

Test Report

Product	Electromechanical Padlock
Name and address of the applicant	Abloy OY Wahlforssinkatu 20, 80100 Joensuu, Finland
Name and address of the manufacturer	Abloy OY Wahlforssinkatu 20, 80100 Joensuu, Finland
Model	PLK/A1
Rating	3Vdc Lithium CR2 or 3.6Vdc 1/2AA Li-SOCI2 batteries
Trademark	ABLOY
Serial number	See page 3
Additional information	The tested device is an electromechanical padlock with a BLE radio.
Tested according to	FCC Part 15.247 Frequency Hopping Transmitters / Digital Transmission Systems Industry Canada RSS-247, Issue 2 Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	388926
Tested in period	2020.01.20 – 2020.01.31
Issue date	2020.02.25
Name and address of the testing laboratory	<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;">  Instituttveien 6 Kjeller, Norway </div> <div style="text-align: center;"> CAB Number: FCC: NO0001 ISED: NO0470 TEL: +47 22 96 03 30 FAX: +47 22 96 05 50 </div> <div style="text-align: center;">   </div> </div> <p style="text-align: center; color: red; font-weight: bold;">An accredited technical test executed under the Norwegian accreditation scheme</p>
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  Prepared by [G.Suhanthakumar] </div> <div style="text-align: center;">  Approved by [Frode Sveinsen] </div> </div>	
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1 INFORMATION

1.1 Test Item

Name	ABLOY
FCC ID	2AI5J-PLKA1
ISED ID	21724-PLKA1
Model/version	PLK/A1
Serial number	Radiated sample: Marked ID "00000650" Conducted sample: Marked by Nemko "3889260003"
Hardware identity and/or version	PLK/A1 (Electronic revisions: 9600051 rev.2 + 9600054 rev. 2)
Software identity and/or version	RF and PER test firmware (is based on Nordic SDK 15.3 / S140 v 6.1.1)
Frequency Range	2402 – 2480 MHz
Tunable Bands	None
Number of Channels	40
Operating Modes	TX and RX
Measured BW (99%)	1.1 MHz
Emission classification	F1D
Transmitter spurious, dBµV/m@3m	50.63 (2.4835GHz), PK
Type of Modulation	GFSK
Data rate	1Mbps
User Frequency Adjustment	None
Conducted Output Power, Max	0.00556 W (7.5 dBm)
Type of Power Supply	3V Lithium CR2 or 3.6V 1/2AA Li-SOCI2 batteries
Antenna Connector	Only integral antenna
Number of Antennas	1
Diversity or Smart Antennas	None
Desktop Charger	N/A

Description of Test Item

The tested device is an padlock which controls closing and opening via BLE with a remote device such as iOS, Android or similar.

1.2 Normal test condition

Temperature: 20 - 24 °C
Relative humidity: 20 - 50 %
Normal test voltage: 3.0Vdc

The values are the limit registered during the test period.

1.3 Test Engineer(s)

G.Suwanthakumar

1.4 Description of modification for Modification Filing

Not applicable.

1.5 Family List Rational

Not Applicable.

1.6 Antenna Requirement

Is the antenna detachable?

☐ Yes ☒ No

If detachable, is the antenna connector non-standard?

☐ Yes ☐ No

Type of antenna connector: Integral Antenna

Ref. FCC §15.203

1.7 Worst-Case Configuration and Mode

Radiated Emissions were performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.

1.8 Comments

All measurements were done with the EUT powered by a fully charged battery.

USB-C port is only used as service port..

The maximum power setting is 8 dBm and measurements are done with this setting.

2 TEST REPORT SUMMARY

2.1 General

All measurements are traceable to national standards.

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and ISED Canada RSS-247 Issue 2 and RSS-GEN Issue 5.

Tests were performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

Radiated tests were made in a semi-anechoic chamber at measuring distances of 1m, 3m and 10m.

A description of the test facility is on file with FCC and ISED.

☒ New Submission

☒ Production Unit

☐ Class II Permissive Change

☐ Pre-production Unit

DTS Equipment Code

☐ Family Listing



THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.

Deviations from, additions to, or exclusions from the test specifications are described in "Summary of Test Data".

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2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 2, RSS-GEN Issue 5 reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	N/A ¹
Number of frequencies	15.31(m)	6.8 (RSS-GEN)	Complies
Antenna Requirement	15.203	6.8 (RSS-GEN)	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	N/A
99% Occupied Bandwidth	N/A	6.7 (RSS-GEN)	Complies
Minimum 6 dB Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	Complies
Peak Power Output	15.247(b)	5.4 (RSS-247)	Complies
Power Spectral Density	15.247(e)	5.2 (2) (RSS-247)	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)(d)	5.5 (RSS-247)	Complies
Spurious Emissions (Radiated)	15.247(c)(d) 15.109(a) 15.209(a)	5.5 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	Complies

¹ The EUT operates from battery only.

USB-C Service port can be used by service personell to open the padlock with a USB power bank in case of emergency.

Revision history

Version	Date	Comment	Sign
00	2020.02.25	First Version	gns

3 TEST RESULTS

3.1 Number of Frequencies

FCC Part 15.31 (m)

RSS-Gen 6.8

Authorized Band:	2400 - 2483.5 MHz
Frequency band width:	83.5MHz
Low Channel:	2402MHz
Mid channel:	2440MHz
High Channel:	2480MHz

3.2 99% Occupied Bandwidth

RSS-Gen, 6.7

ISED Canada RSS-247 Issue 2, Clause 5.1

ISED Canada RSS-GEN Issue 5, Clause 6.7

Measurement procedure: ANSI C63.10-2013 Clause 6.9.2 / 7.8.3

Test Results: Complies

Measurement Data:

Channel Frequency (MHz)	Measured 99% BW (MHz)
2402	1.1
2440	1.1
2480	1.1

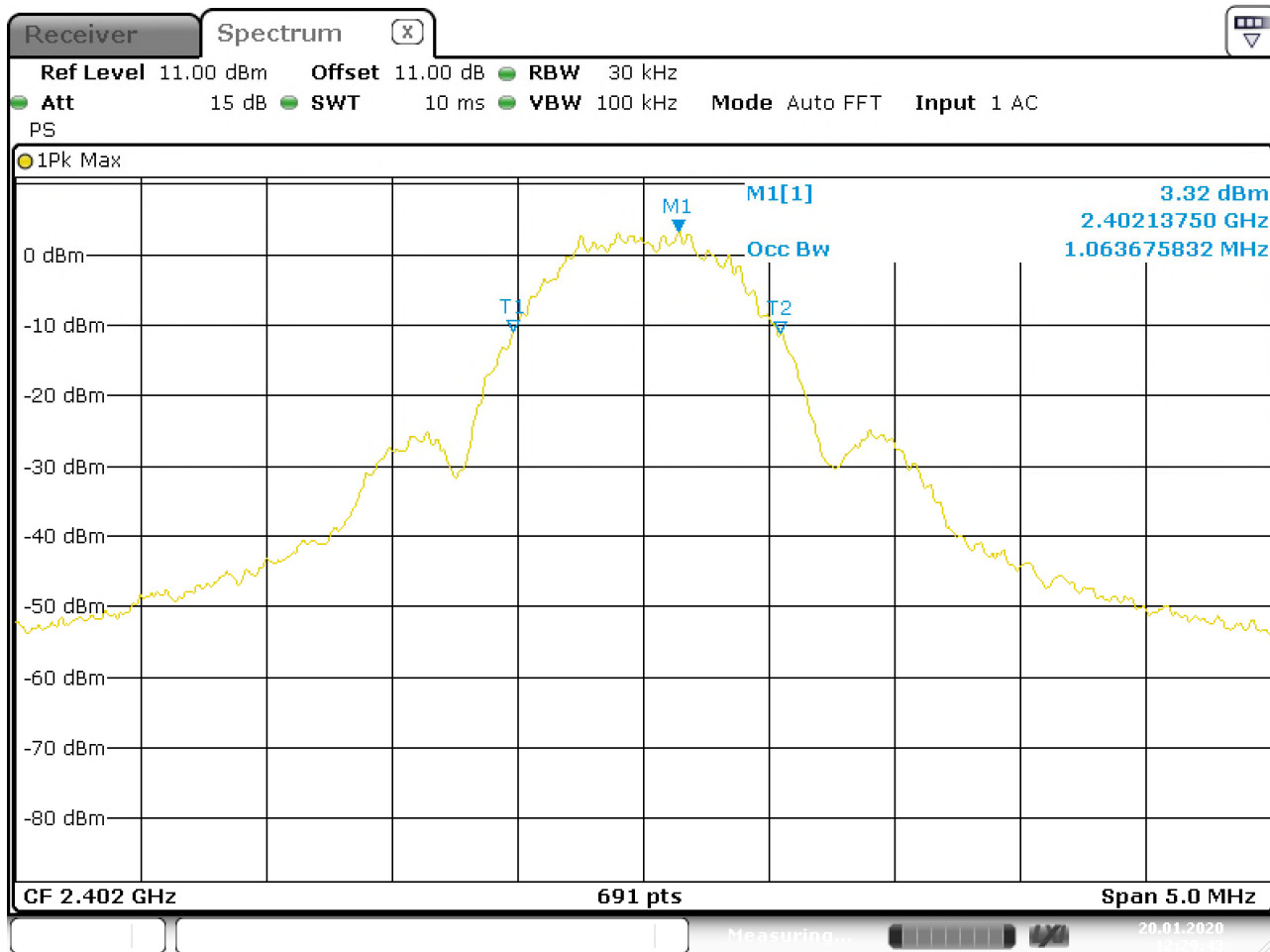
See attached plots.

Requirements:

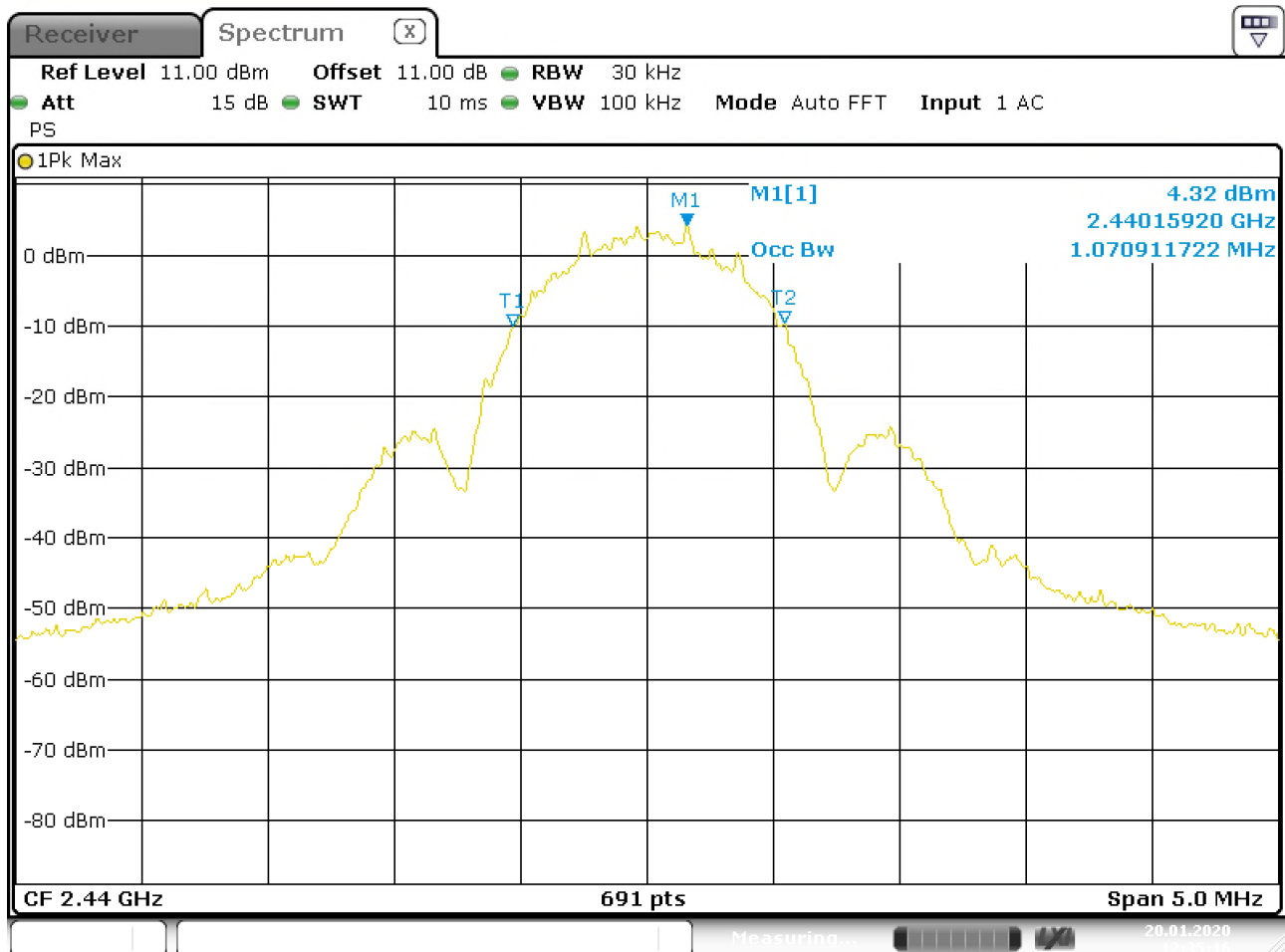
Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels. No requirements for bandwidth for this frequency band.

No requirements for Digital Transmission Systems.

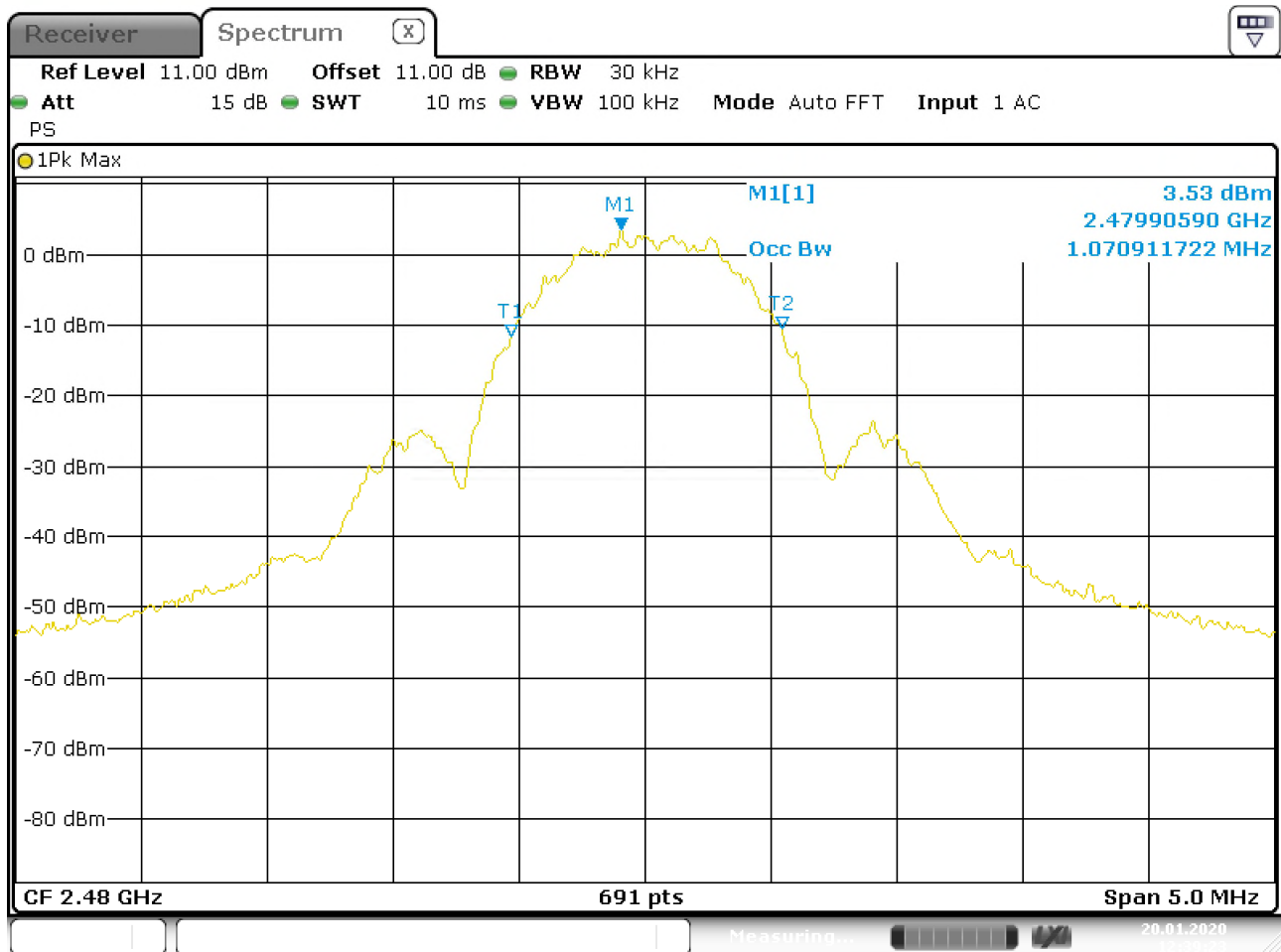
No requirement for 99% BW, reported for information only.



99% Bandwidth, ch2402MHz



99% Bandwidth, ch2440MHz



99% Bandwidth, ch2480MHz

3.3 DTS Bandwidth

FCC Part 15.247 (a)(2)

ISED Canada RSS-247 Issue 2, Clause 5.2 (a)

Measurement procedure: ANSI C63.10-2013 Clause 11.8

Test Results: **Complies**

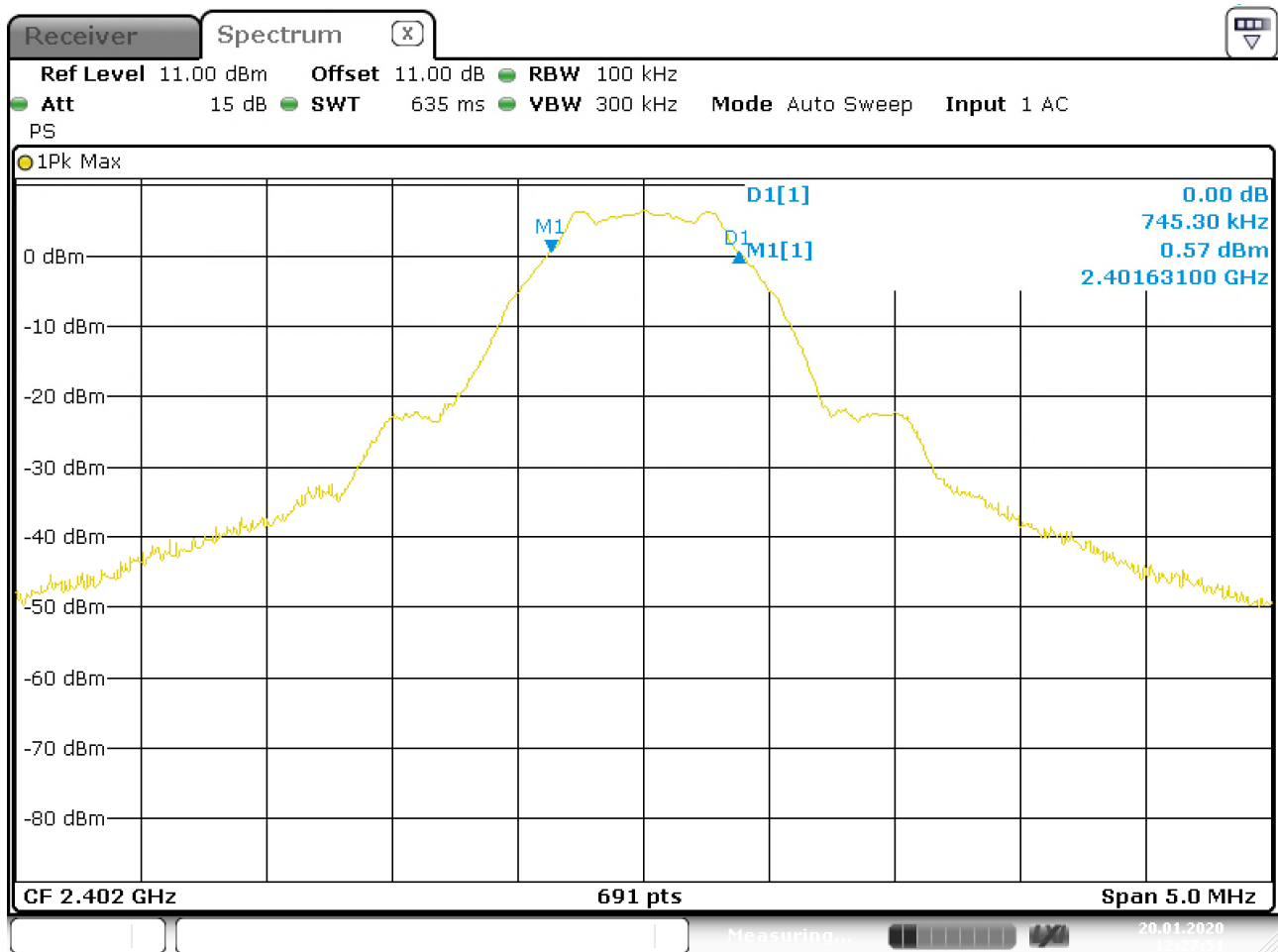
Measurement Data:

