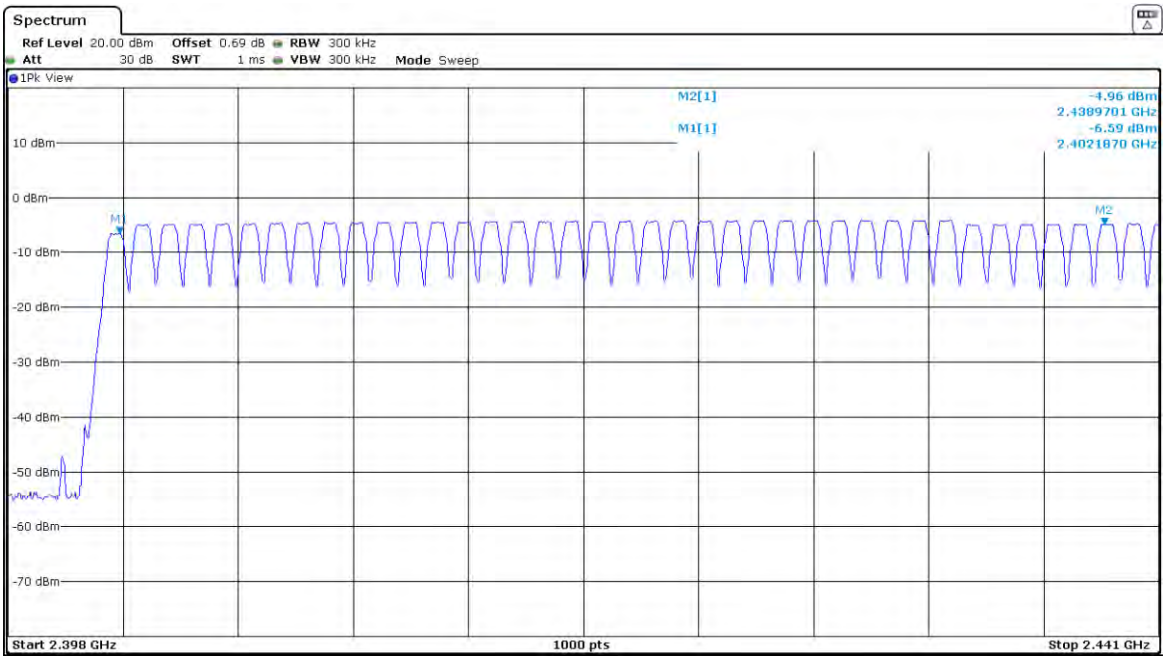
SPECIFICATION:

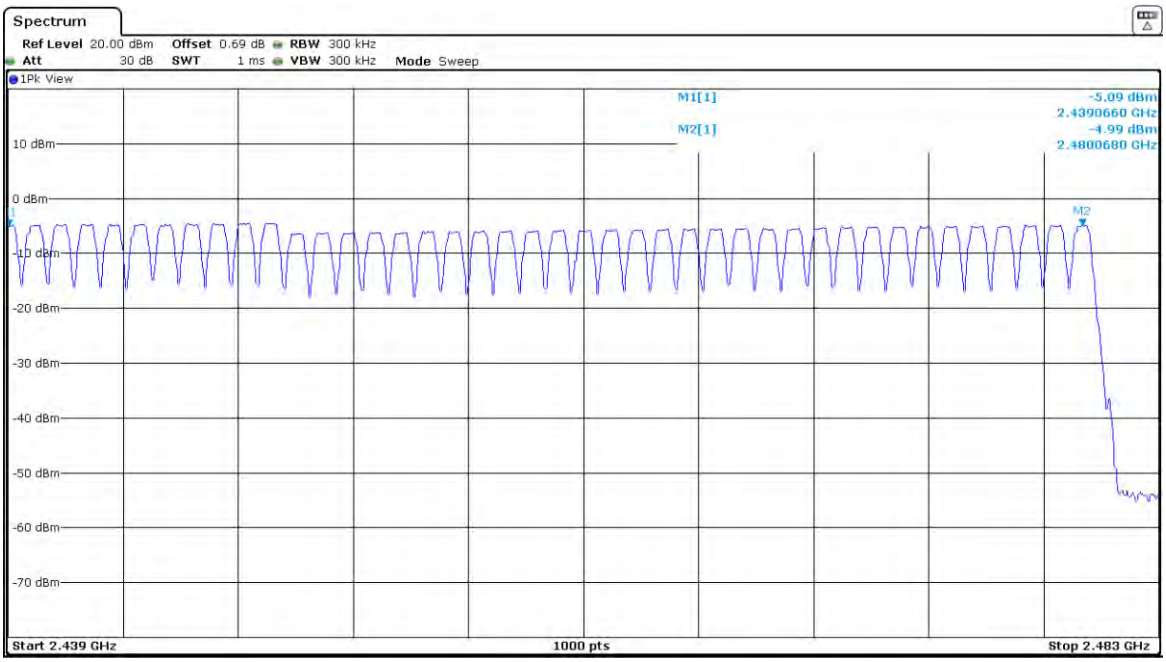
Frequency hopping system in the 2400-2483.5 MHz band shall use at least 15 channels.

RESULTS:

The number of hopping channels is 79 for all three modes.

- **GFSK – Number of hopping channels**

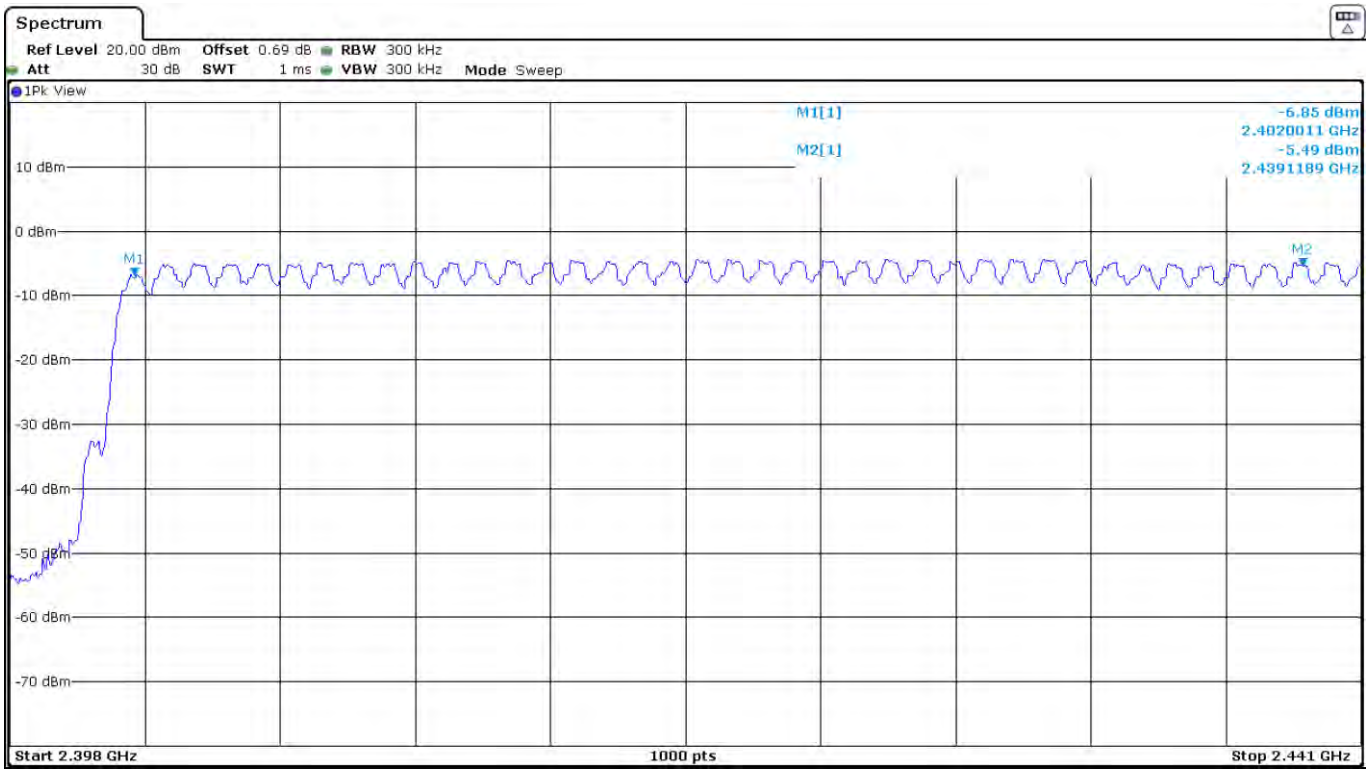


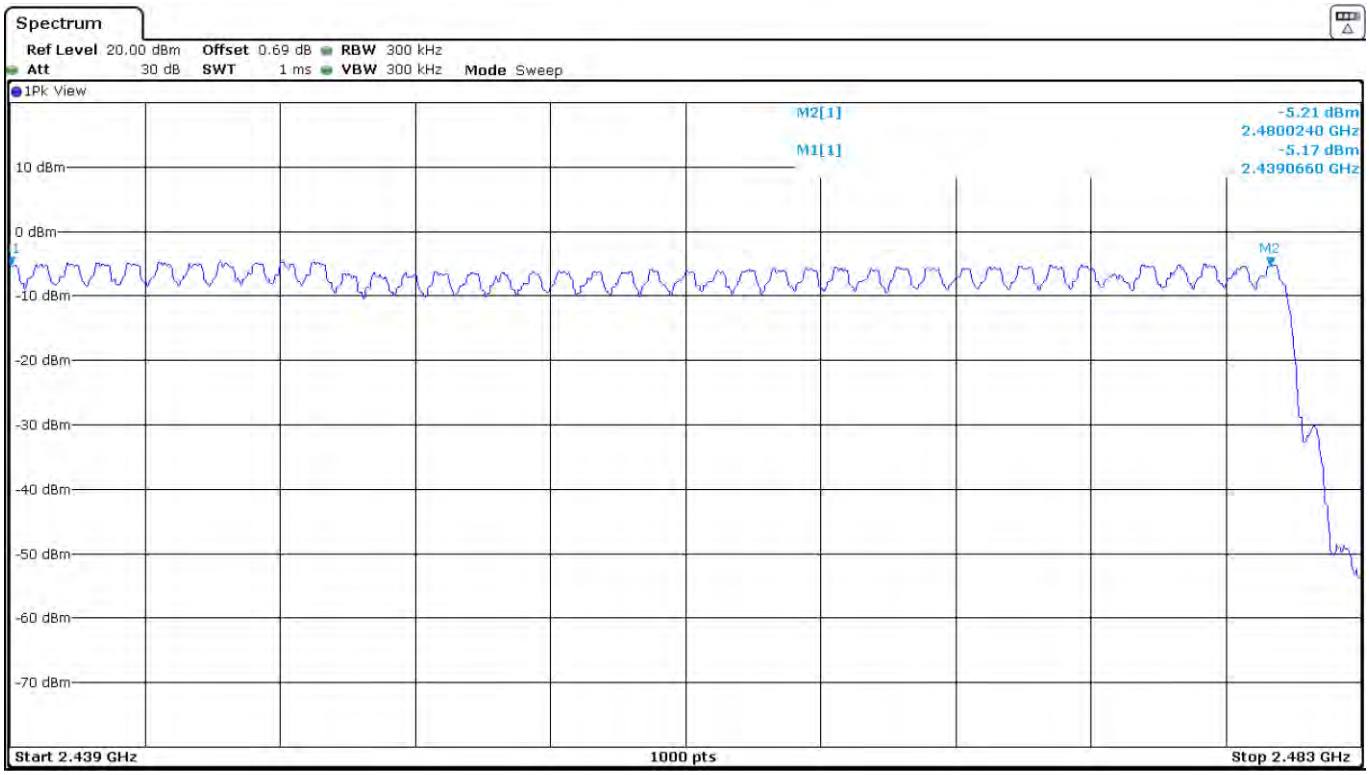


Total number of hopping channels 79

Verdict: PASS

- **Pi/4 DQPSK – Number of hopping channels**

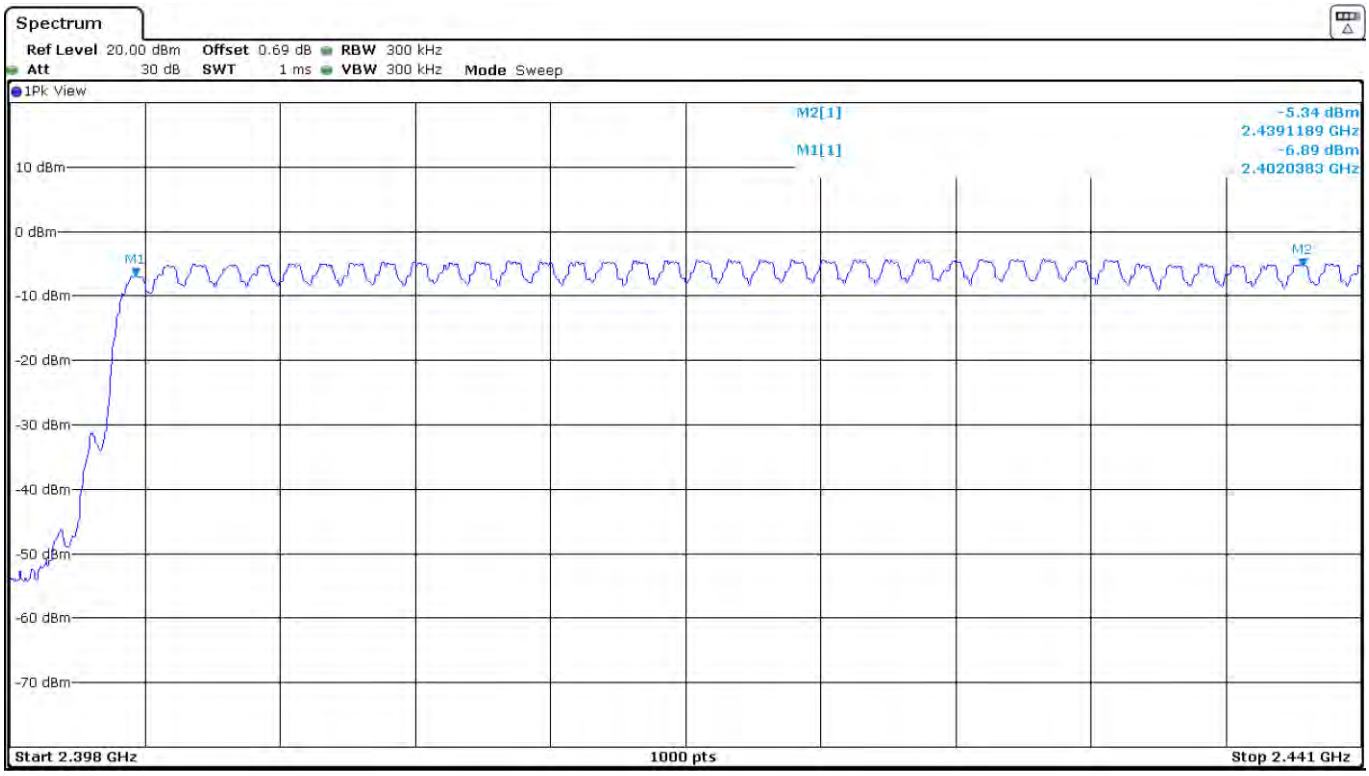


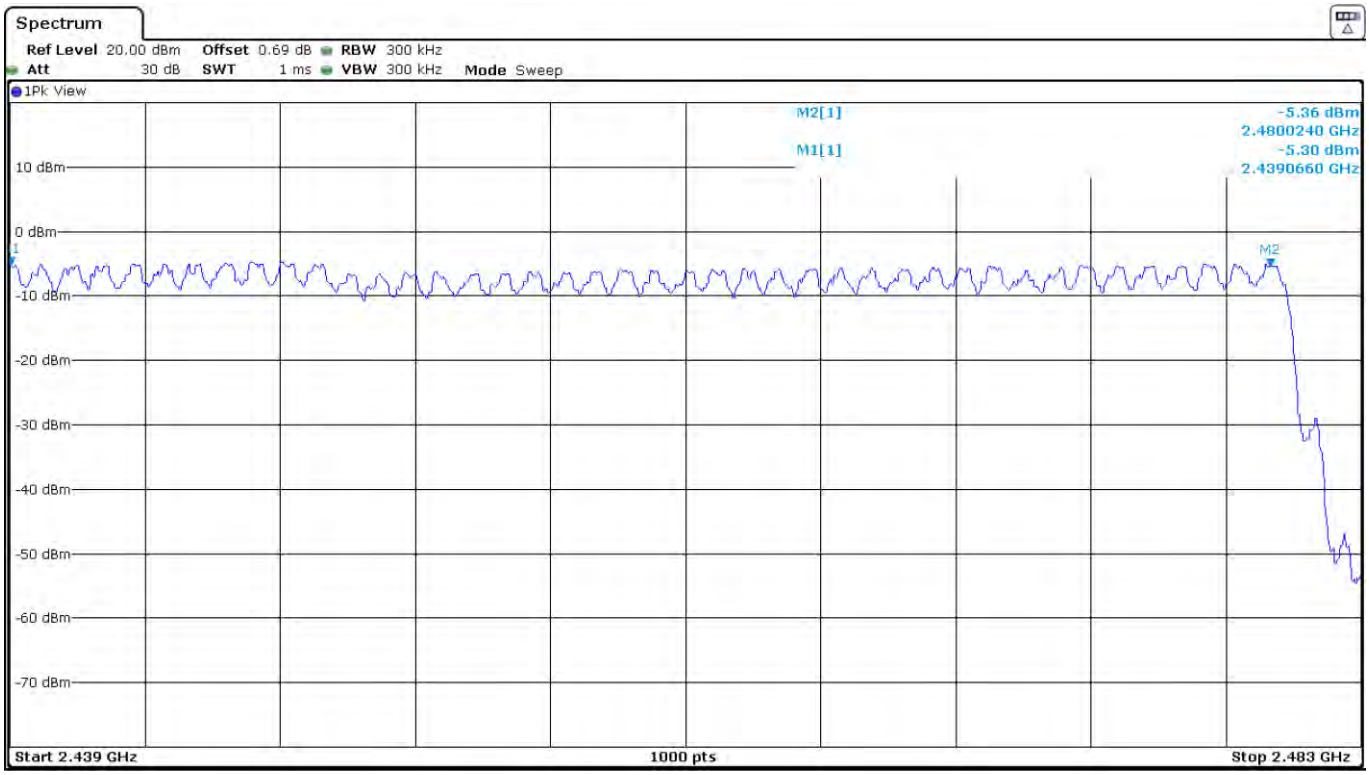


Total number of hopping channels 79

Verdict: PASS

- **8DPSK – Number of hopping channels**





Total number of hopping channels 79

Verdict: PASS

FCC Section 15.247 Subclause (a)(1)(iii) / RSS-247 Clause 5.1 (d) Time of occupancy (Dwell Time).

SPECIFICATION:

The average time of occupancy on any channel shall not be greater than 0.4 seconds (400 ms) within a period of 0.4 seconds multiplied by the number of hopping channels employed = 0.4 x 79= 31.6 seconds.

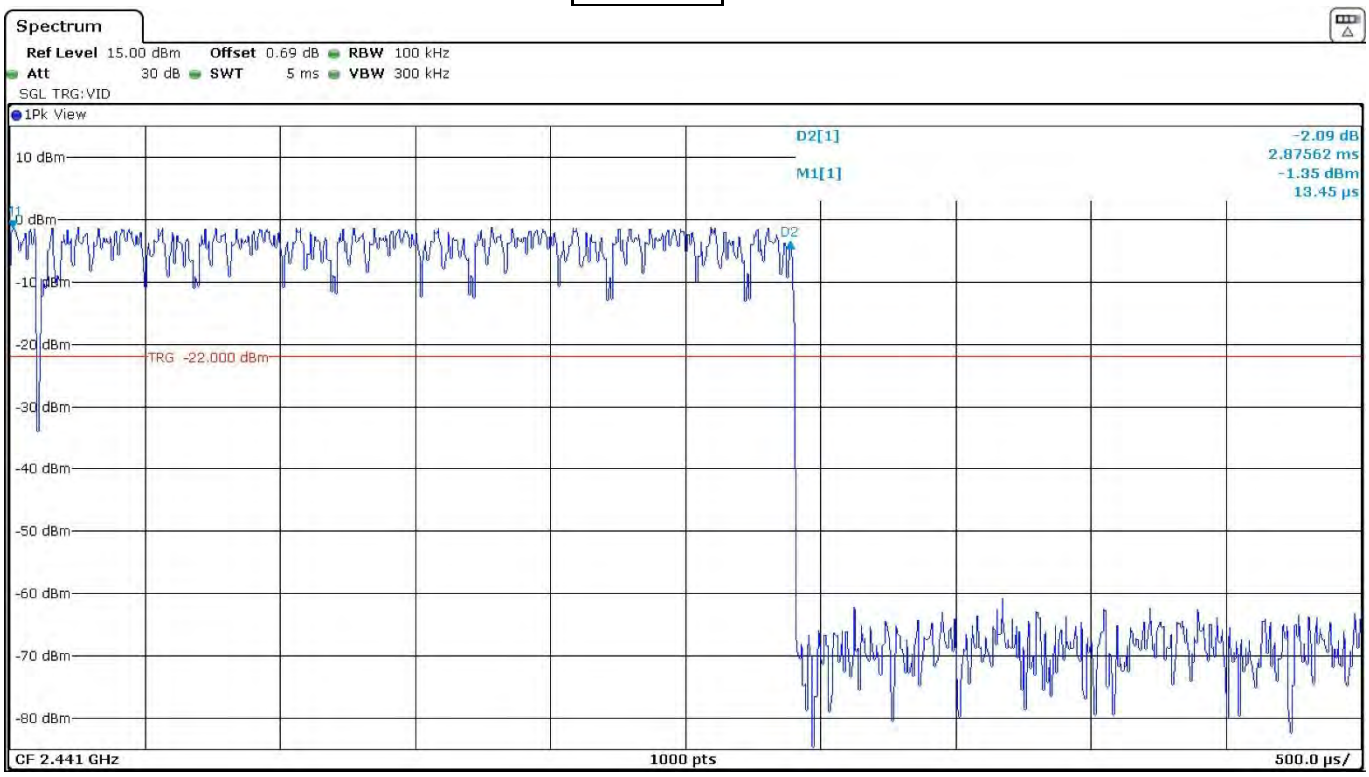
RESULTS:

The worst case is for the longest packets DH5, 2DH5 and 3DH5.

- **GFSK (packet type DH5) – Time of Occupancy (Dwell Time)**

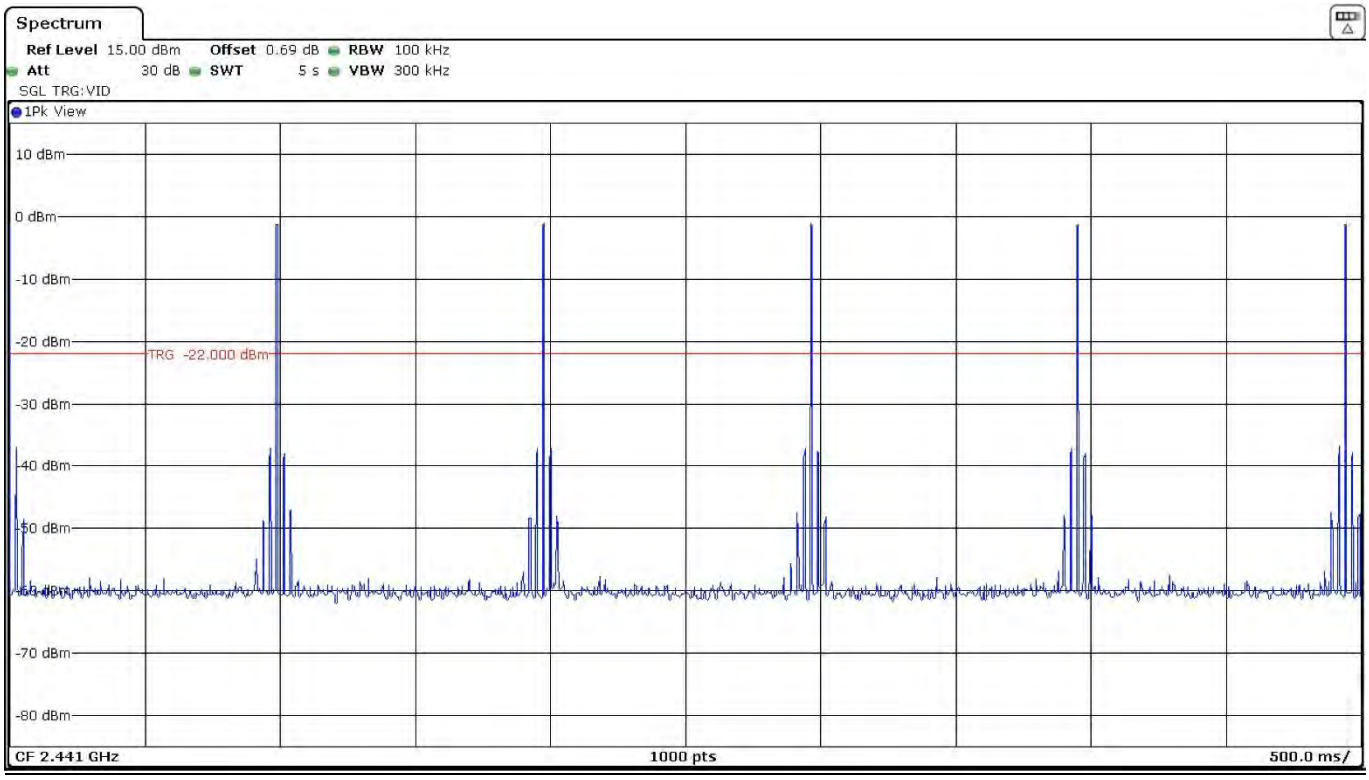
  - Transmit Time per Hop:

2.87562 ms



- Time of Occupancy:

Nº of hops on spectrum analyzer	6	
Nº of hops over the period	37.92	
Average Time of Occupancy	109.0435	ms



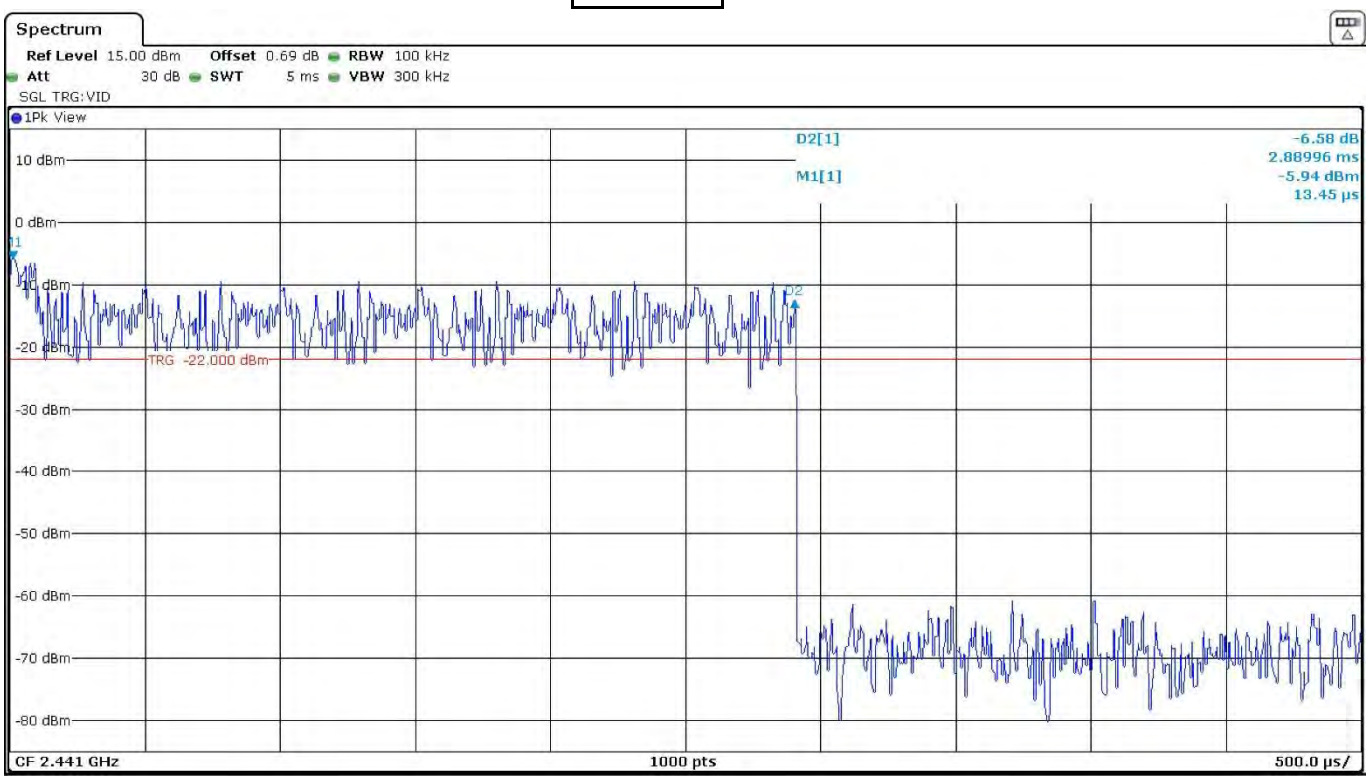
Measurement uncertainty (%)	<±0.01

Verdict: PASS

- **Pi/4 DQPSK (packet type 2DH5) – Time of Occupancy (Dwell Time)**

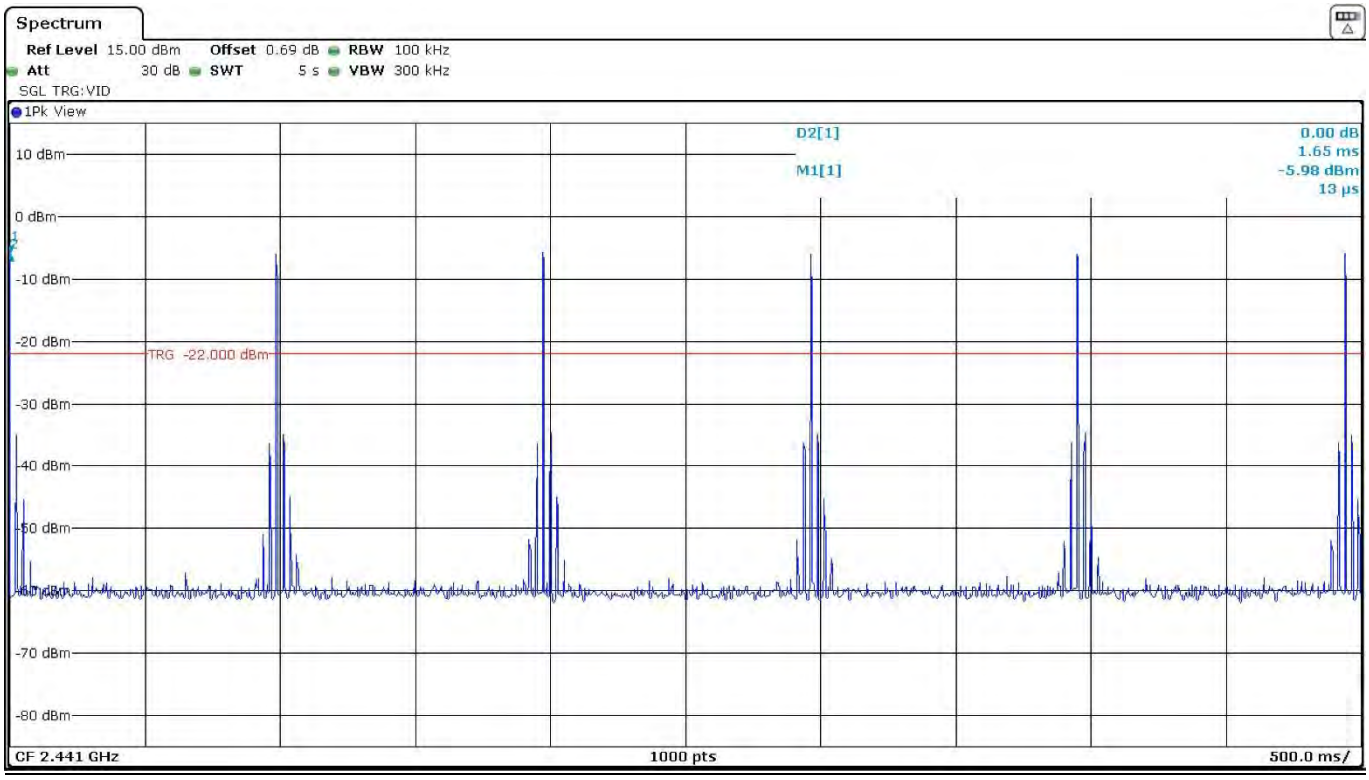
  - Transmit Time per Hop:

2.88996 ms



- Time of Occupancy:

Nº of hops on spectrum analyzer	6	
Nº of hops over the period	37.92	
Average Time of Occupancy	109.5873	ms



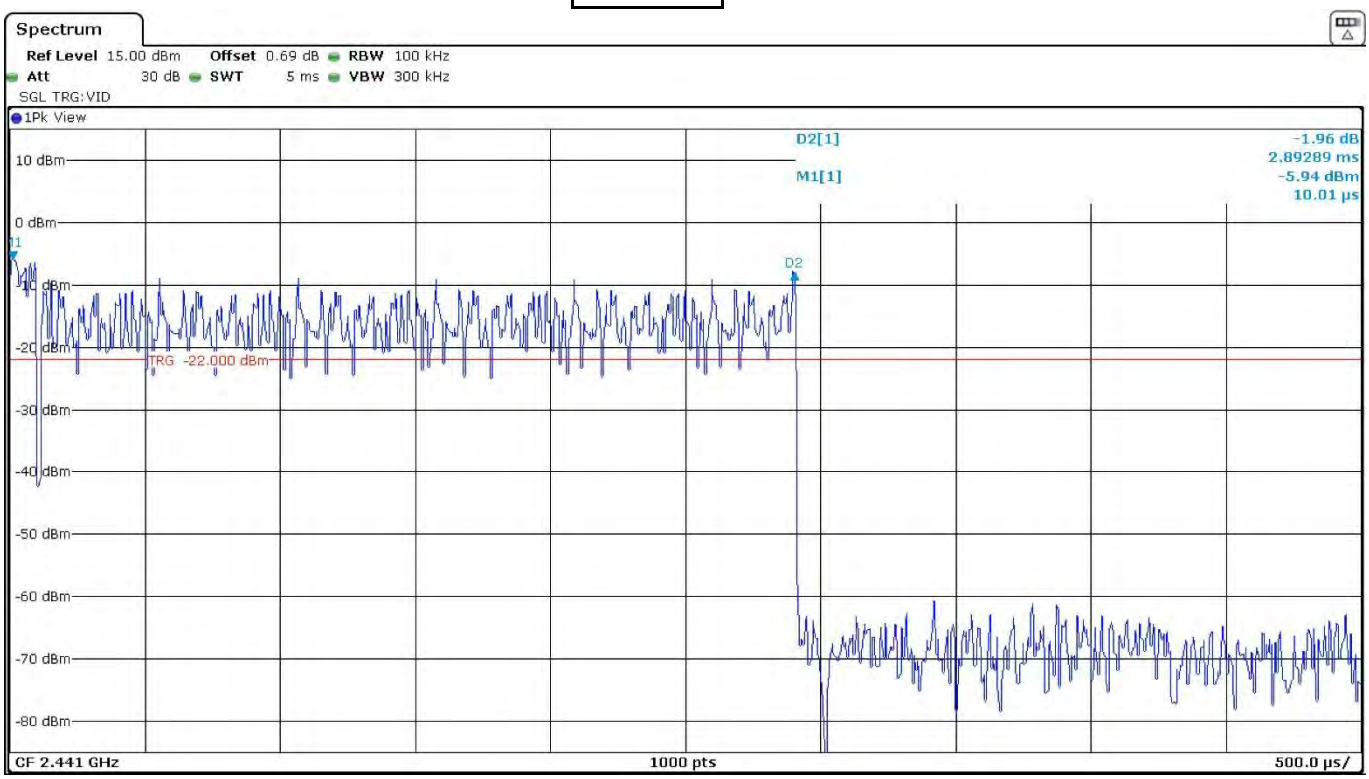
Measurement uncertainty (%)	<±0.01

Verdict: PASS

- **8DPSK (packet type 3DH5) – Time of Occupancy (Dwell Time)**

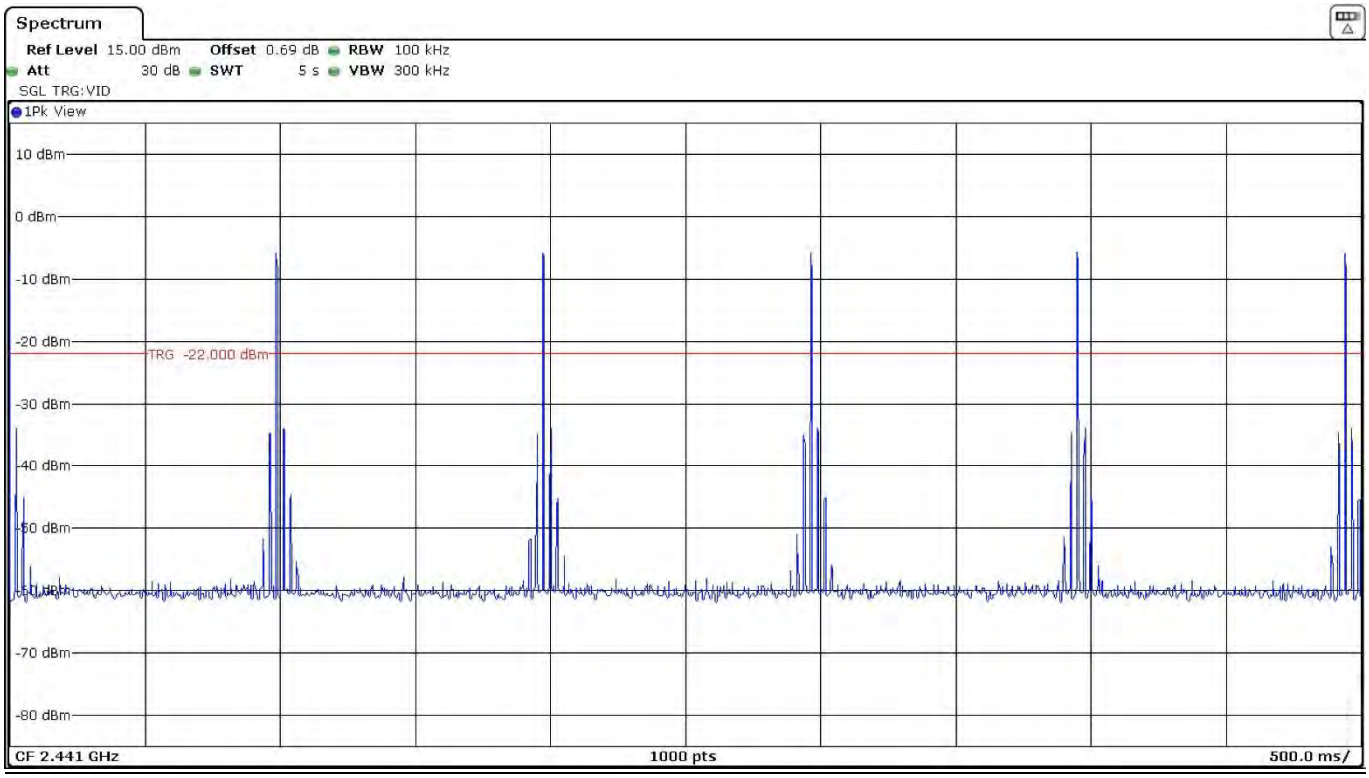
  - Transmit Time per Hop:

2.89289 ms



- Time of Occupancy:

Nº of hops on spectrum analyzer	6	
Nº of hops over the period	37.92	
Average Time of Occupancy	109.6984	ms



Measurement uncertainty (%)	<±0.01

Verdict: PASS

FCC Section 15.247 Subclause (b) / RSS-247 Clause 5.4 (b) Maximum peak output power and antenna gain

SPECIFICATION:

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels: 1 watt (30 dBm). The e.i.r.p. shall not exceed 4 W (RSS-247).

