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Test Report for the FCC and ISED Testing of an Raspberry Pi Pico 2 W to FCC Rule 47CFR 15.247 and ISED RSS-247 for Raspberry Pi Ltd

Report number: C15657TR3
Project number: C8779

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Issue	Description						Issue by	Date
3	Copy 1		Copy 2		PDF	√	JB	14th October 2024

1574

Registered Address
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Registered in England and Wales
Company Reg. No. 6048589
VAT Reg. No. GB 887 1276 83

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Test Report Change History

Issue	Date	Modification Details
1	27th September 2024	First Issue
2	7th October 2024	Customer email amended
3	14th October 2024	Exploratory graph added
4		
5		
6		
7		
8		
9		
10		

Section 1 Test Location

All testing was performed at;

Eurofins E&E UK Ltd	Unit 5
	Speedwell Road
	Castleford
	WF10 5PY
Tel:	01977 731173
Website	http://www.yorkemc.co.uk
UKAS Testing No.	1574

1.1 UKAS Accreditation

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

Eurofins E&E UK Ltd latest accreditation schedule can be found at:
http://www.ukas.org/testing/lab_detail.asp?lab_id=989&location_id=&vMenuOption=3

Eurofins E&E UK Castleford Laboratory, is an Accredited facility recognised by the Federal Communications Commission (FCC) for certification testing. The appropriate FCC Designation Number is UK2013, dated 1st March 2021.

Eurofins E&E UK Castleford Laboratory is recognised by ISED for certification testing.
ISED Assigned Code: 22959
CAB Identifier: UK0004

Section 2 Customer Information

Company name	Raspberry Pi Ltd
Address	194 Cambridge Science Park
	Milton Road
	Cambridge
	CB4 0AB
	United Kingdom
Contact	Tom Westcott
Email	compliance@raspberrypi.com

Section 3 Equipment Details

3.1 Equipment Under Test (EUT)

Date received:	9th September 2024
EUT name:	Raspberry Pi Pico 2 W
PMN:	Raspberry Pi Pico 2 W
HVIN:	Raspberry Pi Pico 2 W
FCC ID:	2ABCB-PICO2W
IC:	20953-PICO2W
EUT description:	The Raspberry Pi Pico 2 W is a mini-PC with an on board radio module and antenna. The module has 2.4GHz Wi-Fi, Bluetooth classic and Bluetooth Low Energy functionality, which allows the user to connect to a 2.4GHz Wi-Fi network, BT Classic 5 compliant devices and BLE devices.
Antenna	Integral Antenna
Transmission	Digital Transmission System (DTS) Wi-Fi
Modulation schemes	IEEE 802.11b,g,n
Channel Bandwidth	20 MHz
Operating frequency band	2400MHz to 2483.5MHz
No of units tested:	Unit 1: radiated tests Unit 2: conducted tests
EUT power:	3.3V via USB port
Highest internal frequency:	2.462GHz
Mode/s of operation:	Continuous transmit of packetised data at top, middle and bottom channels. Channels used: 2412MHz, 2442MHz and 2462MHz
Test software:	The EUT was tested with cyw43-wifi-mfg (3).uf2 Test Firmware installed. The EUT test modes were controlled via USB connection to a Raspberry Pi 400 device. The output power was set to the default value in the test software.
Modifications incorporated during testing:	N/A

Ports and Cables	Cable Length	Screened/ unscreened	Connected to
USB cable	1m	unscreened	External PC

EUT Monitoring/Auxiliary Equipment

Equipment name	Type no.	Serial no
Raspberry Pi 400	RPI-400	80000214328

Output power Q values

The output power of a specific channel was determined in the test mode software by a parameter referred to as a Q-value. The Q-values for each channel is detailed in the table below.

Modulation scheme	Channel number	Frequency (MHz)	Q value
802.11b	1	2412	35
802.11b	2	2417	40
802.11b	3	2422	70
802.11b	4	2427	68
802.11b	5	2432	68
802.11b	6	2437	68
802.11b	7	2442	68
802.11b	8	2447	68
802.11b	9	2452	68
802.11b	10	2457	60
802.11b	11	2462	60
802.11g	1	2412	30
802.11g	2	2417	34
802.11g	3	2422	66
802.11g	4	2427	68
802.11g	5	2432	68
802.11g	6	2437	68
802.11g	7	2442	68
802.11g	8	2447	68
802.11g	9	2452	68
802.11g	10	2457	65
802.11g	11	2462	45
802.11n	1	2412	29
802.11n	2	2417	33
802.11n	3	2422	43
802.11n	4	2427	62
802.11n	5	2432	68
802.11n	6	2437	68
802.11n	7	2442	68
802.11n	8	2447	68
802.11n	9	2452	67
802.11n	10	2457	63
802.11n	11	2462	50

3.2 EUT Photographs

Photographs are supplied separately.

3.3 Configuration of EUT

The apparatus was supplied in one single possible configuration.

3.4 EUT Monitoring/Auxiliary Equipment

None.

3.5 Monitoring Software

None. The channel required was selected via software prior to the testing.

Section 4Test Specifications

For USA:

Regulation / Test Standard	Regulation: Title 47 of the Code of Federal Regulations (CFR) Part 15 (47CFR15) Subpart C – Intentional Radiators Measurement standard: ANSI C63.10-2013 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

Requirement	FCC Rule Part	Comments	Result Summary
6 dB Bandwidth	FCC § 15.247(a)(2)	Applies	Pass
Maximum peak conducted power	FCC § 15.247(b)(3)	Applies	Pass
Power spectral density	FCC § 15.247(e)	Applies	Pass
Band edge compliance	FCC § 15.247(d)	Applies	Pass
Conducted spurious emissions	FCC § 15.247(d)	Applies	Pass
Transmitter radiated spurious emissions – restricted bands	FCC § 15.247(d) FCC § 15.209	Applies	Pass

For Canada:

Regulation / Test Standard	RSS-247 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices Issue 3 August 2023 And, RSS-Gen — General Requirements for Compliance of Radio Apparatus Issue 5 April 2018 +A1 March 2019 +A2 February 2021

Requirement	ISED Ragulation	Comments	Results Summary
99% Occupied Bandwidth	RSS-Gen 6.6	Applies	Pass
6 dB Bandwidth	ISED RSS-247 § 5.2	Applies	Pass
Maximum peak conducted power	ISED RSS-247 § 5.4	Applies	Pass
Power spectral density	ISED RSS-247 § 5.2	Applies	Pass
Band edge compliance	ISED RSS-247 § 3.3 and 5.5 RSS-GEN Issue 5 Section 8.10	Applies	Pass
Conducted spurious emissions	ISED RSS-247 § 5.5	Applies	Pass
Transmitter radiated spurious emissions	ISED RSS-GEN § 8.9	Applies	Pass

4.1 Knowledge Database References

The following KDBs were referenced during the testing.
The latest knowledge database references are available via the FCC KDB website at:

https://apps.fcc.gov/kdb

4.1.1 Radiated Emissions (30MHz to 1000MHz)

Publication Number	Keyword	Publication Date
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017

4.1.2 Radiated Emissions (1GHz to 40GHz)

Publication Number	Keyword	Publication Date
414788	Test Site Validation Requirements above 1 GHz.	07/12/2018
414788	Comparison Noise Emitter (CNE), reference noise source, .pdf	07/12/2018
913591	Measurement of radiated emissions at the band-edge for a Part 15 RF Device	04/05/2017
414788	Comparison Noise Emitters (CNE), test equipment, Broadband.pdf	07/12/2018

4.2 Compliance Statement

The Raspberry Pi Pico 2 W, as tested, was shown to meet requirements of the standards listed in Section 4 of this report.

Note: Only the Wi-Fi functionality has been tested in this report.

Section 5 Spurious Emission Results – Radiated and Conducted

5.1 Test Specification

FCC Rule Part	47CFR 15.247 (d)
Standard	ANSI C63.10:2013
Measurement Uncertainty Radiated tests	The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95% is +/- 5.01dB for the frequency range from 9kHz to 30MHz +/- 6.26dB for the frequency range 30MHz to 1GHz +/- 5.14dB for the frequency range from 1GHz to 6GHz +/- 5.45dB for the frequency range from 6GHz to 18GHz
Measurement Uncertainty Conducted Power tests	±1.4dB
Measurement Uncertainty Frequency tests	$\pm 9 \times 10^{-8}$

5.2 Procedure and Test Software Version

Radiated tests:- 47CFR15.205 and 47CFR15.209

Eurofins E&E UK test procedure (30MHz to 1GHz)	CEP23 Issue 10
Eurofins E&E UK test procedure (1GHz to 40GHz)	CEP64 Issue 11
Test software	RadiMation Version 2023.1.6

Conducted Tests 47CFR 15.247(d)

ANSi C63.10-2013 Clause reference:	11.11.2 and 11.11.3
Test software	N/A

5.3 Radiated Emissions (30MHz to 1GHz)

Radiated electric field emission measurements are applied as defined in 47CFR15.205 and 47CFR15.209.

5.3.1 Limits at 3m

Frequency (MHz)	Electric Field Strength Limit (dBµV/m) at 3m measurement distance
	Quasi Peak
30 - 88	40.0
88 -216	43.5
216 - 960	46.0
960- 1000	54.0

Note: FCC 47 CFR Part 15 Section 15.209 and 15.205 specifies test limits at 3m

Receiver Settings

Receiver Parameters	Setting
Detector Function	Quasi Peak
Start Frequency	30MHz
Stop Frequency	1000MHz
Resolution Bandwidth	120kHz
Video Bandwidth	Auto

5.3.2 Emissions measurements

5.3.3 Date of Test

16th September 2024

5.3.4 Test Area

LAB 1 (SAC)

5.3.5 Tested by

L Trickett

5.3.6 Test Setup

The EUT was configured in the SAC on an 80cm high polystyrene table.

The measurement was performed with an antenna to EUT separation distance of 3m. The results were maximised in orientation 0-360 degrees and height 1-4m.

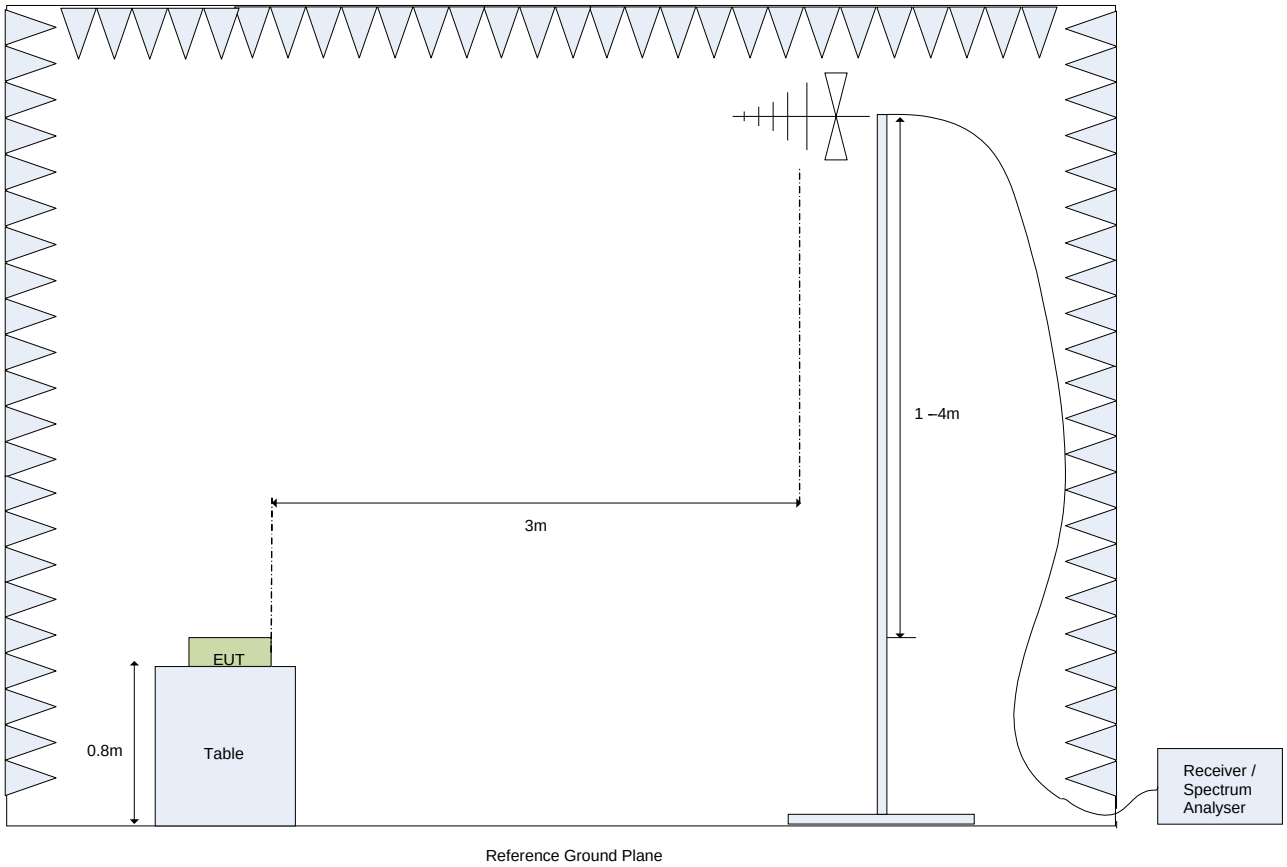


Figure 1 Test Setup for E-Field Measurements from 30MHz to 1GHz

Note 1 : With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.10-2013.

Note 2 : There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

Operating Mode During testing

During spurious emission testing the equipment under test was set to transmit at the same frequency on the following channels: 2412MHz, 2442MHz and 2462MHz for each modulation scheme used.

The equipment under test was pre-scanned using peak detection when operating on all three channels for all three modulation schemes. Final measurements were performed for each modulation scheme with the equipment under test operating on the worse case channel identified during the pre-scans.

5.3.7 Electric field emissions IEEE 802.11b, 30MHz to 1GHz

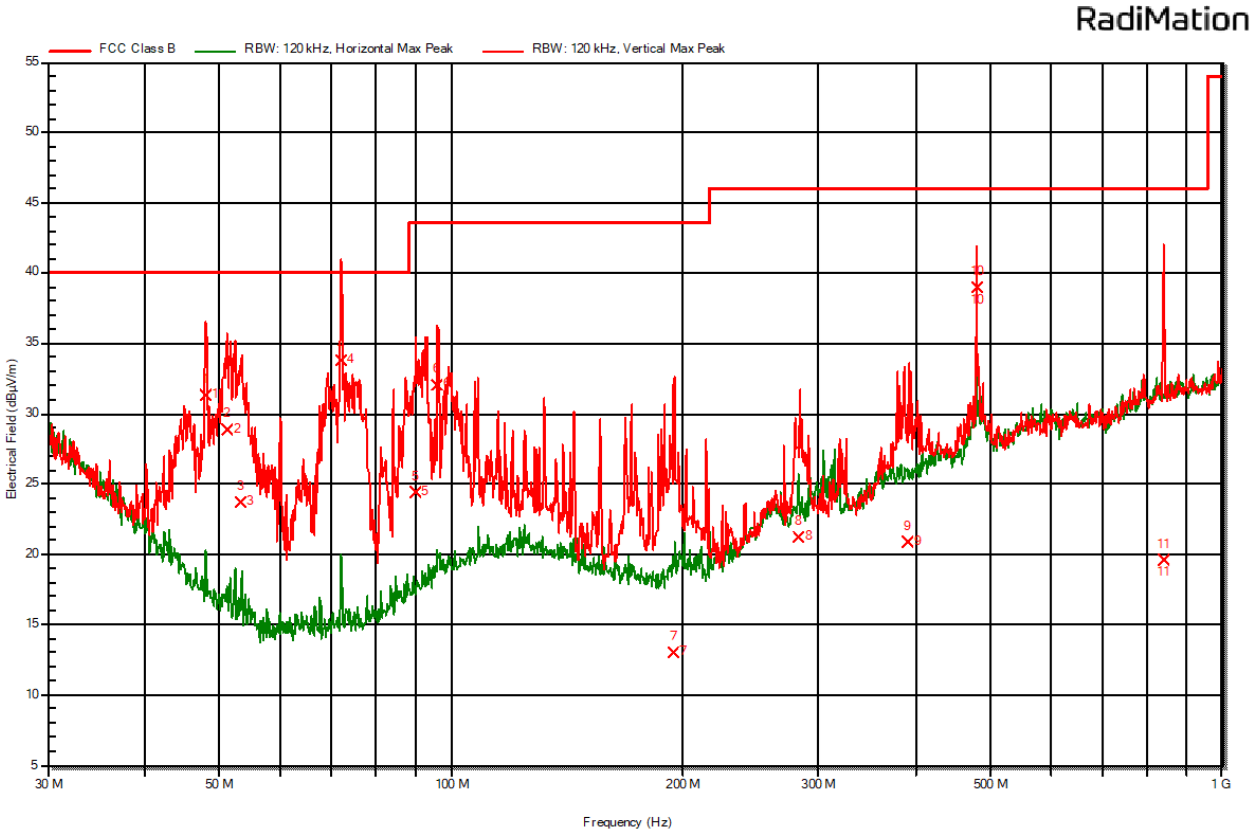


Figure 2 Electric field emissions Plot IEEE 802.11b, 30MHz to 1GHz, 2462MHz Operation

Frequency MHz	Quasi-Peak dBµV/m	Quasi Peak Limit dBµV/m	Quasi-Peak Difference dB	Quasi-Peak Status	Angle degrees	Height m	Polarization
48.06	31.3	40.0	-8.7	Pass	360	1.0	Vertical
51.12	28.9	40.0	-11.1	Pass	295	1.0	Vertical
53.40	23.7	40.0	-16.3	Pass	315	1.0	Vertical
72.00	33.9	40.0	-6.1	Pass	90	1.5	Vertical
89.94	24.5	43.5	-19.0	Pass	45	1.2	Vertical
96.00	32.1	43.5	-11.4	Pass	50	1.0	Vertical
194.22	13.0	43.5	-30.5	Pass	360	1.1	Vertical
282.60	21.2	46.0	-24.8	Pass	30	2.2	Vertical
391.44	20.9	46.0	-25.1	Pass	270	1.1	Vertical
480.06	39.0	46.0	-7.0	Pass	5	1.8	Vertical
839.16	19.6	46.0	-26.4	Pass	85	2.9	Vertical

Table 1 Electric Field Emissions Peaks IEEE 802.11b, 30MHz to 1GHz. 2462MHz Operation

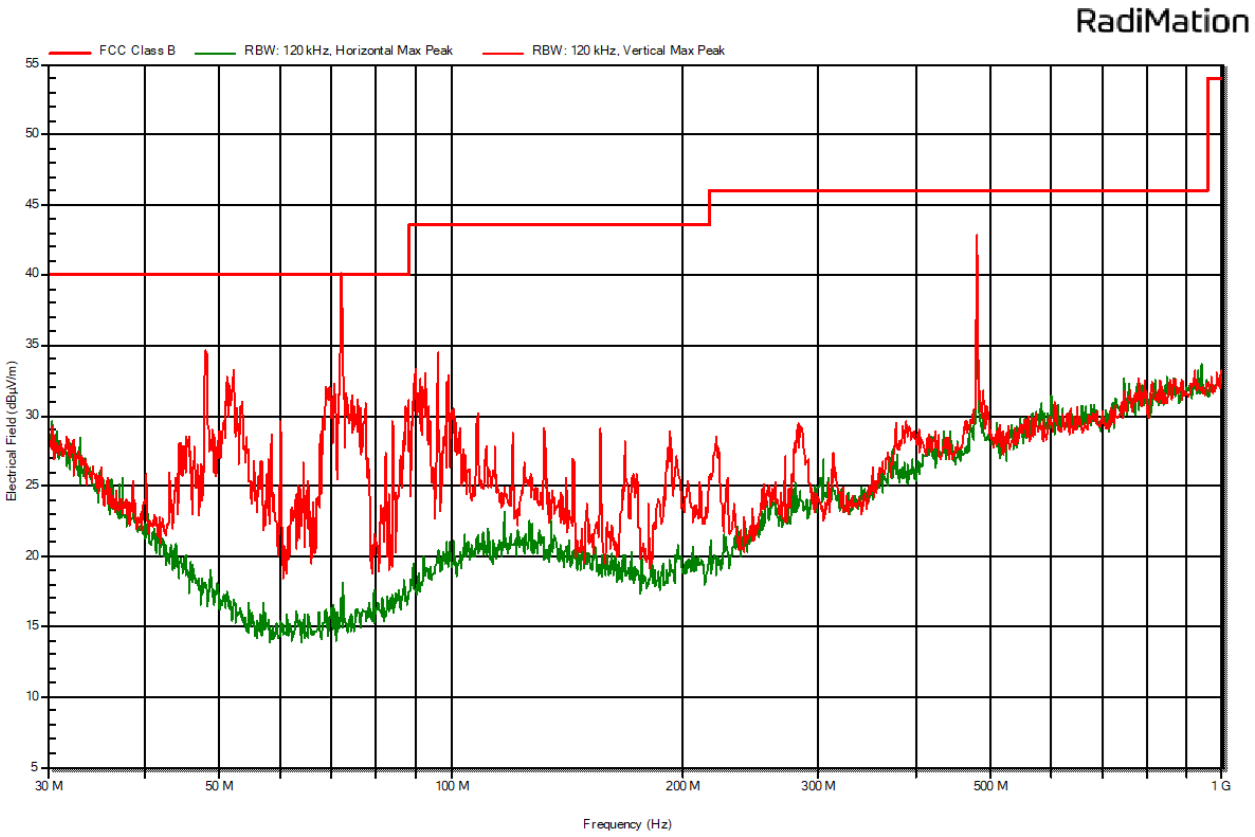


Figure 3 Electric field emissions Plot IEEE 802.11b, 30MHz to 1GHz, Operation on 2412MHz - Peak detector scan

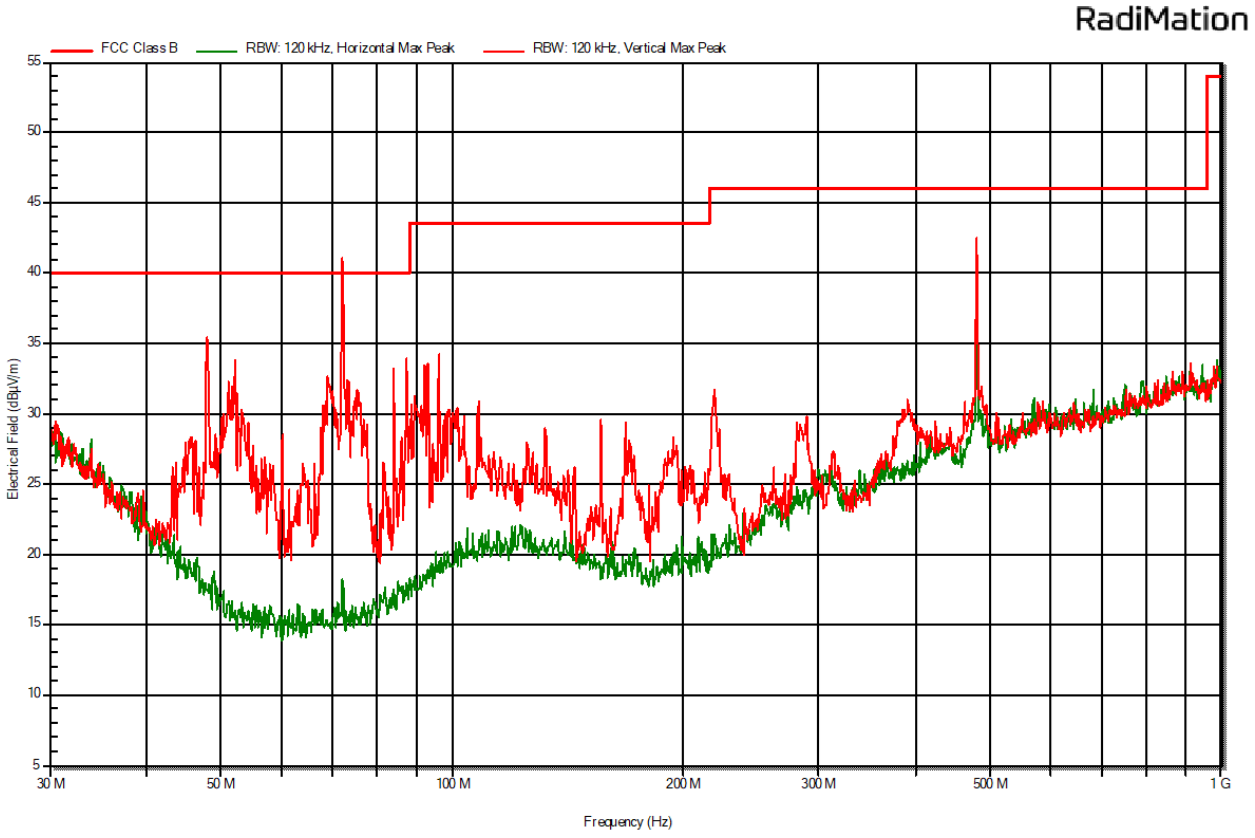


Figure 4 Electric field emissions Plot IEEE 802.11b, 30MHz to 1GHz, Operation on 2442MHz - Peak detector scan

5.3.8 Electric field emissions IEEE 802.11g, 30MHz to 1GHz

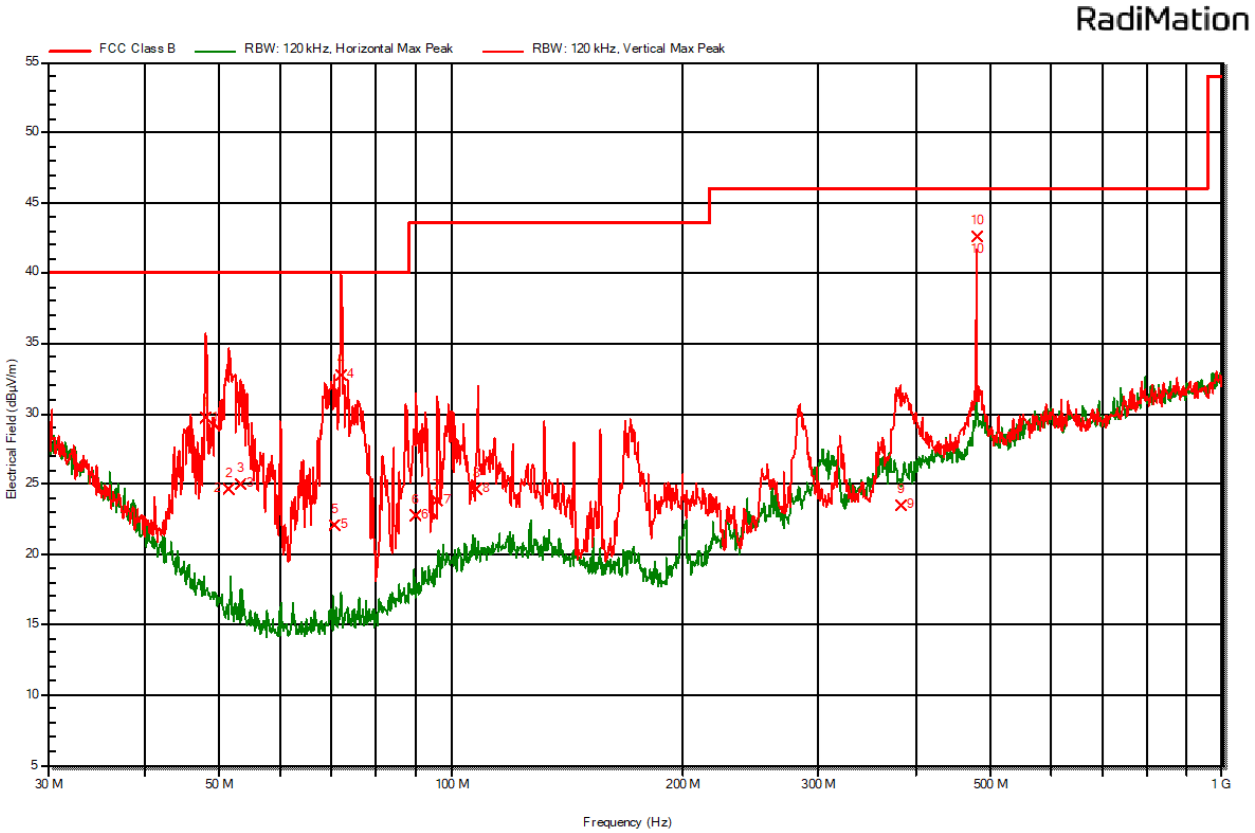


Figure 5 Electric field emissions Plot IEEE 802.11g, 30MHz to 1GHz, 2442MHz Operation

Frequency MHz	Quasi-Peak dBµV/m	Quasi Peak Limit dBµV/m	Quasi-Peak Difference dB	Quasi-Peak Status	Angle degrees	Height m	Polarization
48.00	29.7	40.0	-10.3	Pass	200	1.0	Vertical
51.48	24.7	40.0	-15.3	Pass	54	1.0	Vertical
53.34	25.1	40.0	-14.9	Pass	235	1.0	Vertical
72.06	32.8	40.0	-7.2	Pass	20	1.4	Vertical
70.44	22.1	40.0	-17.9	Pass	320	1.0	Vertical
90.00	22.8	43.5	-20.7	Pass	10	1.5	Vertical
96.00	23.8	43.5	-19.7	Pass	84	1.1	Vertical
108.00	24.7	43.5	-18.8	Pass	30	1.1	Vertical
382.38	23.5	46.0	-22.5	Pass	280	1.4	Vertical
480.06	42.6	46.0	-3.4	Pass	5	2.1	Vertical

Table 2 Electric Field Emissions Peaks IEEE 802.11g, 30MHz to 1GHz. 2442MHz Operation

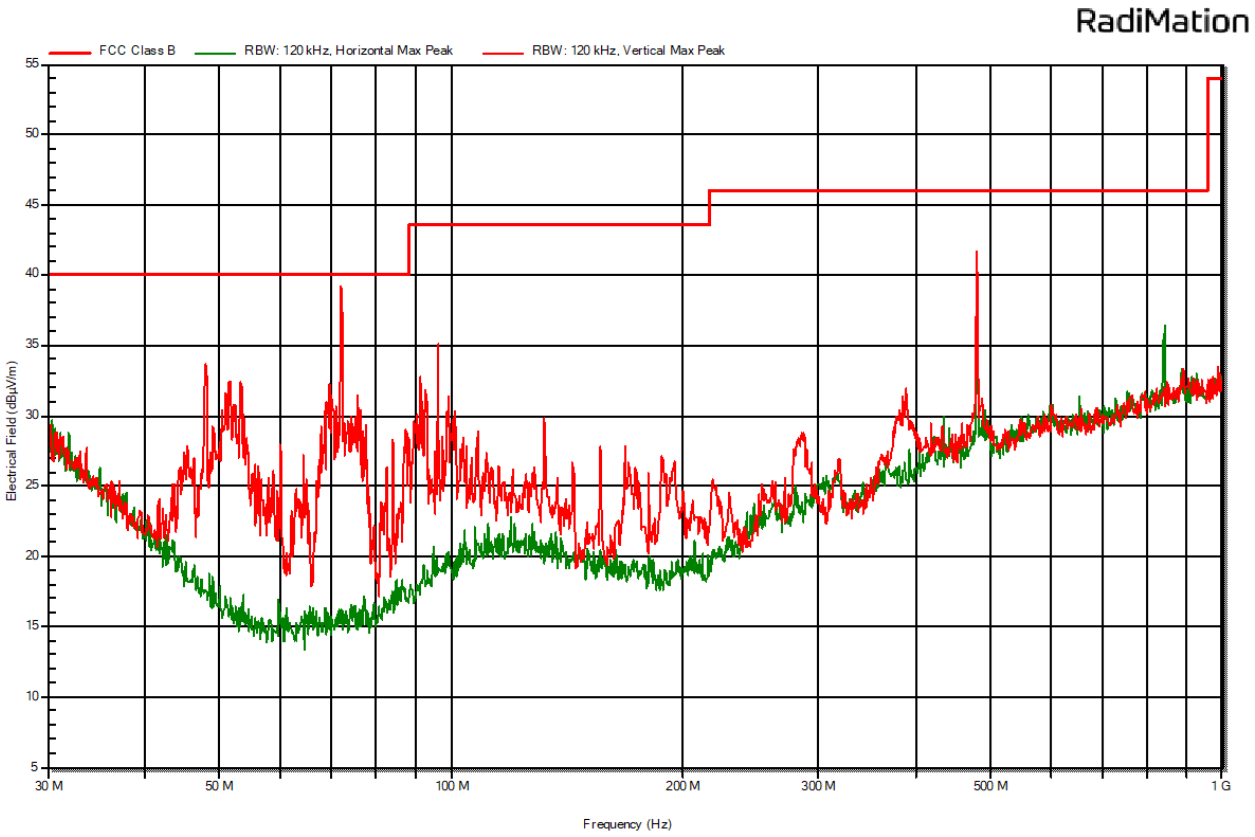


Figure 6 Electric field emissions Plot IEEE 802.11g, 30MHz to 1GHz, Operation on 2412MHz - Peak detector scan

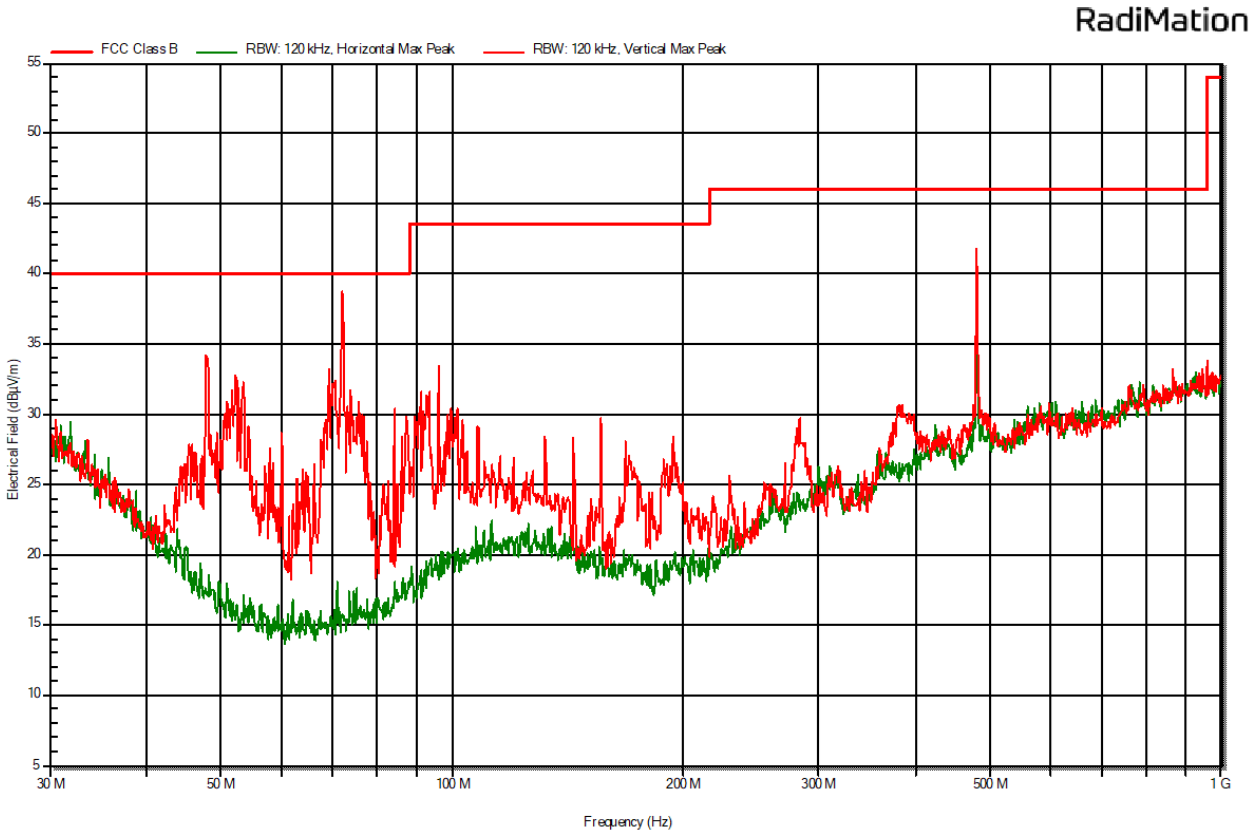


Figure 7 Electric field emissions Plot IEEE 802.11g, 30MHz to 1GHz, Operation on 2462MHz - Peak detector scan

