



## TEST REPORT

Test report no.: 1-6484/18-04-02-E

BNetzA-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 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)

The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-03

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### Manufacturer

**Adeunis**

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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 Module

**Model name:** ARF8133A

**FCC ID:** U3Z-ARF8133

**IC:** 7016A-ARF8133

**Frequency:** ISM band 902 MHz – 928 MHz

**Technology tested:** Long Range Wide Area Network

**Antenna:** External dipole or PCB antenna

**Power supply:** 3.3 V DC by external power supply

**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  
Radio Communications

### Test performed:

p.o.  
Sumit Kumar  
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## 1 Table of contents

1	Table of contents .....	2
2	General information .....	4
2.1	Notes and disclaimer .....	4
2.2	Application details.....	4
2.3	Test laboratories sub-contracted .....	4
3	Test standard/s and references .....	5
4	Test environment.....	6
5	Test item.....	6
5.1	General description.....	6
5.2	Additional information .....	6
6	Description of the test setup.....	7
6.1	Shielded semi anechoic chamber.....	8
6.2	Shielded fully anechoic chamber .....	9
6.3	Conducted measurements .....	10
7	Sequence of testing .....	11
7.1	Sequence of testing radiated spurious 9 kHz to 30 MHz.....	11
7.2	Sequence of testing radiated spurious 30 MHz to 1 GHz.....	12
7.3	Sequence of testing radiated spurious 1 GHz to 12.75 GHz .....	13
8	Measurement uncertainty .....	14
9	Summary of measurement results .....	15
9.1	Part 1: Hybrid mode (915.2-927.8 MHz) .....	15
9.2	Part 2: DTS (915.9-927.1 MHz) .....	16
9.3	Part 3: Hybrid mode (923.2-923.4 MHz) .....	17
10	RF measurements.....	18
10.1	Additional comments .....	18
11	Measurement results Part 1 Hybrid mode (915.2-927.8 MHz) .....	19
11.1	Antenna gain .....	19
11.2	Carrier Frequency Separation .....	20
11.3	Average Time of Occupancy (dwell time).....	22
11.4	Spectrum bandwidth .....	24
11.5	Maximum Output Power.....	28
11.6	Power spectral density.....	31
11.7	Detailed spurious emissions @ the band edge – conducted and radiated .....	34
11.8	Spurious Emissions Conducted .....	37
11.9	Spurious Emissions Radiated < 30 MHz .....	40
11.10	Spurious Emissions Radiated > 30 MHz .....	44
11.10.1	Spurious emissions radiated 30 MHz to 1 GHz .....	44
11.10.2	Spurious emissions radiated above 1 GHz.....	52
12	Measurement results Part 2 DTS (915.9-927.1 MHz) .....	58
12.1	Maximum output power.....	58
12.2	Antenna gain .....	61
12.3	Power spectral density.....	62
12.4	Spectrum bandwidth – 6 dB bandwidth and 99% bandwidth.....	65
12.5	Detailed spurious emissions @ the band edge – conducted and radiated .....	69
12.6	Spurious Emissions Conducted .....	72
12.7	Spurious Emissions Radiated < 30 MHz .....	75

<b>12.8</b>	<b>Spurious Emissions Radiated &gt; 30 MHz</b>	<b>80</b>
12.8.1	Spurious emissions radiated 30 MHz to 1 GHz	80
12.8.2	Spurious emissions radiated above 1 GHz	88
<b>13</b>	<b>Measurement results Part 3 Hybrid Mode (923.2-923.4 MHz)</b>	<b>94</b>
13.1	Antenna gain	94
13.2	Carrier Frequency Separation	95
13.3	Average Time of Occupancy (dwell time)	97
13.4	Spectrum bandwidth	99
13.5	Maximum Output Power	102
13.6	Power spectral density	104
13.7	Detailed spurious emissions @ the band edge – conducted and radiated	106
13.8	Spurious Emissions Conducted	109
13.9	Spurious Emissions Radiated < 30 MHz	111
13.10	Spurious Emissions Radiated > 30 MHz	114
13.10.1	Spurious emissions radiated 30 MHz to 1 GHz	114
13.10.2	Spurious emissions radiated above 1 GHz	119
<b>14</b>	<b>Observations</b>	<b>123</b>
<b>Annex A</b>	<b>Glossary</b>	<b>124</b>
<b>Annex B</b>	<b>Document history</b>	<b>125</b>
<b>Annex C</b>	<b>Accreditation Certificate – D-PL-12076-01-04</b>	<b>125</b>
<b>Annex D</b>	<b>Accreditation Certificate – D-PL-12076-01-05</b>	<b>126</b>

## 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 1-6484/18-04-02-D and dated 2020-04-01.**

### 2.2 Application details

Date of receipt of order:	2019-06-11
Date of receipt of test item:	2019-07-10
Start of test:	2019-07-18
End of test:	2020-01-13
Person(s) present during the test:	-/-





### 2.3 Test laboratories sub-contracted

None

### 3 Test standard/s and references

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	April 2018	Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus

Guidance	Version	Description
DTS: 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 <a href="https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf">https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf</a>	  Deutsche Akkreditierungsstelle D-PL-12076-01-04
D-PL-12076-01-05	Telecommunication FCC requirements <a href="https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf">https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf</a>	  Deutsche Akkreditierungsstelle D-PL-12076-01-05



## 6 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).

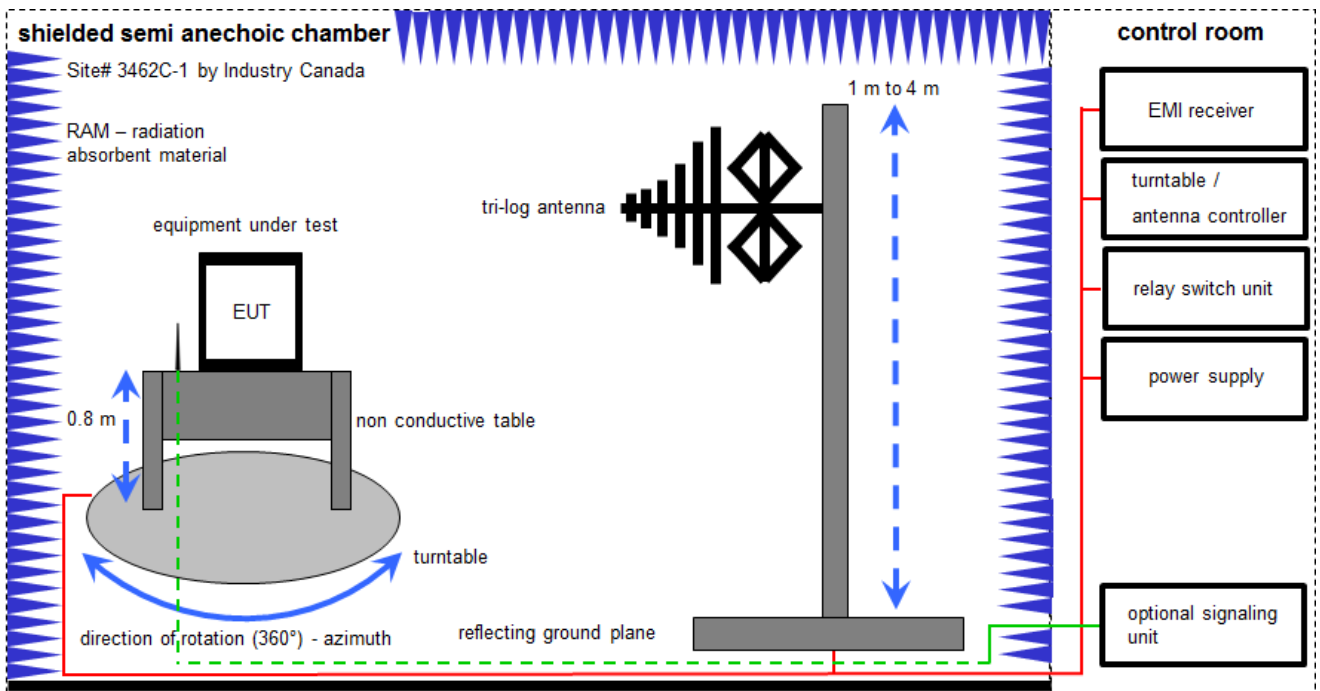
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

### **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

## 6.1 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: 10.30.0

FS = UR + CL + AF

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

Example calculation:

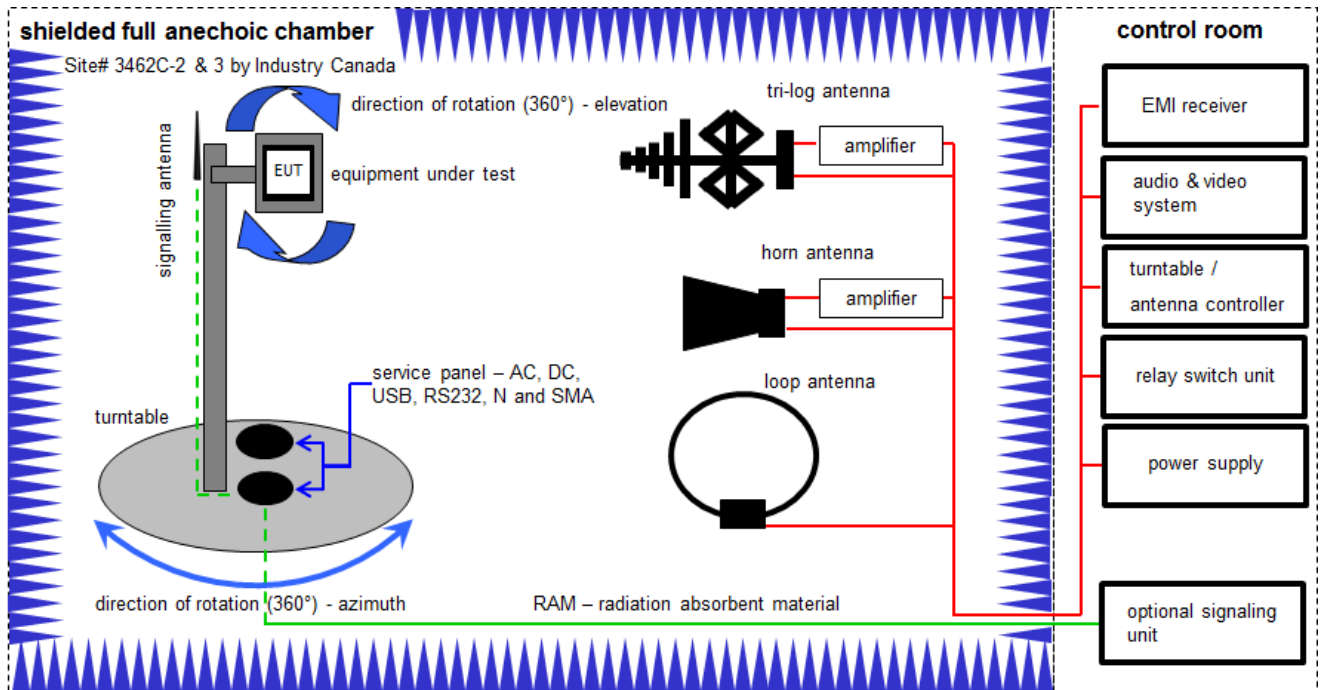
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

### Equipment table:

No.	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	Meßkabine 1	HF-Absorberhalle	MWB AG 300023		300000551	ne	-/-	-/-
3	A	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	21.05.2019	20.05.2020
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	371	300003854	vKI!	24.11.2017	23.11.2020



## 6.2 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:

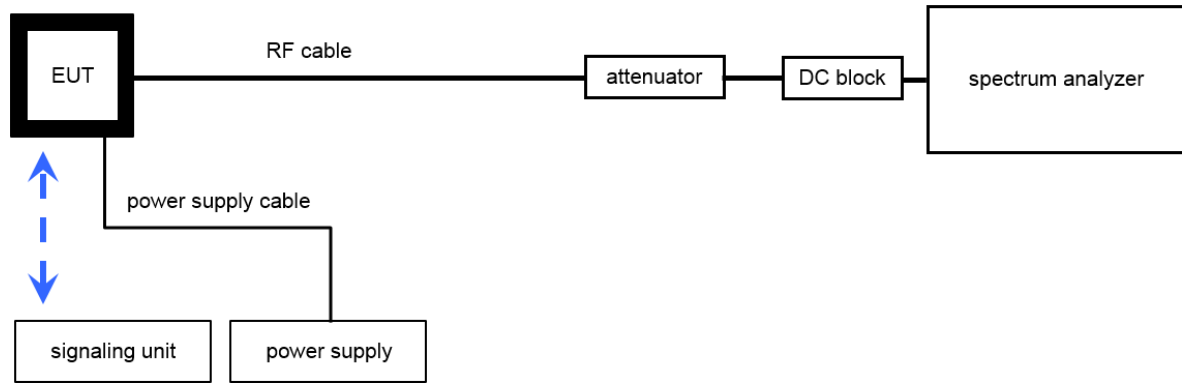
$$FS [dB\mu V/m] = 40.0 [dB\mu V/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dB\mu V/m] (71.61 \mu V/m)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vKI!	27.02.2019	26.02.2021
2	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vKI!	13.06.2019	12.06.2021
3	A,B,C	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04590	300001041	vKI!	14.12.2017	13.12.2020
4	C	Highpass Filter	WHK1.1/15G-10SS	Wainwright	37	400000148	ne	-/-	-/-
5	B	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	318	300003696	vKI!	23.05.2017	22.05.2020
6	C	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22051	300004483	ev	-/-	-/-
7	A,B,C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne	-/-	-/-
8	A,B,C	Computer	Intel Core i3 3220/3,3 GHz, Prozessor		2V2403033A54 21	300004591	ne	-/-	-/-
9	A,B,C	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
10	A,B,C	Anechoic chamber		TDK		300003726	ne	-/-	-/-
11	A,B,C	EMI Test Receiver 9kHz-26,5GHz	ESR26	R&S	101376	300005063	k	19.12.2018	18.12.2019
12	A,B,C	EMI Test Receiver 9kHz-26,5GHz	ESR26	R&S	101376	300005063	k	10.12.2019	09.12.2020

### 6.3 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	Power Supply	2X30V	Zentro	870008	300000830	NK!	-/-	-/-
2	A	Signal- and Spectrum Analyzer 2 Hz - 26 GHz	FSW26	R&S	101455	300004528	k	19.12.2018	18.12.2019
	A	Signal- and Spectrum Analyzer 2 Hz - 26 GHz	FSW26	R&S	101455	300004528	k	12.12.2019	11.12.2020
3	A	Coaxial Attenuator	WA23-20-34	Weinschel Ass	B4661	400001130	ev	-/-	-/-
4	A	RF-Cable SRD021 No. 1	Enviroflex 316 D	Huber & Suhner		400001311	ev	-/-	-/-

## 7 Sequence of testing

### 7.1 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.

## 7.2 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.

### 7.3 Sequence of testing radiated spurious 1 GHz to 12.75 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.

## 8 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

## 9 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.

### 9.1 Part 1: Hybrid mode (915.2-927.8 MHz)

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 (a)	Spectrum bandwidth	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(f) 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(b)(3) 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	<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"/>	-/-
§15.247(f) 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(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"/>	-/-
§15.209(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

**9.2 Part 2: DTS (915.9-927.1 MHz)**

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



### 9.3 Part 3: Hybrid mode (923.2-923.4 MHz)

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 (a)	Spectrum bandwidth	Nominal	Nominal	TX single channel	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(f) 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(b)(3) 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	<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"/>	-/-
§15.247(f) 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(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"/>	-/-
§15.209(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

## 10 RF measurements

### 10.1 Additional comments

Reference documents: None

Special test descriptions: The EUT uses a Long Range Wide Area Network (LoRaWAN) technology with a combination of two hybrid systems in different frequency ranges and a DTS system. All three systems were tested.

Configuration descriptions: **Hybrid mode:** 64 channels (**AU915-928 MHz ISM Band**) with a nominal bandwidth of 125 kHz and 200 kHz channel spacing:

lowest channel	915.2 MHz,
middle channel	921.5 MHz,
highest channel	927.8 MHz.

These channels were tested in part 1 of this test report).

**DTS:** 8 channels (**AU915-928 MHz ISM Band**) with 500 kHz nominal bandwidth and 1600 kHz channel spacing:

lowest channel	915.9 MHz,
middle channel	921.5 MHz,
highest channel	927.1 MHz.

These channels were tested in part 2 of this test report).

**Hybrid mode:** 2 channels (**AS923 MHz ISM Band**) with a nominal bandwidth of 125kHz and 200 kHz channel spacing:

lowest channel	923.2 MHz,
highest channel	923.4 MHz,

These channels were tested in part 3 of this test report).

**NOTE:** In hybrid mode (915.2-927.8 MHz) the minimum number of hopping channels is 8. In this mode the minimum channel separation and bandwidths stay the same as in the mode with 64 channels. Also the device also comply with the dwell time requirements while using 8 channels:

The time slot length: 164.81 ms

Average time of occupancy: 329.62 ms

Hops in 3.2 second: 2

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

## 11 Measurement results Part 1 Hybrid mode (915.2-927.8 MHz)

### 11.1 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 6.2 B (radiated) See sub clause 6.3 A (conducted)
Measurement uncertainty	See sub clause 8

**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	Middle channel	High channel
Conducted power		16.16 dBm	16.38 dBm	16.49 dBm
dipole antenna	Radiated power	21.35 dBm	21.15 dBm	20.35 dBm
	Gain Calculated	5.19 dBi	4.77 dBi	3.86 dBi
PCB antenna	Radiated power	20.32 dBm	19.70 dBm	19.24 dBm
	Gain Calculated	4.16 dBi	3.32 dBi	2.75 dBi

## 11.2 Carrier Frequency Separation

### Description:

Measurement of the carrier frequency separation of a hopping system. The carrier frequency separation is constant for all modulation-modes. We use LoRa modulation to show compliance. 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 6.3 A
Measurement uncertainty	See sub clause 8

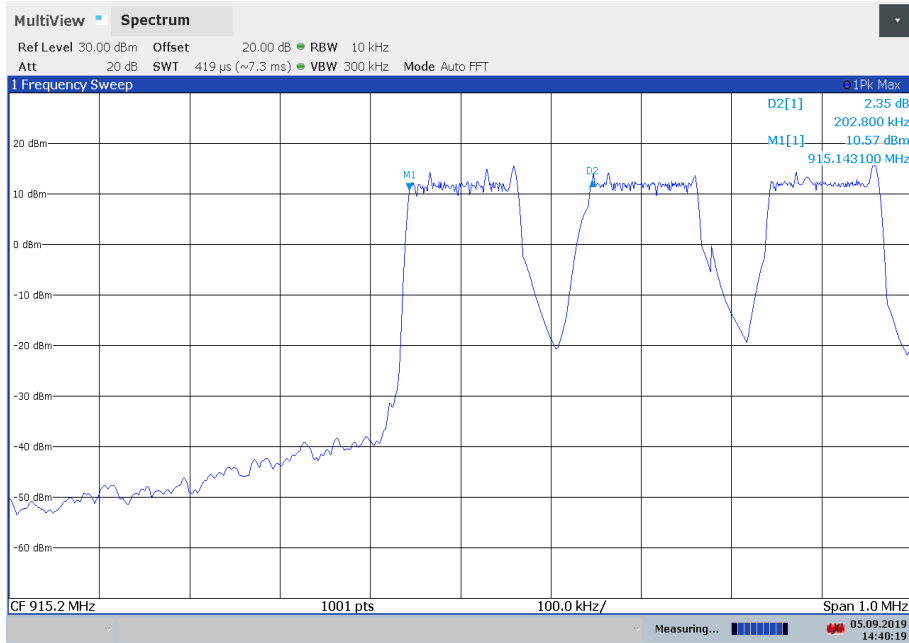
### Limits:

FCC	IC
Carrier frequency separation	
Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater.	

**Result:** The channel separation is 202.800 kHz

**Plots:**

Plot 1: Frequency separation AU915-928MHz ISM Band



14:40:19 05.09.2019

### 11.3 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:**

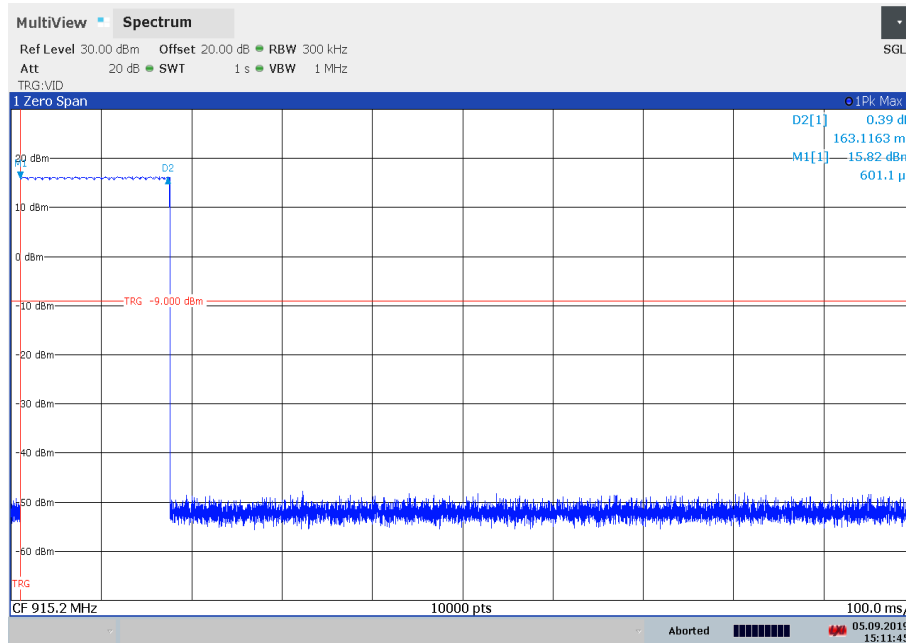
FCC	IC
<b>Average time of occupancy</b>	
For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4	

**Result:**

The time slot length is = 163.1 ms  
 Number of hops / channel @ 25.6s = 2  
 Within 25.6 s period, the average time of occupancy in 25,6 s: 326.22 ms  
 -> The average time of occupancy = **326.22ms**

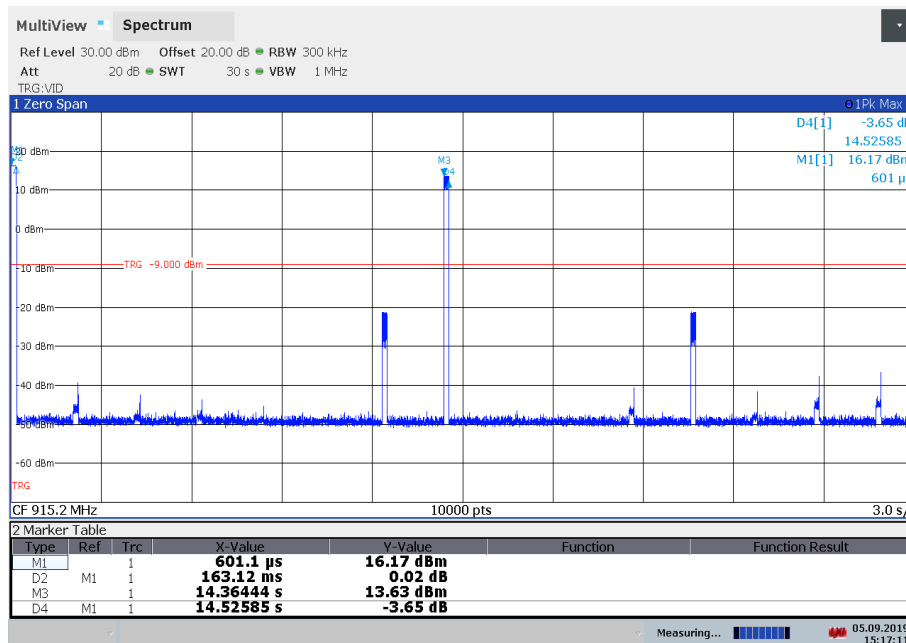
**Plots:**

Plot 1: Time slot length = 163.11ms



15:11:45 05.09.2019

Plot 2: hops / channel @ 25.6s = 2



15:17:12 05.09.2019

## 11.4 Spectrum bandwidth

### Description:

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal. The measurement is performed according to the "Measurement Guidelines" (DA 00-705, March 30, 2000). 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 6.3 A
Measurement uncertainty	See sub clause 8

### Limits:

FCC	IC
None	

### Result:

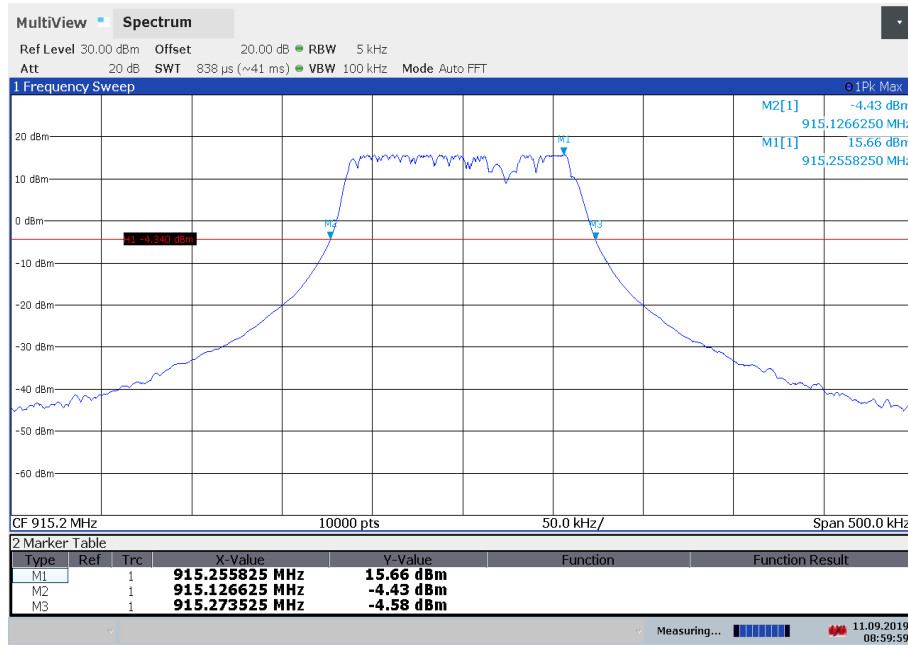
Test Conditions		20dB BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
$T_{nom}$	$V_{nom}$	146.9	146.6	147.55

Test Conditions		99% BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
$T_{nom}$	$V_{nom}$	129.93	129.54	130.04



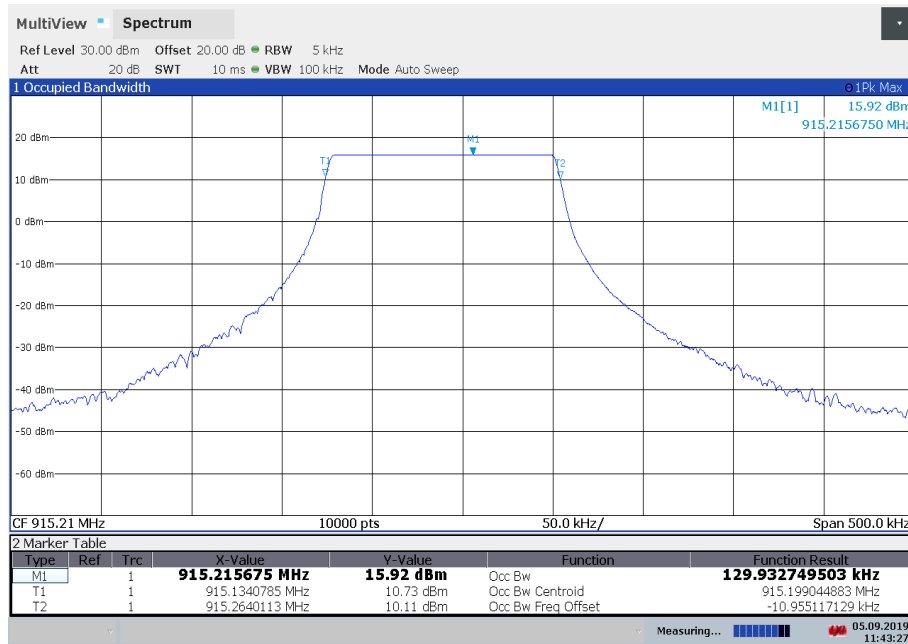
**Plots:**

Plot 1: Lowest Channel, 20 dB-BW



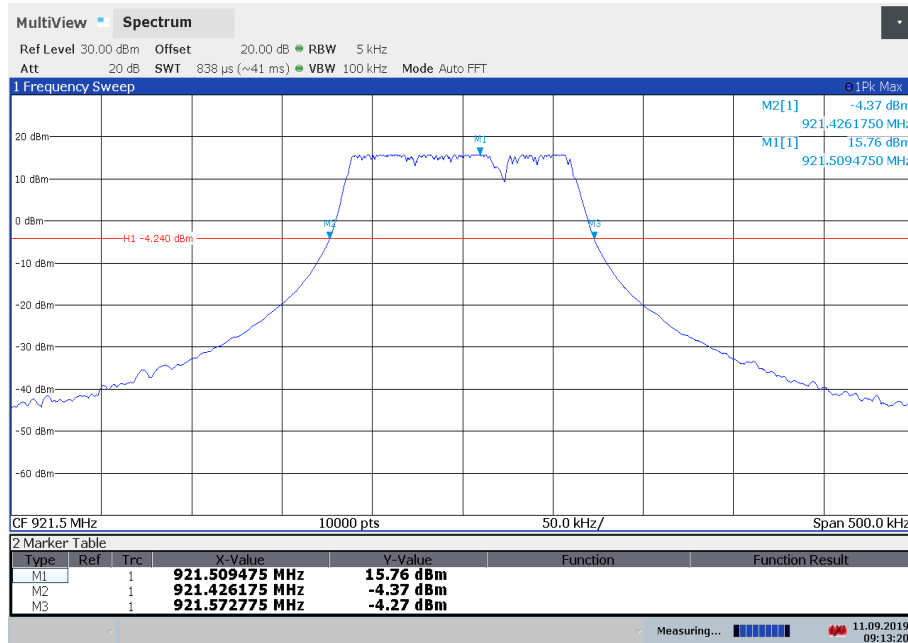
09:00:00 11.09.2019

Plot 2: Lowest Channel, 99%OBW



11:43:27 05.09.2019

Plot 3: Middle Channel, 20 dB-BW



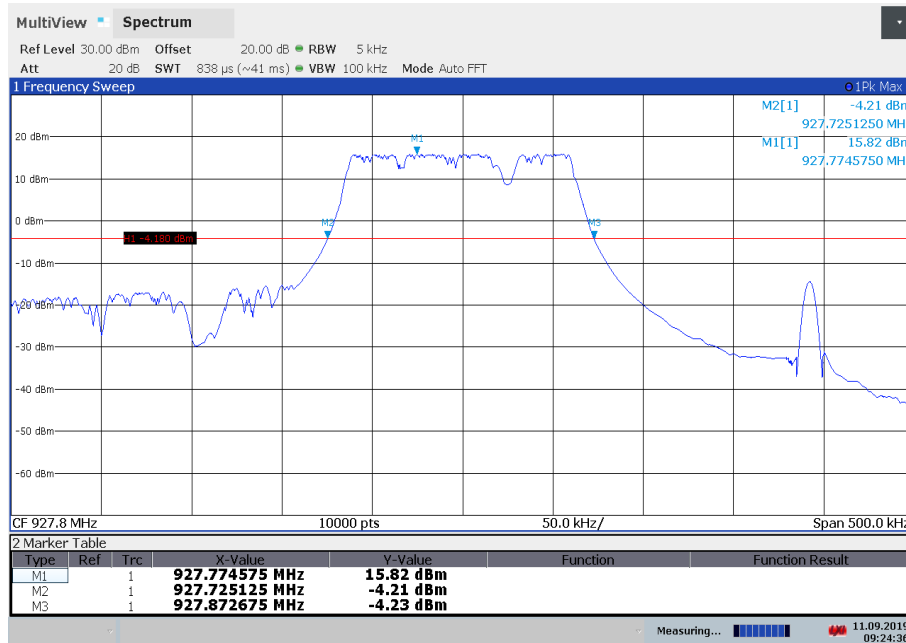
09:13:20 11.09.2019

Plot 4: Middle Channel, 99%OBW



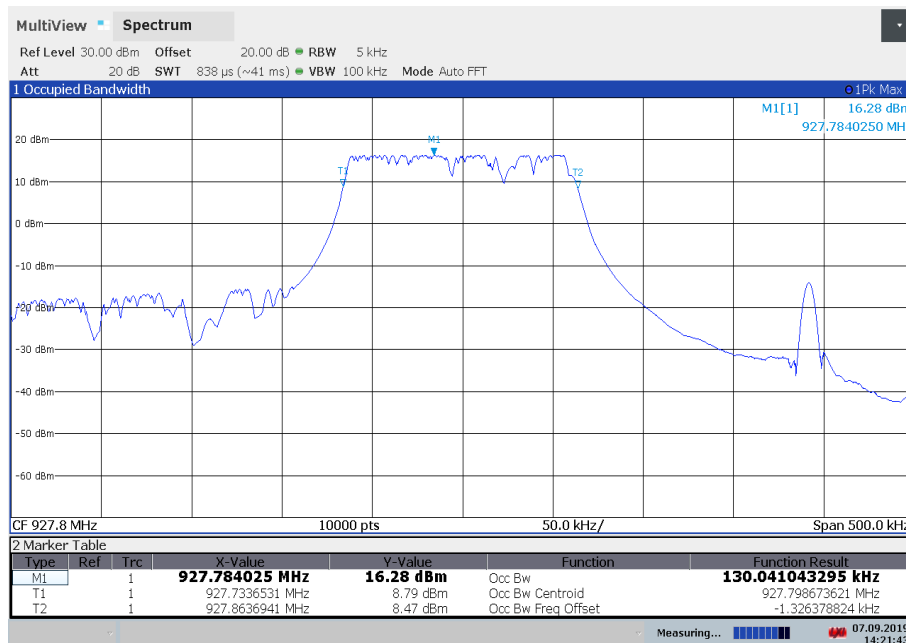
12:18:22 05.09.2019

Plot 5: Highest Channel, 20 dB-BW



09:24:37 11.09.2019

Plot 6: Highest Channel, 99%OBW



14:21:44 07.09.2019

## 11.5 Maximum Output Power

### Measurement:

Measurement parameter	
Detector:	RMS
Sweep time:	300 s
Resolution bandwidth:	5 kHz
Video bandwidth:	20 kHz
Span:	264 kHz
Trace-Mode:	Single sweep
Measurement method	According to ANSI C63.10-2013 11.9.2.2.3 Method AVGSA-1A (alternative)
Used equipment:	See chapter 6.3 A
Measurement uncertainty:	See chapter 8

### Limits:

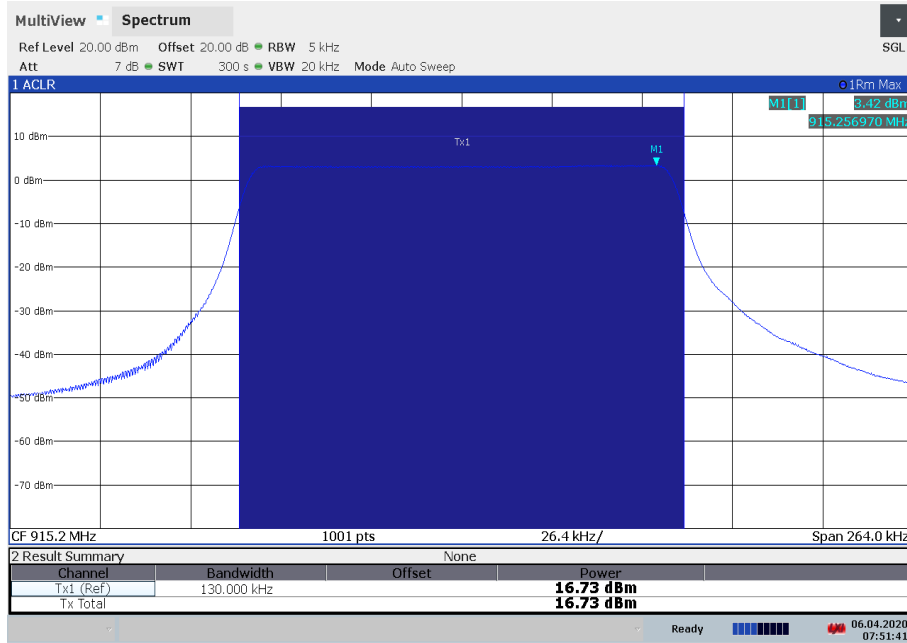
FCC	IC
Maximum Output Power Conducted	
For frequency hopping systems operating in the 902–928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and, 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under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

