



TEST REPORT

Test report no.: 1-9086/19-01-02-B

BNNetzA-CAB-02/21-102

Testing laboratory

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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

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Manufacturer

Elektroniksystem i Umeå AB
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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: LoRa device
Model name: ERS
FCC ID: 2ANX3-ERS01
IC: 26904-ERS01
Frequency: DTS band 902 MHz to 928 MHz
Technology tested: LoRa
Antenna: Integrated antenna
Power supply: 3.1 V to 3.6 V DC by battery
Temperature range: -20°C to +55°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:

Christoph Schneider
Lab Manager
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Test performed:

Hans-Joachim Wolsdorfer
Lab Manager
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2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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This test report replaces the test report with the number 1-9086/19-01-02-A and dated 2021-02-17

2.2 Application details

Date of receipt of order:	2019-08-26
Date of receipt of test item:	2019-08-20
Start of test:*	2020-11-05
End of test:*	2020-12-15
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

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

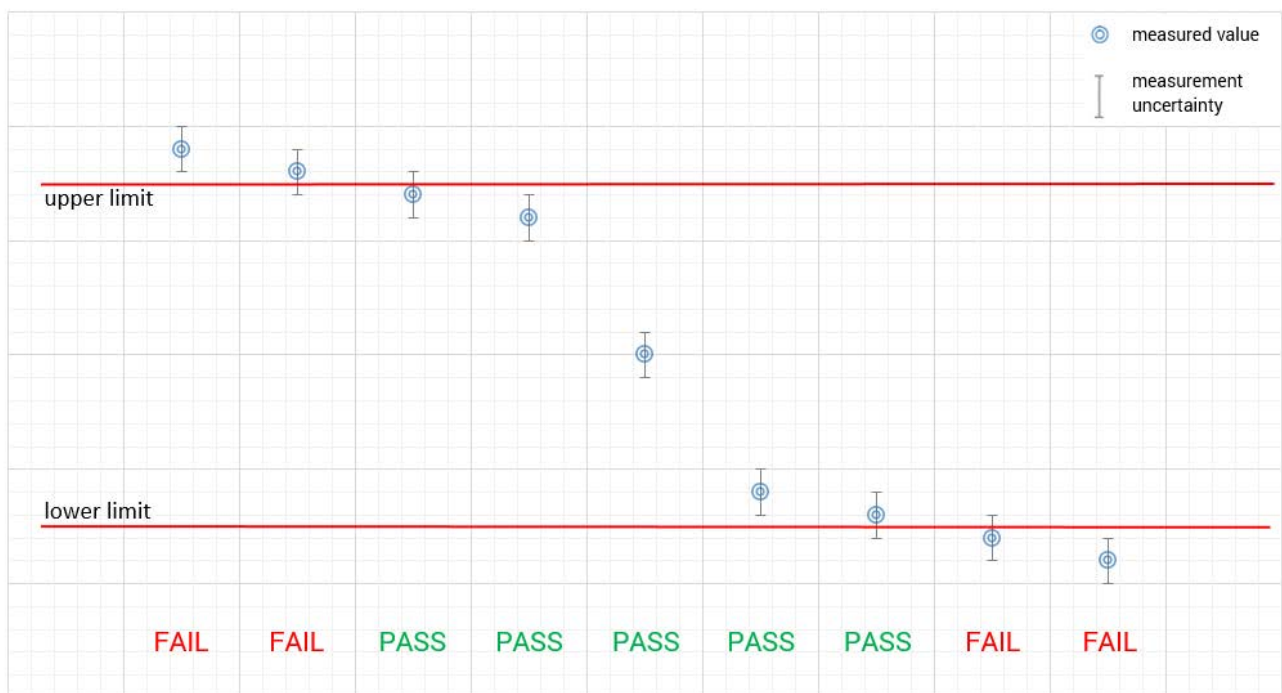
Accreditation	Description	
D-PL-12076-01-04	Telecommunication and EMC Canada https://www.dakks.de/as/ast/d/D-PL-12076-01-04e.pdf	  <p>Deutsche Akkreditierungsstelle D-PL-12076-01-04</p>
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf	  <p>Deutsche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

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."

measured value, measurement uncertainty, verdict



5 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+21 °C during room temperature tests No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.6 V DC by battery No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.

6 Test item

6.1 General description

Kind of test item	:	LoRa device
Model name	:	ERS
HMN	:	n/a
PMN	:	ERS
HVIN	:	ERS, ERS CO2, ERS desk, ERS lite
FVIN	:	2
S/N serial number	:	prototype
Hardware status	:	-/-
Software status	:	-/-
Firmware status	:	-/-
Frequency band	:	DTS band 902 MHz to 928 MHz
Type of radio transmission	:	FHSS
Use of frequency spectrum	:	DTS
Type of modulation	:	Chip spread spectrum
Number of channels	:	FHSS: 64 DTS: 8
Antenna	:	Integrated antenna
Power supply	:	3.1 V to 3.6 V DC by battery
Temperature range	:	-20°C to +55°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:

- 1-9086/19-01-01_AnnexA
- 1-9086/19-01-01_AnnexB
- 1-9086/19-01-01_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).

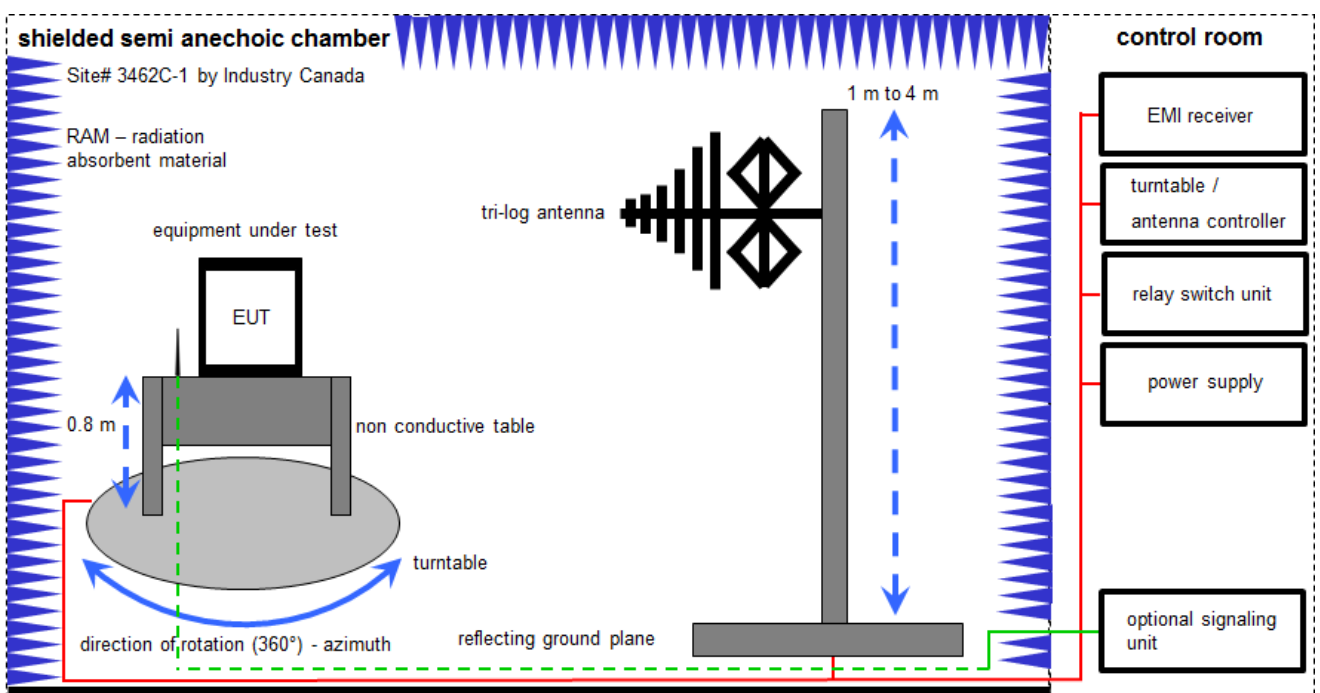
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlk!	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 conducting 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)

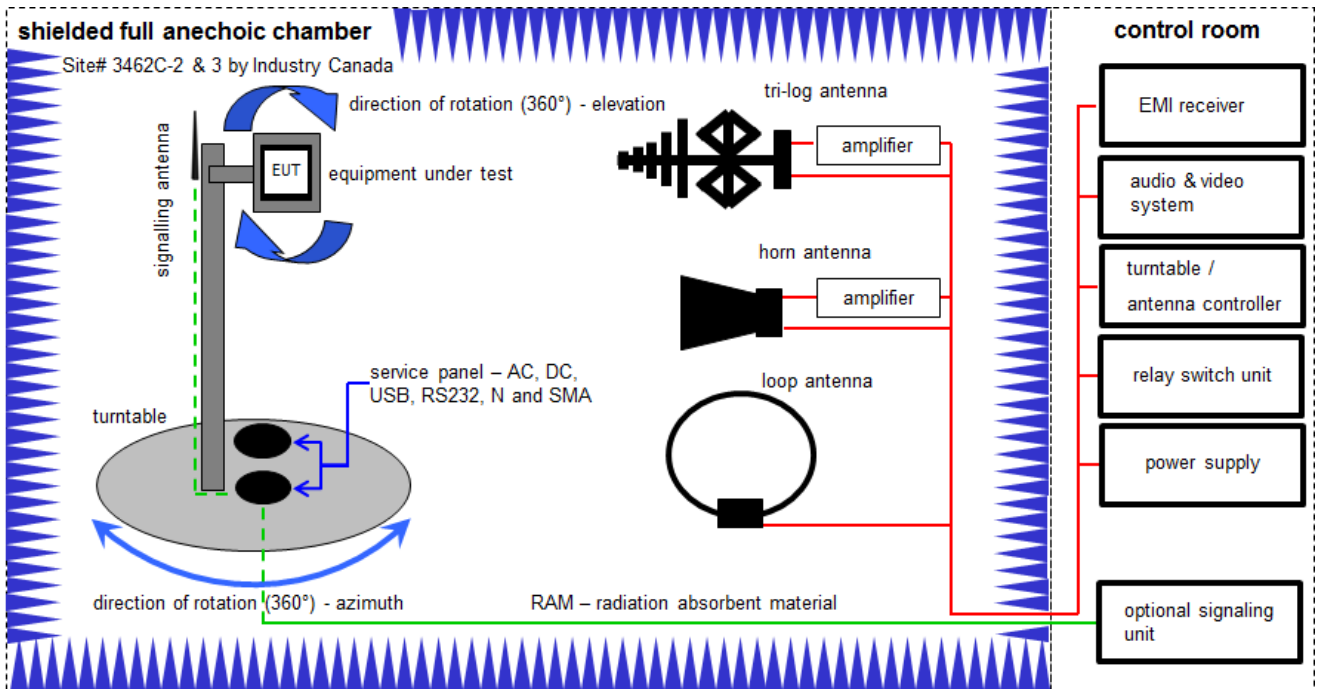
Example calculation:

$FS [dB\mu V/m] = 12.35 [dB\mu V/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dB\mu V/m] (35.69 \mu V/m)$

Equipment table:

No.	Lab / Item	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	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
3	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
4	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
5	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vKI!	19.02.2019	18.02.2021
6	A	Turntable	2089-4.0	EMCO		300004394	ne	-/-	-/-
7	A	PC	Tecline	F+W		300004388	ne	-/-	-/-
8	A	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	10.12.2020	09.12.2021

7.2 Shielded fully anechoic chamber



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

$$FS = UR + CA + AF$$

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

Example calculation:

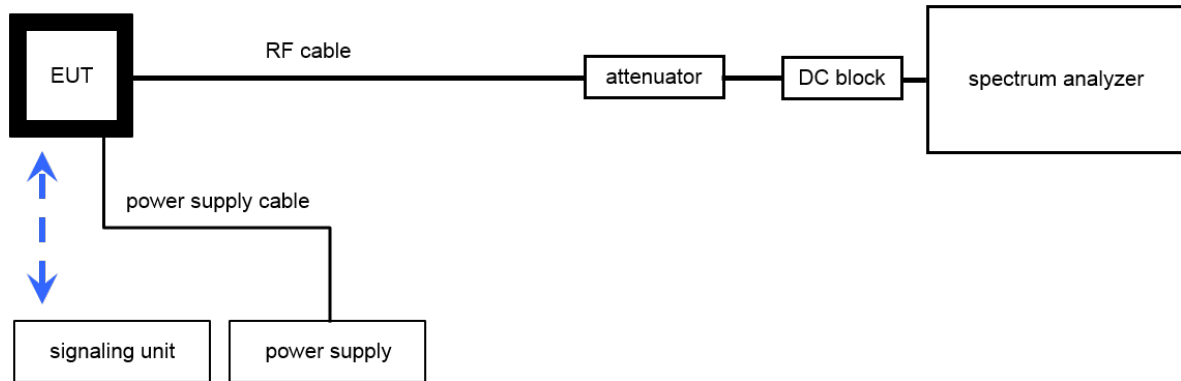
$$FS \text{ [dB}\mu\text{V/m]} = 40.0 \text{ [dB}\mu\text{V/m]} + (-35.8) \text{ [dB]} + 32.9 \text{ [dB/m]} = 37.1 \text{ [dB}\mu\text{V/m]} \text{ (71.61 } \mu\text{V/m)}$$

Equipment table:

No.	Lab / Item	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	vKI!	13.06.2019	12.06.2021
2	A, B, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vKI!	27.02.2019	26.02.2021
4	B	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vKI!	19.02.2019	18.02.2021
5	A, B, C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
6	A, B, C	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	11.12.2020	10.12.2021
7	C	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
8	C	High Pass Filter	VHF-3500+	Mini Circuits	-/-	400000193	ne	-/-	-/-
9	C	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
10	A, B, C.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
11	A, B.,C	NEXIO EMV-Software	BAT EMC V3.19.1.19	EMCO		300004682	ne	-/-	-/-
12	A, B, C	PC	ExOne	F+W		300004703	ne	-/-	-/-
13	C	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

7.3 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.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Signal- and Spectrum Analyzer 2 Hz - 26 GHz	FSW26	R&S	101455	300004528	k	24.02.2020	23.02.2021
2	A	Loop Antenna		ZEG TS Steinfurt		400001208	ev	-/-	-/-
3	A	RF Cable BNC	RG58	Huber & Suhner		400001209	ev	-/-	-/-

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 $\pm 45^\circ$ 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

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input type="checkbox"/>	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

10.1 Part 1: FHSS

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	CFR Part 15 RSS - 247, Issue 2	Passed	2021-02-26	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4 (d)	Antenna gain	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (b)	Carrier frequency separation	Nominal	Nominal	TX hopping	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (d)	Number of hopping channels	Nominal	Nominal	TX hopping	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) (iii) RSS - 247 / 5.1 (d)	Time of occupancy (dwell time)	Nominal	Nominal	TX hopping	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (a)	Spectrum bandwidth of a FHSS system bandwidth	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(b)(1) RSS - 247 / 5.4 (b)	Maximum output power	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge - conducted	Nominal	Nominal	TX hopping TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	-/-	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5	Spurious emissions conducted	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.209(a) RSS - Gen	Spurious emissions radiated below 30 MHz	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated 30 MHz to 1 GHz	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated above 1 GHz	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.107(a) §15.207	Conducted emissions below 30 MHz (AC conducted)	Nominal	Nominal	TX single channel	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	-/-

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

10.2 Part 2: DTS

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	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(e) RSS - 247 / 5.2 (b)	Power spectral density	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(2) RSS Gen clause 4.6.1	Spectrum bandwidth 6dB bandwidth	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(b)(3) RSS - 247 / 5.4 (d)	Maximum output power	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance conducted	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	-/-	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§§15.247(d) RSS - 247 / 5.5	TX spurious emissions conducted	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS-210 / A8.5	TX spurious emissions radiated	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.109 RSS-Gen.	RX spurious emissions radiated	Nominal	Nominal	RX	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.209(a) RSS-Gen	TX spurious emissions radiated < 30 MHz	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-

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: The EUT uses a Long Range Wide Area Network (LoRaWAN) technology with a FHSS system and a DTS system. Both systems were tested.

Configuration descriptions: FHSS: 64 channels with a nominal bandwidth of 125 kHz and 200 kHz channel spacing

lowest channel 902.3 MHz,
middle channel 908.5 MHz,
highest channel 914.9 MHz;

these channels were tested in part 1 of this test report.

DTS: 8 channels with 500 kHz nominal bandwidth and 1600 kHz channel spacing

lowest channel 903.0 MHz,
middle channel 909.4 MHz,
highest channel 914.2 MHz;

these channels were tested in part 2 of this test report.

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

12 Measurement results Part 1 FHSS

12.1 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 7.3 A (conducted)
Measurement uncertainty	See sub clause 9

Limits:

FCC	IC
Antenna gain	
<p>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.</p>	

Results:

	Low channel	Middle channel	High channel
Conducted power / dBm	10.54	10.48	10.32
Radiated power e.r.p. / dBm	11.63	11.84	12.01
Gain / dBi (Calculated)	3.24	3.51	3.84

12.2 Carrier Frequency Separation

Description:

Measurement of the carrier frequency separation of a hopping system. EUT in hopping mode.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	See plots
Video bandwidth	See plots
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 9

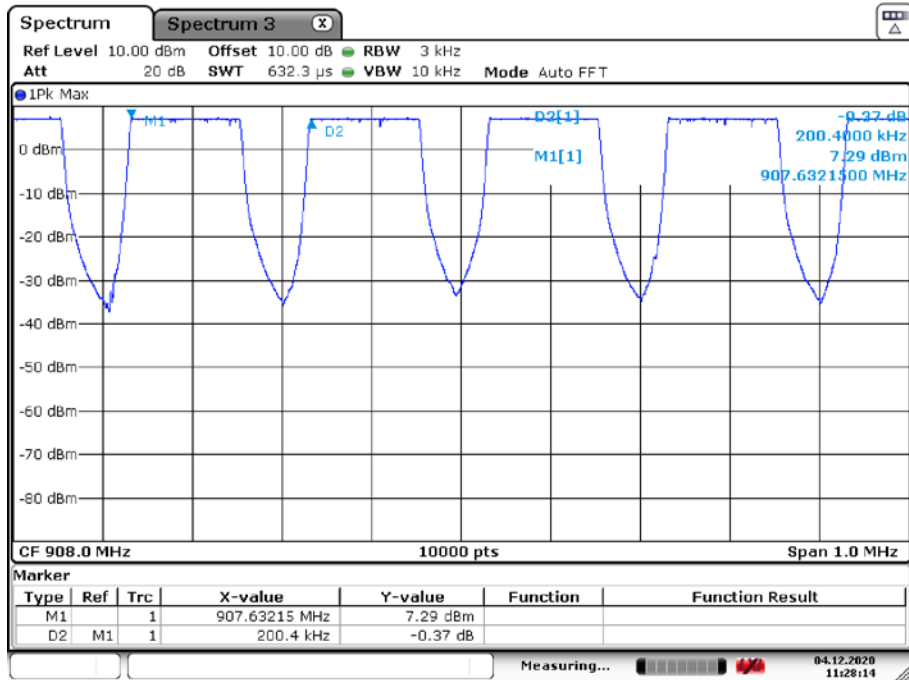
Limits:

FCC	IC
Carrier frequency separation	
Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater. The two-thirds of the 20 dB bandwidth for IC is only valid for the ISM band 2400 – 2483.5 MHz.	