5.3.9 Electric field emissions IEEE 802.11n, 30MHz to 1GHz

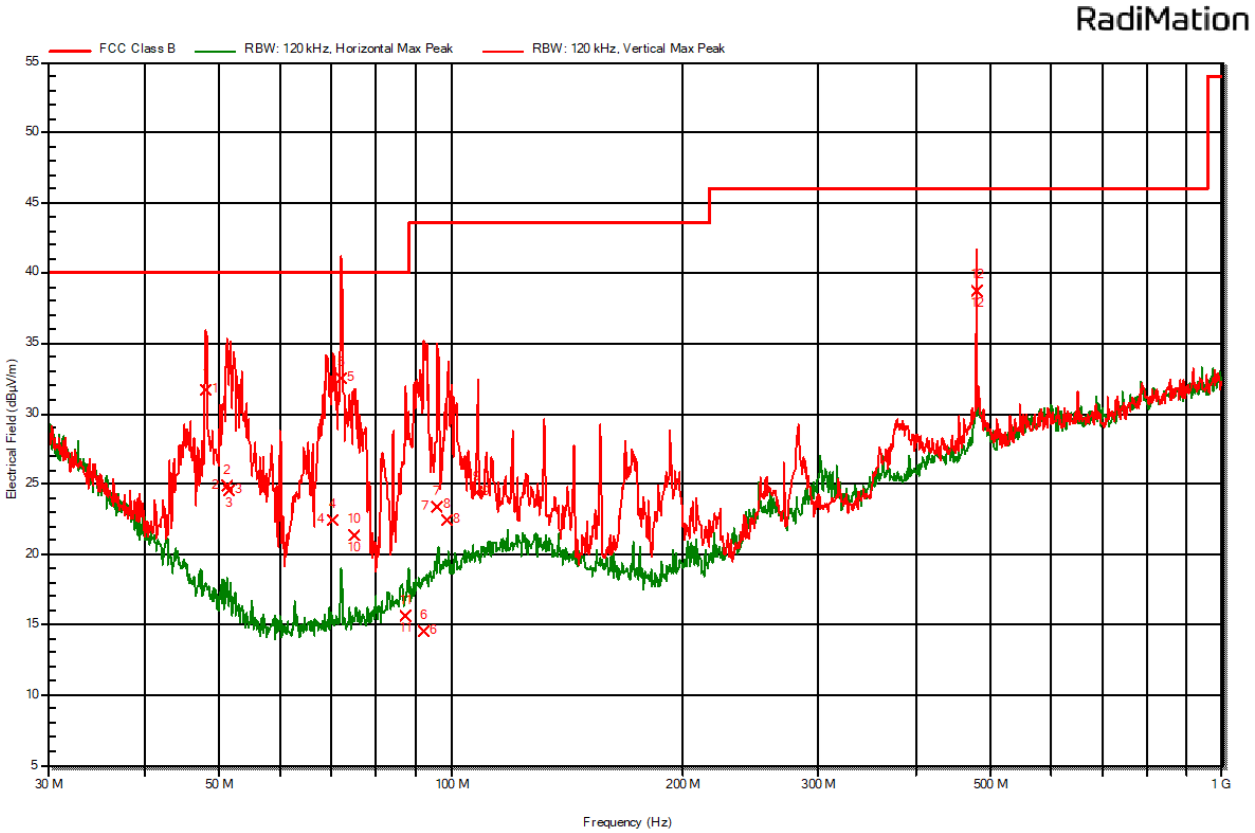


Figure 8 Electric field emissions Plot IEEE 802.11n, 30MHz to 1GHz, 2412MHz Operation

Frequency MHz	Quasi-Peak dBµV/m	Quasi Peak Limit dBµV/m	Quasi-Peak Difference dB	Quasi-Peak Status	Angle degrees	Height m	Polarization
48.00	31.8	40.0	-8.2	Pass	10	1.0	Vertical
51.12	24.8	40.0	-15.2	Pass	45	1.0	Vertical
51.60	24.5	40.0	-15.5	Pass	30	1.0	Vertical
70.26	22.4	40.0	-17.6	Pass	320	1.4	Vertical
72.06	32.5	40.0	-7.5	Pass	35	1.4	Vertical
92.10	14.6	43.5	-28.9	Pass	360	1.3	Vertical
96.00	23.4	43.5	-20.1	Pass	320	1.1	Vertical
98.88	22.4	43.5	-21.1	Pass	315	1.0	Vertical
108.00	24.4	43.5	-19.1	Pass	10	1.0	Vertical
74.82	21.4	40.0	-18.6	Pass	315	1.0	Vertical
87.24	15.6	40.0	-24.4	Pass	315	1.1	Vertical
480.06	38.7	46.0	-7.3	Pass	10	2.3	Vertical

Table 3 Electric Field Emissions Peaks IEEE 802.11n, 30MHz to 1GHz. 2412MHz Operation

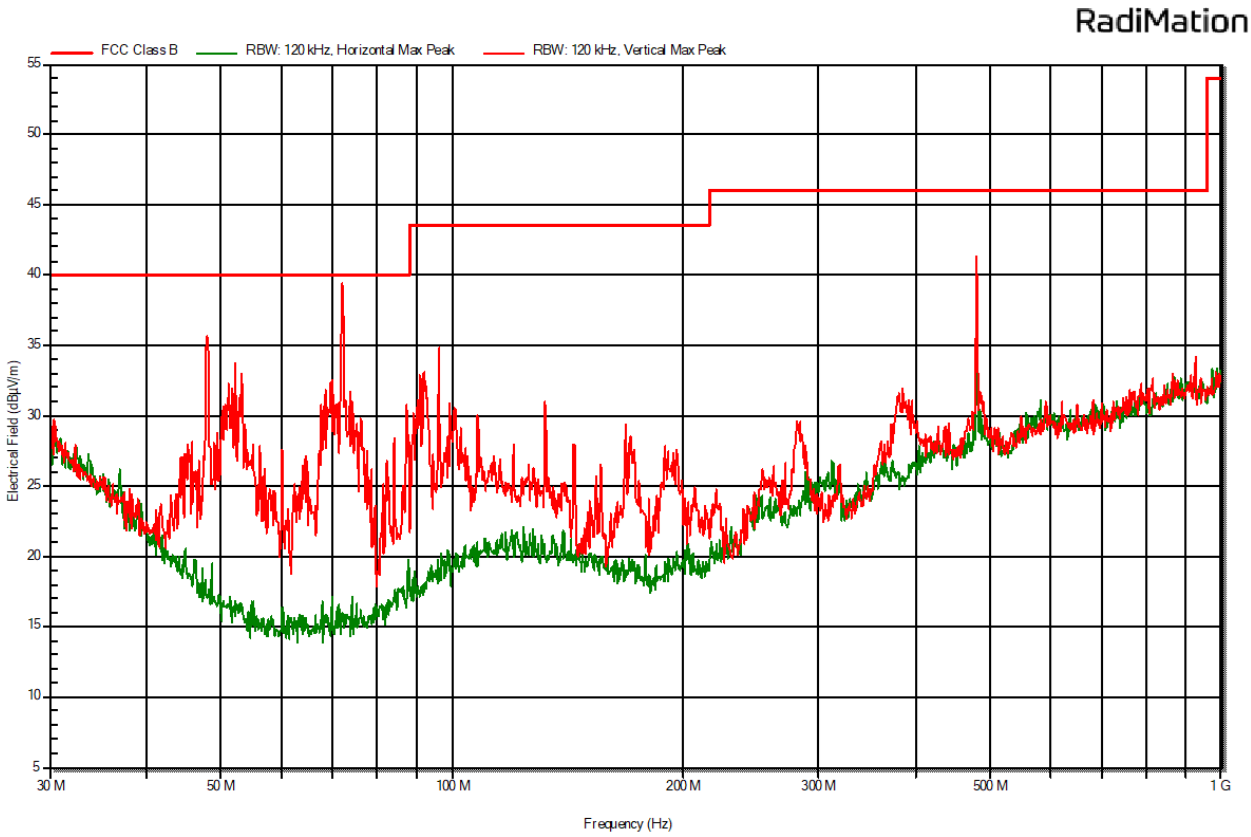


Figure 9 Electric field emissions Plot IEEE 802.11n, 30MHz to 1GHz, Operation on 2442MHz - Peak detector scan

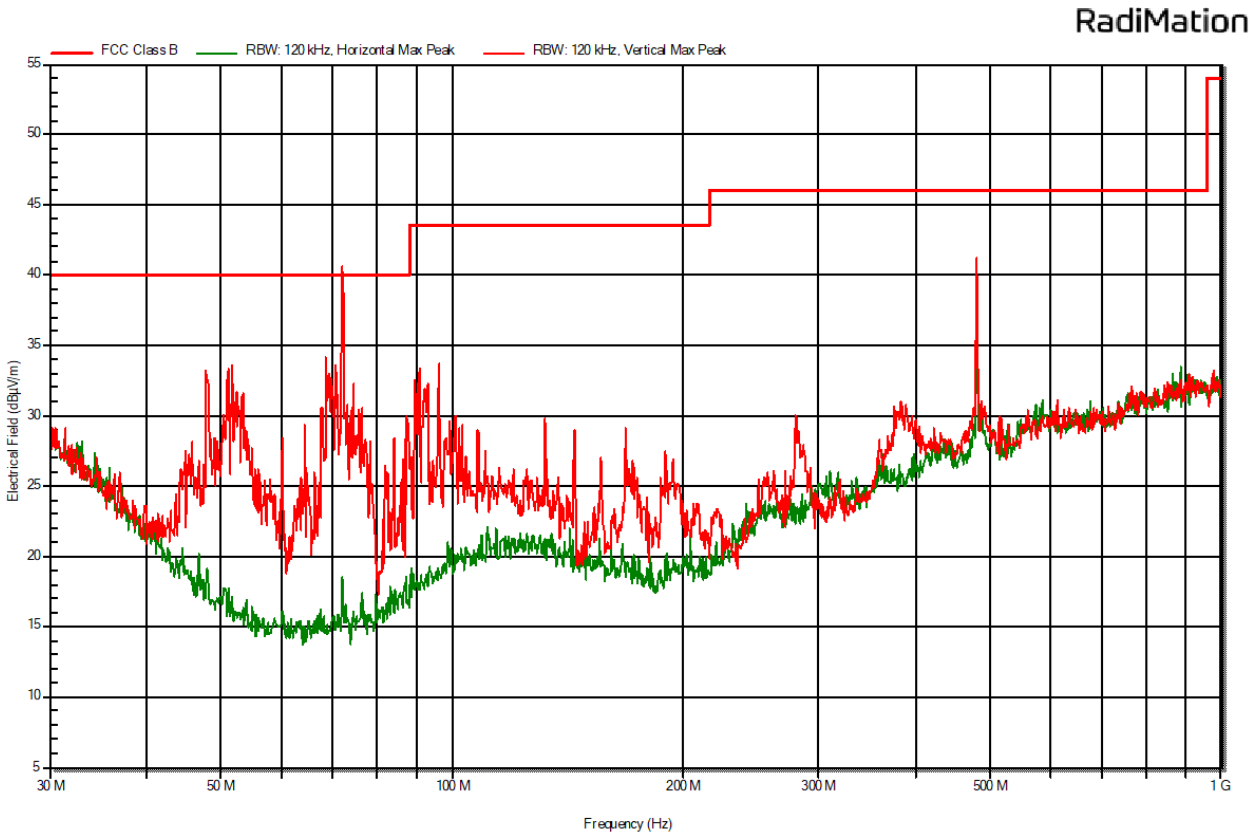


Figure 10 Electric field emissions Plot IEEE 802.11n, 30MHz to 1GHz, Operation on 2462MHz - Peak detector scan

5.4 Radiated Emissions (1GHz to 18GHz)

5.4.1 Limits

Frequency (GHz)	Limit (dBµV/m)	Limit (dBµV/m)
	Peak	Average
1-18	74.0	54.0

5.4.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average and Peak
Start Frequency	1GHz
Stop Frequency	18GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.4.3 Emissions measurements

5.4.4 Date of Test

18th September 2024

5.4.5 Test Area

LAB 1 (SAC)

5.4.6 Tested by

L Trickett

5.4.7 Test Setup

The EUT was configured in the SAC on a 1.5m high table Exploratory measurements on the EUT were carried out to identify suspect frequencies and worst case orientations, see Section 5.4.8.

The measurement was then performed with an antenna to EUT separation distance of 3m.

The antenna was kept in the “cone of radiation” from the EUT and pointed at the area both in azimuth and elevation using the tilt mechanism on the antenna mast.

The results were maximised in orientation 0-360 degrees and height 1-4m.

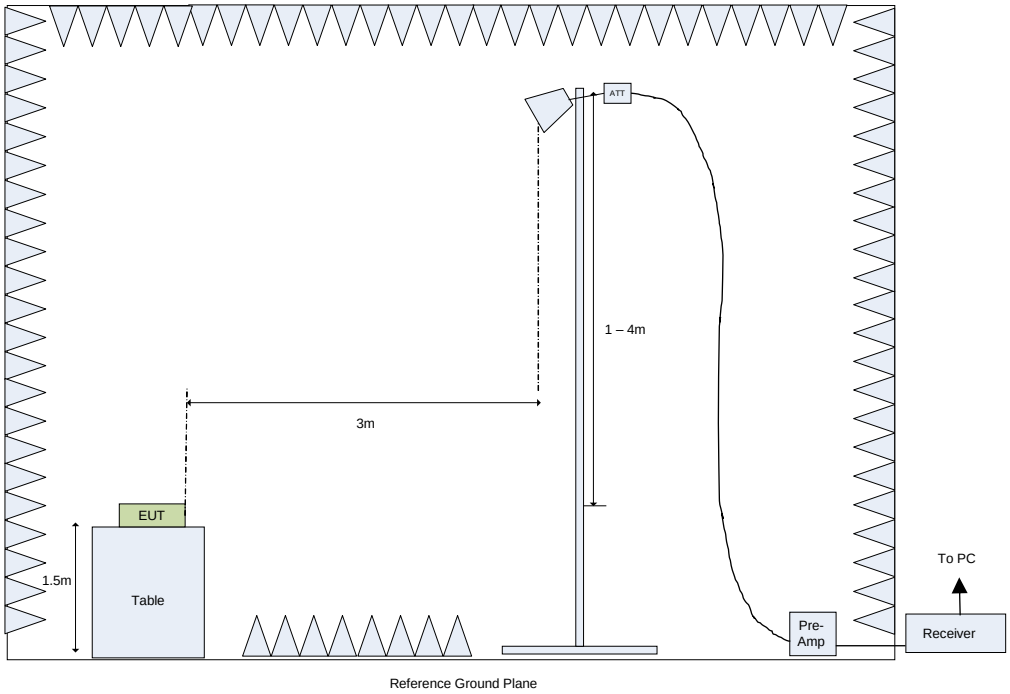


Figure 5.4.7.1: Test Setup for Final E-Field Measurements from 1GHz to 18GHz

Note 1: With the EUT de-energized the ambient radio noise and signals met the 6dB peak detection requirement of ANSI C63.4-2010.

Note 2: There were no significant environmental temperature changes during the test duration and hence it was not considered necessary to consider any variation in cable loss.

Note 3: On all swept and final measurements made between 1GHz and 18GHz a 2.4GHz Microtronics BRM50702 notch filter was placed in the measurement chain between the antenna and pre-amplifier in order to prevent the artificial generation of harmonics within the pre-amplifier.

5.4.8 Exploratory Radiated Emission Maximization

During exploratory testing, suspect emissions from the EUT were identified both in terms of the frequency and directionality. This was achieved by manually positioning the antenna close to the EUT and also by scanning it over all sides of the EUT whilst observing a spectral display. The typical distance between the surface of the EUT and the scanning antenna was circa 30cm.

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
1.025	Transmitting on channel 2412MHz & 2462MHz	Front	0	1.5	V
1.042	Transmitting on channel 2442MHz	Front	0	1.5	V
1.331	Transmitting on channel 2462MHz	Front	0	1.5	V
1.433	Transmitting on channel 2412MHz	Front	0	1.5	V
1.926	Transmitting on channel 2442MHz	Front	0	1.5	V
3.624	Transmitting on channel 2412MHz	Front	0	1.5	V
3.658	Transmitting on channel 2442MHz	Front	0	1.5	V
3.692	Transmitting on channel 2462MHz	Front	0	1.5	V
4.932	Transmitting on channel 2462MHz	Front	0	1.5	V

Table 4 Frequencies identified during Exploratory Radiated Emission maximization. 802.11b

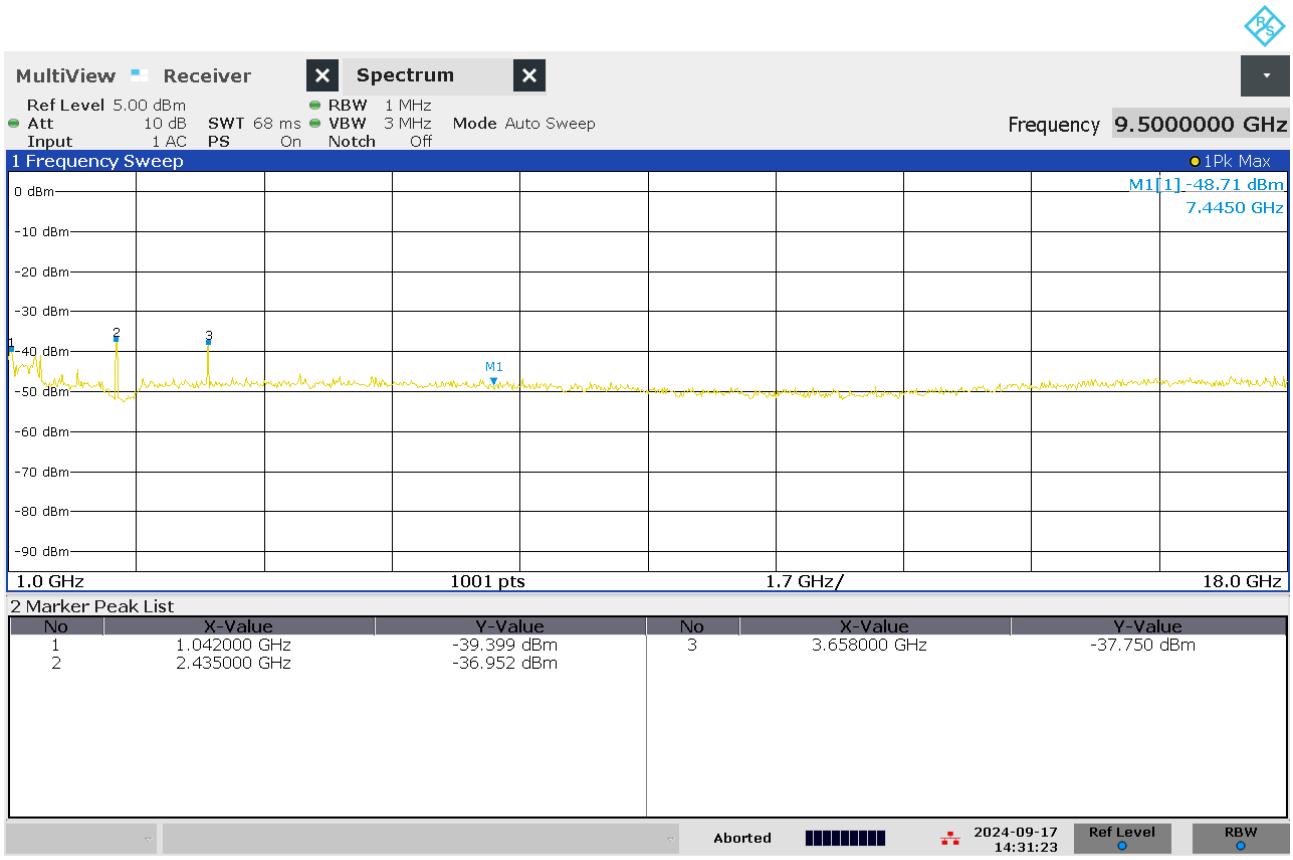


Figure 11 – Manual investigation – Operating on 802.11b channel 2442MHz

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
1.025	Transmitting on channel 2412MHz	Front	0	1.5	V
1.042	Transmitting on channel 2462MHz	Front	0	1.5	V
1.059	Transmitting on channel 2442MHz	Front	0	1.5	V
1.433	Transmitting on channel 2442MHz	Front	0	1.5	V
3.624	Transmitting on channel 2412MHz	Front	0	1.5	V
3.658	Transmitting on channel 2442MHz	Front	0	1.5	V
3.692	Transmitting on channel 2462MHz	Front	0	1.5	V
4.881	Transmitting on channel 2442MHz	Front	0	1.5	V

Table 5 Frequencies identified during Exploratory Radiated Emission maximization. 802.11g

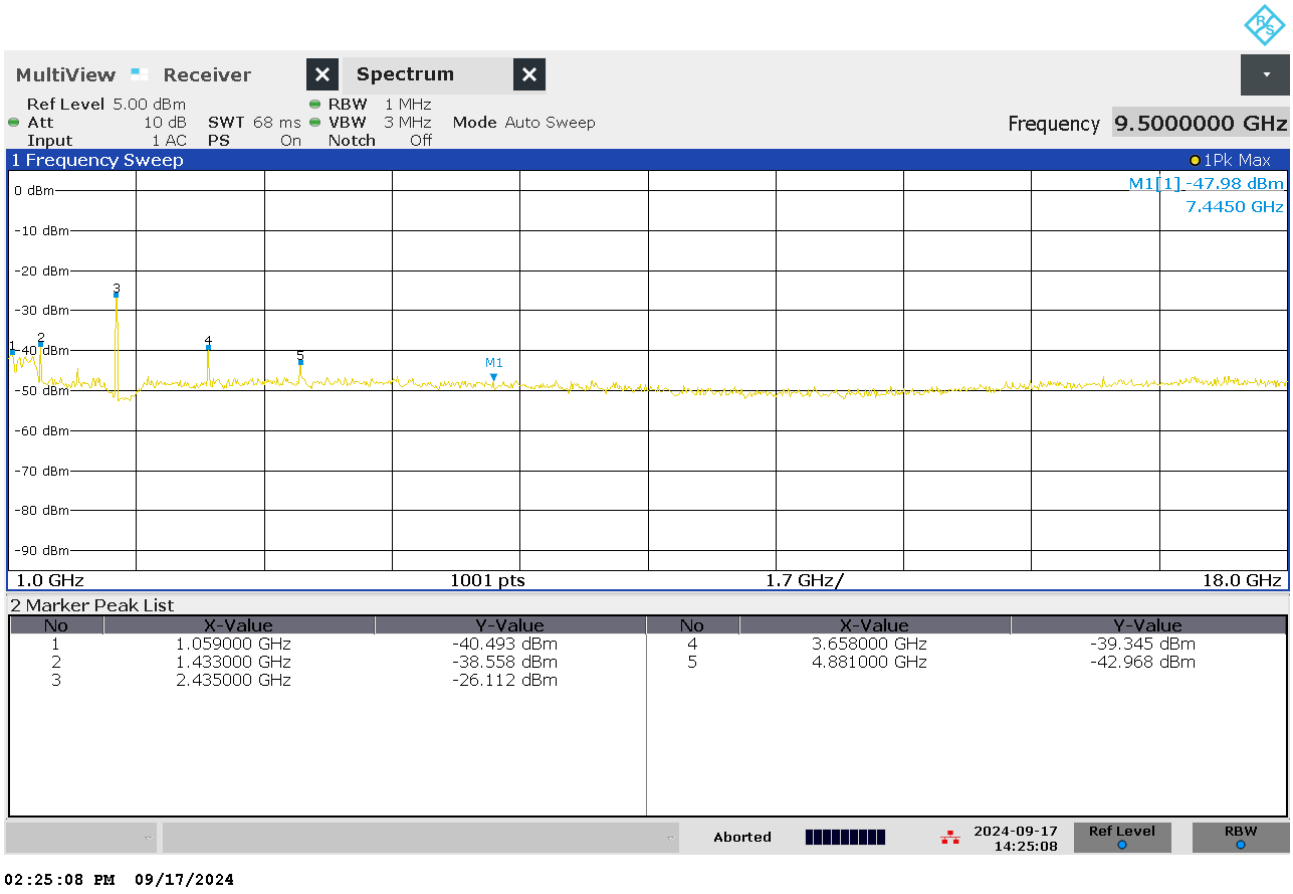


Figure 12 – Manual investigation – Operating on 802.11g channel 2442MHz

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
1.042	Transmitting on channel 2442MHz & 2462MHz	Front	0	1.5	V
1.059	Transmitting on channel 2412MHz	Front	0	1.5	V
1.433	Transmitting on channel 2412MHz	Front	0	1.5	V
3.624	Transmitting on channel 2412MHz	Front	0	1.5	V
3.658	Transmitting on channel 2442MHz	Front	0	1.5	V
3.692	Transmitting on channel 2462MHz	Front	0	1.5	V

Table 6 Frequencies identified during Exploratory Radiated Emission maximization. 802.11n

Note 1: The front face of the EUT is deemed to be 0°, which is then turned in a clockwise direction through 360°.

Note 2: With no emissions observed above 5GHz during the exploratory investigation, final measurements were performed up to 8GHz only.

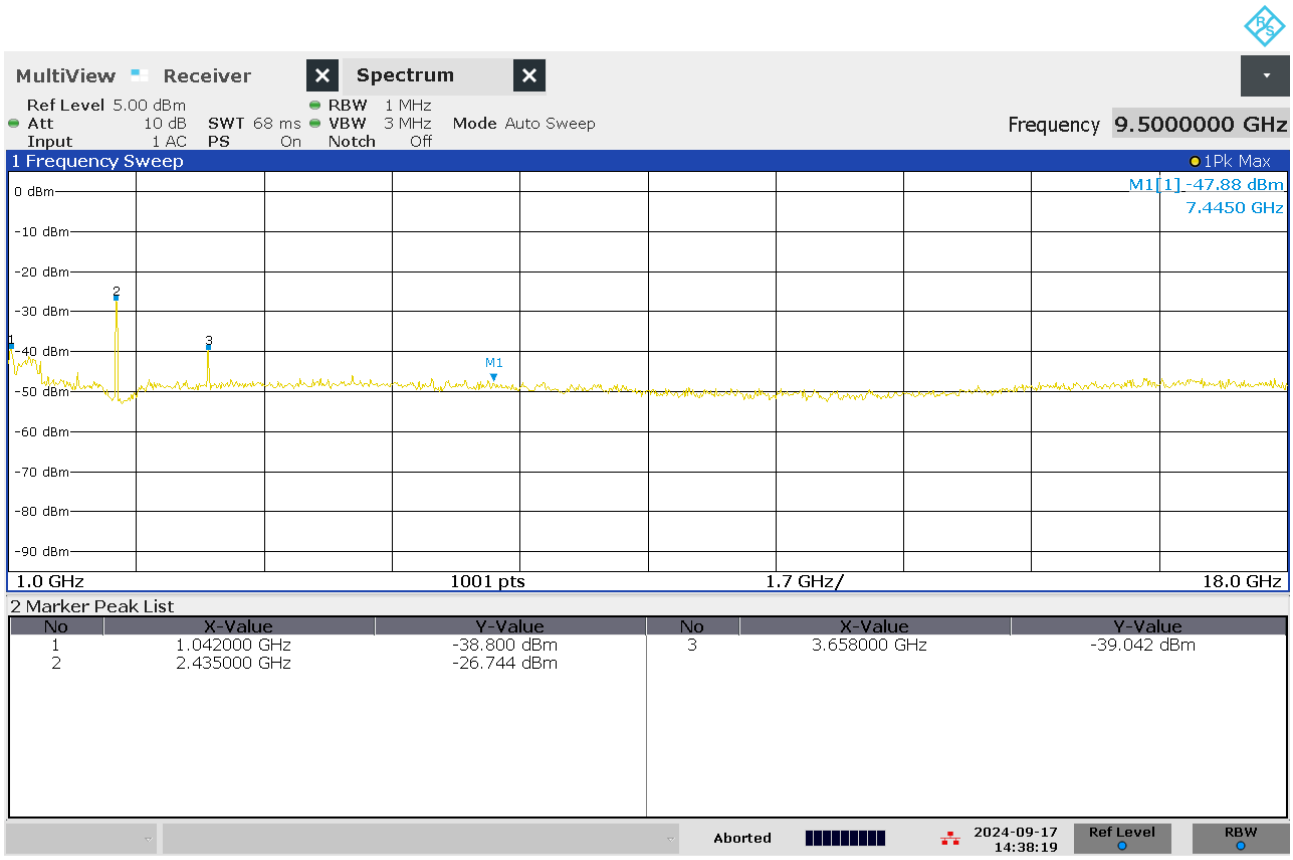


Figure 13 – Manual investigation – Operating on 802.11b channel 2442MHz

5.4.9 Electric field emissions IEEE 802.11b, 1GHz to 8GHz

The equipment under test was pre-scanned using peak detection when operating on all three channels. Final measurements were performed with the equipment under test operating on 2442MHz.

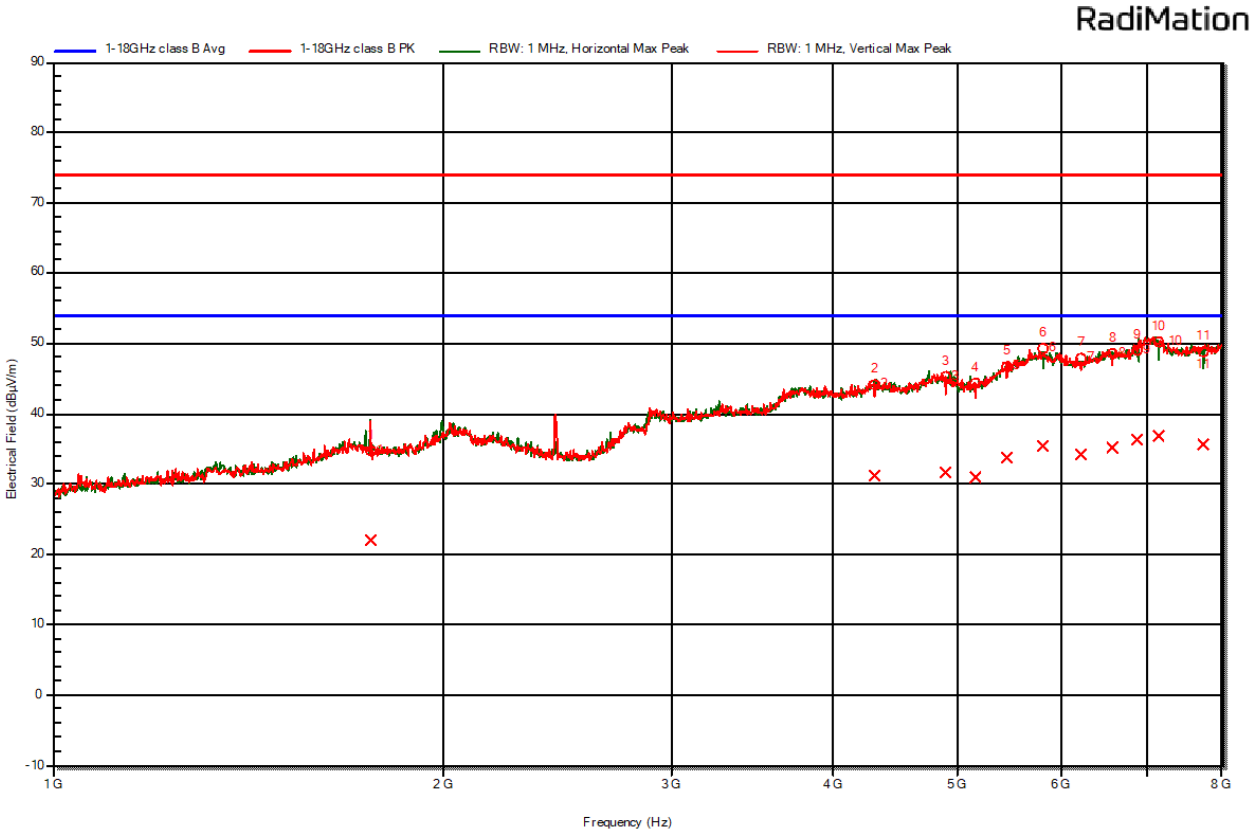


Figure 14 Electric field emissions Plot IEEE 802.11b, 1GHz to 8GHz. Operation on 2442MHz

Frequency GHz	Average dBµV/m	Average Limit dBµV/m	Average Difference dB	Average Status	Angle degrees	Height m	Polarization
1.76	22.0	54.0	-32.0	Pass	85	1.6	Vertical
4.32	31.1	54.0	-22.9	Pass	55	2.1	Vertical
4.89	31.7	54.0	-22.3	Pass	75	1.5	Vertical
5.15	31.0	54.0	-23.0	Pass	155	3.2	Vertical
5.46	33.7	54.0	-20.3	Pass	105	1.9	Vertical
5.81	35.5	54.0	-18.5	Pass	135	3.4	Horizontal
6.22	34.3	54.0	-19.7	Pass	245	1.8	Vertical
6.58	35.1	54.0	-18.9	Pass	10	4.0	Vertical
6.89	36.3	54.0	-17.7	Pass	360	2.1	Horizontal
7.15	36.8	54.0	-17.2	Pass	50	1.2	Horizontal
7.74	35.8	54.0	-18.2	Pass	135	1.6	Horizontal

Table 7 Electric Field Emissions Peaks IEEE 802.11b, 1GHz to 8GHz – Operation on 2442MHz

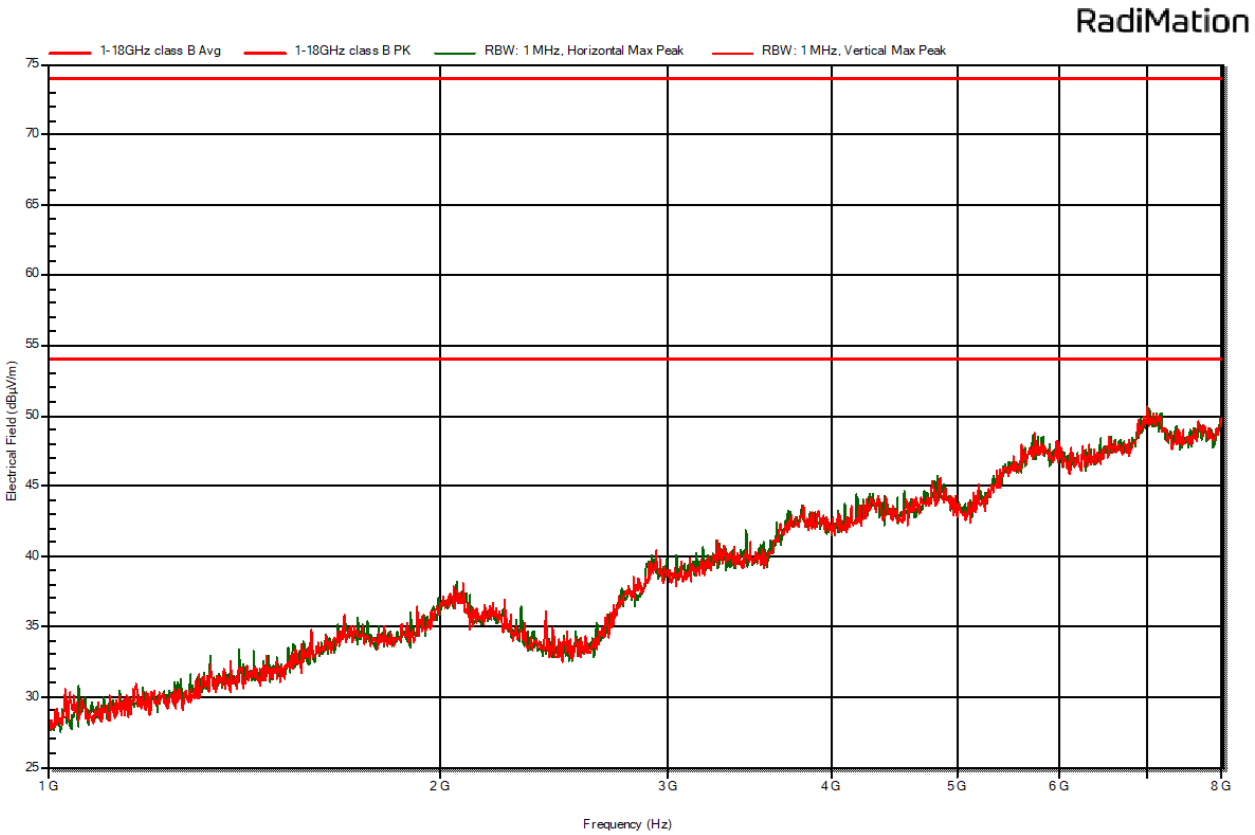


Figure 15 Electric field emissions Plot IEEE 802.11b, 1GHz to 8GHz, Operation on 2412MHz - Peak detector scan

Figure 16 Electric field emissions Plot, 1GHz to 8GHz IEEE 802.11b, Operation on 2462MHz – Peak detector scan

5.4.10 Electric field emissions IEEE 802.11g, 1GHz to 8GHz

The equipment under test was pre-scanned using peak detection when operating on all three channels. Final measurements were performed with the equipment under test operating on 2442MHz.

