

Test Report

Report Number:

F221513E3

Equipment under Test (EUT):

TrackView Pro Transmitter

Applicant:

Ellab A/S

Manufacturer:

Ellab A/S



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **ANSI C63.10-2013**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15**, Radio Frequency Devices
- [3] **558074 D01 15.247 Meas Guidance v05r02 (April 2019)**, GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
- [4] **RSS-247, Issue 2 (2017-02)** Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [5] **RSS-Gen, Issue 5 Amendment 2 (2021-02)** General Requirements for Compliance of Radio Apparatus

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account as stated in clause 1.3 of ANSI C63.10 (2013). However, the measurement uncertainty is calculated and shown in this test report.

Tested by:

Signature

Written by:

Signature

Reviewed and
approved by:

Signature

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The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

1.1 Applicant

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Phone:	+45 44 52 05 00
eMail address:	mIs@ellab.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Ellab A/S
Address:	Trollemindsalle 25 3400 Hilleroed
Country:	Denmark
Name for contact purposes:	Mr. James JACOBSSON
Phone:	+45 4452 0500
eMail address:	info@ellab.com
Manufacturer represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-05e and D-PL-17186-01-06e, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Test object: *	Ellab TrackView Pro Smart RF Transmitter – 915 MHz
Model name: *	TrackView Pro Transmitter
Model number: *	33047341
Order number: *	n/a
FCC ID: *	XUS-TVPTX1
IC certification number: *	8758A-TVPTX1
PMN: *	TrackView Pro Transmitter
HVIN: *	66310000
FVIN: *	-

	EUT number		
	1	2	3
Serial number: *	10001479	-	-
PCB identifier: *	610000126-07	-	-
Hardware version: *	n/a	-	-
Software version: *	n/a	-	-

* Declared by the applicant

One EUT was used for all tests.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC (two AA batteries)		
Supply voltage EUT: *	$U_{nom} = 3 V_{DC}$	$U_{min} = 2.5 V_{DC}$	$U_{max} = 3.5 V_{DC}$
Temperature range: *	-20°C to +60°C		
Lowest / highest internal clock frequency: *	32.768 kHz / 927.5 MHz		

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
USB1	USB A	-	Not connected	-
USB2	USB A	-	Not connected	-
-	-	-	-	-

LoRa frequencies (Uplink channels)			
Channel 64	903.0 MHz	Channel 65	904.6 MHz
Channel 66	906.2 MHz	Channel 67	907.8 MHz
Channel 68	909.4 MHz	Channel 69	911.0 MHz
Channel 70	912.6 MHz	Channel 71	914.2 MHz

LoRa frequencies (Downlink channels)			
Channel (8)0	923.3 MHz	Channel (8)1	923.9 MHz
Channel (8)2	924.5 MHz	Channel (8)3	925.1 MHz
Channel (8)4	925.7 MHz	Channel (8)5	926.3 MHz
Channel (8)6	926.9 MHz	Channel (8)7	927.5 MHz

LoRa radio mode		
Fulfills radio specification: *1	LoRa WAN	
Radio chip: *1	SEMTECH SX1276	
Antenna type: *1	Integrated PCB antenna	
Antenna name: *1	-	
Antenna gain: *2	1.4 dBd	
Antenna connector: *1	-	
Type of modulation: *1	LoRa WAN	LoRa-CSS
Operating frequency range: *1	LoRa WAN	903.0 – 927.5 MHz
Number of channels: *1	LoRa WAN	8

*1 declared by the applicant

*2 based on the antenna test, see 5.3.3 for details

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
Laptop: *1	Lenovo X1
-	-

*1 Provided by the applicant

Ancillary Equipment	
-	-
-	-

1.6 Dates

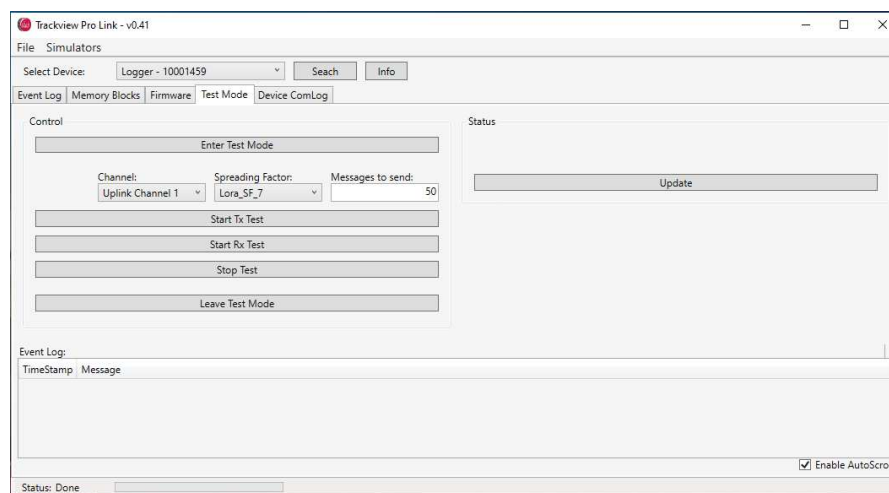
Date of receipt of test sample:	19.12.2022
Start of test:	06.01.2023
End of test:	23.02.2023

2 Operational States

2.1 Description of function of the EUT

During all test the EUT was supplied with 3.0V DC by the internal battery.

Test modes were started via a laptop computer with a special software as provided by the applicant (Trackview Pro Link – v0.41). To start the test mode, the EUT was connected to the laptop computer using a mini USB cable. After starting the test mode and disconnecting the USB cable, the EUT stays in test mode until a power cycle is performed. Using the test software the Tx channel and the spreading factor could be set. The output power was set by the firmware on the EUT.



2.1.1 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Data rate [bps]	Power setting
1	LoRa	903.0	64	SF7	5470	+12 dBm
2	LoRa	914.2	71	SF7	5470	+12 dBm
3	LoRa	927.5	(8)7	SF7	5470	+12 dBm

3 Additional Information

As declared by the applicant, the EUT does not use the full LoRa functionality, just LoRa modulation and a subset of the channels. The EUT does not use the FHSS LoRa channels.

The EUT was not labeled as required by FCC / IC.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Tested EUT	Status
Maximum peak conducted output power	902 - 928	15.247 (b) (3), (4)	5.4 (d) [4]	1	Passed
Maximum conducted output power	902 - 928	15.247 (b) (3), (4)	5.4 (d) [4]	1	Passed
DTS Bandwidth / 99% Bandwidth	902 - 928	15.247 (a) (2)	5.2 (a) [4]	1	Passed
Peak Power Spectral Density	902 - 928	15.247 (e)	5.2 (b) [4]	1	Passed
Average Power Spectral Density	902 - 928	15.247 (e)	5.2 (b) [4]	1	Passed
Band edge compliance	902 - 928	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	1	Passed
Maximum unwanted emissions	0.009 – 10,000*	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	1	Passed*
Antenna Requirement	-	15.203 15.247 (b)	6.8 [5] 5.4 (f) (ii) [4]	1	Passed
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [5]	-	-

*: As declared by the applicant the highest radio clock frequency is 0.927 GHz. Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 10.0 GHz.