Result: The channel separation is 200.4 kHz.

Plots:

Plot 1: Frequency separation



Date: 4.DEC.2020 11:28:13

12.3 Number of Hopping Channels

Description:

Measurement of the total number of used hopping channels. EUT in hopping mode.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	See plots
Video bandwidth	See plots
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 9

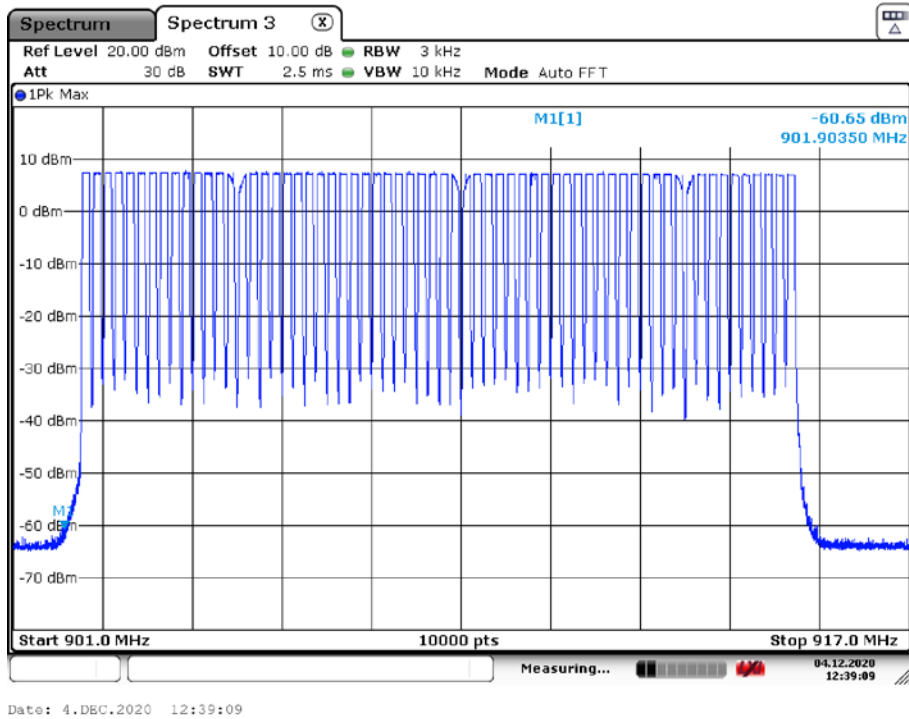
Limits:

FCC	IC
Number of hopping channels	
At least 25 non overlapping hopping channels. If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels.	

Result: The EUT uses 64 channels

Plots:

Plot 1: Number of channels



12.4 Average Time of Occupancy (dwell time)

Measurement:

The measurement is performed in zero span mode to show that none of the 64 used channels is allocated more than 0.4 seconds within a 25.6 seconds interval (64 channels times 0.4s).

Limits:

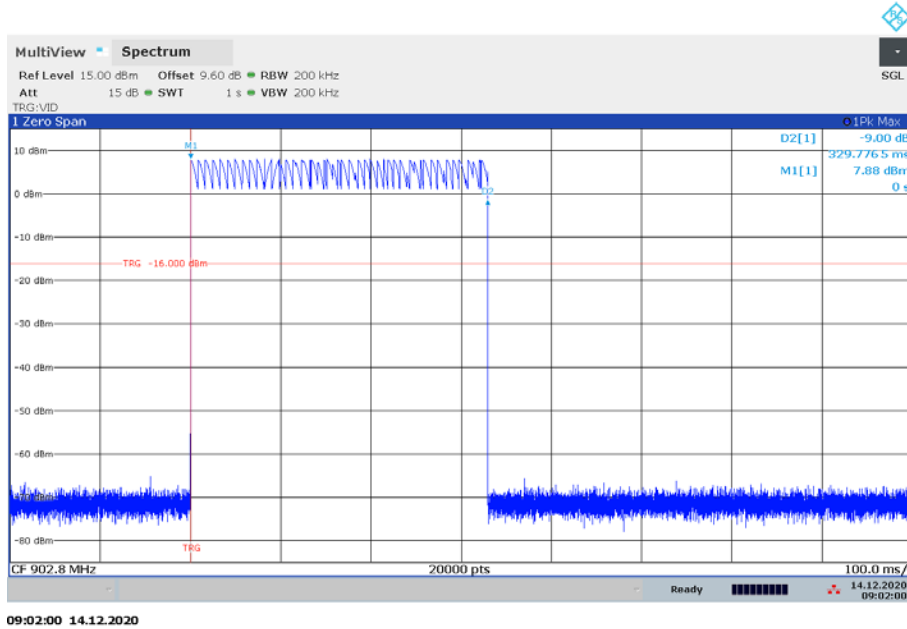
FCC	IC
Average time of occupancy	
For frequency hopping systems operating in the 902-928 MHz band: If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within 10 second period.	

Result: The time slot length for the tested channels is = 329.8 ms

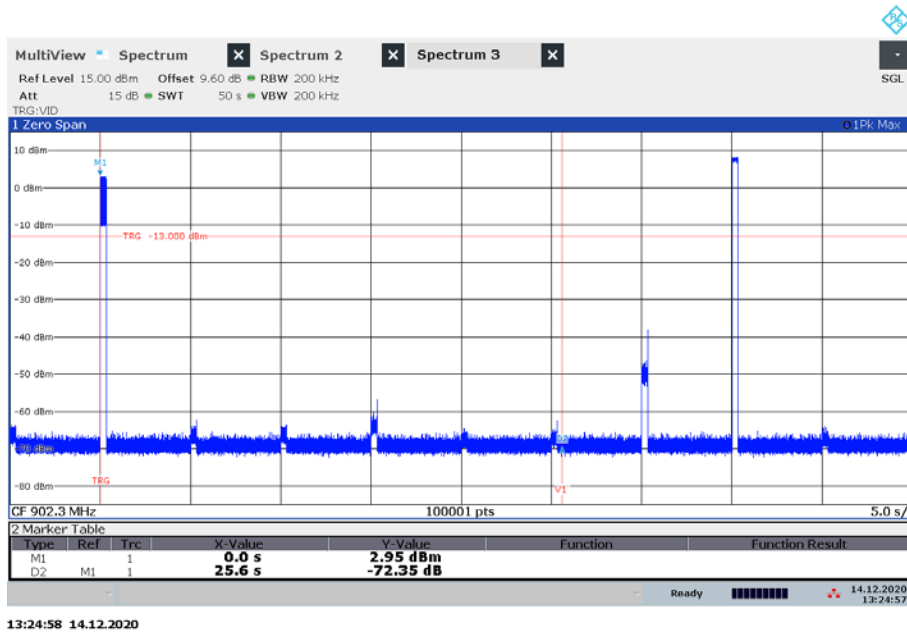
	Low channel	Middle channel	High channel
time slot length (mS)	329.8	329.8	329.8
no of hops in 25.6s timeframe	1	1	1

Plots:

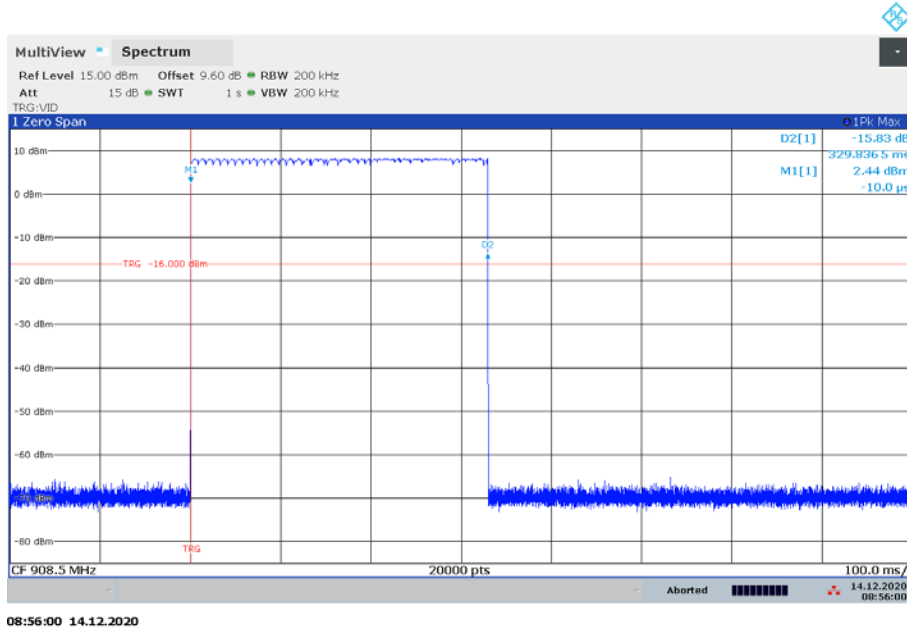
Plot 1: Time slot length low channel = 329.8 ms



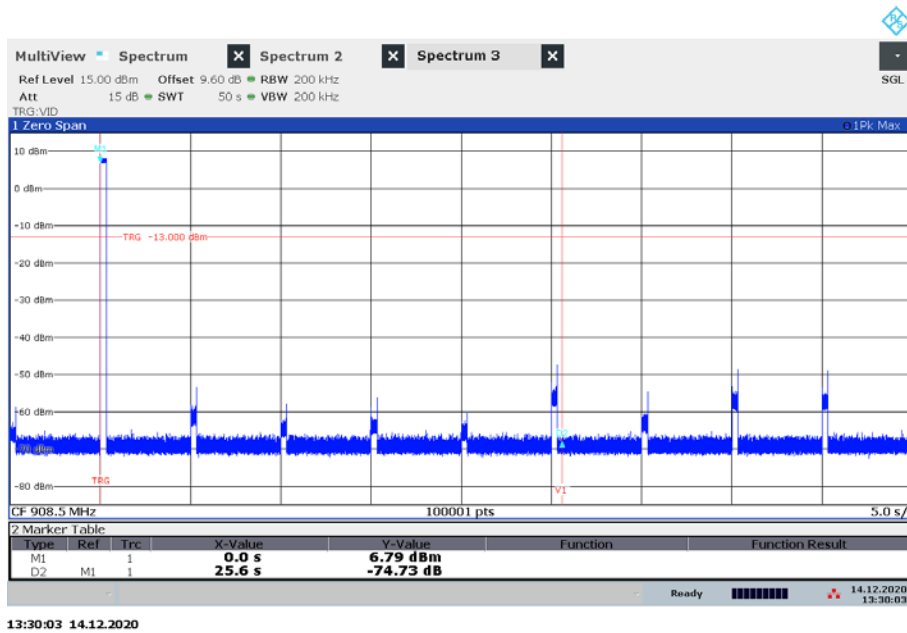
Plot 2: hops / low channel @ 25.6s = 1



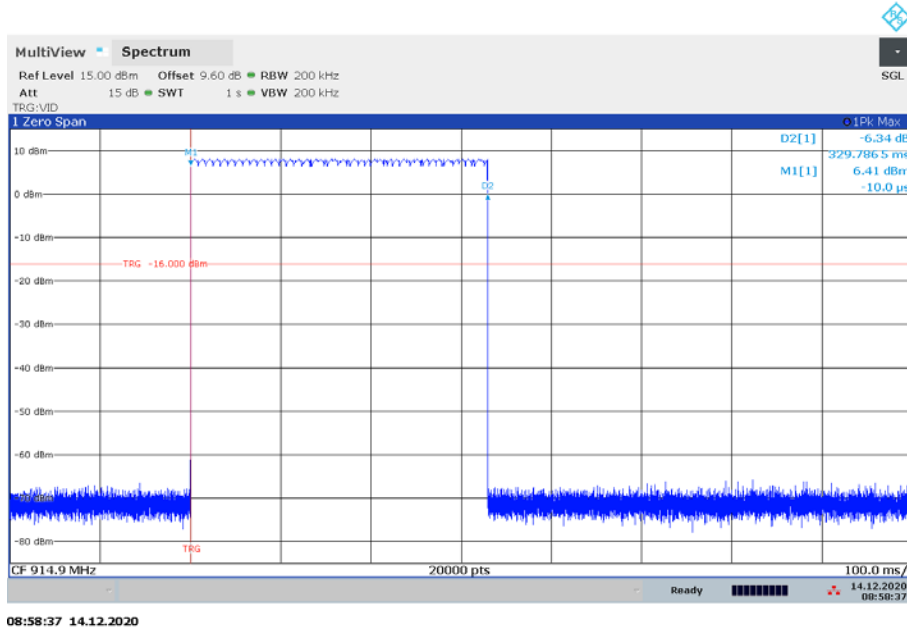
Plot 3: Time slot length middle channel = 329.8 mS



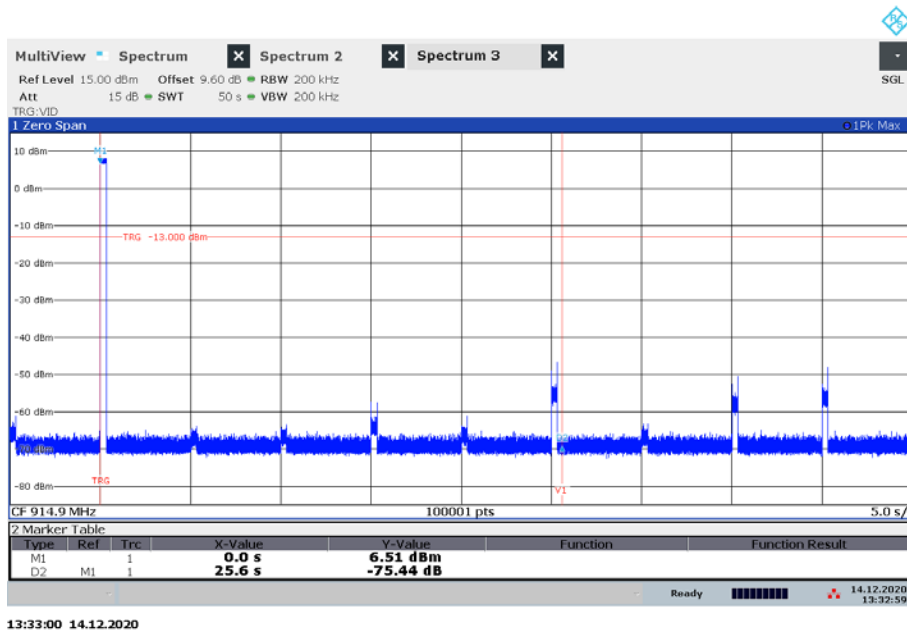
Plot 4: hops / middle channel @ 25.6s = 1



Plot 5: Time slot length high channel = 329.8 mS



Plot 6: hops / high channel @ 25.6s = 1



12.5 Spectrum bandwidth of a FHSS system

Description:

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal. EUT in single channel mode.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	5 kHz
Video bandwidth	100 kHz
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 9

Limits:

FCC	IC
Spectrum bandwidth of a FHSS system	
The maximum allowed 20 dB bandwidth of the hopping channel is 250 kHz.	

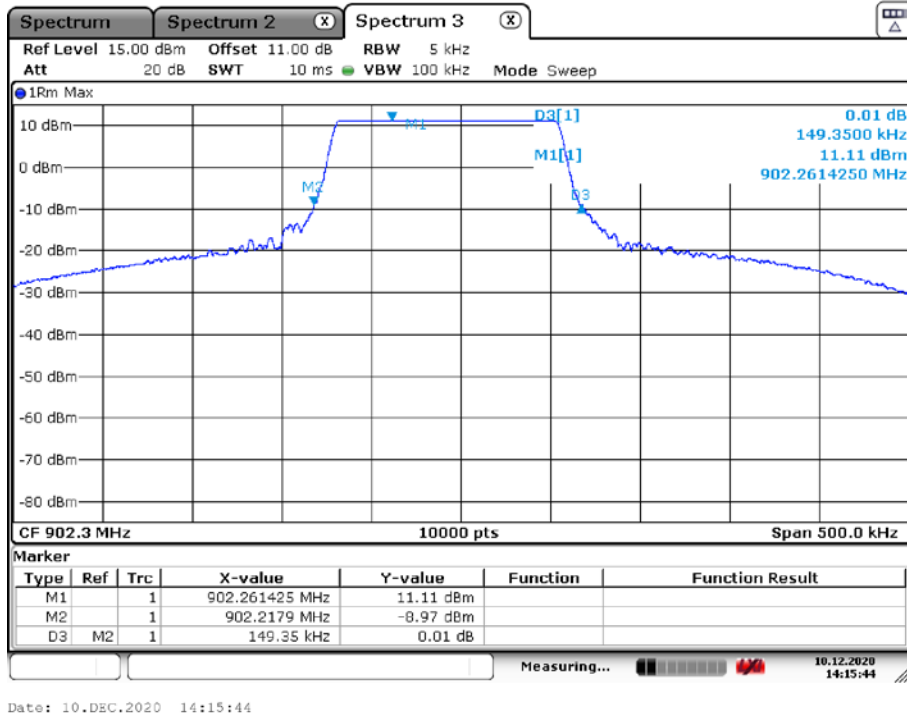
Result:

Test Conditions		20dB Bandwidth / kHz		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	149.3	152.0	150.9

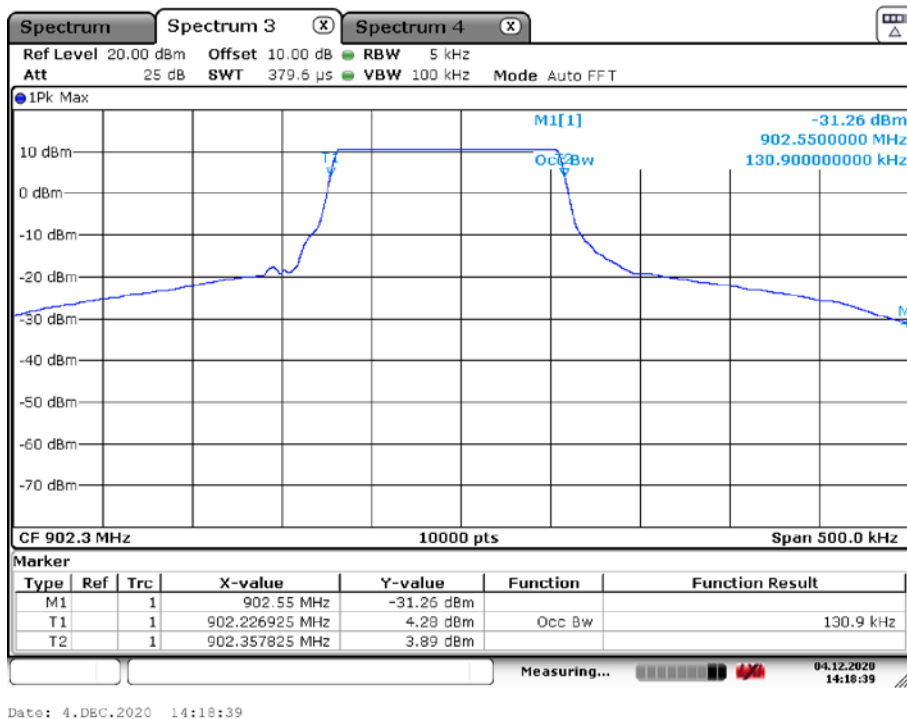
Test Conditions		99% Bandwidth / kHz		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	130.9	130.8	130.55

