

Test Report

Product	Bluetooth Low Energy Transceiver				
Name and address of the applicant	LEGO System A/S Aastvej 1, 7190 Billund, Denmark				
Name and address of the manufacturer	LEGO System A/S Aastvej 1, 7190 Billund, Denmark				
Model	Hub No. 2				
Rating	9.0Vdc (Primary Batteries)				
Trademark	LEGO				
Serial number	Radiated sample: F2-076 Conducted sample: F2-036				
Additional information	The tested device is a Toy which controls dedicated motors.				
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	368147				
Tested in period	2019.02.11				
Issue date	2019.05.02				
Name and address of the testing laboratory	 Instituttveien 6 Kjeller, Norway	CAB Number: FCC: NO0001 ISED: NO0470 TEL: +47 22 96 03 30 FAX: +47 22 96 05 50	  An accredited technical test executed under the Norwegian accreditation scheme		
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; text-align: center; vertical-align: bottom;">  Prepared by [G.Suhanthakumar] </td> <td style="width: 50%; text-align: center; vertical-align: bottom;">  Approved by [Frode Sveinsen] </td> </tr> </table>				 Prepared by [G.Suhanthakumar]	 Approved by [Frode Sveinsen]
 Prepared by [G.Suhanthakumar]	 Approved by [Frode Sveinsen]				
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1 INFORMATION

1.1 Test Item

Name	LEGO
FCC ID	NPI-22127
ISED ID	3072A-22127
Model/version	Hub No. 2
Serial number	Radiated sample : F2-076 Conducted sample: F2-036
Hardware identity and/or version	EP2i
Software identity and/or version	1.0.00.000
Frequency Band	2400 – 2483.5 MHz
Tunable Bands	None
Number of Channels	40
Operating Modes	TX and RX
Measured BW (99%)	1.05 MHz
Emission classification	F1D
Transmitter spurious, dBµV/m@3m	56.5 (7.32GHz)
Type of Modulation	GFSK
User Frequency Adjustment	None
Conducted Output Power,Max	0.0005 W (-3.0dBm)
Type of Power Supply	9Vdc, 6x AAA type batteries
Antenna Connector	Only integral antenna
Number of Antennas	1
Diversity or Smart Antennas	None
Desktop Charger	N/A

Description of Test Item

The device tested is a toy which controls dedicated motors and remotely control via BLE with remote device such as iOS, Android or similar.

1.2 Normal test condition

Temperature: 20 - 24 °C
Relative humidity: 20 - 50 %
Normal test voltage: 9Vdc

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: N/A

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.

All ports were populated during spurious emission measurements.

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 Industry 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 ²
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	N/A ¹
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(d)	5.2 (2) (RSS-247)	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	Complies
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	Complies

¹ The tested equipment only operates with battery.

² Integral antenna.

3 TEST RESULTS

3.1 Number of Frequencies

FCC Part 15.31 (m)

RSS-Gen Issue 5, clause 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 Issue 5, Clause 6.7

Test Results: /

Measurement Data:

Channel Frequency (MHz)	Measured 99% BW (MHz)
2402	1.05
2440	1.04
2480	1.05

See attached plots.

Requirements:

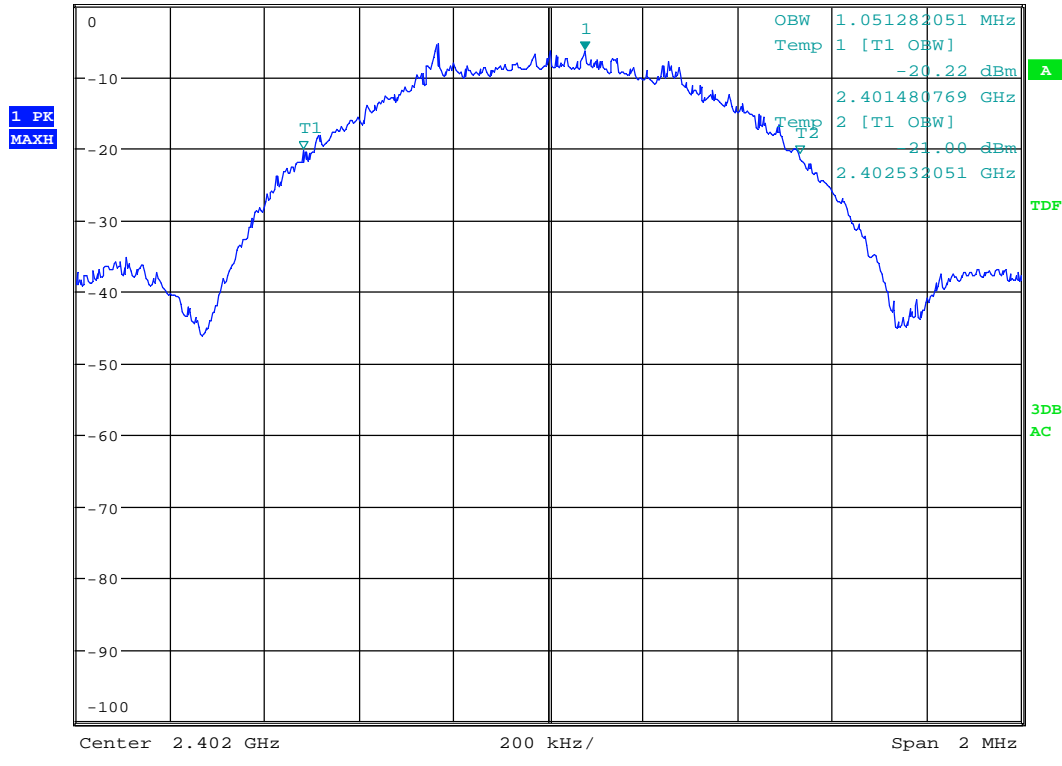
Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels. No requirements for bandwidth for this frequency band.

No requirements for Digital Transmission Systems.

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



MARKER 1
 2.402076923 GHz
 Ref 0 dBm * Att 15 dB * RBW 30 kHz VBW 100 kHz SWT 10 ms
 Marker 1 [T1] -6.50 dBm
 2.402076923 GHz



Date: 11.FEB.2019 16:18:04

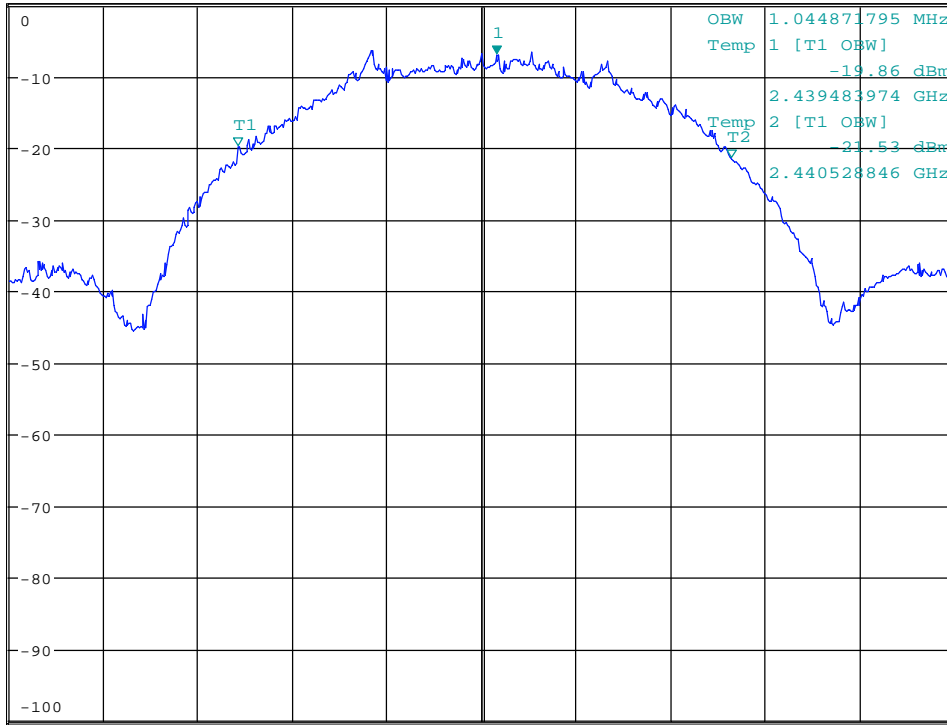
99% Bandwidth , ch2402MHz



MARKER 1
 2.440032051 GHz

*RBW 30 kHz
 VBW 100 kHz
 SWT 10 ms
 Marker 1 [T1]
 -7.12 dBm
 2.440032051 GHz

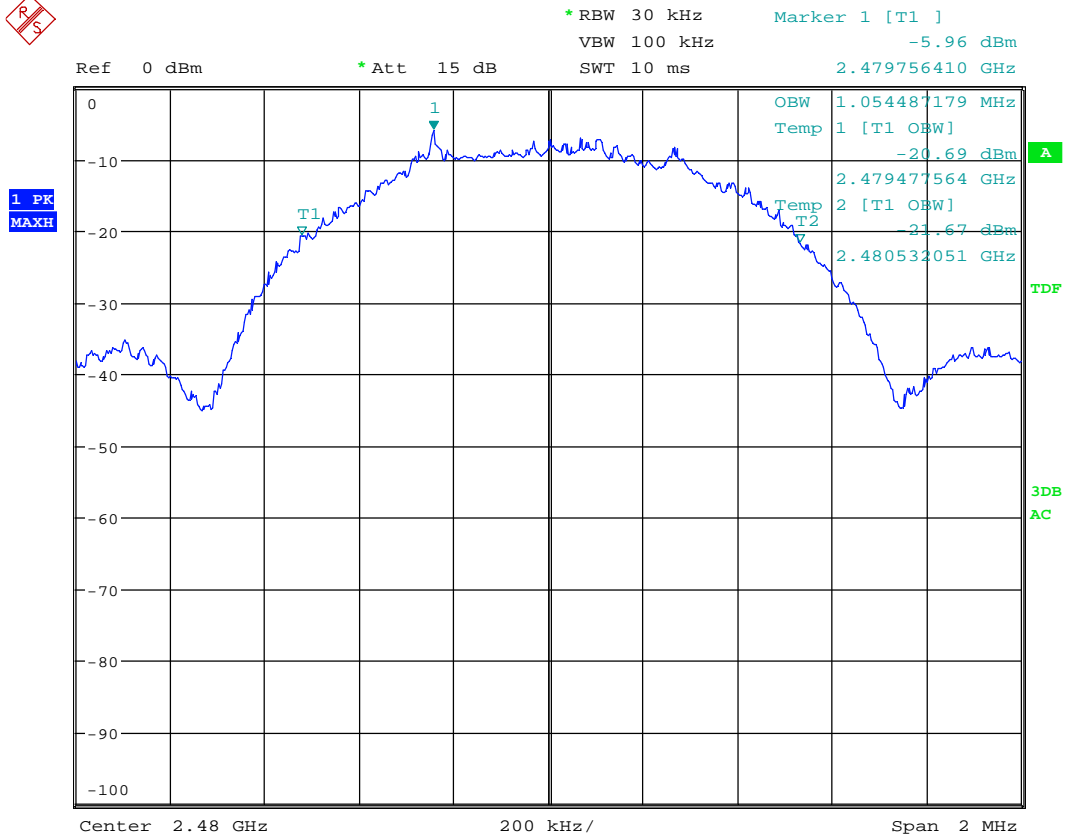
1 PK
 MAXH



Center 2.44 GHz 200 kHz/ Span 2 MHz

Date: 11.FEB.2019 16:18:25

99% Bandwidth , ch2440MHz



Date: 11.FEB.2019 16:17:33

99% Bandwidth , ch2480MHz

3.3 Minimum 6 dB Bandwidth

FCC Part 15.247 (a)(2)

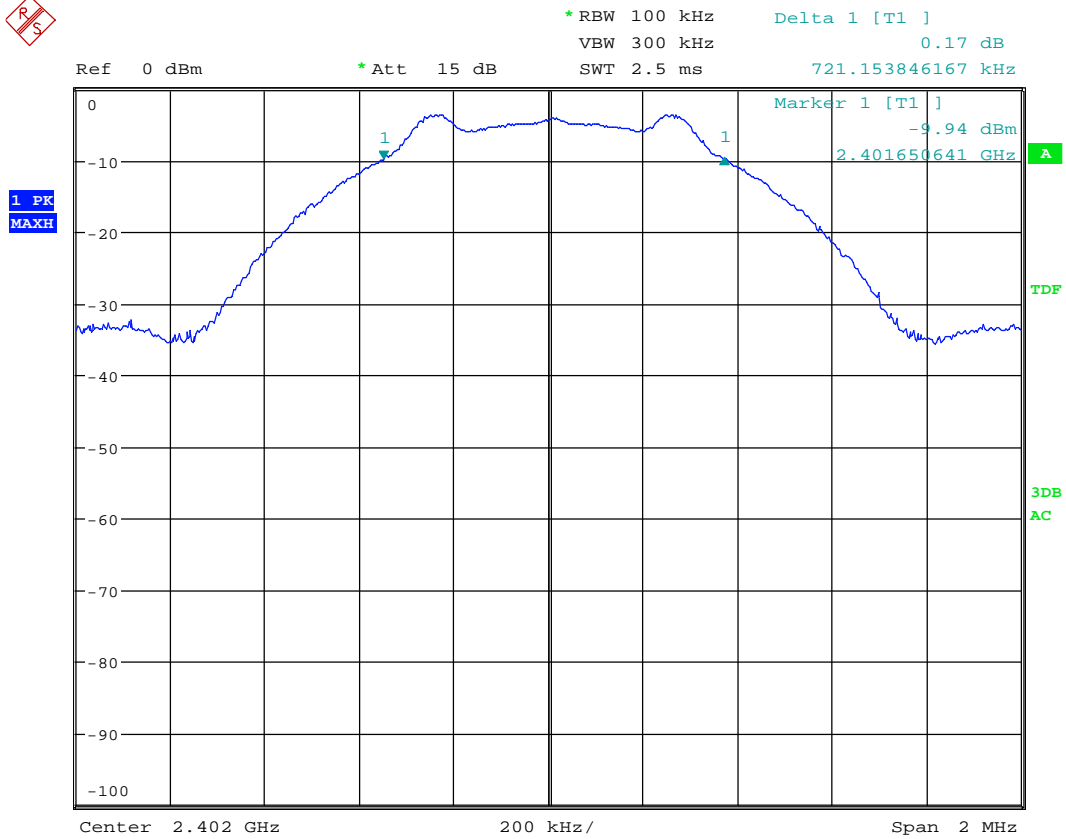
Test Results: Complies

Measurement Data:

Channel Frequency (MHz)	Measured 6 dB BW (kHz)
2402	721.15
2440	778.85
2480	733.97

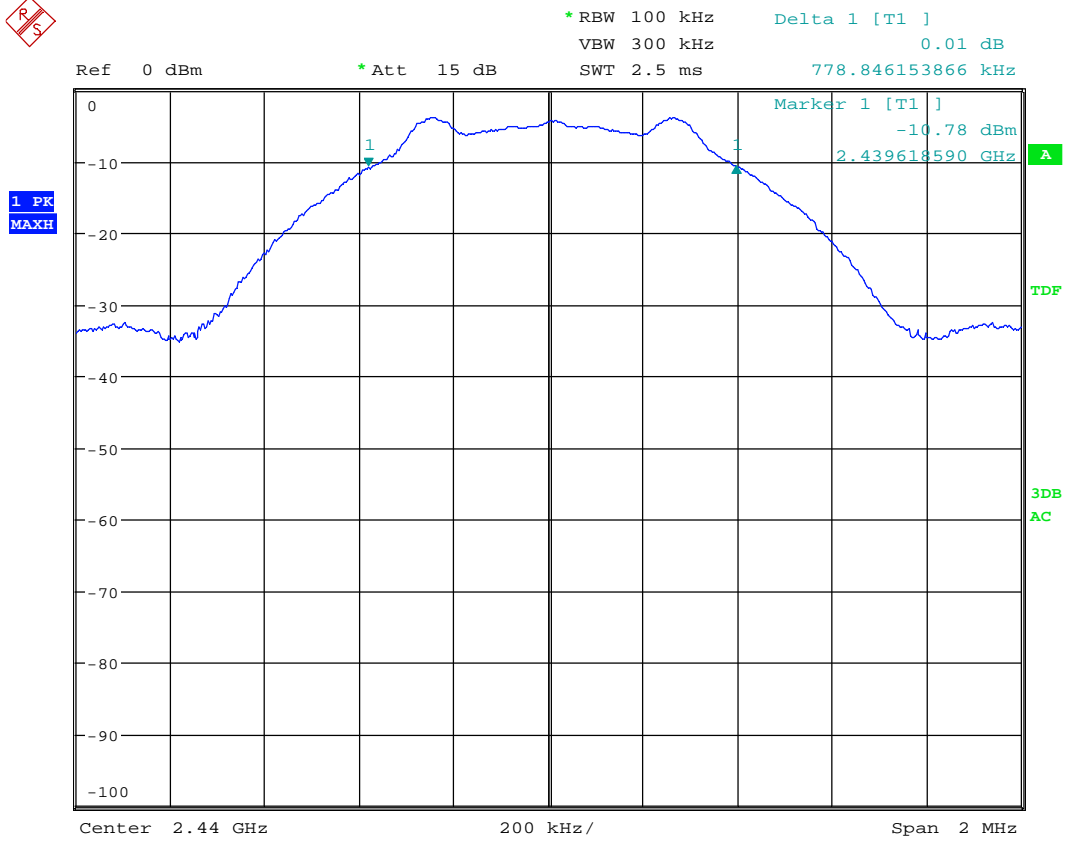
Requirements:

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.



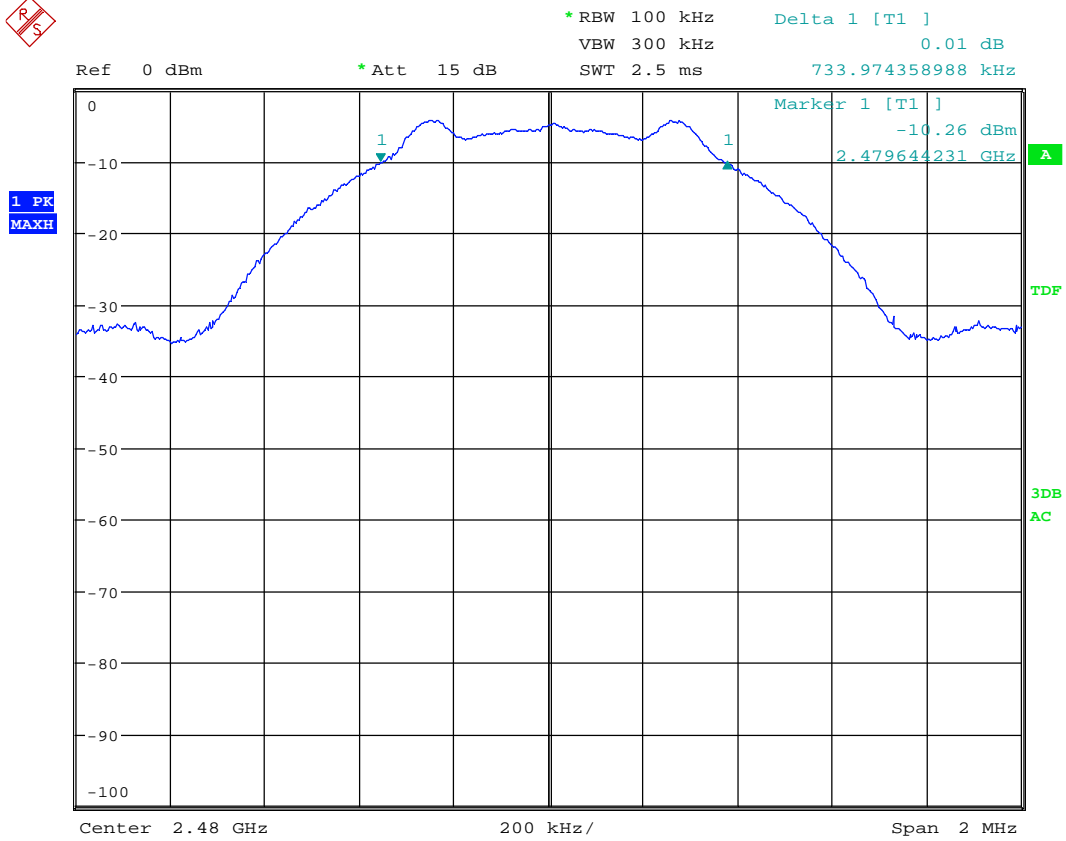
Date: 11.FEB.2019 16:21:15

6 dB Bandwidth, ch2402MHz



Date: 11.FEB.2019 16:19:47

6 dB Bandwidth, ch2440MHz



Date: 11.FEB.2019 16:20:28

6 dB Bandwidth, ch2480MHz

3.4 Peak Power Output

FCC part 15.247 (b)

Test Results: Complies

Measurement Data:

	2402 MHz	2440 MHz	2480 MHz
Conducted Power (dBm)	-3.0	-3.3	-3.7
Conducted Power (mWatts)	0.5	0.47	0.43
Field Strength (dBµV/m), HP	94.5	93.7	92.1
EIRP, Calculated (mWatts)	0.85	0.70	0.49
Antenna gain (dBi)	2.3	1.8	0.6

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.

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

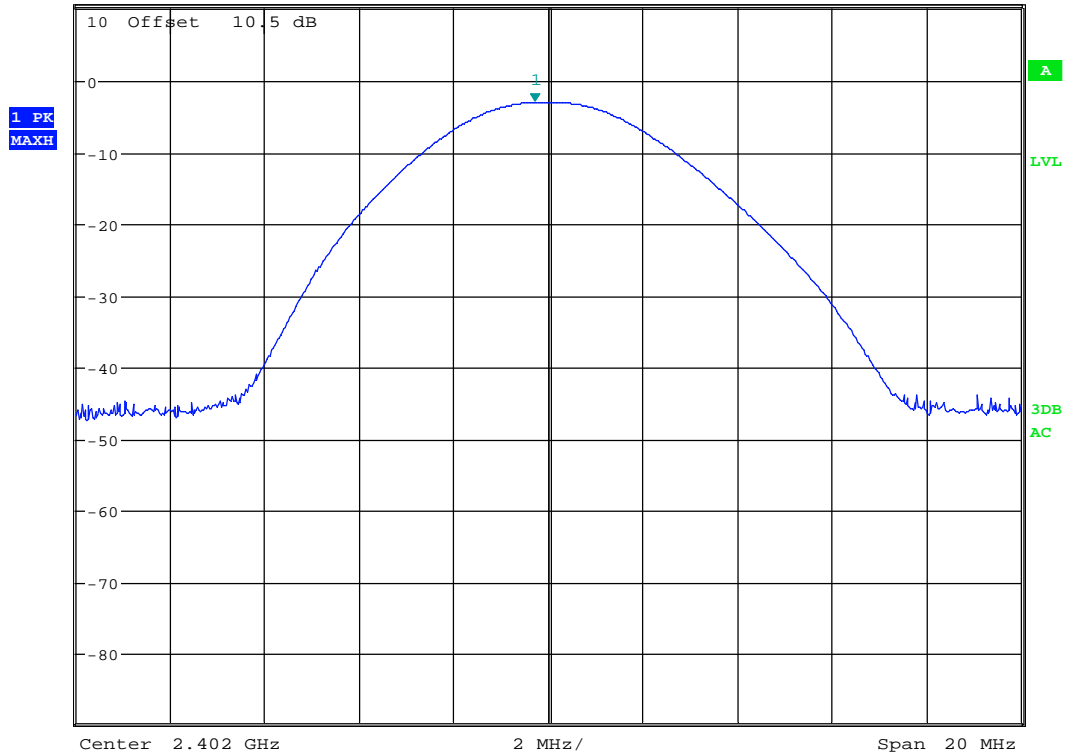
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

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.



