

Test Report

Product	Industrial Powerline Sensor		
Name and address of the applicant	Heimdall Power AS St Olavs gate 28 0166 Oslo, Norway		
Name and address of the manufacturer	Heimdall Power AS St Olavs gate 28 0166 Oslo, Norway		
Model	Neuron V4		
Rating	450 kV, 3 kA Continuous, 100 kA pulse		
Trademark	Heimdall		
Additional information	LoRa		
Tested according to	Parts of FCC Part 15.247 Digital Transmission Systems / Frequency Hopping Spread Spectrum Parts of 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	466845		
Tested in period	2022-08-11 and 2023-05-02		
Issue date	2023-05-02		
Name and address of the testing laboratory	<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;">  Instituttveien 6 Kjeller, Norway www.nemko.com </div> <div style="text-align: center;"> CAB Number: FCC: NO0001 ISED: NO0470 </div> <div style="text-align: center;">   </div> </div> <p style="text-align: center; color: red; font-weight: bold;">An accredited technical test executed under the Norwegian accreditation scheme</p>		
	 Prepared by [Frode Sveisen]	 Approved by [G.Suhanthakumar]	
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Revision history

Revision	Date	Comment	Sign
00	2023-05-02	First edition	FS



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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1 INFORMATION

1.1 Specifications

Name	Heimdall
Model/version	Neuron v4
FCC ID	2A9LZ-HPNV4
Serial number	A-10
Hardware identity and/or version	Neuron v4 revD
Software identity and/or version	V1.6.1
Frequency Range	125kHz: 902.3 – 914.9 MHz 500kHz: 903 – 914.2 MHz
Number of Channels	125kHz: 64 channels 500kHz: 8 channels
Operating Modes	125kHz / 500kHz Mode
Type of Modulation	LoRa
Antenna Connector	None
Number of Antennas	1
Power Supply	Secondary Battery (3.7 V Li-Ion, 9800 mAh)

Description of Test Item

The EUT is an industrial sensor for monitoring high voltage power lines.

The EUT uses a certified LoRa module from Murata.

This report covers only radiated emissions and field strength of fundamental to cover operation with a different antenna, all other tests are covered by report for the module.

Module Manufacturer	Model No.	FCC ID	IC ID
Murata Manufacturing Co., Ltd.	CMWX1ZZABZ	VPYCMABZ	772C-CMABZ

1.2 Normal test condition

Temperature:	20 - 24 °C
Relative humidity:	20 - 50 %
Normal test voltage:	3.7 V DC

The values are the limit registered during the test period.

1.3 Test Engineer(s)

Frode Sveinsen

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO
If detachable, is the antenna connector(s) non-standard?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
The tested equipment has only integral antennas. Conducted tests were performed with a temporary antenna connector.		

Requirement: FCC 15.203, 15.204

1.5 EUT Operating Modes

Operating modes	Frequency Hopping 125 kHz and 500 kHz Bandwidth
Additional information	The EUT was tested with Continuous TX during all tests. Test were performed with the EUT transmitting in 125 kHz and 500 kHz mode. All tests were performed with Spreiding Factor SF=10 for 125 kHz and SF=12 for 500 kHz.

1.6 Comments

This report covers only radiated emissions and field strength of fundamental.

The EUT uses the LoRa technology.

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 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 ISED.

<input checked="" type="checkbox"/> New Submission	<input checked="" type="checkbox"/> Production Unit
<input type="checkbox"/> Class II Permissive Change	<input type="checkbox"/> Pre-production Unit
DTS Equipment Code	<input type="checkbox"/> 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
Occupied Bandwidth (99% BW)	N/A	6.7 (RSS-GEN)	6.9.3	Complies
Peak Field Strength of fundamental	15.247(b)	5.4 (RSS-247)	11.9.1.1	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

For all other tests see SGS-CSTC test report no. SHEM160900621801.

3 TEST RESULTS

3.1 Maximum Field Strength of Fundamental

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:

Bandwidth	Carrier Frequency	Field Strength (dB μ V/m)	Maximum ERP (mW)
125 kHz	902.3 MHz	98.9	1.43
	908.5 MHz	99.5	1.62
	914.9 MHz	99.8	1.74
500 kHz	903.0 MHz	99.0	1.46
	907.8 MHz	99.4	1.61
	914.2 MHz	99.8	1.74

Measurements were performed with Peak Detector.

Radiated Power was calculated from measured Field Strength using the method described in FCC KDB 412172 D01.

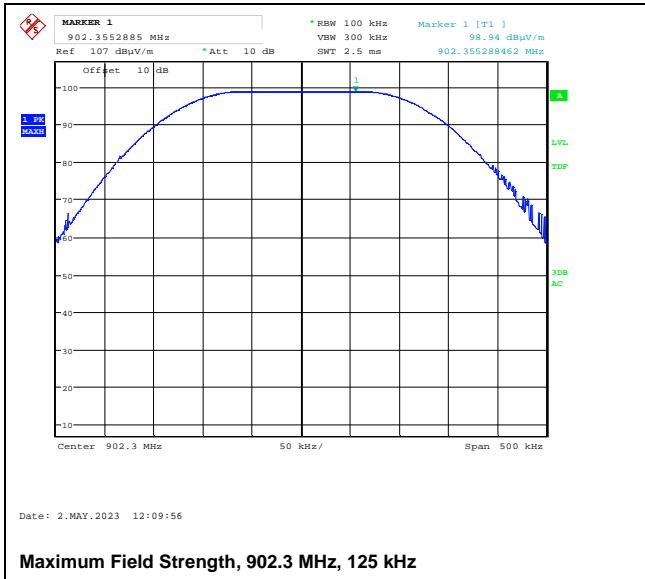
See attached plots.

