
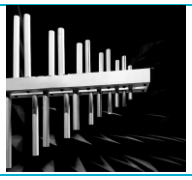
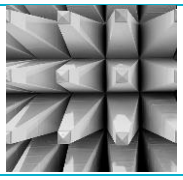

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TEST REPORT

Test report no.: 1-1276/16-07-04-A

DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-01

Testing laboratory

CTC advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
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Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-01

Applicant

SMA Solar Technology AG
Sonnenallee 1
34266 Niestetal / GERMANY
Phone: +49 5619 522-0
Fax: +49 (0) 561 9522-4780
Contact: Dante Bauer
e-mail: Dante.Bauer@sma.de
Phone: +49 (0) 561 9522-2255

Manufacturer

SMA Solar Technology AG
Sonnenallee 1
34266 Niestetal / GERMANY

Test standard/s

47 CFR Part 15	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 1	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:	**Communication Unit**
Model name:	**IND-10/IND-US-10**
FCC ID:	**SVFINDUS10**
IC:	**9440A-INDUS10**
Frequency:	DTS band 2400 MHz to 2483.5 MHz
Technology tested:	WLAN
Antenna:	Integrated chip antenna
Power supply:	24.0 V DC by external power supply
Temperature range:	-20°C to +60°C

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

Test report authorized:

David Lang
cn=David Lang, o=CTC advanced GmbH, ou=LNG-161129, email=david.lang@ctcadvanced.com, c=DE
2017.03.07 07:59:28 +01'00'

David Lang
Lab Manager
Radio Communications & EMC

Test performed:

cn=Rene Oelmann, o=CTC Advanced GmbH, ou=OEL-161129, email=rene.oelmann@ctcadvanced.com, c=DE
2017.03.07 06:21:02 +01'00'

René Oelmann
Lab 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.

This test report replaces the test report with the number 1-1276/16-07-04 and dated 2017-01-12

2.2 Application details

Date of receipt of order:	2016-11-30
Date of receipt of test item:	2016-11-28
Start of test:	2016-11-30
End of test:	2016-12-05
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

3 Test standard/s and references

Test standard	Date	Description
47 CFR Part 15	June 2016	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 1	May 2015	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices
RSS - Gen Issue 4	November 2014	Spectrum Management and Telecommunications Radio Standards Specifications - General Requirements and Information for the Certification of Radio Apparatus

Guidance	Version	Description
DTS: KDB 558074 D01	v03r05	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
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

4 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests +60 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	24.0 V DC by external power supply 30.0 V 10.0 V

5 Test item

5.1 General description

Kind of test item	:	Communication Unit
Type identification	:	IND-10/IND-US-10
HMN	:	-/-
PMN	:	SMA Industrial Manager
HVIN	:	IND-US-10
FVIN	:	-/-
S/N serial number	:	Rad. 17 Cond. 16
HW hardware status	:	P2
SW software status	:	Linux version 4.4.13-sma-160616-Iguana-BSP
Frequency band	:	DTS band 2400 MHz to 2483.5 MHz
Type of radio transmission Use of frequency spectrum	: :	DSSS, CCK, OFDM
Type of modulation	:	BPSK, QPSK, 16 – QAM, 64 - QAM
Number of channels	:	11
Antenna	:	Integrated chip antenna
Power supply	:	24.0 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: 1-1276/16-07-01_AnnexA
1-1276/16-07-01_AnnexB
1-1276/16-07-01_AnnexC

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).

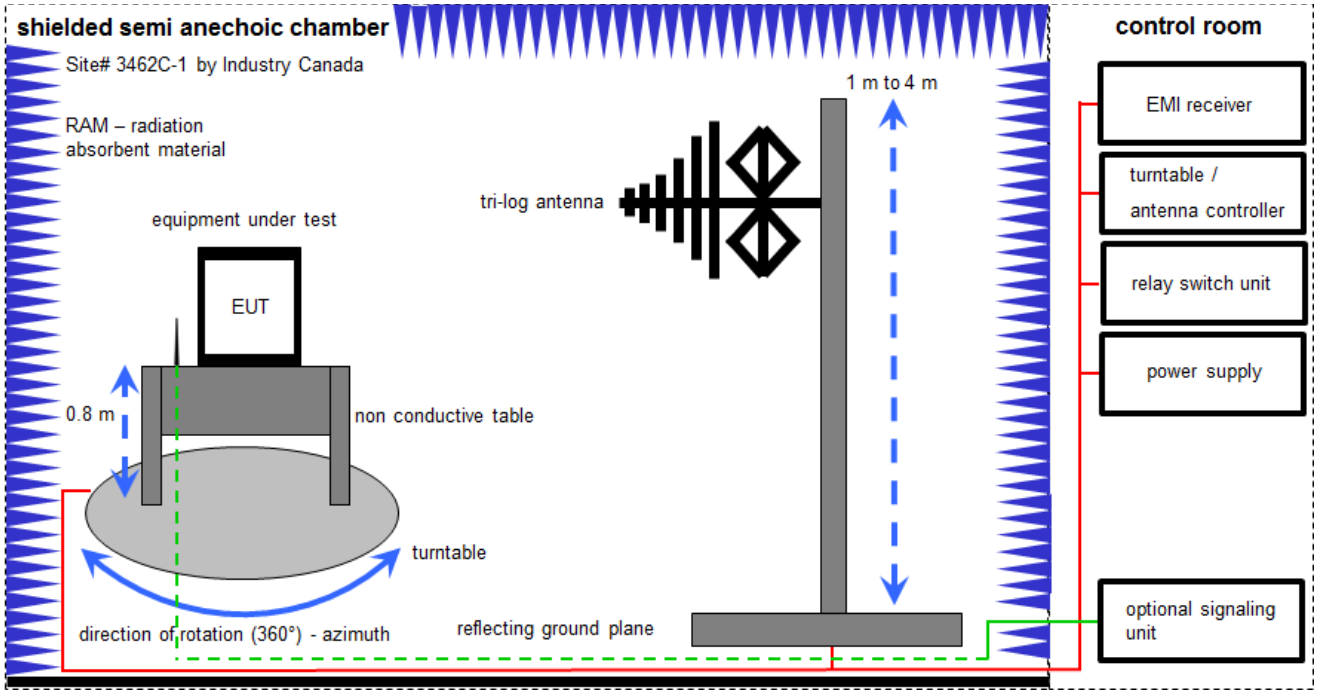
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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 9 kHz 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 confirmed with 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

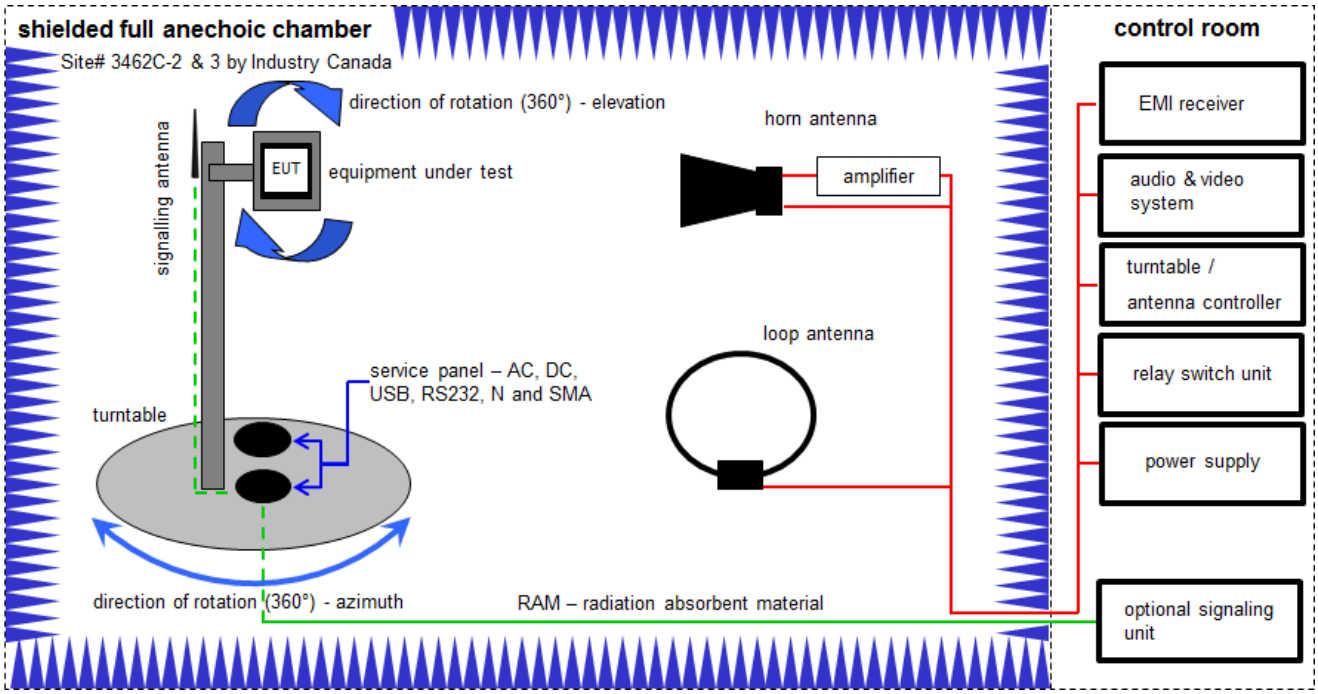
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	08.03.2016	08.03.2017
4	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
5	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	25.04.2016	25.04.2018