MARKER 1		*RBW 3 MHz	Marker 1 [T1]
2.401711538 GHz		VBW 10 MHz	-3.03 dBm
Ref 10.5 dBm	*Att 15 dB	SWT 2.5 ms	2.401711538 GHz



Date: 11.FEB.2019 16:21:58

Conducted Power , Ch2402MHz

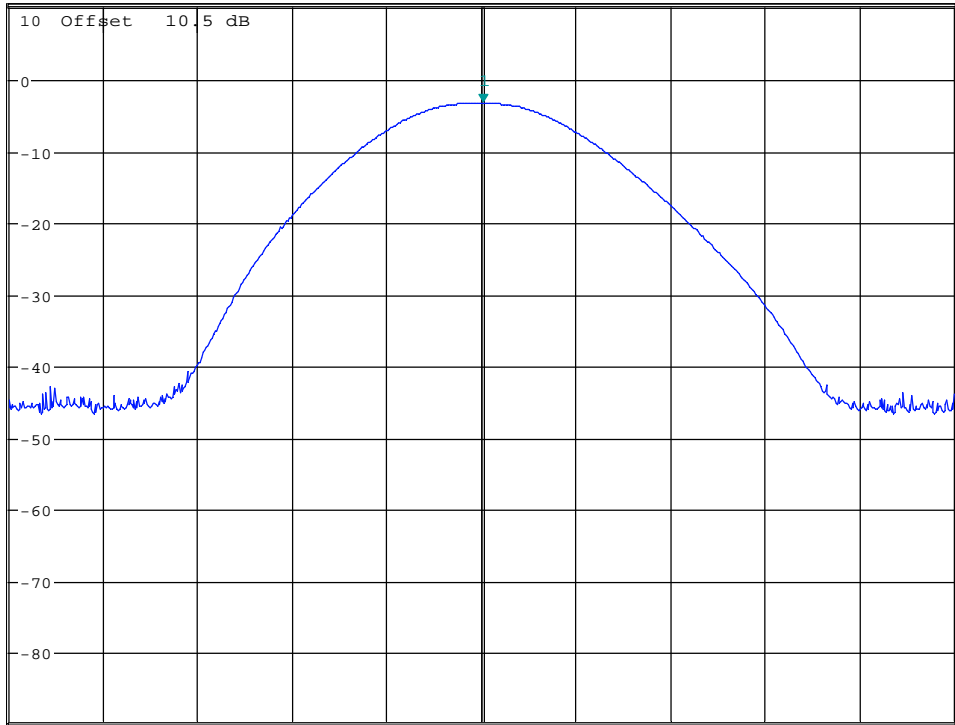


MARKER 1
 2.440032051 GHz

*RBW 3 MHz Marker 1 [T1]
 VBW 10 MHz -3.29 dBm
 SWT 2.5 ms 2.440032051 GHz

Ref 10.5 dBm *Att 15 dB

1 PK
 MAXH



Center 2.44 GHz 2 MHz/ Span 20 MHz

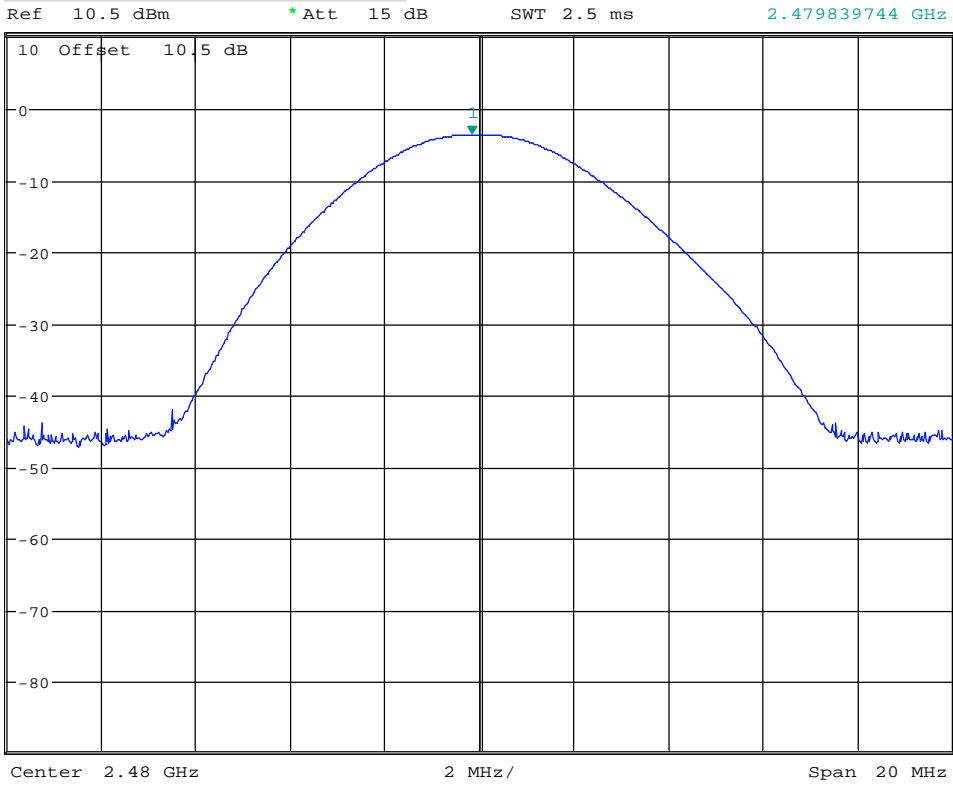
Date: 11.FEB.2019 16:23:01

Conducted Power , Ch2440MHz



MARKER 1
2.479839744 GHz

*RBW 3 MHz Marker 1 [T1]
VBW 10 MHz -3.68 dBm
SWT 2.5 ms 2.479839744 GHz



Date: 11.FEB.2019 16:23:22

Conducted Power, Ch2480MHz

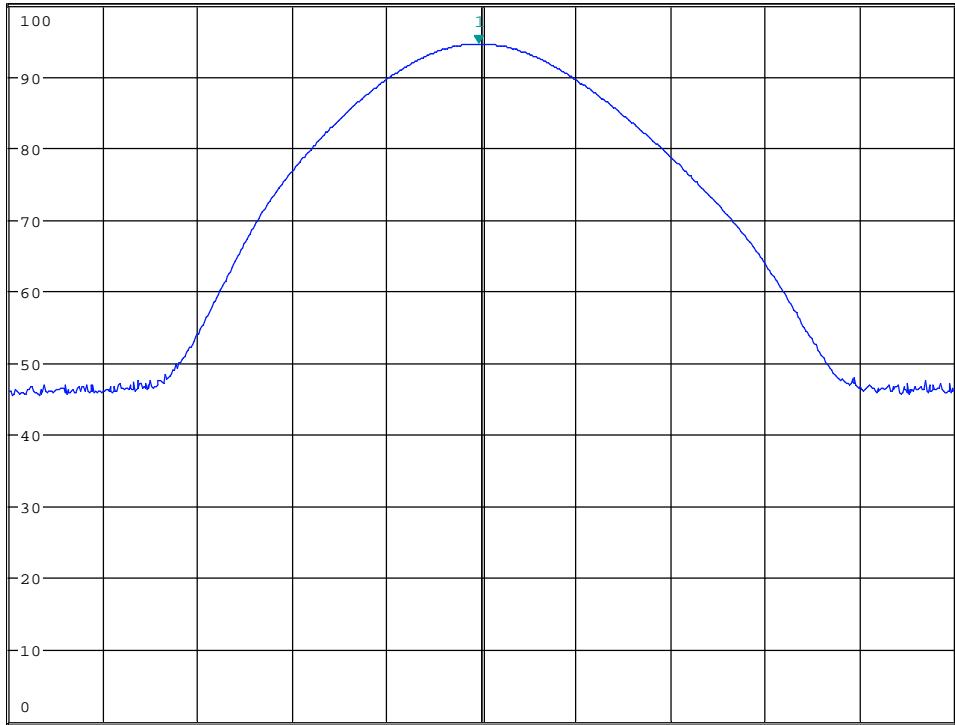


MARKER 1
2.401935897 GHz

*RBW 3 MHz
VBW 10 MHz
SWT 2.5 ms
Marker 1 [T1]
94.52 dBμV/m
2.401935897 GHz

Ref 100 dBμV/m *Att 10 dB

1 PK
MAXH



Center 2.402 GHz 2 MHz/ Span 20 MHz

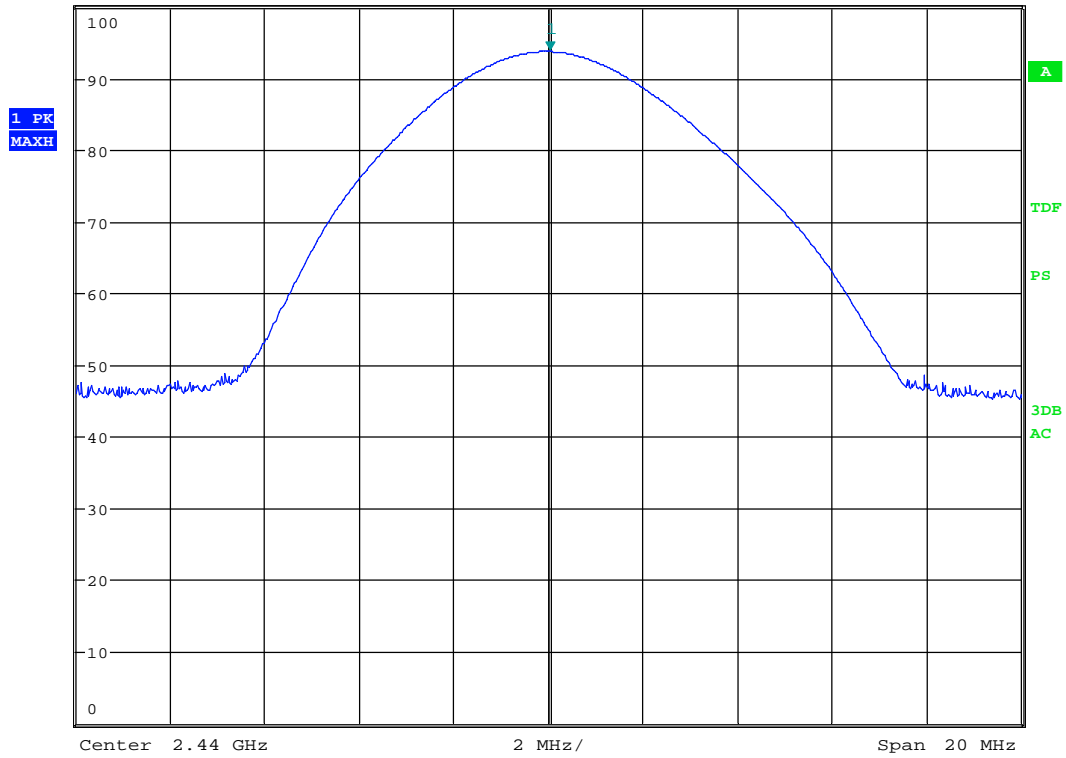
Date: 11.FEB.2019 11:58:01

Radiated Fieldstrength , HP, ch2402MHz



*RBW 3 MHz Marker 1 [T1]
VBW 10 MHz 93.71 dBμV/m
SWT 2.5 ms 2.440032051 GHz

Ref 100 dBμV/m *Att 10 dB



Date: 11.FEB.2019 12:18:35

Radiated Fieldstrength , HP, ch2440MHz

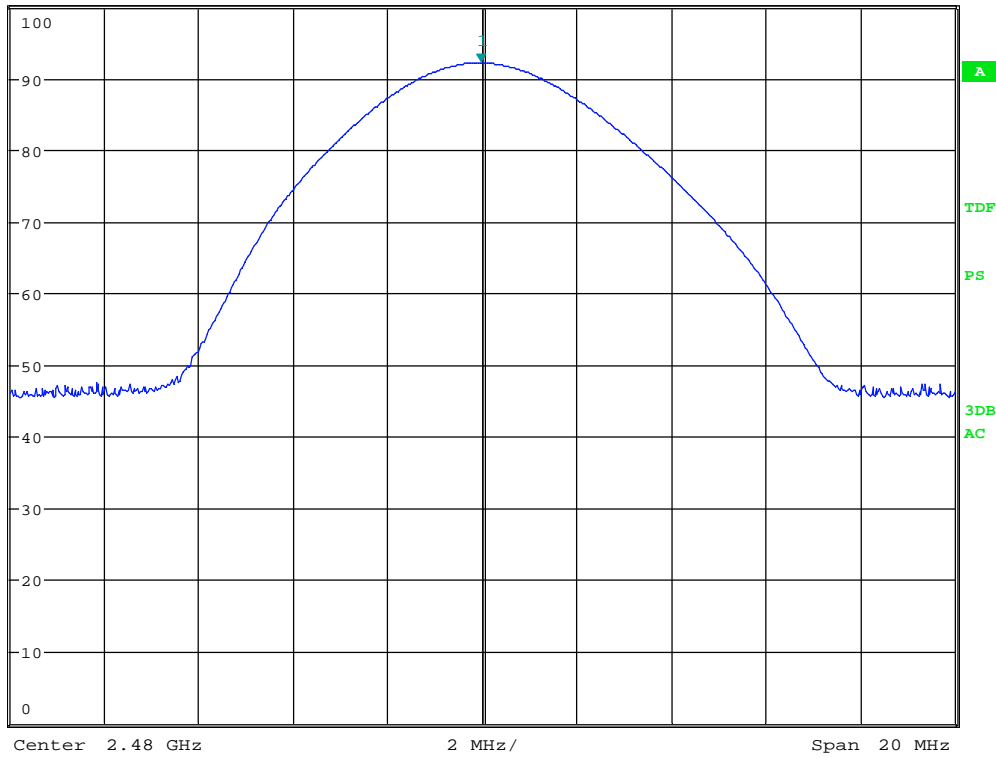


MARKER 1
 2.479967949 GHz

*RBW 3 MHz Marker 1 [T1]
 VBW 10 MHz 92.14 dBμV/m
 SWT 2.5 ms 2.479967949 GHz

Ref 100 dBμV/m *Att 10 dB

1 PK
 MAXH



Date: 11.FEB.2019 12:22:08

Radiated Fieldstrength , HP, ch2480MHz

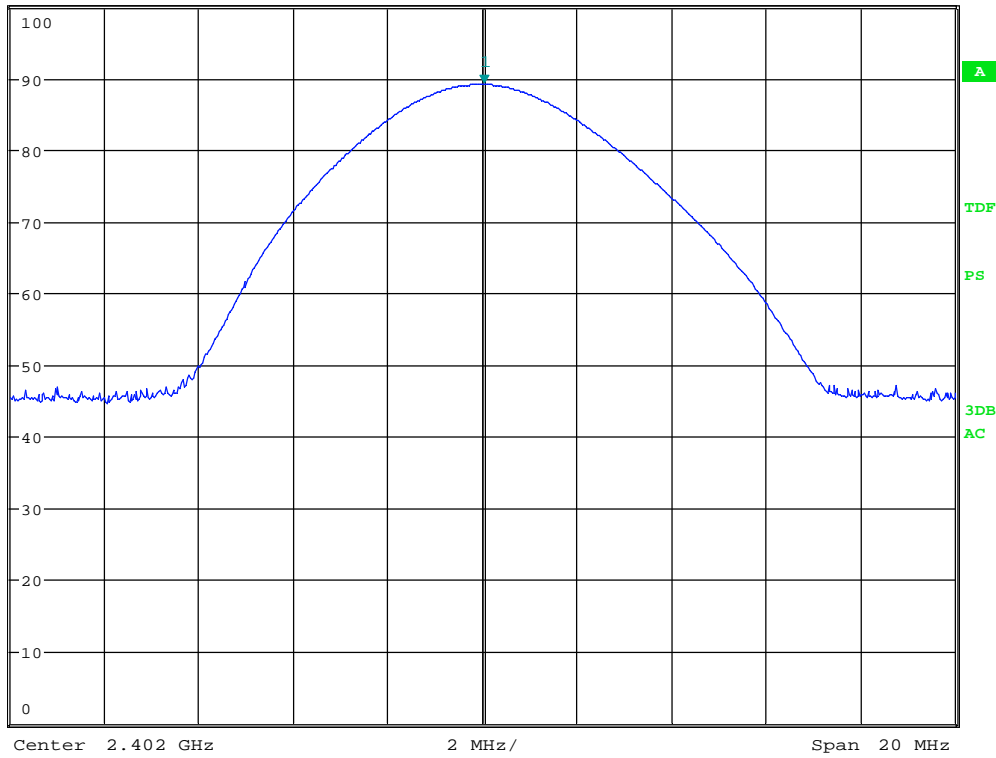


MARKER 1
 2.402032051 GHz

*RBW 3 MHz Marker 1 [T1]
 VBW 10 MHz 89.15 dBμV/m
 SWT 2.5 ms 2.402032051 GHz

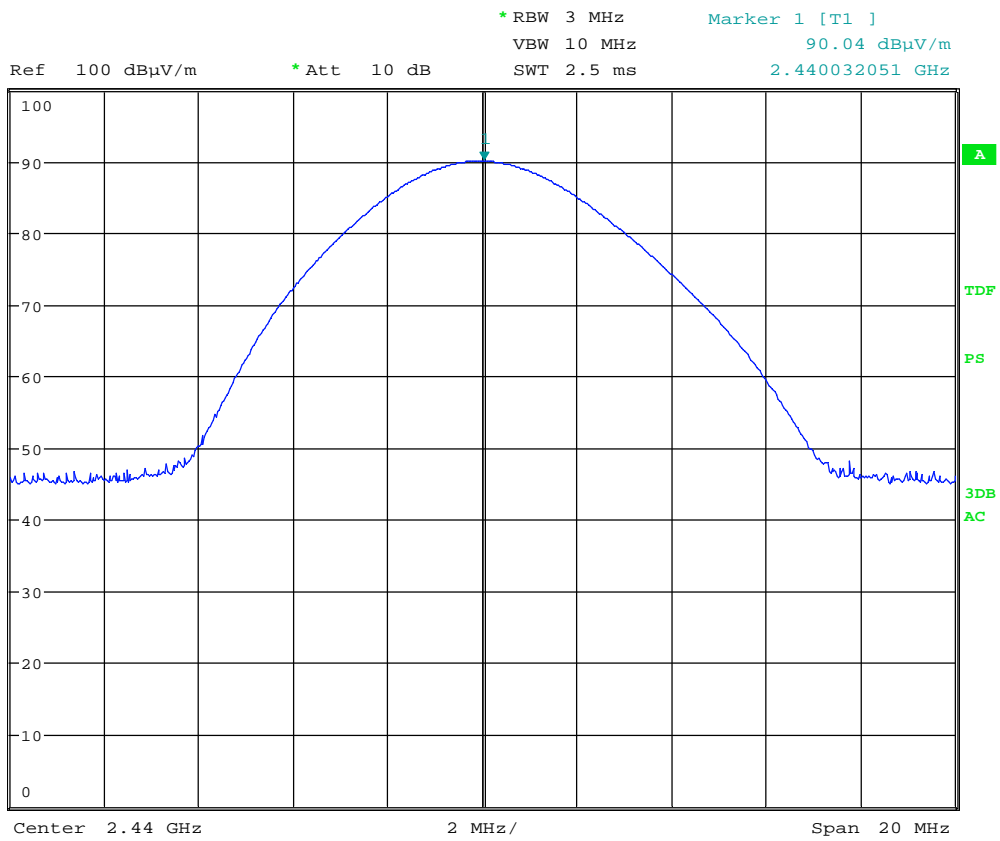
Ref 100 dBμV/m *Att 10 dB

1 PK
 MAXH



Date: 11.FEB.2019 12:02:27

Radiated Fieldstrength , VP, ch2402MHz

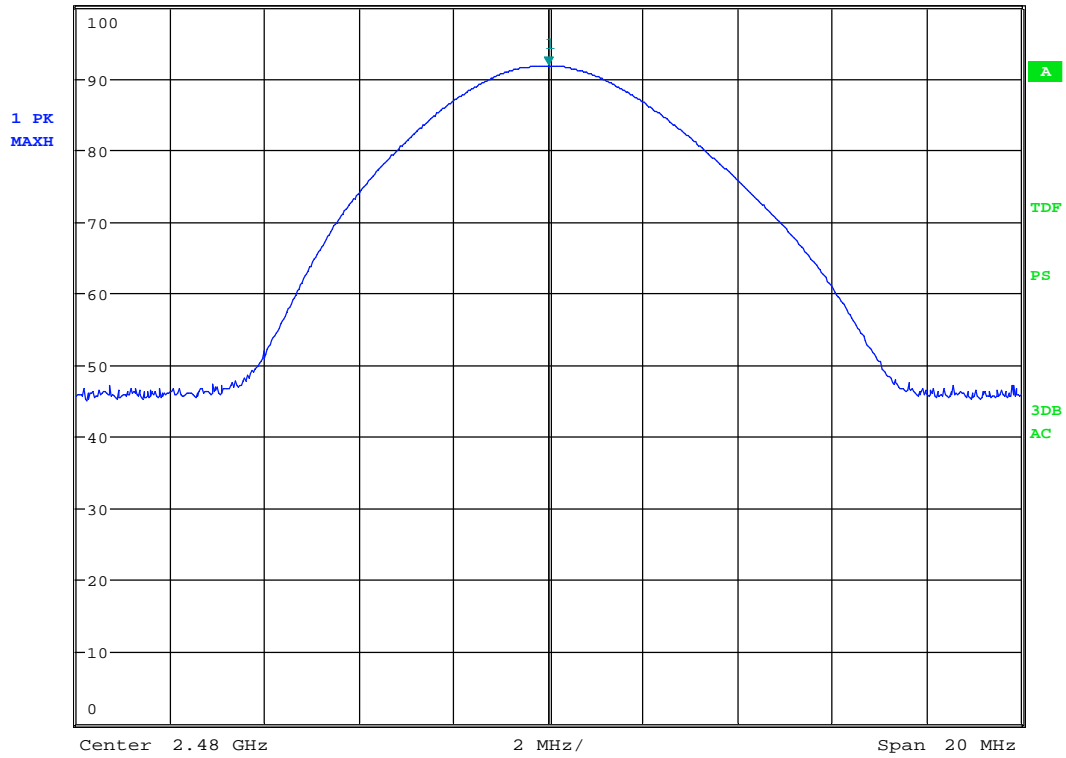


Date: 11.FEB.2019 12:17:11

Radiated Fieldstrength , VP, ch2440MHz



MARKER 1		* RBW 3 MHz	Marker 1 [T1]
2.48 GHz		VBW 10 MHz	91.79 dBμV/m
Ref 100 dBμV/m	* Att 10 dB	SWT 2.5 ms	2.480000000 GHz



