



FCC LISTED, REGISTRATION
NUMBER: 720267

Informe de ensayo nº:
Test report No:

NIE: 49467RRF.002

Test report

USA FCC Part 15.247, 15.209

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.

Identificación del objeto ensayado.....: Identification of item tested	LASER RANGE METER
Marca Trademark	HILTI
Modelo y/o referencia tipo Model and /or type reference	PD-CS (01)
Other identification of the product	FCC ID: SDL-PDCS01
Final HW version	4.00
Final SW version	2.3.9
Características Features	BT, WLAN
Fabricante Manufacturer	HILTI CORPORATION Feldkircherstr. 100 FL-9494 Schaan Principality of Liechtenstein
Método de ensayo solicitado, norma.....: Test method requested, standard	USA FCC Part 15.247 10-1-15 Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 10-1-15 Edition: Radiated emission limits; general requirements. Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Resultado.....: Summary	IN COMPLIANCE

Aprobado por (nombre / cargo y firma) Approved by (name / position & signature)	A. Llamas RF Lab. Manager
Fecha de realización Date of issue	2016-10-20
Formato de informe No. Report template No	FDT08_18

Index

Competences and guarantees.....	4
General conditions.....	4
Uncertainty	4
Usage of samples.....	4
Test sample description	5
Identification of the client	5
Testing period.....	5
Environmental conditions.....	5
Remarks and comments.....	6
Testing verdicts	7
Appendix A – Test result (Bluetooth EDR)	9
Appendix B – Test result “WiFi 2.4 GHz (802.11b/g/n20/n40)”	85

Competences and guarantees

AT4 wireless 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.

AT4 wireless is a laboratory with a measurement facility in compliance with the requirements of Section 2.948 of the FCC rules and has been added to the list of facilities whose measurements data will be accepted in conjunction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Registration Number: 720267.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance program for its measurement equipment.

AT4 wireless 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 AT4 wireless at the time of performance of the test.

AT4 wireless 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.

IMPORTANT: No parts of this report may be reproduced or quoted out of context, in any form or by any means, except in full, without the previous written permission of AT4 wireless.

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 AT4 wireless.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the AT4 wireless internal document PODT000.

Usage of samples

Samples undergoing test have been selected by: **the client**

Sample S/01 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
49467/004	Laser Range Meter	PD-CS (01)	---	2016-05-24

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

Sample S/02 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
48496/007	Laser Range Meter	PD-CS (01)	---	2016-05-24

- Sample S/02 has undergone following test(s).
All conducted tests indicated in appendix A.

Sample S/03 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
48496/019	Laser Range Meter	PD-CS (01)	---	2016-09-19

- Sample S/03 has undergone following test(s).
All conducted tests indicated in appendix B.

Test sample description

The sample consists of a High-End Measurement Device by HILTI. Key marketing points from the product: Measuring precisely in just seconds with only one person. Measuring heights from floor to ceiling. Measuring safely in places where access is difficult. Measuring effectively outdoors in windy conditions. Measuring a wide range of distances, 0.25m to 250m. Measuring with high accuracy +/- 1.5mm. Measuring easily with simple one-button press. Measuring repeatedly with fast calculation time. Measuring small distances with no loss in accuracy or reliability. Measuring long distances with no loss in accuracy and best-in-class reliability. Calculating a relative distance, area, or volume from geometry using angle sensor and software. Relying on technology engineered in Liechtenstein and made in Germany under high quality standards. Relying on guarantee of Hilti's Lifetime Service™ plus for Hilti's Fleet Management customers 1 no-cost "drop".

Identification of the client

BITTIUM WIRELESS LTD.

Tutkijantie 8, 90590. Oulu. FINLAND

Testing period

The performed test started on 2016-06-03 and finished on 2016-09-23.

The tests have been performed at AT4 wireless.

Environmental conditions

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

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω

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

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω
Normal site attenuation (NSA)	< ±4 dB at 10 m distance between item under test and receiver antenna, (30 MHz to 1000 MHz)
Field homogeneity	More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 1000 MHz).

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

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Electric insulation	> 10 kΩ
Reference resistance to earth	< 1 Ω

Remarks and comments

1: Used instrumentation:

Conducted Measurements

	Last Cal. date	Cal. due date
1. Spectrum analyser Agilent E4440A	2015/10	2017/10
2. DC power supply R&S NGPE 40/40	2014/11	2017/11
3. R&S NRP-Z81 Wideband Power Sensor	2016/04	2018/04
4. Coupler NARDA 27000-30	2016/09	2018/09
5. Bluetooth Signalling unit ANRITSU MT8852B	N.A.	N.A.

Radiated Measurements

		Last Cal. date	Cal. due date
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
2.	BiconicalLog antenna ETS LINDGREN 3142E	2014/03	2017/03
3.	Multi Device Controller EMCO 2090	N.A.	N.A.
4.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2013/11	2016/11
5.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2014/03	2017/03
6.	EMI Test Receiver R&S ESU 40	2016/03	2018/03
7.	Spectrum analyser Rohde & Schwarz FSW50	2015/12	2017/12
8.	RF pre-amplifier 10 MHz-6 GHz SCHWARZBECK BBV9743	2016/04	2017/04
9.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-1M	2016/02	2018/02
10.	RF pre-amplifier 18-40 GHz BONN ELEKTRONIK BLMA 1840-1M	2015/12	2017/12
11.	Bluetooth Signalling unit ANRITSU MT8852B	N.A.	N.A.

Testing verdicts

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

1. BT EDR

FCC PART 15 PARAGRAPH		VERDICT			
		NA	P	F	NM
FCC 15.247 Subclause (a) (1)	20 dB Bandwidth and Carrier frequency separation		P		
FCC 15.247 Subclause (a)(1)(iii)	Number of hopping channels		P		
FCC 15.247 Subclause (a)(1)(iii)	Time of occupancy (Dwell Time)		P		
FCC 15.247 Subclause (b)	Maximum peak output power and antenna gain		P		
FCC 15.247 Subclause (d)	Emission limitations conducted (Transmitter)		P		
FCC 15.247 Subclause (d)	Emission limitations radiated (Transmitter)		P		

2. WiFi 2.4 GHz (802.11b/g/n20/n40).

FCC PART 15 PARAGRAPH		VERDICT			
		NA	P	F	NM
Section 15.247 Subclause (a) (2)	6 dB Bandwidth		P		
Section 15.247 Subclause (b)	Maximum output power and antenna gain		P		
Section 15.247 Subclause (d)	Emission limitations conducted (Transmitter)		P		
Section 15.247 Subclause (d)	Band-edge conducted emissions compliance (Transmitter)		P		
Section 15.247 Subclause (e)	Power spectral density		P		
Section 15.247 Subclause (d)	Emission limitations radiated (Transmitter)		P		

Appendix A – Test result (Bluetooth EDR)

INDEX

TEST CONDITIONS	11
FCC Section 15.247 Subclause (a) (1). 20 dB Bandwidth and Carrier frequency separation	14
FCC Section 15.247 Subclause (a) (1) (iii). Number of hopping channels	21
FCC Section 15.247 Subclause (a) (1) (iii). Time of occupancy (Dwell Time)	27
FCC Section 15.247 Subclause (b). Maximum peak output power and antenna gain	37
FCC Section 15.247 Subclause (d). Band-edge compliance of conducted emissions (Transmitter)	43
FCC Section 15.247 Subclause (d). Emission limitations conducted (Transmitter)	50
FCC Section 15.247 Subclause (d). Emission limitations radiated (Transmitter)	56

TEST CONDITIONS

Power supply (V):

$$V_{\text{nominal}} = 3.7 \text{ Vdc}$$

Type of power supply = DC voltage from battery.

Type of antenna = Integral antenna.

Declared Gain for antenna (maximum) = +3.70 dBi

TEST FREQUENCIES:

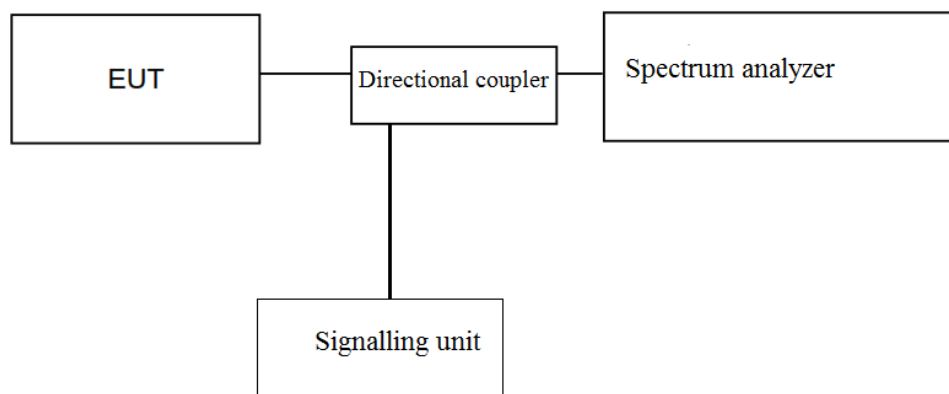
Lowest channel: 2402 MHz

Middle channel: 2441 MHz

Highest channel: 2480 MHz

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is connected to a Bluetooth signalling unit (Bluetooth test set) and to the spectrum analyzer using a directional coupler. The reading in the spectrum analyzer is corrected taking into account the coupler 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 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 1m 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.

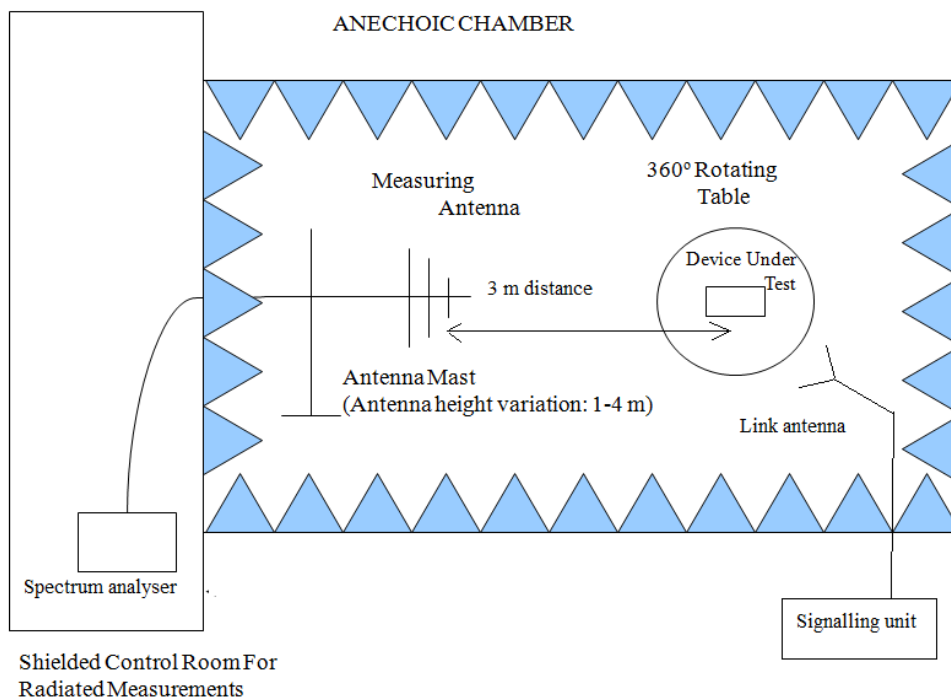
The equipment under test was set up on a non-conductive platform 1.5 meter above the ground plane and the situation and orientation was varied to find the maximum radiated emission.

It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

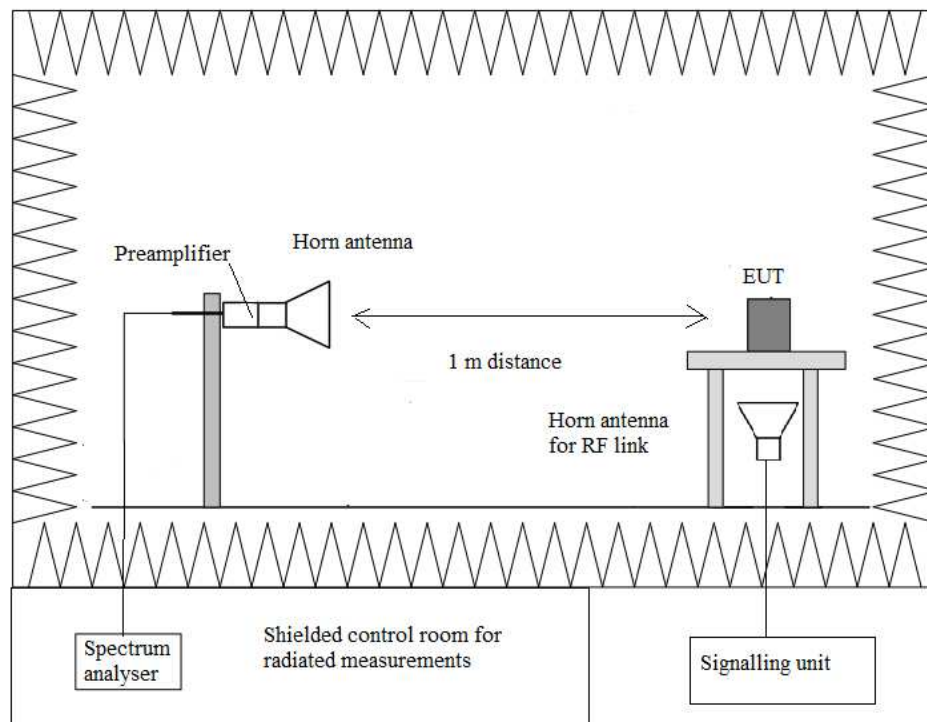
Measurements were made in both horizontal and vertical planes of polarization.

An additional horn antenna is used to control the equipment under test with the Bluetooth signalling unit (Bluetooth test set).

Radiated measurements setup $f < 1$ GHz



Radiated measurements setup $f > 1$ GHz



FCC Section 15.247 Subclause (a) (1). 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

(See next plots)

Modulation: GFSK

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
20 dB Spectrum bandwidth (KHz)	943.608	916.101	925.125
Measurement uncertainty (kHz)	<±5.00		

Modulation: Π/4-DQPSK (2Mbps)

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
20 dB Spectrum bandwidth (kHz)	1278	1278	1278
Measurement uncertainty (kHz)	<±5.00		

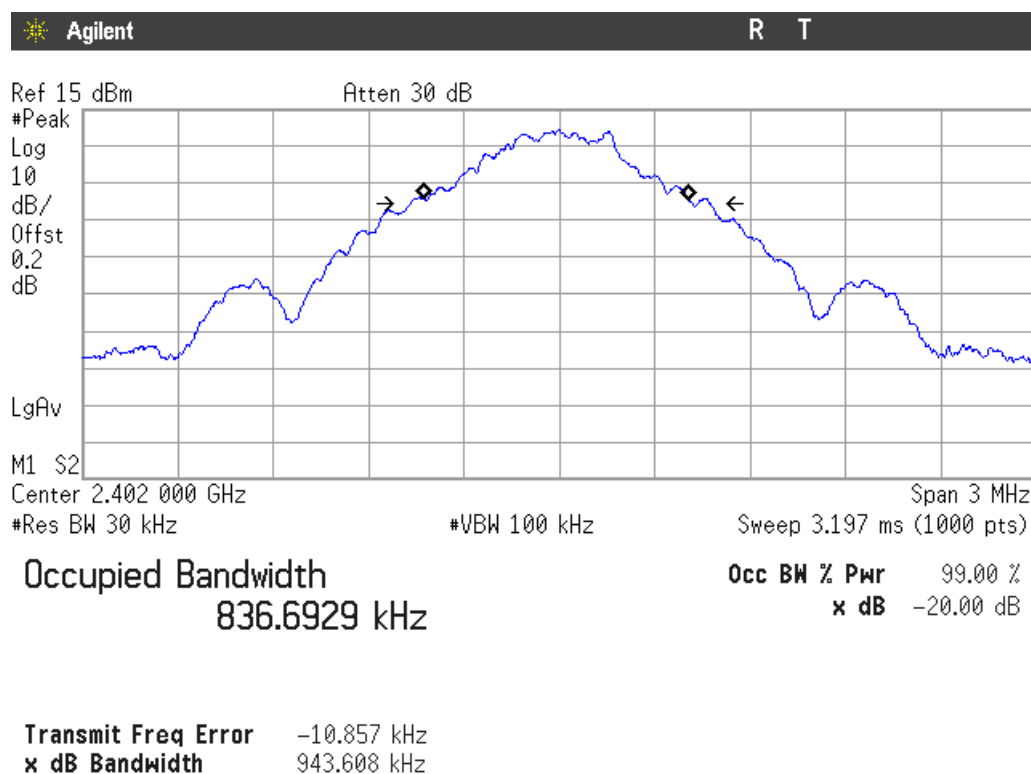
Modulation: 8-DPSK (3Mbps)

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
20 dB Spectrum bandwidth (kHz)	1291	1293	1294
Measurement uncertainty (kHz)	<±5.00		

Modulation: GFSK

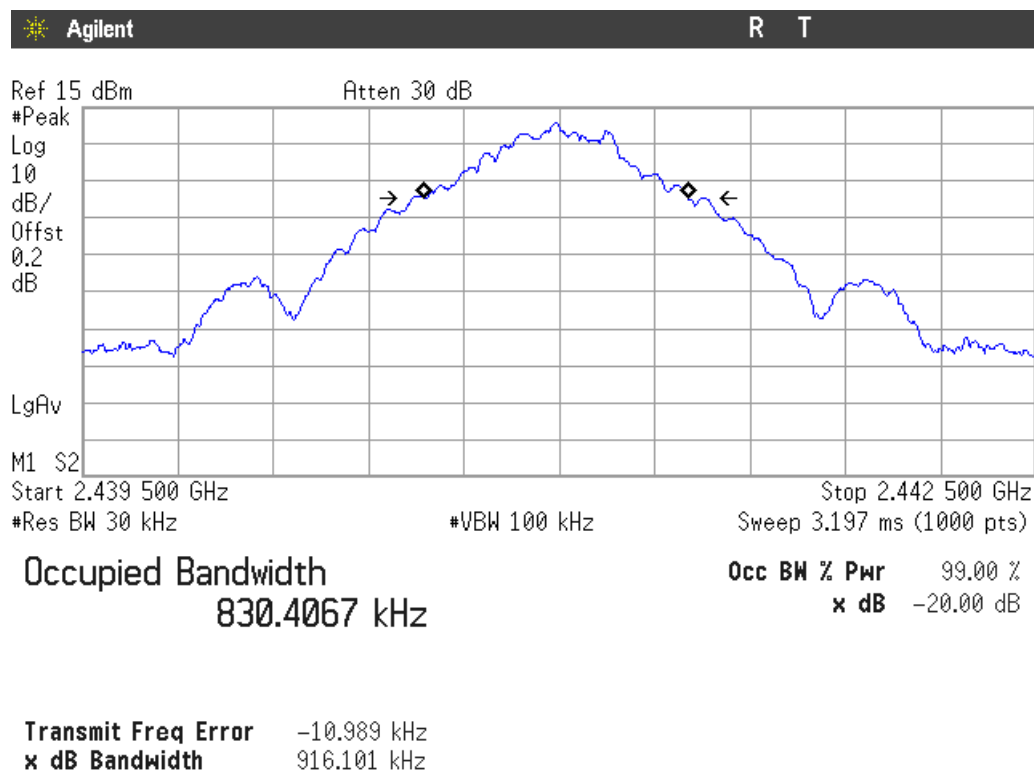
20 dB BANDWIDTH.

Lowest Channel: 2402 MHz.



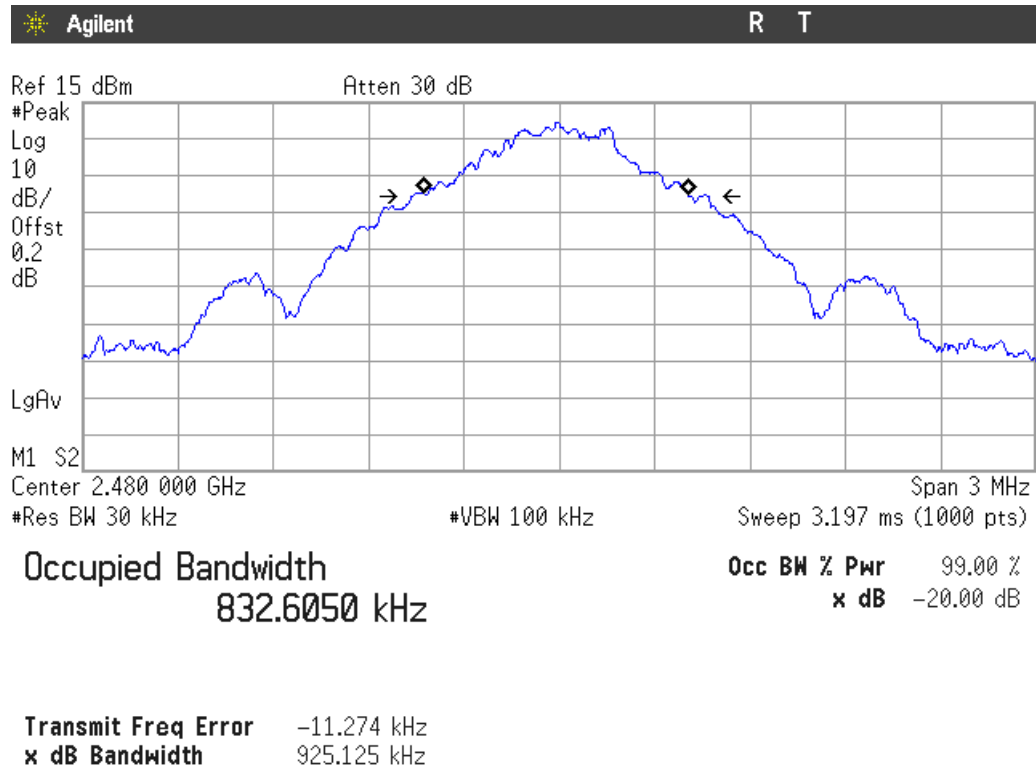
20 dB BANDWIDTH

Middle Channel: 2441 MHz.

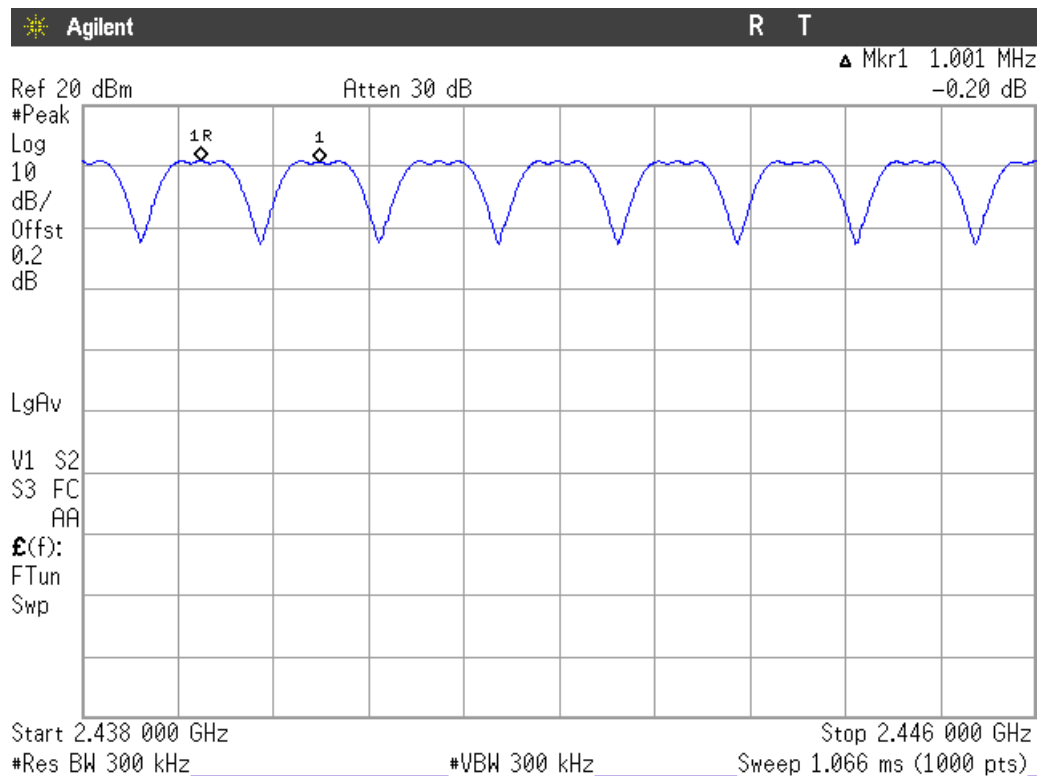


20 dB BANDWIDTH

Highest Channel: 2480 MHz.



Carrier frequency separation



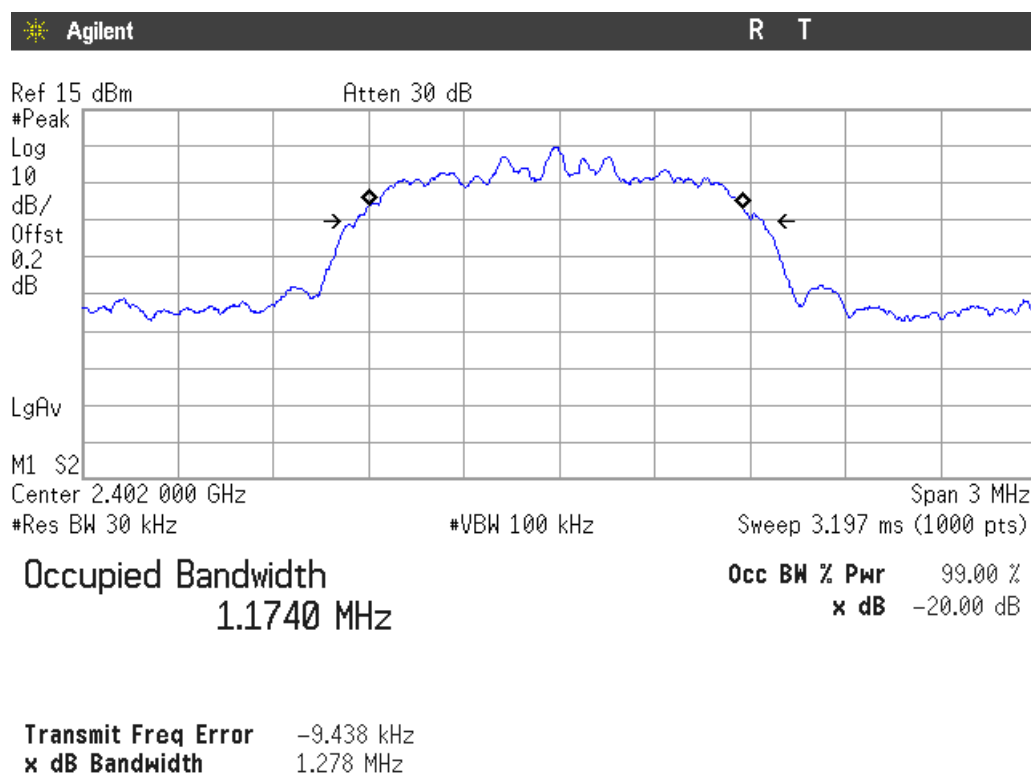
The hopping channel carrier frequencies are separated by a minimum of the 20 dB bandwidth of the hopping channel.

Verdict: PASS

Modulation: $\Pi/4$ -DQPSK

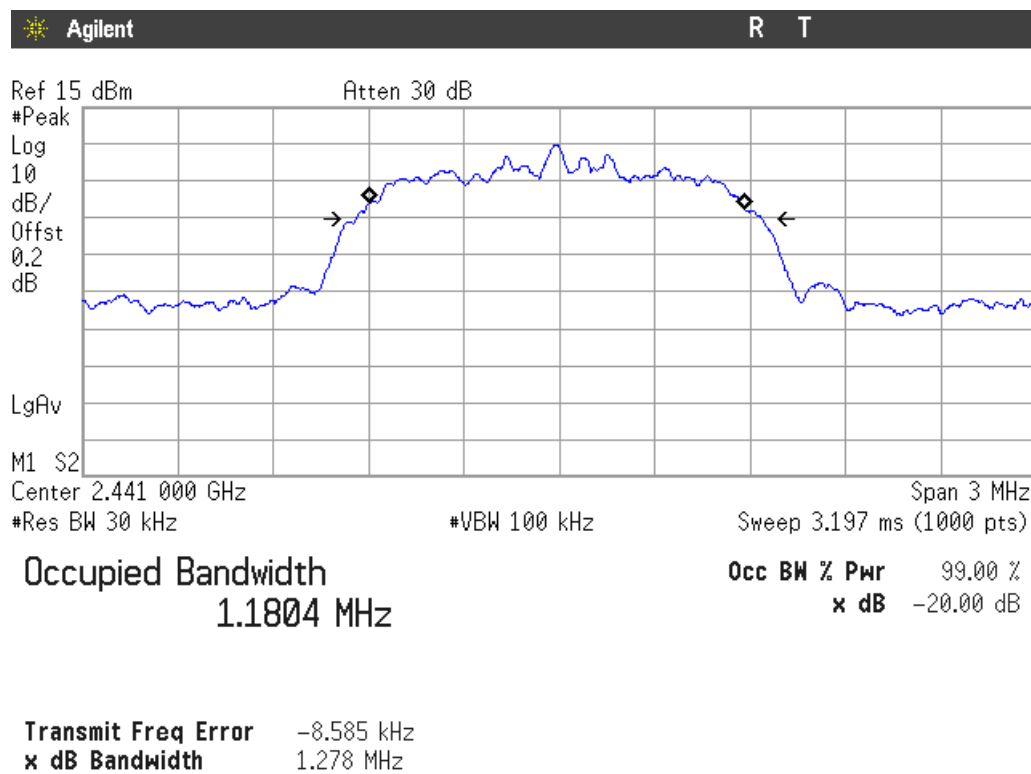
20 dB BANDWIDTH.

Lowest Channel: 2402 MHz.



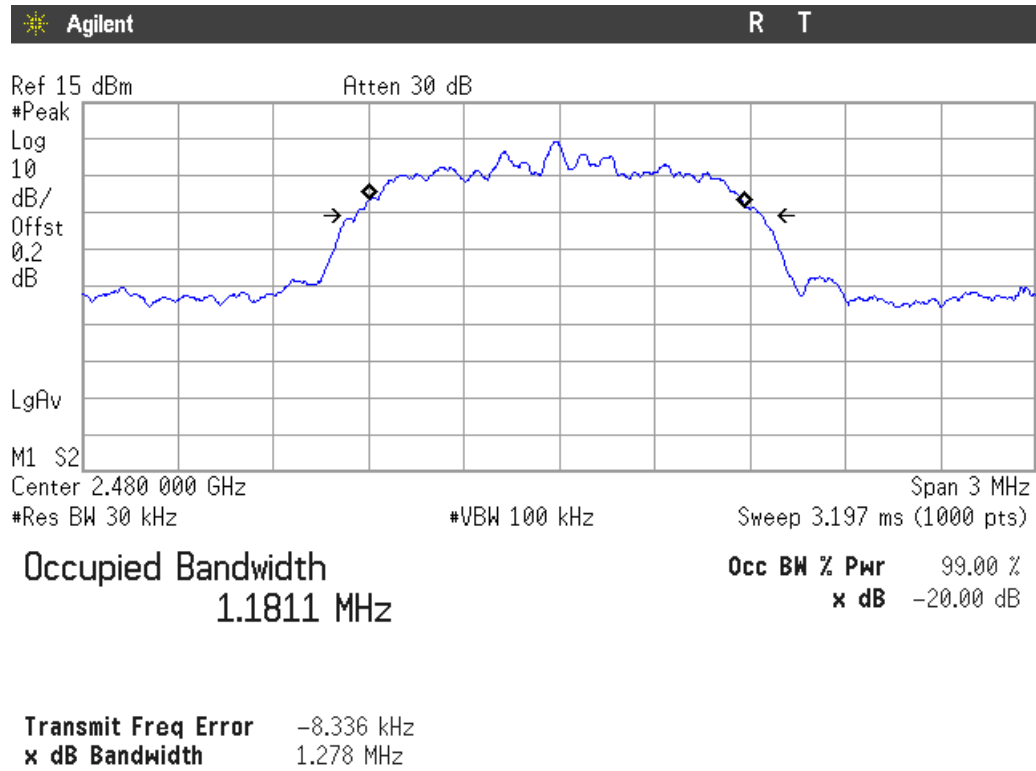
20 dB BANDWIDTH

Middle Channel: 2441 MHz.

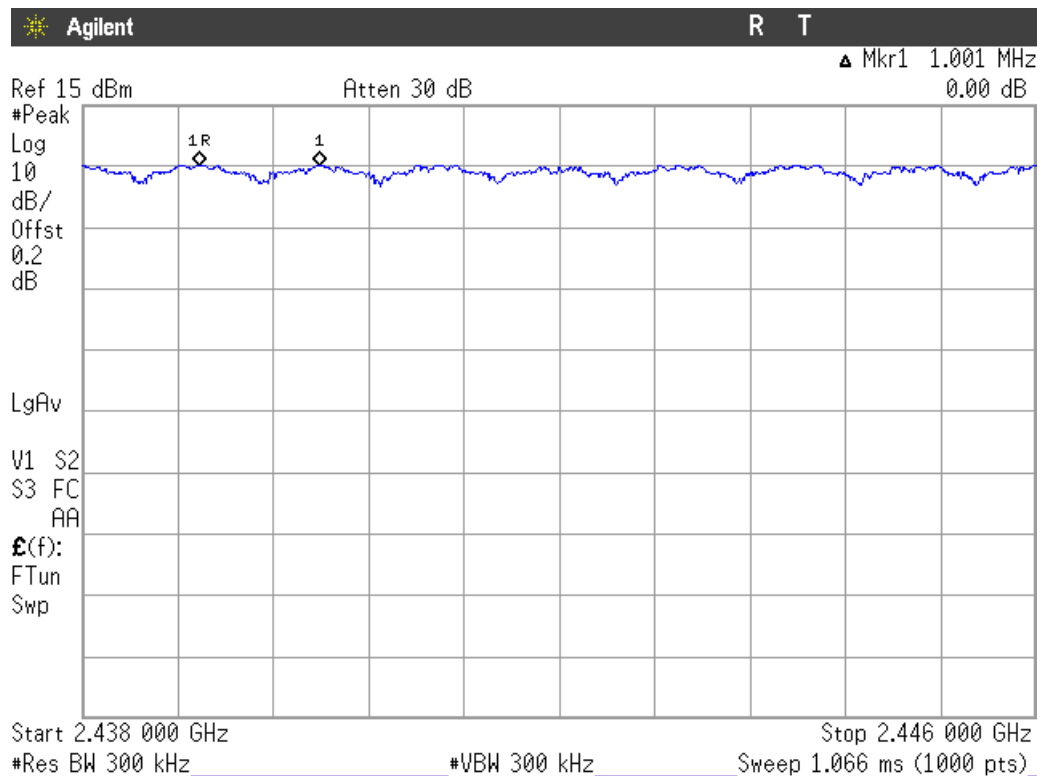


20 dB BANDWIDTH

Highest Channel: 2480 MHz.



Carrier frequency separation



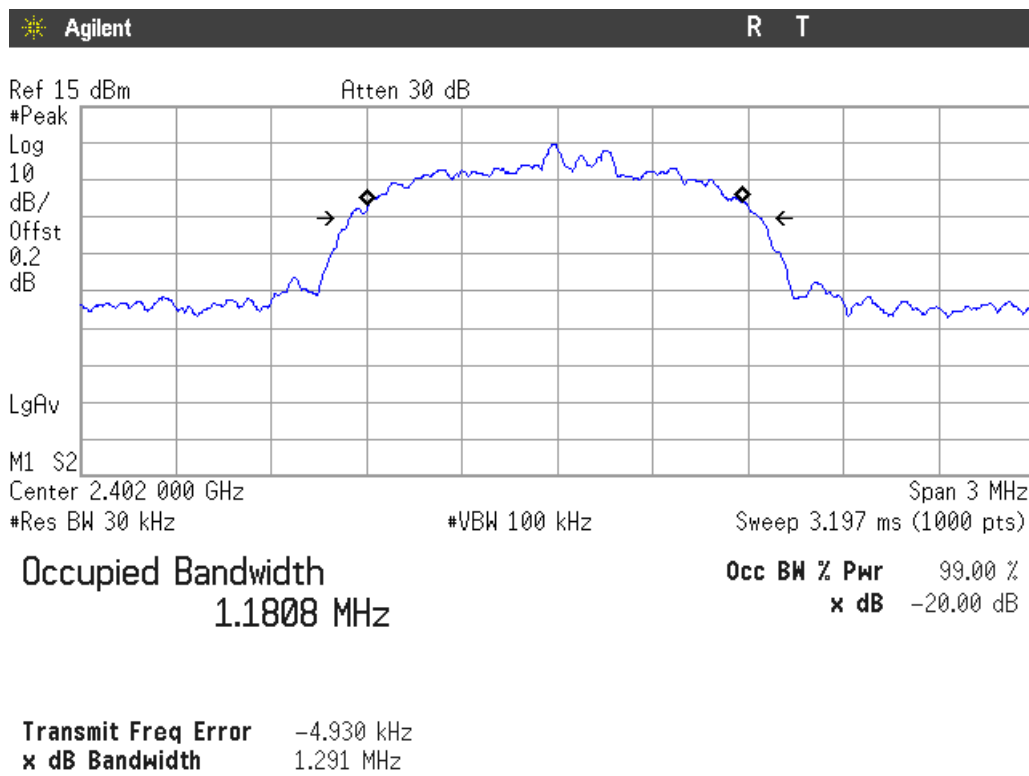
The hopping channel carrier frequencies are separated by a minimum of the two-thirds of the 20 dB bandwidth of the hopping channel

Verdict: PASS

Modulation: 8-DPSK

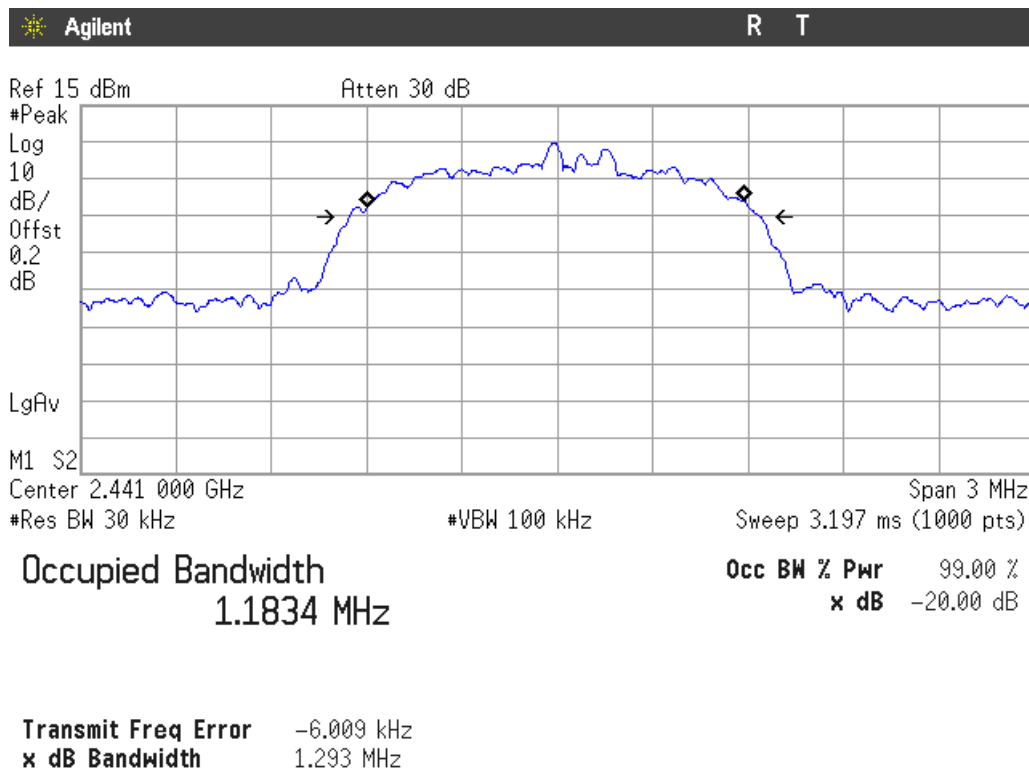
20 dB BANDWIDTH

Lowest Channel: 2402 MHz.



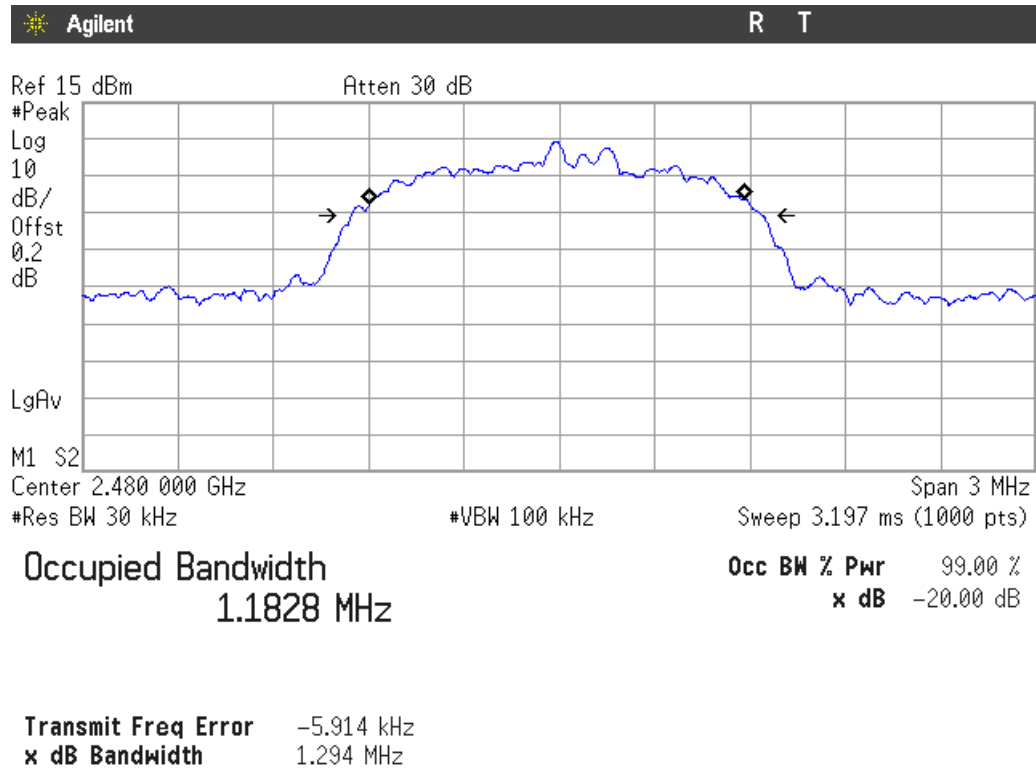
20 dB BANDWIDTH

Middle Channel: 2441 MHz.

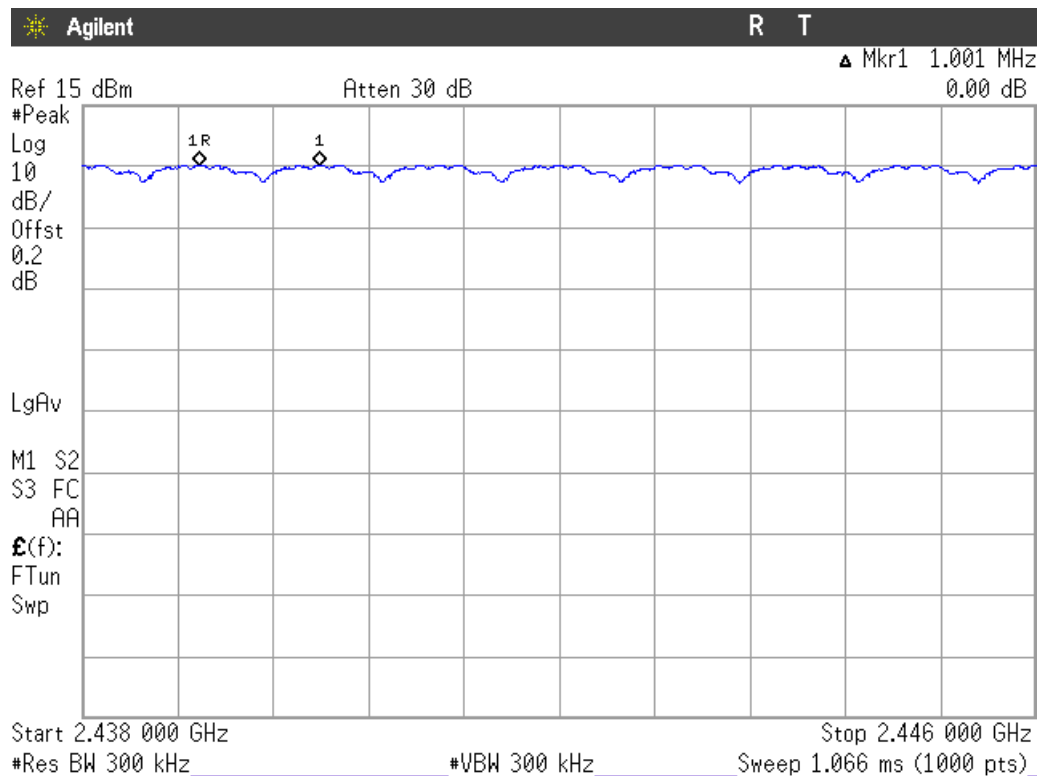


20 dB BANDWIDTH

Highest Channel: 2480 MHz.



Carrier frequency separation



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). Number of hopping channels

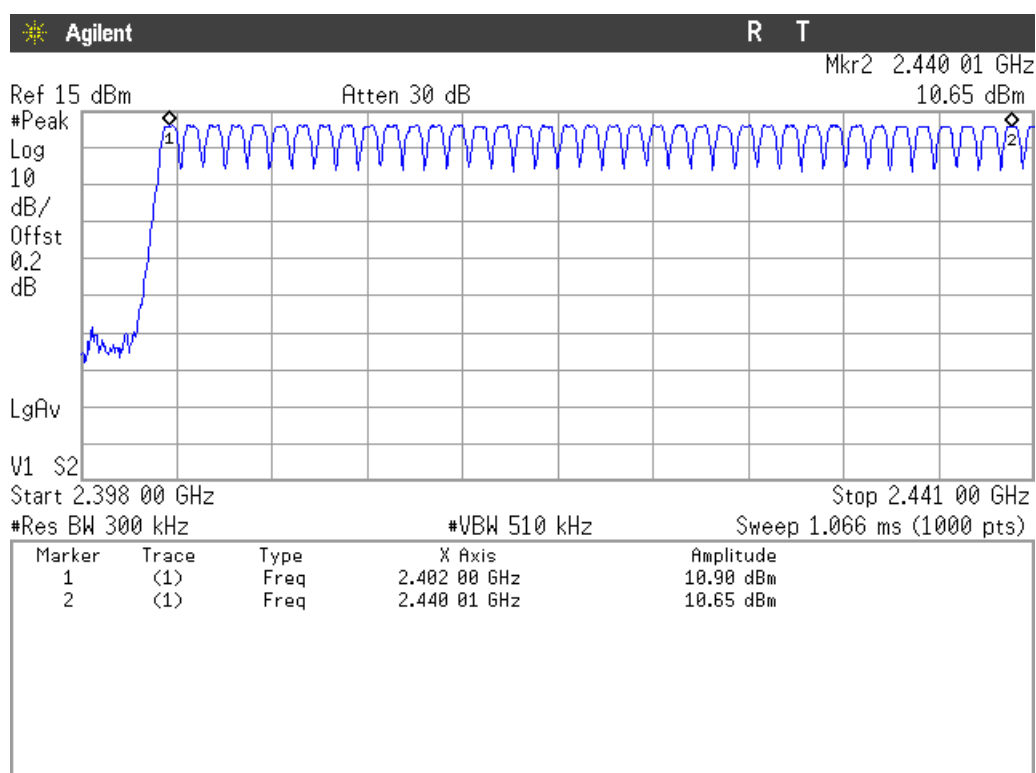
SPECIFICATION

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

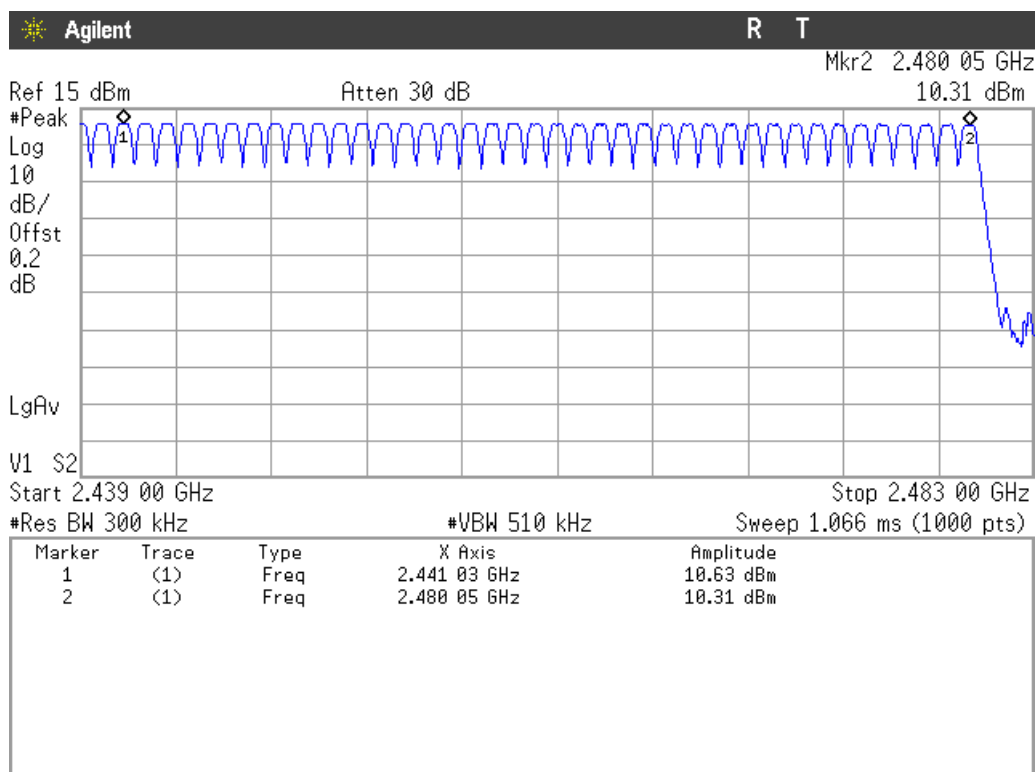
RESULTS

The number of hopping channels is 79 for all three modes (see next plots).

Modulation: GFSK



Number of hopping frequencies: 39

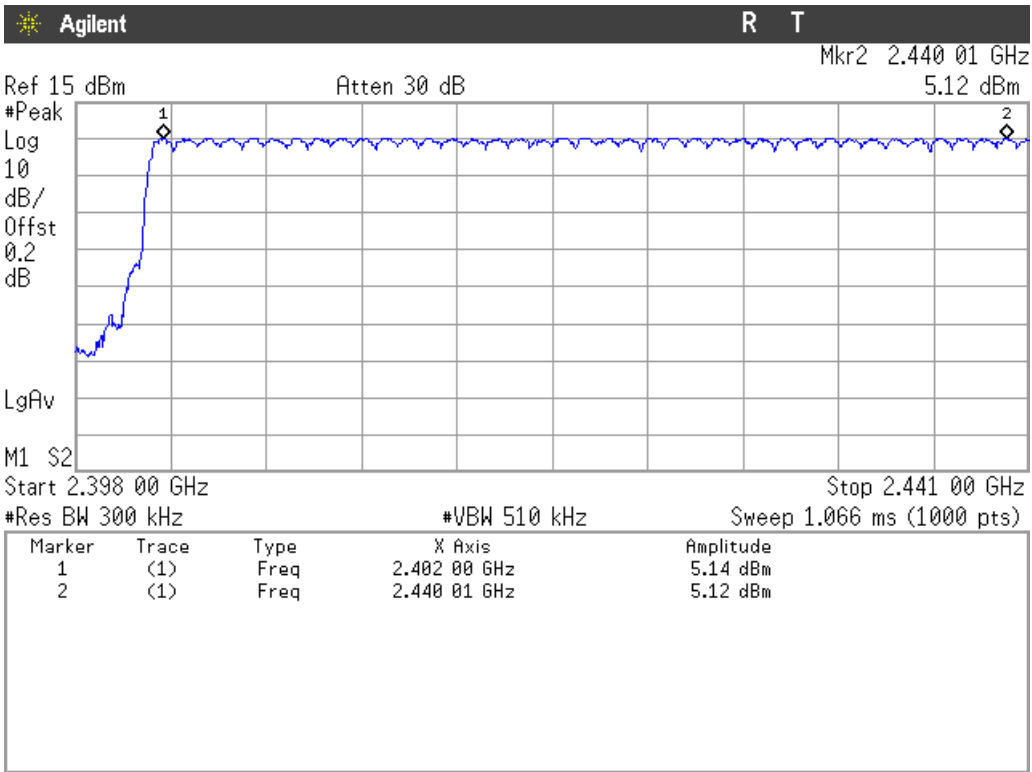


Number of hopping frequencies: 40

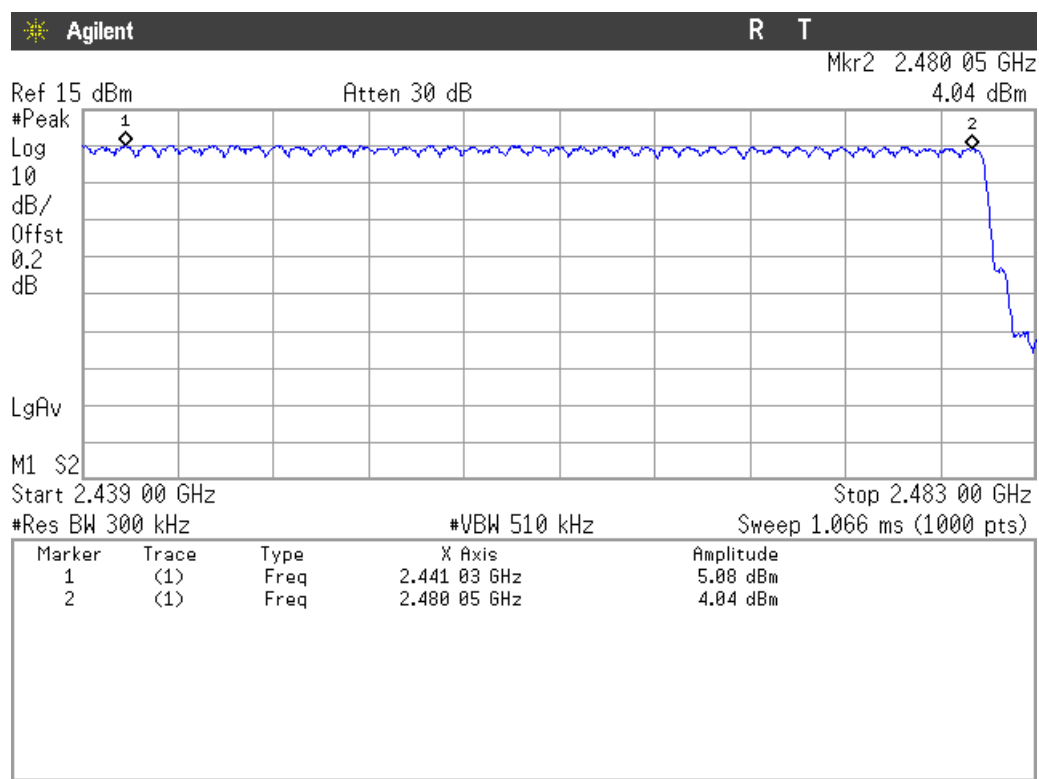
Total number of hopping frequencies: 79

Verdict: PASS

Modulation: $\Pi/4$ -DQPSK



Number of hopping frequencies: 39

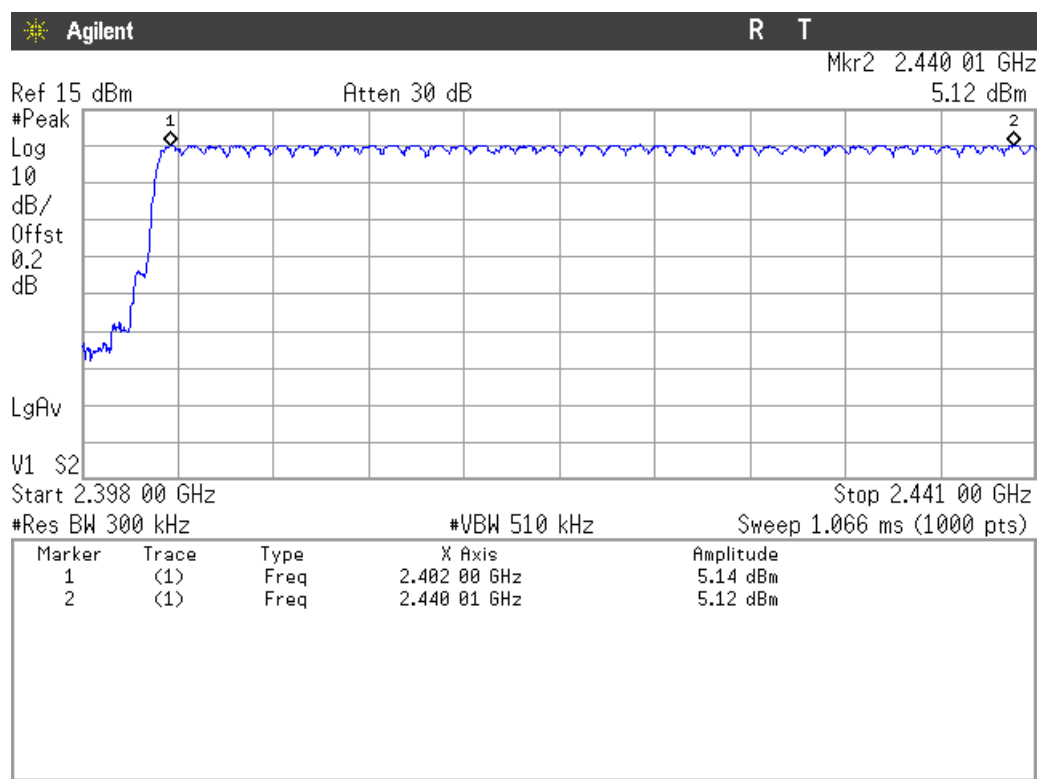


Number of hopping frequencies: 40

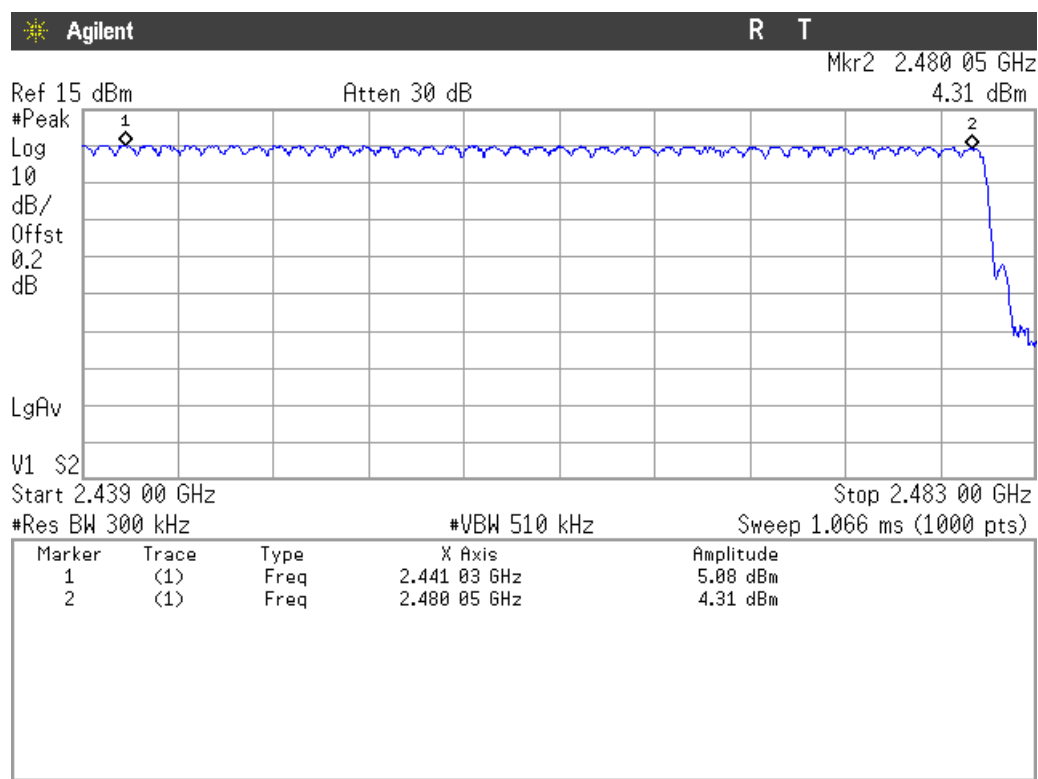
Total number of hopping frequencies: 79

Verdict: PASS

Modulation: 8-DPSK



Number of hopping frequencies: 39



Number of hopping frequencies: 40

Total number of hopping frequencies: 79

Verdict: PASS

FCC Section 15.247 Subclause (a) (1) (iii). Time of occupancy (Dwell Time)

SPECIFICATION

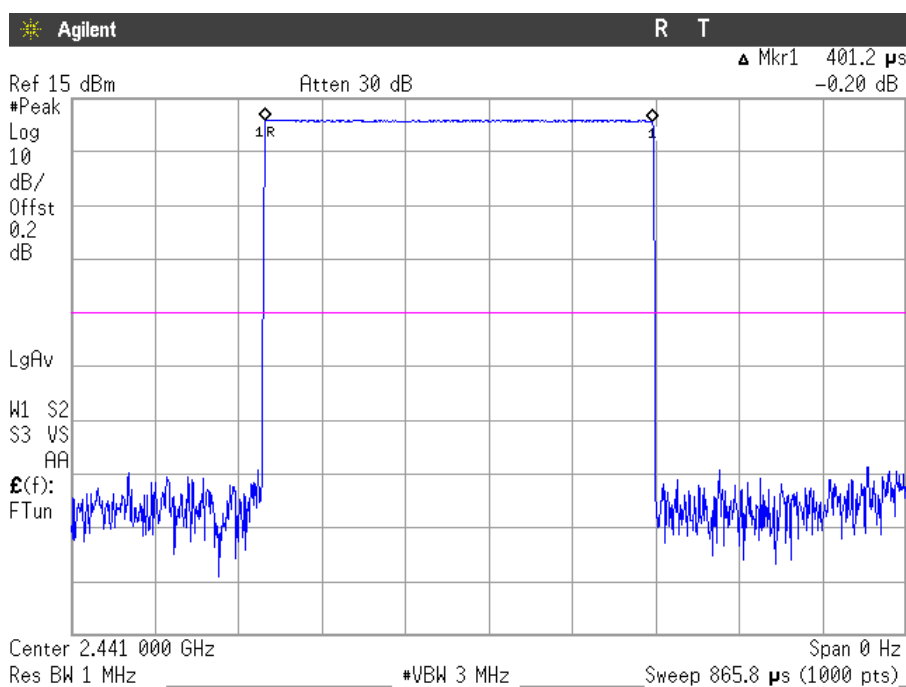
The average time of occupancy on any channel shall not be greater than 0.4 seconds (400 ms) within a period of 0.4 seconds multiplied by the number of hopping channels employed = $0.4 \times 79 = 31.6$ seconds.

RESULTS

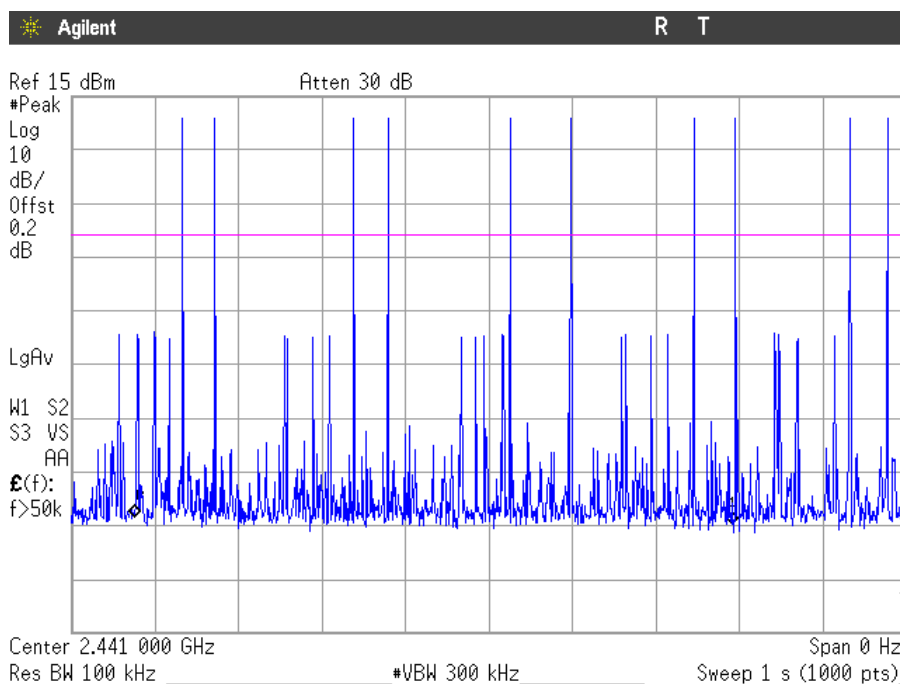
Modulation: GFSK

1. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE DH1.