### Result:

Test Conditions		Maximum Output Power Conducted [dBm]		
		Lowest channel	Middle channel	Highest channel
$T_{nom}$	$V_{nom}$	16.7	16.9	17.0

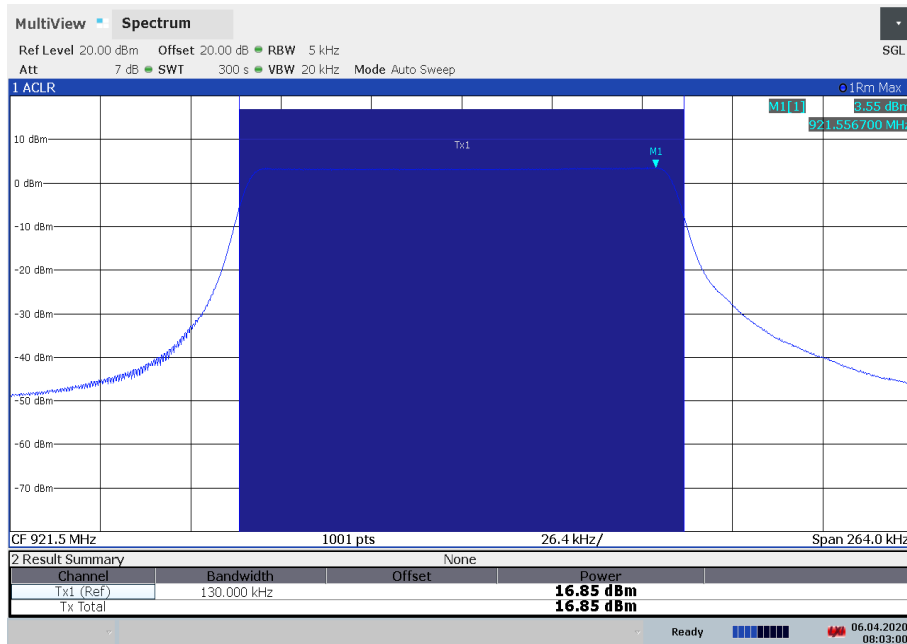
**Plots:**

Plot 1: Lowest Channel



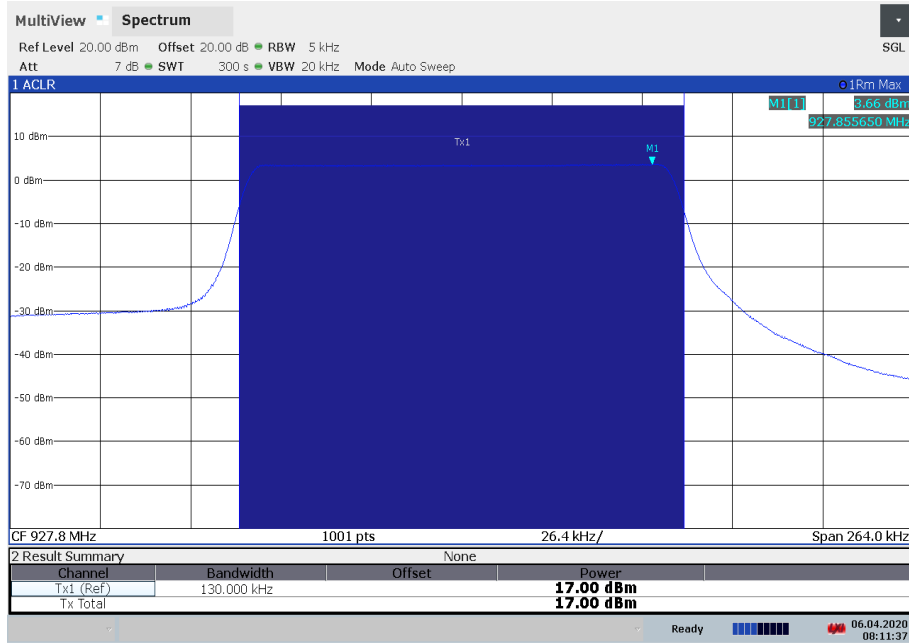
07:51:42 06.04.2020

Plot 2: Middle Channel



08:03:00 06.04.2020

Plot 3: Highest Channel



08:11:37 06.04.2020

## 11.6 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:	RMS
Sweep time:	100 s
Video bandwidth:	10 kHz
Resolution bandwidth:	3 kHz
Span:	200 kHz
Trace mode:	Max Hold
Measurement method	According to ANSI C63.10-2013 11.10.4 Method AVGPSD-1A (alternative)
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

### Limits:

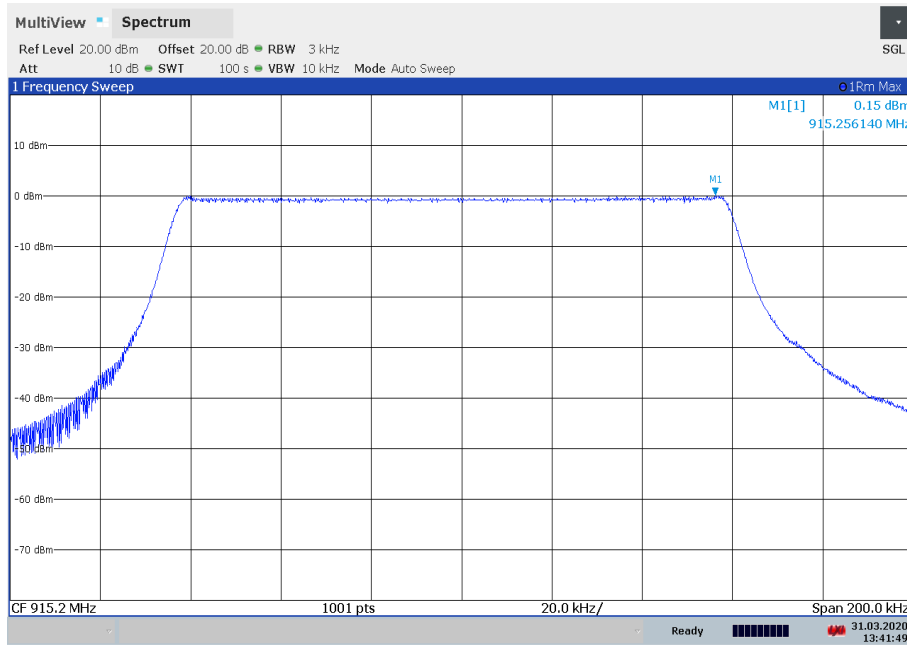
FCC	IC
Power Spectral Density	
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.	

### Results:

Modulation Channel	Power Spectral density [dBm/3kHz]		
	Lowest	Middle	Highest
	0.2	0.2	0.4

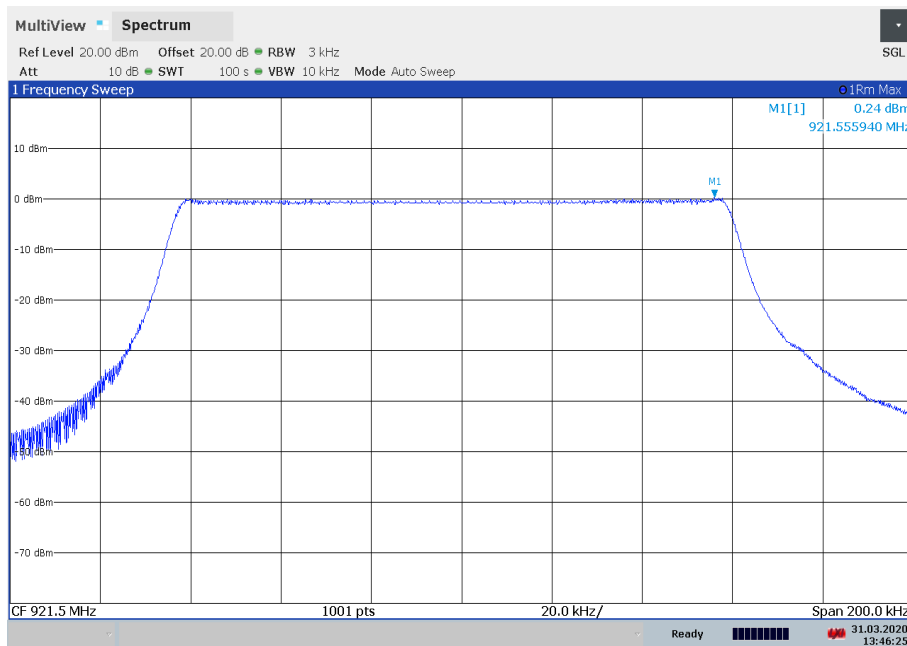
**Plots:**

Plot 1: Low Channel



13:41:50 31.03.2020

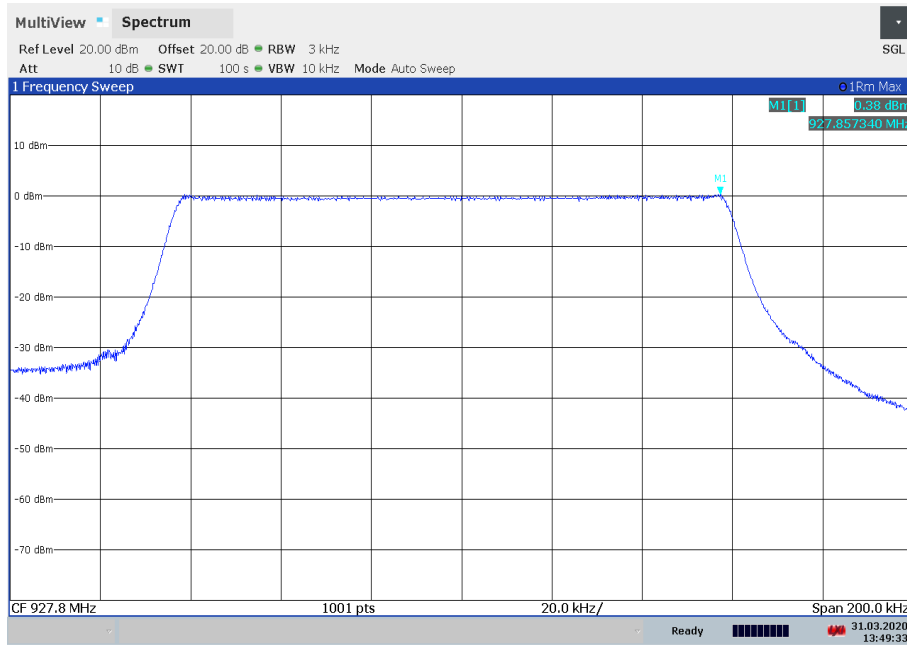
Plot 2: Middle Channel



13:46:26 31.03.2020



Plot 3: High Channel



13:49:34 31.03.2020

## 11.7 Detailed spurious emissions @ the band edge – conducted and radiated

### Description:

Measurement of the conducted band edge compliance.

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 6.3 A
Measurement uncertainty	See sub clause 8

### Limits:

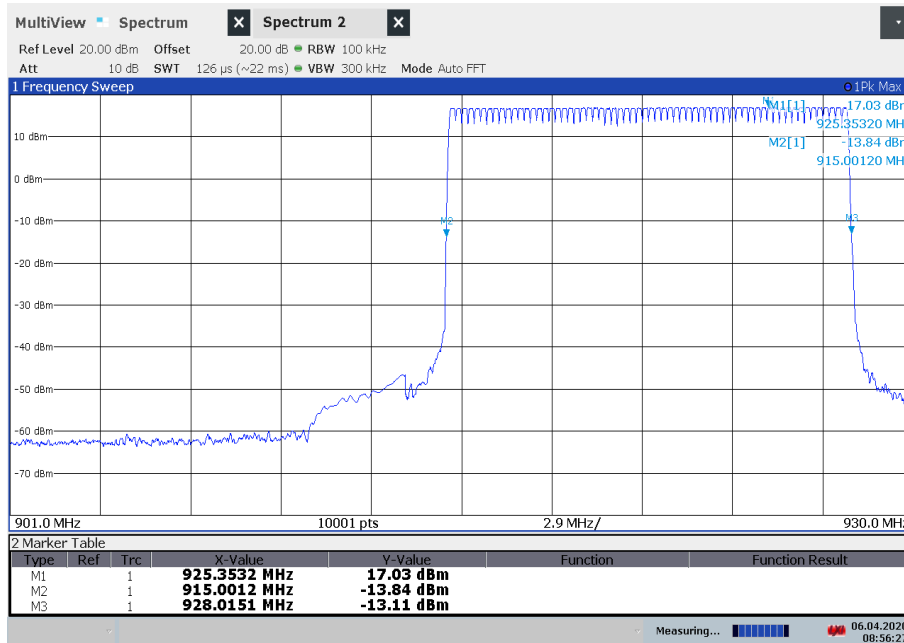
FCC	IC
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that 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>	
<p>RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.</p>	

### Results conducted:

Scenario Modulation	Spurious band edge conducted	
	lowest channel	highest channel
Lower band edge – hopping on	> 30 dB	> 30 dB
Upper band edge – hopping off	> 30 dB	> 30 dB

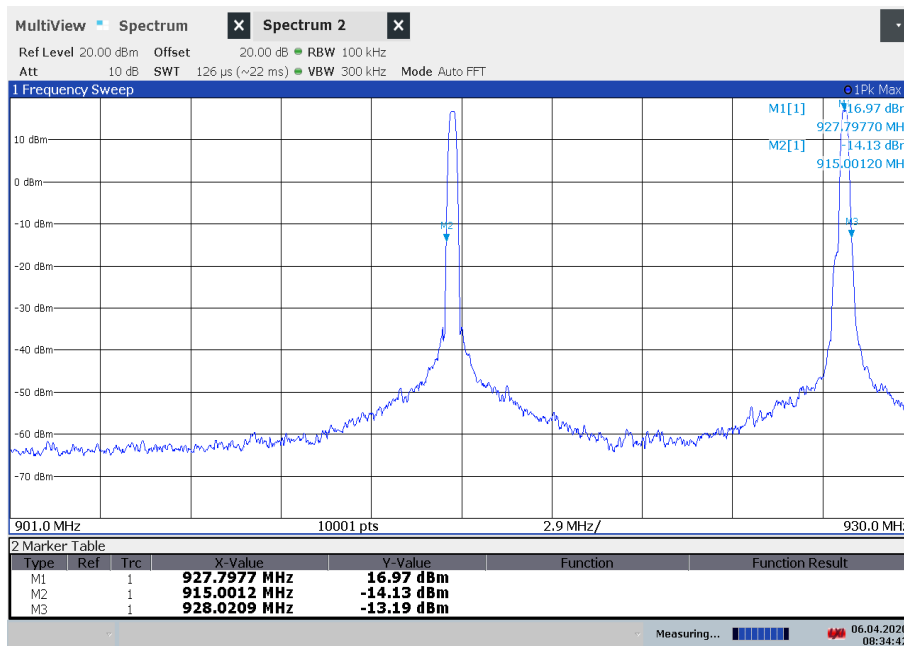
**Plots:**

**Plot 1: 30 dB – hopping on**



08:56:27 06.04.2020

**Plot 2: 30 dB – hopping off**



08:34:43 06.04.2020

**Results radiated:**

No restricted band in the range  $\pm 2$  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
<sup>1</sup> 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	( <sup>2</sup> )
13.36 - 13.41			

## 11.8 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	1 MHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3 A
Measurement uncertainty:	See chapter 8

### Limits:

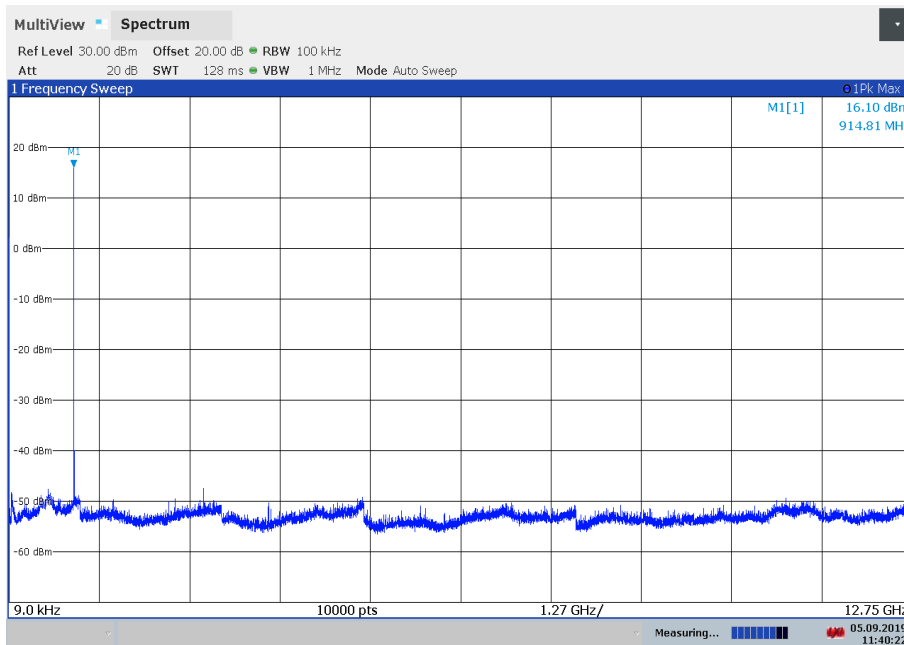
FCC	IC
TX spurious emissions conducted	
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz 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>	
<p>RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.</p>	

### Result:

Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
902.3		16.10	24 dBm		Operating frequency
No emissions detected!			-30 dBc		
909.3		16.27	24 dBm		Operating frequency
No emissions detected!			-30 dBc		
914.2		16.36	24 dBm		Operating frequency
No emissions detected!			-30 dBc		

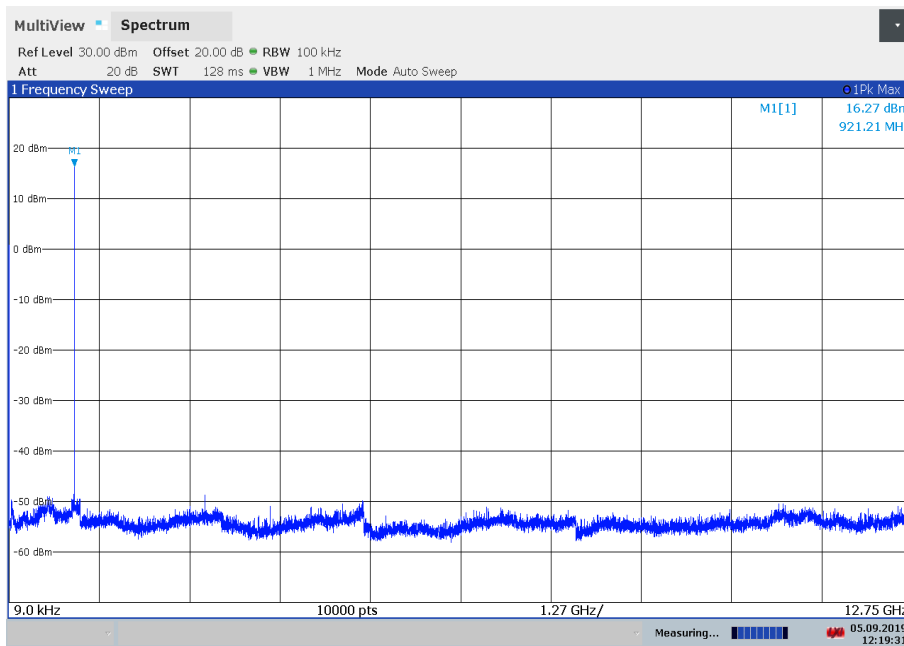
**Plots:**

Plot 1: Lowest channel, 9 kHz – 12.75 GHz



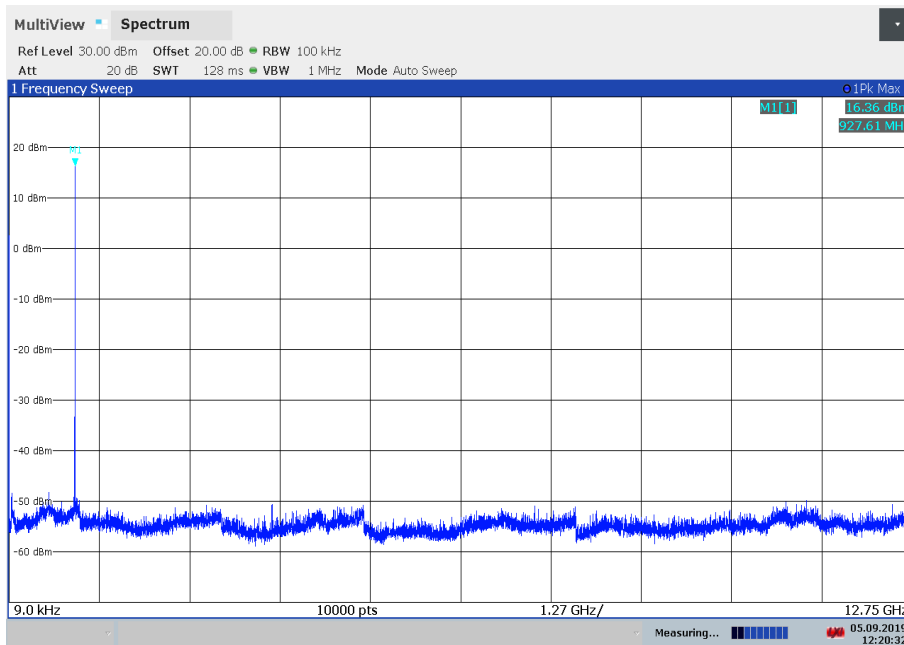
11:40:22 05.09.2019

Plot 2: Middle channel, 9 kHz – 12.75 GHz



12:19:31 05.09.2019

Plot 3: Highest channel, 9 kHz – 12.75 GHz



12:20:33 05.09.2019

## 11.9 Spurious Emissions Radiated < 30 MHz

### Description:

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: 200 Hz F > 150 kHz: 9 kHz
Resolution 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 6.2 B
Measurement uncertainty:	See chapter 8

### Limits:

FCC		IC	
TX spurious emissions radiated < 30 MHz			
Frequency (MHz)	Field strength (dB $\mu$ V/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	

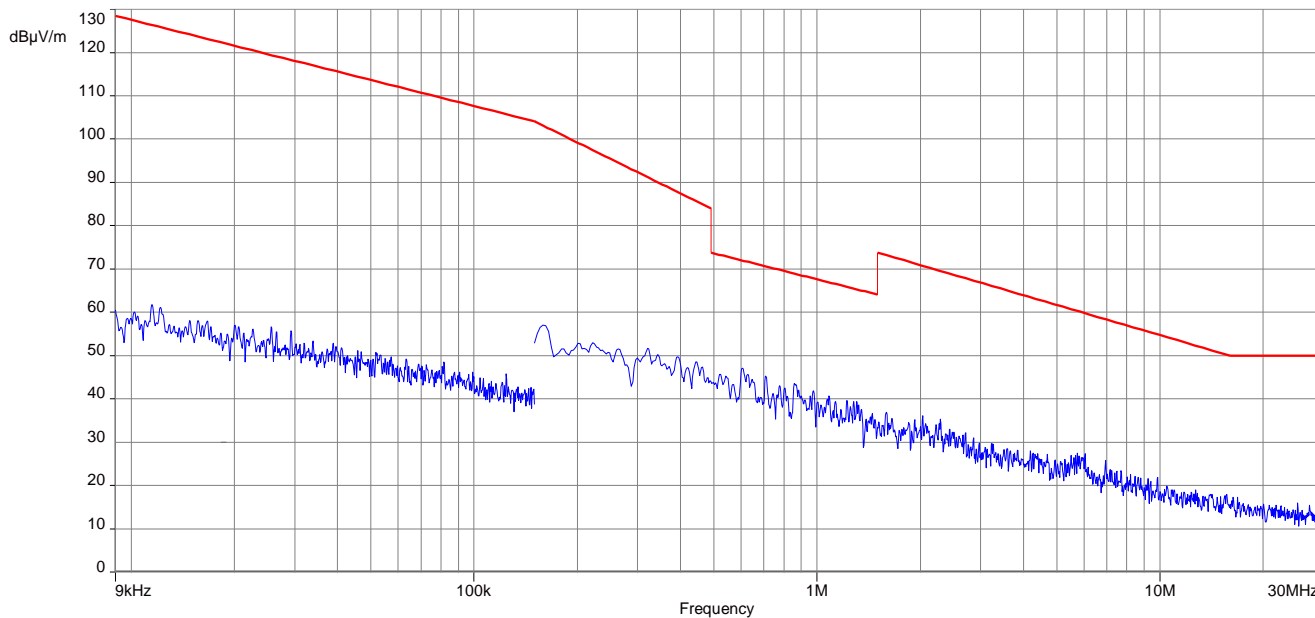
### Result:

SPURIOUS EMISSIONS LEVEL [dB $\mu$ V/m]								
Lowest channel			Middle channel			Highest channel		
Frequency [MHz]	Detector	Level [dB $\mu$ V/m]	Frequency [MHz]	Detector	Level [dB $\mu$ V/m]	Frequency [MHz]	Detector	Level [dB $\mu$ V/m]
All emissions were more than 10 dB below the limit.								

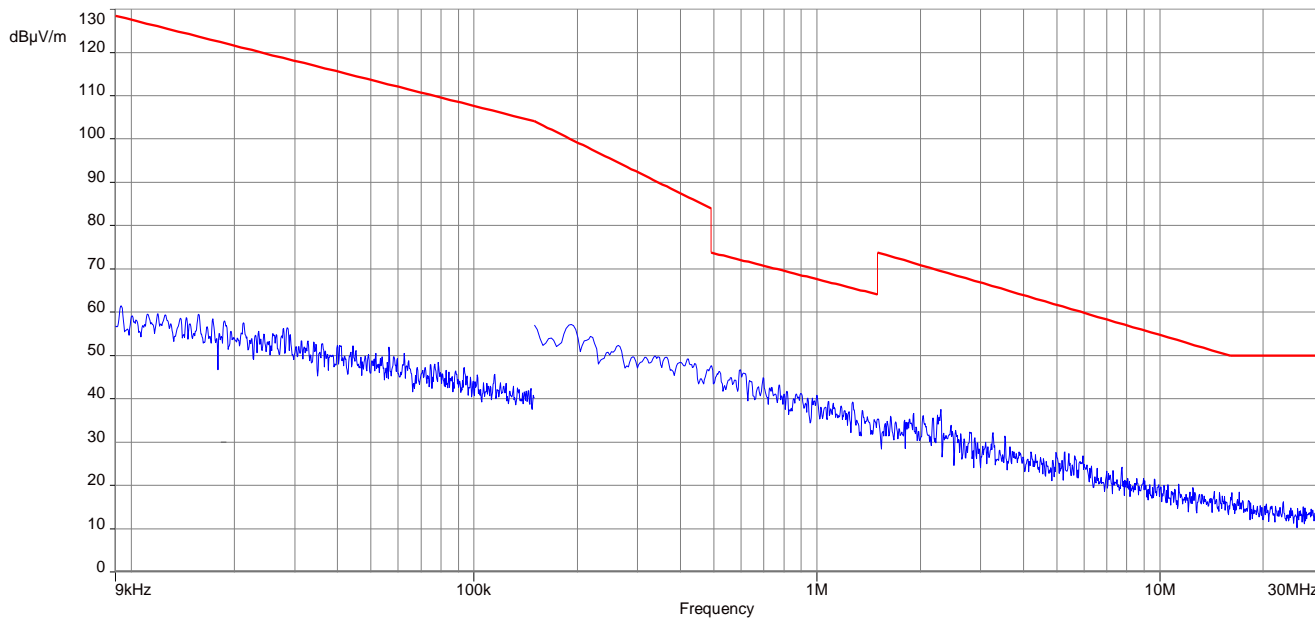


**Plots EUT with dipole antenna:**

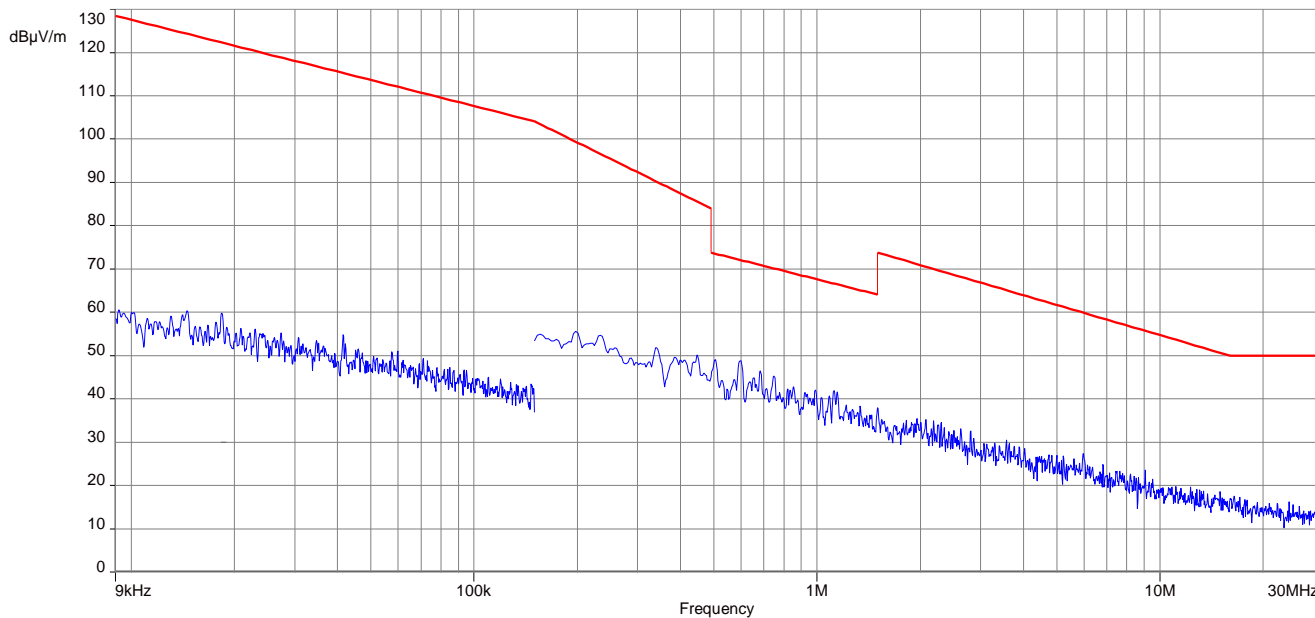
Plot 1: TX-Mode lowest channel



Plot 2: TX-Mode middle channel

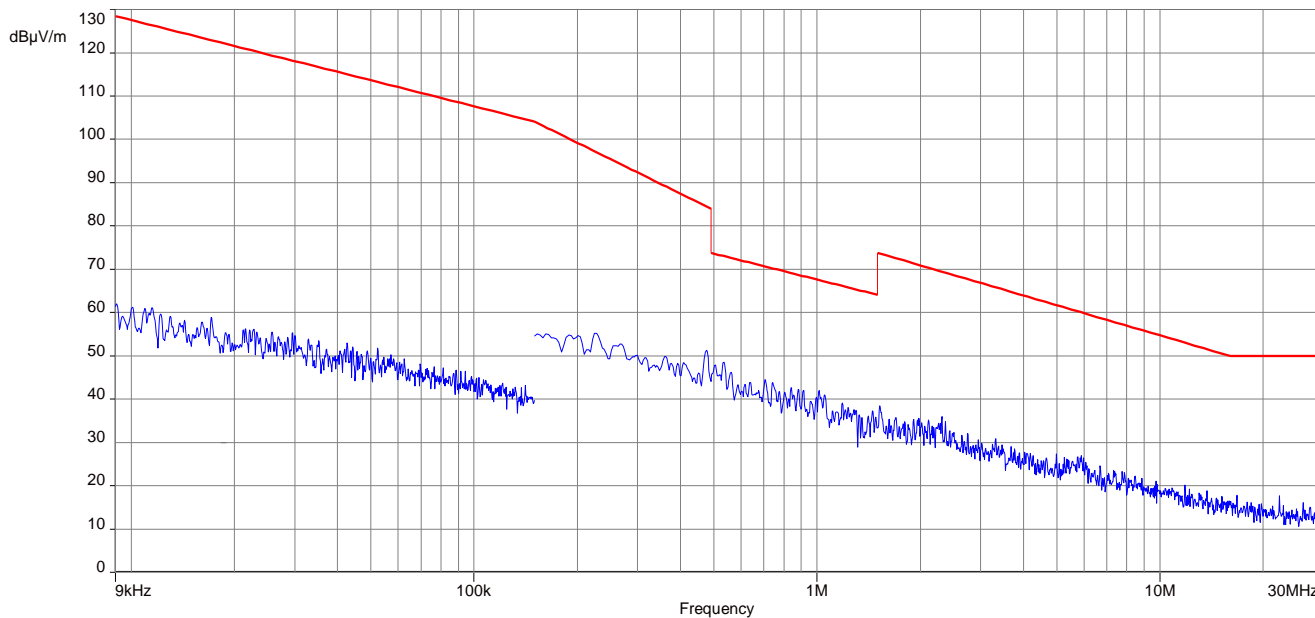


Plot 3: TX-Mode highest channel

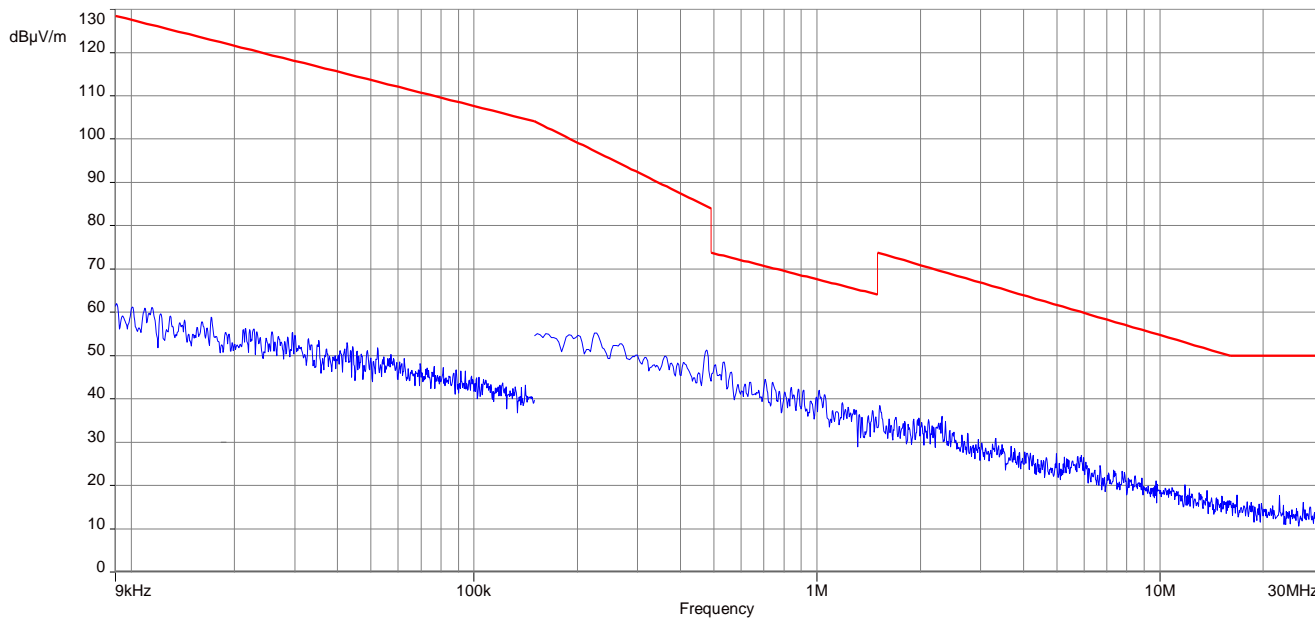


**Plots EUT with PCB antenna:**

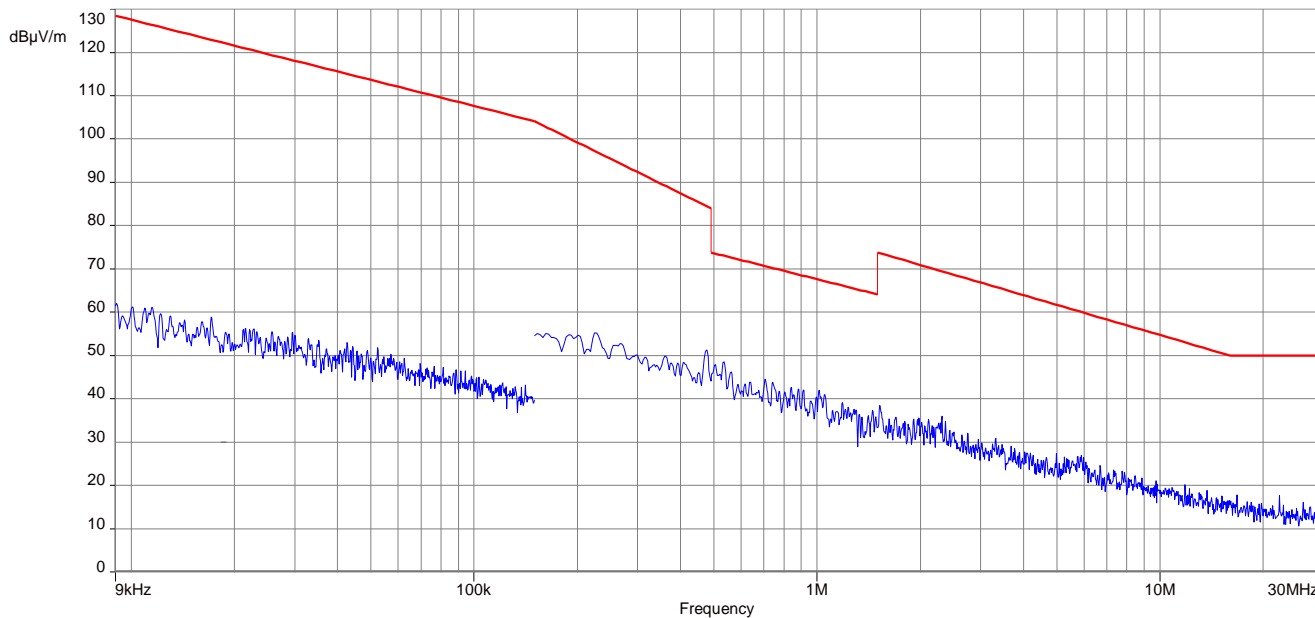
Plot 1: TX-Mode lowest channel



Plot 2: TX-Mode middle channel



Plot 3: TX-Mode highest channel



## 11.10 Spurious Emissions Radiated > 30 MHz

### 11.10.1 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	3 x VBW
Video bandwidth	120 kHz
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	LoRa
Test setup	See sub clause 6.1 A
Measurement uncertainty	See sub clause 8