Channel Frequency (MHz)	Measured DTS BW (MHz)
2402	745.3
2440	752.5
2480	723.6

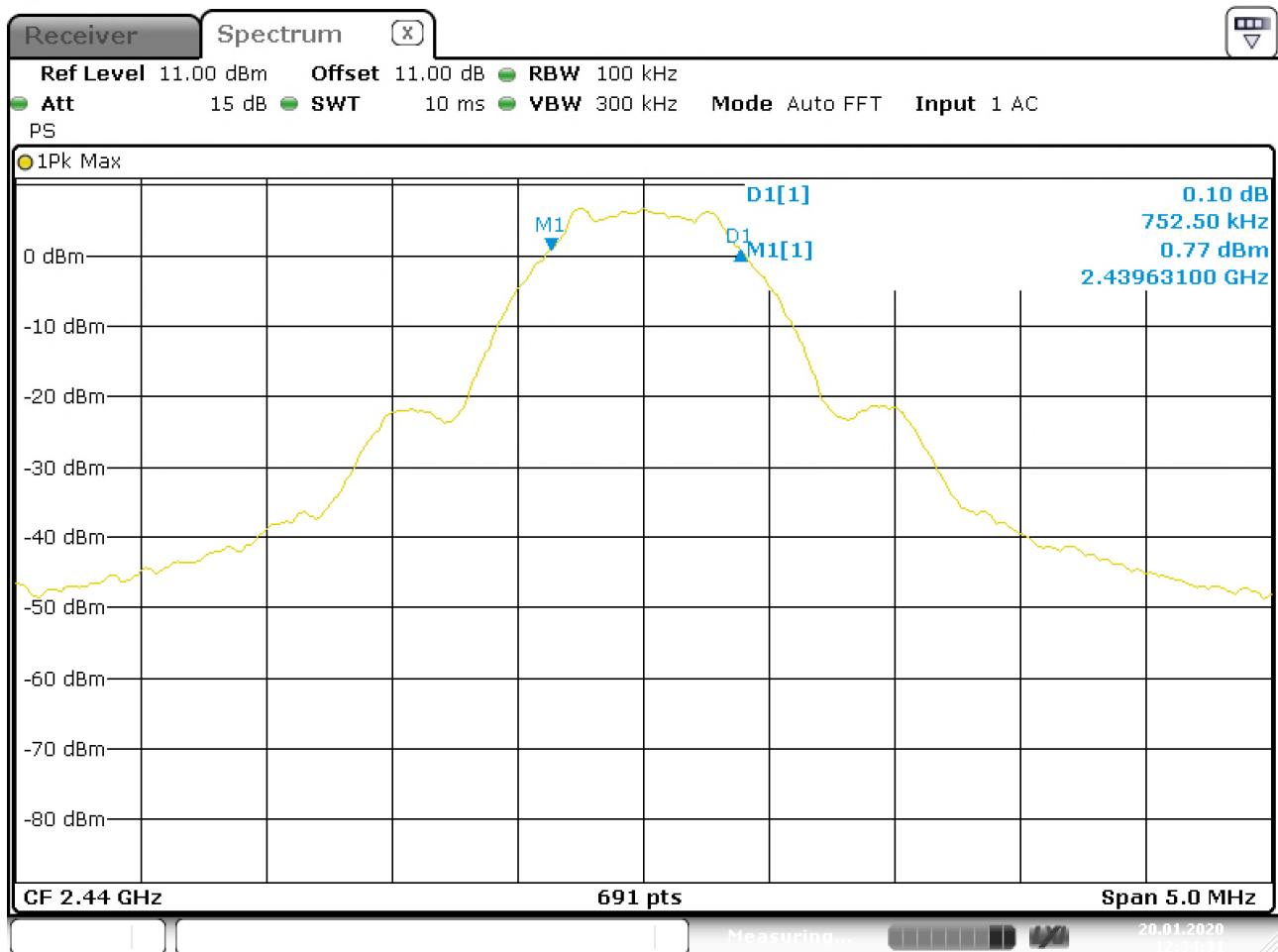
Requirements:

For Digital Transmission Systems in the 2400-2483.5 MHz band the minimum 6 dB bandwidth shall be at least 500 KHz.

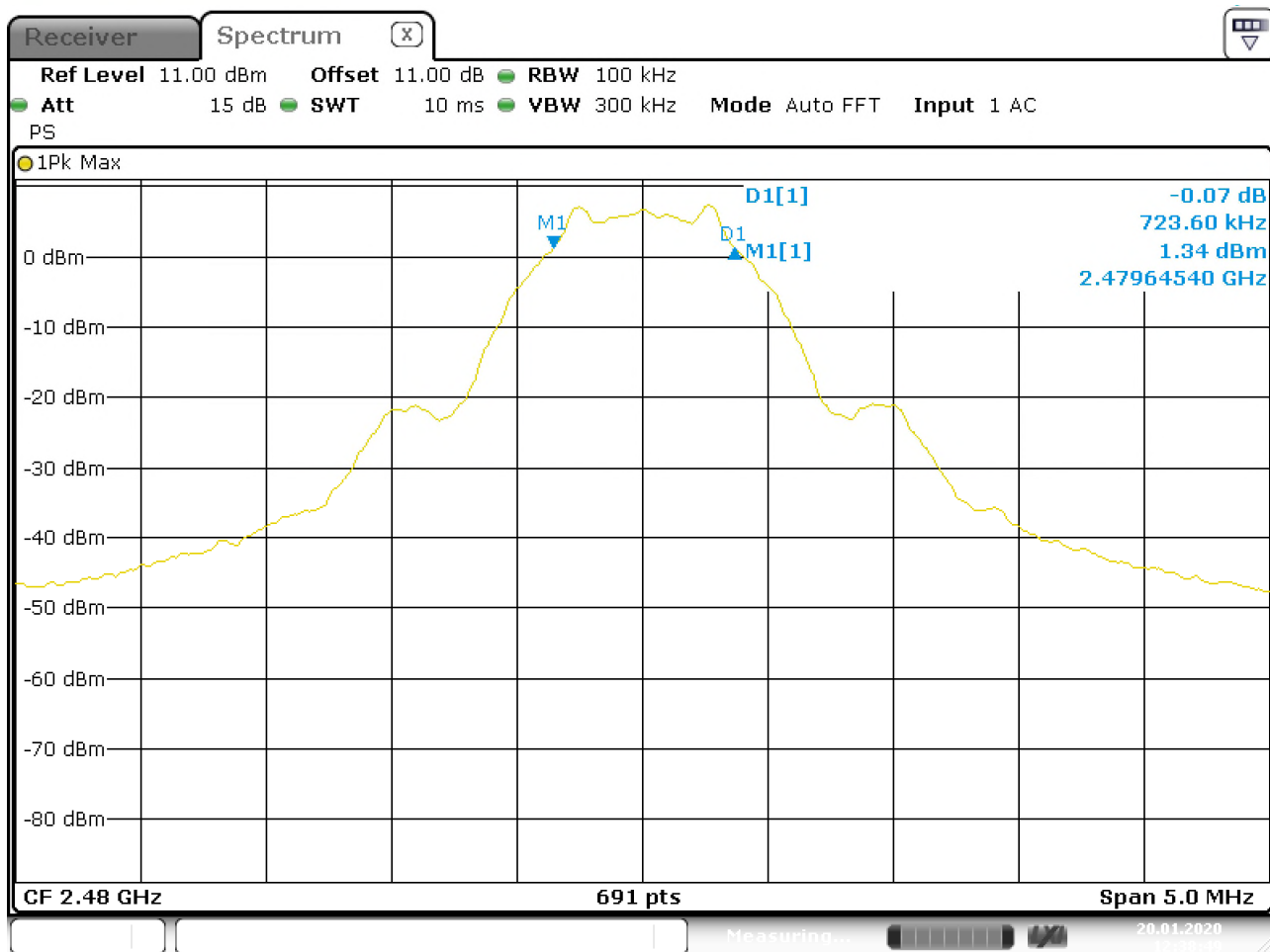
No requirements for Frequency Hopping Systems.



DTS Bandwidth, ch2402MHz



DTS Bandwidth, ch2440MHz



DTS Bandwidth, ch2480MHz

3.4 Peak Power Output

FCC part 15.247 (b)

ISED Canada RSS-247 Issue 2, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

	2402 MHz	2440 MHz	2480 MHz
Conducted Power (dBm)	7.3	7.5	7.4
Conducted Power (mWatts)	5.41	5.56	5.53
Field Strength (dBμV/m), HP	97.55	98.25	98.62
EIRP, Calculated (mWatts)	1.71	2.01	2.18
Antenna gain (dBi)	-5.0	-4.4	-4.0

Maximum field strength is obtained in horizontal polarization and XY plane.

Antenna gain = $10 \cdot \log(\text{EIRP} / \text{Conducted power})$ dBi

EIRP is calculated from measured field strength by the formulas in KDB 412172 D01 Determining ERP and EIRP v01.

See attached plots.

Requirements:

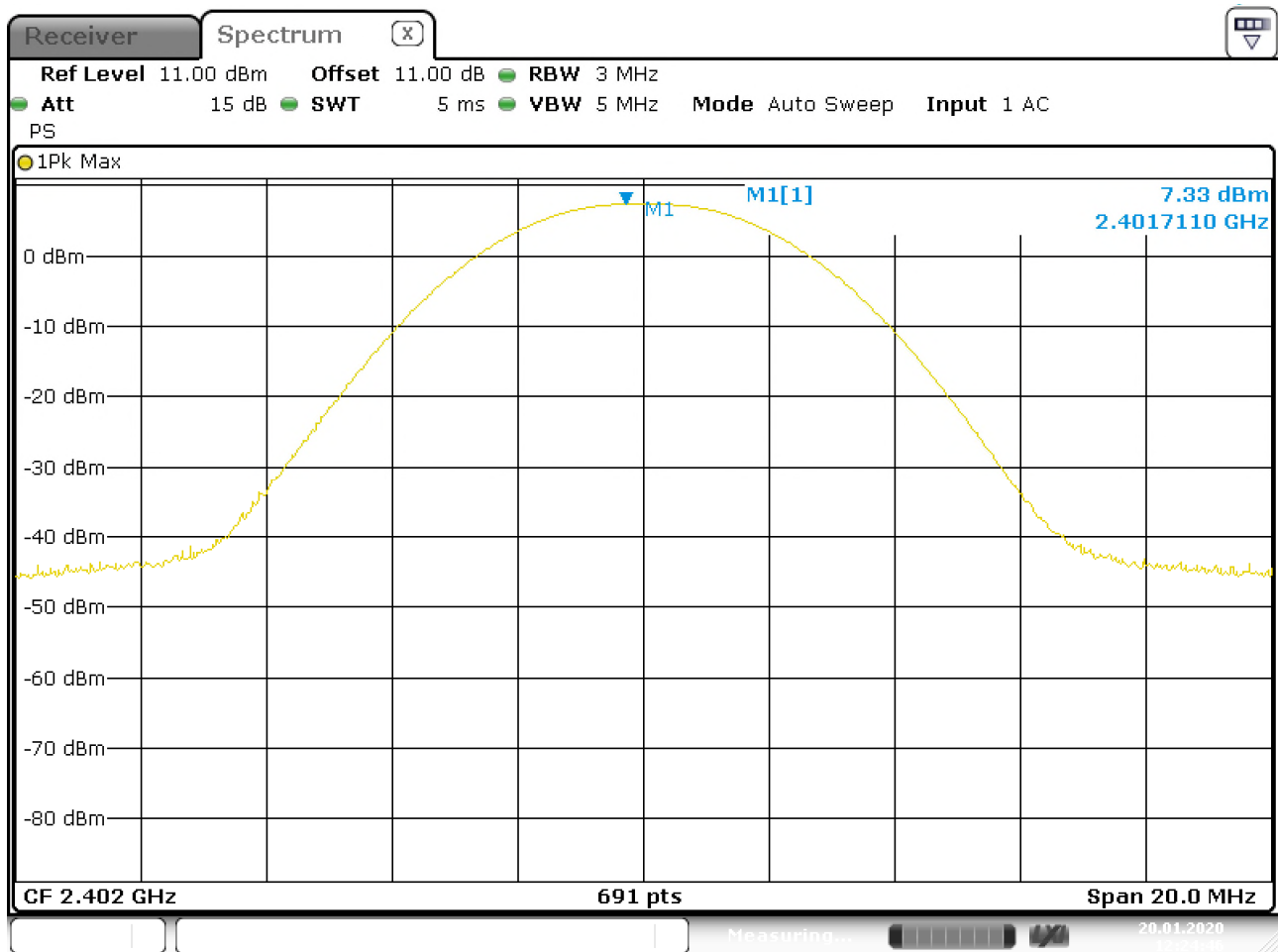
The maximum peak output power shall not exceed the following limits:

For frequency hopping systems employing at least 75 hopping channels: 1 Watt

For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

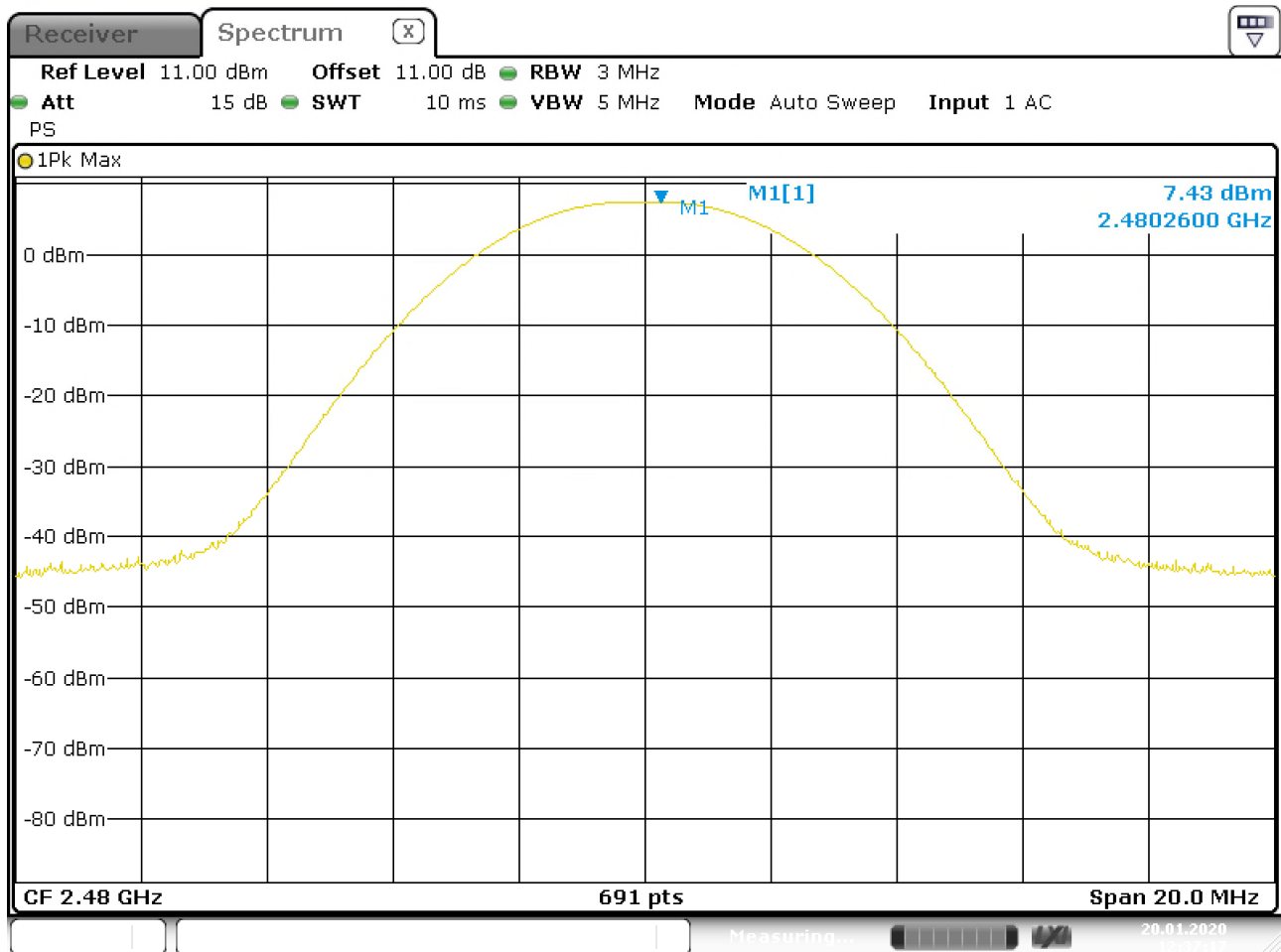
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



