

Test Report

Product	Hearing Protection with Bluetooth
Name and address of the applicant	Husqvarna AB Drottninggatan 2 SE-561 82 Huskvarna, Sweden
Name and address of the manufacturer	Husqvarna AB Drottninggatan 2 SE-561 82 Huskvarna, Sweden
Model	HP500BT-1, HP500BT-2
Rating	3.7Vdc max. 200mA
Trademark	 Husqvarna®
Additional information	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	PRJ0014324
Tested in period	2022-10-14 to 2023-01-18
Issue date	2023-06-30
Name and address of the testing laboratory	 Nemko Scandinavia AS Instituttveien 6 2007 Kjeller, Norway www.nemko.com CAB Number: FCC: NO0001 ISED: NO0470 ISED No: 2040D-1   NORWEGIAN ACCREDITATION TEST 033 An accredited technical test executed under the Norwegian accreditation scheme
 Prepared by [Frode Sveinsen]  Approved by [G.Suhanthakumar]	
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Revision history

Revision	Date	Comment	Sign
A	2023-06-30	First edition	FS

GENERAL REMARKS

This report applies only to the sample(s) tested. It is the manufacturer's responsibility to ensure the additional production units of this product are manufactured with identical electrical and mechanical components. The manufacturer is solely responsible for any modifications to the product that could result in non-compliance with the relevant regulations.

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Opinions expressed within this report regarding general assessments and qualifications for PASS or FAIL to the standards limits and requirements, are not part of the current accreditation. Neither are opinions expressed regarding model variants covered by the testing of this report.

CALIBRATION

All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Between calibrations all test set-ups are controlled and verified on a regular basis by periodic checks to ensure, with 95% confidence, that the instruments remain within the calibrated levels.

MEASUREMENT UNCERTAINTY

Measurement uncertainties are calculated or considered for all instruments and instrument set-ups used during these tests. Uncertainty figures are found in a separate clause in this report.

CONTENTS

1	INFORMATION	4
1.1	Test Item	4
1.2	Model Overview.....	4
1.3	Normal test condition.....	5
1.4	Test Engineer.....	5
1.5	Antenna Requirement.....	5
1.6	EUT Operating Modes.....	5
1.7	Comments.....	5
2	TEST REPORT SUMMARY	6
2.1	General	6
2.2	Test Summary	6
3	TEST RESULTS.....	7
3.1	Power Line Conducted Emissions	7
3.2	20dB Bandwidth	8
3.3	Pseudorandom Hopping Algorithm	11
3.4	Hopping Bandwidth	12
3.5	Occupancy Time.....	14
3.6	Occupied Bandwidth (99% BW).....	16
3.7	Peak Power Output	18
3.8	Conducted Emissions at Antenna Connector.....	21
3.9	Restricted Bands of operation.....	25
3.10	Radiated Emissions, Band Edge.....	26
3.11	Radiated Emission, 30 – 1000 MHz.....	28
3.12	Radiated Emissions, 1-26 GHz.....	30
4	Measurement Uncertainty.....	35
5	LIST OF TEST EQUIPMENT.....	36
6	BLOCK DIAGRAM.....	37
6.1	Power Line Conducted Emission	37
6.2	Test Site Radiated Emission.....	37

1 INFORMATION

1.1 Test Item

Name	Husqvarna
Model/version	HP500BT-1, HP500BT-2
FCC ID	ZASHP500BT
ISED ID	23307-HP500BT
Serial number	Conducted Sample: R317 Radiated Sample: R313
Hardware identity and/or version	853505
Software identity and/or version	0.1.0-EP1_Cert
Frequency Range	2402–2480 MHz
Number of Channels	79
Operating Modes	Bluetooth Basic Rate, Bluetooth 2-EDR and Bluetooth 3-EDR
Type of Modulation	BT Basic Rate: GFSK BT 2-EDR: $\pi/4$ -DQPSK BT 3-EDR: 8-DPSK
Conducted Output Power	BT Basic Rate: 6.0 mW (Peak) BT 2-EDR: 3.7 mW (Peak) BT 3-EDR: 4.3 mW (Peak)
Antenna Connector	None (Integral Antenna)
Number of Antennas	1
Diversity or Smart Antennas	No
Power Supply	Secondary Battery (3.7V Li-Ion)
Interfaces	USB-C port for charging

Description of Test Item

The EUT is a Hearing Protection with Bluetooth.

This Bluetooth part has been tested as a Frequency Hopping system and fulfils all requirements for FHSS systems.

The models covered by this report are identical to the models HP500C-1 and HP500C-2 (FCC ID: ZASHP500 and IC: 23307-HP500), except the DECT transceiver is removed on the models HP500BT-1 and HP500BT-2.

All tests were performed on a HP500C-1 with all transceivers mounted.

1.2 Model Overview

Name	Model No	Style	BT/BLE	DECT	FCC ID	IC ID
X-COM Active	HP500C-1	Headband	YES	YES	ZASHP500	23307-HP500
	HP500C-2	Helmet Mount	YES	YES	ZASHP500	23307-HP500
X-SYNC	HP500BT-1	Headband	YES	NO	ZASHP500BT	23307-HP500BT
	HP500BT-2	Helmet Mount	YES	NO	ZASHP500BT	23307-HP500BT

The Headband and Helmet Mount models are electrically identical.

1.3 Normal test condition

Temperature:	20 - 24 °C
Relative humidity:	20 - 50 %
Normal test voltage:	3.7 V DC (Nominal Battery Voltage)

The values are the limit registered during the test period.

1.4 Test Engineer

Frode Sveinsen

1.5 Antenna Requirement

Does the EUT have detachable antenna(s)?	☐ YES	☒ NO
If detachable, is the antenna connector(s) non-standard?	☐ YES	☐ NO
The tested equipment has only integral antennas. Conducted tests were performed with a temporary antenna connector.		

Requirement: FCC 15.203, 15.204

1.6 EUT Operating Modes

Operating modes	Continuous TX and Hopping, Basic Rate, 2-EDR and 3-EDR
Additional information	The following settings were used for all tests: Power Setting: PL5 Bit Pattern: PSRB Frame Type: DH1, 2-DH1, 3-DH1

1.7 Comments

The EUT uses the Bluetooth protocol with Frequency Hopping.

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

2 TEST REPORT SUMMARY

2.1 General

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

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

Radiated tests were made in a semi-anechoic chamber at measuring distance of 3m.

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

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 2, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	5.13	N/A
Antenna Requirement	15.203	6.8 (RSS-GEN)	5.8	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	6.2	Complies
Channel Separation and 20 dB BW	15.247(a)(1)	5.1 (4) (RSS-247)	7.8.2 (FHSS)	Complies
Number of Hopping Frequencies	15.31(m)	5.1 (6) (RSS-247)	7.8.3 (FHSS)	Complies
Pseudorandom Hopping Algorithm	15.247(a)(1)	5.1 (3) (RSS-247)	N/A (FHSS)	Complies
Time of Occupancy (dwell time)	15.247(a)(1)(iii)	5.1 (5) (RSS-247)	7.8.4 (FHSS)	Complies
Occupied Bandwidth	15.247(a)(1)	5.1 (7) (RSS-247)	6.9.2 FHSS)	Complies
Occupied Bandwidth (99% BW)	N/A	6.7 (RSS-GEN)	6.9.3	Complies
Peak Power Output	15.247(b)	5.4 (RSS-247)	11.9.1.1	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	6.7 7.8.6 (FHSS) 7.8.8 (FHSS)	Complies
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	6.3, 6.5, 6.6, 6.10 11.12	Complies

3 TEST RESULTS

3.1 Power Line Conducted Emissions

FCC Part 15.107 (a)

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

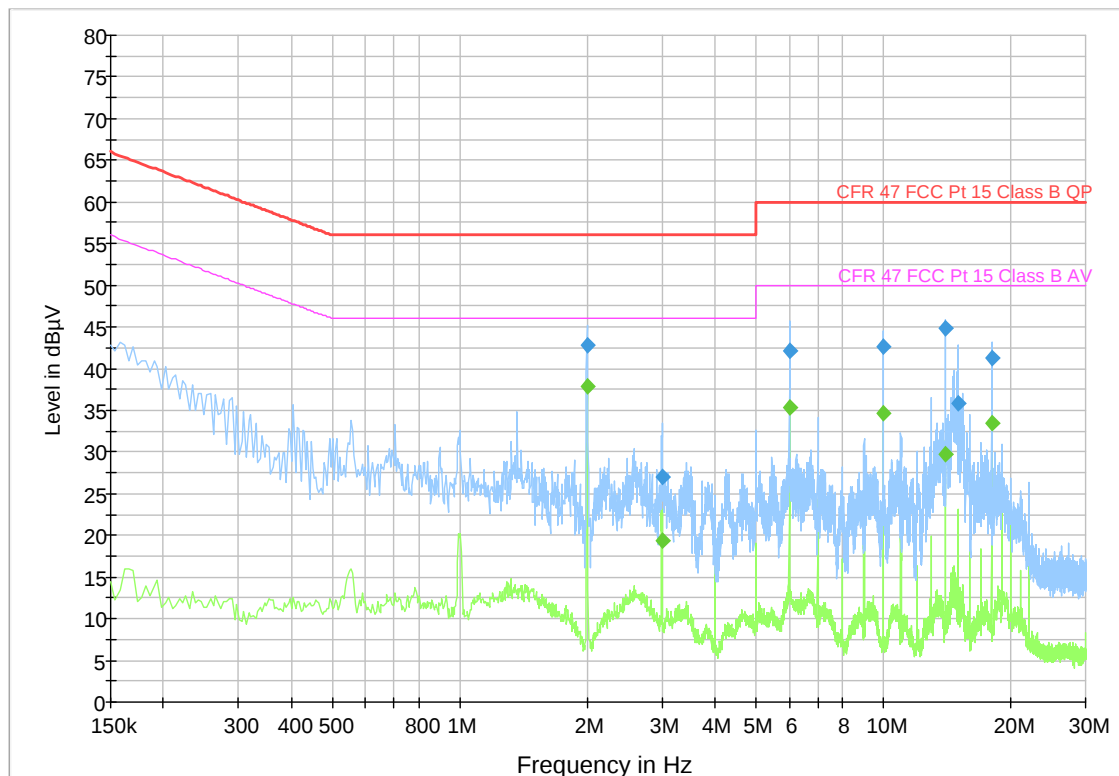
Measurement Data: EUT Charging from USB Charger, 120V 60Hz.

See attached plots.

