

Test Report

Report Number:

F221512E3

Equipment under Test (EUT):

TrackView Pro Access Point

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 and 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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Country:	Denmark
Name for contact purposes:	Mr. Michael LAU SØRENSEN
Phone:	+45 44 52 05 00
eMail address:	mls@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-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISD# 3469A.

1.4 EUT (Equipment under Test)

Test object: *	Ellab TrackView Pro Access Point - 915 MHz
Model name: *	TrackView Pro Access Point
Model number: *	33002741
Order number: *	N/A
FCC ID: *	XUS-TVPAP1
IC certification number: *	8758A-TVPAP1
PMN: *	TrackView Pro Access Point
HVIN: *	66315000
FVIN: *	N/A
Serial number: *	80877831
PCB identifier: *	610000129-06
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: *	Dedicated AC/DC adaptor or PoE		
Supply voltage EUT (with AC/DC adaptor): *	$U_{nom} = 120 \text{ V}_{AC}$	$U_{min} = 100 \text{ V}_{AC}$	$U_{max} = 240 \text{ V}_{AC}$
Supply voltage EUT (with PoE): *	$U_{nom} = 48 \text{ V}_{DC}$	$U_{min} = 36 \text{ V}_{DC}$	$U_{max} = 57 \text{ V}_{DC}$
Temperature range: *	-20°C to +60°C		
Lowest / highest internal clock frequency: *	32.768 kHz / 927.5 MHz		

*: Declared by the applicant

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
Power in	2.1 mm DC power socket	-	3.0 m	No
Ethernet (with PoE)	RJ45	RJ45	3.0 m	Yes
USB (service interface only)	USB type B	USB type A	-	Yes
Relay output	MDC-036-R	-	Not used	-
Relay output	MDC-036-R	-		-

LoRa frequencies			
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
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		
Fulfil radio specification: *1	LoRa WAN	
Radio chip: *1	SEMTECH SX1276	
Antenna type: *1	Internal screw type antenna for each transmitter	
Antenna name: *1	Adactus ADA-901-868-925	
Antenna gain: *2	-13.8 dBd	
Antenna connector: *1	Internal UFL	
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	16

*1: Declared by the applicant

*2: Based on the antenna test, see 0 for details

1.5.1 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
Laptop: *1	Type Lenovo 20KH-006FMD18/08 with software Trackview Pro Link
PoE injector *2	PowerDesine Type 3001

Ancillary Equipment	
AC/DC adaptor (dedicated) *1	Ideal power model DYS818-120150W

*1: Provided by the applicant

*2: Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	02.02.2023
Start of test:	22.02.2022
End of test:	01.03.2023

2 Operational States

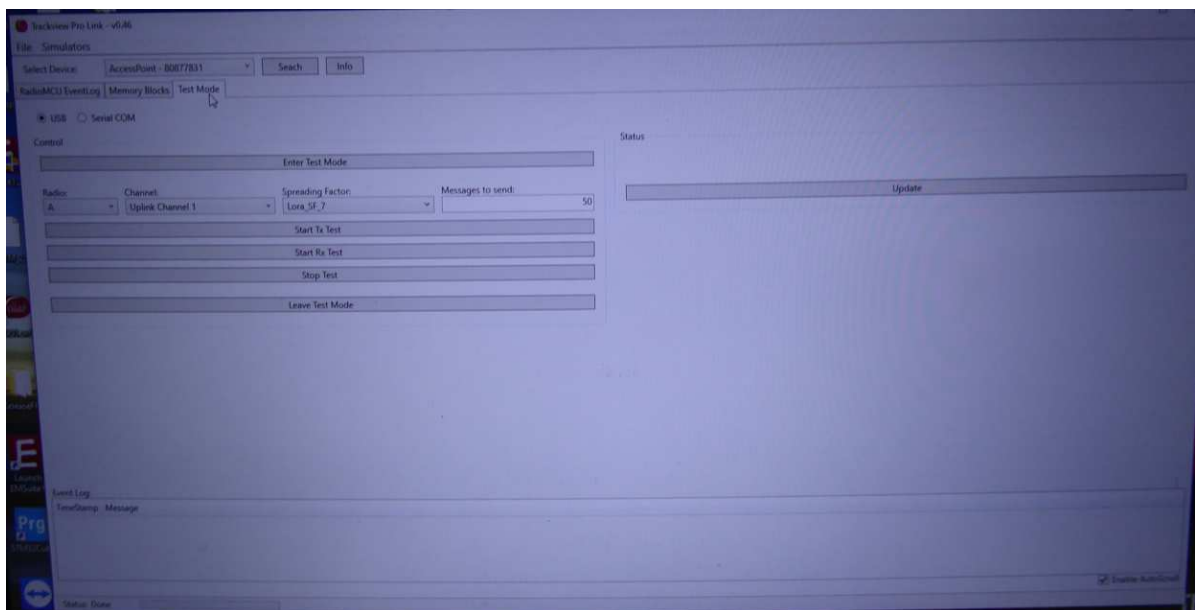
2.1 Description of function of the EUT

The EUT is a gateway for multiple data loggers to transfer data to a cloud-based software solution. It contains two transceivers with internal antennas, operating independent from each other. As declared by the applicant, the transmitters will not transmit on the same time.

All tests were carried out with an unmodified test sample.

If not otherwise stated, during the tests the EUT was supplied with 12 V_{DC} by the dedicated AC/DC adaptor, which was supplied by an AC mains network with 120 V_{AC} / 60 Hz.

The operation mode of the EUT could be adjusted via a laptop computer with a special software as provided by the applicant (Trackview Pro Link – v0.46), connected via USB. 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 transmitter, the TX channel and the spreading factor could be set. The output power was set by the firmware on the EUT and could not be changed by the test software.



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	Not adjustable
2	LoRa	914.2	71	SF7	5470	
3	LoRa	927.5	(8)7	SF7	5470	
4	LoRa	903.0	64	SF8	3125	
5	LoRa	914.2	71	SF8	3125	
6	LoRa	927.5	(8)7	SF8	3125	

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 results of the receiver measurements were documented in a separate test report with the PHOENIX TESTLAB reference F221512E4.

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

4 Overview

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

*: 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

5 Results

5.1 Test setups

5.1.1 Radiated: 9 kHz to 30 MHz

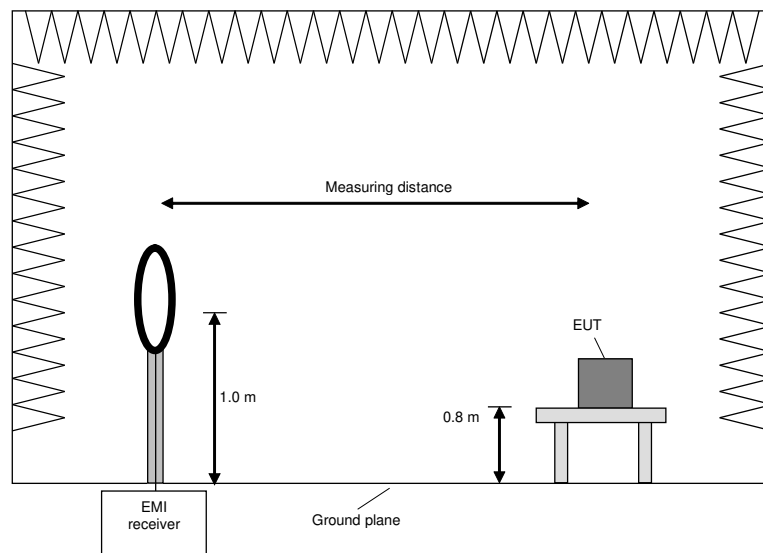
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

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.

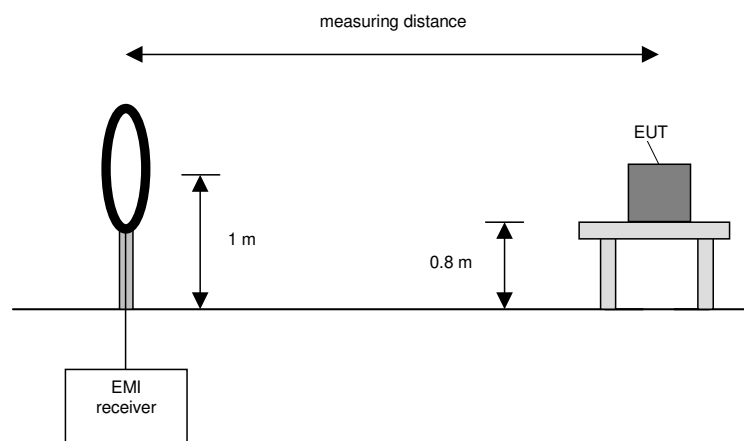
5.1.1.2 Final measurement 9 kHz to 30 MHz

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

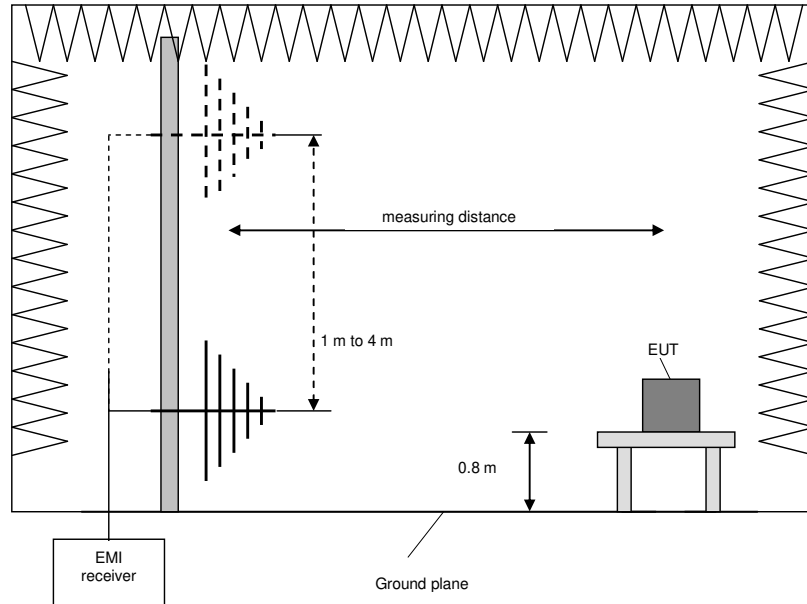
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

