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REGISTRATION NUMBER
4621A-2, 4621A-4

Test report No:
NIE: 56944RRF.005

Test report

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

Radio Frequency Devices. Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz.

Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs)
and Licence-Exempt Local Area Network (LE-LAN) Devices.

General Requirements and Information for the Certification of Radio
Apparatus.

Identification of item tested	27-inch iMac with Retina 5K display
Trademark	Apple
Model and /or type reference	A2115
Other identification of the product	FCC ID: BCGA2115 IC: 579C-A2115
Features	IEEE 802.11 a/b/g/n/ac radio and Bluetooth radio
Applicant	APPLE INC One Apple Park Way, Cupertino, California 95014, USA
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 5 (April 2018). Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05 dated August 24, 2018. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	A. Llamas p.a. RF Lab. Manager  Firmado digitalmente por FRANCISCO CAÑAS ESCRIBANO Fecha: 2019.03.06 15:47:55 +01'00'

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Competences and guarantees

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

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

DEKRA Testing and Certification is 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 and ISED 4621A-4.

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.

DEKRA Testing and Certification is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

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

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification.
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.

Data provided by the client

iMac desktop computer with IEEE 802.11 a/b/g/n/ac radio and Bluetooth radio.

DEKRA declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: the client.

Sample S/01 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
56944/06	iMac with Retina 5K display	A2115	C02WW002K1R4	2018-08-16

Auxiliary elements used with the sample S/01

Control N°	Description	Model	Serial N°	Date of reception
56943/03	Keyboard	A1243	---	2018-04-09
56943/05	Power Cable	---	---	2018-04-09
56943/07	Mouse	A1152	---	2018-04-09
56943/09	USB-C to VGA converter	A1620	---	2018-04-09
56943/11	USB to thunderbolt	A1790	---	2018-04-09
56943/13	Earphones	---	---	2018-04-09

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

Band-edge emissions compliance (Transmitter) indicated in Appendix A. It was determined as the worst case.

Sample S/02 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
56944/05	iMac with Retina 5K display	A2115	C02WW01EKFGK	2018-08-16

Auxiliary elements used with the sample S/02

Control N°	Description	Model	Serial N°	Date of reception
56943/04	Keyboard	A1243	---	2018-04-09
56943/06	Power Cable	---	---	2018-04-09
56943/08	Mouse	A1152	---	2018-04-09
56943/10	USB-C to VGA converter	A1620	---	2018-04-09
56943/12	USB to thunderbolt	A1790	---	2018-04-09
56943/14	Earphones	---	---	2018-04-09

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

Emission limitations radiated (Transmitter) indicated in Appendix A. It was determined as the worst case.

Sample S/03 is composed of the following elements:

Control N°	Description	Model	Serial N°	Date of reception
56944/14	iMac with Retina 5K display	A2115	C02X300EKFDN	2018-09-03

Auxiliary elements used with the sample S/03

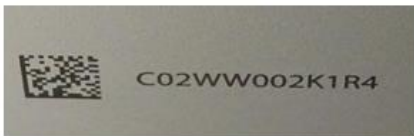
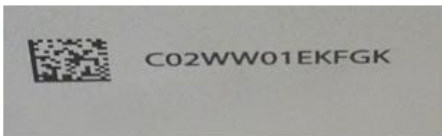
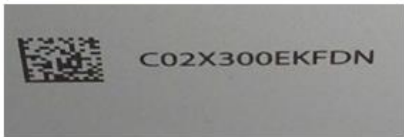
Control N°	Description	Model	Serial N°	Date of reception
56943/04	Keyboard	A1243	---	2018-04-09
56944/13	Power Cable	---	---	2018-04-09
56943/08	Mouse	A1152	---	2018-04-09

1. Sample S/03 has undergone the following test(s):

All conducted tests indicated in Appendix A.

Test sample description

Ports..... :	Port name and description	Cable					
		Specified length [m]	Attached during test	Shielded			
			☐	☐			
			☐	☐			
			☐	☐			
			☐	☐			
Supplementary information to the ports..... :							
Rated power supply ... :	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☒	AC: 120/ 60 Hz	☒	☐	☐	☒	☒
	☐	AC:	☐	☐	☐	☐	☐
	☐	DC:					
☐	DC:						
Rated Power							
Clock frequencies.....							
Other parameters							

Software version	18A334		
Hardware version	EVT		
Dimensions in cm (W x H x D)	65cm wide, 51.65cm high, 20.3cm deep		
Mounting position	☒	Table top equipment	
	☐	Wall/Ceiling mounted equipment	
	☐	Floor standing equipment	
	☐	Hand-held equipment	
	☐	Other:	
Modules/parts.....	Module/parts of test item	Type	Manufacturer
Accessories (not part of the test item)	Description	Type	Manufacturer
	Keyboard	A1243	Apple
	Power Cable	---	Apple
	Mouse	A1152	Apple
	USB-C to VGA converter	A1620	Apple
	USB to thunderbolt	A1790	Apple
	Earphones	---	Apple
Documents as provided by the applicant	Description	File name	Issue date
Copy of marking plate:			
  			

Identification of the client

APPLE INC
One Apple Park Way, Cupertino, California 95010, USA

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2018-08-24
Date (finish)	2019-02-14

Document history

Report number	Date	Description
56944RRF.005	2019-03-05	First release

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. = 35 %
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

The tests have been performed by the technical personnel: Ignacio Cabra, Jose Alberto Aranda, Francisco José Alcaide, Jaime Barranquero, Juan Carlos Fuentes, Miguel Angel Torres.

Used instrumentation:

Radiated Measurements

		Last Cal. date	Cal. due date
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
2.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
3.	Multi Device Controller EMCO 2090	N.A.	N.A.
4.	Positioning Controller INNCO CO3000	N.A.	N.A.
5.	BiconicalLog antenna ETS LINDGREN 3142E	2017/09	2020/09
6.	BiconicalLog antenna ETS LINDGREN 3142E	2018/07	2021/07
7.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2016/11	2019/11
8.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2018/06	2021/06
9.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2017/04	2020/04
10.	Broadband Horn antenna 18-40 GHz SCHWARZBECK BBHA 9170	2018/07	2021/07
11.	EMI Test Receiver R&S ESR7	2018/10	2020/10
12.	EMI Test Receiver R&S ESR7	2018/10	2020/10
13.	Spectrum analyser Rohde & Schwarz FSV40	2018/02	2020/02
14.	Spectrum analyser Rohde & Schwarz FSV40	2017/07	2019/07
15.	RF pre-amplifier 30MHz-6 GHz Bonn Elektronik BLNA 0360-01N	2018/07	2019/07
16.	RF pre-amplifier 10MHz-6 GHz Bonn Elektronik BLNA 0160-01N	2017/09	2019/03
17.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-1M	2018/03	2019/03
18.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-3A	2018/03	2019/03
19.	RF pre-amplifier 18-40 GHz Bonn Elektronik BLMA 1840-1M	2018/03	2019/03
20.	RF pre-amplifier 18-40 GHz NARDA JS44-18004000-33-8P	2018/02	2019/02
21.	RF High Pass Filter 3-18 GHz WAINWRIGHT INSTRUMENTS WHK 3.0/18G-10SS	2017/04	2019/04
22.	RF High Pass Filter 3-18 GHz TEMSTRON ST-3GA2833-HS	2018/09	2019/09
23.	RF Low Pass Filter DC-1GHz WAINWRIGHT INSTRUMENTS WLK1000-6SS	2018/06	2020/06
24.	RF High Pass Filter 18-26.5 GHz MicroWave Circuits H18G26G1	2017/04	2019/04
25.	AC Power Supply Elgar CS-AC35(351SL)	2016/05	2019/05
26.	AC Power Supply California Instruments 5001iM-400	2018/11	2020/11

Conducted Measurements

		Last Cal. date	Cal. due date
1.	Spectrum analyser Rohde & Schwarz FSV40	2017/07	2019/07
2.	AC Power Supply Elgar CS-AC35(351SL)	2016/05	2019/05
3.	Spectrum analyser Rohde & Schwarz FSW50	2018/02	2020/02
4.	3 Ports directional coupler 0.5-18GHz AAMCS-UDS-0.5G-18G-10dB-SF	2019/01	2020/01
5.	3 Ports directional coupler 0.5-18GHz AAMCS-UDS-0.5G-18G-10dB-SF	2019/01	2020/01
6.	3 Ports directional coupler 0.5-18GHz AAMCS-UDS-0.5G-18G-10dB-SF	2019/01	2020/01
7.	Power Divider Advantech P214	2018/05	2019/05
8.	Power Divider Advantech P214	2018/05	2019/05

Testing verdicts

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

Summary

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		Verdict	Remark
Section 15.247 Subclause (a) (2) / RSS-247 5.2. (a)	6 dB Bandwidth	P	
Section 15.247 Subclause (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
Section 15.247 Subclause (e) / RSS-247 5.2. (b)	Power spectral density	P	
Section 15.247 Subclause (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
Section 15.247 Subclause (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
<u>Supplementary information and remarks:</u>			
(1) There are two manufacturers of the WiFi/Bluetooth radio modules, manufacturer 1 and manufacturer 2.			
(2) The WiFi/Bluetooth radio modules have the same mechanical outline (i.e. the same packaging dimension and pin layout), use the same antenna matching circuit, have an identical antenna structure and are built to conform to the same specification and to operate within the same tolerances.			
(3) Preliminary testing was performed on the two manufacturers' samples with different radio modules to determine the worst case.			

Appendix A: Test results.

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FCC Section 15.247 Subclause (e) / RSS-247 5.2. (b) Power spectral density75

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TEST CONDITIONS

Power supply (V):

Vnominal = 120 Vac

Type of power supply = AC voltage main supply.

Type of antenna = Internal antenna.

Declared Gain for antenna (maximum) at each port/core:

$G_{\text{CORE AUX}} = 3.38 \text{ dBi}$

Technology Tested:	IEEE 802.11 b,g,n	
Modes:	802.11b: 1, 2, 5.5 & 11 Mbps (SISO)	
	802.11g: 6, 9, 12, 18, 24, 36, 48 & 54 Mbps (SISO)	
	802.11n HT20: MCS0 to MCS7 (SISO)	
Setting of cores / ports:	Aux	
Beamforming:	No	
Channel Spacing:	20 MHz	
Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channels	Channel	Channel Frequency (MHz)
	1	2412
	2	2417
	3	2422
	4	2427
	5	2432
	6	2437
	7	2442
	8	2447
	9	2452
	10	2457
	11	2462
	12	2467
	13	2472

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v05 dated 24/08/2018.

The EUT was tested in the following operating mode:

- Continuously transmitting with a modulated carrier at maximum power in all required channels selecting the supported data rates/modulations types.

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

For all modes, the EUT was configured in test mode using a software application. The application was used to enable a continuous transmission and to select the test channels as required. The client supplied scripts to configure the EUT. The customer supplied a document containing the setup instructions.

The following modes and data rates were selected based on preliminary testing that identified those corresponding to the worst cases:

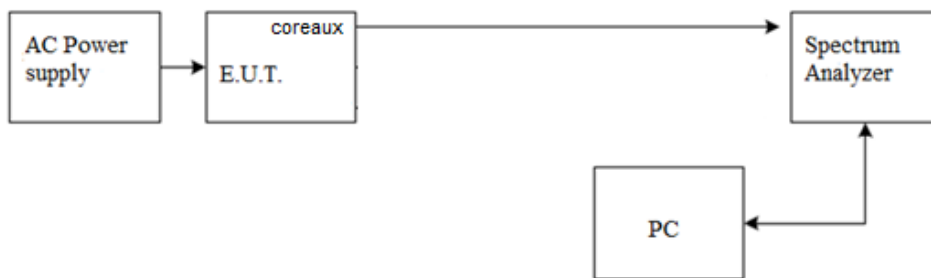
- 802.11b: 1 Mbit/s / SISO on Core Aux
- 802.11g: 6 Mbit/s / SISO on Core Aux
- 802.11n HT20: MCS0 / SISO on Core Aux

The client supplied U.FL RF cables with the EUT in order to perform conducted measurements. The measured additional path loss was included in any path loss calculations.

CONDUCTED MEASUREMENTS

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

For all modes:



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

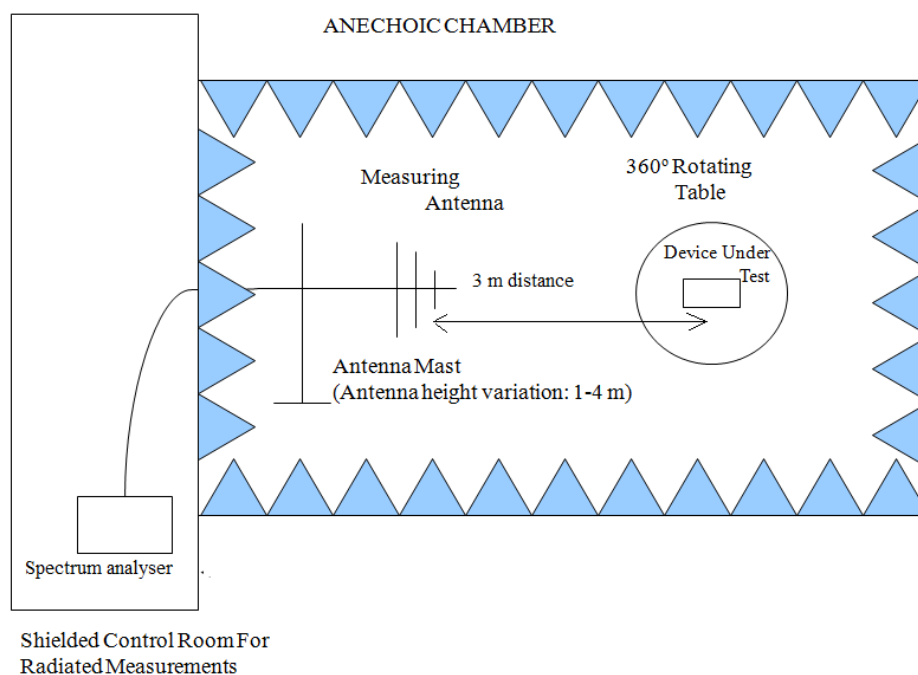
RADIATED MEASUREMENTS

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna is situated at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the center of the chamber turntable to perform the measurements below 1GHz and The EUT was placed at a height of 1.5 meters above the test chamber floor in the center of the chamber turntable to perform the measurements above 1GHz. It was also rotated 360° and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission.

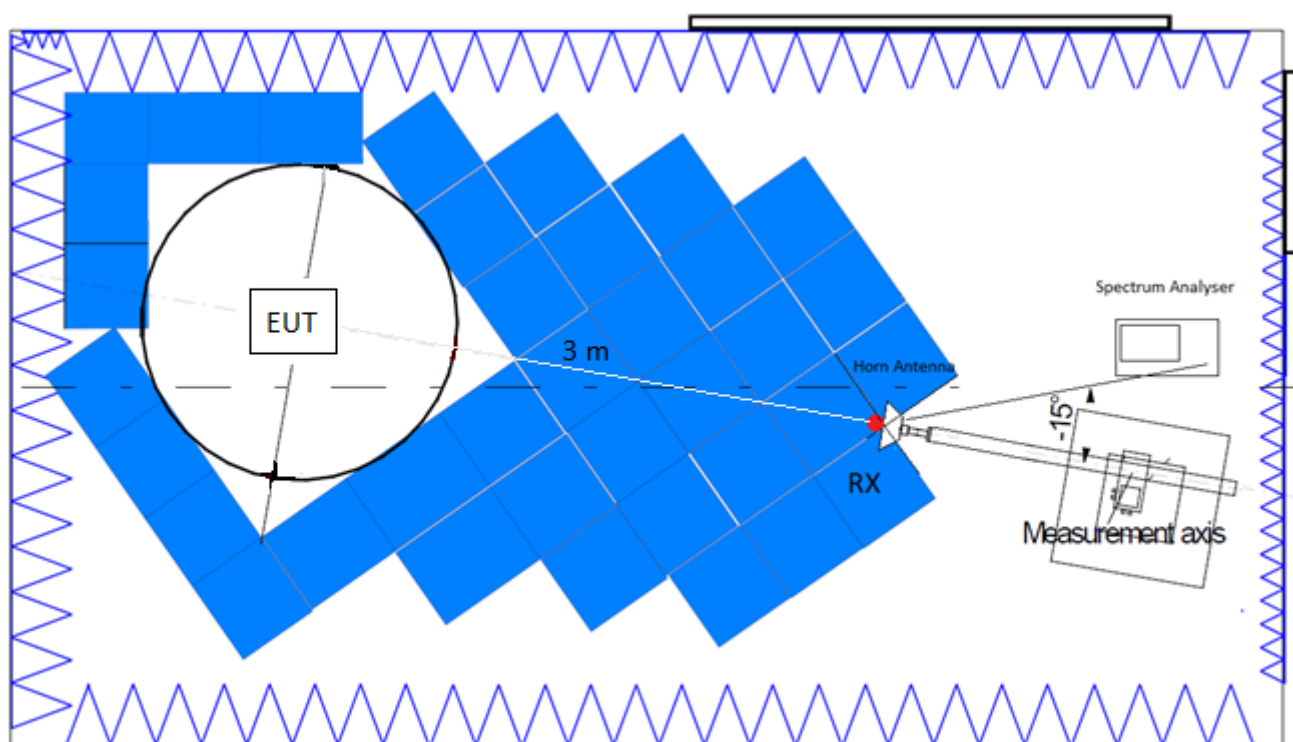
Measurements were made in both horizontal and vertical planes of polarization.

The final measured value, for the given emission, in the tables below incorporates the calibrated antenna factor, preamplifier gain (if used) and cable losses.

Radiated measurements setup $f < 1$ GHz



Radiated measurements setup $f > 1$ GHz



Occupied Bandwidth

RESULTS:

(see next plots)

Test performed on the following modes in all required tests channels:

- 802.11b: 1 Mbit/s / SISO on Core Aux
- 802.11g: 6 Mbit/s / SISO on Core Aux
- 802.11n HT20: MCS0 / SISO on Core Aux

Mode : 802.11b - 20MHz – SISO – CORE Aux

Channel	99 % bandwidth (MHz)
1	10.92
2	10.84
3	11.04
6	11.88
10	10.80
11	11.00
12	11.16
13	11.24
Measurement uncertainty (kHz)	<± 23.08

Mode : 802.11g - 20MHz – SISO – CORE Aux

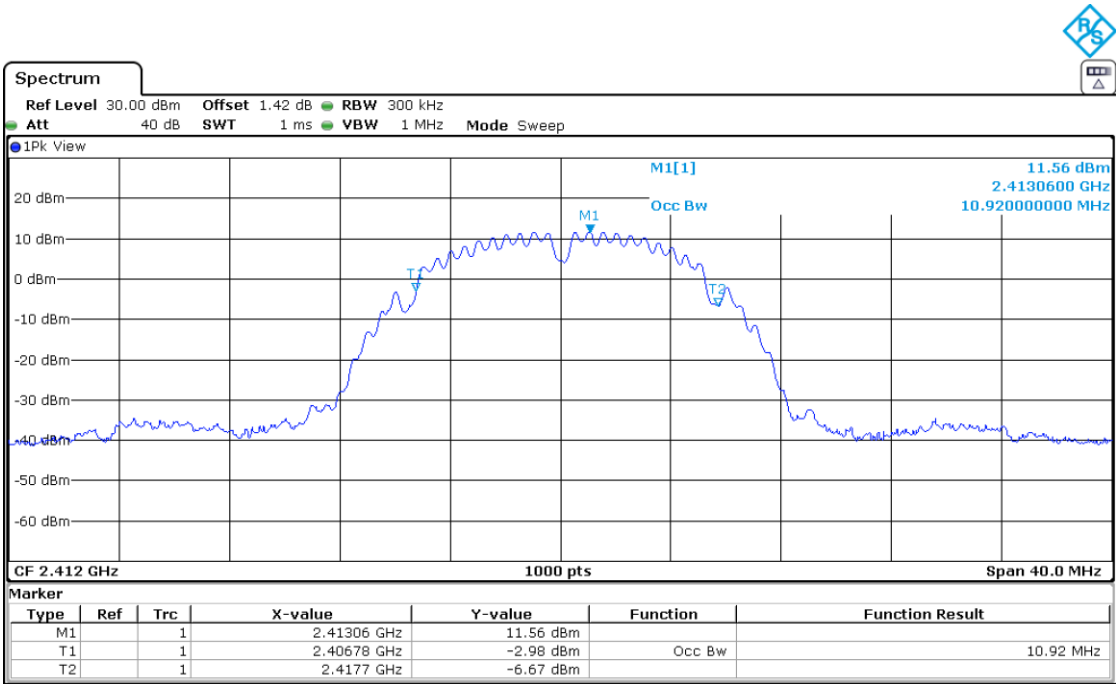
Channel	99 % bandwidth (MHz)
1	17.00
2	16.96
3	17.12
4	17.32
5	17.24
6	17.44
7	17.20
8	17.24
9	17.08
11	17.00
12	17.04
13	17.04
Measurement uncertainty (kHz)	<± 23.08