Highest measured value (L1 and N):

Frequency (MHz)	QuasiPeak (dB μ V)	Average (dB μ V)	Limit (dB μ V)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
1.998000	42.87	---	56.00	13.13	15000.0	9.000	L1	OFF	9.7
2.002000	---	37.82	46.00	8.18	15000.0	9.000	L1	OFF	9.7
6.002000	---	35.29	50.00	14.71	15000.0	9.000	L1	OFF	9.8
6.002000	42.07	---	60.00	17.93	15000.0	9.000	N	OFF	9.6
10.002000	---	34.67	50.00	15.33	15000.0	9.000	N	OFF	9.6
10.002000	42.65	---	60.00	17.35	15000.0	9.000	N	OFF	9.6
14.002000	44.86	---	60.00	15.14	15000.0	9.000	N	OFF	9.7
18.002000	---	33.53	50.00	16.47	15000.0	9.000	N	OFF	9.7
18.002000	41.19	---	60.00	18.81	15000.0	9.000	L1	OFF	9.9

Full Spectrum



3.2 20dB Bandwidth

FCC Part 15.247(a)(1)

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

Measurement procedure: ANSI C63.10-2013 Clause 7.8.2

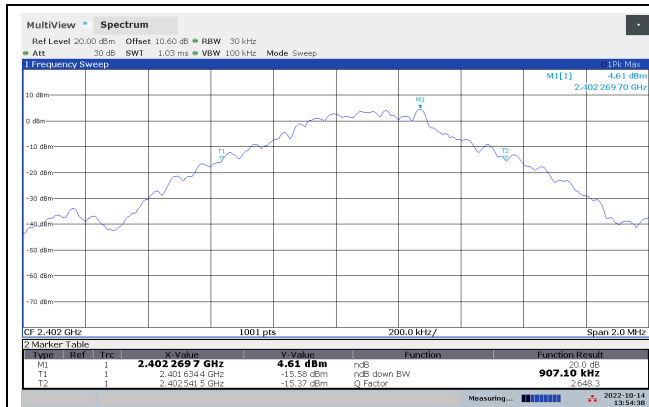
Test Results: Complies

Measurement Data:

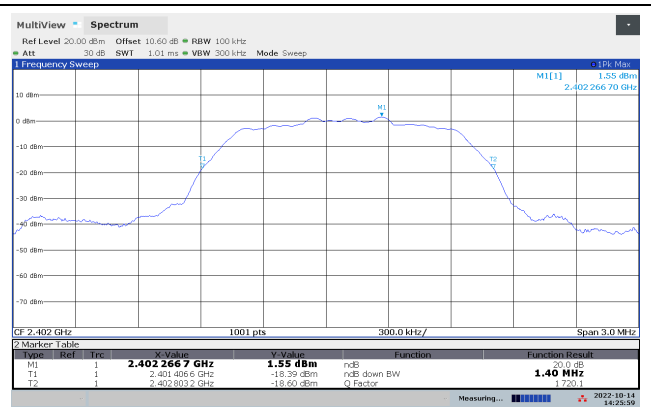
Modulation	20dB Bandwidth (MHz)		
	2402 MHz	2441 MHz	2480 MHz
Basic Rate (GFSK)	0.91	0.91	0.91
2-EDR ($\pi/4$ -DPSK)	1.40	1.40	1.40
3-EDR (8-DPSK)	1.30	1.30	1.30

See attached plots.

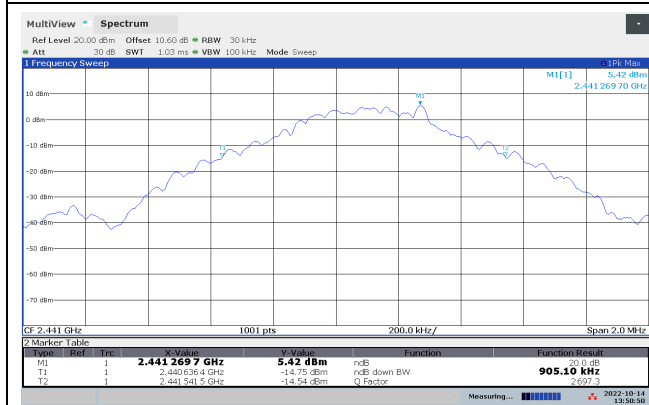
Frequency Band	Requirement for Frequency Hopping
2400-2483.5 MHz	The maximum 20 dB bandwidth shall be less than channel separation, alternatively, less than 150% of channel separation if output power is less than 125 mW.



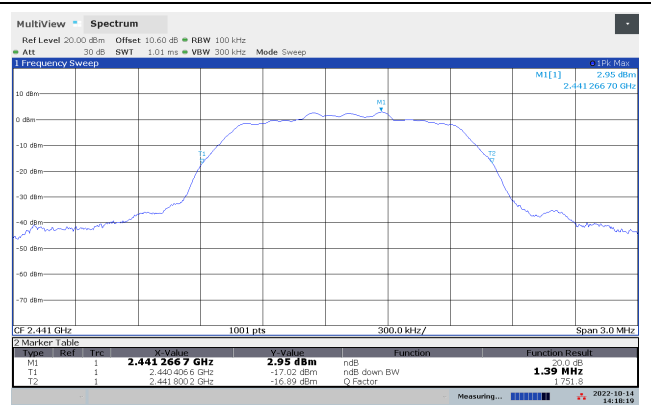
20dB Bandwidth 2402 MHz, GFSK



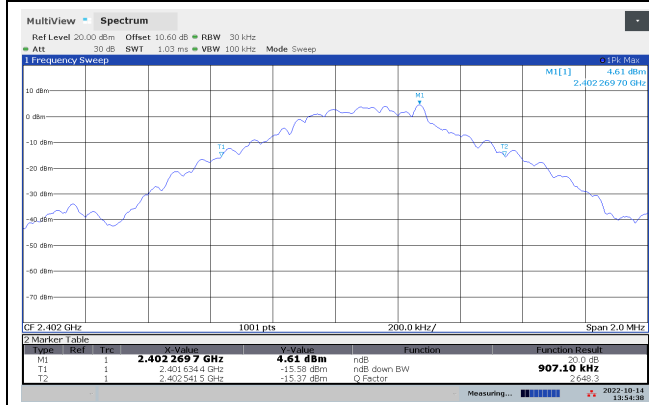
20dB Bandwidth 2402 MHz, $\pi/4$ -DPSK



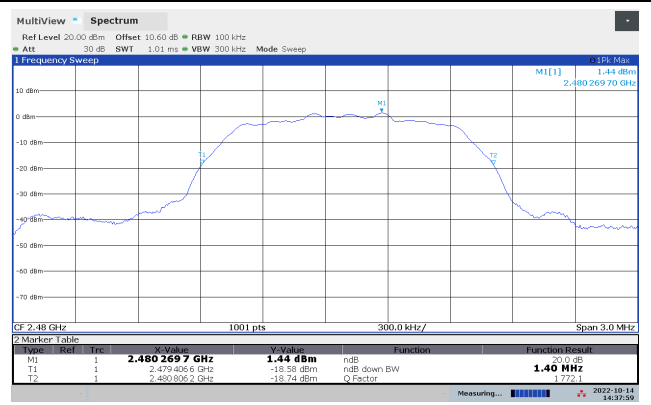
20dB Bandwidth 2441 MHz, GFSK



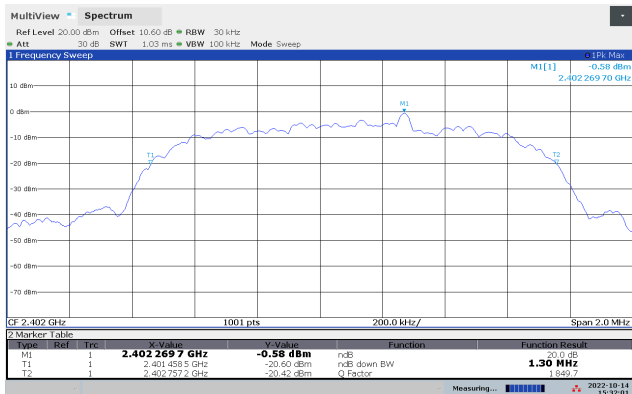
20dB Bandwidth 2441 MHz, $\pi/4$ -DPSK



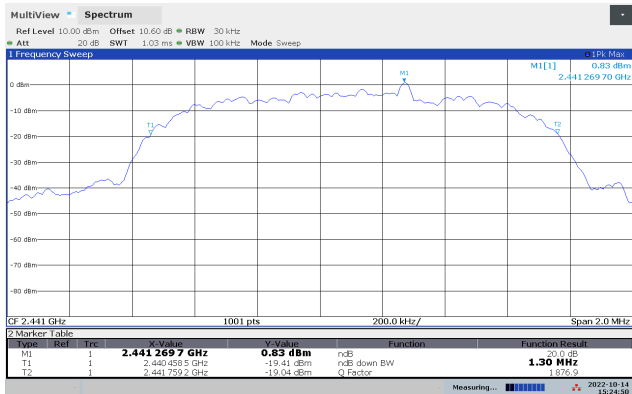
20dB Bandwidth 2480 MHz, GFSK



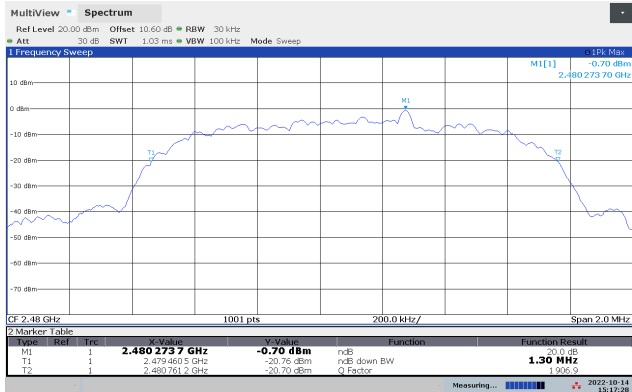
20dB Bandwidth 2480 MHz, $\pi/4$ -DPSK



20dB Bandwidth 2402 MHz, 8-DPSK



20dB Bandwidth 2441 MHz, 8-DPSK



20dB Bandwidth 2480 MHz, 8-DPSK

3.3 Pseudorandom Hopping Algorithm

FCC Part 15.247 (a)(1)

ISED Canada RSS-247 Issue 2, Clause 5.1

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.

3.4 Hopping Bandwidth

FCC Part 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 2, Clause 5.1

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

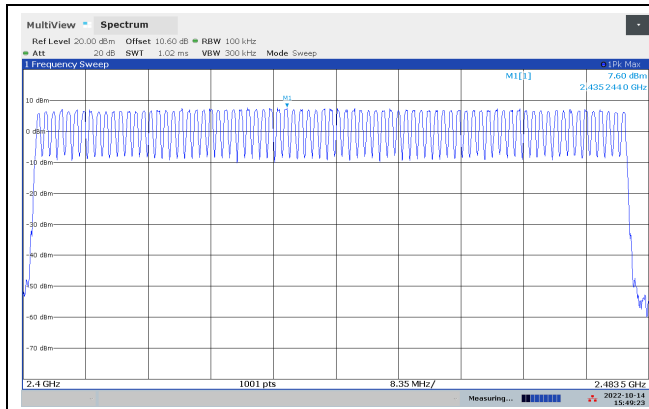
Test Results: Complies

Measurement Data:

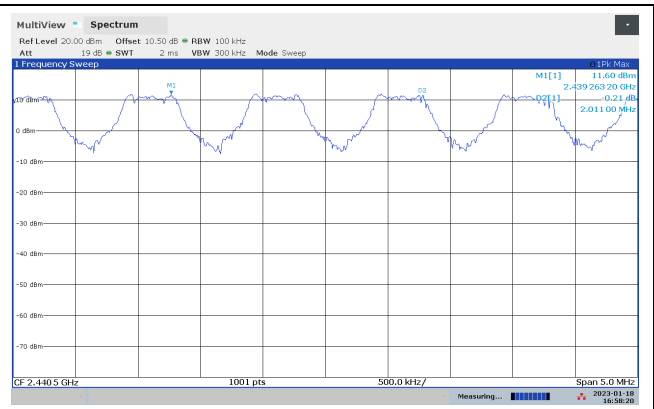
Number of RF Channels in use	20 to 79
Channel Centre Frequencies	2402 to 2480 MHz
Channel Separation	1 MHz

See attached plots.

Frequency Band	Requirement for Frequency Hopping
2400-2483.5 MHz	Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.



