
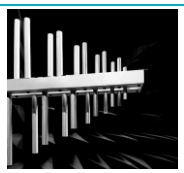
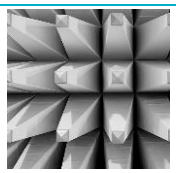

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-7810/19-11-02

Testing laboratory

CTC advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
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

ABITRON Control Systems GmbH
Wiesnerstr. 20
4950 Altheim / AUSTRIA
Phone: +43 (0) 7723 44 860 700
Contact: Mathias Friedl
e-mail: mathias.friedl@abitronremote.com
Phone: +43 (0) 7723 44860 161

Manufacturer

ABITRON Control Systems GmbH
Wiesnerstr. 20
4950 Altheim / AUSTRIA

Test standard/s

CFR47 Part 90	Part 90 – Private land mobile radio services

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

Test Item

Kind of test item:	**456 MHz Radio module**
Model name:	**CS456TRT-1**
FCC ID:	**2AC8P-456TR1**
Frequency:	456.3 MHz – 457.8 MHz
Technology tested:	Proprietary
Antenna:	External antenna
Power supply:	3.0 V to 5.5 V DC by external power supply
Temperature range:	-20°C to +60°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:

p.o.

cn=Joerg Warken, o=CTC advanced GmbH, ou=WAK-281116, email=joerg.warken@ctcadvanced.com, c=DE
2019.12.17 10:55:55 +01'00'

Christoph Schneider
Lab Manager
Radio Communications & EMC

Test performed:

p.o.

cn=Mihail Dorongovskij, o=CTC advanced GmbH, ou=DOR-281116, email=Mihail.Dorongovskij@ctcadvanced.com, c=DE
2019.12.17 10:42:25 +01'00'

Sumit Kumar
Testing Manager
Radio Communications & EMC

1 Table of contents

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.

2.2 Application details

Date of receipt of order:	2019-07-24
Date of receipt of test item:	2019-07-31
Start of test:	2019-08-02
End of test:	2019-08-07
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

3 Test standard/s and references

Test standard	Date	Description
CFR47 Part 90	-/-	Part 90 – Private land mobile radio services

Guidance	Version	Description
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

Accreditation	Description
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}	+23 °C during room temperature tests +60 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		64 %
Barometric pressure	:		1008 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.6 V DC by external power supply 5.5 V 3.0 V

5 Test item

5.1 General description

Kind of test item	:	456 MHz Radio module
Type identification	:	CS456TRT-1
S/N serial number	:	-/-
Hardware status	:	STD 302 S 456 MHz
Software status	:	CS456TRR-1K2_190723
Firmware status	:	-/-
Frequency band	:	456.3 MHz – 457.8 MHz Lowest Channel – 456.3 MHz Middle Channel – 457.1 MHz Highest Channel – 457.8 MHz
Type of radio transmission Use of frequency spectrum	: :	OFDM
OCW	:	25 kHz
Type of modulation	:	-/-
Number of channels	:	32
Antenna	:	External antenna
Power supply	:	3.0 V to 5.5 V DC by external power supply
Temperature range	:	-20°C to +60°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: Photos 456 MHz Radio module certification.pdf
1-7810/19-11-01_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).

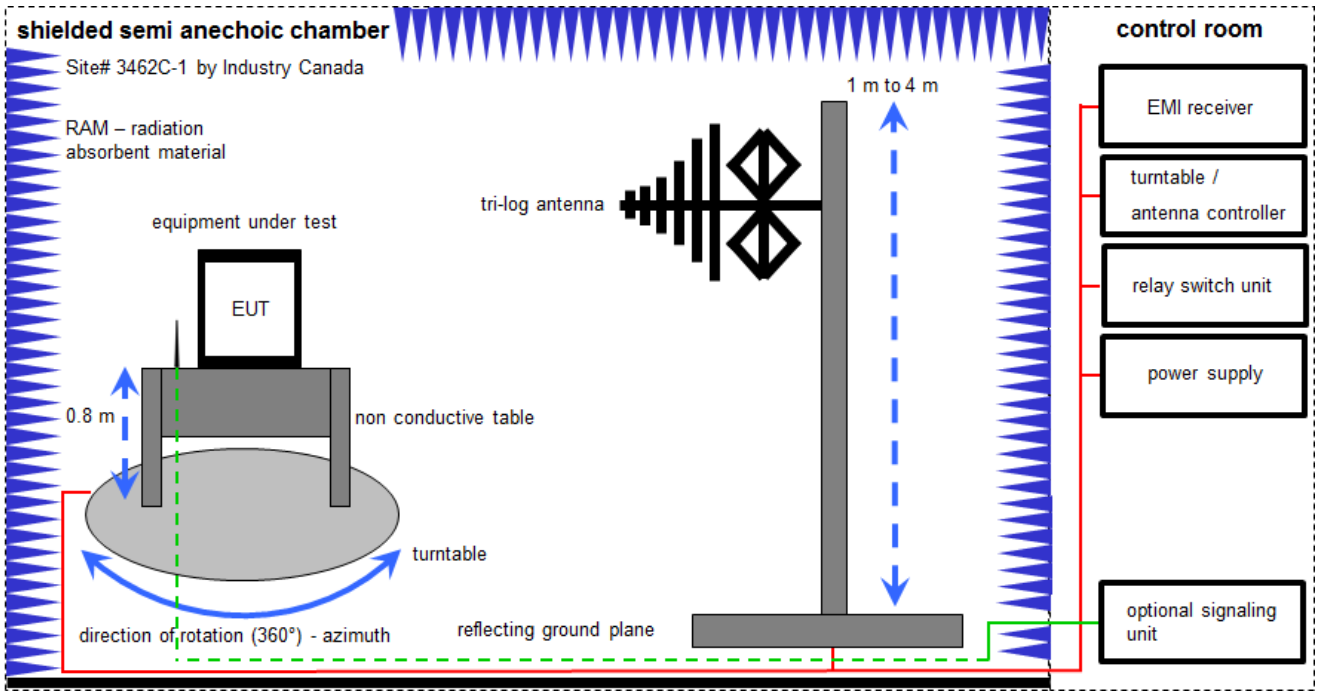
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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

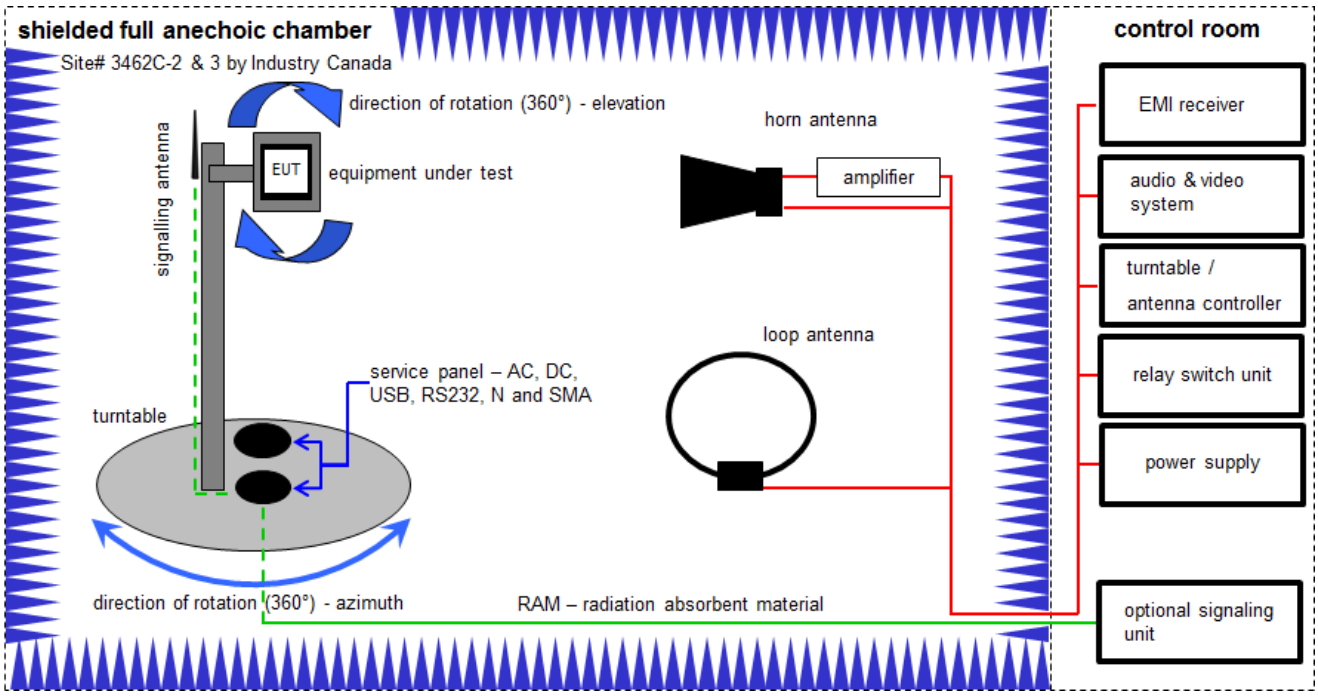
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	Meßkabine 1	HF-Absorberhalle	MWB AG 300023		300000551	ne	-/-	-/-
3	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	12.12.2018	11.12.2019
4	A	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vlKI!	15.01.2018	14.01.2020
5	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
6	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
7	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
8	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)

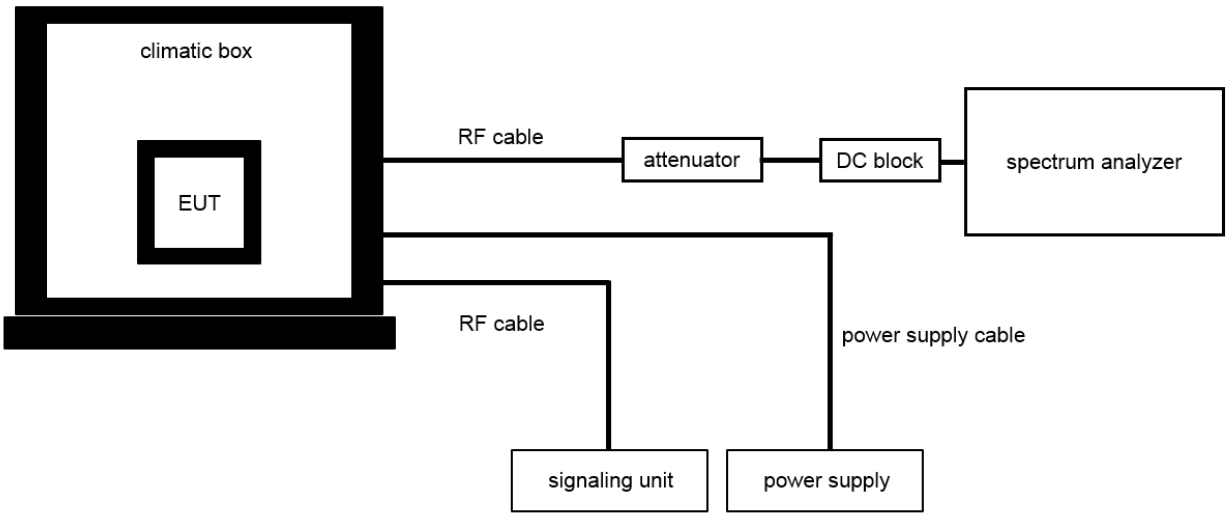
Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3088	300001032	vIKI!	07.07.2017	06.07.2019
2	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vIKI!	07.07.2017	06.07.2019
3	A,B	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04590	300001041	vIKI!	14.12.2017	13.12.2020
4	B	Highpass Filter	WHK1.1/15G-10SS	Wainwright	37	400000148	ne	-/-	-/-
5	B	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22051	300004483	ev	-/-	-/-
6	A,B	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne	-/-	-/-
7	A,B	Computer	Intel Core i3 3220/3,3 GHz, Prozessor		2V2403033A5421	300004591	ne	-/-	-/-
8	A,B	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
9	A,B	Anechoic chamber		TDK		300003726	ne	-/-	-/-
10	A,B	EMI Test Receiver 9kHz-26,5GHz	ESR26	R&S	101376	300005063	k	19.12.2018	18.12.2019

6.3 Conducted measurements normal and extreme conditions

Conducted measurements normal & extreme conditions



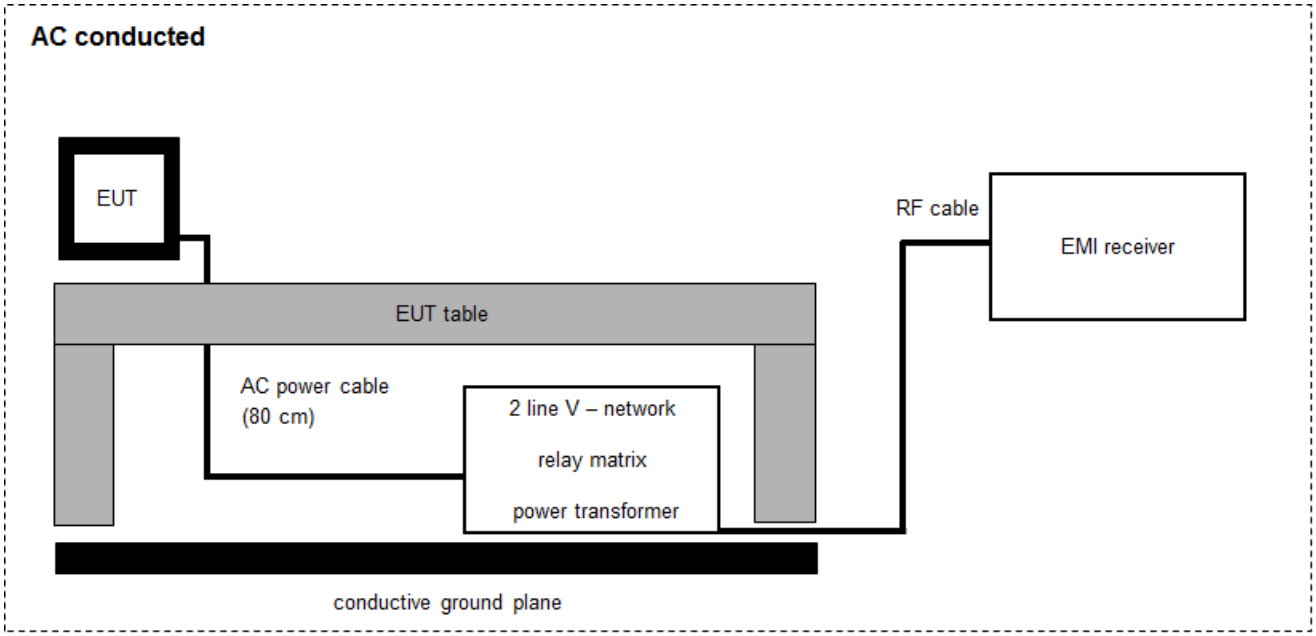
OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

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
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	-/-	-/-
5	A	Climatic Box	VT 4011	Voetsch Industrietechnik	5856623060001 0	300005363	ev	07.05.2018	06.05.2020
6	A	Arbitrary Function Generator	33220A	Agilent Technologies	MY44051717	300004164	vlKI!	11.12.2017	10.12.2019

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 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

8 Measurement uncertainty

Measurement uncertainty	
Occupied channel bandwidth	±5 %
RF power, conducted	±1.5 dB
Conducted spurious emission of transmitter, valid up to 6 GHz	±3 dB
Conducted emission of receivers	±3 dB
Radiated emission of transmitter, valid up to 6 GHz	±6 dB
Radiated emission of receiver, valid up to 6 GHz	±6 dB
RF level uncertainty for a given BER	±1.5 dB
Occupied channel bandwidth	±5 %
Temperature	±2.5 °C
Humidity	±10 %

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	47 CFR Part 2 47 CFR Part 90	See table	2019-12-17	-/-