Date: 11.FEB.2019 12:32:51

Radiated Fieldstrength , VP, ch2480MHz

3.5 Conducted Emissions at Antenna Connector

Para. No.: 15.247 (d)

Carrier Frequency	Highest Value (dBc)	Margin (dB)	Verdict
2402 MHz	27.4	7.4	Pass
2440 MHz	29.2	9.2	Pass
2480 MHz	32.2	12.2	Pass

Measured with Peak Detector

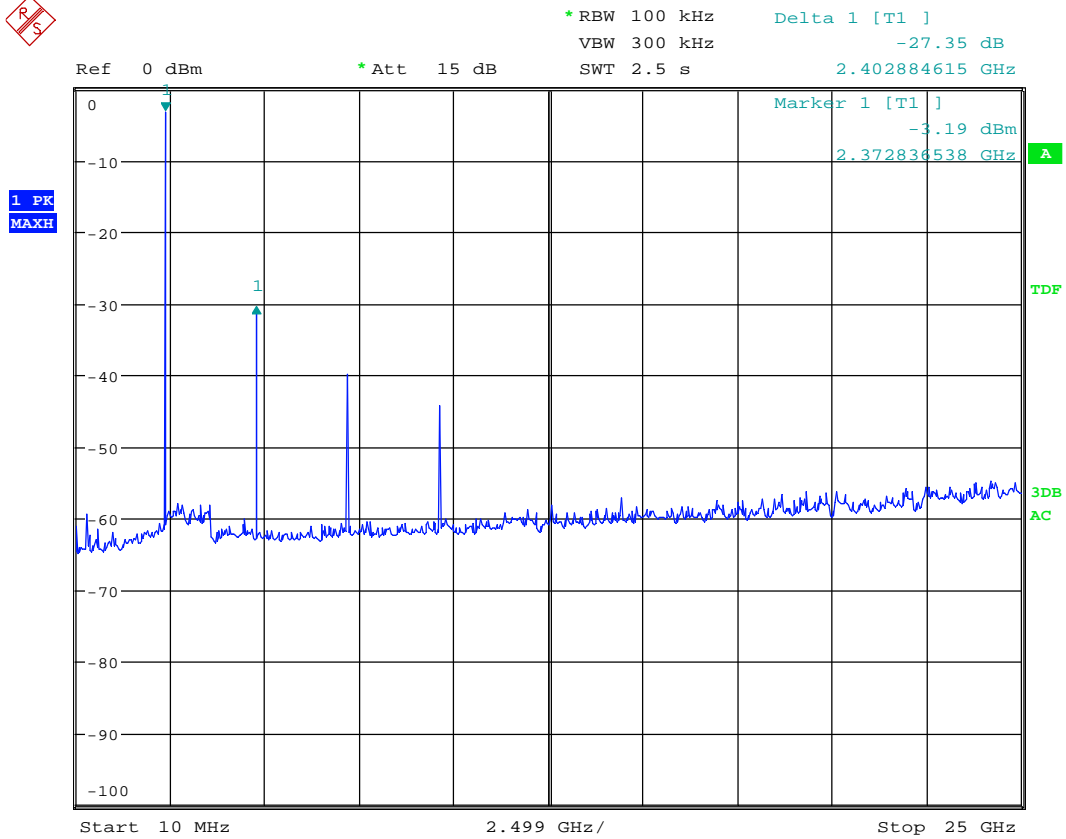
RF conducted power to 25 GHz: see attached plots.

Limit

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

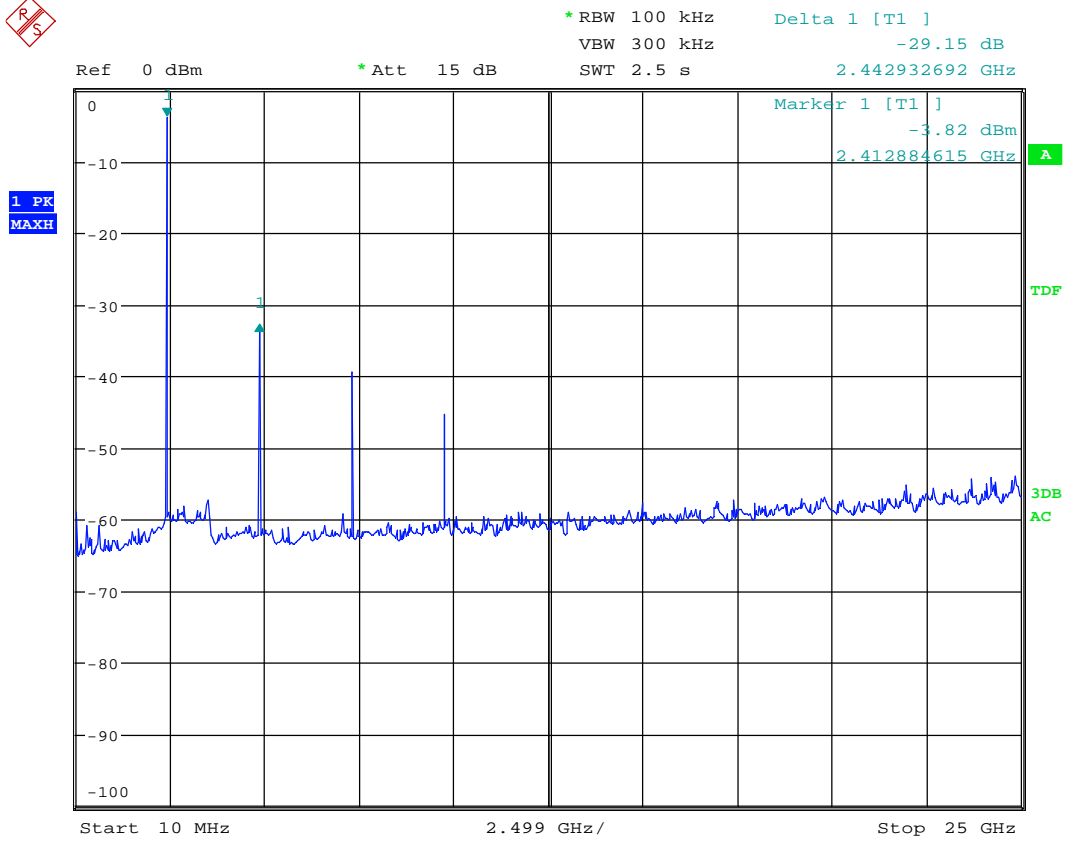
Detector type shall be the same as used for measuring Output Power.

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



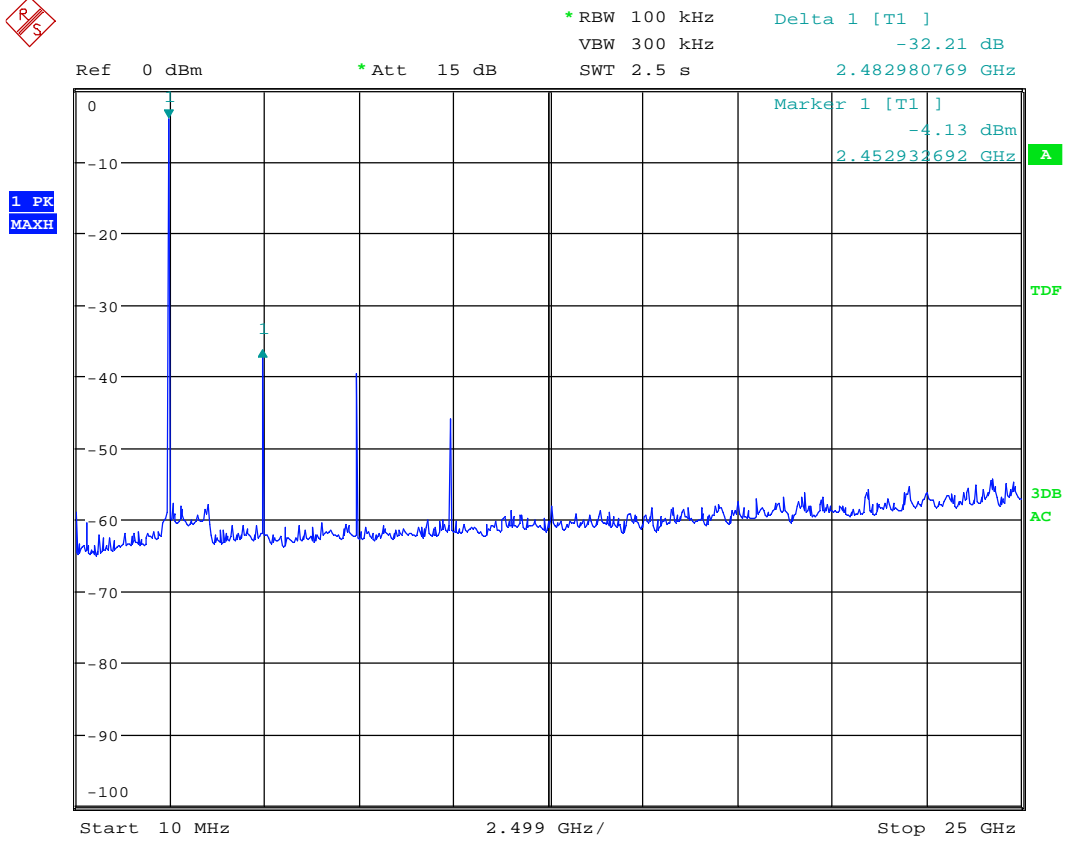
Date: 11.FEB.2019 16:11:32

Conducted spurious emissions, 10MHz - 25GHz, ch2402MHz



Date: 11.FEB.2019 16:12:31

Conducted spurious emissions, 10MHz - 25GHz, ch2440MHz



Date: 11.FEB.2019 16:12:59

Conducted spurious emissions, 10MHz - 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

Test Results: Complies

Measurement Data:

Band-Edge

	Measured field strength (dB μ V/m)		Limit	Margin	
	2390 MHz	2483.5 MHz	dB μ V/m	dB	
Peak Detector	40.65	51.31	74	33.4	22.7
Average Detector	32.10	47.73	54	21.9	6.3

See attached plots.

Duty Cycle Correction Factor Calculation:

Duty Cycle Correction Factor only for information:

$$\text{Duty Cycle} = \text{On Time} / (\text{Period} * \text{Number of Channels}) = 213 \mu\text{s} / (628 \mu\text{s} * 40) = 0.0085$$

$$\text{Duty Cycle Correction factor} = -20 \times \log(\text{Duty Cycle}) = 41.4 \text{ dB}$$

Maximum allowed Duty Cycle Correction: 20 dB

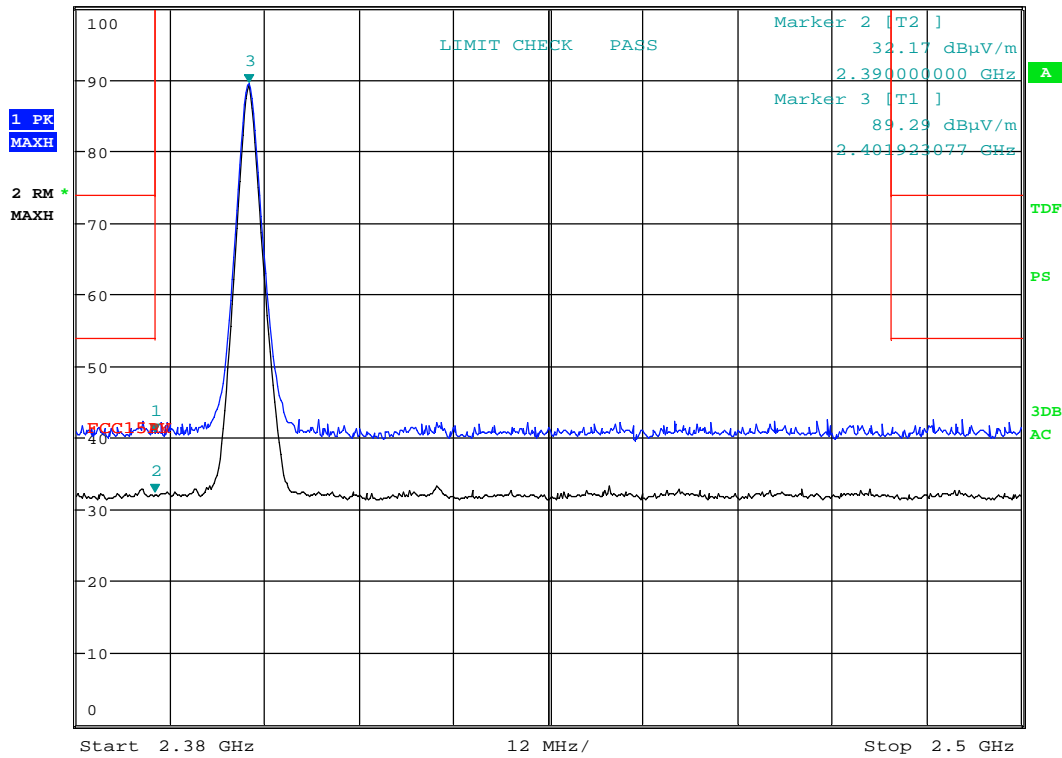
Maximum Duty Cycle Correction Factor according to Para 15.35 (b): 20 dB



MARKER 1
 2.39 GHz
 Ref 100 dB μ V/m * Att 10 dB

*RBW 1 MHz
 VBW 10 MHz
 SWT 2.5 ms

Marker 1 [T1]
 40.65 dB μ V/m
 2.390000000 GHz



Date: 11.FEB.2019 12:14:40

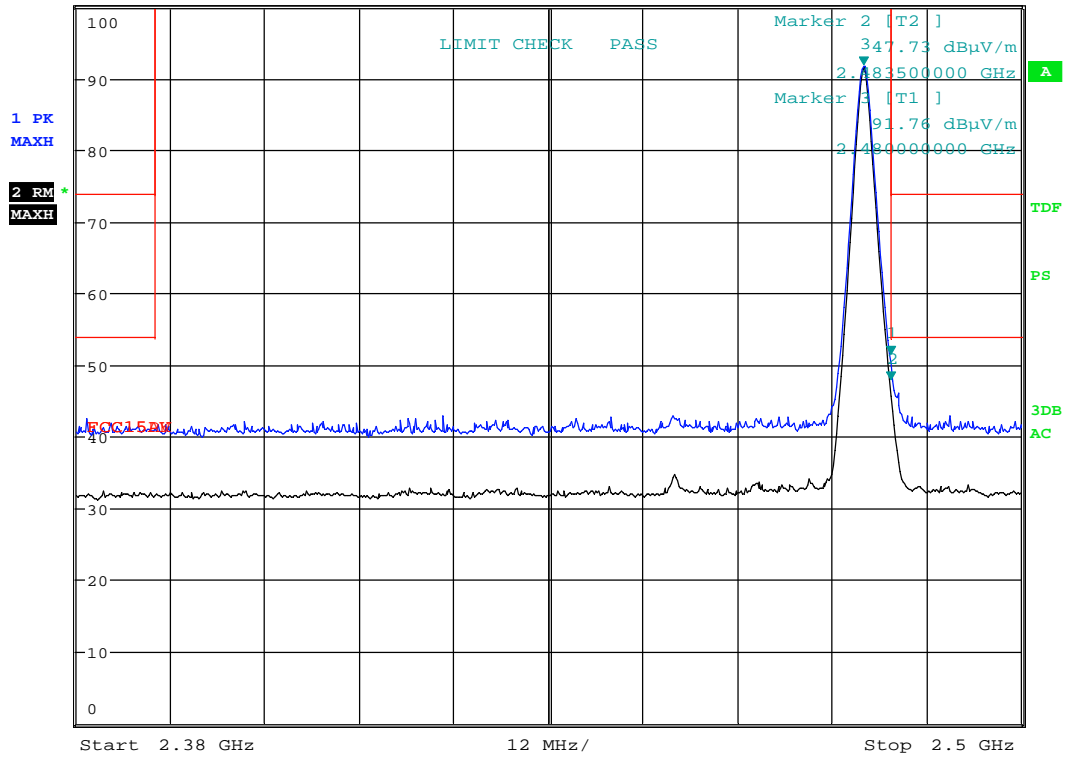
Lower Band Edge , PK and AV , ch2402MHz



MARKER 1
 2.4835 GHz

*RBW 1 MHz
 VBW 10 MHz
 Ref 100 dB μ V/m *Att 10 dB
 SWT 2.5 ms

Marker 1 [T1]
 51.31 dB μ V/m
 2.483500000 GHz



Date: 11.FEB.2019 12:29:49

Upper Band Edge, PK and AV, ch2480MHz

Radiated emissions 10 kHz-30 MHz.

Measuring distance 10 m, Peak detector.

No component detected, see attached graph.

Limit is converted to 10 m using 40 dB/decade according to 15.31 (f) (2).

Radiated emission 30 – 1000 MHz.

Detector: Quasi-Peak

Measuring distance 3 m

Tested in TX mode

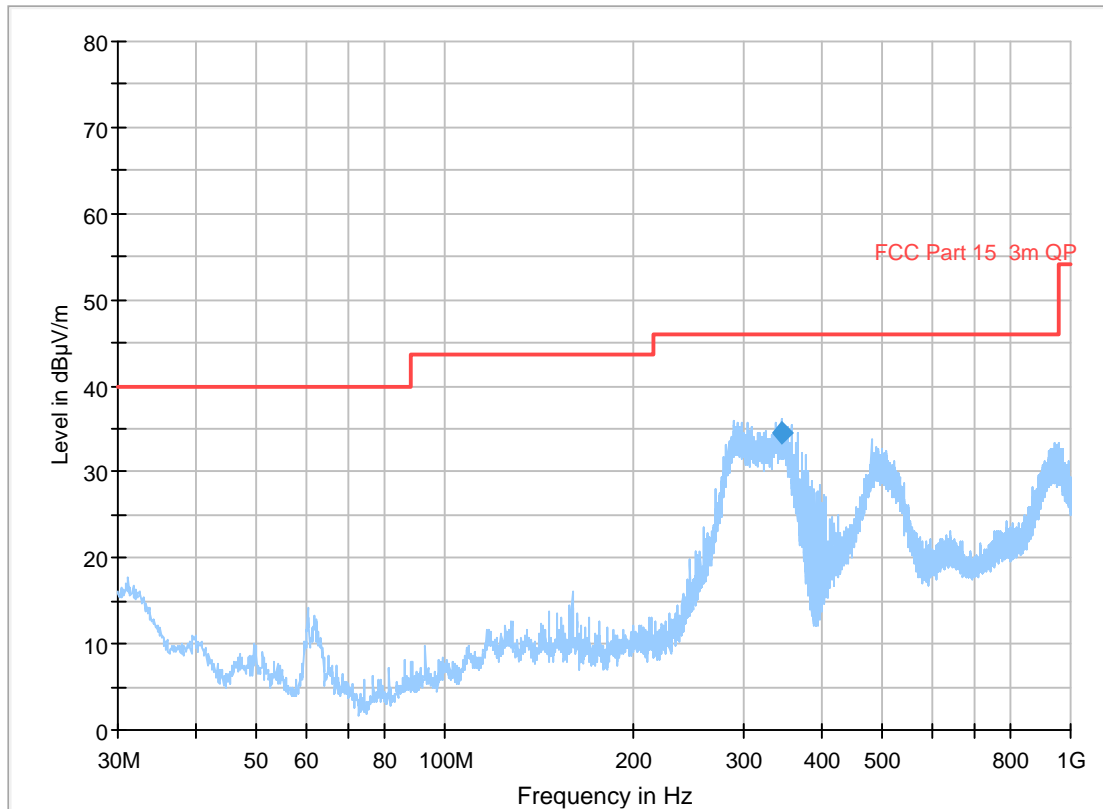
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
346.502300	34.43	46.00	11.57	1000.0	120.000	103.0	H	144.0

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
960 - 1000	500	54.0

Full Spectrum



Radiated Emissions, 1-25 GHz

Measuring distance: 3m (1 – 8 GHz), 1m (8 – 18 GHz)

A pre-scan was performed above 18 GHz and no spurious emissions were detected.

Peak Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
4.80	L	0	49.5	20	74	24.5
4.88	M	0	51.2	20	74	22.8
4.96	H	0	51.6	20	74	22.4
7.2	L	0	52.6	20	74	21.4
7.32	M	0	56.5	20	74	17.5
7.44	H	0	56.0	20	74	18.0
12.39	L,M,H	*	47.7	20	74	>20
Other freqs	L,M,H	0	None detected	20	74	>20

Average Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Average Detector, 3m	Duty cycle corr. factor	Limit	Margin
GHz	L,M,H	dB	dB μ V/m	dB	dB μ V/m	dB
4.80	L	0	43.6	20	54	10.4
4.88	M	0	45.3	20	54	8.7
4.96	H	0	46.7	20	54	7.3
7.2	L	0	45.6	20	54	8.4
7.32	M	0	52.1	20	54	1.9
7.44	H	0	51.6	20	54	2.4
12.39	L,M,H	*	39.3	20	54	>20
Other freqs	L,M,H	/	None detected	20	54	>20

*distance correction is included on the plot.

Duty Cycle Correction Factor only for information:

Duty Cycle = On Time / (Period * Number of Channels) = 213 μ s / (628 μ s * 40) = 0.0085

Duty Cycle Correction factor = -20 x log (Duty Cycle) = 41.4 dB

Maximum allowed Duty Cycle Correction: 20 dB

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

See plots.

