Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-0981/20-01-10

Testing laboratory

CTC advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
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Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

Applicant

Building 36 Technologies, LLC
150 A Street, Suite 104
02494-0249 Needham / UNITED STATES
Phone: 781-474-0500
Contact: Daniel Goodman
e-mail: dan@building36.com

Manufacturer

MEC electronics Entwicklung und Produktion GmbH
Dresdner Straße 45
1200 Vienna / AUSTRIA

Test standard/s

FCC - Title 47 CFR Part 15	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices

For further applied test standards please refer to section 3 of this test report.

Test Item

Kind of test item:	**Display**
Model name:	**ADC-T40-HD**
FCC ID:	**2AC3T-B36T40HDRA**
IC:	**12323A-B36T40HDRA**
Frequency band:	902 MHz – 928 MHz
Technology tested:	Z-Wave longrange
Antenna:	Integrated antenna
Power supply:	5 V DC by external power supply TT electronics DSA-13PFC-05 F
Temperature range:	+5°C to +35°C

This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

Test report authorized:

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2021.05.26 07:32:03 +02'00'

Christoph Schneider
Lab Manager
Radio Communications

Test performed:

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Tobias Wittenmeier
Testing Manager
Radio Communications

1 Table of contents

2 General information

2.1 Notes and disclaimer

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2.2 Application details

Date of receipt of order:	2021-01-27
Date of receipt of test item:	2021-05-06
Start of test:*	2021-05-14
End of test:*	2021-05-10
Person(s) present during the test:	-/-

*Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

2.3 Test laboratories sub-contracted

None

3 Test standard/s, references and accreditations

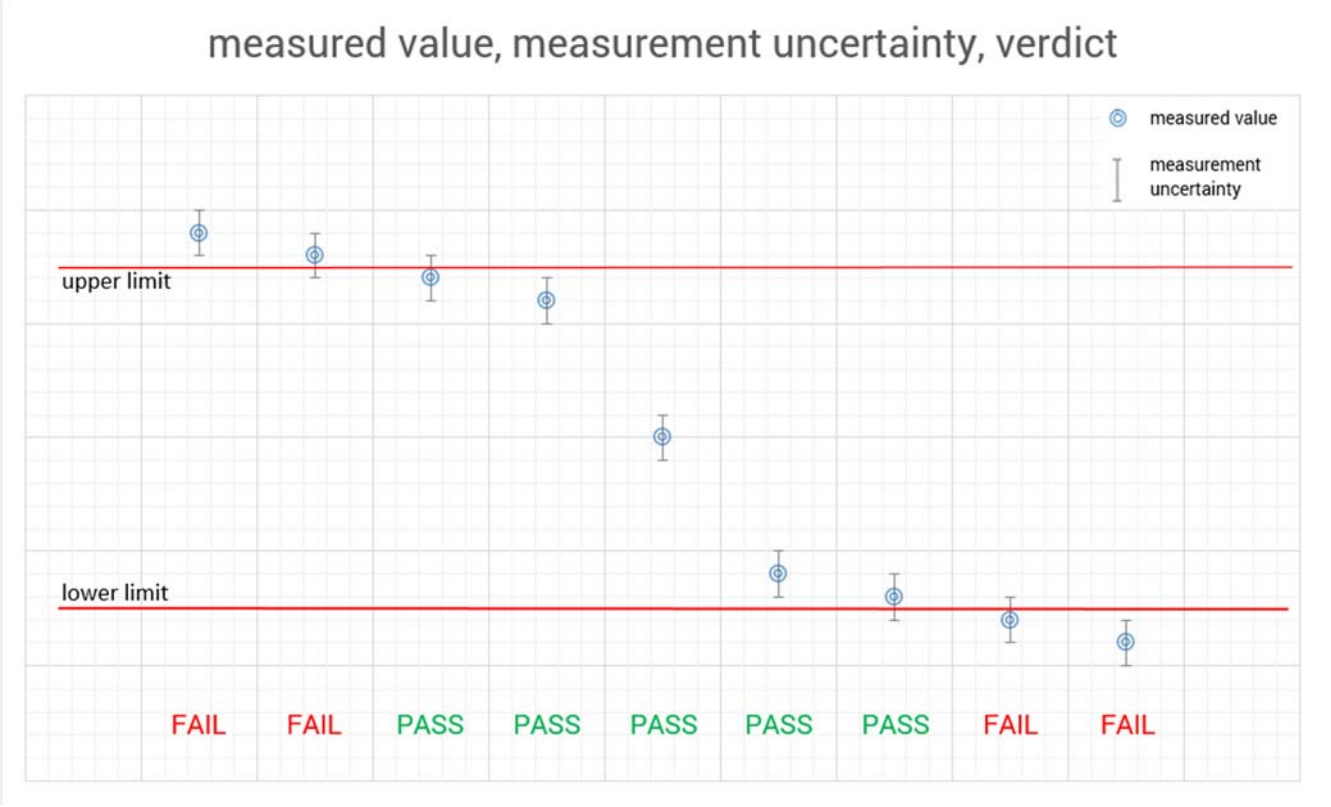
Test standard	Date	Description
FCC - Title 47 CFR Part 15		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 2	February 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices
RSS - Gen Issue 5 incl. Amendment 1 & 2	February 2021	Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus

Guidance	Version	Description
KDB 558074 D01	v05r02	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
ANSI C63.4-2014	-/-	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	-/-	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

Accreditation	Description
D-PL-12076-01-04	Telecommunication and EMC Canada https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf

4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.
The measurement uncertainty is mentioned in this test report, see chapter 9, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



5 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests No testing under extreme temperature conditions required No testing under extreme temperature conditions required
Relative humidity content	:		42 %
Barometric pressure	:		1006 hpa
Power supply	:	V_{nom} V_{max} V_{min}	5.0 V DC by external power supply TT electronics DSA-13PFC-05 F No testing under extreme temperature conditions required No testing under extreme temperature conditions required

6 Test item

6.1 General description

Kind of test item	:	Display
Model name	:	ADC-T40-HD
HMN	:	n/a
PMN	:	Display
HVIN	:	ADC-T40-HD
FVIN	:	n/a
S/N serial number	:	Rad. 1264999921110013 Cond. 1264999921110001
Hardware status	:	B36-T40-HD-Z-A
Software status	:	v1.0
Firmware status	:	-/-
Frequency band	:	902 MHz – 928 MHz
Type of radio transmission Use of frequency spectrum	: :	Modulated carrier
Type of modulation	:	(O)QPSK
Number of channels	:	2
Antenna	:	Integrated antenna
Power supply	:	5.0 V DC by external power supply TT electronics DSA-13PFC-05 F
Temperature range	:	+5°C to +35°C

6.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup and EUT photos are included in test report: 1-0981/20-01-01_AnnexA
1-0981/20-01-01_AnnexB
1-0981/20-01-01_AnnexD

7 Description of the test setup

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed. Where possible, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

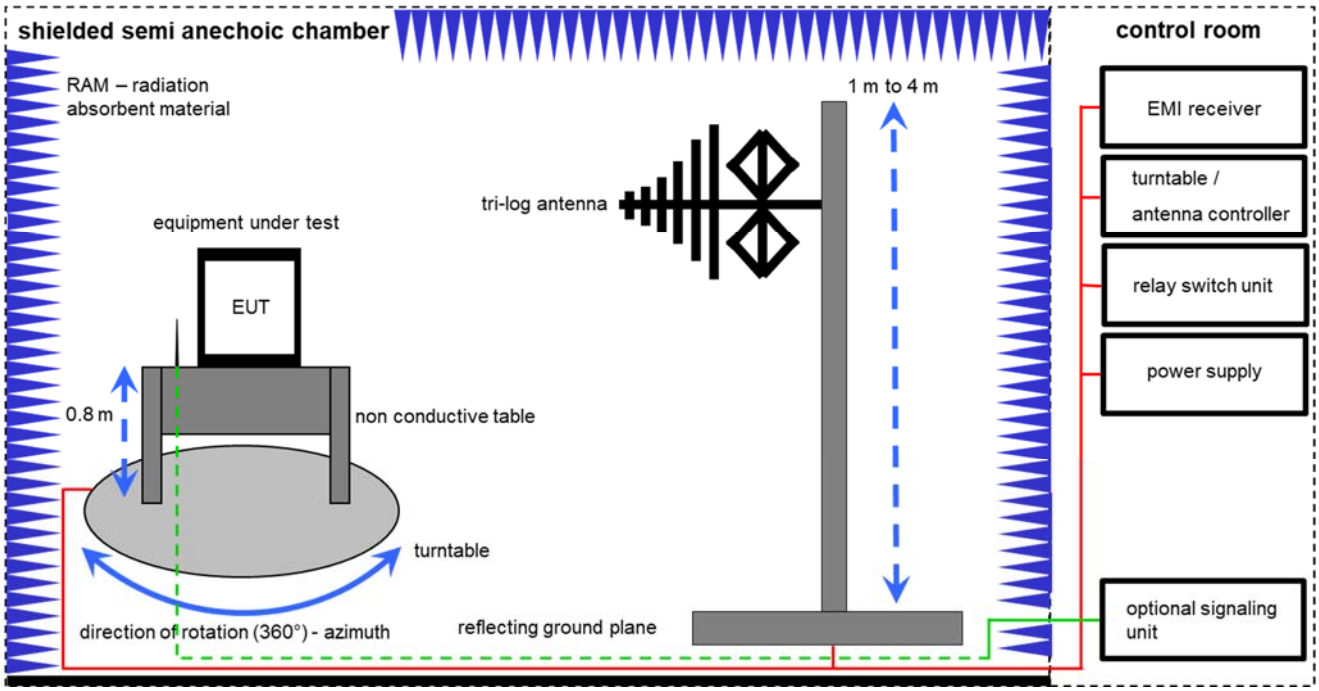
Each block diagram listed can contain several test setup configurations. All devices belonging to a test setup are identified with the same letter syntax. For example: Column Setup and all devices with an A.