Test Specification Clause	Test Case	Temperature Conditions	Power Source Voltages	C	NC	NA	NP	Remark
FCC 47 CFR § 2.1046 § 90.205(h)	Transmitter output power	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90.203 (j)(3)/(7)	Spectrum efficiency	Nominal	Nominal	☐	☐	☒	☐	One way transmitter
FCC 47 CFR § 2.1049 (c) § 90.209 (b)(5)	Occupied bandwidth	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90.210 (a)(b)(c)(d) § 90.217 (a)	Spectrum Mask	Nominal	Nominal	☒	☐	☐	☐	
FCC 47 CFR § 90.214	Transient frequency behaviour	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 90.217	Frequency stability	Nominal	Extreme	Exemption from technical standards				-/-
		Extreme	Nominal					
FCC 47 CFR § 2.1051 § 90.210	Transmitter spurious emissions conducted	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 2.1051 § 90.210	Transmitter spurious emissions (radiated)	Nominal	Nominal	☒	☐	☐	☐	-/-
FCC 47 CFR § 15.209	Receiver spurious emissions (radiated)	Nominal	Nominal	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	-/-

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

10 Measurement results

10.1 Radiated output power

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	1 MHz
Span:	5 MHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 6.3 A
Measurement uncertainty:	See chapter 8

Limits:

FCC 47 CFR § 90.205 (h)										
	Service area radius (km)									
	3	**8**	**13**	**16**	**24**	**32**	**40[4]**	**48[4]**	**64[4]**	**80[4]**
Maximum ERP (w)[1]	2	100	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500	[2]500
Up to reference HAAt (m)[3]	15	15	15	27	63	125	250	410	950	2700

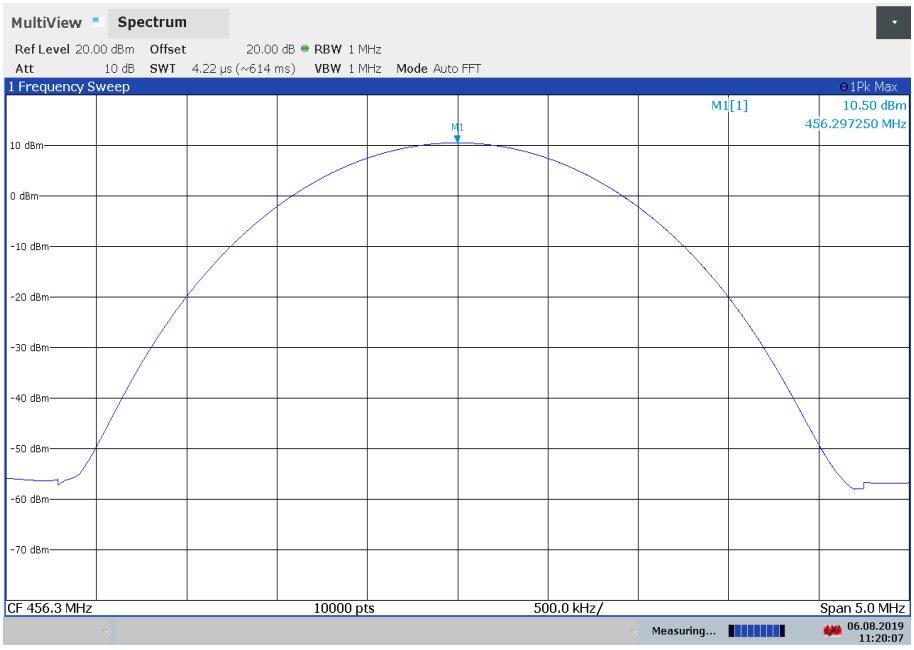
[1]Maximum ERP indicated provides for a 39 dBu signal strength at the edge of the service area per FCC Report R-6602, Fig. 29 (See §73.699, Fig. 10 b)
[2]Maximum ERP of 500 watts allowed. Signal strength at the service area contour may be less than 39 dBu
[3]When the actual antenna HAAT is greater than the reference HAAT, the allowable ERP will be reduced in accordance with the following equation: $ERP_{allow} = ERP_{max} \times (HAAT_{ref} / HAAT_{actual})^2$.
[4]Applications for this service area radius may be granted upon specific request with justification and must include a technical demonstration that the signal strength at the edge of the service area does not exceed 39 dBu.

Result:

Frequency (channel)	Radiated output power
Rated output power by manufacturer	10 dBm / 0.010 W nominal
456.3 MHz	10.50 dBm / 0.011 W
457.1 MHz	10.23 dBm / 0.010 W
457.8 MHz	10.05 dBm / 0.010 W

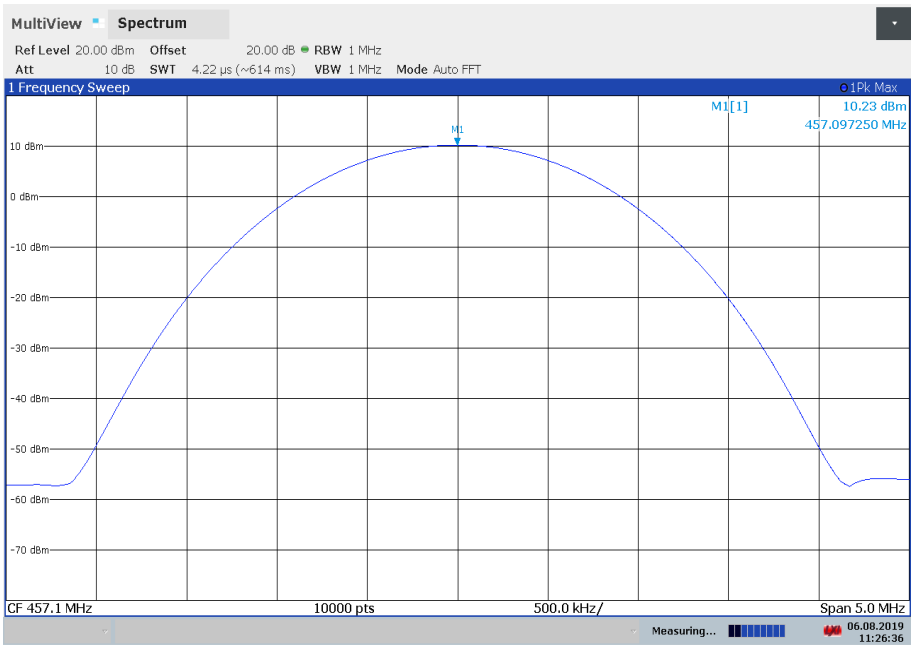
Plots:

Plot 1: Lowest channel



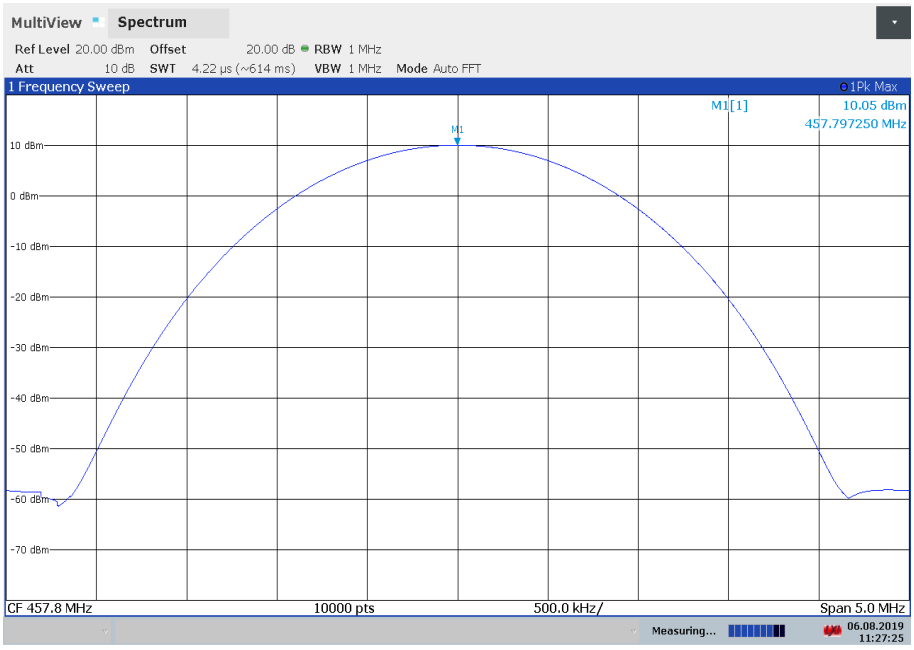
11:20:08 06.08.2019

Plot 2: Middle channel



11:26:37 06.08.2019

Plot 3: Highest channel



10.2 Occupied bandwidth

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	See Plots
Video bandwidth	See plots
Span	See plots
Measurement procedure:	OBW 99 %
Trace mode	Max hold
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

Limits:

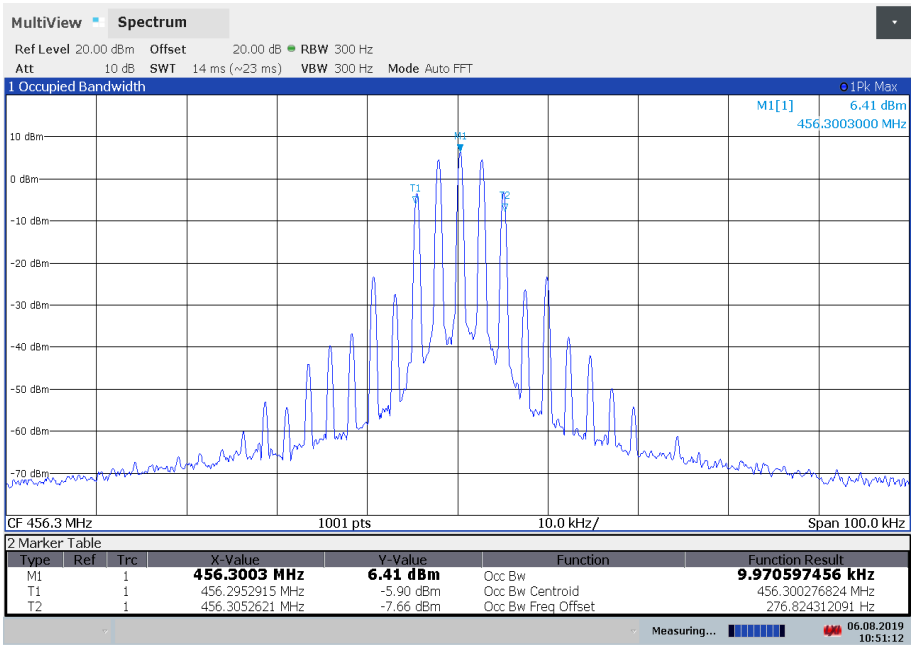
FCC 47 CFR§ 90.209 (b)(5)
a) Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth

Result:

Test Conditions		99% BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T_{nom}	V_{nom}	9.97	9.97	9.96

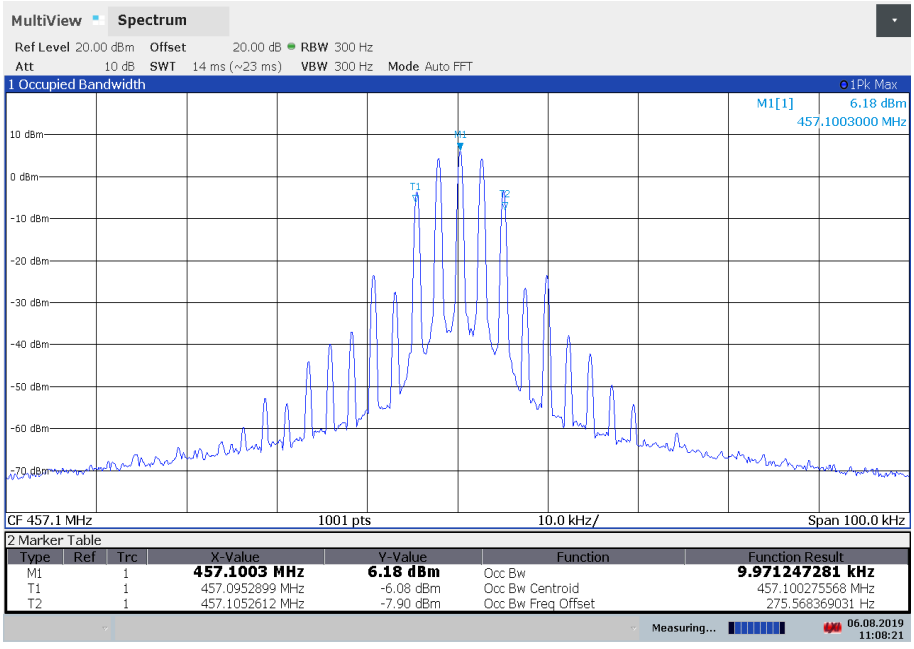
Plots:

Plot 1: Lowest Channel



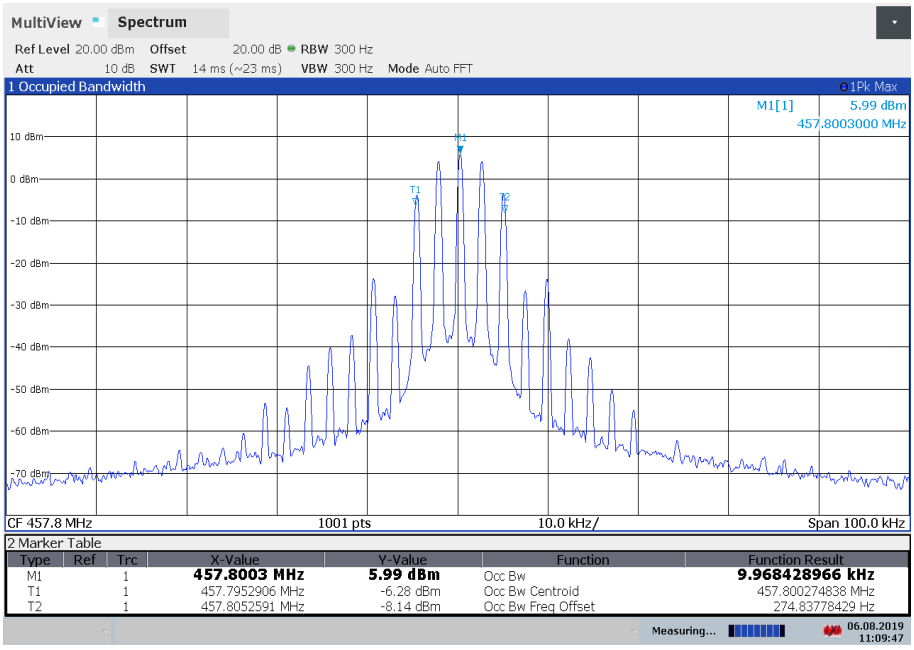
10:51:13 06.08.2019

Plot 2: Middle Channel



11:08:21 06.08.2019

Plot 3: Highest Channel



11:09:48 06.08.2019

10.3 Spectrum Mask

Measurement:

Measurement parameter for emission mask	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	300 Hz
Video bandwidth:	300 Hz
Span:	200 kHz
Trace-Mode:	Max. hold
Test setup	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

Limits:

FCC 47 CFR § 90.210 (d)

Emission Mask C

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

a) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (f_d/5) dB.

b) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (f_d^2/11) dB or 50 dB, whichever is the lesser attenuation.

c) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

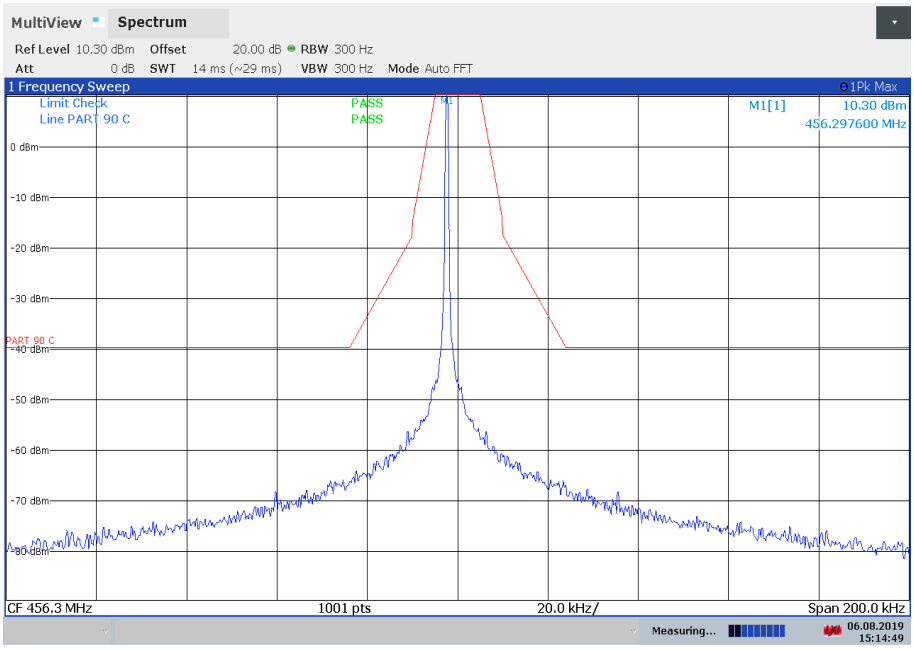
FCC 47 CFR § 90.217 (a)

Except as noted herein, transmitters used at stations licensed below 800 MHz on any frequency listed in subparts B and C of this part or licensed on a business category channel above 800 MHz which have an output power not exceeding 120 milliwatts are exempt from the technical requirements set out in this subpart, but must instead comply with the following:

(a) For equipment designed to operate with a 25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 40 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

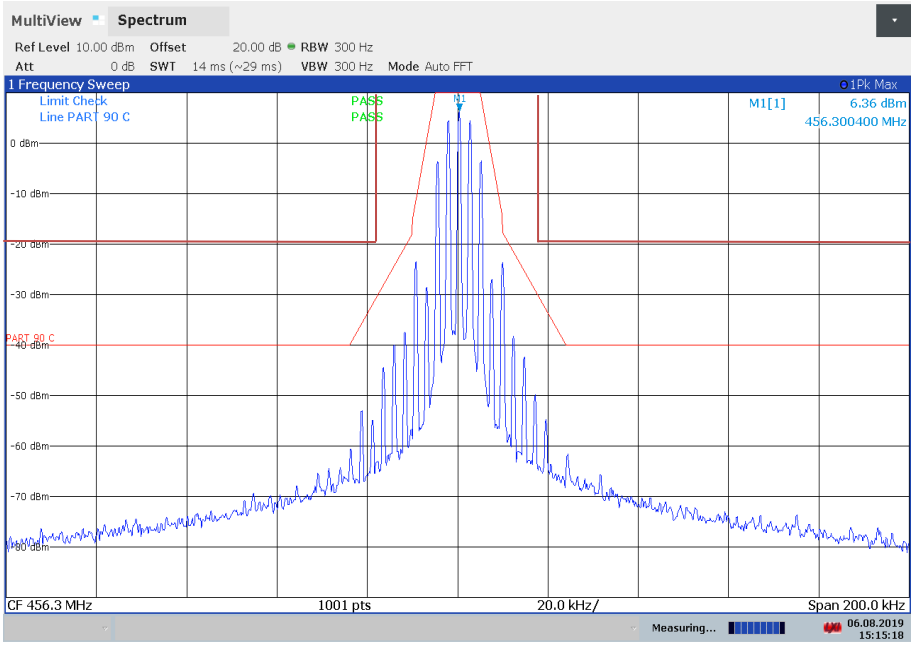
Plots:

Plot 1: Emission Mask C – Lowest channel Carrier unmodulated



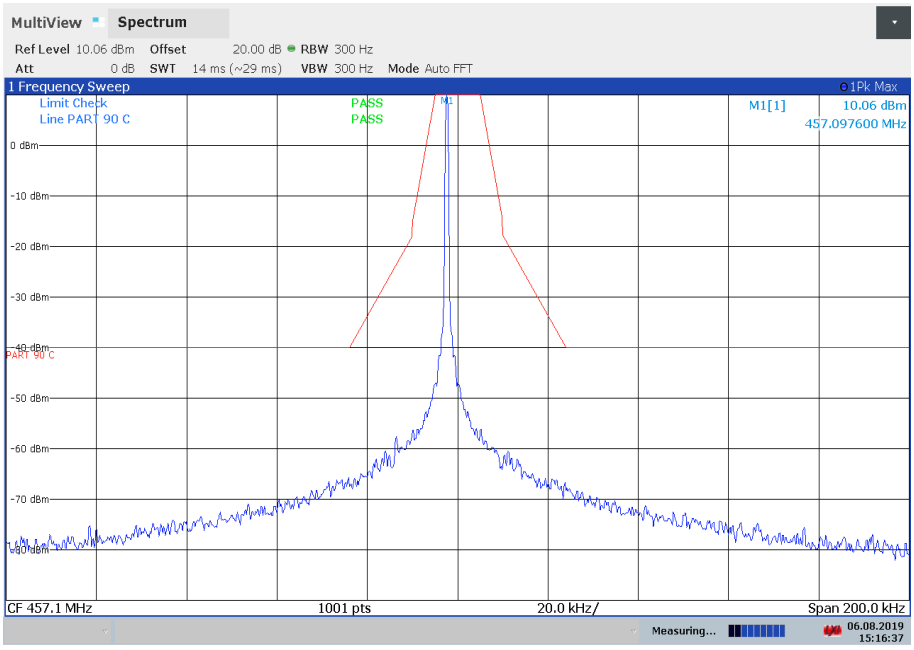
15:14:50 06.08.2019

Plot 2: Emission Mask C – Lowest channel Carrier modulated



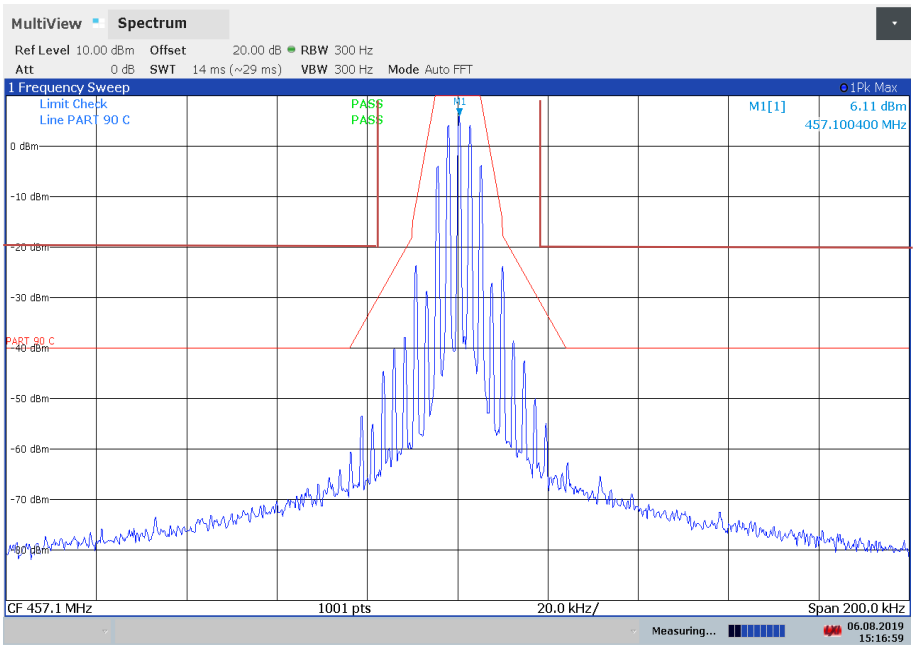
15:15:18 06.08.2019

Plot 3: Emission Mask C – Middle channel Carrier unmodulated



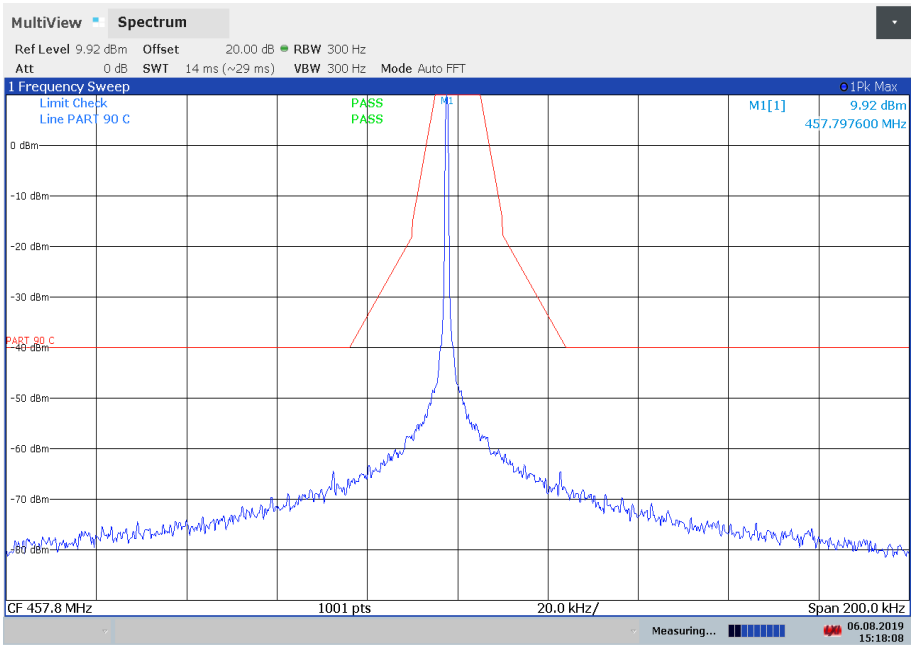
15:16:37 06.08.2019

Plot 4: Emission Mask C – Middle channel Carrier modulated



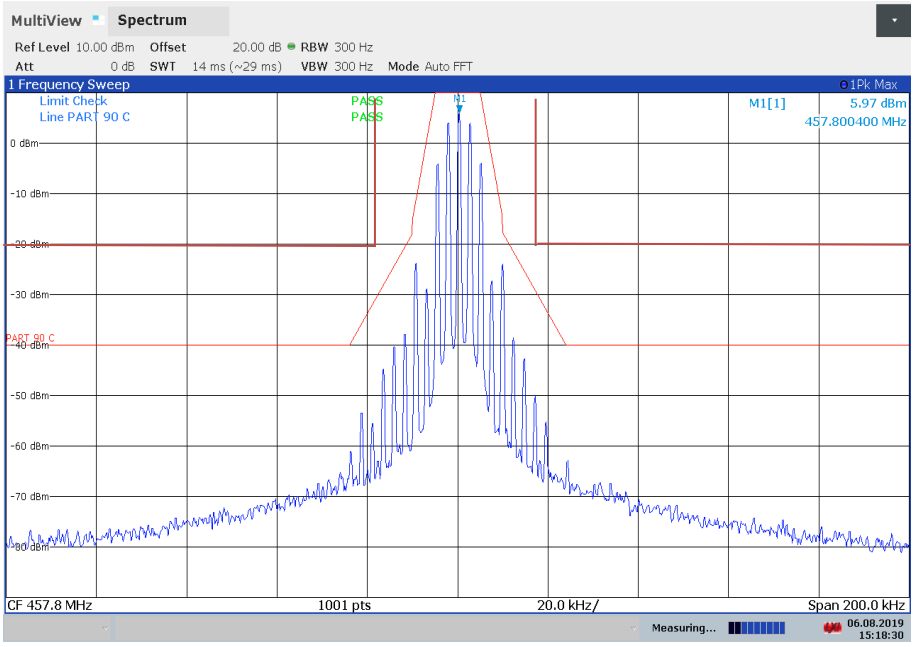
15:17:00 06.08.2019

Plot 5: Emission Mask C – Highest channel Carrier unmodulated



15:18:09 06.08.2019

Plot 6: Emission Mask C – Highest channel Carrier modulated



15:18:31 06.08.2019

10.4 Transient frequency behaviour

Measurement:

The first plot shows the measurement of the carrier signal to show that a clean carrier is transmitted which results in a measured bandwidth of nearly twice the used RBW.
The following plots show triggered measurements in the time domain with a RBW of 6.25 kHz (3-dB filter). A decrease of this power level of 3 dB can be correlated to a frequency error of a half RBW (3.125 kHz). Therefore the frequency error is less than ± 3.125 kHz as long as the power level is in the 3 dB range. This criteria was taken as worst case condition to show compliance.

Limits:

FCC 47 CFR § 90.214

Transient Frequency Behavior for Equipment Designed to Operate on 25 kH Channels

For 25 kHz channels			
Transient periods	Maximum frequency difference	Frequency range 150 – 174 MHz	Frequency range 421 - 512 MHz
t_1 (ms)	±25.0 kHz	5.0 ms	10.0 ms
t_2 (ms)	±12.5 kHz	20.0 ms	25.0 ms
t_3 (ms)	±25.0 kHz	5.0 ms	10.0 ms

t_1 is the time period immediately following t_{on}.
t_2 is the time period immediately following t_1.
t_3 is the time period from the instant when the transmitter is turned off until t_{off}.

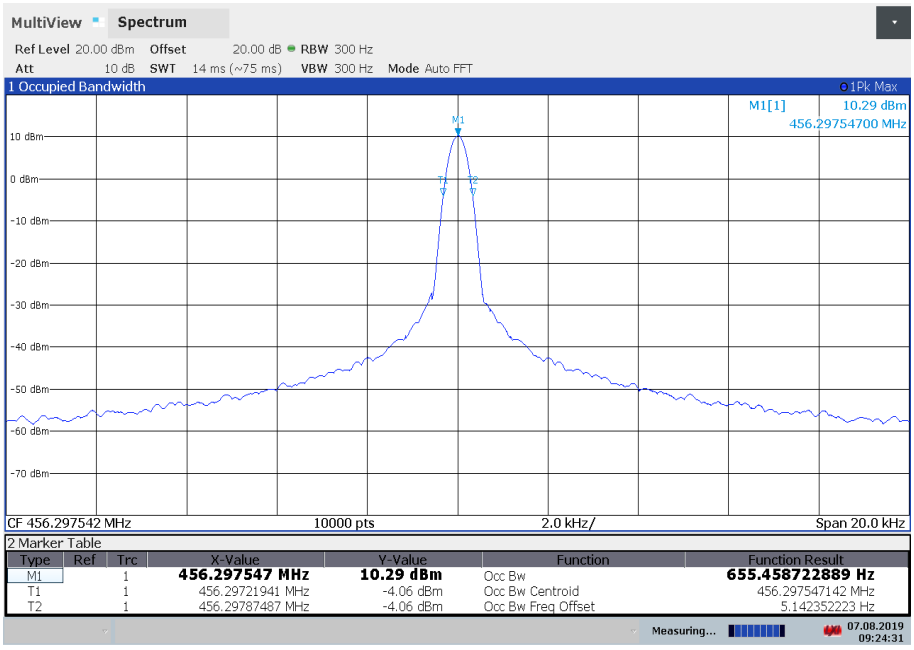
Result:

Confirm that during periods t_1 and t_3 the frequency difference does not exceed the value of one cannel separation	Passed
Confirm that during period t_2 the frequency difference does not exceed half a cannel separation	Passed
Confirm that during periods t_2 to t_3 the frequency difference does not exceed the frequency error limit	Passed

Test scenario	Lowest channel	Middle channel	Highest channel
The frequency stabilizes within the required frequency tolerance range after switching on the transmitter during period t_1 after:	3.05 ms	3.35 ms	1.51 ms
Maximum power deviation during t_2: (power deviation below 3 dB conforms a frequency deviation below ± 3.125 kHz)	0.19 dB	0.28 dB	0.17 dB
Switch off time (t_3):	0.55 ms	0.58 ms	0.75 ms

