

Test Report

of

AT-DG2 running IEEE 802.11g
FCC ID: 2ADEF AT-DG2

according to

FCC 47 CFR, Part 15 Subpart C
15.247 Operation within the band 2400 - 2483.5 MHz**EKTOS Testing & Reliability Services A/S**

Performed by



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Examined by



David Busk

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Report no.:	P18-0060-10	Report date:	2019-04-12
Test started:	2019-04-02	Test ended:	2019-04-05
Number of pages:	49	Client contact:	Henrik Nordgren
Test laboratory:	EKTOS TRS A/S A. C. Meyers Vænge 15 2450 Copenhagen SV Denmark	Client:	Airtame ApS Kulegaardsvej 1 1434 Copenhagen Denmark
Facility reg. no.	FCC Designation number: DK0002		
Test specimen:	Airtame 2 model no. AT-DG2		
Test specification:	<p>FCC 47 CFR Part 15 Subpart C 15.247 Operation within the band 2400 - 2483.5 MHz</p> <p>All tests were performed according to ANSI 63.10:2013</p> <p>This report is a supplement to report P18-0060-3 rev. 1 showing Airtame 2 model no. AT-DG2 compliance to FCC 47 CFR 15.247 when operating in IEEE 802.11g mode.</p> <p>The tests relevant for the test specimens are listed in <i>section 1.1</i>.</p>		
Documentation:	<p>This test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory.</p> <p>The complete test documentation is archived for 10 years at the testing laboratory.</p>		
Test results:	<p>The test specimen complies with relevant parts of the test specifications.</p> <p>The test results relate only to the specimen tested.</p>		
Test personnel:	Søren Søltøft		

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Appendix issued in separate report

1 Photos of test setups and equipment.

1 SUMMARY

See Appendix 1 for photos.

Emission measurements as specified below have been performed.

1.1 Test plan

Standard	Name of the test	Results
FCC 47 CFR Part 15C	15.247 Operation within the band 2400-2483.5 MHz	Passed
-	Duty cycle measurement	n.a.
15.247 (a) (2)	6 dB bandwidth	Passed
15.247 (b) (3)	Maximum conducted power	Passed
15.247 (d)	Emission outside frequency band.	Passed
15.247 (d)	Emission in restricted bands.	Passed ¹
15.247 (d)	Band Edge	Passed
15.247 (e)	Power spectral density	Passed
15.207 (a)	AC conducted emission	Passed

PASSED	The test was performed and the test specimen complies with the essential requirements in the standard.
FAILED	The test was performed and the test specimen does not comply with the essential requirements in the standard.
REF	The test is covered by a test in another report and/or on a similar test specimen.
NR	The test is not relevant for the test specimen or has been waived by the manufacturer.

Note 1: As the results of Maximum conducted power and Power spectral density measurements are very similar to the results from the test of AT-DG2 running IEEE 802.11n the test is omitted, refer to test report 'P18-0060-3 rev1'.

1.2 Test Specimen

Manufacturer	Airtame ApS
Name	Airtame 2
Model No.	AT-DG2
Test Software	Production FW allowing set up of radio parameters.
Supply voltage	5 VDC from USB

The AT-DG2 enables streaming from computers and mobile devices to TVs and projectors wirelessly or through Ethernet by a Ethernet to USB adaptor with PoE.

The wireless connection is built on a Cypress (CYG89342) chip.

The 2.4 GHz radio uses frequencies in the range 2412 MHz to 2472 MHz.

The AT-DG2 had a production firm ware which enabled control of the Cypress chip.

As the frequency range is greater than 10 MHz, at least 3 frequencies are selected for test.

For the conducted test AT-DG2 no 12 was stripped of housing and equipped with a temporary antenna connector.

For radiated test AT-DG2 no 10 were used. It was not modified except for the firmware enabling control of radio parameters.

The following radio parameters were used during test.

Band: 2.4 GHz

Antenna chain: 0

Standard: 802.11g

Bandwidth: 20 MHz

TX power: max. +17 dBm

Channel: 1 to 11

Control script and parameters was delivered by client.

"rf-control -t 192.168.1.104 -b 20 -s g -T 1 -p 17 -c 1 -m 6"

Channel	Power level setting
1	11
2	15
3 to 9	17
10	15
11	12

Table 1. Channel power setting.

See photo in appendix 1.

1.1 Auxiliary Equipment

1.1.1 AC/DC adaptor

Manufacturer	Airtame ApS
Model	GS5V-2.3C-1U
Details	marked : 1
Supply voltage	100 VAC to 240 VAC 50 / 60 Hz
Output voltage	5 VDC 2.3 A

See photo in appendix 1.

1.1.2 AT-PoE

Manufacturer	Airtame Aps
Model	AT-PoE
Serial no.	201809GR - 002
Details	-
Supply voltage	PoE input:44-57 VDC (55 VDC used during tests), PoE class 1
Output voltage	5 VDC / 3000 mA
Operational mode	Supplying AT-DG2

See photo in appendix 1.

1.1.3 PoE Injector

Manufacturer	AXIS COMMUNICATIONS
Model	T8133 30W
Details	-
Supply voltage	100 VAC to 240 VAC 50 / 60 Hz
Output voltage	55 VDC 0.6 A

1.1.4 Laptop

Manufacturer	Lenovo
Model	X220
Product ID	42903WG
Serial no.	R9-KVYB6 11/12
Software	Microsoft Windows 10 Professional
Details	-
Supply voltage	20 VDC from AC/DC power supply

1.1.5 AC/DC power supply for laptop

Manufacturer	Lenovo
Model	42T4424
Serial no.	11S42T4424Z1ZF3E15B6DA REV 05
Details	-
Supply voltage	100 – 240 VAC (120 VAC 60 Hz was used during tests)
Output voltage	20 VDC

1.2 I/O ports / cables to test specimen

I/O Port Cable	Type	Shielding	Cable length
USB-C branching out to HDMI and USB-A	Customer	Shielded	107 cm

1.3 Test set-up

The nominal input voltage to AT-DG2 is 5 VDC

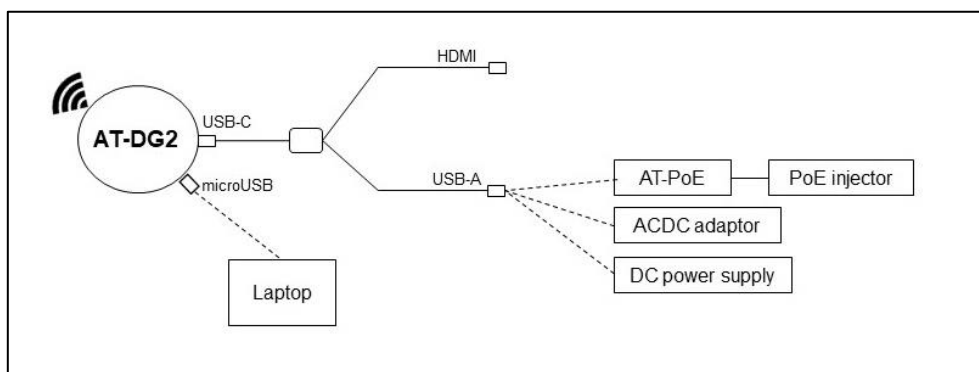


Figure 1. Test set up.

The dotted lines at USB-A indicates that just one is in use at a time.

The dotted line from laptop indicates that this connection was only present during set up of radio, not during test.

2 TESTS

2.1 Duty Cycle

Test specimen	AT-DG2 no.12
Test specification	47 CFR Part 15 Subpart C
Test method	ANSI C63.10:2013
Comments	None
Temperature / Humidity	21°C / 26%RH
Dates of measurements	2019-04-04
Test personnel	Søren Søltøft

2.1.1 Test setup

The test specimen was connected directly to a spectrum analyzer using a temporary antenna connector.

See photo of test set up in appendix 1.

2.1.2 Test result

The duty cycle was measured at channel 11 at 2462 MHz.

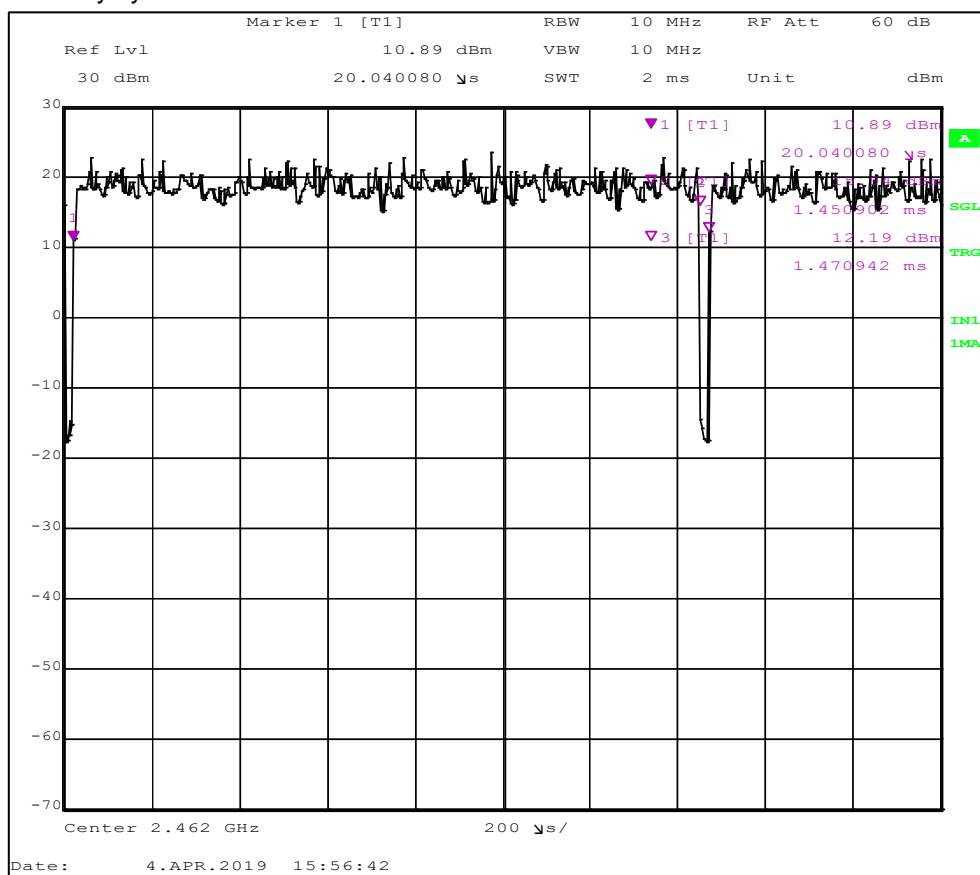


Figure 2. Duty Cycle.

T: 1.45938 ms.

t_{on}: 1.430862 ms

Duty cycle = t_{on} / T = 1.430862 ms / 1.45938 ms = 0.9804588 = 98,05 %

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Duty cycle [%]	Duty cycle limit [%]	Result
98.05	98	Passed

Table 2. Duty cycle.

2.1.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.2 6 dB Bandwidth

Test specimen	AT-DG2 no.12
Test specification	FCC 47 CFR Part 15.247 (a) (2)
Test method	ANSI C63.10:2013 sec. 11.8
Comments	None
Temperature / Humidity	22°C / 23%RH
Dates of measurements	2019-04-02
Test personnel	Søren Søltøft

2.2.1 Test setup

The test specimen was connected to a spectrum analyzer using a temporary antenna connector.

See photo of test set up in appendix 1.

2.2.2 Test result

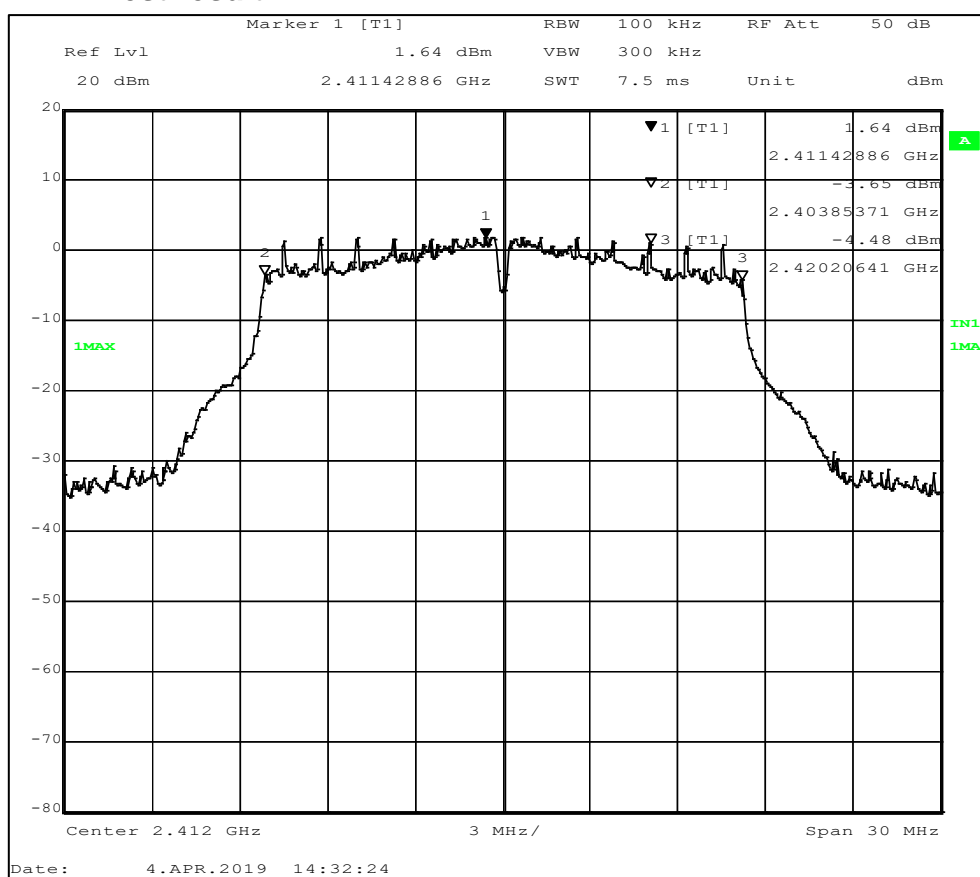


Figure 3. 6 dB Band Width at channel 1 .

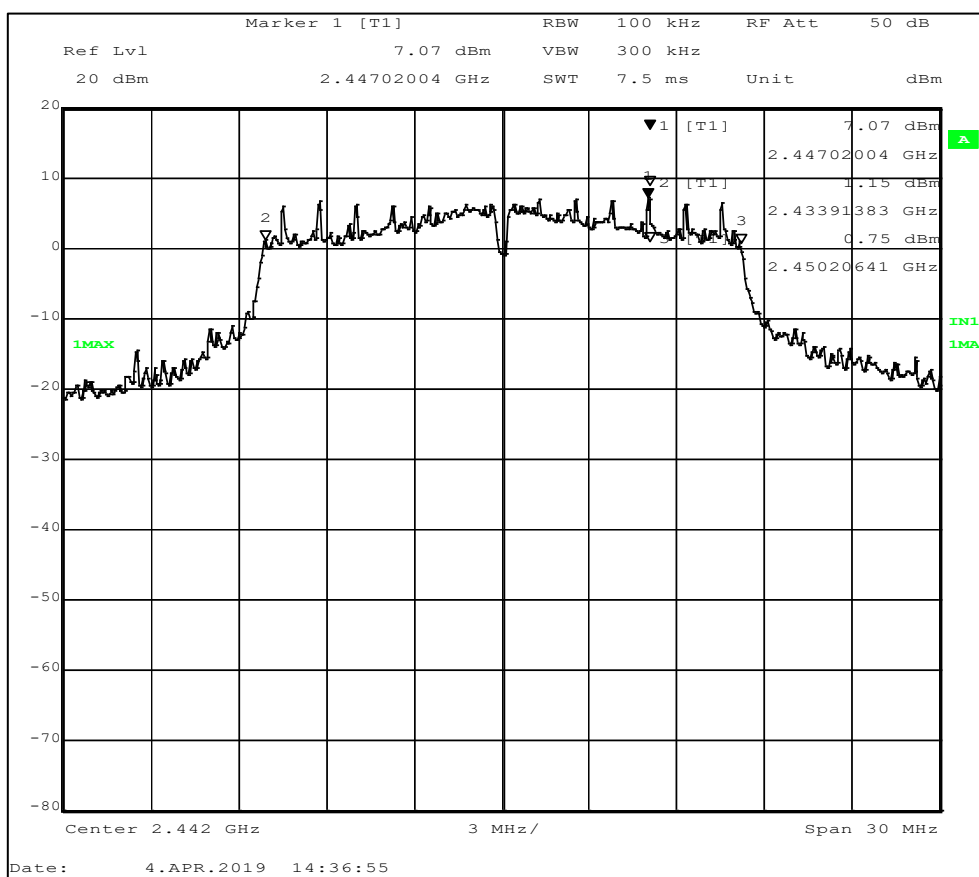


Figure 4. 6 dB Band Width channel 7.

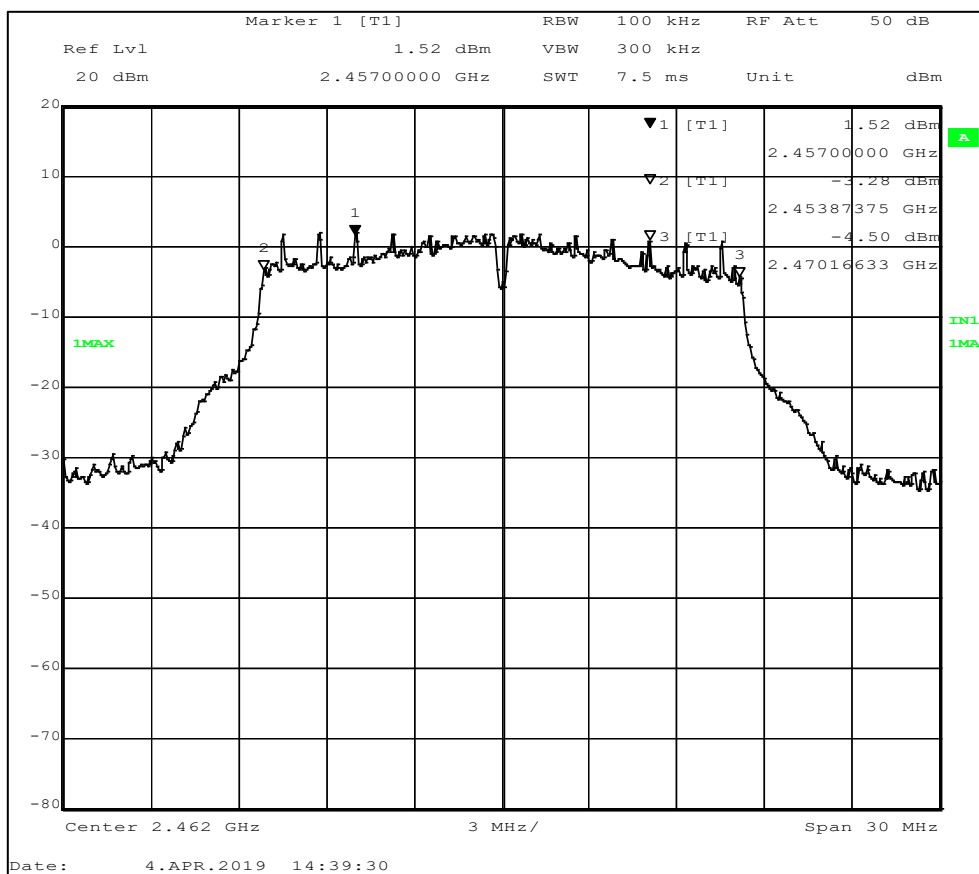


Figure 5. 6 dB Band Width channel 11.

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Channel	6 dB BW [kHz]	Limit [kHz]	Result
1	16352.7	500	Passed
7	16292,6	500	Passed
11	16292,6	500	Passed

Table 3. 6 dB Band Width.