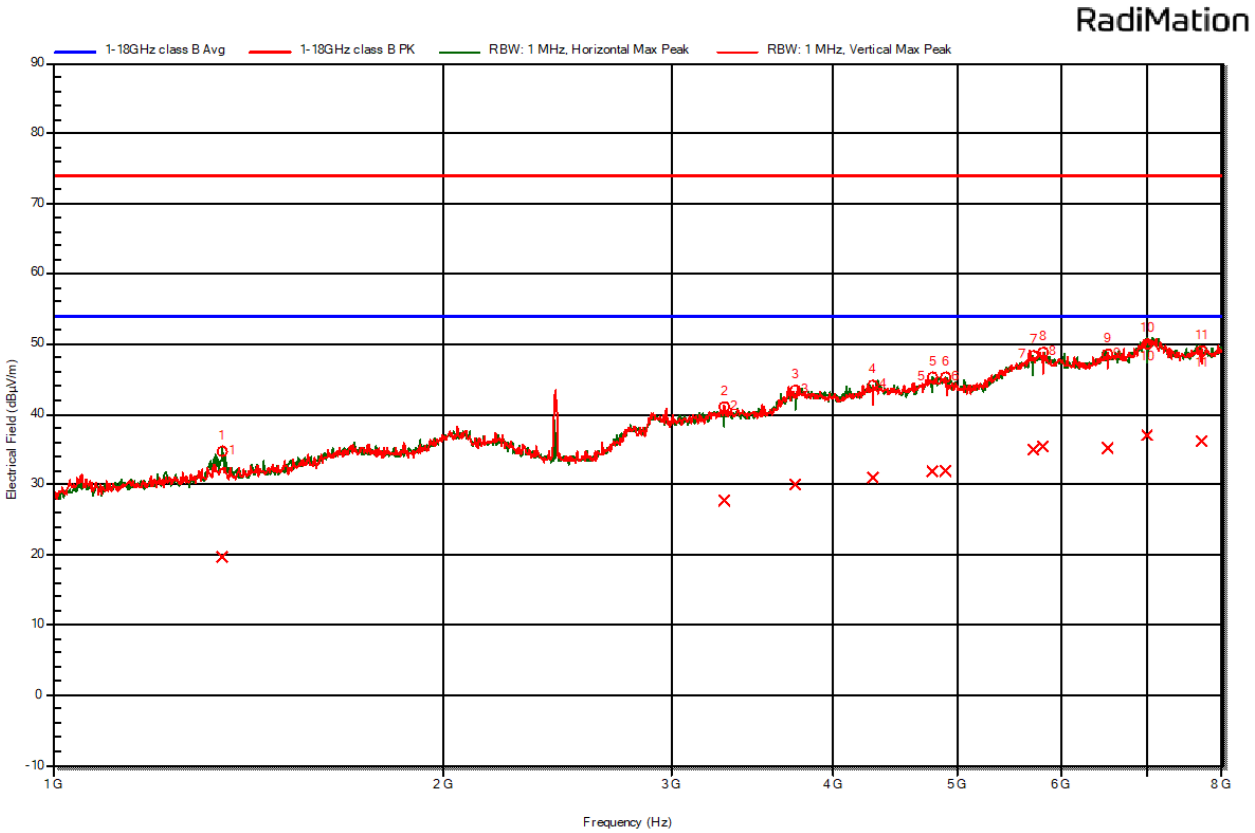


Figure 17 Electric field emissions Plot IEEE 802.11g, 1GHz to 8GHz. Operation on 2442MHz

Frequency GHz	Average dBµV/m	Average Limit dBµV/m	Average Difference dB	Average Status	Angle degrees	Height m	Polarization
1.35	19.8	54.0	-34.2	Pass	175	2.0	Horizontal
3.30	27.6	54.0	-26.4	Pass	150	1.5	Horizontal
3.74	30.0	54.0	-24.0	Pass	315	2.5	Horizontal
4.30	31.1	54.0	-23.0	Pass	240	3.5	Vertical
4.78	31.8	54.0	-22.2	Pass	335	3.3	Horizontal
4.90	31.9	54.0	-22.1	Pass	265	3.0	Vertical
5.71	35.0	54.0	-19.0	Pass	325	2.1	Horizontal
5.81	35.5	54.0	-18.5	Pass	195	2.5	Vertical
6.53	35.2	54.0	-18.8	Pass	120	2.3	Vertical
7.01	37.1	54.0	-16.9	Pass	15	1.0	Horizontal
7.71	36.0	54.0	-18.0	Pass	245	2.4	Vertical

Table 8 Electric Field Emissions Peaks IEEE 802.11g, 1GHz to 8GHz – Operation on 2442MHz

Figure 18 Electric field emissions Plot IEEE 802.11g, 1GHz to 8GHz, Operation on 2412MHz - Peak detector scan

Figure 19 Electric field emissions Plot, 1GHz to 8GHz IEEE 802.11g, Operation on 2462MHz – Peak detector scan

5.4.11 Electric field emissions IEEE 802.11n, 1GHz to 8GHz

The equipment under test was pre-scanned using peak detection when operating on all three channels. Final measurements were performed with the equipment under test operating on 2442MHz.

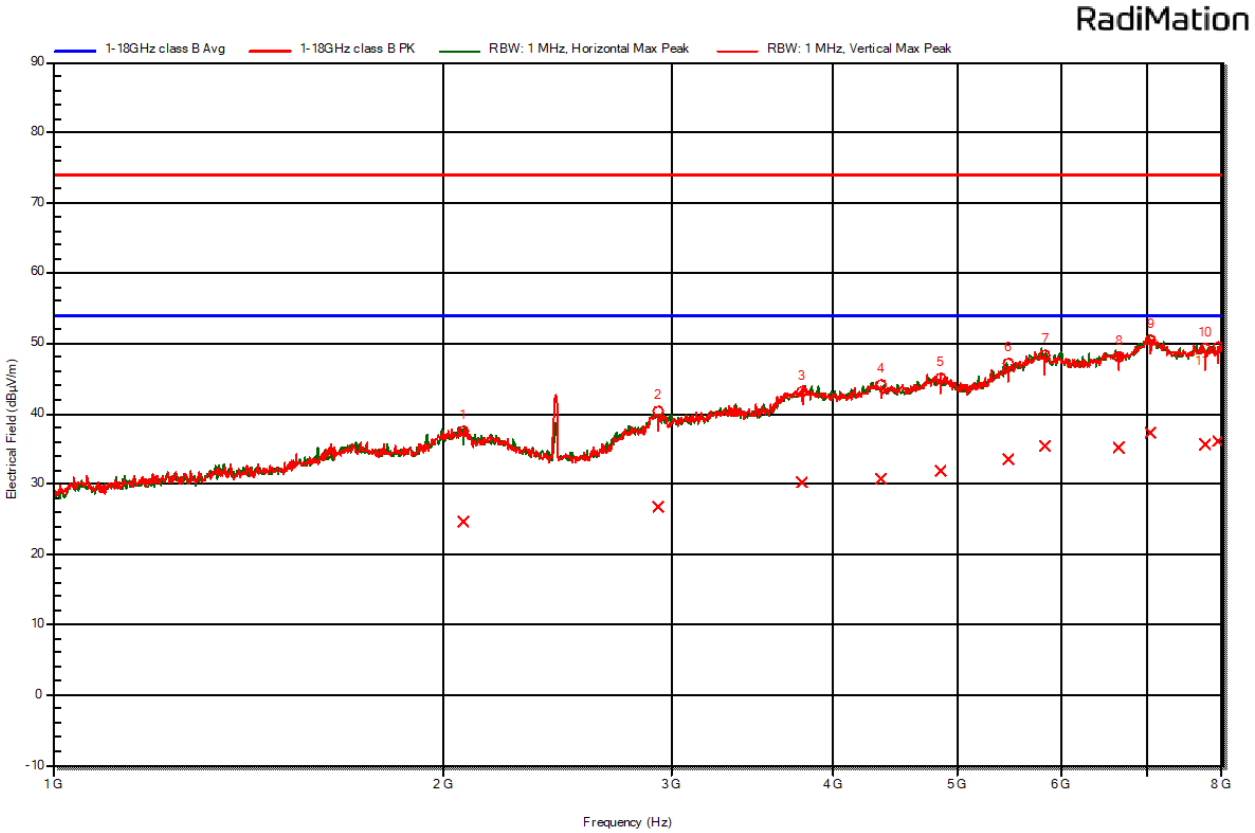


Figure 20 Electric field emissions Plot IEEE 802.11n, 1GHz to 8GHz. Operation on 2442MHz

Frequency GHz	Average dBµV/m	Average Limit dBµV/m	Average Difference dB	Average Status	Angle degrees	Height m	Polarization
2.08	24.6	54.0	-29.4	Pass	25	3.2	Horizontal
2.93	26.8	54.0	-27.2	Pass	10	2.2	Vertical
3.79	30.3	54.0	-23.7	Pass	170	3.2	Vertical
4.37	30.8	54.0	-23.2	Pass	240	3.0	Vertical
4.84	32.0	54.0	-22.0	Pass	5	3.5	Vertical
5.47	33.5	54.0	-20.5	Pass	235	2.4	Vertical
5.83	35.3	54.0	-18.7	Pass	150	1.3	Vertical
6.66	35.3	54.0	-18.7	Pass	55	2.4	Vertical
7.04	37.3	54.0	-16.8	Pass	245	1.0	Vertical
7.76	35.8	54.0	-18.2	Pass	245	2.5	Vertical
7.95	36.1	54.0	-17.9	Pass	250	3.6	Vertical

Table 9 Electric Field Emissions Peaks IEEE 802.11n, 1GHz to 8GHz – Operation on 2442MHz

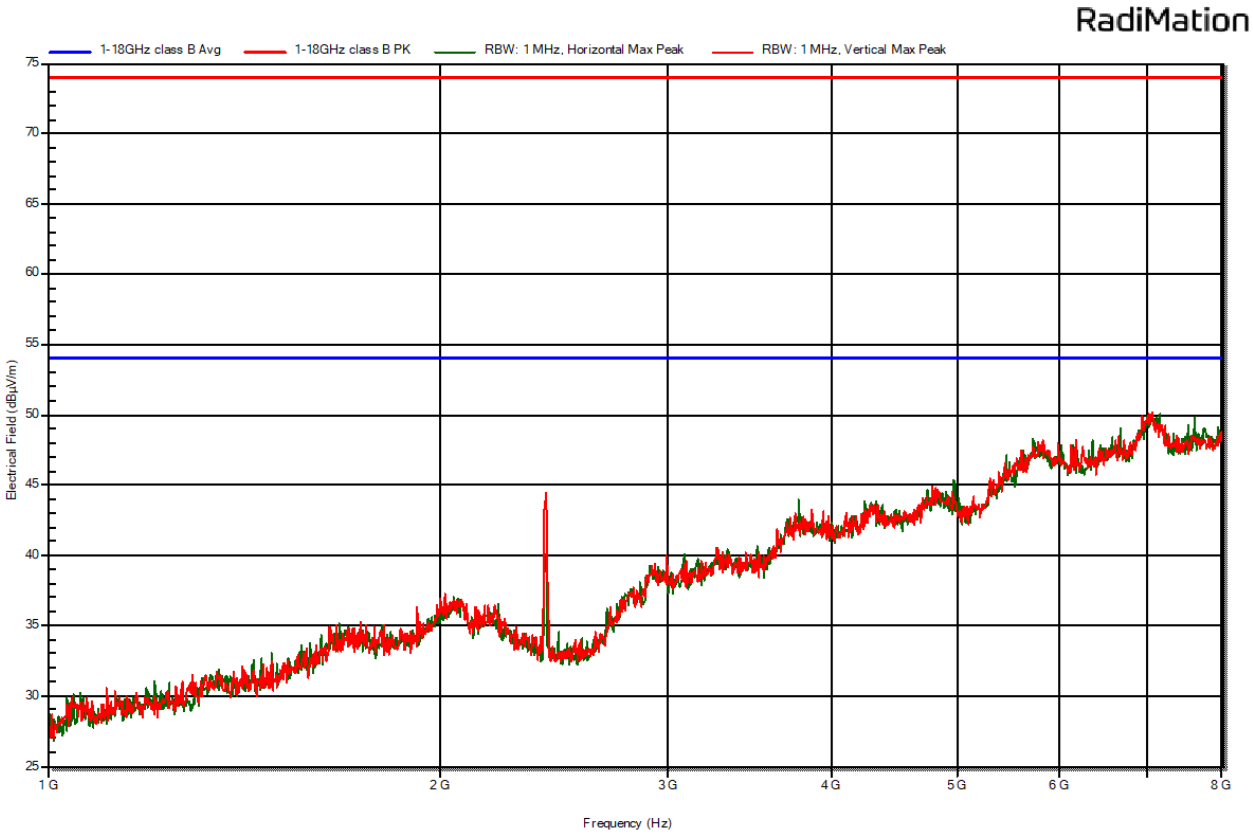


Figure 21 Electric field emissions Plot IEEE 802.11n, 1GHz to 8GHz, Operation on 2412MHz - Peak detector scan

Figure 22 Electric field emissions Plot, 1GHz to 8GHz IEEE 802.11n, Operation on 2462MHz – Peak detector scan

5.4.12 Example field strength calculation

The total average corrections are shown in the above table. This correction figure consists of Preamplifier gain (PG), Antenna factor (AF); and Cable loss (CL), and where necessary distance extrapolation factor (dB).

Field strength (FS) is calculated as follows:

FS (dBµV/m) = Indicated Signal Level (dBµV) - PG (dB) + AF (dB) + CL (dB)

5.4.13 Sample Data

From Figure 20 and table 9, The Average level at 7.95GHz is calculated as follows:

FS (dBµV/m) = 45.1(dBµV) – 54.4(dB) + 39.2(dB) + 6.2 (dB) = 36.1dBµV/m

5.5 Radiated Emissions (18GHz to 26GHz)

5.5.1 Limits

Frequency (GHz)	Limit (dBµV/m)	Limit (dBµV/m)
	Peak	Average
18-25	74.0	54.0

5.5.2 Receiver Settings

Receiver Parameters	Setting
Detector Function	Average and Peak
Start Frequency	18GHz
Stop Frequency	25GHz
Resolution Bandwidth	1MHz
Video Bandwidth	Auto

5.5.3 Emissions measurements

5.5.4 Date of Test

17th September 2024

5.5.5 Test Area

LAB 1 (SAC)

5.5.6 Tested by

L Trickett

5.5.7 Test Setup

This is the same as for the 1-18GHz range for final measurements, except with a measurement distance of 1m.

5.5.8 Exploratory Radiated Emission Maximization

During exploratory testing, suspect emissions from the EUT were identified both in terms of the frequency and directionality. This was achieved by manually positioning the antenna close to the EUT and also by scanning it over all sides of the EUT whilst observing a spectral display. The typical distance between the surface of the EUT and the scanning antenna was circa 30cm.

Frequency (GHz)	Mode of operation	EUT face *	Emissions Angle (w.r.t. turntable)	Height	Polarization
-	Tx on channels 2402MHz, 2440MHz and 2480MHz.	-	-	-	-

Table 10 Frequencies identified during Exploratory Radiated Emission maximization

Note 1: The front face of the EUT is deemed to be 0°, which is then turned in a clockwise direction through 360°.

Note 2: No emissions were identified for further investigation above 18GHz.

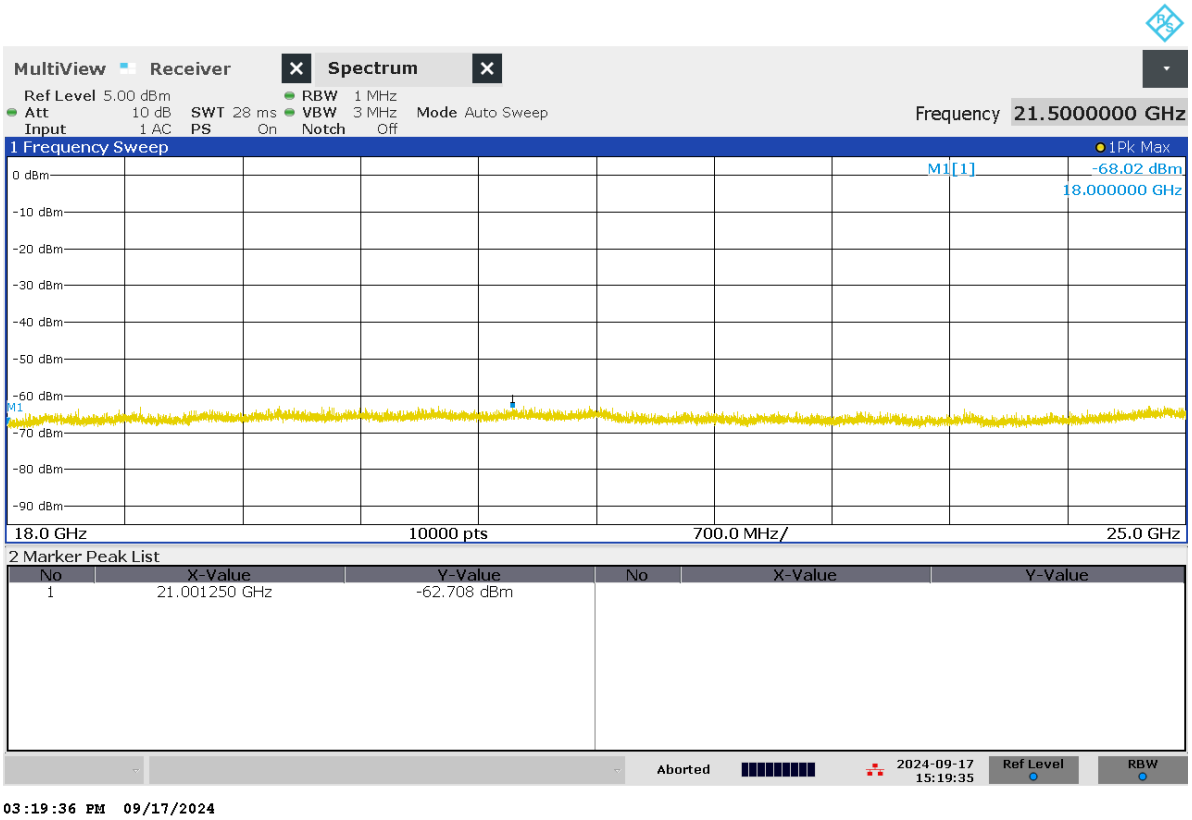


Figure 23 – manual investigation – Operating on IEEE 802.11b channel 2412MHz

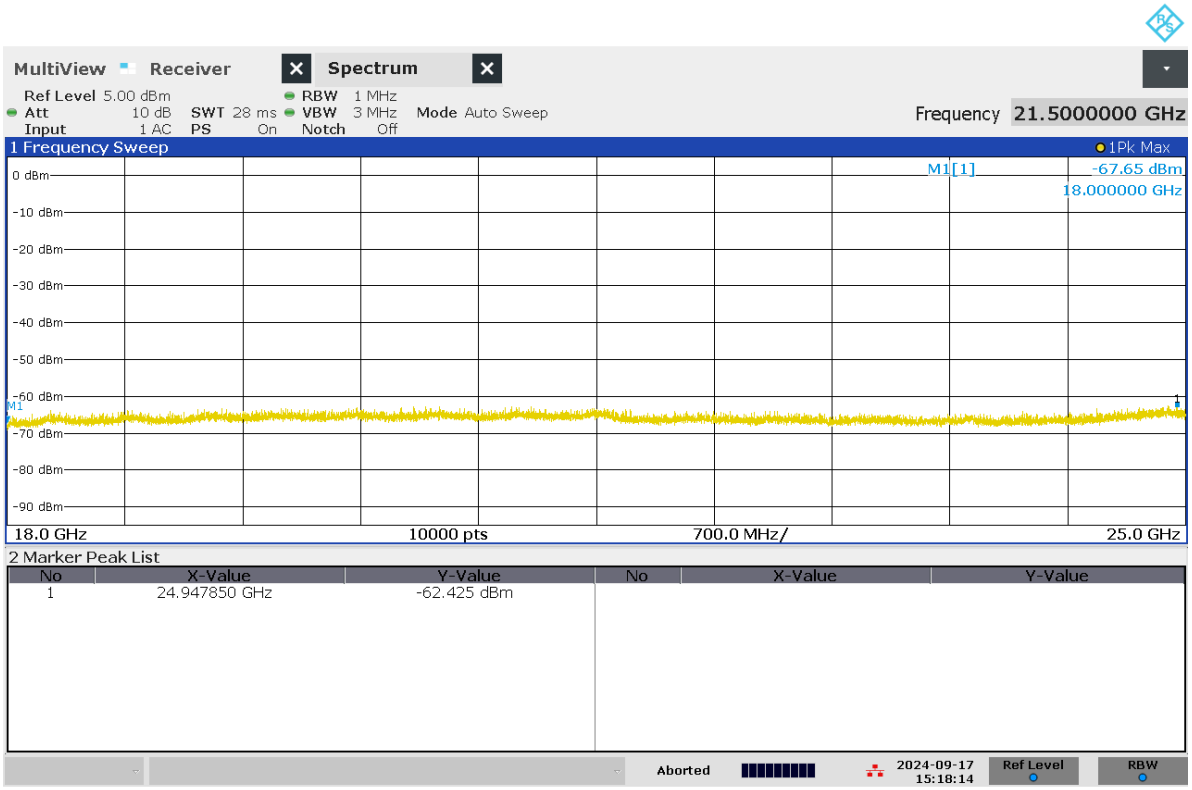


Figure 24 – manual investigation – Operating on IEEE 802.11b channel 2442MHz

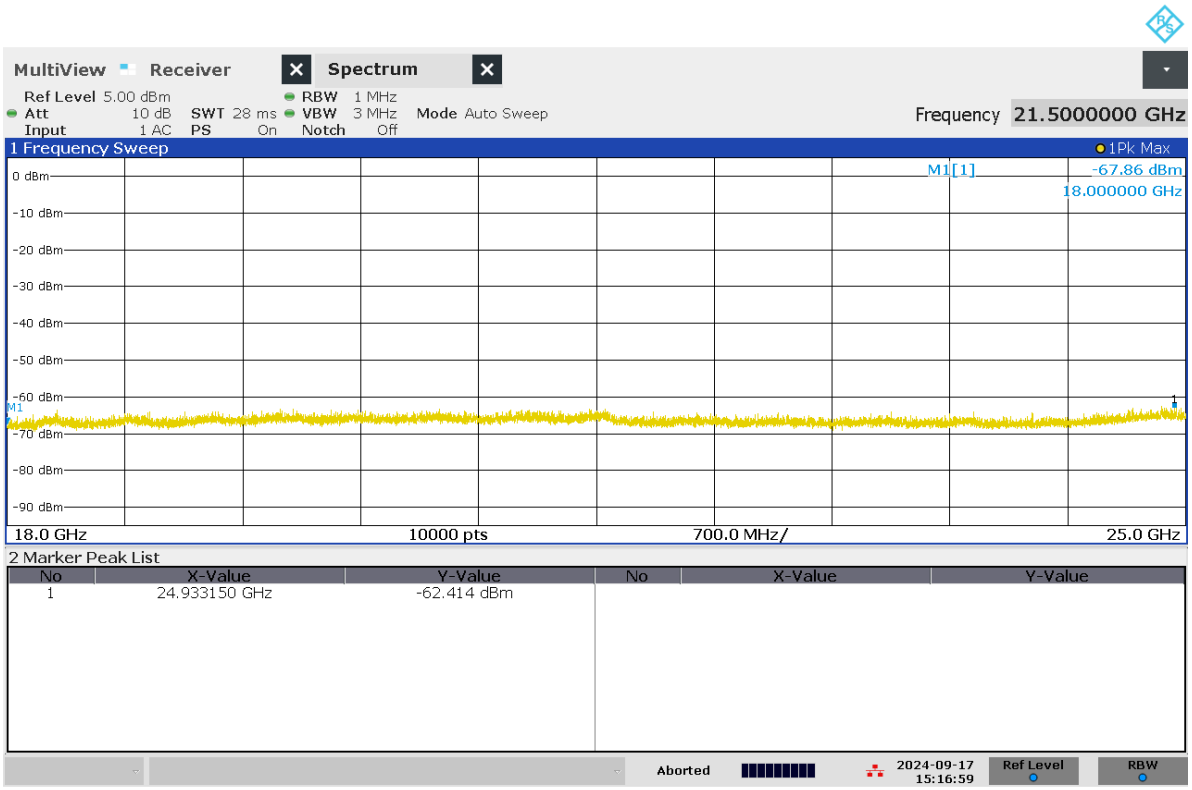


Figure 25 – manual investigation – Operating on IEEE 802.11b channel 2462MHz

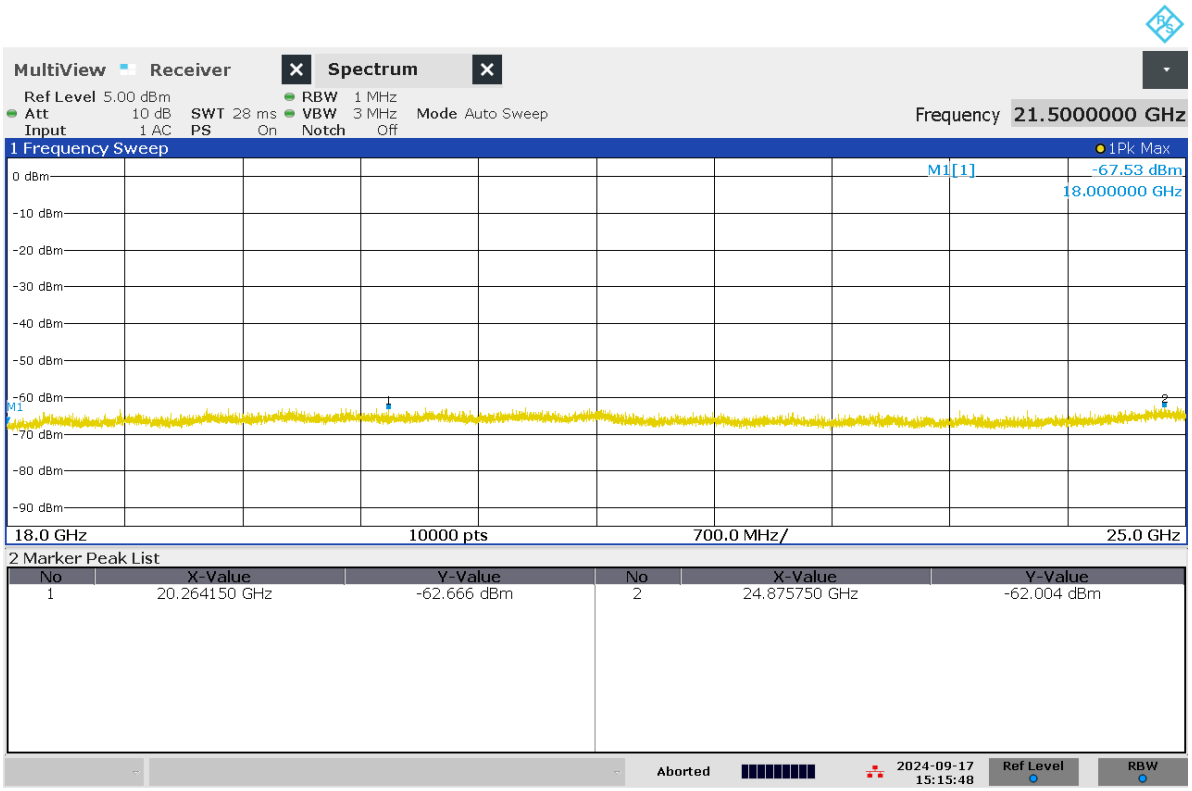


Figure 26 – manual investigation – Operating on IEEE 802.11g channel 2412GHz

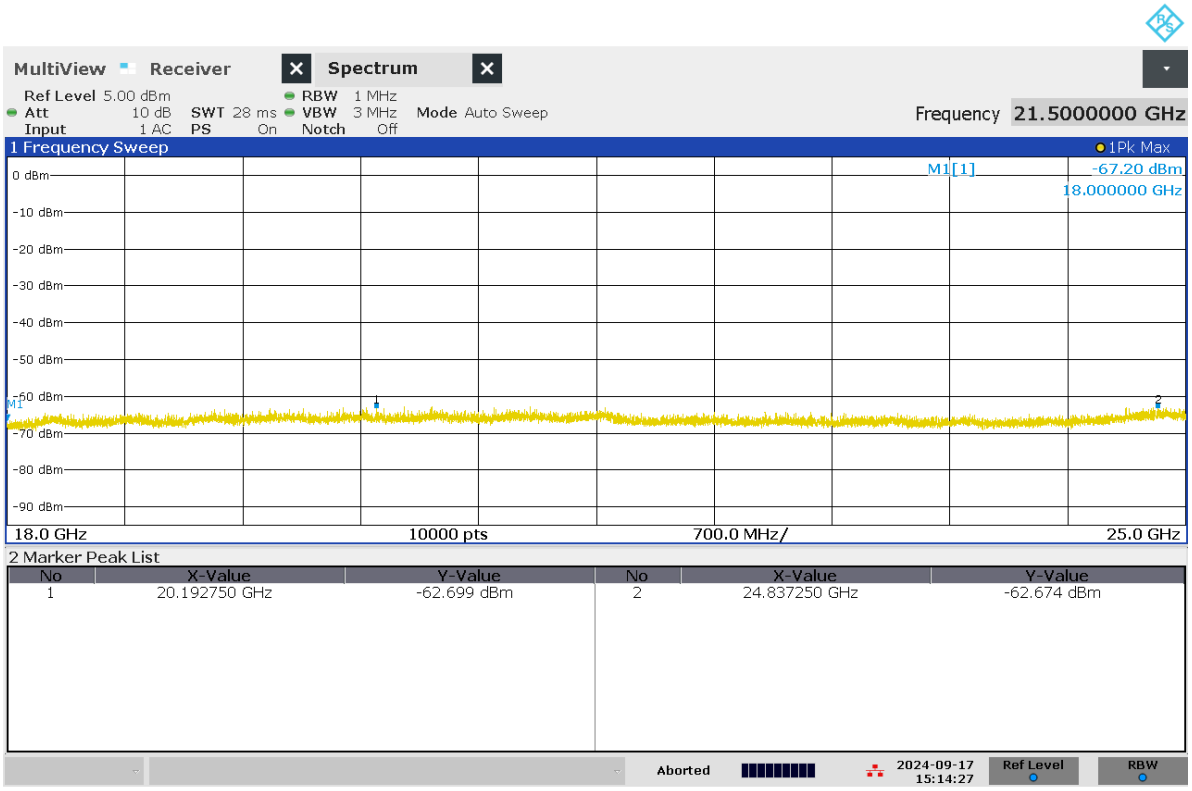


Figure 27 – manual investigation – Operating on IEEE 802.11g channel 2442MHz

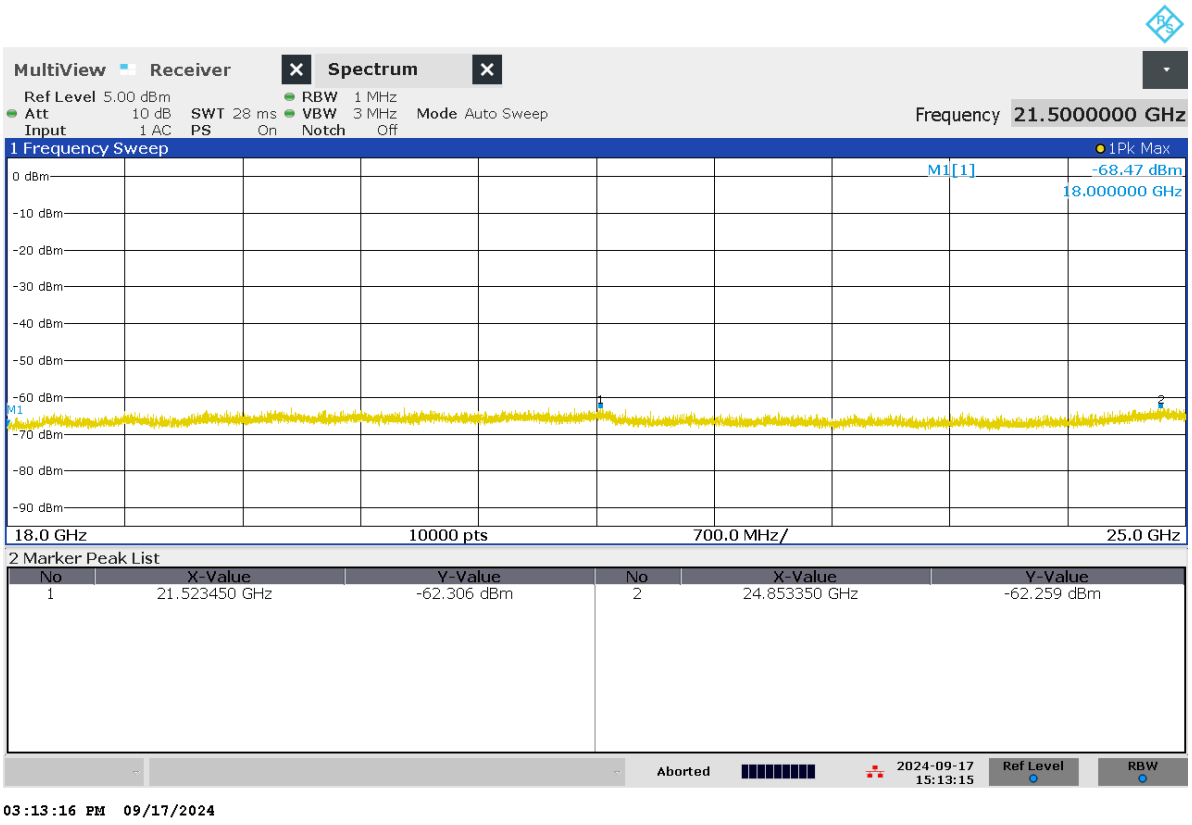
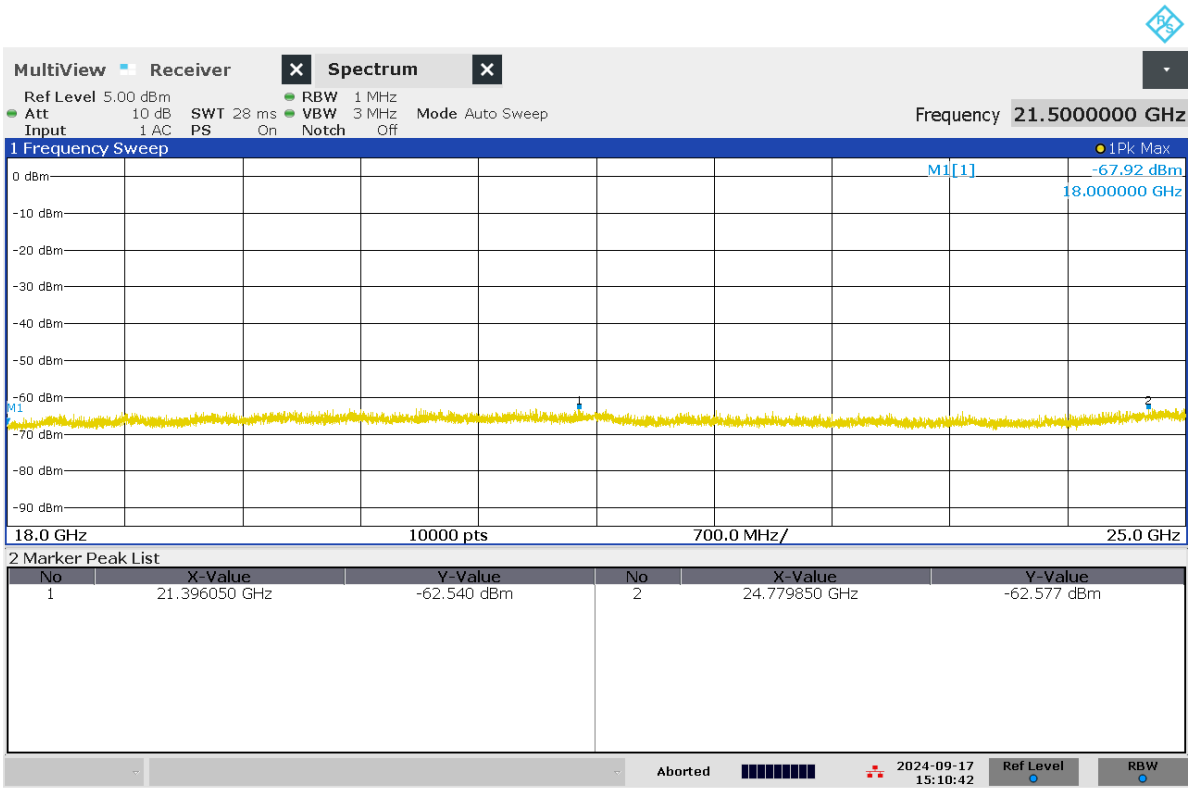
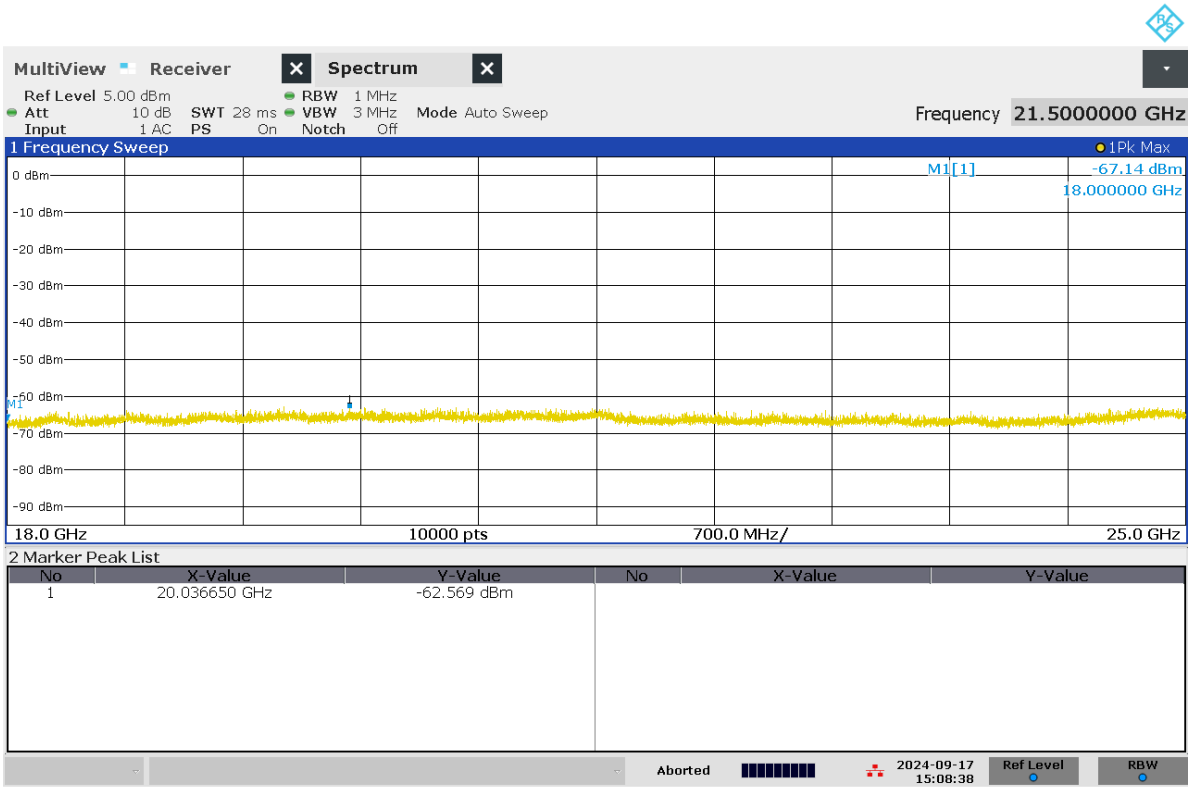


