

Test Report

Product	Bluetooth 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.7
Rating	7.3Vdc (Secondary Batteries)
Trademark	LEGO
Serial number	See page 3
Additional information	This tested device can be operated either with BLE or classic Bluetooth.
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	396223
Tested in period	2020.11.04 – 2020.11.09
Issue date	2020.11.30
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
 Prepared by [G.Suhanthakumar]  Approved by [Frode Sveinsen]	
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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
2.3	Revision history	6
3	TEST RESULTS.....	7
3.1	Number of Frequencies	7
3.2	Power Line Conducted Emissions	8
3.3	Pseudorandom Hopping Algorithm	11
3.4	Occupancy Time.....	12
3.5	Occupied Bandwidth.....	14
3.6	Peak Power Output.....	18
3.7	Conducted Emissions at Antenna Connector	22
3.8	Spurious Emissions (Radiated).....	25
4	Measurement Uncertainty.....	46
5	LIST OF TEST EQUIPMENT.....	47
6	BLOCK DIAGRAM	48
6.1	Power Line Conducted Emission	48
6.2	Test Site Radiated Emission.....	48

1 INFORMATION

1.1 Test Item

Name	LEGO
FCC ID	NPI47591
ISED ID	3072A - 47591
Model/version	HUB NO.7
Serial number	Radiated sample : Marked as "FEP2-530" Conducted sample: Marked as "Nemko 396223001"
Hardware identity and/or version	C
Software identity and/or version	1.00.00.0
Frequency Range	2400 – 2483.5 MHz
Tunable Bands	None
Number of Channels	79
Operating Modes	TX and RX
Measured BW (99%)	1.03 MHz
Emission clasification	F1D
Transmitter spurious, dBμV/m@3m	61.96dBuV/m (7.32GHz) PK and 41.96dBuV/m AV(7.32GHz)
Type of Modulation	GFSK, 8DPSK and π/4-DQPSK
Data rate	1, 2 and 3 Mbit/s
User Frequency Adjustment	None
Conducted Output Power,Max	0.00158 W (1.99dBm)
Type of Power Supply	7.3Vdc, Rechargeble Lithium ion battery
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 sensors remotely control via BLE or Bluetooth clasic 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	7.3 Vdc

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.

Channel no	Frequency (MHz)	Modulation	Modulation	Modulation	Power setting (dBm)
0	2402	GFSK	$\pi/4$ -DQPSK	8DPSK	2
39	2441	GFSK	$\pi/4$ -DQPSK	8DPSK	2
79	2480	GFSK	$\pi/4$ -DQPSK	8DPSK	2

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 ISSED.

☒ 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".

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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 Operating Frequencies	15.31(m)	5.1 (d) (RSS-247)	Complies
Antenna Requirement	15.203	8.3 (RSS-GEN)	N/A ²
Power Line Conducted Emission	15.107(a) 15.207(a)	8.8 (RSS-GEN)	Complies ³
Channel Separation	15.247(a)(1)	5.1 (b) (RSS-247)	Complies
Pseudorandom Hopping Algorithm	15.247(a)(1)	5.1 (a) (RSS-247)	Complies
Time of Occupancy	15.247(a)(1)(iii)	5.1 (d) (RSS-247)	Complies
Occupied Bandwidth	15.247(a)(1)	5.1 (a) (RSS-247)	Complies
Occupied Bandwidth	N/A	6.6 (RSS-GEN)	N/A ⁴
Minimum 6 dB Bandwidth	15.247(a)(2)	5.2 (a) (RSS-247)	N/A ⁴
Peak Power Output	15.247(b)	5.4(b) (RSS-247)	Complies
Power Spectral Density	15.247(d)	5.2 (b) (RSS-247)	N/A ⁴
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) 6.13 (RSS-GEN) 8.9 (RSS-GEN)	Complies

N/A¹: The tested equipment only operates with rechargeable battery. And recharged with USB power.

N/A²: Integral antenna

3 : For rechargeable battery.

N/A³: FHSS

2.3 Revision history

Version	Date	Comment	Sign
00	2020.11.30	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
Low Channel:	2402MHz
Mid channel:	2441MHz
High Channel:	2480MHz

3.2 Power Line Conducted Emissions

FCC Part 15.207

ISED RSS-GEN Issue 5, Clause 7.2 / 8.8

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

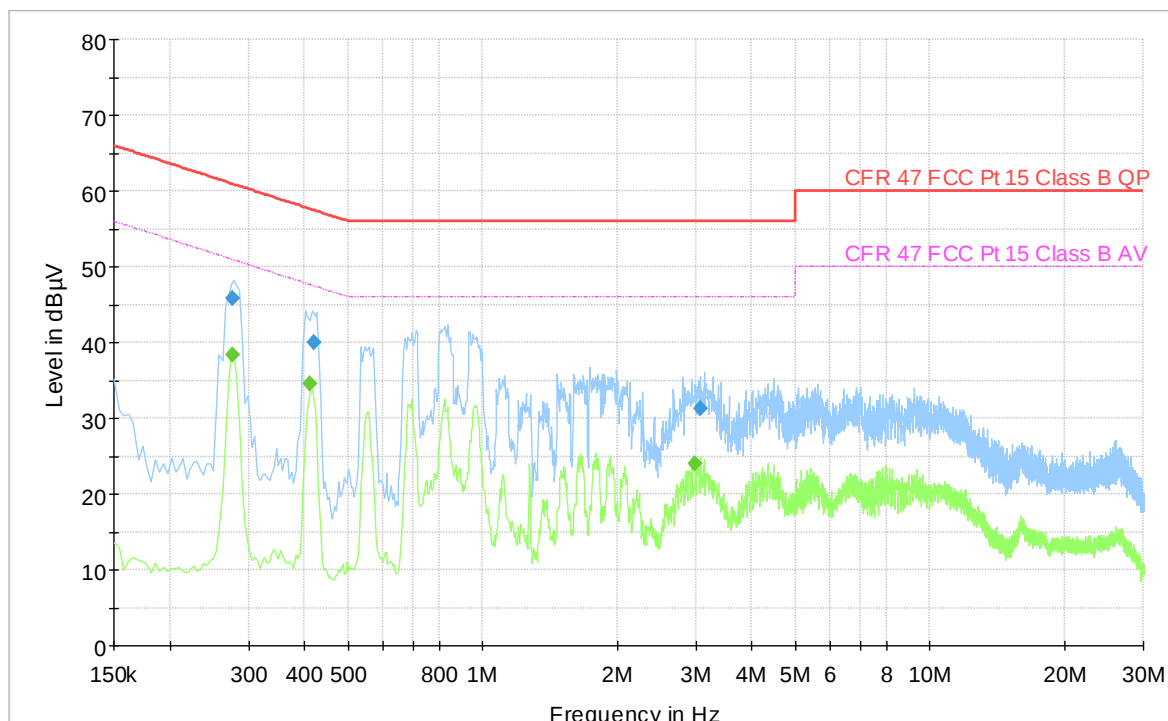
Test Results: Complies

Measurement Data: See attached plots

Highest measured value (L1 and N): 120Vac, 60Hz with USB AC/DC adaptor, model no: A1401

Frequency (MHz)	QuasiPeak (dB μ V)	Average (dB μ V)	Limit (dB μ V)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter
0.276	---	38.43	50.94	12.51	1000	9	N	OFF
0.276	45.80	---	60.94	15.14	1000	9	L1	OFF
0.412	---	34.62	47.61	12.98	1000	9	L1	OFF
0.420	40.02	---	57.45	17.43	1000	9	N	OFF
2.988	---	23.95	46.00	22.05	1000	9	L1	OFF
3.072	31.33	---	56.00	24.67	1000	9	L1	OFF

Full Spectrum



Channel Separation

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

ISED RSS-247 Issue 2, Clause 5.1 (b)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.2

Test Results: Complies

Measurement Data:

Channel Separation:	1 MHz
Nominal value for Channel Separation	0.88 MHz

See attached plots

Requirement:

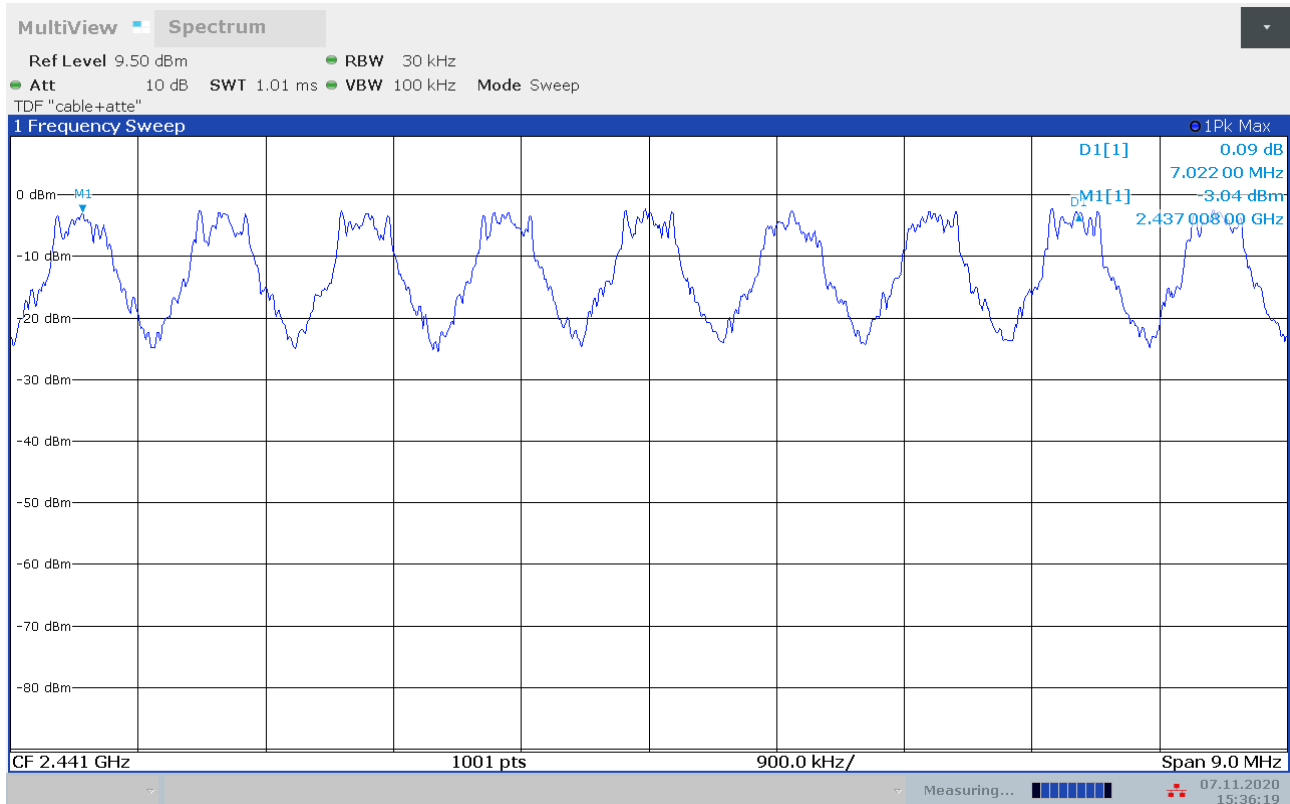
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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.

Channel Separation



3.3 Pseudorandom Hopping Algorithm

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

ISED Canada RSS-247 Issue 2, Clause 5.1

Test Results: Complies

Measurement Data: /

The hopping sequence follows the Bluetooth standard.

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.

3.4 Occupancy Time

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

ISED Canada RSS-247 Issue 2, Clause 5.1 (c)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.4

Test Results: Complies

Measurement Data:

	DH1	DH3	DH5
Number of RF Channels:	79	79	79
Maximum Length of RF Burst pr. Channel, ms	0.290	1.19	2.22
Minimum Time between RF Burst on same RF Channel, ms	63.8	452.7	389.5
Time of Occupancy, S	0.144	0.083	0.180

BT, 79 Ch Mode:

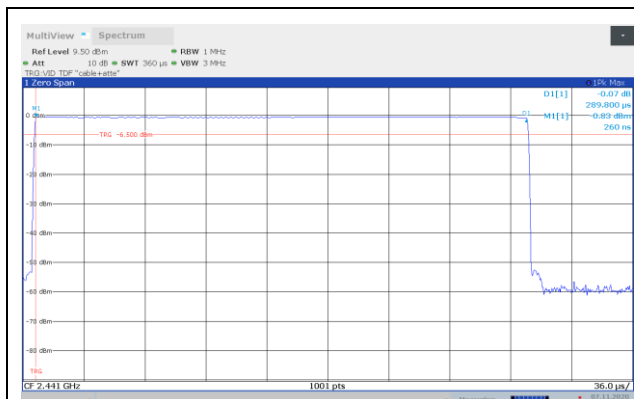
Time of occupancy: $(0.290 \times 400 \times 79) / 63.8 = 144\text{ms}$

See attached graph.

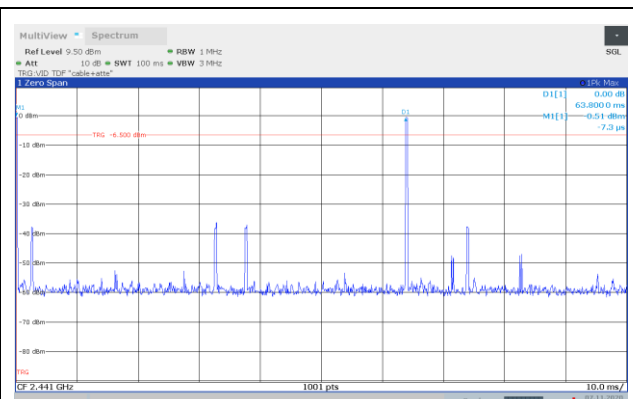
Requirements:

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.

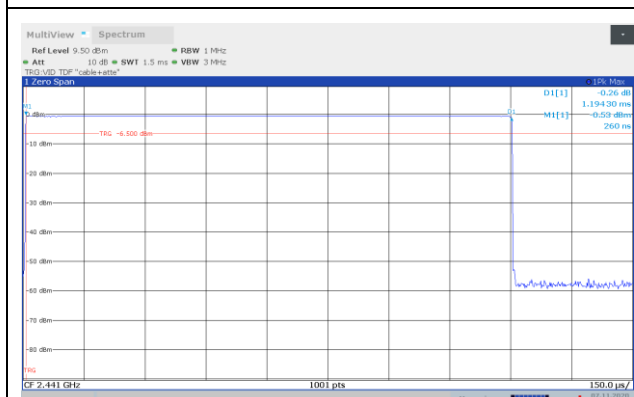
No requirements for Digital Transmission Systems.