RESULTS:

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

Maximum Declared Antenna Gain: +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

- **GFSK** (1 Mbps)

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	-2.31	-0.06	-0.60
Maximum EIRP Power (dBm)	-0.31	1.94	1.40
Measurement uncertainty (dB)	<±1.20		

- **Pi/4 DQPSK** (2 Mbps)

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	-4.62	-2.67	-2.81
Maximum EIRP Power (dBm)	-2.62	-0.67	-0.81
Measurement uncertainty (dB)	<±1.20		

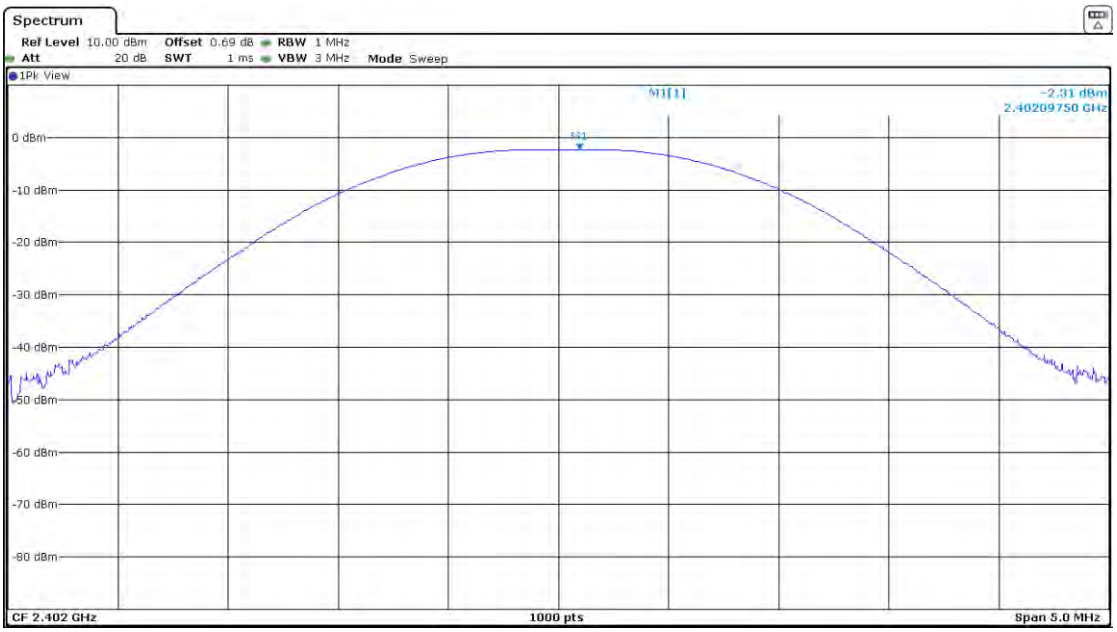
- **8DPSK** (3 Mbps)

Peak Conducted Output Power	Low Channel 2402 MHz	Middle Channel 2441 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	-4.97	-3.05	-3.34
Maximum EIRP Power (dBm)	-2.97	-1.05	-1.34
Measurement uncertainty (dB)	<±1.20		

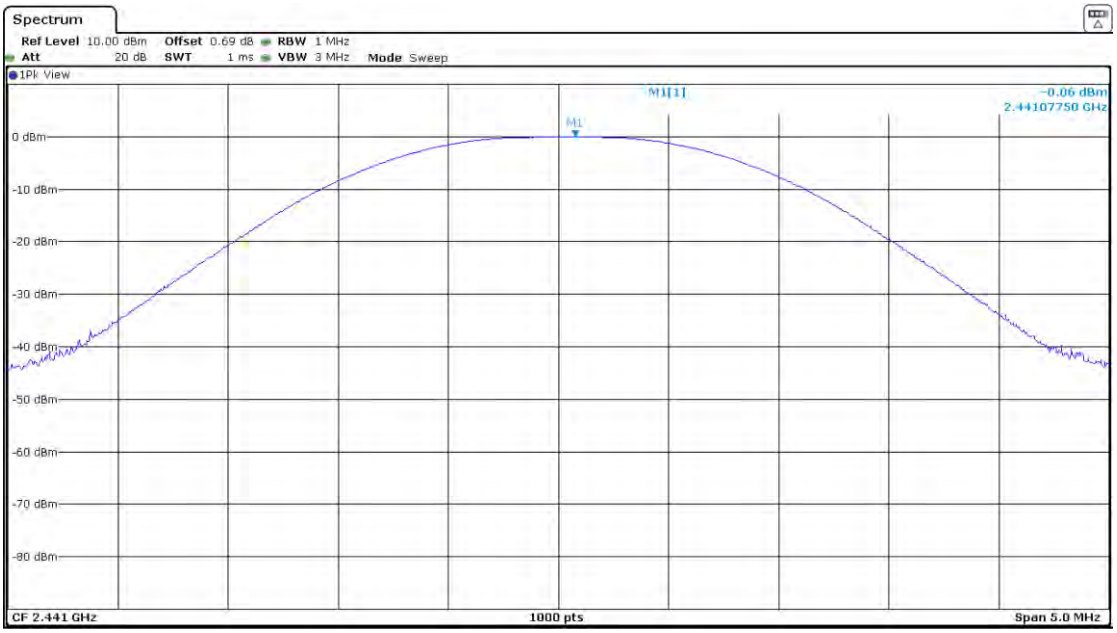
Verdict: PASS

- **GFSK – Peak Output Power**

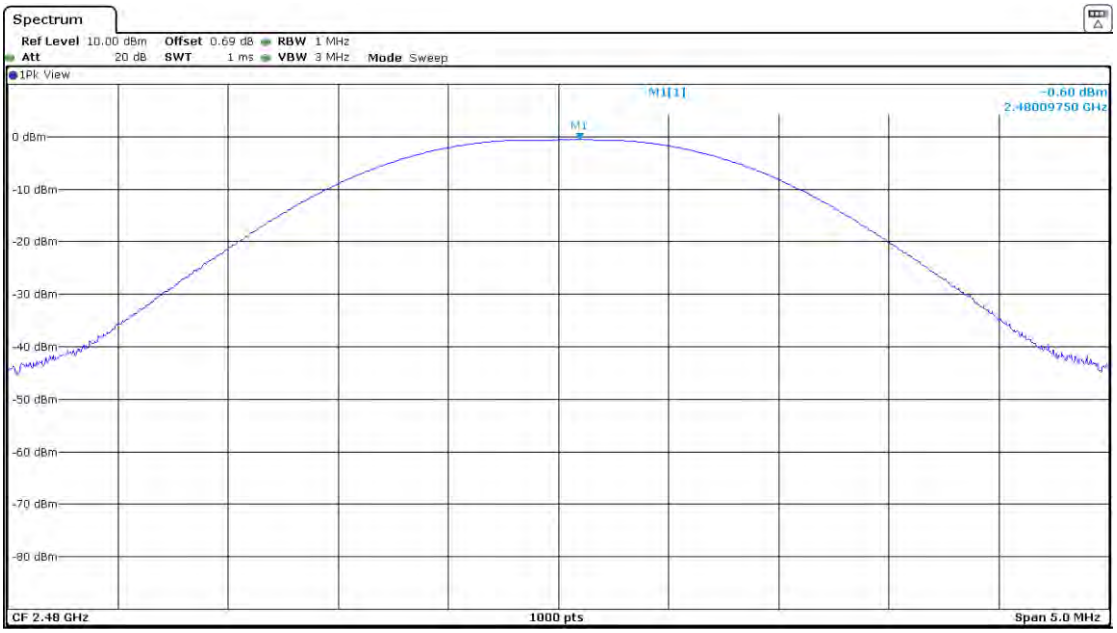
- Low Channel:



- Middle Channel:

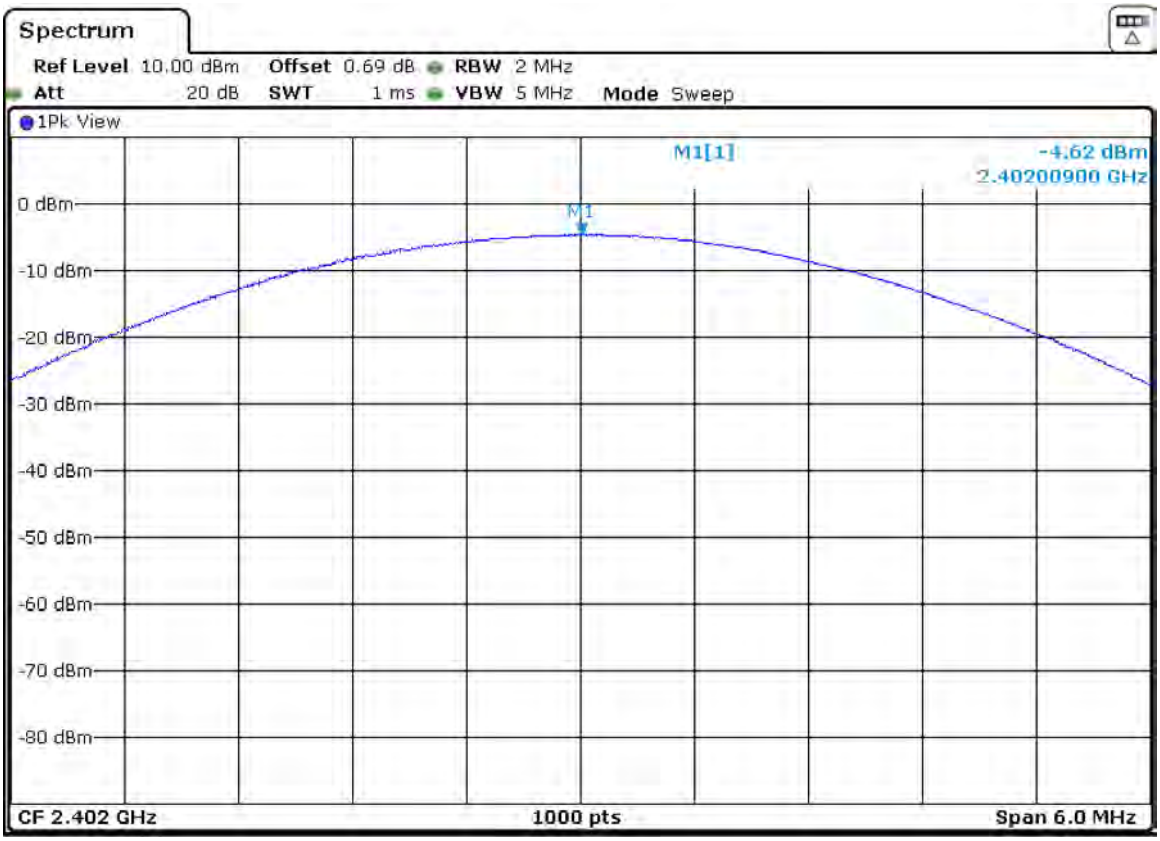


- High Channel:

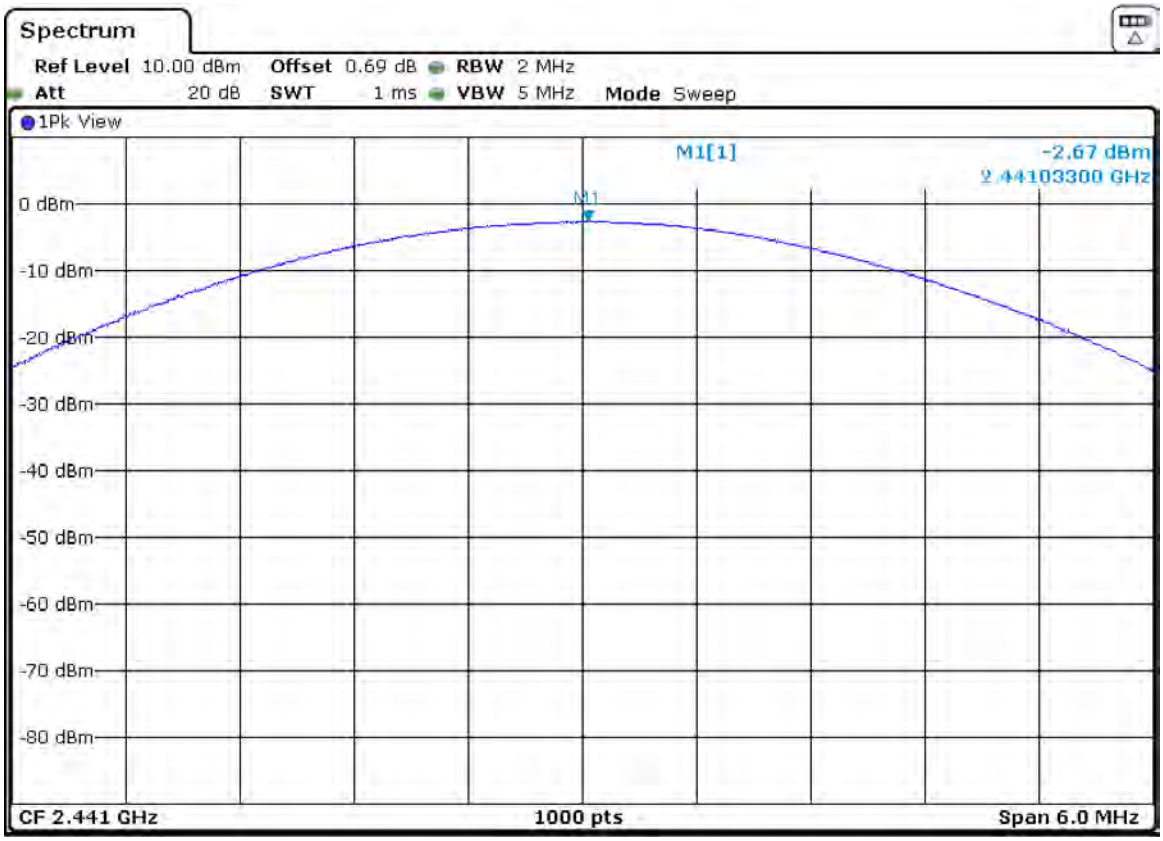


- **Pi/4 DQPSK – Peak Output Power**

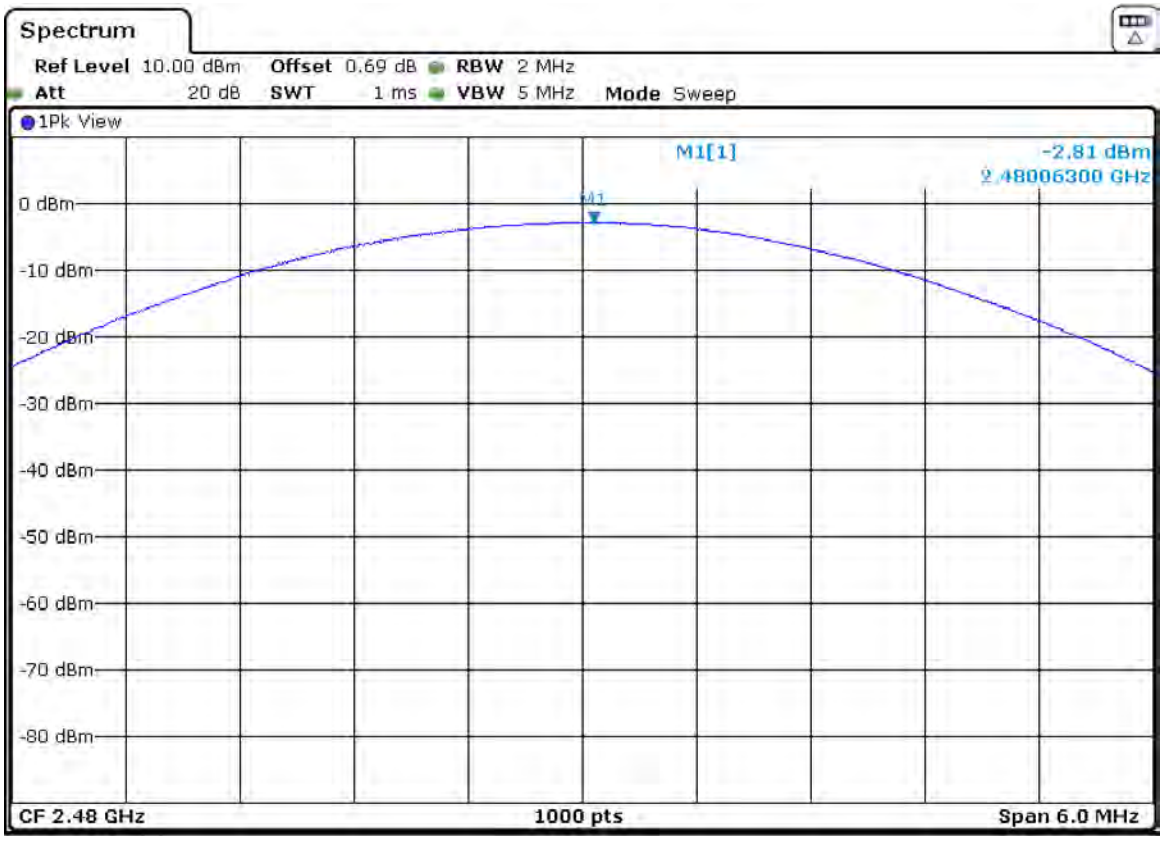
- Low Channel:



- Middle Channel:

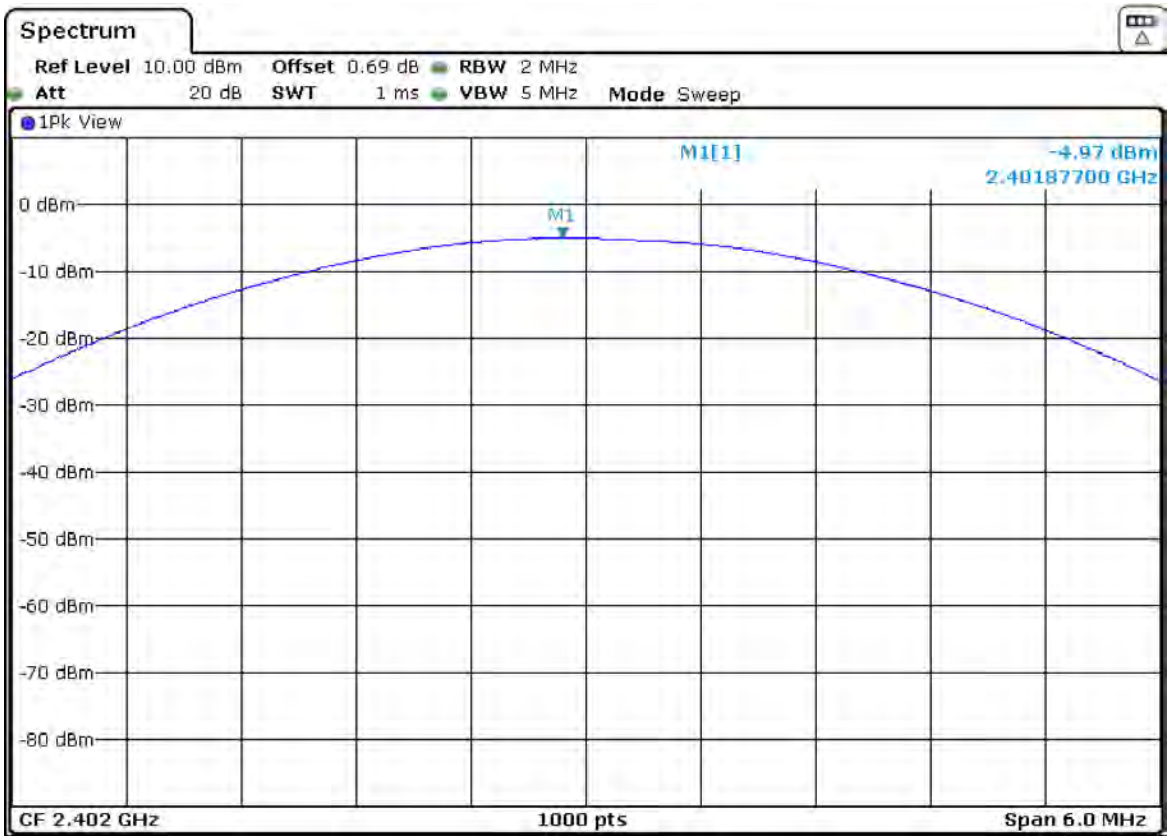


- High Channel:

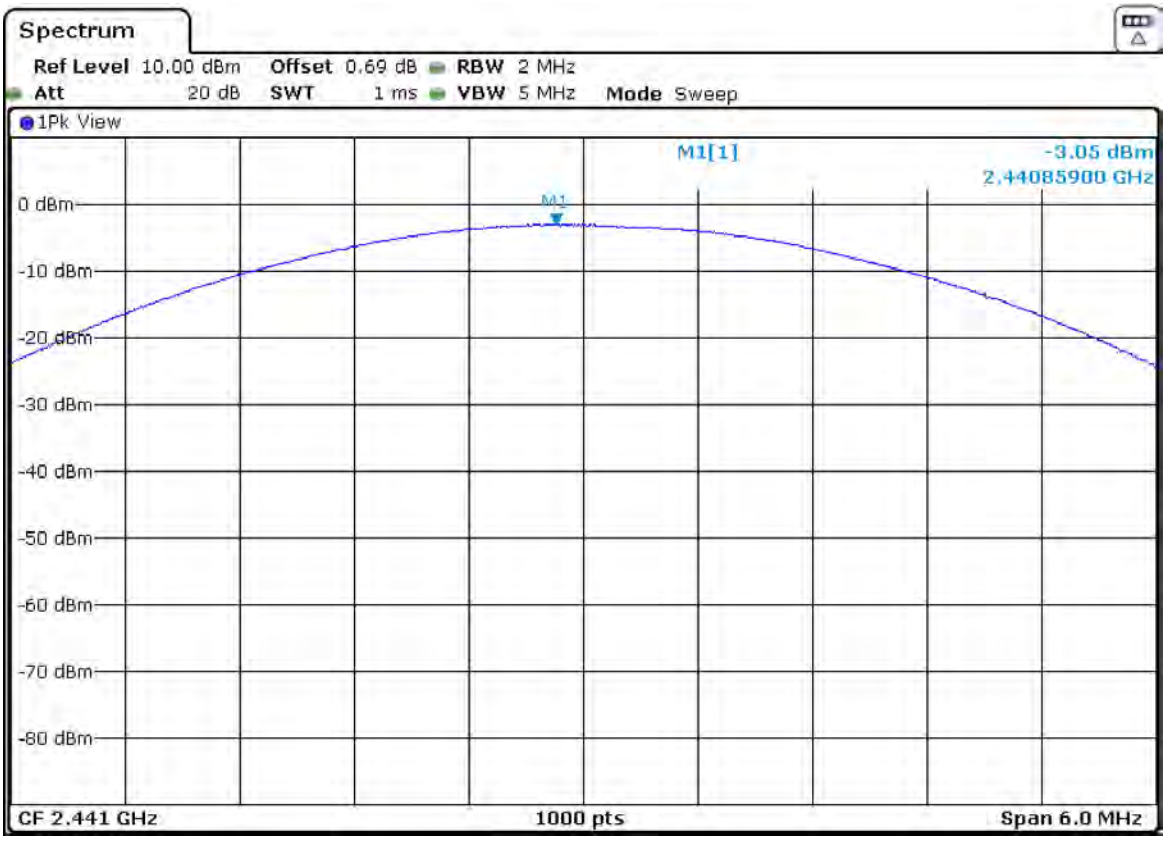


- **8DPSK – Peak Output Power**

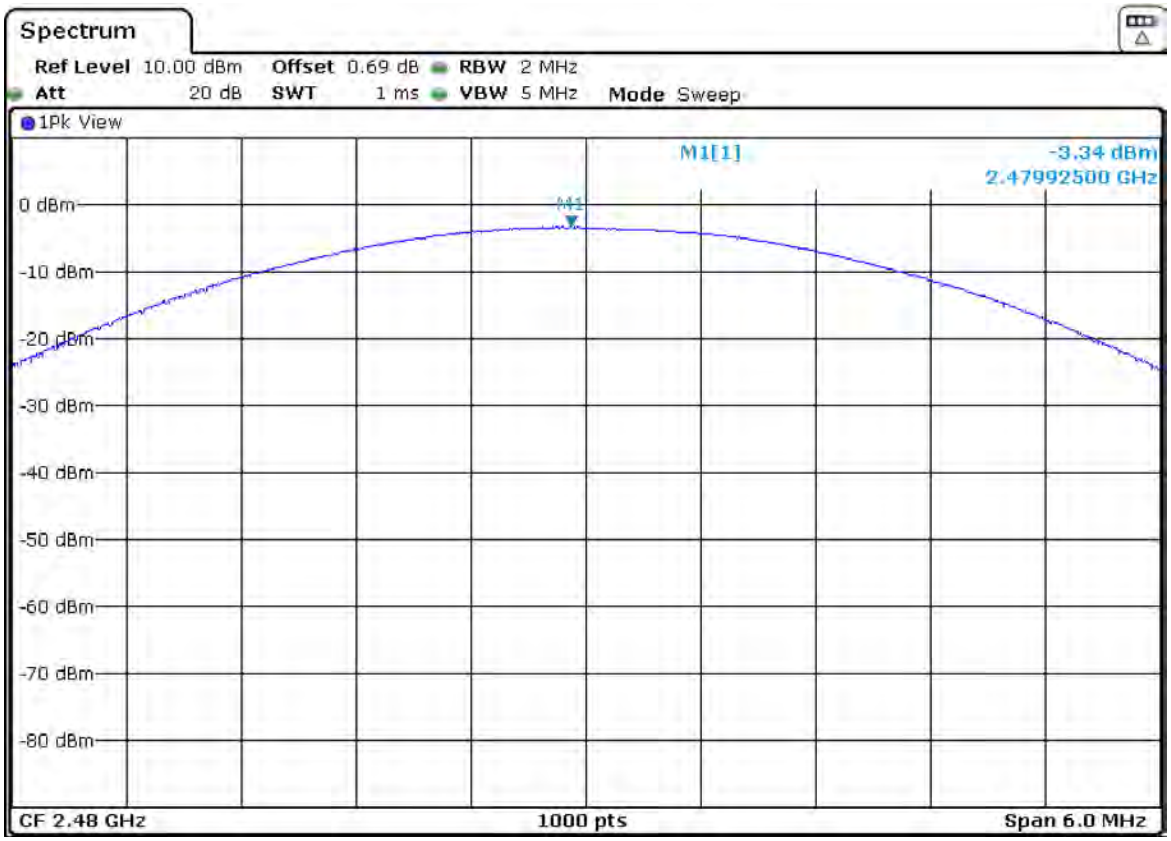
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

Emissions outside the frequency band in which the intentional radiator is operating shall be at least 20 dB below the highest level of the desired power.

RESULTS:

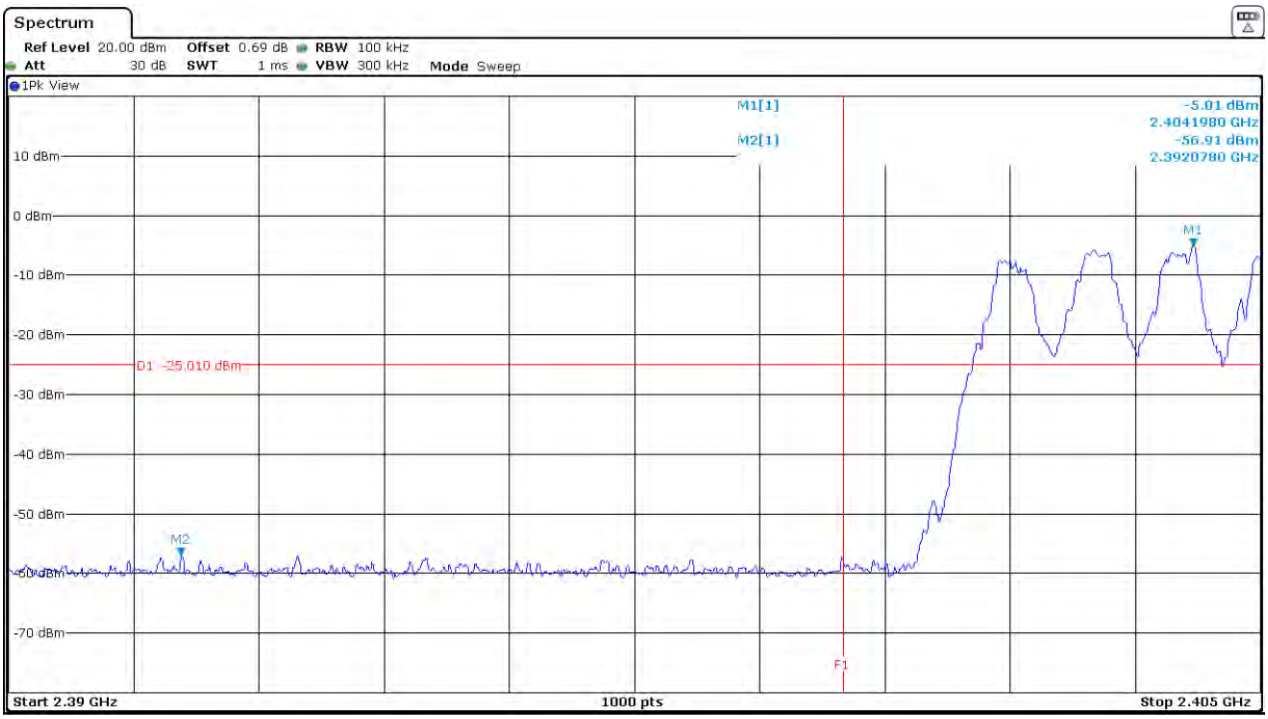
Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Measurement uncertainty (dB)	<±1.56

- **GFSK – Band-edge emissions compliance**

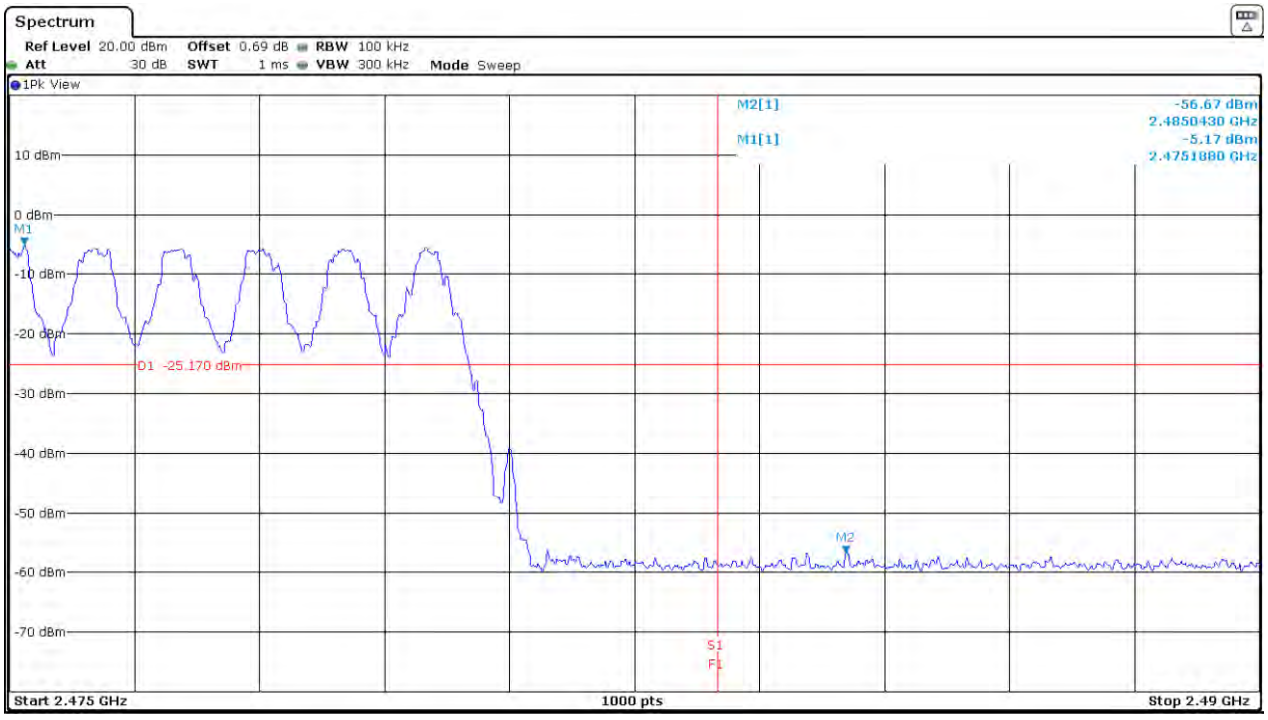
❖ HOPPING ON:

▪ Low Frequency Section 2402 MHz:



Verdict: PASS

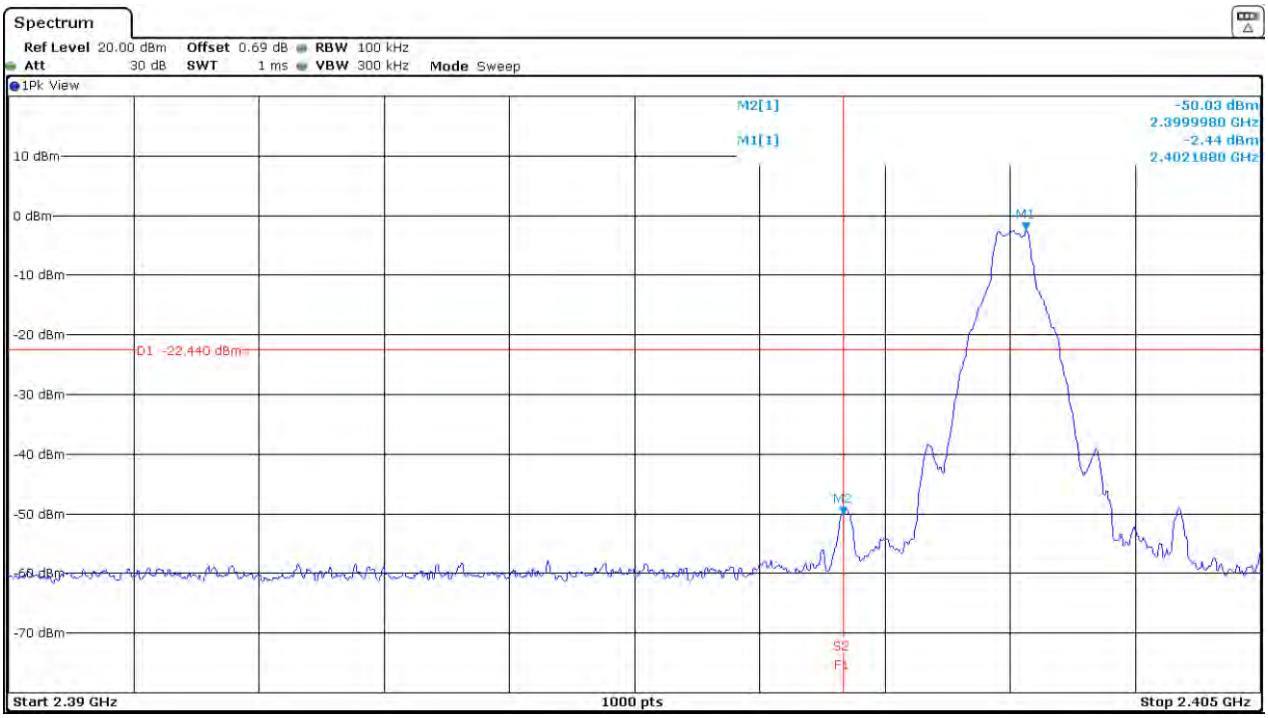
▪ High Frequency Section 2480 MHz:



Verdict: PASS

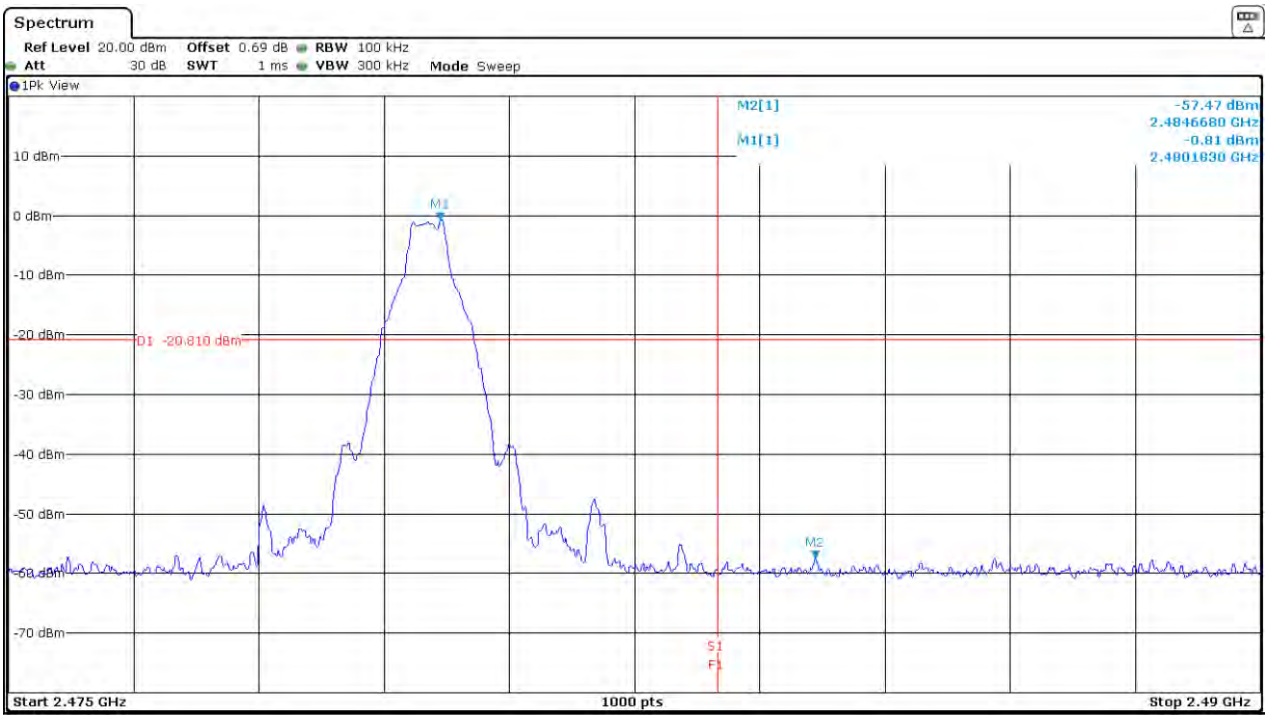
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:

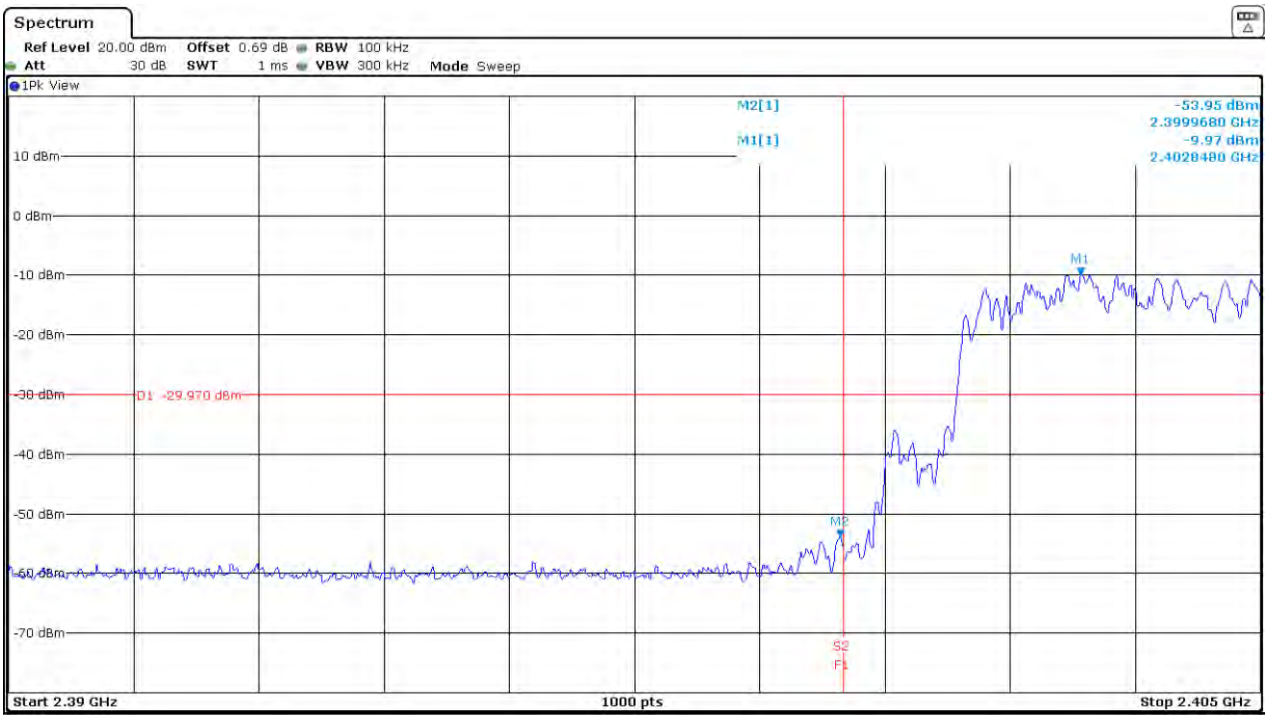


Verdict: PASS

- **Pi/4 DQPSK – Band-edge emissions compliance**

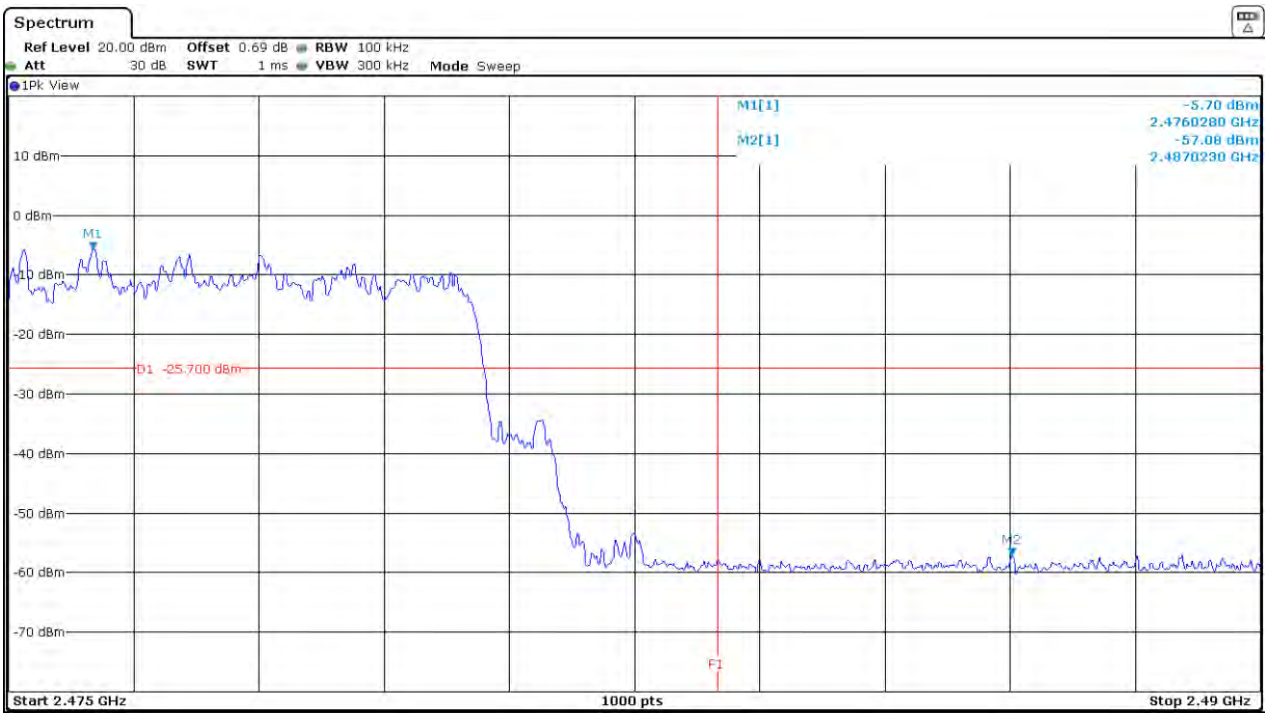
❖ HOPPING ON:

