ENAC ENSAYOS Nº 51/LE147

FCC LISTED, REGISTRATION NUMBER: 720267

ISED LISTED REGISTRATION NUMBER 4621A-2

Informe de ensayo nº:
Test report No:

NIE: 54913RRF.001

Test report

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

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

Identificación del objeto ensayado.....: Identification of item tested	Zigbee module 2.4 GHz
Marca .....: Trademark	Soltec
Modelo y/o referencia tipo .....: Model and /or type reference	SolBee
Other identification of the product .....:	FCC ID: 2AOO8SOLBEE IC: 23674-SOLBEE
Final HW version .....:	1.2
Final SW version .....:	1.0
Características .....: Features	Operating voltage: 3.3vdc. Mount type: SMD. SPI control interface. Up to 20 dBm.
Solicitante.....: Applicant	SOLTEC ENERGIAS RENOVABLES S.L. C/ Gabriel Campillo s/n, 30500 Molina de Segura Murcia, Spain.
Método de ensayo solicitado, norma.....: Test method requested, standard	USA FCC Part 15.247 10-1-17 Edition: Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 10-1-17 Edition: Radiated emission limits; general requirements. CANADA RSS-247 Issue 2 (February 2017). CANADA RSS-Gen Issue 4 (November 2014). Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v04 dated 04/05/2017. 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	Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ Fecha: 2018.03.26 08:47:45 +02'00'
Fecha de realización .....: Date of issue	2018-03-21	
Formato de informe No. .....: Report template No	FDT08_20	

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Competences and guarantees

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

DEKRA Testing and Certification is a 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 conjuction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Registration Number: 720267.

DEKRA Testing and Certification is a laboratory with a measurement site in compliance with the requirements of RSS 212, Issue 1 (Provisional) and has been added to the list of filed sites of the Canadian Certification and Engineering Bureau. Reference File Number: ISED 4621A-2.

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

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

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

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

Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification.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 Nº	Description	Model	Serial Nº	Date of reception
54913C/025	Zigbee module 2.4GHz	SolBee	442000021XS00	2018-02-20
54913C/14	SMA cable with cover	---	---	2018-01-15
54913C/16	SMA cable with cover	---	---	2018-01-15
54913C/17	Antenna	---	---	2018-01-15
54913C/19	Antenna	---	---	2018-01-15
51732B/001	Board	---	---	2017-03-07

1. Sample S/01 has undergone following test(s).

   All radiated tests indicated in appendix A.

Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
54913C/025	Zigbee module 2.4GHz	SolBee	442000021XS00	2018-02-20
54913C/14	SMA cable with cover	---	---	2018-01-15
54913C/16	SMA cable with cover	---	---	2018-01-15
51732B/001	Board	---	---	2017-03-07

1. Sample S/02 has undergone following test(s).

   All conducted tests indicated in appendix A.

Test sample description

The sample under test consists of a 2.4 GHz IEEE 802.15.4 radio transceiver module with integrated matching circuitry, LNA, PA, filter, U.FL 50 Ω connector for external antenna and SPI interface.

Identification of the client

SOLTEC ENERGIAS RENOVABLES S.L.

C/ Gabriel Campillo s/n, 30500 Molina de Segura Murcia, Spain.

Testing period

The performed test started on 2018-02-21 and finished on 2018-02-22.

The tests have been performed at DEKRA Testing and Certification S.A.U.

Environmental conditions

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

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %
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 ºC Max. = 35 ºC
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 ºC Max. = 35 ºC
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; The tests have been performed by the technical personnel: Carolina Postigo and Carlos Alberto Contreras.

2: Used instrumentation:

Conducted Measurements

		Last Cal. date	Cal. due date
1.	Spectrum analyser Agilent PSA E4440A	2017/10	2019/10
2.	Digital Multimeter Fluke 179	2017/05	2018/05
3.	DC power supply Keysight Technologies U8002A	---	---

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	2017/07	2020/04
3.	Multi Device Controller EMCO 2090	N.A.	N.A.
4.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2016/11	2019/11
5.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2017/03	2020/03
6.	EMI Test Receiver R&S ESU 40	2016/03	2018/03
7.	Signal and spectrum analyzer R&S FSV40	2017/07	2019/07
8.	RF pre-amplifier 30 MHz-6 GHz Bonn Elektronik BLNA 0360-01N	2017/07	2018/09
9.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-1M	2016/02	2018/02
10.	RF pre-amplifier 18-40 GHz Narda JS44-18004000-33-9P	2018/02	2019/02

Testing verdicts

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

1. ZIGBEE 2.4GHz

FCC PART 15 PARAGRAPH / RSS-247		VERDICT			
		NA	P	F	NM
Section 15.247 Subclause (a) (2) / RSS-247 5.2. (a)	6 dB Bandwidth		P		
Section 15.247 Subclause (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain		P		
Section 15.247 Subclause (d) / RSS-247 5.5	Emission limitations conducted (Transmitter)		P		
Section 15.247 Subclause (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)		P		
Section 15.247 Subclause (e) / RSS-247 5.2. (b)	Power spectral density		P		
Section 15.247 Subclause (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)		P		

Appendix A – Test result (Zigbee)

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TEST CONDITIONS

Power supply (V):

$V_{nominal}$ = 3.3 Vdc

Type of power supply = DC voltage from auxiliary board.

Type of antennas = External antenna.

Antenna 1 assembly declared gain (dBi) = +2.00 dBi.

Antenna 2 assembly declared gain (dBi) = +2.00 dBi.

TEST FREQUENCIES:

Lowest channel: 2405 MHz

Middle channel: 2440 MHz

Highest channel: 2475 MHz

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v04 dated 04/05/2017.

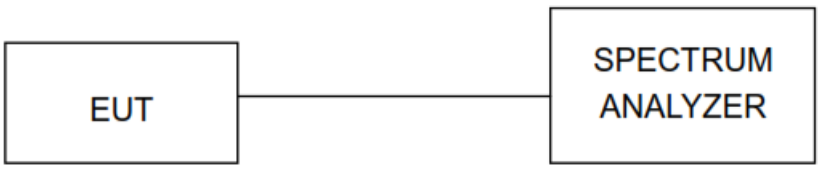
The sample was used to configure the EUT to continuously transmit at a specified output power in all channels.

Mode	Channel / Freq.	Power adjustment
2.4 GHz IEEE 802.15.4	11 / 2405	10.7 dBm
	18 / 2440	10.7 dBm
	25 / 2475	10.7 dBm

Equipment with two diversity antennas but only one antenna active at any moment in time.

CONDUCTED MEASUREMENTS

The equipment under test was set up in a shielded room and it is connected to the spectrum analyzer through its low loss SMA cable.



The DC supply voltage is applied using an auxiliary board.

RADIATED MEASUREMENTS

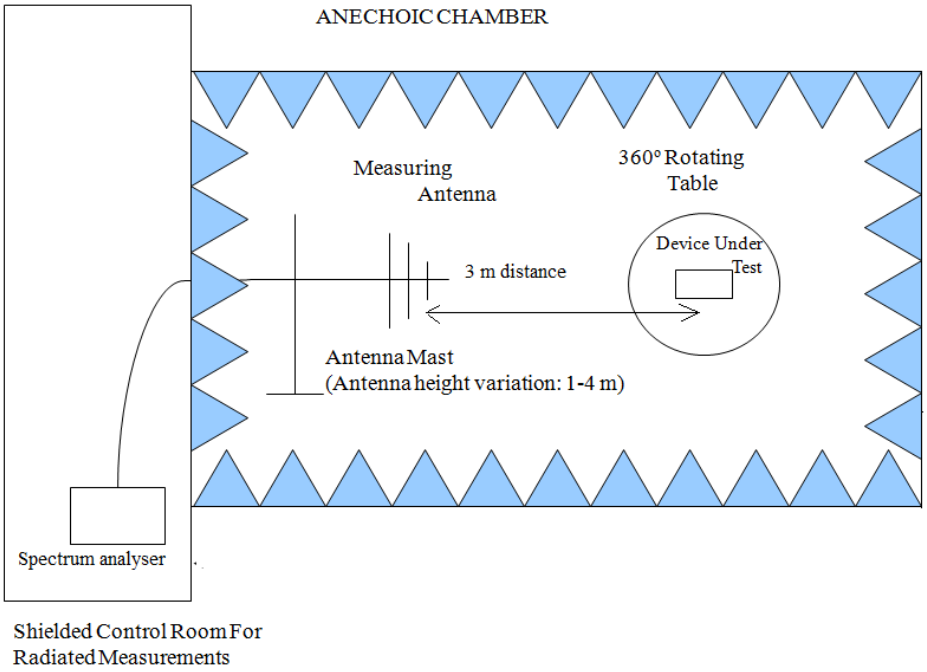
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m for the frequency range 30 MHz-1000 MHz (30 MHz-1000 MHz Bilog antenna) and at a distance of 1m for the frequency range 1 GHz-25 GHz (1 GHz-18 GHz Double ridge horn antenna and 18 GHz-40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

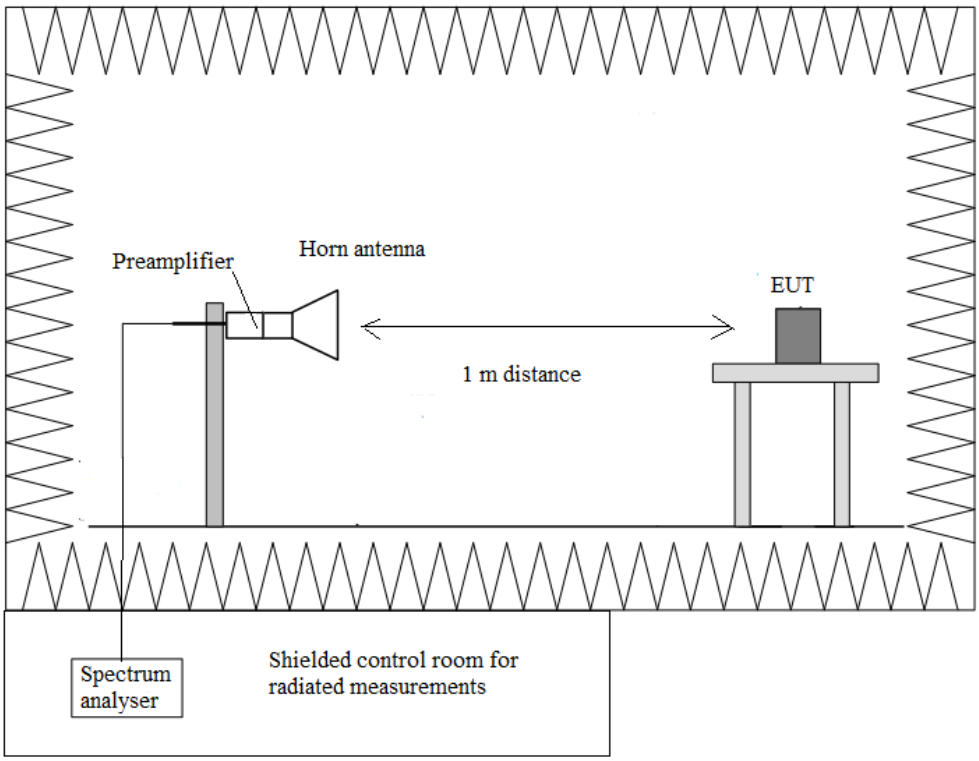
The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360º and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