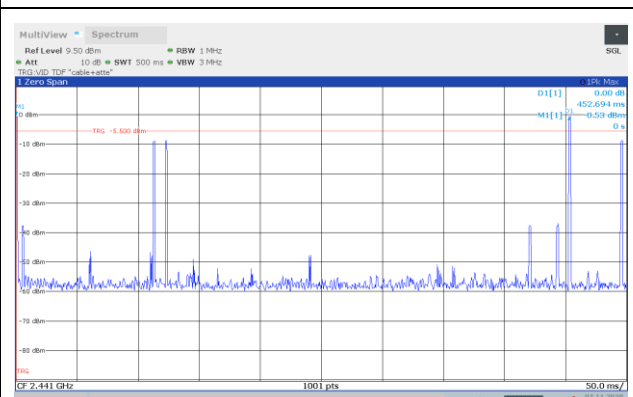
Burst Length, DH1



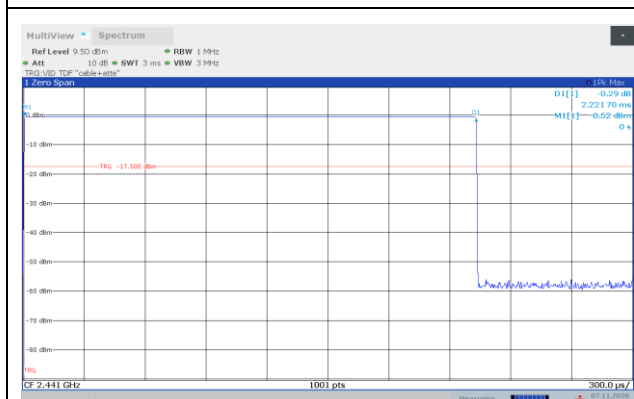
Dwell Time, DH1



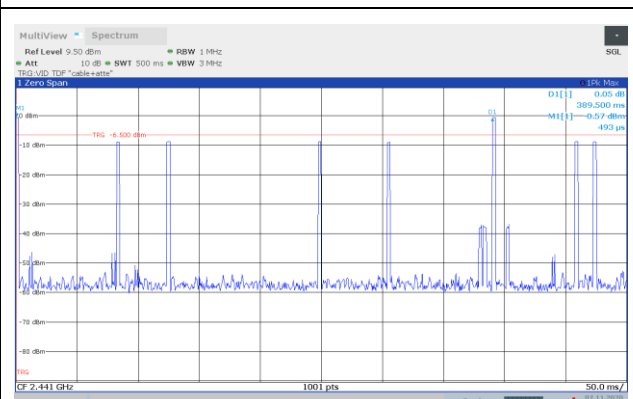
Burst Length, DH3



Dwell Time, DH3



Burst Length, DH5



Dwell Time, DH5

3.5 Occupied Bandwidth

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

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:

Number of RF Channels in use:	79	79	79
Channel Centre Frequencies:	2402 to 2480 MHz	2402 to 2480 MHz	2402 to 2480 MHz
Modulation	GFSK	8DPSK	$\pi/4$ -DQPSK
99% BW, MHz	0.869	1.22	1.22
20 dB BW, MHz	1.11	1.43	1.44

RF channel has no influence on 20 dB bandwidth.

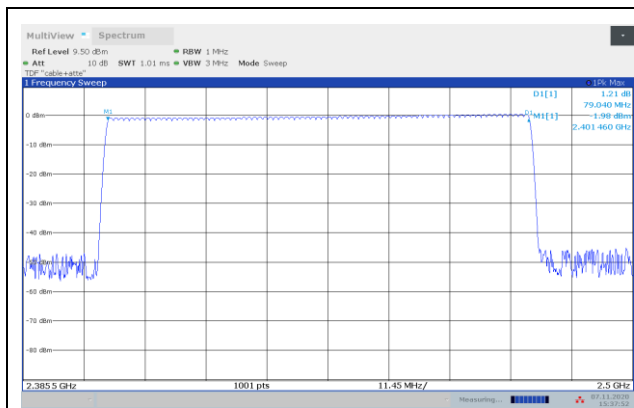
See attached plots.

Requirements:

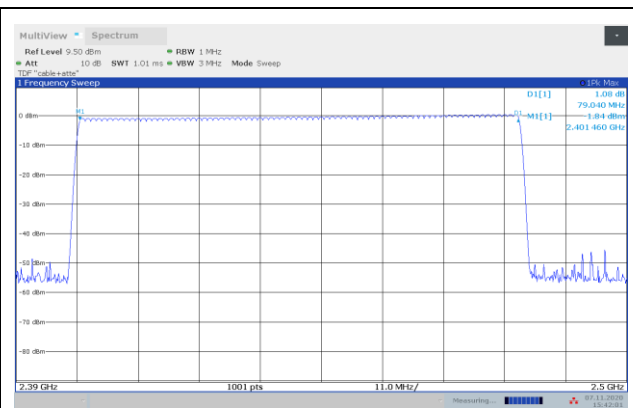
Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels.
No requirements for bandwidth for this frequency band.

No requirements for Digital Transmission Systems.

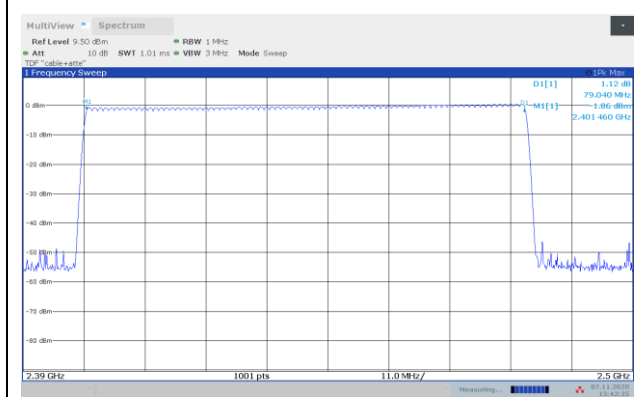
No requirement for 99% BW, reported for information only.



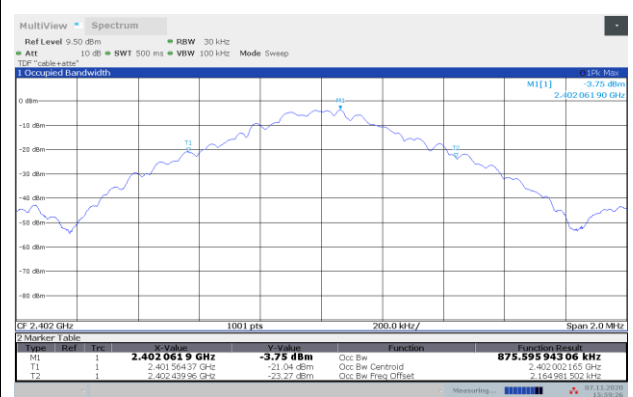
RF channels in use, DH1



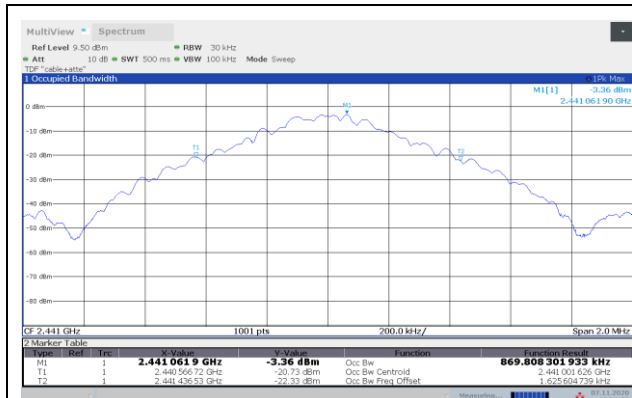
RF channels in use, DH3



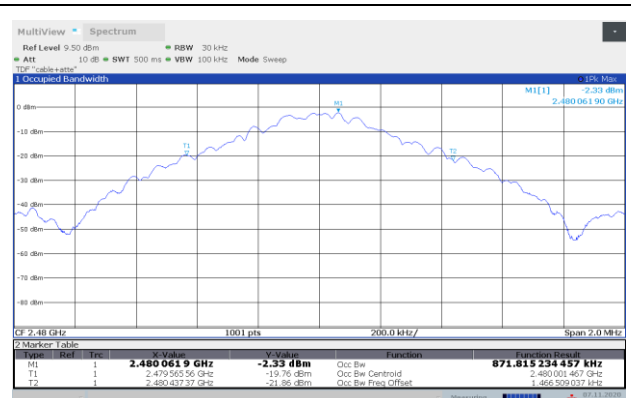
RF channels in use, DH5



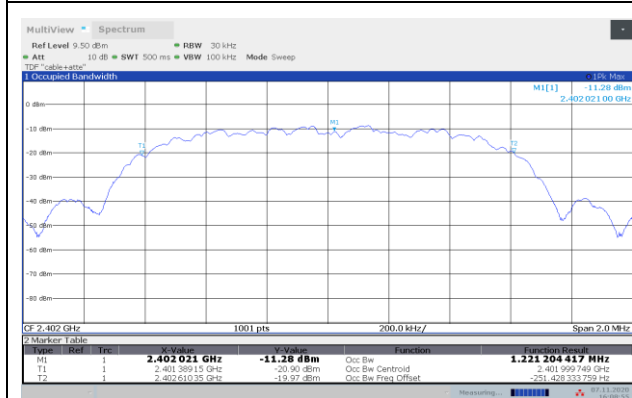
99% Bandwidth – GFSK, ch2402MHz



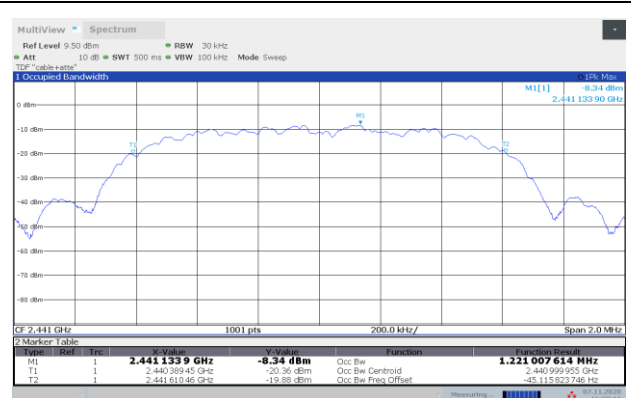
99% Bandwidth – GFSK, ch2441MHz



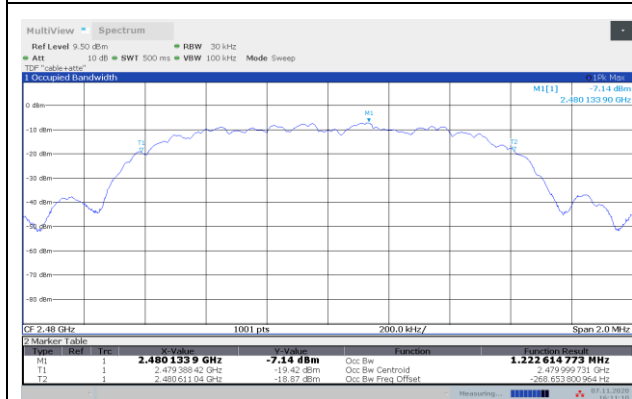
99% Bandwidth – GFSK, ch2480MHz



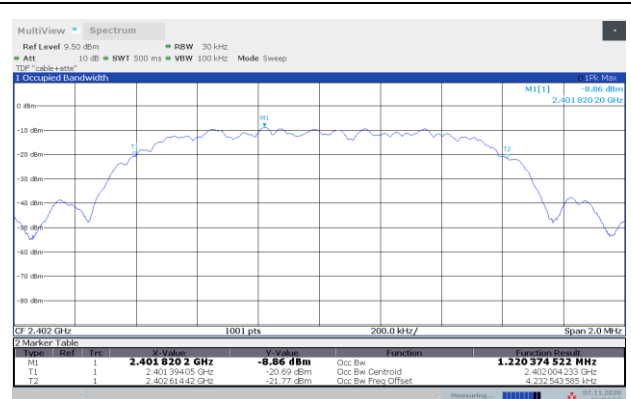
99% Bandwidth – 8DPSK, ch2402MHz



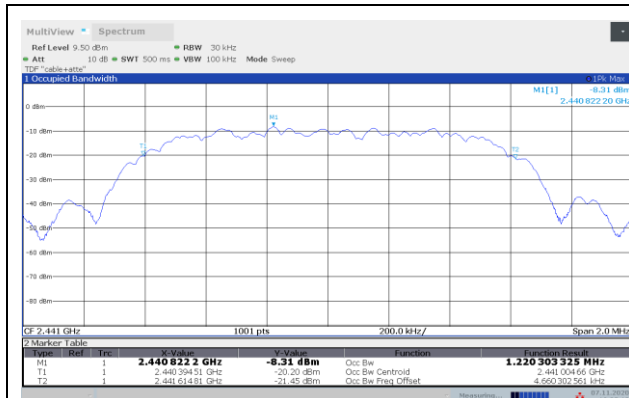
99% Bandwidth – 8DPSK, ch2441MHz



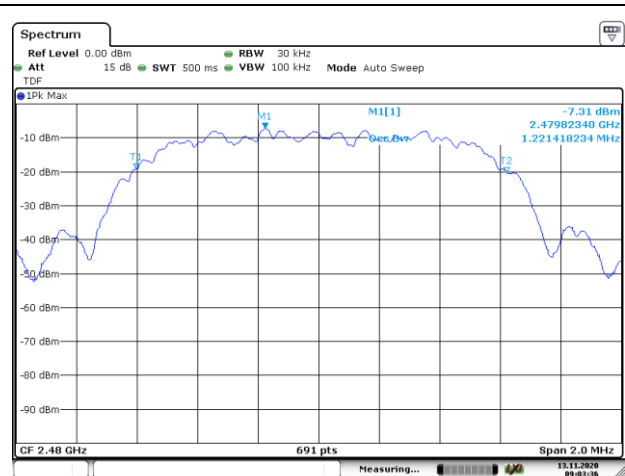
99% Bandwidth – 8DPSK, ch2480MHz



99% Bandwidth – DQPSK, ch2402MHz

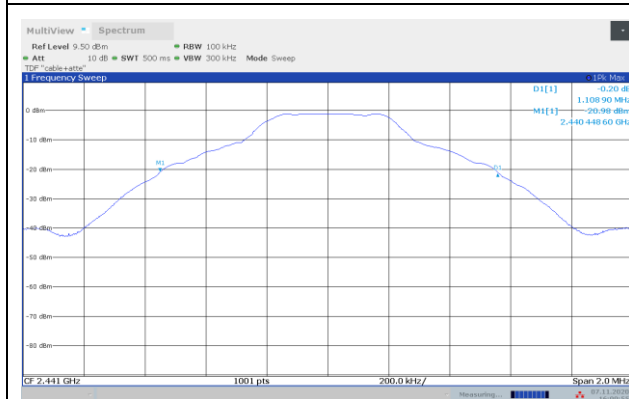


99% Bandwidth – DQPSK, ch2441MHz

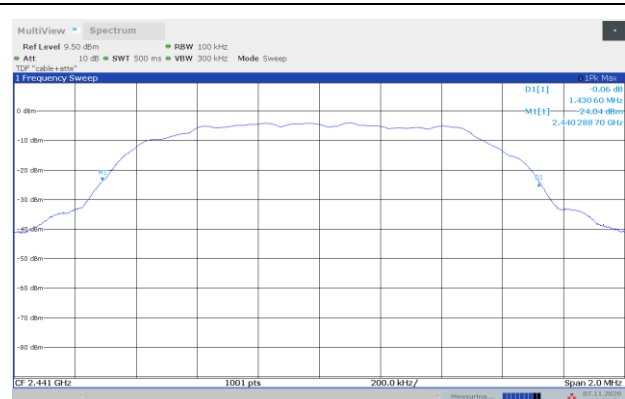


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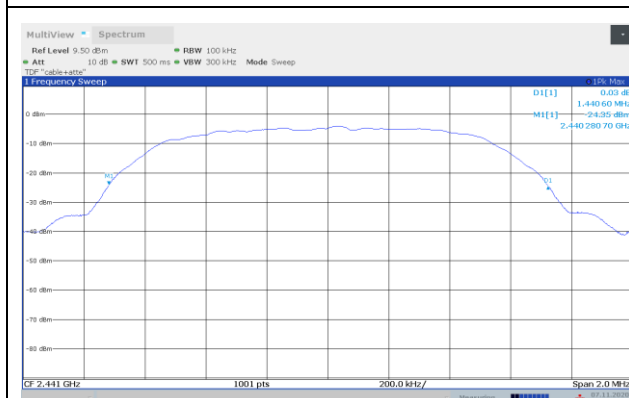
99% Bandwidth – DQPSK, ch2480MHz