- Tx- time per hop = 401.2 μ s (see next plot).



- Number of hops over a period of 1 second = 10 (see next plot).



Number of hops in the period specified in the requirements = (10 hops) x (31.6 s / 1 s) = 316 hops.

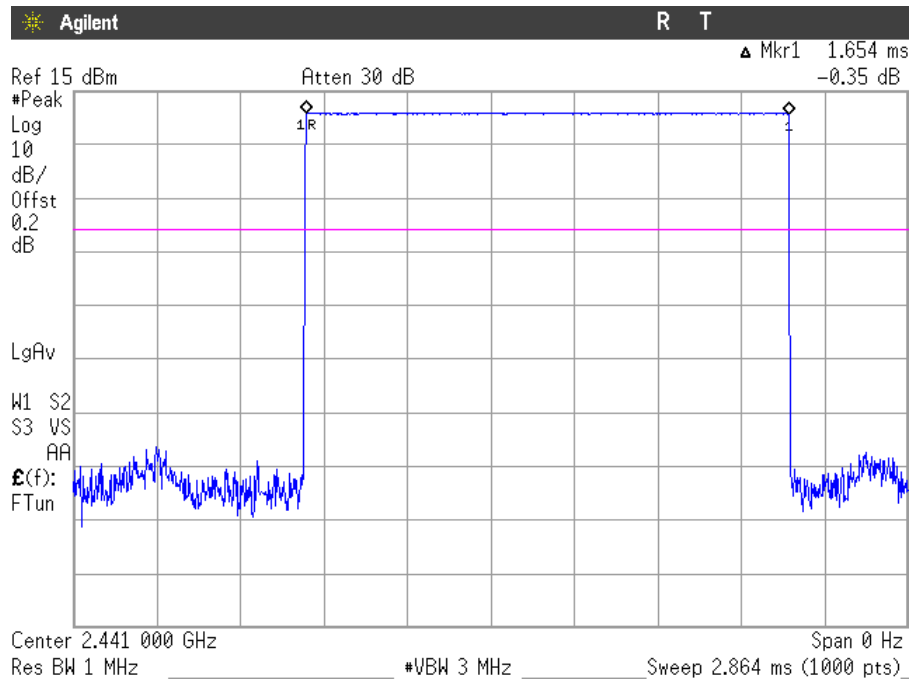
Averaging time of occupancy = 401.2 μ s x 316 hops = 126.78 ms per 31.6 seconds.

Measurement uncertainty (%)	< $\pm$ 0.01
-----------------------------	--------------

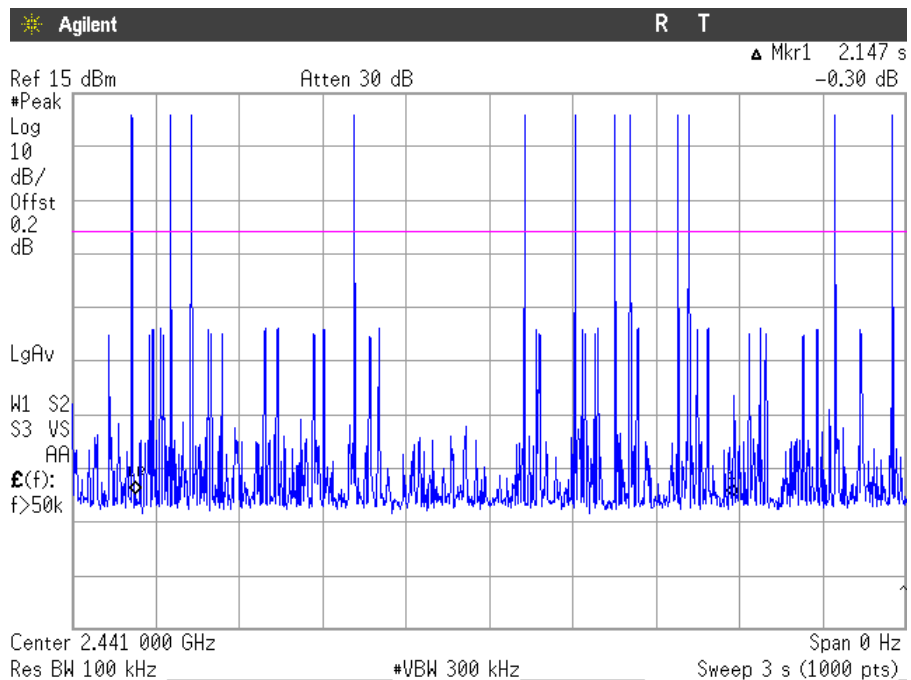
Verdict: PASS

2. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE DH3.

- Tx-time per hop = 1.654 ms (see next plot).



- Number of hops over a period of 3 seconds = 12 (see next plot).



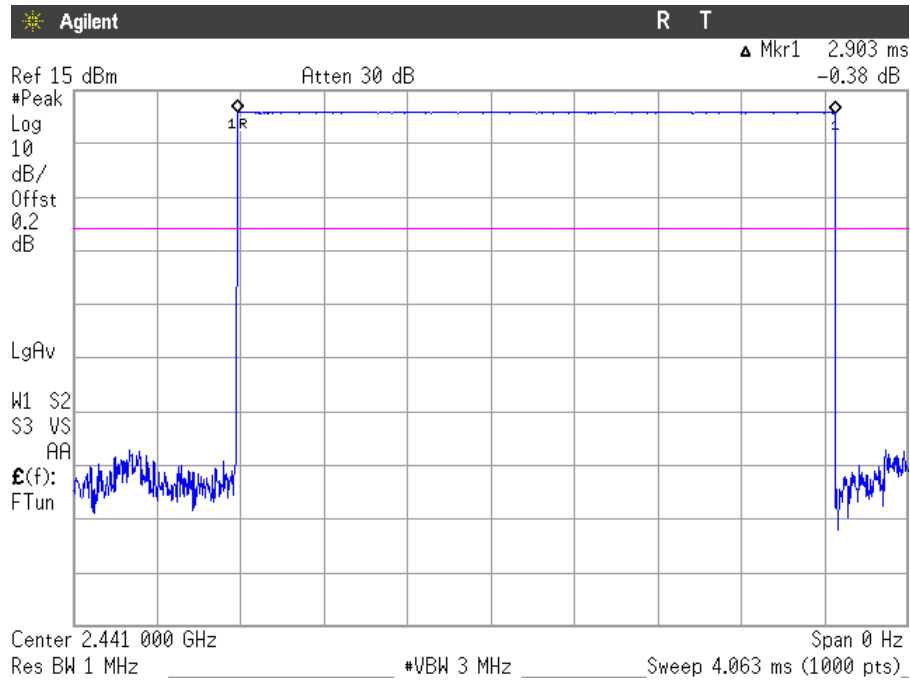
Number of hops in the period specified in the requirements = (12 hops) x (31.6 s / 3 s) = 126.4 hops.
Averaging time of occupancy = 1.654 ms x 126.4 hops = 209.06 ms per 31.6 seconds.

Measurement uncertainty (%)	<±0.01
-----------------------------	--------

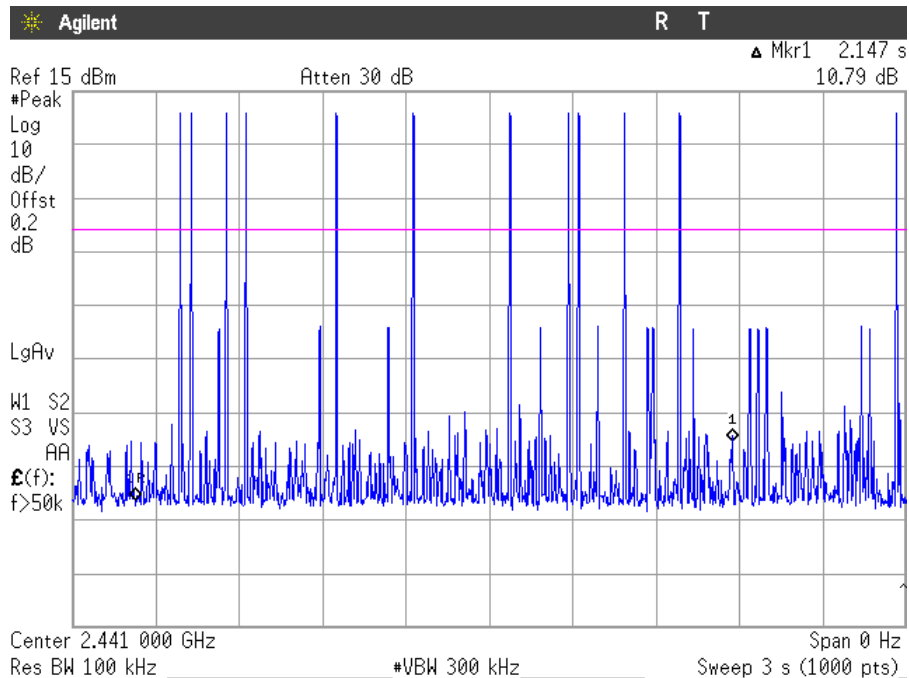
Verdict: PASS

3. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE DH5.

- Tx- time per hop = 2.903 ms (see next plot).



- Number of hops over a period of 3 seconds = 12 (see next plot).



Number of hops in the period specified in the requirements = (12 hops) x (31.6 s / 3 s) = 126.4 hops.
Averaging time of occupancy = 2.903 ms x 126.4 hops = 366.94 ms per 31.6 seconds.

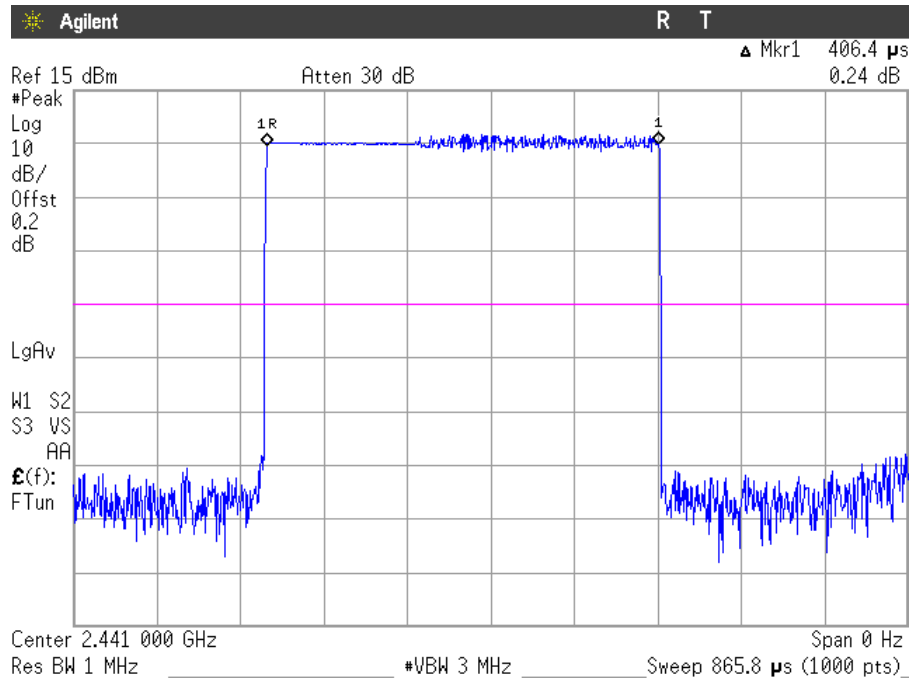
Measurement uncertainty (%)	<±0.01
-----------------------------	--------

Verdict: PASS

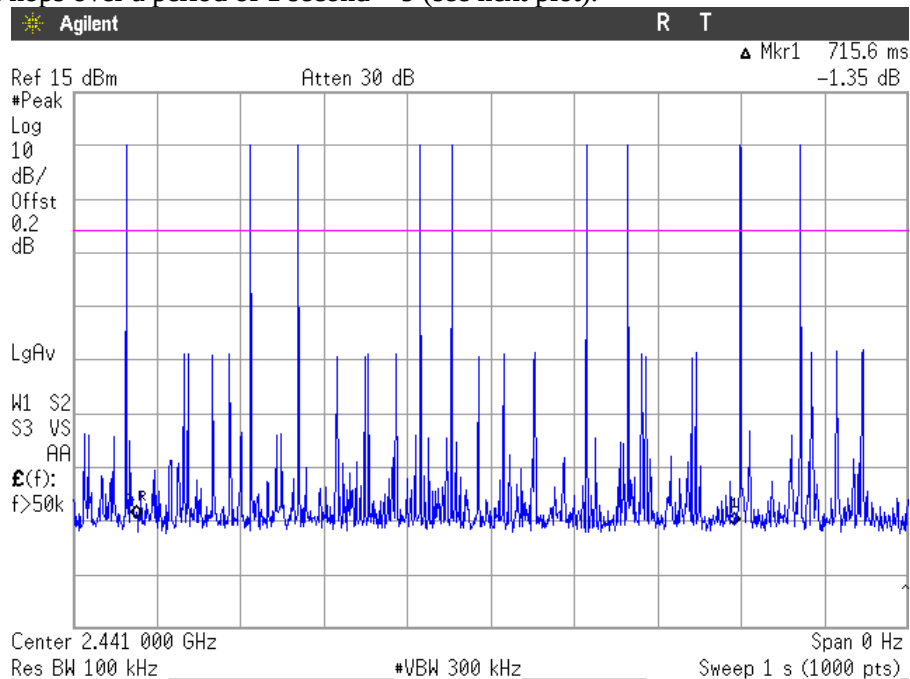
Modulation: $\Pi/4$ -DQPSK

1. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE 2-DH1.

- Tx- time per hop = 406.4 μ s (see next plot).



- Number of hops over a period of 1 second = 9 (see next plot).



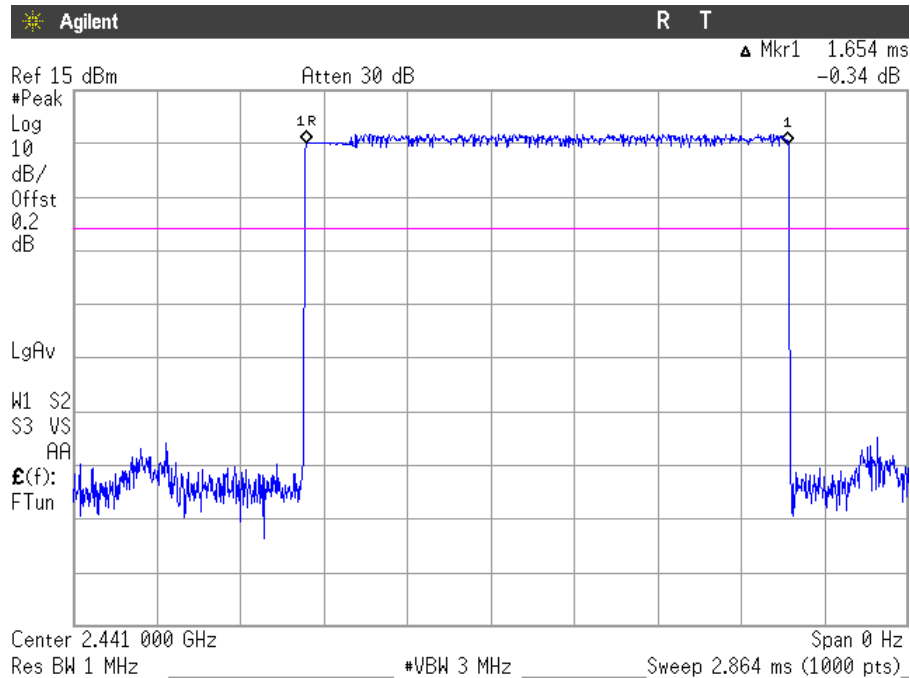
Number of hops in the period specified in the requirements = (9 hops) x (31.6 s / 1 s) = 284.4 hops.
Averaging time of occupancy = 406.4 μ s x 284.4 hops = 115.58 ms per 31.6 seconds.

Measurement uncertainty (%)	< $\pm$ 0.01
-----------------------------	--------------

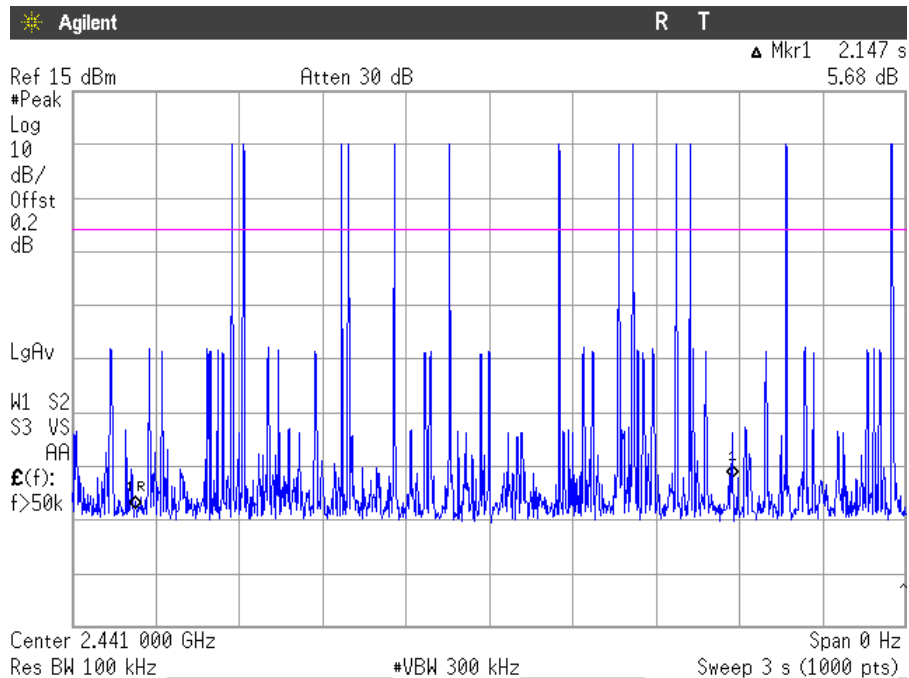
Verdict: PASS

2. TIME OF OCCUPANCY (DWEELL TIME) FOR PACKET TYPE 2-DH3.

- Tx- time per hop = 1.654 ms (see next plot).



- Number of hops over a period of 3 seconds = 13(see next plot).



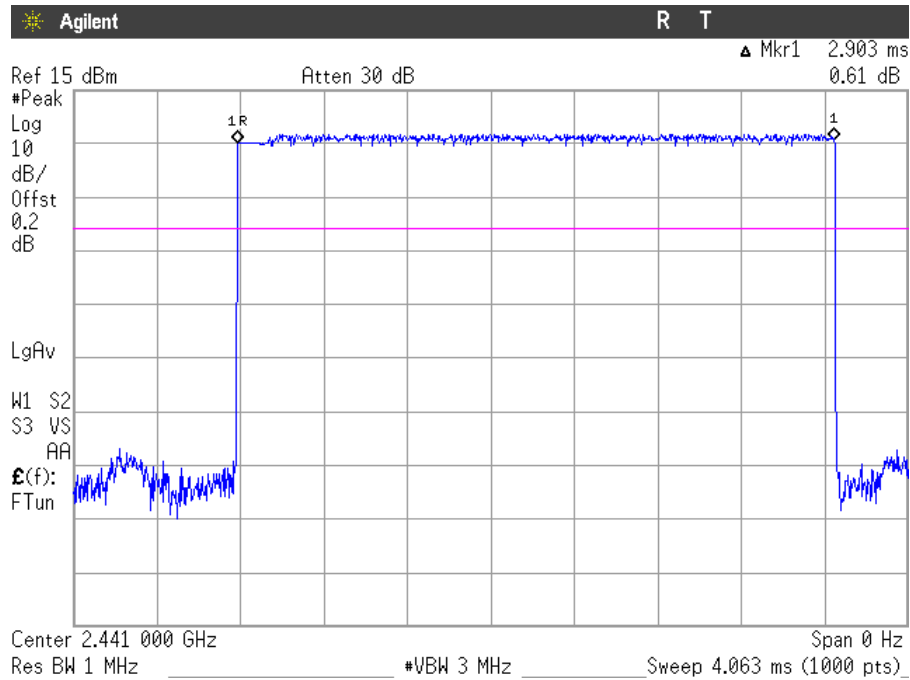
Number of hops in the period specified in the requirements = (13 hops) x (31.6 s / 3 s) = 136.93 hops.
Averaging time of occupancy = 1.654 ms x 136.93 hops = 226.49 ms per 31.6 seconds.

Measurement uncertainty (%)	<±0.01
-----------------------------	--------

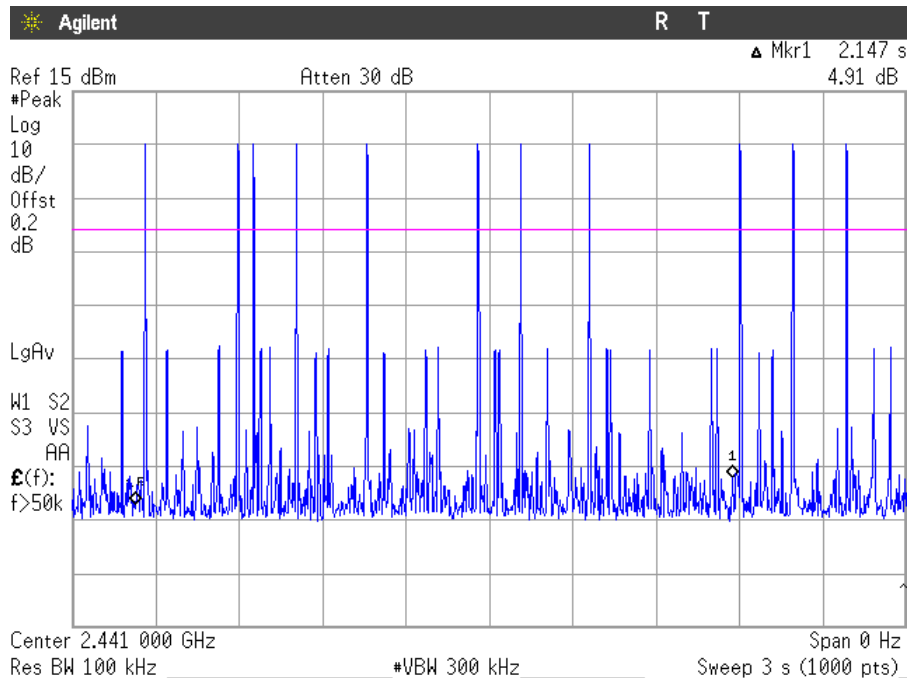
Verdict: PASS

3. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE 2-DH5.

- Tx- time per hop = 2.903 ms (see next plot).



- Number of hops over a period of 3 seconds = 11 (see next plot).



Number of hops in the period specified in the requirements = (11 hops) x (31.6 s / 3 s) = 115.87 hops.
Averaging time of occupancy = 2.903 ms x 115.87 hops = 336.36 ms per 31.6 seconds.

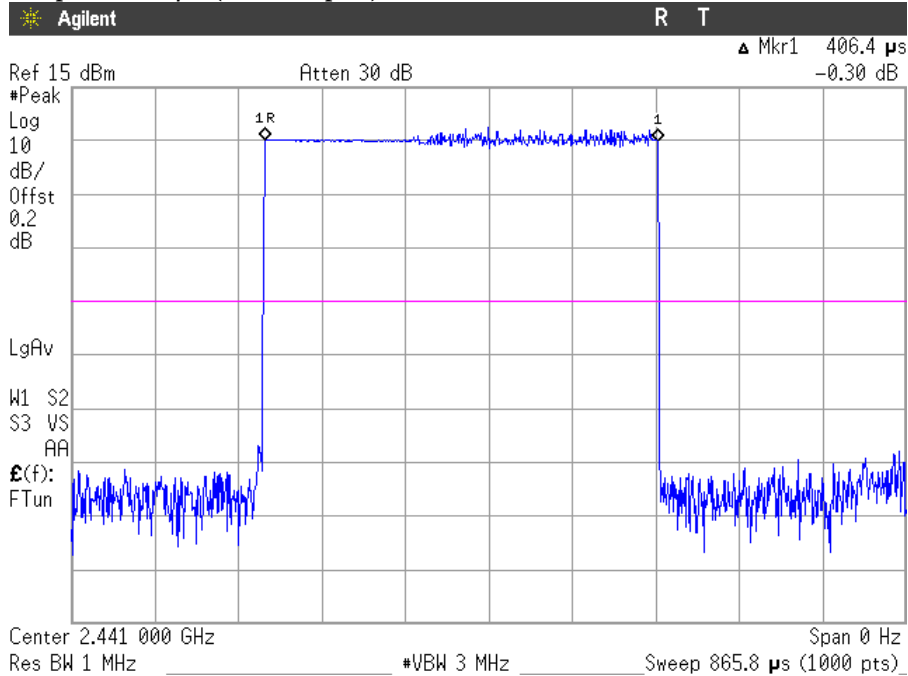
Measurement uncertainty (%)	<±0.01
-----------------------------	--------

Verdict: PASS

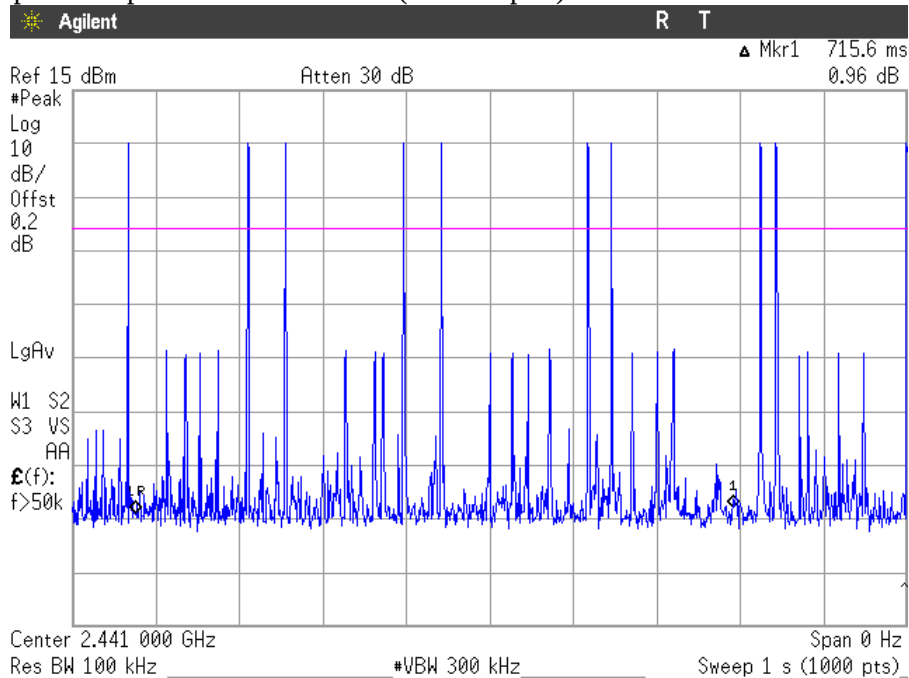
Modulation: 8-DPSK

1. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE 3-DH1.

- Tx-time per hop = 406.4 μ s (see next plot).



- Number of hops over a period of 1 second = 9 (see next plot).



Number of hops in the period specified in the requirements = (9 hops) x (31.6 s / 1 s) = 284.4 hops.
Averaging time of occupancy = 406.4 μ s x 284.4 hops = 115.58 ms per 31.6 seconds.

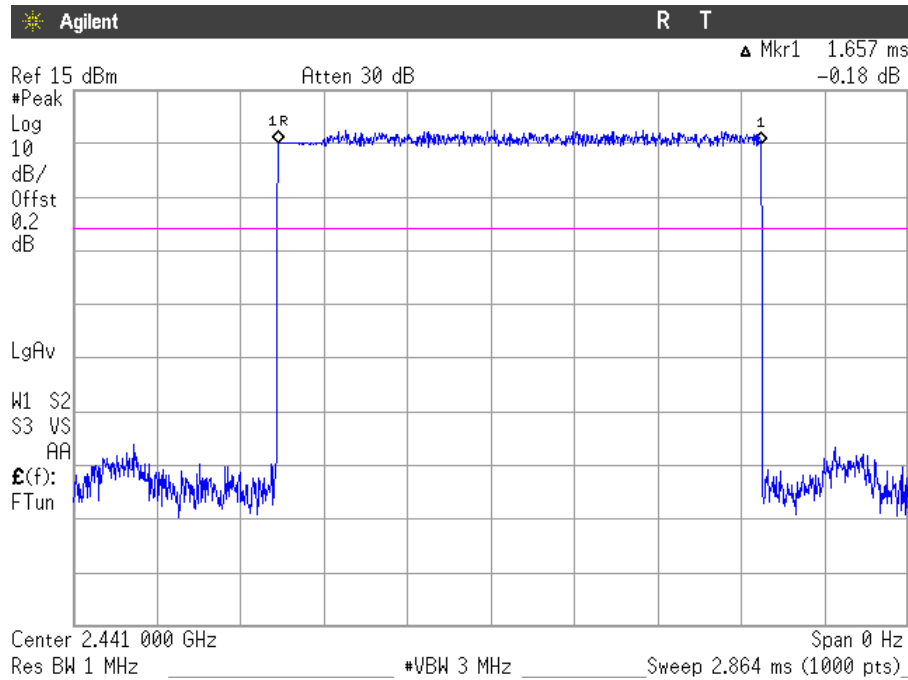
Measurement uncertainty (%)

< $\pm$ 0.01

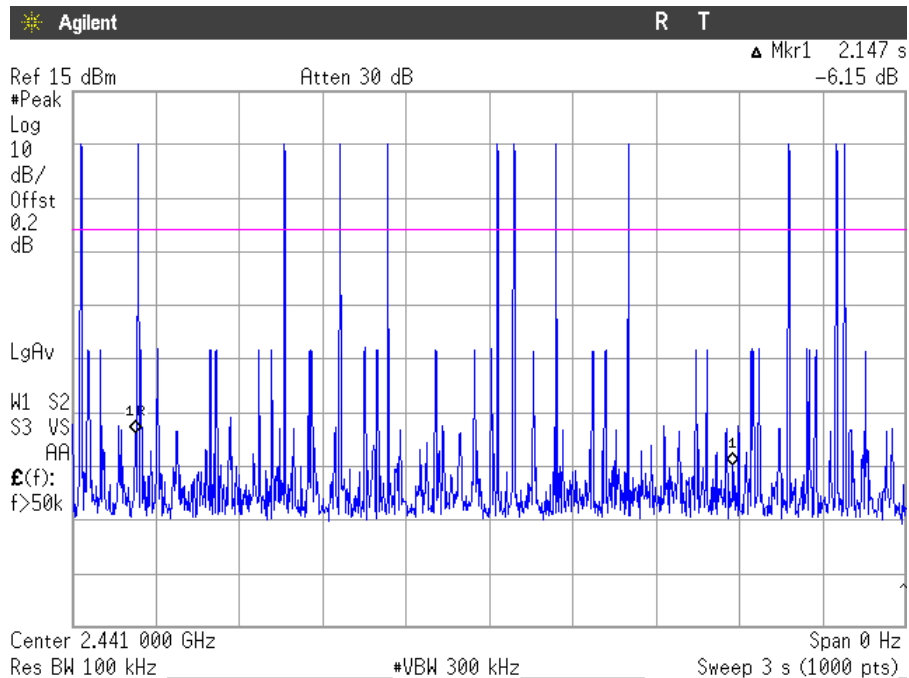
Verdict: PASS

2. TIME OF OCCUPANCY (DWEELL TIME) FOR PACKET TYPE 3-DH3.

- Tx- time per hop = 1.657 ms (see next plot).



- Number of hops over a period of 3 seconds = 12 (see next plot).



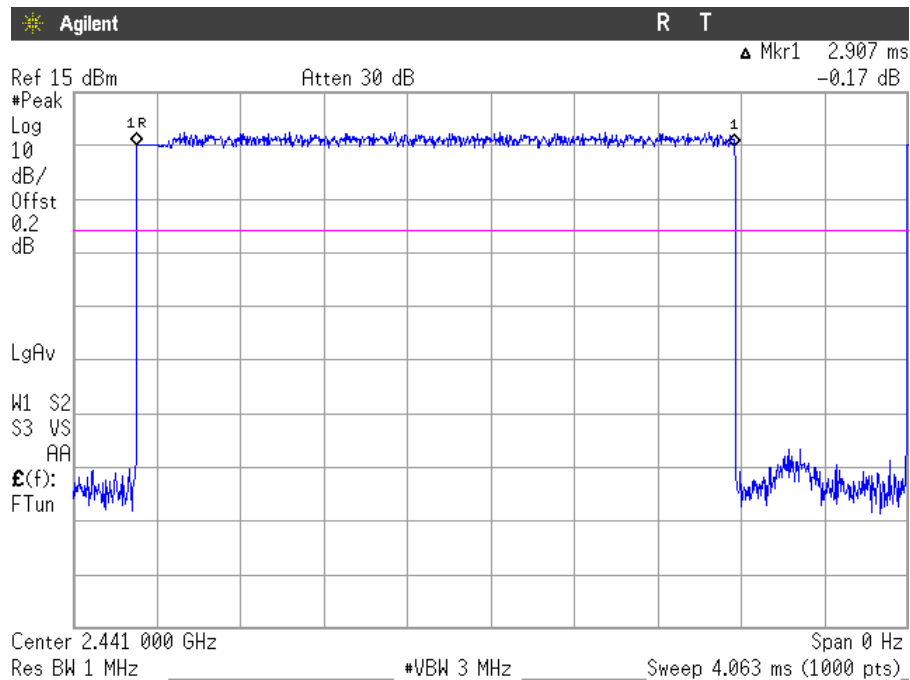
Number of hops in the period specified in the requirements = (12 hops) x (31.6 s / 3 s) = 126.4 hops.
Averaging time of occupancy = 1.657 ms x 126.4 hops = 209.44 ms per 31.6 seconds.

Measurement uncertainty (%)	<±0.01
-----------------------------	--------

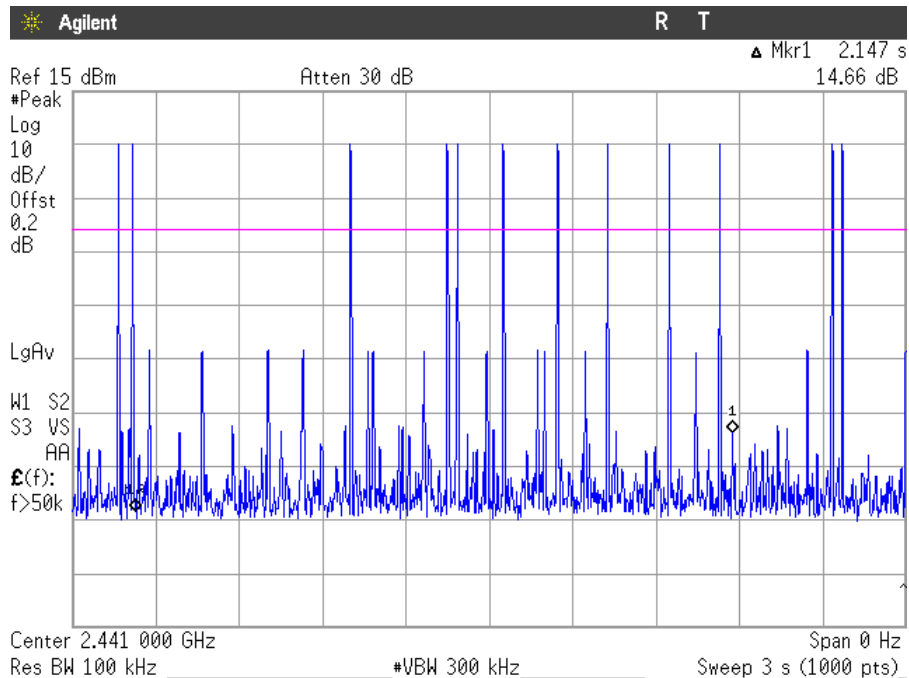
Verdict: PASS

3. TIME OF OCCUPANCY (DWELL TIME) FOR PACKET TYPE 3-DH5.

- Tx- time per hop = 2.907 ms (see next plot).



- Number of hops over a period of 3 seconds = 12 (see next plot).



Number of hops in the period specified in the requirements = (12 hops) x (31.6 s / 3 s) = 126.4 hops.
Averaging time of occupancy = 2.907 ms x 126.4 hops = 367.44 ms per 31.6 seconds.

Measurement uncertainty (%)	<±0.01
-----------------------------	--------

Verdict: PASS

FCC Section 15.247 Subclause (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).

MAXIMUM OUTPUT POWER. See next plots.

Declared maximum antenna gain: +3.70 dBi.

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

Modulation: GFSK

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
Maximum peak power (dBm)	11.08	10.85	10.49
Maximum EIRP power (dBm)	14.78	14.55	14.19
Measurement uncertainty (dB)	<±0.78		

Modulation: Π/4-DQPSK (2Mbps)

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
Maximum peak power (dBm)	7.40	7.26	6.77
Maximum EIRP power (dBm)	11.10	10.96	10.47
Measurement uncertainty (dB)	<±0.78		

Modulation: 8-DPSK (3Mbps)

	Lowest frequency 2402 MHz	Middle frequency 2441 MHz	Highest frequency 2480 MHz
Maximum peak power (dBm)	7.99	7.84	7.39
Maximum EIRP power (dBm)	11.69	11.54	11.09
Measurement uncertainty (dB)	<±0.78		

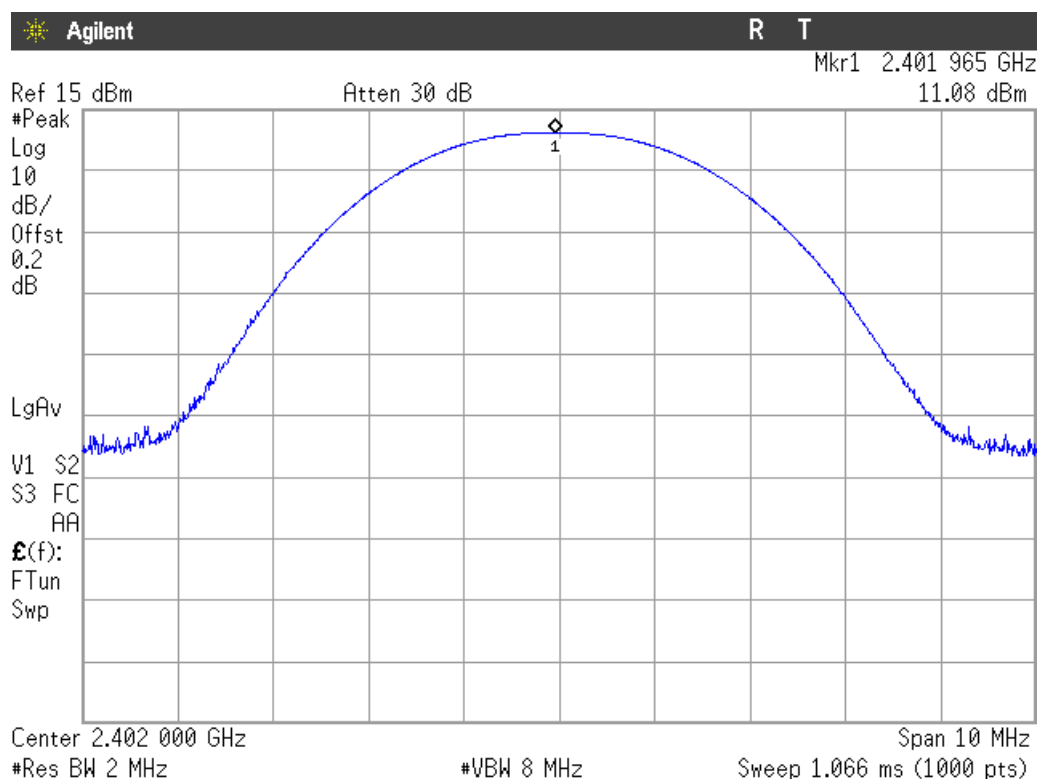
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Verdict: PASS

PEAK OUTPUT POWER (CONDUCTED).

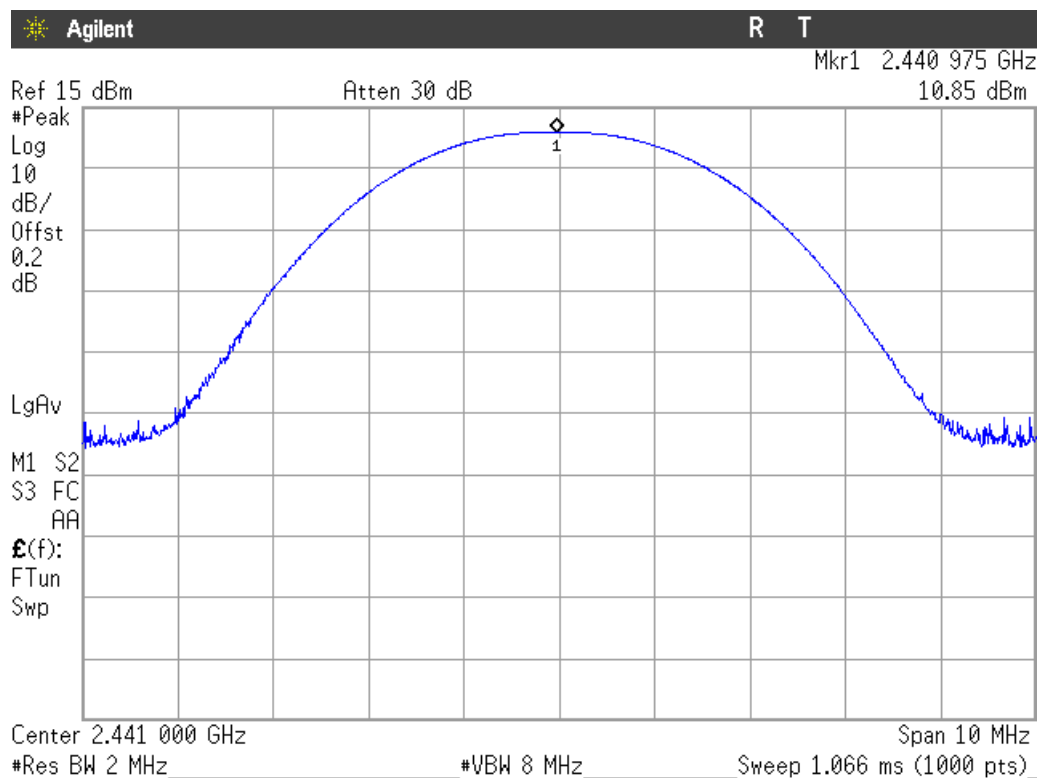
Modulation: GFSK

Lowest Channel: 2402 MHz.



Modulation: GFSK

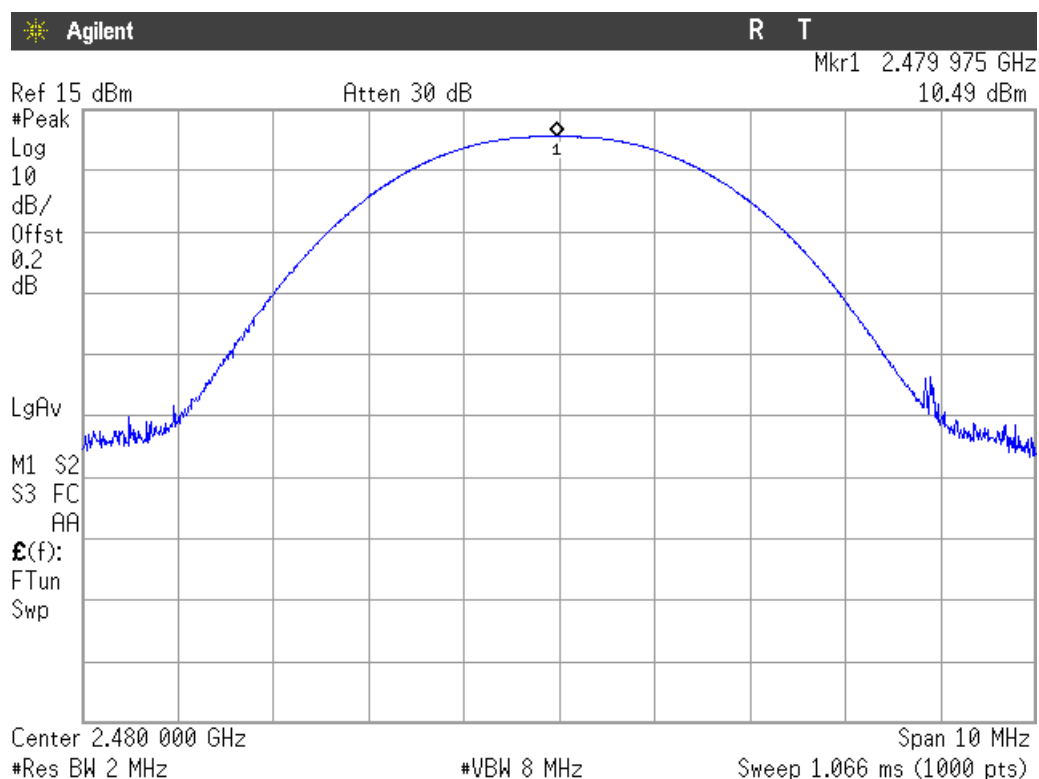
Middle Channel: 2441 MHz.



PEAK OUTPUT POWER (CONDUCTED).

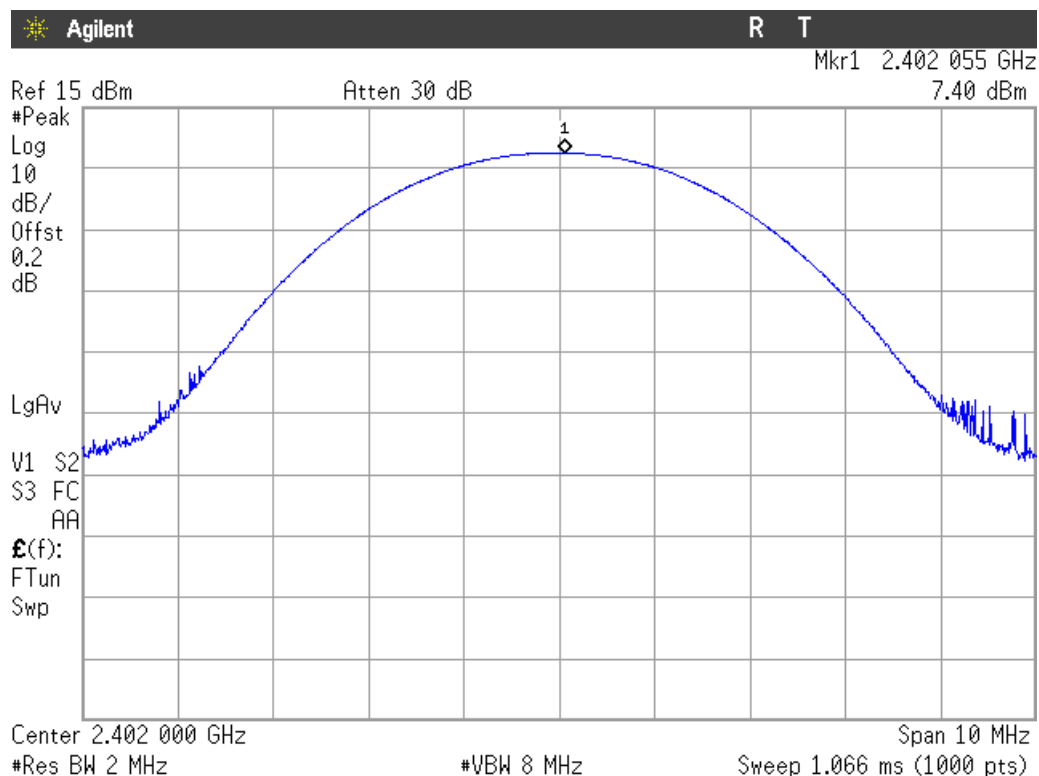
Modulation: GFSK

Highest Channel: 2480 MHz.



Modulation: $\Pi/4$ -DQPSK

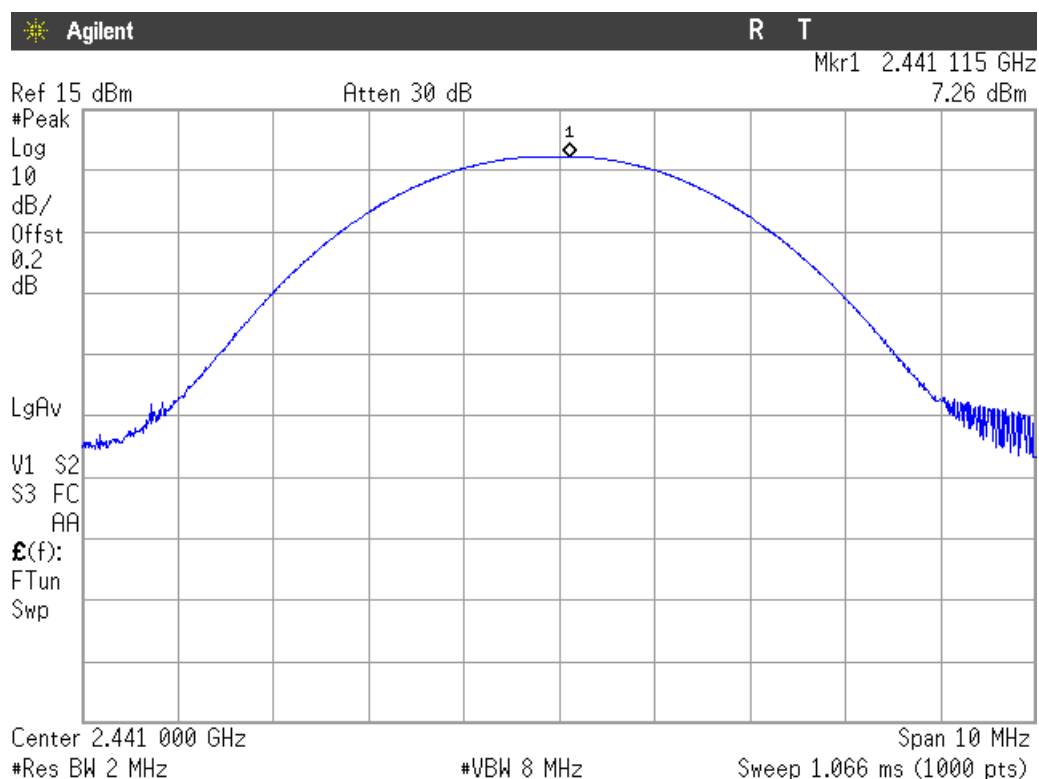
Lowest Channel: 2402 MHz



PEAK OUTPUT POWER (CONDUCTED)

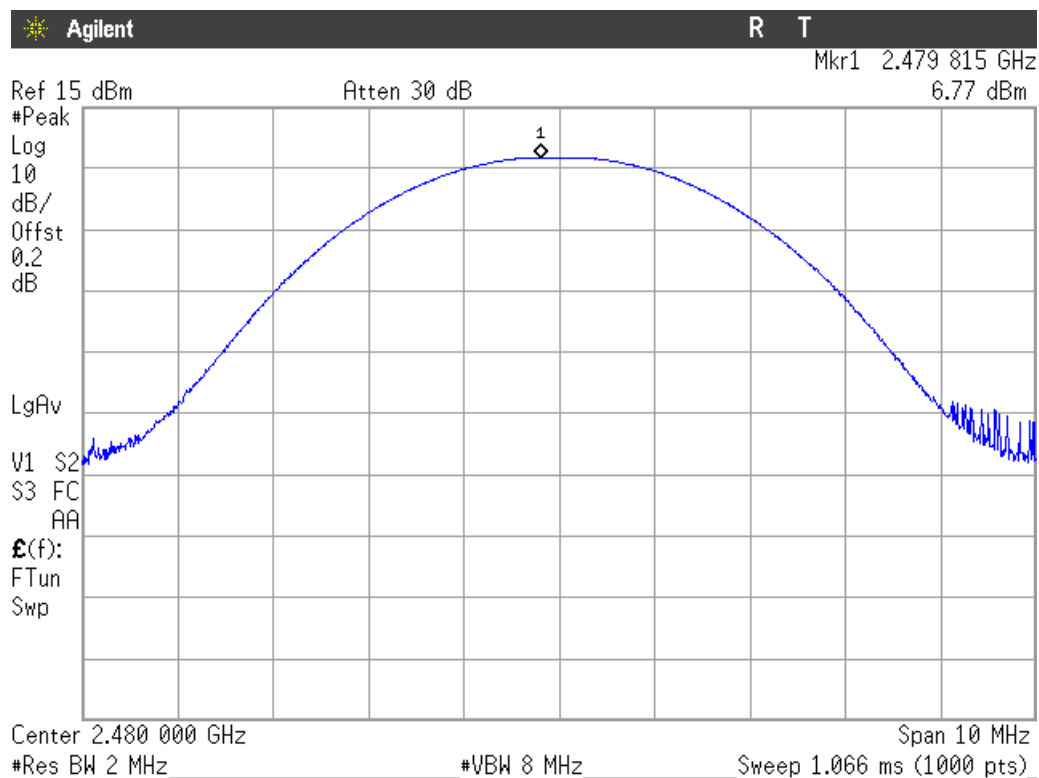
Modulation: $\Pi/4$ -DQPSK

Middle Channel: 2441 MHz.



Modulation: $\Pi/4$ -DQPSK

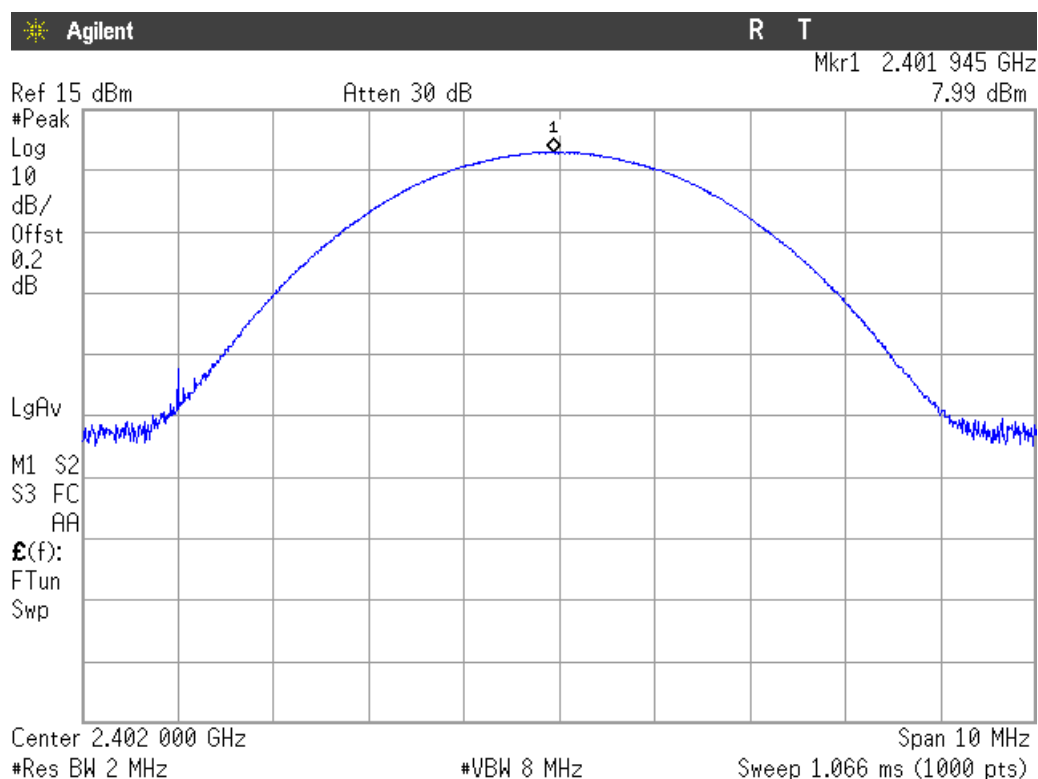
Highest Channel: 2480 MHz.



PEAK OUTPUT POWER (CONDUCTED).

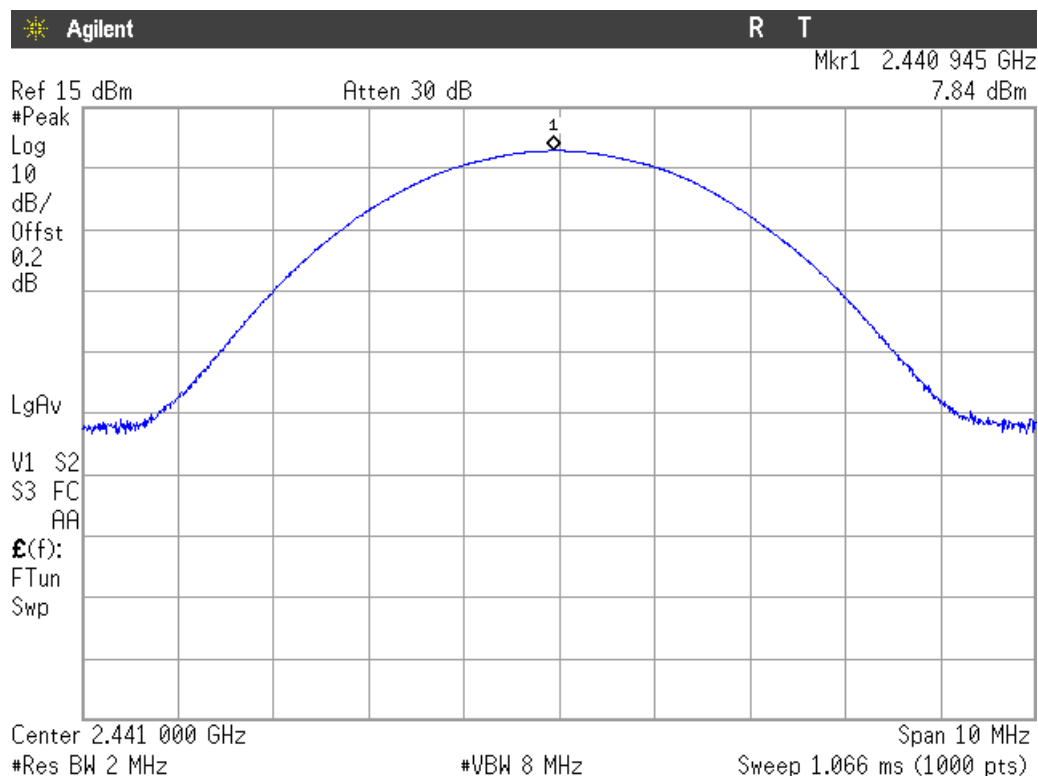
Modulation: 8-DPSK

Lowest Channel: 2402 MHz



Modulation: 8-DPSK

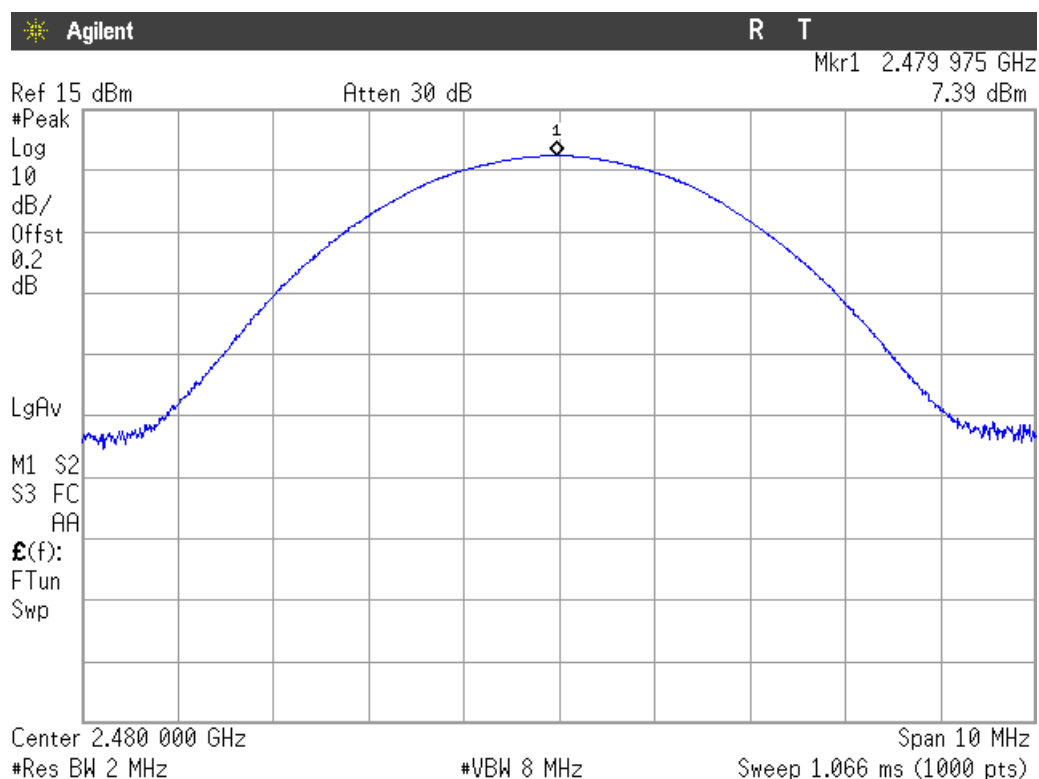
Middle Channel: 2441 MHz.



PEAK OUTPUT POWER (CONDUCTED).

Modulation: 8-DPSK

Highest Channel: 2480 MHz.