▪ Low Frequency Section 2402 MHz:



Verdict: PASS

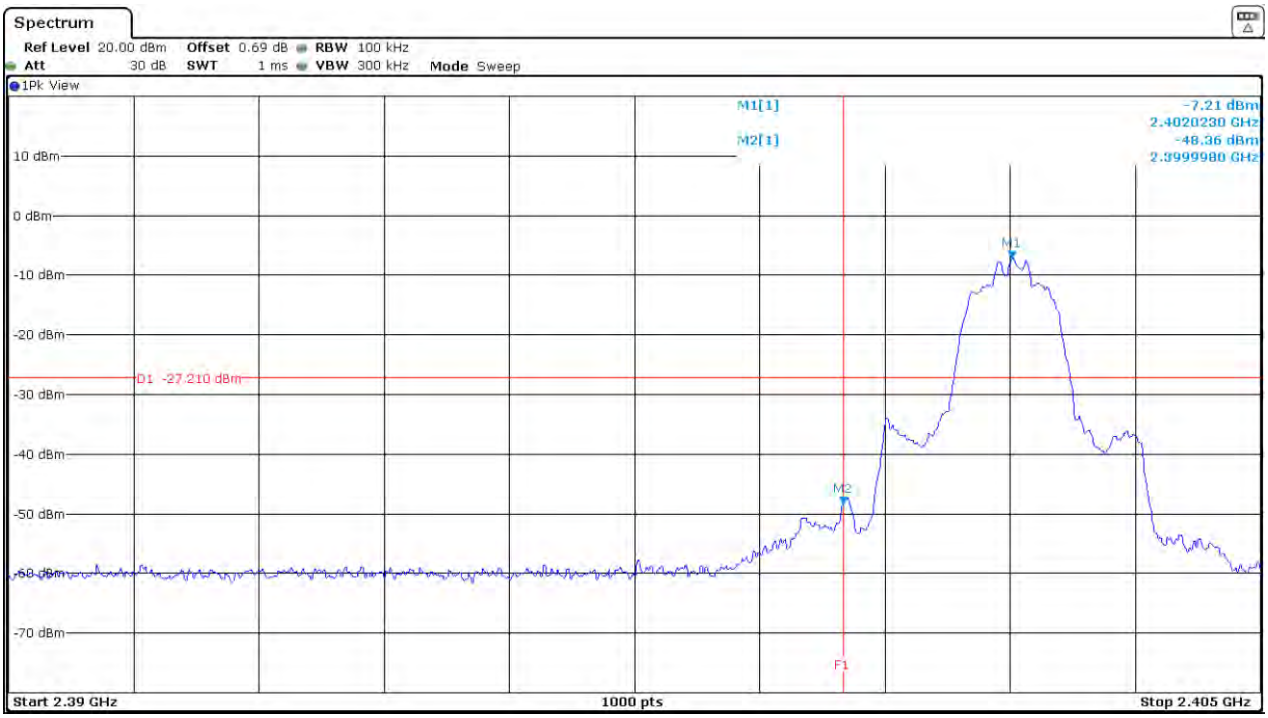
▪ High Frequency Section 2480 MHz:



Verdict: PASS

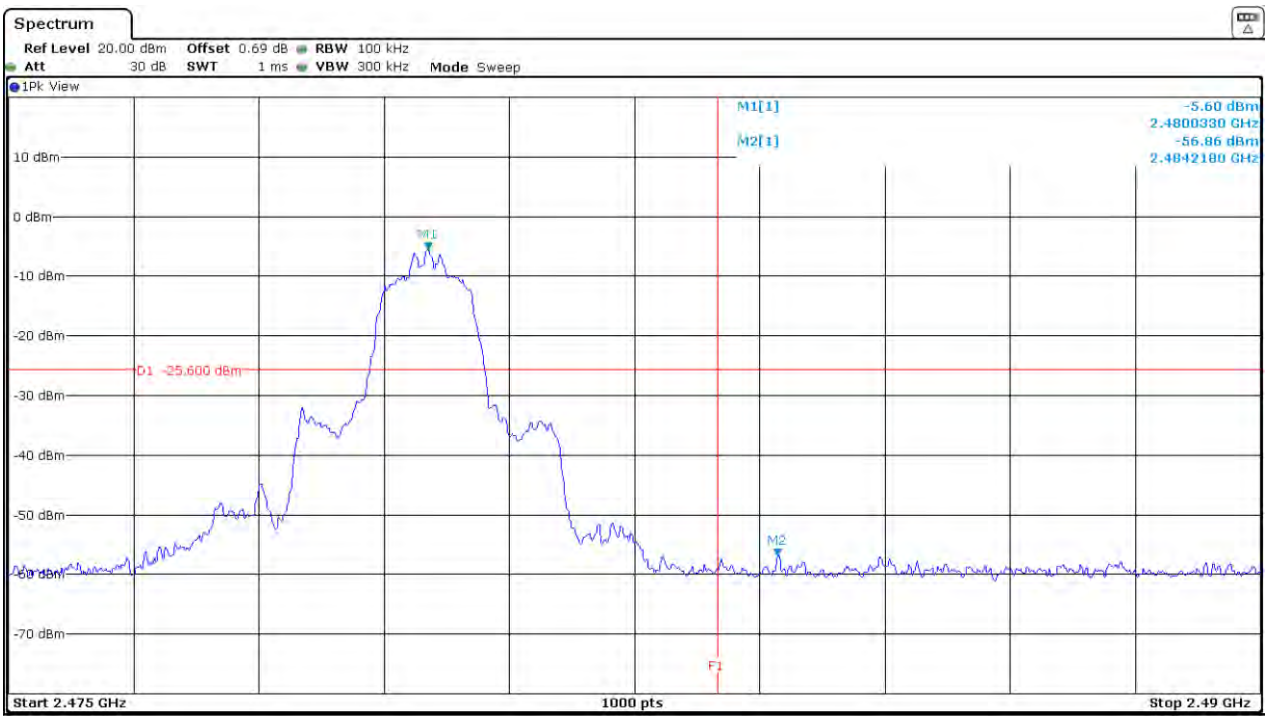
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:

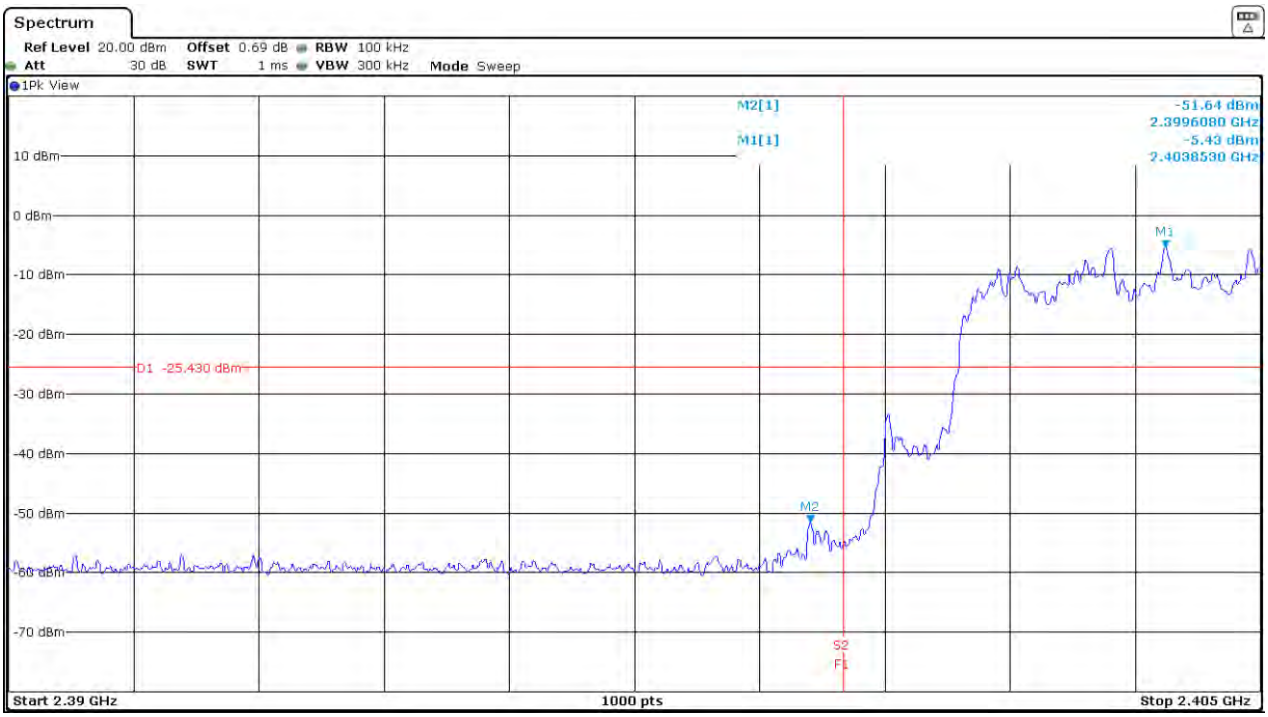


Verdict: PASS

- **8DPSK – Band-edge emissions compliance**

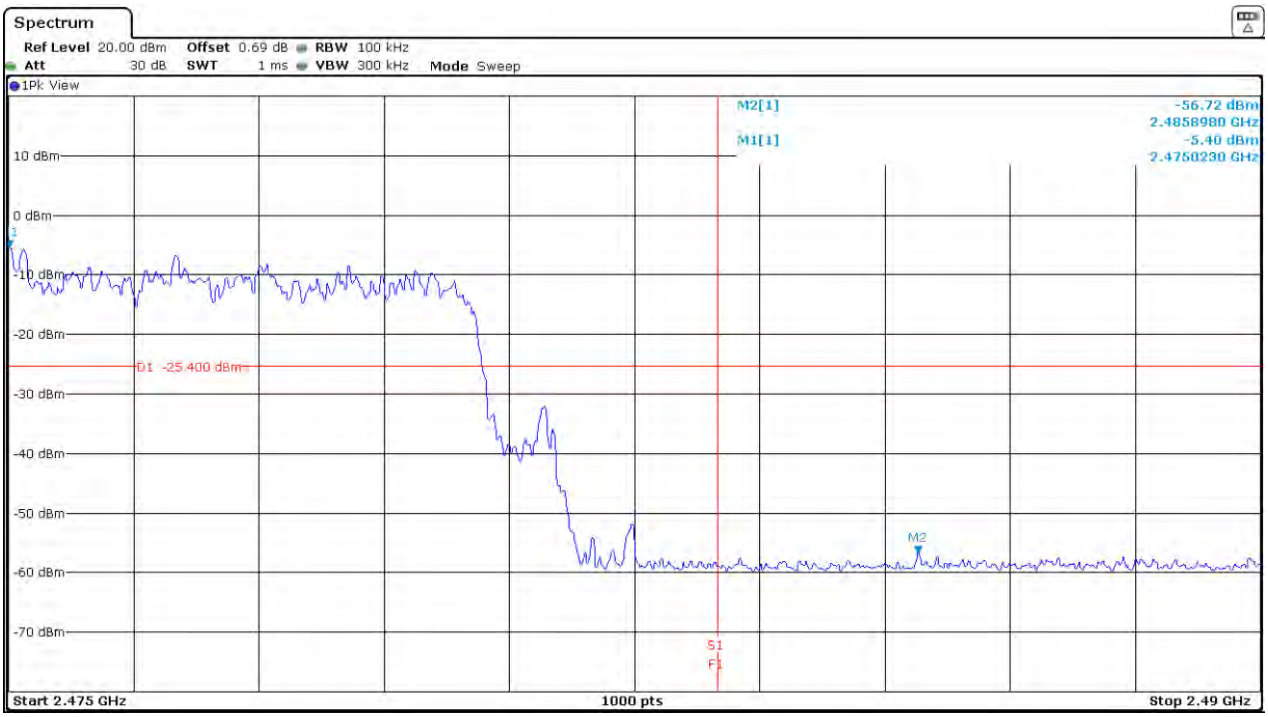
❖ HOPPING ON:

▪ Low Frequency Section 2402 MHz:



Verdict: PASS

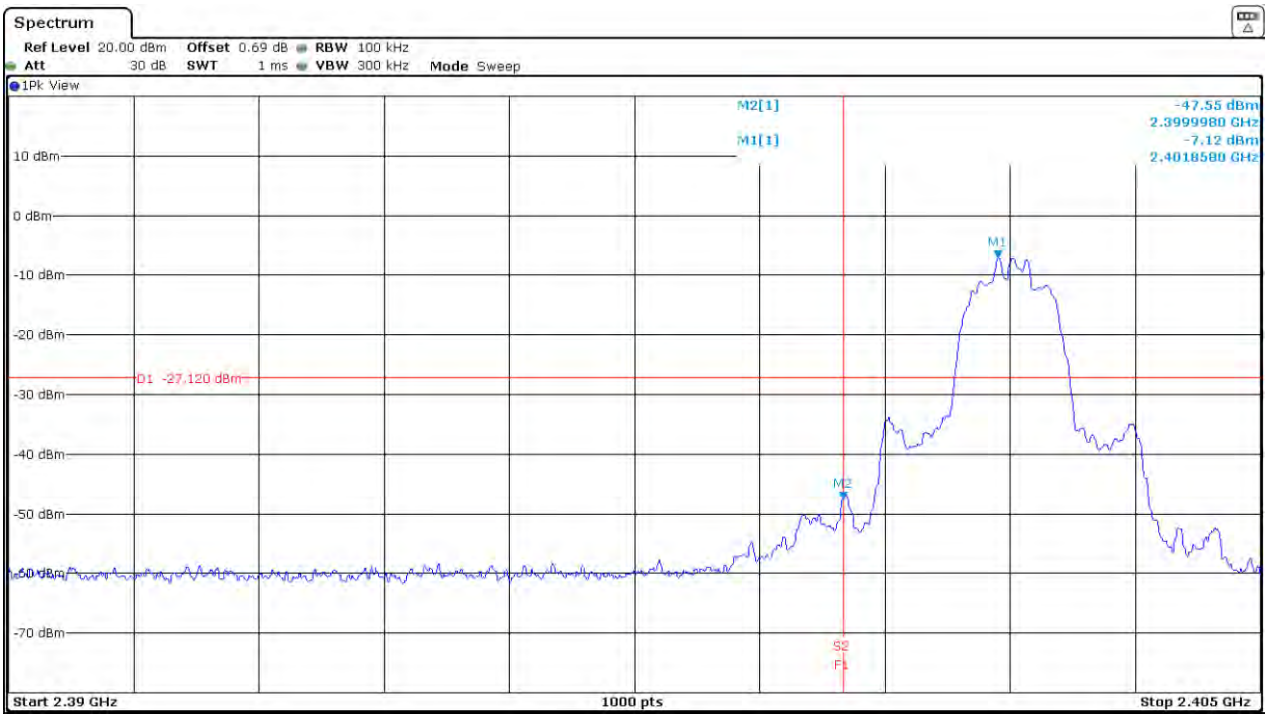
▪ High Frequency Section 2480 MHz:



Verdict: PASS

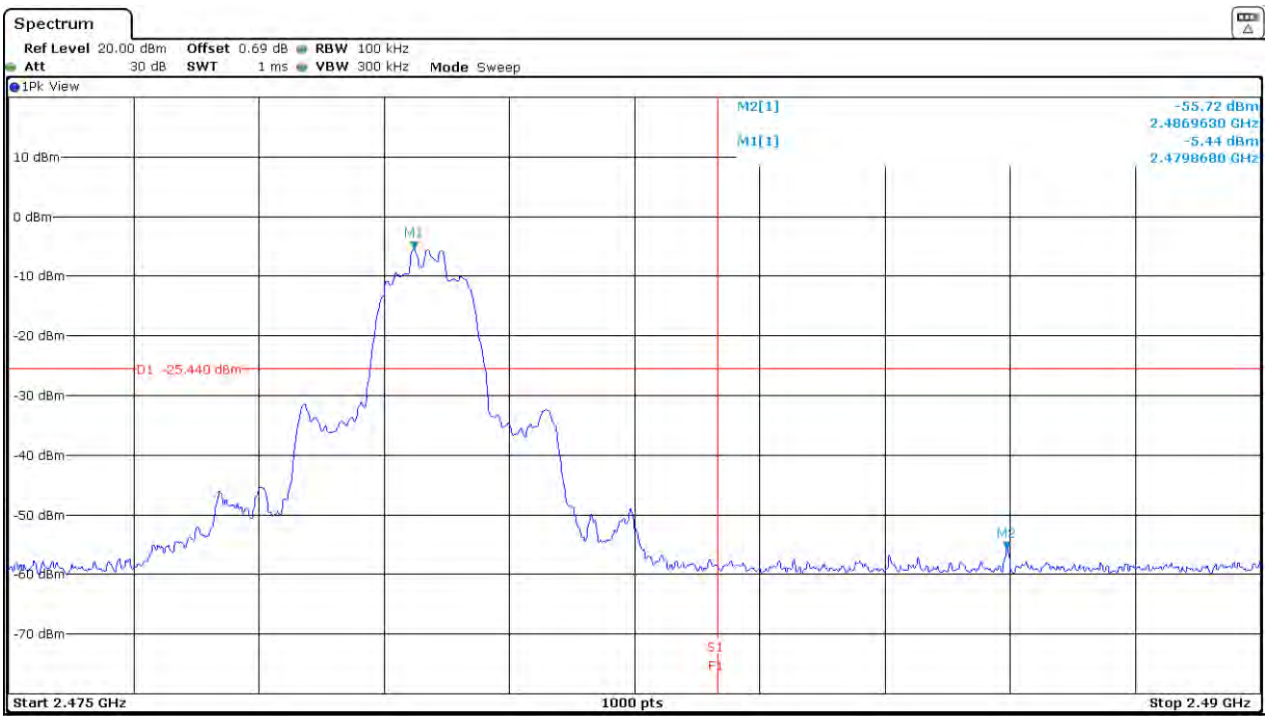
❖ HOPPING OFF:

- Low Frequency Section 2402 MHz:



Verdict: PASS

- High Frequency Section 2480 MHz:



Verdict: PASS

FCC Section 15.247 Subclause (d) / RSS-247 Clause 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 - 25000	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-1000 MHz and at distance of 1m for the frequency range 1 GHz-25 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:

The spurious frequencies do not depend on either on the operating channel or the modulation.

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
480.0315	Vertical	Quasi peak	29.0	<± 3.86
639.9845	Horizontal	Quasi peak	39.2	<± 3.86
680.0455	Vertical	Quasi peak	31.8	<± 3.86
720.0580	Vertical	Quasi peak	35.1	<± 3.86
760.0220	Horizontal	Quasi peak	38.1	<± 3.86

Frequency range 1 - 26 GHz:

The results in the next tables show the maximum measured levels in the 1-26 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Spurious signals 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.

Modulation: GFSK (DH5)

1. CHANNEL: LOWEST (2402 MHz).

No radiated spurious signals were detected at less than 20 dB below the limit.

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2285.03	Vertical	Peak	49.09	<± 4.72
2310.97	Vertical	Peak	48.60	<± 4.72
2597.26	Vertical	Peak	50.40	<± 4.72
4881.83	Horizontal	Peak	40.29	<± 4.72
19528.25	Horizontal	Peak	39.43	<± 4.72

3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2324.07	Vertical	Peak	50.32	<± 4.72
2324.30	Vertical	Peak	48.95	<± 4.72
2636.16	Vertical	Peak	49.66	<± 4.72
4960.23	Vertical	Peak	39.91	<± 4.72

Verdict: PASS

Modulation: Π/4-DQPSK (2DH5)

1. CHANNEL: LOWEST (2402 MHz).

No radiated spurious signals were detected at less than 20 dB below the limit.

2. CHANNEL: MIDDLE (2441 MHz).

No radiated spurious signals were detected at less than 20 dB below the limit.

3. CHANNEL: HIGHEST (2480 MHz).

No radiated spurious signals were detected at less than 20 dB below the limit.

Verdict: PASS

Modulation: 8-DPSK (3DH5)

1. CHANNEL: LOWEST (2402 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2246.24	Vertical	Peak	47.65	<± 4.72
2558.26	Vertical	Peak	50.37	<± 4.72
4803.90	Vertical	Peak	40.73	<± 4.72

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2285.08	Vertical	Peak	49.56	<± 4.72
2597.04	Vertical	Peak	50.25	<± 4.72
4881.83	Vertical	Peak	40.57	<± 4.72

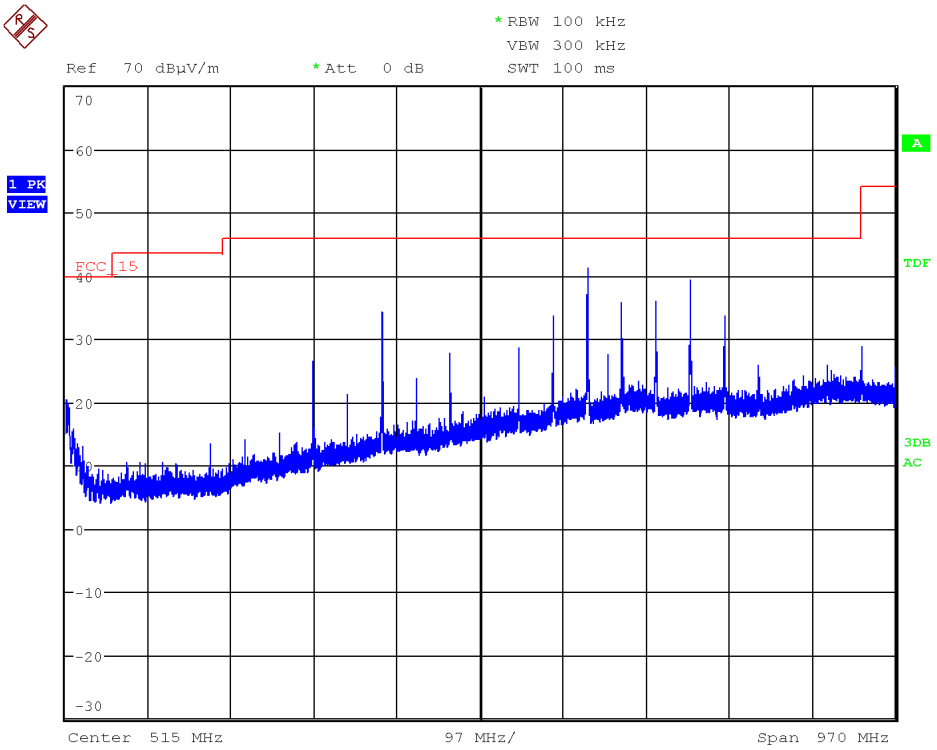
3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2324.25	Vertical	Peak	50.25	<± 4.72
2349.86	Vertical	Peak	48.94	<± 4.72
4960.23	Vertical	Peak	40.93	<± 4.72

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

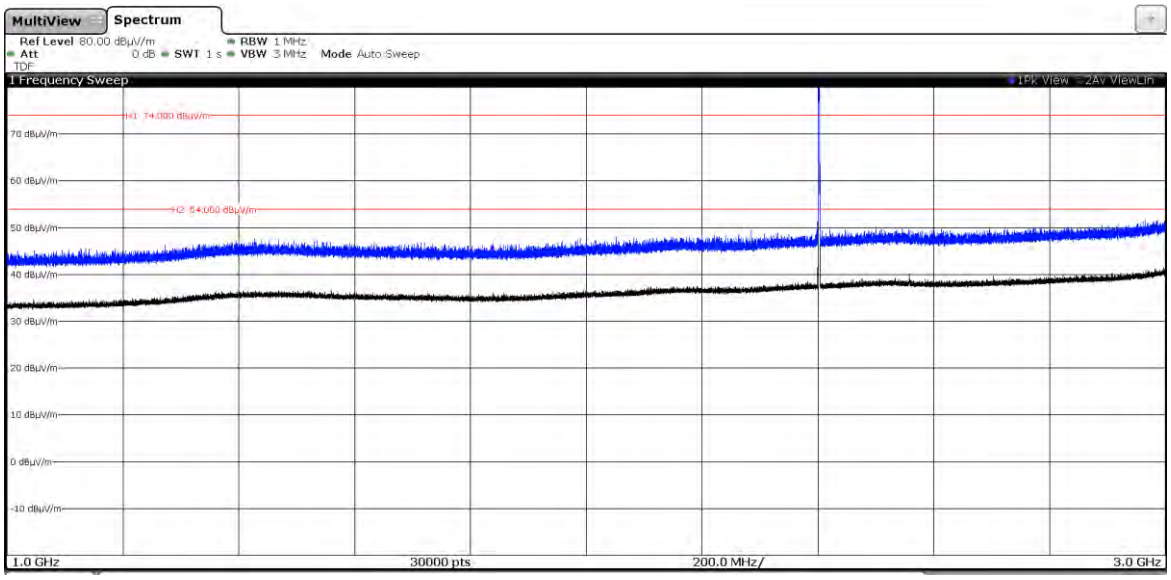
The spurious signals detected do not depend on either the operating channel or the modulation mode.



FREQUENCY RANGE 1 - 3 GHz:

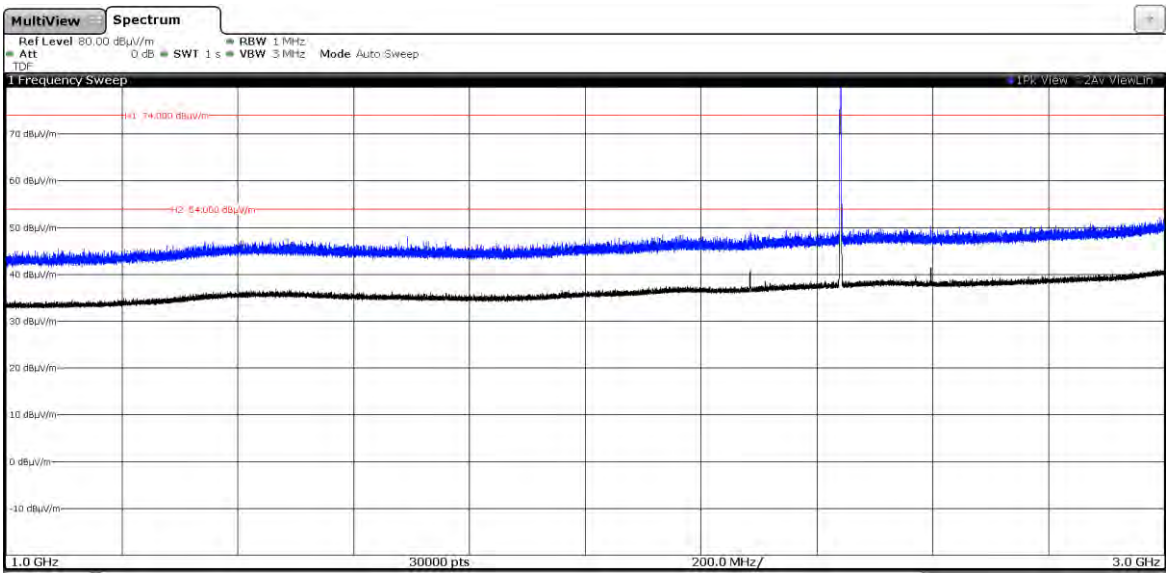
- **WORST CASE (GFSK)**

CHANNEL: LOWEST (2402 MHz).



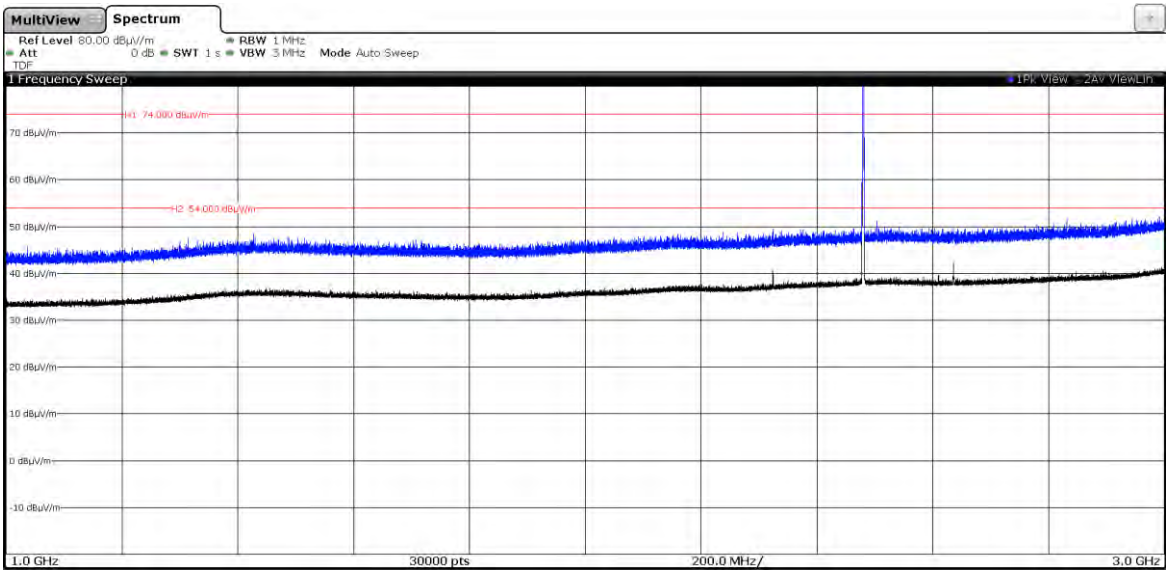
The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE (2441 MHz).



The peak above the limit is the carrier frequency

CHANNEL: HIGHEST (2480 MHz).

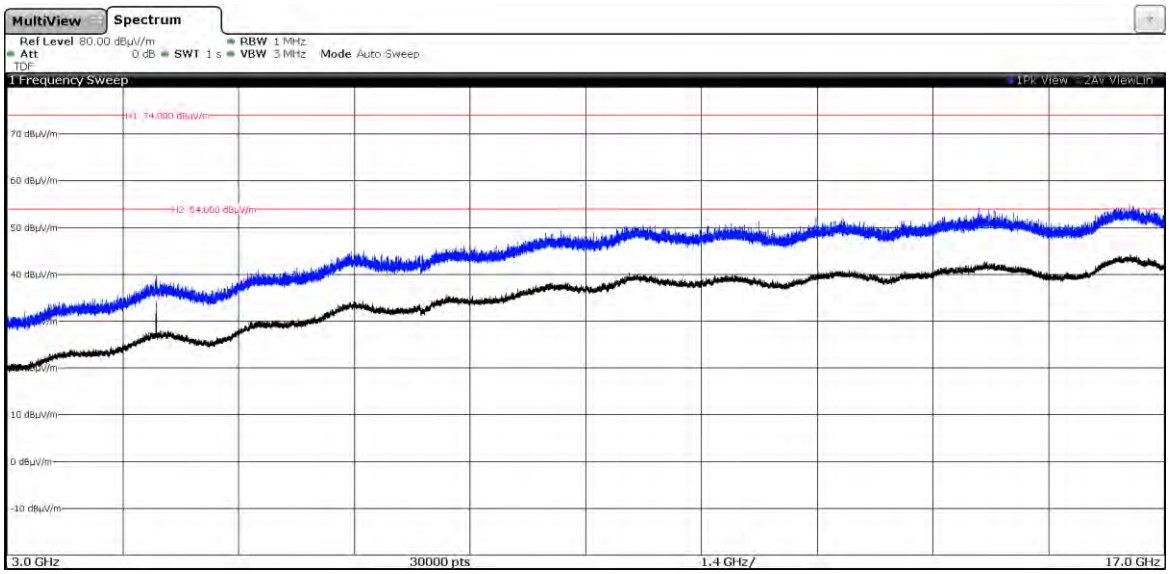


The peak above the limit is the carrier frequency

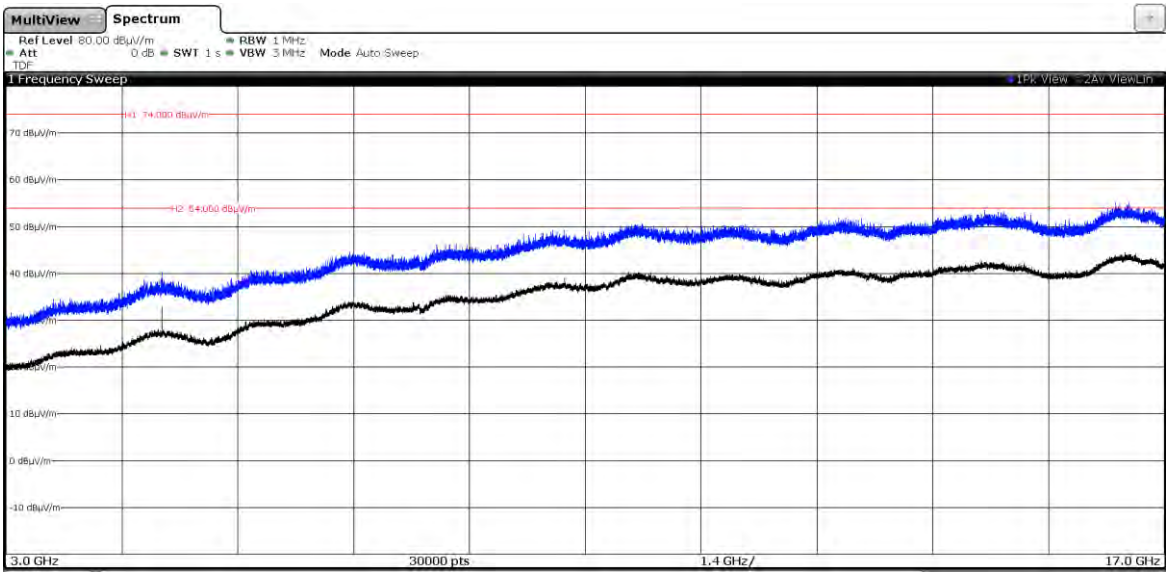
FREQUENCY RANGE 3 - 17 GHz:

- **WORST CASE (GFSK)**

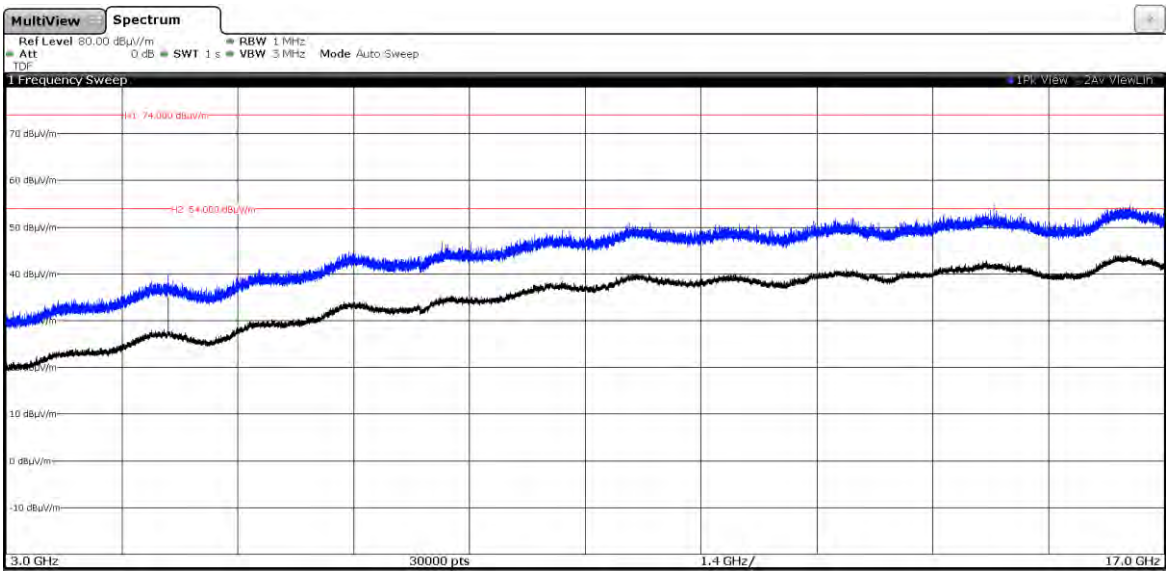
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2441 MHz).



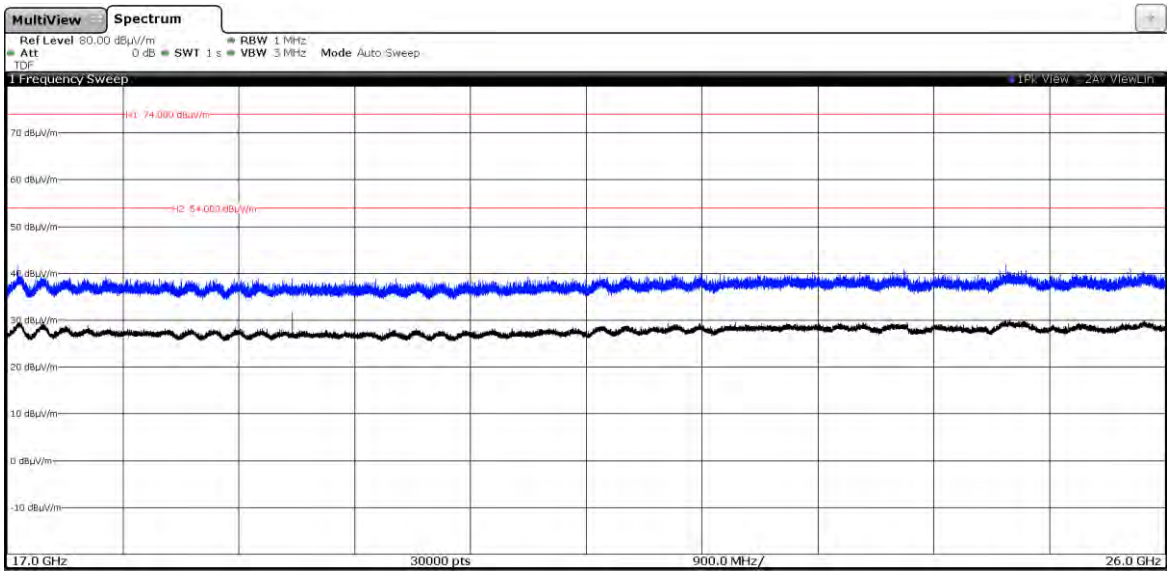
CHANNEL: HIGHEST (2480 MHz).



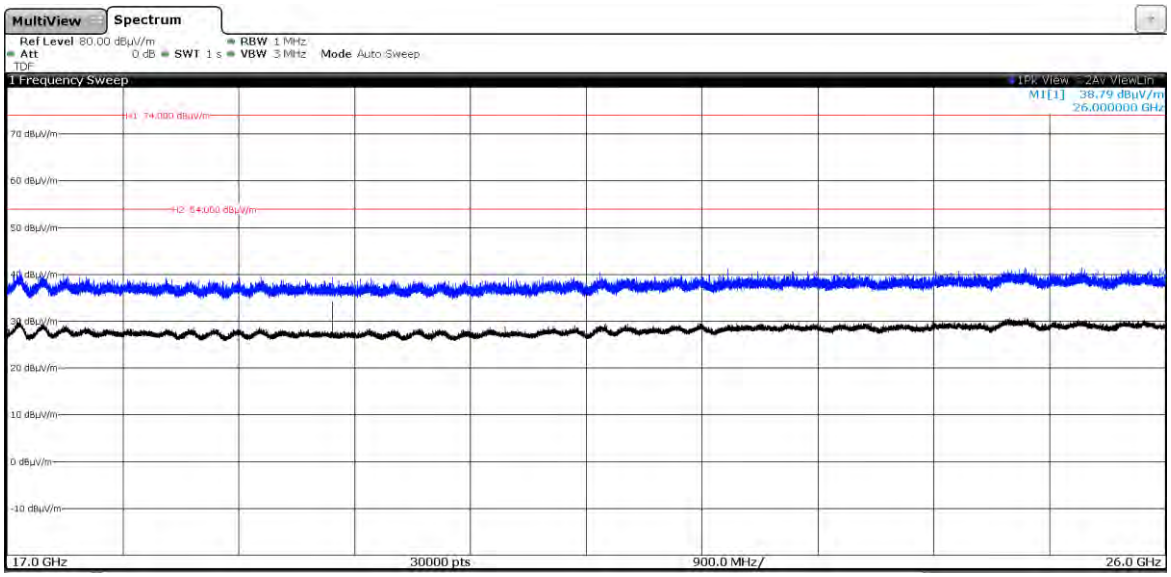
FREQUENCY RANGE 17 - 26 GHz:

- **WORST CASE (GFSK)**

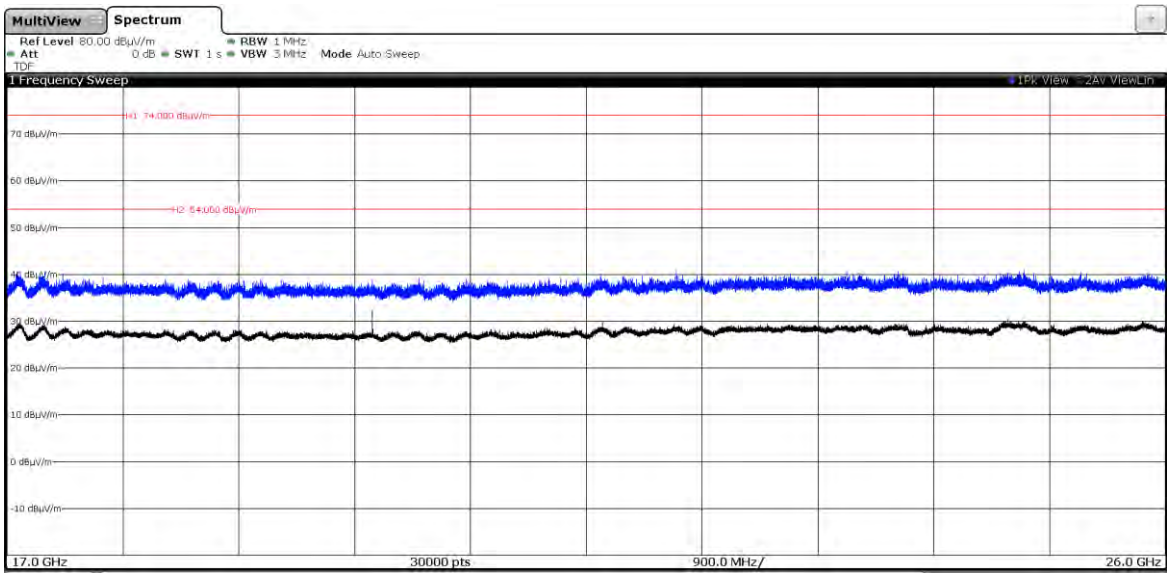
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2441 MHz).