20 dB BW – GFSK, ch 2441MHz



20 dB BW – 8DPSK, ch 2441MHz



20 dB BW – DQPSK, ch 2441MHz

3.6 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:

Mode		2402 MHz	2441 MHz	2480 MHz
GFSK	Measured Conducted Power (dBm)	-0.89	-0.45	0.45
	Short cable loss from EUT (dB)	1	1	1
	Calculated conducted power(dBm)	0.11	0.55	1.45
	Conducted Power (mW)	1.03	1.14	1.4
	Field Strength (dBμV/m),HP	98.12	97.14	94.31
	EIRP, Calculated (mW)	1.95	1.55	0.81
	Antenna gain (dBi)	2.8	1.4	-2.4
8-DPSK	Conducted Power (dBm)	0.42	0.88	1.71
	Short cable loss from EUT (dB)	1	1	1
	Calculated conducted power(dBm)	1.42	1.88	2.71
	Conducted Power (mW)	1.39	1.54	1.87
	Field Strength (dBμV/m),HP	99.14	97.39	95.61
	EIRP, Calculated (mW)	2.45	1.64	1.09
	Antenna gain (dBi)	2.5	0.3	-2.3
π/4-DQPSK	Conducted Power (dBm)	-0.22	0.24	1.14
	Short cable loss from EUT (dB)	1	1	1
	Calculated conducted power(dBm)	0.78	1.24	2.14
	Conducted Power (mW)	1.20	1.33	1.64
	Field Strength (dBμV/m),HP	98.37	96.09	94.23
	EIRP, Calculated (mW)	2.06	1.22	0.79
	Antenna gain (dBi)	2.4	-0.4	-3.1

Maximum field strength is obtained in HP and in XZ 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.

See attached plots.

Requirements:

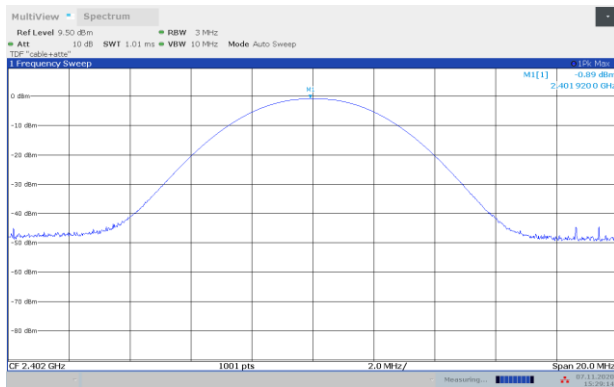
The maximum peak output power shall not exceed the following limits:

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

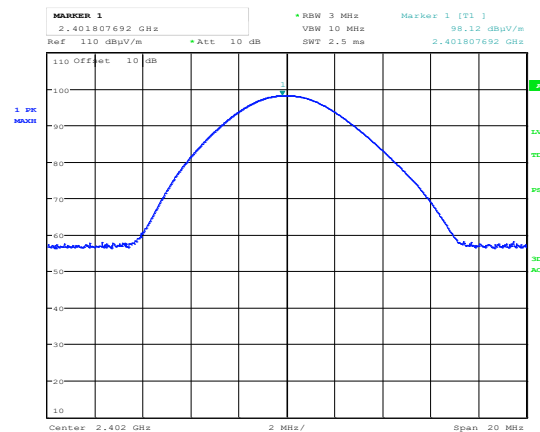
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

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.

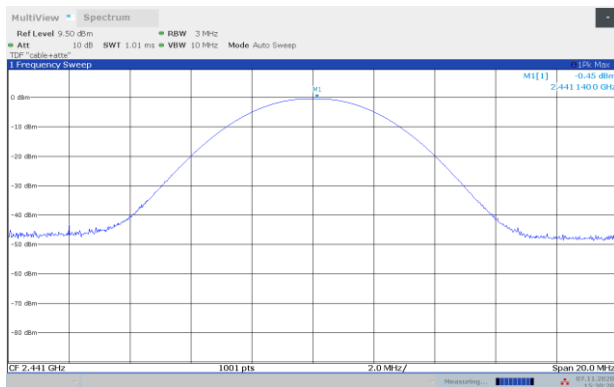


Conducted output Power, ch2402MHz , GFSK

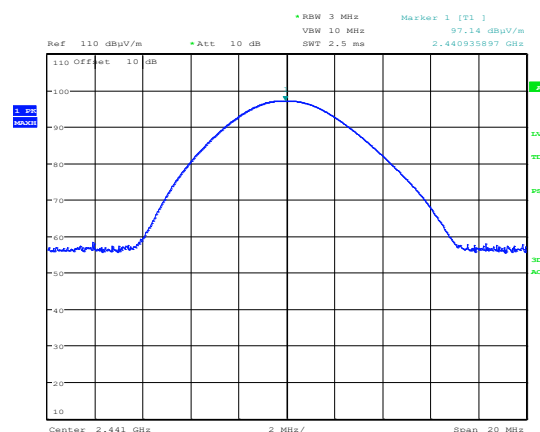


Date: 3.NOV.2020 12:28:35

Radiated field strength-HP, ch2402MHz , GFSK

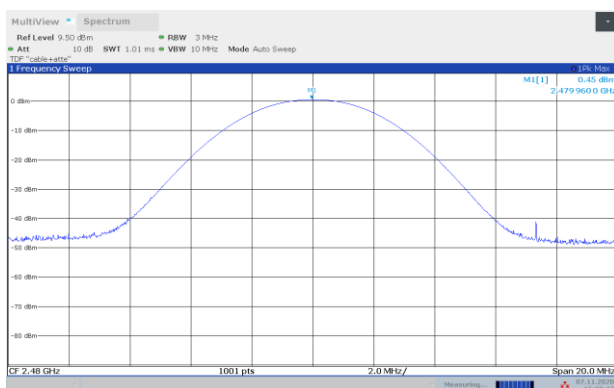


Conducted output Power, ch2441MHz , GFSK

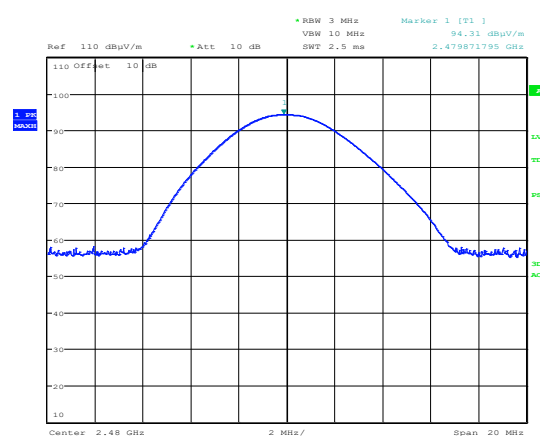


Date: 3.NOV.2020 12:36:35

Radiated field strength-HP, ch2441MHz , GFSK

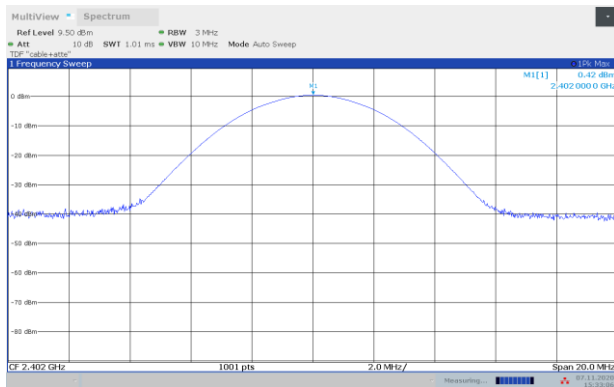


Conducted output Power, ch2480MHz , GFSK

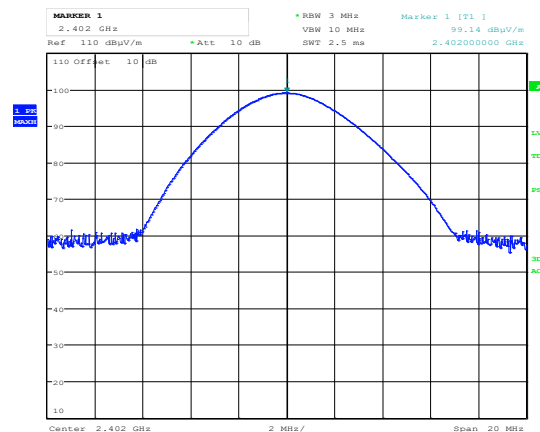


Date: 3.NOV.2020 12:37:49

Radiated field strength-HP, ch2480MHz , GFSK

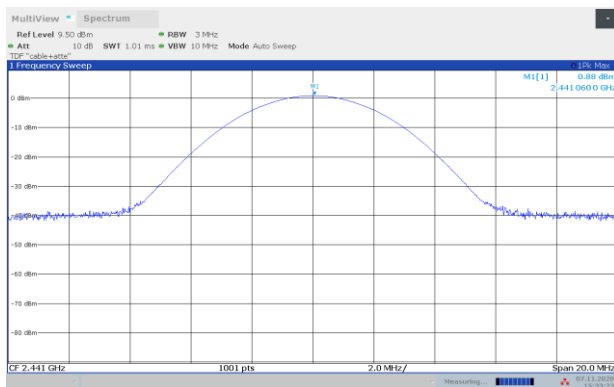


Conducted output Power, ch2402MHz , 8DPSK

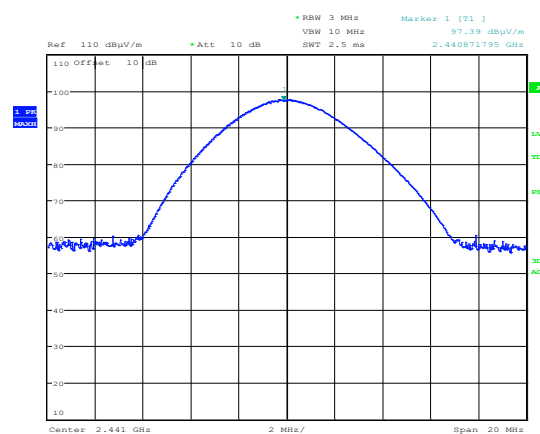


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Radiated field strength-HP, ch2402MHz , 8DPSK

