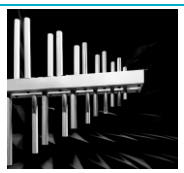
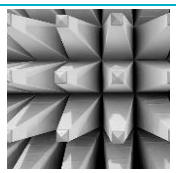

CTC advanced
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Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-6484/18-04-05-A

Testing laboratory

CTC advanced GmbH
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66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
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Internet: http://www.ctcadvanced.com
e-mail: mail@ctcadvanced.com

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

Applicant

Adeunis
283 Rue Louis Néel - Parc technologique Pré Roux
38920 Crolles / FRANCE
Phone: +33 (0) 4 76 92 07 77
Contact: Emmanuel Monnet
e-mail: e.monnet@adeunis-rf.com
Phone: +33 4 56 40 01 20

Manufacturer

Adeunis
283 Rue Louis Néel - Part technologique Pré Roux
38920 Crolles / FRANCE

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:	**Radio Module**
Model name:	**ARF8119A**
FCC ID:	**U3Z-ARF8119**
IC:	**n/a**
Frequency:	ISM Band 902 MHz – 928 MHz
Technology tested:	Sigfox
Antenna:	External dipole or PCB antenna
Power supply:	3.3 V DC by external power supply
Temperature range:	-30°C to +70°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:

cn=Christoph Schneider, o=CTC advanced GmbH, ou=SND-161128, email=Christoph.Schneider@ctcadvanced.com, c=DE
2019.10.21 15:08:50 +02'00'

Christoph Schneider
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Test performed:

Sumit Kumar

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2019.10.21 15:07:39 +02'00'

Sumit Kumar
Testing Manager
Radio Communications & EMC

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2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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This test report is electronically signed and valid without handwritten signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

This test report replaces the test report with the number 1-6484/18-04-05 and dated 2019-09-12.

2.2 Application details

Date of receipt of order:	2019-06-14
Date of receipt of test item:	2019-07-03
Start of test:	2019-07-16
End of test:	2019-07-20
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 https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf

4 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests No tests under extreme condition required. No tests under extreme condition required.
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.3 V DC by external power supply No tests under extreme condition required. No tests under extreme condition required.

5 Test item

5.1 General description

Kind of test item	:	Radio Module
Type identification	:	ARF8119A
HMN	:	n/a
PMN	:	n/a
HVIN	:	n/a
FVIN	:	n/a
S/N serial number	:	-/-
Hardware status	:	-/-
Software status	:	-/-
Firmware status	:	-/-
Frequency band	:	ISM Band 902 MHz – 928 MHz
Type of radio transmission Use of frequency spectrum	: :	FHSS
Type of modulation	:	BPSK
Number of channels	:	54
Antenna	:	External dipole or PCB antenna
Power supply	:	3.3 V DC by external power supply
Temperature range	:	-30°C to +70°C

5.2 Additional information

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

Test setup and EUT photos are included in test report: 1-6484/18-04-01_AnnexA
1-6484/18-04-01_AnnexD

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).

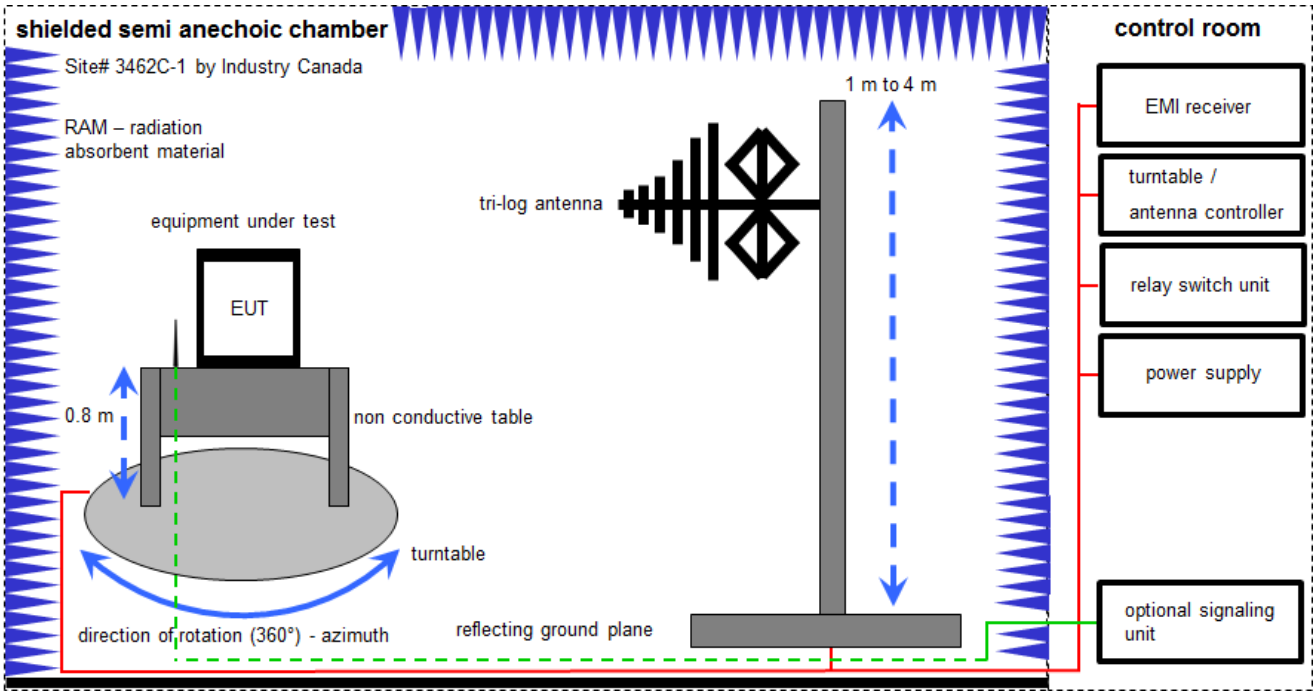
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlkl!	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

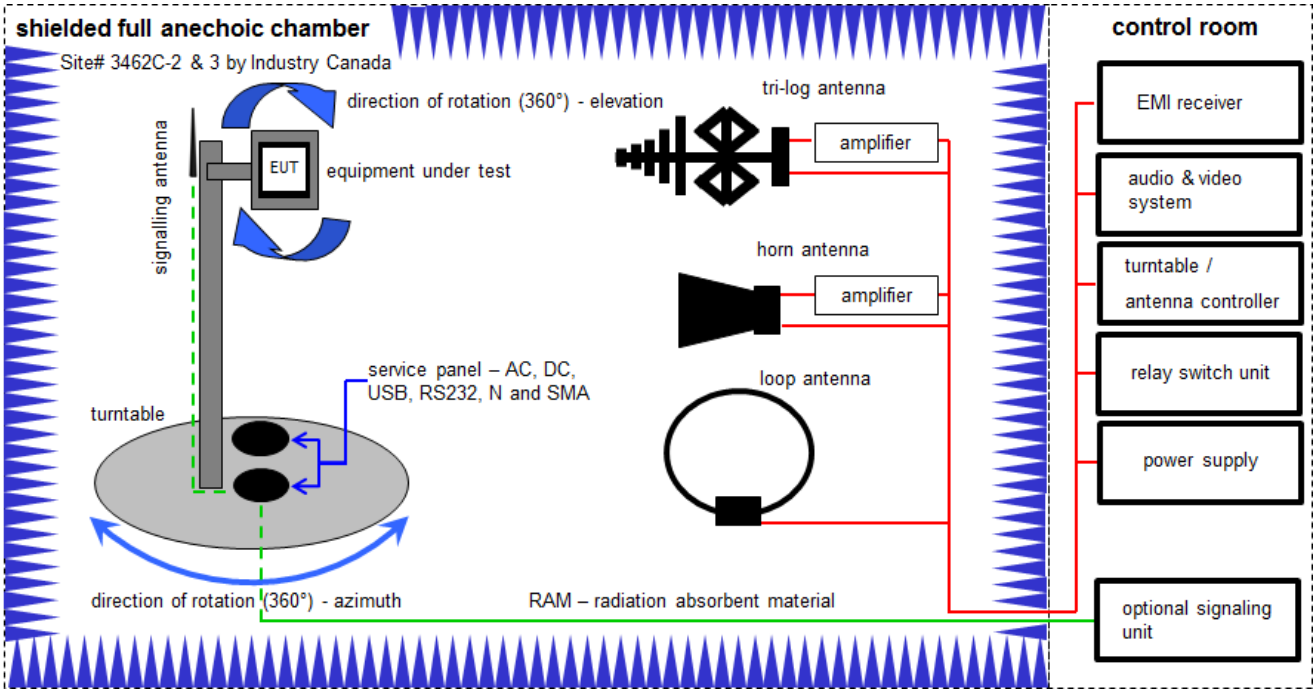
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
3	A	Meßkabine 1	HF-Absorberhalle	MWB AG 300023		300000551	ne	-/-	-/-
4	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	12.12.2018	11.12.2019
6	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
7	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
8	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
9	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	371	300003854	vlKI!	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)

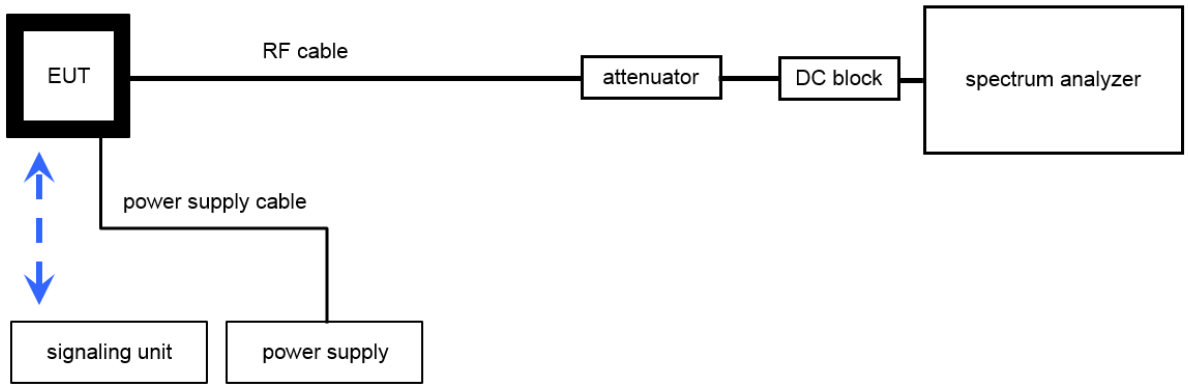
Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A.	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vlKl!	13.06.2019	12.06.2021
2	A, B, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vlKl!	27.02.2019	26.02.2021
4	A, B, C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
5	A, B, C	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	14.09.2018	13.12.2019
6	B	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	295	300003787	vlKl!	19.02.2019	18.02.2021
7	A, B, C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
8	A, B, C	NEXIO EMV-Software	BAT EMC V3.19.1.8	EMCO		300004682	ne	-/-	-/-
9	A, B, C	PC	ExOne	F+W		300004703	ne	-/-	-/-

6.3 Conducted measurements

Conducted measurements normal conditions



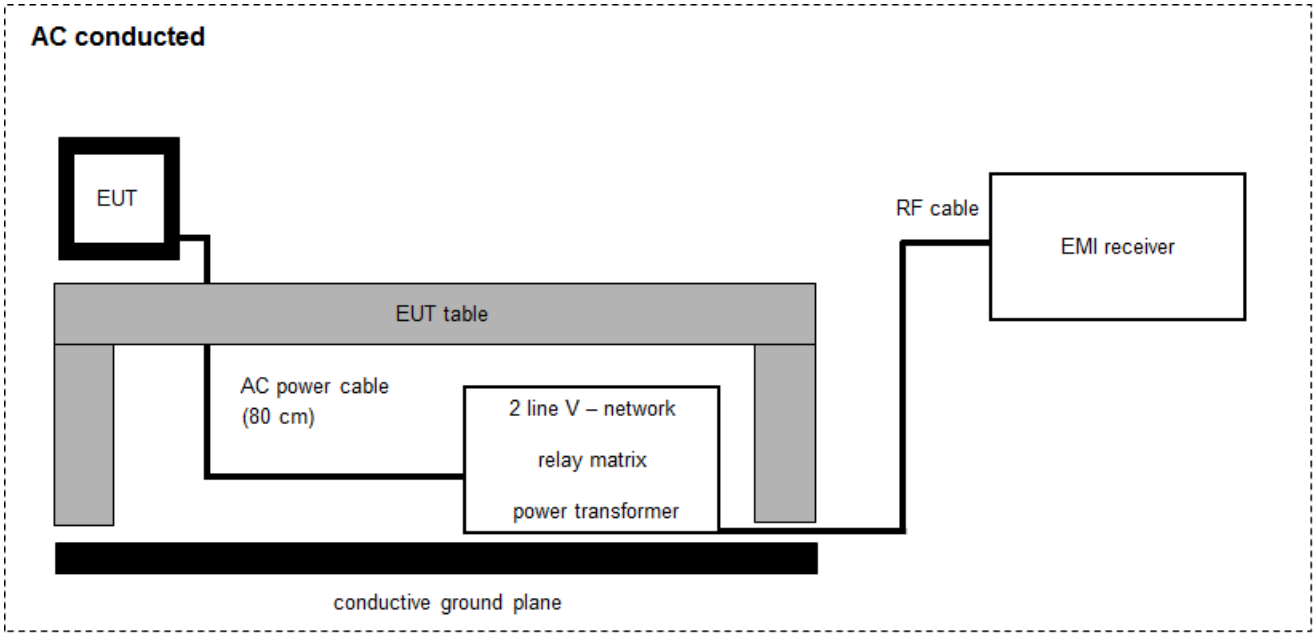
OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

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 0-20V; 0-5A	6632B	HP	US37478366	400000117	vIKI!	12.12.2018	11.12.2020
2	A	Signal- and Spectrum Analyzer 2 Hz - 26 GHz	FSW26	R&S	101455	300004528	k	19.12.2018	18.12.2019
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	-/-	-/-

6.4 AC conducted



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

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	892475/017	300002209	vlKI!	13.12.2017	12.12.2019
2	A	RF-Filter-section	85420E	HP	3427A00162	300002214	NK!	-/-	-/-
3	A	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
4	A	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	12.12.2018	11.12.2019

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 ± 45° and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

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

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

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	CFR Part 15 RSS - 247, Issue 2	Passed	2019-10-21	-/-

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	☒	☐	☐	☐	-/-
§15.247(a)(1) RSS - 247 / 5.1 (b)	Carrier frequency separation	Nominal	Nominal	TX hopping	☒	☐	☐	☐	-/-
§15.247(a)(1) RSS - 247 / 5.1 (d)	Number of hopping channels	Nominal	Nominal	TX hopping	☒	☐	☐	☐	-/-
§15.247(a)(1) (iii) RSS - 247 / 5.1 (d)	Time of occupancy (dwell time)	Nominal	Nominal	TX hopping	☒	☐	☐	☐	-/-
§15.247(a)(1) RSS - 247 / 5.1 (a)	Spectrum bandwidth of a FHSS system bandwidth	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(b)(1) RSS - 247 / 5.4 (b)	Maximum output power	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge - conducted	Nominal	Nominal	TX hopping	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	-/-	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Spurious emissions conducted	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.209(a) RSS - Gen	Spurious emissions radiated below 30 MHz	Nominal	Nominal	TX single channel	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated 30 MHz to 1 GHz	Nominal	Nominal	TX single channel / RX	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated above 1 GHz	Nominal	Nominal	TX single channel / RX	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions below 30 MHz (AC conducted)	Nominal	Nominal	TX hybrid	☐	☐	☒	☐	-/-

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 two different hopping frequency blocks:

Frequency table1: 902.1375 MHz – 904.6625 MHz
Frequency table2: 920.1375 MHz – 922.6625 MHz
Both blocks were tested and stated in this test report.
For single channel test we used the following nominal frequencies:

RC2 Band:
a) 902.1375 MHz lowest channel;
b) 903.3875 MHz middle channel;
c) 904.6625 MHz highest channel

RC4 Band:
a) 920.1375 MHz lowest channel;
b) 921.3875 MHz middle channel;
c) 922.6625 MHz highest channel

Used antennas: See user manual (UG_SIGFOX_RTU_US_V2.pdf)

Configuration descriptions: None

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

Hopping table 1:

Table RC2:

One for the low part of the band: (902.1375-904.6625MHz)

Micro Channel 1 (MHz)	Micro Channel 2 (MHz)	Micro Channel 3 (MHz)	Micro Channel 4 (MHz)	Micro Channel 5 (MHz)	Micro Channel 6 (MHz)
902.1375	902.1625	902.1875	902.2125	902.2375	902.2625
902.4375	902.4625	902.4875	902.5125	902.5375	902.5625
902.7375	902.7625	902.7875	902.8125	902.8375	902.8625
903.0375	903.0625	903.0875	903.1125	903.1375	903.1625
903.3375	903.3625	903.3875	903.4125	903.4375	903.4625
903.6375	903.6625	903.6875	903.7125	903.7375	903.7625
903.9375	903.9625	903.9875	904.0125	904.0375	904.0625
904.2375	904.2625	904.2875	904.3125	904.3375	904.3625
904.5375	904.5625	904.5875	904.6125	904.6375	904.6625

Hopping table 2:

Table RC4:

Another for the high part of the band: (920.1375-922.6625MHz)

Micro Channel 1 (MHz)	Micro Channel 2 (MHz)	Micro Channel 3 (MHz)	Micro Channel 4 (MHz)	Micro Channel 5 (MHz)	Micro Channel 6 (MHz)
920,1375	920,1625	920,1875	920,2125	920,2375	920,2625
920,4375	920,4625	920,4875	920,5125	920,5375	920,5625
920,7375	920,7625	920,7875	920,8125	920,8375	920,8625
921,0375	921,0625	921,0875	921,1125	921,1375	921,1625
921,3375	921,3625	921,3875	921,4125	921,4375	921,4625
921,6375	921,6625	921,6875	921,7125	921,7375	921,7625
921,9375	921,9625	921,9875	922,0125	922,0375	922,0625
922,2375	922,2625	922,2875	922,3125	922,3375	922,3625
922,5375	922,5625	922,5875	922,6125	922,6375	922,6625

11 Measurement results

11.1 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 7.3 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:

a) RC2 Band

		Low channel	Middle channel	High channel
Conducted power [dBm]		22.56	22.74	22.90
dipole antenna	Radiated power [dBm]	24.16	24.39	24.45
	Gain [dBi]	**1.60**	**1.65**	**1.55**
PCB antenna	Radiated power [dBm]	23.05	22.93	23.74
	Gain [dBi]	**0.49**	**0.19**	**0.84**

b) RC4 Band

		Low channel	Middle channel	High channel
Conducted power [dBm]		21.93	22.24	21.52
dipole antenna	Radiated power [dBm]	23.06	22.75	21.96
	Gain [dBi]	**1.13**	**0.51**	**0.44**
PCB antenna	Radiated power [dBm]	22.07	21.26	20.71
	Gain [dBi]	**0.14**	**-0.98**	**-0.81**

11.2 Carrier Frequency Separation

Description:

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

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. The two-thirds of the 20 dB bandwidth for IC is only valid for the ISM band 2400 – 2483.5 MHz.	

Result:

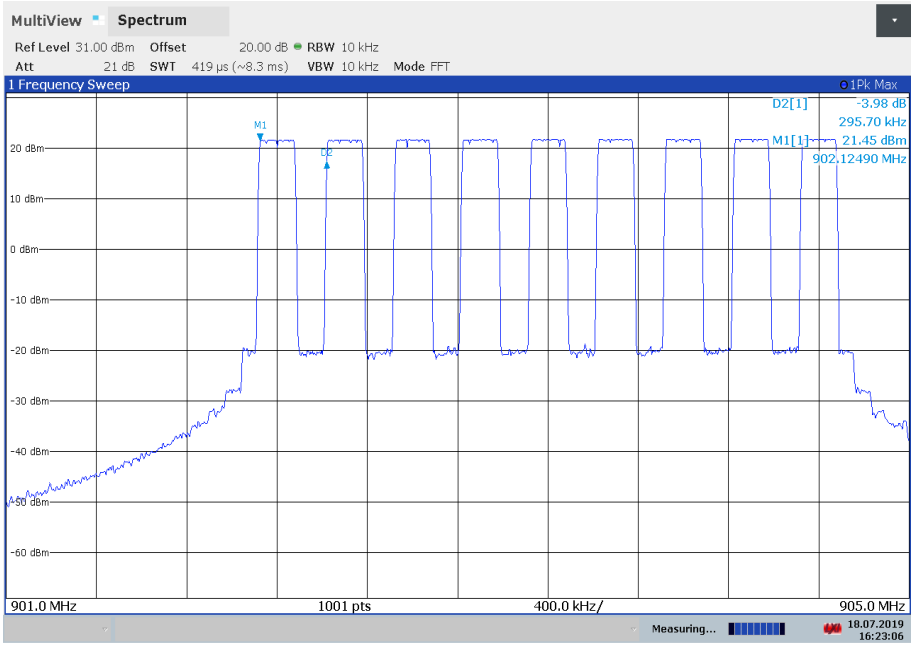
a) For RC2 Band the channel separation is 295.70 kHz for the macro channels and 25.17 kHz for the micro channels

b) For RC4 Band the channel separation is 299.70 kHz for the macro channels and 25.20 kHz for the micro channels

Plots:

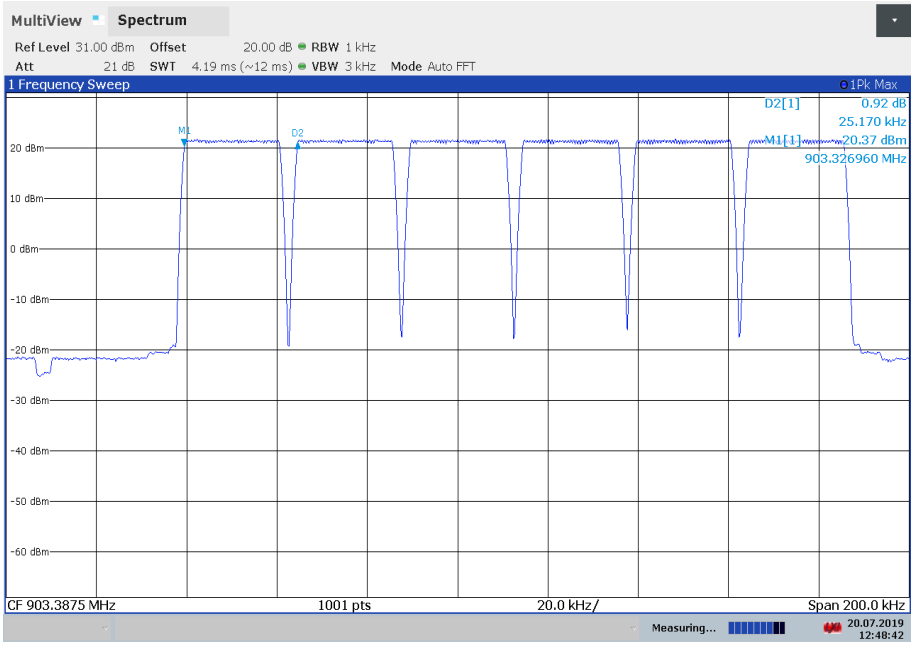
a) RC2 Band

Plot 1: Frequency separation macro channels



16:23:06 18.07.2019

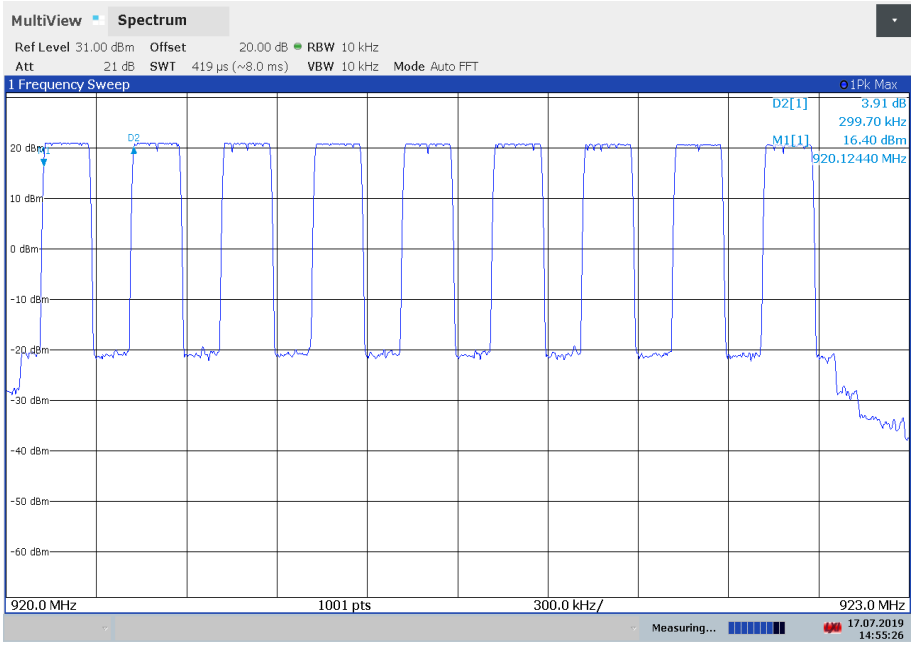
Plot 2: Frequency separation micro channels



12:48:43 20.07.2019

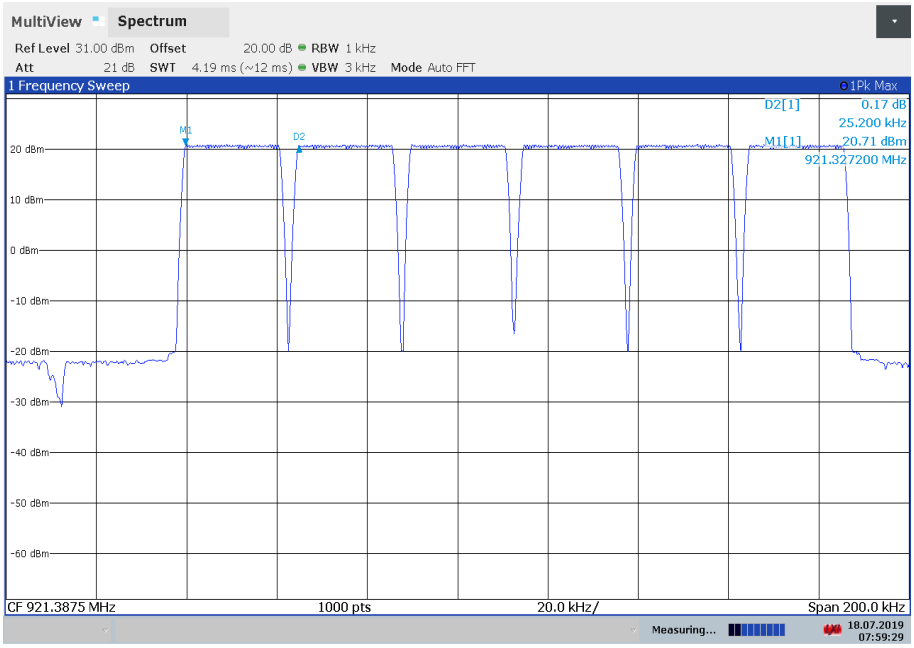
b) RC4 Band

Plot 1: Frequency separation macro channels



14:55:27 17.07.2019

Plot 2: Frequency separation micro channels



07:59:30 18.07.2019

11.3 Number of Hopping Channels

Description:

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

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
Number of hopping channels	
At least 15 non overlapping hopping channels. If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels.	