Requirements:

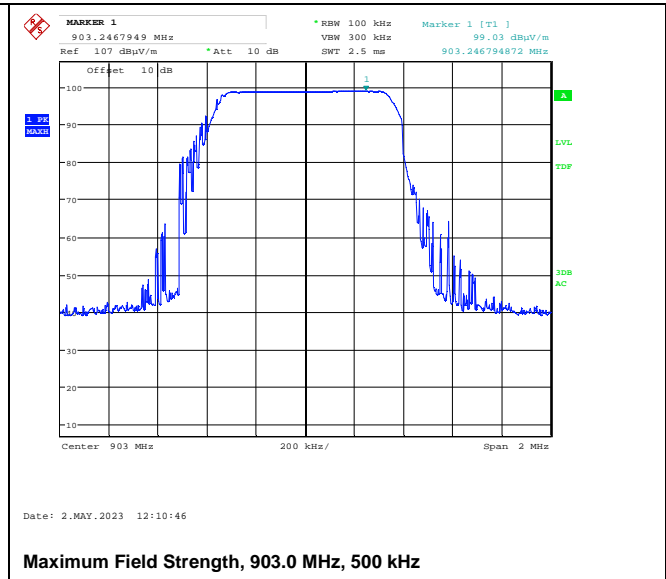
The maximum peak output power shall not exceed the following limits:

For frequency hopping systems employing at least 50 hopping channels: 1 Watt

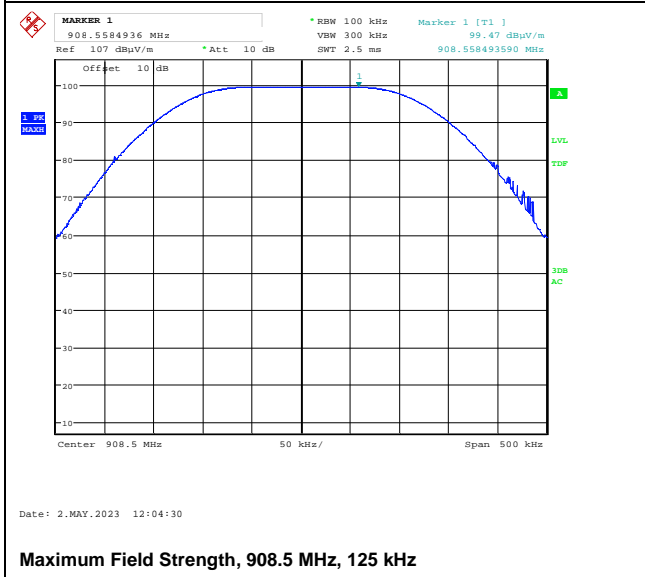
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



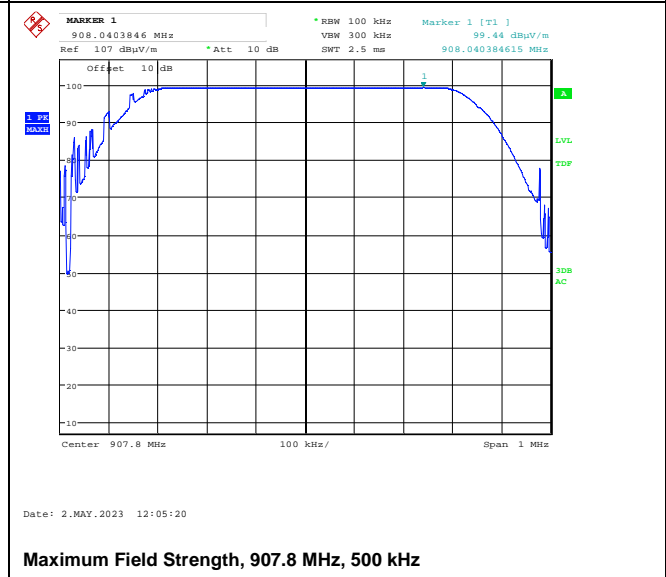
Maximum Field Strength, 902.3 MHz, 125 kHz



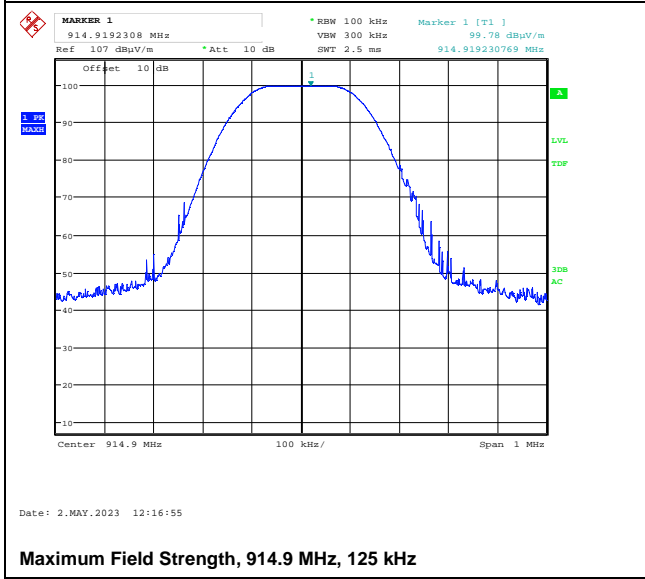
Maximum Field Strength, 903.0 MHz, 500 kHz



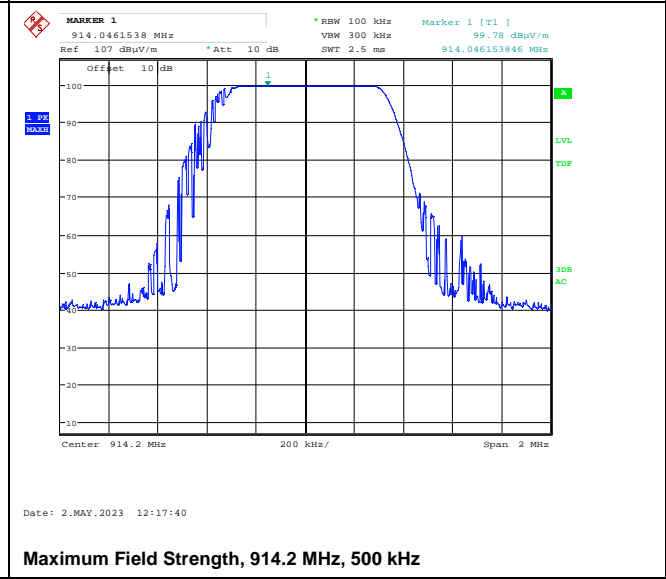
Maximum Field Strength, 908.5 MHz, 125 kHz



Maximum Field Strength, 907.8 MHz, 500 kHz



Maximum Field Strength, 914.9 MHz, 125 kHz



Maximum Field Strength, 914.2 MHz, 500 kHz

3.2 Restricted Bands of operation

Restricted Bands of operation for FCC and ISED are defined in FCC Part 15.205 and ISED 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 ISED, all other frequencies are common.

