

Test Report

Product	High Power Sigfox module for SIGFOX
Name and address of the applicant	Radiocrafts Sandakerveien 64, Norway
Name and address of the manufacturer	Radiocrafts Sandakerveien 64, Norway
Model	RC1692HP-SIG
Rating	3.6Vdc
Trademark	Radiocrafts
Serial number	/
Additional information	902 - 928MHz FHSS radio module
Tested according to	FCC Part 15.247 Frequency Hopping Transmitters / Digital Transmission Systems
Order number	312816
Tested in period	2016.08.10 - 2017.02.23
Issue date	2017.03.10
Name and address of the testing laboratory	 Instituttveien 6 Kjeller, Norway FCC No: 994405 IC OATS: 2040D-1 TEL: +47 22 96 03 30 FAX: +47 22 96 05 50
 Prepared by [G.Suhanthakumar]  Approved by [Frode Sveinsen]	
This report shall not be reproduced except in full without the written approval of Nemko. Opinions and interpretations expressed within this report are not part of the current accreditation. This report was originally distributed electronically with digital signatures. For more information contact Nemko.	

CONTENTS

1	INFORMATION	3
1.1	Test Item.....	3
1.2	Normal test condition	4
1.3	Test Engineer(s)	4
1.4	Description of modification for Modification Filing.....	4
1.5	Family List Rational	4
1.6	Antenna Requirement.....	4
1.7	Worst-Case Configuration and Mode.....	4
1.8	Comments	4
2	TEST REPORT SUMMARY	5
2.1	General.....	5
2.2	Test Summary	6
3	TEST RESULTS.....	7
3.1	Power Line Conducted Emissions	7
3.2	Channel Separation.....	10
3.3	Pseudorandom Hopping Algorithm	15
3.4	Occupancy Time.....	16
3.5	Occupied Bandwidth.....	21
3.6	Peak Power Output.....	25
3.7	Conducted Emissions at Antenna Connector	36
3.8	Spurious Emissions (Radiated).....	40
4	Measurement Uncertainty.....	83
5	LIST OF TEST EQUIPMENT.....	84
6	BLOCK DIAGRAM.....	85
6.1	Power Line Conducted Emission.....	85
6.2	Test Site Radiated Emission.....	85

1 INFORMATION

1.1 Test Item

Name :	Radio Module for SIGFOX System
FCC ID :	Y2NRC1692HP-SIG
Industry Canada ID :	N/A
Model/version :	RC1692HP-SIG
Serial number :	/
Hardware identity and/or version:	2.10
Software identity and/or version :	2.00
Frequency Range :	FCC band: 902 - 928MHz Hopping mode 1: 902.1375 - 904.6625 MHz Hopping mode 2: 920.1375 - 922.6625 MHz
Tunable Bands :	None
Number of Channels :	54 in each hopping mode
Operating Modes :	TX & RX
Type of Modulation :	Transmit : Single sideband with fully suppressed carrier and subcarrier is modulated with 600 bps BPSK, (ITU modulation acronym is: 25KJ2D) Receive: 2GFSK
User Frequency Adjustment :	None
Rated Output Power :	0.32W
Type of Power Supply :	3.6Vdc
Antenna Connector :	RP-SMA (monopole , quarter wave antenna type W915-RS)
Antenna Diversity Supported :	None
Desktop Charger :	N/A

Description of Test Item

Test item is RC1692HP-SIG module soldered on a carrier board.

Theory of Operation

Separate document

1.2 Normal test condition

Temperature: 20 - 24 °C
Relative humidity: 20 - 50 %
Normal test voltage: 3.6 V DC

The values are the limit registered during the test period.

1.3 Test Engineer(s)

G.Suhanthakumar

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: RP-SMA

Ref. FCC §15.203

1.7 Worst-Case Configuration and Mode

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

1.8 Comments

The measurements were done with the EUT powered by 3.6Vdc. It was checked that power variations between 85% and 115% did not make the test results non-compliance.

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 the purpose of demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247.

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 the FCC and Industry Canada.

☒ New Submission

☒ Production Unit

☐ Class II Permissive Change

☐ Pre-production Unit

DSS 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".

Nemko Group authorizes the above named company to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any reproduction of parts of this report requires approval in writing from Nemko Group.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Nemko Group accepts no responsibility for damages suffered by any third party as a result of decisions made or actions based on this report.

2.2 Test Summary

Name of test	FCC Part 15 reference	Result
Supply Voltage Variations	15.31(e)	Complies
Number of Operating Frequencies	15.31(m)	Complies
Antenna Requirement	15.203	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	Complies
Channel Separation	15.247(a)(1)(i)	Complies
Pseudorandom Hopping Algorithm	15.247(a)(1)(i)	Complies
Time of Occupancy	15.247(a)(1)(i)	Complies
Occupied Bandwidth	15.247(a)(1)(i)	
Peak Power Output	15.247(b)	Complies
Power Spectral Density	15.247(d)	N/A ¹
Spurious Emissions (Antenna Conducted)	15.247(c)2(d)	Complies
Spurious Emissions (Radiated)	15.247(c)2(d) 15.109(a) 15.209(a)	Complies

N/A¹:FHSS system

3 TEST RESULTS

3.1 Power Line Conducted Emissions

Para. No.: 15.207 (a)

Test Performed By: G.Suhandhakumar

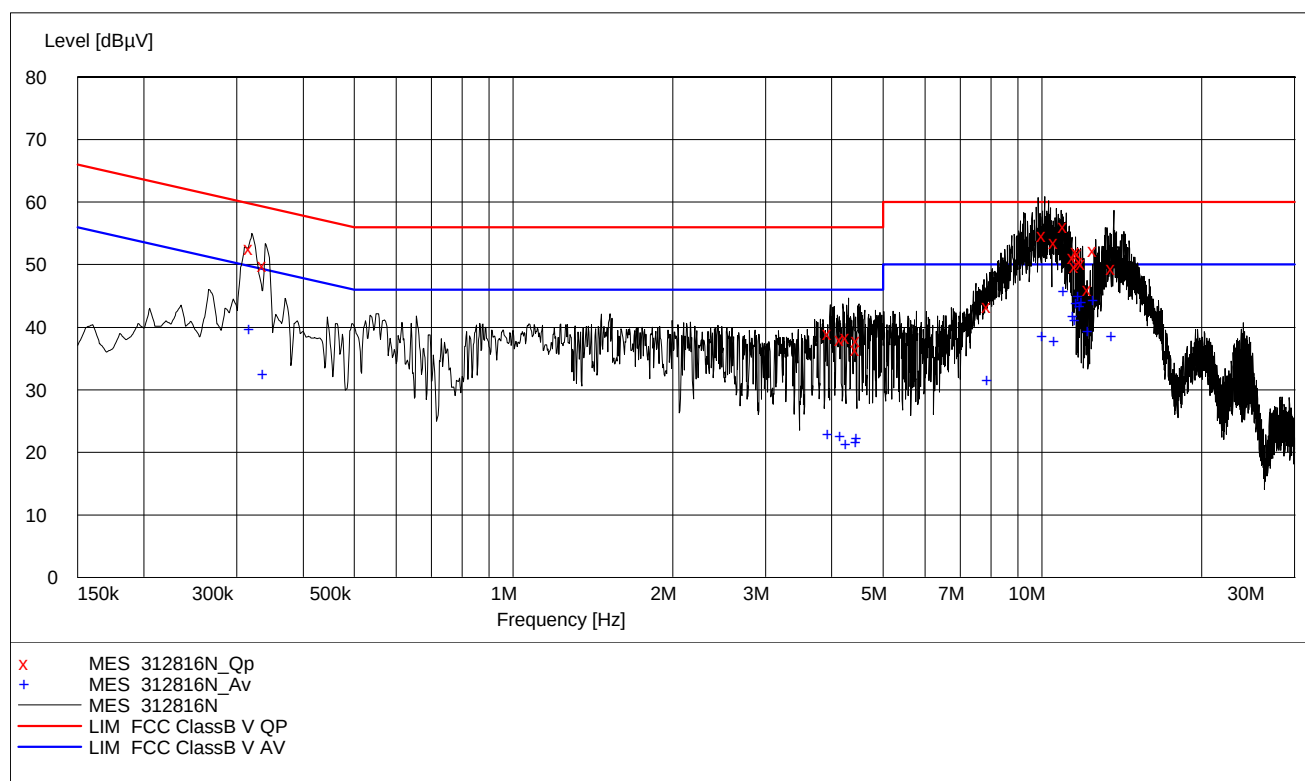
Date of Test: 2016.08.10

Measurement procedure: ANSI C63.4-2014 using 50 μ H/50 ohms LISN.

Test Results: Complies.

Measurement Data: See attached graph, (Peak detector).

AC/DC adapter model: PowerPax Model SW4305



QP detector:

Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.320000	52.60	10.50	59.70	7.10	QP	L1	Pass
0.340000	49.90	10.50	59.20	9.30	QP	N	Pass
3.970000	39.00	10.40	56.00	17.00	QP	N	Pass
4.200000	38.00	10.50	56.00	18.00	QP	N	Pass
4.300000	38.40	10.50	56.00	17.60	QP	L1	Pass
4.495000	36.50	10.50	56.00	19.50	QP	N	Pass
4.510000	37.90	10.50	56.00	18.10	QP	L1	Pass
7.970000	43.30	10.60	60.00	16.70	QP	L1	Pass
10.110000	54.70	10.70	60.00	5.30	QP	N	Pass
10.645000	53.60	10.70	60.00	6.40	QP	N	Pass
11.115000	56.10	10.70	60.00	3.90	QP	N	Pass
11.555000	51.20	10.70	60.00	8.80	QP	N	Pass
11.645000	49.70	10.70	60.00	10.30	QP	N	Pass
11.735000	52.10	10.70	60.00	7.90	QP	N	Pass
11.825000	51.90	10.70	60.00	8.10	QP	N	Pass
11.915000	50.60	10.70	60.00	9.40	QP	N	Pass
12.000000	50.30	10.70	60.00	9.70	QP	N	Pass
12.355000	46.00	10.70	60.00	14.00	QP	N	Pass
12.620000	52.30	10.70	60.00	7.70	QP	N	Pass
13.655000	49.50	10.80	60.00	10.50	QP	N	Pass

AV detector:

Frequency [MHz]	Level [dBuV]	Af [dB]	Limit [dBuV]	Margin [dB]	Det	Position	Verdict [Pass/Fail]
0.320000	39.60	10.50	49.70	10.10	AV	L1	Pass
0.340000	32.50	10.50	49.20	16.70	AV	N	Pass
3.970000	22.90	10.40	46.00	23.10	AV	N	Pass
4.200000	22.50	10.50	46.00	23.50	AV	N	Pass
4.300000	21.30	10.50	46.00	24.70	AV	L1	Pass
4.495000	21.50	10.50	46.00	24.50	AV	N	Pass
4.510000	22.20	10.50	46.00	23.80	AV	L1	Pass
7.970000	31.60	10.60	50.00	18.40	AV	L1	Pass
10.110000	38.60	10.70	50.00	11.40	AV	N	Pass
10.645000	37.80	10.70	50.00	12.20	AV	N	Pass
11.115000	45.70	10.70	50.00	4.30	AV	N	Pass
11.555000	41.70	10.70	50.00	8.30	AV	N	Pass
11.645000	41.10	10.70	50.00	8.90	AV	N	Pass
11.735000	43.80	10.70	50.00	6.20	AV	N	Pass
11.825000	45.00	10.70	50.00	5.00	AV	N	Pass
11.915000	43.30	10.70	50.00	6.70	AV	N	Pass
12.000000	44.00	10.70	50.00	6.00	AV	N	Pass
12.355000	39.30	10.70	50.00	10.70	AV	N	Pass
12.620000	44.40	10.70	50.00	5.60	AV	N	Pass
13.655000	38.50	10.80	50.00	11.50	AV	N	Pass

3.2 Channel Separation

Para. No.: 15.247 (a)(1)(i)

Test Performed By: G.Suwanthakumar

Date of Test: 2017.02.14

Test Results: **Complies**

Measurement Data:

Hopping mode 1:

Channel Separation:	25 kHz
20 dB Bandwidth of hopping channel:	21.9 kHz
Nominal value for Channel Separation	25.026 kHz

Hopping mode 2:

Channel Separation:	25 kHz
20 dB Bandwidth of hopping channel:	21.8 kHz
Nominal value for Channel Separation	25.032 kHz

Nominal channel separation is obtain from first plot given in page 11 for hopping mode 1 and from first plot in page 13 for hopping mode 2.

f.eg.

Channel bandwidth for 5 channel is 125.160kHz,

Channel separation is $125.130\text{kHz}/5 = 25.026\text{kHz}$ in hopping mode 1

RF channel has no influence on 20 dB bandwidth.

See attached plots

Requirement:

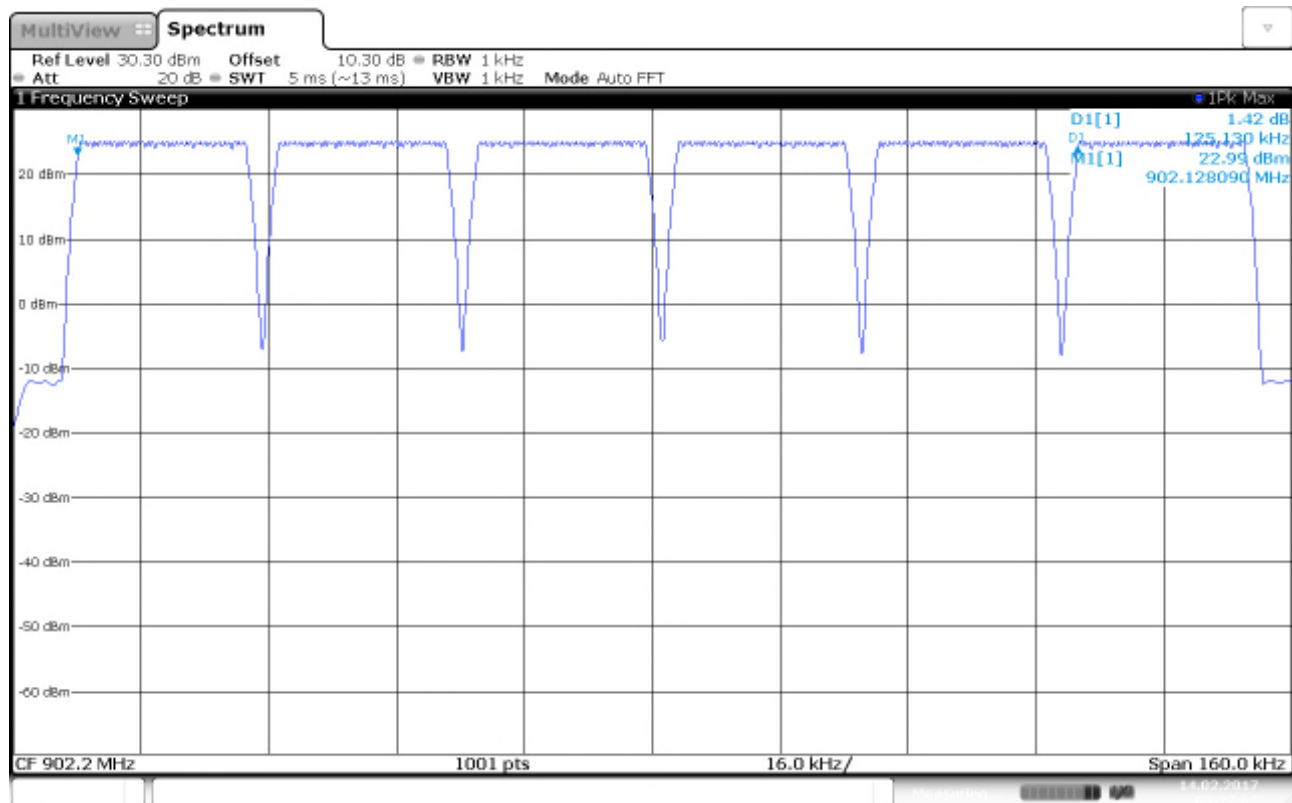
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

or:

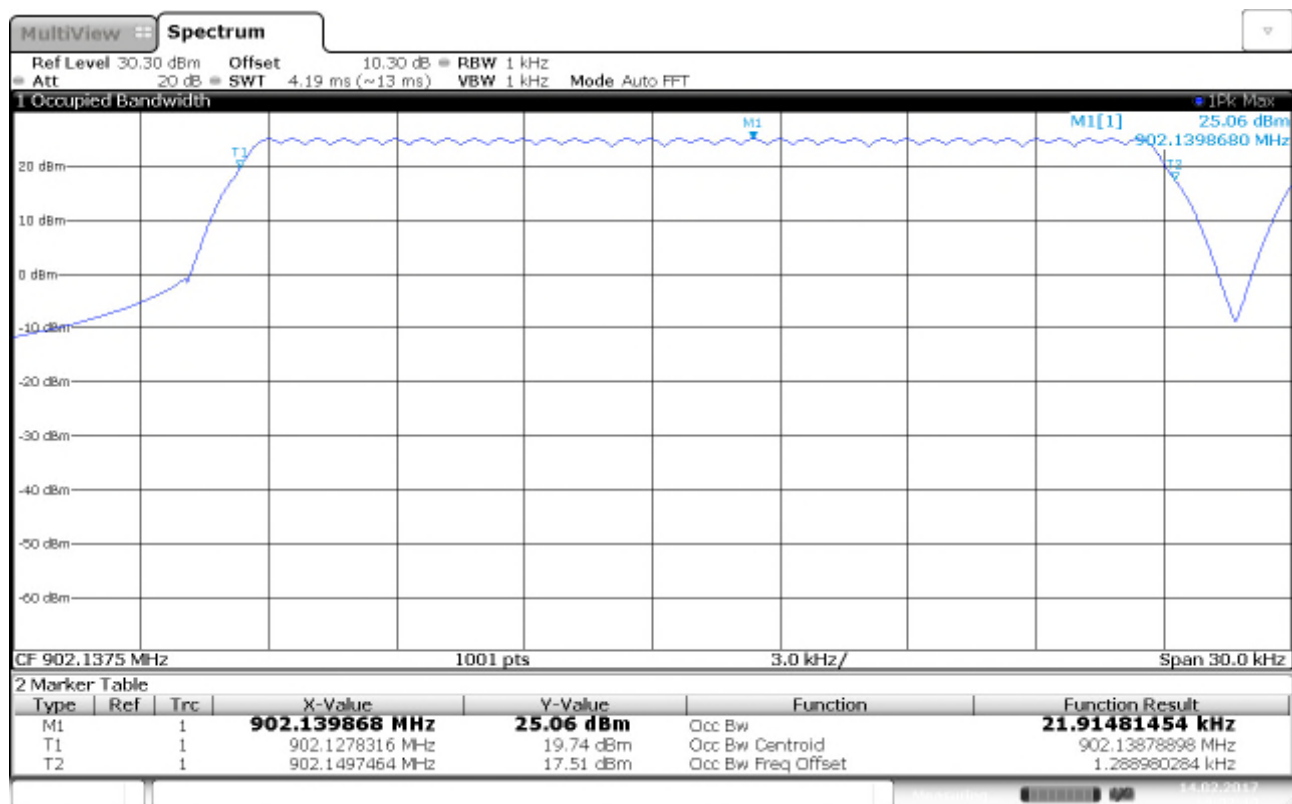
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the system operates with an output power no greater than 125 mW.

No requirements for Digital Transmission Systems.

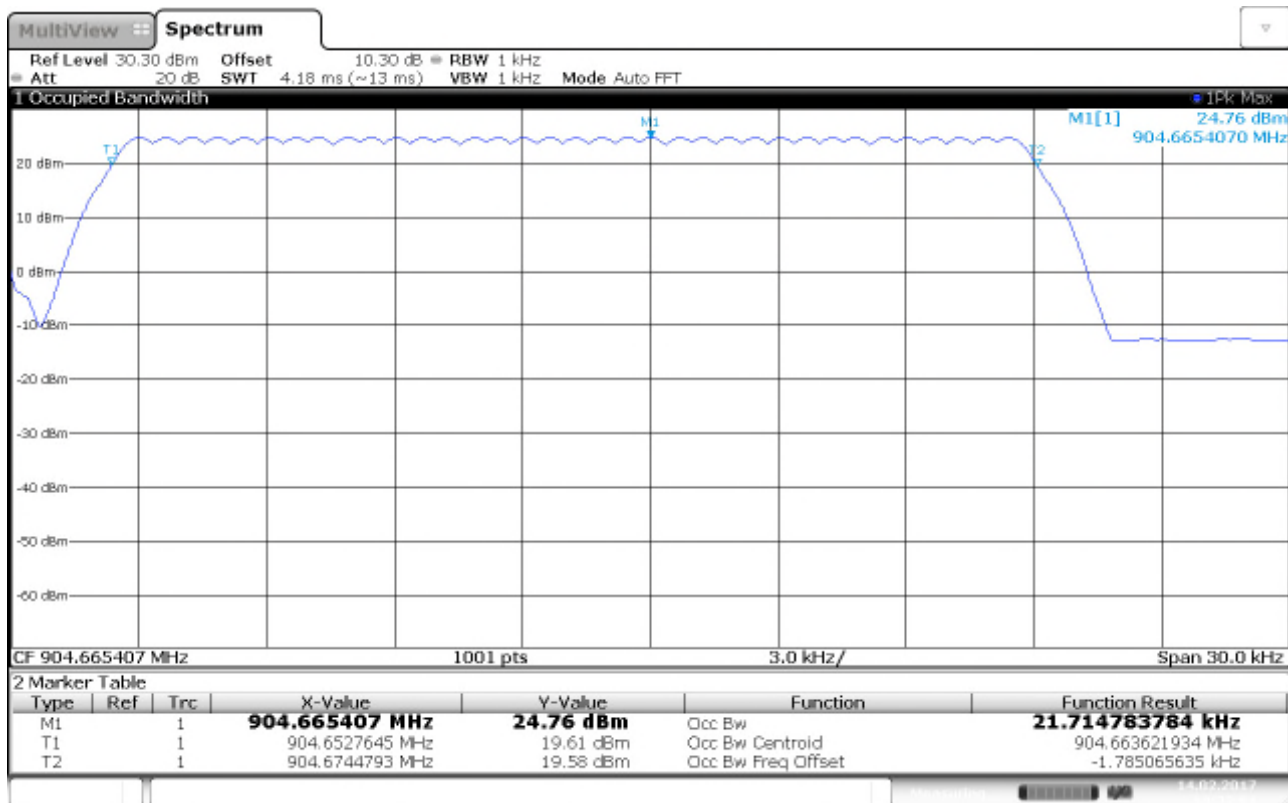
Hopping mode 1:



Channel Separation

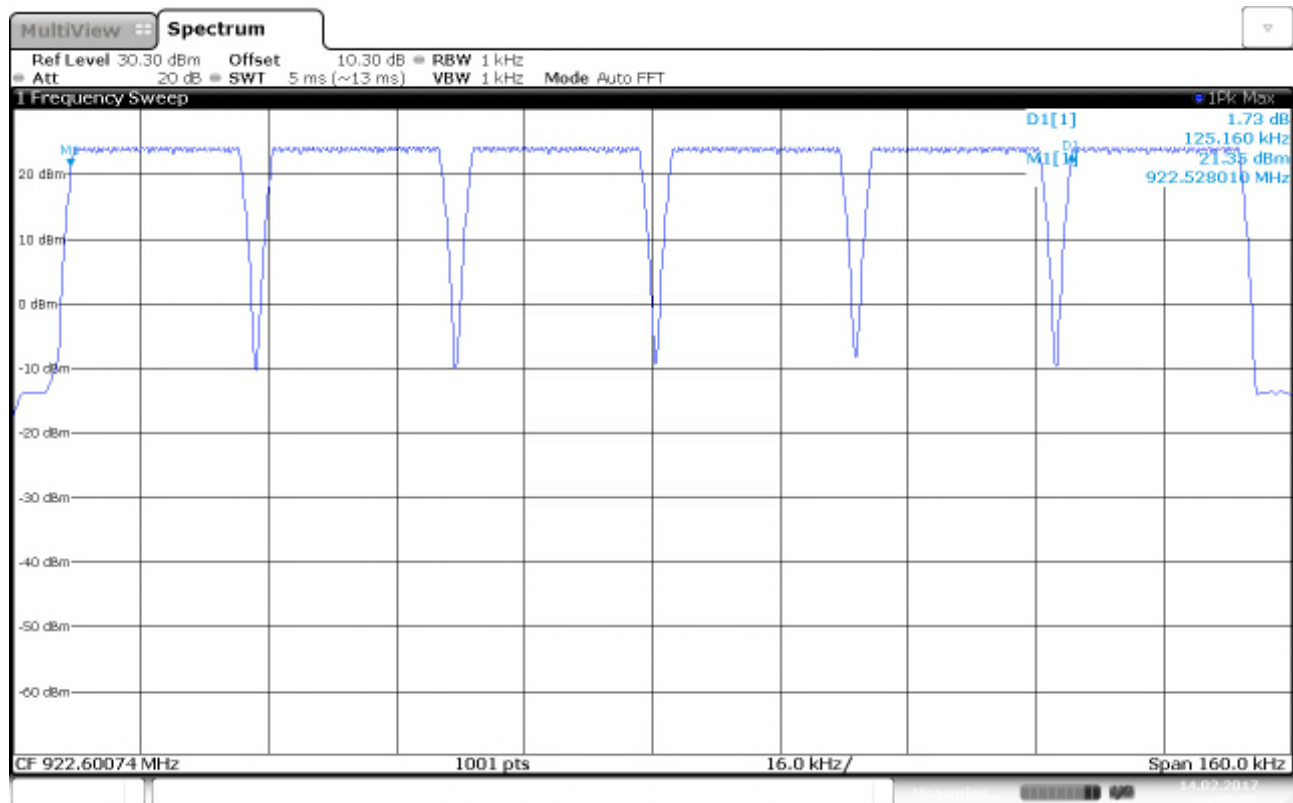


20dB Bandwidth, 902.1375 MHz

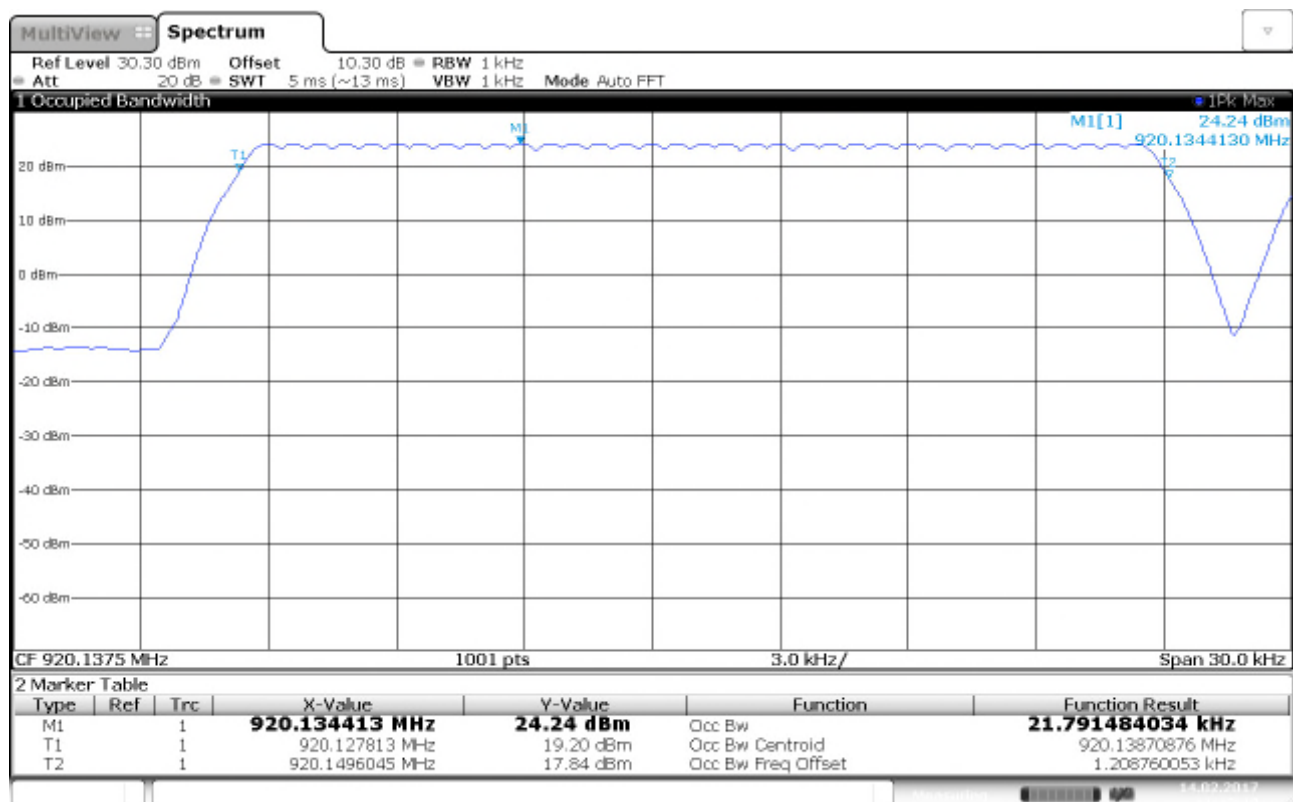


20dB Bandwidth, 904.6625 MHz

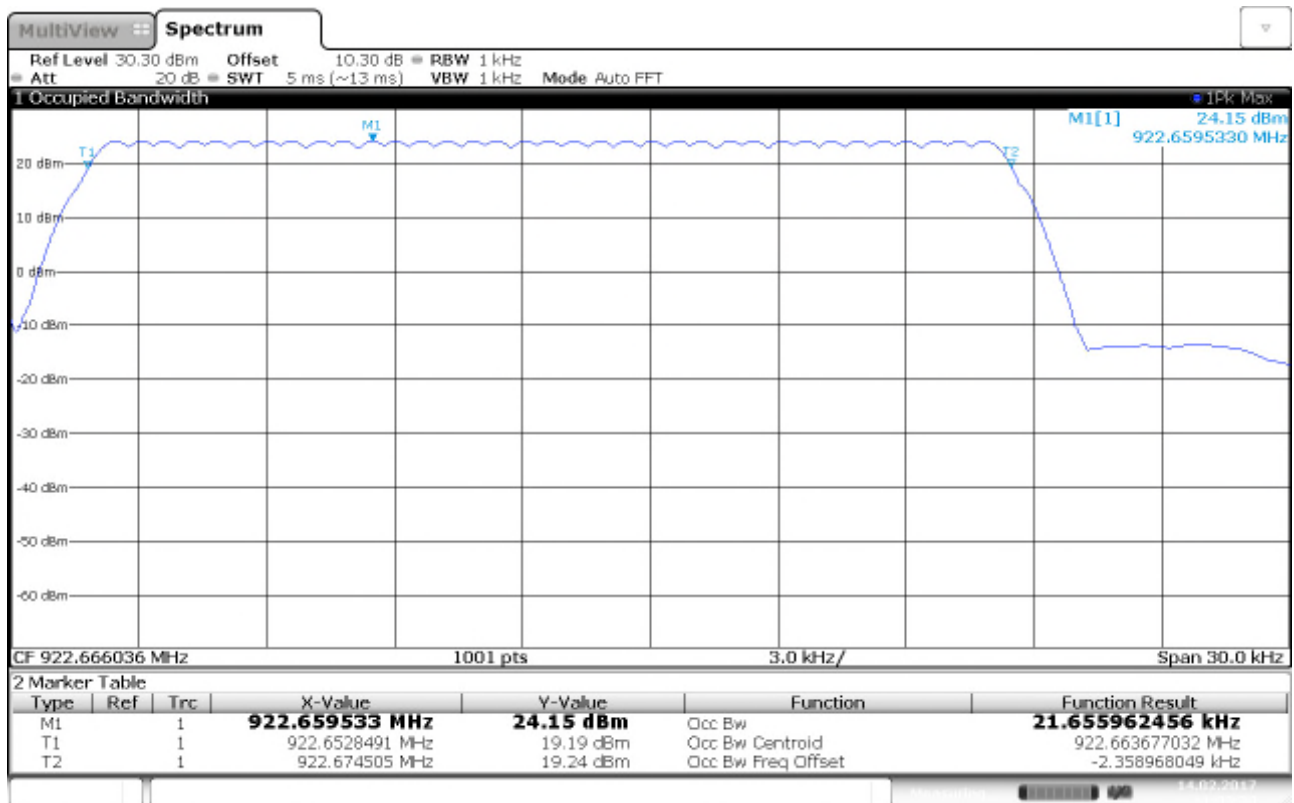
Hopping mode 2:



Channel Separation



20dB Bandwidth, 920.1375 MHz



20dB Bandwidth, 922.6625 MHz

3.3 Pseudorandom Hopping Algorithm

Para. No.: 15.247 (a)(1)(i)

Test Results: Complies

Measurement Data: /

Requirements:

The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies. Each frequency must be used equally by the transmitter.

No requirements for Digital Transmission Systems.