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

Radiated measurements setup f < 1 GHz



Radiated measurements setup f > 1 GHz



Occupied Bandwidth

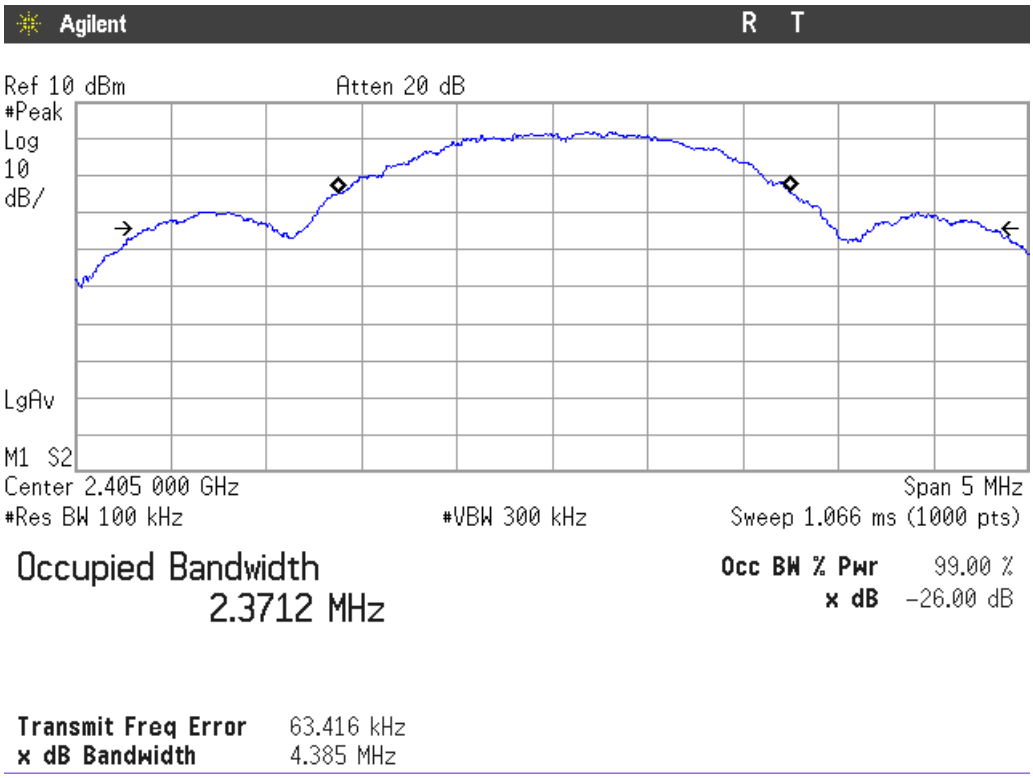
RESULTS

Antenna port 1 (worst case):

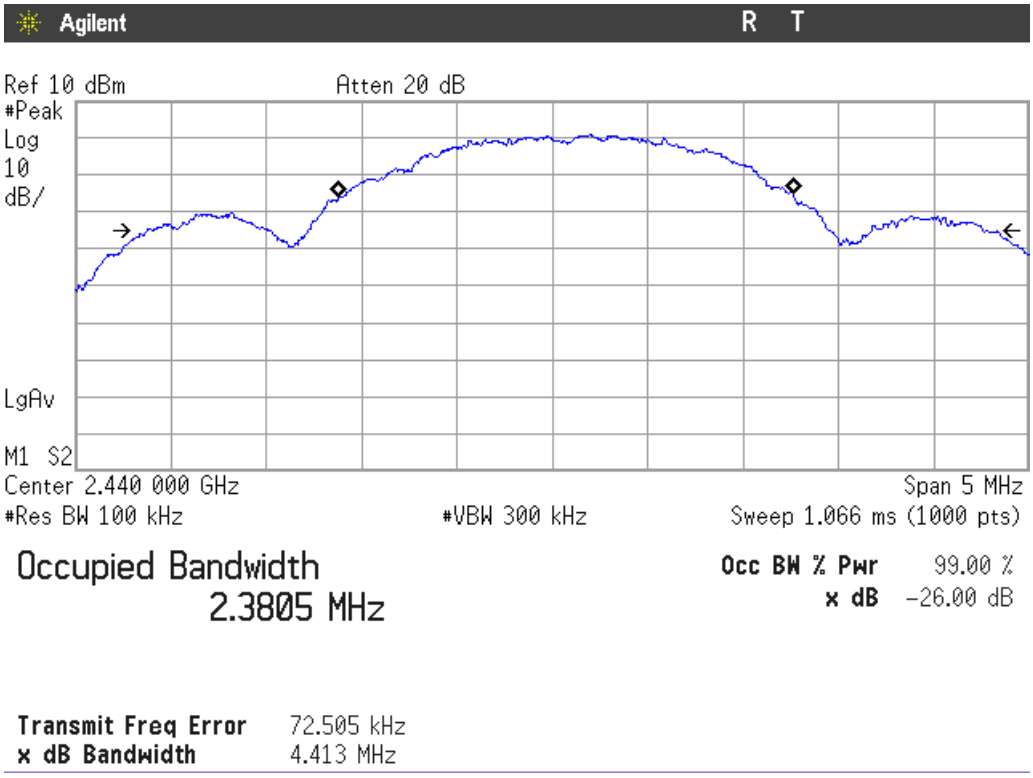
(see next plots).

	Lowest frequency 2405 MHz	Middle frequency 2440 MHz	Highest frequency 2475 MHz
99% bandwidth (MHz)	2.371	2.380	2.381
-26 dBc bandwidth (MHz)	4.385	4.413	4.451
Measurement uncertainty (kHz)	<± 8.33		

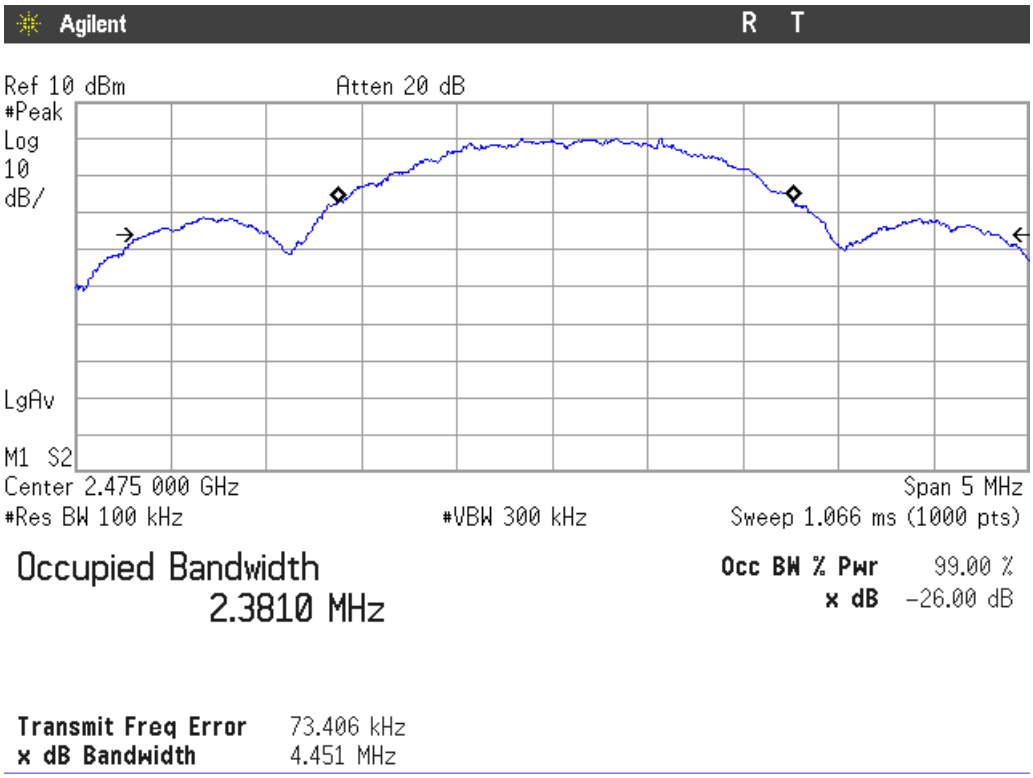
Lowest Channel



Middle Channel



Highest channel



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

SPECIFICATION

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

RESULTS

Antenna port 1 (worst case):

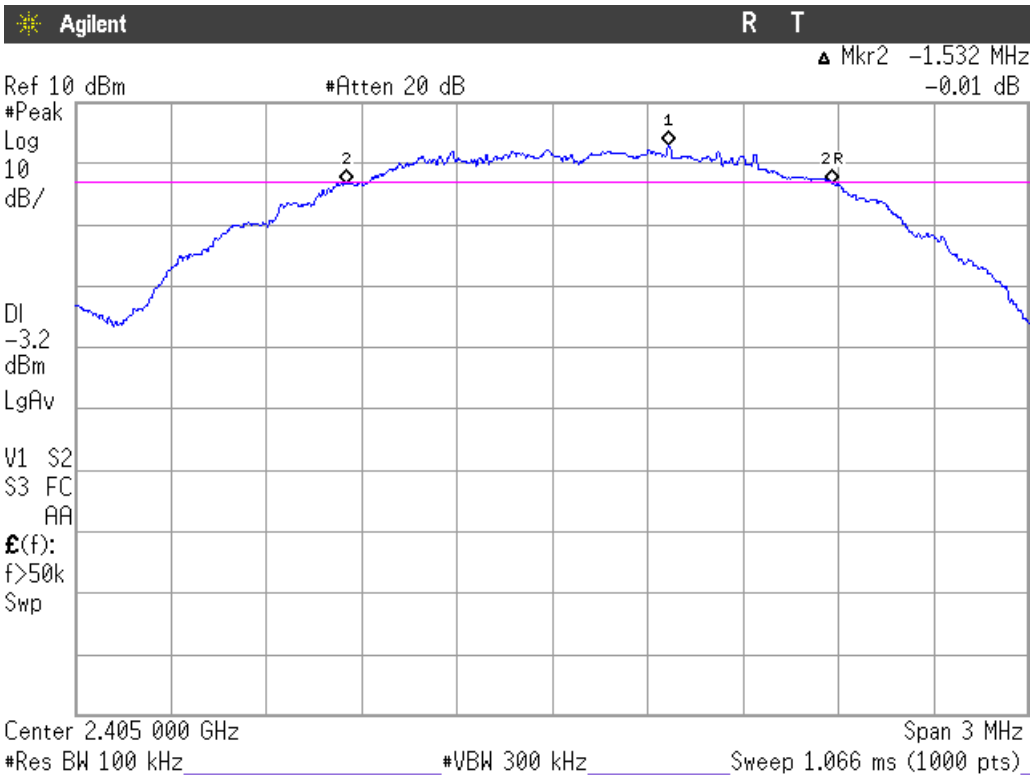
6 dB Bandwidth (see next plots).

	Lowest frequency 2405 MHz	Middle frequency 2440 MHz	Highest frequency 2475 MHz
6 dB Spectrum bandwidth (kHz)	1532	1613	1613
Measurement uncertainty (kHz)	<±14.0		

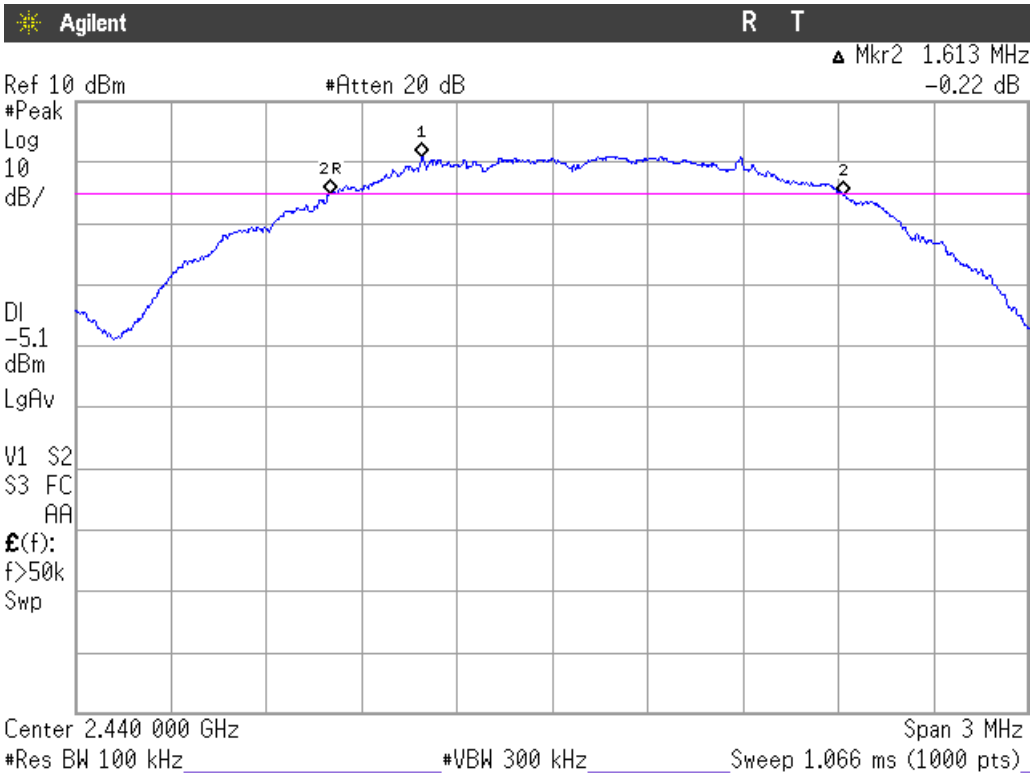
Verdict: PASS

6 dB BANDWIDTH.