Requirements/Limit

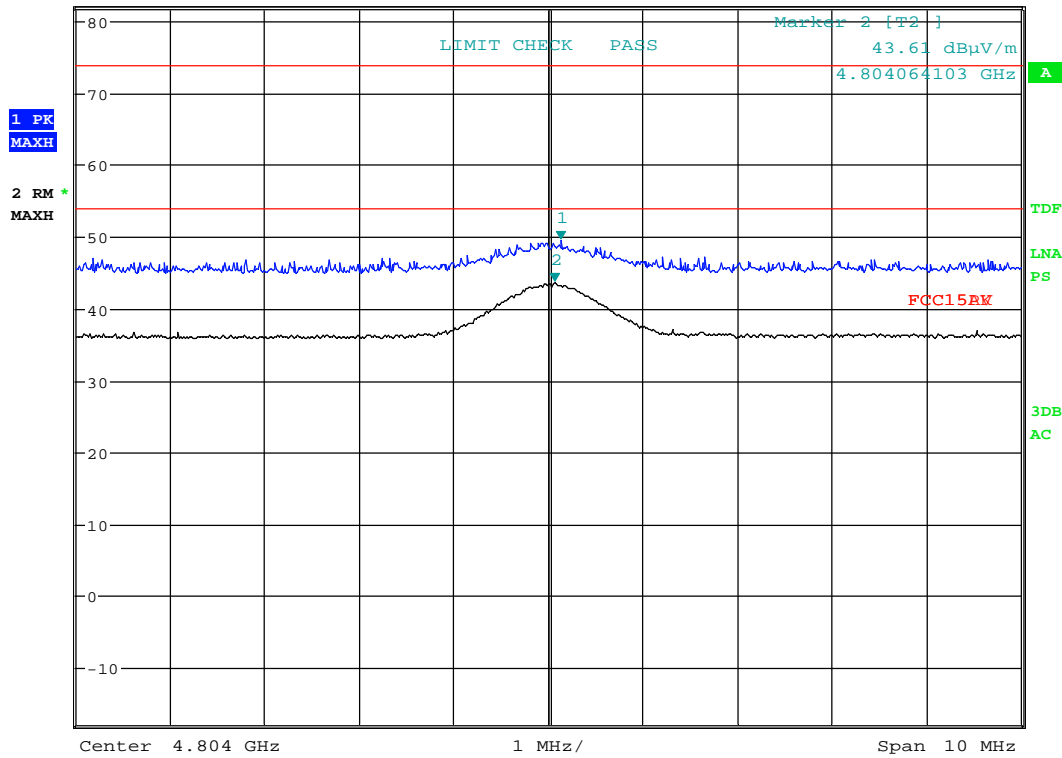
FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	Average Detector	Peak Detector
Above 1 GHz	54.0 dB μ V/m	74.0 dB μ V/m



MARKER 1
 4.804128205 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 20 ms
 Marker 1 [T1]
 49.50 dBµV/m
 4.804128205 GHz

Ref 82 dBµV/m *Att 10 dB



Date: 11.FEB.2019 13:01:00

Radiated spurious emissions,4.08GHz, HP, ch2402MHz



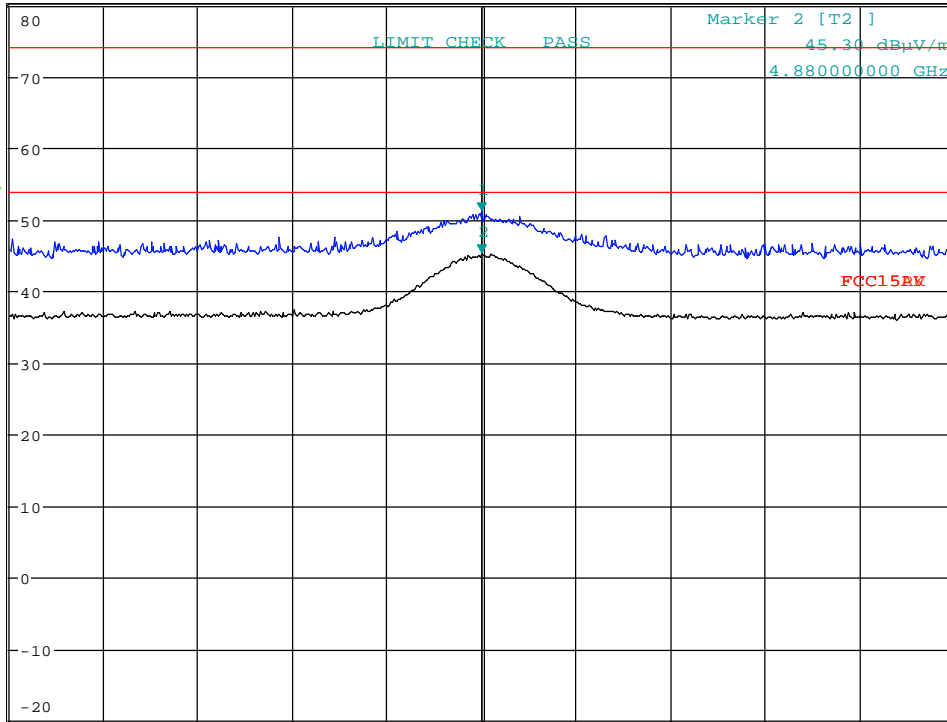
MARKER 1
 4.88 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 20 ms
 Marker 1 [T1]
 51.18 dB μ V/m
 4.880000000 GHz

Ref 80 dB μ V/m *Att 10 dB

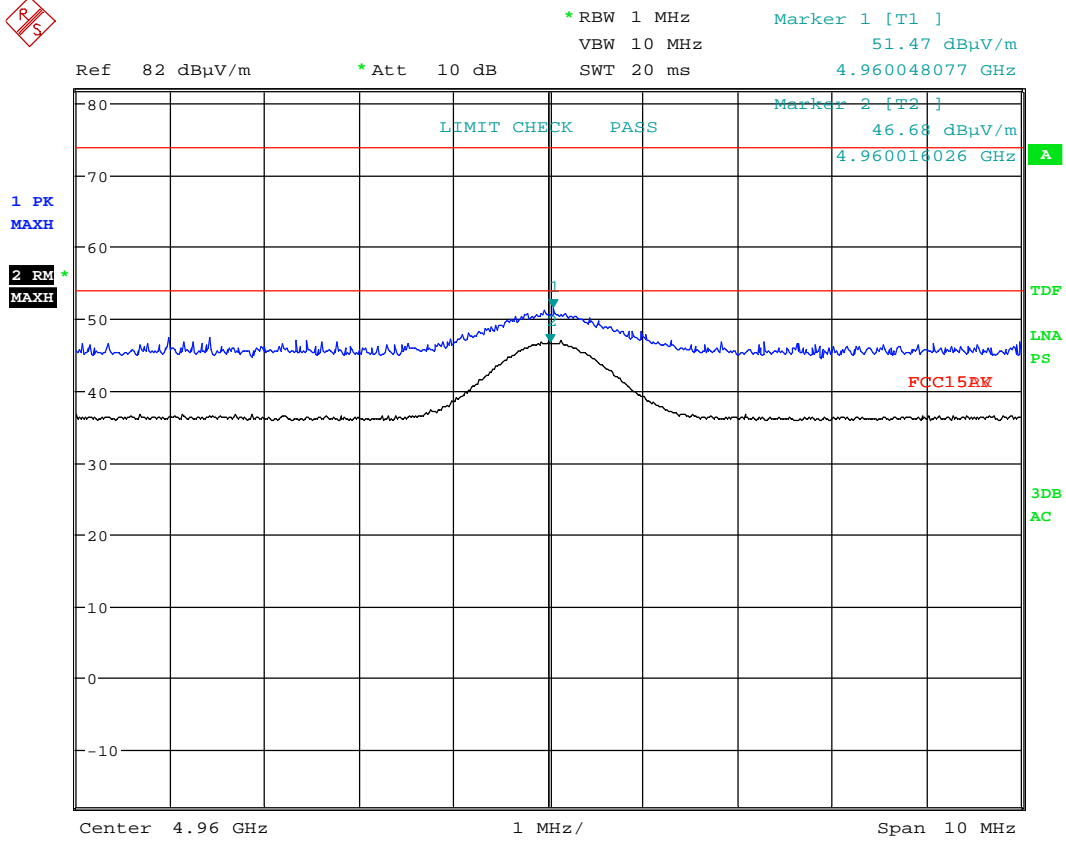
1 PK
 MAXH

2 RM *
 MAXH



Date: 11.FEB.2019 13:53:06

Radiated spurious emissions,4.88GHz, HP, ch2440MHz



Date: 11.FEB.2019 12:47:47

Radiated spurious emissions, 4.96GHz, HP, ch2480MHz



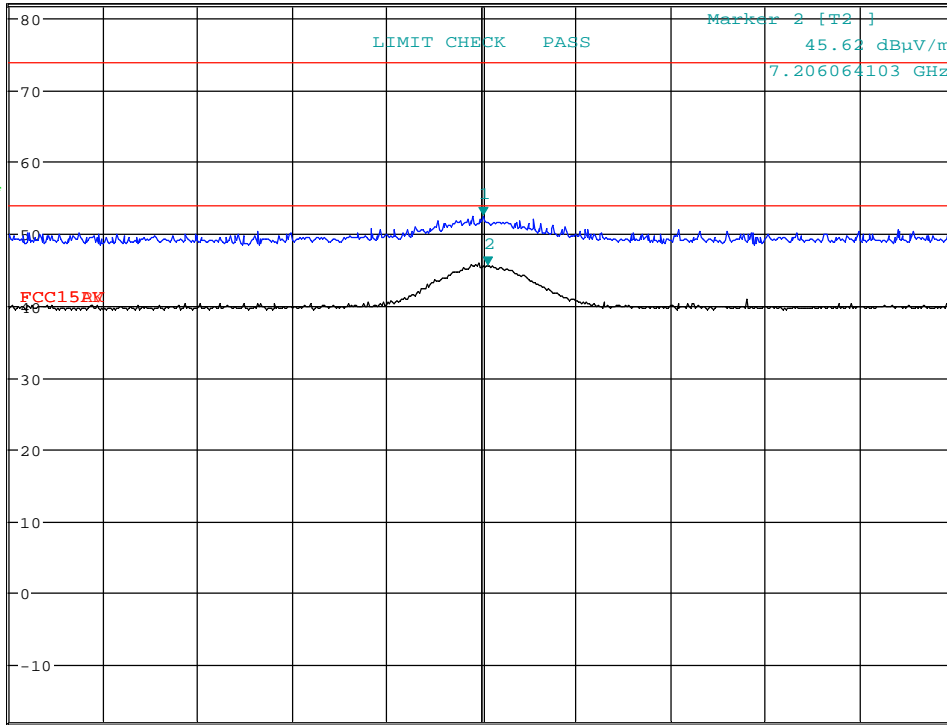
MARKER 1
 7.206016026 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 20 ms
 Marker 1 [T1]
 52.55 dB μ V/m
 7.206016026 GHz

Ref 82 dB μ V/m *Att 10 dB

1 PK
 MAXH

2 RM
 MAXH



Center 7.206 GHz 1 MHz/ Span 10 MHz

Date: 11.FEB.2019 13:04:48

Radiated spurious emissions, 7,206GHz, VP, ch2402MHz



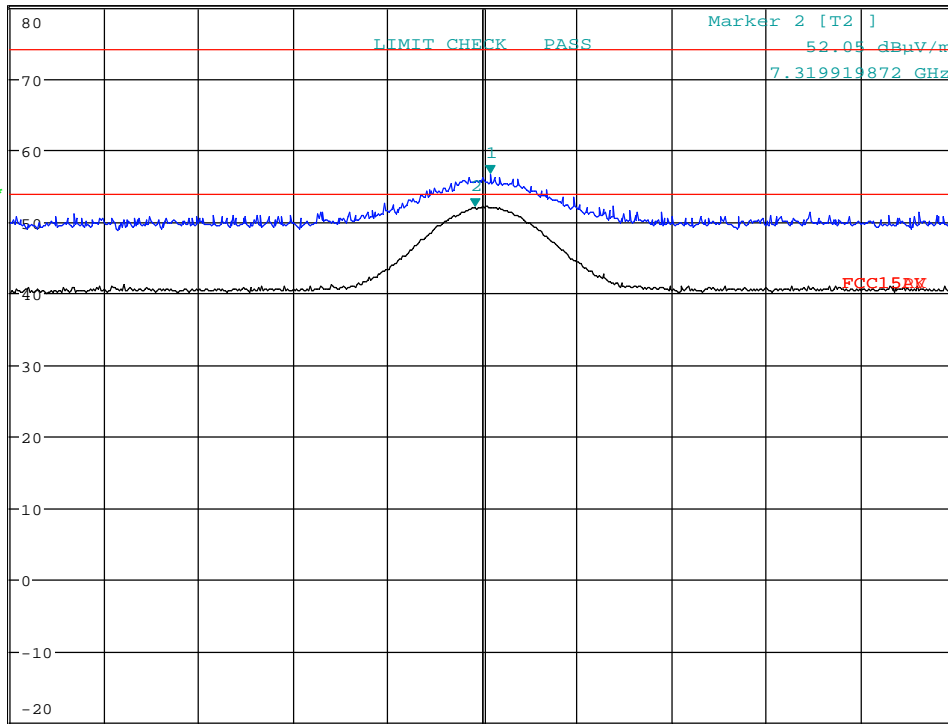
MARKER 1
 7.320080128 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 20 ms
 Marker 1 [T1]
 56.52 dBμV/m
 7.320080128 GHz

Ref 80 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM *
 MAXH



Center 7.32 GHz 1 MHz/ Span 10 MHz

Date: 11.FEB.2019 13:52:09

Radiated spurious emissions, 7,32GHz, HP, ch2440MHz



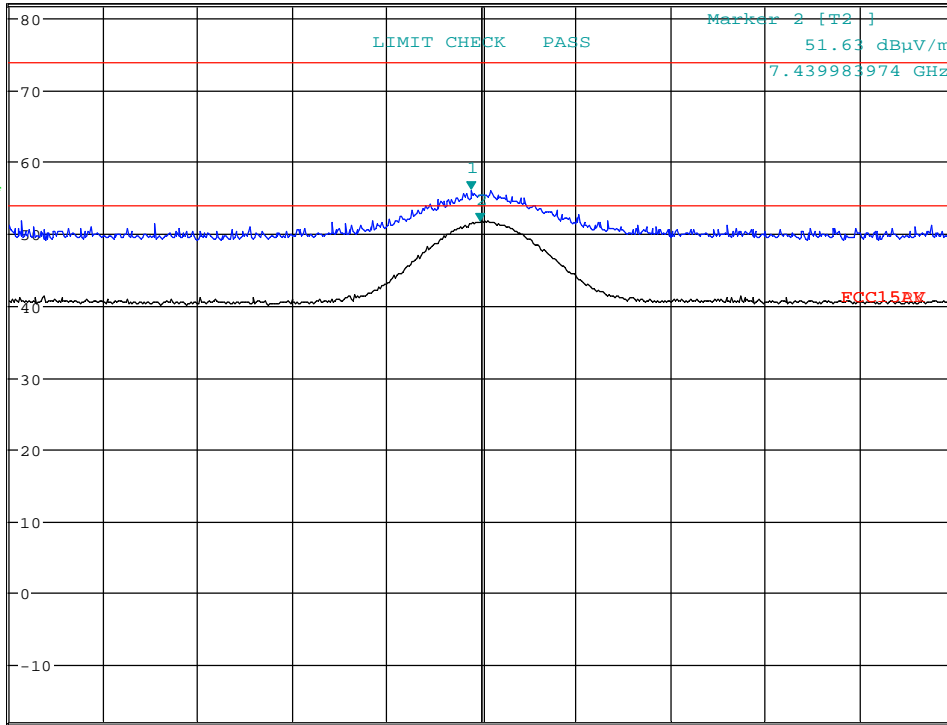
MARKER 1
 7.439887821 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 20 ms
 Marker 1 [T1]
 55.99 dB μ V/m
 7.439887821 GHz

Ref 82 dB μ V/m *Att 10 dB

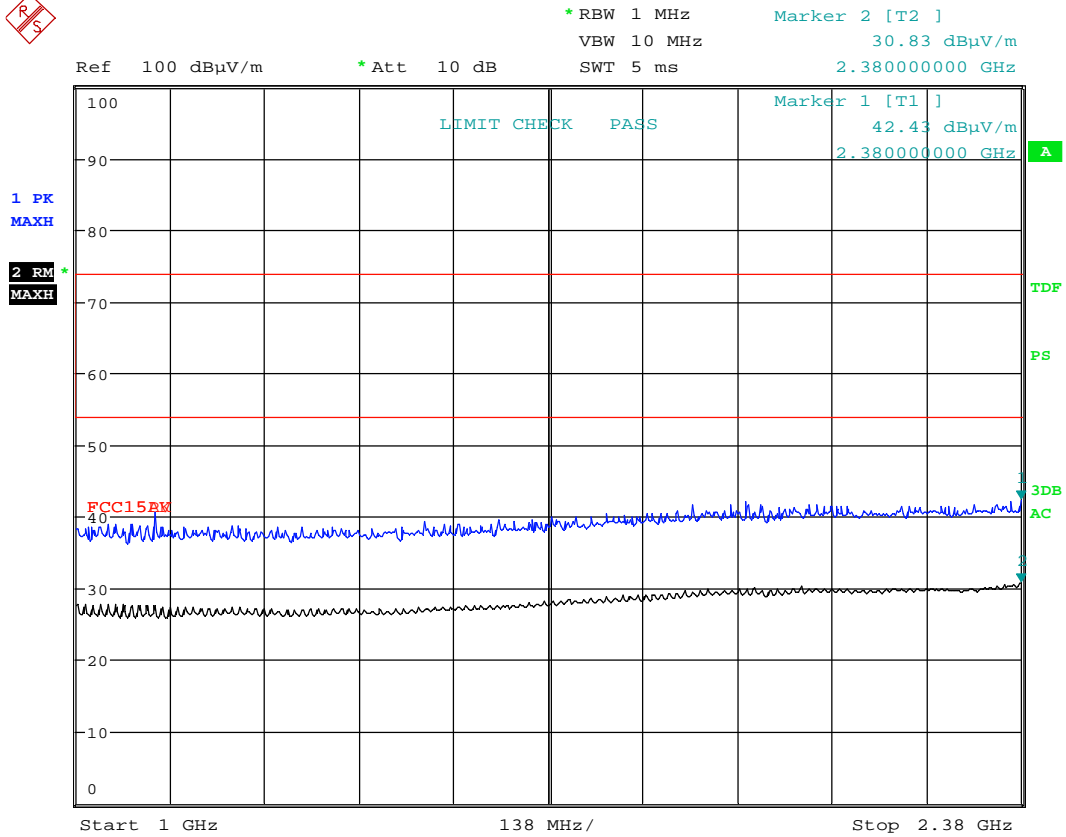
1 PK
 MAXH

2 RM
 MAXH



Date: 11.FEB.2019 12:52:02

Radiated spurious emissions, 7,44GHz, VP, ch2480MHz



Date: 11.FEB.2019 12:06:50

Radiated spurious emissions, VP, 1 - 2.38GHz, ch2402MHz



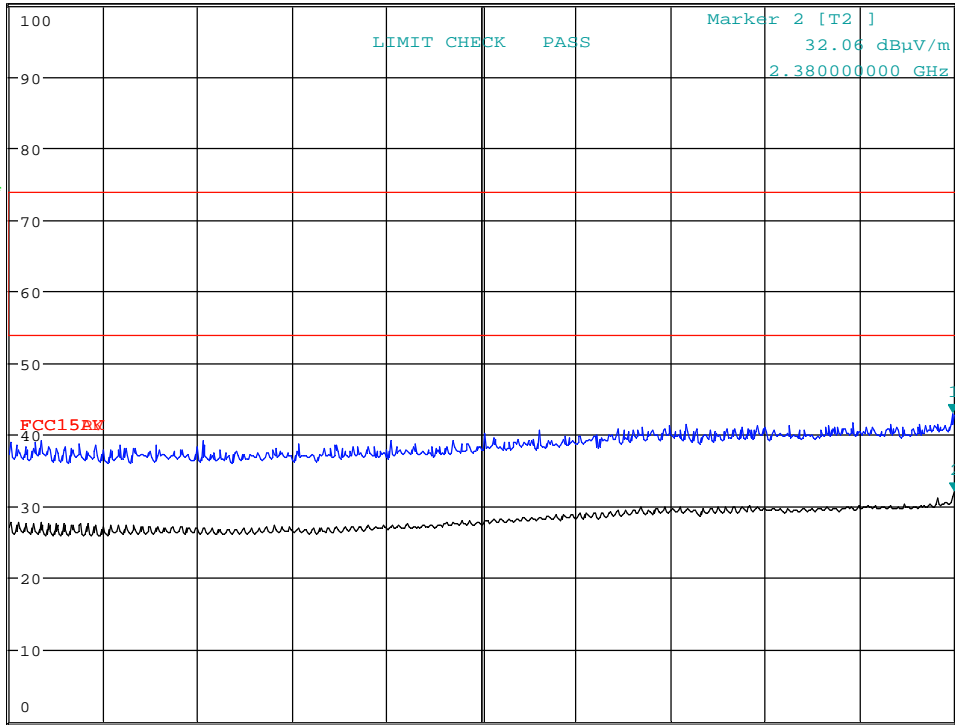
MARKER 1
 2.377788462 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 5 ms
 Marker 1 [T1]
 42.87 dBμV/m
 2.377788462 GHz