Result:

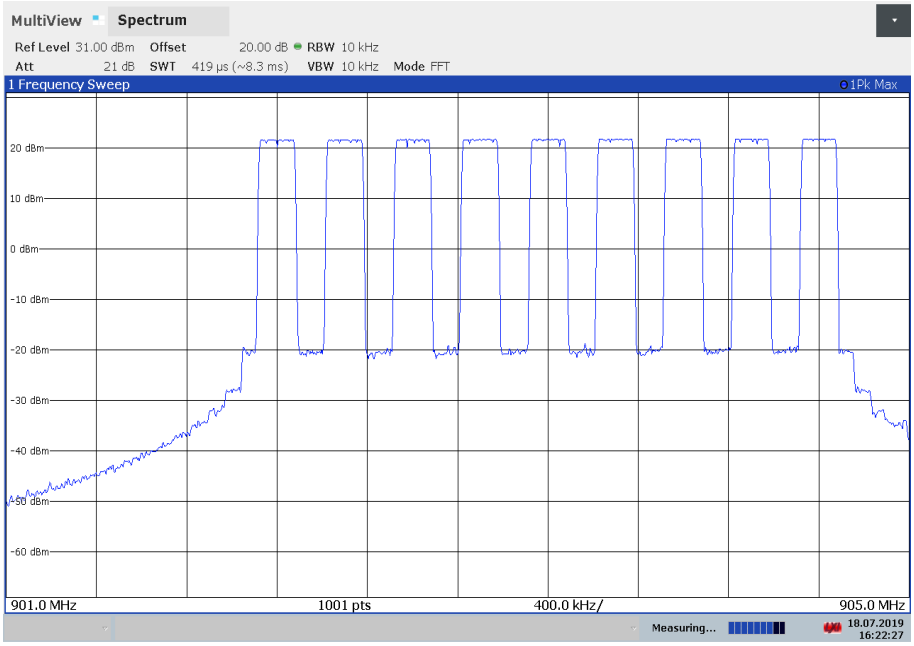
a) For RC2 Band the number of macro channels is 9. Each macro channel is divided into 6 micro channels. So in summary the EUT uses 9*6 = 54 channels.

b) For RC4 Band the number of macro channels is 9. Each macro channel is divided into 6 micro channels. So in summary the EUT uses 9*6 = 54 channels.

Plots:

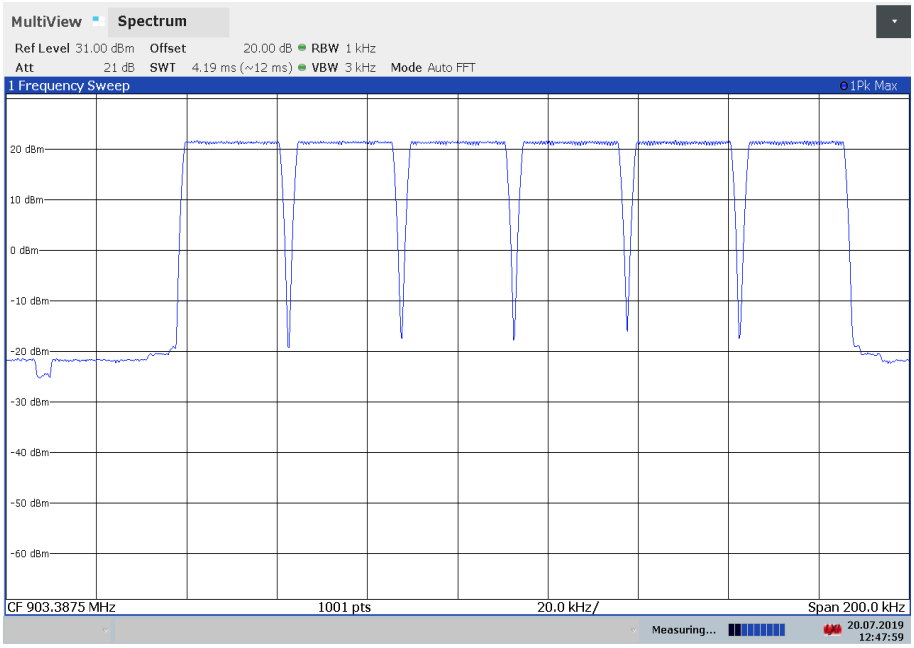
a) RC2 Band

Plot 1: Number of macro channels



16:22:28 18.07.2019

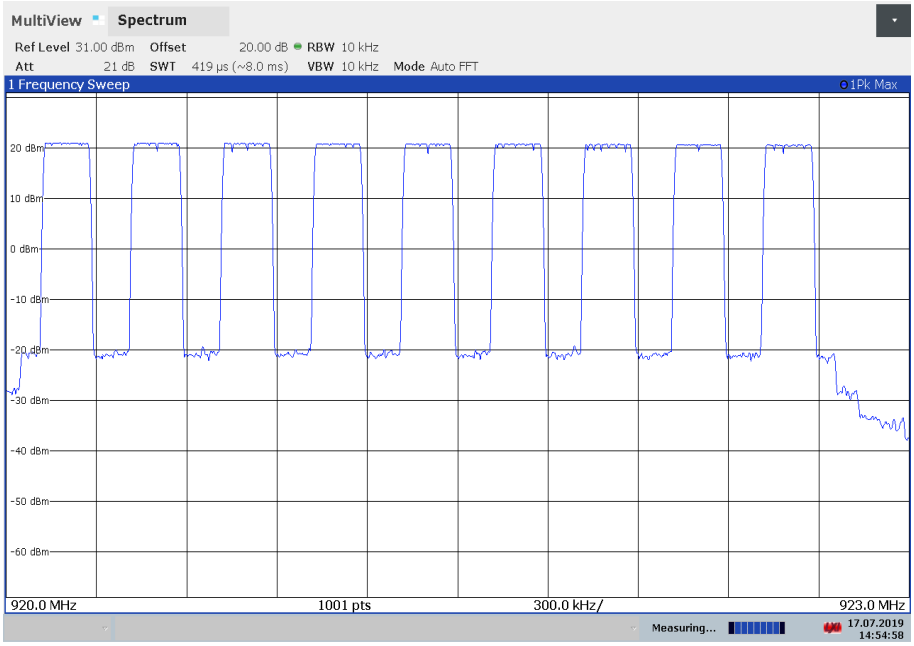
Plot 2: Number of micro channels in one single macro channel zoomed



12:48:00 20.07.2019

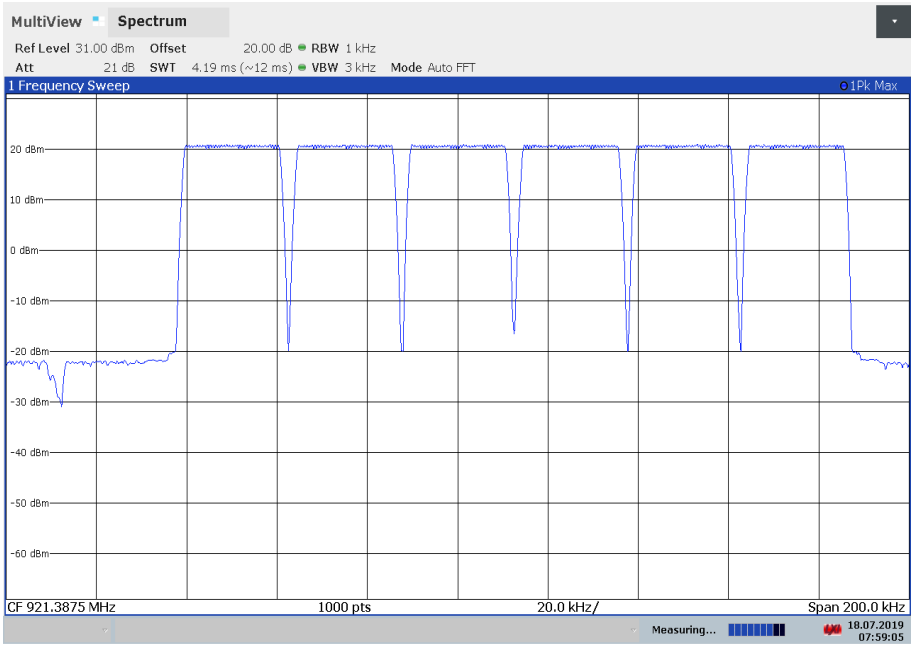
b) RC4 Band

Plot 1: Number of macro channels



14:54:58 17.07.2019

Plot 2: Number of micro channels in one single macro channel zoomed



07:59:06 18.07.2019

11.4 Average Time of Occupancy (dwell time)

Measurement:

The measurement is performed in zero span mode to show that none of the 54 used channels is allocated more than 0.4 seconds within a 10 seconds interval (54 channels times 0.4s).

Limits:

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

Result:

a) RC2 Band

The time slot length is = 352.23 ms
Number of hops / channel @ 20s = 1

Within 20 s period, the average time of occupancy in 20 s: 1* 352.23 ms

→ The average time of occupancy = **352.23 ms**

b) RC4 Band

The time slot length is = 352.63ms
Number of hops / channel @ 20s = 1

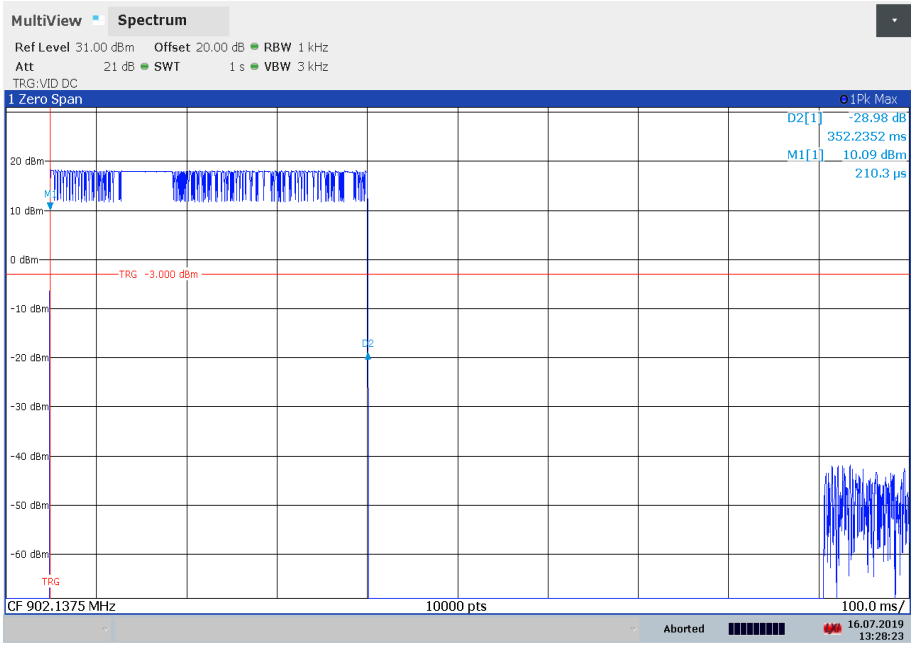
Within 20 s period, the average time of occupancy in 20 s: 1* 352.63 ms

→ The average time of occupancy = **352.63 ms**

Plots:

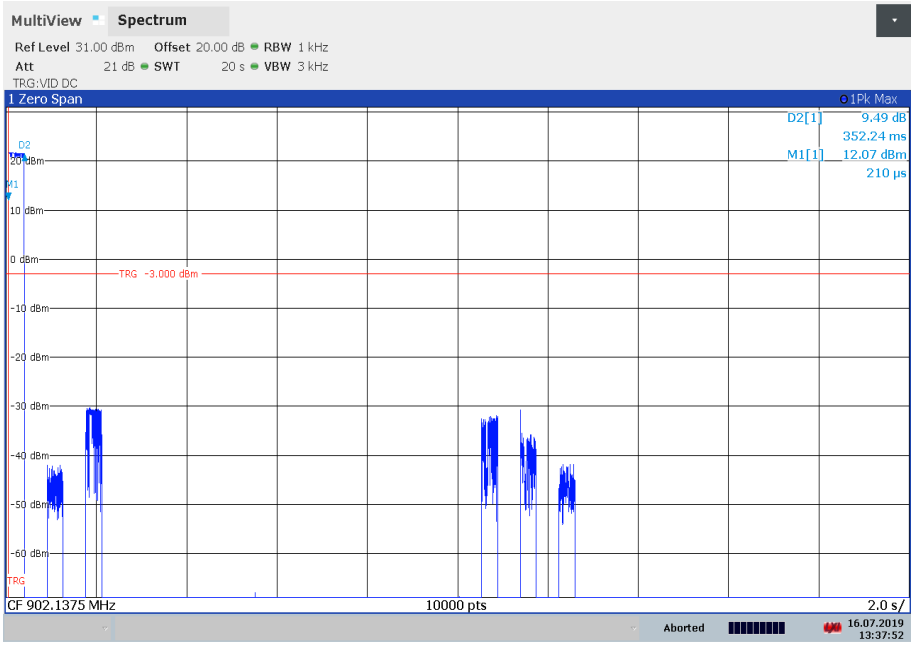
a) RC2 Band

Plot 1: Time slot length = 352.23 ms



13:28:24 16.07.2019

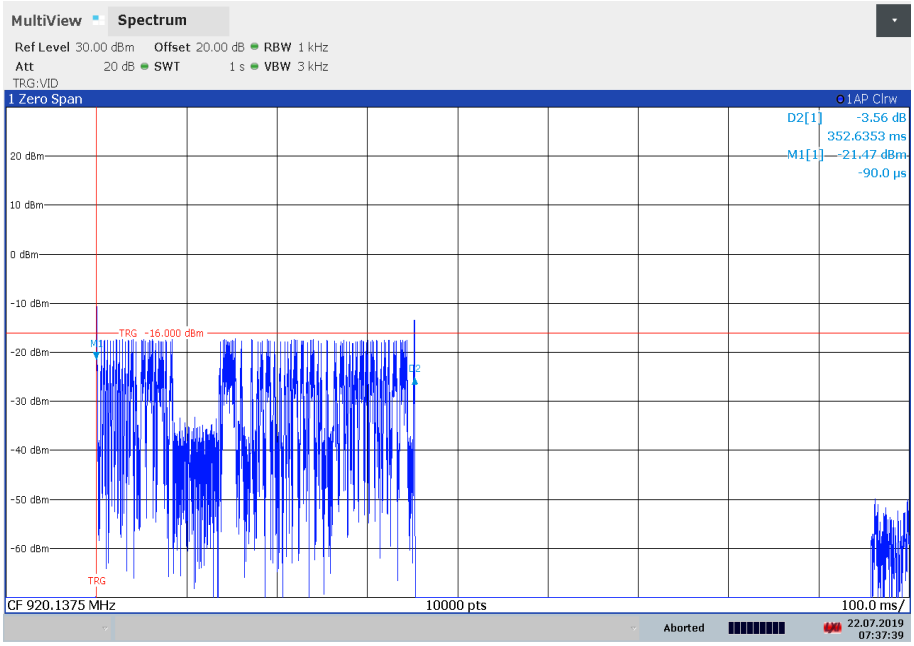
Plot 2: hops / channel @ 20s = 1



13:37:52 16.07.2019

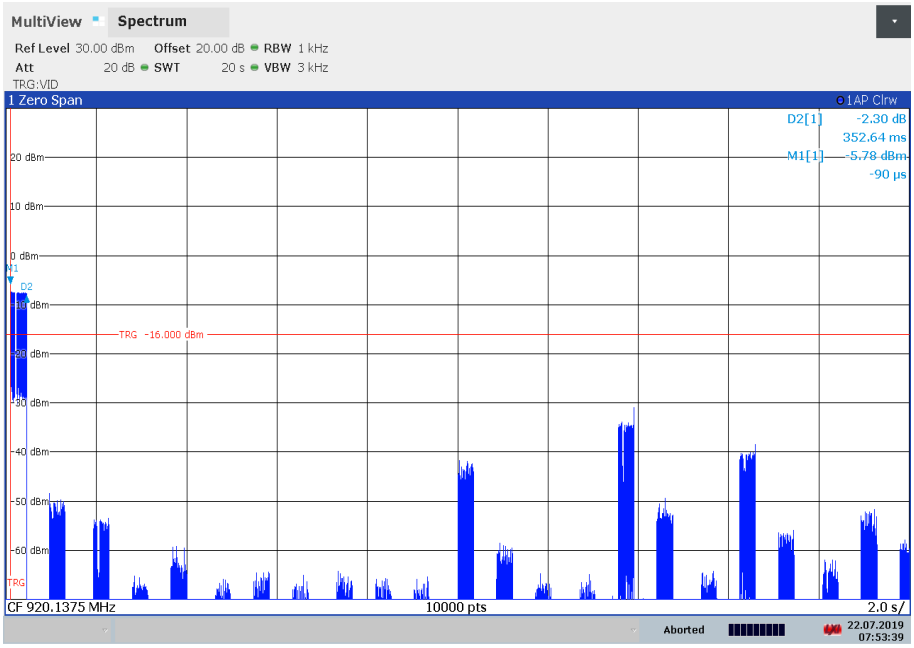
b) RC4 Band

Plot 1: Time slot length = 352.63 ms



07:37:39 22.07.2019

Plot 2: hops / channel @ 20s = 1



07:53:39 22.07.2019

11.5 Spectrum bandwidth of a FHSS system

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	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
Spectrum bandwidth of a FHSS system	
The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.	

Result:

a) RC2 Band

Test Conditions		20dB BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	21.68	21.06	21.79

Test Conditions		99% BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	20.82	21.60	20.98

b) RC4 Band

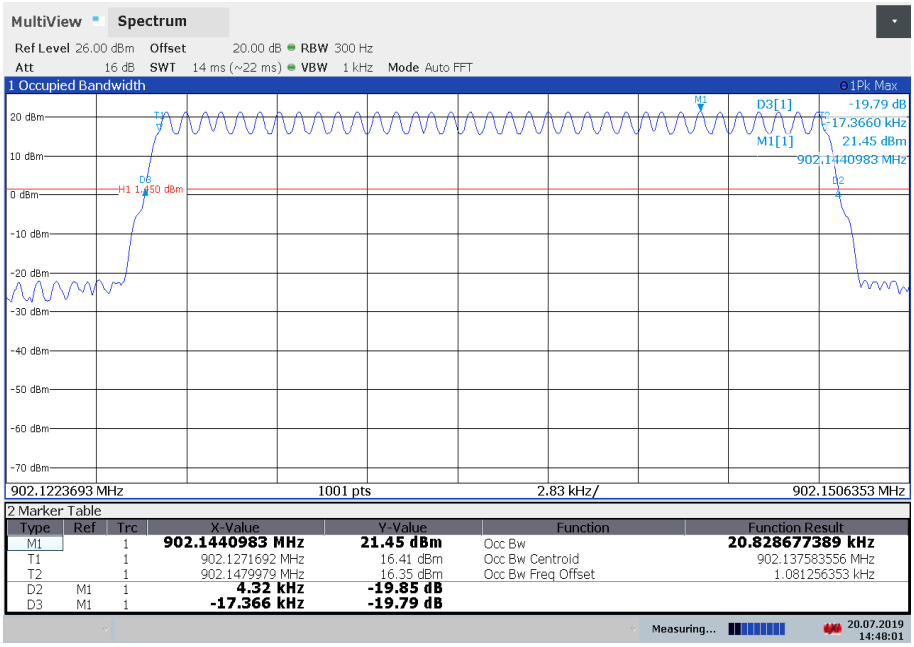
Test Conditions		20dB BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	21.68	21.65	21.81

Test Conditions		99% BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	20.83	20.86	20.95

Plots:

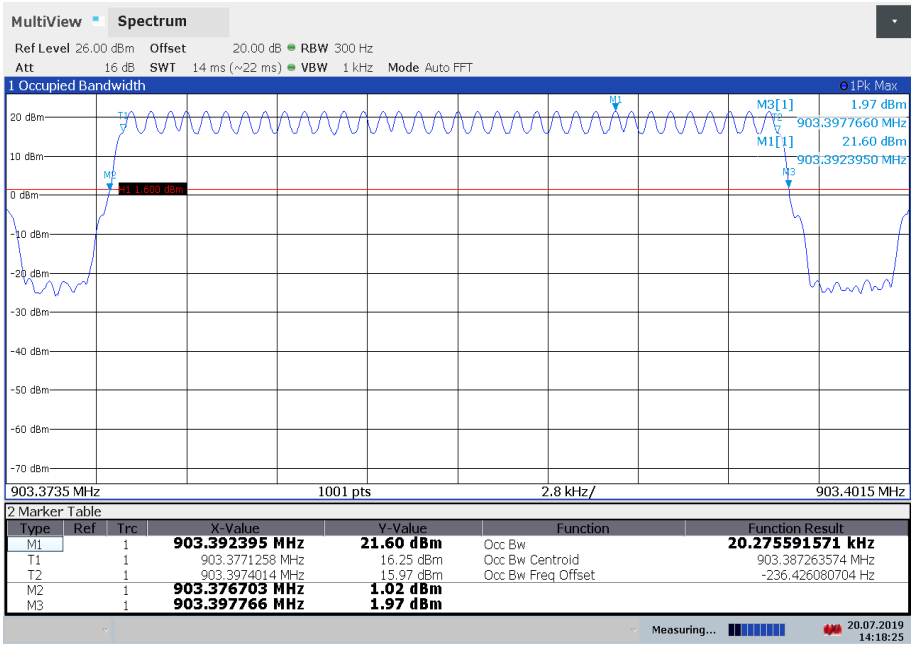
a) RC2 Band

Plot 1: Low Channel



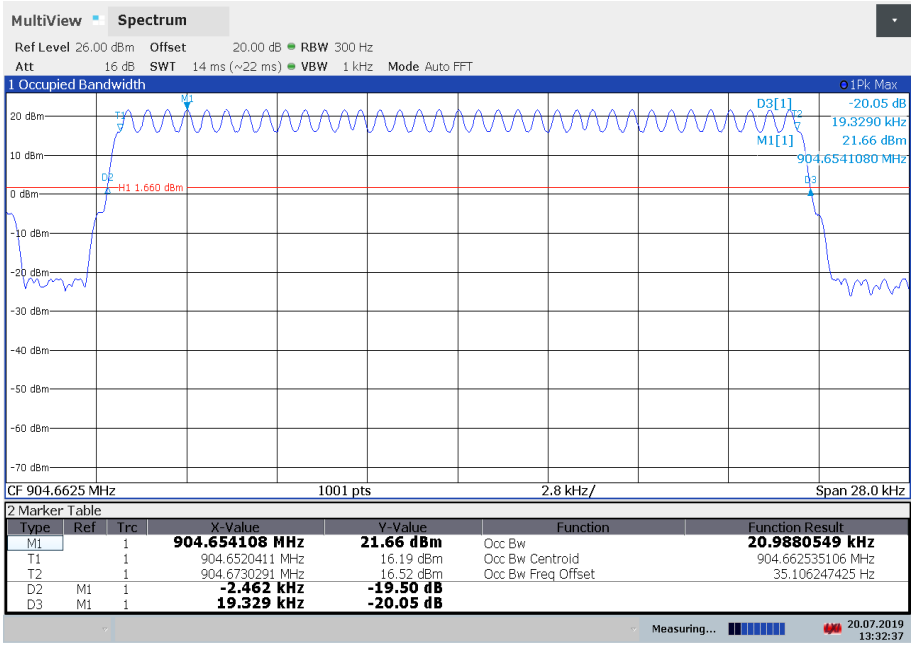
14:48:02 20.07.2019

Plot 2: Middle Channel



14:18:25 20.07.2019

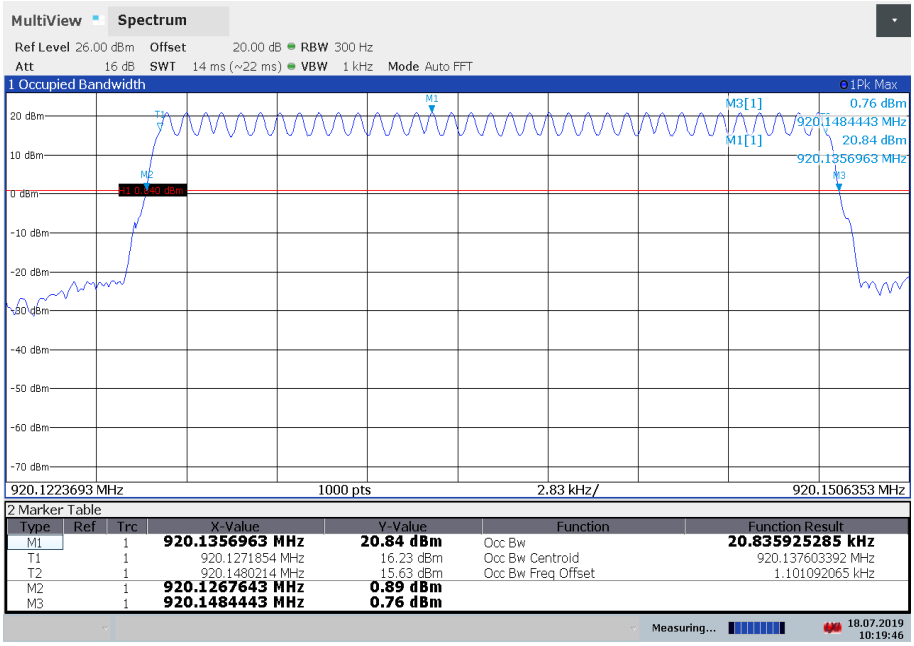
Plot 3: High Channel



13:32:37 20.07.2019

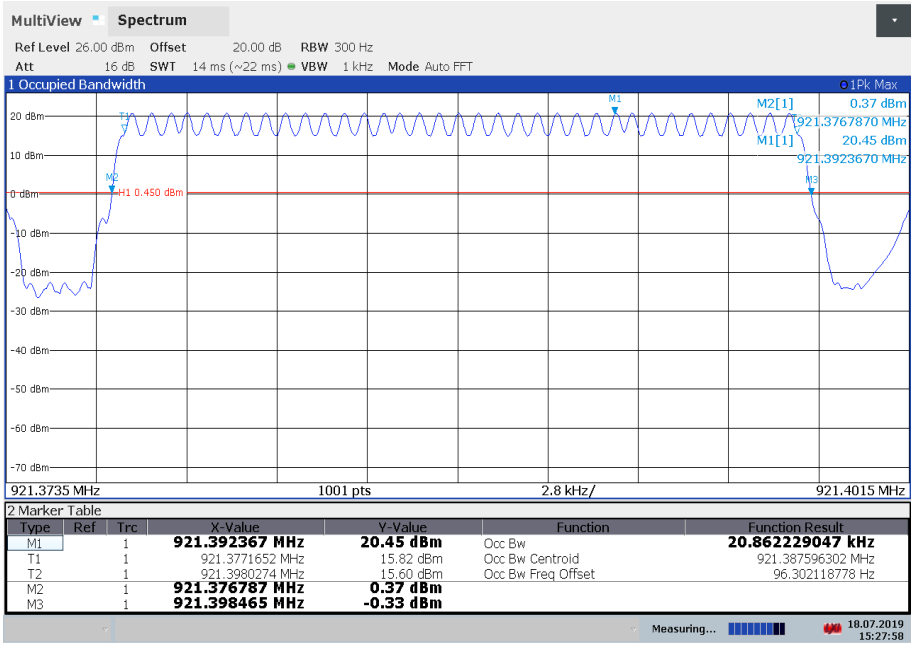
b) RC4 Band

Plot 1: Low Channel



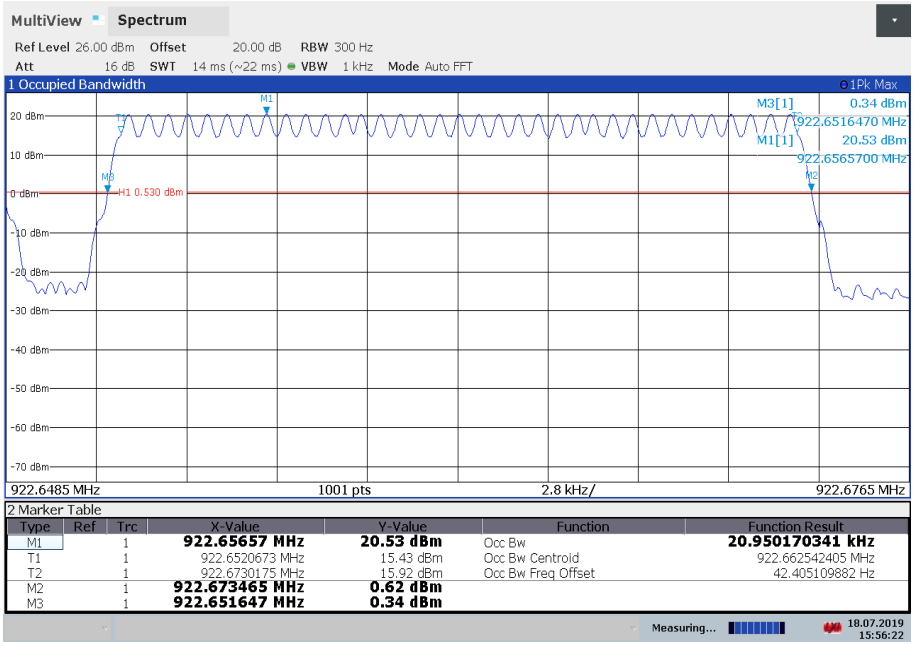
10:19:46 18.07.2019

Plot 2: Middle Channel



15:27:58 18.07.2019

Plot 3: High Channel



15:56:24 18.07.2019

11.6 Maximum Output Power

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	See Plots
Video bandwidth:	See Plots
Span:	See Plots
Trace-Mode:	Max Hold
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:

a) RC2 Band

Test Conditions		Maximum Output Power Conducted [dBm]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	22.56	22.74	22.90