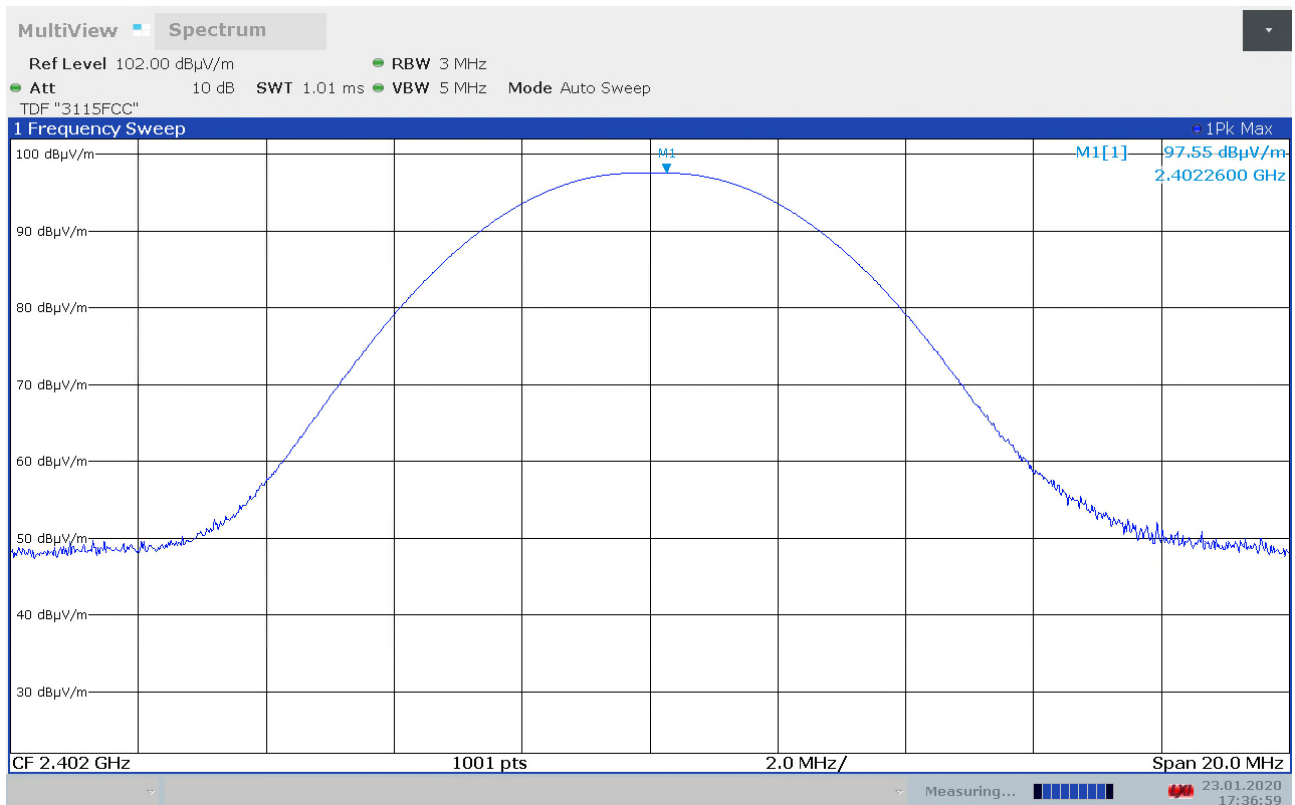
Conducted Power, Ch2402MHz



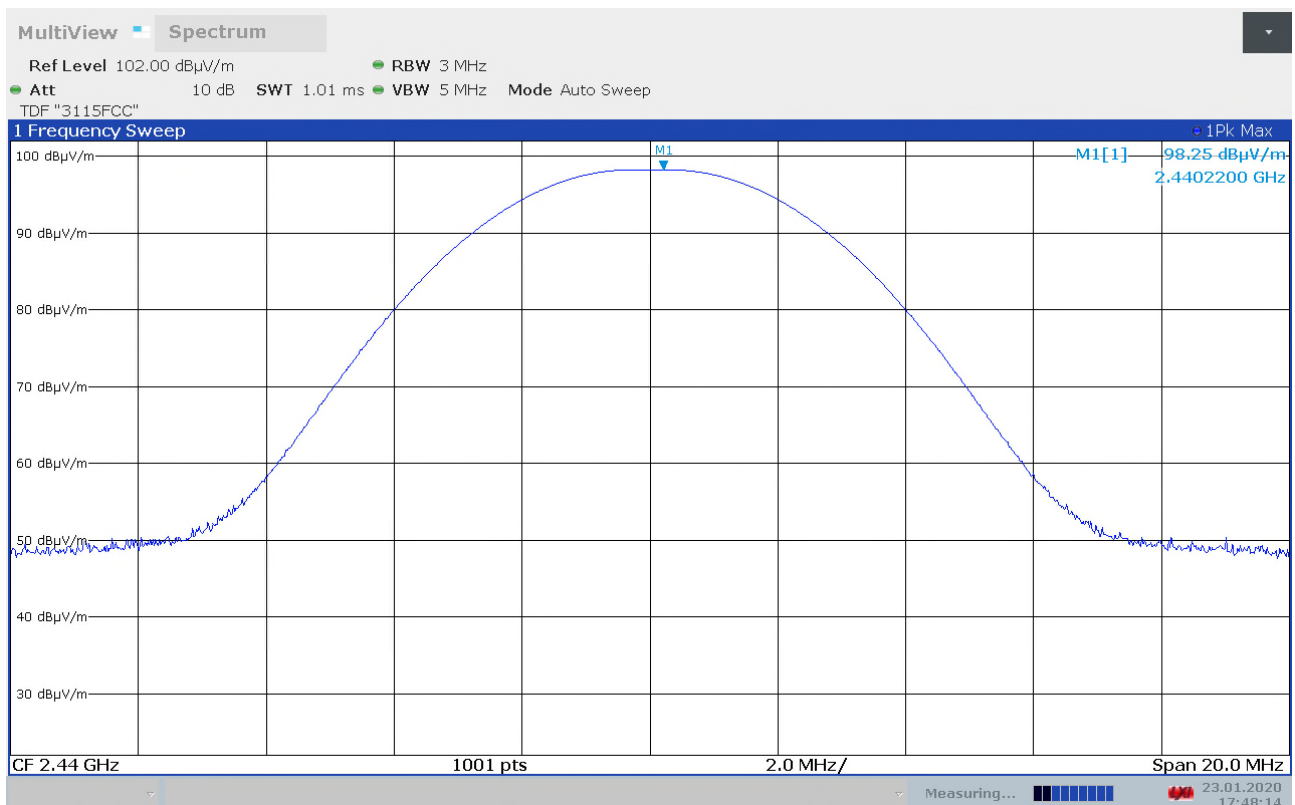
Conducted Power, Ch2440MHz



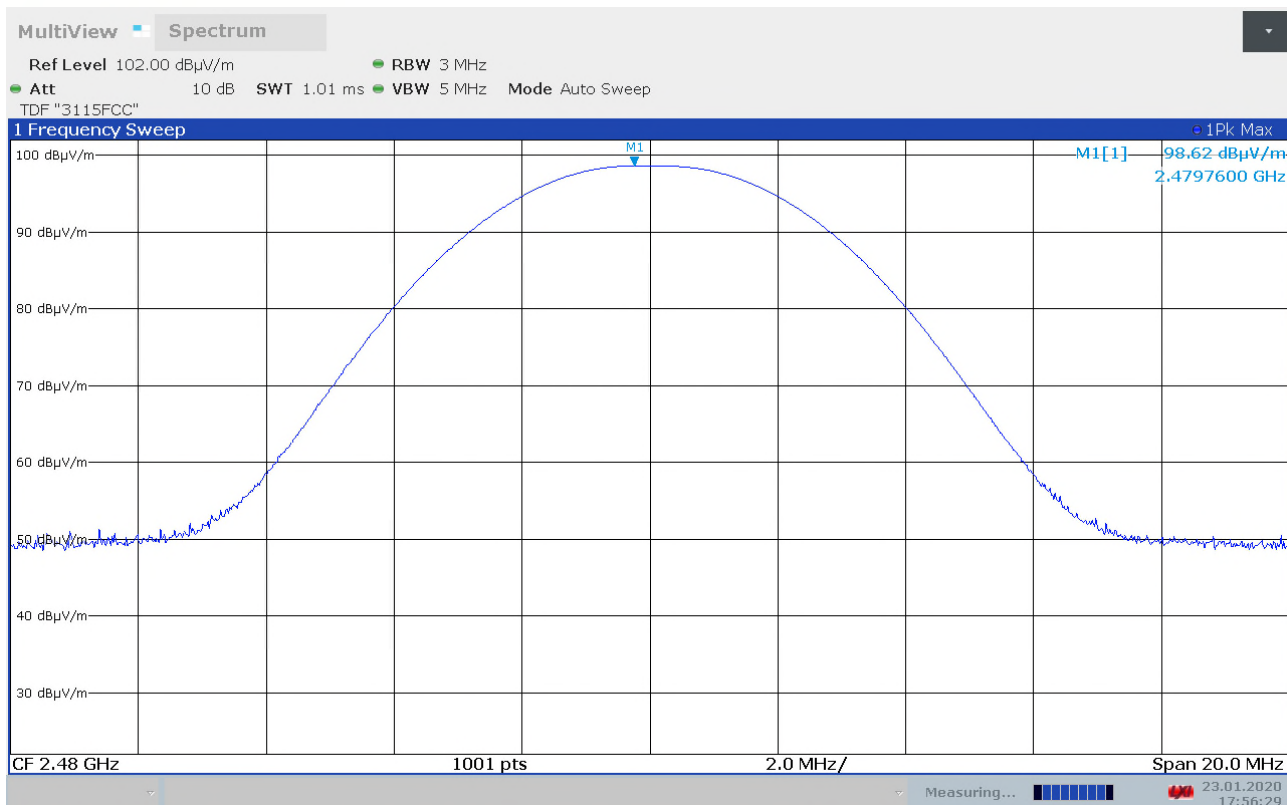
Conducted Power, Ch2480MHz



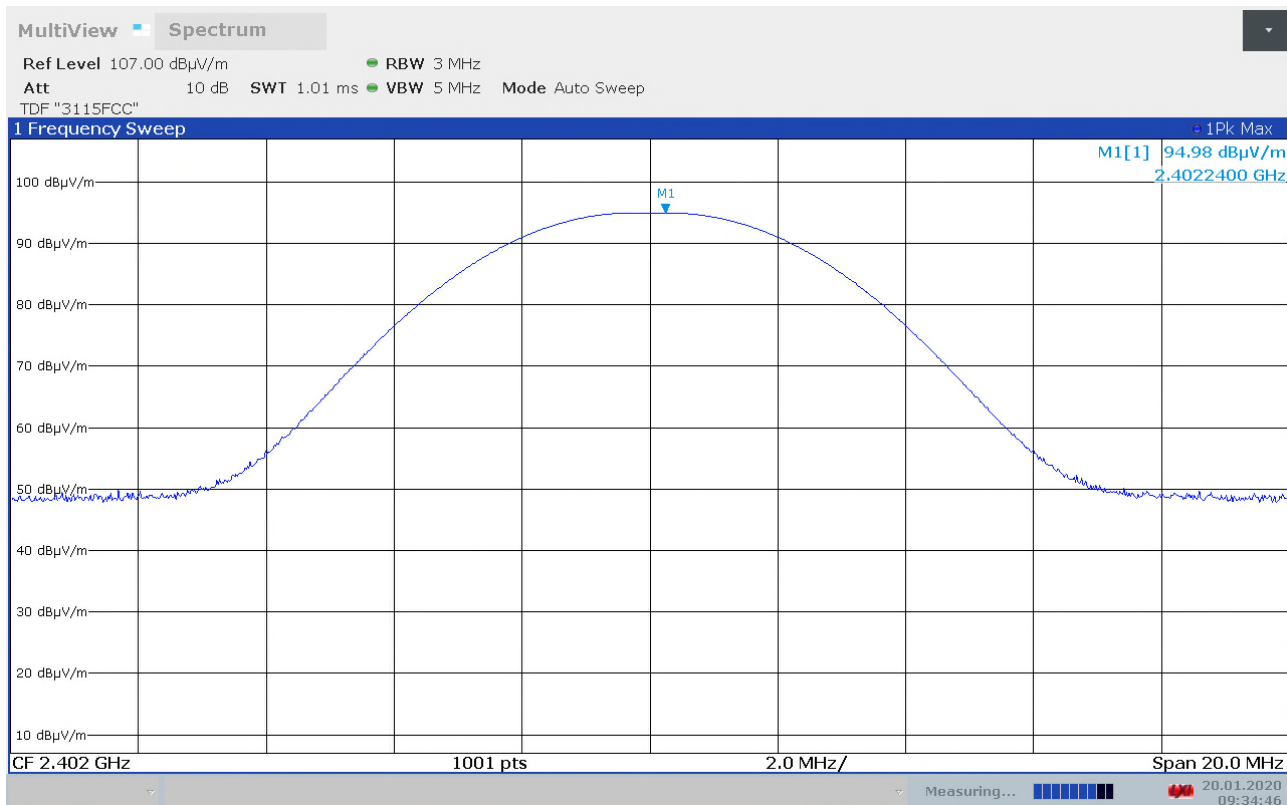
Field strength, HP, ch2402MHz



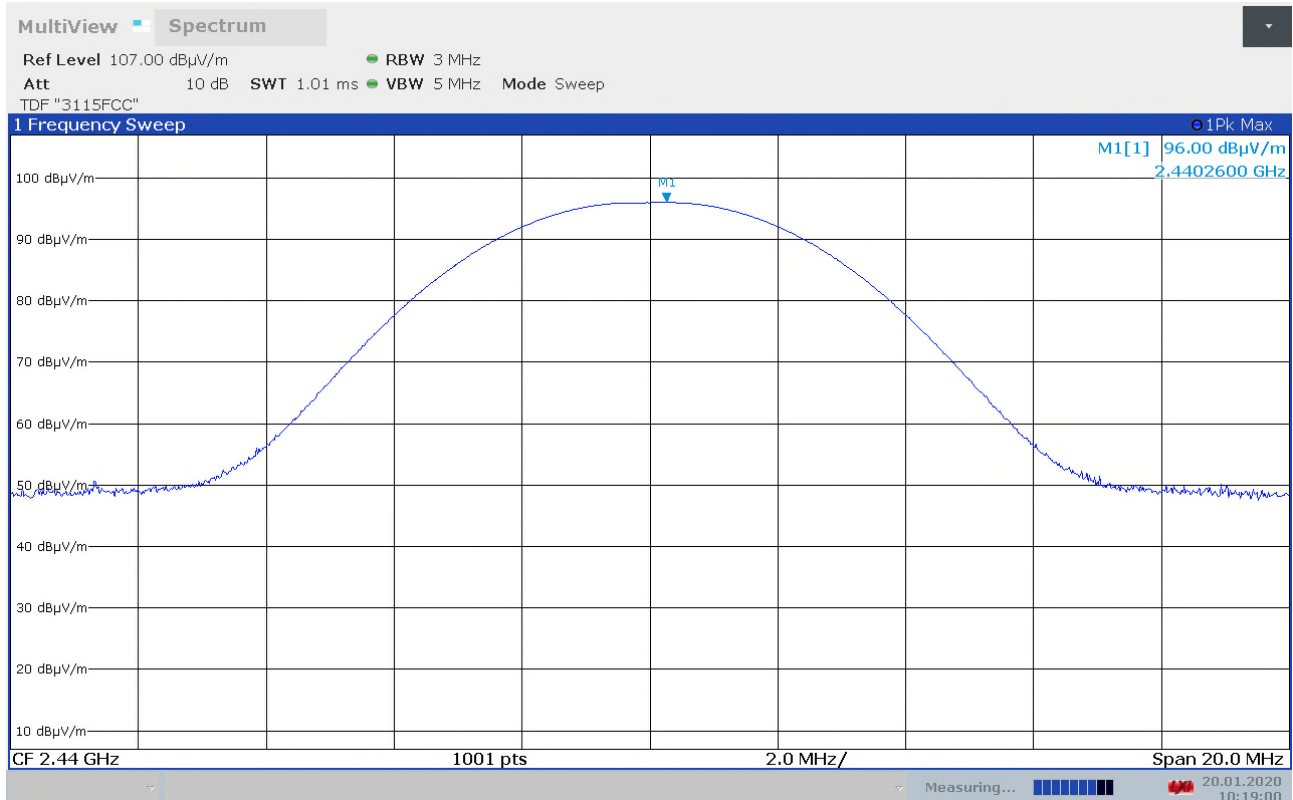
Field strength, HP, ch2440MHz



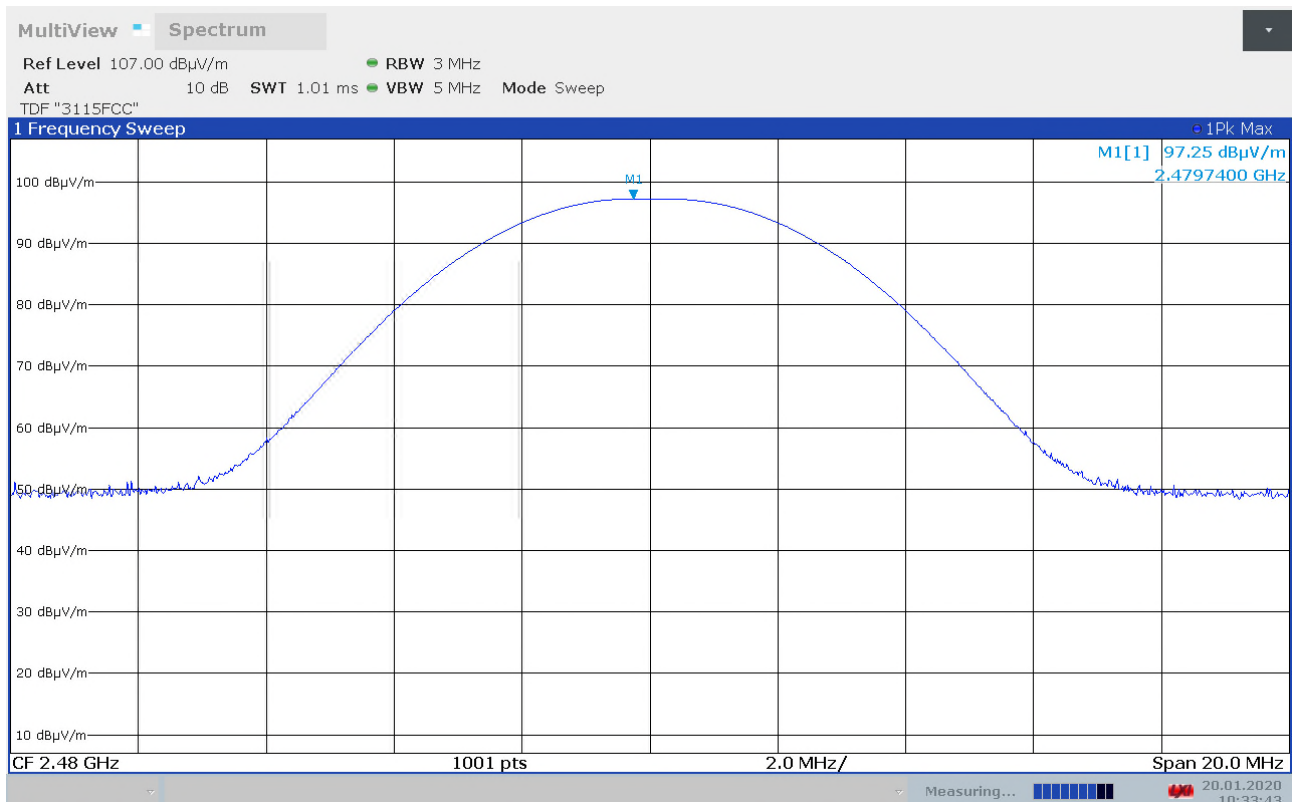
Field strength, HP, ch2480MHz



Field strength, VP, ch2402MHz



Field strength, VP, ch2440MHz



Field strength, VP, ch2480MHz

3.5 Conducted Emissions at Antenna Connector

Para. No.: 15.247 (d)

ISED Canada RSS-247 Issue 2, Clause 5.5

Measurement procedure: ANSI C63.10-2013 Clause 11.11

Test Results: Complies

Carrier Frequency	Highest Value (dBc)	Margin (dB)	Verdict
2402 MHz	41.7	>30	Pass
2440 MHz	43.9	>30	Pass
2480 MHz	48.1	>30	Pass

Measured with Peak Detector

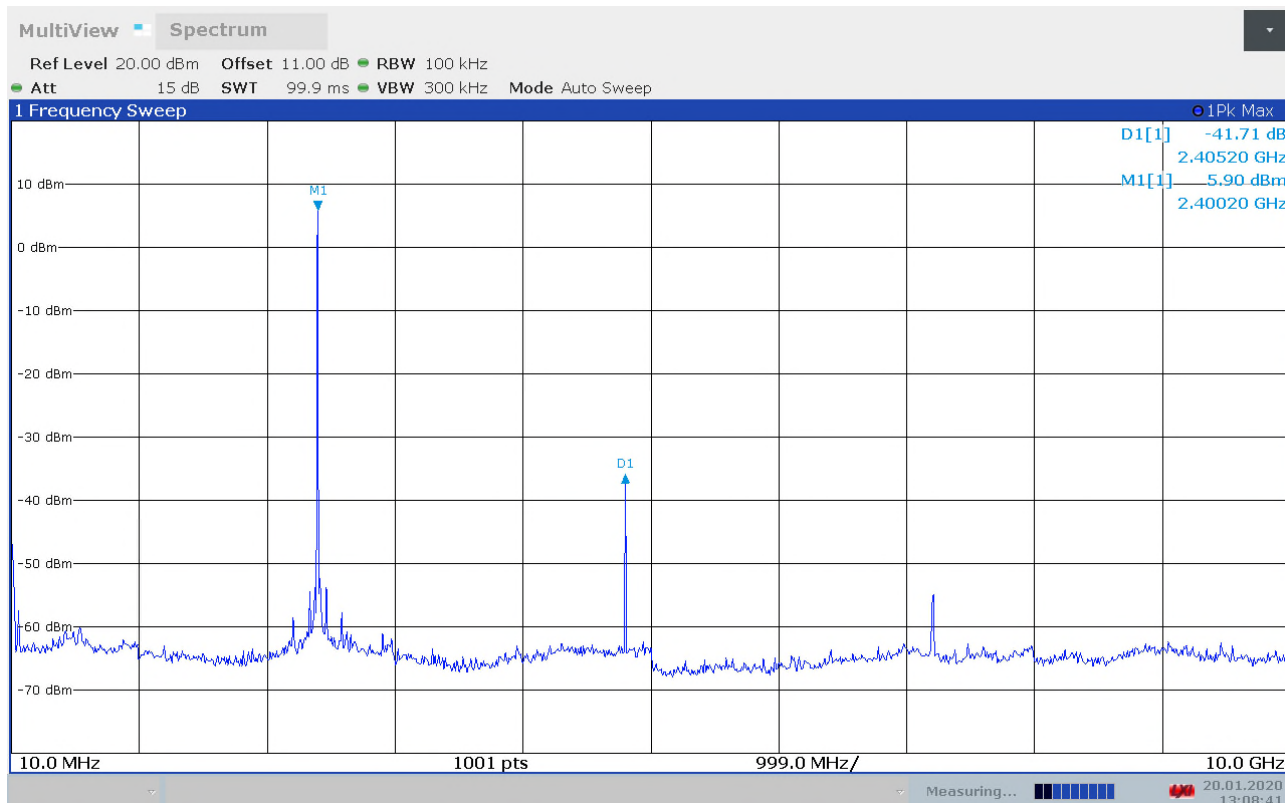
RF conducted power to 25 GHz: see attached plots.

Limit

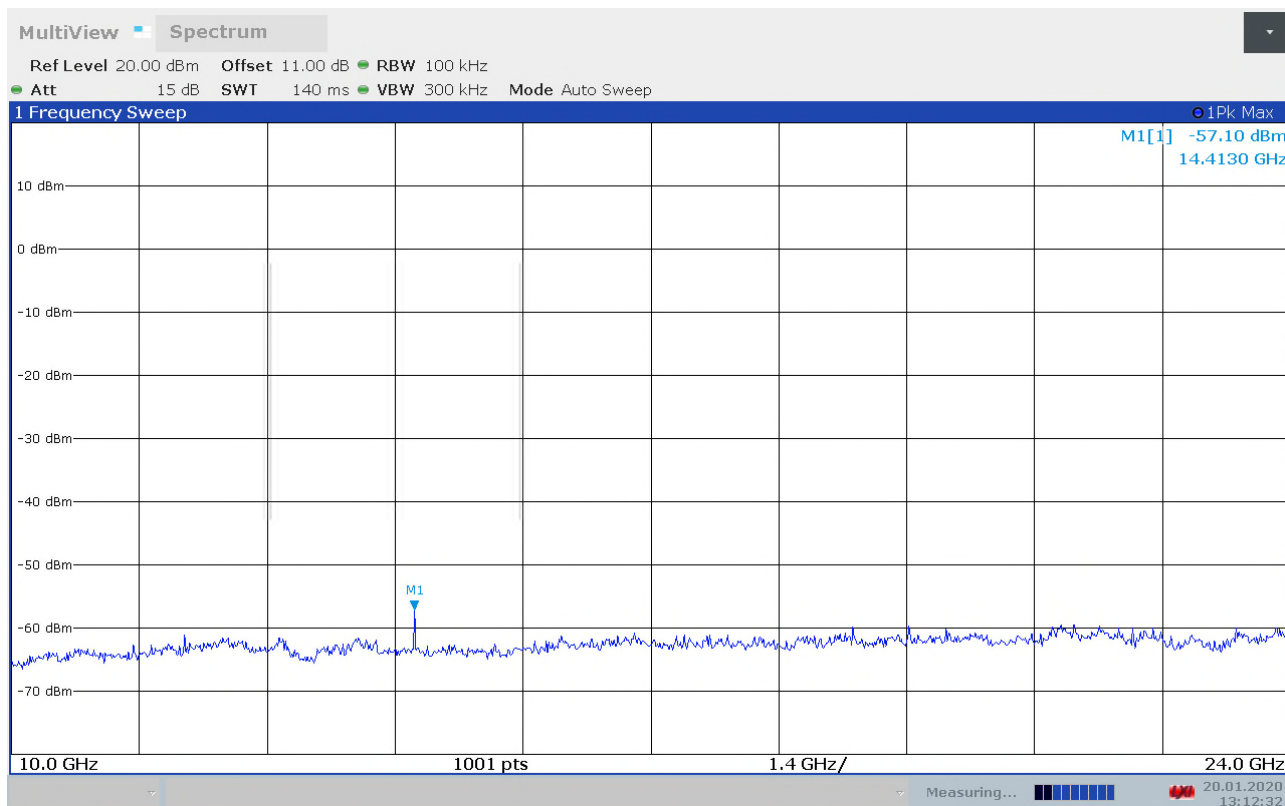
Peak measurement	RMS averaging
20 dBc or more in 100 kHz bandwidth	30 dBc or more in 100 kHz bandwidth

Detector type shall be the same as used for measuring Output Power.