Mode : 802.11n HT20 - 20MHz – SISO – CORE Aux

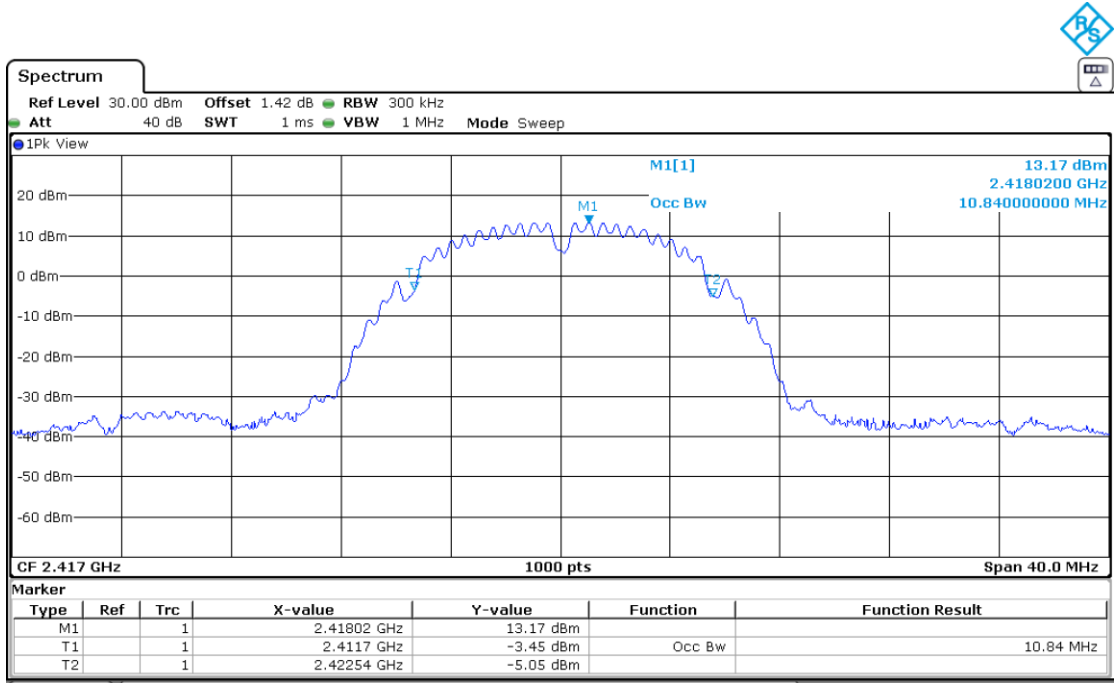
Channel	99 % bandwidth (MHz)
1	18.20
2	18.16
3	18.36
4	18.56
5	18.60
6	18.68
7	18.44
8	18.44
9	18.28
11	18.16
12	18.16
13	18.20
Measurement uncertainty (kHz)	<± 23.08

Mode : 802.11b - 20MHz – SISO – CORE Aux

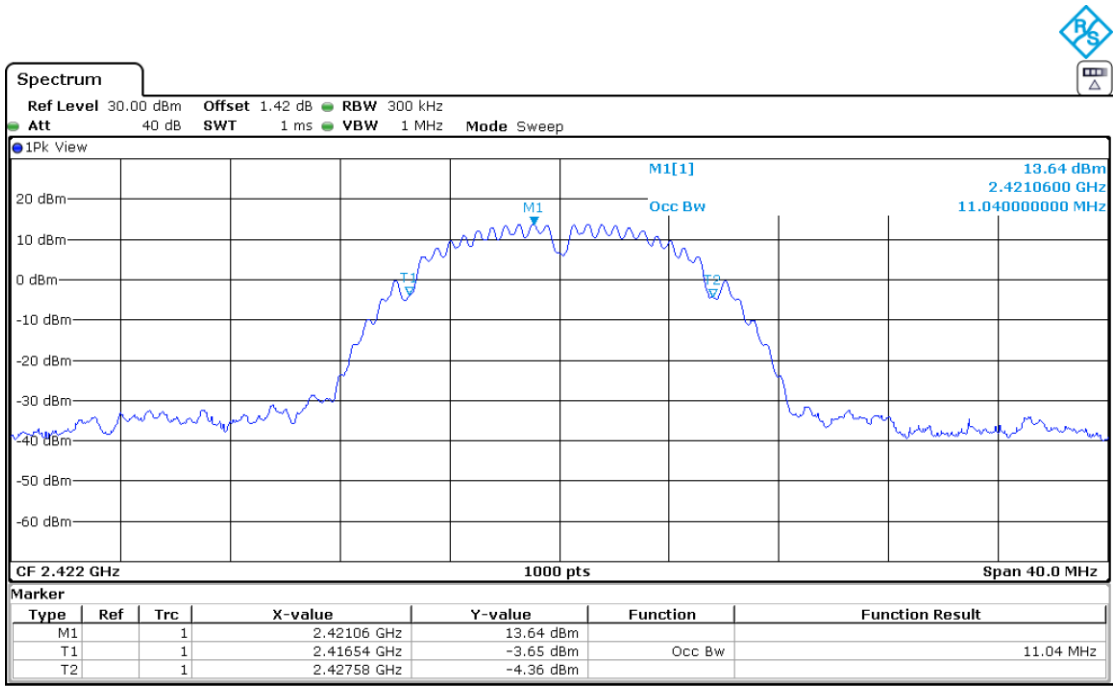
Channel 1



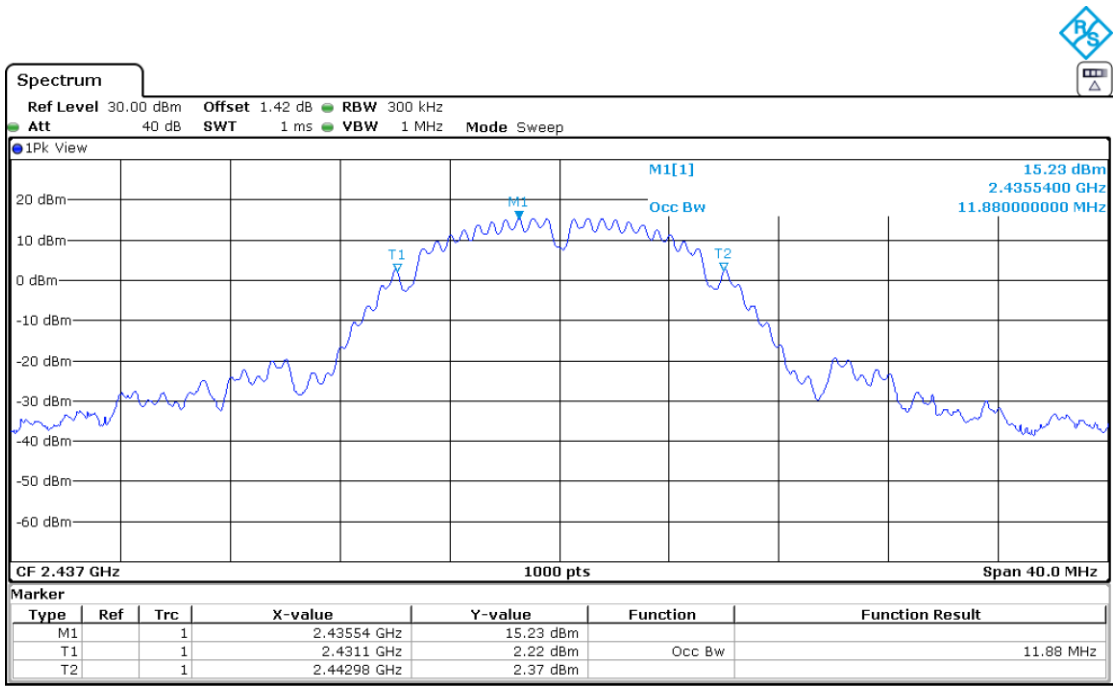
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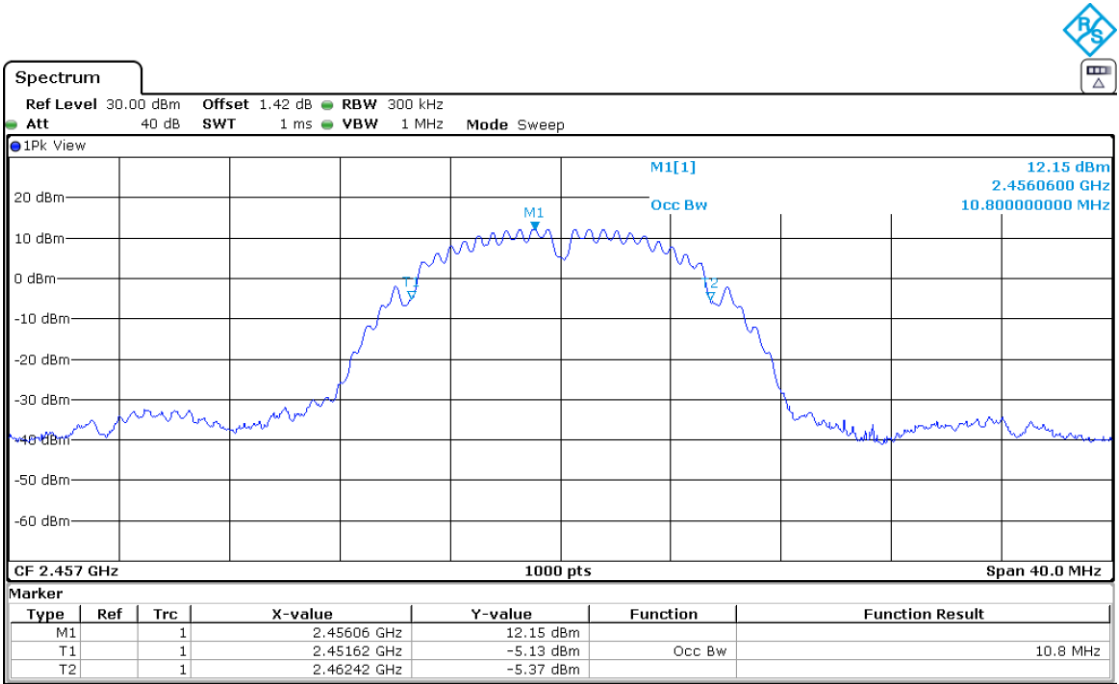
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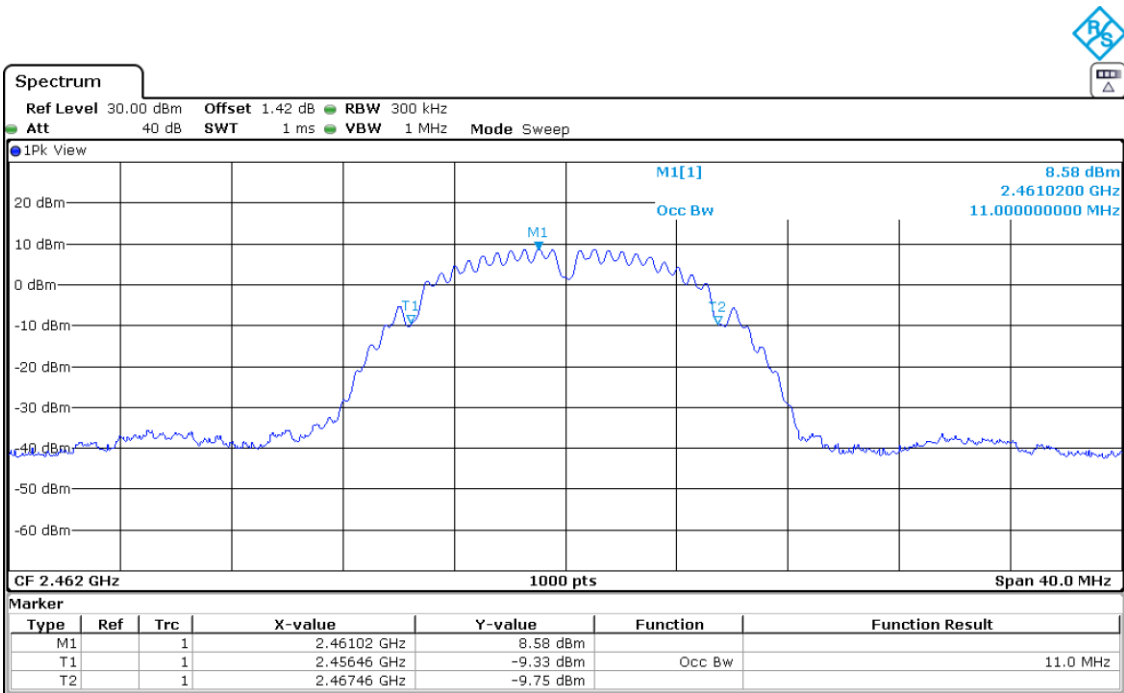
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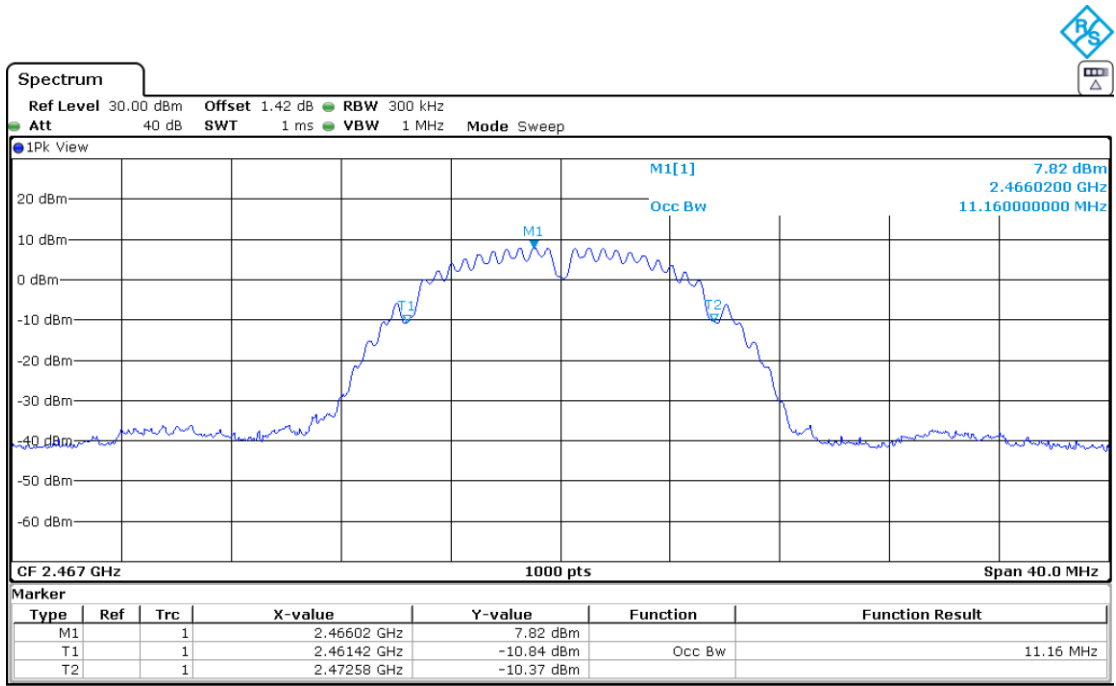
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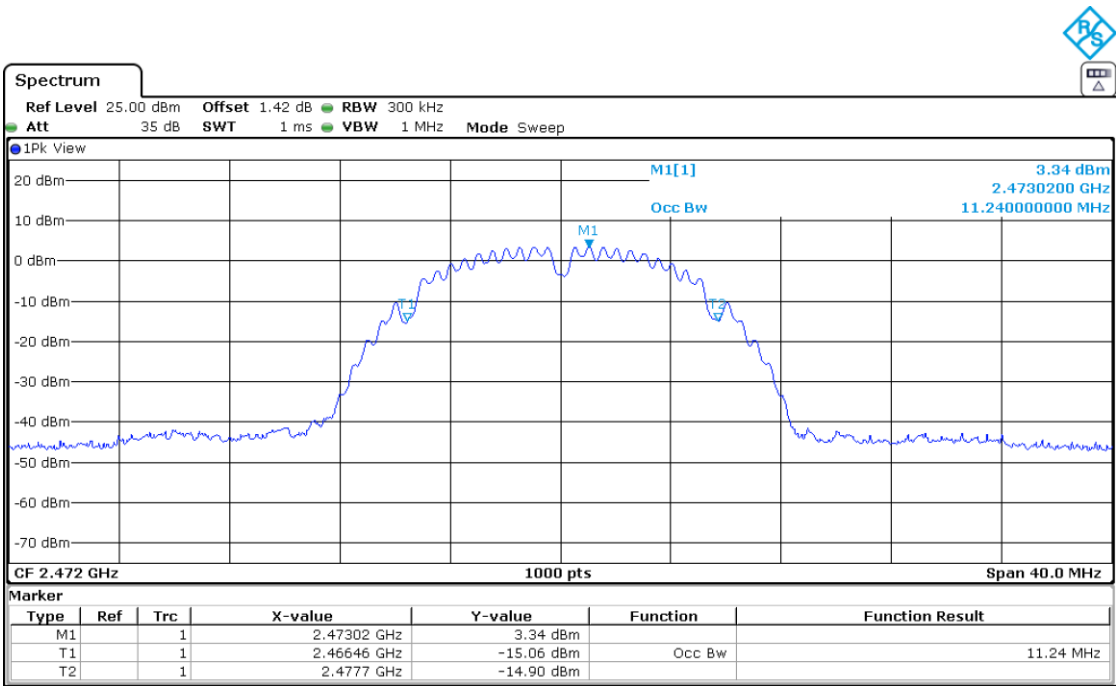
Channel 11