Base Table Hopping Sequence

The hopping sequence is described in the document RC1692HP-SIG_Theory_OF_Operation_Public

There are 2 lists of frequency hopping channels.

One for the low part of the band: (902.1375-904.6625MHz)

Micro Channel 1 (MHz)	Micro Channel 2 (MHz)	Micro Channel 3 (MHz)	Micro Channel 4 (MHz)	Micro Channel 5 (MHz)	Micro Channel 6 (MHz)
902.1375	902.1625	902.1875	902.2125	902.2375	902.2625
902.4375	902.4625	902.4875	902.5125	902.5375	902.5625
902.7375	902.7625	902.7875	902.8125	902.8375	902.8625
903.0375	903.0625	903.0875	903.1125	903.1375	903.1625
903.3375	903.3625	903.3875	903.4125	903.4375	903.4625
903.6375	903.6625	903.6875	903.7125	903.7375	903.7625
903.9375	903.9625	903.9875	904.0125	904.0375	904.0625
904.2375	904.2625	904.2875	904.3125	904.3375	904.3625
904.5375	904.5625	904.5875	904.6125	904.6375	904.6625

Another for the high part of the band: (920.1375-922.6625MHz).

Micro Channel 1 (MHz)	Micro Channel 2 (MHz)	Micro Channel 3 (MHz)	Micro Channel 4 (MHz)	Micro Channel 5 (MHz)	Micro Channel 6 (MHz)
920.1375	920.1625	920.1875	920.2125	920.2375	920.2625
920.4375	920.4625	920.4875	920.5125	920.5375	920.5625
920.7375	920.7625	920.7875	920.8125	920.8375	920.8625
921.0375	921.0625	921.0875	921.1125	921.1375	921.1625
921.3375	921.3625	921.3875	921.4125	921.4375	921.4625
921.6375	921.6625	921.6875	921.7125	921.7375	921.7625
921.9375	921.9625	921.9875	922.0125	922.0375	922.0625
922.2375	922.2625	922.2875	922.3125	922.3375	922.3625
922.5375	922.5625	922.5875	922.6125	922.6375	922.6625

3.4 Occupancy Time

Para. No.: 15.247 (a)(1)(i)

Test Performed By: G.Suwanthakumar

Date of Test: 2017.02.14

Test Results: Complies

Measurement Data:

Hopping mode 1:

	Ch 902.1375MHz	Ch 904.6625MHz
Number of RF Channels:	54	54
Maximum Length of RF Burst pr. channel	350.80 ms	350.04 ms
Time between RF Burst on same RF Channel	50.0948 s	47.5200 s
Time of Occupancy	0.151 s	0.159 s

Hopping Mode 1:

Ch902.1375MHz; Time of occupancy: $(0.3508 \times 0.4 \times 54) / 50.0948 = 0.151s$

Ch904.6625MHz; Time of occupancy: $(0.35004 \times 0.4 \times 54) / 47.52 = 0.159s$

Hopping mode 2:

	Ch 920.1375MHz	Ch 922.6625MHz
Number of RF Channels:	54	54
Maximum Length of RF Burst pr. channel	350.28 ms	350.40 ms
Time between RF Burst on same RF Channel	47.5793 s	47.8200 s
Time of Occupancy	0.159 s	0.158 s

Hopping Mode 2:

Ch920.1375MHz; Time of occupancy: $(0.35028 \times 0.4 \times 54) / 47.5793 = 0.159s$

Ch922.6625MHz; Time of occupancy: $(0.3504 \times 0.4 \times 54) / 47.8200 = 0.158s$

See attached graph.

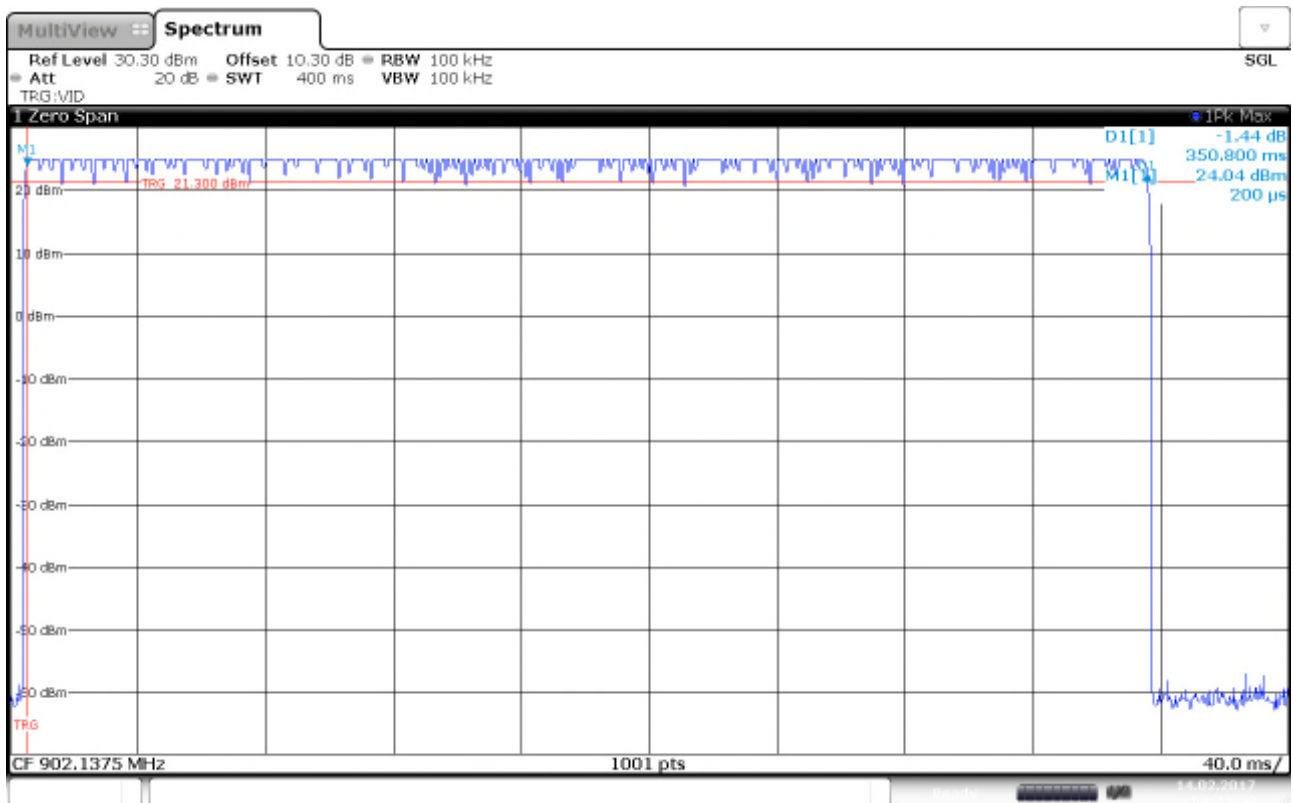
Requirements:

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

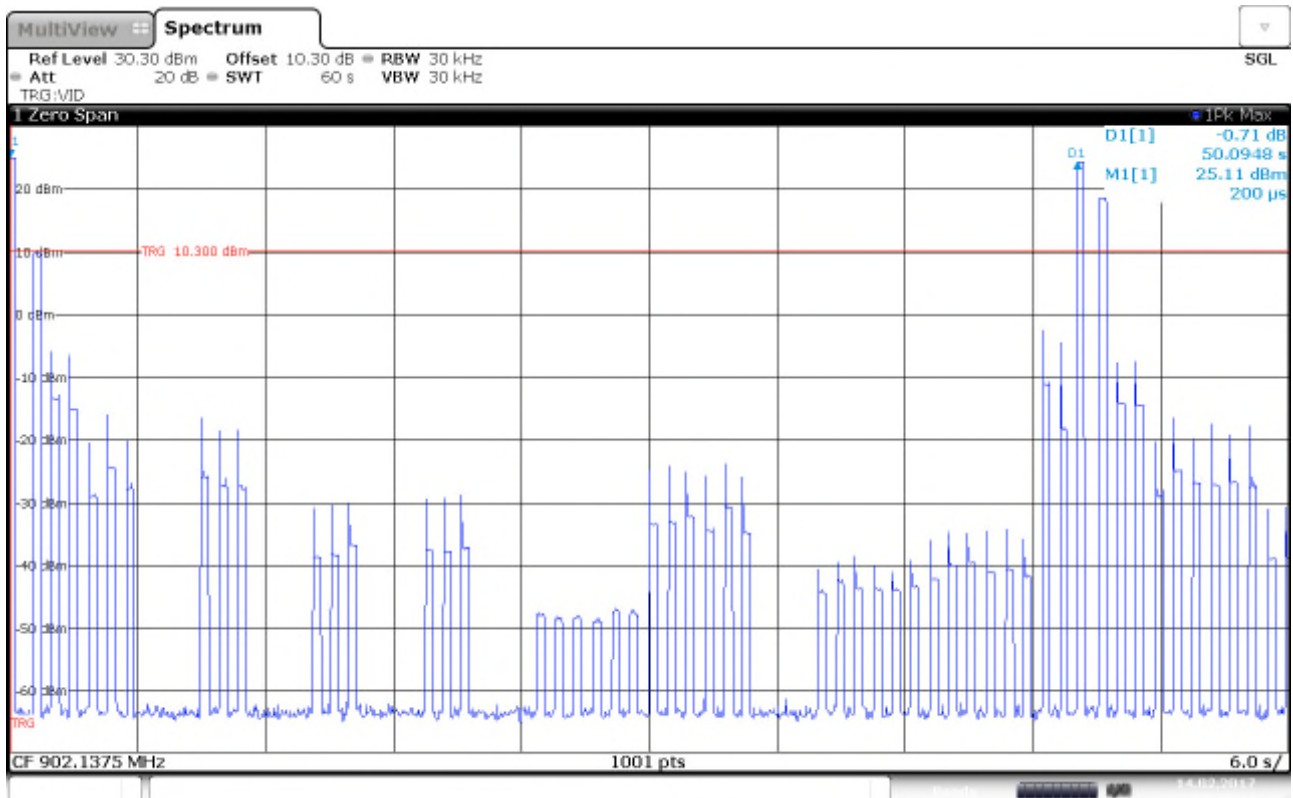
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

No requirements for Digital Transmission Systems.

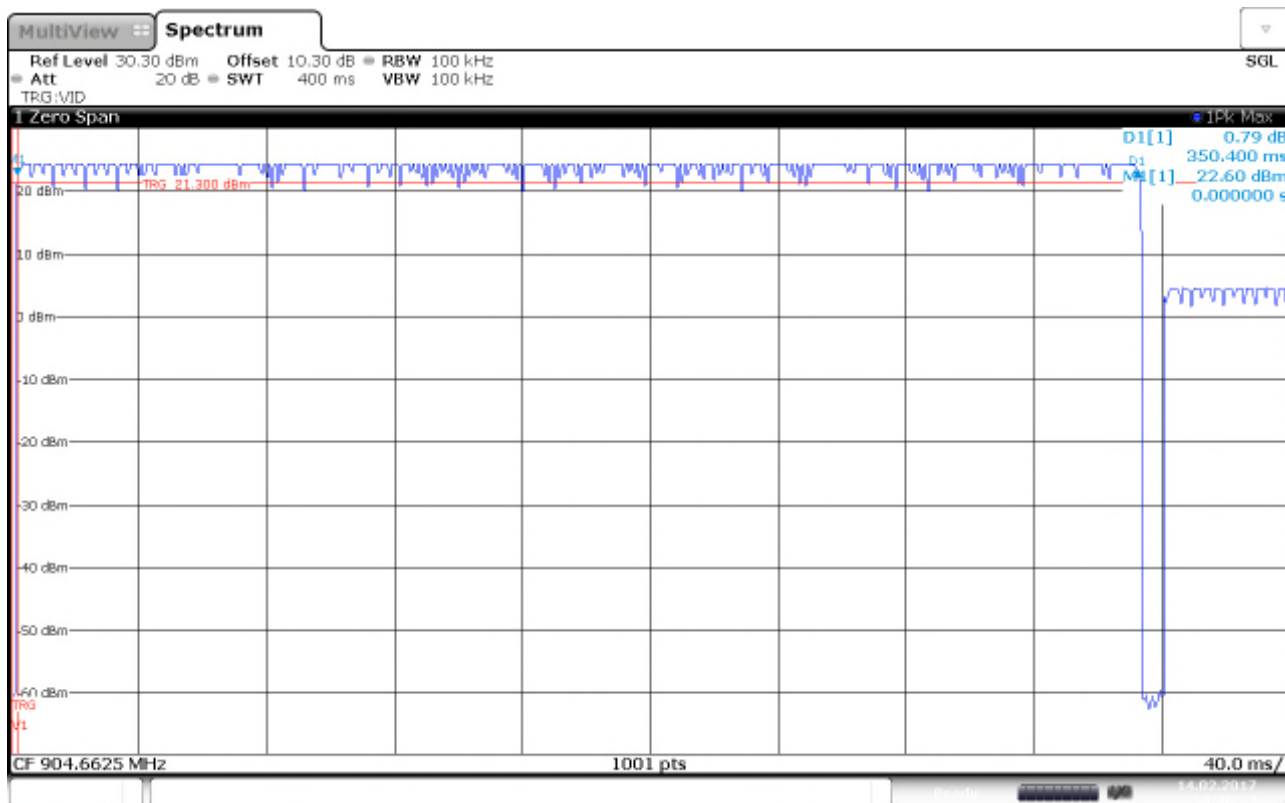
Hopping mode 1:



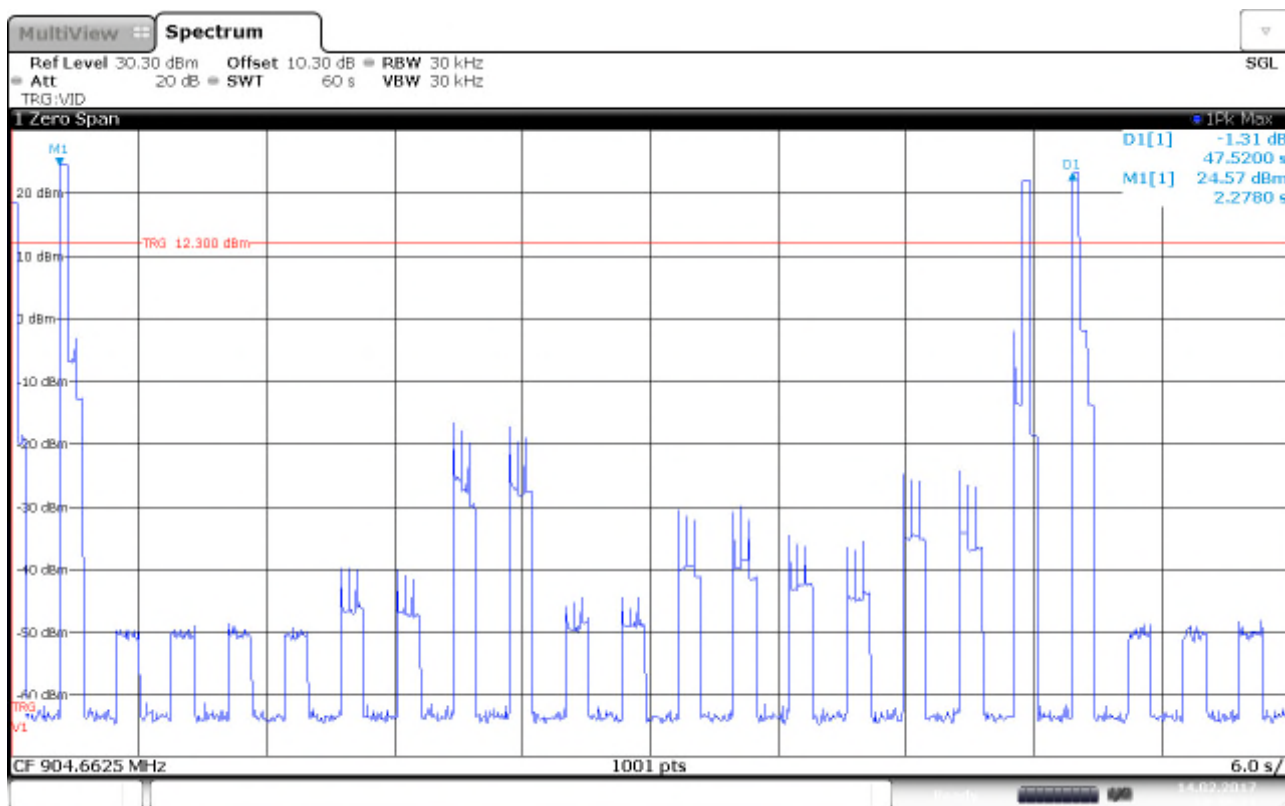
Burst Length, ch902.1375MHz



Time between each burst, ch902.1375MHz

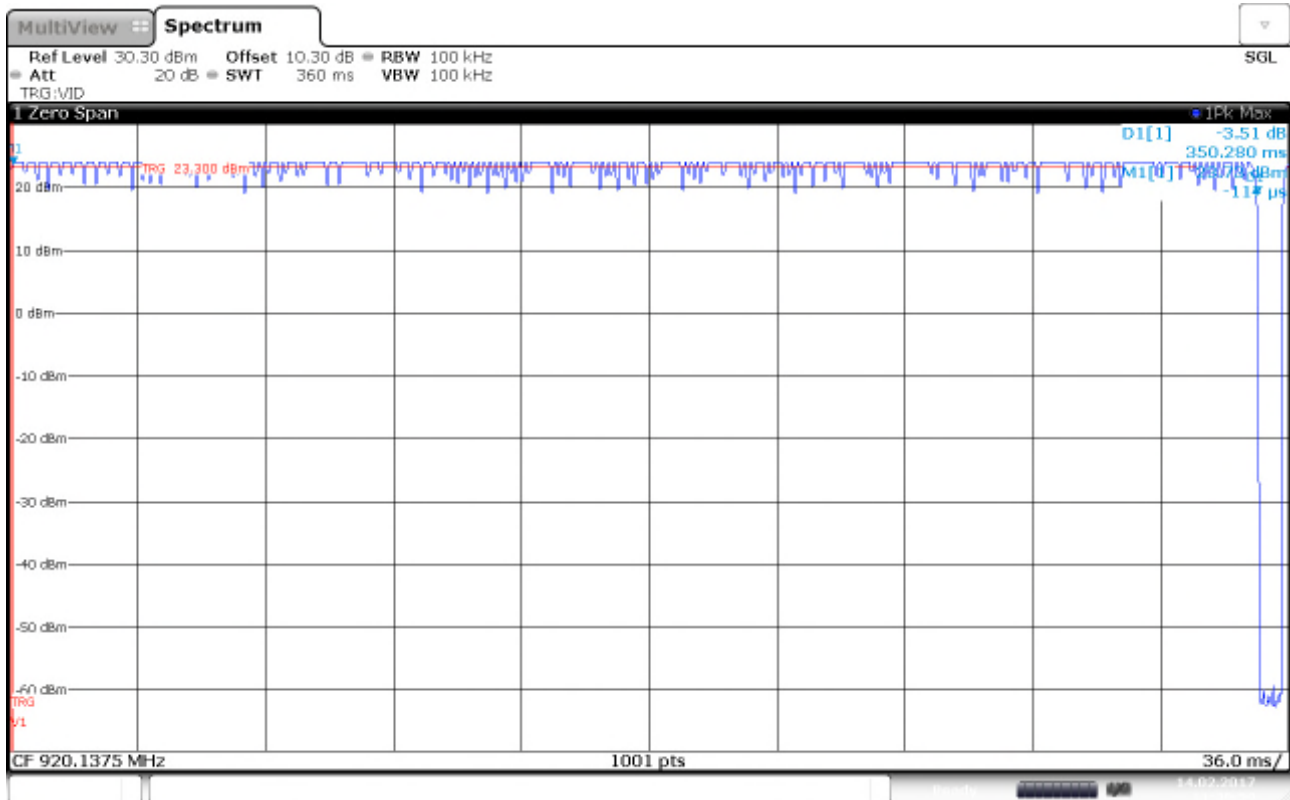


Burst Length, ch904.6625MHz

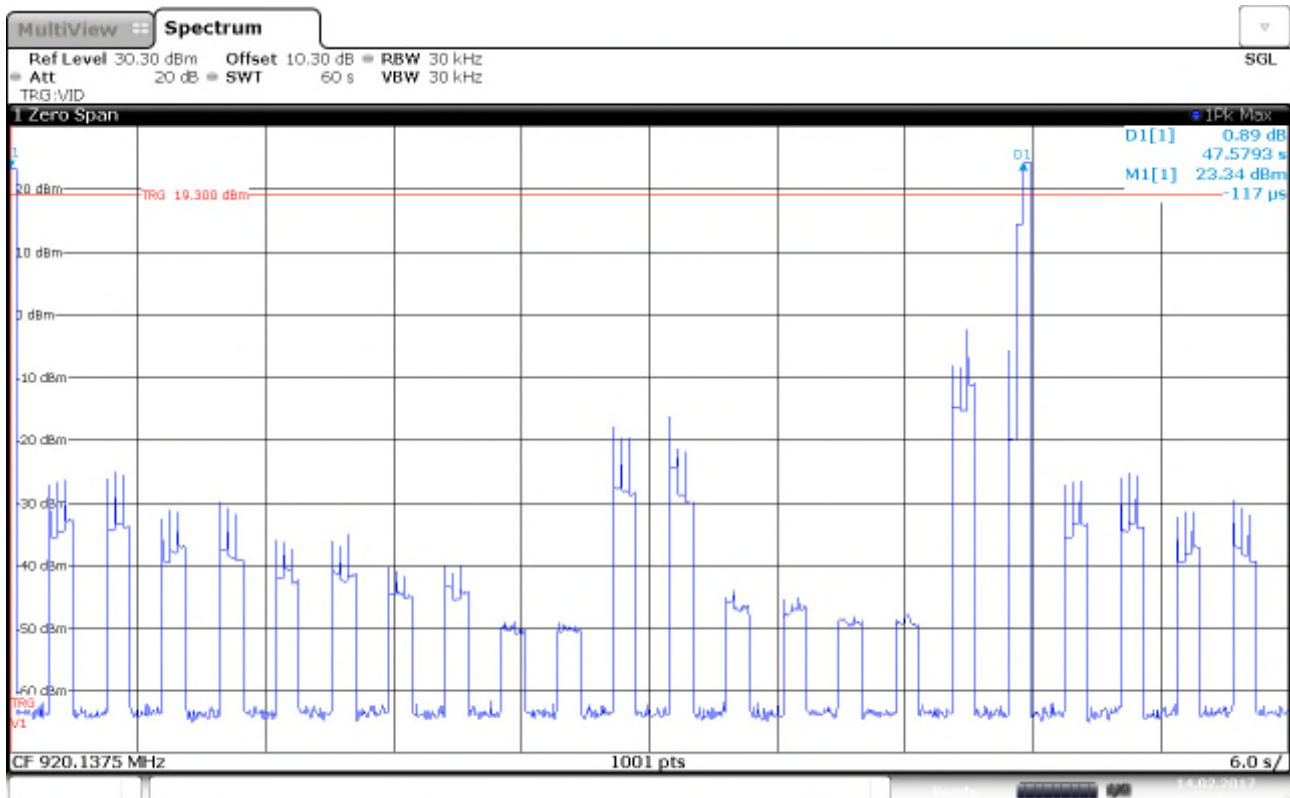


Time between each burst, ch904.6625MHz

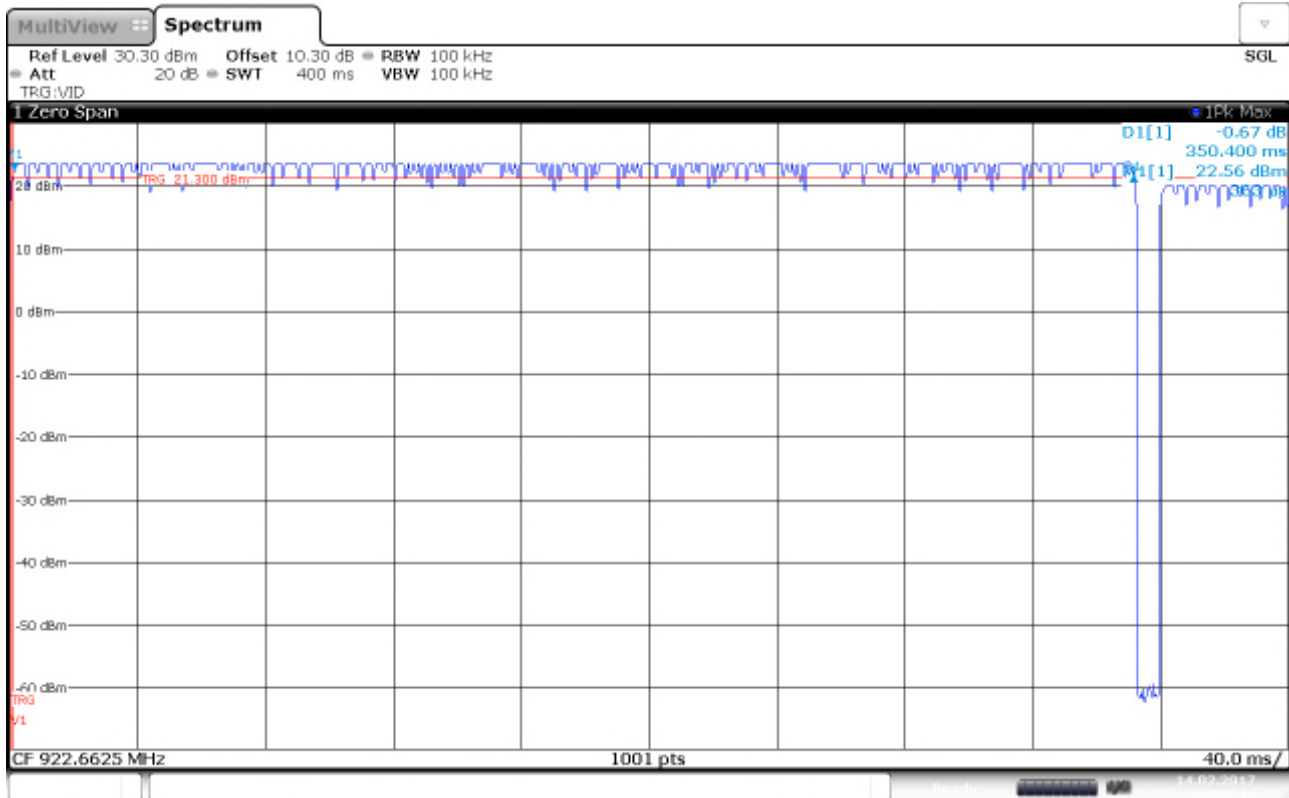
Hopping mode 2:



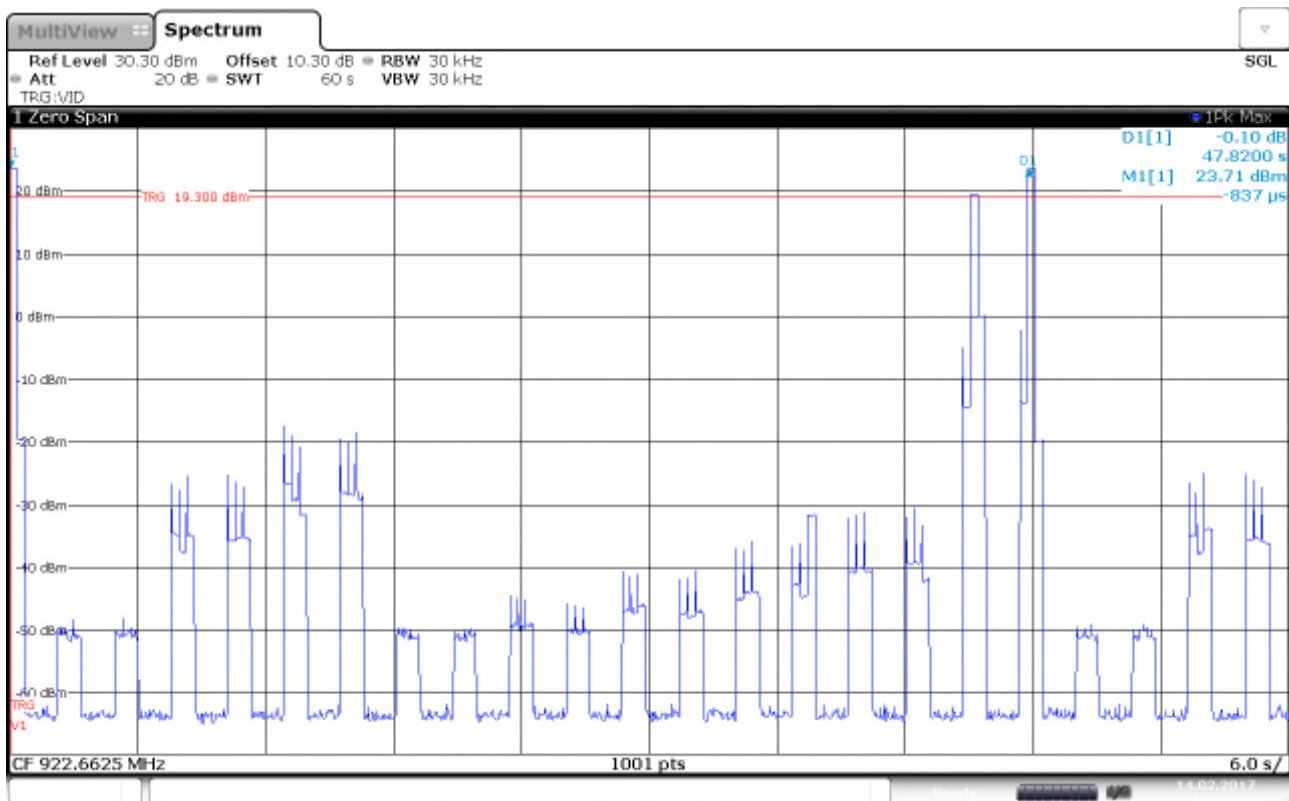
Burst Length, ch920.1375MHz



Time between each burst, ch920.1375MHz



Burst Length, ch922.6625MHz



Time between each burst, ch922.6625MHz

3.5 Occupied Bandwidth

Para. No.: 15.247 (a)(1)(i) (iii)

Test Performed By: G.Suwanthakumar

Date of Test: 2017.02.14

Test Results: Complies

Measurement Data:

Hopping mode 1:

Number of RF Channels in use:	9x6 = 54
Channel Centre Frequencies:	902 - 905 MHz
99% BW Measured , ch902.1375MHz	21.91 kHz
99% BW Measured , ch904.6625MHz	21.71 kHz

The first plot in page 22 "RF channels in use in hopping mode 1" consists of 9 groups of hopping channels and each group contains 6 hopping channels. This 6 hopping channels are zoomed in page 11 first plot.

Hopping mode 2:

Number of RF Channels in use:	9x6 = 54
Channel Centre Frequencies:	920 - 928 MHz
99% BW Measured , ch920.1375MHz	21.79 kHz
99% BW Measured , ch922.6625MHz	21.66 kHz

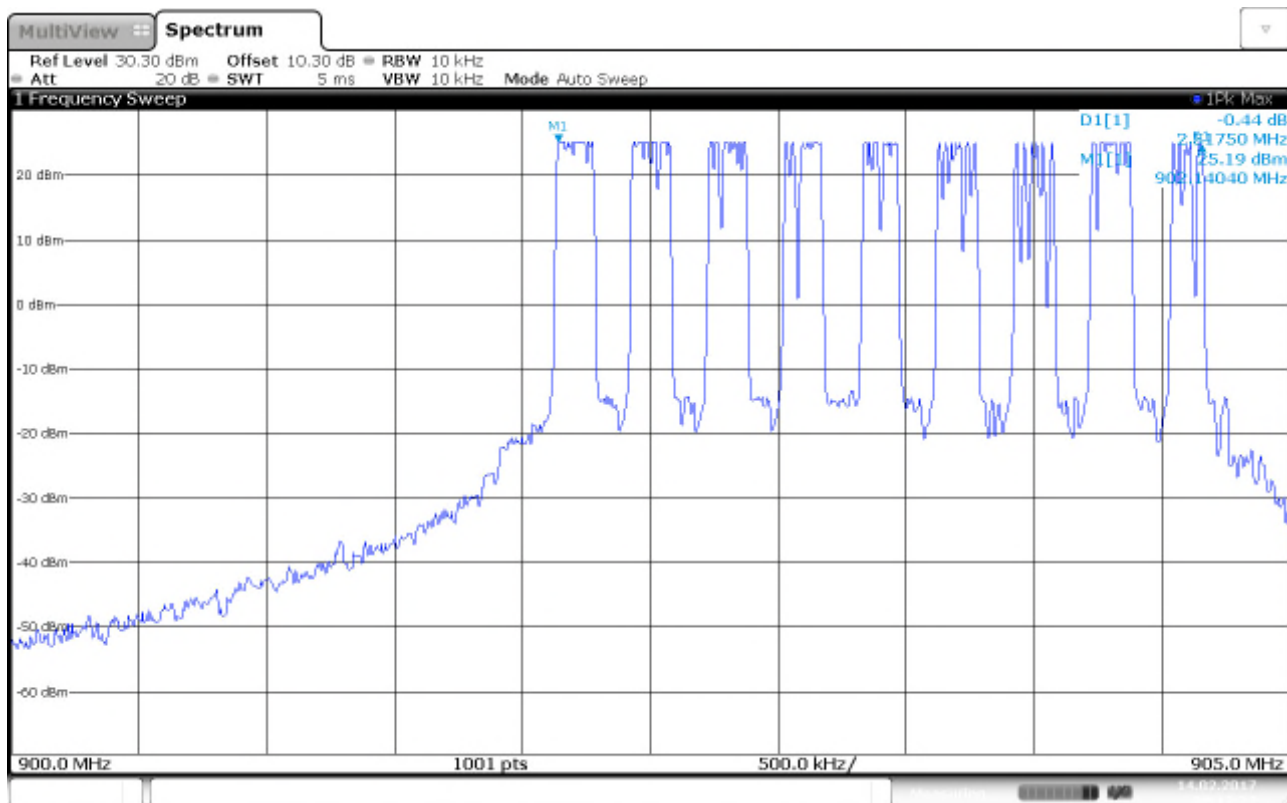
The first plot in page 23 "RF channels in use in hopping mode 2" consists of 9 groups of hopping channels and each group contains 6 hopping channels. This 6 hopping channels are zoomed in page 13 first plot.