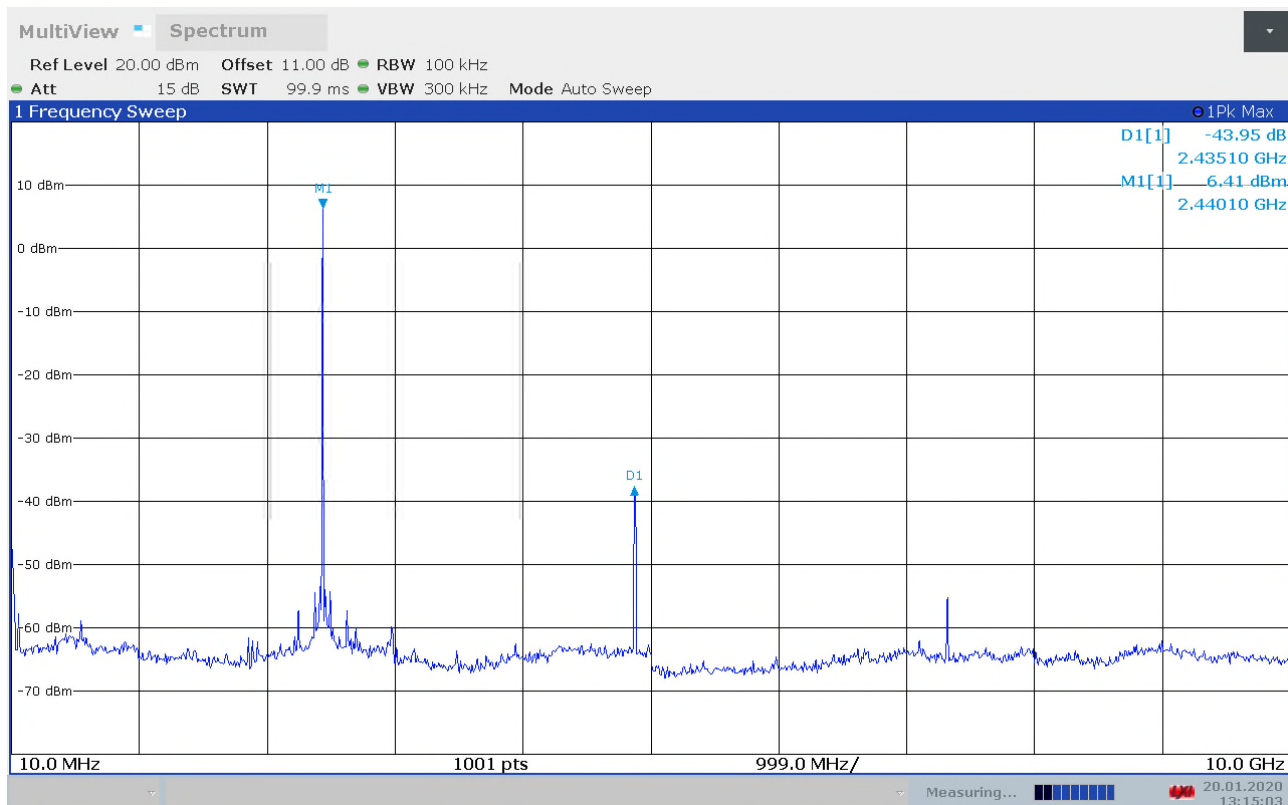
Attenuation below the general limits specified in part 15.209(a) is not required.



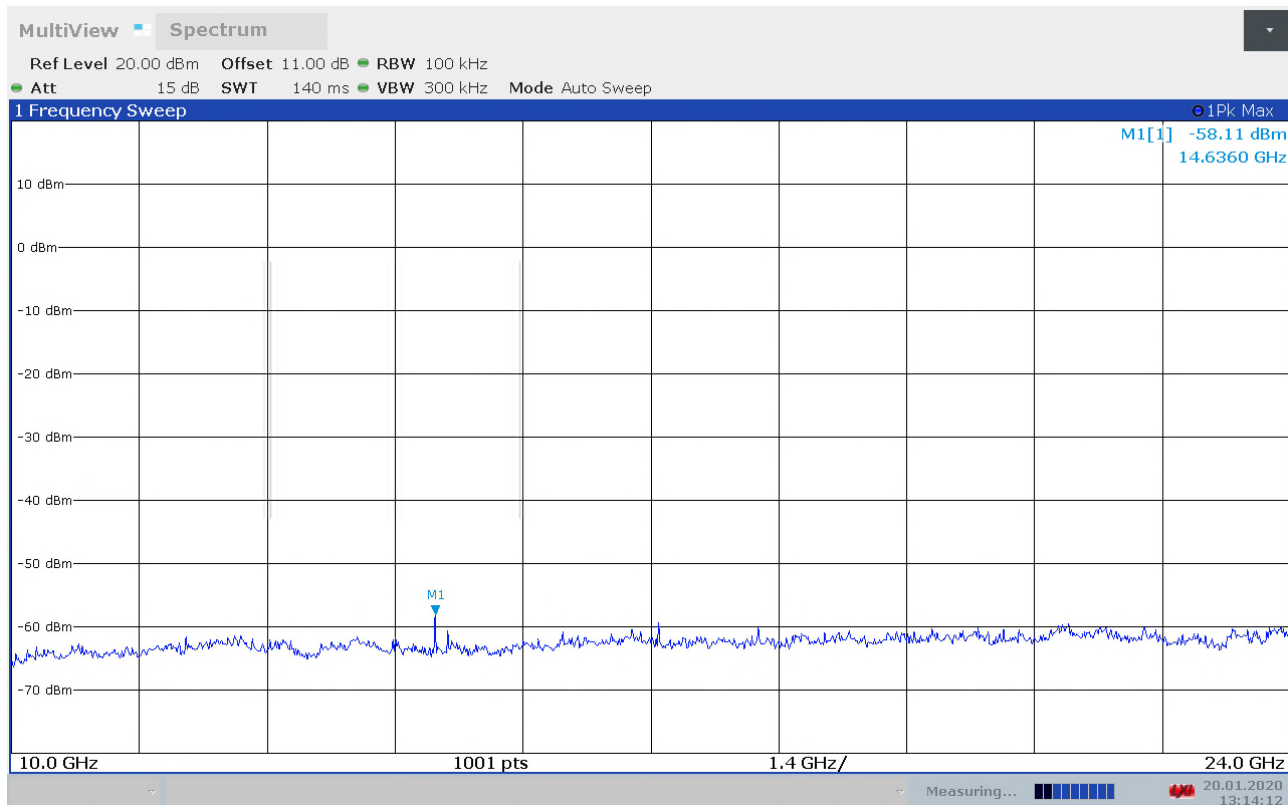
Conducted spurious emissions, 10MHz - 10GHz, ch2402MHz



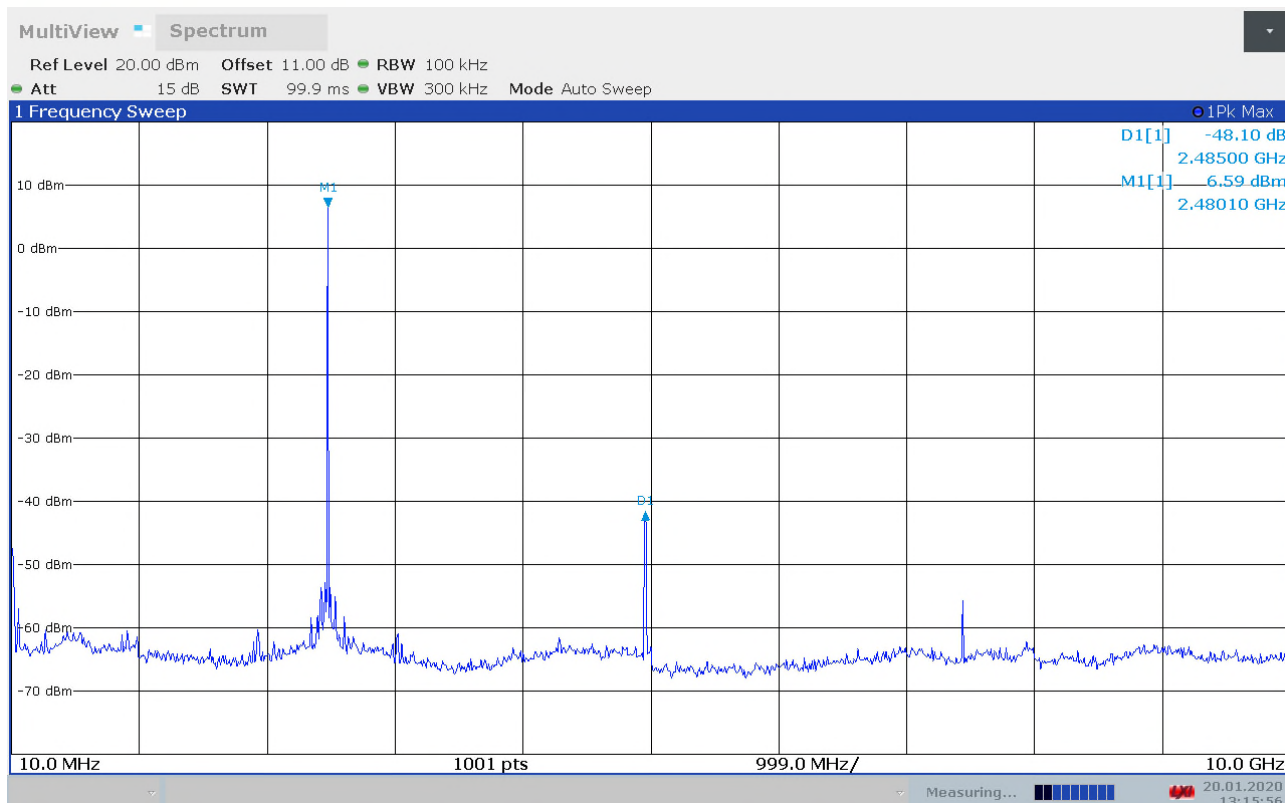
Conducted spurious emissions, 10 - 25GHz, ch2402MHz



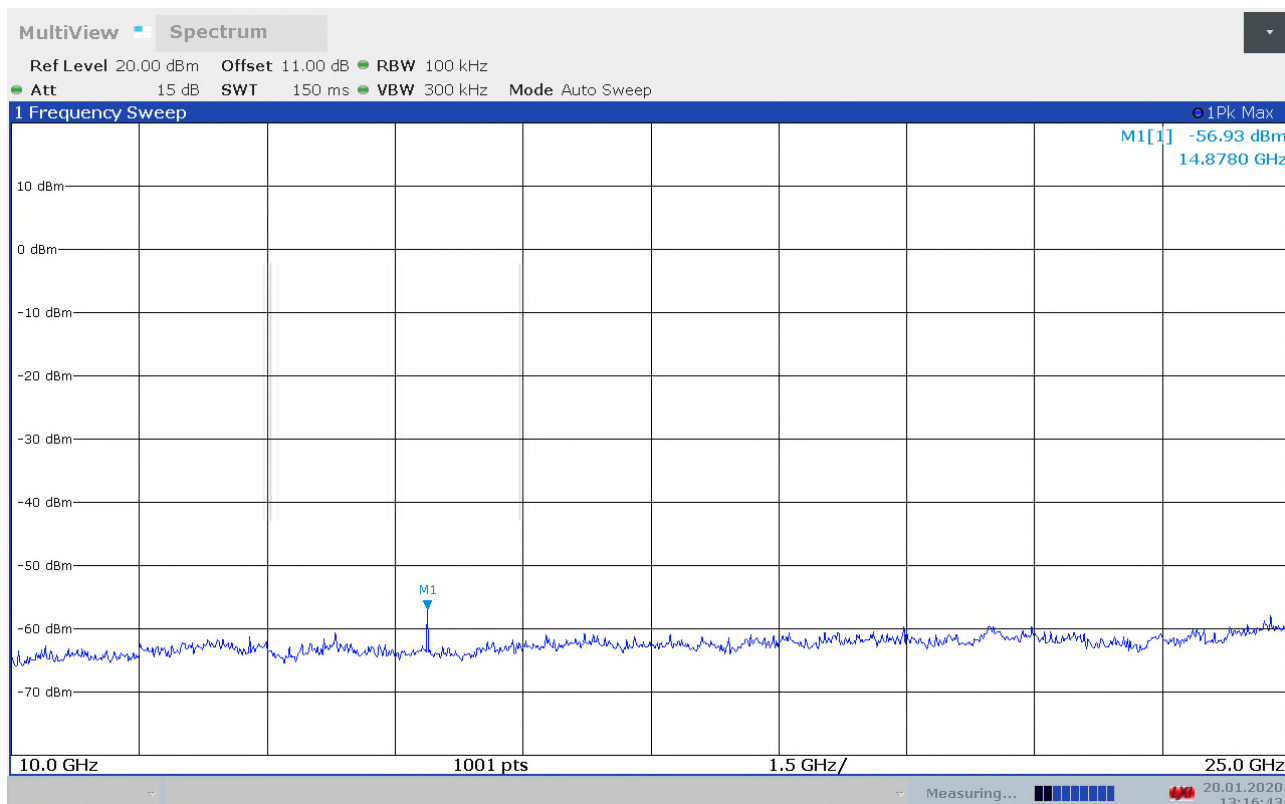
Conducted spurious emissions, 10MHz - 10GHz, ch2440MHz



Conducted spurious emissions, 10 - 25GHz, ch2440MHz



Conducted spurious emissions, 10MHz - 10GHz, ch2480MHz



Conducted spurious emissions, 10 - 25GHz, ch2480MHz

3.6 Restricted Bands of operation

Restricted Bands of operation for FCC and ISSED are defined in FCC Part 15.205 and ISSED RSS-GEN, Issue 4 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 5, clause 8.9.

FCC (MHz)	ISED (MHz)	FCC (GHz)	ISED (GHz)
0.090-0.110		0.96-1.24 1.3-1.427	0.96-1.427
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	1.660-1.710	
4.125-4.128		1.7188-1.7222	
4.17725-4.17775		2.2-2.3	
4.20725-4.20775		2.31-2.39	
	5.677-5.683	2.4835-2.5	
6.215-6.218		2.69-2.9	2.655-2.9
6.26775-6.26825		3.26-3.267	
6.31175-6.31225		3.332-3.339	
8.291-8.294		3.3458-3.358	
8.362-8.366		3.6-4.4	3.5-4.4
8.37625-8.38675		4.5-5.15	
8.41425-8.41475		5.35-5.46	
12.29-12.293		7.25-7.75	
12.51975-12.52025		8.025-8.5	
12.57675-12.57725		9.0-9.2	
13.36-13.41		9.3-9.5	
16.42-16.423		10.6-12.7	
16.69475-16.69525		13.25-13.4	
16.80425-16.80475		14.47-14.5	
25.5-25.67		15.35-16.2	
37.5-38.25		17.7-21.4	
73-74.6		22.01-23.12	
74.8-75.2		23.6-24.0	
108-121.94 123-138	108-138	31.2-31.8	
149.9-150.05		36.43-36.5	
156.52475-156.52525		Above 38.6	
156.7-156.9			
162.0125-167.17			
167.72-173.2			
240-285			
322-335.4			
399.9-410			
608-614			

Frequencies in **Bold** text are specific for FCC or ISSED, all other frequencies are common.

3.7 Spurious Emissions (Radiated)

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3 / 8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

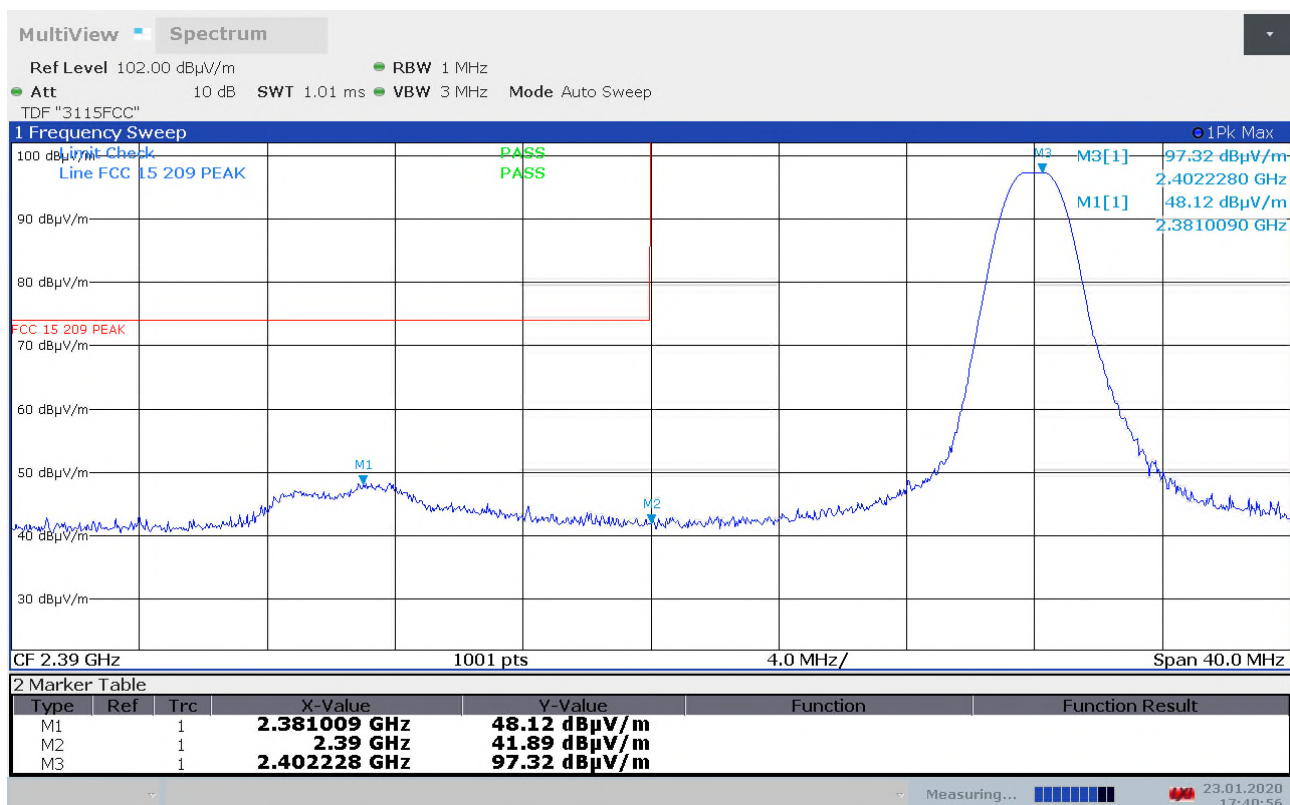
Band-Edge

	Measured field strength (dB μ V/m)		Limit	Margin	
	2381.0/2.39 MHz	2483.5/2500 MHz	dB μ V/m	dB	
Peak Detector	48.12/41.89	49.74/50.97	74	25.9/32.1	24.3/23.0
Average Detector	/	/	54	/	/
Average with DC correction	/	/	54	/	/

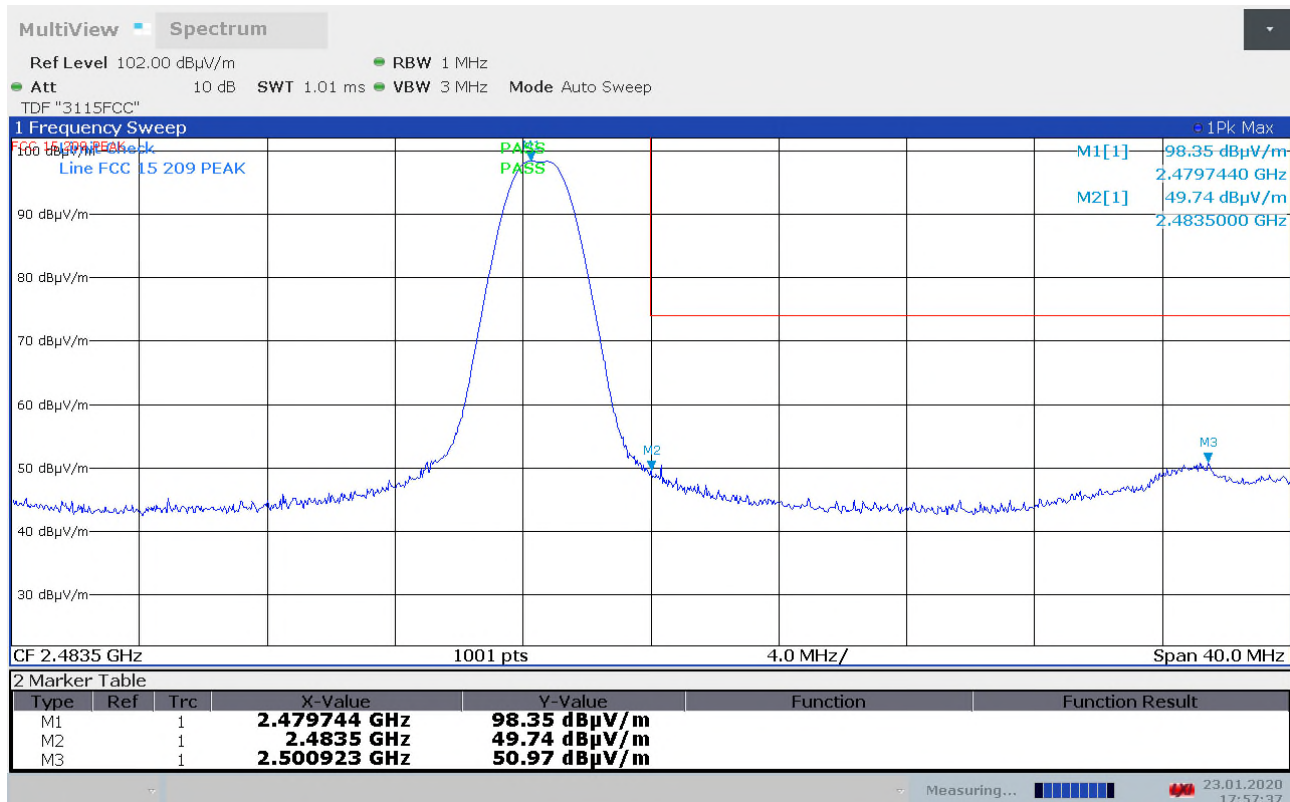
Peak values are below Average Limit.

Restricted band values in the table

See attached plots.