Plots:

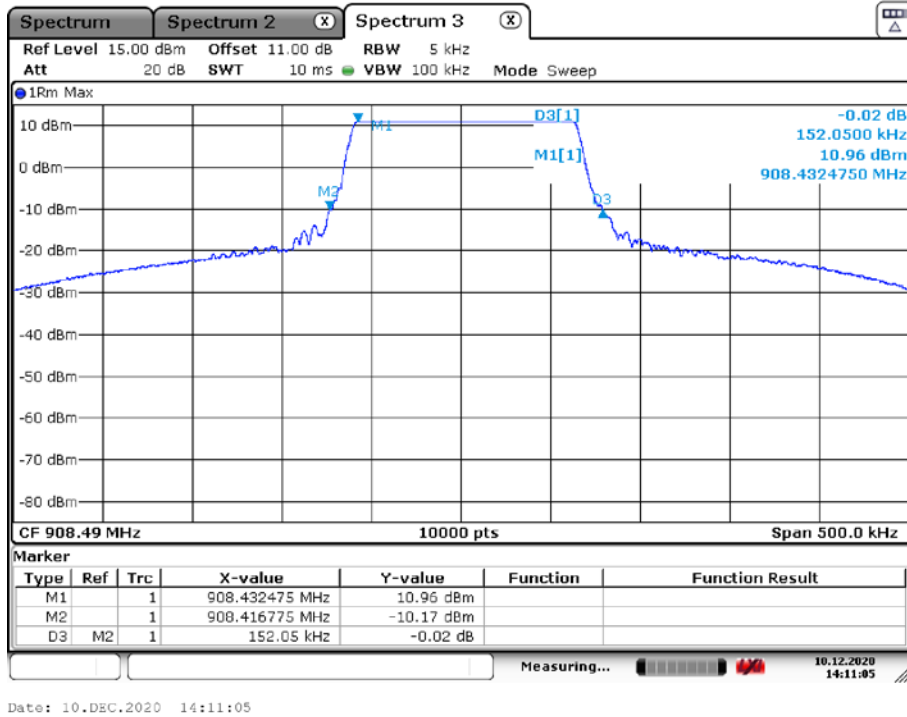
Plot 1: Low Channel, 20 dB-BW



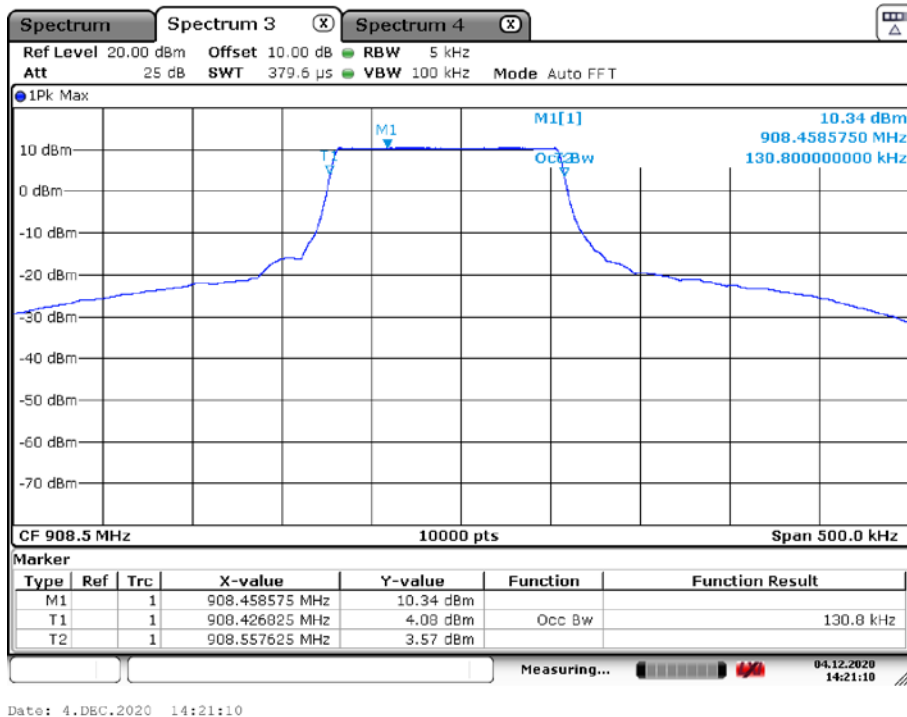
Plot 2: Low Channel, 99%OBW



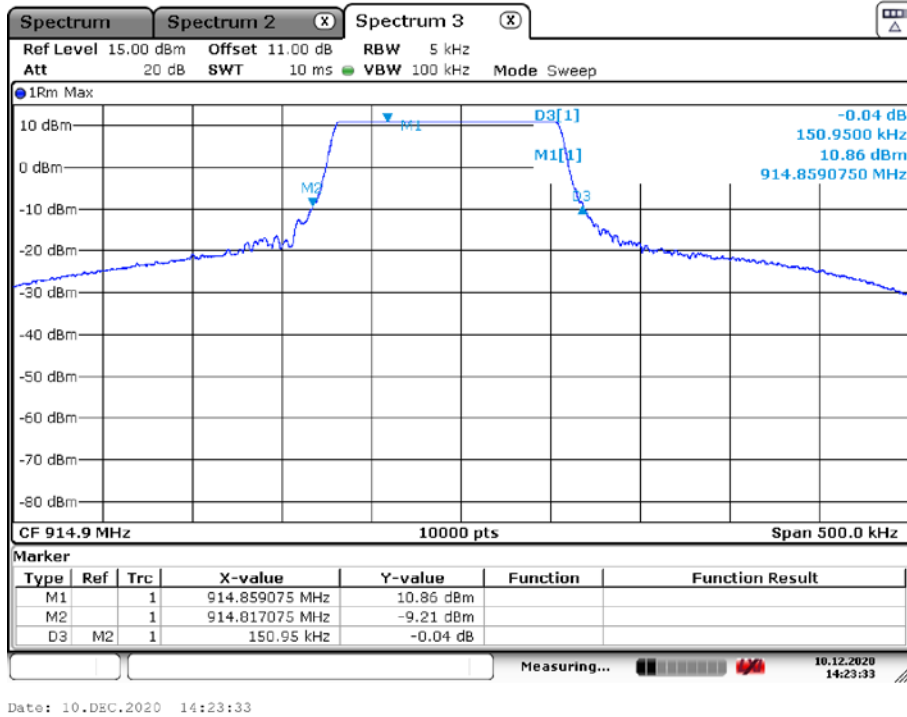
Plot 3: Middle Channel, 20 dB-BW



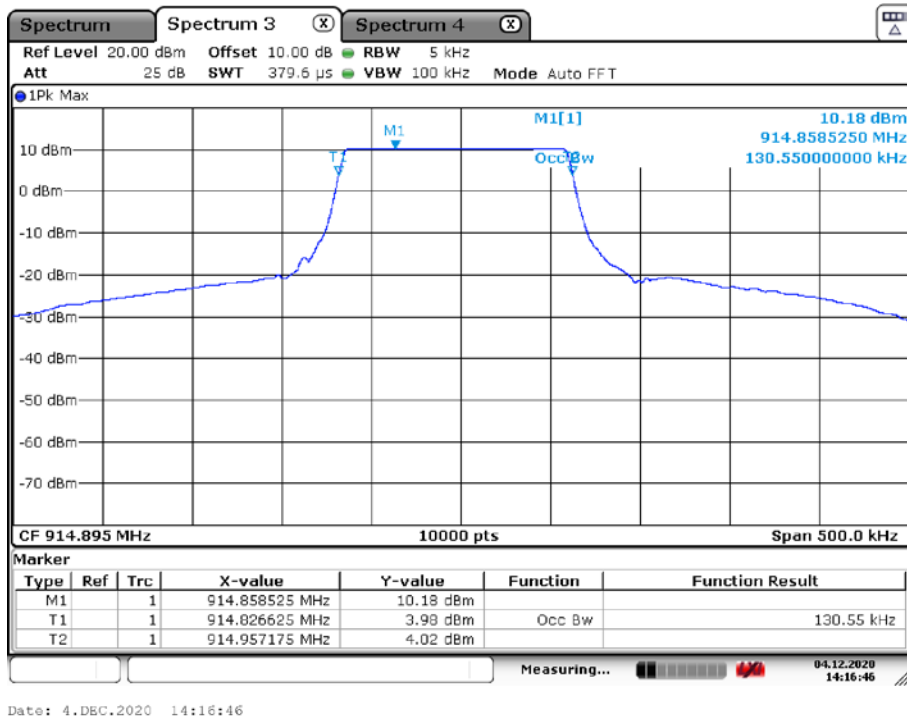
Plot 4: Middle Channel, 99%OBW



Plot 5: High Channel, 20 dB-BW



Plot 6: High Channel, 99%OBW



12.6 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
Used equipment:	See chapter 7.3 A
Measurement uncertainty:	See chapter 9

Limits:

FCC	IC
Maximum Output Power Conducted	
For frequency hopping systems operating in the 902–928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and, 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.	

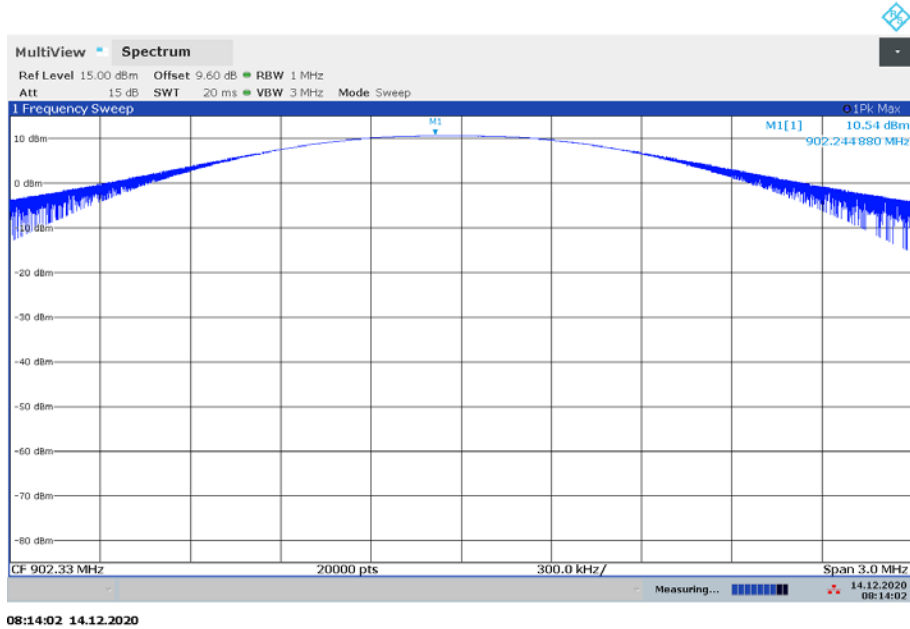
Result:

Test Conditions		Maximum Output Power Conducted / dBm		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	10.54	10.48	10.32

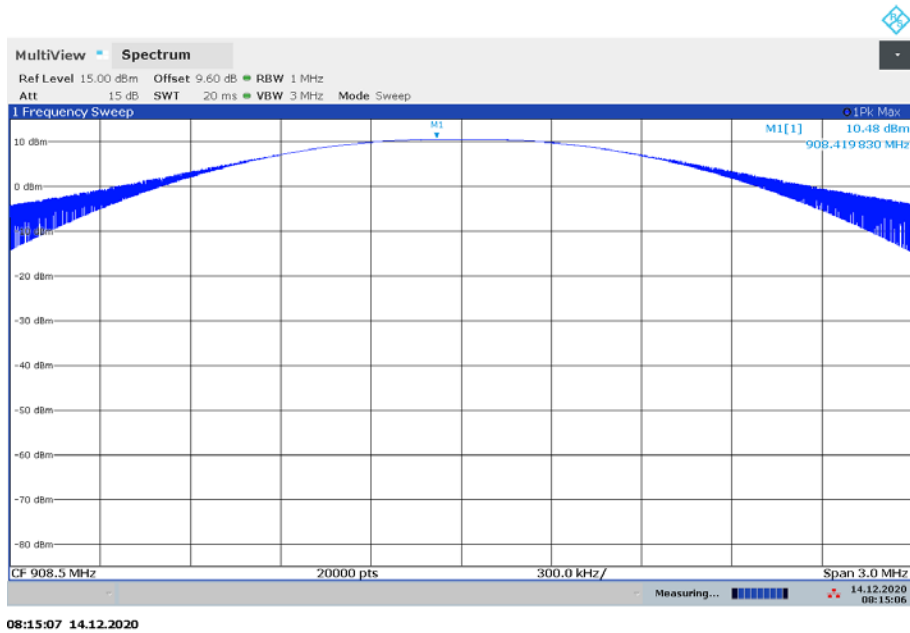
Test Conditions		ERP / dBm		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	11.48	11.70	11.87

Plots:

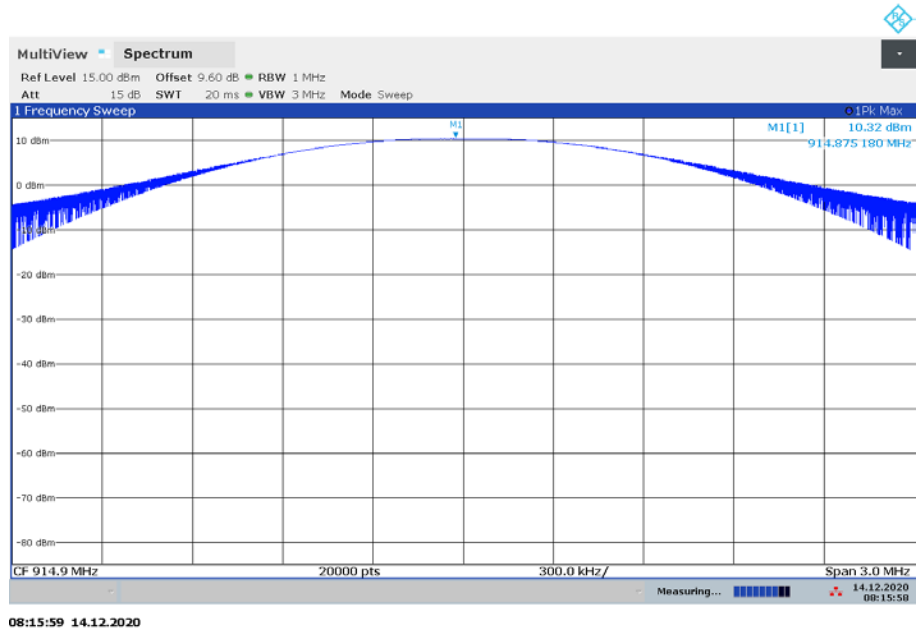
Plot 1: Low Channel



Plot 2: Middle Channel



Plot 3: High Channel



12.7 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 7.3 A
Measurement uncertainty	See sub clause 8

Limits:

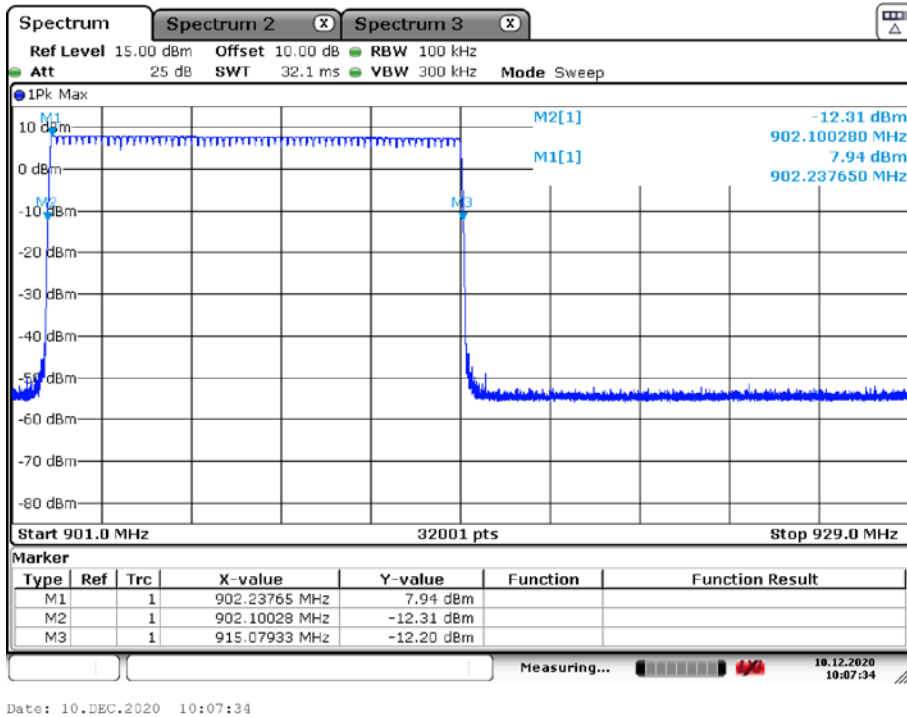
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains 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:

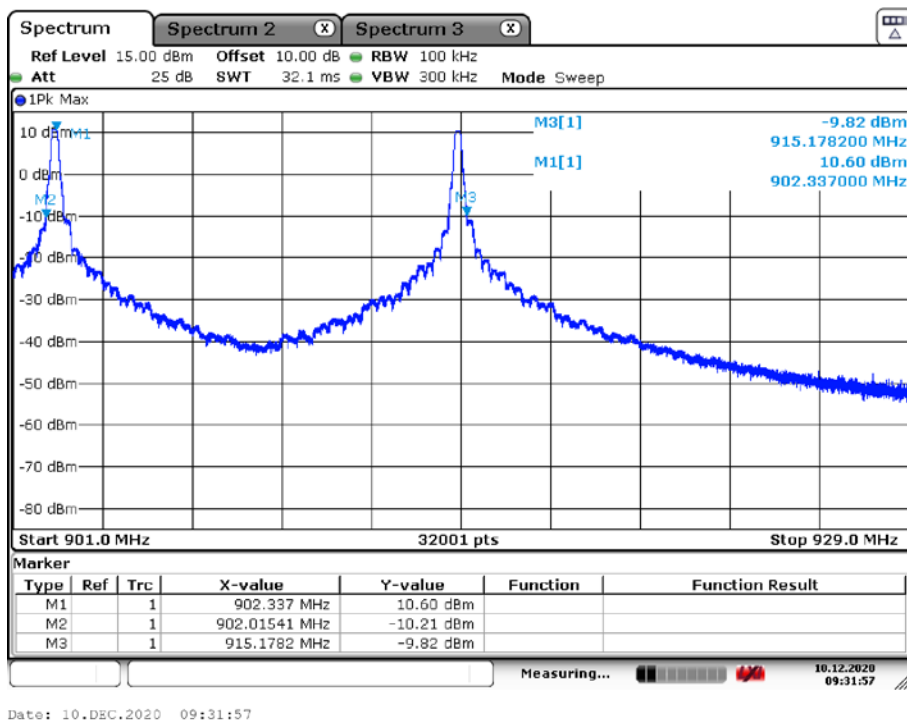
Scenario	Spurious band edge conducted	
	lowest channel	highest channel
Lower band edge – hopping on	> 20 dB	> 20 dB
Upper band edge – hopping on	> 20 dB	> 20 dB