RF Channels in Use, GFSK



Channel Separation

3.5 Occupancy Time

FCC Part 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:

Frame Type and Data Rate	Burst Length (ms)	Frame Length (ms)	Time of Occupancy (ms)	Verdict
DH1	0.384	1.25	123	Complies
DH3	1.65	2.50	264	Complies
DH5	2.90	3.75	309	Complies

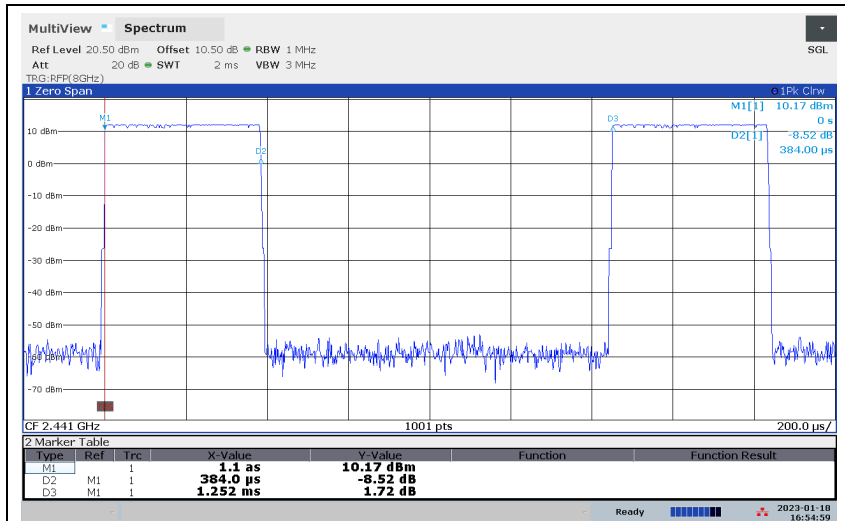
Maximum Burst length for GFSK modulation

Time between RF burst on same channel = Frame Length * Number of Channels

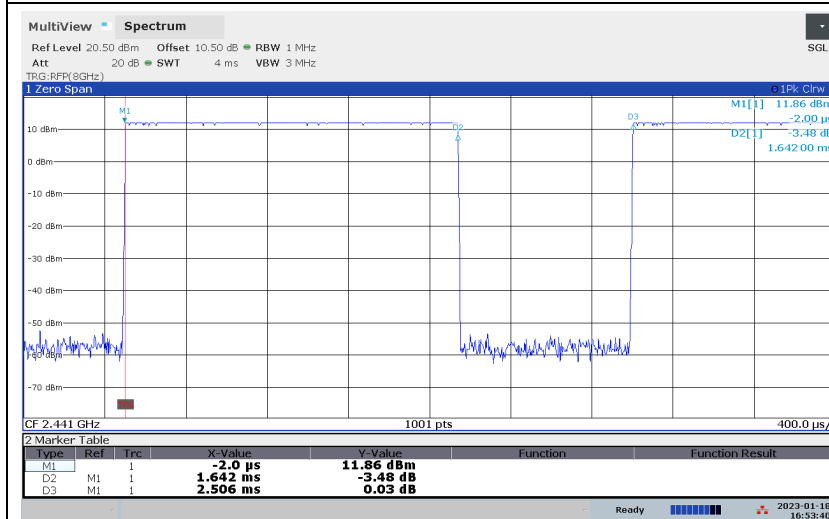
Time of occupancy = (Burst Length * Number of Channels * 400 ms) / Time Between Burst on Same Channel
= (Burst Length * 400 ms) / Frame Length

Number of RF channels is minimum 20 and maximum 78

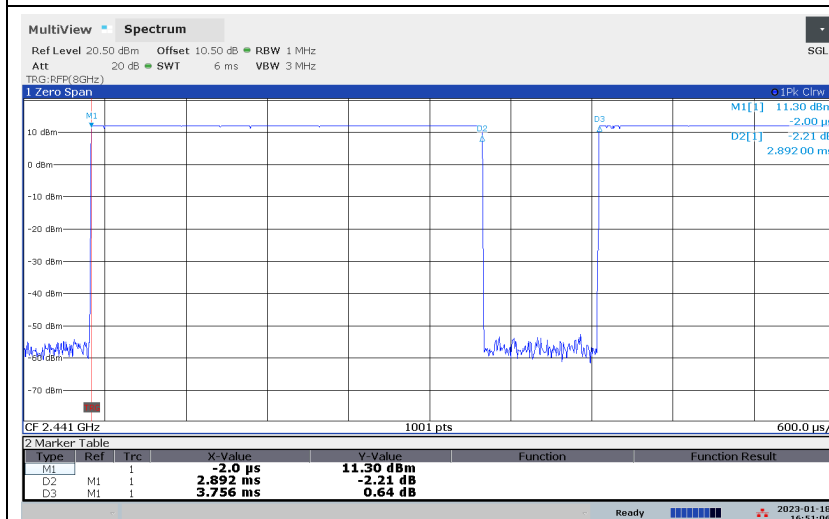
Frequency Band	Requirement for Frequency Hopping
2400-2483.5 MHz	The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.



Frame Type DH1



Frame Type DH3



Frame Type DH5

3.6 Occupied Bandwidth (99% BW)

FCC Part 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 6.9.3 / 7.8.3

Test Results: Complies

Measurement Data:

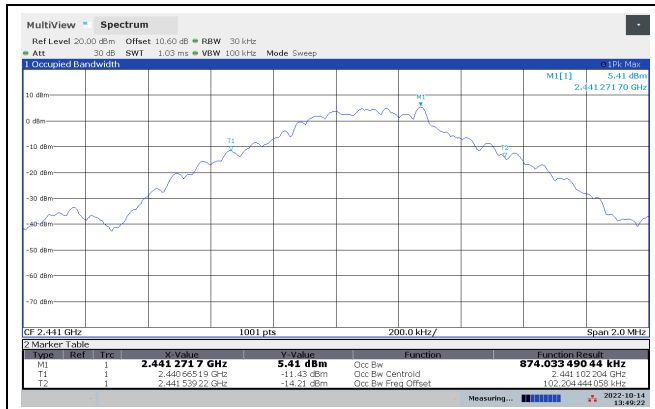
Carrier Frequency and Data Rate	Occupied Bandwidth (99% BW)
2441 MHz Basic Rate	0.87 MHz
2441 MHz 2-EDR	1.19 MHz
2441 MHz 3-EDR	1.19 MHz

Occupied Bandwidth is the same for all channels.

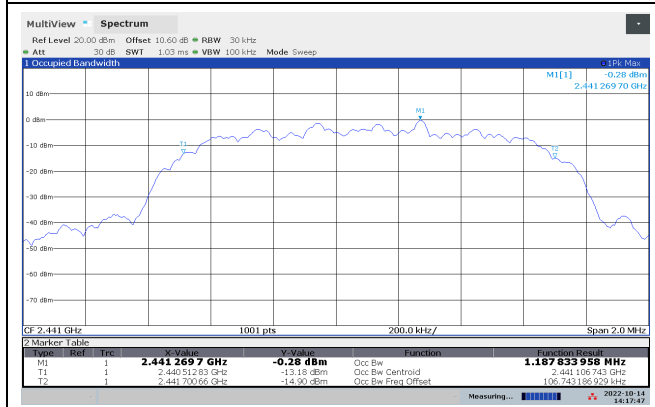
See attached plots.

Requirements:

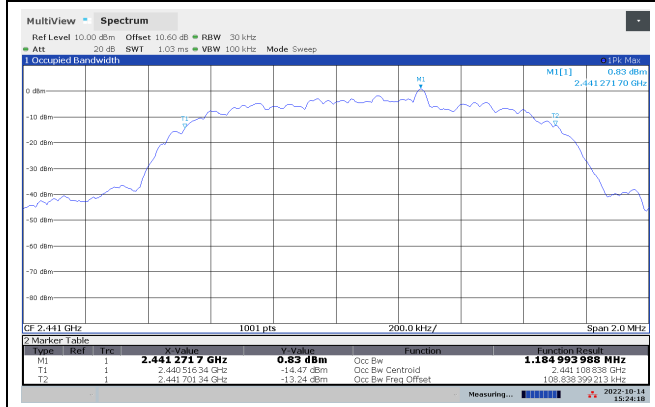
No requirement for 99% BW, reported for information only.



99% Occupied BW, GFSK



99% Occupied BW, $\pi/4$ -DPSK



99% Occupied BW, 8-DPSK

3.7 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:

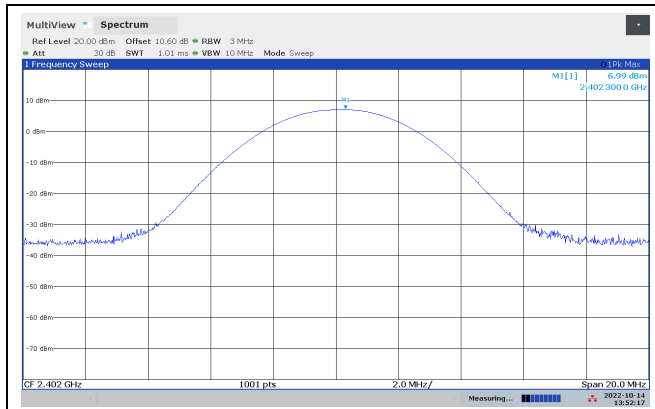
Carrier Frequency	Modulation Type	Conducted Power (dBm)	Conducted Power (mW)
2402 MHz	GFSK	7.0	5.0
	$\pi/4$ -DPSK	4.4	2.8
	8-DPSK	5.1	3.2
2441 MHz	GFSK	7.8	6.0
	$\pi/4$ -DPSK	5.7	3.7
	8-DPSK	6.3	4.3
2480 MHz	GFSK	7.0	5.0
	$\pi/4$ -DPSK	4.4	2.7
	8-DPSK	5.1	3.3

Output Power reported is Maximum Peak Power. Reported values are with PL5.

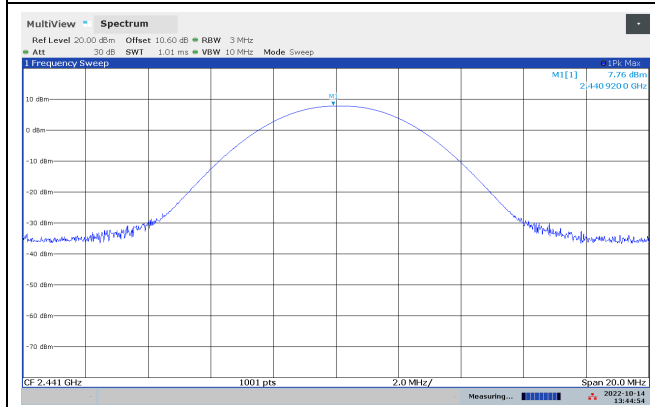
Bluetooth Classic uses the same antenna as Bluetooth Low Energy.

See attached plots.

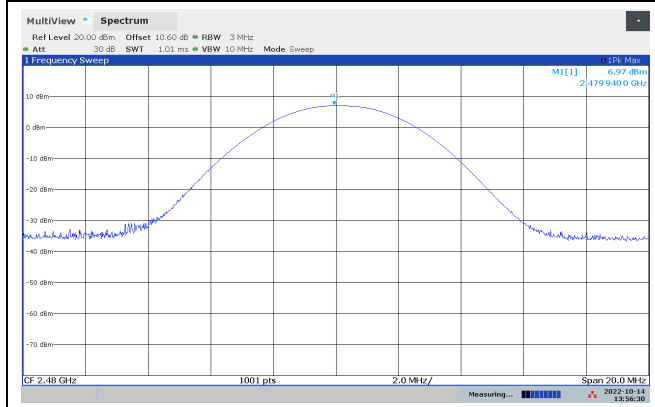
Frequency Band	Requirements for Frequency Hopping systems
2400-2483.5 MHz	For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels: 1 watt For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts
Maximum allowed Antenna Gain	
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.	