3.4 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 (found frequencies were measured with Quasi-Peak Detector)

Measuring distance 3 m

Tested in speech mode with active connection

Measured Frequency (MHz)	Carrier Frequency (MHz)	Measured Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
72.02	Any	27.0	40.0	13.0
120.02	Any	23.7	43.5	19.8
30 – 88	Any	< 30	40.0	> 10
88 – 216	Any	< 30	43.5	> 13
216 – 960	Any	< 40	46.0	> 6
960 – 1000	Any	< 40	54.0	> 14

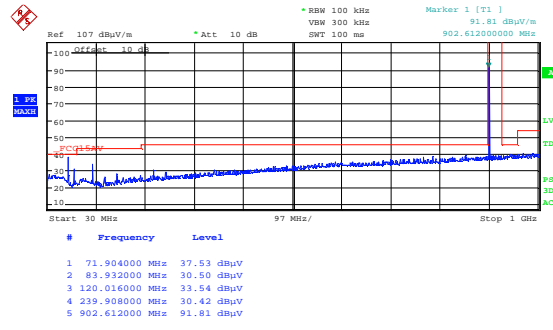
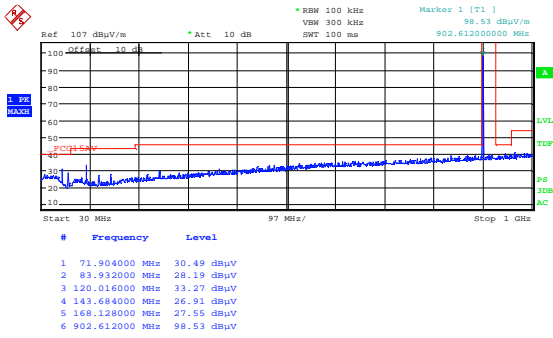
See attached plots.

Measurements were performed with a 10 dB attenuator before the Pre-Amp.

No filters were used for this measurement.

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 μ V/m	40.0 dB μ V/m
88 – 216 MHz	150 μ V/m	43.5 dB μ V/m
216 – 960 MHz	200 μ V/m	46.0 dB μ V/m
960 – 1000 MHz	500 μ V/m	54.0 dB μ V/m
Limits above are with Quasi Peak Detector		

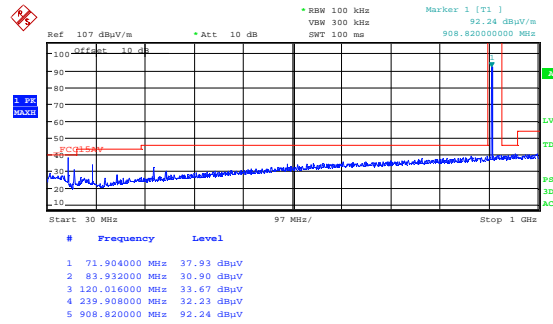
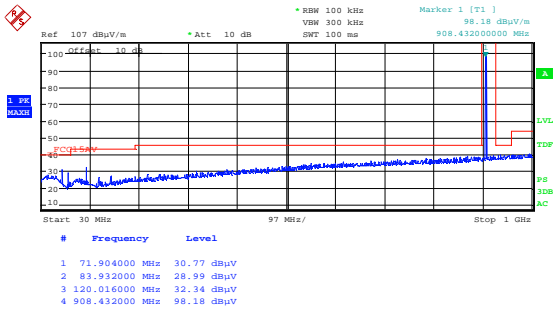


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Date: 2.MAY.2023 10:39:30

Radiated Emissions 30 - 1000 MHz, 902.3 MHz, 125 kHz, HP

VP

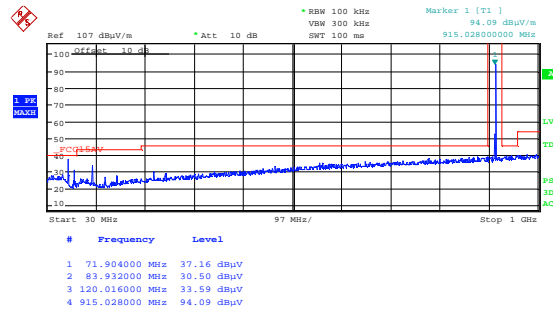
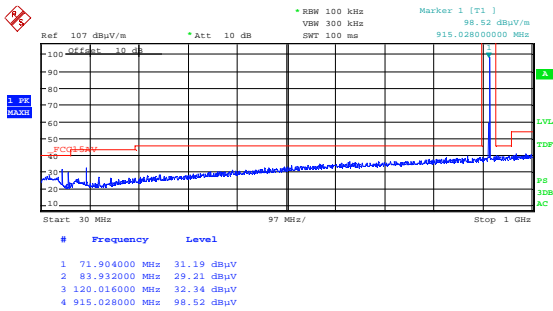