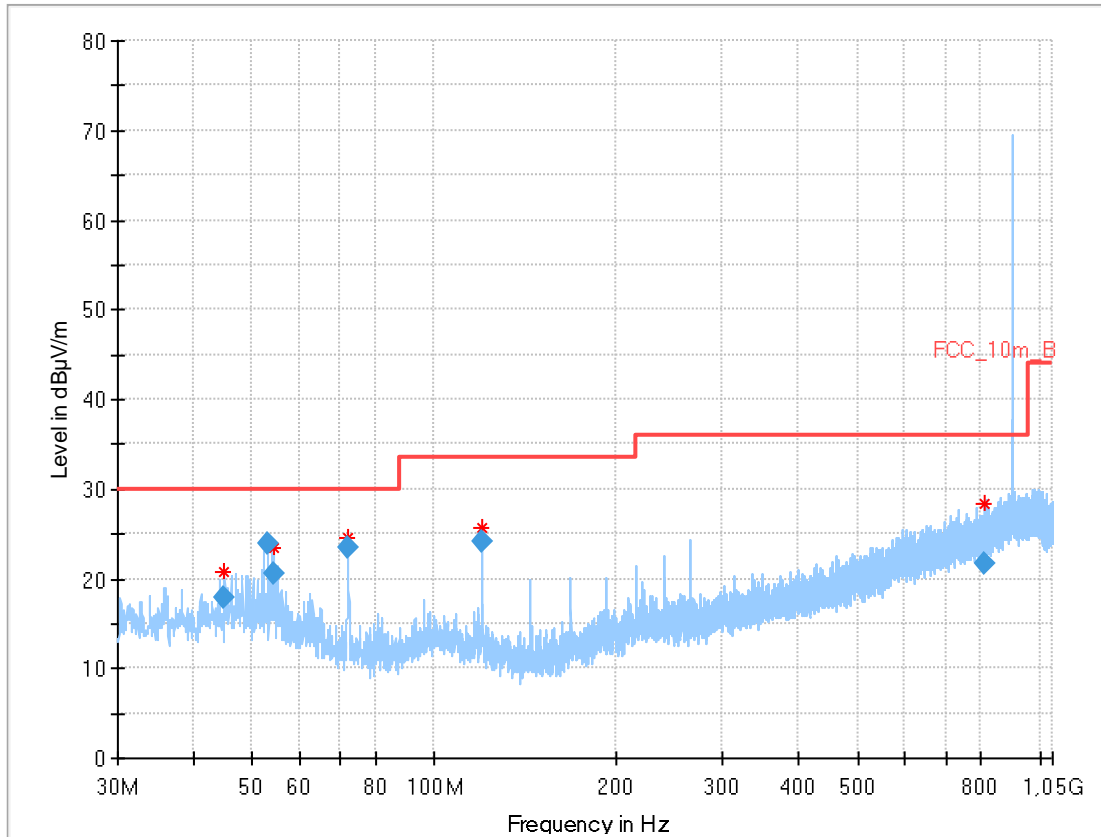
**Limits:**

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
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.

**Plots EUT with dipole antenna:**

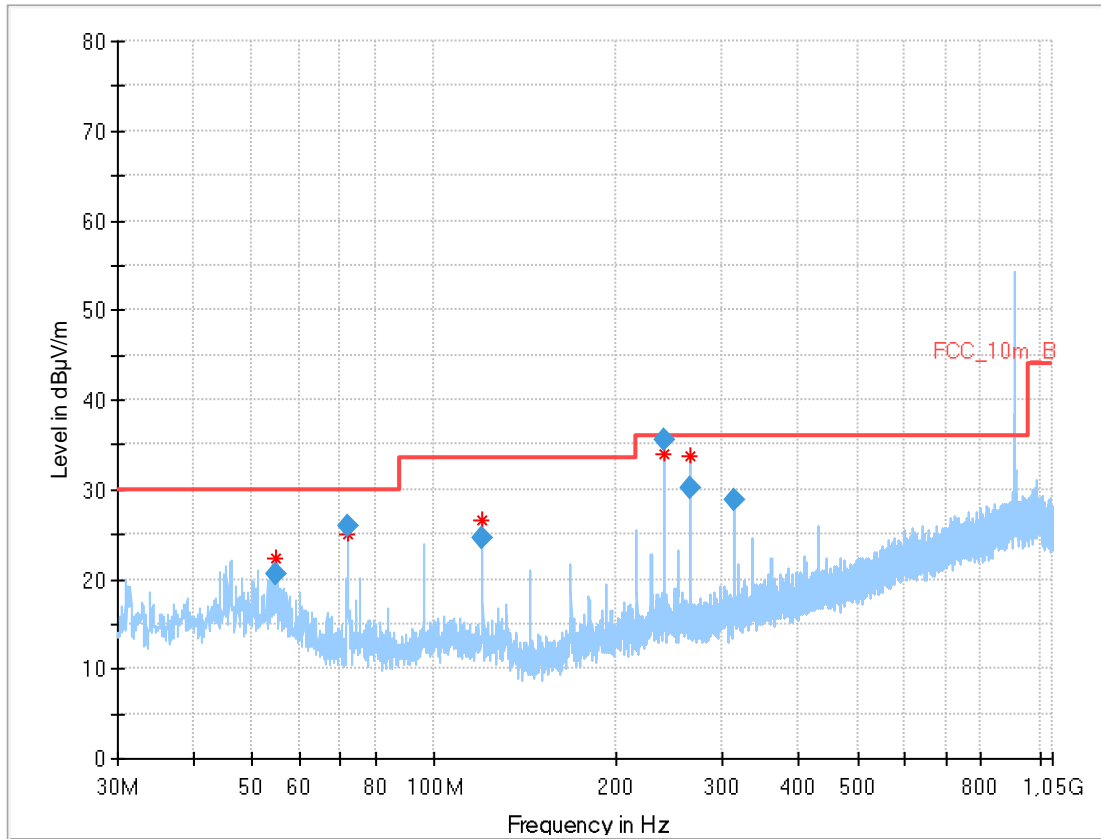
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
45.061	17.90	30.0	12.10	1000	120	101.0	V	202.0	15
53.045	24.01	30.0	5.99	1000	120	98.0	V	248.0	14
54.233	20.66	30.0	9.34	1000	120	101.0	V	161.0	14
72.060	23.51	30.0	6.49	1000	120	170.0	V	-10.0	11
120.119	24.19	33.5	9.31	1000	120	170.0	V	270.0	11
809.355	21.71	36.0	14.29	1000	120	170.0	V	157.0	23

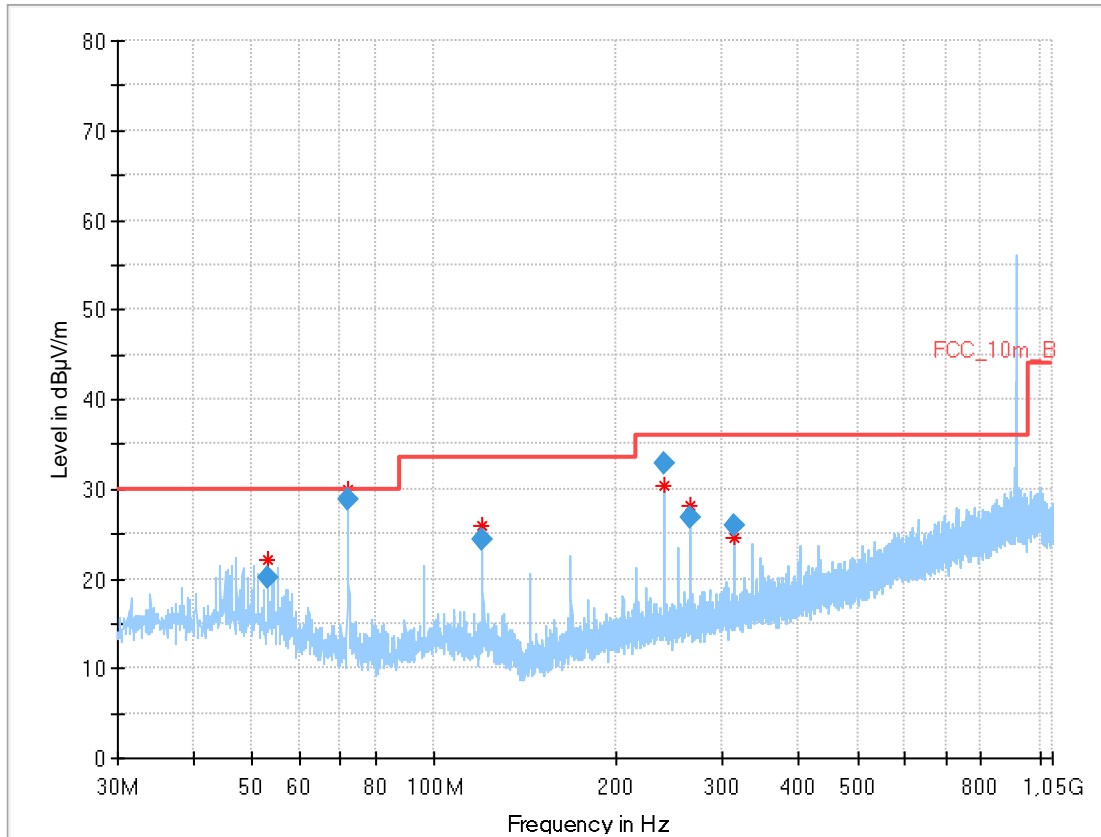
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



## 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)
54.934	20.46	30.0	9.54	1000	120	101.0	V	-22.0	14
72.071	25.91	30.0	4.09	1000	120	170.0	V	157.0	11
120.096	24.55	33.5	8.95	1000	120	147.0	V	259.0	11
240.214	35.56	36.0	0.44	1000	120	98.0	V	158.0	13
264.242	30.08	36.0	5.92	1000	120	101.0	V	112.0	14
312.268	28.93	36.0	7.07	1000	120	98.0	V	259.0	15

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

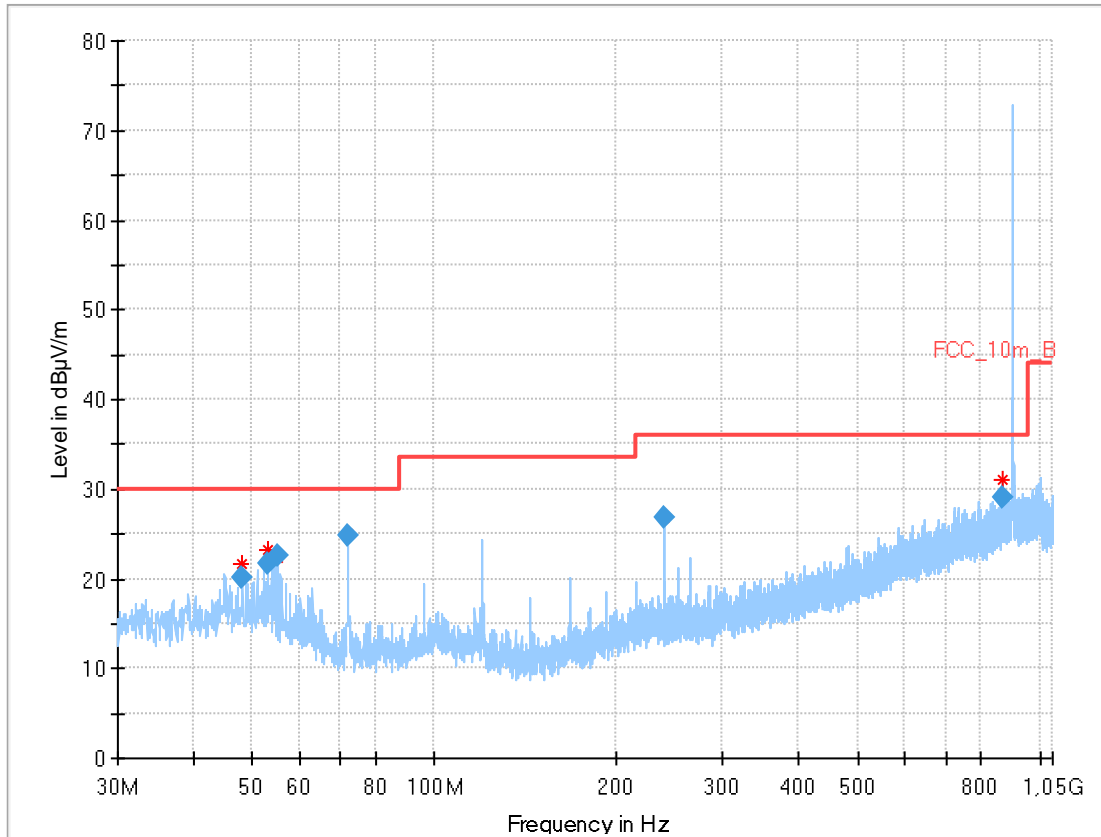


## Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
53.144	20.02	30.0	9.98	1000	120	170.0	V	259.0	14
72.065	28.73	30.0	1.27	1000	120	170.0	V	-10.0	11
120.105	24.44	33.5	9.06	1000	120	147.0	V	202.0	11
240.229	32.84	36.0	3.16	1000	120	98.0	V	180.0	13
264.235	26.76	36.0	9.24	1000	120	101.0	V	112.0	14
312.288	25.86	36.0	10.14	1000	120	98.0	V	270.0	15

**Plots EUT with PCB antenna:**

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

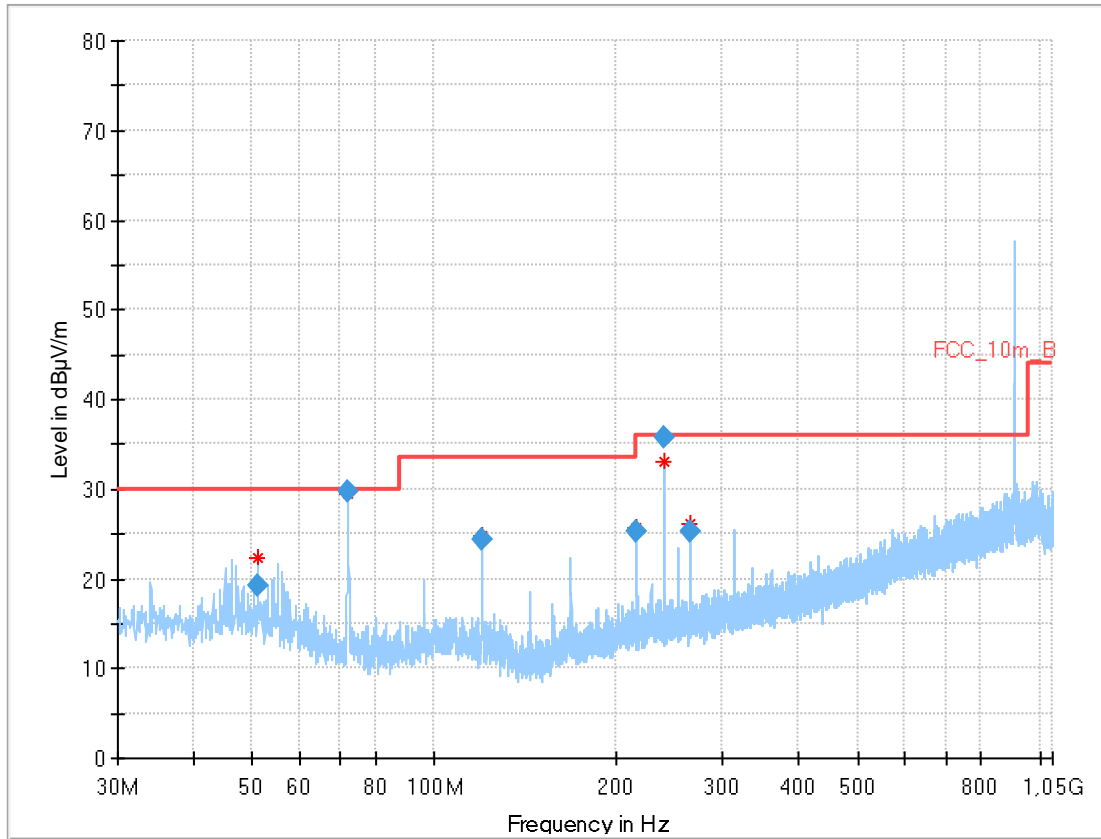


**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
48.219	20.16	30.0	9.84	1000	120	101.0	V	191.0	15
53.030	21.64	30.0	8.36	1000	120	101.0	V	292.0	14
55.000	22.54	30.0	7.46	1000	120	98.0	V	247.0	14
72.070	24.74	30.0	5.26	1000	120	170.0	V	112.0	11
240.227	26.76	36.0	9.24	1000	120	101.0	V	90.0	13
870.302	29.00	36.0	7.00	1000	120	101.0	H	259.0	23



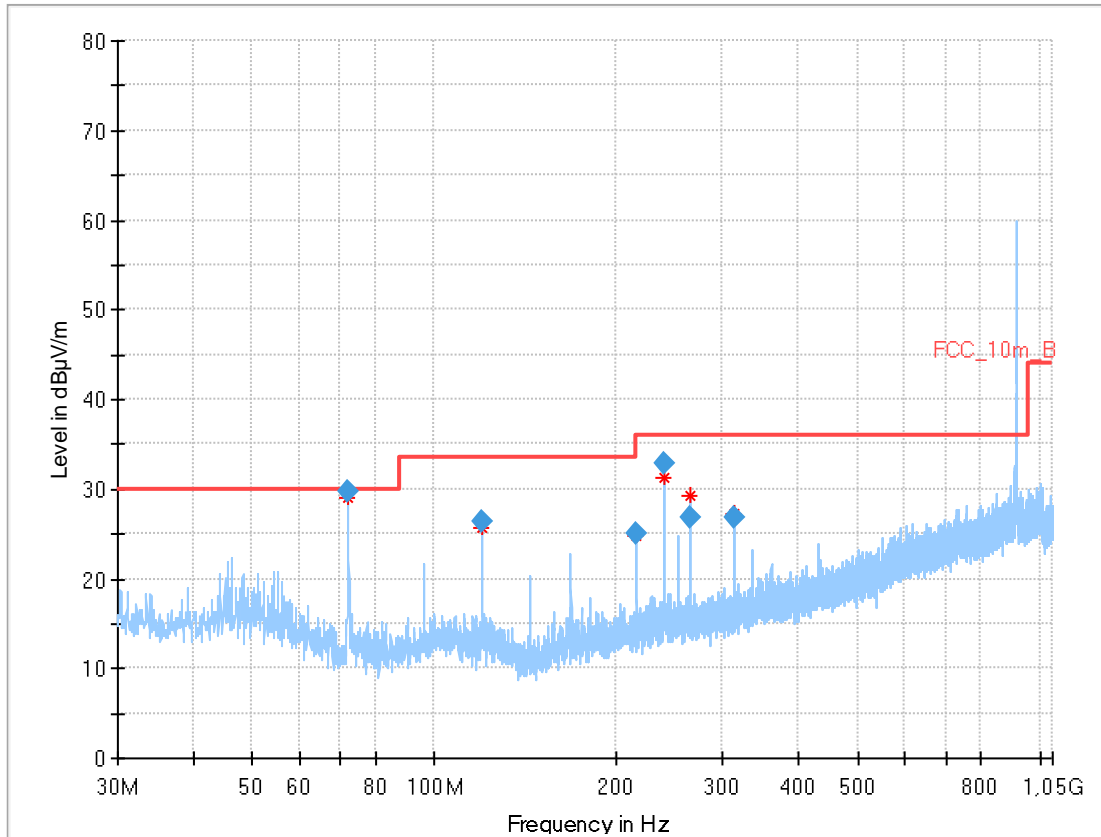
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



## 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)
51.139	19.30	30.0	10.70	1000	120	101.0	V	259.0	15
72.063	29.63	30.0	0.37	1000	120	170.0	V	22.0	11
120.103	24.36	33.5	9.14	1000	120	170.0	V	292.0	11
216.196	25.29	36.0	10.71	1000	120	98.0	V	-22.0	13
240.215	35.86	36.0	0.14	1000	120	98.0	V	72.0	13
264.232	25.31	36.0	10.69	1000	120	98.0	V	112.0	14

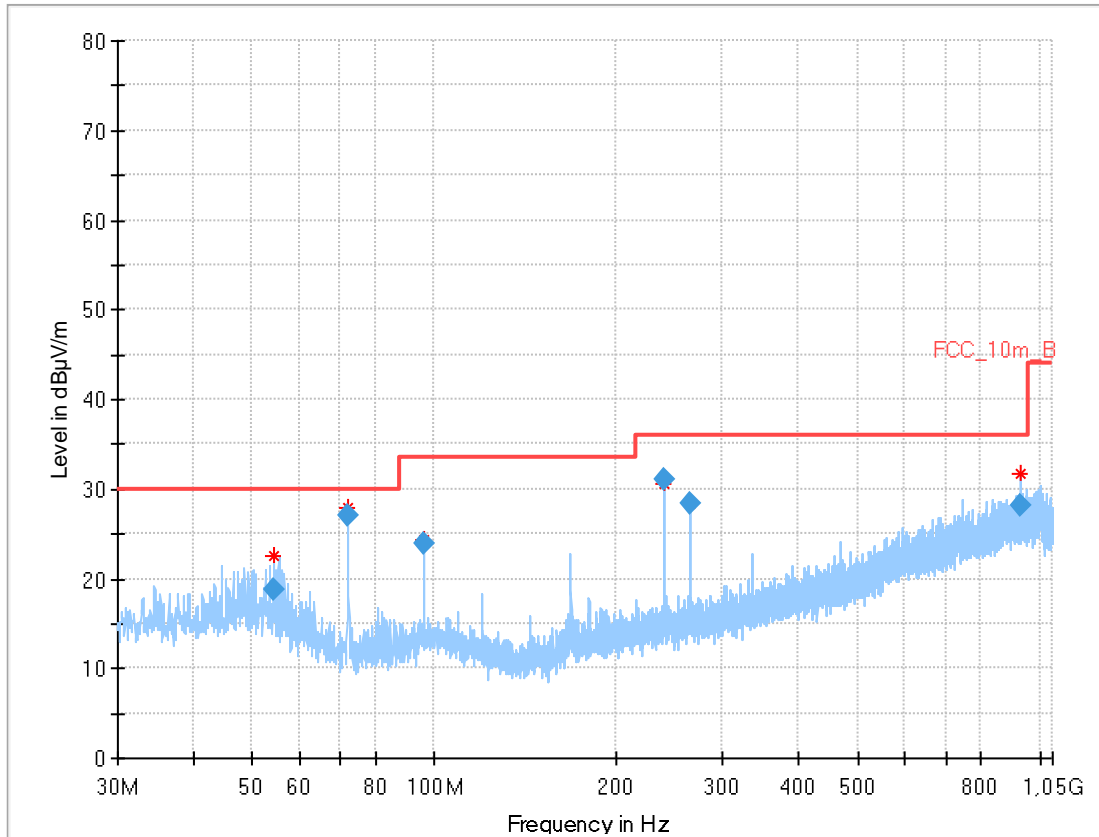
Plot 3: 30 MHz – 1 GHz, horizontal & vertical polarisation (highest channel)



## 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)
72.057	29.74	30.0	0.26	1000	120	170.0	V	190.0	11
120.117	26.30	33.5	7.20	1000	120	147.0	V	-21.0	11
216.204	25.09	36.0	10.91	1000	120	98.0	V	-22.0	13
240.225	32.82	36.0	3.18	1000	120	98.0	V	169.0	13
264.249	26.71	36.0	9.29	1000	120	101.0	V	112.0	14
312.285	26.77	36.0	9.23	1000	120	98.0	V	248.0	15

Plot 4: 30 MHz – 1 GHz, horizontal & vertical polarisation (RX-Mode)



## 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)
54.203	18.75	30.0	11.25	1000	120	101.0	V	3.0	14
72.070	27.07	30.0	2.93	1000	120	101.0	V	68.0	11
96.093	23.85	33.5	9.65	1000	120	101.0	V	-21.0	13
240.220	31.06	36.0	4.94	1000	120	98.0	V	112.0	13
264.241	28.44	36.0	7.56	1000	120	145.0	V	90.0	14
927.258	28.26	36.0	7.74	1000	120	170.0	V	68.0	24

### 11.10.2 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 26 GHz
Trace mode	Max hold
Measured modulation	LoRa
Test setup	See sub clause 6.2 C (1 GHz – 12.75 GHz)
Measurement uncertainty	See sub clause 8

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	
Above 960	54.0	3	

**Result:**

For radiated spurious emission the limits of 15.209 applies for all frequencies mentioned in 15.205. According to FCC Public Notice DA 00-705 (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:

$$F = 20 \cdot \log(\text{dwell time}/100 \text{ ms})$$

One pulse train is higher than 100 ms so the correction factor is 0 (see plots in chapter 11.4)

**1) EUT with dipole antenna:**

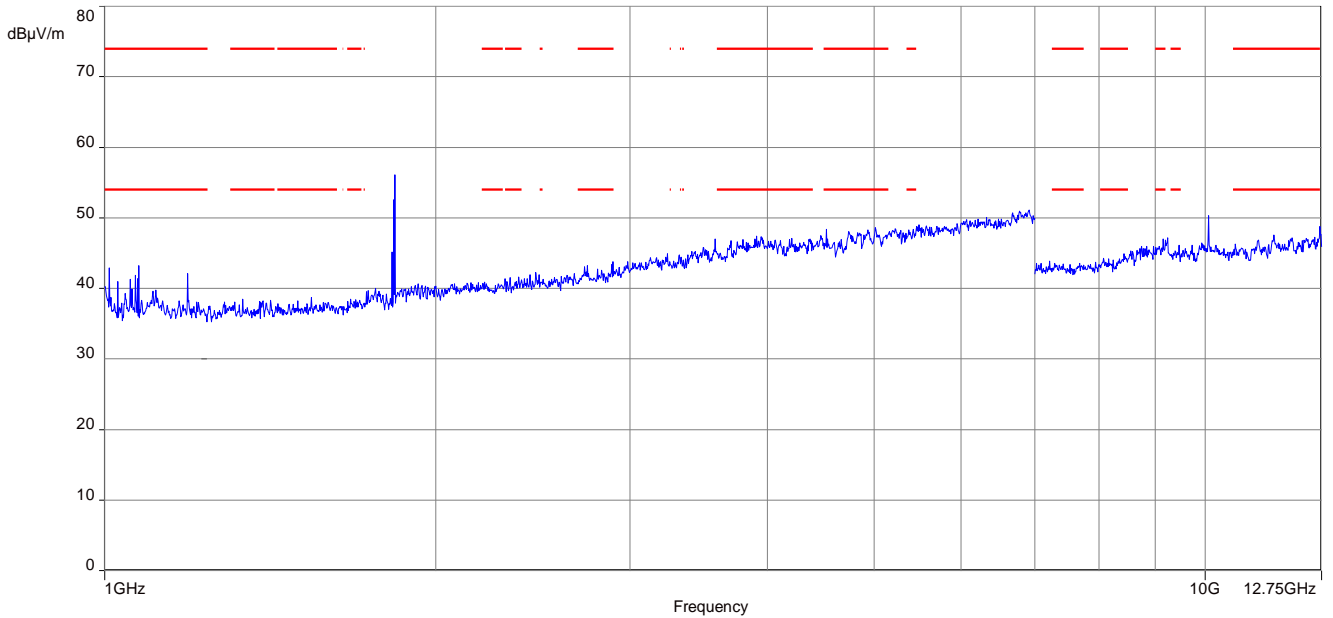
TX spurious emissions radiated								
Lowest channel			Middle channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
No Spurious Emissions in restricted bands detected.								