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:

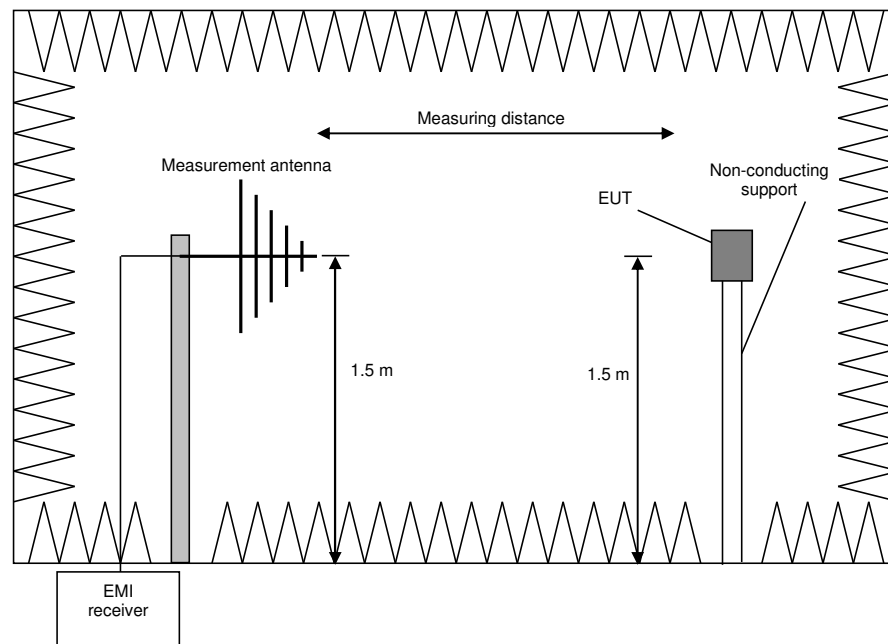
- 1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
- 2) The software determines the exact peak frequencies by doing a partial scan with reduced step size of the pre-scan of the selected peaks.
- 3) If the EUT is portable or ceiling mounted, find the worst-case 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.

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

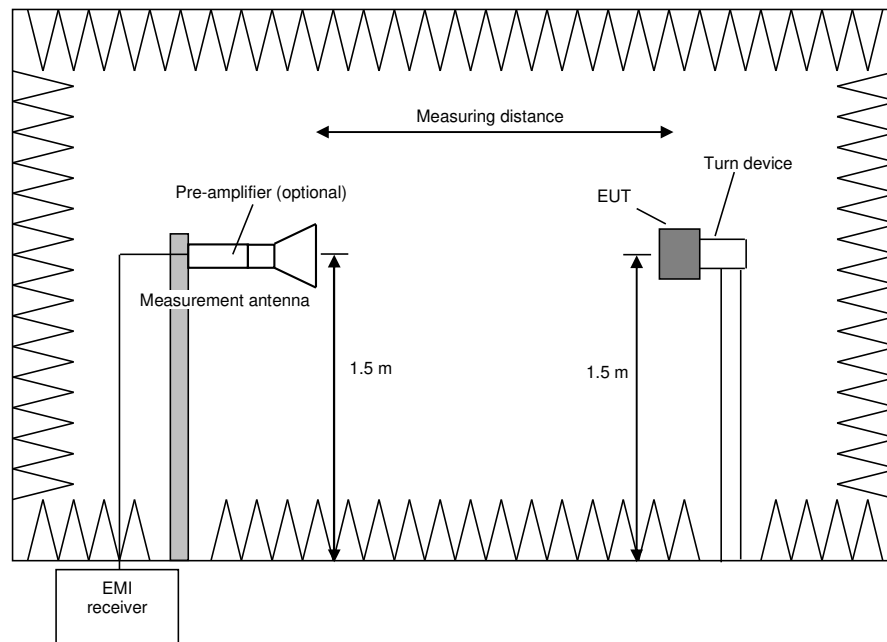
5.1.4.1 Preliminary and final measurement 1 to 40 GHz

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.

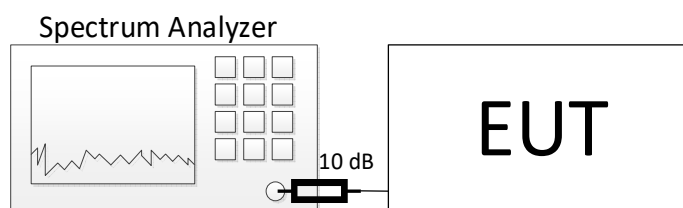
Procedure final measurement:

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"/>	Internal antenna connector	-
<input type="checkbox"/>	Normal antenna connector	-



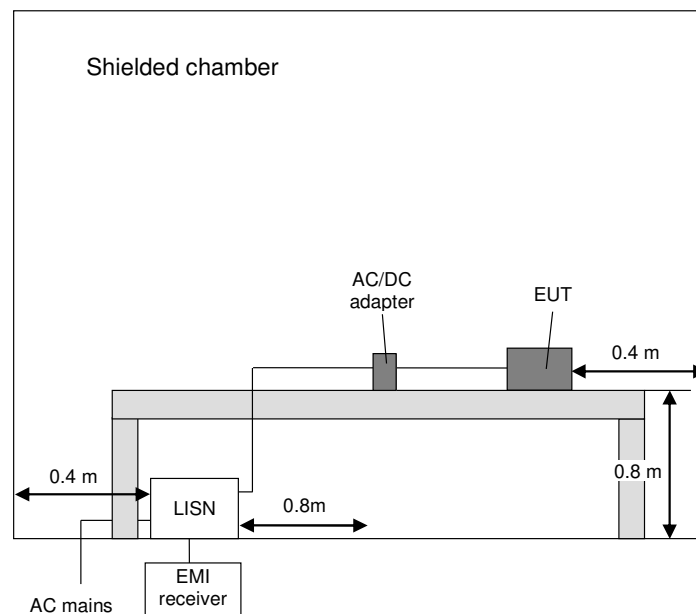
The 10 dB external attenuation are considered in all relevant plots.

5.1.6 Conducted: AC power line

The test is carried out in a shielded chamber. 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 above the ground plane. Floor-standing devices are placed directly on the ground plane. In case of DC powered equipment, which is not exclusively powered by a battery, it is connected to the LISN via a suitable AC/DC adaptor. The setup of the equipment under test is in accordance with [1].

The frequency range 150 kHz to 30 MHz is measured with an EMI receiver set to MAX hold mode with Peak and Average detectors and a resolution bandwidth of 9 kHz. A scan is carried out on the phase and neutral line of the AC mains network. If emissions less than 10 dB below the appropriate limit are detected, these emissions are measured with an Average and Quasi-Peak detector on all lines.

Frequency range	Resolution bandwidth	Measuring time
150 kHz to 30 MHz	9 kHz	5 s



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	-

5.3.3 Test results (Transmit antenna performance considerations)

Ambient temperature:	21 °C
Relative humidity:	19 %

Date:	27.02.2023
Tested by:	Th. KÜHN

Transmitter A				
	903.0 [MHz]	914.2 [MHz]	927.5 [MHz]	
Conducted output power [dBm]	14.6	14.4	14.3	
Radiated ERP [dBm ERP]	-2.4	-5.0	-6.1	
Antenna Gain [dBd]	-17.0	-19.4	-20.3	
Position of maximum gain	Azimuth	172 °	170 °	45 °
	Elevation	0 ° (pos. 1)	0 ° (pos. 1)	90 ° (pos 2.)
	Polarisation	Horizontal	Horizontal	Horizontal

Result (Transmitter A antenna performance considerations)		
Integral antenna	Antenna gain \leq 6dBi	Comment
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Max gain -17.0 dBd	No output power reduction necessary

TransmitterB				
	903.0 [MHz]	914.2 [MHz]	927.5 [MHz]	
Conducted output power [dBm]	14.4	14.3	14.1	
Radiated ERP [dBm ERP]	0.6	-0.6	-0.5	
Antenna Gain [dBd]	-13.8	-14.9	-14.6	
Position of maximum gain	Azimuth	334 °	336 °	334 °
	Elevation	0 ° (pos. 1)	0 ° (pos. 1)	0 ° (pos. 1)
	Polarisation	Horizontal	Horizontal	Horizontal

Result (Transmitter A antenna performance considerations)		
Integral antenna	Antenna gain \leq 6dBi	Comment
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> Max gain -13.8 dBd	No output power reduction necessary

Test equipment (please refer to chapter 7 for details)
1, 12 – 18, 20, 22, 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)