FCC Section 15.247 Subclause (d). Band-edge compliance of conducted emissions (Transmitter)

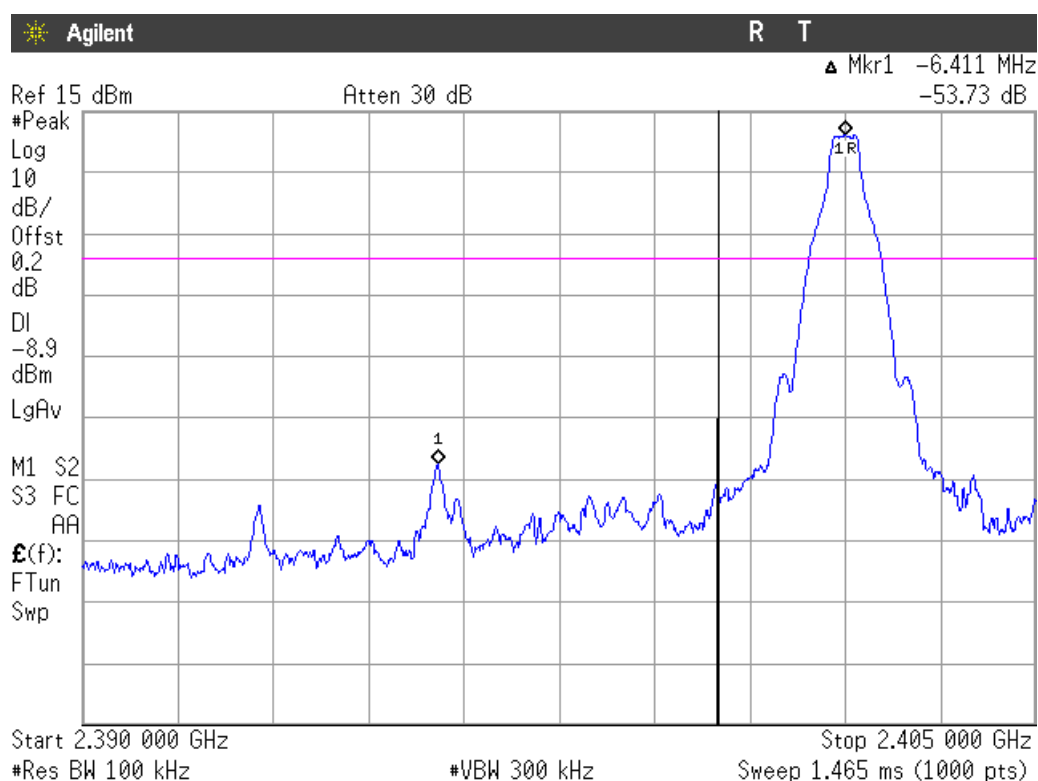
SPECIFICATION

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

RESULTS:

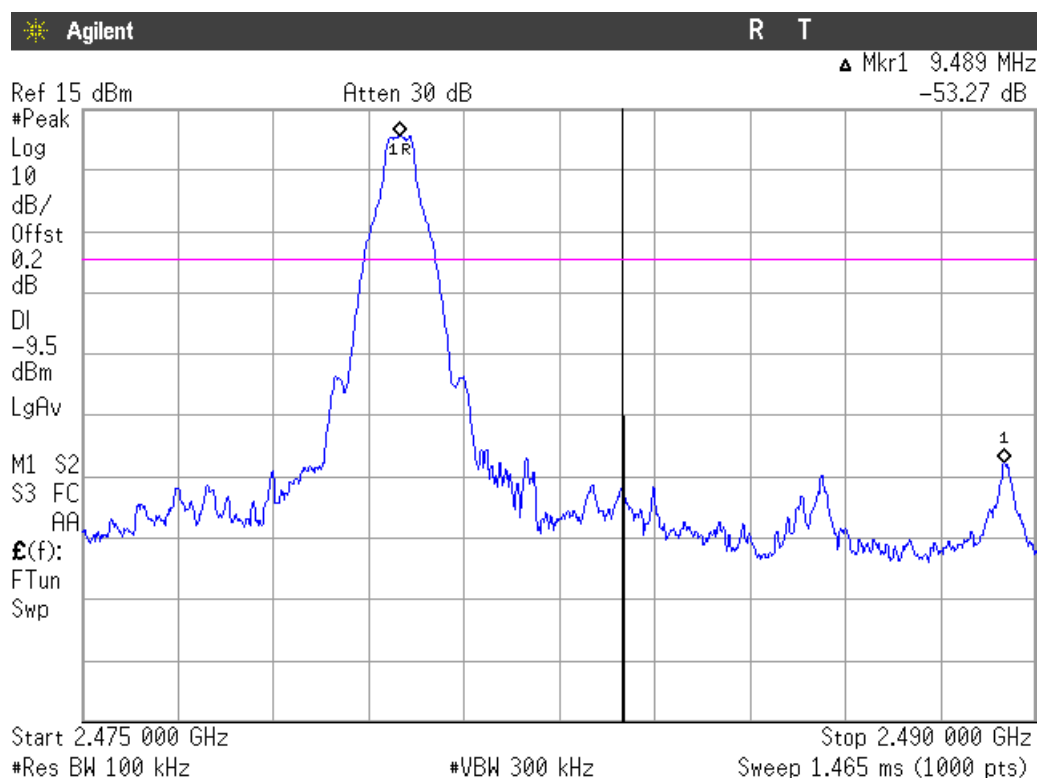
Modulation: GFSK

1. LOW FREQUENCY SECTION 2402 MHz (HOPPING OFF). See next plot.



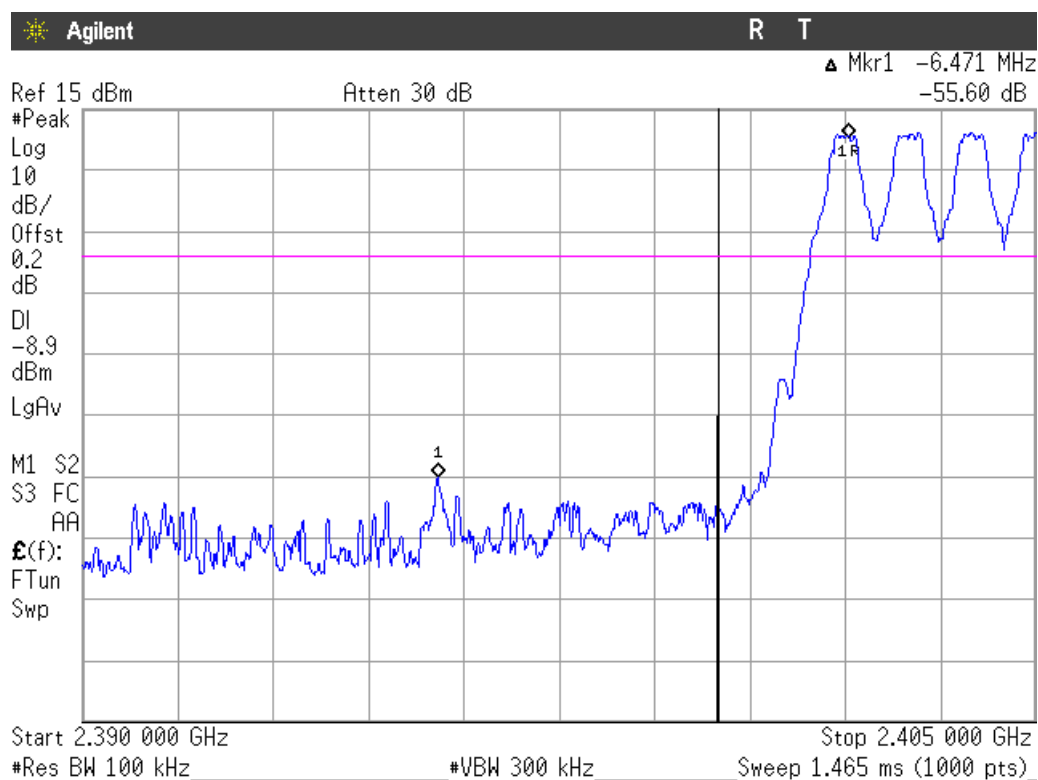
Verdict: PASS

2. HIGH FREQUENCY SECTION 2480 MHz (HOPPING OFF). See next plot.



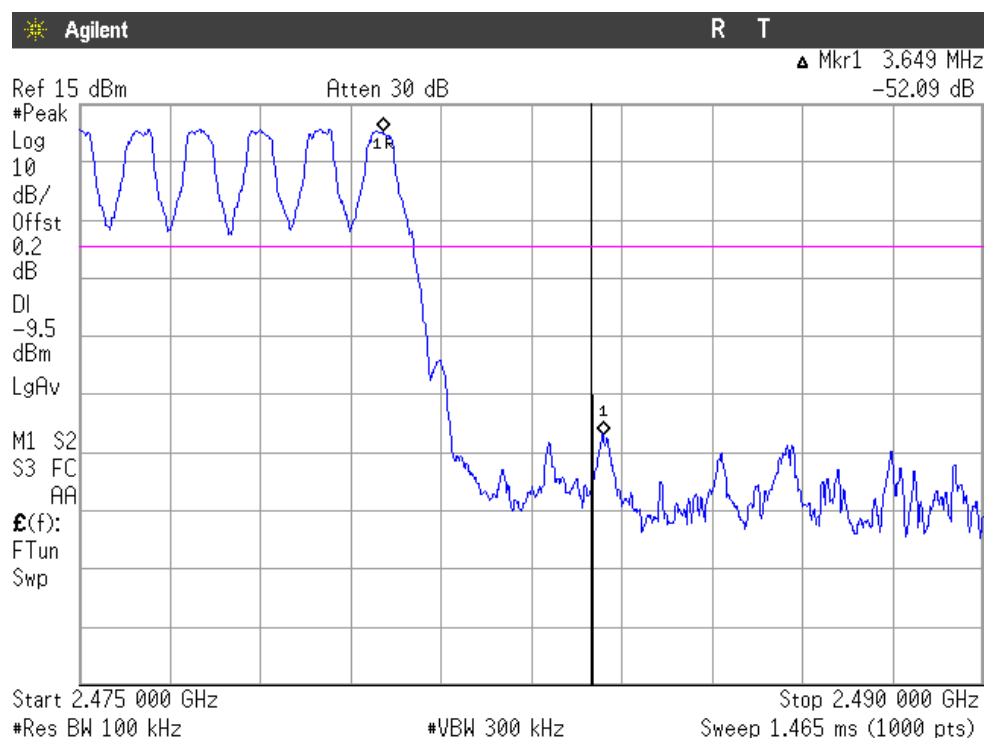
Verdict: PASS

3. LOW FREQUENCY SECTION (HOPPING ON). See next plot.



Verdict: PASS

4. HIGH FREQUENCY SECTION (HOPPING ON). See next plot.

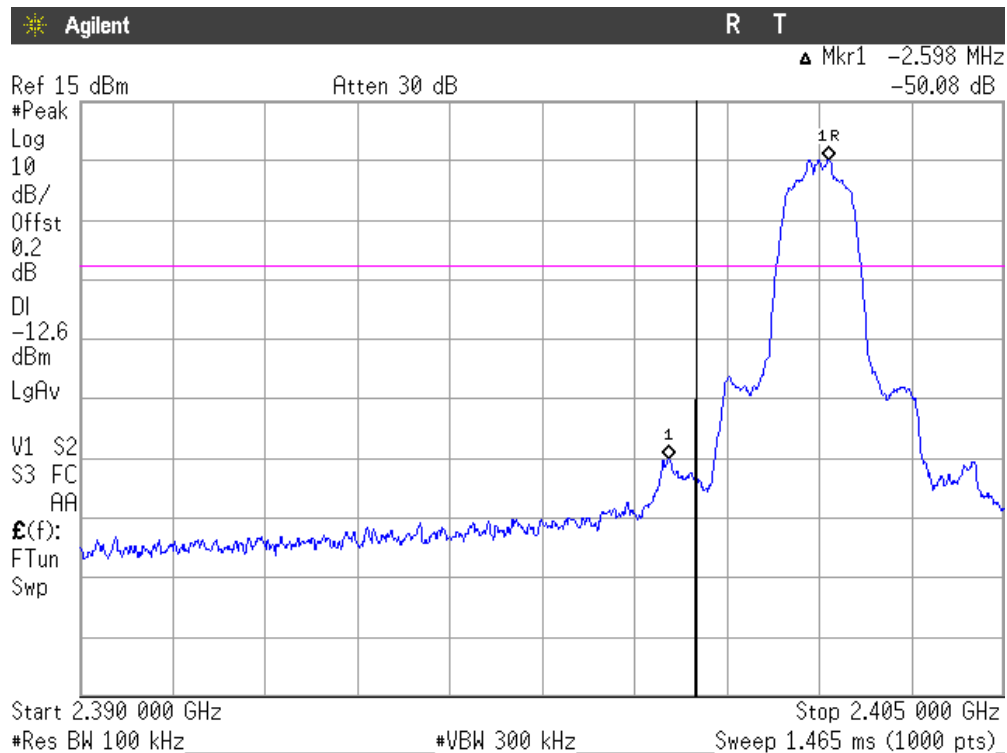


Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

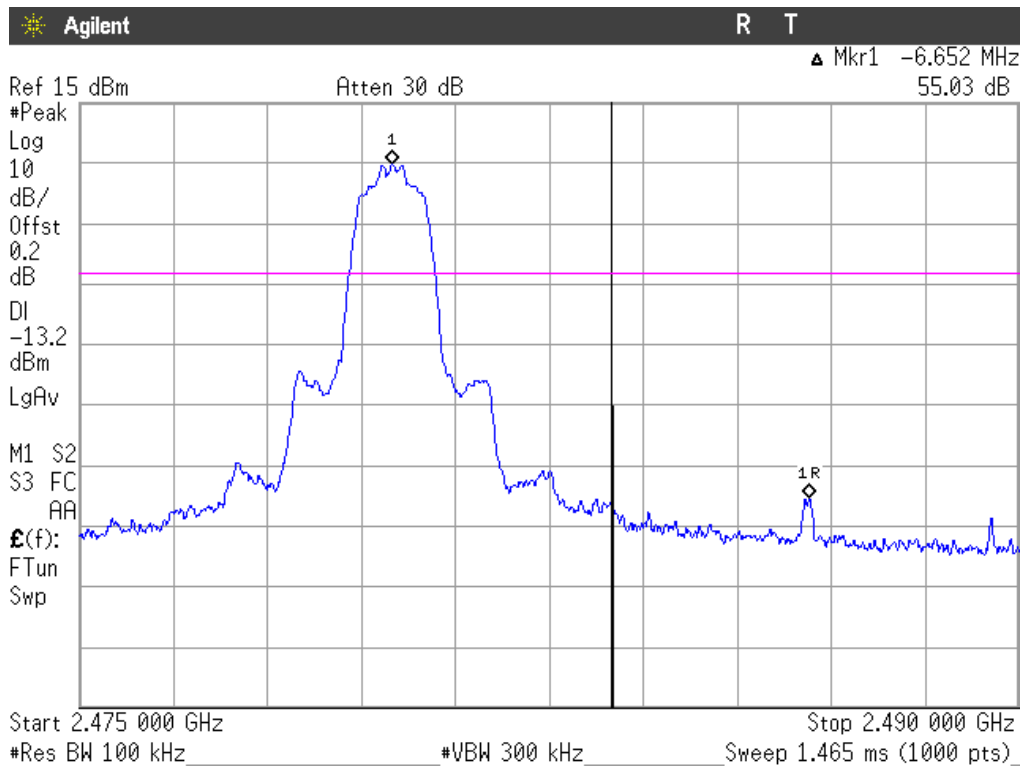
Modulation: $\Pi/4$ -DQPSK

1. LOW FREQUENCY SECTION 2402 MHz (HOPPING OFF). See next plot.



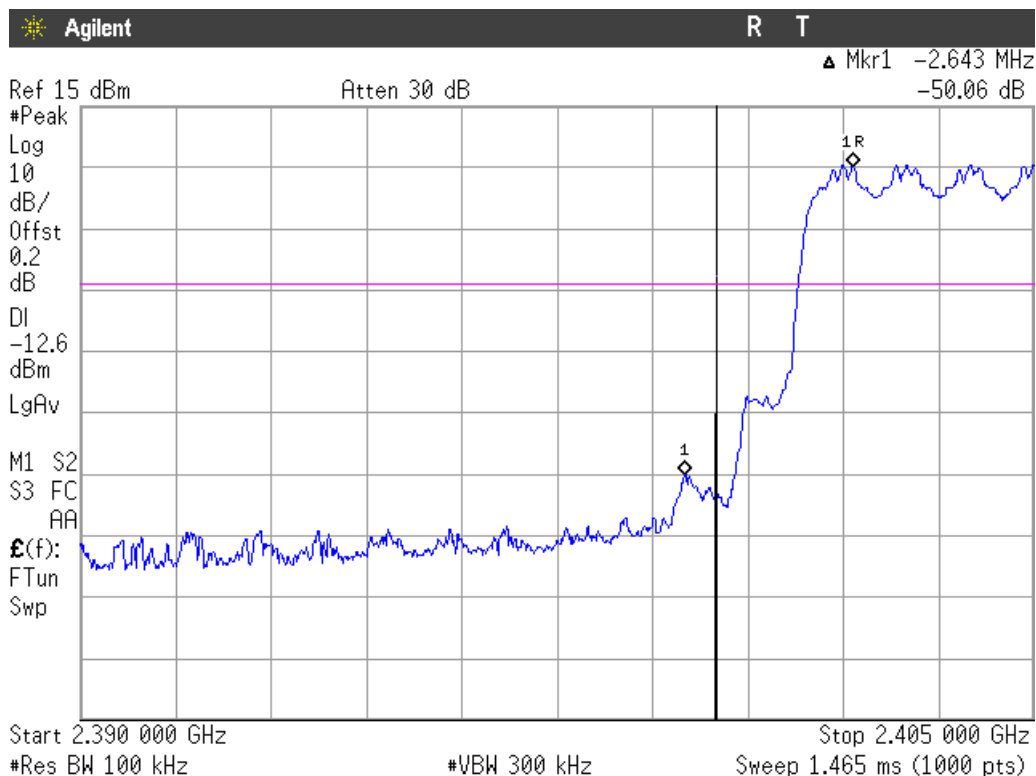
Verdict: PASS

2. HIGH FREQUENCY SECTION 2480 MHz (HOPPING OFF). See next plot.



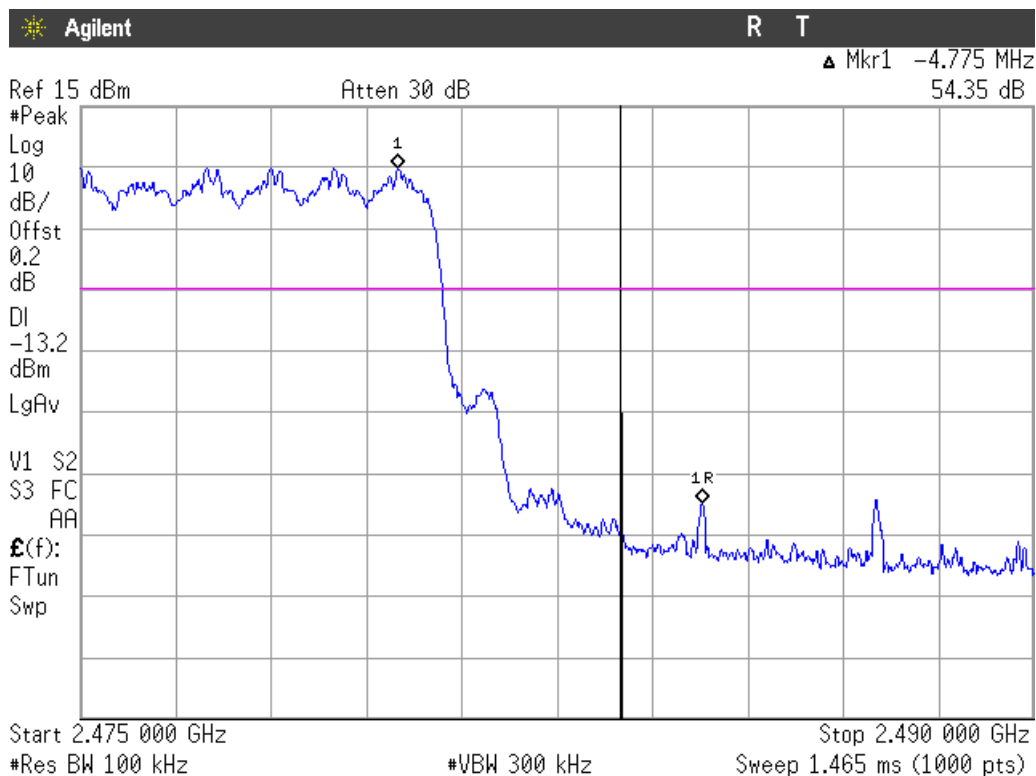
Verdict: PASS

3. LOW FREQUENCY SECTION (HOPPING ON). See next plot.



Verdict: PASS

4. HIGH FREQUENCY SECTION (HOPPING ON). See next plot.

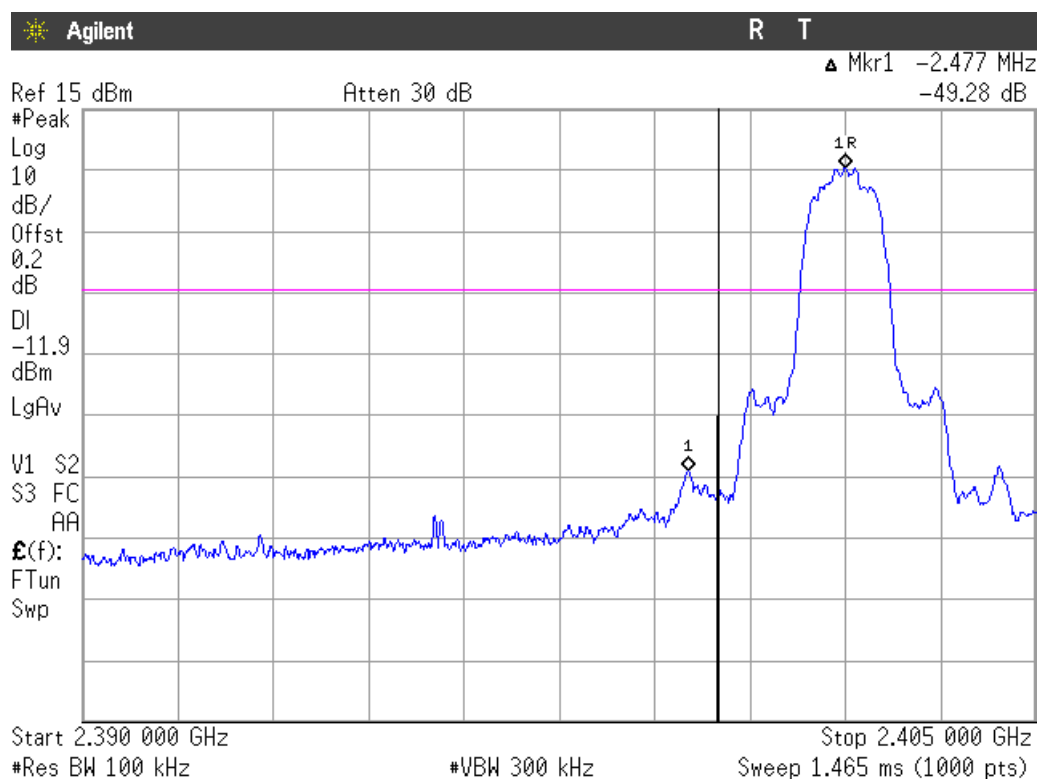


Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

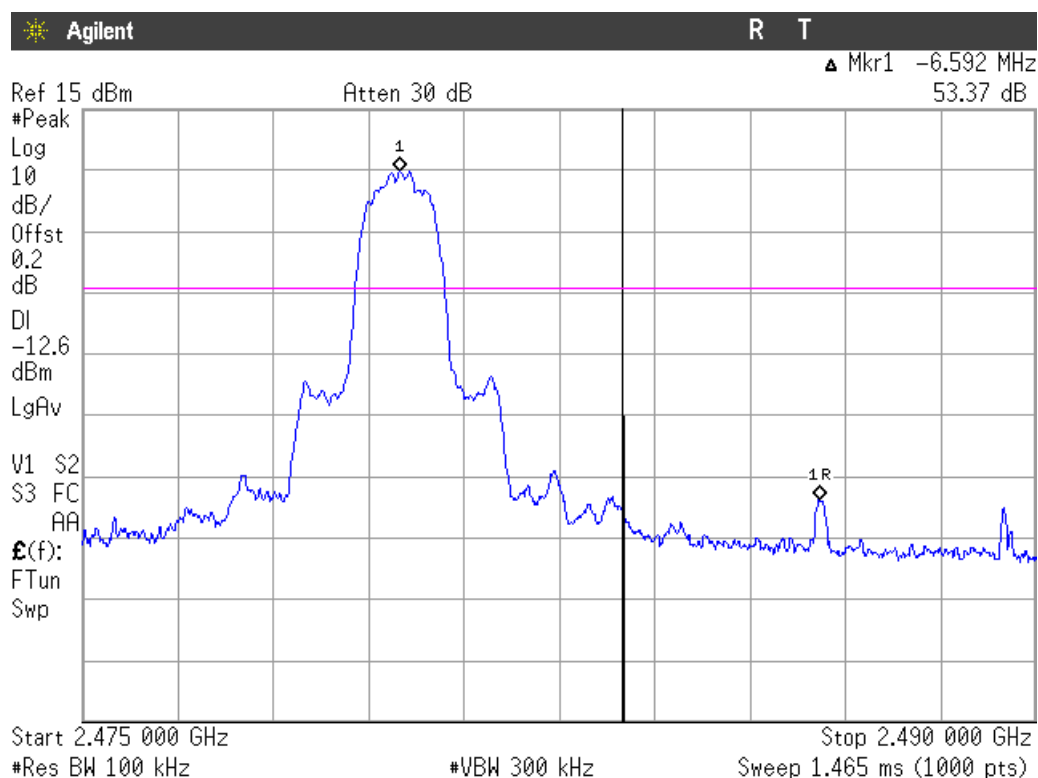
Modulation: 8-DPSK

1. LOW FREQUENCY SECTION 2402 MHz (HOPPING OFF). See next plot.



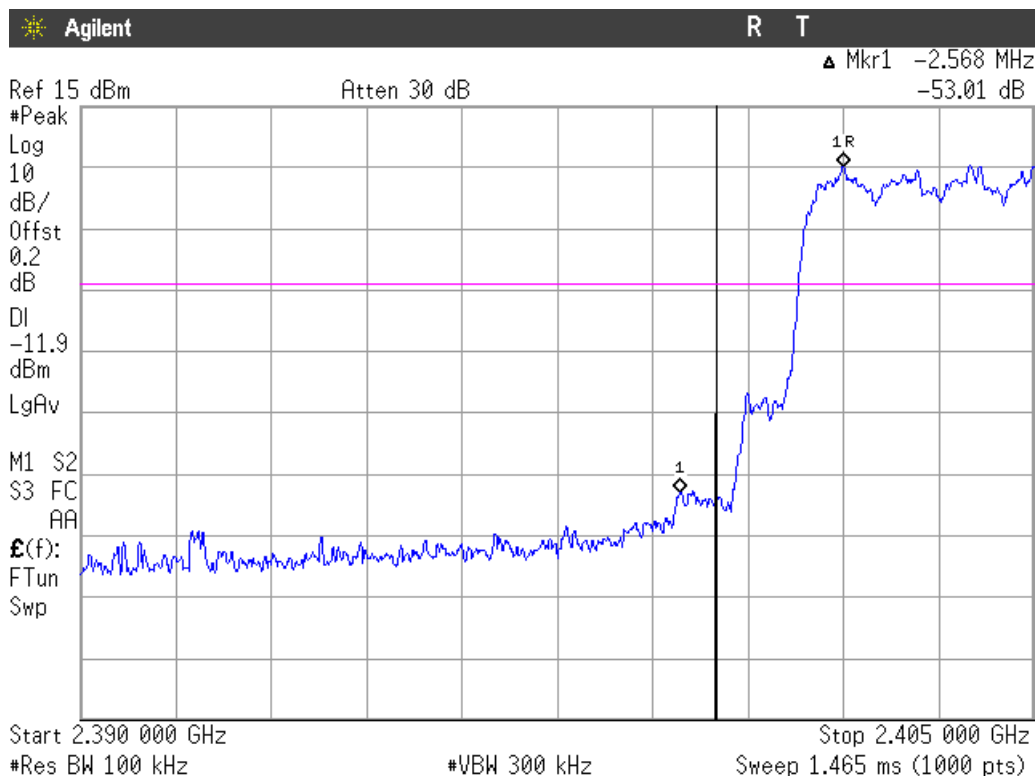
Verdict: PASS

2. HIGH FREQUENCY SECTION 2480 MHz (HOPPING OFF). See next plot.



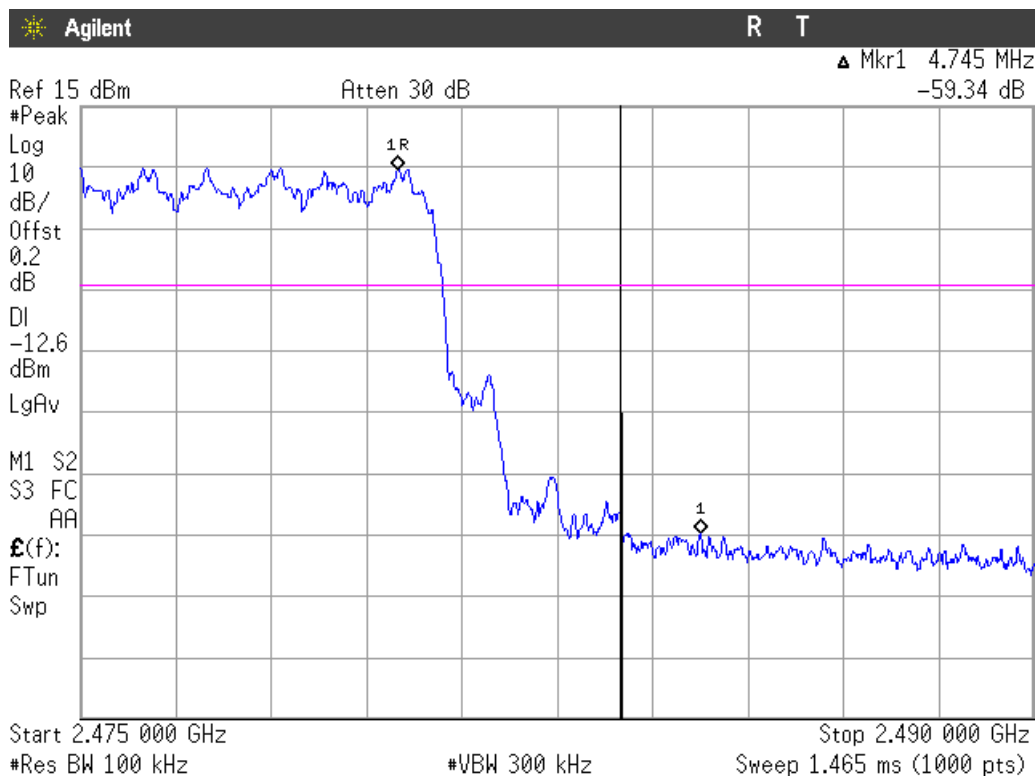
Verdict: PASS

3. LOW FREQUENCY SECTION (HOPPING ON). See next plot.



Verdict: PASS

4. HIGH FREQUENCY SECTION (HOPPING ON). See next plot.



Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

FCC Section 15.247 Subclause (d). Emission limitations conducted (Transmitter)

SPECIFICATION

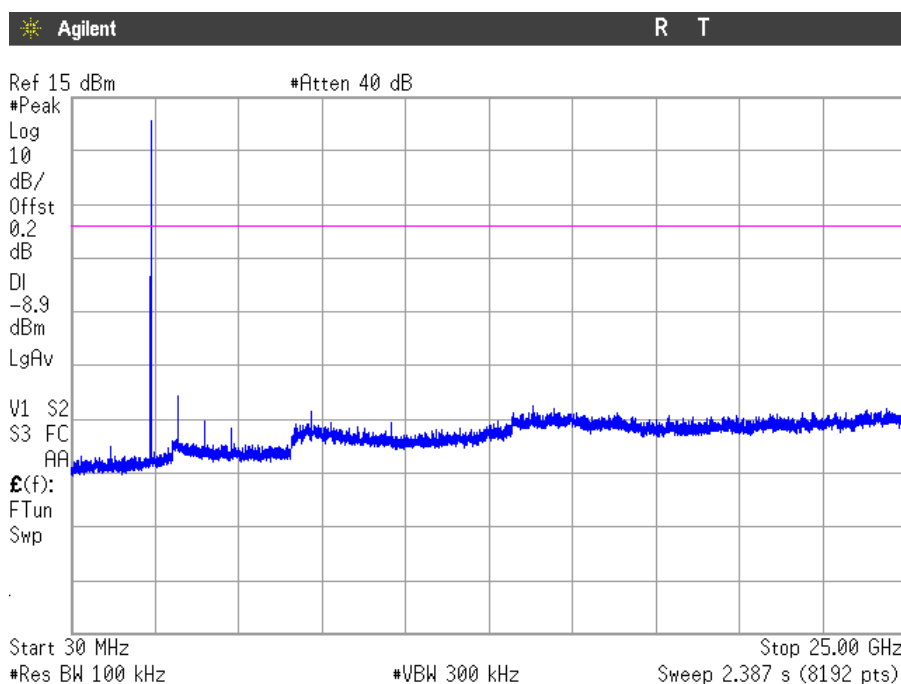
In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

RESULTS:

All peaks are more than 20 dB below the limit.

Modulation: GFSK

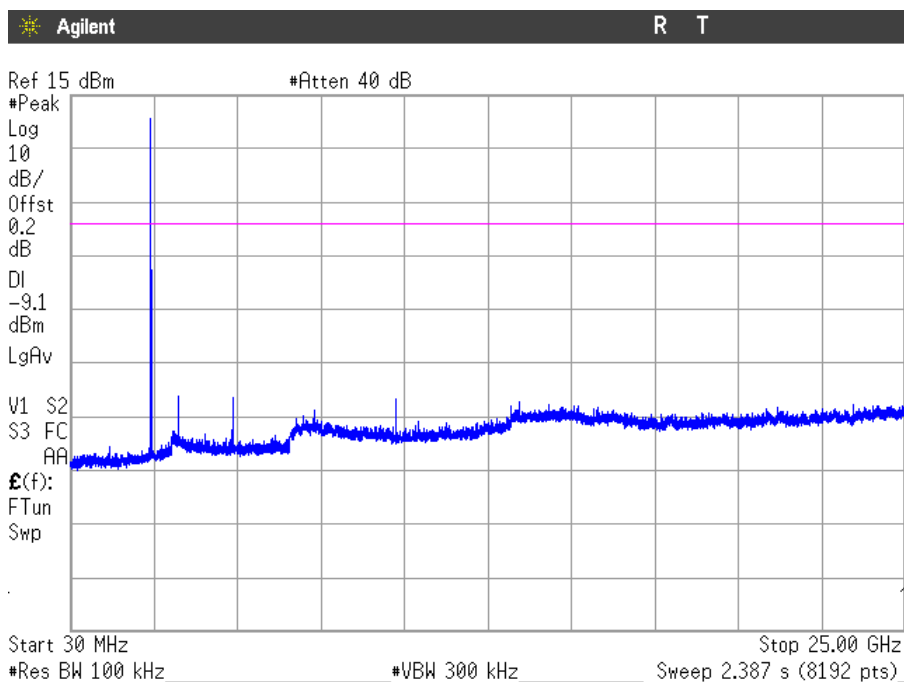
1. LOWEST CHANNEL (2402 MHz): 30 MHz-25 GHz (see next plot).



Note: The peak above the limit is the carrier frequency.

Verdict: PASS

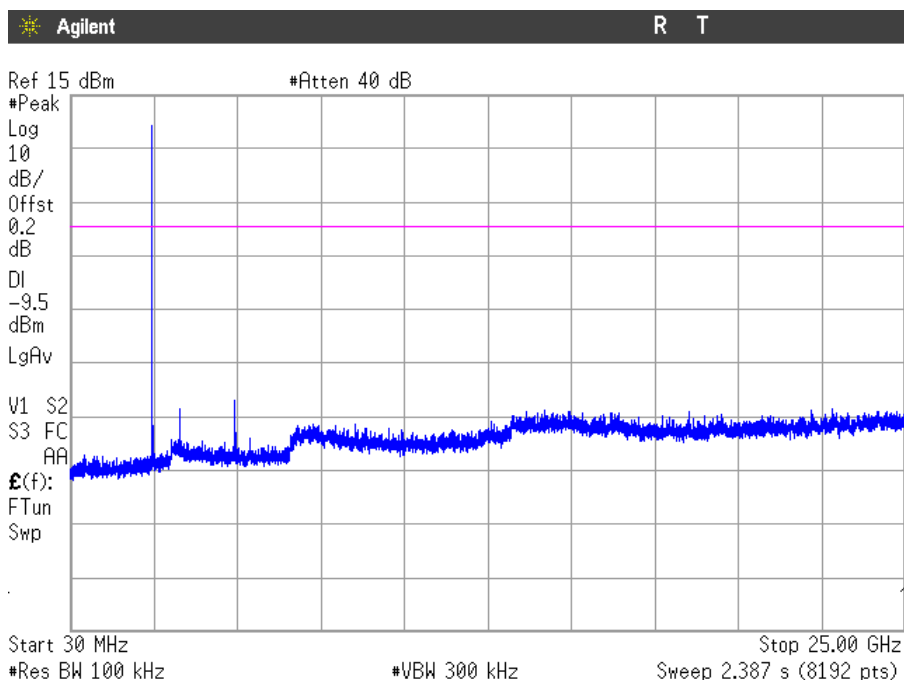
2. MIDDLE CHANNEL (2441 MHz): 30 MHz-25 GHz (see next plot).



Note: The peak above the limits is the carrier frequency.

Verdict: PASS

3. HIGH CHANNEL (2480 MHz): 30 MHz-25 GHz (see next plot).



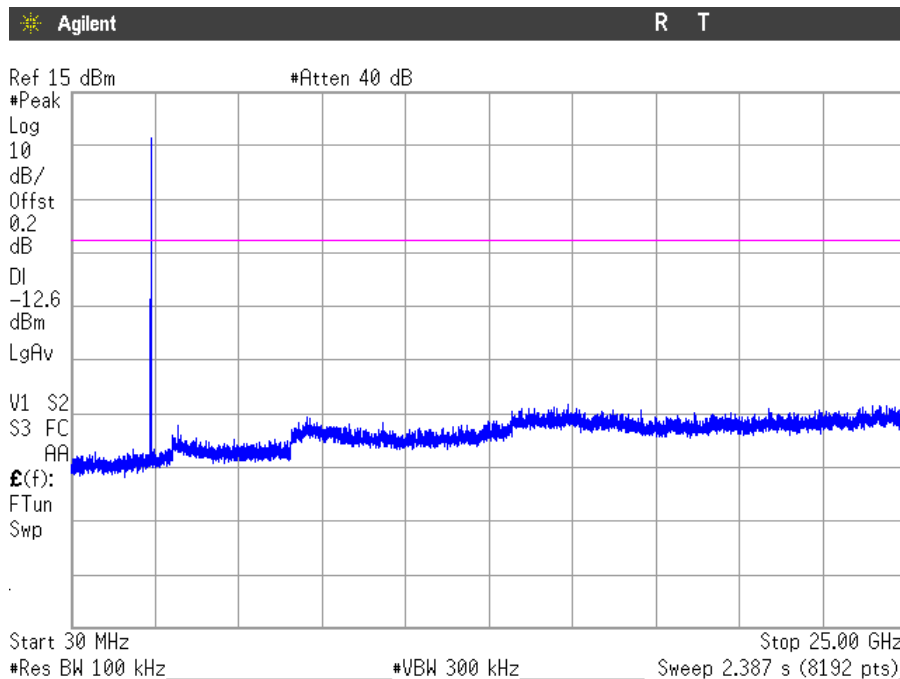
Note: The peak above the limits is the carrier frequency.

Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

Modulation: $\Pi/4$ -DQPSK

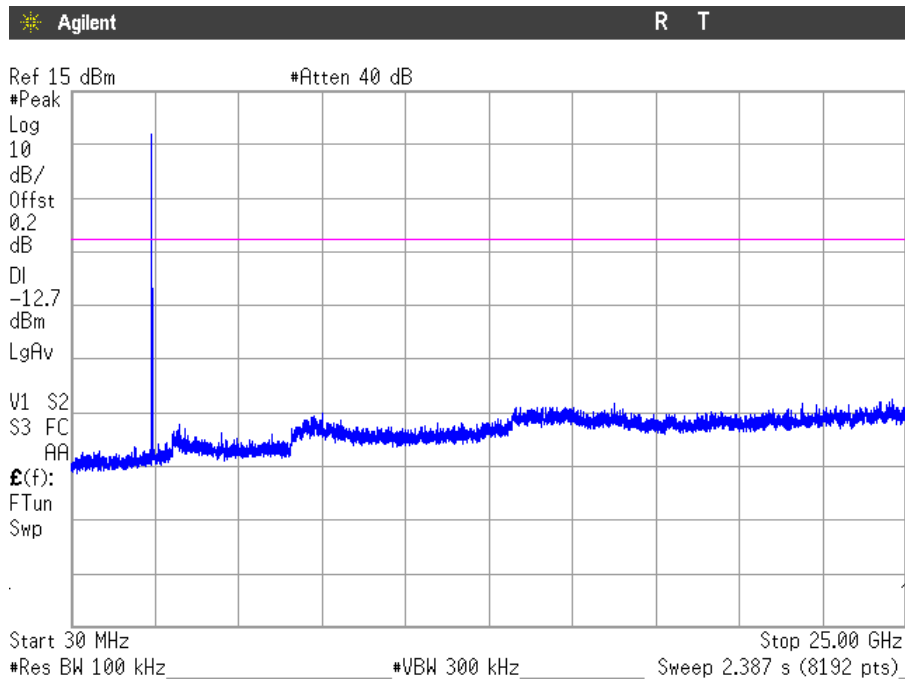
1. LOWEST CHANNEL (2402 MHz): 30 MHz-25 GHz (see next plot).



Note: The peak above the limits is the carrier frequency.

Verdict: PASS

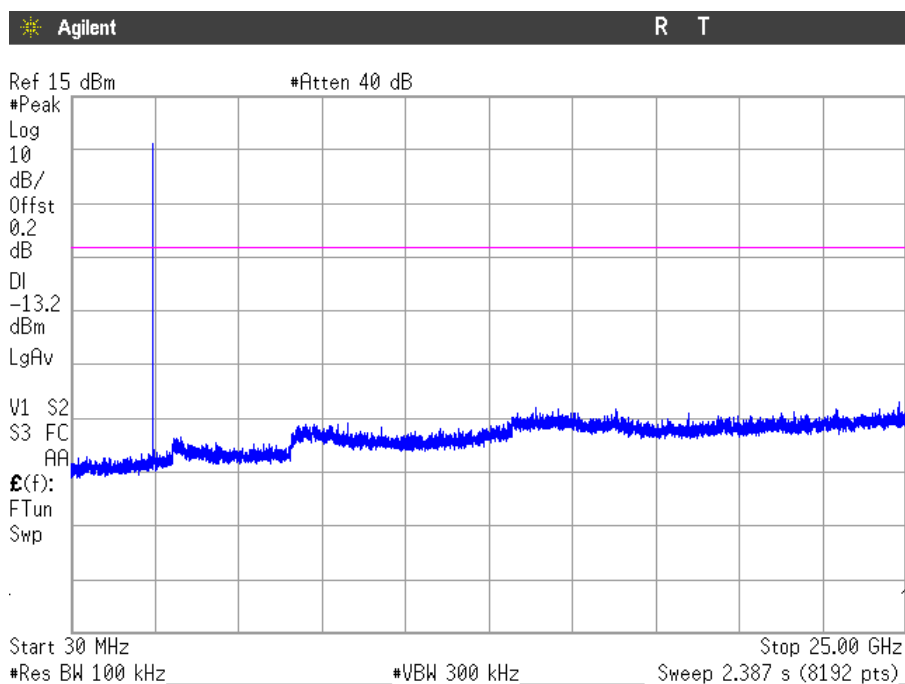
2. MIDDLE CHANNEL (2441 MHz): 30 MHz-25 GHz (see next plot).



Note: The peaks above the limits are the carrier frequencies.

Verdict: PASS

3. HIGH CHANNEL (2480 MHz): 30 MHz-25 GHz (see next plot).



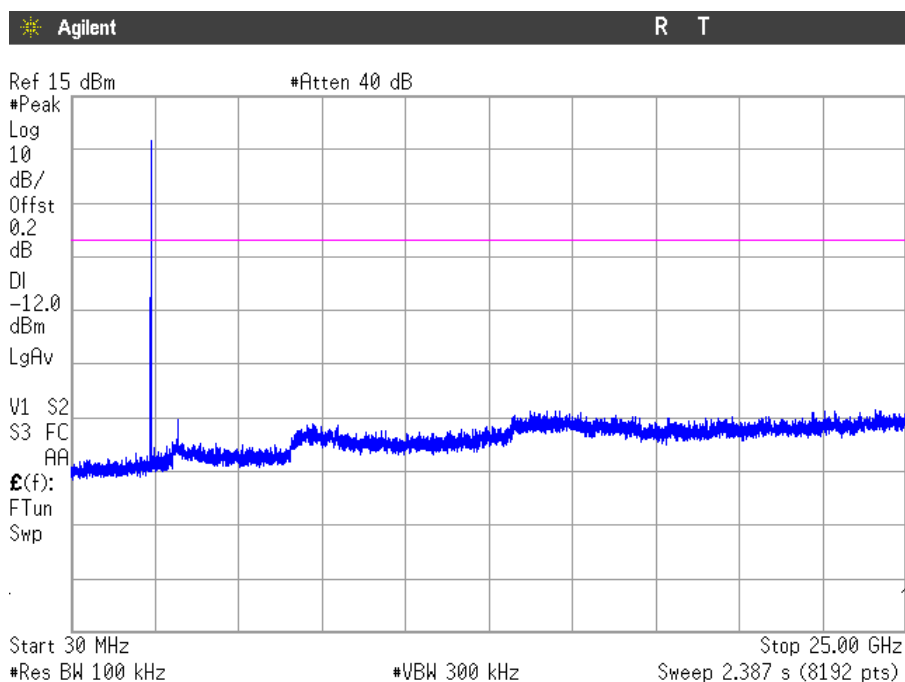
Note: The peak above the limit is the carrier frequency.

Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

Modulation: 8-DPSK

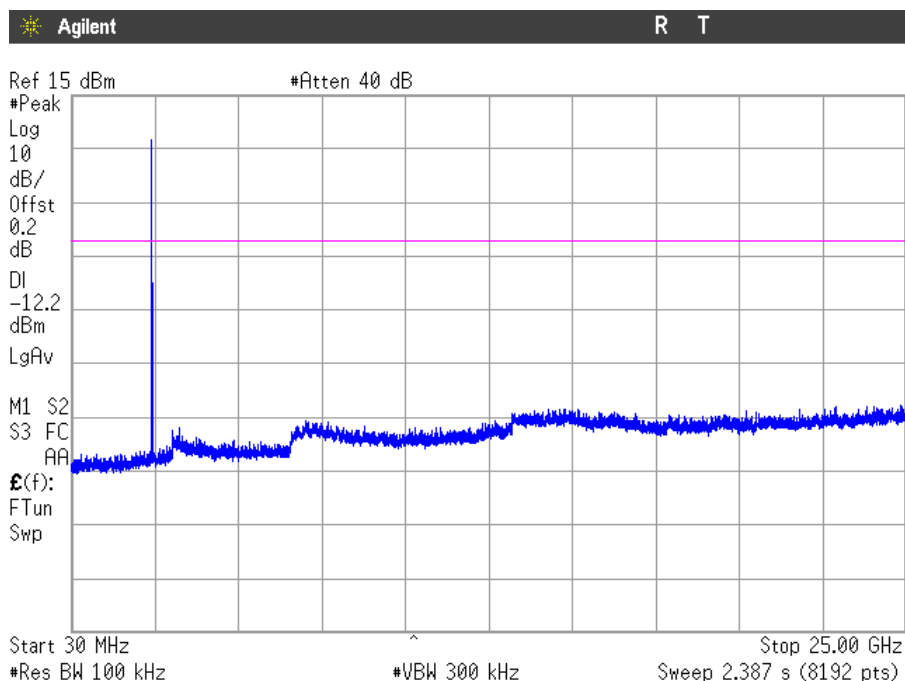
1. LOWEST CHANNEL (2402 MHz): 30 MHz-25 GHz (see next plot).



Note: The peak above the limits is the carrier frequency.

Verdict: PASS

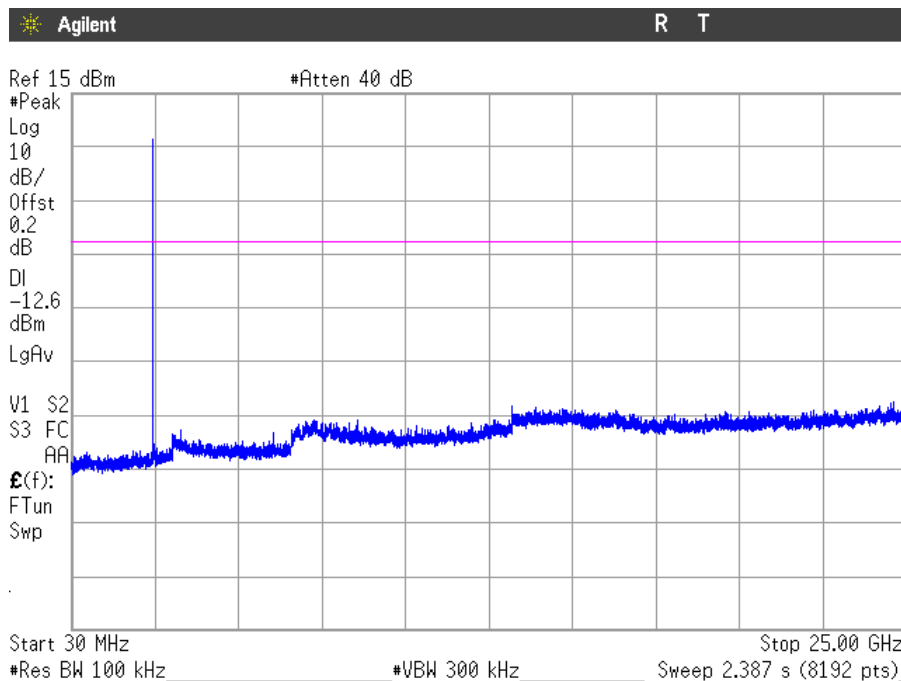
2. MIDDLE CHANNEL (2441 MHz): 30 MHz-25 GHz (see next plot).



Note: The peaks above the limit are the carrier frequencies.

Verdict: PASS

3. HIGH CHANNEL (2480 MHz): 30 MHz-25 GHz (see next plot).



Note: The peak above the limit is the carrier frequency.

Verdict: PASS

Measurement uncertainty (dB)	<±2.03
------------------------------	--------

FCC Section 15.247 Subclause (d). 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)):

Frequency Range (MHz)	Field strength ($\mu\text{V/m}$)	Field strength ($\text{dB}\mu\text{V/m}$)	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.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° 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-1000 MHz.

Note: The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

Spurious signals closest to the limit:

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dB μ V/m)	Measurement Uncertainty (dB)
124.769	V	Quasi-Peak	24.00	± 3.88
144.201	V	Quasi-Peak	20.37	± 3.88

Frequency range 1 GHz-25 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 (see next plots).

Modulation: GFSK

1. CHANNEL: LOWEST (2402 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dB μ V/m)	Measurement Uncertainty (dB)
2.37694	V	Peak	55.58	± 4.87
		Average	37.03	
2.38972	V	Peak	49.48	± 4.87
		Average	41.24	
3.20225	V	Peak	49.27	± 4.87
		Average	47.14	
4.00325	V	Peak	42.04	± 4.87
		Average	39.42	
4.80375	V	Peak	44.28	± 4.87
		Average	41.37	
5.60475	V	Peak	40.70	± 4.87
		Average	34.79	
7.20675	V	Peak	53.30	± 4.87
		Average	46.67	
9.60725	V	Peak	55.77	± 4.87
		Average	49.09	
12.0125	V	Peak	51.69	± 4.87
		Average	43.84	

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.38983	V	Peak	51.87	± 4.87
		Average	36.90	
2.49166	V	Peak	54.11	± 4.87
		Average	37.45	
3.25475	V	Peak	45.48	± 4.87
		Average	44.28	
4.06775	V	Peak	41.65	± 4.87
		Average	36.57	
4.88175	V	Peak	45.79	± 4.87
		Average	43.70	
5.69575	V	Peak	42.62	± 4.87
		Average	38.02	
7.32225	V	Peak	53.89	± 4.87
		Average	47.97	
8.95075	V	Peak	45.96	± 4.87
		Average	37.56	
9.76325	V	Peak	56.04	± 4.87
		Average	50.34	
12.20525	V	Peak	52.49	± 4.87
		Average	45.74	

3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.483558	V	Peak	54.05	± 4.87
		Average	41.43	
2.48623	V	Peak	54.68	± 4.87
		Average	44.97	
2.48967	V	Peak	53.81	± 4.87
		Average	46.88	
2.50557	V	Peak	56.98	± 4.87
		Average	38.56	
3.30625	V	Peak	43.99	± 4.87
		Average	40.91	
4.13325	V	Peak	40.19	± 4.87
		Average	37.96	
4.96025	V	Peak	48.50	± 4.87
		Average	45.75	
5.78675	V	Peak	42.62	± 4.87
		Average	38.86	
7.43925	V	Peak	52.54	± 4.87
		Average	46.36	
9.91925	V	Peak	54.62	± 4.87
		Average	49.25	
12.39925	V	Peak	51.93	± 4.87
		Average	45.14	

Verdict: PASS

Modulation: $\Pi/4$ -DQPSK

1. CHANNEL: LOWEST (2402 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dB μ V/m)	Measurement Uncertainty (dB)
2.37712	V	Peak	50.66	± 4.87
		Average	35.87	
3.20225	V	Peak	45.81	± 4.87
		Average	41.01	
7.20575	V	Peak	49.08	± 4.87
		Average	43.62	
9.60725	V	Peak	48.05	± 4.87
		Average	37.92	
12.00925	V	Peak	51.02	± 4.87
		Average	42.78	

2. CHANNEL: MIDDLE (2441 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dB μ V/m)	Measurement Uncertainty (dB)
3.25425	V	Peak	41.54	± 4.87
		Average	36.88	
7.32275	V	Peak	50.23	± 4.87
		Average	44.43	
9.76325	V	Peak	47.65	± 4.87
		Average	40.58	
12.20375	V	Peak	51.48	± 4.87
		Average	45.01	

3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dB μ V/m)	Measurement Uncertainty (dB)
2.38991	V	Peak	50.36	± 4.87
		Average	36.99	
2.49176	V	Peak	53.74	± 4.87
		Average	37.89	
2.48365	H	Peak	53.73	± 4.87
		Average	40.38	
2.49183	V	Peak	51.80	± 4.87
		Average	37.27	
3.30675	V	Peak	41.03	± 4.87
		Average	35.81	
7.43975	V	Peak	48.58	± 4.87
		Average	43.37	
9.91925	V	Peak	49.63	± 4.87
		Average	39.51	
12.39925	V	Peak	52.07	± 4.87
		Average	43.23	

Verdict: PASS

Modulation: 8-DPSK

1. CHANNEL: LOWEST (2402 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.37703	V	Peak	51.06	± 4.87
		Average	36.11	
3.20275	V	Peak	46.06	± 4.87
		Average	41.56	
7.20525	V	Peak	50.05	± 4.87
		Average	42.09	
9.60825	V	Peak	46.87	± 4.87
		Average	39.89	
12.01125	V	Peak	49.89	± 4.87
		Average	40.11	

2. CHANNEL: MIDDLE (2441 MHz).

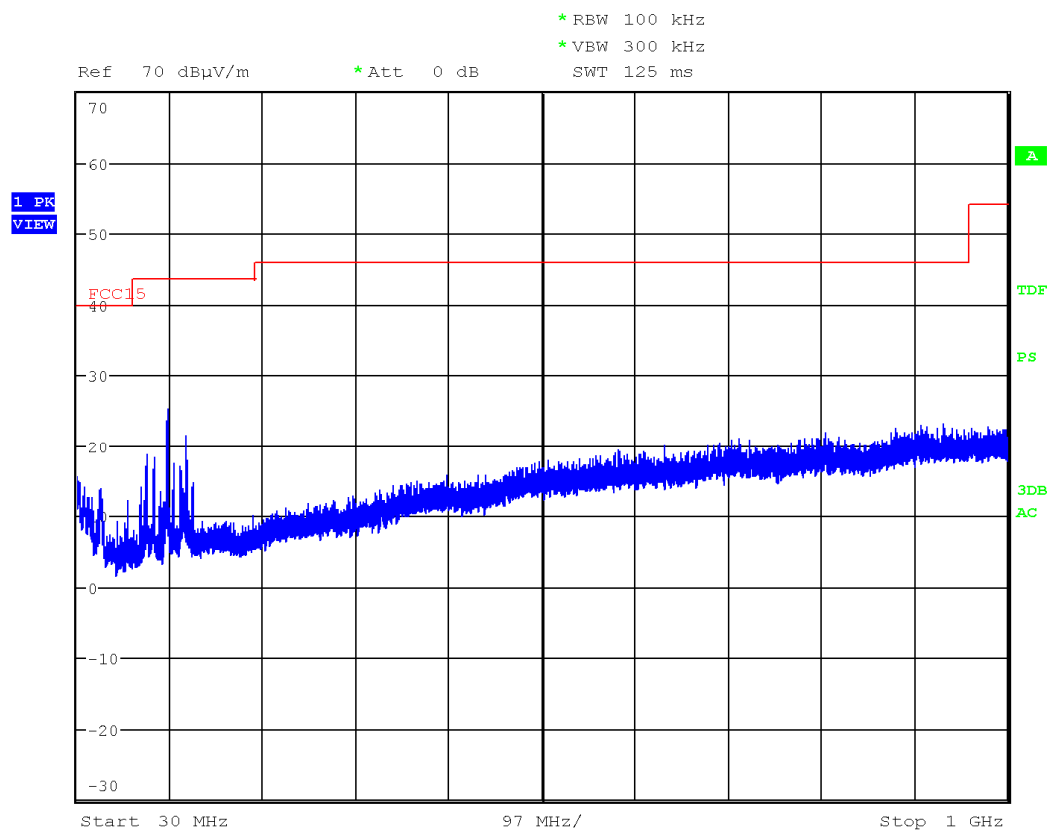
Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
3.25427	V	Peak	42.77	± 4.87
		Average	37.43	
7.32275	V	Peak	50.51	± 4.87
		Average	44.74	
9.76475	V	Peak	48.17	± 4.87
		Average	40.42	
12.20375	V	Peak	50.57	± 4.87
		Average	42.64	

3. CHANNEL: HIGHEST (2480 MHz).

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.48353	V	Peak	55.15	± 4.87
		Average	42.70	
3.30675	V	Peak	41.93	± 4.87
		Average	36.12	
7.43975	V	Peak	49.50	± 4.87
		Average	43.10	
9.91975	V	Peak	48.89	± 4.87
		Average	39.98	
12.39975	V	Peak	51.10	± 4.87
		Average	43.34	

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

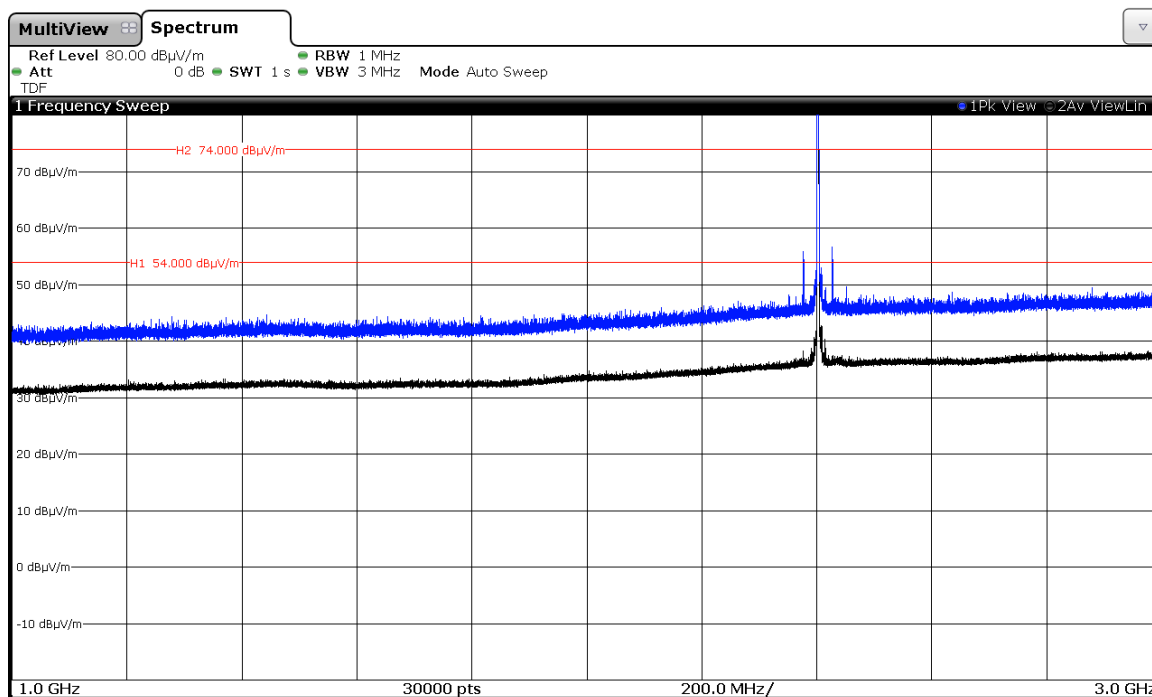


(This plot is valid for all three channels and all modulation modes).

FREQUENCY RANGE 1 GHz to 3 GHz.

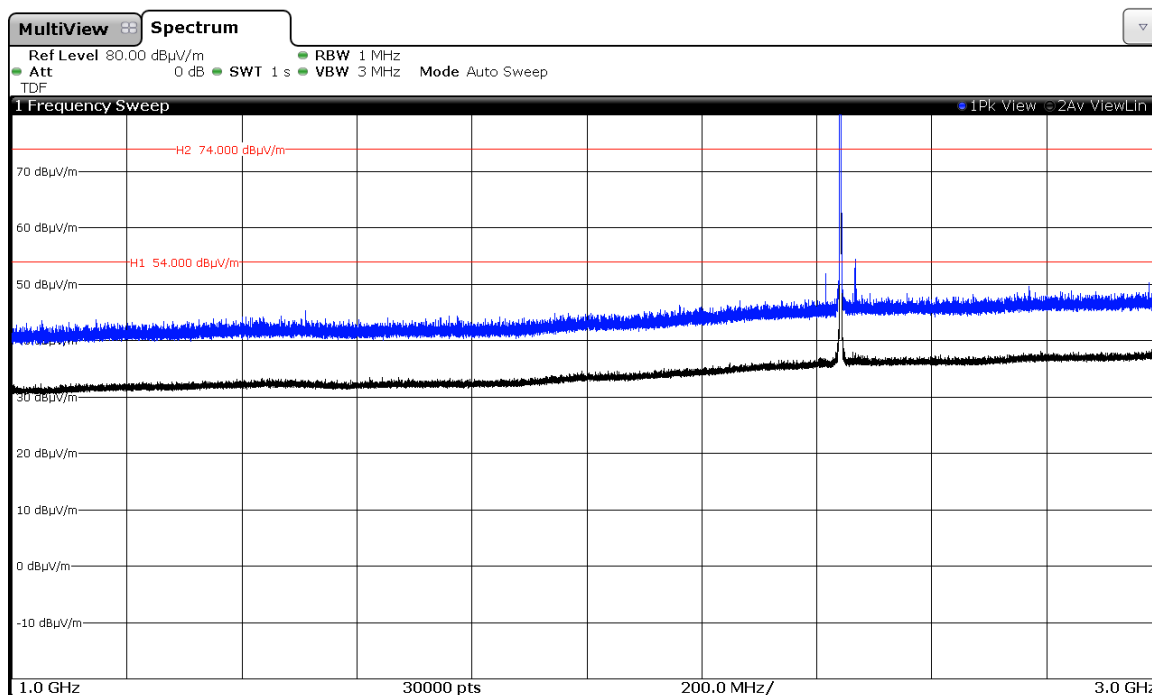
Modulation: GFSK

CHANNEL: Lowest (2402 MHz).



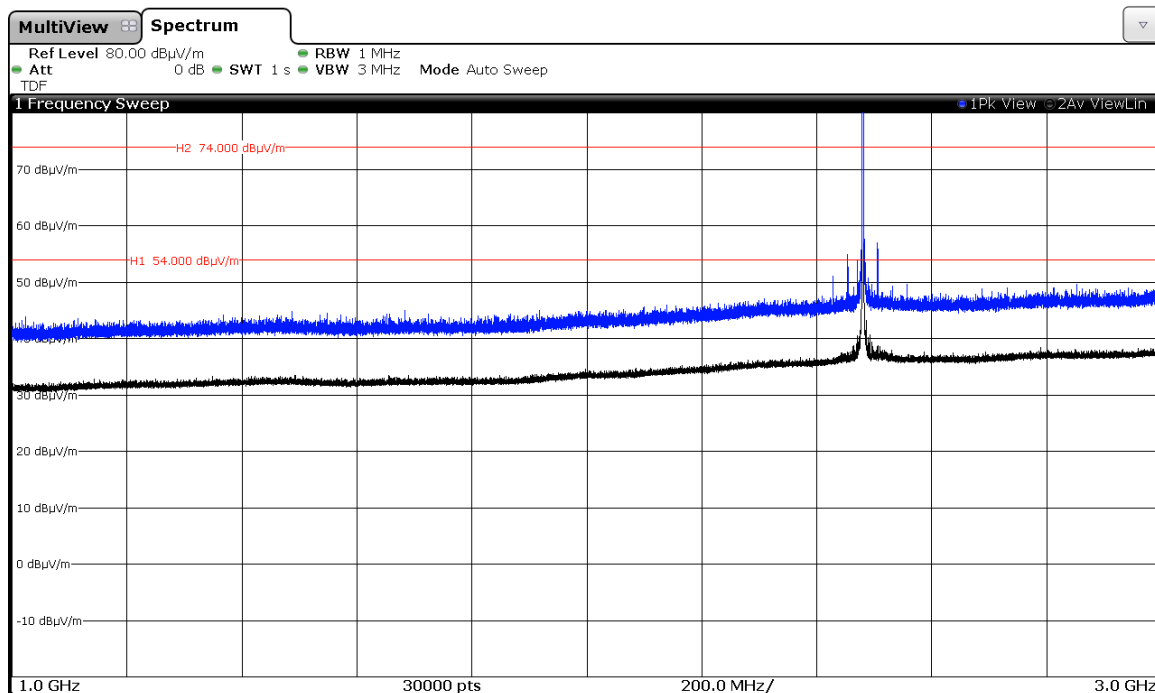
Note: The peak shown in the plot above the limits is the carrier frequency.

CHANNEL: Middle (2441 MHz).



Note: The peak shown in the plot above the limits is the carrier frequency.