**2) EUT with PCB antenna**

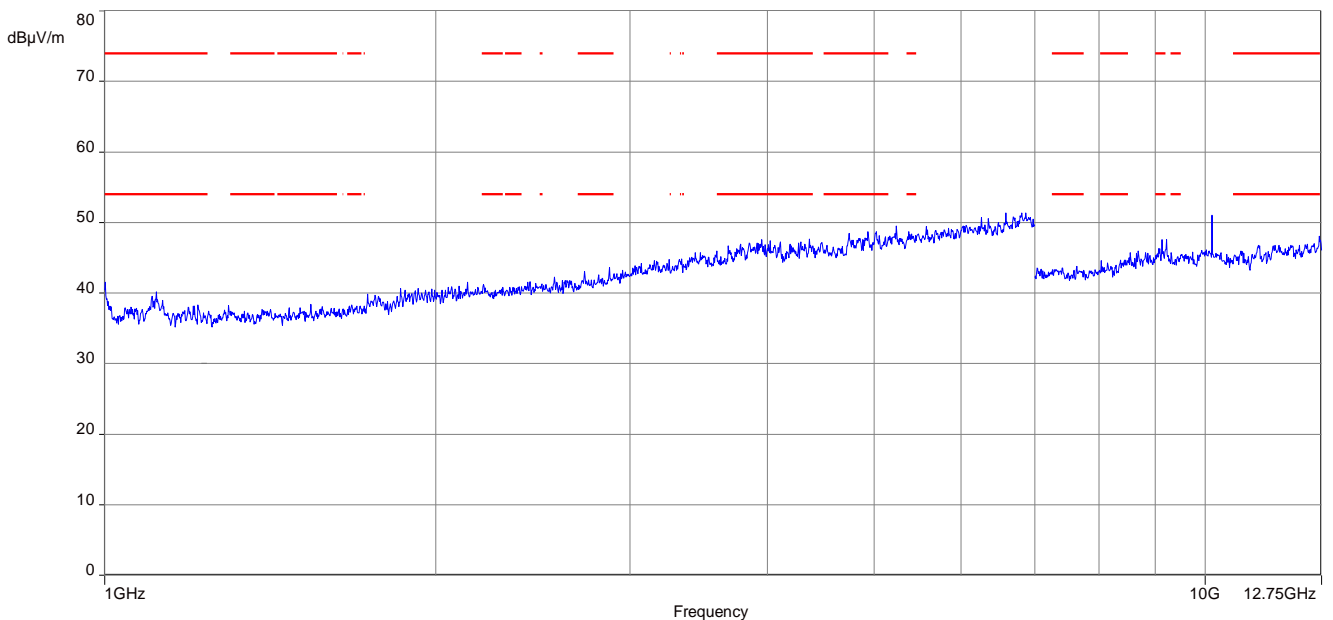
TX spurious emissions radiated								
Lowest channel			Middle channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
9151.07	Peak	53.69	No Spurious Emissions in restricted bands detected.			No Spurious Emissions in restricted bands detected.		
	AVG	50.38						

**Plots EUT with dipole antenna:**

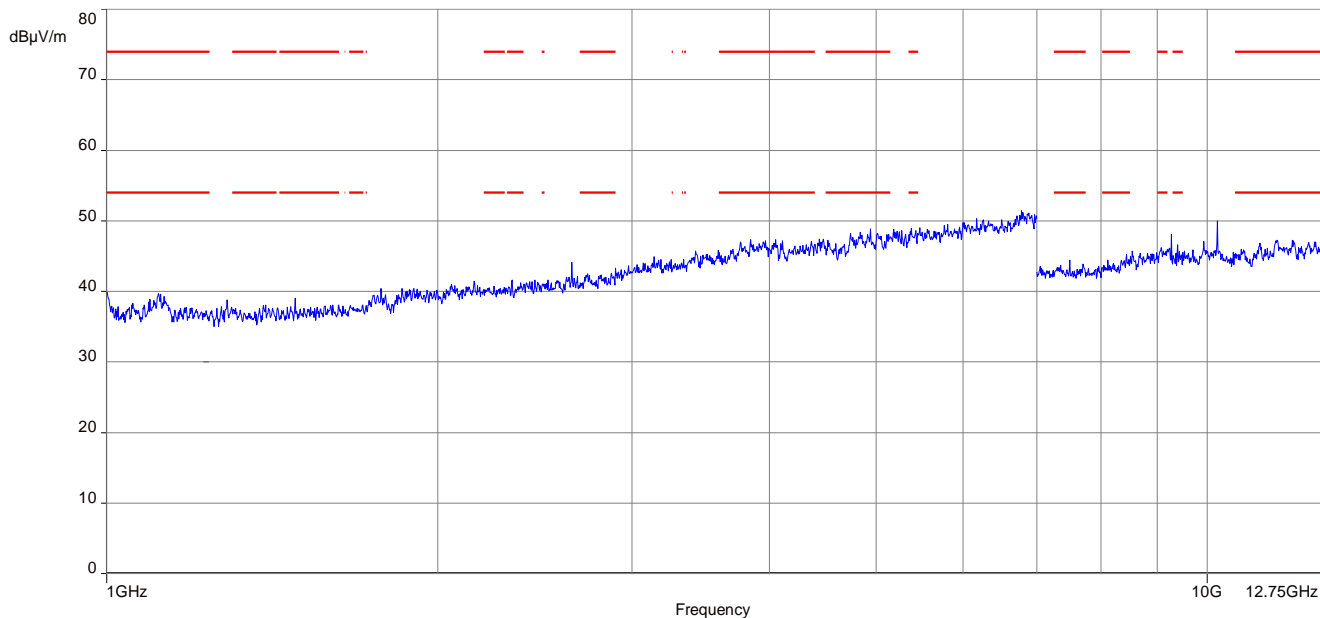
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



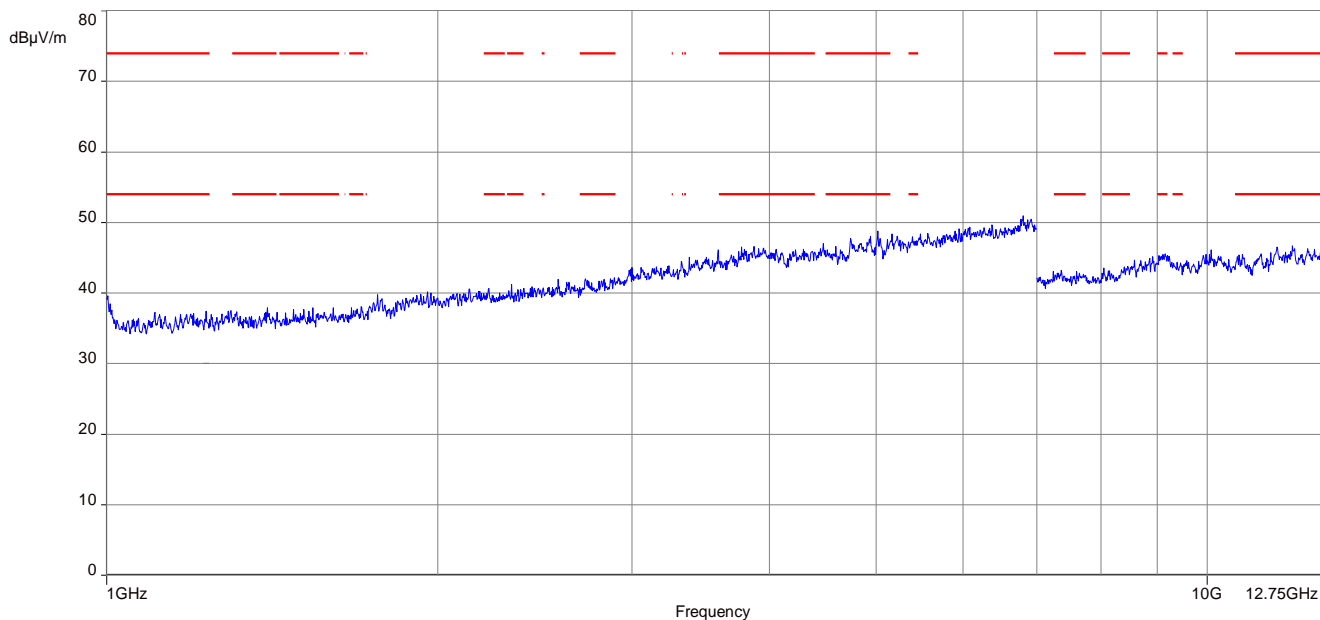
Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)

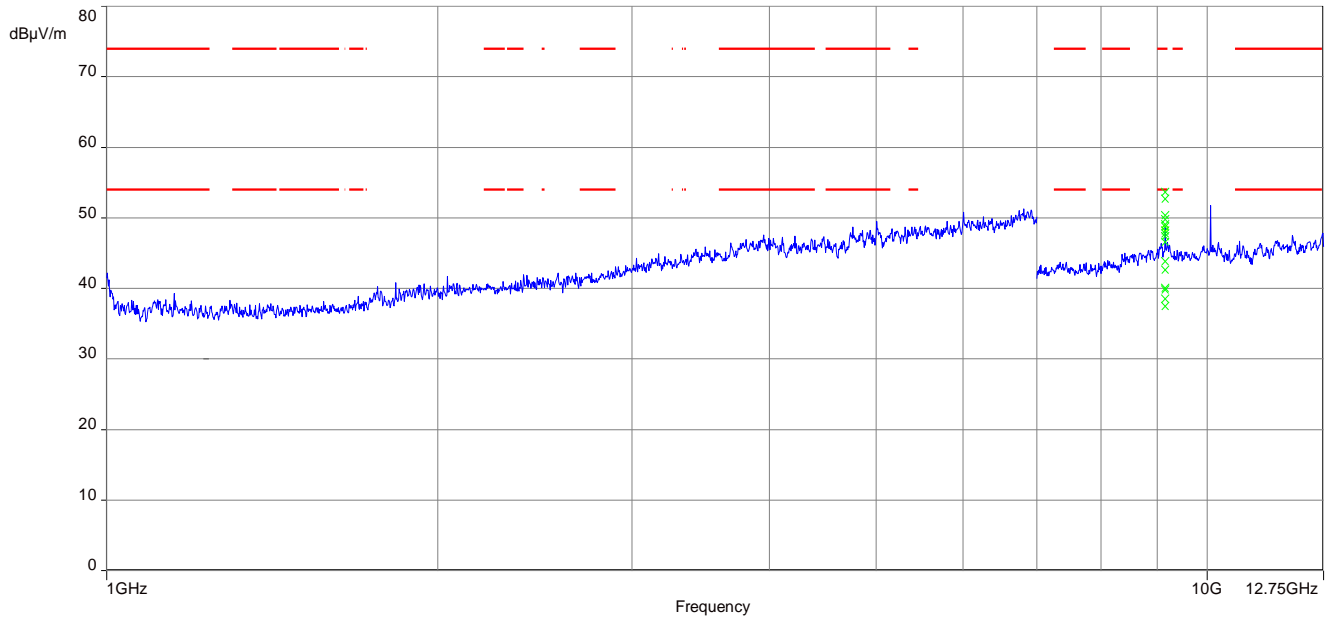


Plot 4: 1 GHz – 12.75 GHz, RX-Mode, horizontal & vertical polarisation (valid for both antenna types)

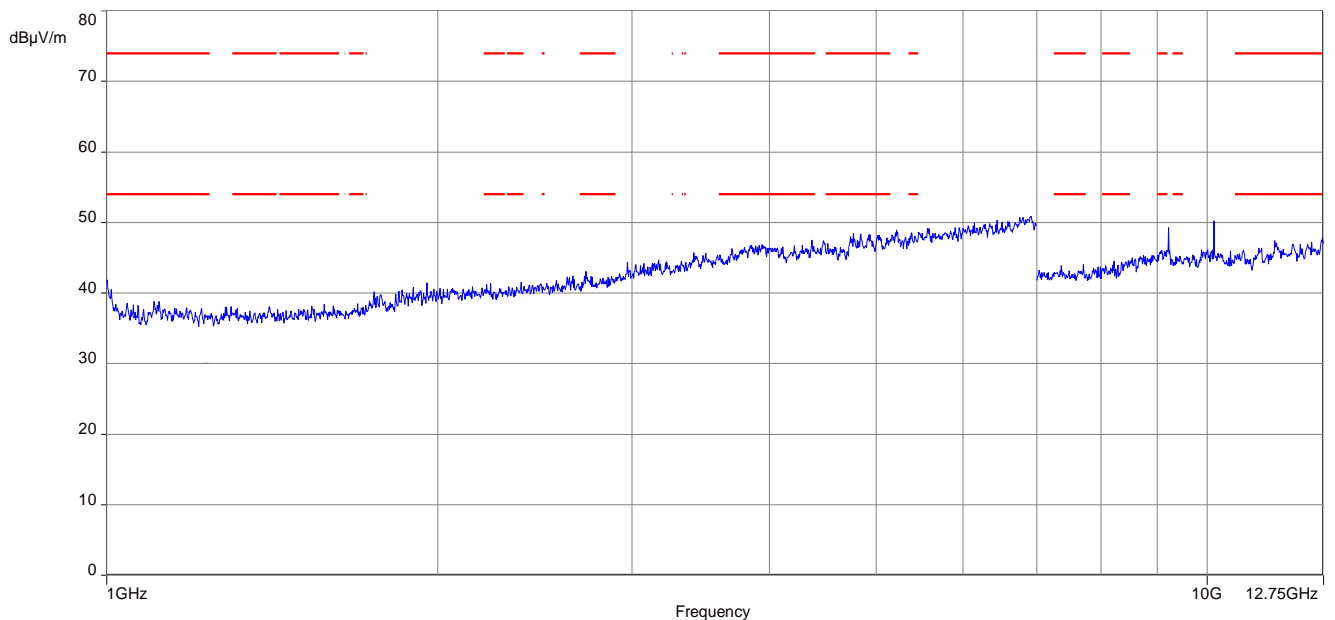


**Plots EUT with PCB antenna:**

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

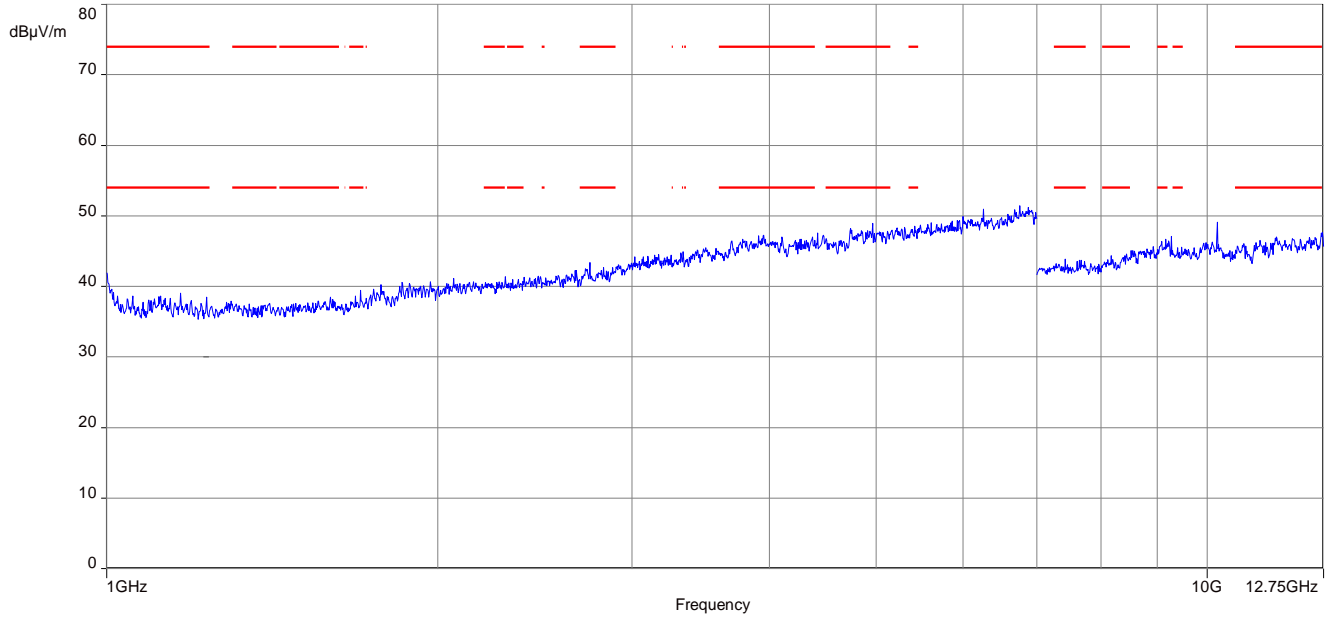


Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)





Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)



## 12 Measurement results Part 2 DTS (915.9-927.1 MHz)

### 12.1 Maximum output power

**Measurement:**

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	5 MHz
Measurement method	According to ANSI C63.10-2013 11.9.1.1 RBW ≥ DTS bandwidth
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3 A
Measurement uncertainty:	See chapter 8

**Limits:**

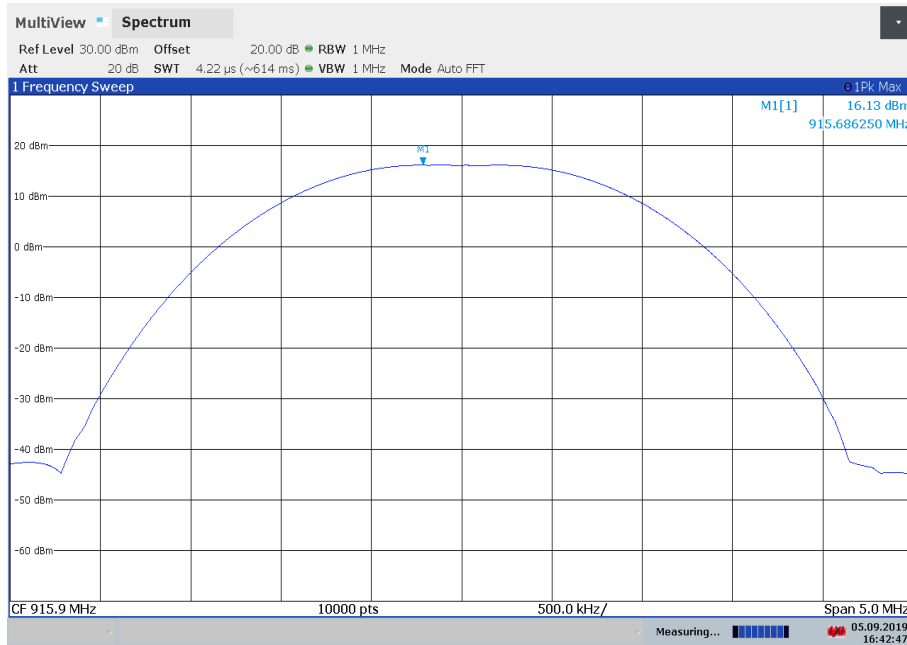
FCC	IC
1 watt (30 dBm) Maximum Output Power Conducted	

**Result:**

Test Conditions		Maximum Output Power Conducted		
		Lowest channel	Middle channel	Highest channel
$T_{nom}$	$V_{nom}$	16.13 dBm	16.23 dBm	16.30 dBm

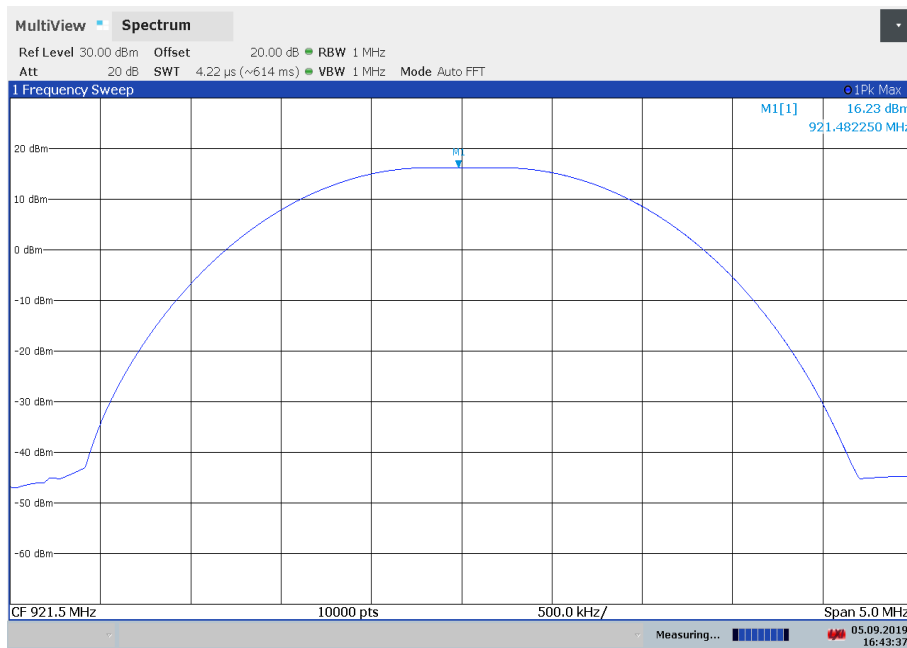
**Plots:**

Plot 1: Lowest Channel



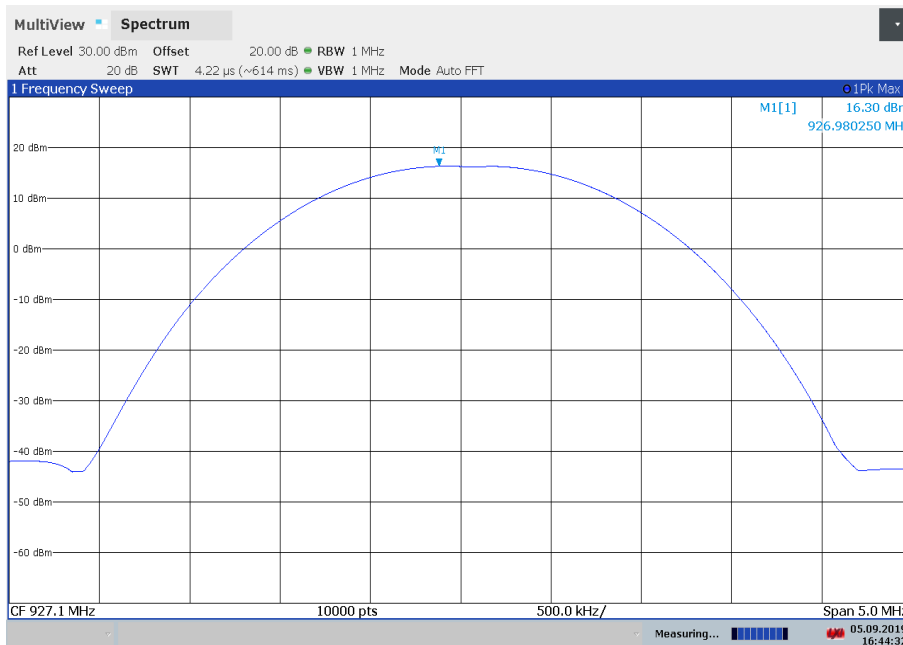
16:42:47 05.09.2019

Plot 2: Middle Channel



16:43:37 05.09.2019

Plot 3: Highest Channel



16:44:33 05.09.2019

## 12.2 Antenna gain

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 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 6.2 B (radiated) See sub clause 6.3 A (conducted)
Measurement uncertainty	See sub clause 8

### 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:

		Lowest channel	Middle channel	Highest channel
Conducted power		16.13 dBm	16.23 dBm	16.30 dBm
dipole antenna	Radiated power	21.00 dBm	20.91 dBm	20.34 dBm
	Gain Calculated	<b>4.87 dBi</b>	<b>4.68 dBi</b>	<b>4.04 dBi</b>
PCB antenna	Radiated power	20.52 dBm	19.61 dBm	19.11 dBm
	Gain Calculated	<b>4.39 dBi</b>	<b>3.38 dBi</b>	<b>2.81 dBi</b>

### 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:	2 MHz
Trace-Mode:	Max Hold
Measurement method	According to ANSI C63.10-2013 11.10.2 Method PKPSD (peak PSD)
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

**Limits:**

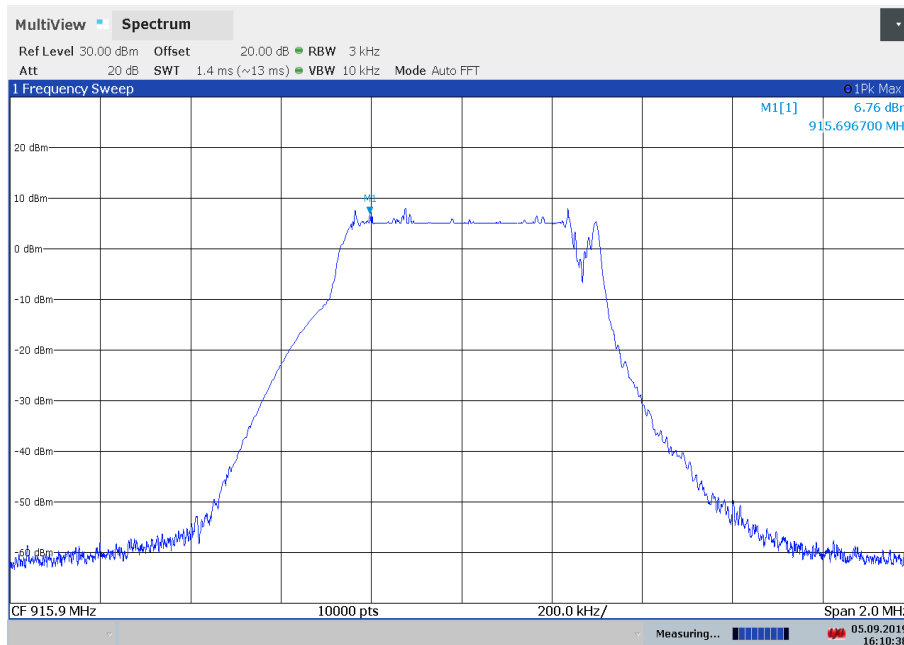
FCC	IC
Power Spectral Density	
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration.	

**Results:**

Power Spectral density [dBm/3kHz]			
Channel	Lowest	Middle	Highest
	6.76	6.75	7.12

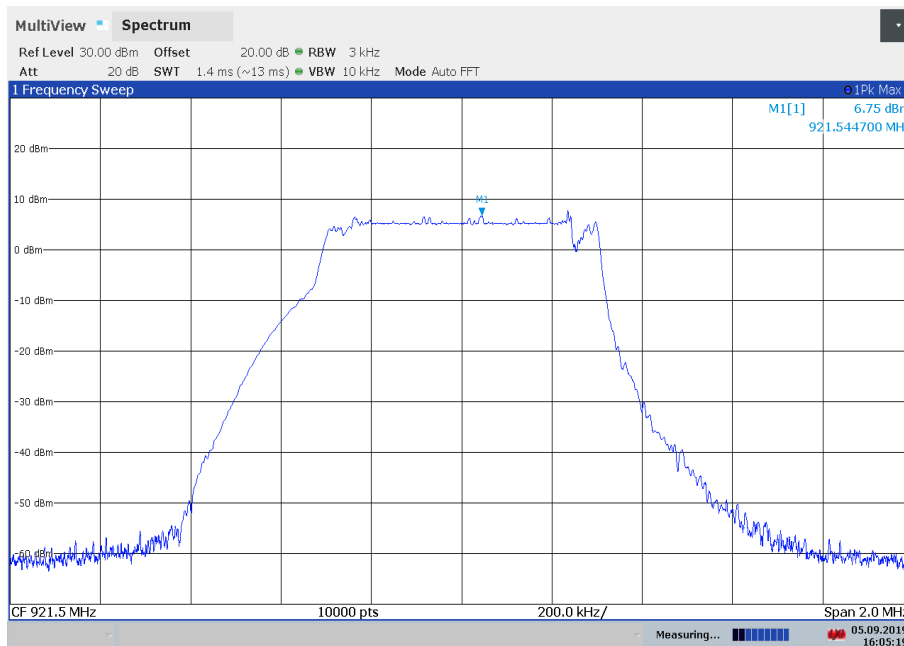
**Plots:**

Plot 1: Lowest Channel



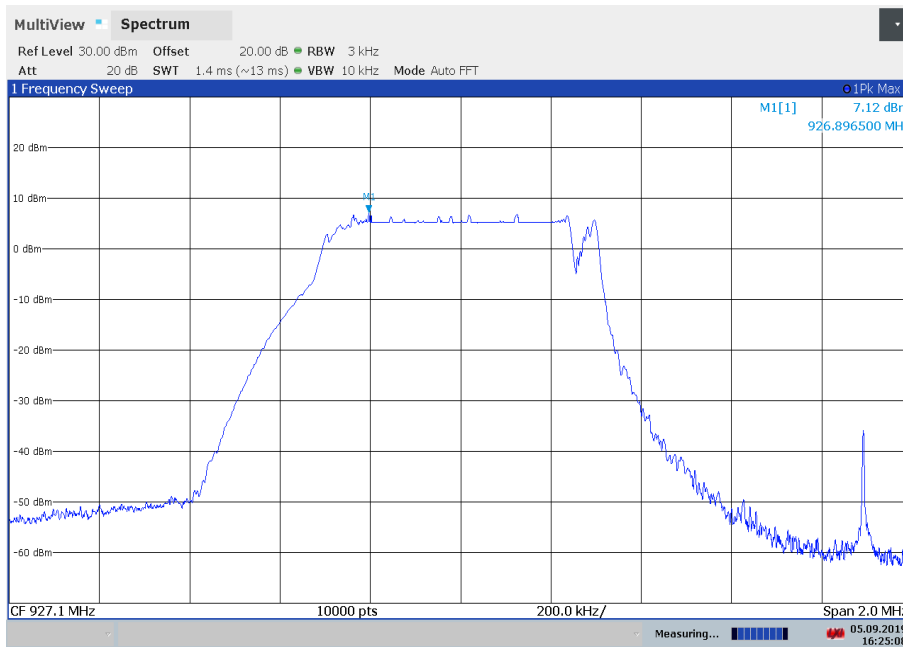
16:10:39 05.09.2019

Plot 2: Middle Channel



16:05:19 05.09.2019

Plot 3: Highest Channel



16:25:08 05.09.2019



## 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
Video bandwidth:	300 kHz
Resolution bandwidth:	100 kHz
Span:	2 MHz
Trace-Mode:	Max Hold
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

### Limits:

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

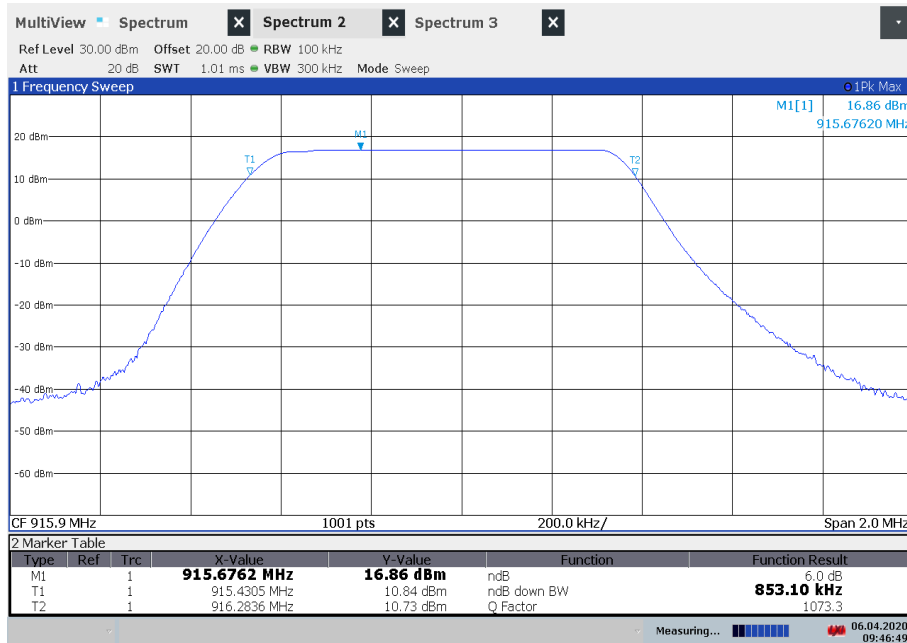
### Results:

Test Conditions		6-dB BANDWIDTH [kHz]		
		Lowest channel	Middle channel	Highest channel
$T_{nom}$	$V_{nom}$	853.1	849.2	845.2

Test Conditions		99% BANDWIDTH [kHz]		
		Lowest channel	Middle channel	Highest channel
$T_{nom}$	$V_{nom}$	889.9	886.6	878.9

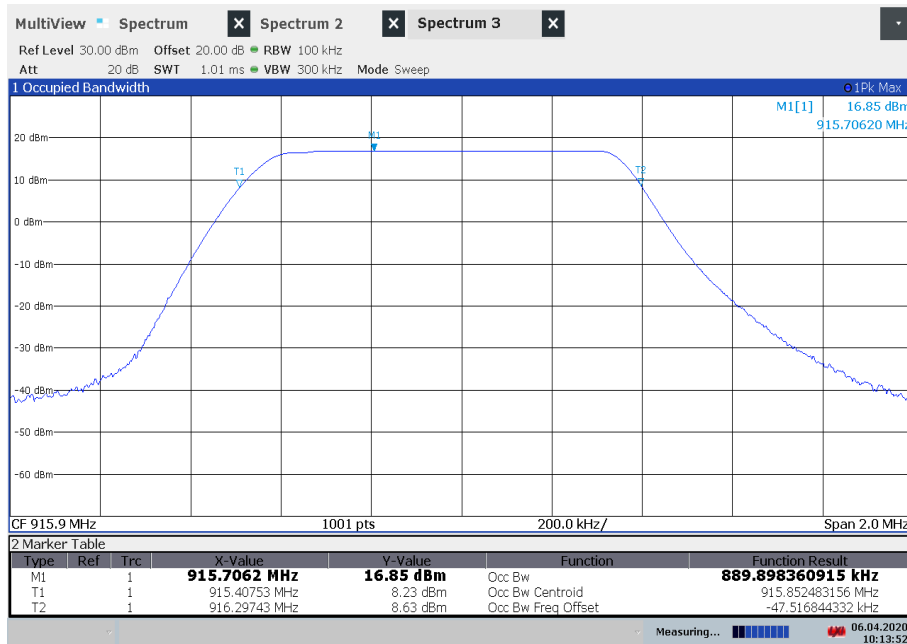
**Plots:**

Plot 1: Lowest Channel, 6 dB-BW



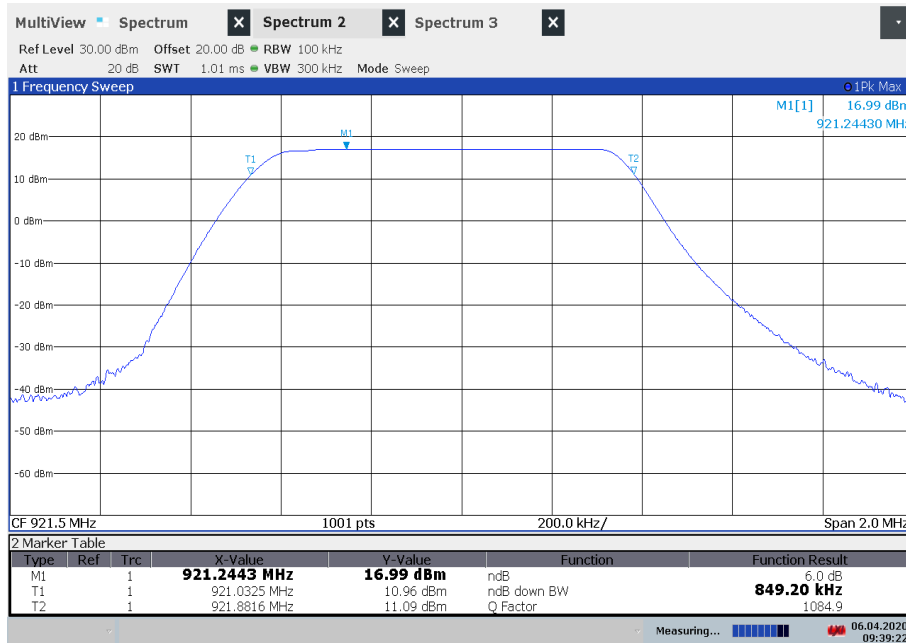
09:46:50 06.04.2020

Plot 2: Lowest Channel, 99%OBW



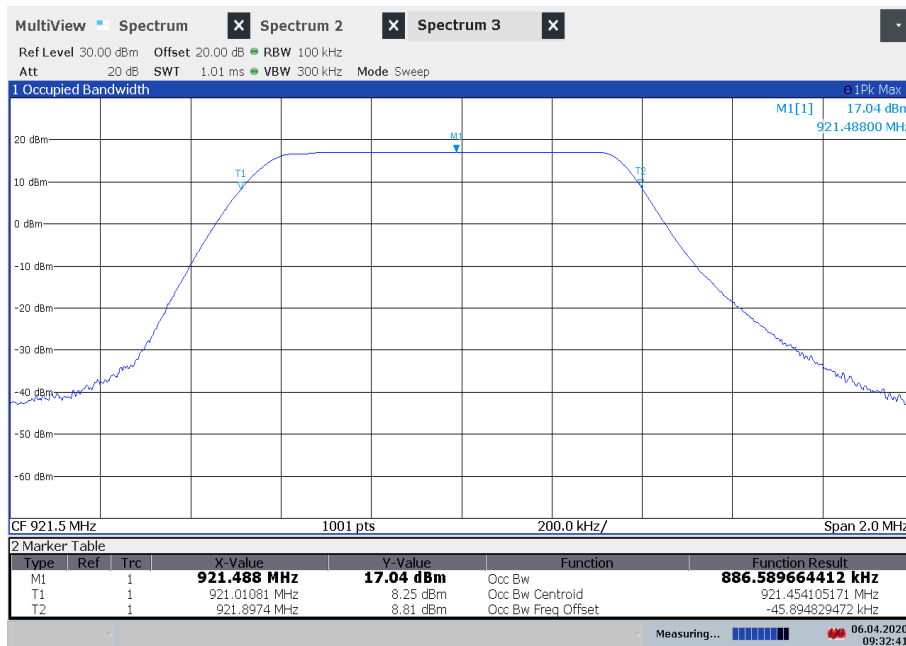
10:13:53 06.04.2020

Plot 3: Middle Channel, 6 dB-BW



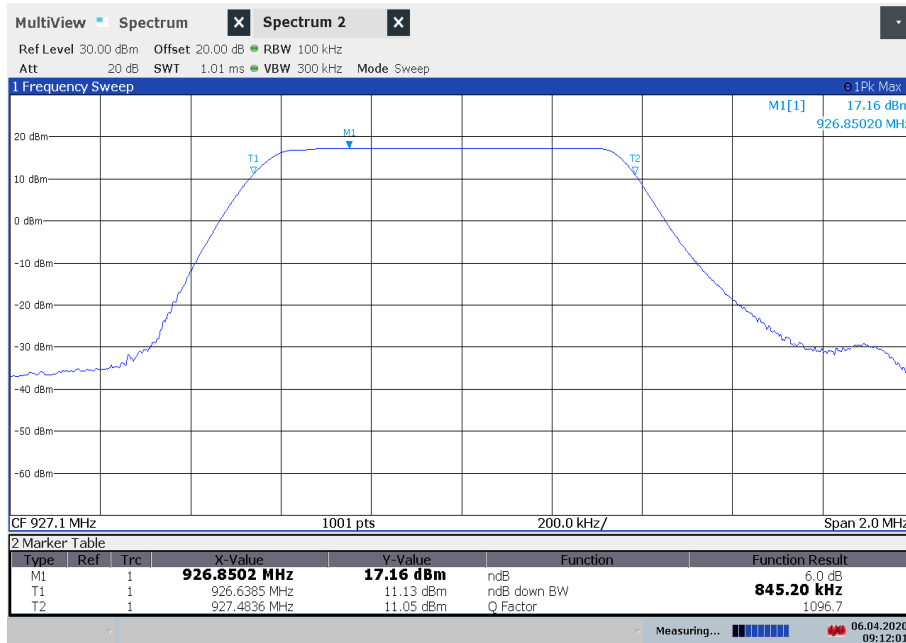
09:39:23 06.04.2020

Plot 4: Middle Channel, 99%OBW



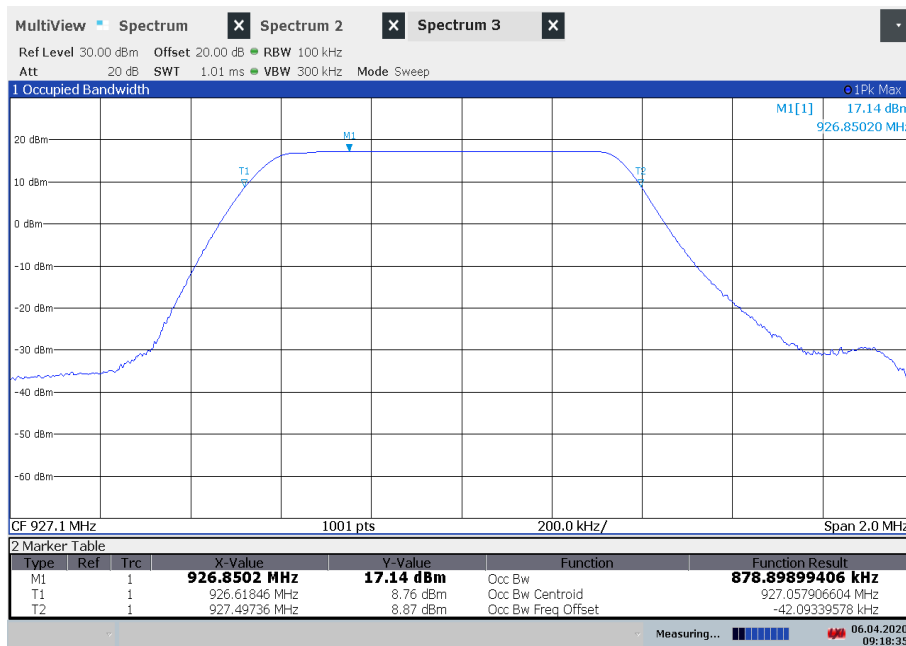
09:32:41 06.04.2020

Plot 5: Highest Channel, 6 dB-BW



09:12:02 06.04.2020

Plot 6: Highest Channel, 99%OBW



09:18:36 06.04.2020

## 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: 915 MHz Upper Band Edge: 928 MHz
Trace mode	Max hold
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