Channel 12

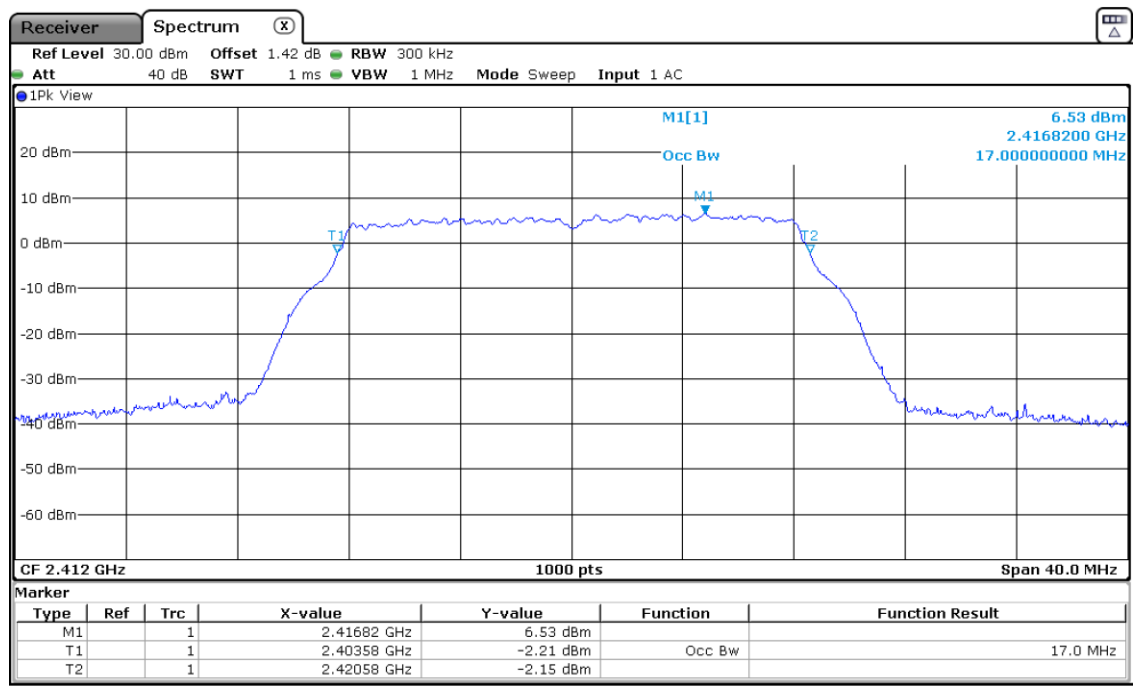


Channel 13

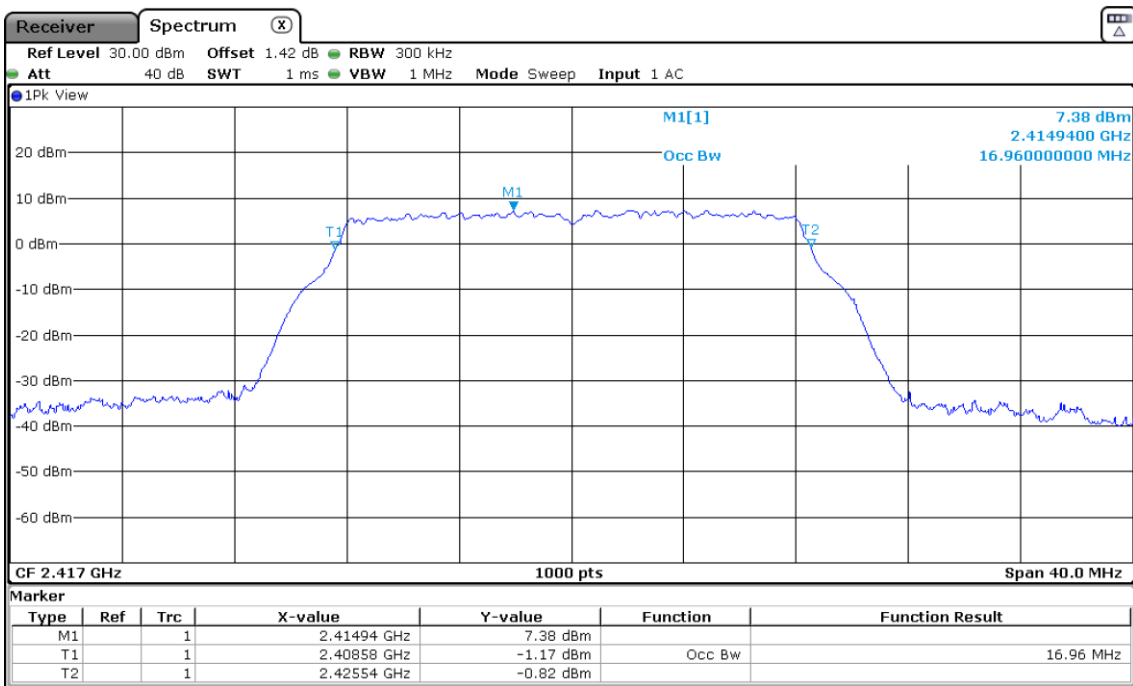


Mode : 802.11g - 20MHz – SISO – CORE Aux

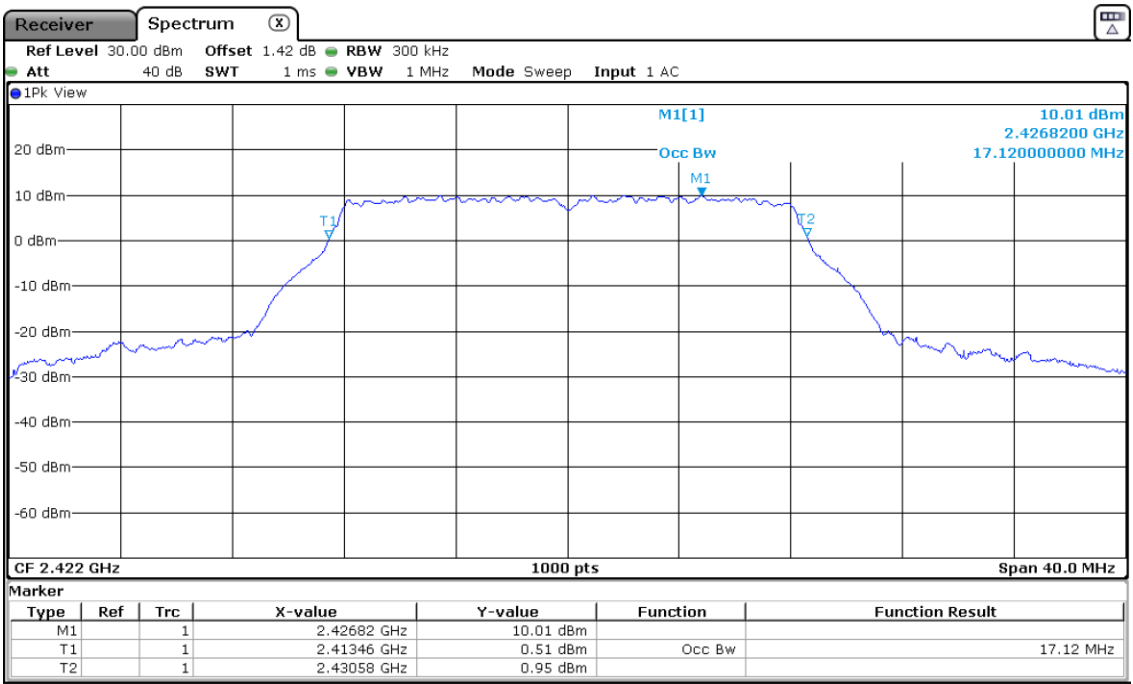
Channel 1



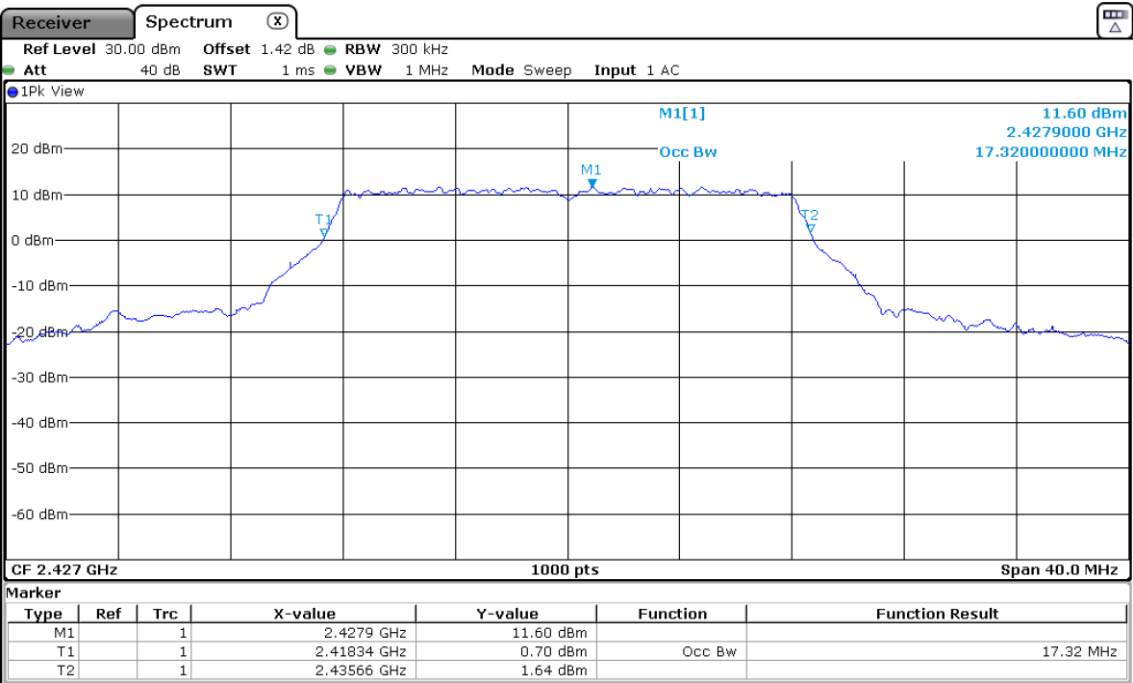
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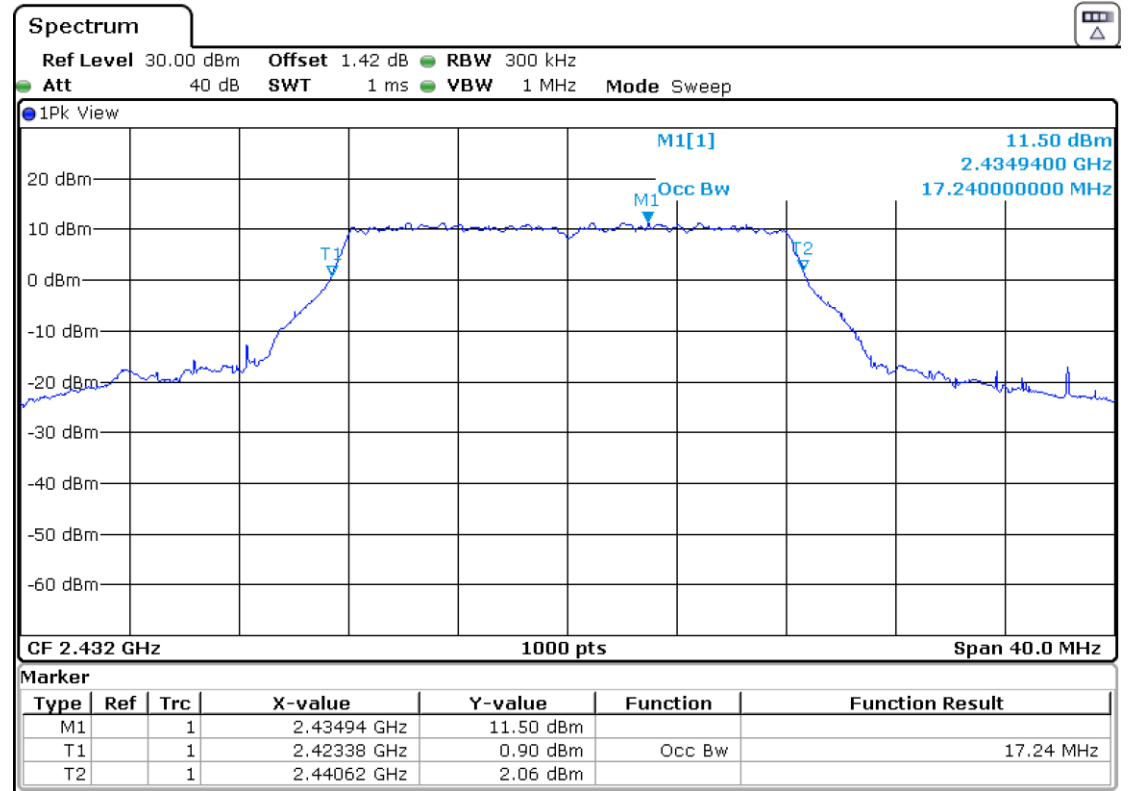
Channel 3



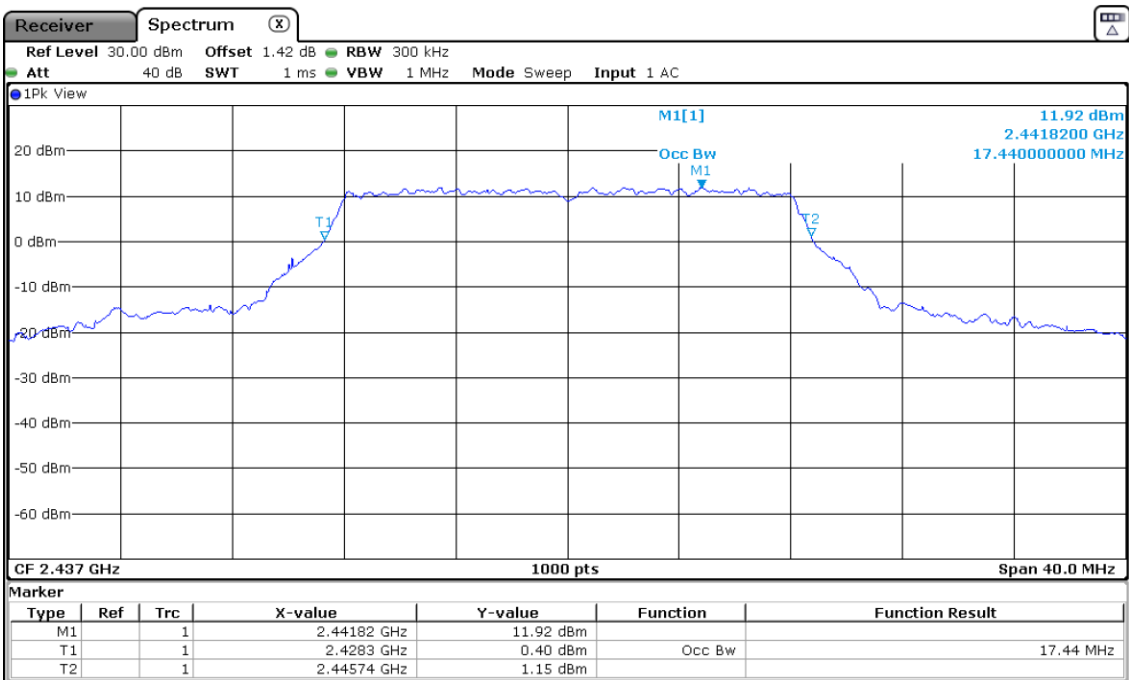
Channel 4



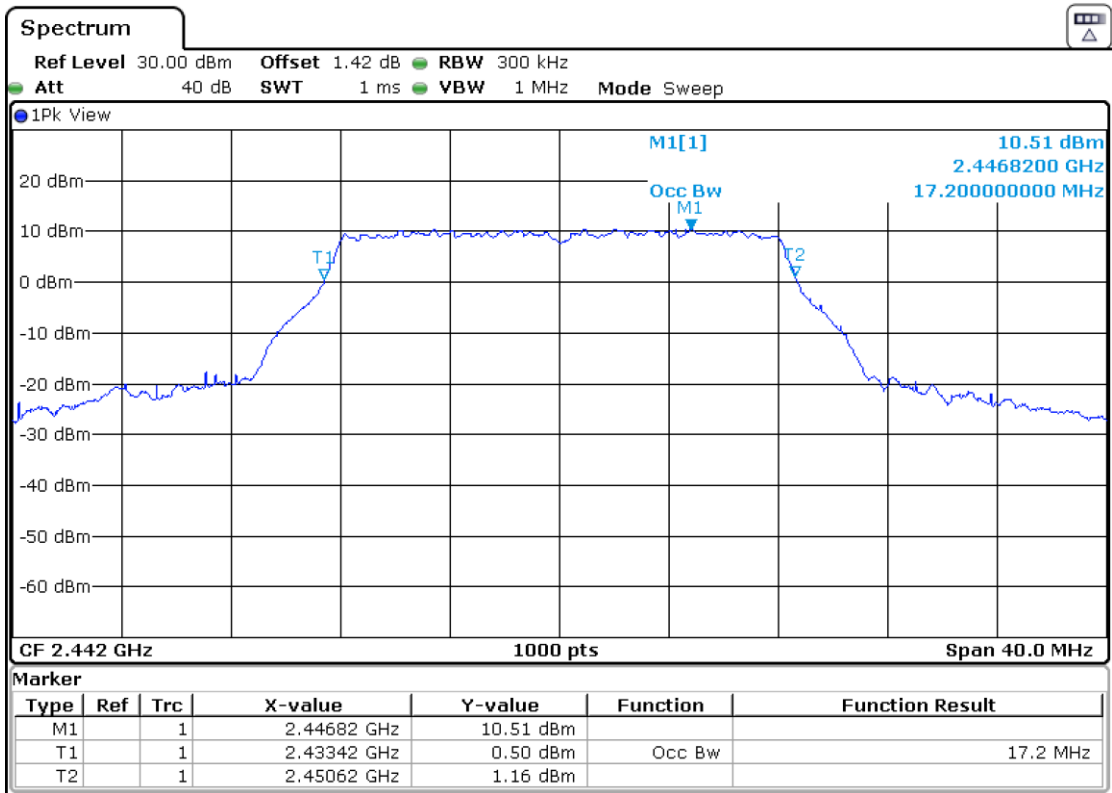
Channel 5



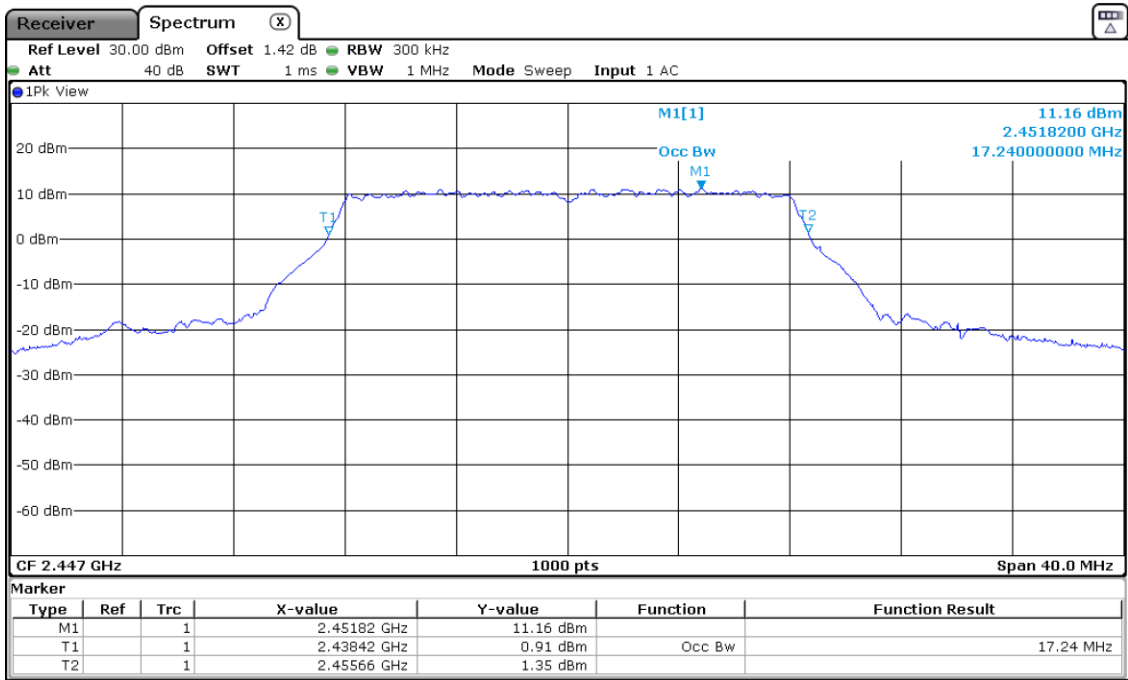
Channel 6



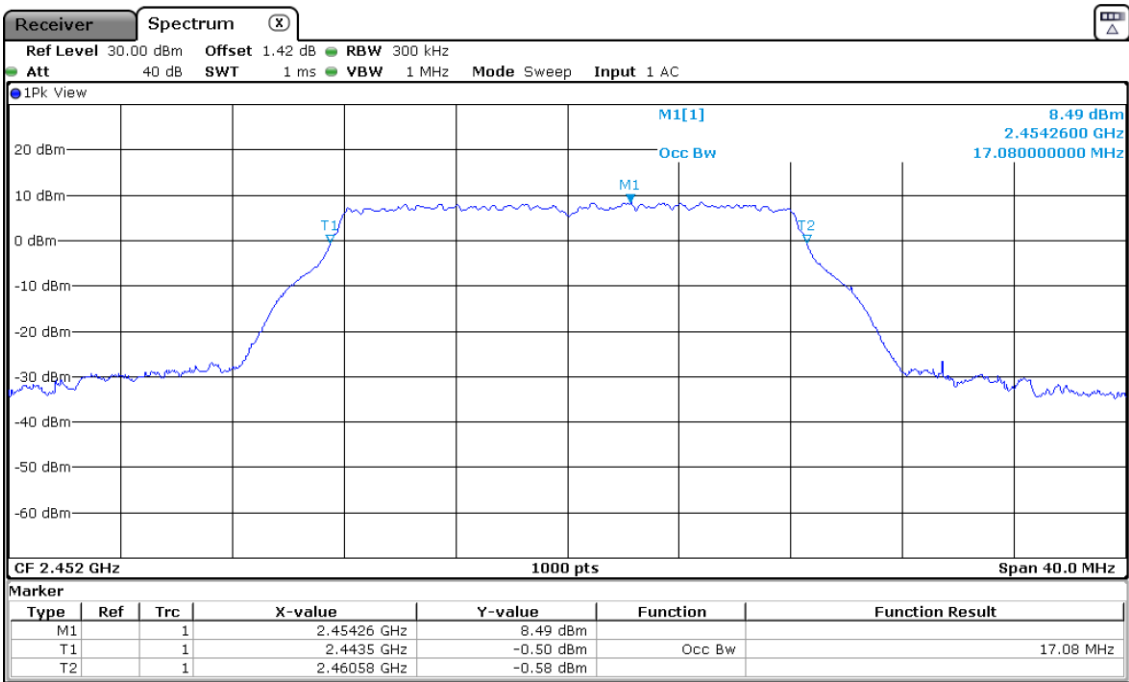
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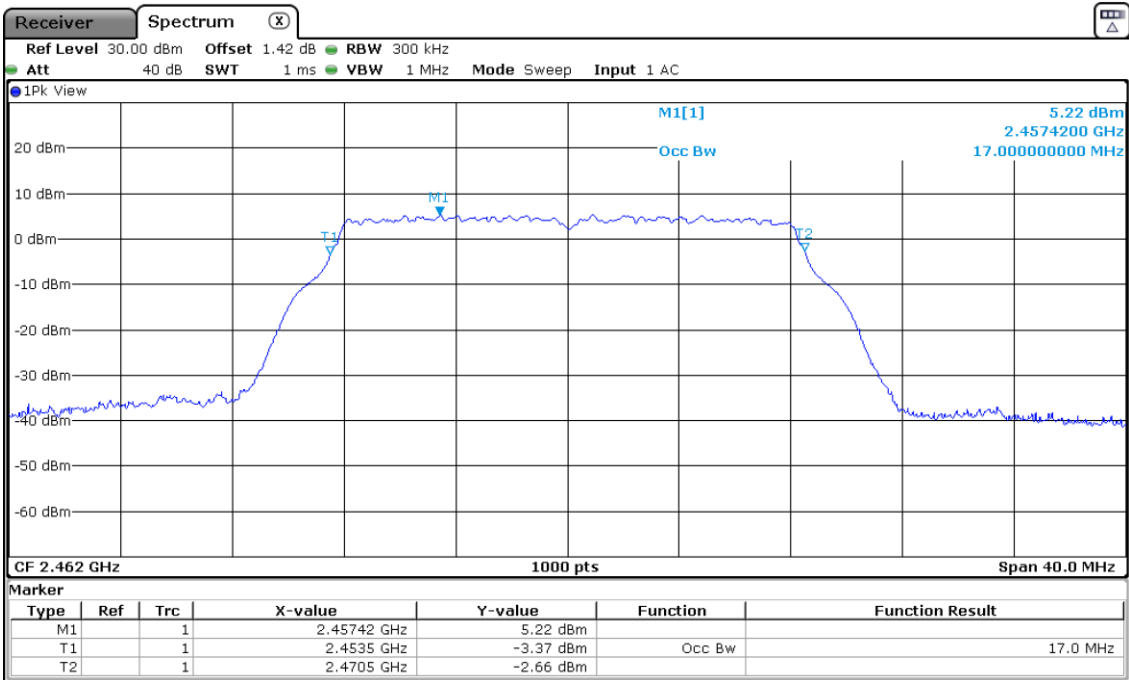
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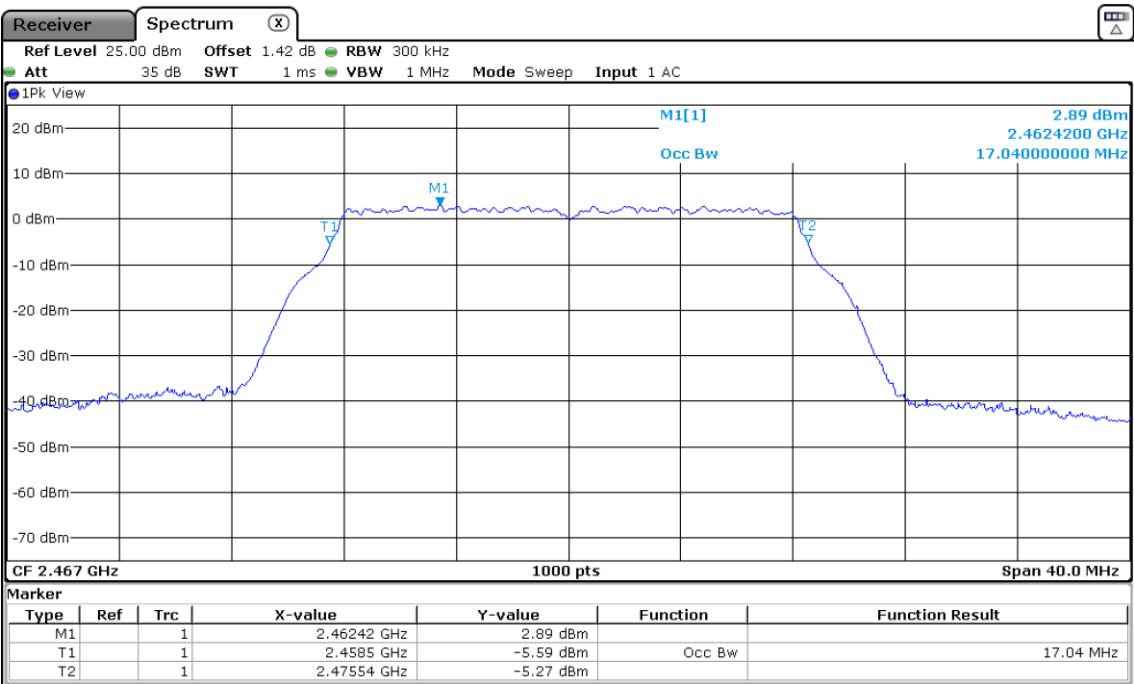
Channel 9