Figure 28 – manual investigation – Operating on IEEE 802.11g channel 2462MHz



03:10:42 PM 09/17/2024

Figure 29 – manual investigation – Operating on IEEE 802.11n channel 2412MHz



03:08:38 PM 09/17/2024

Figure 30 – manual investigation – Operating on IEEE 802.11n channel 2442MHz

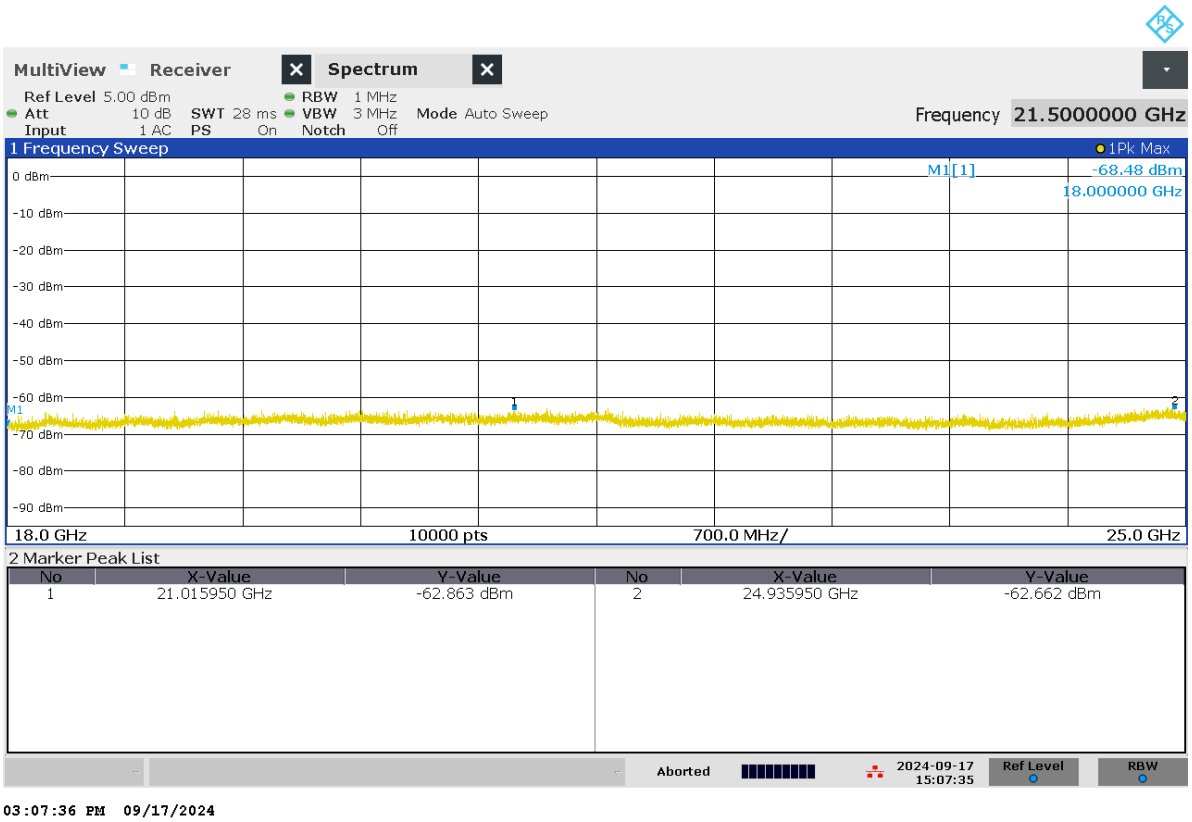


Figure 31 – manual investigation – Operating on IEEE 802.11n channel 2462MHz

5.6 Conducted Spurious Emissions 30MHz to 25GHz

5.6.1 Limits

Frequency (MHz)	Limit, 47CFR 15.247(d)
	Peak
30 – 25000	-20dBc

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.11.2

Receiver Parameters	Setting
Detector Function	Peak
Start Frequency	30MHz
Stop Frequency	25000MHz
Resolution Bandwidth	100kHz
Video Bandwidth	300kHz
Sweep rate	Auto couple
Trace mode	Max hold

5.6.2 Emissions measurements

5.6.3 Date of Test

17th September 2024

5.6.4 Test Area

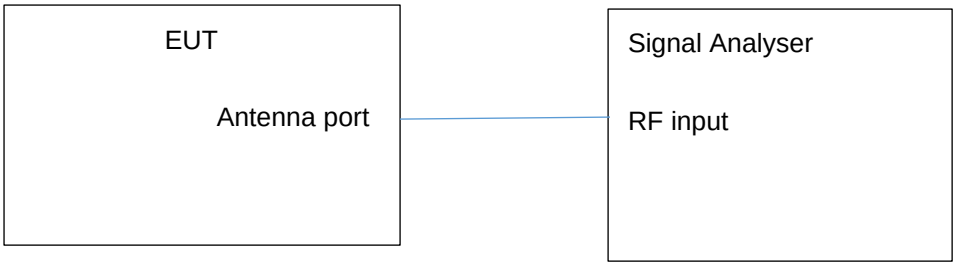
LAB 8

5.6.5 Tested by

J Beevers

5.6.6 Test Setup

The antenna port was connected directly to the signal analyser.



5.6.7 Test Results

The results of the conducted spurious emissions are stated below and by the signal analyser images.

All disturbances detected were > 20dB below the carrier.

5.6.8 Antenna port conducted emissions IEEE 802.11b, 30MHz to 25GHz

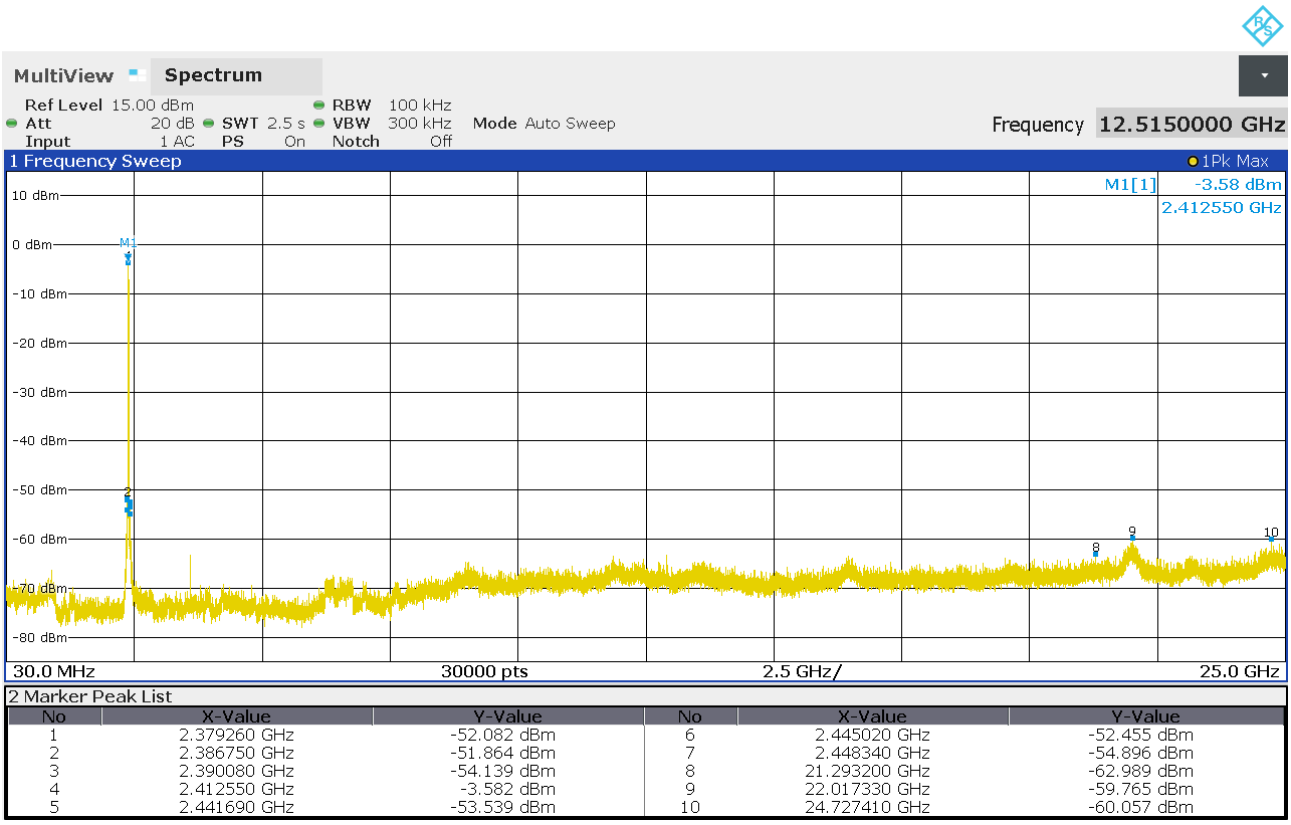


Figure 32 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11b channel 2412MHz.

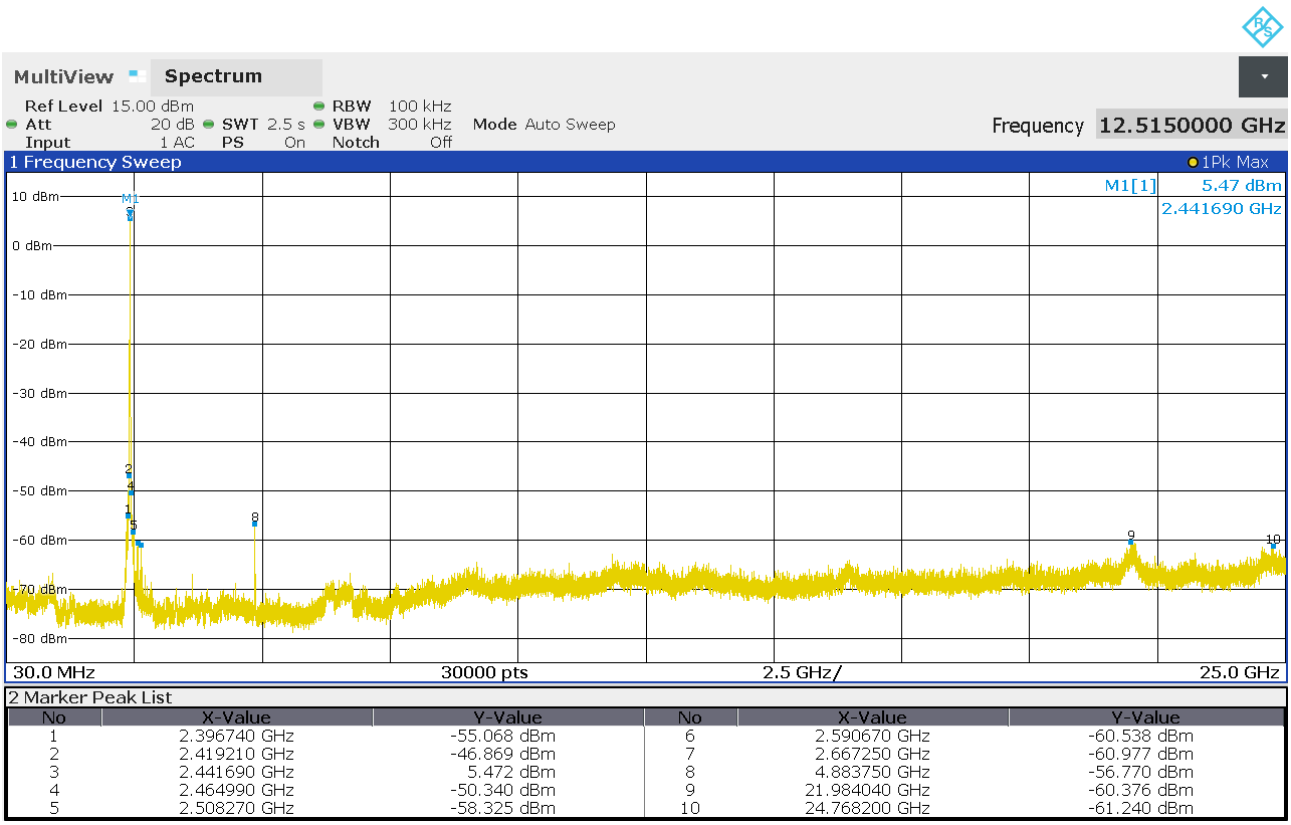
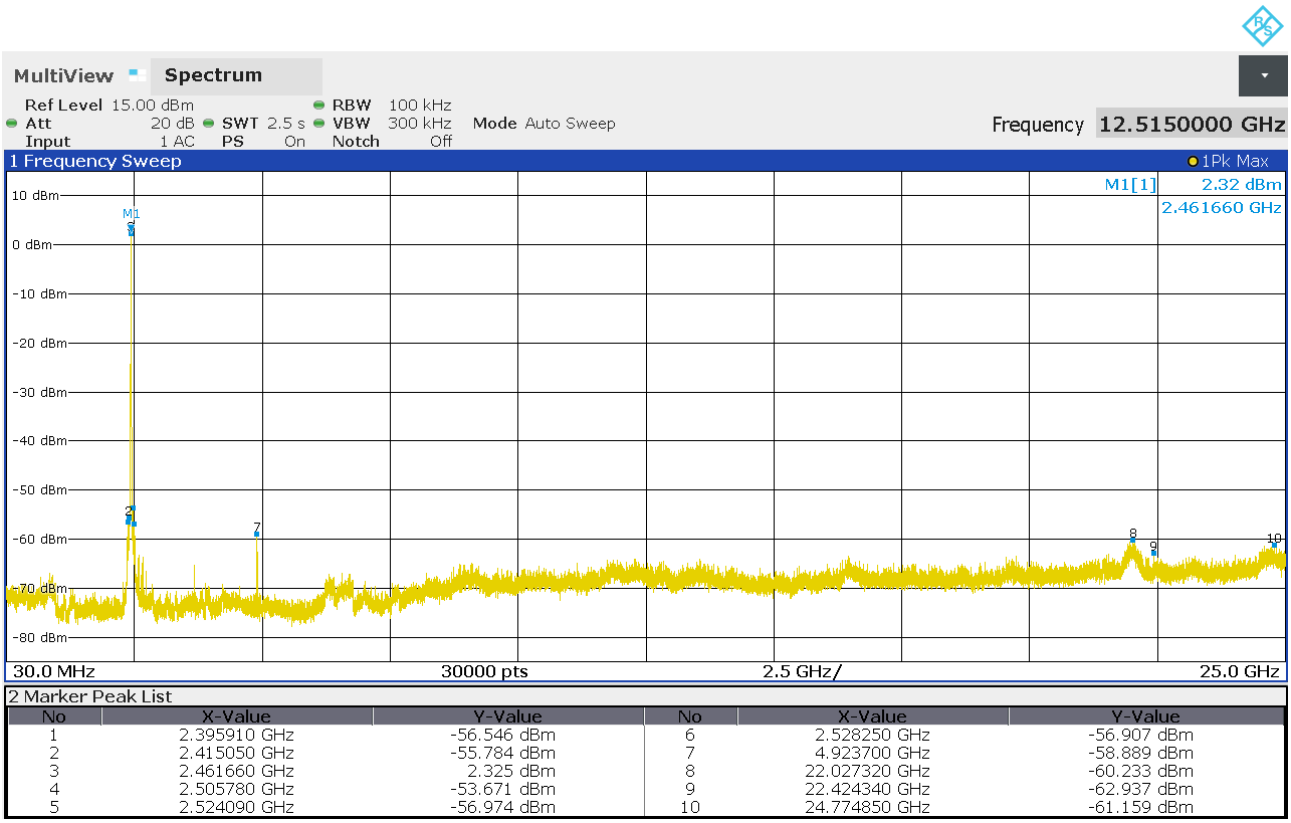


Figure 33 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11b channel 2442MHz.

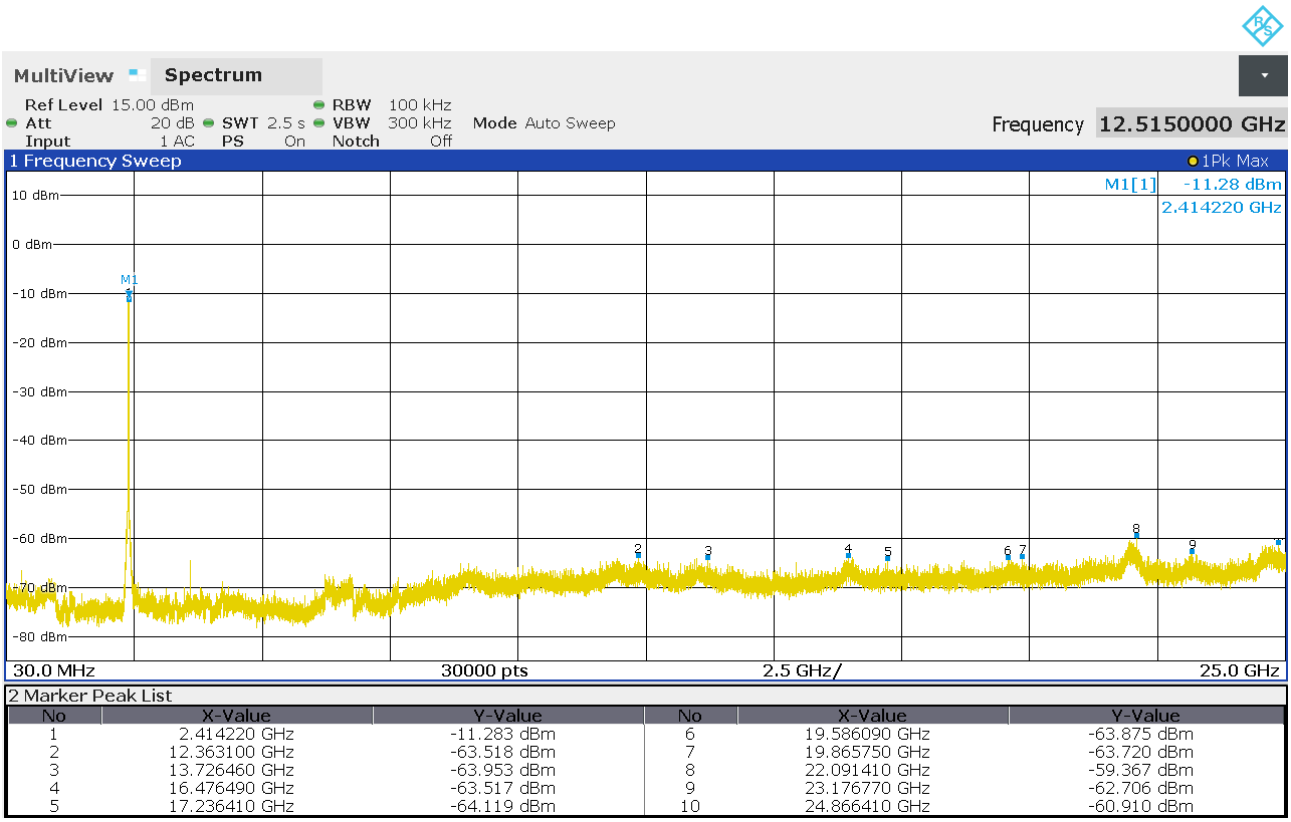


2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	2.395910 GHz	-56.546 dBm	6	2.528250 GHz	-56.907 dBm
2	2.415050 GHz	-55.784 dBm	7	4.923700 GHz	-58.889 dBm
3	2.461660 GHz	2.325 dBm	8	22.027320 GHz	-60.233 dBm
4	2.505780 GHz	-53.671 dBm	9	22.424340 GHz	-62.937 dBm
5	2.524090 GHz	-56.974 dBm	10	24.774850 GHz	-61.159 dBm

Figure 34 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11b channel 2462MHz.

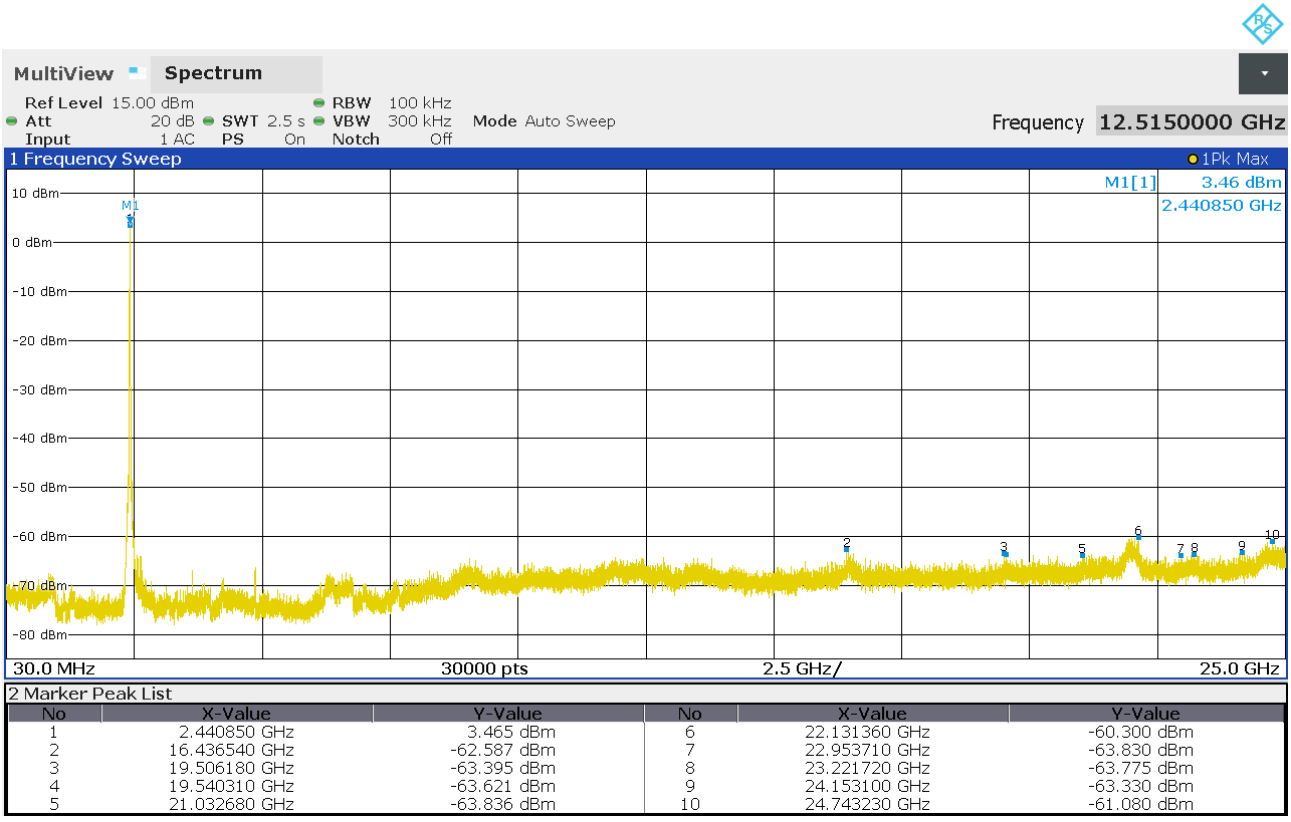
5.6.9 Antenna port conducted emissions IEEE 802.11g, 30MHz to 25GHz



2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	2.414220 GHz	-11.283 dBm	6	19.586090 GHz	-63.875 dBm
2	12.363100 GHz	-63.518 dBm	7	19.865750 GHz	-63.720 dBm
3	13.726460 GHz	-63.953 dBm	8	22.091410 GHz	-59.367 dBm
4	16.476490 GHz	-63.517 dBm	9	23.176770 GHz	-62.706 dBm
5	17.236410 GHz	-64.119 dBm	10	24.866410 GHz	-60.910 dBm

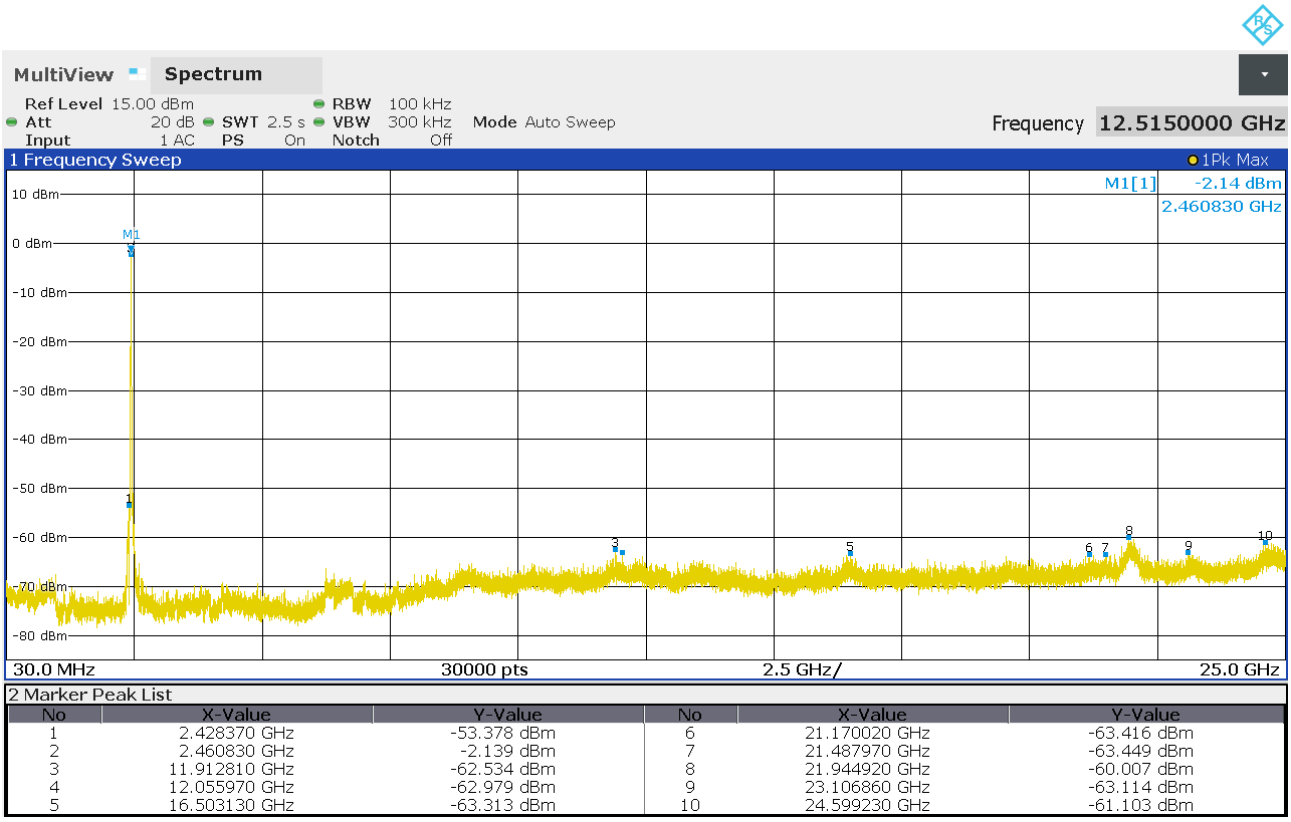
Figure 35 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11g channel 2412MHz.



2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	2.440850 GHz	3.465 dBm	6	22.131360 GHz	-60.300 dBm
2	16.436540 GHz	-62.587 dBm	7	22.953710 GHz	-63.830 dBm
3	19.506180 GHz	-63.395 dBm	8	23.221720 GHz	-63.775 dBm
4	19.540310 GHz	-63.621 dBm	9	24.153100 GHz	-63.330 dBm
5	21.032680 GHz	-63.836 dBm	10	24.743230 GHz	-61.080 dBm

Figure 36 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11g channel 2442MHz.

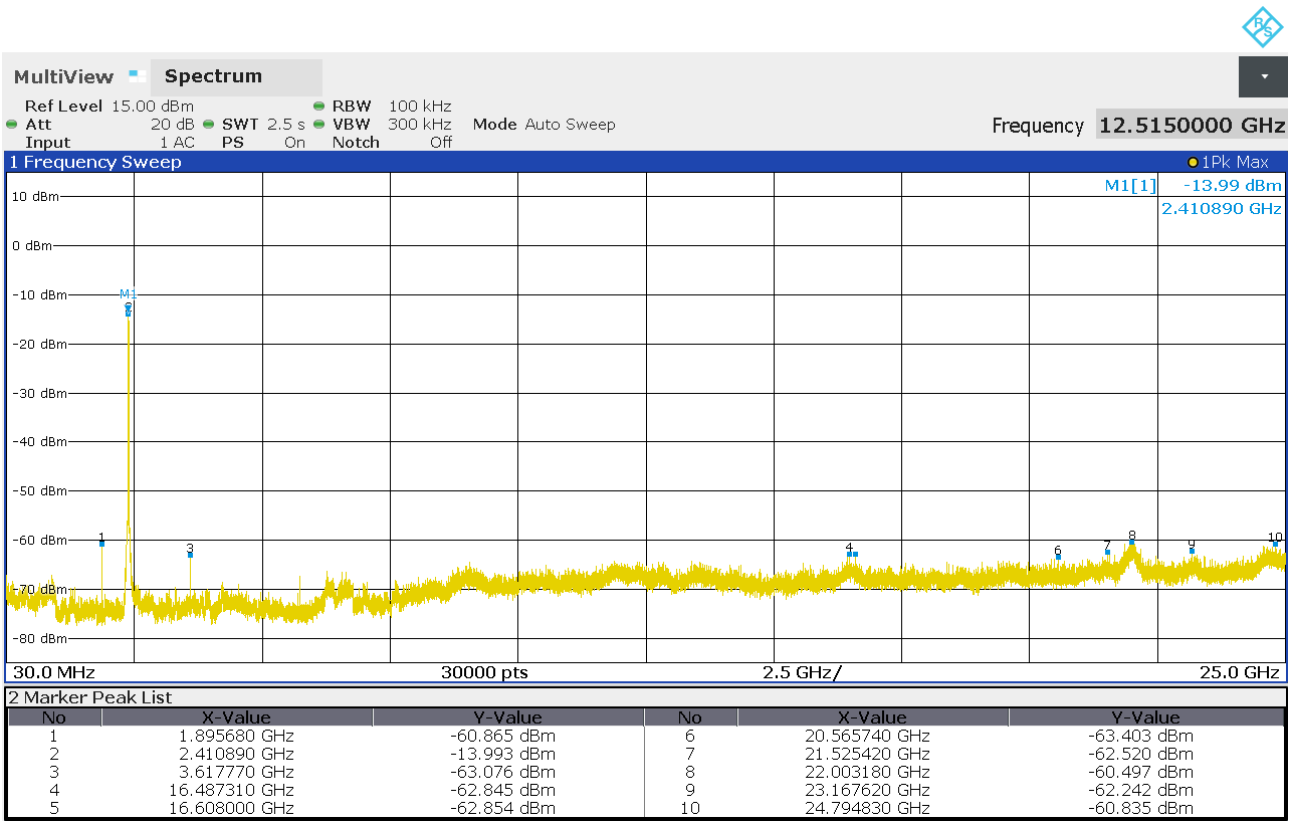


2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	2.428370 GHz	-53.378 dBm	6	21.170020 GHz	-63.416 dBm
2	2.460830 GHz	-2.139 dBm	7	21.487970 GHz	-63.449 dBm
3	11.912810 GHz	-62.534 dBm	8	21.944920 GHz	-60.007 dBm
4	12.055970 GHz	-62.979 dBm	9	23.106860 GHz	-63.114 dBm
5	16.503130 GHz	-63.313 dBm	10	24.599230 GHz	-61.103 dBm

Figure 37 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11g channel 2462MHz.

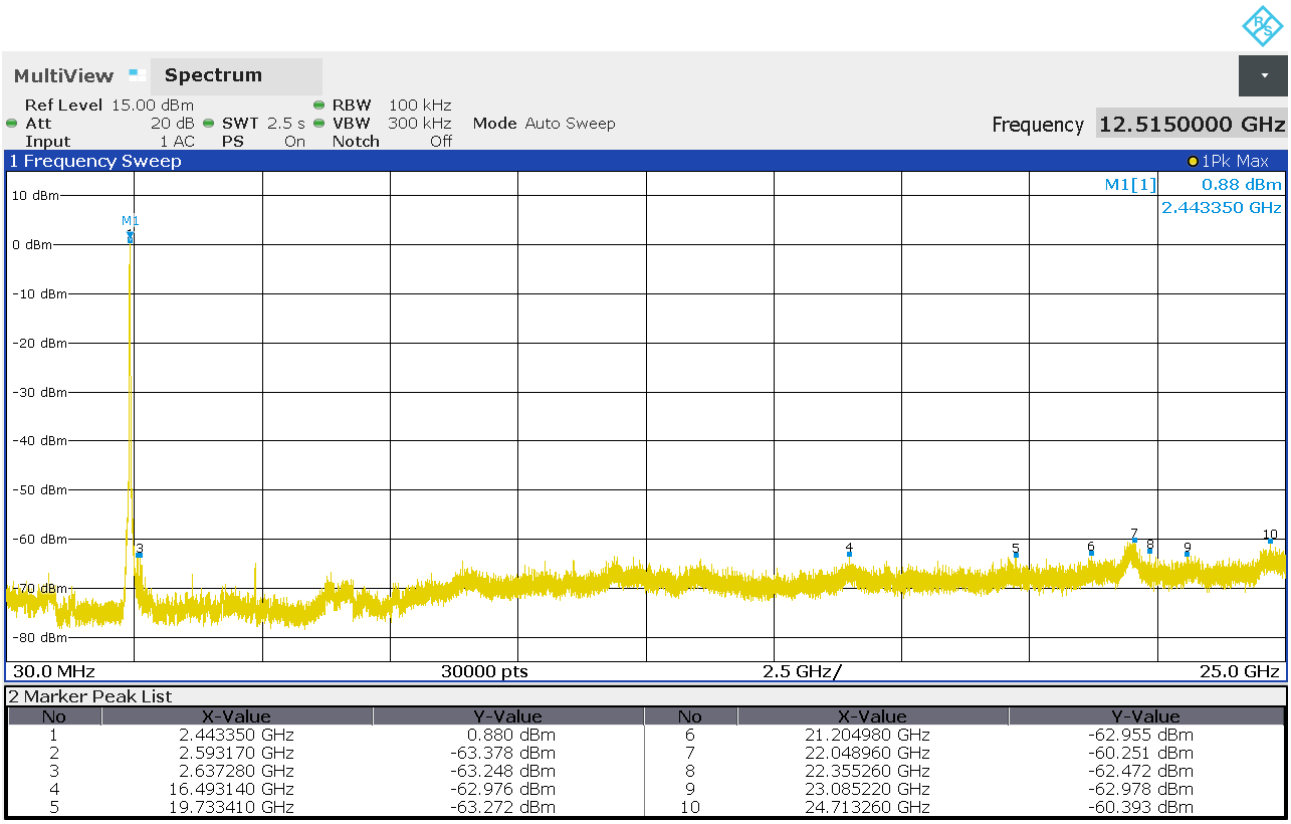
5.6.10 Antenna port conducted emissions IEEE 802.11n, 30MHz to 25GHz



2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	1.895680 GHz	-60.865 dBm	6	20.565740 GHz	-63.403 dBm
2	2.410890 GHz	-13.993 dBm	7	21.525420 GHz	-62.520 dBm
3	3.617770 GHz	-63.076 dBm	8	22.003180 GHz	-60.497 dBm
4	16.487310 GHz	-62.845 dBm	9	23.167620 GHz	-62.242 dBm
5	16.608000 GHz	-62.854 dBm	10	24.794830 GHz	-60.835 dBm

Figure 38 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11n channel 2412MHz.