### Limits:

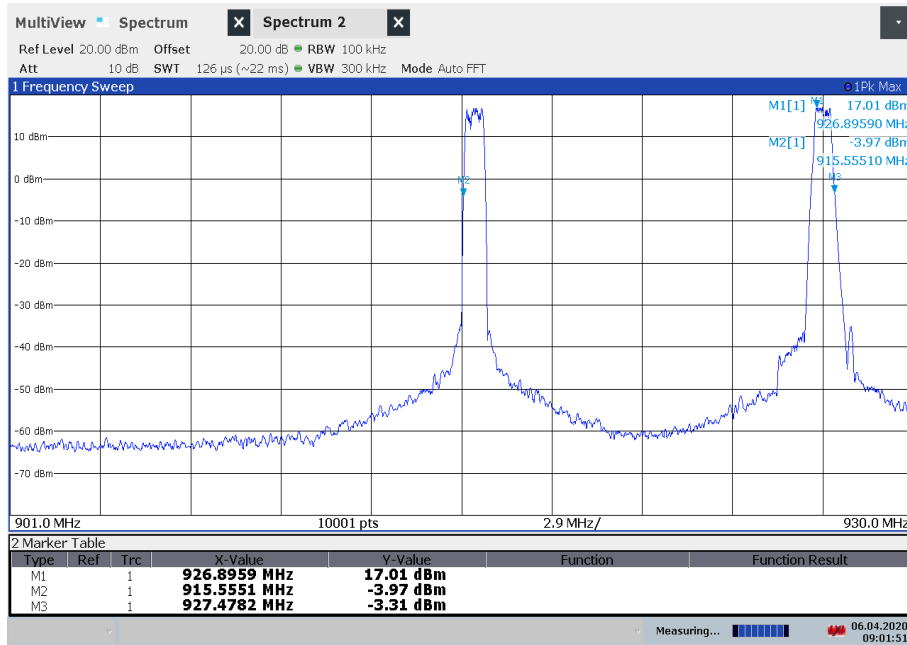
FCC	IC
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that 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>	
<p>RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.</p>	

### Results conducted:

Scenario Modulation	Spurious band edge conducted	
	lowest channel	highest channel
Lower band edge	> 20 dB	> 20 dB
Upper band edge	> 20 dB	> 20 dB

**Plots:**

**Plot 1: lowest and highest channel**



09:01:52 06.04.2020

**Results radiated:**

No restricted band in the range  $\pm 2$  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
<sup>1</sup> 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	( <sup>2</sup> )
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:	1 MHz
Resolution bandwidth:	100 kHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3A
Measurement uncertainty:	See chapter 8

### 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>	
<p>RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.</p>	

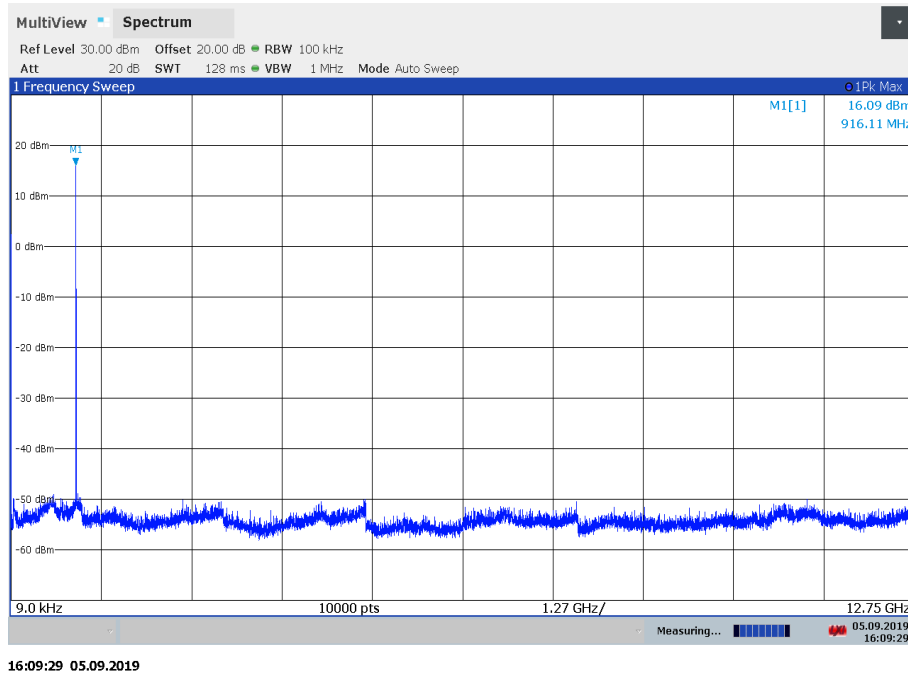
### Result:

Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
903.0		16.09	24 dBm		Operating frequency
	See plots		-20 dBc	No emissions detected!	
909.4		16.18	24 dBm		Operating frequency
	See plots		-20 dBc	No emissions detected!	
914.2		16.27	24 dBm		Operating frequency
	See plots		-20 dBc	No emissions detected!	

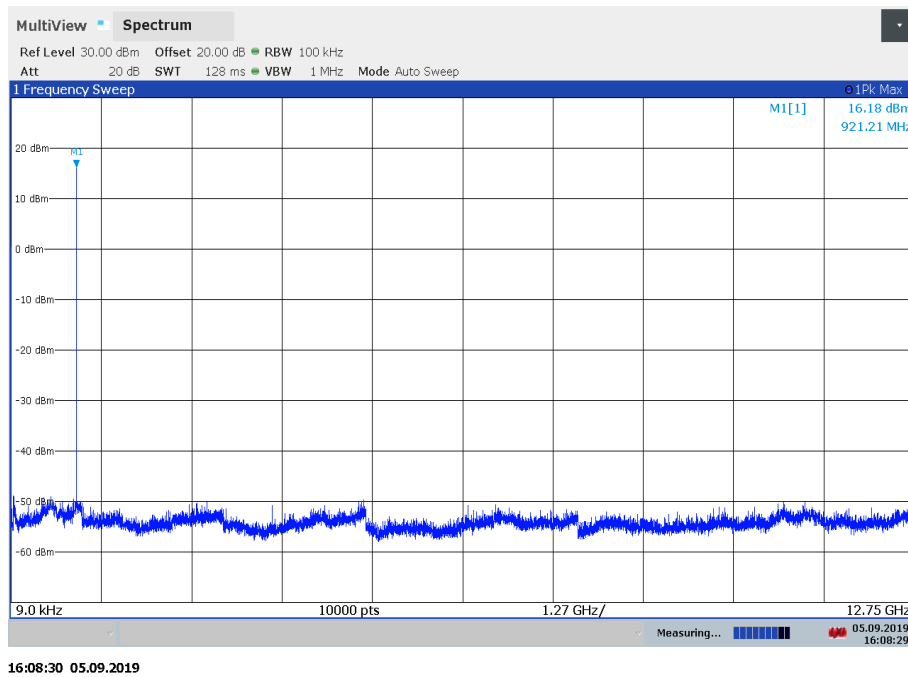


**Plots:**

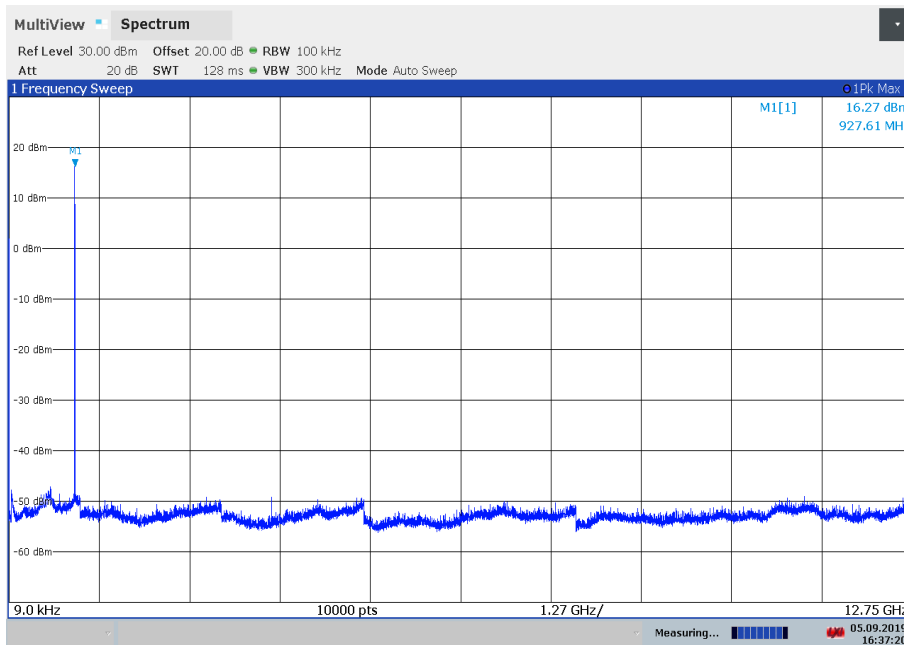
Plot 1: Lowest channel, 9 kHz – 12.75 GHz



Plot 2: Middle channel, 9 kHz – 12.75 GHz



Plot 3: Highest channel, 9 kHz – 12.75 GHz



16:37:20 05.09.2019

## 12.7 Spurious Emissions Radiated < 30 MHz

### Description:

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: 200 Hz F > 150 kHz: 9 kHz
Resolution 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 6.2 A
Measurement uncertainty:	See chapter 8

### Limits:

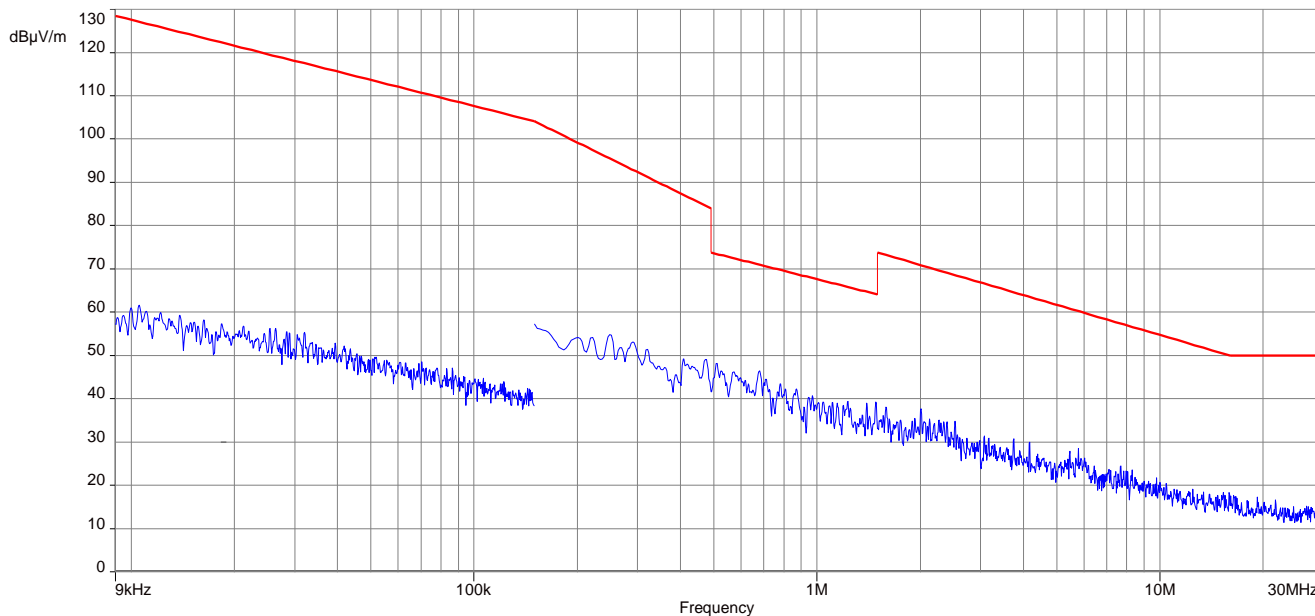
FCC		IC	
TX spurious emissions radiated < 30 MHz			
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance	
0.009 – 0.490	2400/F(kHz)	300	
0.490 – 1.705	24000/F(kHz)	30	
1.705 – 30.0	30	30	

### Result:

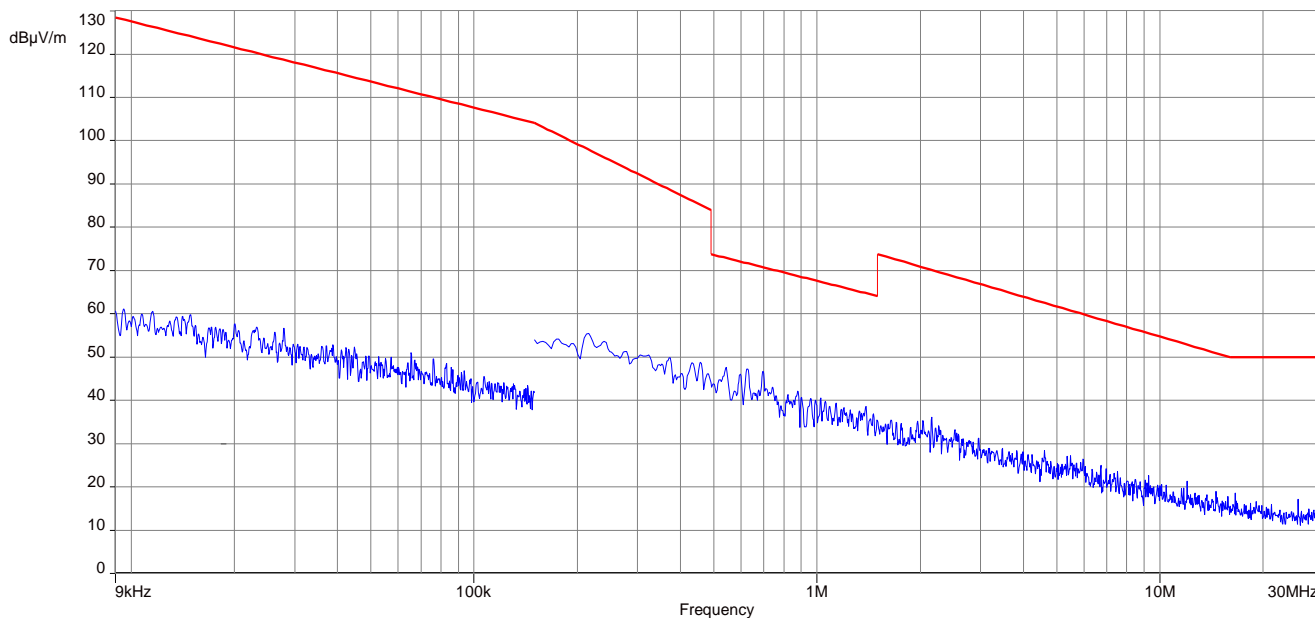
SPURIOUS EMISSIONS LEVEL								
Lowest channel			Middle channel			Highest channel		
Frequency [MHz]	Detector	Level [dBµV/m]	Frequency [MHz]	Detector	Level [dBµV/m]	Frequency [MHz]	Detector	Level [dBµV/m]
All emissions were more than 10 dB below the limit.								

**Plots EUT with dipole antenna:**

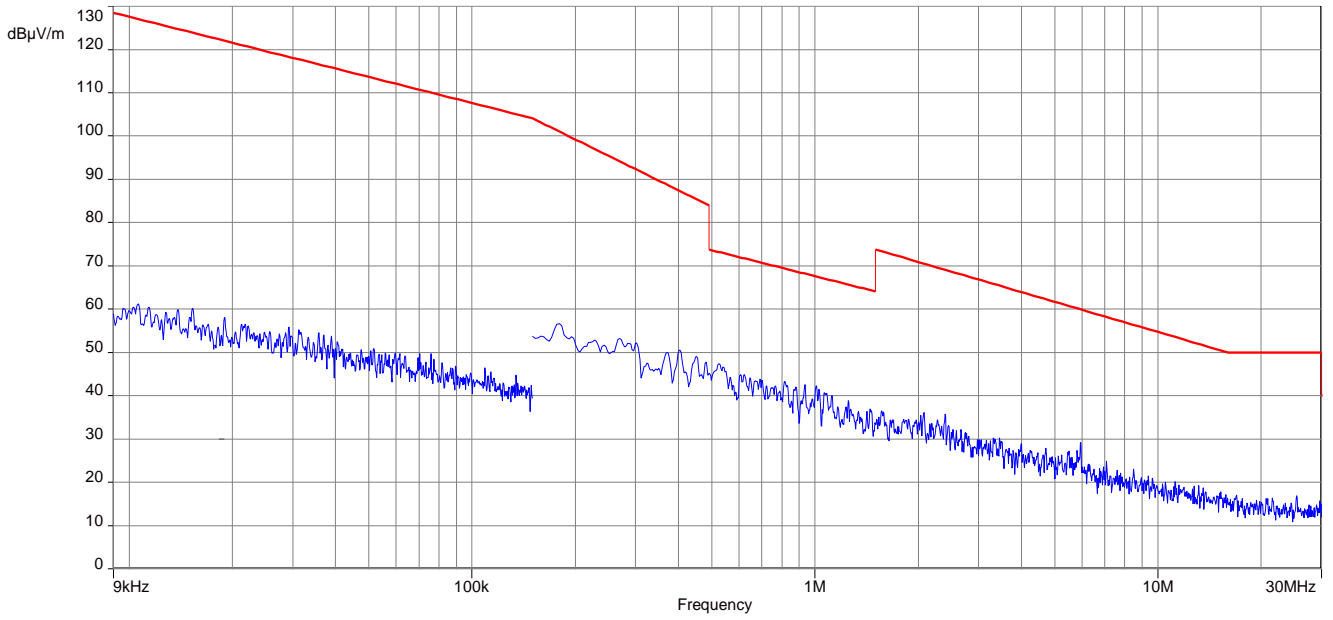
Plot 1: TX-Mode lowest channel



Plot 2: TX-Mode middle channel

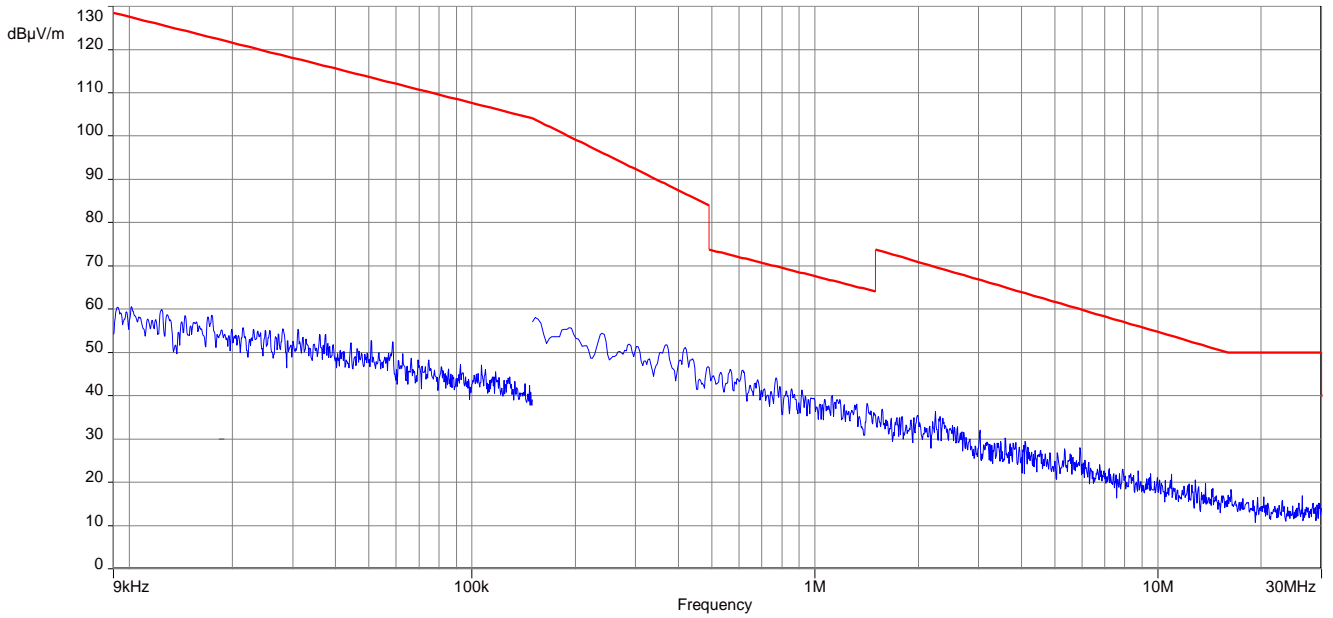


Plot 3: TX-Mode highest channel

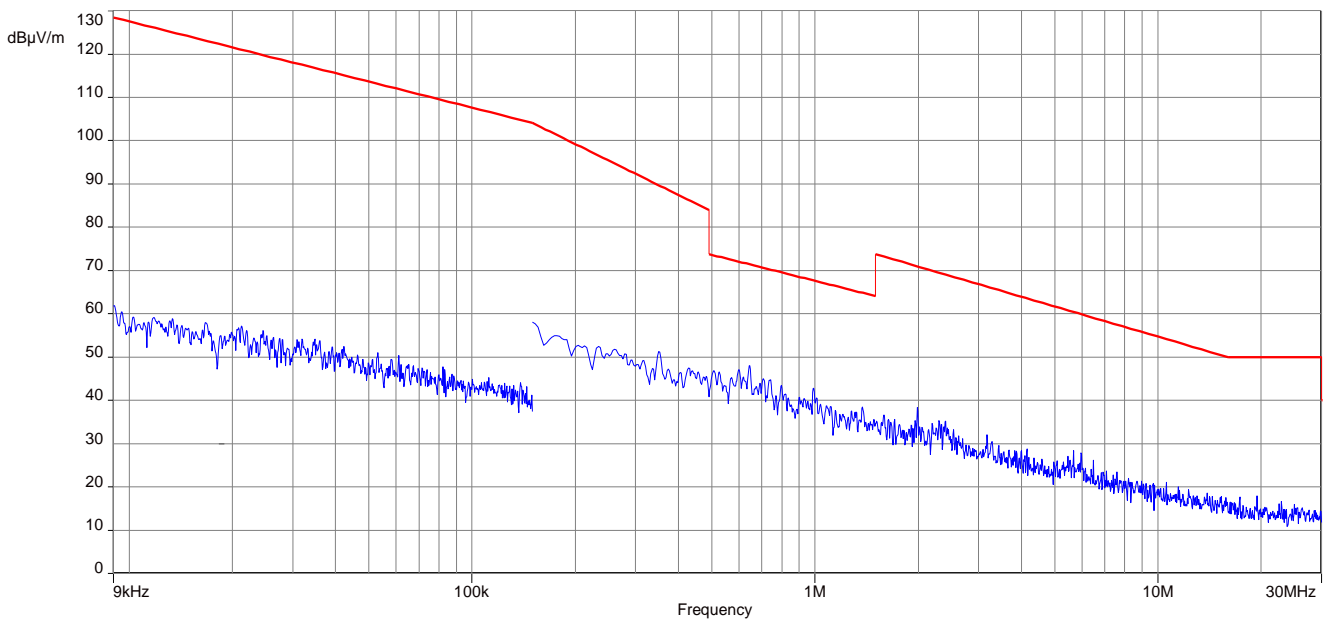


**Plots EUT with PCB antenna:**

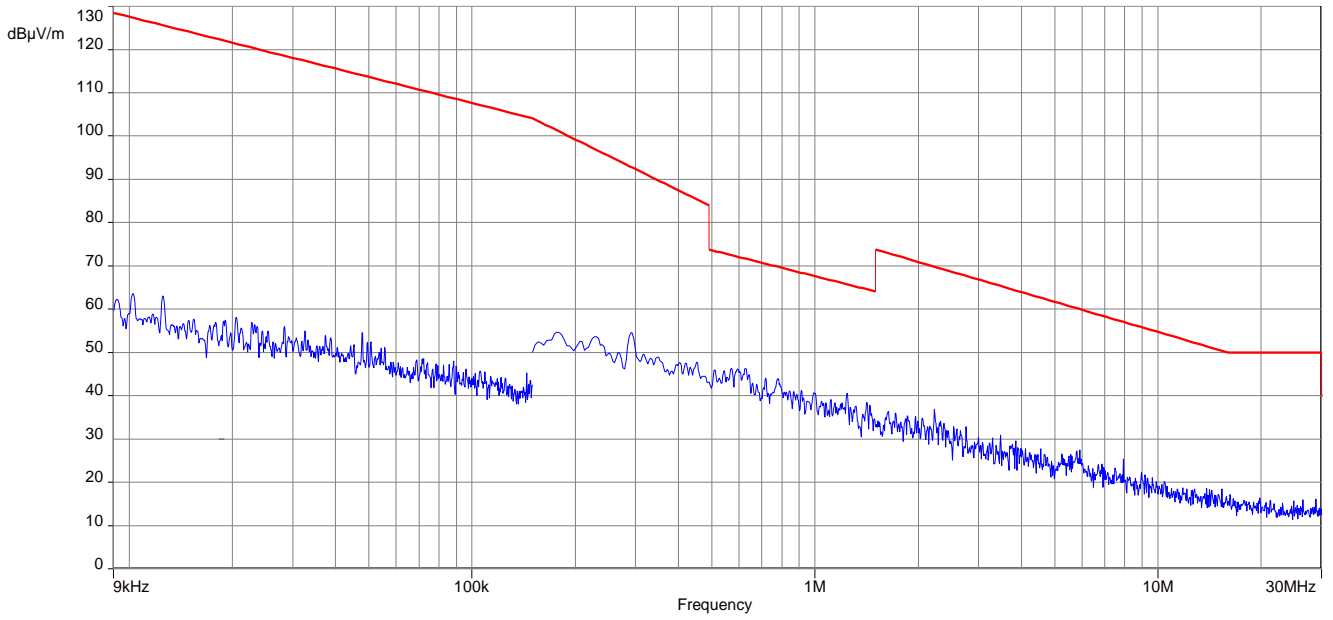
Plot 1: TX-Mode lowest channel



Plot 2: TX-Mode middle channel



Plot 3: TX-Mode highest 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 6.1 A
Measurement uncertainty	See sub clause 8

#### 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
30 - 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

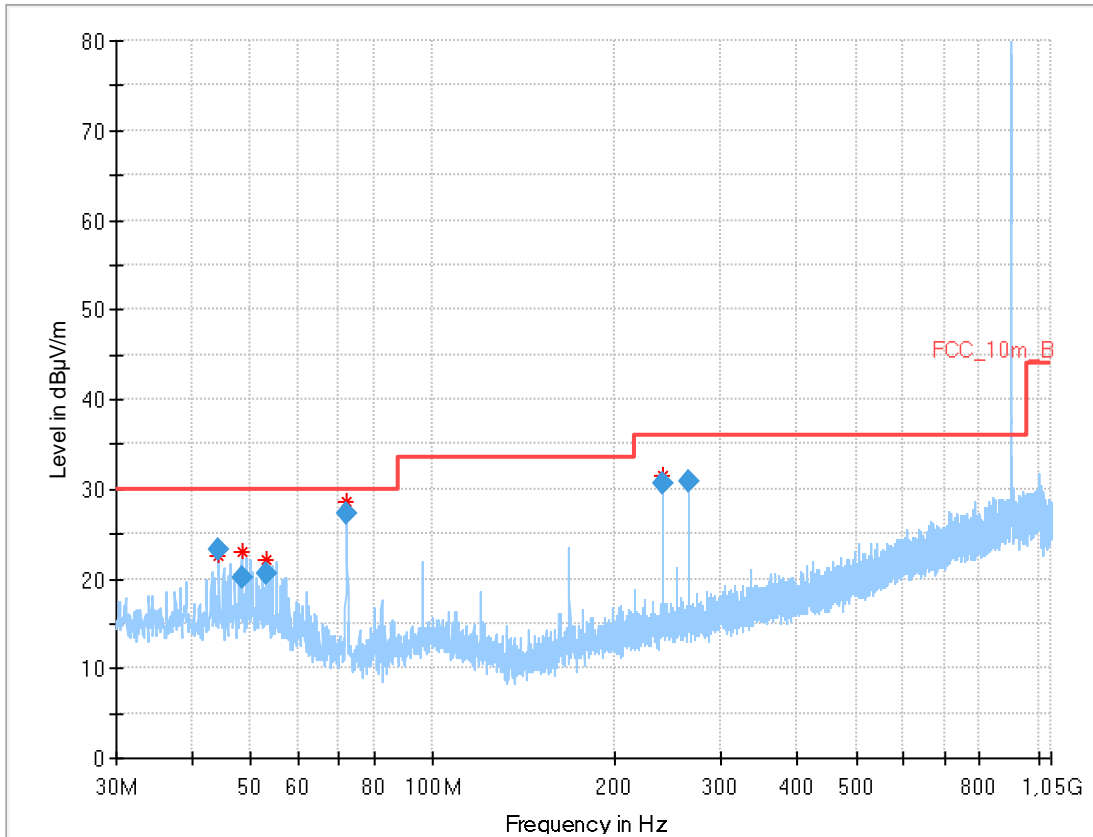
#### Result:

See result table below the plots.



**Plots EUT with dipole antenna:**

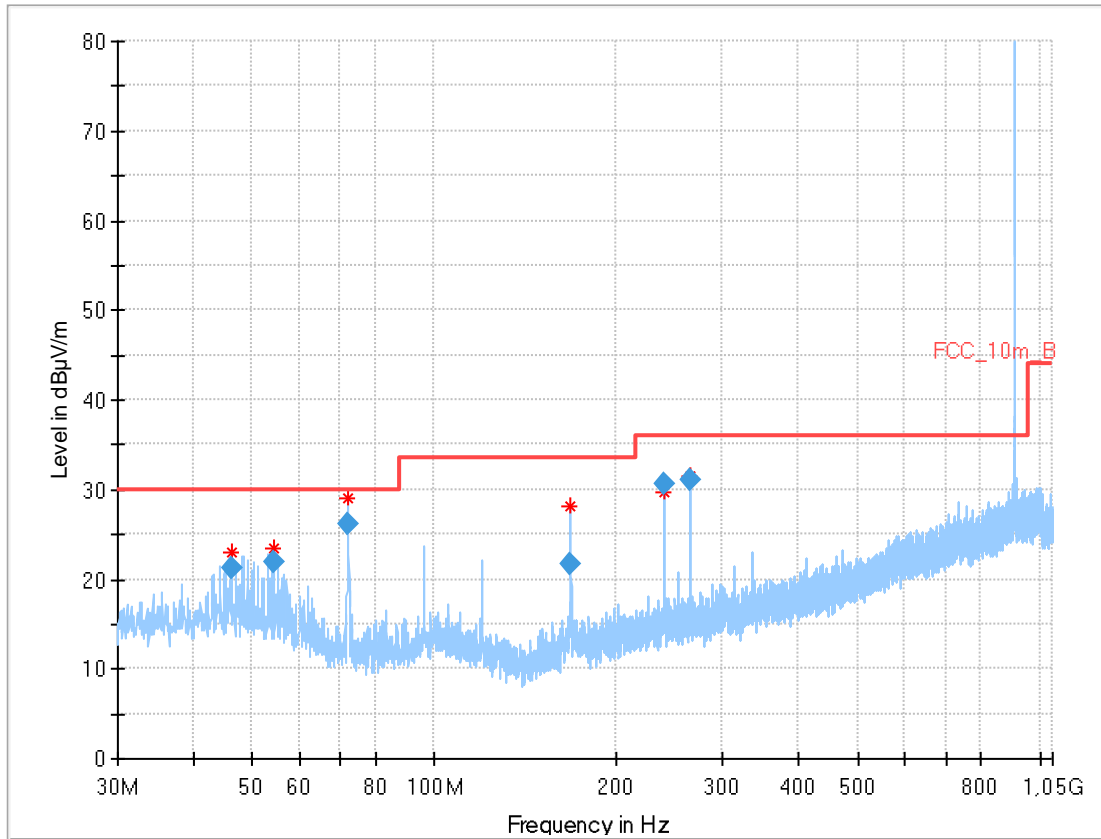
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



**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)
44.340	23.15	30.0	6.85	1000	120	101.0	V	112.0	15
48.348	20.11	30.0	9.89	1000	120	100.0	V	252.0	15
53.122	20.49	30.0	9.51	1000	120	170.0	V	12.0	14
72.068	27.31	30.0	2.69	1000	120	170.0	V	68.0	11
240.219	30.53	36.0	5.47	1000	120	98.0	V	67.0	13
264.242	30.78	36.0	5.22	1000	120	98.0	V	90.0	14

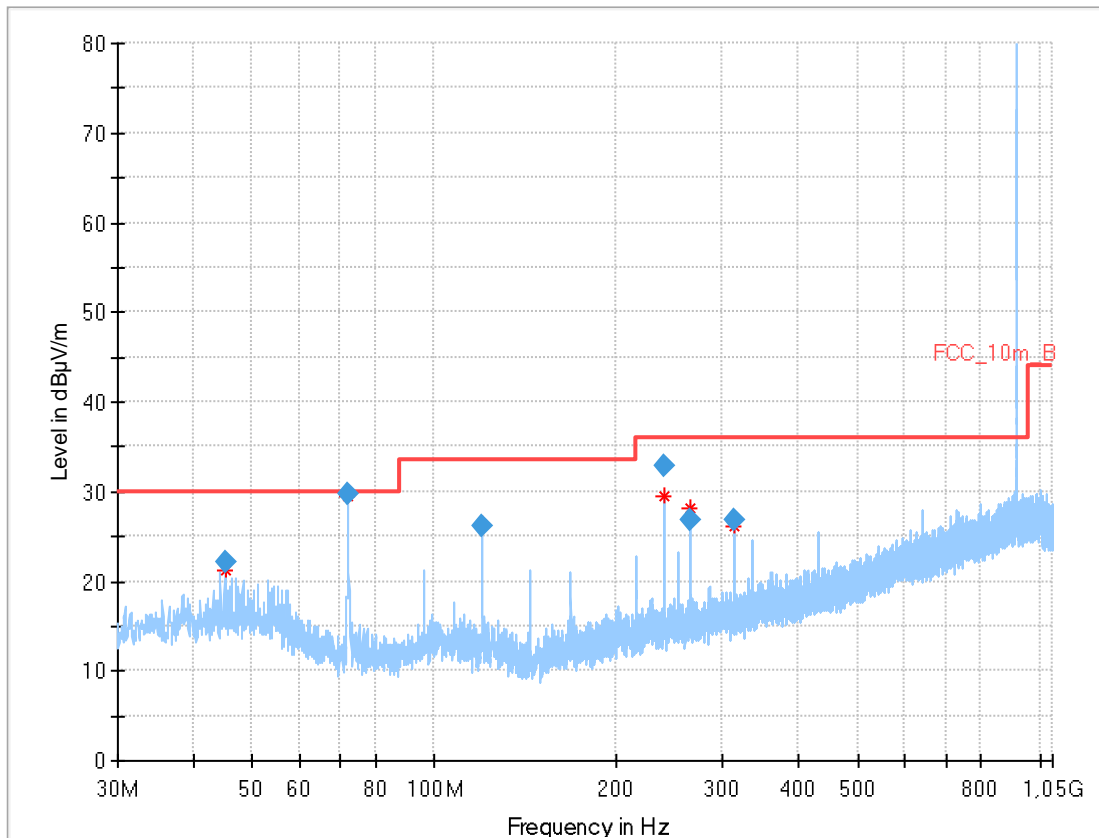
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