Date: 2.MAY.2023 11:53:24

Date: 2.MAY.2023 11:51:28

Radiated Emissions 30 - 1000 MHz, 908.5 MHz, 125 kHz, HP

VP

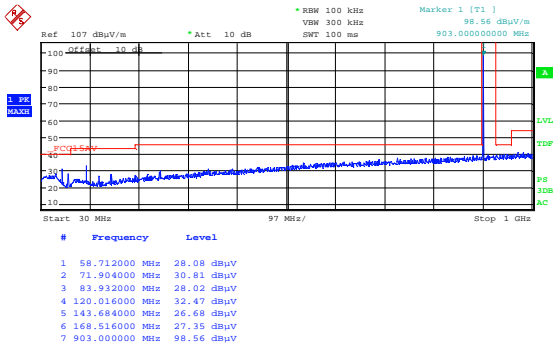


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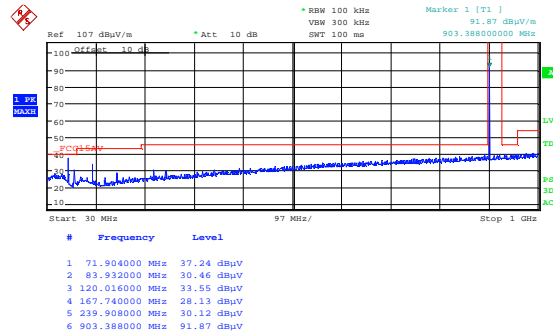
Radiated Emissions 30 - 1000 MHz, 914.9 MHz, 125 kHz, HP

VP



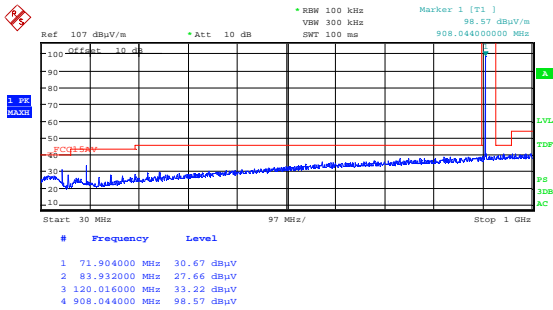
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Radiated Emissions 30 - 1000 MHz, 903.0 MHz, 500 kHz, HP



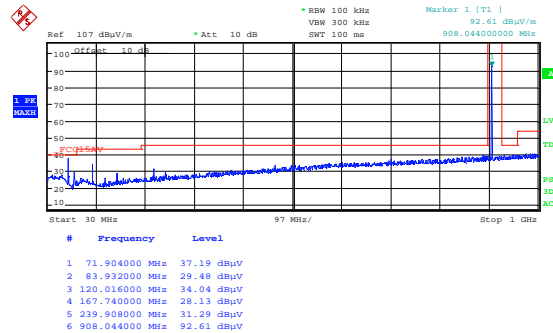
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VP



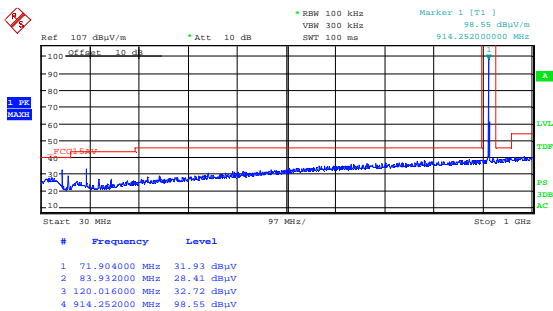
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Radiated Emissions 30 - 1000 MHz, 907.8 MHz, 500 kHz, HP



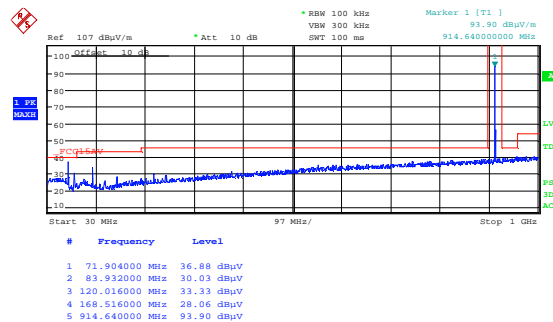
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VP



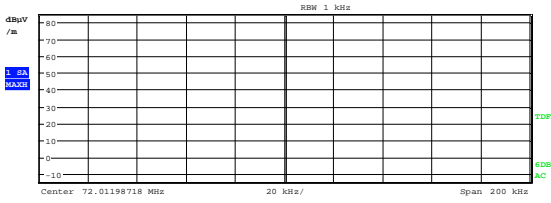
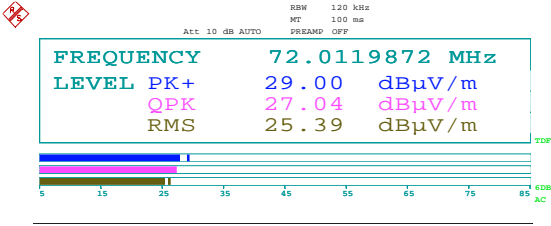
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Radiated Emissions 30 - 1000 MHz, 914.2 MHz, 500 kHz, HP



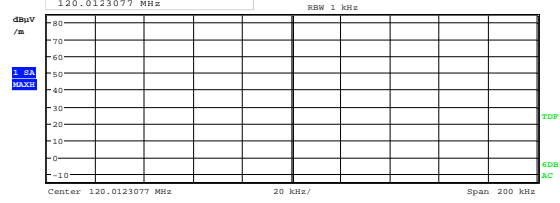
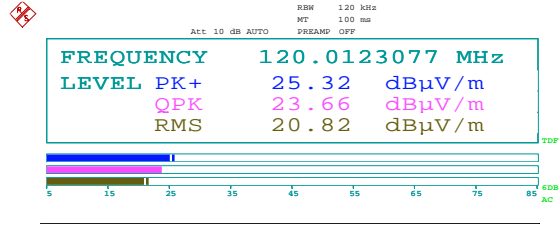
Date: 2.MAY.2023 10:07:00