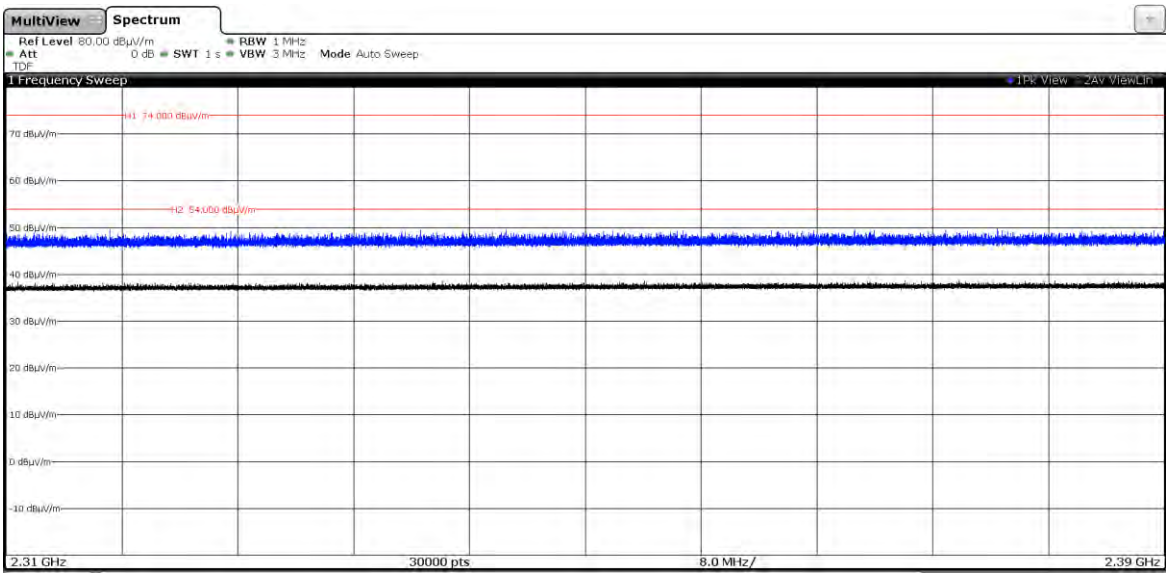
CHANNEL: HIGHEST (2480 MHz).



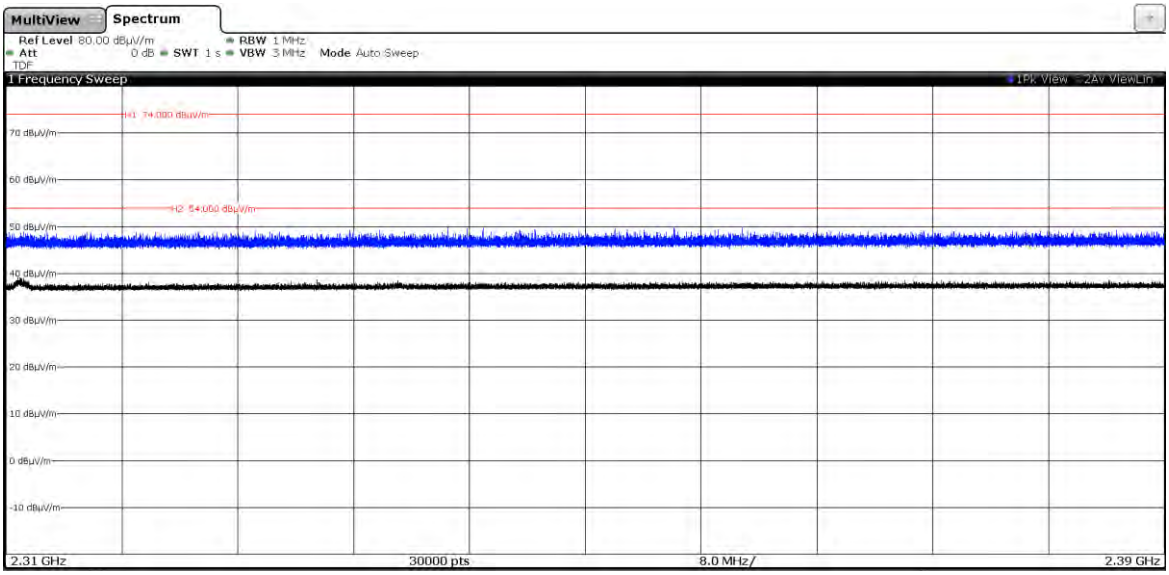
FREQUENCY RANGE 2.31-2.39 GHz (Restricted Band 1):

- **WORST CASE (GFSK)**

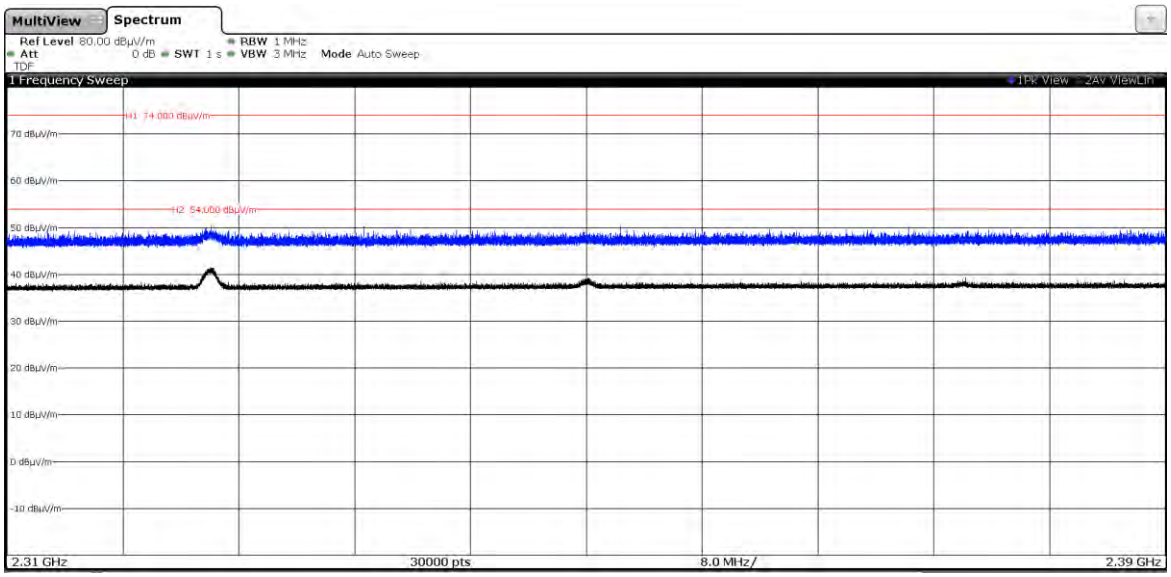
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2441 MHz).



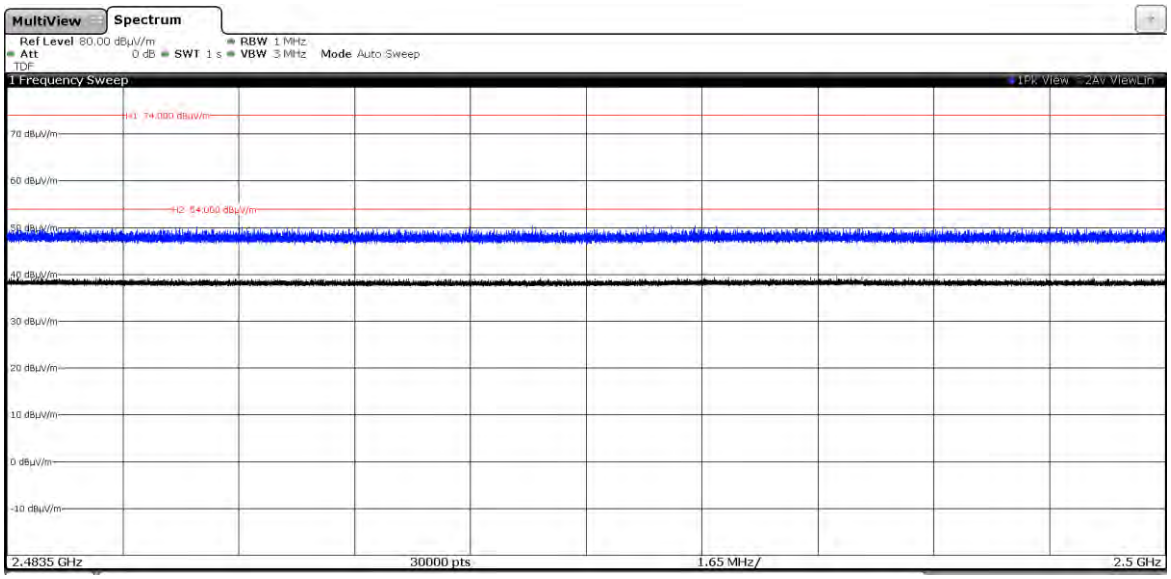
CHANNEL: HIGHEST (2480 MHz).



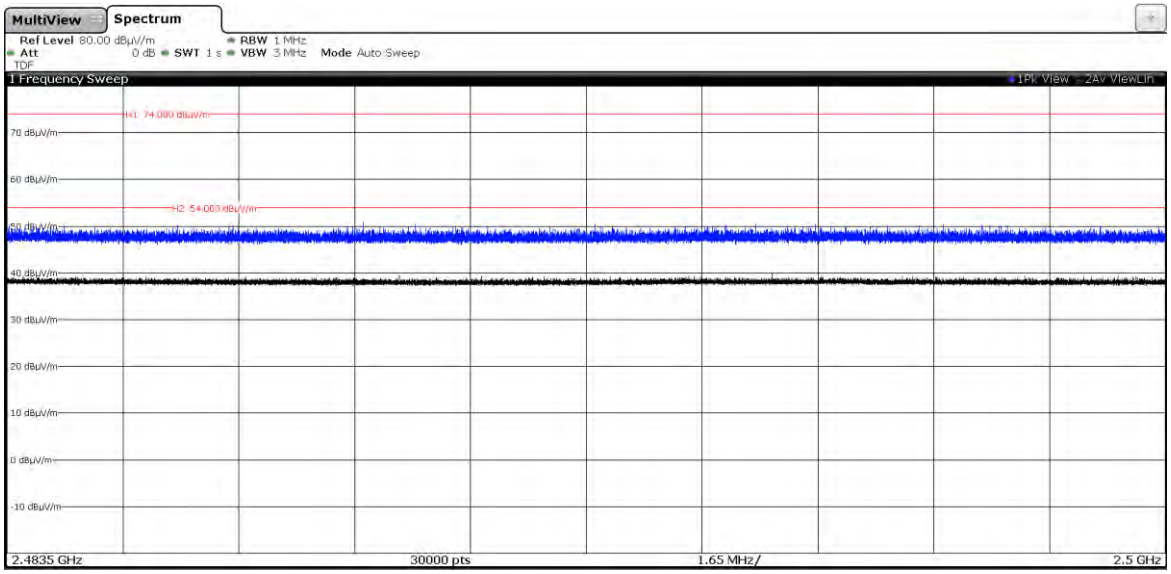
FREQUENCY RANGE 2.4835-2.5 GHz (Restricted Band 2):

- **WORST CASE (GFSK)**

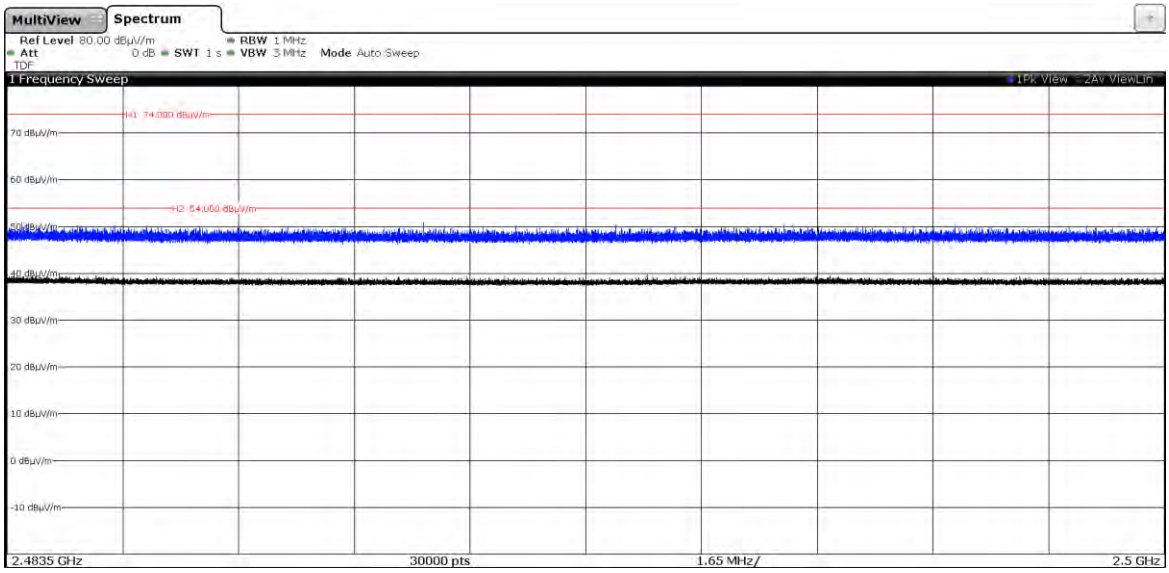
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2441 MHz).



CHANNEL: HIGHEST (2480 MHz).



Appendix B: Test results. Bluetooth Low Energy.

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TEST CONDITIONS

POWER SUPPLY (V):

V nonimal:	3.7 Vdc
Type of Power Supply:	Battery Li Ion.
Type of Antenna:	Internal.
Maximum Declared Antenna Gain:	+2 dBi

TEST FREQUENCIES:

Low Channel:	2402 MHz
Middle Channel:	2440 MHz
High Channel:	2480 MHz

CONDUCTED MEASUREMENTS

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

RADIATED MEASUREMENTS

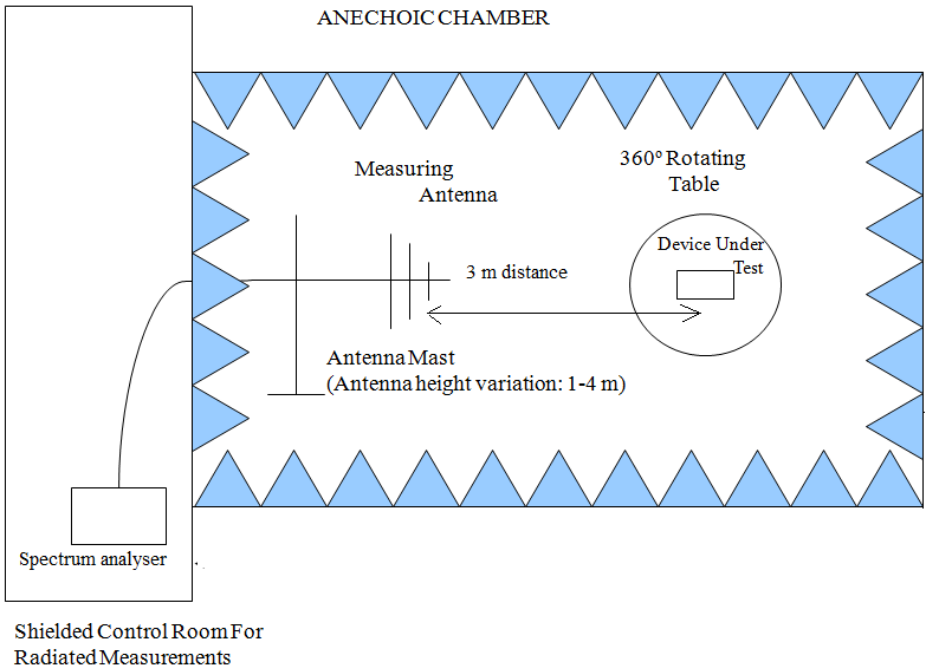
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz) is situated at a distance of 3 m and at a distance of 1m for the frequency range 1 GHz-26 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

For radiated emissions in the range 1 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

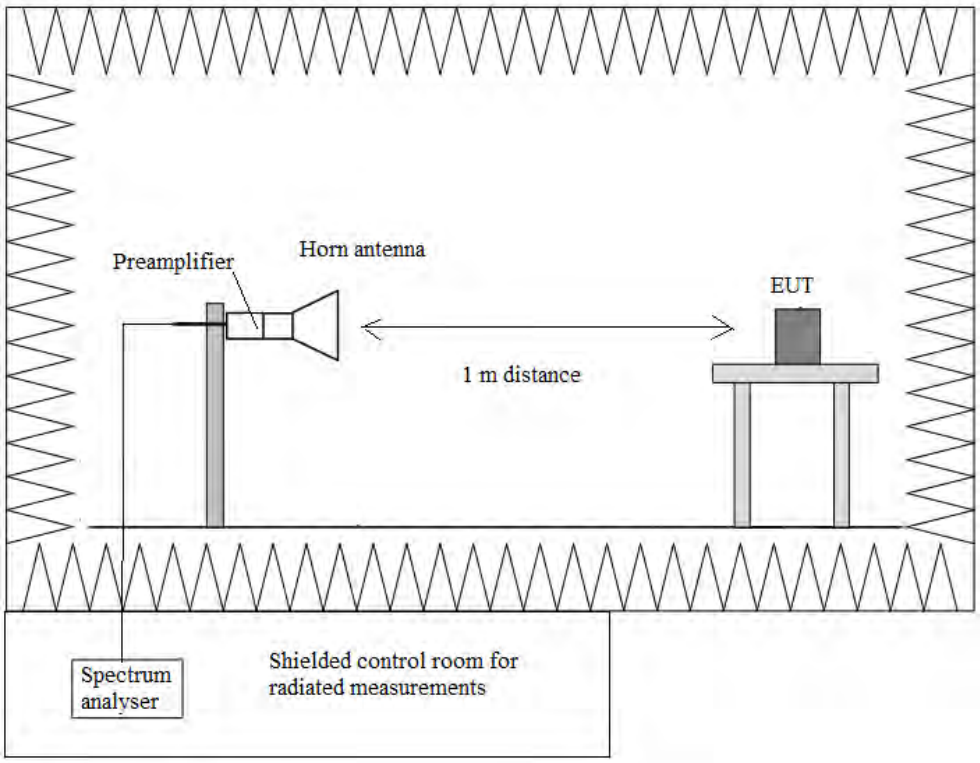
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find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

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

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup f > 1 GHz:

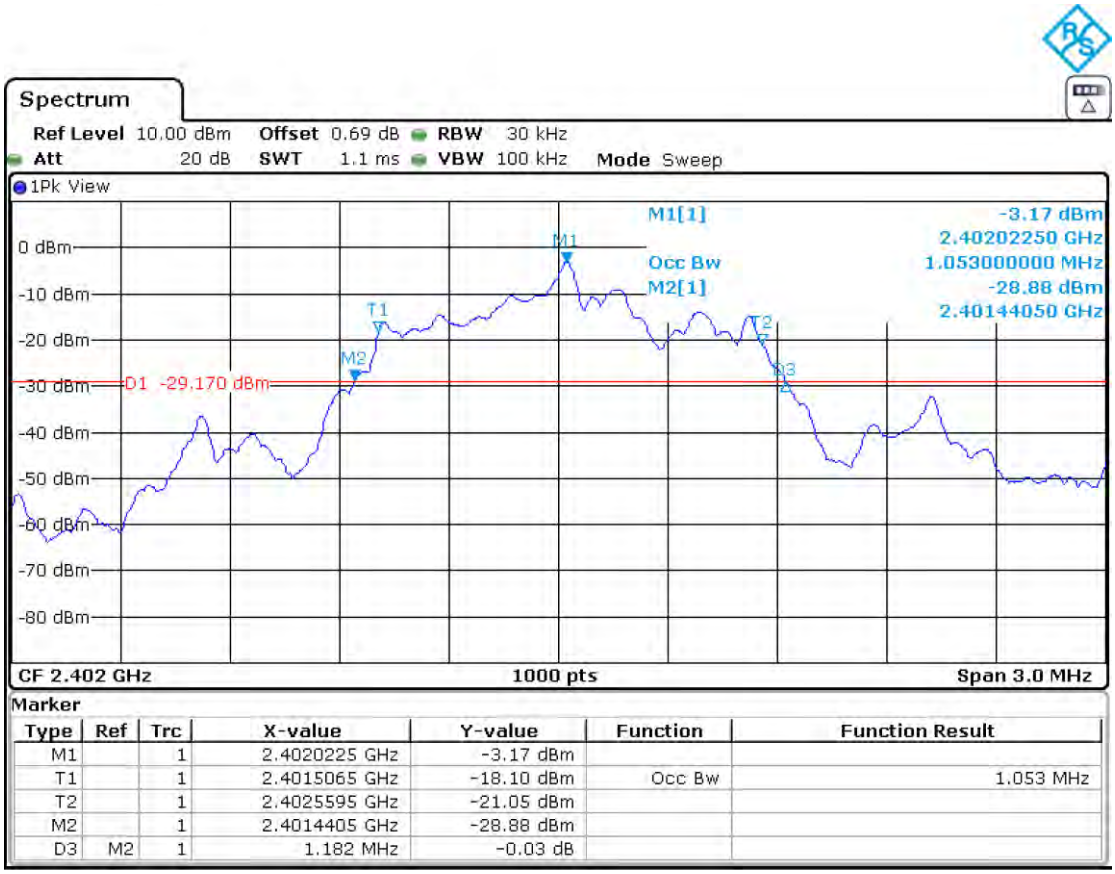


Occupied Bandwidth

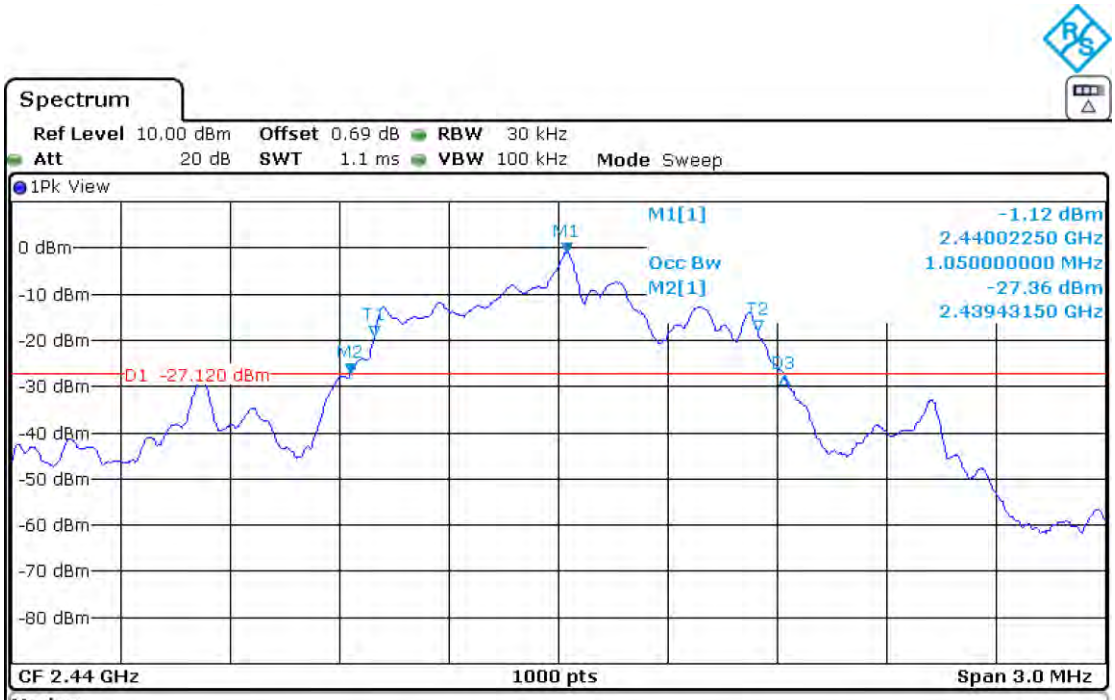
RESULTS:

	Low Channel 2402 MHz	Middle Channel 2440 MHz	High Channel 2480 MHz
99% Bandwidth (MHz)	1.053	1.050	1.053
Measurement uncertainty (kHz)	<± 0.45		

- Low Channel:



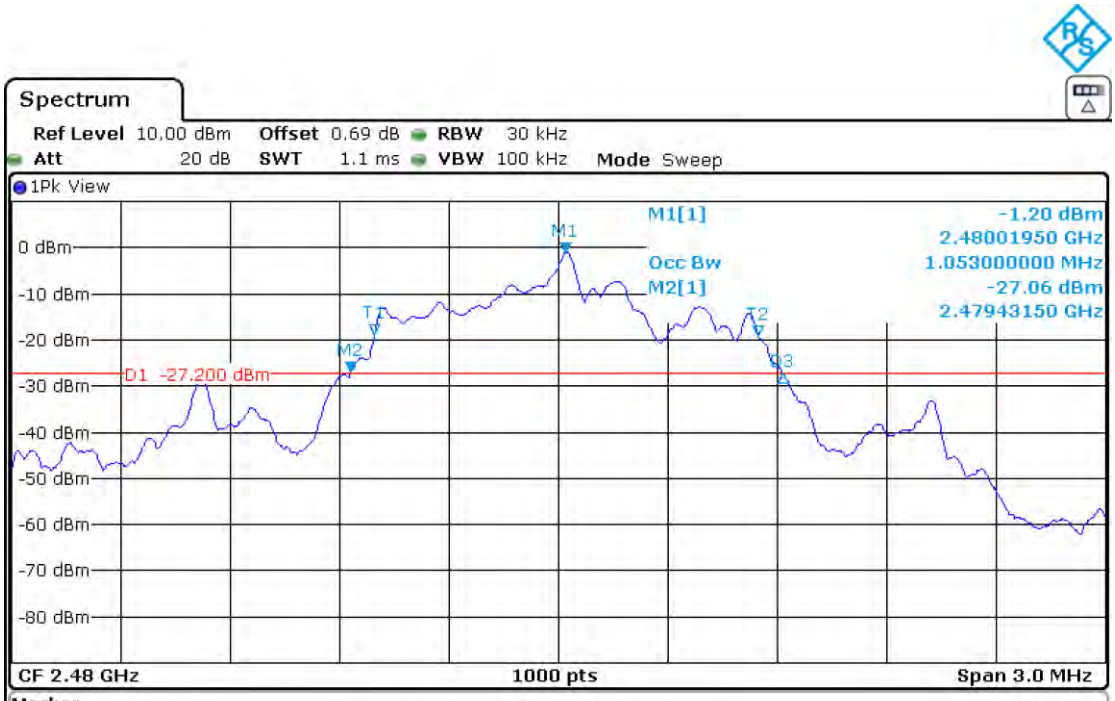
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4400225 GHz	-1.12 dBm		
T1		1	2.4394945 GHz	-19.14 dBm	Occ Bw	1.05 MHz
T2		1	2.4405445 GHz	-18.06 dBm		
M2		1	2.4394315 GHz	-27.36 dBm		
D3	M2	1	1.185 MHz	-0.10 dB		

- High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4800195 GHz	-1.20 dBm		
T1		1	2.4794945 GHz	-18.97 dBm	Occ Bw	1.053 MHz
T2		1	2.4805475 GHz	-19.04 dBm		
M2		1	2.4794315 GHz	-27.06 dBm		
D3	M2	1	1.182 MHz	-0.08 dB		

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

SPECIFICATION:

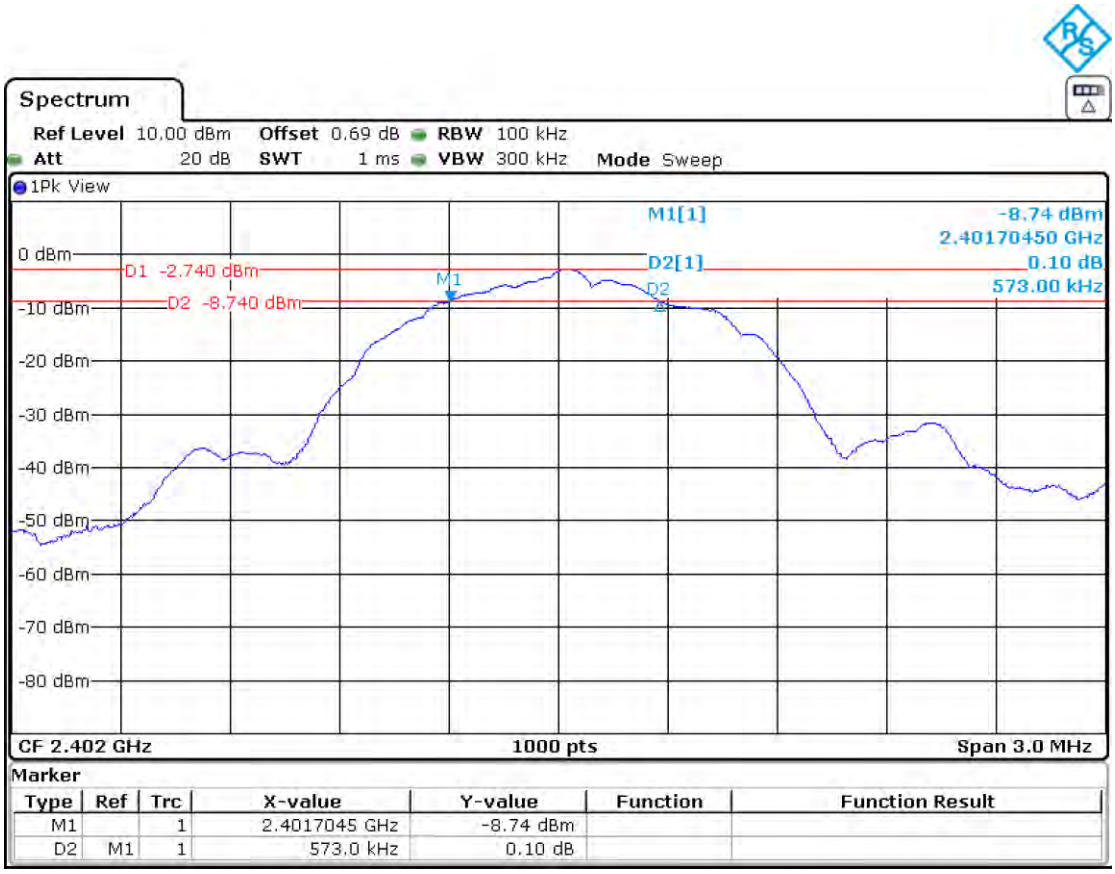
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS:

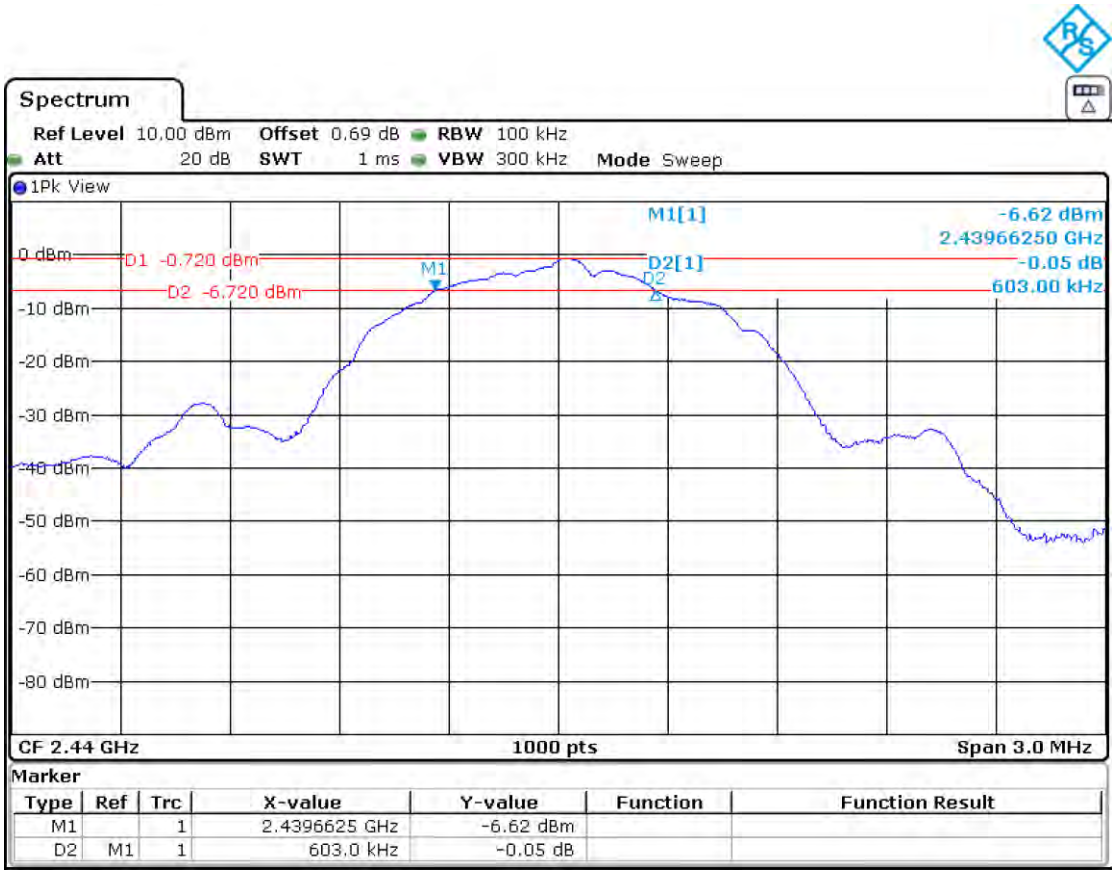
	Low Channel 2402 MHz	Middle Channel 2440 MHz	High Channel 2480 MHz
6 dB Spectrum Bandwidth (kHz)	573	603	603
Measurement uncertainty (kHz)	<±1.15		

Verdict: PASS

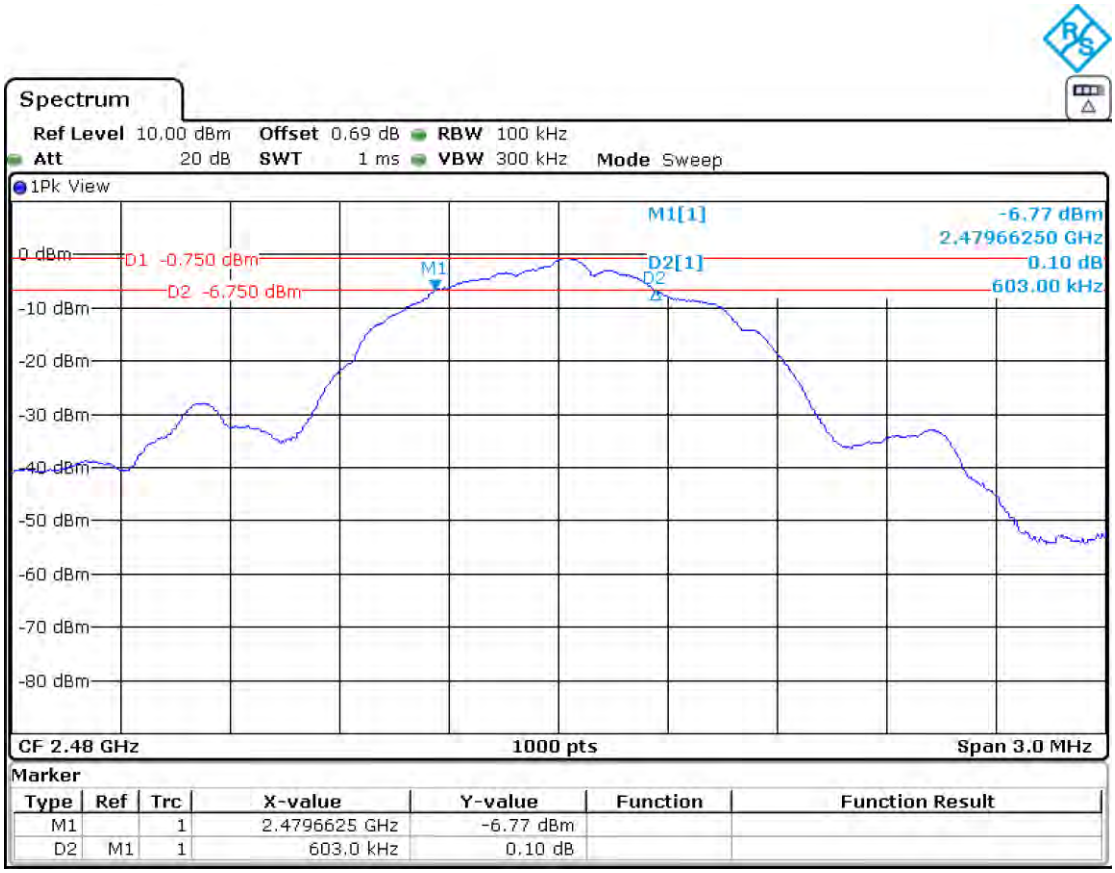
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).

The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

RESULTS:

The maximum peak conducted output power was measured using the method according to point 8.3.1.1. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247 558074 D01 DTS Meas Guidance v05r02 dated 2019/04/02.