2.2.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.3 Maximum conducted output power

Test specimen	AT-DG2 no.12
Test specification	FCC 47 CFR Part 15.247 (b) (3)
Test method	ANSI C63.10:2013 sec 11.9.2.2.2
Frequency range	2400-2483.5 MHz
Limits	FCC 47 CFR Part 15.247 (b) (3)
Comments	None
Temperature / Humidity	22°C / 23%RH
Dates of measurements	2019-04-02
Test personnel	Søren Søltoft

2.3.1 Test setup

The test specimen was connected to a spectrum analyzer using a temporary antenna connector.

See photo of test set up in appendix 1.

The output power was measured at channel 7 at the different Data rates to establish worst case. Data rate 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s were tested. The other channels were tested at the found Data rate.

2.3.2 Test results

2.3.2.1 Output power as function of data rate

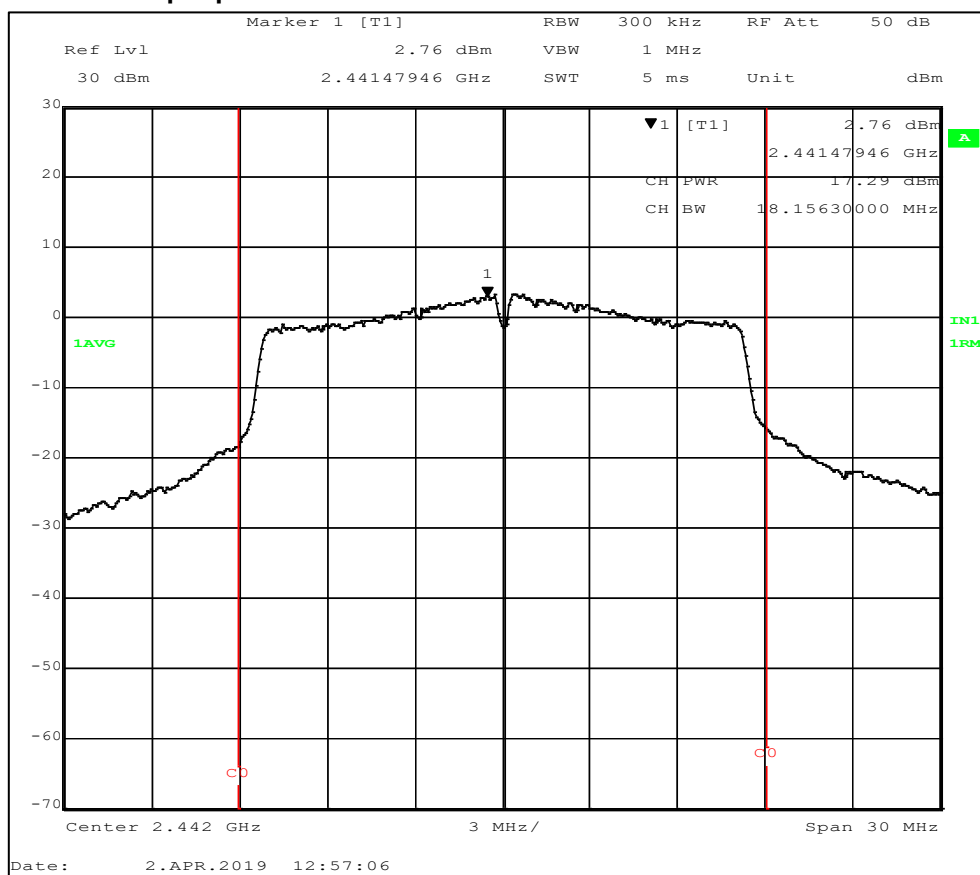


Figure 6. Output power channel 7 at data rate 6.

Data rate [Mbit/s]	Output power [dBm]
6	17.29
9	17.12
12	17.01
18	16.46
24	16.45
36	15.91
48	15.50
54	15.42

Table 4. Test result of Data rate on channel 7.

2.3.2.2 Maximum conducted output power at data rate 6.

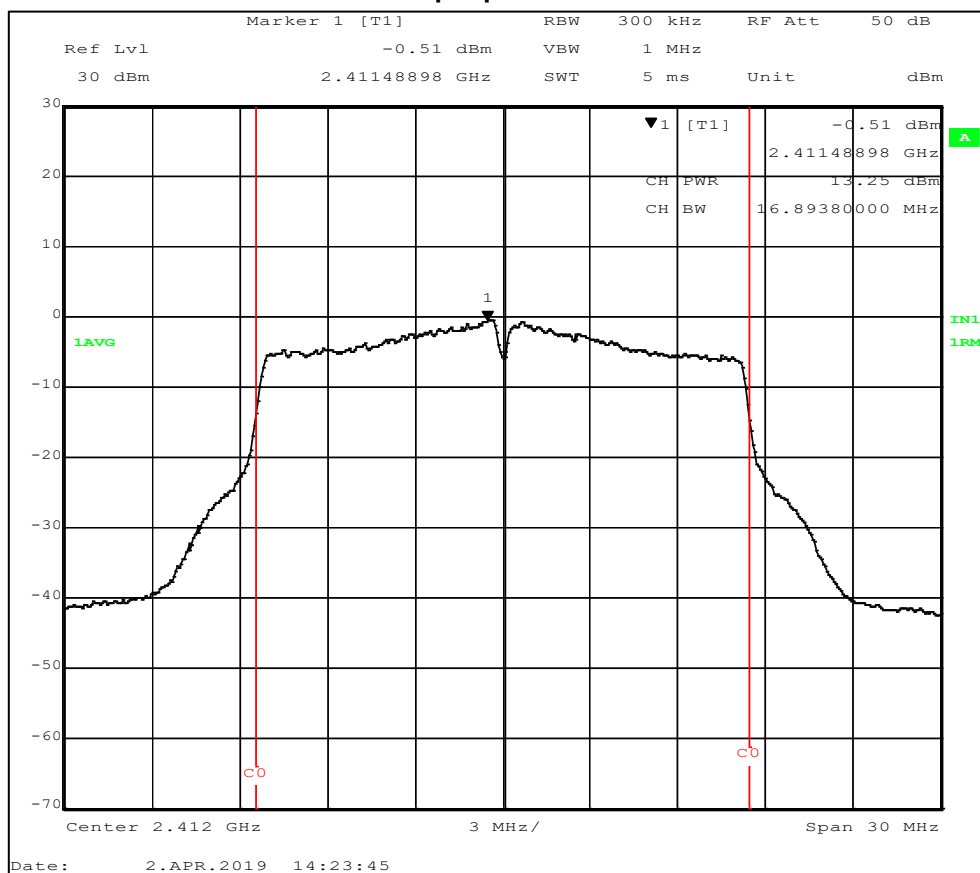


Figure 7. Output power channel 1.

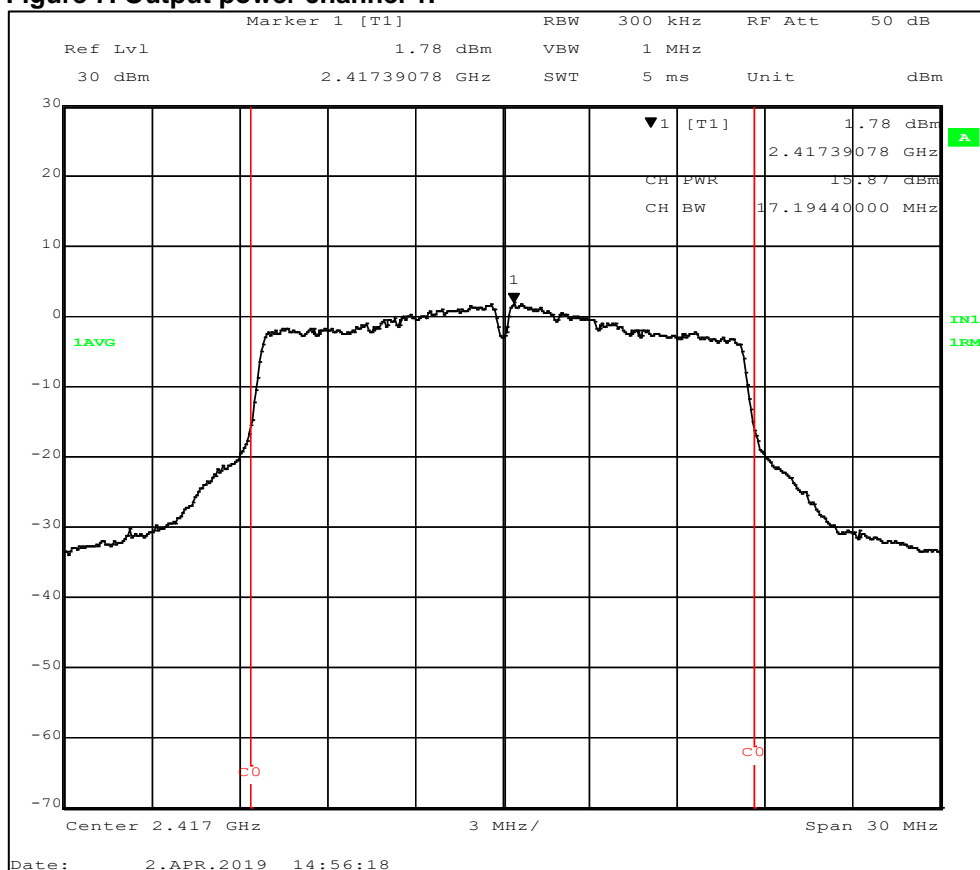


Figure 8. Output power channel 2.

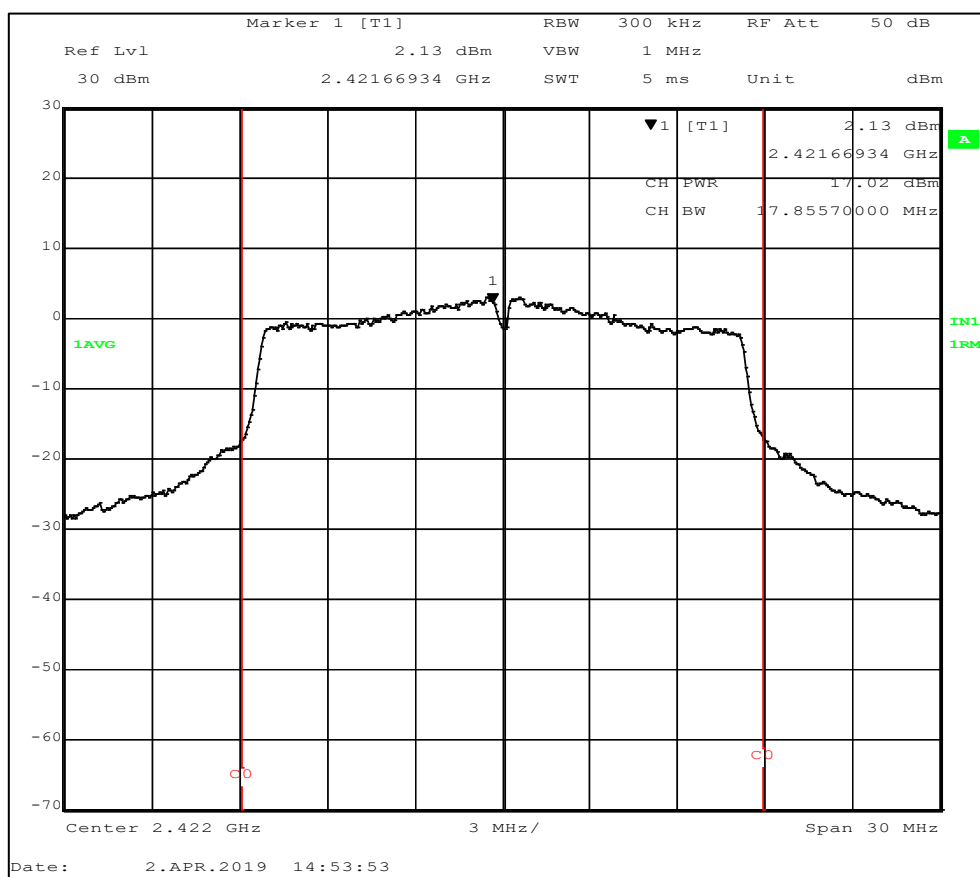


Figure 9. Output power channel 3.

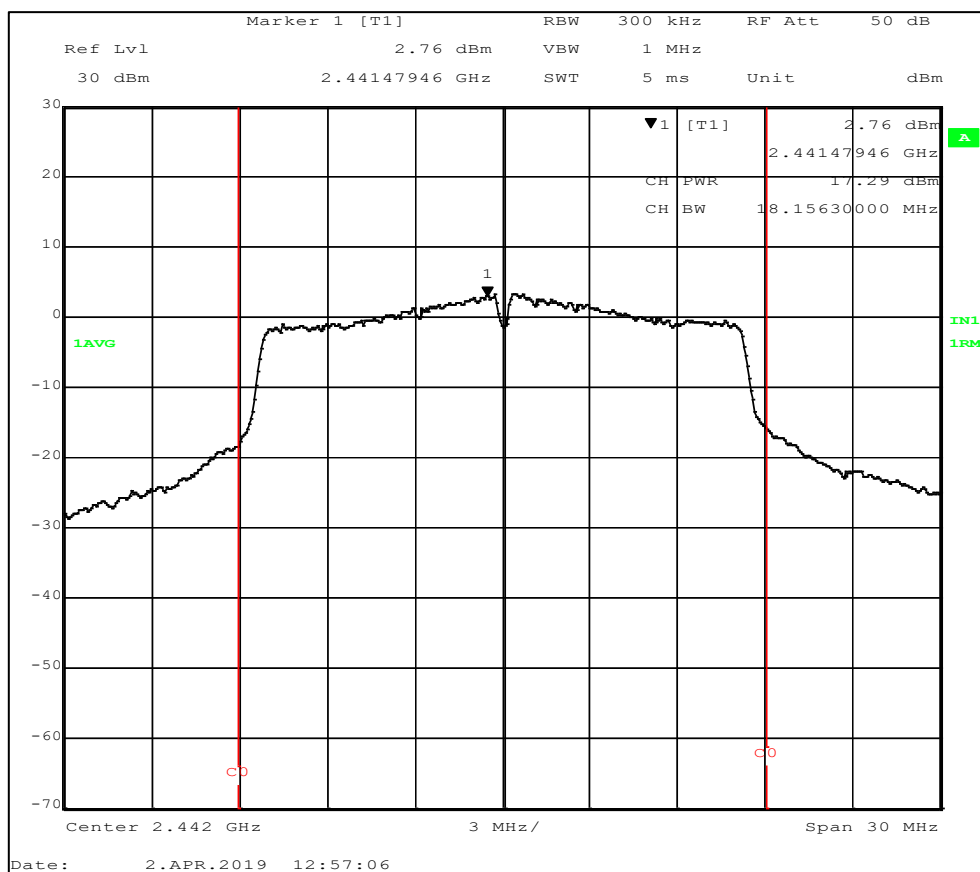


Figure 10. Output power channel 7.

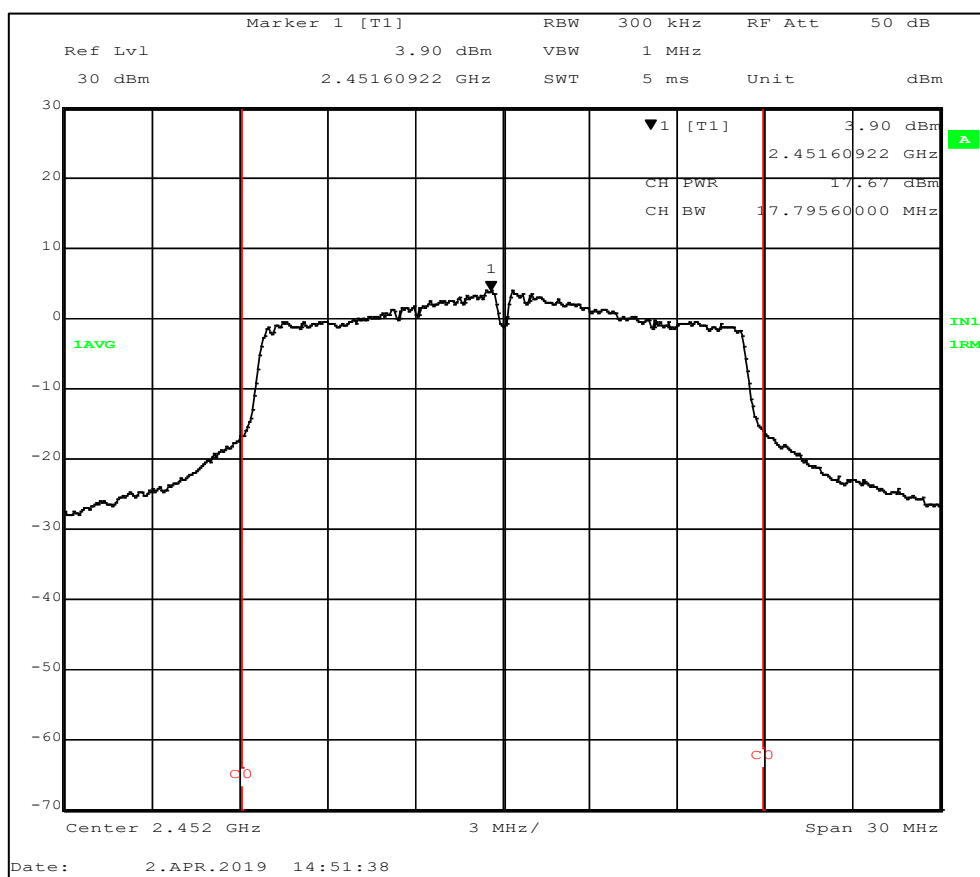


Figure 11. Output power channel 9.

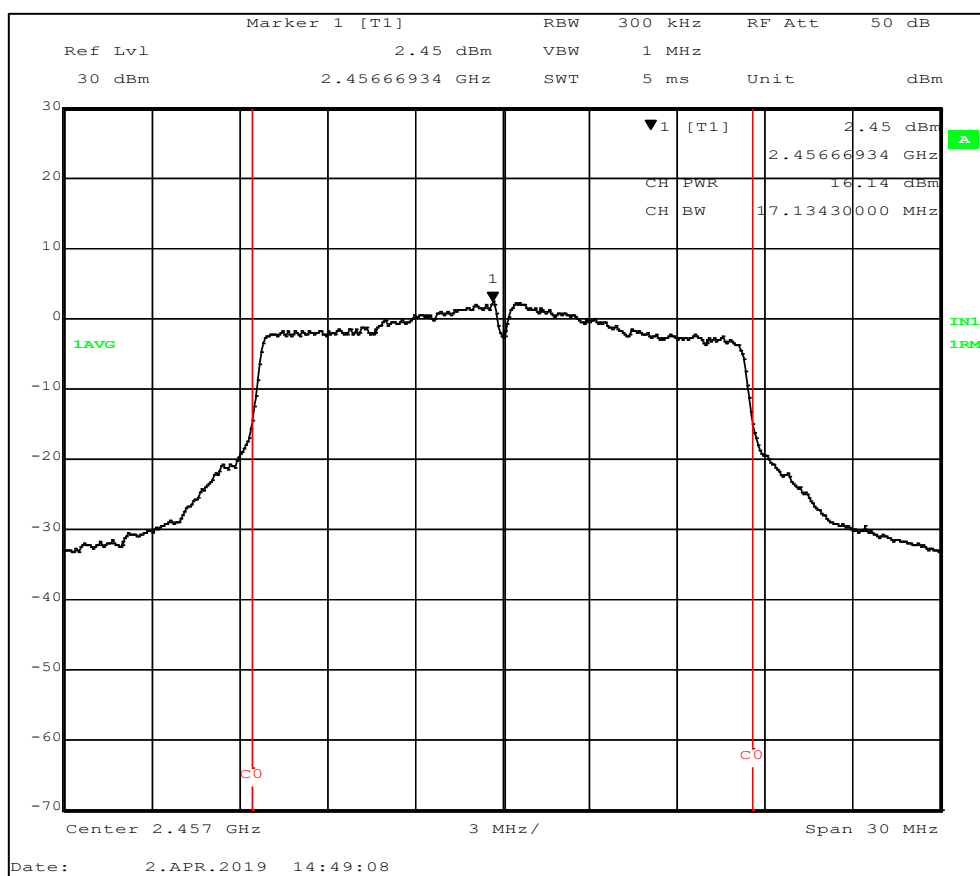


Figure 12. Output power channel 10.