6.2 Shielded fully anechoic chamber



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

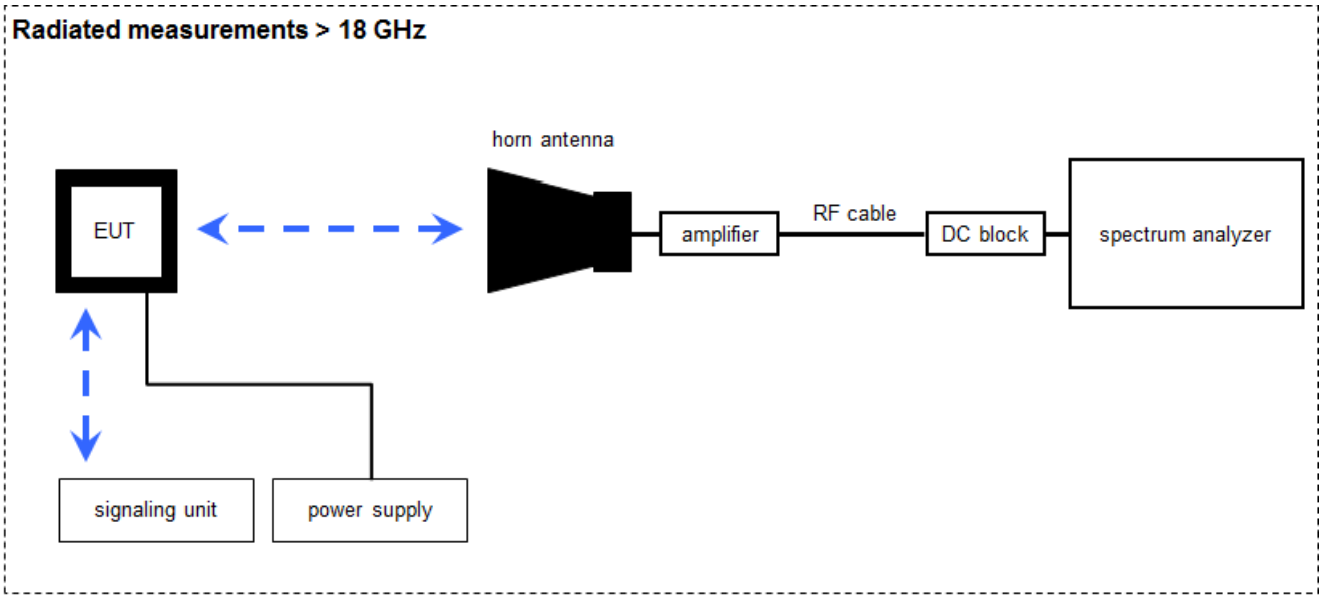
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3088	300001032	vIKI!	20.05.2015	20.05.2017
2	A	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
4	A	Active Loop Antenna 10 kHz to 30 MHz	6502	EMCO/2	8905-2342	300000256	k	24.06.2015	24.06.2017
5	A	Band Reject filter	WRCG2400/2483-2375/2505-50/10SS	Wainwright	11	300003351	ev	-/-	-/-
6	A	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	02.02.2016	02.02.2017
7	A	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne	-/-	-/-
8	A	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
9	A	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-

6.3 Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

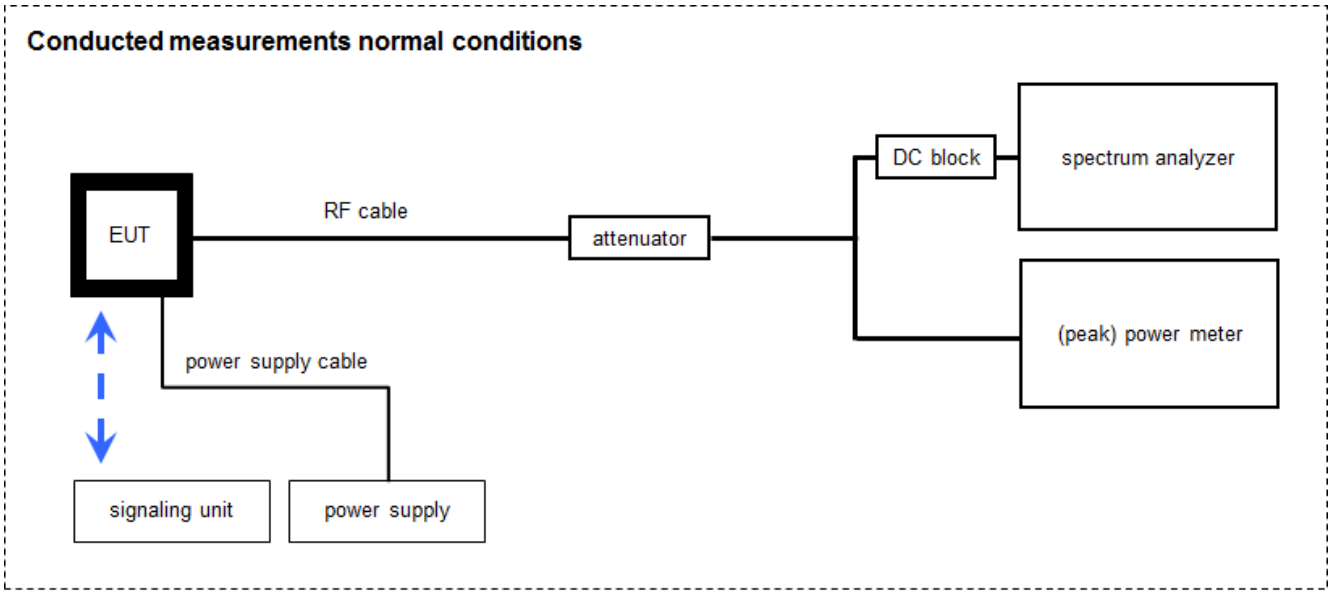
FS = U_R + CA + AF
(FS-field strength; U_R-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Std. Gain Horn Antenna 18.0 to 26.5 GHz	638	Narda	-/-	300000486	k	10.09.2015	10.09.2017
2	A	Amplifier 2-40 GHz	JS32-02004000-57-5P	MITEQ	1777200	300004541	ev	-/-	-/-
3	A	Signal Analyzer 40 GHz	FSV40	R&S	101353	300004819	k	19.09.2016	19.09.2017
4	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
5	A	RF-Cable	ST18/SMAm/SMm/48	Huber & Suhner	Batch no. 127377	400001183	ev	-/-	-/-