5 Results

5.1 Test setups

5.1.1 Radiated: 9 kHz to 30 MHz

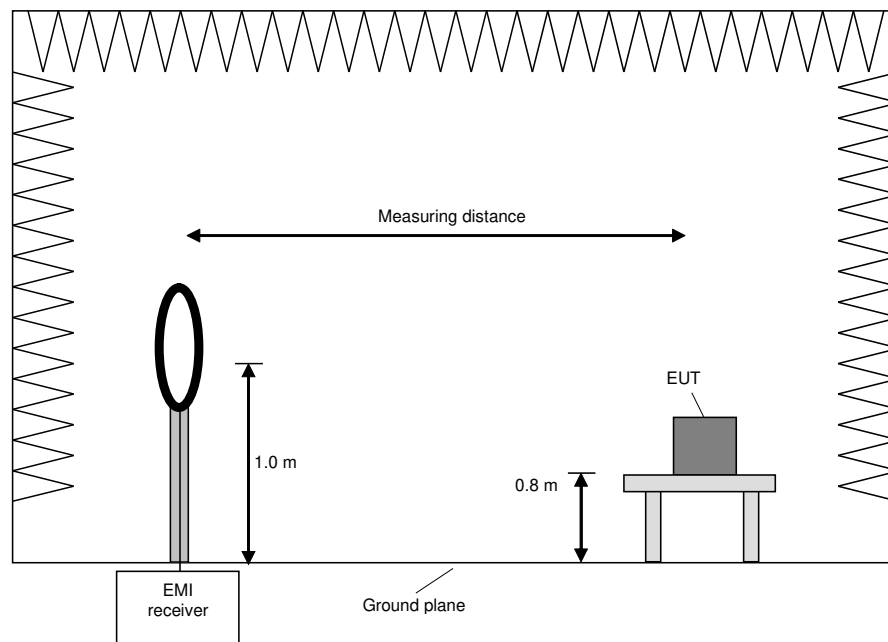
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in a semi-anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

The frequency range 9 kHz to 30 MHz is monitored with an EMI receiver while the system and its cables are manipulated to find out the configuration with the maximum emission levels if applicable. The EMI receiver is set to MAX hold mode. The EUT and the measuring antenna are rotated around their vertical axis to find the maximum emission levels.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure is used:

- 1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0°.
- 2) Manipulate the system cables to produce the maximum levels of emissions.
- 3) Rotate the EUT by 360° to maximize the detected signals.

- 4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
- 5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x,y,z) of the EUT.
- 6) Rotate the measuring antenna and repeat steps 1 to 5.

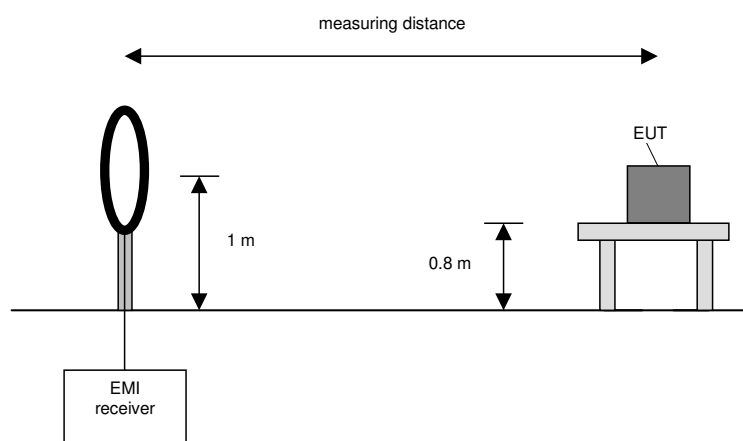
5.1.1.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane at a measuring distance of 3 m, 10 m, or 30 m. If the standard requires larger measuring distances for a given frequency, the results are extrapolated according to section 15.31 (f) (2) [2]. The final measurement is performed with an EMI receiver set to Quasi-Peak detector, except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an Average detector is used according section 15.209 (d) [2].

At the frequencies, which were detected during the preliminary measurements, the final measurement is performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum level value is found.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth	Measuring time
9 kHz to 150 kHz	200 Hz	1 s
150 kHz to 30 MHz	9 kHz	1 s



Procedure final measurement:

The following procedure is used:

- 1) Monitor the selected frequencies from the preliminary measurement with the measuring antenna facing the EUT and an EUT azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals.
- 3) Rotate the measuring antenna and repeat steps 1 to 2 until the maximum value is found and note it.
- 4) If the EUT is portable or ceiling mounted, repeat steps 1 to 3 with other orientations (x,y,z) of the EUT.

5.1.2 Radiated: 30 MHz to 1 GHz

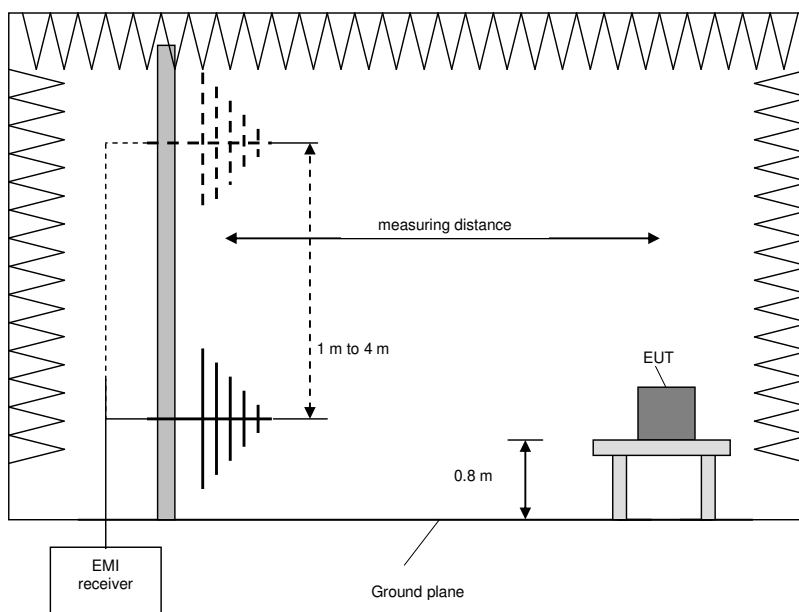
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 °, the measuring antenna is set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI receiver is set to the following values:

Test	Frequency range	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	30 MHz to 1 GHz	30 kHz	120 kHz	-	Peak Average
Frequency peak search	± 120 kHz	10 kHz	120 kHz	1 s	Peak
Final measurement	30 MHz to 1 GHz	-	120 kHz	1 s	QuasiPeak



Procedure preliminary measurement:

The following procedure is used:

- 1) Set the measuring antenna to 1 m height.
- 2) Monitor the frequency range at horizontal polarization of the measuring antenna and an EUT / turntable azimuth of 0 °.
- 3) Rotate the EUT by 360° to maximize the detected signals.
- 4) Repeat steps 2 to 3 with the vertical polarization of the measuring antenna.
- 5) Increase the height of the measuring antenna for 0.5 m and repeat steps 2 to 4 until the final height of 4 m is reached.
- 6) The highest values for each frequency are saved by the software, including the measuring antenna height and polarization and the turntable azimuth for that value.

Procedure final measurement:

The following procedure is used:

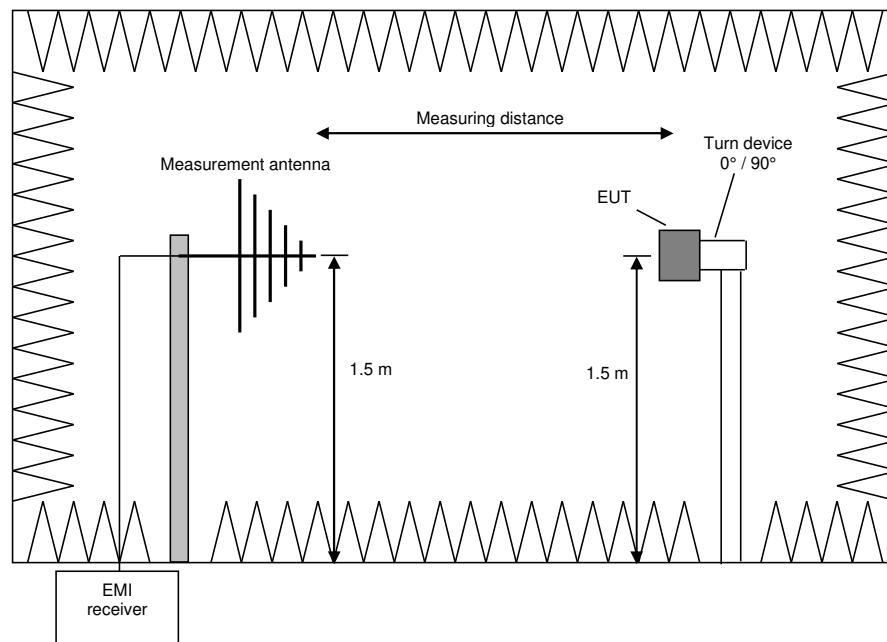
- 1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
- 2) The software determines the exact peak frequencies by doing a partial scan with reduced step size of the pre-scan of the selected peaks.
- 3) If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x,y,z) for the final test.
- 4) The worst-case measuring antenna height is found via varying the height by +/- 0.5 m from the value obtained in the preliminary measurement while monitoring the emission level.
- 5) The worst-case turntable position is found via varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement while monitoring the emission level.
- 6) The final measurement is performed at the worst-case measuring antenna height and the worst-case turntable azimuth.
- 7) Steps 2 to 6 are repeated for each frequency peak selected in step 1.