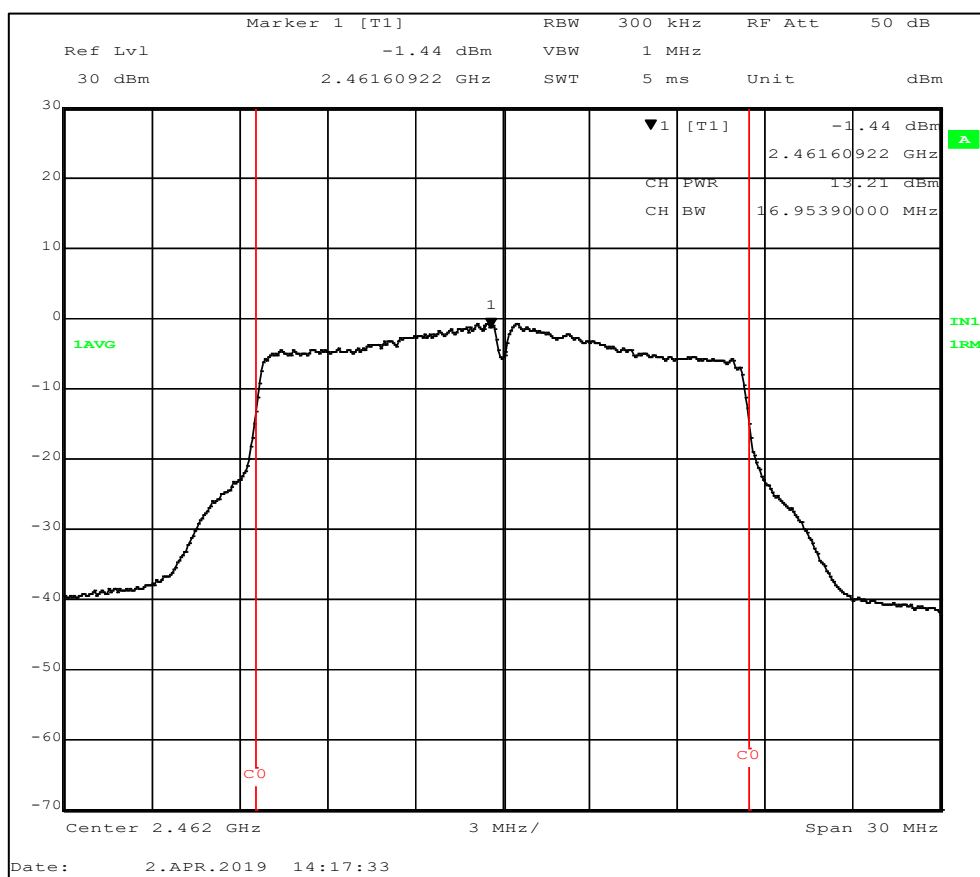


Figure 13. Output power channel 11.

Channel	Frequency [MHz]	Output power [dBm]	Limit [dBm]	Result
1	2412	13.25	30	PASSED
2	2417	15.87	30	PASSED
3	2422	17.02	30	PASSED
7	2442	17.29	30	PASSED
9	2452	17.67	30	PASSED
10	2457	16.14	30	PASSED
11	2462	13.21	30	PASSED

The nominal voltage of 5 VDC were varied between 85% and 115% without any increase of the output power.

2.3.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.4 Emission outside frequency band.

Test specimen	AT-DG2 no.12
Test specification	47 CFR Part 15.247 (d)
Test method	ANSI C63.10:2013 sec. 11.11
Frequency range	30 MHz – 25 GHz
Limits	47 CFR Part 15.247 (d).
Comments	None
Temperature / Humidity	25°C / 24%RH
Dates of measurements	2019-04-04
Test personnel	Søren Søltøft

2.4.1 Test setup

The temporary antenna connector of the test specimen was connected directly to the spectrum analyzer.

See appendix 1 for photo of test set up

2.4.2 Test results

2.4.2.1 Reference level for test.

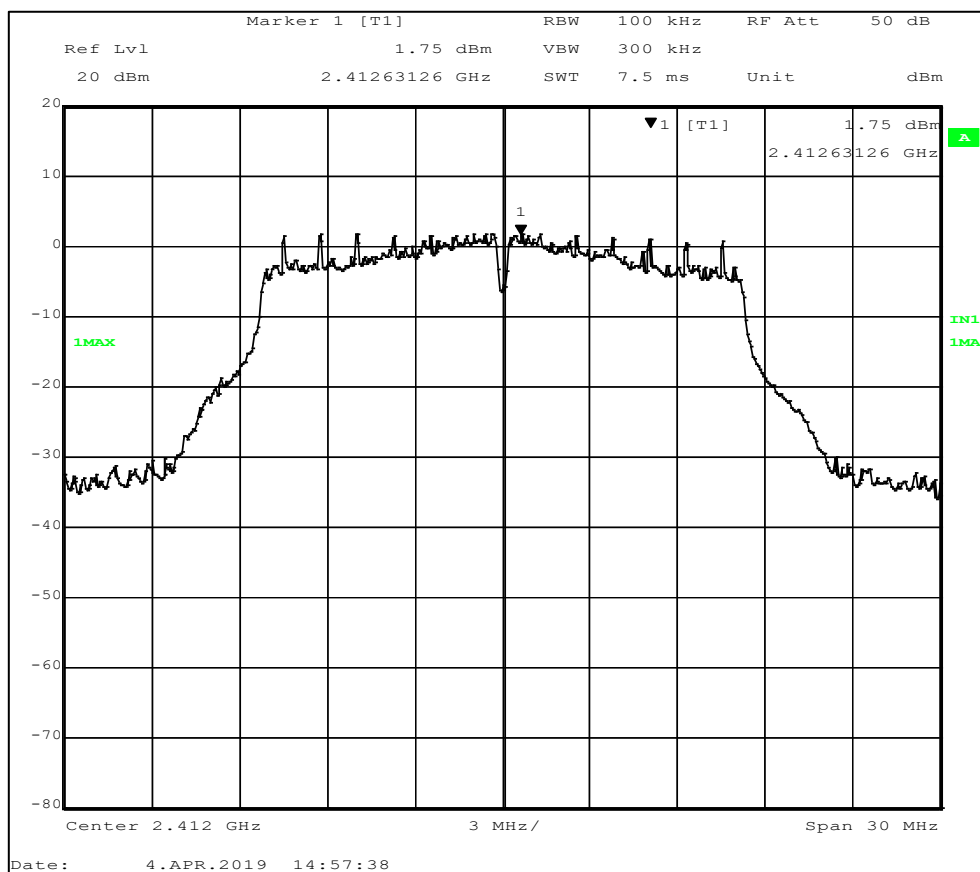


Figure 14. Reference level for channel 1.

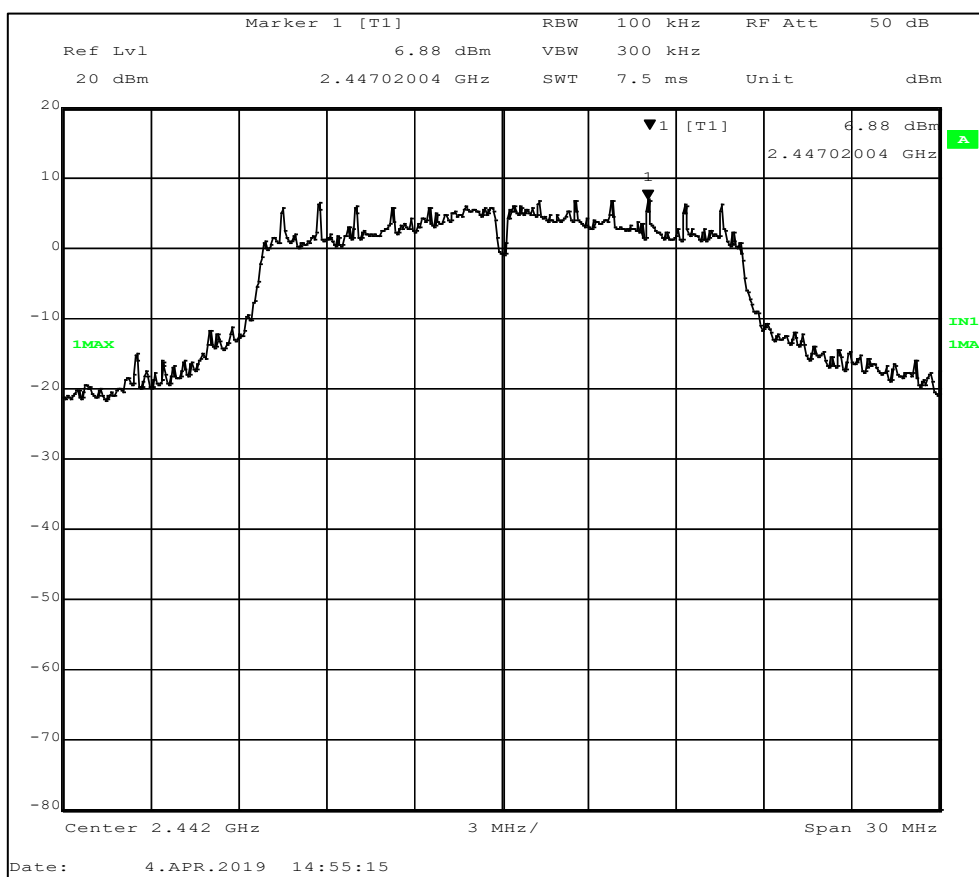


Figure 15. Reference level for channel 7.

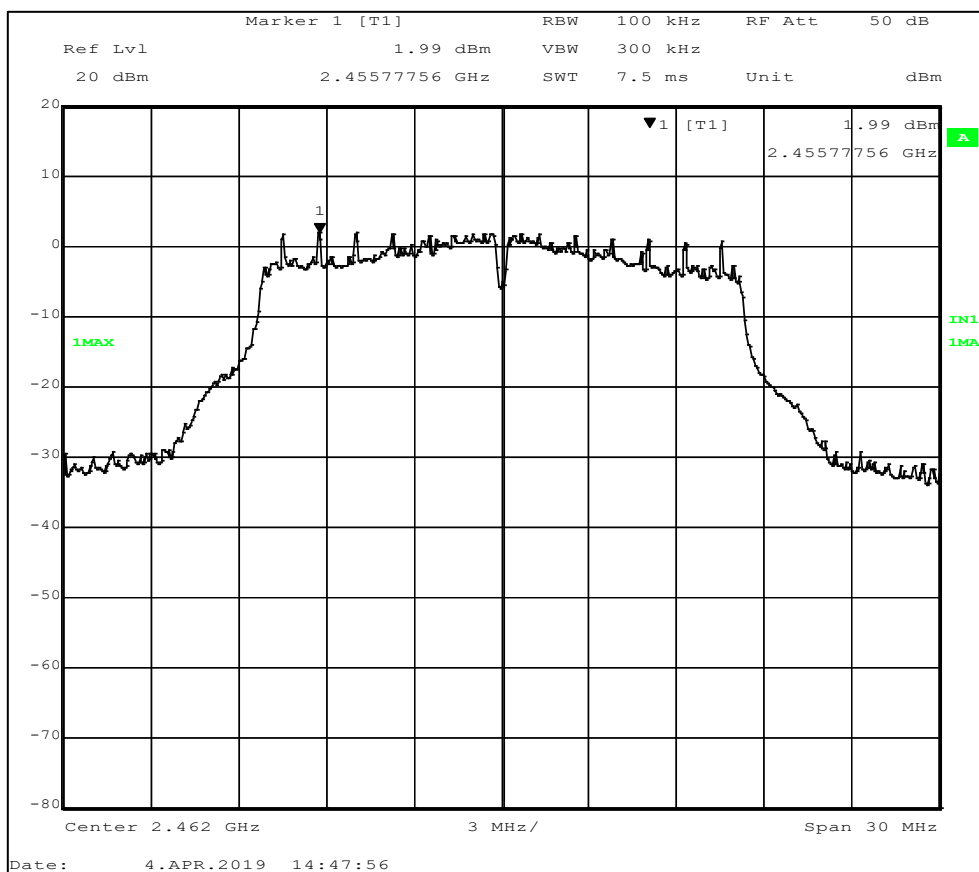


Figure 16. Reference level for channel 11.

2.4.2.2 Test result for channel 1 at 2412 MHz

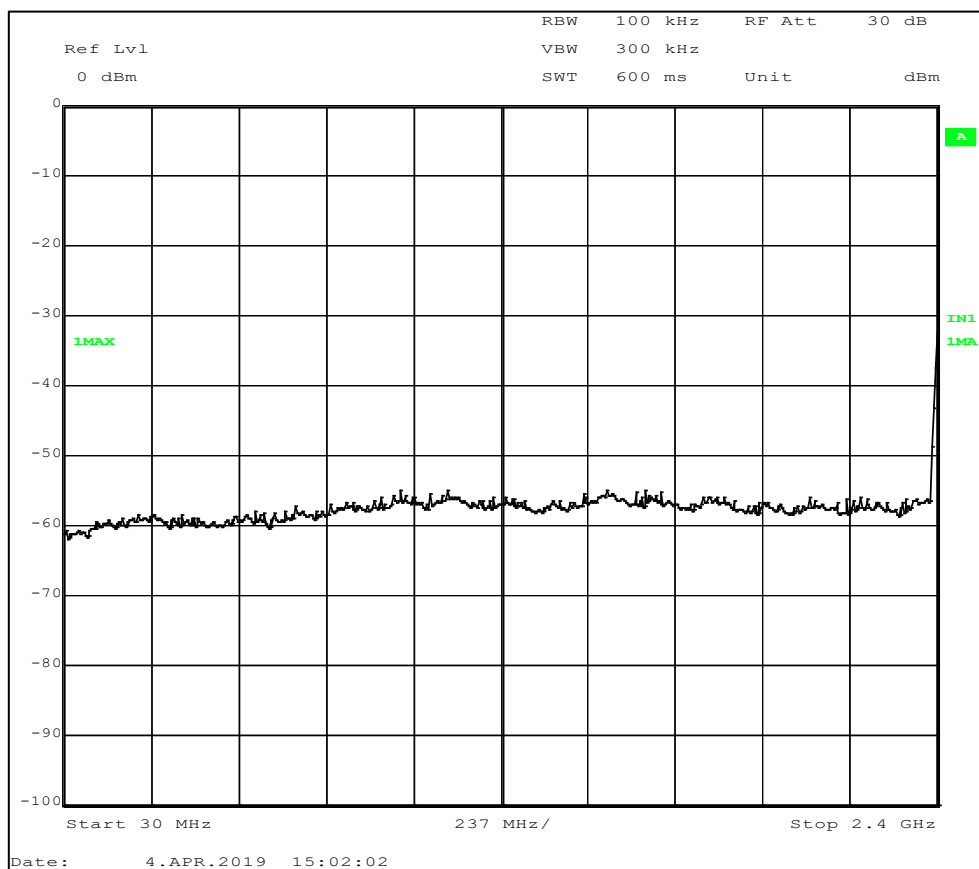


Figure 17. Emission test results. 30 MHz – 2.4 GHz.

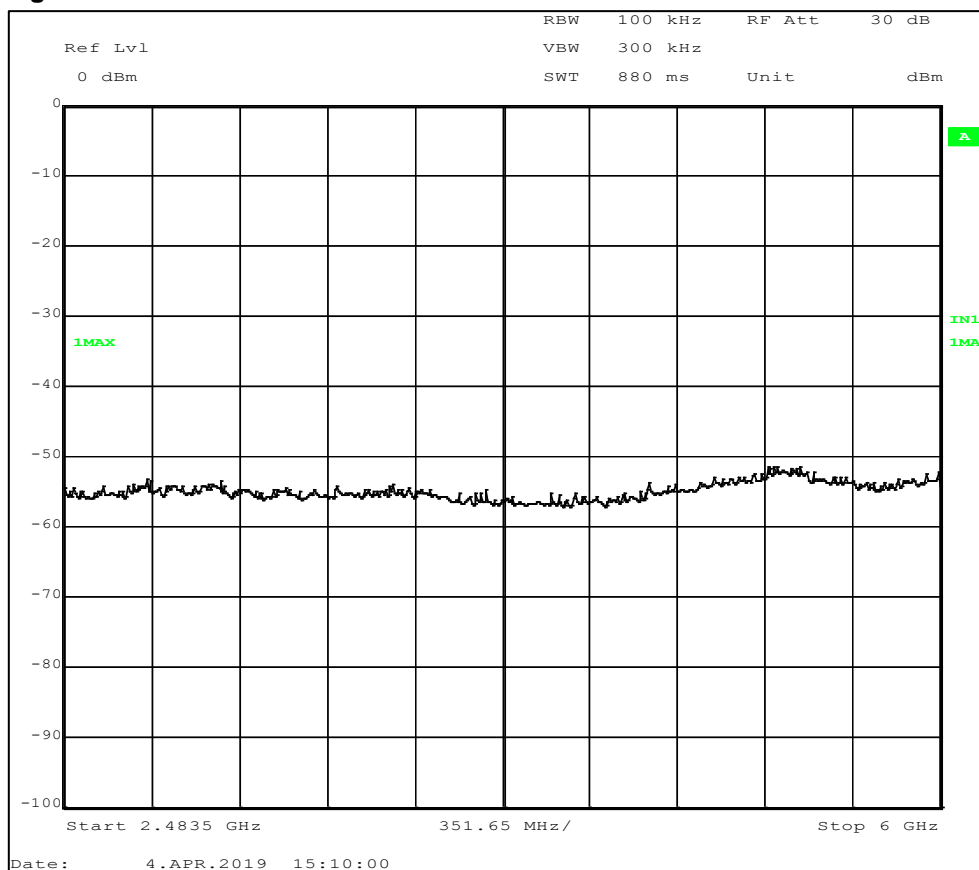


Figure 18. Emission test result 2.4835 GHz to 6 GHz.

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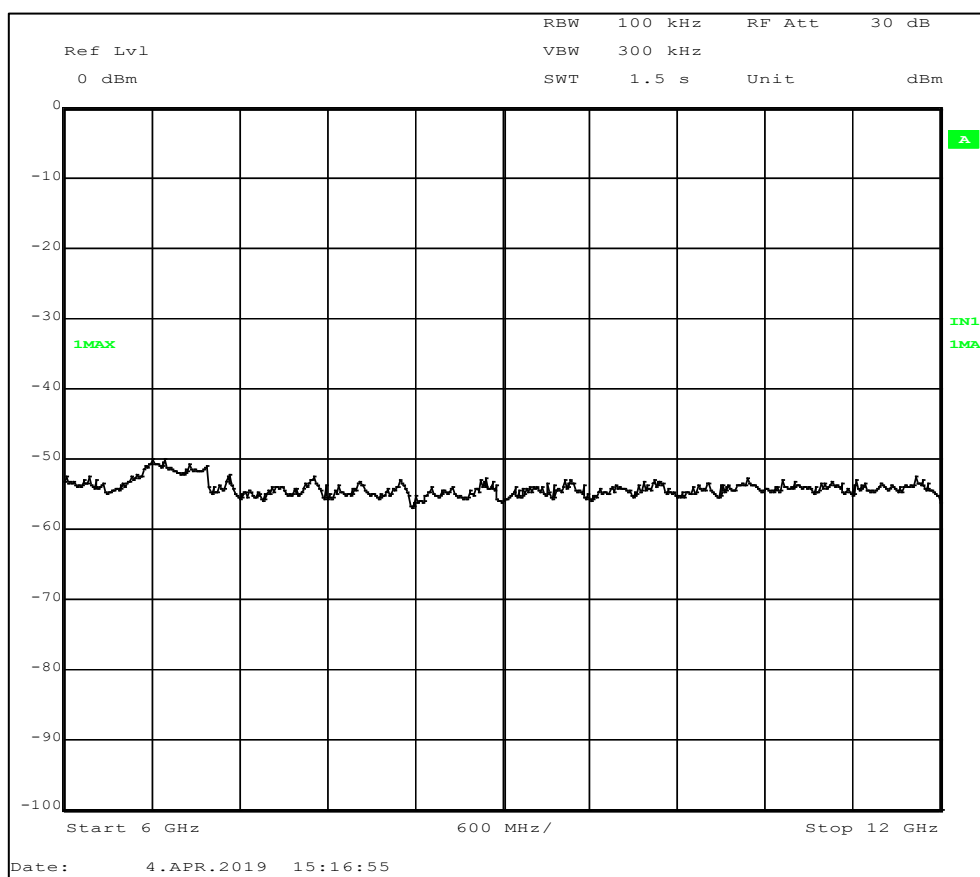
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Figure 19. Emission test result 6 GHz to 12 GHz.