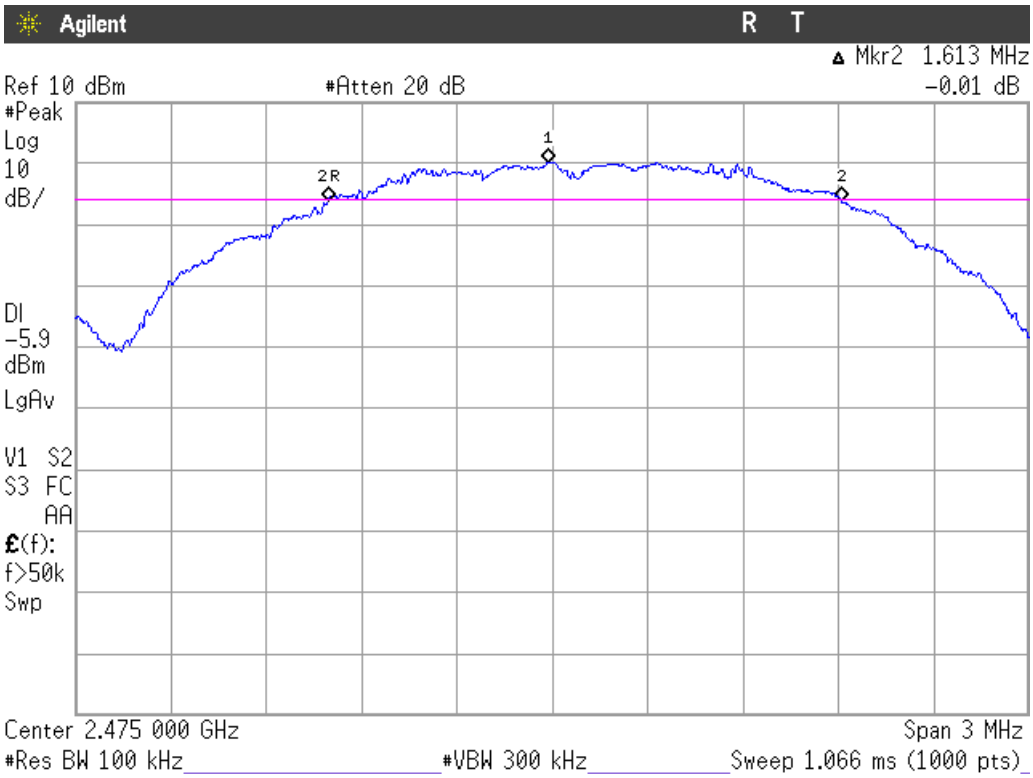
Lowest Channel



Middle Channel



Highest Channel



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

SPECIFICATION

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).
The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

RESULTS

The maximum peak conducted output power was measured using the method according to point 9.1.1. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v04 dated 04/05/2017.

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

MAXIMUM OUTPUT POWER. See next plots.

Antenna port 1 (worst case):

Maximum declared antenna gain: 2 dBi.

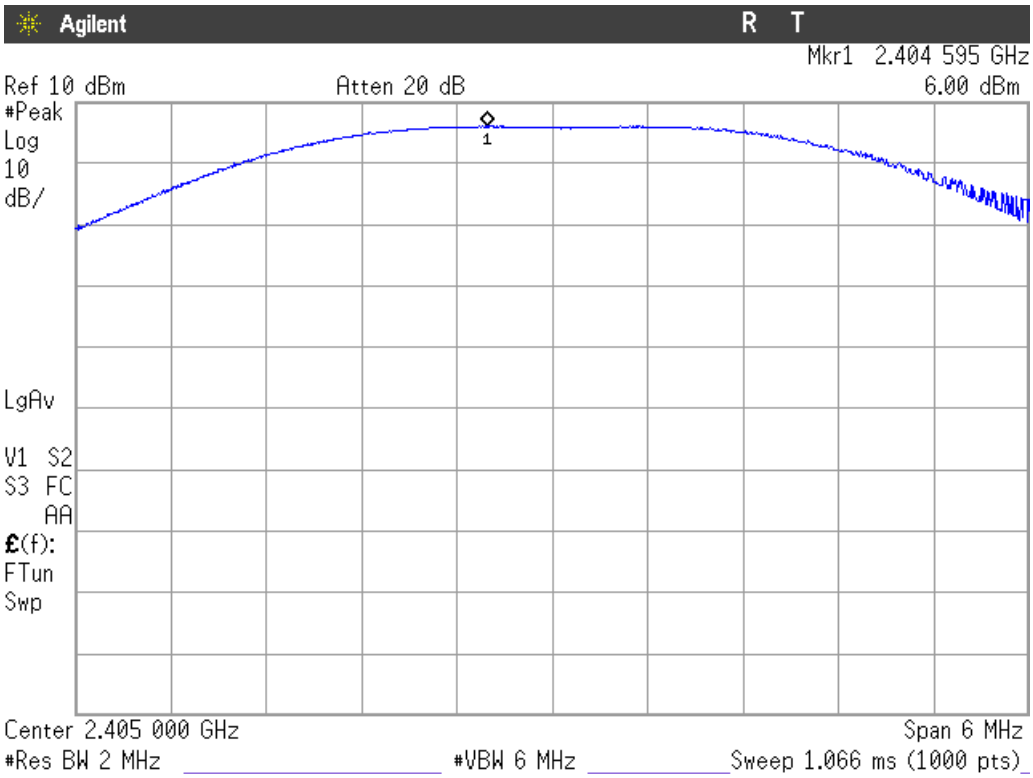
	Lowest frequency 2405 MHz	Middle frequency 2440 MHz	Highest frequency 2475 MHz
Maximum conducted power (dBm)	6.00	5.10	4.11
Maximum EIRP power (dBm)	8.00	7.10	6.11
Measurement uncertainty (dB)	<±0.78		

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.

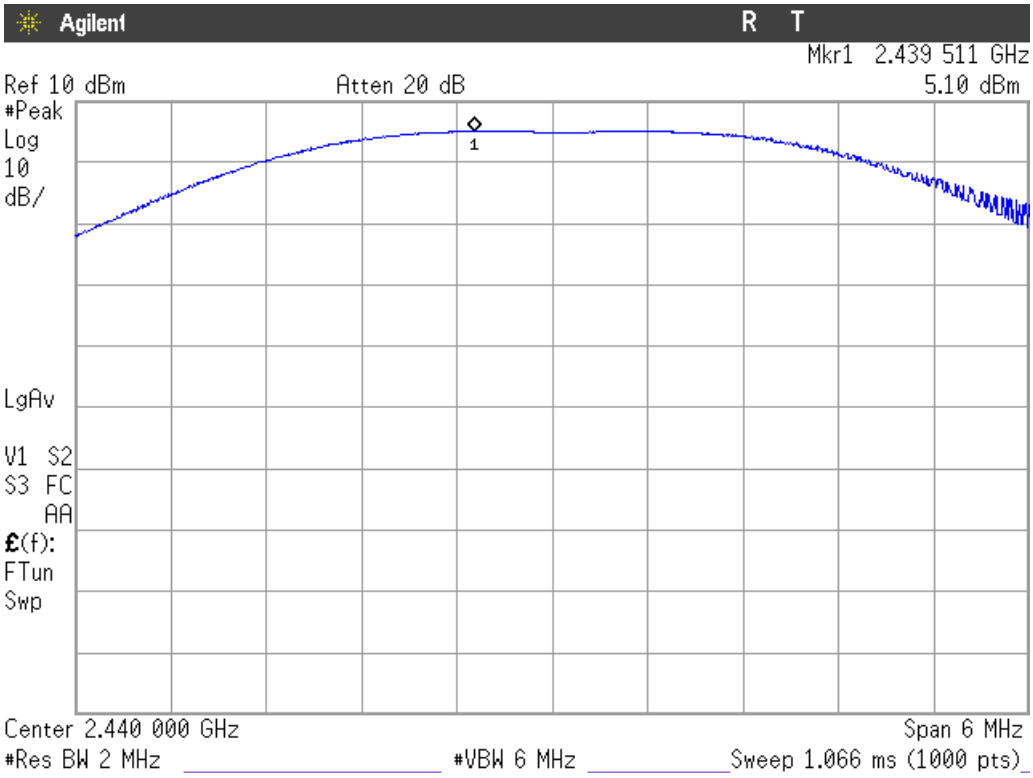
Verdict: PASS

CONDUCTED PEAK POWER.

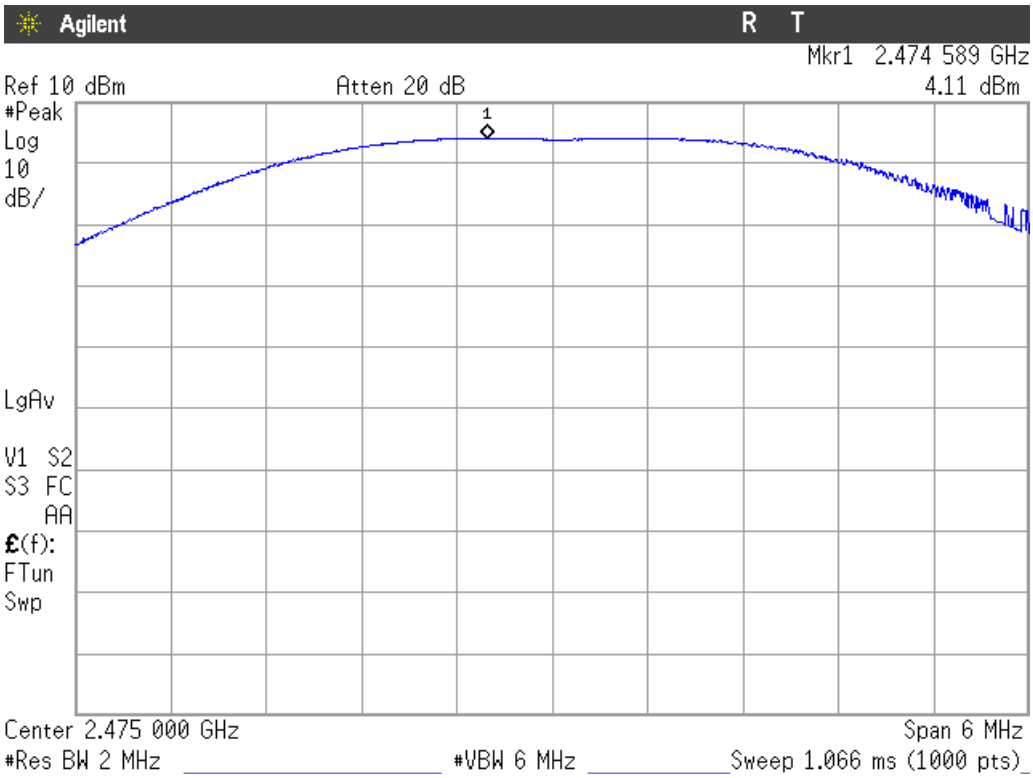
Lowest frequency



Middle frequency



Highest frequency



Section 15.247 Subclause (d) / RSS-247 5.5. 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:

Antenna port 1 (worst case):

Reference Level Measurement

	Lowest frequency 2405 MHz	Middle frequency 2440 MHz	Highest frequency 2475 MHz
Reference Level Measurement (dBm)	1.79	1.00	-0.02
Measurement uncertainty (dB)	<±0.78		

Lowest frequency 2402 MHz:

All peaks are more than 20 dB below the limit.