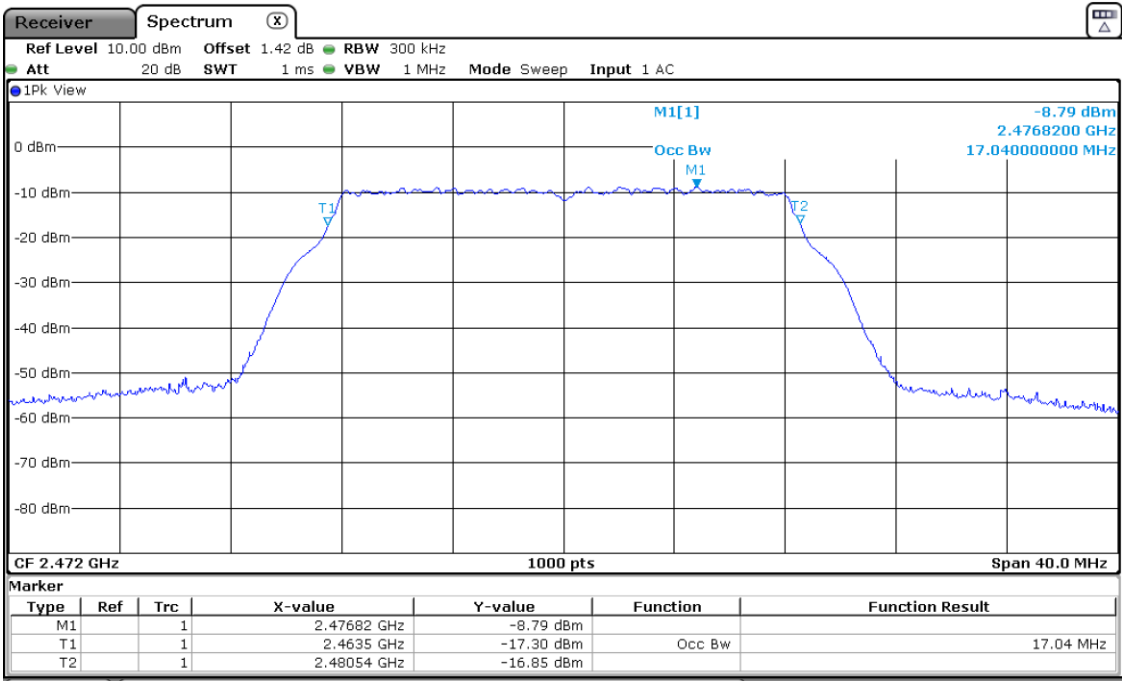
Channel 11



Channel 12

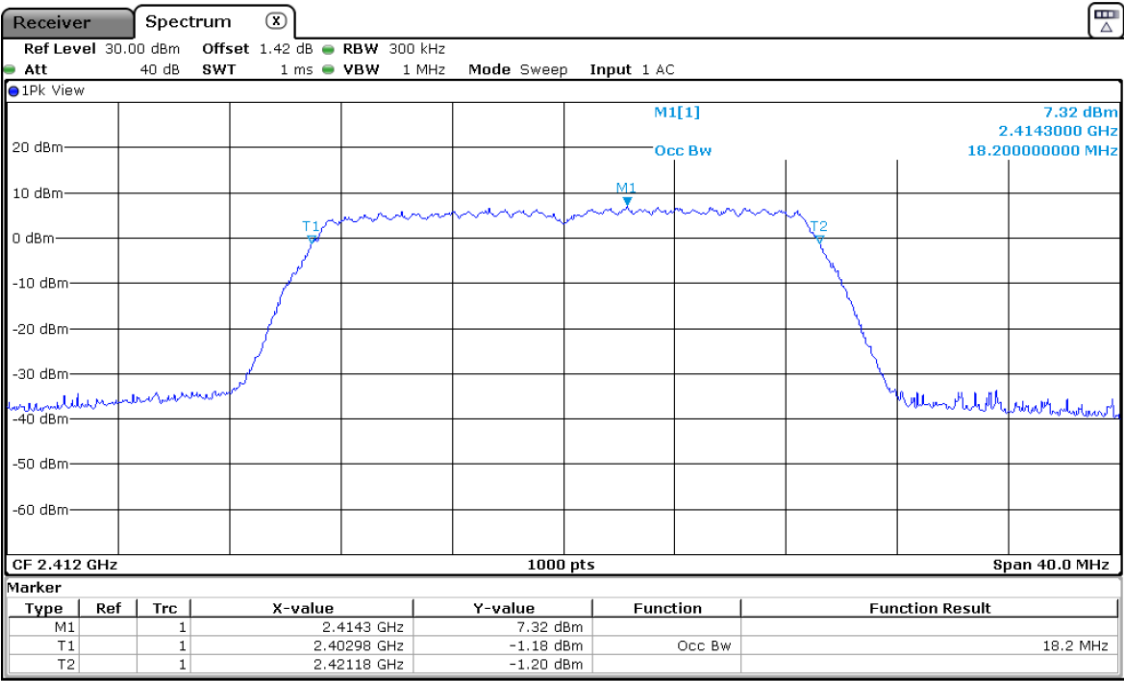


Channel 13

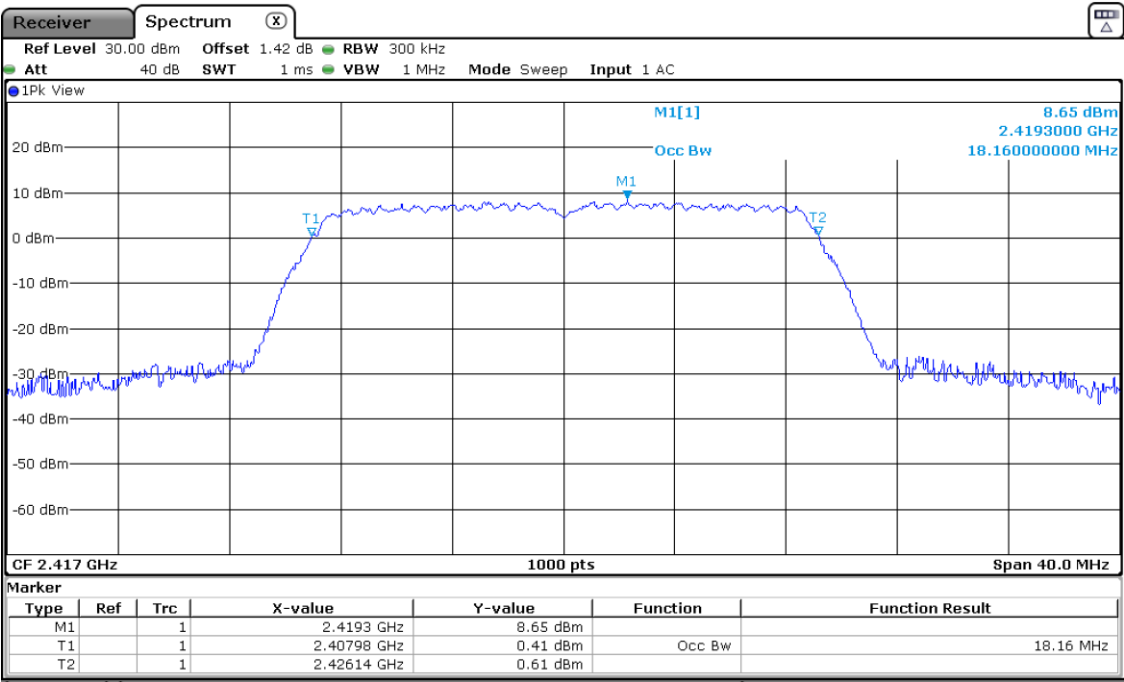


Mode : 802.11n HT20 - 20MHz – SISO – CORE Aux

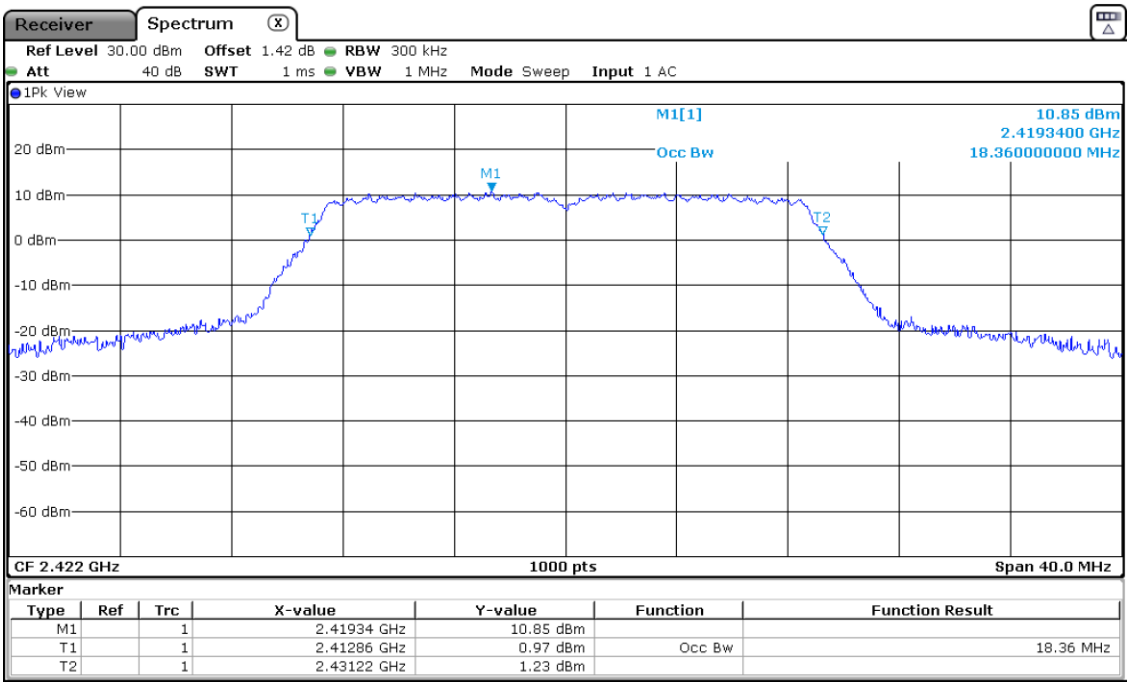
Channel 1



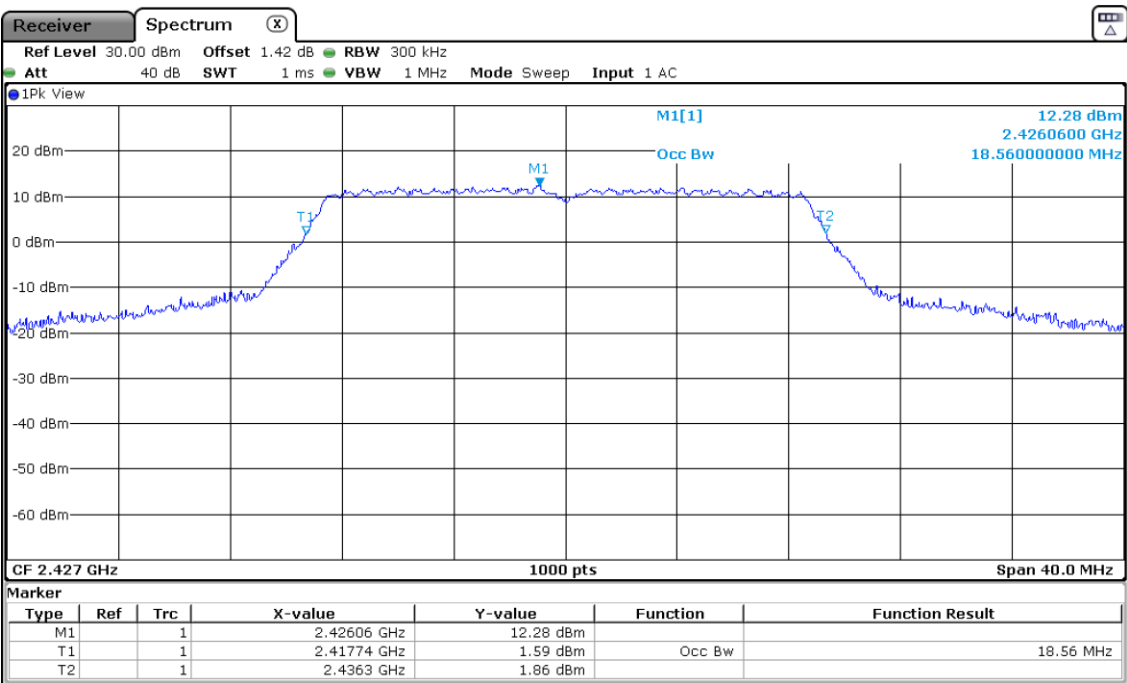
Channel 2



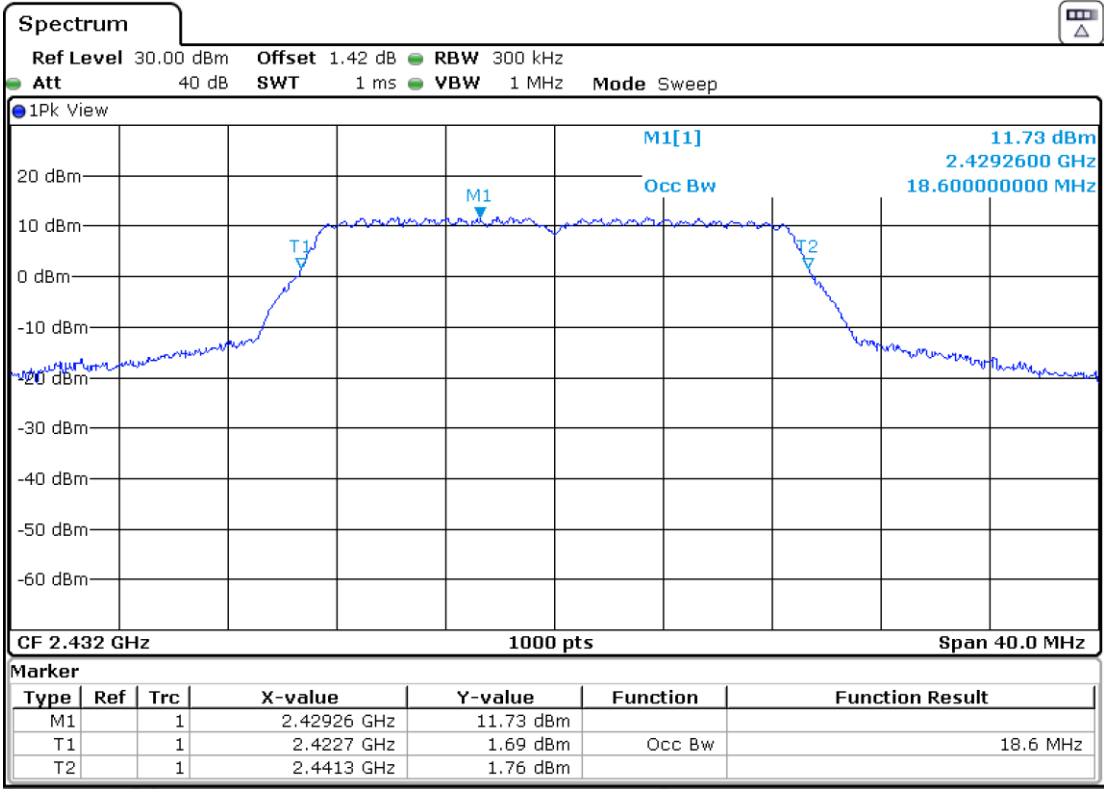
Channel 3



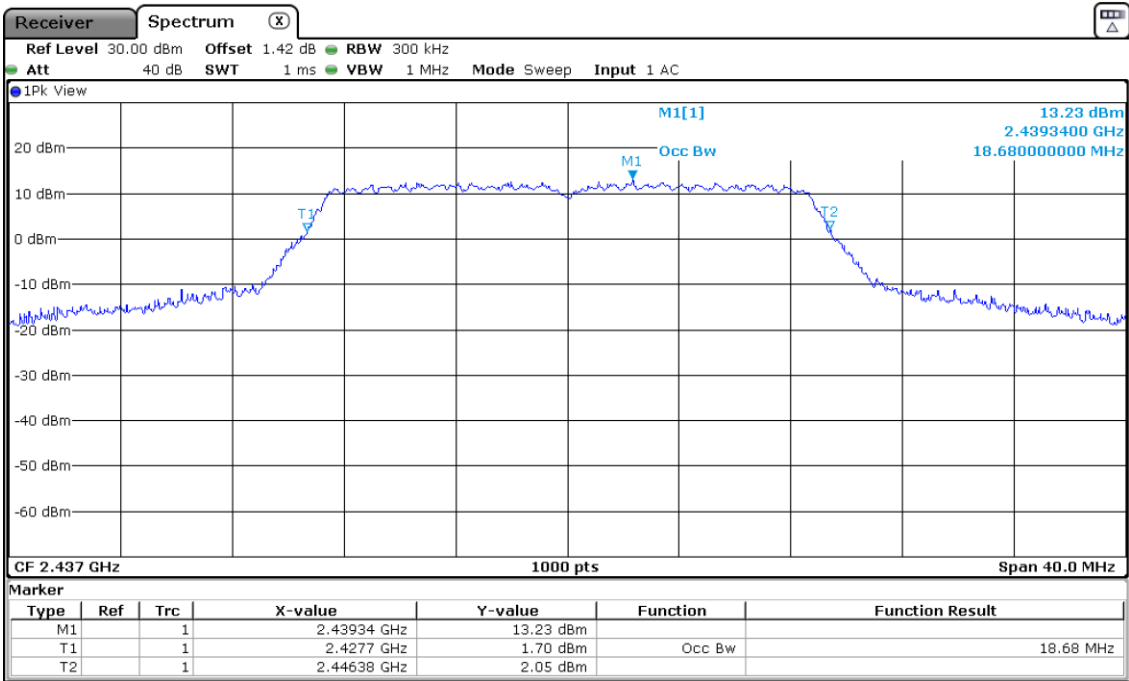
Channel 4



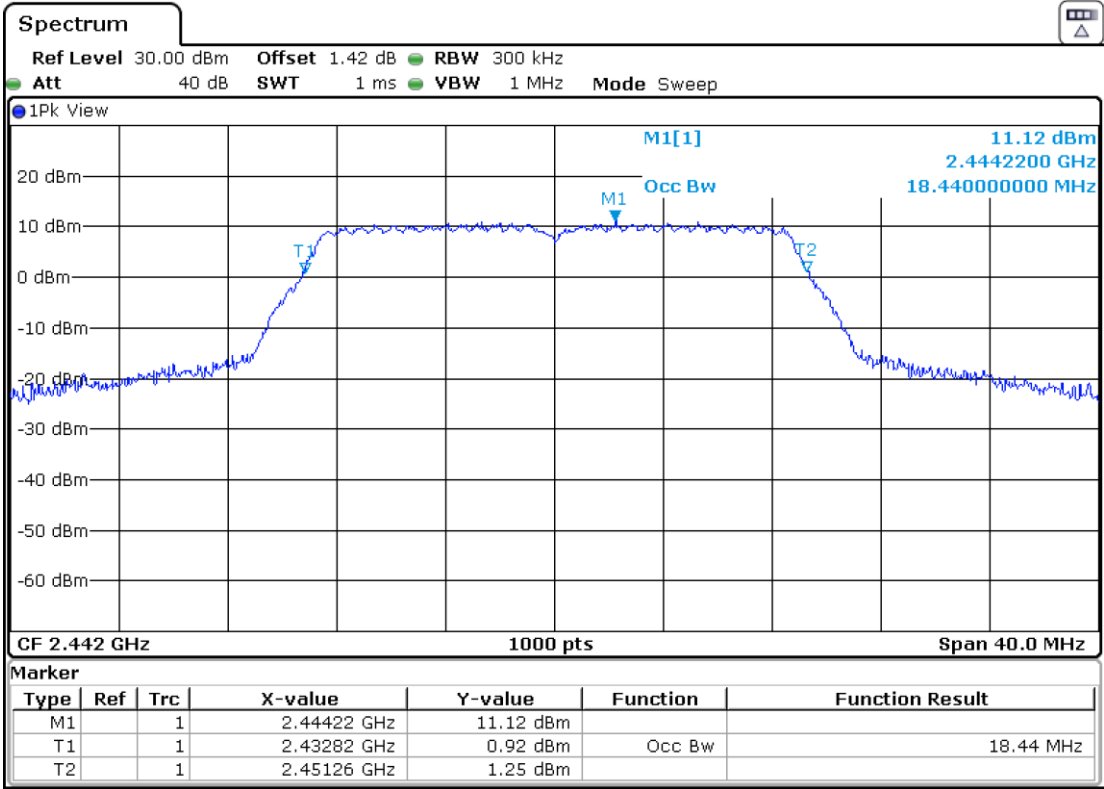
Channel 5



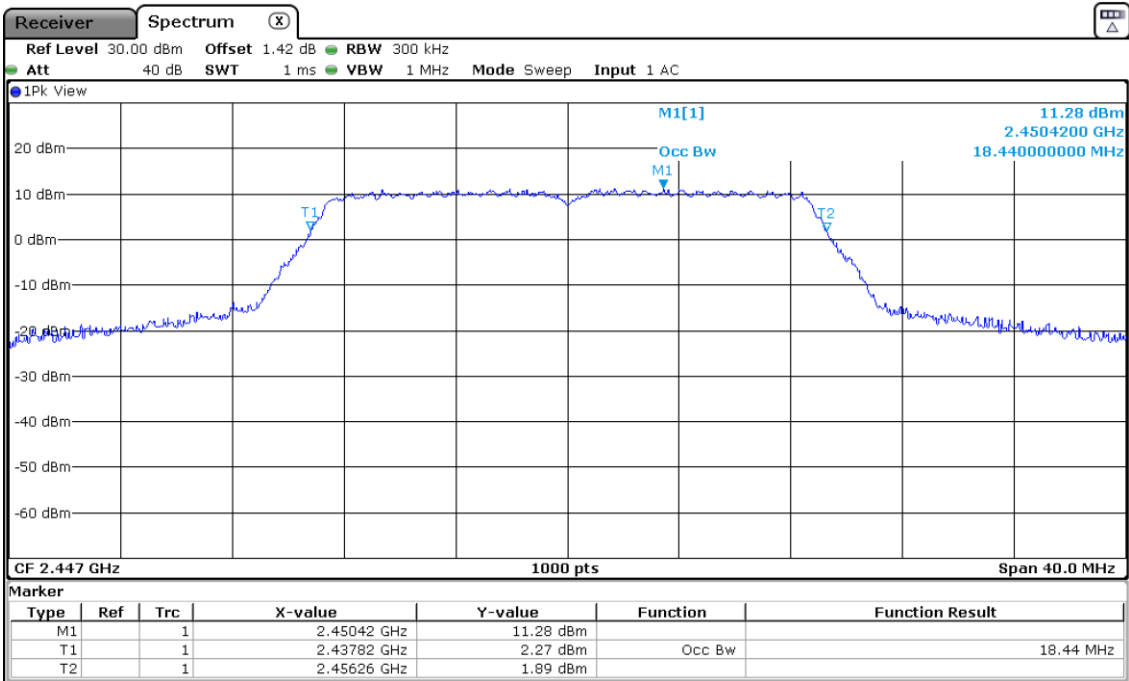
Channel 6



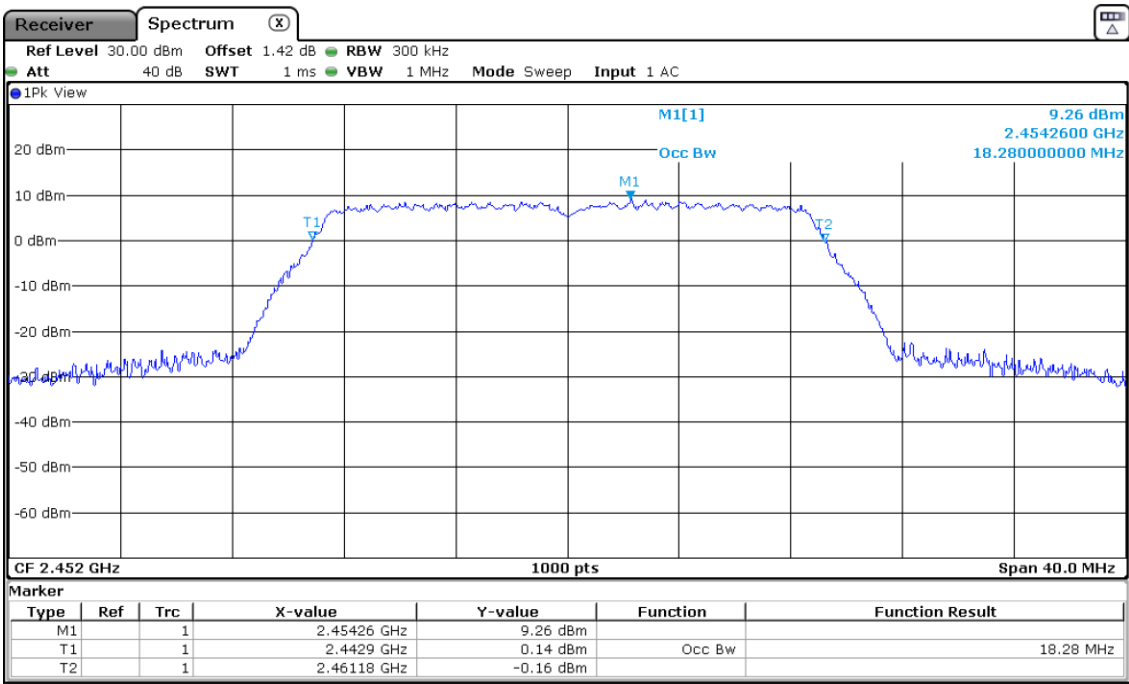
Channel 7



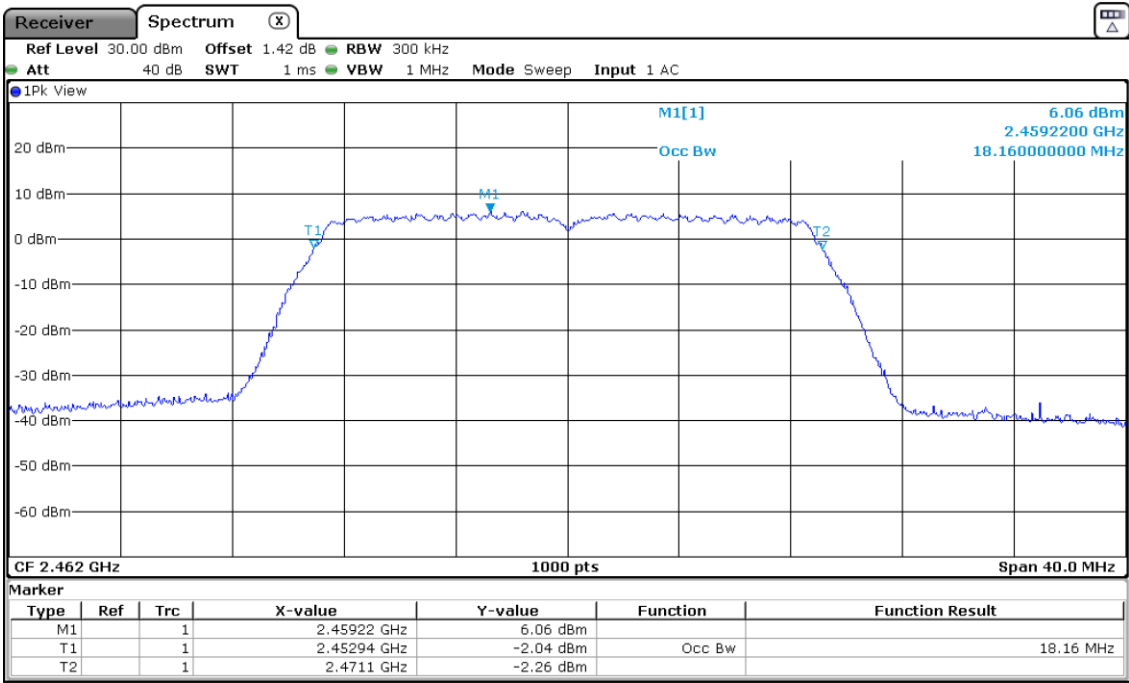
Channel 8



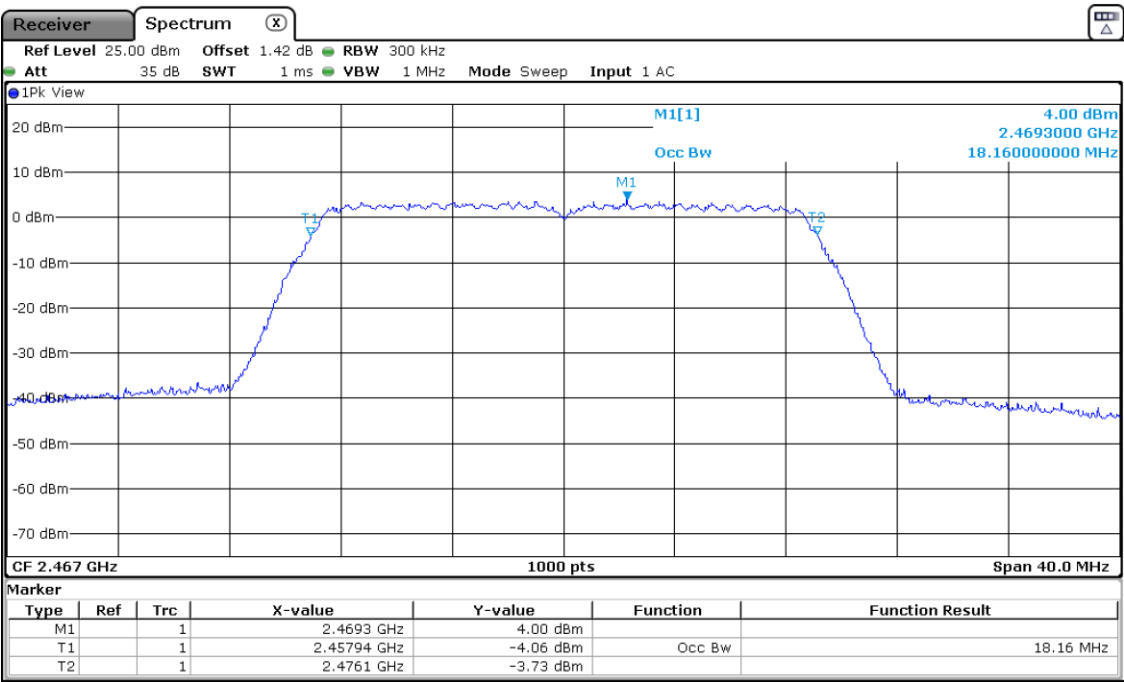
Channel 9



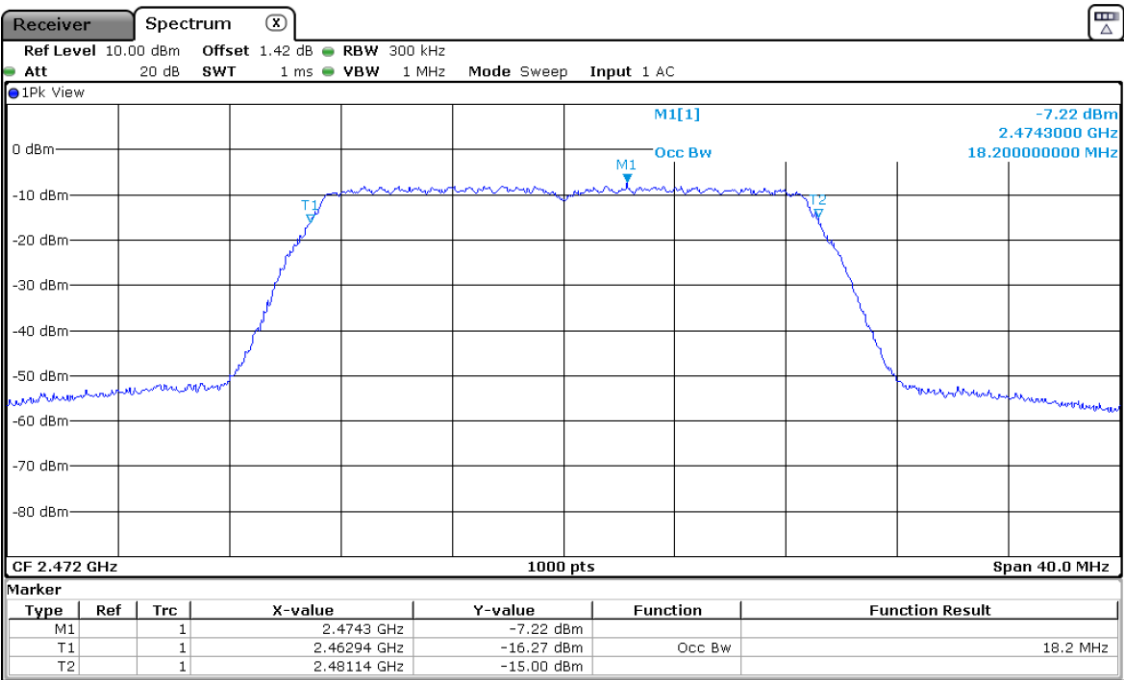
Channel 11



Channel 12



Channel 13



Transmitter Duty Cycle

RESULTS:

The equipment transmits continuously in all modes with a duty cycle > 98 %.