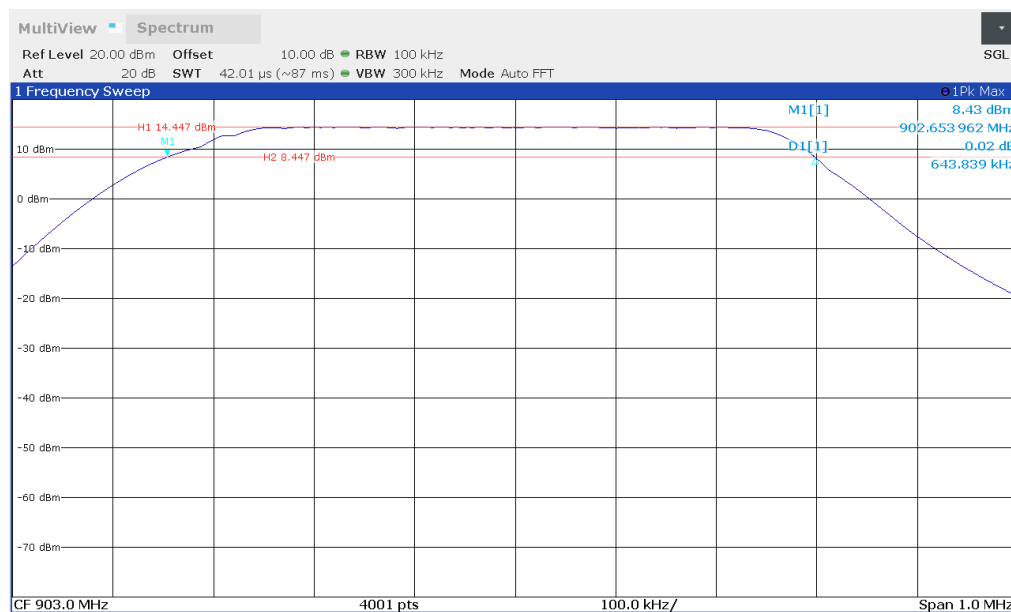
Test method (DTS bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	11.8.1	Option 1	No limitations	-
<input type="checkbox"/>	11.8.2	Option 2	No limitations	6 dB down function

5.4.3 Test results (DTS bandwidth, transmitter A)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	01.03.2023
Tested by:	Th. KÜHN

Worst case plot (operation mode #1)



Operation mode #	DTS bandwidth [MHz]	Minimum DTS bandwidth Limit [MHz]
1	0.644	0.5
2	0.655	0.5
3	0.645	0.5
4	0.688	0.5
5	0.679	0.5
6	0.657	0.5

Test result: Passed

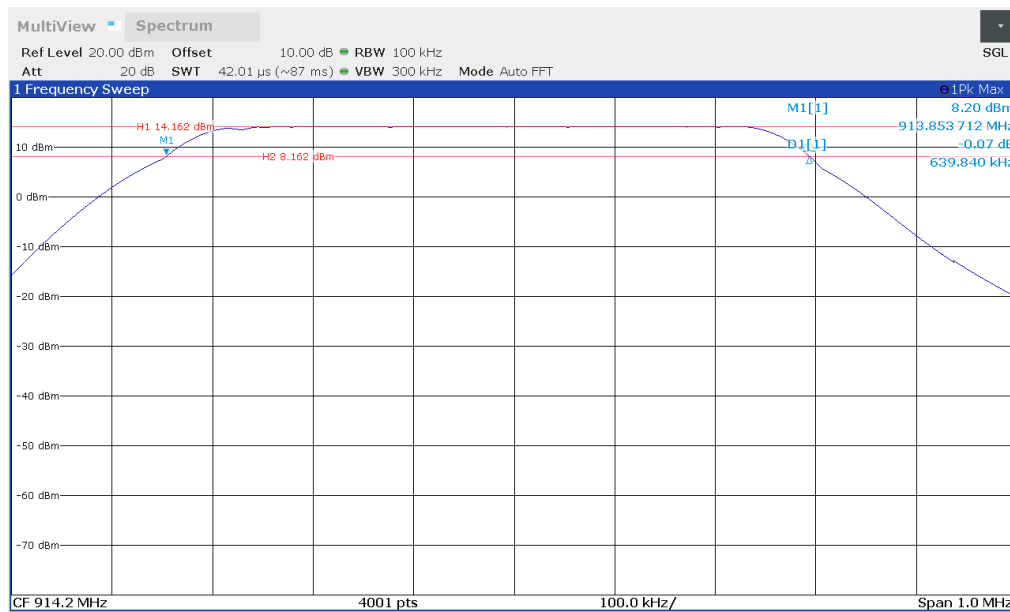
Test equipment (please refer to chapter 7 for details)
1

5.4.4 Test results (DTS bandwidth, transmitter B)

Ambient temperature:	23 °C
Relative humidity:	16 %

Date:	28.02.2023
Tested by:	Th. KÜHN

Worst case plot (operation mode #5)



Operation mode #	DTS bandwidth [MHz]	Minimum DTS bandwidth Limit [MHz]
1	0.681	0.5
2	0.643	0.5
3	0.641	0.5
4	0.684	0.5
5	0.640	0.5
6	0.644	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

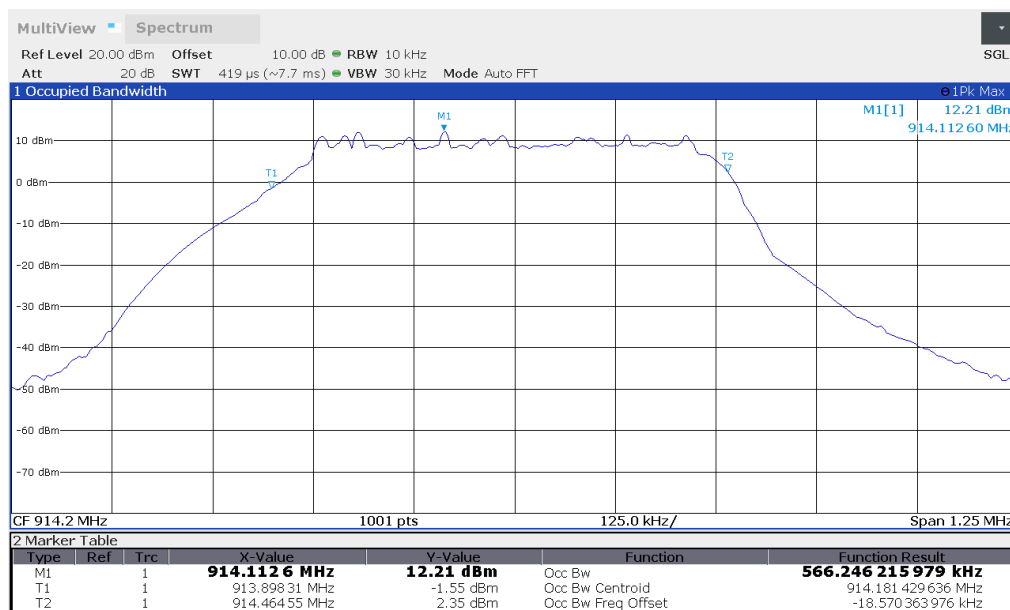
*1: See RSS-GEN Issue 5 (2018-05) sub-clause 6.7 for details.

5.5.3 Test results (Occupied bandwidth – power bandwidth (99%), transmitter A)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	01.03.2023
Tested by:	Th. KÜHN

Worst case plot (operation mode #5):



Operation mode #	99% bandwidth [MHz]
1	0.604
2	0.596
3	0.598
4	0.585
5	0.566
6	0.588

Test result: Passed

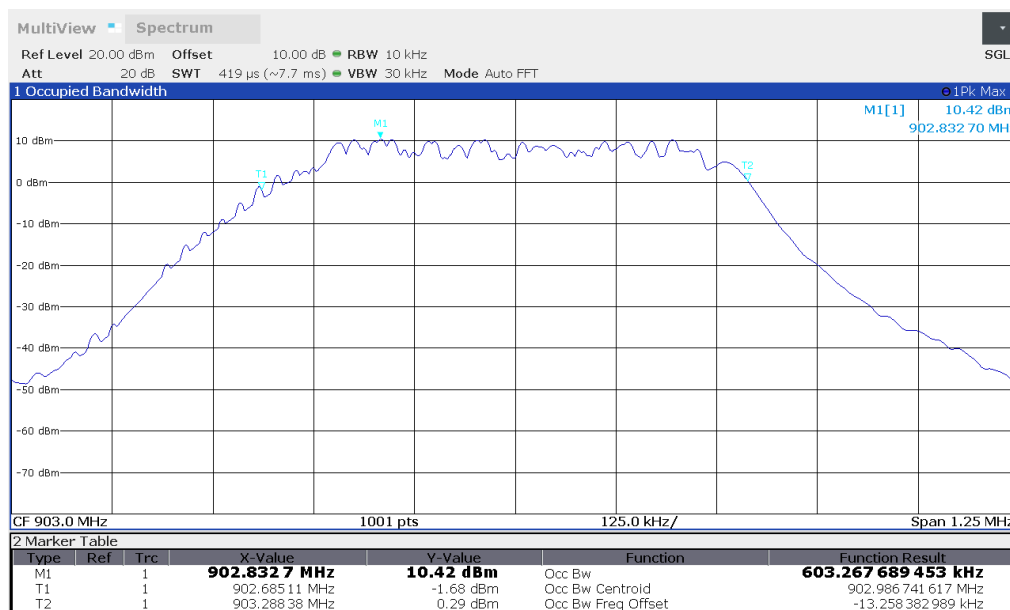
Test equipment (please refer to chapter 7 for details)
1

5.5.4 Test results (Occupied bandwidth – power bandwidth (99%), transmitter B)

Ambient temperature:	23 °C
Relative humidity:	16 %

Date:	28.02.2023
Tested by:	Th. KÜHN

Worst case plot (operation mode #1):



Operation mode #	99% bandwidth [MHz]
1	0.603
2	0.601
3	0.588
4	0.602
5	0.598
6	0.593