Agenda: Kind of Calibration

k	calibration / calibrated	EK	limited calibration
ne	not required (k, ev, izw, zw not required)	zw	cyclical maintenance (external cyclical maintenance)
ev	periodic self verification	izw	internal cyclical maintenance
Ve	long-term stability recognized	g	blocked for accredited testing
vlkl!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

7.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter
EMC32 software version: 10.59.00

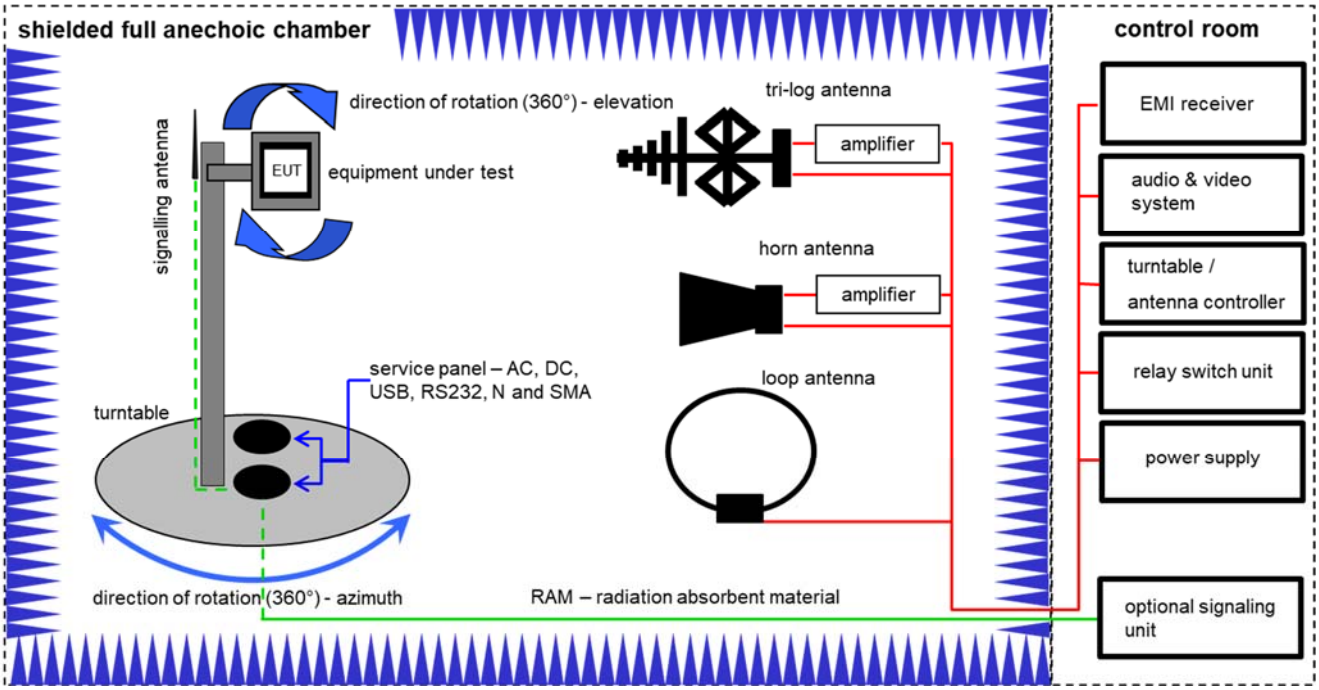
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	A	Semi anechoic chamber	3000023	MWB AG		300000551	ne	-/-	-/-
3	A	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vlKl!	17.01.2020	16.01.2022
4	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
5	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
7	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vlKl!	19.02.2021	18.02.2023
8	A	Turntable	2089-4.0	EMCO		300004394	ne	-/-	-/-
9	A	PC	TecLine	F+W		300004388	ne	-/-	-/-
10	A	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	10.12.2020	09.06.2022

7.2 Shielded fully anechoic chamber



Measurement distance: tri-log antenna and horn antenna 3 meter; loop antenna 3 meter / 1 meter

FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

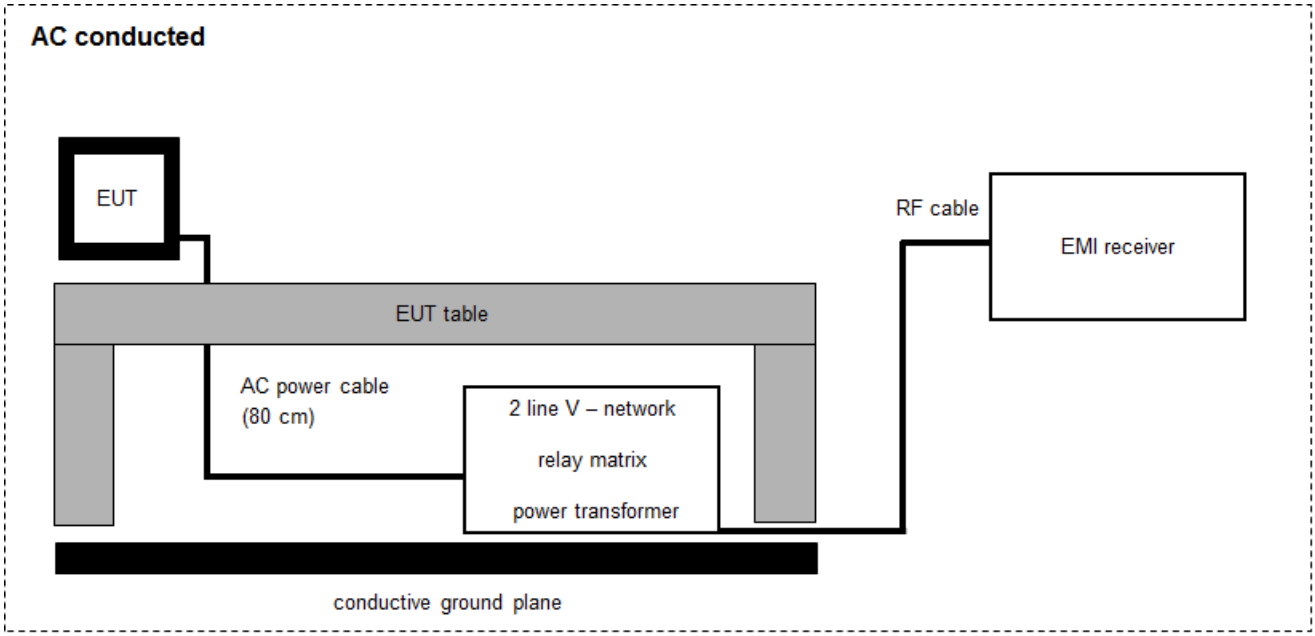
OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 µW)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vIKI!	13.06.2019	12.06.2021
2	C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3696	300001604	vIKI!	12.03.2021	11.03.2023
3	C	Highpass Filter	WHK1.1/15G-10SS	Wainwright	37	400000148	ne	-/-	-/-
4	C	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne	-/-	-/-
5	A,B,C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne	-/-	-/-
6	A,B,C	Computer	Intel Core i3 3220/3,3 GHz, Prozessor		2V2403033A54 21	300004591	ne	-/-	-/-
7	C	Highpass Filter	WHKX2.6/18G-10SS	Wainwright	12	300004651	ne	-/-	-/-
8	A,B,C	NEXIO EMV-Software	BAT EMC V3.20.0.17	EMCO		300004682	ne	-/-	-/-
9	A,B,C	Anechoic chamber		TDK		300003726	ne	-/-	-/-
10	C	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011571	300005240	ev	-/-	-/-
11	B	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	01029	300005379	vIKI!	02.07.2019	01.07.2021

7.3 AC conducted



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

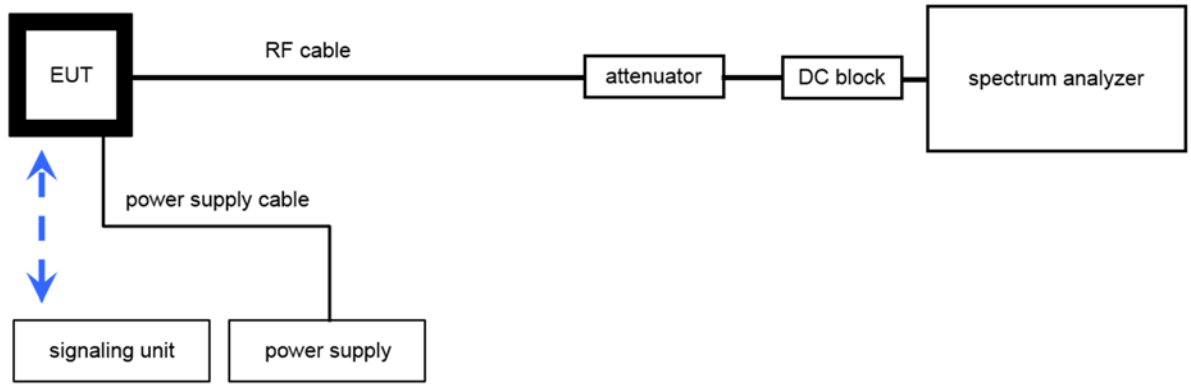
Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	892475/017	300002209	vIKI!	11.12.2019	10.12.2021
2	A	RF-Filter-section	85420E	HP	3427A00162	300002214	NK!	-/-	-/-
3	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	9.12.2021	8.12.2022
4	A	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
5	A	PC	TecLine	F+W	-/-	300003532	ne	-/-	-/-

7.4 Conducted measurements

Conducted measurements normal conditions



OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

Example calculation:
OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	RF-Cable SRD021 No. 1	Enviroflex 316 D	Huber & Suhner		400001311	ev	-/-	-/-
2	A	Spectrum Analyzer	FSV30	Rohde & Schwarz	104365	300005923	k	16.12.2020	15.12.2021

8 Sequence of testing

8.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, it is placed on a table with 0.8 m height.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement*

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

Final measurement

- Identified emissions during the pre-measurement are maximized by the software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated about its vertical axis for maximum response at each azimuth about the EUT. (For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT)
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

*)Note: The sequence will be repeated three times with different EUT orientations.