Test Conditions		ERP [dBm] dipole antenna		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	24.16	24.39	24.45

Test Conditions		ERP [dBm] PCB antenna		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	23.05	22.93	23.74

b) RC4 Band

Test Conditions		Maximum Output Power Conducted [dBm]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	21.93	22.24	21.52

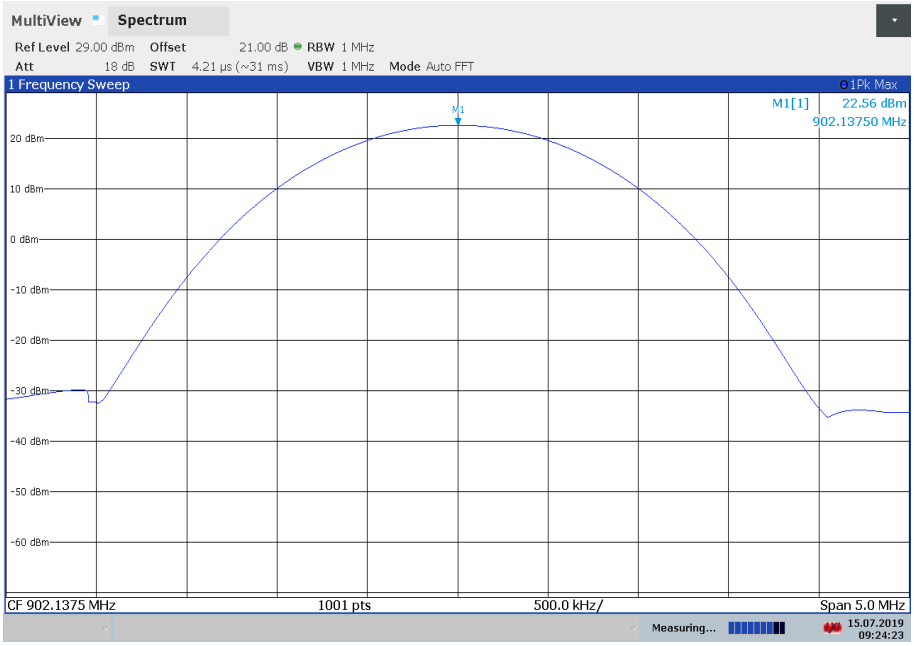
Test Conditions		ERP [dBm] dipole antenna		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	23.06	22.75	21.96

Test Conditions		ERP [dBm] PCB antenna		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	22.07	21.26	20.71

Plots:

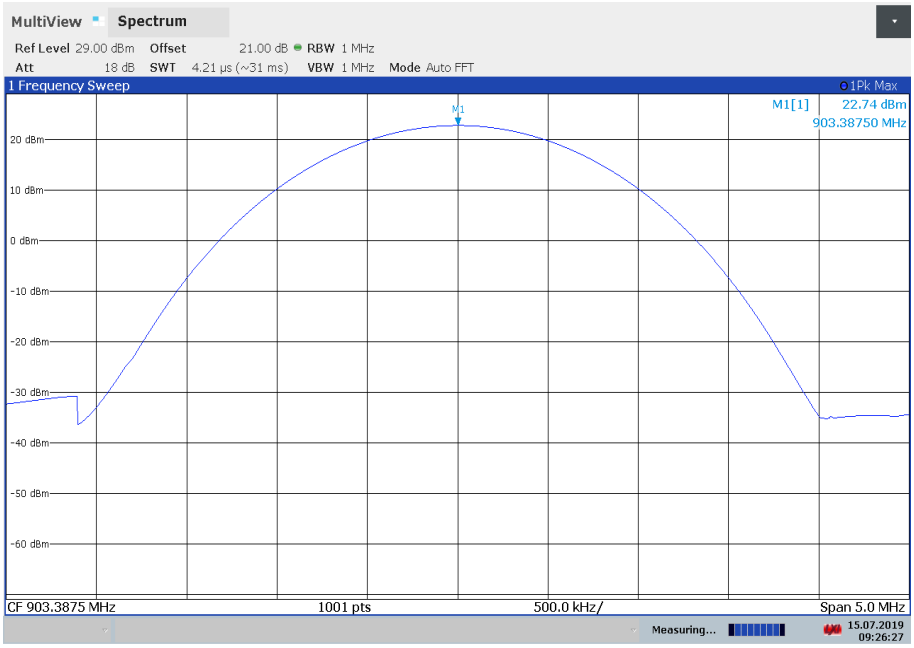
a) RC2 Band

Plot 1: Low Channel



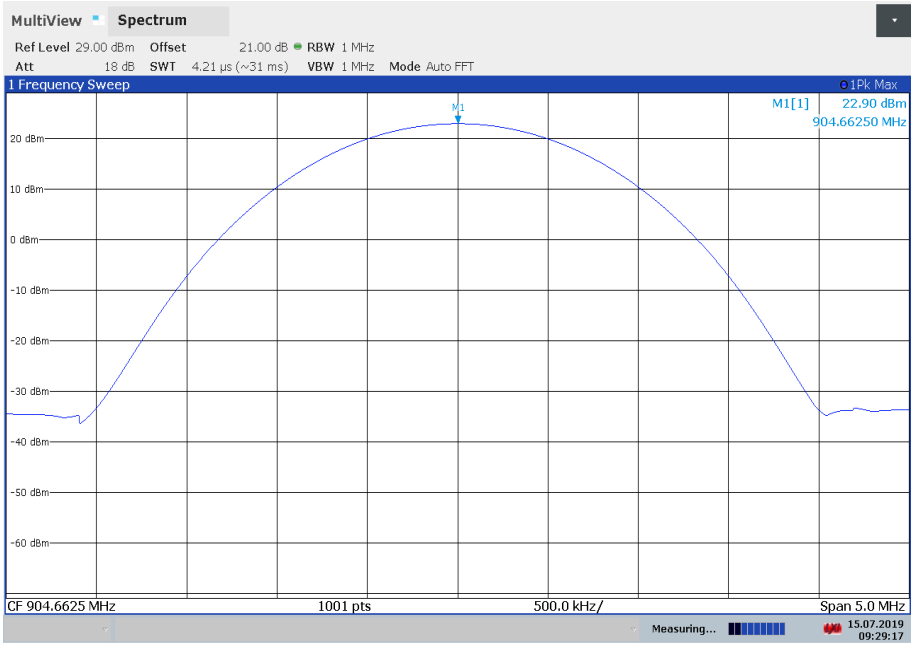
09:24:24 15.07.2019

Plot 2: Middle Channel



09:26:27 15.07.2019

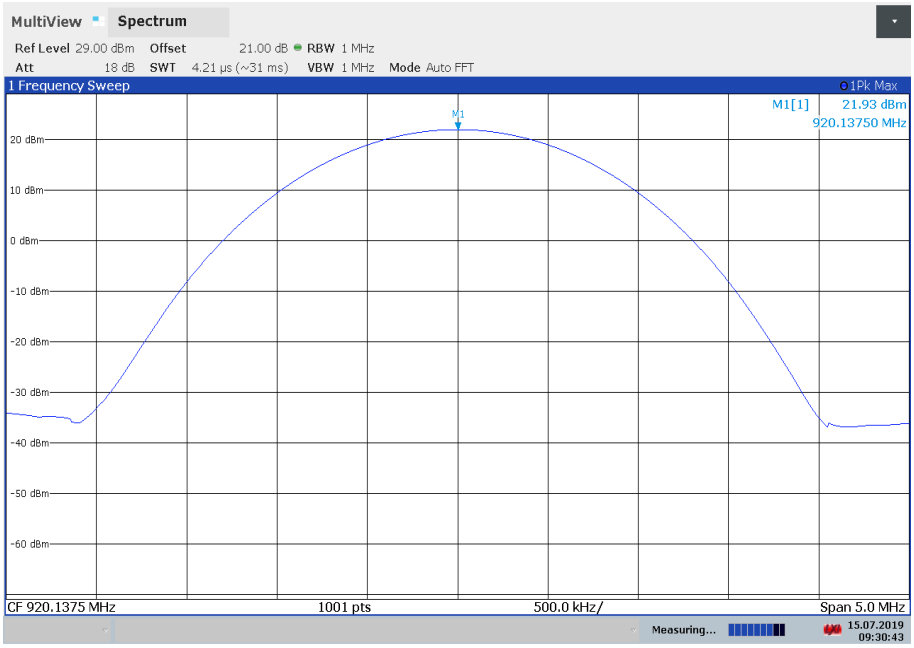
Plot 3: High Channel



09:29:18 15.07.2019

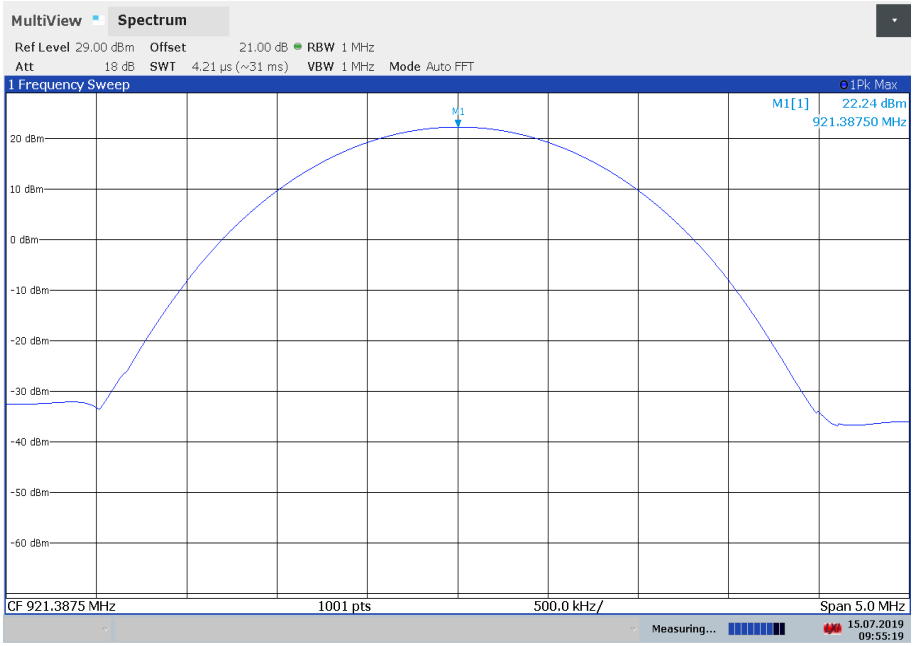
b) RC4 Band

Plot 1: Low Channel



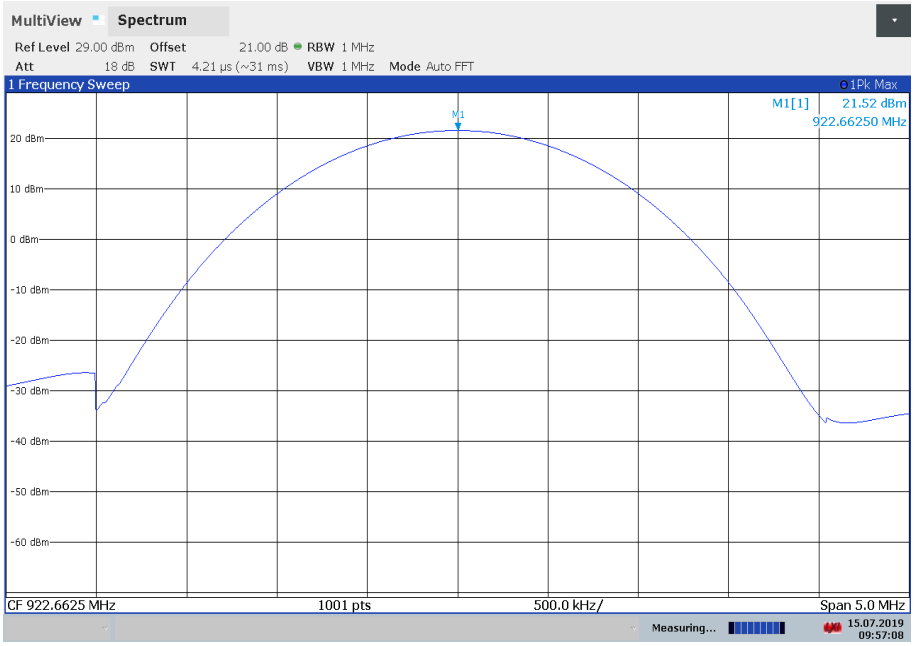
09:30:44 15.07.2019

Plot 2: Middle Channel



09:55:20 15.07.2019

Plot 3: High Channel



09:57:09 15.07.2019

11.7 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 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:

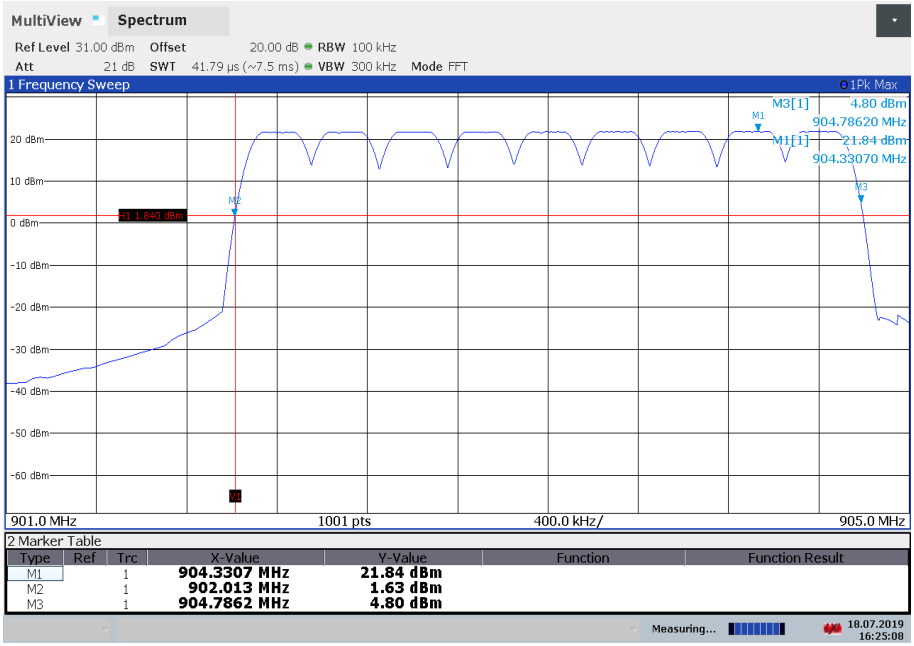
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains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

Results conducted:

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

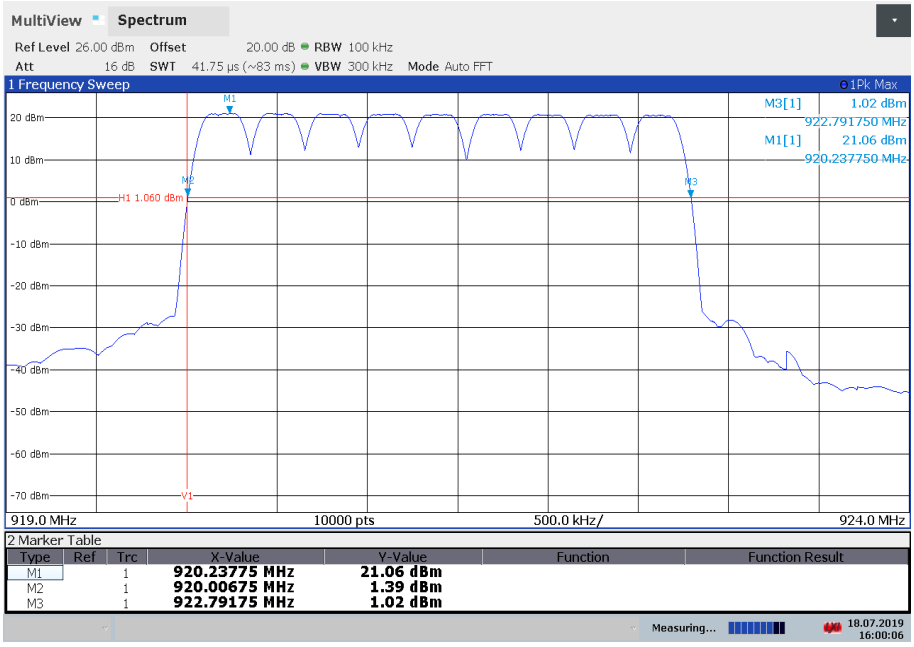
Plots:

Plot 1: 20 dB – hopping on RC2 Band



16:25:09 18.07.2019

Plot 2: 20 dB – hopping on RC4 Band



16:00:07 18.07.2019

Results radiated:

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

Section 15.205 Restricted bands of operation.

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

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

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
Video bandwidth:	F < 1 GHz: 1 MHz F > 1 GHz: 1 MHz
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 100 kHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3A
Measurement uncertainty:	See chapter 8

Limits:

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

Result:

a) RC2 Band

Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
902.1375		21.44	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	
903.3875		21.55	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	
904.6625		21.79	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	

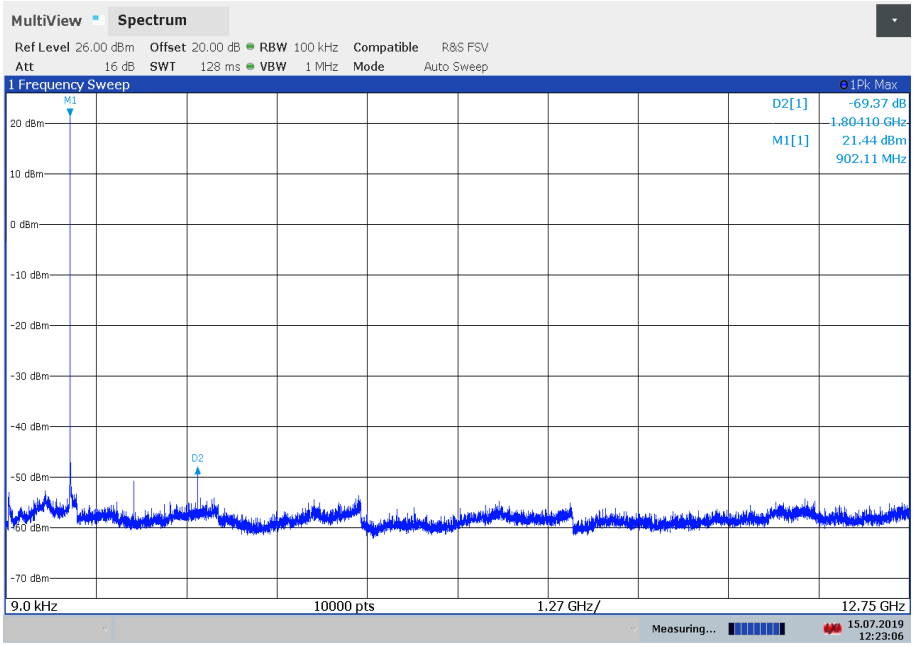
b) RC4 Band

Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
920.1375		21.46	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	
921.3875		20.72	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	
922.6625		20.46	24 dBm		Operating frequency
	See plot		-20 dBc	No emissions detected!	

Plots:

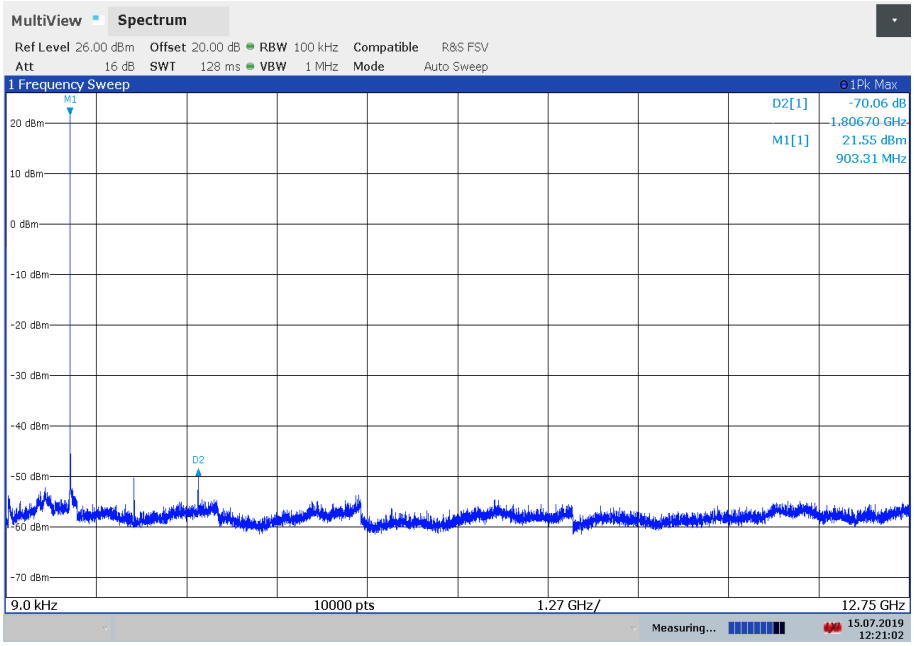
a) RC2 Band

Plot 1: Low channel, 9 kHz – 12.75 GHz



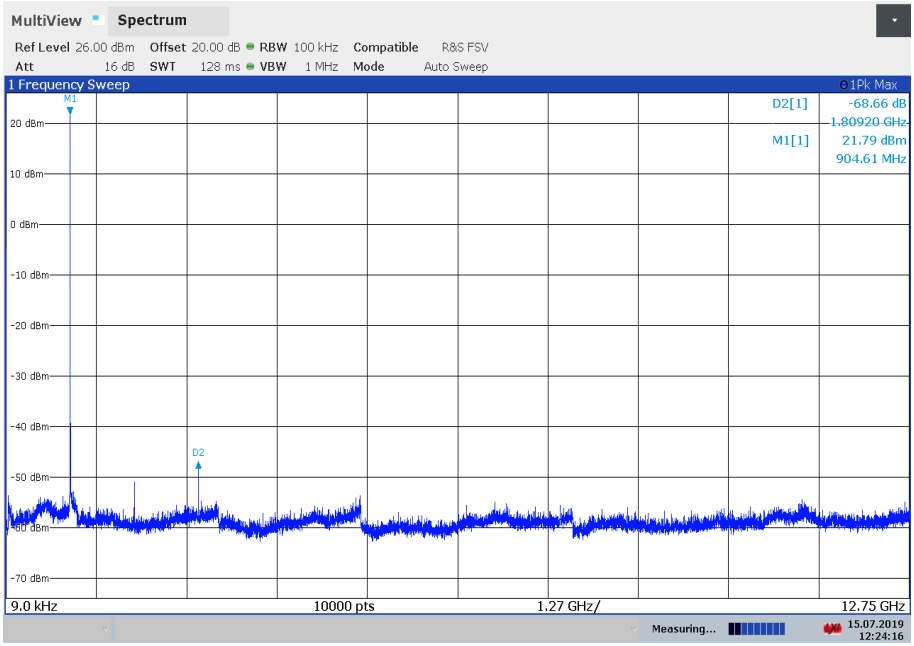
12:23:07 15.07.2019

Plot 2: Middle channel, 9 kHz – 12.75 GHz



12:21:03 15.07.2019

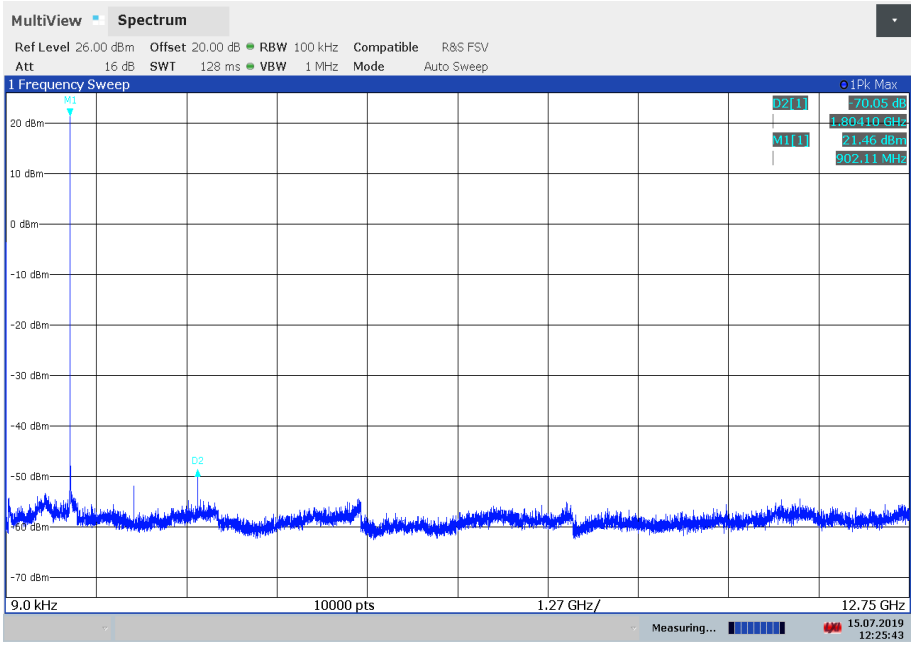
Plot 3: High channel, 9 kHz – 12.75 GHz



12:24:16 15.07.2019

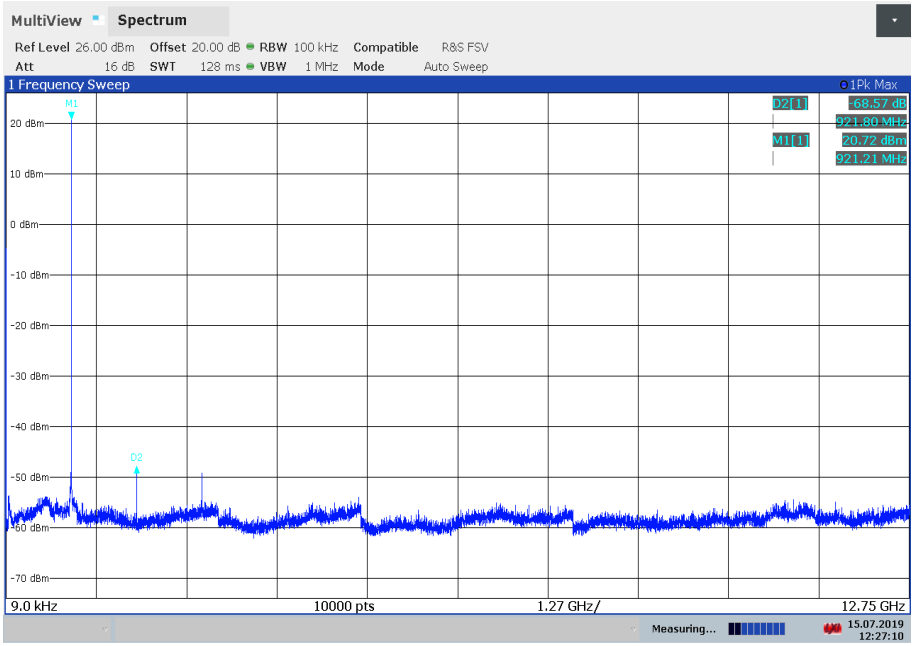
b) RC4 Band

Plot 1: Low channel, 9 kHz – 12.75 GHz



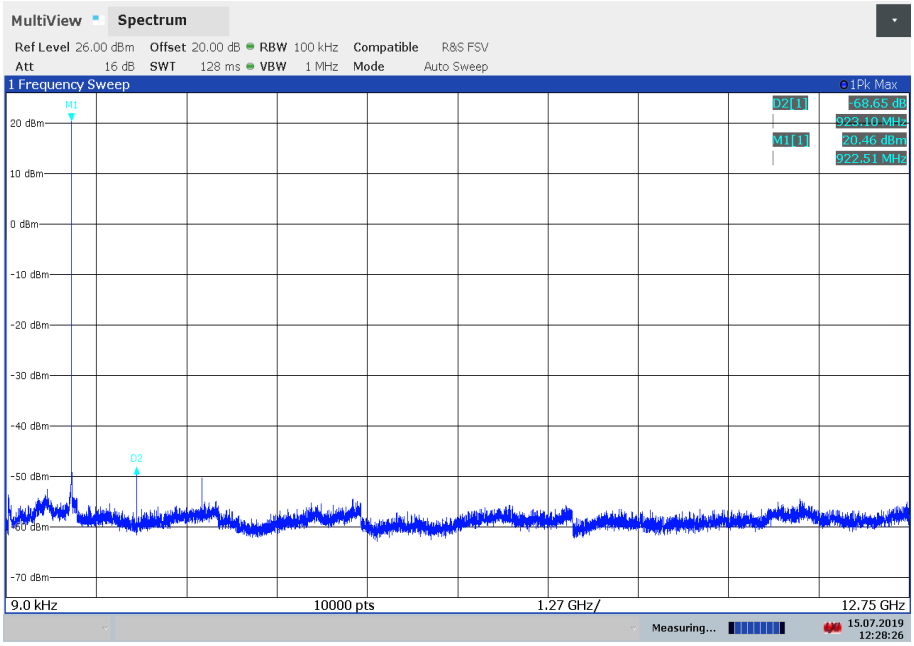
12:25:43 15.07.2019

Plot 2: Middle channel, 9 kHz – 12.75 GHz



12:27:11 15.07.2019

Plot 3: High channel, 9 kHz – 12.75 GHz



12:28:27 15.07.2019

11.9 Spurious Emissions Radiated < 30 MHz

Description:

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

Measurement:

Measurement parameter	
Detector:	Peak / Quasi Peak
Sweep time:	Auto
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 (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

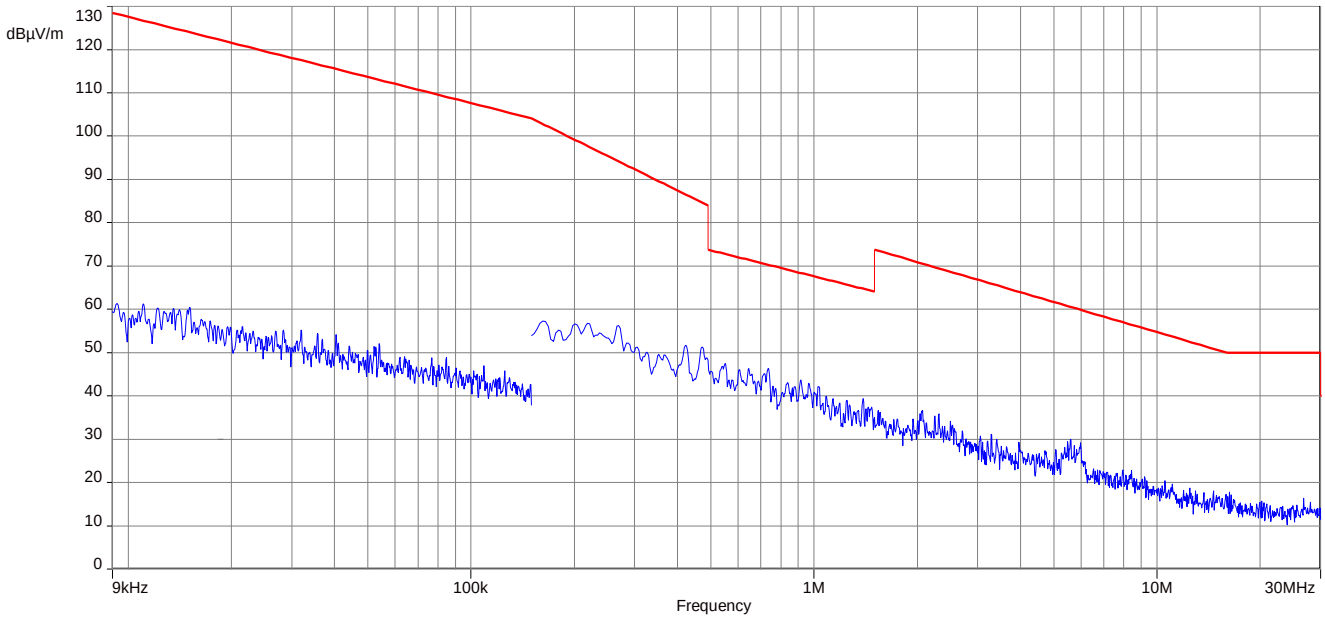
Result:

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.								

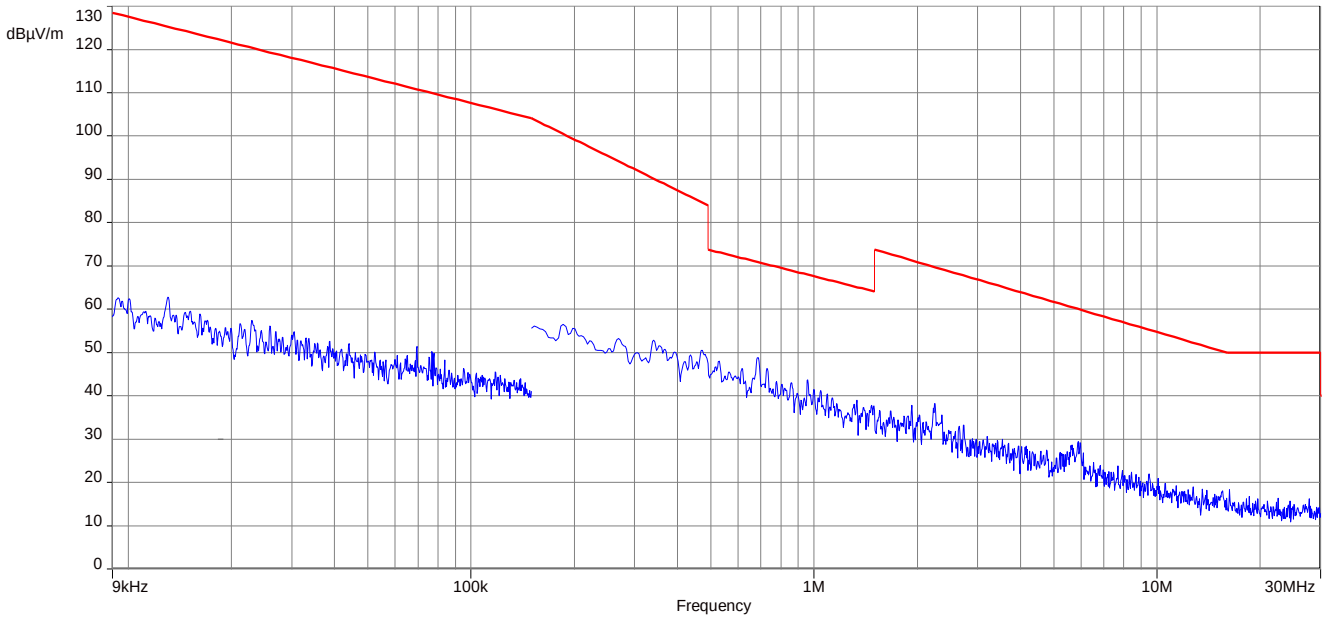
Plots EUT with dipole antenna:

a) RC2 Band

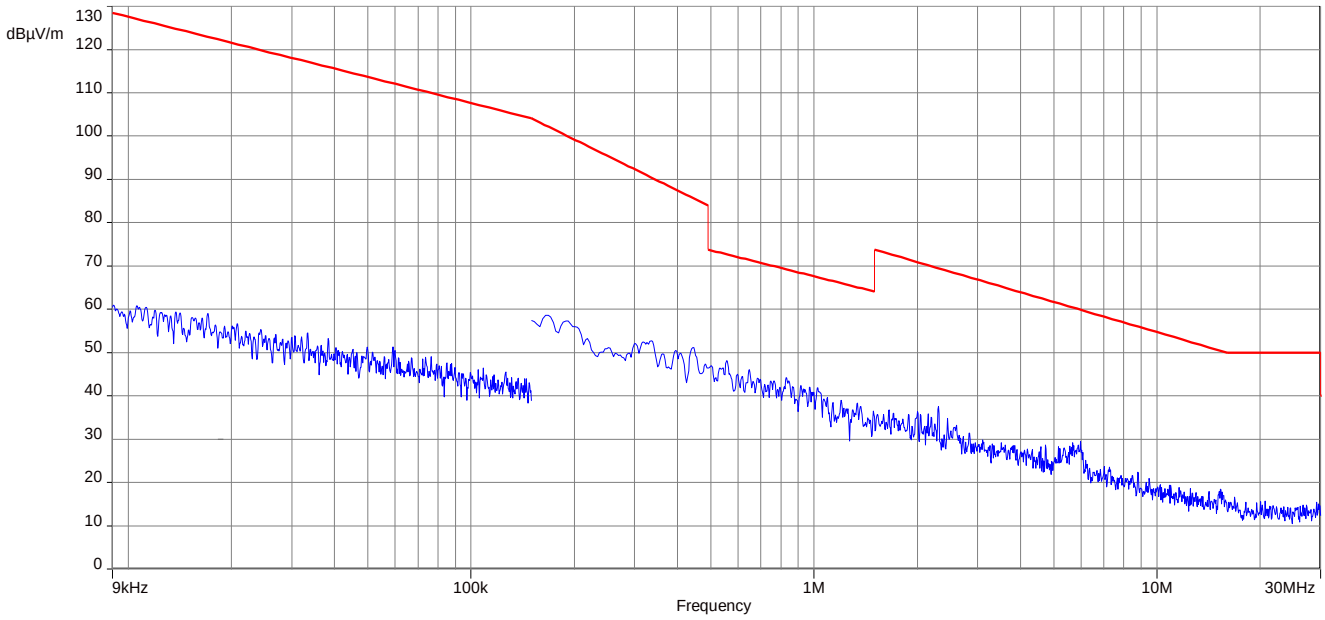
Plot 1: TX-Mode low channel



Plot 2: TX-Mode mid channel

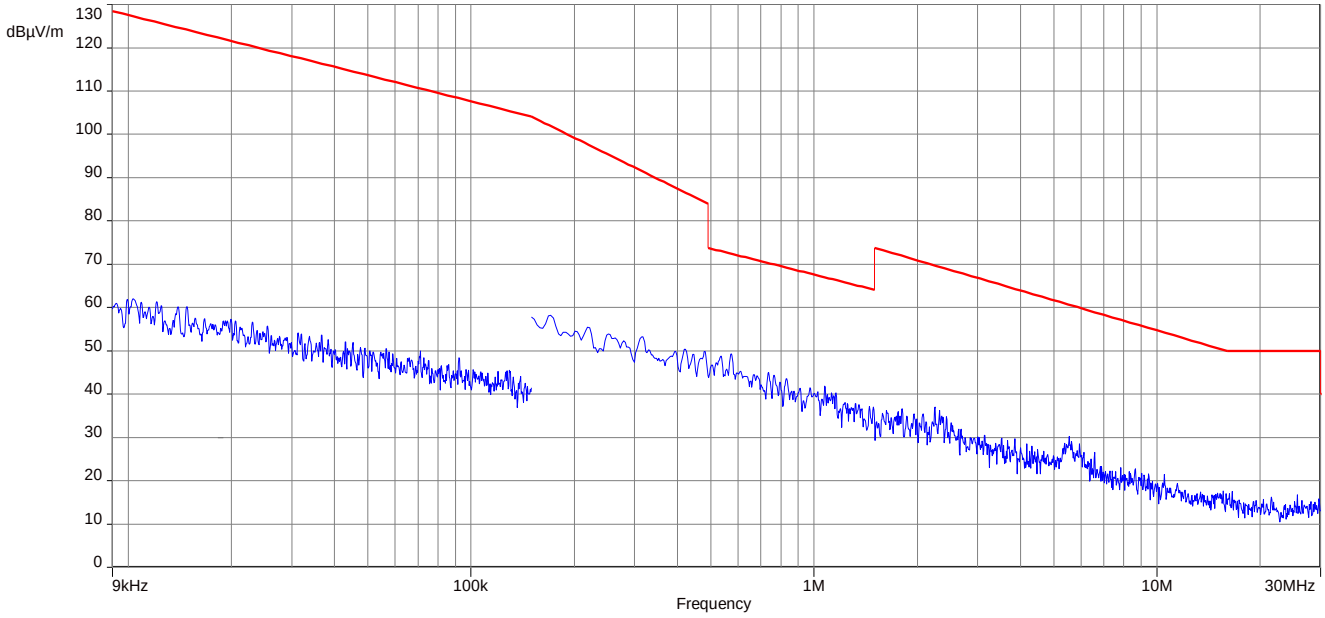


Plot 3: TX-Mode high channel

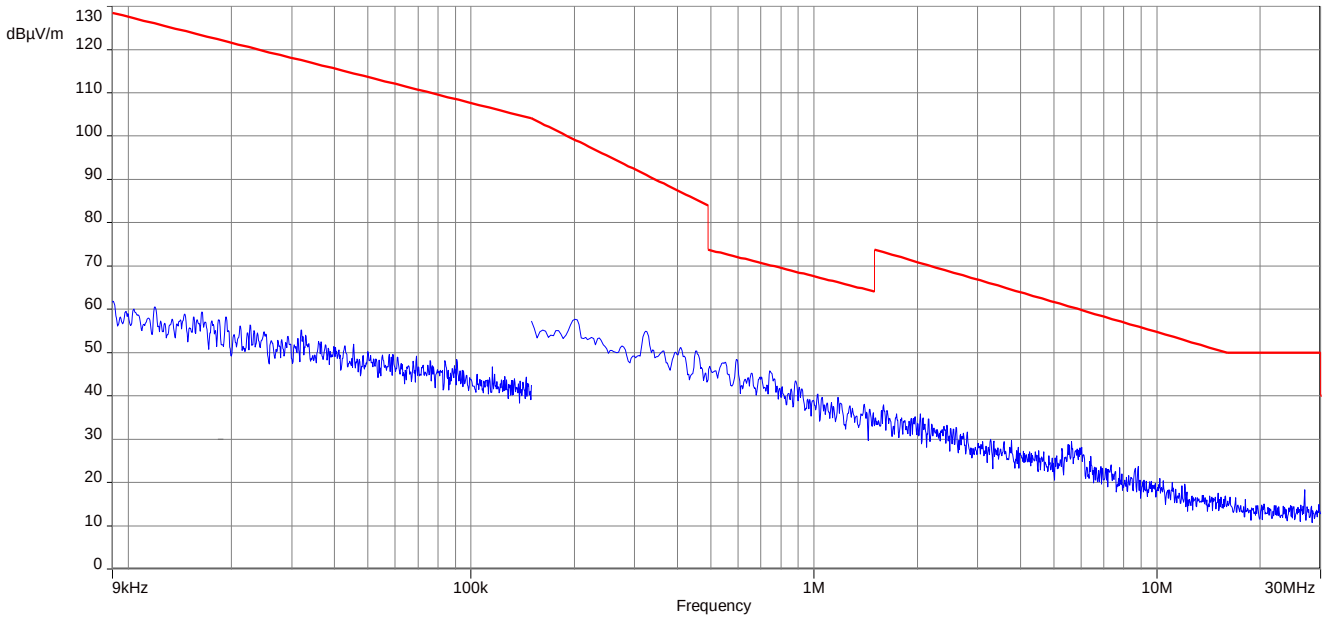


b) RC4 Band

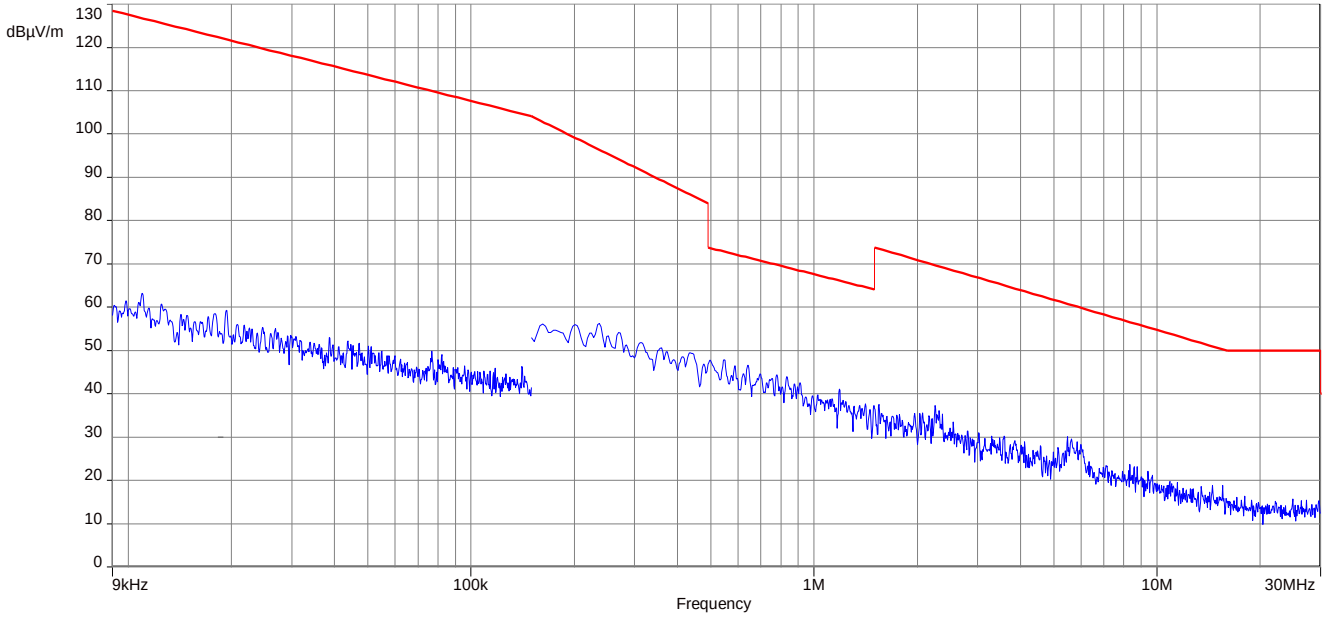
Plot 1: TX-Mode low channel



Plot 2: TX-Mode mid channel



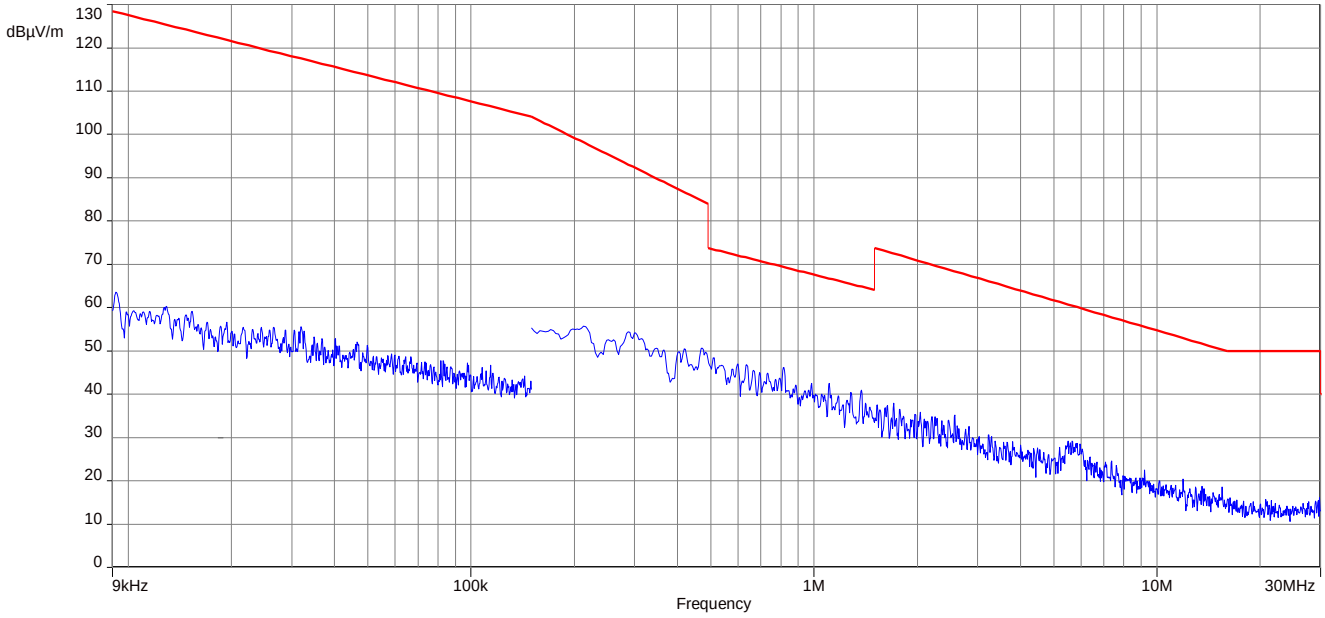
Plot 3: TX-Mode high channel



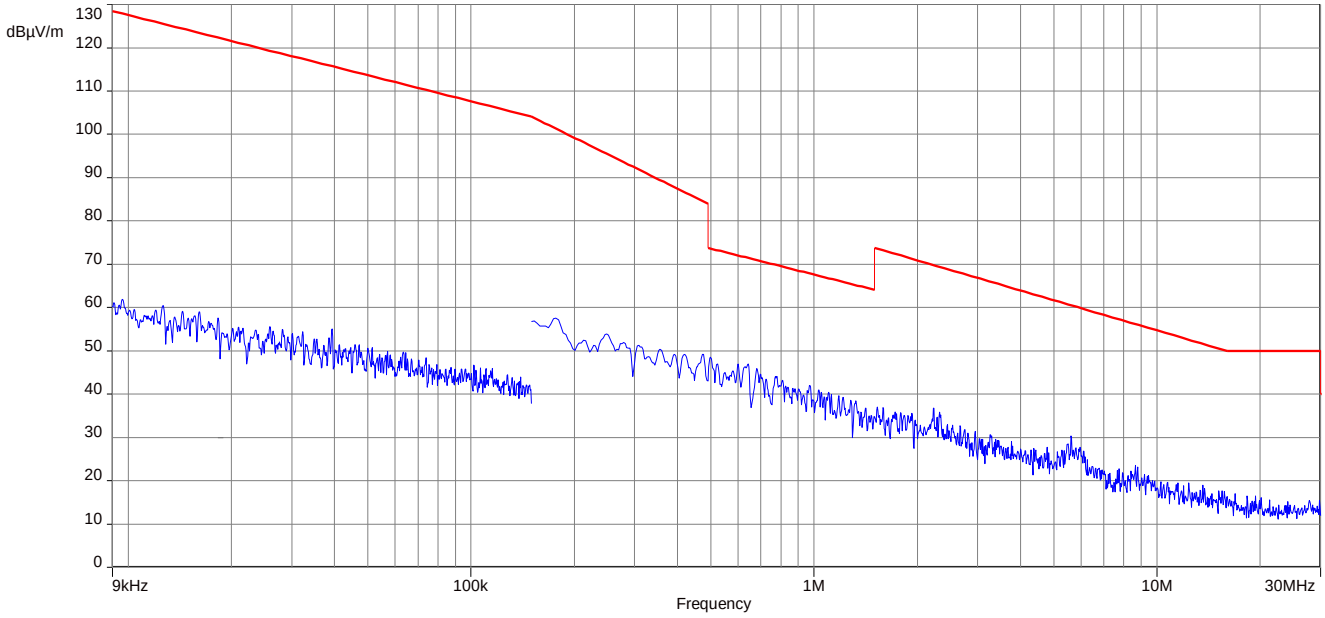
Plots EUT with PCB antenna:

a) RC2 Band

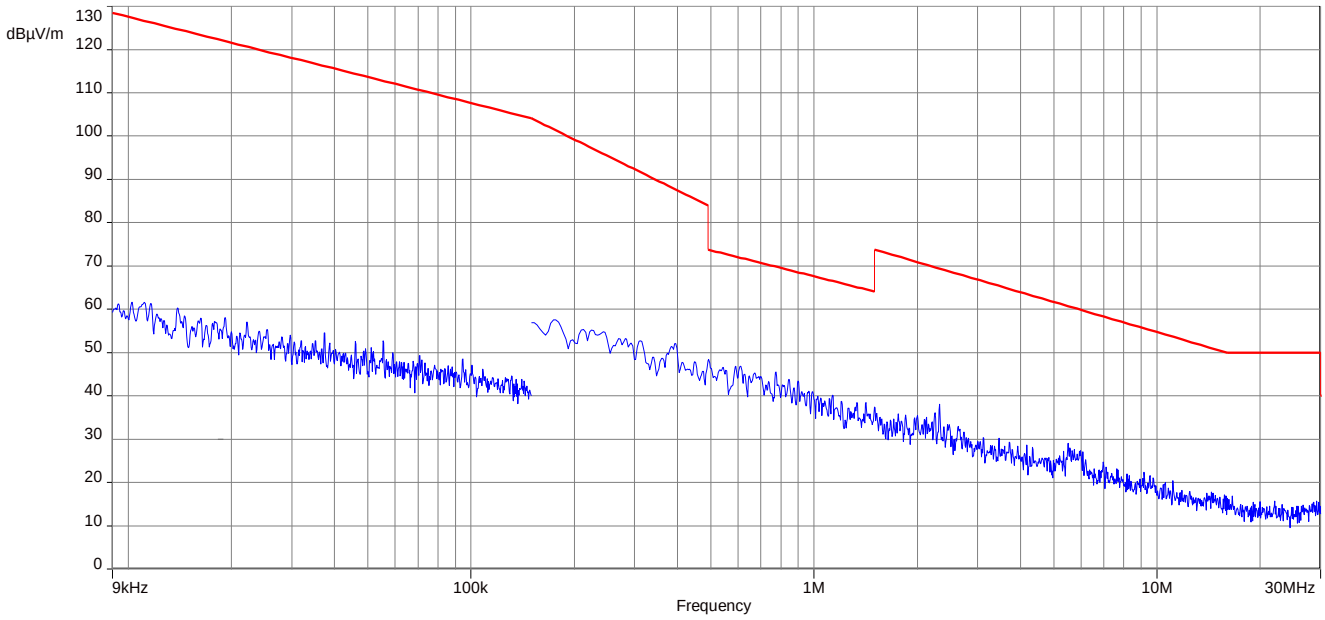
Plot 1: TX-Mode low channel



Plot 2: TX-Mode mid channel

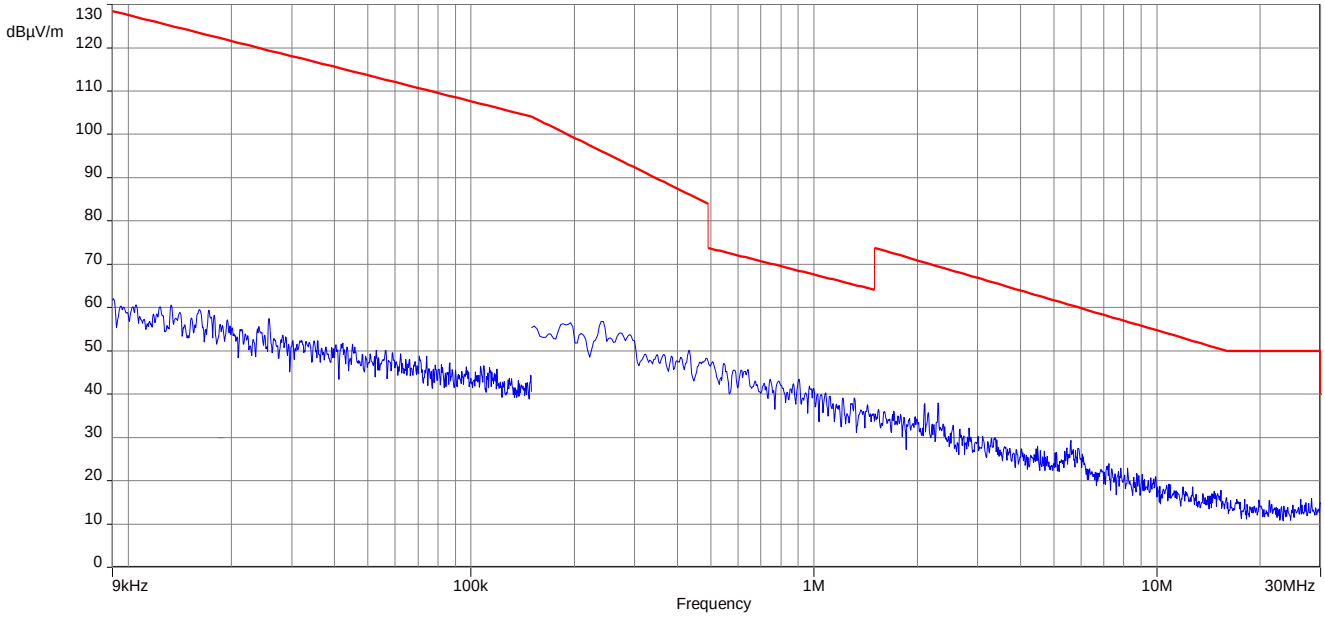


Plot 3: TX-Mode high channel

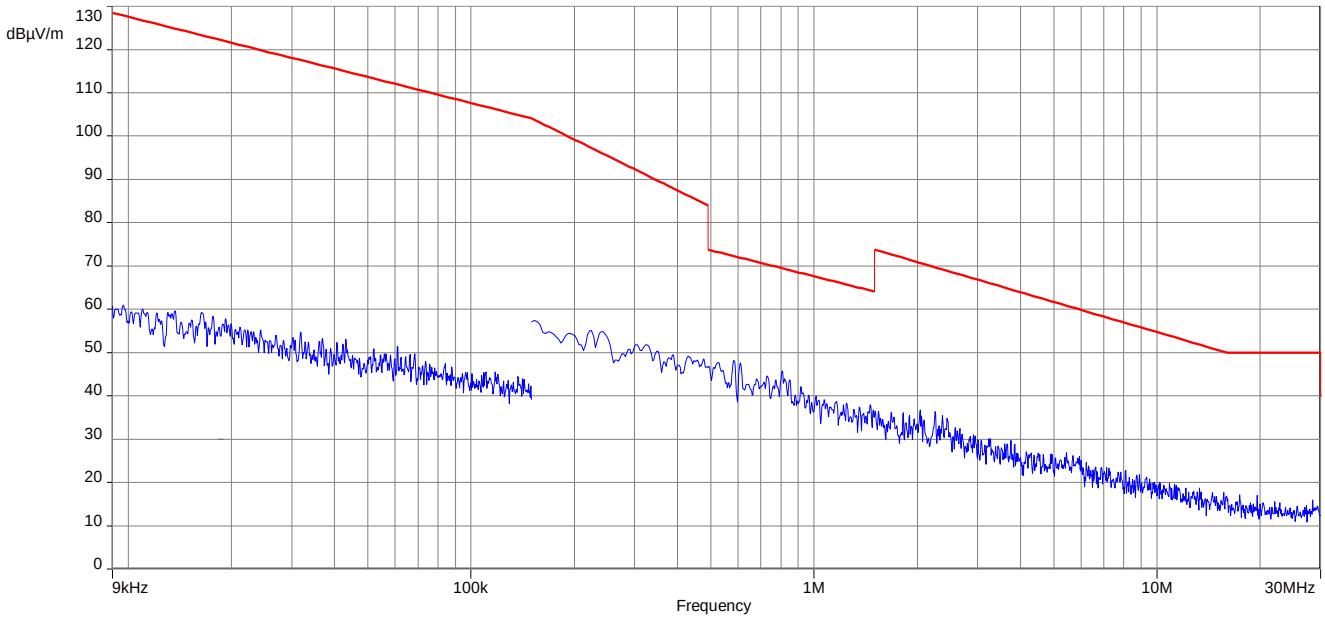


b) <u>RC4 Band</u>

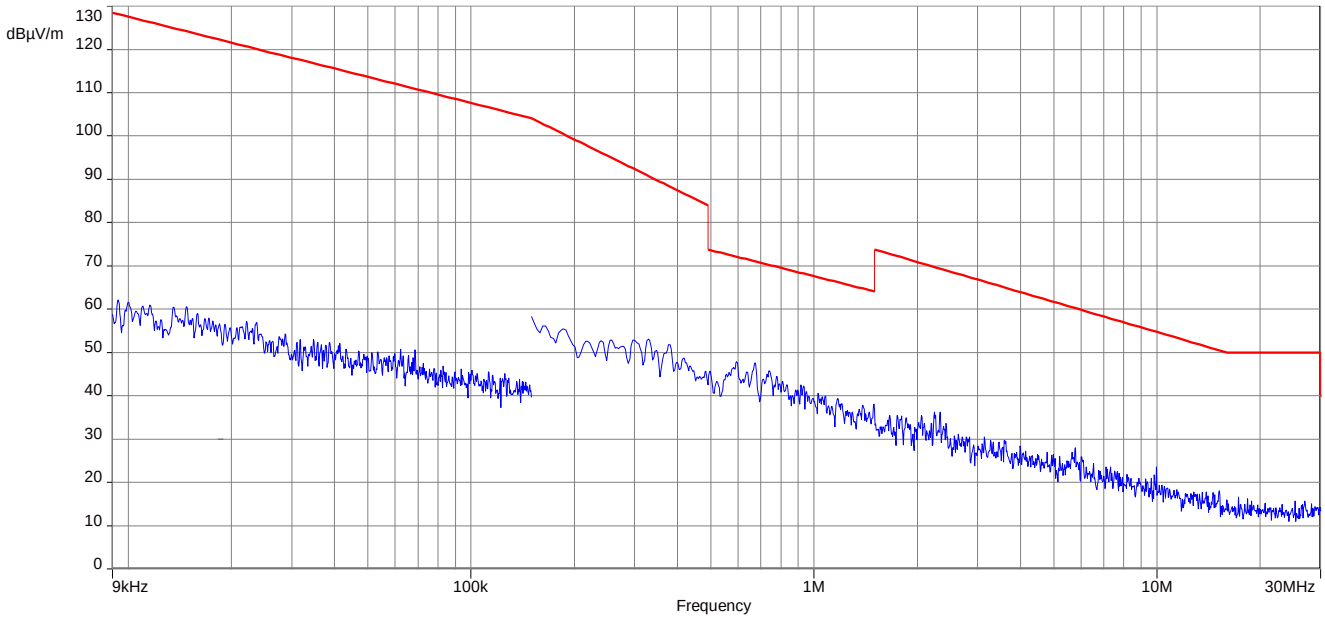
Plot 1: TX-Mode low channel



Plot 2: TX-Mode mid channel



Plot 3: TX-Mode high 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	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	FHSS single channel mode
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

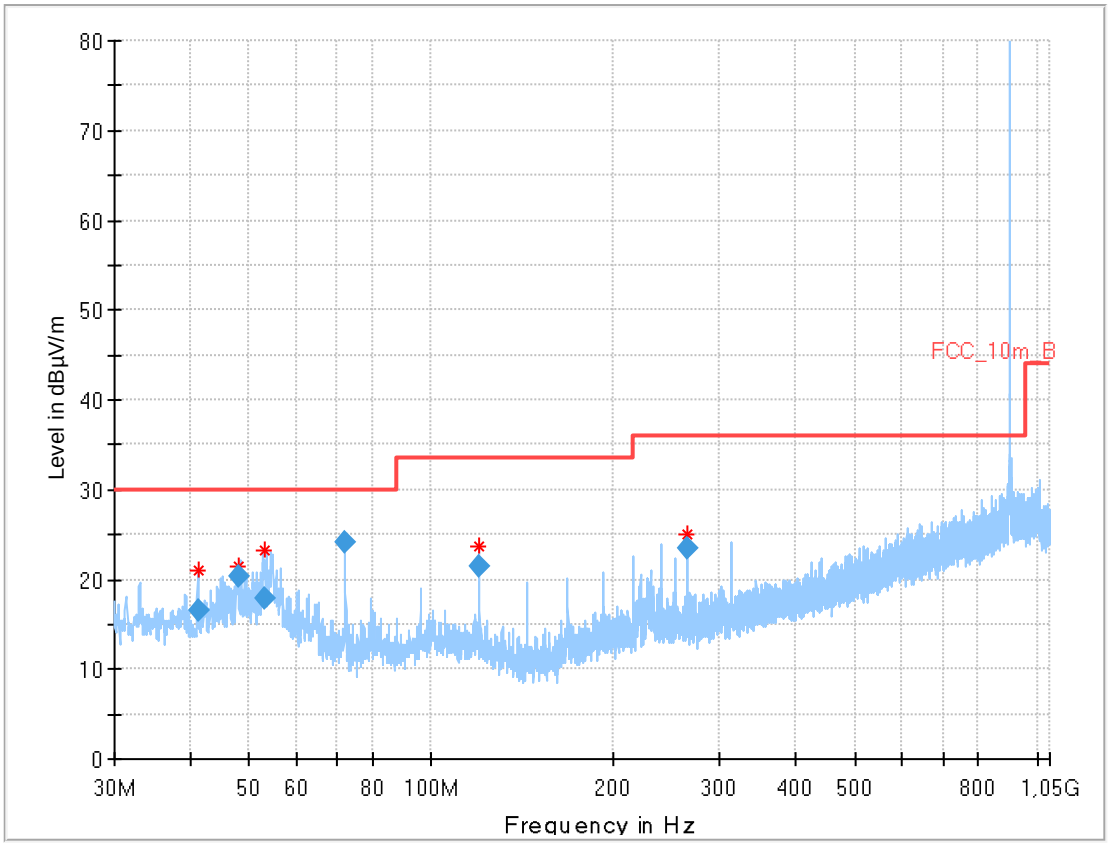
Result:

See result table below the plots.

a) **RC2 Band**

Plots EUT with dipole antenna:

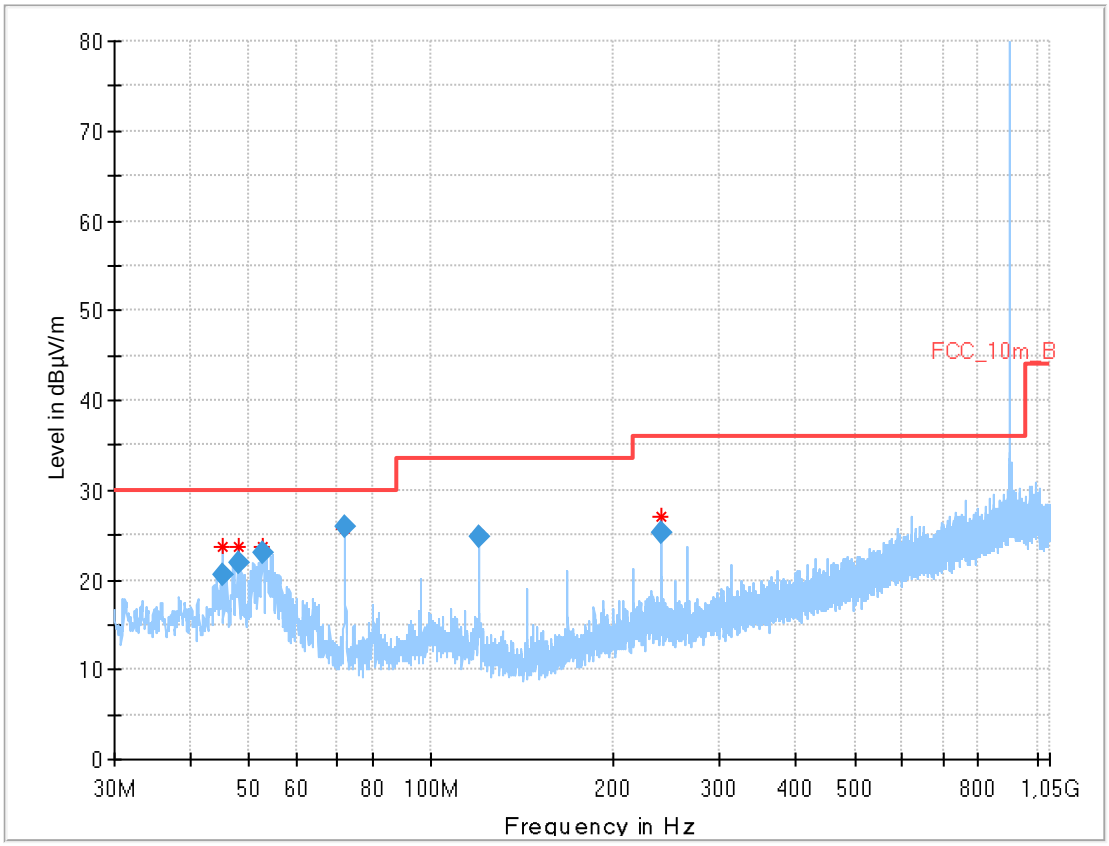
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



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)
41.269	16.57	30.0	13.43	1000	120	170.0	V	280.0	14
48.045	20.41	30.0	9.59	1000	120	101.0	V	280.0	15
52.947	17.77	30.0	12.23	1000	120	170.0	V	112.0	14
72.062	24.14	30.0	5.86	1000	120	145.0	V	12.0	11
120.106	21.51	33.5	11.99	1000	120	170.0	V	72.0	11
264.226	23.55	36.0	12.45	1000	120	98.0	V	112.0	14

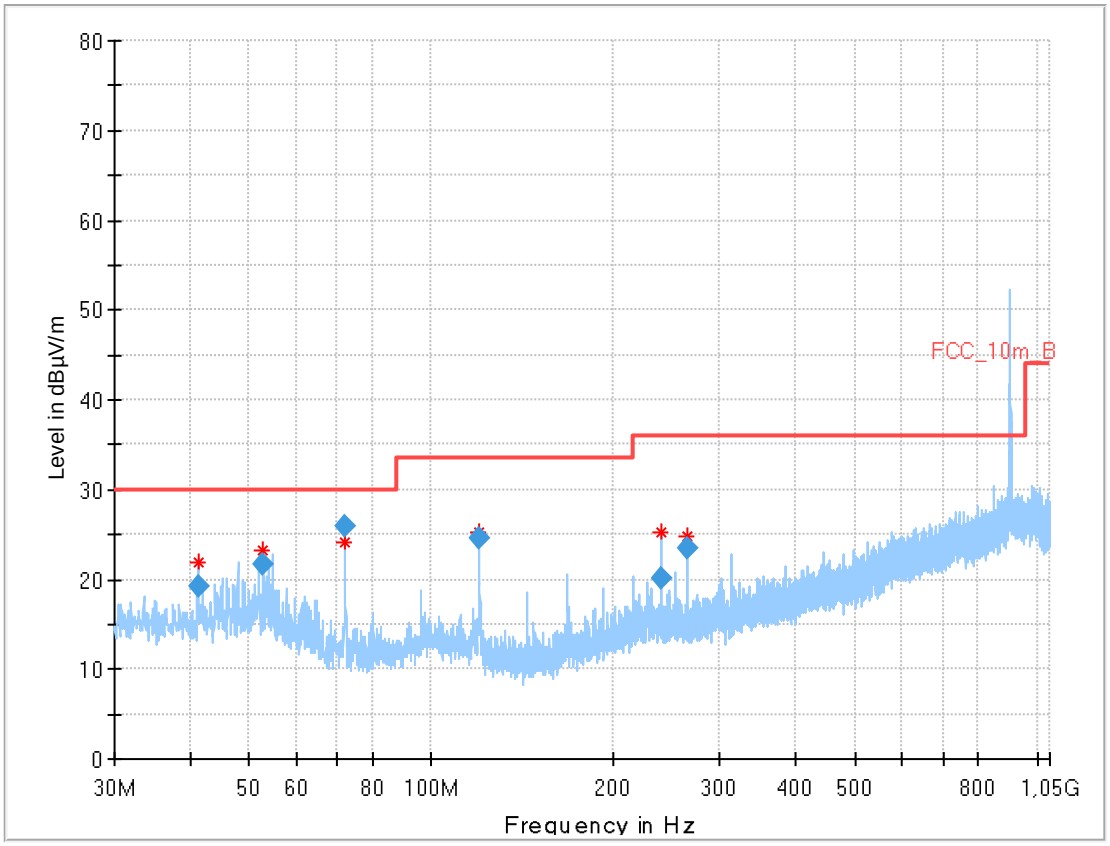
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



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)
45.208	20.49	30.0	9.51	1000	120	101.0	V	292.0	15
48.040	21.79	30.0	8.21	1000	120	98.0	V	292.0	15
52.822	22.95	30.0	7.05	1000	120	98.0	V	270.0	15
72.062	25.95	30.0	4.05	1000	120	170.0	V	68.0	11
120.088	24.77	33.5	8.73	1000	120	146.0	V	271.0	11
240.217	25.22	36.0	10.78	1000	120	98.0	V	79.0	13

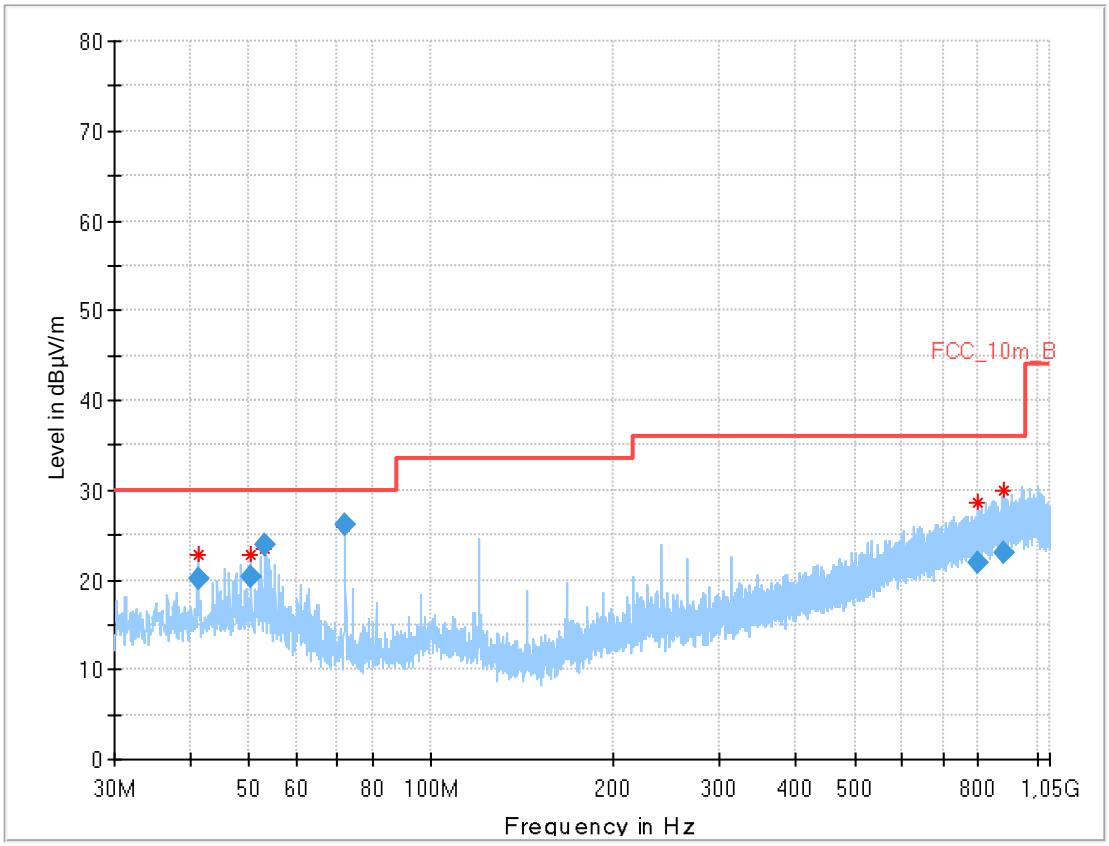
Plot 3: 30 MHz – 1 GHz, horizontal & vertical polarisation (highest channel)



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)
41.271	19.14	30.0	10.86	1000	120	147.0	H	292.0	14
52.764	21.76	30.0	8.24	1000	120	170.0	V	202.0	15
72.066	25.83	30.0	4.17	1000	120	170.0	V	79.0	11
120.100	24.69	33.5	8.81	1000	120	170.0	V	280.0	11
240.012	20.01	36.0	15.99	1000	120	98.0	V	112.0	13
264.240	23.39	36.0	12.61	1000	120	98.0	V	180.0	14

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

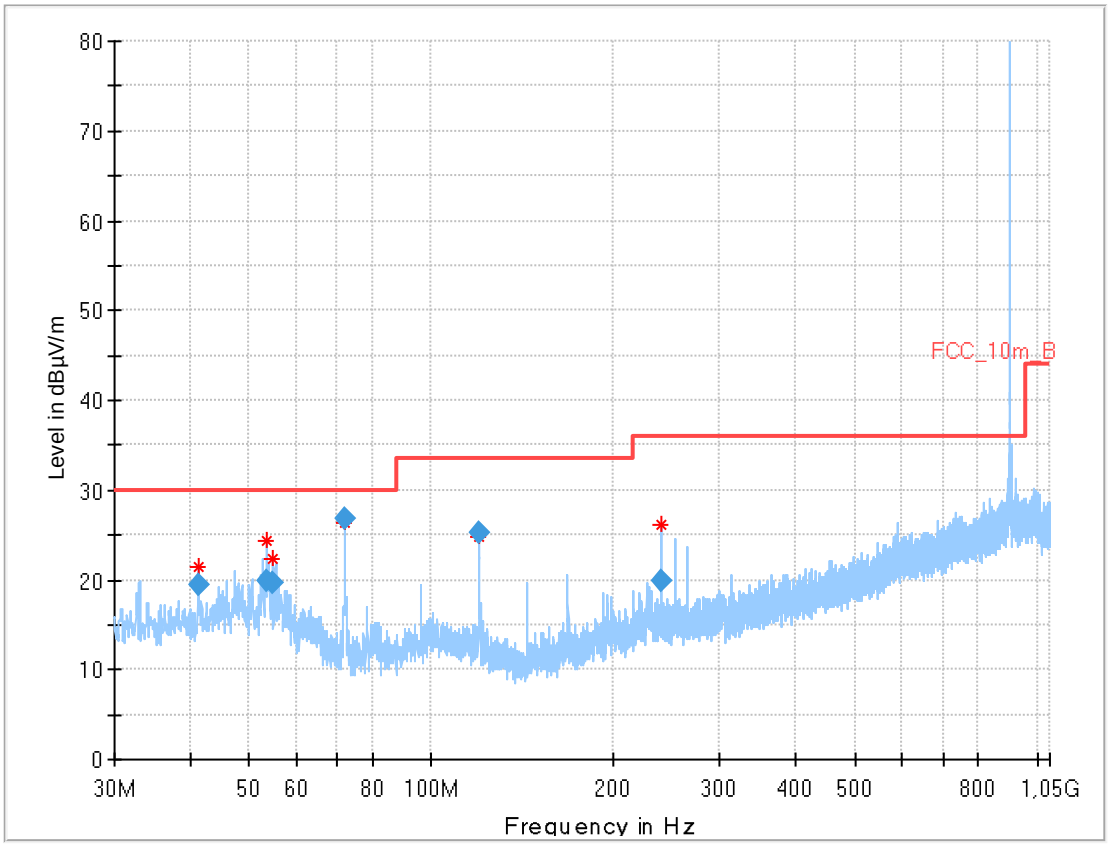


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
41.269	20.14	30.0	9.86	1000	120	146.0	H	292.0	14
50.426	20.40	30.0	9.60	1000	120	101.0	V	259.0	15
53.277	23.82	30.0	6.18	1000	120	170.0	V	248.0	14
72.072	26.10	30.0	3.90	1000	120	170.0	V	68.0	11
799.513	21.98	36.0	14.02	1000	120	147.0	H	202.0	22
882.607	23.12	36.0	12.88	1000	120	170.0	V	270.0	24