FCC 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:

6 dB Bandwidth (see next plots).

Test performed on the following modes in all required tests channels:

- 802.11b: 1 Mbit/s / SISO on Core Aux
- 802.11g: 6 Mbit/s / SISO on Core Aux
- 802.11n HT20: MCS0 / SISO on Core Aux

Mode : 802.11b - 20MHz – SISO – CORE Aux

Channel	6 dB bandwidth (MHz)
1	9.095
2	9.048
3	9.084
6	9.109
10	9.060
11	9.092
12	9.090
13	9.109
Measurement uncertainty (kHz)	<± 1.80

Mode : 802.11g - 20MHz – SISO – CORE Aux

Channel	6 dB bandwidth (MHz)
1	16.372
2	16.357
3	16.410
4	16.410
5	16.394
6	16.424
7	16.433
8	16.409
9	16.424
11	16.411
12	16.381
13	16.468
Measurement uncertainty (kHz)	<± 1.80

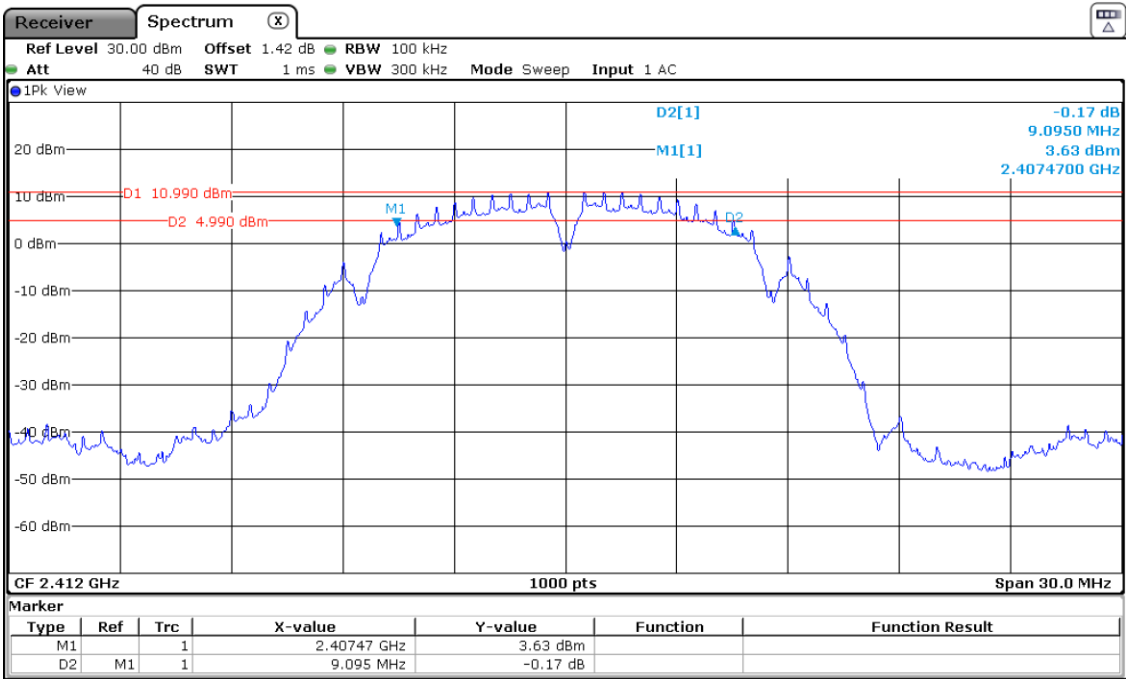
Mode : 802.11n HT20 - 20MHz – SISO – CORE Aux

Channel	6 dB bandwidth (MHz)
1	17.580
2	17.640
3	17.640
4	17.640
5	17.623
6	17.640
7	17.638
8	17.640
9	17.640
11	17.640
12	17.640
13	17.640
Measurement uncertainty (kHz)	<± 1.80