8.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position ± 45° and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

8.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height is 1.5 m.
- At each turntable position and antenna polarization the analyzer sweeps with positive peak detector to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximizes the peaks by rotating the turntable from 0° to 360°. This measurement is repeated for different EUT-table positions (0° to 150° in 30°-steps) and for both antenna polarizations.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

9 Measurement uncertainty

Measurement uncertainty	
Test case	**Uncertainty**
Antenna gain	± 3 dB
Carrier frequency separation	± 21.5 kHz
Number of hopping channels	-/-
Spectrum bandwidth	± 21.5 kHz absolute; ± 15.0 kHz relative
Maximum output power	± 1 dB
Detailed conducted spurious emissions @ the band edge	± 1 dB
Band edge compliance radiated	± 3 dB
Spurious emissions conducted	± 3 dB
Spurious emissions radiated below 30 MHz	± 3 dB
Spurious emissions radiated 30 MHz to 1 GHz	± 3 dB
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB
Spurious emissions radiated above 12.75 GHz	± 4.5 dB

10 Summary of measurement results

☒	No deviations from the technical specifications were ascertained
☐	There were deviations from the technical specifications ascertained
☐	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	47 CFR Part 15 RSS 210 Issue 10 RSS Gen Issue 5	See table!	2021-05-26	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS 210 / A8.4(2)	Antenna gain	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(e) RSS - 247 / 5.2 (b)	Power spectral density	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(a)(2) RSS Gen clause 4.6.1	Spectrum bandwidth 6dB bandwidth	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(b)(3) RSS - 247 / 5.4 (d)	Maximum output power	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance conducted	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	-/-	☒	☐	☐	☐	-/-
§§15.247(d) RSS - 247 / 5.5	TX spurious emissions conducted	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(d) RSS-210 / A8.5	TX spurious emissions radiated	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.209(a) RSS-Gen	TX spurious emissions radiated < 30 MHz	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-

Note: C = Compliant; NC = Not compliant; NA = Not applicable; NP = Not performed

11 RF measurements

11.1 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: The EUT was set to the maximum possible output power supported by the test software (value 155). Both channels were tested.

Test mode: ☒ Special software is used.
EUT is transmitting pseudo random data by itself

12 Measurement results

12.1 Maximum output power

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	5 MHz
Trace-Mode:	Max Hold
Measurement method	According to ANSI C63.10-2013 11.9.1.1 Maximum peak conducted output power
Used equipment:	See chapter 7.2B & 7.4 A
Measurement uncertainty:	See chapter 9

Limits:

FCC	IC
1 watt (30 dBm) Maximum Output Power Conducted	

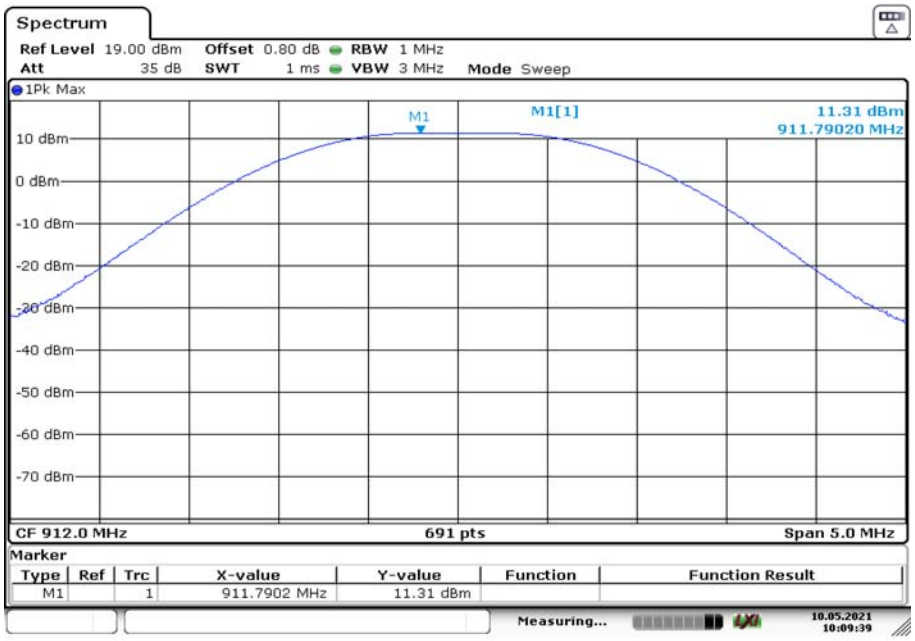
Result:

Test Conditions		Maximum Output Power Conducted / dBm		
		Low channel	-/-	High channel
T_{nom}	V_{nom}	11.3		10.0

Test Conditions		ERP / dBm		
		Low channel	-/-	High channel
T_{nom}	V_{nom}	10.4		7.8

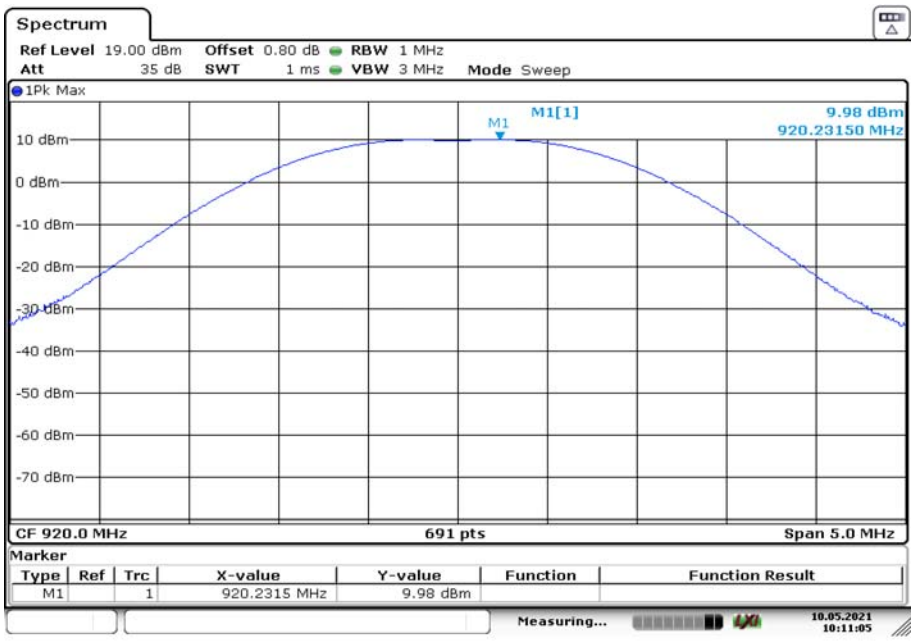
Plots:

Plot 1: Low Channel



Date: 10.MAY.2021 10:09:39

Plot 2: High Channel



Date: 10.MAY.2021 10:11:05

12.2 Antenna gain

Description:

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Span	5 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 B (radiated) See sub clause 7.4 A (conducted)
Measurement uncertainty	See sub clause 9

Limits:

FCC	IC
Antenna gain	
The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.	

Results:

	Low channel	-/-	High channel
Conducted power / dBm	11.3		10.0
Radiated power / dBm	10.4		7.8
Gain / dBi (Calculated)	-0.9		-2.2

12.3 Power spectral density

Description:

Measurement of the power spectral density of a digital modulated system. The measurement is repeated at the lowest, middle and highest channel.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	10 kHz
Resolution bandwidth:	3 kHz
Span:	1.5 MHz
Trace-Mode:	Max Hold
Measurement method	According to ANSI C63.10-2013 11.10.2 Method PKPSD
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 9

Limits:

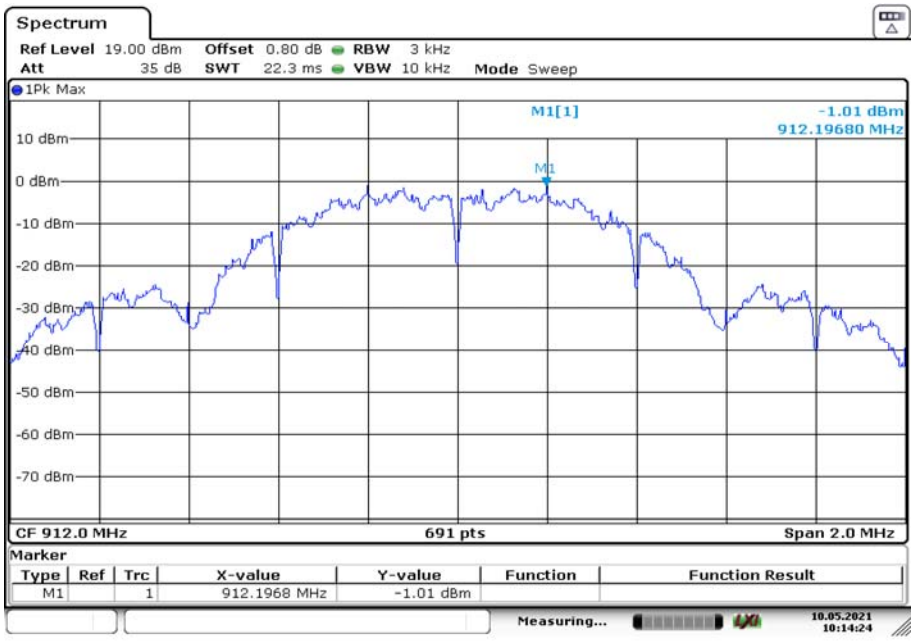
FCC	IC
Power Spectral Density	
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration.	