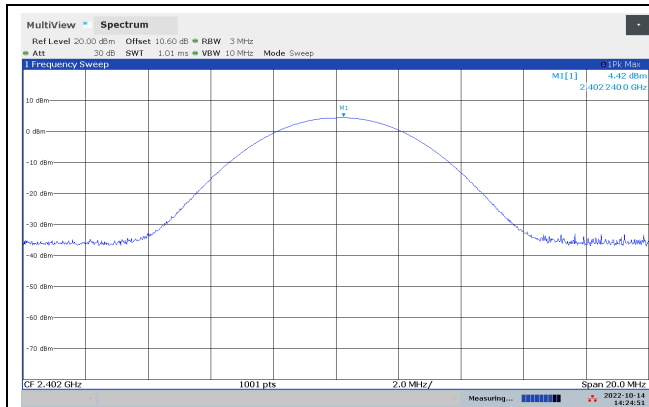
Peak Power, 2402 MHz, GFSK



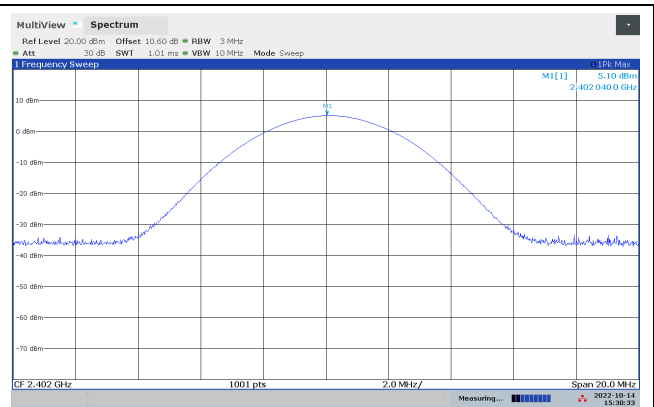
Peak Power, 2441 MHz, GFSK



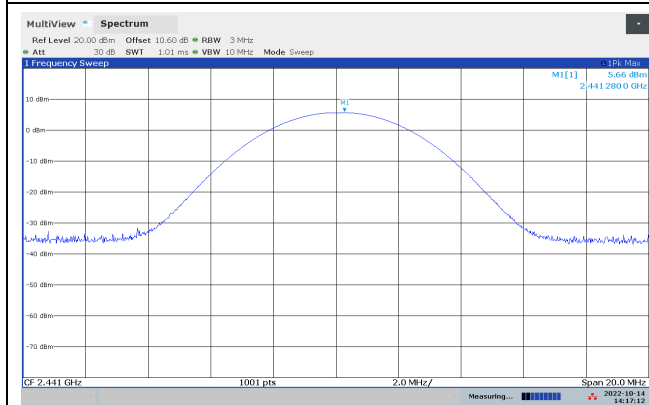
Peak Power, 2480 MHz, GFSK



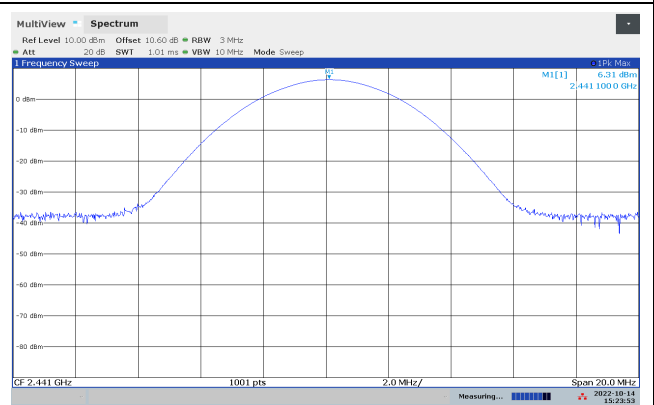
Peak Power, 2402 MHz, $\pi/4$ -DPSK



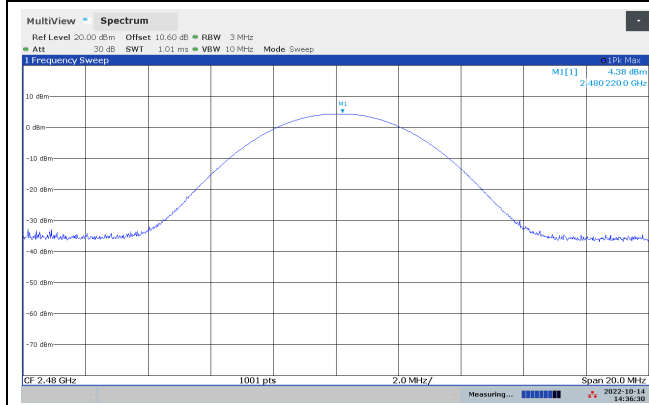
Peak Power, 2402 MHz, 8-DPSK



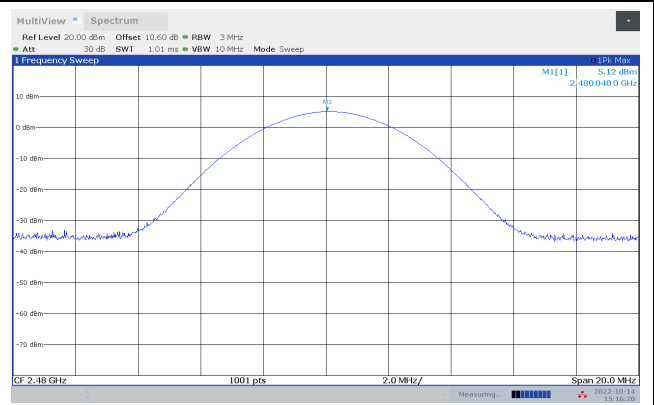
Peak Power, 2441 MHz, $\pi/4$ -DPSK



Peak Power, 2441 MHz, 8-DPSK



Peak Power, 2480 MHz, $\pi/4$ -DPSK



Peak Power, 2480 MHz, 8-DPSK

3.8 Conducted Emissions at Antenna Connector

FCC Part 15.247 (d)

ISED Canada RSS-247 Issue 2, Clause 5.5

Measurement procedure: ANSI C63.10-2013 Clause 11.11

Test Results: Complies

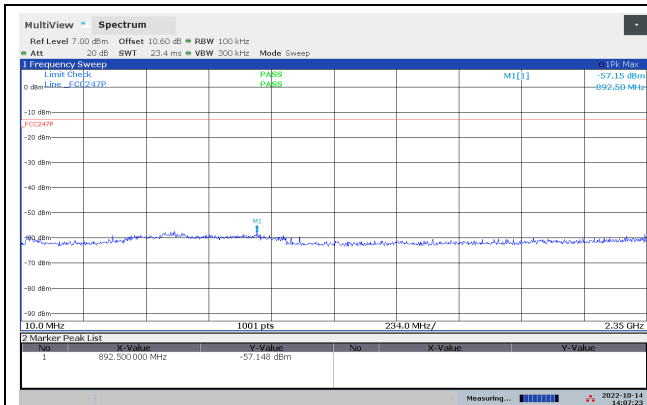
Measurement Data:

Carrier Frequency	Highest Value (dBc)	Margin (dB)	Verdict
2402 MHz	> 50	> 30	Pass
2441 MHz	> 50	> 30	Pass
2480 MHz	> 50	> 30	Pass

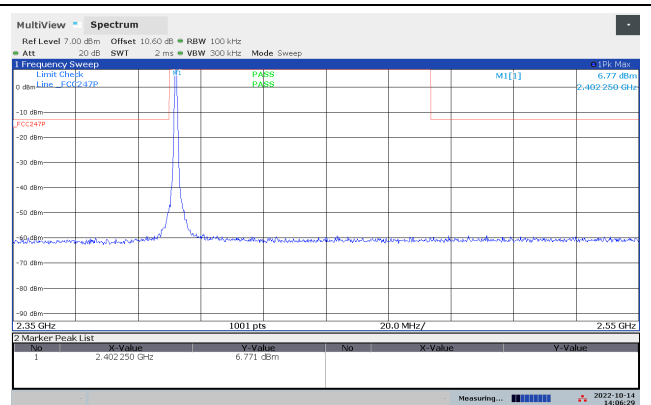
Measured with Peak Detector.

RF conducted power to 25 GHz: see attached plots.

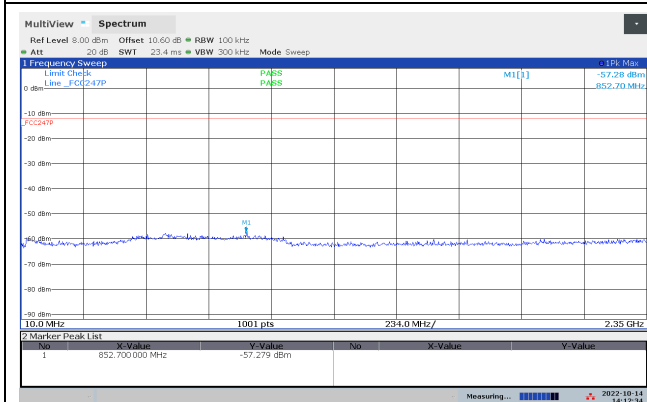
Requirements for all systems	
Peak measurement	RMS averaging (alternative measurement)
20 dB or more below carrier measured in 100 kHz bandwidth	30 dB or more below carrier measured in 100 kHz bandwidth
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required.	



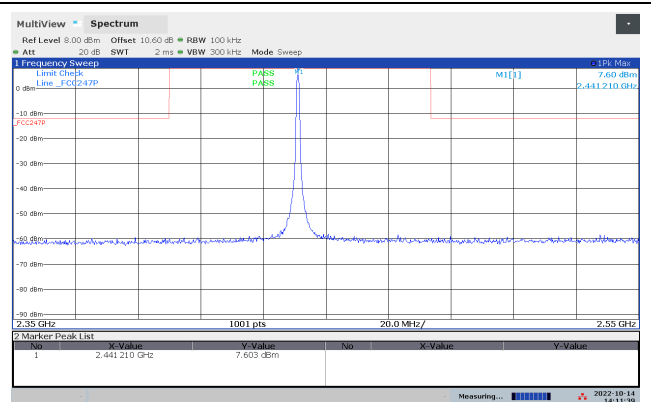
Conducted Emissions 10-2350 MHz, 2402 MHz, GFSK



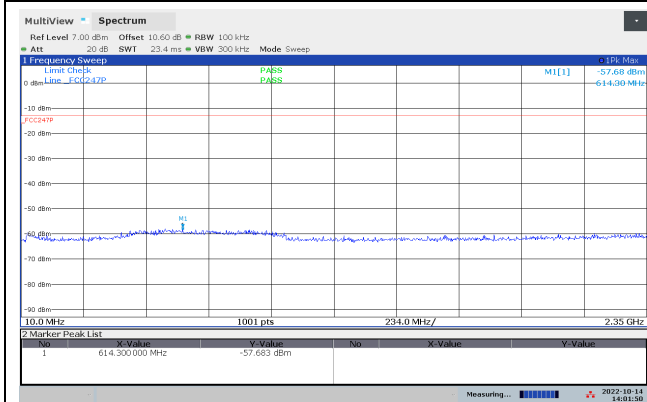
Conducted Emissions 2350-2550 MHz, 2402 MHz, GFSK



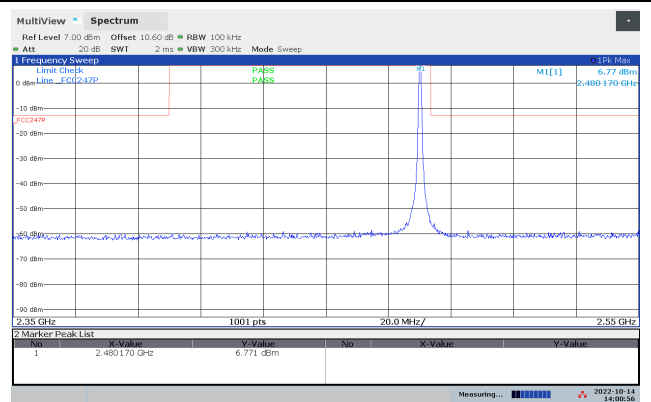
Conducted Emissions 10-2350 MHz, 2441 MHz, GFSK



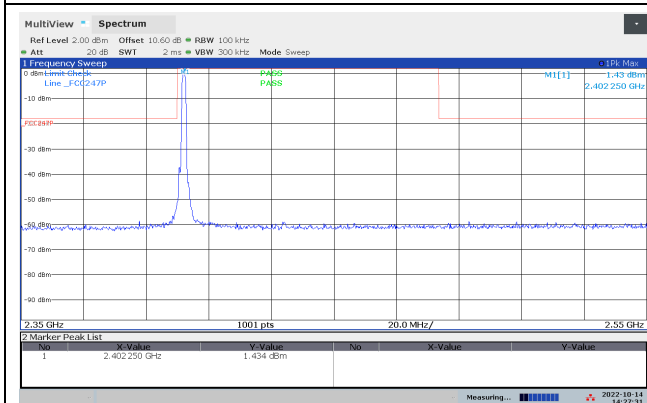
Conducted Emissions 2350-2550 MHz, 2441 MHz, GFSK