5.1.3 Radiated: 30 MHz – 1 GHz (Azimuth Chart)

The measurements are performed in a fully anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting turn device at the height of 1.5 m. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 ° and the measuring antenna is set to horizontal and vertical polarization to find the maximum level of emissions. After these steps, the measurement is repeated after reorientating the EUT in 90 ° steps.

The resolution bandwidth of the EMI receiver is set accordingly to the OBW of the EUT, to encompass the complete wanted signal.



5.1.4 Radiated: 1 GHz to 40 GHz

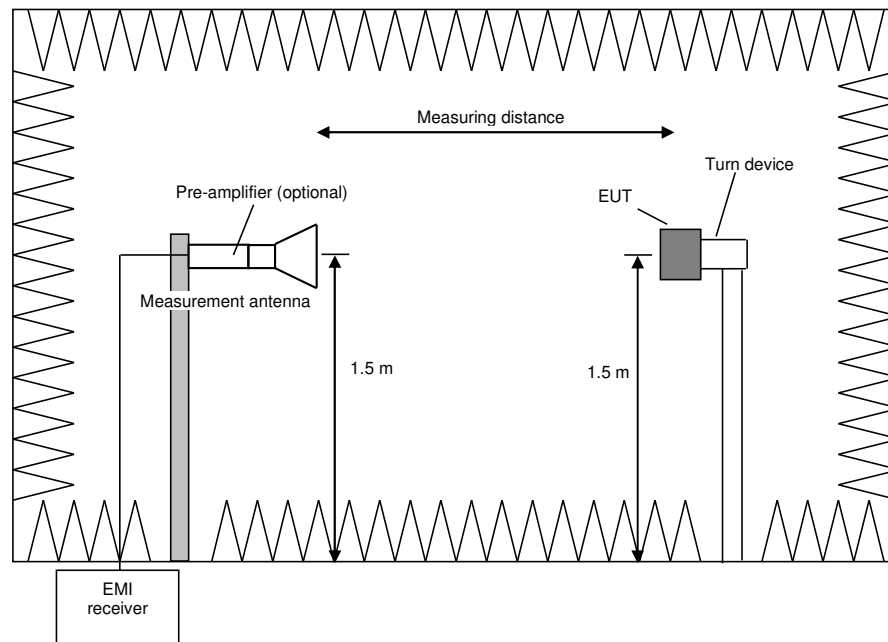
5.1.4.1 Preliminary and final measurement 1 to 40 GHz

The preliminary and final measurements are performed in a fully anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting turn device at the height of 1.5 m. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 ° and the measuring antenna is set to horizontal and vertical polarization to find the maximum level of emissions. After these steps, the measurement is repeated after reorientating the EUT in 30 ° steps.

The resolution bandwidth of the EMI receiver is set to the following values:

Test	Frequency range	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	1 - 40 GHz	250 kHz	1 MHz	-	Peak Average
Final measurement	1 - 40 GHz	-	1 MHz	100 ms	Peak Average



Procedure preliminary measurement:

The following procedure is used:

- 1) Monitor the frequency range at horizontal polarisation of the measuring antenna and an EUT / turntable azimuth of 0 °.
- 2) Rotate the EUT by 360° to maximize the detected signals.
- 3) Repeat steps 1 to 2 with the vertical polarisation of the measuring antenna.
- 4) Repeat steps 1 to 3 with the EUT reorientated by an angle of 30° (60°, 90°, 120° and 150°), according to 6.6.5.4 in [1].
- 5) The highest values for each frequency are saved by the software, including the measuring antenna polarization, the turntable azimuth and the turn device elevation for that value.

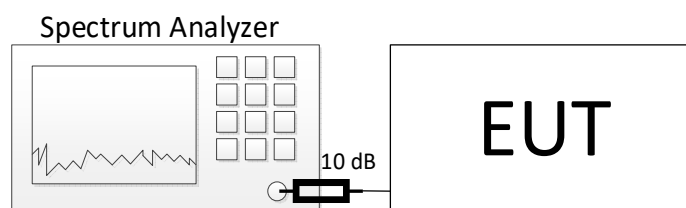
Procedure final measurement:

The following procedure is used:

- 1) Set the turntable and the turn device to the position which leads to the highest emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna to the polarisation which leads to the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyser to EMI mode with Peak and Average detector activated.
- 4) The worst-case turntable position is found via varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement while monitoring the emission level.
- 5) The final measurement is performed at the worst-case turntable azimuth.
- 6) Repeat steps 1 to 5 for each frequency detected during the preliminary measurements.

5.1.5 Conducted: Antenna port

Test setup (conducted)		
Used	Antenna connector	Comment
<input checked="" type="checkbox"/>	Temporary antenna connector	As provided by the applicant
<input type="checkbox"/>	Normal antenna connector	-



The 10 dB external attenuation are considered in all relevant plots

5.2 Duty cycle

As declared by the applicant the duty cycle in test mode is >98%, no DCCF applied.

5.3 Transmit antenna performance considerations

5.3.1 Test setup (Transmit antenna performance considerations)

Test setup (DTS bandwidth)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.3	ERP
	Conducted: Antenna port	5.1.5	Reference
<input type="checkbox"/>	None	-	External Report

5.3.2 Test method (Transmit antenna performance considerations)

Test method (Transmit antenna performance considerations)			
Used	Method	Applicability	Comment
<input checked="" type="checkbox"/>	Comparison: Conducted Power and Radiated ERP/EIRP power	Same power setting	dBd for f<1GHz dBi for f>1GHz
<input type="checkbox"/>	Antenna report as provided by the applicant	No limitations	Report: -

5.3.3 Test results (Transmit antenna performance considerations)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	10.01.2023
Tested by:	P. NEUFELD

		903.0 [MHz]	914.2 [MHz]	927.5 [MHz]
Conducted output power*1 [dBm]		7.39	7.39	7.28
Radiated ERP*2 [dBm ERP]		8.80	8.35	7.86
Antenna Gain [dBd]		1.41	0.96	0.58
Position of maximum gain	Azimuth	100°	101°	97°
	Elevation	90°	90°	90°
	Polarisation	Vertical	Vertical	Vertical

*1 see 5.6.3.1

*2 see Annex B Transmit antenna calculation

Result (Transmit antenna performance considerations)		
Integral antenna	Antenna gain ≤ 6dBi	Comment
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Max gain 1.41 dBd	No output power reduction necessary

Test equipment (please refer to chapter 7 for details)
15 - 25

5.4 DTS bandwidth

5.4.1 Test setup (DTS bandwidth)

Test setup (DTS bandwidth)			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.2	-
<input checked="" type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.4.2 Test method (DTS bandwidth)