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

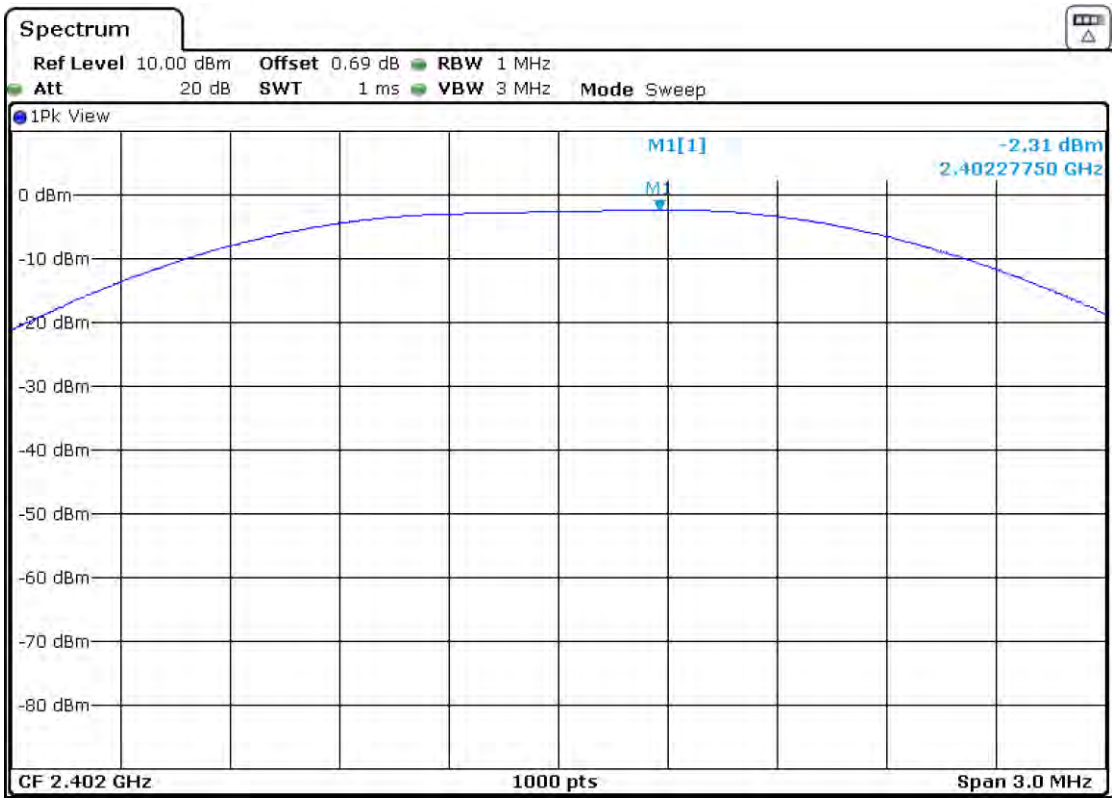
Maximum Declared Antenna Gain: +2 dBi

	Low Channel 2402 MHz	Middle Channel 2440 MHz	High Channel 2480 MHz
Maximum Conducted Power (dBm)	-2.31	-0.38	-0.43
Maximum EIRP Power (dBm)	-0.31	1.62	1.57
Measurement uncertainty (dB)	<±1.20		

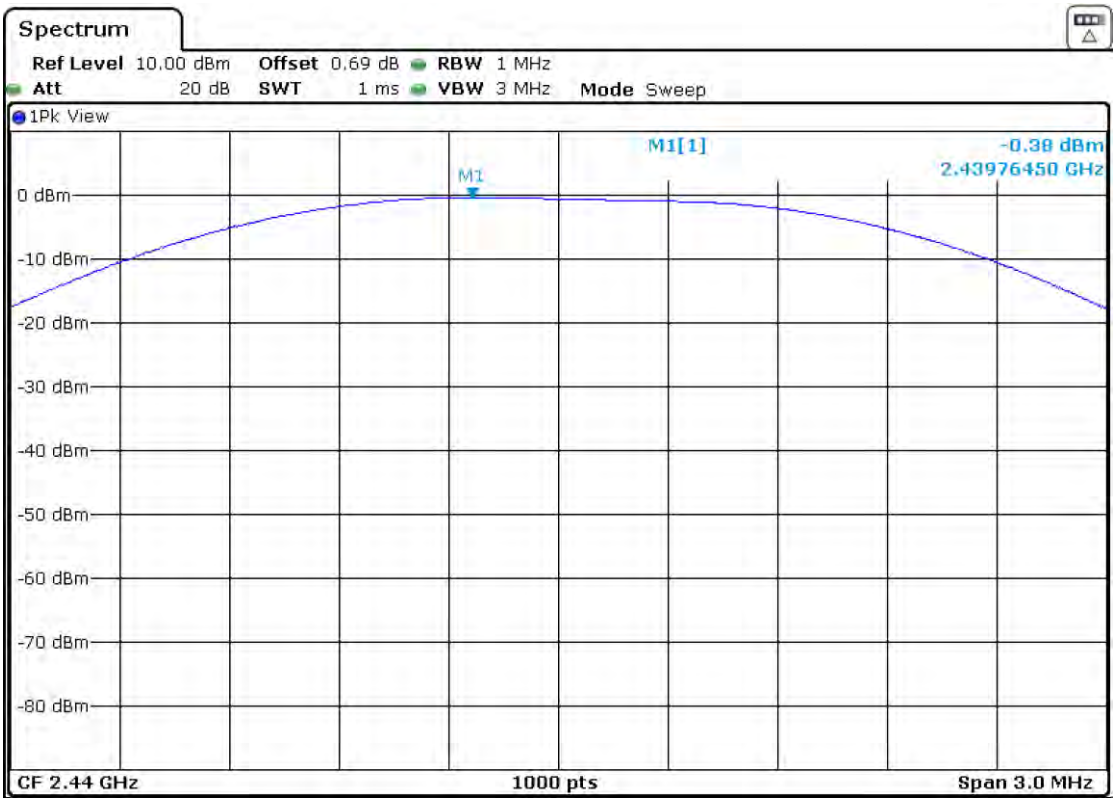
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Verdict: PASS

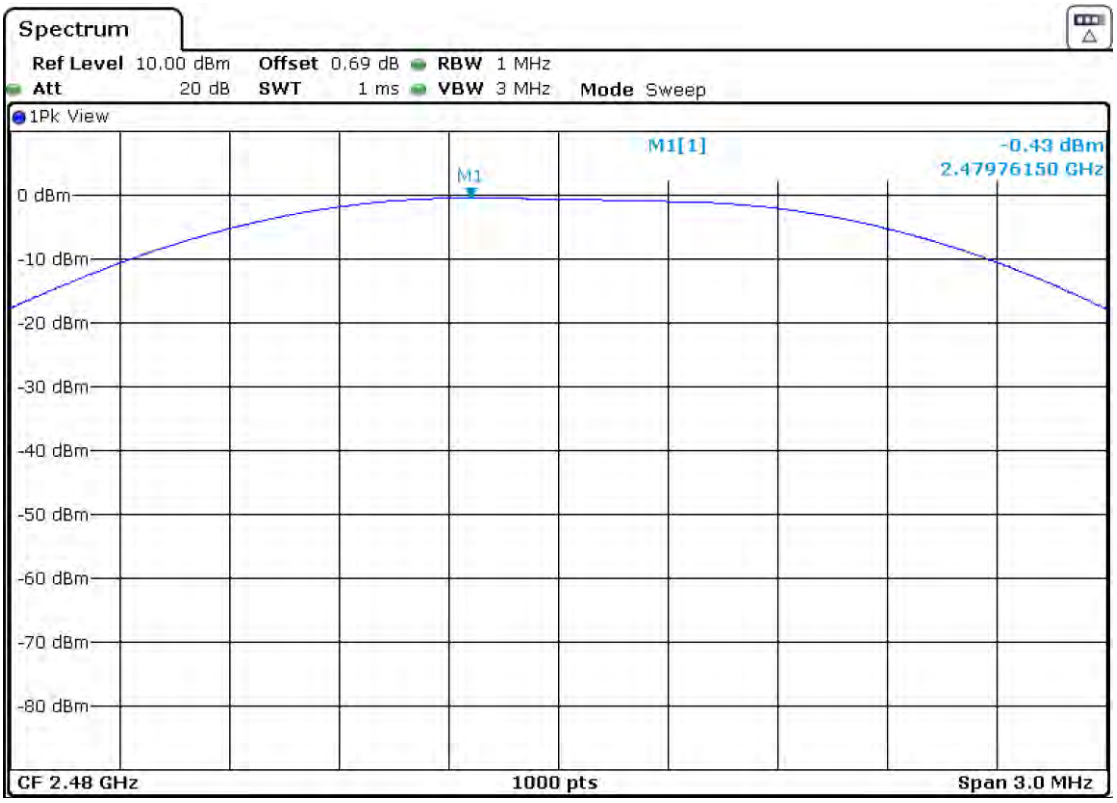
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

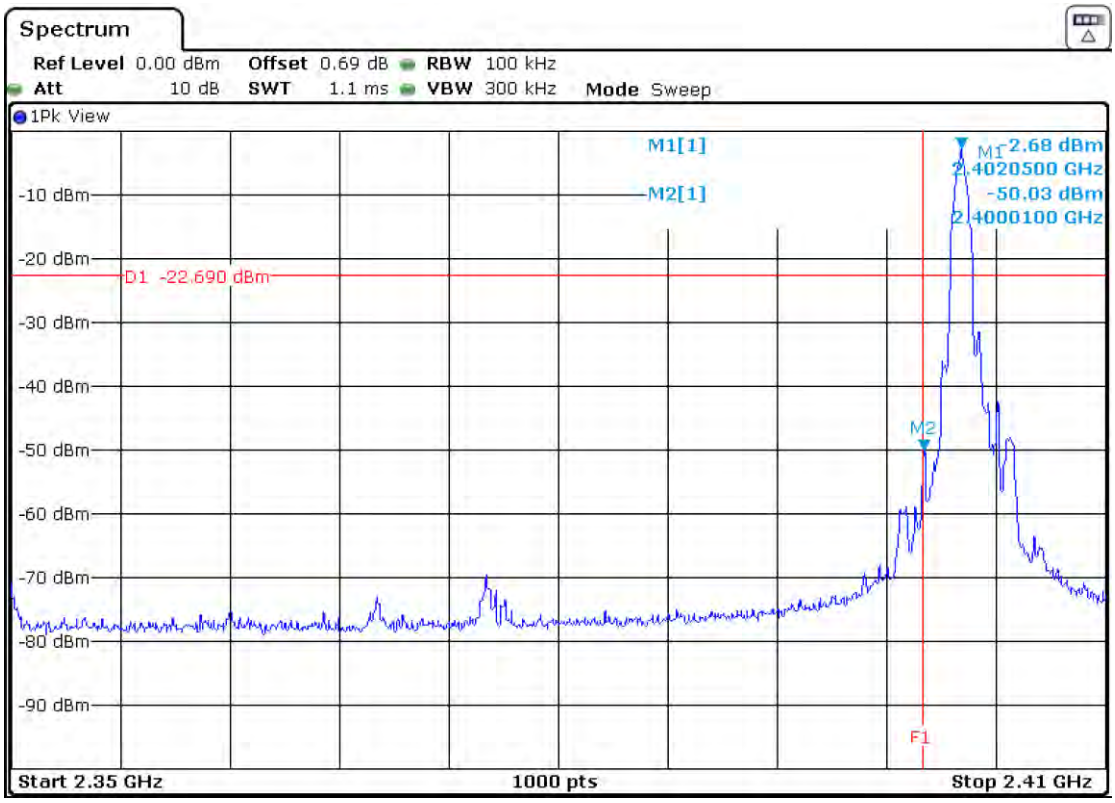
In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power,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

Note: Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

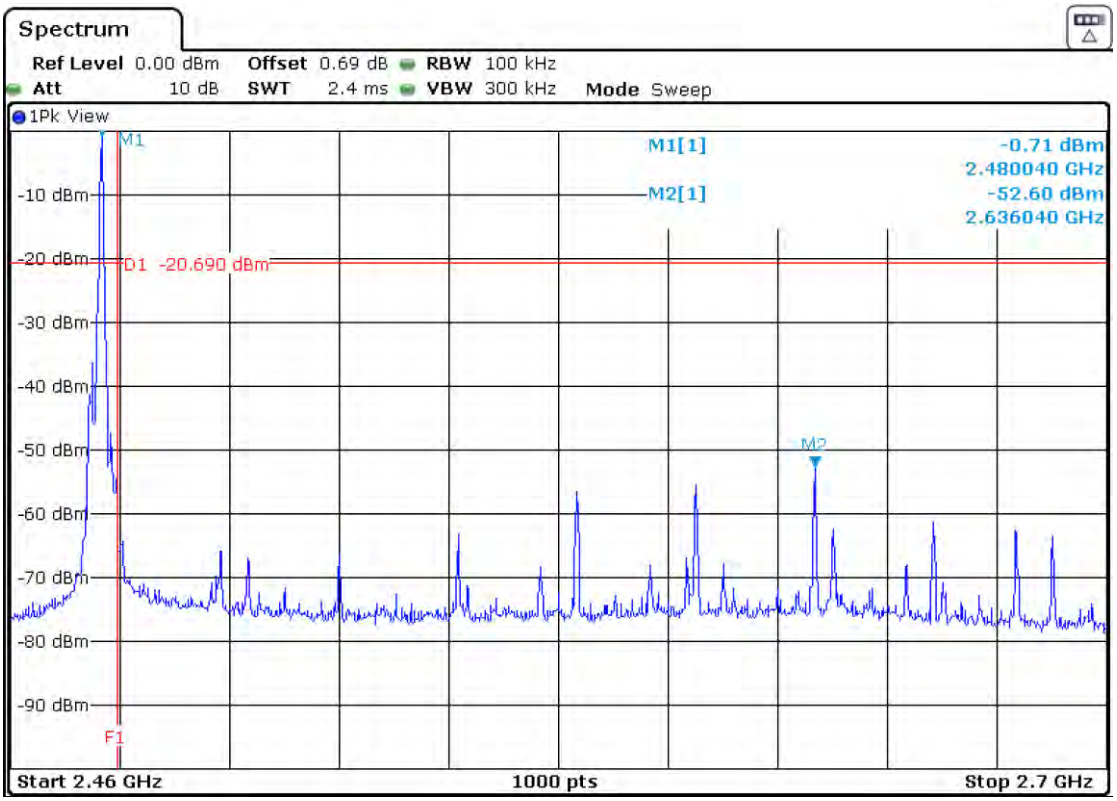
1. LOW FREQUENCY SECTION. CONDUCTED.

See next plot.



Verdict: PASS

2. HIGH FREQUENCY SECTION. CONDUCTED.



Measurement uncertainty (dB)	< ±1.20

Verdict: PASS

FCC Section 15.247 Subclause (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.

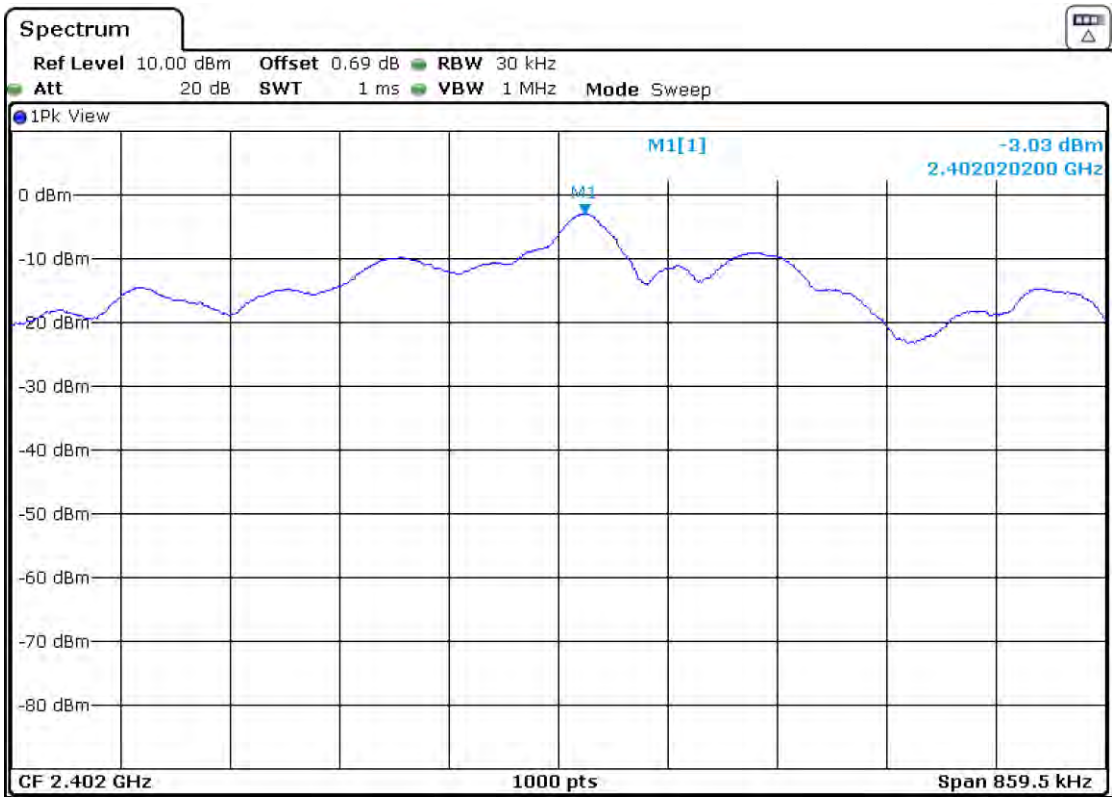
RESULTS:

The maximum power spectral density level in the fundamental emission was measured using the method PKPSD (Peak PSD) according to point 8.4.of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247 558074 D01 DTS Meas Guidance v05r02 dated 2019/04/02.

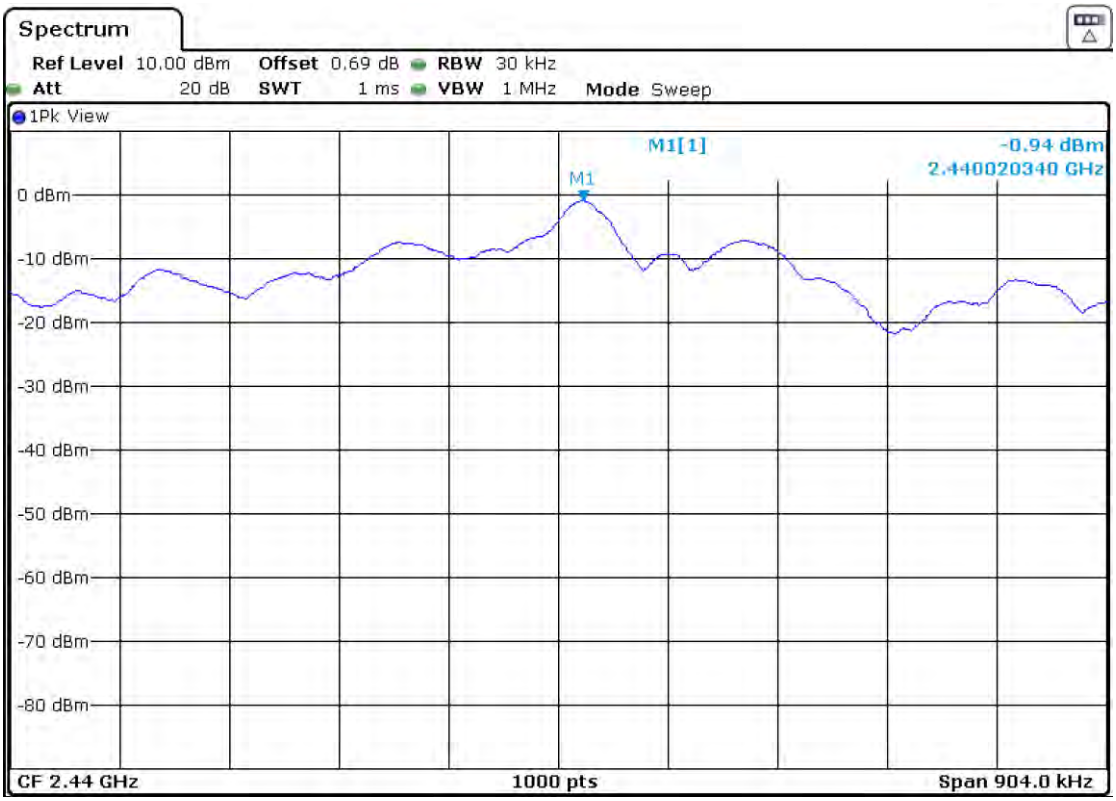
	Low Channel 2402 MHz	Middle Channel 2440 MHz	High Channel 2480 MHz
Power Spectral Density (dBm)	-3.03	-0.94	-0.97
Measurement uncertainty (dB)	<±1.20		

Verdict: PASS

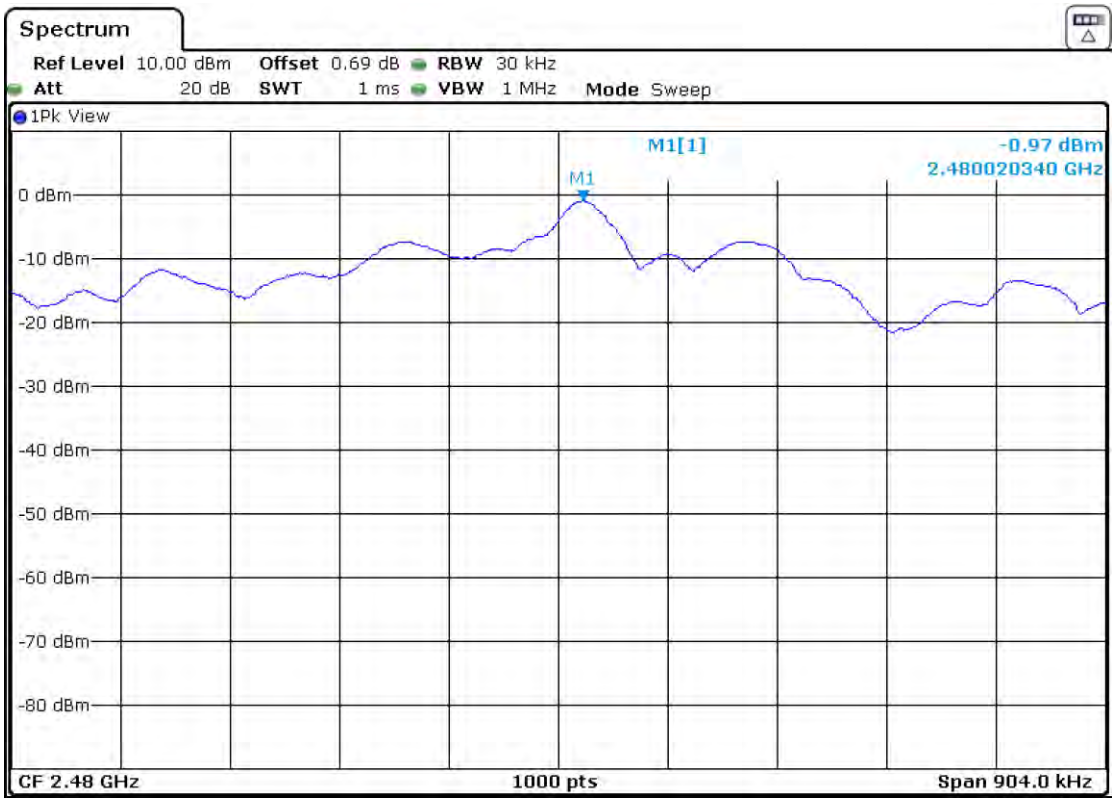
- Low Channel:



- Middle Channel:



- High Channel:



FCC Section 15.247 Subclause (d) / RSS-247 Clause 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-1000 MHz and at distance of 1m for the frequency range 1 GHz-26 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:

The spurious frequencies detected do not depend on the operating channel.

Spurious signals closest to the limit:

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
480.0315	Vertical	Quasi peak	29.3	<± 3.86
639.9845	Horizontal	Quasi peak	39.1	<± 3.86
679.9970	Horizontal	Quasi peak	34.6	<± 3.86
720.0580	Horizontal	Quasi peak	33.4	<± 3.86
760.0220	Horizontal	Quasi peak	38.0	<± 3.86
800.0345	Horizontal	Quasi peak	33.5	<± 3.86
840.0470	Horizontal	Quasi peak	26.35	<± 3.86

Frequency range 1 - 26 GHz:

The results in the next tables show the maximum measured levels in the 1-25 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Spurious signals 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.

1. CHANNEL: LOWEST (2402 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2531.767	Vertical	Peak	49.64	<± 4.72
2557.462	Vertical	Peak	49.80	<± 4.72
4803.450	Vertical	Peak	40.47	<± 4.72

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2283.967	Vertical	Peak	48.43	<± 4.72
2595.815	Vertical	Peak	49.97	<± 4.72
4880.790	Vertical	Peak	40.23	<± 4.72
19516.25	Horizontal	Peak	38.73	<± 4.72

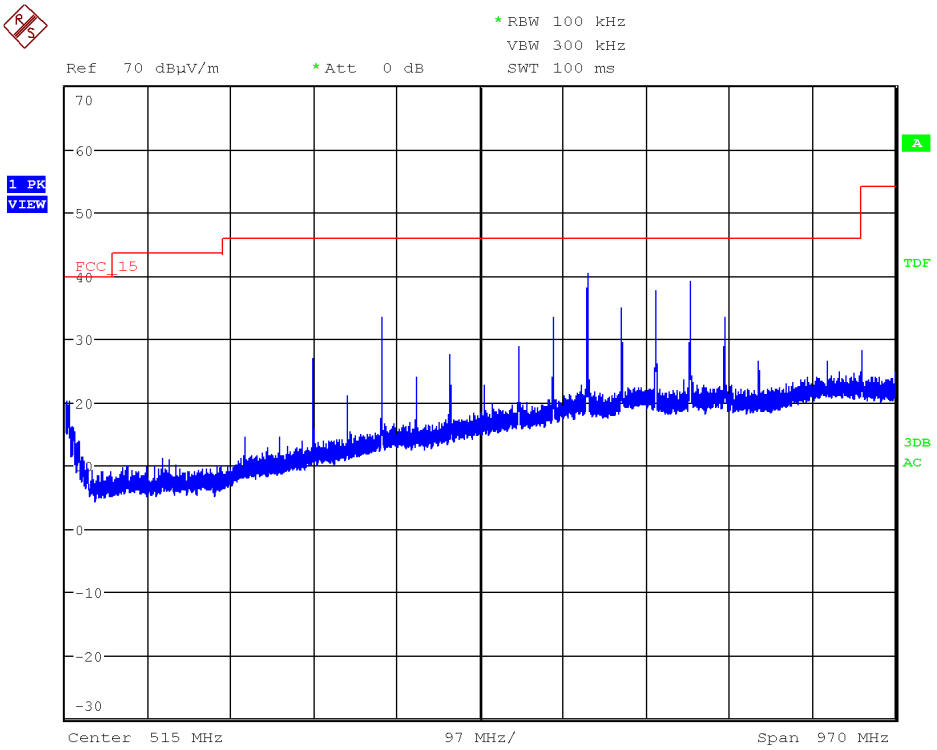
3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2324.170	Vertical	Peak	48.74	<± 4.72
2635.965	Vertical	Peak	49.52	<± 4.72
4959.610	Vertical	Peak	41.00	<± 4.72

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

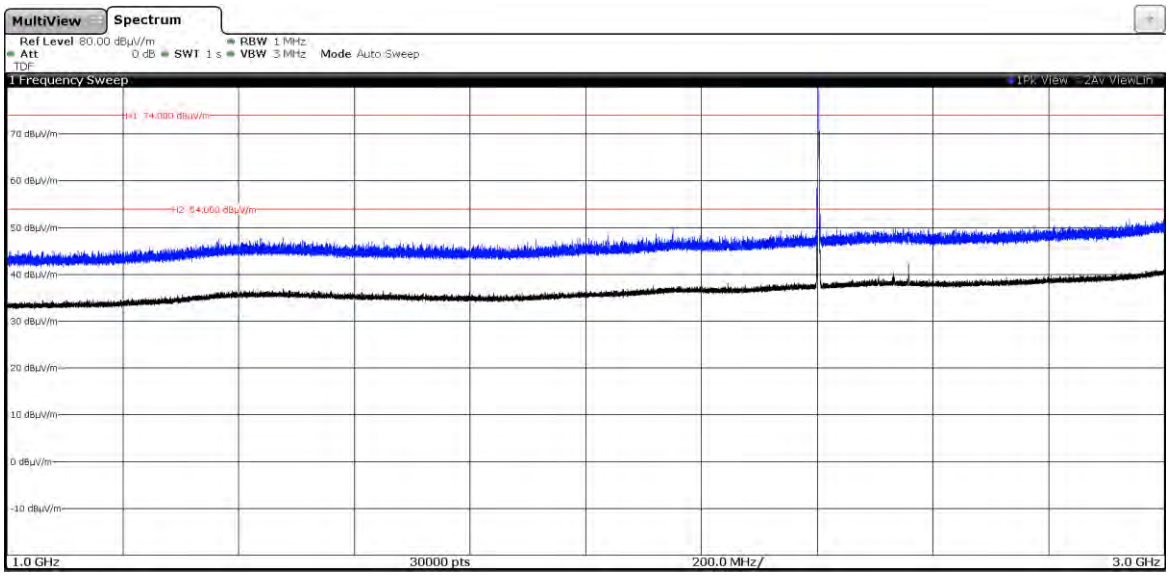
The spurious signals detected do not depend on the operating channel.



This plot is valid for the Low, Middle and High Channels.

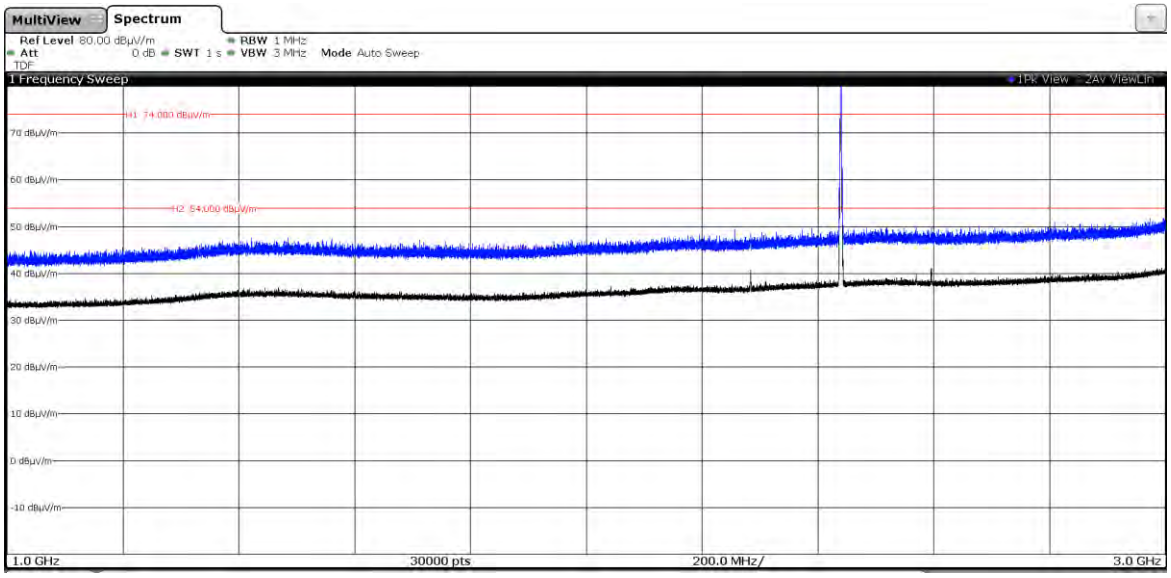
FREQUENCY RANGE 1 - 3 GHz:

CHANNEL: LOWEST (2402 MHz).



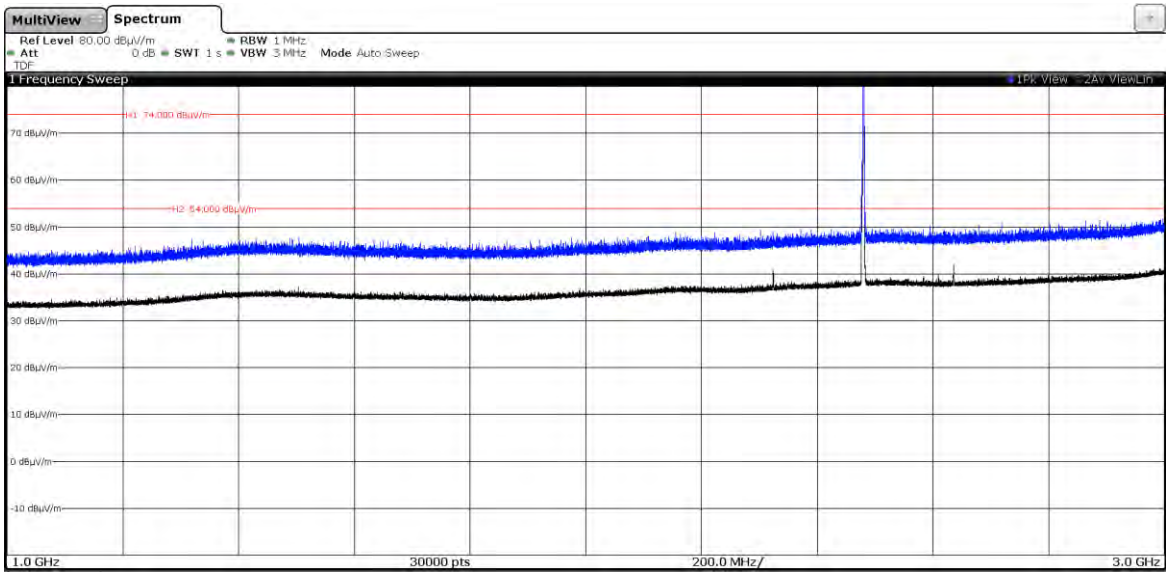
The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE (2440 MHz).



The peak above the limit is the carrier frequency.

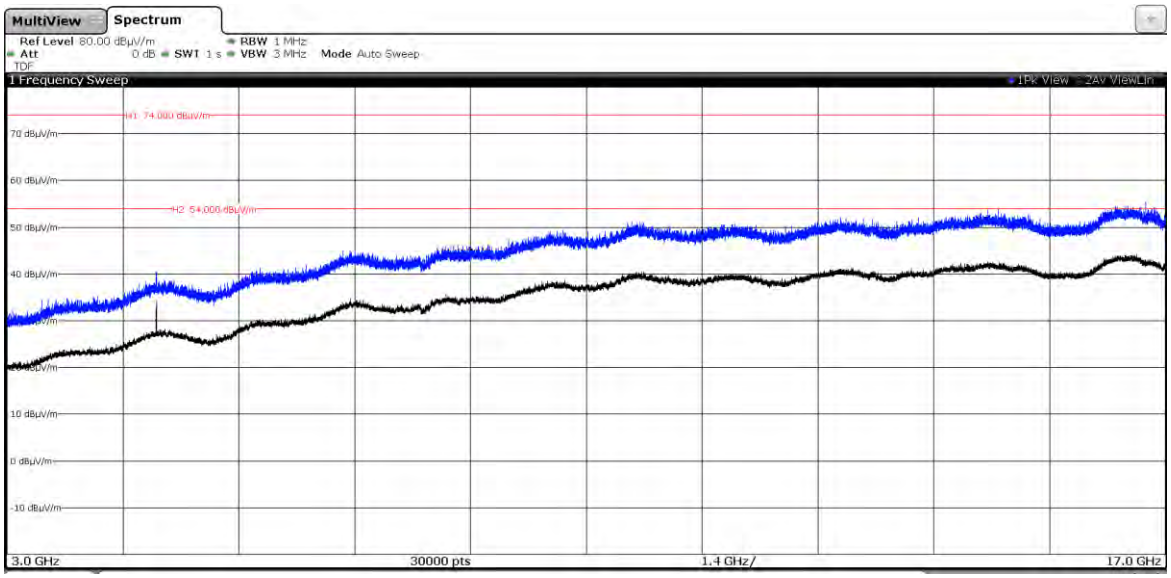
CHANNEL: HIGHEST (2480 MHz).



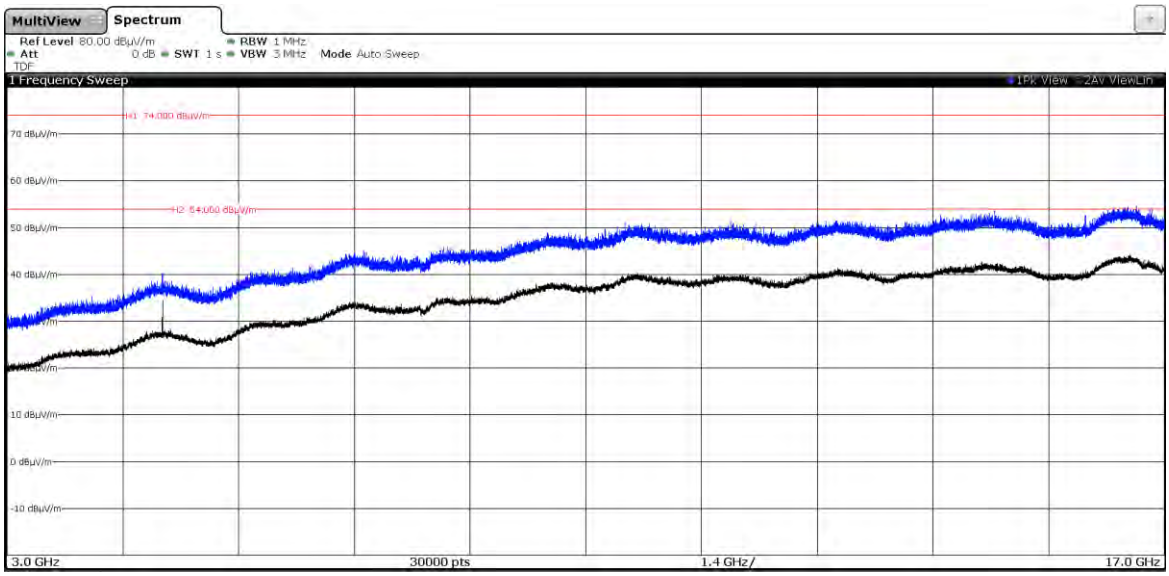
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

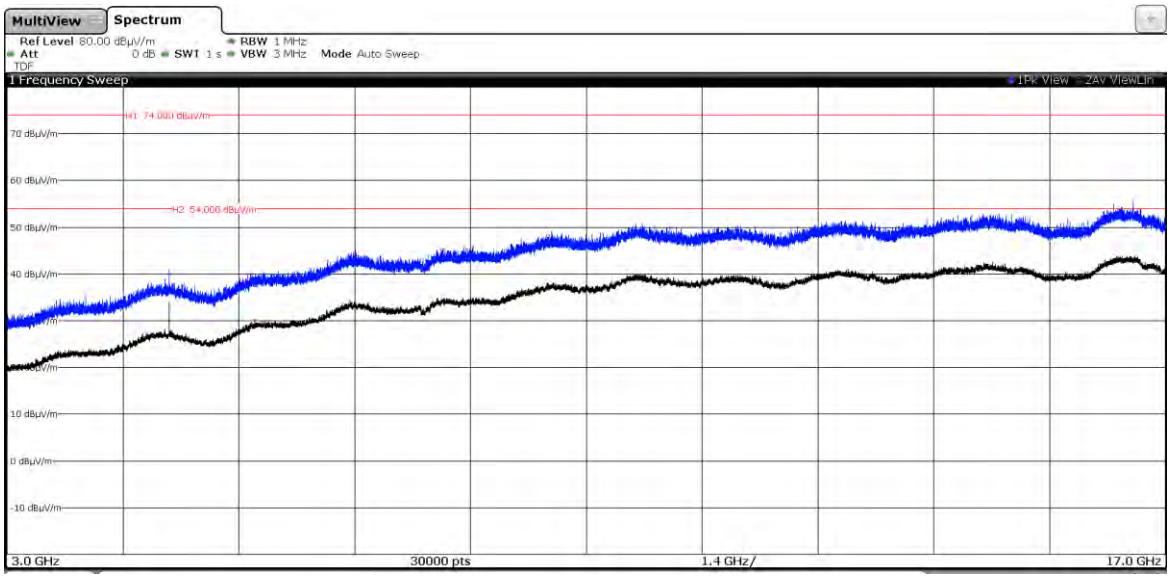
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2440 MHz).

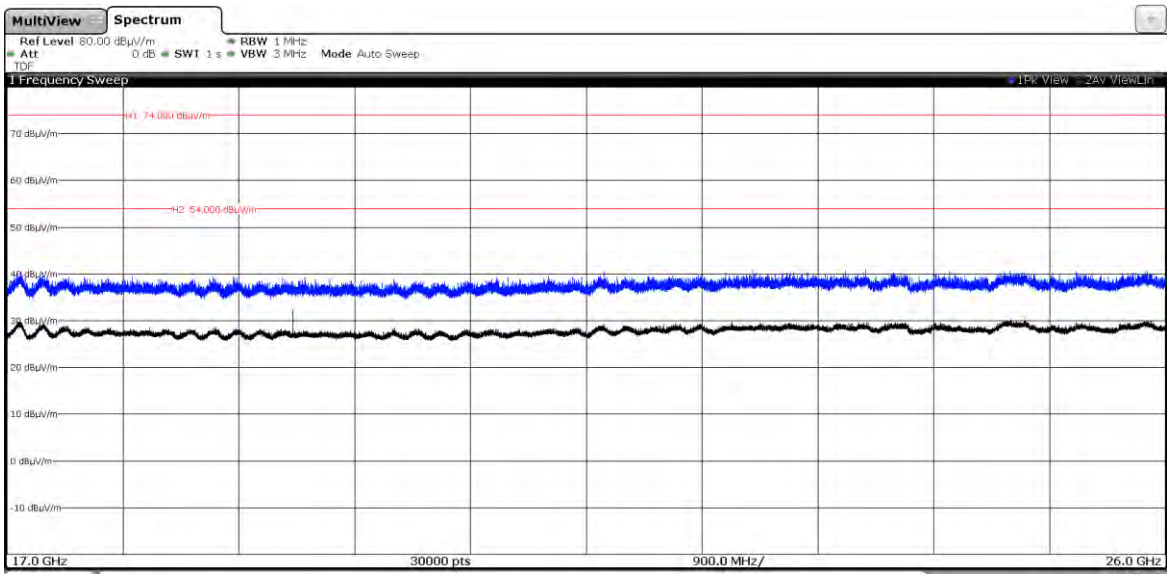


CHANNEL: HIGHEST (2480 MHz).

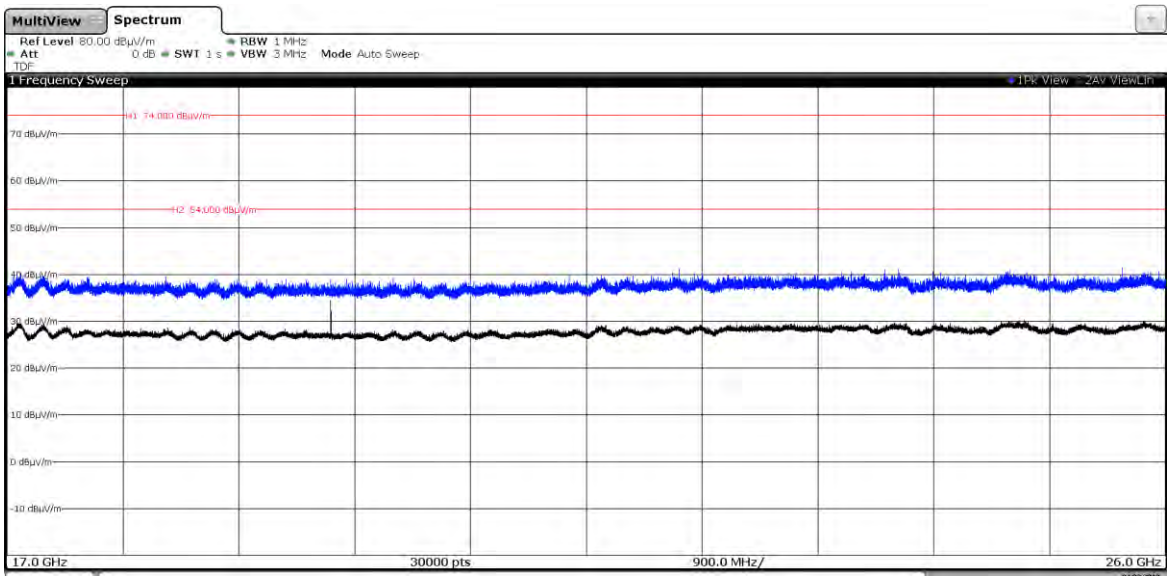


FREQUENCY RANGE 17 - 26 GHz:

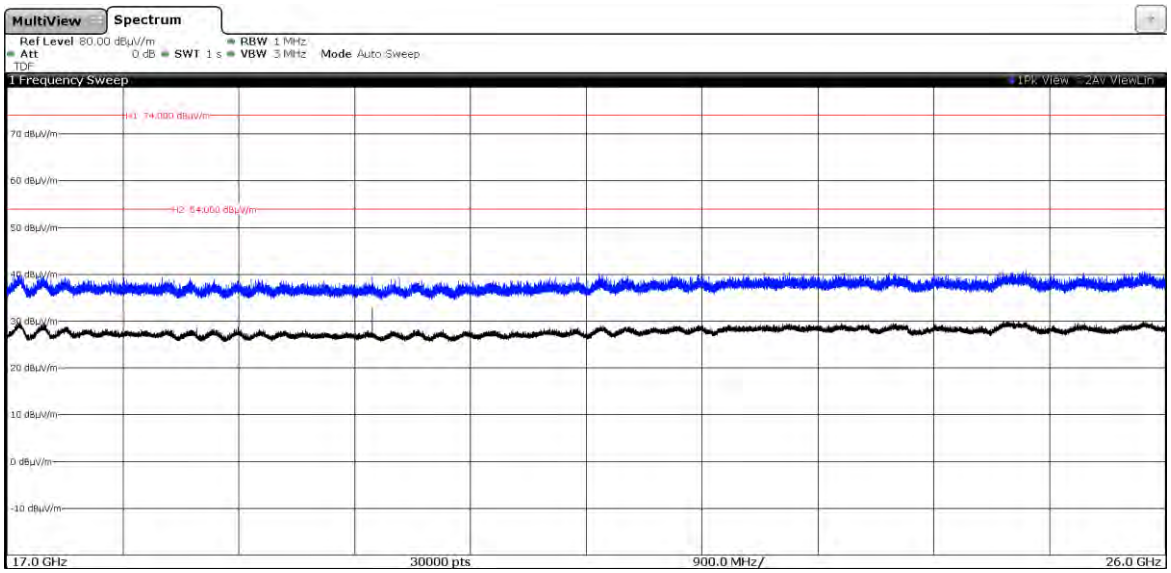
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2440 MHz).