Ref 100 dBμV/m *Att 10 dB

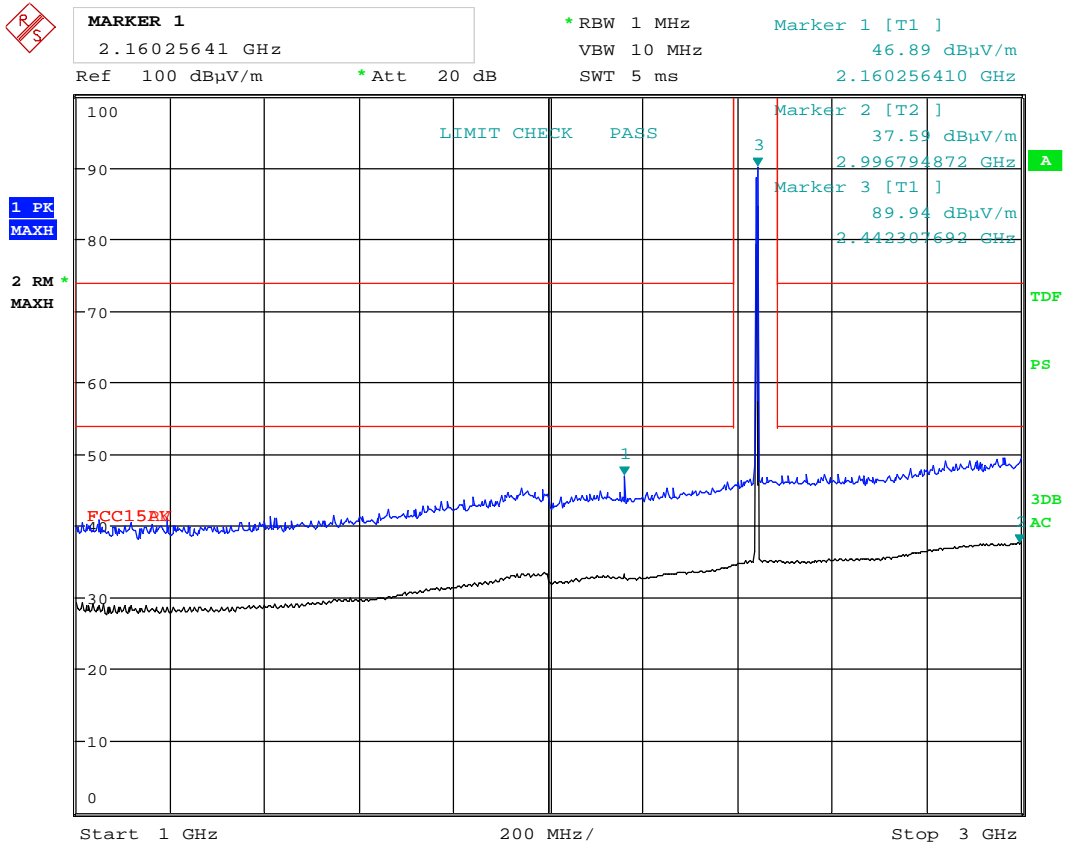
1 PK
 MAXH

2 RM *
 MAXH



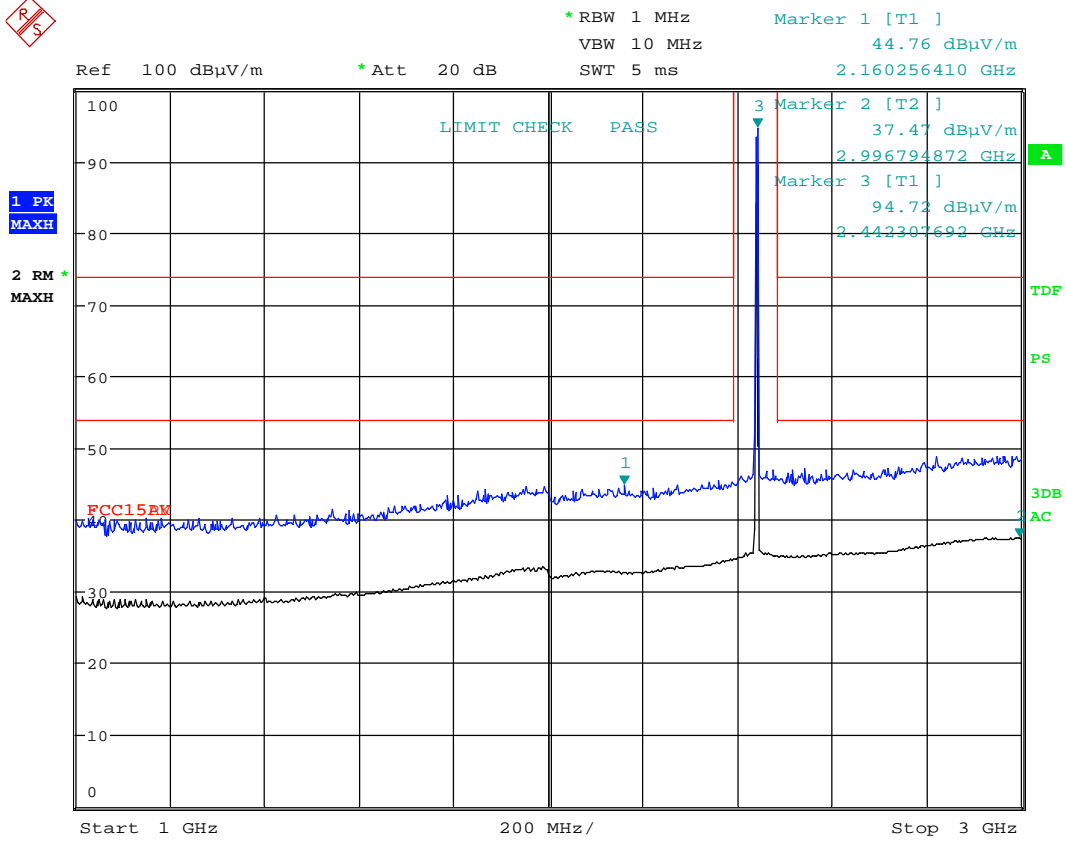
Date: 11.FEB.2019 12:12:46

Radiated spurious emissions, HP, 1 - 2.38GHz, ch2402MHz



Date: 11.FEB.2019 13:46:46

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



Date: 11.FEB.2019 13:48:04

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



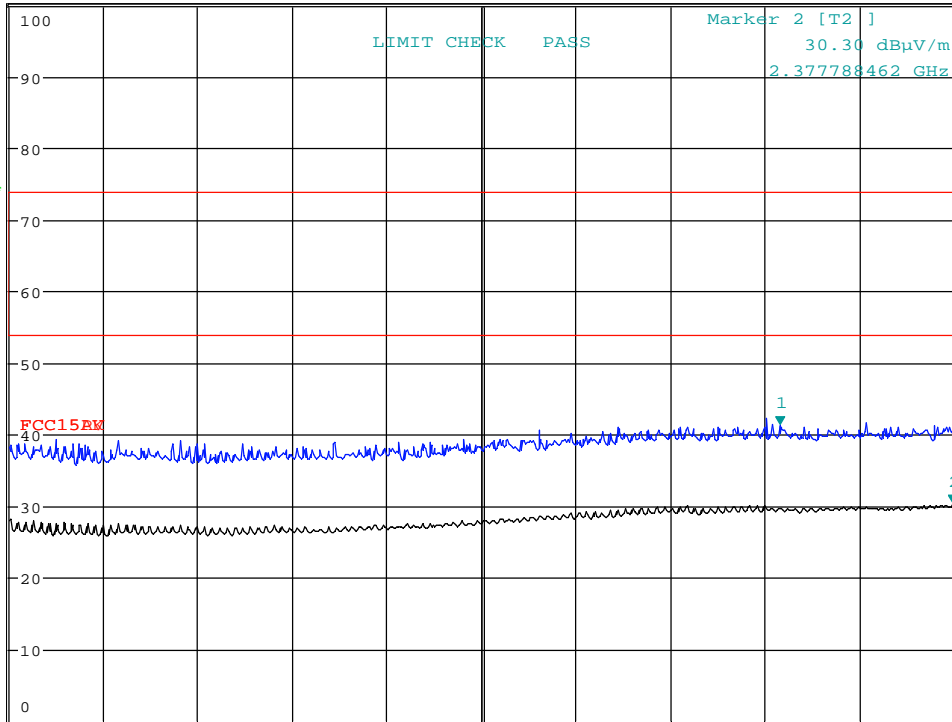
MARKER 1
 2.125673077 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 5 ms
 Marker 1 [T1]
 41.35 dBμV/m
 2.125673077 GHz

Ref 100 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM *
 MAXH



Date: 11.FEB.2019 12:31:21

Radiated spurious emissions, VP, 1 - 2.38GHz, ch2480MHz



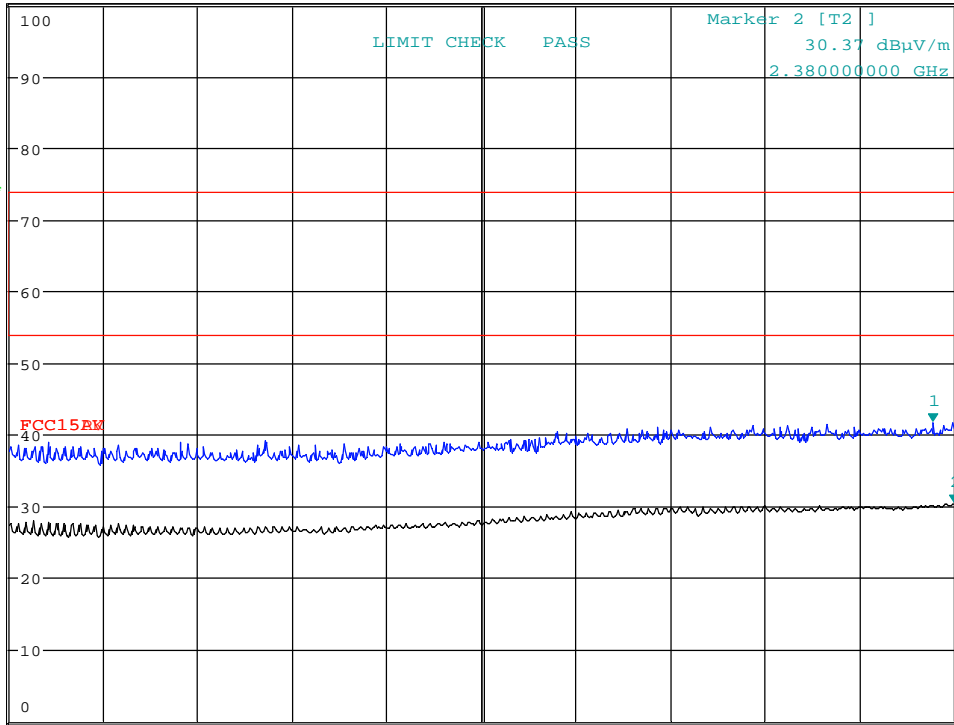
MARKER 1
 2.349038462 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 5 ms
 Marker 1 [T1]
 41.67 dBμV/m
 2.349038462 GHz

Ref 100 dBμV/m *Att 10 dB

1 PK
 MAXH

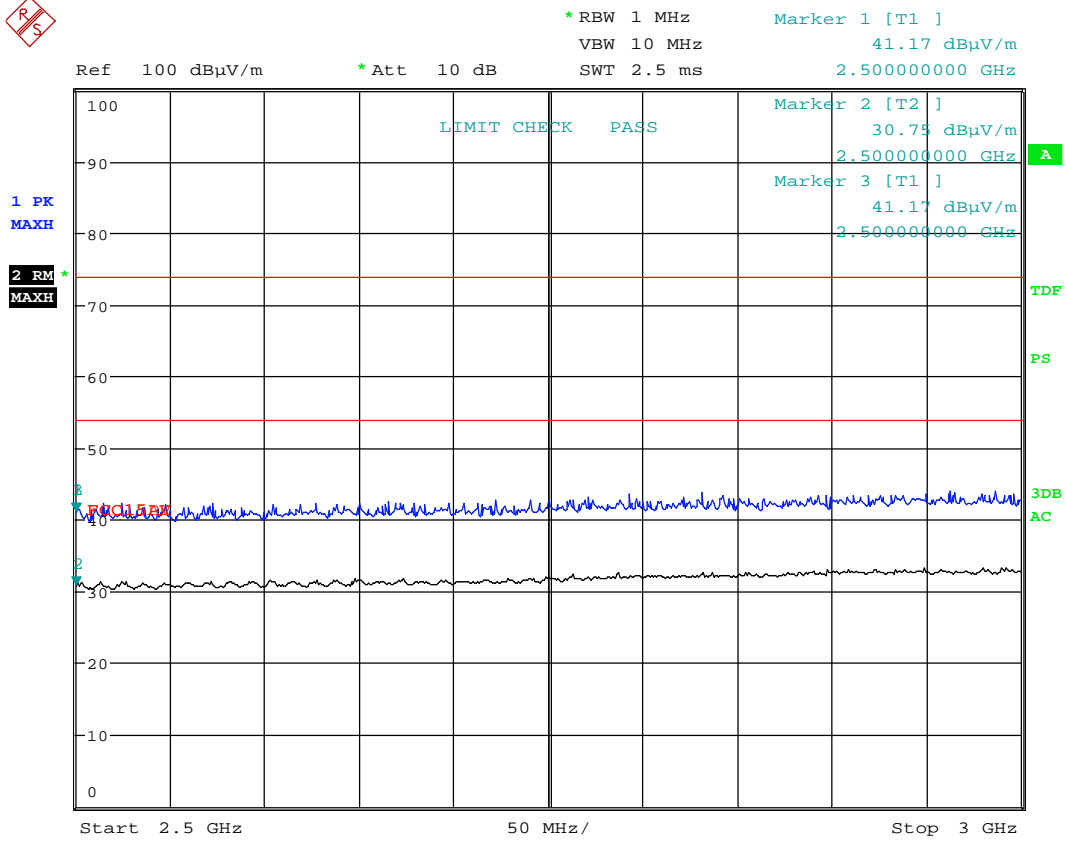
2 RM
 MAXH



Center 1.69 GHz 138 MHz / Span 1.38 GHz

Date: 11.FEB.2019 12:23:52

Radiated spurious emissions, HP, 1 - 2.38GHz, ch2480MHz



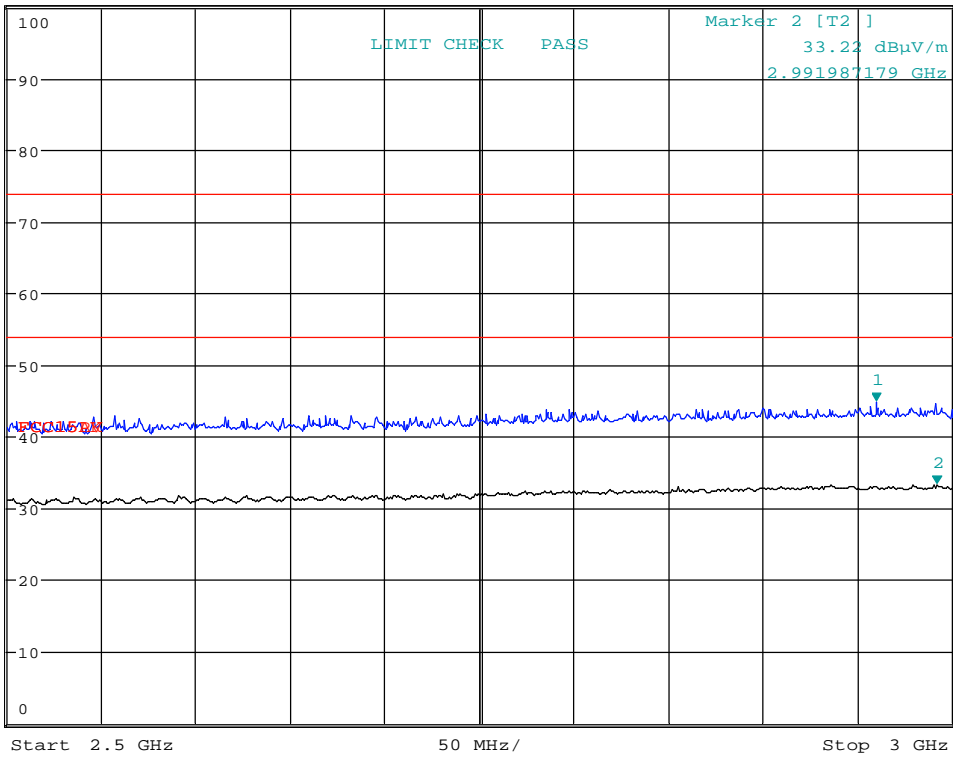
Date: 11.FEB.2019 12:08:58

Radiated spurious emissions, VP, 2.5 - 3GHz, ch2402MHz



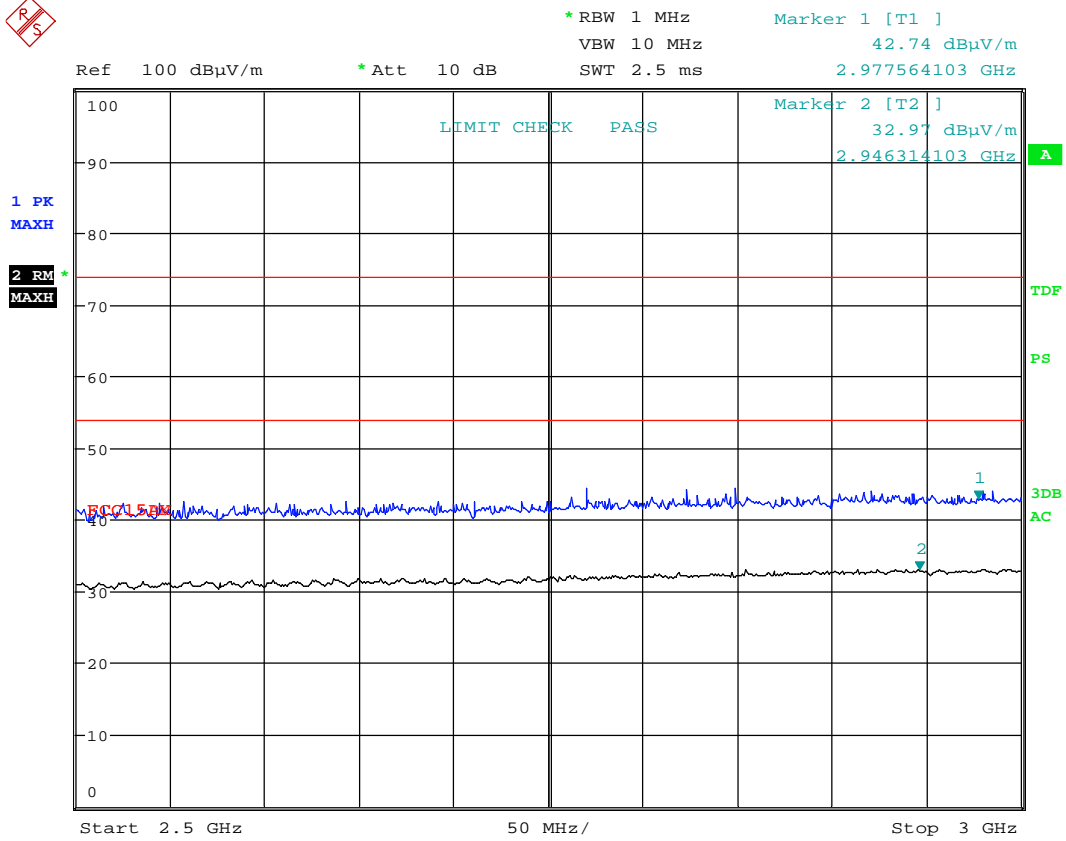
MARKER 1
 2.959935897 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 44.85 dBμV/m
 SWT 2.5 ms 2.959935897 GHz



Date: 11.FEB.2019 12:10:31

Radiated spurious emissions, HP, 2.5 - 3GHz, ch2402MHz



Date: 11.FEB.2019 12:28:26

Radiated spurious emissions, VP, 2.5 - 3GHz, ch2480MHz



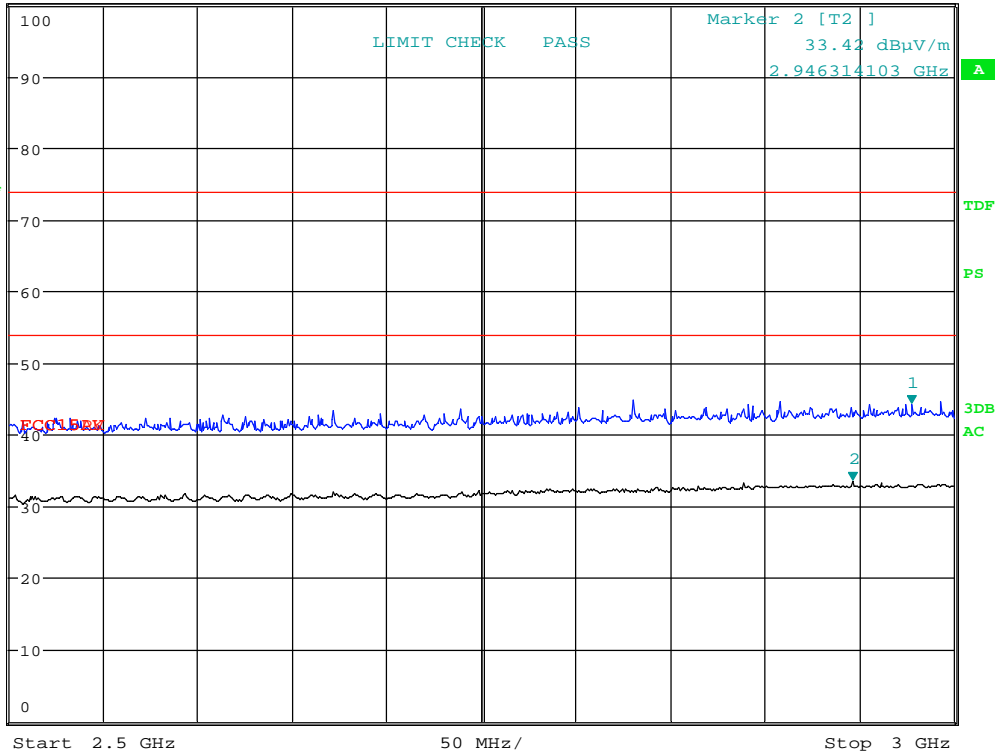
MARKER 1
 2.977564103 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 44.23 dBμV/m
 SWT 2.5 ms 2.977564103 GHz

Ref 100 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM*
 MAXH



Date: 11.FEB.2019 12:26:42

Radiated spurious emissions, HP, 2.5 - 3GHz, ch2480MHz



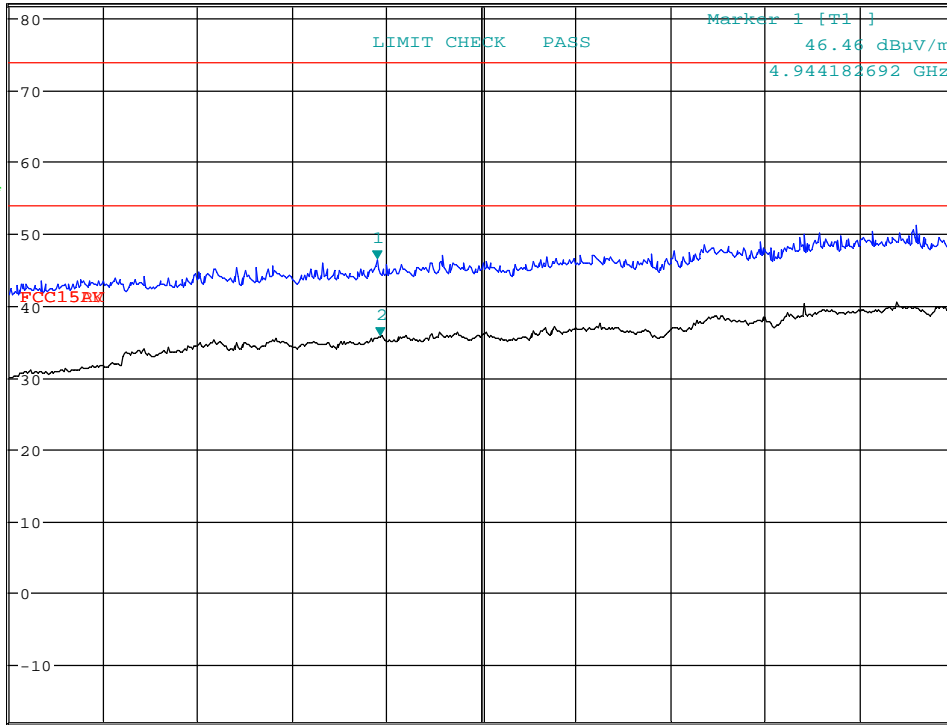
MARKER 2
 4.959983974 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 30 ms
 Marker 2 [T2]
 35.77 dBμV/m
 4.959983974 GHz