Lower Band Edge, Peak, ch2402MHz



Upper Band Edge, Peak, ch2480MHz

3.8 Radiated emission 30 – 1000 MHz.

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Detector: Quasi-Peak

Measuring distance 3 m

Tested in TX mode

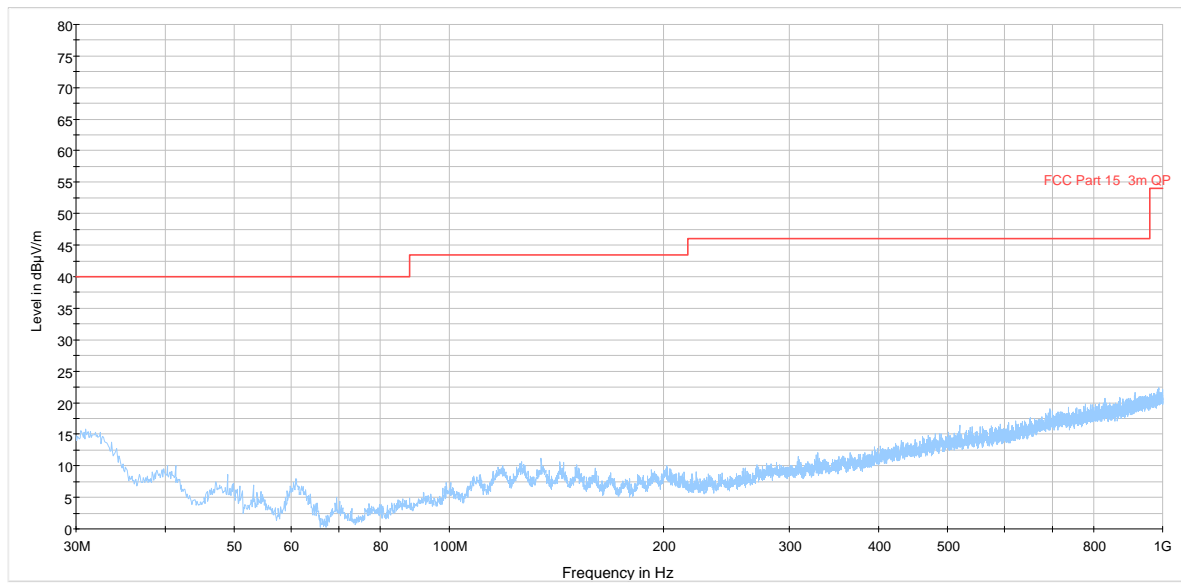
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
-	-	-	-	-	-	-	-	-

See attached plots

Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	Quasi Peak (μV/m)	Quasi Peak (dBμV/m)
30 – 88	100	40.0
88 – 216	150	43.5
216 – 960	200	46.0
Above 960	500	54.0

The limit above 1000 MHz is specified for Average Detector, when the measurement is performed with a Peak Detector a Duty-Cycle Correction Factor has to be calculated to find the corresponding Average Detector value.



3.9 Radiated Emissions, 1-25 GHz

FCC Part 15.209 (a), ISSED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Measuring distance: 3m (1 – 8 GHz), 1m (8 – 25 GHz)

Peak Detector: (Restricted band frequencies)

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 3m	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB μ V/m	dB
4.804	M	0	48.48	74	25.52
4.88	H	0	48.62	74	25.38
4.96	L	0	50.29	74	23.71
7.32	M	0	51.89	74	22.11
7.44	H	0	52.49	74	21.51
Other freqs	L,M,H	0	None detected	74	>20

All Peak values are below Average Limit.

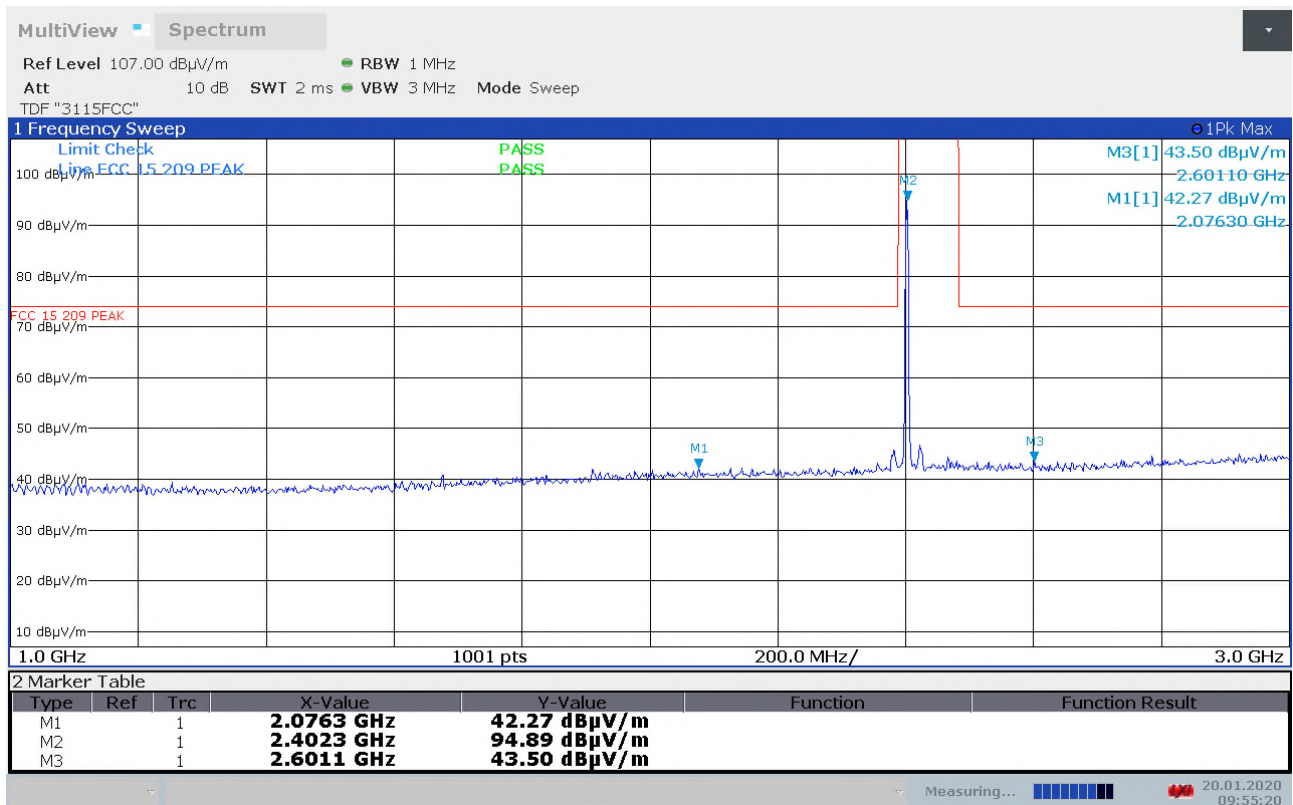
*distance correction is included on the plot.

Maxium is obtained in VP and in YZ plane

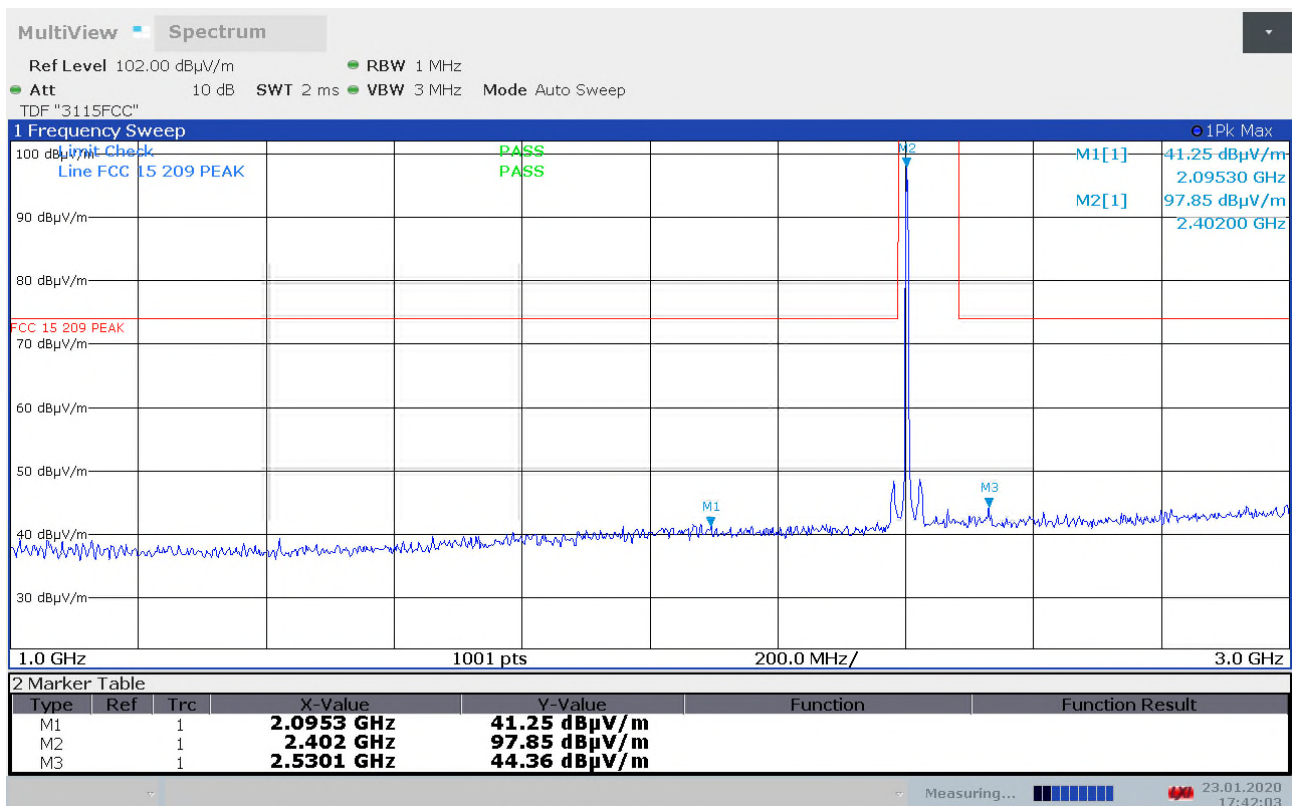
Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor"., See plots.

Requirements/Limit

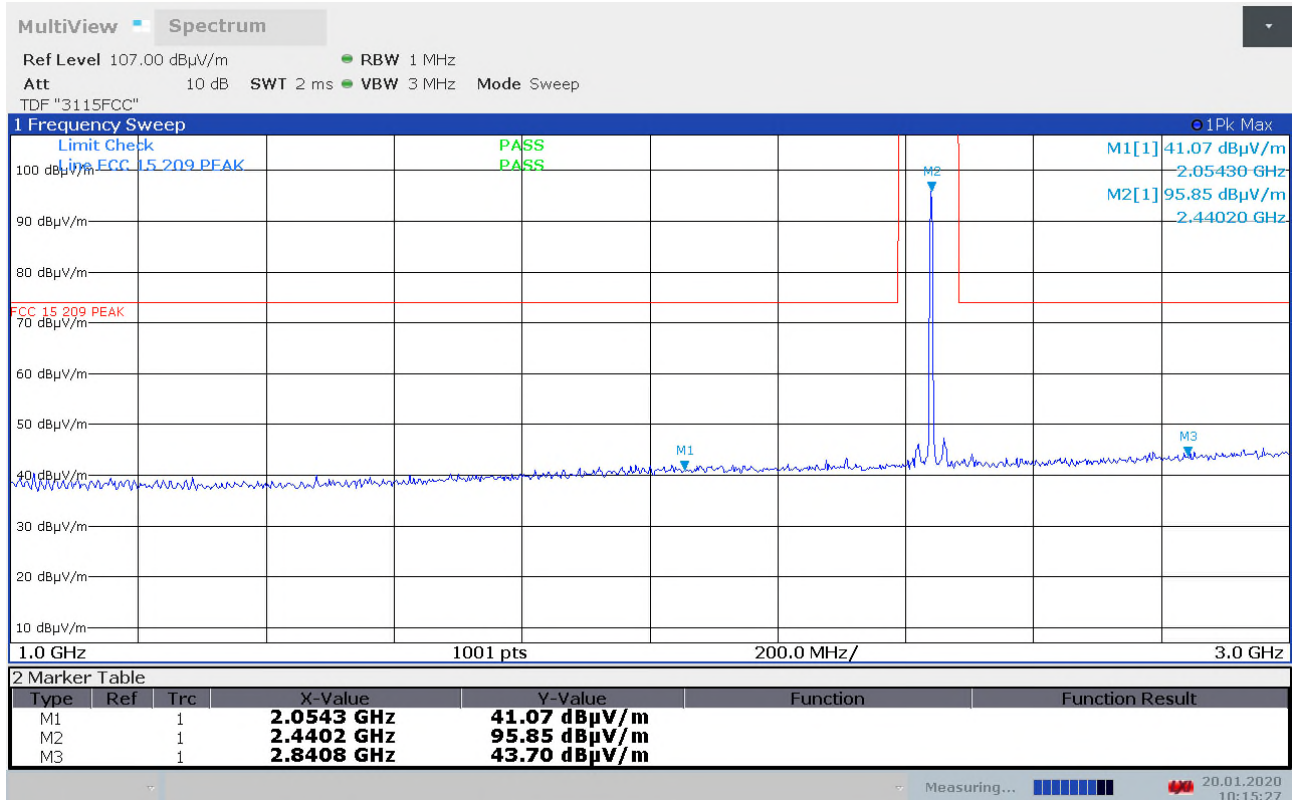
FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



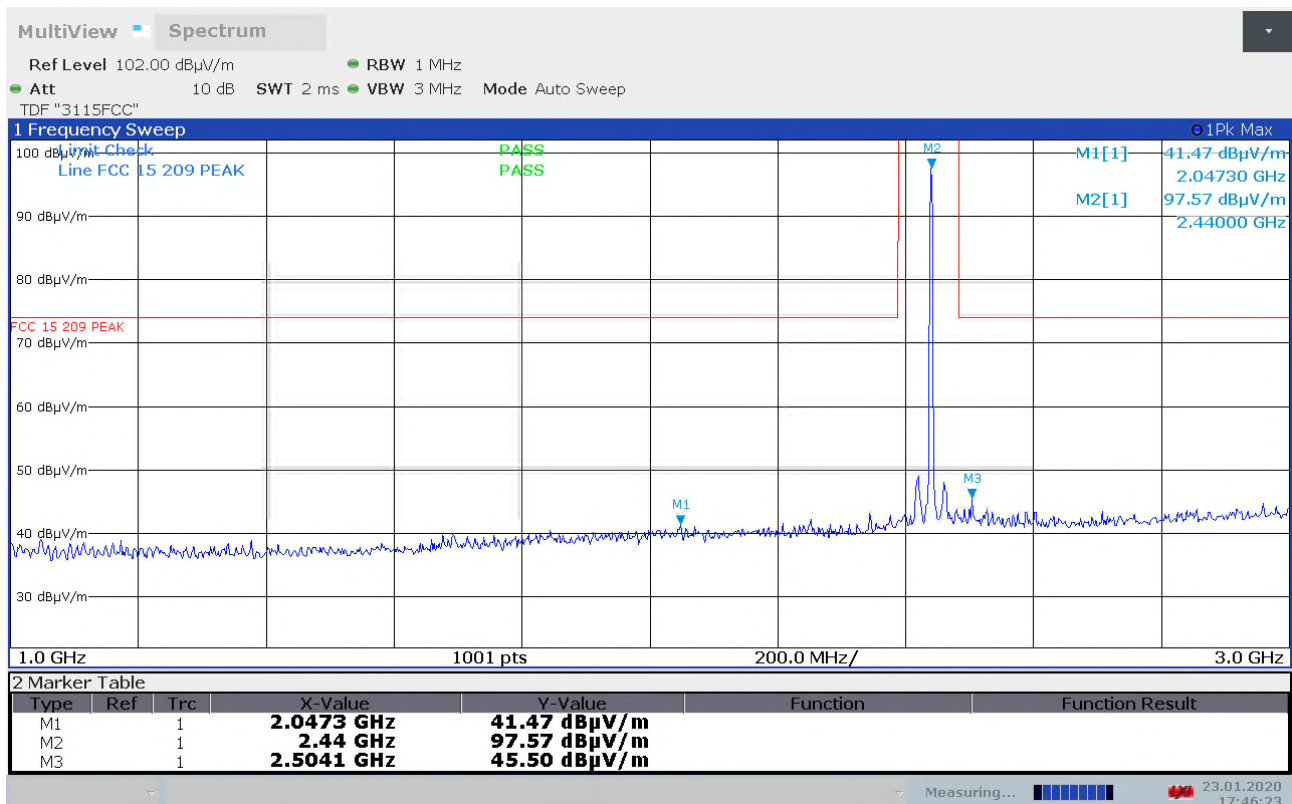
Radiated spurious emissions, VP, 1 - 3GHz, ch2402MHz, PK scan



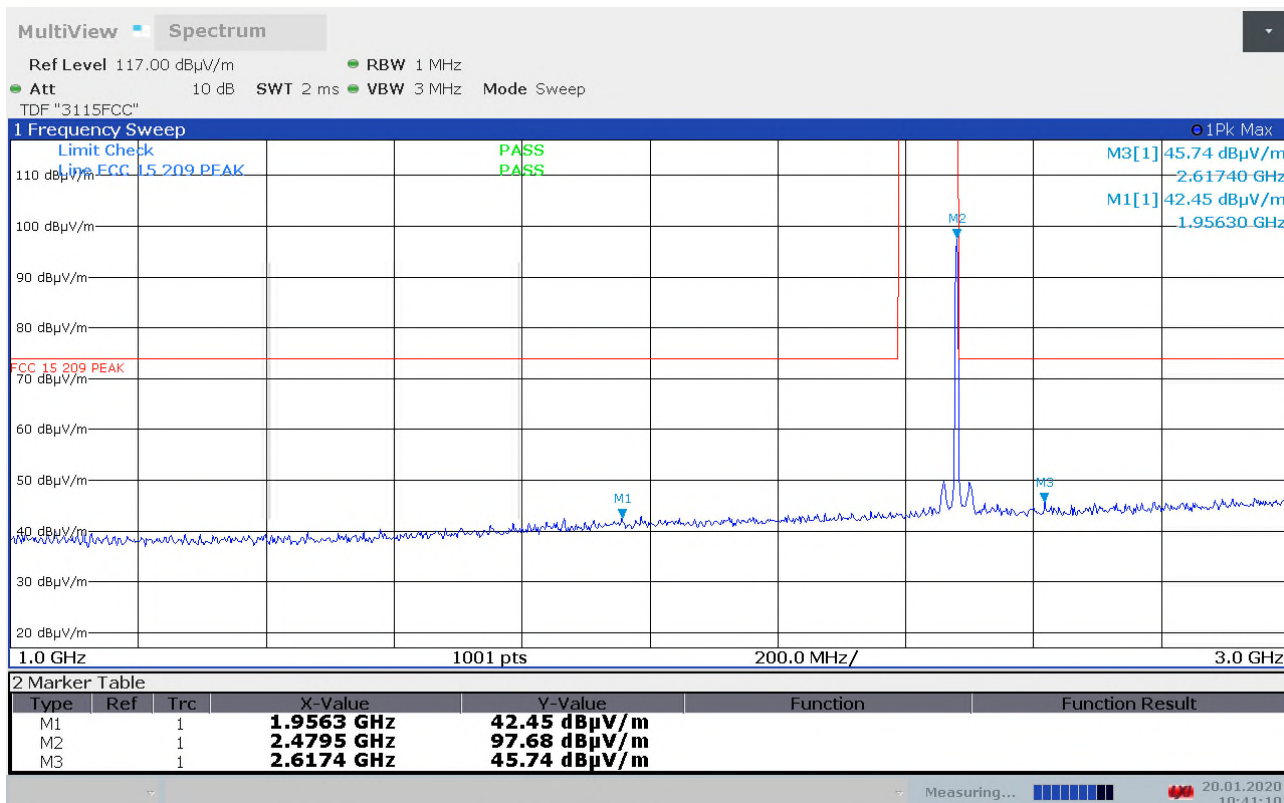
Radiated spurious emissions, HP, 1 - 3GHz, ch2402MHz, PK scan



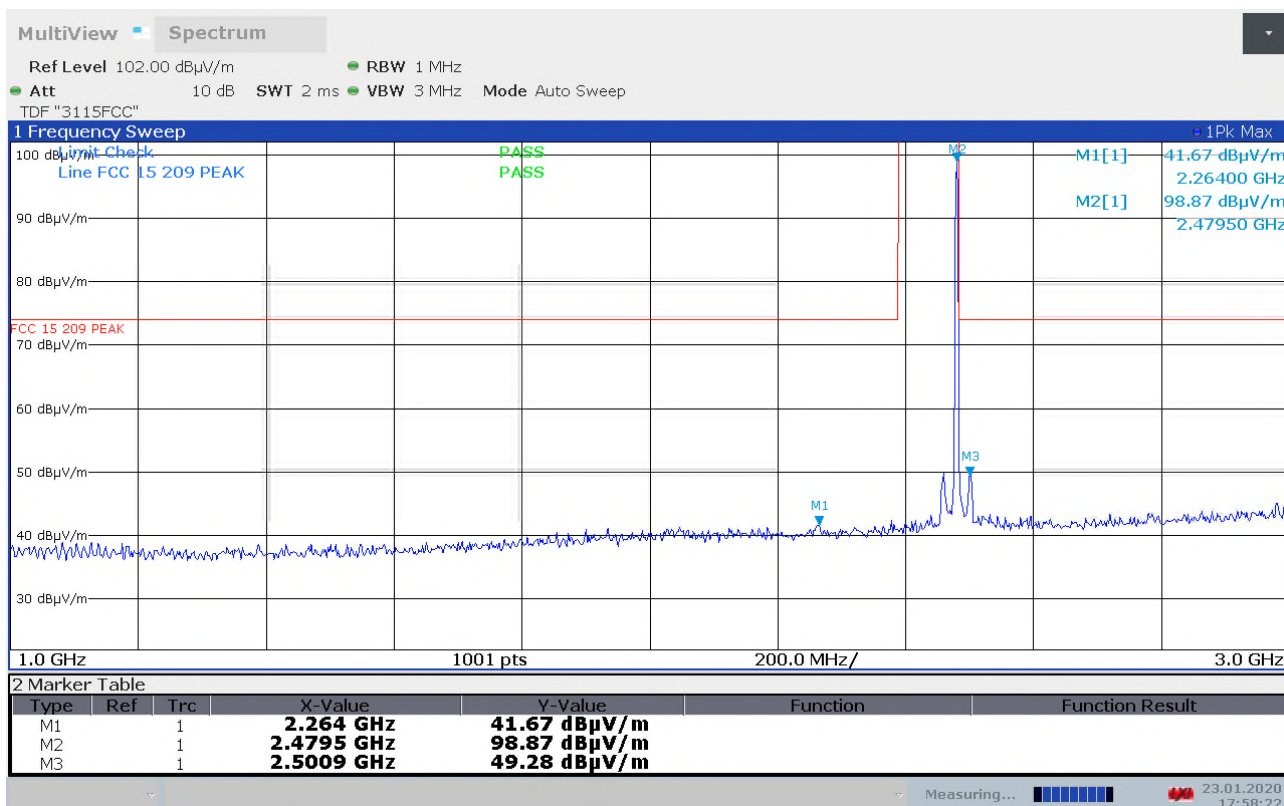
Radiated spurious emissions, VP, 1 - 3GHz, ch2440MHz, PK scan