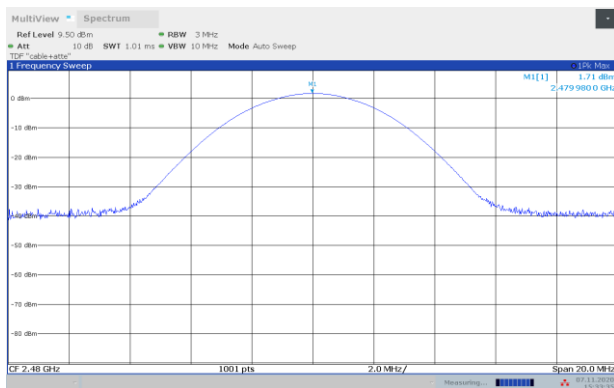


Conducted output Power, ch2441MHz , 8DPSK

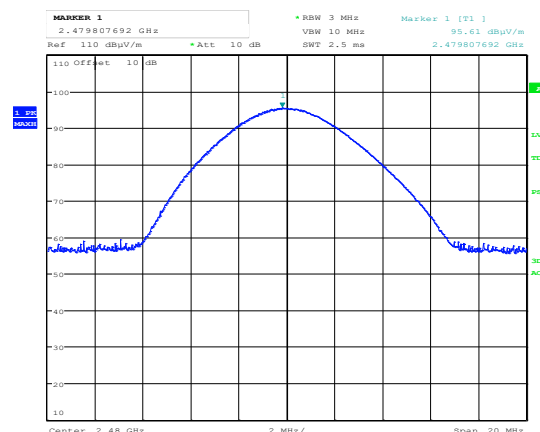


Date: 3.NOV.2020 12:56:32

Radiated field strength-HP, ch2441MHz , 8DPSK

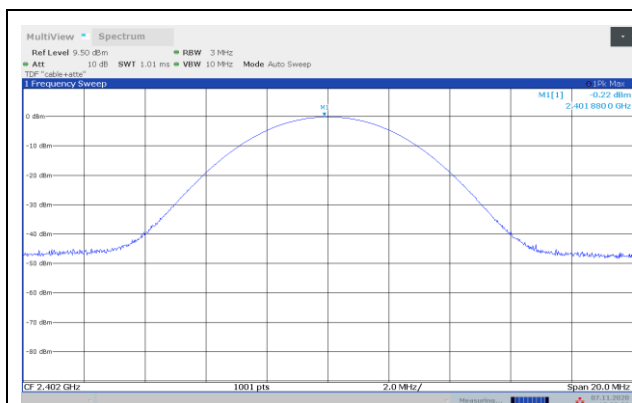


Conducted output Power, ch2480MHz , 8DPSK

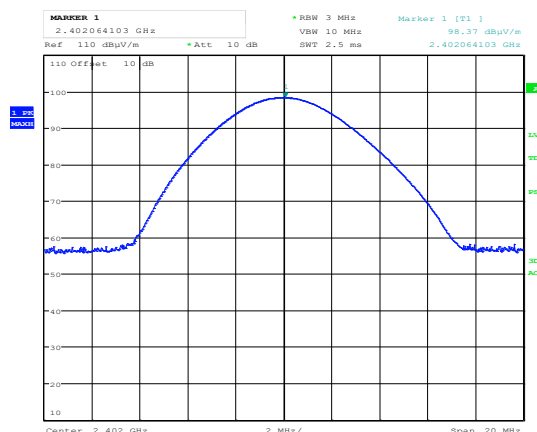


Date: 3.NOV.2020 13:00:19

Radiated field strength-HP, ch2480MHz , 8DPSK

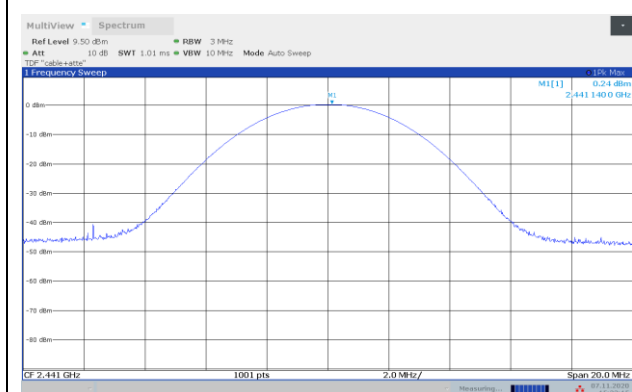


Conducted output Power, ch2402MHz , $\pi/4$ -DQPSK

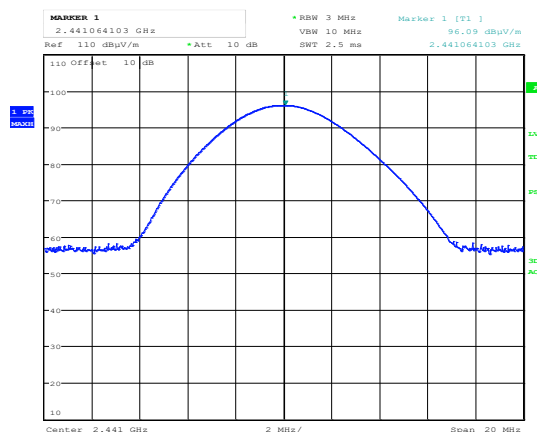


Date: 3.NOV.2020 12:43:17

Radiated field strength-HP, ch2402MHz , $\pi/4$ -DQPSK

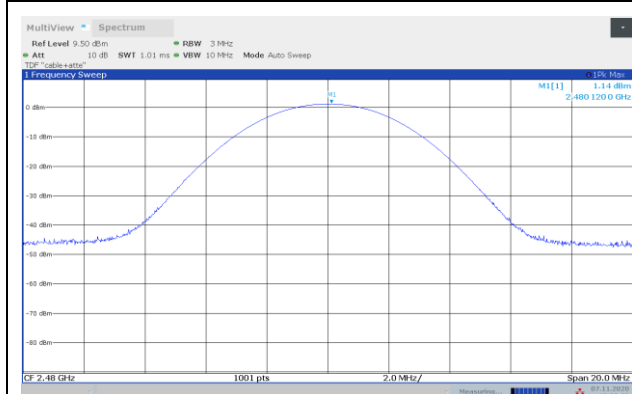


Conducted output Power, ch2441MHz , $\pi/4$ -DQPSK

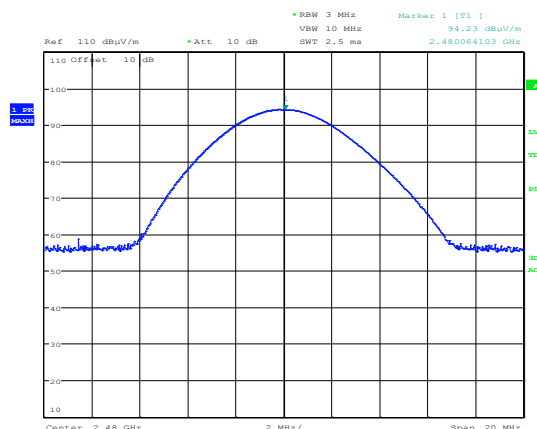


Date: 3.NOV.2020 12:45:04

Radiated field strength-HP, ch2441MHz , $\pi/4$ -DQPSK



Conducted output Power, ch2480MHz , $\pi/4$ -DQPSK



Date: 3.NOV.2020 12:49:01

Radiated field strength-HP, ch2480MHz , $\pi/4$ -DQPSK

3.7 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

RF conducted power to 25 GHz see attached plots.

Maximum RF level outside operating band:

RF in, GFSK: >48 dB/C, margin >20 dB

RF in, 8DPSK: >49 dB/C, margin >20 dB

RF in, 4π8DPSK: >47 dB/C, margin >20 dB

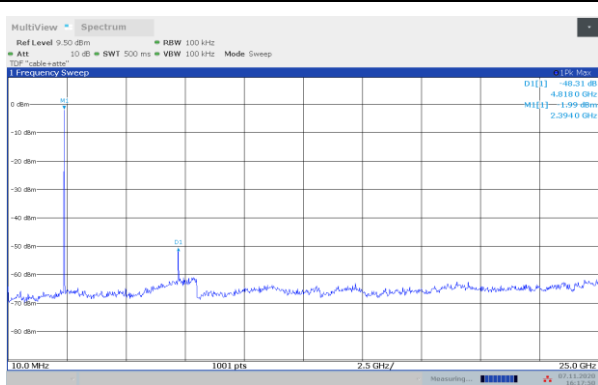
RF in hopping mode, DH1: >48 dB/C, margin >20 dB

Limit

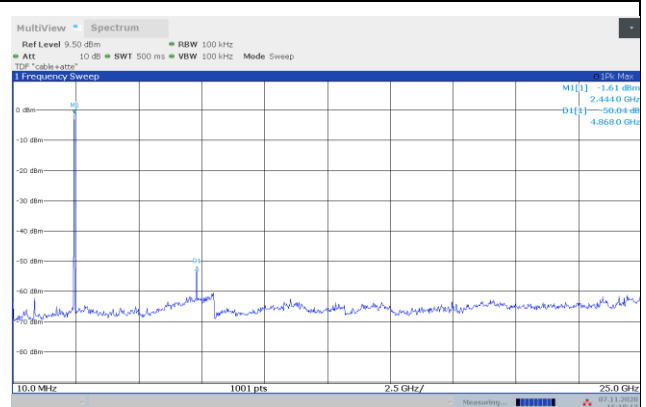
Peak measurement	RMS averaging
20 dBc or more in 100 kHz bandwidth	30 dBc or more in 100 kHz bandwidth

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

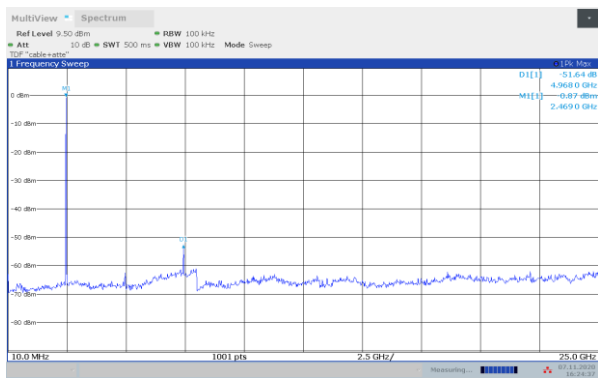
Attenuation below the general limits specified in part 15.209(a) is not required.



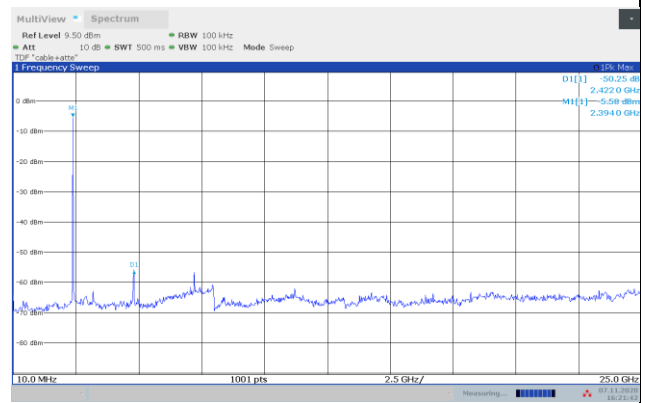
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, GFSK



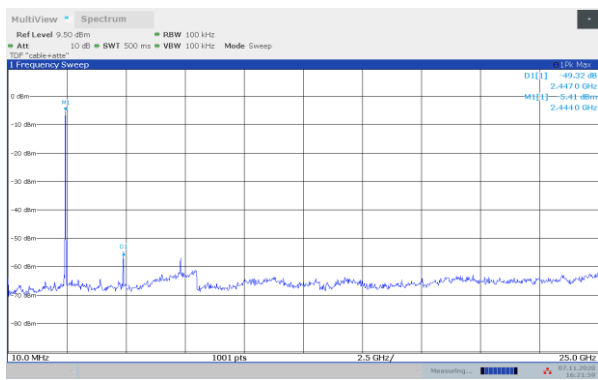
Conducted spurious emissions 10MHz – 25GHz , ch2441MHz, GFSK



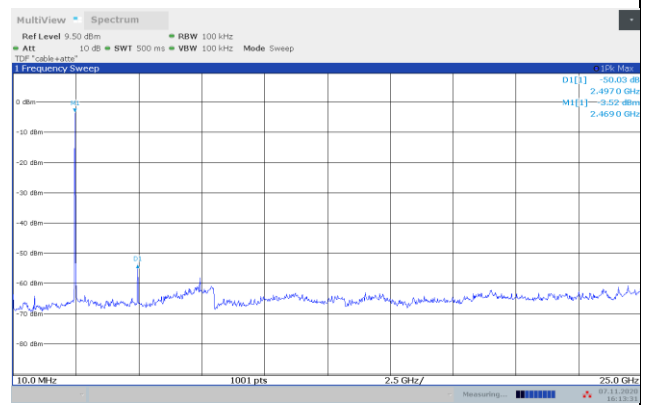
Conducted spurious emissions 10MHz – 25GHz , ch2480MHz, GFSK



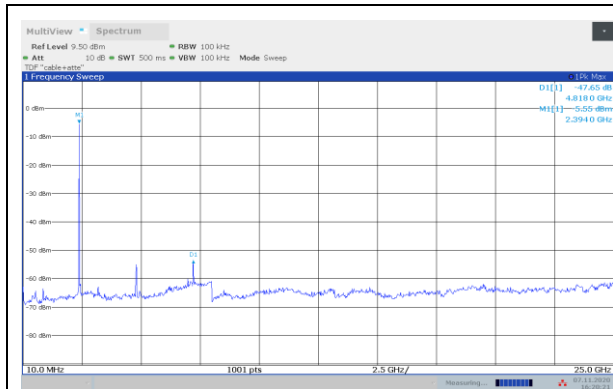
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, 8DPSK



Conducted spurious emissions 10MHz – 25GHz , ch2441MHz, 8DPSK



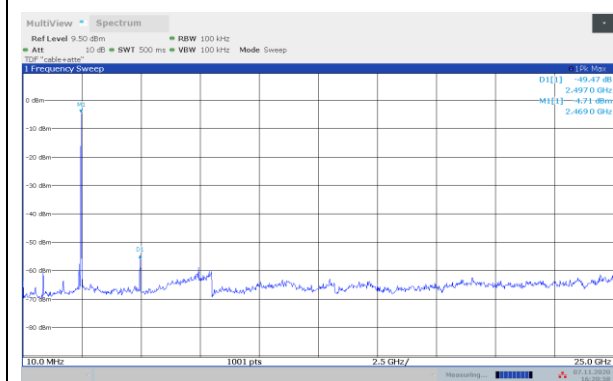
Conducted spurious emissions 10MHz – 25GHz , ch2480MHz, 8DPSK



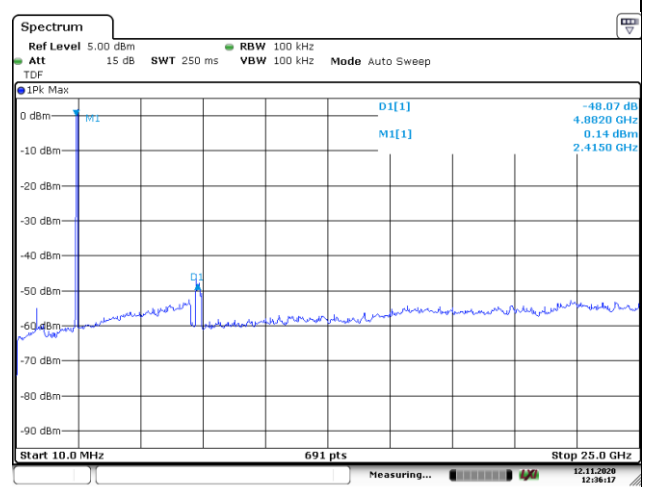
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, 4_PI_8DPSK



Conducted spurious emissions 10MHz – 25GHz , ch2441MHz, 4_PI_8DPSK

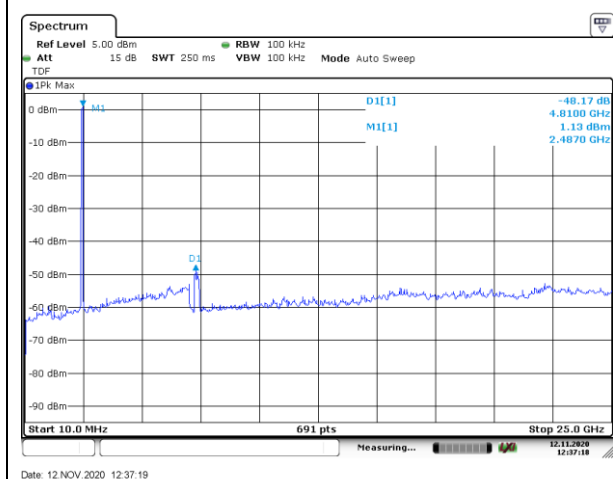


Conducted spurious emissions 10MHz – 25GHz , ch2480MHz, 4_PI_8DPSK



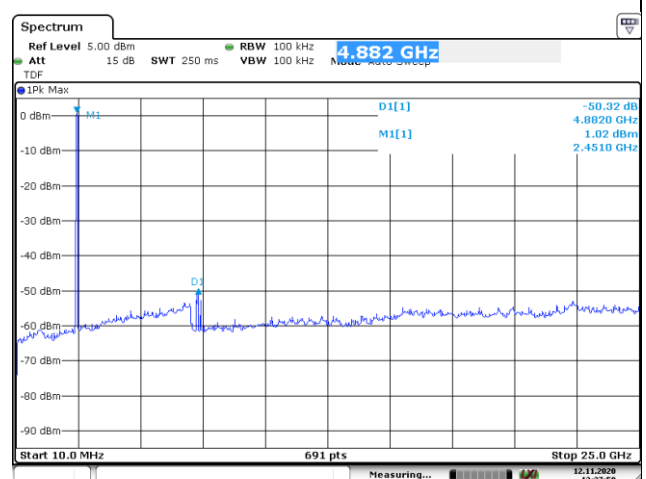
Date: 12 NOV 2020 12:36:17

Conducted spurious emissions 10MHz – 25GHz , in hopping mode DH1



Date: 12 NOV 2020 12:37:19

Conducted spurious emissions 10MHz – 25GHz , in hopping mode DH3



Date: 12 NOV 2020 12:37:57

Conducted spurious emissions 10MHz – 25GHz , in hopping mode DH5

3.8 Spurious Emissions (Radiated)

FCC Part 15.247

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 radiated:

Modulation Scheme	Detector	Measured field strength (dBμV/m)		Limit dBμV/m	Margin	
		2390 MHz	2483.5 MHz		dB	
GFSK/3Mbit	Peak Detector	51.9	55.1	74	22.1	18.9
	Average Detector	/	35.1	54	/	18.9
8DPSK/3Mbit	Peak Detector	53.7	55.6	74	20.3	18.4
	Average Detector	/	35.6	54	/	18.4
π/4-DQPSK /3Mbit	Peak Detector	51.3	55.2	74	22.7	18.8
	Average Detector	/	35.2	54	/	18.8
DH1, Hopping mode	Peak Detector	52.4	52.9	74	21.6	21.1
	Average Detector	/	/	54	/	/
DH3, Hopping mode	Peak Detector	52.0	53.3	74	22	20.7
	Average Detector	/	/	54	/	/
DH5, Hopping mode	Peak Detector	51.7	53.3	74	22.3	20.7
	Average Detector	/	/	54	/	/

Average Detector values are measured with Peak Detector and corrected for Duty Cycle.