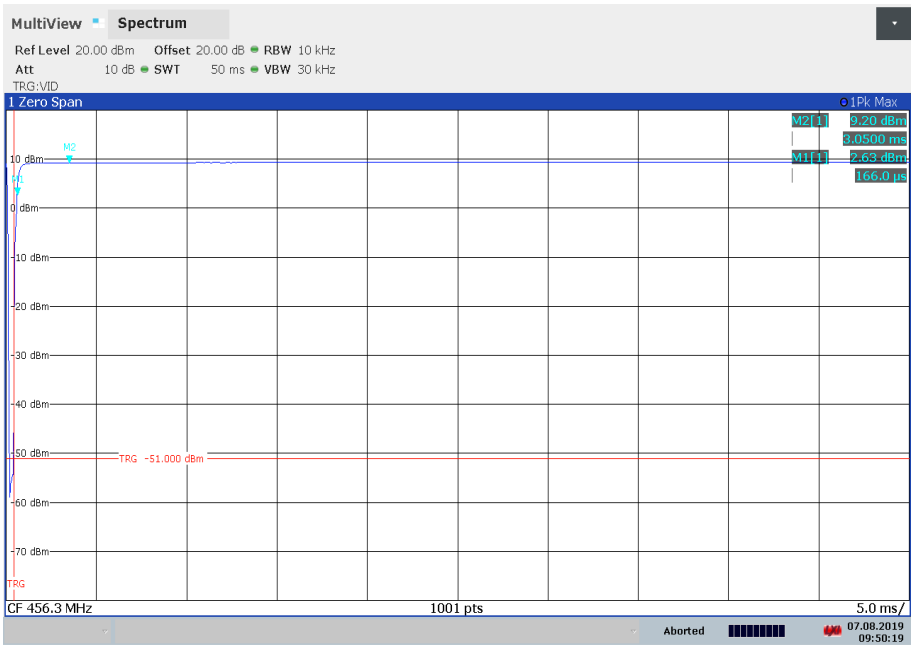
Plots:

Plot 1: Lowest channel - Carrier



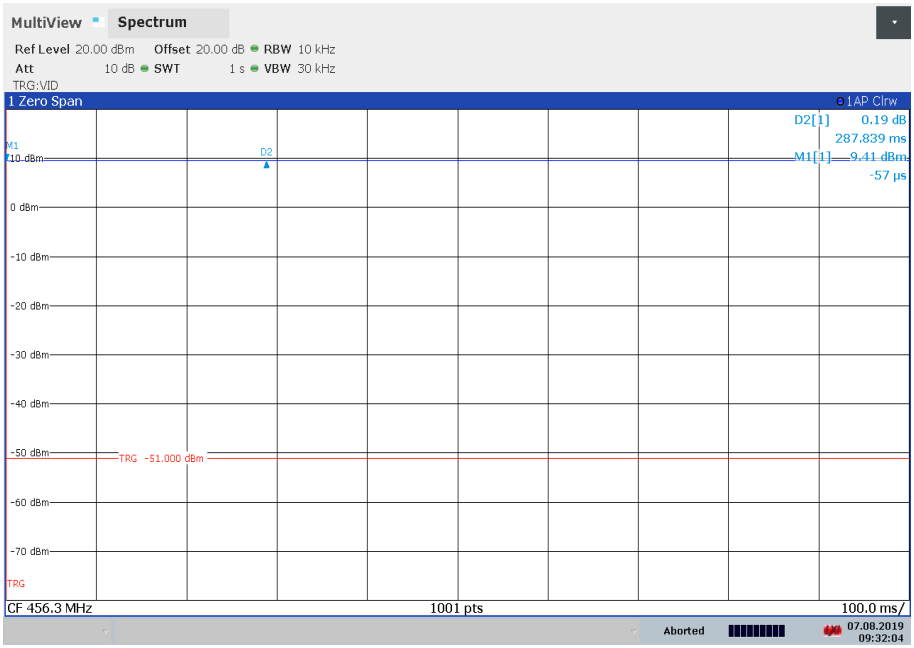
09:24:32 07.08.2019

Plot 2: Lowest channel – Switch on (zoomed)



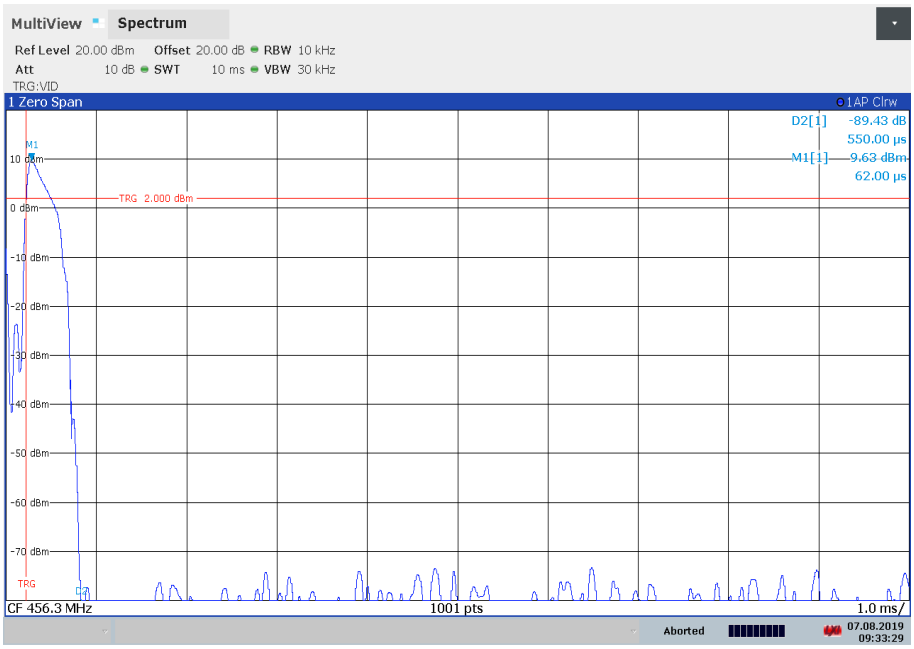
09:50:19 07.08.2019

Plot 3: Lowest channel – Operating



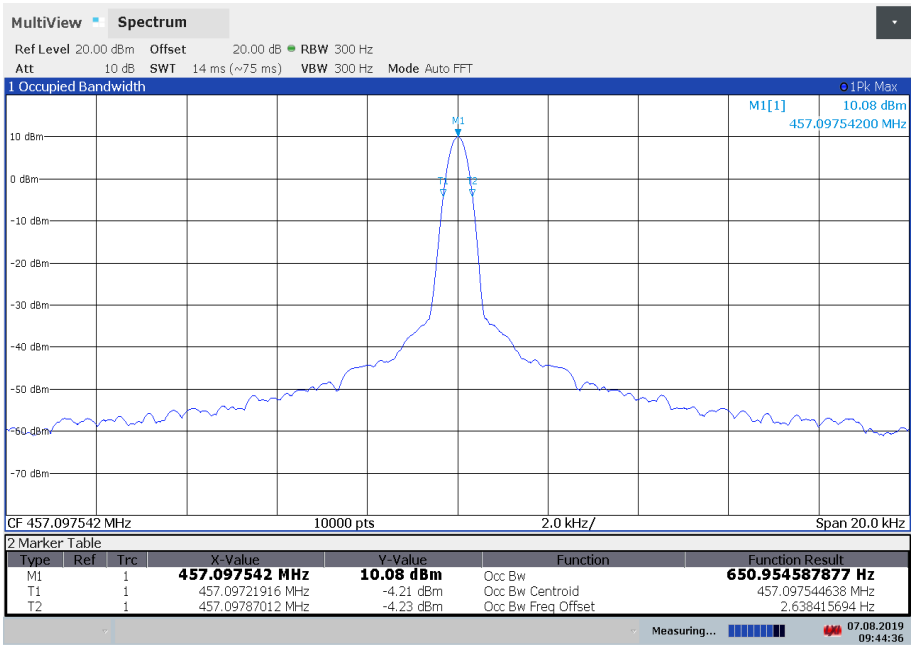
09:32:04 07.08.2019

Plot 4: Lowest channel – Switch off (zoomed)



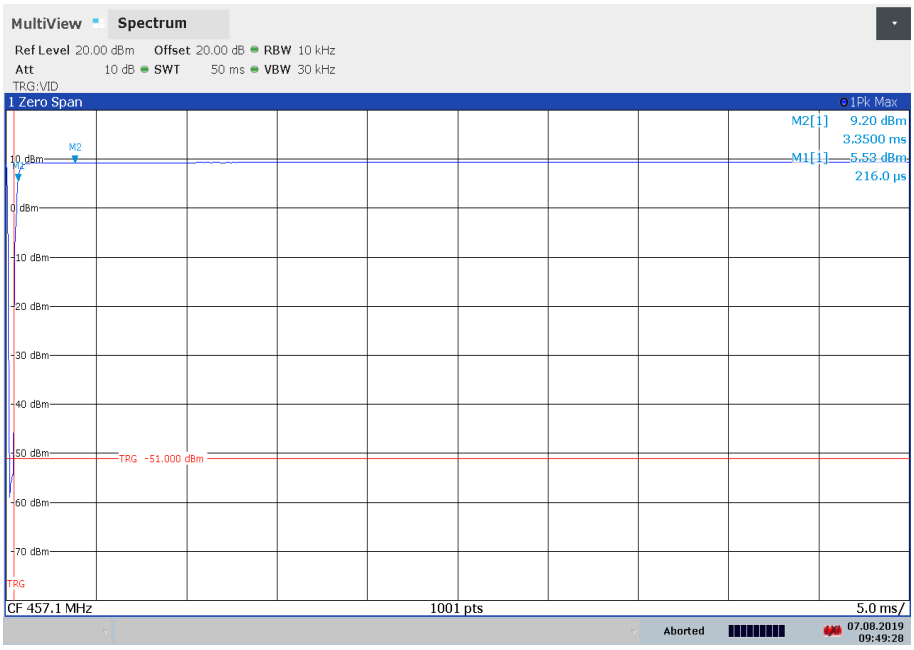
09:33:30 07.08.2019

Plot 5: Middle channel - Carrier



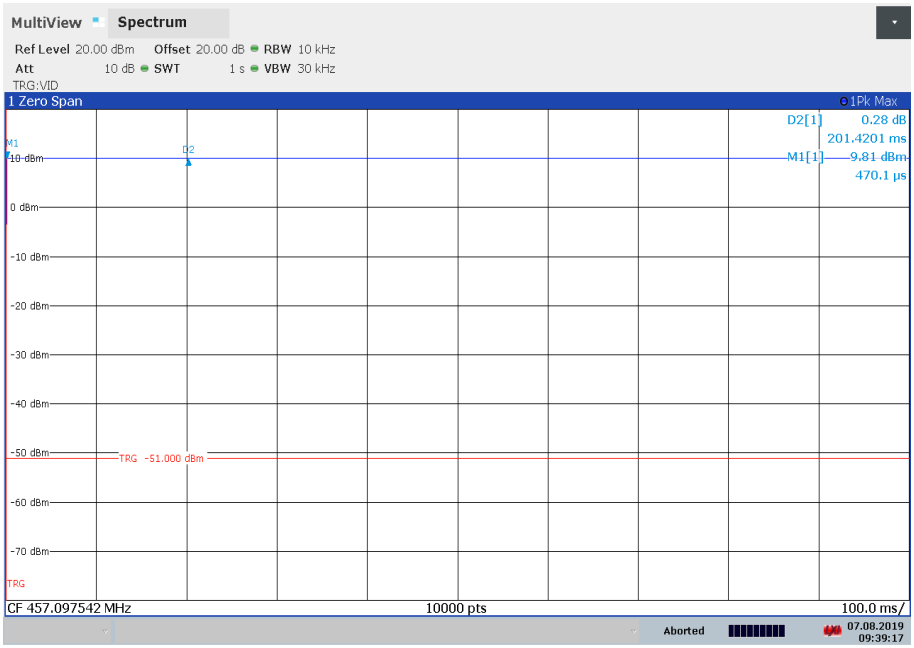
09:44:36 07.08.2019

Plot 6: Middle channel – Switch on (zoomed)



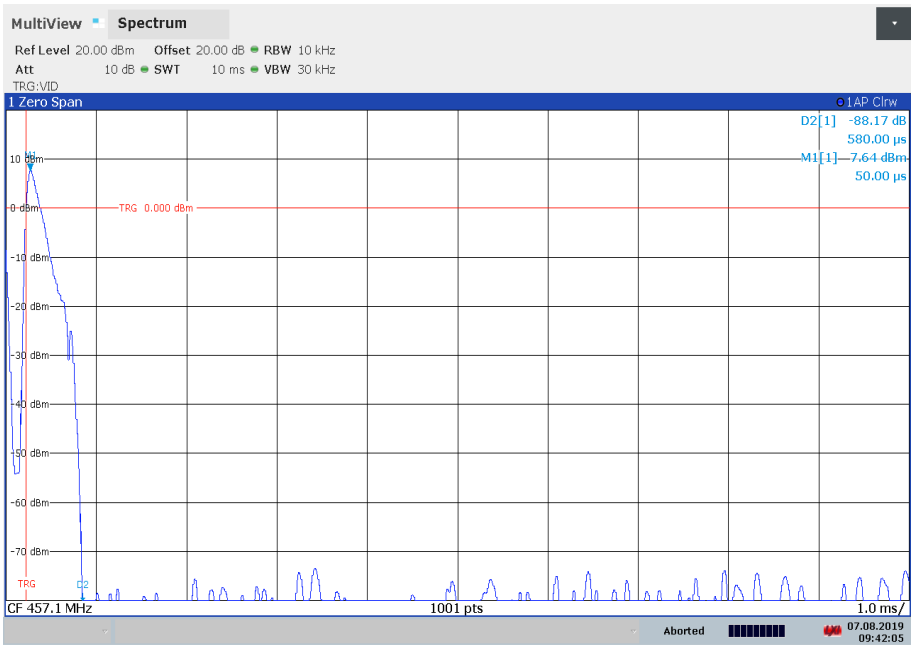
09:49:28 07.08.2019

Plot 7: Middle channel – Operating



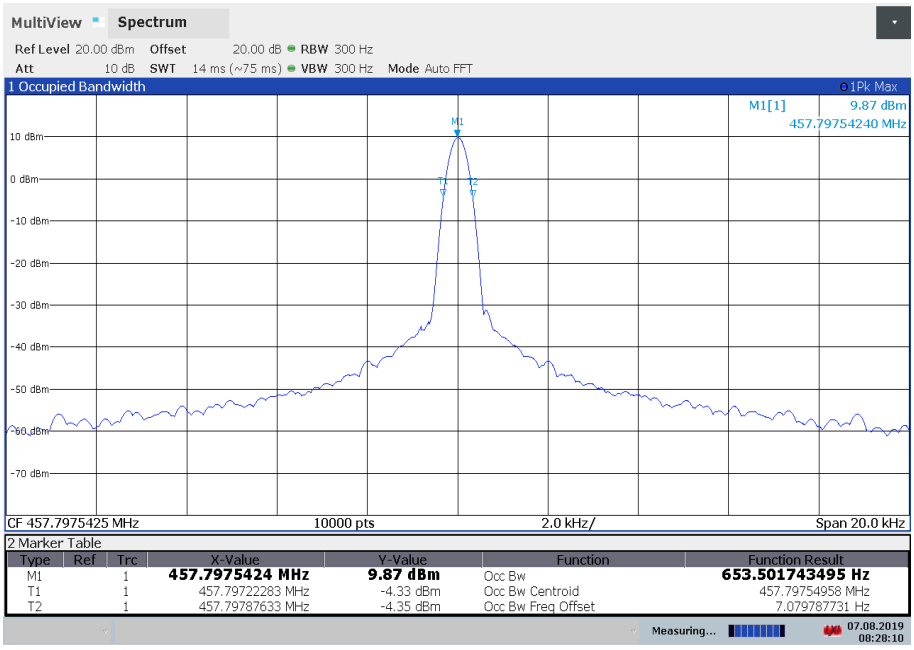
09:39:18 07.08.2019

Plot 8: Middle channel – Switch off (zoomed)