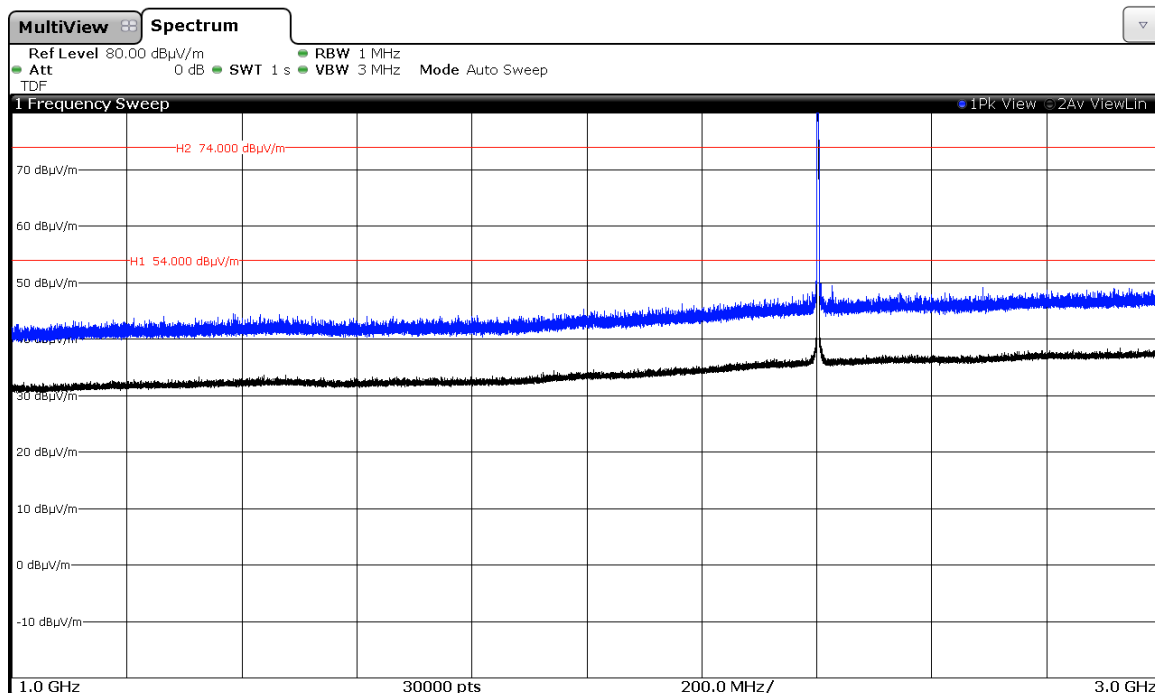
CHANNEL: Highest (2480 MHz).



Note: The peak shown in the plot above the limits is the carrier frequency.

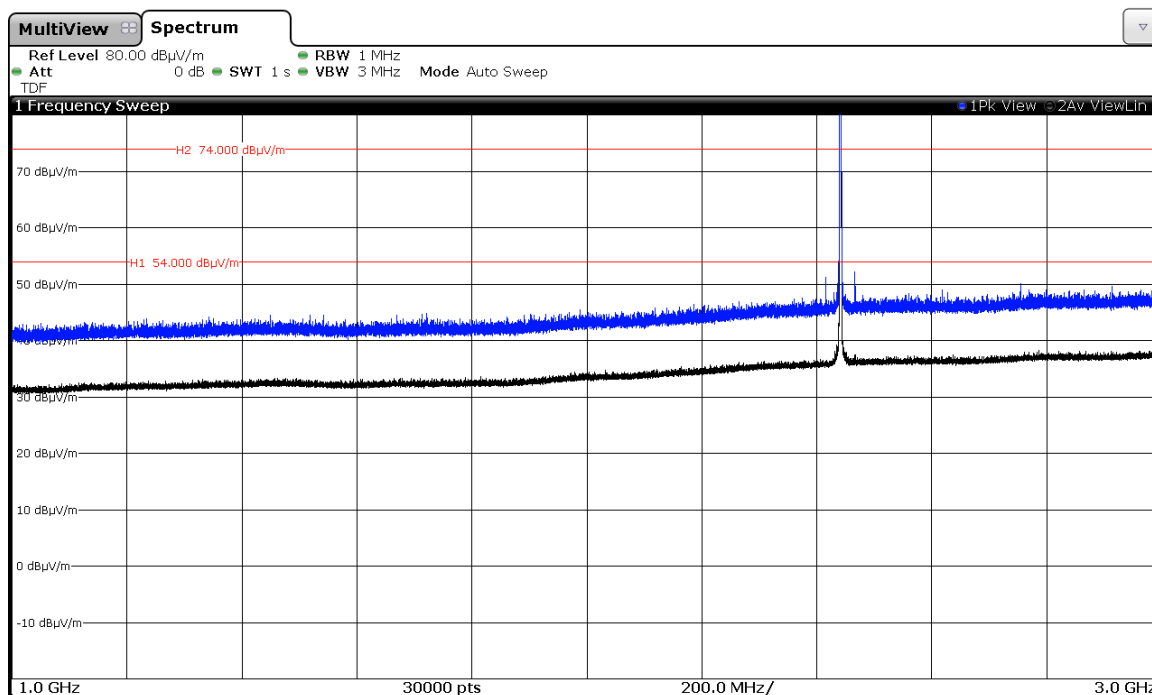
Modulation: $\Pi/4$ -DQPSK

CHANNEL: Lowest (2402 MHz).



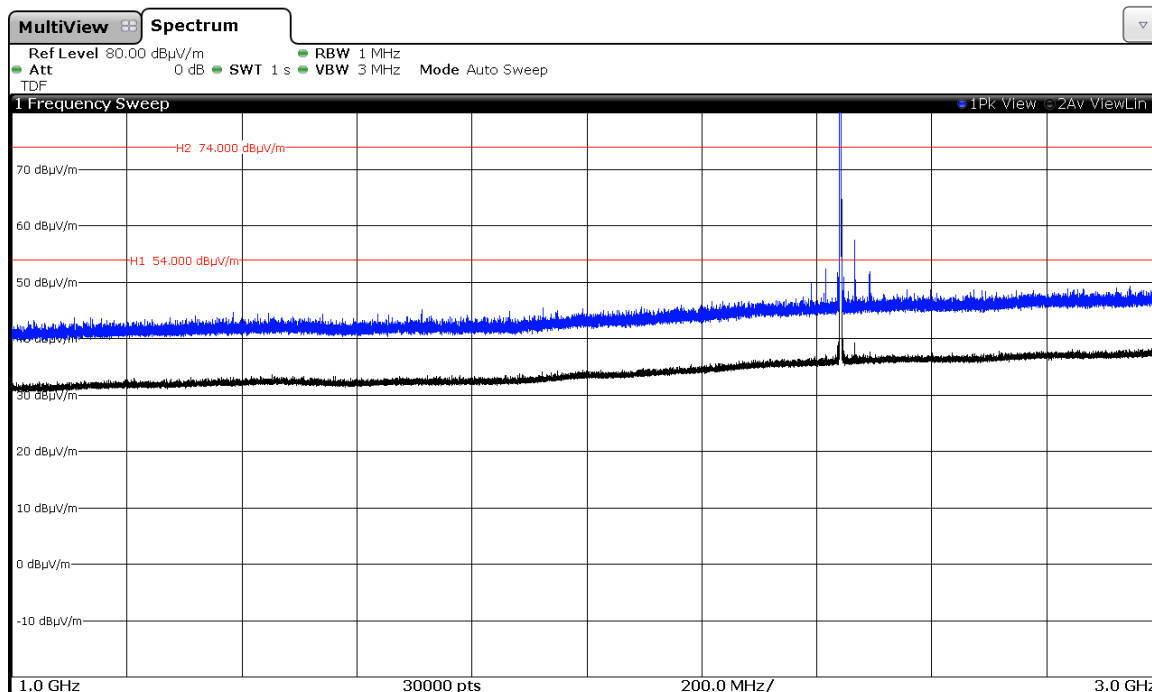
Note: The peak shown in the plot above the limits is the carrier frequency.

CHANNEL: Middle (2441 MHz).



Note: The peak shown in the plot above the limits is the carrier frequency.

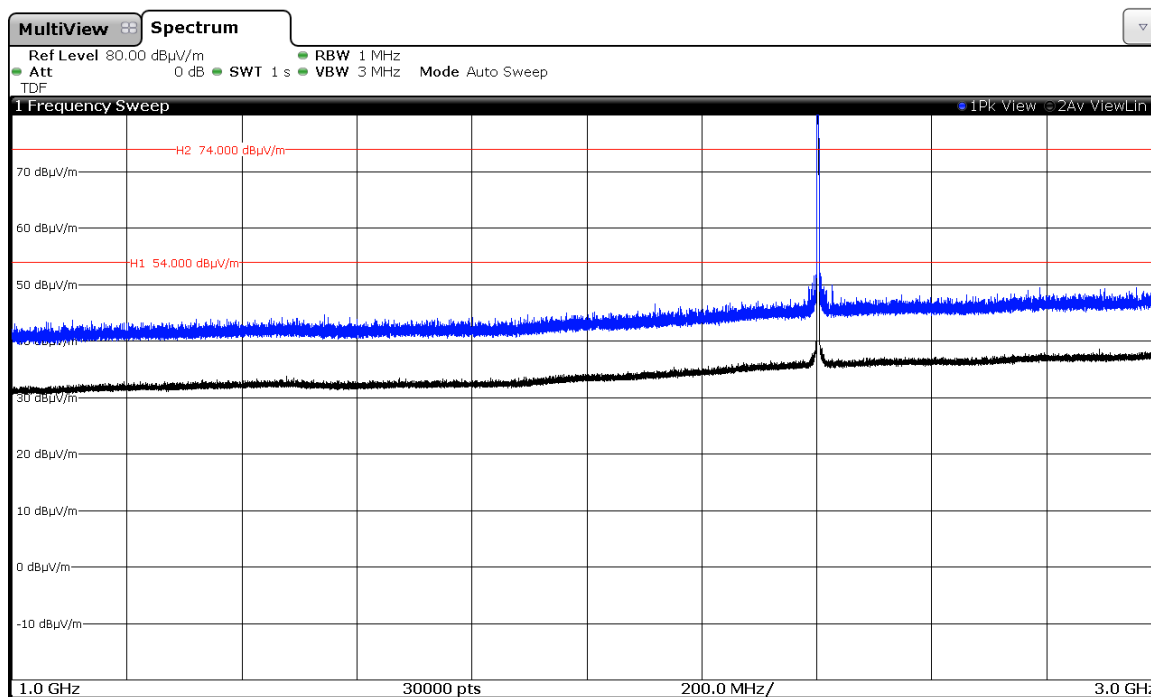
CHANNEL: Highest (2480 MHz).



Note: The peak shown in the plot above the limits is the carrier frequency.

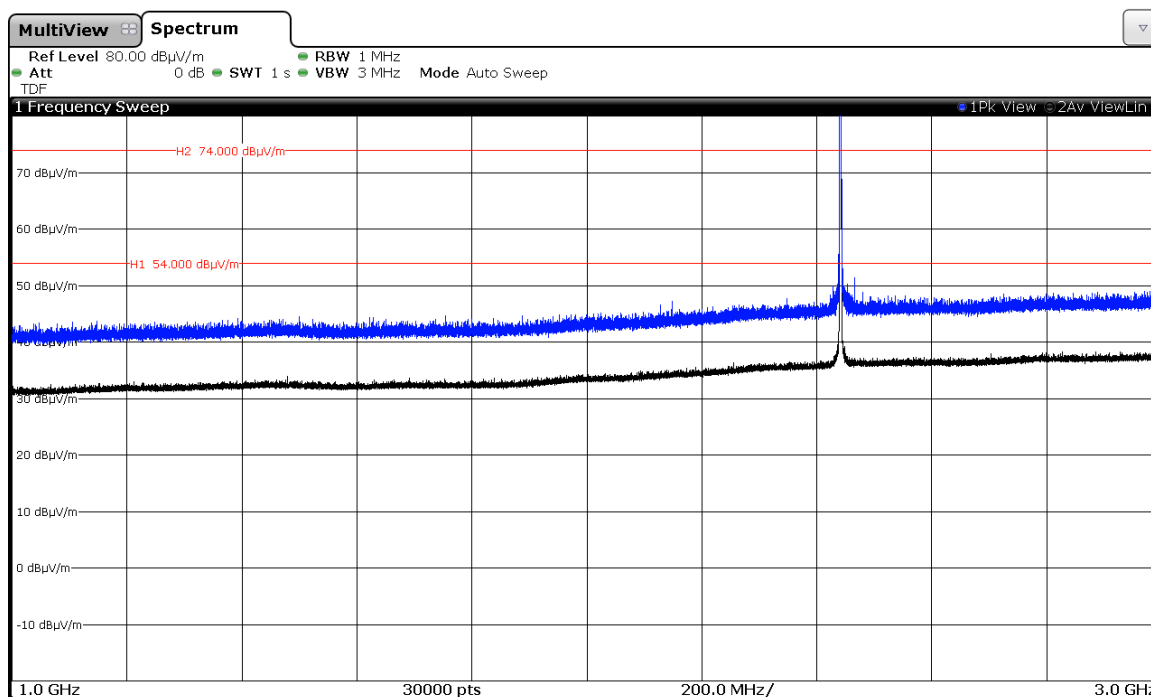
Modulation: 8-DPSK

CHANNEL: Lowest (2402 MHz).



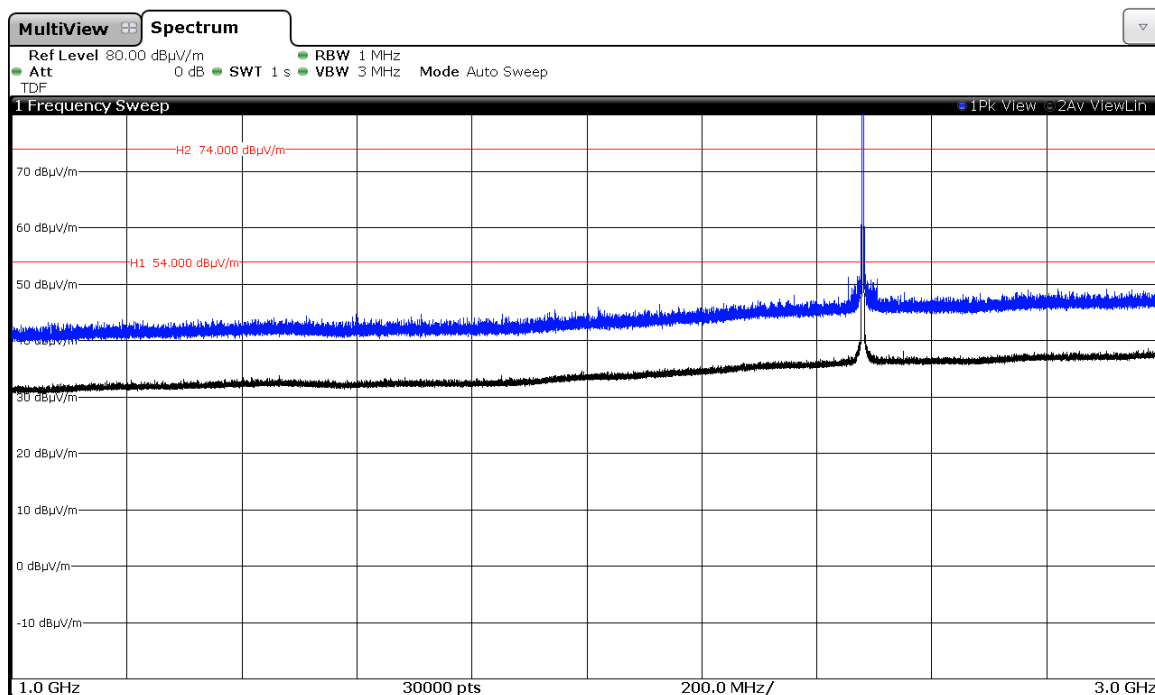
Note: The peak shown in the plot above the limits is the carrier frequency.

CHANNEL: Middle (2441 MHz).



Note: The peak shown in the plot above the limits is the carrier frequency.

CHANNEL: Highest (2480 MHz).

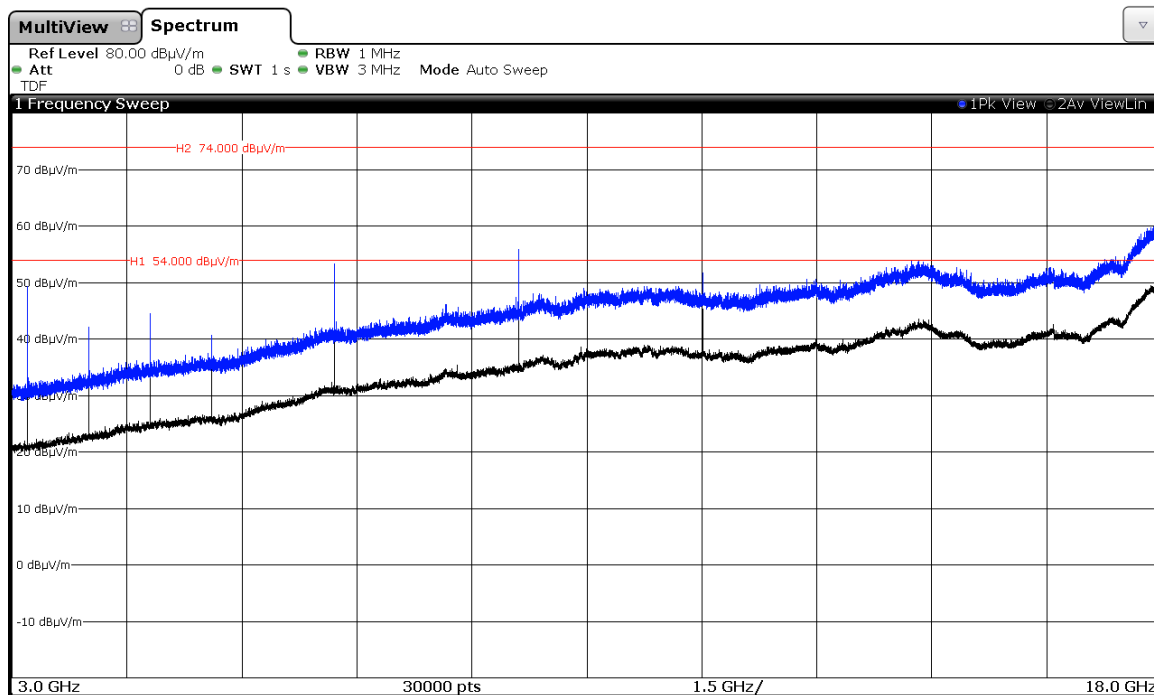


Note: The peak shown in the plot above the limits is the carrier frequency.

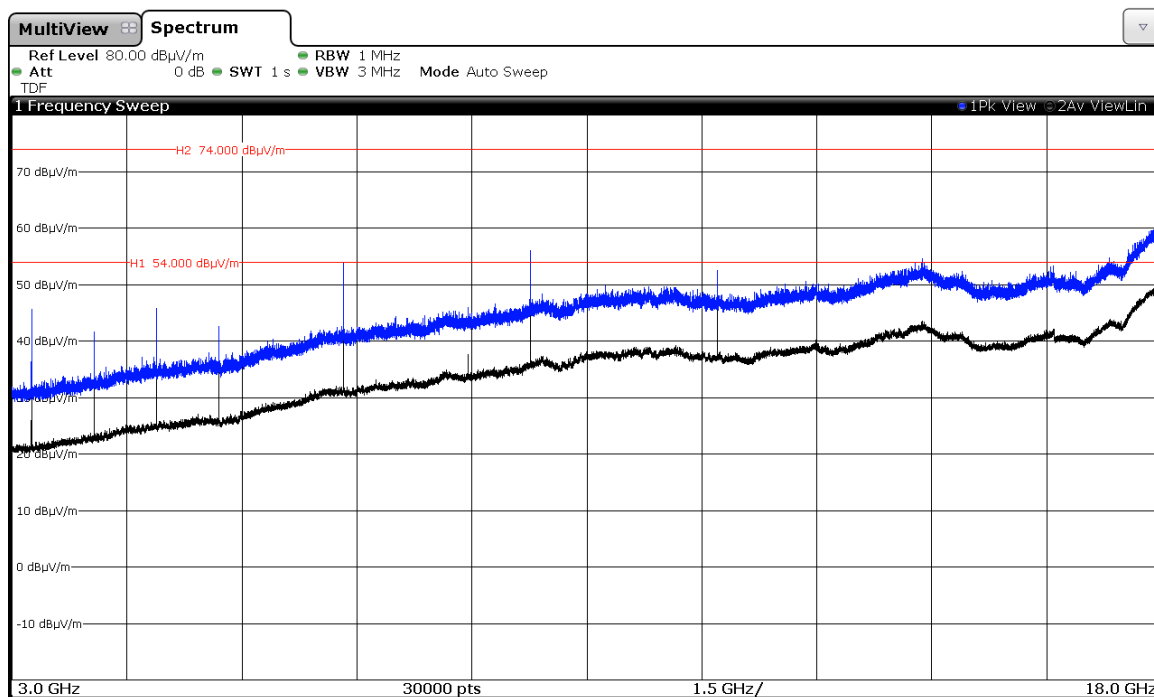
FREQUENCY RANGE 3 GHz to 18 GHz.

Modulation: GFSK

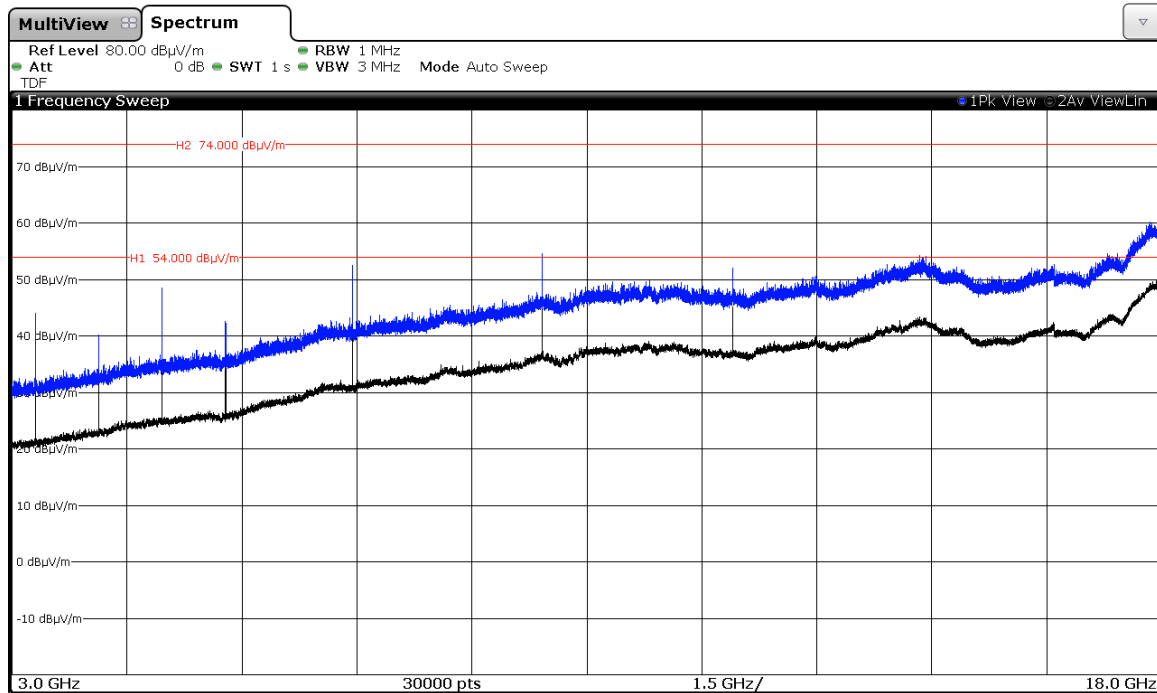
CHANNEL: Lowest (2402 MHz).



CHANNEL: Middle (2441 MHz).

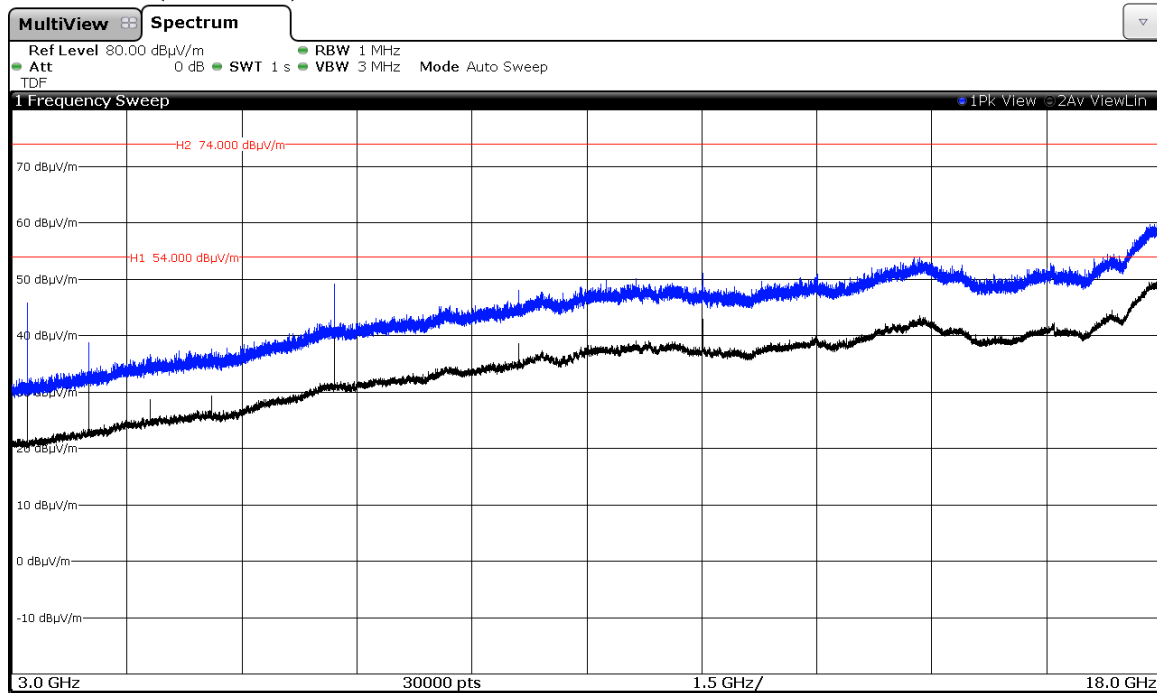


CHANNEL: Highest (2480 MHz).

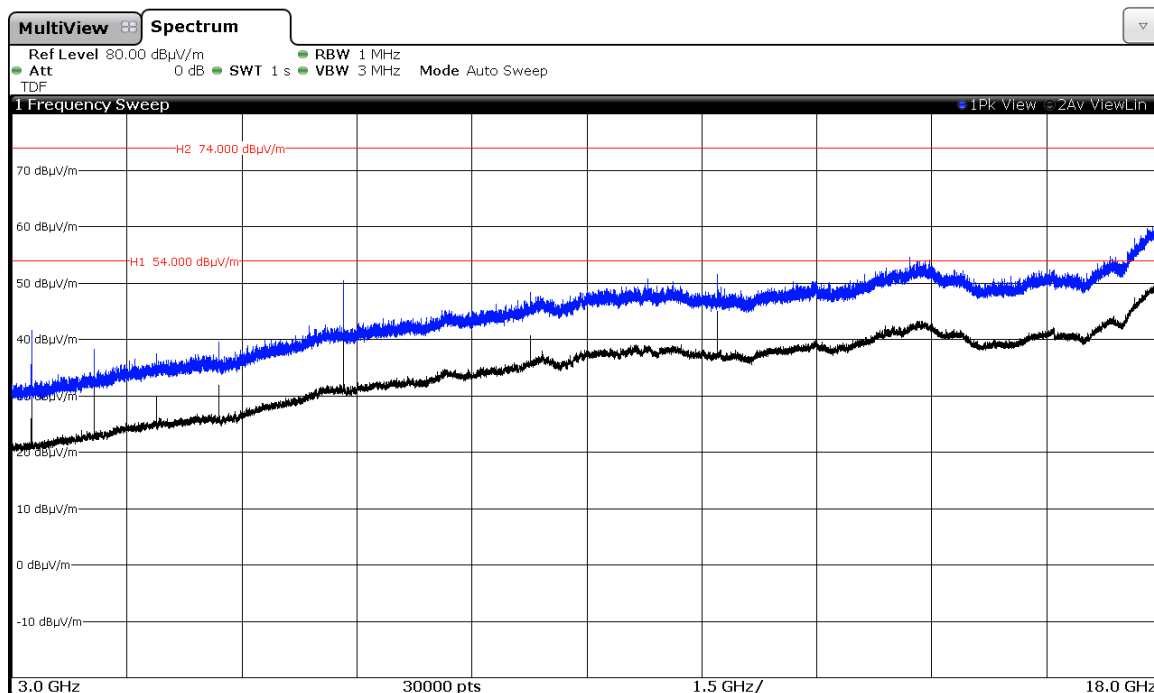


Modulation: $\Pi/4$ -DQPSK

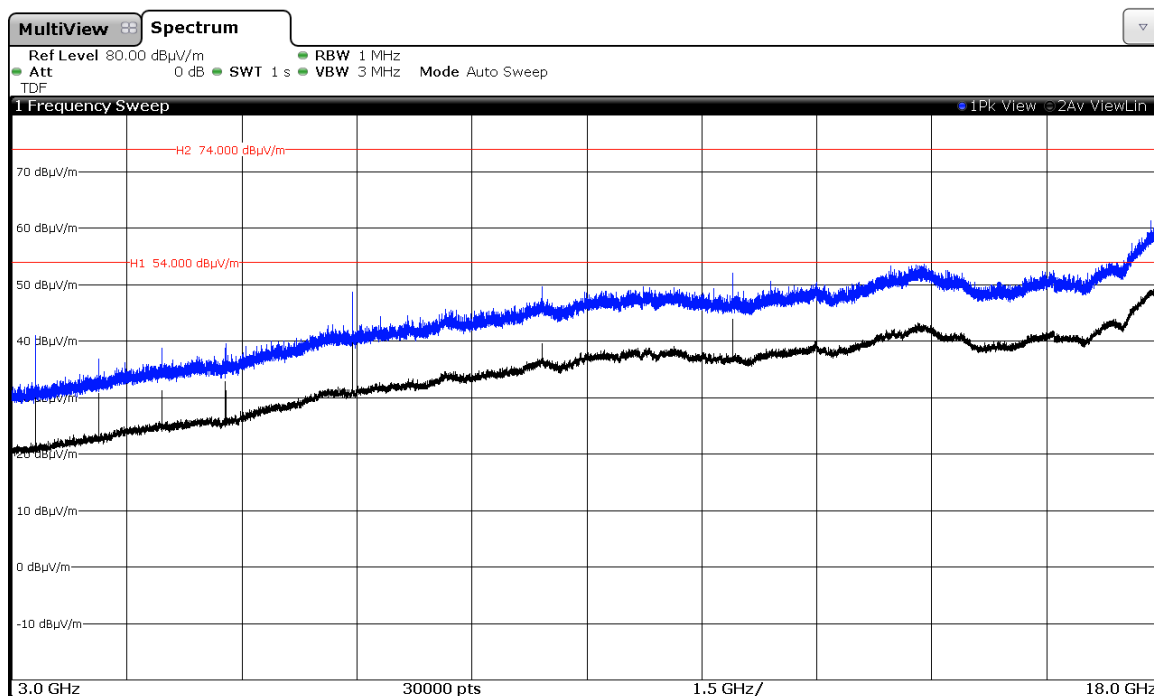
CHANNEL: Lowest (2402 MHz).



CHANNEL: Middle (2441 MHz).

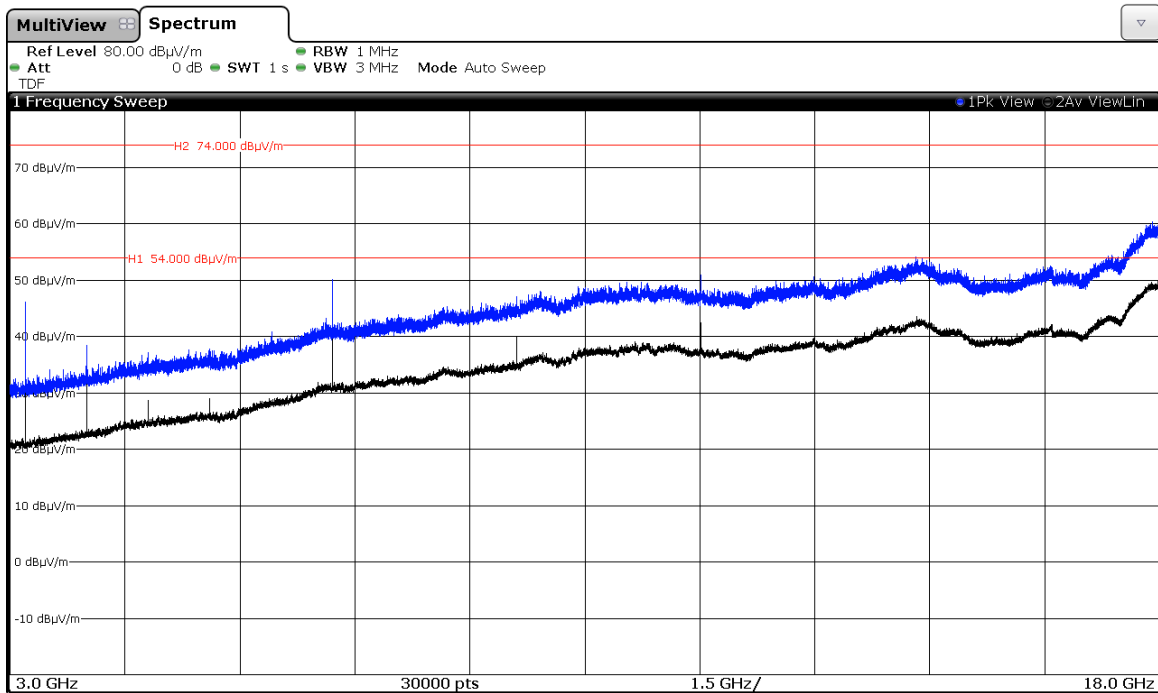


CHANNEL: Highest (2480 MHz).

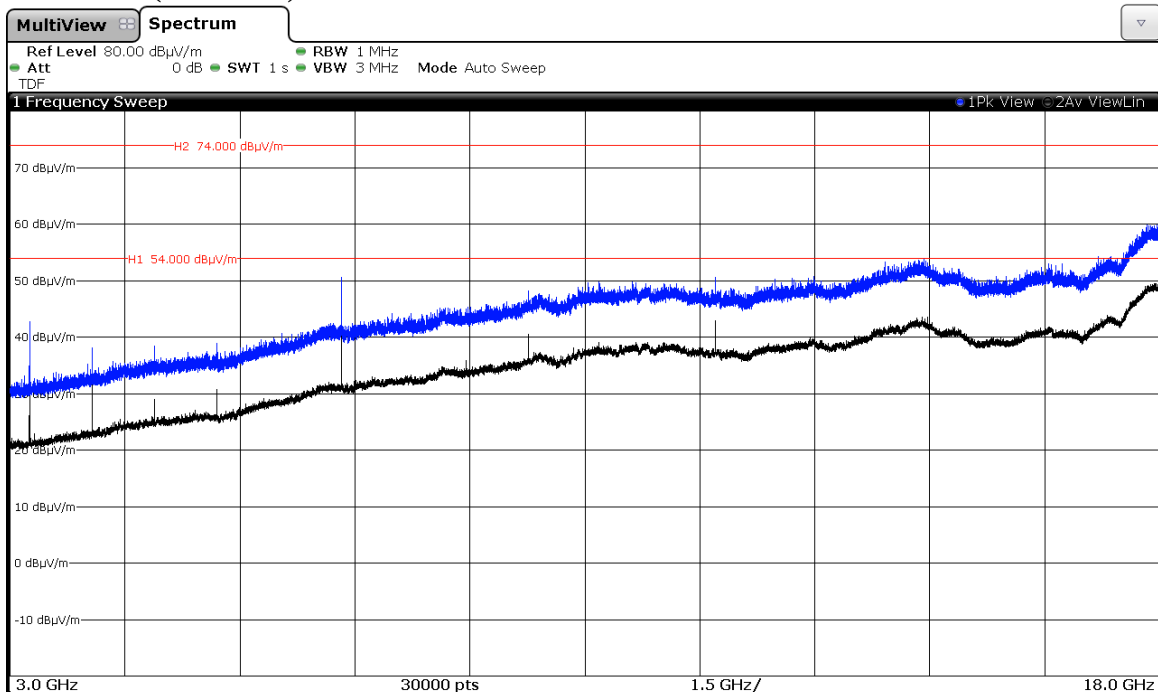


Modulation: 8-DPSK

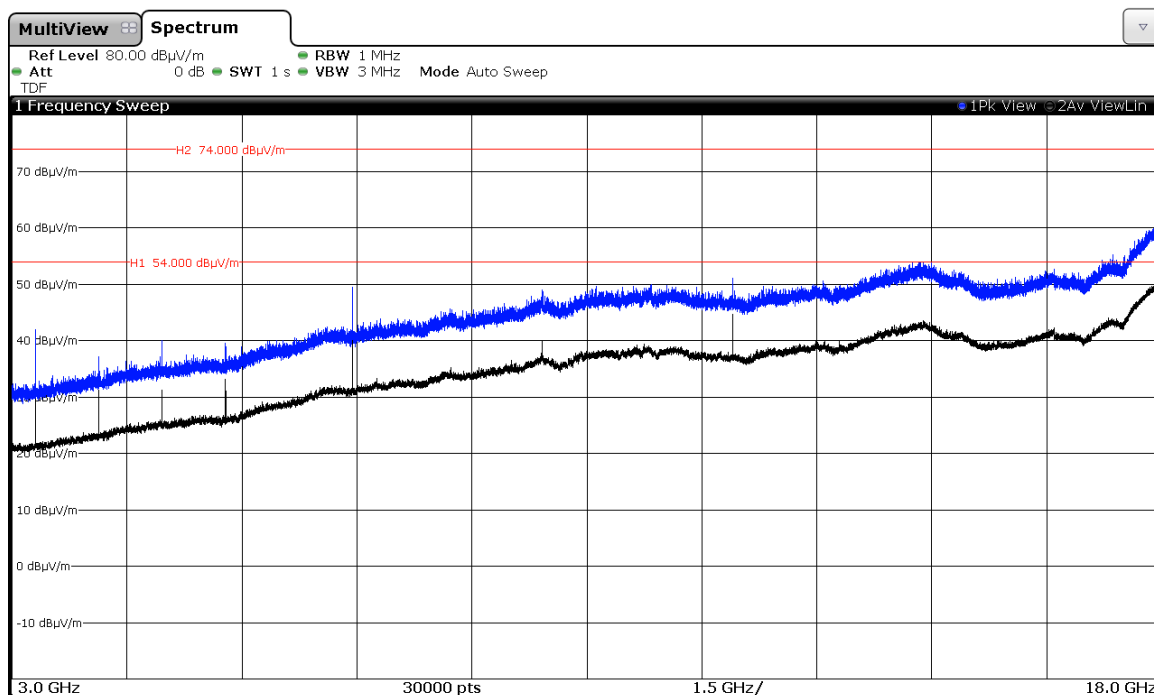
CHANNEL: Lowest (2402 MHz).



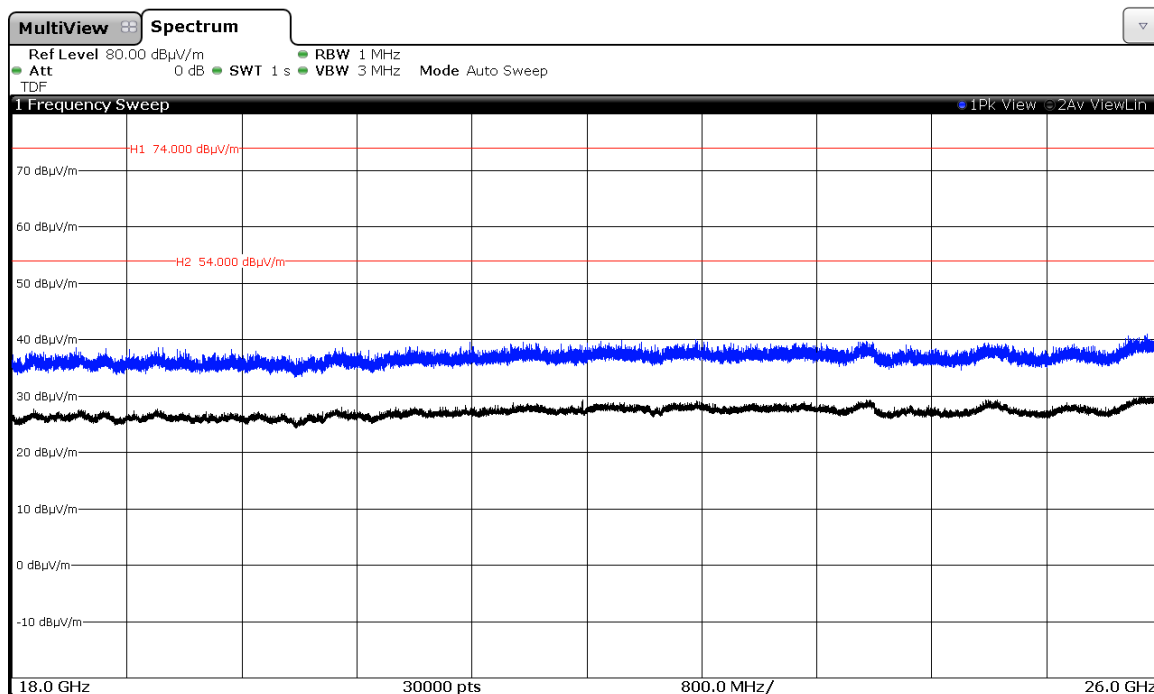
CHANNEL: Middle (2441 MHz).



CHANNEL: Highest (2480 MHz).



FREQUENCY RANGE 18 GHz to 26 GHz.

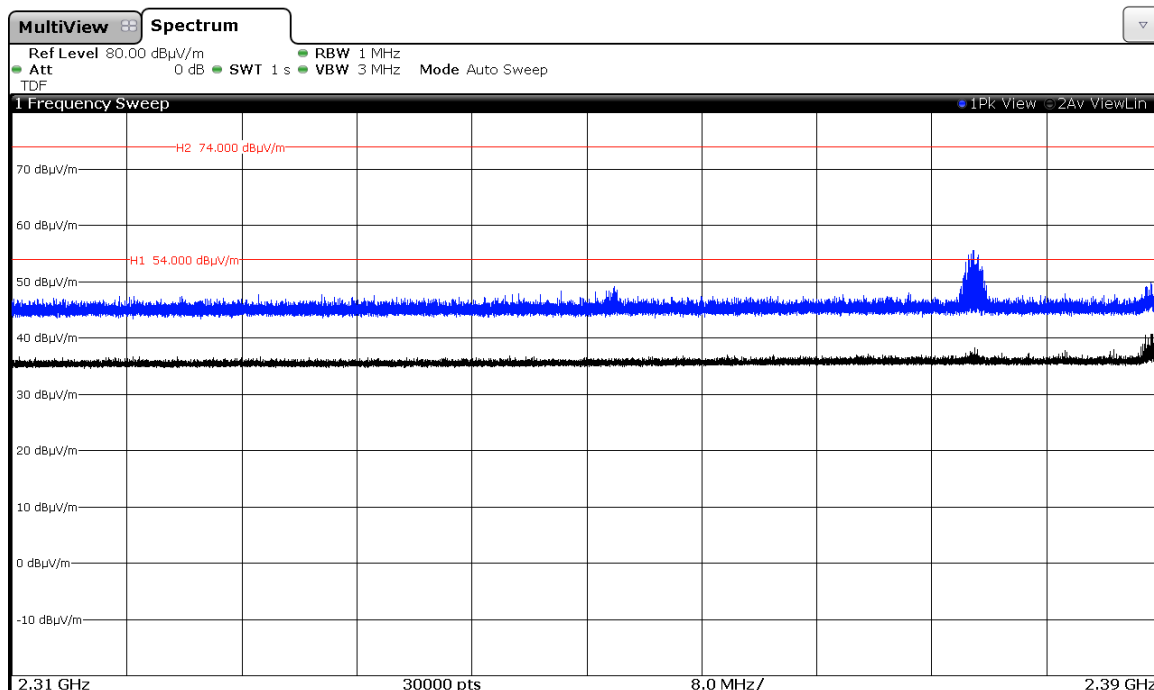


(This plot is valid for all three channels and for all modulations).

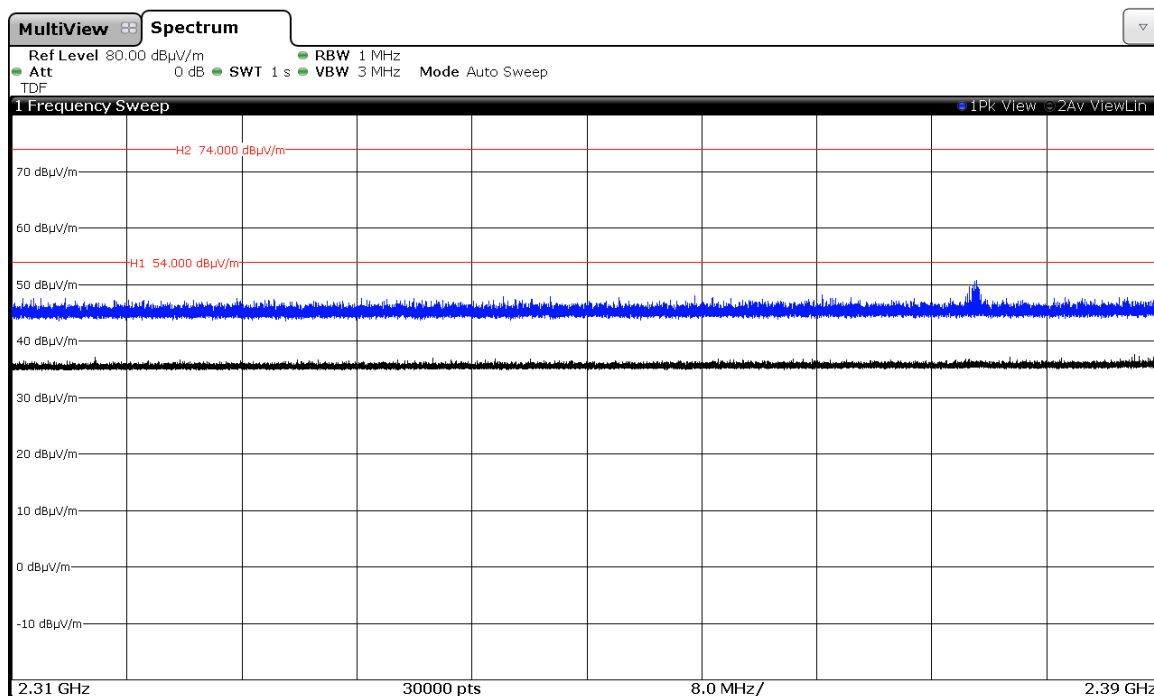
FREQUENCY RANGE 2.31 GHz to 2.39 GHz. (RESTRICTED BAND)

CHANNEL: Lowest

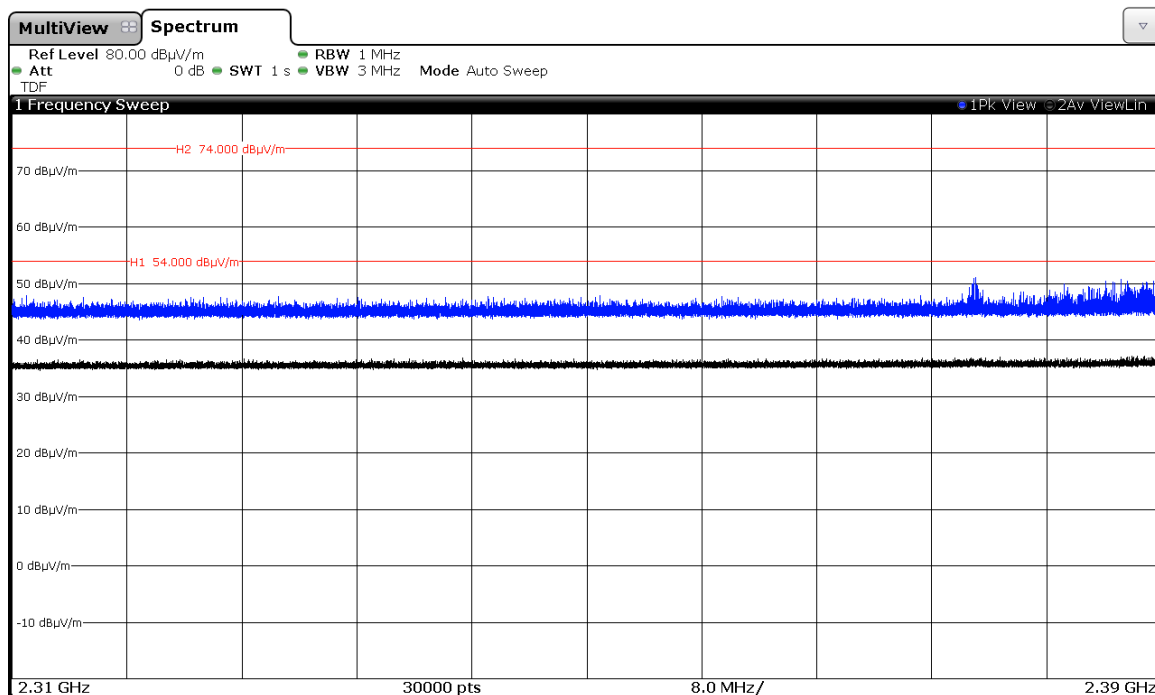
Modulation: GFSK



Modulation: $\Pi/4$ -DQPSK

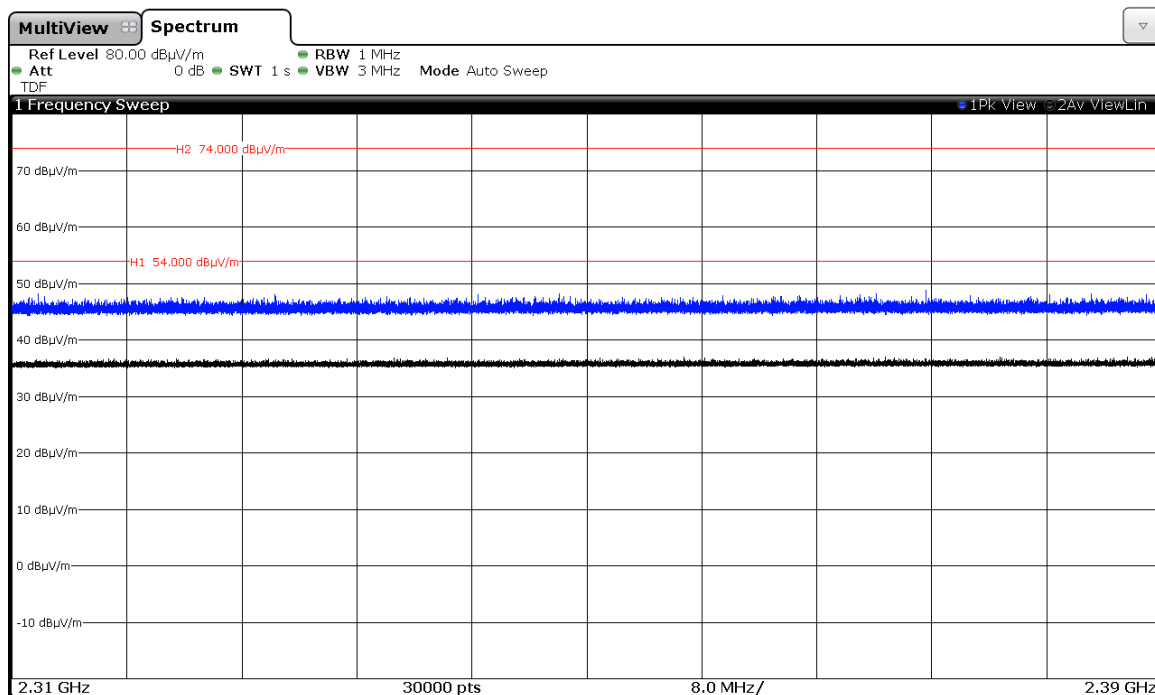


Modulation: 8-DPSK

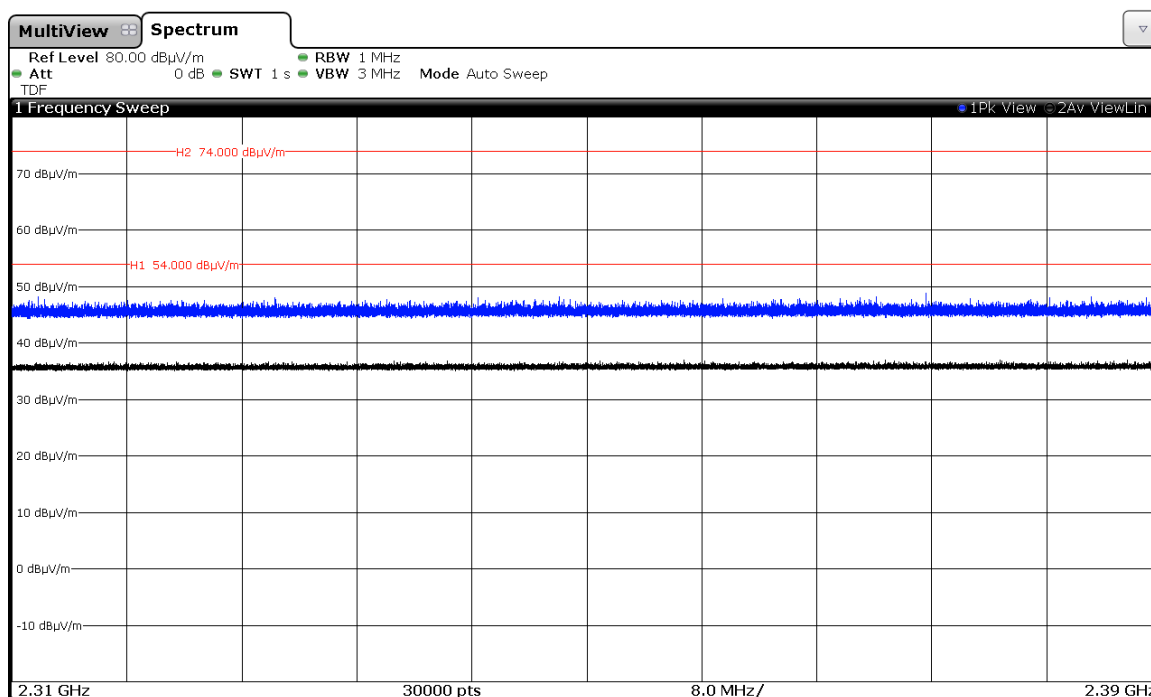


CHANNEL: Middle

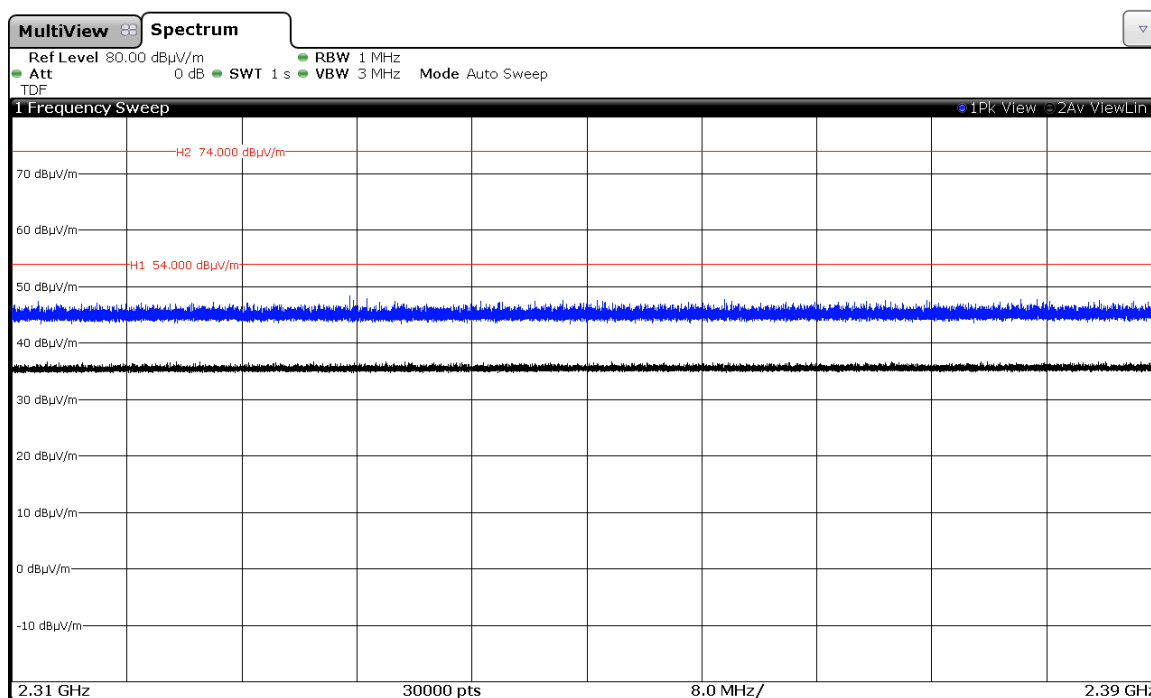
Modulation: GFSK



Modulation: $\Pi/4$ -DQPSK

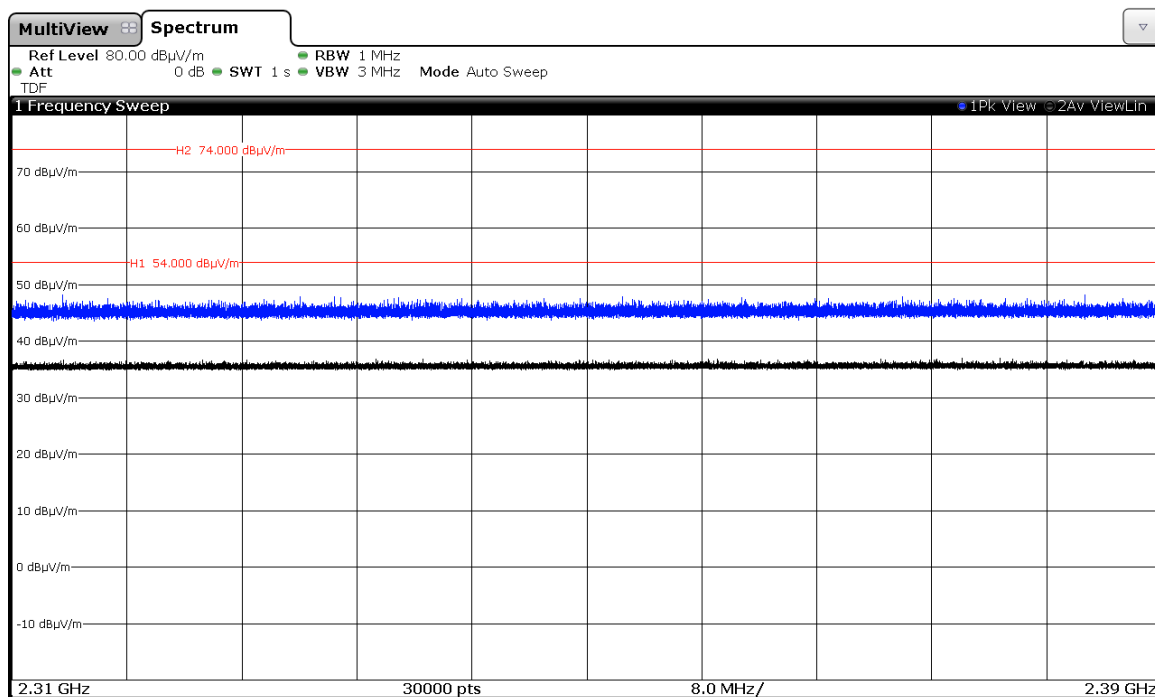


Modulation: 8-DPSK

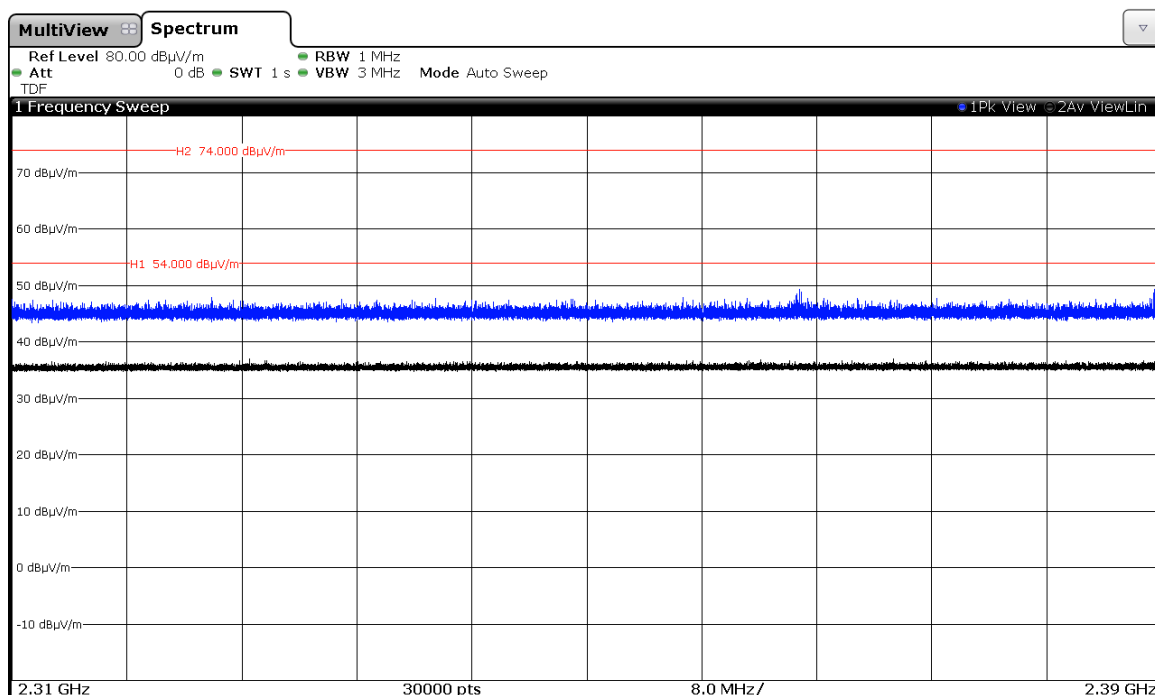


CHANNEL: Highest

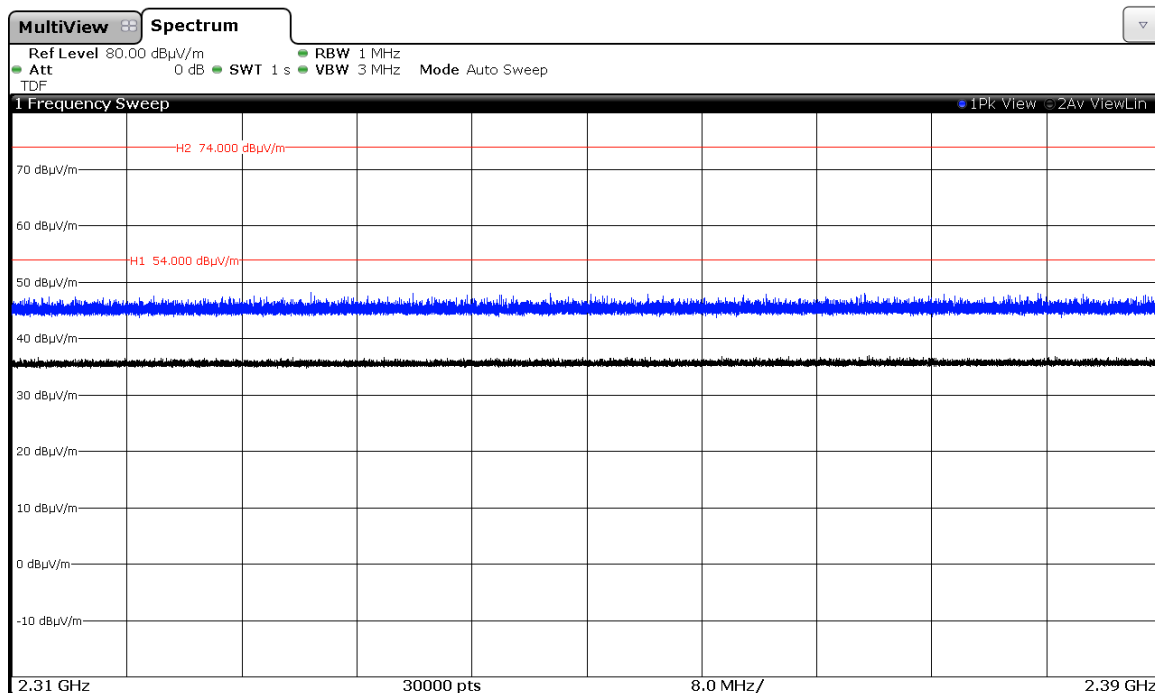
Modulation: GFSK



Modulation: Π/4-DQPSK



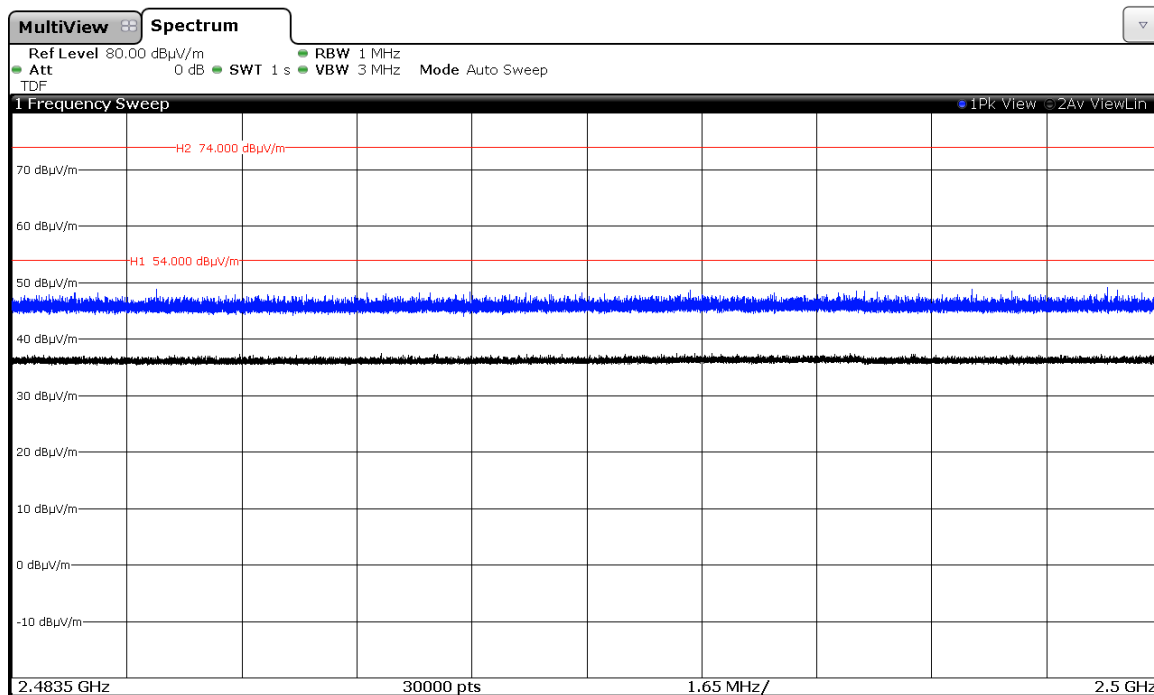
Modulation: 8-DPSK



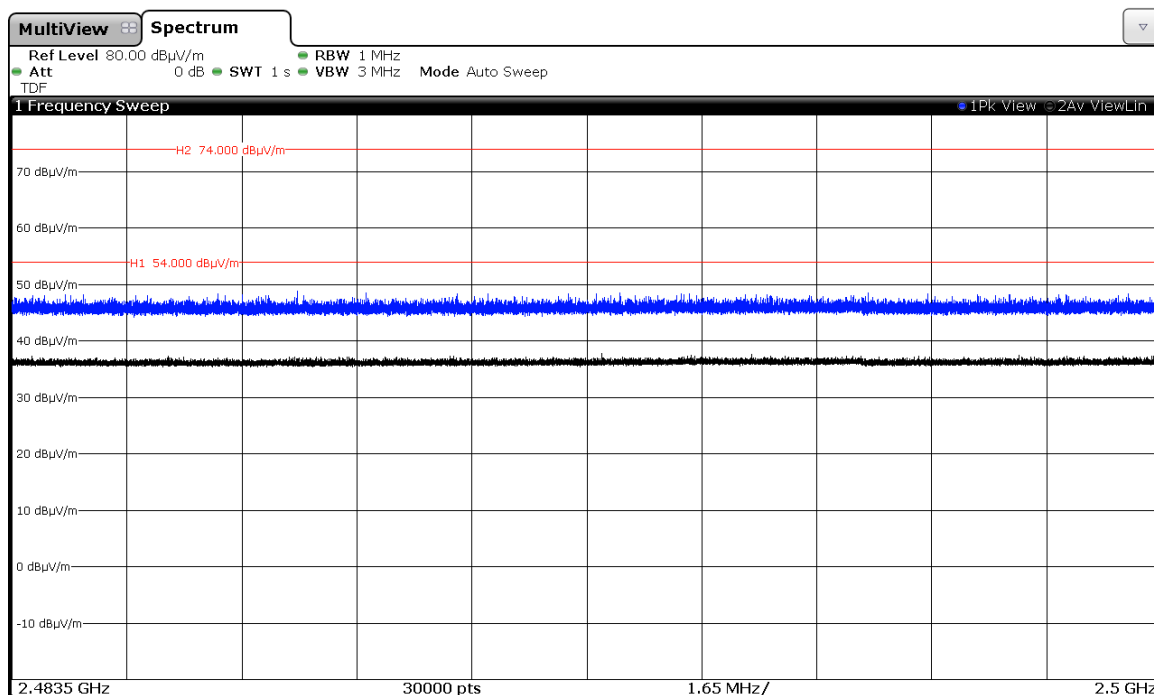
FREQUENCY RANGE 2.4835 GHz to 2.5 GHz. (RESTRICTED BAND)