VP



Date: 2.MAY.2023 11:02:43

Radiated Emissions 72.02 MHz, Any Freq/BW, Max: VP



Date: 2.MAY.2023 11:14:40

Radiated Emissions 120.02 MHz, Any Freq/BW, Max: VP

3.5 Radiated Emissions, 1-10 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 – 10 GHz)

RBW/VBW = 1 MHz / 3 MHz

Bandwidth (kHz)	Carrier Freq. (MHz)	Spurious Freq. (MHz)	Measured Emission (dB μ V/m)		Limit (dB μ V/m)		Margin (dB)	
			Peak	Average	Pk	Av	Pk	Av
125	902.3	7218.4	57.4	53.9	74	54	16.6	0.1
	908.5	7268.0	56.6	52.6	74	54	17.4	1.4
	914.9	7319.2	55.6	51.2	74	54	18.4	2.8
500	903.0	7224.2	56.8	53.6	74	54	17.2	0.4
	907.8	7264.4	56.6	52.8	74	54	17.4	1.2
	914.2	7313.6	55.6	51.1	74	54	18.4	2.9

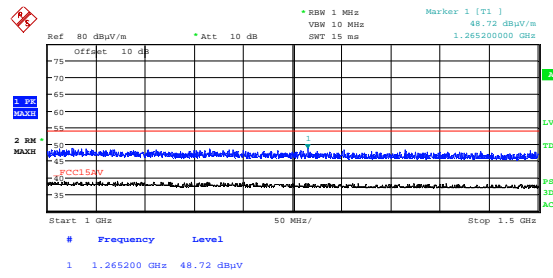
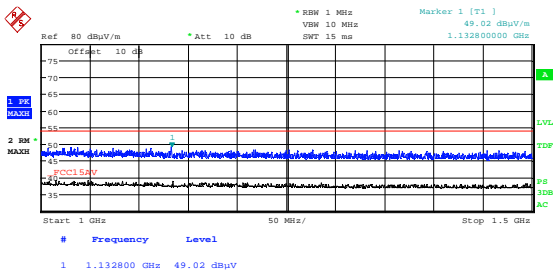
A High Pass Filter was used for measurements from 1.5 GHz to 10 GHz.

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 – 10 GHz	54.0 dB μ V/m	74.0 dB μ V/m

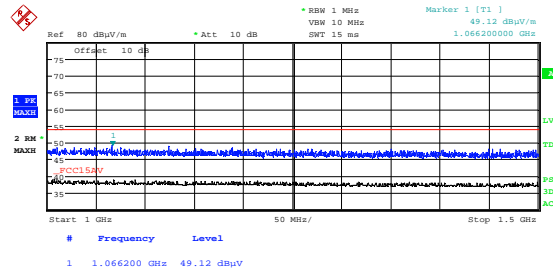
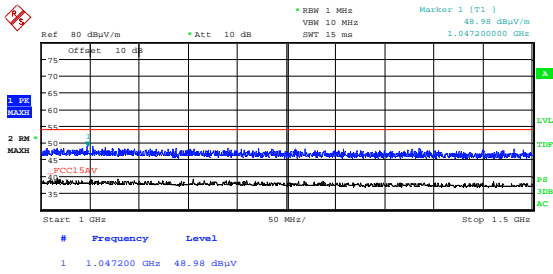


Date: 2.MAY.2023 13:57:35

Radiated Emissions 1000 – 1500 MHz, 908.5 MHz, 125 KHz, HP

Date: 2.MAY.2023 13:55:39

VP

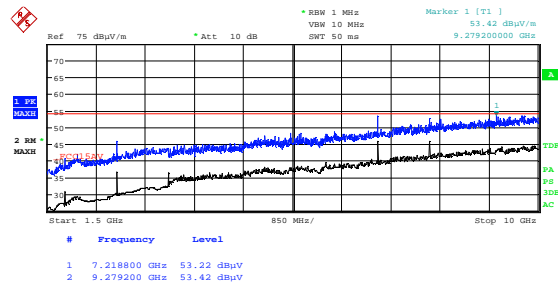
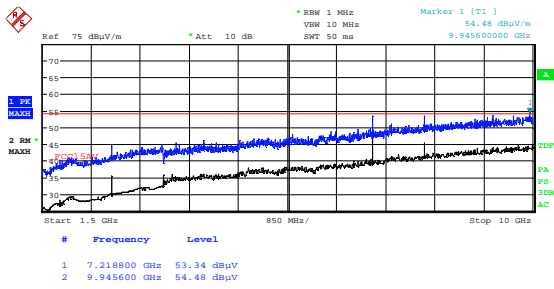


Date: 2.MAY.2023 13:52:23

Radiated Emissions 1000 – 1500 MHz, 907.8 MHz, 500 KHz, HP

Date: 2.MAY.2023 13:50:27

VP

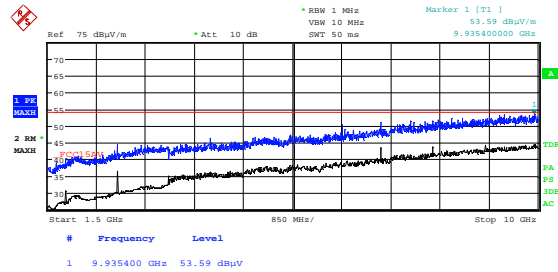
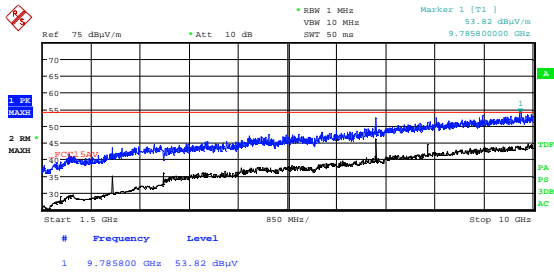