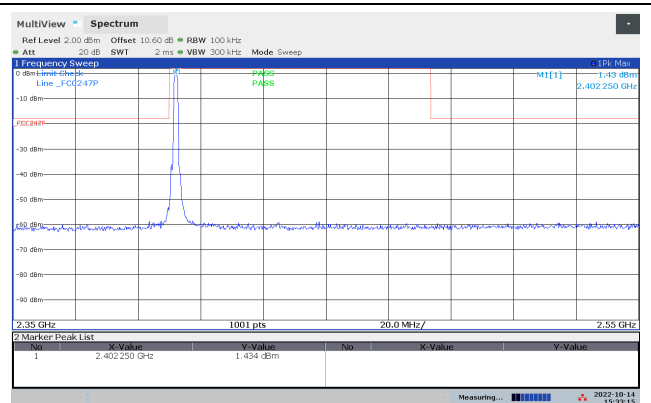
Conducted Emissions 10-2350 MHz, 2480 MHz, GFSK



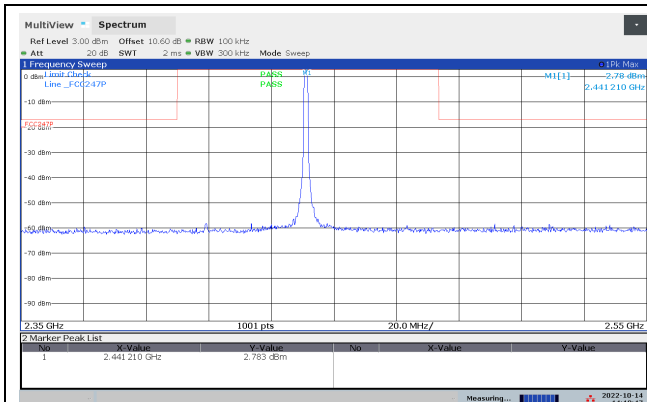
Conducted Emissions 2350-2550 MHz, 2480 MHz, GFSK



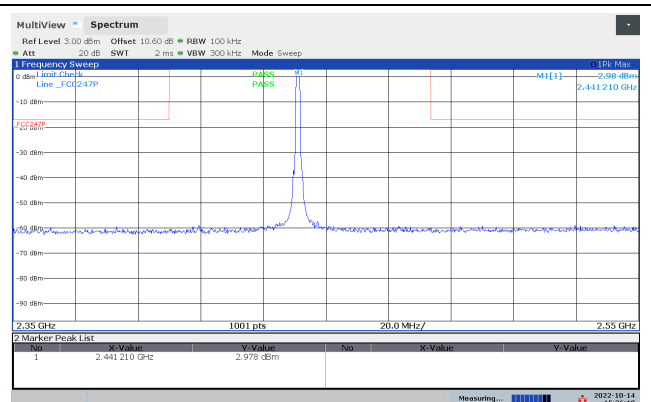
Conducted Emissions 2350-2550 MHz, 2402 MHz, $\pi/4$ -DPSK



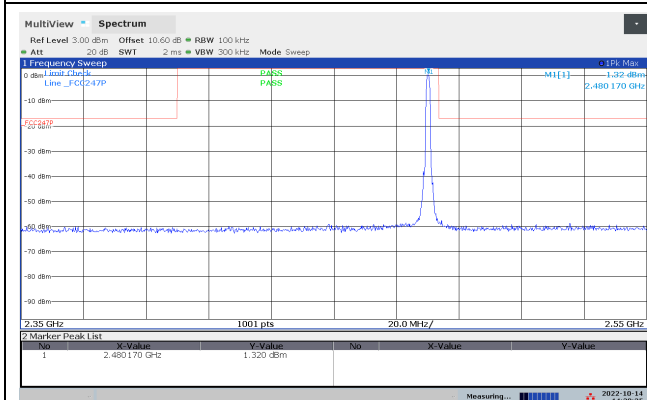
Conducted Emissions 2350-2550 MHz, 2402 MHz, 8-DPSK



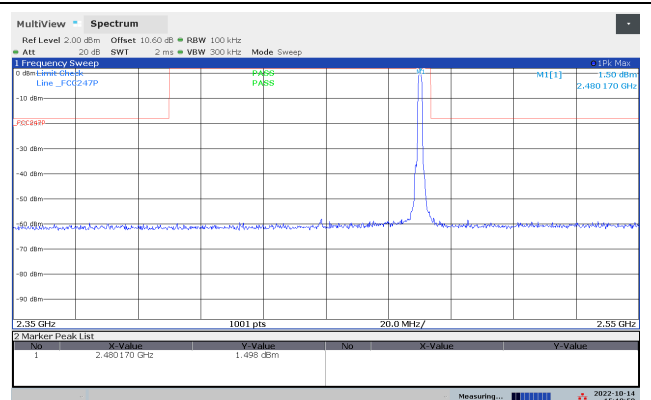
Conducted Emissions 2350-2550 MHz, 2441 MHz, $\pi/4$ -DPSK



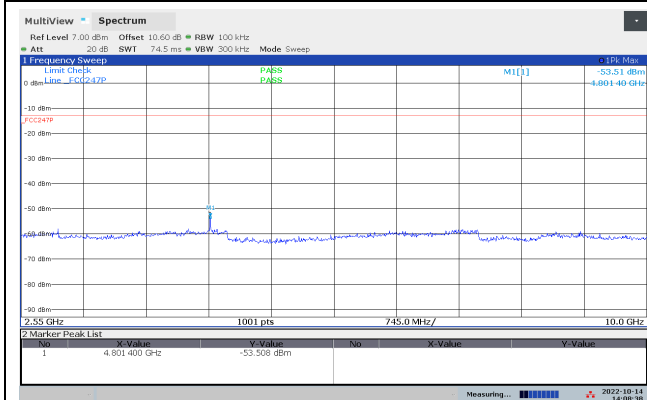
Conducted Emissions 2350-2550 MHz, 2441 MHz, 8-DPSK



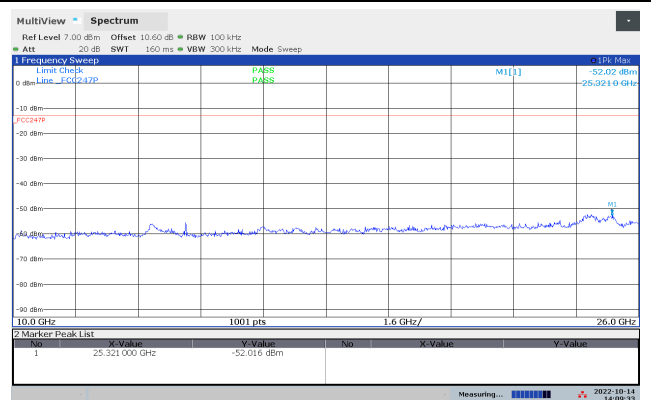
Conducted Emissions 2350-2550 MHz, 2480 MHz, $\pi/4$ -DPSK



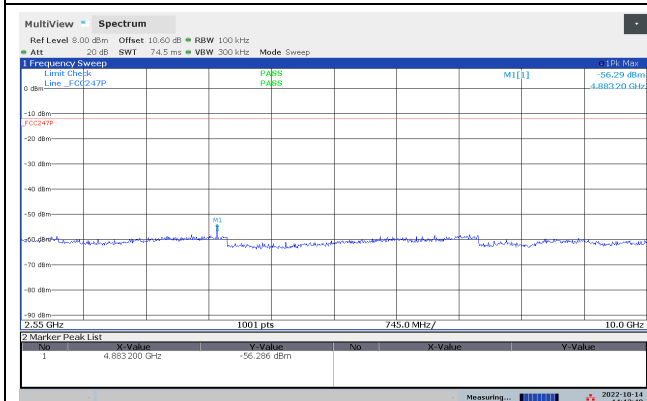
Conducted Emissions 2350-2550 MHz, 2402 MHz, 8-DPSK



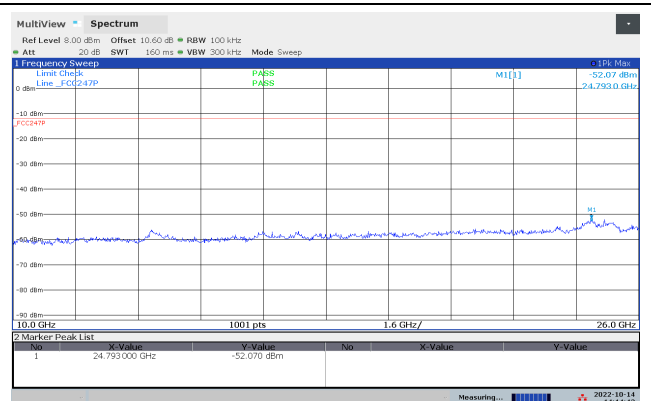
Conducted Emissions 2550-10000 MHz, 2402 MHz, GFSK



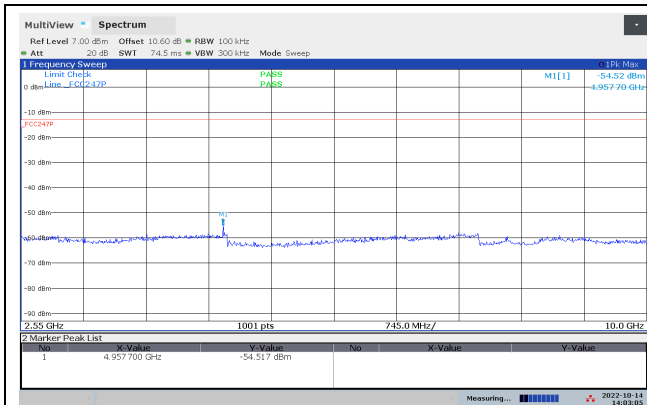
Conducted Emissions 10000-26000 MHz, 2402 MHz, GFSK



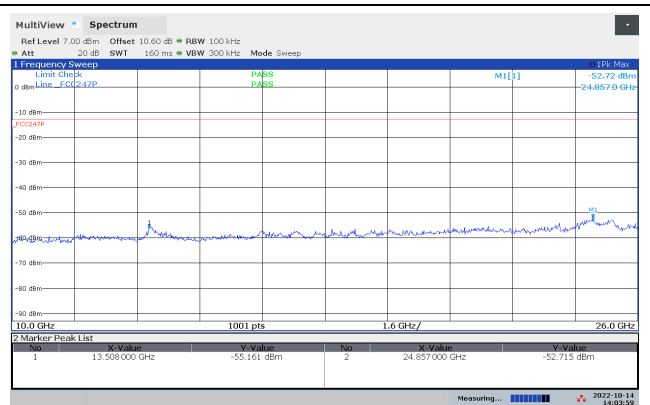
Conducted Emissions 2550-10000 MHz, 2441 MHz, GFSK



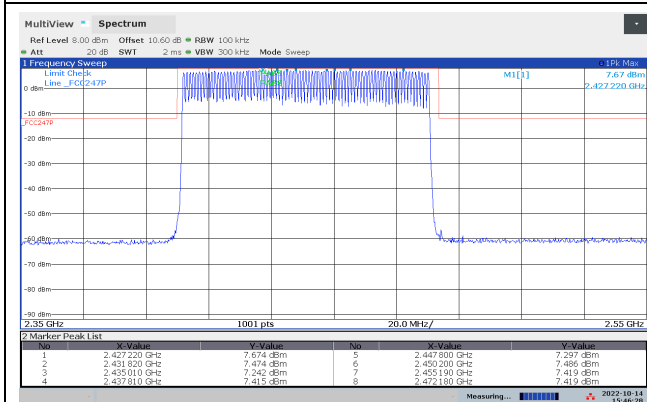
Conducted Emissions 10000-26000 MHz, 2441 MHz, GFSK