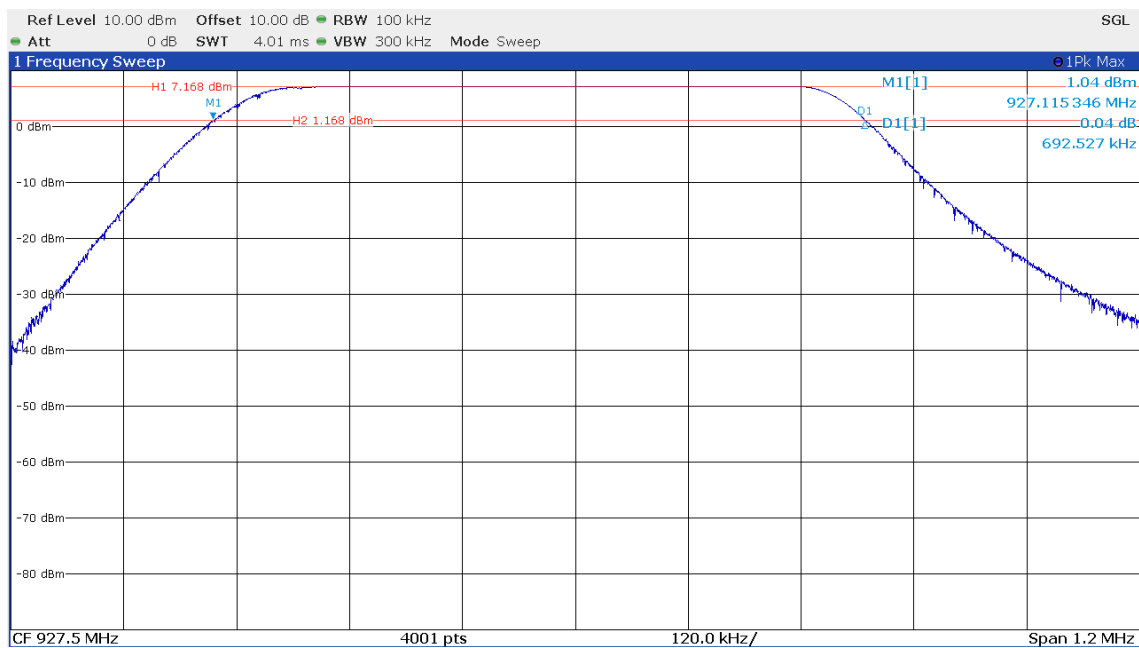
Test method (DTS bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.8.1	Option 1	No limitations	-
<input type="checkbox"/>	11.8.2	Option 2	No limitations	6 dB down function

5.4.3 Test results (DTS bandwidth)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	09.01.2023
Tested by:	P. NEUFELD

Worst case plot (operation mode #3)



Operation mode #	DTS bandwidth [MHz]	Minimum DTS bandwidth Limit [MHz]
1	0.700	0.5
2	0.696	0.5
3	0.693	0.5

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.5 Occupied bandwidth – power bandwidth (99%)

5.5.1 Test Setup (Occupied bandwidth – power bandwidth (99%))

Test setup (Occupied bandwidth – power bandwidth (99%))			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.2	-
<input checked="" type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.5.2 Test method (Occupied bandwidth – power bandwidth (99%))

Test method (Occupied bandwidth – power bandwidth (99%))				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input type="checkbox"/>	6.9.2	Relative measurement procedure	-	n-dB down
<input checked="" type="checkbox"/>	6.9.3	Power bandwidth (99%)	*1	99% power function

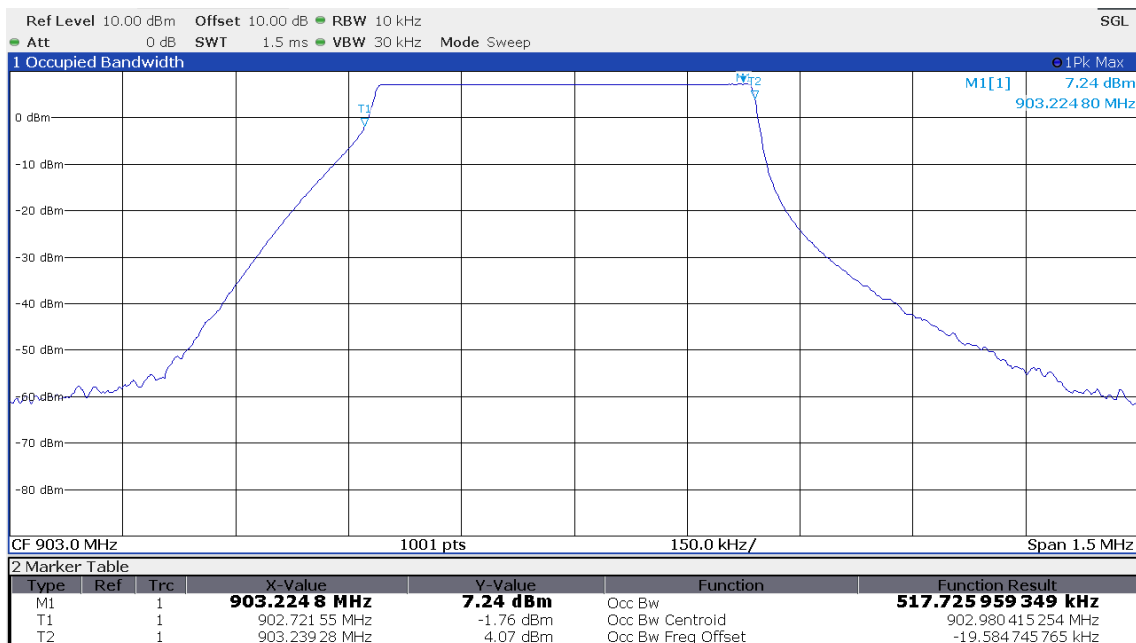
*1 See RSS-GEN Issue 5 (2018-05) sub-clause 6.7 for details.

5.5.3 Test results (Occupied bandwidth – power bandwidth (99%))

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	09.01.2023
Tested by:	P. NEUFELD

Worst case plot (operation mode #1):



Operation mode #	99% bandwidth [MHz]
1	0.518
2	0.516
3	0.515

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.6 DTS fundamental emission output power

5.6.1 Test setup (DTS fundamental emission output power)

Test setup (DTS fundamental emission output power)			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.2	-
<input checked="" type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.6.2 Test method (DTS fundamental emission output power)

Test method (Maximum peak conducted output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.9.1.1	RBW \geq DTS bandwidth	-	Zero span mode
<input type="checkbox"/>	11.9.1.2	Integrated band power method	Not for DTS	-
<input type="checkbox"/>	11.9.1.3	PKPM1 Peak power meter method* ¹	-	-

*¹ VBW of the peak power meter has to be $>$ OBW of the fundamental.

Test method (Maximum conducted (average) output power)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.9.2.2.2	Method AVGSA-1	D \geq 98%	-
<input type="checkbox"/>	11.9.2.2.3	Method AVGSA-1A (alternative)	D \geq 98%	-
<input type="checkbox"/>	11.9.2.2.4	Method AVGSA-2	Constant D ($\pm 2\%$)	-
<input type="checkbox"/>	11.9.2.2.5	Method AVGSA-2A (alternative)	Constant D ($\pm 2\%$)	-
<input type="checkbox"/>	11.9.2.2.6	Method AVGSA-3A	-	-
<input type="checkbox"/>	11.9.2.2.7	Method AVGSA-3A (alternative)	-	-
<input type="checkbox"/>	11.9.2.3.1	Method AVGPM	Constant D ($\pm 2\%$)	-
<input type="checkbox"/>	11.9.2.3.2	Method AVGPM-G	-	-