Date: 2.MAY.2023 12:37:43

Date: 2.MAY.2023 12:35:46

Radiated Emissions 1500 - 10000 MHz, 902.3 MHz, 125 kHz, HP

VP

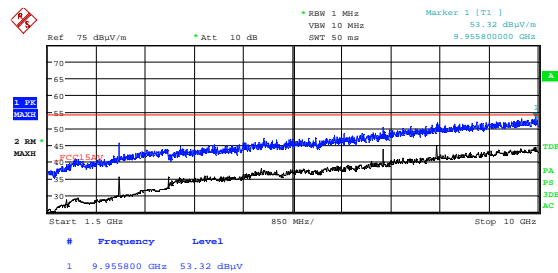
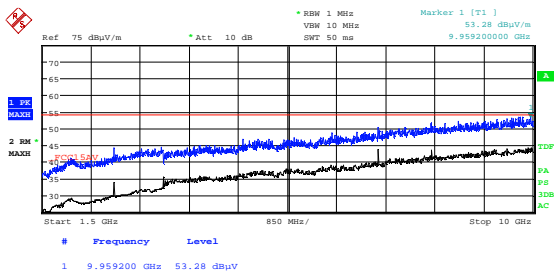


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Radiated Emissions 1500 - 10000 MHz, 908.5 MHz, 125 kHz, HP

VP

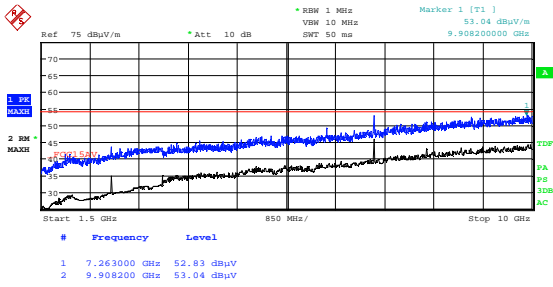


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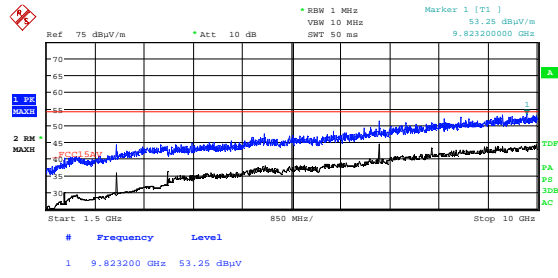
Radiated Emissions 1500 - 10000 MHz, 914.9 MHz, 125 kHz, HP

VP



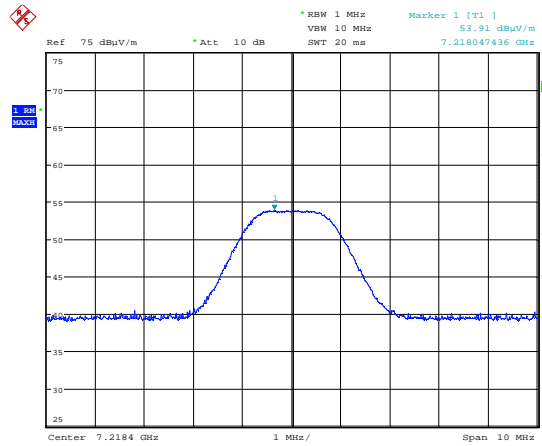
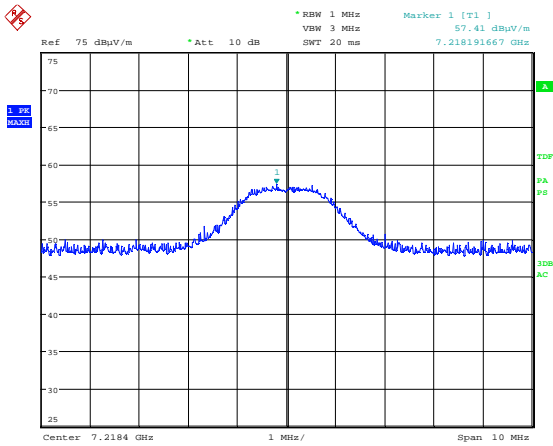
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Radiated Emissions 1500 - 10000 MHz, 907.8 MHz, 500 kHz, HP



Date: 2.MAY.2023 13:41:00

VP

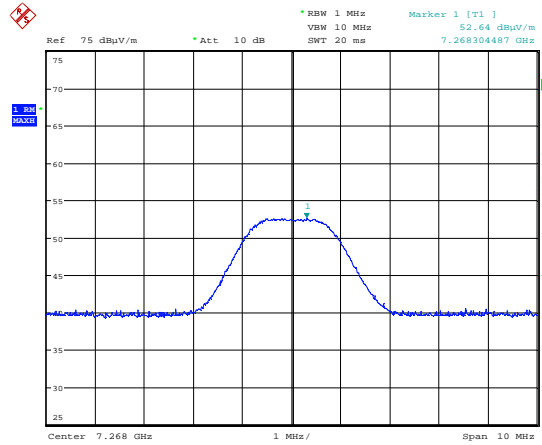
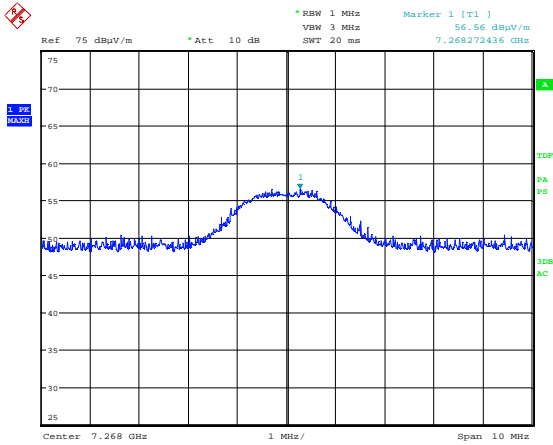