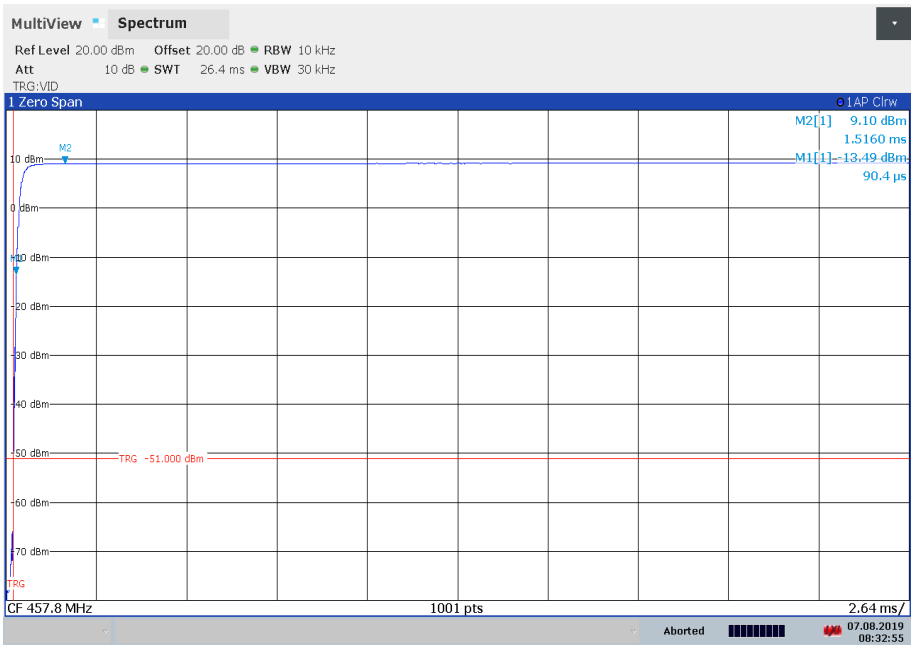
09:42:05 07.08.2019

Plot 9: Highest channel - Carrier



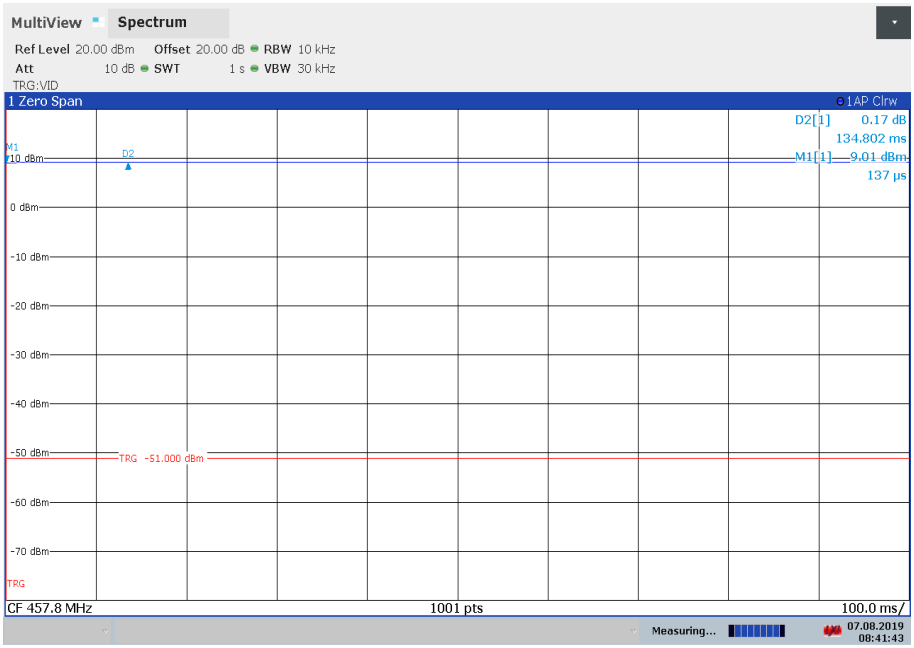
08:28:10 07.08.2019

Plot 10: Highest channel – Switch on (zoomed)



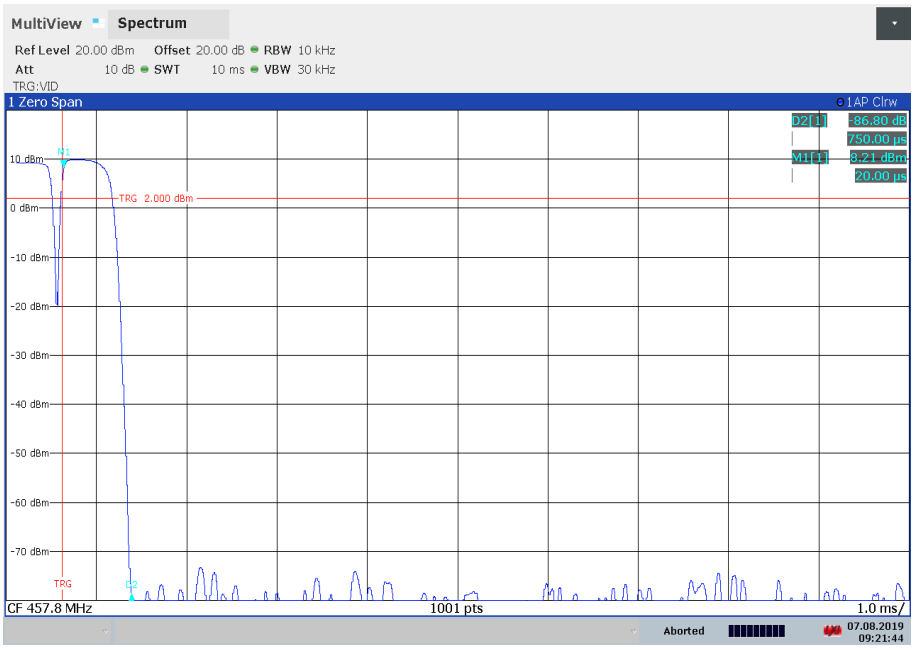
08:32:55 07.08.2019

Plot 11: Highest channel – Operating



08:41:43 07.08.2019

Plot 12: Highest channel – Switch off (zoomed)



09:21:44 07.08.2019

10.5 Frequency stability

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	30 Hz
Video bandwidth:	300 Hz
Span:	5 kHz
Trace mode:	Max. hold
Test setup:	See sub clause 6.3 A
Measurement uncertainty	See sub clause 8

Limits:

FCC 47 CFR § 90.217
No restriction

Results:

Temperature	Deviation (kHz)	Deviation (ppm)	Deviation (kHz)	Deviation (ppm)	Deviation (kHz)	Deviation (ppm)
	Low channel		Middle channel		High channel	
-20 °C	-2.35	-5.16	-2.53	-5.54	-2.37	-5.18
-10 °C	-2.45	-5.37	-2.36	-5.17	-2.31	-5.05
0 °C	-2.33	-5.12	-2.27	-4.98	-2.37	-5.19
10 °C	-2.44	-5.35	-2.31	-5.07	-2.43	-5.31
20 °C (V nom)	-2.46	-5.40	-2.38	-5.22	-2.48	-5.41
30 °C	-2.49	-5.47	-2.44	-5.34	-2.49	-5.45
40 °C	-2.51	-5.51	-2.48	-5.44	-2.49	-5.45
50 °C	-2.50	-5.49	-2.49	-5.46	-2.52	-5.50
Voltage	Deviation (kHz)	Deviation (ppm)	Deviation (kHz)	Deviation (ppm)	Deviation (kHz)	Deviation (ppm)
85 %	-2.47	-5.41	-2.39	-5.23	-2.47	-5.39
115 %	-2.46	-5.40	-2.39	-5.24	-2.47	-5.40

10.6 Transmitter spurious emissions conducted

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Video bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Span:	See plots
Trace-Mode:	Max. hold
Test setup:	See sub clause 6.3 B
Measurement uncertainty	See sub clause 8

Limits:

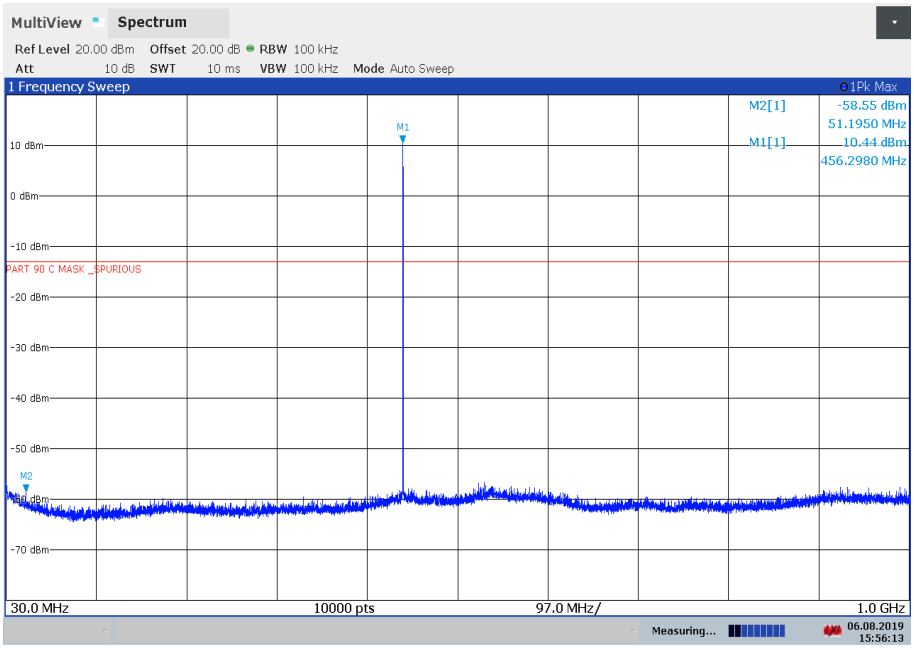
FCC 47 CFR § 90.210 (d)
Emission Mask C For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows: a) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

Results:

Spurious Emission Level								
Harmonic	Ch. low Freq. (MHz)	Level [dBm]	Harmonic	Ch. mid Freq. (MHz)	Level [dBm]	Harmonic	Ch. high Freq. (MHz)	Level [dBm]
2		All detected spurious emissions are more than 10 dB below the limit..	2		All detected spurious emissions are more than 10 dB below the limit.	2		All detected spurious emissions are more than 10 dB below the limit.
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
Measurement uncertainty			± 3dB					

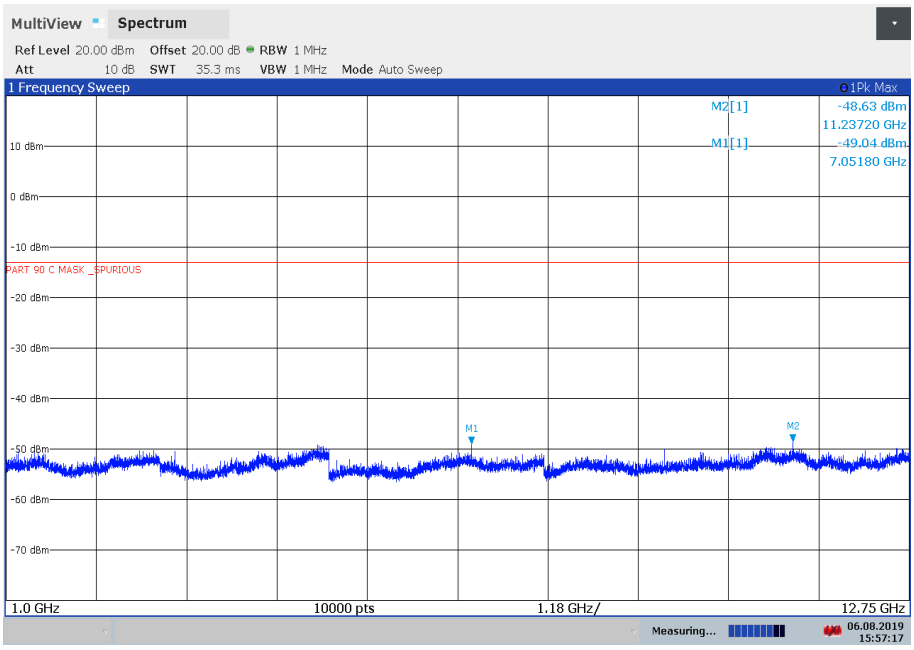
Plots:

Plot 1: 30 MHz to 1 GHz Lowest channel



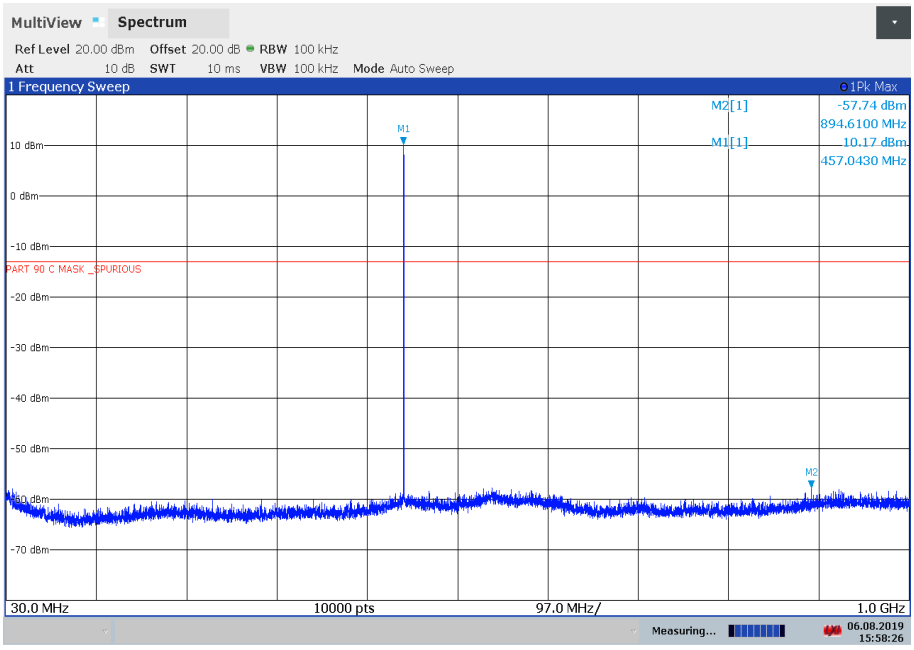
15:56:13 06.08.2019

Plot 2: 1GHz to 12.75 GHz Lowest channel



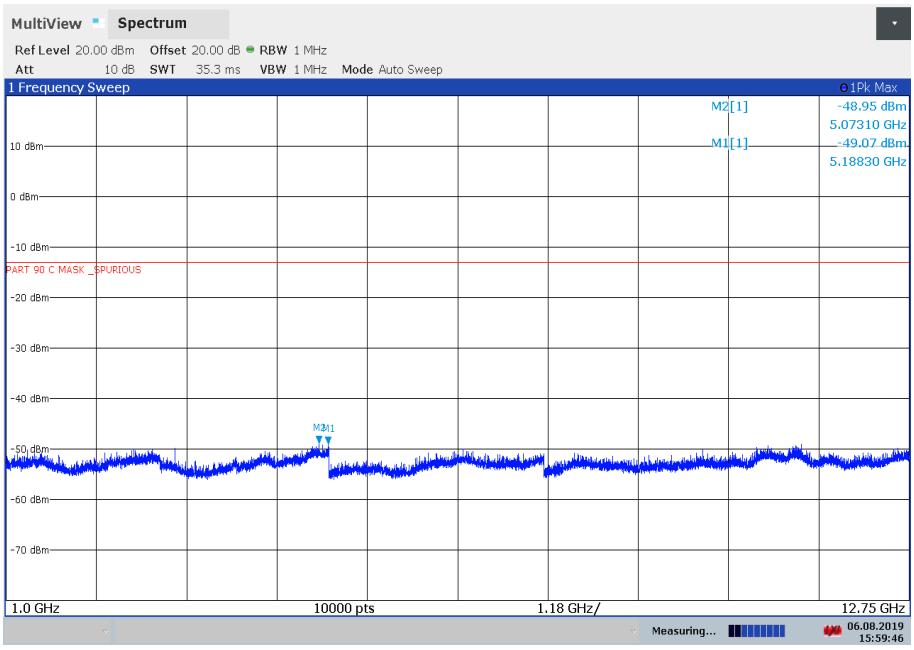
15:57:17 06.08.2019

Plot 3: 30 MHz to 1 GHz Middle channel



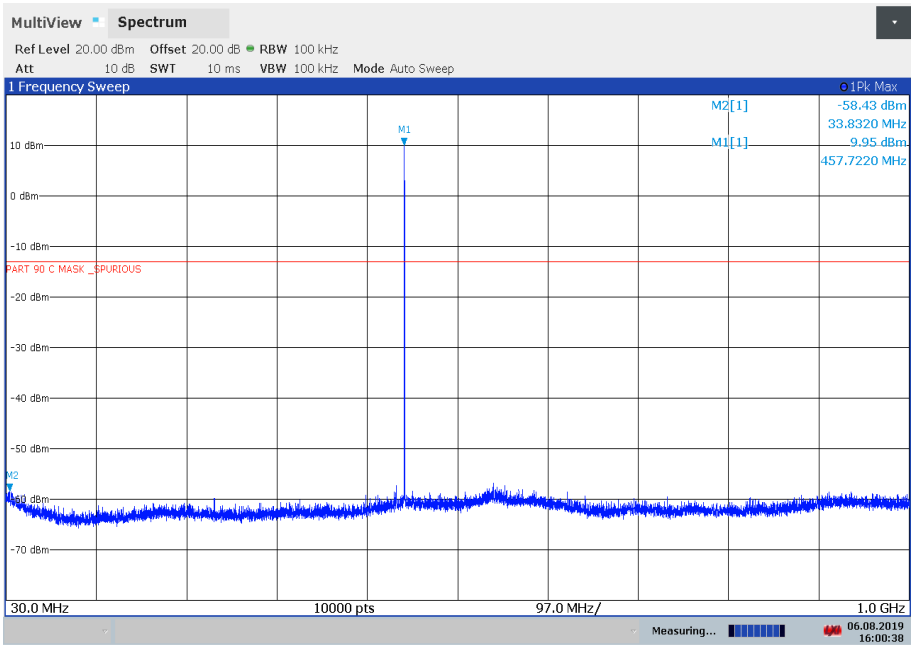
15:58:26 06.08.2019

Plot 4: 1GHz to 12.75 GHz Middle channel



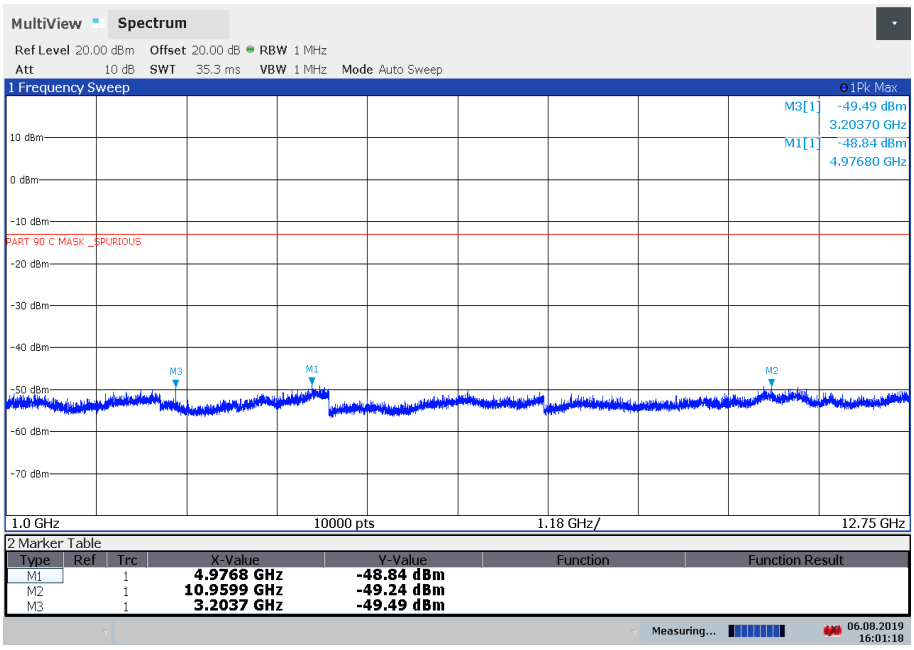
15:59:46 06.08.2019

Plot 5: 30 MHz to 1 GHz Highest channel



16:00:39 06.08.2019

Plot 6: 1GHz to 12.75 GHz Highest channel



16:01:19 06.08.2019

10.7 Transmitter spurious emissions (radiated) above 1 GHz

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Video bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Span:	See plots
Trace mode:	Max. hold
Test setup:	See sub clause 6.2 A
Measurement uncertainty	See sub clause 8

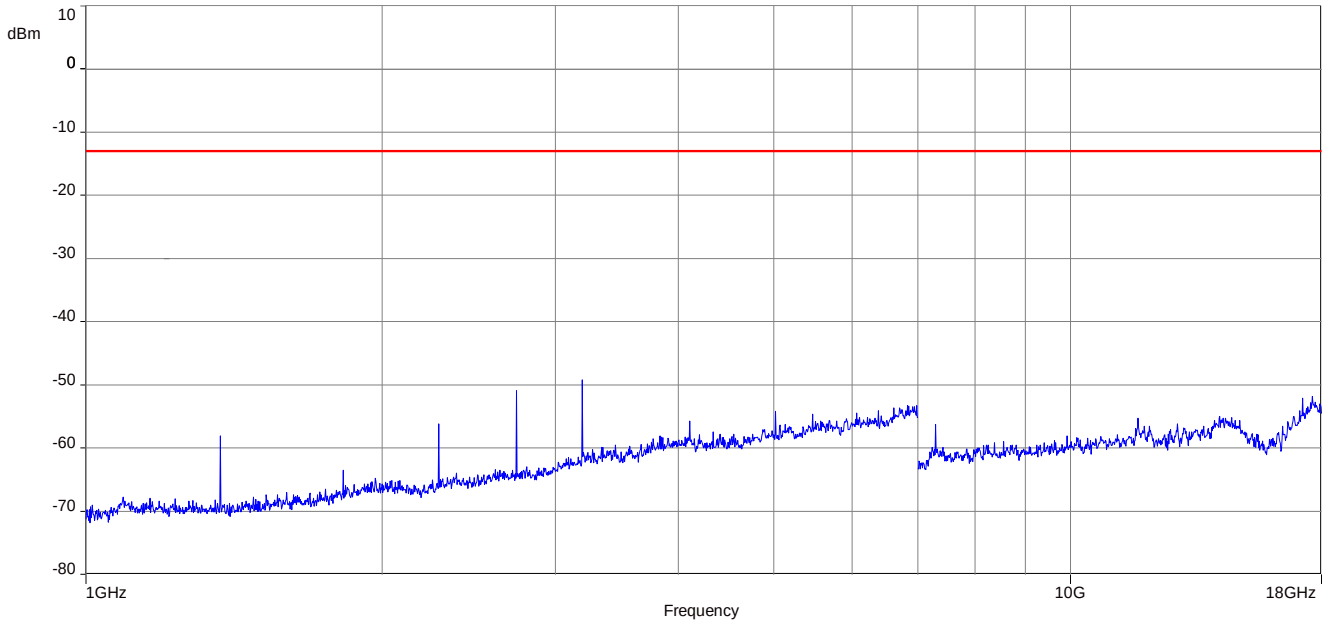
Limits:

FCC 47 CFR § 90.210 (d)
Emission Mask C a) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

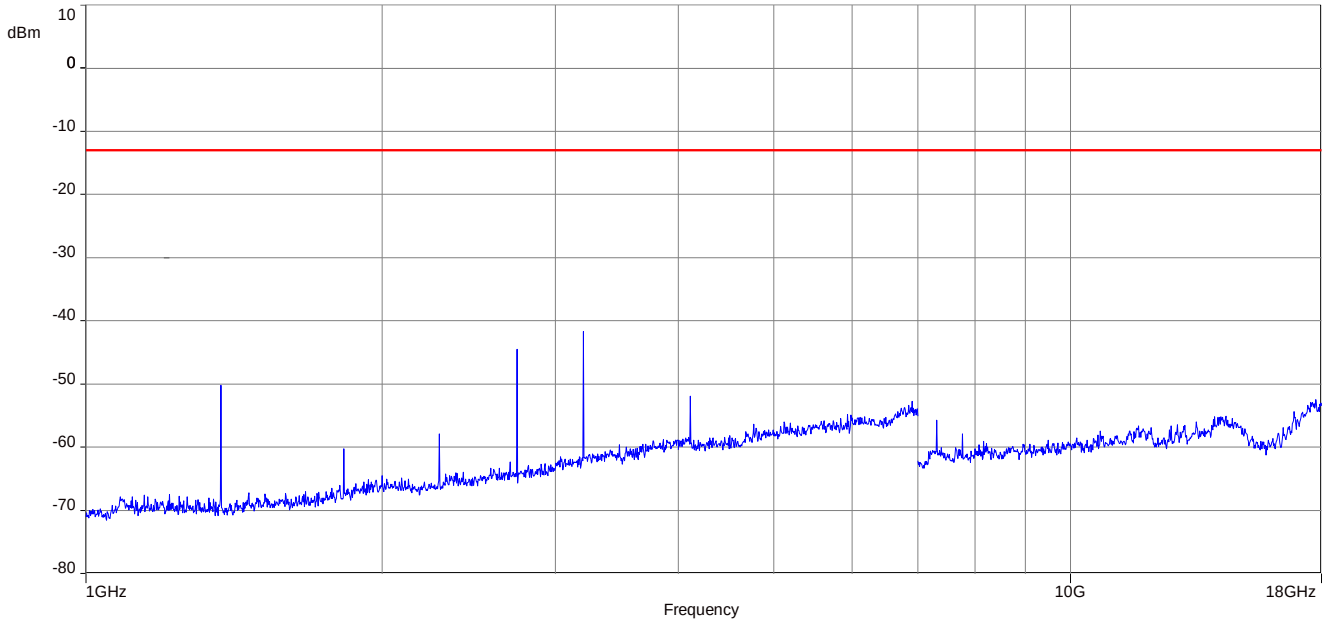
Results:

Transmitter spurious emissions								
Lowest channel			Middle channel			Highest channel		
Frequency	Detector	Level	Frequency	Detector	Level	Frequency	Detector	Level
All detected spurious emissions are more than 20 dB below the limit.			All detected spurious emissions are more than 20 dB below the limit.			All detected spurious emissions are more than 20 dB below the limit.		
Measurement uncertainty ± 3 dB								

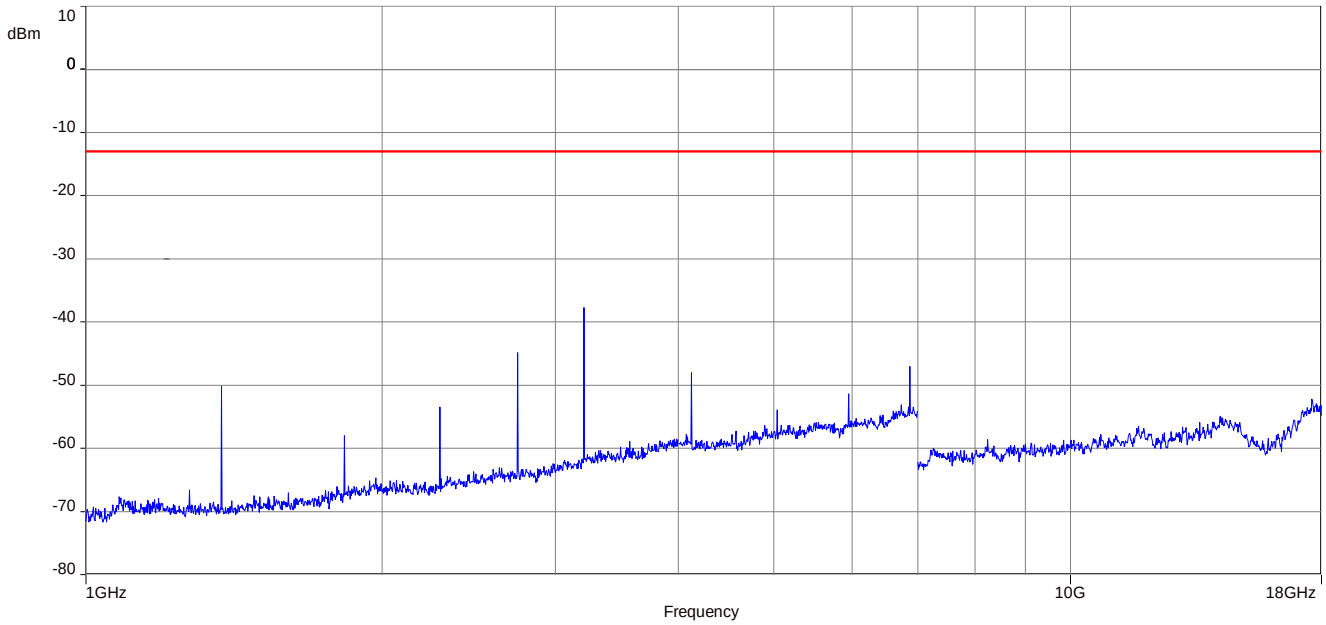
Plot 1: 1 GHz – 18 GHz, horizontal & vertical polarisation (lowest channel)



Plot 2: 1 GHz – 18 GHz, horizontal & vertical polarisation (middle channel)



Plot 3: 1 GHz – 18 GHz, horizontal & vertical polarisation (highest channel)



10.8 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:

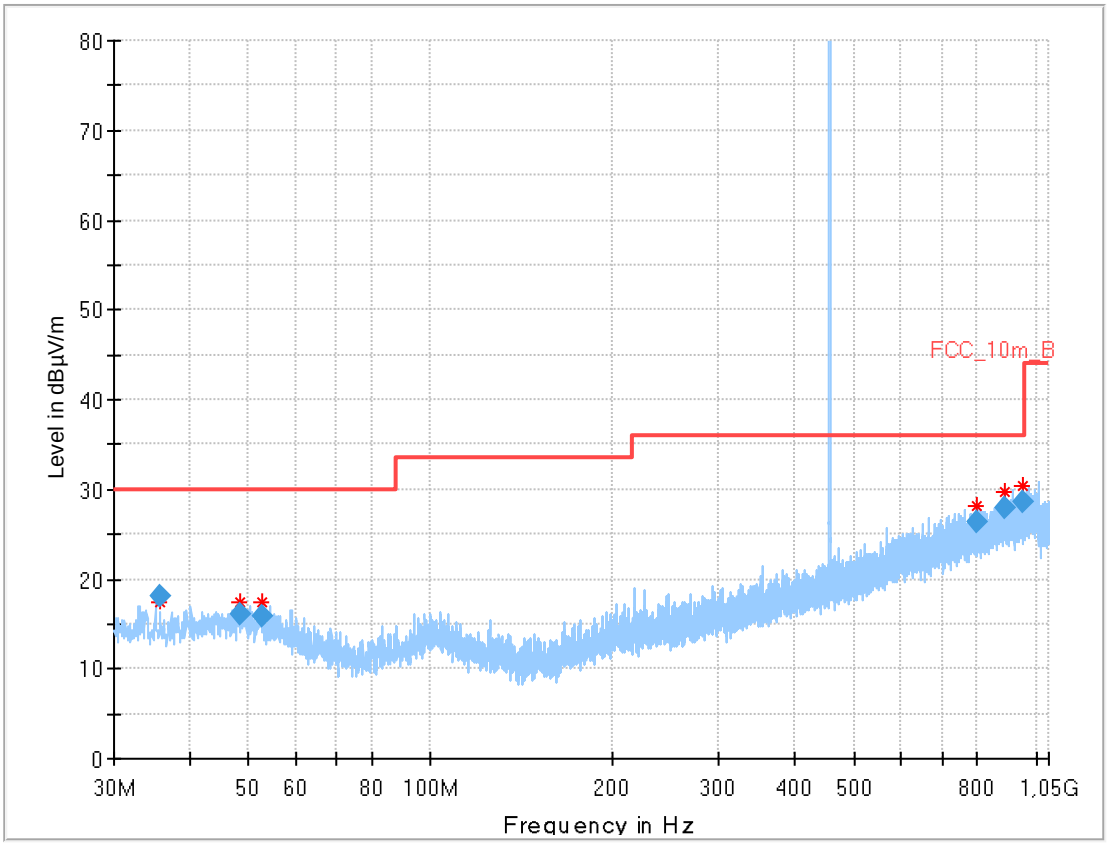
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	3 x VBW
Video bandwidth	120 kHz
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	DBPSK
Test setup	See sub clause 6.1 A
Measurement uncertainty	See sub clause 8