2 Marker Peak List

No	X-Value	Y-Value	No	X-Value	Y-Value
1	2.443350 GHz	0.880 dBm	6	21.204980 GHz	-62.955 dBm
2	2.593170 GHz	-63.378 dBm	7	22.048960 GHz	-60.251 dBm
3	2.637280 GHz	-63.248 dBm	8	22.355260 GHz	-62.472 dBm
4	16.493140 GHz	-62.976 dBm	9	23.085220 GHz	-62.978 dBm
5	19.733410 GHz	-63.272 dBm	10	24.713260 GHz	-60.393 dBm

Figure 39 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11n channel 2442MHz.

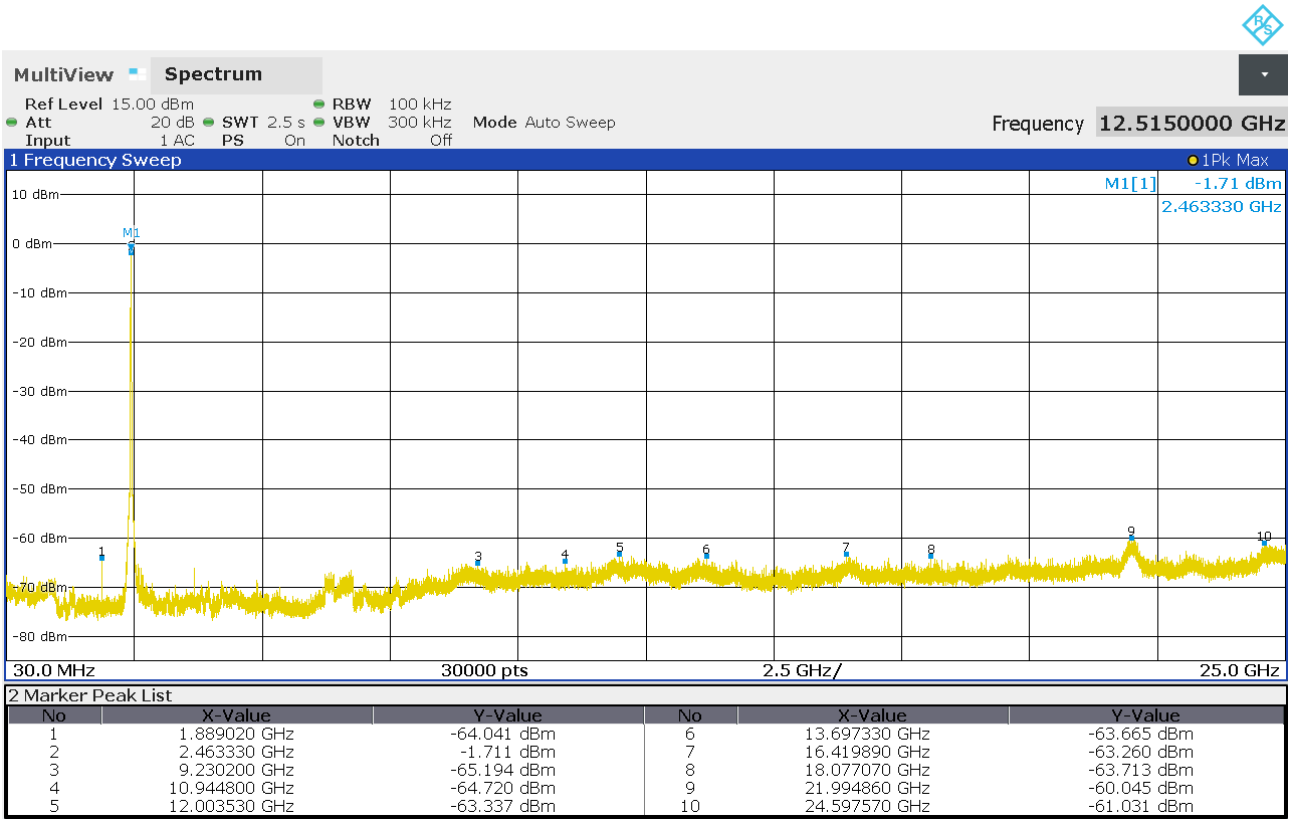


Figure 40 Conducted emissions 30MHz to 25GHz. Operation on IEEE 802.11n channel 2462MHz.

Section 6 6dB Bandwidth and 99% Occupied Bandwidth

6.1 Test Specification

FCC Rule Part	46CFR 15.247 (b)(2)
Standard	ANSI C63.10:2013
Measurement Uncertainty Frequency tests	$\pm 9 \times 10^{-8}$

6.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	11.9.1.1 (RBW>DTS bandwidth)
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(a)(2) 6dB bandwidth
	Peak
2400MHz to 2483.5MHz	At least 500kHz

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.8.1

Receiver Parameters	Setting
Detector Function	Peak
Span	30MHz
Resolution Bandwidth	100kHz
Video Bandwidth	300kHz
Sweep rate	Auto couple
Trace mode	Max hold

6.2.1 Emissions measurements

6.2.2 Date of Test

17th September 2024

6.2.3 Test Area

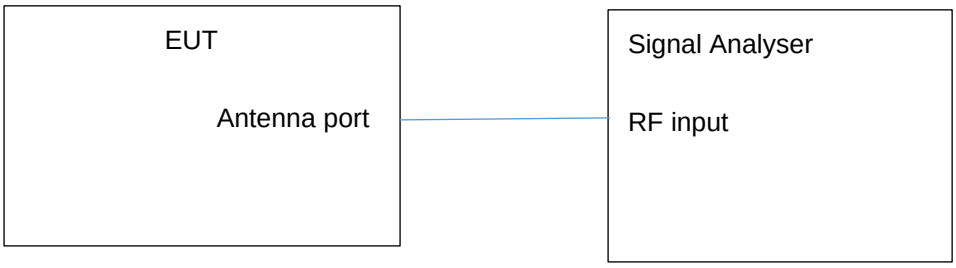
LAB 8

6.2.4 Tested by

J Beevers

6.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



6.2.6 Test Results

The results of the 6dB bandwidth measurements are stated in the table below and by the signal analyser images.

Channel (MHz)	99% Occupied Bandwidth (MHz)	Measured 6dB bandwidth (kHz)	Minimum requirement (kHz)	Figure	Result
2412.0	14.11	8678	500.0	41 & 44	Pass
2442.0	14.16	9054	500.0	42 & 45	Pass
2462.0	14.18	9048	500.0	43 & 46	Pass

Table 11 IEEE 802.11b Bandwidth Measurements

Channel (MHz)	99% Occupied Bandwidth (MHz)	Measured 6dB bandwidth (kHz)	Minimum requirement (kHz)	Figure	Result
2412.0	16.60	15306	500.0	47 & 50	Pass
2442.0	16.56	16299	500.0	48 & 51	Pass
2462.0	16.47	16290	500.0	49 & 52	Pass

Table 12 IEEE 802.11g Bandwidth Measurements

Channel (MHz)	99% Occupied Bandwidth (MHz)	Measured 6dB bandwidth (kHz)	Minimum requirement (kHz)	Figure	Result
2412.0	17.59	15282	500.0	53 & 56	Pass
2442.0	17.65	17028	500.0	54 & 57	Pass
2462.0	17.52	16014	500.0	55 & 58	Pass