## 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)
46.301	21.13	30.0	8.87	1000	120	101.0	V	259.0	15
54.301	21.88	30.0	8.12	1000	120	98.0	V	247.0	14
72.074	26.25	30.0	3.75	1000	120	170.0	V	101.0	11
168.154	21.63	33.5	11.87	1000	120	98.0	V	-17.0	11
240.220	30.55	36.0	5.45	1000	120	98.0	V	90.0	13
264.249	31.11	36.0	4.89	1000	120	98.0	V	101.0	14

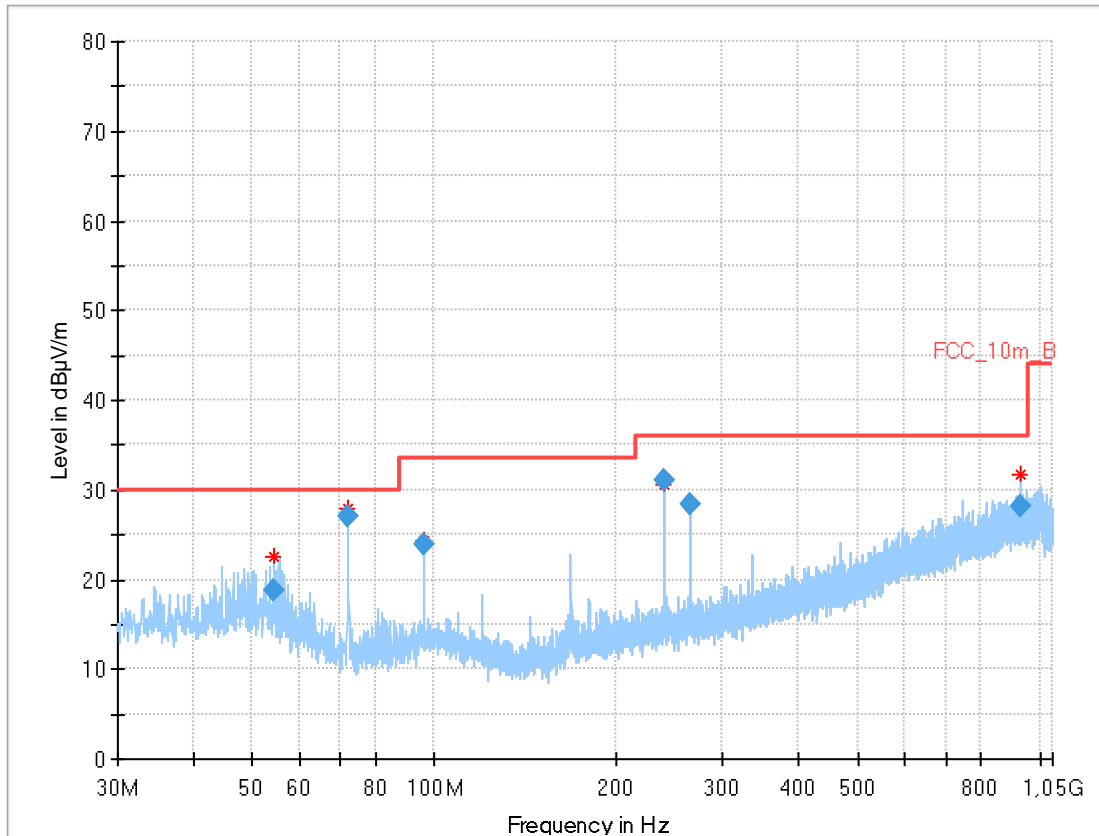
Plot 3: 30 MHz – 1 GHz, horizontal & vertical polarisation (highest channel)



## 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)
45.143	22.11	30.0	7.89	1000	120	101.0	V	292.0	15
72.066	29.78	30.0	0.22	1000	120	170.0	V	112.0	11
120.112	26.13	33.5	7.37	1000	120	170.0	V	-21.0	11
240.217	32.83	36.0	3.17	1000	120	98.0	V	191.0	13
264.229	26.78	36.0	9.22	1000	120	98.0	V	112.0	14
312.281	26.82	36.0	9.18	1000	120	98.0	V	259.0	15

Plot 4: 30 MHz – 1 GHz, horizontal & vertical polarisation (RX-Mode, valid for both antenna types)

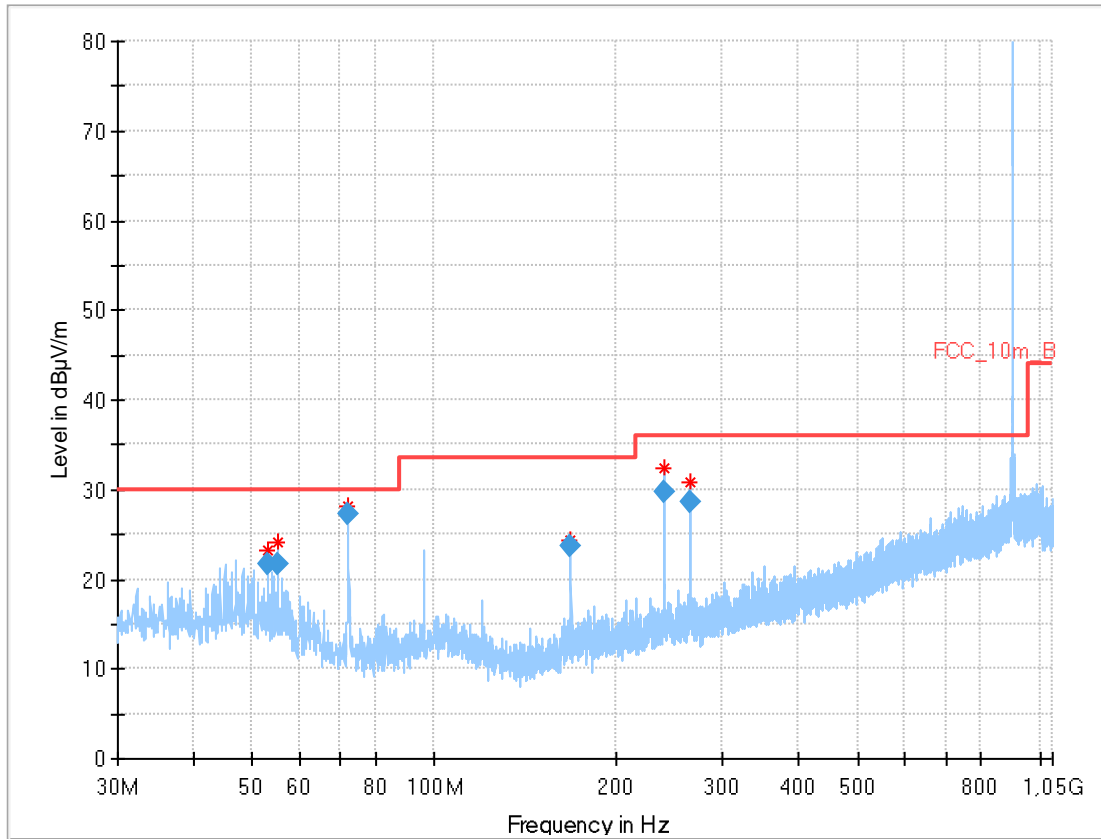


## Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
54.203	18.75	30.0	11.25	1000	120	101.0	V	3.0	14
72.070	27.07	30.0	2.93	1000	120	101.0	V	68.0	11
96.093	23.85	33.5	9.65	1000	120	101.0	V	-21.0	13
240.220	31.06	36.0	4.94	1000	120	98.0	V	112.0	13
264.241	28.44	36.0	7.56	1000	120	145.0	V	90.0	14
927.258	28.26	36.0	7.74	1000	120	170.0	V	68.0	24

**Plots EUT with PCB antenna:**

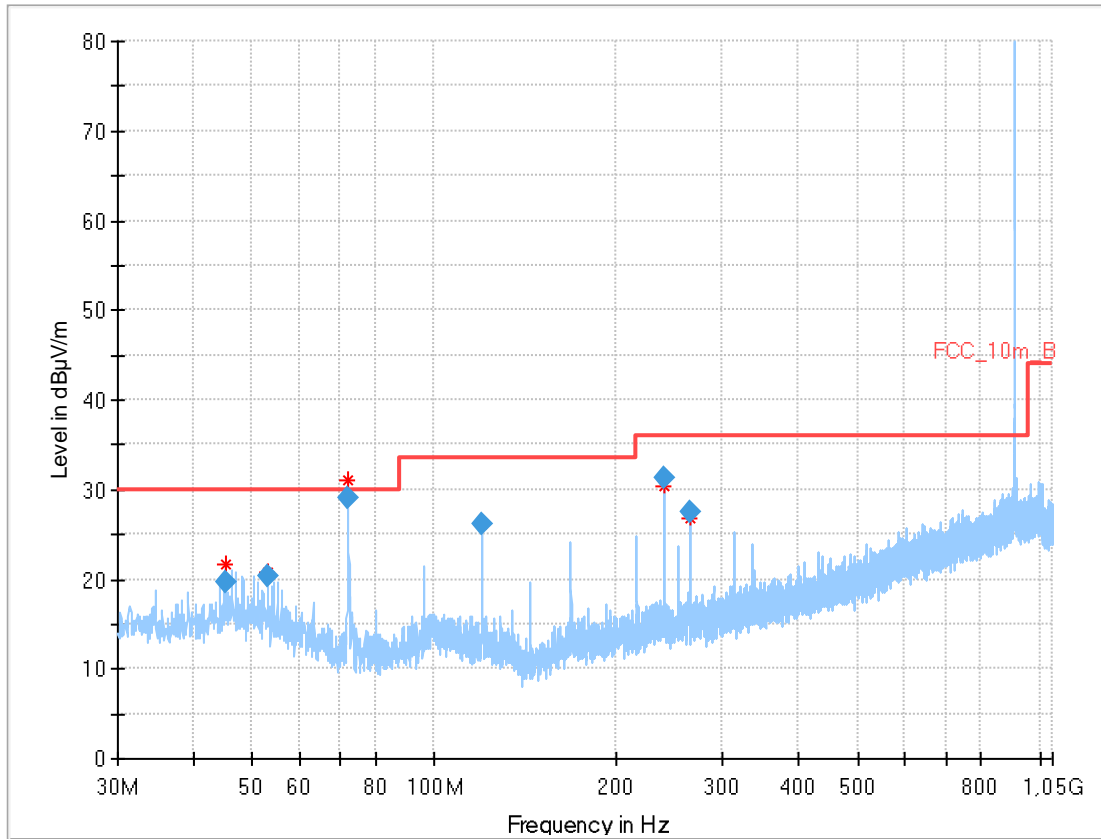
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



**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)
53.120	21.60	30.0	8.40	1000	120	101.0	V	2.0	14
55.108	21.71	30.0	8.29	1000	120	98.0	V	292.0	14
72.067	27.32	30.0	2.68	1000	120	170.0	V	102.0	11
168.156	23.68	33.5	9.82	1000	120	98.0	V	202.0	11
240.219	29.71	36.0	6.29	1000	120	98.0	V	101.0	13
264.256	28.59	36.0	7.41	1000	120	170.0	V	91.0	14

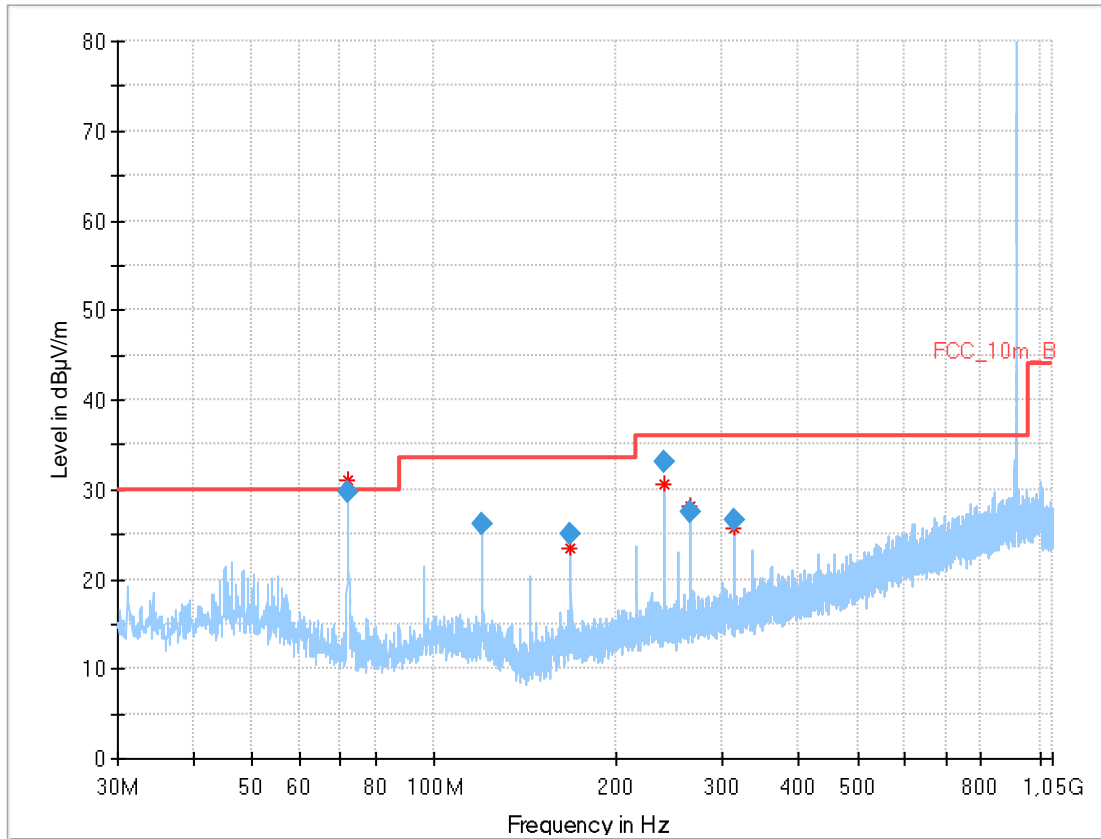
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



## 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)
45.112	19.60	30.0	10.40	1000	120	98.0	V	292.0	15
53.104	20.30	30.0	9.70	1000	120	100.0	V	248.0	14
72.072	29.04	30.0	0.96	1000	120	170.0	V	12.0	11
120.120	26.13	33.5	7.37	1000	120	145.0	V	-17.0	11
240.218	31.20	36.0	4.80	1000	120	98.0	V	158.0	13
264.255	27.57	36.0	8.43	1000	120	101.0	V	90.0	14

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



## 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)
72.068	29.79	30.0	0.21	1000	120	170.0	V	-9.0	11
120.120	26.19	33.5	7.31	1000	120	170.0	V	-22.0	11
168.148	25.13	33.5	8.37	1000	120	98.0	V	292.0	11
240.222	33.04	36.0	2.96	1000	120	98.0	V	180.0	13
264.243	27.54	36.0	8.46	1000	120	147.0	V	90.0	14
312.295	26.58	36.0	9.42	1000	120	98.0	V	247.0	15

## 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 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 6.2 C (1 GHz – 12.75 GHz)
Measurement uncertainty	See sub clause 8

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	
Above 960	54.0	3	



**Result:**

For radiated spurious emission the limits of 15.209 applies for all frequencies mentioned in 15.205. According to FCC Public Notice DA 00-705 (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:

$$F = 20 \cdot \log(\text{dwell time}/100 \text{ ms})$$

One pulse train is higher than 100 ms so the correction factor is 0 (see plots in chapter 11.4)

**a) EUT with dipole antenna**

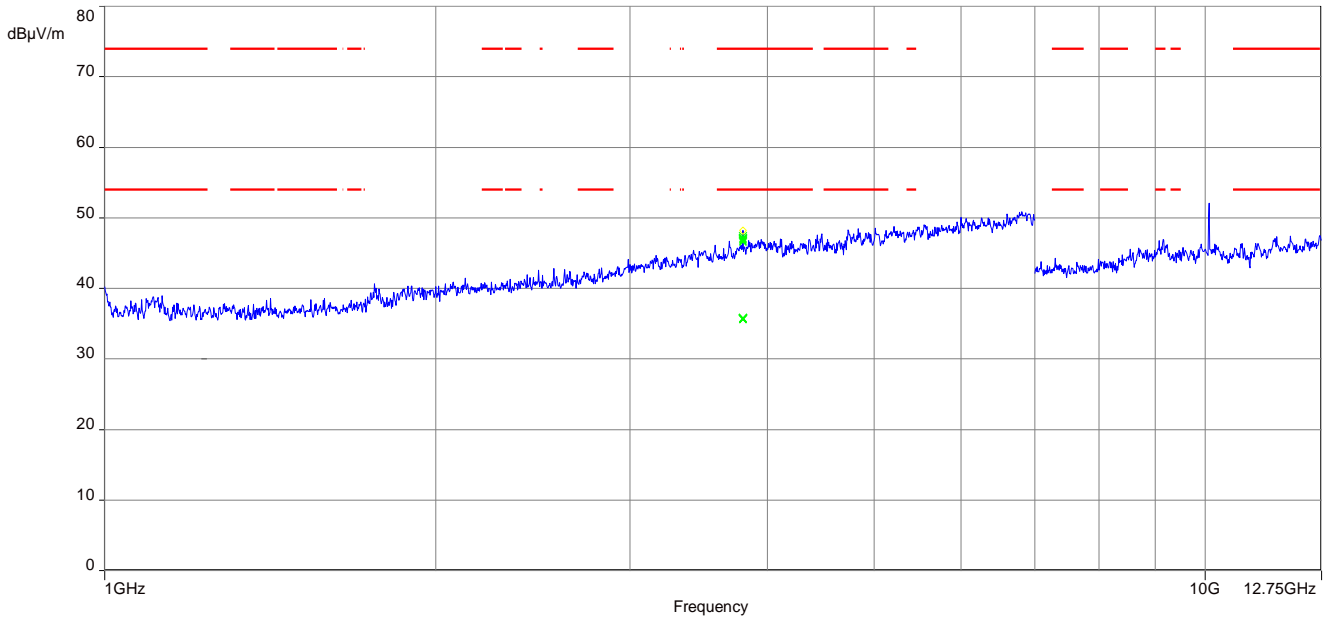
TX spurious emissions radiated								
Lowest channel			Middle channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
3798.40	Peak	47.38	No Spurious Emissions in restricted bands detected.			No Spurious Emissions in restricted bands detected.		
	AVG	35.70						

**b) EUT with PCB antenna**

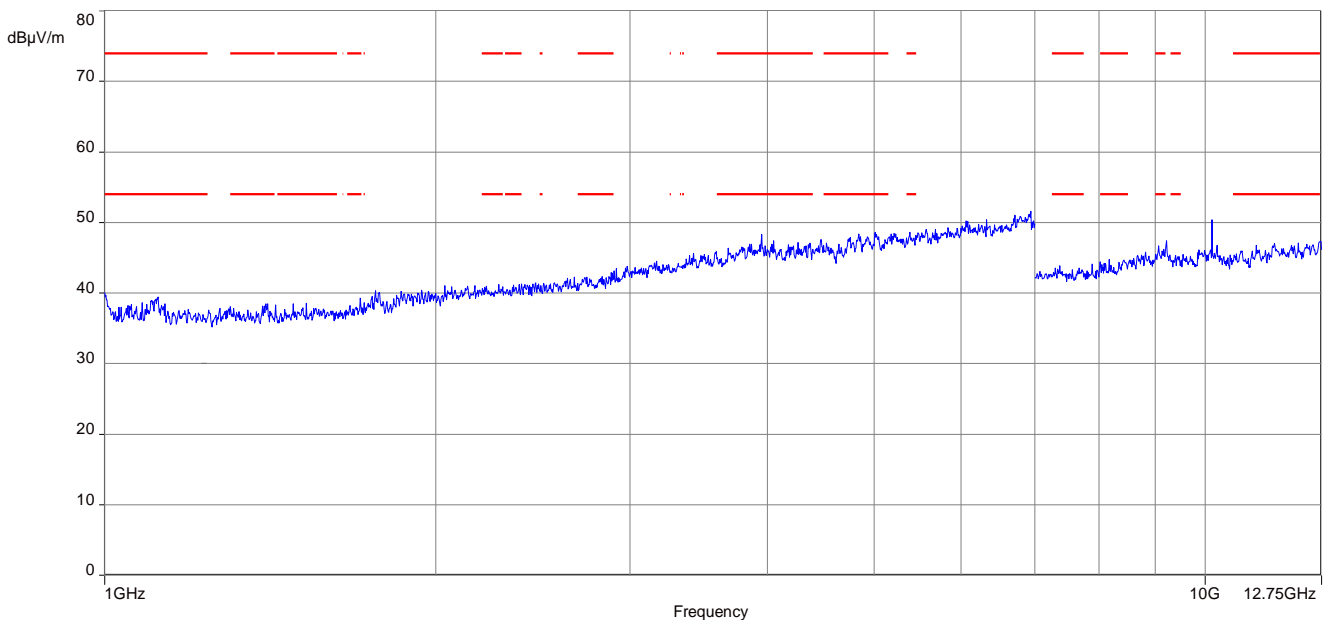
TX spurious emissions radiated								
Lowest channel			Middle channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
9158.55	Peak	53.81	No Spurious Emissions in restricted bands detected.			No Spurious Emissions in restricted bands detected.		
	AVG	50.63						

**Plots EUT with dipole antenna:**

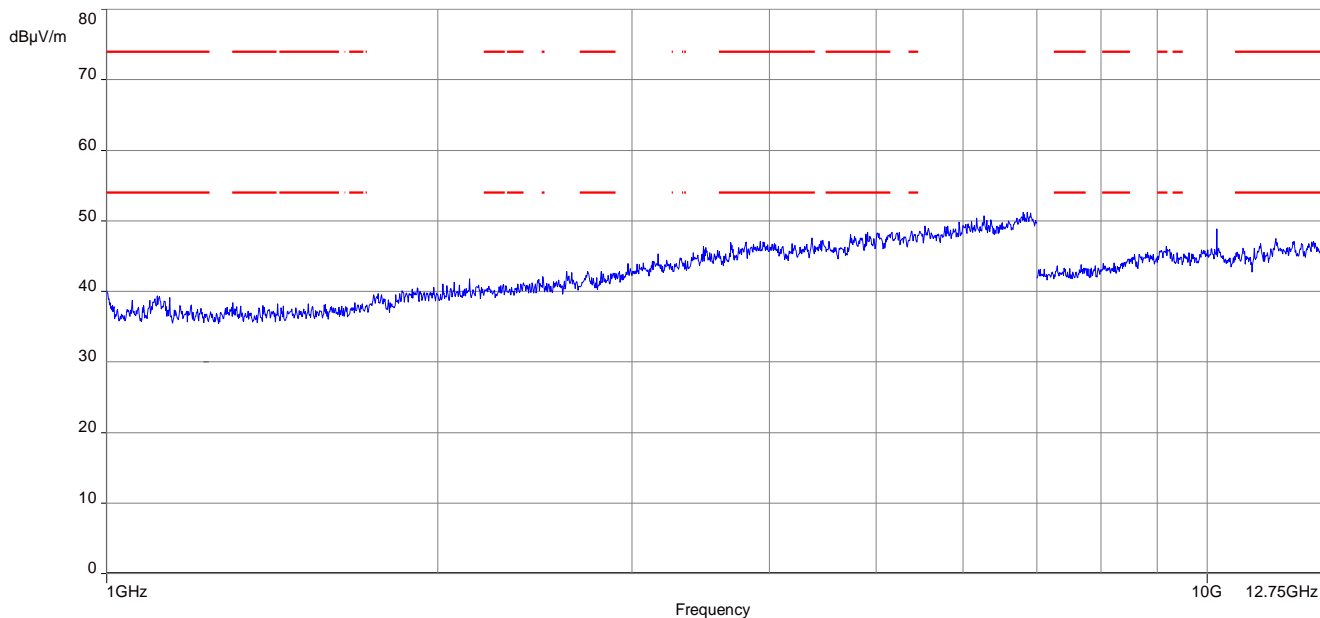
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



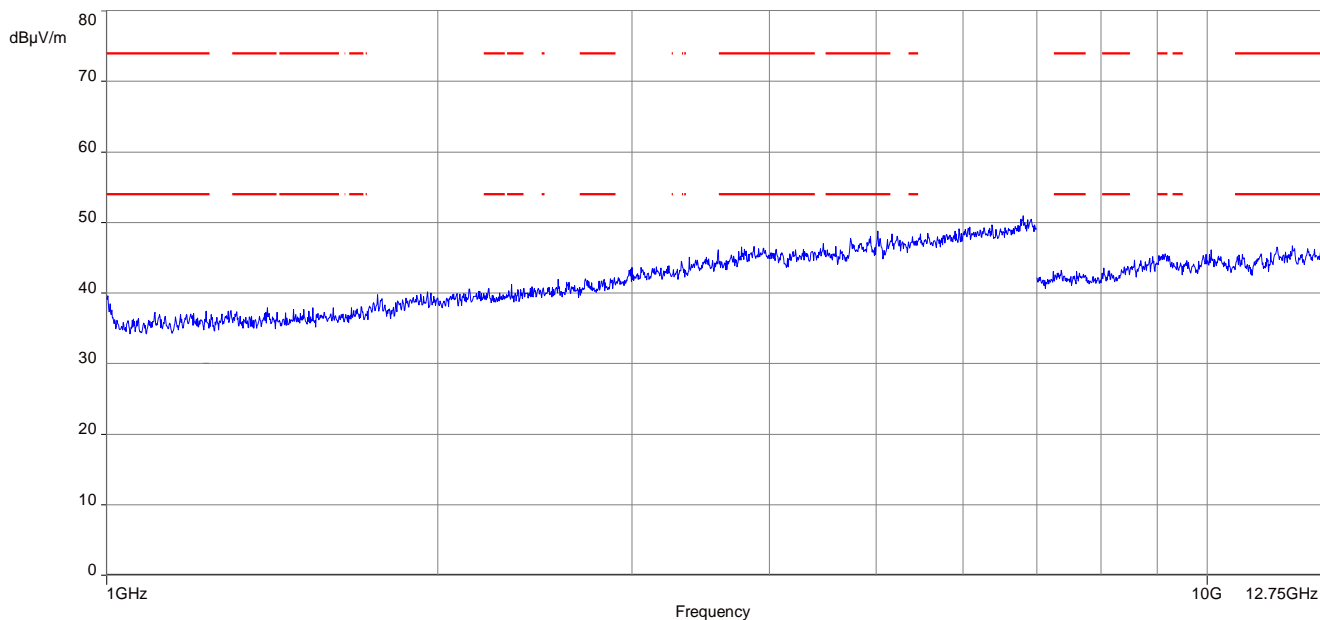
Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)

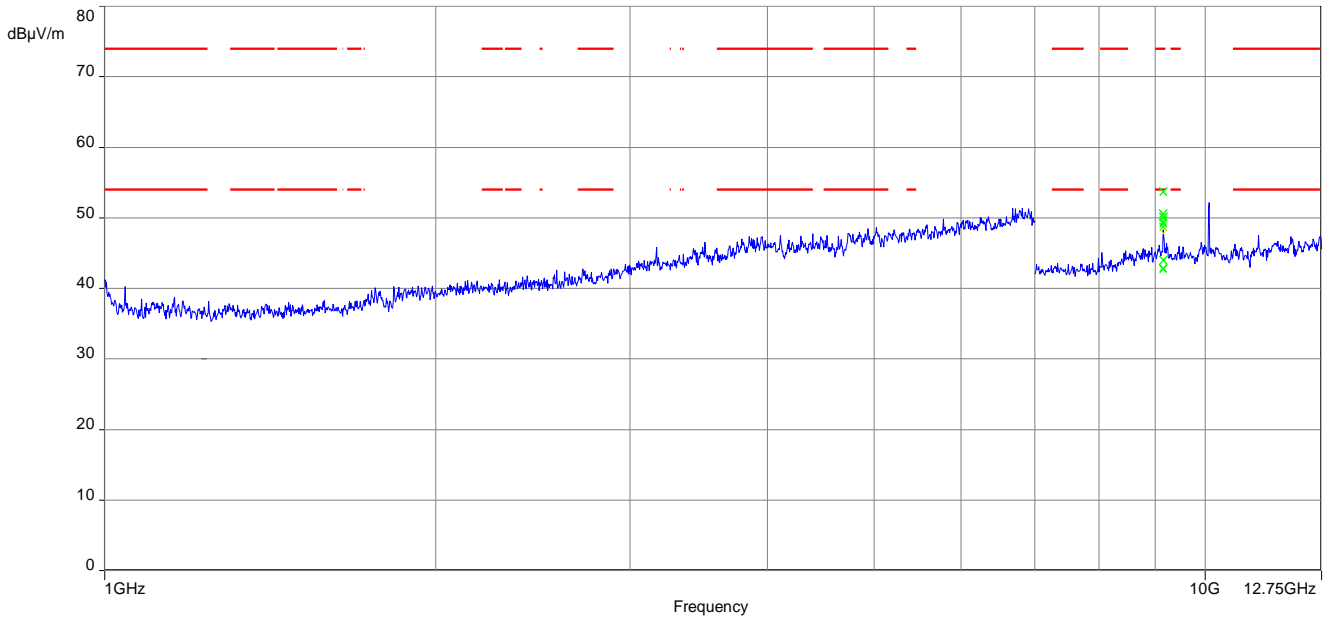


Plot 4: 1 GHz – 12.75 GHz, RX-Mode, horizontal & vertical polarisation, valid for both antenna types

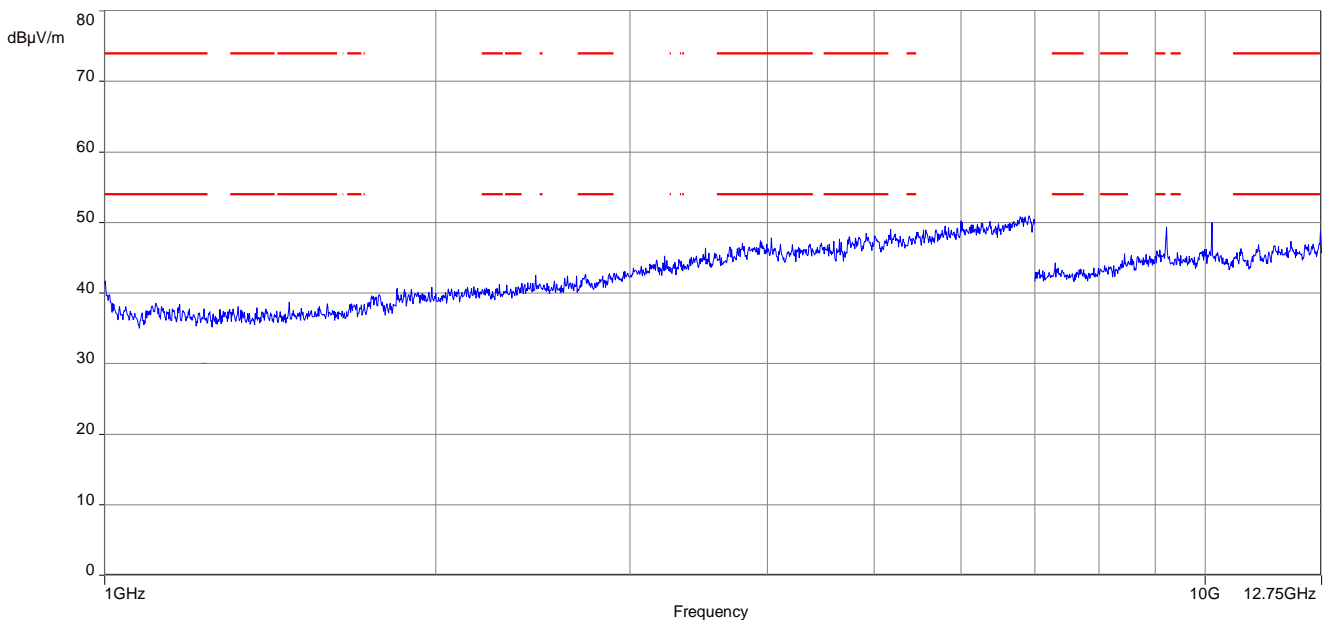


**Plots EUT with PCB antenna:**

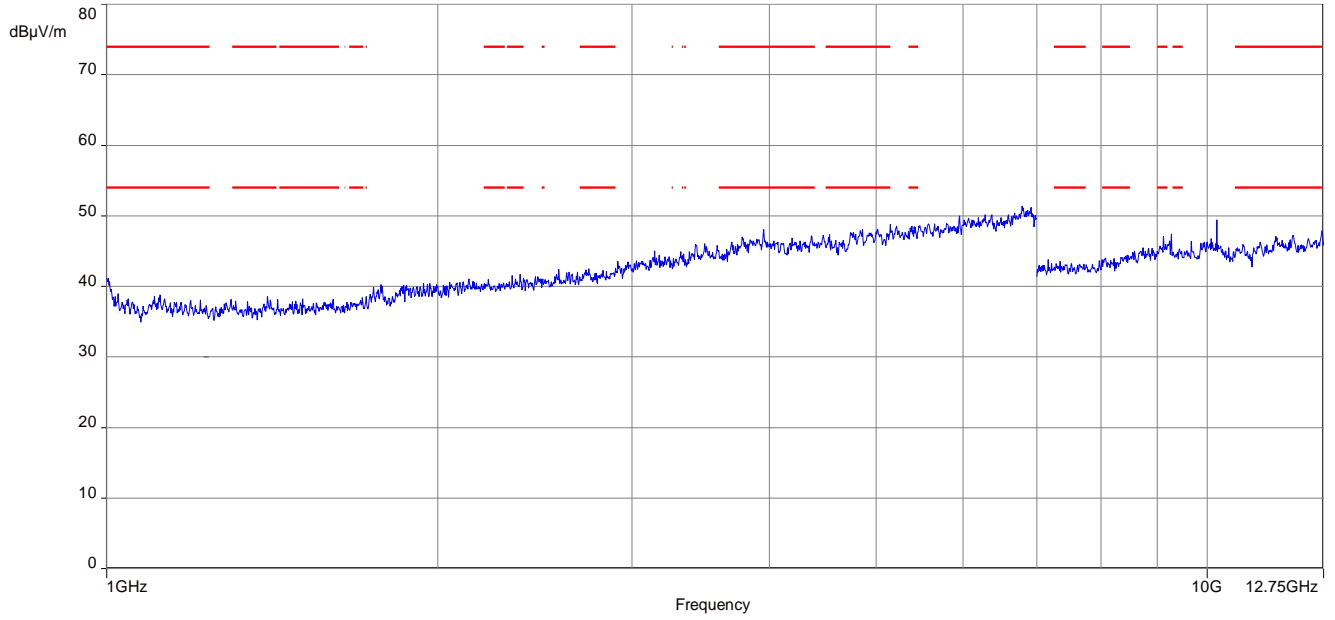
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



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



Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (Highest channel)



### 13 Measurement results Part 3 Hybrid Mode (923.2-923.4 MHz)

#### 13.1 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 6.2 B (radiated) See sub clause 6.3 A (conducted)
Measurement uncertainty	See sub clause 8

**Limits:**

FCC
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		15.28 dBm	15.16 dBm
dipole antenna	Radiated power	19.58 dBm	19.71 dBm
	Gain Calculated	<b>4.30 dBi</b>	<b>4.55 dBi</b>
PCB antenna	Radiated power	18.45 dBm	20.24 dBm
	Gain Calculated	<b>3.17 dBi</b>	<b>5.08 dBi</b>

## 13.2 Carrier Frequency Separation

### Description:

Measurement of the carrier frequency separation of a hopping system. The carrier frequency separation is constant for all modulation-modes. We use LoRa-modulation to show compliance. 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 6.3 A
Measurement uncertainty	See sub clause 8

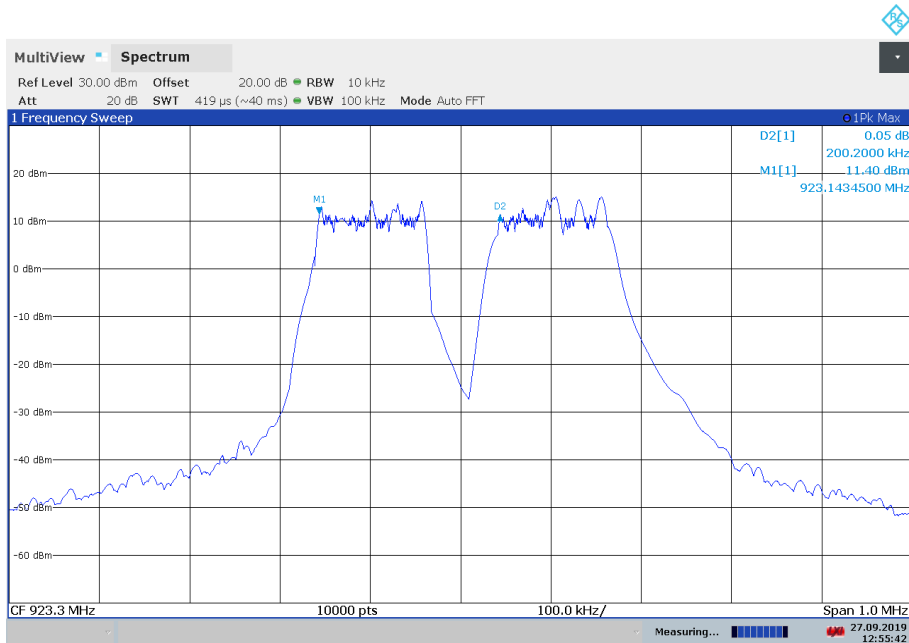
### Limits:

FCC
Carrier frequency separation
Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater.