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	-	-

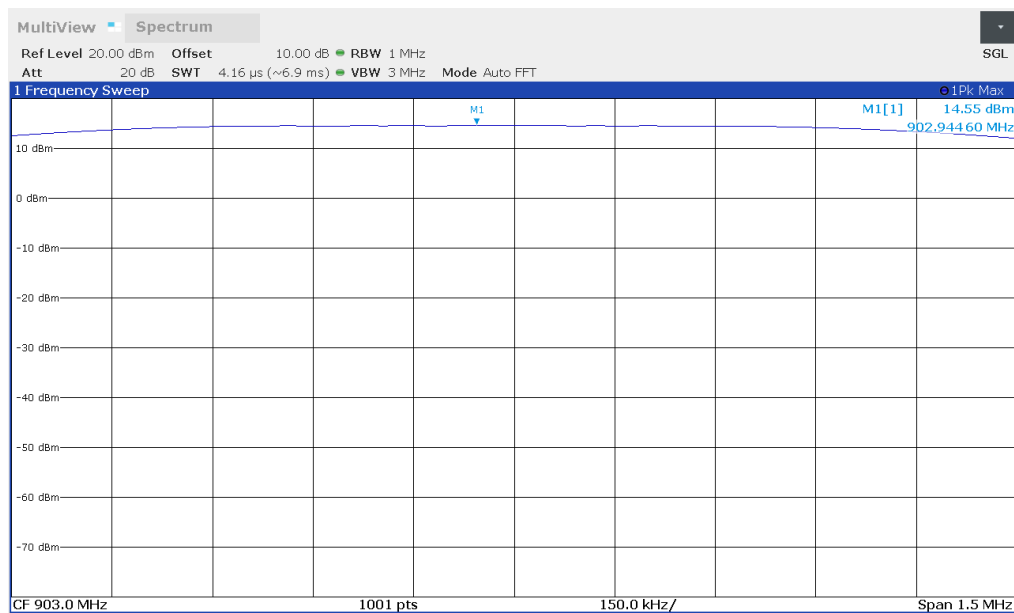
5.6.3 Test results (DTS fundamental emission output power, transmitter A)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	01.03.2023
Tested by:	Th. KÜHN

5.6.3.1 Maximum peak conducted output power (transmitter A):

Worst case plot (operation mode #4):

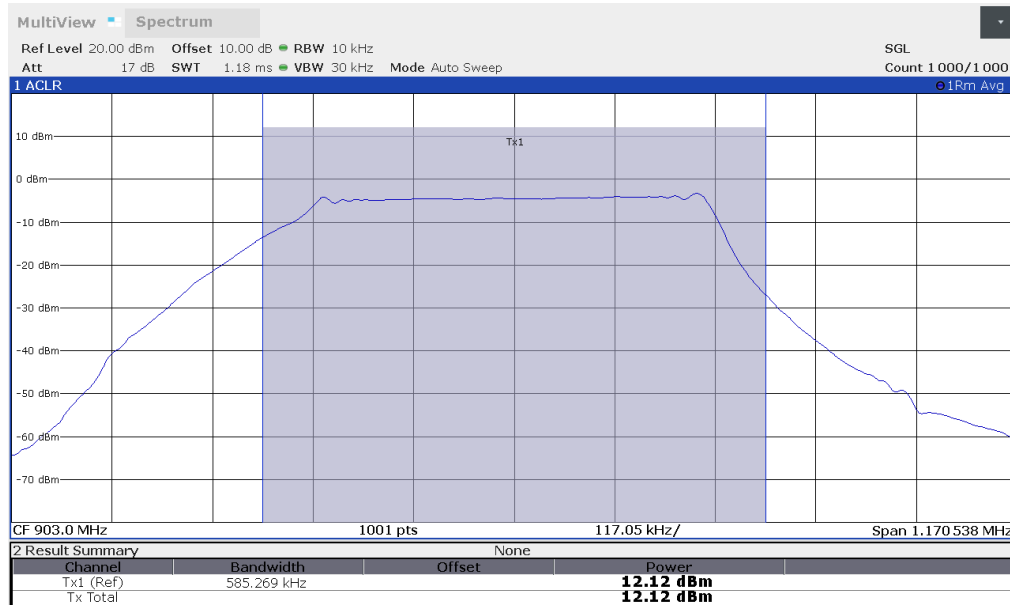


Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]
1	14.5	0.0	14.5	30
2	14.4	0.0	14.4	30
3	14.3	0.0	14.3	30
4	14.6	0.0	14.6	30
5	14.4	0.0	14.4	30
6	14.3	0.0	14.3	30

Test result: Passed

5.6.3.2 Maximum conducted (average) output power (transmitter A)

Worst case plot (operation mode #4):



Operation mode	Reading [dBm]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm]	Antenna gain [dBd]	ERP [dBm]	Limit [dBm]
1	9.8	0.0	0.0	9.8	-17.0	-7.2	30
2	10.1	0.0	0.0	10.1	-19.4	-9.3	30
3	10.0	0.0	0.0	10.0	-20.3	-10.3	30
4	12.1	0.0	0.0	12.1	-17.0	-4.9	30
5	11.5	0.0	0.0	11.5	-19.4	-7.9	30
6	11.1	0.0	0.0	11.1	-20.3	-9.2	30

Test result: Passed

Test equipment (please refer to chapter 7 for details)

1

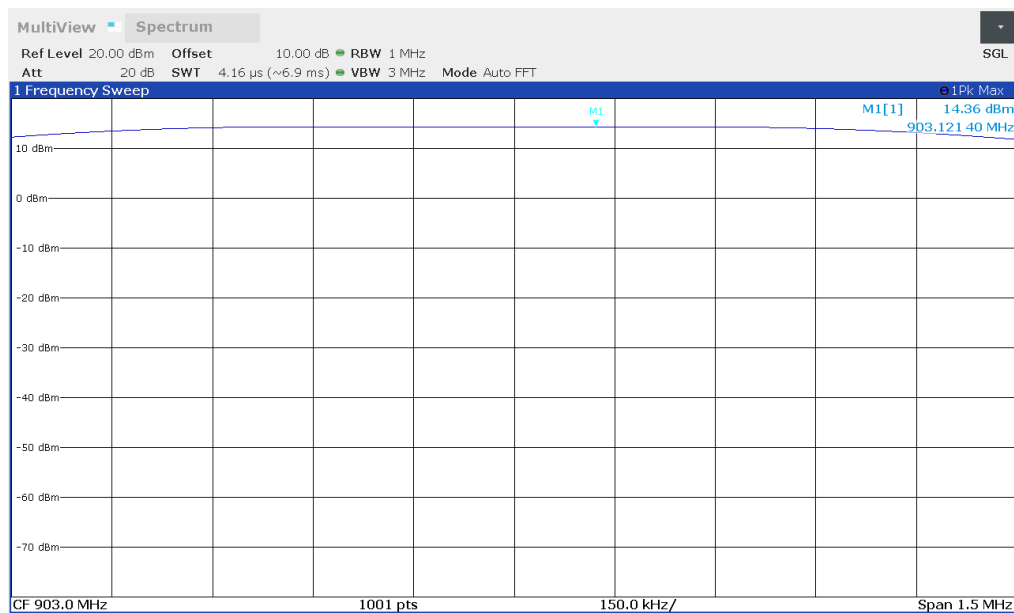
5.6.4 Test results (DTS fundamental emission output power, transmitter B)

Ambient temperature:	23 °C
Relative humidity:	16 %

Date:	28.02.2023
Tested by:	Th. KÜHN

5.6.4.1 Maximum peak conducted output power (transmitter B):

Worst case plot (operation mode #1):

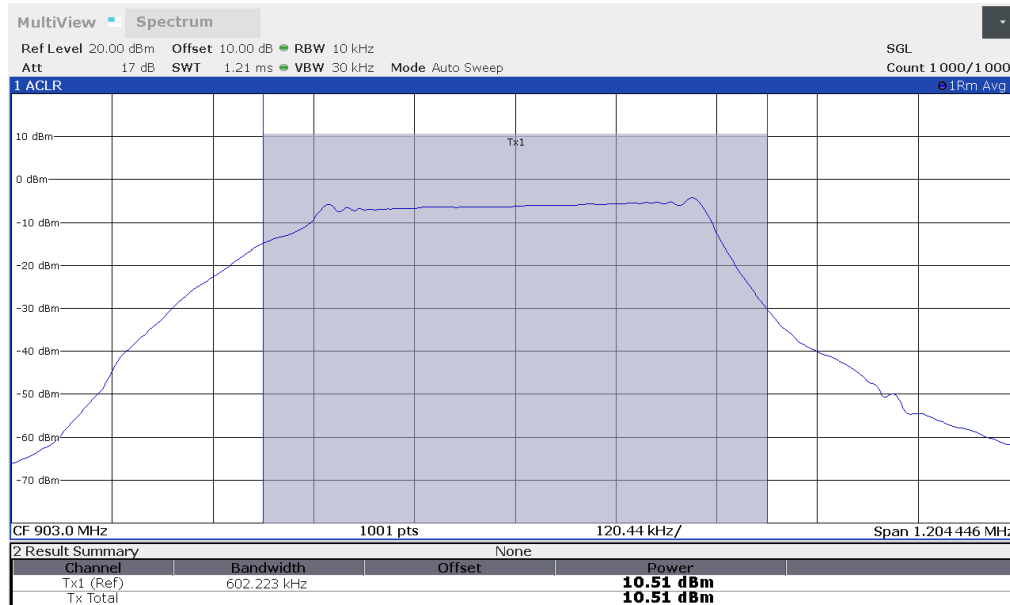


Operation mode	Reading [dBm]	Corr. Fact. [dB]	Result [dBm]	Limit [dBm]
1	14.4	0.0	14.4	30
2	14.3	0.0	14.3	30
3	14.1	0.0	14.1	30
4	14.4	0.0	14.4	30
5	14.3	0.0	14.3	30
6	14.2	0.0	14.2	30

Test result: Passed

5.6.4.2 Maximum conducted (average) output power (transmitter B)

Worst case plot (operation mode #4):



Operation mode	Reading [dBm]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm]	Antenna gain [dBd]	ERP [dBm]	Limit [dBm]
1	10.2	0.0	0.0	10.2	-13.8	-3.6	30
2	10.0	0.0	0.0	10.0	-14.9	-4.9	30
3	10.9	0.0	0.0	10.9	-14.6	-3.7	30
4	10.5	0.0	0.0	10.5	-13.8	-3.3	30
5	11.0	0.0	0.0	11.0	-14.9	-3.9	30
6	10.7	0.0	0.0	10.7	-14.6	-3.9	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	-