Table 13 IEEE 802.11n Bandwidth Measurements

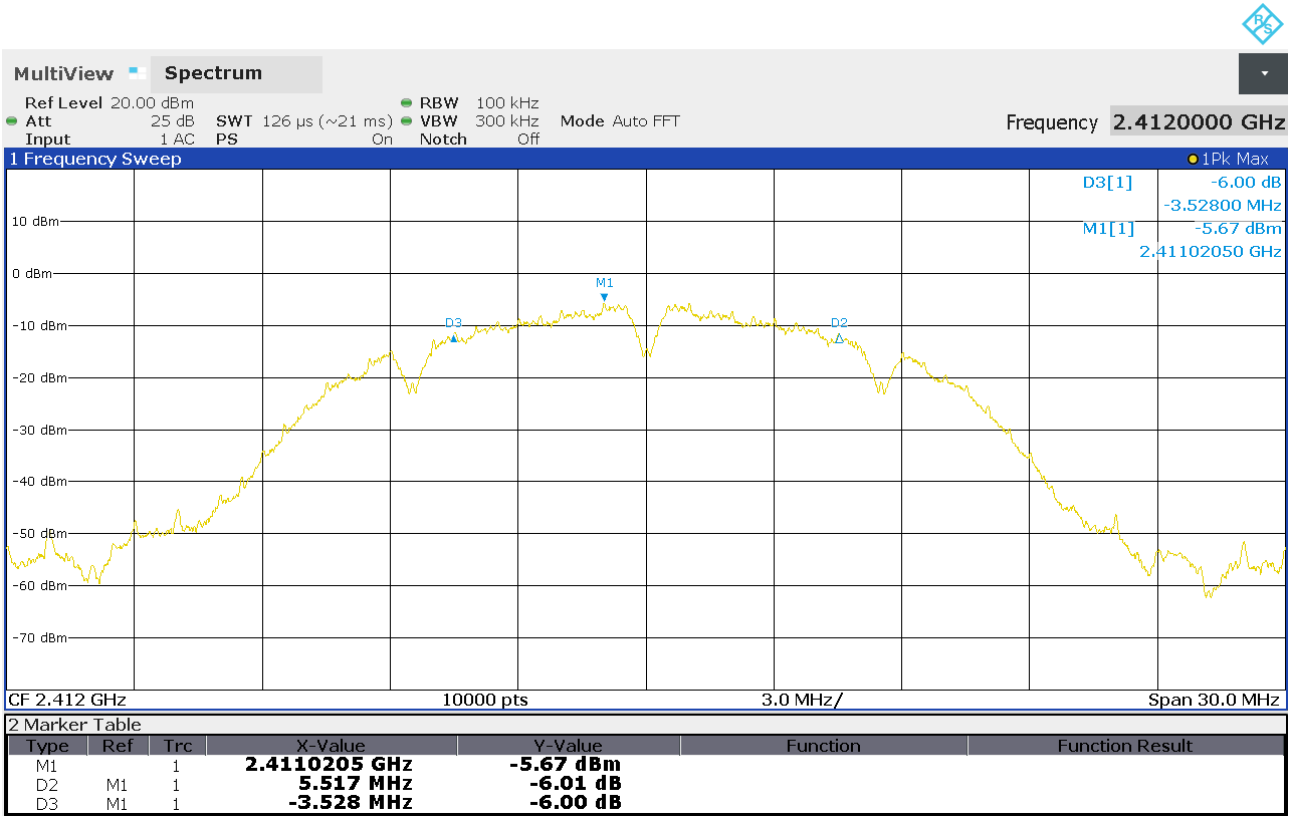


Figure 41 Bandwidth at 6dB Point. Operation on IEEE 802.11b channel 2412MHz

Figure 42 Bandwidth at 6dB Point. Operation on IEEE 802.11b channel 2442MHz

Figure 43 Bandwidth at 6dB Point. Operation on IEEE 802.11b channel 2462MHz

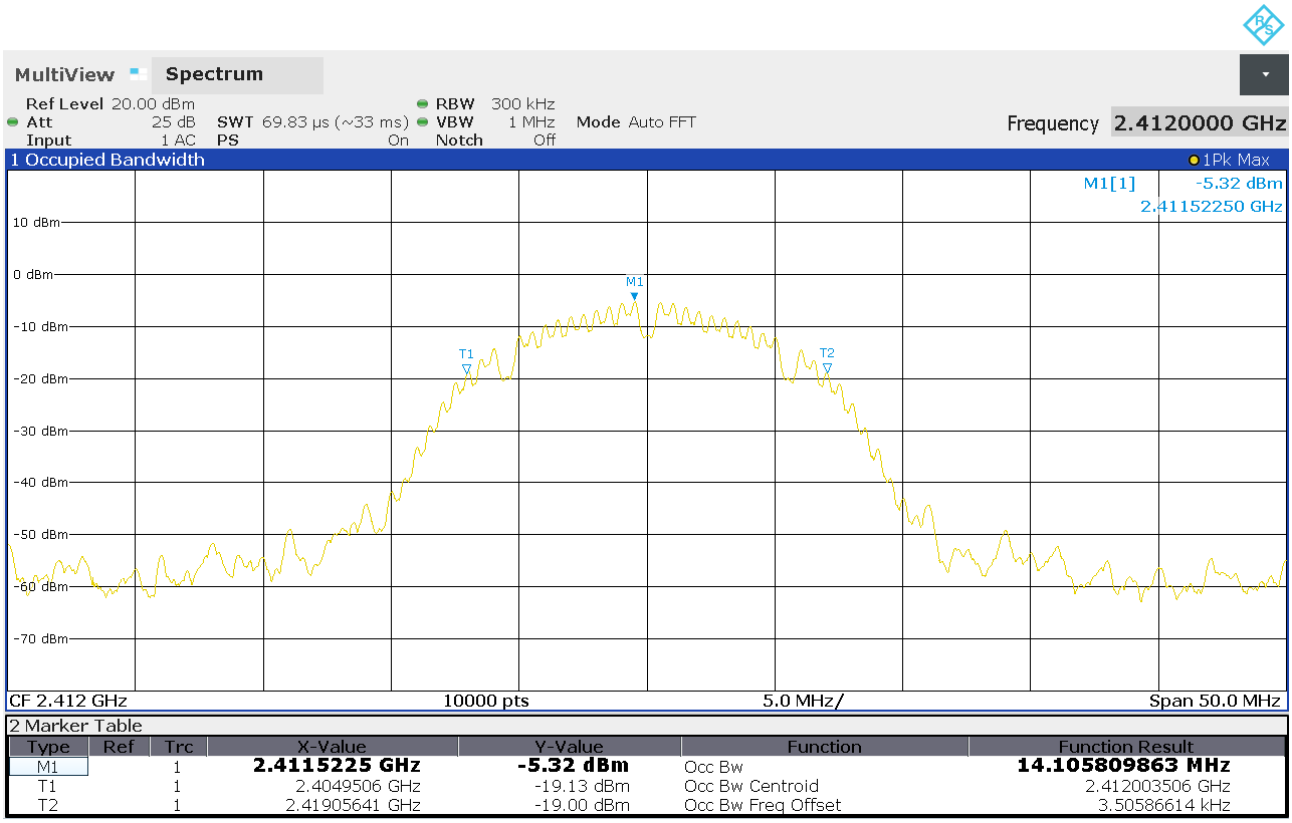


Figure 44 99% Occupied Bandwidth. Operation on IEEE 802.11b channel 2412MHz

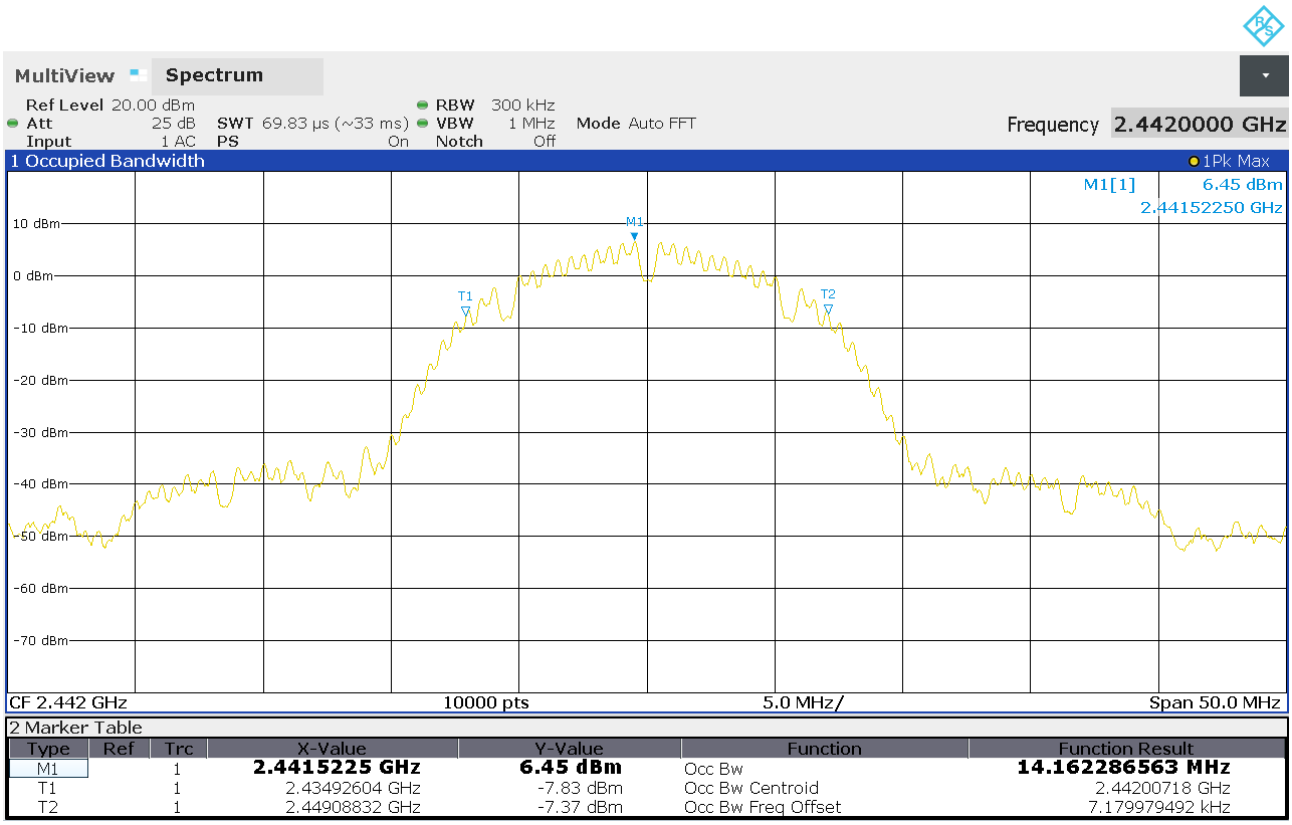


Figure 45 99% Occupied Bandwidth. Operation on IEEE 802.11b channel 2442MHz

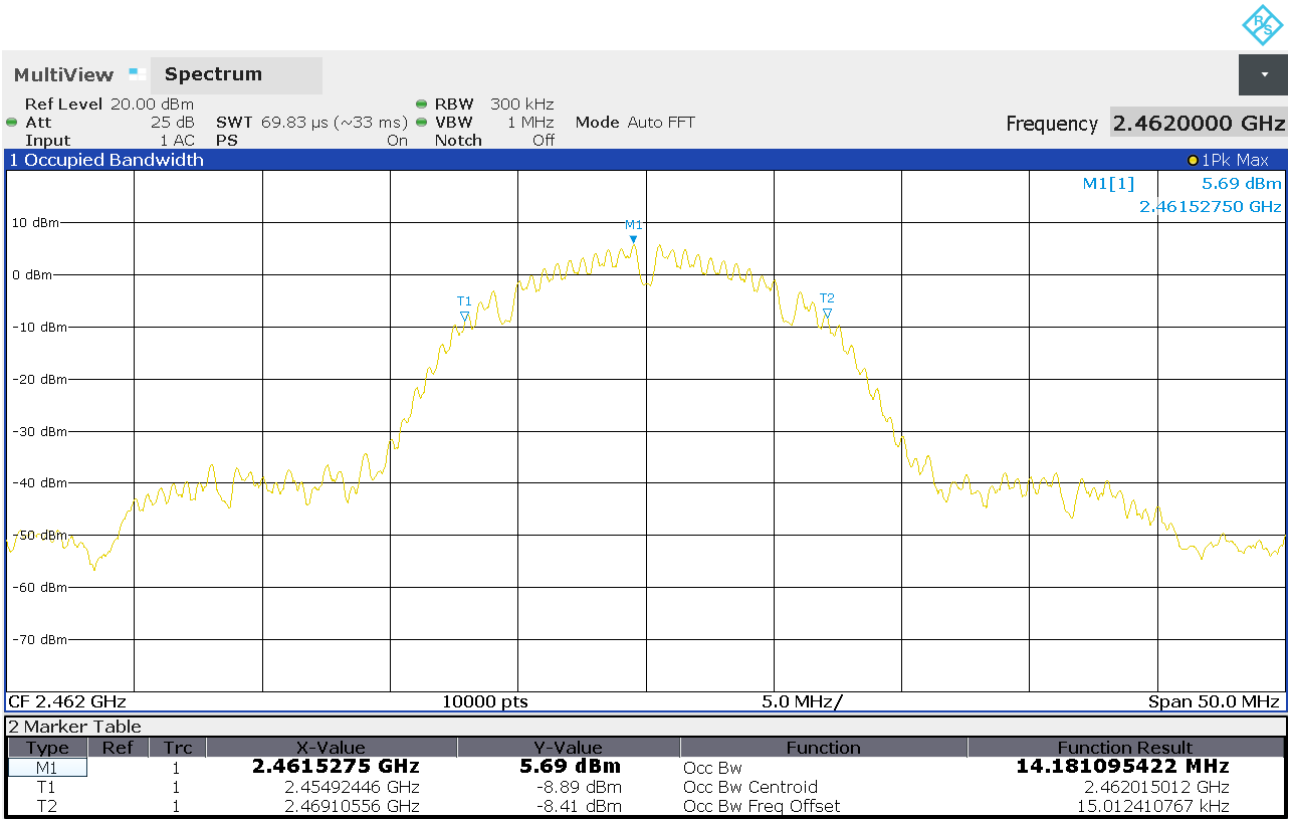


Figure 46 99% Occupied Bandwidth. Operation on IEEE 802.11b channel 2462MHz

Figure 47 Bandwidth at 6dB Point. Operation on IEEE 802.11g channel 2412MHz

Figure 48 Bandwidth at 6dB Point. Operation on IEEE 802.11g channel 2442MHz

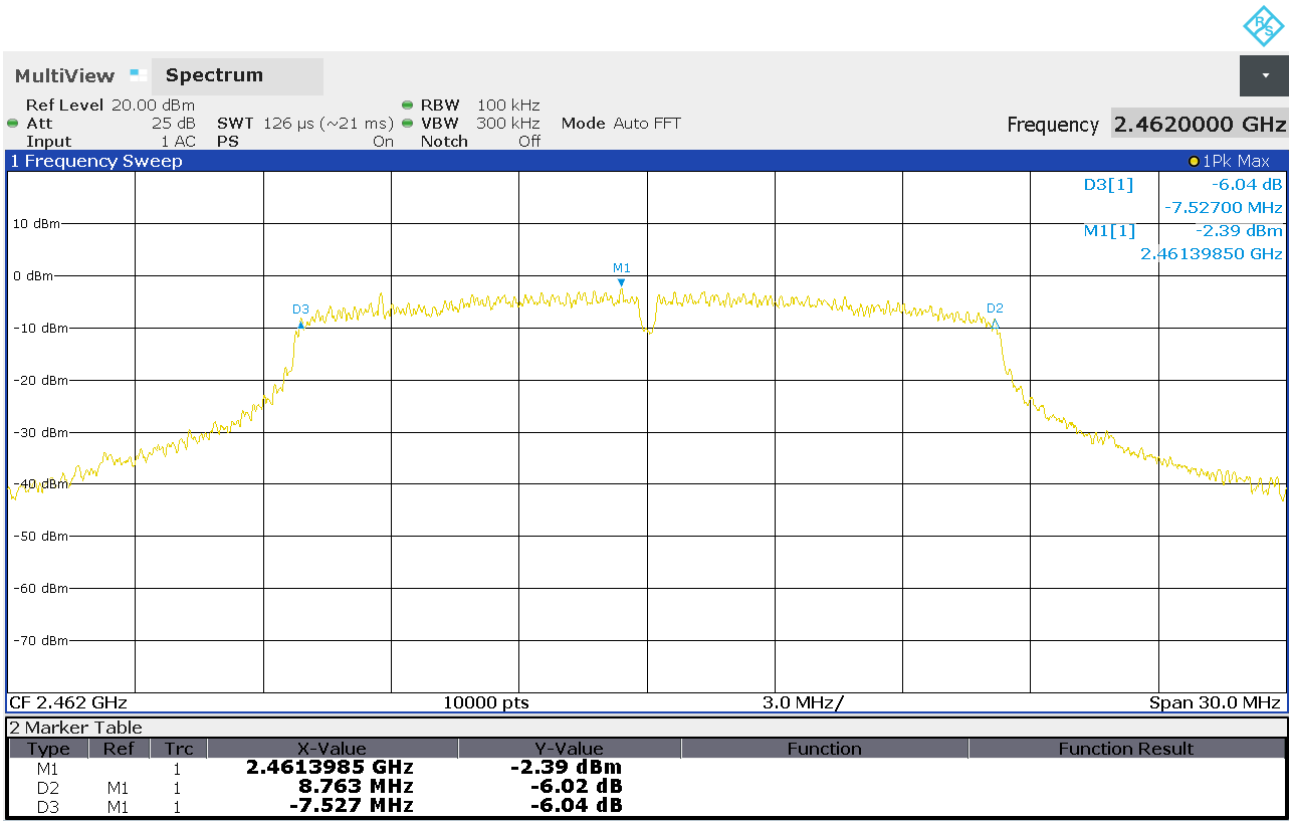


Figure 49 Bandwidth at 6dB Point. Operation on IEEE 802.11g channel 2462MHz

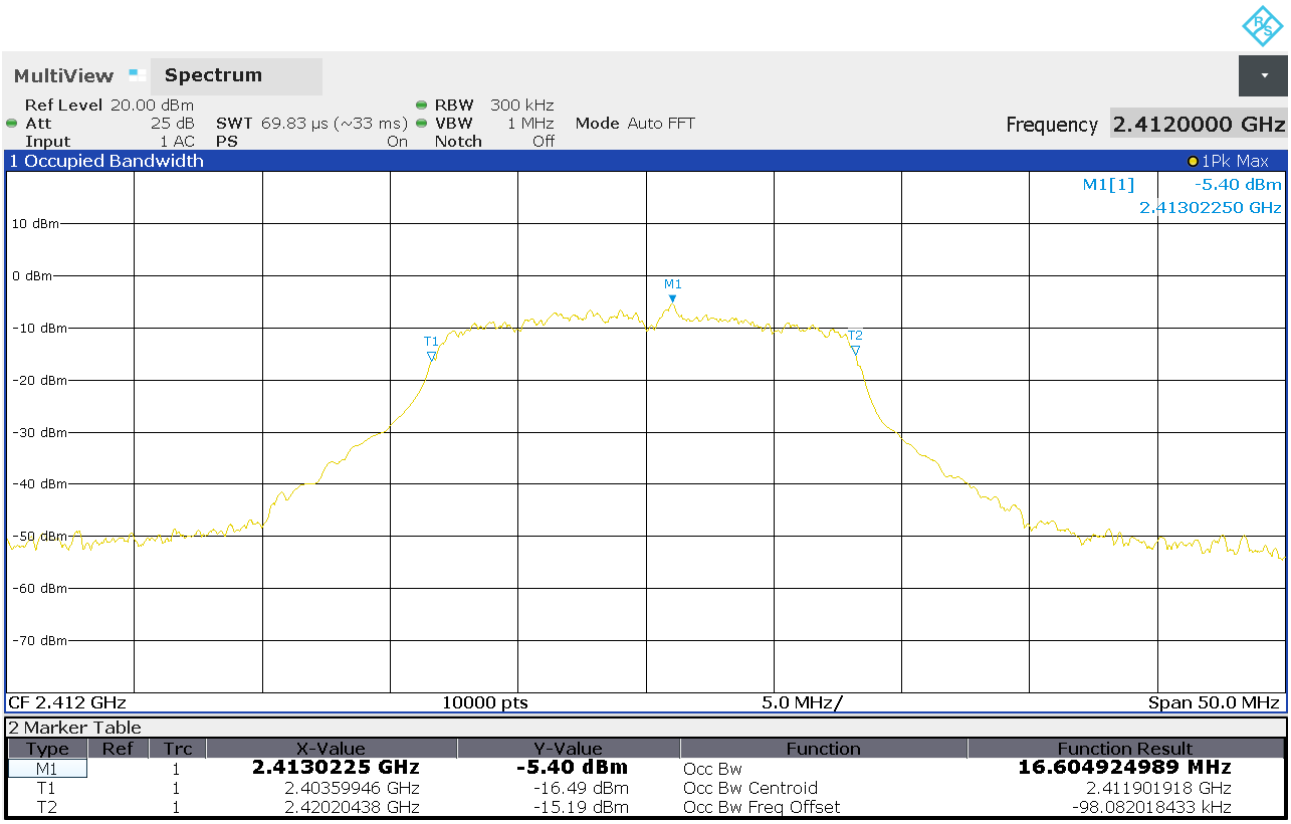


Figure 50 99% Occupied Bandwidth. Operation on IEEE 802.11g channel 2412MHz

Figure 51 99% Occupied Bandwidth. Operation on IEEE 802.11g channel 2442MHz

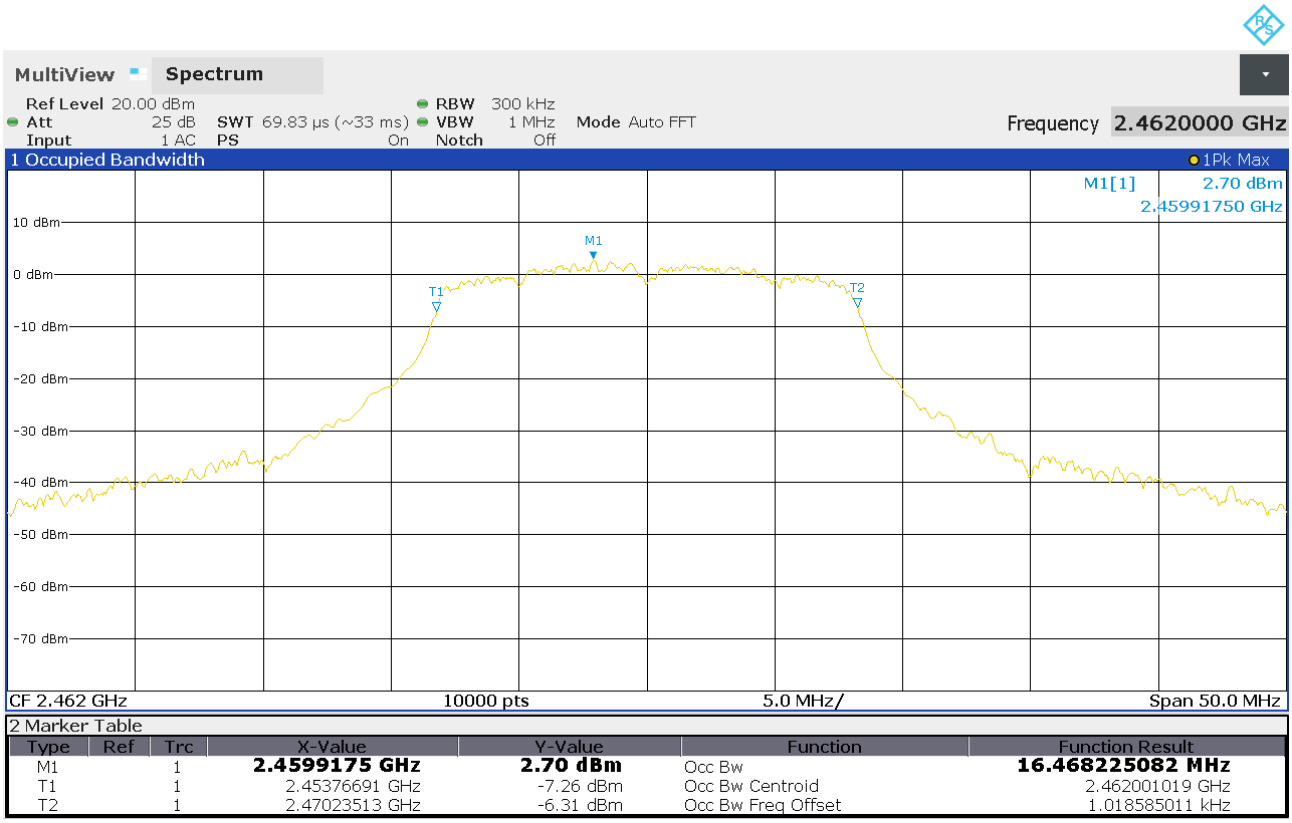


Figure 52 99% Occupied Bandwidth. Operation on IEEE 802.11g channel 2462MHz

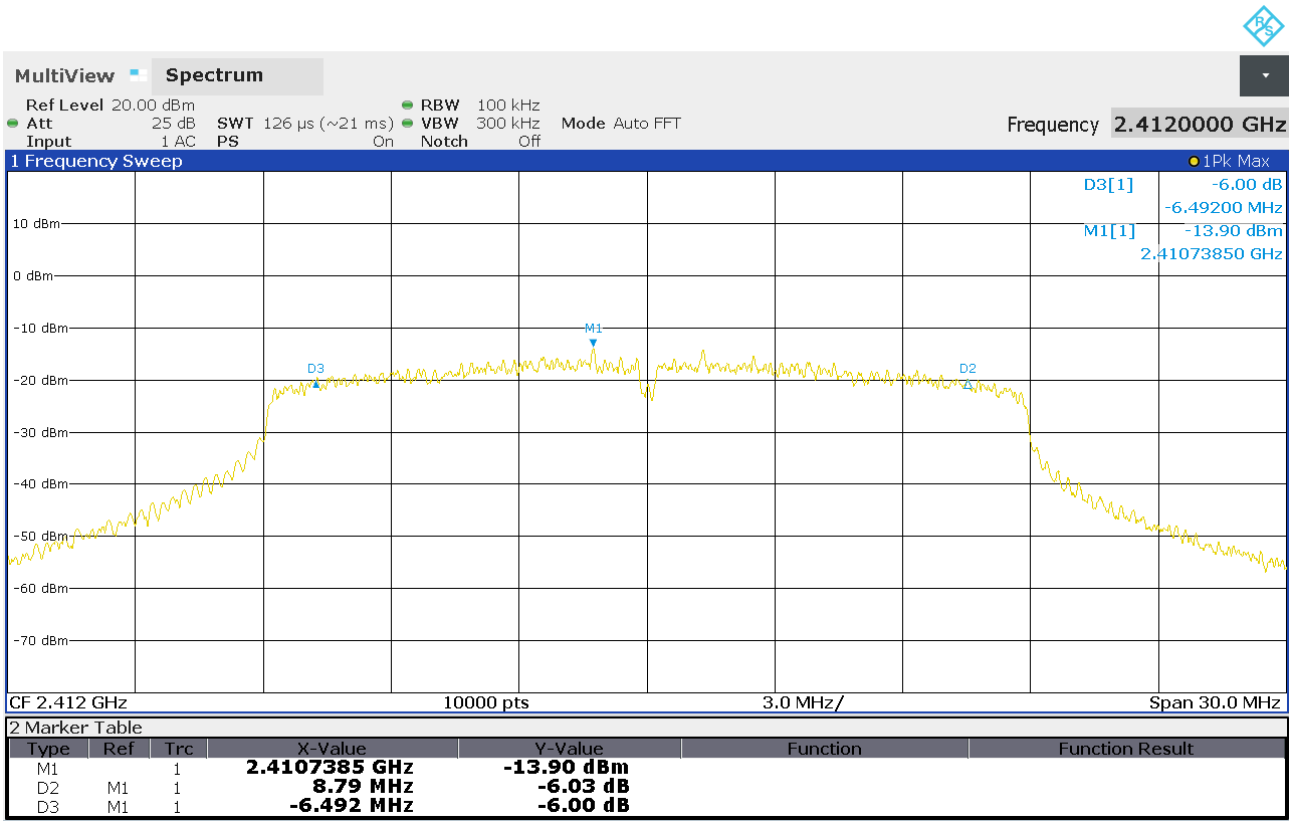


Figure 53 Bandwidth at 6dB Point. Operation on IEEE 802.11n channel 2412MHz

Figure 54 Bandwidth at 6dB Point. Operation on IEEE 802.11n channel 2442MHz

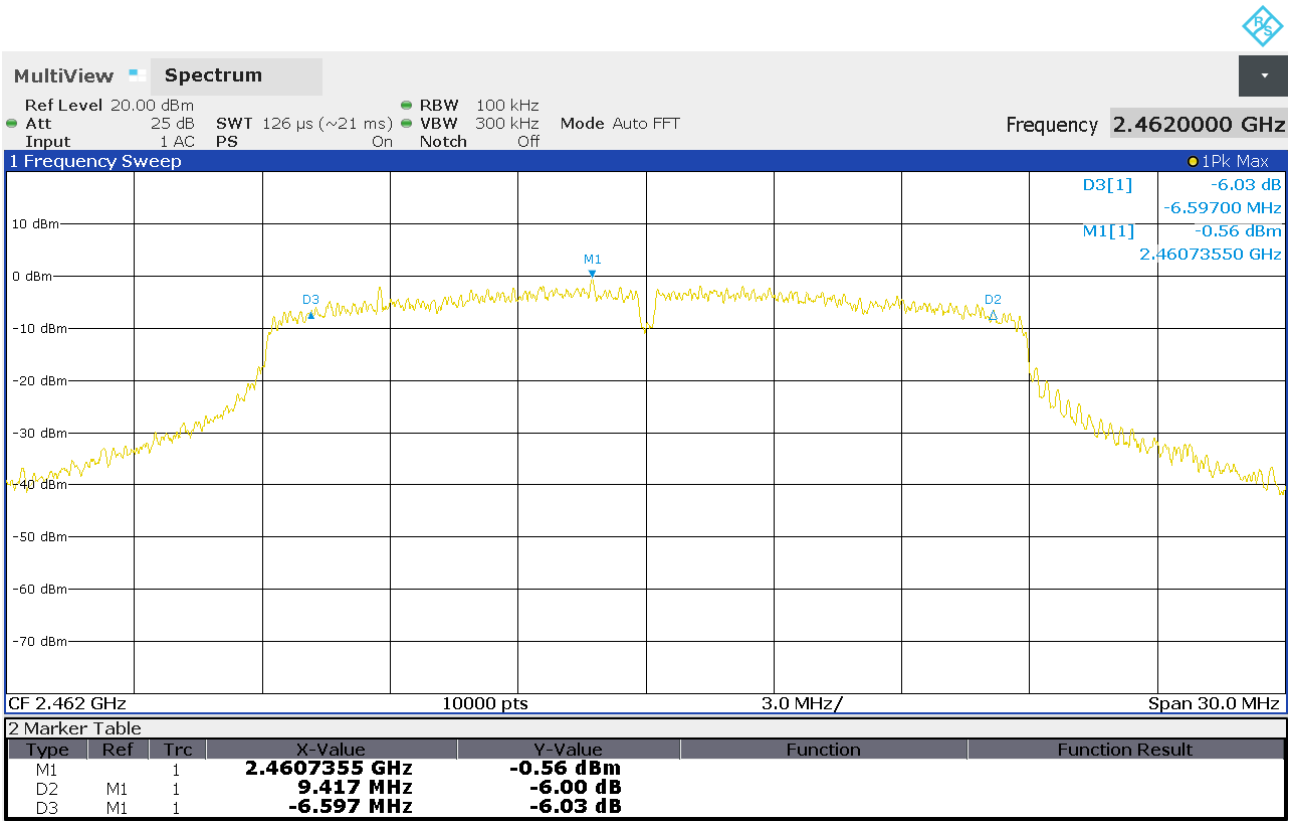


Figure 55 Bandwidth at 6dB Point. Operation on IEEE 802.11n channel 2462MHz

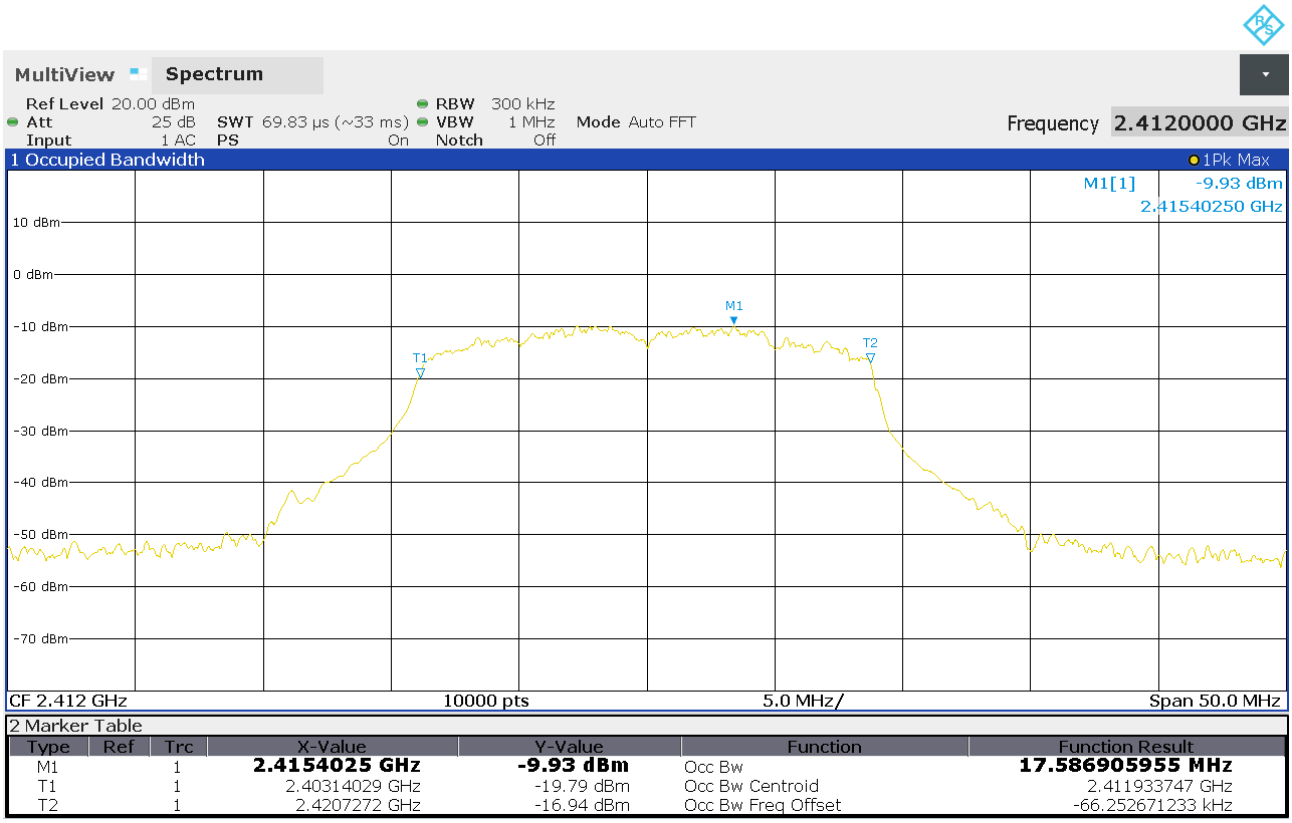


Figure 56 99% Occupied Bandwidth. Operation on IEEE 802.11n channel 2412MHz

Figure 57 99% Occupied Bandwidth. Operation on IEEE 802.11n channel 2442MHz

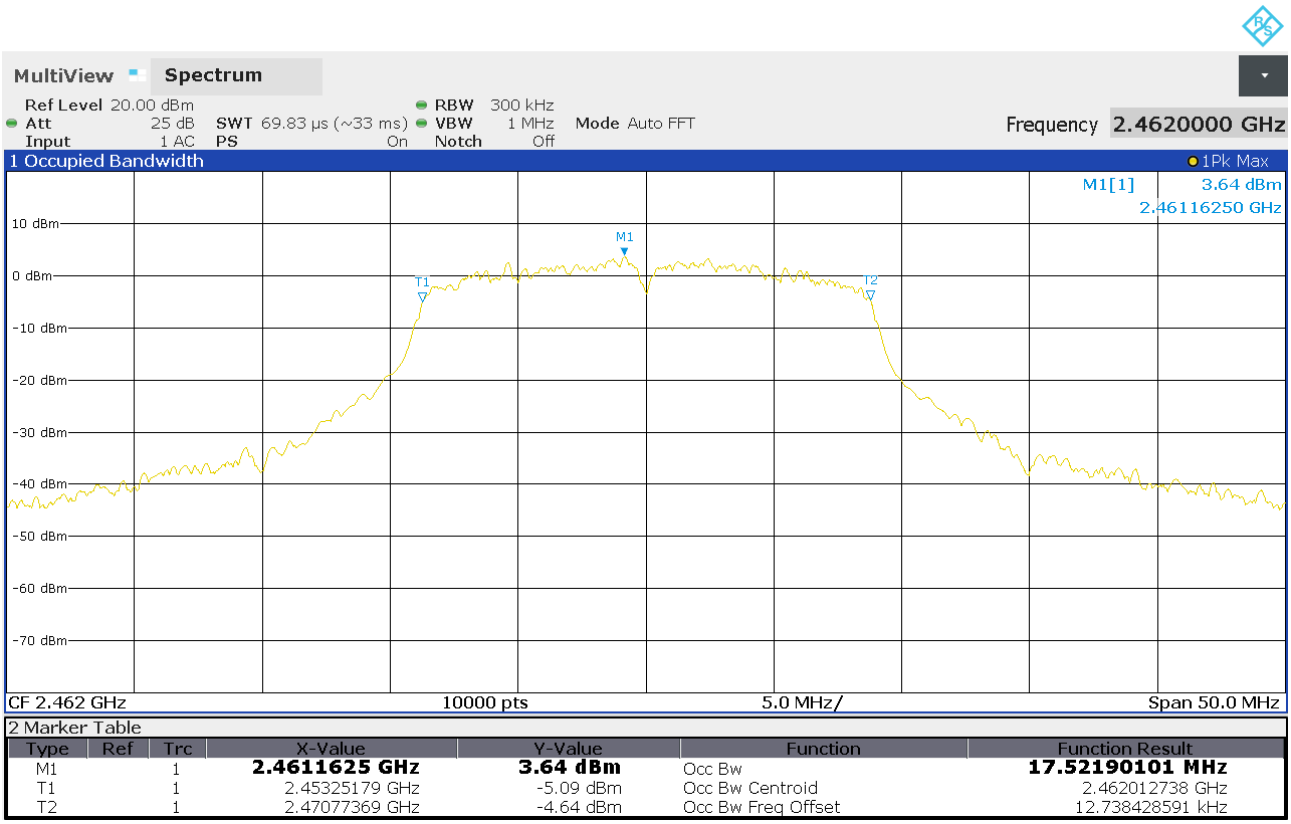


Figure 58 99% Occupied Bandwidth. Operation on IEEE 802.11n channel 2462MHz

Section 7 Peak Output Power

7.1 Test Specification

FCC Rule Part	46CFR 15.247 (b)(3)
Standard	ANSI C63.10:2013
Measurement Uncertainty Conducted Power tests	±1.4dB

7.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	11.9.1.1 (RBS>DTS bandwidth)
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(b)(2)
	Peak
2400MHz to 2483.5MHz	1 watt

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.11.2

Receiver Parameters	Setting
Detector Function	Peak
Span	100MHz
Resolution Bandwidth	20MHz
Video Bandwidth	80MHz
Sweep rate	Auto couple
Trace mode	Max hold

7.2.1 Emissions measurements

7.2.2 Date of Test

17th September 2024

7.2.3 Test Area

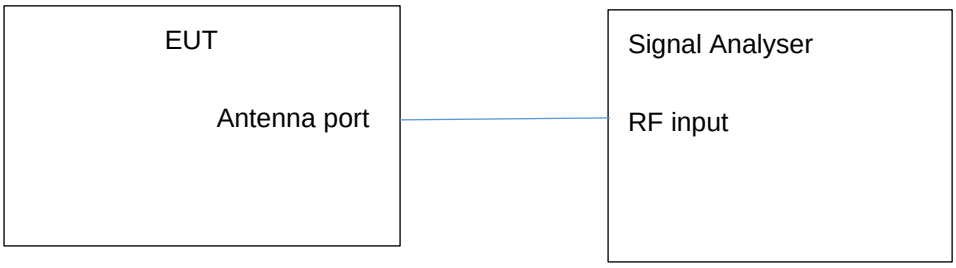
LAB 8

7.2.4 Tested by

J Beevers

7.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



7.2.6 Test Result

The results of the peak output power measurements are stated in the table below and by the signal analyser images.

Modulation scheme	Channel (MHz)	Peak Power (dBm)	Peak Power (Watts)	Limit (Watts)	Figure
IEEE 802.11b	2412	6.94	0.005	1	59
IEEE 802.11b	2442	16.55	0.045	1	60
IEEE 802.11b	2462	16.36	0.043	1	61
IEEE 802.11g	2412	12.75	0.019	1	62
IEEE 802.11g	2442	24.93	0.311	1	63
IEEE 802.11g	2462	21.94	0.156	1	64
IEEE 802.11n	2412	11.39	0.014	1	65
IEEE 802.11n	2442	24.18	0.262	1	66
IEEE 802.11n	2462	21.72	0.149	1	67

Table 14 Peak Output Power Measurements

The MAX antenna gain is 2.0 dBi, MAX EIRP=MAX peak power *MAX antenna gain=24.93 + 2.0 = 26.93 dBm. The Max EIRP is 26.93 dBm (0.493W) and does not exceed 4W, which meets the EIRP requirement of RSS-247 section 5.4.