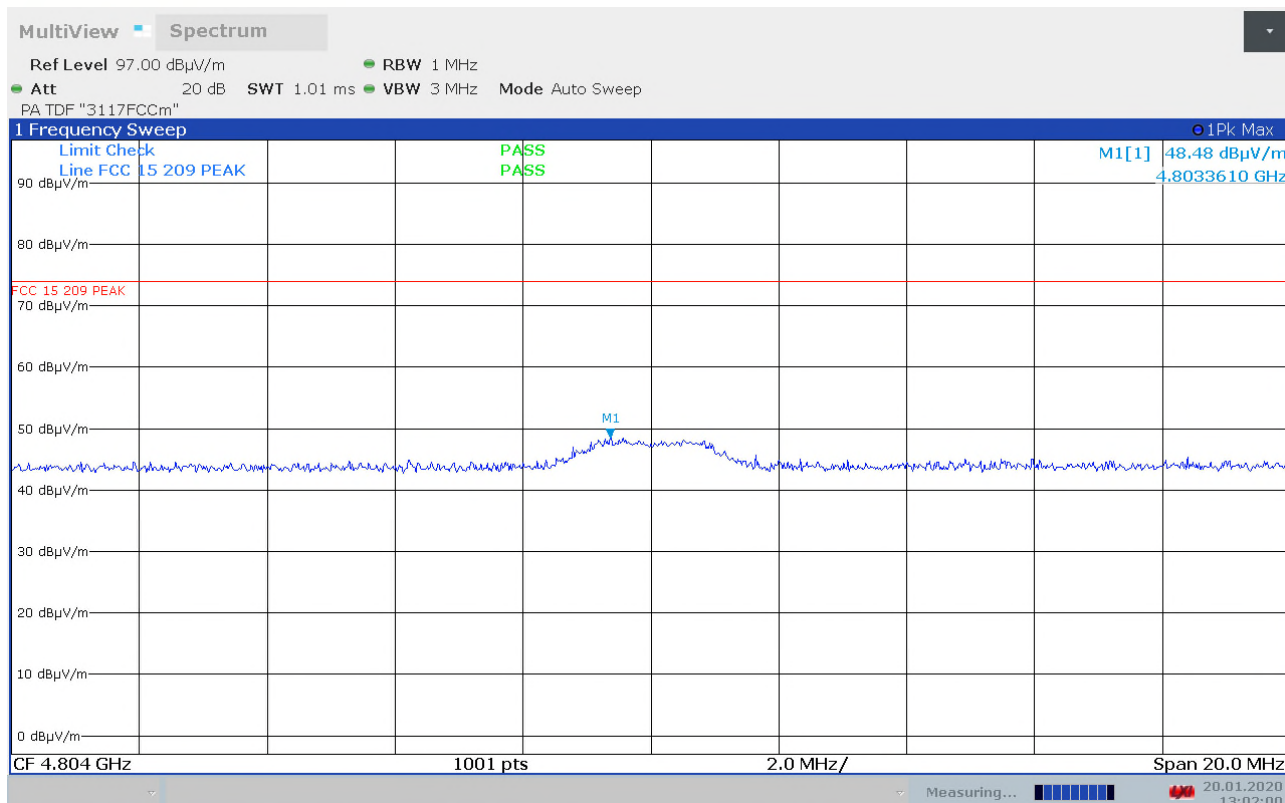
Radiated spurious emissions, HP, 1 - 3GHz, ch2440MHz, PK scan



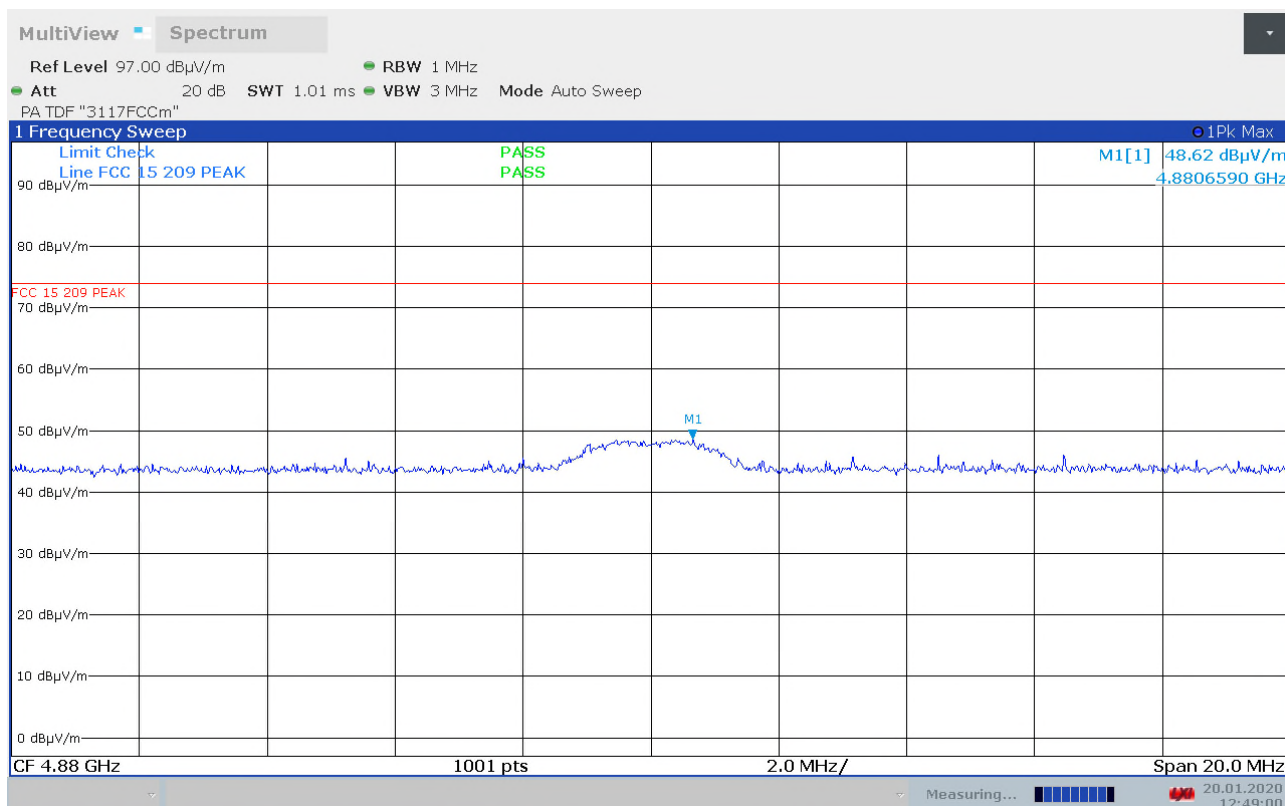
Radiated spurious emissions, VP, 1 - 3GHz, ch2480MHz, PK scan



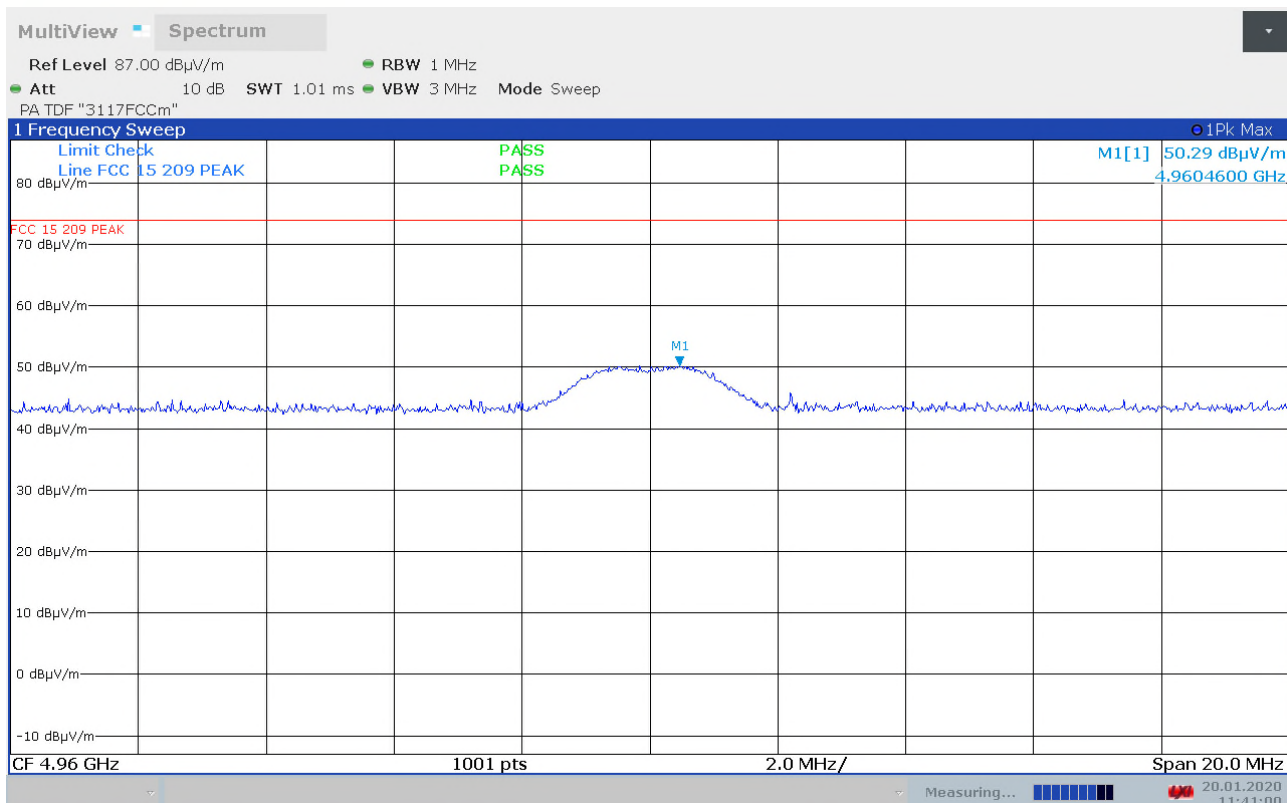
Radiated spurious emissions, HP, 1 - 3GHz, ch2480MHz, PK scan