Middle frequency 2440 MHz:

All peaks are more than 20 dB below the limit.

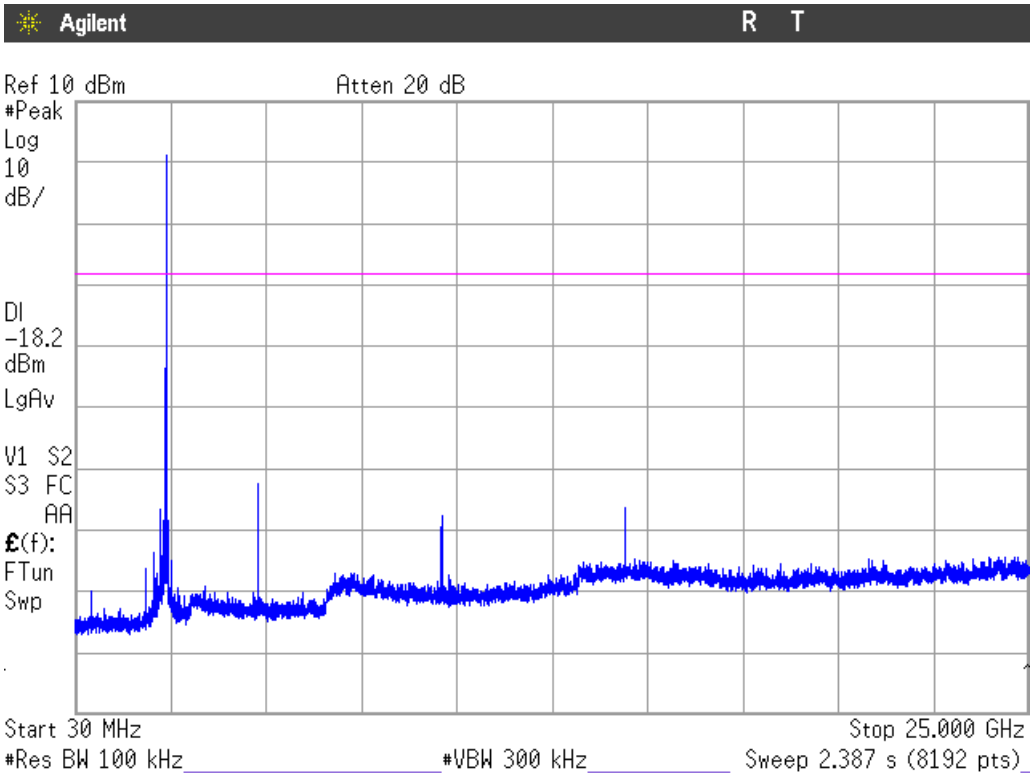
Highest frequency 2480 MHz:

All peaks are more than 20 dB below the limit.

Measurement uncertainty (dB): < 2.03

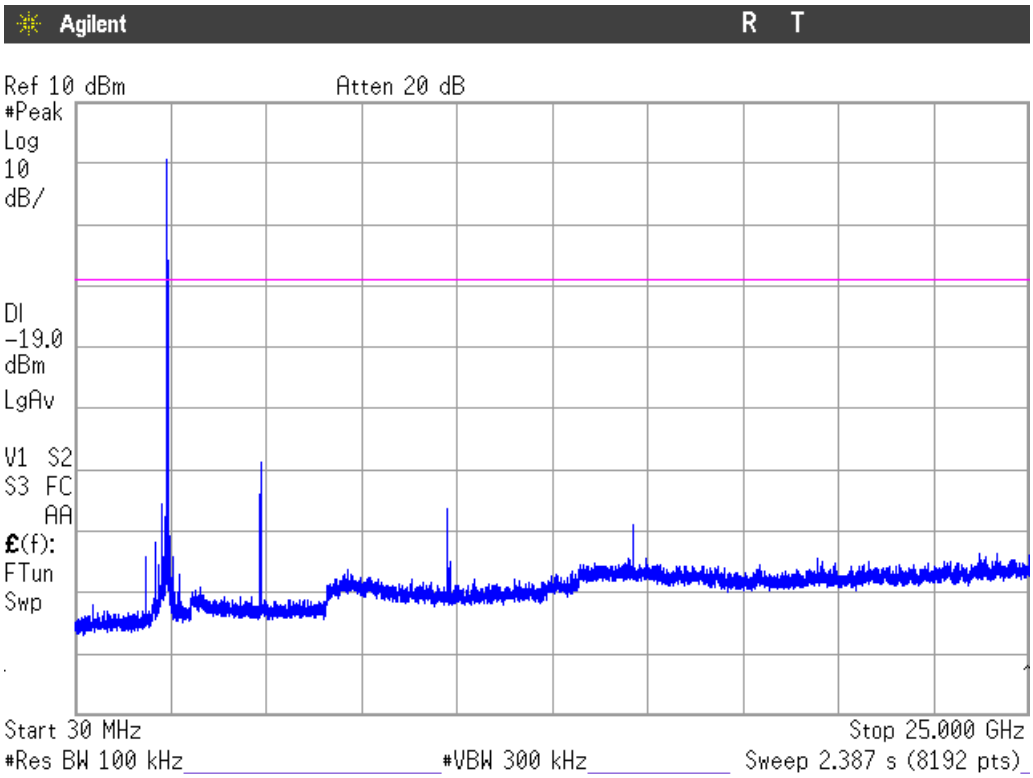
Verdict: PASS

Lowest frequency



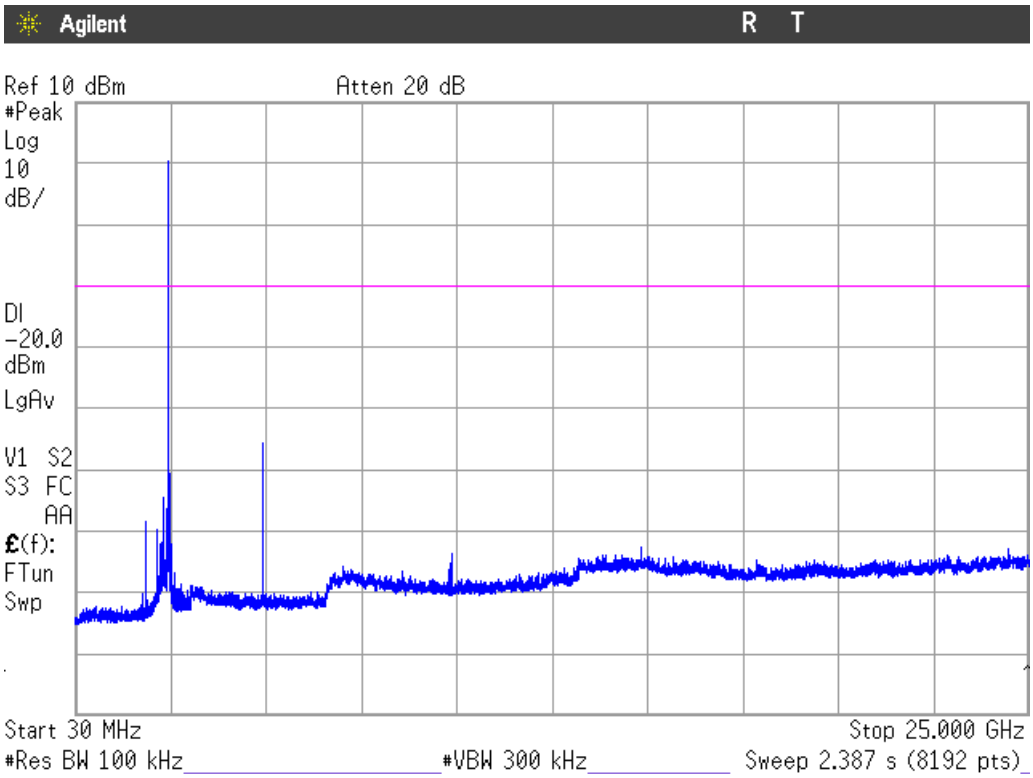
Note: The peak shown in the plot above the limit is the carrier frequency.

Middle frequency



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

Highest frequency



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

Section 15.247 Subclause (d) / RSS-247 5.5. 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.

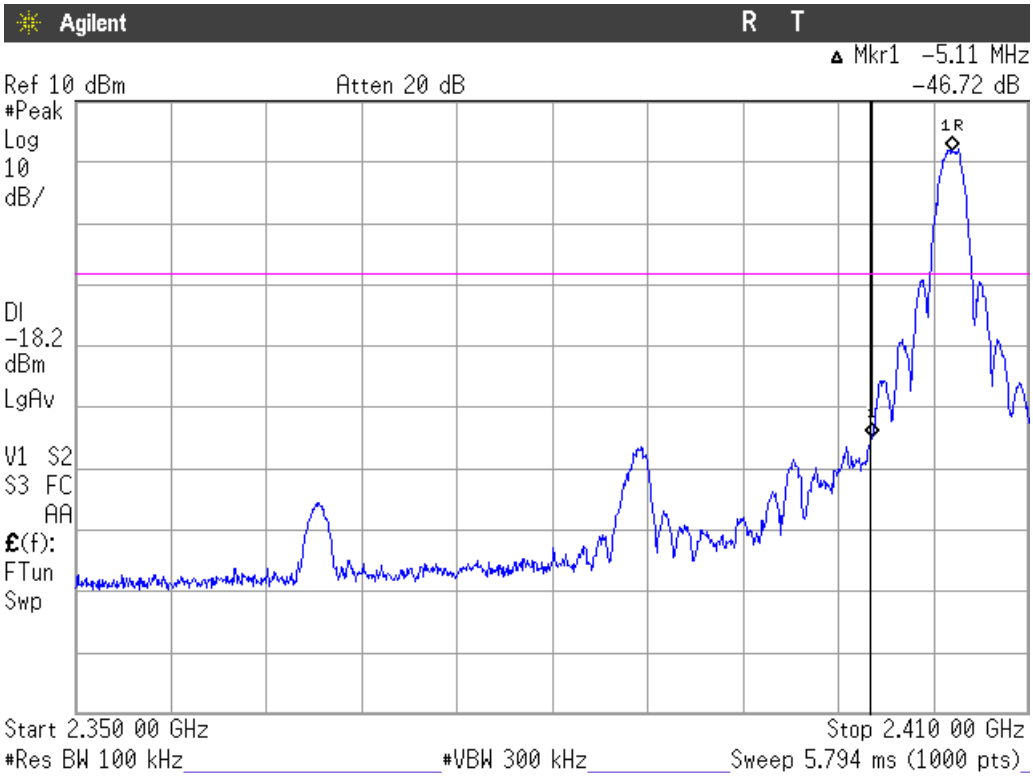
RESULTS:

Antenna port 1 (worst case):