Plots:

Plot 1: 20 dB – hopping on



Plot 2: 20 dB – tx 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			

12.8 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
Resolution bandwidth:	100 KHz
Video bandwidth:	300 KHz
Span:	9 kHz to 10 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.3A
Measurement uncertainty:	See chapter 9

Limits:

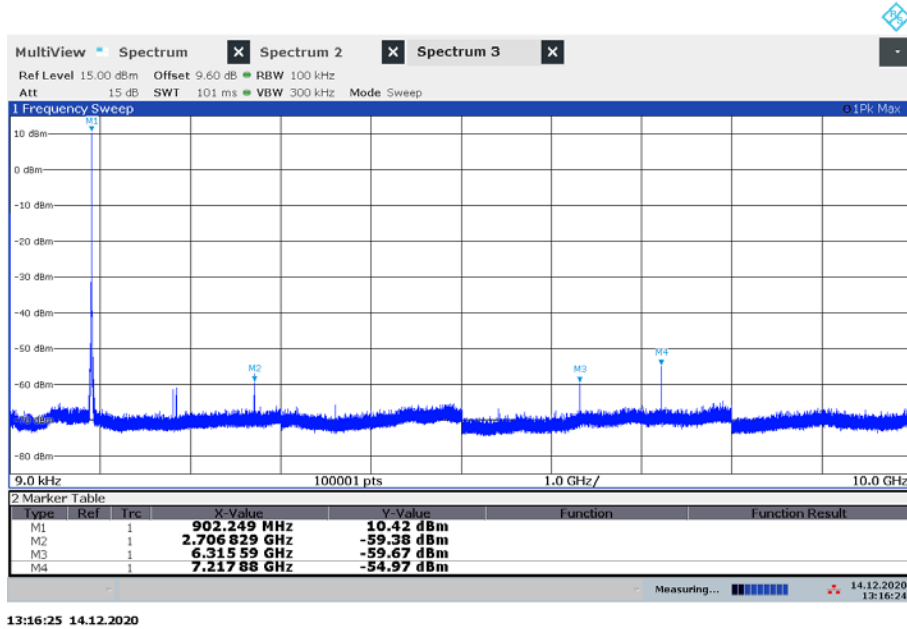
FCC	IC
TX spurious emissions conducted	
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz 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</p>	

Result:

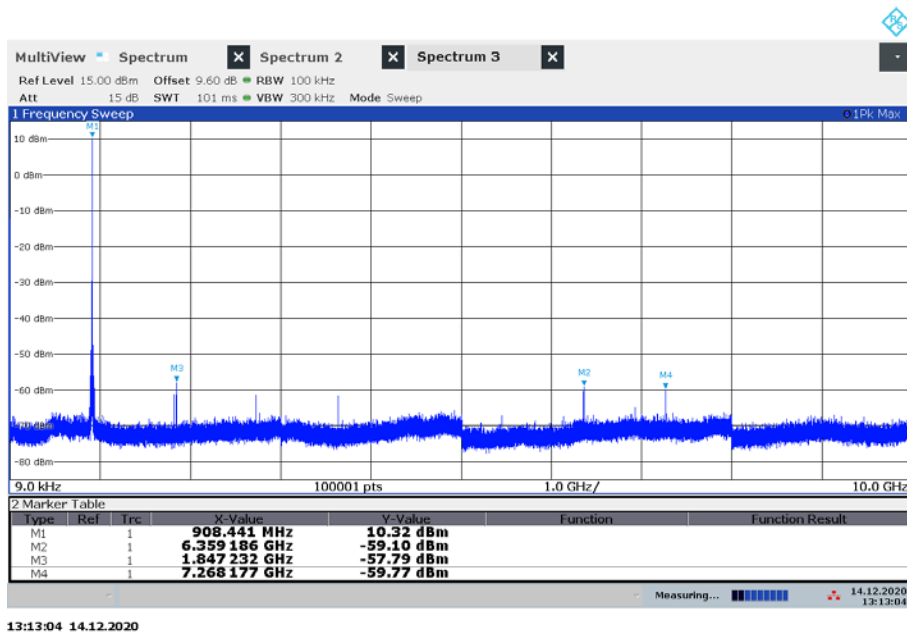
Frequency / MHz	Amplitude of emission / dBm	Limit max. allowed emission power	actual attenuation below frequency of operation / dBc	Results
902.2	10.42	24 dBm	-/-	Operating frequency
2706	-59.38	-20dBc	69.80	> 20dBc
6315	-59.67	-20dBc	70.09	> 20dBc
7217	-54.97	-20dBc	65.39	> 20dBc
908.4	10.32	24 dBm	-/-	Operating frequency
1847	57.79	-20dBc	68.11	> 20dBc
6359	59.10	-20dBc	69.42	> 20dBc
7268	59.77	-20dBc	70.09	> 20dBc
914.8	10.21	24 dBm	-/-	Operating frequency
2744	-58.91	-20dBc	69.12	> 20dBc
6404	-57.41	-20dBc	67.61	> 20dBc
7318	-60.20	-20dBc	70.41	> 20dBc

Plots:

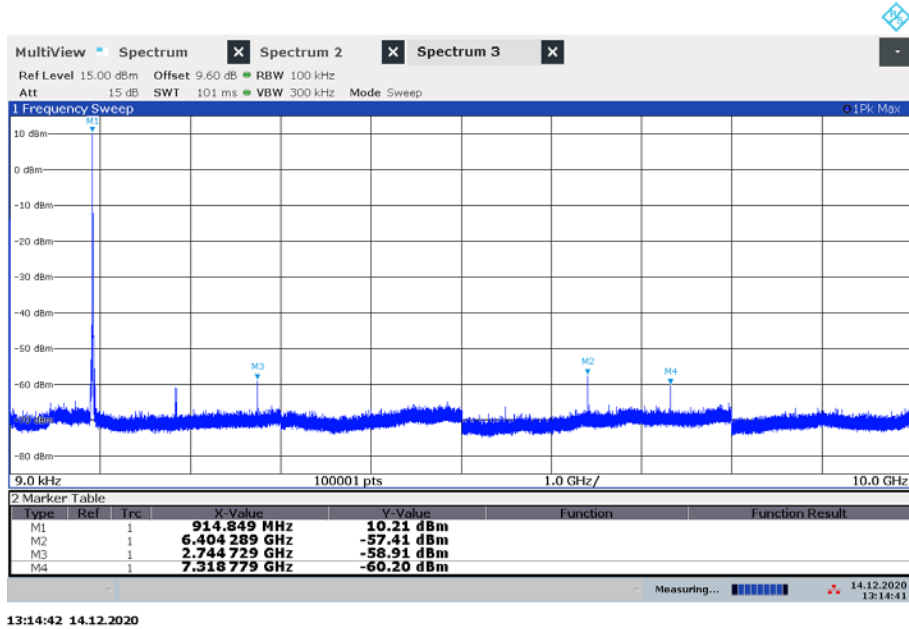
Plot 1: Low channel, 9 kHz – 10 GHz



Plot 2: Middle channel, 9 kHz – 10 GHz



Plot 3: High channel, 9 kHz – 10 GHz



12.9 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
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
Used equipment:	See chapter 7.2 A
Measurement uncertainty:	See chapter 9

Limits:

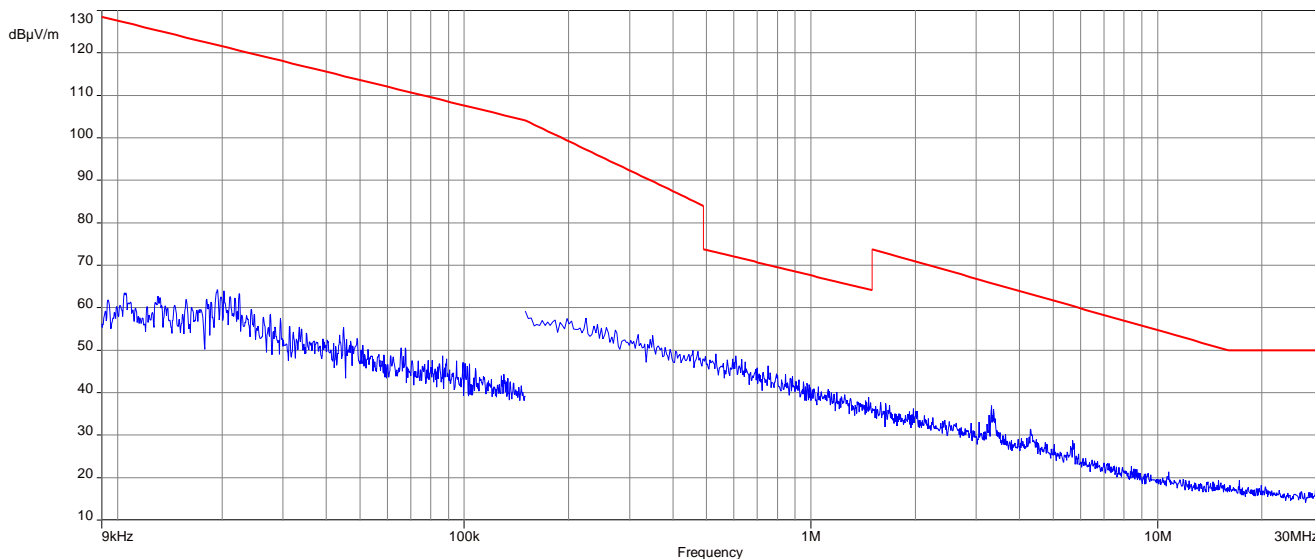
FCC		IC	
TX spurious emissions radiated < 30 MHz			
Frequency / MHz	Field strength / (dBµV/m)	Measurement distance	
0.009 – 0.490	2400/F(kHz)	300	
0.490 – 1.705	24000/F(kHz)	30	
1.705 – 30.0	30	30	

Result:

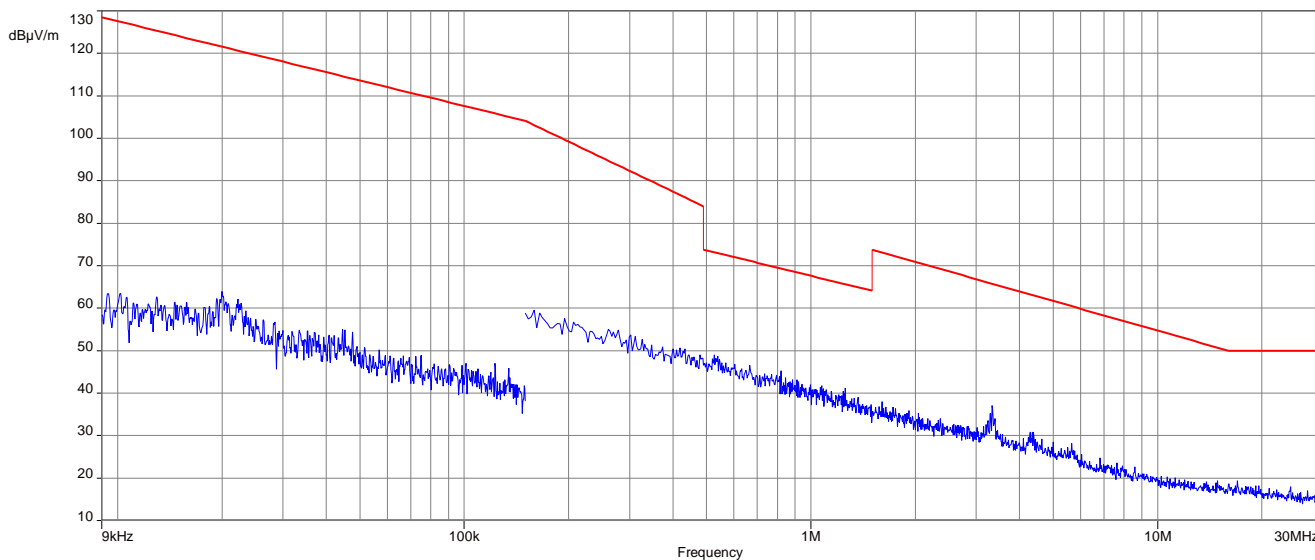
Spurious emission level								
Lowest channel			Middle channel			Highest channel		
Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

Plots:

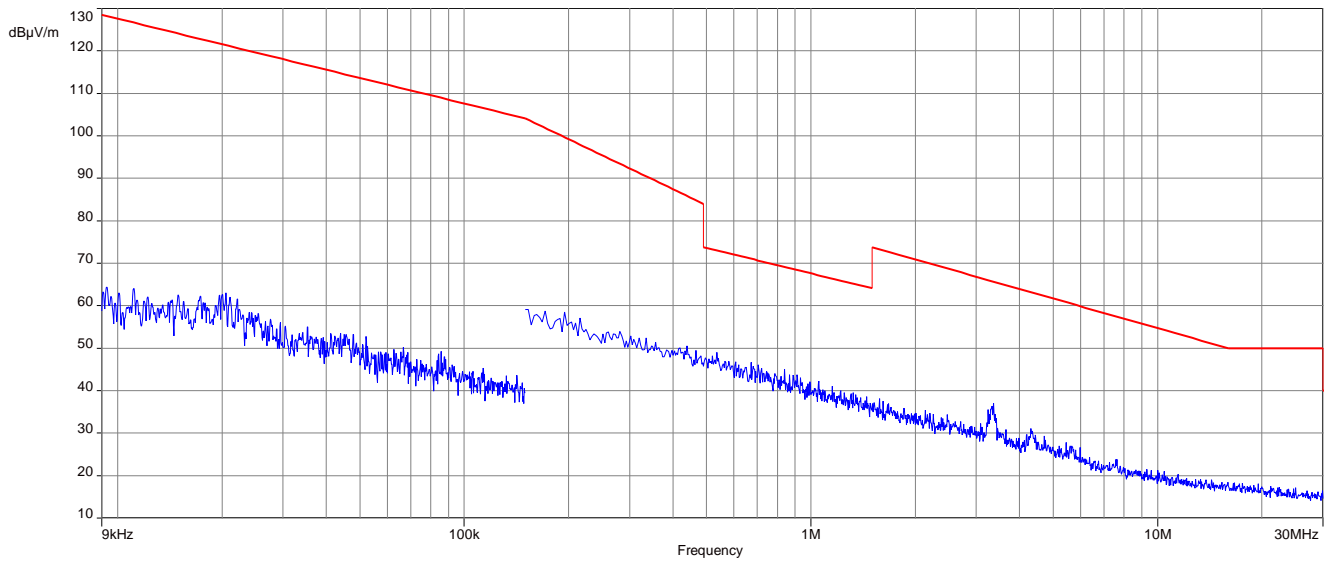
Plot 1: TX-Mode Low channel



Plot 2: TX-Mode Middle channel



Plot 3: TX-Mode High channel



12.10 Spurious Emissions Radiated > 30 MHz

12.10.1 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:

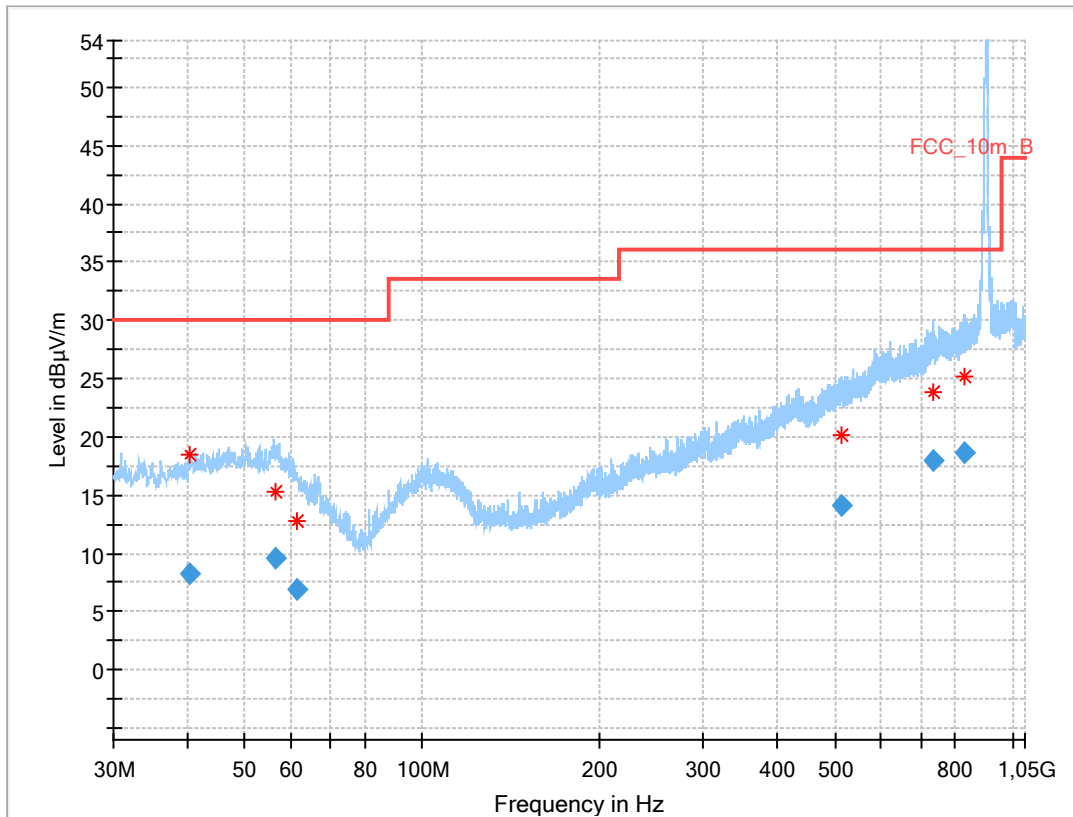
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x VBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	FHSS single channel mode
Test setup	See sub clause 7.1 A
Measurement uncertainty	See sub clause 9

Limits:

FCC	IC	
Band-edge Compliance of conducted and radiated emissions		
<p>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)).</p>		
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 (Low channel)

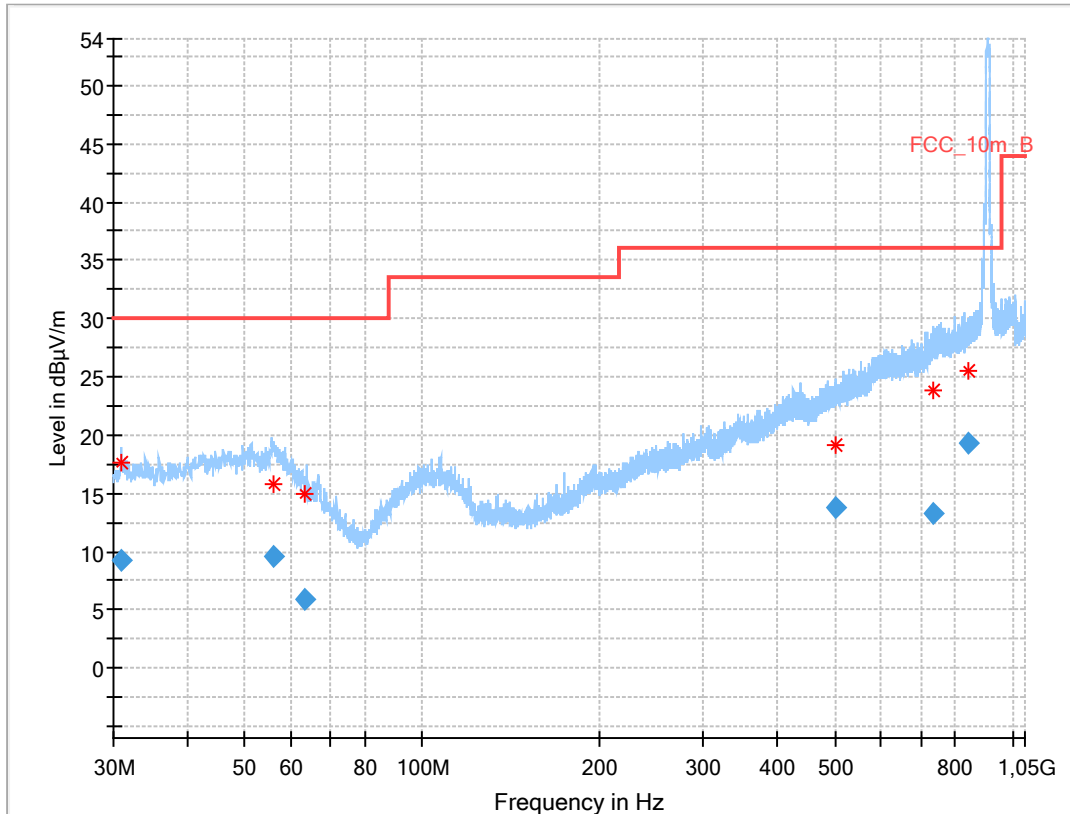


NOTE: TX carrier is not notched.