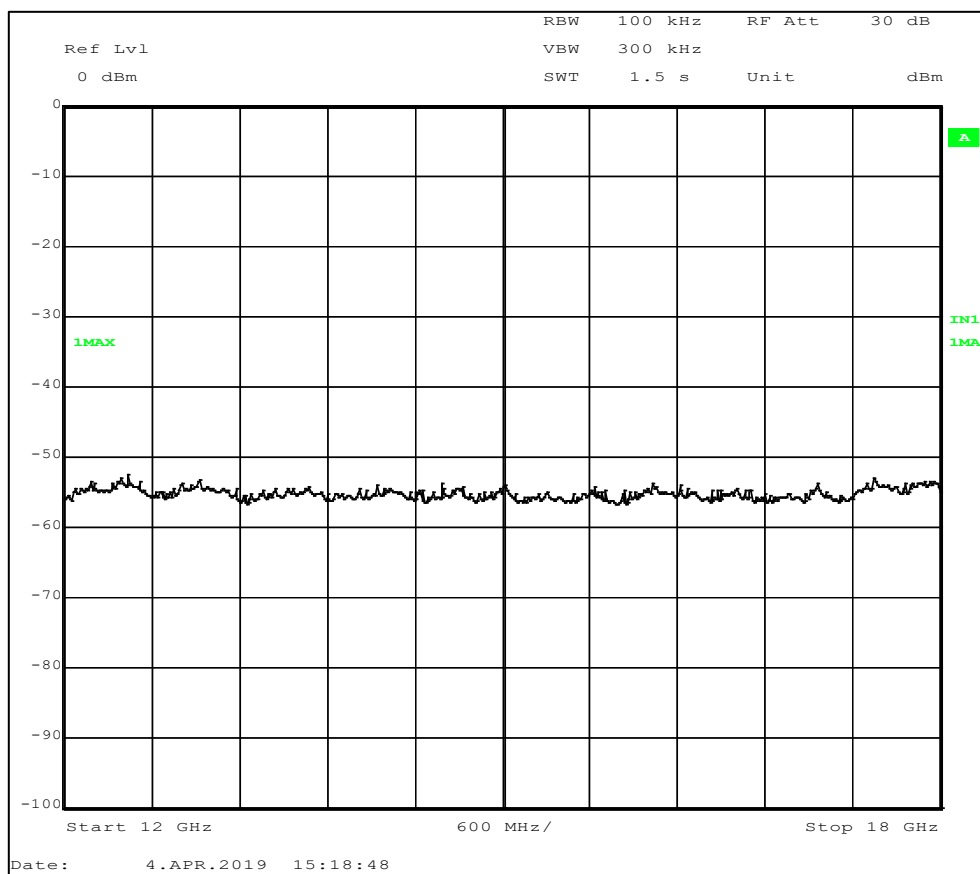


Figure 20. Emission test result 12 GHz to 18 GHz.

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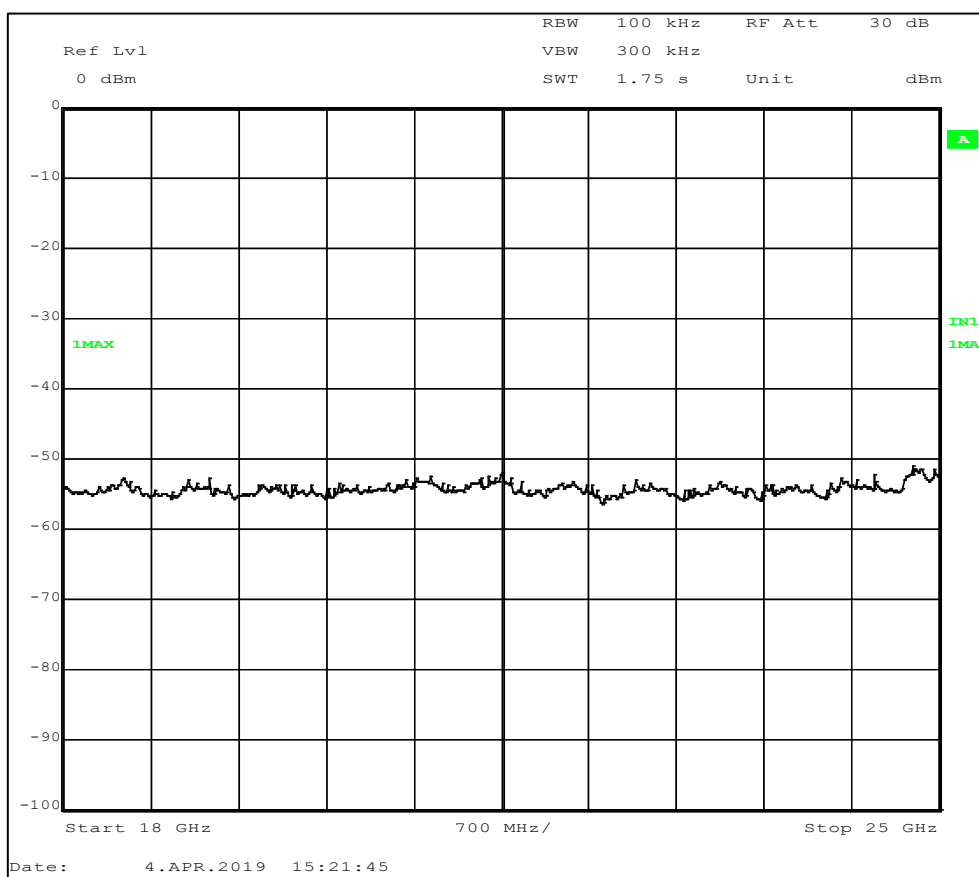
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Figure 21. Emission test result 18 GHz to 25 GHz.

Frequency [MHz]	Peak [dBm]	BW [kHz]	Margin [dB]	Limit [dBm]	Result
2398.71743	-32,22	100	3,97	-28,25	PASSED

Table 5. Emission test results. Channel 1. 30 MHz to 25 GHz.

2.4.2.3 Test result for channel 7 at 2417 MHz

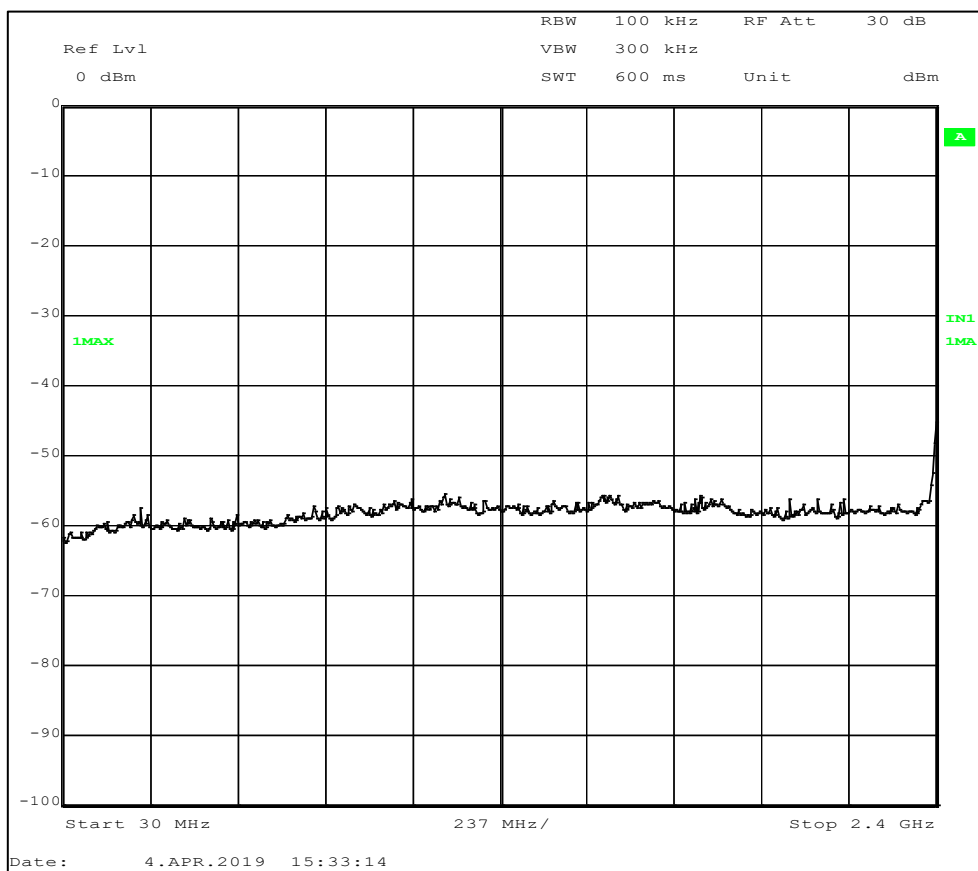


Figure 22. Emission test results. 30 MHz – 2.4 GHz.

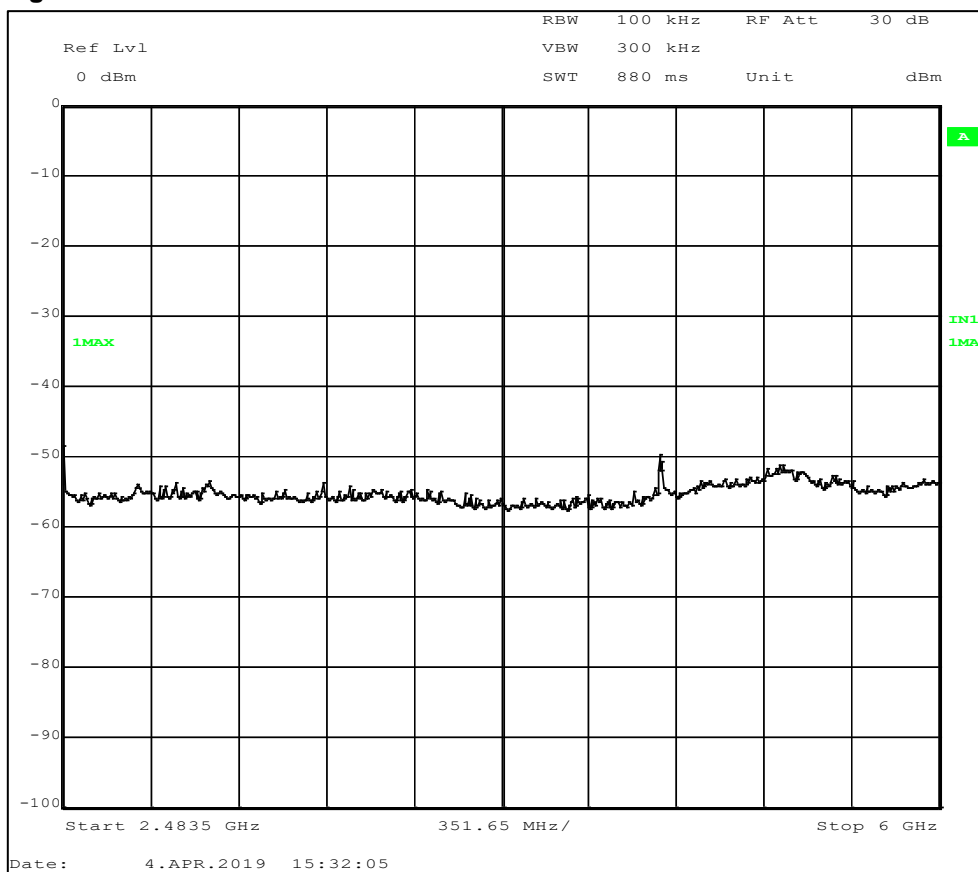


Figure 23. Emission test result 2.4835 GHz to 6 GHz.

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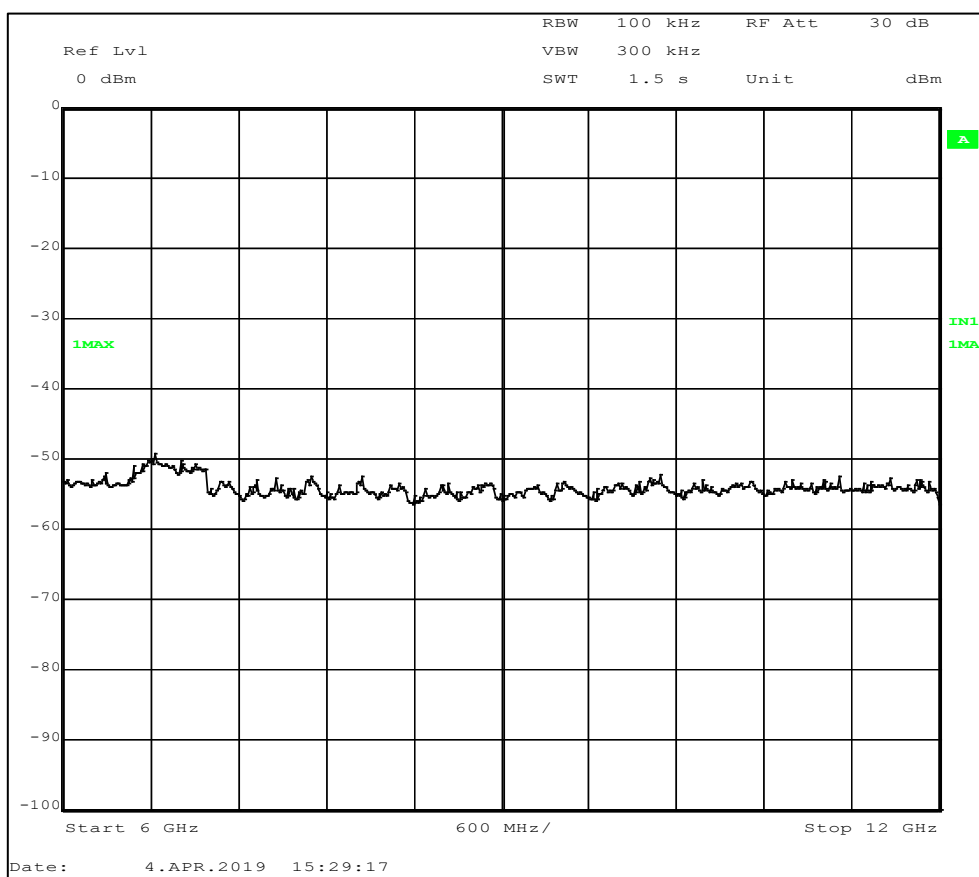
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Figure 24. Emission test result 6 GHz to 12 GHz.

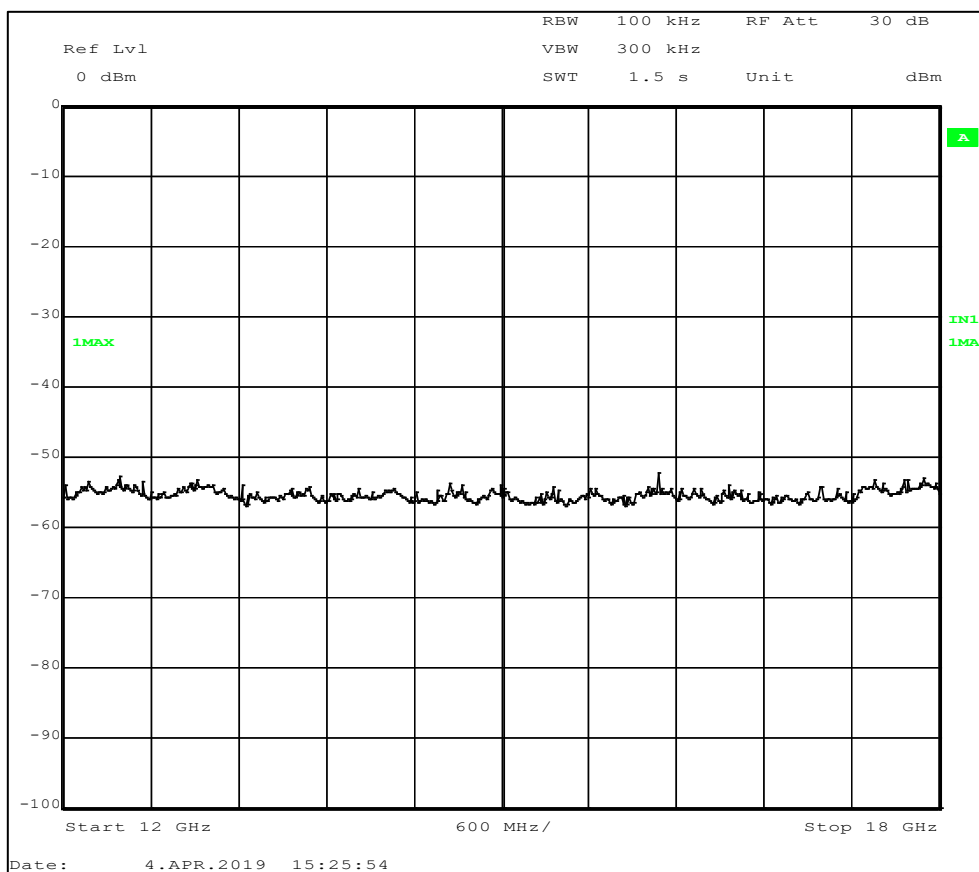


Figure 25. Emission test result 12 GHz to 18 GHz.

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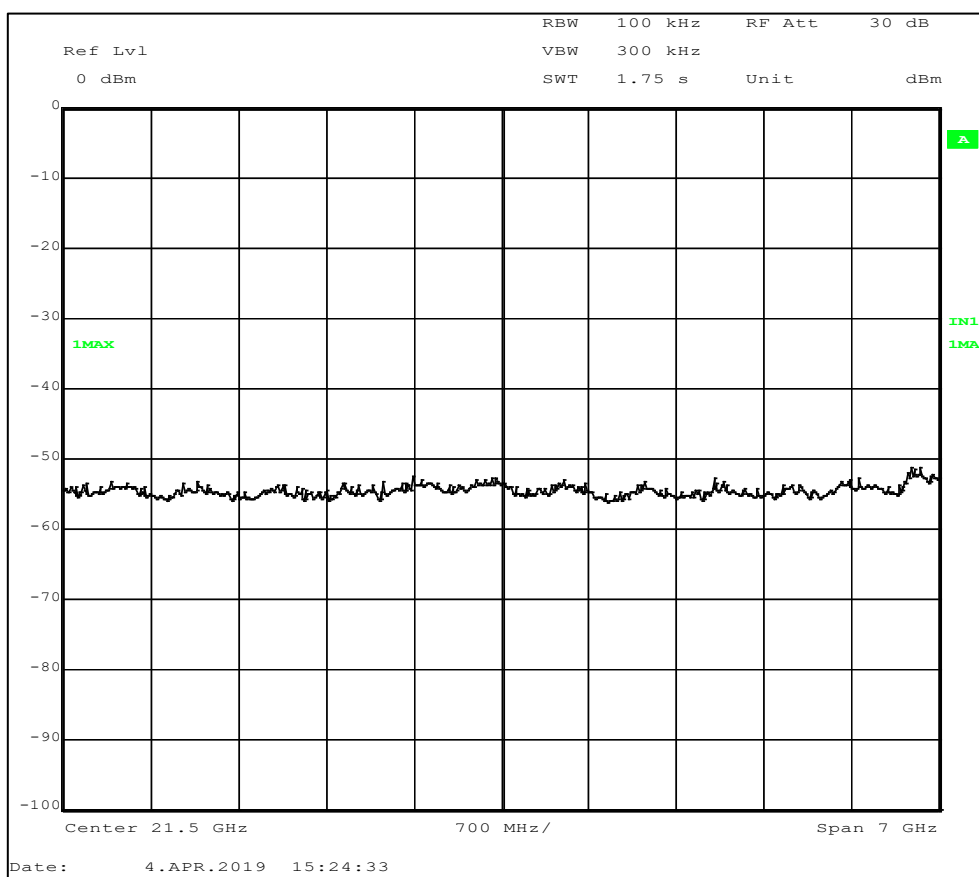
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Figure 26. Emission test result 18 GHz to 25 GHz.