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

1. LOW FREQUENCY SECTION. CONDUCTED.

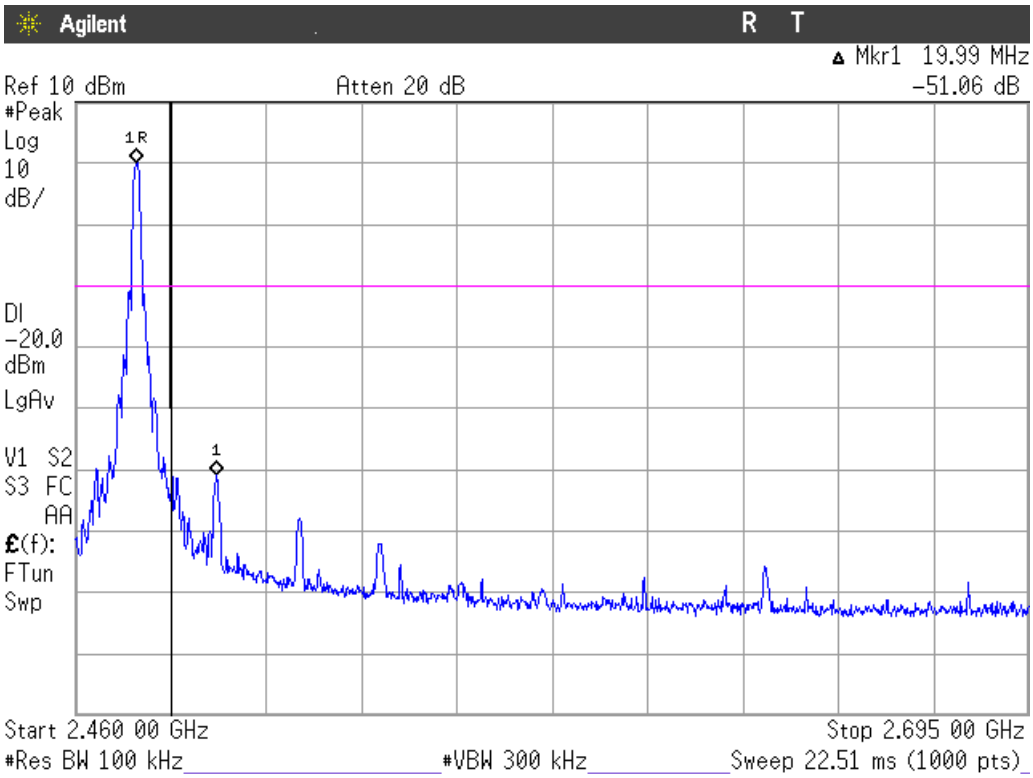
See next plot.



Verdict: PASS

2. HIGH FREQUENCY SECTION. CONDUCTED.

See next plot.



Measurement uncertainty (dB)	< ±0.78

Verdict: PASS

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

SPECIFICATION

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

RESULTS

The maximum power spectral density level in the fundamental emission was measured using the method PKPSD (Peak PSD) according to point 10.2. of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 558074 D01 DTS Meas Guidance v04 dated 05/04/2017.

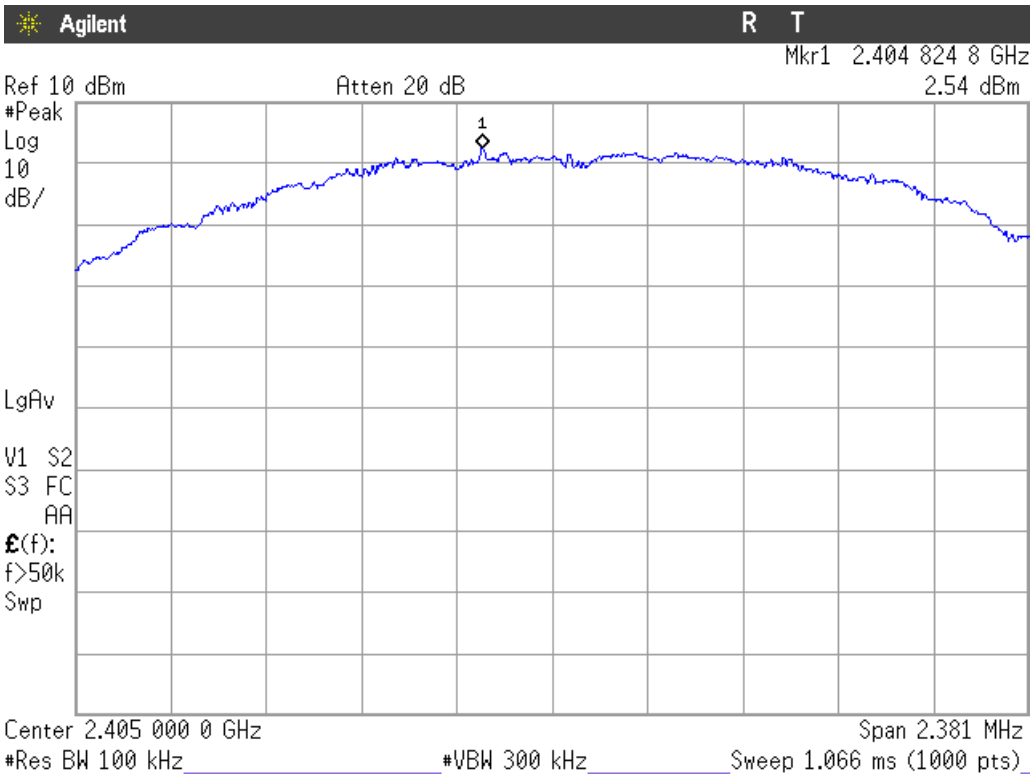
Power spectral density (see next plots).
Antenna port 1 (worst case):

	Lowest frequency 2405 MHz	Middle frequency 2440 MHz	Highest frequency 2475 MHz
Power spectral density (dBm)	2.54	1.75	0.66
Measurement uncertainty (dB)	<±0.78		

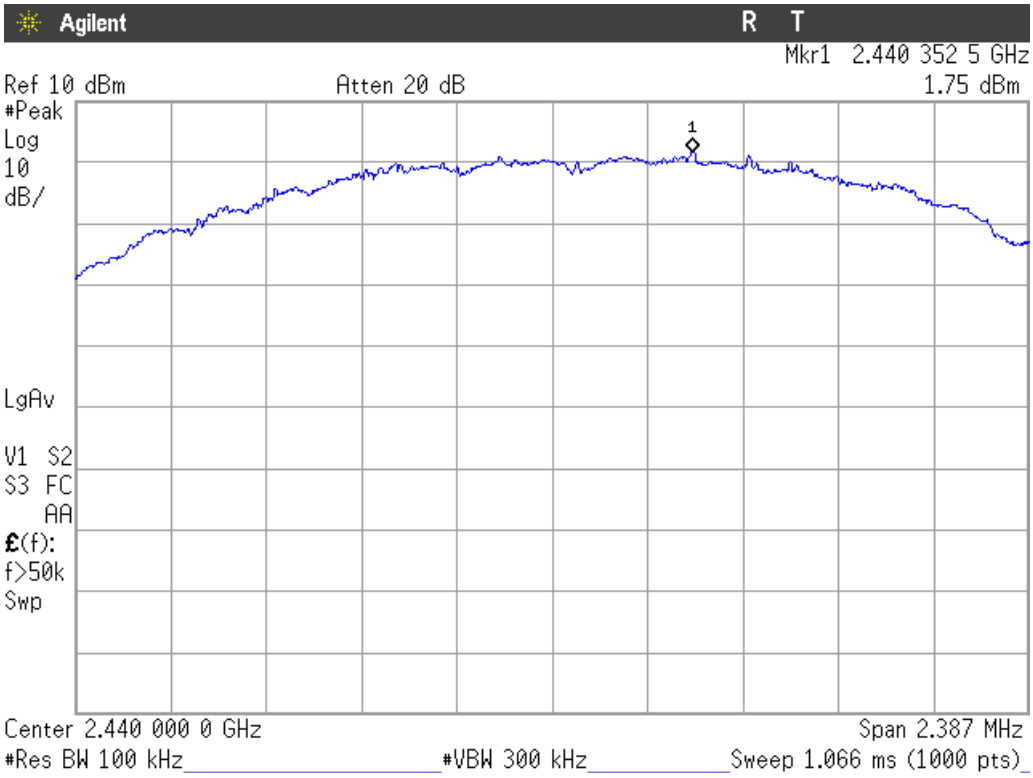
Verdict: PASS

POWER SPECTRAL DENSITY

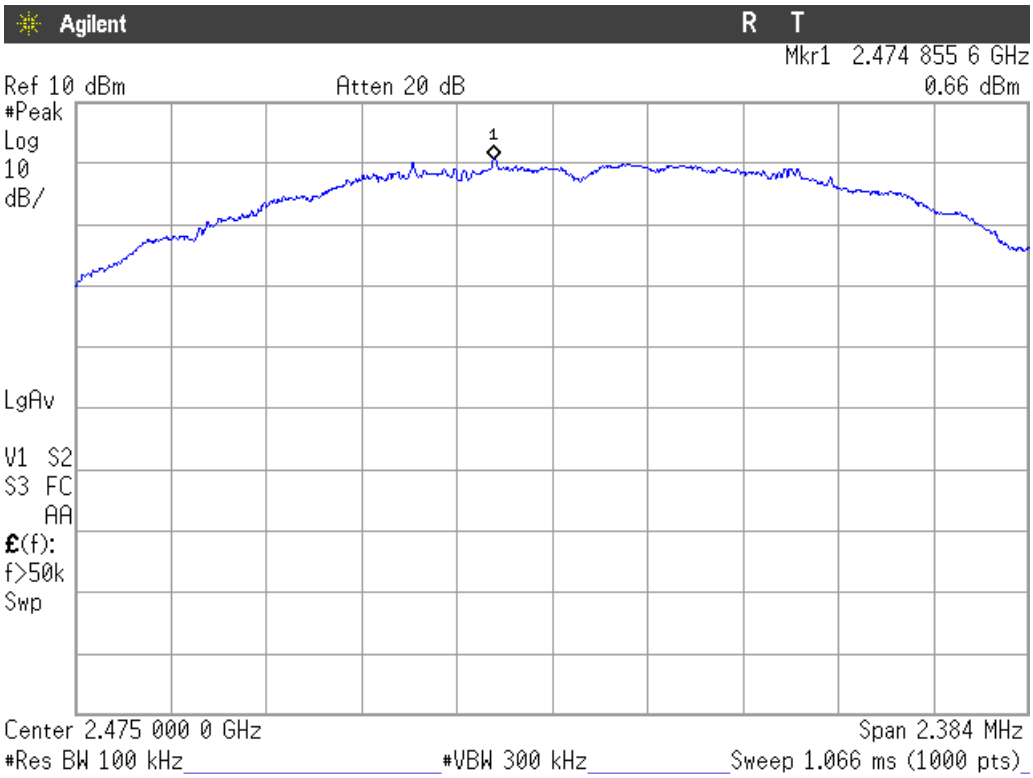
Lowest Channel



Middle Channel



Highest Channel



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

SPECIFICATION

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

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

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

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

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

RESULTS:

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

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

All tests were performed in a semi-anechoic chamber at a distance of 3 m for the frequency range 30 MHz-1000 MHz and at distance of 1m for the frequency range 1 GHz-25 GHz.

The test was performed with the equipment transmitting first with only the 2.4 GHz Zigbee (antenna port 1) radio and repeated with only the 2.4 GHz Zigbee (antenna port 2) radio. The results and plots below show the worst results obtained (antenna port 1).

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.

Antenna port 1 (worst case):

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

Spurious frequency (MHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
55.317	V	Quasi-peak	24.30	± 3.88
109.992	V	Quasi-peak	27.30	± 3.88
125.998	V	Quasi-peak	36.40	± 3.88
229.949	V	Quasi-peak	36.20	± 3.88
735.255	V	Quasi-peak	30.20	± 3.88
787.085	H	Quasi-peak	35.80	± 3.88

Frequency range 1 GHz-25 GHz

Antenna port 1 (worst case):

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).