6.4 Conducted measurements with peak power meter & spectrum analyzer



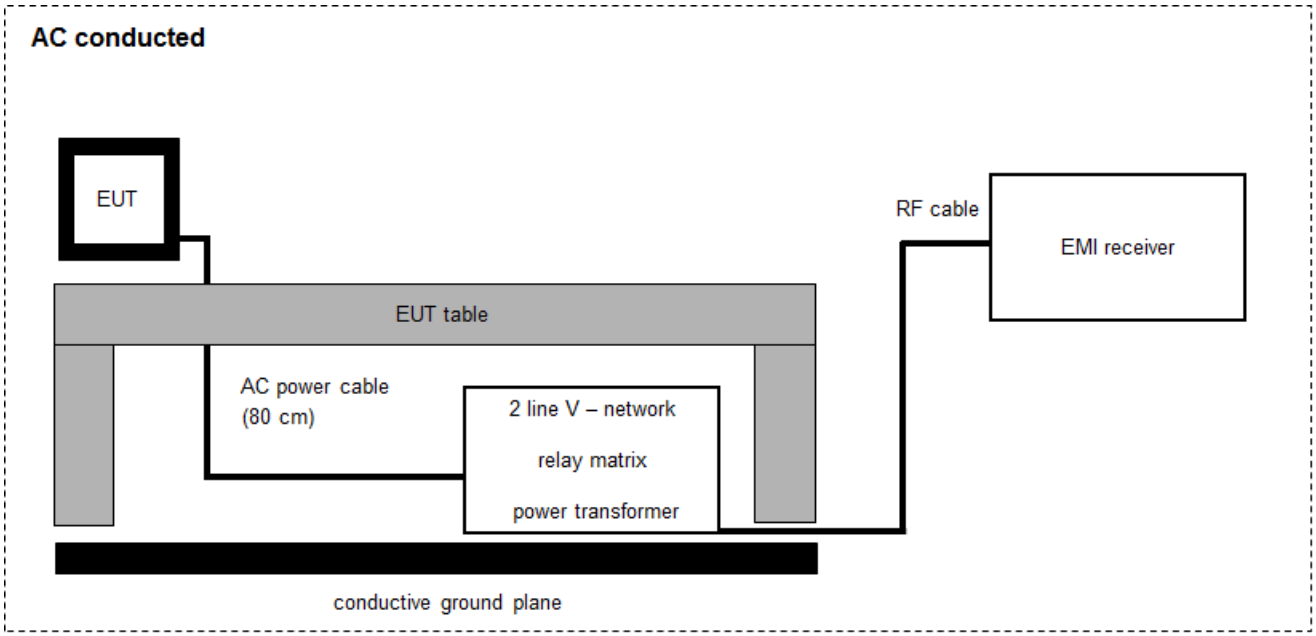
OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

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 Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch / Control Unit	3488A	HP	-/-	300000929	ne	-/-	-/-
2	A	Power Supply	NGSM 32/10	R&S	3939	400000192	vlKl!	22.01.2015	22.01.2017
3	A	Signal Analyzer 30GHz	FSV30	R&S	103170	300004855	k	25.01.2016	25.01.2017
4	A	Power Sensor	NRP-Z81	R&S	100010	300003780	k	25.01.2016	25.01.2017
5	A	Directional Coupler	101020010	Krytar	70215	300002840	ev	-/-	-/-
6	A	DC-Blocker	8143	Inmet Corp.	none	300002842	ne	-/-	-/-
7	A	Powersplitter	6005-3	Inmet Corp.	none	300002841	ev	-/-	-/-
8	A	RF-Cable	ST18/SMAm/SMAm/ 72	Huber & Suhner	Batch no. 605505	400001187	ev	-/-	-/-
9	A	RF-Cable	Sucoflex 104	Huber & Suhner	147636/4	400001188	ev	-/-	-/-

6.5 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	893045/004	300000584	k	02.02.2016	01.02.2017
2	A	Power Supply	NGSM 32/10	R&S	3939	400000192	vlKl!	22.01.2015	22.01.2017
3	A	RF-Filter-section	85420E	HP	3427A00162	300002214	k	27.11.2006	-/-
4	A	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	08.04.2008	-/-
5	A	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	16.08.2016	16.08.2017

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, 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 height is 1.5 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 premeasurement are maximized by the software by rotating the turntable from 0° to 360°. In case of the 2-axis positioner is used the elevation axis is also rotated from 0° to 360°.
- 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.

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.

7.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- 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.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

Premeasurement

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

8 Measurement uncertainty

Measurement uncertainty	
Test case	**Uncertainty**
Antenna gain	± 3 dB
Power spectral density	± 1.5 dB
DTS bandwidth	± 100 kHz (depends on the used RBW)
Occupied bandwidth	± 100 kHz (depends on the used RBW)
Maximum output power	± 1.5 dB
Detailed spurious emissions @ the band edge - conducted	± 1.5 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
Spurious emissions conducted below 30 MHz (AC conducted)	± 2.6 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 1	See table!	2017-03-06	-/-

Test specification clause	Test case	Guideline	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4 (4)	Antenna gain	-/-	Nominal	Nominal	DSSS	-/-				-/-
RSS – 247 / 6.0	Duty cycle	-/-	Nominal	Nominal	DSSS OFDM	-/-				-/-
§15.247(e) RSS - 247 / 5.2 (2)	Power spectral density	KDB 558074 DTS clause: 10.2	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(a)(2) RSS - 247 / 5.2 (1)	DTS bandwidth	KDB 558074 DTS clause: 8.1	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
RSS Gen clause 4.6.1	Occupied bandwidth	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(b)(3) RSS - 247 / 5.4 (4)	Maximum output power	KDB 558074 DTS clause: 9.1.2	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge - conducted	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance conducted and radiated	KDB 558074 DTS clause: 13.3.2 and clause 12.2.2	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	TX spurious emissions conducted	KDB 558074 DTS clause: 11.1 & 11.2 11.3	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.209(a) RSS-Gen	TX spurious emissions radiated below 30 MHz	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions radiated 30 MHz to 1 GHz	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions radiated above 1 GHz	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-
§15.109 RSS-Gen	RX spurious emissions radiated 30 MHz to 1 GHz	-/-	Nominal	Nominal	RX / idle	☒	☐	☐	☐	-/-
§15.109 RSS-Gen	RX spurious emissions radiated above 1 GHz	-/-	Nominal	Nominal	RX / idle	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions < 30 MHz	-/-	Nominal	Nominal	DSSS OFDM	☒	☐	☐	☐	-/-

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

10 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: Power settings versus modulation (data rate):

Modulation	Power setting
b-mode (1Mbit)	13000
g-mode (6Mbit)	18000
n-mode (MCS0)	18000

Test mode:

☐ No test mode available.
Iperf was used to ping another device with the largest support packet size

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

Antennas and transmit operating modes:

☒ Operating mode 1 (single antenna)

- *Equipment with 1 antenna,*
- *Equipment with 2 diversity antennas operating in switched diversity mode by which at any moment in time only 1 antenna is used,*
- *Smart antenna system with 2 or more transmit/receive chains, but operating in a mode where only 1 transmit/receive chain is used)*

☐ Operating mode 2 (multiple antennas, no beamforming)

- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously but without beamforming.*

☐ Operating mode 3 (multiple antennas, with beamforming)

- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously with beamforming.*
  In addition to the antenna assembly gain (G), the beamforming gain (Y) may have to be taken into account when performing the measurements.

11 Measurement results

11.1 Antenna gain

Measurement:

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For normal WLAN devices, the DSSS mode is used.