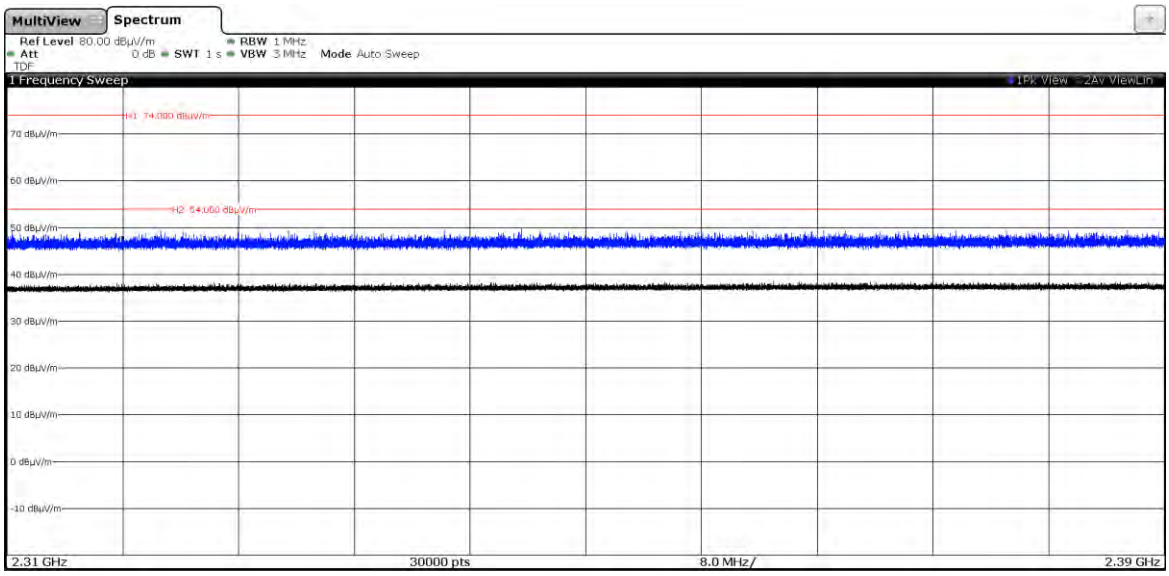


CHANNEL: HIGHEST (2480 MHz).

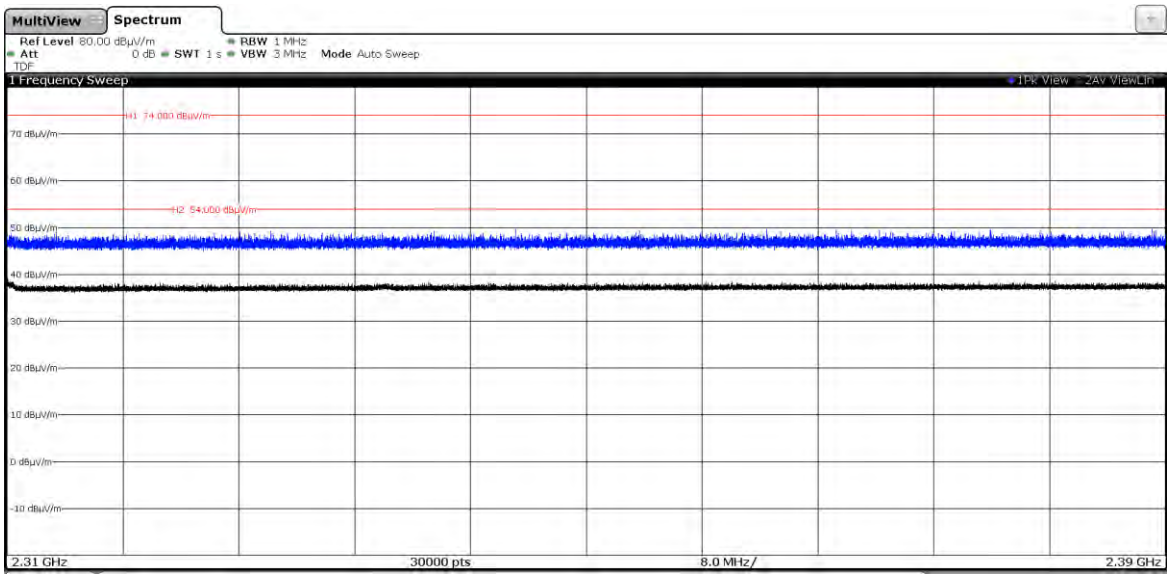


FREQUENCY RANGE 2.31-2.39 GHz (Restricted Band 1):

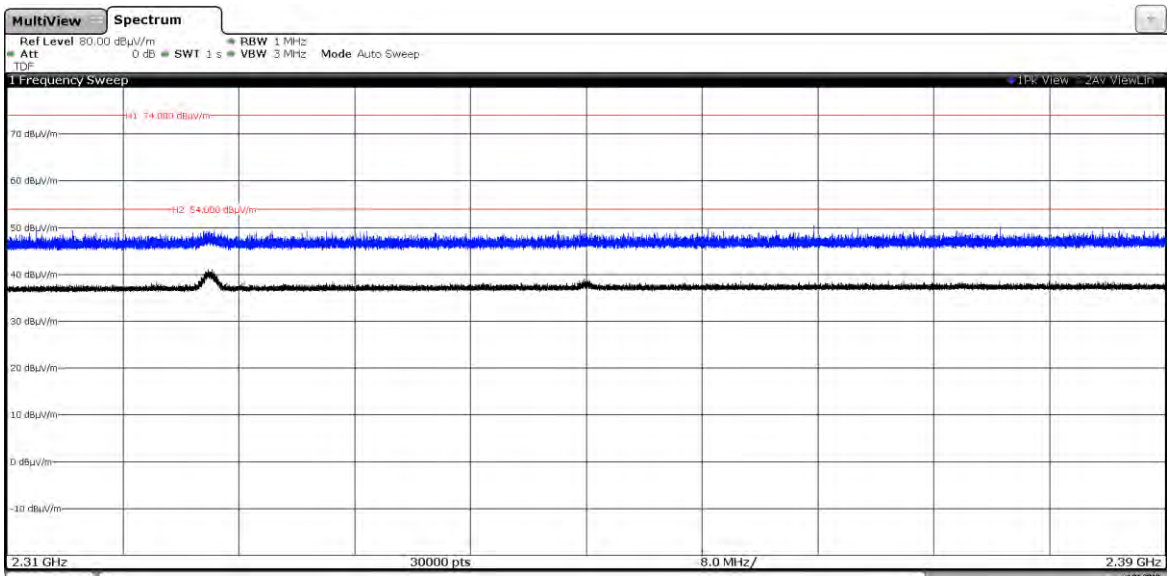
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2440 MHz).

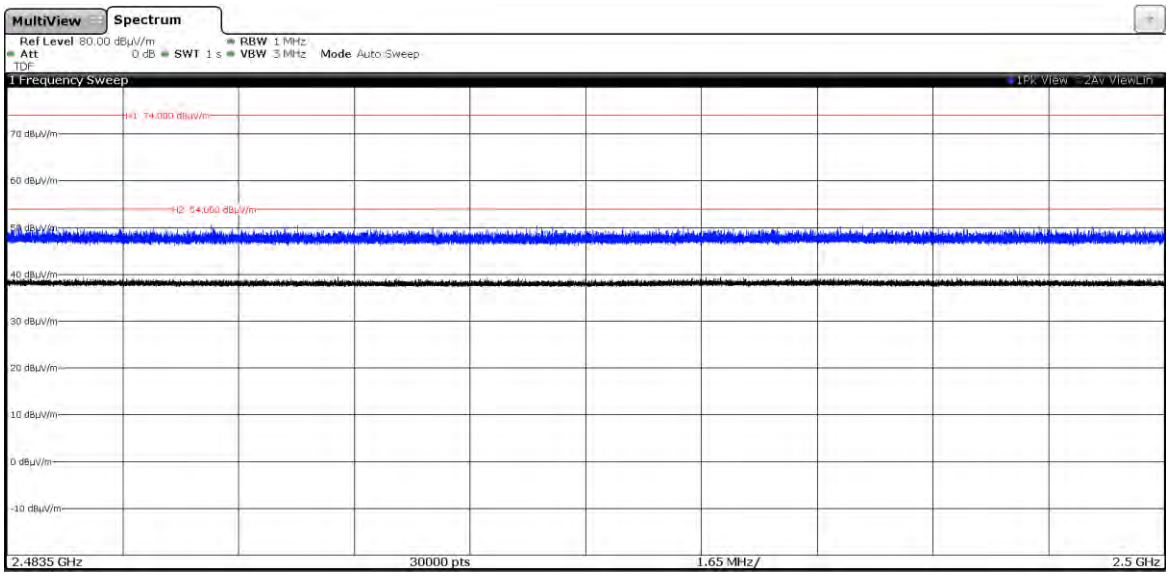


CHANNEL: HIGHEST (2480 MHz).

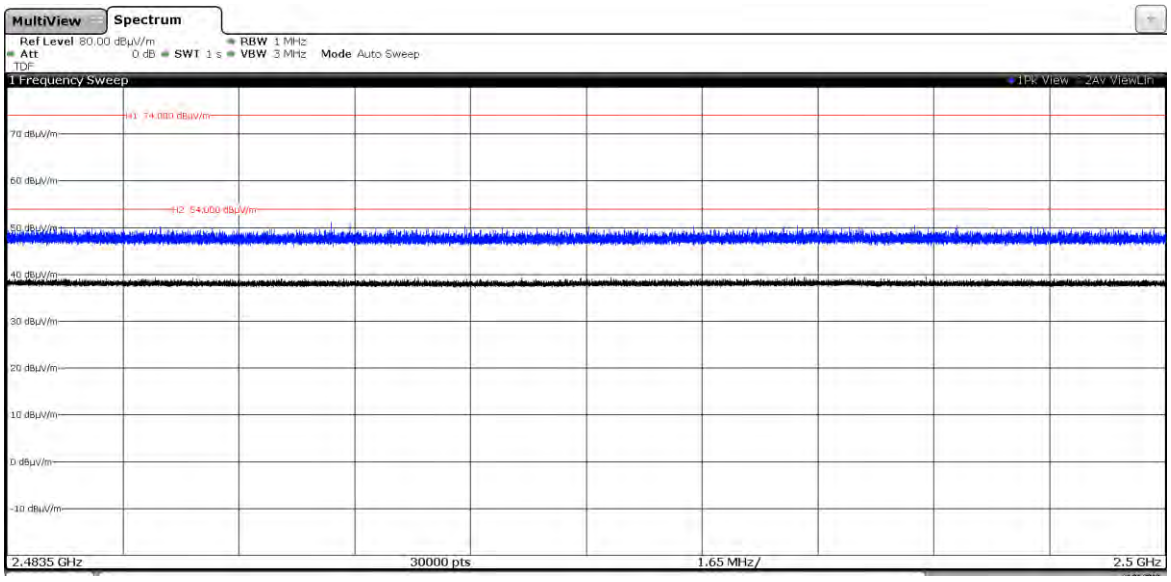


FREQUENCY RANGE 2.4835-2.5 GHz (Restricted Band 2):

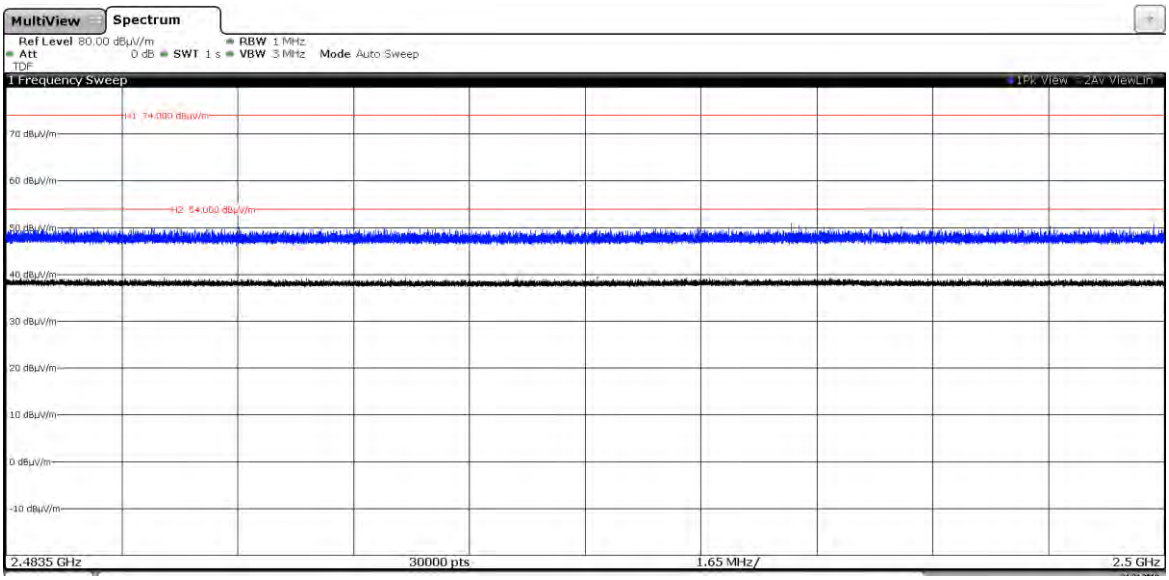
CHANNEL: LOWEST (2402 MHz).



CHANNEL: MIDDLE (2440 MHz).



CHANNEL: HIGHEST (2480 MHz).



Appendix C: Test results. Proprietary Protocol Intercom.

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FCC Section 15.247 Subclause (e) / RSS-247 5.2. (b) Power spectral density 105

TEST CONDITIONS

POWER SUPPLY (V):

V nonimal:	3.7 Vdc
Type of Power Supply:	Battery Li Ion.
Type of Antenna:	SMA.
Maximum Declared Antenna Gain:	+1 dBi

TEST FREQUENCIES:

Low Channel:	2405 MHz
Middle Channel:	2440 MHz
High Channel:	2470 MHz

The sample was used to configure the EUT to continuously transmit at a specified output power in all channels.

CONDUCTED MEASUREMENTS

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

RADIATED MEASUREMENTS

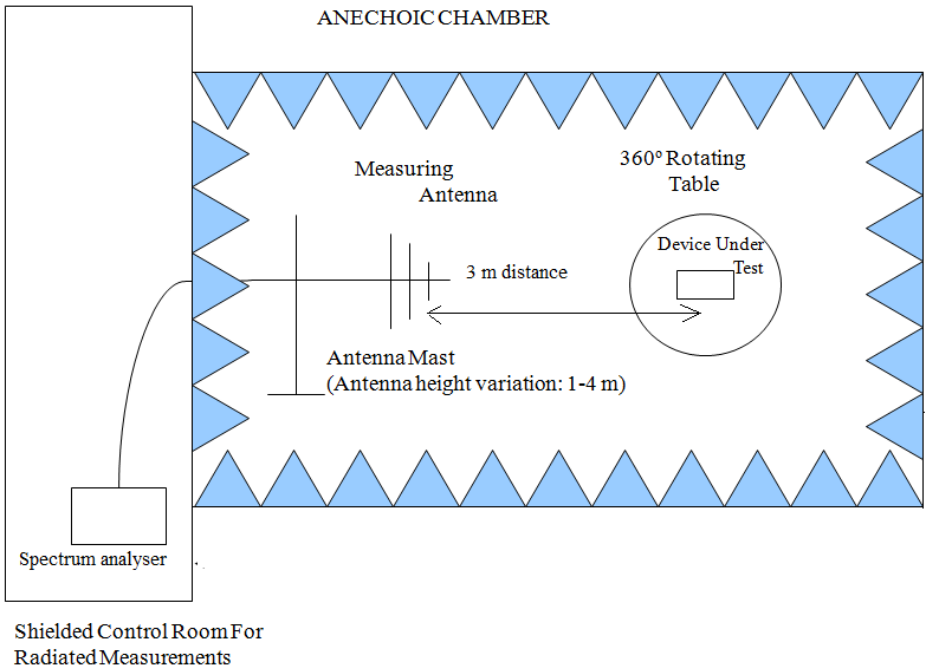
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m for the frequency range 30 MHz-1000 MHz (30 MHz-1000 MHz Bilog antenna) and at a distance of 1 m for the frequency range 1 GHz-25 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

For radiated emissions in the range 1 GHz-25 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

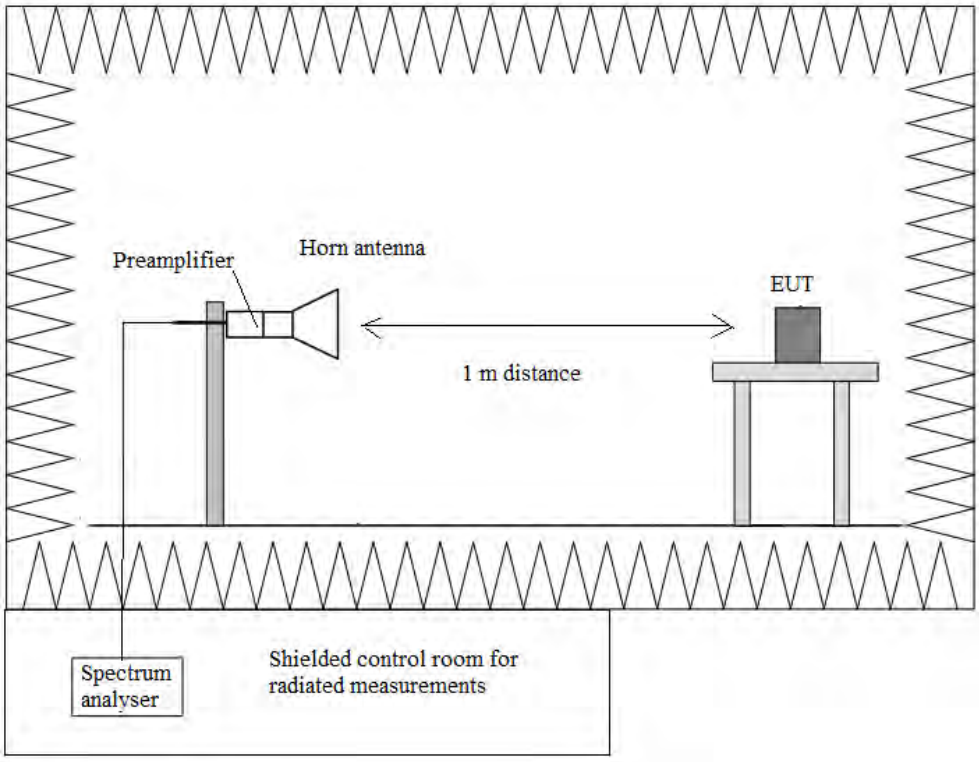
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

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

Radiated measurements setup f < 1 GHz



Radiated measurements setup f > 1 GHz:



Occupied Bandwidth

RESULTS:

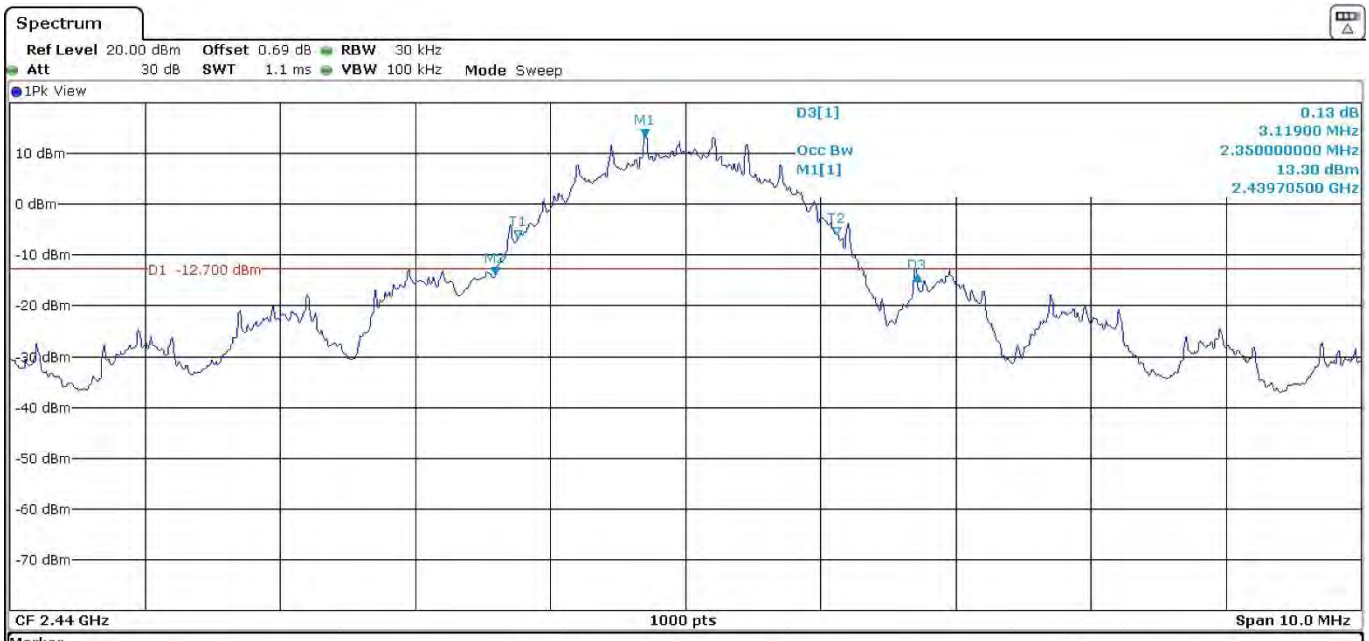
	Low Channel 2405 MHz	Middle Channel 2440 MHz	High Channel 2470 MHz
99% Bandwidth (MHz)	2.31	2.35	2.38
Measurement uncertainty (kHz)	<± 1.00		

- Low Channel:

Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.404705 GHz	13.38 dBm		
T1		1	2.403795 GHz	-6.65 dBm	Occ Bw	2.31 MHz
T2		1	2.406105 GHz	-4.29 dBm		
M2		1	2.403597 GHz	-13.77 dBm		
D3	M2	1	2.712 MHz	1.03 dB		

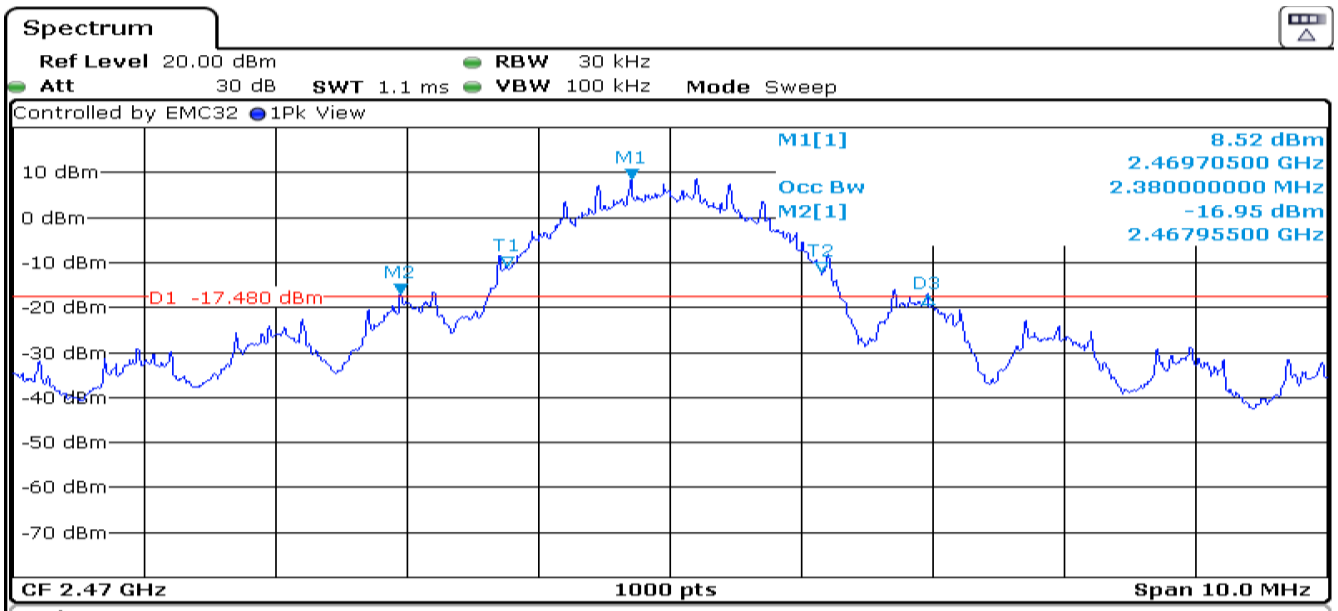
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.439705 GHz	13.30 dBm		
T1		1	2.438765 GHz	-6.67 dBm	Occ Bw	2.35 MHz
T2		1	2.441115 GHz	-6.11 dBm		
M2		1	2.438596 GHz	-13.93 dBm		
D3	M2	1	3.119 MHz	0.13 dB		

- High Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.469705 GHz	8.52 dBm		
T1		1	2.468765 GHz	-10.81 dBm	Occ Bw	2.38 MHz
T2		1	2.471145 GHz	-12.18 dBm		
M2		1	2.467955 GHz	-16.95 dBm		
D3	M2	1	4.01 MHz	-0.39 dB		

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

SPECIFICATION:

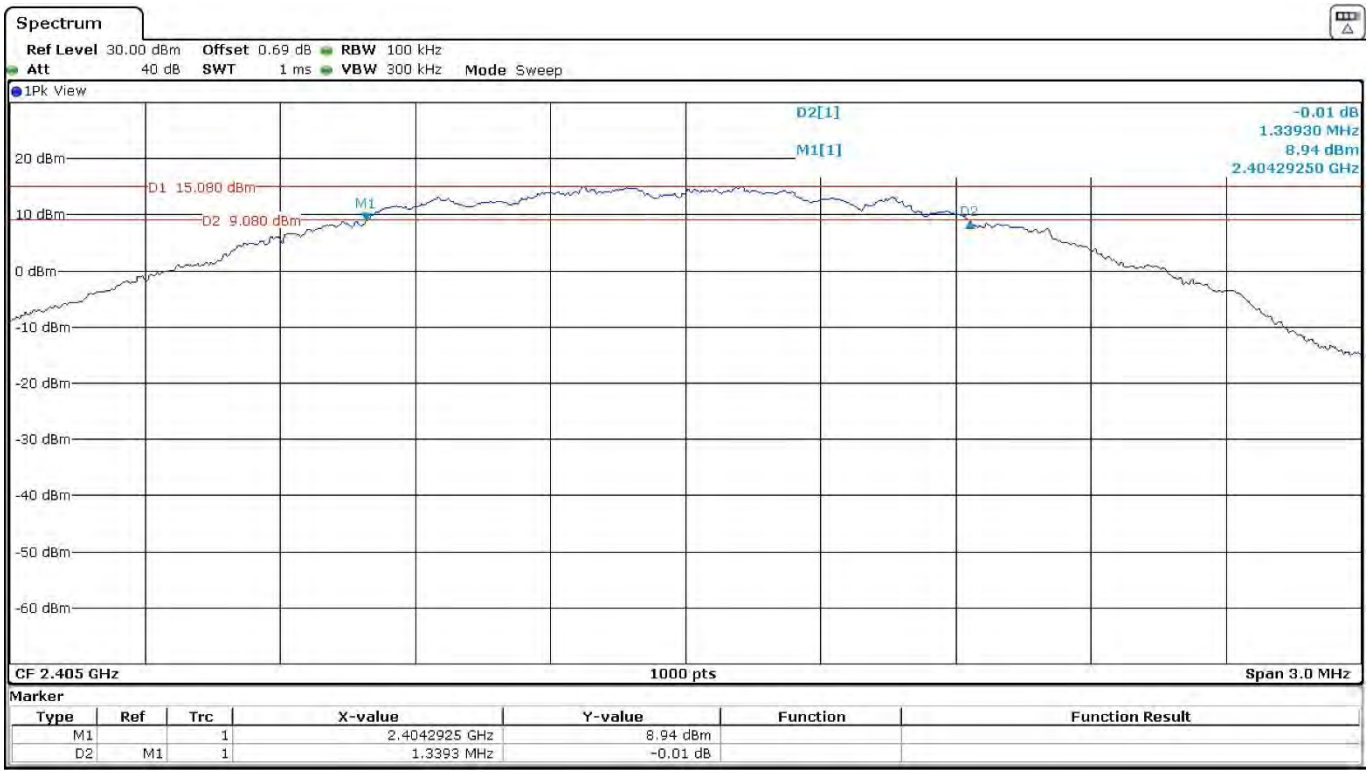
The minimum 6 dB bandwidth shall be at least 500 kHz.

RESULTS:

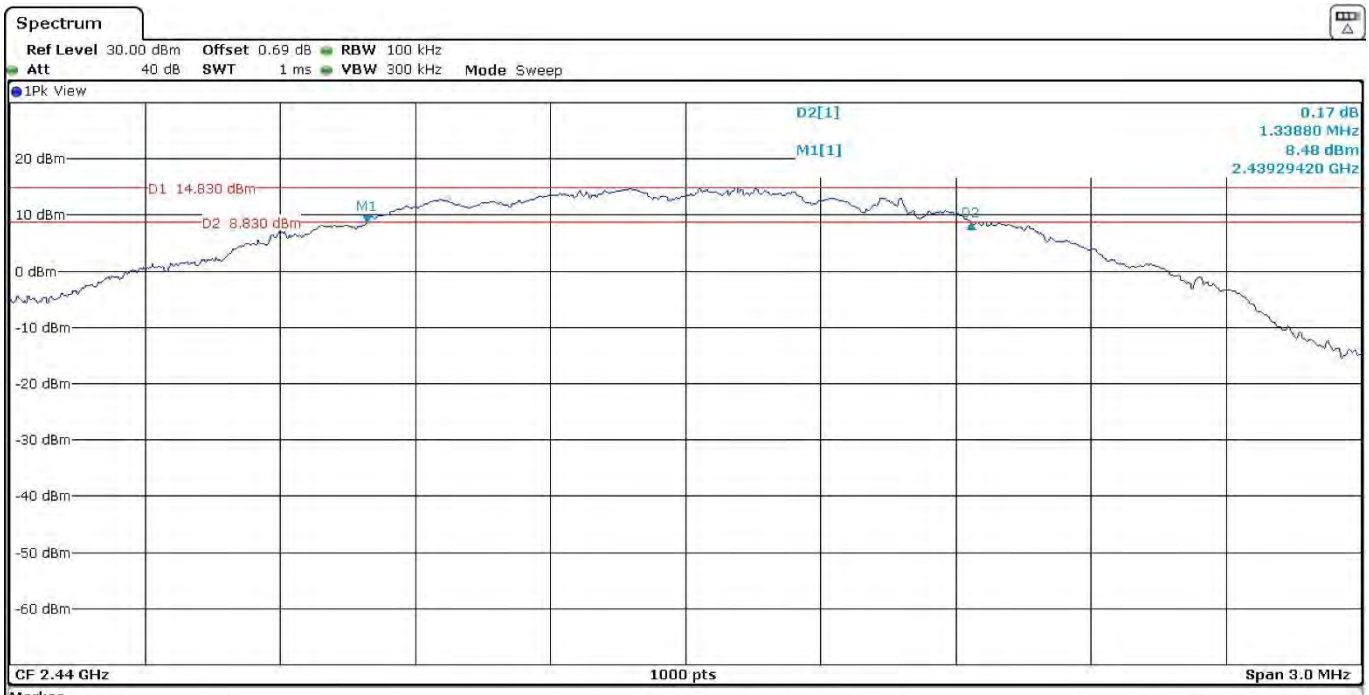
	Low Channel 2405 MHz	Middle Channel 2440 MHz	High Channel 2470 MHz
6 dB Spectrum Bandwidth (kHz)	1339.3	1338.8	1542.0
Measurement uncertainty (kHz)	<±1.15		

Verdict: PASS

- Low Channel:



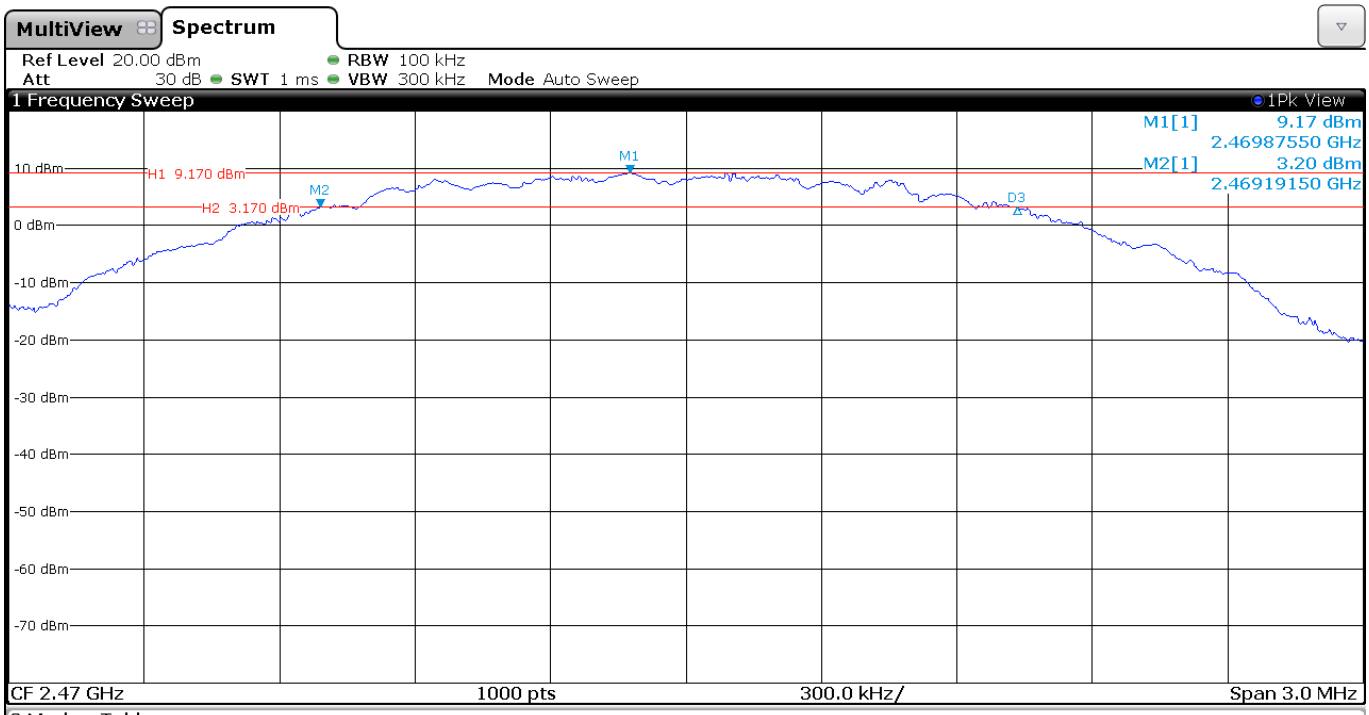
- Middle Channel:



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4392942 GHz	8.48 dBm		
D2	M1	1	1.3388 MHz	0.17 dB		

- High Channel:



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4698755 GHz**	**9.17 dBm**		
M2		1	**2.4691915 GHz**	**3.20 dBm**		
D3	M2	1	**1.542 MHz**	**-0.02 dB**		

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

SPECIFICATION:

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).

The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

RESULTS:

The maximum peak conducted output power was measured using the method according to point 8.3.1.1. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247 558074 D01 DTS Meas Guidance v05r02 dated 2019/04/02.