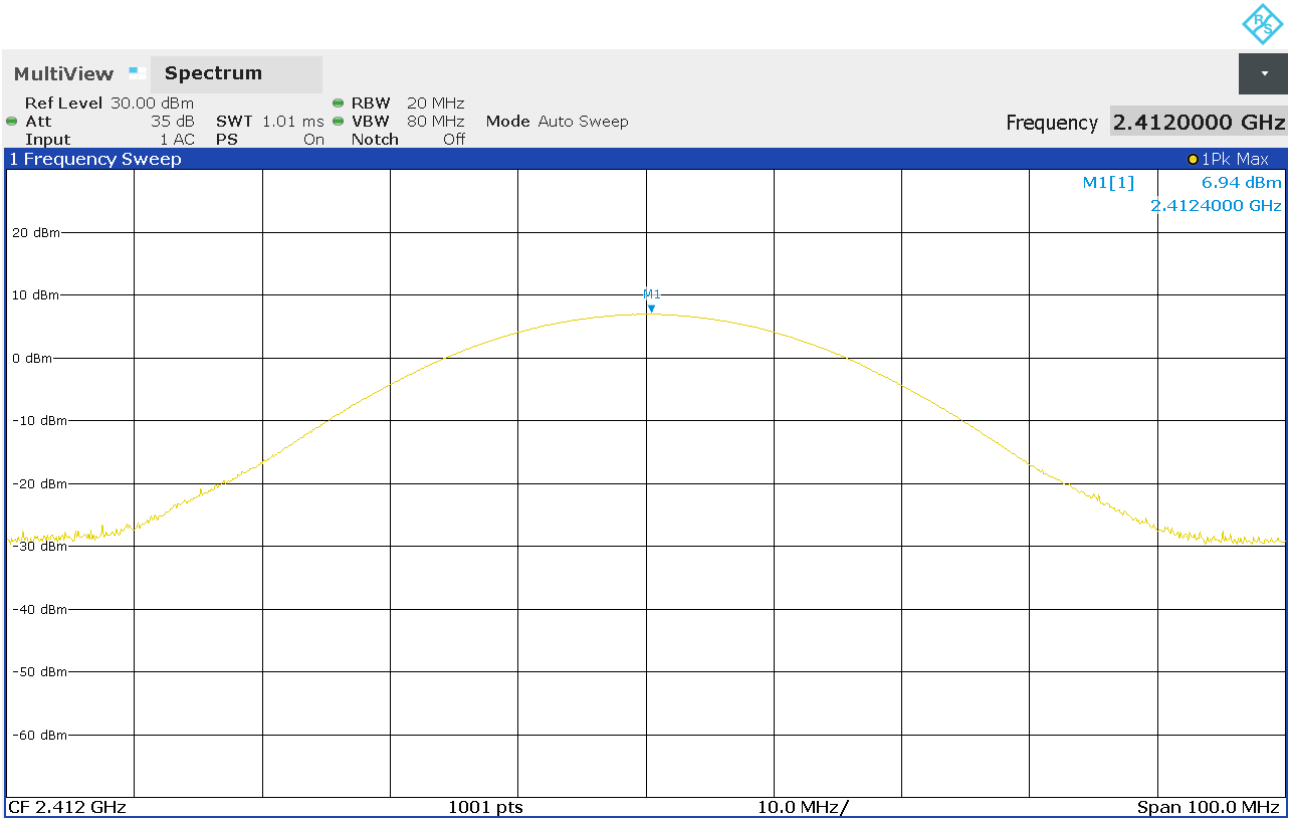


Figure 59 Peak output power, Operation on IEEE 802.11b channel 2412MHz

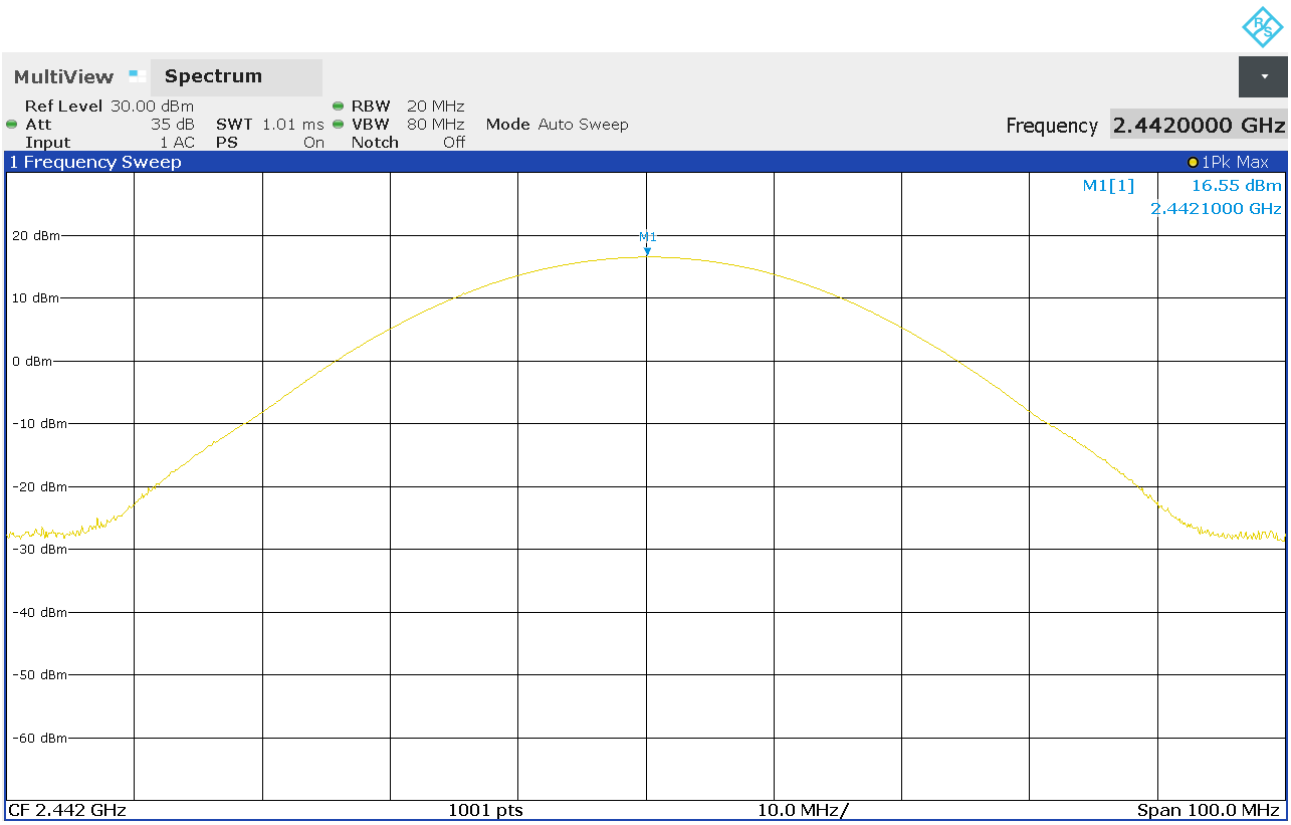


Figure 60 Peak output power, Operation on IEEE 802.11b channel 2442MHz

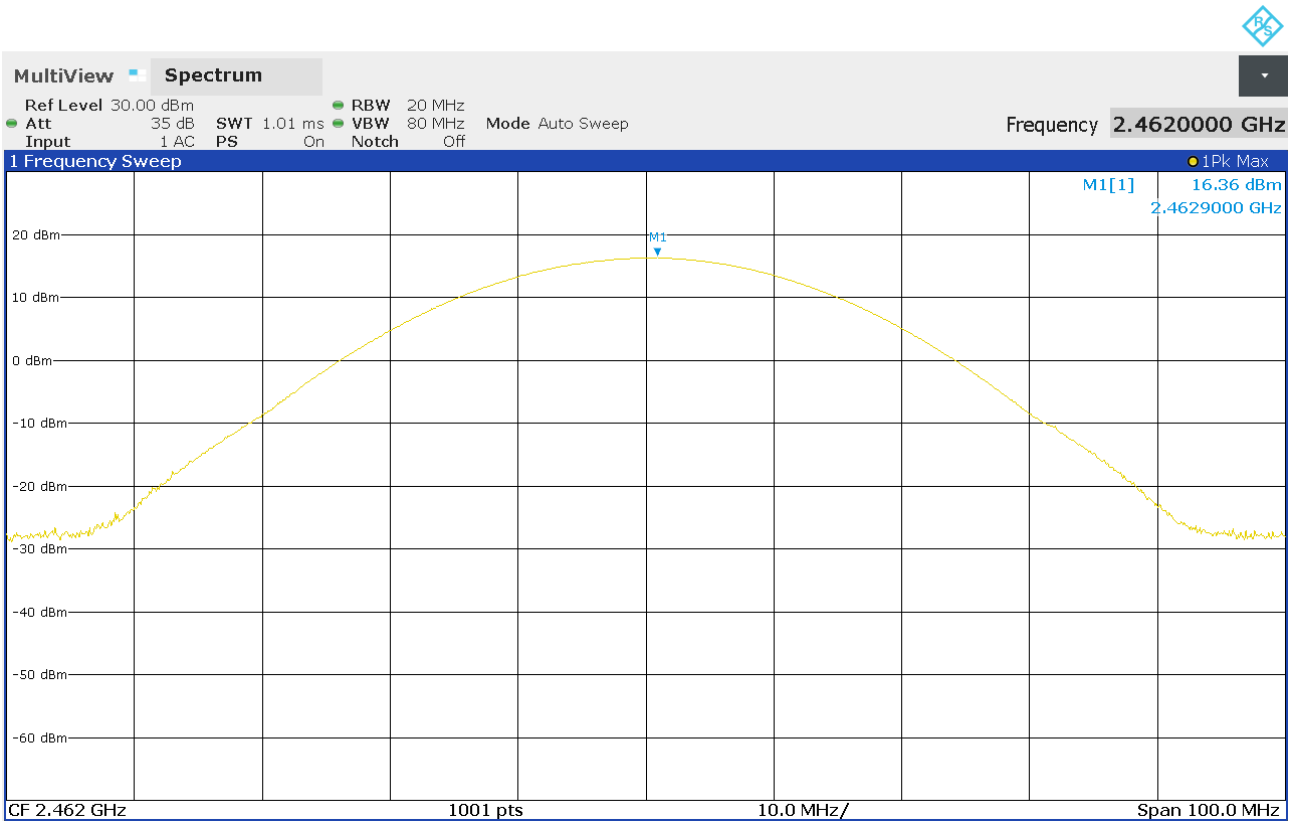


Figure 61 Peak output power, Operation on IEEE 802.11b channel 2462MHz

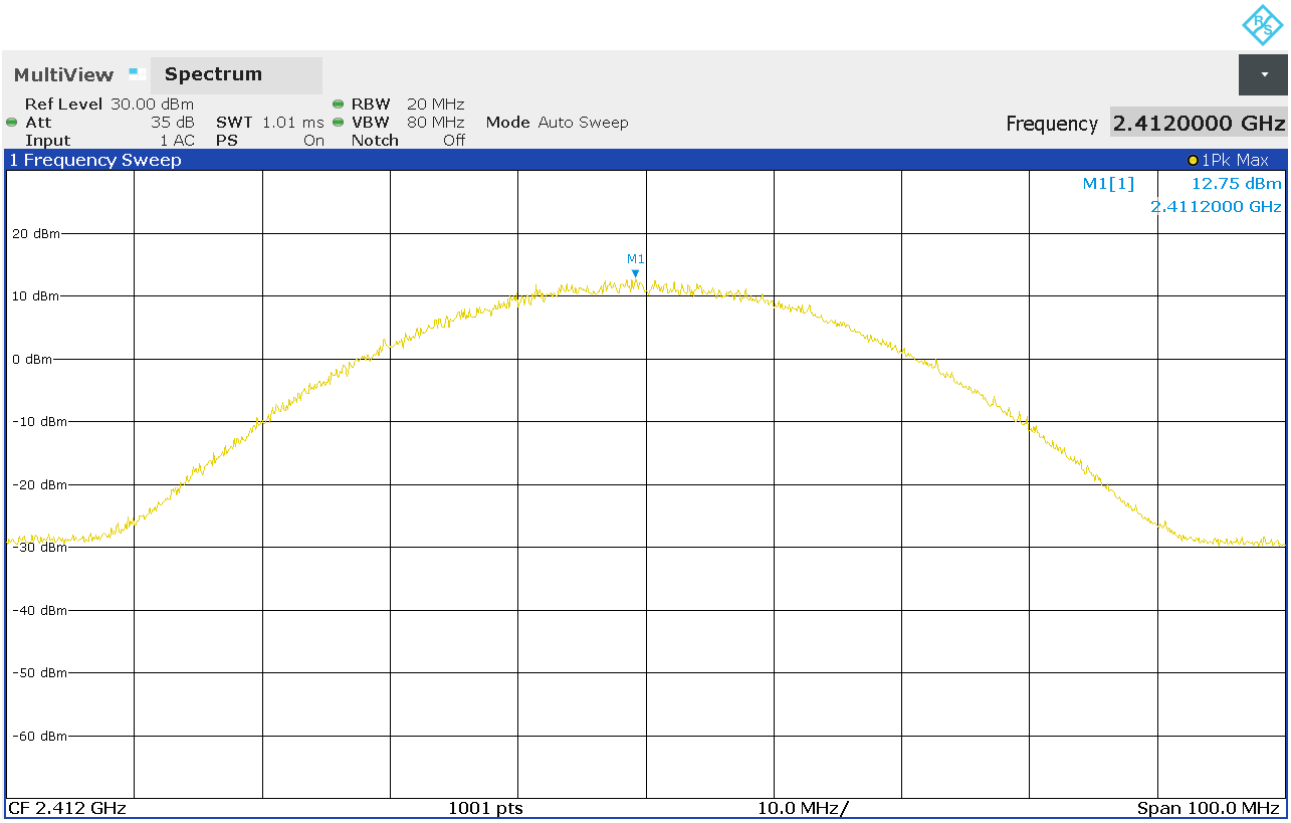


Figure 62 Peak output power, Operation on IEEE 802.11g channel 2412MHz

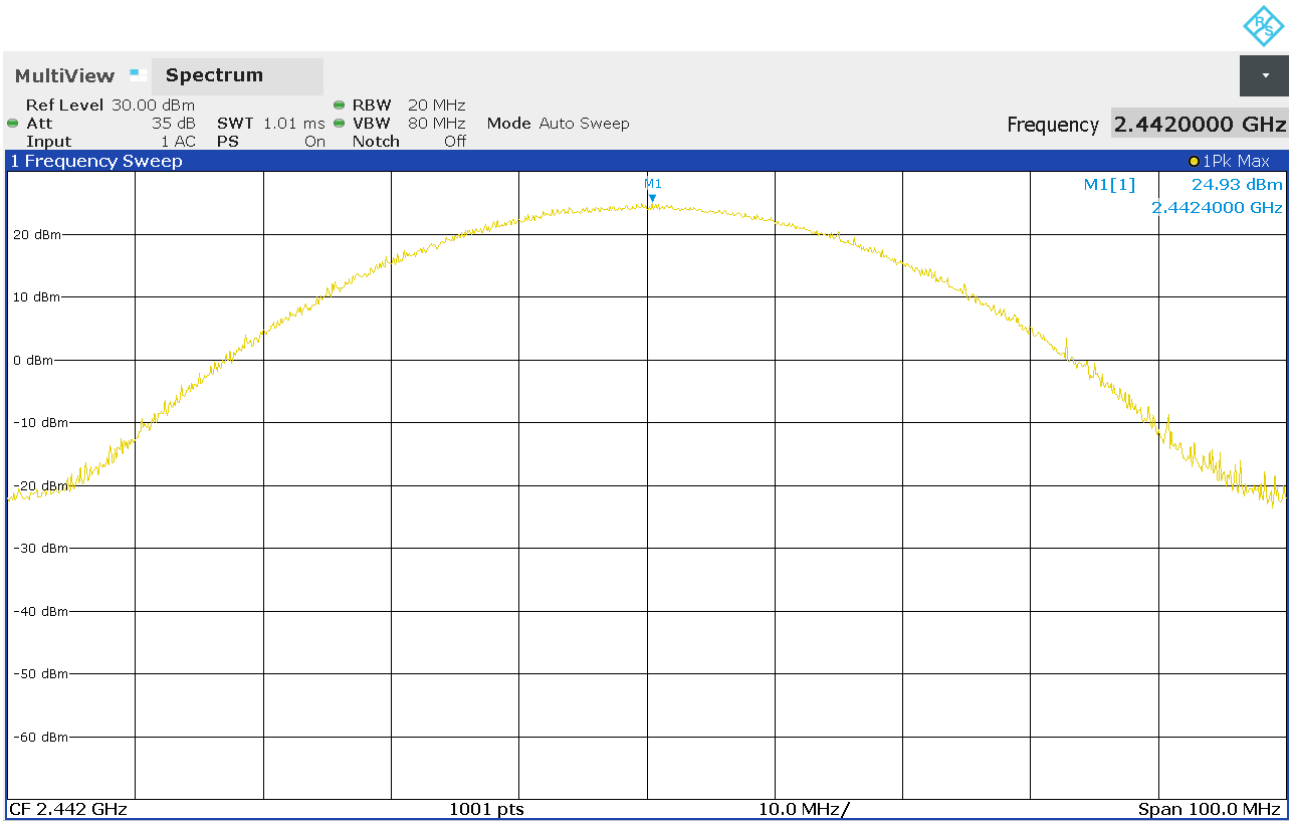


Figure 63 Peak output power, Operation on IEEE 802.11g channel 2442MHz

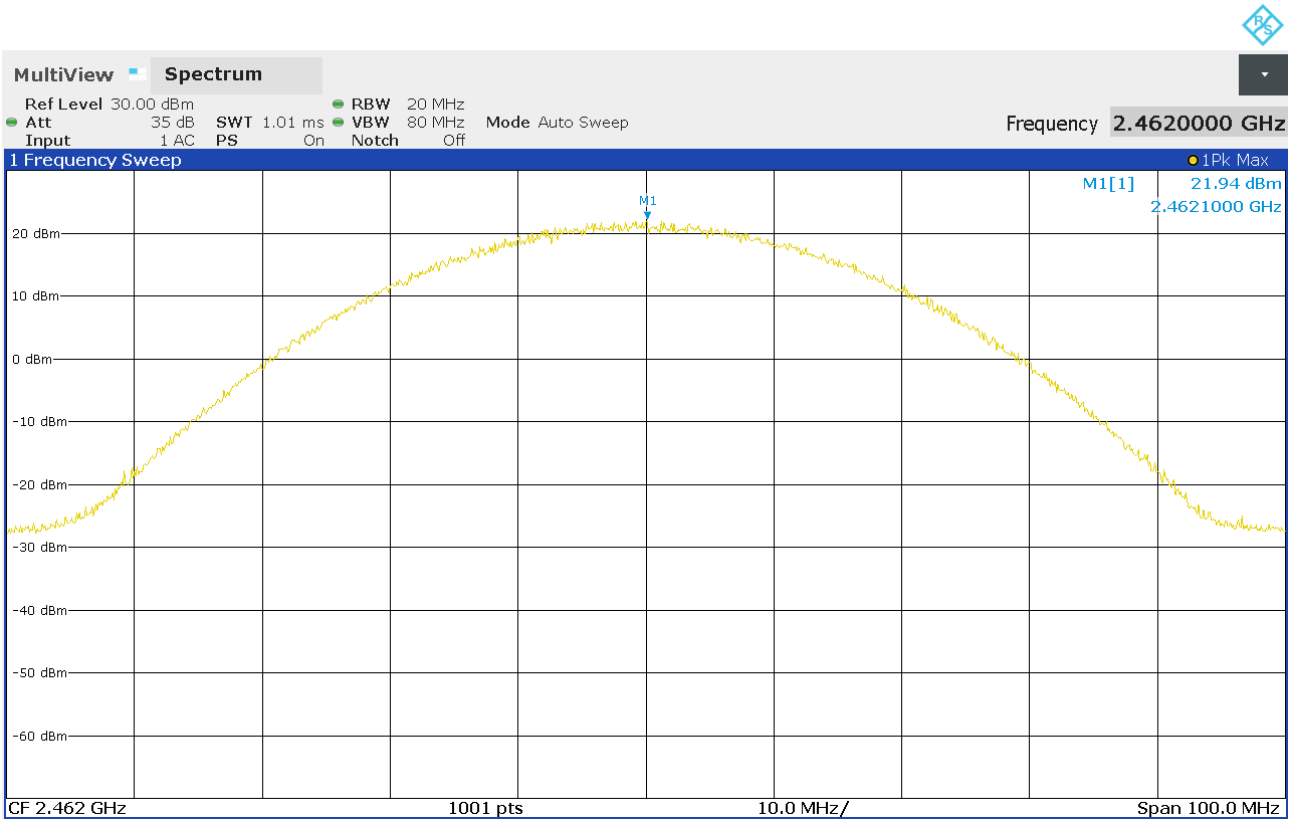


Figure 64 Peak output power, Operation on IEEE 802.11g channel 2462MHz

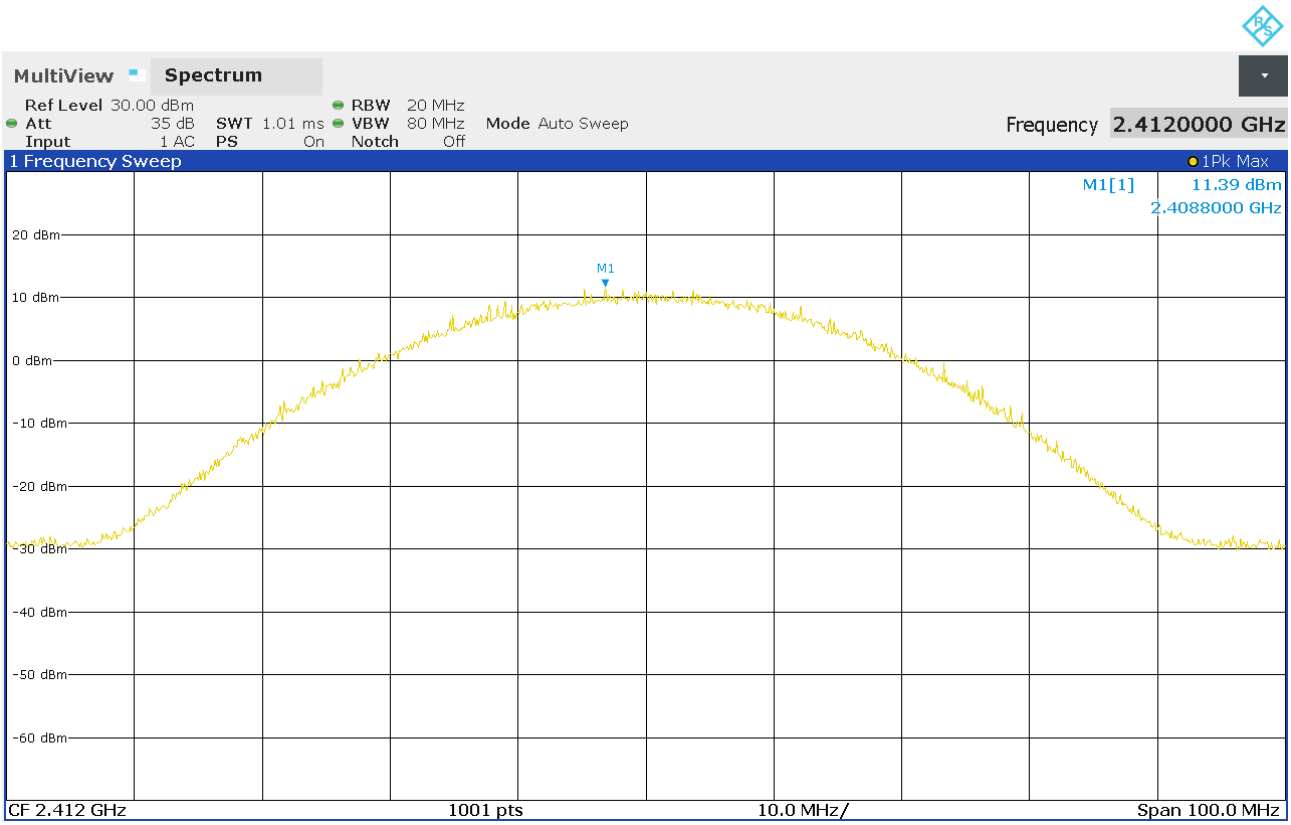


Figure 65 Peak output power, Operation on IEEE 802.11n channel 2412MHz

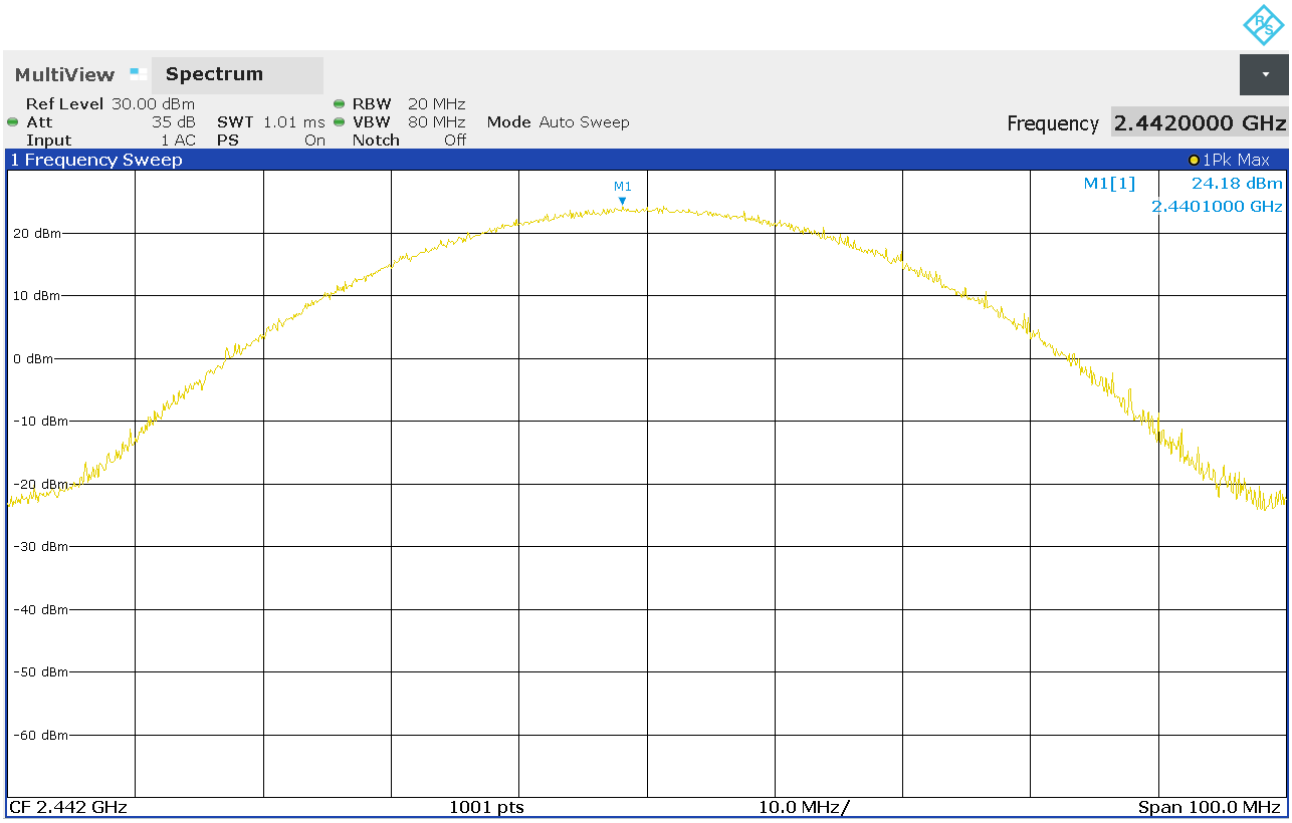


Figure 66 Peak output power, Operation on IEEE 802.11n channel 2442MHz

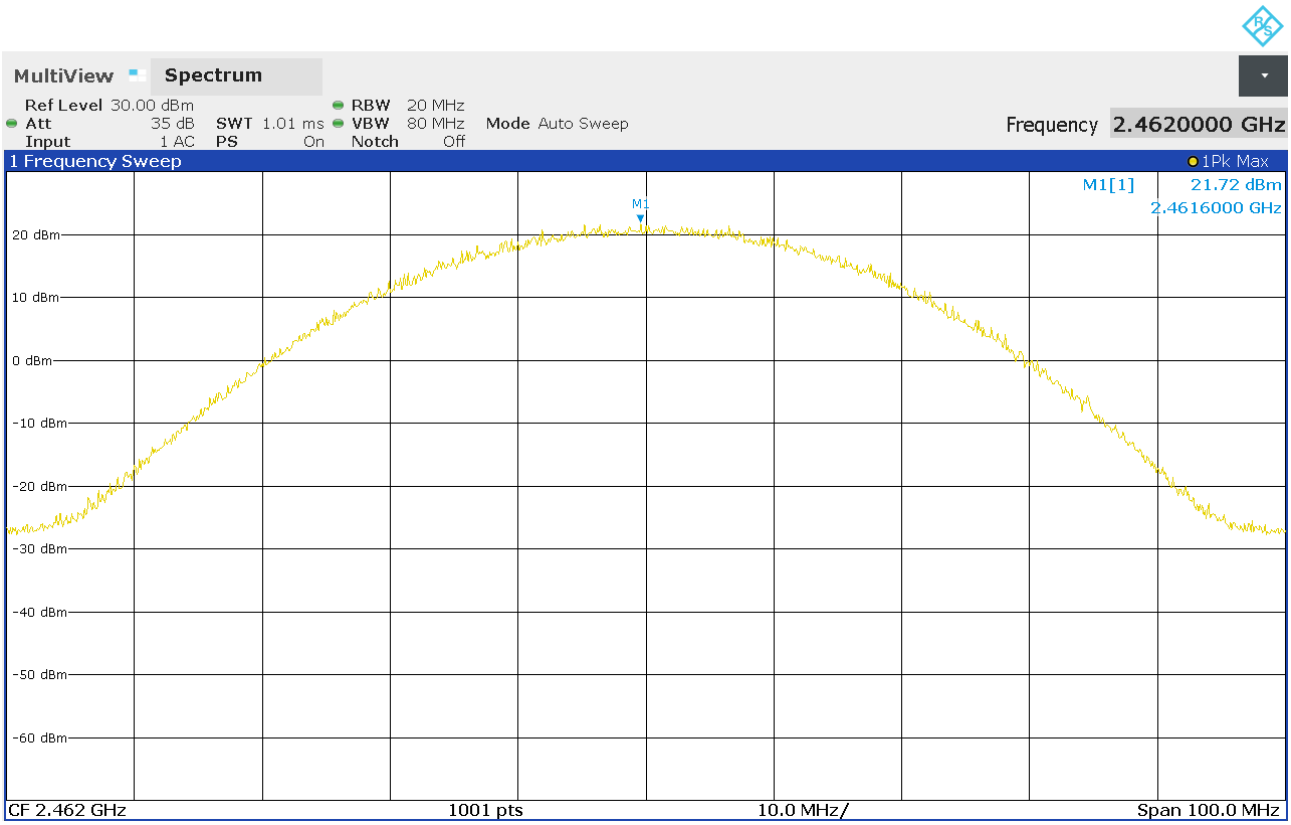


Figure 67 Peak output power, Operation on IEEE 802.11n channel 2462MHz

Section 8 Power Spectral Density

8.1 Test Specification

FCC Rule Part	46CFR 15.247 (e)
Standard	ANSI C63.10:2013
Measurement Uncertainty Conducted Power tests	±1.4dB

8.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	Clause 11.10.2
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(e)
	Peak
2400MHz to 2483.5MHz	<8dBm in any 3kHz band during any time interval of complete transmission

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 11.10.2

Receiver Parameters	Setting
Detector Function	Peak
Span	1.5xDTS bandwidth
Resolution Bandwidth	3kHz ≤RBW ≤100kHz
Video Bandwidth	3 x RBW
Sweep rate	Auto couple
Trace mode	Max hold

8.2.1 Emissions measurements

8.2.2 Date of Test

17th September 2024

8.2.3 Test Area

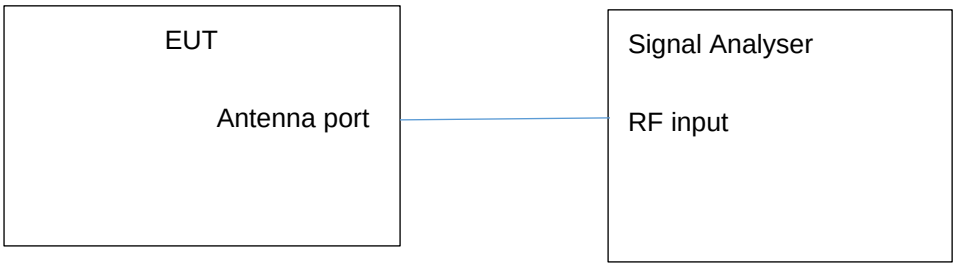
LAB 8

8.2.4 Tested by

J Beevers

8.2.5 Test Setup

The antenna port was connected directly to the signal analyser.



8.2.6 Test Results

Modulation scheme	Channel (MHz)	Power in 3kHz RBW (dBm)	Limit (dBm)	Figure	Result
IEEE 802.11b	2412	-17.42	8.0	68	Pass
IEEE 802.11b	2442	-7.52	8.0	69	Pass
IEEE 802.11b	2462	-7.59	8.0	70	Pass
IEEE 802.11g	2412	-21.66	8.0	71	Pass
IEEE 802.11g	2442	-9.29	8.0	72	Pass
IEEE 802.11g	2462	-14.00	8.0	73	Pass
IEEE 802.11n	2412	-25.25	8.0	74	Pass
IEEE 802.11n	2442	-8.84	8.0	75	Pass
IEEE 802.11n	2462	-12.74	8.0	76	Pass

Table 15 Peak Spectral Density Measurements

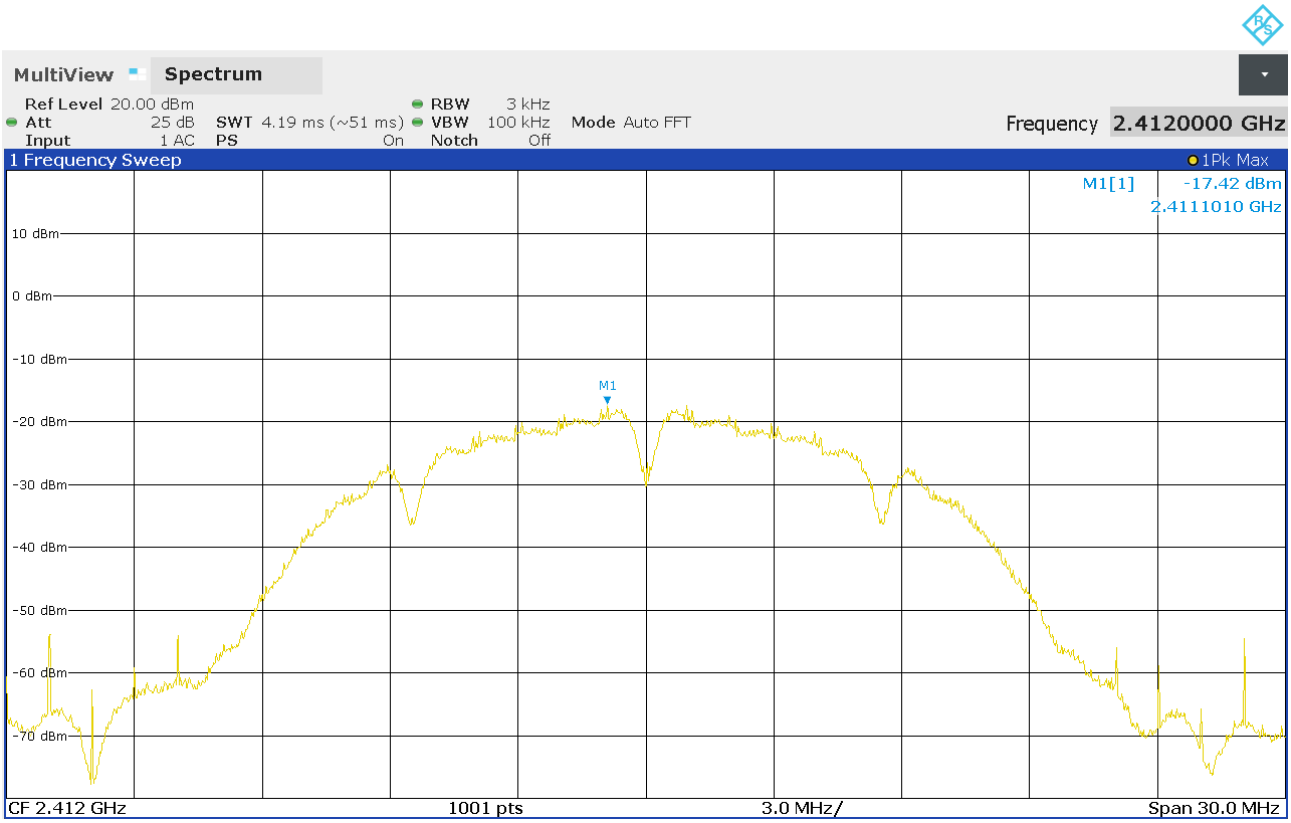


Figure 68 Power spectral density, Operation on IEEE 802.11b channel 2412MHz

Figure 69 Power spectral density, Operation on IEEE 802.11b channel 2442MHz

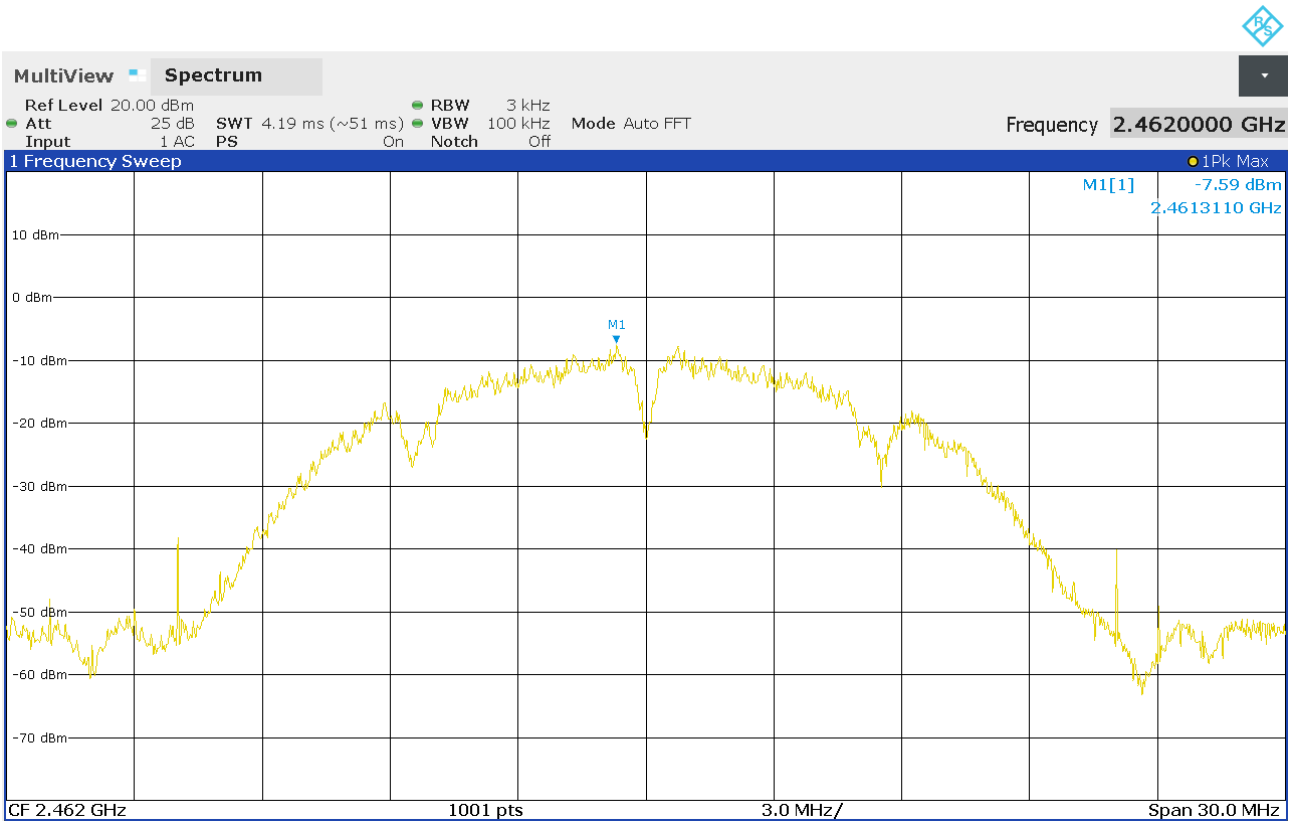


Figure 70 Power spectral density, Operation on IEEE 802.11b channel 2462MHz

Figure 71 Power spectral density, Operation on IEEE 802.11g channel 2412MHz

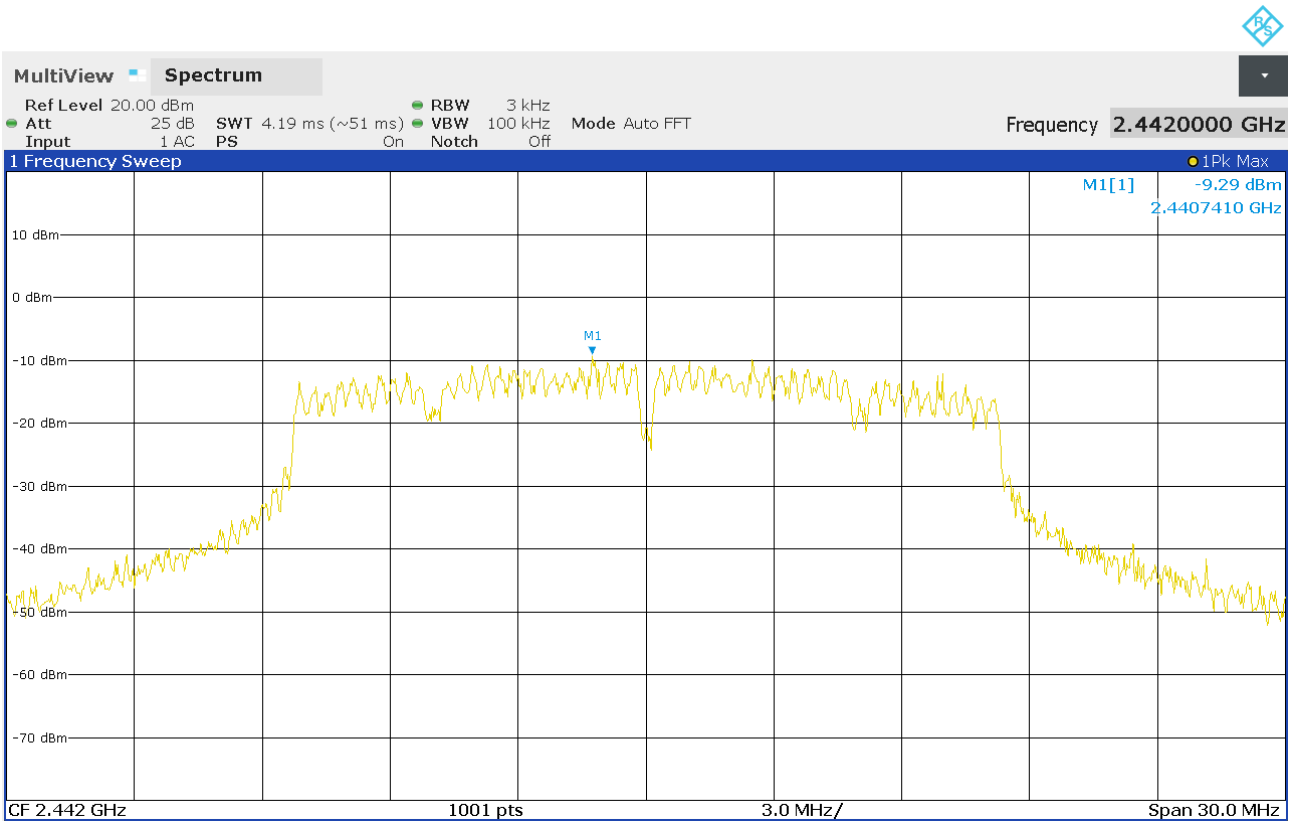


Figure 72 Power spectral density, Operation on IEEE 802.11g channel 2442MHz

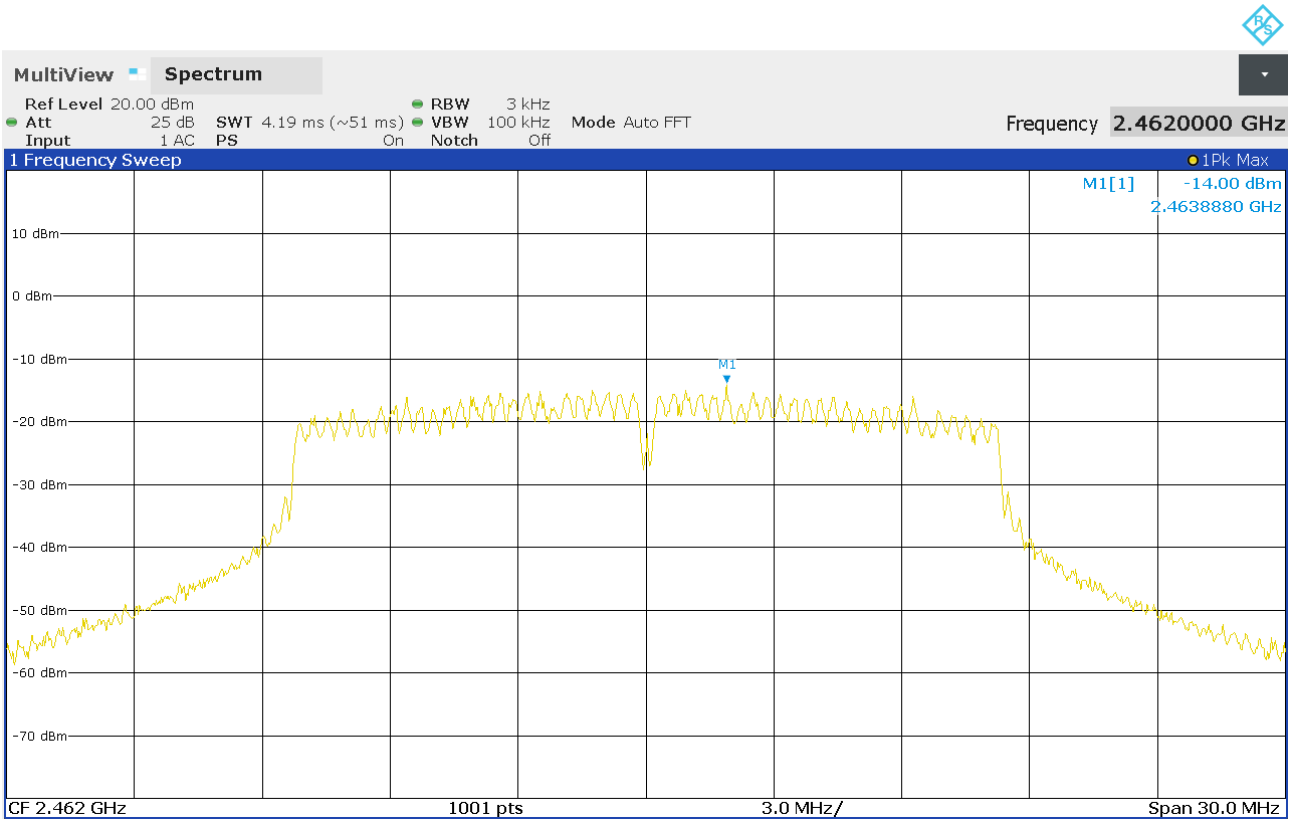


Figure 73 Power spectral density, Operation on IEEE 802.11g channel 2462MHz

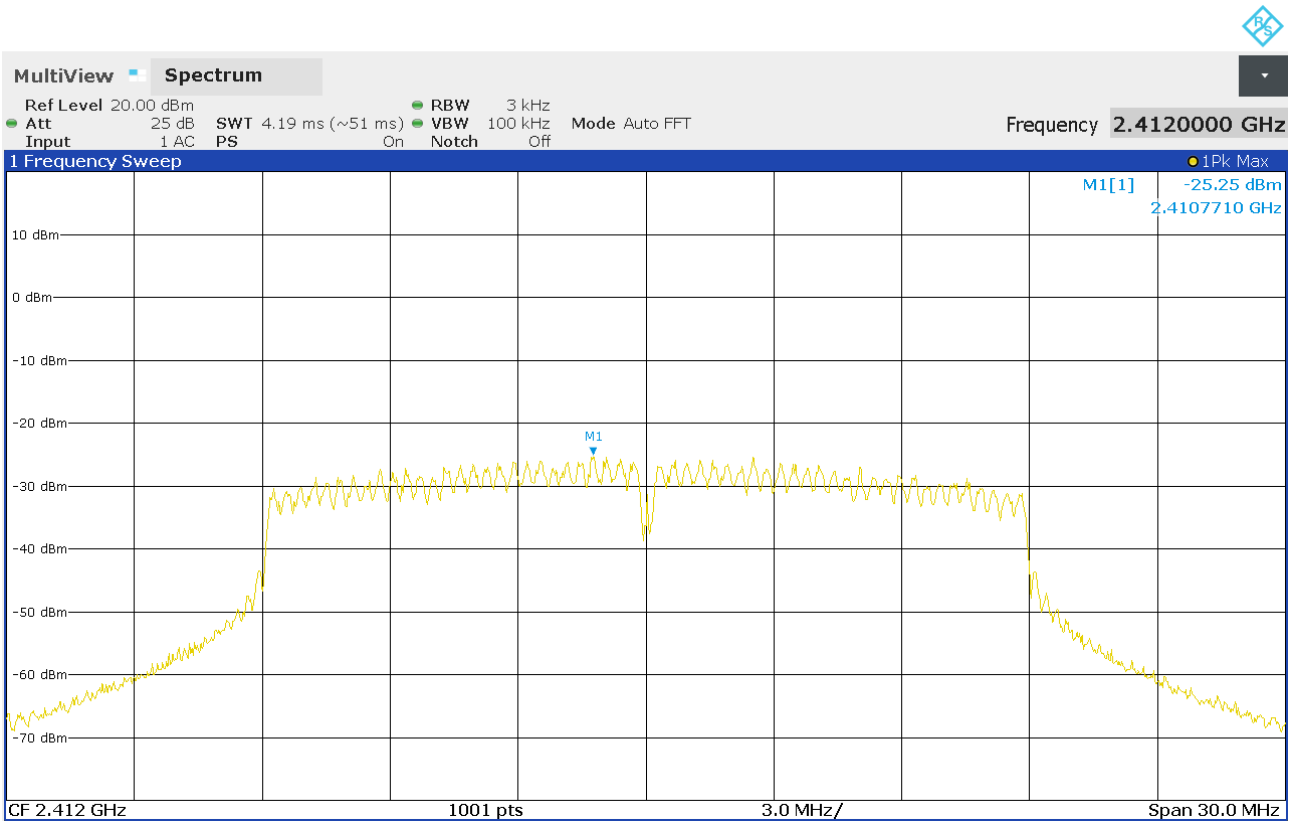


Figure 74 Power spectral density, Operation on IEEE 802.11n channel 2412MHz

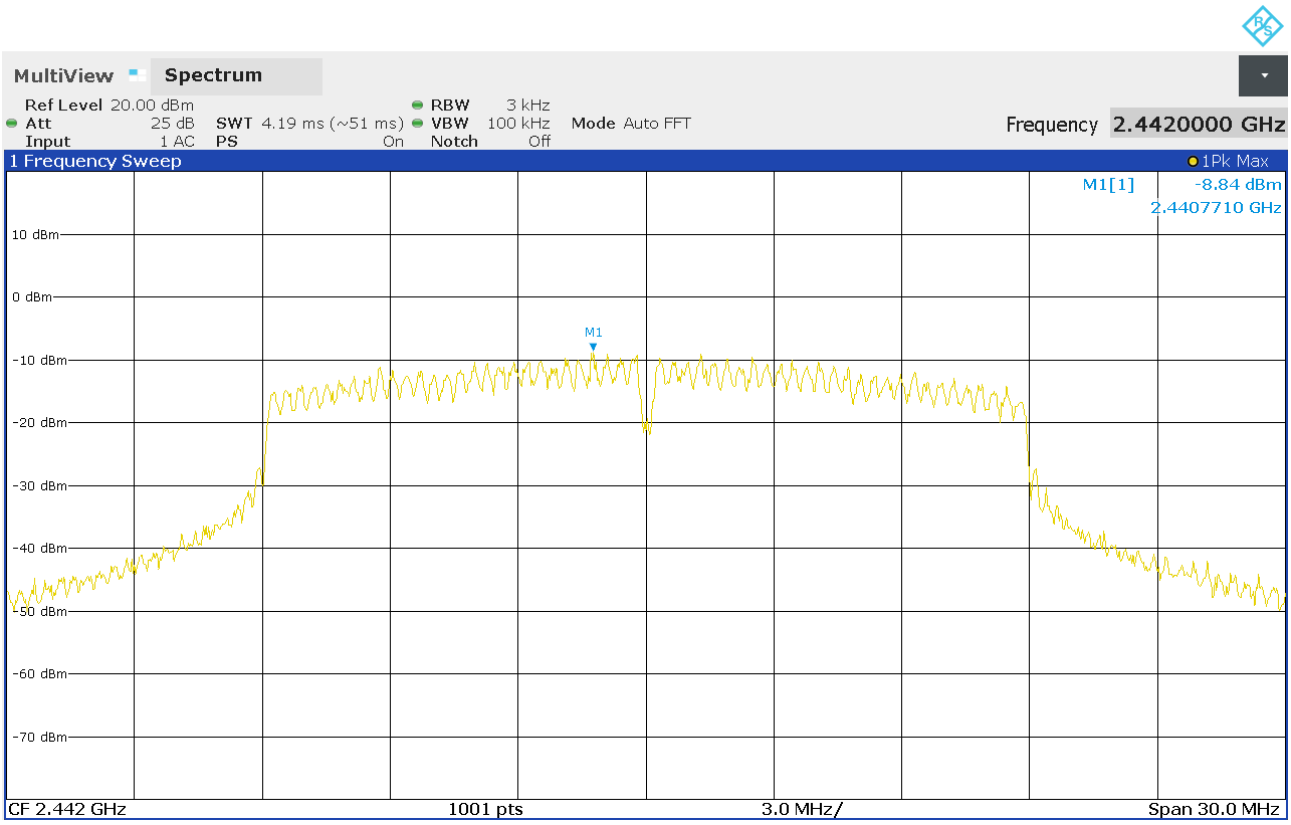


Figure 75 Power spectral density, Operation on IEEE 802.11n channel 2442MHz

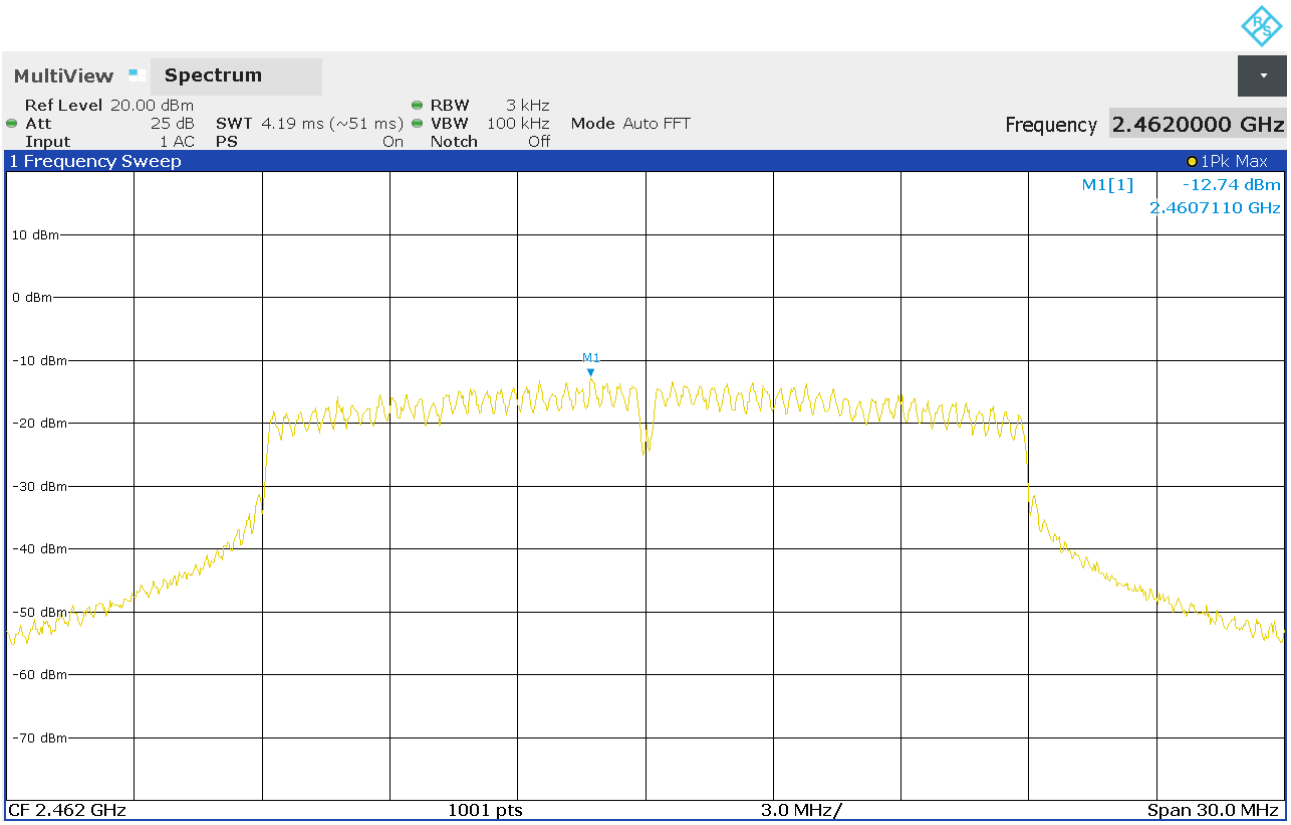


Figure 76 Power spectral density, Operation on IEEE 802.11n channel 2462MHz

Section 9 Band Edge Compliance

9.1 Test Specification

FCC Rule Part	46CFR 15.205 and 47CFR15.209
Standard	ANSI C63.10:2013
Measurement Uncertainty Radiated tests	The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95% is +/- 5.14dB for the frequency range from 1GHz to 6GHz

9.2 Procedure and Test Software Version

Conducted Tests

ANSi C63.10-2013 Clause reference:	Clause 6.10.4 Authorised band-edge measurements
Test software	N/A

Frequency (MHz)	Limit, 47CFR 15.247(e)
	Peak
2400MHz to 2483.5MHz	Measured signal at the band edge must be below the radiated emission limits of 47CFR15.209

Spectrum analyser settings as specified by ANSI C63.10-2013 Clause 6.10.5 “Restricted band-edge measurements”

Receiver Parameters	Setting
Detector Function	Peak
Span	As necessary
Resolution Bandwidth	100kHz
Video Bandwidth	3 x RBW
Sweep rate	Auto couple
Trace mode	Max hold

9.2.1 Emissions measurements

9.2.2 Date of Test

20th September 2024

9.2.3 Test Area

LAB 1

9.2.4 Tested by

L Trickett

9.2.5 Test Setup

The test setup was identical to radiated emissions testing 1-18GHz.

9.2.6 Test Results

Results are presented in two formats:

Tabular results of measurements at the band edges. Manual measurements were performed to measure the maximum value of signal at the band edge. The tabular data includes the following:

1. Polarity of the measurement antenna
2. Frequency at the band edge
3. Amplitude of signal at the input of the test receiver
4. Pre-amplifier gain
5. Cable loss
6. Antenna factor
7. Resultant Electric field strength = 3-4+5+6

Spectrum analyser screen displays are also included. Please note that the screen displays do not include losses or antenna factor.