See attached plots.

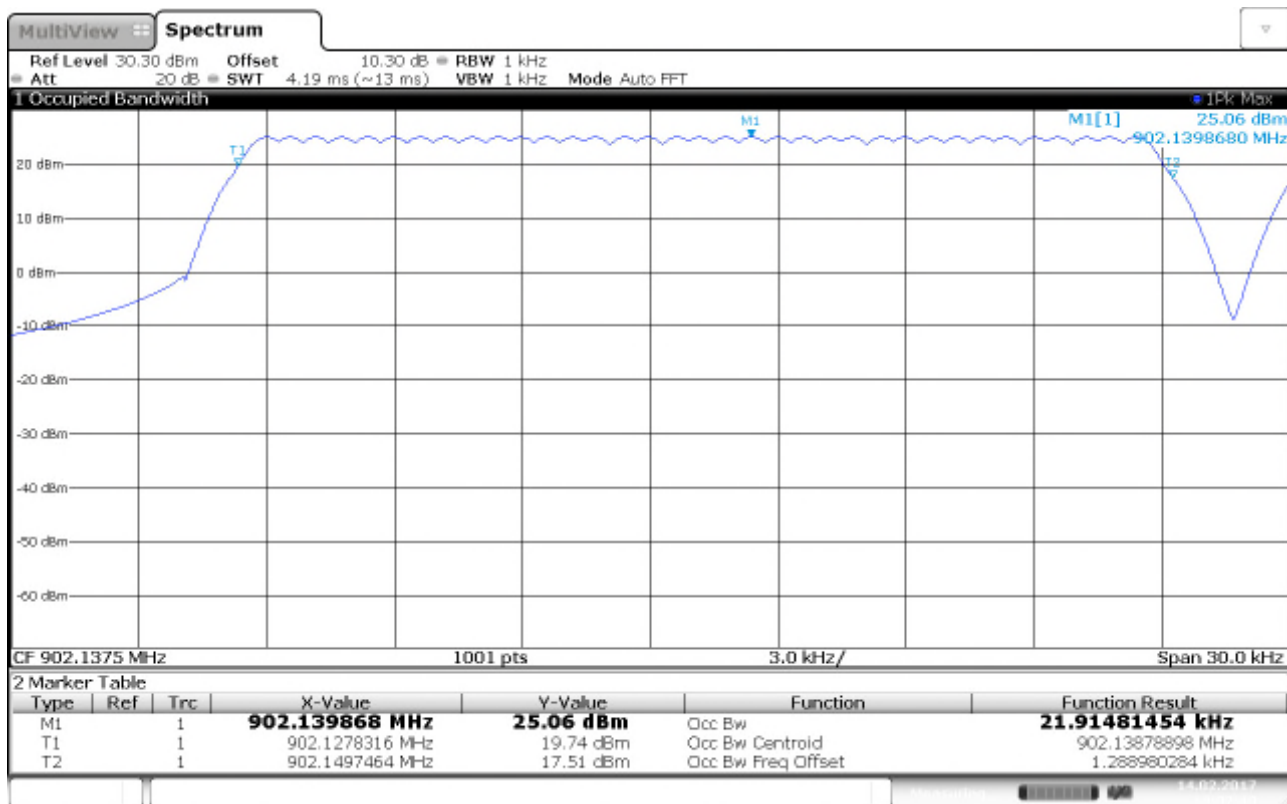
Requirements:

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

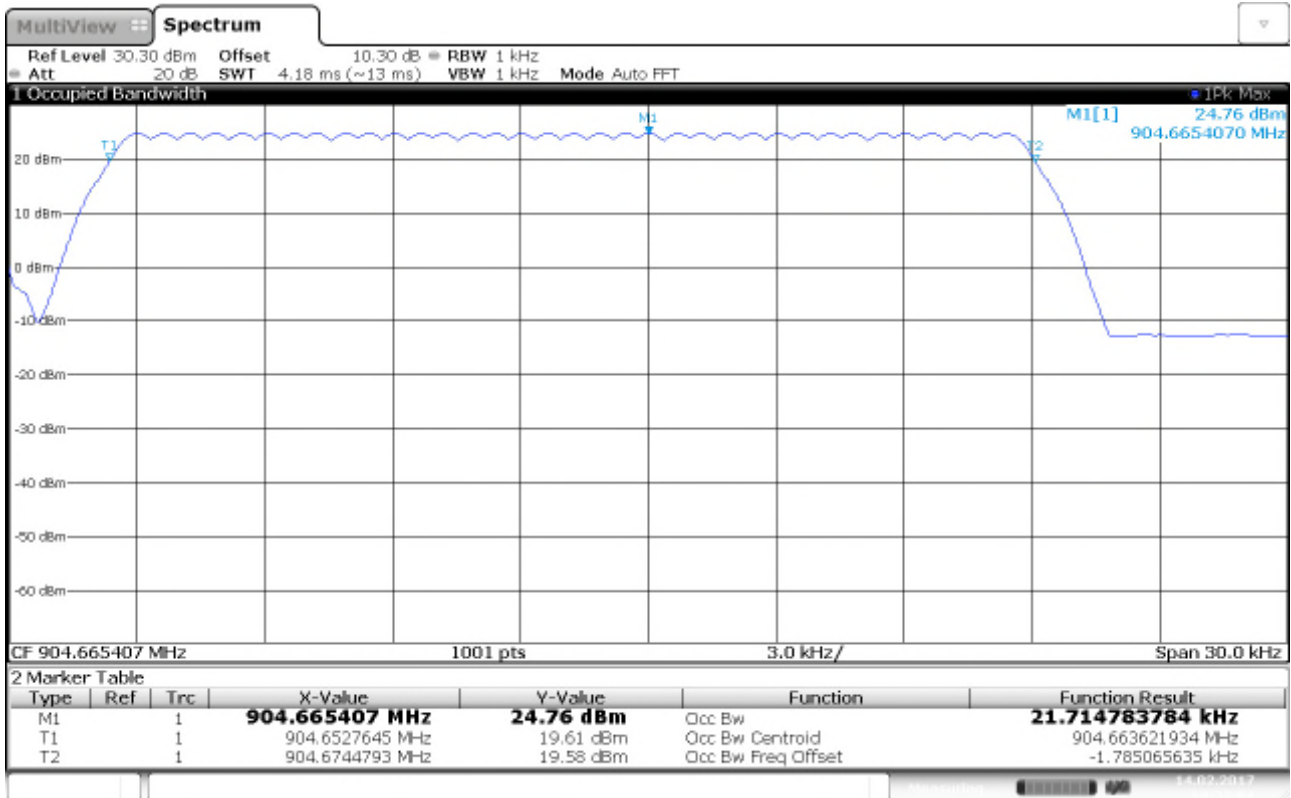
No requirements for Digital Transmission Systems.



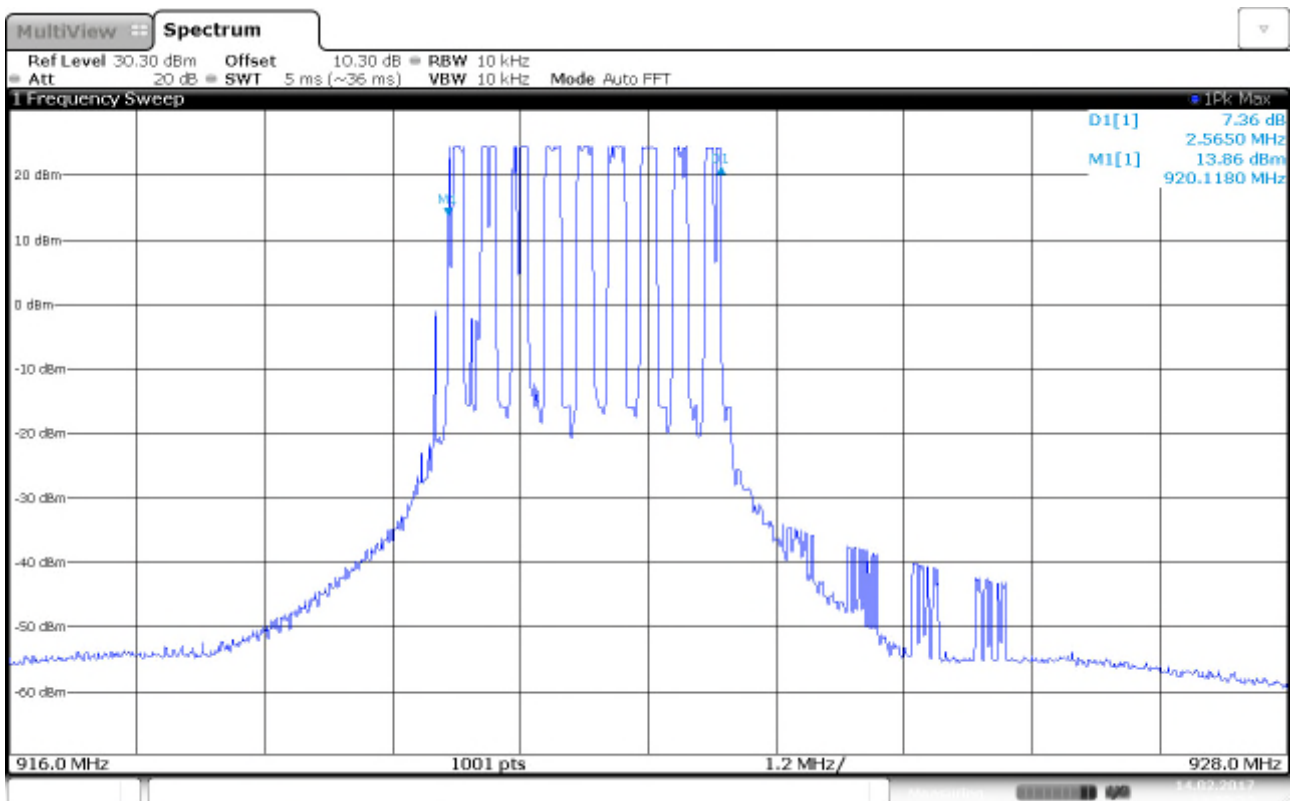
RF Channels in Use in hopping mode 1



99% Bandwidth – ch902.1375MHz



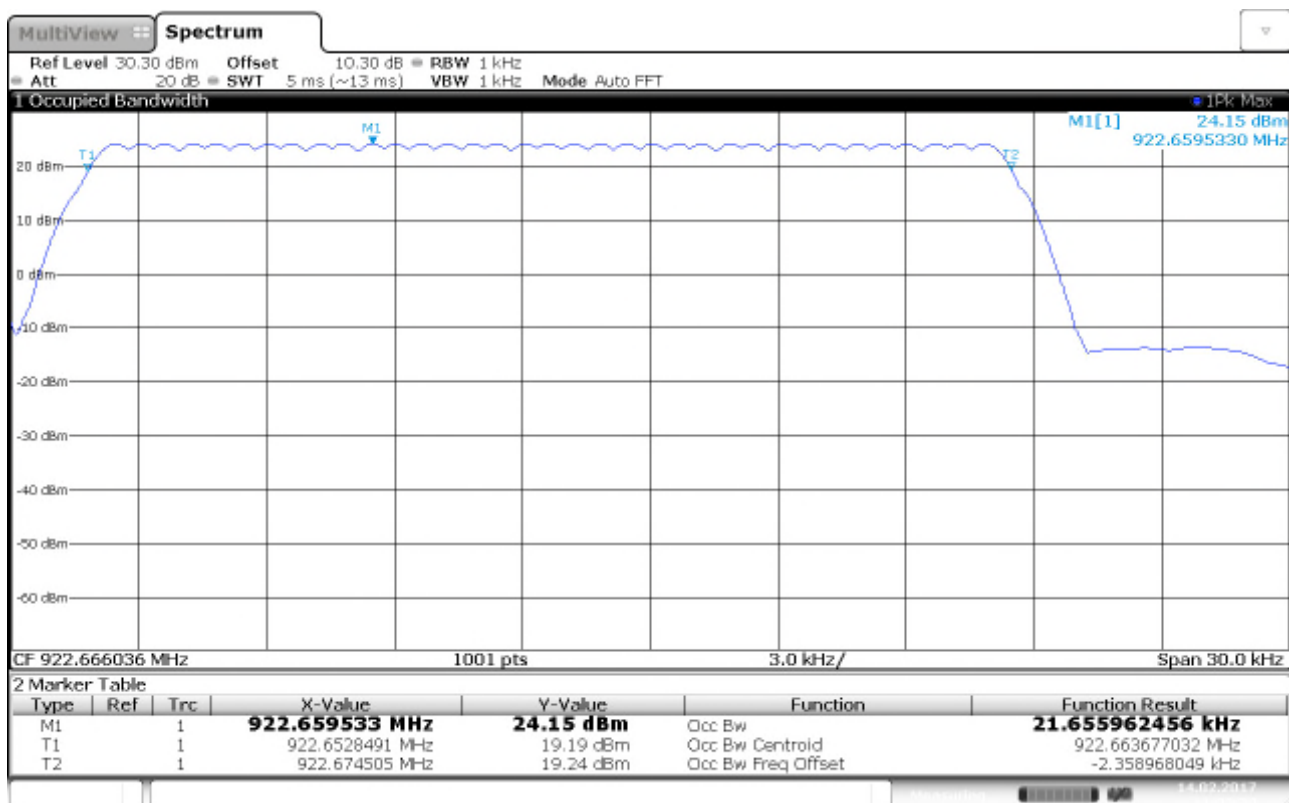
99% Bandwidth – ch904.6625MHz



RF Channels in Use in hopping mode 2



99% Bandwidth – ch920.1375MHz



99% Bandwidth – ch922.6625MHz

3.6 Peak Power Output

FCC part 15.247 (b)

Test Performed By: G.Suwanthakumar

Date of Test: 2016.08.09 –
2017.02.10

Test Results: Complies

Measurement Data:

	Hopping mode 1		Hopping mode 2	
	902.1375 MHz	904.6625 MHz	920.1375 MHz	922.6625 MHz
Conducted Power (dBm)	25.08	24.81	24.16	24.17
Conducted Power (mWatts)	322.11	302.69	260.62	261.22
Field Strength (dBμV/m) -VP	121.42	121.07	121.33	121.37
EIRP, Calculated (mWatts)	416.03	383.81	407.49	411.26
Antenna gain (dBd)	-1.0	-1.1	-0.2	-0.2

The out-put power is measured with peak detector and 20dBc is used for spurious emission.

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

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

See attached plots.

Requirements:

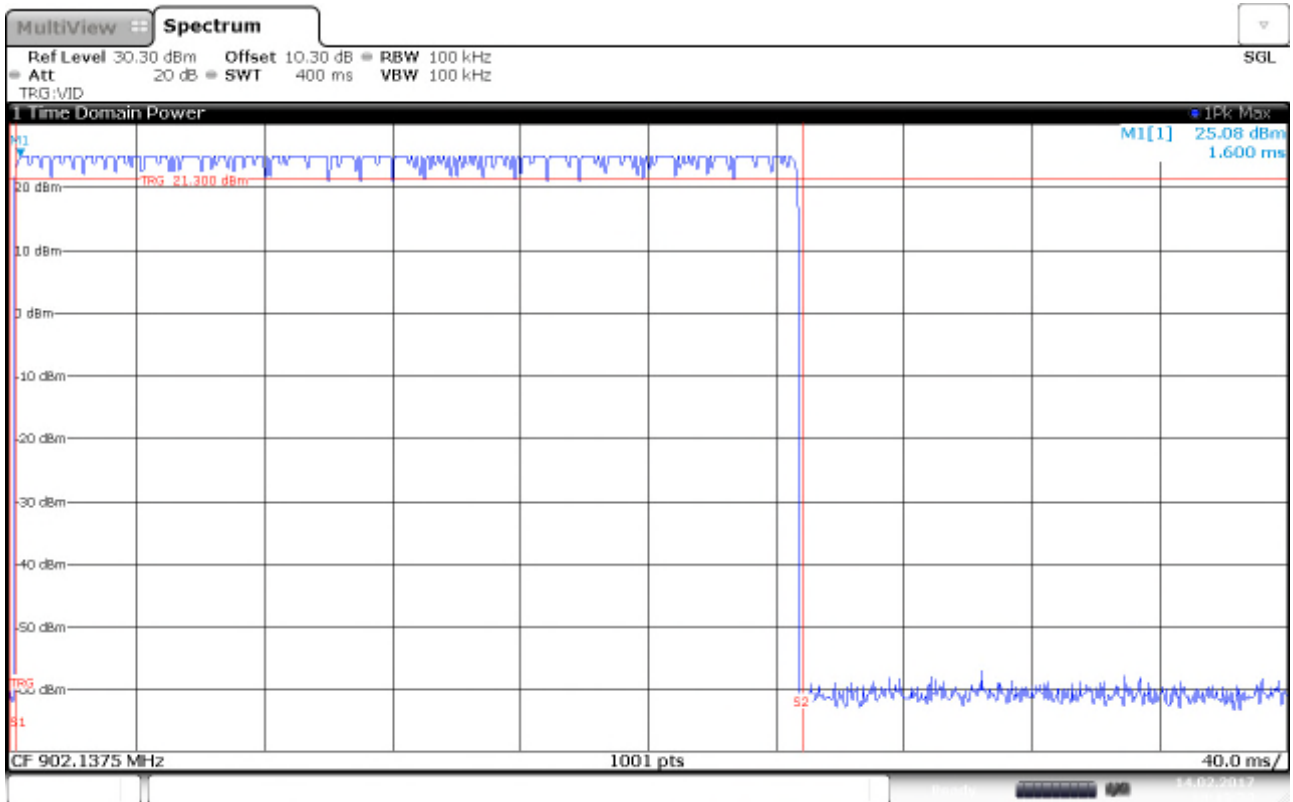
The maximum peak output power shall not exceed the following limits:

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

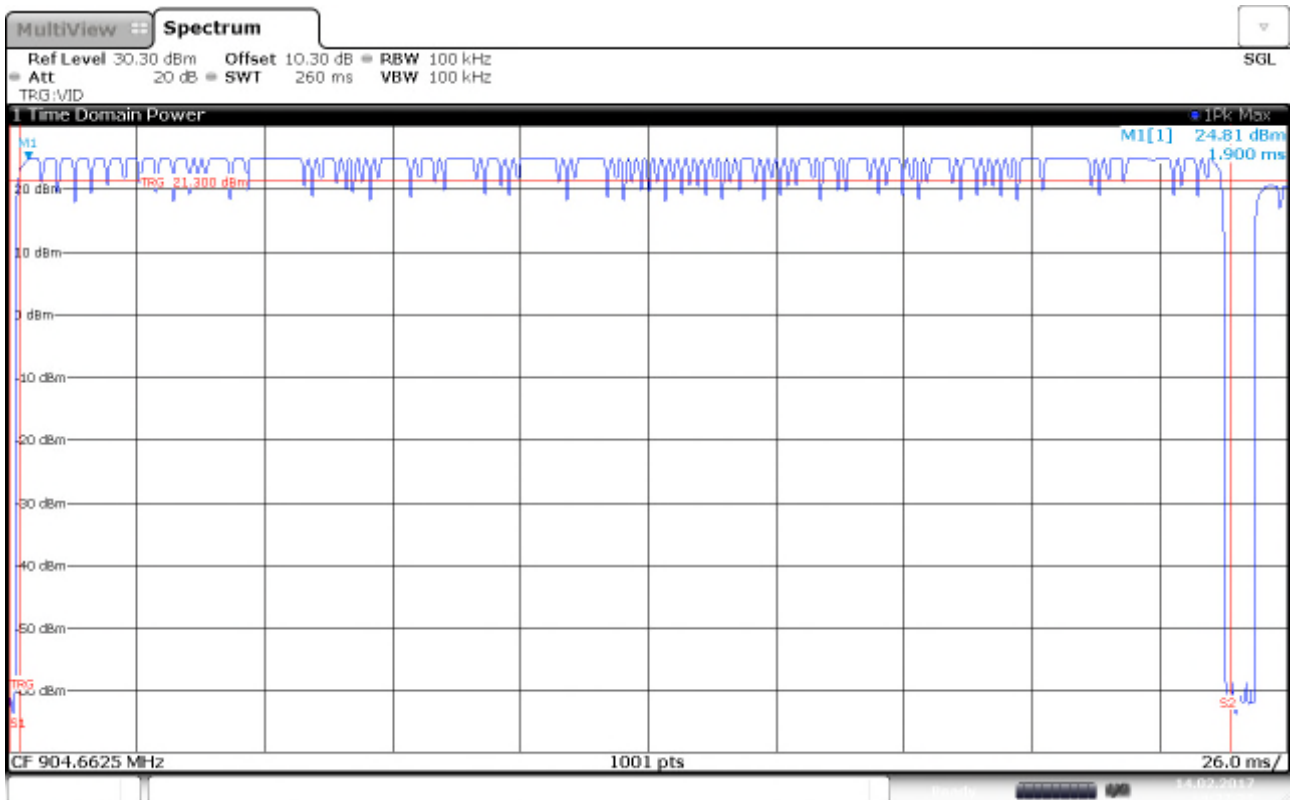
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

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 peak power, ch902.1375MHz – hopping mode 1



Conducted peak power, ch904.6625MHz – hopping mode 1



MARKER 1

902.1375 MHz

Ref 140 dBμV/m

* Att 25 dB

* RBW 100 kHz

VBW 300 kHz

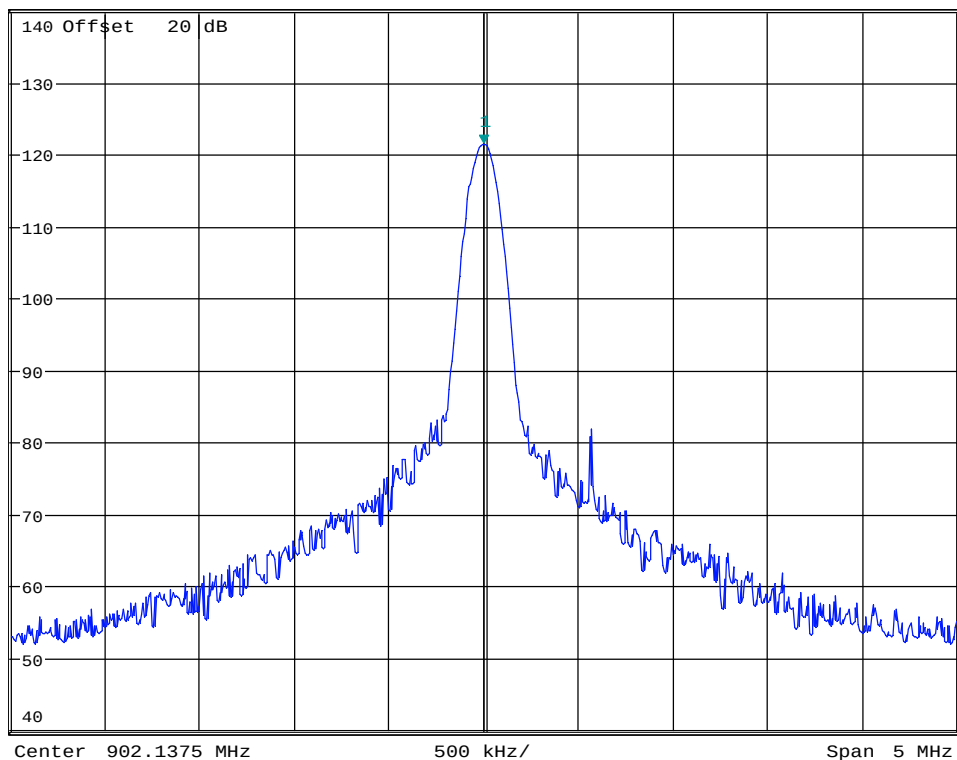
SWT 2.5 ms

Marker 1 [T1]

121.42 dBμV/m

902.137500000 MHz

1 PK
MAXH



Date: 9.AUG.2016 13:43:08

Radaited Field strength –VP , ch902.1375MHz , hoping mode 1



MARKER 1

902.1375 MHz

Ref 140 dBμV/m

* Att 25 dB

* RBW 100 kHz

VBW 300 kHz

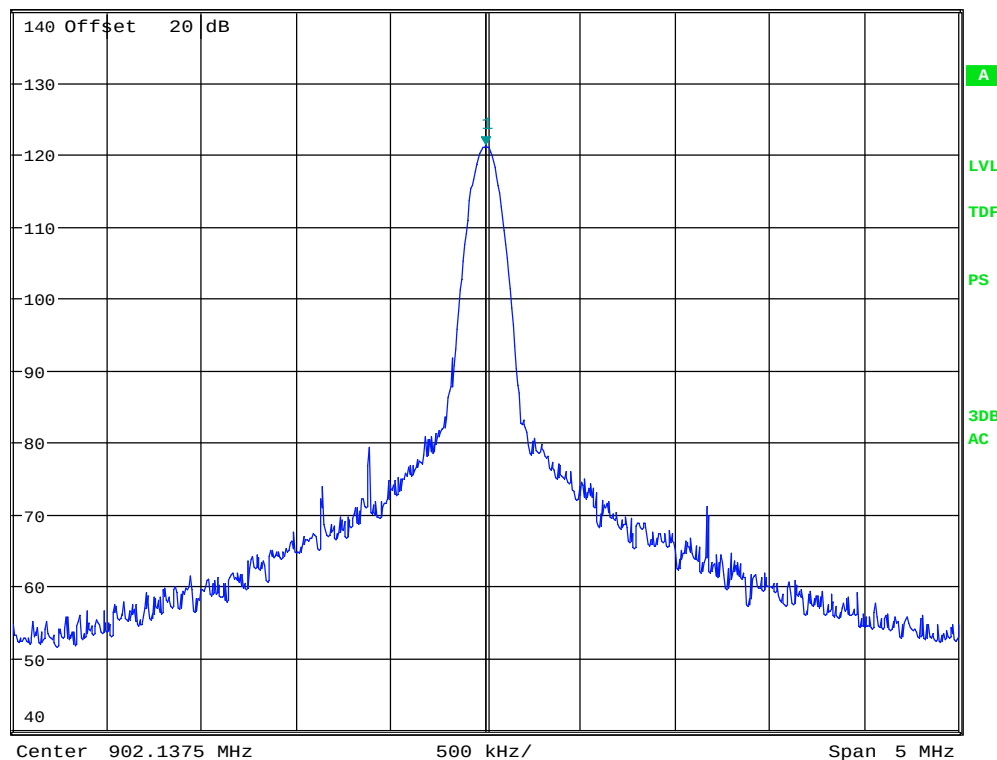
SWT 2.5 ms

Marker 1 [T1]

121.11 dBμV/m

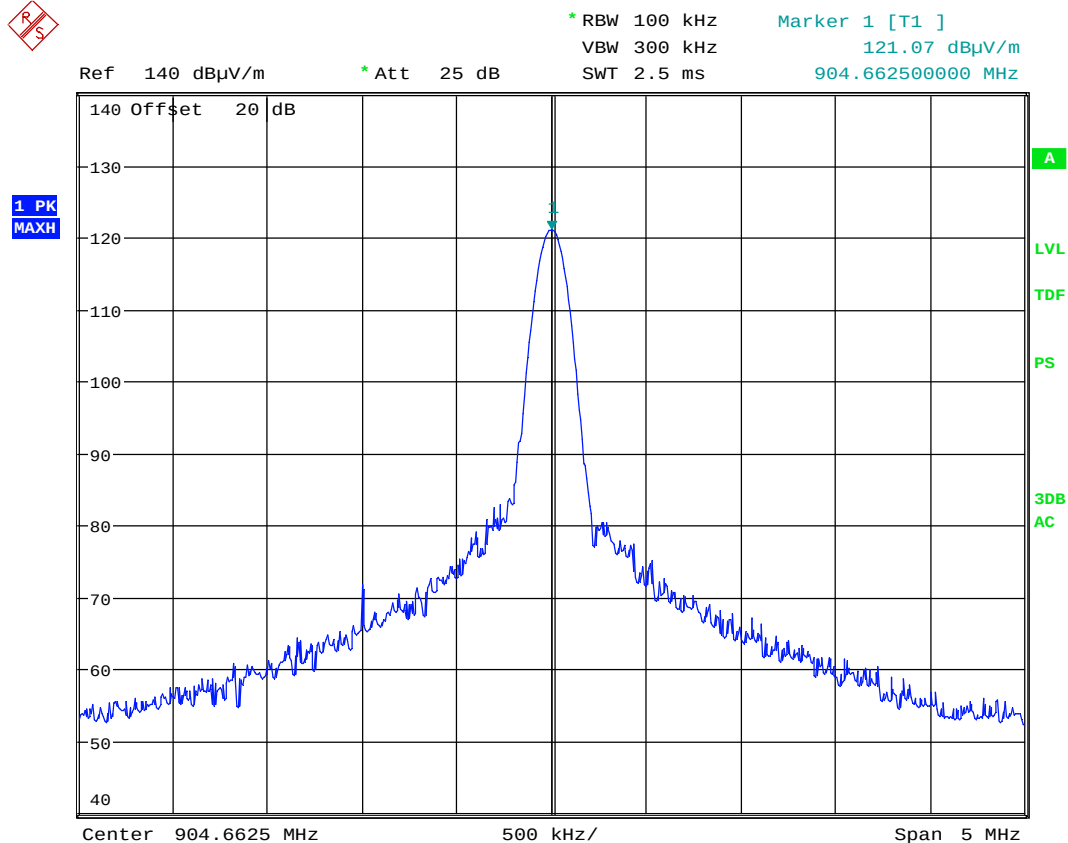
902.137500000 MHz

1 PK
MAXH



Date: 9.AUG.2016 13:50:09

Radaited Field strength –HP , ch902.1375MHz , hoping mode 1



Date: 9.AUG.2016 13:41:50

Radaited Field strength –VP , ch904.6625MHz , hoping mode 1



MARKER 1

904.6625 MHz

Ref 140 dBμV/m

* Att 25 dB

* RBW 100 kHz

VBW 300 kHz

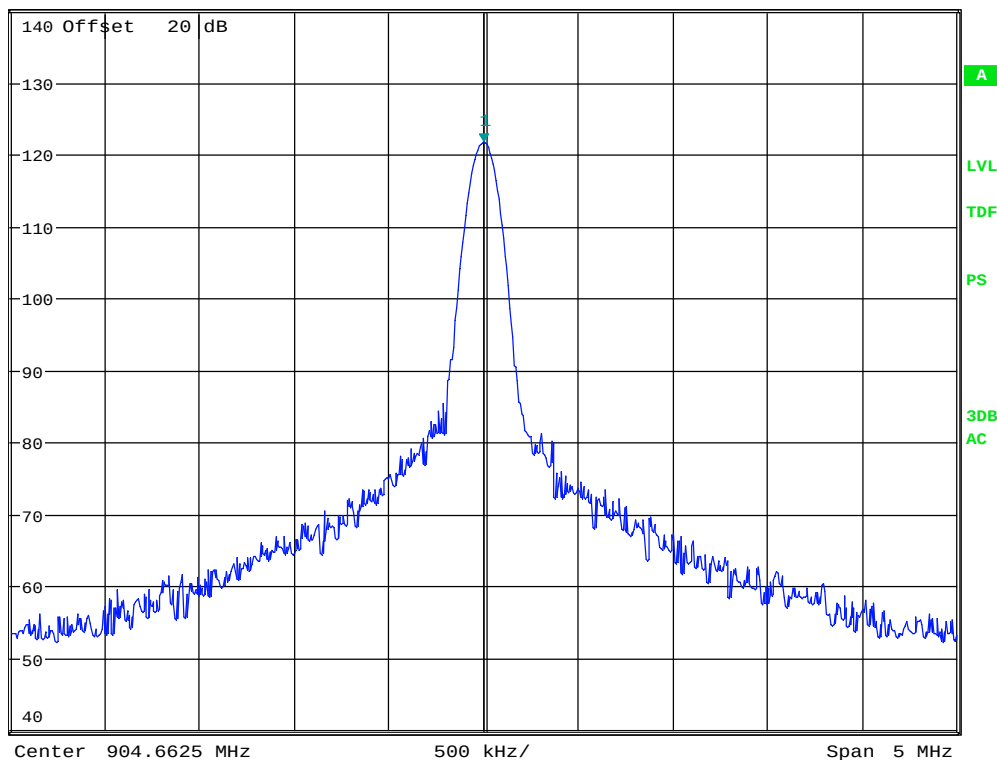
SWT 2.5 ms

Marker 1 [T1]