Frequency [MHz]	Peak [dBm]	BW [kHz]	Margin [dB]	Limit [dBm]	Result
-	-	100	-	-	PASSED

Table 6. Emission test results. Channel 2. 30 MHz to 25 GHz.

2.4.2.4 Test result for channel 11 at 2462 MHz.

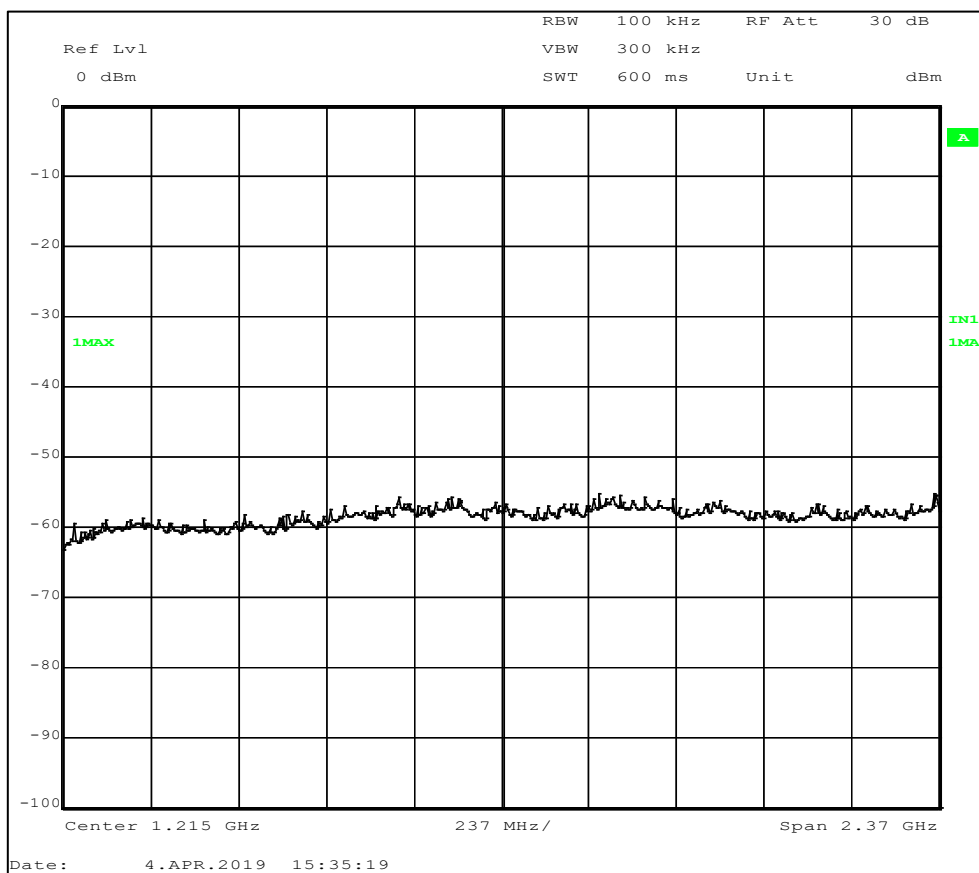


Figure 27. Emission test results. 30 MHz to 2.4 GHz.

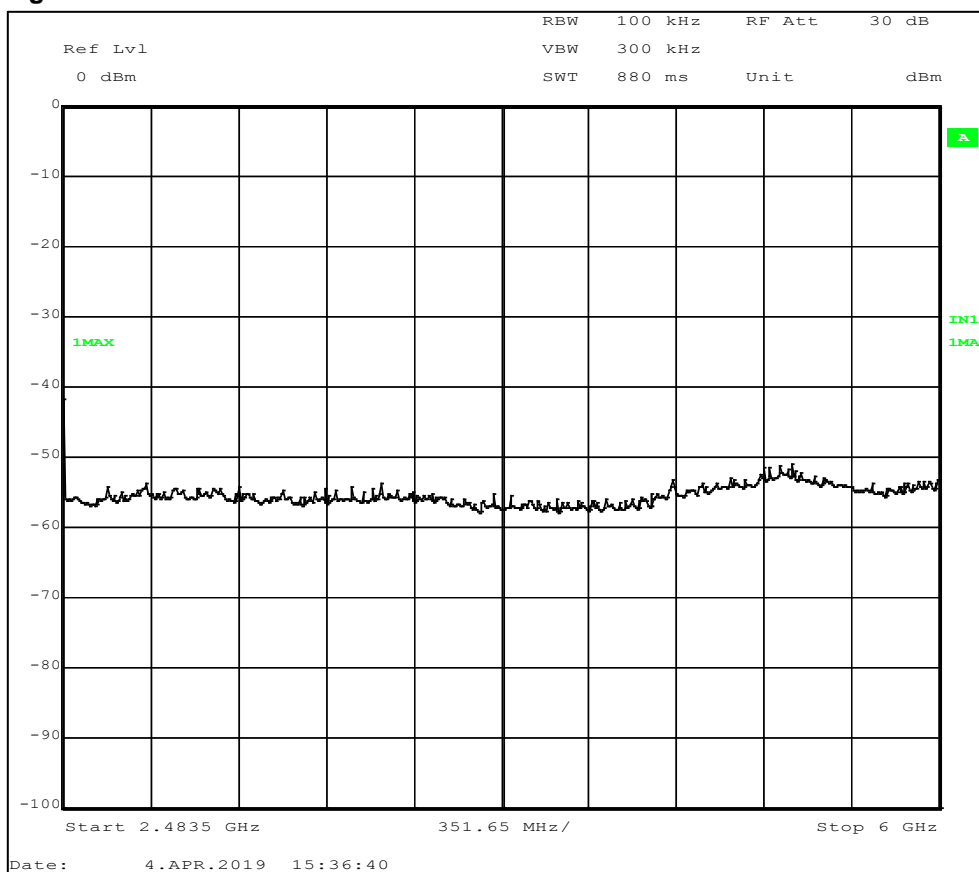


Figure 28. Emission test results. 2.4835 GHz to 6 GHz.

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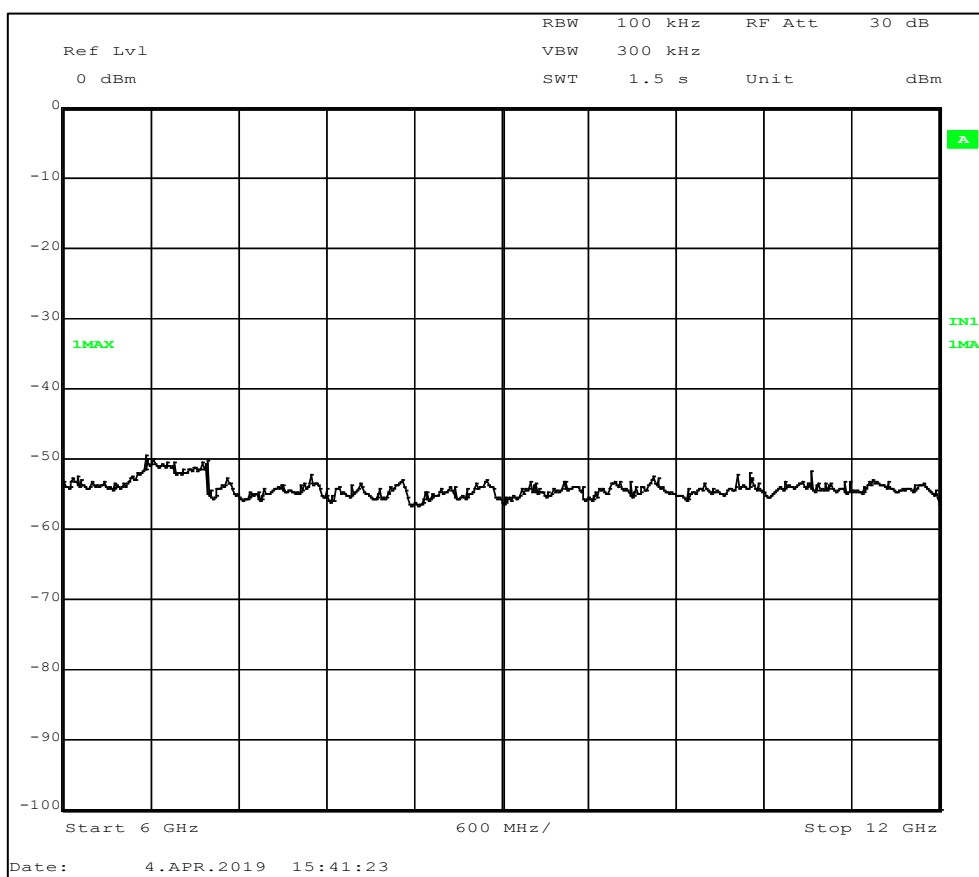
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Figure 29. Emission test results. 6 GHz to 12 GHz.

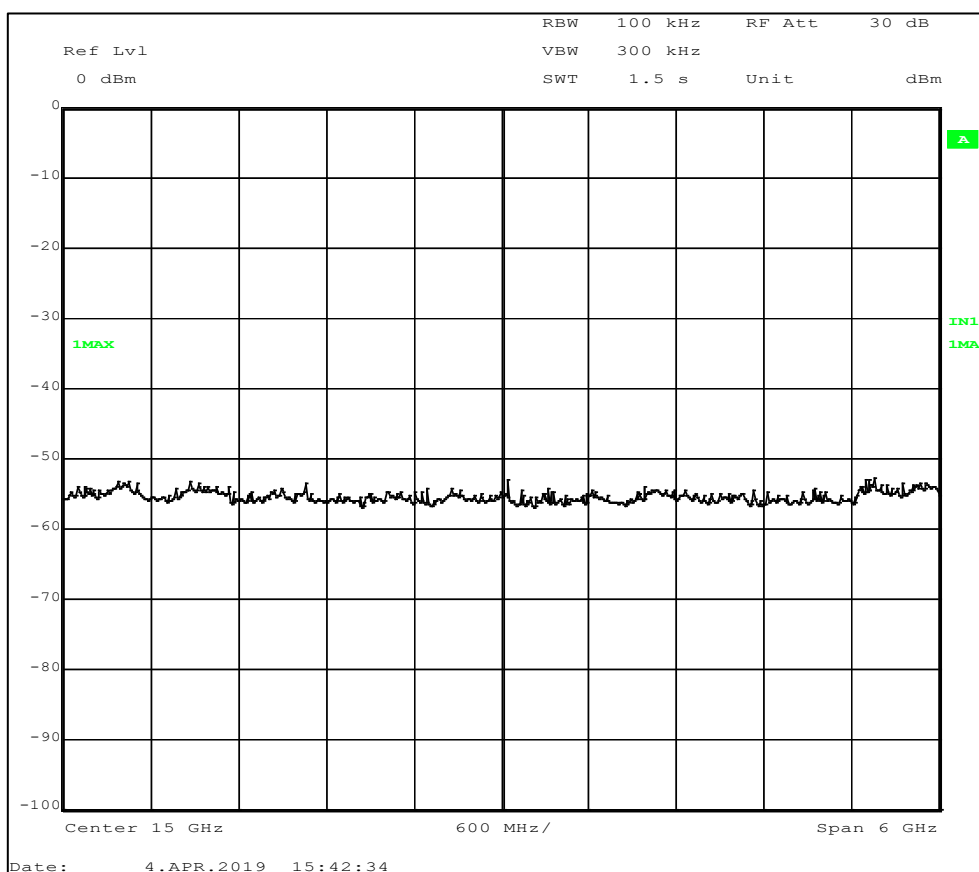


Figure 30. Emission test results. 12 GHz to 18 GHz.

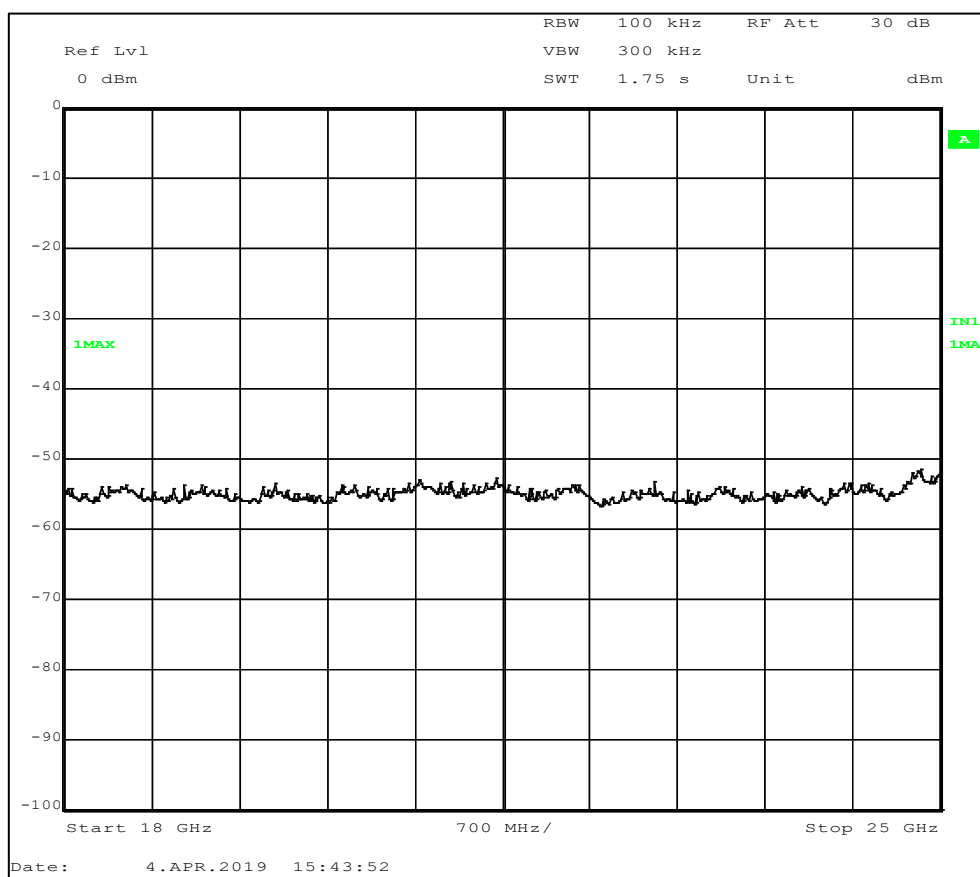


Figure 31. Emission test results. 18 GHz to 25 GHz.

Frequency [MHz]	Peak [dBm]	BW [kHz]	Margin [dB]	Limit [dBm]	Result
2483.54008	-41.44	100	13.43	-28,01	PASSED

Table 7. Emission test results. Channel 11. 30 MHz to 25 GHz.

2.4.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.5 Band edge

Test specimen	DG2 no.10
Test specification	558074 D01 15.247 Measurement Guidance v05
Test method	ANSI C63.10:2013 sec. 11.12
Comments	None
Temperature / Humidity	21°C / 26%RH
Dates of measurements	2019-04-04
Test personnel	Søren Søltoft

2.5.1 Test setup

The measurement was performed radiated in a semi anechoic chamber with absorbers on the floor.

The measuring distance was 3 m.

The EUT was placed on a non-conductive table, 1.5 m above the floor.

The test specimen was placed in the orientation giving the highest RF output at the fundamental frequency.

The measurements were performed at the edge of the nearest restricted band below and above the DTS band. Below at 2390 MHz and above at 2483.5 MHz.