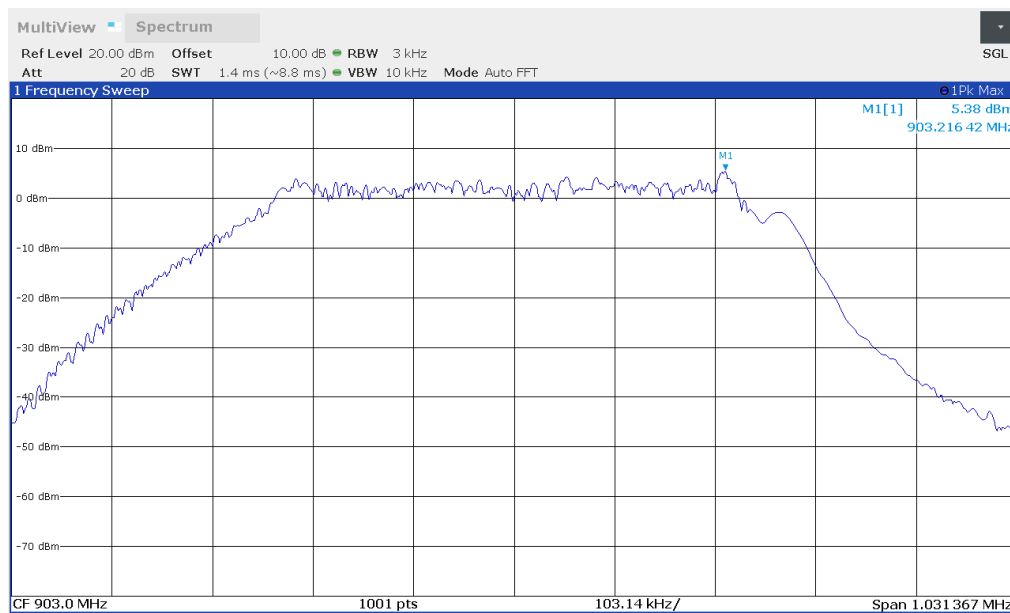
5.7.3 Test results (DTS maximum PSD level in the fundamental emission, transmitter A)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	01.03.2023
Tested by:	Th. KÜHN

5.7.3.1 Maximum peak PSD, transmitter A

Worst case plot (operation mode #4):

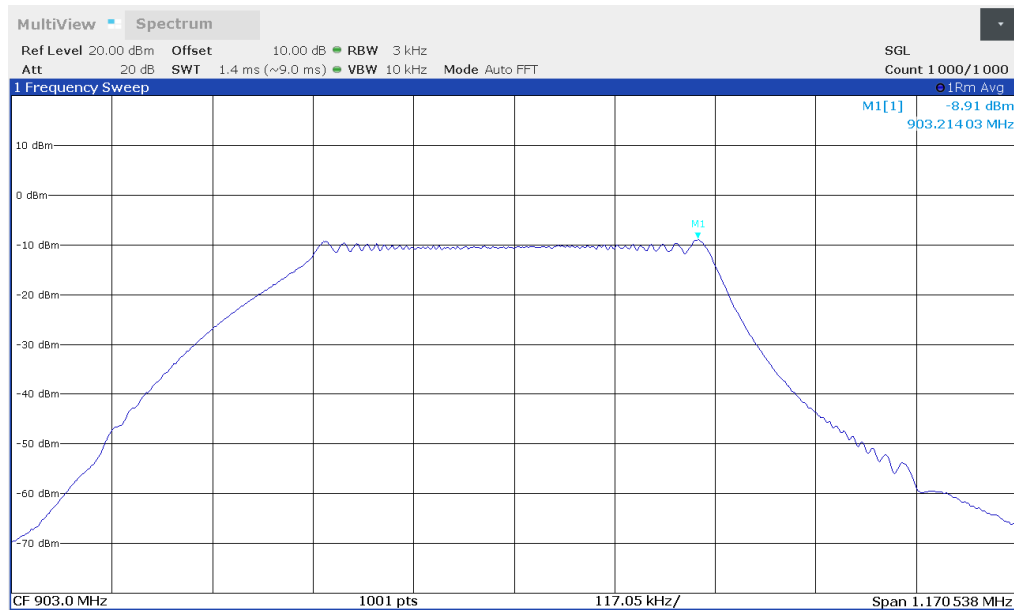


Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	2.4	0.0	2.4	8.0
2	2.7	0.0	2.7	8.0
3	1.8	0.0	1.8	8.0
4	5.4	0.0	5.4	8.0
5	5.2	0.0	5.2	8.0
6	5.0	0.0	5.0	8.0

Test result: Passed

5.7.3.2 Maximum average PSD, transmitter A

Worst case plot (operation mode #4):



Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-9.9	0.0	0.0	-9.9	8.0
2	-10.2	0.0	0.0	-10.2	8.0
3	-9.9	0.0	0.0	-9.9	8.0
4	-8.9	0.0	0.0	-8.9	8.0
5	-8.9	0.0	0.0	-8.9	8.0
6	-9.0	0.0	0.0	-9.0	8.0

Test result: Passed

Test equipment (please refer to chapter 7 for details)

1

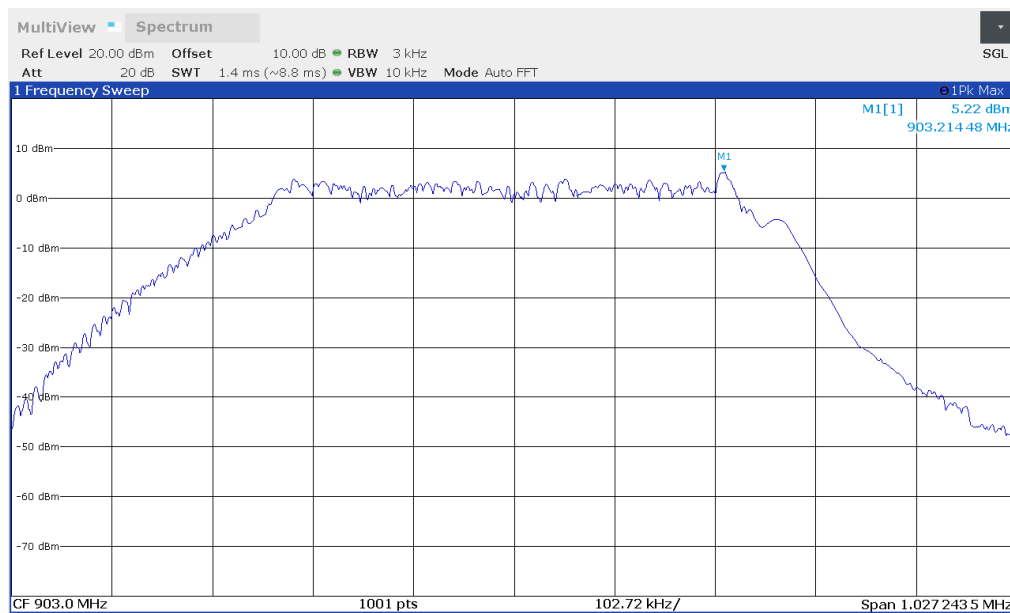
5.7.4 Test results (DTS maximum PSD level in the fundamental emission, transmitter B)

Ambient temperature:	23 °C
Relative humidity:	16 %

Date:	28.02.2023
Tested by:	Th. KÜHN

5.7.4.1 Maximum peak PSD, transmitter B

Worst case plot (operation mode #4):

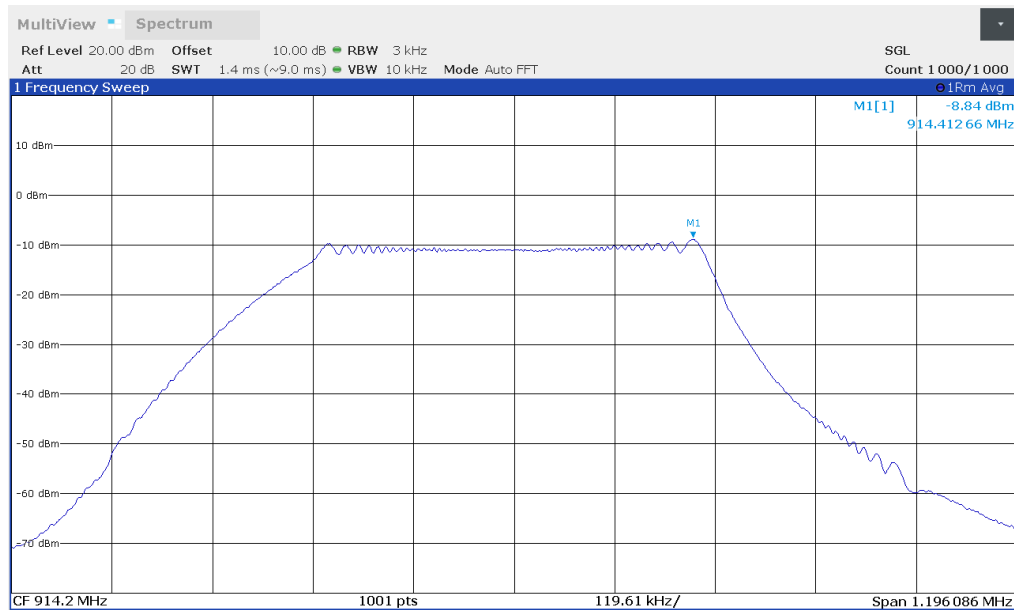


Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	2.6	0.0	2.6	8.0
2	2.4	0.0	2.4	8.0
3	4.7	0.0	4.7	8.0
4	5.2	0.0	5.2	8.0
5	5.1	0.0	5.1	8.0
6	5.0	0.0	5.0	8.0

Test result: Passed

5.7.4.2 Maximum average PSD, transmitter B

Worst case plot (operation mode #5):



Operation mode	Reading [dBm/3 kHz]	Corr. Fact. [dB]	DCCF [dB]	Result [dBm/3 kHz]	Limit [dBm/3 kHz]
1	-10.4	0.0	0.0	-10.4	8.0
2	-10.0	0.0	0.0	-10.0	8.0
3	-9.3	0.0	0.0	-9.3	8.0
4	-9.1	0.0	0.0	-9.1	8.0
5	-8.8	0.0	0.0	-8.8	8.0
6	-9.2	0.0	0.0	-9.2	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