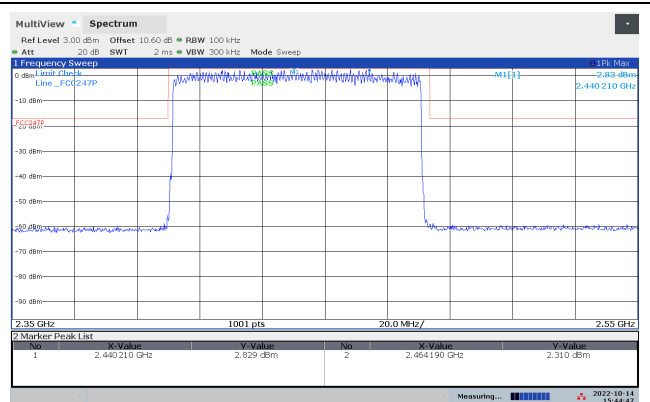
Conducted Emissions 2550-10000 MHz, 2480 MHz, GFSK



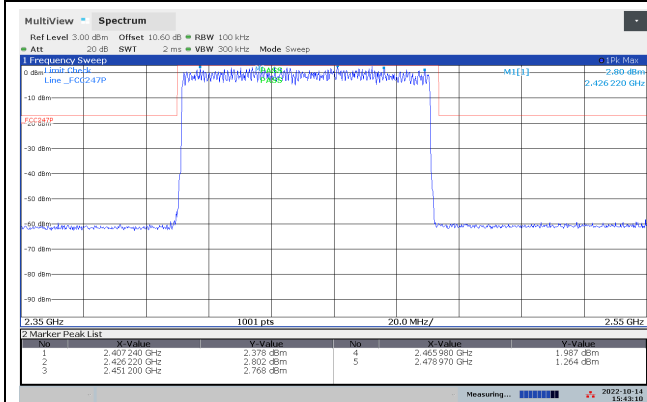
Conducted Emissions 10000-26000 MHz, 2480 MHz, GFSK



Conducted Emissions 2300-2600 MHz, Hopping, GFSK



Conducted Emissions 2300-2600 MHz, Hopping, $\pi/4$ -DPSK



Conducted Emissions 2300-2600 MHz, Hopping, 8-DPSK

3.9 Restricted Bands of operation

Restricted Bands of operation for FCC and ISSED are defined in FCC Part 15.205 and ISSED RSS-GEN, Issue 5 clause 8.10.

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

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

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

3.10 Radiated Emissions, Band Edge

FCC Part 15.209 (a)

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

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Carrier Frequency and Data Rate	Band Edge Frequency	Measured Field Strength (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
		Peak Detector	Average Detector	Peak Det	Average Det	Peak Det	Average Det
2402 MHz GFSK	2390 MHz	56.5	36.5	74	54	17.5	17.5
2402 MHz π/4-DPSK	2390 MHz	54.6	34.6			19.4	19.4
2402 MHz 8-DPSK	2390 MHz	54.3	34.3			19.7	19.7
2480 MHz GFSK	2483.5 MHz	70.9	50.9			3.1	3.1
2480 MHz π/4-DPSK	2483.5 MHz	71.6	51.6			2.4	2.4
2480 MHz 8-DPSK	2483.5 MHz	72.0	52.0			2.0	2.0

Average Detector values are calculated from Peak Values by correcting for Duty Cycle.

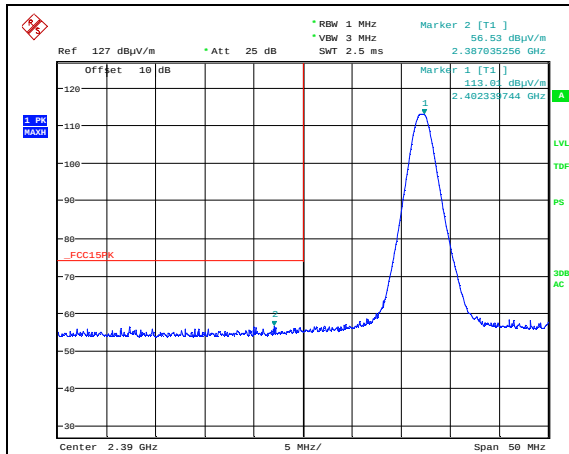
See attached plots.

Duty Cycle Correction Factor Calculation:

Duty Cycle = slot length / frame length

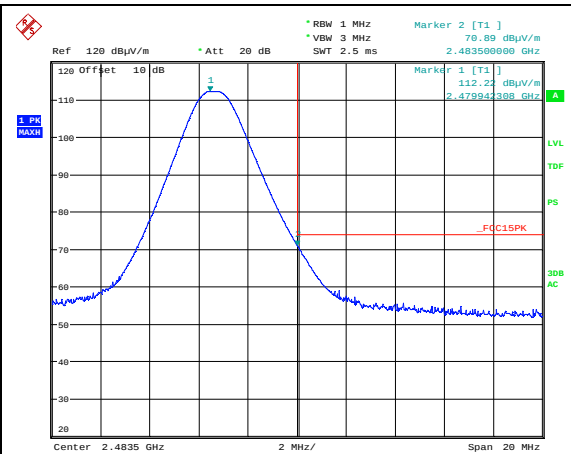
Duty Cycle Correction factor = $-20 \times \log(\text{Duty Cycle}) = 27.5 \text{ dB}$

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



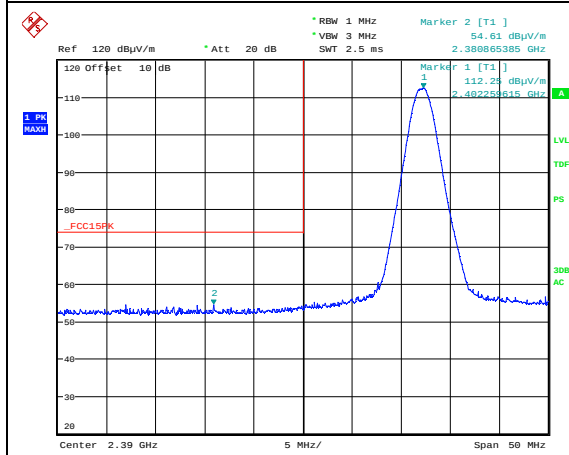
Date: 18.OCT.2022 10:48:29

Lower Band Edge 2402 MHz, GFSK, Peak



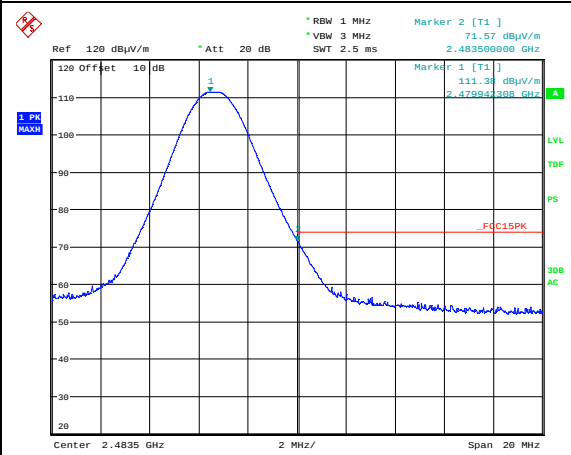
Date: 18.OCT.2022 12:07:23

Upper Band Edge 2480 MHz, GFSK, Peak



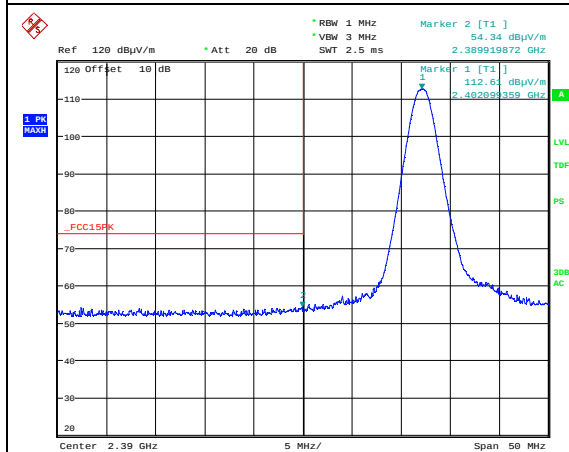
Date: 18.OCT.2022 10:52:49

Lower Band Edge 2402 MHz, $\pi/4$ -DPSK, Peak



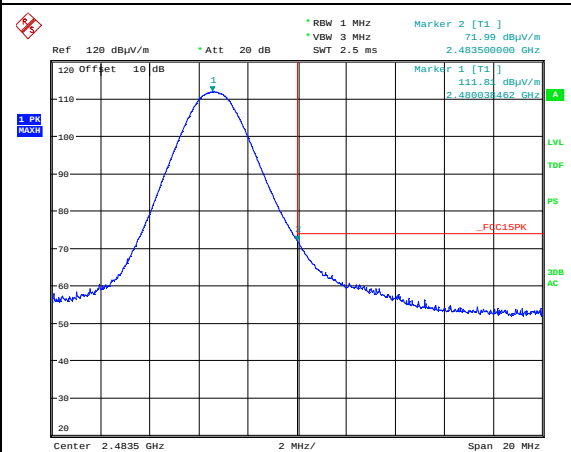
Date: 18.OCT.2022 12:09:39

Upper Band Edge 2480 MHz, $\pi/4$ -DPSK, Peak



Date: 18.OCT.2022 11:00:42

Lower Band Edge 2402 MHz, 8-DPSK, Peak



Date: 18.OCT.2022 12:11:54

Upper Band Edge 2480 MHz, 8-DPSK, Peak

3.11 Radiated Emission, 30 – 1000 MHz.

FCC Part 15.209 (a)

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

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Detector: Peak (Pre-scan)

Measuring distance 3m

Tested in test mode with the transmitter active

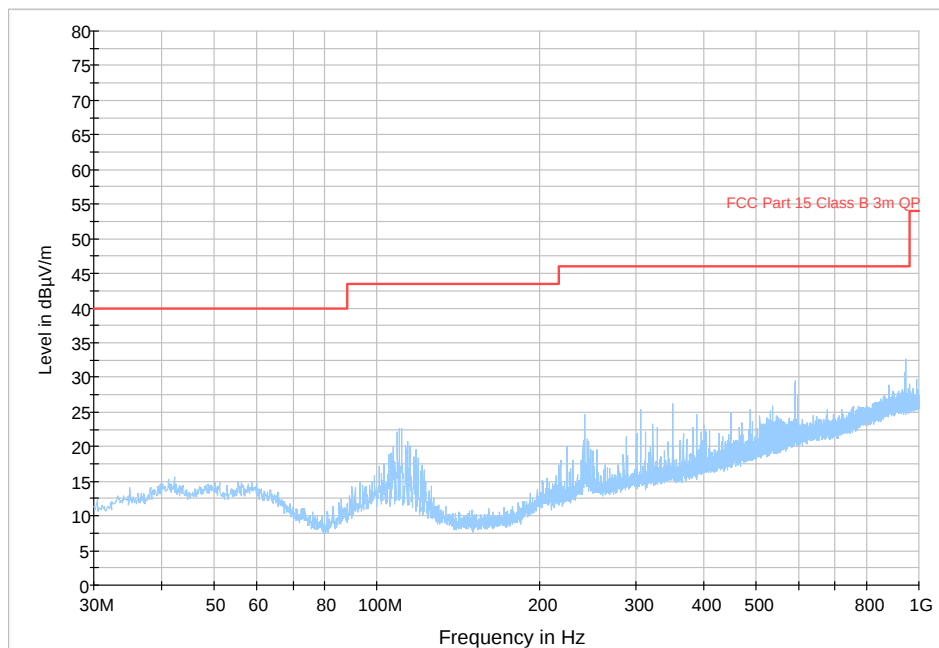
Measured Frequency (MHz)	Carrier Frequency (MHz)	Modulation	Measured Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
30 – 88	2441	GFSK	< 20	40.0	> 20
88 – 216	2441	GFSK	< 23.5	43.5	> 20
216 – 960	2441	GFSK	< 33	46.0	> 13
960 – 1000	2441	GFSK	< 34	54.0	> 20

See attached plots

Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
Frequency	Radiated emission limit @3 meters	
30 – 88 MHz	100 µV/m	40.0 dBµV/m
88 – 216 MHz	150 µV/m	43.5 dBµV/m
216 – 960 MHz	200 µV/m	46.0 dBµV/m
960 – 1000 MHz	500 µV/m	54.0 dBµV/m
Limits above are with Quasi Peak Detector		

Full Spectrum



Radiated Emissions 30 - 1000 MHz, GFSK

3.12 Radiated Emissions, 1-26 GHz

FCC Part 15.209 (a)

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

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Measuring distance: 3m (1 – 18 GHz)

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

Carrier freq. (MHz)	Measured Frequency (GHz)	Modulation	Measured Emission (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Pk	Av	Pk	Av
2402	4804	GFSK	53.0	33.0	74	54	21.0	21.0
	9608	GFSK	57.4	37.4	74	54	16.6	16.6
	14412	GFSK	56.5	36.5	74	54	17.5	17.5
2441	4882	GFSK	51.6	31.6	74	54	22.4	22.4
	9764	GFSK	54.0	34.0	74	54	20.0	20.0
	14646	GFSK	56.1	36.1	74	54	17.9	17.9
2480	4960	GFSK	55.4	35.4	74	54	18.6	18.6
	9920	GFSK	57.9	37.9	74	54	16.2	16.2
	14880	GFSK	58.5	38.5	74	54	15.5	15.5

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

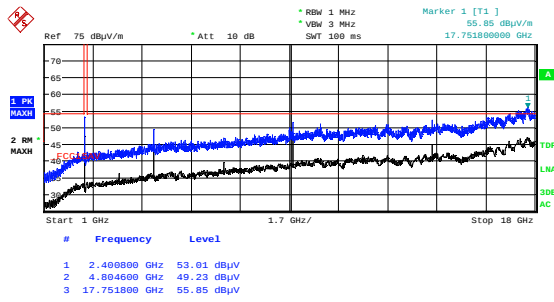
A Band Reject Filter was used for measurements from 1 GHz to 18 GHz

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

See plots.