Plots EUT with PCB antenna:

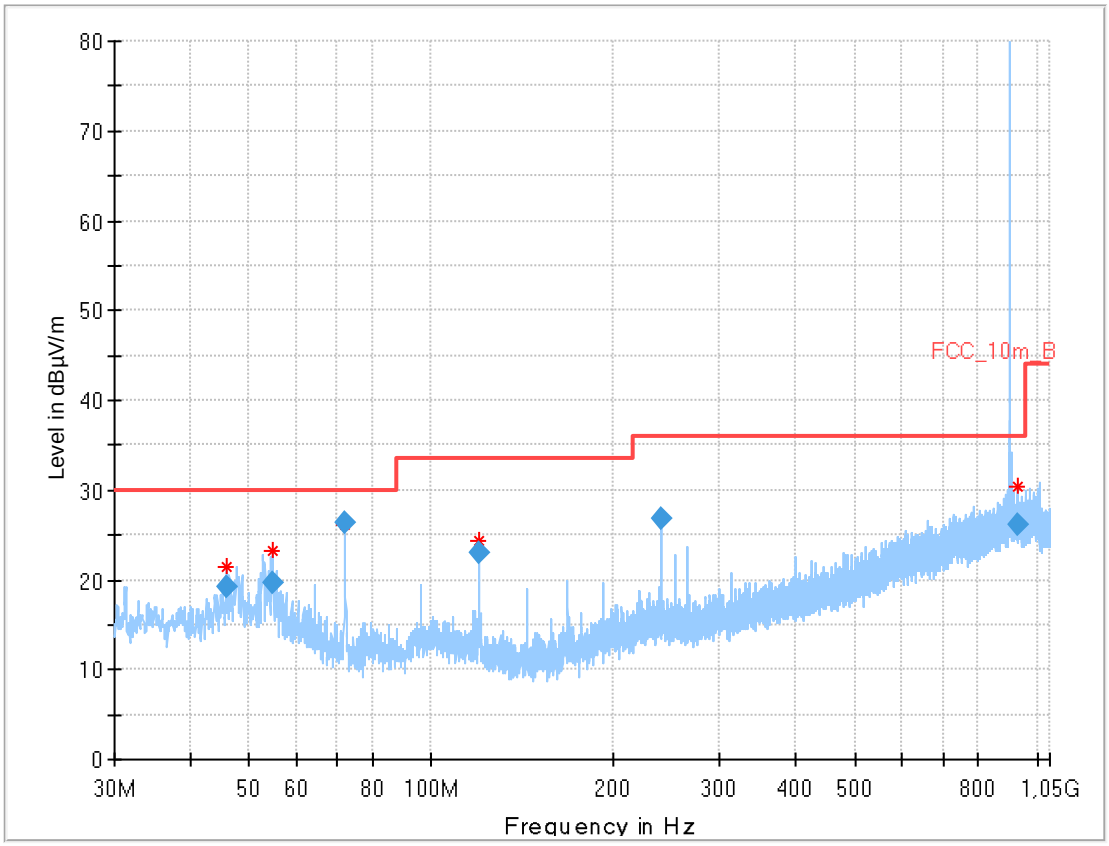
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



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)
41.243	19.34	30.0	10.66	1000	120	101.0	V	202.0	14
53.338	19.85	30.0	10.15	1000	120	101.0	V	280.0	14
54.740	19.70	30.0	10.30	1000	120	101.0	V	270.0	14
72.060	26.83	30.0	3.17	1000	120	170.0	V	68.0	11
120.101	25.25	33.5	8.25	1000	120	170.0	V	292.0	11
239.991	19.82	36.0	16.18	1000	120	98.0	V	71.0	13

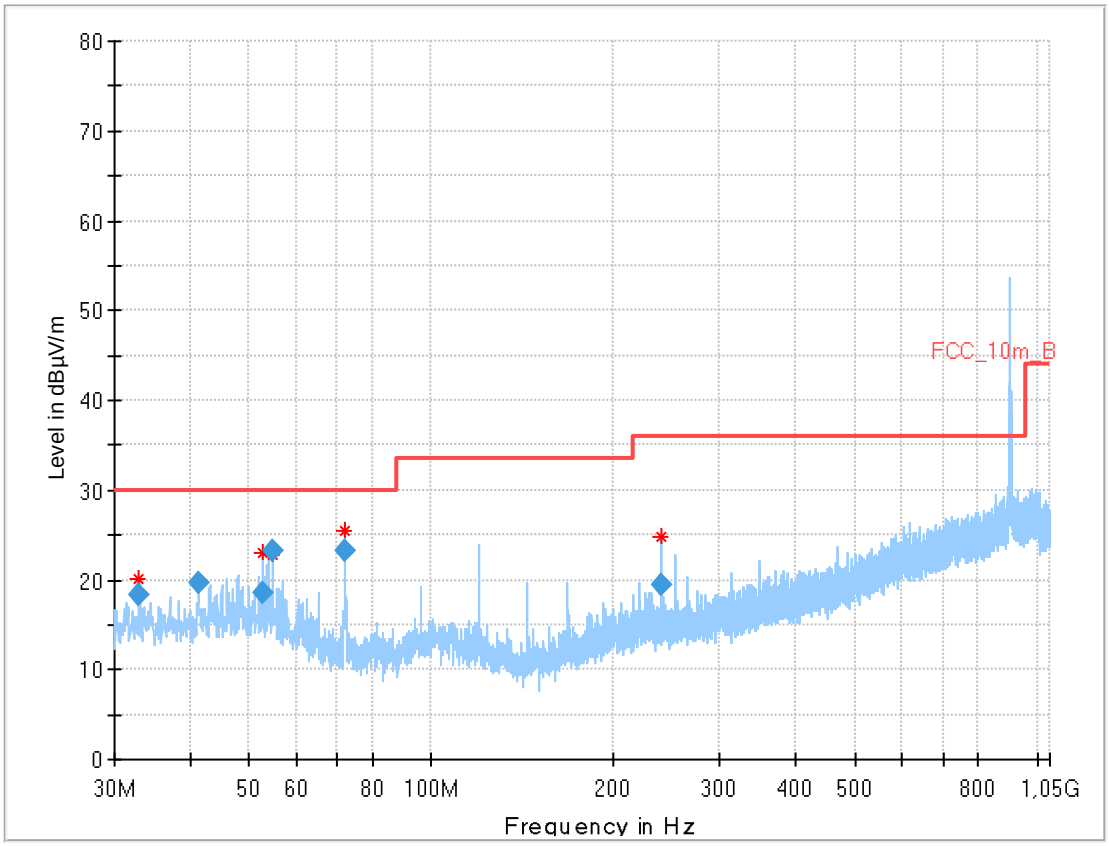
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



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)
45.996	19.13	30.0	10.87	1000	120	146.0	V	270.0	15
54.670	19.74	30.0	10.26	1000	120	98.0	V	247.0	14
72.057	26.43	30.0	3.57	1000	120	170.0	V	67.0	11
120.110	23.08	33.5	10.42	1000	120	148.0	V	-21.0	11
240.199	26.75	36.0	9.25	1000	120	101.0	V	68.0	13
927.994	26.18	36.0	9.82	1000	120	98.0	H	281.0	24

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



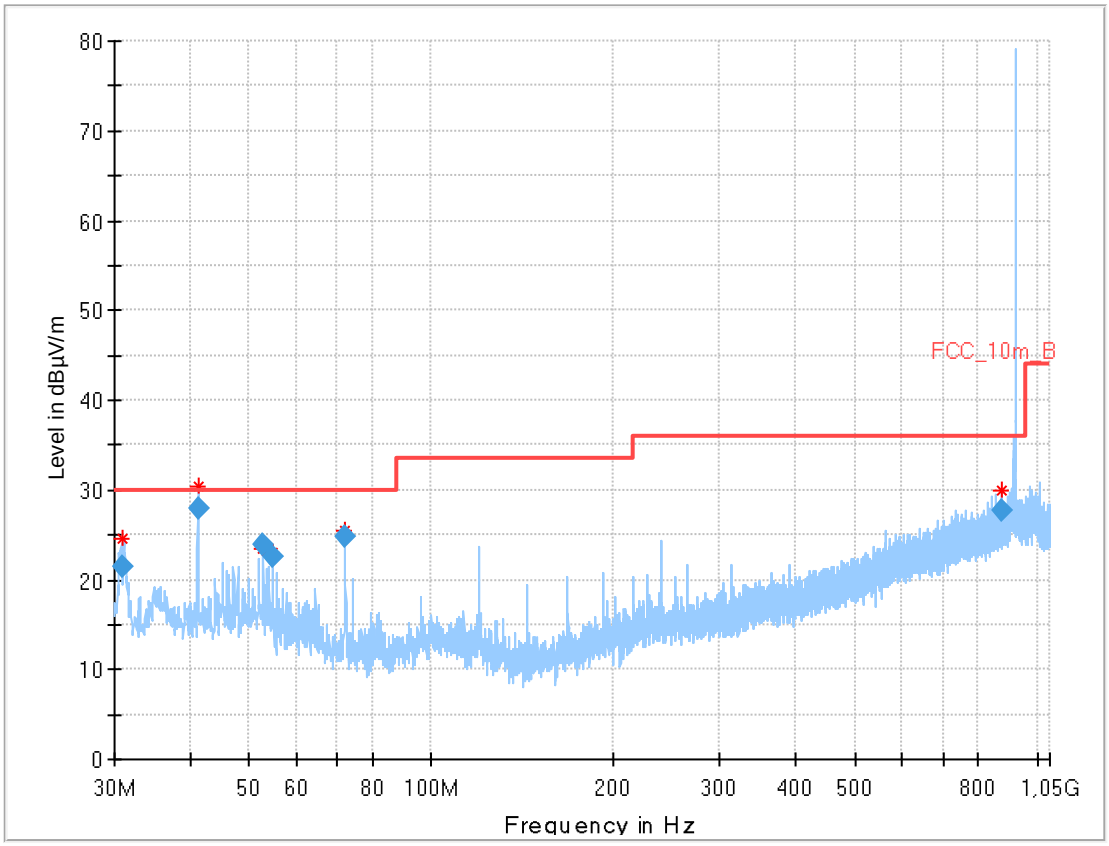
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
32.977	18.28	30.0	11.72	1000	120	101.0	V	247.0	13
41.279	19.56	30.0	10.44	1000	120	101.0	V	292.0	14
52.798	18.65	30.0	11.35	1000	120	101.0	V	259.0	15
54.755	23.20	30.0	6.80	1000	120	101.0	V	247.0	14
72.067	23.17	30.0	6.83	1000	120	147.0	V	162.0	11
239.995	19.48	36.0	16.52	1000	120	104.0	V	91.0	13

a) **RC4 Band**

Plots EUT with dipole antenna:

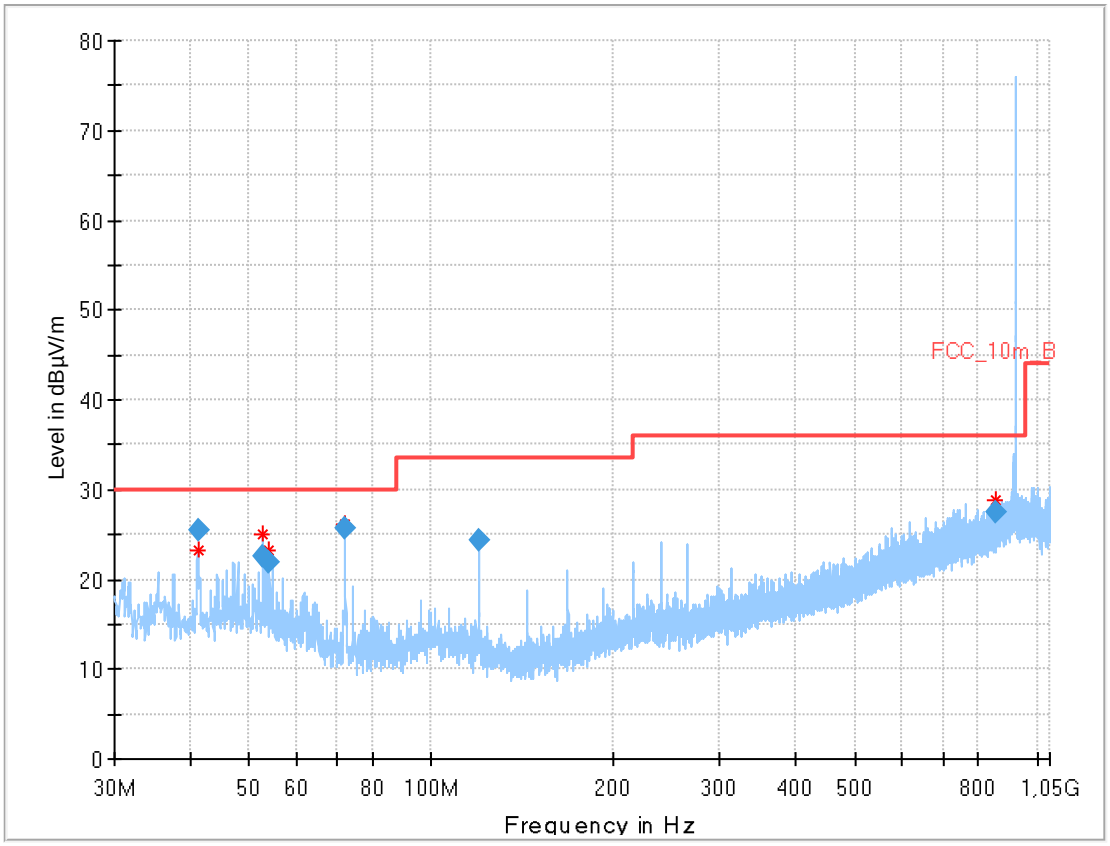
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



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)
30.939	21.35	30.0	8.65	1000	120	101.0	V	252.0	13
41.251	27.86	30.0	2.14	1000	120	170.0	H	180.0	14
52.850	23.81	30.0	6.19	1000	120	101.0	V	247.0	15
54.844	22.56	30.0	7.44	1000	120	98.0	V	-22.0	14
72.064	24.70	30.0	5.30	1000	120	147.0	V	112.0	11
872.316	27.74	36.0	8.26	1000	120	101.0	V	259.0	24

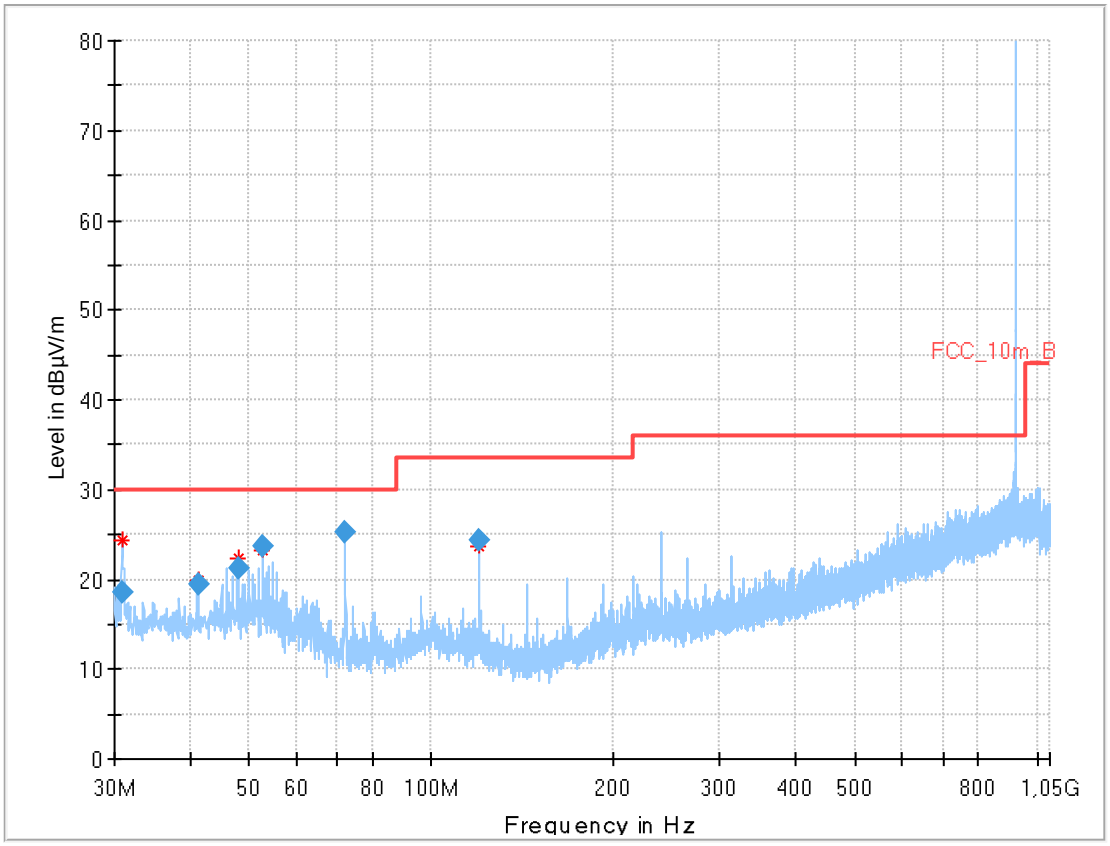
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



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)
41.273	25.37	30.0	4.63	1000	120	98.0	V	292.0	14
52.837	22.67	30.0	7.33	1000	120	98.0	V	292.0	15
54.035	21.97	30.0	8.03	1000	120	101.0	V	247.0	14
72.058	25.72	30.0	4.28	1000	120	170.0	V	72.0	11
120.118	24.38	33.5	9.12	1000	120	170.0	V	252.0	11
854.683	27.51	36.0	8.49	1000	120	170.0	V	-21.0	23

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

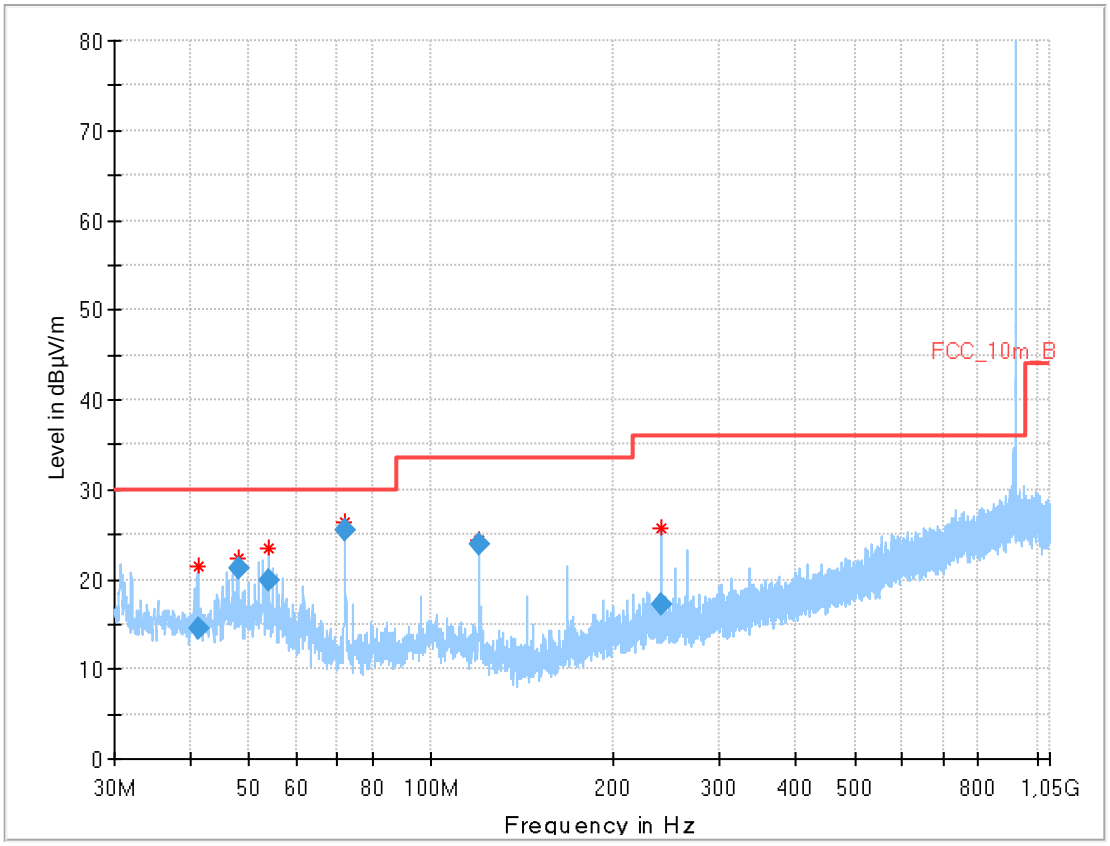


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.913	18.44	30.0	11.56	1000	120	148.0	V	259.0	13
41.234	19.44	30.0	10.56	1000	120	101.0	V	22.0	14
47.982	21.14	30.0	8.86	1000	120	101.0	V	202.0	15
52.763	23.66	30.0	6.34	1000	120	101.0	V	270.0	15
72.065	25.14	30.0	4.86	1000	120	101.0	V	71.0	11
120.110	24.32	33.5	9.18	1000	120	170.0	V	270.0	11

Plots EUT with PCB antenna:

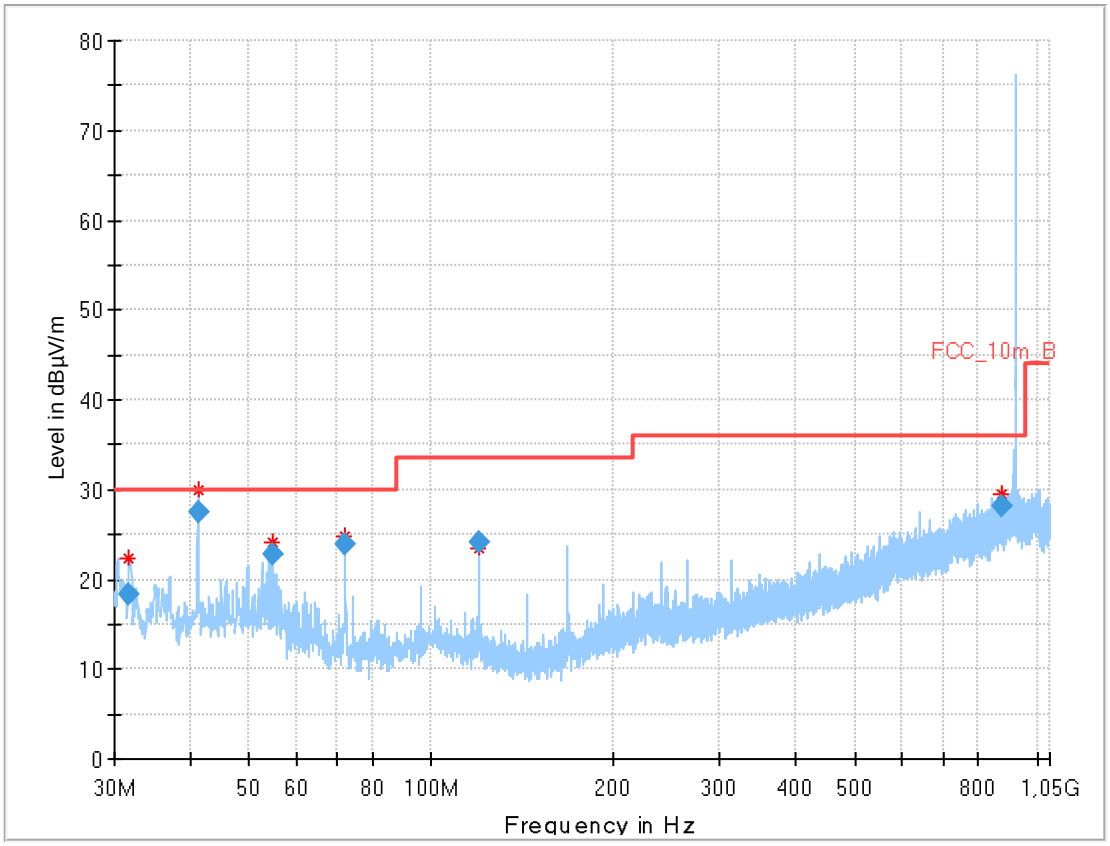
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



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)
41.268	14.55	30.0	15.45	1000	120	98.0	V	251.0	14
48.009	21.20	30.0	8.80	1000	120	98.0	V	269.0	15
53.973	19.83	30.0	10.17	1000	120	101.0	V	179.0	14
72.076	25.54	30.0	4.46	1000	120	170.0	V	112.0	11
120.122	24.01	33.5	9.49	1000	120	170.0	V	292.0	11
240.008	17.26	36.0	18.74	1000	120	101.0	V	79.0	13

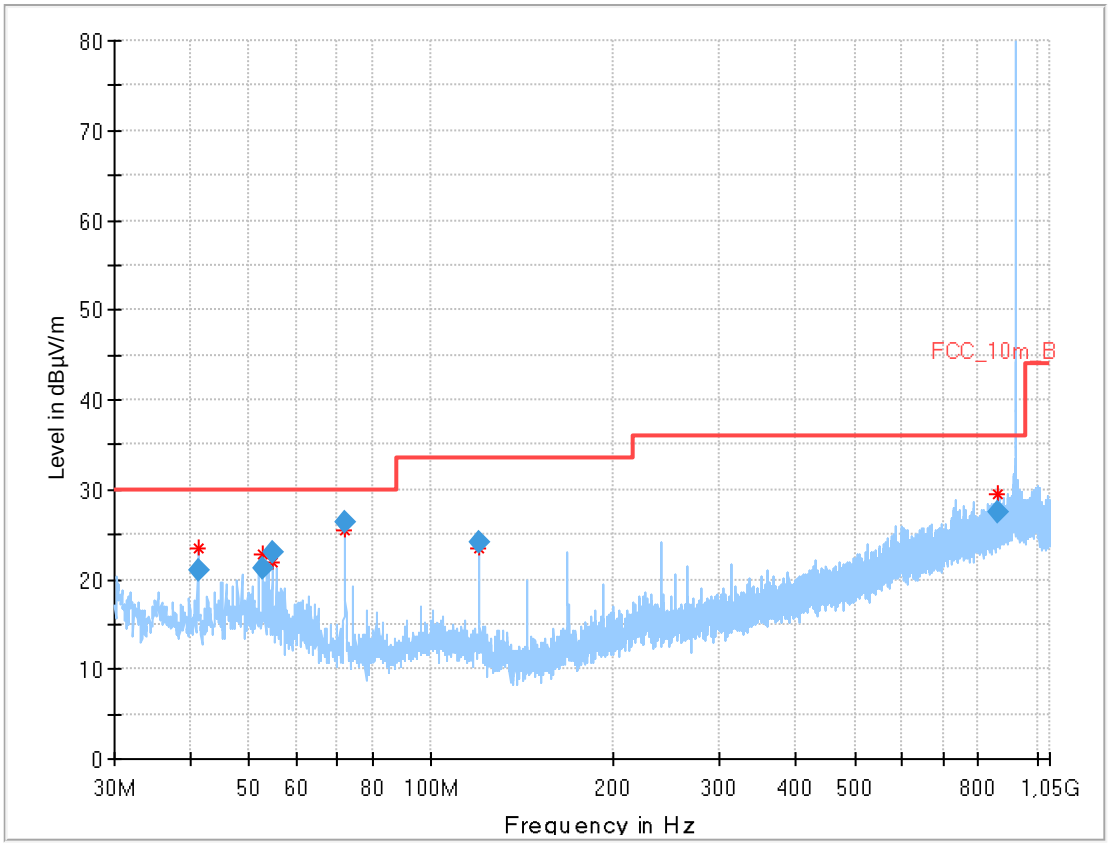
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