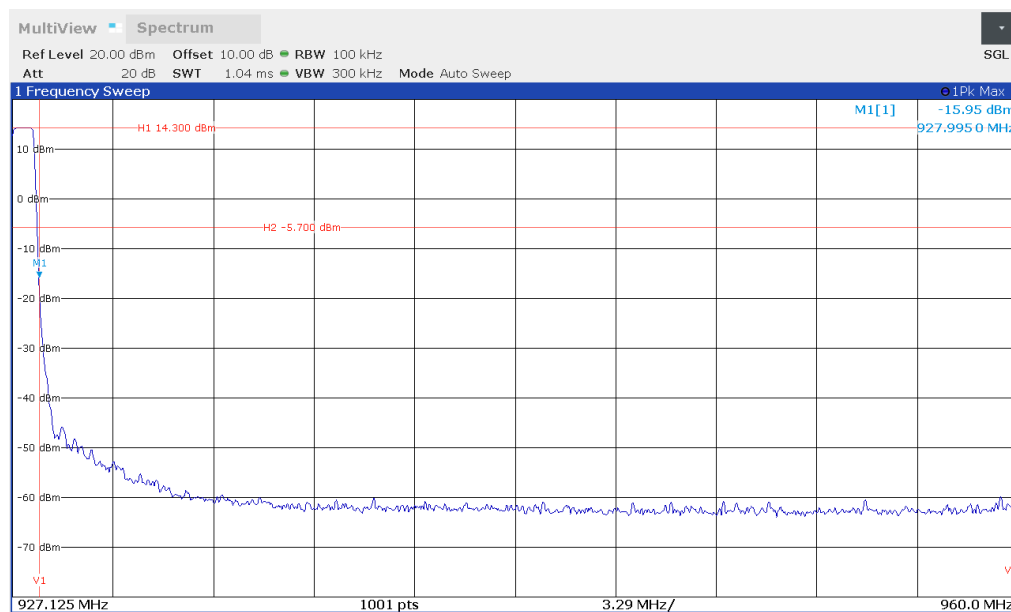
- *1: As declared in "47 CFR 15.247(d)" In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth 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, transmitter A)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	01.03.2023
Tested by:	Th. KÜHN

Worst case plot Upper band edge (operation mode #6):



Lower band edge (operation mode 1 and 4):

Operation mode	Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
1	901.781	14.5	-5.5	-44.2	38.7
4	901.858	14.5	-5.5	-46.0	40.5

Upper band edge (operation mode 3 and 6):

Operation mode	Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
3	927.995	14.3	-5.7	-16.6	10.9
6	927.995	14.3	-5.7	-16.0	10.3

Test result: Passed

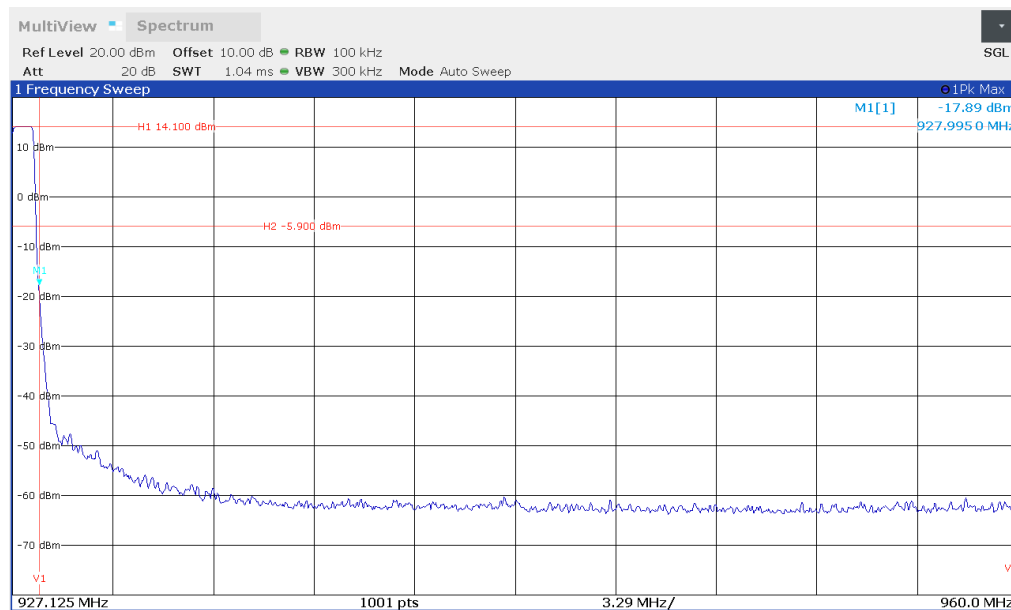
Test equipment (please refer to chapter 7 for details)
1

5.8.4 Test results (Band edge – unrestricted bands, transmitter B)

Ambient temperature:	23 °C
Relative humidity:	16 %

Date:	28.02.2023
Tested by:	Th. KÜHN

Worst case plot Upper band edge (operation mode #6):



Lower band edge (operation mode 1 and 4):

Operation mode	Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
1	901.858	14.3	-5.7	-42.7	37.0
4	901.991	14.4	-5.6	-44.4	38.8

Upper band edge (operation mode 3 and 6):

Operation mode	Frequency [MHz]	Reference [dBm]	Limit [dBm]	Unrestricted band emission [dBm]	Margin [dB]
3	927.995	14.1	-5.9	-18.2	12.3
6	927.995	14.1	-5.9	-17.9	12.0

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
Relative humidity:	37 %

Date:	22.02.2023
Tested by:	Th. KÜHN

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).

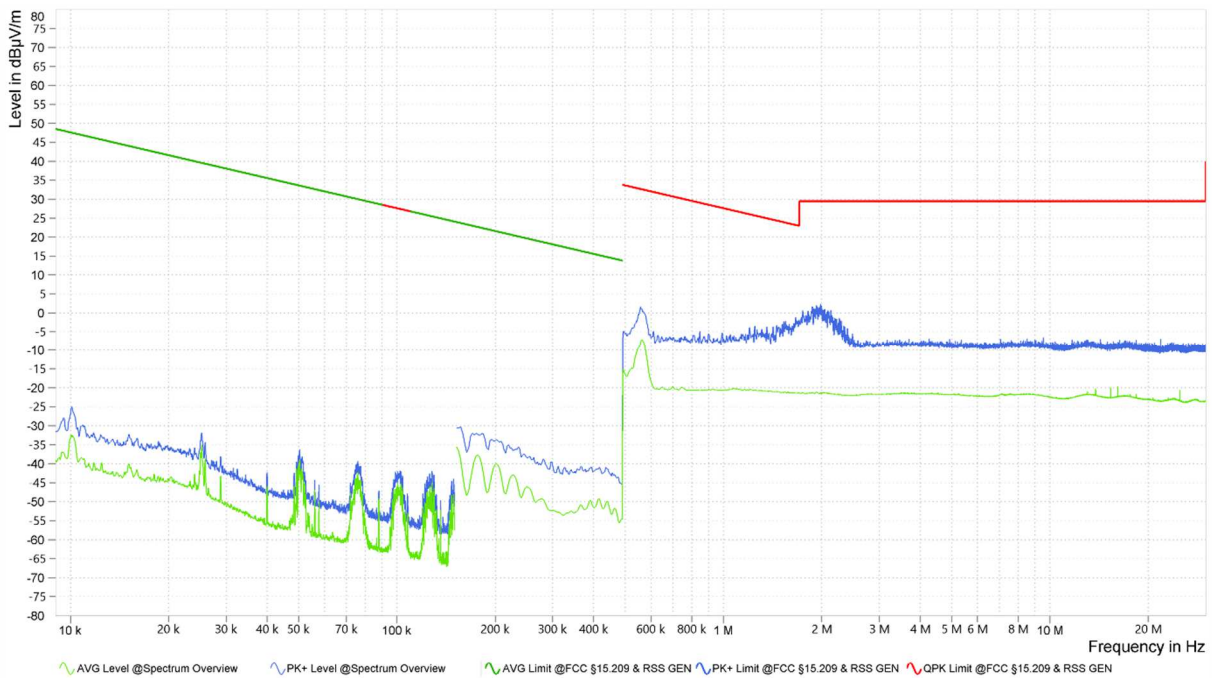
Calculations:

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

Result @ norm. dist. [dBμA/m] = Result @ norm. dist. [dBμV/m] – 20 x log₁₀ (377 Ω)

Margin [dB] = Limit [dB(μV|μA)/m] - Result [dB(μV|μA)/m]

Worst case plot: Spurious emissions from 9 kHz to 30 MHz (operation mode #2, Transmitter A):



Remark: No emissions closer 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 – 9

5.9.3.2 Test results (30 MHz – 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	37 %

Date:	22.02.2023
Tested by:	Th. KÜHN

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.

Remark: The EUT was only tested in the dedicated position (wall mounted – see test setup photographs). As pretests have shown, there is no measurable difference between SF7 and SF8 modulation, therefore, SF7 modulation was tested only.