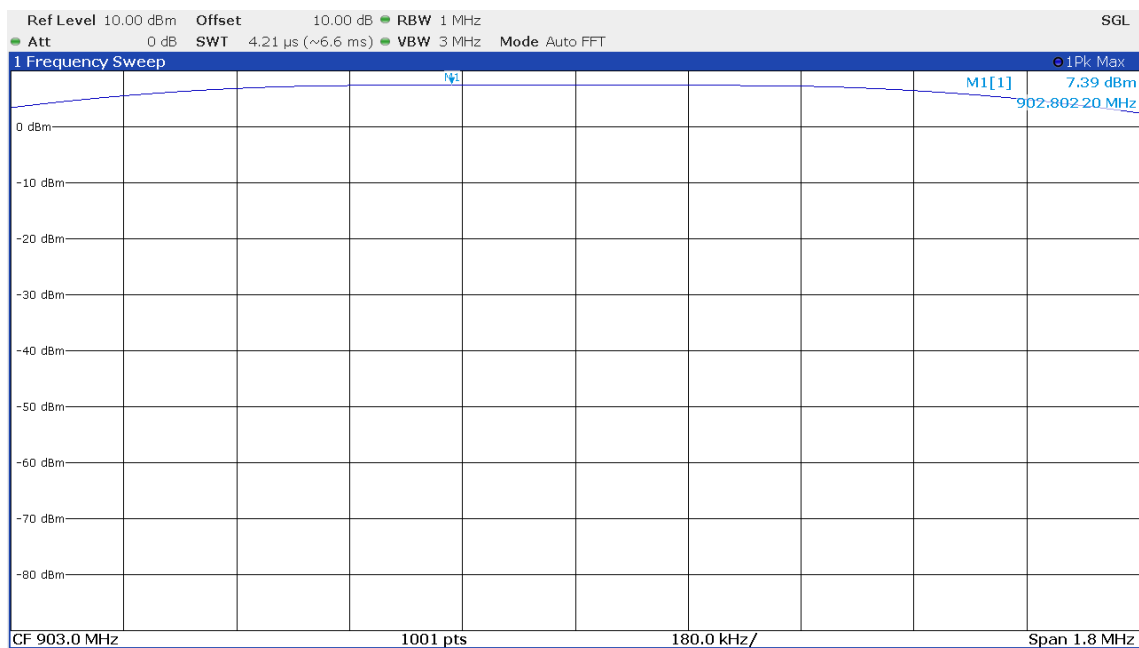
5.6.3 Test results (DTS fundamental emission output power)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	09.01.2023
Tested by:	P. NEUFELD

5.6.3.1 Maximum peak conducted output power:

Worst case plot (operation mode #1):

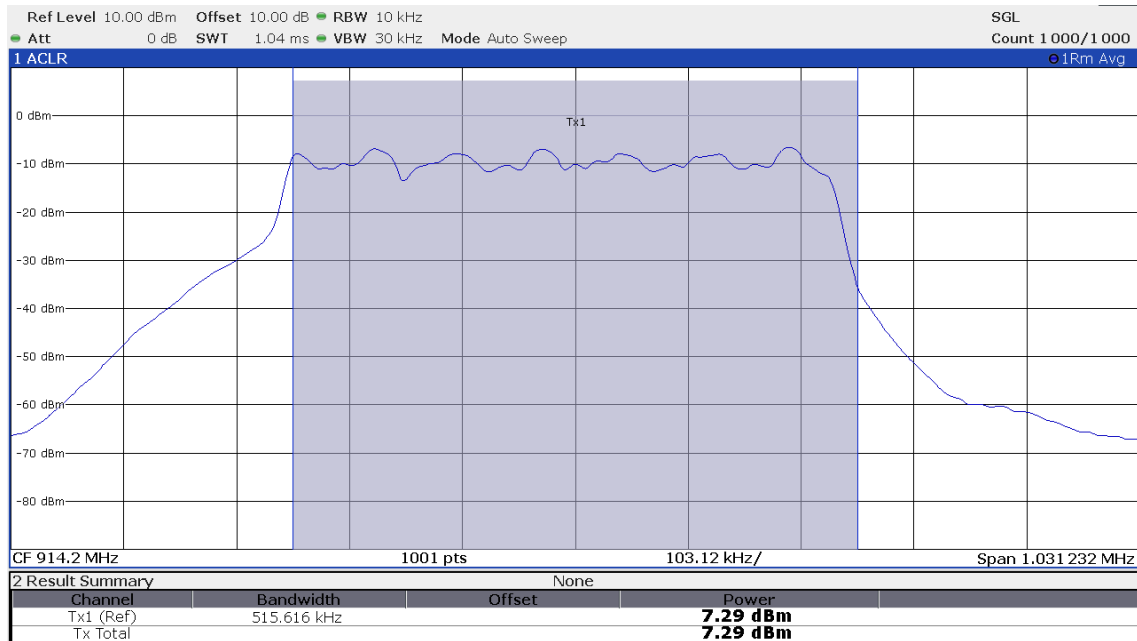


Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]
1	7.39	0.0	7.39	30
2	7.39	0.0	7.39	30
3	7.28	0.0	7.28	30

Test result: Passed

5.6.3.2 Maximum conducted (average) output power

Worst case plot (operation mode #2):



Operation mode	Reading [dBm]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm]	Antenna gain [dBd]	ERP [dBm]	Limit [dBm]
1	7.25	0.0	0.0	7.25	1.41	8.66	30
2	7.29	0.0	0.0	7.29	0.96	8.25	30
3	7.13	0.0	0.0	7.13	0.58	7.71	30

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.7 DTS maximum power spectral density

5.7.1 Test setup (DTS maximum PSD level in the fundamental emission)

Test setup (DTS fundamental emission output power)			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.2	-
<input checked="" type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.7.2 Test method (DTS maximum PSD level in the fundamental emission)

Test method (Maximum <i>peak</i> power spectral density level in the fundamental emission)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.10.2	Method PKPSD (peak PSD)	No limitations	-

Test method (Maximum <i>average</i> power spectral density level in the fundamental emission)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.10.3	Method AVGPSD-1	D ≥ 98%	-
<input type="checkbox"/>	11.10.4	Method AVGPSD-1A (alternative)	D ≥ 98%	-
<input type="checkbox"/>	11.10.5	Method AVGPSD-2	Constant D (±2%)	-
<input type="checkbox"/>	11.10.6	Method AVGPSD-2A (alternative)	Constant D (±2%)	-
<input type="checkbox"/>	11.10.7	Method AVGPSD-3	No limitations	-
<input type="checkbox"/>	11.10.8	Method AVGPSD-3A (alternative)	No limitations	-

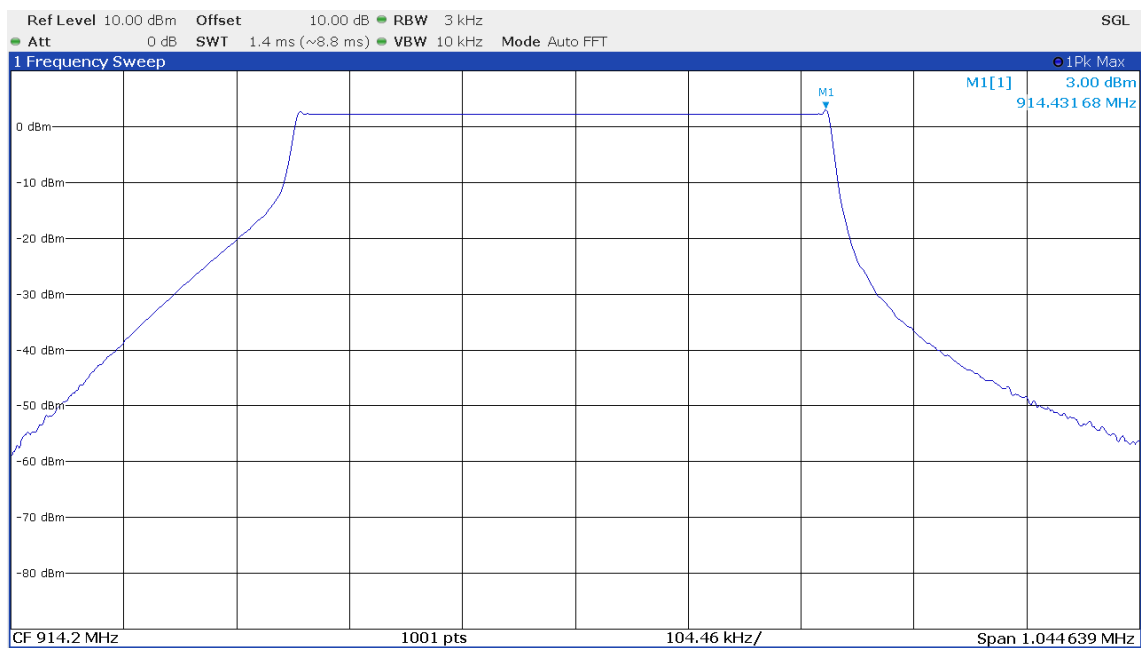
5.7.3 Test results (DTS maximum PSD level in the fundamental emission)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	09.01.2023
Tested by:	P. NEUFELD