See appendix 1 for photo of test set up

2.5.2 Test results

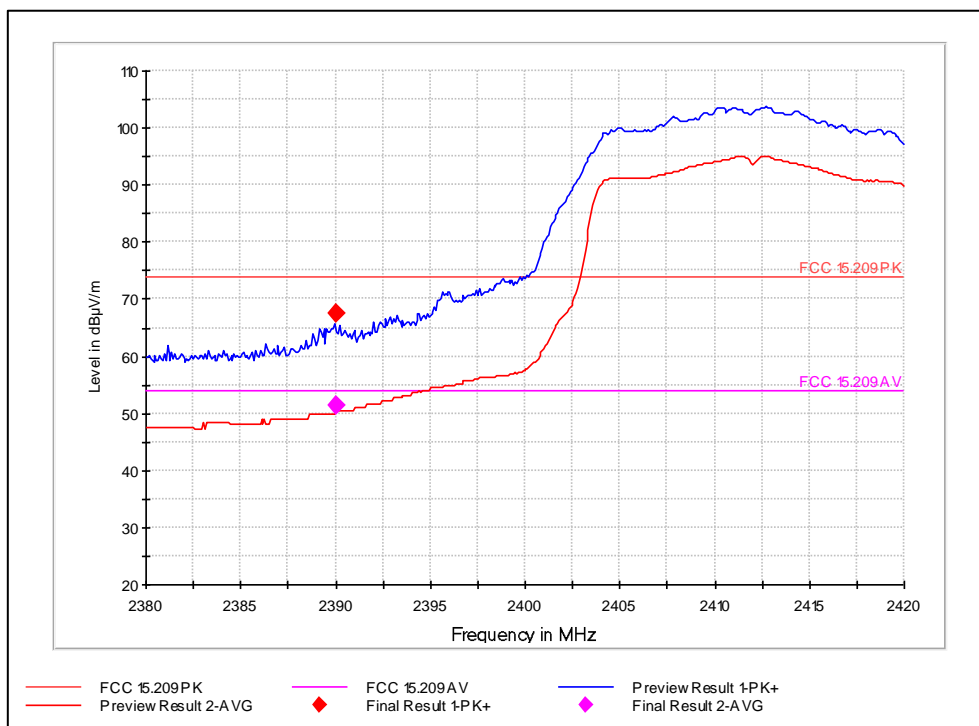


Figure 32. Band Edge for channel 1

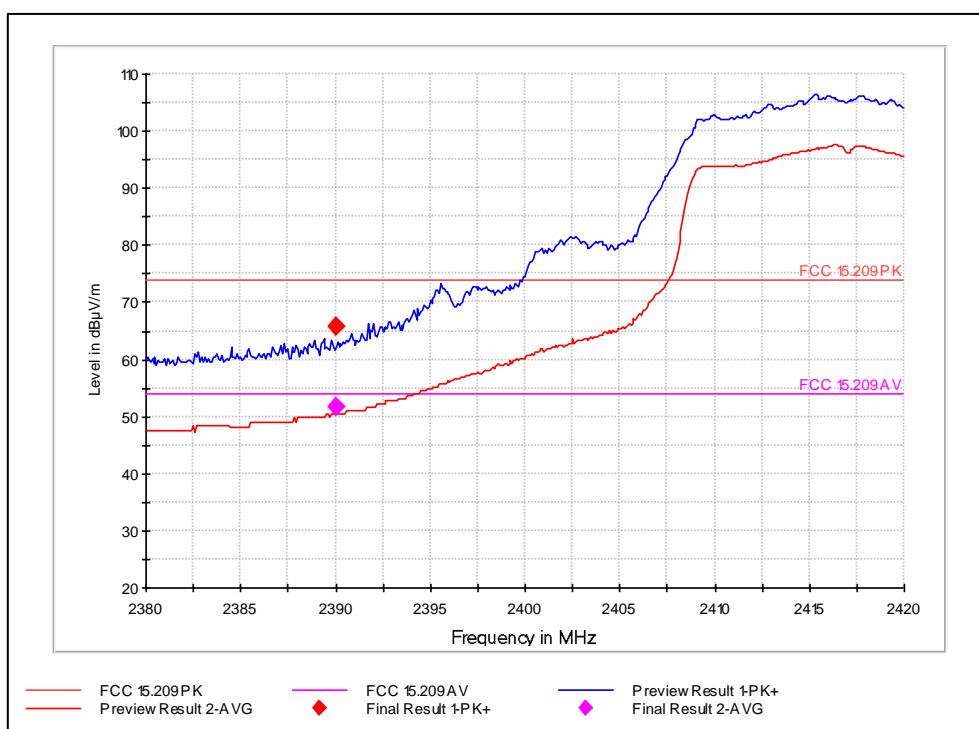


Figure 33. Band Edge for channel 2

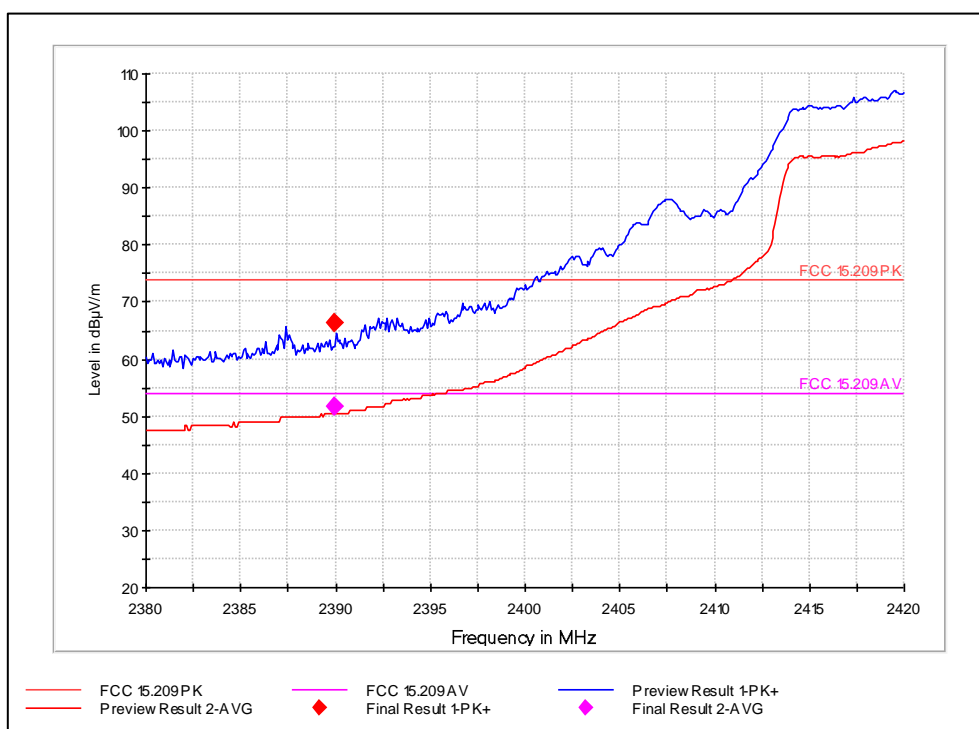


Figure 34. Band Edge for channel 3

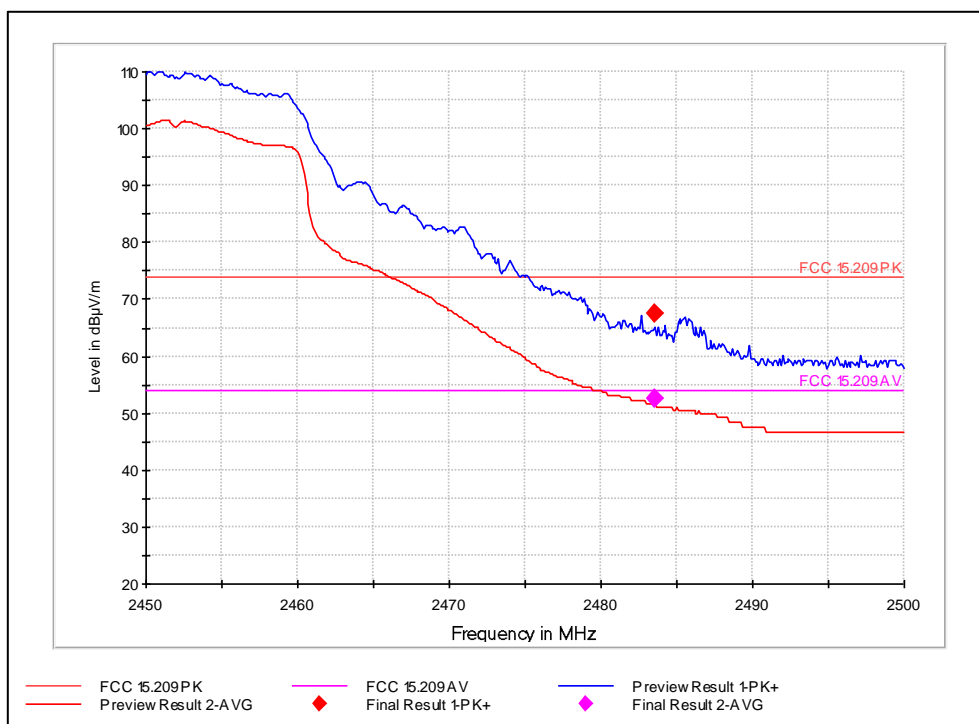


Figure 35. Band Edge for channel 9

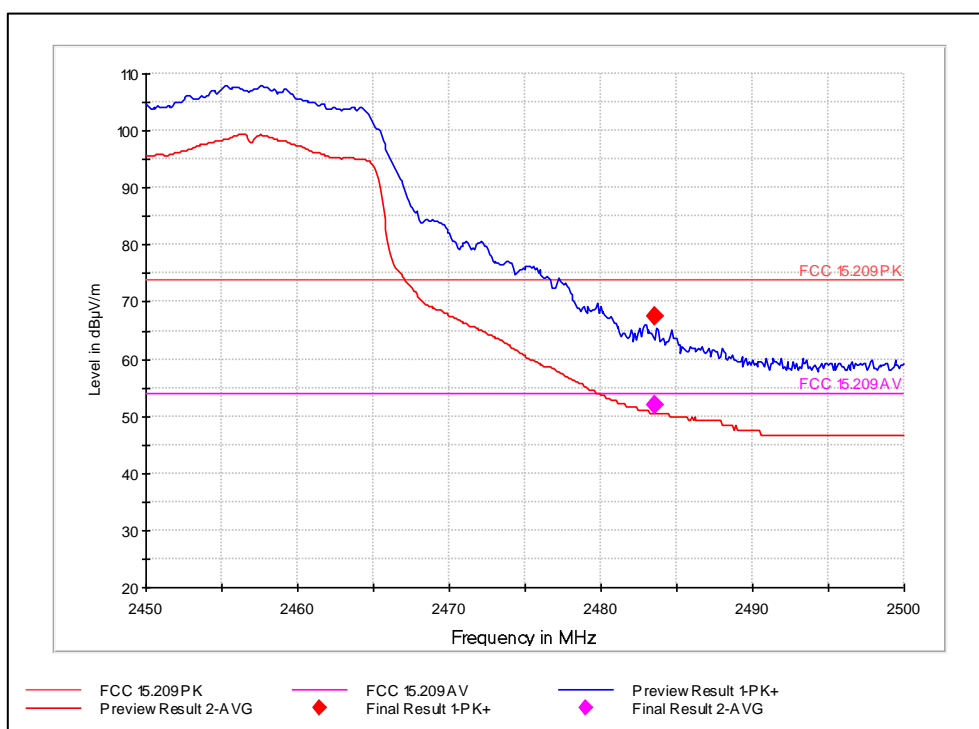


Figure 36. Band Edge for channel 10

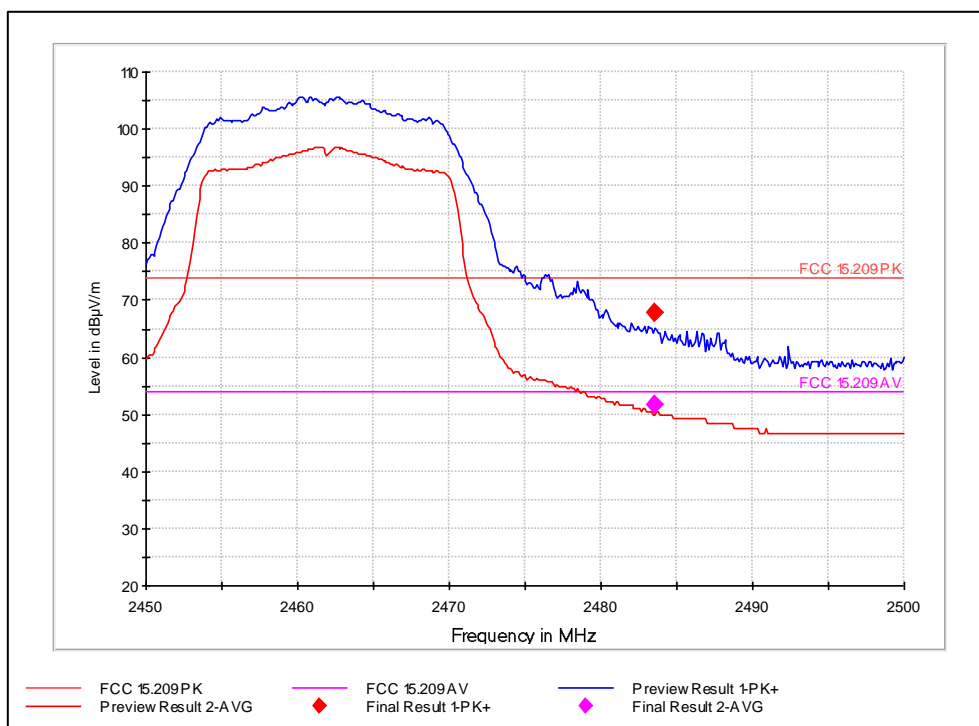


Figure 37. Band Edge for channel 11.

Channel	Peak [dBμV/m]	Average [dBμV/m]	Limit		Margin		Result
			Peak [dBμV/m]	Average [dBμV/m]	Peak [dB]	Average [dB]	
1	67.5	51.4	74	54	6.5	2.6	Passed
2	65.8	51.8	74	54	8.2	2.2	Passed
3	66.3	51.8	74	54	7.7	2.2	Passed
9	67.5	52.6	74	54	6.5	1.4	Passed
10	67.5	51.9	74	54	6.5	2.1	Passed
11	67.9	51.6	74	54	6.1	2.4	Passed

Table 8. Band Edge results.

2.5.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESI 26	20763	2019-12-10

Table 9. Band Edge test equipment.

2.6 Power spectral density

Test specimen	AT-DG2 no. 12
Test specification	FCC 47 CFR Part 15.247 (e)
Test method	ANSI C63.10:2013 sec 11.10.2
Limits	FCC 47 CFR Part 15.247 (e)
Comments	None
Temperature / Humidity	22°C / 23%RH
Dates of measurements	2019-04-02
Test personnel	Søren Søltoft

2.6.1 Test setup

The test specimen was connected to a spectrum analyzer using a temporary antenna connector.

See photo of test set up in appendix 1.

The Power spectral density was measured at channel 7 at the different Data rates to establish worst case.

Data rate 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s were tested.

The other channels were tested at the found Data rate.

2.6.2 Test results

2.6.2.1 Power spectral density as function of data rate

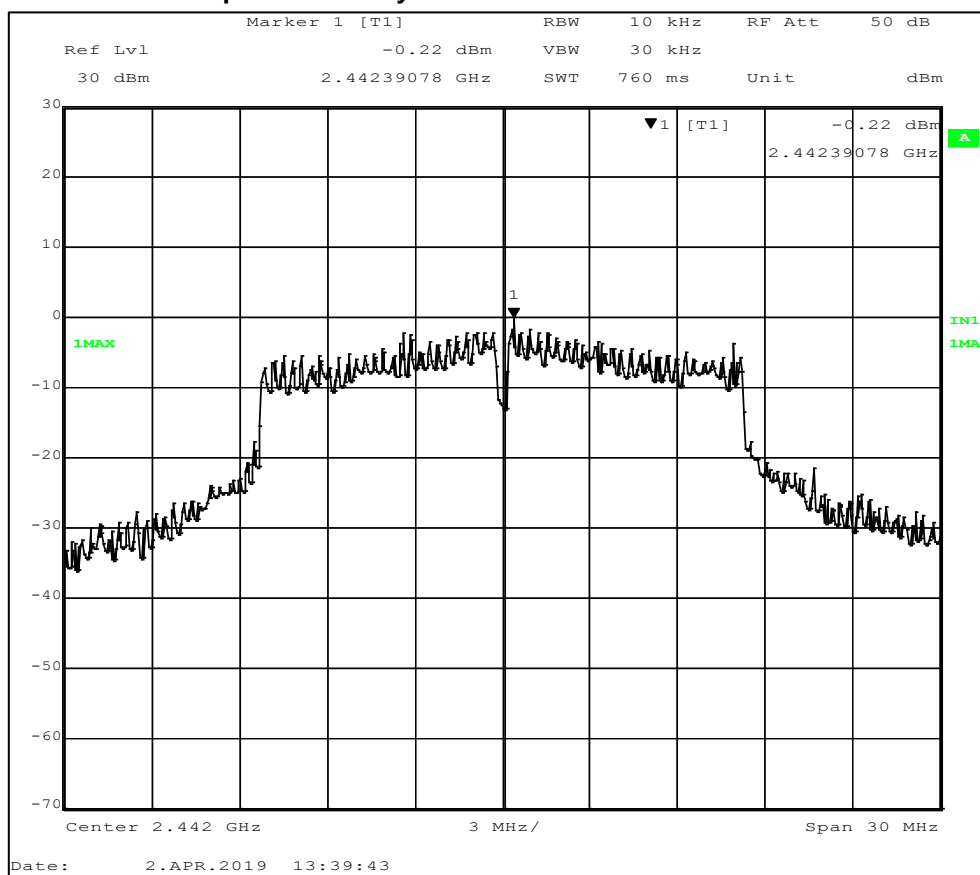


Figure 38. Power spectral density at channel 7 at Data rate 6.

Data rate [Mbit/s]	Power spectral density [dBm]
6	-0.22
9	-0.33
12	-0.69
18	-2.98
24	-3.11
36	-2.71
48	-2.45
54	-2.47

Table 10. Test result of Data rate on channel 7.

2.6.2.2 Power spectral density at data rate 6.

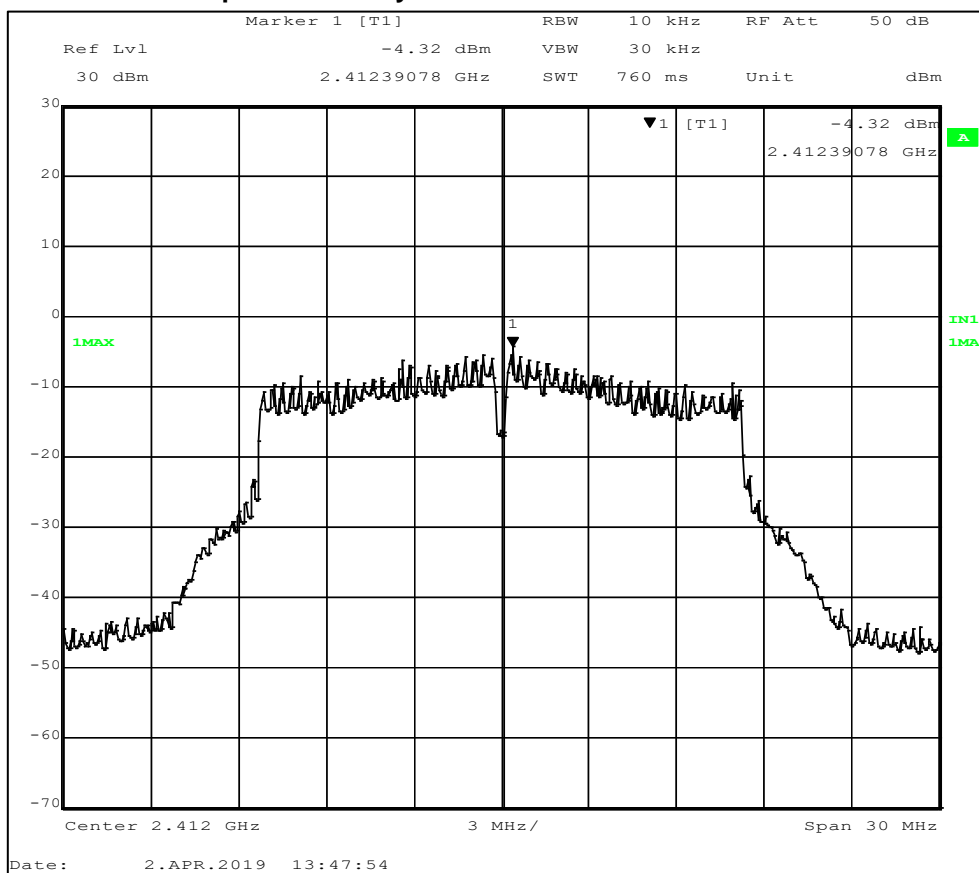


Figure 39. Power spectral density channel 1.

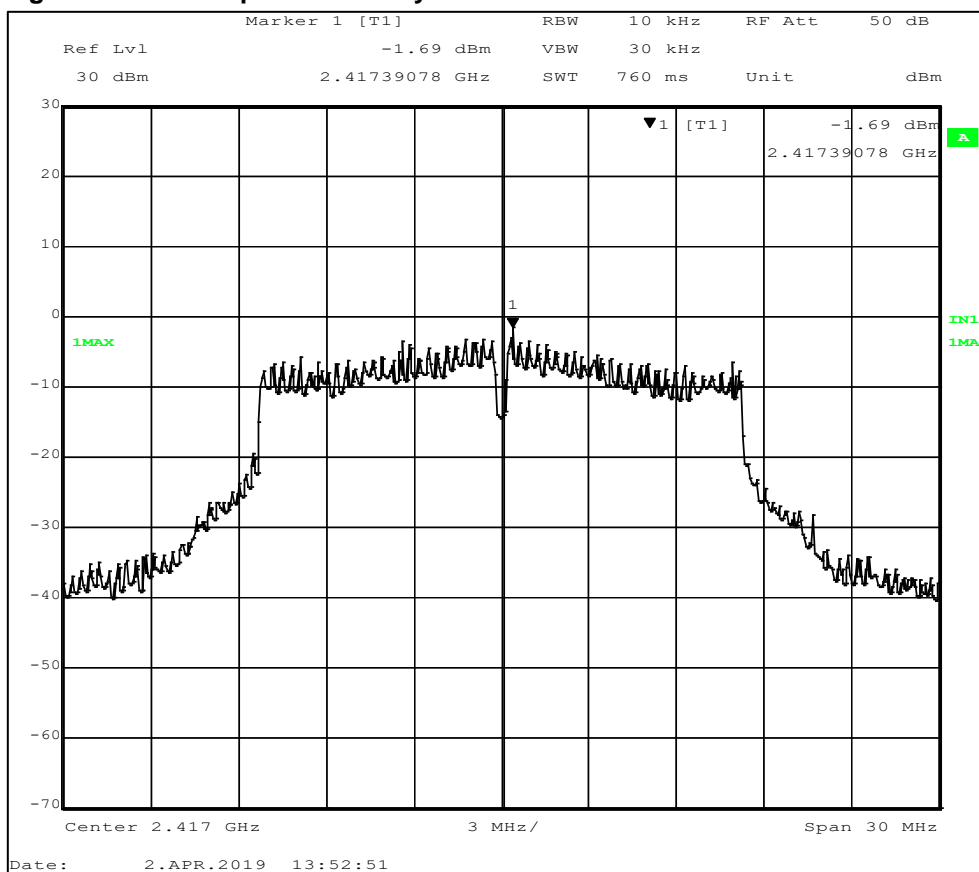


Figure 40. Power spectral density channel 2.