Tabular Data IEEE 802.11b modulation

The following radiated measurements were made at the band edges:

Upper band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	63.50	54.25	4.08	30.55	43.88	74.00	30.12
V	2483.5	69.60	54.25	4.08	30.55	49.98	74.00	24.02

Table 16 Operation on IEEE 802.11b 2462MHz Channel, Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	51.90	54.25	4.08	30.55	32.28	54.00	21.72
V	2483.5	60.20	54.25	4.08	30.55	40.58	54.00	13.42

Table 17 Operation on IEEE 802.11b Channel 2462MHz, average detector measurements

Lower band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	62.50	54.24	4.00	30.01	42.27	74.00	31.73
V	2400	72.70	54.24	4.00	30.01	52.47	74.00	21.53

Table 18 Operation on IEEE 802.11b channel 2412MHz Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	52.20	54.24	4.00	30.01	31.97	54.00	22.03
V	2400	66.70	54.24	4.00	30.01	46.47	54.00	7.53

Table 19 Operation on IEEE 802.11b channel 2412MHz average detector measurements

Spectrum analyser displays IEEE 802.11b modulation

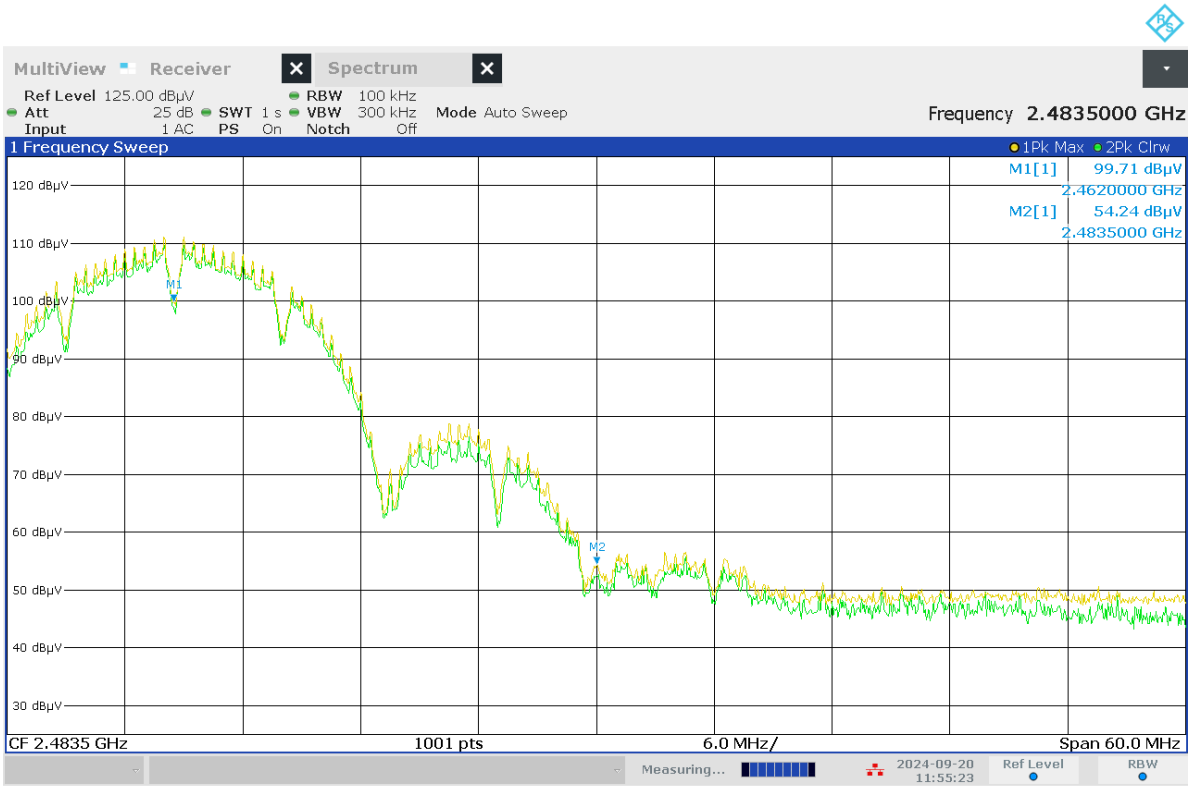


Figure 77 Band Edge Measurement IEEE 802.11b – upper band edge - horizontal polarity

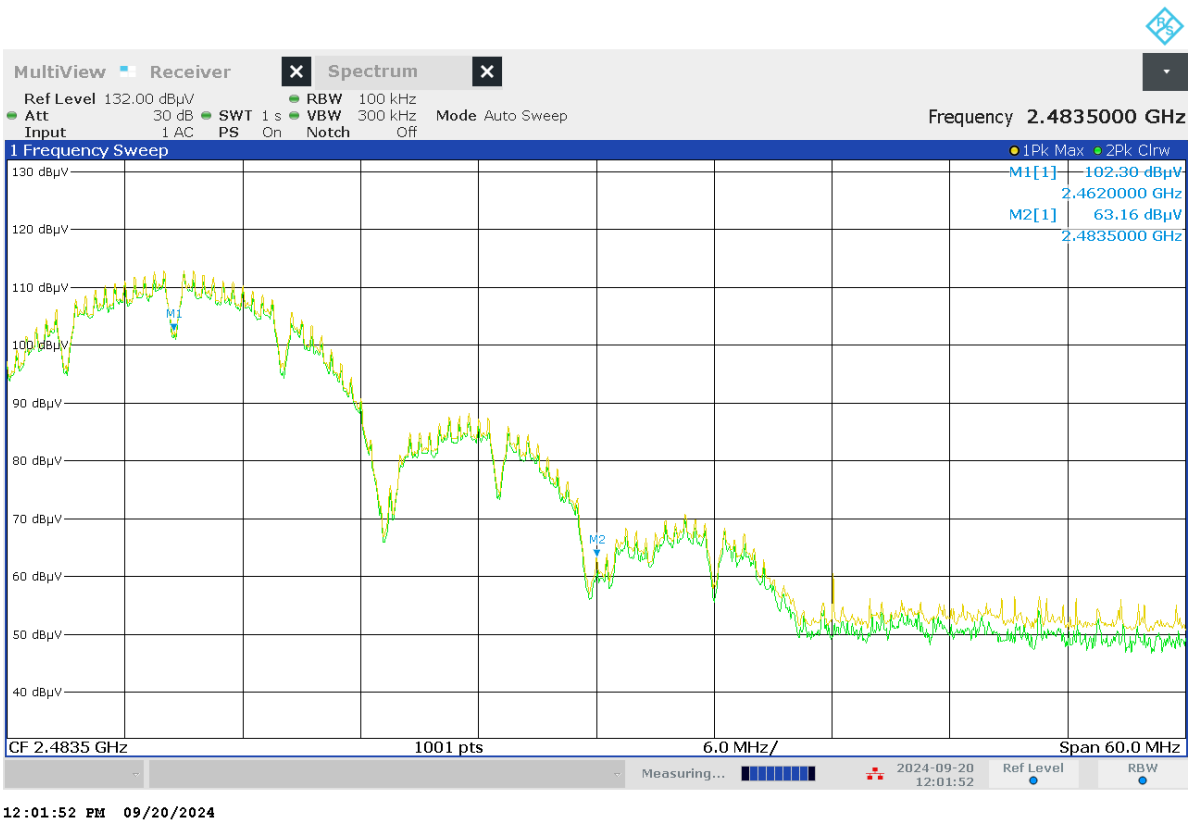
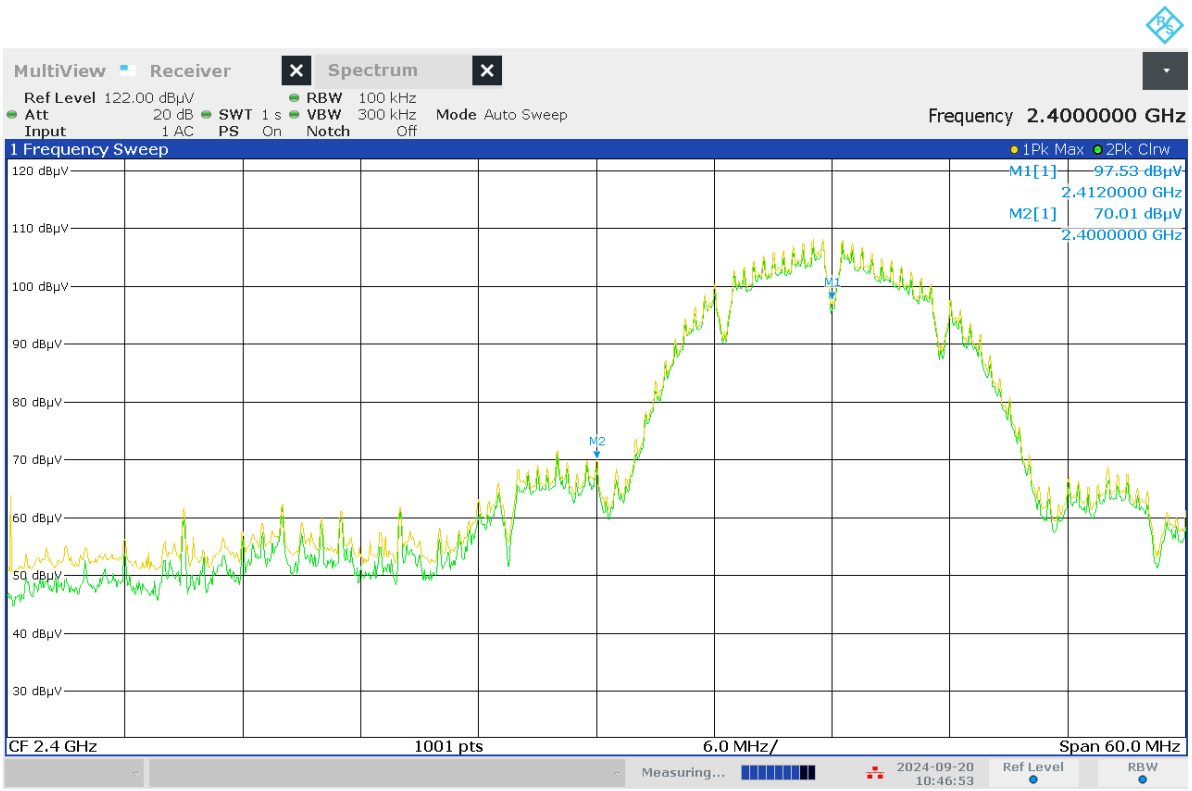


Figure 78 Band Edge Measurement IEEE 802.11b – upper band edge - vertical polarity

10:54:54 AM 09/20/2024

Figure 79 Band Edge Measurement IEEE 802.11b – lower band edge - horizontal polarity



10:46:54 AM 09/20/2024

Figure 80 Band Edge Measurement IEEE 802.11b – lower band edge - vertical polarity

Tabular Data IEEE 802.11g modulation

The following radiated measurements were made at the band edges:

Upper band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	83.60	54.25	4.08	30.55	63.98	74.00	10.02
V	2483.5	91.70	54.25	4.08	30.55	72.08	74.00	1.92

Table 20 Operation on IEEE 802.11g 2462MHz Channel, Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	63.20	54.25	4.08	30.55	43.58	54.00	10.42
V	2483.5	73.00	54.25	4.08	30.55	53.38	54.00	0.62

Table 21 Operation on IEEE 802.11g Channel 2462MHz, average detector measurements

Lower band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	82.40	54.24	4.00	30.01	62.17	74.00	11.83
V	2400	88.60	54.24	4.00	30.01	68.37	74.00	5.63

Table 22 Operation on IEEE 802.11g channel 2412MHz Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	62.50	54.24	4.00	30.01	42.27	54.00	11.73
V	2400	71.70	54.24	4.00	30.01	51.47	54.00	2.53

Table 23 Operation on IEEE 802.11g channel 2412MHz average detector measurements

Spectrum analyser displays IEEE 802.11g modulation

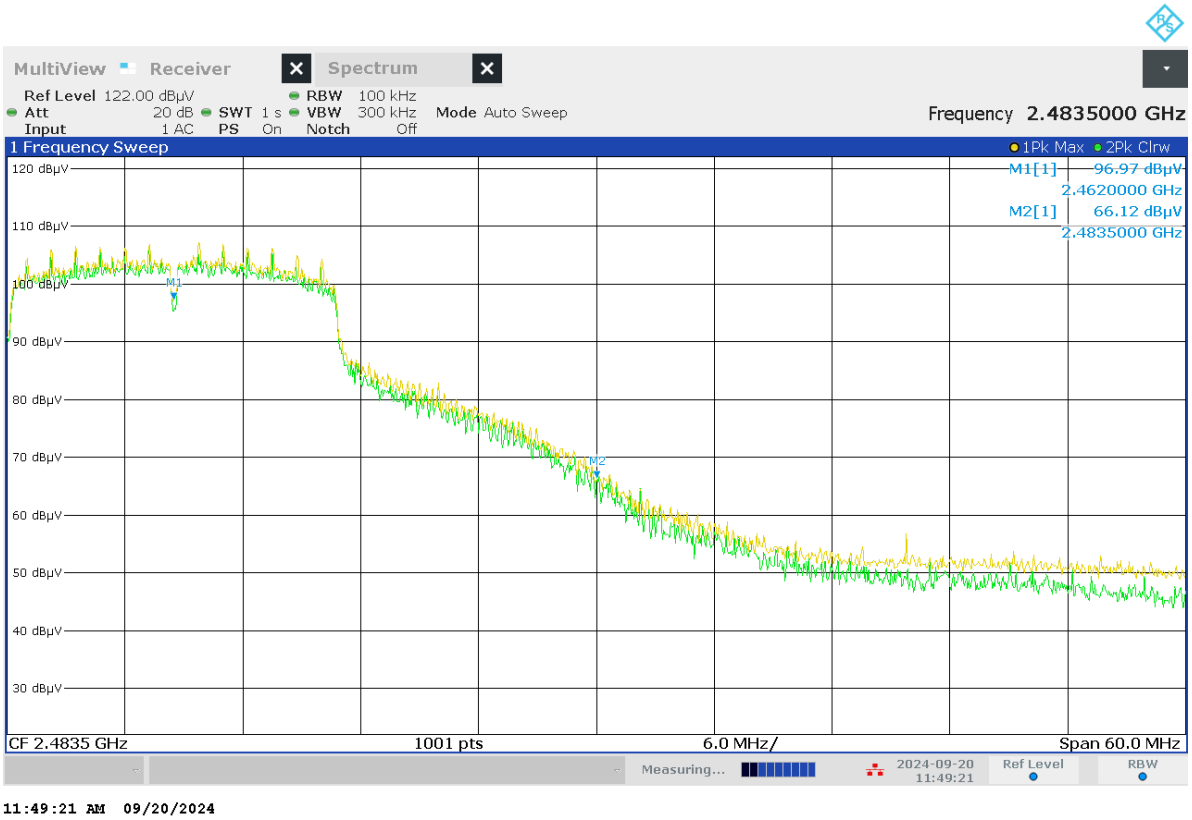


Figure 81 Band Edge Measurement IEEE 802.11g – upper band edge - horizontal polarity

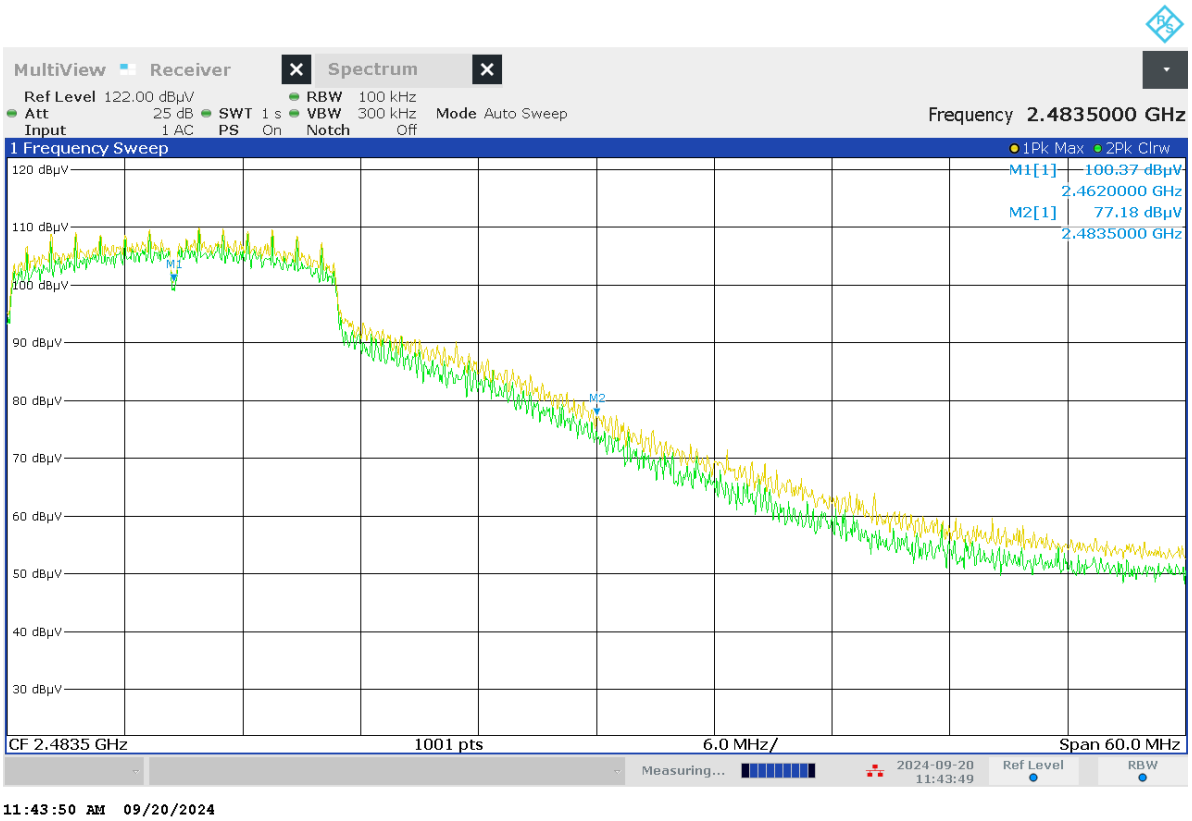


Figure 82 Band Edge Measurement IEEE 802.11g – upper band edge - vertical polarity

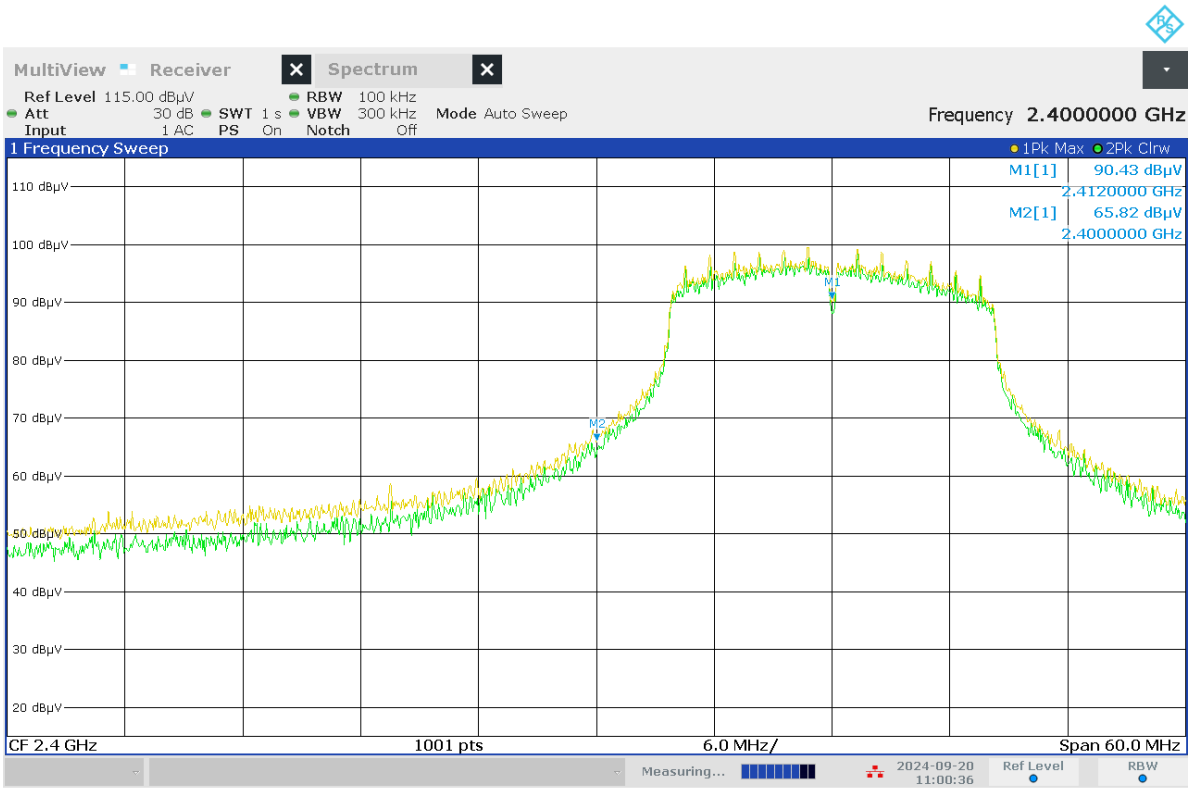


Figure 83 Band Edge Measurement IEEE 802.11g – lower band edge - horizontal polarity

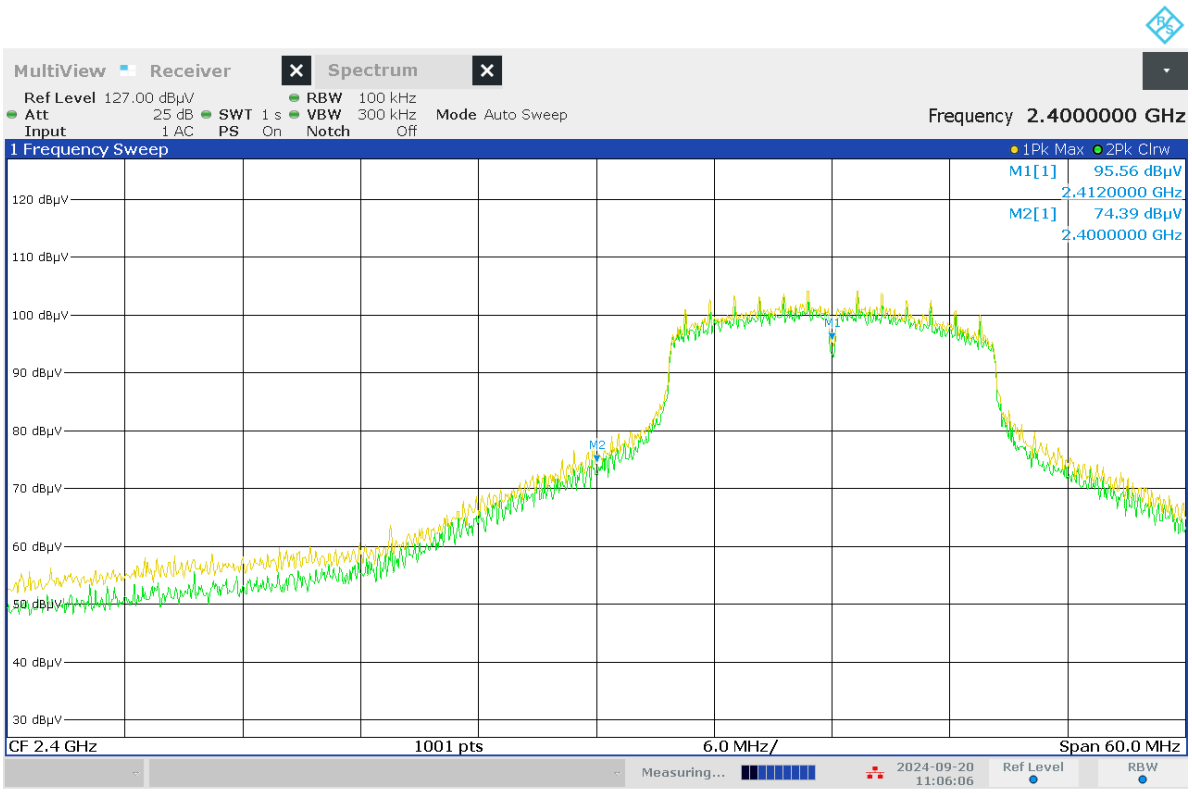


Figure 84 Band Edge Measurement IEEE 802.11g – lower band edge - vertical polarity

Tabular Data IEEE 802.11n modulation

The following radiated measurements were made at the band edges:

Upper band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	88.60	54.25	4.08	30.55	68.98	74.00	5.02
V	2483.5	92.20	54.25	4.08	30.55	72.58	74.00	1.42

Table 24 Operation on IEEE 802.11n 2462MHz Channel, Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2483.5	68.00	54.25	4.08	30.55	48.38	54.00	5.62
V	2483.5	72.20	54.25	4.08	30.55	52.58	54.00	1.42

Table 25 Operation on IEEE 802.11n Channel 2462MHz, average detector measurements

Lower band edge

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	80.20	54.24	4.00	30.01	59.97	74.00	14.03
V	2400	88.40	54.24	4.00	30.01	68.17	74.00	5.83

Table 26 Operation on IEEE 802.11n channel 2412MHz Peak detector measurements

Polarity	frequency (MHz)	Amplitude (dBuV)	Preamp (dB)	Cable loss (dB)	AF(dB/m)	E (dBuV/m)	Limit (dBuV/m)	Margin (dB)
H	2400	58.30	54.24	4.00	30.01	38.07	54.00	15.93
V	2400	70.10	54.24	4.00	30.01	49.87	54.00	4.13

Table 27 Operation on IEEE 802.11n channel 2412MHz average detector measurements

Spectrum analyser displays IEEE 802.11n modulation

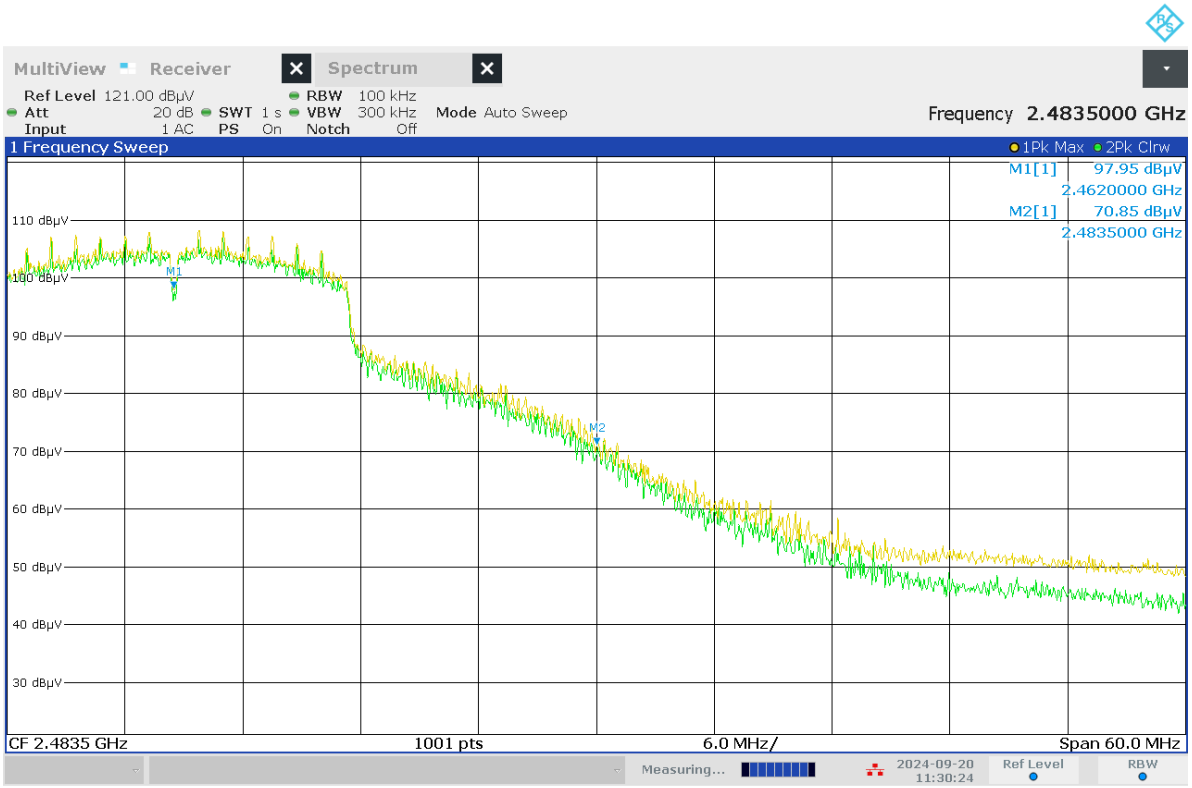


Figure 85 Band Edge Measurement IEEE 802.11n – upper band edge - horizontal polarity

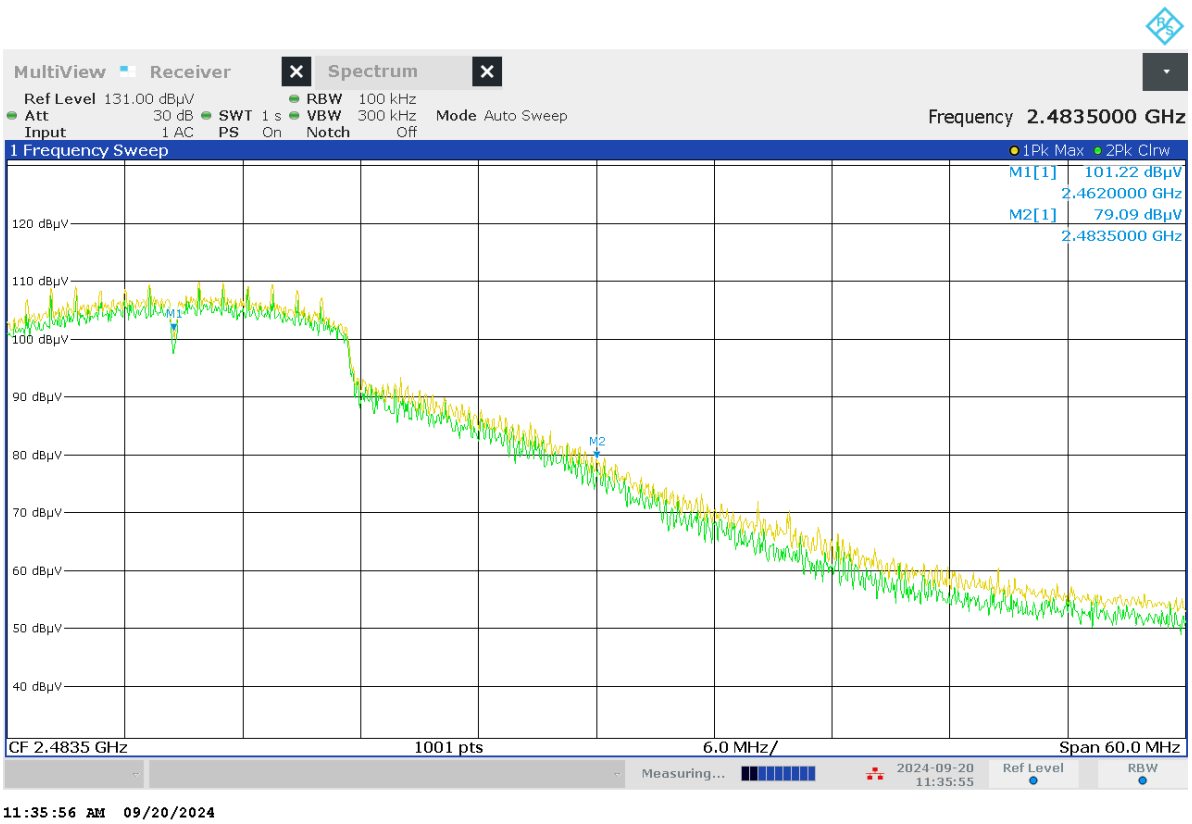


Figure 86 Band Edge Measurement IEEE 802.11n – upper band edge - vertical polarity

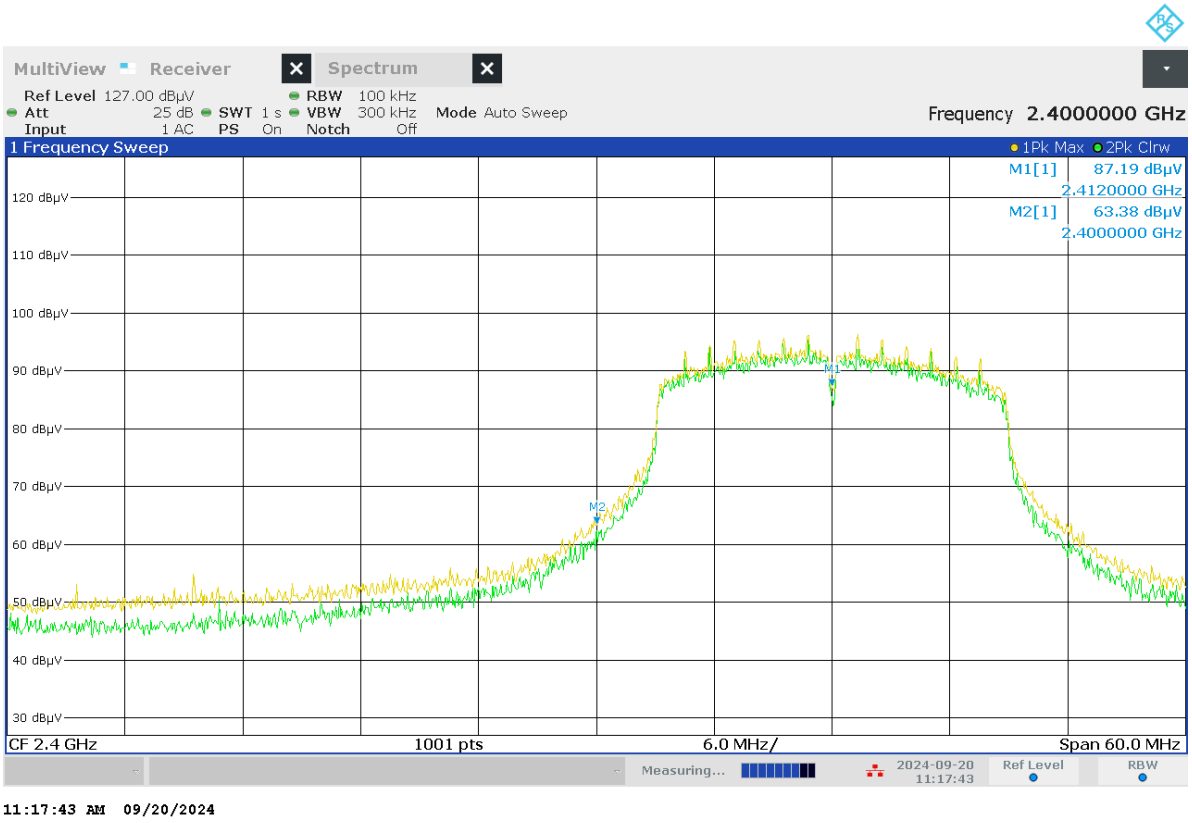


Figure 87 Band Edge Measurement IEEE 802.11n – lower band edge - horizontal polarity

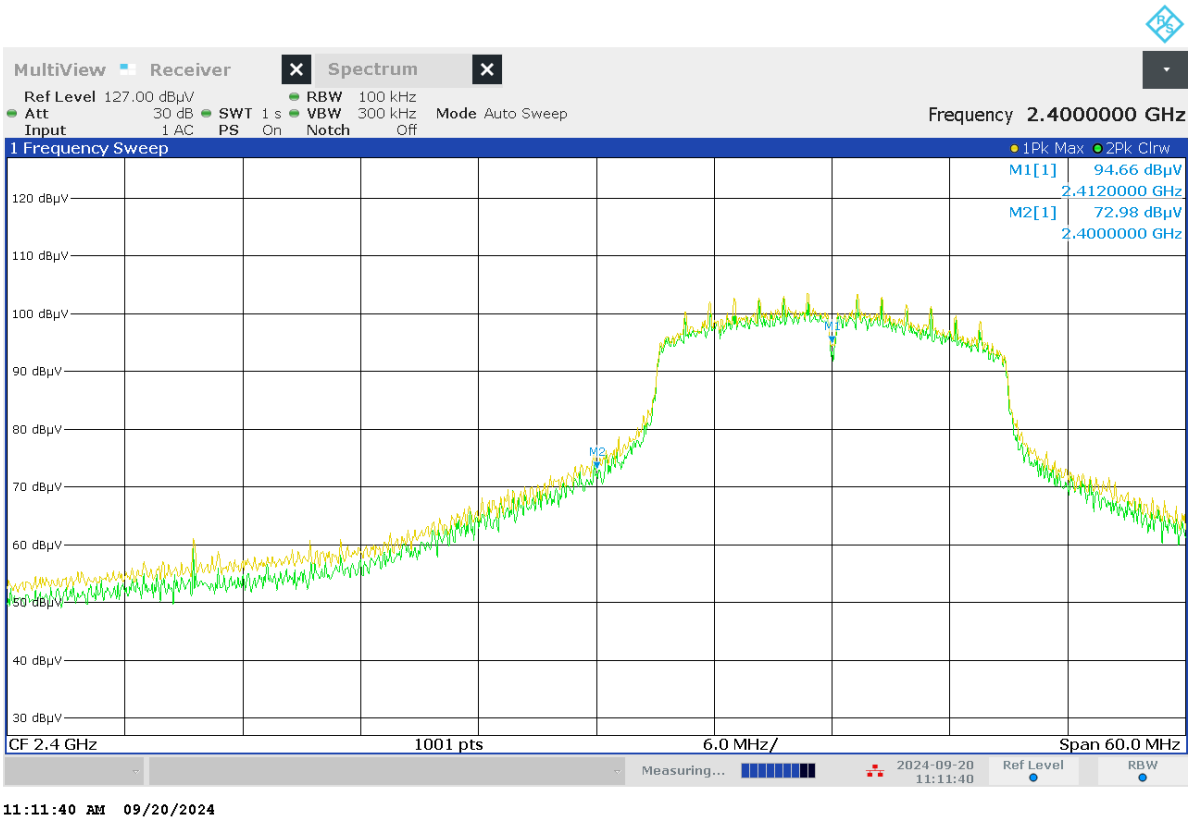


Figure 88 Band Edge Measurement IEEE 802.11n – lower band edge - vertical polarity

Appendix A EUT Test Photos

Test set up photographs are supplied separately.

Appendix B Test Equipment List

Conducted Emissions from Antenna Port

Item	Serial No.	Last Calibration Date	Calibration Interval
R&S ESW44 EMI Receiver	C0658	30th October 2023	12 Months
Kikusui PCR200M	C0198	-	-

Radiated Emissions Equipment

Item	Serial No.	Last Calibration Date	Calibration Interval
Laboratory 1 Semi-Anechoic Chamber	C0471	6th December 2022	36 Months
ETS Lindgren 2017B Mast (1 – 4m) with tilting mechanism	--	N/A	N/A
R&S ESW44 EMI Receiver	C0751	5th August 2024	12 Months
Kikusui PCR200M	C0198	-	-
Teseq CBL6112D Bilog Antenna	C0506	22nd August 2024	36 Months
HF27 Cable	19149.03.13.004	13th December 2023	12 Months
HF29 Cable	20147.01.09.001	13th December 2023	12 Months
HF32 Cable	19149.01.09.003	13th December 2023	12 Months
HF35 Cable	19149.02.13.003	13th December 2023	12 Months
HF47 Cable	E44808	7th March 2024	12 Months
Schwarzbeck STLP 9148 Antenna 1-18GHz	C0626	26th March 2024	24 Months
2.4GHz Microtronics BRM50702 notch filter	79178	7th December 2023	12 Months
BONN BLMA 0118-M Preamplifier	C0702	1st August 2024	12 Months
ETS Lingren 3116C-PA Horn Antenna 18-40GHz	C0433	29th September 2022	36 Months

----------END OF REPORT----------