Results:

Modulation	Power Spectral density / (dBm/3kHz)		
Channel	Lowest	-/-	Highest
	-1.01		-2.14

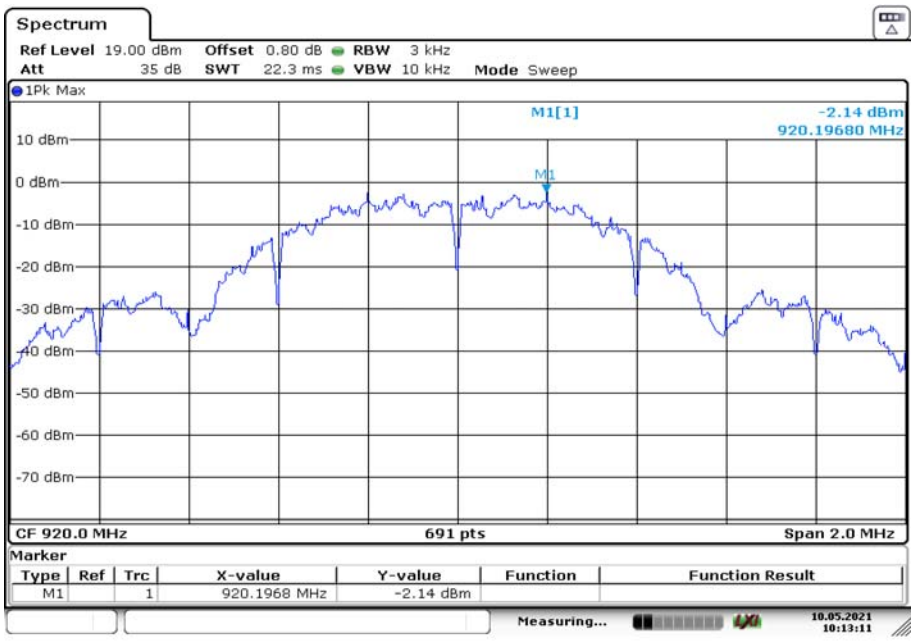
Plots:

Plot 1: Low Channel



Date: 10.MAY.2021 10:14:25

Plot 2: High Channel



Date: 10.MAY.2021 10:13:11

12.4 Spectrum bandwidth – 6 dB bandwidth and 99% bandwidth

Description:

Measurement of the 6 dB bandwidth of the modulated signal.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	99% OBW: 1% - 5% 0f the OBW 6 dB BW: 100 kHz
Video bandwidth:	≥ 3 x RBW
Span:	See plots
Trace-Mode:	Max Hold
Measurement method	According to ANSI C63.10-2013 11.8 DTS bandwidth
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 9

Limits:

FCC	IC
Spectrum Bandwidth – 6 dB Bandwidth	
The minimum 6 dB bandwidth shall be at least 500 kHz.	

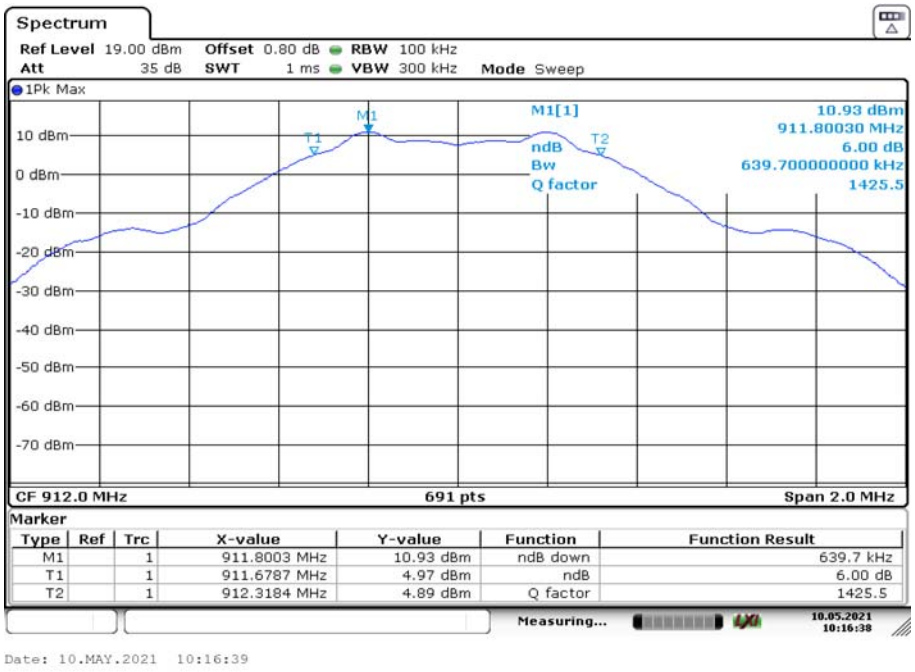
Results:

Test Conditions		6 dB Bandwidth / kHz		
		Low channel	-/-	High channel
T_{nom}	V_{nom}	679.7		639.7

Test Conditions		99% Bandwidth / kHz		
		Low channel	-/-	High channel
T_{nom}	V_{nom}	940.67		933.43

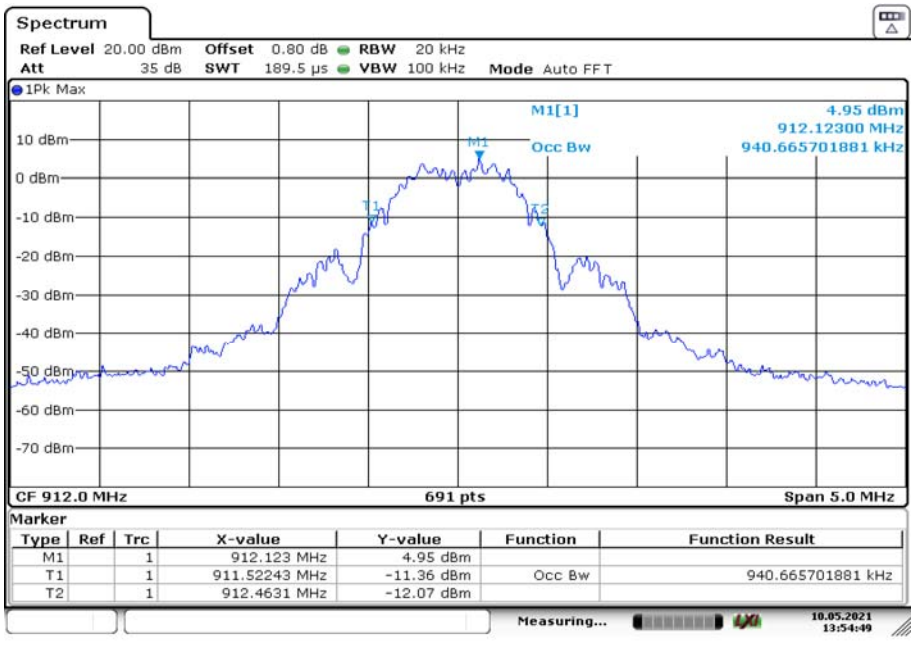
Plots:

Plot 1: Low Channel, 6 dB-BW



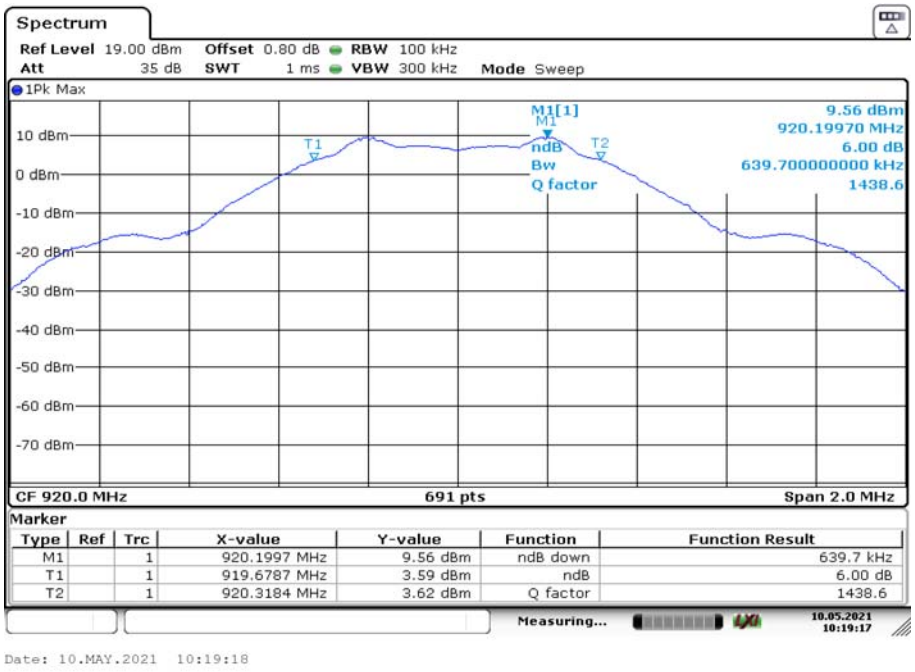
Date: 10.MAY.2021 10:16:39

Plot 2: Low Channel, 99%OBW



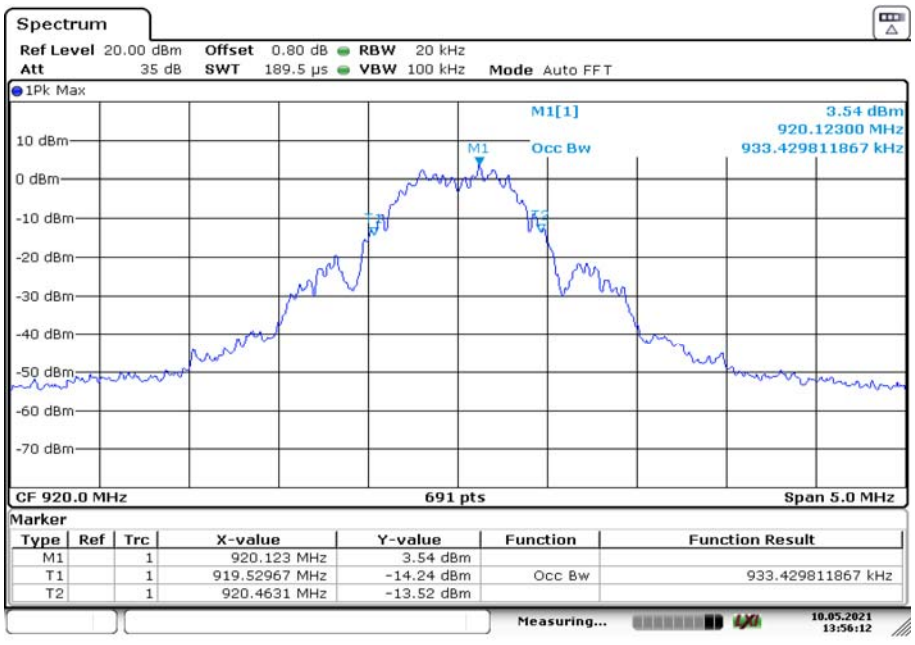
Date: 10.MAY.2021 13:54:49

Plot 3: High Channel, 6 dB-BW



Date: 10.MAY.2021 10:19:18

Plot 4: High Channel, 99%OBW



Date: 10.MAY.2021 13:56:12

12.5 Detailed spurious emissions @ the band edge – conducted and radiated

Description:

Measurement of the conducted band edge compliance. EUT is measured at the lower and upper band edge in single channel mode.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Span	Lower Band Edge: 902 MHz Upper Band Edge: 928 MHz
Trace mode	Max hold
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 9

Limits:

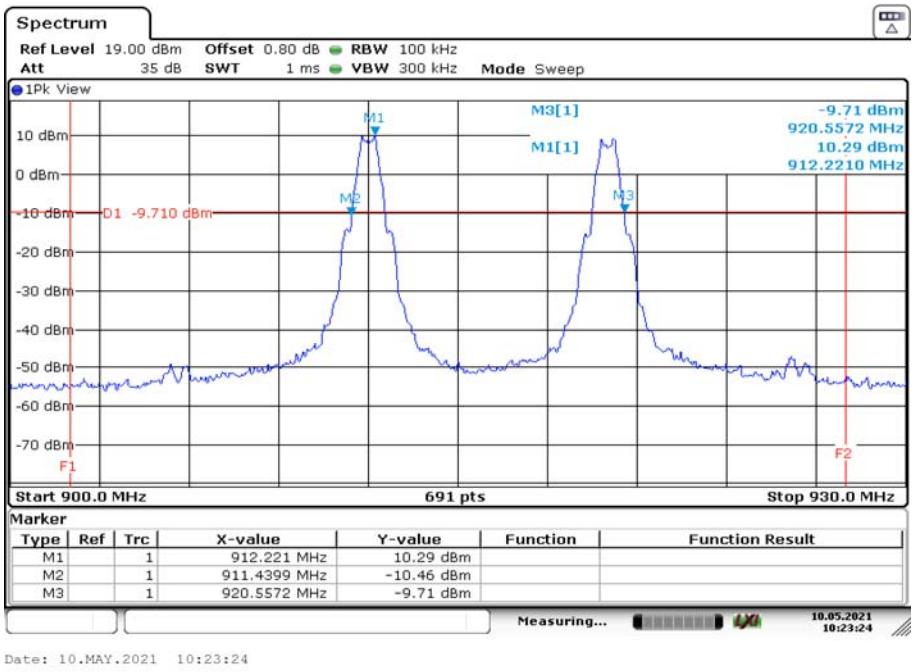
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.	

Results conducted:

Scenario	Spurious band edge conducted / dB		
Modulation	lowest channel	-/-	highest channel
Lower band edge – single channel mode	> 20 dB	-/-	> 20 dB
Upper band edge – single channel mode	> 20 dB	-/-	> 20 dB

Plots:

Plot 1: lowest and highest channel



Results radiated:

No restricted band in the range ± 2 channel bandwidths of the Band-edges of the specified emission band! (608 MHz – 614 MHz and 960 MHz – 1240 MHz).

Section 15.205 Restricted bands of operation.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

12.6 Spurious Emissions Conducted

Description:

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode. The measurement is repeated for low, mid and high channel.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	F < 1 GHz: 1 MHz F > 1 GHz: 1 MHz
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 100 kHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.4A
Measurement uncertainty:	See chapter 9

Limits:

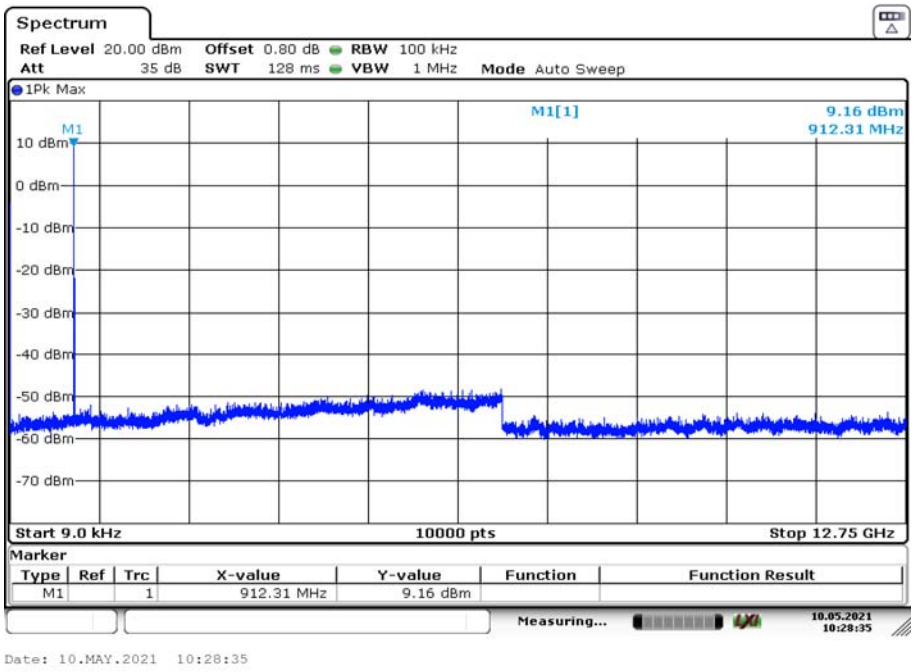
FCC	IC
TX spurious emissions conducted	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required	

Result:

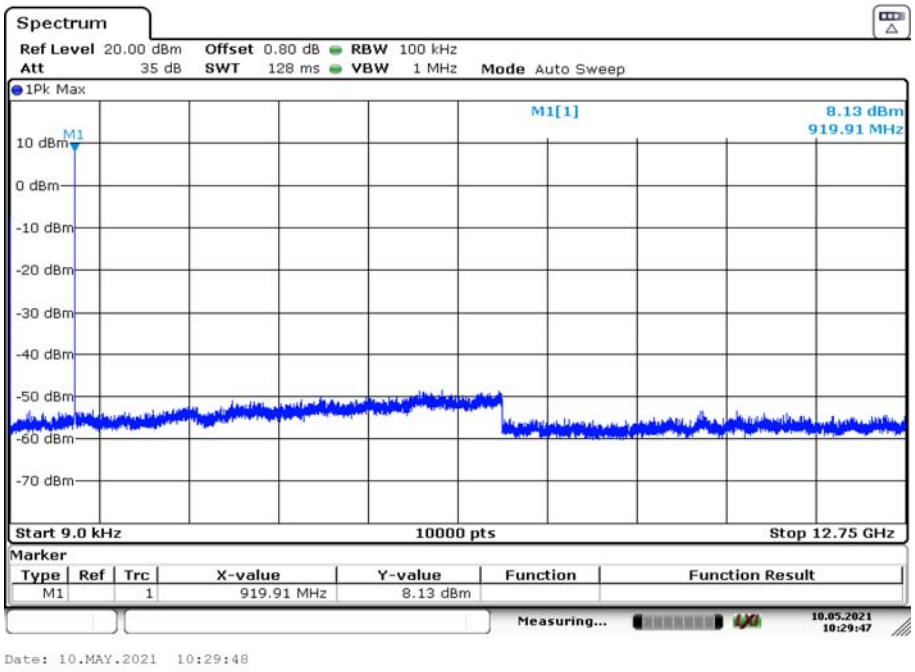
Emission Limitation					
Frequency / MHz		Amplitude of emission / dBm	Limit max. allowed emission power	actual attenuation below frequency of operation / dB	Results
912.0		9.16	24 dBm		Operating frequency
			-20 dBc	No emissions detected!	
920.0		8.13	24 dBm		Operating frequency
			-20 dBc	No emissions detected!	

Plots:

Plot 1: Low channel, 9 kHz – 12.75 GHz



Plot 2: High channel, 9 kHz – 12.75 GHz



12.7 Spurious Emissions Radiated < 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit channels are 00; 39 and 78. The measurement is performed in the mode with the highest output power. The limits are recalculated to a measurement distance of 3 m according the ANSI C63.10.