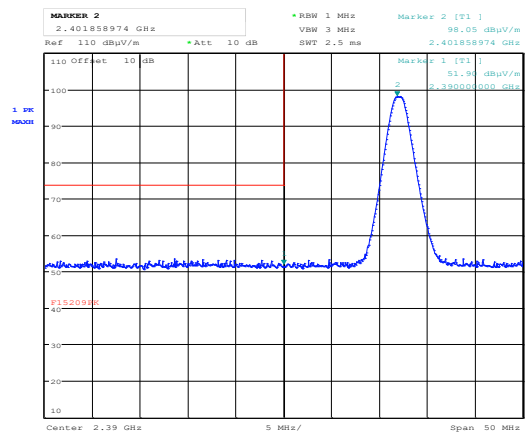
See attached plots.

Duty Cycle Correction Factor Calculation:

Duty Cycle = slot length / (frame length x hopping channels) = 0.626ms / (216ms x 79) = 2.9

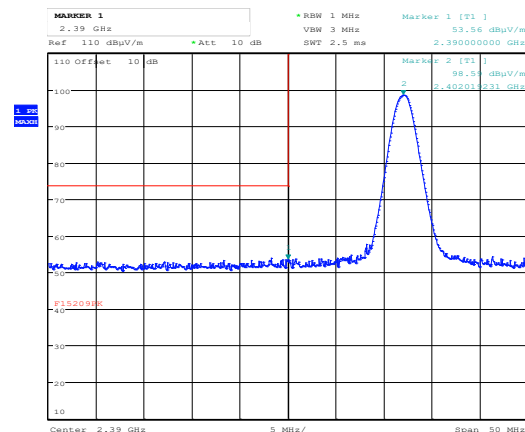
Duty Cycle Correction factor = -20 x log (Duty Cycle) = -30.7 dB

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



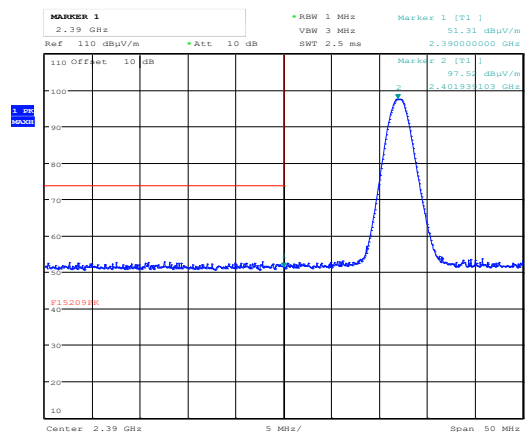
Date: 3.NOV.2020 12:29:31

Lower Band Edge, ch2402MHz , GFSK, Peak Det



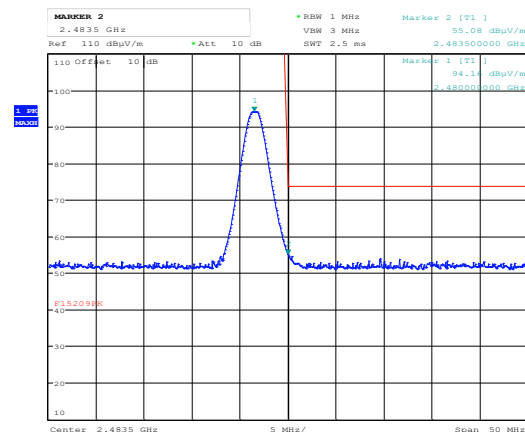
Date: 3.NOV.2020 12:53:53

Lower Band Edge, ch2402MHz , 8DPSK, Peak Det



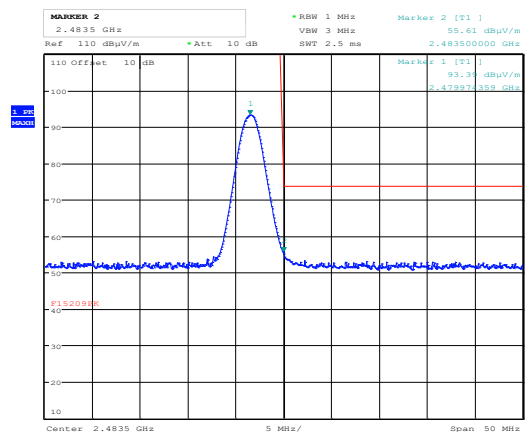
Date: 3.NOV.2020 12:43:56

Lower Band Edge, ch2402MHz, $\pi/4$ -DQPSK, Peak Det



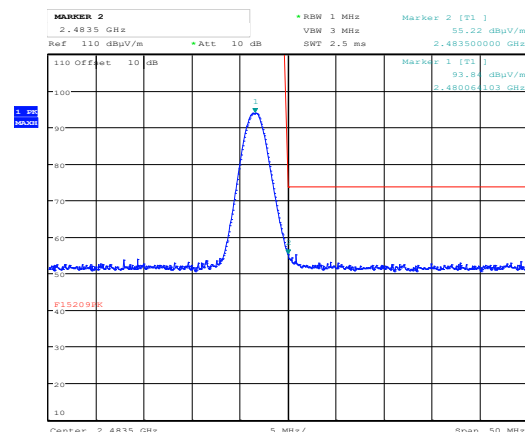
Date: 3.NOV.2020 12:38:42

Upper Band Edge, ch2480MHz , GFSK, Peak Det



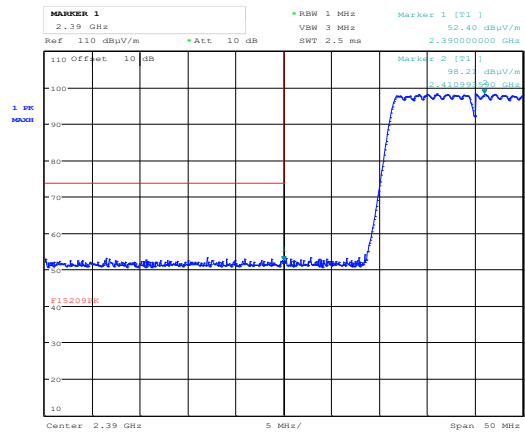
Date: 3.NOV.2020 13:01:01

Upper Band Edge, ch2480MHz , 8DPSK, Peak Det



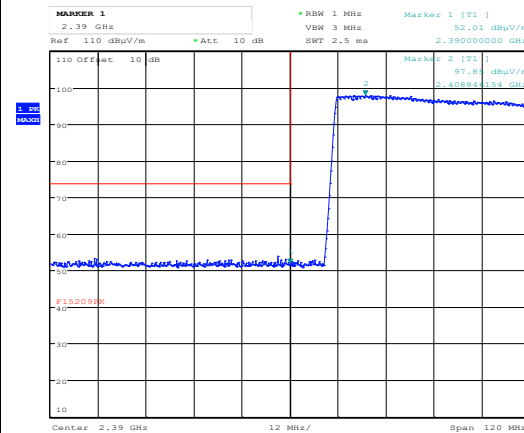
Date: 3.NOV.2020 12:49:39

Upper Band Edge, ch2480MHz, $\pi/4$ -DQPSK, Peak Det



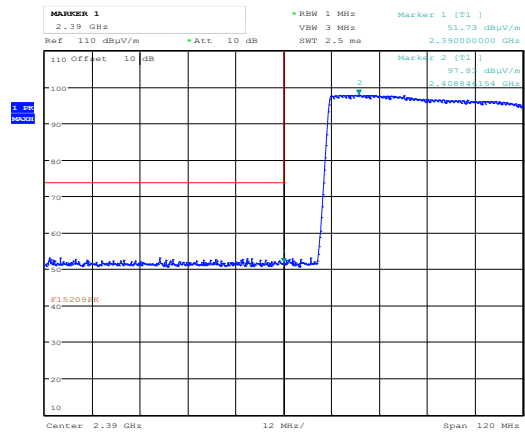
Date: 3.NOV.2020 13:04:54

Lower Band Edge, Hopping mode , DH1, Peak Det



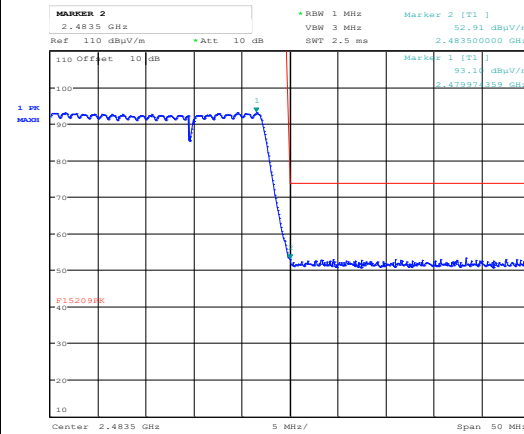
Date: 3.NOV.2020 13:09:17

Lower Band Edge, Hopping mode , DH3, Peak Det



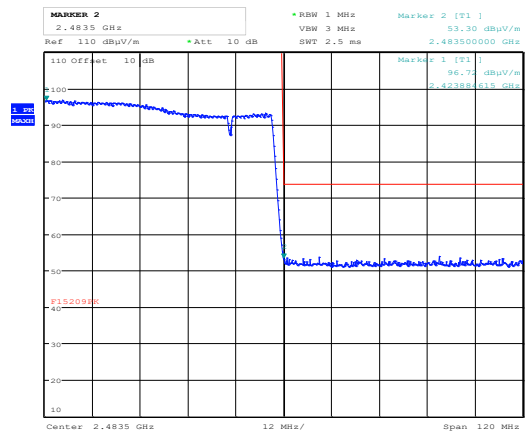
Date: 3.NOV.2020 13:12:53

Lower Band Edge, Hopping mode , DH5, Peak Det



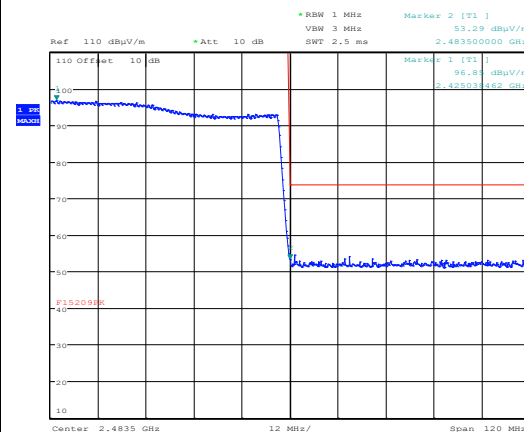
Date: 3.NOV.2020 13:04:18

Upper Band Edge, Hopping mode , DH1, Peak Det



Date: 3.NOV.2020 13:09:47

Upper Band Edge, Hopping mode , DH3, Peak Det



Date: 3.NOV.2020 13:12:26

Upper Band Edge, Hopping mode , DH5, Peak Det

Radiated emission 30 – 1000 MHz.

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

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Measuring distance 3 m according to ANSI.

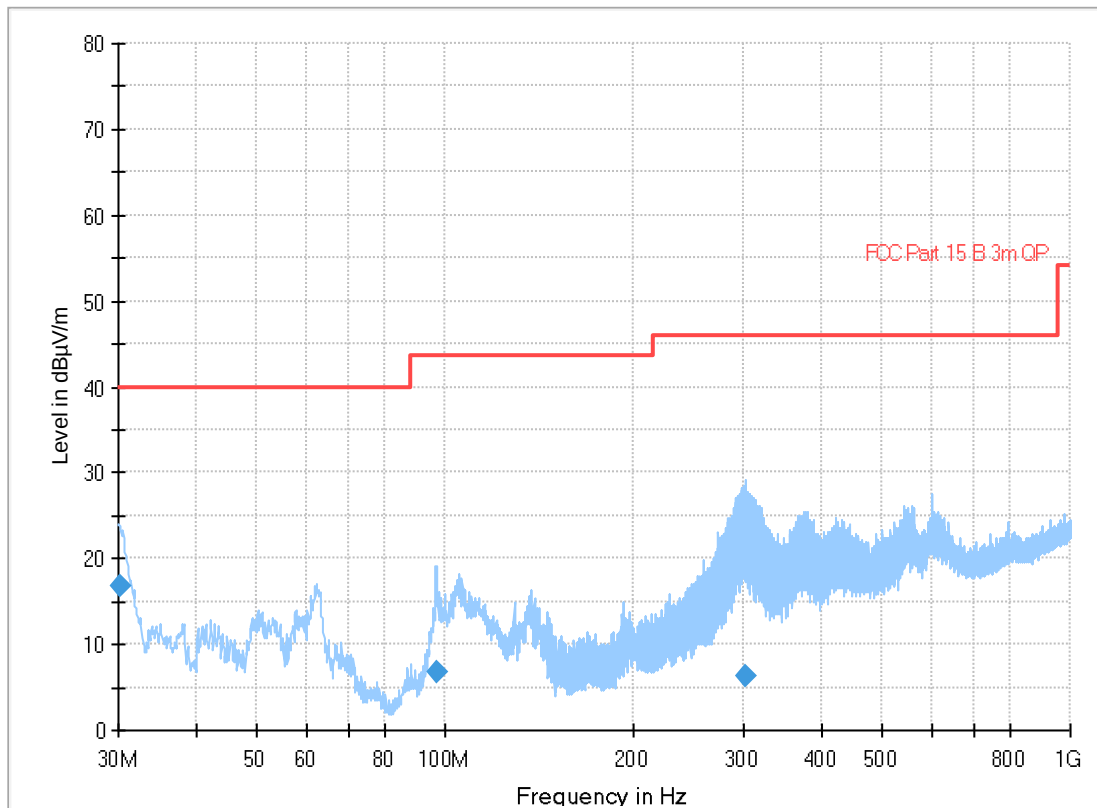
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.165866	16.86	40.00	23.14	1000.0	120.000	106.0	V	12.0
96.758050	6.82	43.50	36.68	1000.0	120.000	105.0	V	141.0
302.384100	6.35	46.00	39.65	1000.0	120.000	115.0	H	102.0

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

Full Spectrum



30MHz - 1000MHz - In hopping mode

GFSK Modulation:

Radiated Emissions, 1-25 GHz; Measuring distance: 3m (1 – 18 GHz), 1m (18 – 25 GHz); A pre-scan was performed above 18 GHz and no spurious emissions were detected.