121.62 dBμV/m

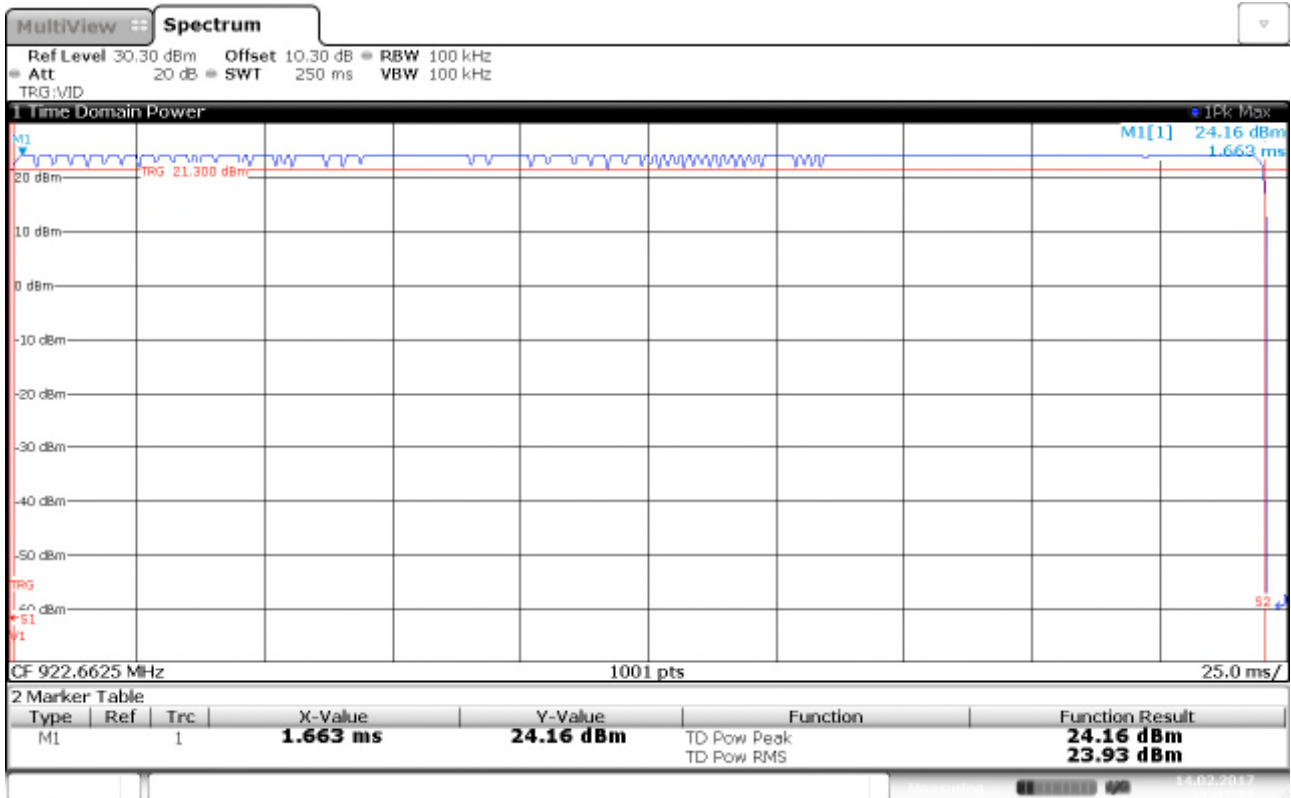
904.662500000 MHz

1 PK
MAXH

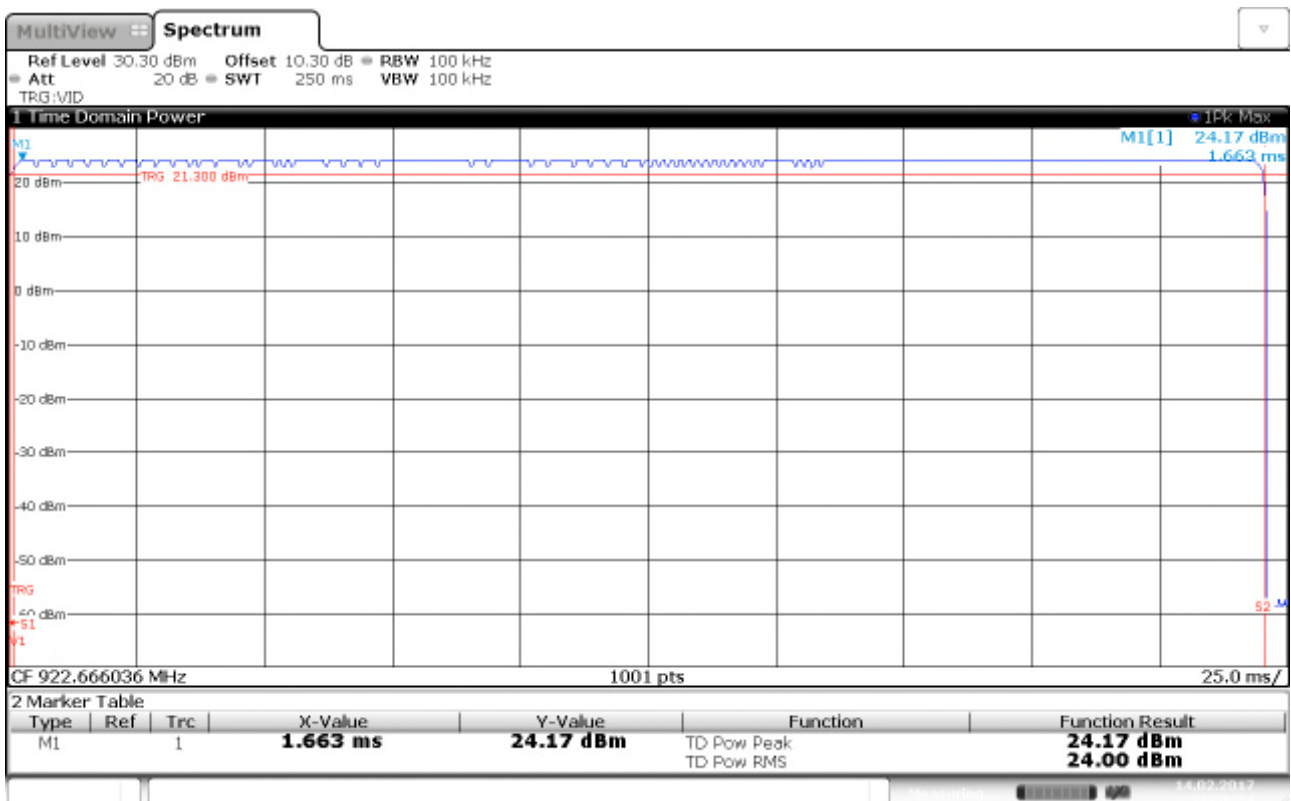


Date: 9.AUG.2016 13:40:44

Radaited Field strength –HP , ch904.6625MHz , hoping mode 1



Conducted peak power , ch920.1375MHz , hoping mode 2



Conducted peak power , ch922.6625MHz , hoping mode 2



MARKER 1

920.1375 MHz

Ref 140 dBμV/m

* Att 25 dB

* RBW 100 kHz

VBW 300 kHz

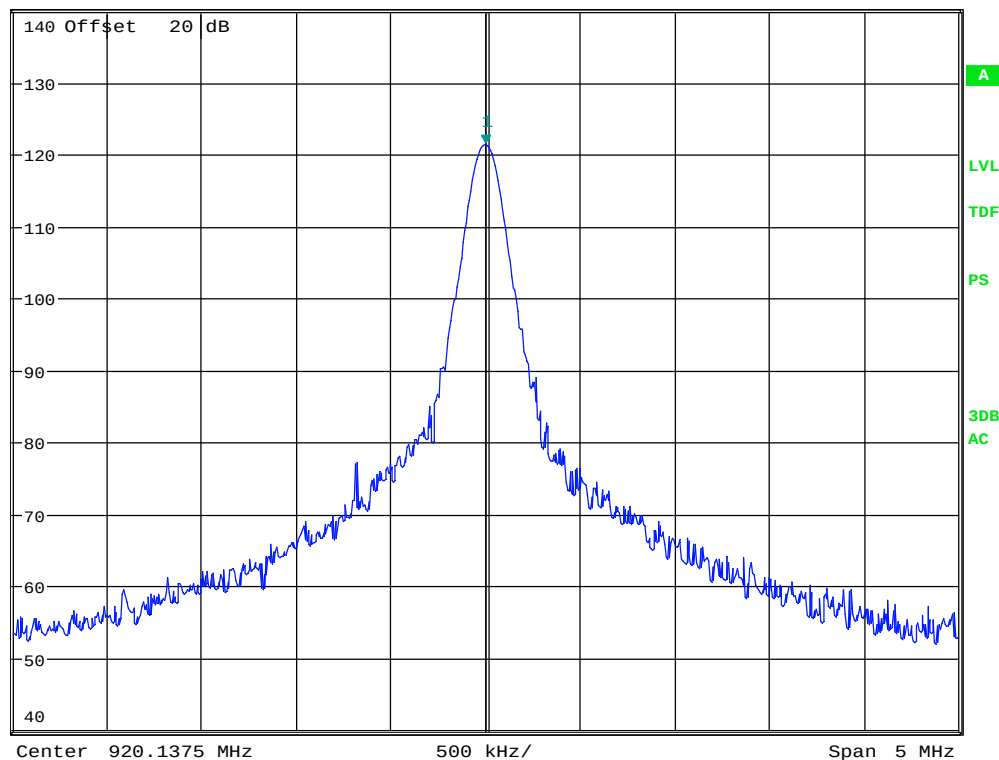
SWT 2.5 ms

Marker 1 [T1]

121.33 dBμV/m

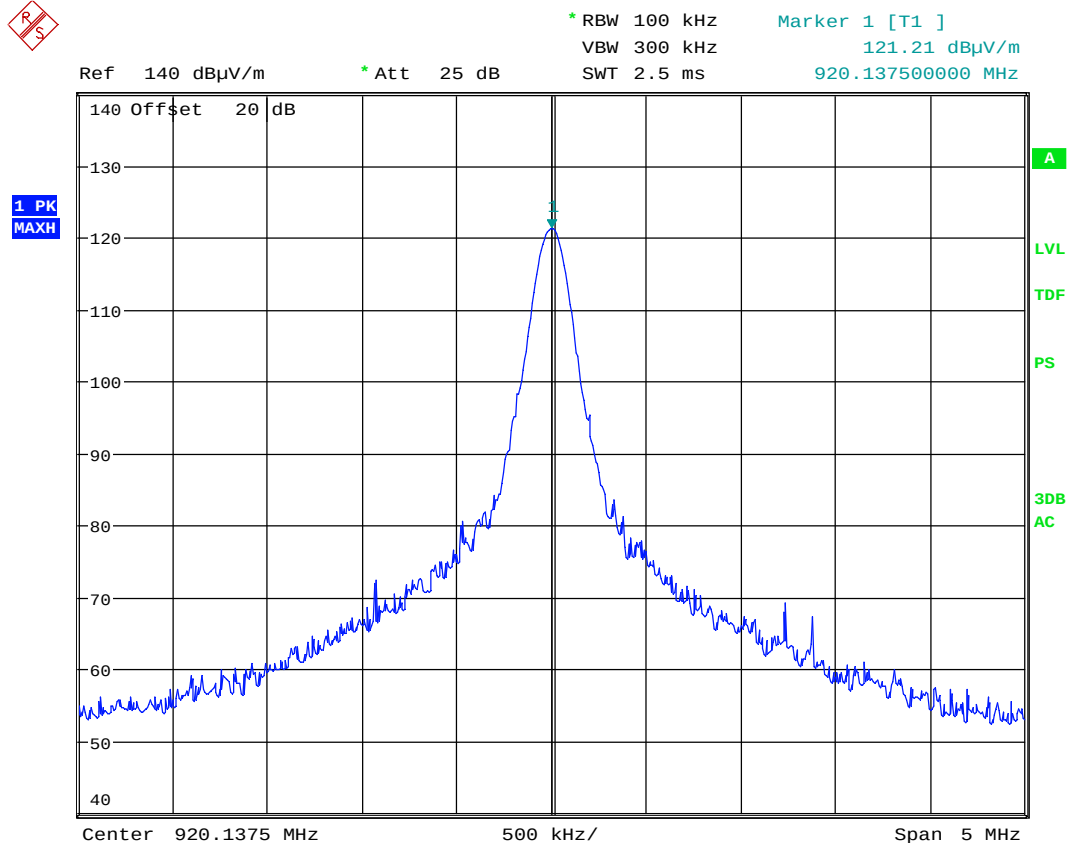
920.137500000 MHz

1 PK
MAXH



Date: 9.AUG.2016 13:37:52

Radaited Field strength –VP , ch920.1375MHz , hoping mode 2



Date: 9.AUG.2016 13:38:38

Radaited Field strength –HP , ch920.1375MHz , hoping mode 2



MARKER 1

922.6625 MHz

Ref 140 dBμV/m

* Att 25 dB

* RBW 100 kHz

VBW 300 kHz

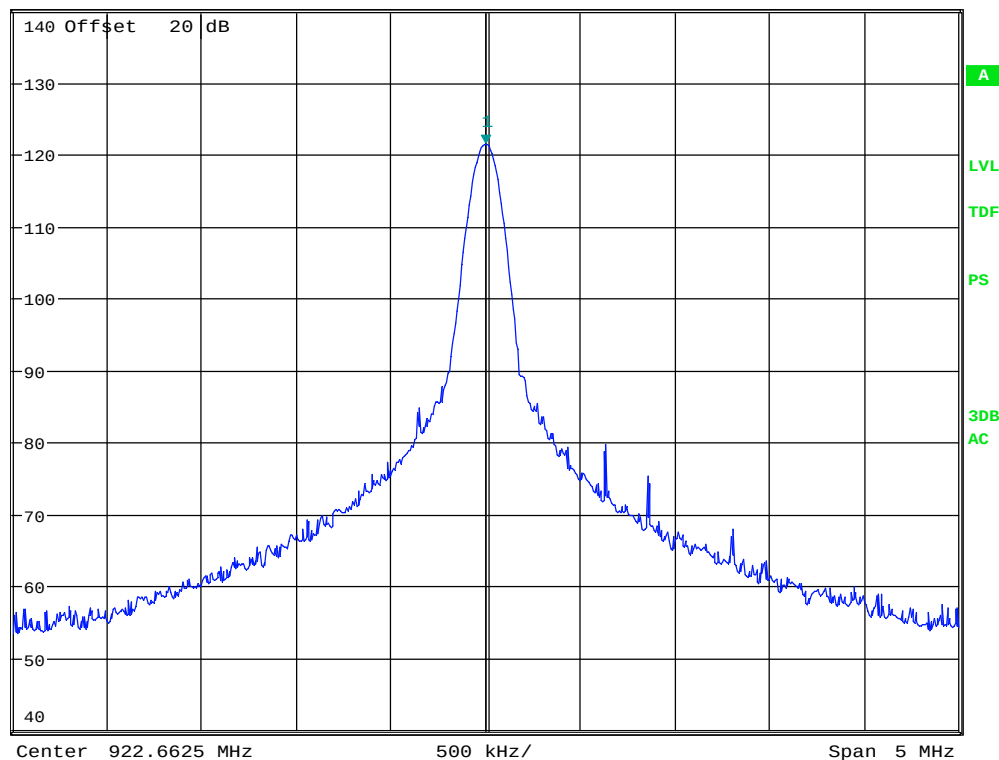
SWT 2.5 ms

Marker 1 [T1]

121.37 dBμV/m

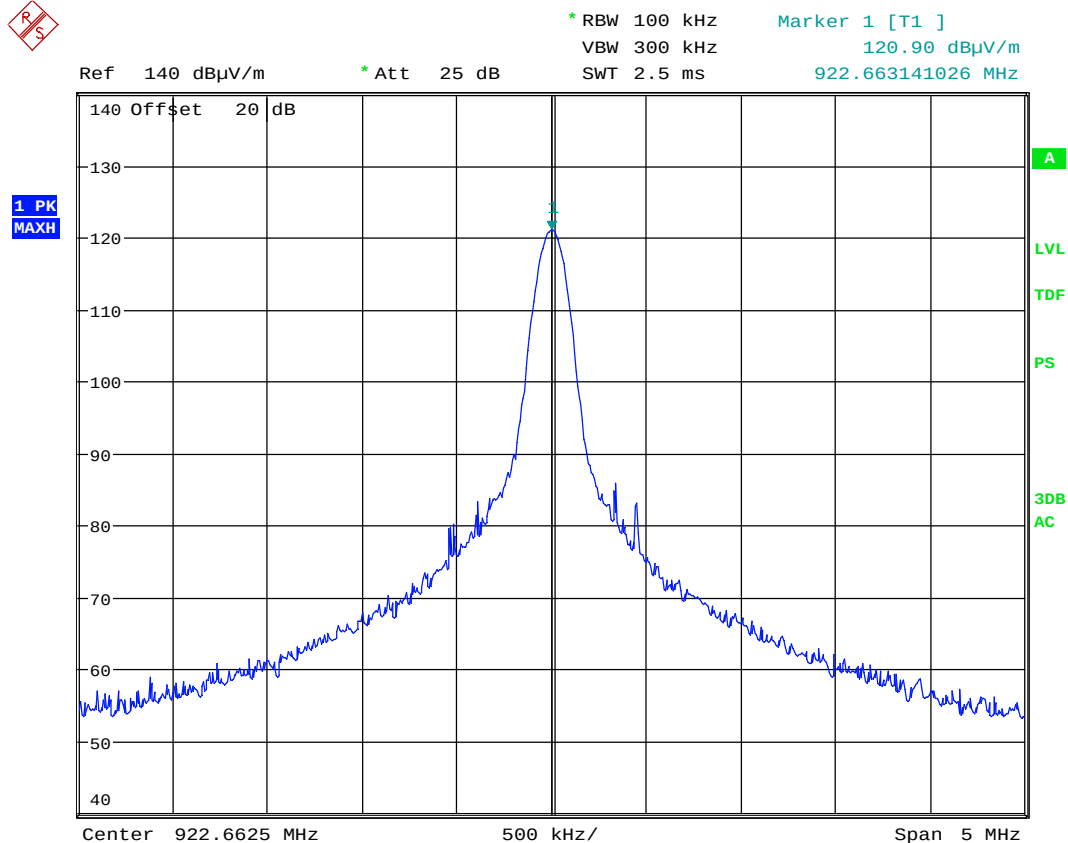
922.662500000 MHz

1 PK
MAXH



Date: 9.AUG.2016 13:35:38

Radaited Field strength –VP , ch922.6625MHz , hoping mode 2



Date: 9.AUG.2016 13:34:41

Radaited Field strength –HP , ch922.6625MHz , hoping mode 2

3.7 Conducted Emissions at Antenna Connector

Para. No.: 15.247 2(d)

Test Performed By: G.Suwanthakumar

Date of Test: 2017.02.14

RF conducted power to 10 GHz see attached plots.

Maximum RF level outside operating band:

RF ch 902.1375: 28.5 dB/C, margin >8.5 dB

RF ch 904.6625: 28.4 dB/C, margin >8.4 dB

RF ch 922.6625: 27.8 dB/C, margin >7.8 dB

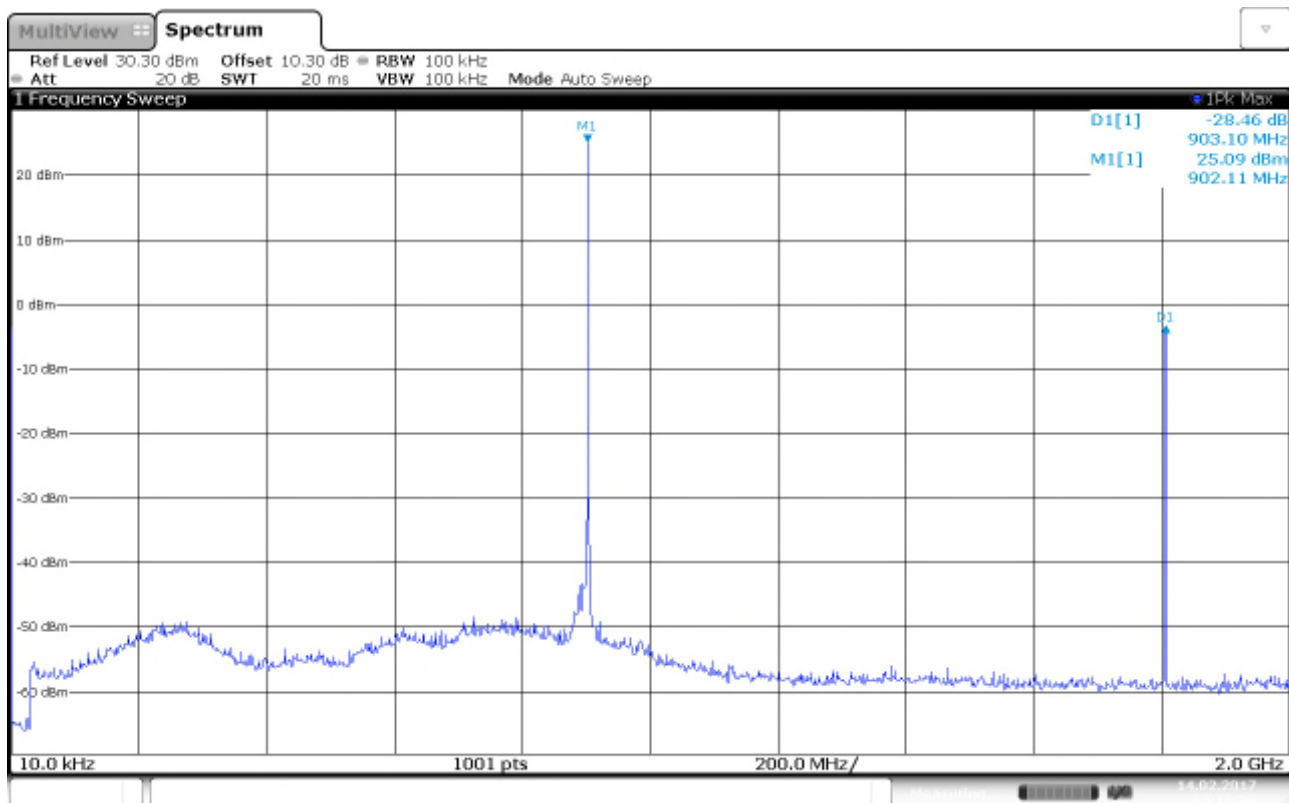
Measured with Peak Detector.

Limit

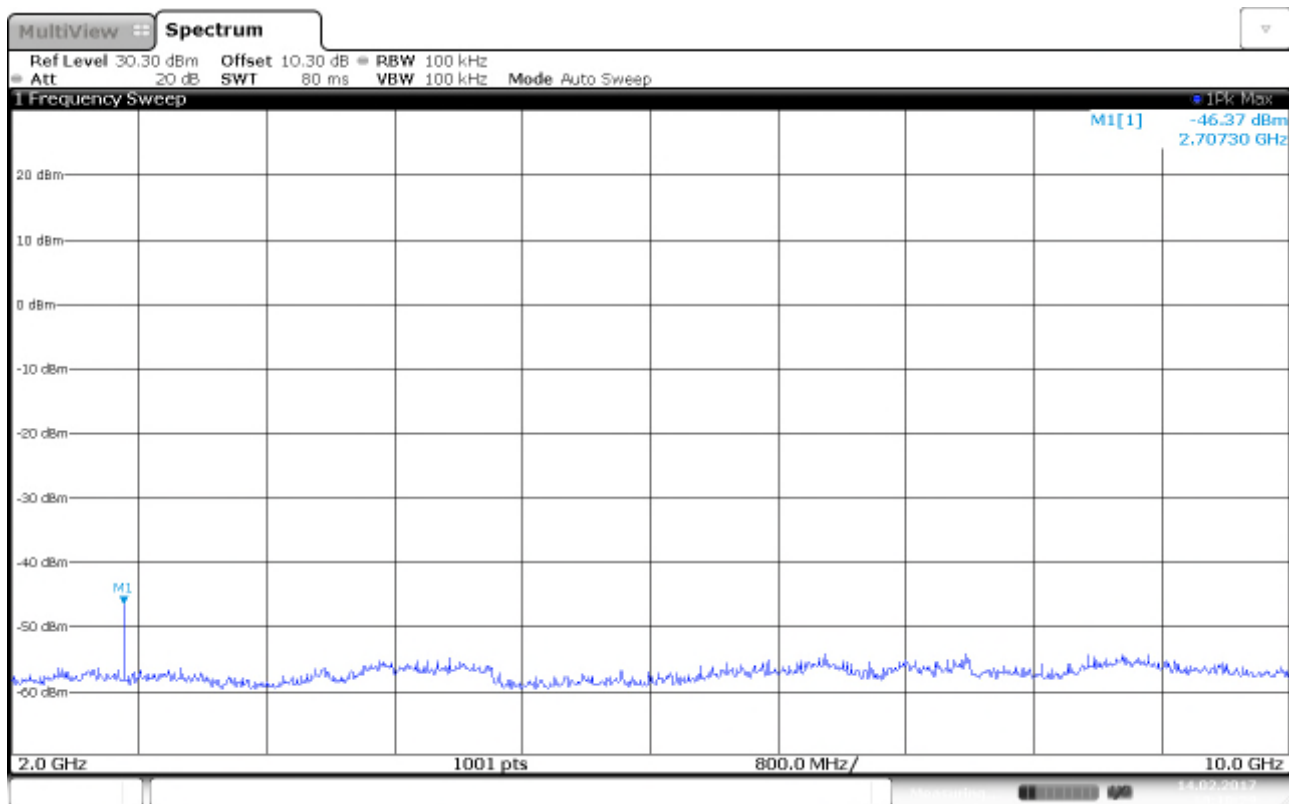
Peak measurement	RMS averaging
20 dBc or more in 100 kHz bandwidth	30 dBc or more in 100 kHz bandwidth

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

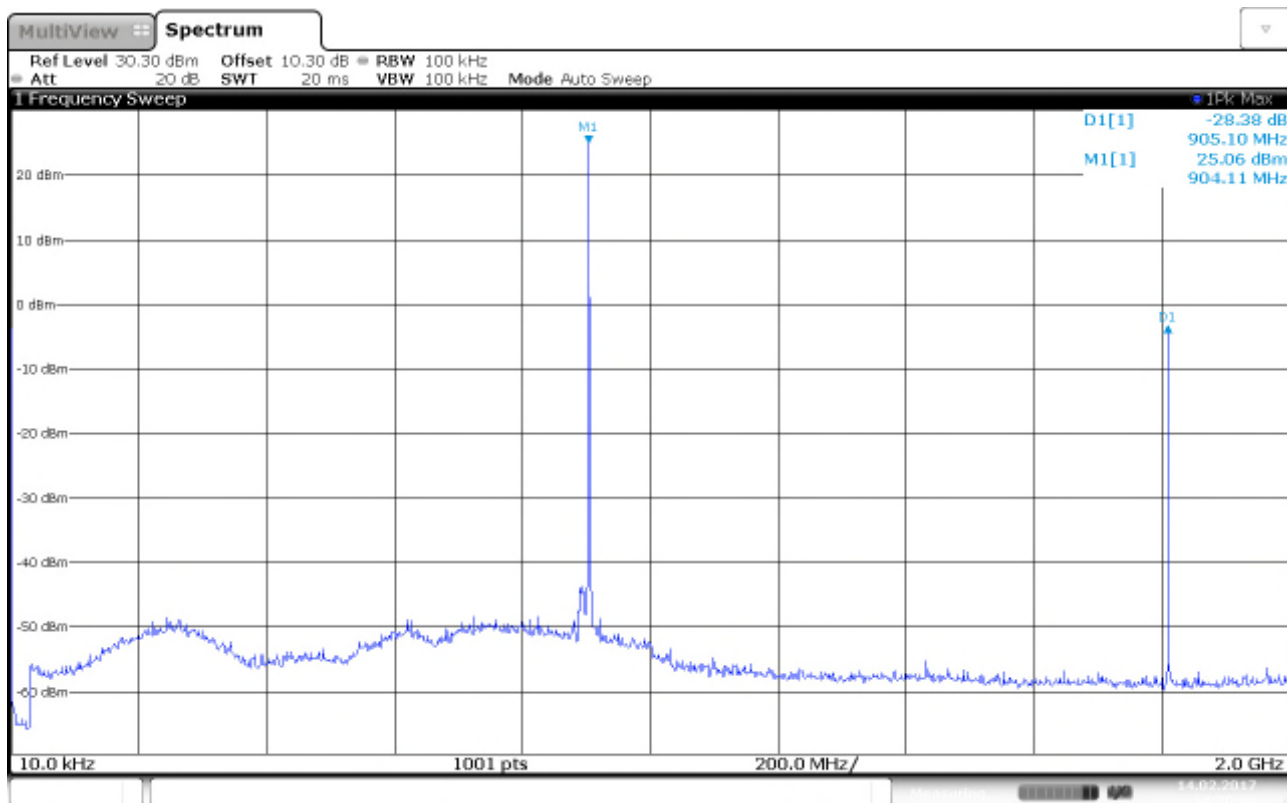
Attenuation below the general limits specified in part 15.209(a) is not required.