Ref 82 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM *
 MAXH



Start 3 GHz 500 MHz/ Stop 8 GHz

Date: 11.FEB.2019 12:57:01

Radiated spurious emissions, VP, 3 - 8GHz, ch2402MHz



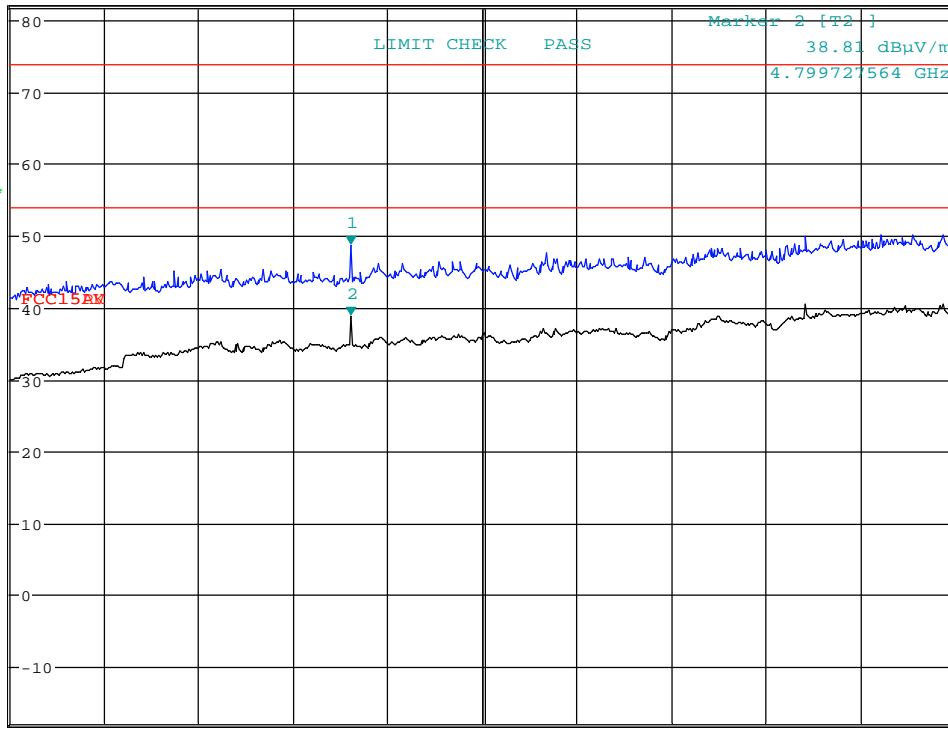
MARKER 1
 4.799951923 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 30 ms
 Marker 1 [T1]
 48.64 dB μ V/m
 4.799951923 GHz

Ref 82 dB μ V/m *Att 10 dB

1 PK
 MAXH

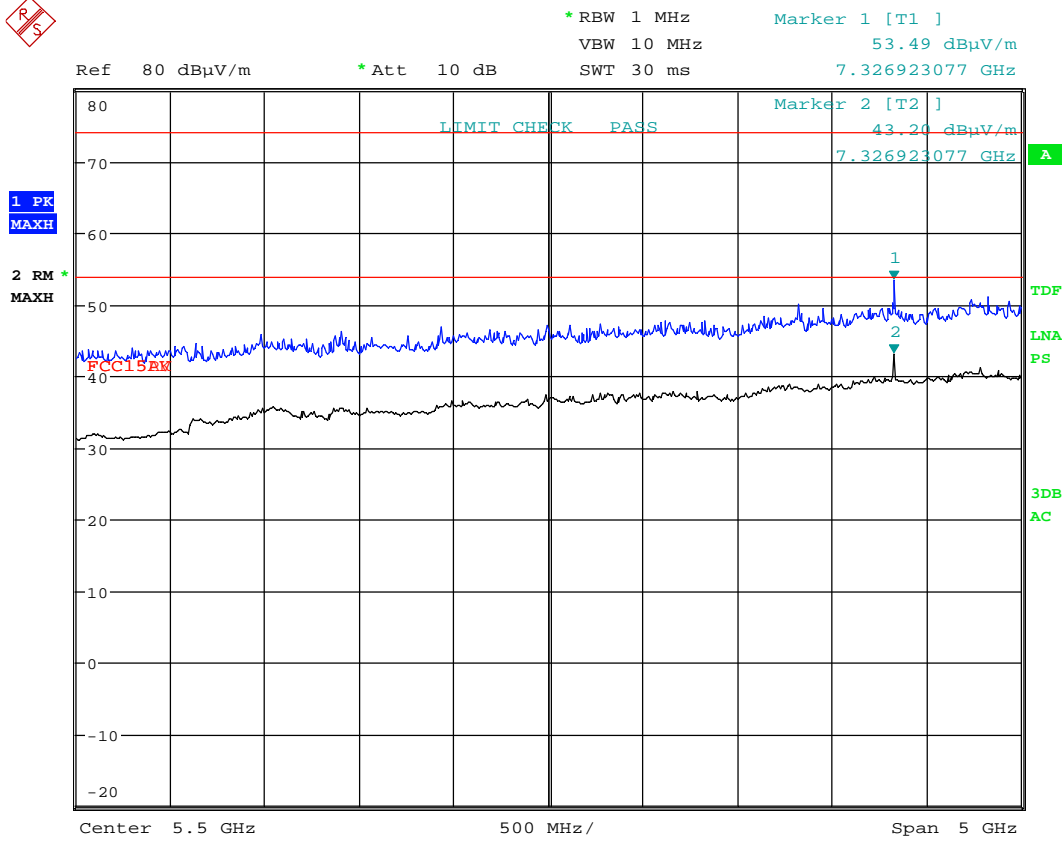
2 RM *
 MAXH



Start 3 GHz 500 MHz/ Stop 8 GHz

Date: 11.FEB.2019 12:58:46

Radiated spurious emissions, HP, 3 - 8GHz, ch2402MHz



Date: 11.FEB.2019 13:51:07

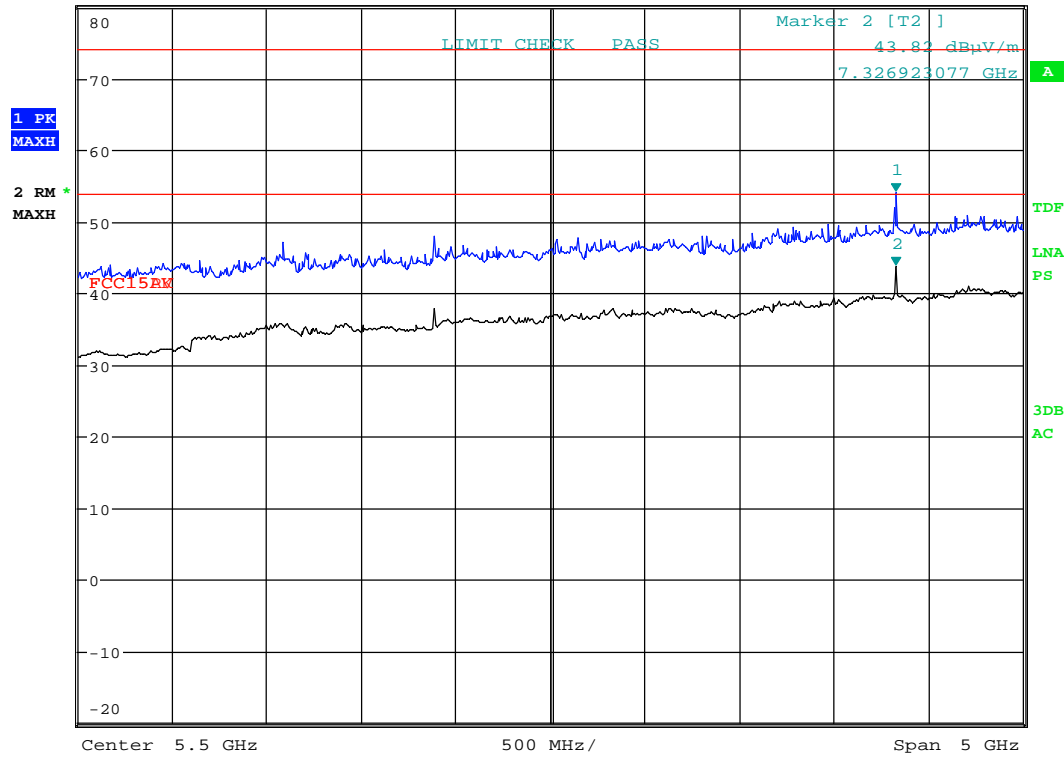
Radiated spurious emissions, VP, 3 - 8GHz, ch2440MHz



MARKER 1
 7.326923077 GHz
 Ref 80 dB μ V/m *Att 10 dB

*RBW 1 MHz
 VBW 10 MHz
 SWT 30 ms

Marker 1 [T1]
 54.02 dB μ V/m
 7.326923077 GHz



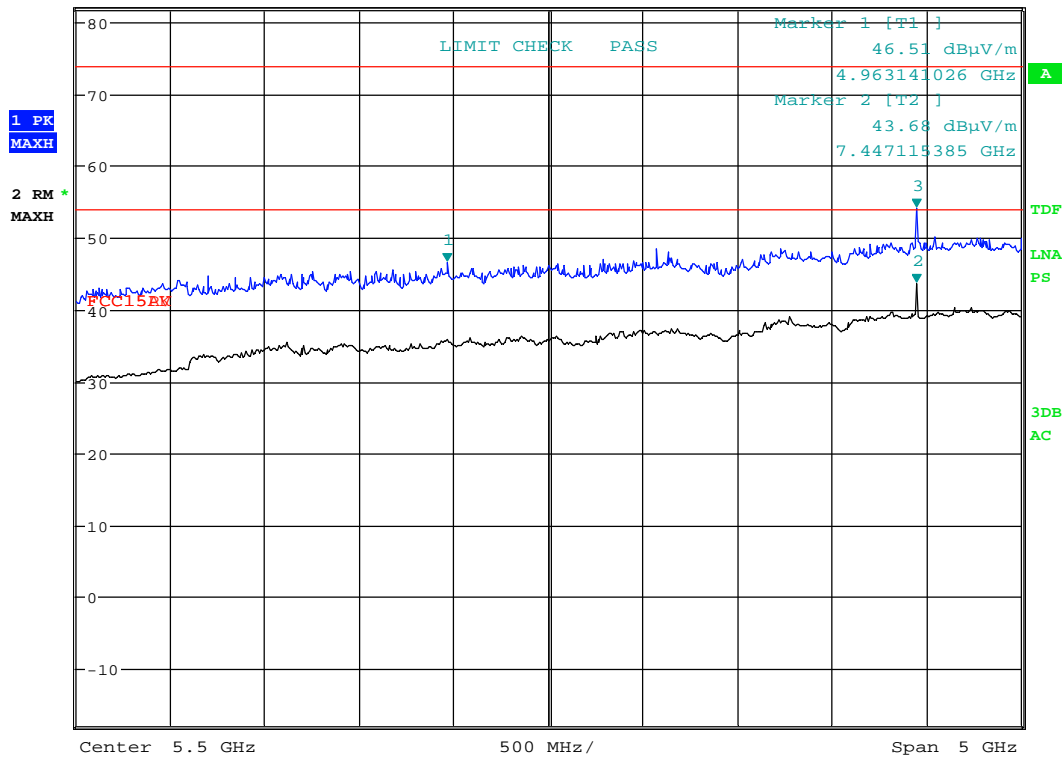
Date: 11.FEB.2019 13:50:14

Radiated spurious emissions, HP, 3 - 8GHz, ch2440MHz



MARKER 3
 7.447115385 GHz

*RBW 1 MHz Marker 3 [T1]
 VBW 10 MHz 54.14 dBμV/m
 Ref 82 dBμV/m *Att 10 dB SWT 30 ms 7.447115385 GHz



Date: 11.FEB.2019 12:42:05

Radiated spurious emissions, VP, 3 - 8GHz, ch2480MHz



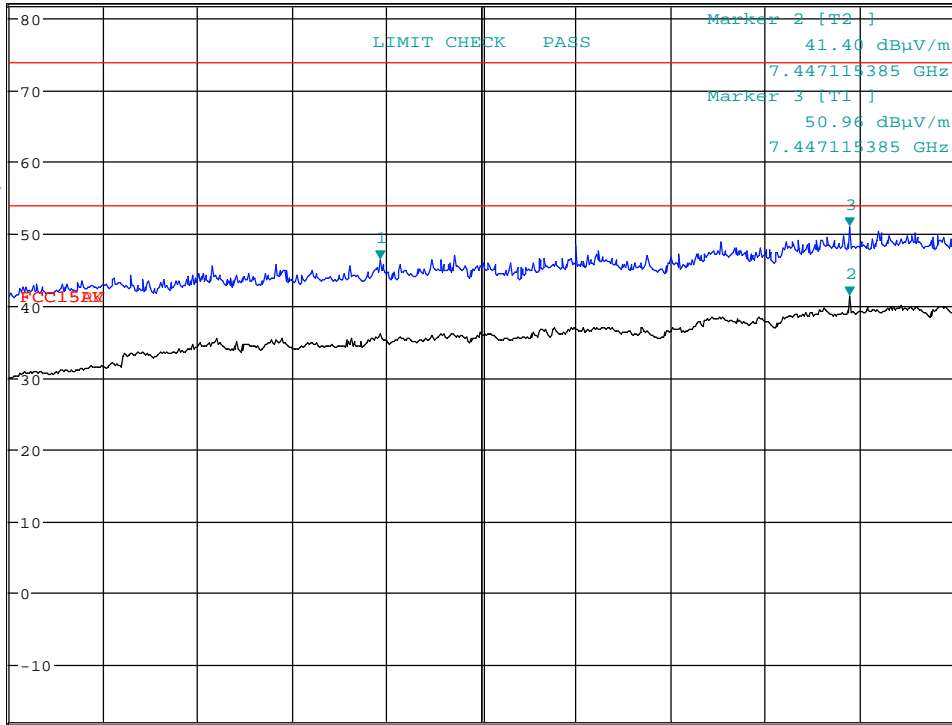
MARKER 1
 4.963141026 GHz

*RBW 1 MHz
 VBW 10 MHz
 SWT 30 ms
 Marker 1 [T1]
 46.36 dBµV/m
 4.963141026 GHz

Ref 82 dBµV/m *Att 10 dB

1 PK
 MAXH

2 RM *
 MAXH



Start 3 GHz 500 MHz/ Stop 8 GHz

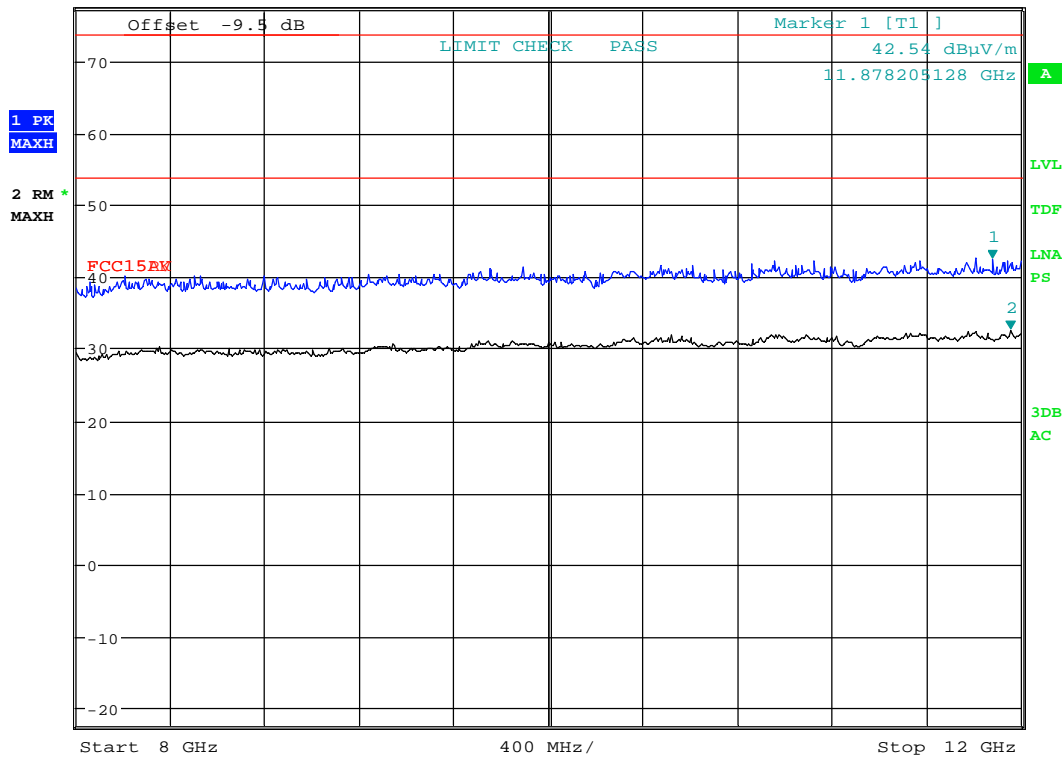
Date: 11.FEB.2019 12:43:41

Radiated spurious emissions, HP, 3 - 8GHz, ch2480MHz



MARKER 2
 11.95512821 GHz
 Ref 77.5 dBμV/m *Att 15 dB

*RBW 1 MHz Marker 2 [T2]
 VBW 10 MHz 32.66 dBμV/m
 SWT 25 ms 11.955128205 GHz



Date: 11.FEB.2019 13:23:38

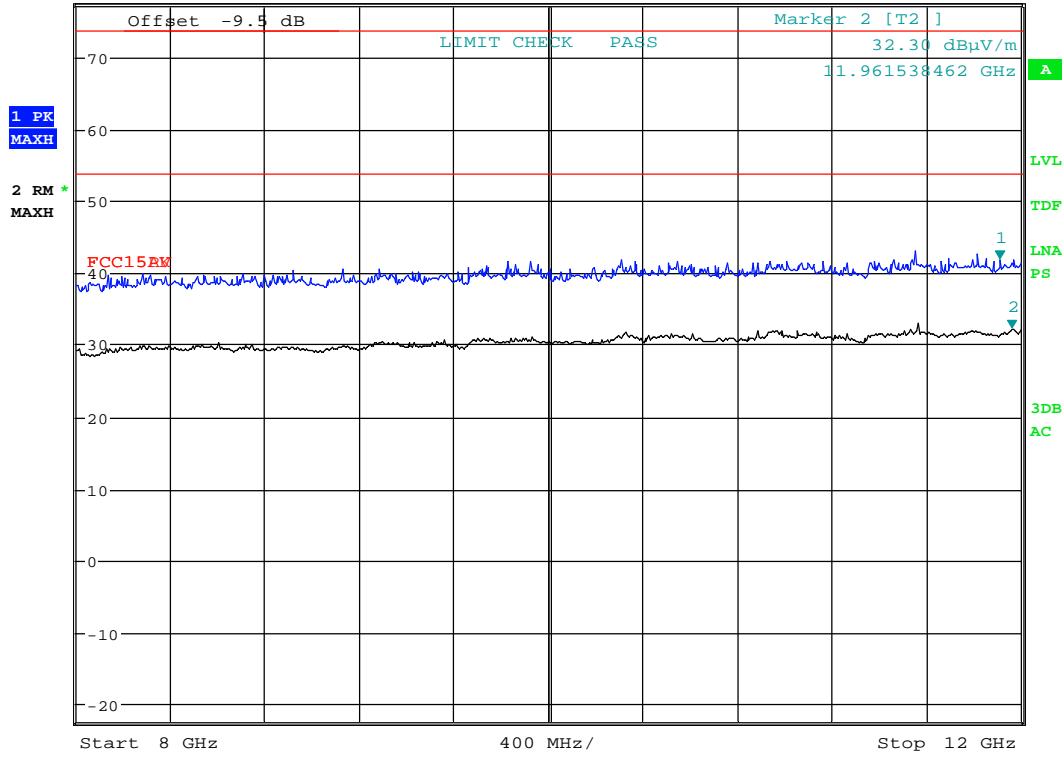
Radiated spurious emissions, VP, 8 - 12GHz, ch2402MHz, @ 1m distance



MARKER 1
 11.91025641 GHz
 Ref 77.5 dBμV/m *Att 15 dB

*RBW 1 MHz
 VBW 10 MHz
 SWT 25 ms

Marker 1 [T1]
 41.84 dBμV/m
 11.910256410 GHz



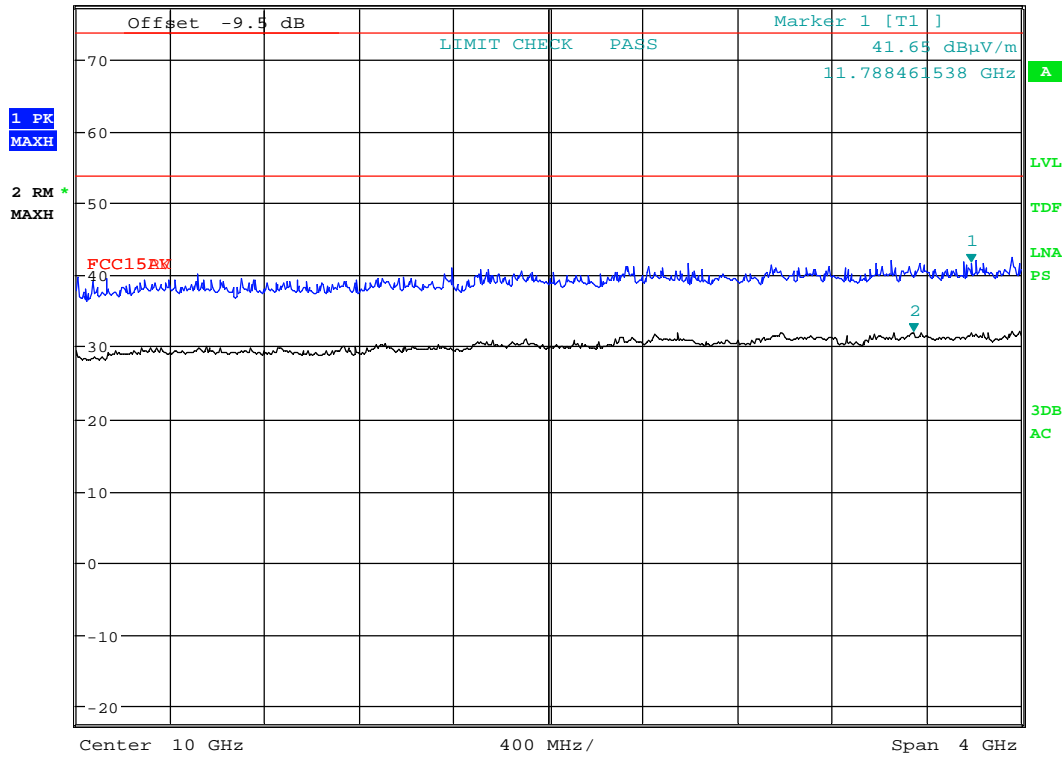
Date: 11.FEB.2019 13:25:03

Radiated spurious emissions, HP, 8 - 12GHz, ch2402MHz, @ 1m distance



MARKER 2
 11.54487179 GHz

*RBW 1 MHz Marker 2 [T2]
 VBW 10 MHz 31.97 dBμV/m
 Ref 77.5 dBμV/m *Att 15 dB SWT 25 ms 11.544871795 GHz