5.7.3.1 Maximum peak PSD

Worst case plot (operation mode #2):

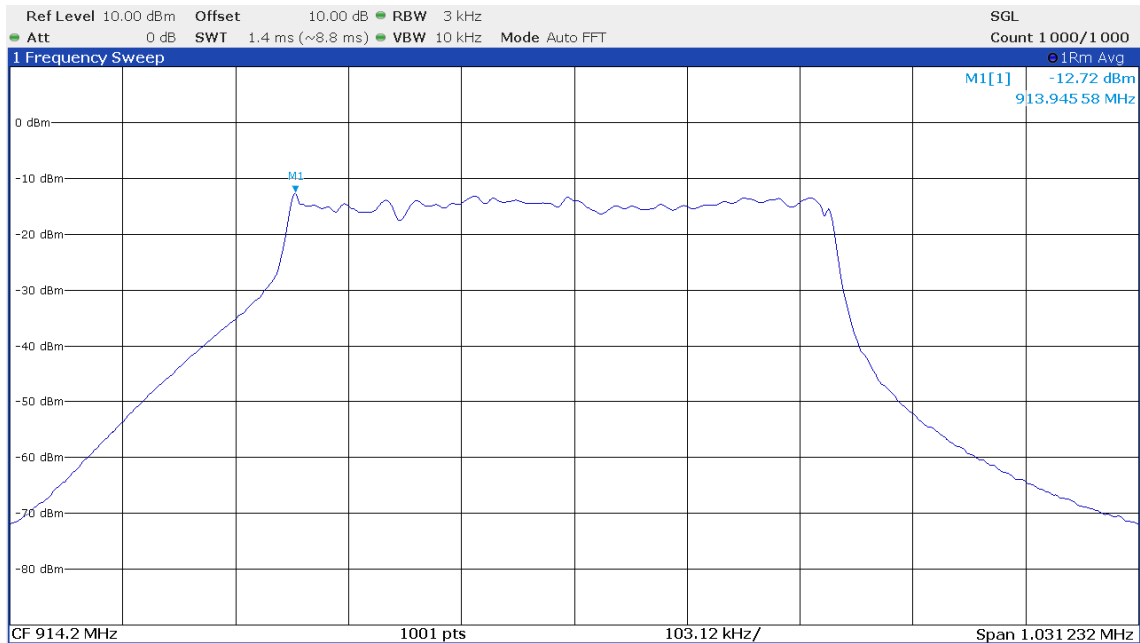


Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	2.99	0.0	2.99	8.0
2	3.00	0.0	3.00	8.0
3	2.92	0.0	2.92	8.0

Test result: Passed

5.7.3.2 Maximum average PSD

Worst case plot (operation mode #2):



Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-12.95	0.0	0.0	-12.95	8.0
2	-12.72	0.0	0.0	-12.72	8.0
3	-13.26	0.0	0.0	-13.26	8.0

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.8 DTS band-edge emission measurements

5.8.1 Test setup (Band edge – unrestricted bands)

Test setup (Band edge – unrestricted bands)			
Used	Setup	See sub-clause	Comment
<input type="checkbox"/>	Radiated: 30 MHz - 1 GHz	5.1.2	-
<input checked="" type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.8.2 Test method (Band edge – unrestricted bands)

Test method (Band edge – unrestricted bands)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.11.	20 dBc (Peak)	Peak power	*1
<input type="checkbox"/>	11.11.	30 dBc (Average)	RMS power	*2

*1 As declared in "47 CFR 15.247(d)" 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

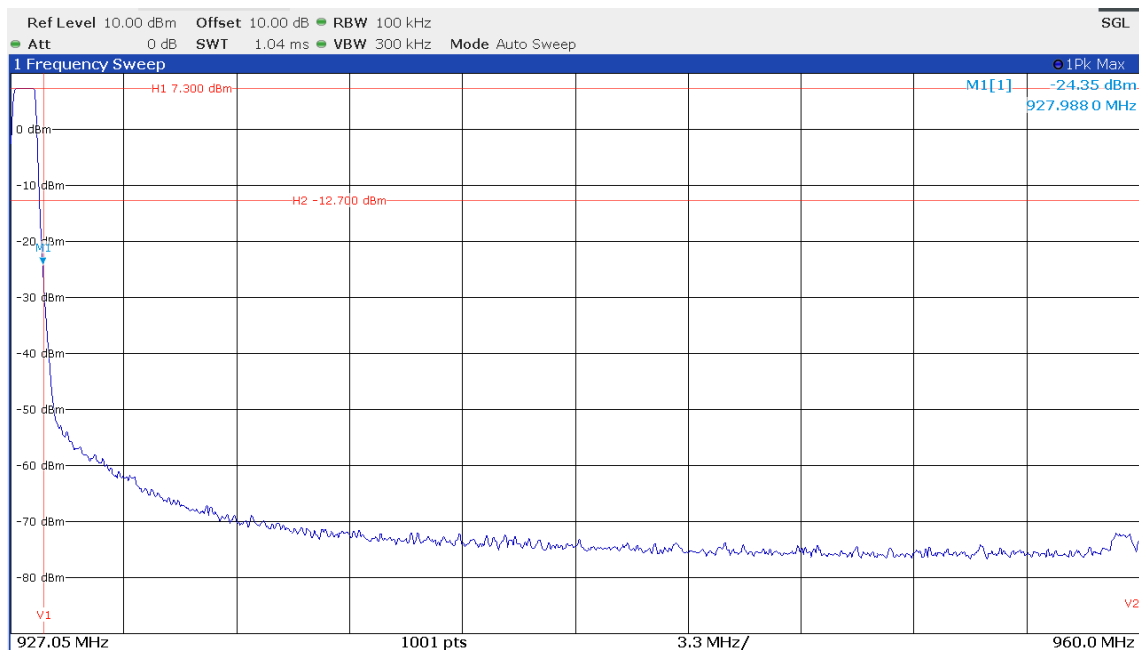
*2 If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.8.3 Test results (Band edge – unrestricted bands)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	09.01.2023
Tested by:	P. NEUFELD

Worst case plot Upper band edge (operation mode #3):



Lower band edge (operation mode 1):

Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
901.963	7.5	-12.5	-53.5	41.0

Upper band edge (operation mode 3):

Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
927.988	7.3	-12.7	-24.4	11.7

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1

5.9 Radiated emissions

5.9.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz / 1 GHz to 40 GHz	5.1.1 / 5.1.2 / 5.1.4	Tested in dedicated position (wall mounted EUT)
<input type="checkbox"/>	Conducted: Antenna port	5.1.5	-

5.9.2 Test method (Maximum unwanted emissions)

Test method (radiated) see sub-clause 5.1.1 / 5.1.2 / 5.1.4 as described herein

5.9.3 Test results (Maximum unwanted emissions)

5.9.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C	Date:	06.01.2023
Relative humidity:	35 %	Tested by:	P. NEUFELD

Position of EUT: For tests for f between 9 kHz to 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: The measurement value was already corrected by 40 dB/decade as described in 47 CFR 15.31(f)(2) regarding to the measurement distance as requested in 47 CFR 15.209(a)

Remark: The EUT was only tested in the dedicated position (wall mounted – refer test setup photographs).