Peak Detector:

Modulation scheme	Frequency	Polarization	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
GFSK	4.804	HP	0	/	/	74	/
	4.882	HP	0	/	/	74	/
	4.960	HP	0	/	/	74	/
GFSK	7.206	HP	0	56.93	/	74	17.07
	7.323	HP	0	/	/	74	/
	7.440	HP	0	/	/	74	/
GFSK	9.608	HP	0	/	/	74	/
	9.760	HP	0	/	/	74	/
	9.920	HP	0	/	/	74	/
GFSK	12.01	HP	0	/	/	74	/
	12.205	HP	0	/	/	74	/
	12.400	HP	0	/	/	74	/
Other freqs	L,M,H	VP/HP	/	None detected	/	74	>20

*distance correction is included in the plot

Average:

Modulation scheme	Frequency	Polarization	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
	MHz		dB	dBμV/m	dB	dBμV/m	dB
GFSK	4.804	VP	0	/	20	54	/
	4.882	VP	0	/	20	54	/
	4.960	VP	0	/	20	54	/
GFSK	7.206	VP	0	36.93	20	54	17.07
	7.323	VP	0	/	20	54	/
	7.440	VP	0	/	20	54	/
GFSK	9.608	VP	0	/	20	54	/
	9.760	VP	0	/	20	54	/
	9.920	VP	0	/	20	54	/
GFSK	12.01	VP	0	/	20	54	/
	12.205	VP	0	/	20	54	/
	12.400	VP	0	/	20	54	/
Other freqs	L,M,H	VP/HP	/	None detected	20	54	>20

Distance correction for 1m is included in the spectrum analyser.

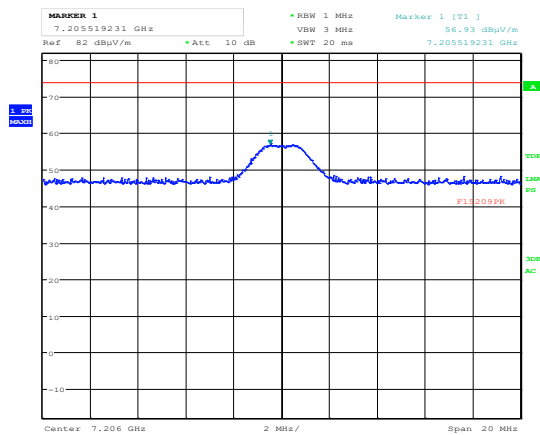
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

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

See plots.

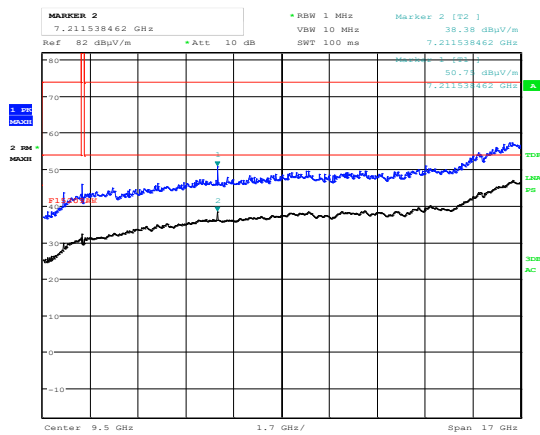
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



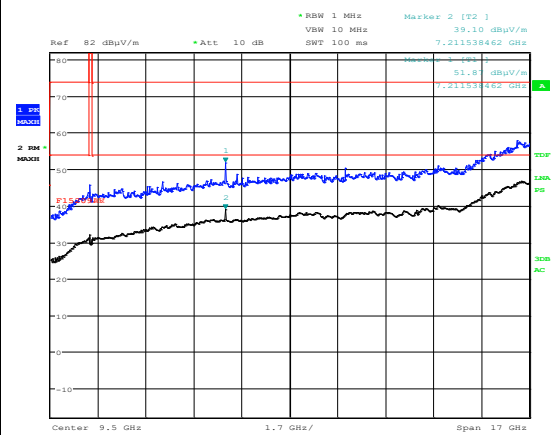
Date: 4.NOV.2020 08:02:47

3rd har, PK, ch2402MHz, GFSK – VP



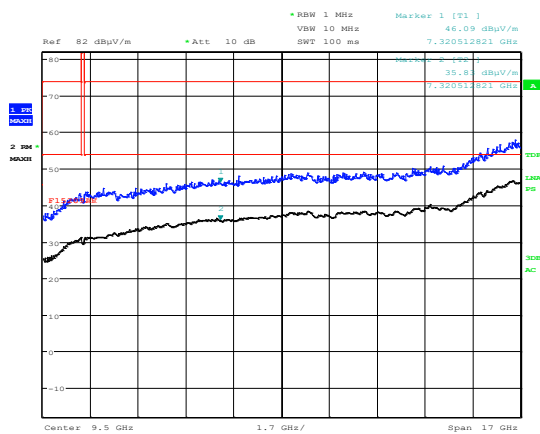
Date: 3.NOV.2020 15:55:12

VP, 1 - 18GHz , GFSK, ch2402MHz, PK scan



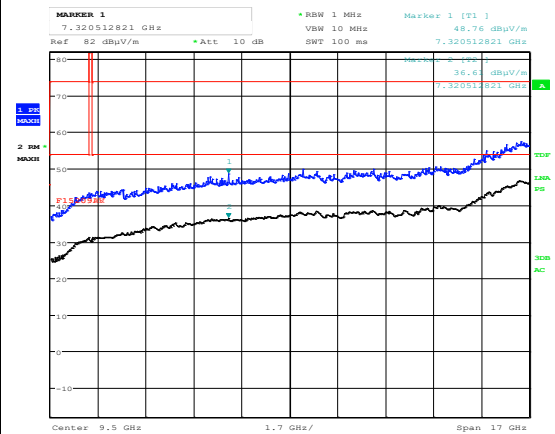
Date: 3.NOV.2020 15:56:40

HP, 1 - 18GHz , GFSK, ch2402MHz, PK scan



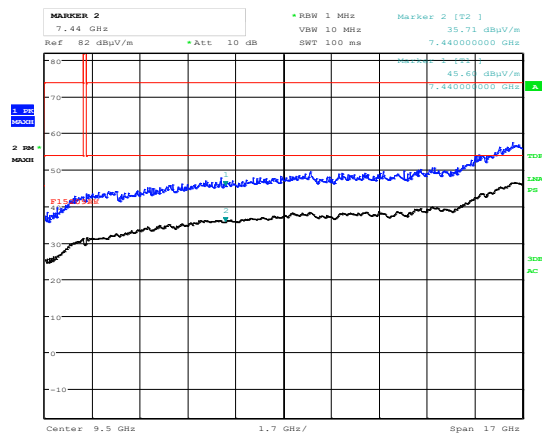
Date: 3.NOV.2020 15:59:52

VP, 1 - 18GHz , GFSK, ch2441MHz, PK scan



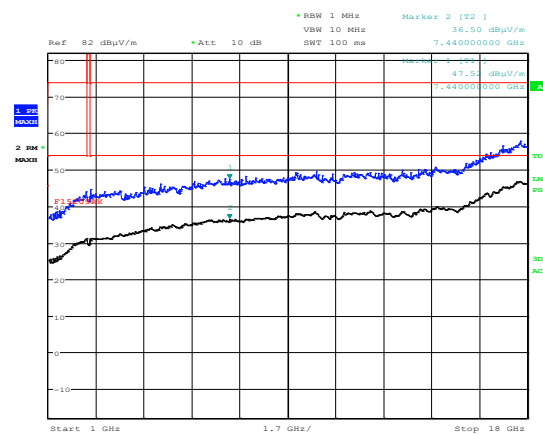
Date: 3.NOV.2020 15:58:47

HP, 1 - 18GHz , GFSK, ch2441MHz, PK scan



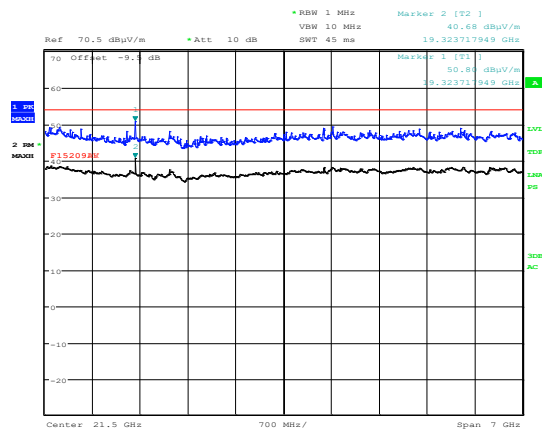
Date: 3.NOV.2020 16:01:33

VP, 1 - 18GHz , GFSK, ch2480MHz, PK scan



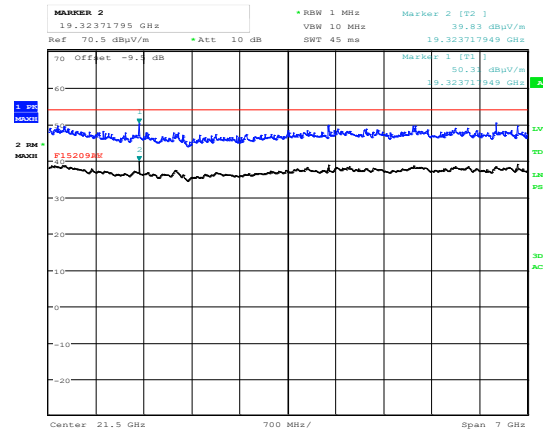
Date: 3.NOV.2020 16:03:17

HP, 1 - 18GHz , GFSK, ch2480MHz, PK scan



Date: 4.NOV.2020 09:53:54

Pre-scan VP, 18 - 25GHz , GFSK @ 1m distance



Date: 4.NOV.2020 09:53:22

Pre-scan HP, 18 - 25GHz , GFSK @ 1m distance

8DPSK Modulation:

Radiated Emissions, 1-25 GHz; Measuring distance: 3m (1 – 18 GHz), 1m (18 – 25 GHz); A pre-scan was performed above 18 GHz and no spurious emissions were detected.

Peak Detector:

Modulation scheme	Frequency	Polarization	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
8DPSK	4.804	VP	0	49.0	/	74	25.0
	4.882	VP	0	49.1	/	74	24.9
	4.960	VP	0	50.0	/	74	24.0
8DPSK	7.206	VP	0	52.5	/	74	21.5
	7.323	VP	0	/	/	74	/
	7.440	VP	0	/	/	74	/
8DPSK	9.608	VP	0	/	/	74	/
	9.760	VP	0	/	/	74	/
	9.920	VP	0	/	/	74	/
8DPSK	12.01	VP	0	/	/	74	/
	12.205	VP	0	/	/	74	/
	12.400	VP	0	/	/	74	/
Other freqs	L,M,H	VP/HP	/	None detected	/	74	>20

*distance correction is included in the plot

Average:

Modulation scheme	Frequency	Polarization	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
	MHz		dB	dBμV/m	dB	dBμV/m	dB
8DPSK	4.804	HP	0	/	20	54	/
	4.882	HP	0	/	20	54	/
	4.960	HP	0	/	20	54	/
8DPSK	7.206	HP	0	/	20	54	/
	7.323	HP	0	/	20	54	/
	7.440	HP	0	/	20	54	/
8DPSK	9.608	HP	0	/	20	54	/
	9.760	HP	0	/	20	54	/
	9.920	HP	0	/	20	54	/
8DPSK	12.01	HP	0	/	20	54	/
	12.205	HP	0	/	20	54	/
	12.400	HP	0	/	20	54	/
Other freqs	L,M,H	VP/HP	/	None detected	20	54	>20

*distance correction is included in the plot

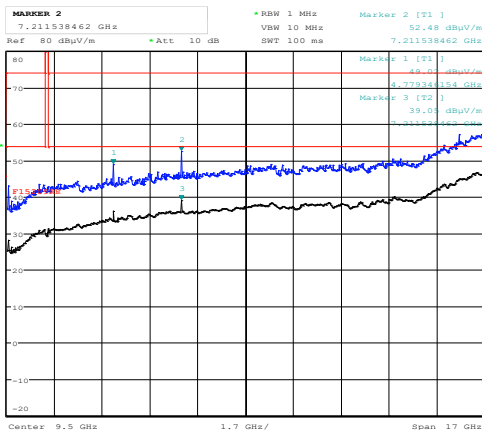
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

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

See attached plots.

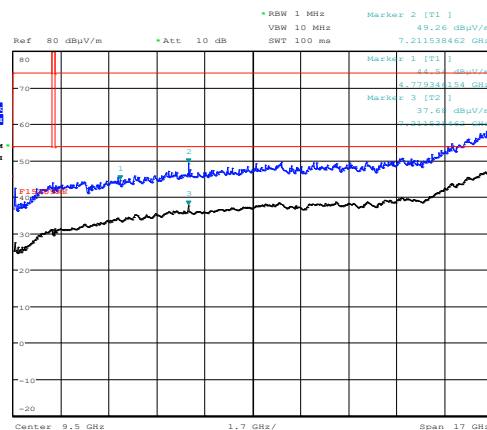
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