**Result:** The channel separation is 200.2 kHz

**Plots:**

Plot 1: Frequency separation



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### 13.3 Average Time of Occupancy (dwell time)

**Measurement:**

The measurement is performed in zero span mode to show that none of the 2 used channels is allocated more than 0.4 seconds within a 0.8 seconds interval (2 channels times 0.4s).

**Limits:**

FCC
<b>Average time of occupancy</b>
For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4

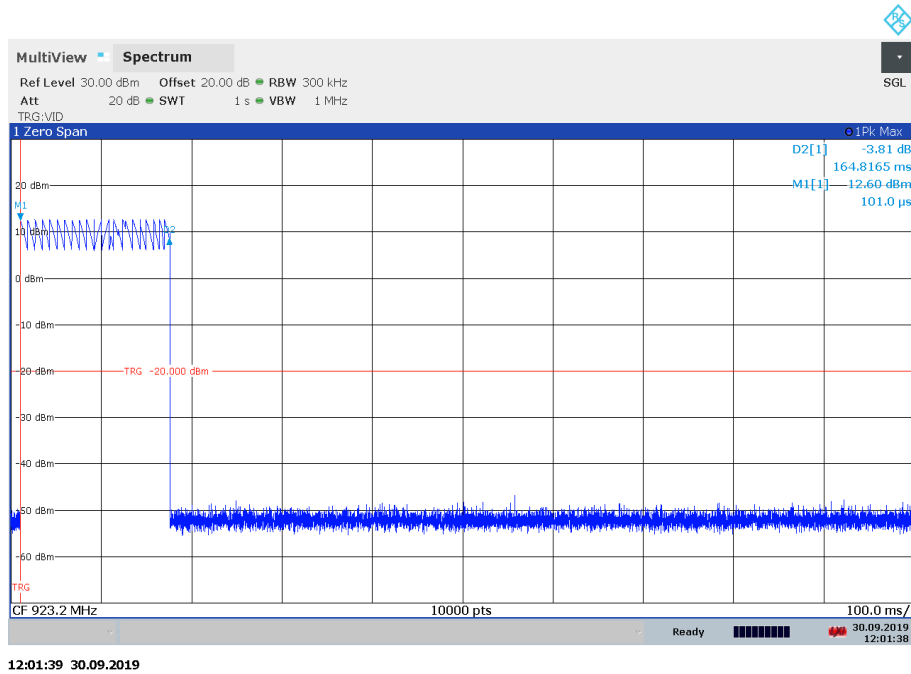
**Result:**      The time slot length is = 164.81 ms  
                          Number of hops / channel @ 0.8s = 1

Within 0.8 s period, the average time of occupancy in 0.8 s: 1\* 164.81 ms

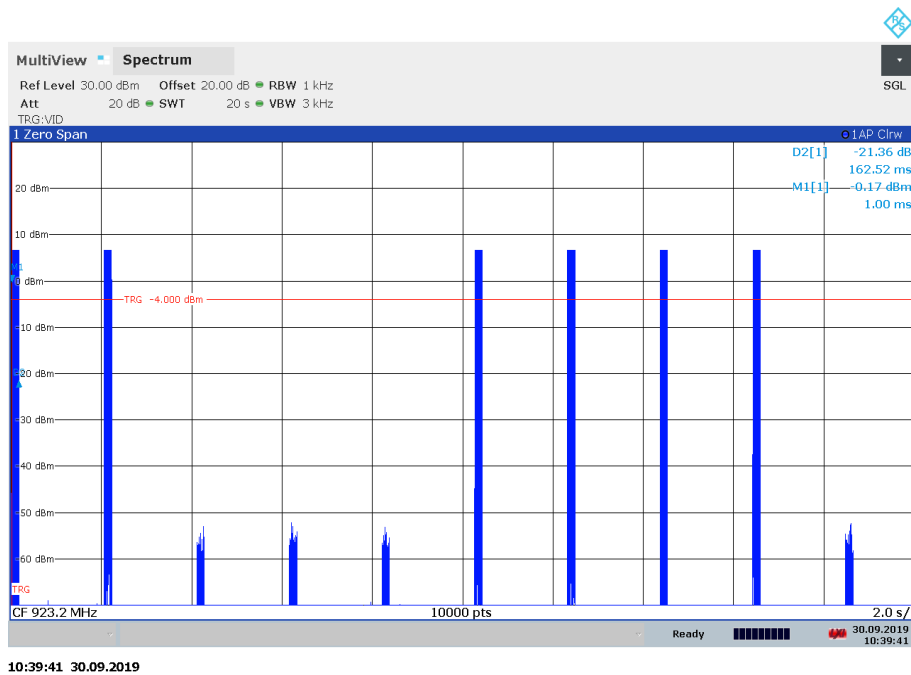
→ The average time of occupancy = 164.81 ms

**Plots:**

Plot 1: Time slot length = 164.81ms



Plot 2: hops / channel @ 20s = 5



### 13.4 Spectrum bandwidth

**Description:**

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal. The measurement is performed according to the "Measurement Guidelines" (DA 00-705, March 30, 2000). EUT in single channel mode.

**Measurement:**

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	100 kHz
Resolution bandwidth:	20 kHz
Span:	2 MHz
Trace-Mode:	Max Hold
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

**Limits:**

FCC	IC
None	

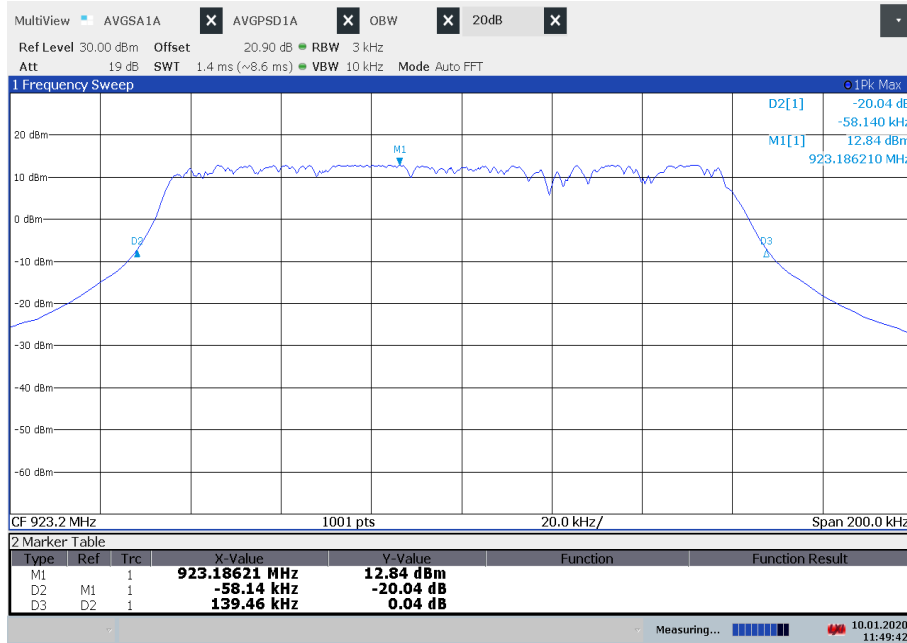
**Results:**

Test Conditions		20-dB BANDWIDTH [kHz]	
		Lowest channel	Highest channel
$T_{nom}$	$V_{nom}$	139.5	139.0

Test Conditions		99% BANDWIDTH [kHz]	
		Lowest channel	Highest channel
$T_{nom}$	$V_{nom}$	127.8	126.9

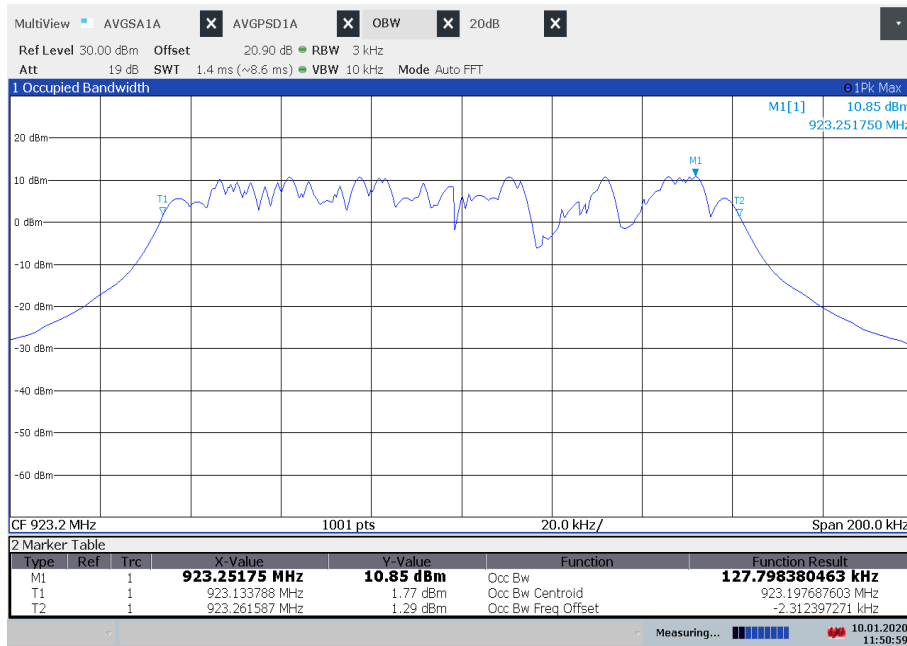
**Plots:**

Plot 1: Lowest Channel, 20 dB-BW



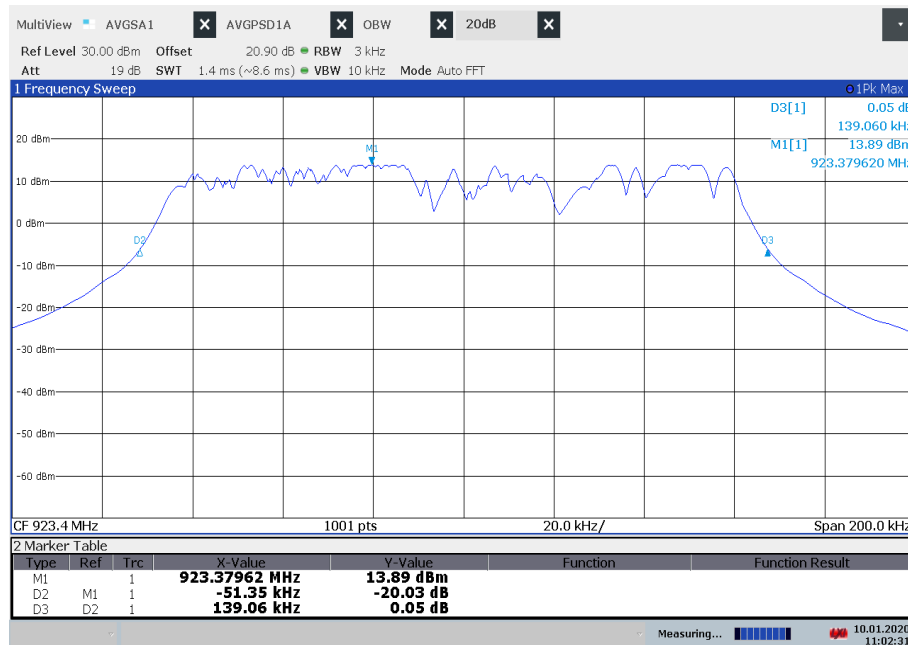
11:49:43 10.01.2020

Plot 2: Lowest Channel, 99%OBW



11:51:00 10.01.2020

Plot 5: Highest Channel, 20 dB-BW



11:02:32 10.01.2020

Plot 6: Highest Channel, 99%OBW



11:05:17 10.01.2020

### 13.5 Maximum Output Power

**Measurement:**

Measurement parameter*	
Detector:	RMS
Sweep time:	See plots
Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Span:	258 kHz
Trace-Mode:	Single sweep
Measurement method	According to ANSI C63.10-2013 11.9.2.2.3 Method AVGSA-1A (alternative)
Used equipment:	See chapter 6.3 A
Measurement uncertainty:	See chapter 8

**Limits:**

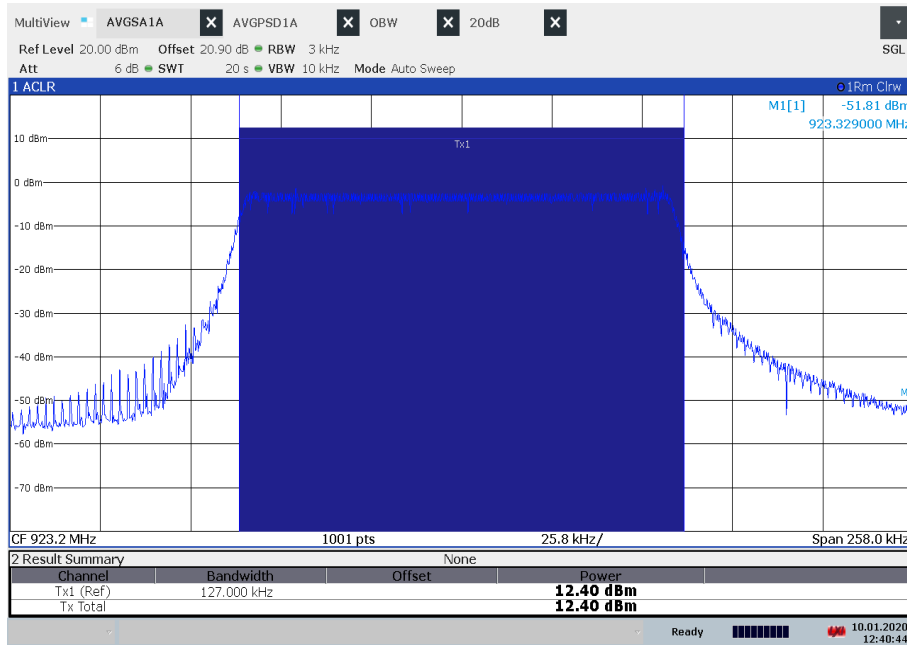
FCC	IC
Maximum Output Power Conducted	
For frequency hopping systems operating in the 902–928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and, 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under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

**Result:**

Test Conditions		Maximum Output Power Conducted [dBm]	
		Lowest channel	Highest channel
$T_{nom}$	$V_{nom}$	12.4	13.9

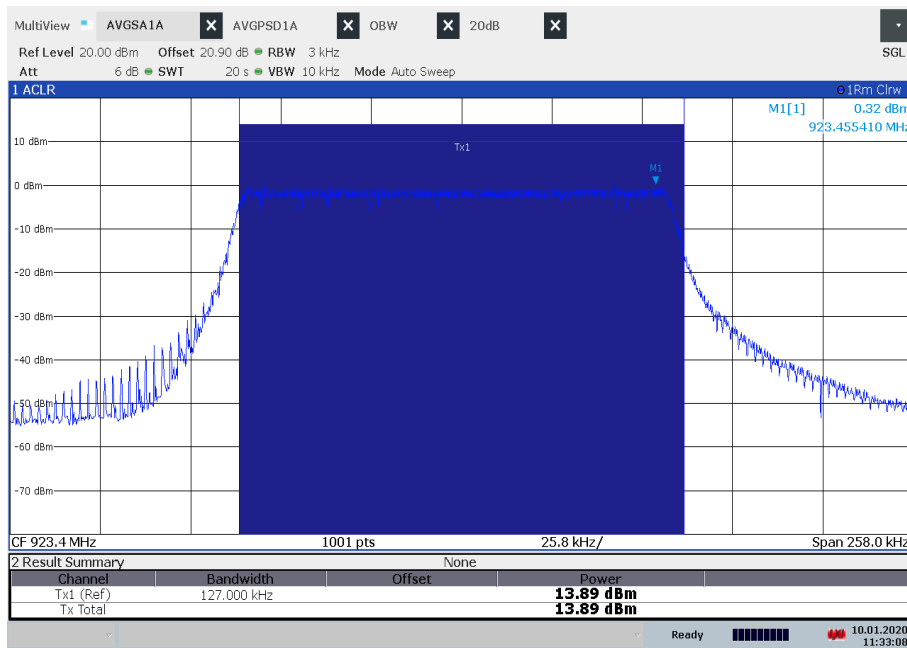
**Plots:**

Plot 1: Lowest Channel



12:40:44 10.01.2020

Plot 2: Highest Channel



11:33:09 10.01.2020

### 13.6 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:	RMS
Sweep time:	20 s
Video bandwidth:	10 kHz
Resolution bandwidth:	3 kHz
Span:	200 kHz
Trace-Mode:	Single sweep
Measurement method	According to ANSI C63.10-2013 11.10.4 Method AVGPSD-1A (alternative)
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

**Limits:**

FCC	IC
Power Spectral Density	
A hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off.	

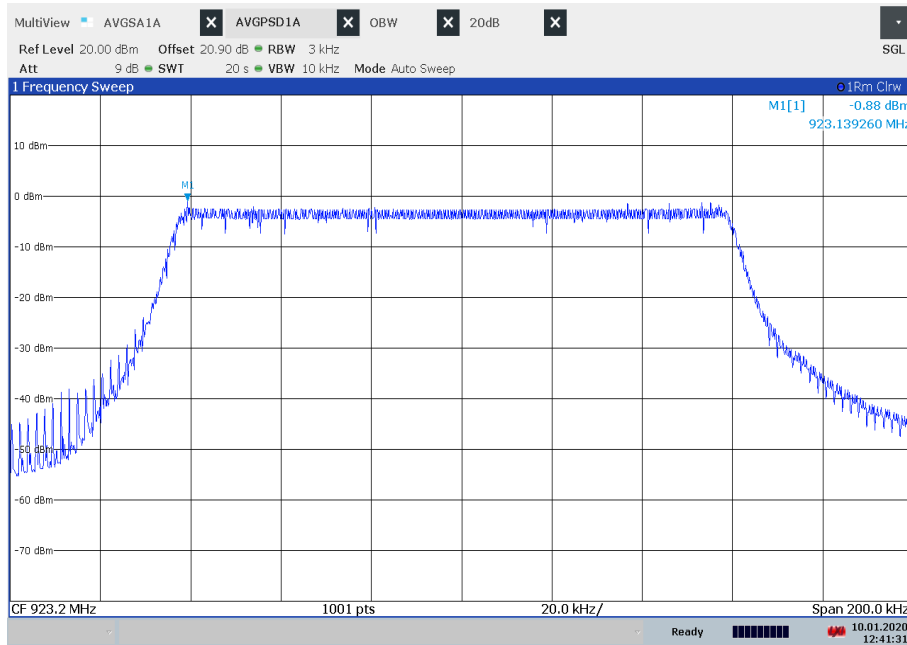
**Results:**

Channel	Power Spectral density / 3 kHz	
	Lowest	Highest
	-0.88 dBm	1.41 dBm



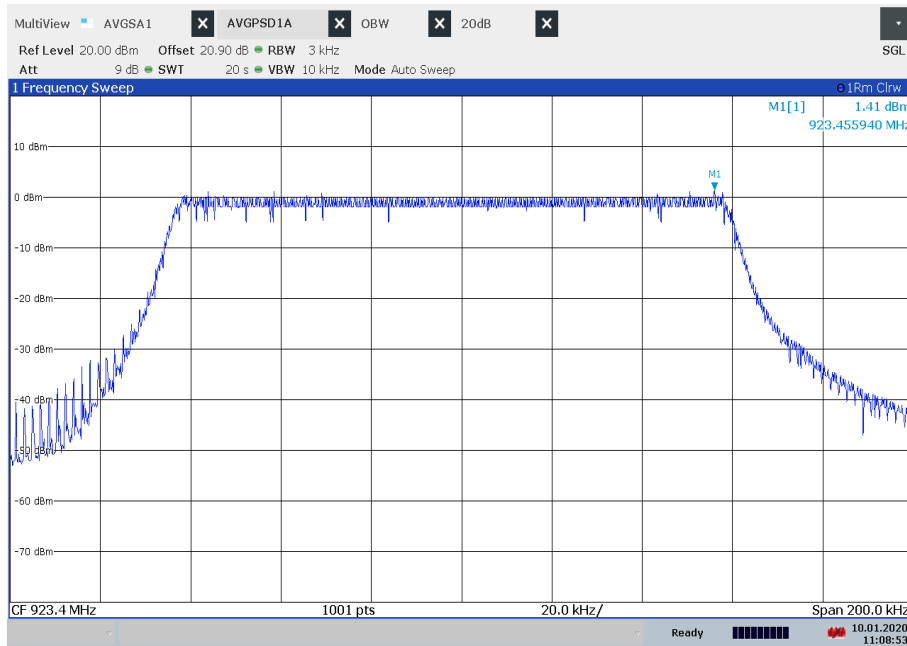
**Plots:**

Plot 1: Lowest Channel



12:41:32 10.01.2020

Plot 2: Highest Channel



11:08:54 10.01.2020

### 13.7 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 6.3 A
Measurement uncertainty	See sub clause 8

**Limits:**

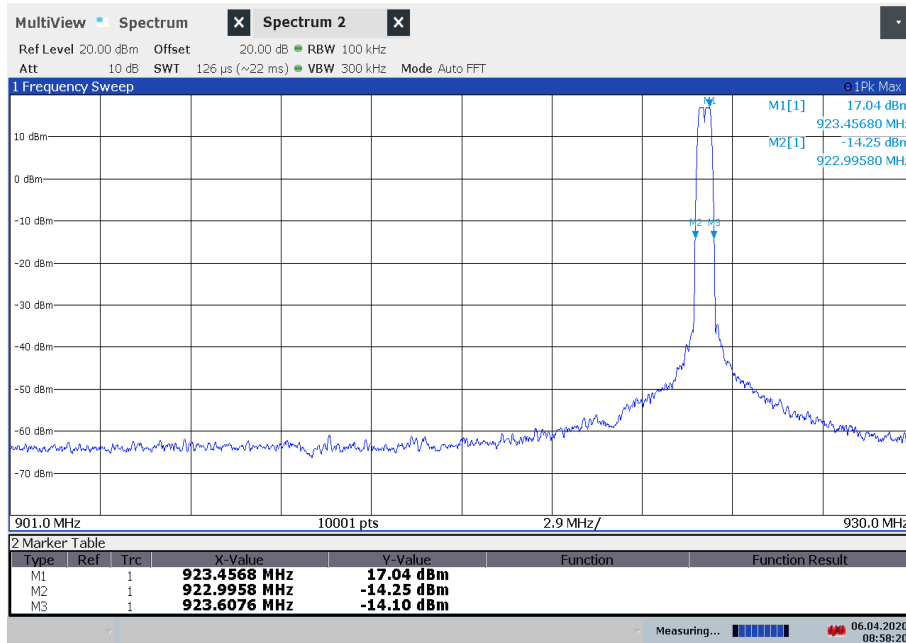
FCC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains 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.
RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

**Results conducted:**

Scenario Modulation	Spurious band edge conducted	
	lowest channel	highest channel
Lower band edge – hopping on	> 30 dB	> 30 dB
Upper band edge – hopping off	> 30 dB	> 30 dB

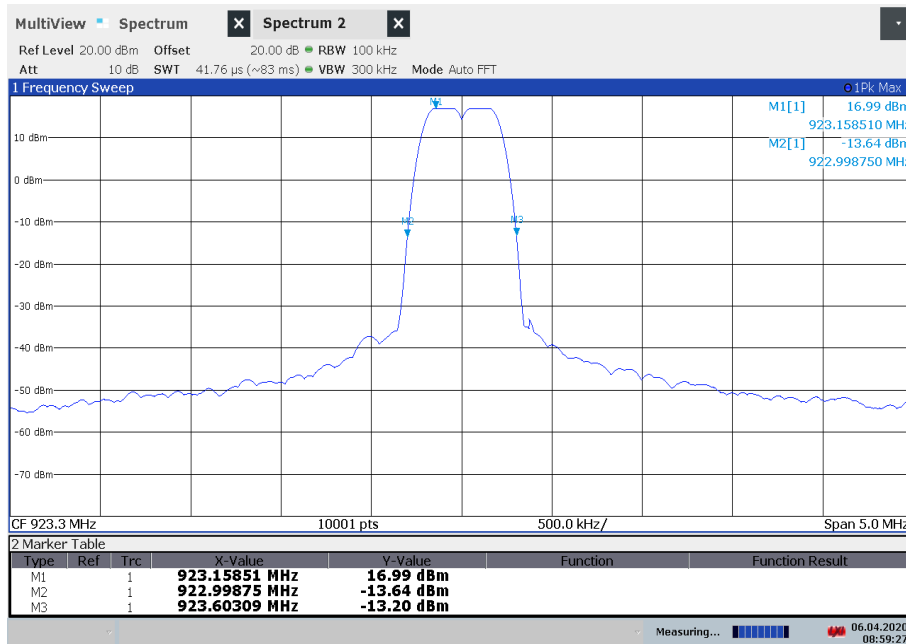
**Plots:**

**Plot 1: 30 dB – hopping on**



08:58:21 06.04.2020

**Plot 2: 30 dB – hopping off**



08:59:28 06.04.2020

**Results radiated:**

No restricted band in the range  $\pm 2$  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
<sup>1</sup> 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	( <sup>2</sup> )
13.36 - 13.41			

### 13.8 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
Video bandwidth:	300 kHz
Resolution bandwidth:	100 kHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3A
Measurement uncertainty:	See chapter 8

**Limits:**

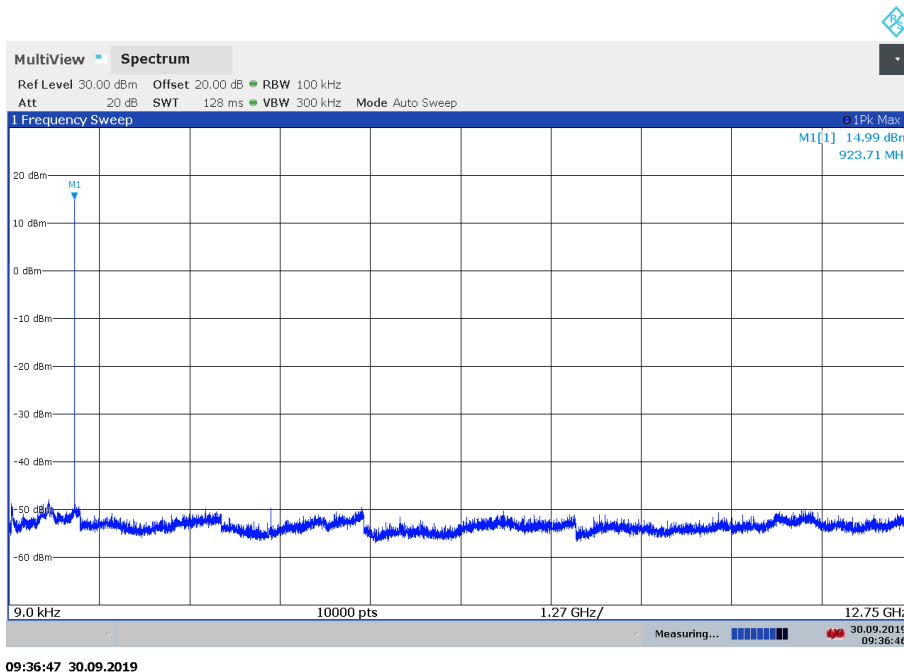
FCC
TX spurious emissions conducted
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth 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.
RSS-247, Issue 2: 5.5 Unwanted emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

**Result:**

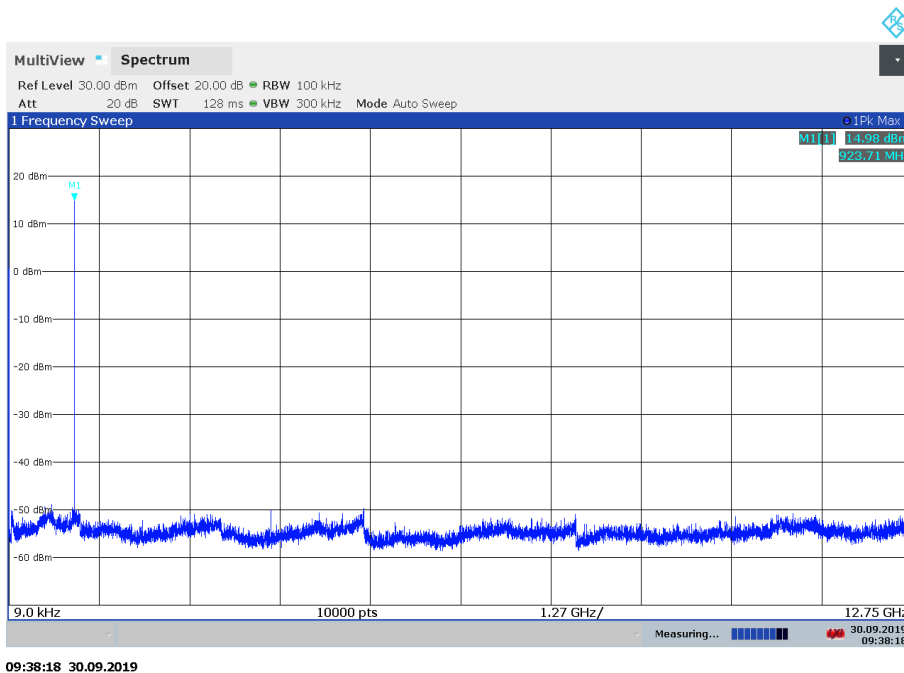
Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
923.2		14.99	24 dBm		Operating frequency
	See plots		-30 dBc	No emissions detected!	
923.4		14.98	24 dBm		Operating frequency
	See plots		-30 dBc	No emissions detected!	

**Plots:**

Plot 1: Lowest channel, 9 kHz – 12.75 GHz



Plot 3: Highest channel, 9 kHz – 12.75 GHz



### 13.9 Spurious Emissions Radiated < 30 MHz

**Description:**

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: 200 Hz F > 150 kHz: 9 kHz
Resolution 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 6.2 A
Measurement uncertainty:	See chapter 8

**Limits:**

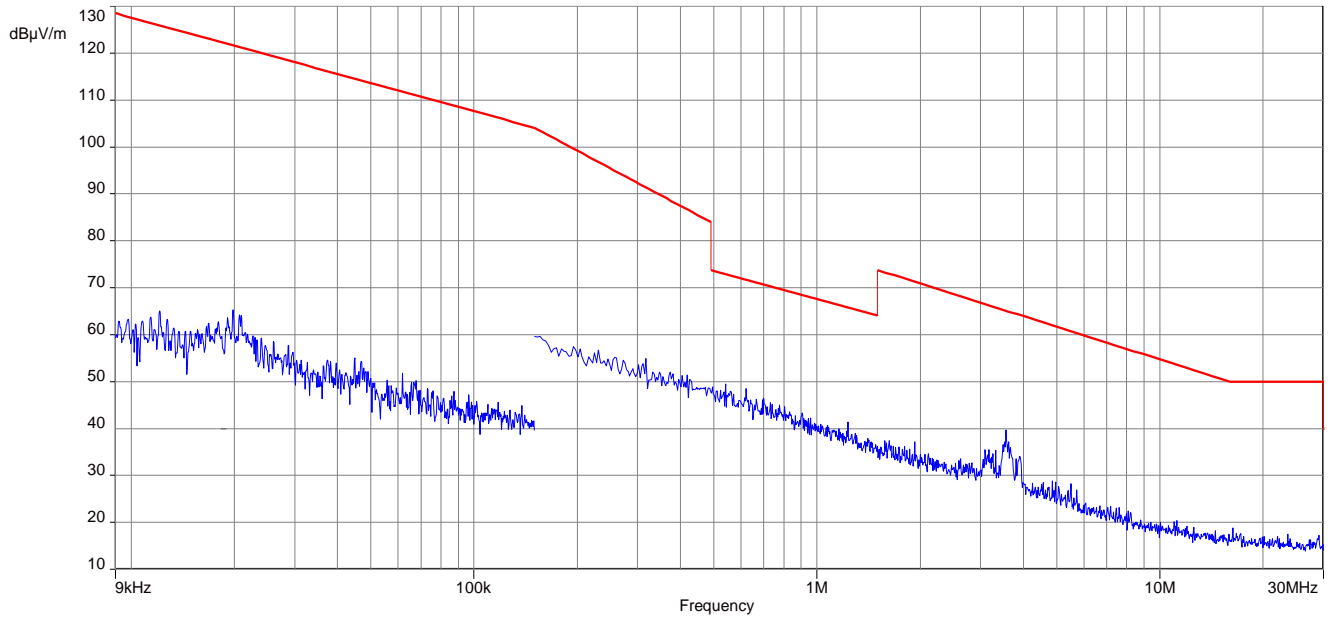
FCC		
TX spurious emissions radiated < 30 MHz		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

**Result:**

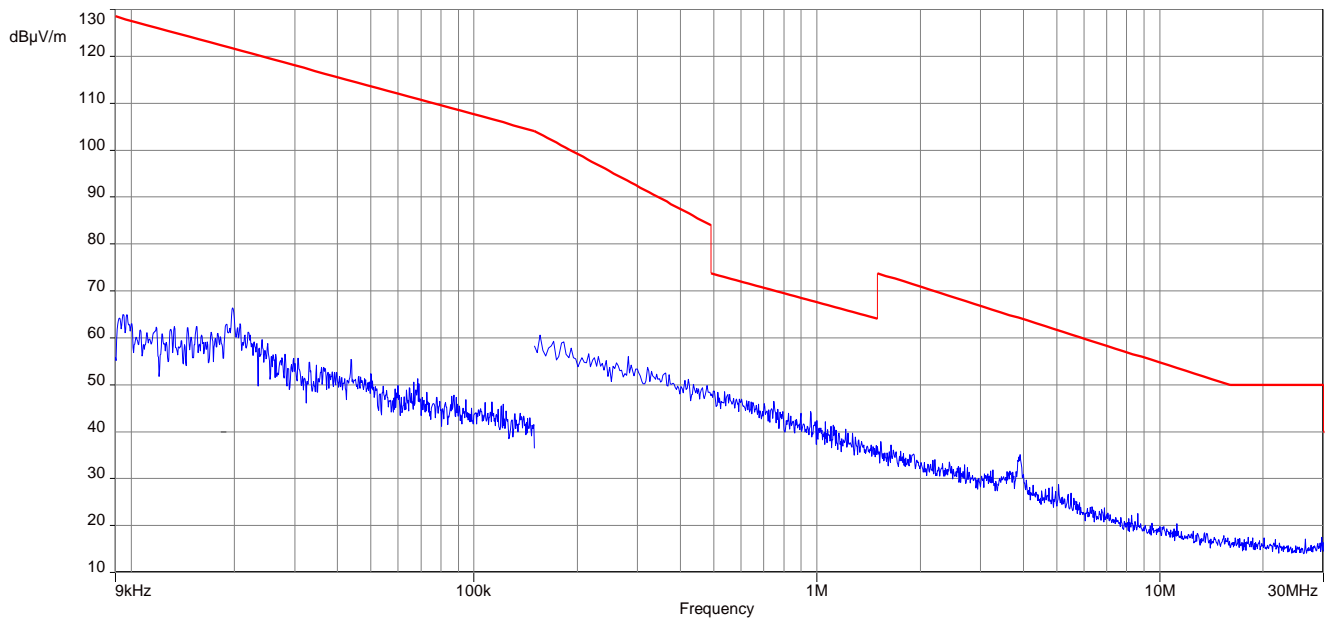
SPURIOUS EMISSIONS LEVEL								
Lowest channel			Middle channel			Highest channel		
Frequency [MHz]	Detector	Level [dBµV/m]	Frequency [MHz]	Detector	Level [dBµV/m]	Frequency [MHz]	Detector	Level [dBµV/m]
All emissions were more than 10 dB below the limit.								