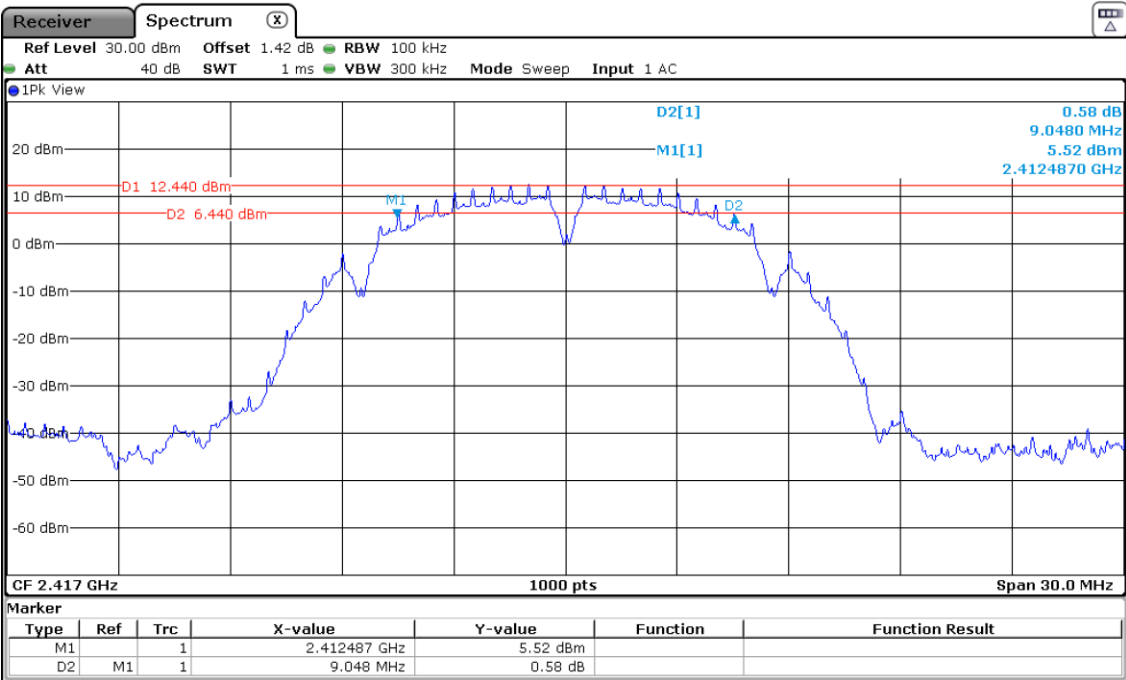
Verdict: PASS

Mode : 802.11b - 20MHz – SISO – CORE Aux

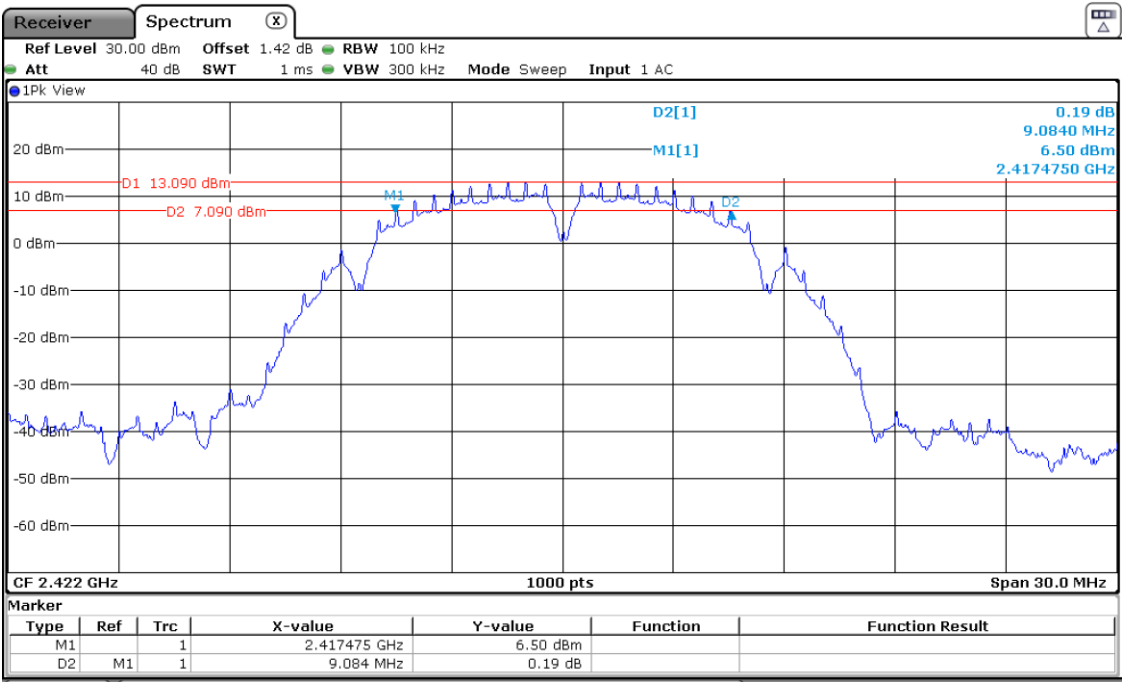
Channel 1



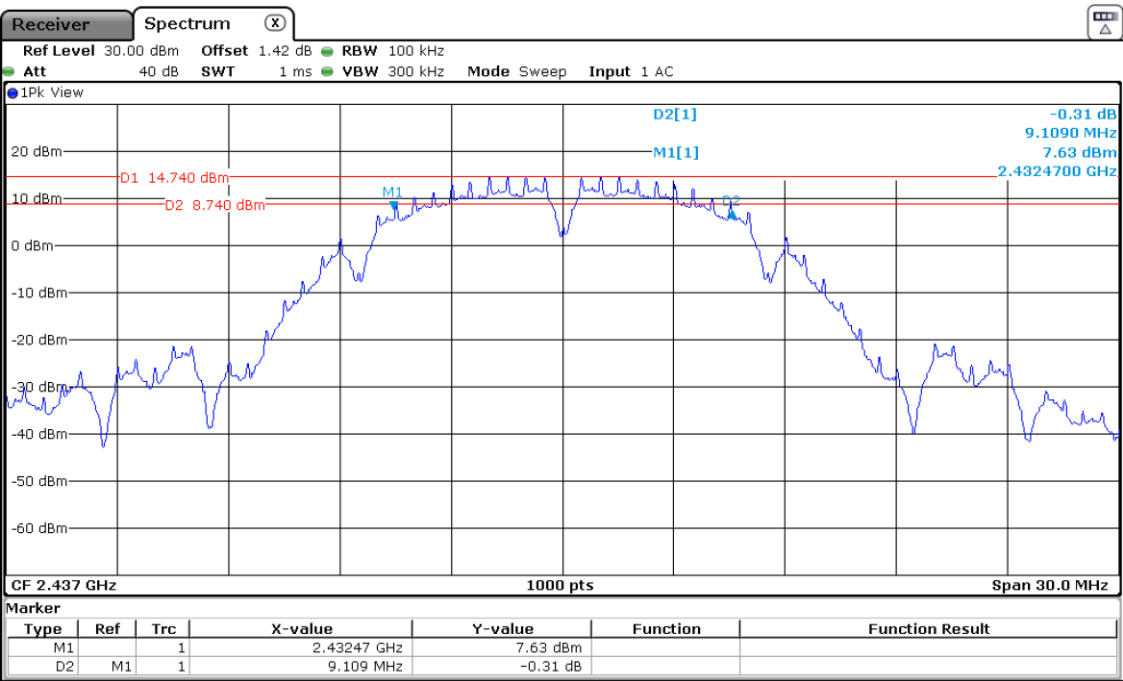
Channel 2



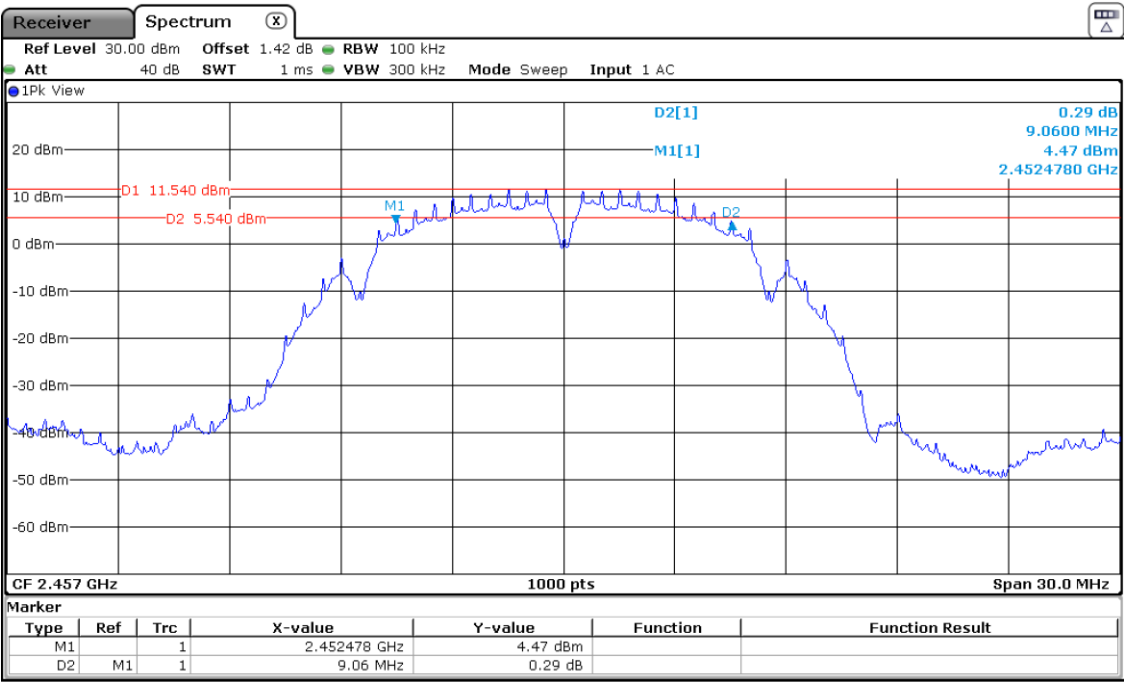
Channel 3



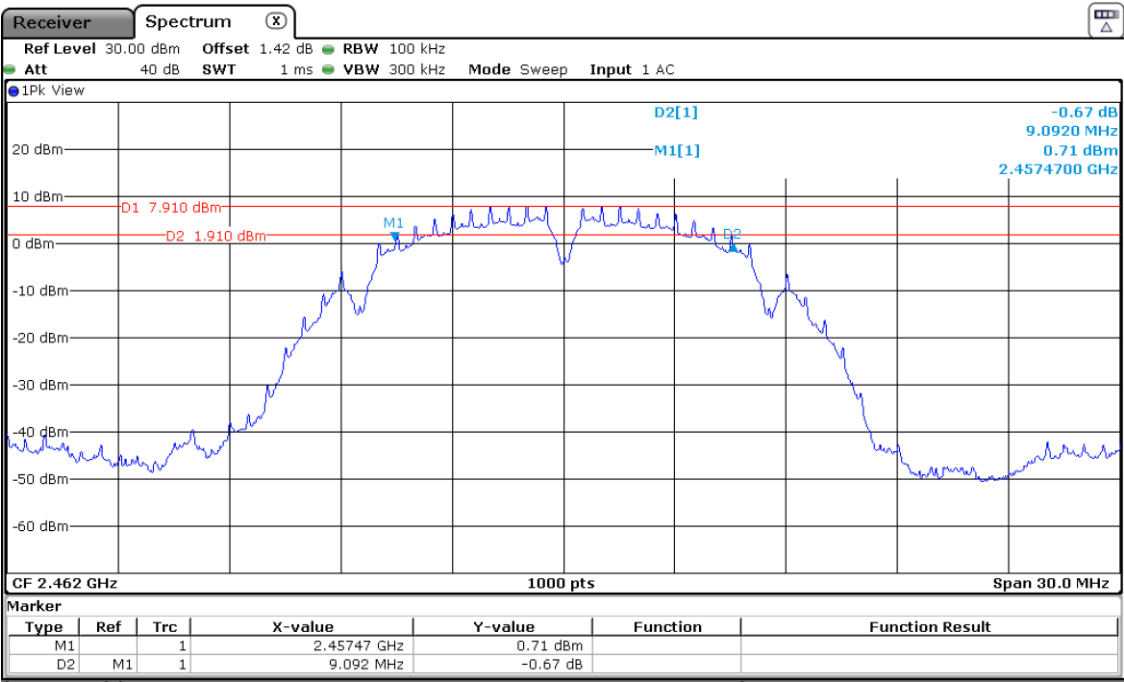
Channel 6



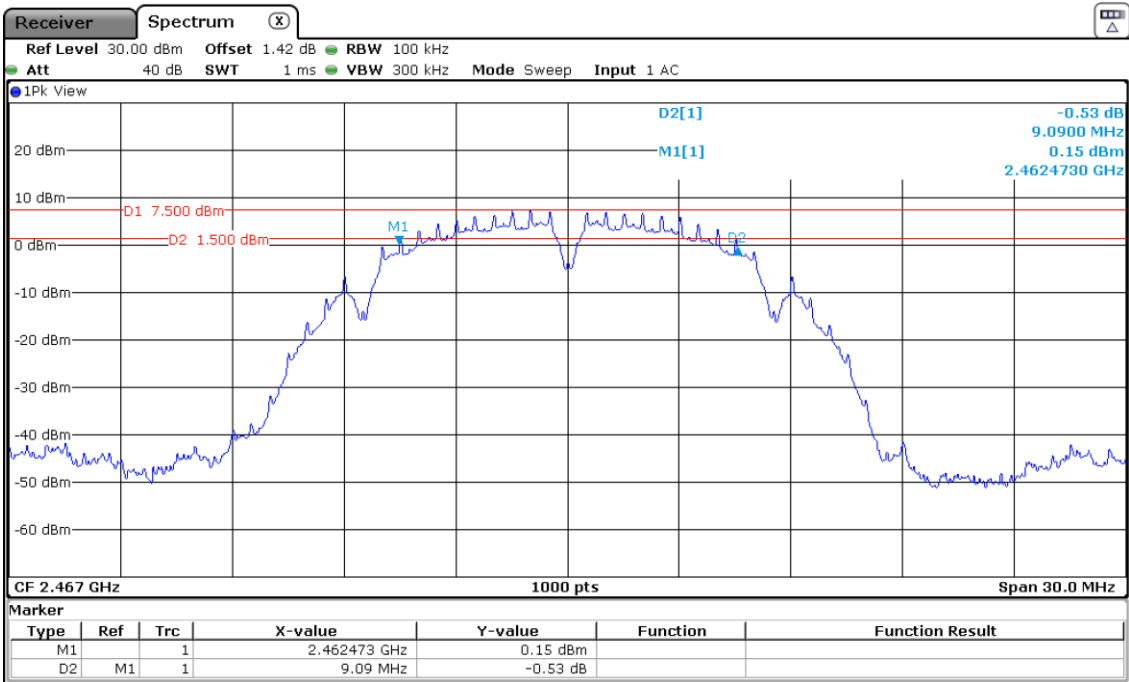
Channel 10



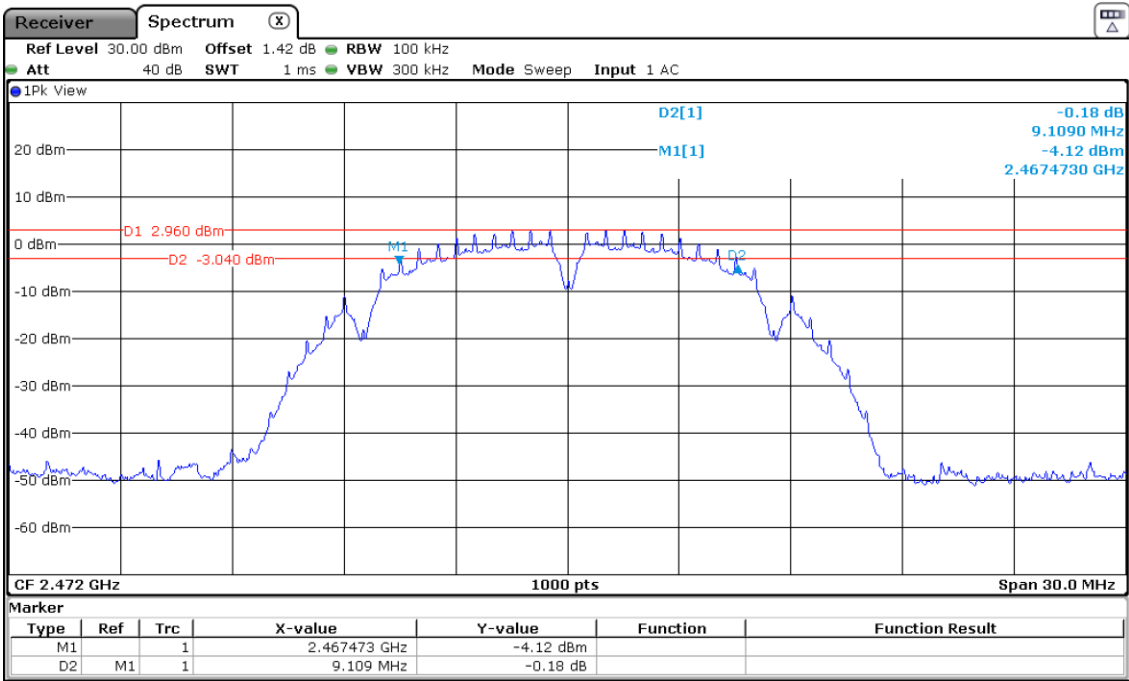
Channel 11



Channel 12