Calculations:

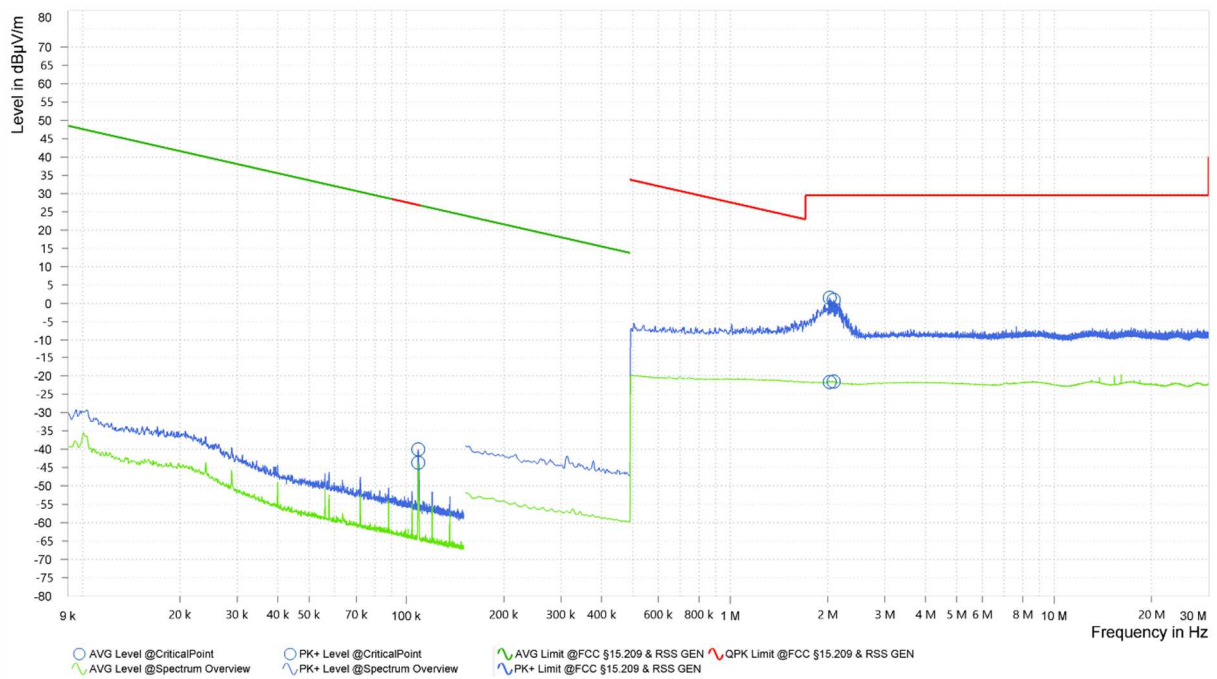
Result @ norm. dist. [dB μ V/m] = Reading [dB μ V] + AF [dB/m] + Distance corr. fact. [dB μ V/m]

Result @ norm. dist. [dB μ A/m] = Result @ norm. dist. [dB μ V/m] – 20 x log₁₀(377 Ω)

Margin [dB] = Limit [dB(μ V| μ A)/m] - Result [dB(μ V| μ A)/m]

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode #2):



Remark: No emissions close than 20 dB to the limit, so no final measurement will be carried out.

Test result: Passed

Test equipment (please refer to chapter 7 for details)

2 - 10

5.9.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	06.01.2023
Tested by:	P. NEUFELD

Position of EUT: For tests for f between 30 MHz to 1 GHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Plots for each frequency range are submitted below.

Remark: The EUT was only tested in the dedicated position (wall mounted – refer test setup photographs).

Calculations:

Result [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

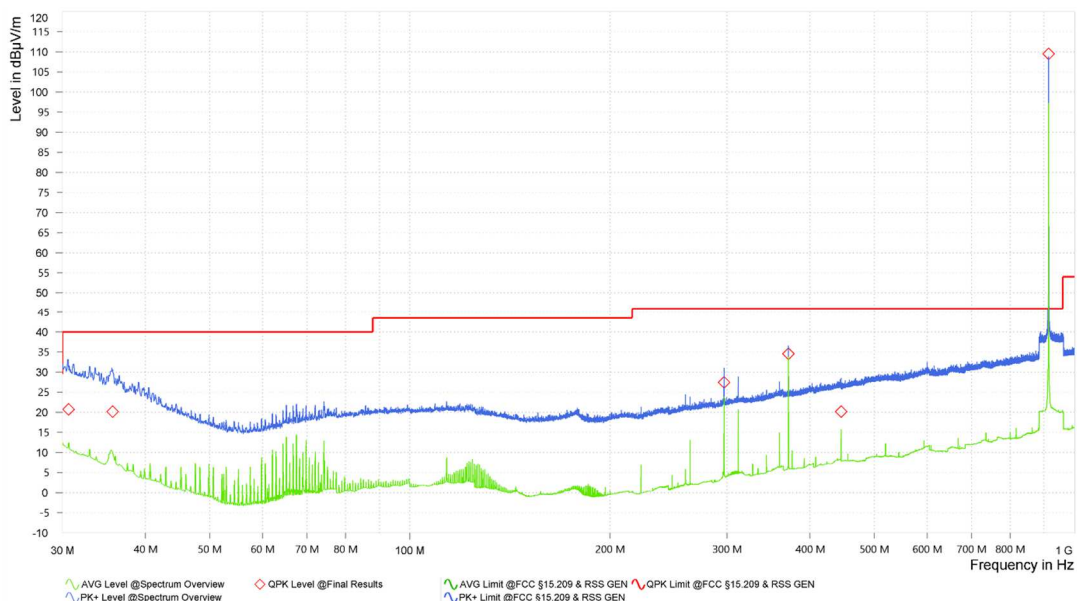
Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

Margin [dB] = Limit [dBμV/m] - Result [dBμV/m]

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with “◇” are the measured results of the standard subsequent measurement in a semi-anechoic chamber.

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode #2):



Result tables:

(Operation mode #1):

Frequency [MHz]	QPK Level [dB μ V/m]	QPK Limit [dB μ V/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Position
30.690	20.03	40.00	19.97	25.56	V	232.44	2.83	#1
67.500	16.54	40.00	23.46	14.21	V	191.28	1.42	#1
297.030	27.56	46.00	18.44	18.95	V	169.85	2.63	#1
312.000	23.36	46.00	22.64	19.41	V	322.44	3.24	#1
371.280	34.56	46.00	11.44	21.18	V	325.99	1	#1
903.090	109.35	---	---	30.02	V	171.6	1.1	#1

(Operation mode #2):

Frequency [MHz]	QPK Level [dB μ V/m]	QPK Limit [dB μ V/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Position
30.660	20.71	40.00	19.29	25.58	V	22.44	1.1	#1
35.700	20.21	40.00	19.79	22.64	H	69.7	1.00	#1
297.030	27.47	46.00	18.53	18.95	V	155.67	2.87	#1
371.280	34.56	46.00	11.44	21.18	V	214.05	1.00	#1
445.530	20.21	46.00	25.79	22.95	V	216.07	3.81	#1
914.400	109.51	---	---	30.26	V	173.79	1.08	#1
914.400	109.51	---	---	30.26	V	173.79	1.08	#1

(Operation mode #3):

Frequency [MHz]	QPK Level [dB μ V/m]	QPK Limit [dB μ V/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Position
30.000	20.73	40.00	19.27	25.98	H	275.67	3.43	#1
297.030	27.37	46.00	18.63	18.95	V	261	2.94	#1
312.000	23.69	46.00	22.31	19.41	V	113.79	2.39	#1
371.280	34.52	46.00	11.48	21.18	V	290.23	1.00	#1
927.630	108.97	---	---	30.17	V	177.61	1.05	#1
927.720	108.94	---	---	30.17	V	175.99	1.05	#1

Test result: Passed

Test equipment (please refer to chapter 7 for details)
4 - 12

5.9.3.3 Test results (radiated 1 to 10 GHz)

Ambient temperature:	22 °C
Relative humidity:	35 %

Date:	06.01.2023
Tested by:	P. NEUFELD

Position of EUT: For tests for f between 1 GHz and the 10th harmonic, the EUT was set-up on a positioner device with a height of 150 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Plots for each frequency range are submitted below.