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

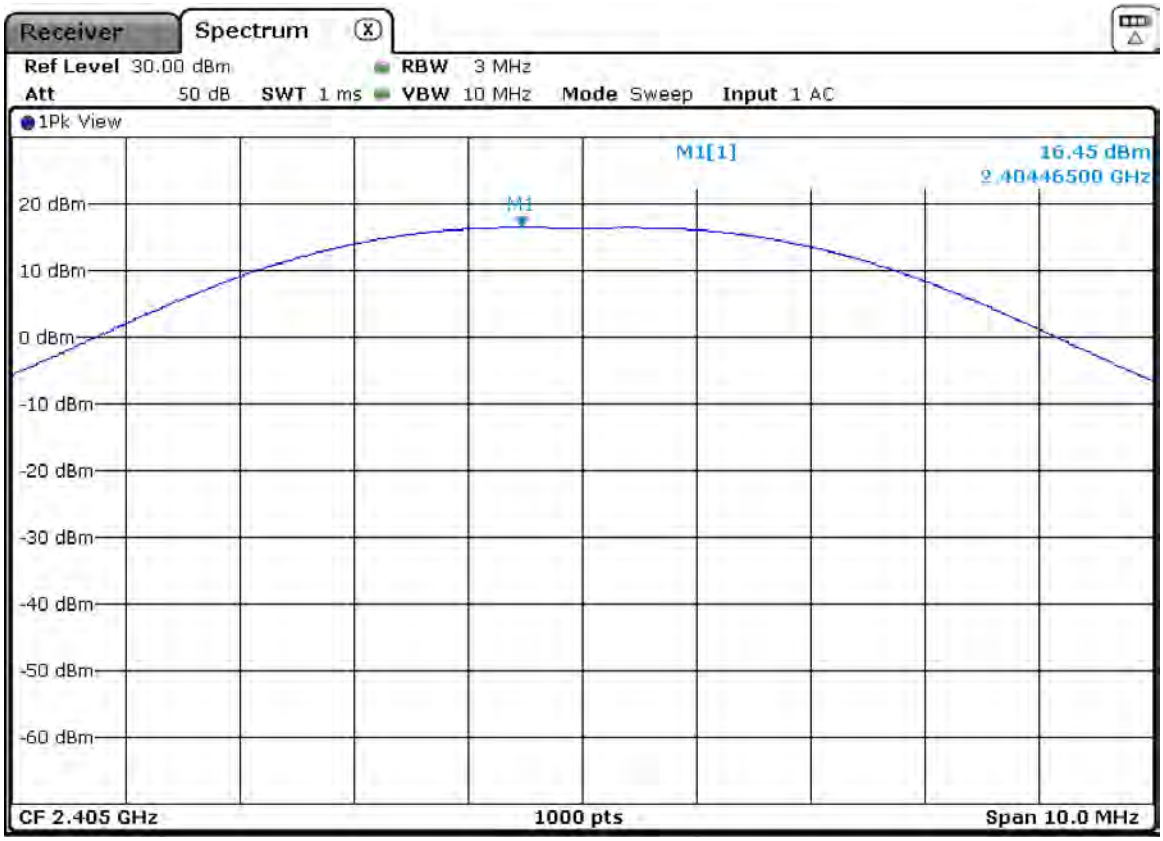
Maximum Declared Antenna Gain: 1 dBi

	Low Channel 2405 MHz	Middle Channel 2440 MHz	High Channel 2470 MHz
Maximum Conducted Power (dBm)	16.45	16.88	12.00
Maximum EIRP Power (dBm)	17.45	17.88	13.00
Measurement uncertainty (dB)	<±1.20		

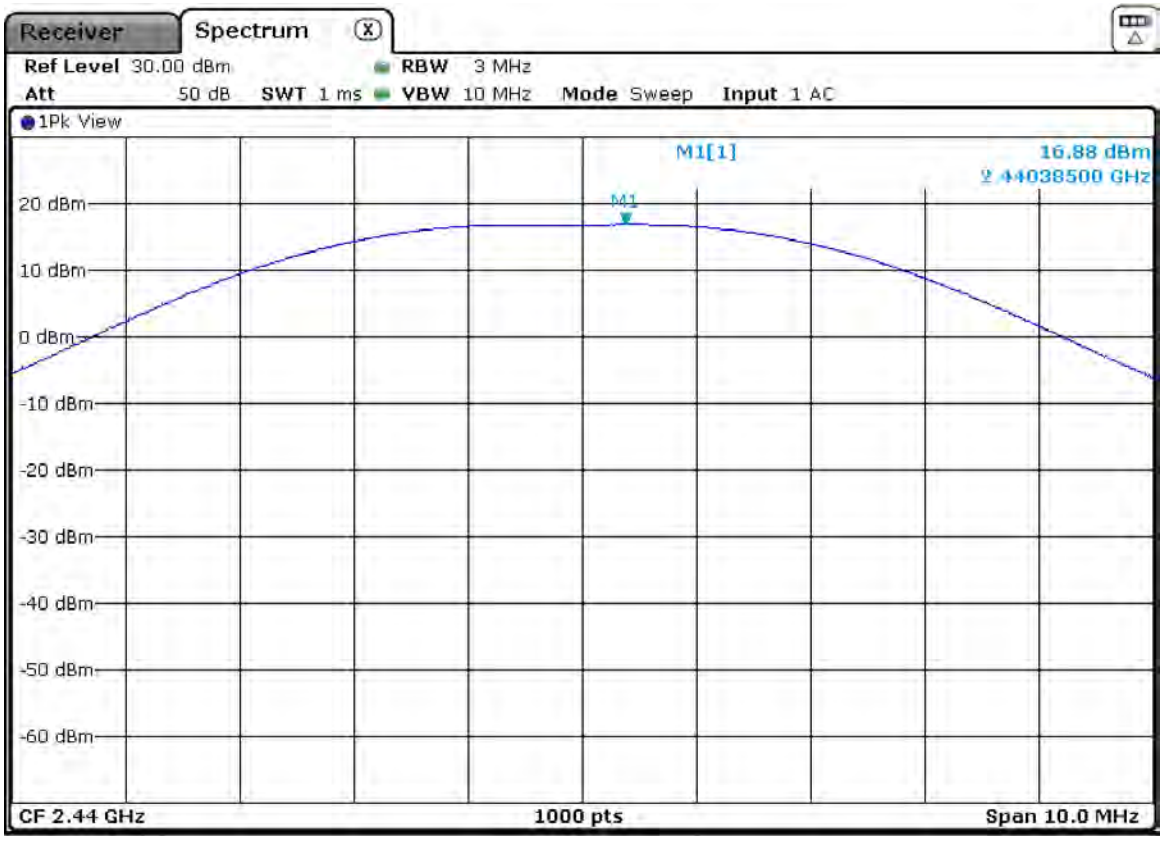
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Verdict: PASS

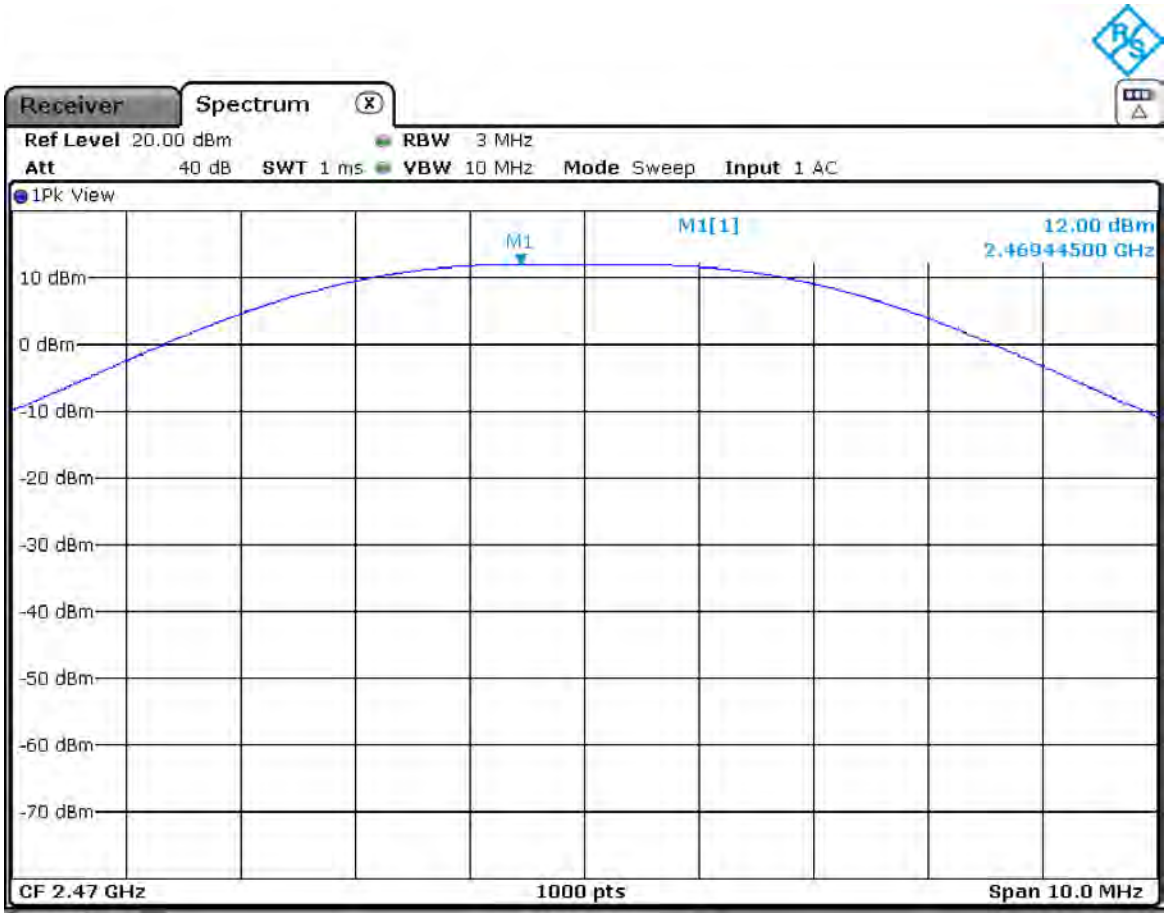
- Low Channel:



- Middle Channel:



- High Channel:



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

SPECIFICATION:

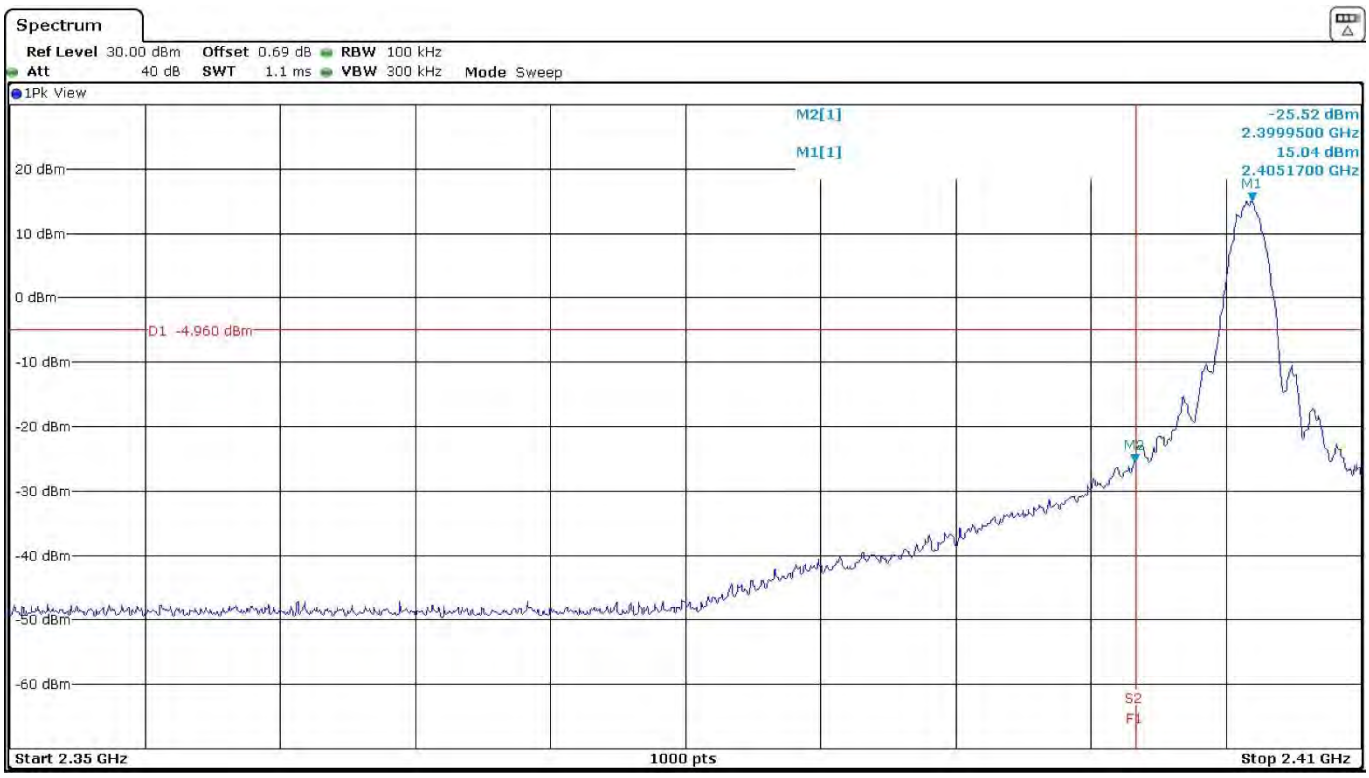
In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power,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

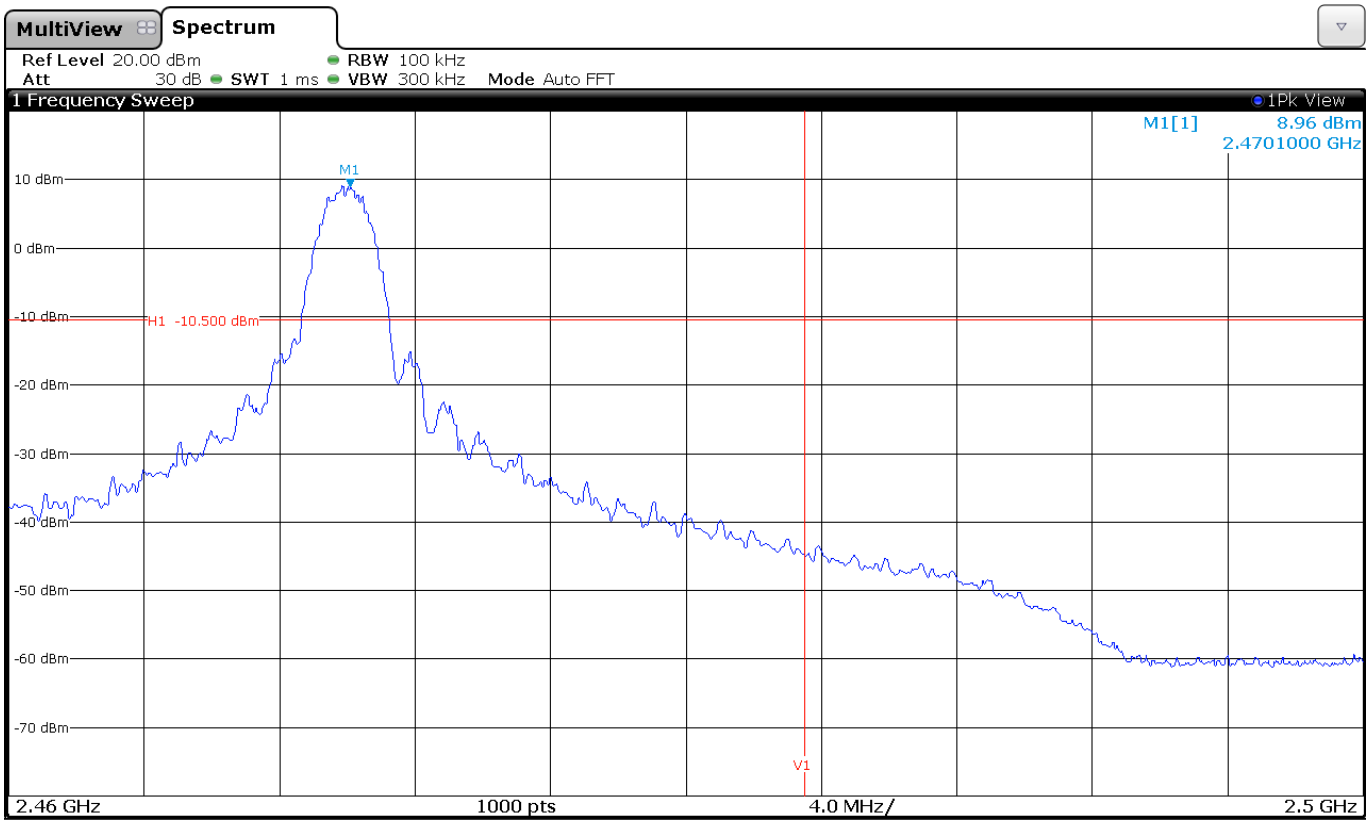
Note: Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

1. LOW FREQUENCY SECTION. CONDUCTED.

See next plot.



2. HIGH FREQUENCY SECTION. CONDUCTED.



Measurement uncertainty (dB)	< ±1.20

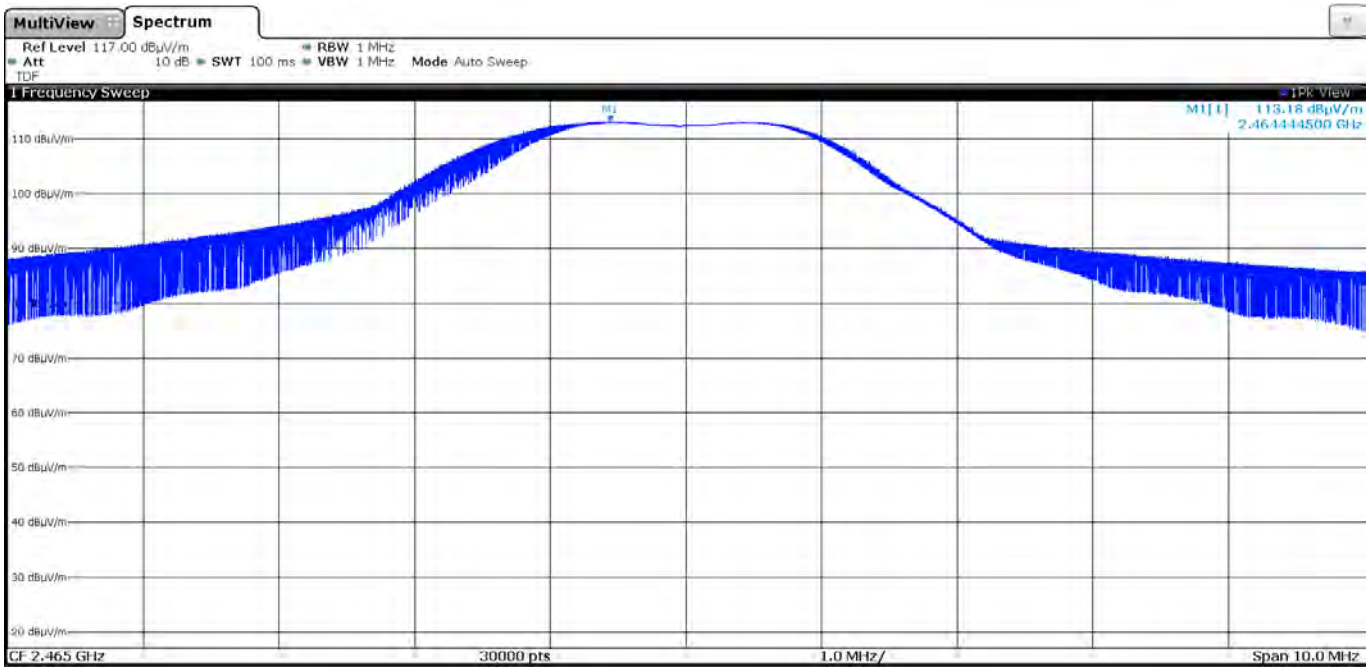
Verdict: PASS

Band-edge compliance of radiated emissions.

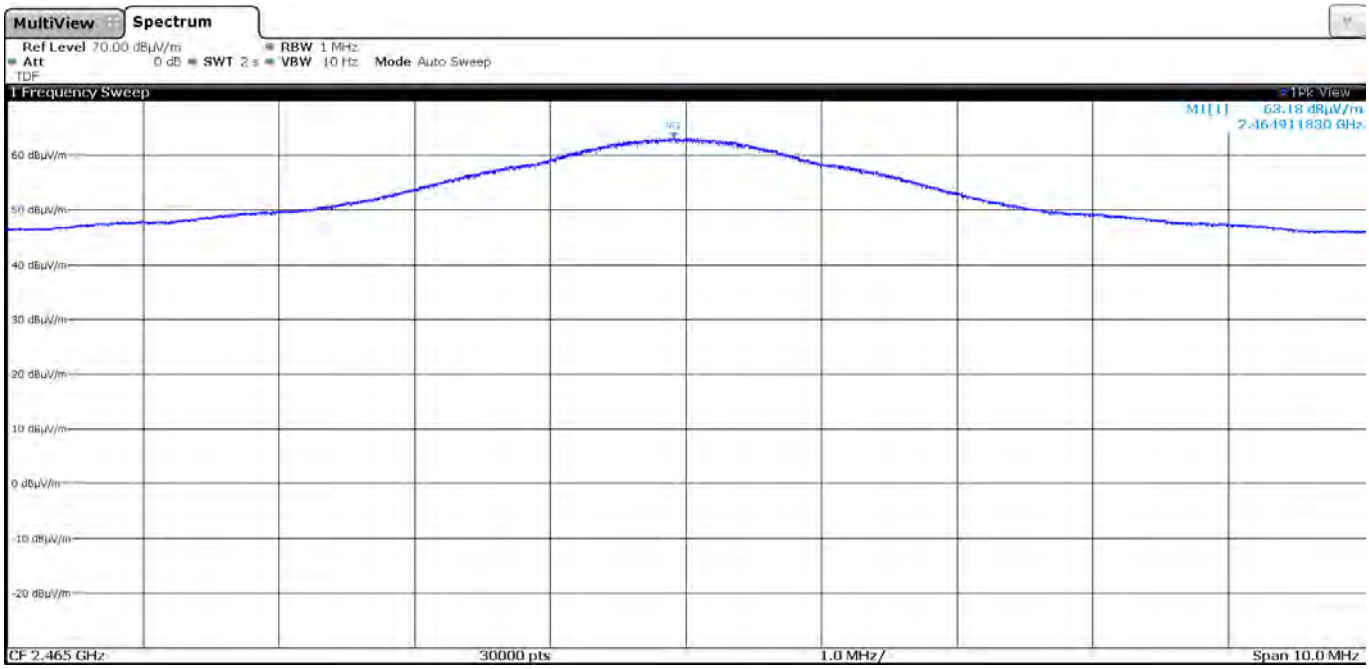
Maximum peak and average field strength of fundamental emission at 3 m distance

CHANNEL (2465 MHz).

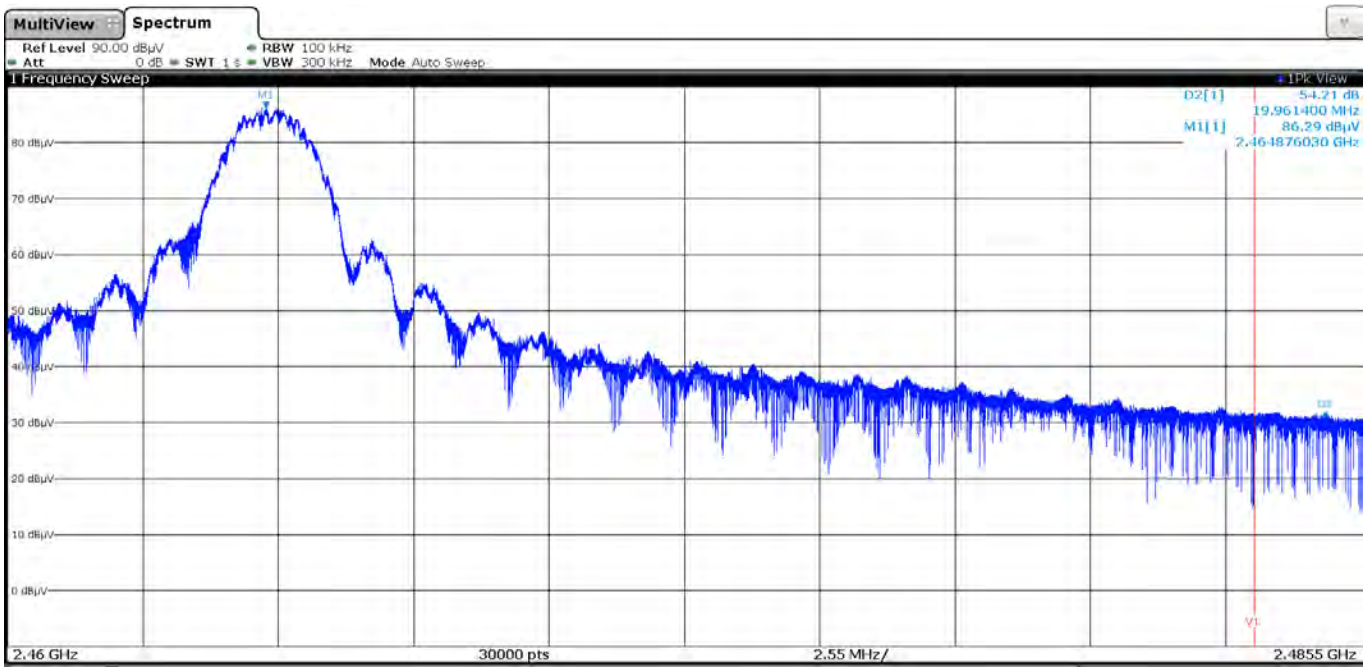
Maximum field strength at 3 m. Peak value:



Maximum field strength at 3 m. Average value:



BAND-EDGE COMPLIANCE. RADIATED. Marker-Delta Method.



Note: No correction is applied for this relative measurement.

Band edge compliance of radiated emissions

Fundamental max. average value 3 m	Delta value	Calculated value 3 m	Limit
63.18 dBµV/m	54.21 dB	8.97 dBµV/m	54 dBµV/m

Fundamental max. Peak value 3 m	Delta value	Calculated value 3 m	Limit
113.18 dBµV/m	54.21 dB	58.97 dBµV/m	74 dBµV/m

Verdict: PASS

FCC Section 15.247 Subclause (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.

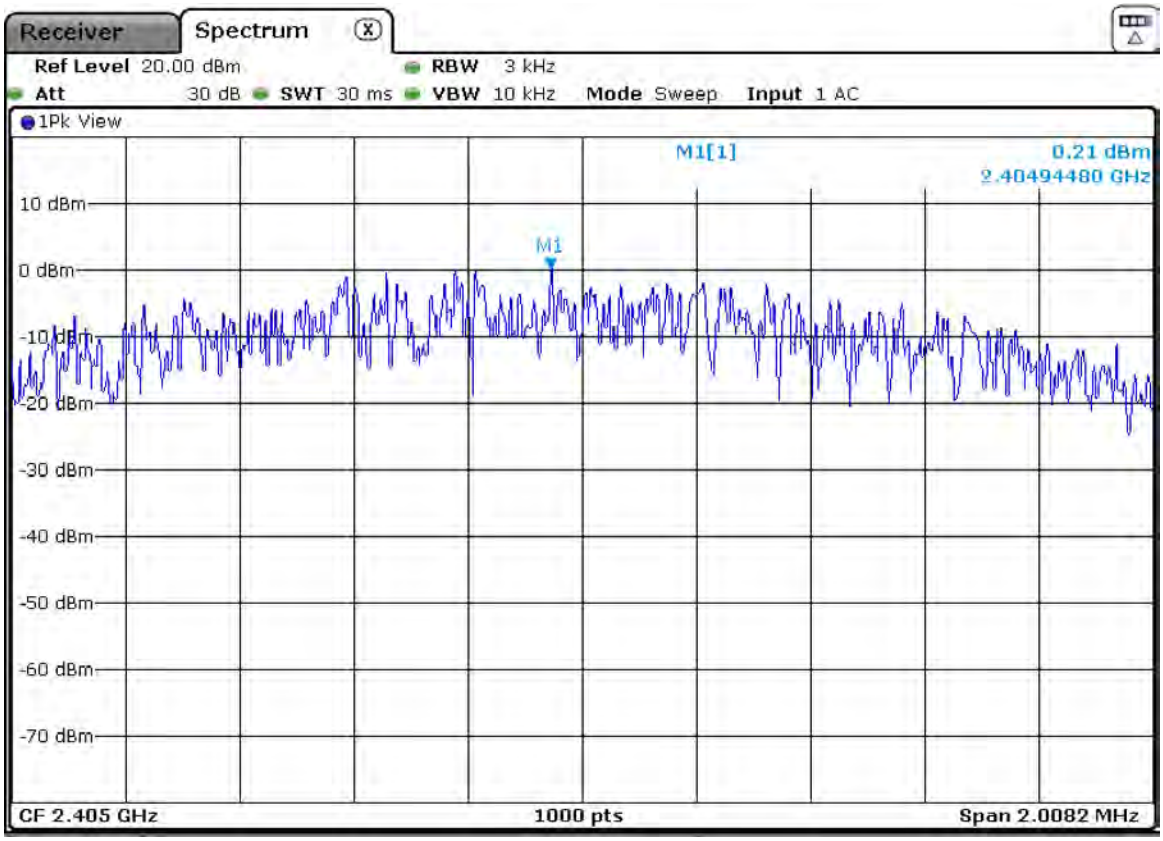
RESULTS:

The maximum power spectral density level in the fundamental emission was measured using the method PKPSD (Peak PSD) according to point 8.4.of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247 558074 D01 DTS Meas Guidance v05r02 dated 2019/04/02.

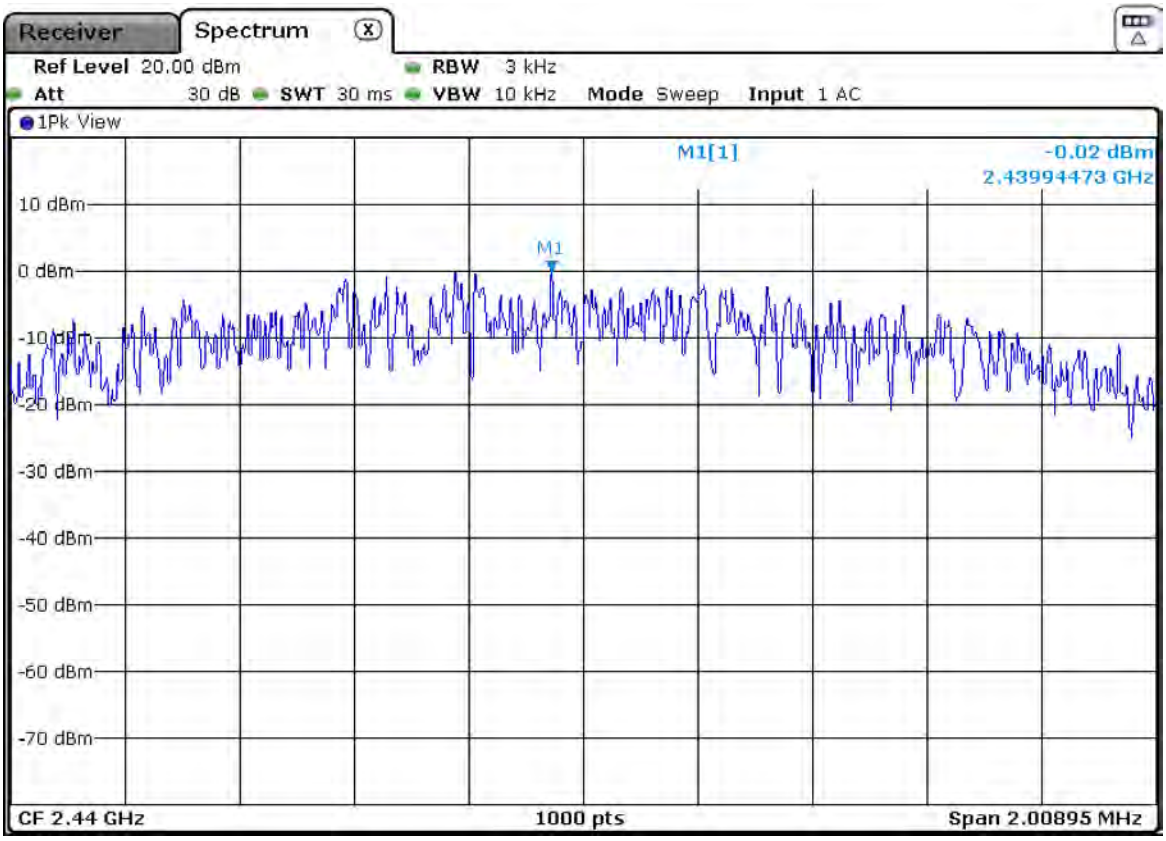
	Low Channel 2405 MHz	Middle Channel 2440 MHz	High Channel 2470 MHz
Power Spectral Density (dBm)	0.21	-0.02	-4.29
Measurement uncertainty (dB)	<±1.20		

Verdict: PASS

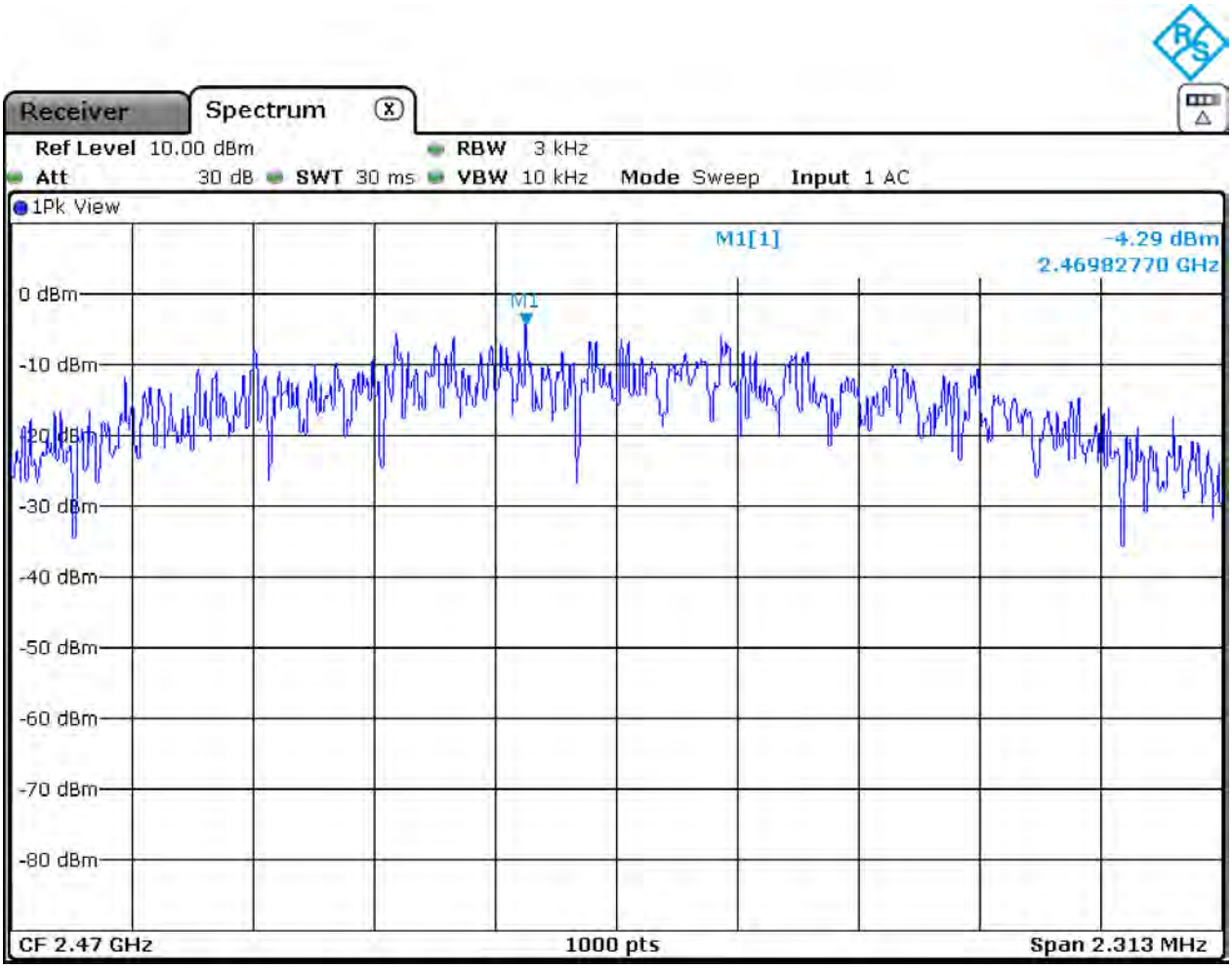
- Low Channel:



- Middle Channel:



- High Channel:



FCC Section 15.247 Subclause (d) / RSS-247 Clause 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-1000 MHz and at distance of 1m for the frequency range 1 GHz-26 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:

The spurious frequencies detected do not depend on the operating channel.

Spurious signals closest to the limit:

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
200.025	Horizontal	Quasi peak	32.4	<± 3.86
400.007	Horizontal	Quasi peak	34.9	<± 3.86
479.999	Vertical	Quasi peak	31.9	<± 3.86
600.21	Horizontal	Quasi peak	41.2	<± 3.86
680.013	Horizontal	Quasi peak	41.1	<± 3.86
760.006	Horizontal	Quasi peak	44.6	<± 3.86
800.035	Horizontal	Quasi peak	40.8	<± 3.86
959.988	Vertical	Quasi peak	35.4	<± 3.86

Frequency range 1 - 26 GHz:

The results in the next tables show the maximum measured levels in the 1-25 GHz range including the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Spurious signals 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.

1. CHANNEL: LOWEST (2405 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
1079.993	Vertical	Peak	46.32	<± 4.72
1159.930	Vertical	Peak	46.34	<± 4.72
1239.960	Vertical	Peak	46.43	<± 4.72
1319.704	Vertical	Peak	47.81	<± 4.72
1680.083	Horizontal	Peak	47.27	<± 4.72
1740.300	Horizontal	Peak	51.89	<± 4.72
2389.921	Vertical	Peak	63.10	<± 4.72
		Average	40.51	<± 4.72
2483.661	Vertical	Peak	53.26	<± 4.72
4809.030	Vertical	Peak	55.63	<± 4.72
		Average	49.83	<± 4.72
7216.100	Vertical	Peak	48.61	<± 4.72
9618.030(*)	Vertical	Peak	67.93	<± 4.72
		Average	61.81	<± 4.72
12022.770	Vertical	Peak	52.36	<± 4.72
14426.570	Vertical	Peak	57.12	<± 4.72
		Average	47.62	<± 4.72
19232.450	Horizontal	Peak	51.81	<± 4.72
21639.650	Vertical	Peak	50.67	<± 4.72
24054.650	Vertical	Peak	59.05	<± 4.72
		Average	51.70	<± 4.72

(*): This spurious frequency is outside the restricted bands as defined in §15.205(a). The measured maximum carrier level at 3 m was 110.49 dBµV/m (Peak) so the spurious level is more than 20 dB below the carrier level.

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
1080.233	Horizontal	Peak	47.11	<± 4.72
1160.167	Vertical	Peak	46.18	<± 4.72
1239.900	Horizontal	Peak	46.67	<± 4.72
1319.700	Horizontal	Peak	48.47	<± 4.72
1399.700	Horizontal	Peak	48.46	<± 4.72
1600.700	Vertical	Peak	47.57	<± 4.72
1738.900	Horizontal	Peak	52.42	<± 4.72
2389.881	Vertical	Peak	63.81	<± 4.72
		Average	40.16	<± 4.72
2483.76648	Vertical	Peak	69.46	<± 4.72
		Average	42.19	<± 4.72
2495.6778	Vertical	Peak	54.48	<± 4.72
		Average	39.14	<± 4.72
4879.030	Vertical	Peak	54.22	<± 4.72
		Average	48.36	<± 4.72
7321.570	Vertical	Peak	50.45	<± 4.72
9761.770 (*)	Vertical	Peak	65.05	<± 4.72
		Average	58.51	<± 4.72
12207.970	Vertical	Peak	50.86	<± 4.72
14636.57	Vertical	Peak	56.05	<± 4.72
		Average	48.41	<± 4.72
17083.250	Horizontal	Peak	47.80	<± 4.72
19515.950	Vertical	Peak	46.92	<± 4.72
21964.250	Vertical	Peak	51.94	<± 4.72
24404.450	Horizontal	Peak	59.49	<± 4.72
		Average	53.08	<± 4.72

(*): This spurious frequency is outside the restricted bands as defined in §15.205(a). The measured maximum carrier level at 3 m was 110.55 dBµV/m (Peak) so the spurious level is more than 20 dB below the carrier level.

3. CHANNEL: (2465 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2389.644	Vertical	Peak	60.66	<± 4.88
		Average	39.13	<± 4.88
2485.530	Vertical	Peak	73.89	<± 4.88
		Average	45.57	<± 4.88

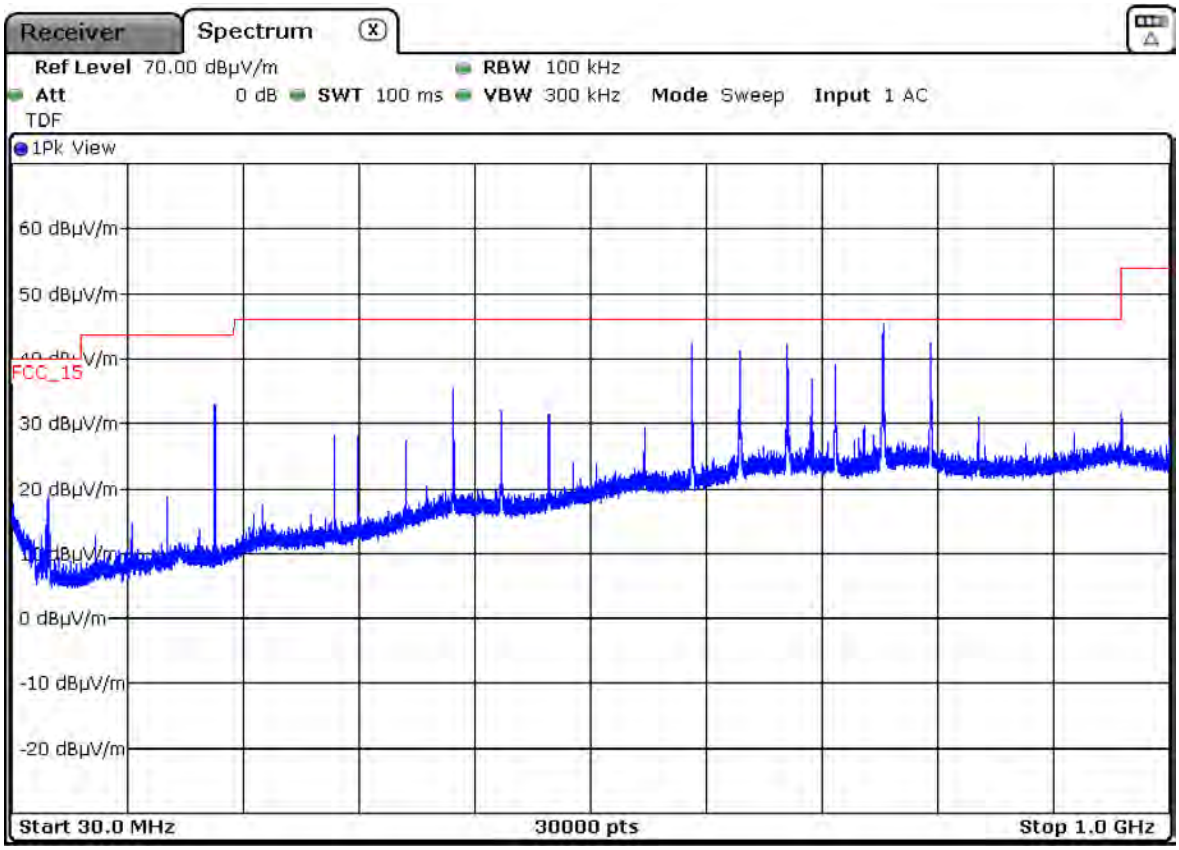
4. CHANNEL: HIGHEST (2470 MHz).

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
1736.290	Horizontal	Peak	53.49	<± 4.88
2389.160	Vertical	Peak	57.77	<± 4.88
		Average	40.99	<± 4.88
2483.537	Vertical	Peak	73.99	<± 4.88
		Average	50.65	<± 4.88
2483.940	Horizontal	Peak	65.88	<± 4.88
		Average	44.48	<± 4.88
4940.630	Vertical	Peak	53.83	<± 4.88
7411.170	Vertical	Peak	48.82	<± 4.88
9877.970	Horizontal	Peak	58.26	<± 4.88
		Average	50.15	<± 4.88
14816.700	Vertical	Peak	52.03	<± 4.88
17292.950	Horizontal	Peak	43.35	<± 4.88
19763.450	Horizontal	Peak	42.30	<± 4.88
22225.25	Vertical	Peak	43.56	<± 4.88
24694.850	Horizontal	Peak	42.30	<± 4.88

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz:

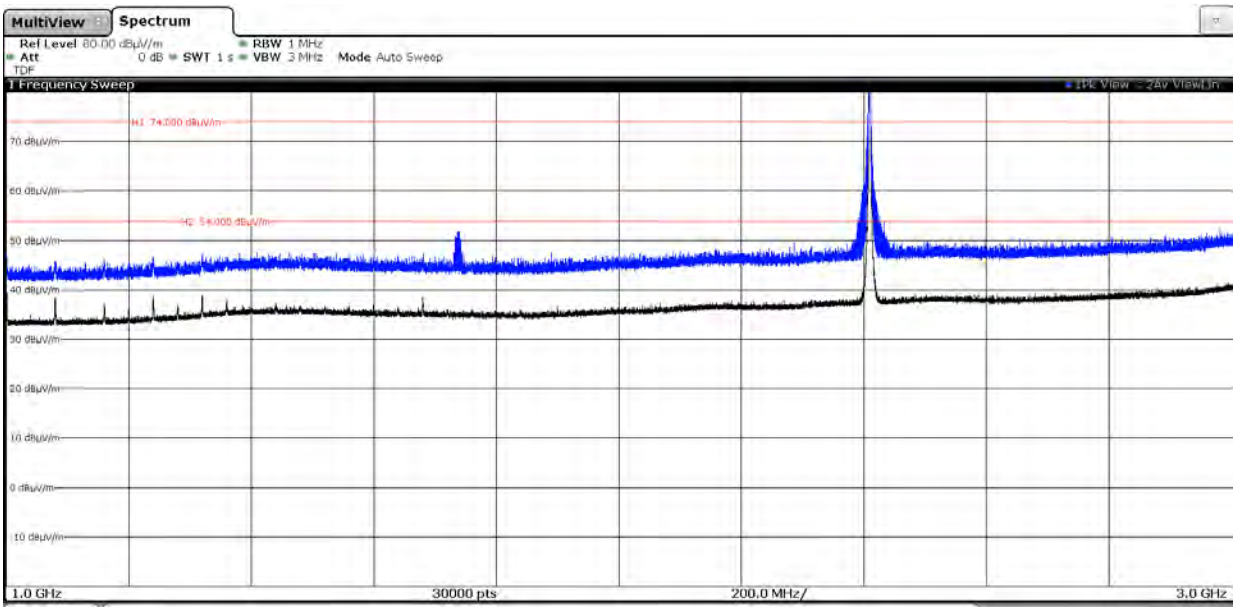
The spurious signals detected do not depend on the operating channel.



This plot is valid for the Low, Middle and High Channels.