**Plots EUT with dipole antenna:**

Plot 1: TX-Mode lowest channel



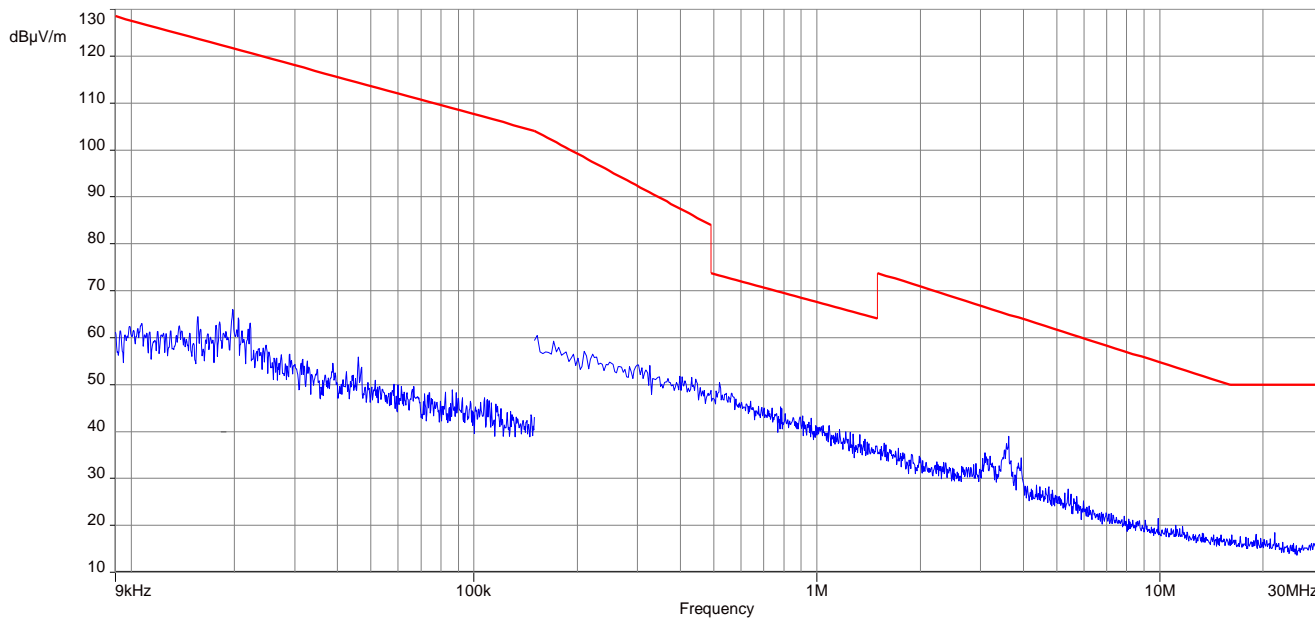
Plot 2: TX-Mode highest channel



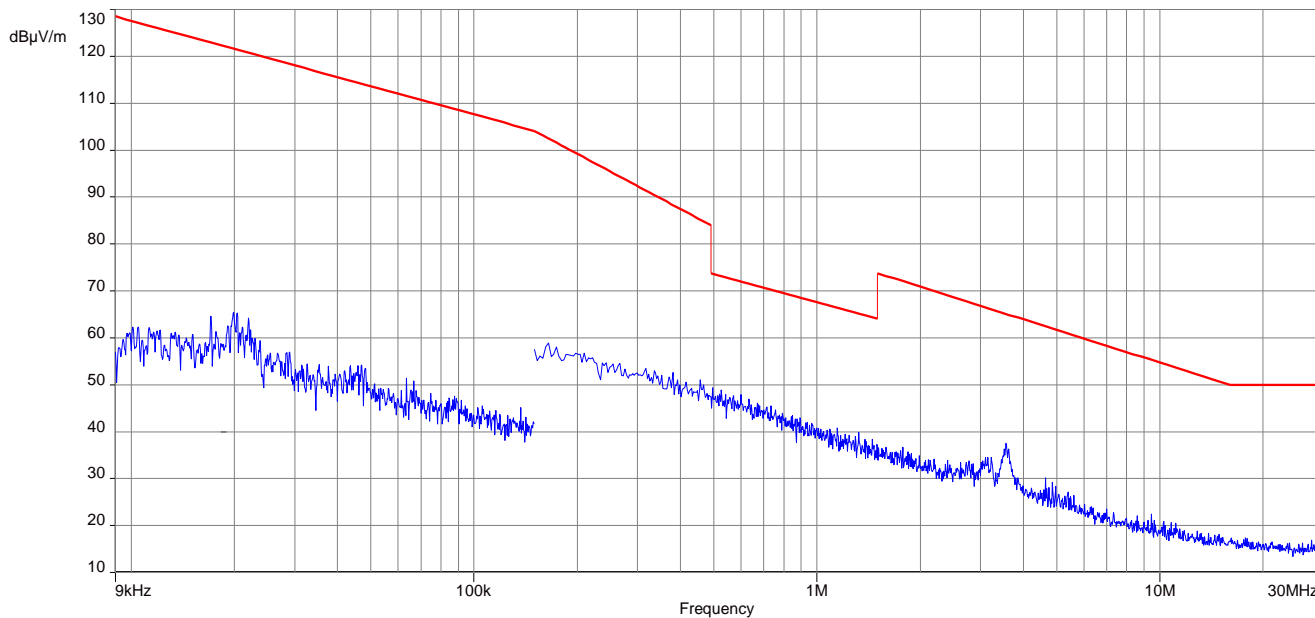


**Plots EUT with PCB antenna:**

Plot 1: TX-Mode lowest channel



Plot 2: TX-Mode highest channel



### 13.10 Spurious Emissions Radiated > 30 MHz

#### 13.10.1 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 RBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Test setup	See sub clause 6.1 A
Measurement uncertainty	See sub clause 8

**Limits:**

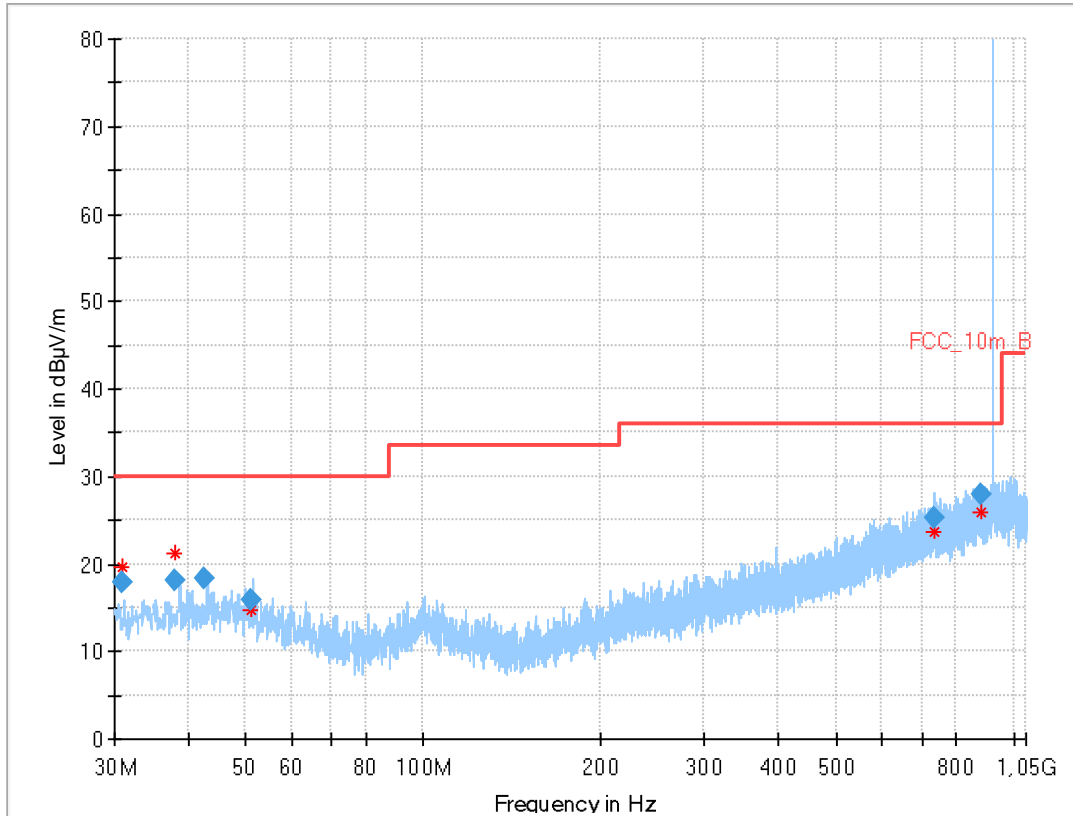
FCC	IC	
Band-edge Compliance of conducted and radiated emissions		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB 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
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.

**Plots EUT with dipole antenna:**

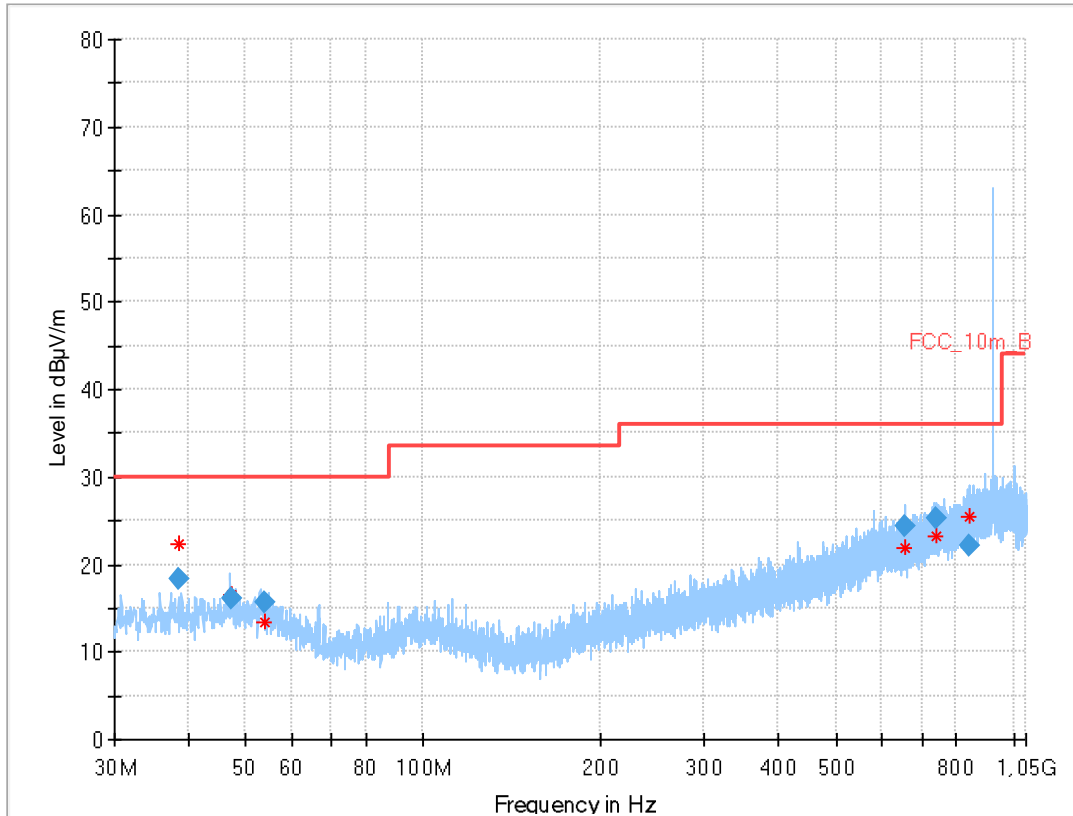
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.998	17.78	30.0	12.22	1000	120	152.0	H	112.0	13
38.102	18.16	30.0	11.84	1000	120	170.0	H	-22.0	14
42.470	18.39	30.0	11.61	1000	120	108.0	H	280.0	15
50.994	15.96	30.0	14.04	1000	120	170.0	H	67.0	15
735.953	25.14	36.0	10.86	1000	120	170.0	H	247.0	22
879.366	27.94	36.0	8.06	1000	120	170.0	V	157.0	24

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

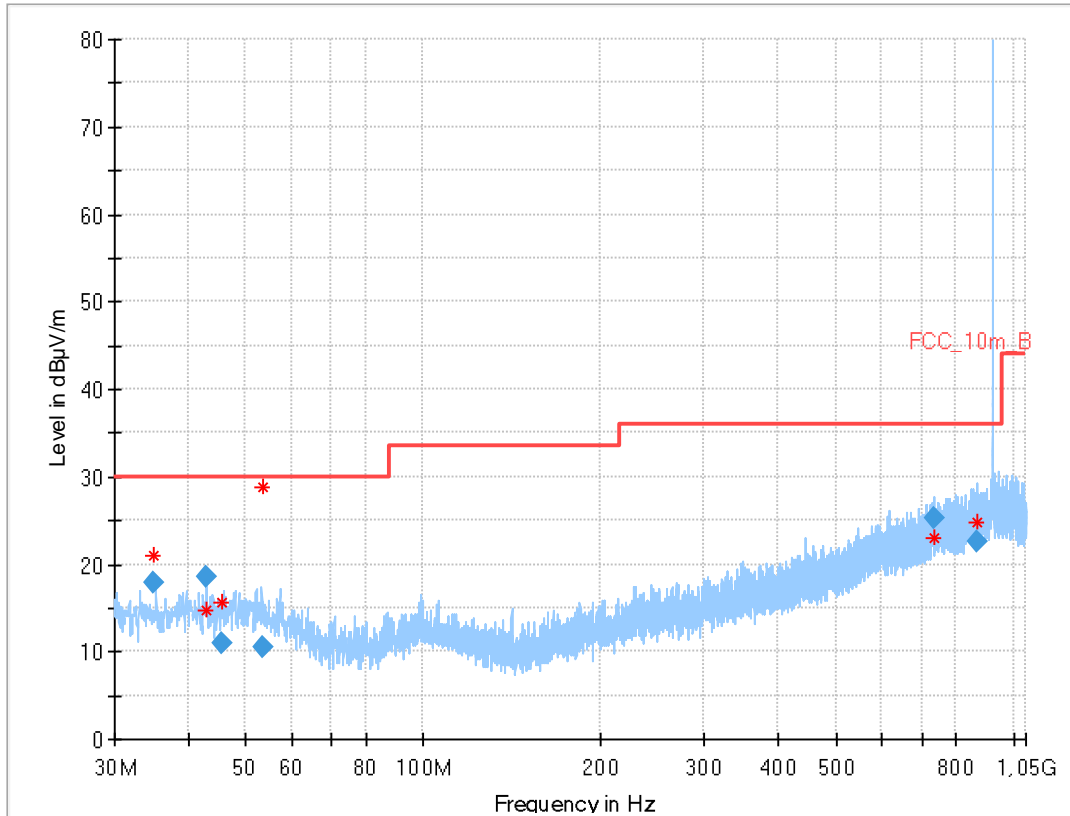


## Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
38.649	18.24	30.0	11.76	1000	120	126.0	H	165.0	14
47.413	16.04	30.0	13.96	1000	120	170.0	H	169.0	15
53.951	15.55	30.0	14.45	1000	120	170.0	V	247.0	14
656.672	24.40	36.0	11.60	1000	120	163.0	H	157.0	21
741.588	25.31	36.0	10.69	1000	120	170.0	V	-14.0	22
844.868	22.23	36.0	13.77	1000	120	151.0	V	157.0	23

**Plots EUT with PCB antenna:**

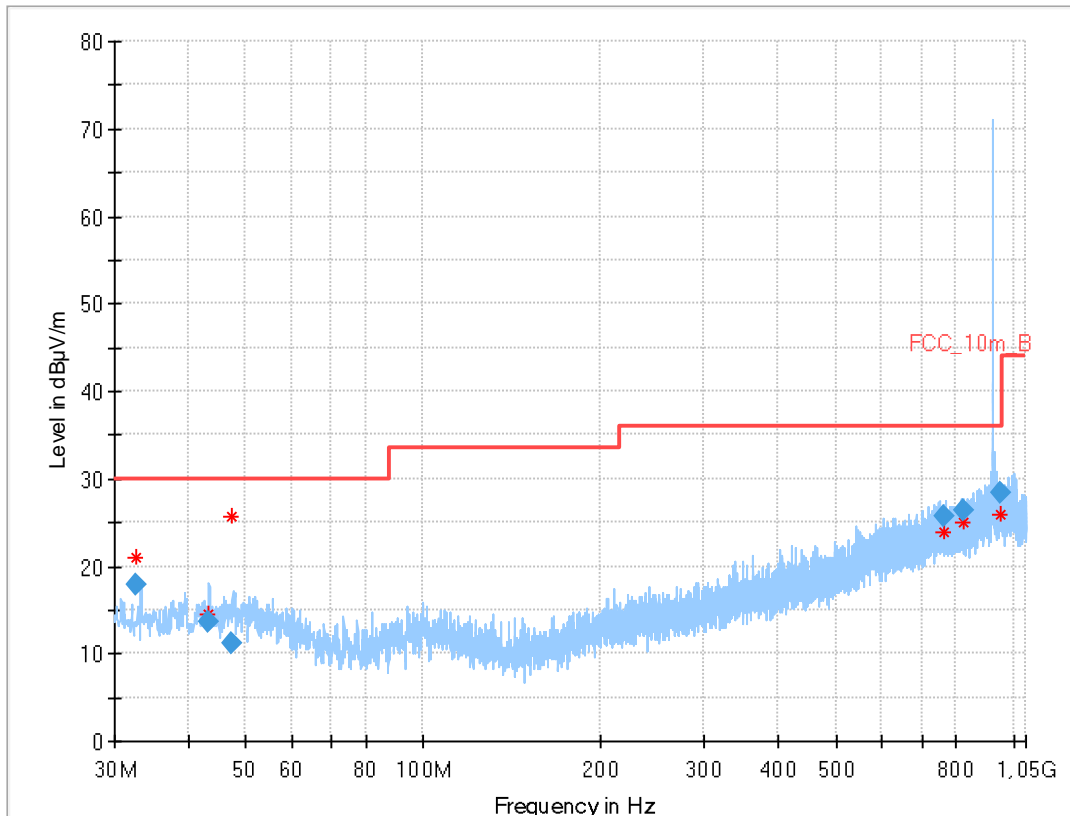
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
34.802	17.95	30.0	12.05	1000	120	170.0	H	112.0	14
42.828	18.44	30.0	11.56	1000	120	170.0	H	247.0	15
45.641	10.94	30.0	19.06	1000	120	150.0	H	67.0	15
53.609	10.45	30.0	19.55	1000	120	154.0	H	67.0	14
732.215	25.21	36.0	10.79	1000	120	170.0	V	247.0	22
865.241	22.61	36.0	13.39	1000	120	170.0	V	96.0	23

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



## Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth h (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
32.726	17.85	30.0	12.15	1000	120	163.0	H	292.0	13
43.090	13.62	30.0	16.38	1000	120	170.0	H	-22.0	15
47.285	11.13	30.0	18.87	1000	120	170.0	H	247.0	15
760.982	25.74	36.0	10.26	1000	120	170.0	H	157.0	22
820.796	26.44	36.0	9.56	1000	120	170.0	H	247.0	23
950.208	28.46	36.0	7.54	1000	120	170.0	H	178.0	24

### 13.10.2 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 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 6.2 C (1 GHz – 12.75 GHz)
Measurement uncertainty	See sub clause 8

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		
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
Above 960	54.0	3

**Result:**

For radiated spurious emission the limits of 15.209 applies for all frequencies mentioned in 15.205. According to FCC Public Notice DA 00-705 (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:

$$F = 20 \cdot \log(\text{dwell time}/100 \text{ ms})$$

One pulse train is higher than 100 ms so the correction factor is 0 (see plots in chapter 11.4)

**a) EUT with dipole antenna**

TX spurious emissions radiated					
Lowest channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz] Detector	Level	[dBµV/m]
No Spurious Emissions in restricted bands detected.			No Spurious Emissions in restricted bands detected.		

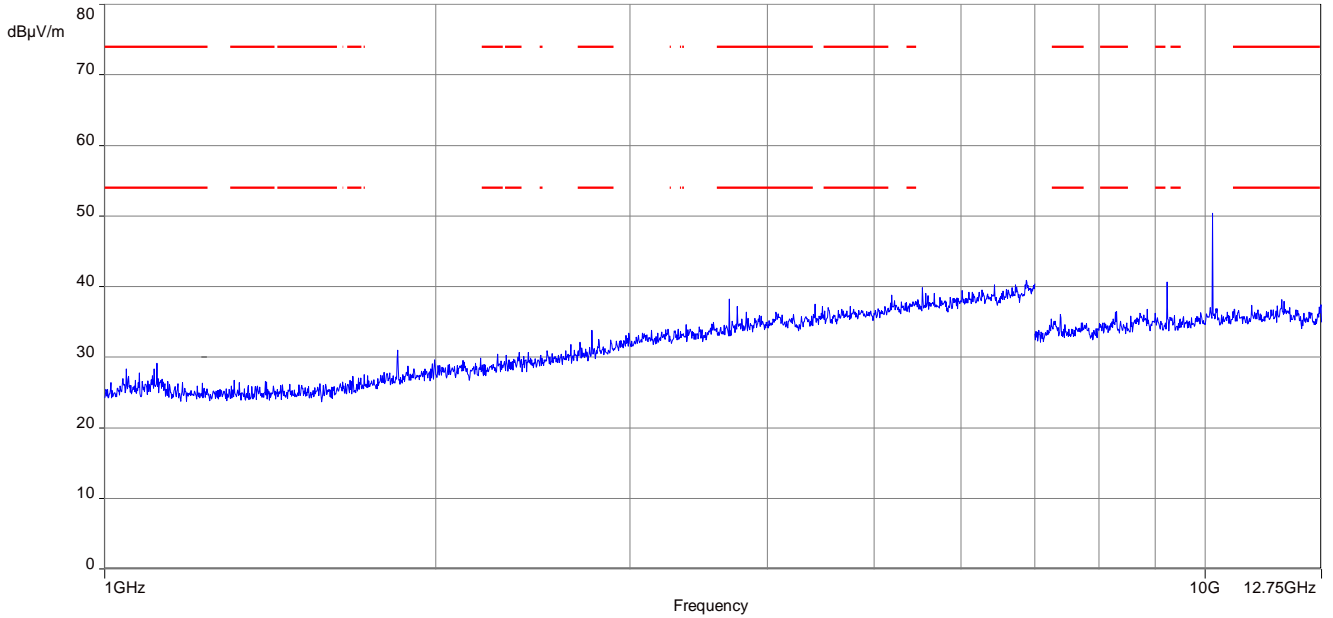
**b) EUT with PCB antenna**

TX spurious emissions radiated					
Lowest channel			Highest channel		
F [MHz]	Detector	Level [dBµV/m]	F [MHz] Detector	Level	[dBµV/m]
No Spurious Emissions in restricted bands detected.			No Spurious Emissions in restricted bands detected.		

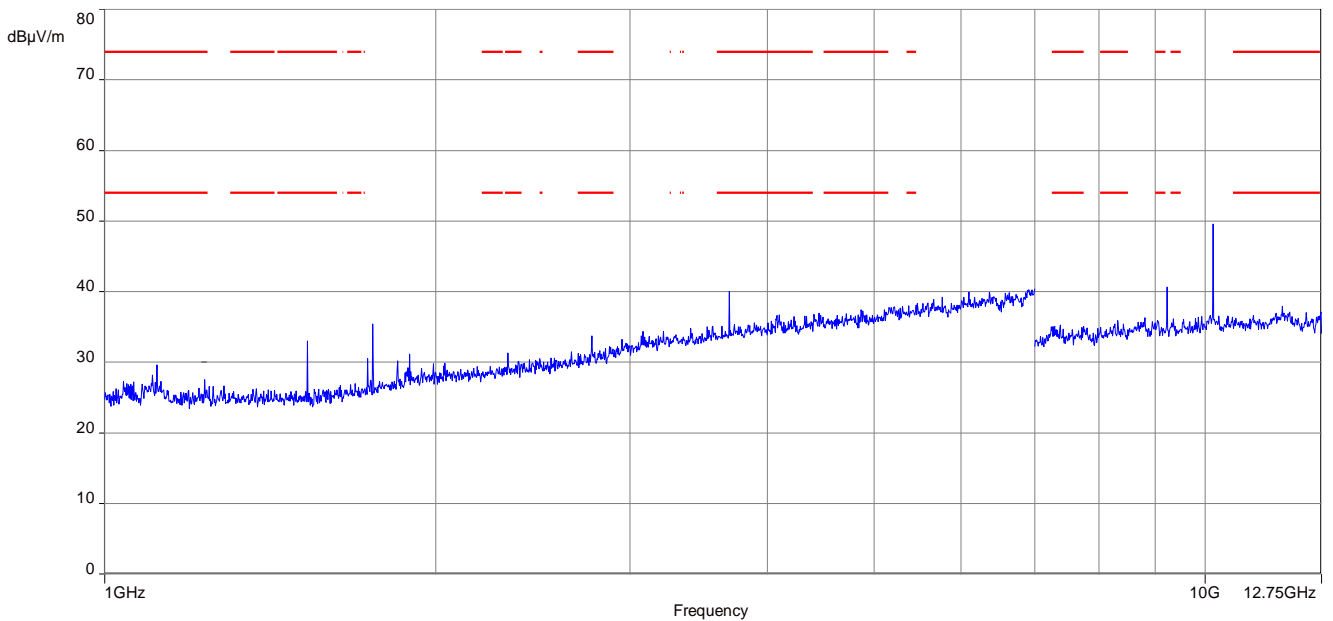


**Plots EUT with dipole antenna:**

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

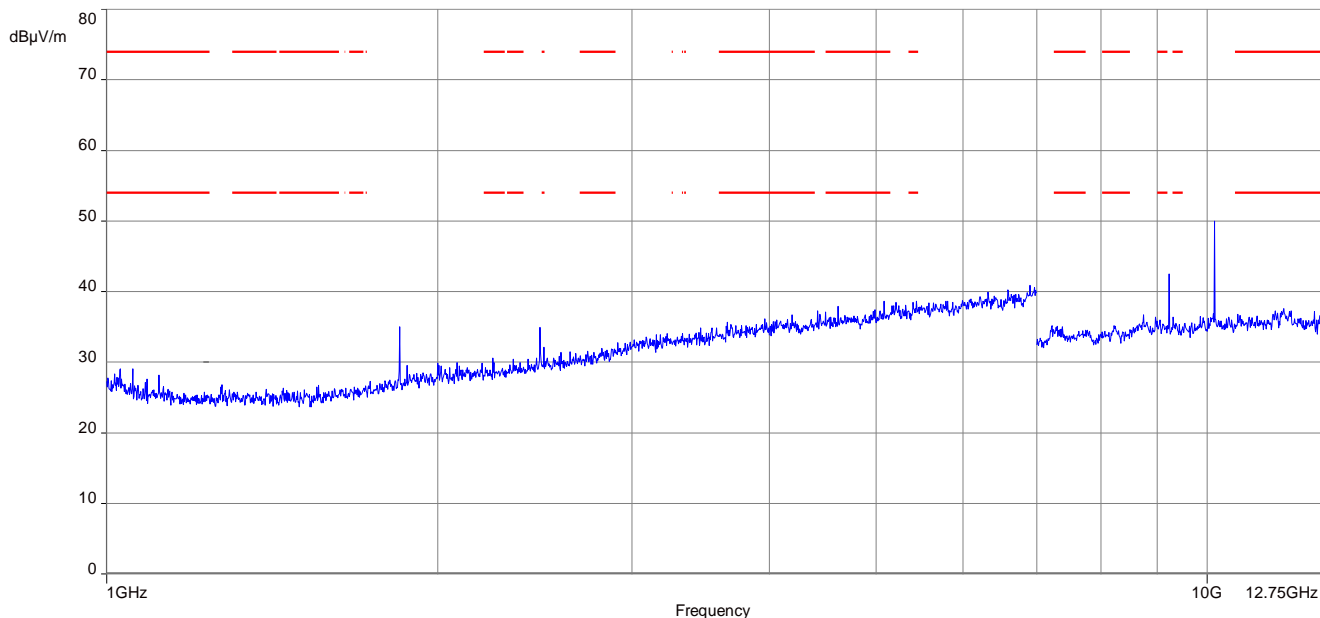


Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)

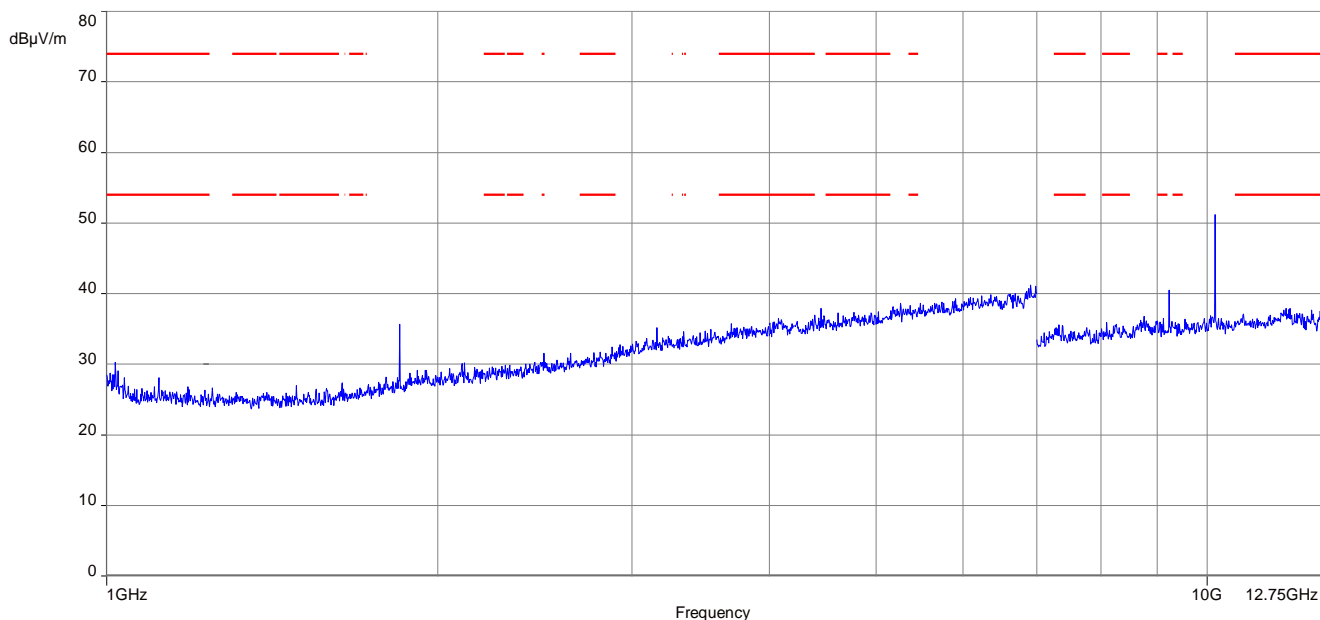


**Plots EUT with PCB antenna:**

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



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



## 14 Observations

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

## Annex A Glossary

<b>EUT</b>	Equipment under test
<b>DUT</b>	Device under test
<b>UUT</b>	Unit under test
<b>GUE</b>	GNSS User Equipment
<b>ETSI</b>	European Telecommunications Standards Institute
<b>EN</b>	European Standard
<b>FCC</b>	Federal Communications Commission
<b>FCC ID</b>	Company Identifier at FCC
<b>IC</b>	Industry Canada
<b>PMN</b>	Product marketing name
<b>HMN</b>	Host marketing name
<b>HVIN</b>	Hardware version identification number
<b>FVIN</b>	Firmware version identification number
<b>EMC</b>	Electromagnetic Compatibility
<b>HW</b>	Hardware
<b>SW</b>	Software
<b>Inv. No.</b>	Inventory number
<b>S/N or SN</b>	Serial number
<b>C</b>	Compliant
<b>NC</b>	Not compliant
<b>NA</b>	Not applicable
<b>NP</b>	Not performed
<b>PP</b>	Positive peak
<b>QP</b>	Quasi peak
<b>AVG</b>	Average
<b>OC</b>	Operating channel
<b>OCW</b>	Operating channel bandwidth
<b>OBW</b>	Occupied bandwidth
<b>OOB</b>	Out of band
<b>DFS</b>	Dynamic frequency selection
<b>CAC</b>	Channel availability check
<b>OP</b>	Occupancy period
<b>NOP</b>	Non occupancy period
<b>DC</b>	Duty cycle
<b>PER</b>	Packet error rate
<b>CW</b>	Clean wave
<b>MC</b>	Modulated carrier
<b>WLAN</b>	Wireless local area network
<b>RLAN</b>	Radio local area network
<b>DSSS</b>	Dynamic sequence spread spectrum
<b>OFDM</b>	Orthogonal frequency division multiplexing
<b>FHSS</b>	Frequency hopping spread spectrum
<b>GNSS</b>	Global Navigation Satellite System
<b>C/N<sub>0</sub></b>	Carrier to noise-density ratio, expressed in dB-Hz

**Annex B Document history**

Version	Applied changes	Date of release
-/-	Initial release	2019-12-18
A	Output Power, Spectral Bandwidth & Spectral Power updated for Hybrid Systems	2020-01-10
B	Editorial changes	2020-01-13
C	FHSS mode removed, Hybrid mode added, Editorial changes	2020-03-31
D	Editorial changes	2020-04-01
E	Several plots and measurement results replaced	2020-04-06

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

first page

last page



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 17025:2005 to carry out tests in the following fields:

**Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards**

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.

Registration number of the certificate: **D-PL-12076-01-04**

Frankfurt am Main, 11.01.2019

Dipl.-Ing. Uwe Zimmermann  
Head of Division

See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

Office Berlin  
Spittelmarkt 10  
10117 Berlin

Office Frankfurt am Main  
Europa-Allee 52  
60327 Frankfurt am Main

Office Braunschweig  
Bundesallee 100  
38116 Braunschweig

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](http://www.european-accreditation.org)  
ILAC: [www.ilac.org](http://www.ilac.org)  
IAF: [www.iaf.nu](http://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-12076-01-04.pdf

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

first page

last page



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 17025:2005 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 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 5 pages.

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

Frankfurt am Main, 11.01.2019

Signature of Dipl.-Ing. Uwe Zimmermann, Head of Division

See notes on back!

Deutsche Akkreditierungsstelle GmbH

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-12076-01-05.pdf

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