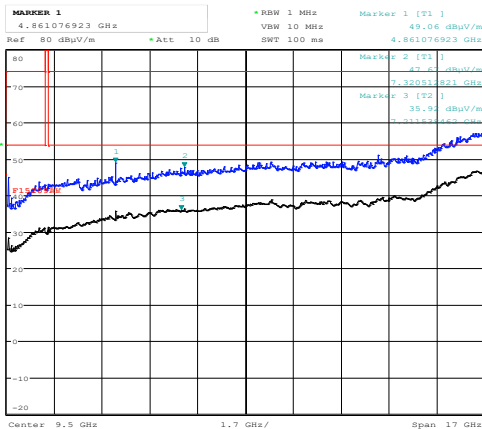
Date: 4.NOV.2020 08:22:11

VP, 1 - 18GHz, 8DPSK, ch2402MHz, PK scan



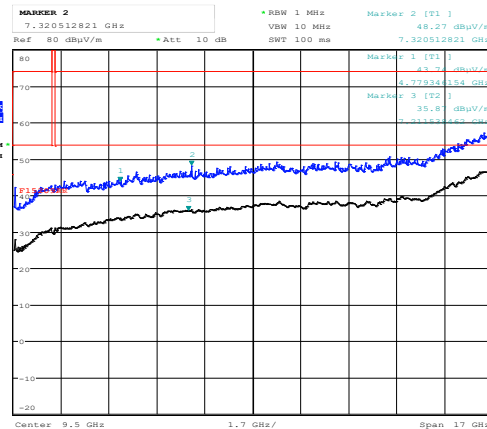
Date: 4.NOV.2020 08:23:33

HP, 1 - 18GHz, 8DPSK, ch2402MHz, PK scan



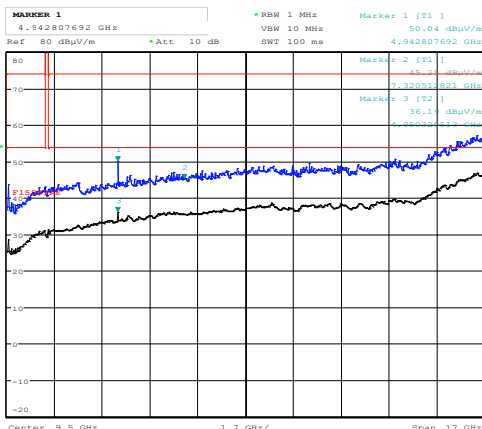
Date: 4.NOV.2020 08:26:19

VP, 1 - 18GHz, 8DPSK, ch2441MHz, PK scan



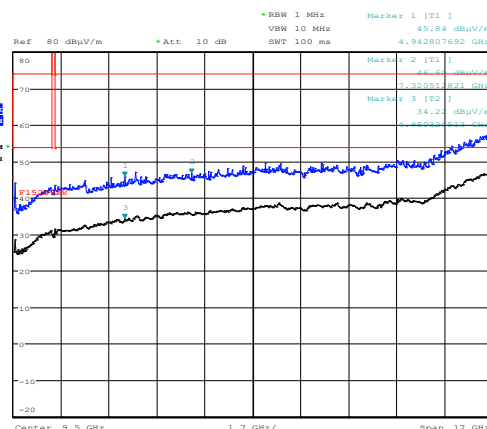
Date: 4.NOV.2020 08:24:34

HP, 1 - 18GHz, 8DPSK, ch2441MHz, PK scan



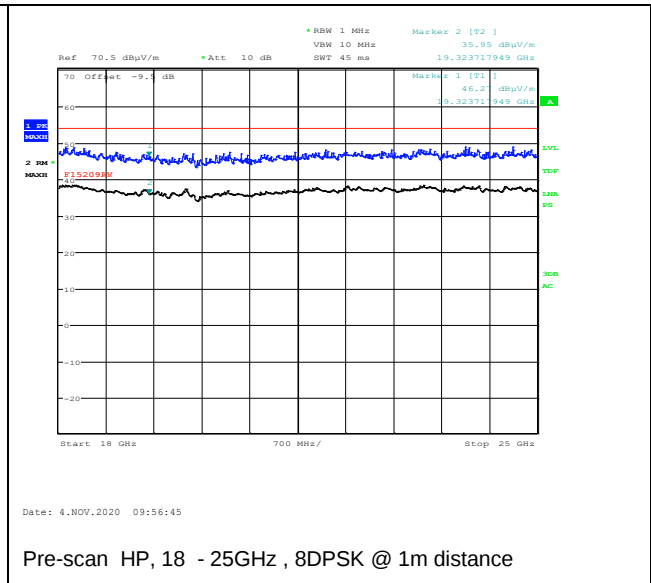
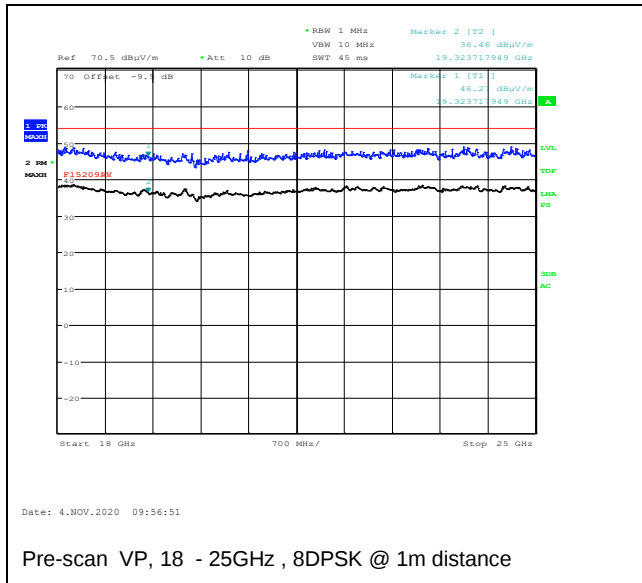
Date: 4.NOV.2020 08:27:39

VP, 1 - 18GHz, 8DPSK, ch2480MHz, PK scan



Date: 4.NOV.2020 08:28:36

HP, 1 - 18GHz, 8DPSK, ch2480MHz, PK scan



$\pi/4$ -DQPSK Modulation:

Radiated Emissions, 1-25 GHz; Measuring distance: 3m (1 – 18 GHz), 1m (18 – 25 GHz); A pre-scan was performed above 18 GHz and no spurious emissions were detected.

Peak Detector:

Modulation scheme	Frequency	Polarization	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
$\pi/4$ -DQPSK	4.804	HP	0	/	/	74	/
	4.882	HP	0	/	/	74	/
	4.960	HP	0	/	/	74	/
$\pi/4$ -DQPSK	7.206	HP	0	56.2	/	74	17.8
	7.323	HP	0	49.9	/	74	24.1
	7.440	HP	0	49.3	/	74	24.7
$\pi/4$ -DQPSK	9.608	HP	0	/	/	74	/
	9.760	HP	0	/	/	74	/
	9.920	HP	0	/	/	74	/
$\pi/4$ -DQPSK	12.01	HP	0	/	/	74	/
	12.205	HP	0	/	/	74	/
	12.400	HP	0	/	/	74	/
Other freqs	L,M,H	VP/HP	/	None detected	/	74	>20

*distance correction is included in the plot

Average:

Modulation scheme	Frequency	Polarization	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
	MHz		dB	dBμV/m	dB	dBμV/m	dB
π/4-DQPSK	4.804	HP	0	/	20	54	/
	4.882	HP	0	/	20	54	/
	4.960	HP	0	/	20	54	/
π/4-DQPSK	7.206	HP	0	36.2	20	54	17.8
	7.323	HP	0	/	20	54	/
	7.440	HP	0	/	20	54	/
π/4-DQPSK	9.608	HP	0	/	20	54	/
	9.760	HP	0	/	20	54	/
	9.920	HP	0	/	20	54	/
π/4-DQPSK	12.01	HP	0	/	20	54	/
	12.205	HP	0	/	20	54	/
	12.400	HP	0	/	20	54	/
Other freqs	L,M,H	VP/HP	/	None detected	20	54	>20

Distance correction for 1m is included in the spectrum analyser.

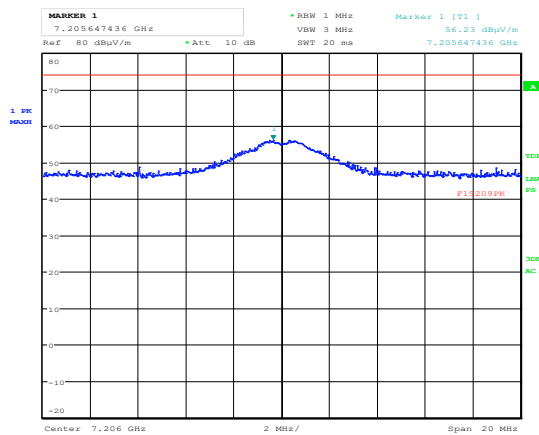
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

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

See plots.

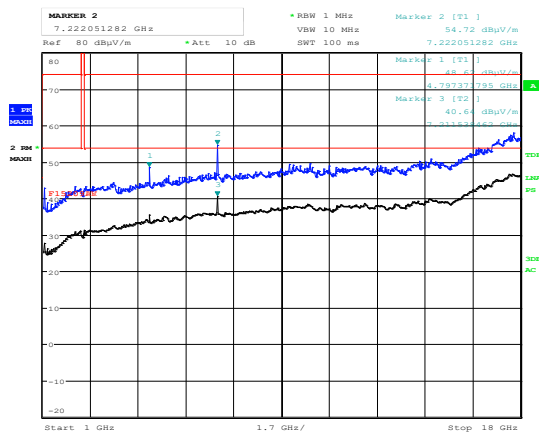
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



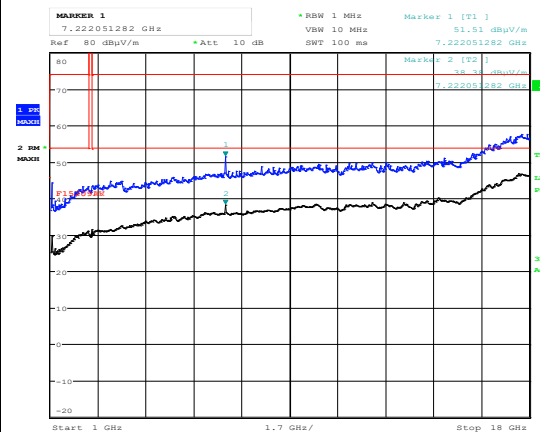
Date: 4.NOV.2020 08:15:33

3rd har, PK, ch2402MHz, 4πDPSK – VP



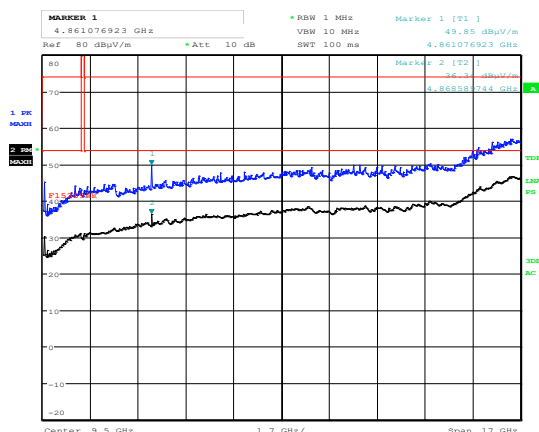
Date: 4.NOV.2020 08:14:21

VP, 1 - 18GHz, 4πDPSK, ch2402MHz, PK scan



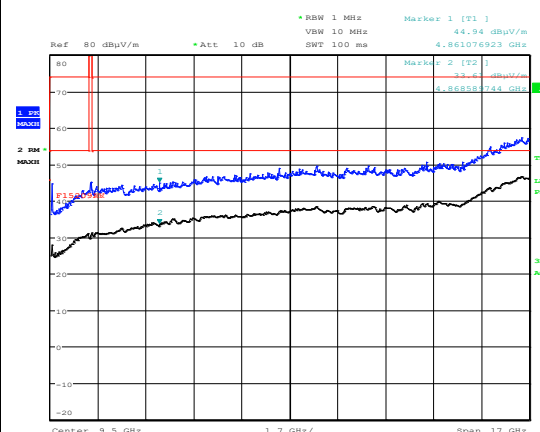
Date: 4.NOV.2020 08:12:30

HP, 1 - 18GHz, 4πDPSK, ch2402MHz, PK scan



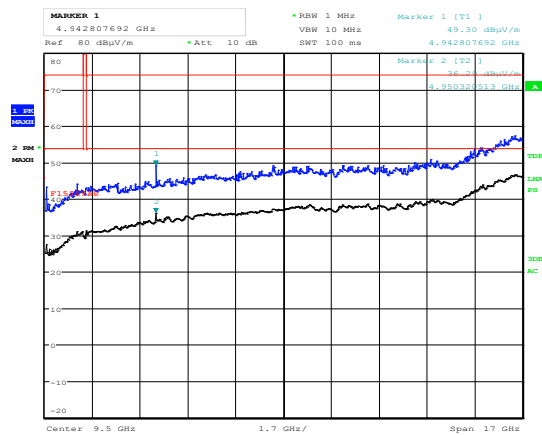
Date: 4.NOV.2020 08:17:32

VP, 1 - 18GHz, 4πDPSK, ch2441MHz, PK scan



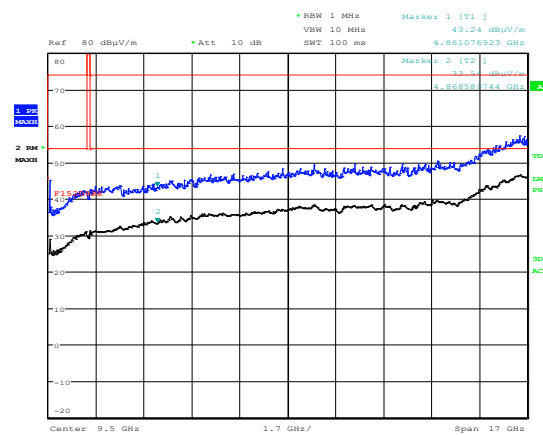
Date: 4.NOV.2020 08:18:51

HP, 1 - 18GHz, 4πDPSK, ch2441MHz, PK scan



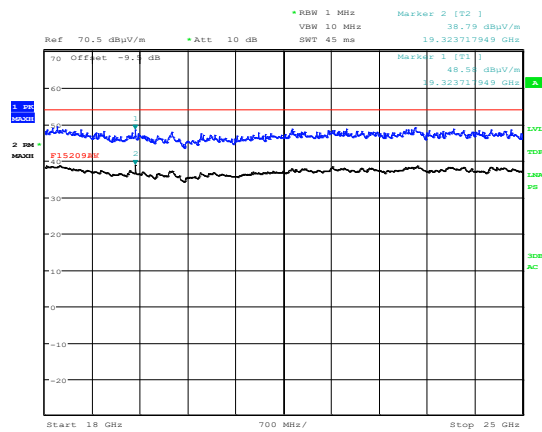
Date: 4.NOV.2020 08:20:55

VP, 1 - 18GHz, 4πDPSK, ch2480MHz, PK scan



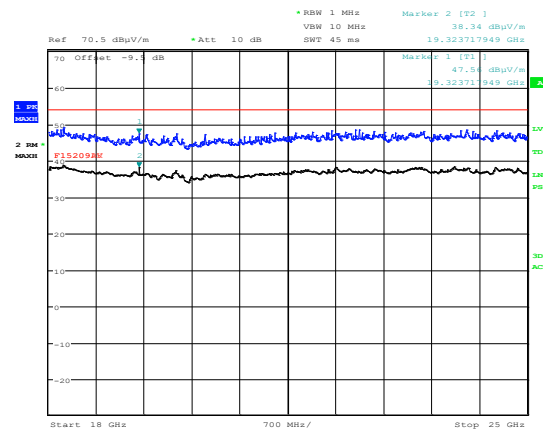
Date: 4.NOV.2020 08:19:37

HP, 1 - 18GHz, 4πDPSK, ch2480MHz, PK scan



Date: 4.NOV.2020 09:55:17

Pre-scan VP, 18 - 25GHz, 4πDPSK @ 1m distance



Date: 4.NOV.2020 09:56:19

Pre-scan HP, 18 - 25GHz, 4πDPSK @ 1m distance

Hopping MODE:

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:

Modulation scheme	Frequency	Polarization	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
DH1	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	/	/	74	/
	9.72 – 9.81	VP	0	/	/	74	/
	12.16 – 12.45	VP	0	/	/	74	/
DH3	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	56.5	/	74	17.5
	9.72 – 9.81	VP	0	/	/	74	/
	12.16 – 12.45	VP	0	/	/	74	/
DH5	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	53.8	/	74	20.2
	9.72 – 9.81	VP	0	/	/	74	/
	12.16 – 12.45	VP	0	/	/	74	/
Other	L,M,H	VP/HP	/	None detected	/	74	>20

*distance correction is included in the plot

Average:

Modulation scheme	Frequency	Polarization	Dist. corr. factor	Field strength, Peak Detector, 3m	Duty cycle corr. factor	Limit	Margin
	MHz		dB	dB μ V/m	dB	dB μ V/m	dB
DH1	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	/	20	54	/
	9.72 – 9.81	VP	0	/	20	54	/
	12.16 – 12.45	VP	0	/	20	54	/
DH3	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	36.5	20	54	17.5
	9.72 – 9.81	VP	0	/	20	54	/
	12.16 – 12.45	VP	0	/	20	54	/
DH5	/	/	/	/	/	/	/
	7.2 – 7.45	VP	0	33.8	20	54	20.2
	9.72 – 9.81	VP	0	/	20	54	/
	12.16 – 12.45	VP	0	/	20	54	/
Other	L,M,H	VP/HP	/	None detected	20	54	>20

*Distance correction for 1m is included in the spectrum analyser.