CHANNEL: Lowest

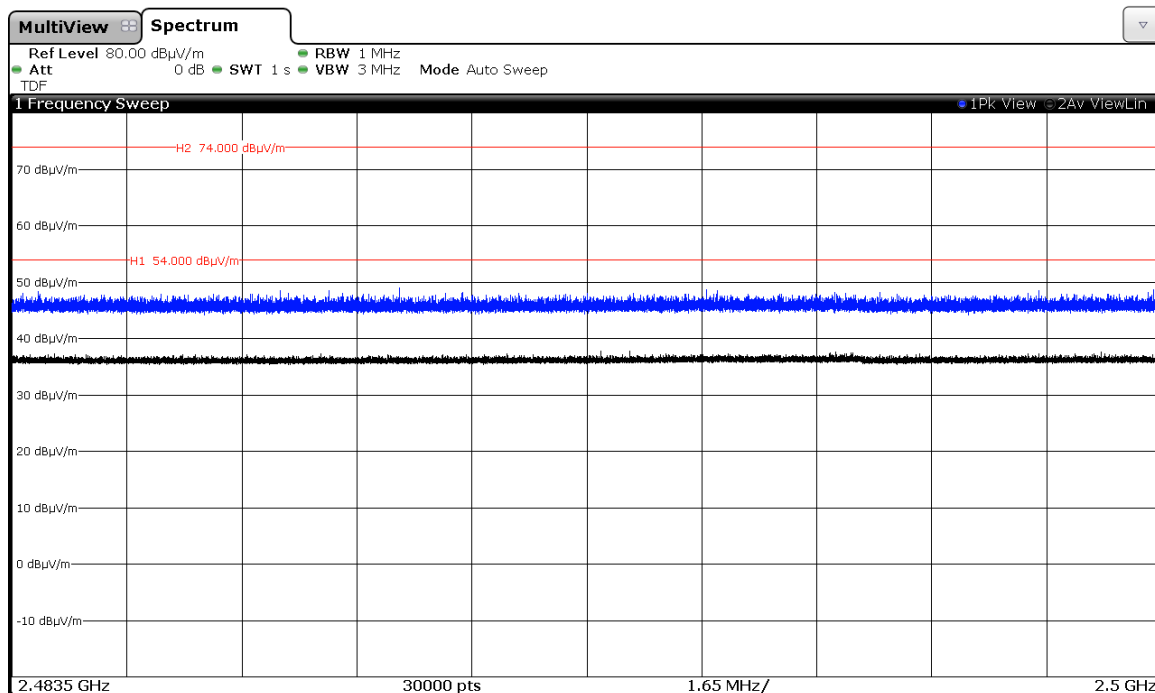
Modulation: GFSK



Modulation: $\Pi/4$ -DQPSK

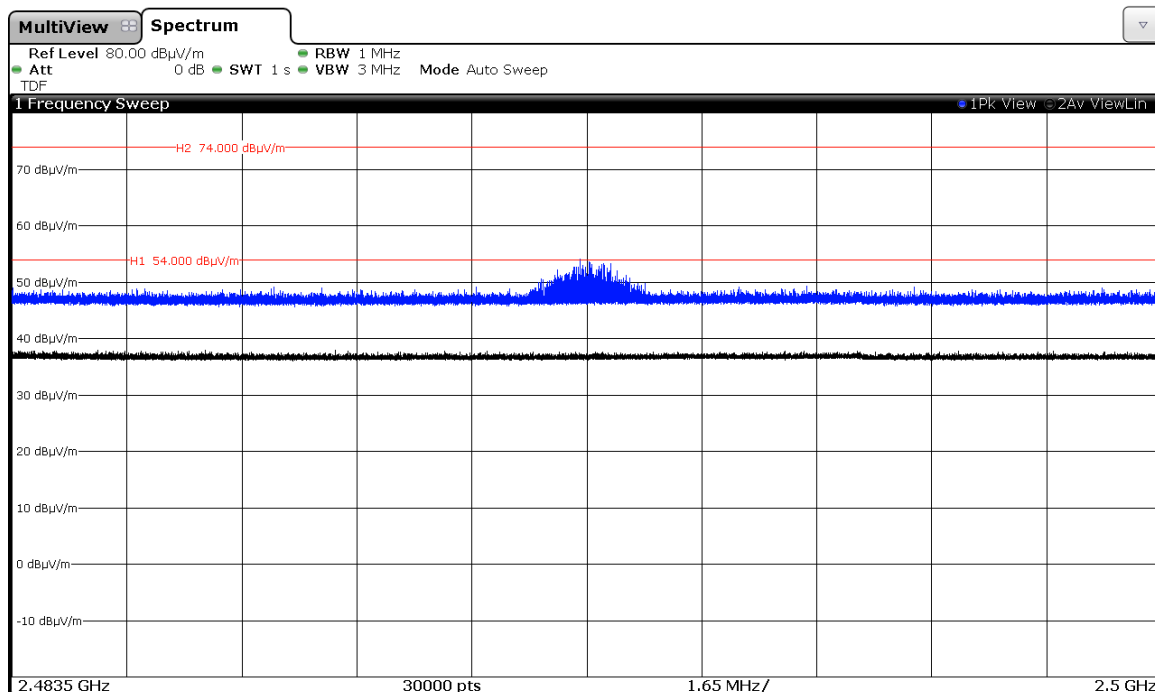


Modulation: 8-DPSK

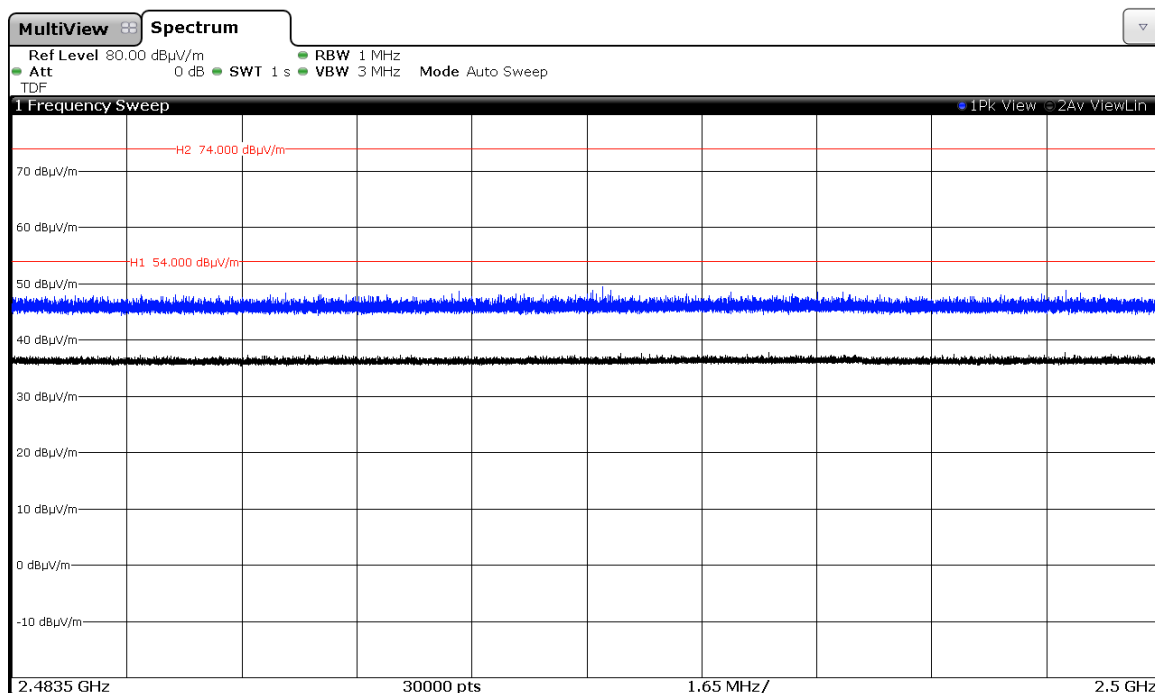


CHANNEL: Middle

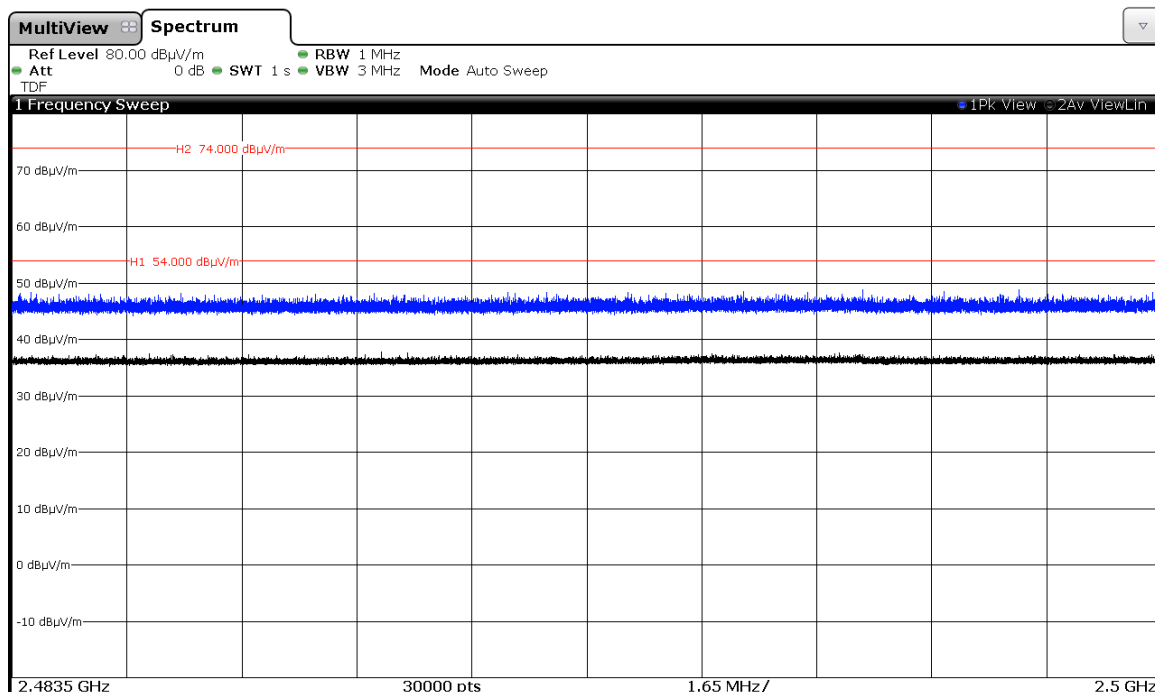
Modulation: GFSK



Modulation: $\Pi/4$ -DQPSK

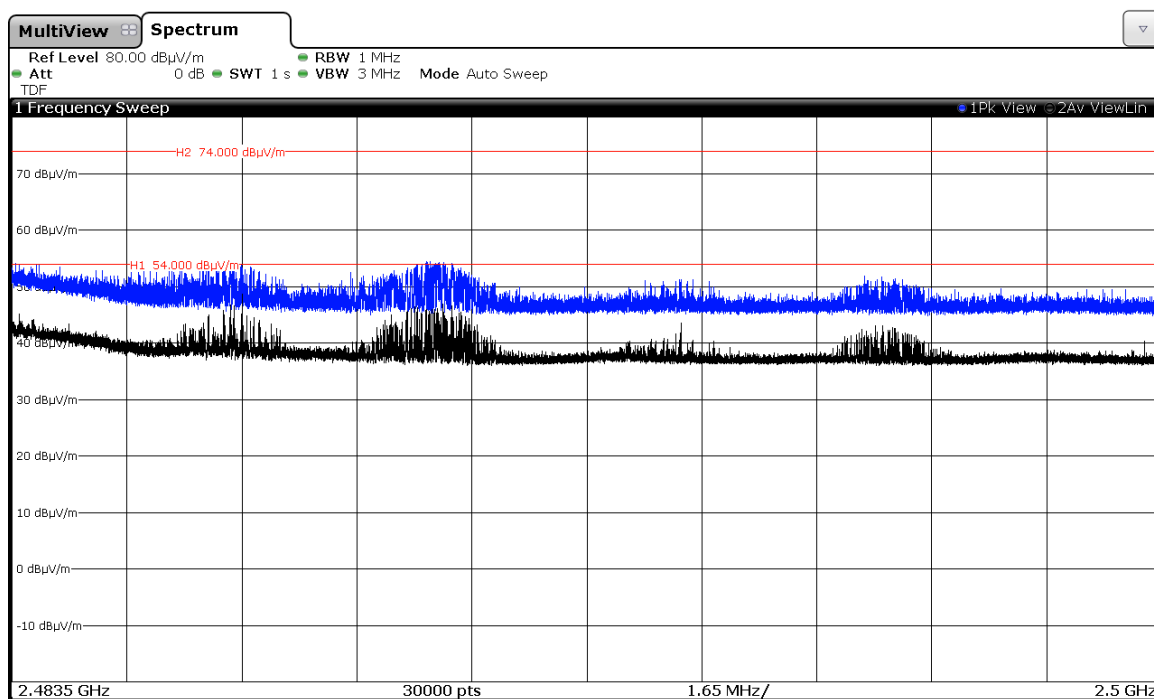


Modulation: 8-DPSK

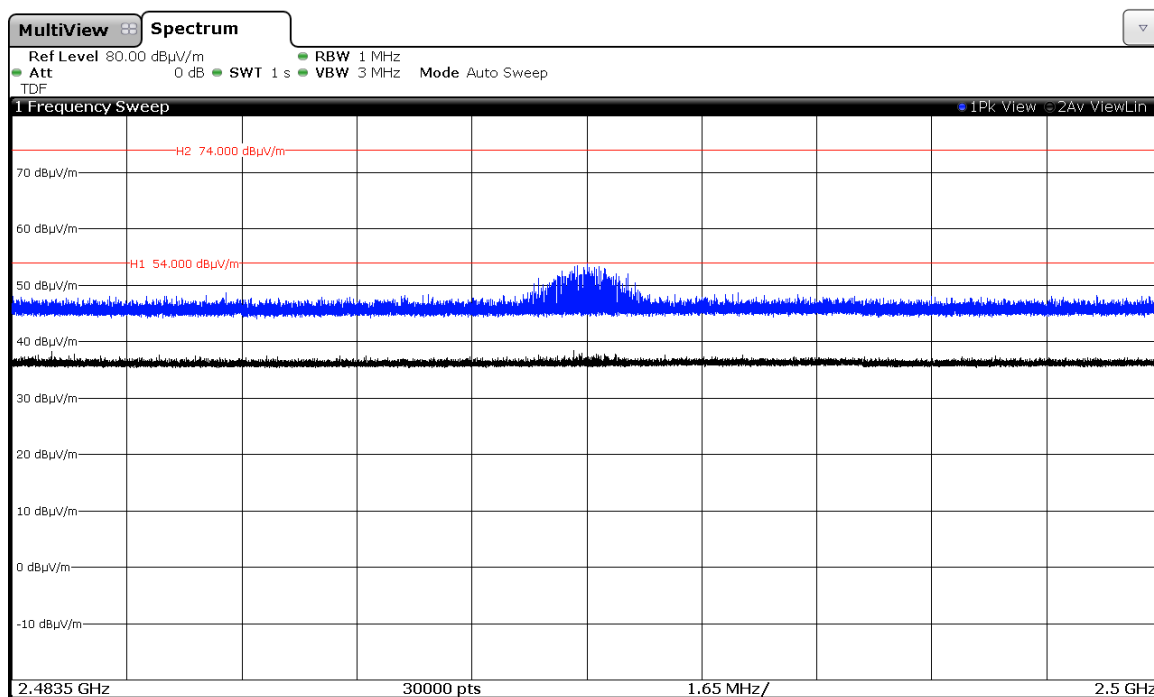


CHANNEL: Highest

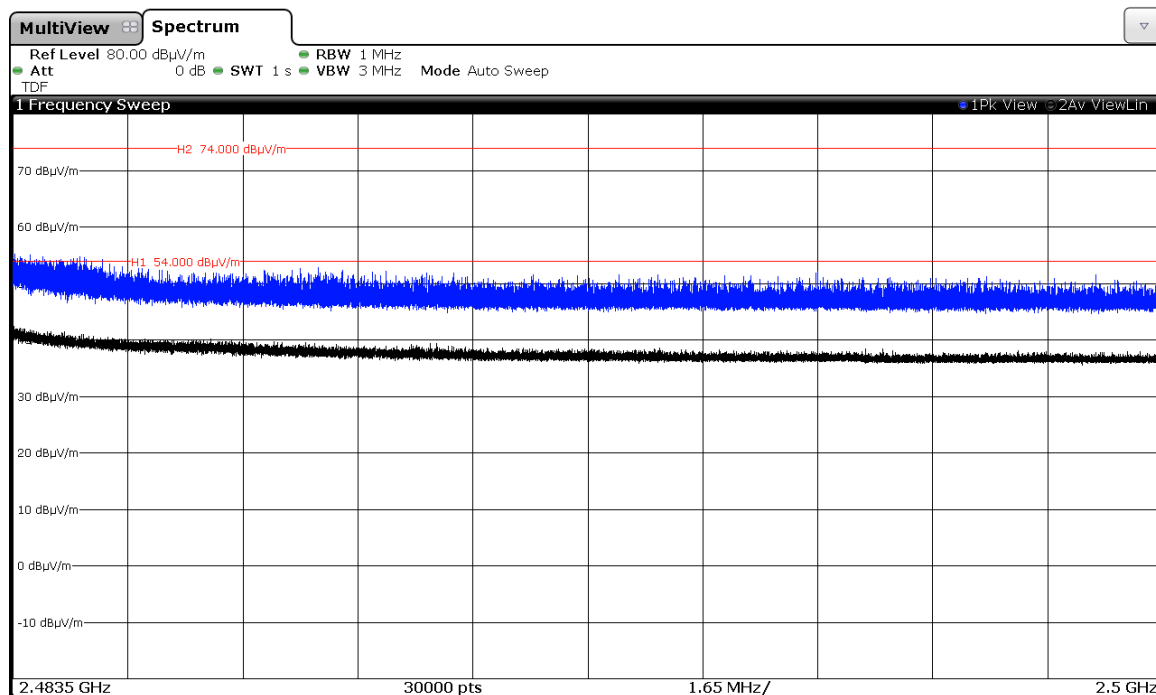
Modulation: GFSK



Modulation: Π/4-DQPSK



Modulation: 8-DPSK



Appendix B – Test result “WiFi 2.4 GHz (802.11b/g/n20/n40)”

INDEX

TEST CONDITIONS	87
Occupied Bandwidth	90
Section 15.247 Subclause (a) (2). 6 dB Bandwidth	97
Section 15.247 Subclause (b). Maximum output power and antenna gain	104
Section 15.247 Subclause (d). Emission limitations conducted (Transmitter)	108
Section 15.247 Subclause (d). Band-edge emissions compliance (Transmitter)	117
Section 15.247 Subclause (e). Power spectral density	121
Section 15.247 Subclause (d). Emission limitations radiated (Transmitter)	129

TEST CONDITIONS

Power supply (V):

$$V_{\text{nominal}} = 3.7 \text{ Vdc}$$

Type of power supply = DC voltage from battery.

Type of antenna = Integral antenna.

Declared Gain for antenna (maximum) = +3.70 dBi

TEST FREQUENCIES:

For WiFi 802.11b/g/n20:

Lowest channel (1): 2412 MHz

Middle channel (6): 2437 MHz

Highest channel (11): 2462 MHz

For WiFi 802.11n40:

Lowest channel (3): 2422 MHz

Middle channel (6): 2437 MHz

Highest channel (9): 2452 MHz

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016.

The Software of EUT was used to configure to continuously transmit at a specified output power in all channels with different modes and modulation schemes.

WiFi 2.4 GHz	WIFI Tool: TX Power (dBm)
802.11b	15
802.11g	13
802.11n20	12
802.11n40	11

The field strength at the band edges was evaluated for each mode for the channel under test.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

The data rates of 1Mb/s for 802.11b, 6Mb/s for 802.11g, MSC0 for 802.11n20 and MSC0 for 802.11n40 were selected based on preliminary testing that identified those rates corresponding to the worst cases for output power and band edge levels at restricted bands.

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is directly connected to the spectrum analyzer.



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 1m for the frequency range 1 GHz-25 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40 GHz horn antenna).

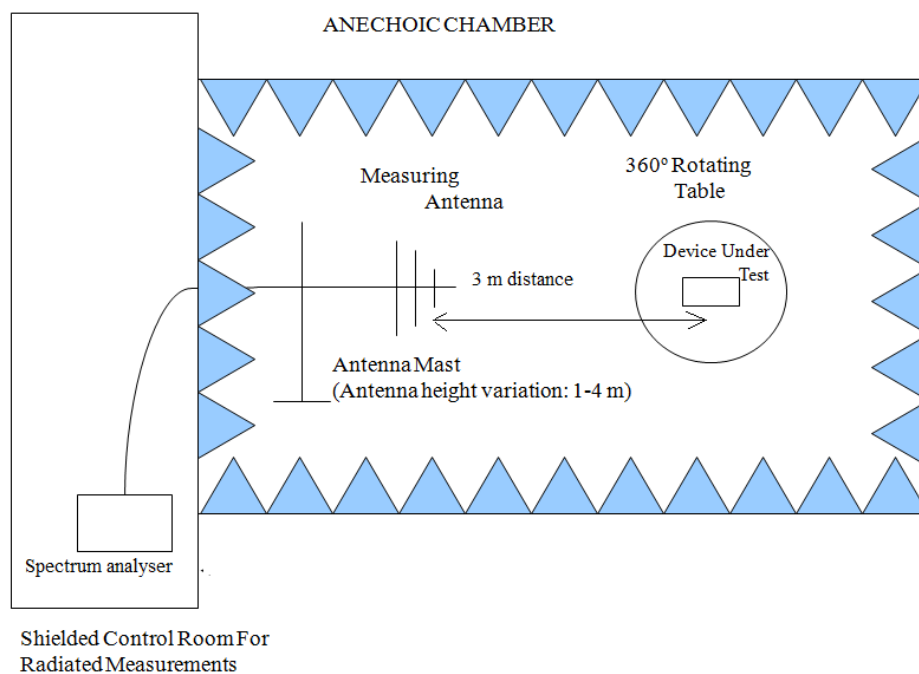
For radiated emissions in the range 1 GHz-25 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform 1.5 meter above the ground plane and the situation and orientation was varied to find the maximum radiated emission.

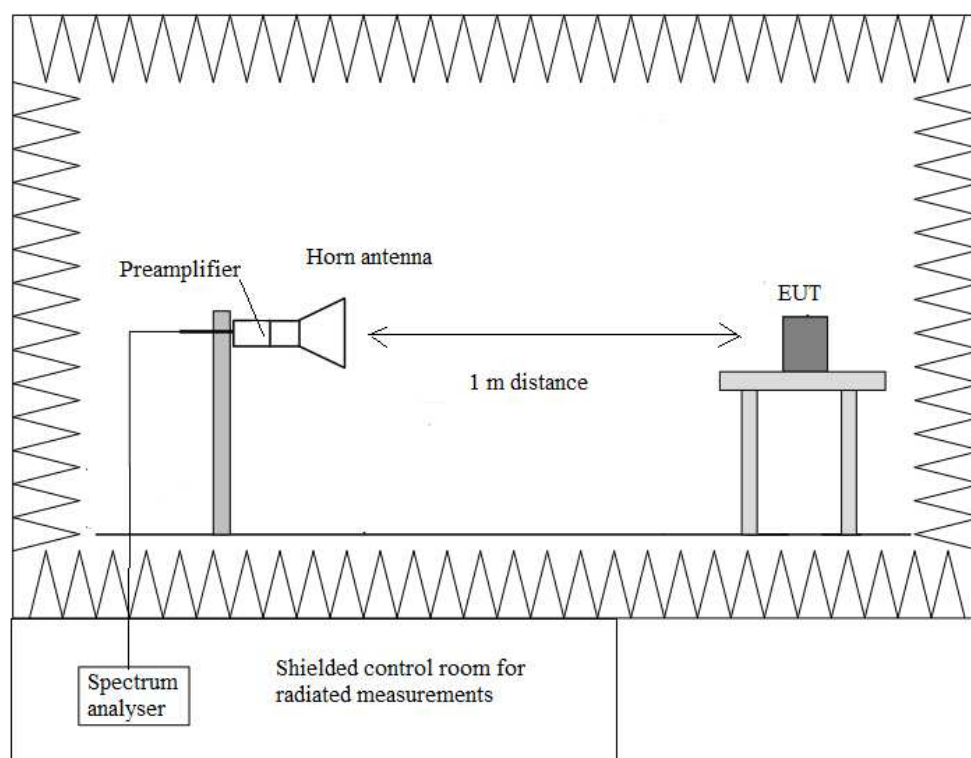
It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

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

(see next plots)

Mode B

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
99% bandwidth (MHz)	14.626	14.617	14.654
-26 dBc bandwidth (MHz)	18.261	18.253	18.274
Measurement uncertainty (kHz)	<±50		

Mode G

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
99% bandwidth (MHz)	17.342	17.164	17.199
-26 dBc bandwidth (MHz)	29.519	30.114	29.412
Measurement uncertainty (kHz)	<±66.66		

Mode N20

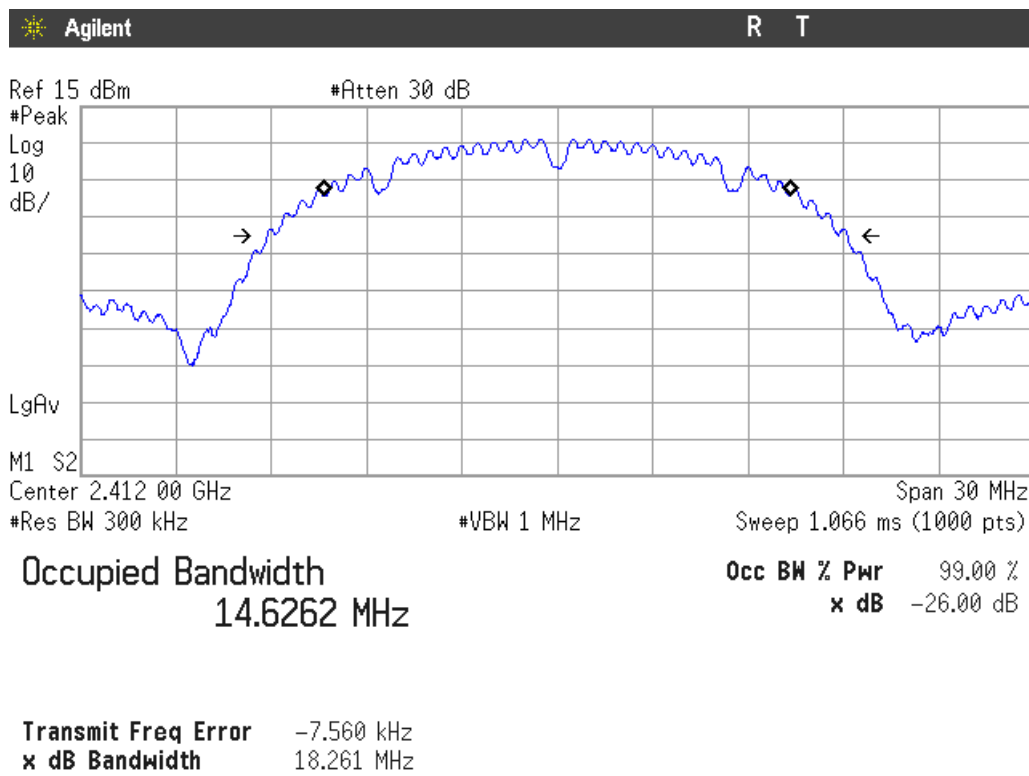
	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
99% bandwidth (MHz)	18.197	18.011	18.001
-26 dBc bandwidth (MHz)	27.698	28.527	28.074
Measurement uncertainty (kHz)	<±66.66		

Mode N40

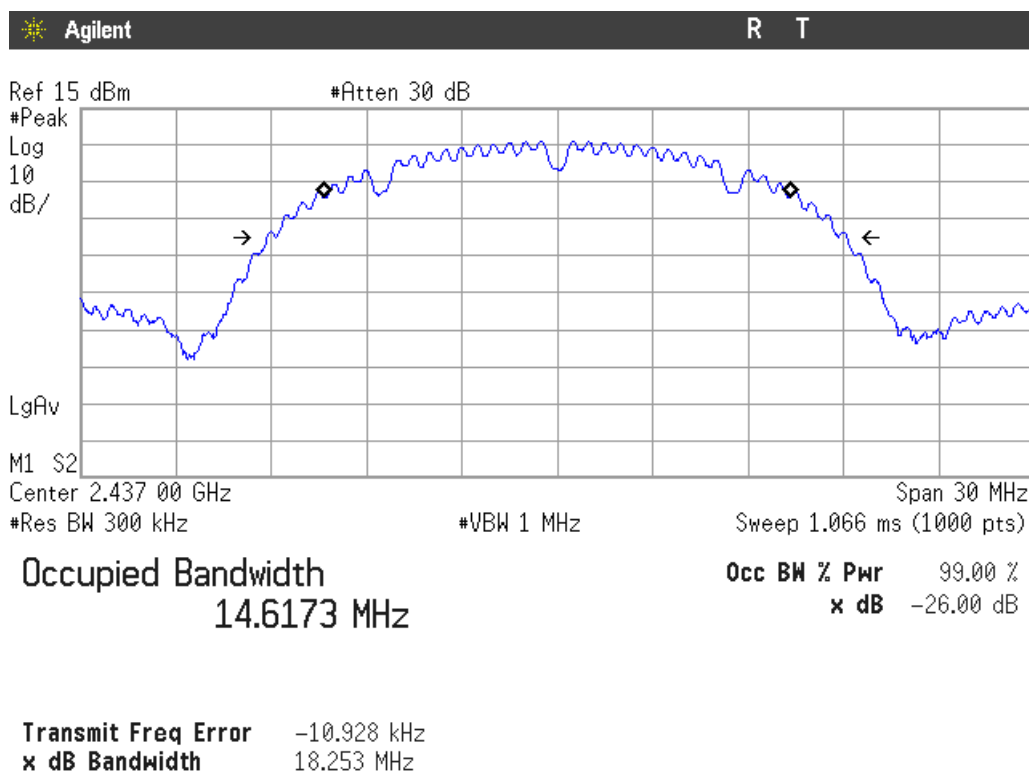
	Lowest frequency 2422 MHz	Middle frequency 2437 MHz	Highest frequency 2452 MHz
99% bandwidth (MHz)	36.032	36.077	35.973
-26 dBc bandwidth (MHz)	46.321	45.489	45.633
Measurement uncertainty (kHz)	<±108.33		

Mode B

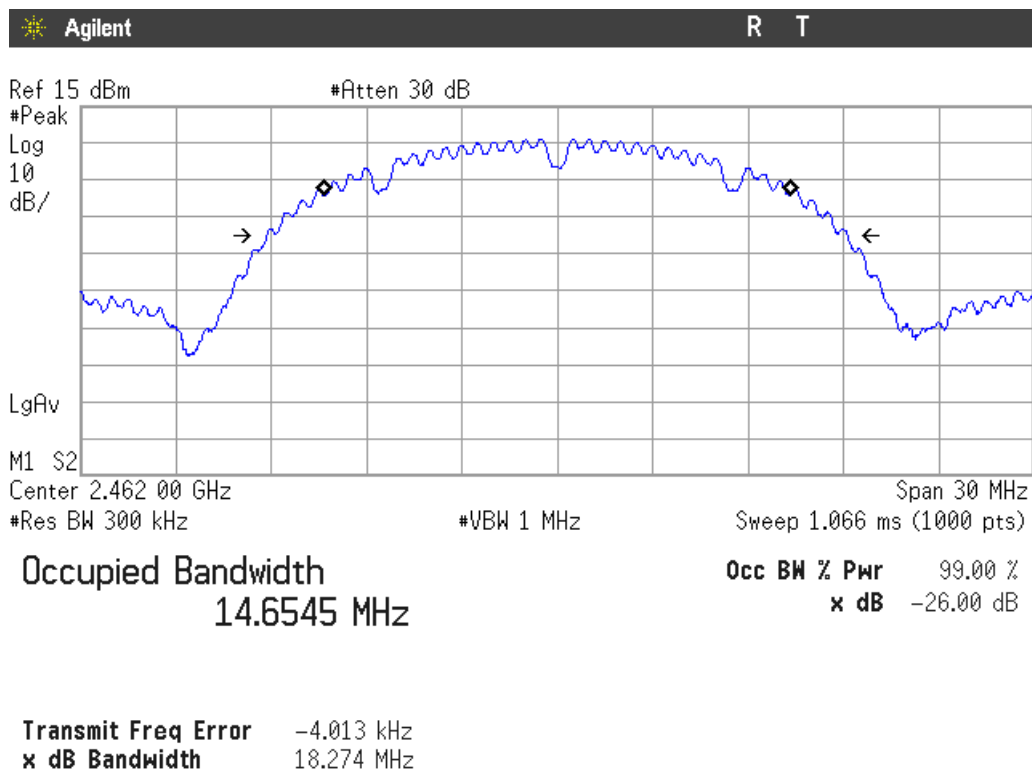
Lowest Channel



Middle Channel

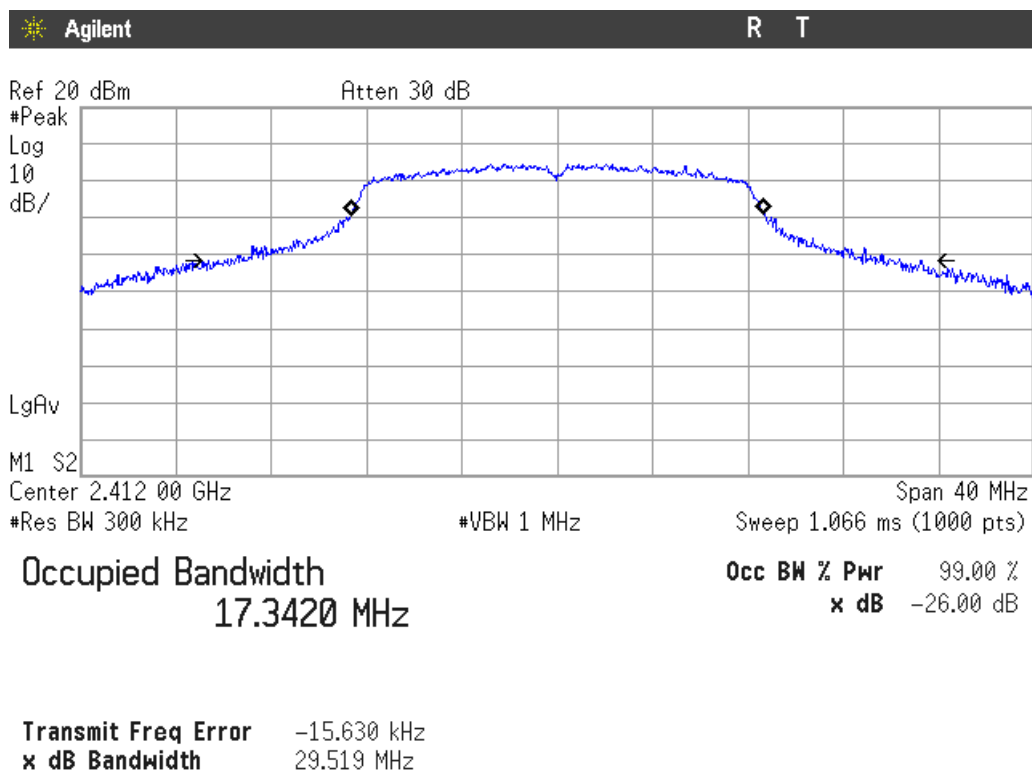


Highest channel

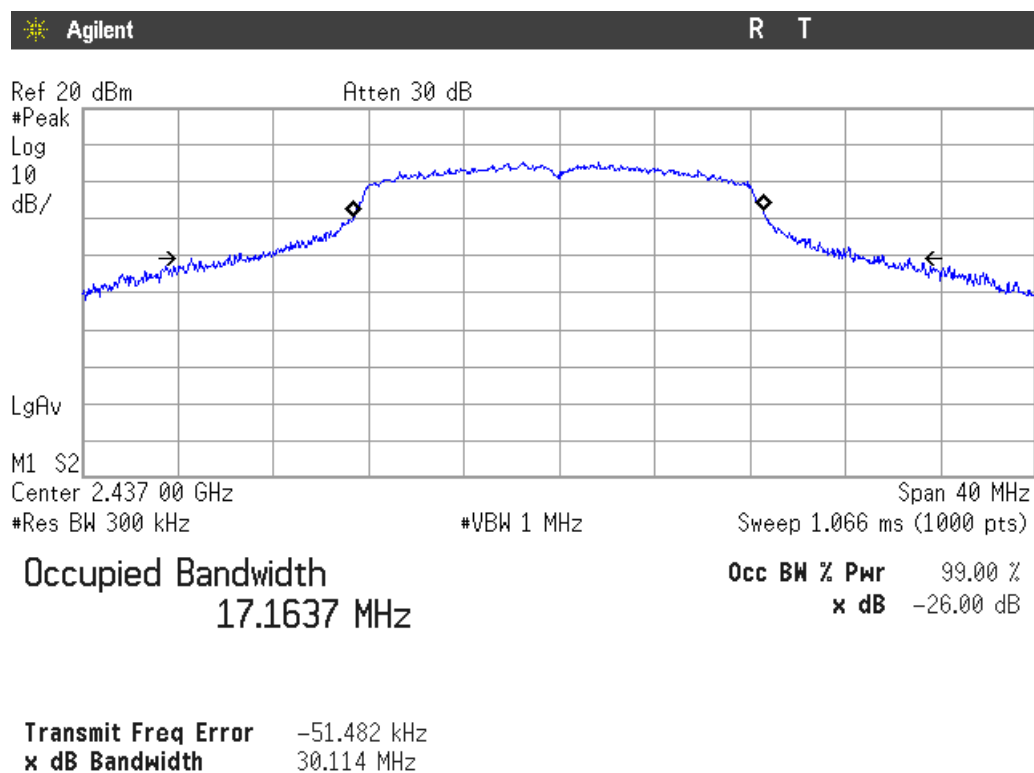


Mode G

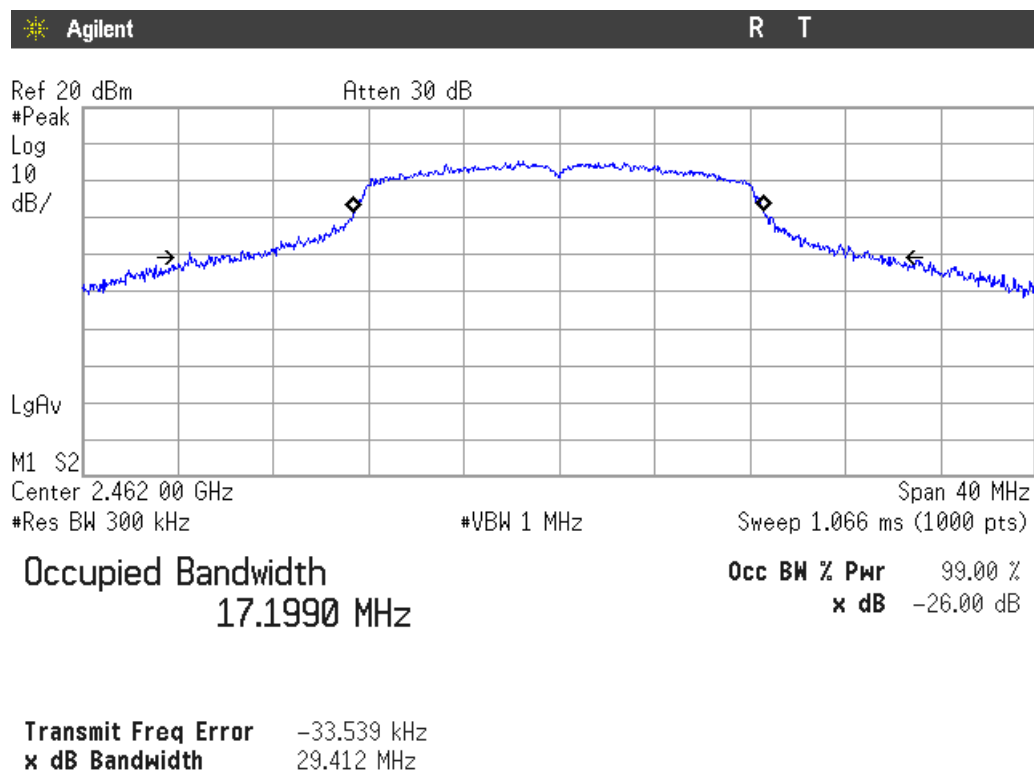
Lowest Channel



Middle Channel

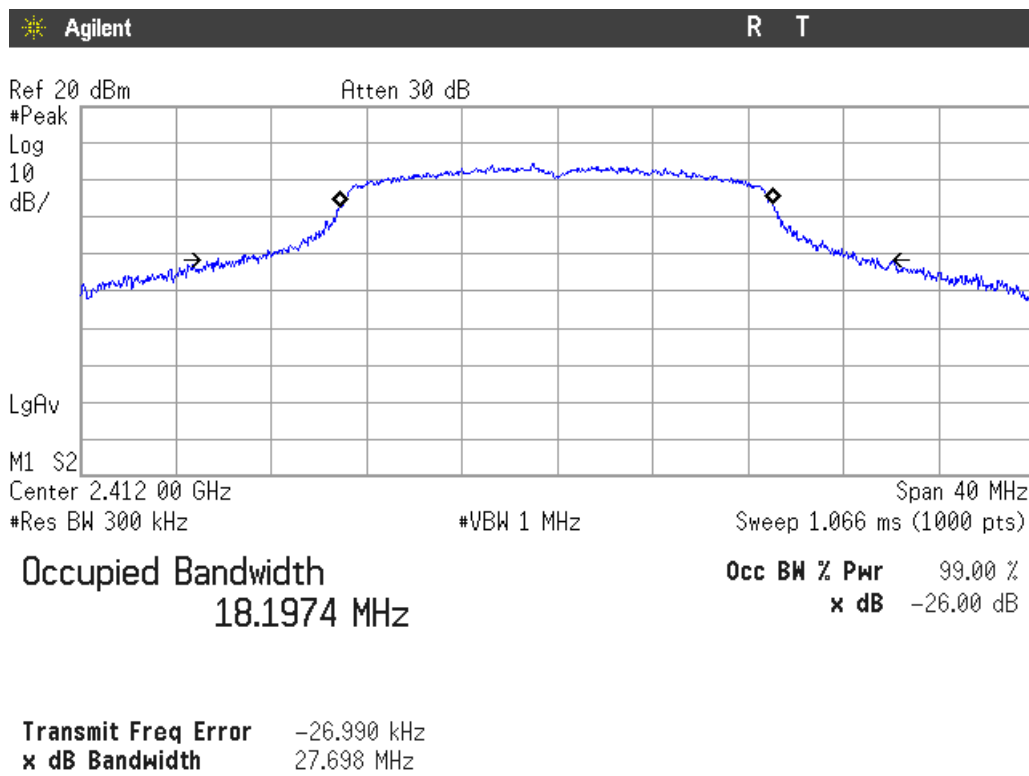


Highest channel

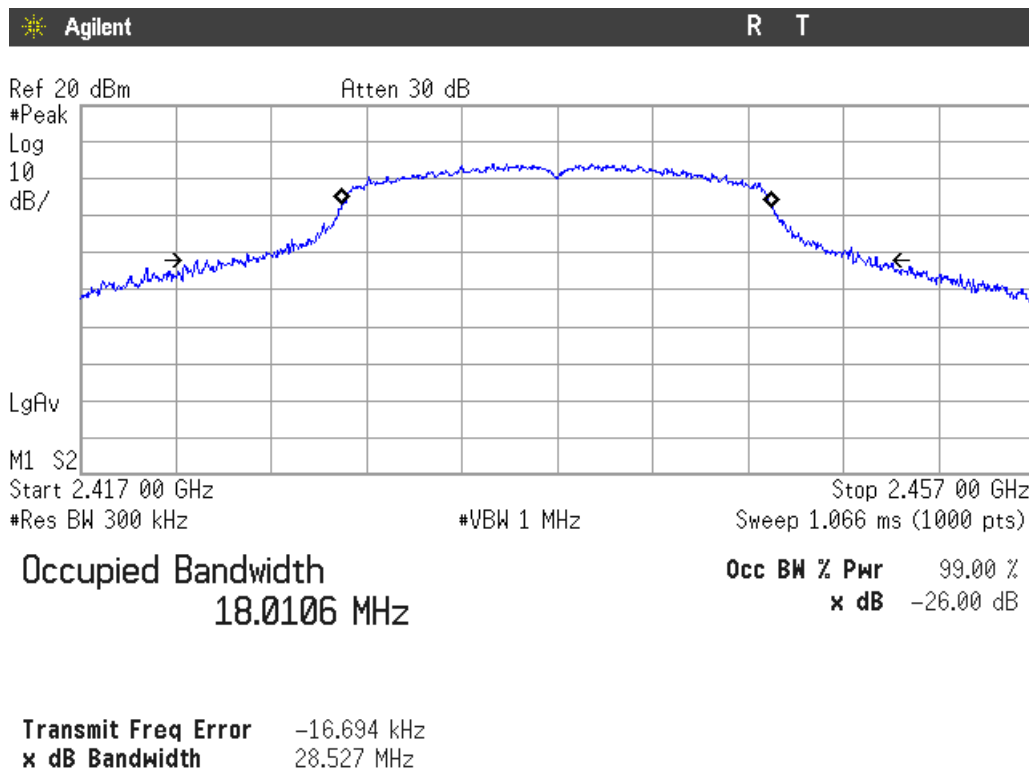


Mode N20

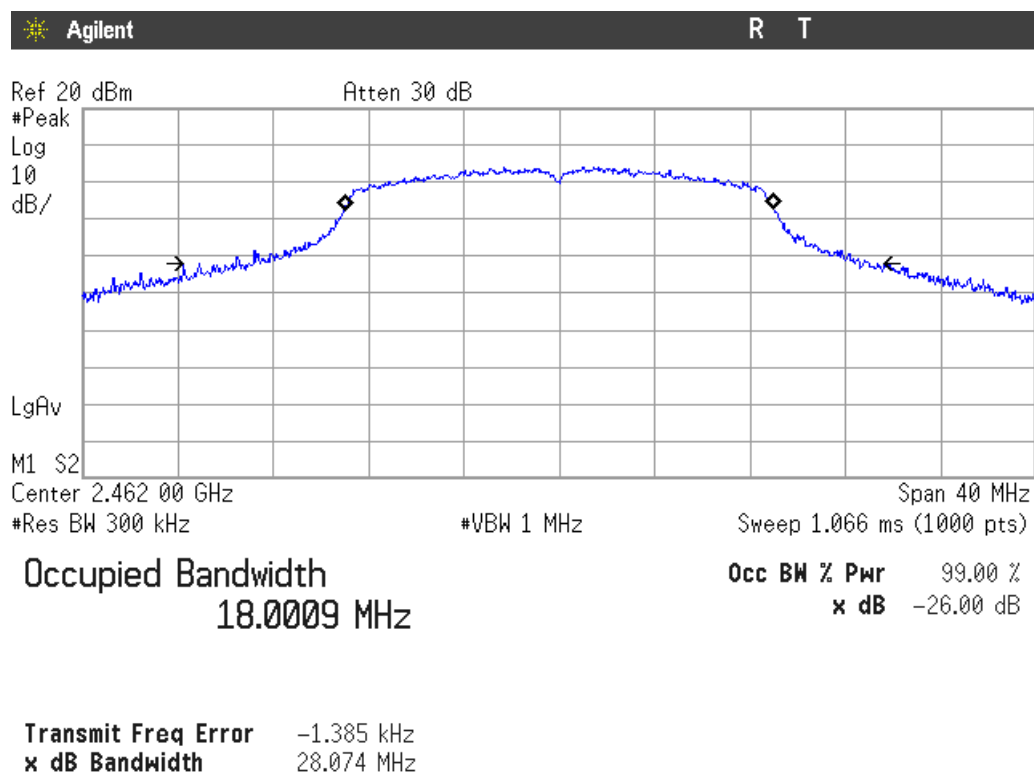
Lowest Channel



Middle Channel

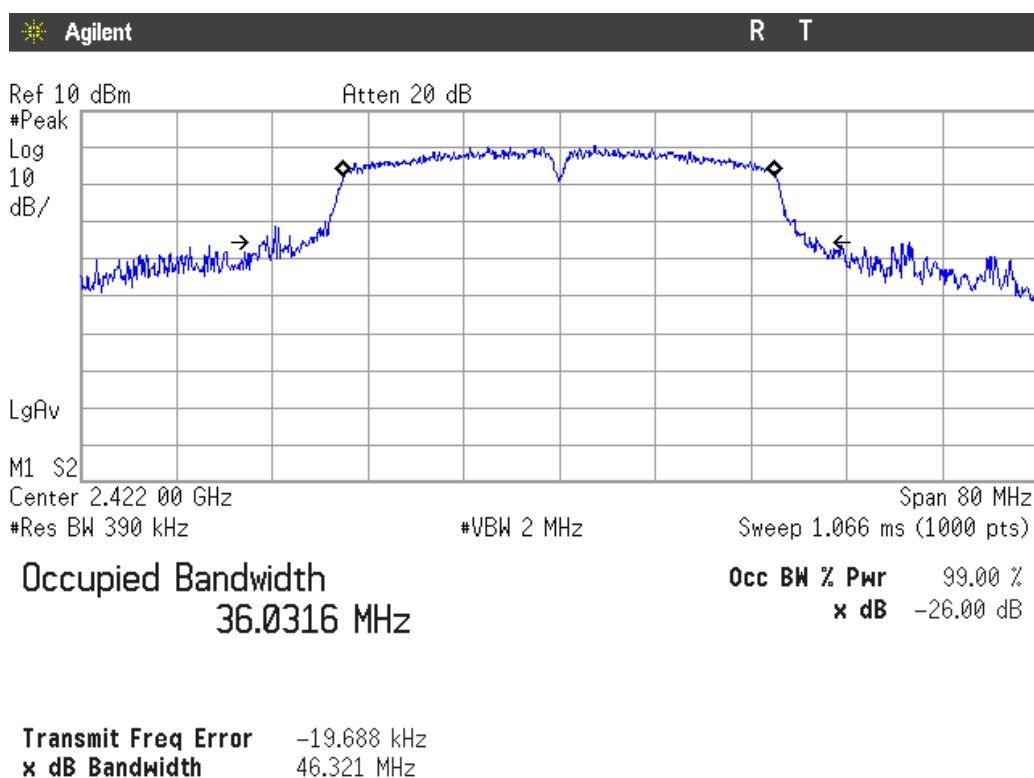


Highest channel

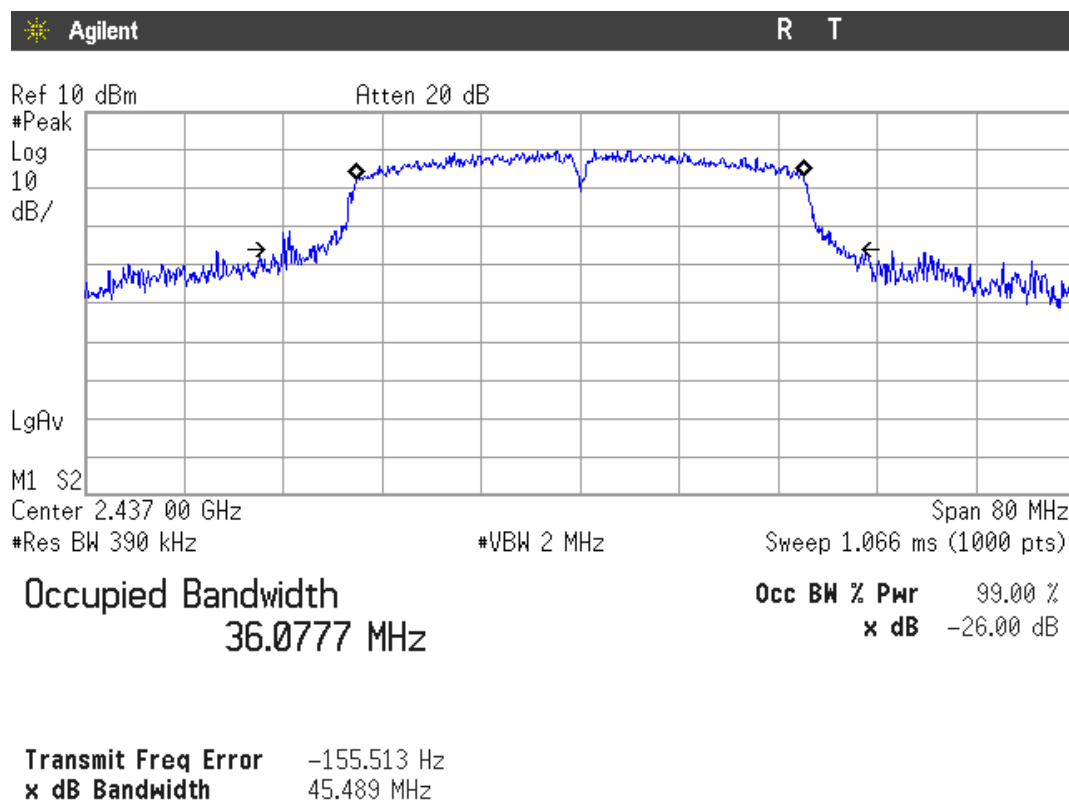


Mode N40

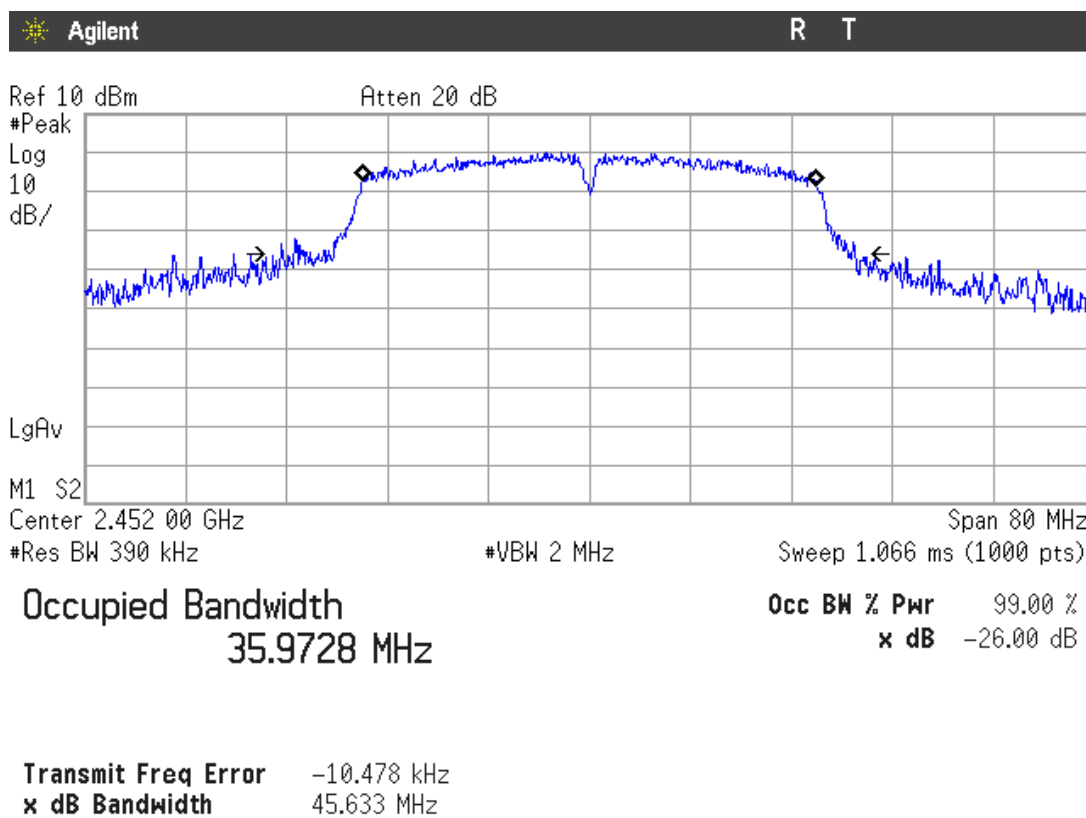
Lowest Channel



Middle Channel



Highest channel



Section 15.247 Subclause (a) (2). 6 dB Bandwidth

SPECIFICATION

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

RESULTS

6 dB Bandwidth (see next plots).

Mode B

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
6 dB Spectrum bandwidth (MHz)	10.060	10.064	10.060
Measurement uncertainty (kHz)	<±65.0		

Mode G

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
6 dB Spectrum bandwidth (MHz)	15.135	15.083	15.081
Measurement uncertainty (kHz)	<±65.0		

Mode N20

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
6 dB Spectrum bandwidth (MHz)	15.101	15.099	15.099
Measurement uncertainty (kHz)	<±65.0		

Mode N40

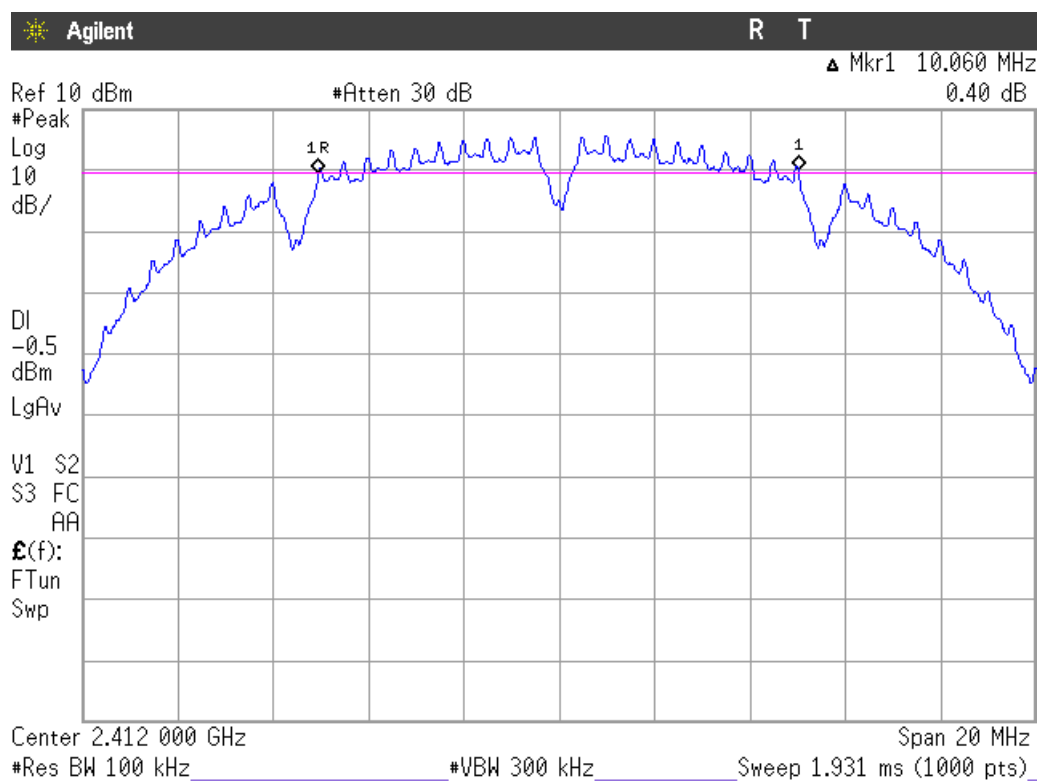
	Lowest frequency 2422 MHz	Middle frequency 2437 MHz	Highest frequency 2452 MHz
6 dB Spectrum bandwidth (MHz)	35.130	35.140	35.120
Measurement uncertainty (kHz)	<±65.0		

Verdict: PASS

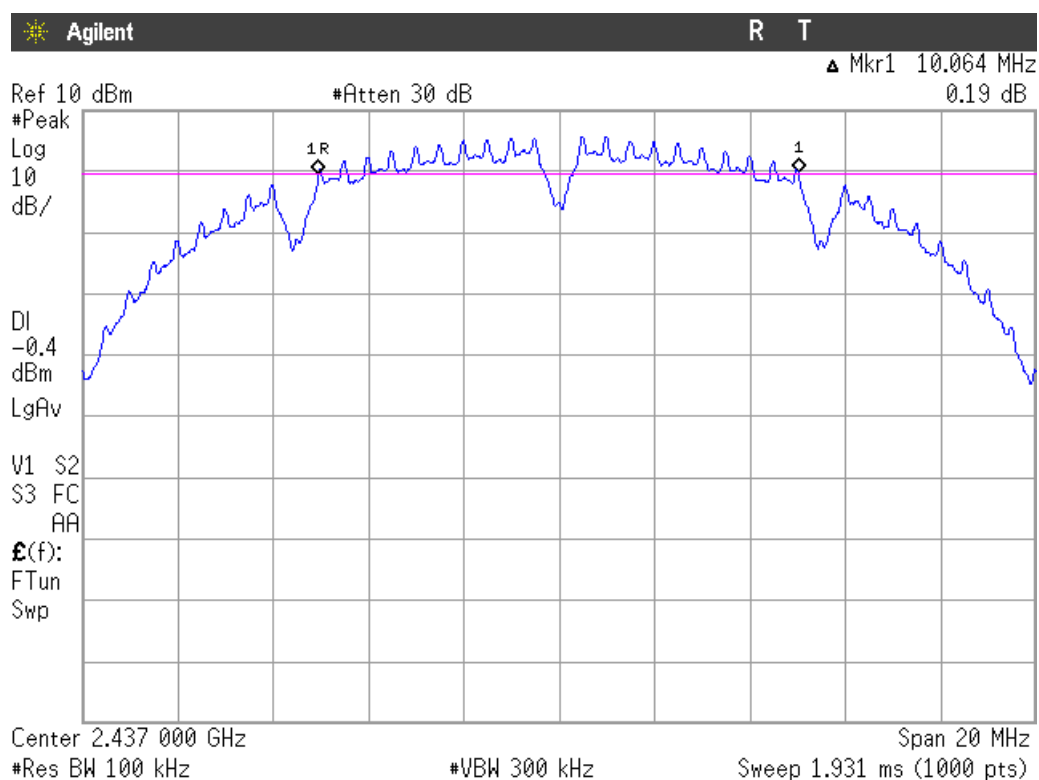
6 dB BANDWIDTH.