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)
40.378	8.23	30.0	21.8	1000	120.0	315.0	V	70	13
56.250	9.54	30.0	20.5	1000	120.0	200.0	H	220	15
61.340	6.98	30.0	23.0	1000	120.0	400.0	H	0	12
512.801	14.13	36.0	21.9	1000	120.0	200.0	V	52	19
736.279	17.93	36.0	18.1	1000	120.0	125.0	H	225	22
827.445	18.72	36.0	17.3	1000	120.0	400.0	V	270	23

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

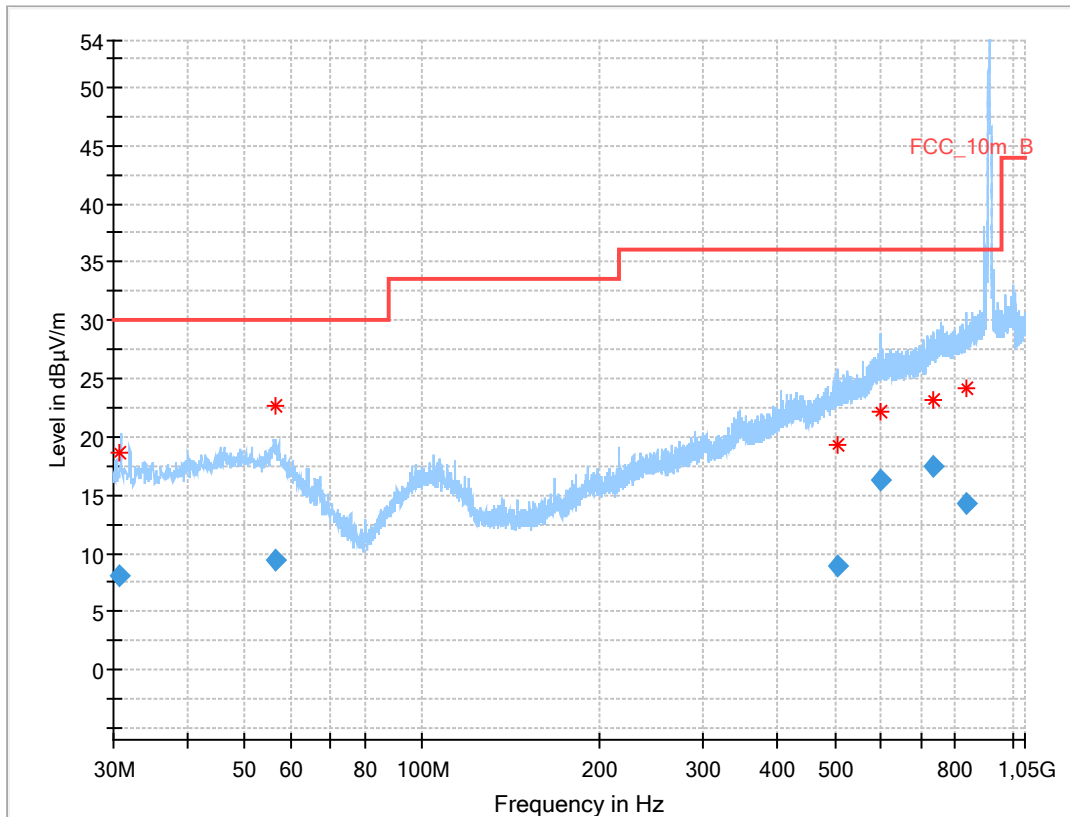


NOTE: TX carrier is not notched.

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)
30.917	9.26	30.0	20.7	1000	120.0	106.0	V	180	12
55.993	9.60	30.0	20.4	1000	120.0	119.0	V	180	15
63.429	5.90	30.0	24.1	1000	120.0	106.0	V	-45	12
501.406	13.77	36.0	22.2	1000	120.0	103.0	H	161	18
734.584	13.32	36.0	22.7	1000	120.0	395.0	H	180	22
844.949	19.36	36.0	16.6	1000	120.0	340.0	H	45	23

Plot 3: 30 MHz – 1 GHz, horizontal & vertical polarisation (High channel)



NOTE: TX carrier is not notched.

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)
30.668	8.11	30.0	21.9	1000	120.0	123.0	V	-13	12
56.407	9.47	30.0	20.5	1000	120.0	191.0	H	45	15
504.387	8.99	36.0	27.0	1000	120.0	260.0	V	135	18
597.058	16.21	36.0	19.8	1000	120.0	354.0	V	180	20
732.812	17.45	36.0	18.6	1000	120.0	225.0	H	90	22
834.872	14.29	36.0	21.7	1000	120.0	245.0	V	249	23

12.10.2 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 10 GHz
Trace mode	Max hold
Measured modulation	FHSS single channel mode
Test setup	See sub clause 7.2 C
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:

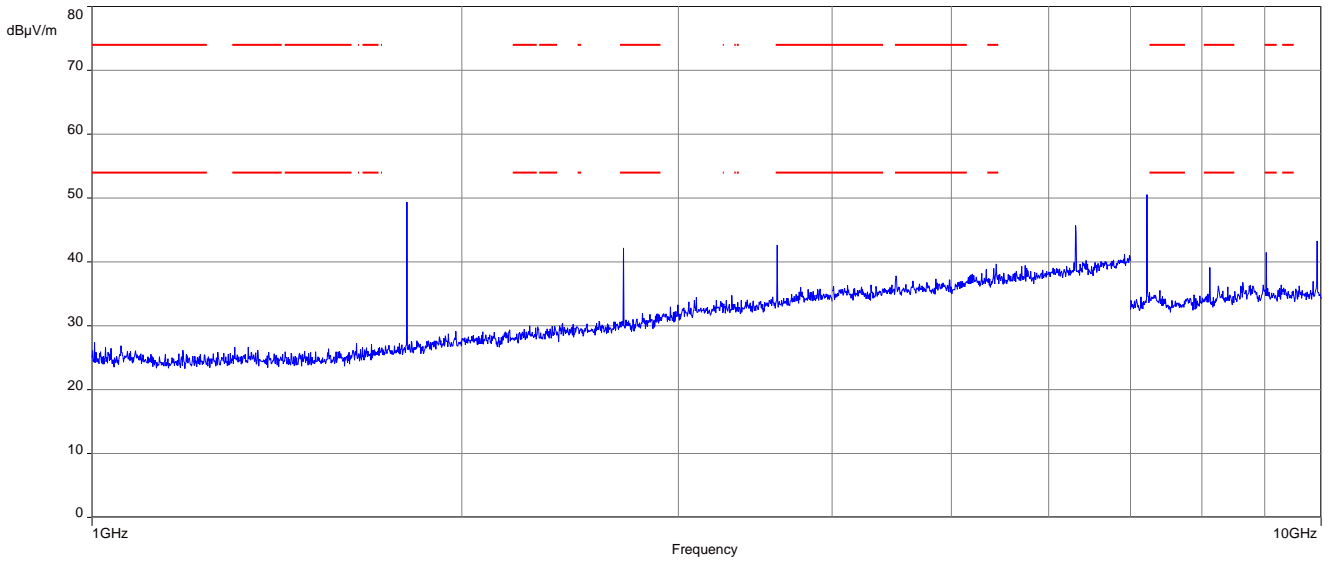
ANSI C63.10
The average emission shall be determined by using Video averaging (VBW = 10 Hz). If the dwell time of the hopping signal is less than 100 ms (per channel), the VBW=10 Hz reading may be adjusted by a factor: $F = 20 \log(\text{dwell time}/100 \text{ ms})$

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

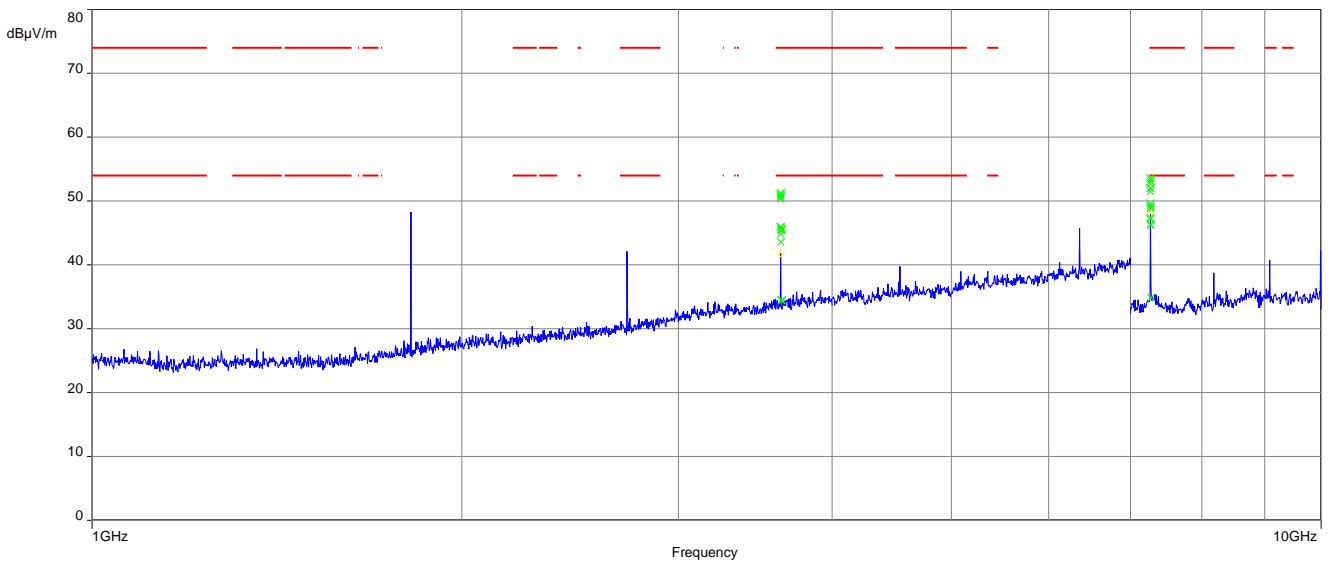
Result:

TX spurious emissions radiated								
Lowest channel			Middle channel			Highest channel		
Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)
- / -	Peak	- / -	3633	Peak	51.26	2744	Peak	50.96
	AVG	- / -		AVG	45.92		AVG	44.68
- / -	Peak	- / -	7267	Peak	53.62	3659	Peak	51.55
	AVG	- / -		AVG	49.63		AVG	46.00
- / -	Peak	- / -	- / -	Peak	- / -	7319	Peak	51.45
	AVG	- / -		AVG	- / -		AVG	46.22

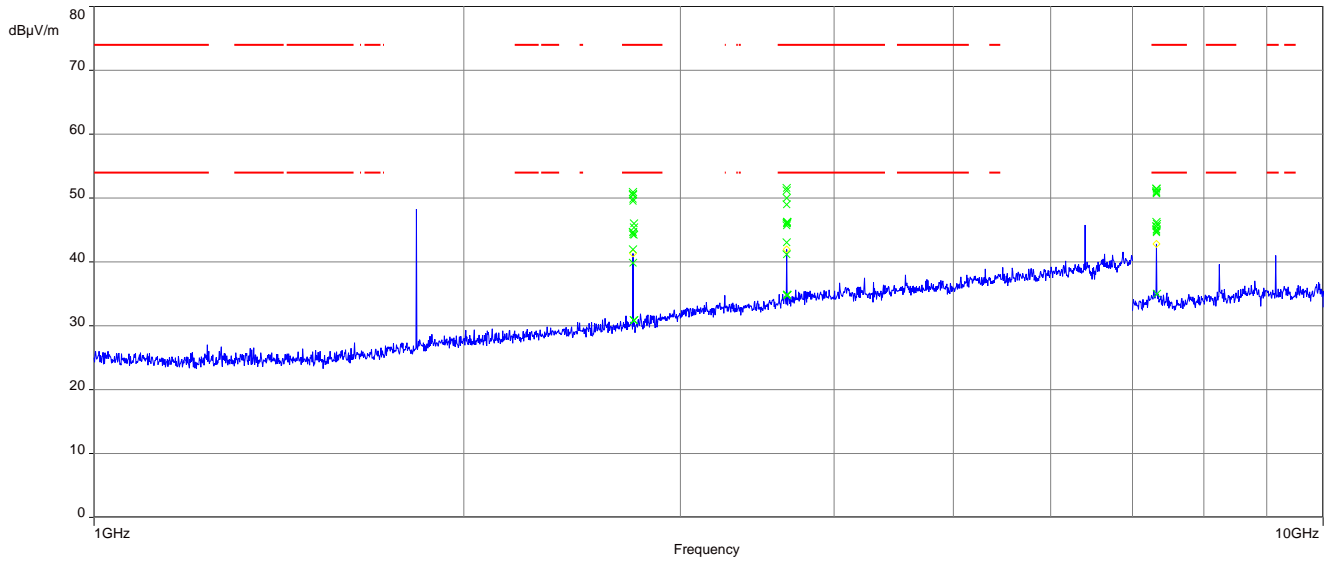
Plot 1: 1 GHz – 10 GHz, horizontal & vertical polarisation (Low channel)



Plot 2: 1 GHz – 10 GHz, horizontal & vertical polarisation (middle channel)



Plot 3: 1 GHz – 10 GHz, horizontal & vertical polarisation (High channel)



13 Measurement results Part 2 DTS

13.1 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 7.3 A
Measurement uncertainty:	See chapter 9

Limits:

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

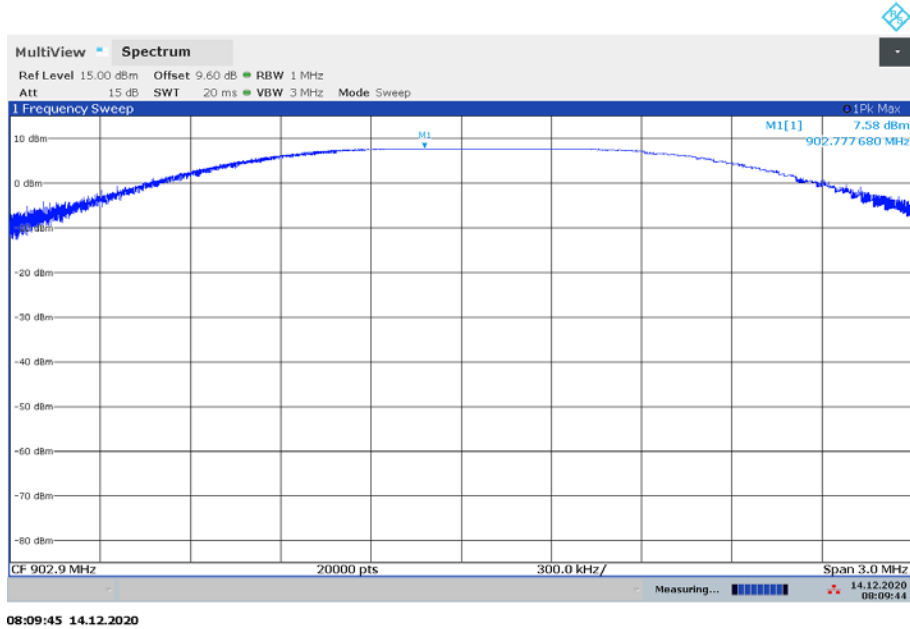
Result:

Test Conditions		Maximum Output Power Conducted / dBm		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	7.58	7.55	7.52

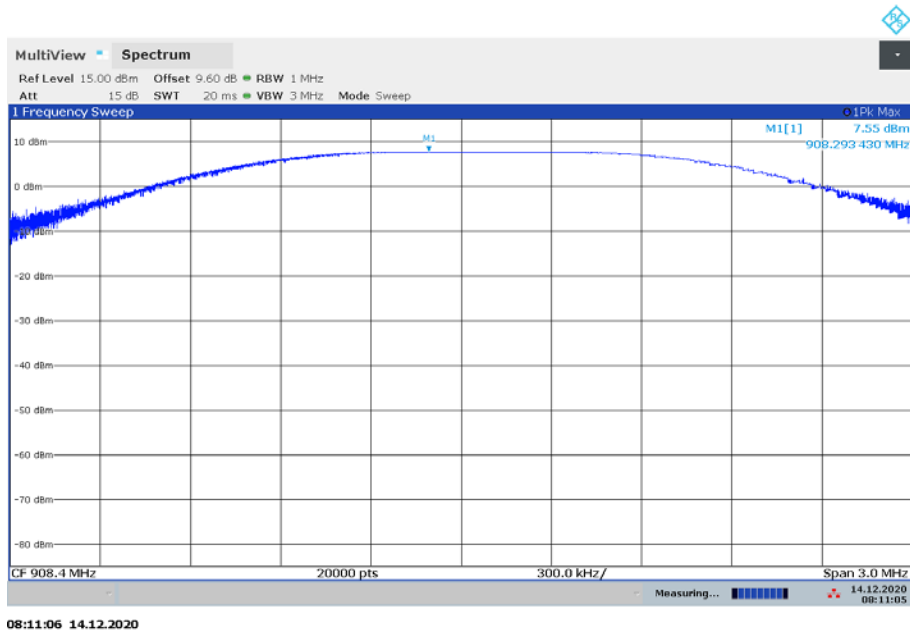
Test Conditions		ERP / dBm		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	10.90	11.22	11.56

Plots:

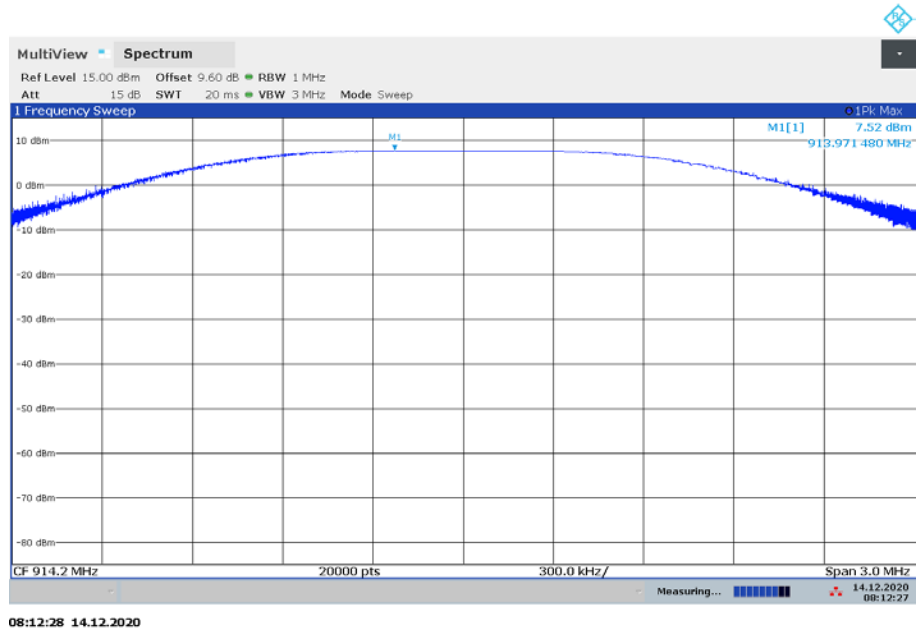
Plot 1: Low Channel



Plot 2: Middle Channel



Plot 3: High Channel



13.2 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:	16.7 ms
Resolution bandwidth:	3 kHz
Video bandwidth:	10 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 7.3 A
Measurement uncertainty:	See chapter 9

Limits:

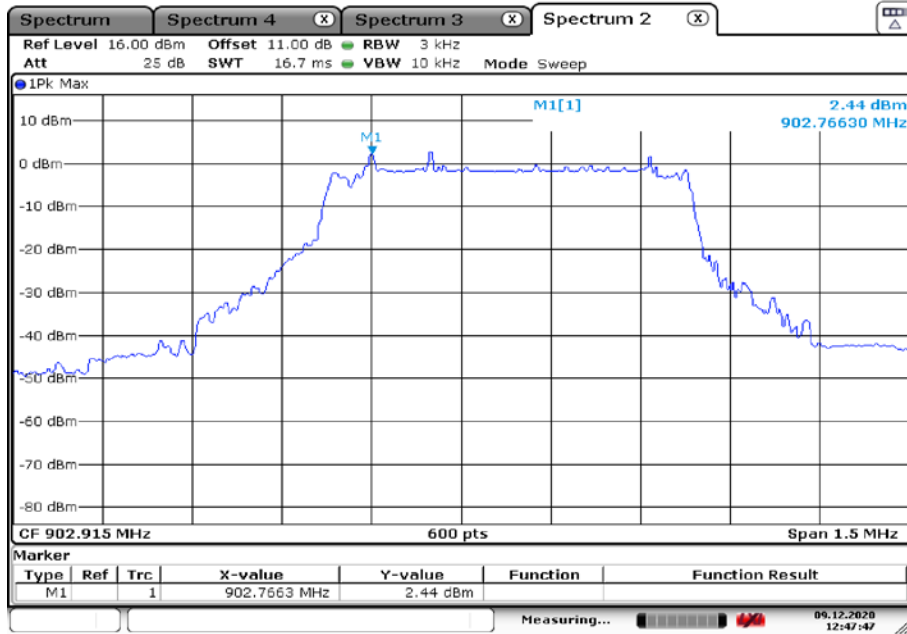
FCC	IC
Power Spectral Density	
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration.	

Results:

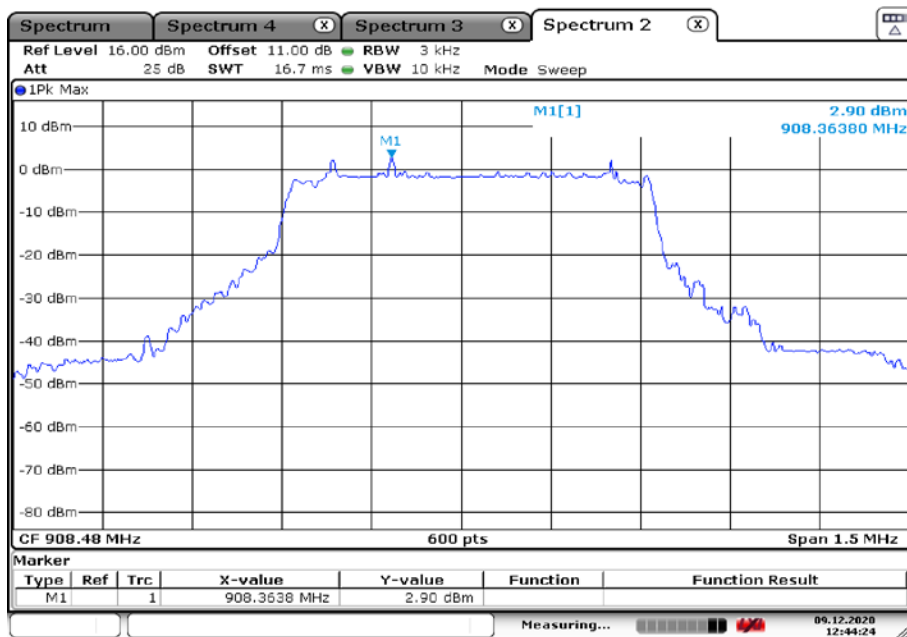
Modulation Channel	Power Spectral density / (dBm/3kHz)		
	Low	Middle	High
	2.44	2.90	2.68

Plots:

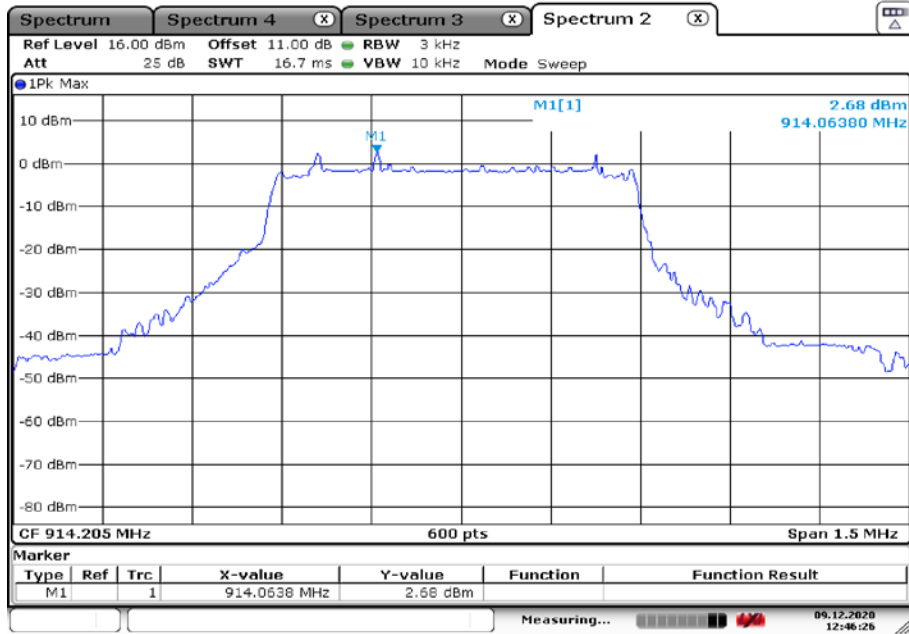
Plot 1: Low Channel



Plot 2: Middle Channel



Plot 3: High Channel



Date: 9. Dec. 2020 12:46:26

13.3 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% Of 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 7.3 A
Measurement uncertainty:	See chapter 9

Limits:

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

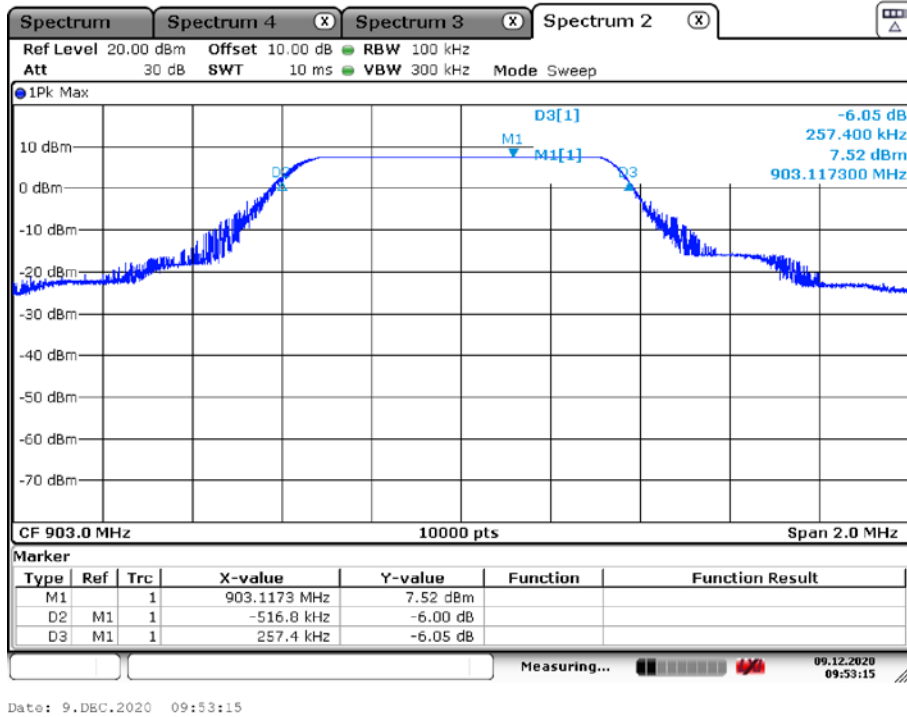
Results:

Test Conditions		6 dB Bandwidth / kHz		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	774.2	779.6	769.4

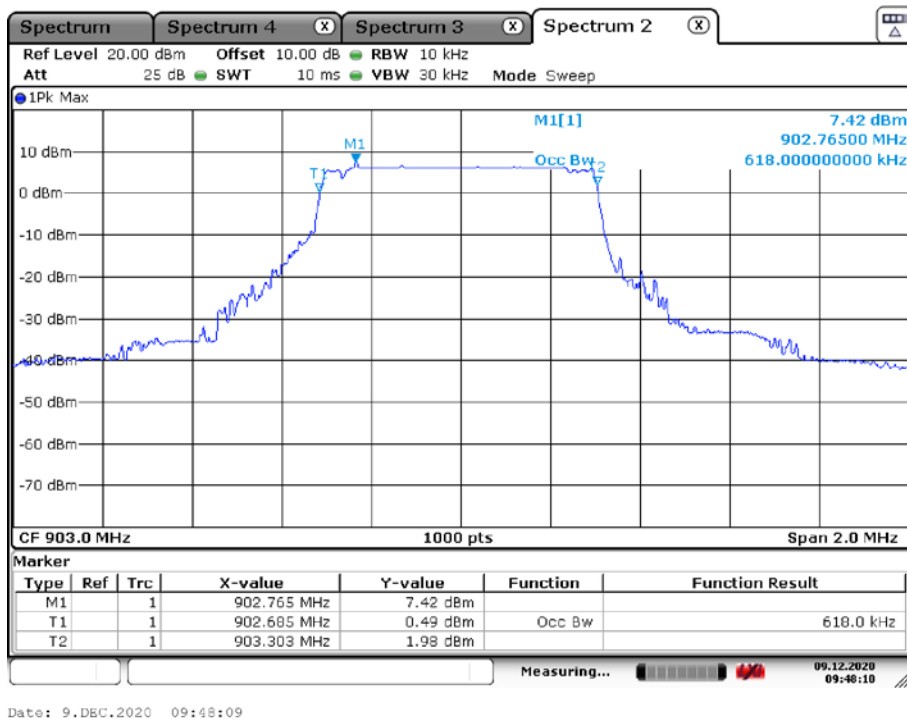
Test Conditions		99% Bandwidth / kHz		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	618.0	616.0	614

Plots:

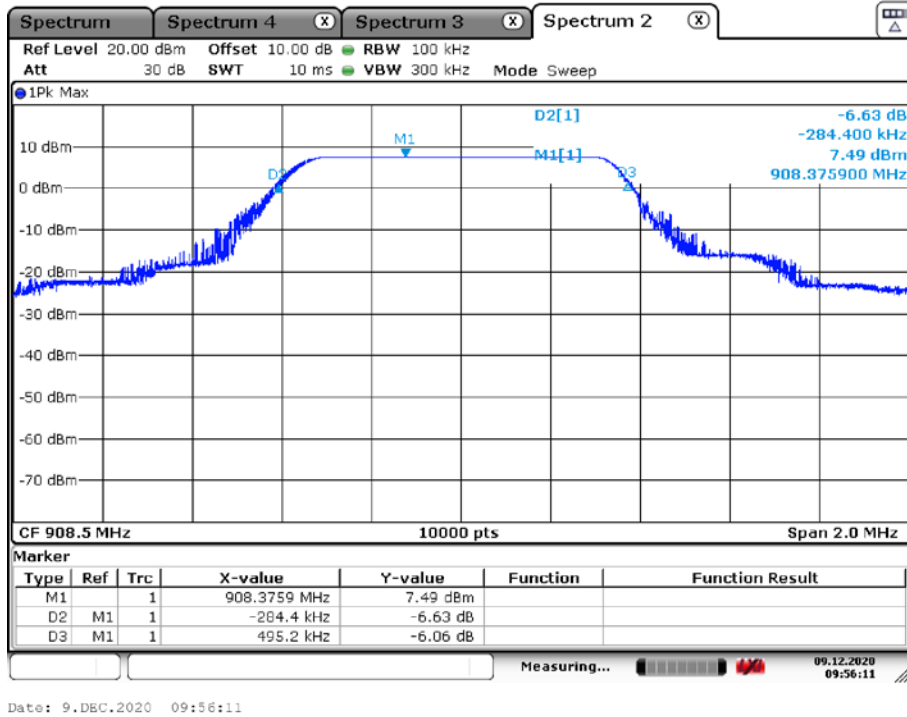
Plot 1: Low Channel, 6 dB-BW



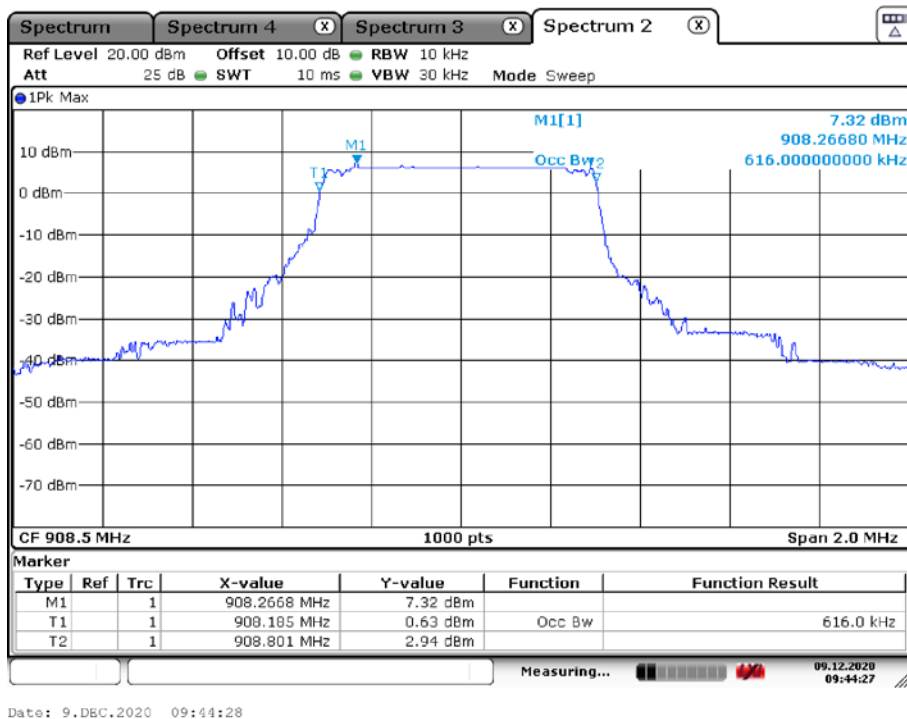
Plot 2: Low Channel, 99%OBW



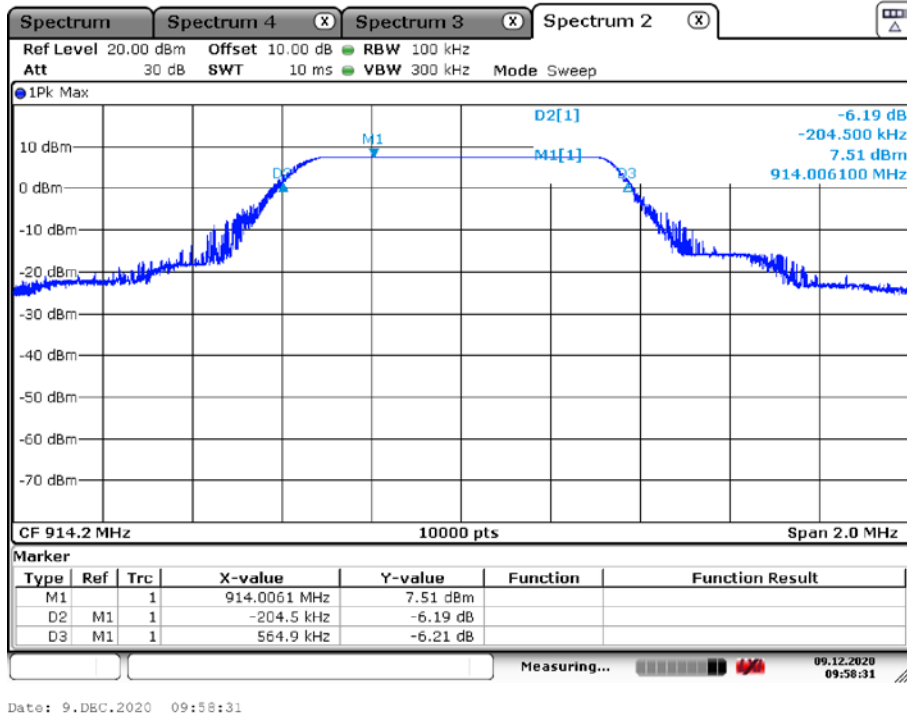
Plot 3: Middle Channel, 6 dB-BW



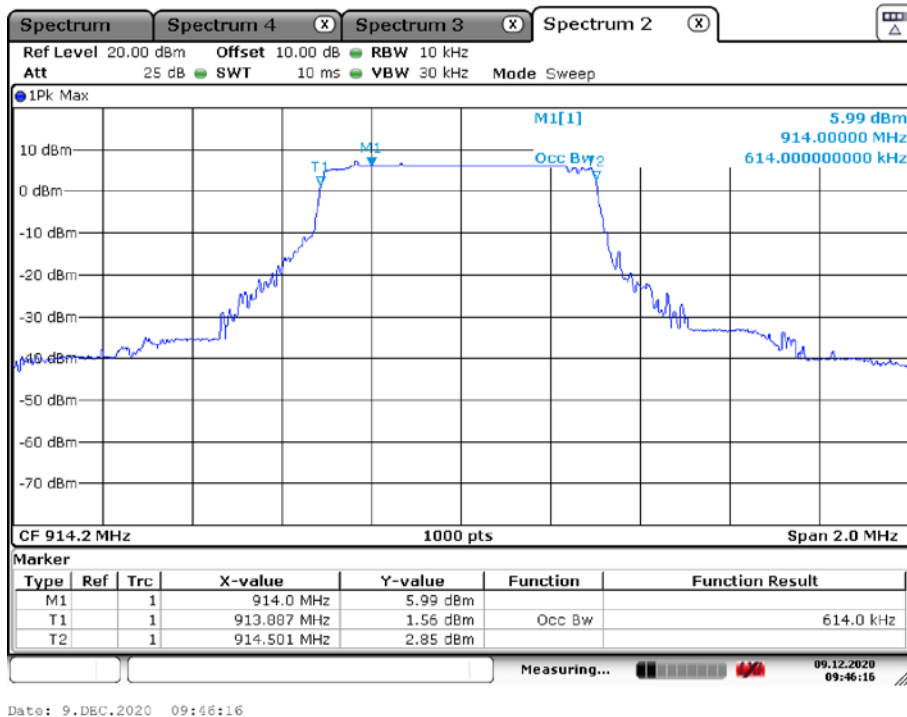
Plot 4: Middle Channel, 99%OBW



Plot 5: High Channel, 6 dB-BW



Plot 6: High Channel, 99%OBW



13.4 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 7.3 A
Measurement uncertainty:	See chapter 9