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

Plots:

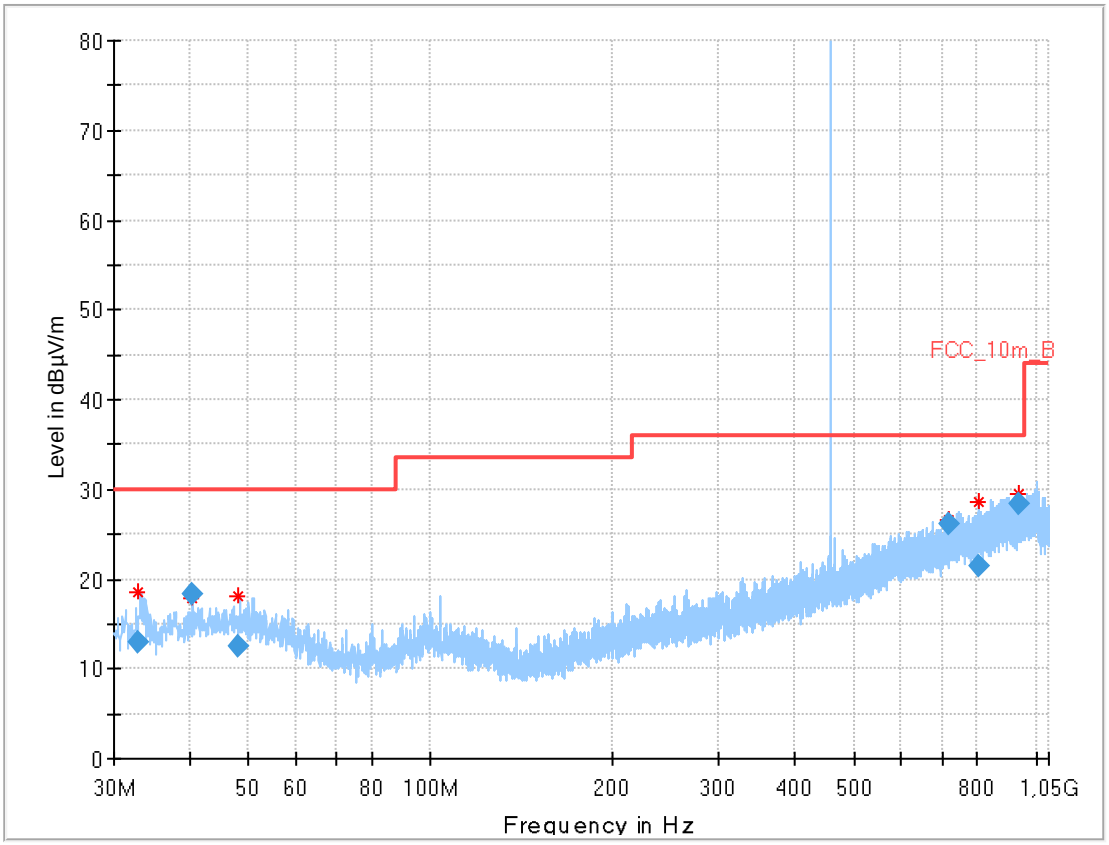
Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)



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)
35.699	18.04	30.0	11.96	1000	120	101.0	V	68.0	14
48.648	16.10	30.0	13.90	1000	120	101.0	V	202.0	15
52.576	15.87	30.0	14.13	1000	120	101.0	V	22.0	15
798.050	26.34	36.0	9.66	1000	120	98.0	H	79.0	22
884.852	27.92	36.0	8.08	1000	120	170.0	V	269.0	24
953.721	28.57	36.0	7.43	1000	120	170.0	V	248.0	24

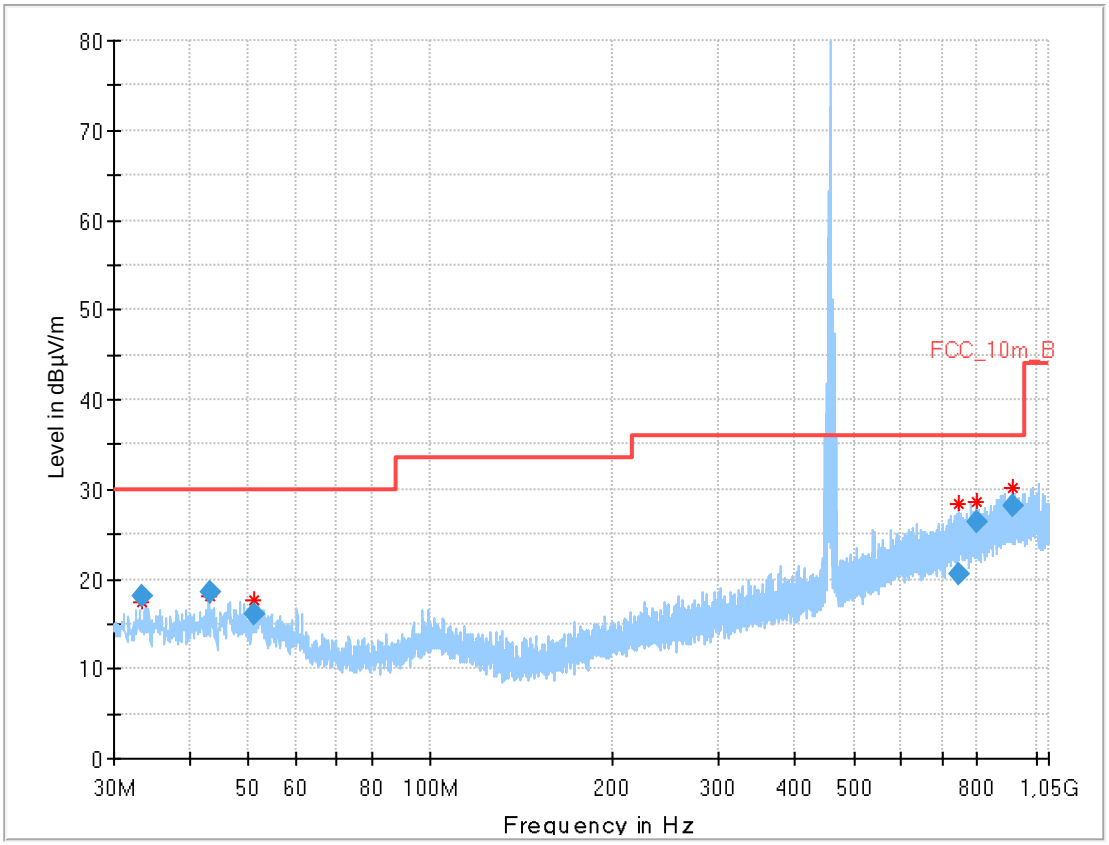
Plot 2: 30 MHz – 1 GHz, horizontal & vertical polarisation (middle channel)



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)
32.902	13.04	30.0	16.96	1000	120	148.0	V	-9.0	13
40.404	18.33	30.0	11.67	1000	120	101.0	H	-10.0	14
47.934	12.47	30.0	17.53	1000	120	101.0	V	-21.0	15
717.890	26.08	36.0	9.92	1000	120	170.0	H	112.0	22
806.053	21.41	36.0	14.59	1000	120	101.0	H	22.0	22
935.825	28.46	36.0	7.54	1000	120	170.0	H	292.0	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)
33.361	18.16	30.0	11.84	1000	120	101.0	V	181.0	14
43.082	18.59	30.0	11.41	1000	120	101.0	H	292.0	15
51.218	16.05	30.0	13.95	1000	120	170.0	V	-21.0	15
743.459	20.62	36.0	15.38	1000	120	170.0	V	2.0	22
800.538	26.42	36.0	9.58	1000	120	170.0	V	1.0	22
915.447	28.14	36.0	7.86	1000	120	170.0	V	259.0	24

10.9 Spurious emissions radiated < 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The limits are recalculated to a measurement distance of 3 m with 40 dB/decade according CFR Part 2.

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
Test setup:	See sub clause 6.2 B
Measurement uncertainty	See sub clause 8

Limits:

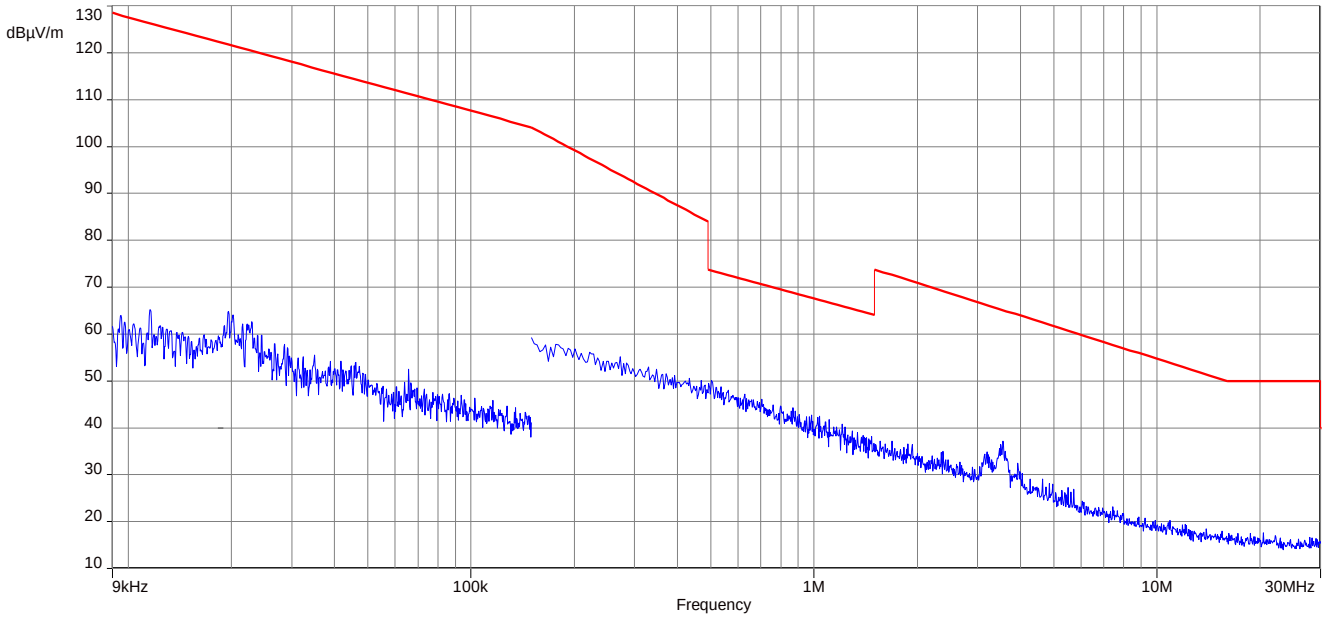
FCC		
TX Spurious Emissions Radiated < 30 MHz		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results:

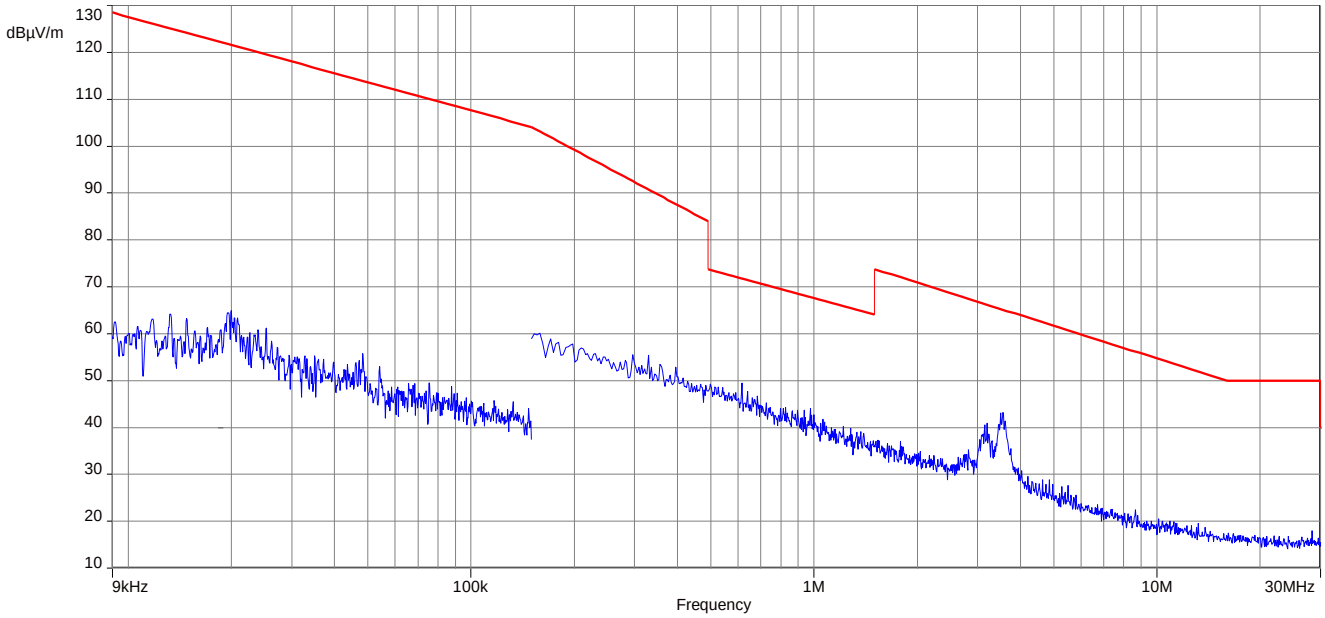
Transmitter spurious emissions								
Lowest channel			Middle channel			Highest channel		
Frequency	Detector	Level	Frequency	Detector	Level	Frequency	Detector	Level
No Spurious Emissions detected			No Spurious Emissions detected			No Spurious Emissions detected		