Mode B

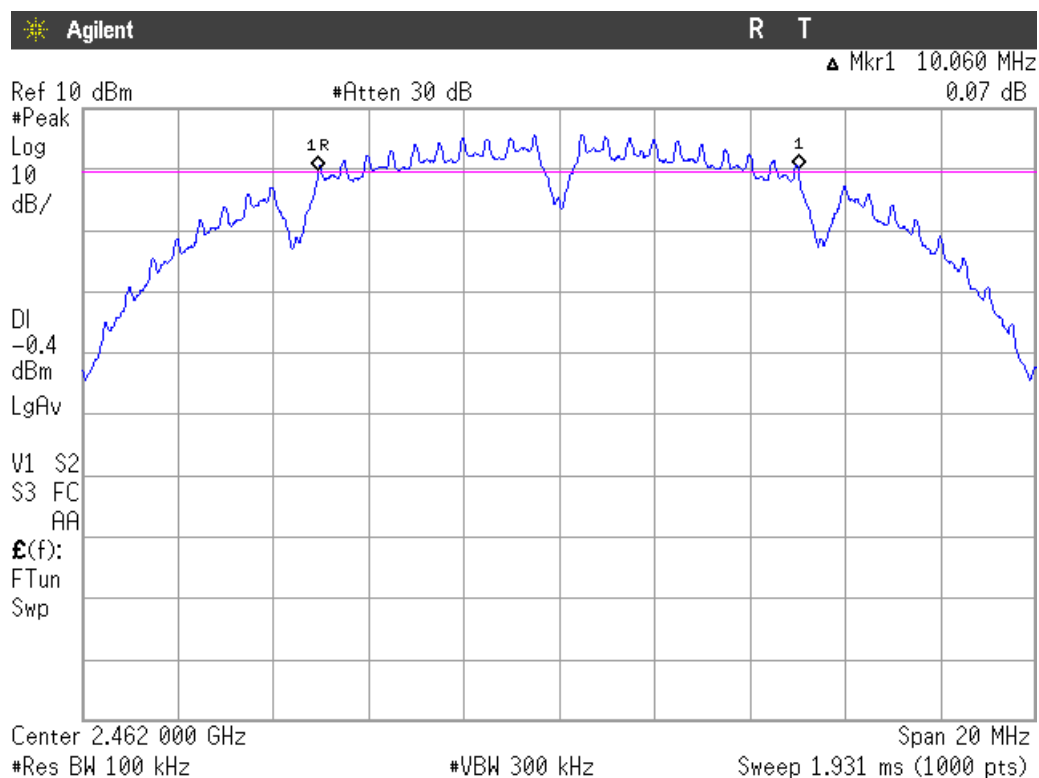
Lowest Channel



Middle Channel

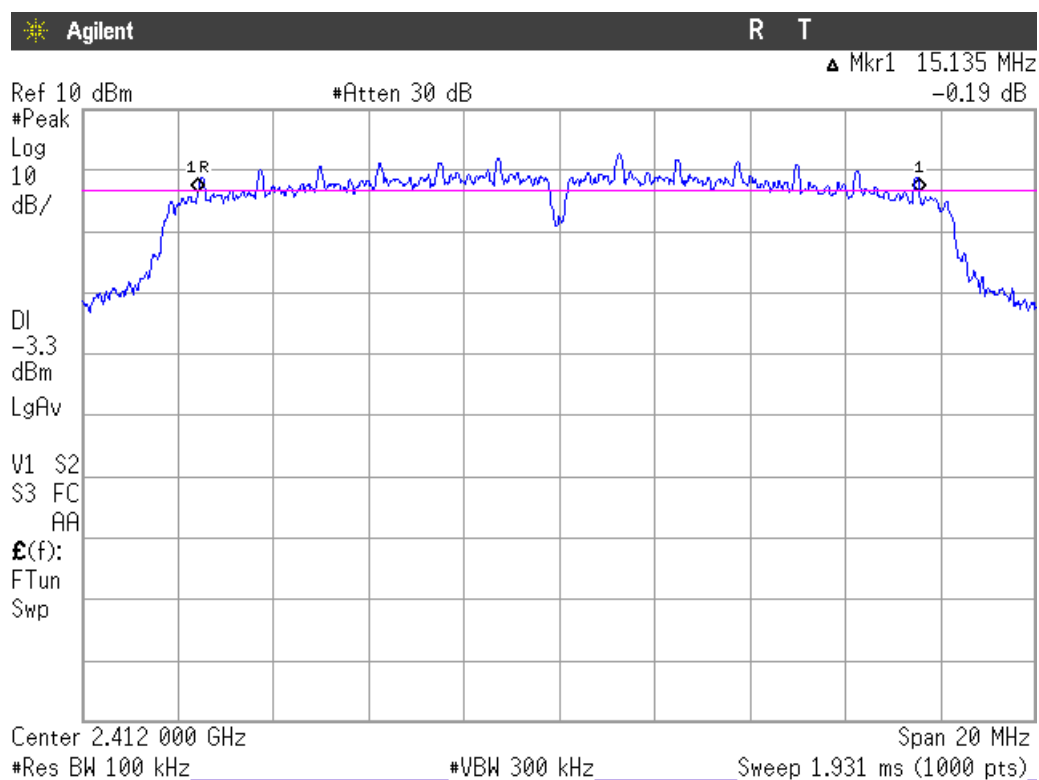


Highest channel

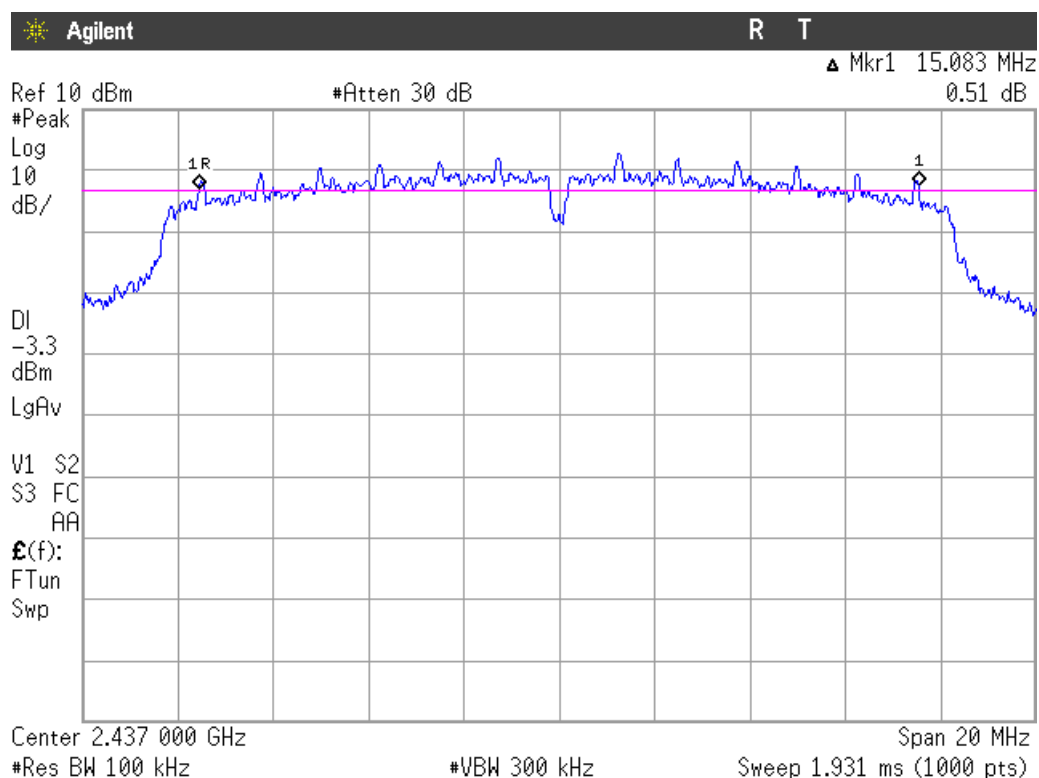


Mode G

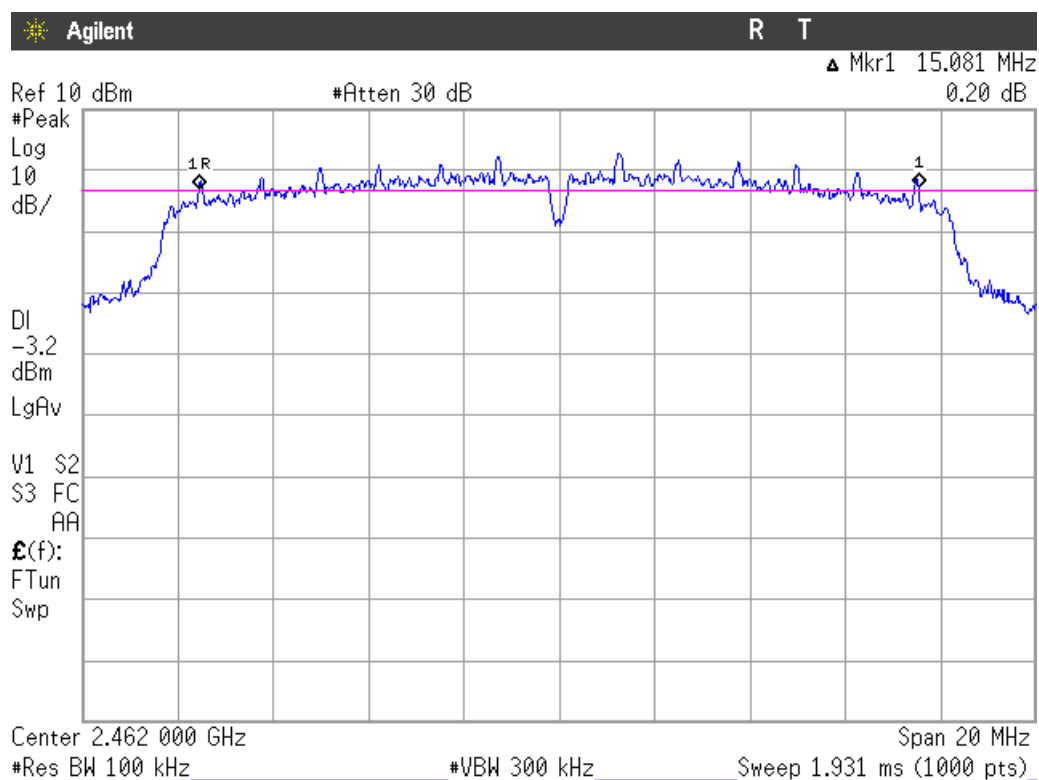
Lowest Channel



Middle Channel

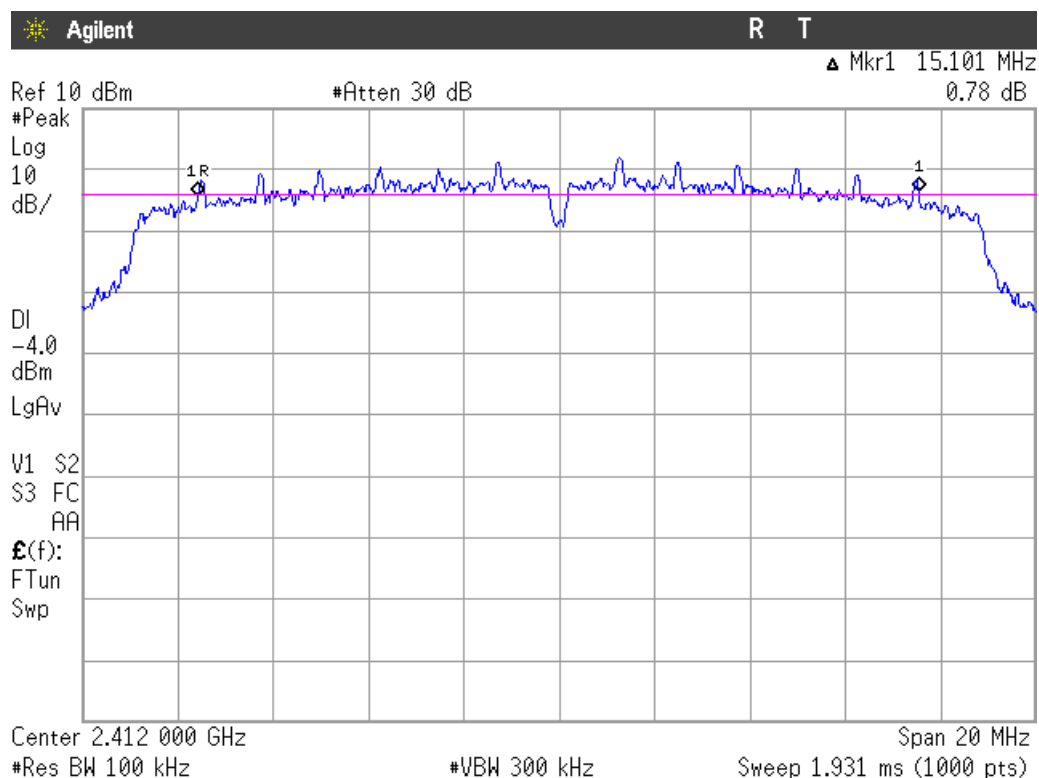


Highest channel

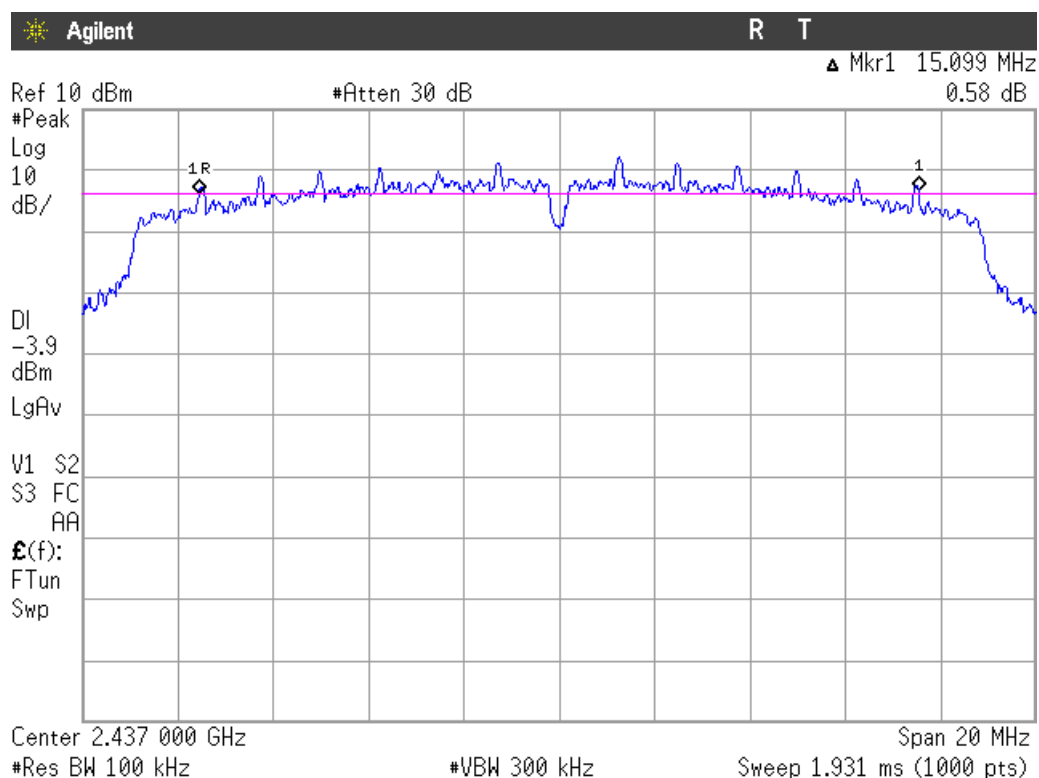


Mode N20

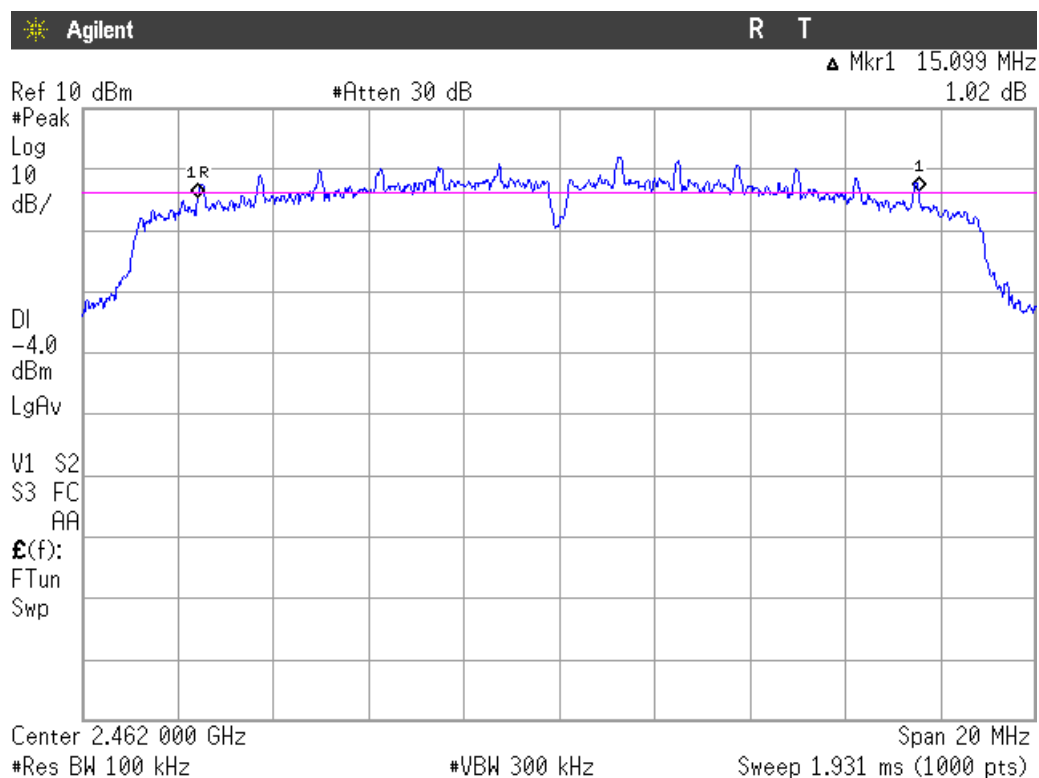
Lowest Channel



Middle Channel

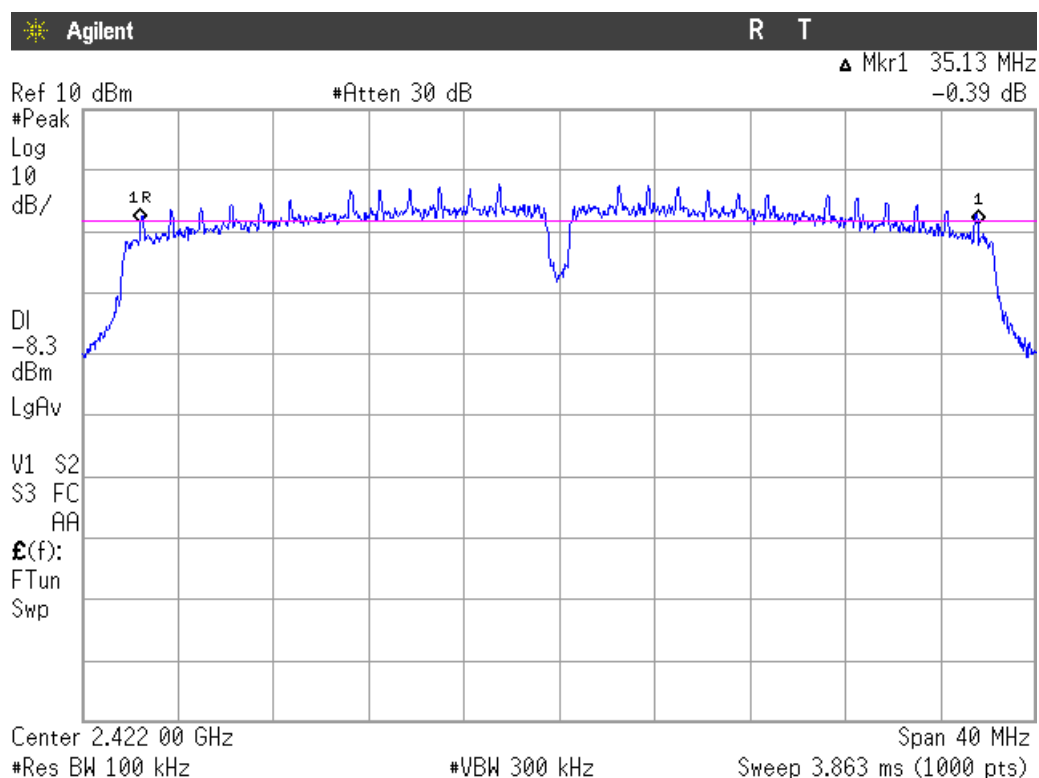


Highest channel

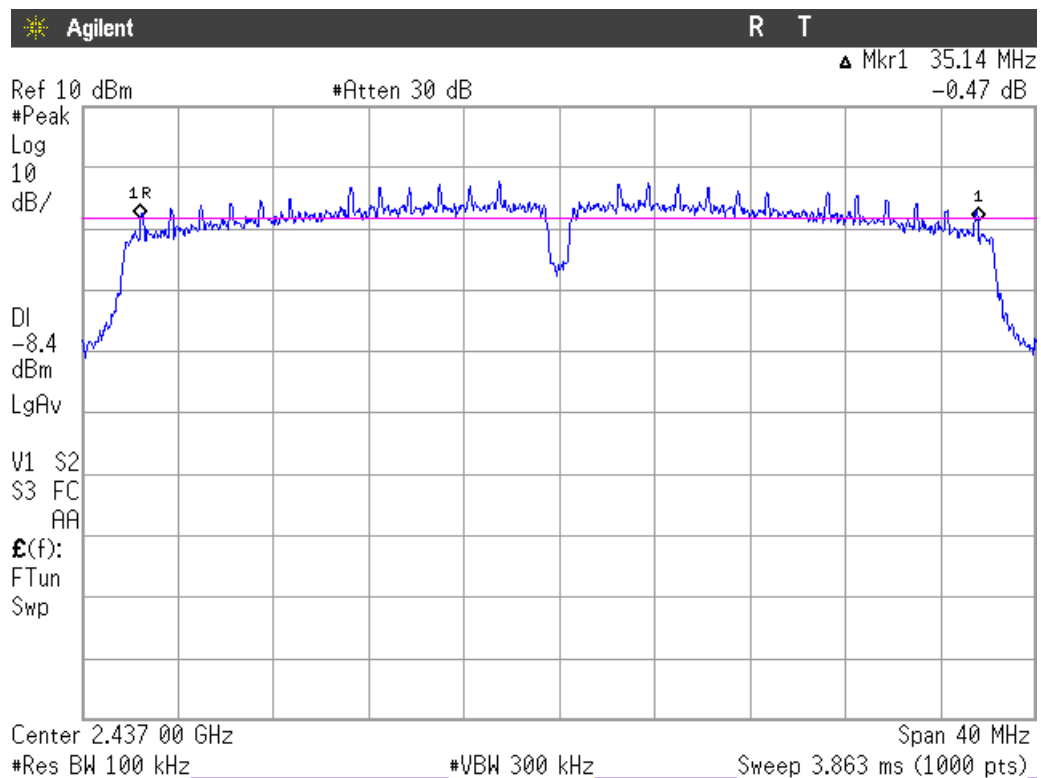


Mode N40

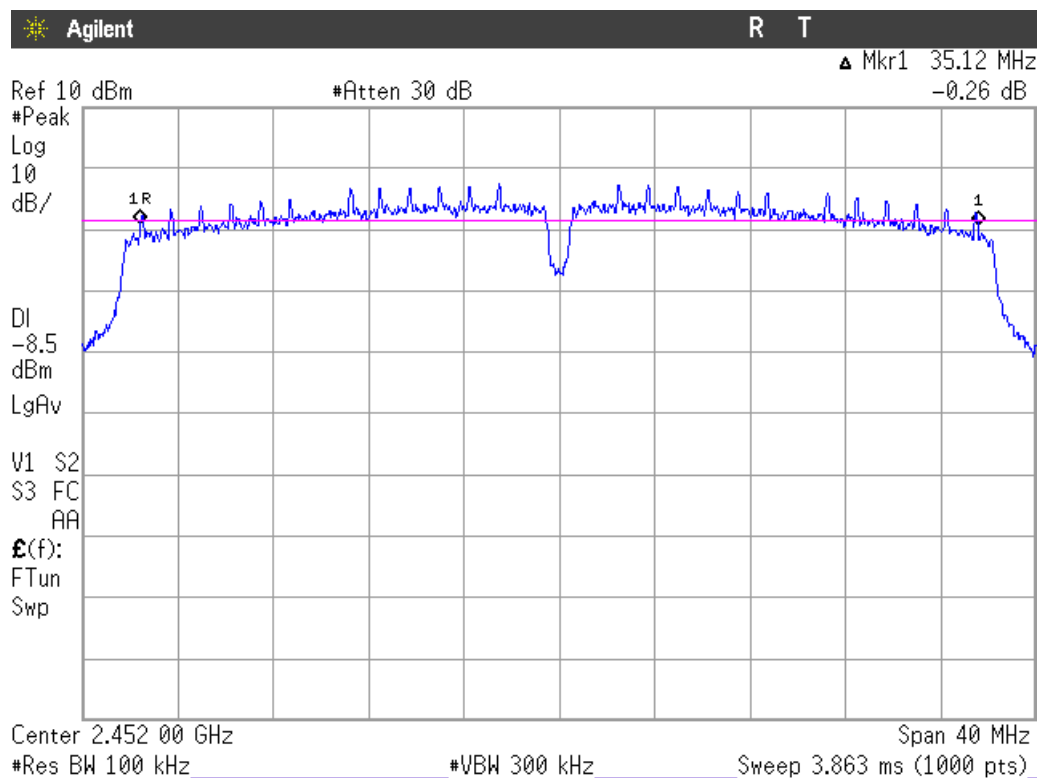
Lowest Channel



Middle Channel



Highest channel



Section 15.247 Subclause (b). Maximum output power and antenna gain

SPECIFICATION

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

RESULTS

For b mode, the maximum conducted (average) output power was measured using the method according to point 9.2.2.2. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016.

For g/n20/n40 modes, the maximum conducted (peak) output power was measured using the method according to point 9.1.2. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016.

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

MAXIMUM OUTPUT POWER.

Maximum declared antenna gain: +3.70 dBi.

Mode B (See next plots).

MAXIMUM OUTPUT POWER. Conducted (average) output power:

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Maximum conducted power (dBm)	13.56	13.92	14.06
Maximum EIRP power (dBm)	17.26	17.62	17.76
Measurement uncertainty (dB)	<±0.79		

Mode G

MAXIMUM OUTPUT POWER. Peak Conducted Output Power:

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Maximum conducted power (dBm)	18.33	18.44	18.53
Maximum EIRP power (dBm)	22.03	22.14	22.23
Measurement uncertainty (dB)	<±0.33		

Mode N20

MAXIMUM OUTPUT POWER. Peak Conducted Output Power

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Maximum conducted power (dBm)	18.42	18.44	18.51
Maximum EIRP power (dBm)	22.12	22.14	22.21
Measurement uncertainty (dB)	<±0.33		

Mode N40

MAXIMUM OUTPUT POWER. Peak Conducted Output Power

	Lowest frequency 2422 MHz	Middle frequency 2437 MHz	Highest frequency 2452 MHz
Maximum conducted power (dBm)	18.35	18.32	18.47
Maximum EIRP power (dBm)	22.05	22.02	22.17
Measurement uncertainty (dB)	<±0.33		

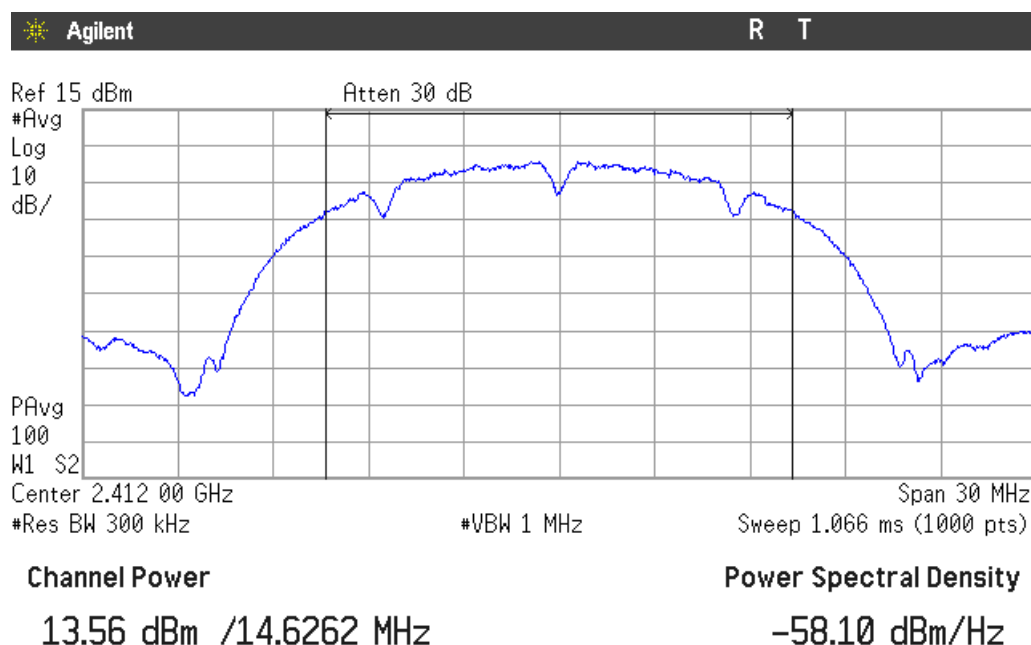
The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Verdict: PASS

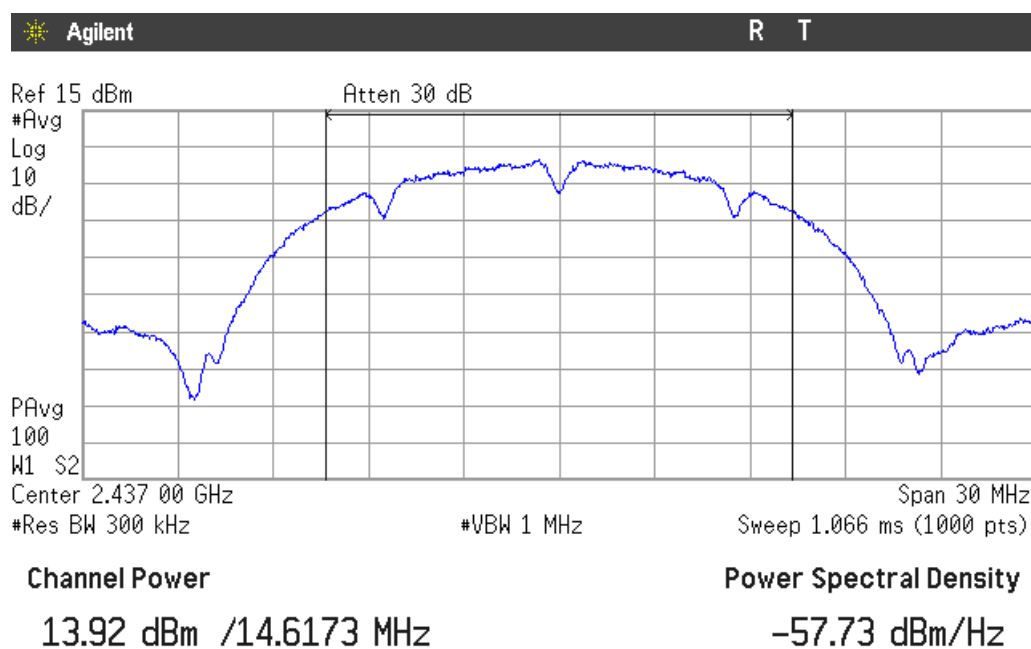
CONDUCTED AVERAGE POWER.

Mode B

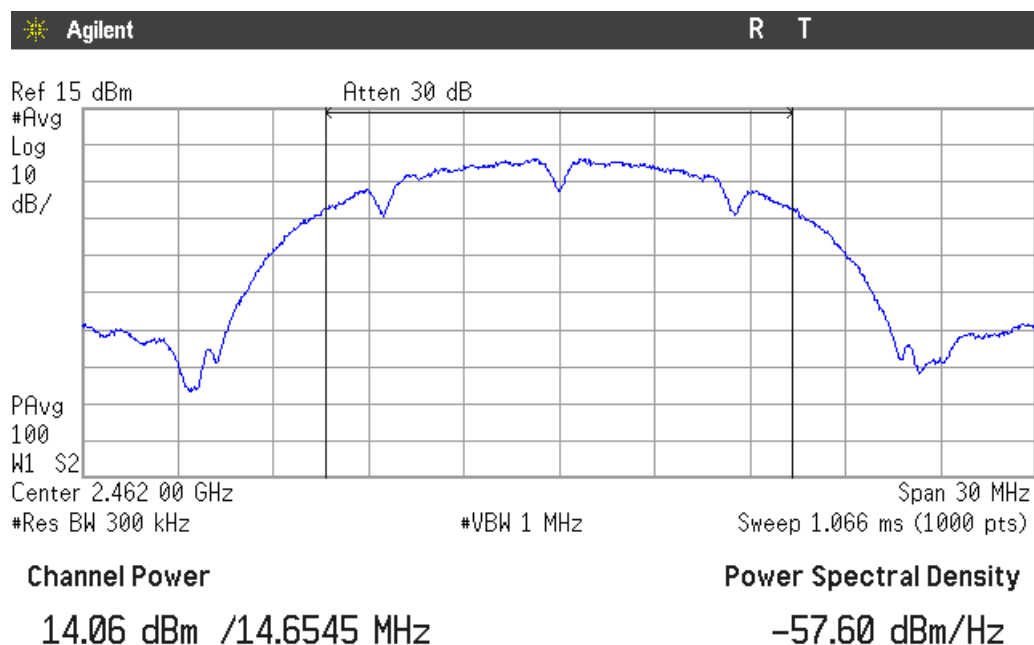
Lowest Channel



Middle Channel



Highest channel



Section 15.247 Subclause (d). Emission limitations conducted (Transmitter)

SPECIFICATION

In any 100 kHz bandwidth outside the frequency band in which the digitally modulated 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. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.

RESULTS:

Reference Level Measurement

Mode B

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Reference Level Measurement (dBm)	5.49	5.63	5.62
Measurement uncertainty (dB)	<±0.78		

Mode G

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Reference Level Measurement (dBm)	2.69	2.68	2.76
Measurement uncertainty (dB)	<±0.78		

Mode N20

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Reference Level Measurement (dBm)	2.00	2.07	2.04
Measurement uncertainty (dB)	<±0.78		

Mode N40

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Reference Level Measurement (dBm)	-2.31	-2.38	-2.49
Measurement uncertainty (dB)	<±0.78		

Mode B

Lowest frequency 2412 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-24.51

Middle frequency 2437 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-24.37

Highest frequency 2462 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-24.38

Mode G

Lowest frequency 2412 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-17.31

Middle frequency 2437 MHz

Middle frequency 2437 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-17.32

Highest frequency 2462 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-17.24

Mode N20

Lowest frequency 2412 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-18.00

Middle frequency 2437 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-17.93

Highest frequency 2462 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-17.96

Mode N40

Lowest frequency 2422 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-22.31

Middle frequency 2437 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-22.38

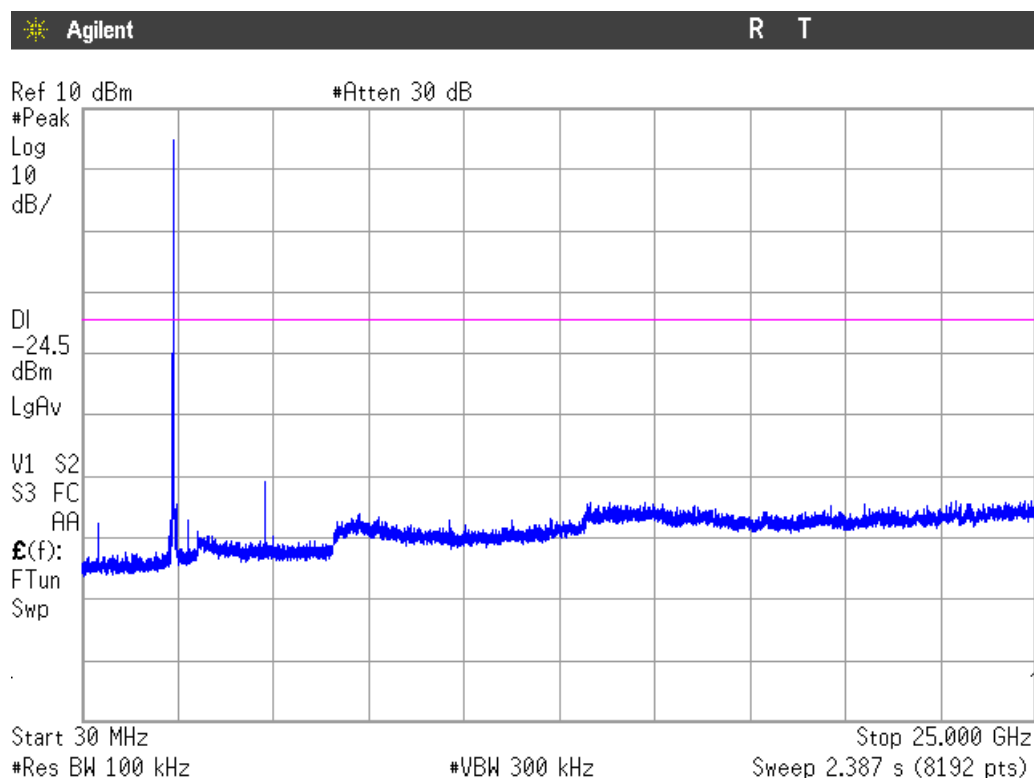
Highest frequency 2452 MHz

Lowest frequency 2412 MHz	Limit (dBm)
All peaks are more than 20 dB below the limit.	-22.49

Verdict: PASS

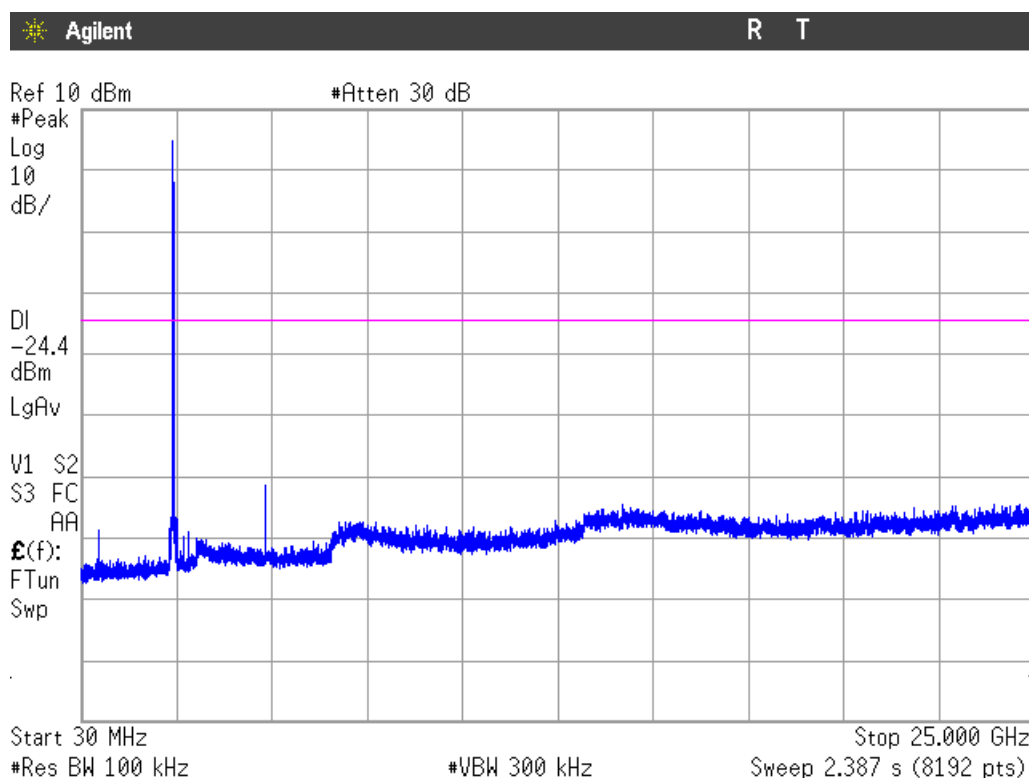
Mode B

Lowest Channel



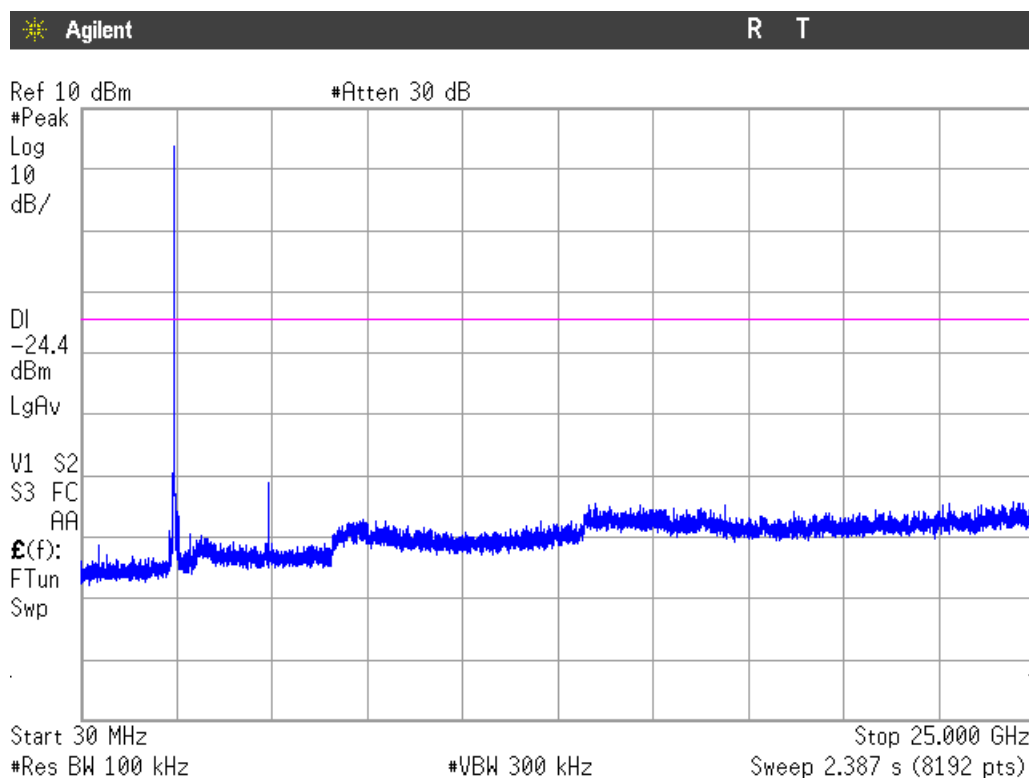
Note: The peak shown in the plot above the limit is the carrier frequency.

Middle Channel



Note: The peak shown in the plot above the limit is the carrier frequency.

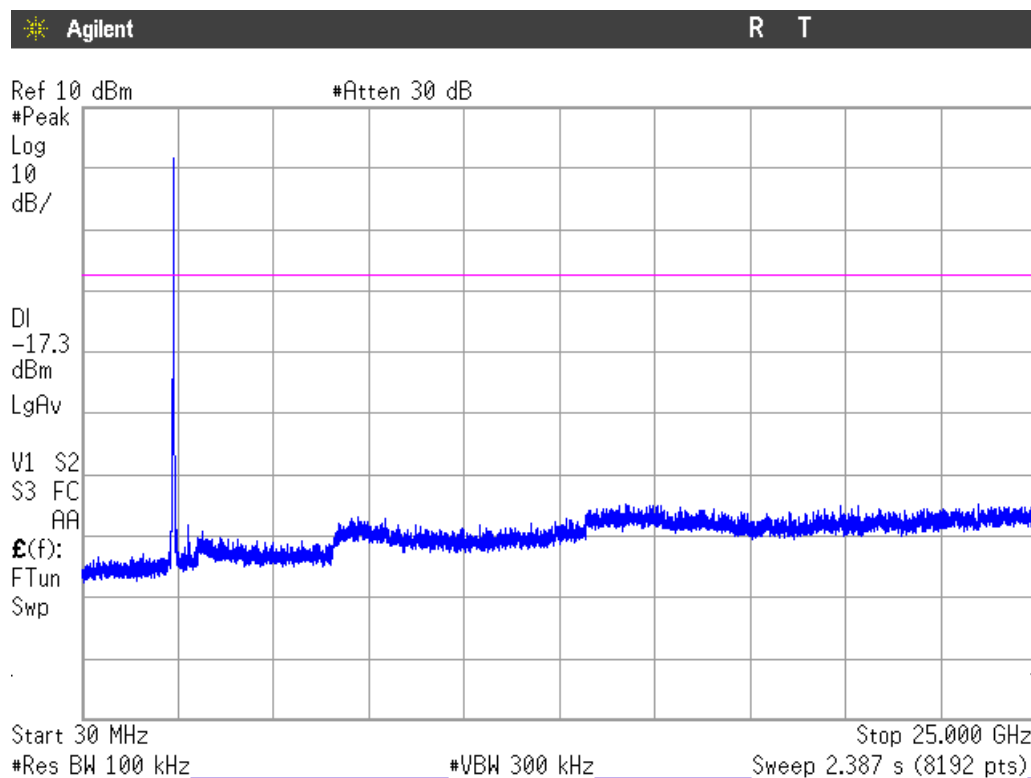
Highest channel



Note: The peak shown in the plot above the limit is the carrier frequency.

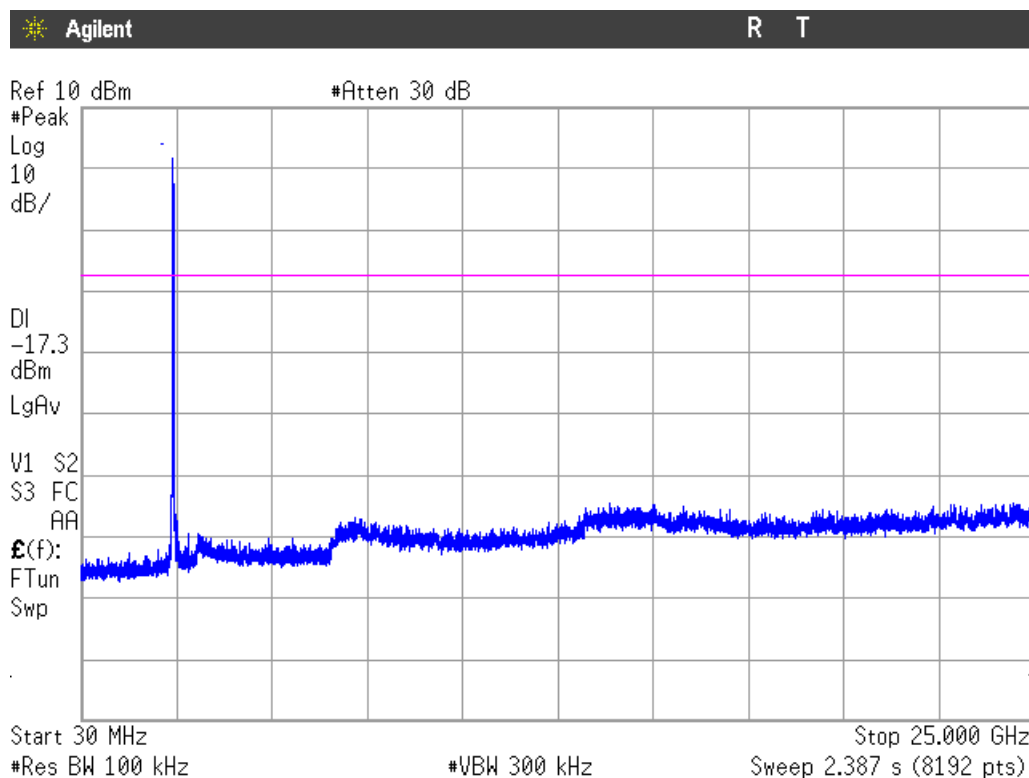
Mode G

Lowest Channel



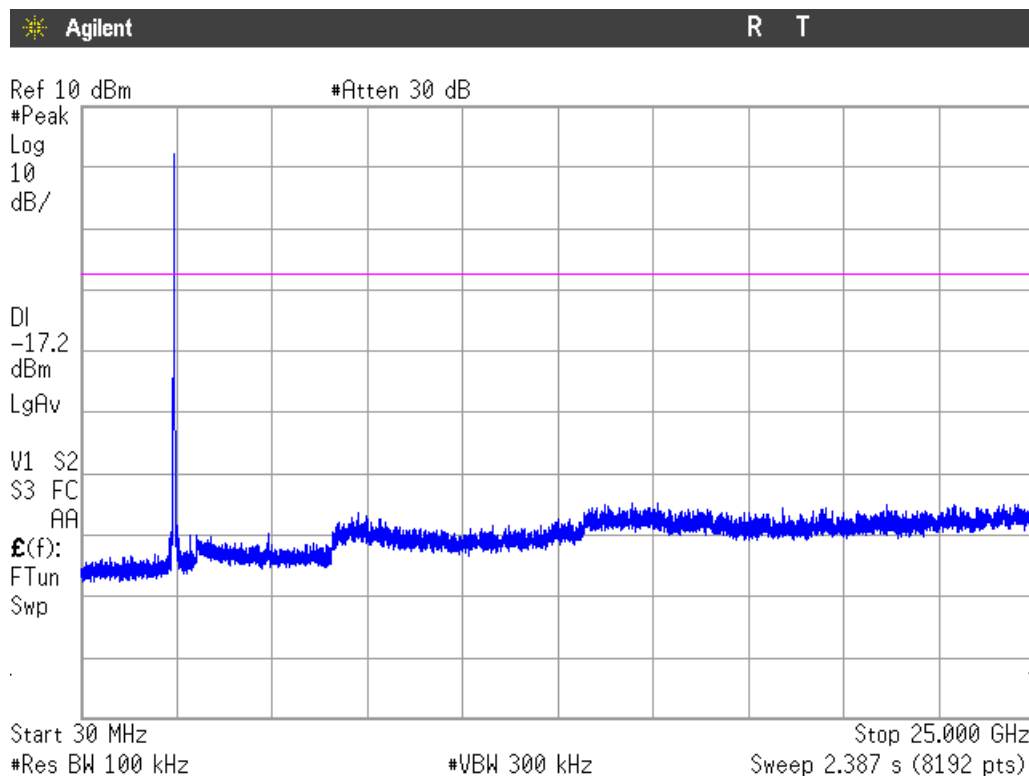
Note: The peak shown in the plot above the limit is the carrier frequency.

Middle Channel



Note: The peak shown in the plot above the limit is the carrier frequency.

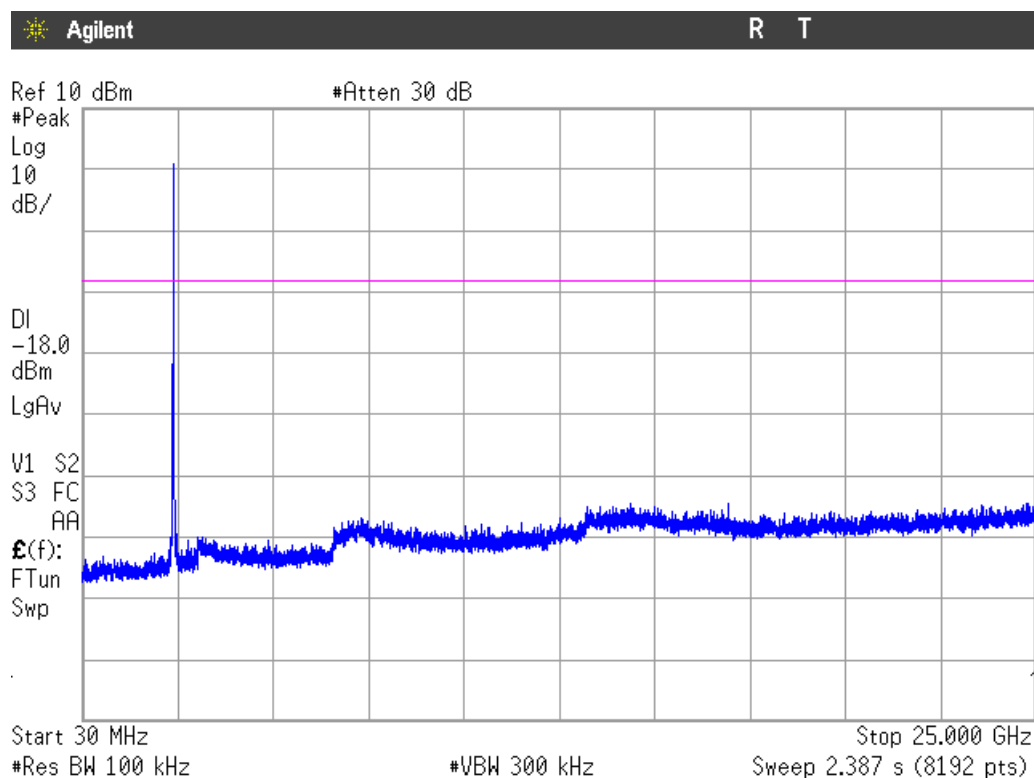
Highest channel



Note: The peak shown in the plot above the limit is the carrier frequency.

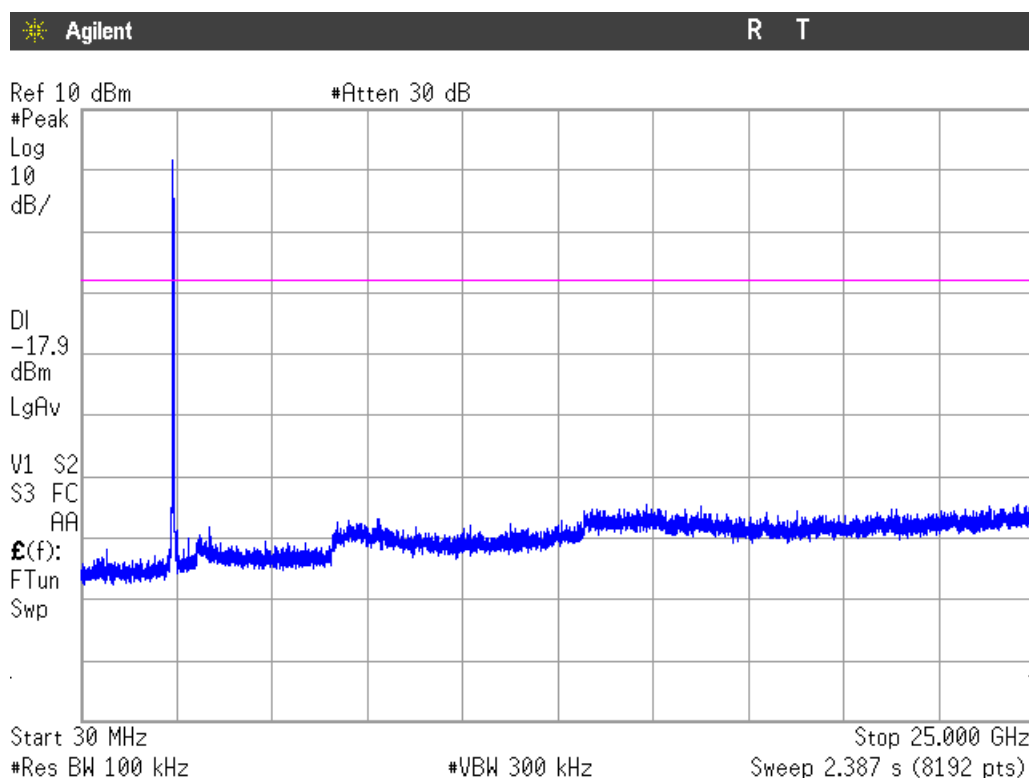
Mode N20

Lowest Channel



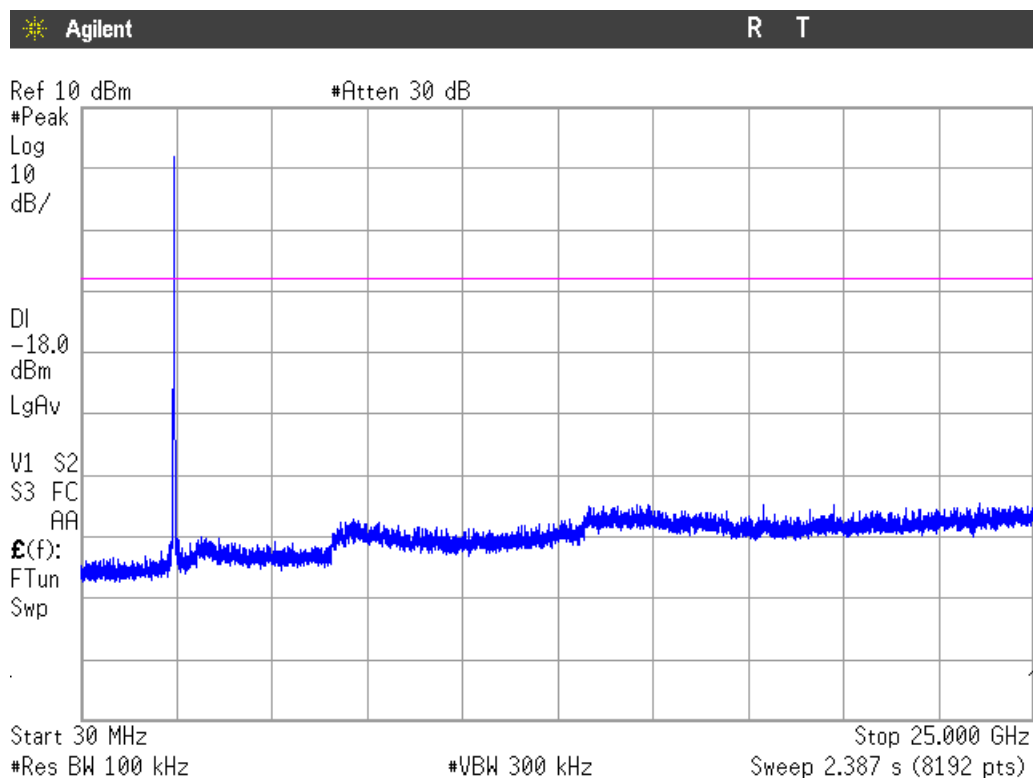
Note: The peak shown in the plot above the limit is the carrier frequency.

Middle Channel



Note: The peak shown in the plot above the limit is the carrier frequency.

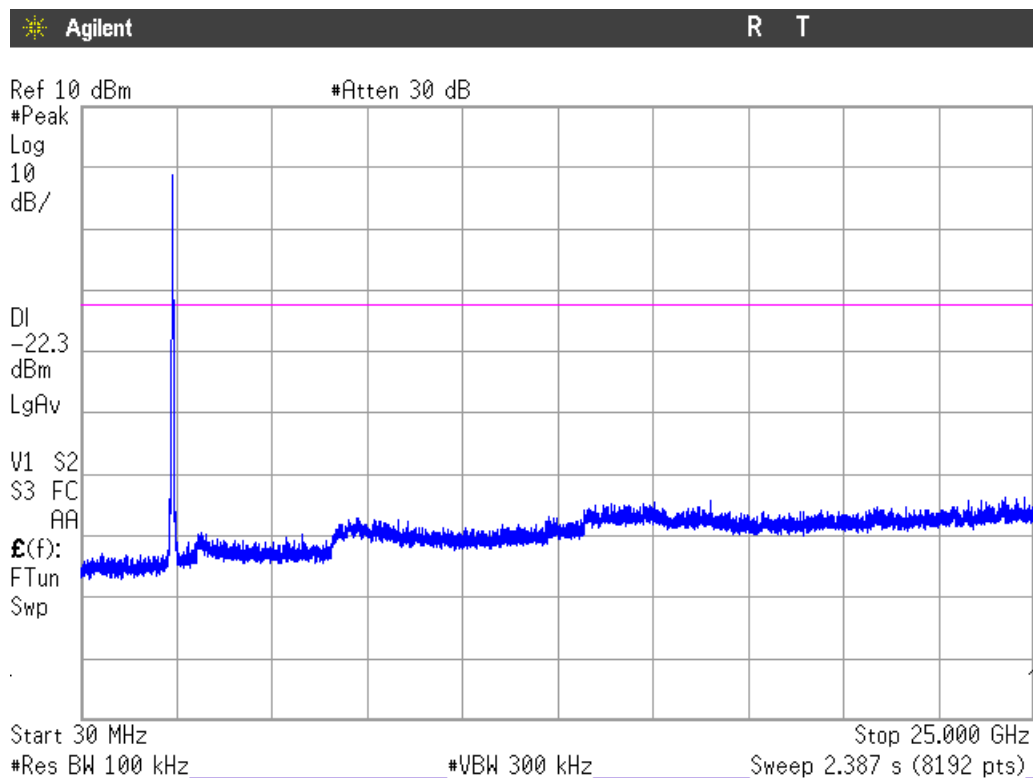
Highest channel



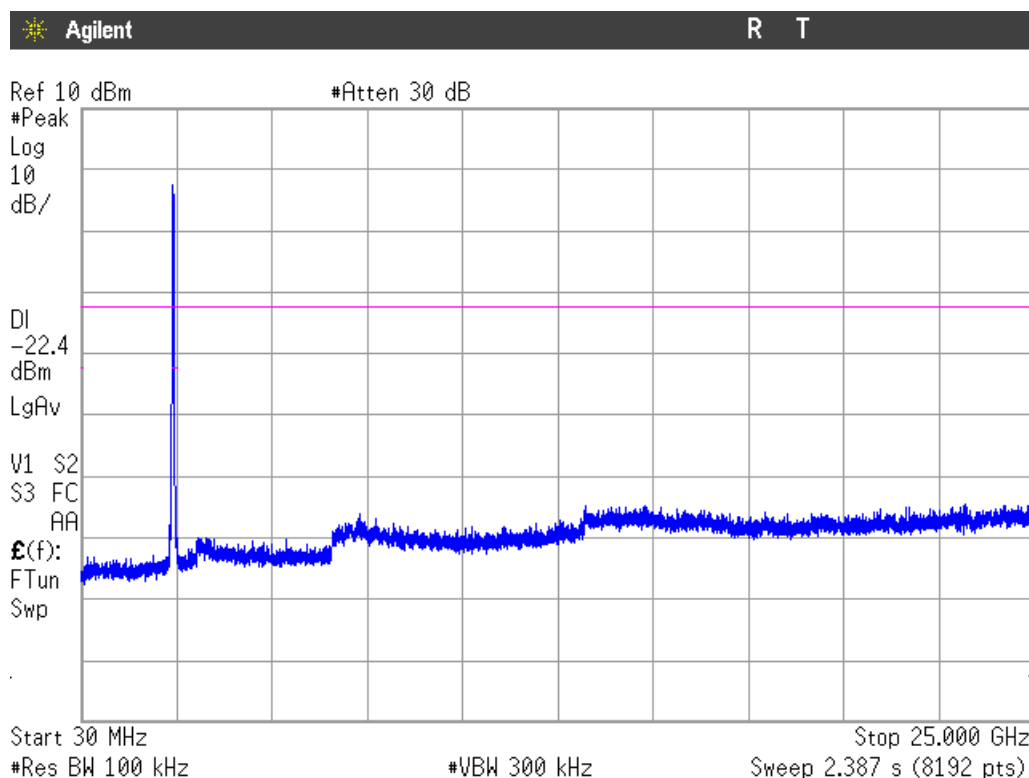
Note: The peak shown in the plot above the limit is the carrier frequency.