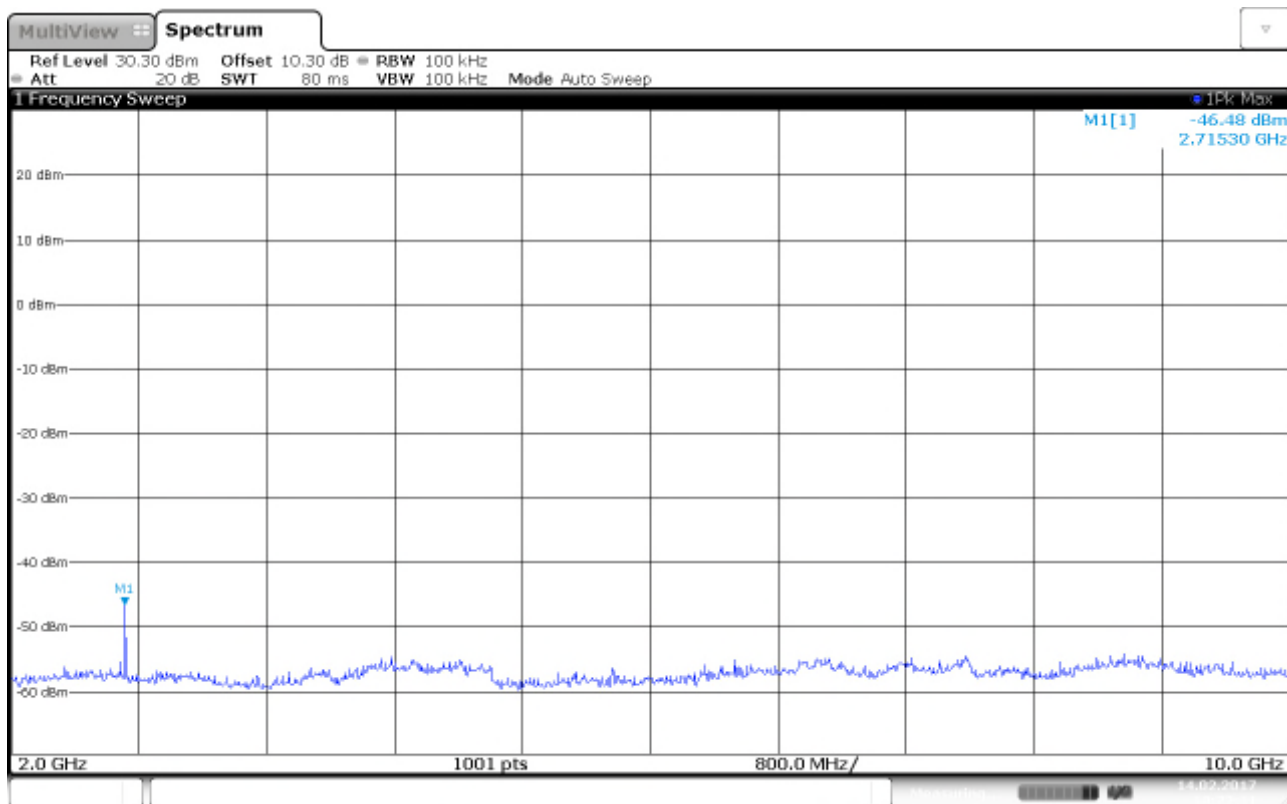
Conducted spurious emissions , hopping mode 1, ch902.1375MHz : 9kHz – 2GHz



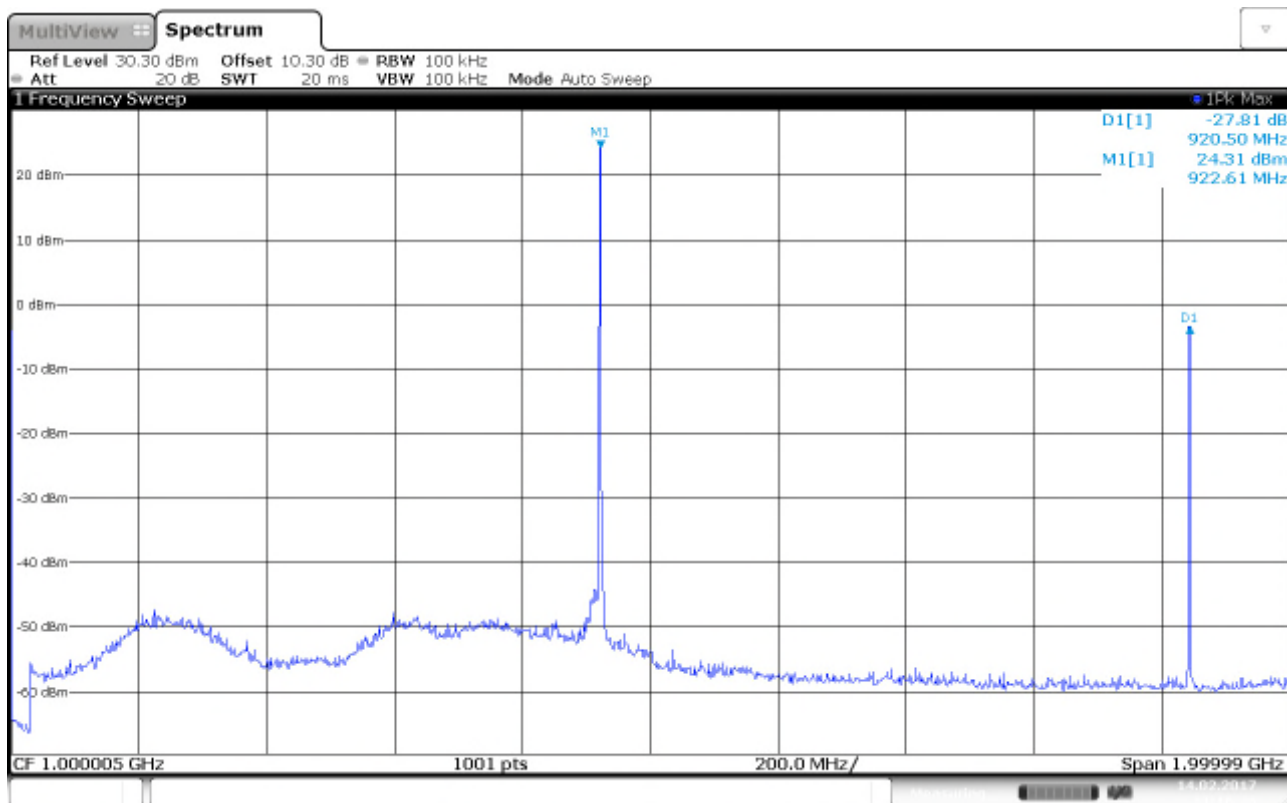
Conducted spurious emissions , hopping mode 1, ch902.1375MHz : 2GHz – 10GHz



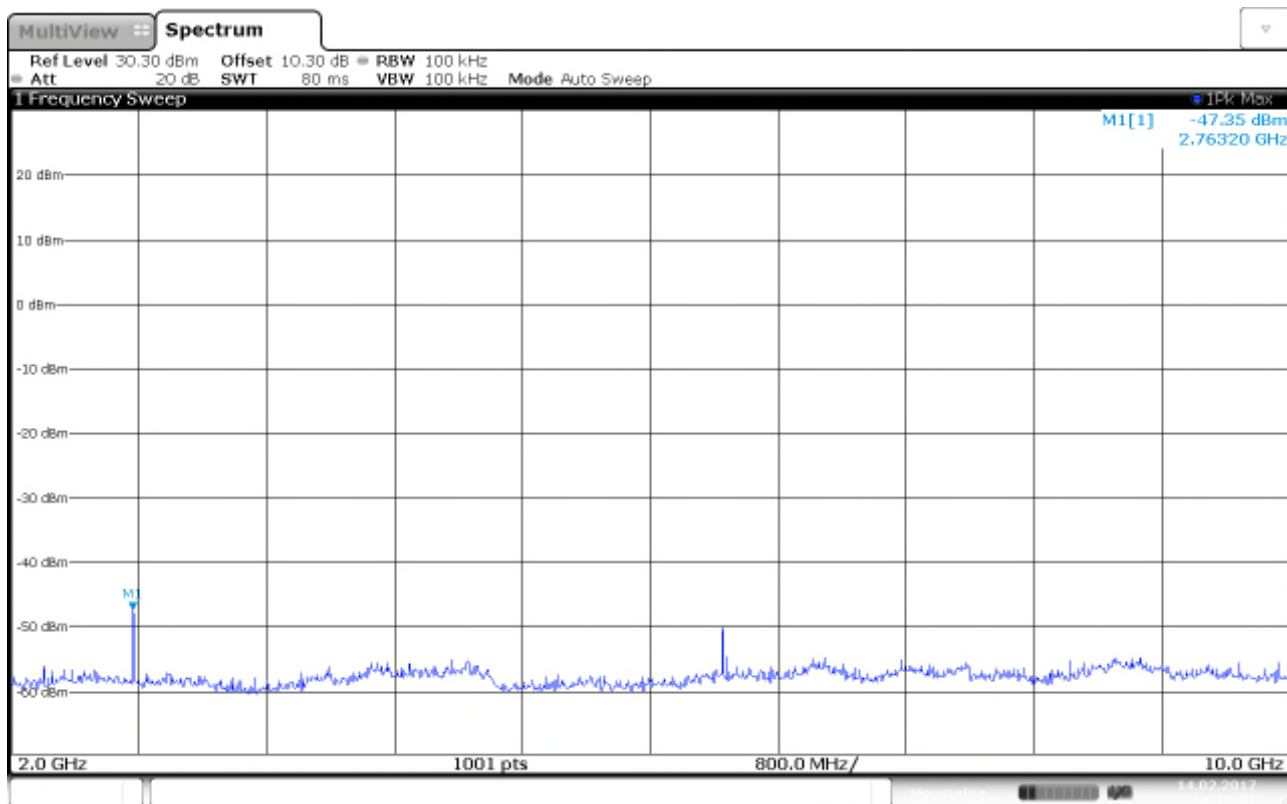
Conducted spurious emissions , hopping mode 1, ch904.6625MHz : 9kHz – 2GHz



Conducted spurious emissions , hopping mode 1, ch904.6625MHz : 2GHz – 10GHz



Conducted spurious emissions , hopping mode 2, ch922.6625MHz : 10kHz – 2GHz



Conducted spurious emissions , hopping mode 2, ch922.6625MHz : 2GHz – 10GHz

3.8 Spurious Emissions (Radiated)

FCC Part 15.247

Test Performed By: G.Suwanthakumar

Date of Test: 2017.02.14

Test Results: Complies

Measurement Data:

Band-edge radiated field strength

	Measured field strength (dBμV/m)		Limit	Margin	
	Hopping mode 1 Lower band edge 902MHz	Hopping mode 2 Upper band edge 928MHz	dBc	dB	
Peak Detector	98.26	49.74	20	22.92	> 70

Hopping mode 1:

PK field strength at fundamental frequency ch902.1375MHz: 121.18 dBuV/m, dbc=121.18 – 98.26=22.92

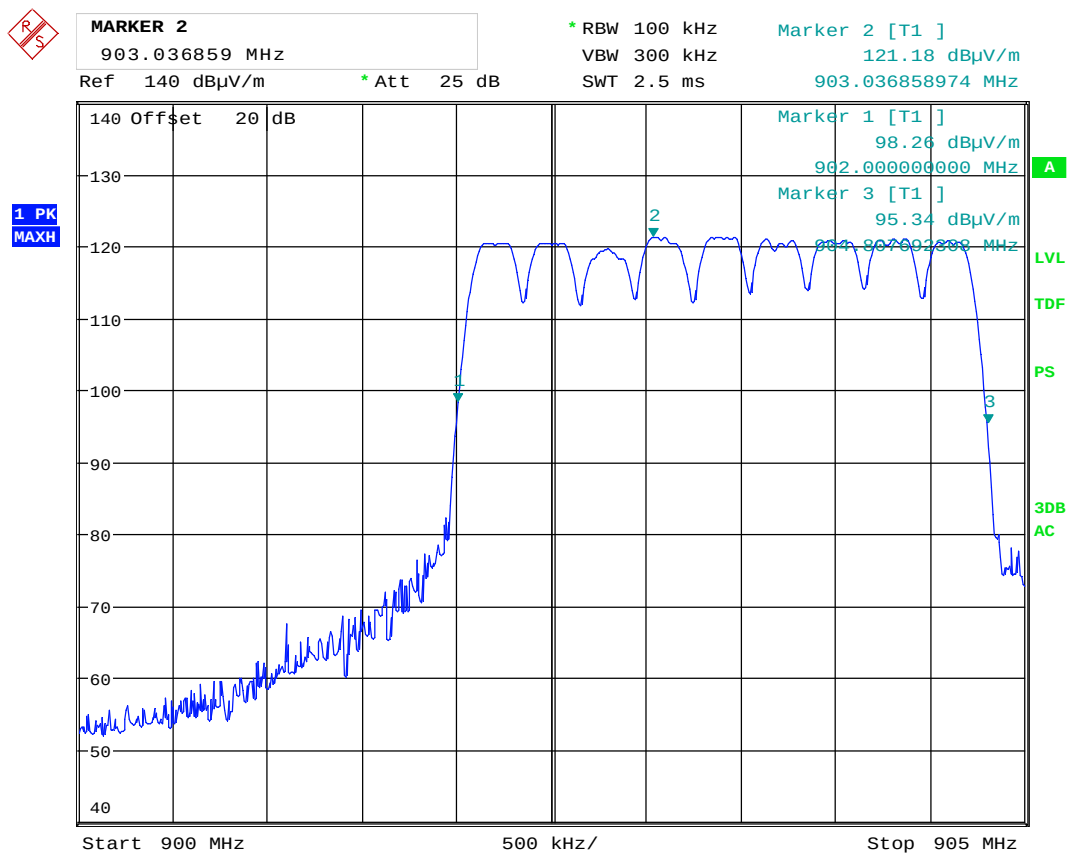
Hopping mode 2:

PK field strength at fundamental frequency ch922.6625MHz: 121.95 dBuV/m, dbc=121.95 – 49.74=72.21

100% duty cycle

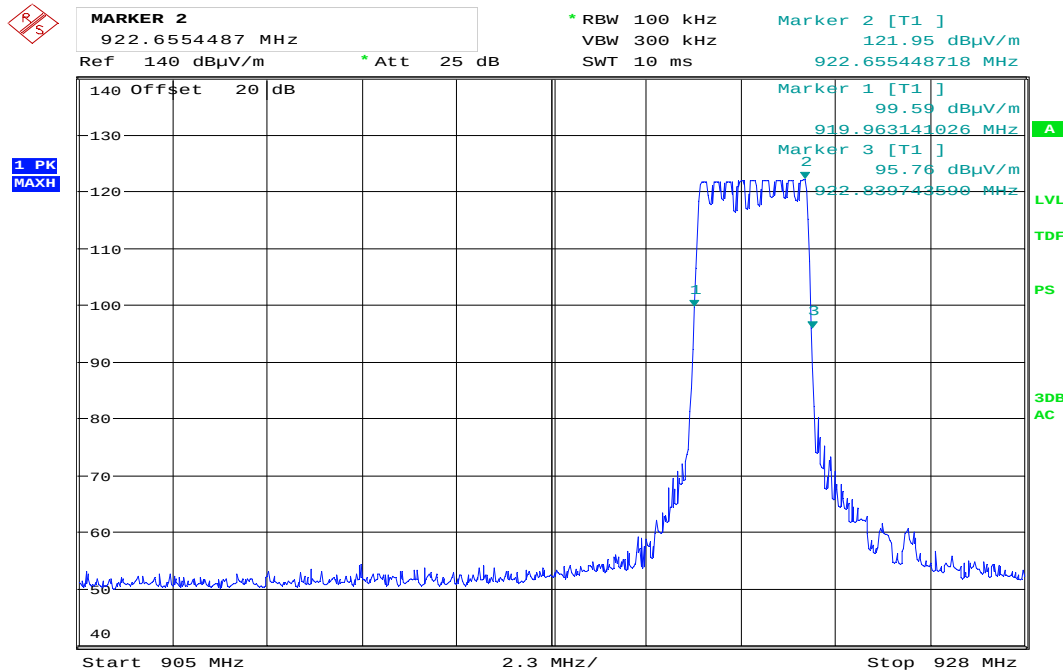
See attached plots.

§15.35 c) Unless otherwise specified, e.g., §§ 15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

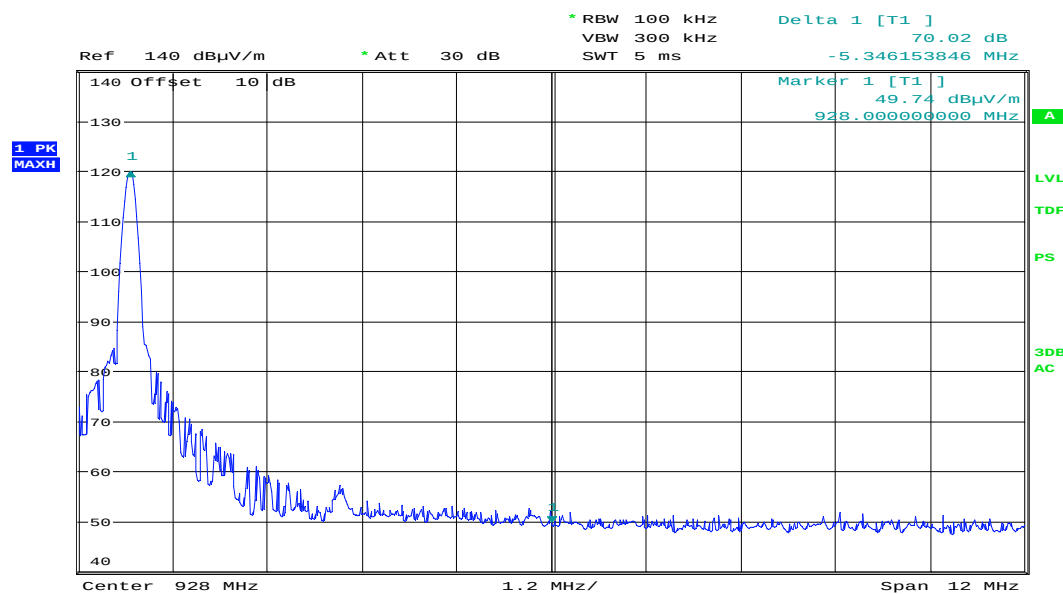


Date: 9.AUG.2016 13:57:01

Radiated field strength – VP , hopping mode 1: @ Lower band edge 902MHz



Date: 9.AUG.2016 13:59:23



Date: 10.FEB.2017 14:05:54

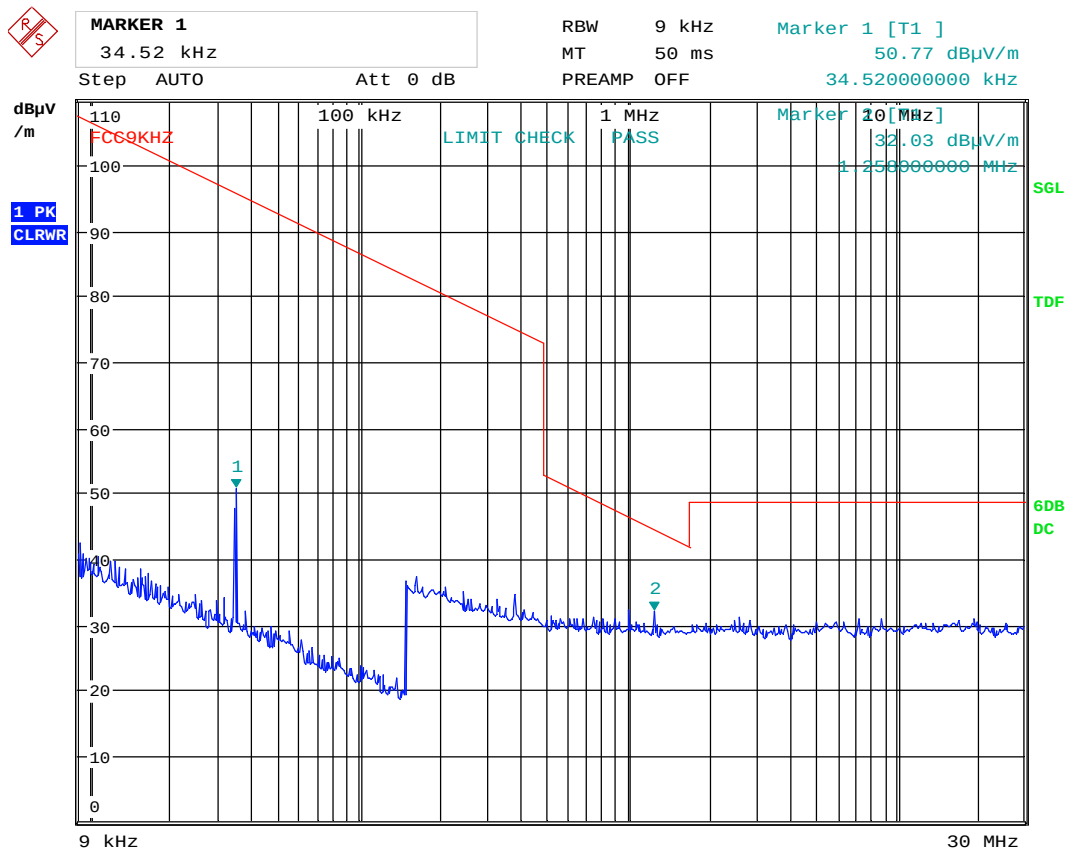
Radiated field strength – VP , hopping mode 2: @ Upper band edge 928MHz

Radiated emissions 9 kHz-30 MHz.

Measuring distance 10 m, measured with Peak detector.

No component detected, see attached graph.

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



Date: 9.AUG.2016 17:28:30

9kHz – 30MHz@10m

Radiated emission 30 – 1000 MHz.

Detector: Quasi-Peak

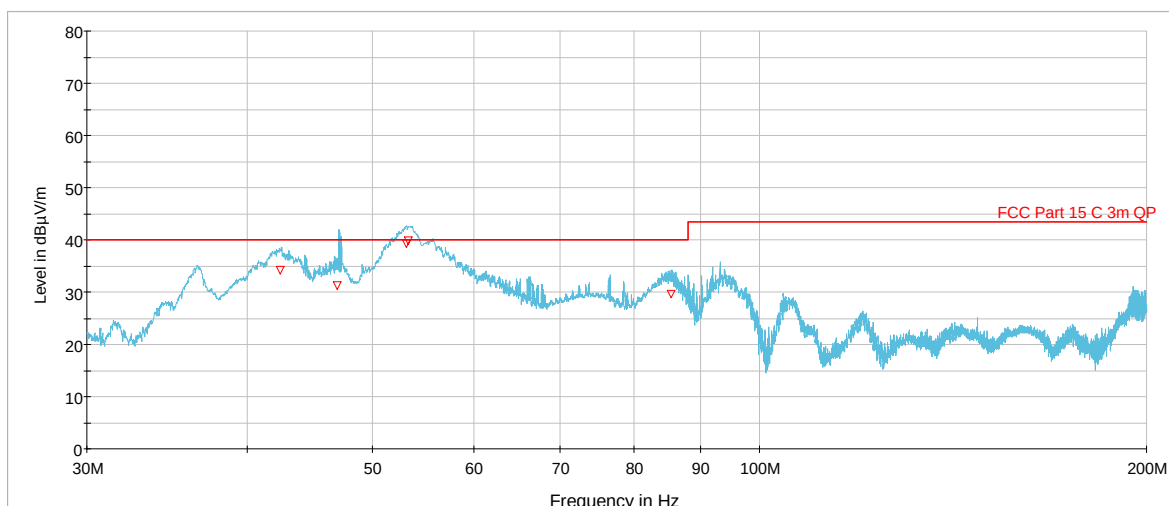
Measuring distance 3 m .

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
42.457	34.19	40.00	5.81	1000.0	120.000	110.0	V	27	-26.8
46.981	31.19	40.00	8.81	1000.0	120.000	100.0	V	133	-27.6
53.215	39.26	40.00	0.74	1000.0	120.000	112.0	V	206	-28.4
53.352	39.90	40.00	0.10	1000.0	120.000	100.0	V	150	-28.4
85.440	29.60	40.00	10.40	1000.0	120.000	145.0	V	157	-27.8

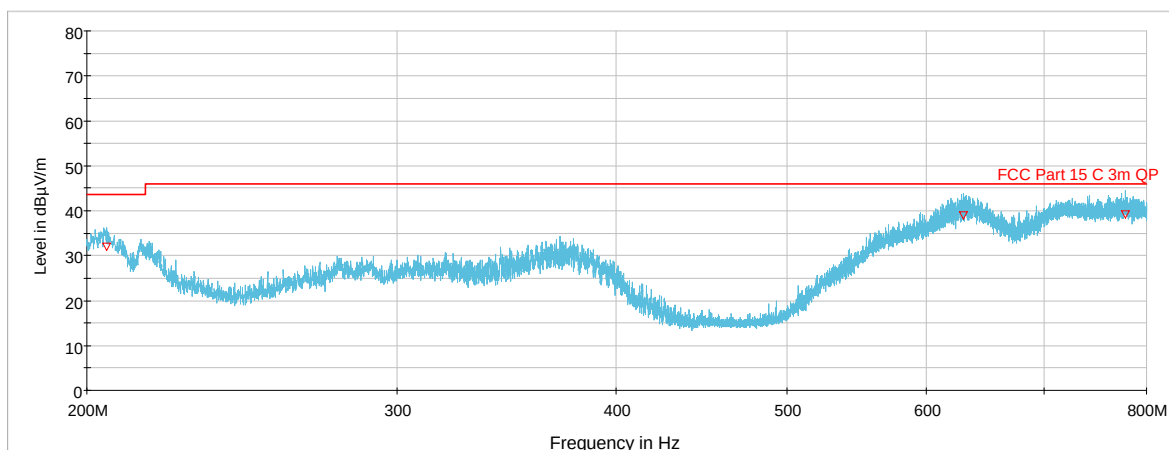
See attached graphs.

Requirements/Limit

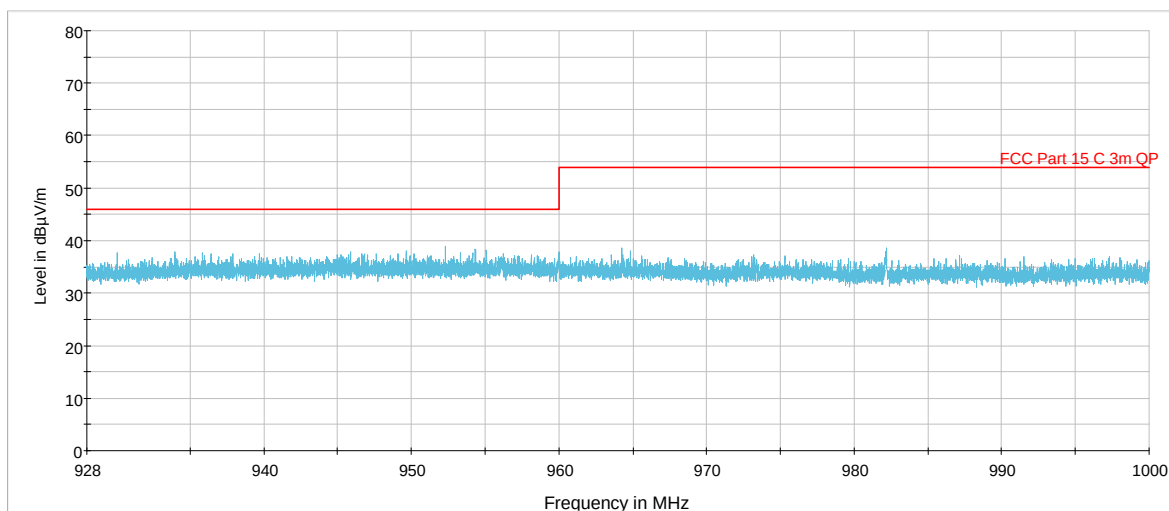
FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	Quasi Peak (μV/m)	Quasi Peak (dBμV/m)
30 – 88	100	40.0
88 – 216	150	43.5
216 – 960	200	46.0
Above 960	500	54.0



30 - 200MHz, Pk scan



200 - 800MHz , ch902.1375MHz, PK scan



800 - 1000MHz , ch922.6625MHz, PK scan

Radiated Emissions, 1-10 GHz

Measuring distance: 3m (1 – 8 GHz)
1m (8 – 10 GHz)

Restricted band:

Peak Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
GHz		dB	dB μ V/m	dB	dB μ V/m	dB
2714.056	904.6625	0	53.95	/	74	20.05
2760.412	920.1375	0	52.97	/	74	21.03
3618.742	904.6625	0	54.94	/	74	19.06
2760.412	920.1375	0	52.97	/	74	21.03
Other freqs	/	0	Below AV limit	/	74	>20

Restricted band:

Average Detector:

Frequency	RF channel	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
GHz		dB	dB μ V/m	dB	dB μ V/m	dB
3618.742	904.6625	0	52.83	/	54	1.17
Other freqs	/	0	Below AV limit	/	74	>20

Non- Restricted band:

Peak Detector:

Frequency	RF channel	Dist. corr. factor	Field strength of emission Peak Detector, 3m	Field strength of Fundamental frequency Peak Detector, 3m	Limit	Margin
MHz	MHz	dB	dB μ V/m	dB μ V/m	dBc	dB
1804.275	902.1375	0	87.01	121.42	20	34.41
1809.275	904.6625	0	87.06	121.07	20	34.01
1840.275	920.1375	0	86.43	121.33	20	34.90
1845.325	922.6625	0	87.28	121.37	20	34.09
6314.9625	902.1375	0	None detcted	121.42	20	/
6332.4625	904.6625	0	None detcted	121.07	20	/
6440.9625	920.1375	0	None detcted	121.33	20	/
6458.6375	922.6625	0	None detcted	121.37	20	/
7217.1000	902.1375	0	None detcted	121.42	20	/
7237.1000	904.6625	0	None detcted	121.07	20	/
9201.3750	920.1375	0	46.80	121.33	20	> 60
9226.6250	922.6625	0	50.58	121.37	20	> 60

Maximum is obtained in vertical polarization.

94% duty cycle

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 4, Clause 8.9 @ frequencies defined in clause 8.10	
Non-Restricted band	Part 15.247, 2 (d)	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



MARKER 1

1.8042625 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

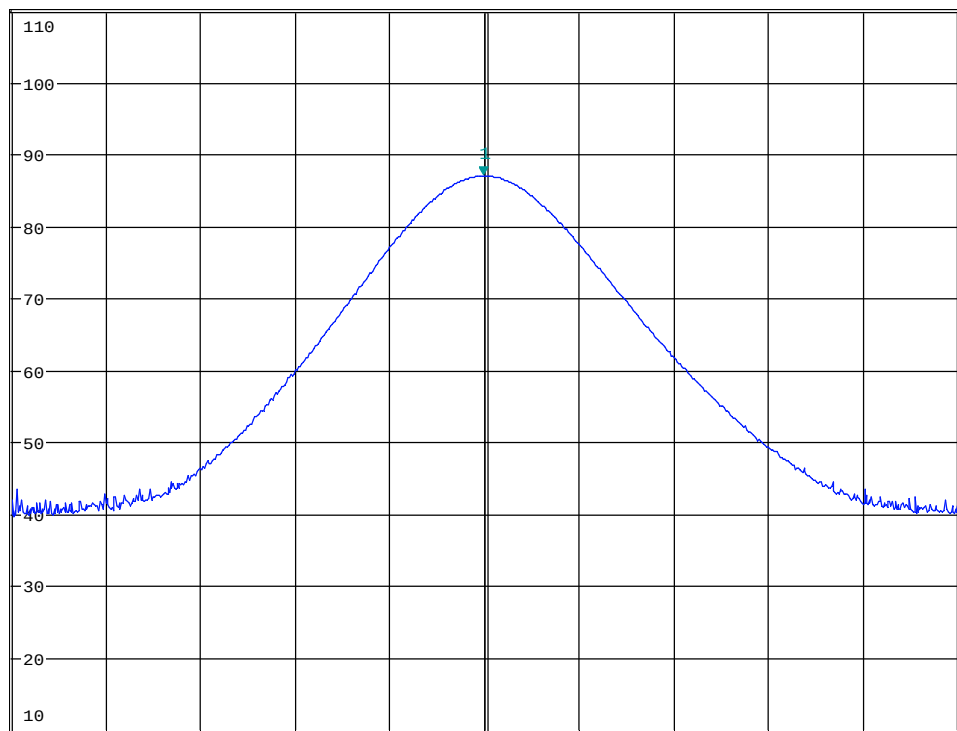
SWT 5 ms

Marker 1 [T1]

87.01 dBμV/m

1.804262500 GHz

1 PK
MAXH



Center 1.804275 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 10:55:00

VP: 2nd harmonic , ch902.1375MHz - PK



MARKER 1

1.8093375 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

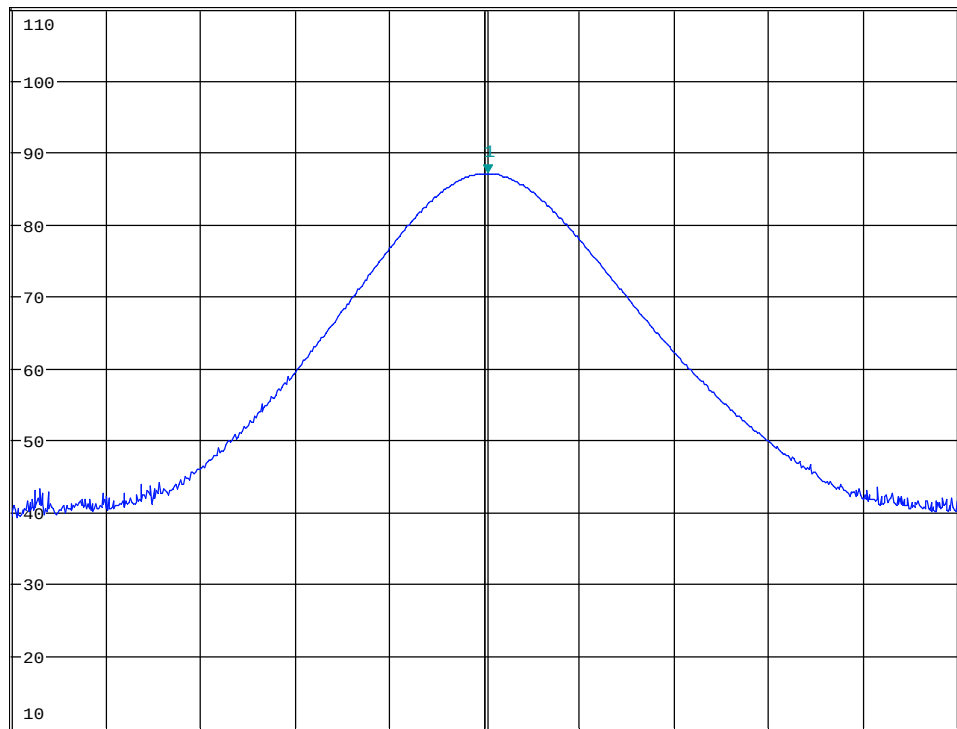
SWT 5 ms

Marker 1 [T1]