Date: 2.MAY.2023 13:18:04

Date: 2.MAY.2023 13:19:06

Radiated Emissions 7218 MHz, 902.3 MHz, 125 kHz, Peak, Max: VP

Av

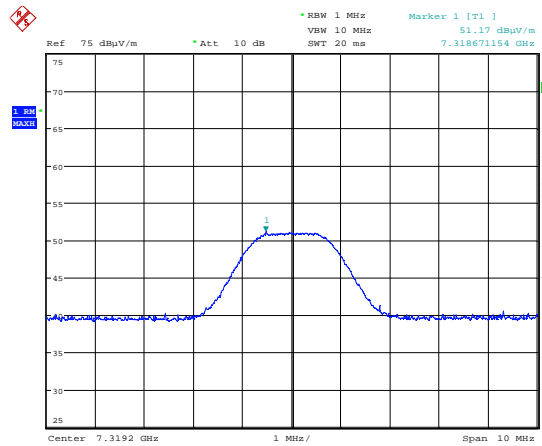
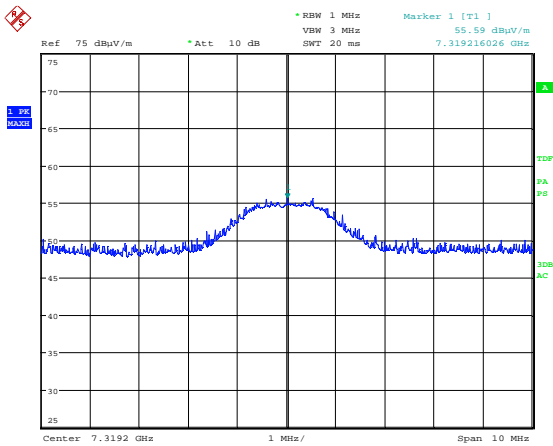


Date: 2.MAY.2023 12:55:40

Date: 2.MAY.2023 12:56:41

Radiated Emissions 7268 MHz, 908.5 MHz, 125 kHz, Peak, Max: VP

Av

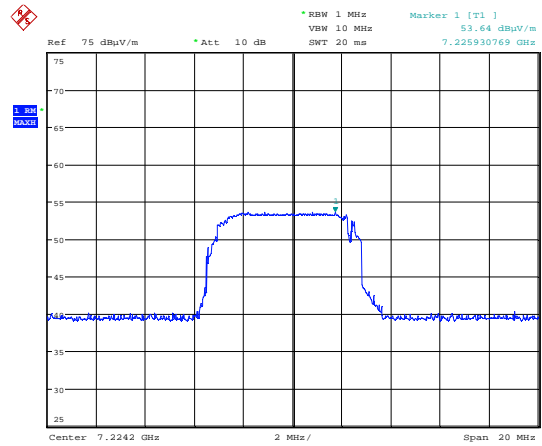
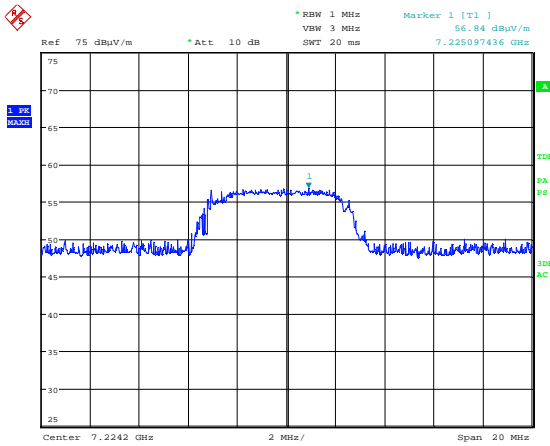


Date: 2.MAY.2023 13:02:53

Date: 2.MAY.2023 13:03:32

Radiated Emissions 7319.2 MHz, 914.9 MHz, 125 kHz, Peak, Max: VP

Av

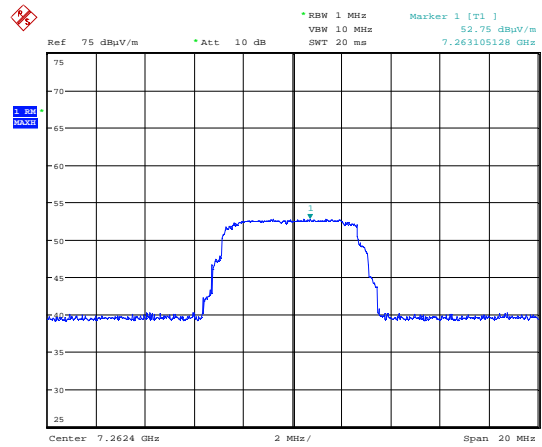
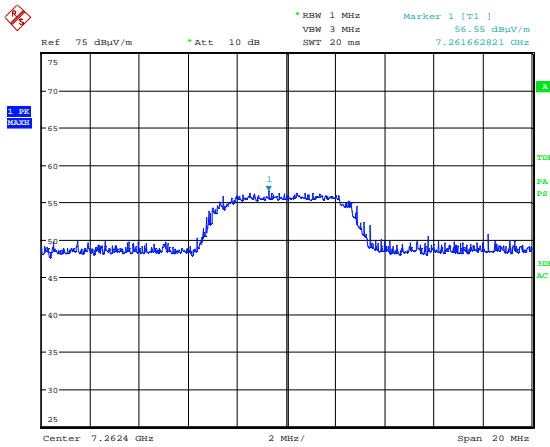


Date: 2.MAY.2023 13:22:19

Date: 2.MAY.2023 13:24:13

Radiated Emissions 7224.2 MHz, 903.0 MHz, 500 kHz, Peak, Max: VP

Av

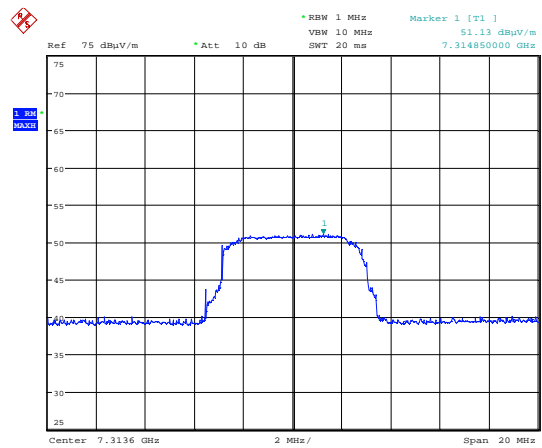
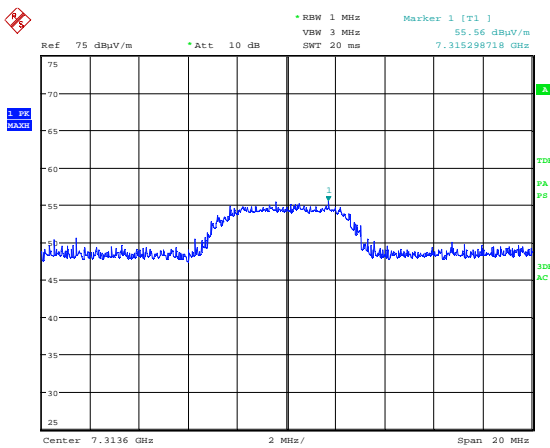