Plots: TX mode

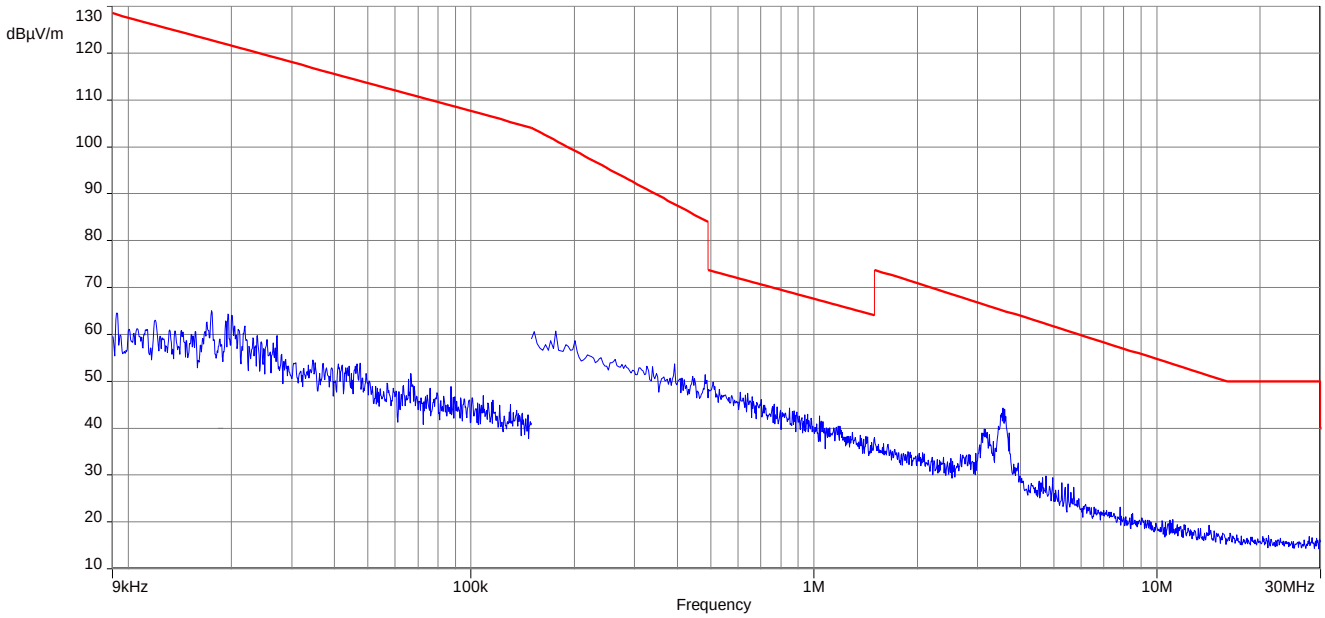
Plot 1: 9 kHz to 30 MHz- Lowest channel



Plot 2: 9 kHz to 30 MHz- Middle channel



Plot 3: 9 kHz to 30 MHz- Highest channel



10.10 Receiver spurious emissions (radiated)

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Resolution bandwidth:	f < 1 GHz : 100 kHz f ≥ 1GHz : 1 MHz
Span:	See plots
Trace mode:	Max. hold
Test setup:	See sub clause 6.1 / 6.2 A & B
Measurement uncertainty	See sub clause 8

Limits:

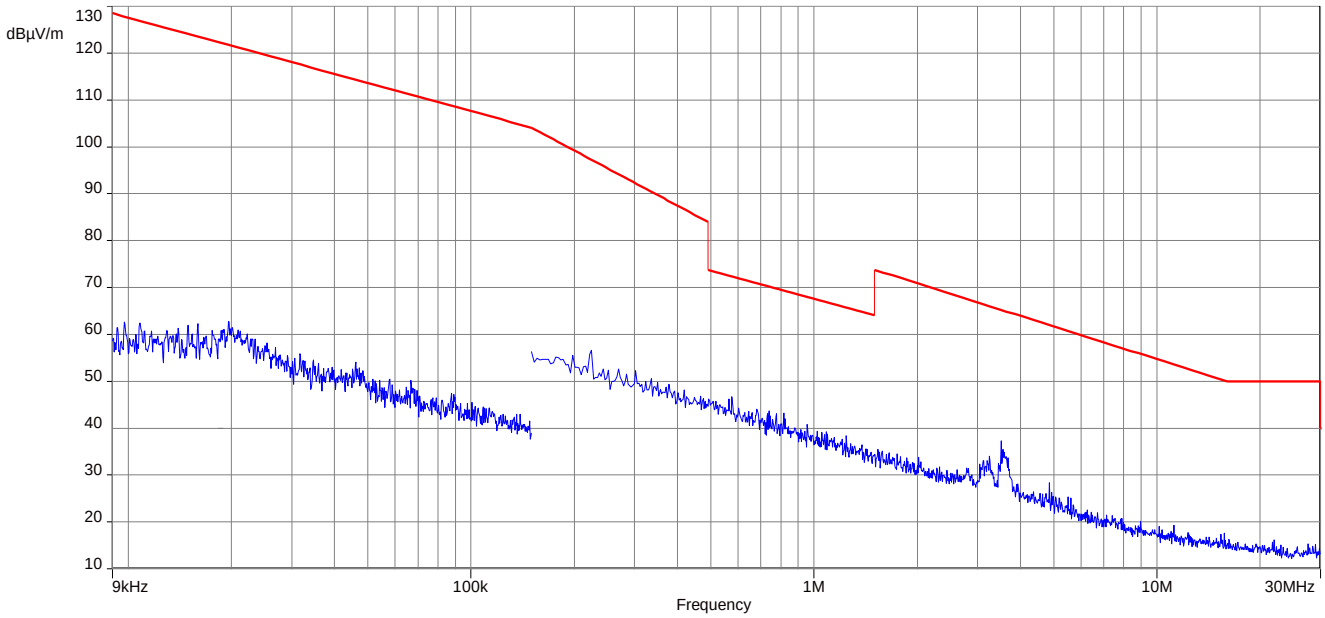
FCC 47 CFR § 15.209		
Receiver spurious emission (radiated)		
Frequency (MHz)	**Field strength (µV/m)**	**Measurement distance (m)**
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
above 960	500	3

Results:

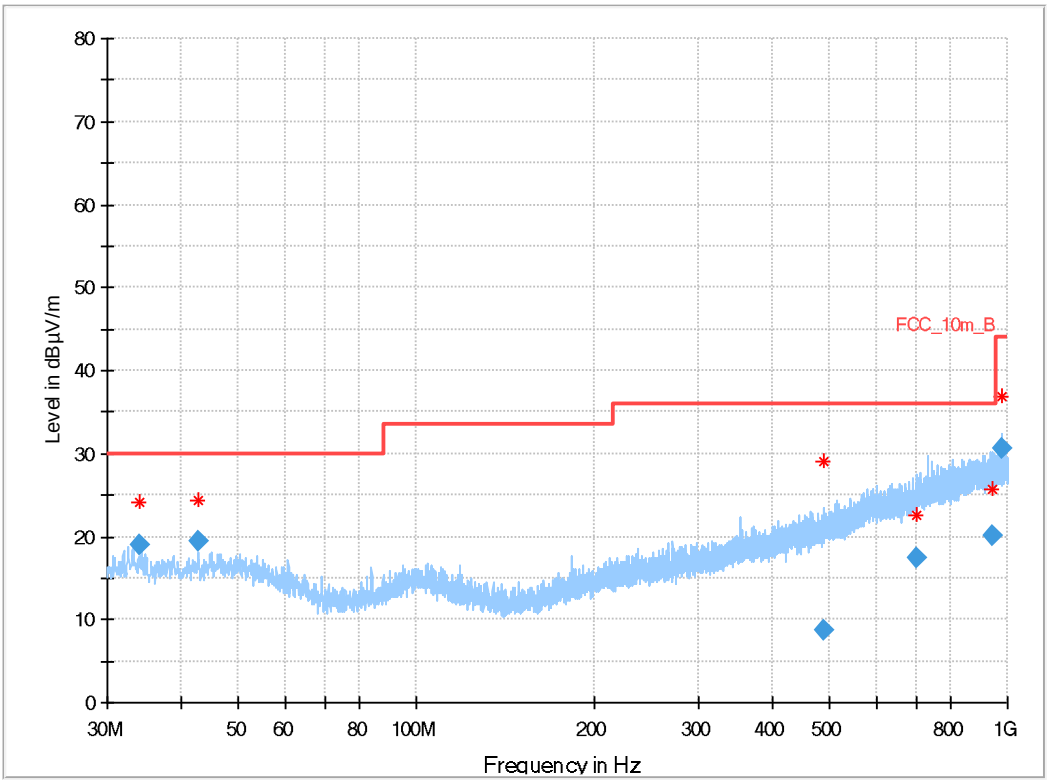
RX mode			
Spurious emissions (valid for all channels)			
Frequency	RBW	Detector	Power
No Spurious Emissions detected.			

Plots:

Plot 1: 9 kHz - 30 MHz



Plot 2: 30 MHz – 1 GHz



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)
33.904	18.93	30.0	11.07	1000	120	139.0	V	139.0	14
42.853	19.37	30.0	10.63	1000	120	143.0	H	333.0	15
489.741	8.61	36.0	27.39	1000	120	104.0	V	339.0	18
702.054	17.45	36.0	18.55	1000	120	170.0	H	26.0	21
941.683	20.22	36.0	15.78	1000	120	170.0	V	151.0	24
980.840	30.68	44.0	13.32	1000	120	170.0	V	329.0	24

10.11 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

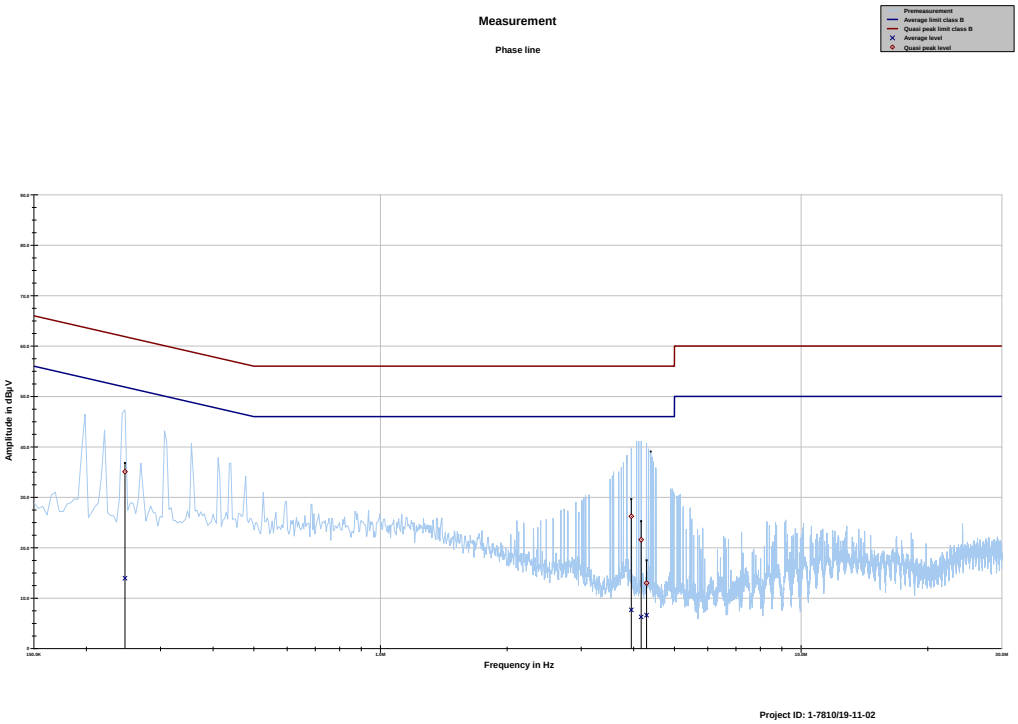
*Decreases with the logarithm of the frequency

Results:

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

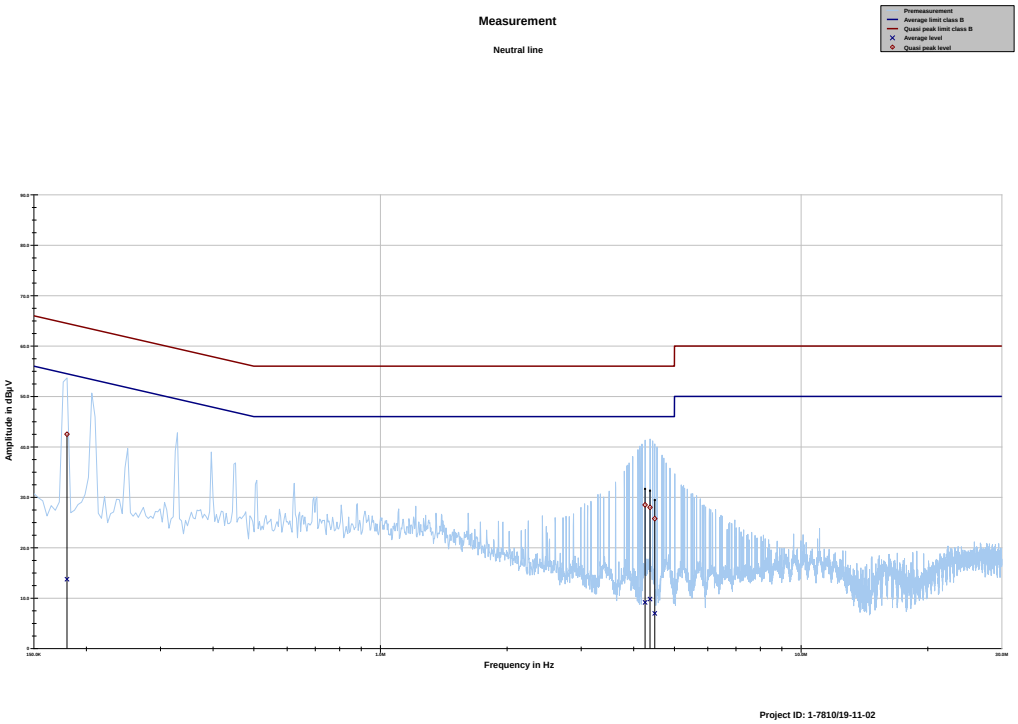
Plots:

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



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.247012	35.09	26.77	61.857	13.95	39.28	53.228
3.948412	26.22	29.78	56.000	7.67	38.33	46.000
4.168556	21.59	34.41	56.000	6.27	39.73	46.000
4.291688	12.98	43.02	56.000	6.61	39.39	46.000

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



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.179850	42.50	21.99	64.493	13.75	41.40	55.147
4.258106	28.50	27.50	56.000	9.14	36.86	46.000
4.373775	27.99	28.01	56.000	9.81	36.19	46.000
4.489444	25.77	30.23	56.000	6.96	39.04	46.000

11 Observations

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

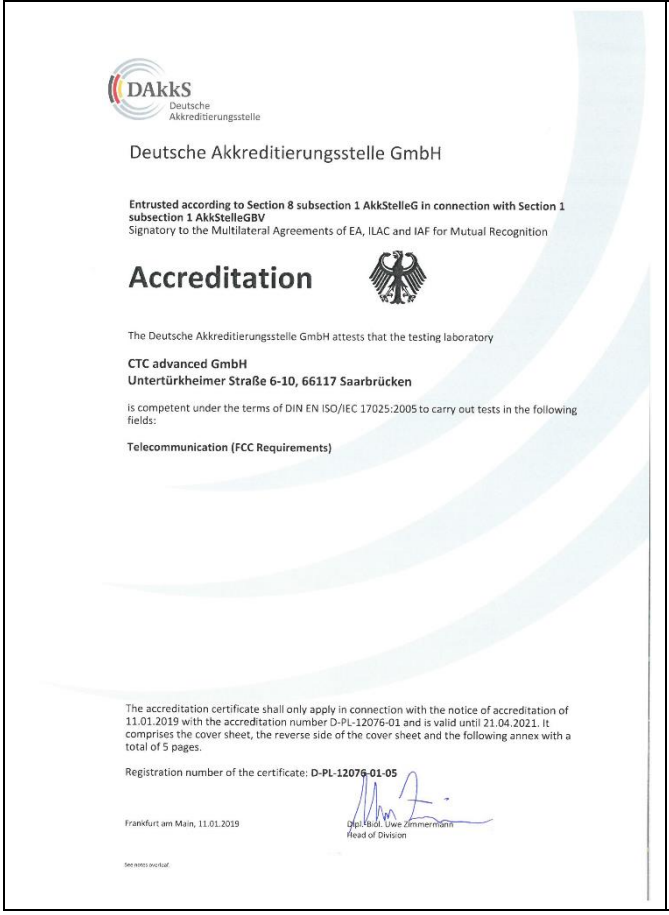
Annex A Glossary

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	2019-12-17

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

first page	last page
	

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

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

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