Measurement parameters:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	3 MHz
Video bandwidth:	3 MHz
Trace mode:	Max hold
Test setup:	See sub clause 6.2 – A; 6.4 - A
Measurement uncertainty:	See sub clause 8

Limits:

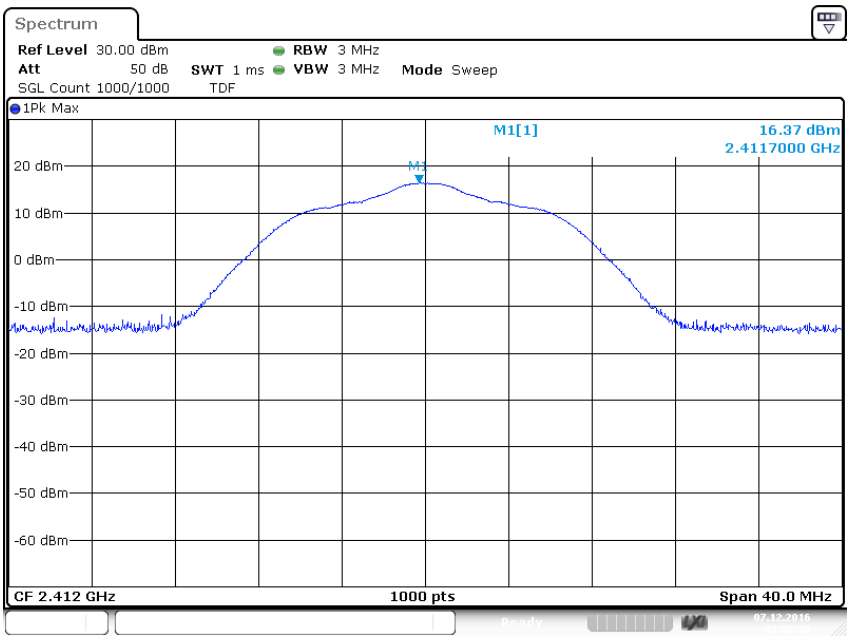
FCC	IC
6 dBi / > 6 dBi output power and power density reduction required	

Results:

T_{nom}	V_{nom}	lowest channel 2412 MHz	middle channel 2437 MHz	highest channel 2462 MHz
Conducted power [dBm] Measured with DSSS modulation		16.4	16.2	15.7
Radiated power [dBm] Measured with DSSS modulation		17.8	17.9	17.6
Gain [dBi] Calculated		1.4	1.7	1.9

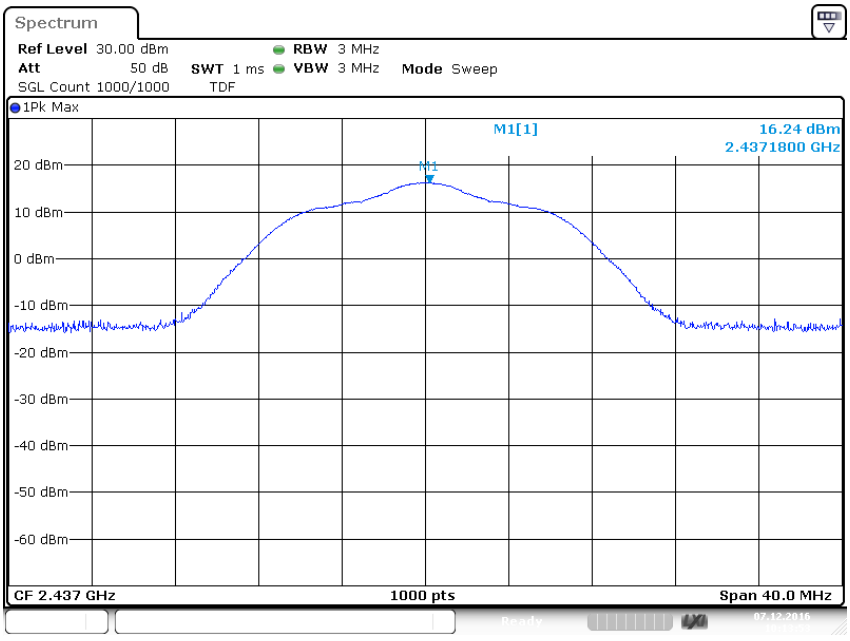
Plots: DSSS / b – mode

Plot 1: Lowest channel



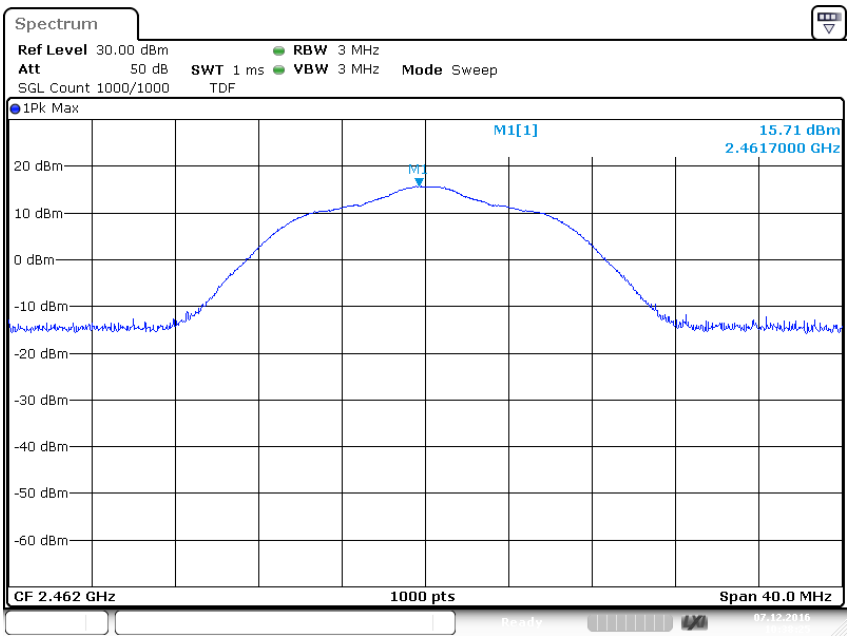
Date: 7.DEC.2016 09:58:26

Plot 2: Middle channel



Date: 7.DEC.2016 10:13:54

Plot 3: Highest channel



11.2 Identify worst case data rate

Results:

Modulation	Modulation scheme / bandwidth
DSSS / b – mode	1 Mbit/s
OFDM / g – mode	6 Mbit/s
OFDM / n HT20 – mode	MCS0

11.3 Maximum output power

Description:

Measurement of the maximum output power conducted and radiated. The measurements are performed using the data rate producing the highest conducted output power.

Measurement:

Measurement parameter	
According to DTS clause: 9.1.2	
Peak power meter	
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
Conducted: 1.0 W – Antenna gain with max. 6 dBi	

Results:

Frequency	Maximum Output Power [dBm]		
	2412 MHz	2437 MHz	2462 MHz
Output power conducted DSSS / b – mode	18.8	19.1	18.6
Output power conducted OFDM / g – mode	21.5	21.7	21.1
Output power conducted OFDM / n HT20 – mode	21.5	21.7	21.1

11.4 Duty cycle

Measurement:

Measurement parameters:

Measurement parameter	
Detector:	Peak
Sweep time:	Depends on the signal see plot
Resolution bandwidth:	10 MHz
Video bandwidth:	10 MHz
Trace mode:	Max hold
Test setup:	See sub clause 6.4 - A
Measurement uncertainty:	See sub clause 8

Limits:

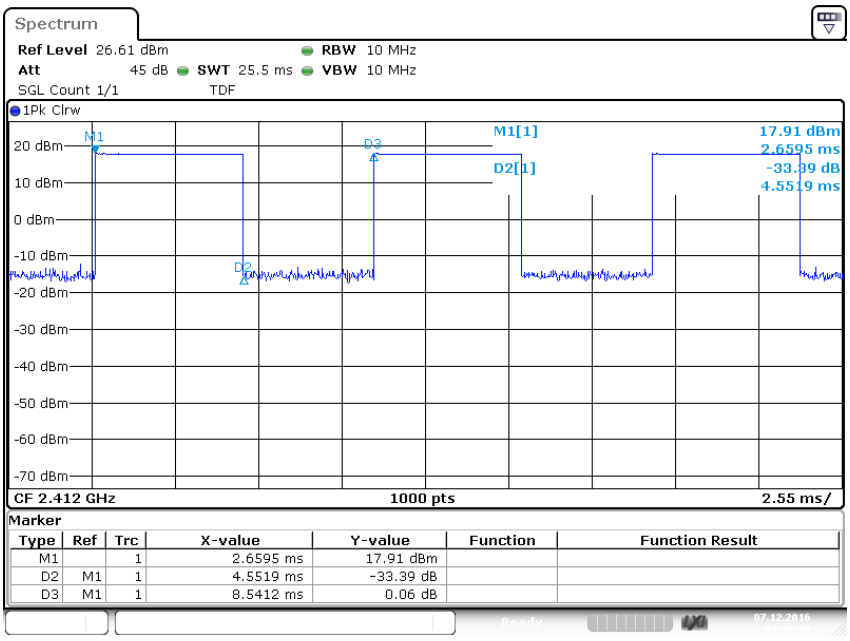
FCC	IC
-/-	

Results:

T_{nom}	V_{nom}	lowest channel 2412 MHz	middle channel 2437 MHz	highest channel 2462 MHz
DSSS / b – mode		53.3 % / 2.73 dB	53.5 % / 2.72 dB	53.5 % / 2.72 dB
OFDM / g – mode		16.2 % / 7.90 dB	15.9 % / 7.98 dB	16.0 % / 7.97 dB
OFDM / n HT20 – mode		15.3 % / 8.15 dB	15.3 % / 8.15 dB	15.4 % / 8.14 dB