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)
31.727	18.36	30.0	11.64	1000	120	101.0	H	157.0	13
41.241	27.49	30.0	2.51	1000	120	170.0	H	292.0	14
54.584	22.71	30.0	7.29	1000	120	101.0	V	292.0	14
72.075	23.93	30.0	6.07	1000	120	170.0	V	180.0	11
120.118	24.12	33.5	9.38	1000	120	170.0	V	281.0	11
875.024	28.15	36.0	7.85	1000	120	170.0	V	280.0	24

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)
41.240	21.11	30.0	8.89	1000	120	147.0	V	191.0	14
52.675	21.14	30.0	8.86	1000	120	101.0	V	190.0	15
54.632	23.10	30.0	6.90	1000	120	101.0	V	248.0	14
72.060	26.39	30.0	3.61	1000	120	170.0	V	68.0	11
120.107	24.08	33.5	9.42	1000	120	170.0	V	270.0	11
858.858	27.54	36.0	8.46	1000	120	170.0	H	202.0	23

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 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
Measured modulation	FHSS single channel mode
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:

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

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

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

a) RC2 Band

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]
2706.4	Peak	52.48	2710	Peak	52.59	2714.2	Peak	54.03
	AVG	50.03		AVG	50.25		AVG	52.01

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]
No Spurious Emissions detected.								

b) RC4 Band

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]
2760.4	Peak	54.01	2764	Peak	52.75	2767.6	Peak	51.24
	AVG	51.89		AVG	50.43		AVG	48.42

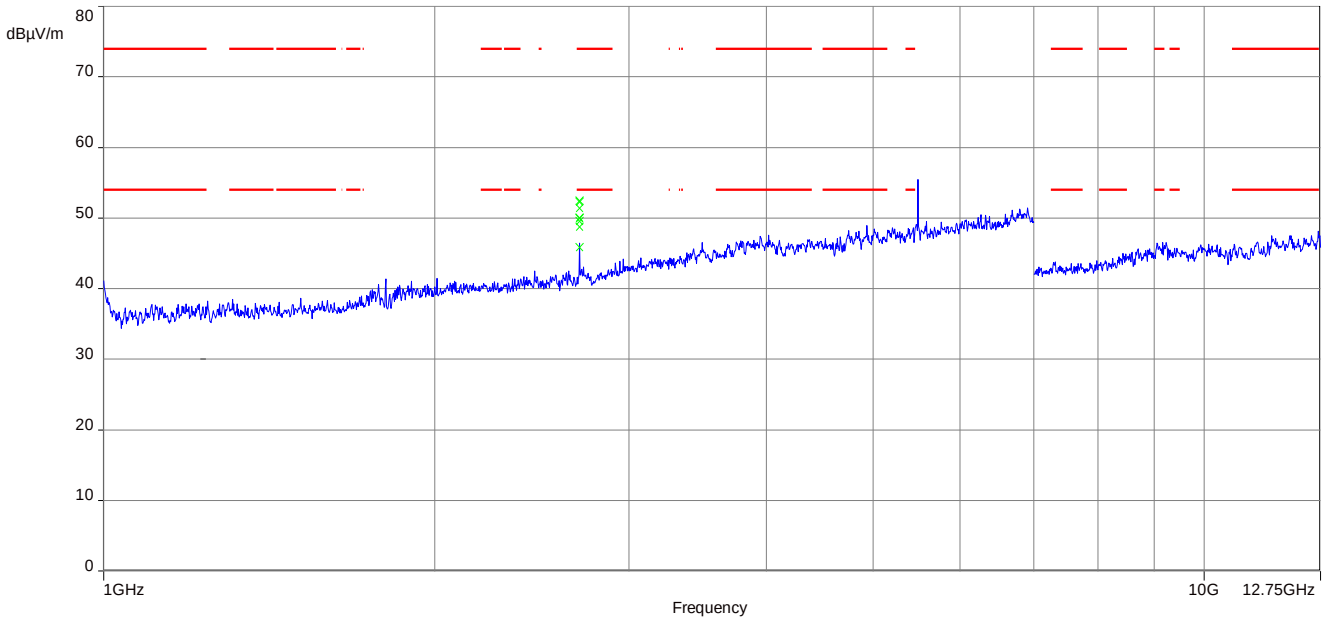
2) EUT with PCB antenna

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]
No Spurious Emissions detected.								

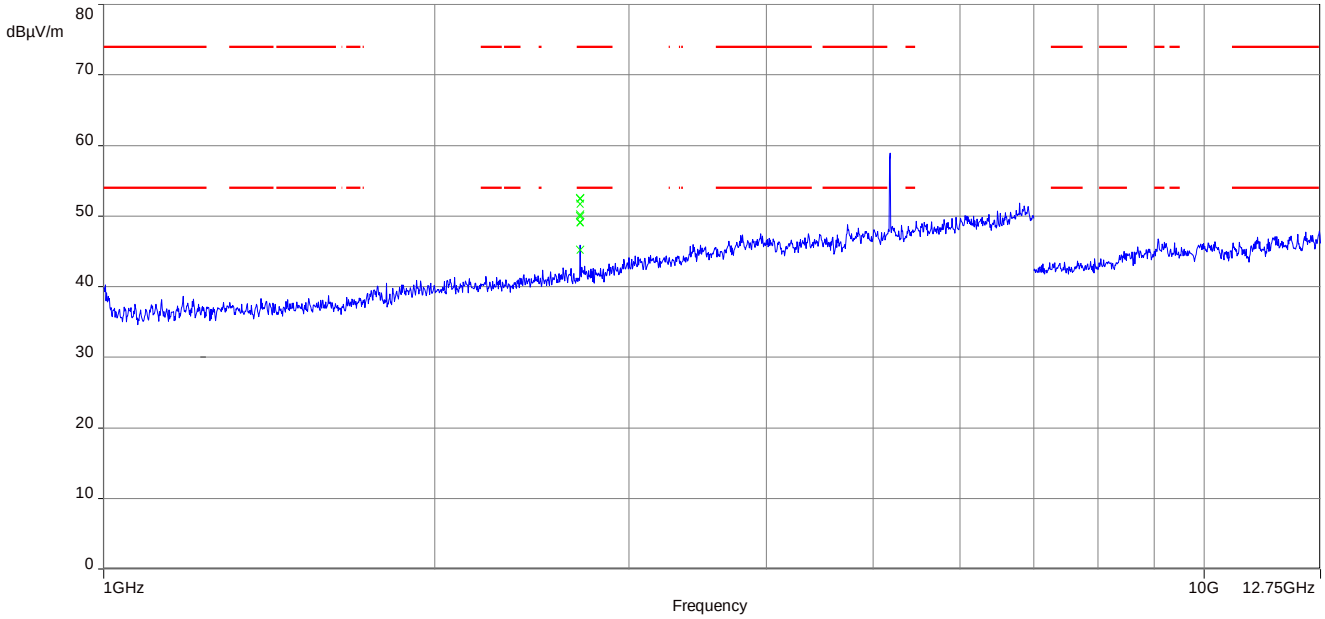
Plots EUT with dipole antenna:

a) RC2 Band

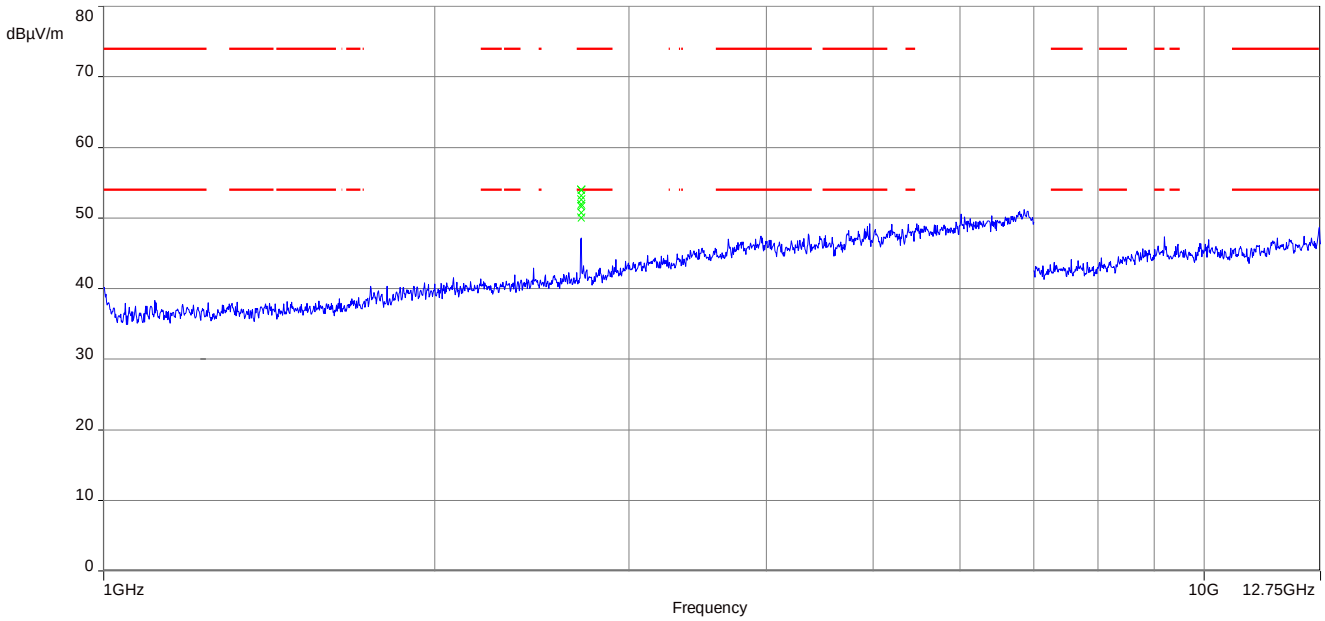
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



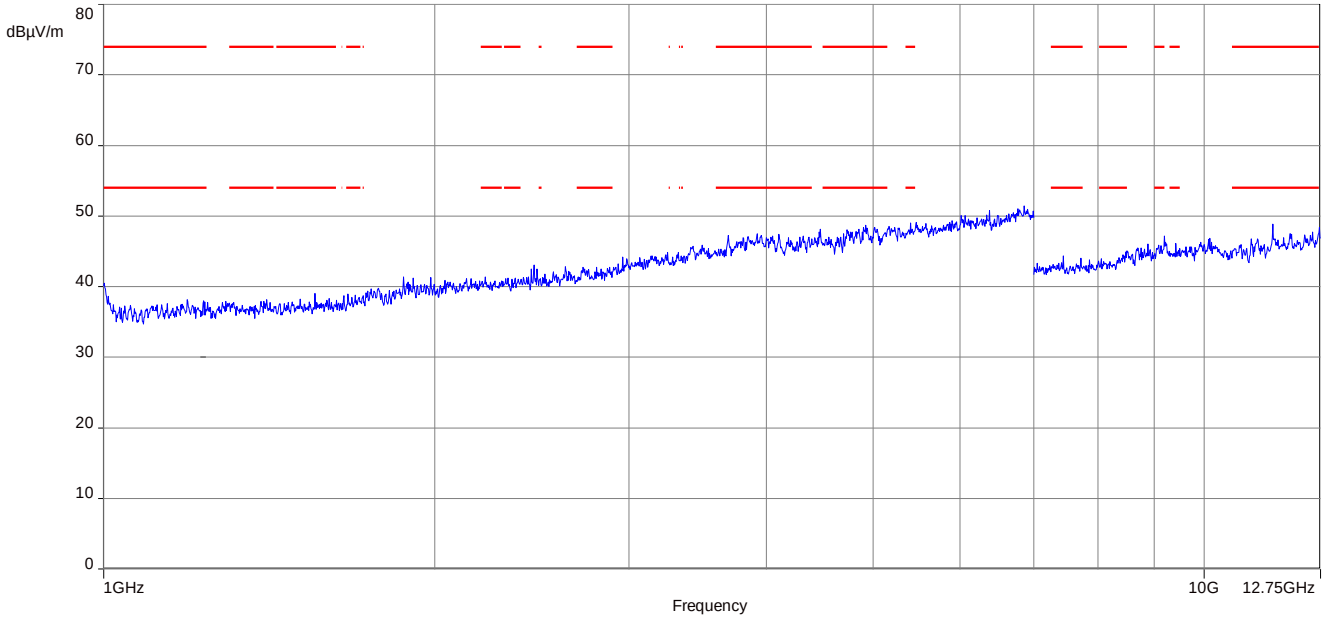
Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



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

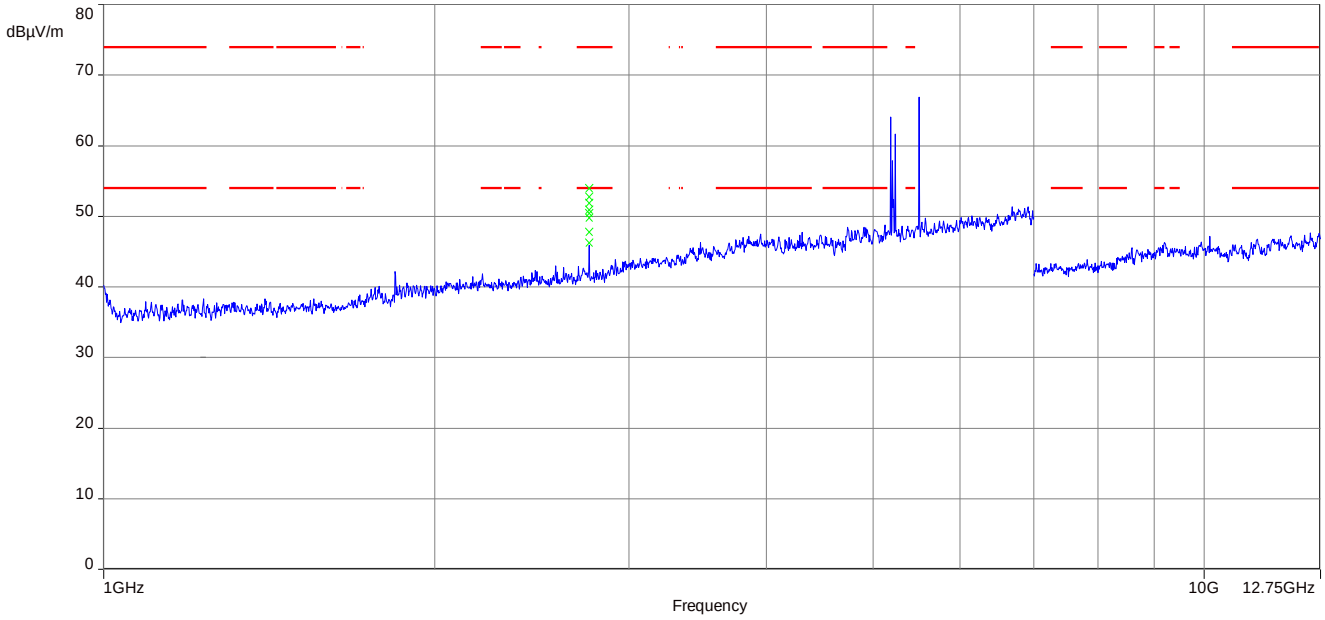


Plot 4: 1GHz – 12.75 GHz, RX-Mode, horizontal & vertical polarisation (valid for both antenna types)

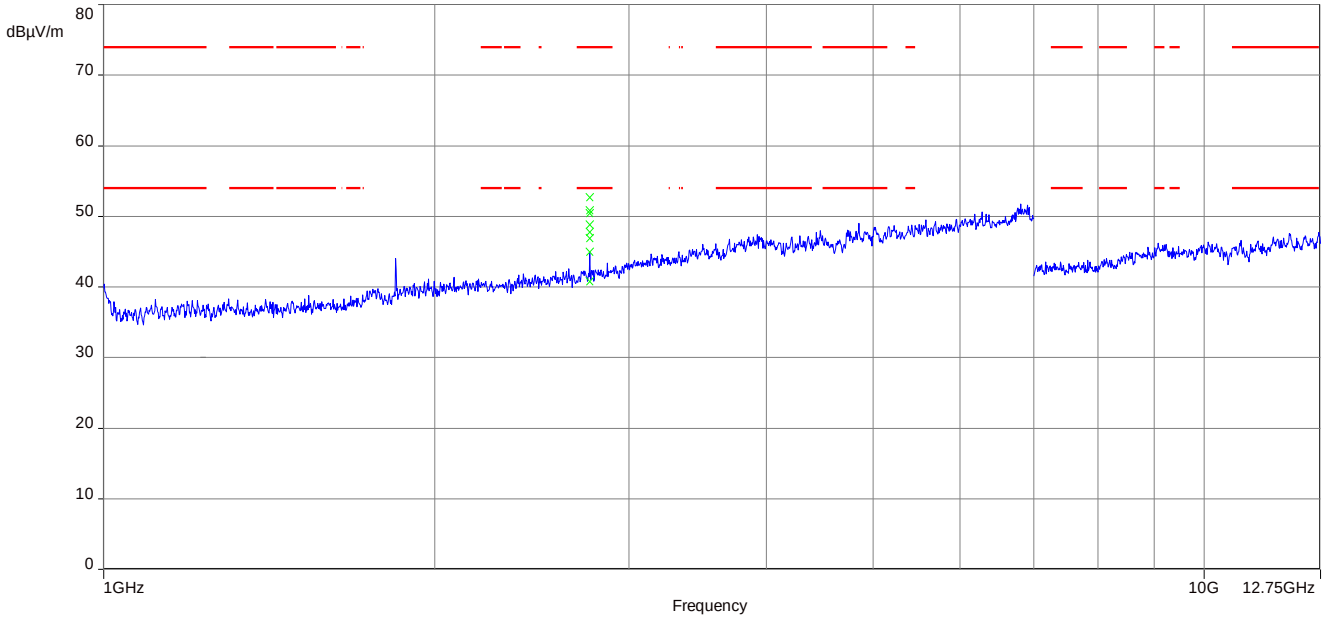


b) RC4 Band

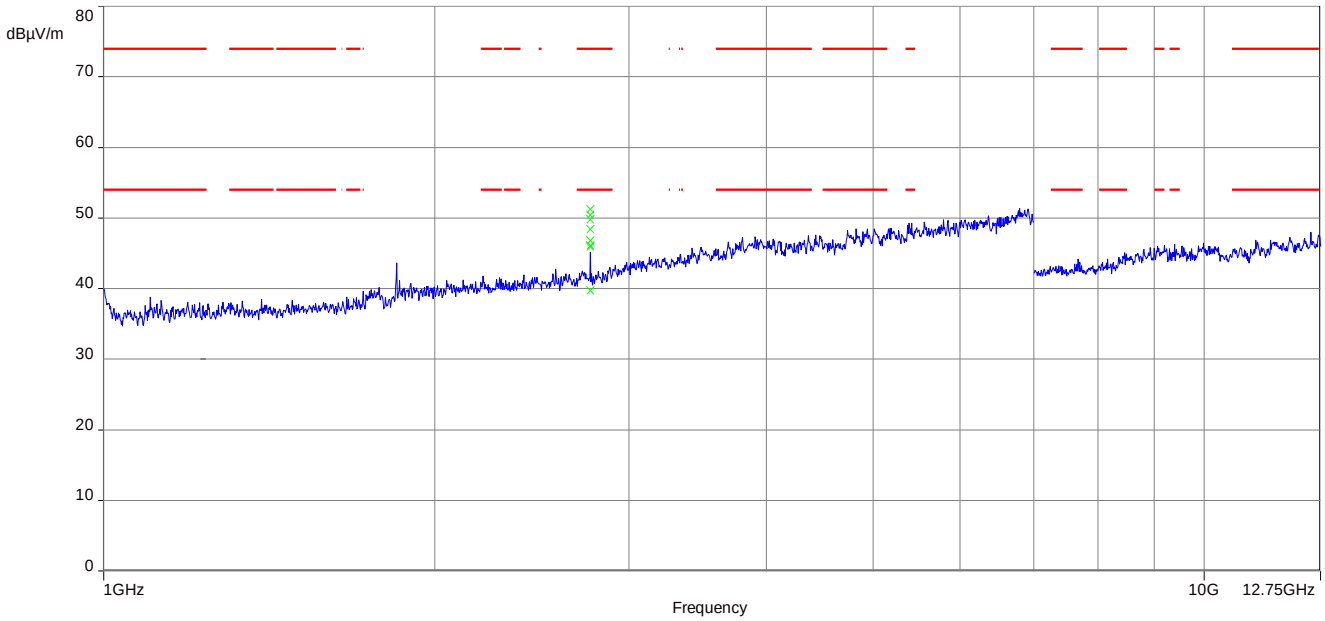
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



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



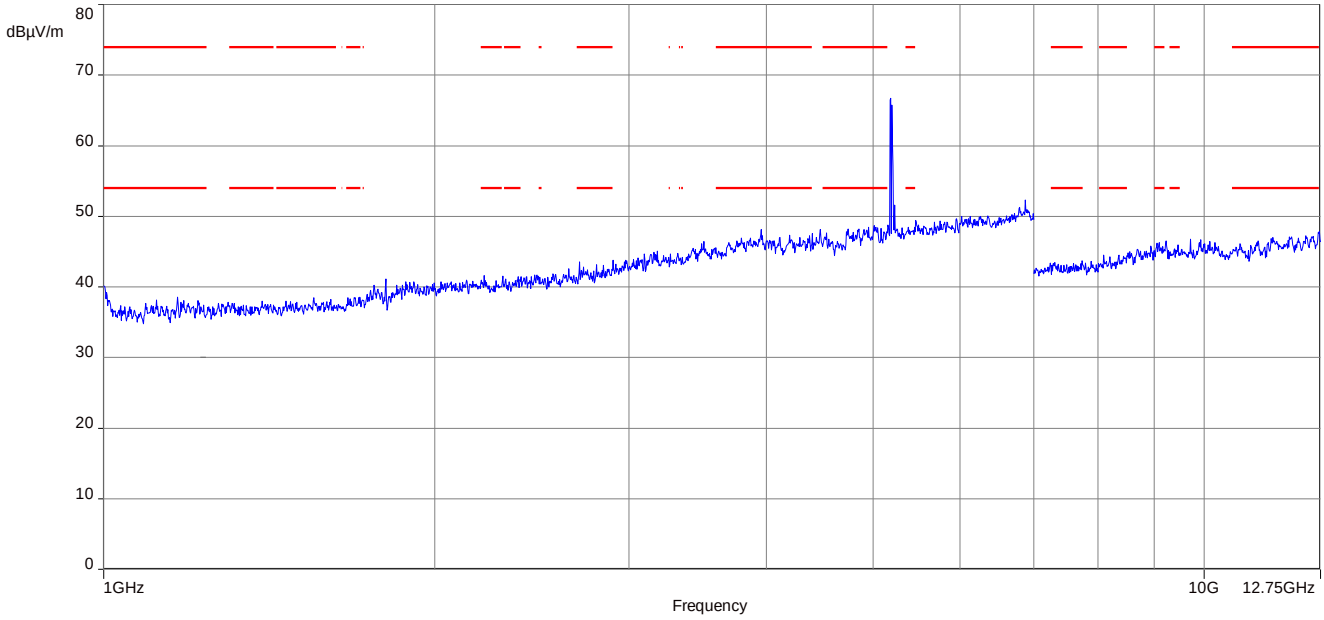
Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)



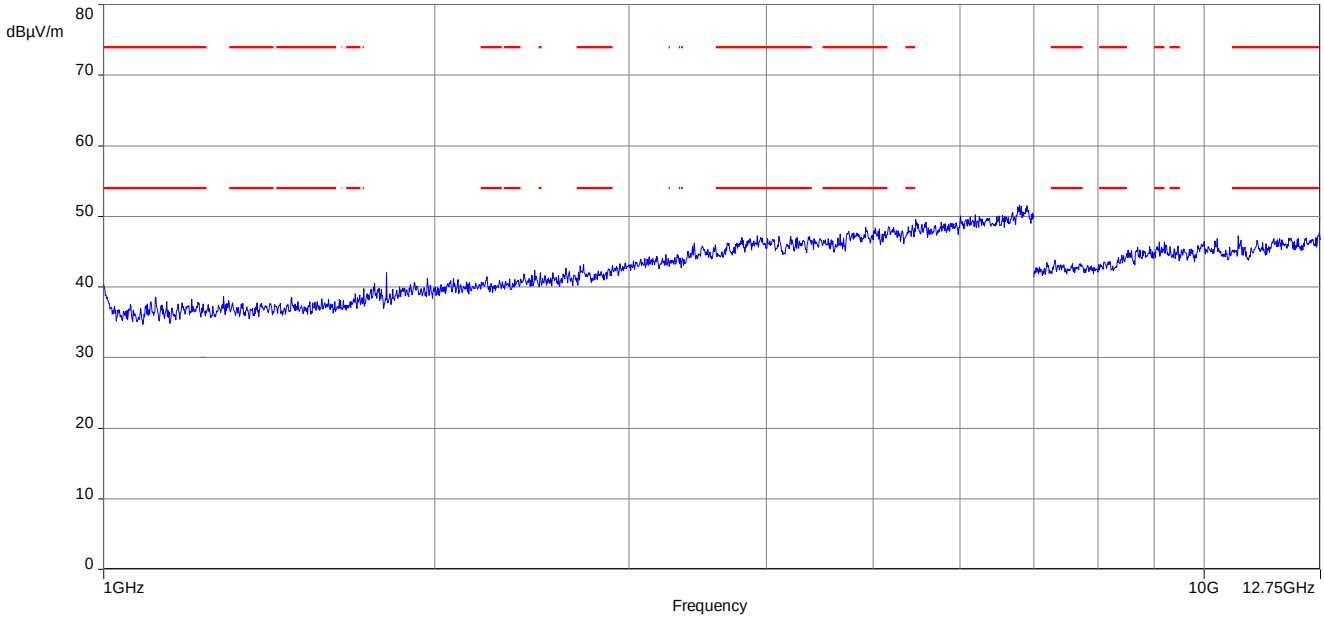
Plots EUT with PCB antenna:

a) RC2 Band

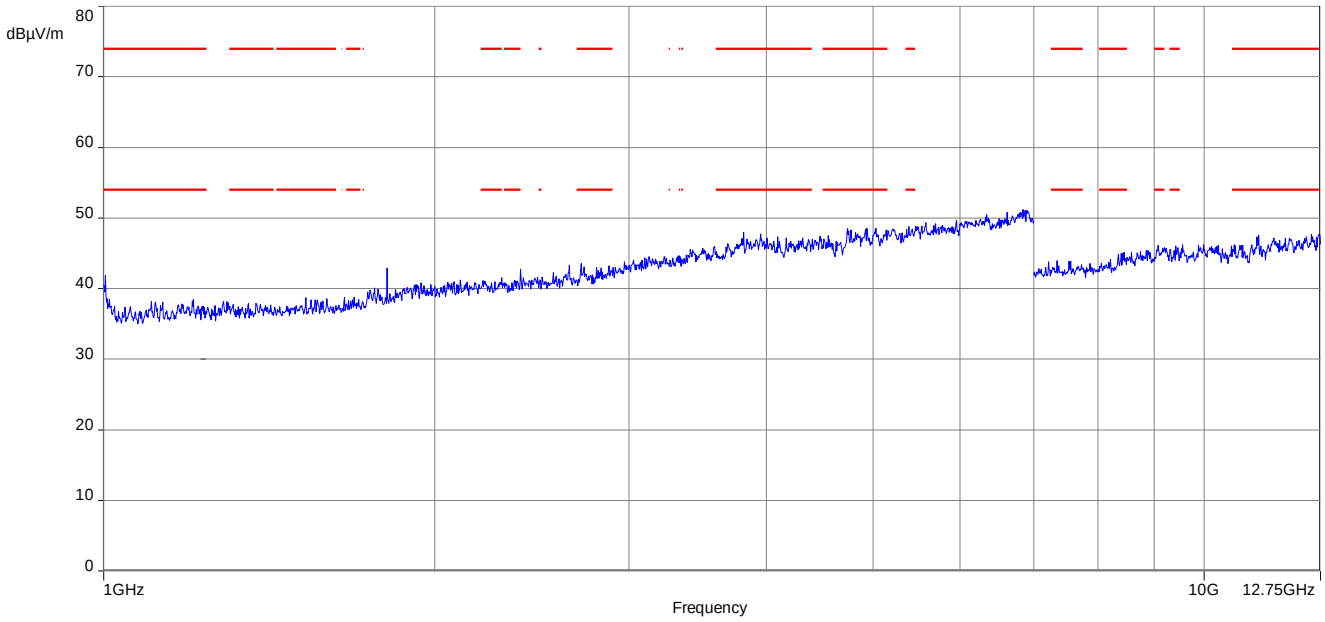
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