Mode N40

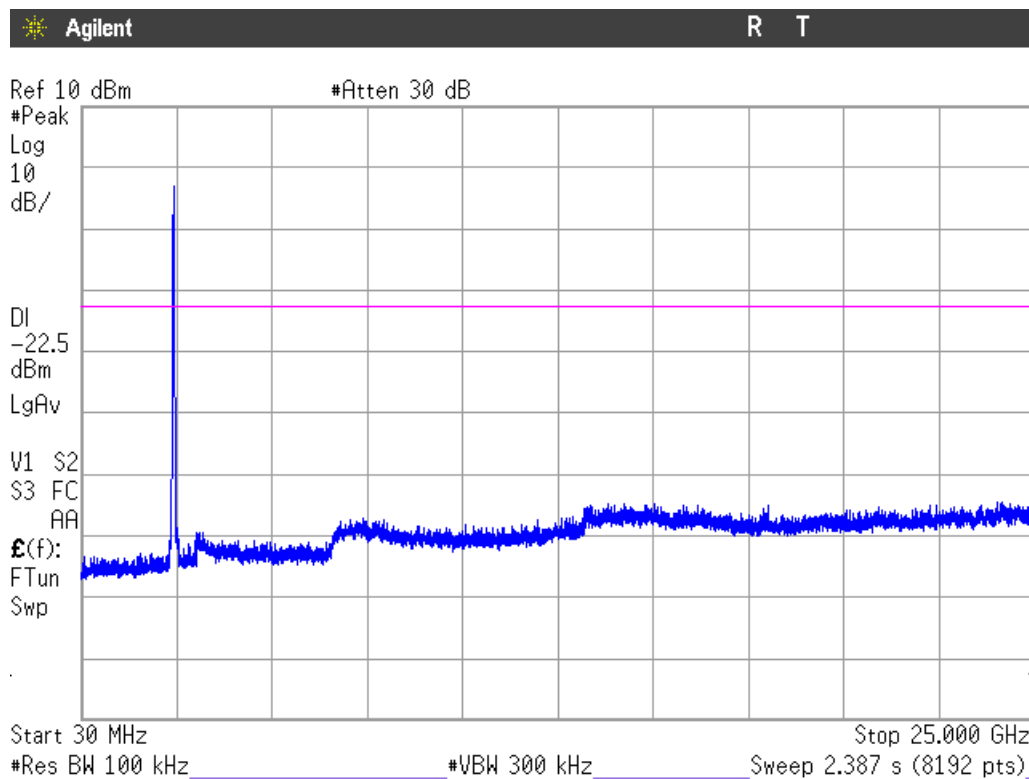
Lowest Channel



Middle Channel



Highest channel



Section 15.247 Subclause (d). Band-edge emissions compliance (Transmitter)

SPECIFICATION

In any 100 kHz bandwidth outside the frequency band in which the digitally modulated 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. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.

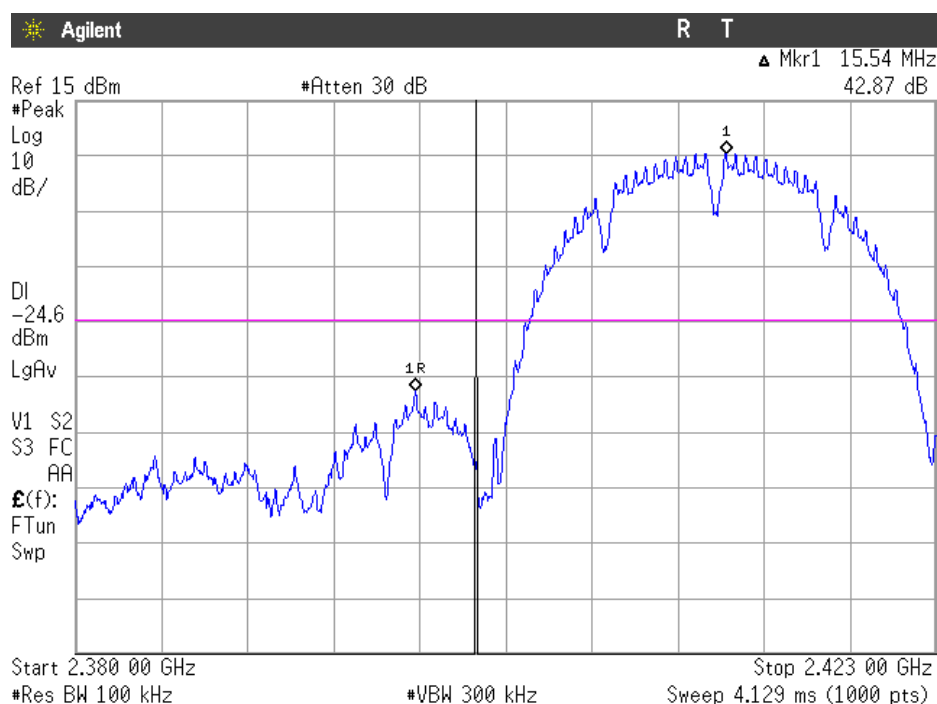
RESULTS:

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.

LOW FREQUENCY SECTION 2412 MHz (b/g/n20/n40). CONDUCTED.

Mode B

See next plots.



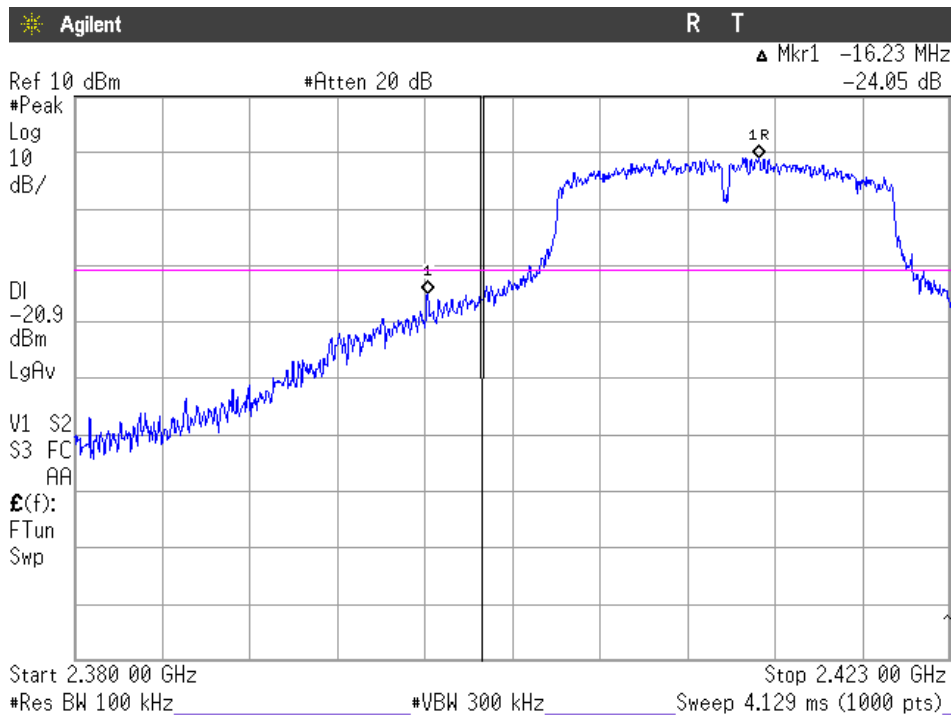
Measurement uncertainty (dB)

< ±2.03

Verdict: PASS

Mode G

See next plot.

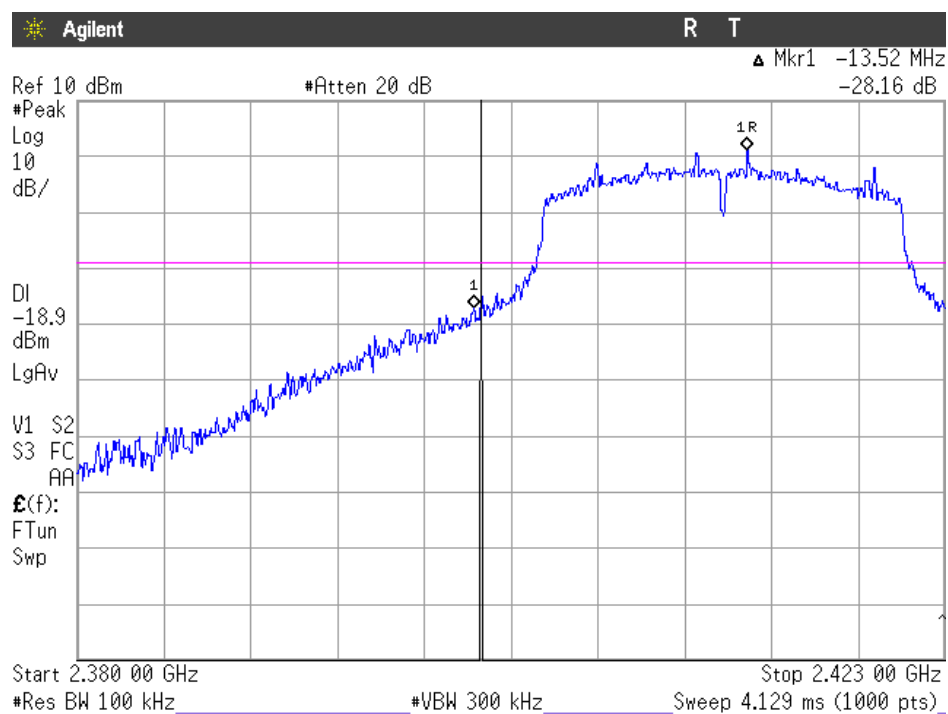


Measurement uncertainty (dB)	< ±2.03
------------------------------	---------

Verdict: PASS (NOTE: The limit is set to -20 dBc since the maximum peak conducted output power was measured for this mode.)

Mode N20

See next plot.

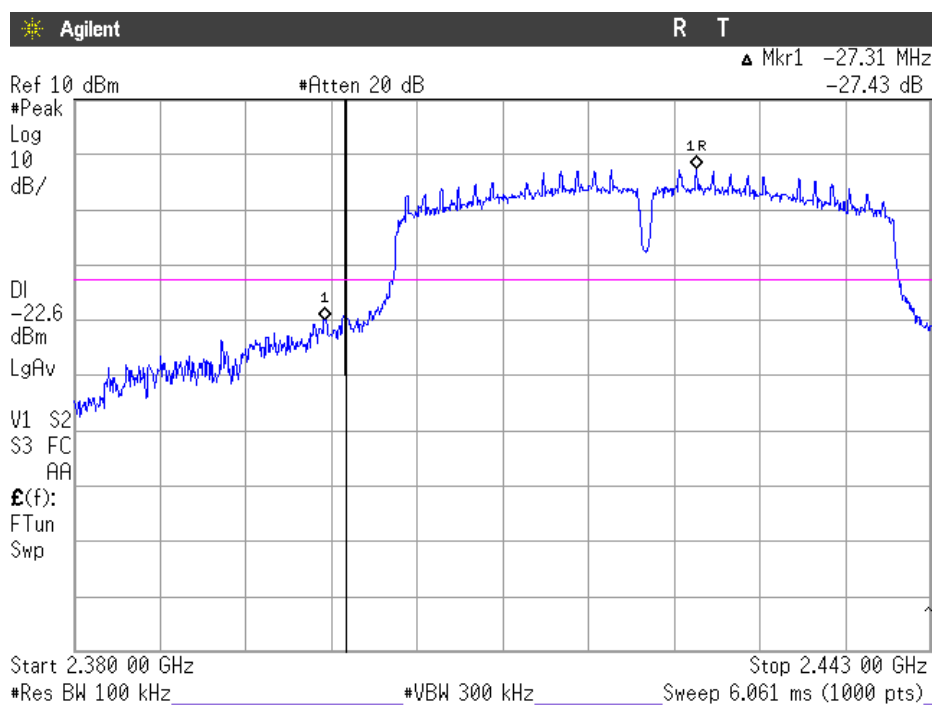


Measurement uncertainty (dB)	< ±2.03
------------------------------	---------

Verdict: PASS (NOTE: The limit is set to -20 dBc since the maximum peak conducted output power was measured for this mode.)

Mode N40

See next plot.



Measurement uncertainty (dB)

< ±2.03

Verdict: PASS (NOTE: The limit is set to -20 dBc since the maximum peak conducted output power was measured for this mode.)

Section 15.247 Subclause (e). 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

For b mode, the maximum power spectral density level in the fundamental emission was measured using the method AVGPSD-1 (AVG PSD) according to point 10.3. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016.

For g/n20/n40 modes, the maximum power spectral density level in the fundamental emission was measured using the method PKPSD according to point 10.2 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v03r05 dated 04/08/2016.

Power spectral density (see next plots).

Mode B

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Power spectral density (dBm)	-3.24	-2.99	-2.89
Measurement uncertainty (dB)	<±0.78		

Verdict: PASS

Mode G

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Power spectral density (dBm)	2.16	1.68	2.19
Measurement uncertainty (dB)	<±0.78		

Verdict: PASS (NOTE: the PKPSD (peak PSD) method was used since the maximum peak conducted output power was measured for this mode).

Mode N20

	Lowest frequency 2412 MHz	Middle frequency 2437 MHz	Highest frequency 2462 MHz
Power spectral density (dBm)	1.88	1.83	2.09
Measurement uncertainty (dB)	<±0.78		

Verdict: PASS (NOTE: the PKPSD (peak PSD) method was used since the maximum peak conducted output power was measured for this mode).

Mode N40

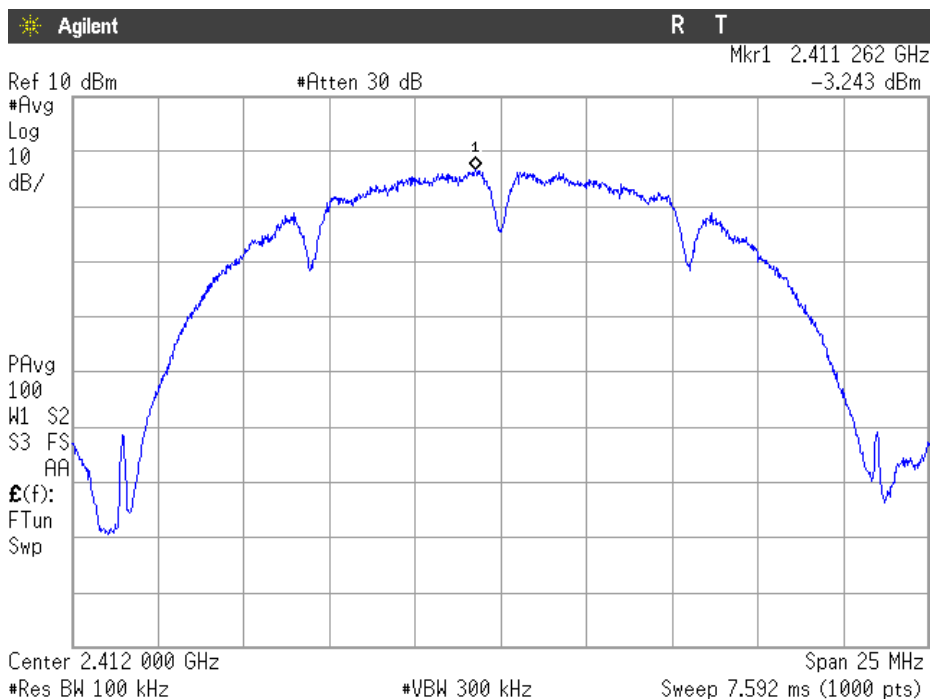
	Lowest frequency 2422 MHz	Middle frequency 2437 MHz	Highest frequency 2452 MHz
Power spectral density (dBm)	-2.28	-2.56	-2.32
Measurement uncertainty (dB)	<±0.78		

Verdict: PASS (NOTE: the PKPSD (peak PSD) method was used since the maximum peak conducted output power was measured for this mode).

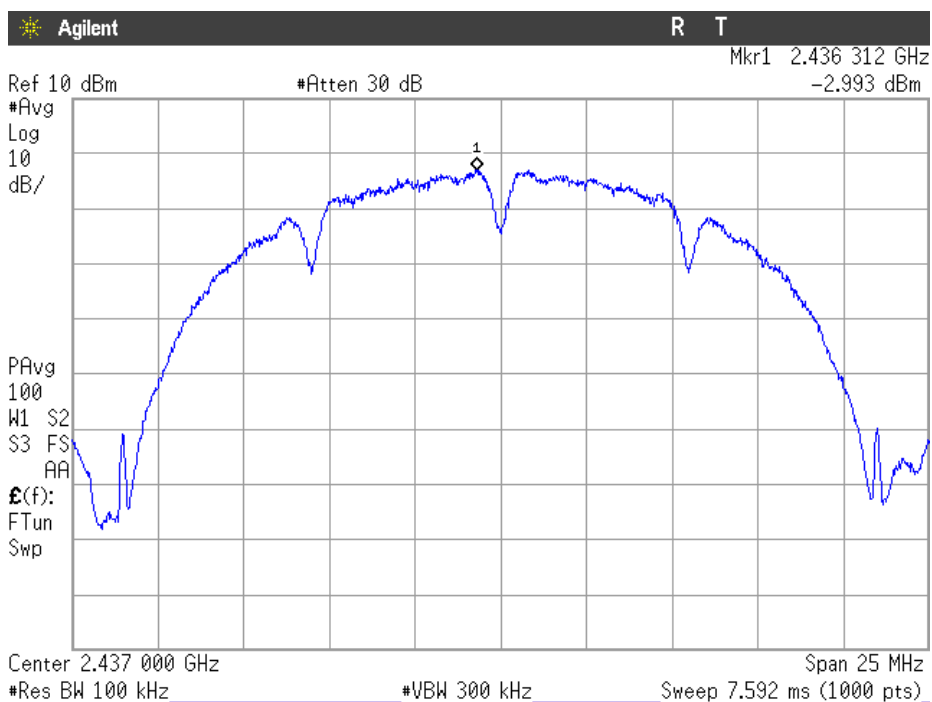
Power spectral density.

Mode B

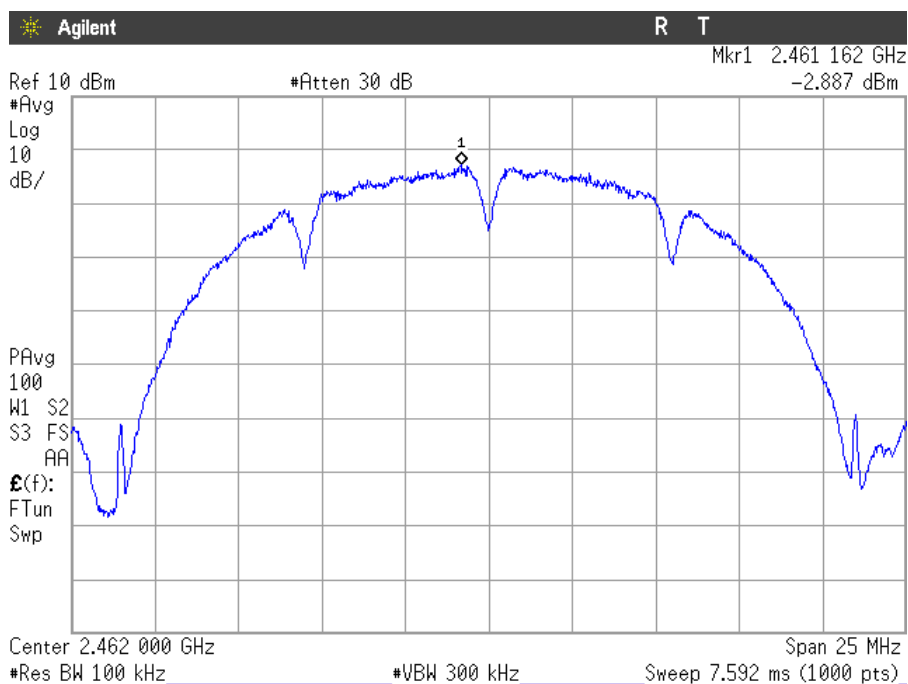
Lowest Channel



Middle Channel

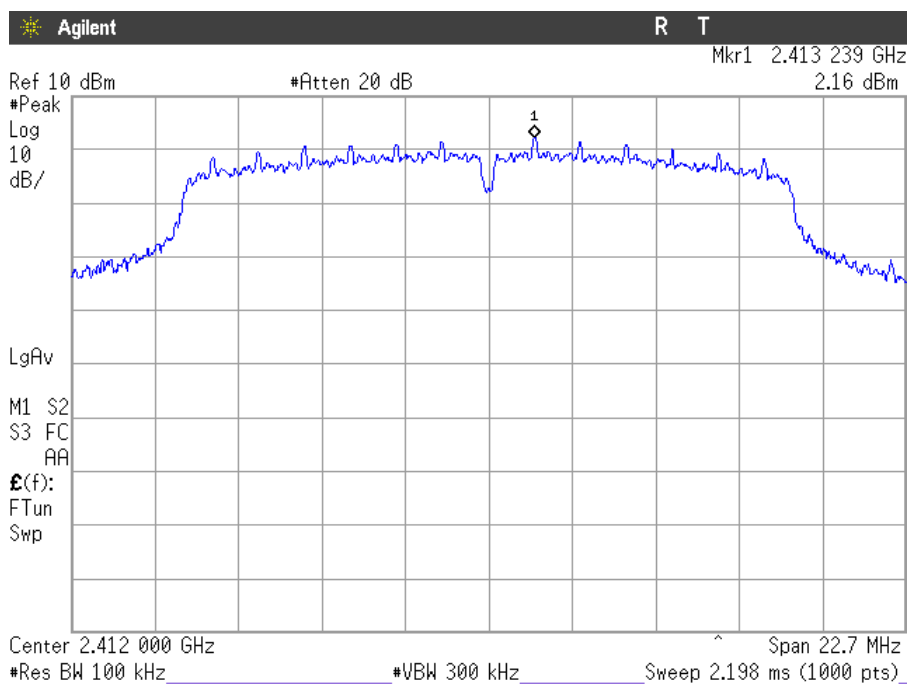


Highest channel

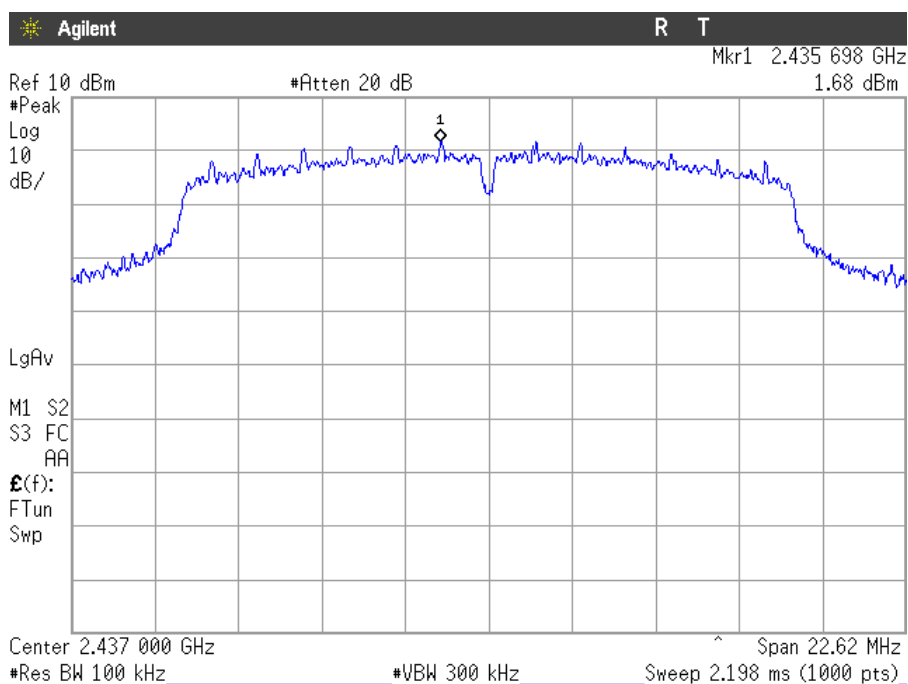


Mode G

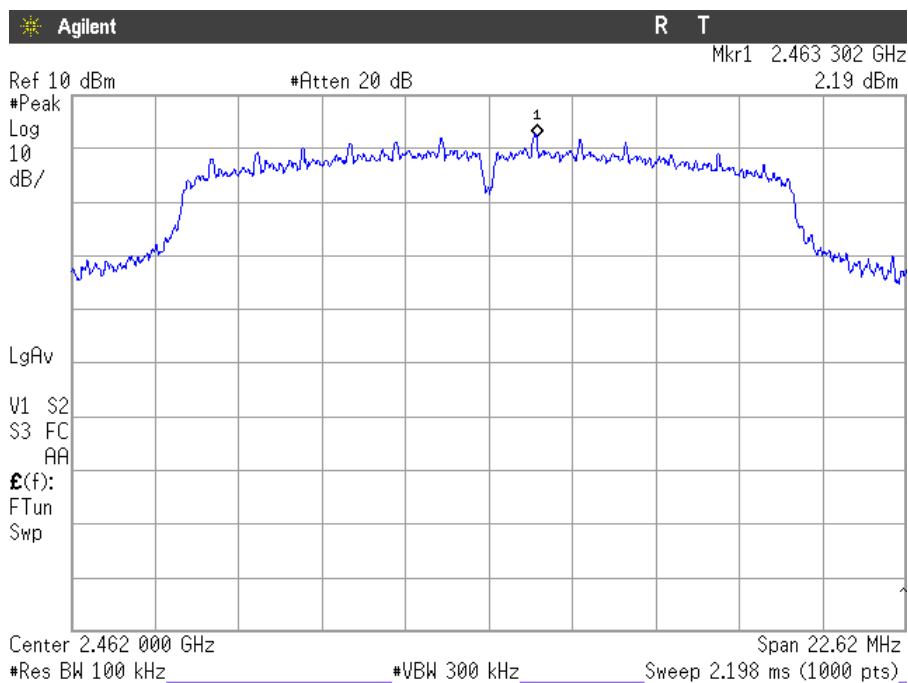
Lowest Channel



Middle Channel

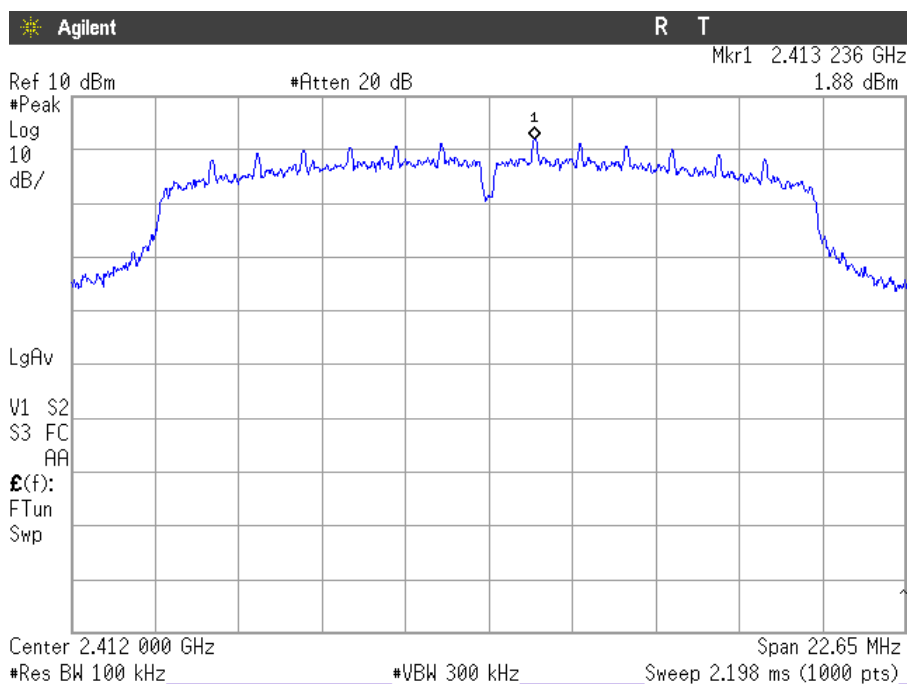


Highest channel

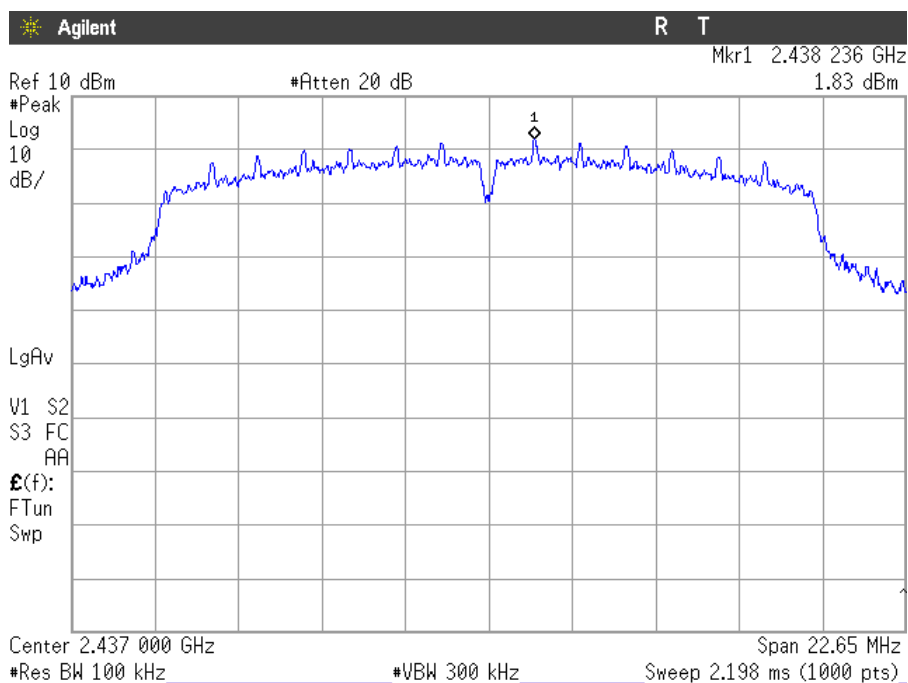


Mode N20

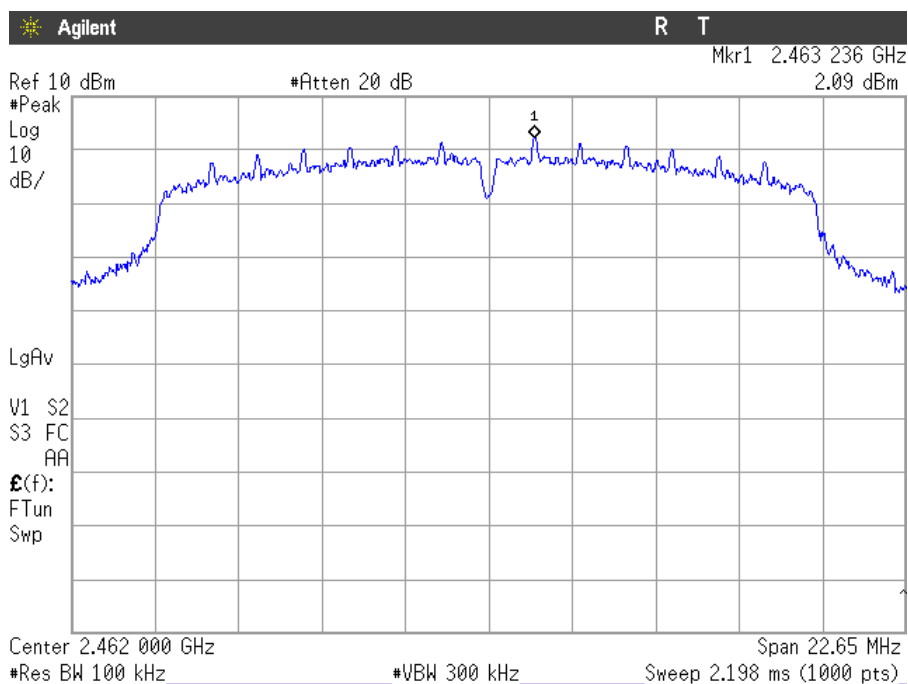
Lowest Channel



Middle Channel

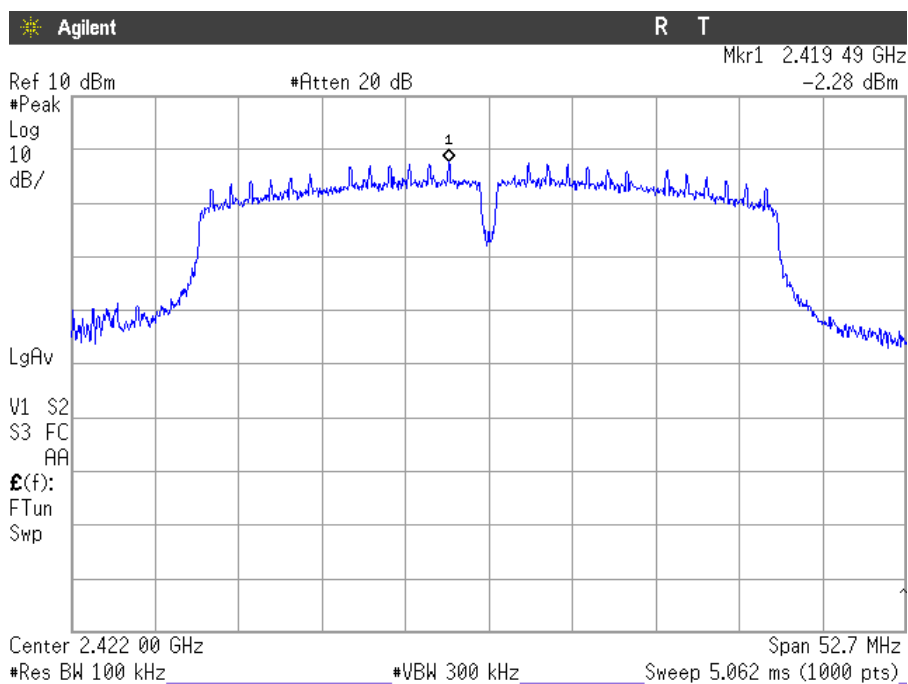


Highest channel

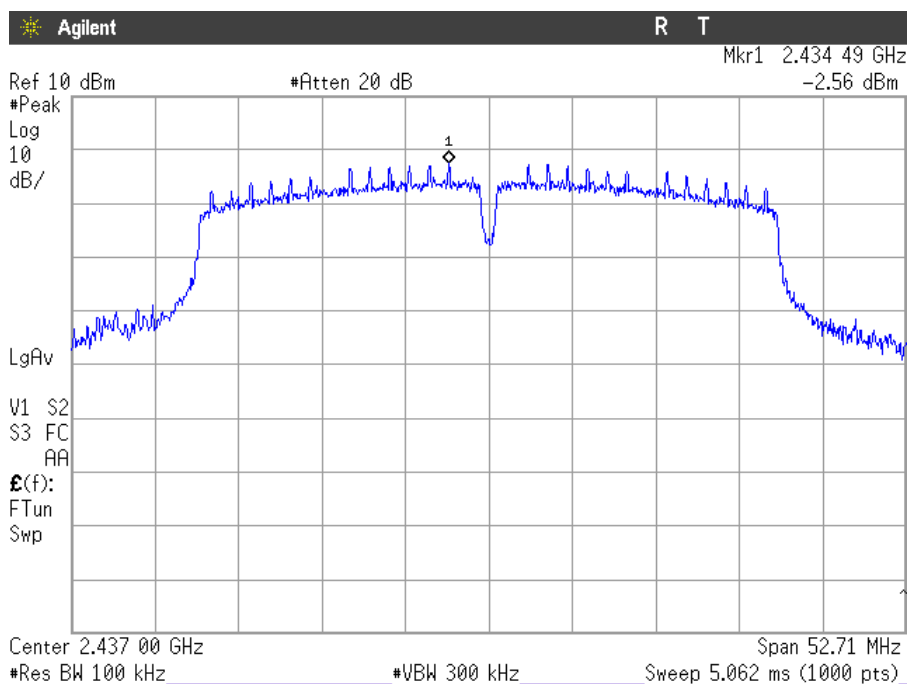


Mode N40

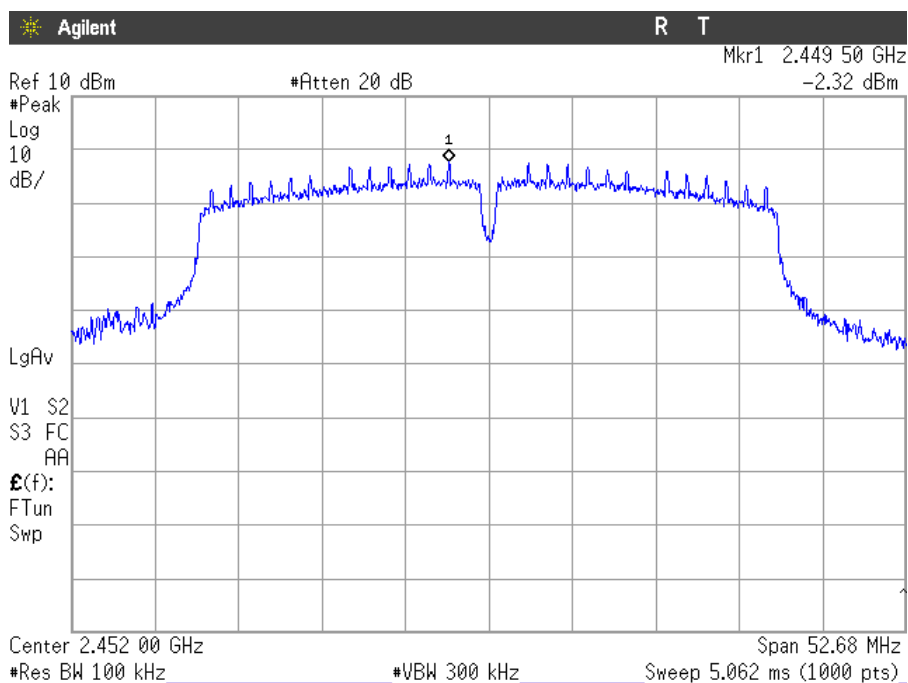
Lowest Channel



Middle Channel



Highest channel



Section 15.247 Subclause (d). 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)):

Frequency Range (MHz)	Field strength ($\mu\text{V/m}$)	Field strength ($\text{dB}\mu\text{V/m}$)	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.

RESULTS:

The situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° 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-1000 MHz.

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

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
450.592	V	Quasi-Peak	25.36	± 3.88
675.971	V	Quasi-Peak	24.71	± 3.88

All other peaks are more than 20 dB below the limit.

Frequency range 1 GHz-25 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 (see next plots).

The field strength at the band edges was evaluated for each mode for the channel under test.

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

1. WiFi 2.4GHz 802.11 b mode.

1.1. CHANNEL 1: LOWEST (2412 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.31-2.39 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.37446	V	Peak	47.71	± 4.87
2.38696	V	Peak	50.63	± 4.87
2.51697	V	Peak	47.76	± 4.87
4.82425	V	Peak	42.82	± 4.87

1.2. CHANNEL 6: MIDDLE (2437 MHz). Out-of-band spurious emissions in the 1-25 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.54377	V	Peak	47.81	± 4.87
4.87425	V	Peak	43.42	± 4.87

1.3. CHANNEL 11: HIGHEST (2462 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.4835-2.5 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.48740	V	Peak	52.13	± 4.87
2.56550	V	Peak	48.11	± 4.87
4.92375	V	Peak	44.63	± 4.87

Verdict: PASS

2. WiFi 2.4GHz 802.11 g mode

2.1. CHANNEL 1: LOWEST (2412 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.31-2.39 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.38956	V	Peak	69.36	± 4.87
		Average	50.62	± 4.87
2.52003	V	Peak	47.83	± 4.87

2.2. CHANNEL 6: MIDDLE (2437 MHz). Out-of-band spurious emissions in the 1-25 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.53917	V	Peak	47.83	± 4.87

2.3. CHANNEL 11: HIGHEST (2462 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.4835-2.5 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.48358	V	Peak	72.88	± 4.87
		Average	53.98	± 4.87
2.56950	V	Peak	49.38	± 4.87

Verdict: PASS

3. WiFi 2.4GHz 802.11 n20 mode

3.1. CHANNEL 1: LOWEST (2412 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.31-2.39 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.38989	V	Peak	70.84	± 4.87
		Average	52.63	± 4.87

3.2. CHANNEL 6: MIDDLE (2437 MHz). Out-of-band spurious emissions in the 1-25 GHz.

All peaks are more than 20 dB below the limit.

3.3. CHANNEL 11: HIGHEST (2462 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.4835-2.5 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.48354	V	Peak	70.25	± 4.87
		Average	52.56	± 4.87
2.56557	V	Peak	46.12	± 4.87

Verdict: PASS

4. WiFi 2.4GHz 802.11 n40 mode

4.1. CHANNEL 3: LOWEST (2422 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.31-2.39 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμV/m)	Measurement Uncertainty (dB)
2.38913	V	Peak	72.62	± 4.87
		Average	53.41	± 4.87

4.2. CHANNEL 6: MIDDLE (2437 MHz). Out-of-band spurious emissions in the 1-25 GHz.

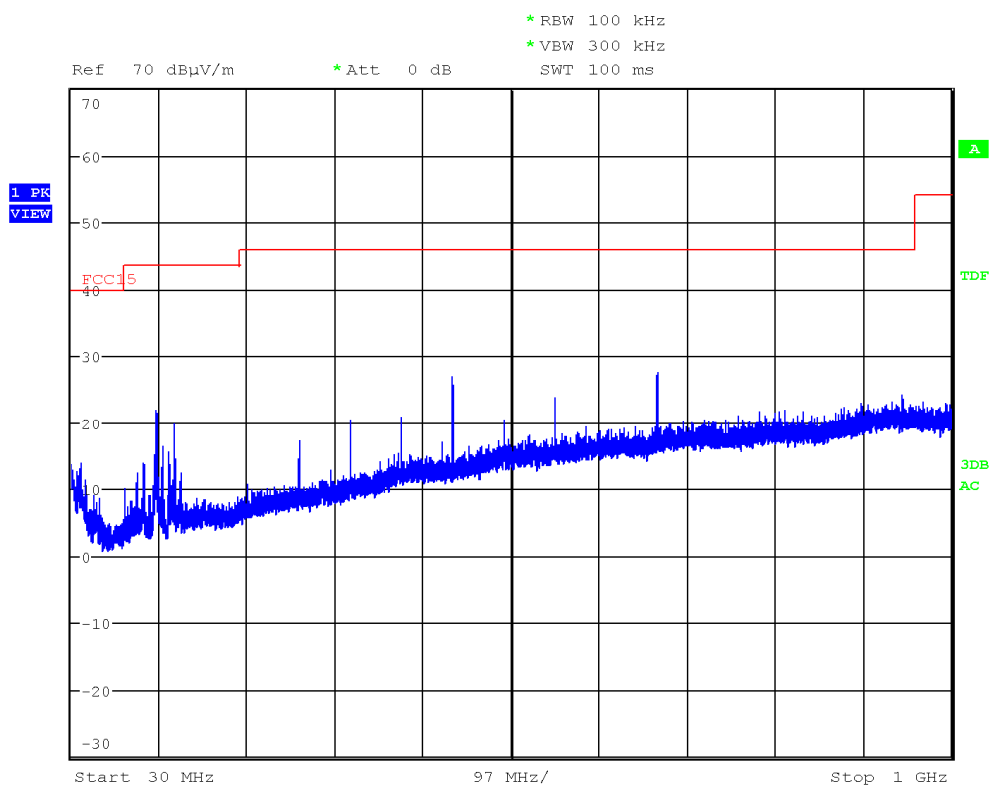
All peaks are more than 20 dB below the limit.

4.3. CHANNEL 9: HIGHEST (2452 MHz). Out-of-band spurious emissions in the 1-25 GHz range and inside restricted band 2.4835-2.5 GHz.

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBμ V/m)	Measurement Uncertainty (dB)
2.48420	H	Peak	69.92	± 4.87
		Average	52.50	± 4.87

Verdict: PASS

FREQUENCY RANGE 30 MHz-1000 MHz.

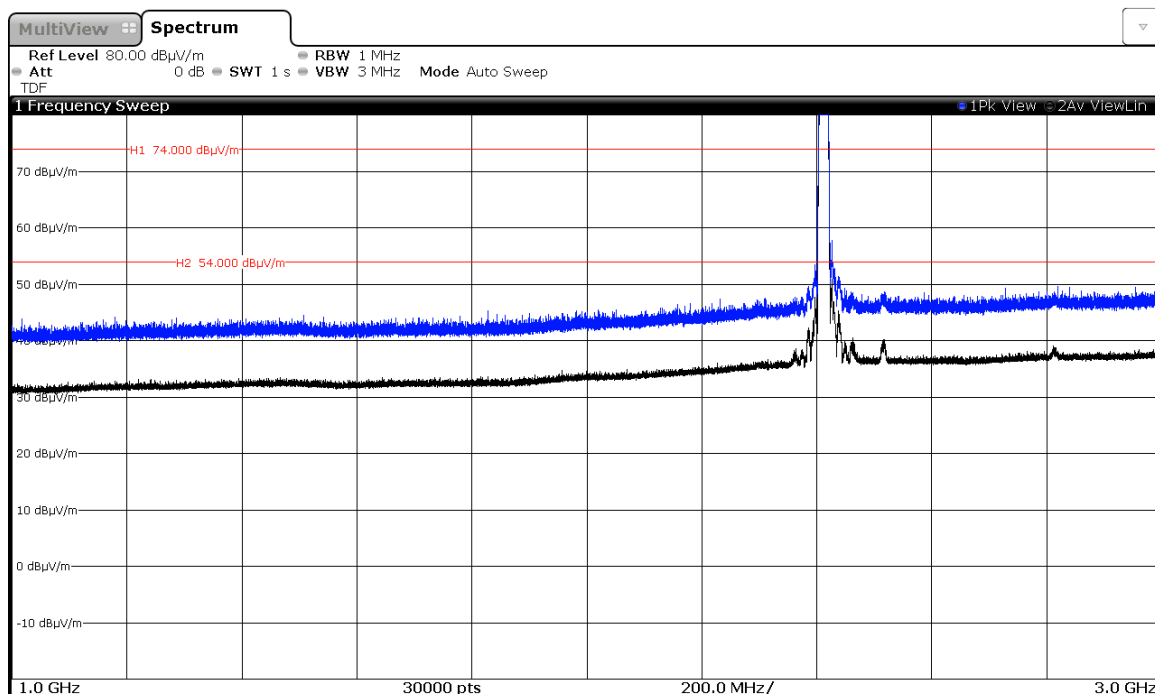


(This plot is valid for all modulation modes).

FREQUENCY RANGE 1 GHz to 3 GHz.

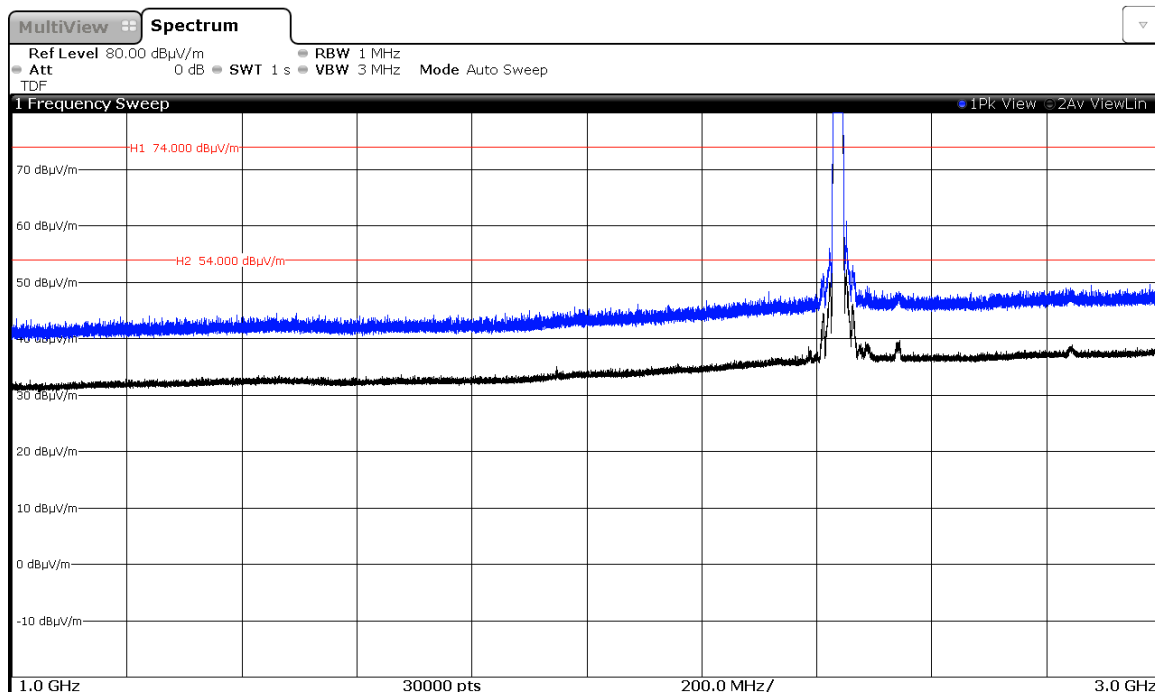
1. WiFi 2.4GHz 802.11 b mode

CHANNEL 1 (2412 MHz).



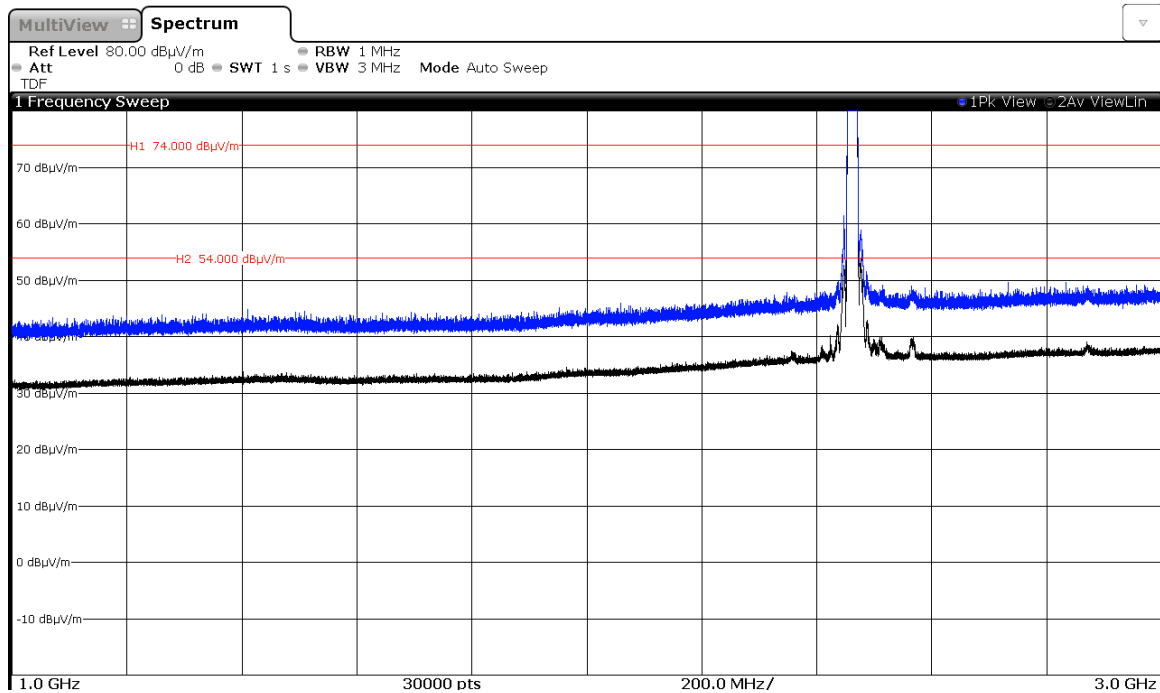
Note: The peak above the limit is the carrier frequency.

CHANNEL 6 (2437 MHz).



Note: The peak above the limit is the carrier frequency.

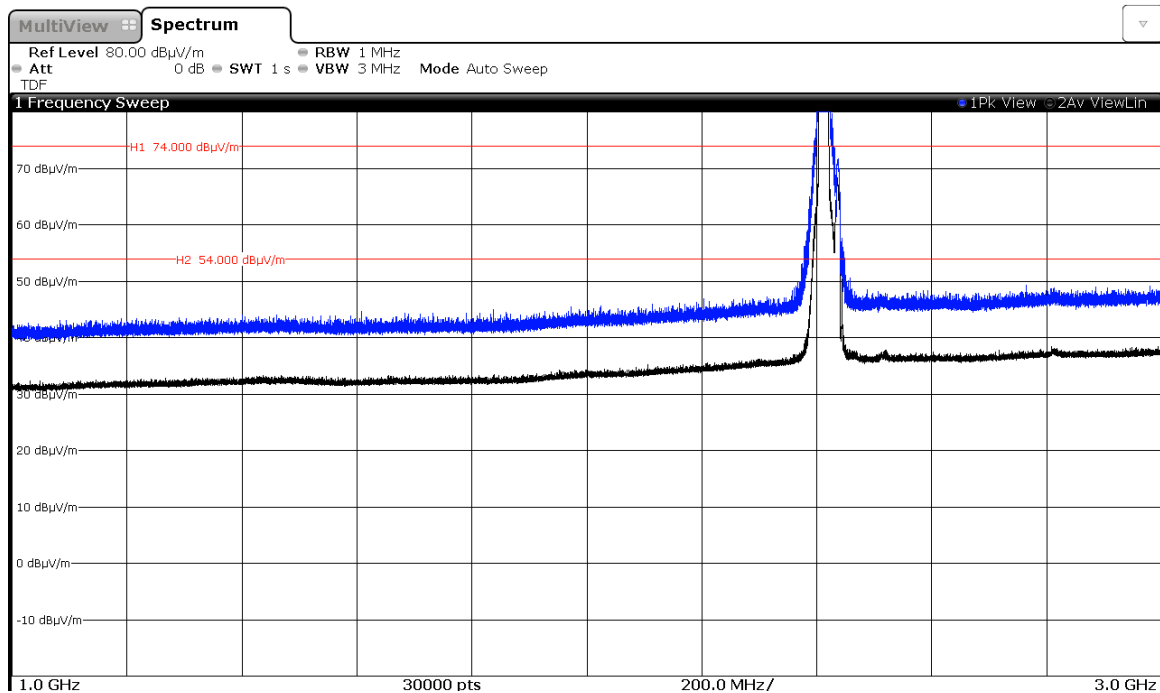
CHANNEL 11 (2462 MHz).



Note: The peak above the limit is the carrier frequency.

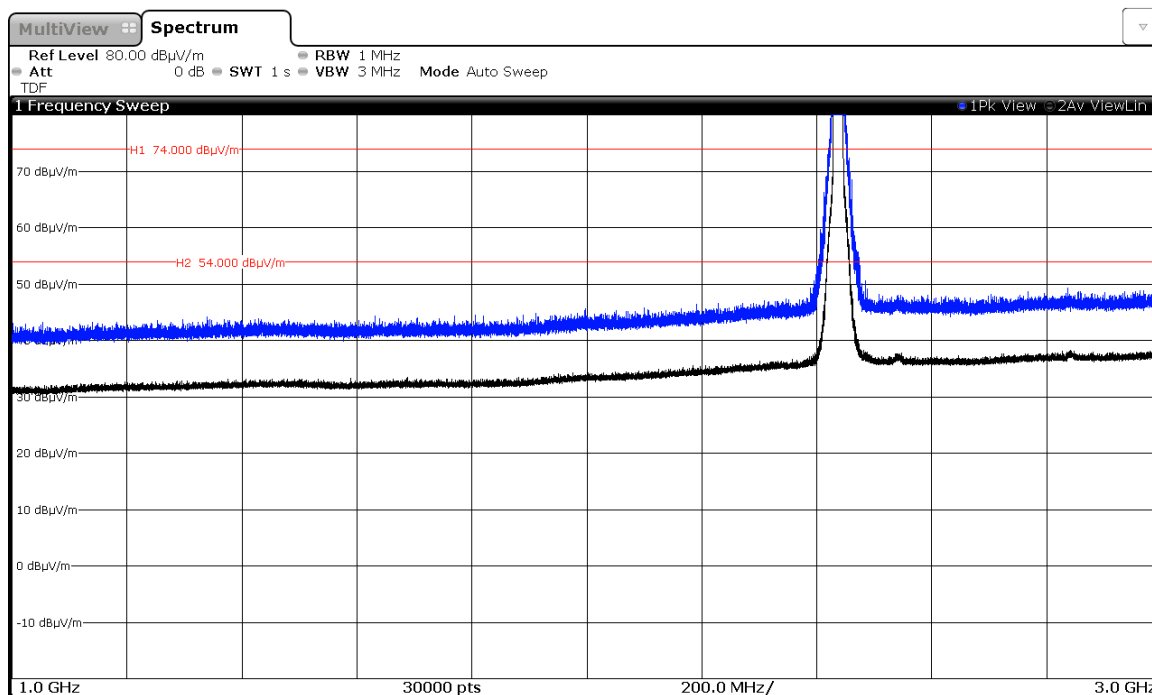
2. WiFi 2.4GHz 802.11 g mode

CHANNEL 1 (2412 MHz).



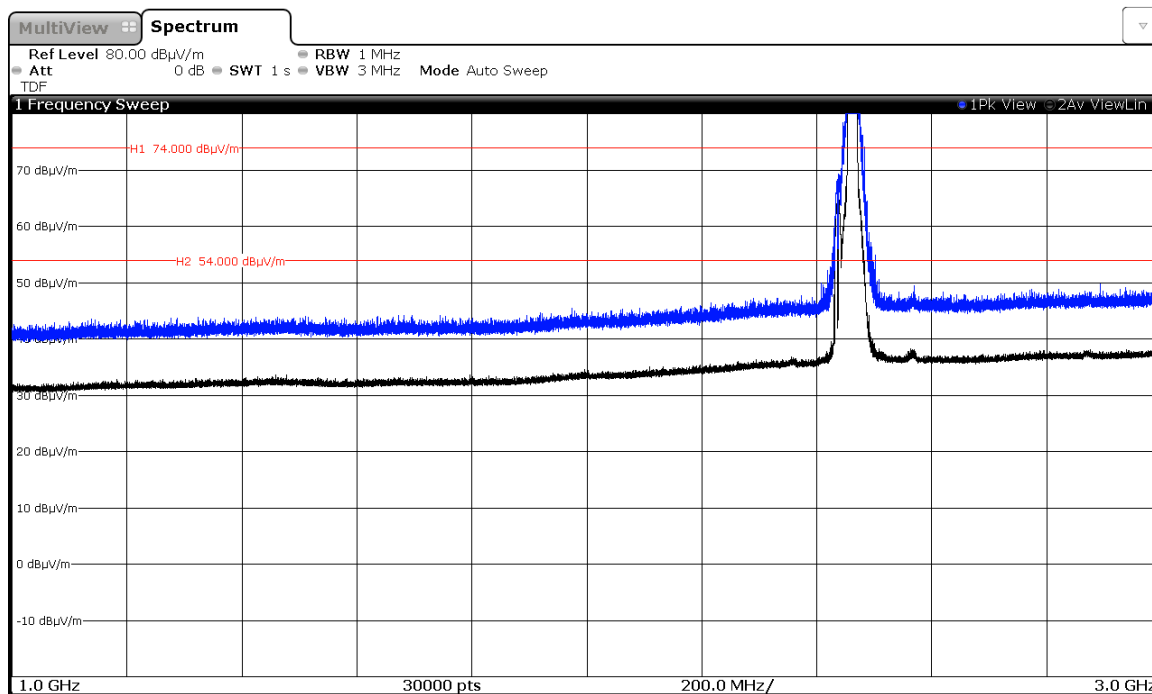
Note: The peak above the limit is the carrier frequency.

CHANNEL 6 (2437 MHz).



Note: The peak above the limit is the carrier frequency.

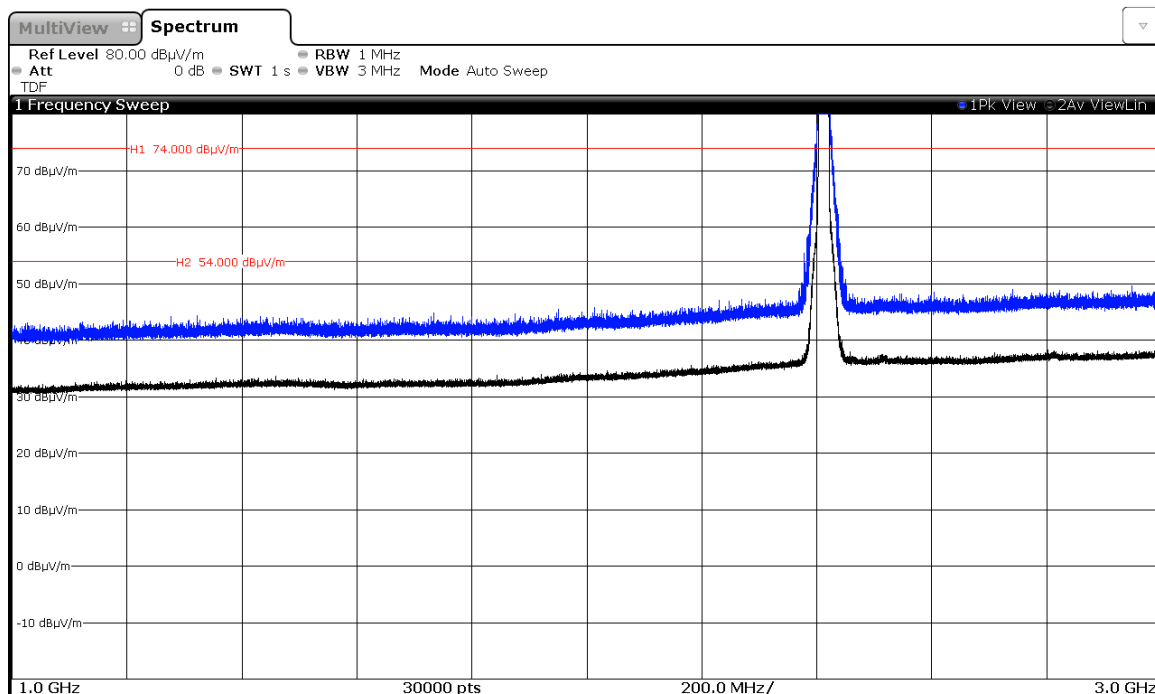
CHANNEL 11 (2462 MHz).



Note: The peak above the limit is the carrier frequency.