Measurement:

Measurement parameter	
Detector:	Peak / Quasi Peak
Sweep time:	Auto
Video bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Resolution bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.2 A
Measurement uncertainty:	See chapter 9

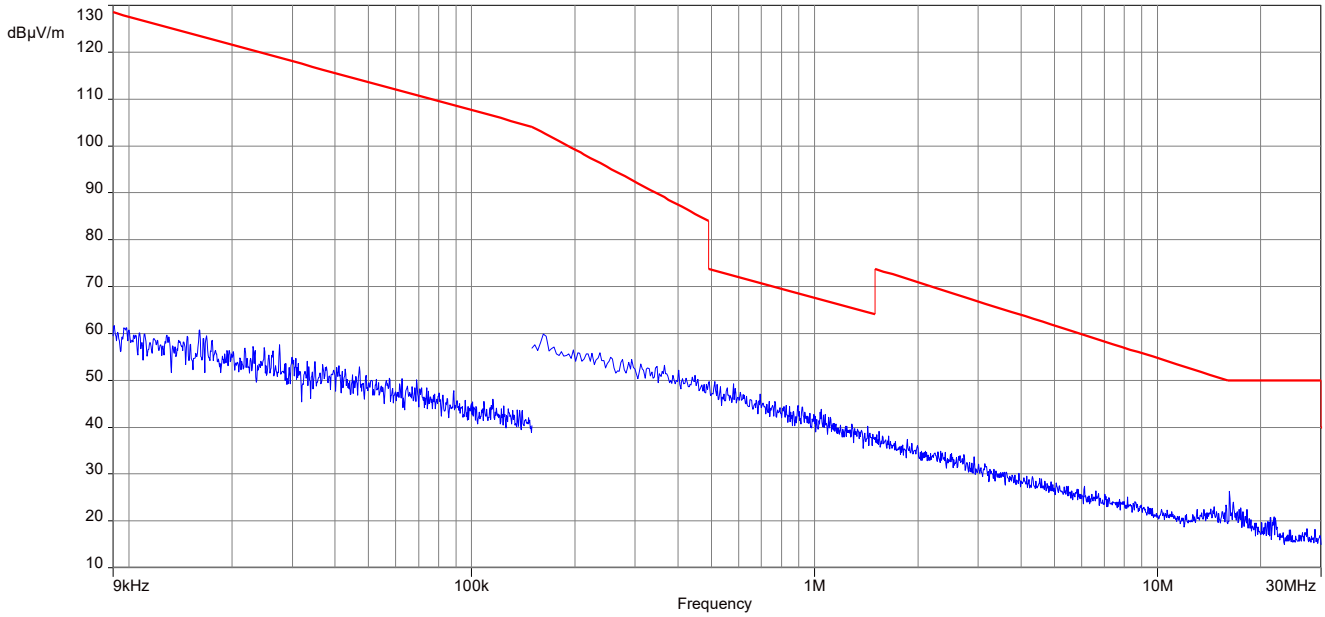
Limits:

FCC		IC
TX spurious emissions radiated < 30 MHz		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

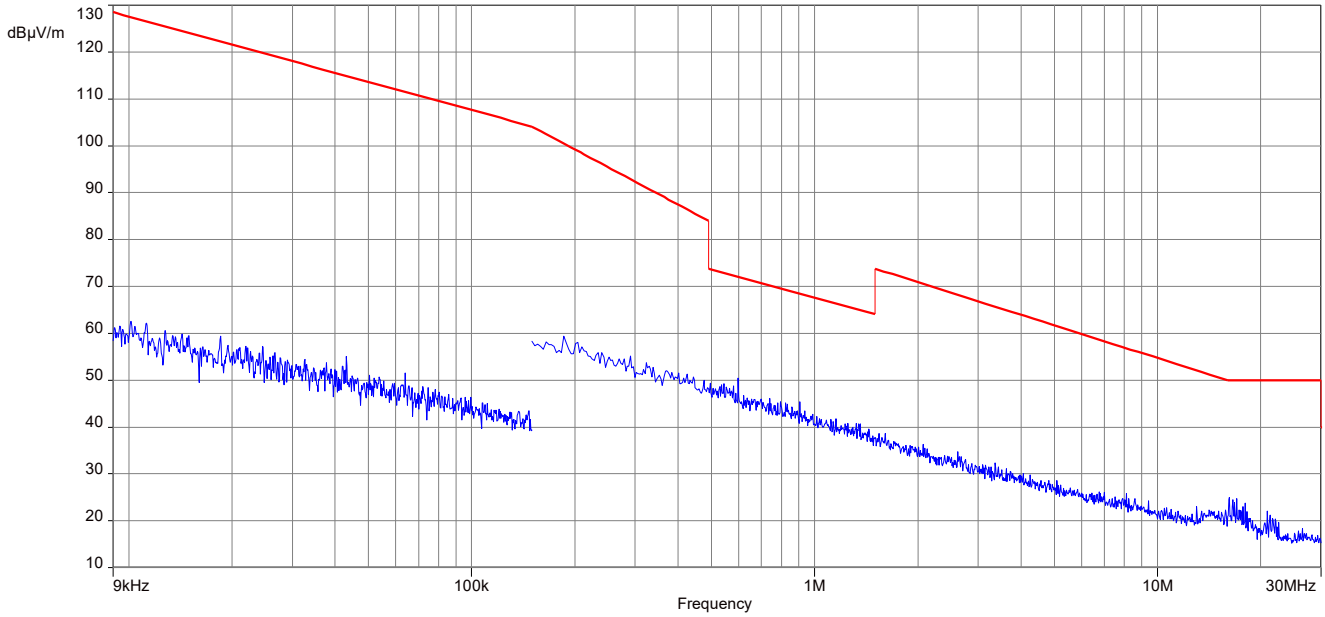
Result:

Spurious emission level								
Lowest channel			-/-			-/-		
Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)
No emissions detected.						No emissions detected.		

Plot 1: TX-Mode low channel



Plot 2: TX-Mode high channel



12.8 Spurious Emissions Radiated > 30 MHz

12.8.1 Spurious emissions radiated 30 MHz to 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The measurement is performed at channel low, mid and high.

Measurement:

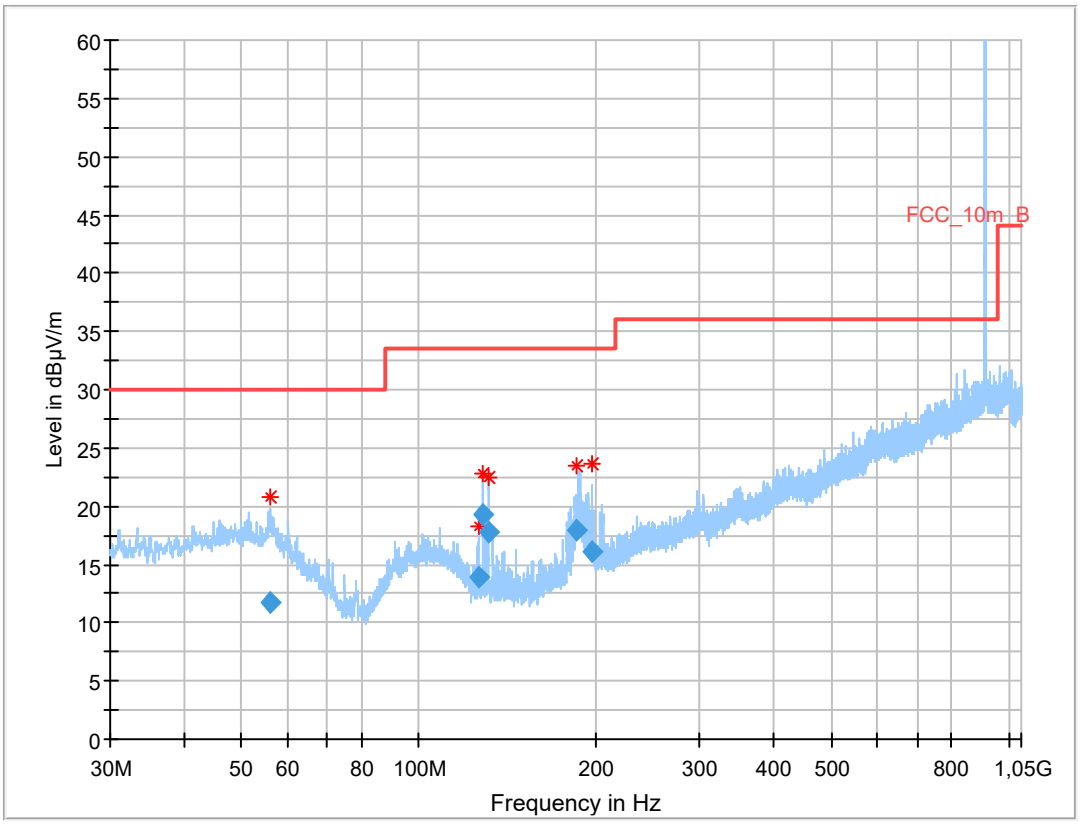
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	3 x VBW
Video bandwidth	120 kHz
Span	30 MHz to 1 GHz
Trace mode	Max hold
Test setup	See sub clause 7.1 A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC	
Band-edge Compliance of conducted and radiated emissions		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
Frequency / MHz	Field Strength / (dBµV/m)	Measurement distance / m
30 - 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

Result: See result table below the plots.

Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)

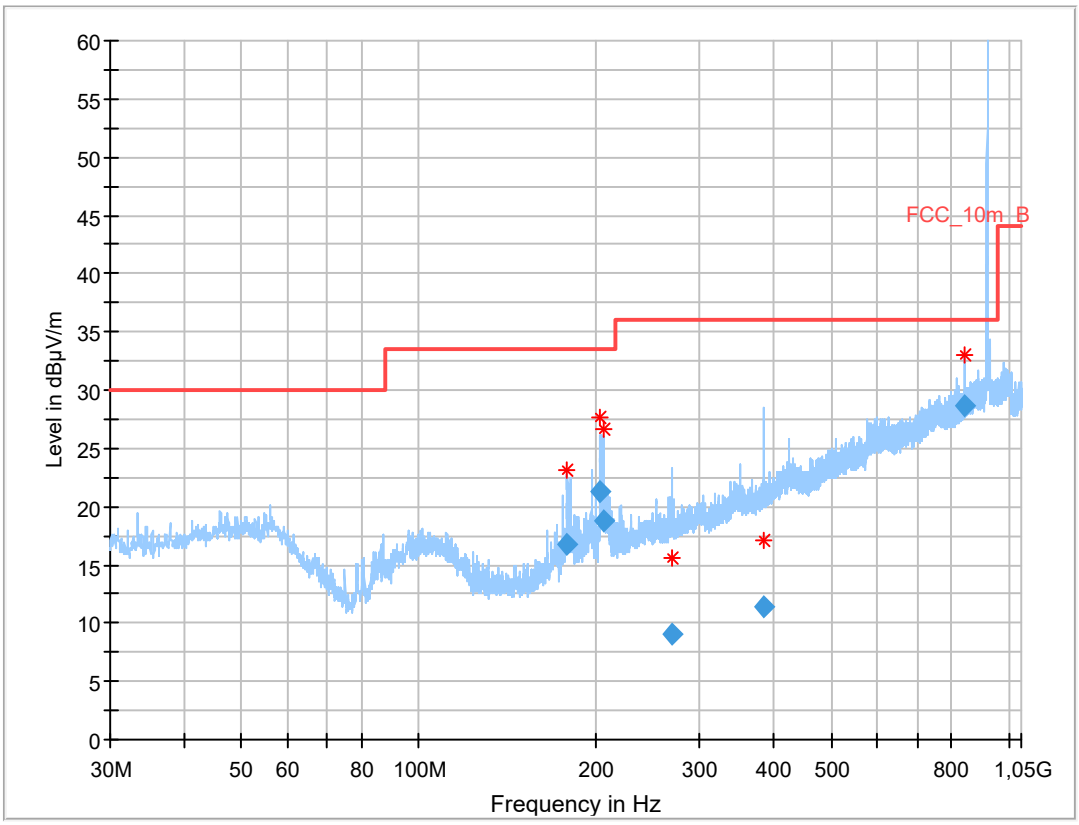


Red stars = Frequency markers; Blue points = QuasiPeak values

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
56.101	11.72	30.0	18.3	1000	120.0	111.0	V	171	15
126.130	13.92	33.5	19.6	1000	120.0	170.0	V	247	9
128.468	19.23	33.5	14.3	1000	120.0	170.0	V	247	9
131.024	17.76	33.5	15.7	1000	120.0	165.0	V	292	9
185.771	17.93	33.5	15.6	1000	120.0	102.0	V	248	11
196.200	16.05	33.5	17.5	1000	120.0	102.0	V	252	12

Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (highest channel)



Red stars = Frequency markers; Blue points = QuasiPeak values

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
178.562	16.83	33.5	16.7	1000	120.0	100.0	V	0	10
203.528	21.21	33.5	12.3	1000	120.0	400.0	H	-22	11
205.324	18.82	33.5	14.7	1000	120.0	400.0	H	-6	11
268.490	9.04	36.0	27.0	1000	120.0	104.0	V	90	13
383.893	11.36	36.0	24.6	1000	120.0	120.0	V	90	16
840.042	28.69	36.0	7.3	1000	120.0	103.0	H	161	23

12.8.2 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The measurement is performed in the mode with the highest output power.

Measurement:

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 x RBW
Span	1 GHz to 12.75 GHz
Trace mode	Max hold
Test setup	See sub clause 7.2 C (1 GHz – 12.75 GHz)
Measurement uncertainty	See sub clause 9

The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

Limits:

ANSI C63.10
The average emission shall be determined by using Video averaging (VBW = 10 Hz). If the dwell time of the hopping signal is less than 100 ms (per channel), the VBW=10 Hz reading may be adjusted by a factor: F = 20log (dwell time/100 ms)

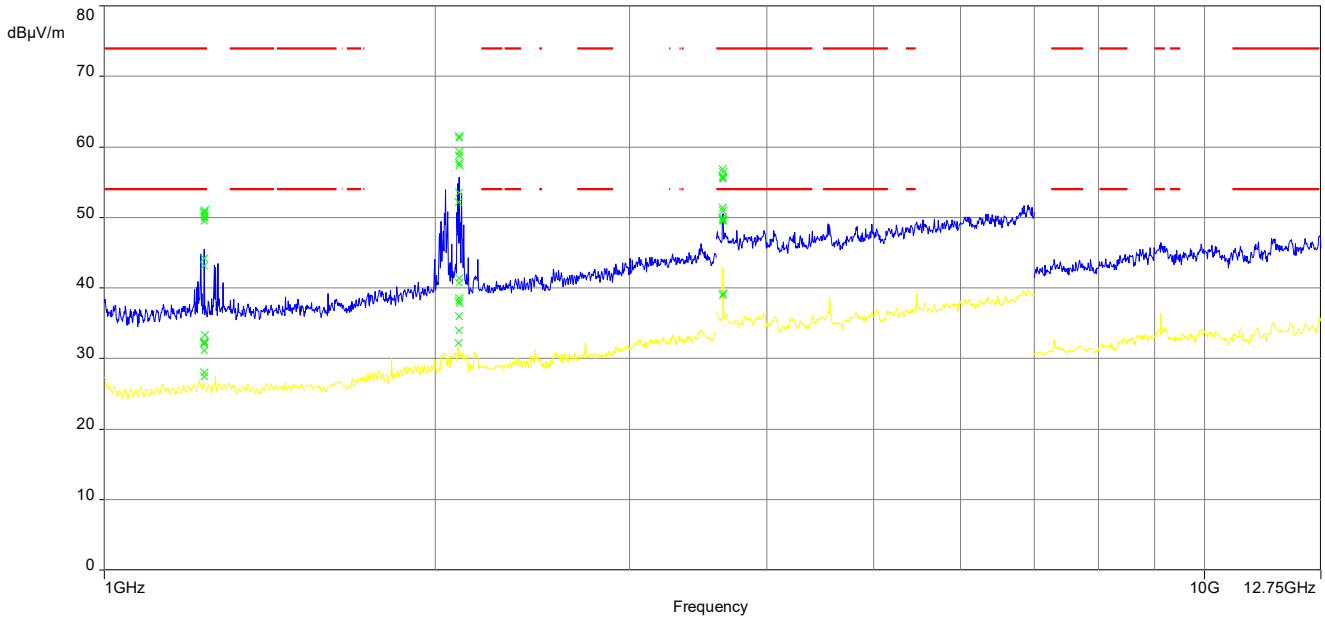
FCC	IC	
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency / MHz	Field strength / (dBµV/m)	Measurement distance / m
Above 960	54.0	3

Result:

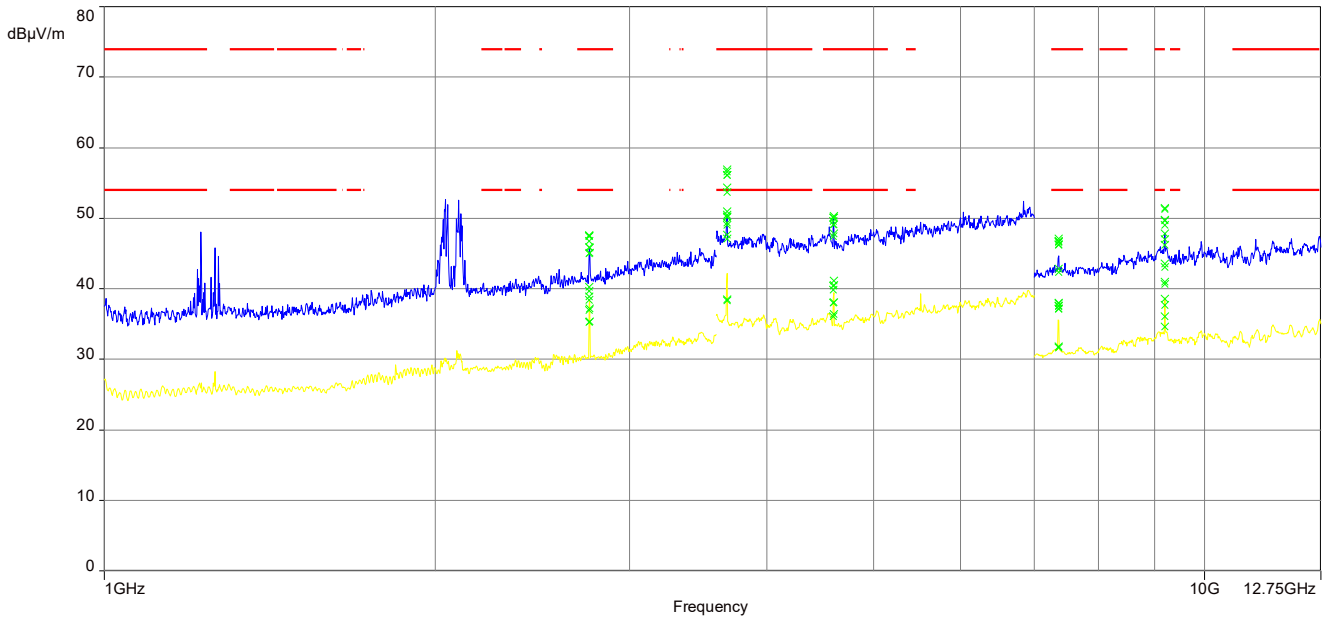
TX spurious emissions radiated								
Lowest channel			-/-			Highest channel		
Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)
1234	Peak	51.0 (23 dB margin)				2759	Peak	47.6 (26.4 dB margin)
	AVG	33.3 (20.7 dB margin)					AVG	40.3 (13.7 dB margin)
2101	Peak	61.5 (12.5 dB margin)				3679	Peak	56.9 (17.1 dB margin)
	AVG	40.8 (13.2 dB margin)					AVG	51.0 (3.0 dB margin)
3647	Peak	55.6 (18.4 dB margin)				4601	Peak	50.3 (23.7 dB margin)
	AVG	49.8 (4.2 dB margin)					AVG	41.1 (12.9 dB margin)
						7362	Peak	47.1 (26.9 dB margin)
							AVG	38.0 (16.0 dB margin)
						9197	Peak	51.4 (22.6 dB margin)
							AVG	43.5 (10.5 dB margin)

Plots:

Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)



12.1 Spurious emissions conducted below 30 MHz (AC conducted)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit frequency is 2440 MHz. This measurement is representative for all channels and modes. If critical peaks are found frequency 2402 MHz and 2480 MHz will be measured too. The measurement is performed in the mode with the highest output power. Both power lines, phase and neutral line, are measured. Found peaks are remeasured with average and quasi peak detection to show compliance to the limits.