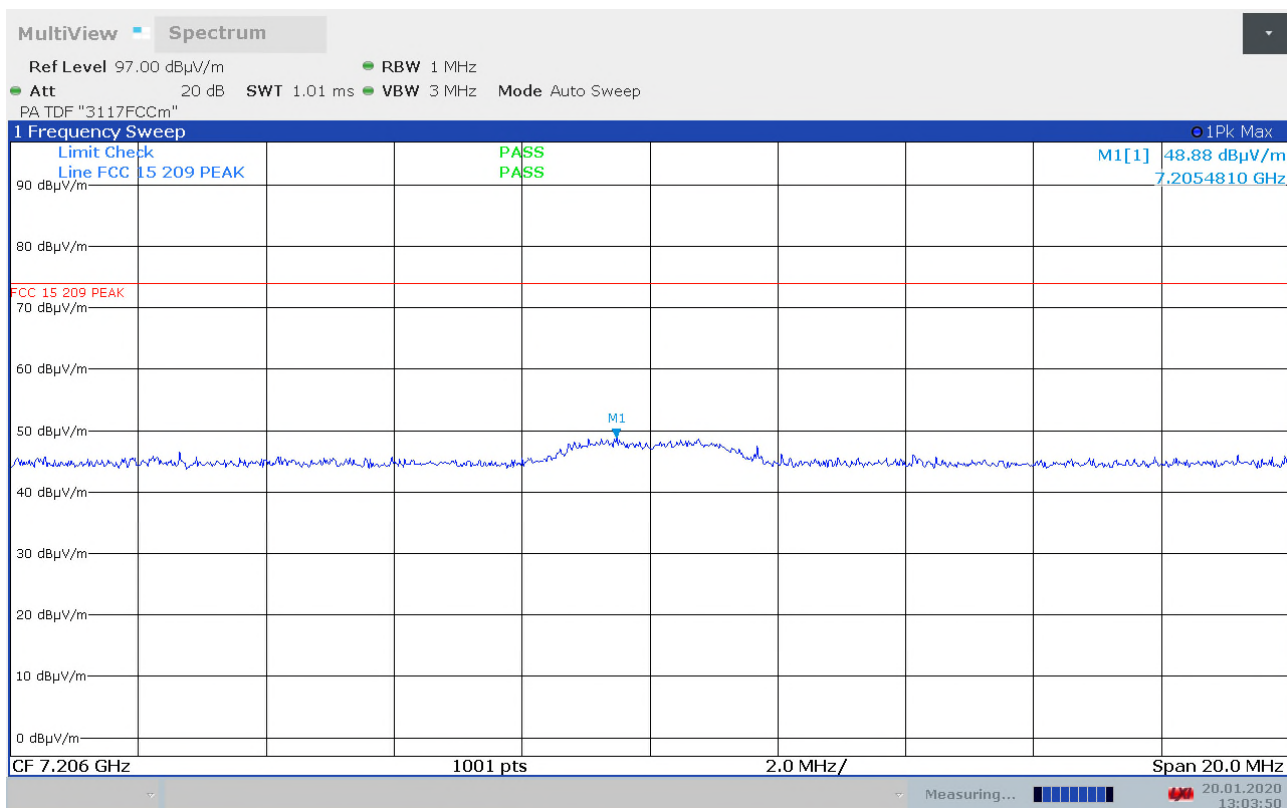
2nd Harmonic, VP, ch2402MHz, PK



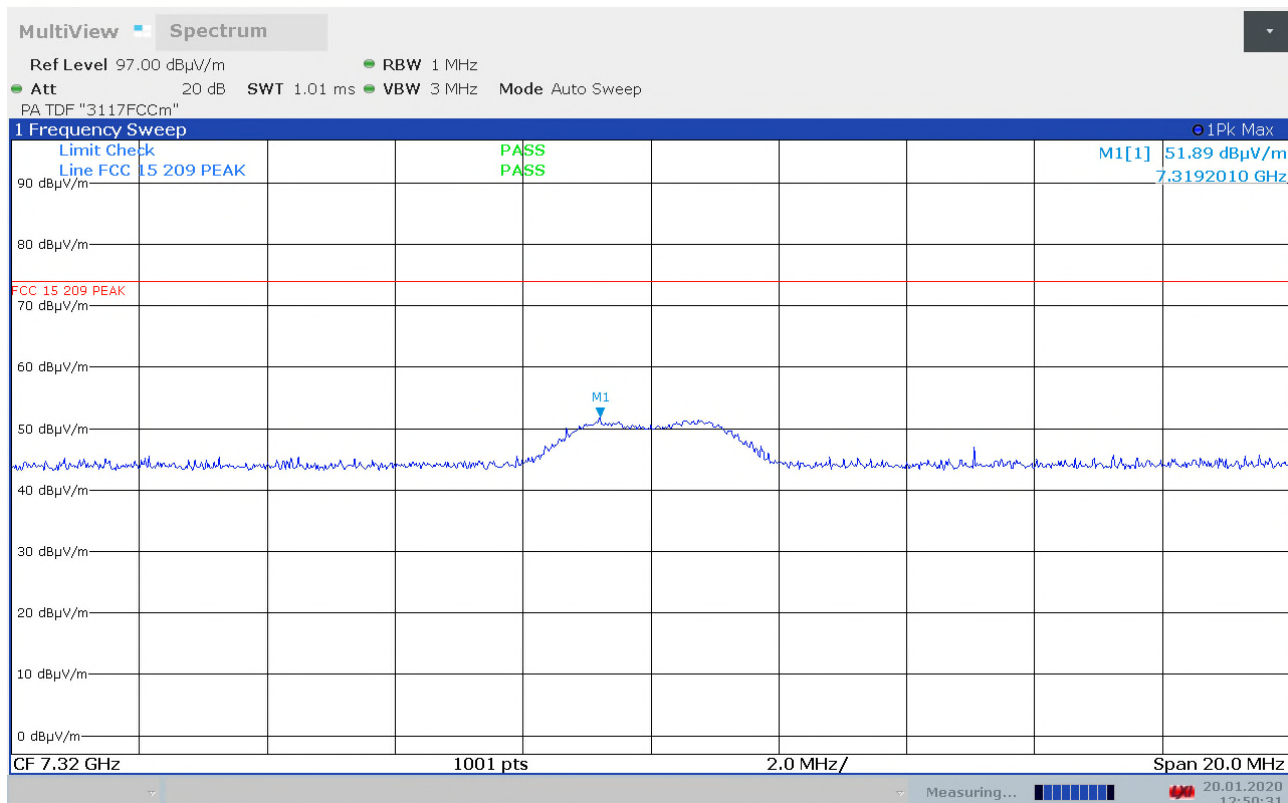
2nd Harmonic, VP, ch2440MHz, PK



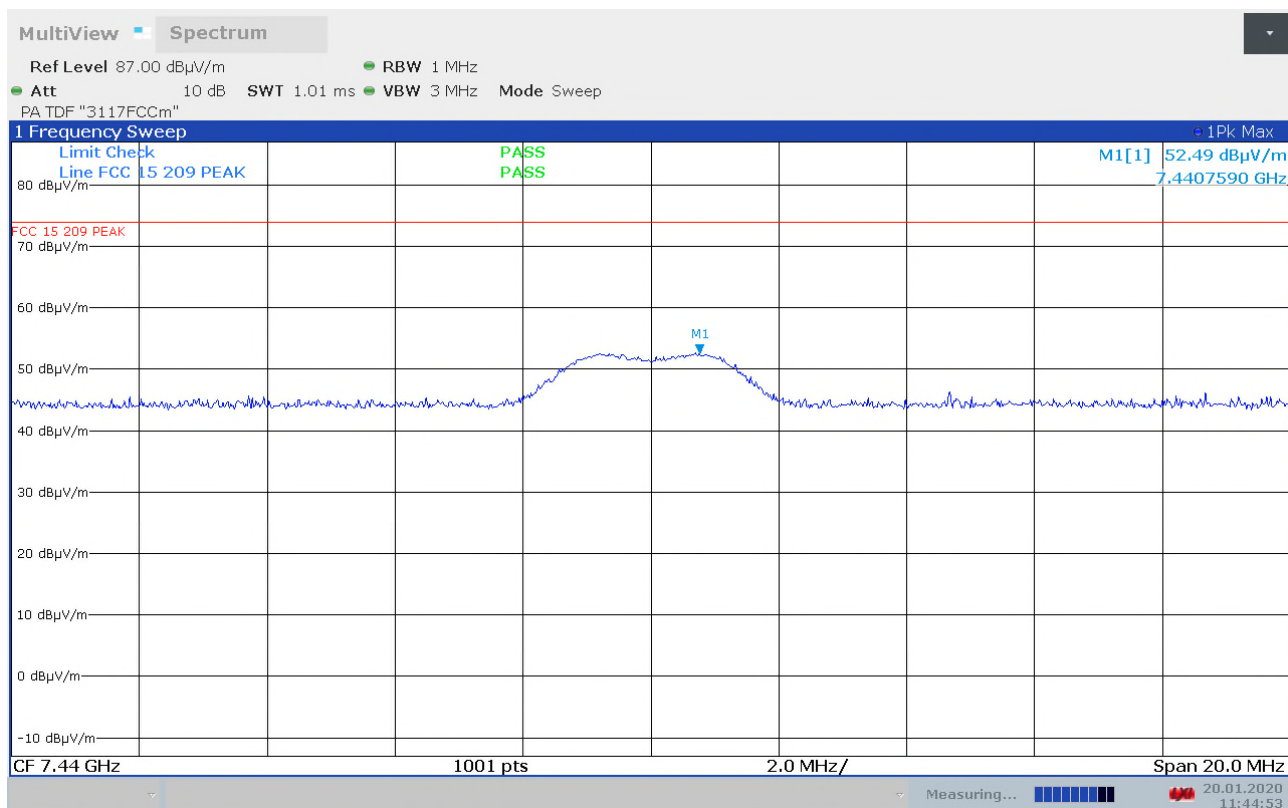
2nd Harmonic, VP, ch2480MHz, PK



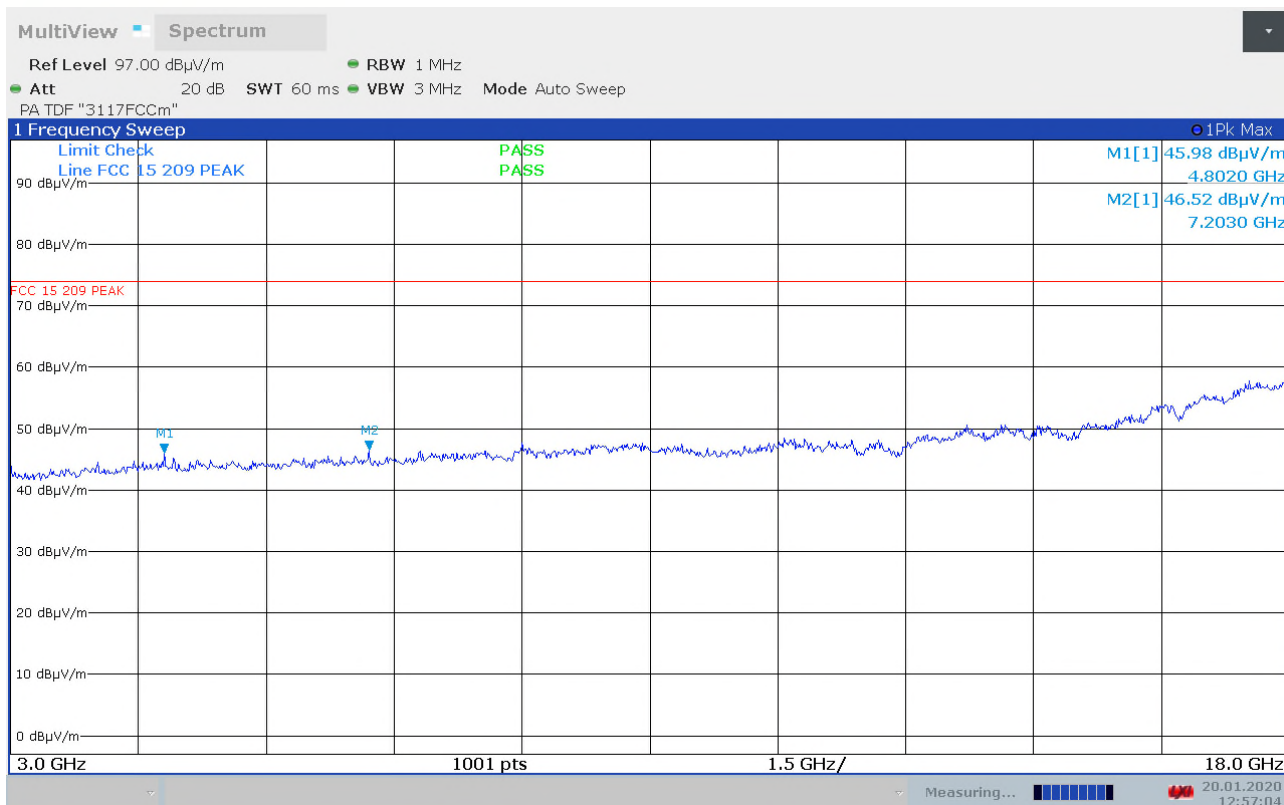
3rd Harmonic, VP, ch2402MHz, PK



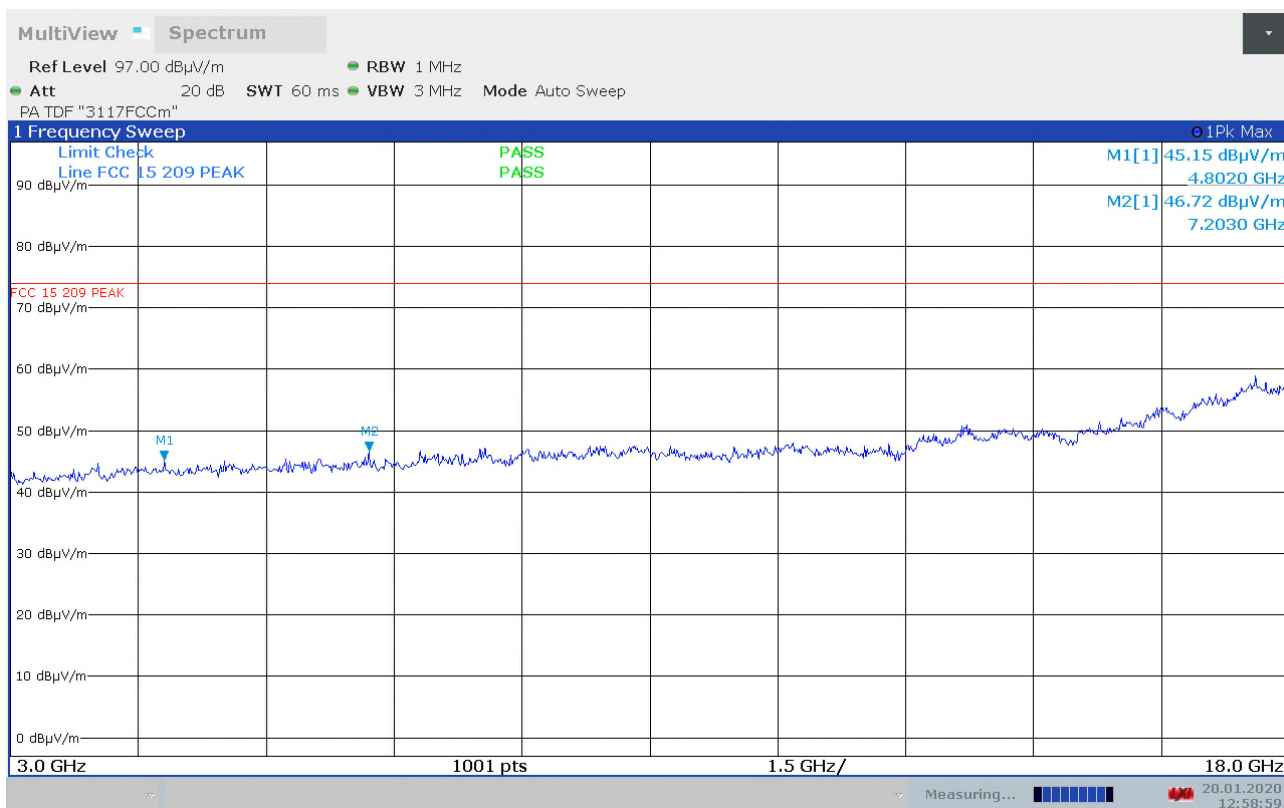
3rd Harmonic, VP, ch2440MHz, PK



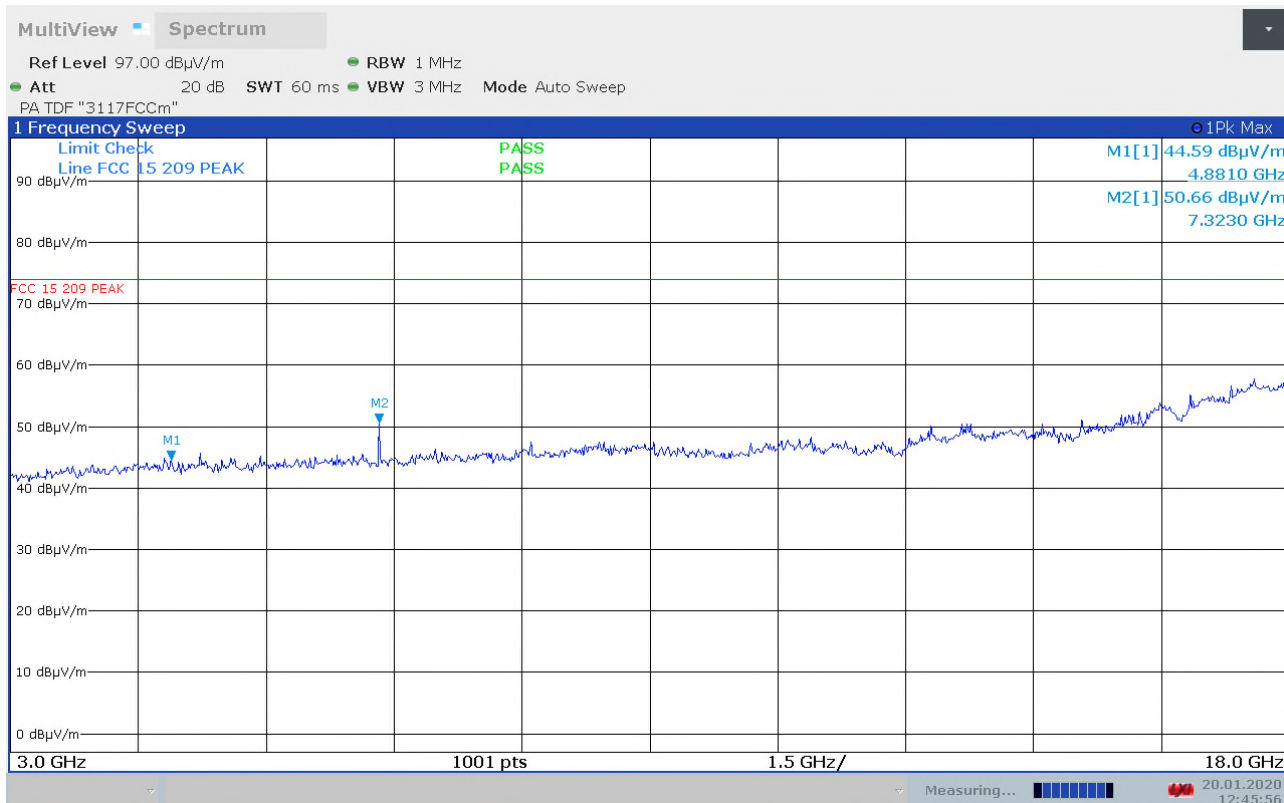
3rd Harmonic, VP, ch2480MHz, PK



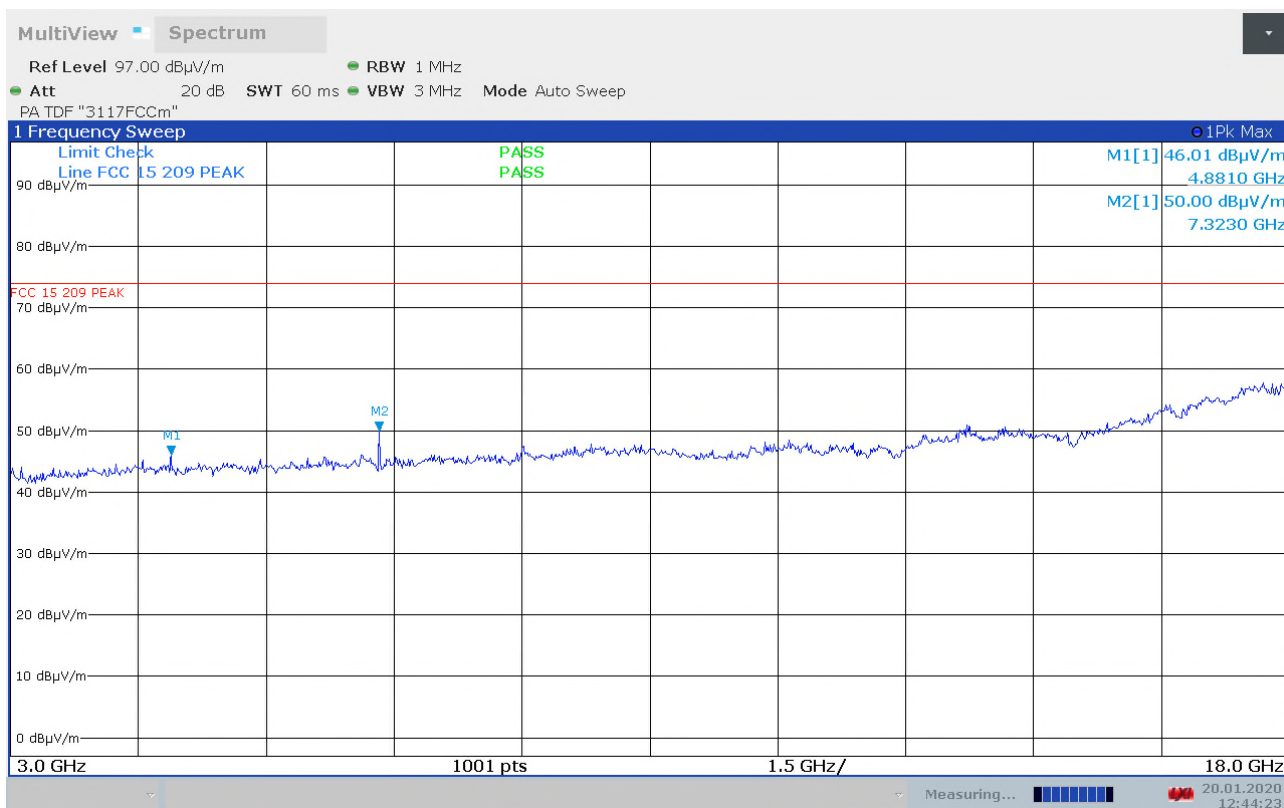
Radiated spurious emissions, VP, 3 - 18GHz, ch2402MHz, PK scan



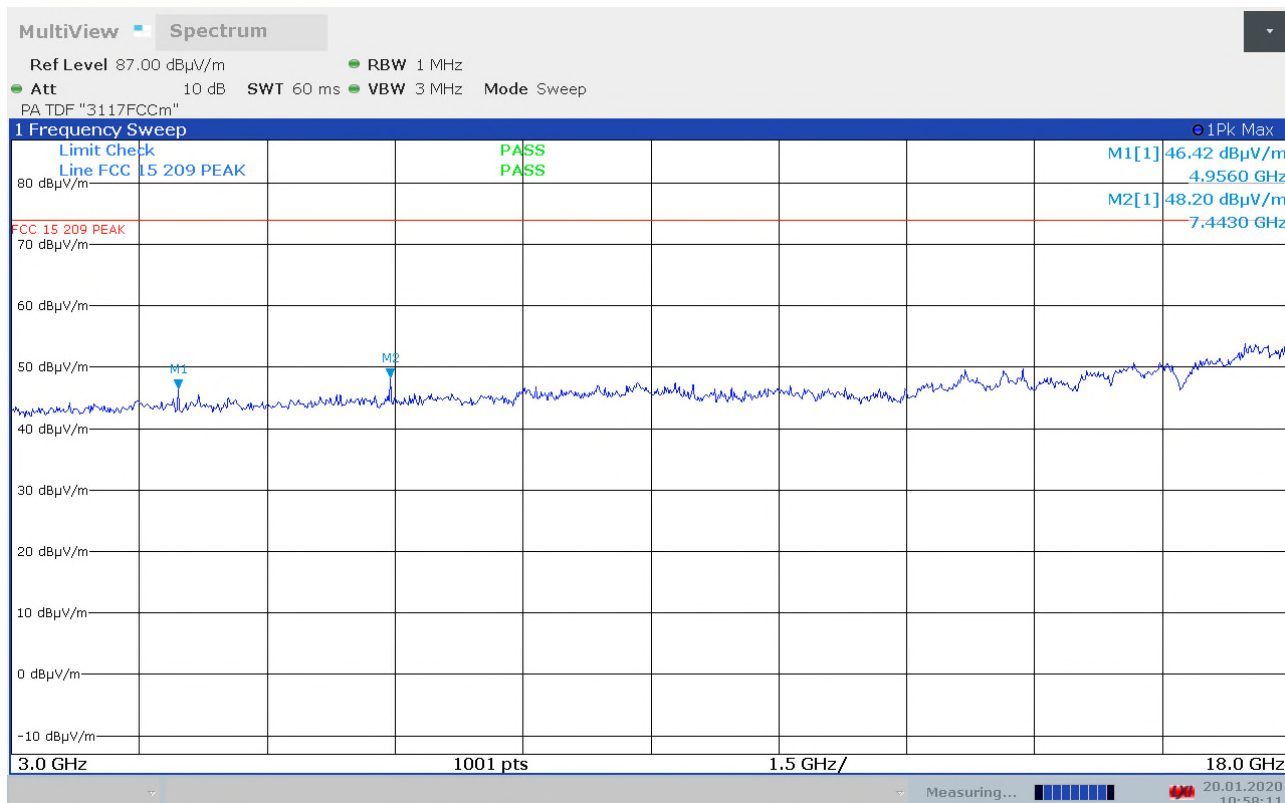
Radiated spurious emissions, HP, 3 - 18GHz, ch2402MHz, PK scan



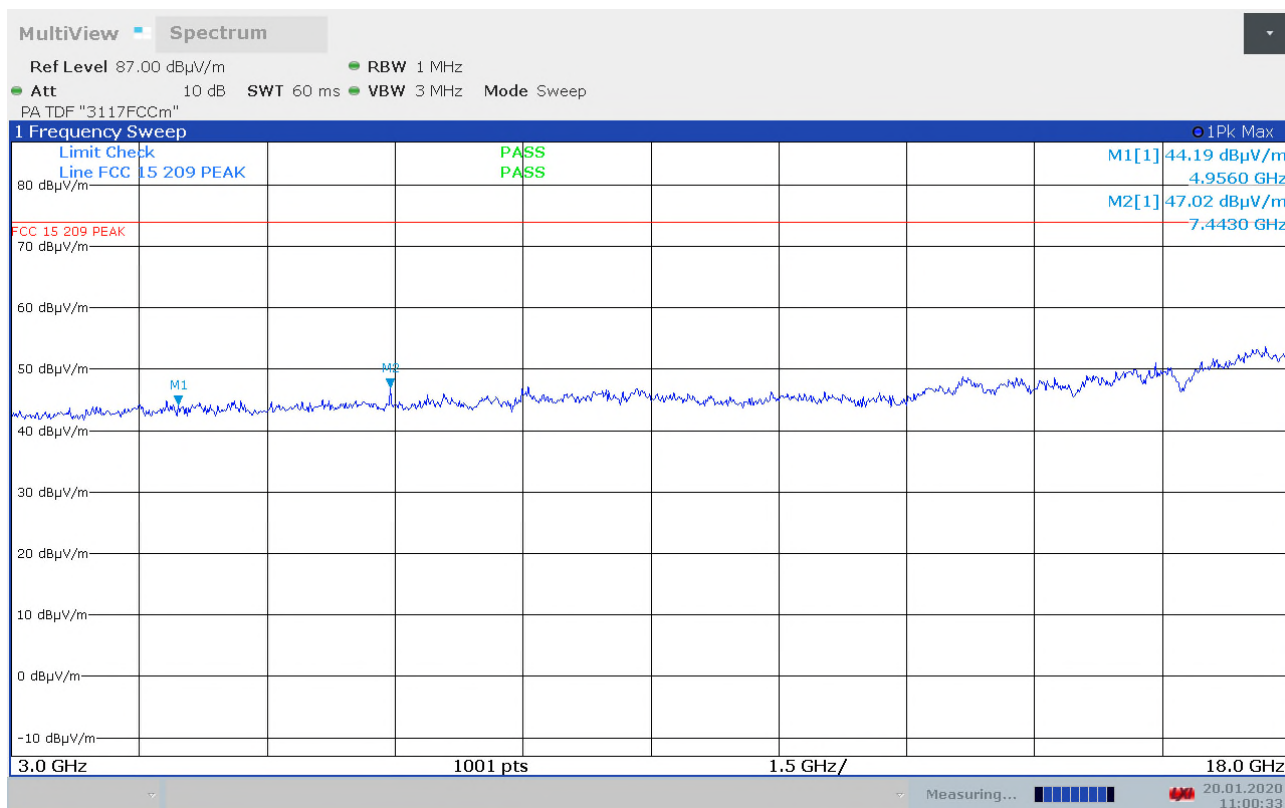
Radiated spurious emissions, VP, 3 - 18GHz, ch2440MHz, PK scan



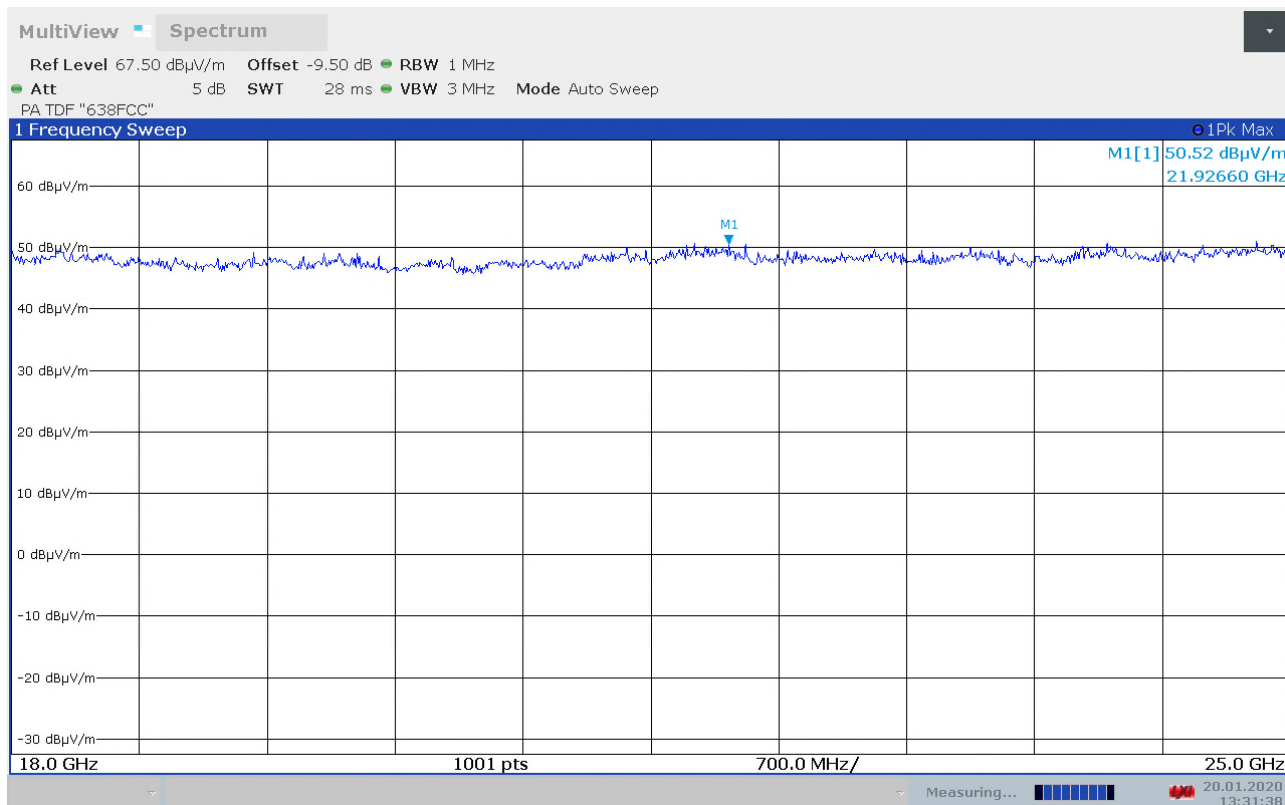
Radiated spurious emissions, HP, 3 - 18GHz, ch2440MHz, PK scan