Remark: The EUT was only tested in the dedicated position (wall mounted – refer test setup photographs).

Calculation:

Max Peak [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

Average [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]+DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

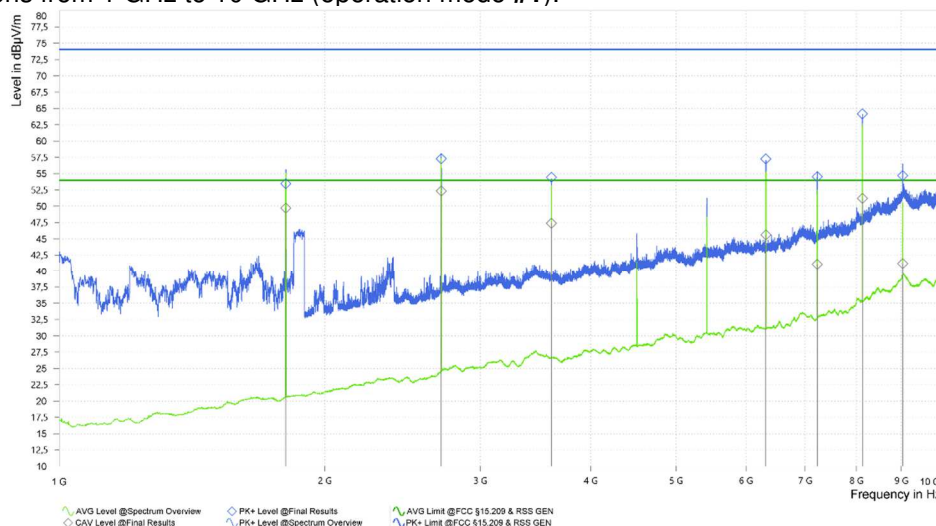
Margin [dB] = Limit [dBμV/m] – Max Peak | Average [dBμV/m]

The curves in the diagram only represent the maximum measured value for each frequency point of all preliminary measurements, which were carried out with various EUT and antenna positions.

The top measured curve represents the peak measurement. The measured points marked with "◇" are frequency points for the final peak detector measurement. These values are indicated in the following table. The bottom measured curve represents the average measurement. The measured points marked with "◇" are frequency points for the final average detector measurement.

Worst case plots:

Spurious emissions from 1 GHz to 10 GHz (operation mode #1):



Result tables:

Operation mode #1:

Frequency [MHz]	PK+ Level [dB μ V/m]	PK+ Limit [dB μ V/m]	PK+ Margin [dB]	AV Level [dB μ V/m]	AV Limit [dB μ V/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [m]
1806.250	53.47	74.00	20.53	49.71	54.00	4.29	-4.39	V	90	134	1.5
2708.750	57.29	74.00	16.71	52.36	54.00	1.64	1.25	V	120	283	1.5
3612.000	54.43	74.00	19.57	47.41	54.00	6.59	5.06	H	90	255	1.5
6320.000	57.25	74.00	16.75	45.62	54.00	8.38	12.46	V	60	72	1.5
7225.500	54.54	74.00	19.46	41.10	54.00	12.90	13.79	V	30	59	1.5
8127.500	64.16	74.00	9.84	51.20	54.00	2.80	15.89	V	150	88	1.5
9031.500	54.70	74.00	19.30	41.20	54.00	12.80	19.06	V	150	106	1.5

Operation mode #2:

Frequency [MHz]	PK+ Level [dB μ V/m]	PK+ Limit [dB μ V/m]	PK+ Margin [dB]	AV Level [dB μ V/m]	AV Limit [dB μ V/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [m]
1828.750	54.92	74.00	19.08	50.19	54.00	3.81	-4.16	V	90	151	1.5
2742.750	56.14	74.00	17.86	50.99	54.00	3.01	1.84	H	30	228	1.5
3656.000	53.67	74.00	20.33	44.18	54.00	9.82	4.86	H	90	245	1.5
6400.750	57.61	74.00	16.39	44.61	54.00	9.39	12.71	V	120	102	1.5
7312.250	55.79	74.00	18.21	43.25	54.00	10.75	14.46	V	60	160	1.5
8228.000	63.13	74.00	10.87	49.87	54.00	4.13	16.13	V	150	65	1.5
9141.250	54.39	74.00	19.61	40.80	54.00	13.20	18.70	V	150	75	1.5

Operation mode #3:

Frequency [MHz]	PK+ Level [dB μ V/m]	PK+ Limit [dB μ V/m]	PK+ Margin [dB]	AV Level [dB μ V/m]	AV Limit [dB μ V/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [m]
1855.000	53.60	74.00	20.40	50.85	54.00	3.15	-4.10	V	90	153	1.5
2782.500	52.62	74.00	21.38	47.50	54.00	6.50	2.31	H	30	219	1.5
3709.500	52.22	74.00	21.78	44.26	54.00	9.74	4.63	H	90	268	1.5
6492.000	56.72	74.00	17.28	45.23	54.00	8.77	12.88	V	60	70	1.5
7418.750	56.86	74.00	17.14	44.20	54.00	9.80	14.93	V	60	145	1.5
8348.250	60.16	74.00	13.84	47.05	54.00	6.95	16.84	V	150	62	1.5
9274.250	55.31	74.00	18.69	41.62	54.00	12.38	17.83	V	150	102	1.5

Test result: Passed

Test equipment (please refer to chapter 7 for details)
4 - 10, 13 - 14

6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Frequency error	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions using a spectrum analyzer		
< 3.6 GHz	ETSI TR 100 028	2.3 dB
3.6 – 8 GHz	ETSI TR 100 028	2.8 dB
8 – 22 GHz	ETSI TR 100 028	3.2 dB
22 – 40 GHz	ETSI TR 100 028	3.6 dB
Power measurements		
Power meter	ETSI TR 100 028	0.9 dB
Conducted emissions from 150 kHz to 30 MHz with LISN		
	CISPR 16-4-2	2.8 dB

Radiated measurements		
Frequency error		
(Semi-) Anechoic chamber	ETSI TR 100 028	4.5×10^{-8}
OATS	ETSI TR 100 028	4.5×10^{-8}
Test fixture	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M20		
CBL6112B @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	5.3 dB
R&S HL050 @ 3 m		
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 dB
R&S HL050 @ 3 m	-	
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
OATS		
Field strength measurements below 30 MHz on OATS without ground plane	-	4.4 dB

7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	19.11.2021	11.2023
2	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
3	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	22.02.2022	02.2024
4	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
5	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
6	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
7	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
8	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
9	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
10	Test software M276	Elektra	Rohde&Schwarz	101381	483755	Calibration not necessary	
11	Attenuator 6 dB	WA2-6	Weinschel		482793	Calibration not necessary	
12	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
13	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2022	02.2024
14	Log.-Per. antenna	HL050	Rohde & Schwarz	100908	482977	22.09.2022	09.2025
15	Antenna Log Per	HL223	Rohde & Schwarz	835556/014	480123	Calibration not necessary	
16	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
17	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
18	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
19	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
20	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024
21	Positioners	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
22	Software	EMC32 V10.60.20	Rohde & Schwarz		483261	Calibration not necessary	
23	Precision Dipole	HZ-13	Rohde & Schwarz	831782/02	480062	Calibration not necessary	
24	CW Generator Microwave	83650L	Agilent	3844A00554	480333	22.02.2022	02.2024
25	RF cable	SF106B/11N/11N/4500.0	Huber & Suhner	500218/6B	482415	Calibration not necessary	

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA/RSM	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	03.03.2021	02.03.2023
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	25.02.2021	24.02.2023

9 Report History

Report Number	Date	Comment
F221513E3	06.03.2023	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	6 pages
Annex B	Transmit antenna calculation	2 pages