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

Lowest Channel

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2.38595	H	Peak	55.44	± 4.87
		Average	48.13	± 4.87
4.81125	V	Peak	52.79	± 4.87
9.62225	V	Peak	54.56	± 4.87
		Average	47.26	± 4.87

Middle Channel

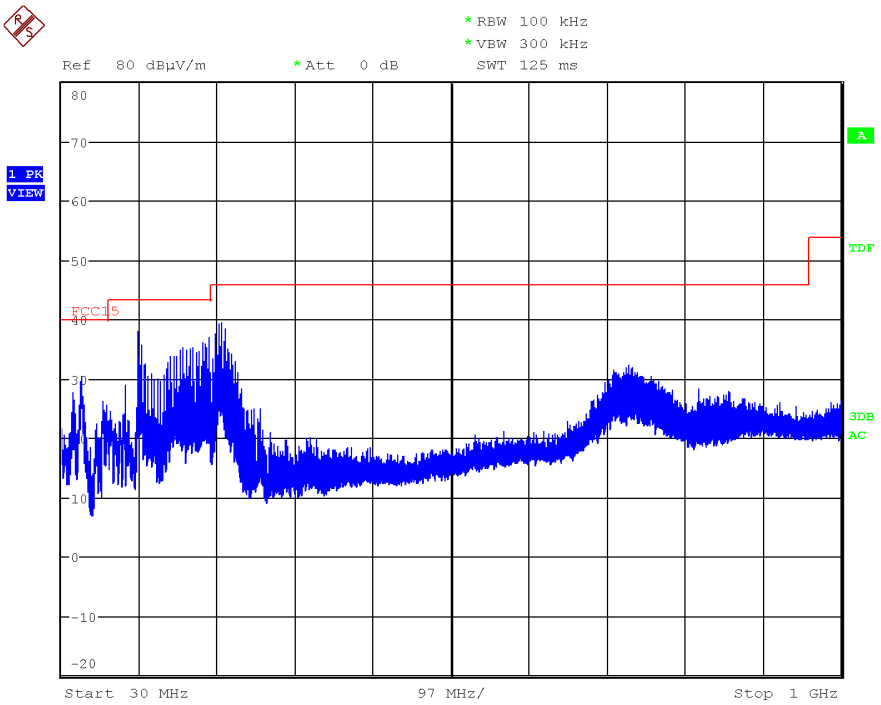
Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2.38024	H	Peak	49.24	± 4.87
4.88125	V	Peak	53.86	± 4.87
9.82425	H	Peak	53.79	± 4.87

Highest Channel

Spurious frequency (GHz)	Polarization	Detector	Emission Level (dBµV/m)	Measurement Uncertainty (dB)
2.32021	H	Peak	51.53	± 4.87
2.48375	V	Peak	57.51	± 4.87
		Average	43.41	± 4.87
2.49466	H	Peak	53.54	± 4.87
4.95125	V	Peak	54.93	± 4.87
		Average	49.27	± 4.87
9.82725	H	Peak	52.87	± 4.87

Verdict: PASS

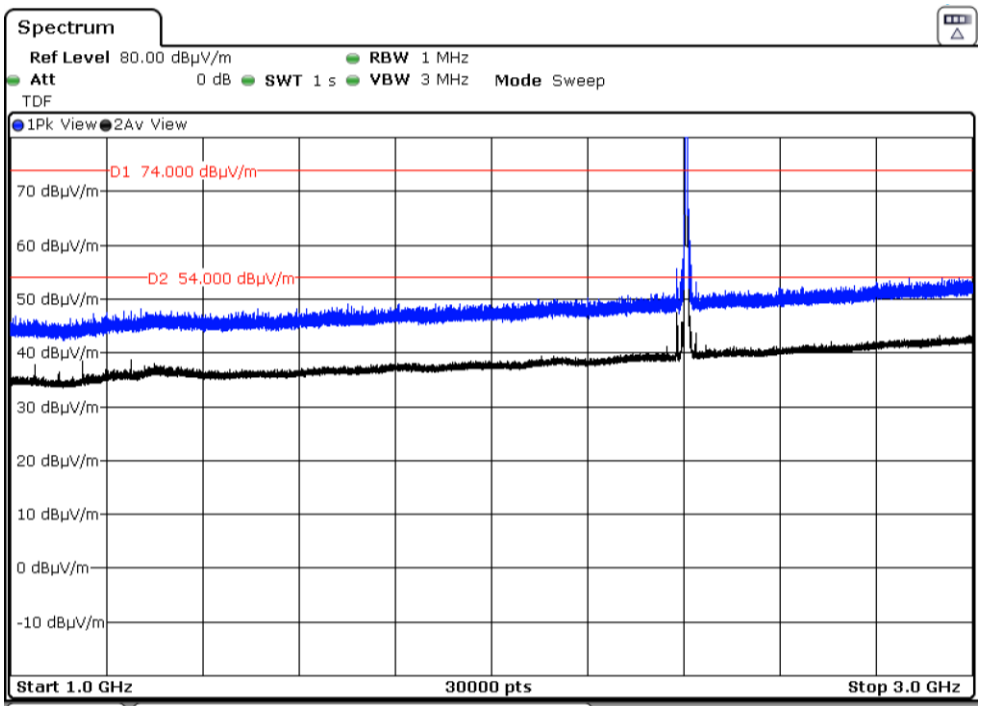
FREQUENCY RANGE 30 MHz-1000 MHz.



(This plot is valid for all three channels).

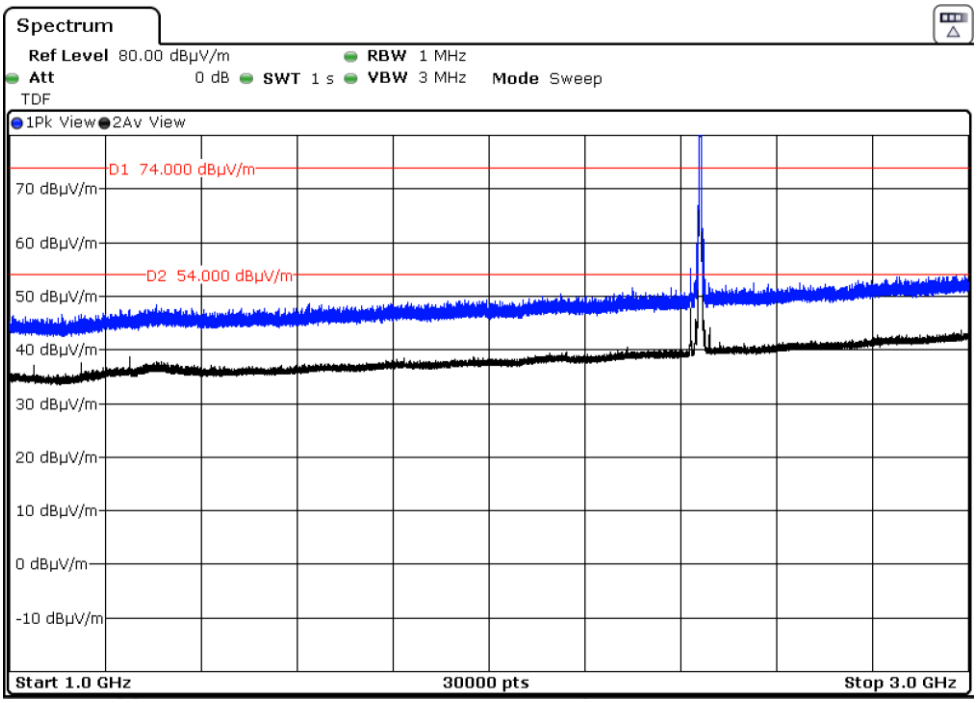
FREQUENCY RANGE 1 GHz to 3 GHz.

CHANNEL: Lowest (2405 MHz).



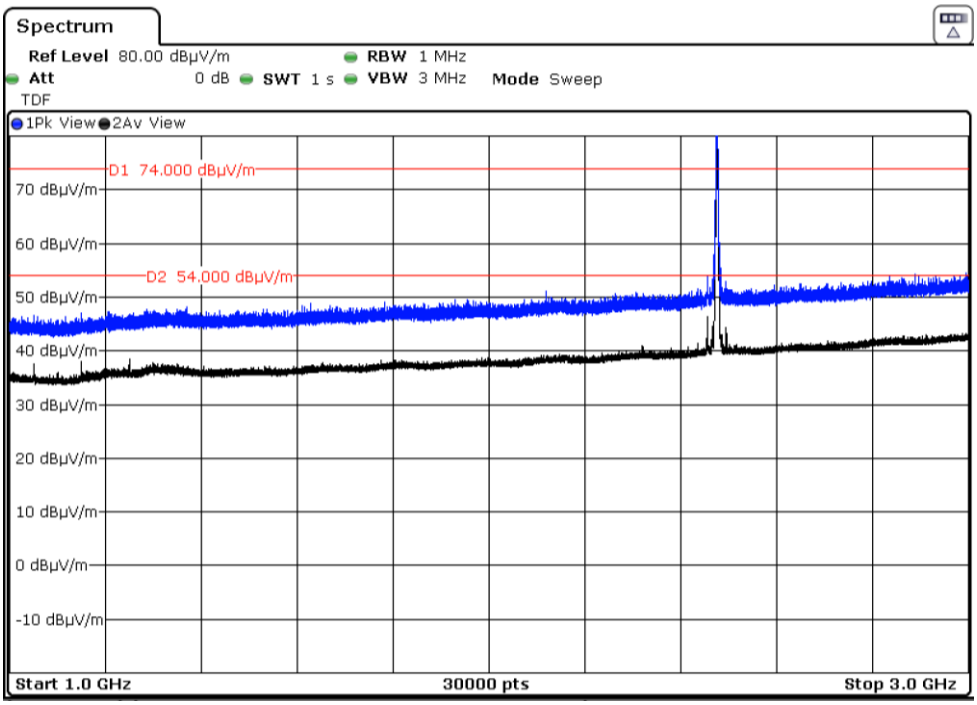
Note: The peak shown in the plot above the limit is the carrier frequency.

CHANNEL: Middle (2440 MHz).



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

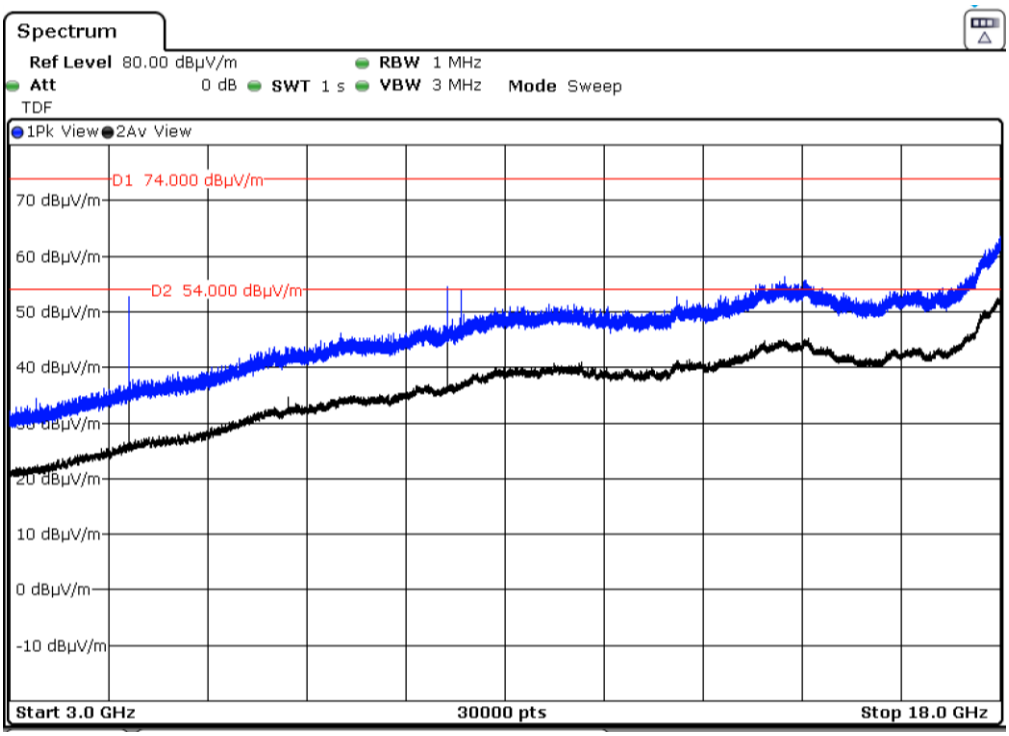
CHANNEL: Highest (2475 MHz).