Date: 2.MAY.2023 13:10:51

Date: 2.MAY.2023 13:12:20

Radiated Emissions 7262.4 MHz, 907.8 MHz, 500 kHz, Peak, Max: VP

Av



Date: 2.MAY.2023 13:31:34

Date: 2.MAY.2023 13:32:11

Radiated Emissions 7313.6 MHz, 914.2 MHz, 500 kHz, Peak, Max: VP

Av

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.

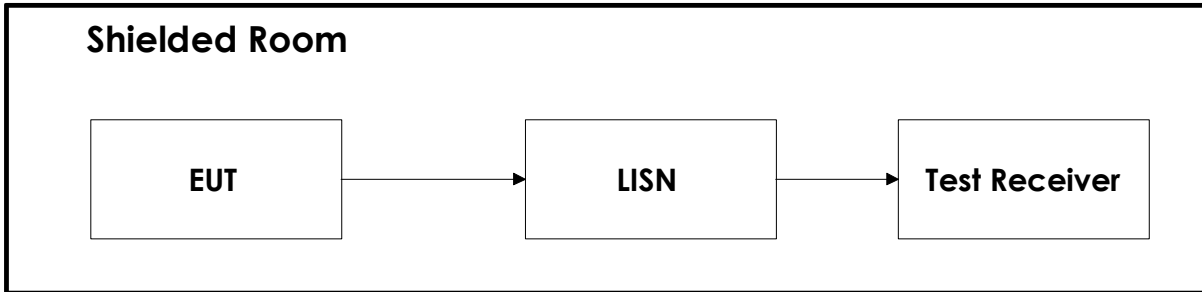
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2022-01 2023-01	2023-01 2024-01
2	6810.17B	Attenuator	Suhner	LR 1669	2022-08	2023-08
3	6HC1500/18000-3-KK	High Pass Filter (1.5 GHz)	Trilithic	LR 1612	COU	
4	VULB 9163	BiLog Antenna	Schwarzbech	LR 1616	2021-05	2024-05
5	310	Preamplifier	Sonoma Inst.	LR 1686	2022-08	2023-08
6	3115	Horn Antenna	EMCO	LR 1226	2022-12	2027-12
7	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2022-08	2023-08

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

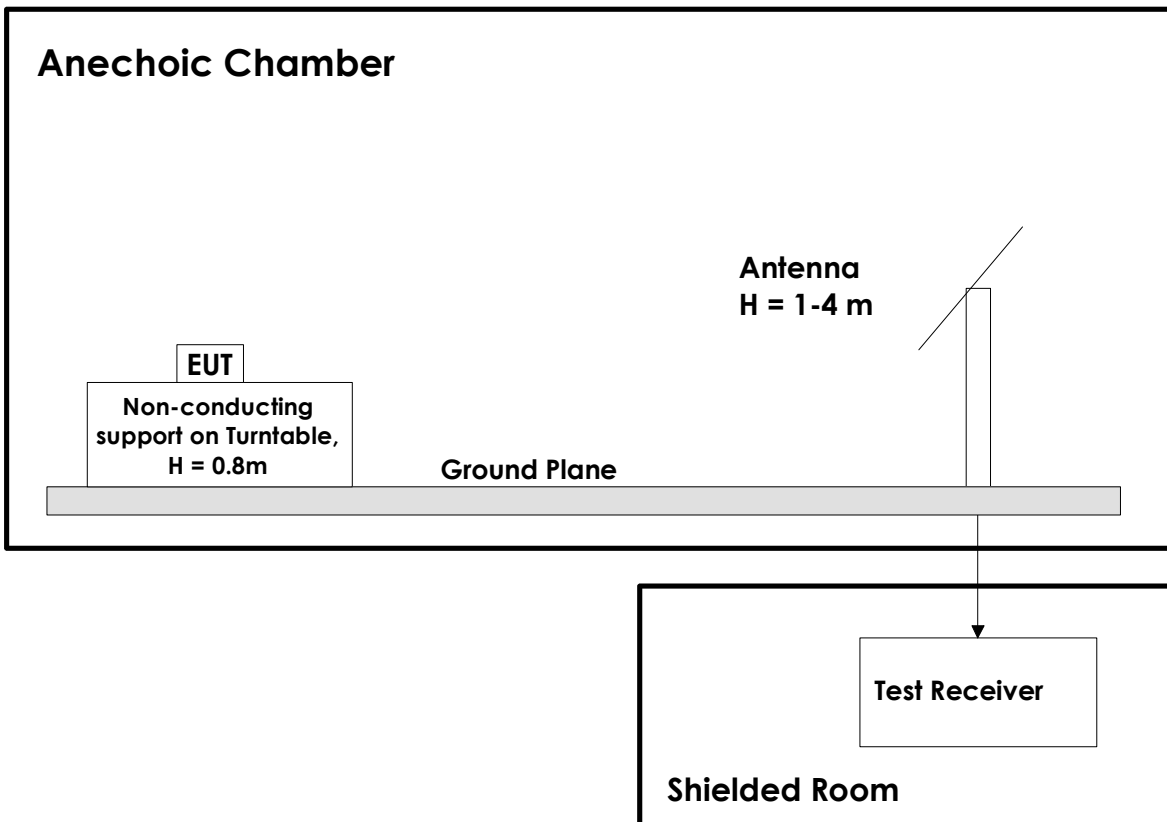
No.	Manufacturer	Name	Version	Comment
1	Nemko	RSPlot	1.0.8.0	Screenshots from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



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