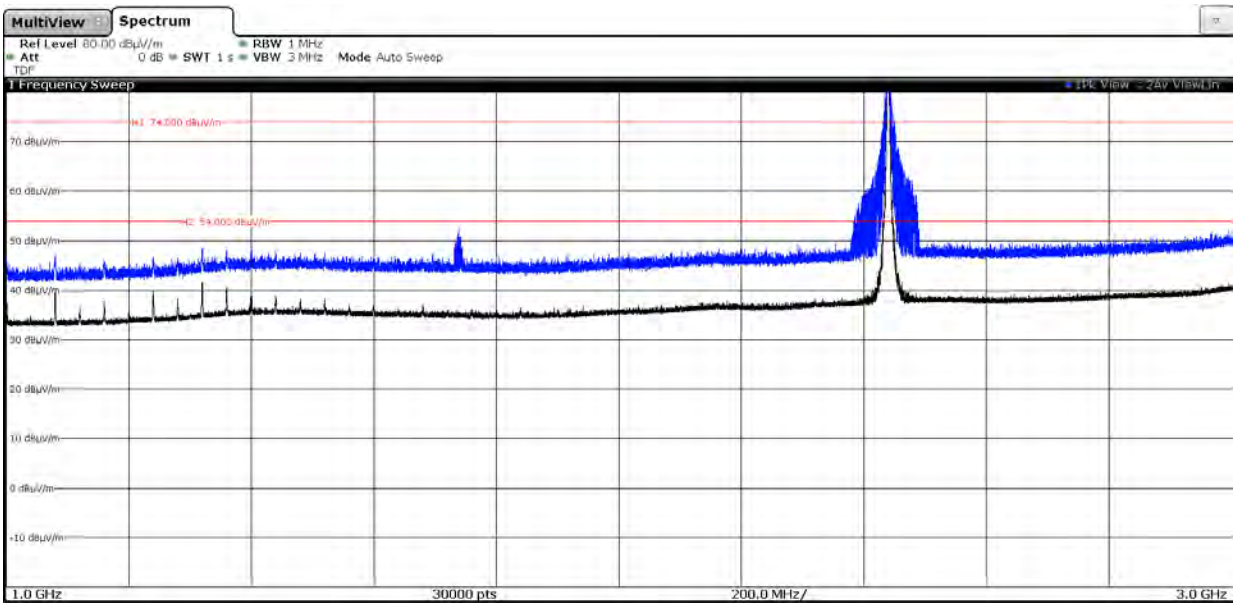
FREQUENCY RANGE 1 - 3 GHz:

CHANNEL: LOWEST (2405 MHz).



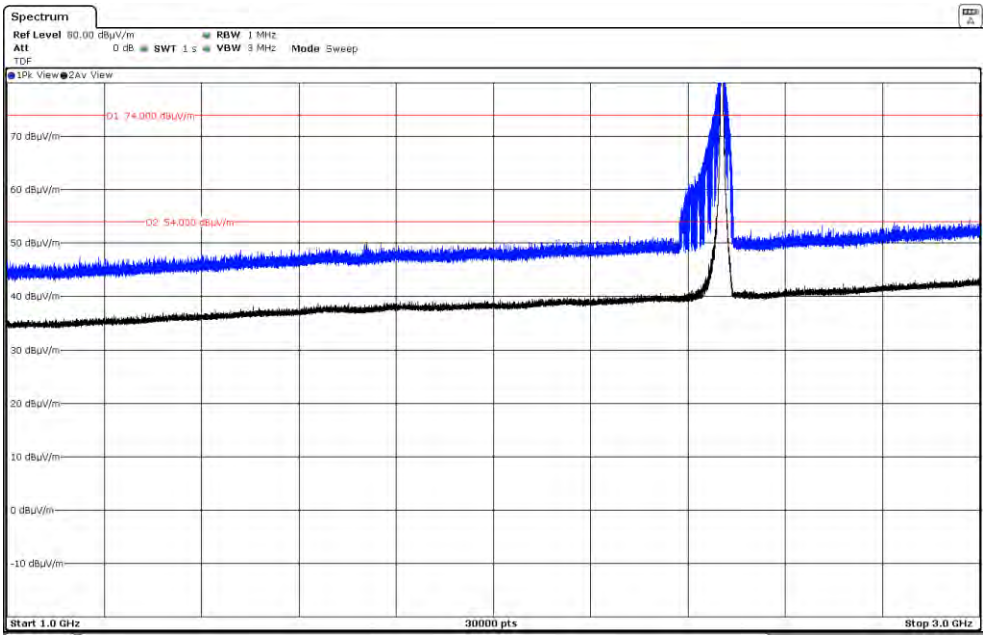
The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE (2440 MHz).



The peak above the limit is the carrier frequency.

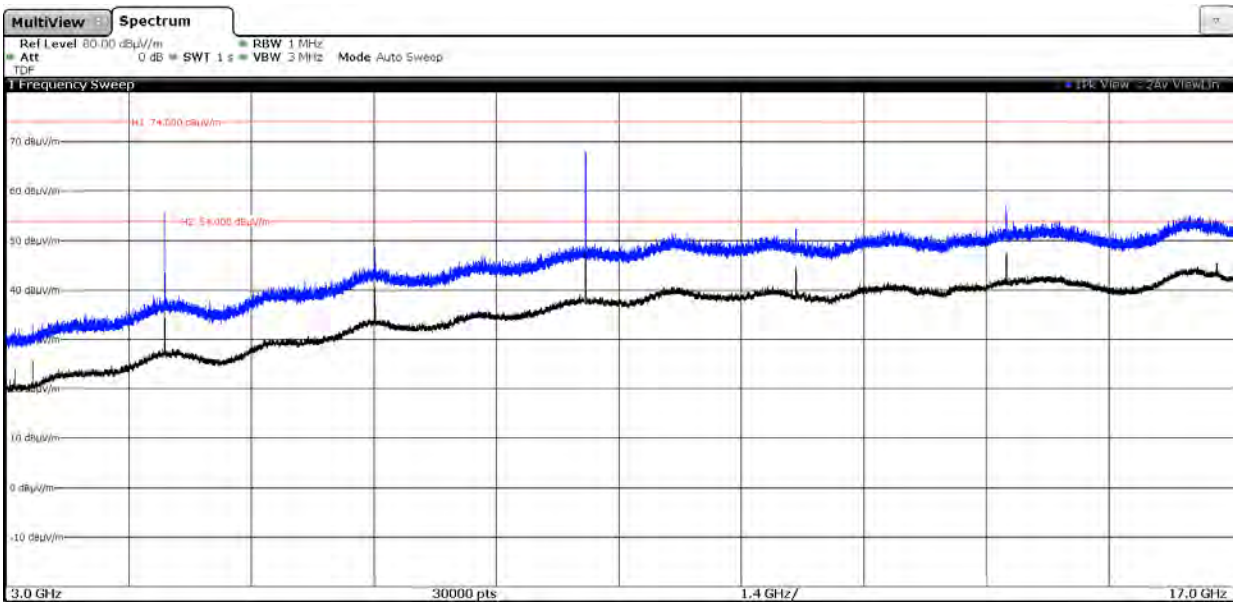
CHANNEL: HIGHEST (2470 MHz).



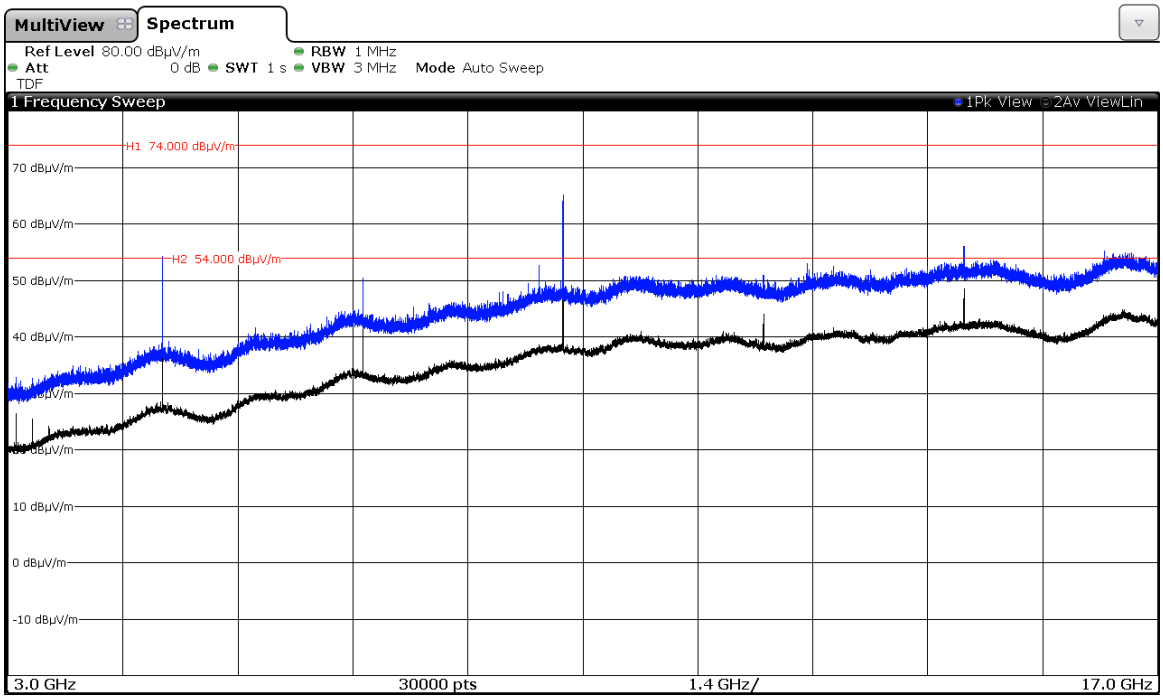
The peak above the limit is the carrier frequency.

FREQUENCY RANGE 3 - 17 GHz:

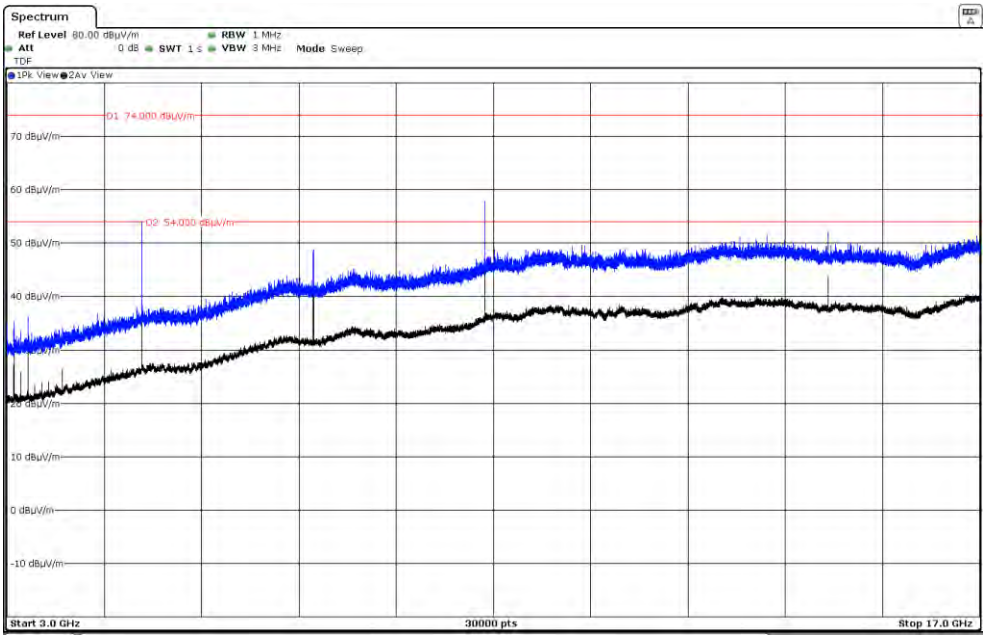
CHANNEL: LOWEST (2405 MHz).



CHANNEL: MIDDLE (2440 MHz).

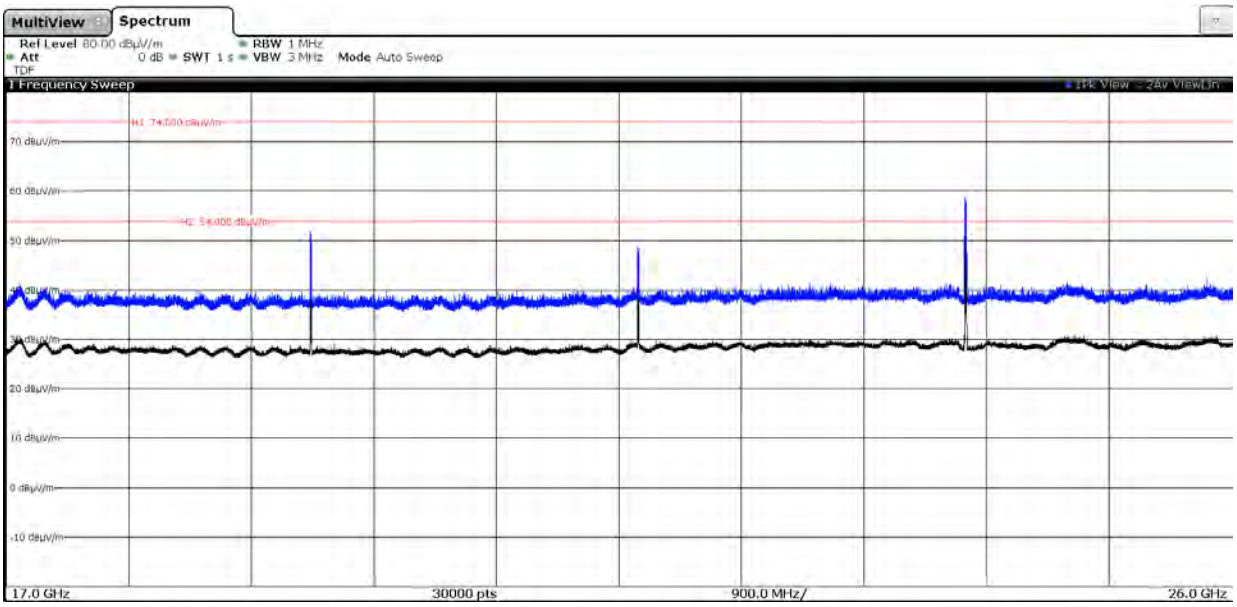


CHANNEL: HIGHEST (2470 MHz).

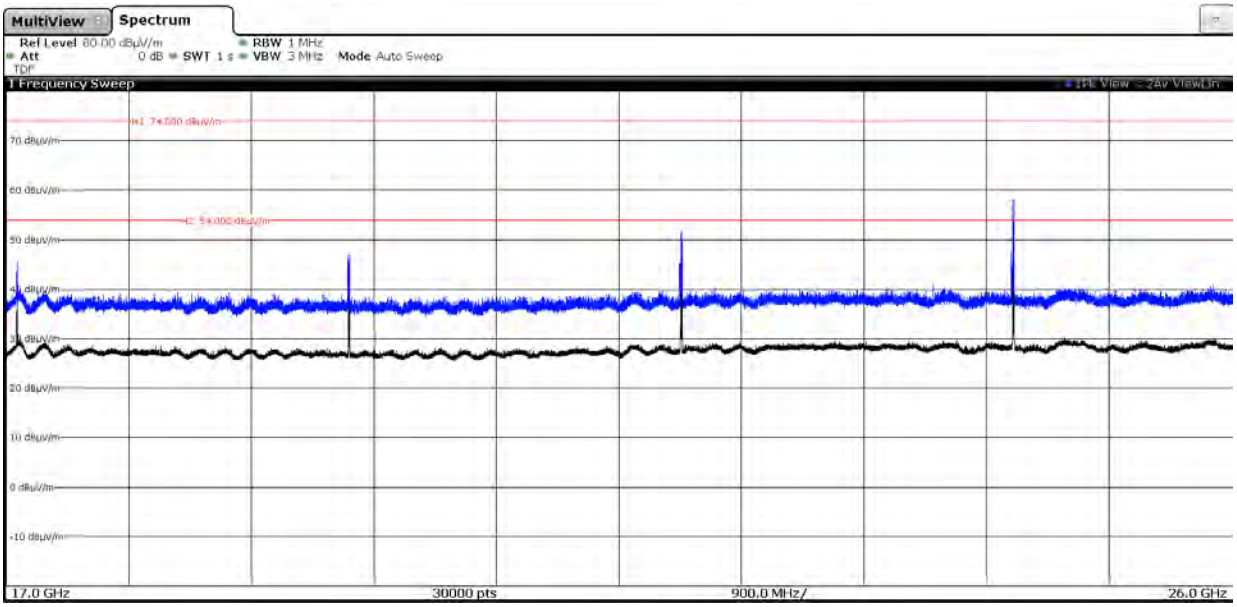


FREQUENCY RANGE 17 - 26 GHz:

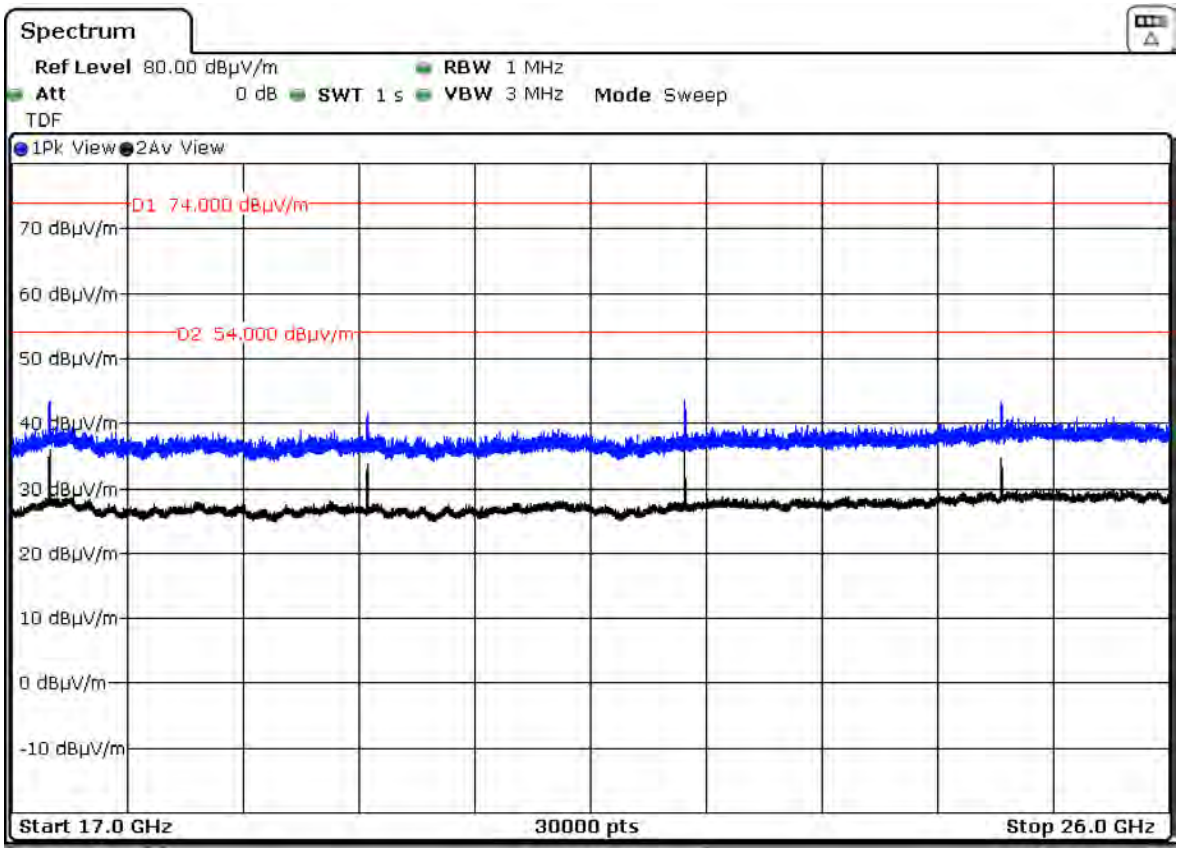
CHANNEL: LOWEST (2405 MHz).



CHANNEL: MIDDLE (2440 MHz).

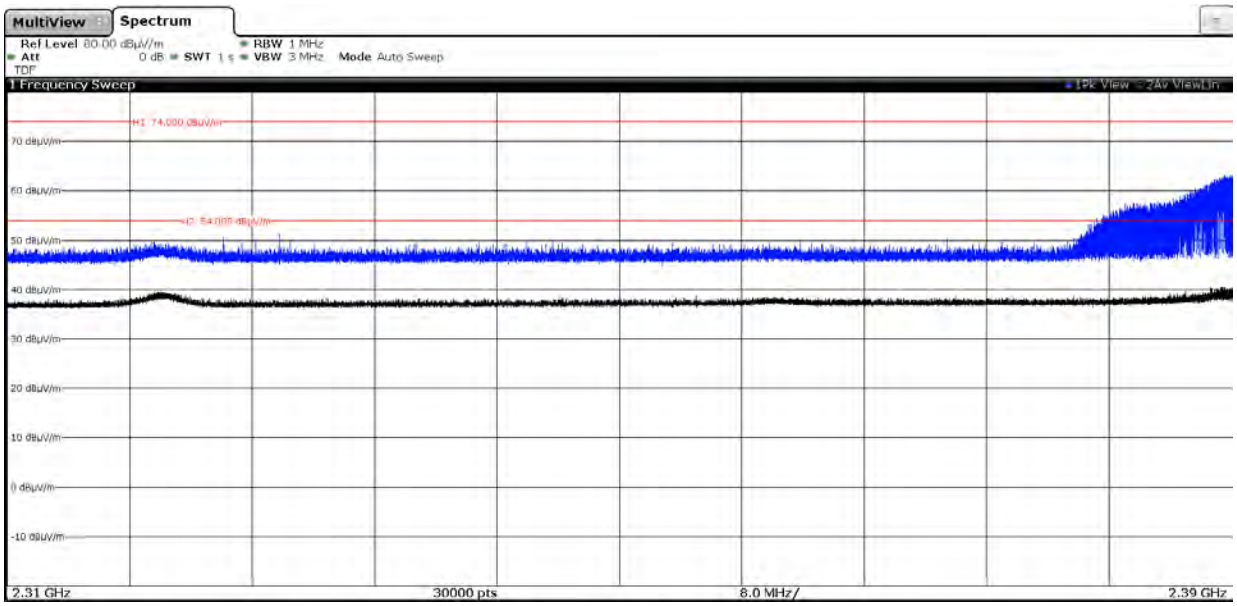


CHANNEL: HIGHEST (2470 MHz).

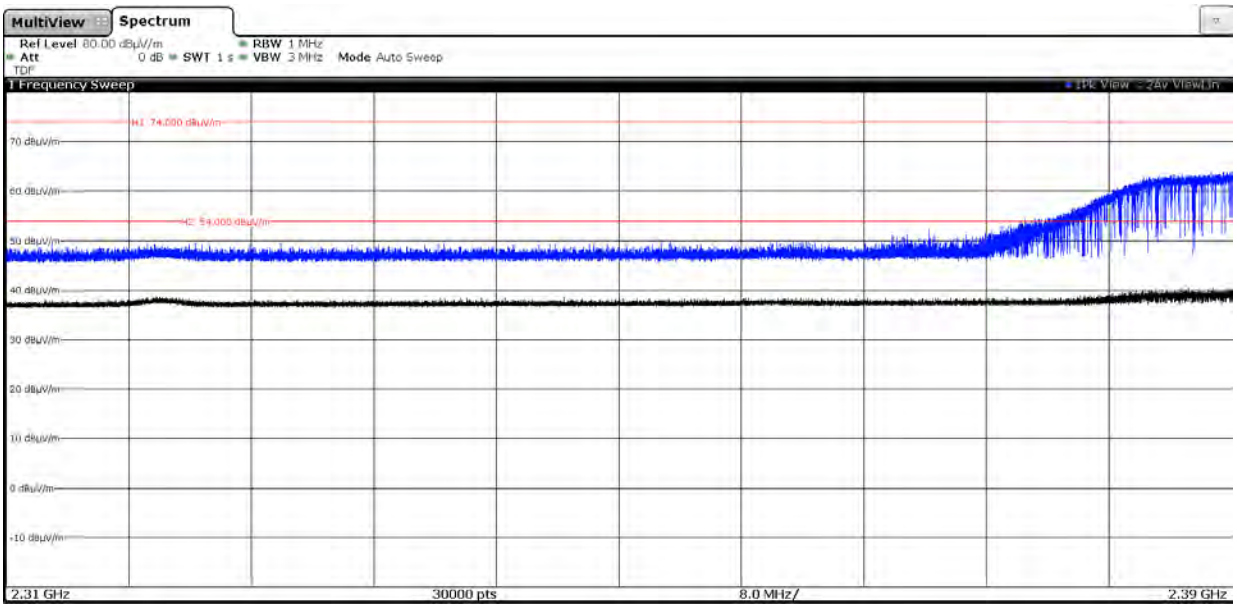


FREQUENCY RANGE 2.31-2.39 GHz (Restricted Band 1):

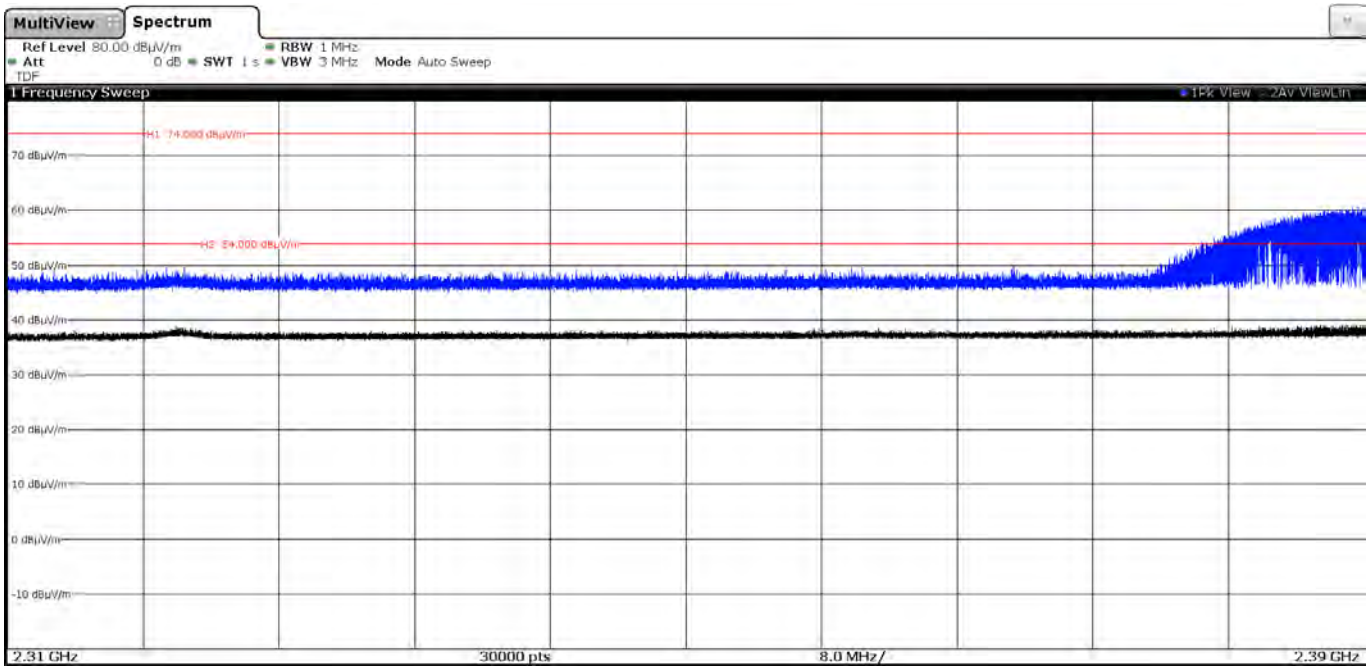
CHANNEL: LOWEST (2405 MHz).



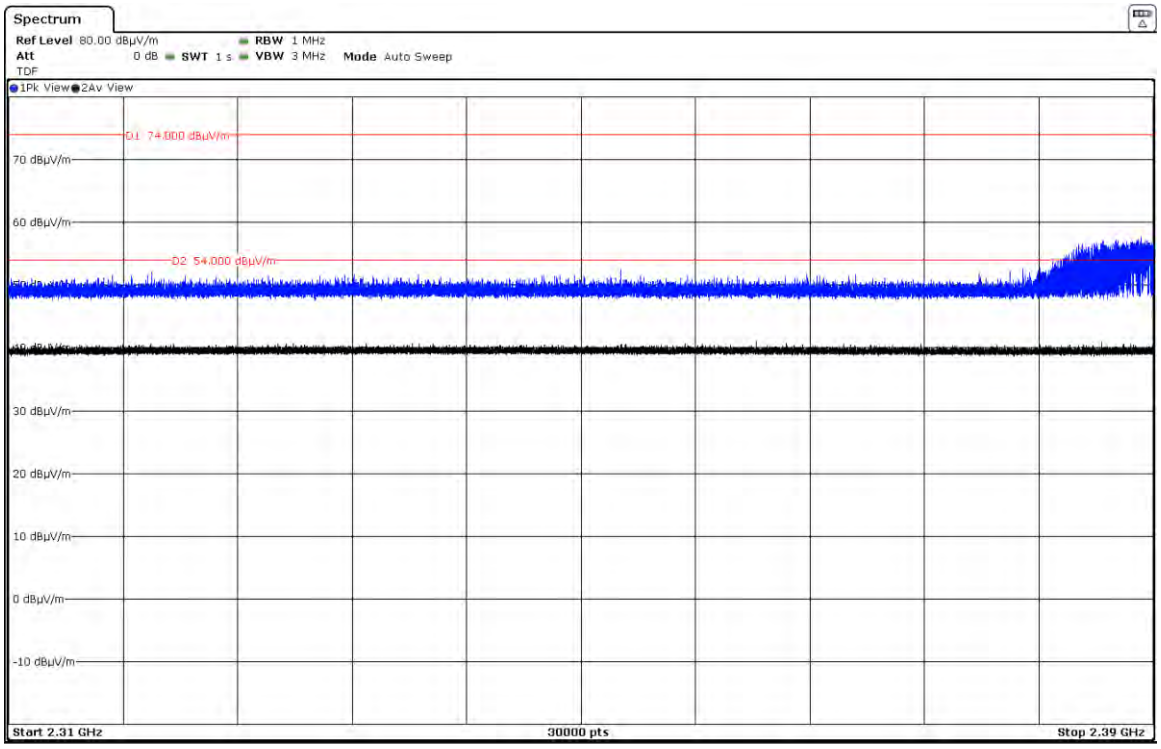
CHANNEL: MIDDLE (2440 MHz).



CHANNEL: (2465 MHz).

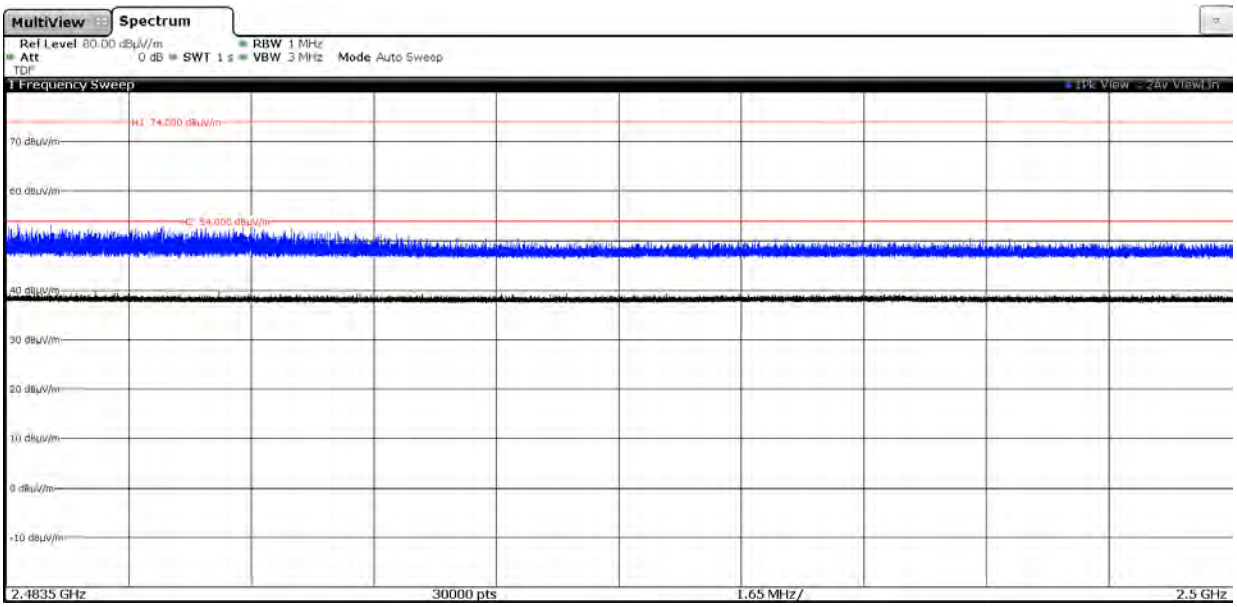


CHANNEL: HIGHEST (2470 MHz).

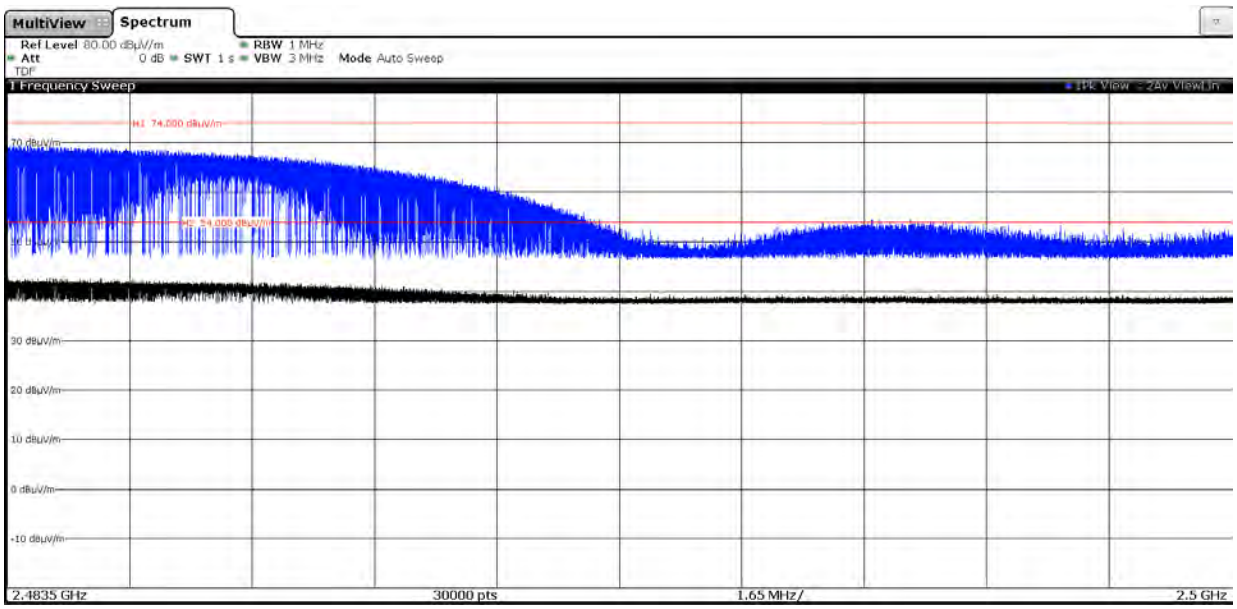


FREQUENCY RANGE 2.4835-2.5 GHz (Restricted Band 2):

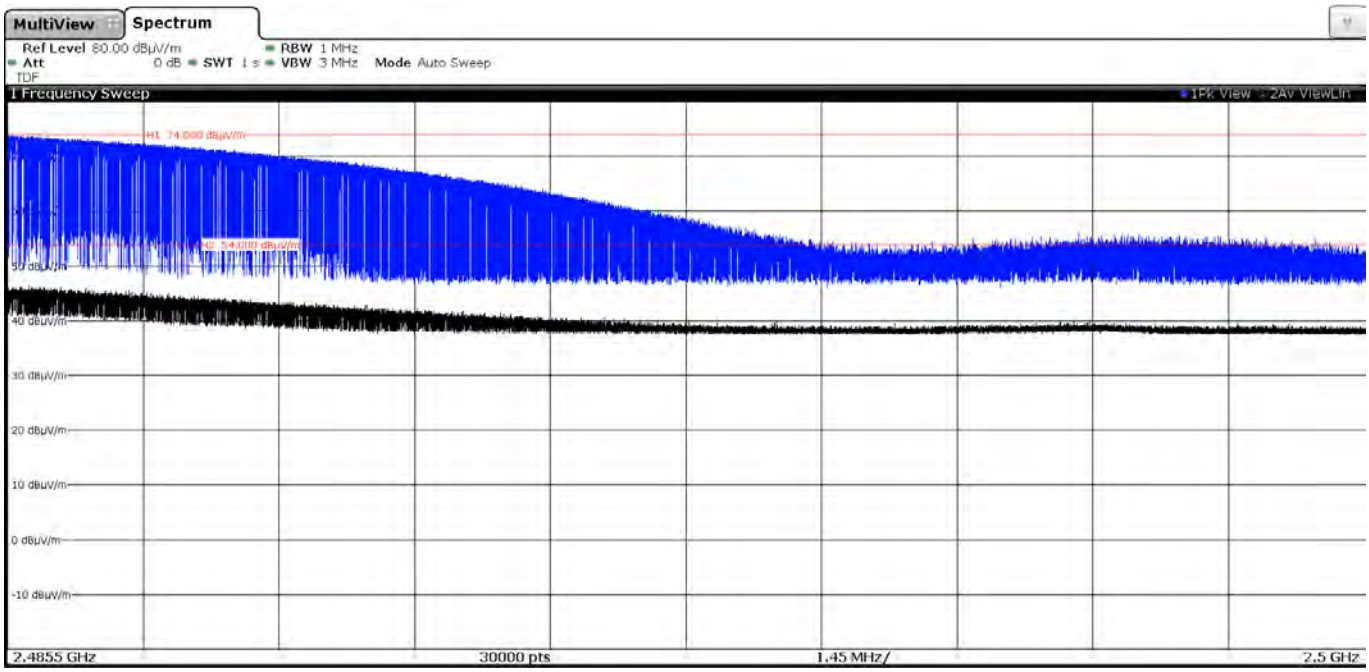
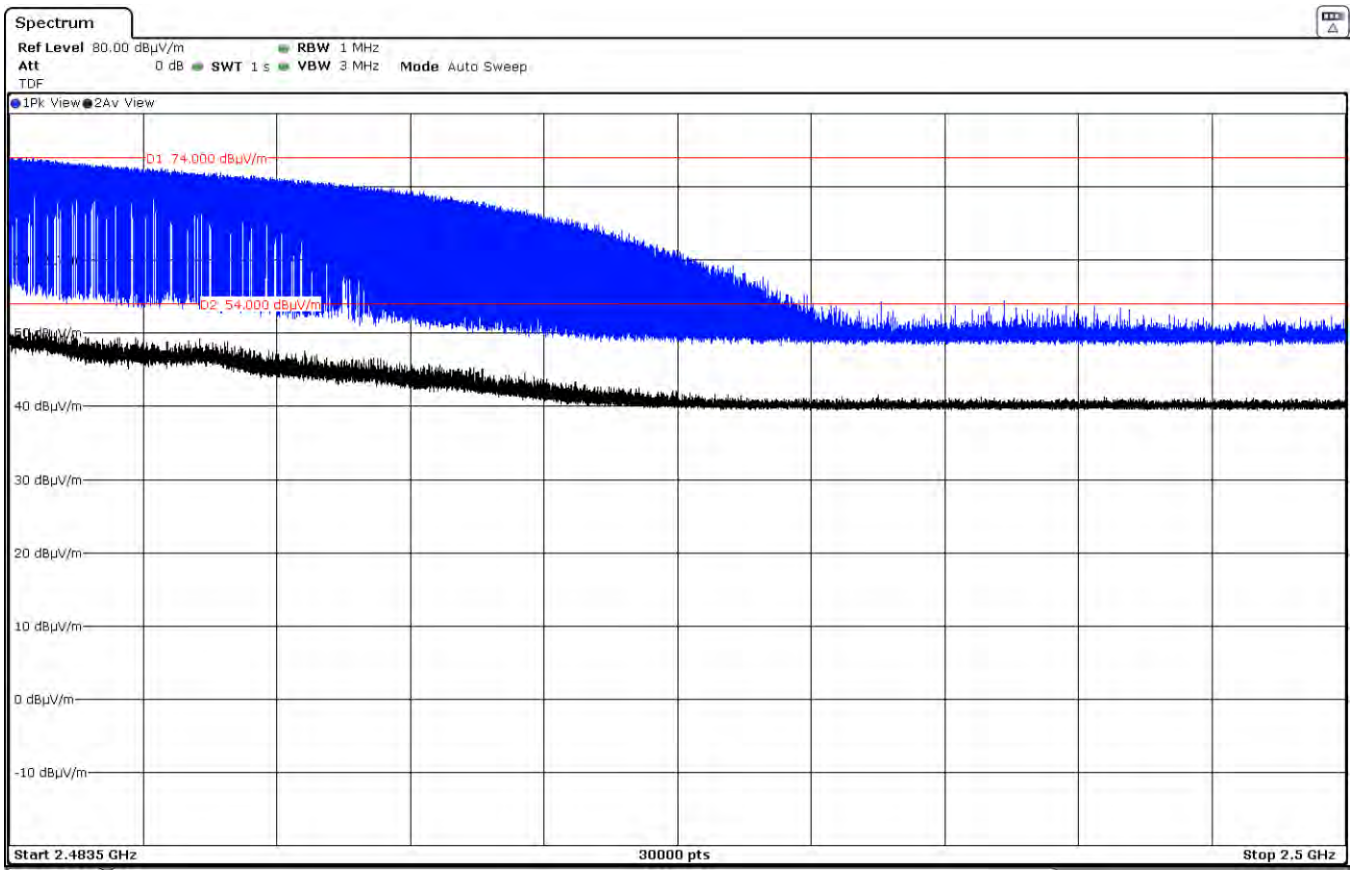
CHANNEL: LOWEST (2405 MHz).



CHANNEL: MIDDLE (2440 MHz).



CHANNEL: (2465 MHz).



CHANNEL: HIGHEST (2470 MHz).