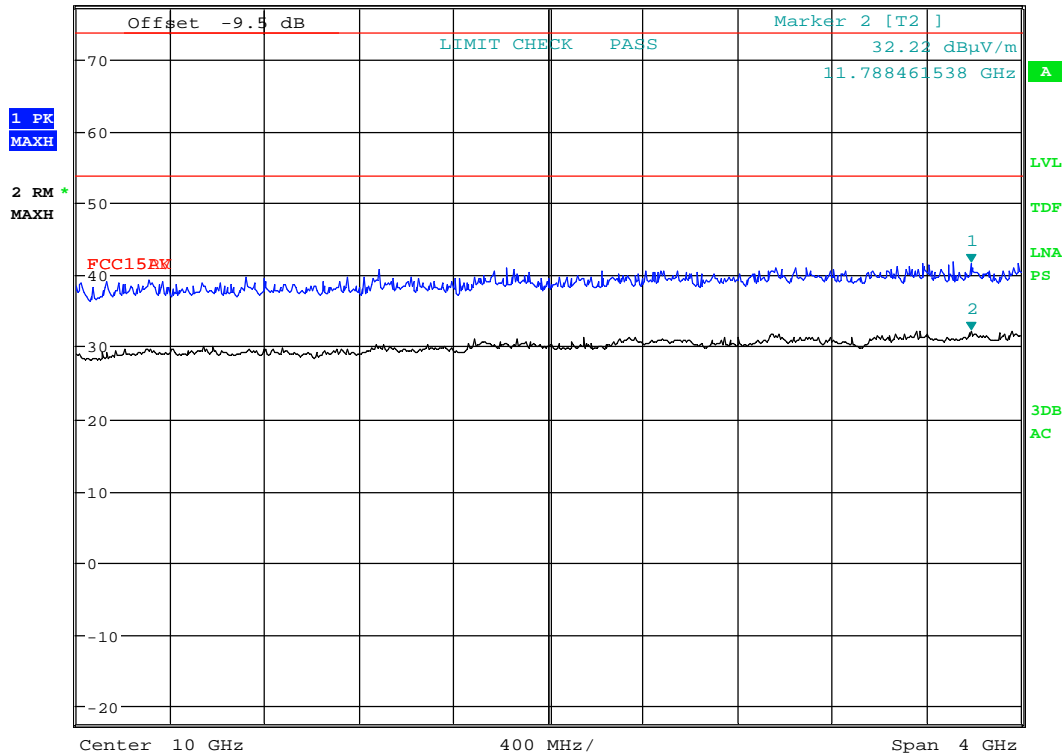
Date: 11.FEB.2019 13:40:36

Radiated spurious emissions, VP, 8 - 12GHz, ch2440MHz, @ 1m distance



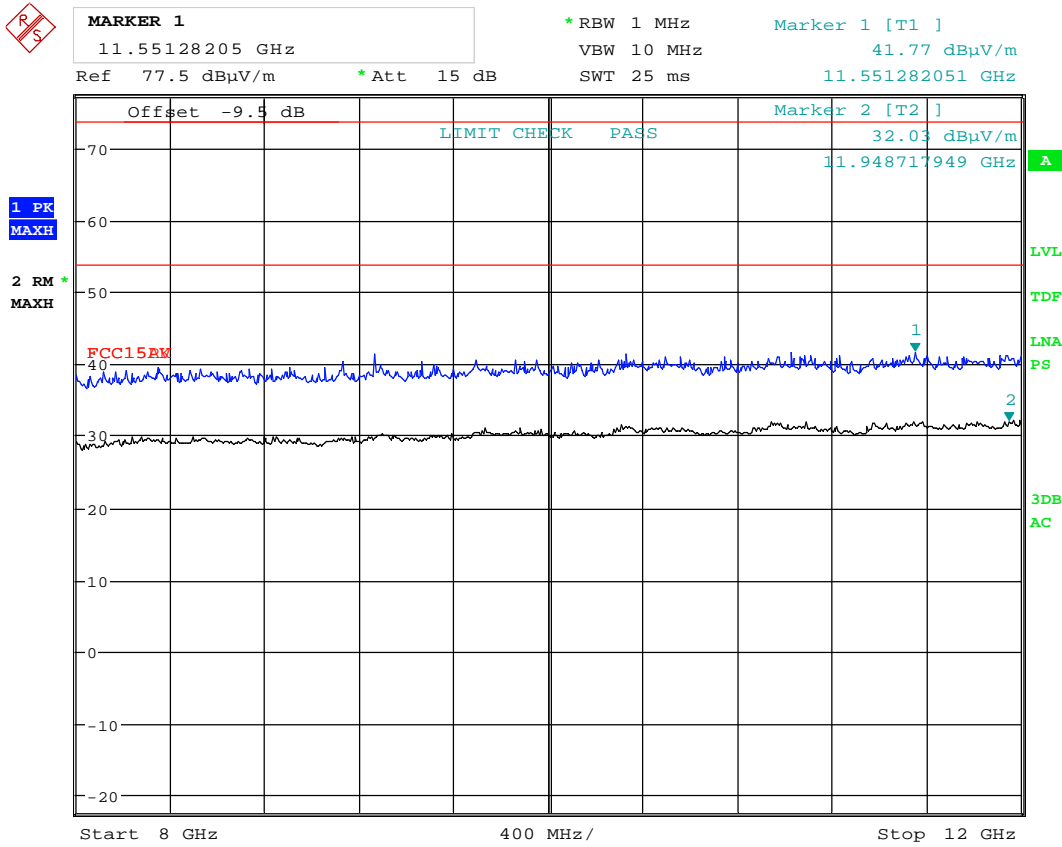
MARKER 1
 11.78846154 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 41.77 dBμV/m
 Ref 77.5 dBμV/m *Att 15 dB SWT 25 ms 11.788461538 GHz



Date: 11.FEB.2019 13:41:12

Radiated spurious emissions, HP, 8 - 12GHz, ch2440MHz, @ 1m distance



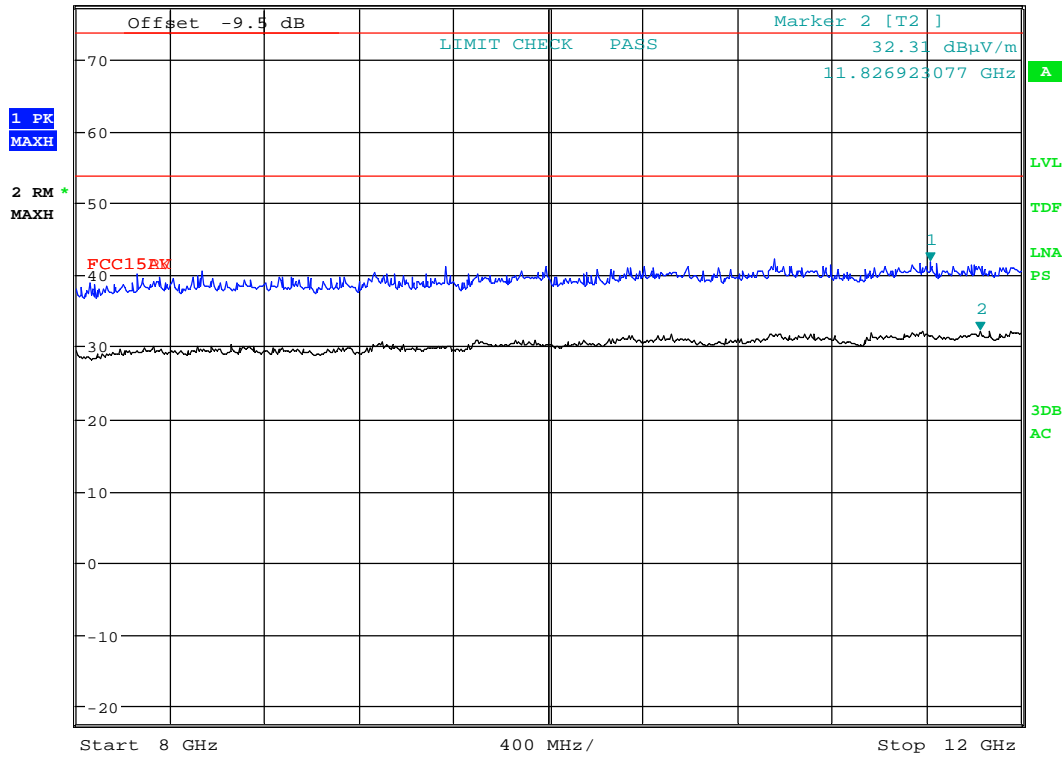
Date: 11.FEB.2019 13:27:41

Radiated spurious emissions, VP, 8 - 12GHz, ch2480MHz, @ 1m distance



MARKER 1
 11.61538462 GHz
 Ref 77.5 dB μ V/m *Att 15 dB

*RBW 1 MHz
 VBW 10 MHz
 SWT 25 ms
 Marker 1 [T1]
 41.79 dB μ V/m
 11.615384615 GHz



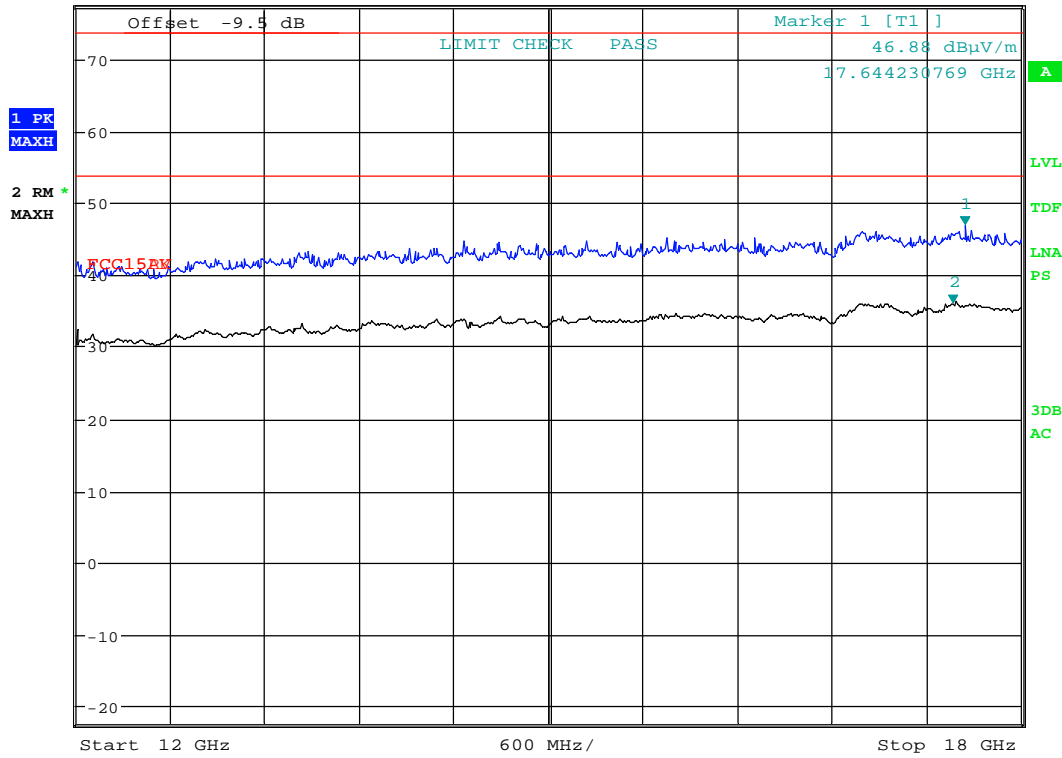
Date: 11.FEB.2019 13:27:08

Radiated spurious emissions, HP, 8 - 12GHz, ch2480MHz, @ 1m distance



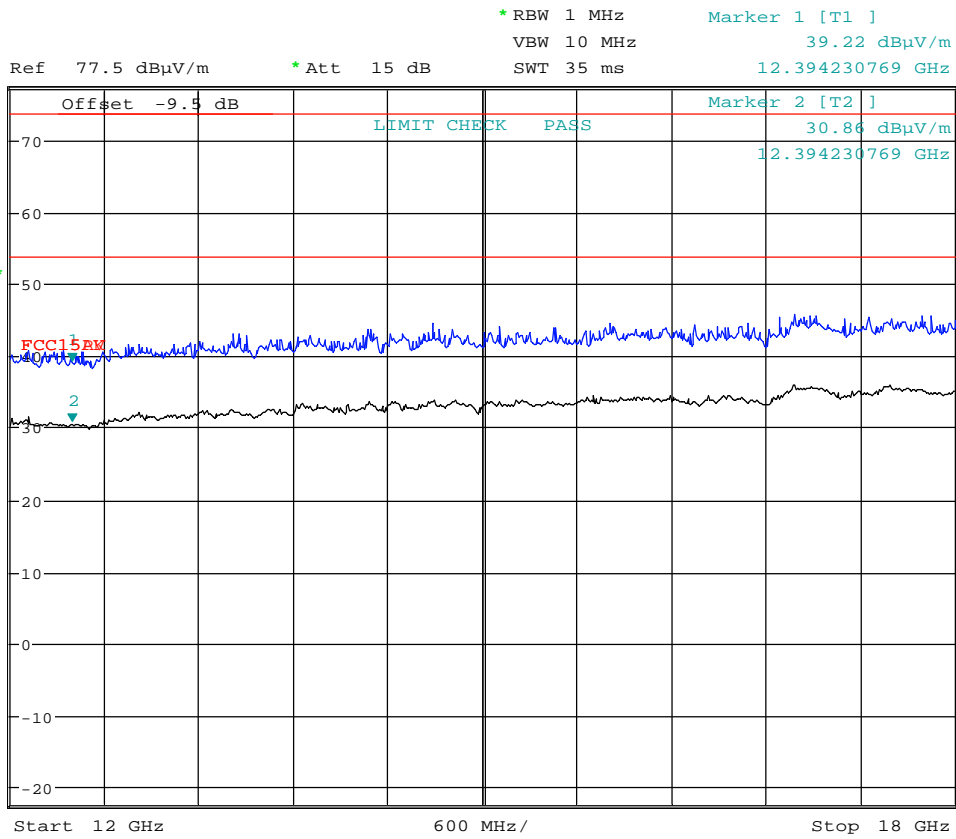
MARKER 2
 17.56730769 GHz

*RBW 1 MHz Marker 2 [T2]
 VBW 10 MHz 36.08 dBμV/m
 Ref 77.5 dBμV/m *Att 15 dB SWT 35 ms 17.567307692 GHz



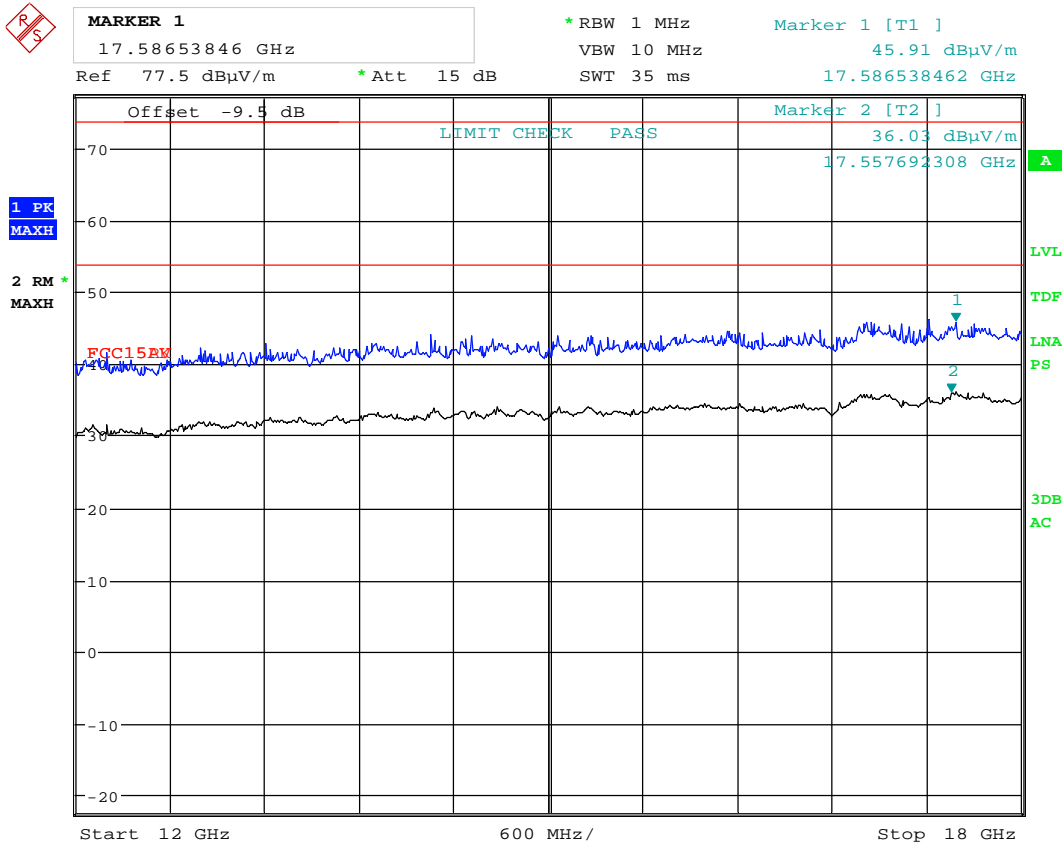
Date: 11.FEB.2019 13:35:45

Radiated spurious emissions, VP, 12 - 18GHz, ch2402MHz, @ 1m distance



Date: 11.FEB.2019 13:35:07

Radiated spurious emissions, HP, 12 - 18GHz, ch2402MHz, @ 1m distance



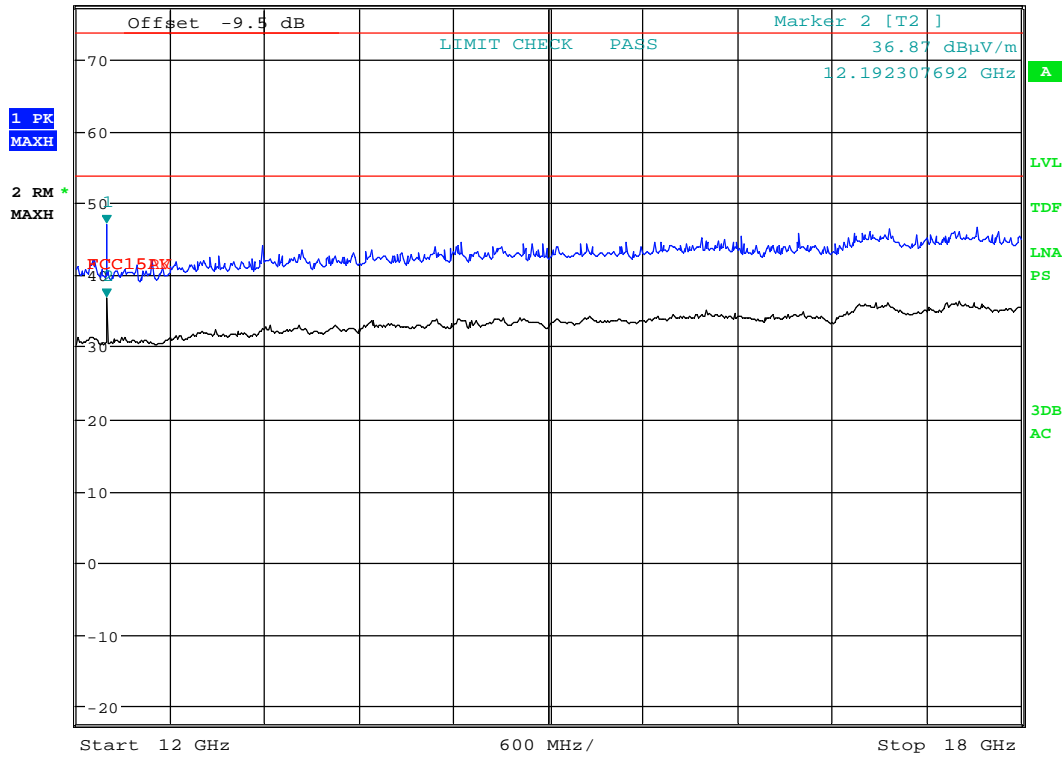
Date: 11.FEB.2019 13:37:35

Radiated spurious emissions, VP, 12 - 18GHz, ch2440MHz,@ 1m distance



MARKER 1
 12.19230769 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 47.07 dBμV/m
 Ref 77.5 dBμV/m *Att 15 dB SWT 35 ms 12.192307692 GHz