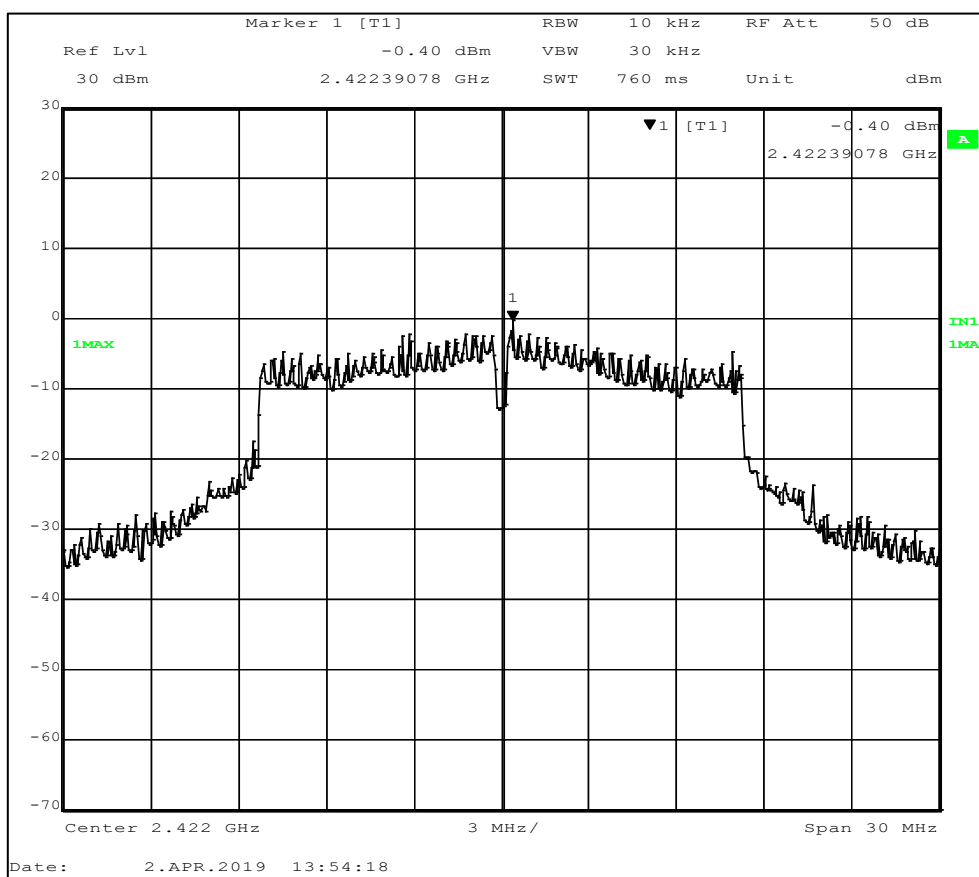


Figure 41 Power spectral density channel 3.

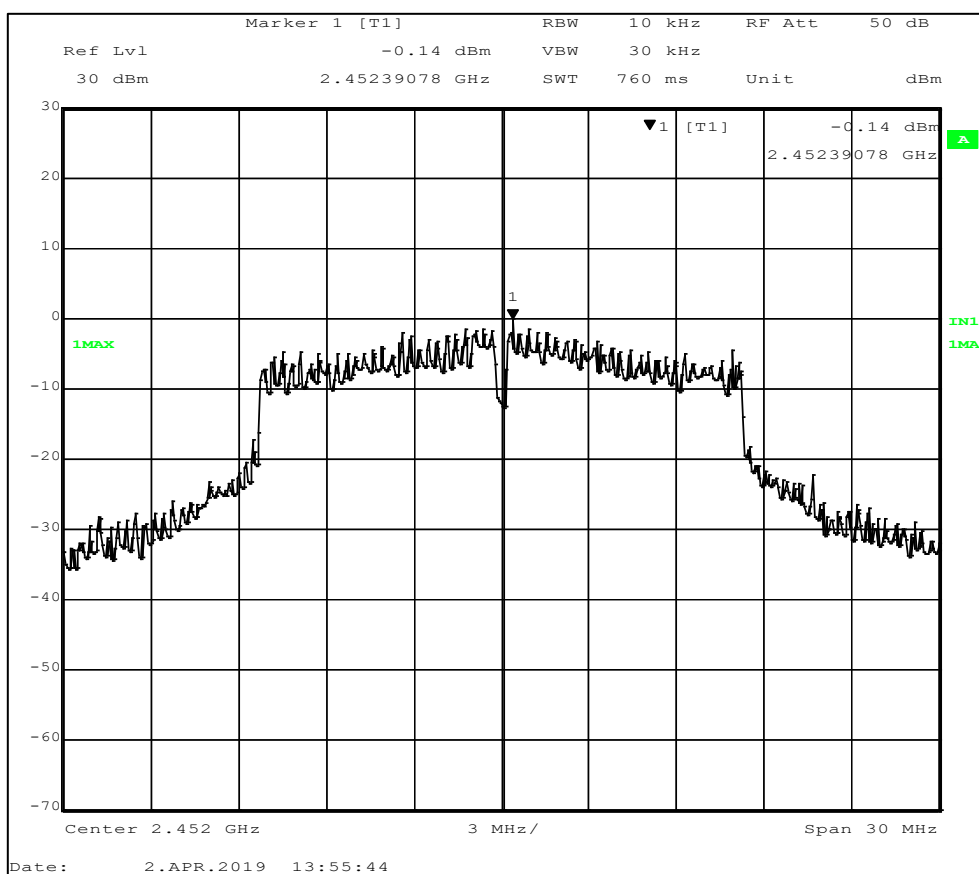


Figure 42. Power spectral density channel 9.

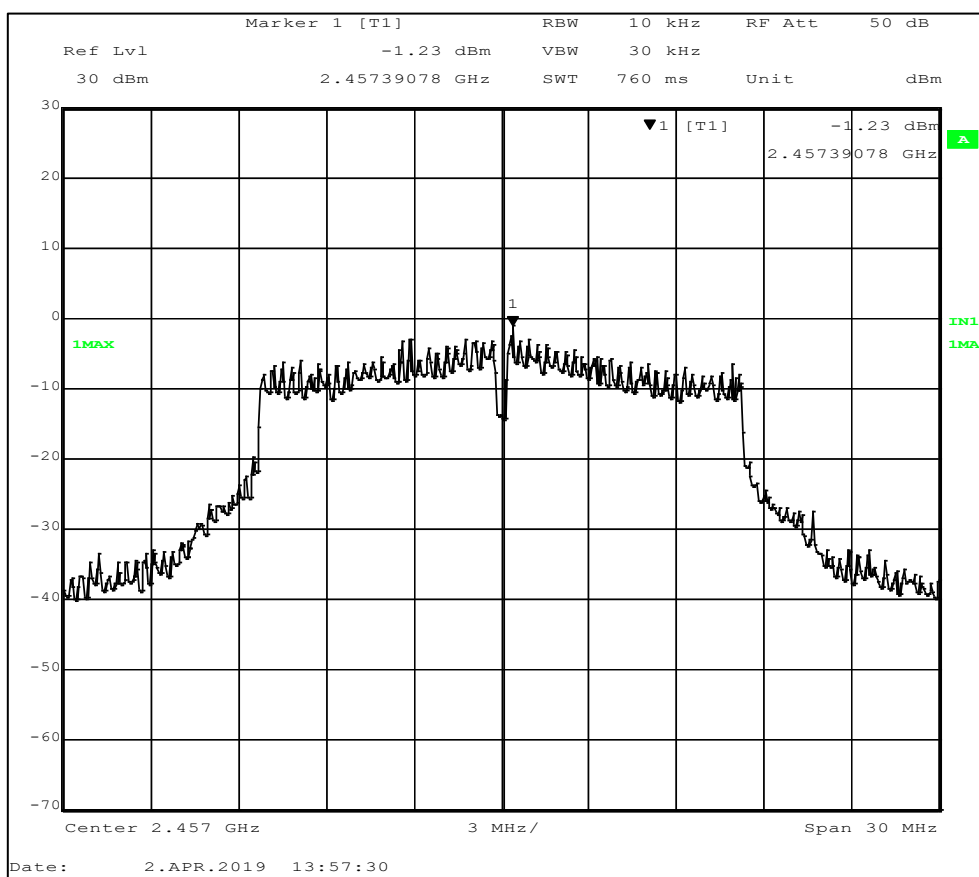


Figure 43. Power spectral density channel 10.

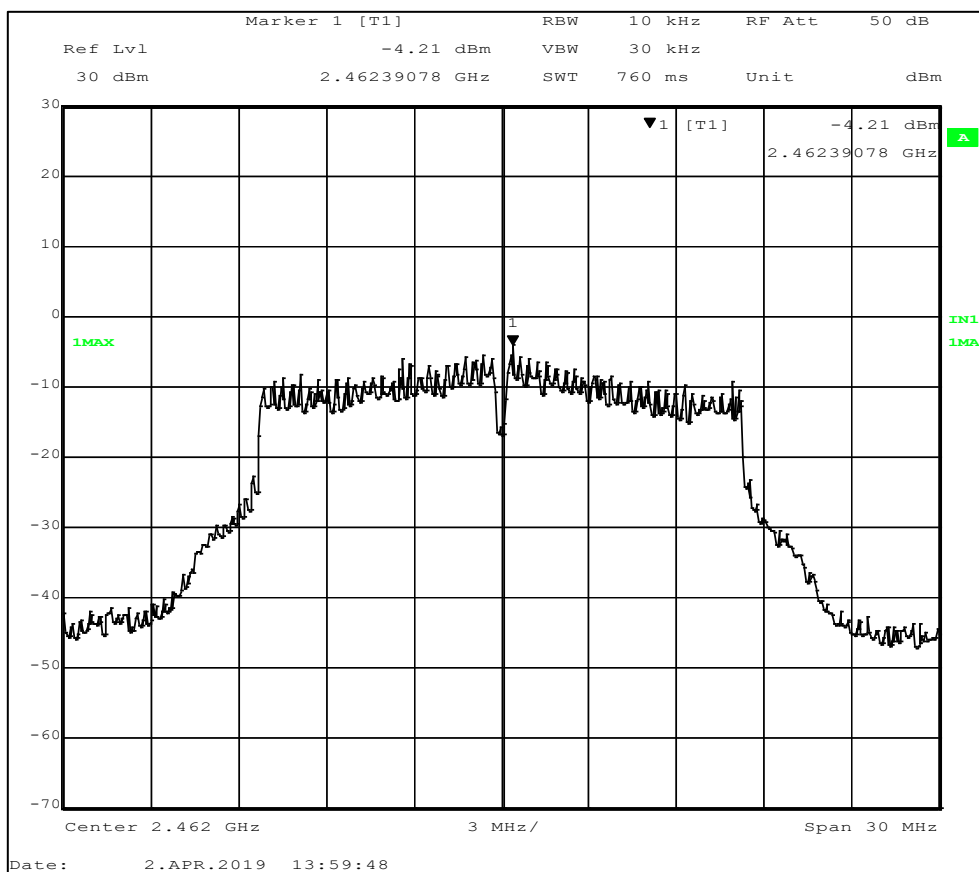


Figure 44. Power spectral density channel 11.

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Channel	Frequency [MHz]	Power Spectral density [dBm]	Limit [dBm]	Result
1	2412	-4.32	8	PASSED
2	2417	-1.69	8	PASSED
3	2422	-0.40	8	PASSED
7	2442	-0.22	8	PASSED
9	2452	-0.14	8	PASSED
10	2457	-1.23	8	PASSED
11	2462	-4.21	8	PASSED

2.6.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.7 AC Conducted emission

Test specimen	AT-DG2 No 10
Test specification	47 CFR Part 15.207
Test method	ANSI C63.10:2013 sec. 6.2
Frequency range	0.15 - 30 MHz
Limits	47 CFR Part 15.207
Comments	None
Temperature / Humidity	21°C / 29%RH
Dates of measurements	2019-04-05
Test personnel	Søren Søltoft

2.7.1 Test setup

Measurements were performed with the test specimen powered from a AC/DC adaptor (EMC 1) and from Poe injector through Airtame Ethernet to USB adaptor with PoE (PoE 2). The PoE Injector was used as power supply.

The test specimen was set to max power with max duty cycle at channel 7.
The mains supply was 120 VAC.

See appendix 1 for photo of test set up

2.7.2 Test results

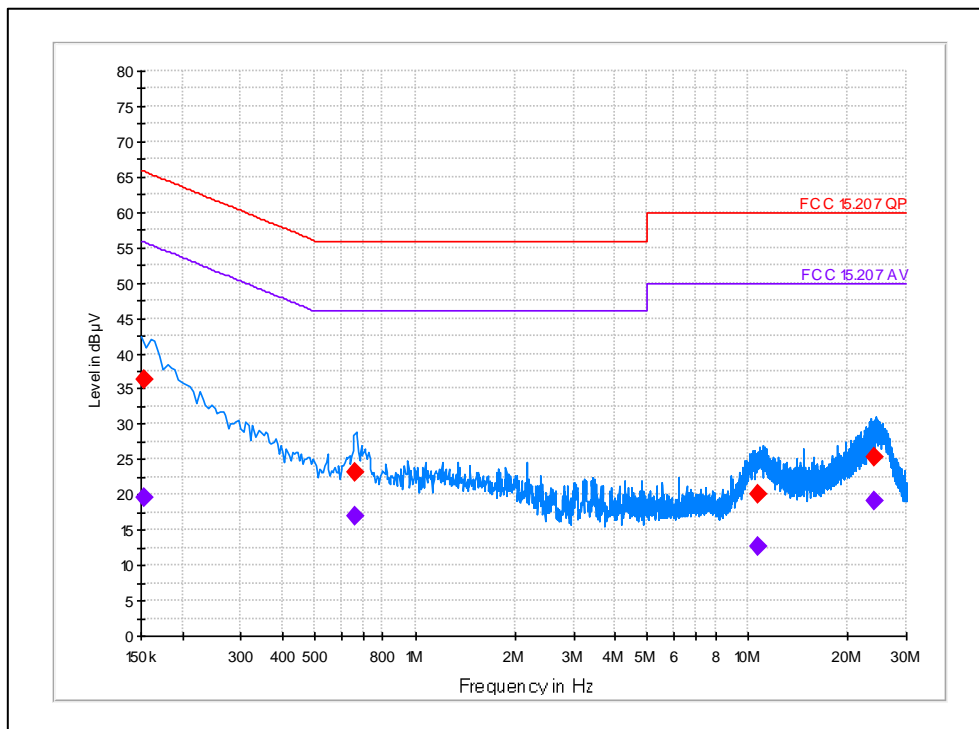


Figure 45. AC Conducted emission. Powered by ACDC adaptor

Frequency [MHz]	QuasiPeak [dBµV]	BW [kHz]	Line	Margin [dB]	Limit [dBµV]	Result
0.153000	36.4	9.000	N	29.40	65.80	PASSED
0.663500	23.3	9.000	N	32.70	56.00	PASSED
10.722100	20.0	9.000	N	40.00	60.00	PASSED
24.001500	25.4	9.000	N	34.60	60.00	PASSED

Table 11. AC Conducted emission. Powered by ACDC adaptor. QuasiPeak detector.

Frequency [MHz]	Average [dBµV]	BW [kHz]	Line	Margin [dB]	Limit [dBµV]	Result
0.153000	19.6	9.000	N	36.30	55.80	PASSED
0.663500	16.9	9.000	N	29.10	46.00	PASSED
10.722100	12.5	9.000	N	37.50	50.00	PASSED
24.001500	19.0	9.000	N	31.00	50.00	PASSED

Table 12. AC Conducted emission. Powered by ACDC adaptor. Average detector.

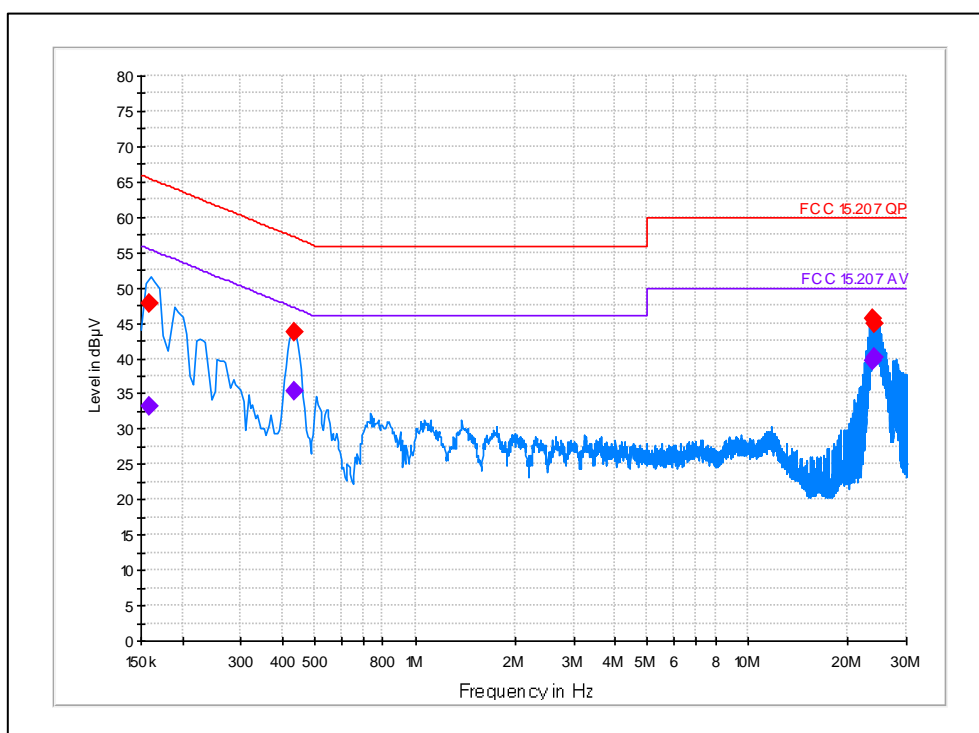


Figure 46. AC Conducted emission. Powered by PoE Injector 2.

Frequency [MHz]	QuasiPeak [dBμV]	BW [kHz]	Line	Margin [dB]	Limit [dBμV]	Result
0.158100	47.7	9.000	L1	17.80	65.60	PASSED
0.432900	43.8	9.000	L1	13.40	57.20	PASSED
23.668700	45.7	9.000	N	14.30	60.00	PASSED
24.167200	45.0	9.000	N	15.00	60.00	PASSED

Table 13. AC Conducted emission. Powered by PoE Injector 2. QuasiPeak detector.

Frequency [MHz]	Average [dBμV]	BW [kHz]	Line	Margin [dB]	Limit [dBμV]	Result
0.158100	33.2	9.000	L1	22.30	55.60	PASSED
0.432900	35.4	9.000	L1	11.80	47.20	PASSED
23.668700	39.6	9.000	N	10.40	50.00	PASSED
24.167200	40.2	9.000	N	9.80	50.00	PASSED

Table 14. AC Conducted emission. Powered by PoE Injector 2. Average detector.

2.7.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
V-network Two Line	R&S	ESH3-Z5	13935	2019-09-25
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

2.8 Occupied bandwidth

Test specimen	AT-DG2 no. 12
Test specification	47 CFR 2.1049
Test method	ANSI C63.10:2013 sec. 6.9.3
Comments	None
Temperature / Humidity	22°C / 23%RH
Dates of measurements	2019-04-02
Test personnel	Søren Søltøft

2.8.1 Test setup

The test specimen was connected to a spectrum analyzer using a temporary antenna connector.

See photo of test set up in appendix 1.