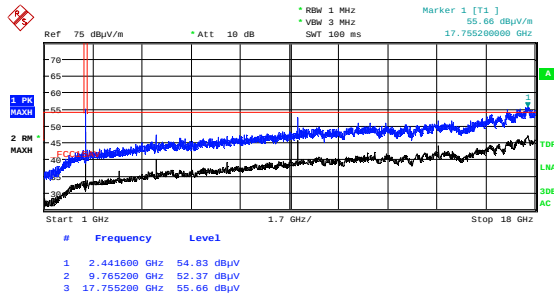
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency	Average Detector	Peak Detector
1 – 26 GHz	54.0 dBµV/m	74.0 dBµV/m



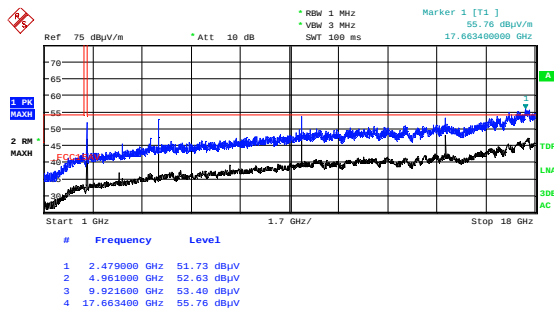
Date: 18.OCT.2022 13:26:22

Radiated Emissions 1 - 18 GHz, 2402 MHz, GFSK, HP



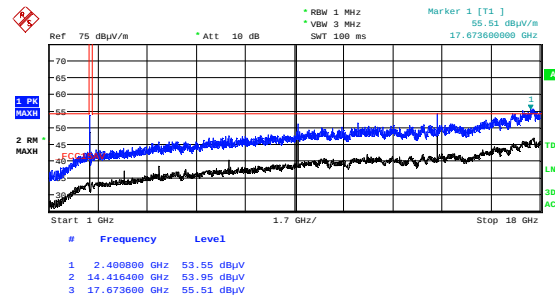
Date: 18.OCT.2022 13:16:59

Radiated Emissions 1 - 18 GHz, 2441 MHz, GFSK, HP



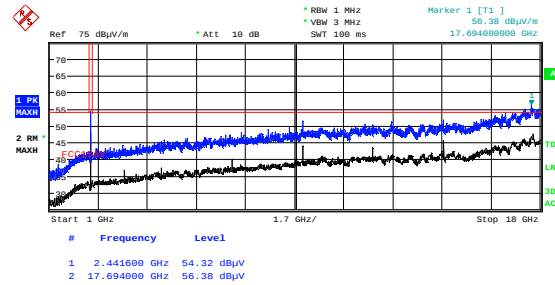
Date: 18.OCT.2022 13:33:25

Radiated Emissions 1 - 18 GHz, 2480 MHz, GFSK, HP



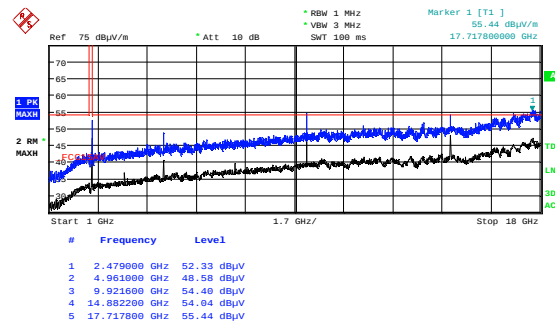
Date: 18.OCT.2022 13:24:26

VP



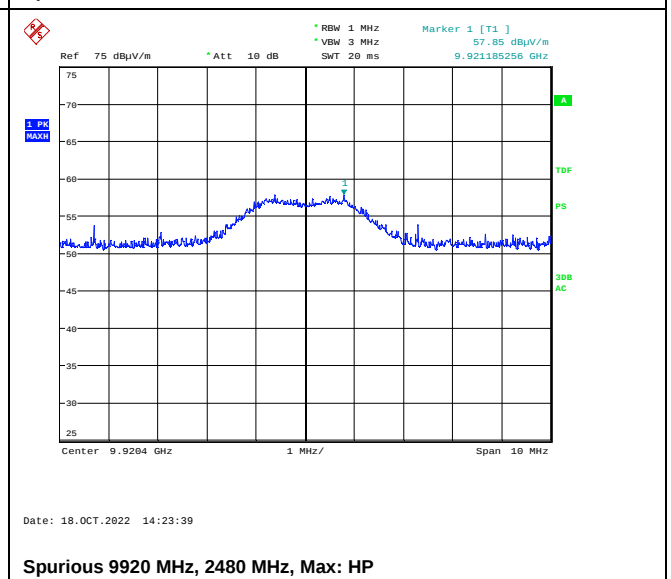
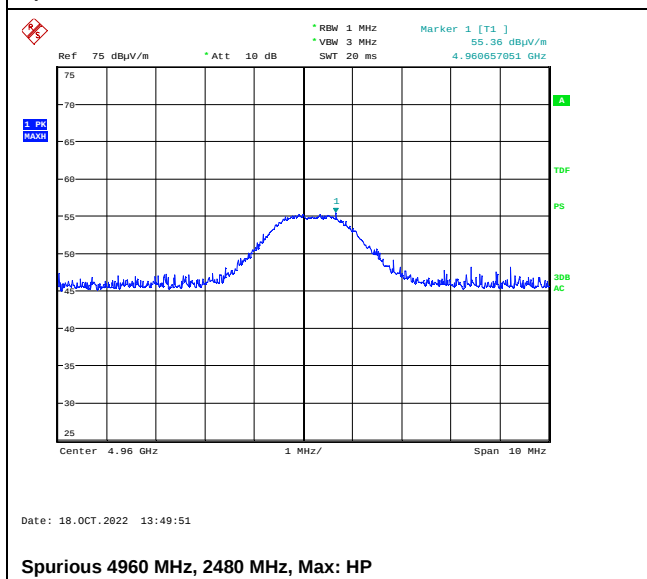
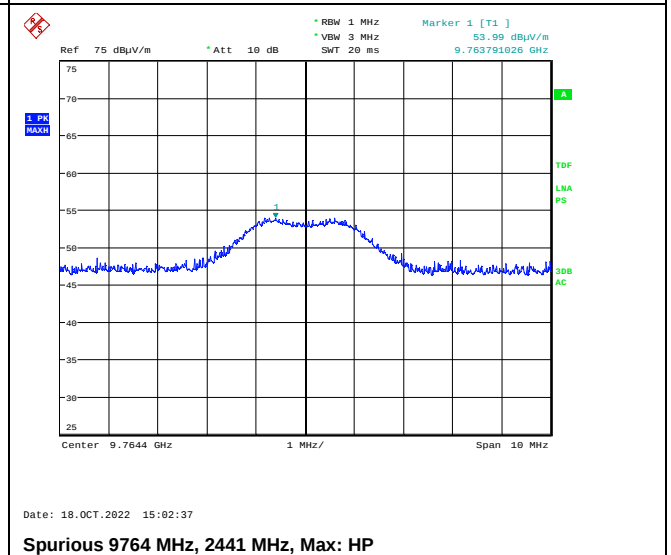
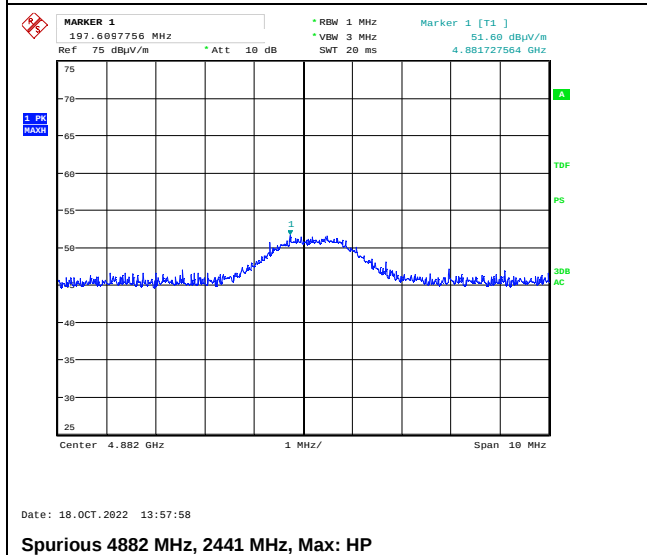
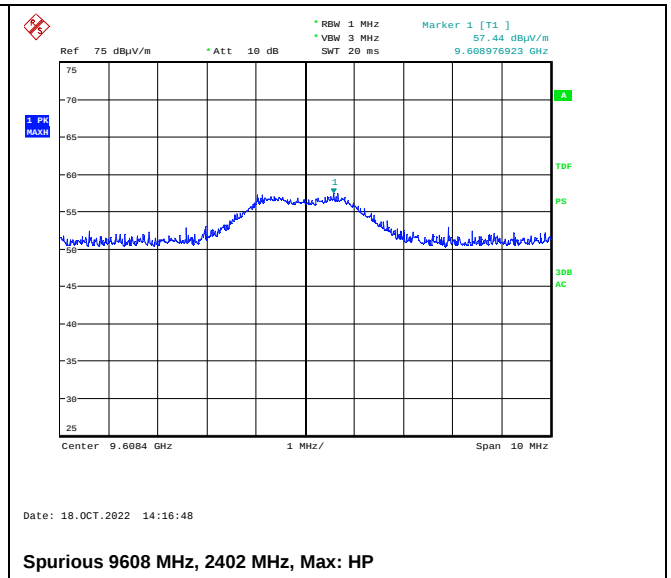
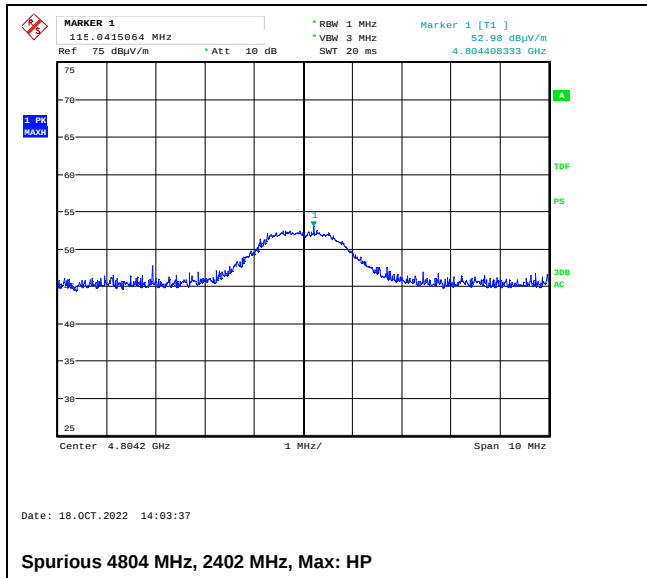
Date: 18.OCT.2022 13:15:03