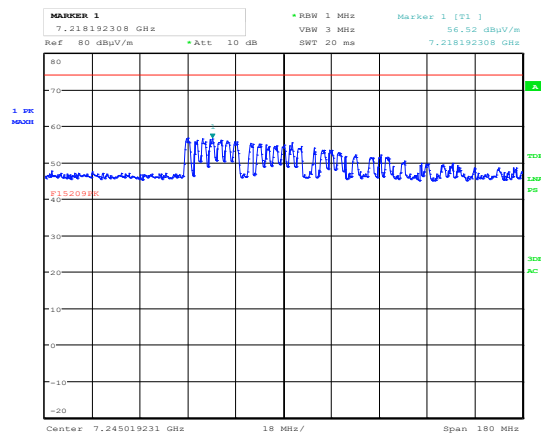
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

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

See plots.

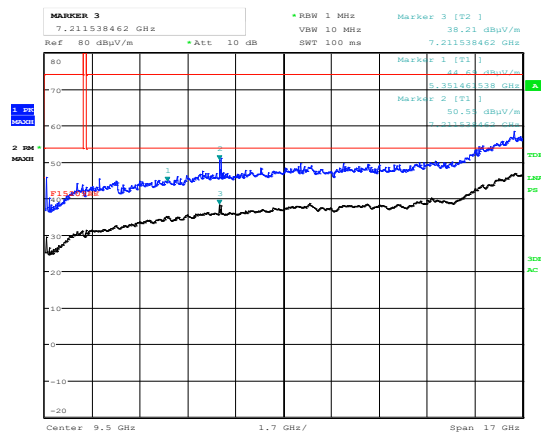
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency (MHz)	AV (dBμV/m)	Peak (dBμV/m)
Above 1 GHz	54.0	74.0



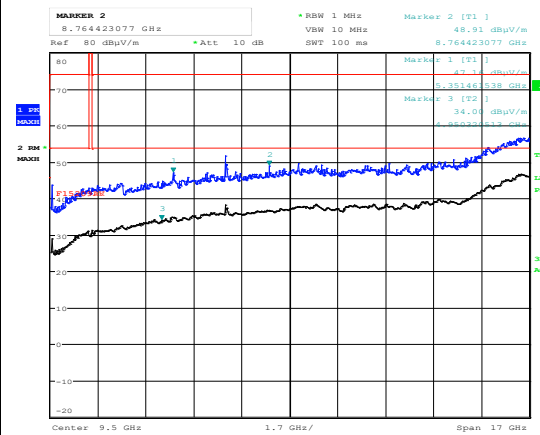
Date: 4.NOV.2020 08:37:10

3rd har, PK, hopping mode, DH3 – VP



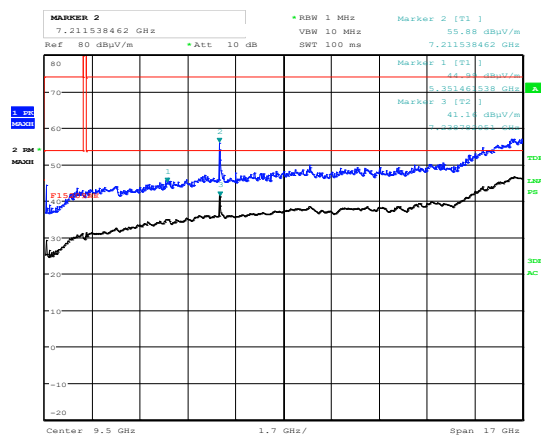
Date: 4.NOV.2020 08:30:52

VP, 1 - 18GHz, hopping mode DH1, PK scan



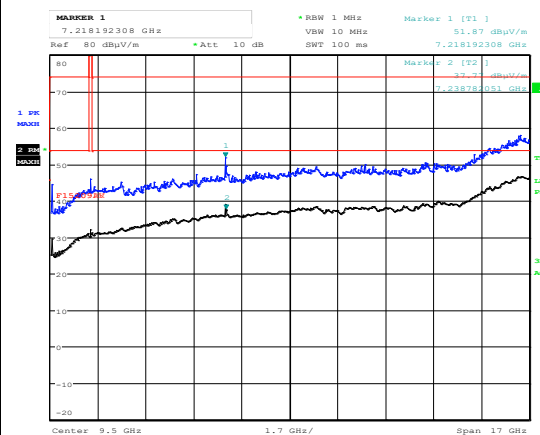
Date: 4.NOV.2020 08:29:42

HP, 1 - 18GHz, hopping mode DH1, PK scan



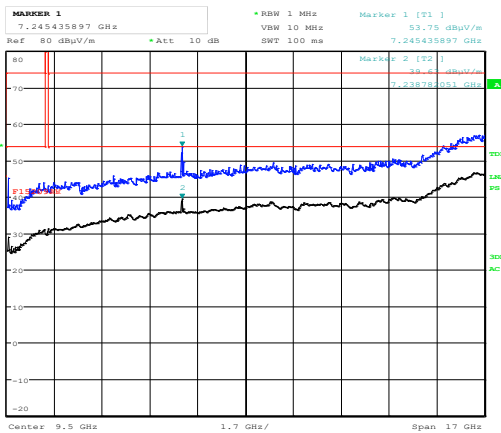
Date: 4.NOV.2020 08:32:04

VP, 1 - 18GHz, hopping mode DH3, PK scan



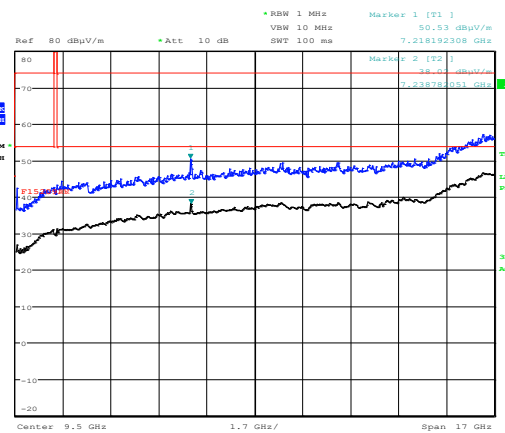
Date: 4.NOV.2020 08:42:16

HP, 1 - 18GHz, hopping mode DH3, PK scan



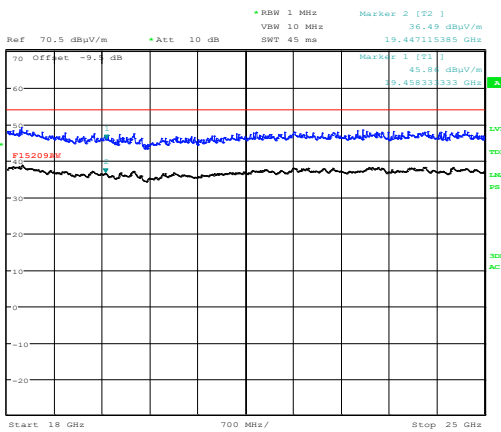
Date: 4.NOV.2020 08:44:47

VP, 1 - 18GHz , hopping mode DH5, PK scan



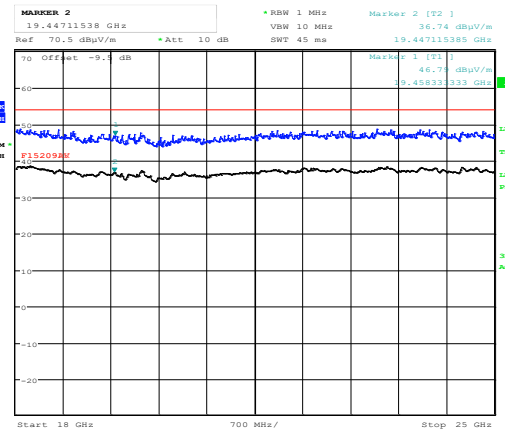
Date: 4.NOV.2020 08:43:46

HP, 1 - 18GHz , hopping mode DH5, PK scan



Date: 4.NOV.2020 09:58:13

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



Date: 4.NOV.2020 09:57:53

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

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.

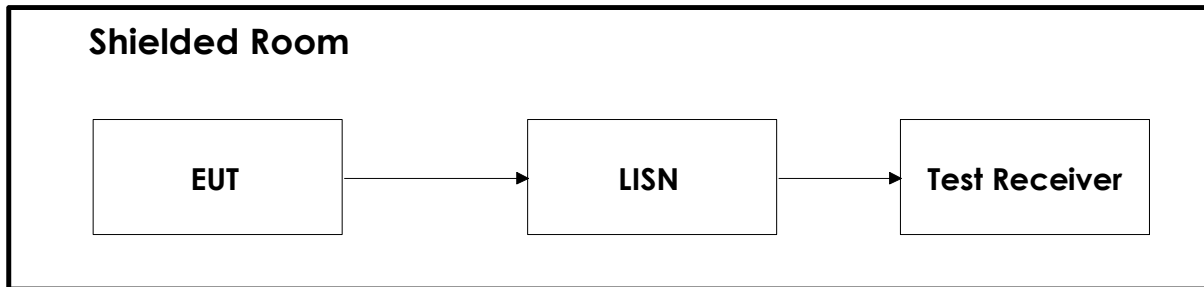
No.	Instrument/ ancillary	Type of instrument/ ancillary	Manufacturer	Ref. no.	Cal. Date	Cal. Due
1.	ESU40	EMI Receiver	Rohde & Schwarz	LR1639	2020.01	2021.01
2.	HFH2-Z2	Active Loop antenna	Rohde & Schwarz	LR1660	2019.11	2021.11
3.	3117-PA	Horn antenna with PreA	EMCO	LR 1717	2017.12	2020.12
4.	638	Antenna Horn	NARDA	LR 1480	N/A	
5.	637	Antenna Horn	NARDA	LR 099	N/A	
6.	VULB9163	Bi-log Hybrid Antenna	Schwarzbeck	LR 1616	2020.01	2022.01
7.	4768-10	Attenuator	Narda	LR 1356	Cal b4 use	
8.	NO324415	Notch Filter	Microwave	LR 1760	Cal b4 use	
9.	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2020.08	2021.08
10.	310N	Pre-amplifier	Sonoma	LR 1686	2020.08	2021.08
11.	Model 45	Multimeter	Fluke	LT 5218	2018.11	2020.11
12.	6812B	AC power source	Agilent	LR 1515	2020.04	2021.04
13.	ESCI3	EMI Receiver	Rohde & Schwarz	N-4529	2019.10	2021.10
14.	ENV216	Two line network	Rohde & Schwarz	LR 1665	2019.11	2021.11

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

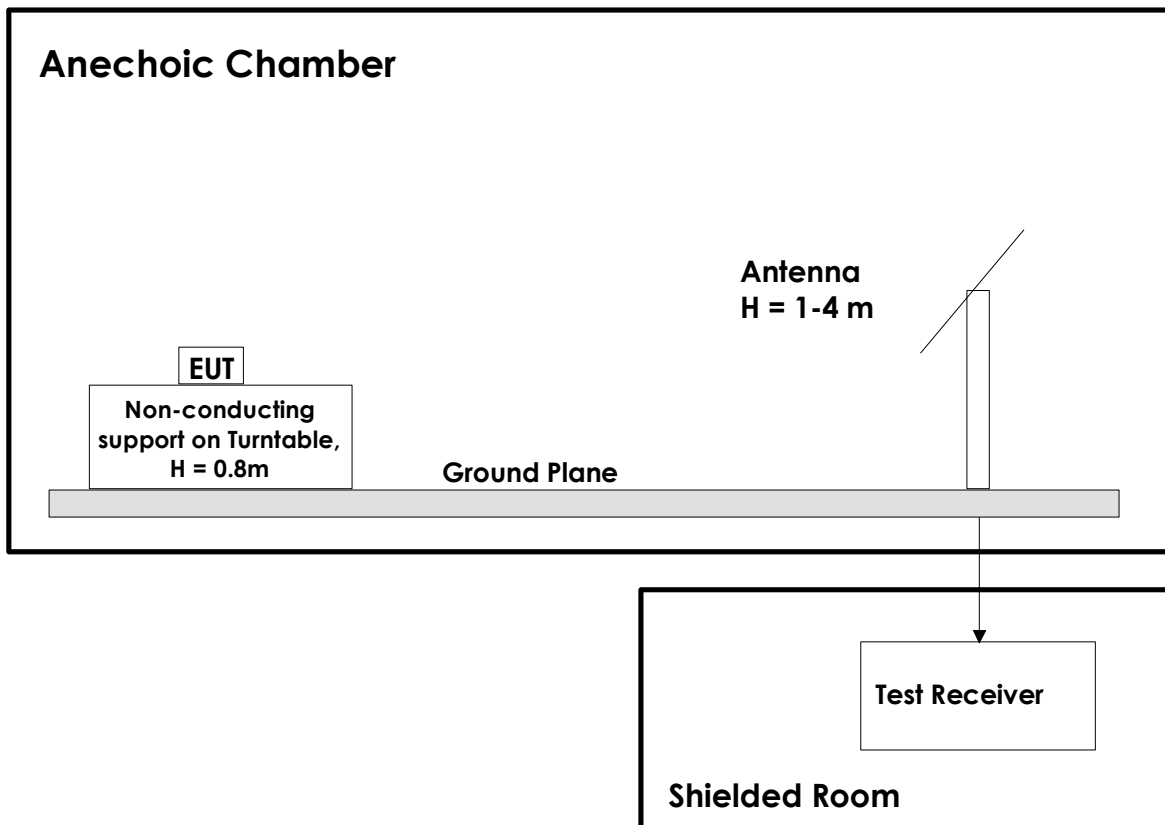
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	GPBShot	2.7	Screenshots from R&S Spectrum Analyzers
2	Rohde & Schwarz	RSCommander	1.9.2 64bit	Versatile Software Tool for R&S Instruments
3	Rohde & Schwarz	EMC 32	10.50.40	Radiated Emission test software

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.