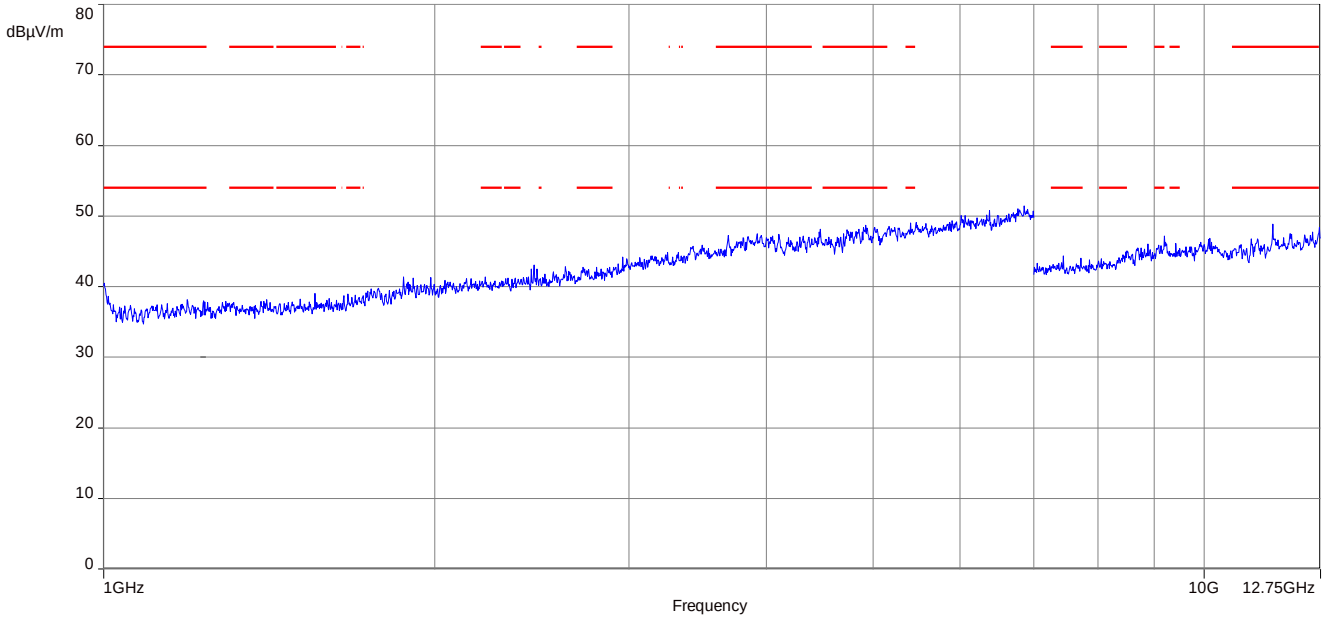
Plot 2: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



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

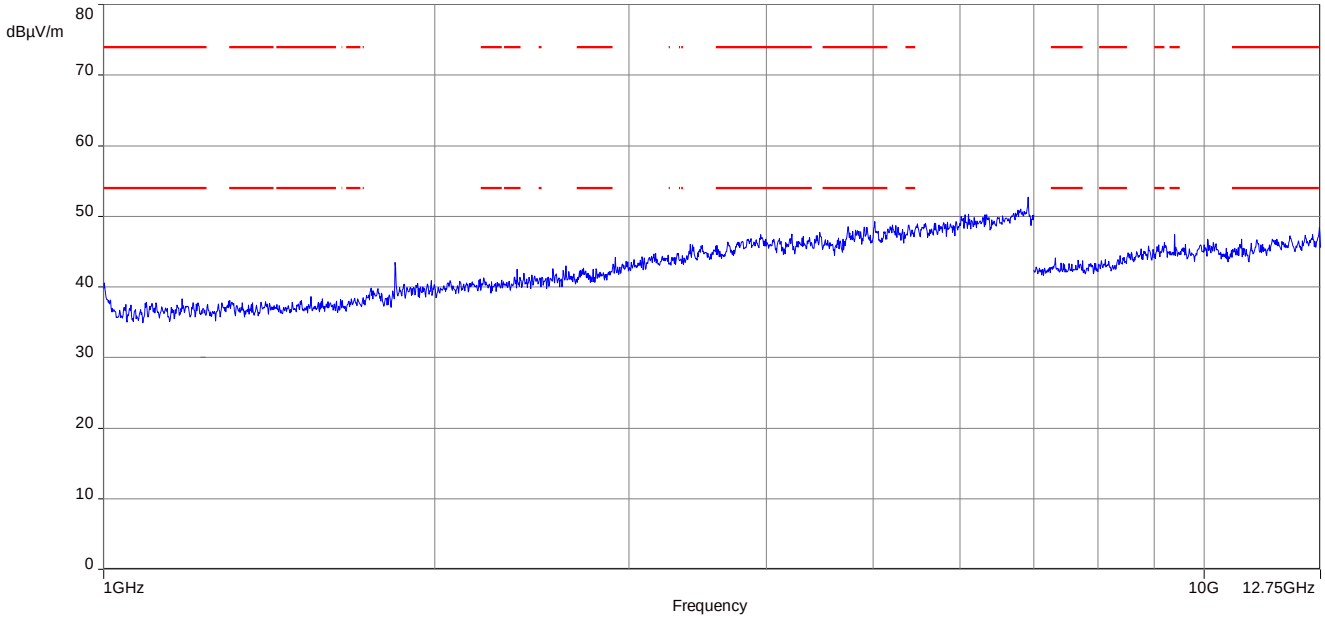


Plot 4: 1GHz – 12.75 GHz, RX-Mode, horizontal & vertical polarisation (valid for both antenna types)

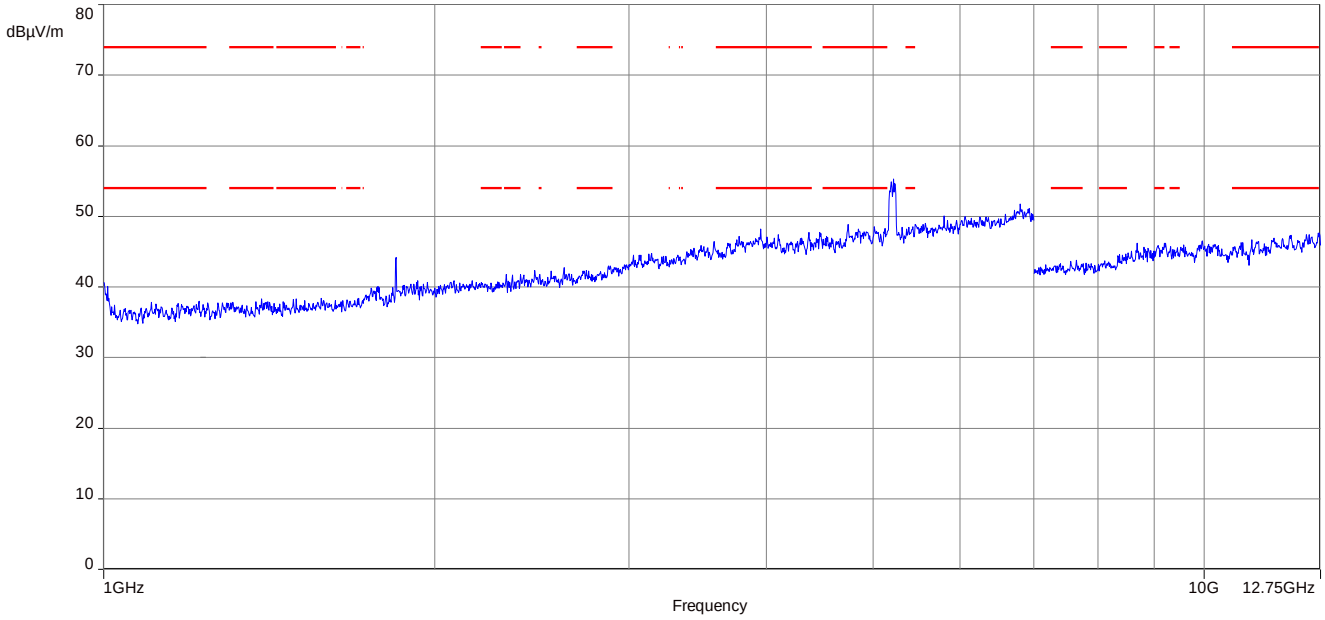


b) RC4 Band

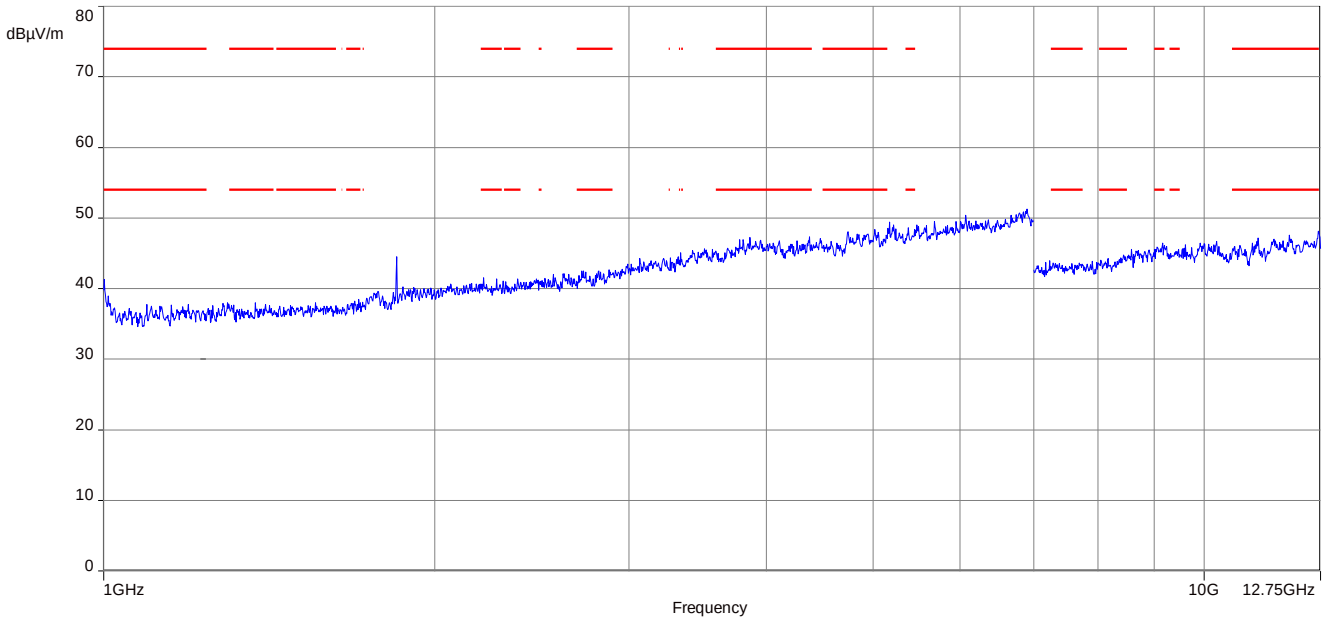
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



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



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



11.11 Spurious emissions conducted < 30 MHz

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The measurement is performed with the data rate producing the highest output power. Both power lines, phase and neutral line, are measured. Found peaks are remeasured with average and quasi peak detection to show compliance to the limits.

Measurement:

Measurement parameter	
Detector:	Peak - Quasi peak / Average
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
Test setup:	See sub clause 6.4 A
Measurement uncertainty	See sub clause 8

Limits:

FCC		
TX Spurious Emissions Conducted < 30 MHz		
Frequency (MHz)	Quasi-Peak (dBµV/m)	Average (dBµV/m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

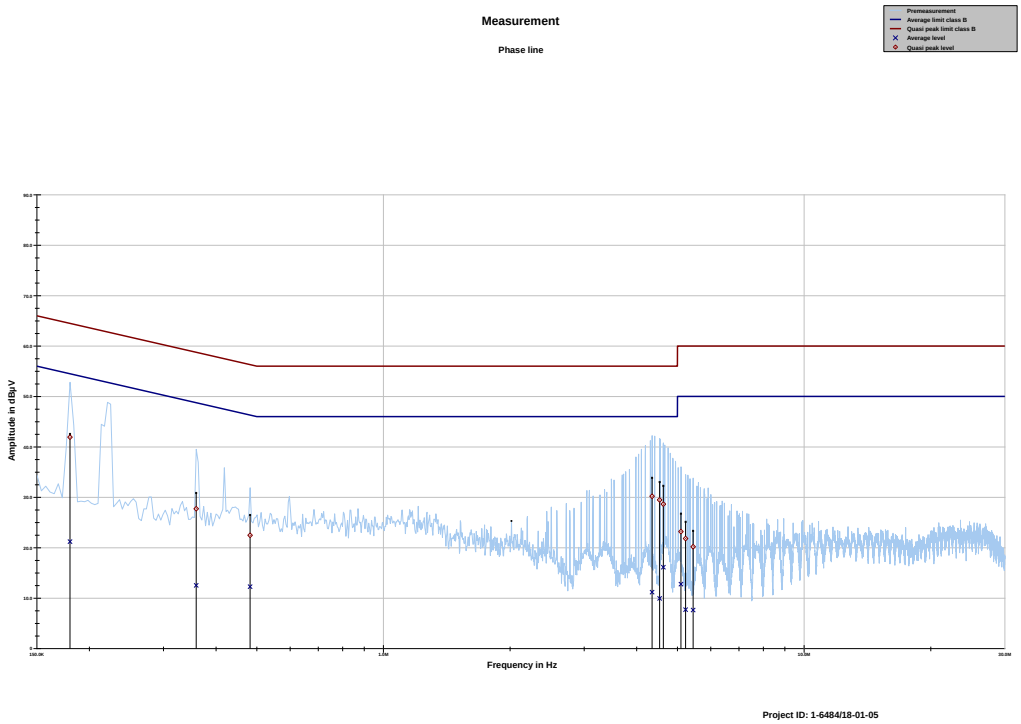
*Decreases with the logarithm of the frequency

Results:

TX Spurious Emissions Conducted < 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
No peaks detected.		
Measurement uncertainty	± 3 dB	

Plots: EUT with dipole antenna

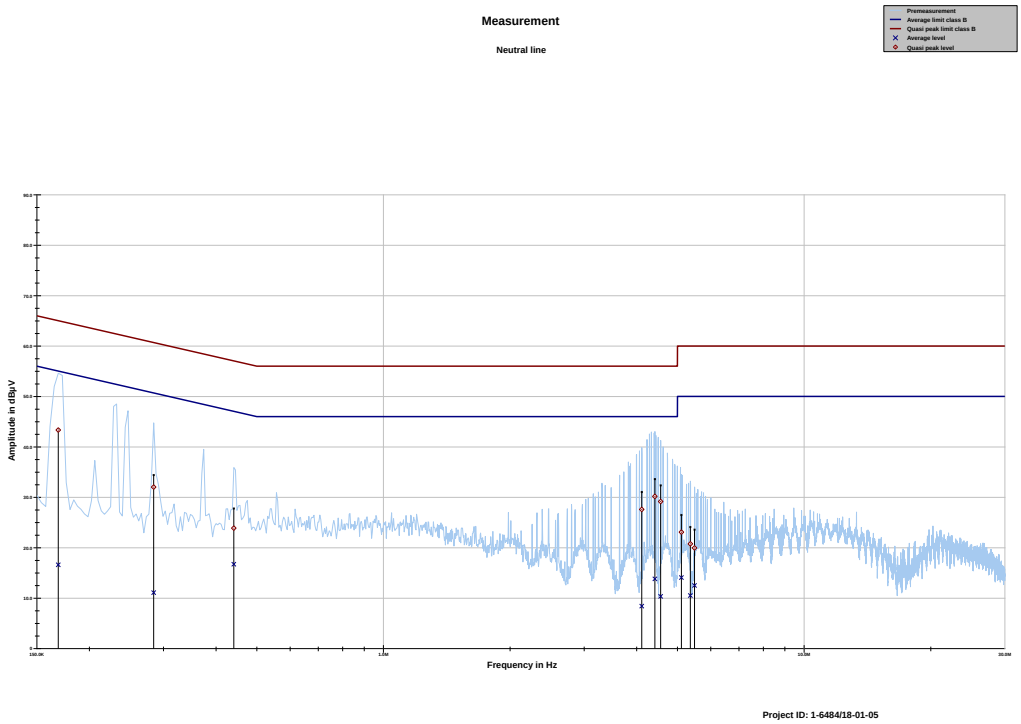
Plot 1: TX mode, 150 kHz to 30 MHz, phase line



Final Results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.179850	41.92	22.57	64.493	21.20	33.95	55.147
0.358950	27.72	31.03	58.753	12.53	37.50	50.030
0.482081	22.45	33.85	56.303	12.26	34.25	46.512
4.351388	30.20	25.80	56.000	11.18	34.82	46.000
4.534219	29.47	26.53	56.000	9.95	36.05	46.000
4.627500	28.65	27.35	56.000	16.13	29.87	46.000
5.097638	23.20	36.80	60.000	12.76	37.24	50.000
5.228231	21.82	38.18	60.000	7.70	42.30	50.000
5.448375	20.18	39.82	60.000	7.64	42.36	50.000

Plot 2: TX mode, 150 kHz to 30 MHz, neutral line

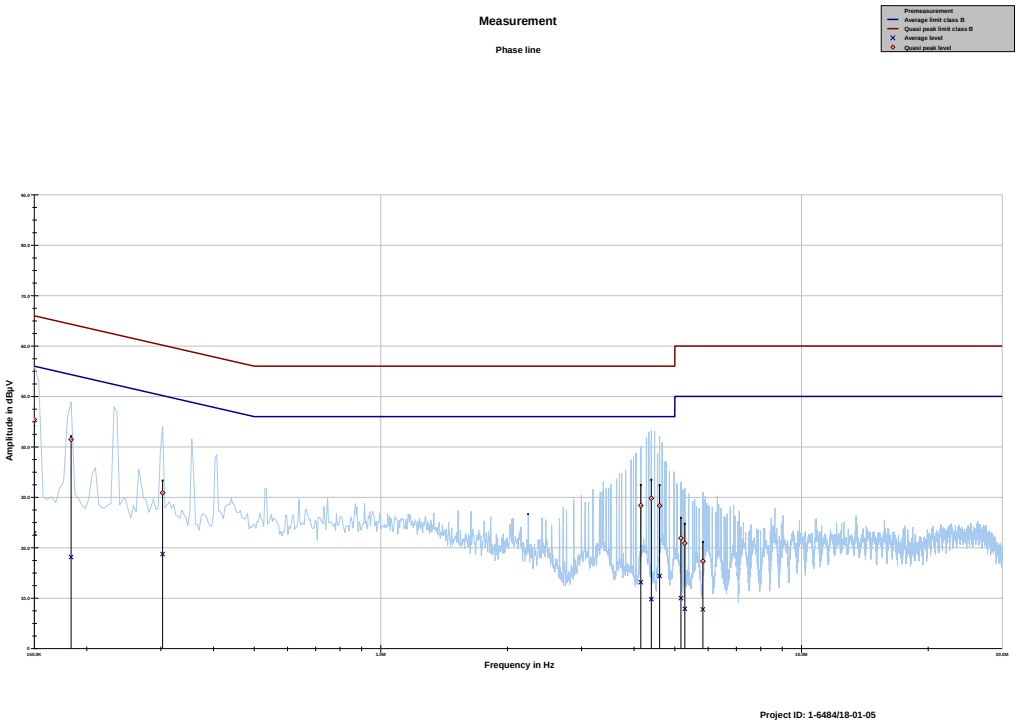


Final Results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.168656	43.33	21.70	65.026	16.61	38.85	55.467
0.284325	32.03	28.66	60.689	11.09	41.08	52.162
0.441038	23.88	33.17	57.042	16.71	30.97	47.685
4.112588	27.58	28.42	56.000	8.41	37.59	46.000
4.418550	30.17	25.83	56.000	13.81	32.19	46.000
4.560338	29.15	26.85	56.000	10.35	35.65	46.000
5.108831	23.09	36.91	60.000	14.07	35.93	50.000
5.366288	20.76	39.24	60.000	10.52	39.48	50.000
5.489419	19.95	40.05	60.000	12.50	37.50	50.000

Plots: EUT with PCB antenna

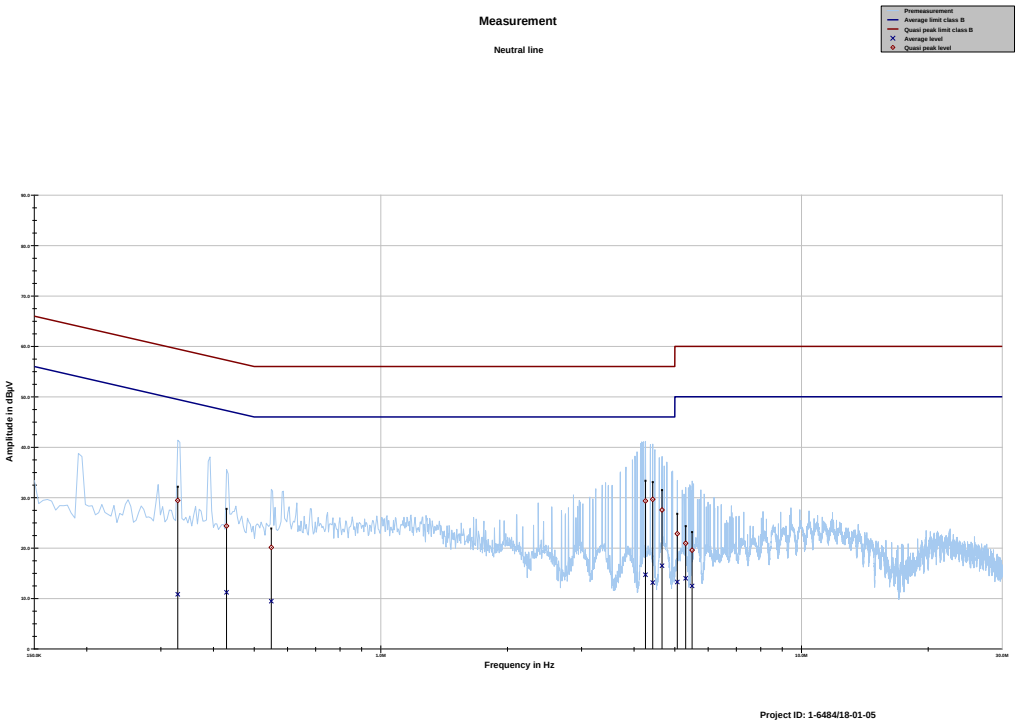
Plot 1: TX mode, 150 kHz to 30 MHz, phase line



Final Results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150000	45.43	20.57	66.000	22.85	33.15	56.000
0.183581	41.47	22.85	64.322	18.13	36.91	55.041
0.302981	30.88	29.28	60.161	18.73	32.90	51.629
4.149900	28.37	27.63	56.000	13.16	32.84	46.000
4.396162	29.80	26.20	56.000	9.80	36.20	46.000
4.601381	28.33	27.67	56.000	14.39	31.61	46.000
5.168531	21.89	38.11	60.000	9.99	40.01	50.000
5.280469	20.87	39.13	60.000	7.88	42.12	50.000
5.828963	17.32	42.68	60.000	7.77	42.23	50.000

Plot 2: TX mode, 150 kHz to 30 MHz, neutral line



Final Results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.329100	29.44	30.03	59.474	10.83	40.06	50.883
0.429844	24.38	32.87	57.256	11.22	36.79	48.004
0.549244	20.13	35.87	56.000	9.45	36.55	46.000
4.258106	29.35	26.65	56.000	14.71	31.29	46.000
4.429744	29.65	26.35	56.000	13.16	32.84	46.000
4.661081	27.56	28.44	56.000	16.49	29.51	46.000
5.067787	22.84	37.16	60.000	13.26	36.74	50.000
5.306588	20.94	39.06	60.000	14.00	36.00	50.000
5.496881	19.58	40.42	60.000	12.49	37.51	50.000

12 Observations

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

Annex A Glossary

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

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2019-09-12
A	Editorial changes, Chapter 11.11 added	2019-10-21

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

first page	last page
DAkkS Deutsche Akkreditierungsstelle Deutsche Akkreditierungsstelle GmbH **Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV** Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition **Accreditation** The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory **CTC advanced GmbH** **Untertürkheimer Straße 6-10, 66117 Saarbrücken** is competent under the terms of DIN EN ISO/IEC 17025:2005 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.-Biol. Uwe Zimmermann Head of Division	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 ILAC: www.ilac.org IAF: www.iaf.nu

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

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

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

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DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

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

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

is competent under the terms of DIN EN ISO/IEC 17025:2005 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

Dipl.-Biol. Uwe Zimmermann
Head of Division

See notes overleaf.

Deutsche Akkreditierungsstelle GmbH

Office Berlin	Office Frankfurt am Main	Office Braunschweig
Spittelmarkt 10	Europa-Allee 52	Bundesallee 100
10117 Berlin	60327 Frankfurt am Main	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.

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EA: www.european-accreditation.org
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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

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