87.06 dBμV/m

1.809337500 GHz

1 PK
MAXH



Center 1.8093 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 11:04:15

VP: 2nd harmonic , ch904.6625MHz -PK



MARKER 1

1.8403125 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

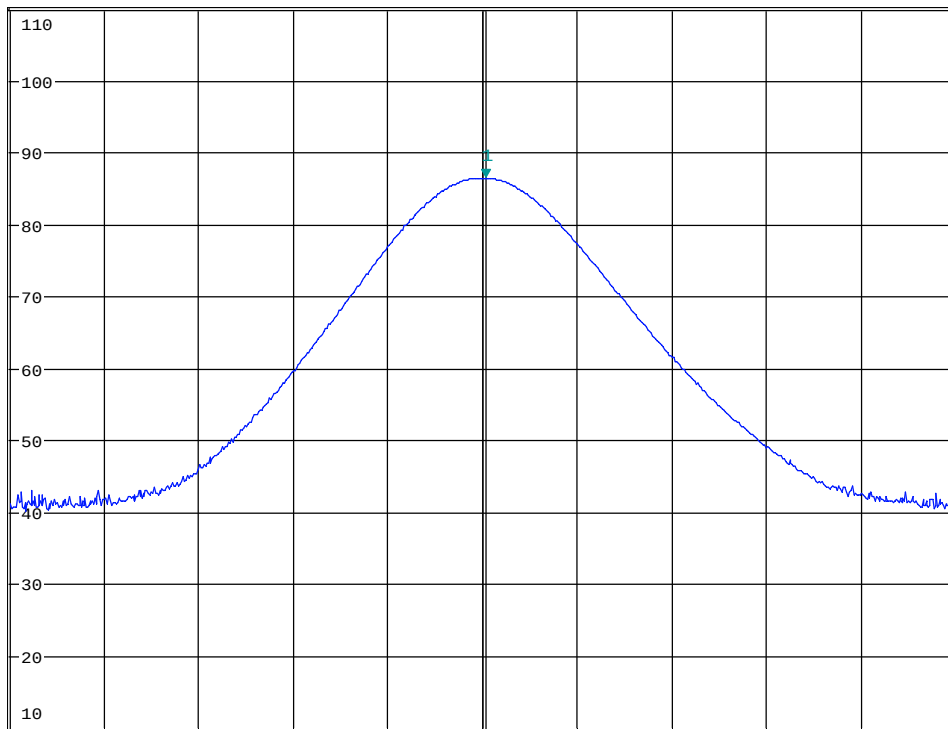
SWT 5 ms

Marker 1 [T1]

86.43 dBμV/m

1.840312500 GHz

1 PK
MAXH



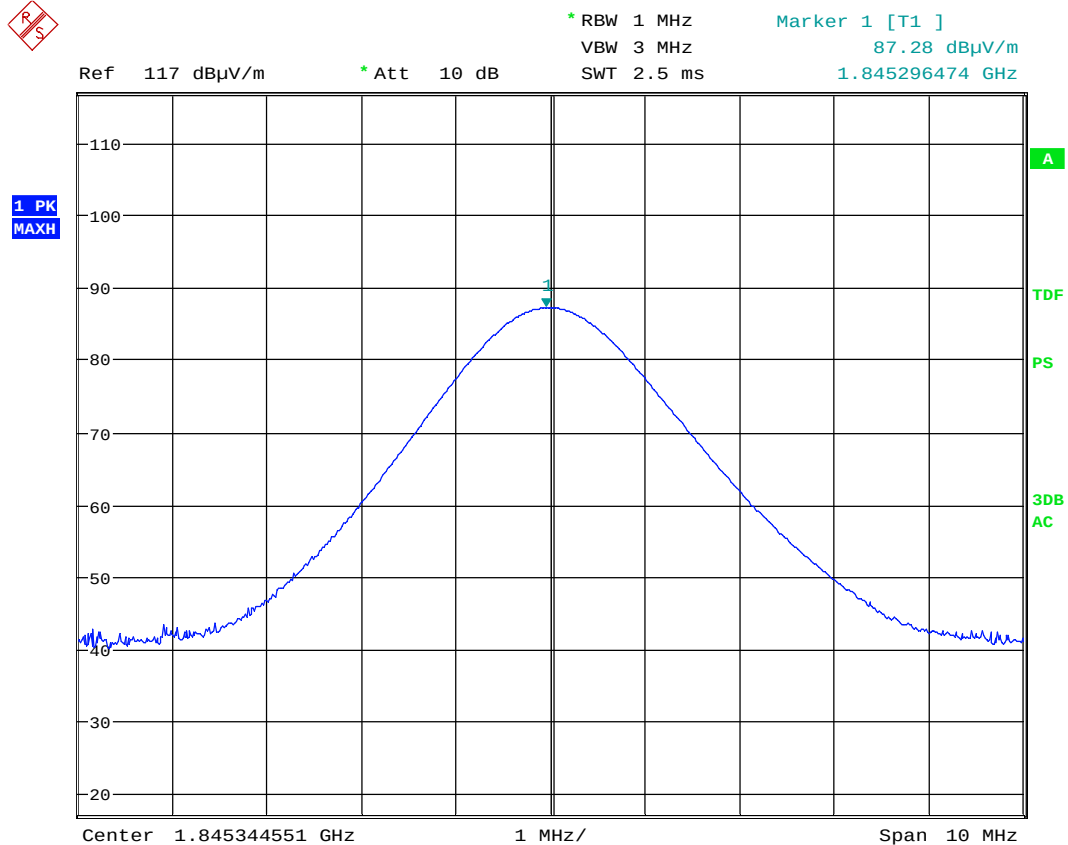
Center 1.840275 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 10:49:14

VP: 2nd harmonic , ch920.1375MHz -Pk



Date: 23.FEB.2017 16:21:09

VP: 2nd harmonic , ch922.6625MHz -Pk



MARKER 1

2.713906731 GHz

Ref 77 dB μ V/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

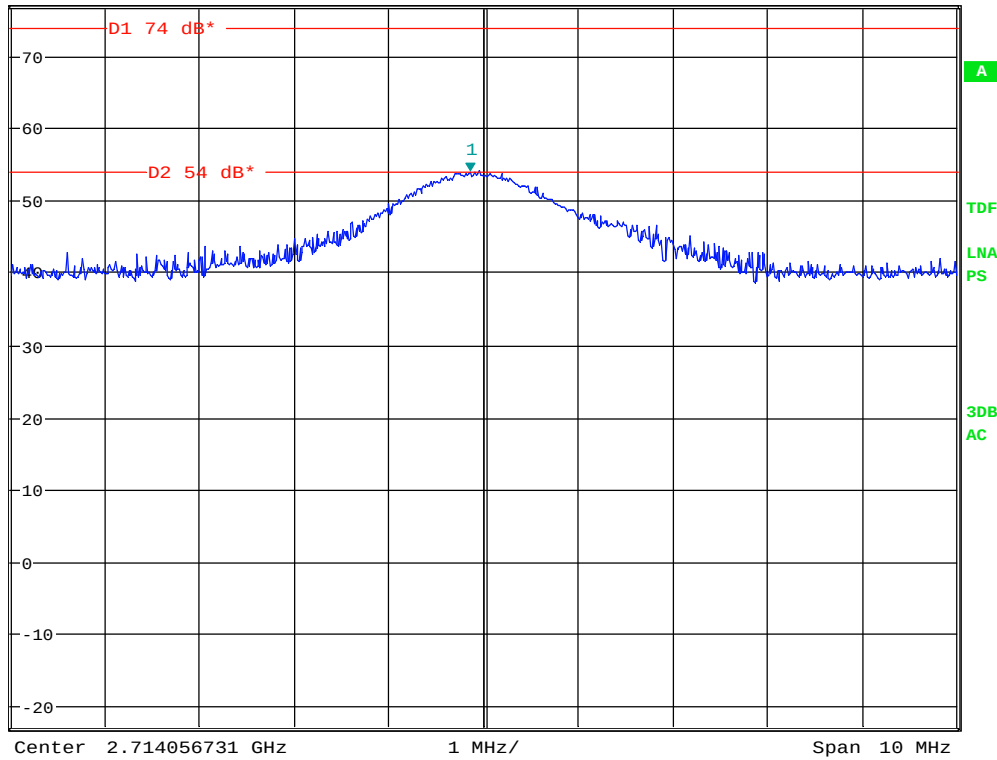
SWT 5 ms

Marker 1 [T1]

53.95 dB μ V/m

2.713906731 GHz

1 PK
MAXH



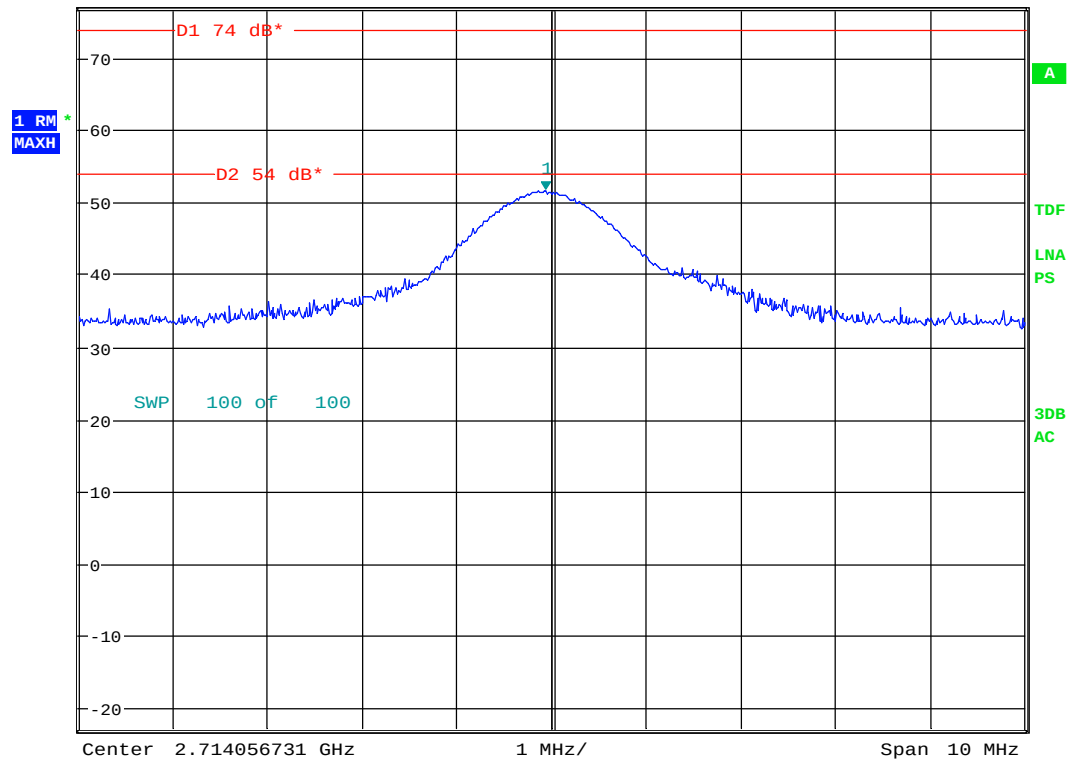
Date: 10.FEB.2017 09:30:14

VP: 3rd harmonic , ch904.6625MHz -PK



MARKER 1
2.713994231 GHz
Ref 77 dB μ V/m * Att 5 dB

* RBW 1 MHz Marker 1 [T1]
VBW 10 MHz 51.69 dB μ V/m
SWT 5 ms 2.713994231 GHz



Date: 10.FEB.2017 09:31:33

VP: 3rd harmonic , ch904.6625MHz- rms



MARKER 1

3.618579808 GHz

Ref 77 dB μ V/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

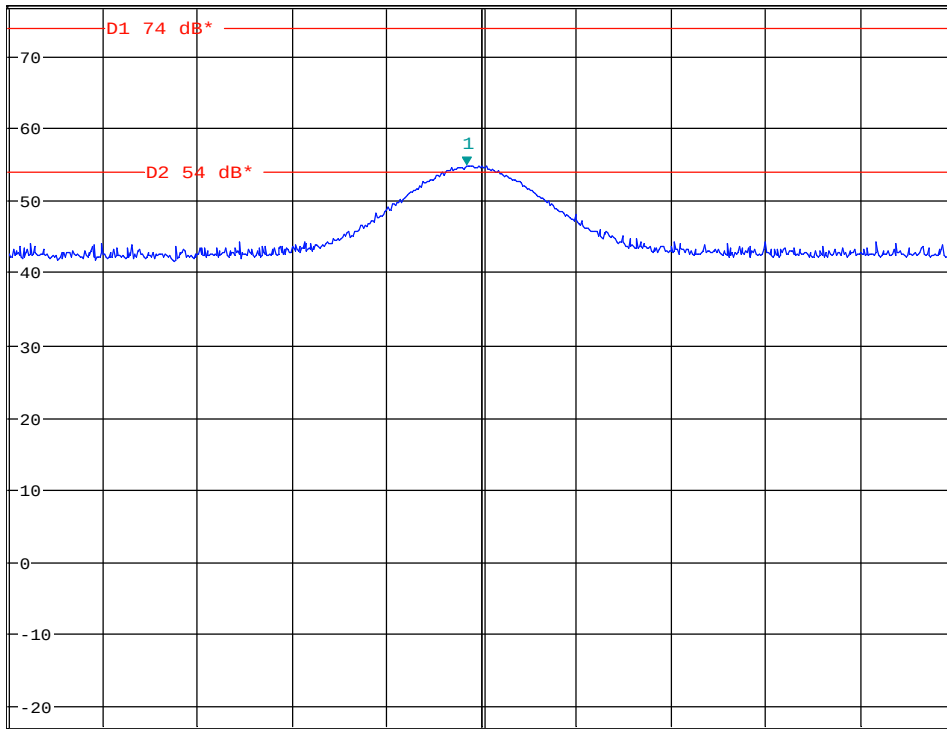
SWT 20 ms

Marker 1 [T1]

54.94 dB μ V/m

3.618579808 GHz

1 PK
MAXH



Center 3.618742308 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 09:35:37

VP: 4th harmonic , ch904.6625MHz-PK



MARKER 1

3.618654808 GHz

Ref 77 dB μ V/m

* Att 5 dB

* RBW 1 MHz

VBW 10 MHz

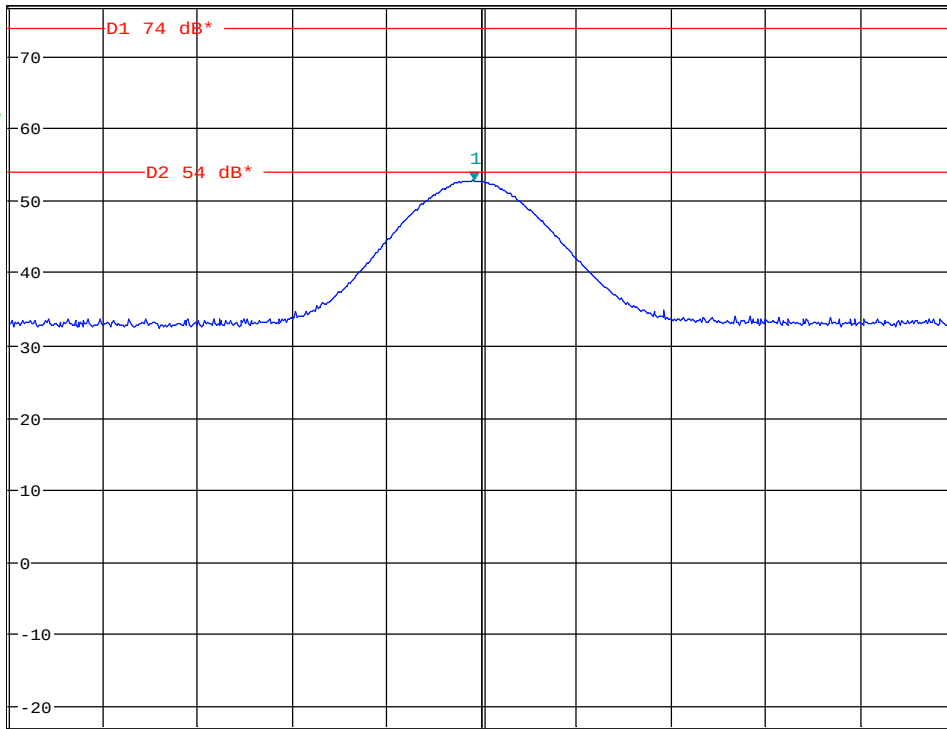
SWT 20 ms

Marker 1 [T1]

52.83 dB μ V/m

3.618654808 GHz

1 RM
MAXH



Center 3.618742308 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 09:37:23

VP: 4th harmonic , ch904.6625MHz – rms



MARKER 1

4.523465385 GHz

Ref 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

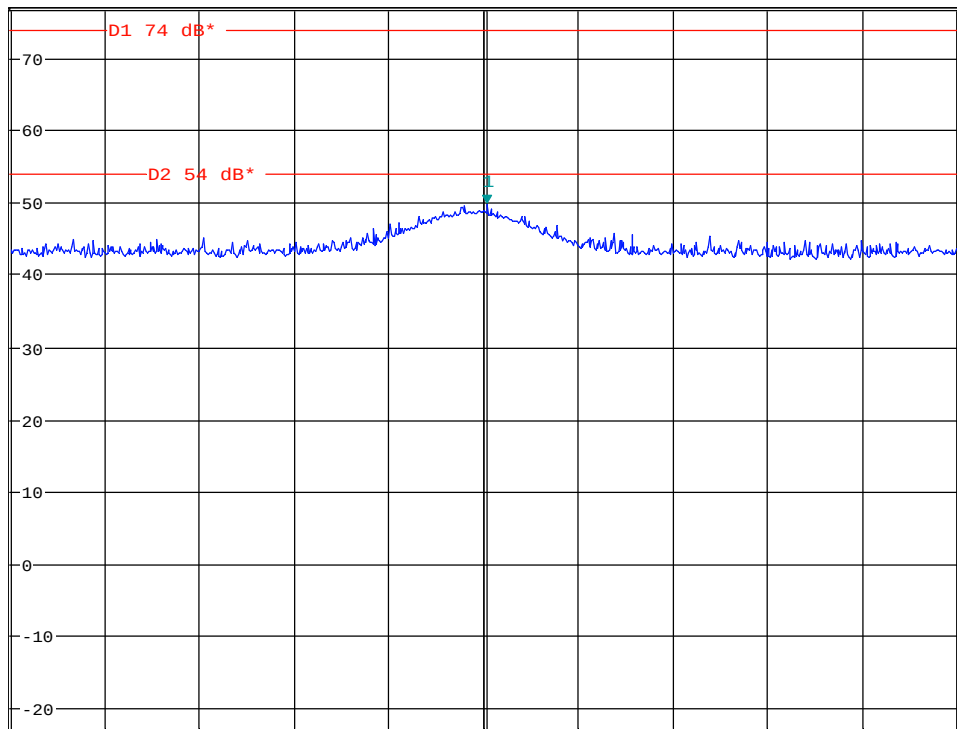
SWT 20 ms

Marker 1 [T1]

49.84 dBμV/m

4.523465385 GHz

1 PK
MAXH



Center 4.523427885 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 09:43:22

VP: 5th harmonic , ch904.6625MHz -PK



MARKER 1

2.7603375 GHz

Ref 77 dB μ V/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

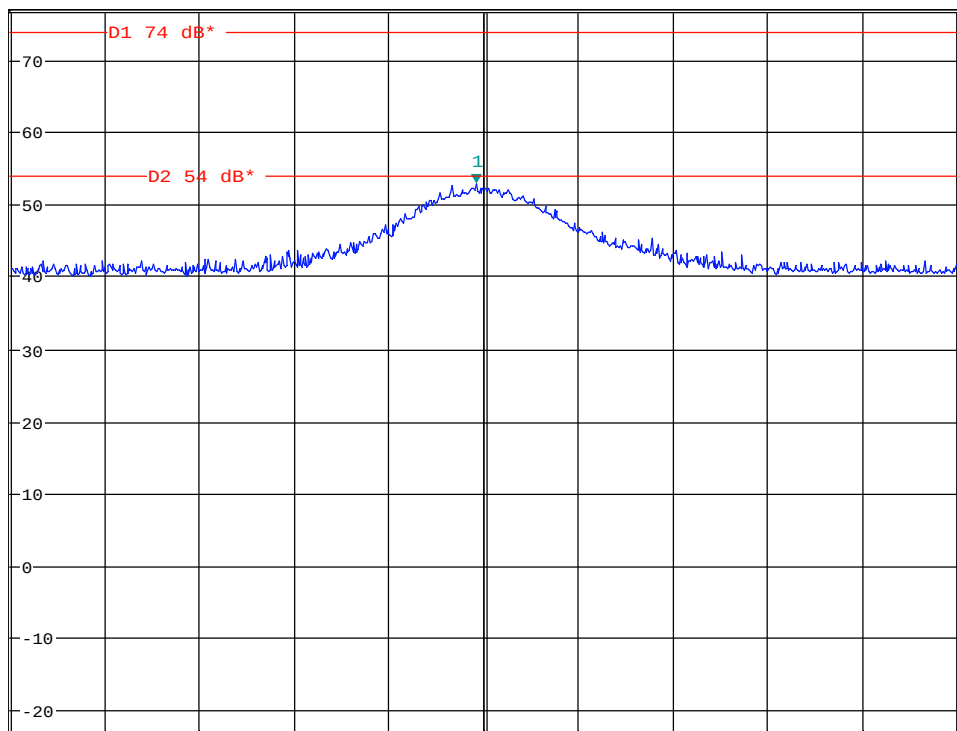
SWT 5 ms

Marker 1 [T1]

52.97 dB μ V/m

2.760337500 GHz

1 PK
MAXH



Center 2.7604125 GHz

1 MHz/

Span 10 MHz

Date: 10.FEB.2017 10:16:41

VP: 3rd harmonic , ch920.1375MHz -PK



MARKER 1

3.6805625 GHz

Ref 77 dB μ V/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

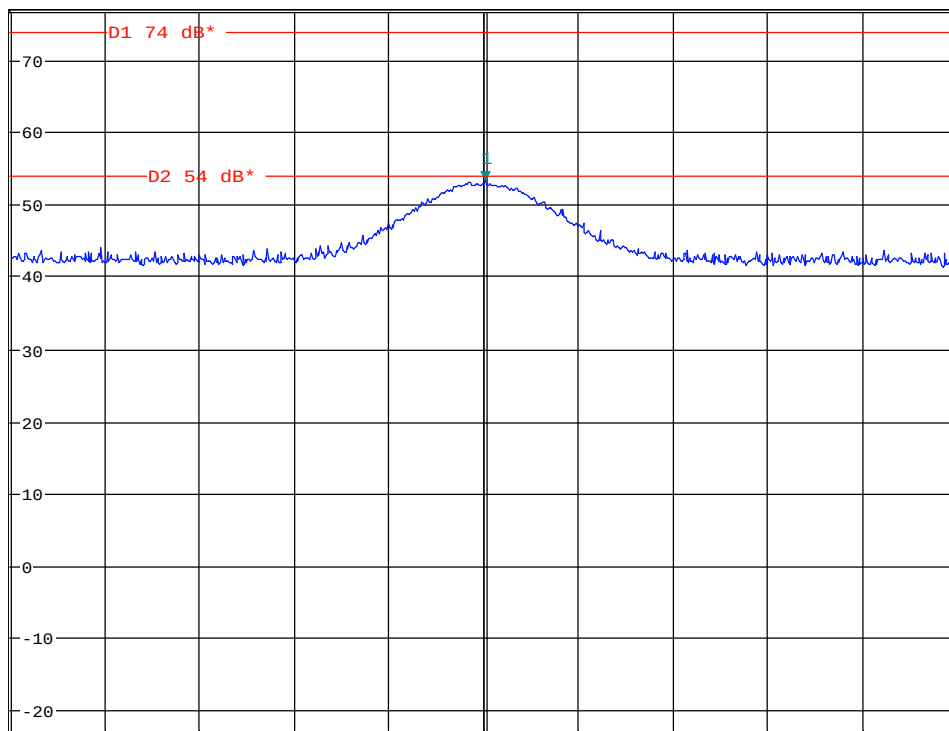
SWT 20 ms

Marker 1 [T1]

53.46 dB μ V/m

3.680562500 GHz

1 PK
MAXH



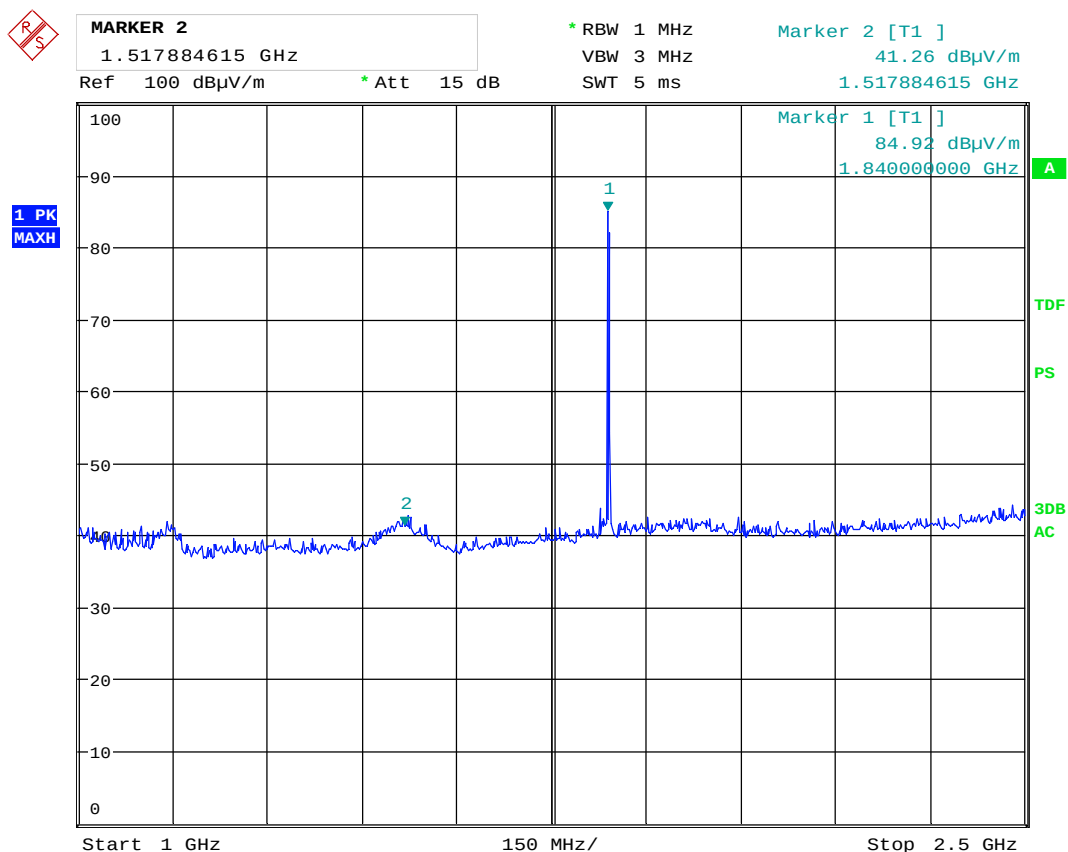
Center 3.68055 GHz

1 MHz/

Span 10 MHz

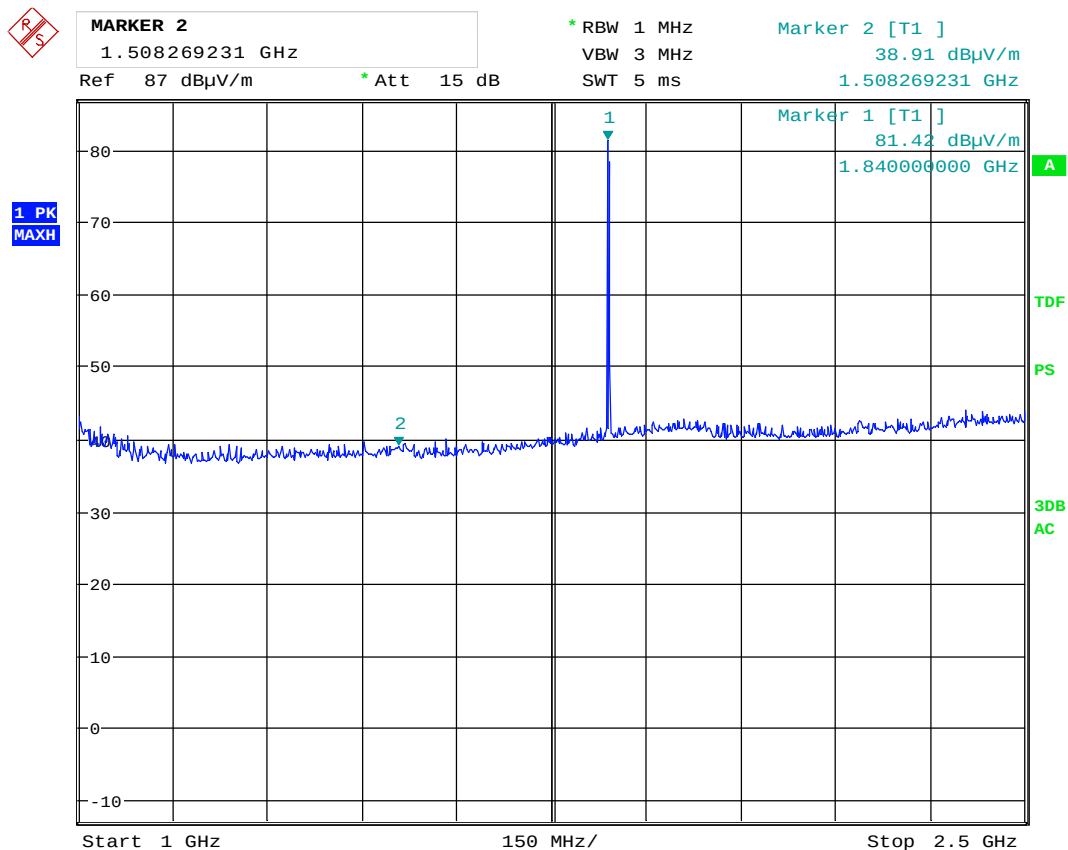
Date: 10.FEB.2017 10:20:00

VP: 4th harmonic , ch920.1375MHz -PK



Date: 10.FEB.2017 10:42:20

Hopping mode 1: VP, 1 - 2.5GHz -ch902.1375MHz- PK scan



Date: 10.FEB.2017 10:41:19

Hopping mode 1: HP, 1 – 2.5GHz –ch902.1375MHz- PK scan



MARKER 1

2.702724359 GHz

Step 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

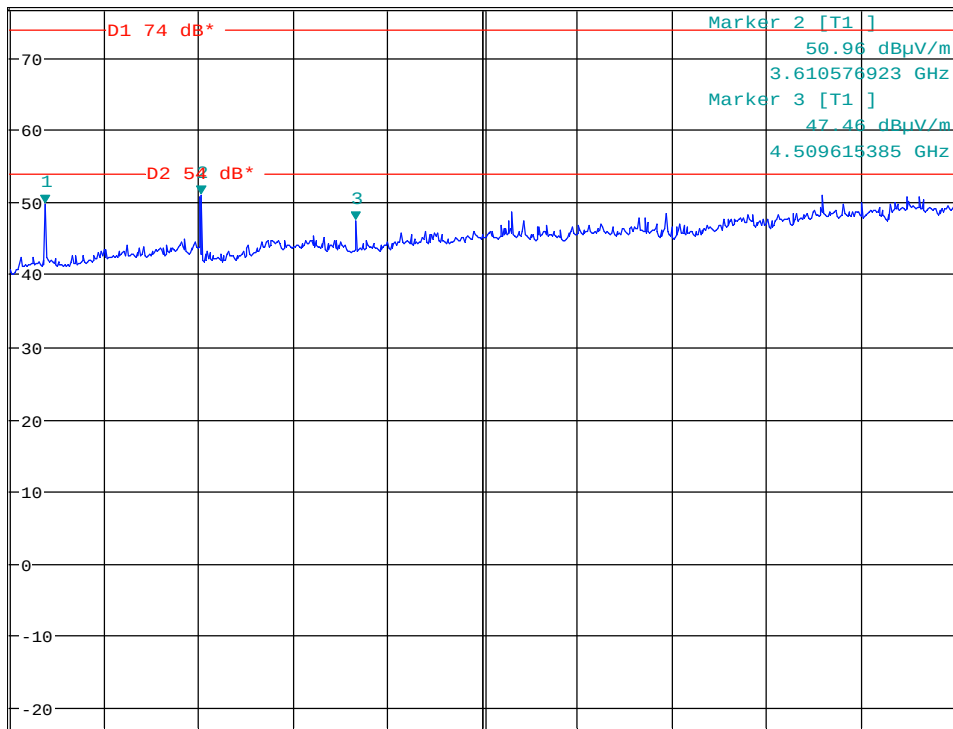
SWT 35 ms

Marker 1 [T1]