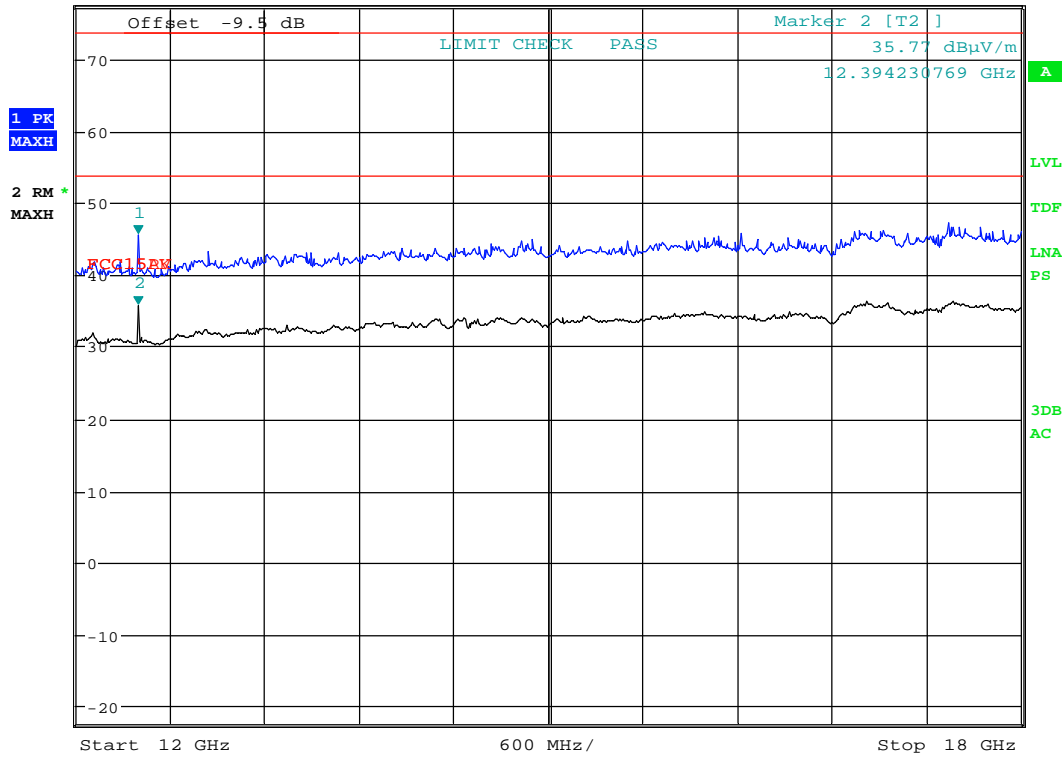
Date: 11.FEB.2019 13:38:28

Radiated spurious emissions, HP, 12 - 18GHz, ch2440MHz, @ 1m distance



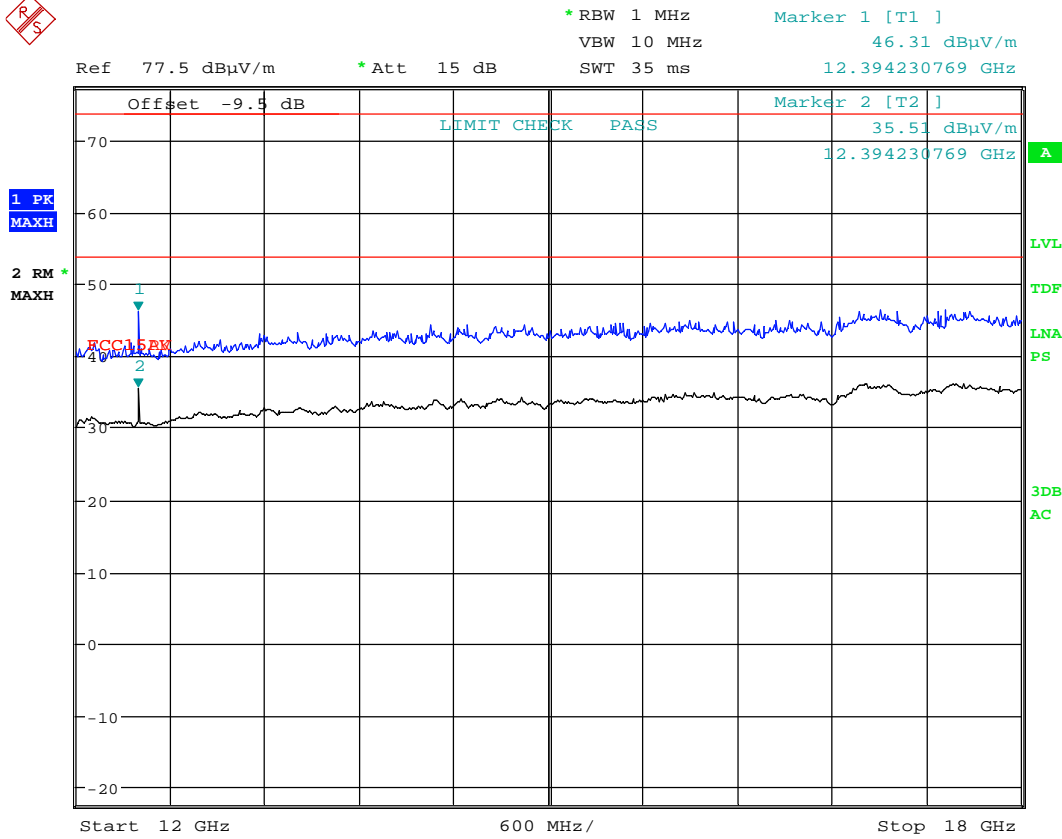
MARKER 1
 12.39423077 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 45.71 dBμV/m
 Ref 77.5 dBμV/m *Att 15 dB SWT 35 ms 12.394230769 GHz



Date: 11.FEB.2019 13:30:43

Radiated spurious emissions, VP, 12 - 18GHz, ch2480MHz, @ 1m distance



Date: 11.FEB.2019 13:31:38

Radiated spurious emissions, HP, 12 - 18GHz, ch2480MHz, @ 1m distance



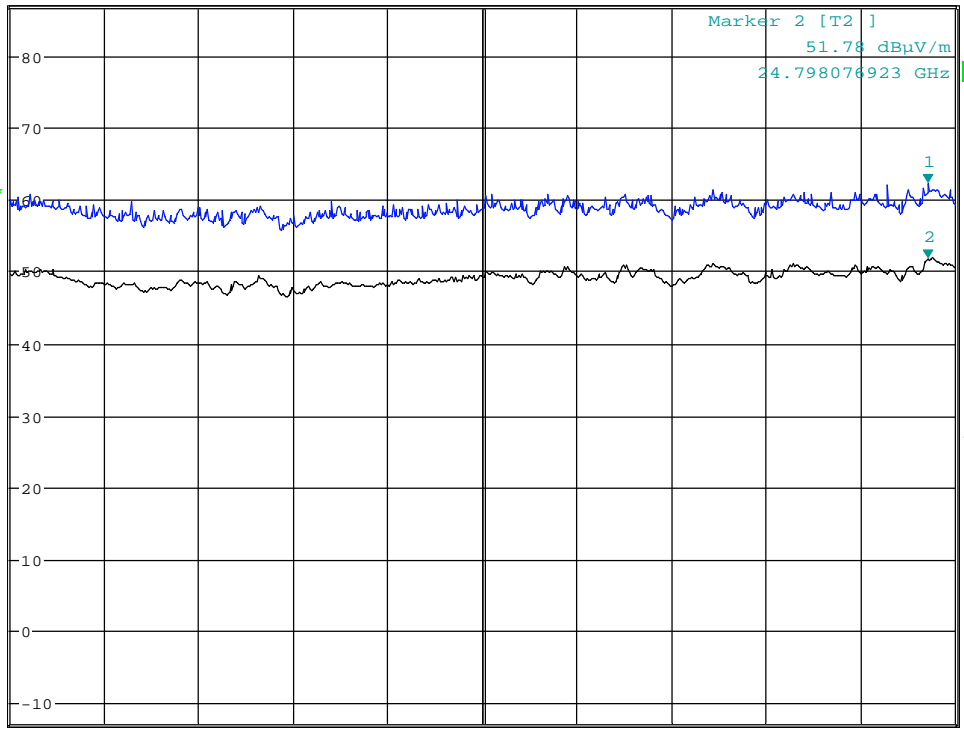
MARKER 1
 24.79807692 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 62.33 dBμV/m
 SWT 45 ms 24.798076923 GHz

Ref 87 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM
 MAXH



Start 18 GHz 700 MHz/ Stop 25 GHz

Date: 11.FEB.2019 16:07:17

Pre-scan, Radiated spurious emissions, VP, 18 - 25GHz



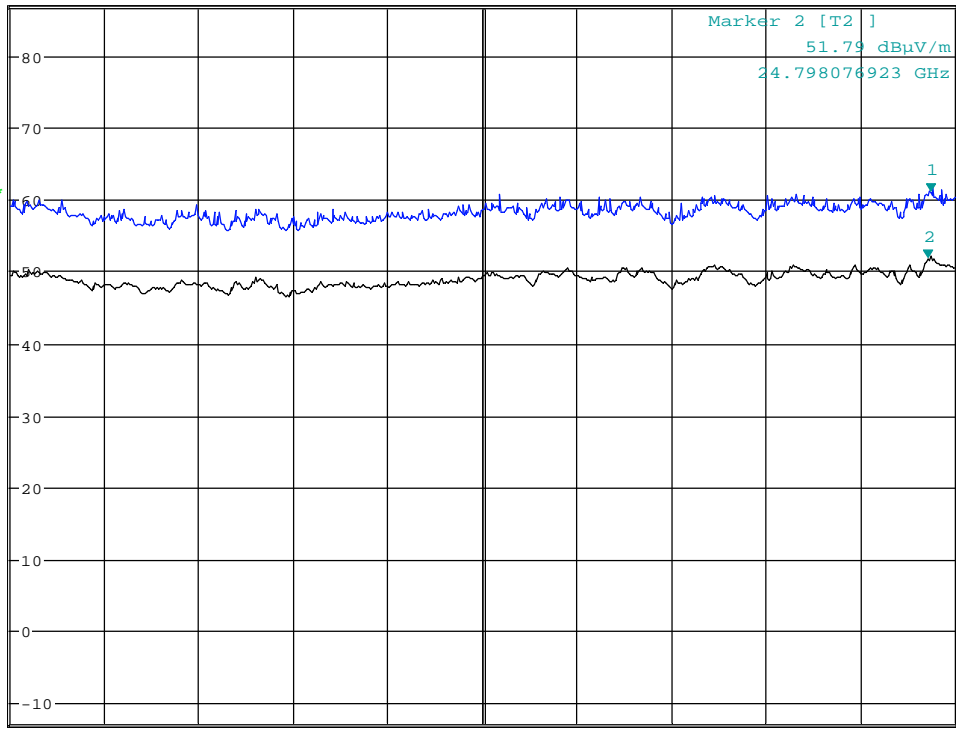
MARKER 1
 24.82051282 GHz

*RBW 1 MHz Marker 1 [T1]
 VBW 10 MHz 61.00 dBμV/m
 SWT 45 ms 24.820512821 GHz

Ref 87 dBμV/m *Att 10 dB

1 PK
 MAXH

2 RM *
 MAXH



Start 18 GHz 700 MHz/ Stop 25 GHz

Date: 11.FEB.2019 16:08:00

Pre-scan, Radiated spurious emissions, HP, 18 - 25GHz

3.8 Power Spectral Density (PSD)

FCC part 15.247(e)

Test Results: Passed

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)	-15.4	-14.7	-14.4

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.

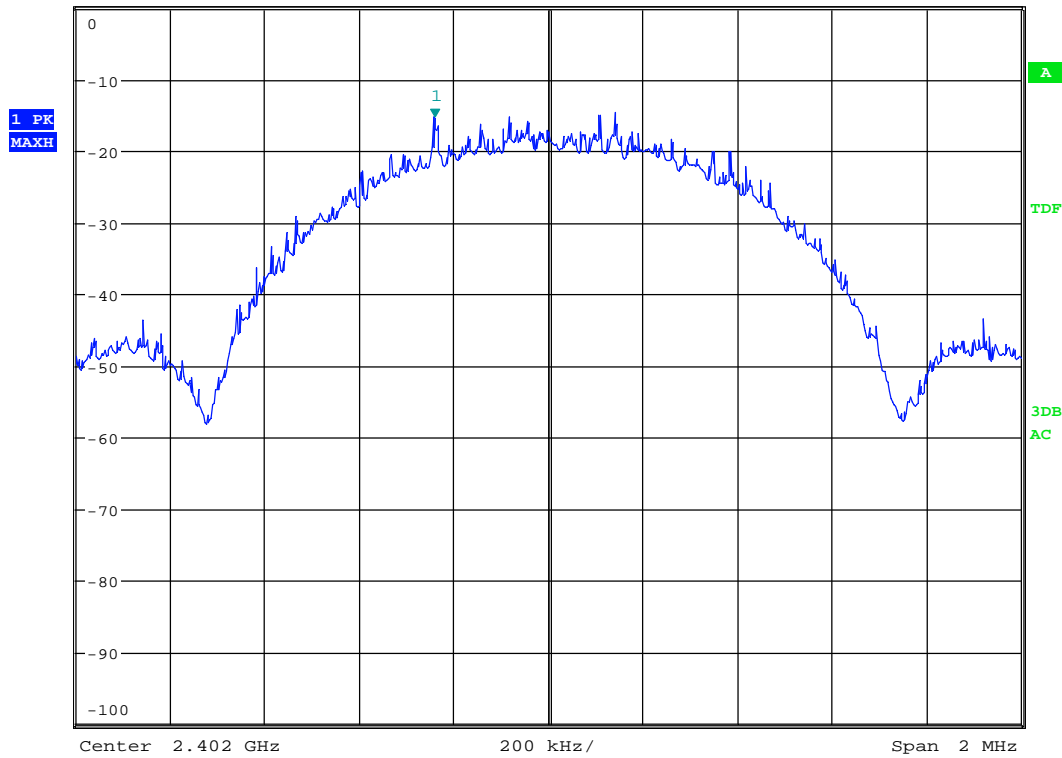


MARKER 1
 2.401759615 GHz

*RBW 3 kHz
 VBW 10 kHz
 SWT 225 ms

Marker 1 [T1]
 -15.36 dBm
 2.401759615 GHz

Ref 0 dBm *Att 15 dB



Date: 11.FEB.2019 16:15:29

Conducted PSD, ch2402MHz

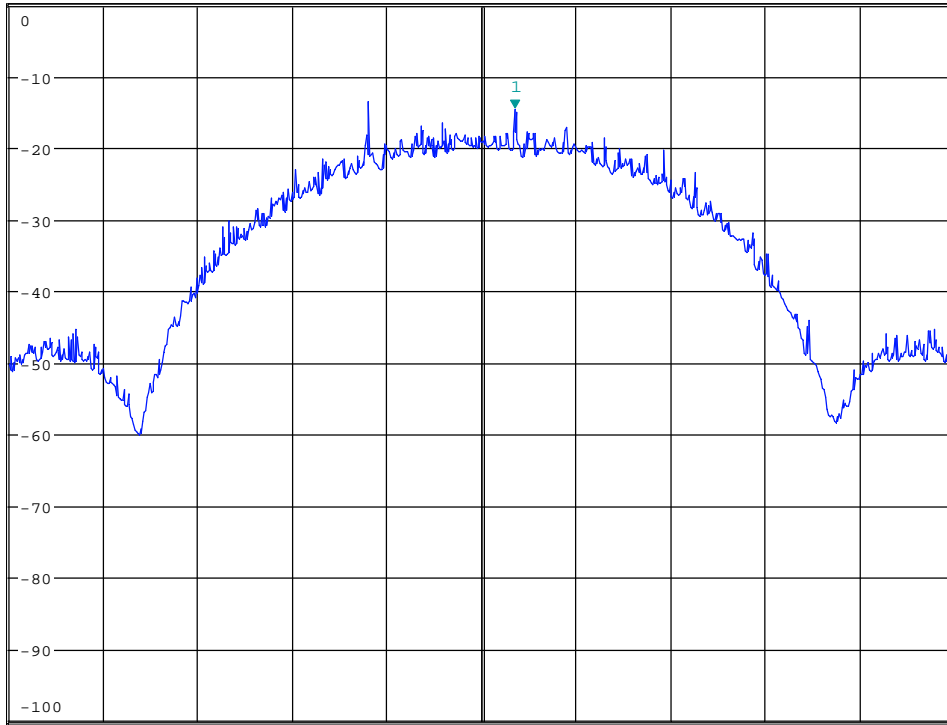


MARKER 1
2.440070513 GHz

*RBW 3 kHz
VBW 10 kHz
SWT 225 ms
Marker 1 [T1]
-14.65 dBm
2.440070513 GHz

Ref 0 dBm *Att 15 dB

1 PK
MAXH



Center 2.44 GHz 200 kHz/ Span 2 MHz

Date: 11.FEB.2019 16:16:02

Conducted PSD, ch2440MHz

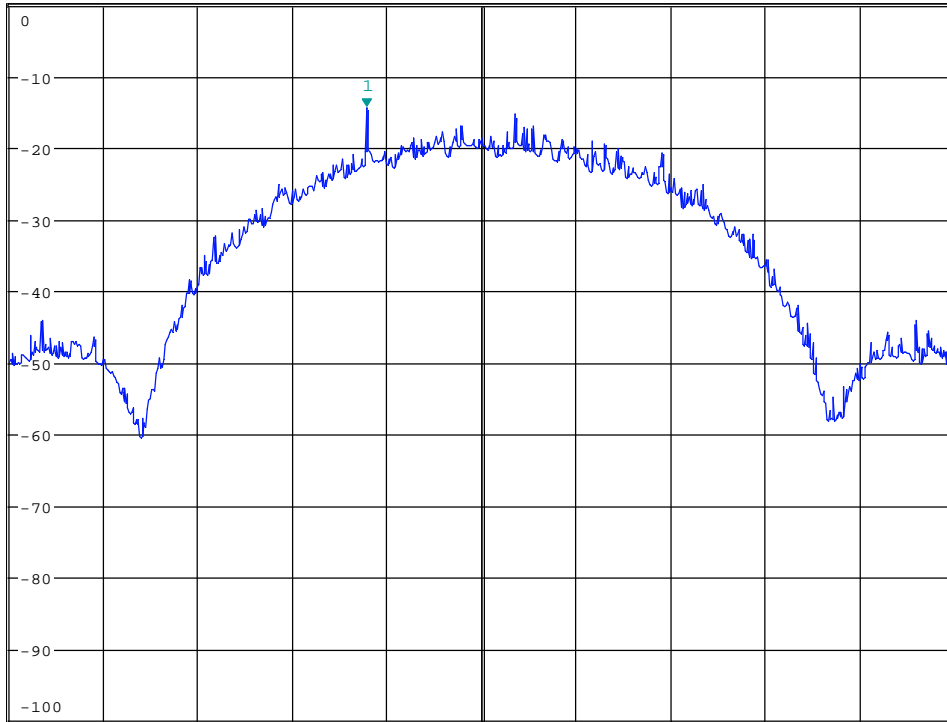


MARKER 1
 2.47975641 GHz

*RBW 3 kHz
 VBW 10 kHz
 SWT 225 ms
 Marker 1 [T1]
 -14.43 dBm
 2.479756410 GHz

Ref 0 dBm *Att 15 dB

1 PK
 MAXH



Center 2.48 GHz 200 kHz/ Span 2 MHz

Date: 11.FEB.2019 16:16:38

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.

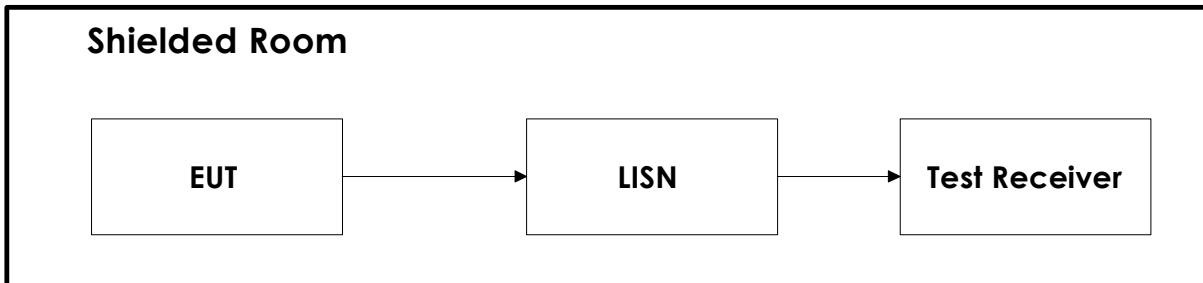
No.	Instrument/ ancillary	Type of instrument/ ancillary	Manufacturer	Ref. no.	Cal. Date	Cal. Due
1.	ESU40	EMI Receiver	Rohde & Schwarz	LR1639	2019.01	2020.01
2.	HFH2-Z2	Active Loop antenna	Rohde & Schwarz	LR1660	2016.11	2019.11
3.	3115	Antenna horn	EMCO	LR 1330	2016.10	2020.10
4.	PM 320K	Antenna Horn	Sivers	LR 1717	N/A	
5.	DBF-520-20	Antenna Horn	Systron-Donner corp	LR 102	N/A	
6.	638	Antenna Horn	NARDA	LR 1480	N/A	
7.	637	Antenna Horn	NARDA	LR 099	N/A	
8.	ARJB1	Bi-log Hybrid Antenna	Sunol	LR 1734	2018.05	2020.05
9.	4768-10	Attenuator	Narda	LR 1356	Cal b4 use	
10.	6HC3000/18000	Highpass Filter	Trilithic	LR 1614	Cal b4 use	
11.	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2018.07	2019.07
12.	310N	Pre-amplifier	Sonoma	LR 1686	2018.07	2019.07
13.	Model 87 V	Multimeter	Fluke	LR 1597	2018.02	2020.02

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

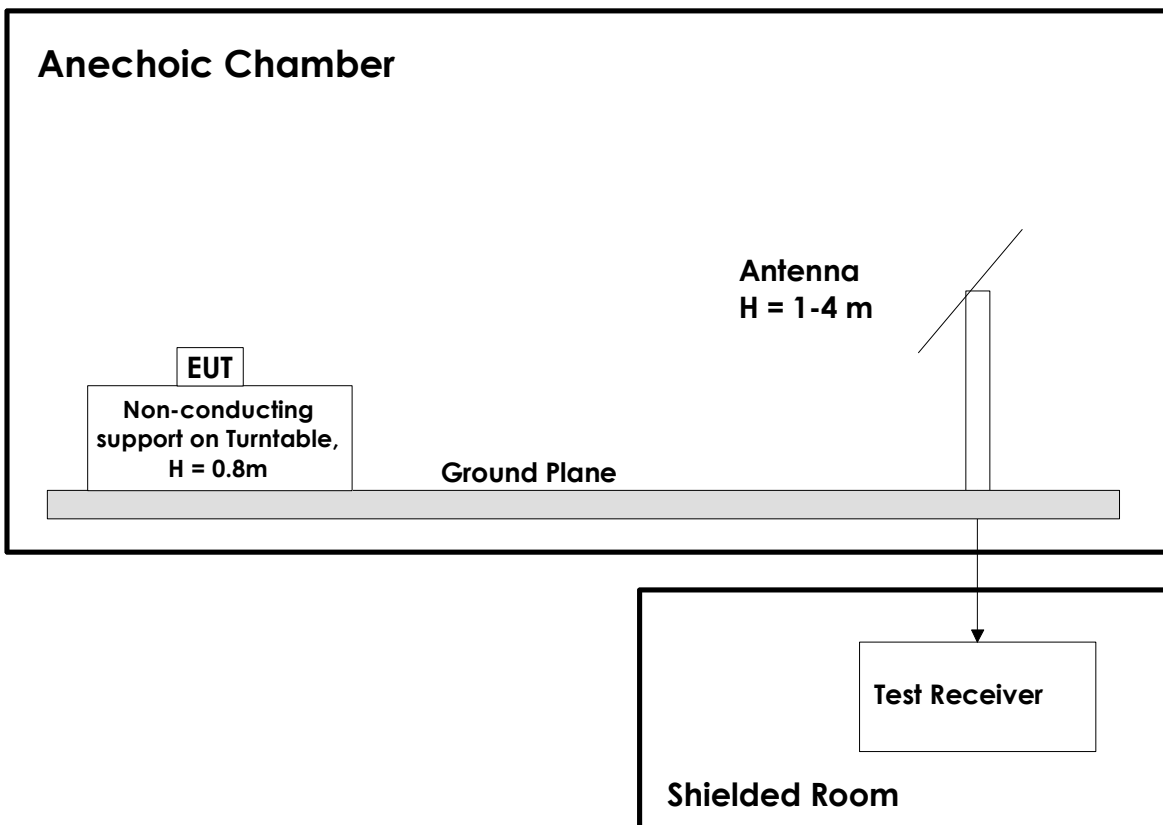
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	GPIBShot	2.7	Screenshots from R&S Spectrum Analyzers

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.

Revision history

Version	Date	Comment	Sign
01	2019.03.07	First Version	gns