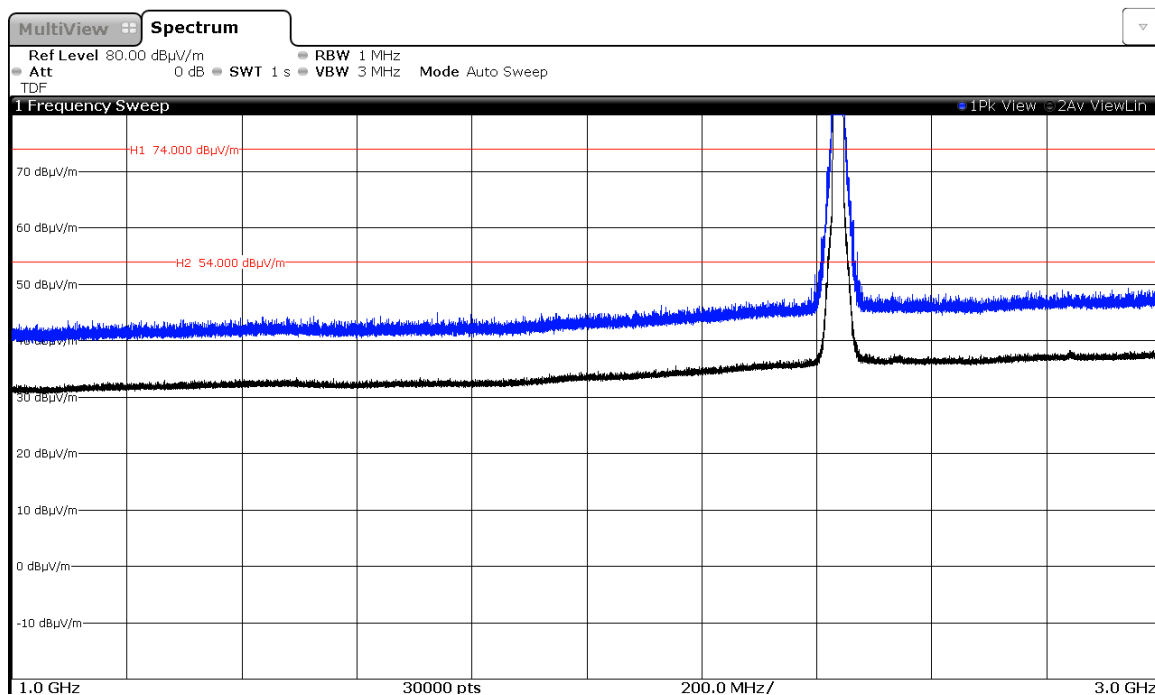
3. WiFi 2.4GHz 802.11 n20 mode

CHANNEL 1 (2412 MHz).



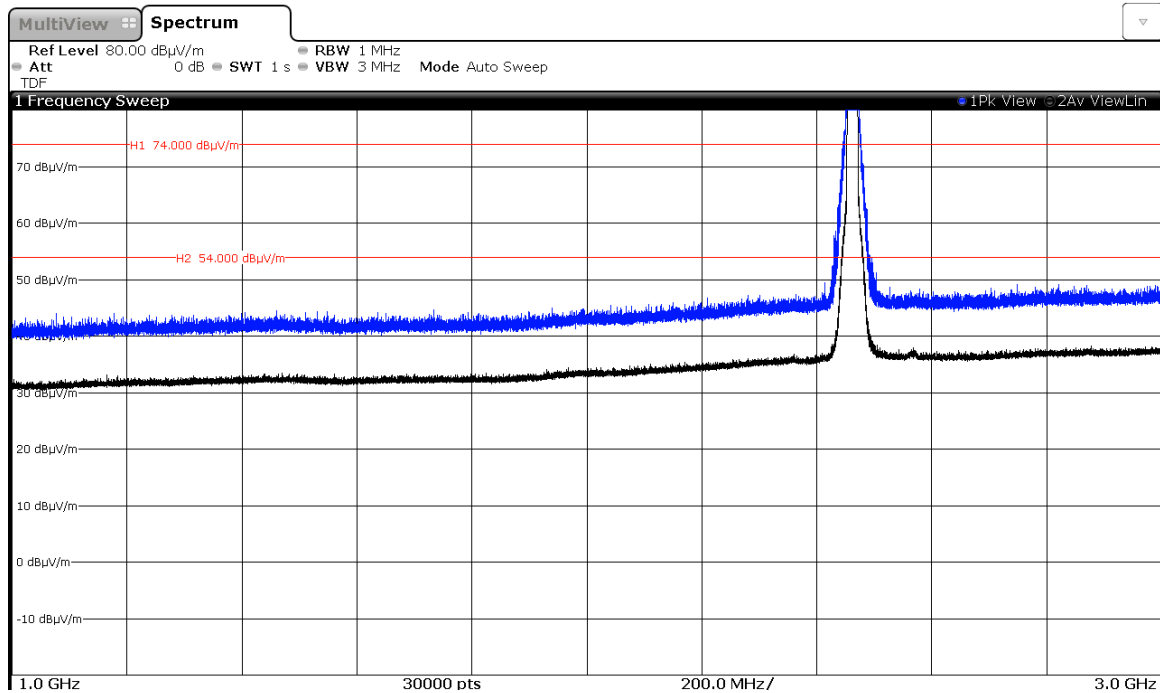
Note: The peak above the limit is the carrier frequency.

CHANNEL 6 (2437 MHz).



Note: The peak above the limit is the carrier frequency.

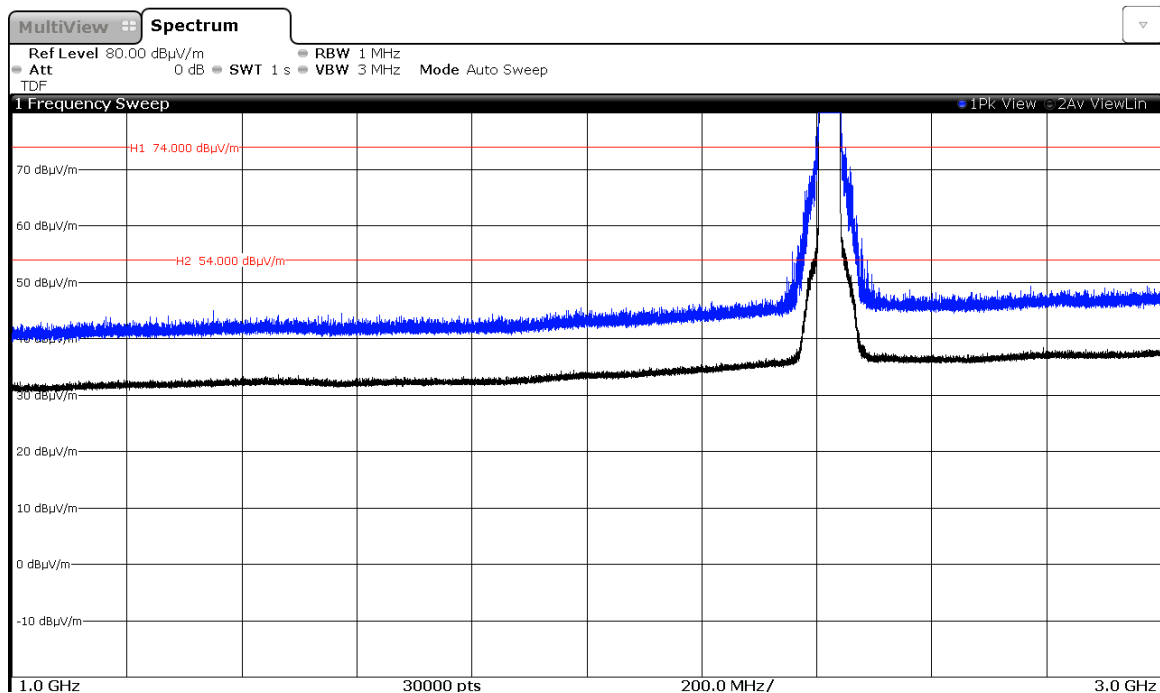
CHANNEL 11 (2462 MHz).



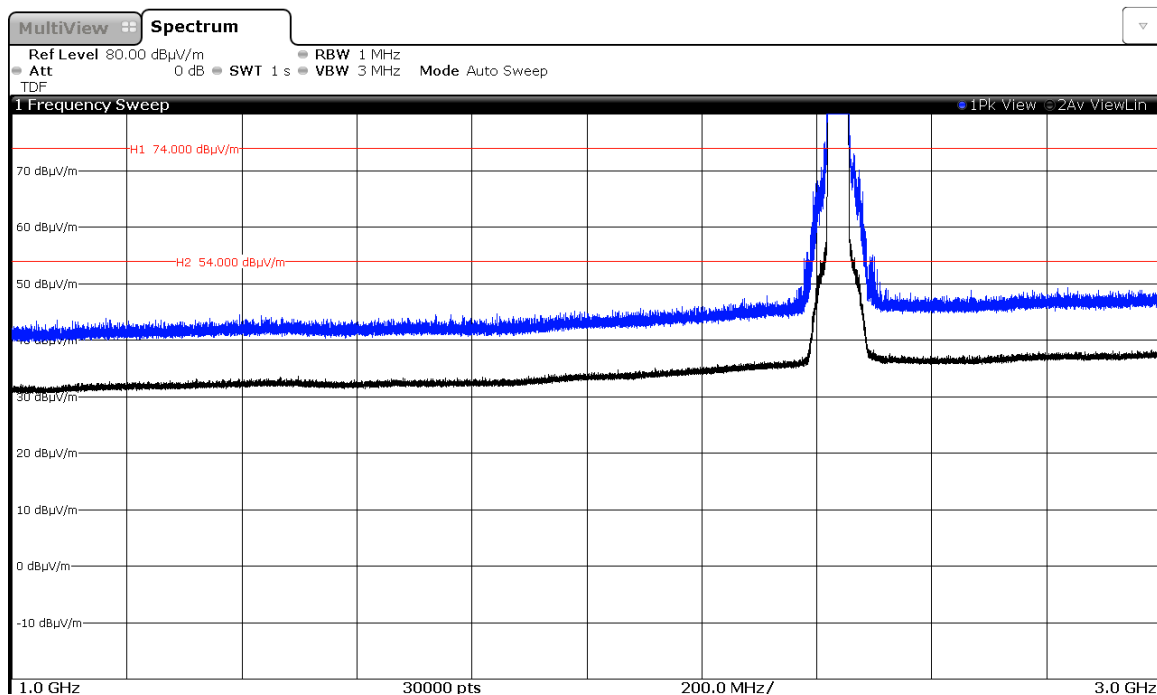
Note: The peak above the limit is the carrier frequency.

4. WiFi 2.4GHz 802.11 n40 mode

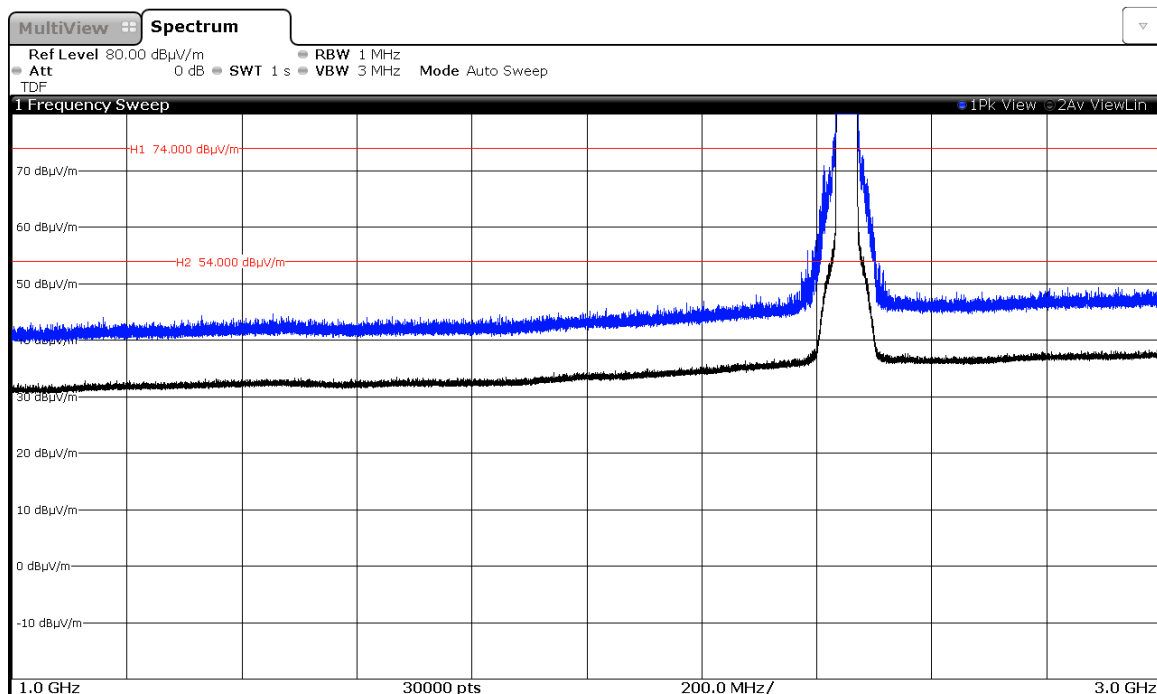
CHANNEL 3 (2422 MHz).



CHANNEL 6 (2437 MHz).



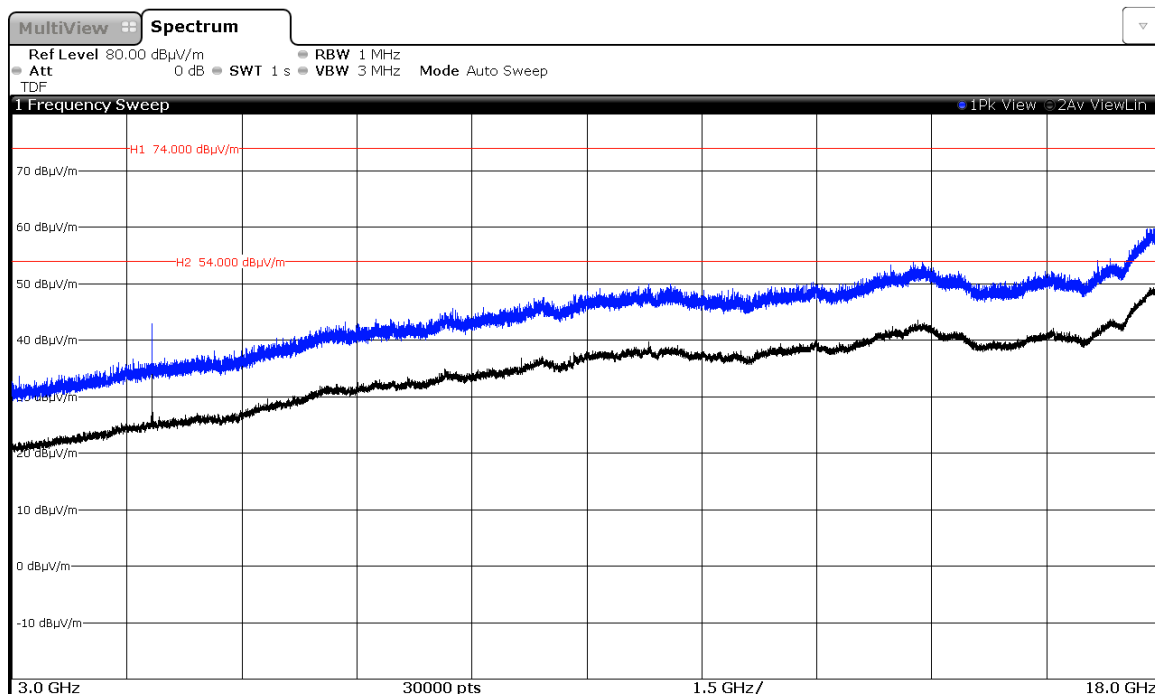
CHANNEL 9 (2452 MHz).



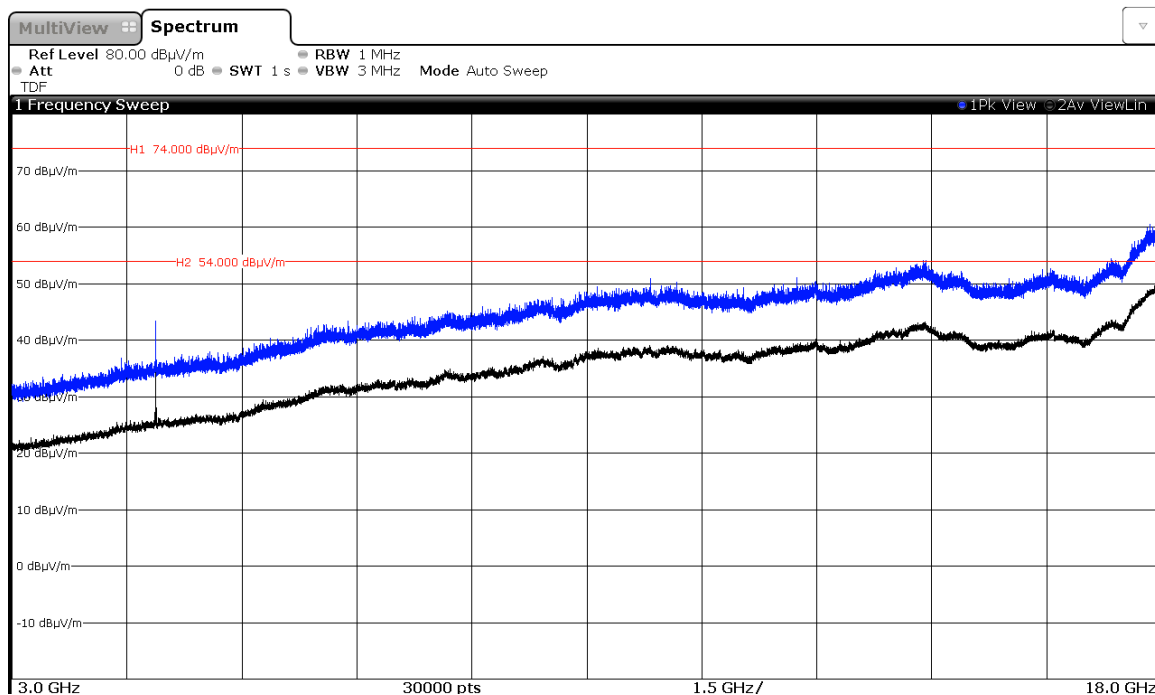
FREQUENCY RANGE 3 GHz to 18 GHz.

1. WiFi 2.4GHz 802.11 b mode

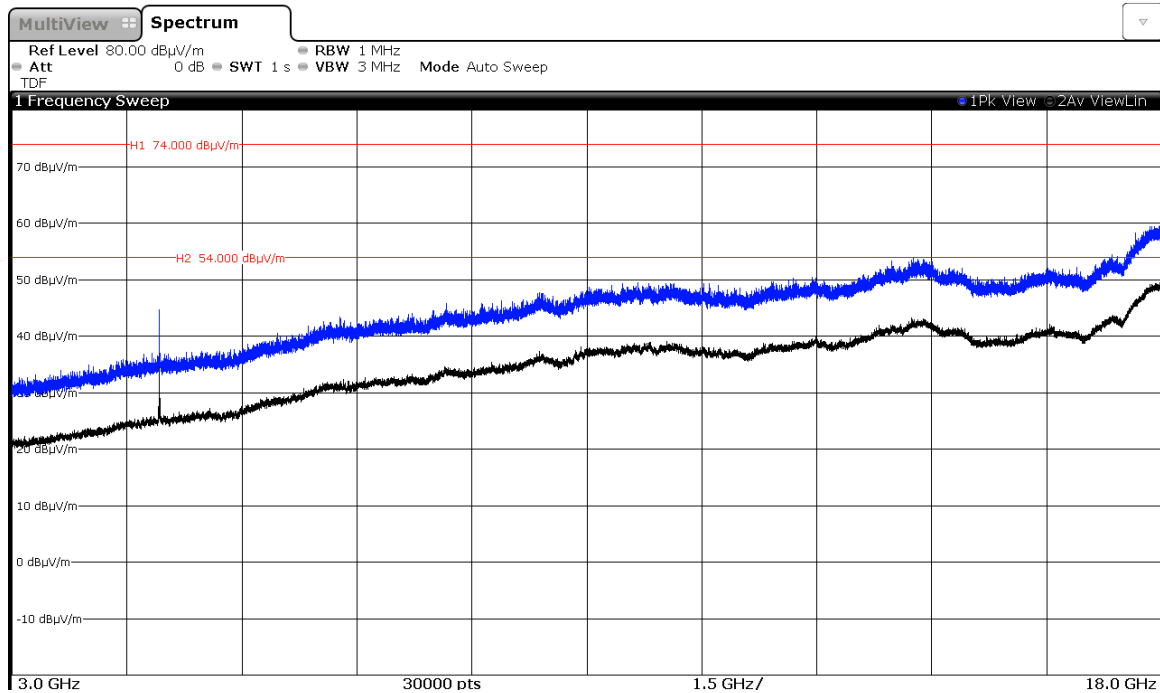
CHANNEL 1 (2412 MHz).



CHANNEL 6 (2437 MHz).

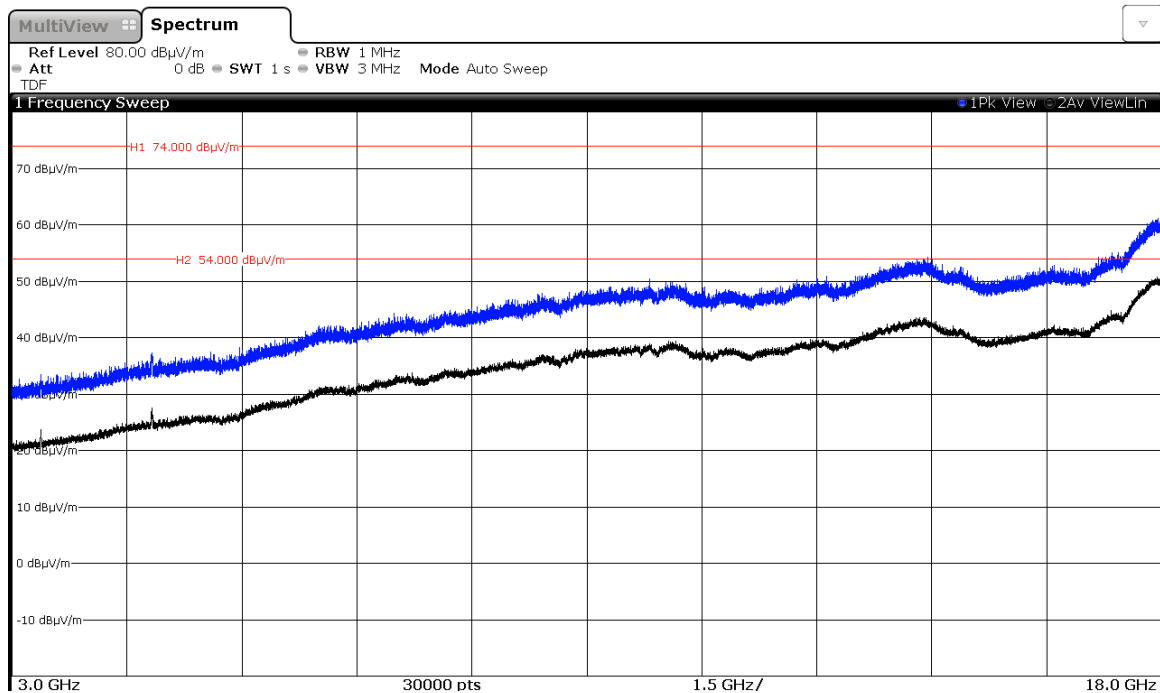


CHANNEL 11 (2462 MHz).

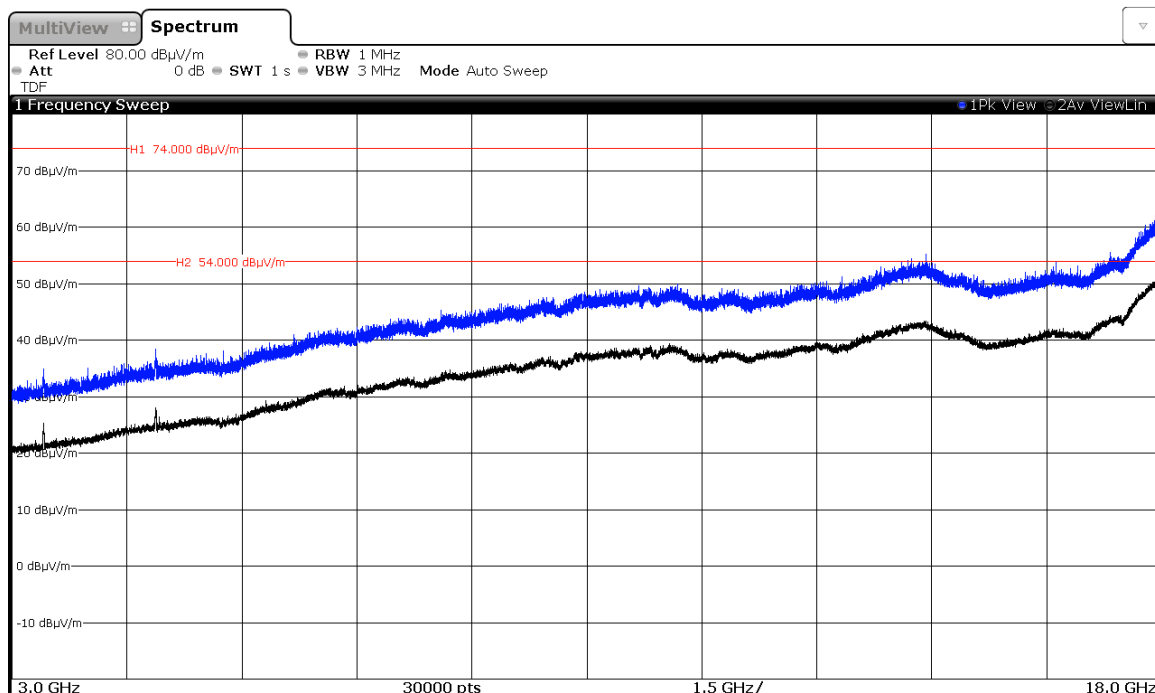


2. WiFi 2.4GHz 802.11 g mode

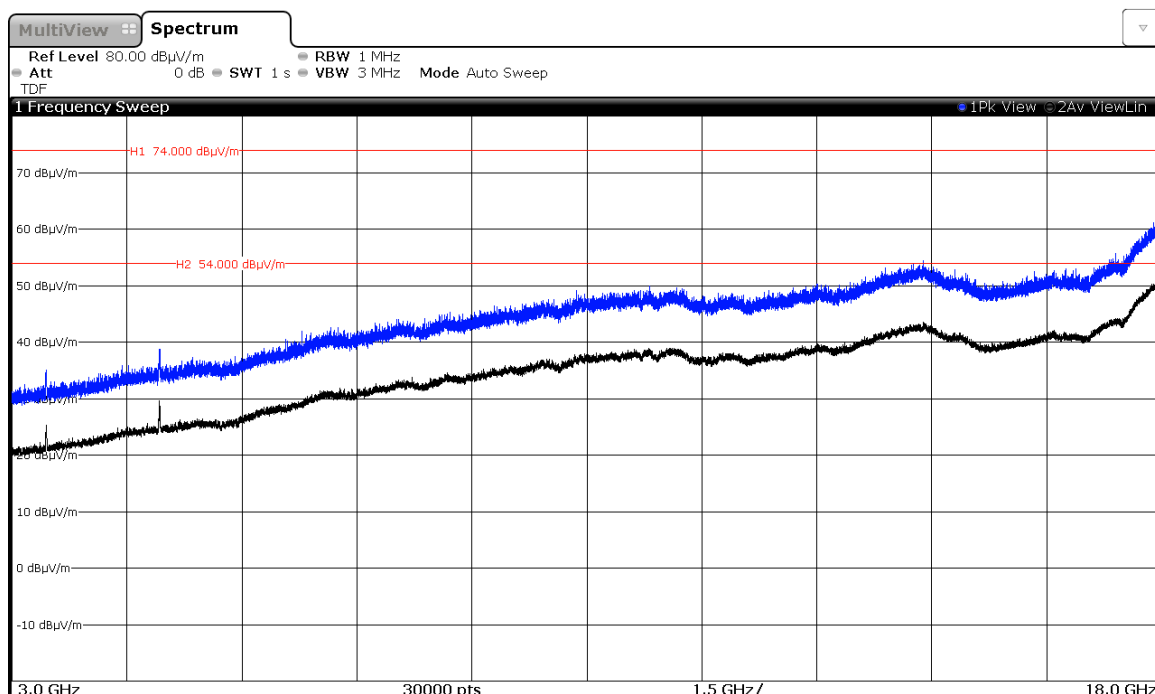
CHANNEL 1 (2412 MHz).



CHANNEL 6 (2437 MHz).

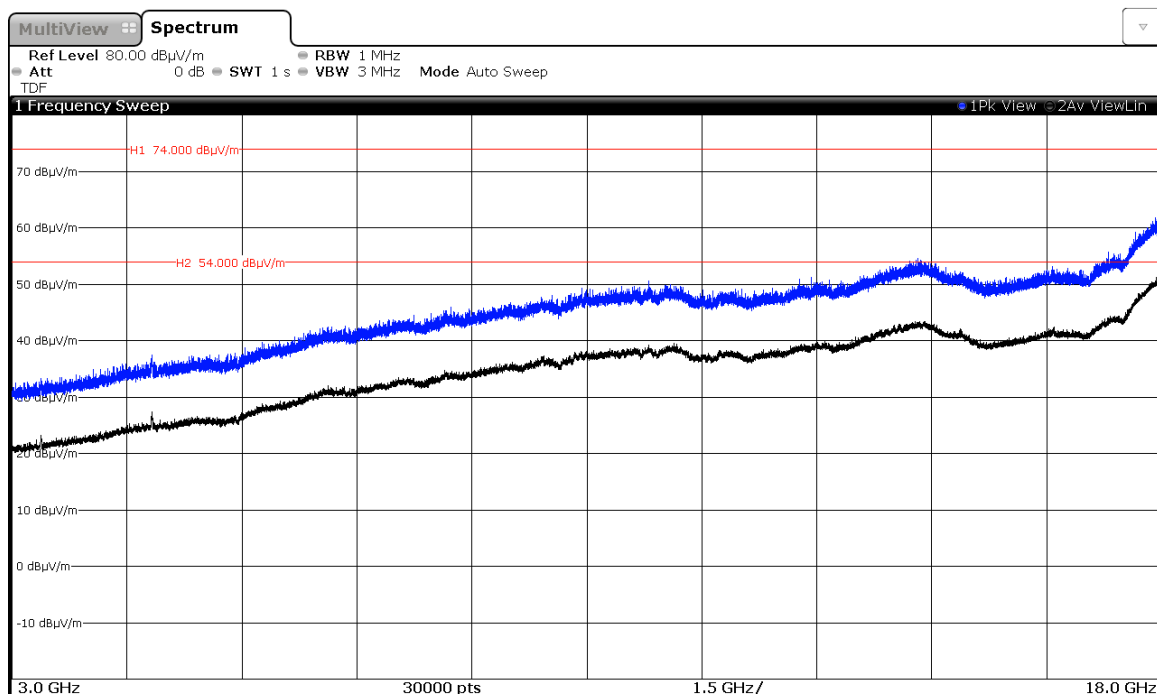


CHANNEL 11 (2462 MHz).

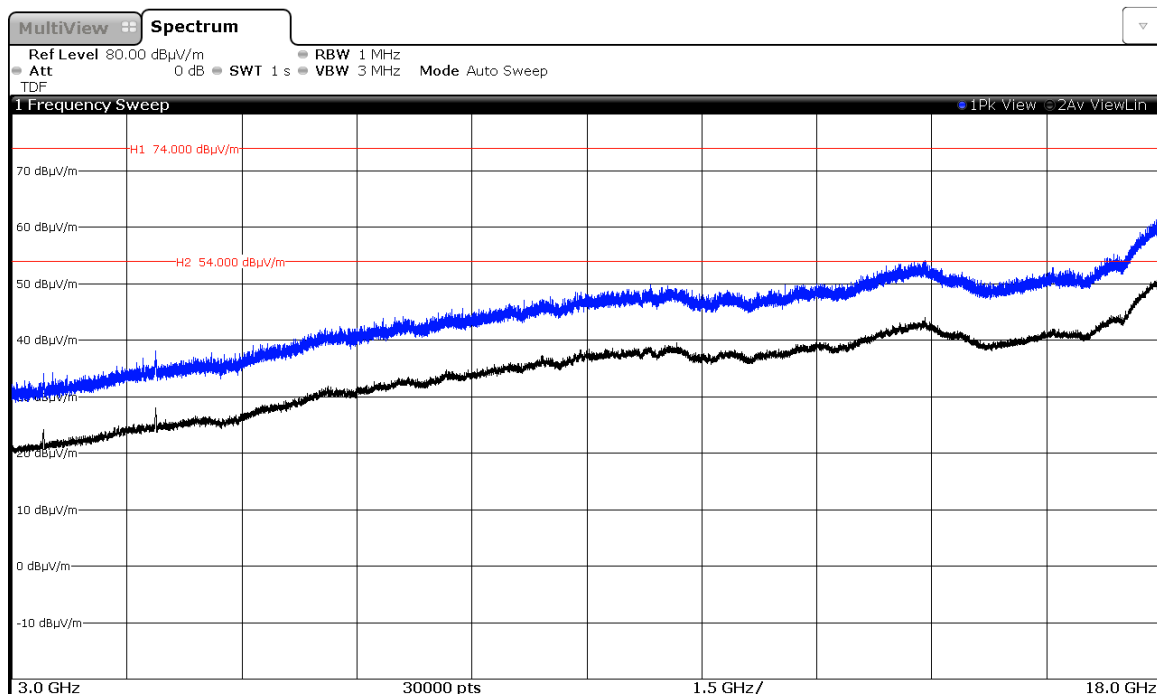


3. WiFi 2.4GHz 802.11 n20 mode

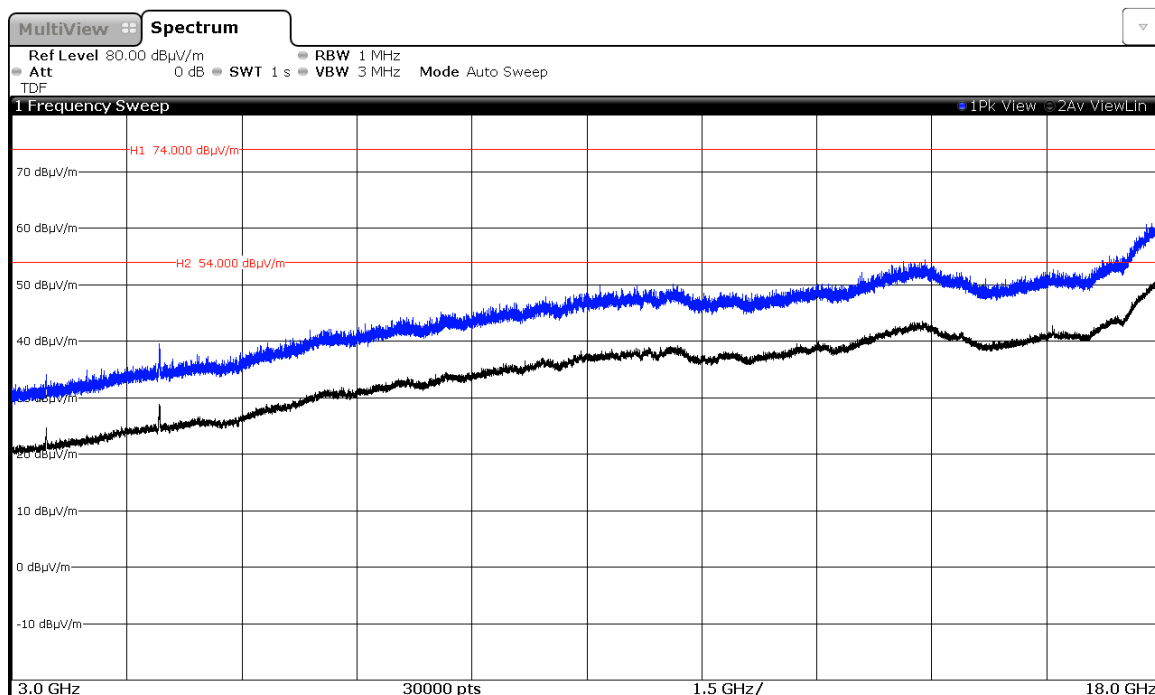
CHANNEL 1 (2412 MHz).



CHANNEL 6 (2437 MHz).

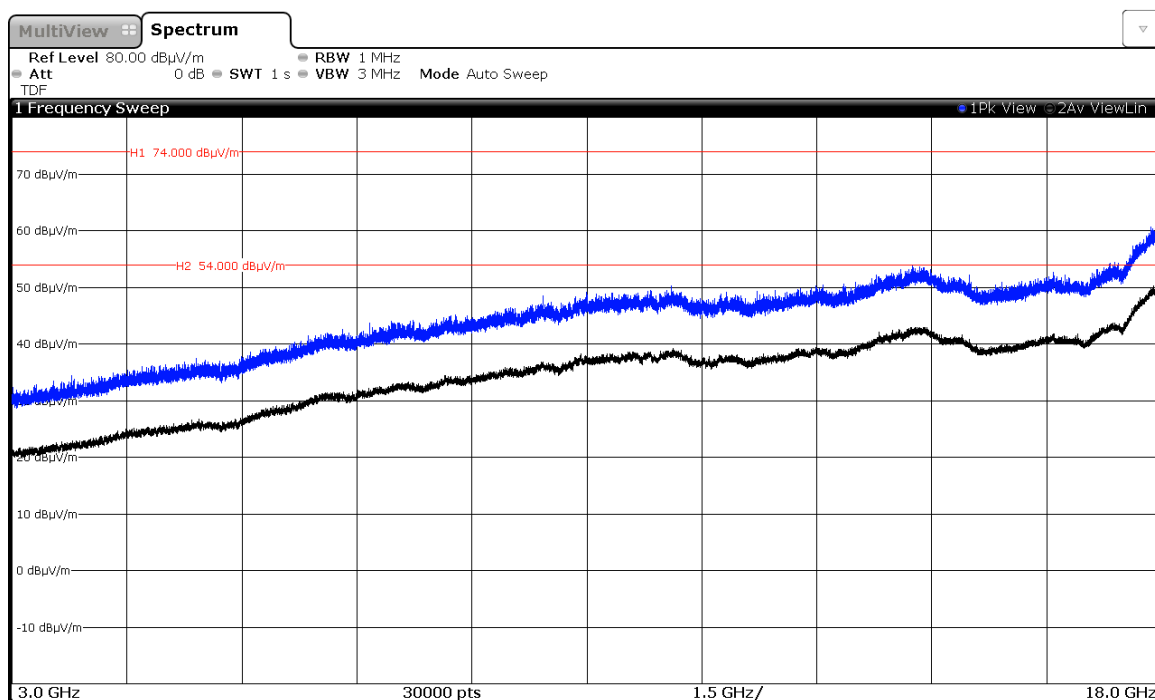


CHANNEL 11 (2462 MHz).

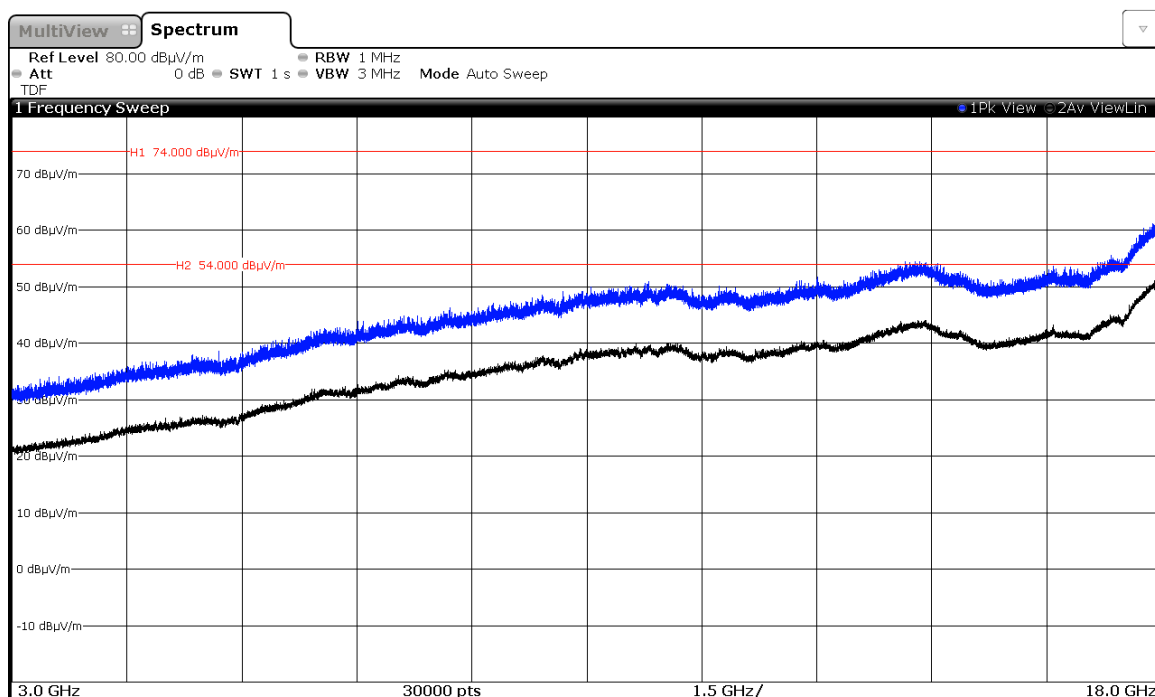


4. WiFi 2.4GHz 802.11 n40 mode

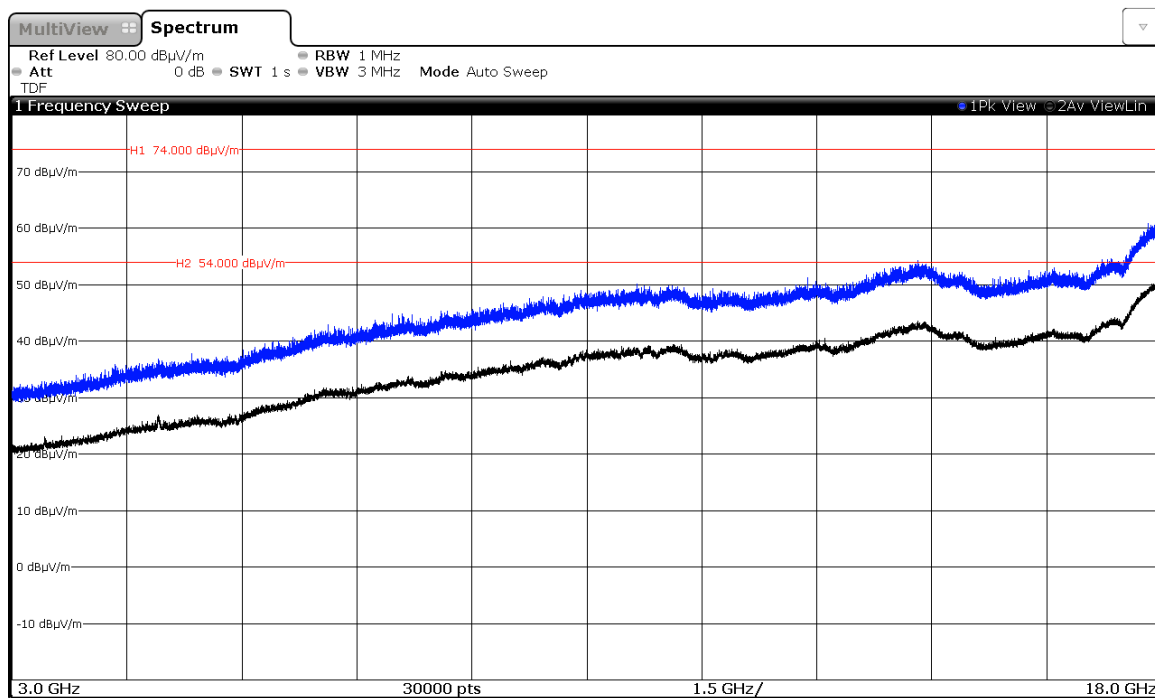
CHANNEL 3 (2422 MHz).



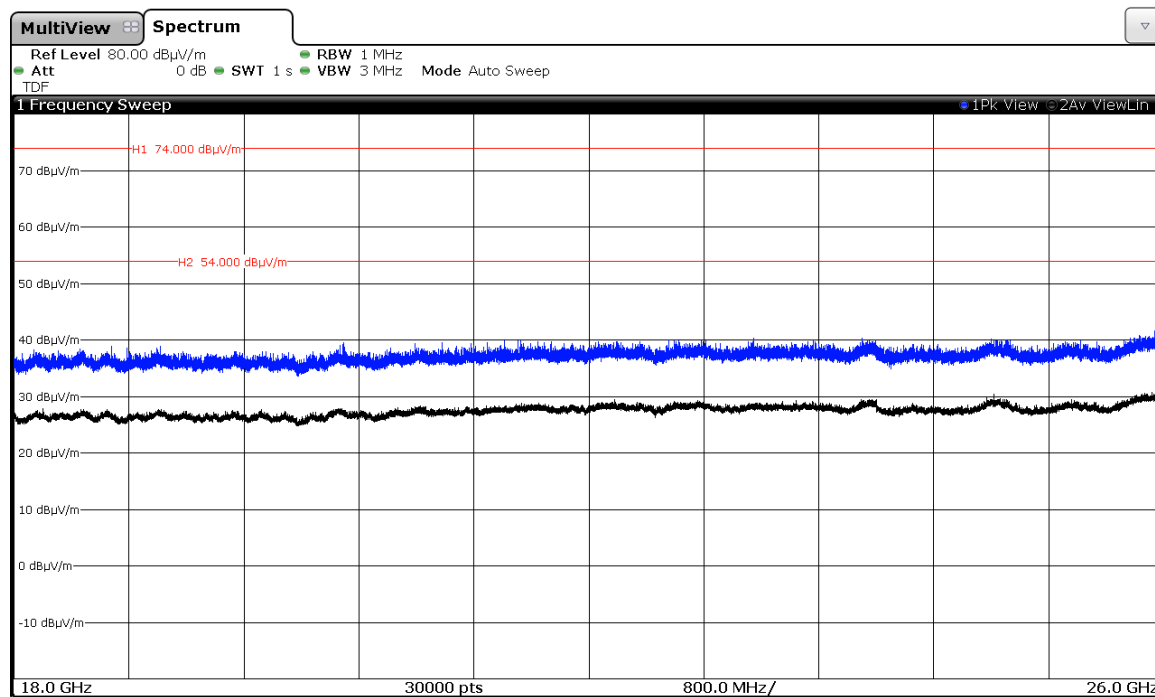
CHANNEL 6 (2437 MHz).



CHANNEL 9 (2452 MHz).



FREQUENCY RANGE 18 GHz to 26 GHz.

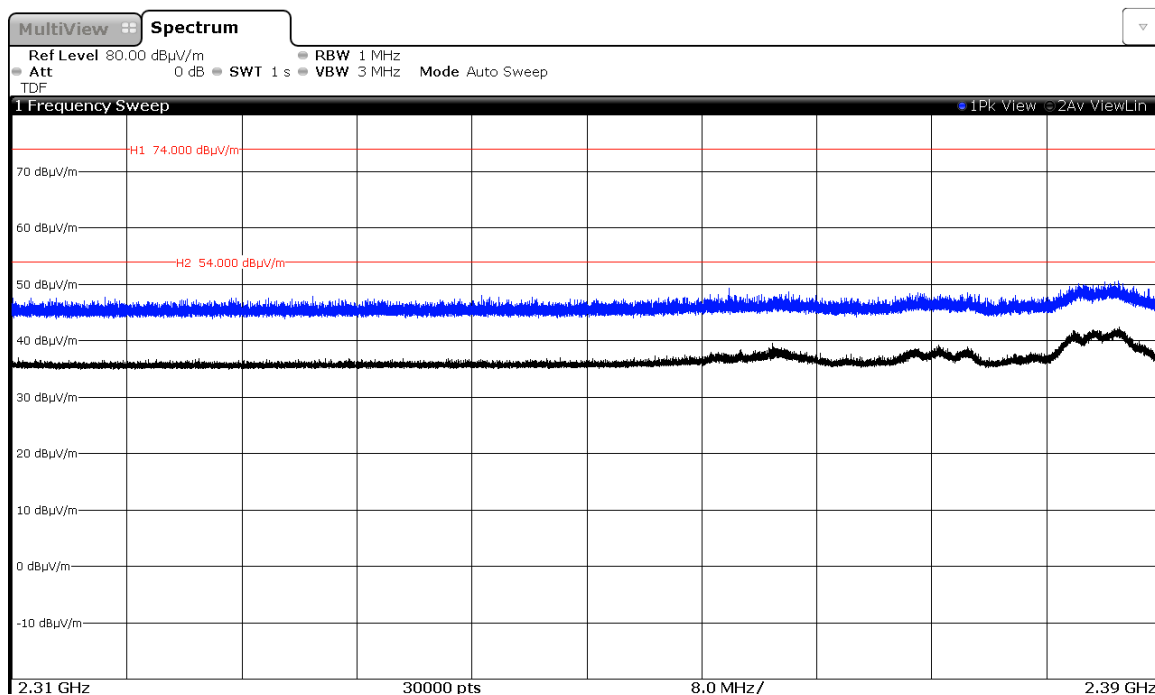


(This plot is valid for all three channels and all modulations).

FREQUENCY RANGE 2.31 GHz to 2.39 GHz. (RESTRICTED BAND)

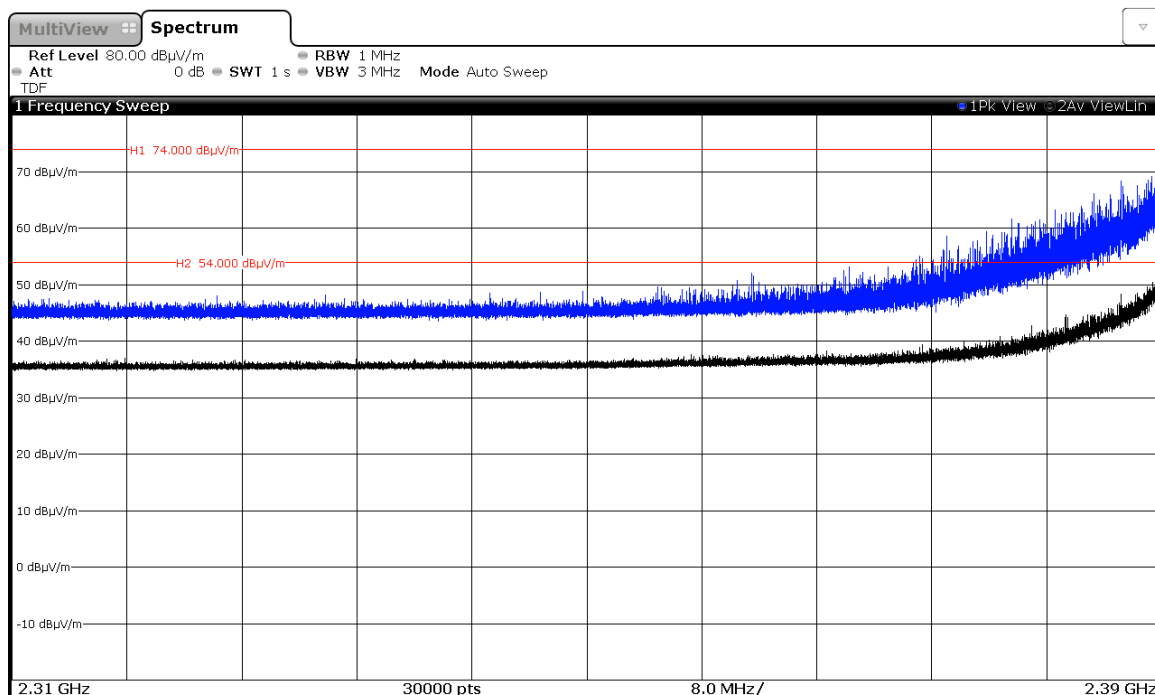
1. WiFi 2.4GHz 802.11 b mode

CHANNEL 1 (2412 MHz).



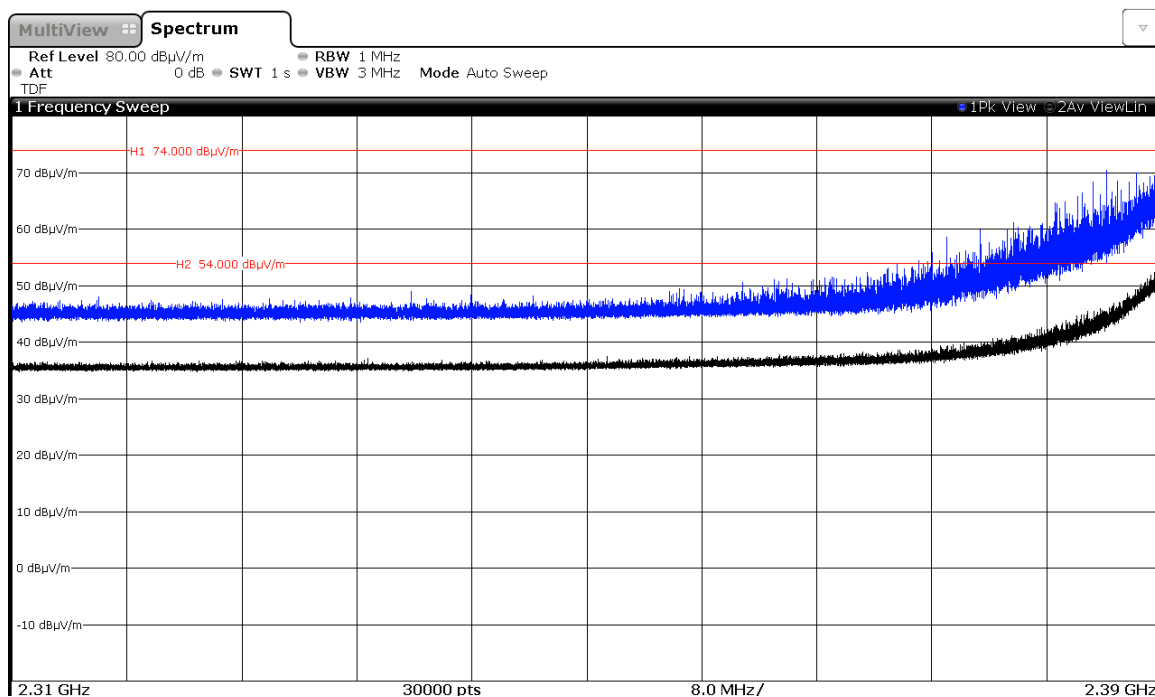
2. WiFi 2.4GHz 802.11 g mode

CHANNEL 1 (2412 MHz).



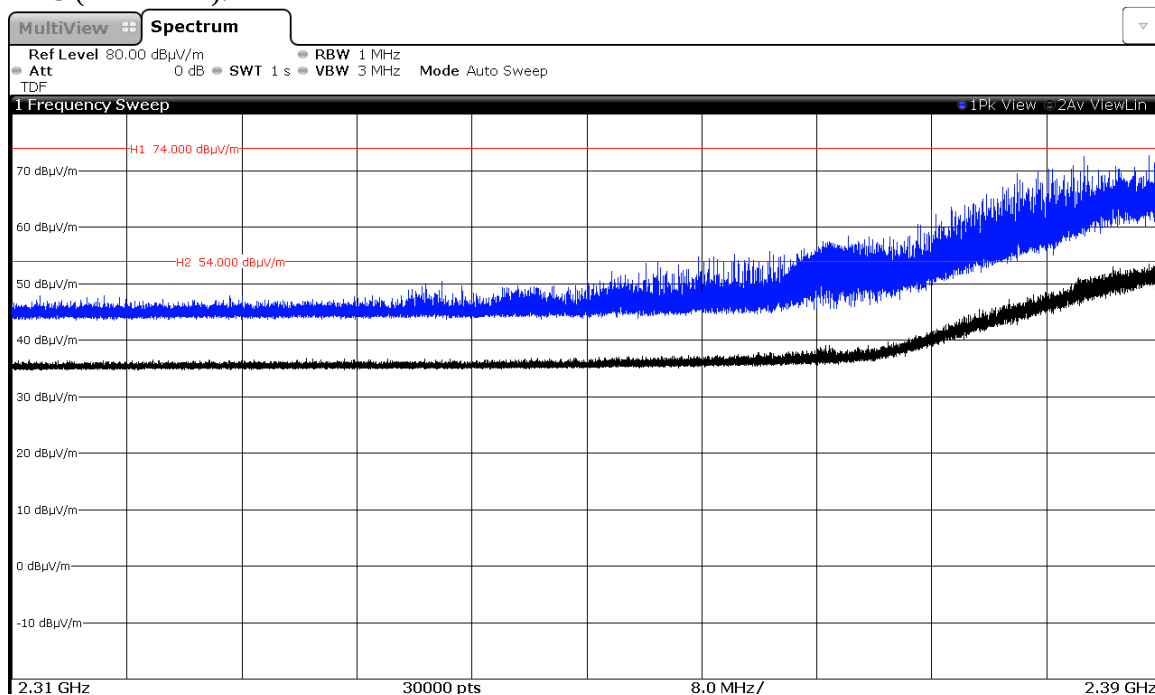
3. WiFi 2.4GHz 802.11 n20 mode

CHANNEL 1 (2412 MHz).



4. WiFi 2.4GHz 802.11 n40 mode

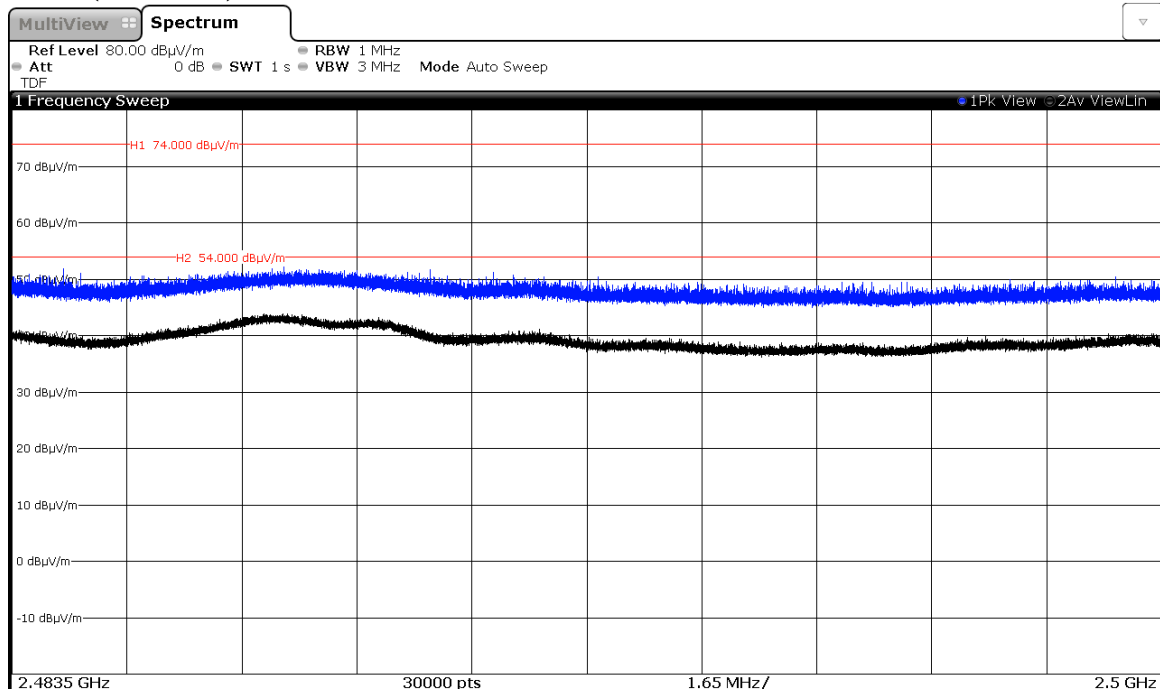
CHANNEL 3 (2422 MHz).



FREQUENCY RANGE 2.4835 GHz to 2.5 GHz. (RESTRICTED BAND)

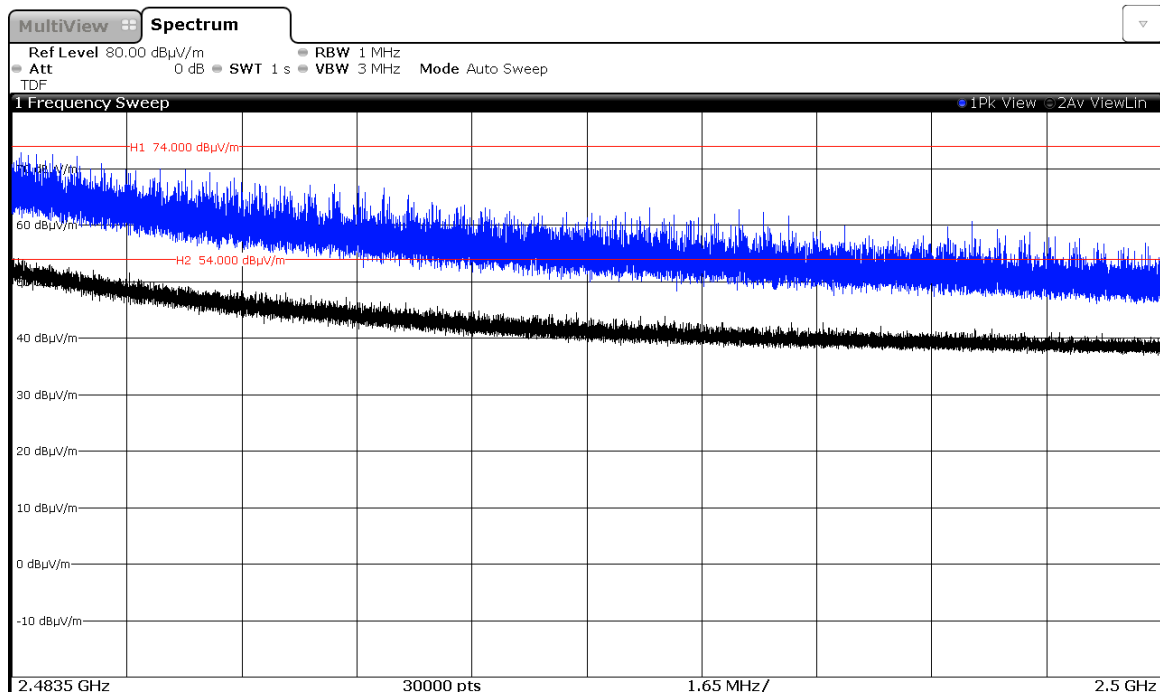
1. WiFi 2.4GHz 802.11 b mode

CHANNEL 11 (2462 MHz).



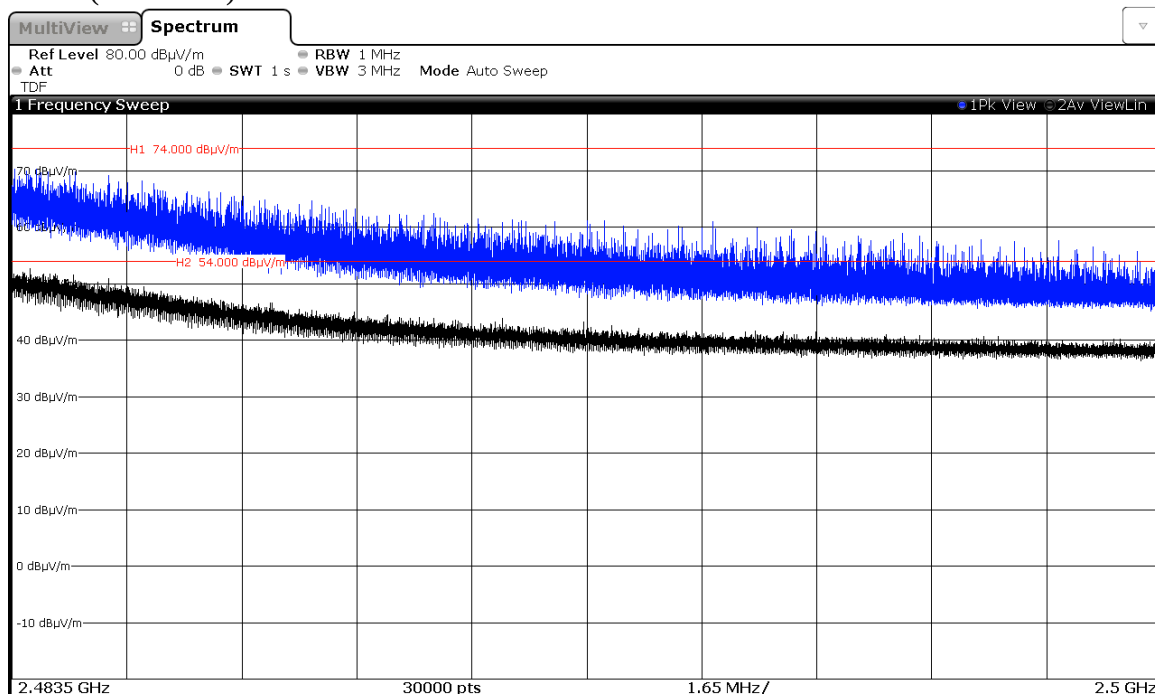
2. WiFi 2.4GHz 802.11 g mode

CHANNEL 11 (2462 MHz).



3. WiFi 2.4GHz 802.11 n20 mode

CHANNEL 11 (2462 MHz).



4. WiFi 2.4GHz 802.11 n40 mode

CHANNEL 9 (2452 MHz).