Limits:

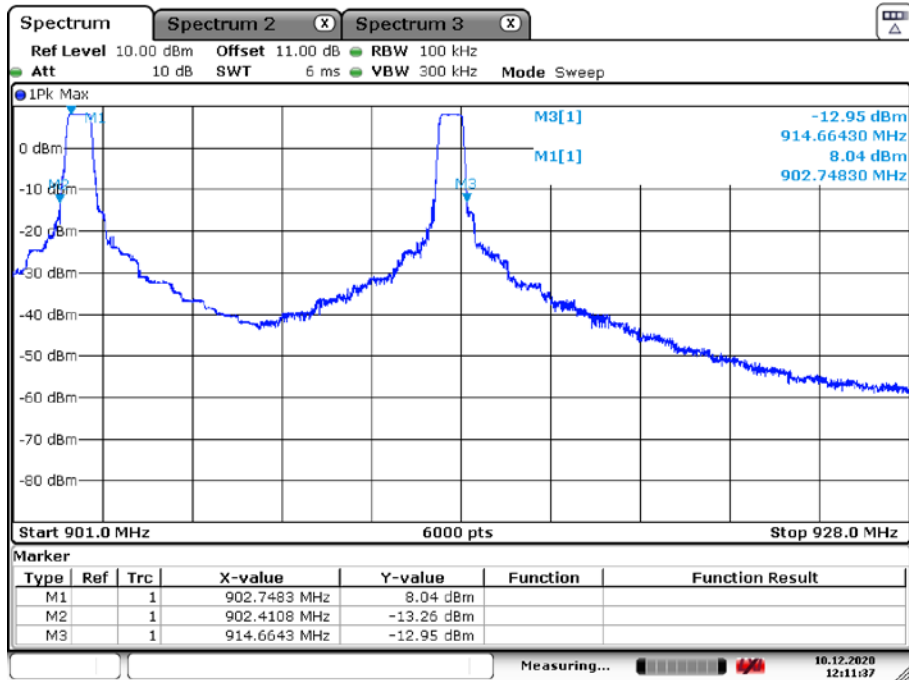
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains 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	
	lowest channel	highest channel
Modulation		
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



Date: 10.DEC.2020 12:11:37

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			

13.5 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, middle and high channel.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	100 KHz
Video bandwidth:	300 KHz
Span:	9 kHz to 1GHz 1GHz to 10GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.3A
Measurement uncertainty:	See chapter 9

Limits:

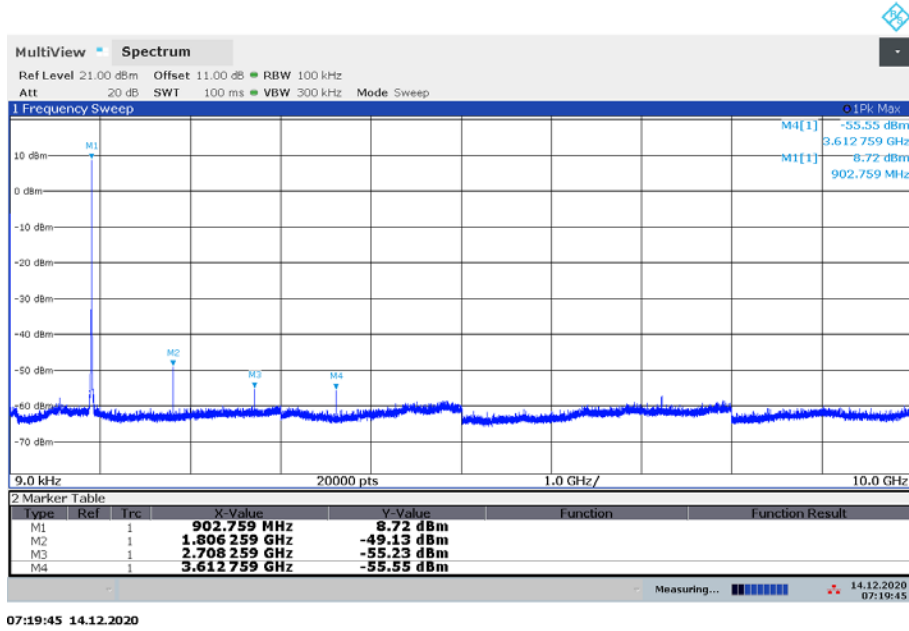
FCC	IC
TX spurious emissions conducted	
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz 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</p>	

Result:

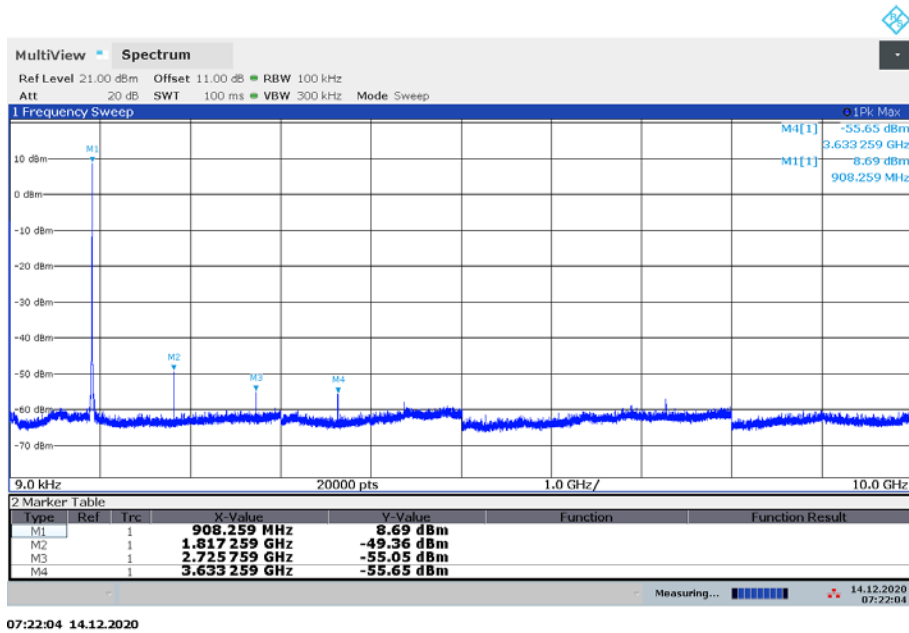
Frequency / MHz	Amplitude of emission / dBm	Limit max. allowed emission power	actual attenuation below frequency of operation / dBc	Results
902.7	8.72	24 dBm	-/-	Operating frequency
1806	-49.13	-20dBc	57.85	> 20dBc
2708	-55.23	-20dBc	63.95	> 20dBc
3612	-55.55	-20dBc	64.27	> 20dBc
908.2	8.69	24 dBm	-/-	Operating frequency
1817	-49.36	-20dBc	58.05	> 20dBc
2725	-55.05	-20dBc	63.74	> 20dBc
3633	-55.65	-20dBc	64.34	> 20dBc
914.2	8.52	24 dBm	-/-	Operating frequency
1828	-48.72	-20dBc	57.24	> 20dBc
2742	-55.23	-20dBc	63.75	> 20dBc
3656	-55.31	-20dBc	63.83	> 20dBc

Plots:

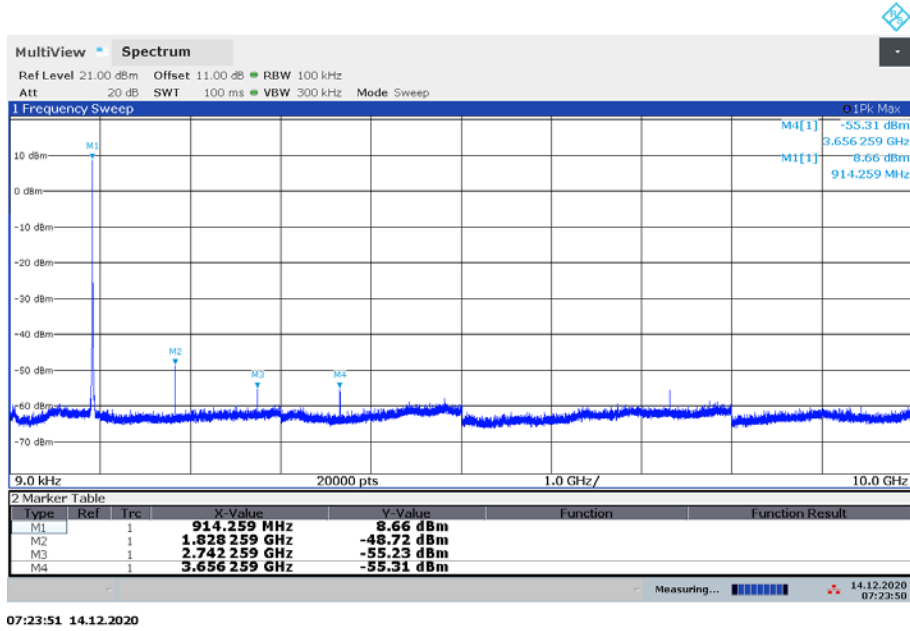
Plot 1: Low channel, 9 kHz – 10 GHz



Plot 2: Middle channel, 9 kHz – 10 GHz



Plot 3: Middle channel, 1 GHz – 10 GHz



13.6 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
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
Used equipment:	See chapter 7.2 A
Measurement uncertainty:	See chapter 9

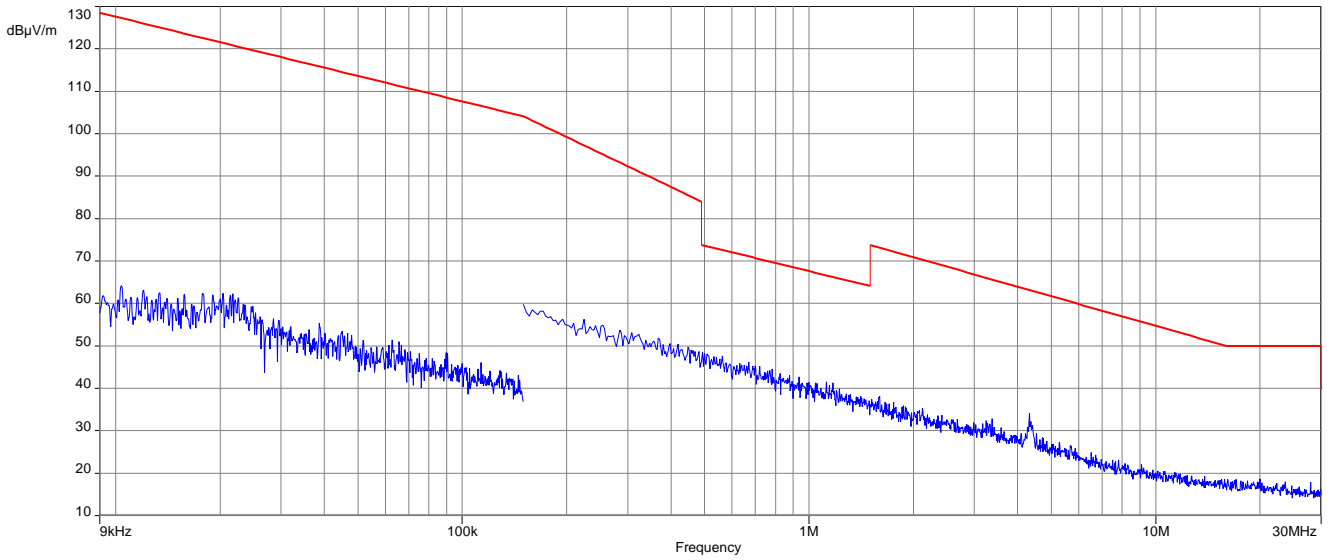
Limits:

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	

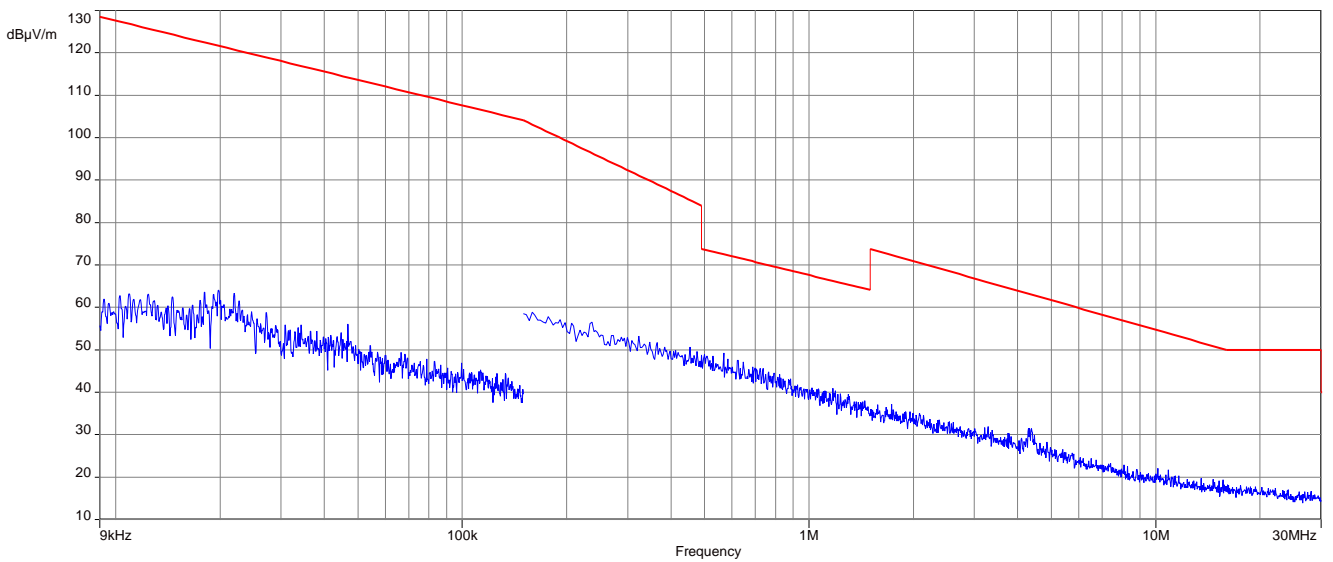
Result:

Spurious emission level								
Lowest channel			Lowest channel			Lowest channel		
Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)	Frequency / MHz	Detector	Level / (dBµV/m)
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

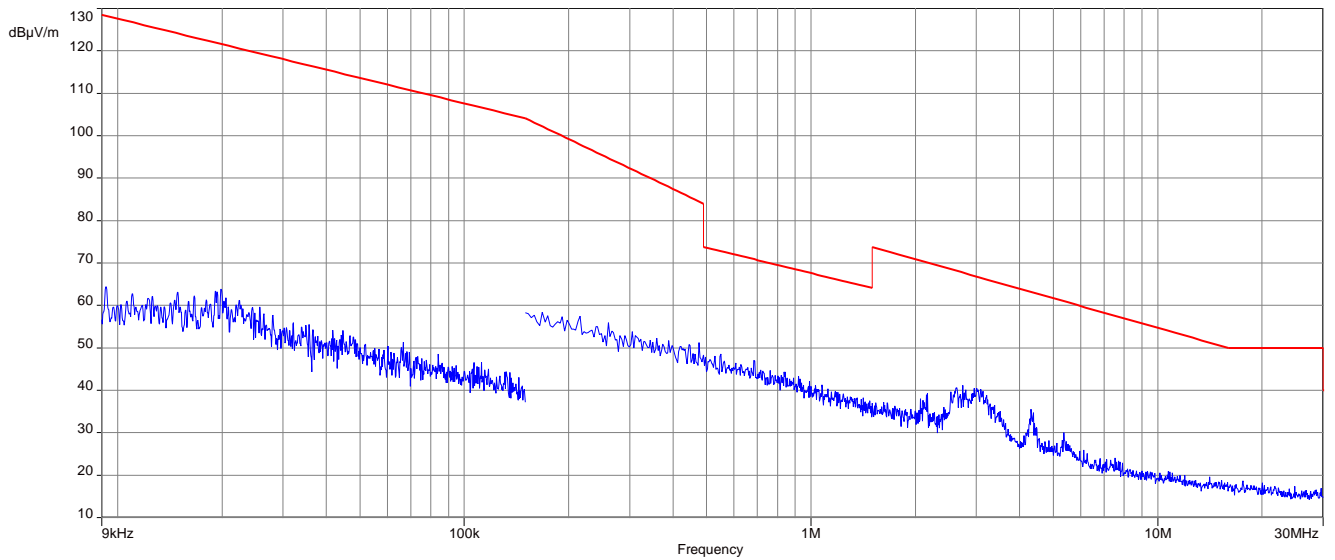
Plot 1: TX-Mode Low channel



Plot 2: TX-Mode Middle channel



Plot 3: TX-Mode High channel



13.7 Spurious Emissions Radiated > 30 MHz

13.7.1 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, middle and high.