2.8.2 Test results

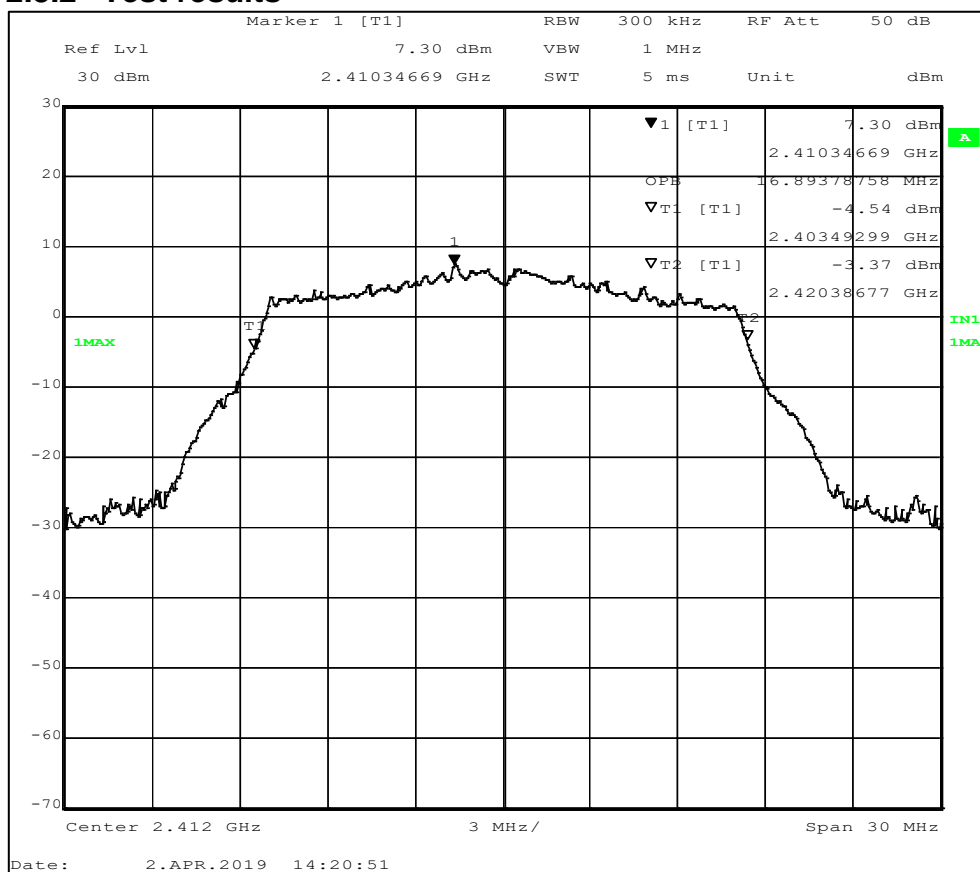


Figure 47. Occupied bandwidth 99% channel 1.

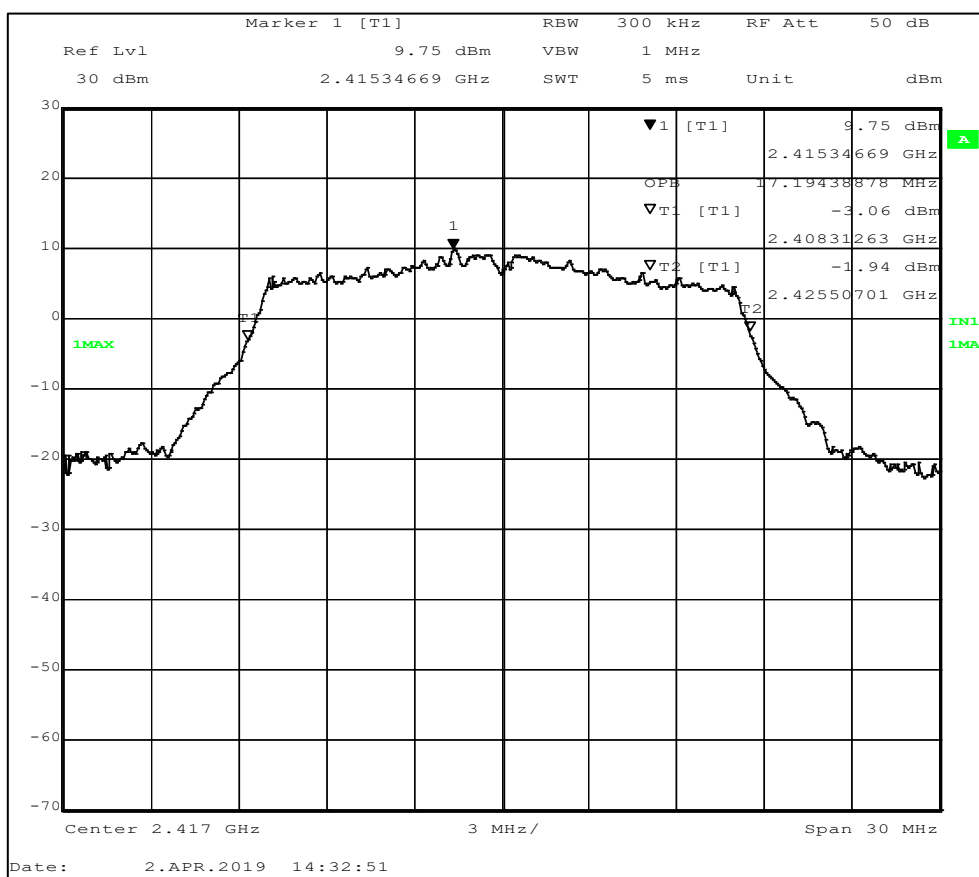


Figure 48. Occupied bandwidth 99% channel 2.

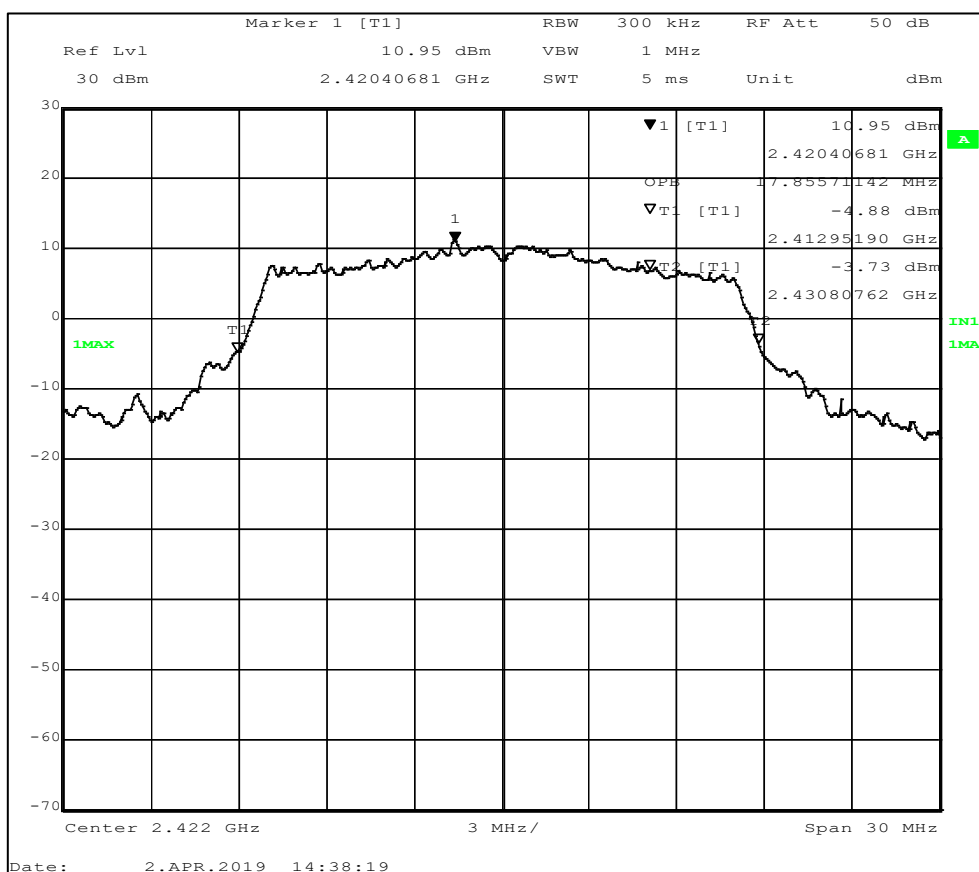


Figure 49. Occupied bandwidth 99% channel 3.

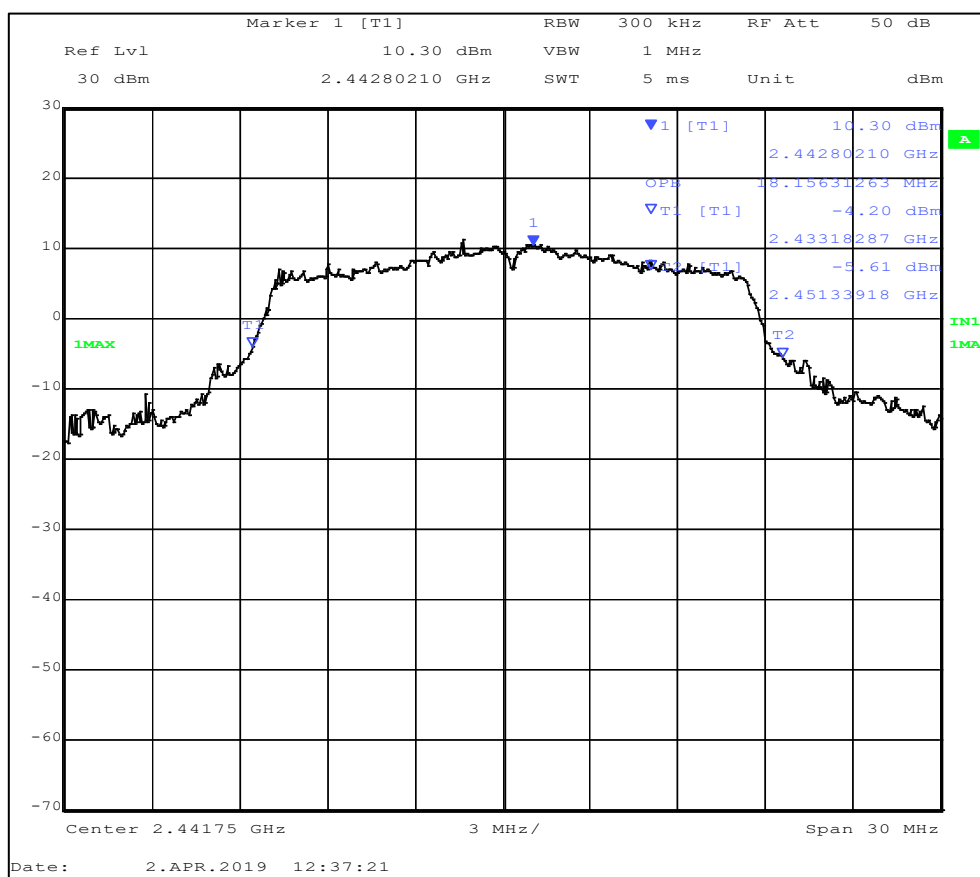


Figure 50. Occupied bandwidth 99% channel 7.

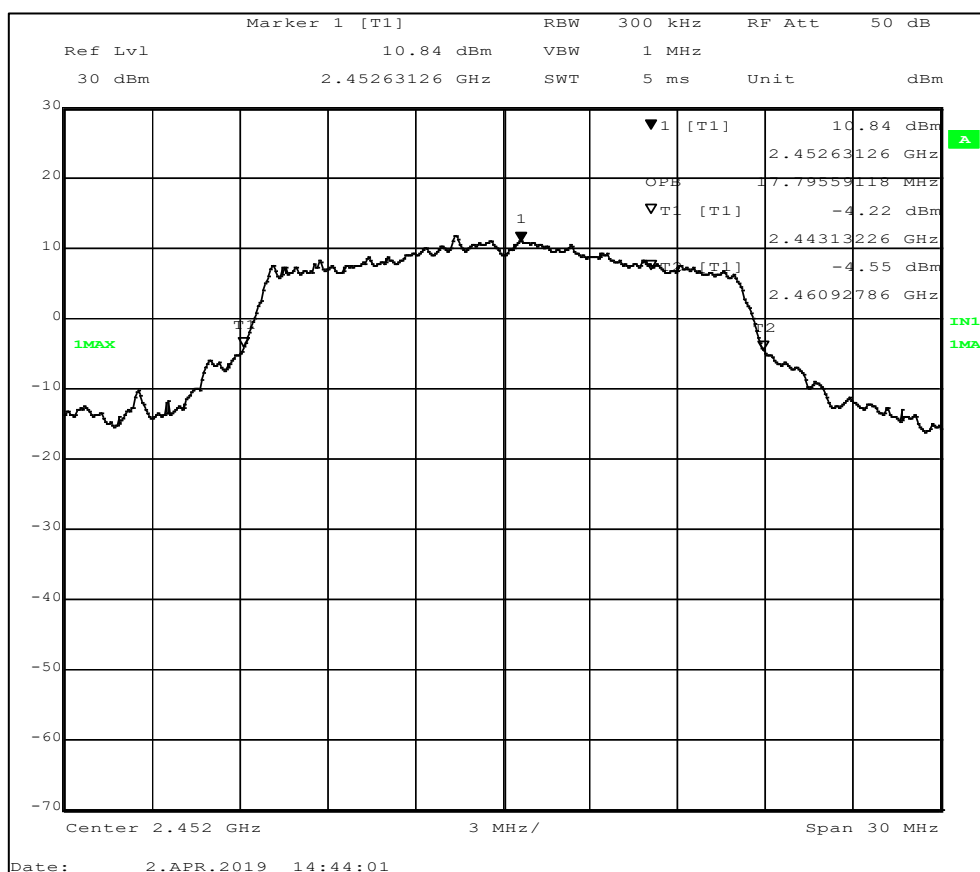


Figure 51. Occupied bandwidth 99% channel 9.

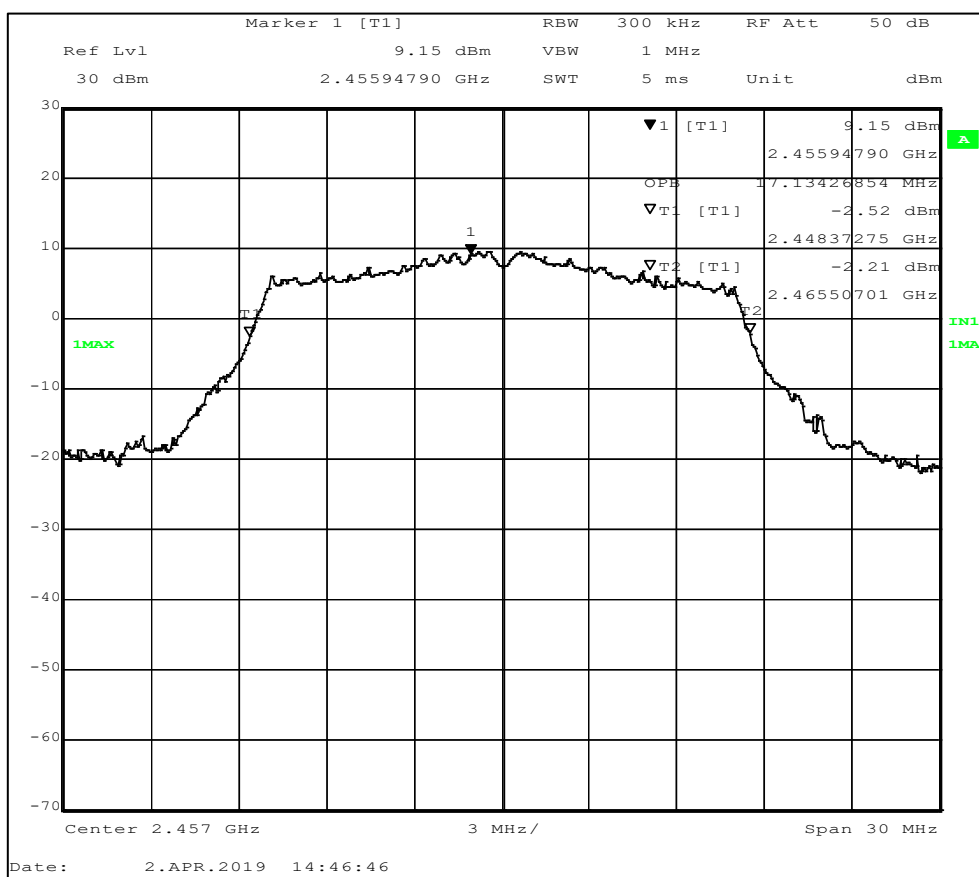


Figure 52. Occupied bandwidth 99% channel 10.

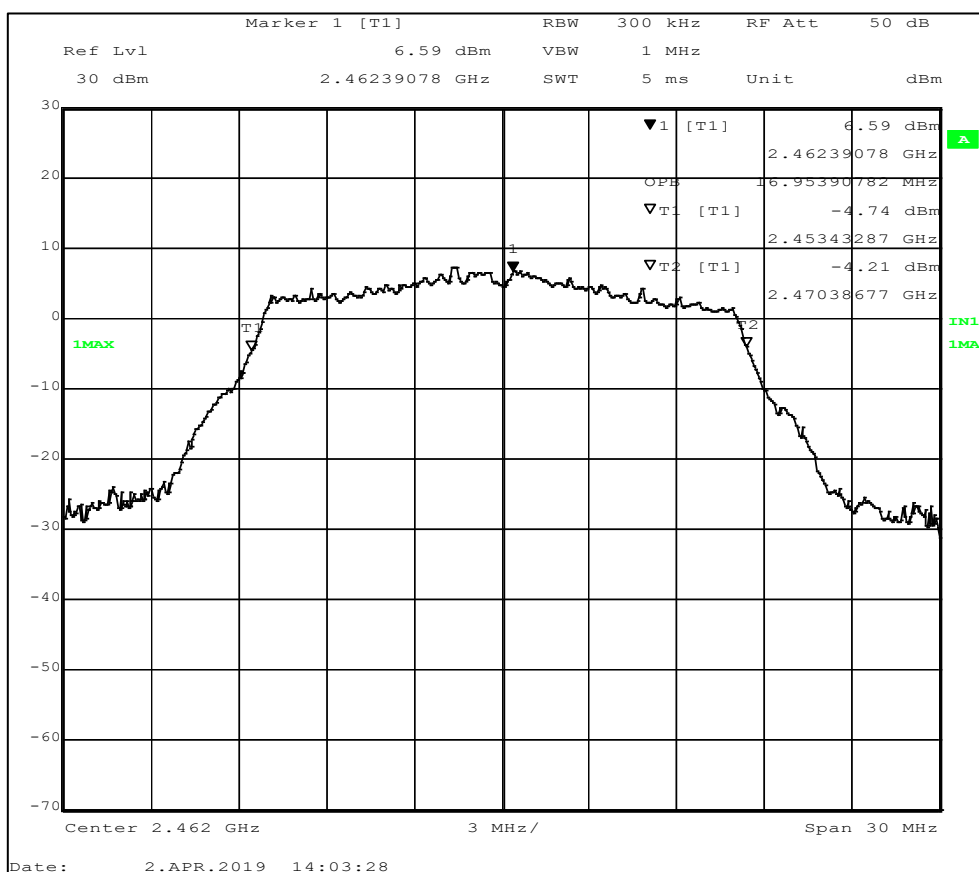


Figure 53. Occupied bandwidth 99% channel 11.

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Channel	Frequency [MHz]	Occupied bandwidth 99% [MHz]	Result
1	2412	16.89378758	PASSED
2	2417	17.19438878	PASSED
3	2422	17.85571142	PASSED
7	2442	18.15631263	PASSED
9	2452	17.79559118	PASSED
10	2457	17.13426854	PASSED
11	2462	16.95390782	PASSED

Table 15. 99% Occupied bandwidth results.

2.8.3 Test equipment

Description	Supplier	Model	Tag no.	Cal. due date
Receiver EMI Test 20Hz-26.5GHz	Rohde & Schwarz	ESIB 26	18880	2019-09-24

Table 16. 99% Occupied bandwidth test equipment.

3 MEASURING UNCERTAINTIES

Compliance evaluation is based on a shared risk principle with respect to the measurement uncertainty.

	Frequency [MHz]	Polarization	Expanded Uncertainty [dB] (k=2)
Radiated emission	30 - 200	Vertical	4.59
	200 - 1000	Vertical	4.77
	1000 - 18000	Vertical	3.76
	18000 - 25000	Vertical	4.10
	30 - 200	Horizontal	4.57
	200 - 1000	Horizontal	4.86
	1000 - 18000	Horizontal	3.77
	18000 - 26500	Horizontal	4.11
Conducted emission (CISPR 16-4)	0.01 - 30	-	3.44
Conducted emission (ESIB 26)	<1000		2.58
	1000 - 7000		2.76
	7000 - 18000		3.38
	18000 - 26500		3.79