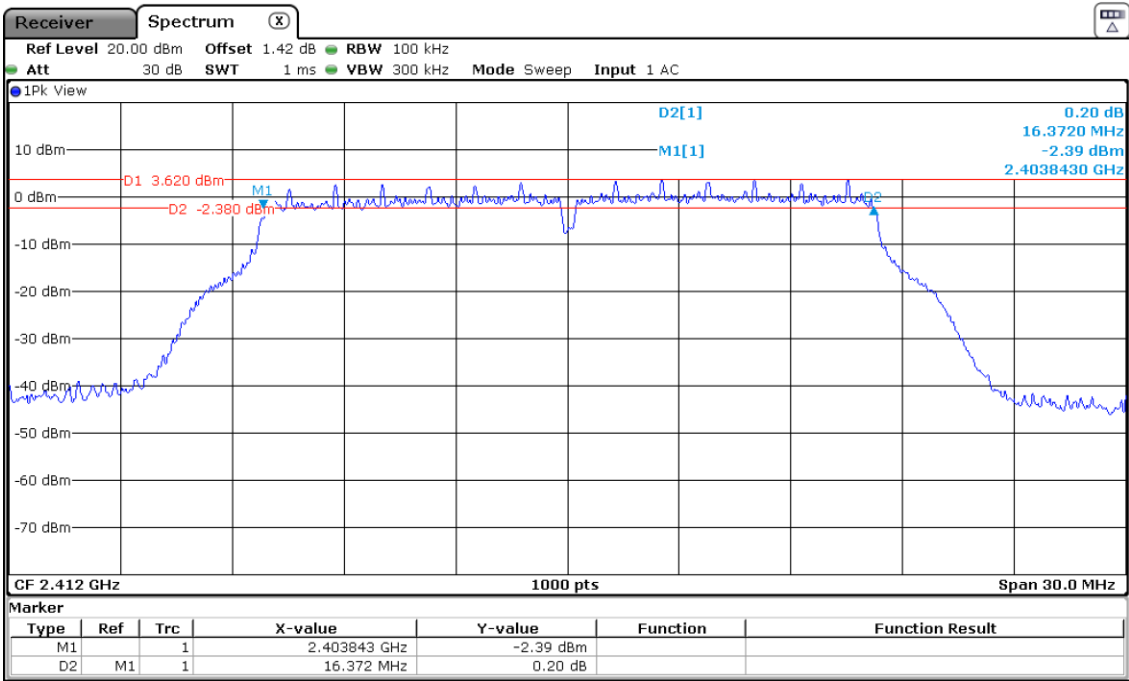


Channel 13

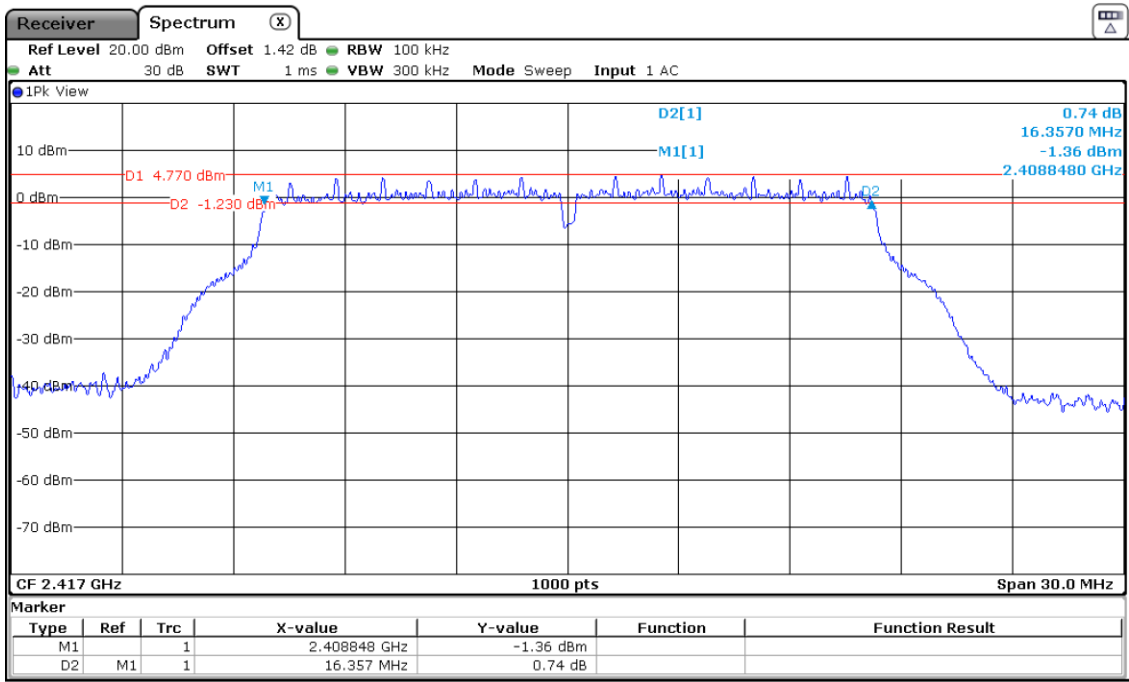


Mode : 802.11g - 20MHz – SISO – CORE Aux

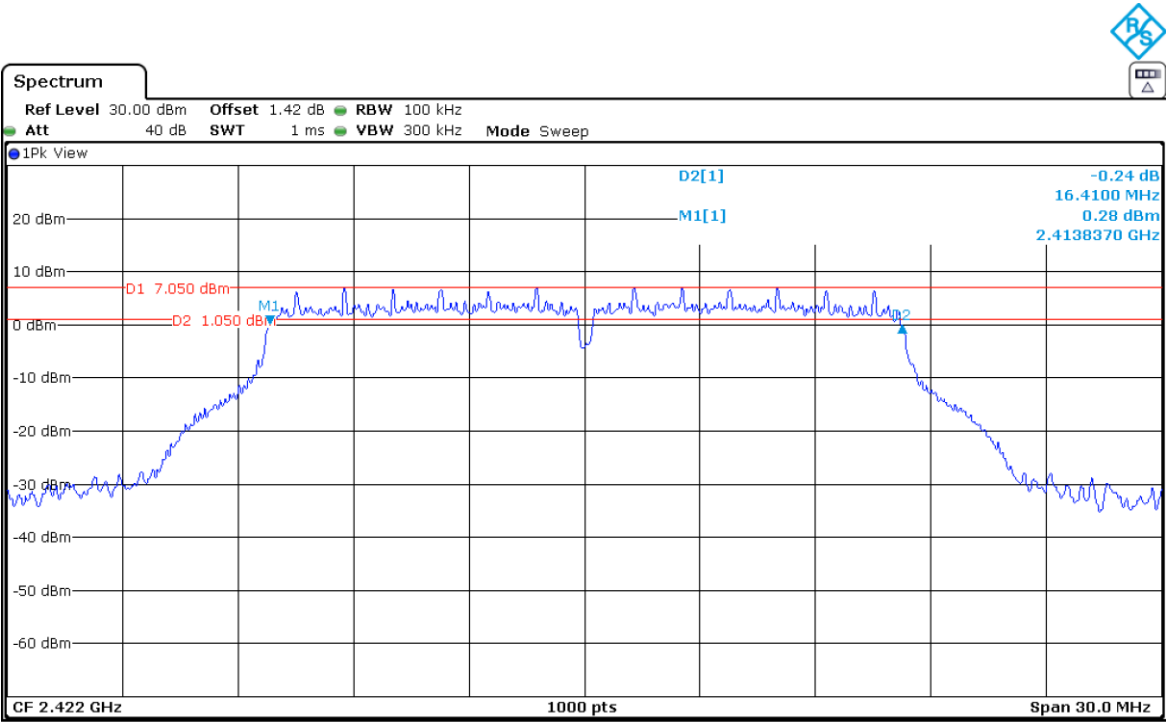
Channel 1



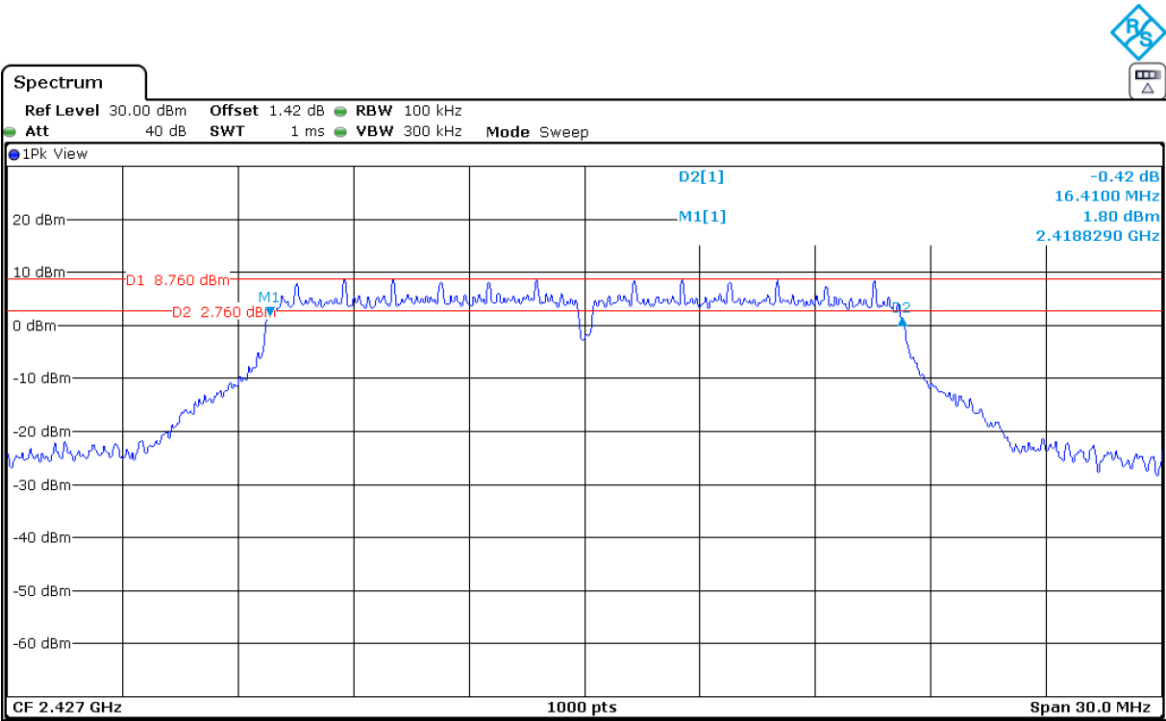
Channel 2



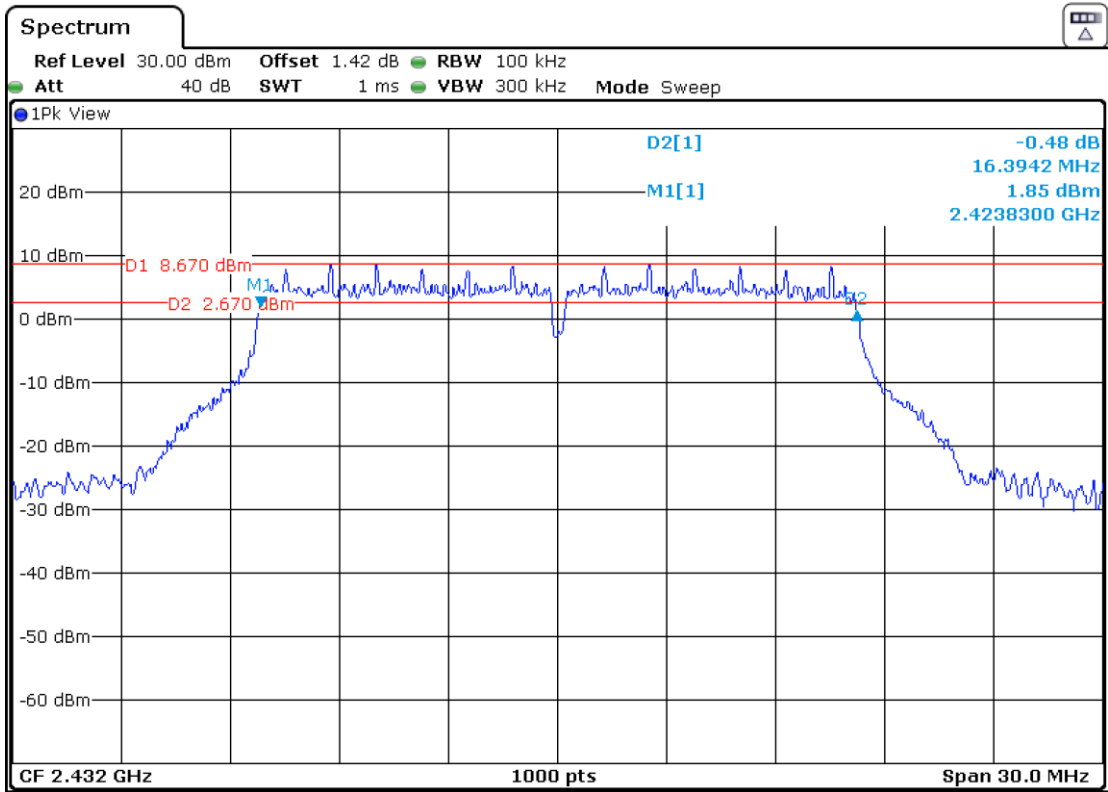
Channel 3



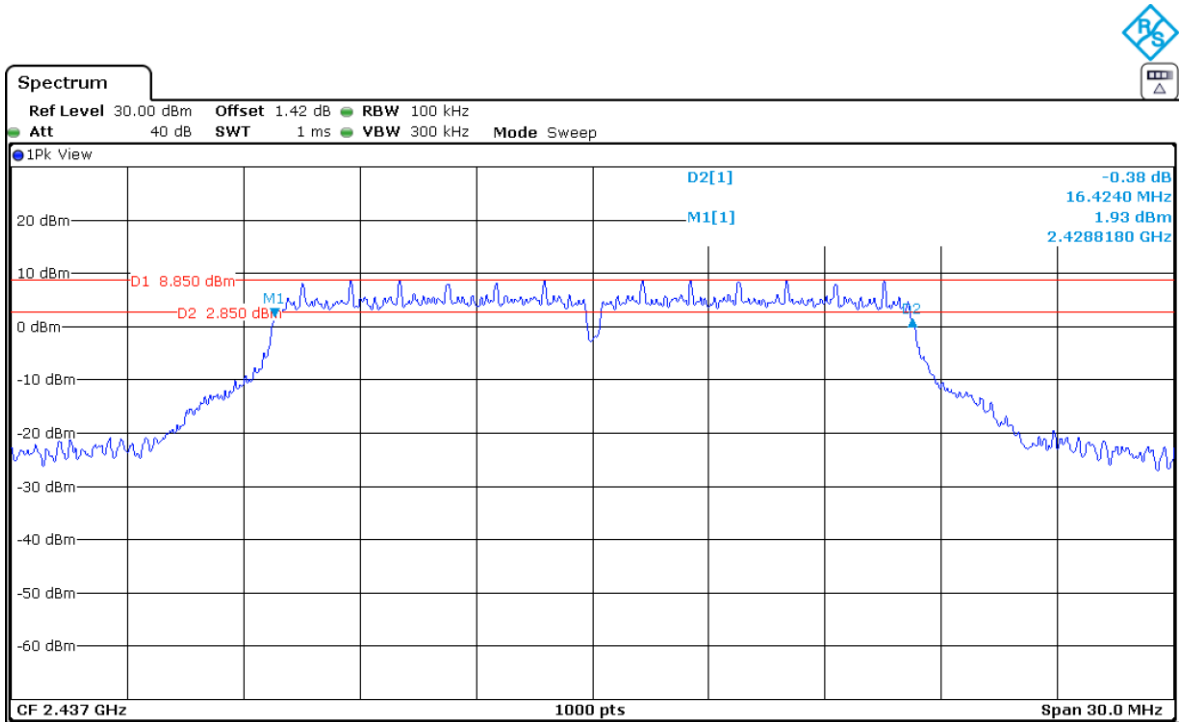
Channel 4

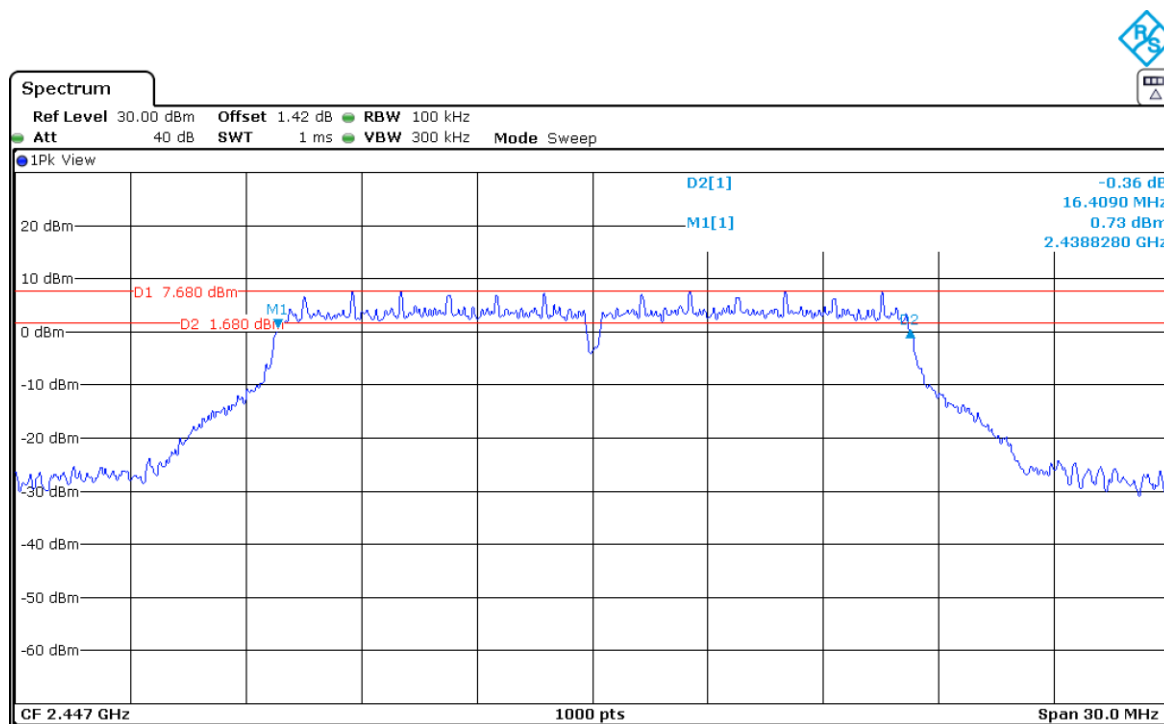
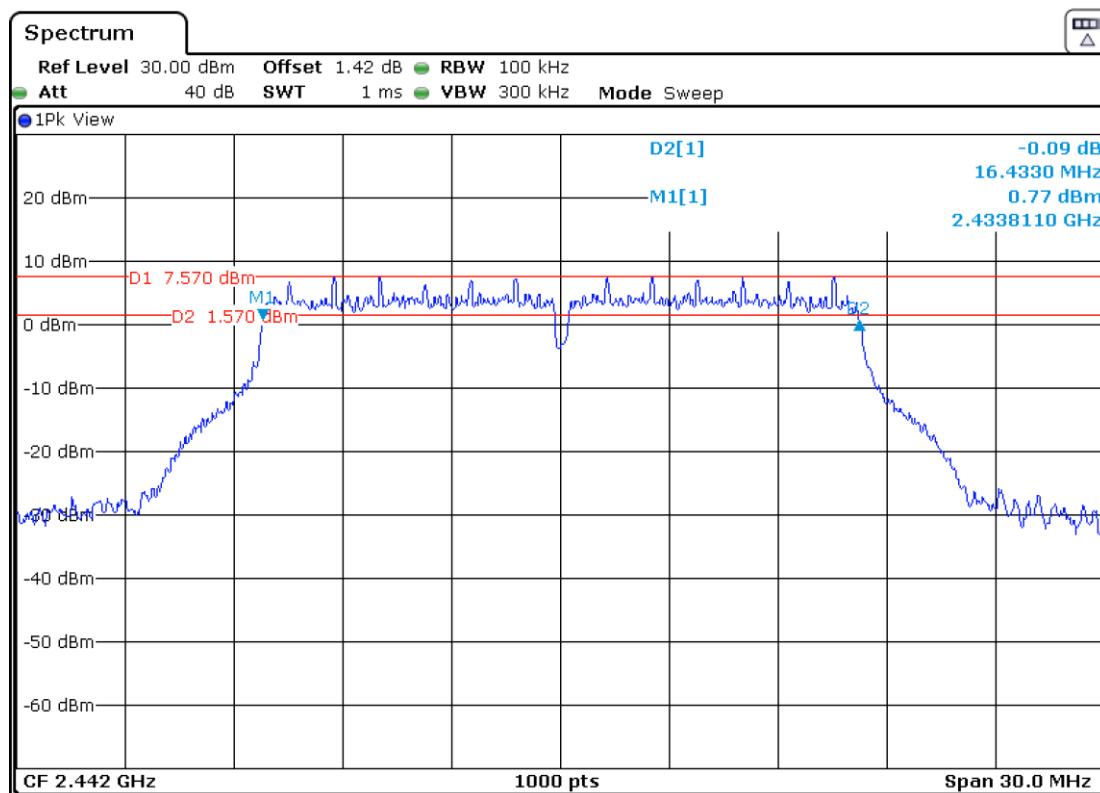