Calculations:

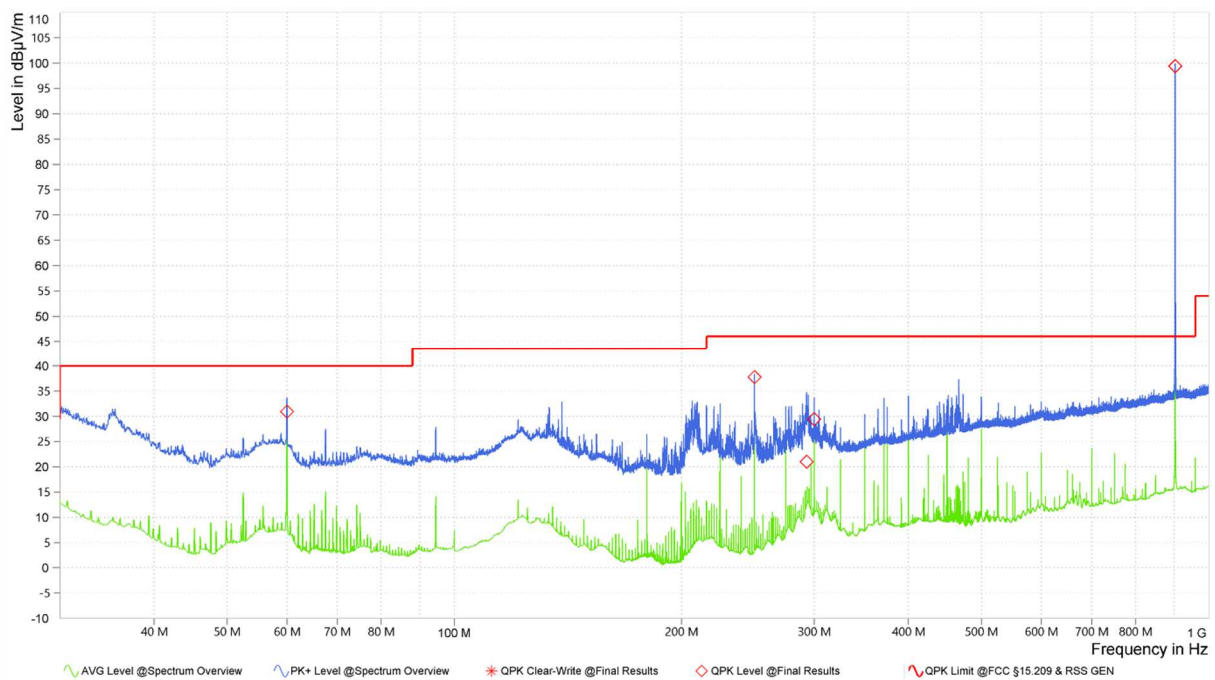
Result [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

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 #1, transmitter B):



Result tables:

(Operation mode #1, transmitter A):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	31.2	40.0	8.8	12.4	Vert.	190	175
250.020	36.4	46.0	9.6	17.3	Hor.	140	113
293.160	21.6	46.0	24.4	18.8	Hor.	141	100
300.000	30.7	46.0	15.3	19.1	Hor.	128	102
902.850	96.8	---	---	30.0	Hor.	160	193
902.850	96.8	---	---	30.0	Hor.	160	192
902.850	96.8	---	---	30.0	Hor.	160	192

(Operation mode #2, transmitter A):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	31.0	40.0	9.0	12.4	Vert.	182	199
225.030	26.6	46.0	19.4	16.3	Hor.	140	118
250.020	37.4	46.0	8.6	17.3	Hor.	240	100
300.000	29.7	46.0	16.3	19.1	Hor.	141	102
371.280	30.9	46.0	15.1	21.2	Vert.	214	100
914.070	96.4	---	---	30.3	Hor.	152	134
914.280	96.4	---	---	30.3	Hor.	152	133

(Operation mode #3, transmitter A):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	31.1	40.0	8.9	12.4	Vert.	194	171
225.030	28.4	46.0	17.6	16.3	Hor.	141	125
250.020	36.6	46.0	9.4	17.3	Hor.	242	103
300.000	30.3	46.0	15.7	19.1	Hor.	140	100
450.060	31.2	46.0	14.8	23.1	Vert.	266	110
927.360	94.9	---	---	30.2	Hor.	168	195
927.390	94.9	---	---	30.2	Hor.	168	193

(Operation mode #1, transmitter B):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	30.9	40.0	9.1	12.4	Vert.	186	182
250.020	37.8	46.0	8.2	17.3	Hor.	238	106
293.160	21.0	46.0	25.0	18.8	Hor.	138	117
300.000	29.4	46.0	16.6	19.1	Hor.	139	106
902.970	99.4	---	---	30.0	Hor.	-8.2	192
903.030	99.4	---	---	30.0	Hor.	-8.2	192

(Operation mode #2, transmitter B):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	31.1	40.0	8.9	12.4	Vert.	201	185
225.030	28.7	46.0	17.3	16.3	Hor.	132	110
250.020	37.1	46.0	8.9	17.3	Hor.	240	100
371.280	31.0	46.0	15.0	21.2	Vert.	208	100
450.060	31.3	46.0	14.7	23.1	Vert.	262	120
914.220	99.5	---	---	30.3	Hor.	208	197
914.400	99.5	---	---	30.3	Hor.	208	197

(Operation mode #3, transmitter B):

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [cm]
60.000	31.1	40.0	8.9	12.4	Vert.	204	175
225.030	27.8	46.0	18.2	16.3	Hor.	120	137
250.020	36.9	46.0	9.1	17.3	Hor.	244	102
350.040	30.6	46.0	15.4	20.7	Vert.	196	128
450.060	31.2	46.0	14.8	23.1	Vert.	266	113
927.540	100.7	---	---	30.2	Hor.	342	183
927.690	100.7	---	---	30.2	Hor.	342	182

Test result: Passed

Test equipment (please refer to chapter 7 for details)
3 – 11

5.9.3.3 Test results (radiated 1 to 10 GHz)

Ambient temperature:	22 °C
Relative humidity:	27 %

Date:	24.02.2023
Tested by:	Th. KÜHN

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.

Remark: The EUT was only tested in the dedicated position (wall mounted – see test setup photographs). As pretests have shown, there is no measurable difference between SF7 and SF8 modulation, therefore, SF7 modulation was tested only.

Calculation:

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

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

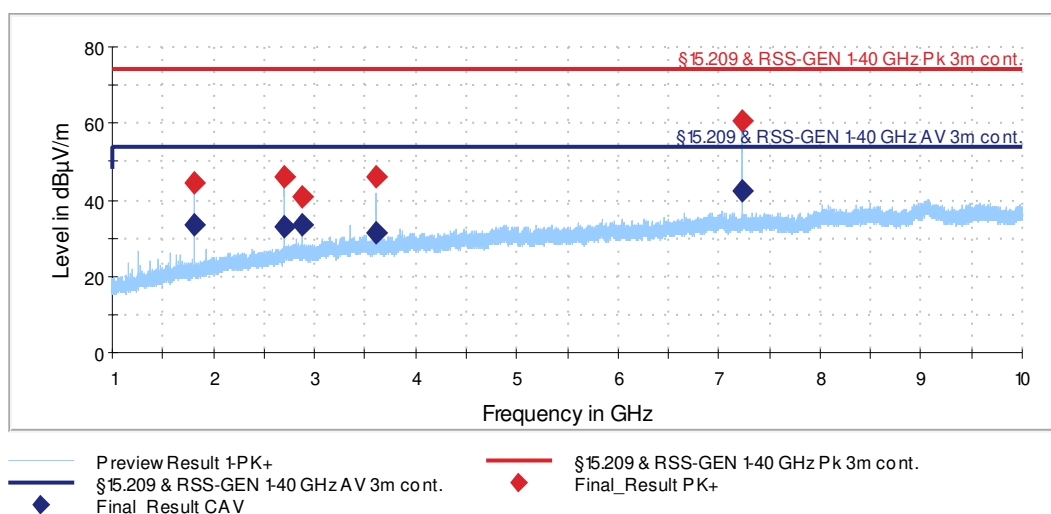
Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB] + DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

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 plot: Spurious emissions from 1 GHz to 10 GHz (operation mode #1, transmitter B):



Result tables:

Operation mode #1, transmitter A:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1806.370	49.8	74.0	24.2	37.2	54.0	16.8	-13.0	Vert	150	315	150
2709.400	43.6	74.0	30.4	30.0	54.0	24.0	-8.1	Hor.	90	239	150
2879.886	40.7	74.0	33.3	33.8	54.0	20.2	-7.9	Vert.	120	0	150
3611.770	44.8	74.0	29.2	30.7	54.0	23.3	-6.1	Vert.	120	0	150
7223.540	47.5	74.0	26.5	32.8	54.0	21.2	4.2	Vert.	150	96	150

Operation mode #2, transmitter A:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1828.239	50.6	74.0	23.4	40.0	54.0	14.0	-12.8	Vert.	150	314	150
2742.010	43.2	74.0	30.8	28.9	54.0	25.1	-7.8	Hor.	60	241	150
2879.882	41.0	74.0	33.0	33.7	54.0	20.3	-7.9	Vert.	120	0	150
3656.015	44.0	74.0	30.0	29.1	54.0	24.9	-6.0	Vert.	120	359	150

Operation mode #3, transmitter A:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1854.500	49.3	74.0	24.7	35.1	54.0	18.9	-12.7	Hor.	90	212	150
2782.642	41.1	74.0	32.9	28.7	54.0	25.3	-7.7	Vert.	0	212	150
2879.887	40.7	74.0	33.3	33.4	54.0	20.6	-7.9	Vert.	120	348	150
3708.895	42.4	74.0	31.6	27.0	54.0	27.0	-6.2	Vert.	120	0	150
9053.170	48.8	74.0	25.2	36.2	54.0	17.8	8.6	Hor.	90	141	150

Operation mode #1, transmitter B:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1805.791	44.5	74.0	29.5	33.2	54.0	20.8	-13.0	Vert.	150	355	150
2708.606	46.2	74.0	27.8	33.0	54.0	21.0	-8.1	Vert.	150	141	150
2879.883	40.9	74.0	33.1	33.7	54.0	20.3	-7.9	Vert.	120	0	150
3611.490	45.8	74.0	28.2	31.5	54.0	22.5	-6.1	Hor.	150	212	150
7223.135	60.6	74.0	13.4	42.4	54.0	11.6	4.2	Hor.	0	324	150