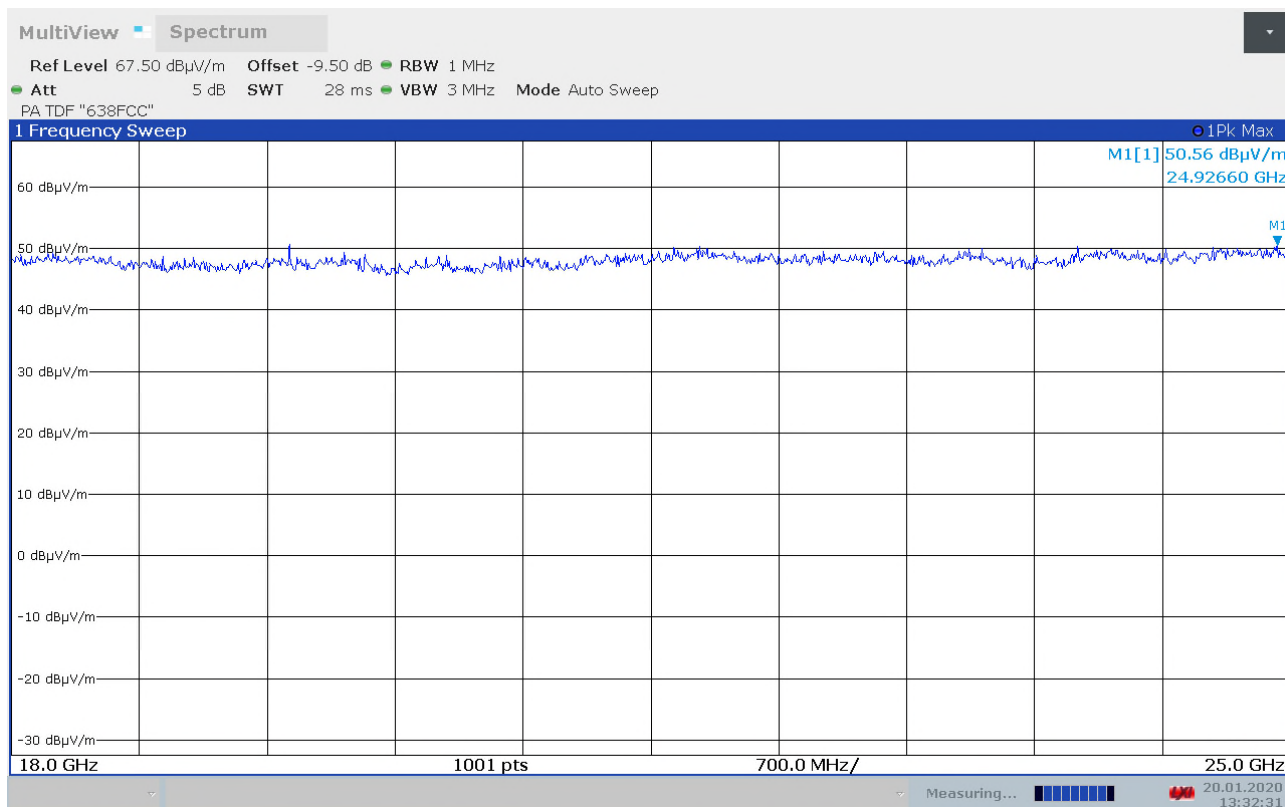
Radiated spurious emissions, VP, 3 - 18GHz, ch2480MHz, PK scan



Radiated spurious emissions, HP, 3 - 18GHz, ch2480MHz, PK scan



Pre-scan, Radiated spurious emissions, VP, 18 - 25GHz @ 1m distance



Pre-scan, Radiated spurious emissions, HP, 18 - 25GHz @ 1m distance

3.10 Power Spectral Density (PSD)

FCC part 15.247(e)

ISED Canada RSS-247 Issue 2, Clause 5.2 (2)

Measurement procedure: ANSI C63.10-2013 Clause 11.10

Test Results: Complies

Measured and Calculated Data:

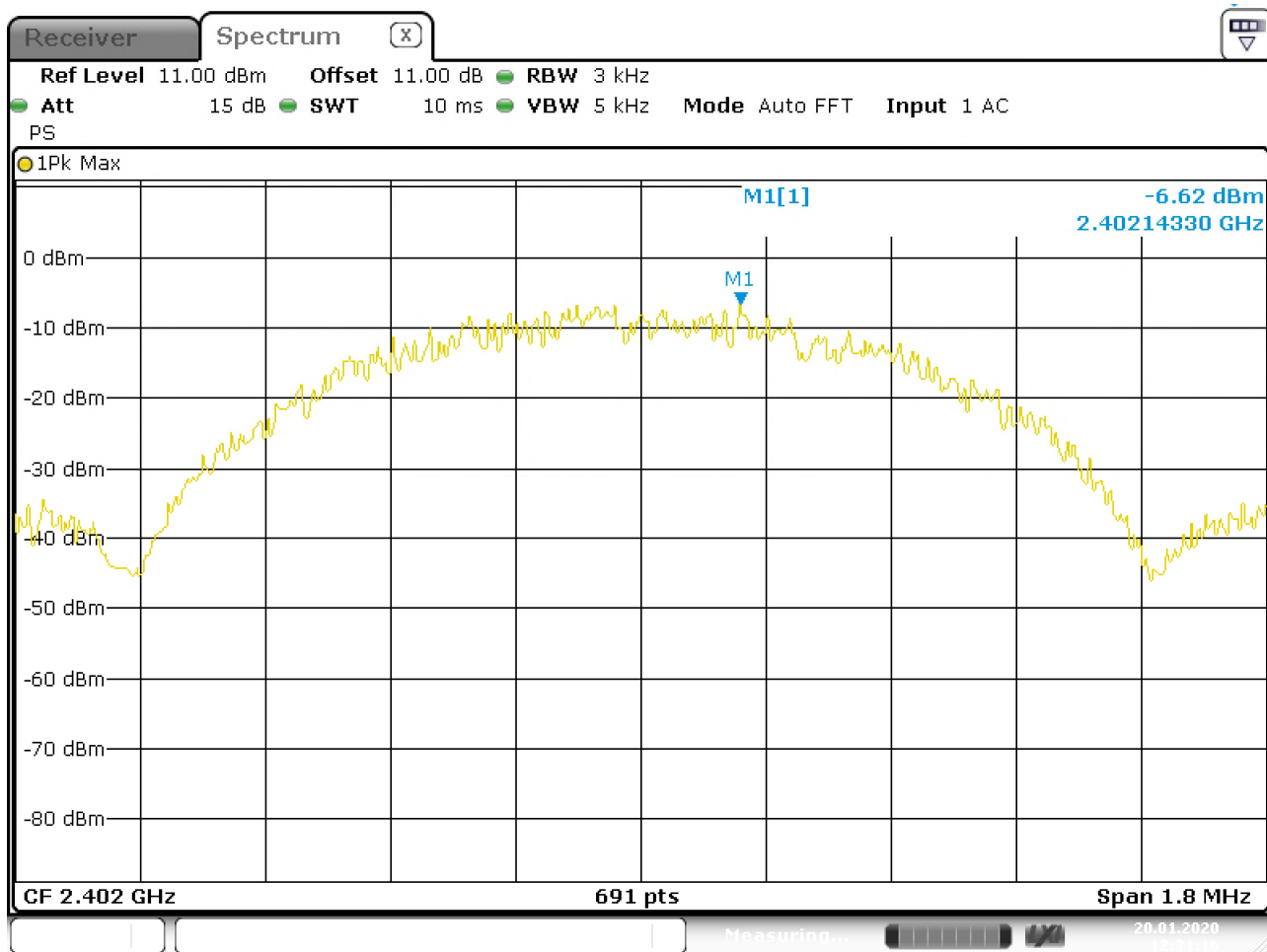
The measurement procedures PKPSD described in ANSI C63.10-2013 was used.

	2402 MHz	2440 MHz	2480 MHz
Measured value (dBm)	-6.62	-6.01	-5.98

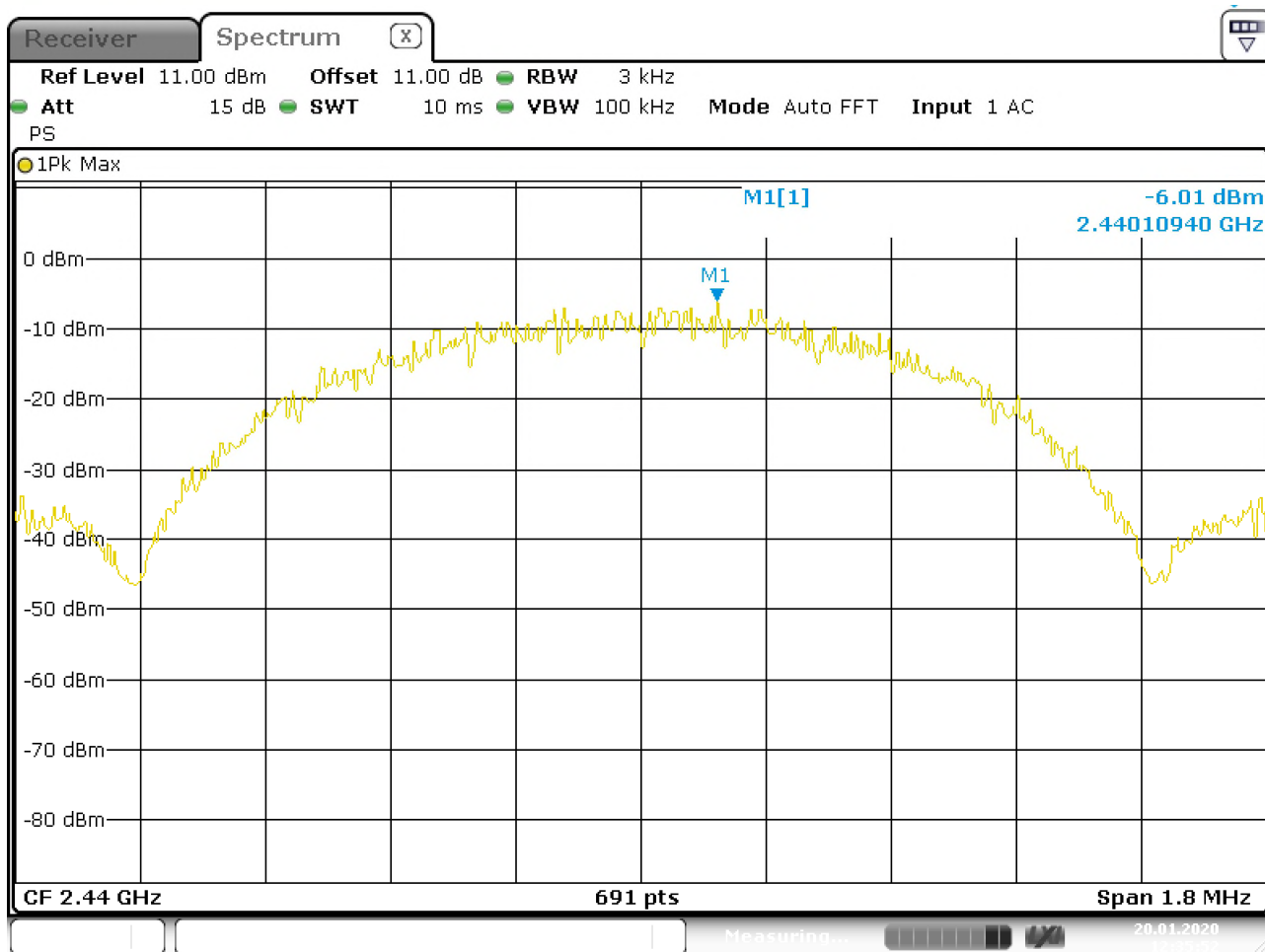
Requirements:

The Power Spectral Density of a Digital Transmission System shall be no greater than +8 dBm in any 3 kHz band

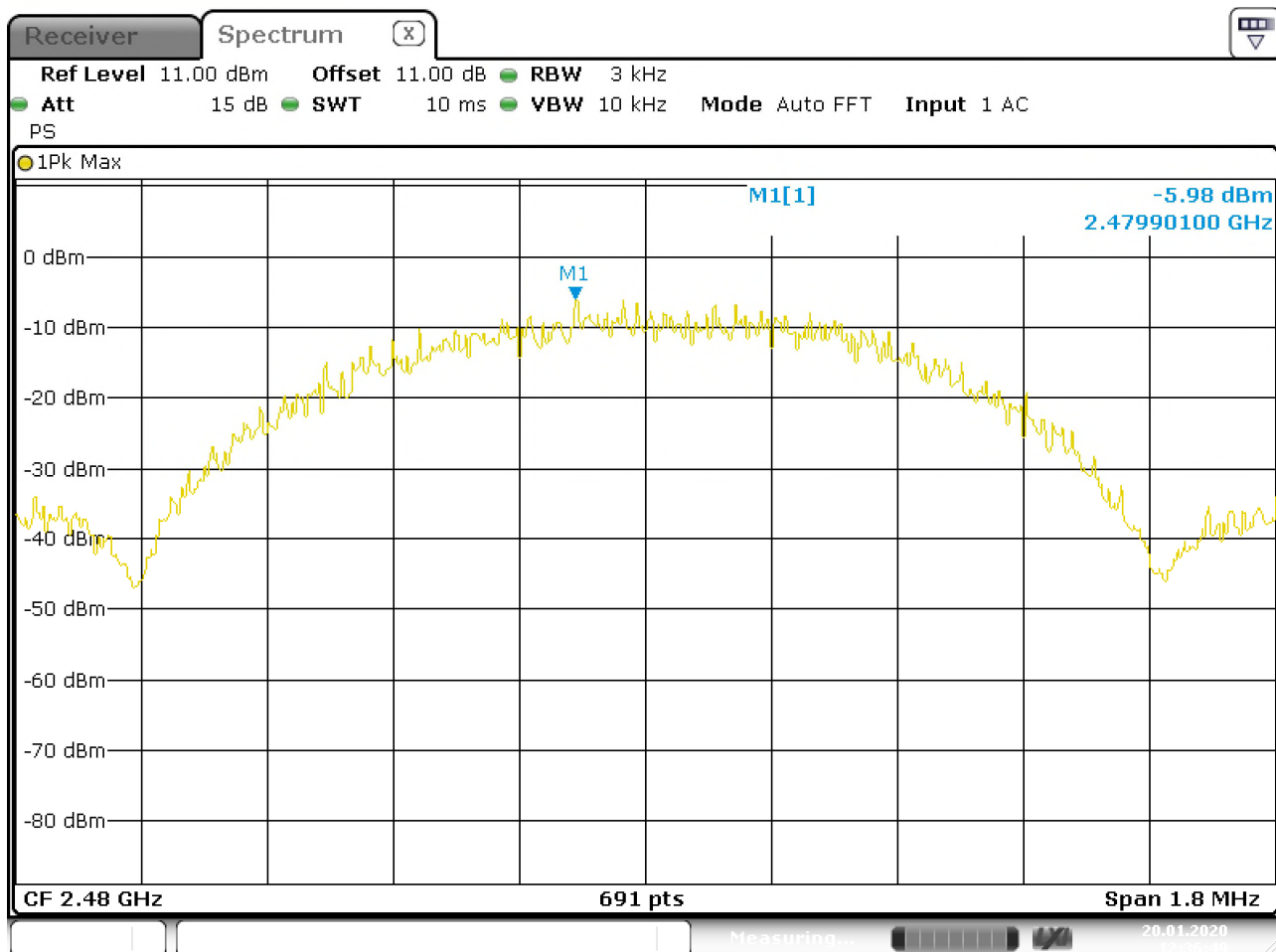
No requirements for Frequency Hopping Systems.



Conducted PSD, ch2402MHz



Conducted PSD, ch2440MHz



Conducted PSD, ch2480MHz

4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		Uncertainty
Output Power		±0.5 dB
Power Spectral Density		±0.5 dB
Out of Band Emissions, Conducted	< 3.6 GHz	±0.6 dB
	> 3.6 GHz	±0.9 dB
Spurious Emissions, Radiated	< 1 GHz	±2.5 dB
	> 1 GHz	±2.2 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		+2.9 / -4.1 dB
Spectrum Mask Measurements	Frequency	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

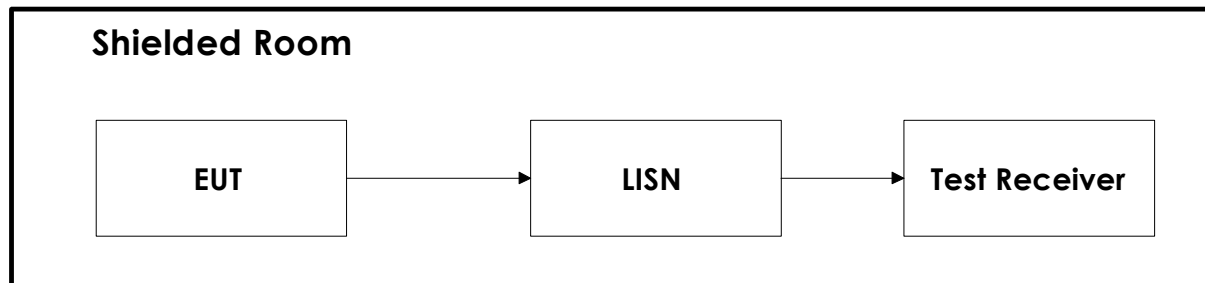
No.	Instrument/ ancillary	Type of instrument/ ancillary	Manufacturer	Ref. no.	Cal. Date	Cal. Due
1.	ESR 7	EMI Receiver	Rohde & Schwarz	LR1675	2019.01	2021.01
2.	FSW43	Spectrum analyser	Rohde & Schwarz	LR1690	2020.01	2021.01
3.	HFH2-Z2	Active Loop antenna	Rohde & Schwarz	LR1660	2019.06	2021.06
4.	3115	Antenna horn	EMCO	LR 1330	2016.10	2020.10
5.	3117-PA	Horn antenna with PreA	EMCO	LR 1717	2017.12	2020.12
6.	PM 320K	Antenna Horn	Sivers	LR 1717	N/A	
7.	DBF-520-20	Antenna Horn	Systron-Donner corp	LR 102	N/A	
8.	638	Antenna Horn	NARDA	LR 1480	N/A	
9.	637	Antenna Horn	NARDA	LR 099	N/A	
10.	ARJB1	Bi-log Hybrid Antenna	Sunol	LR 1734	2018.05	2020.05
11.	4768-10	Attenuator	Narda	LR 1356	Cal b4 use	
12.	6HC3000/18000	Highpass Filter	Trilithic	LR 1614	Cal b4 use	
13.	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2020.07	2021.07
14.	310N	Pre-amplifier	Sonoma	LR 1686	2020.07	2021.07
15.	Model 45	Multimeter	Fluke	LT 5218	2018.11	2020.11
16.		AC power source	Agilent			
17.	ENV216	AMN	Rohde & Schwarz	LR 1665	2019.11	2021.11
18.	EMI receiver	ESCI	Rohde & Schwarz	N4259	2019.10	2021.10

The software listed below has been used for one or more tests.

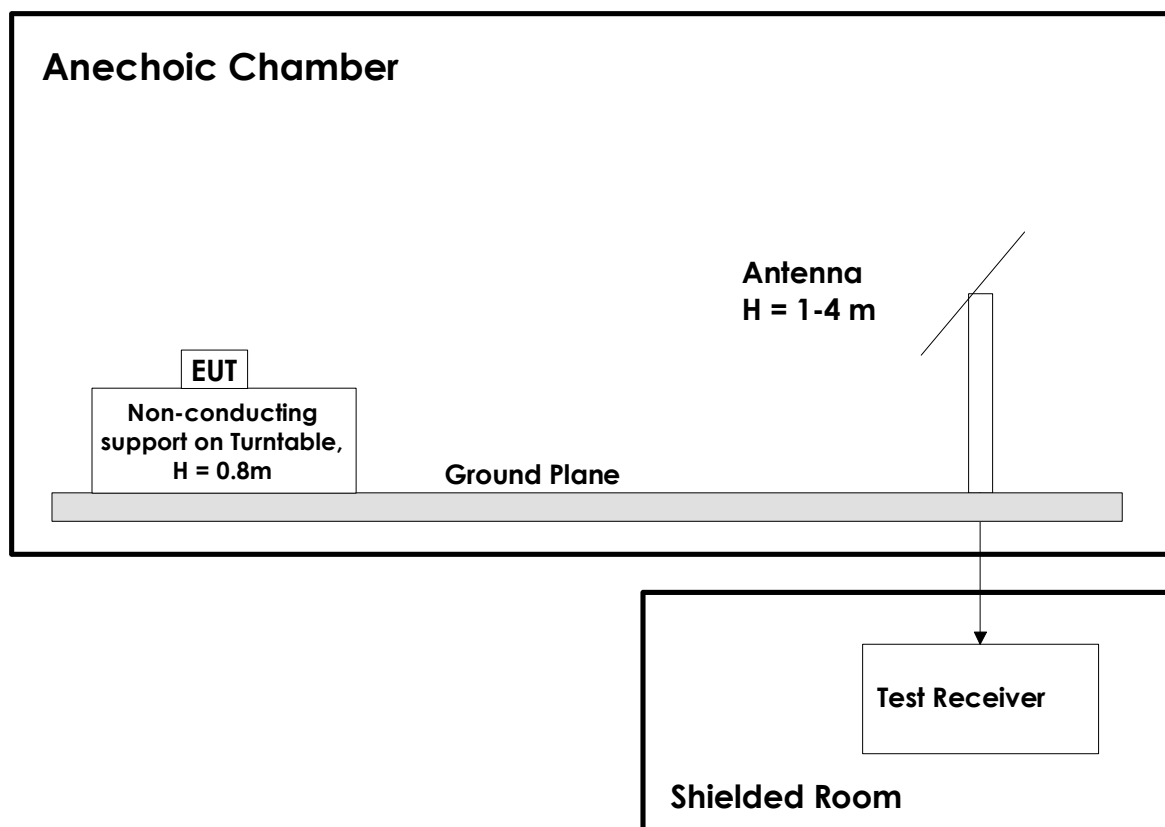
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	GPIBSHOT	2.7	Screenshots from R&S Spectrum Analyzers
2	Rohde & Schwarz	RScommander	1.9.2 64bit	Versatile Software Tool for R&S Instruments
3	Rohde & Schwarz	EMC 32	10.50.40	Radiated Emission test software

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



This test setup is used for all radiated emissions tests. For frequencies below 30 MHz the measuring distance is 10m, for all other frequencies it is 3m or 1m. Emissions above 1 GHz are measured with a Spectrum Analyzer and Horn Antenna. For measurements above 18 GHz the test receiver is moved inside the anechoic chamber and located next to the antenna to minimize the cable loss. All measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers. A pre-amplifier is used for all measurements above 30 MHz, and High-Pass or Band-Pass filter is used for all harmonics.