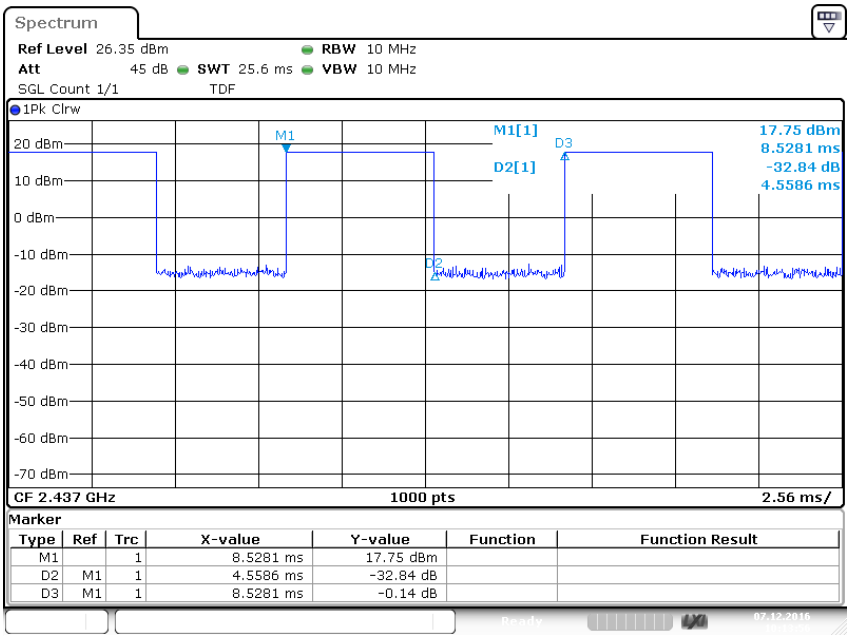
Plots: DSSS / b – mode

Plot 1: Lowest channel



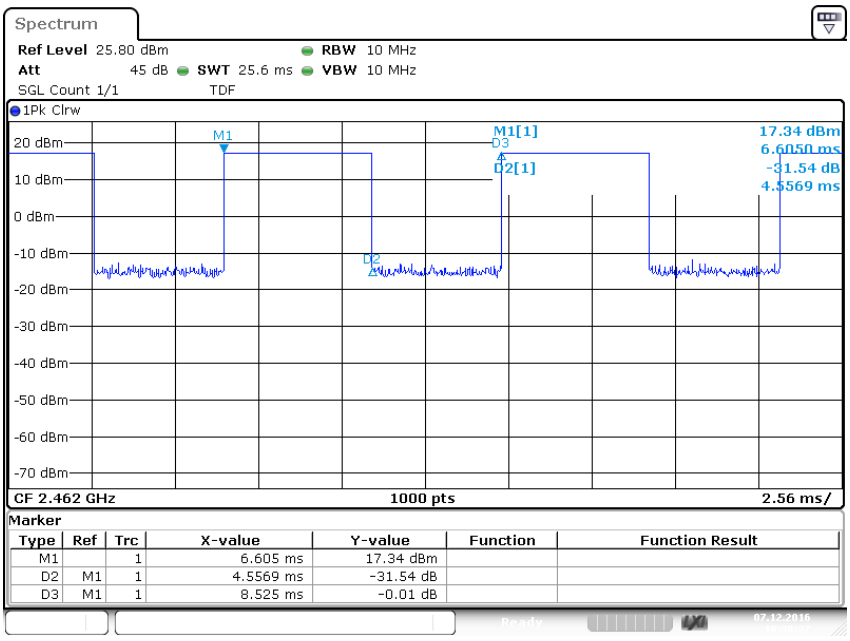
Date: 7.DEC.2016 09:58:29

Plot 2: Middle channel



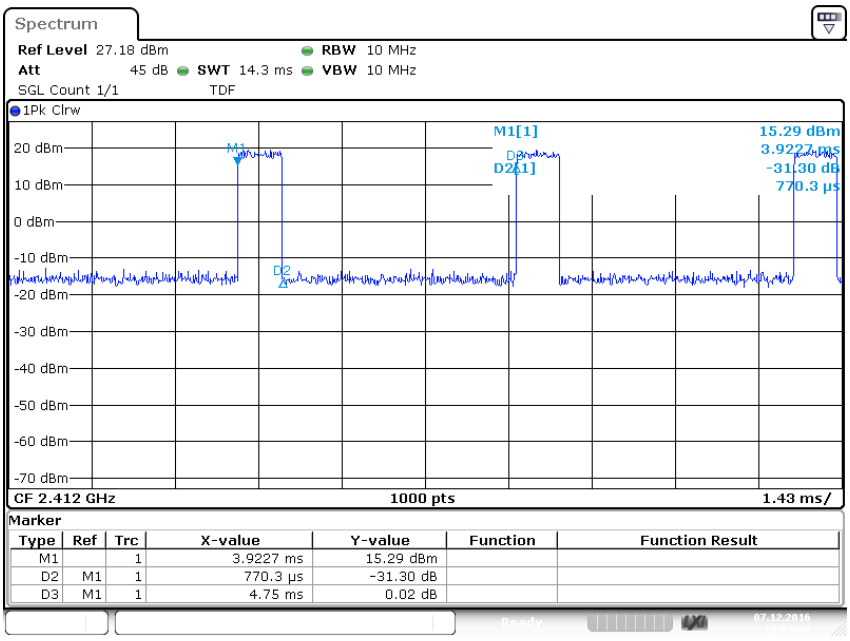
Date: 7.DEC.2016 10:13:56

Plot 3: Highest channel



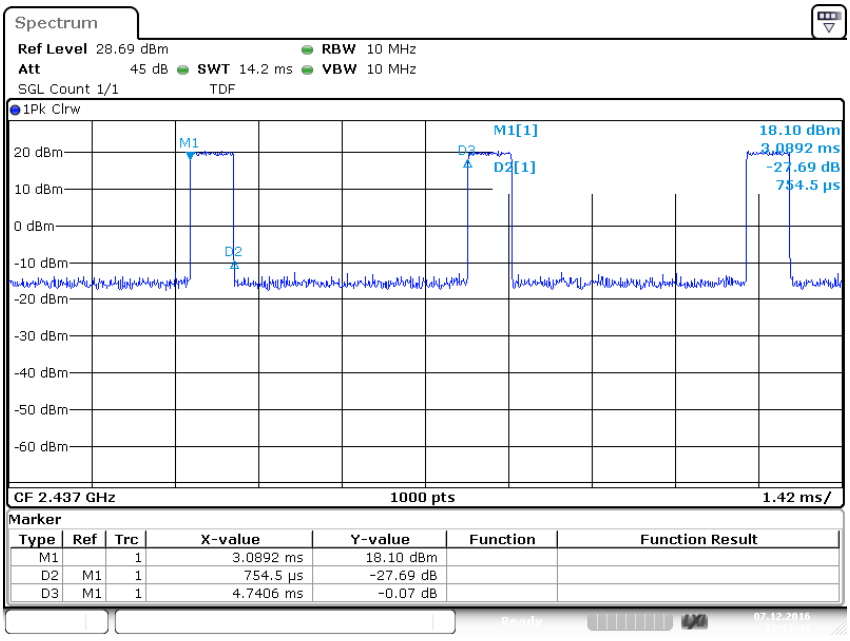
Plots: OFDM / g – mode

Plot 1: Lowest channel



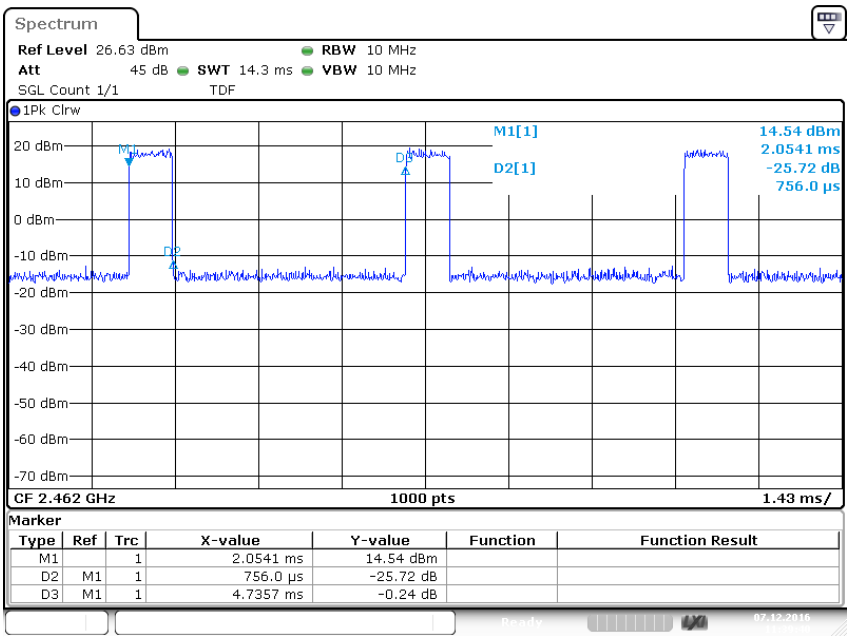
Date: 7.DEC.2016 10:53:08

Plot 2: Middle channel



Date: 7.DEC.2016 11:13:42

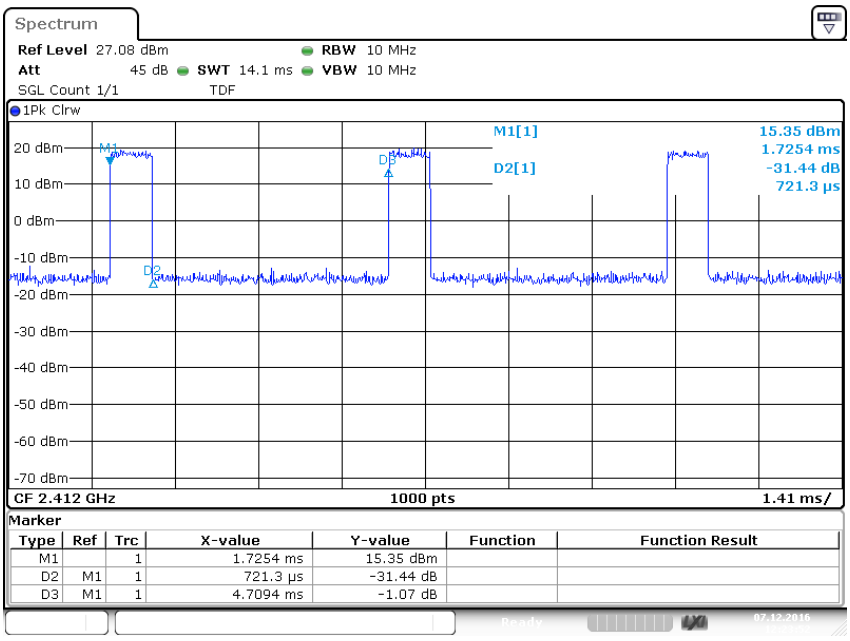
Plot 3: Highest channel



Date: 7.DEC.2016 11:39:40

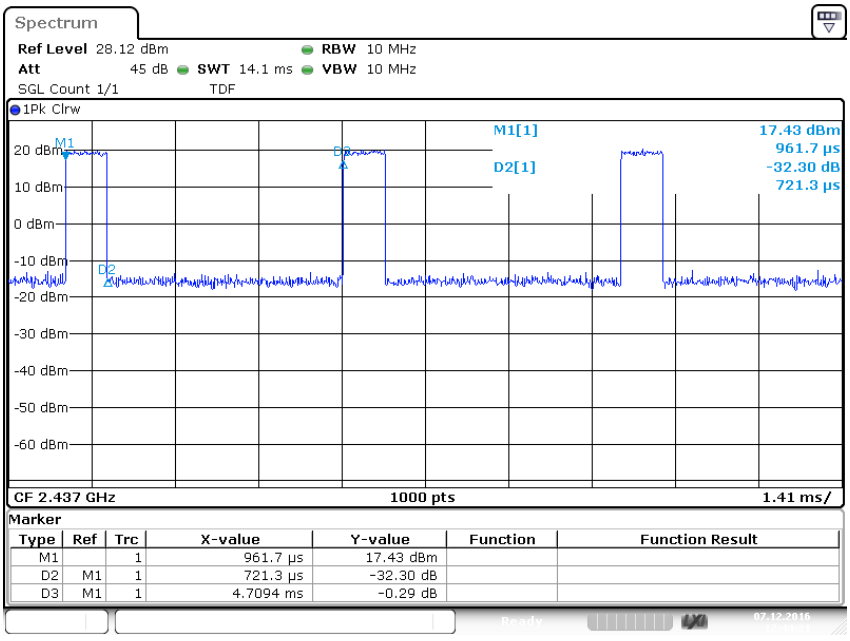
Plots: OFDM / n HT20 – mode

Plot 1: Lowest channel



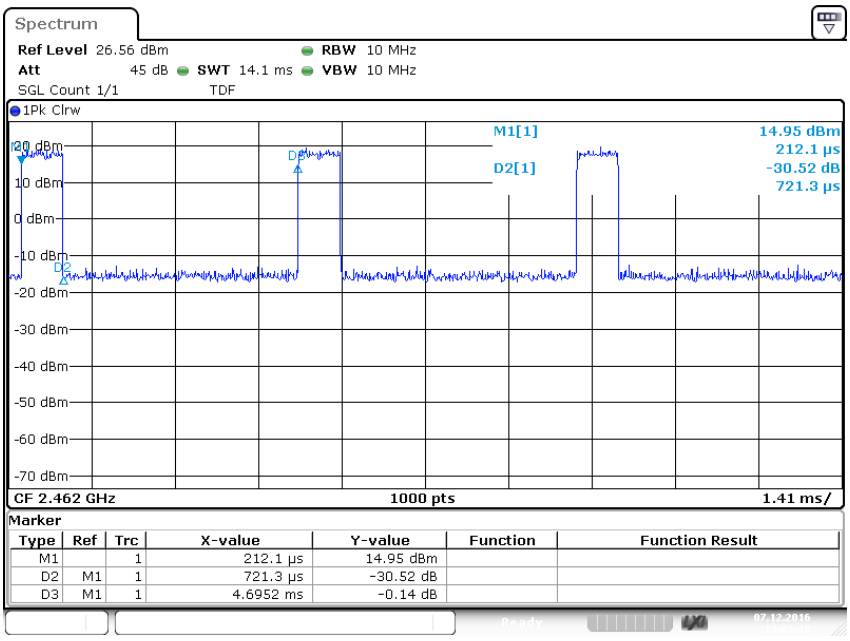
Date: 7.DEC.2016 12:23:53

Plot 2: Middle channel



Date: 7.DEC.2016 12:44:21

Plot 3: Highest channel



11.5 Peak power spectral density

Description:

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

Measurement:

Measurement parameter	
According to DTS clause: 10.2	
Detector:	Positive Peak
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Span:	30 MHz
Trace mode:	Max hold (allow trace to fully stabilize)
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
8 dBm / 3kHz (conducted)	

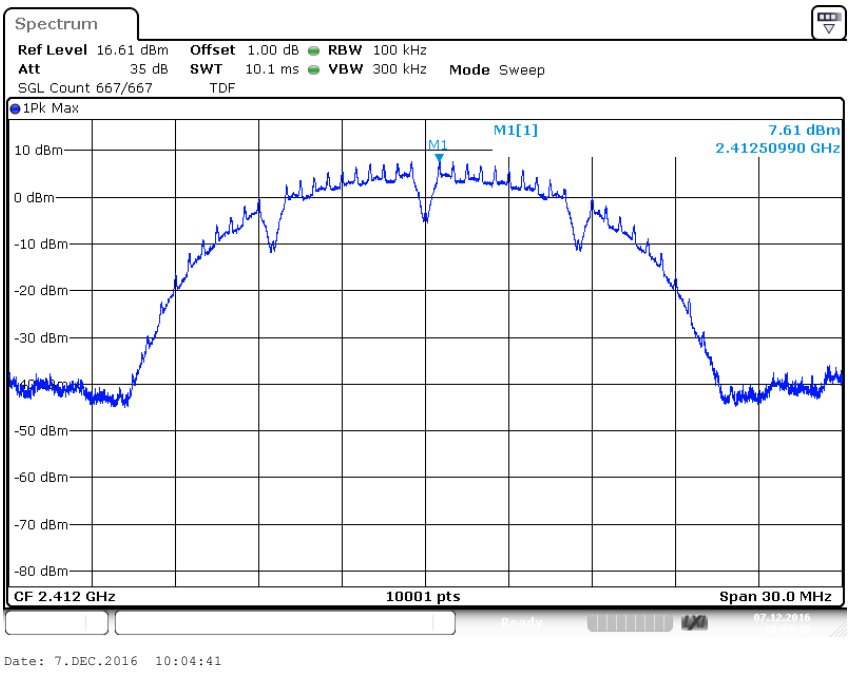
Results:

Modulation	Peak power spectral density [dBm]		
Frequency	2412 MHz	2437 MHz	2462 MHz
DSSS / b – mode	7.6	7.9	7.5
OFDM / g – mode	3.8	6.7	3.2
OFDM / n HT20 – mode	4.1	6.3	3.6

Note 1: Measured worst case with 100 kHz RBW instead of 3 kHz RBW.