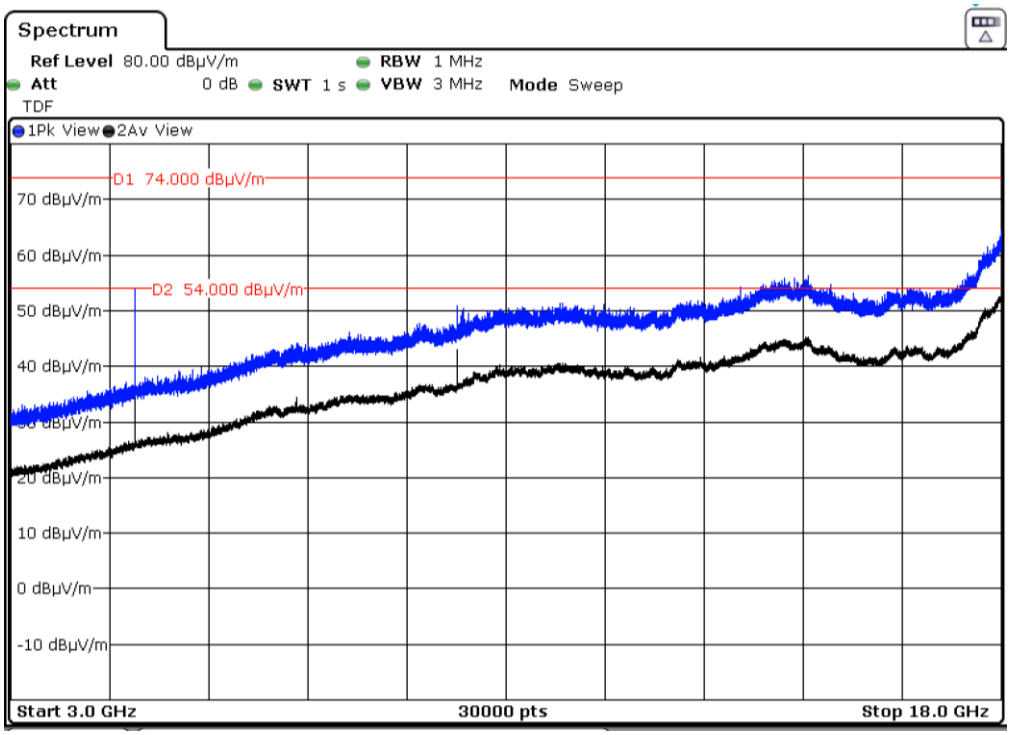
Note: The peak shown in the plot above the limit is the carrier frequency.

FREQUENCY RANGE 3 GHz to 18 GHz.

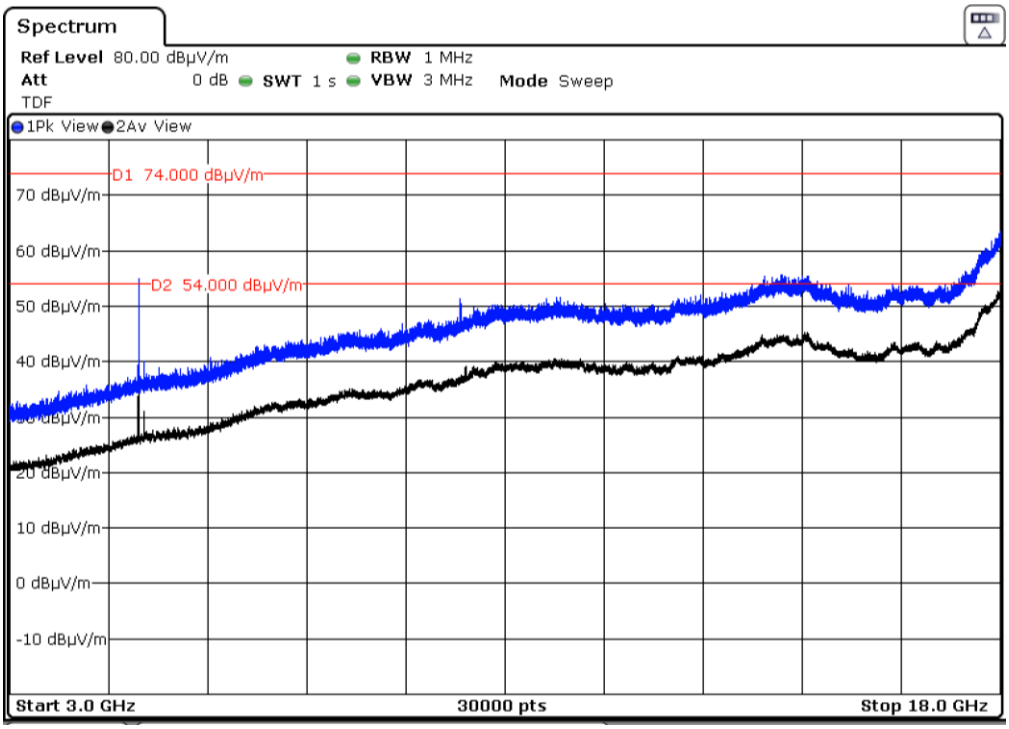
CHANNEL: Lowest (2405 MHz).



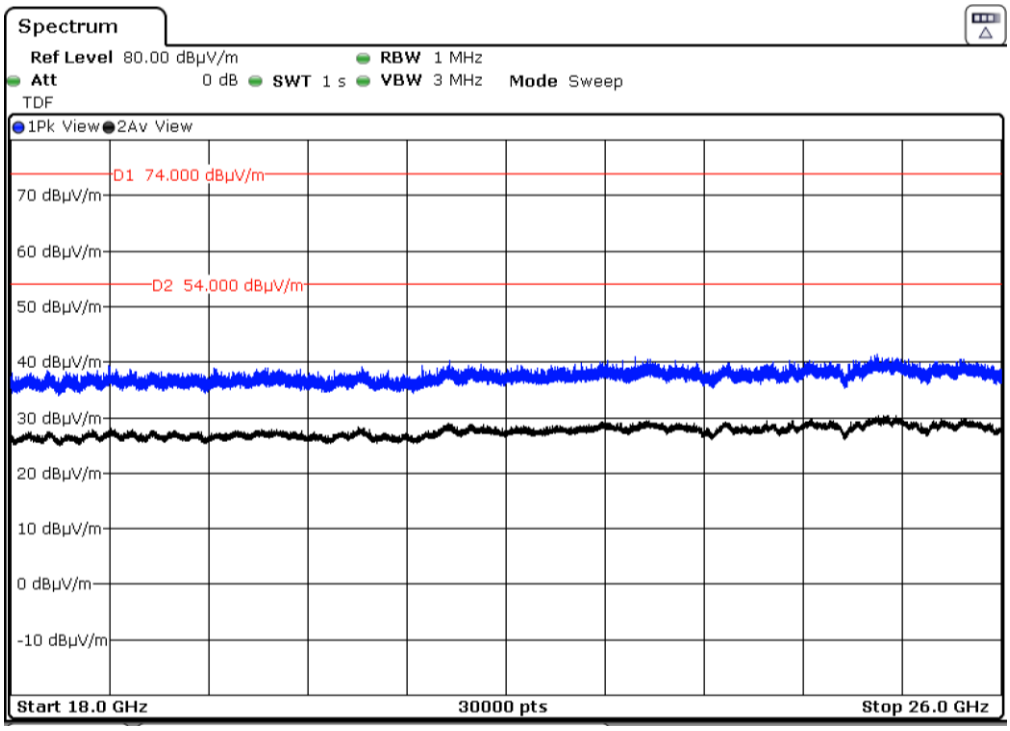
CHANNEL: Middle (2440 MHz).



CHANNEL: Highest (2475 MHz).



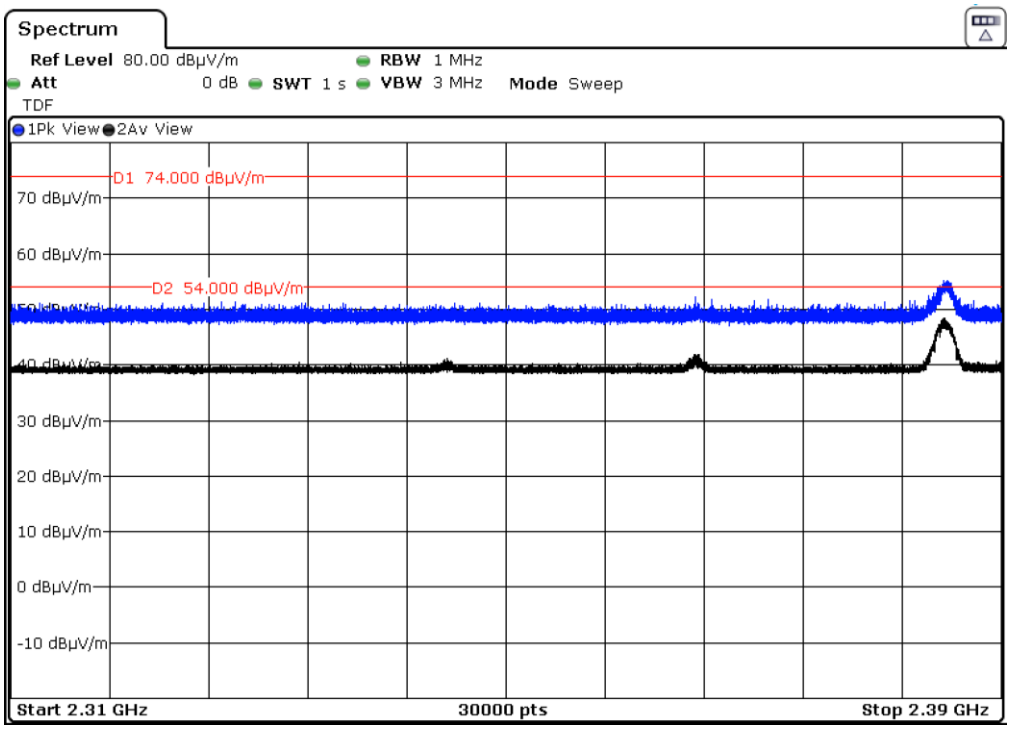
FREQUENCY RANGE 18 GHz to 26 GHz.