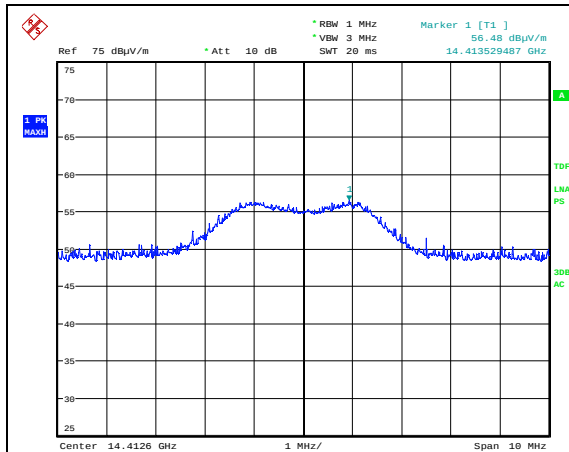
VP



Date: 18.OCT.2022 13:31:28

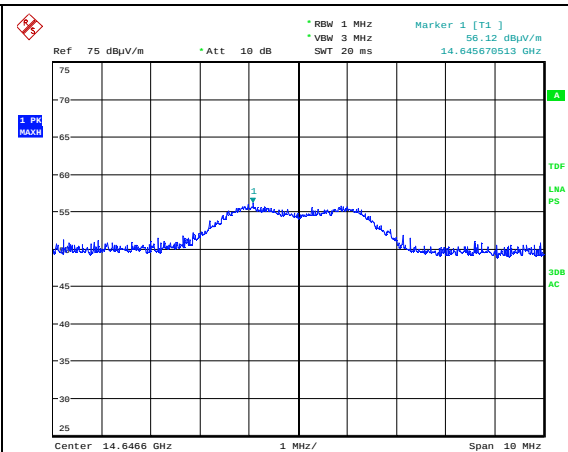
VP





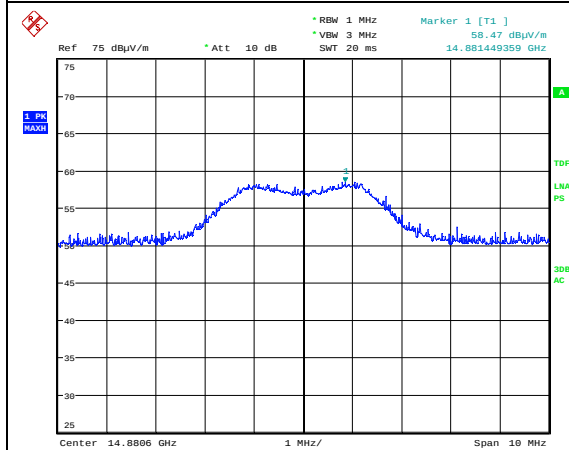
Date: 18.OCT.2022 14:43:32

Spurious 14412 MHz, 2402 MHz, Max: HP



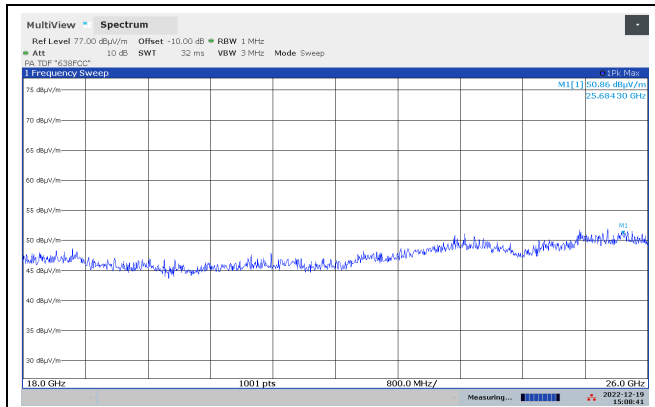
Date: 18.OCT.2022 14:55:22

Spurious 14646 MHz, 2441 MHz, Max: HP

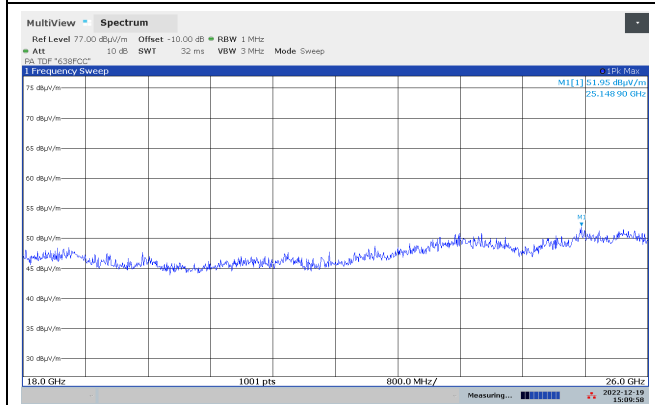


Date: 18.OCT.2022 14:36:44

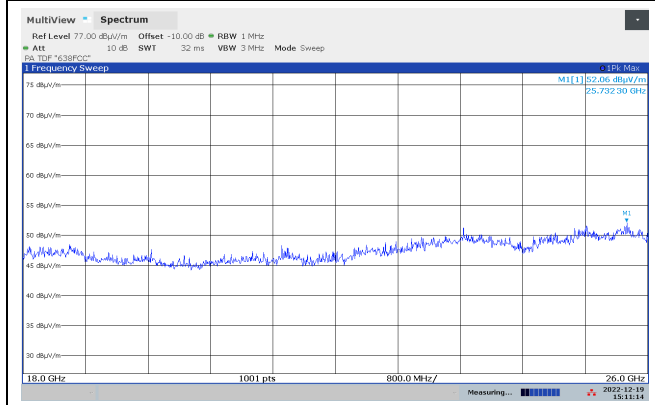
Spurious 14880 MHz, 2480 MHz, Max: HP



Pre-scan 18 - 26 GHz, 2441 MHz, GFSK, @10cm



Pre-scan 18 - 26 GHz, 2441 MHz, $\pi/4$ -DQPSK, @10cm



Pre-scan 18 - 26 GHz, 2441 MHz, 8-DPSK, @10cm

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.

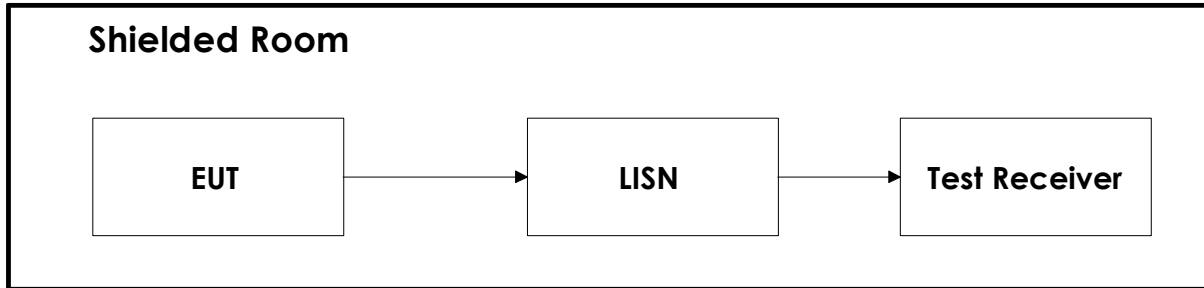
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	FSW43	Spectrum Analyzer	Rohde & Schwarz	LR 1690	2022-01	2023-01
2	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2022-01	2023-01
3	6810.17B	Attenuator	Suhner	LR 1669	2019-07	2020-07
4	NO324415	Band Reject Filter (2.4 GHz)	Microwave Circuits	LR 1760	COU	
5	VULB 9163	BiLog Antenna	Schwarzbech	LR 1616	2021-05	2024-05
6	317	Pre-amplifier	Sonoma Inst.	LR 1687	2022-08	2023-08
7	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2022-08	2023-08
8	L01G18G1	LowPass Filter (1 GHz)	Microwave Circuits	LR 1768	COU	
9	8449B	Pre-amplifier	Hewlett Packard	LR 1322	2022-08	2023-08
10	638	Antenna Horn	Narda	LR 1480	N/A	
11	6812B	AC Power Source	Agilent	LR 1515	2022-11	2024-11
12	Model 87V	Multimeter	Fluke	LR 1600	2022-03	2024-03
13	ESC13	Measuring Receiver	Rohde & Schwarz	N-4259	2021-10	2023-10
14	ENV216	Two Line V-Network	Rohde & Schwarz	LR 1665	2021-12	2023-12
15	ST18/SMA/N/36	RF Cable	Suhner	LR 1627	COU	

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

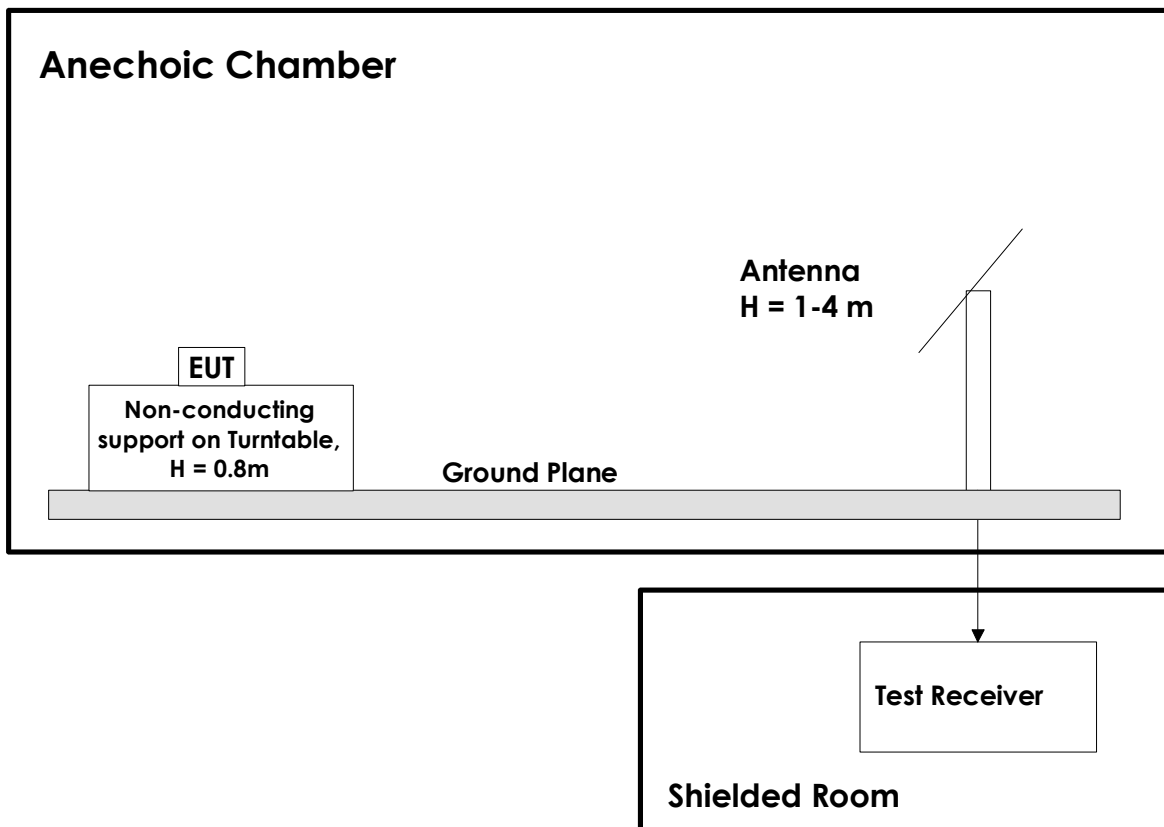
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	EMC32	10.50.40	EMC test software
2	Nemko AS	RSPlot	1.0.8.0	Screen capture from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



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