Operation mode #2, transmitter B:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1828.820	47.0	74.0	27.0	34.0	54.0	20.0	-12.8	Hor.	90	221	150
2742.997	45.4	74.0	28.6	31.9	54.0	22.1	-7.8	Vert.	150	118	150
2879.886	40.8	74.0	33.2	33.6	54.0	20.4	-7.9	Vert.	120	0	150
3656.400	45.5	74.0	28.5	31.4	54.0	22.6	-6.0	Vert.	120	0	150
7312.247	52.7	74.0	21.3	35.7	54.0	21.3	4.2	Hor.	0	342	150

Operation mode #3, transmitter B:

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AV Level [dBμV/m]	AV Limit [dBμV/m]	AV Margin [dB]	Correction [dB]	Polarization	Elevation [deg]	Azimuth [deg]	Antenna Height [cm]
1854.628	49.7	74.0	24.3	37.7	54.0	16.3	-12.7	Hor.	0	186	150
2783.054	44.9	74.0	29.1	30.6	54.0	23.4	-7.7	Hor.	90	107	150
2879.889	41.1	74.0	32.9	33.8	54.0	20.2	-7.9	Vert.	120	1	150
3710.299	45.2	74.0	28.8	31.6	54.0	22.4	-6.2	Vert.	90	187	150
7420.680	48.2	74.0	25.8	33.4	54.0	20.6	4.5	Hor.	0	338	150

Test result: Passed

Test equipment (please refer to chapter 7 for details)
12 – 16, 19, 21 – 25

5.10 AC power-line conducted emissions

5.10.1 Test setup (AC power-line conducted emissions)

Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Conducted: AC power line	5.1.6	-
<input type="checkbox"/>	Not applicable, because ...	-	-

5.10.2 Test method (AC power-line conducted emissions)

Used	Clause	Name of method	Sub-clause	Comment
<input checked="" type="checkbox"/>	6.2 [1], 8.8 [5]	Tabletop equipment testing	5.1.6	The EUT is DC supplied, therefore, the dedicated AC / DC adaptor was used.
<input type="checkbox"/>	6.2 [1] 8.8 [5]	Floor-standing equipment testing	-	-

Because the EUT could be supplied either by the dedicated AC/DC adaptor or via PoE, both variants were tested. The EUT was supplied either by the dedicated AC/DC adaptor Ideal power model DYS818-120150W or by an PoE injector type PowerDesine 3001. Both devices were supplied by an AC mains network with 120V_{AC} 60Hz.

5.10.3 Test results (AC power-line conducted emissions with dedicated AC/DC adaptor)

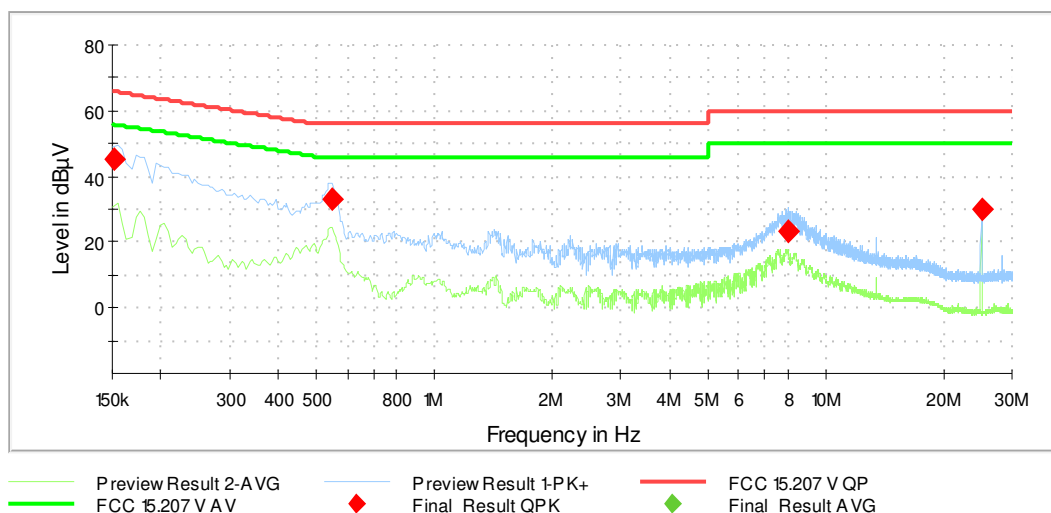
Ambient temperature:	22 °C
Relative humidity:	17 %

Date:	01.03.2023
Tested by:	Thomas KÜHN

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.

Remark: The EUT was only with the transmitter A operating in operation mode 2 with SF7 modulation.

The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.151800	44.9	---	65.9	21.0	5000	9	L1	FLO	9.8
0.546900	33.2	---	56.0	22.8	5000	9	L1	FLO	9.9
8.025000	23.4	---	60.0	36.6	5000	9	N	GND	10.5
25.002600	30.0	---	60.0	30.0	5000	9	L1	FLO	11.1

Test result: Passed

Test equipment (please refer to chapter 6 for details)
26 – 30

5.10.4 Test results (AC power-line conducted emissions with PoE injector)

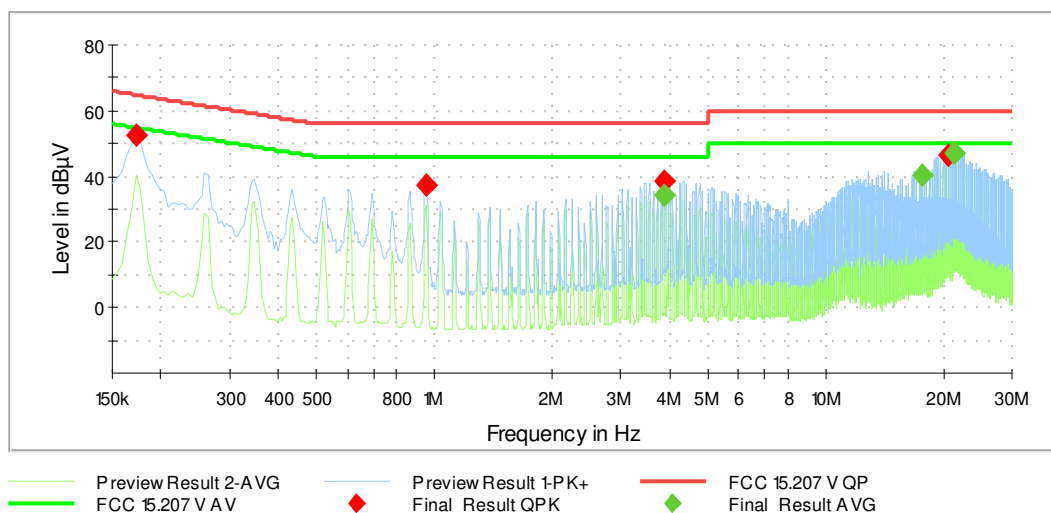
Ambient temperature:	22 °C
Relative humidity:	17 %

Date:	01.03.2023
Tested by:	Thomas KÜHN

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.

Remark: The EUT was only with the transmitter B operating in operation mode 2 with SF8 modulation.

The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆ and the average measured points by ◆.



Frequency (MHz)	QuasiPeak (dBμV)	Average (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.172500	52.7	---	64.8	12.1	5000	9	N	GND	9.8
0.950100	37.6	---	56.0	18.4	5000	9	N	FLO	9.9
3.887700	---	34.5	46.0	11.5	5000	9	N	GND	10.3
3.887700	38.4	---	56.0	17.6	5000	9	L1	GND	10.3
17.620800	---	40.7	50.0	9.3	5000	9	N	GND	10.9
20.514300	46.8	---	60.0	13.2	5000	9	L1	GND	10.9
21.302700	---	47.3	50.0	2.7	5000	9	L1	GND	10.9

Test result: Passed

Test equipment (please refer to chapter 6 for details)
26 – 31

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	100417	481912	22.02.2022	02.2024
3	RF Switch Matrix	OSP220	Rohde & Schwarz	-	482976	Calibration not necessary	
4	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
5	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
6	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
7	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
8	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
9	Test software M276	Elektra	Rohde&Schwarz	101381	483755	Calibration not necessary	
10	Attenuator 6 dB	WA2-6	Weinschel	-	482793	Calibration not necessary	
11	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
12	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
13	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
14	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
15	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
16	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024
17	Log-Per Antenna	HL 223	Rohde & Schwarz	835556/014	480123	Calibration not necessary	
18	Precision Dipole	HZ-13	Rohde & Schwarz	831782/02	480062	Calibration not necessary	
19	Log-Per Antenna	HL050	Rohde & Schwarz	100438	481170	09.10.2020	10.2023
20	Signal generator	SMB100A	Rohde & Schwarz	113140	482190	16.02.2022	02.2023
21	Position device	TDF 1.5- 10Kg	Maturo	15920215	482034	Calibration not necessary	
22	Software	EMC32 V10.60.20	Rohde & Schwarz	-	483261	Calibration not necessary	
23	High Pass Filter	WHKX12-935-1000-15000-40ST	Wainwright Instruments GmbH	12	482908	Calibration not necessary	
24	Preamplifier	AFS6-00101600-23-10P-6-R	Miteq	2011215	482333	17.02.2022	02.2024
25	RF cable	SF106B/11N/11N/4500.0	Huber & Suhner	500218/6B	482415	Calibration not necessary	
26	Transient Filter Limiter	CFL 9206A	Teseq	38268	481982	15.02.2022	02.2024
27	LISN	NSLK8128	Schwarzbeck	8128161	480138	15.02.2022	02.2024
28	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
29	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
30	EMI Receiver / Spectrum Analyser	ESIB 26	Rohde & Schwarz	100292	481182	16.02.2022	02.2024
31	Coupling / decoupling network	CDN EMV-ETH S B	PHOENIX TESTLAB	-	480449	Calibration not necessary	

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	12.05.2020	11.05.2023
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
Fully anechoic chamber M20	480303	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	17.08.2022	16.08.2024

9 Report History

Report Number	Date	Comment
F221512E3	15.03.2023	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	7 pages
Annex B	Transmit antenna calculation	3 pages