Channel 5

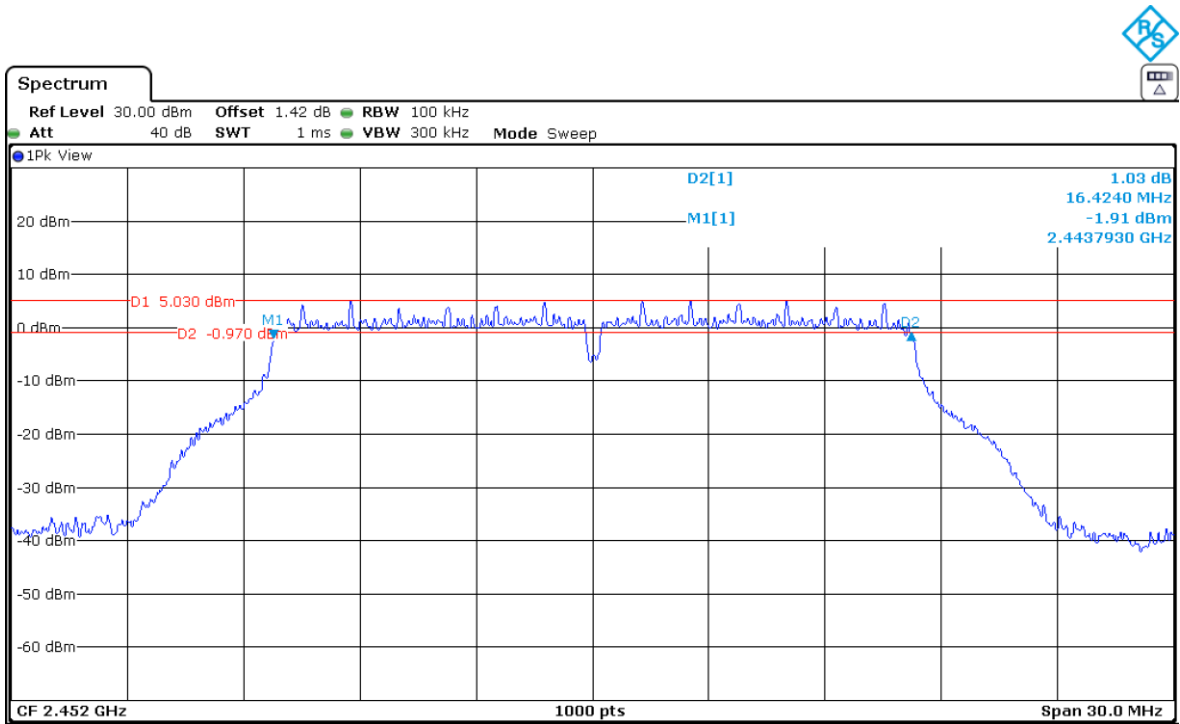


Channel 6

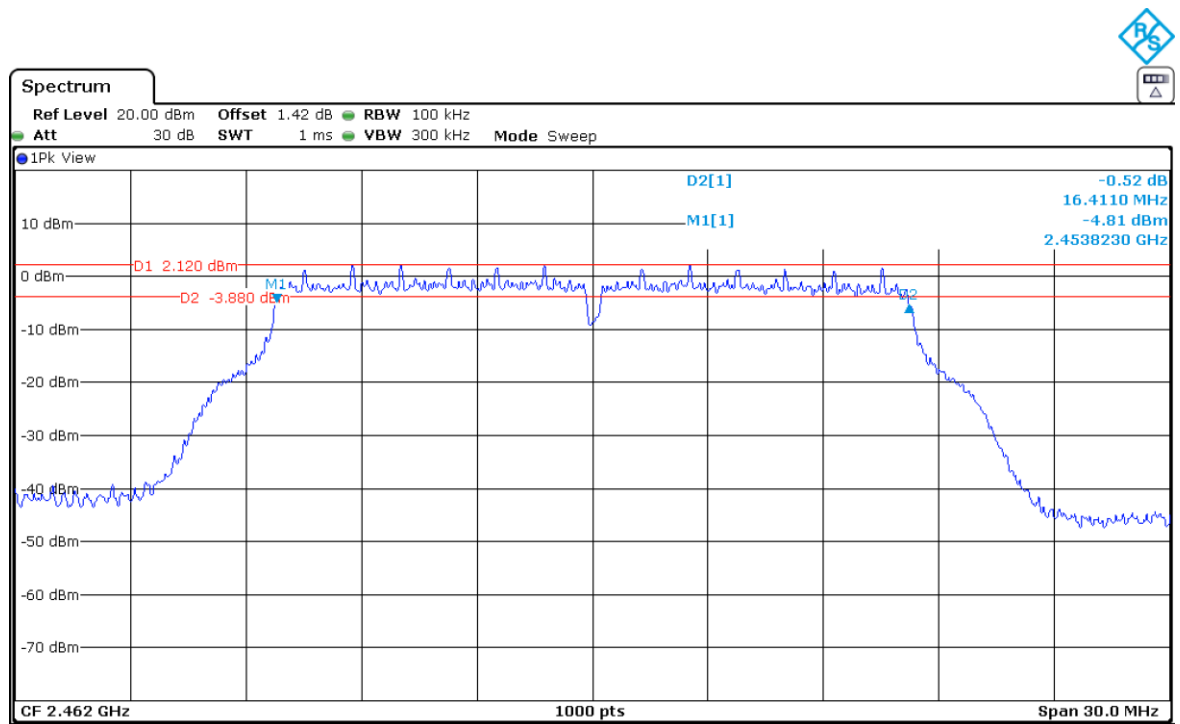




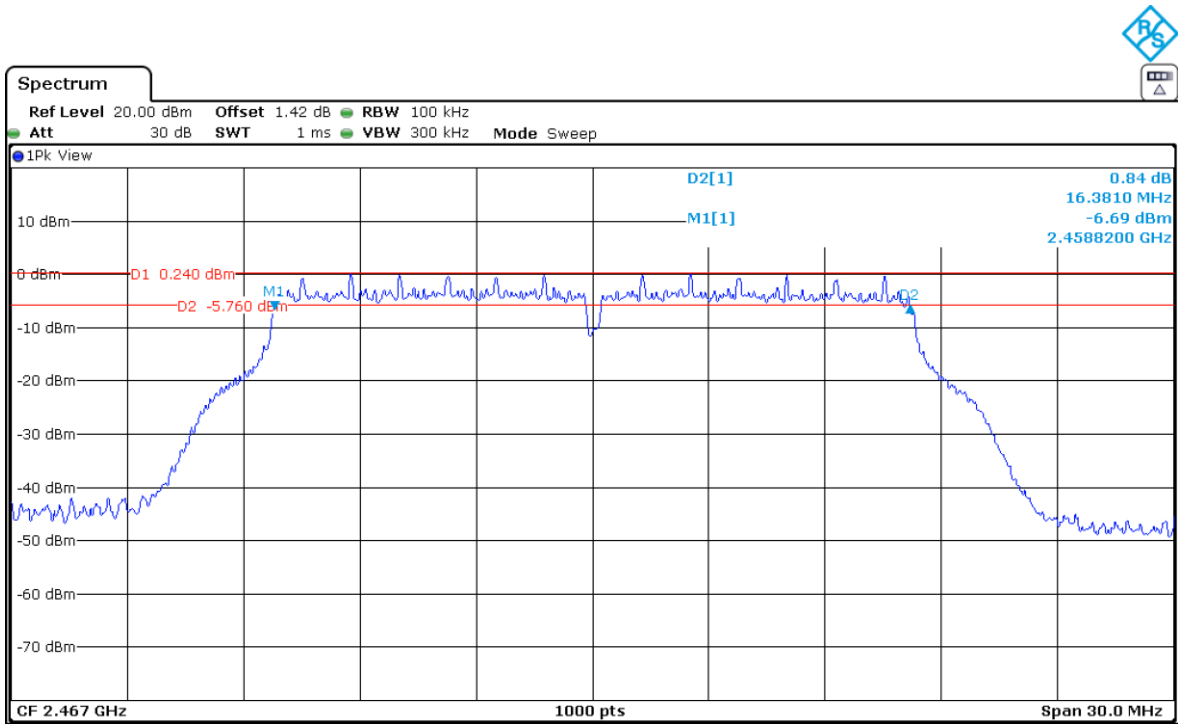
Channel 9



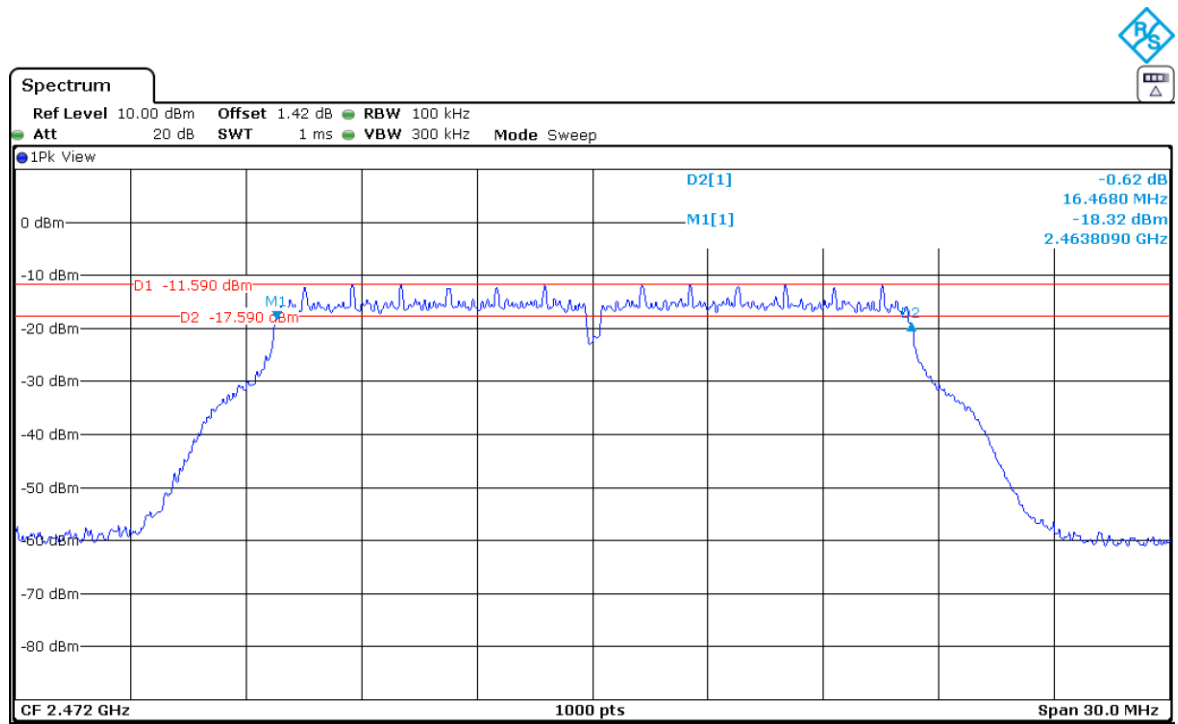
Channel 11



Channel 12

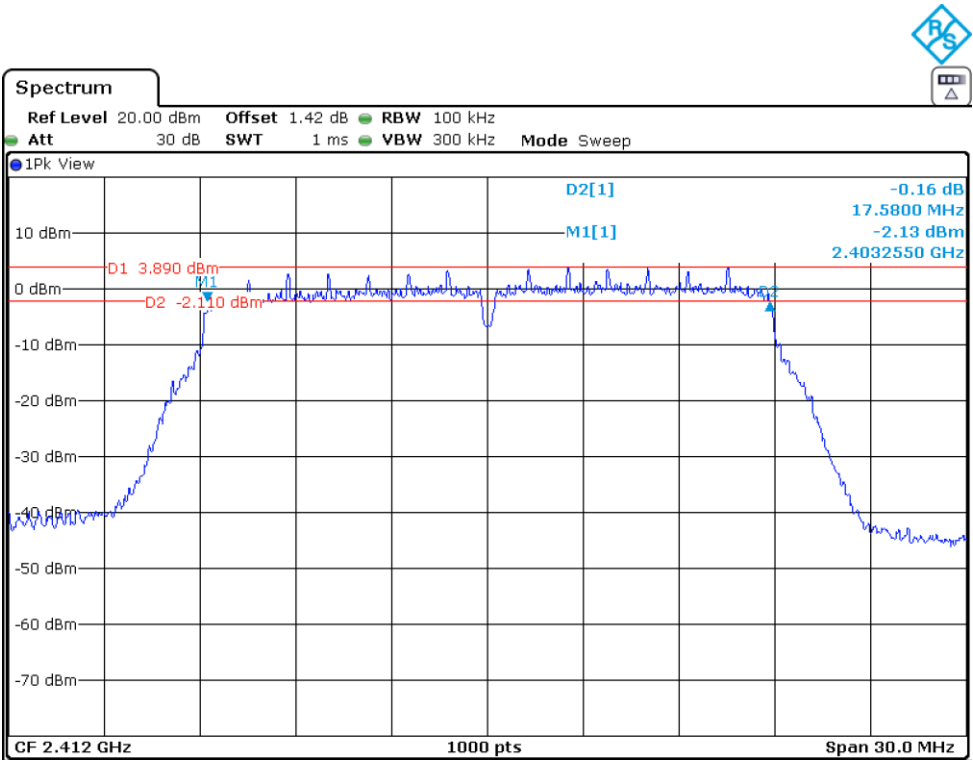


Channel 13

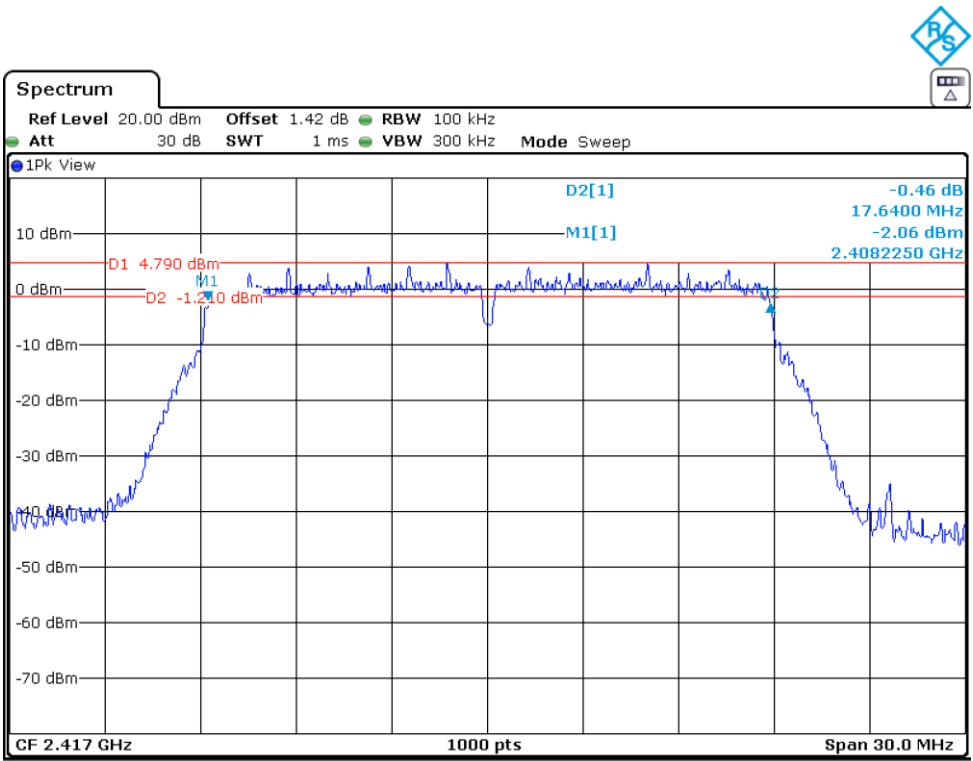


Mode : 802.11n HT20 - 20MHz – SISO – CORE Aux

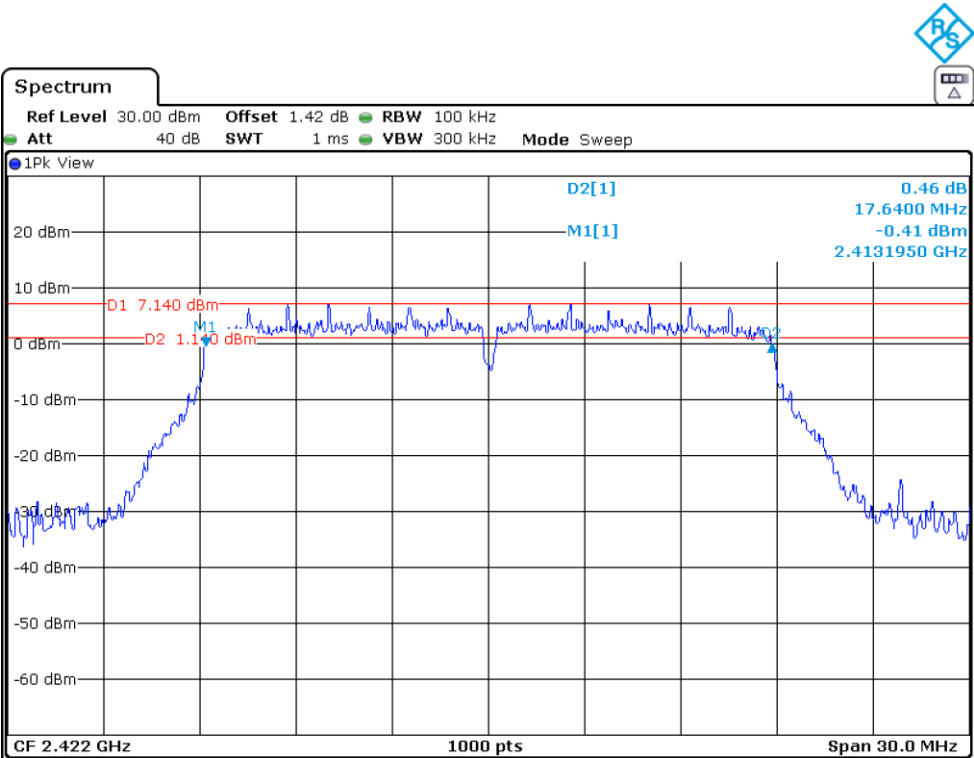
Channel 1



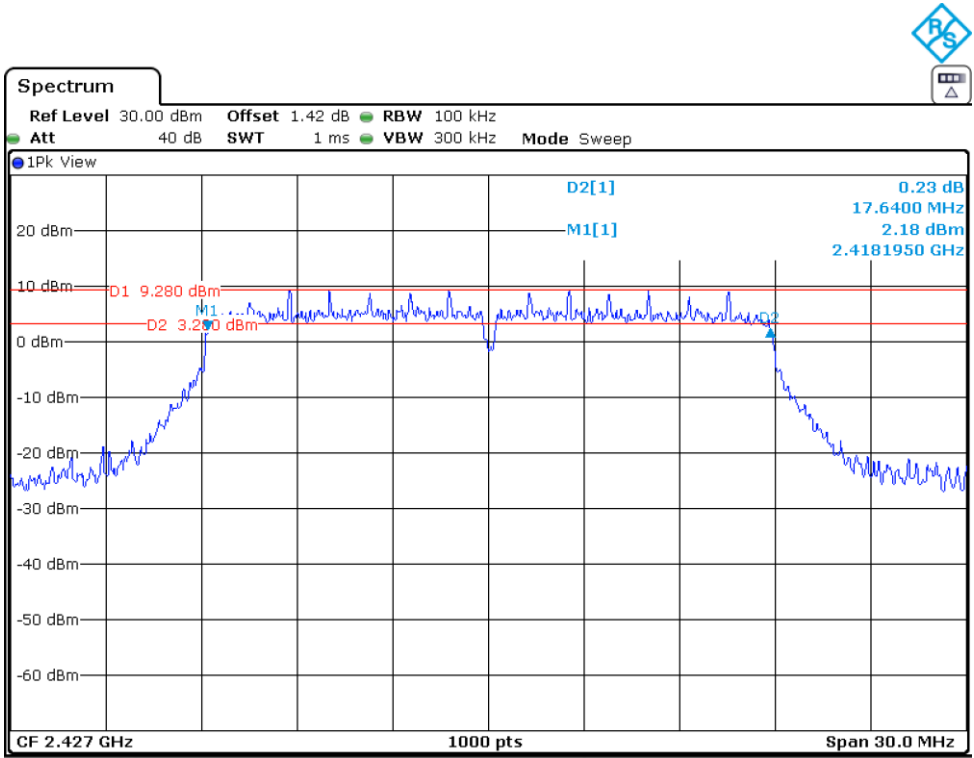
Channel 2



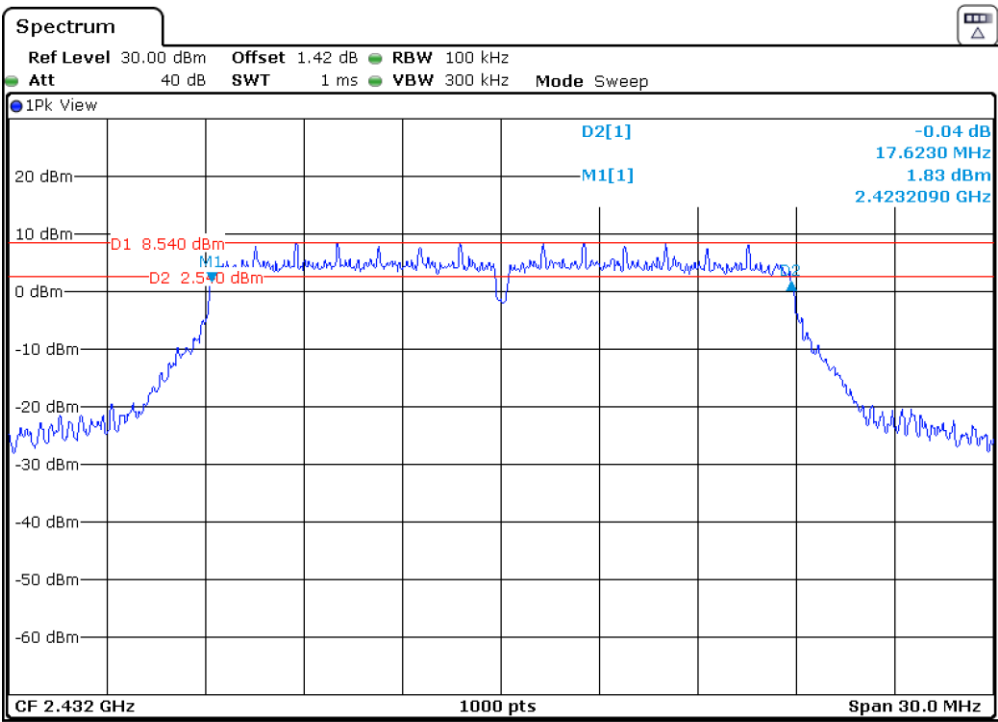
Channel 3



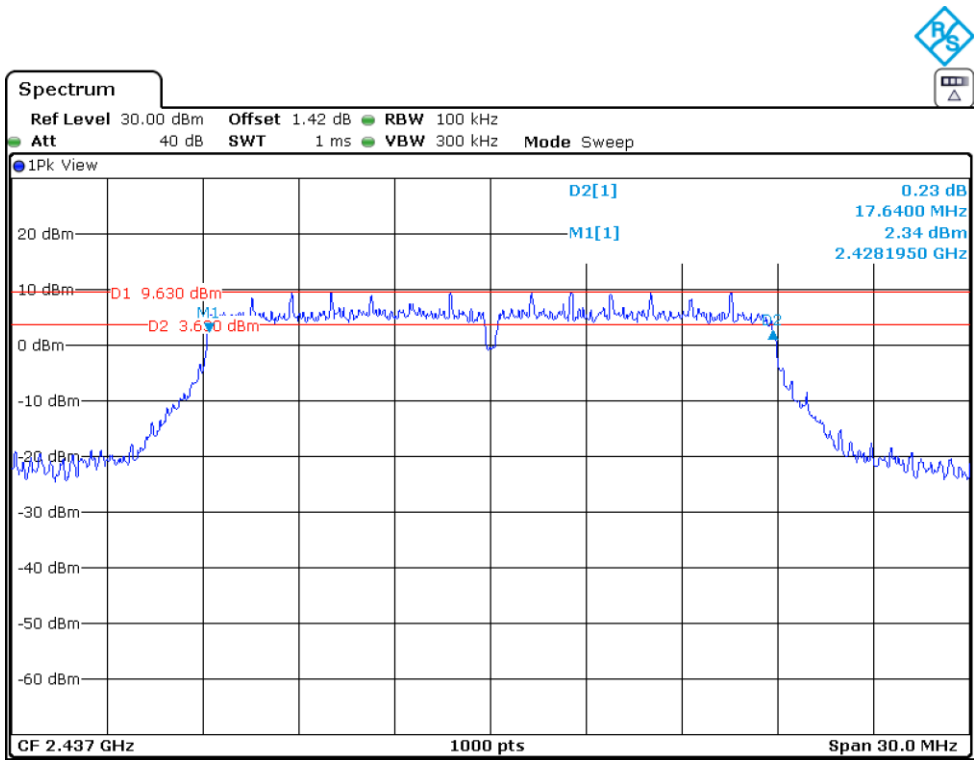
Channel 4



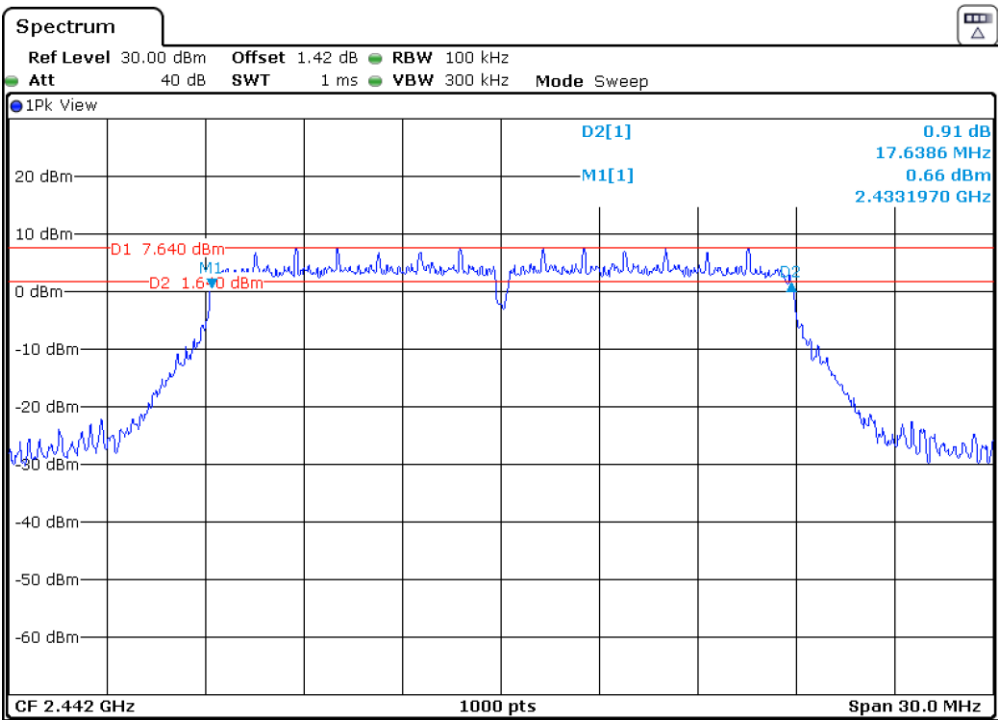
Channel 5



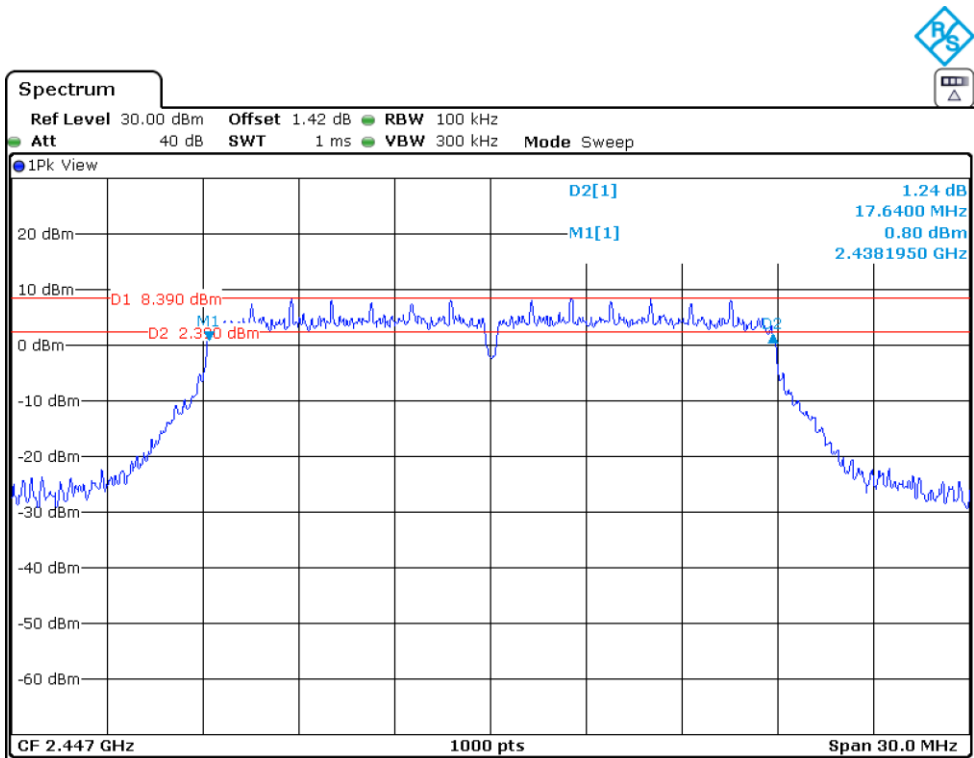
Channel 6



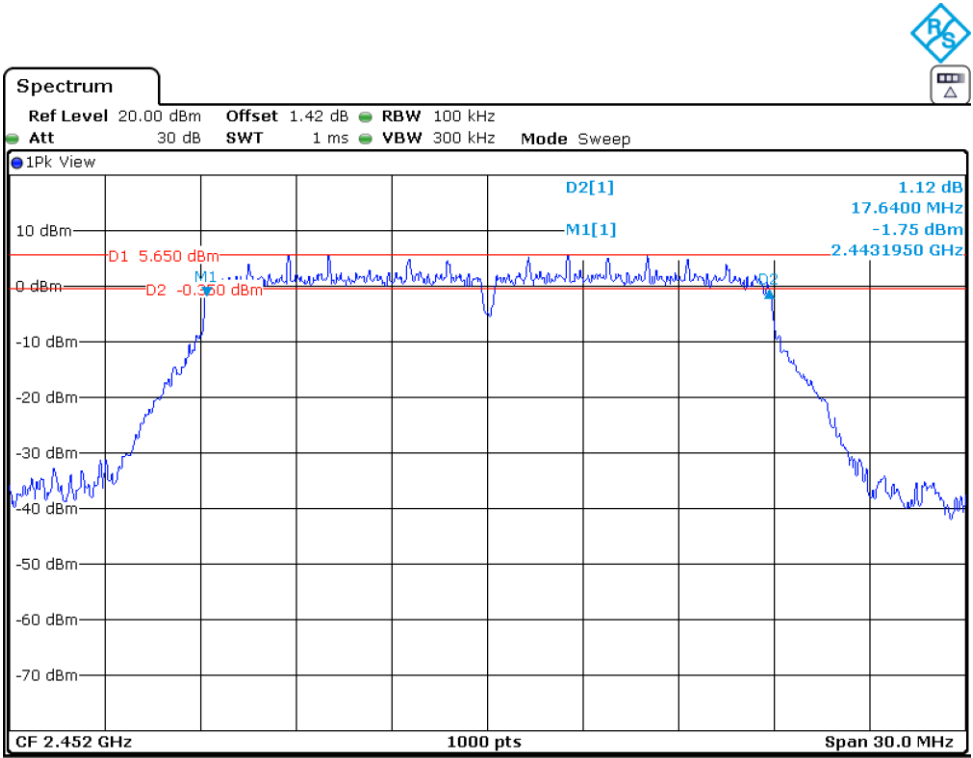
Channel 7



Channel 8



Channel 9



Channel 11