Measurement:

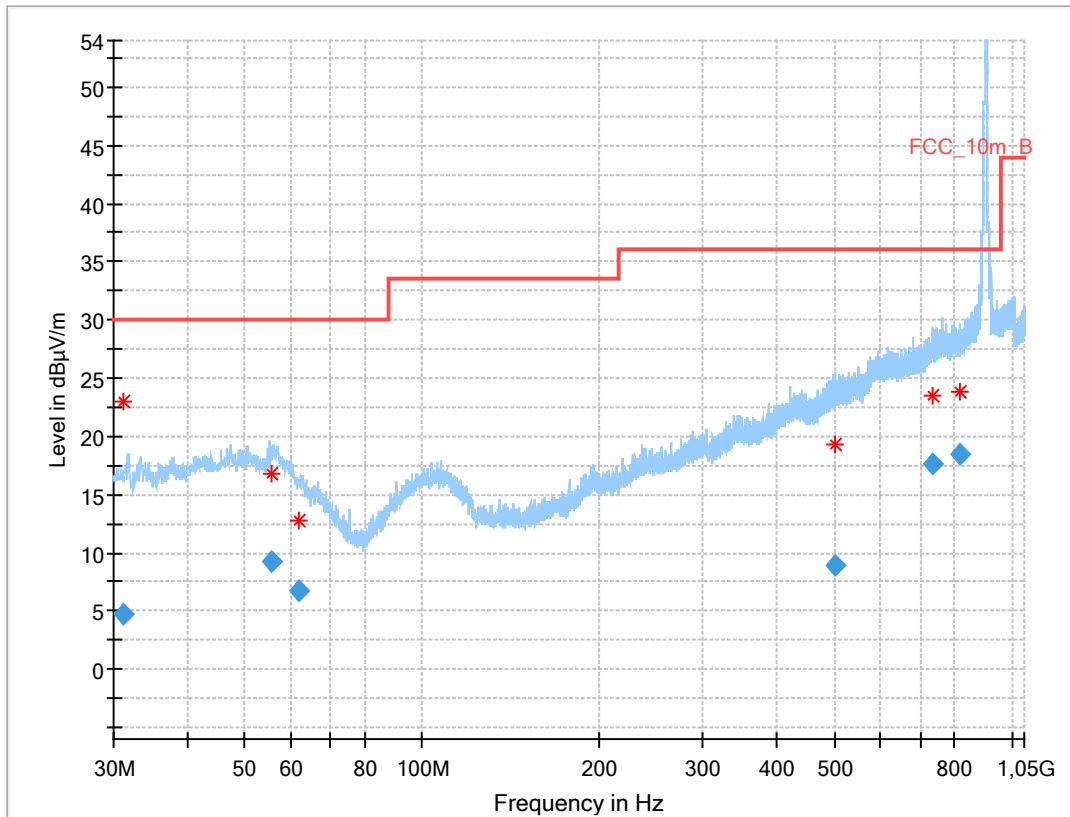
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x VBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	DTS
Test setup	See sub clause 7.1 A
Measurement uncertainty:	See chapter 9

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 (Low channel)

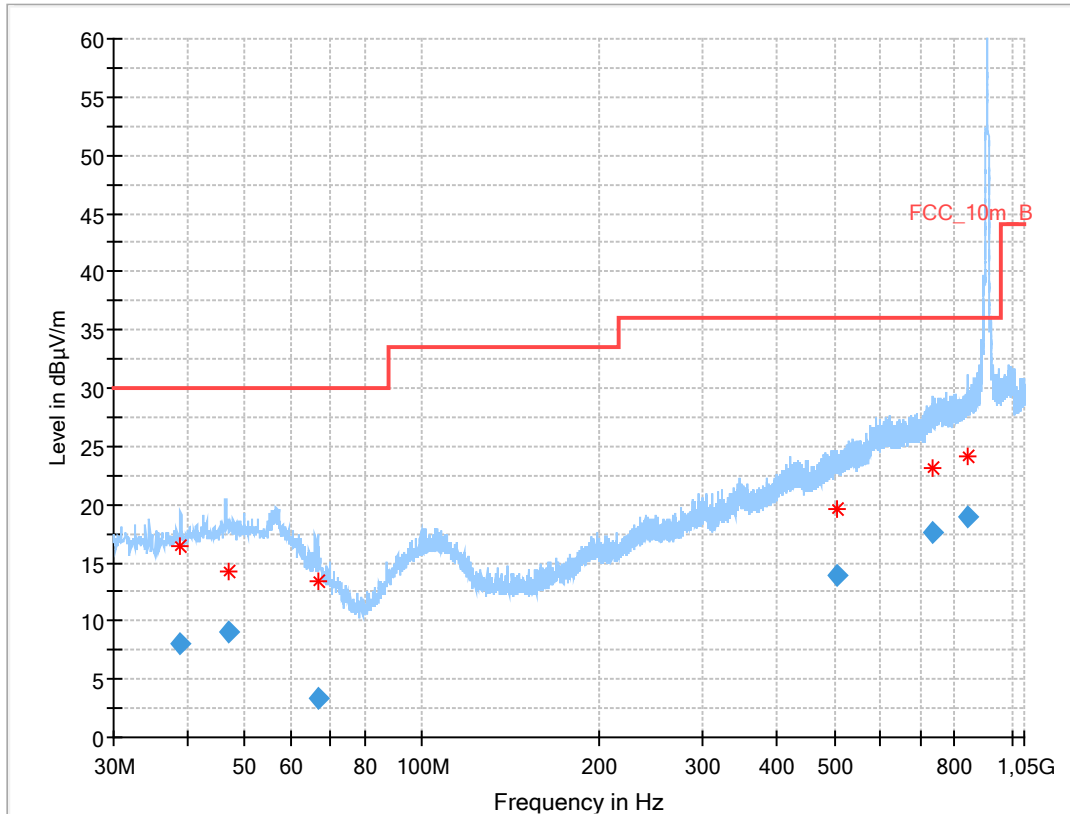


NOTE: TX carrier is not notched.

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)
31.198	4.69	30.0	25.3	1000	120.0	145.0	V	197	12
55.713	9.30	30.0	20.7	1000	120.0	391.0	H	0	15
61.769	6.73	30.0	23.3	1000	120.0	200.0	H	-45	12
500.381	8.88	36.0	27.1	1000	120.0	200.0	H	90	18
736.167	17.64	36.0	18.4	1000	120.0	188.0	H	226	22
814.235	18.45	36.0	17.6	1000	120.0	400.0	H	135	22

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

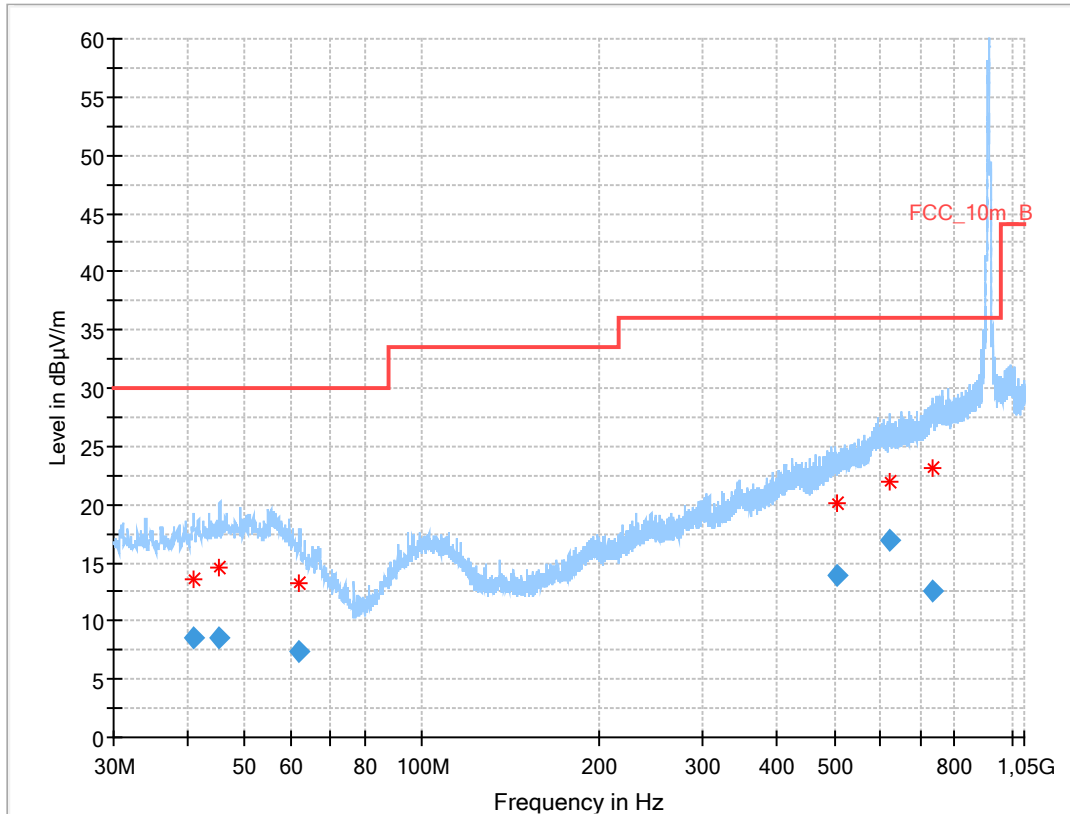


NOTE: TX carrier is not notched.

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)
38.874	8.11	30.0	21.9	1000	120.0	237.0	V	195	13
47.041	9.13	30.0	20.9	1000	120.0	200.0	H	-45	14
66.792	3.38	30.0	26.6	1000	120.0	194.0	H	180	11
506.210	13.88	36.0	22.1	1000	120.0	400.0	H	270	18
734.674	17.61	36.0	18.4	1000	120.0	150.0	V	270	22
840.158	18.99	36.0	17.0	1000	120.0	200.0	H	0	23

Plot 3: 30 MHz – 1 GHz, horizontal & vertical polarisation (High channel)



NOTE: TX carrier is not notched.

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)
40.956	8.50	30.0	21.5	1000	120.0	200.0	V	79	14
45.318	8.50	30.0	21.5	1000	120.0	318.0	V	122	14
62.007	7.30	30.0	22.7	1000	120.0	200.0	H	180	12
504.107	13.91	36.0	22.1	1000	120.0	128.0	V	219	18
623.184	16.95	36.0	19.1	1000	120.0	200.0	H	180	21
735.657	12.65	36.0	23.4	1000	120.0	400.0	V	0	22

13.7.2 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 10 GHz
Trace mode	Max hold
DTS, FHSS Hybrid	DTS
Test setup	See sub clause 7.2 C (1 GHz – 10 GHz)
Measurement uncertainty:	See chapter 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:

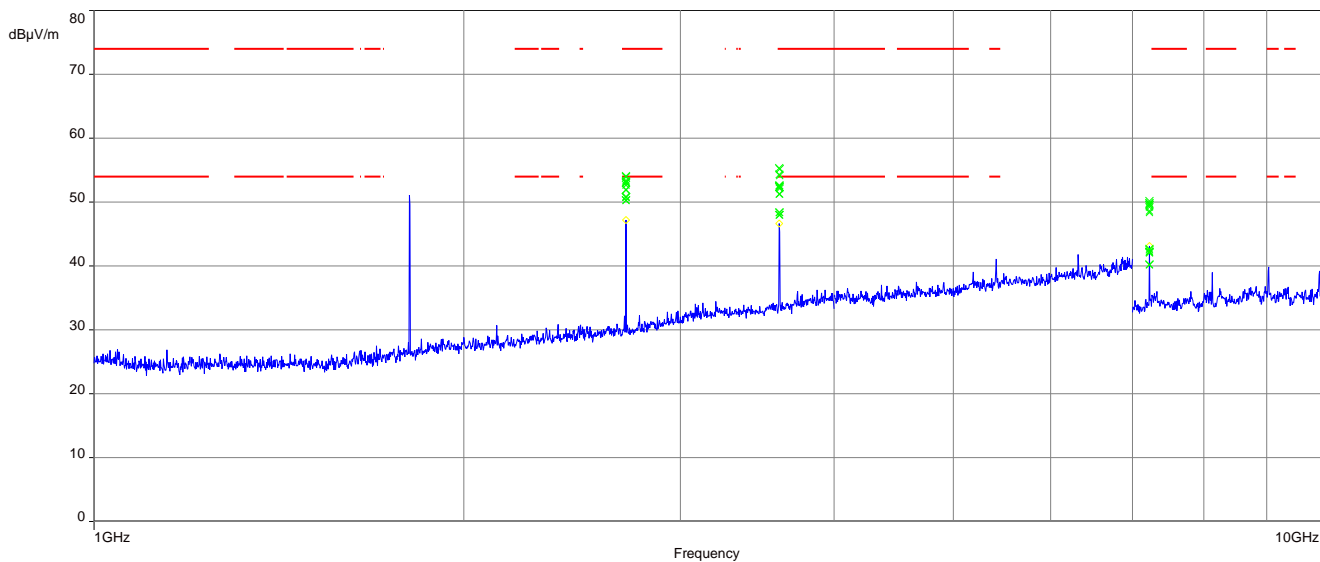
FCC		IC	
TX spurious emissions radiated			
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz 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:

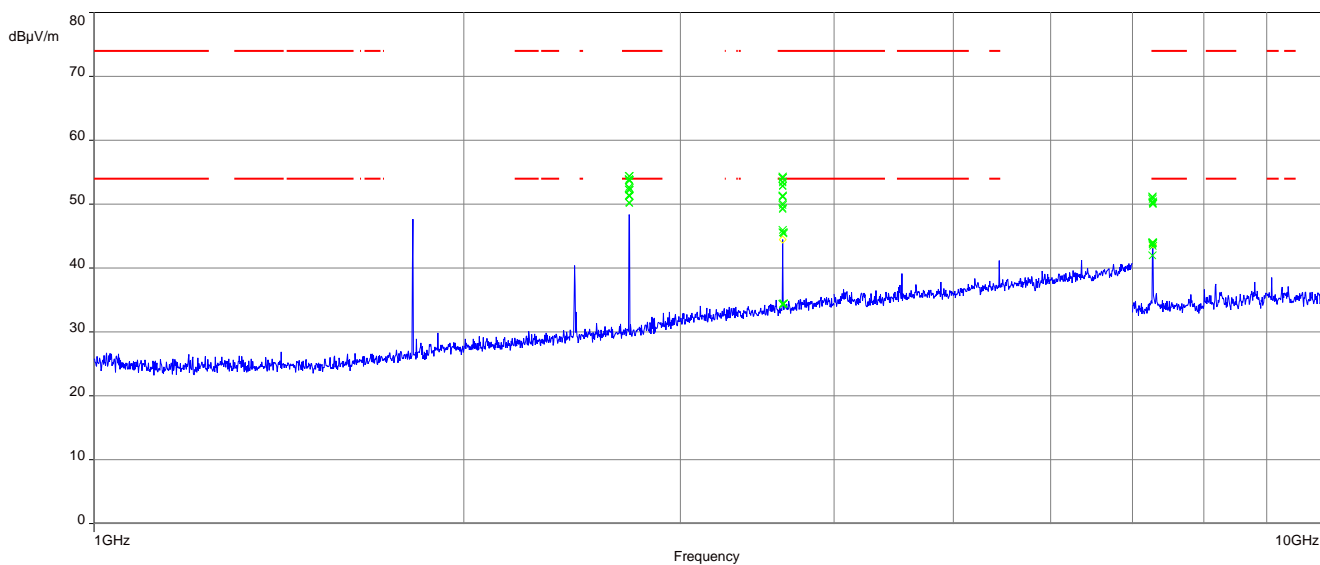
TX spurious emissions radiated								
Low channel			Middle channel			High channel		
Frequency / MHz	Detector	Level / (dB μ V/m)	Frequency / MHz	Detector	Level / (dB μ V/m)	Frequency / MHz	Detector	Level / (dB μ V/m)
2708	Peak	54.10	2724	Peak	54.39	2742	Peak	54.30
	AVG	51.94		AVG	52.31		AVG	52.01
3611	Peak	55.29	3636	Peak	54.33	3656	Peak	54.20
	AVG	52.55		AVG	51.32		AVG	50.81
7222	Peak	50.14	7269	Peak	51.15	7312	Peak	51.92
	AVG	42.64		AVG	44.01		AVG	46.59

Plots:

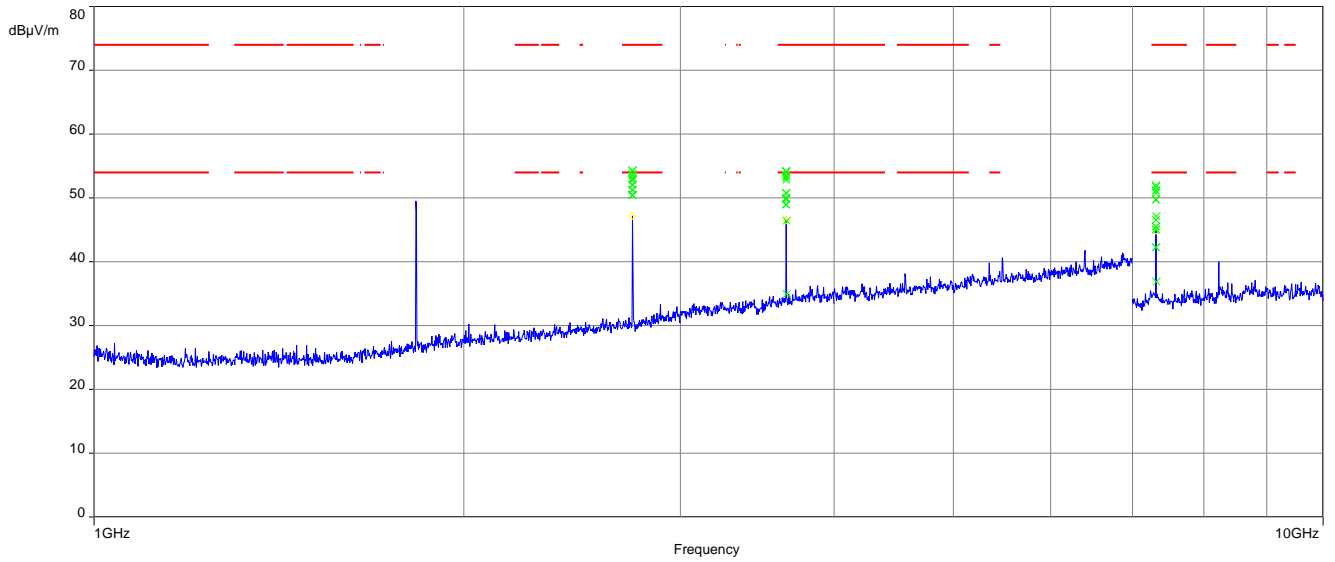
Plot 1: 1 GHz – 10 GHz, horizontal & vertical polarisation (Low channel)



Plot 2: 1 GHz – 10 GHz, horizontal & vertical polarisation (Middle channel)



Plot 3: 1 GHz – 10 GHz, horizontal & vertical polarisation (High channel)



14 Observations

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

Annex A 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/N₀	Carrier to noise-density ratio, expressed in dB-Hz

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2021-02-16
A	IC number corrected, Model Name changed to "ERS"	2021-02-17
B	RBW/VBW table positions corrected	2021-02-26

Annex C Accreditation Certificate – D-PL-12076-01-04

first page	last page			
 <p>Deutsche Akkreditierungsstelle GmbH</p> <p>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</p> <p>Accreditation </p> <p>The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory CTC advanced GmbH Untertürkheimer Straße 6-10, 66117 Saarbrücken</p> <p>is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following fields: Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards</p> <p>The accreditation certificate shall only apply in connection with the notice of accreditation of 11.01.2019 with the accreditation number D-PL-12076-01 and is valid until 21.04.2021. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 7 pages.</p> <p>Registration number of the certificate: D-PL-12076-01-04</p> <p>Frankfurt am Main, 11.01.2019</p> <p> Dipl. Ing. Ulrike Zimmermann Head of Division</p>	<p>Deutsche Akkreditierungsstelle GmbH</p> <table border="0"> <tr> <td>Office Berlin Spittelmarkt 10 10117 Berlin</td> <td>Office Frankfurt am Main Europa-Allee 52 60327 Frankfurt am Main</td> <td>Office Braunschweig Bundesallee 100 38116 Braunschweig</td> </tr> </table> <p>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.</p> <p>No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkks.</p> <p>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.</p> <p>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</p>	Office Berlin Spittelmarkt 10 10117 Berlin	Office Frankfurt am Main Europa-Allee 52 60327 Frankfurt am Main	Office Braunschweig Bundesallee 100 38116 Braunschweig
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<https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf>

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

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END OF TEST REPORT