Measurement parameters	
Detector	Peak - Quasi peak / average
Sweep time	Auto
Resolution bandwidth	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace mode:	Max hold
Test setup	See chapter 7.3 A
Measurement uncertainty	See chapter 9

Limits:

FCC		ISED
TX spurious emissions conducted < 30 MHz		
Frequency (MHz)	Quasi-peak (dBµV/m)	Average (dBµV/m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

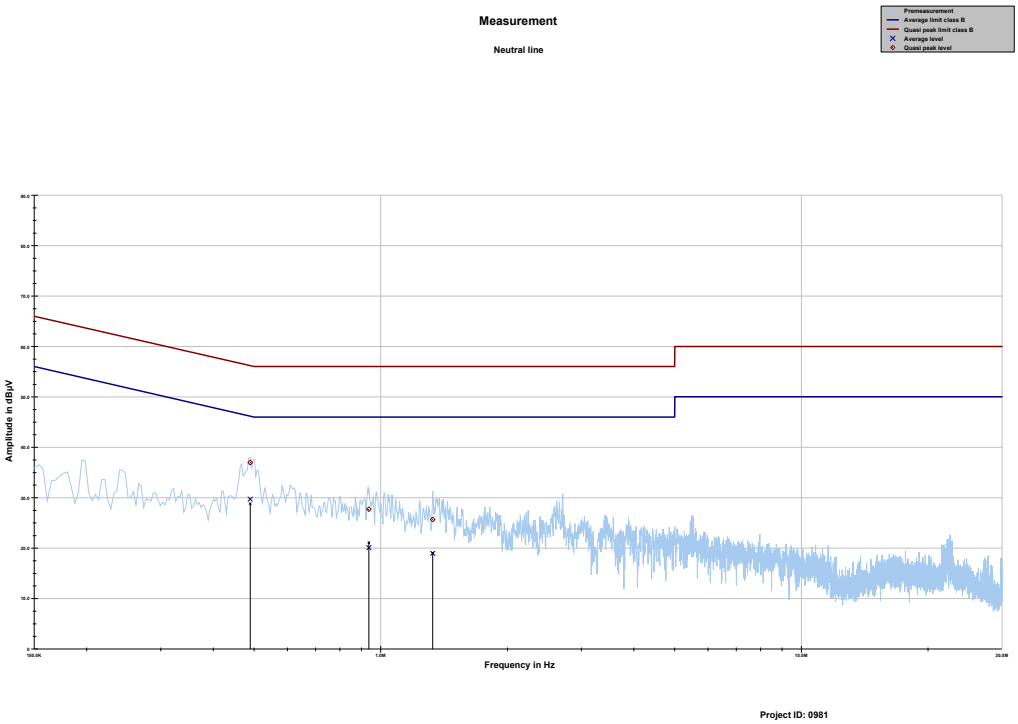
*Decreases with the logarithm of the frequency

Results:

See result table below the plots.

Plots:

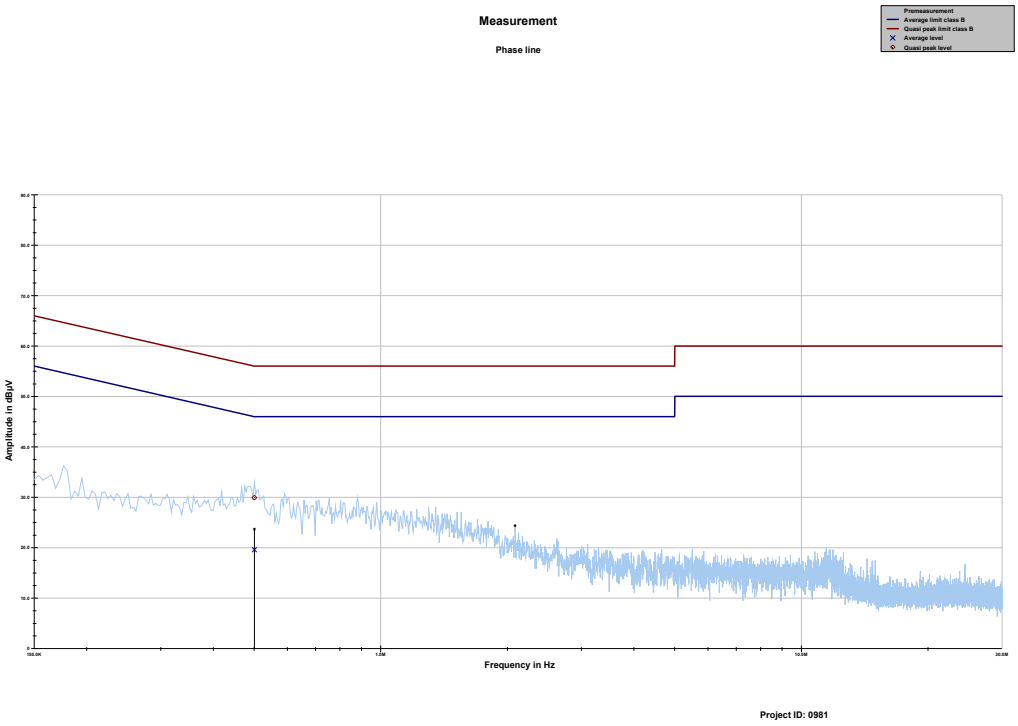
Plot 1: 150 kHz to 30 MHz, phase line



Final_Result

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.489544	36.97	19.20	56.176	29.72	16.58	46.299
0.937294	27.71	28.29	56.000	20.10	25.90	46.000
1.329075	25.67	30.33	56.000	18.95	27.05	46.000

Plot 2: 150 kHz to 30 MHz, neutral line



Final_Result

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.500737	29.94	26.06	56.000	19.58	26.42	46.000

13 Observations

No observations except those reported with the single test cases have been made.

14 Glossary

EUT	Equipment under test
DUT	Device under test
UUT	Unit under test
GUE	GNSS User Equipment
ETSI	European Telecommunications Standards Institute
EN	European Standard
FCC	Federal Communications Commission
FCC ID	Company Identifier at FCC
IC	Industry Canada
PMN	Product marketing name
HMN	Host marketing name
HVIN	Hardware version identification number
FVIN	Firmware version identification number
EMC	Electromagnetic Compatibility
HW	Hardware
SW	Software
Inv. No.	Inventory number
S/N or SN	Serial number
C	Compliant
NC	Not compliant
NA	Not applicable
NP	Not performed
PP	Positive peak
QP	Quasi peak
AVG	Average
OC	Operating channel
OCW	Operating channel bandwidth
OBW	Occupied bandwidth
OOB	Out of band
DFS	Dynamic frequency selection
CAC	Channel availability check
OP	Occupancy period
NOP	Non occupancy period
DC	Duty cycle
PER	Packet error rate
CW	Clean wave
MC	Modulated carrier
WLAN	Wireless local area network
RLAN	Radio local area network
DSSS	Dynamic sequence spread spectrum
OFDM	Orthogonal frequency division multiplexing
FHSS	Frequency hopping spread spectrum
GNSS	Global Navigation Satellite System
C/N_0	Carrier to noise-density ratio, expressed in dB-Hz

15 Document history

Version	Applied changes	Date of release
-/-	Initial release	2021-05-20

16 Accreditation Certificate – D-PL-12076-01-04

first page	last page
	

Note: The current certificate annex is published on the website (link see below) of the Accreditation Body DAkkS or may be received by CTC advanced GmbH on request

https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf

17 Accreditation Certificate – D-PL-12076-01-05

first page	last page
	

DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

is competent under the terms of DIN EN ISO/IEC 17025:2018 to carry out tests in the following fields:

Telecommunication (FCC Requirements)

The accreditation certificate shall only apply in connection with the notice of accreditation of 09.06.2020 with the accreditation number D-PL-12076-01. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 05 pages.

Registration number of the certificate: **D-PL-12076-01-05**

Frankfurt am Main, 09.06.2020

by order Dipl.-Ing. (FH) Ralf Egner
Head of Division

The certificate together with its annex reflects the status at the time of the date of issue. The current status of the scope of accreditation can be found in the database of accredited bodies of Deutsche Akkreditierungsstelle GmbH.
https://www.dakks.de/en/content/accredited-bodies-dakks

See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

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The publication of extracts of the accreditation certificate is subject to the prior written approval by Deutsche Akkreditierungsstelle GmbH (DAkkS). Exempted is the unchanged form of separate disseminations of the cover sheet by the conformity assessment body mentioned overleaf.

No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkkS.

The accreditation was granted pursuant to the Act on the Accreditation Body (AkkStelleG) of 31 July 2009 (Federal Law Gazette I p. 2625) and the Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products (Official Journal of the European Union L 218 of 9 July 2008, p. 30). DAkkS is a signatory to the Multilateral Agreements for Mutual Recognition of the European co-operation for Accreditation (EA), International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC). The signatories to these agreements recognise each other's accreditations.

The up-to-date state of membership can be retrieved from the following websites:
EA: www.european-accreditation.org
ILAC: www.ilac.org
IAF: www.iaf.nu

Note: The current certificate annex is published on the website (link see below) of the Accreditation Body DAkkS or may be received by CTC advanced GmbH on request

https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf

########## END OF TEST REPORT ##########