49.76 dBμV/m

2.702724359 GHz

1 PK
MAXH



Start 2.5 GHz

550 MHz/

Stop 8 GHz

Date: 23.JAN.2017 15:05:39

Hopping mode 1: VP, 2.5 - 8GHz -ch902.1375MHz- PK scan



MARKER 1

2.702724359 GHz

Step 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

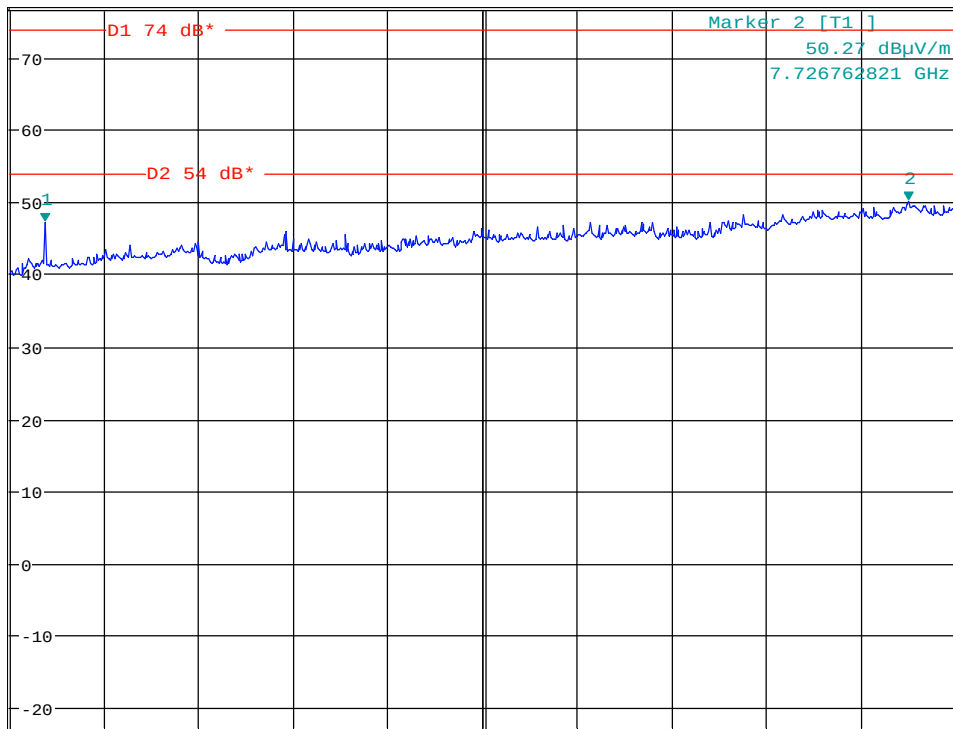
SWT 35 ms

Marker 1 [T1]

47.23 dBμV/m

2.702724359 GHz

1 PK
MAXH



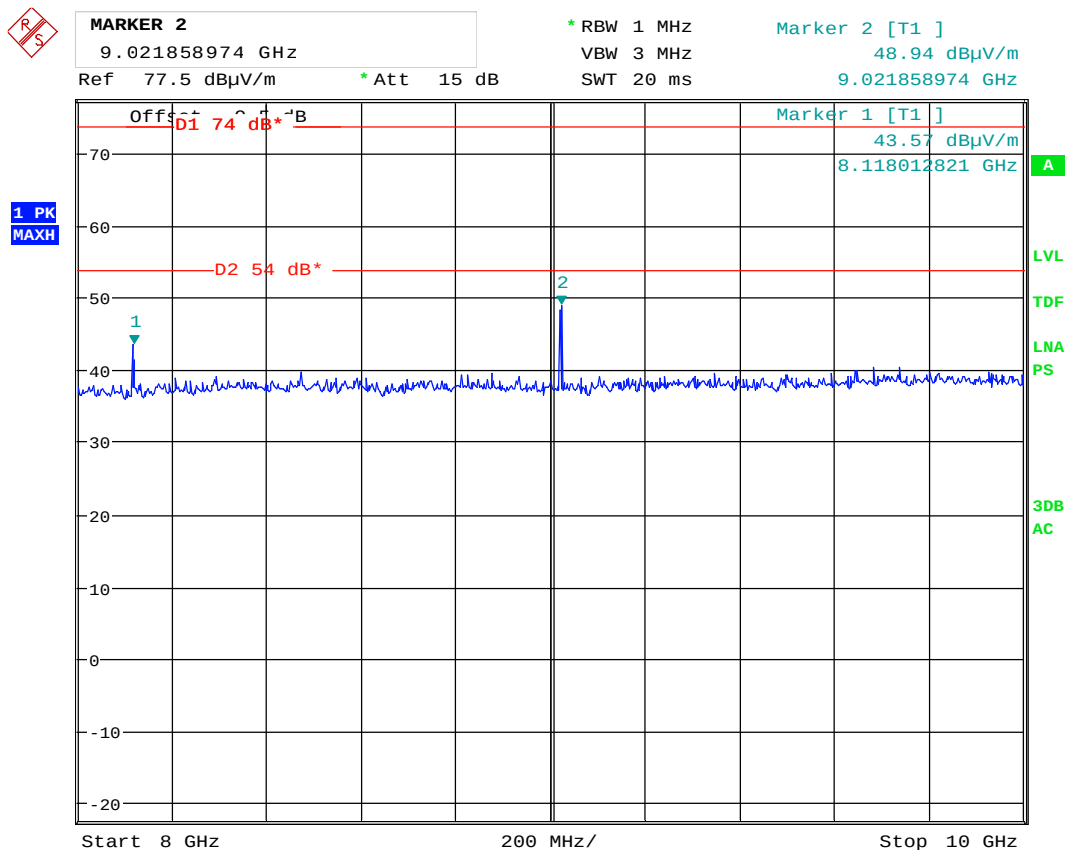
Start 2.5 GHz

550 MHz/

Stop 8 GHz

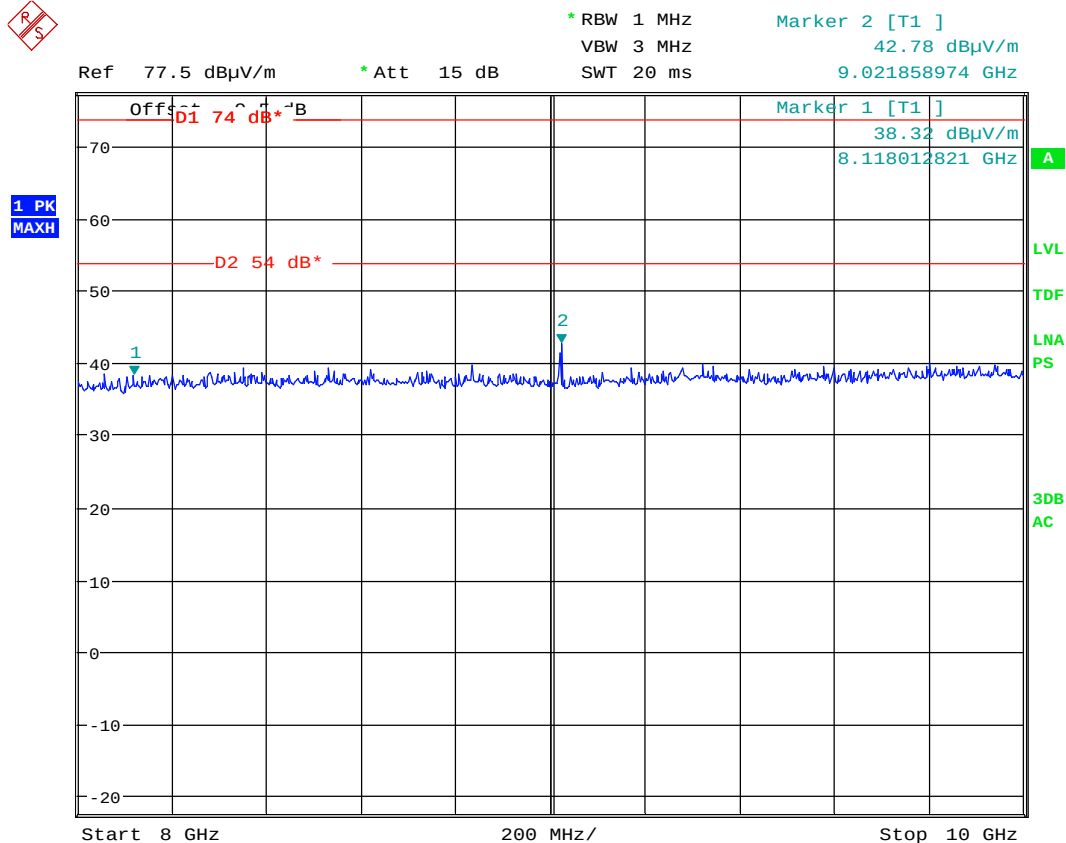
Date: 23.JAN.2017 15:07:39

Hopping mode 1: HP, 2.5 - 8GHz -ch902.1375MHz- PK scan



Date: 10.FEB.2017 11:21:55

Hopping mode 1: VP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch902.1375MHz- PK scan



Date: 10.FEB.2017 11:22:58

Hopping mode 1: HP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch902.1375MHz- PK scan



MARKER 2

1.483173077 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

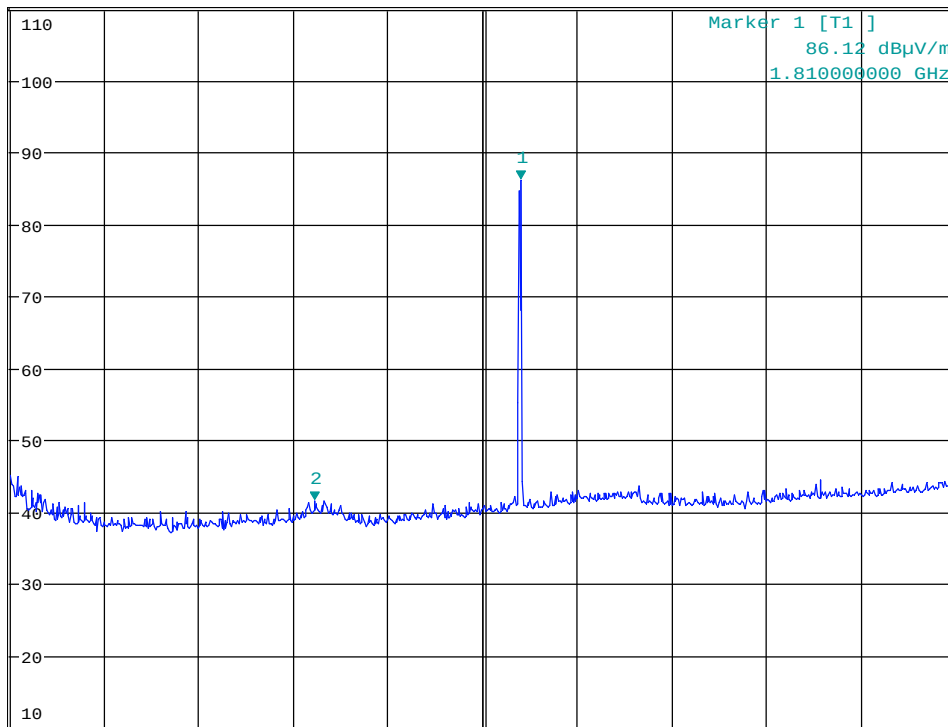
SWT 5 ms

Marker 2 [T1]

41.62 dBμV/m

1.483173077 GHz

1 PK
MAXH



Start 1 GHz

150 MHz/

Stop 2.5 GHz

Date: 10.FEB.2017 11:02:49

Hopping mode 1: VP, 1 – 2.5GHz –ch904.6625MHz- PK scan



MARKER 2

1.002403846 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

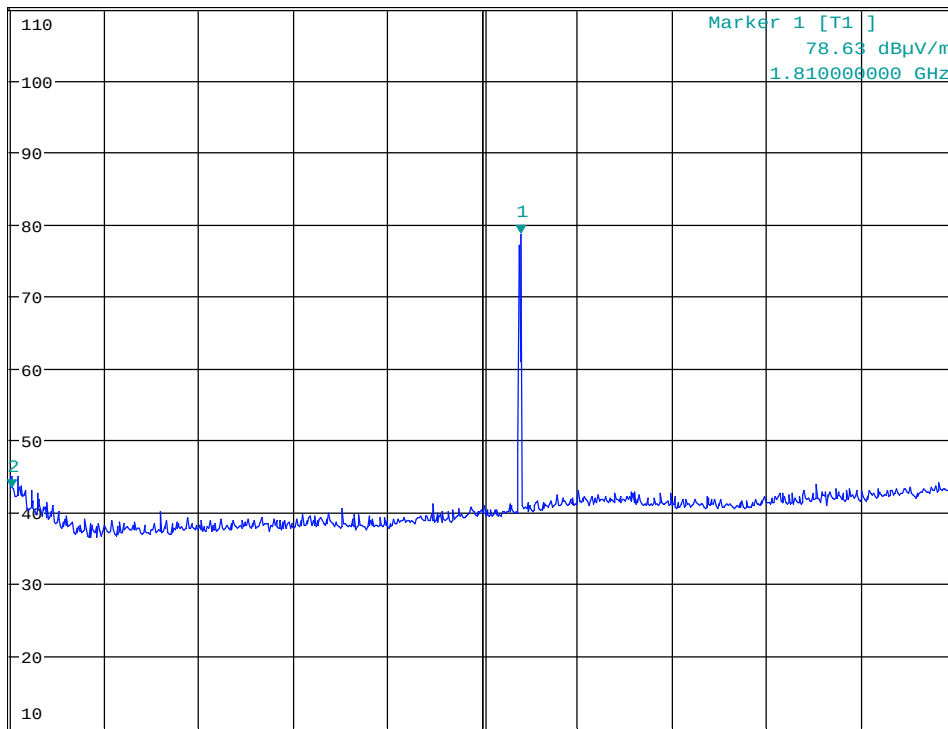
SWT 5 ms

Marker 2 [T1]

43.35 dBμV/m

1.002403846 GHz

1 PK
MAXH



Start 1 GHz

150 MHz/

Stop 2.5 GHz

A

TDF

PS

3DB

AC

Date: 10.FEB.2017 11:01:59

Hopping mode 1: HP, 1 – 2.5GHz –ch904.6625MHz- PK scan

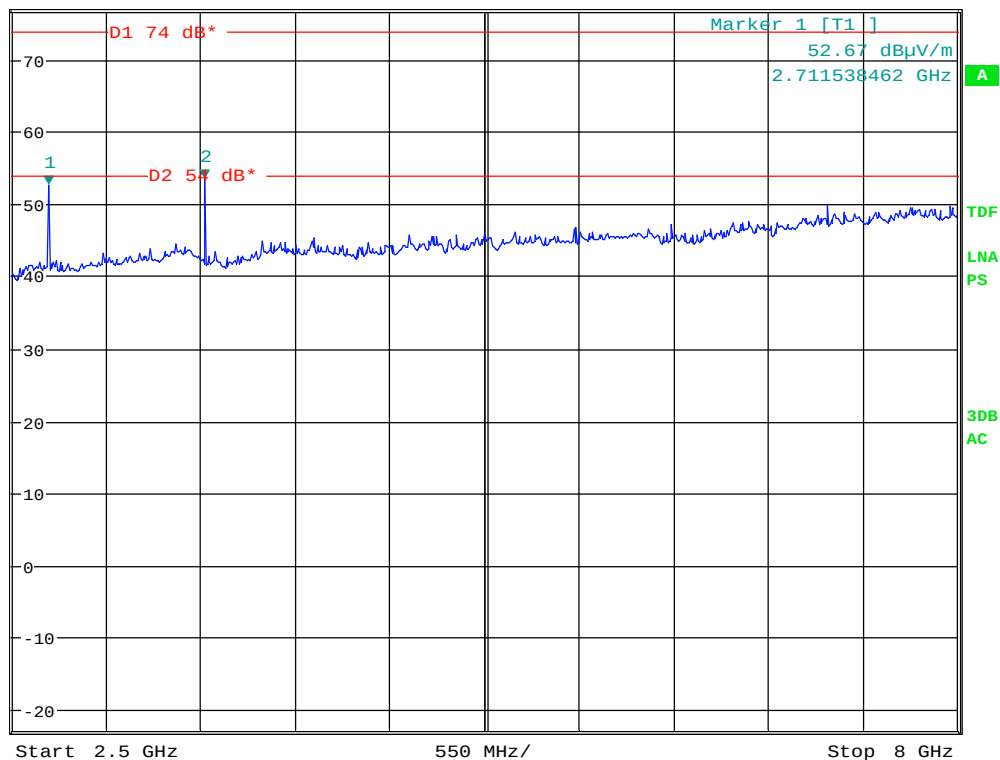


MARKER 2
3.619391026 GHz
Ref 77 dBμV/m * Att 5 dB

* RBW 1 MHz
VBW 3 MHz
SWT 35 ms

Marker 2 [T1]
53.63 dBμV/m
3.619391026 GHz

1 PK
MAXH



Date: 10.FEB.2017 09:21:24

Hopping mode 1: VP, 2.5 - 8GHz -ch904.6625MHz- PK scan



MARKER 1

2.711538462 GHz

Ref 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

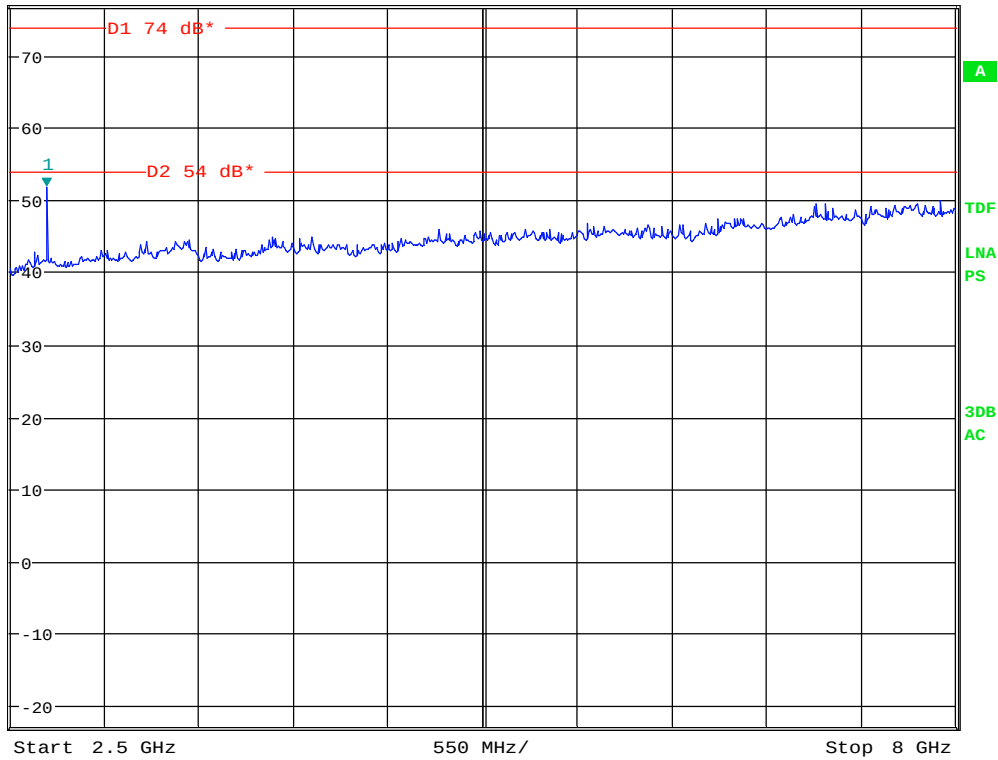
SWT 35 ms

Marker 1 [T1]

51.93 dBμV/m

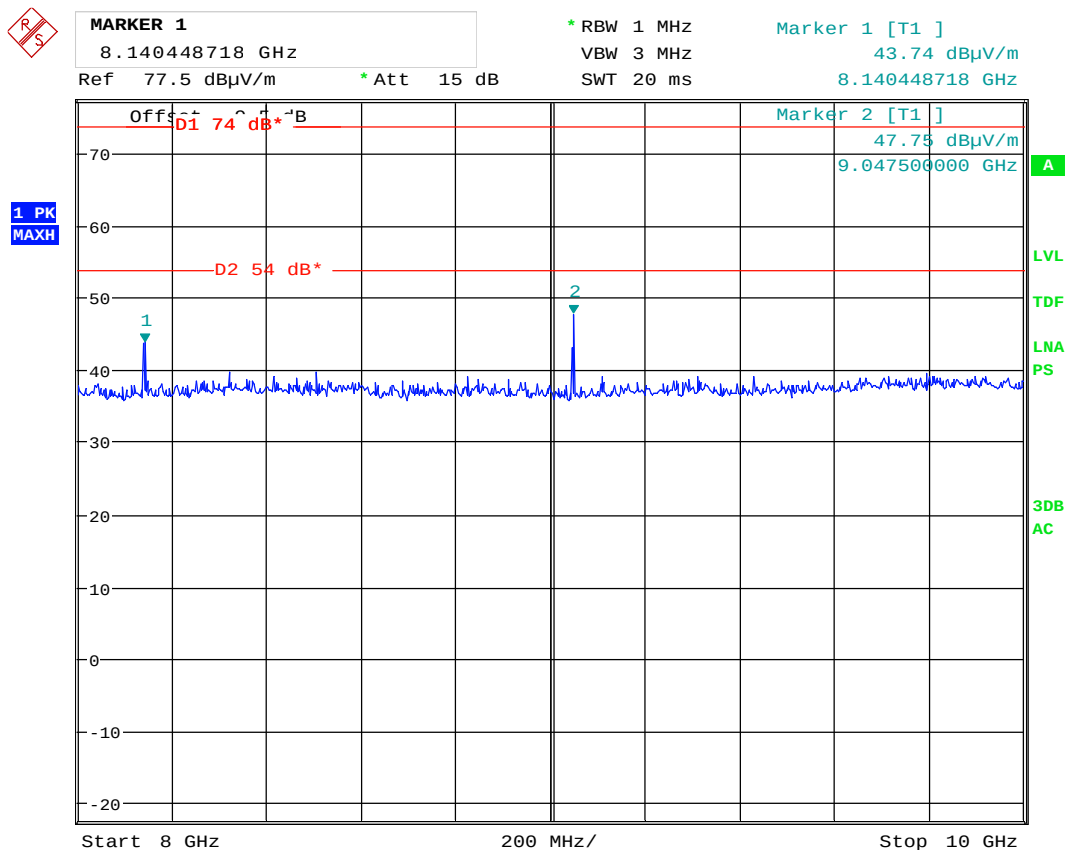
2.711538462 GHz

1 PK
MAXH



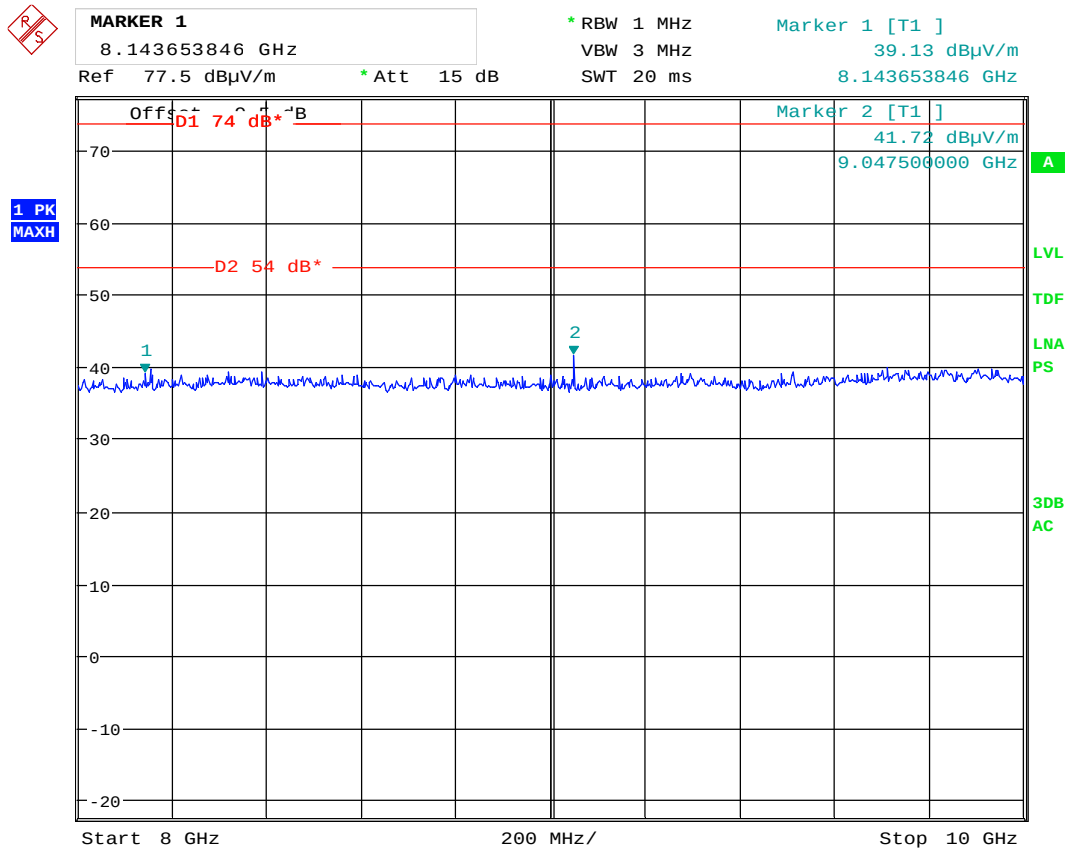
Date: 10.FEB.2017 09:25:11

Hopping mode 1: HP, 2.5 - 8GHz -ch904.6625MHz- PK scan



Date: 10.FEB.2017 11:16:49

Hopping mode 1: VP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch904.6625MHz- PK scan



Date: 10.FEB.2017 11:19:04

Hopping mode 1: HP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch904.6625MHz- PK scan



MARKER 2

1.002403846 GHz

Ref 110 dBμV/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

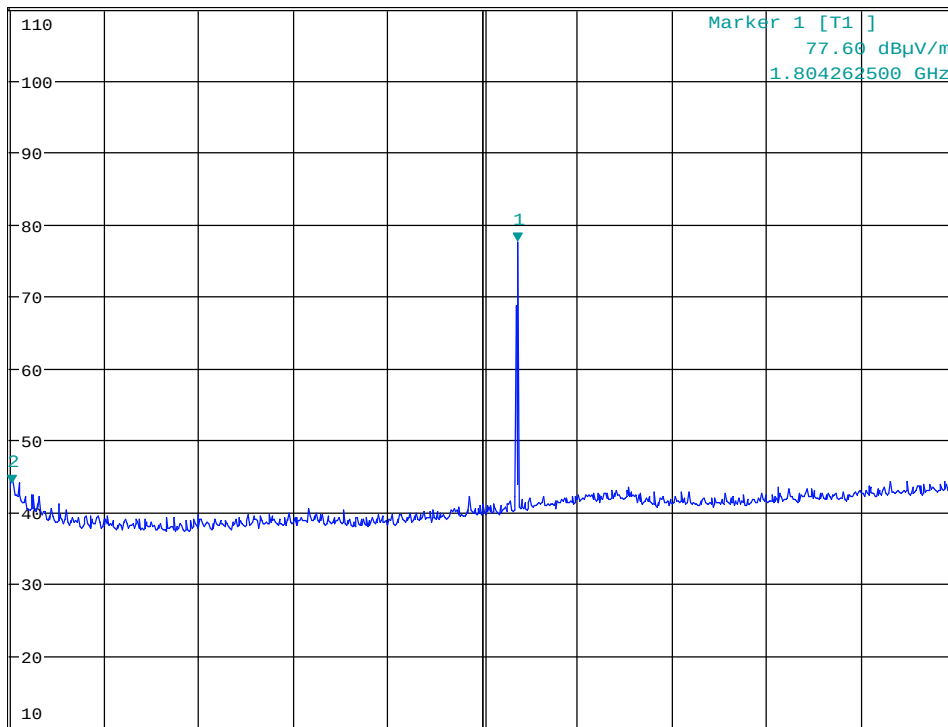
SWT 5 ms

Marker 2 [T1]

43.87 dBμV/m

1.002403846 GHz

1 PK
MAXH



Start 1 GHz

150 MHz/

Stop 2.5 GHz

Date: 10.FEB.2017 10:58:45

Hopping mode 2: VP, 1 – 2.5GHz –ch920.1375MHz- PK scan



MARKER 2

1.508269231 GHz

Ref 87 dB μ V/m

* Att 15 dB

* RBW 1 MHz

VBW 3 MHz

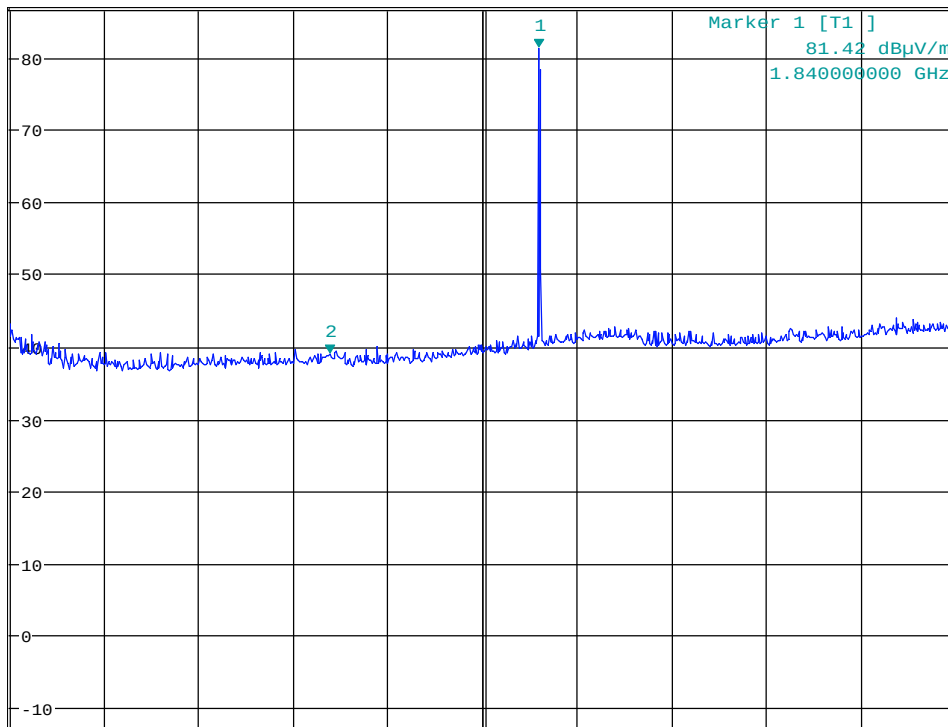
SWT 5 ms

Marker 2 [T1]

38.91 dB μ V/m

1.508269231 GHz

1 PK
MAXH



Start 1 GHz

150 MHz/

Stop 2.5 GHz

A

TDF

PS

3DB

AC

Date: 10.FEB.2017 10:41:19

Hopping mode 2: HP, 1 – 2.5GHz –ch920.1375MHz- PK scan



MARKER 1

2.755080128 GHz

Ref 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

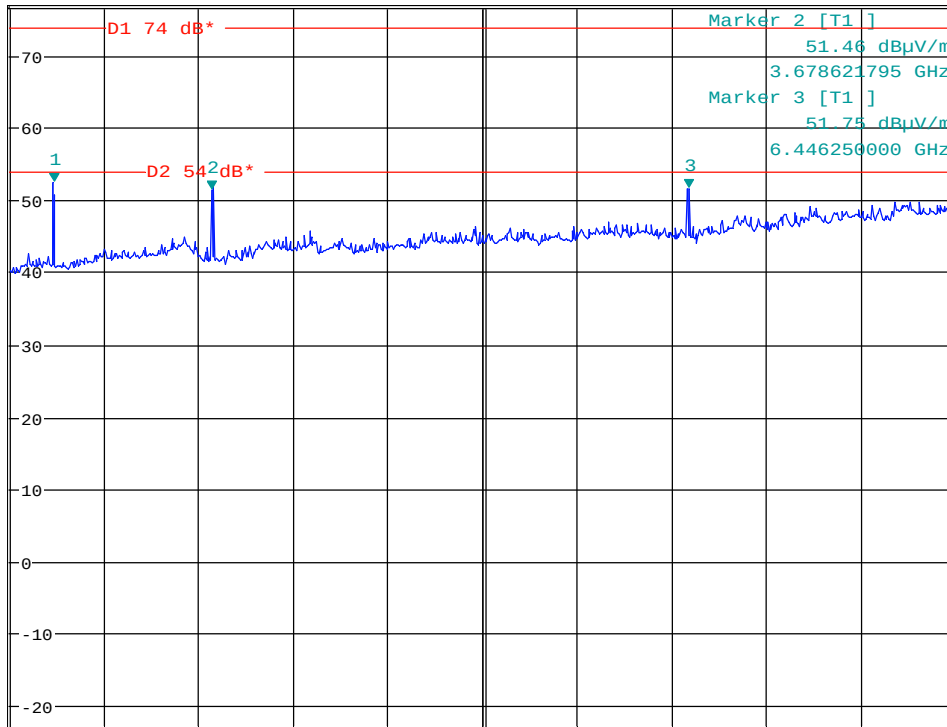
SWT 35 ms

Marker 1 [T1]