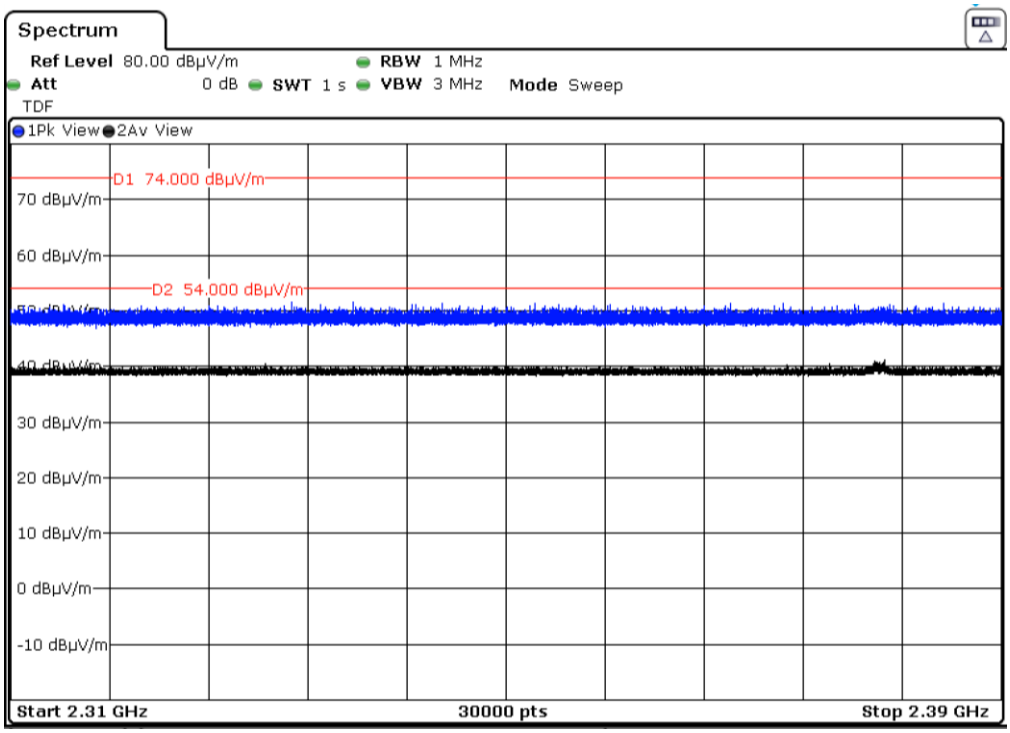
(This plot is valid for all three channels).

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

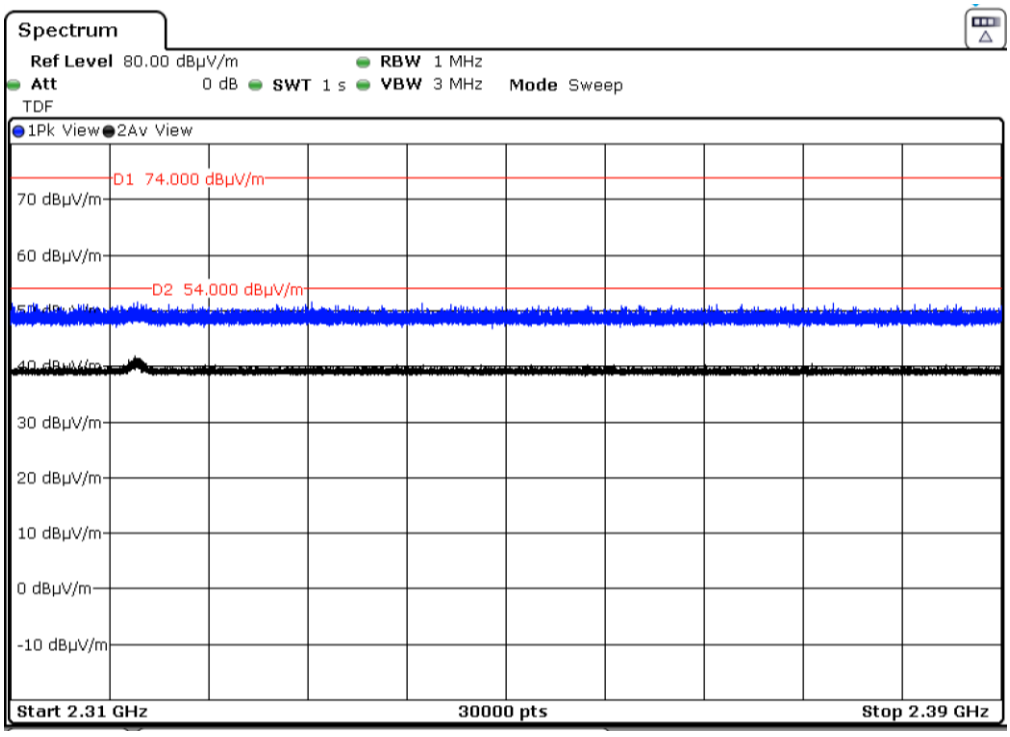
CHANNEL: Lowest (2405 MHz).



CHANNEL: Middle (2440 MHz).

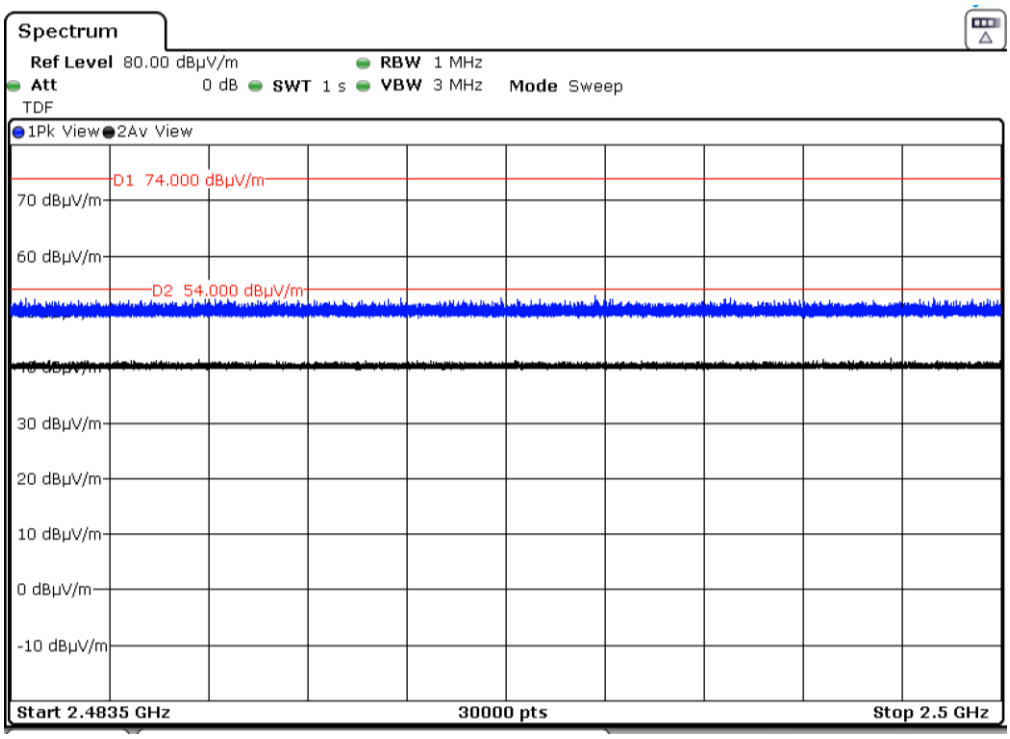


CHANNEL: Highest (2480 MHz).

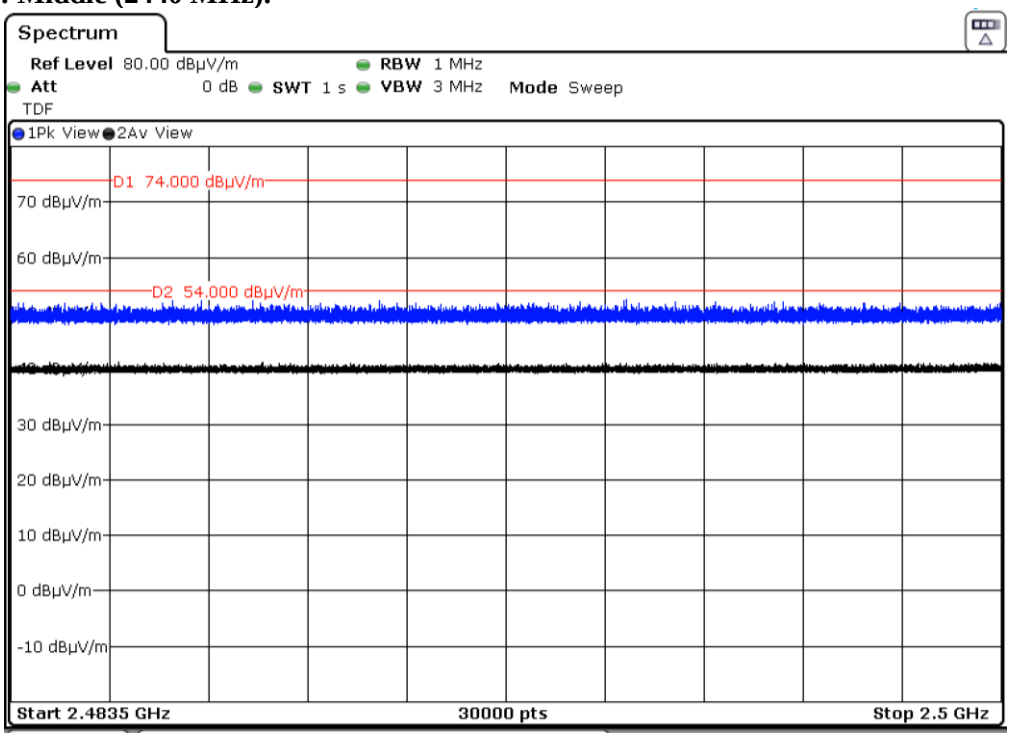
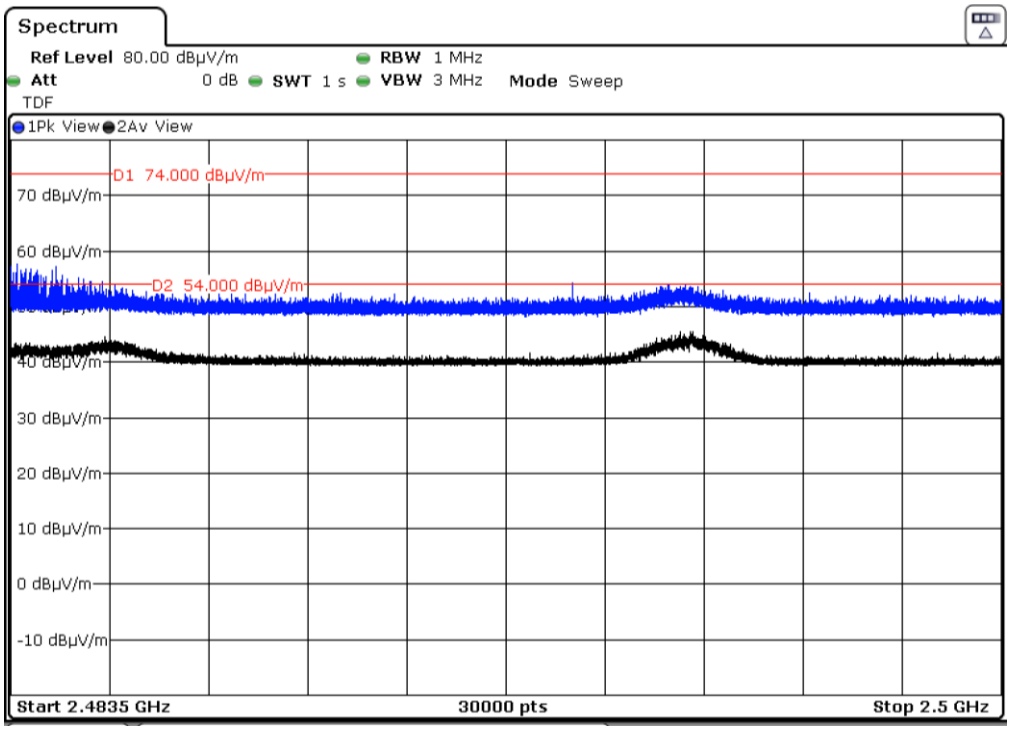


FREQUENCY RANGE 2.4835 GHz to 2.5 GHz. (RESTRICTED BAND).

CHANNEL: Lowest (2405 MHz).



CHANNEL: Middle (2440 MHz).



CHANNEL: Highest (2475 MHz).