52.43 dBμV/m

2.755080128 GHz

1 PK
MAXH



Start 2.5 GHz

550 MHz/

Stop 8 GHz

Date: 10.FEB.2017 10:08:38

Hopping mode 2: VP, 2.5 - 8GHz -ch920.1375MHz- PK scan



MARKER 1

2.755080128 GHz

Ref 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

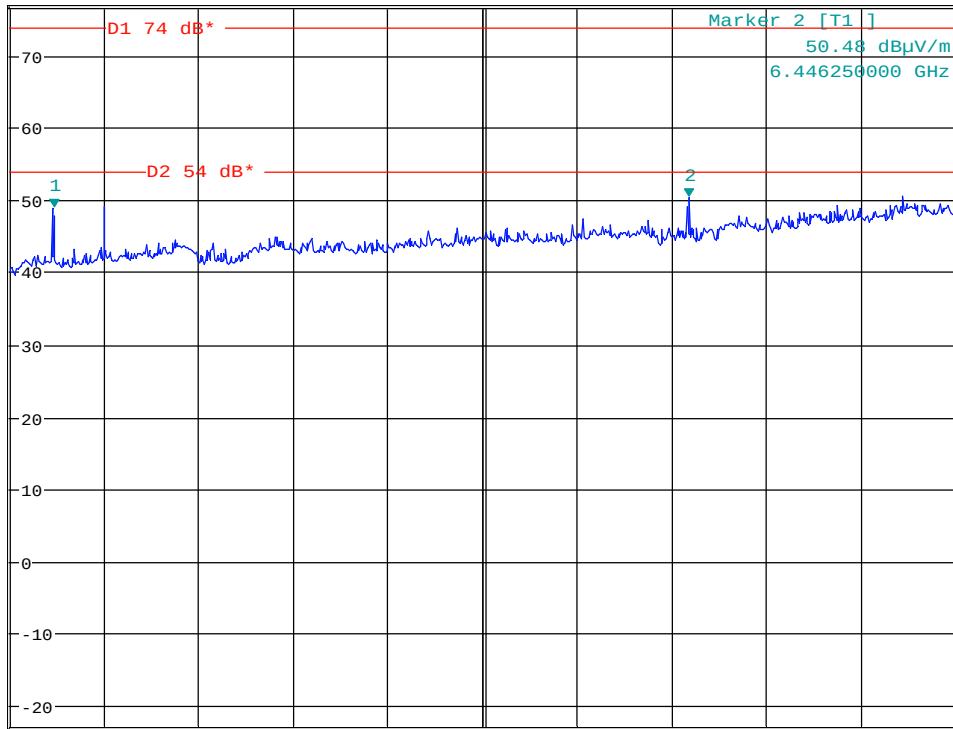
SWT 35 ms

Marker 1 [T1]

48.94 dBμV/m

2.755080128 GHz

1 PK
MAXH



Start 2.5 GHz

550 MHz/

Stop 8 GHz

A

TDF

LNA

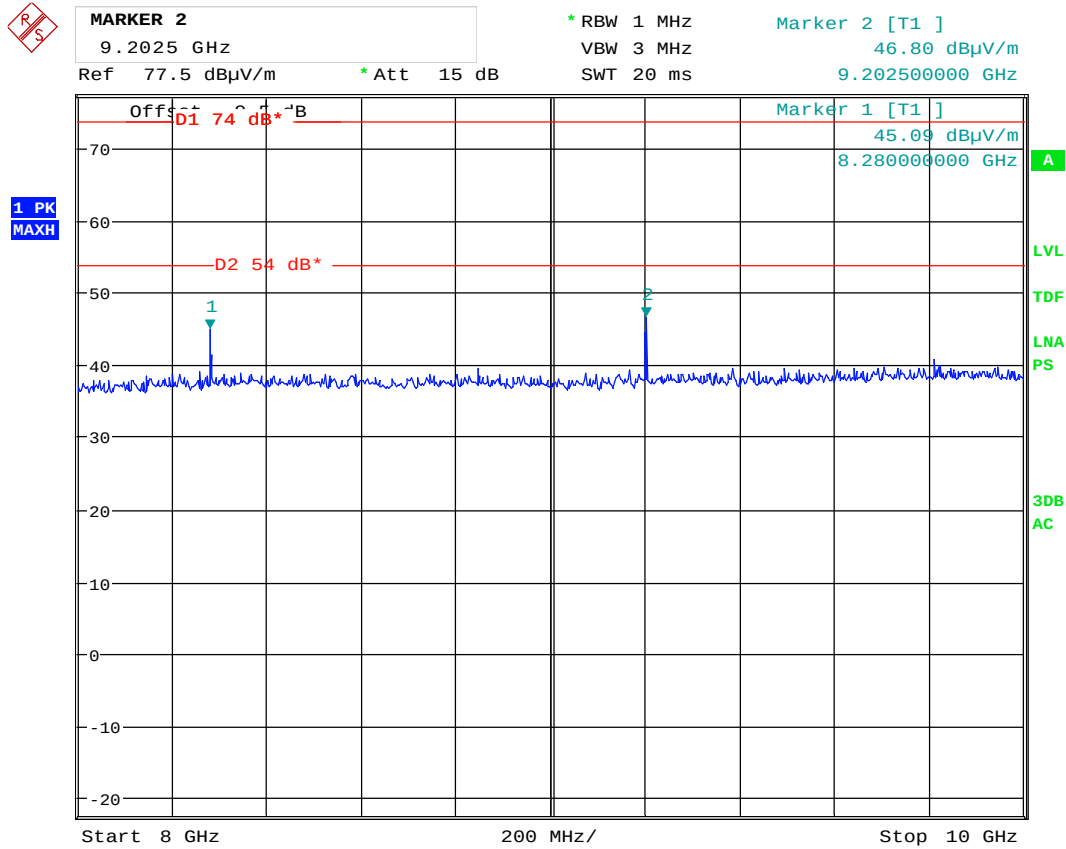
PS

3DB

AC

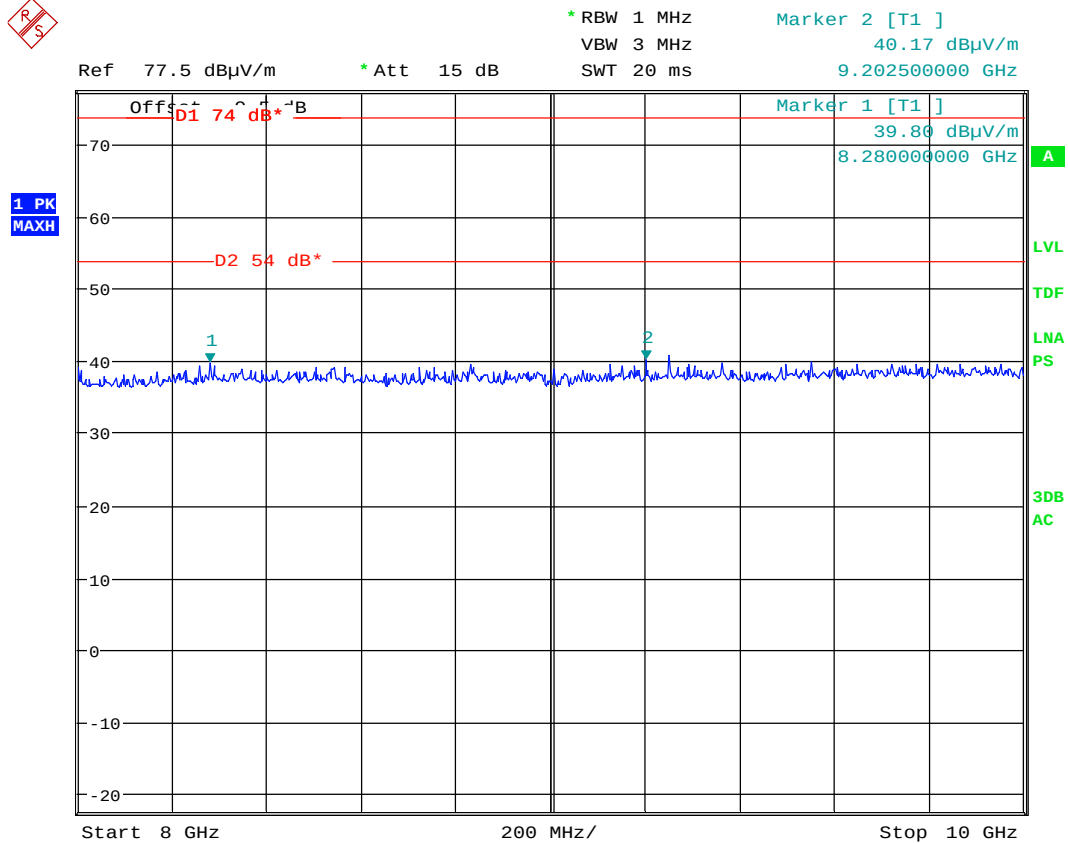
Date: 10.FEB.2017 10:11:39

Hopping mode 2: HP, 2.5 - 8GHz -ch920.1375MHz- PK scan



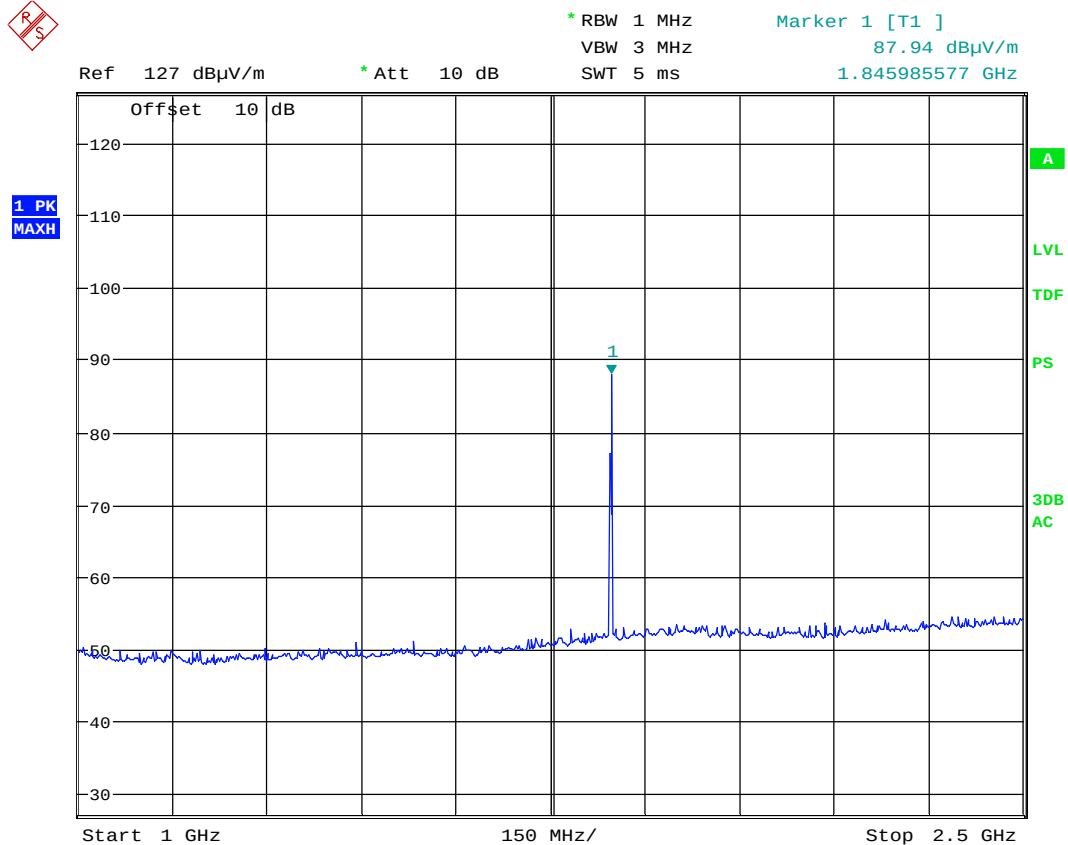
Date: 10.FEB.2017 11:26:02

Hopping mode 2: VP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch920.1375MHz- PK scan



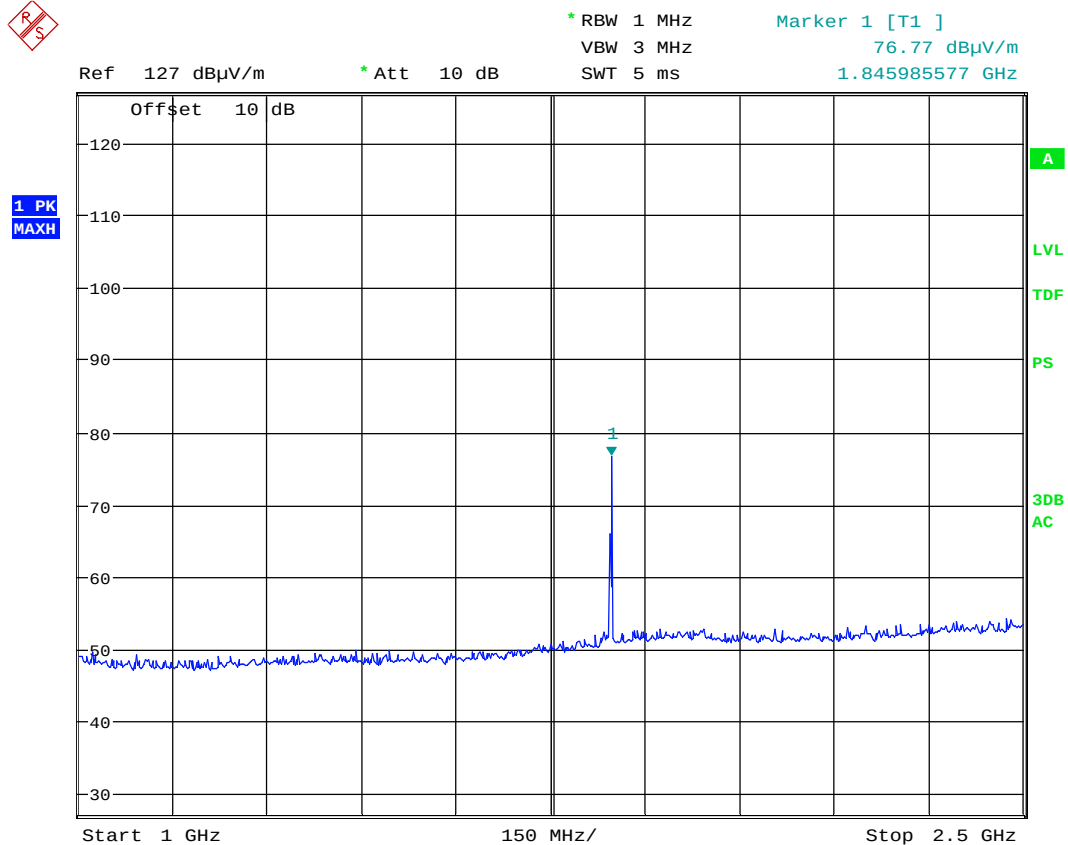
Date: 10.FEB.2017 11:27:19

Hopping mode 2: HP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch920.1375MHz- PK scan



Date: 23.FEB.2017 16:14:10

Hopping mode 2: VP, 1 – 2.5GHz –ch922.6625MHz- PK scan



Date: 23.FEB.2017 16:16:52

Hopping mode 2: HP, 1 – 2.5 GHz ch922.6625MHz- PK scan



MARKER 1

2.764423077 GHz

Step 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

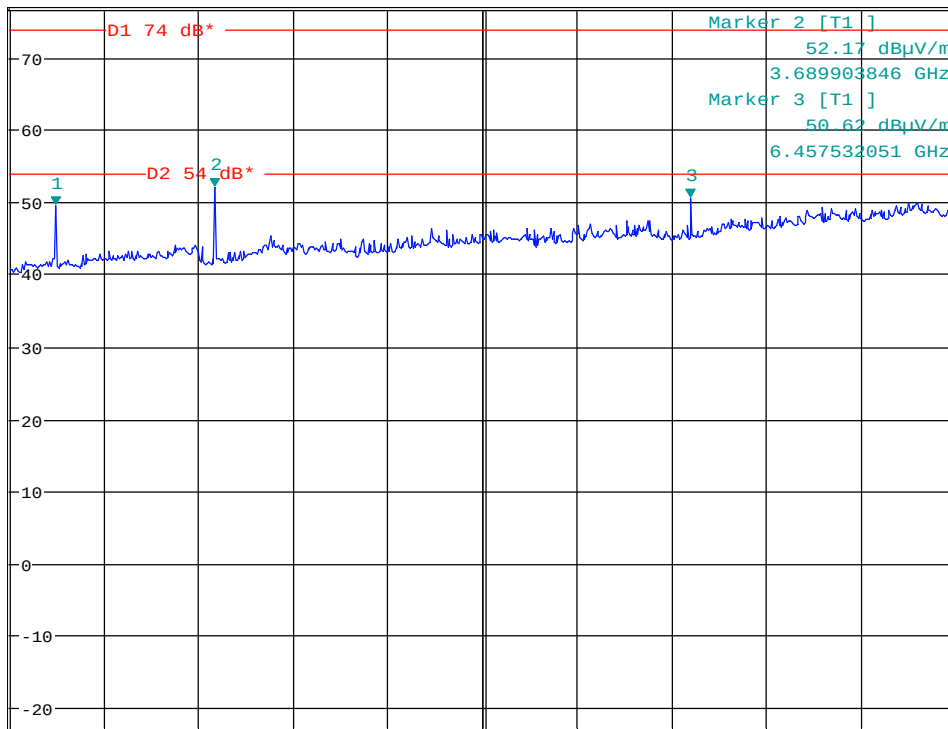
SWT 35 ms

Marker 1 [T1]

49.67 dBμV/m

2.764423077 GHz

1 PK
MAXH



Start 2.5 GHz

550 MHz/

Stop 8 GHz

Date: 23.JAN.2017 15:33:00

Hopping mode 2: VP, 2.5 - 8GHz -ch922.6625MHz- PK scan



MARKER 1

2.764423077 GHz

Step 77 dBμV/m

* Att 5 dB

* RBW 1 MHz

VBW 3 MHz

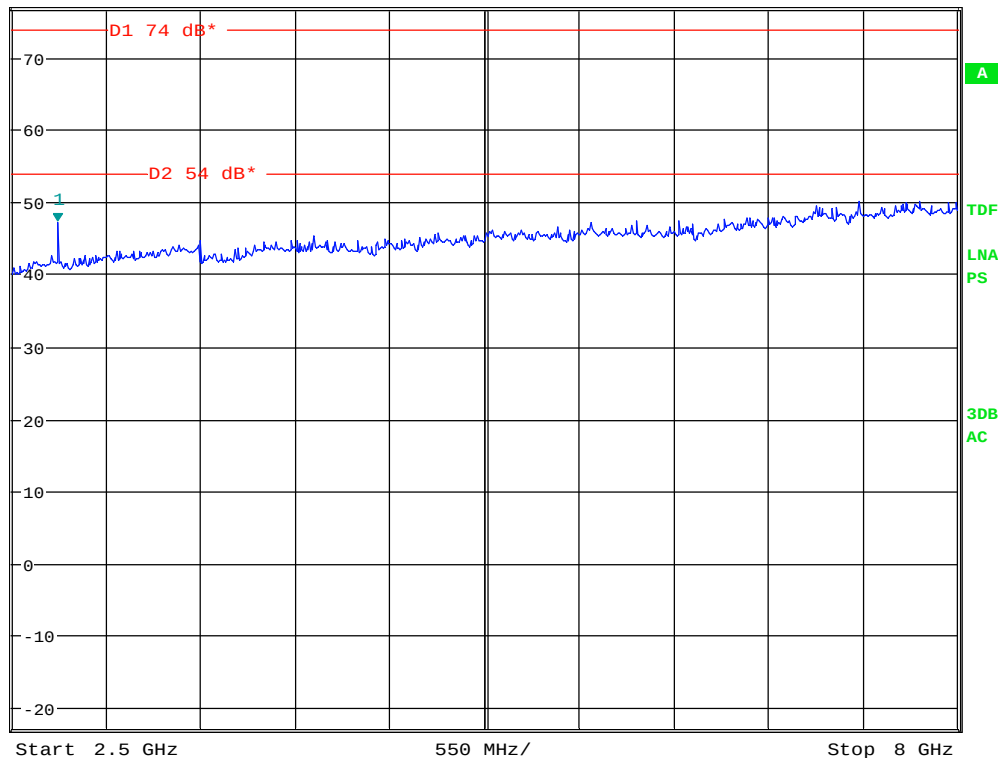
SWT 35 ms

Marker 1 [T1]

47.36 dBμV/m

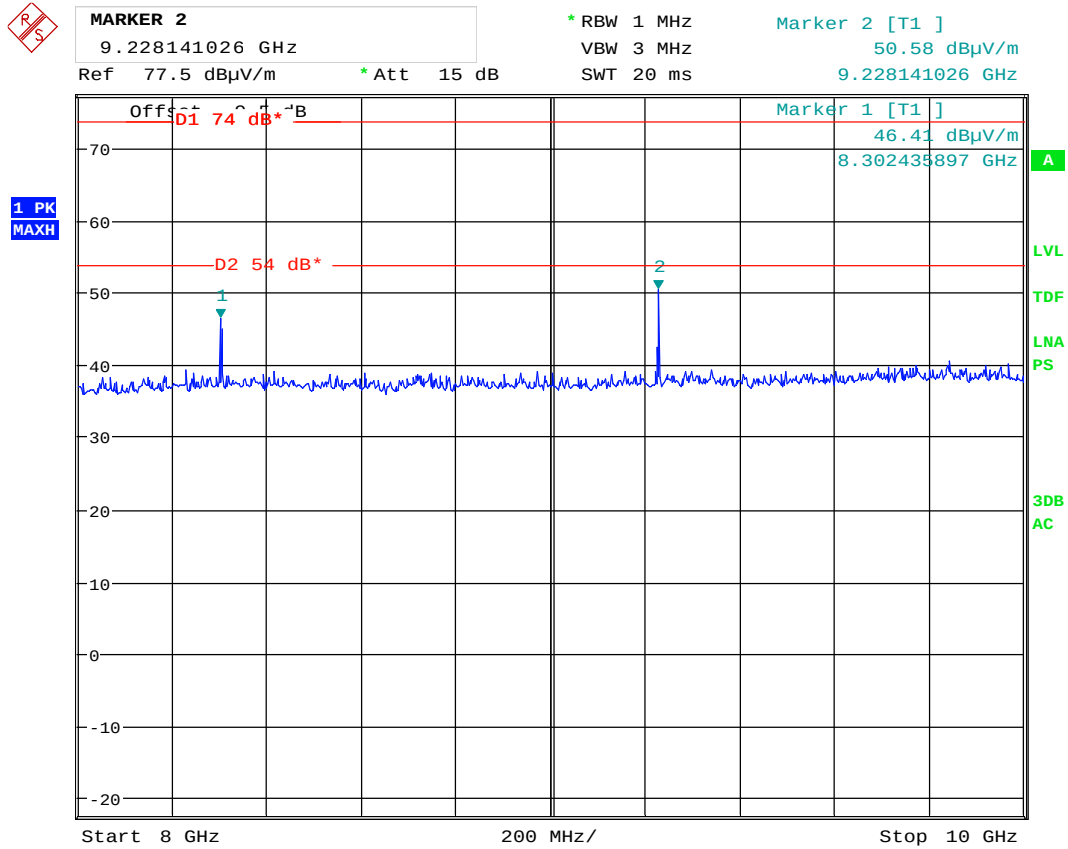
2.764423077 GHz

1 PK
MAXH



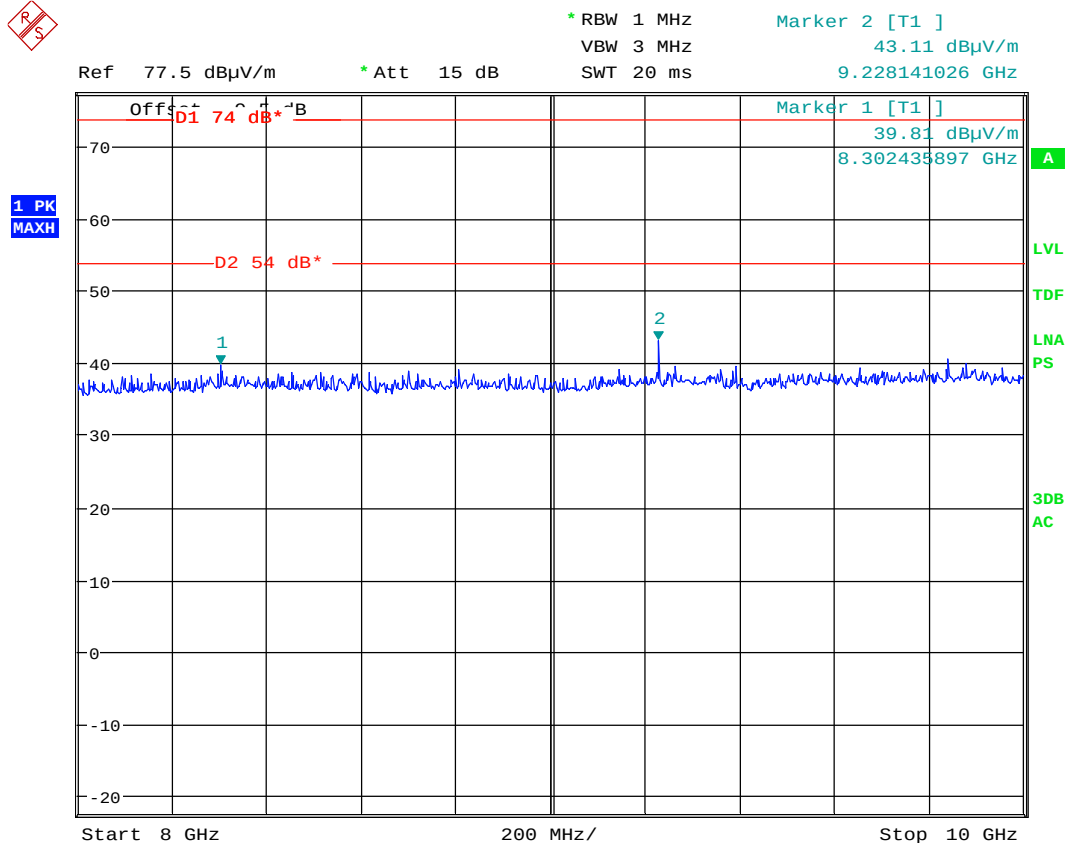
Date: 23.JAN.2017 15:38:11

Hopping mode 2: HP, 2.5 - 8GHz -ch922.6625MHz- PK scan



Date: 10.FEB.2017 11:29:28

Hopping mode 1: VP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch922.6625MHz- PK scan



Date: 10.FEB.2017 11:30:24

Hopping mode 1: HP, 8 - 10GHz @ 1m distance, correction factor is included in the plot –
ch922.6625MHz- PK scan

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

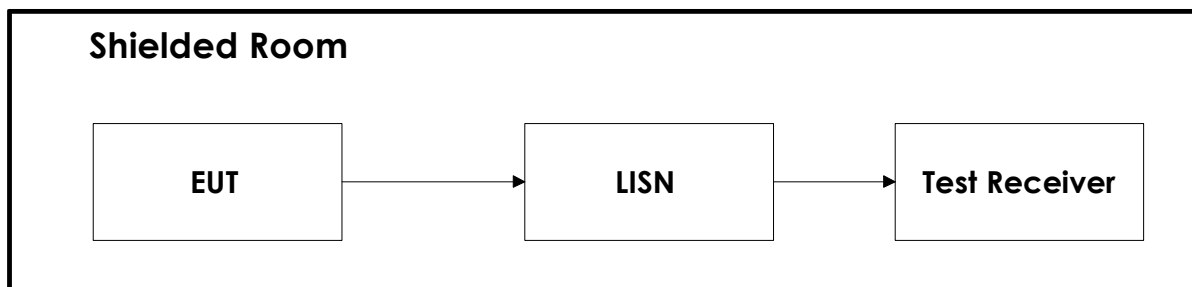
5 LIST OF TEST EQUIPMENT

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.

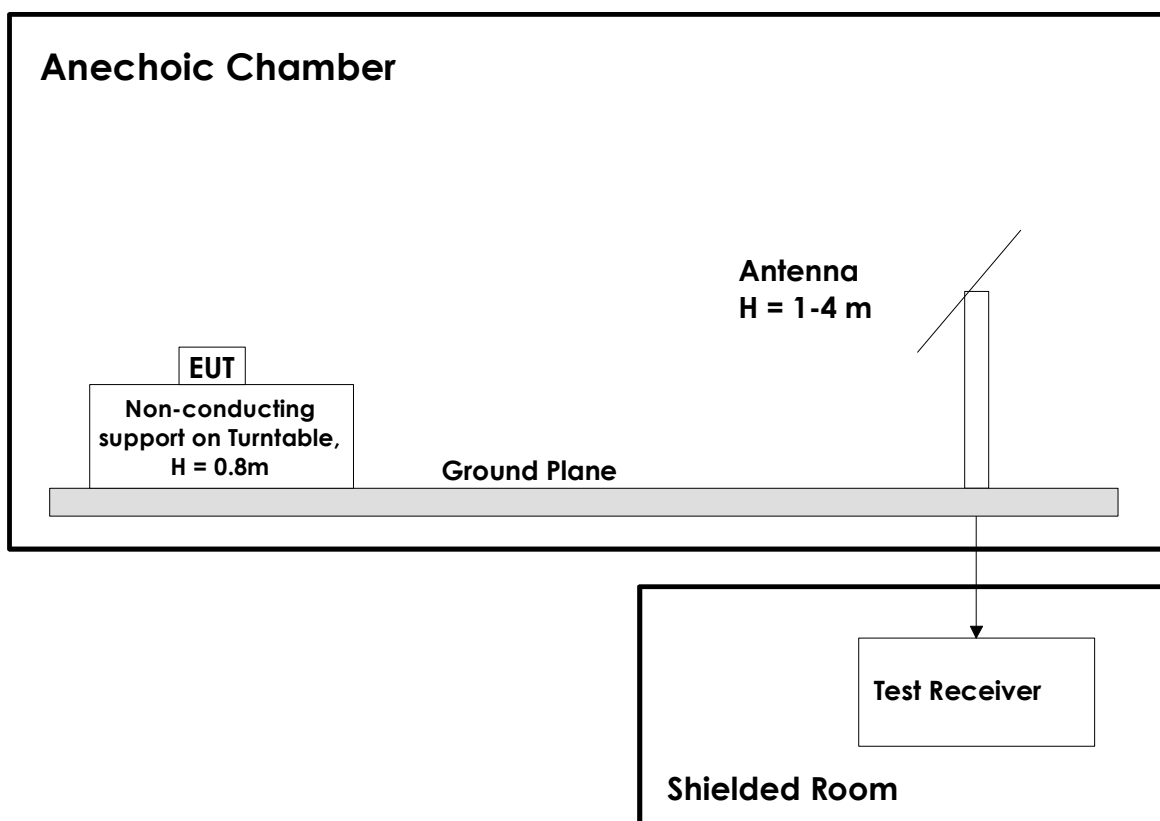
No.	Instrument/ ancillary	Type of instrument/ ancillary	Manufacturer	Ref. no.	Cal. Date	Cal. Due
1.	ESU40	EMI Receiver	Rohde & Schwarz	LR 1639	2016.11	2017.11
2.	FSW40	Spectrum analyser	Rohde & Schwarz	LR 1690	2016.07	2018.07
3.	5VF1000/2000	Band pass filter	Trilithic	LR 1174	Cal b4 use	
4.	3115	Antenna horn	EMCO	LR 1330	2010.08	2018.08
5.	HFH2-Z2	Loop antenna	Rohde & Schwarz	LR1660	2016.08	2018.08
6.	HK116	Biconical Antenna	Rohde & Schwarz	LR 1260	2013.12	2017.12
7.	HL223	Log Periodic antenna	Rohde & Schwarz	LR 1261	2013.12	2017.12
8.	PM7320X	Antenna horn	Siverts lab	LR 103	2009.01	2018.01
9.	DBF-520-20	Antenna horn	Systron Donner	LR 101	2009.01	2018.01
10.	638	Antenna horn	Narda	LR 098	2010.06	2018.06.
11.	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2016.11	2017.11
12.	310N	Pre-amplifier	Sonoma	LR 1686	2016.05	2017.05
13.	D100-1	DC power supply	Farnell	LT 5109	Cal b4 use	
14.	6032A	DC power supply	Hewlett Packard	LT 1062	Cal b4 use	
15.	Model 87 V	Multimeter	Fluke	LR 1599	2016.10	2018.10
16.	4768-10	10 attenuator	NARDA	LR 1673	Cal b4 use	
17.	FA210A1010003030	Microwave cable	Rosenberger	LR1566	Cal b4 use	
18.	6HC 3000-18000	HP Filter	Trithlic	LR1614	Cal b4 use	
19.	6HC 1000-10000	HP Filter	Trithlic	LR1363	Cal b4 use	
20.	6HC 2000-18000	HP Filter	Trithlic	LR1613	Cal b4 use	

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



Measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers.

Revision history

Version	Date	Comment	Sign
00	2017.02.27	First version	gns
01	2017.03.10	Clear explanation is given in page 10, 21 & 25 for number of hopping channels and for channel separation	gns