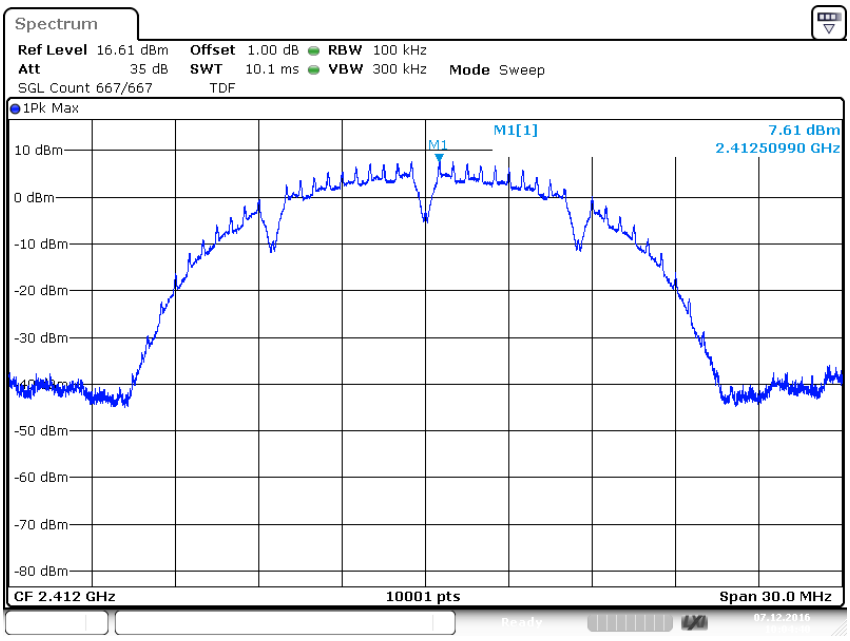
Plots: DSSS / b – mode

Plot 1: Lowest channel

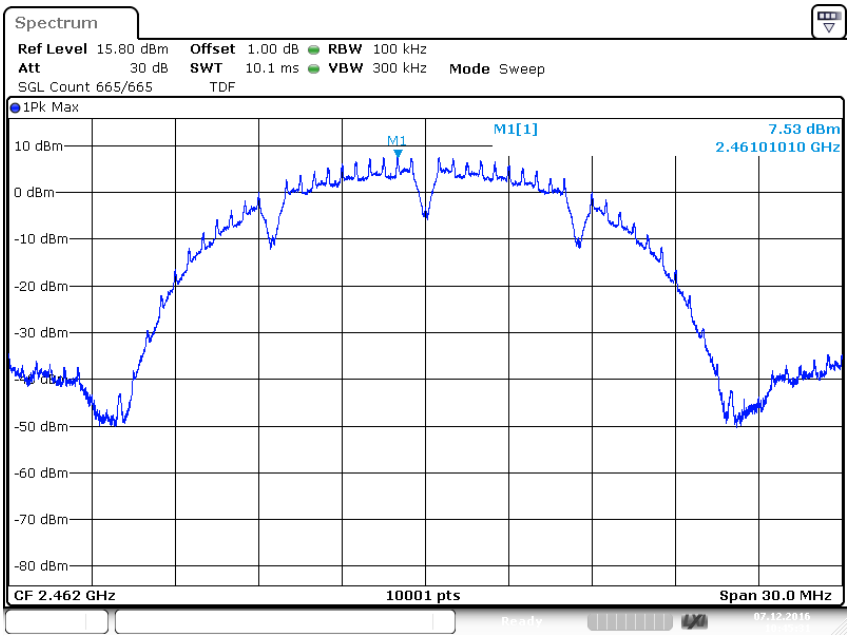


Date: 7.DEC.2016 10:04:41

Plot 2: Middle channel

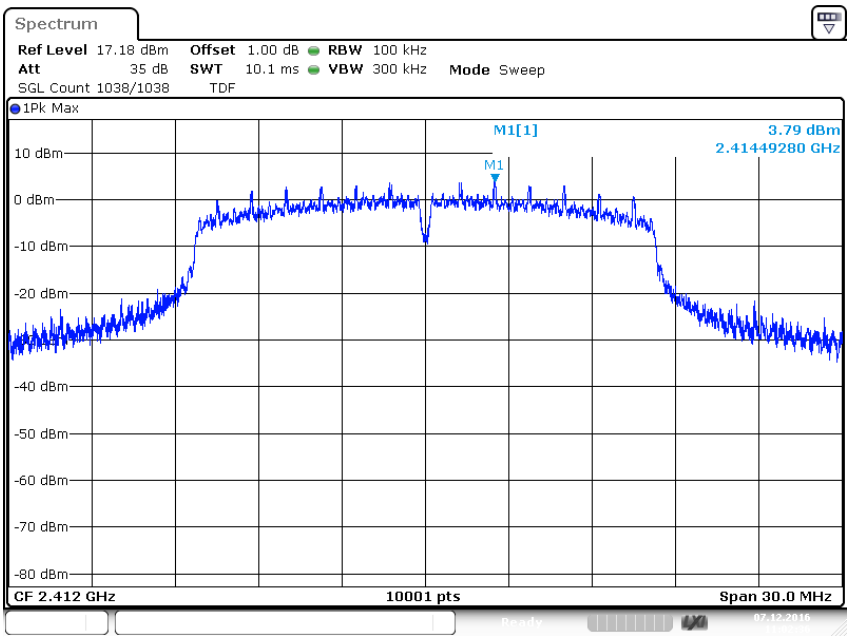


Plot 3: Highest channel



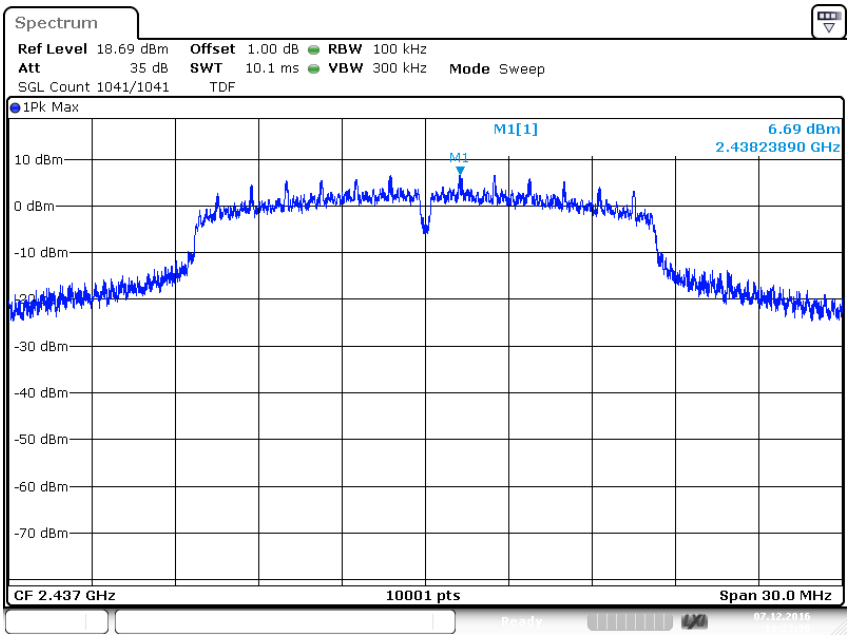
Plots: OFDM / g – mode

Plot 1: Lowest channel



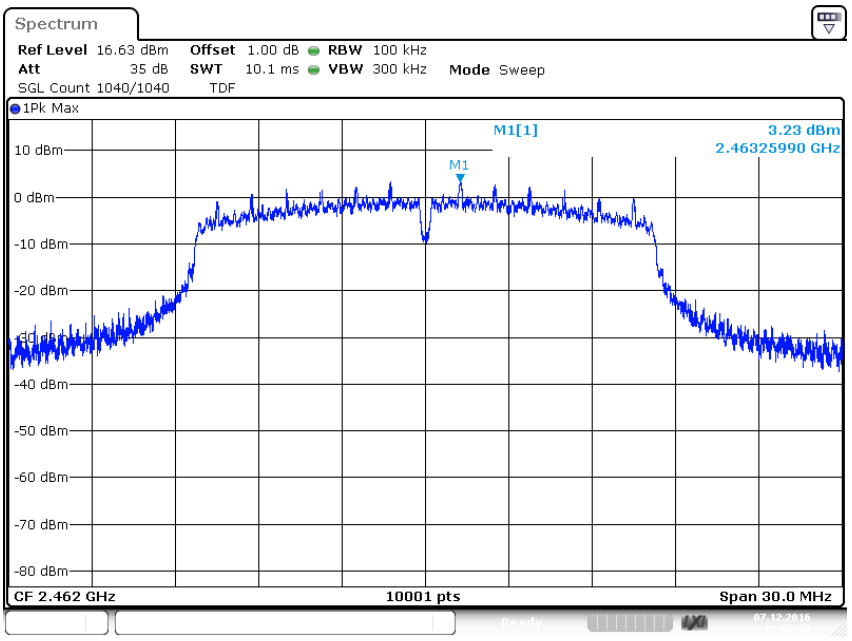
Date: 7.DEC.2016 11:02:36

Plot 2: Middle channel



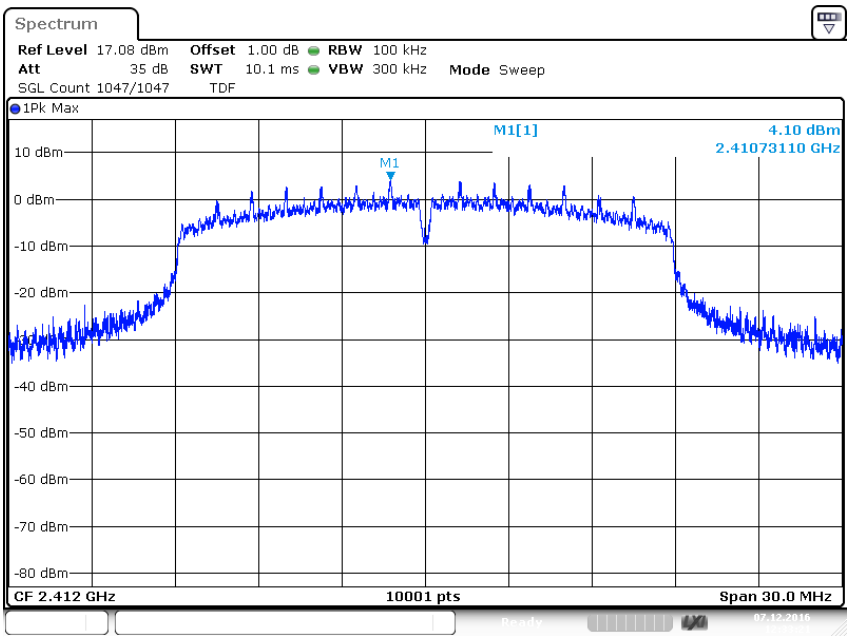
Date: 7.DEC.2016 11:23:38

Plot 3: Highest channel



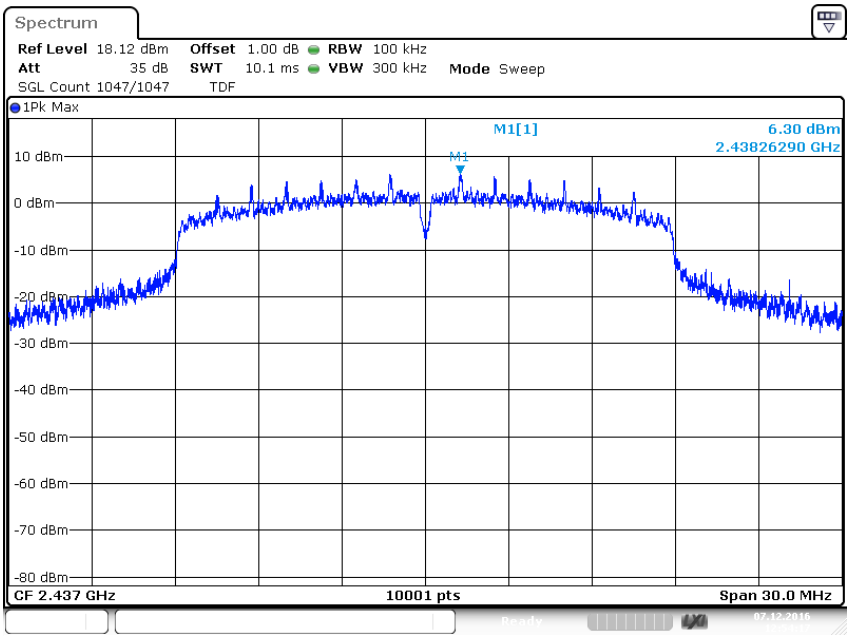
Plots: OFDM / n HT20 – mode

Plot 1: Lowest channel



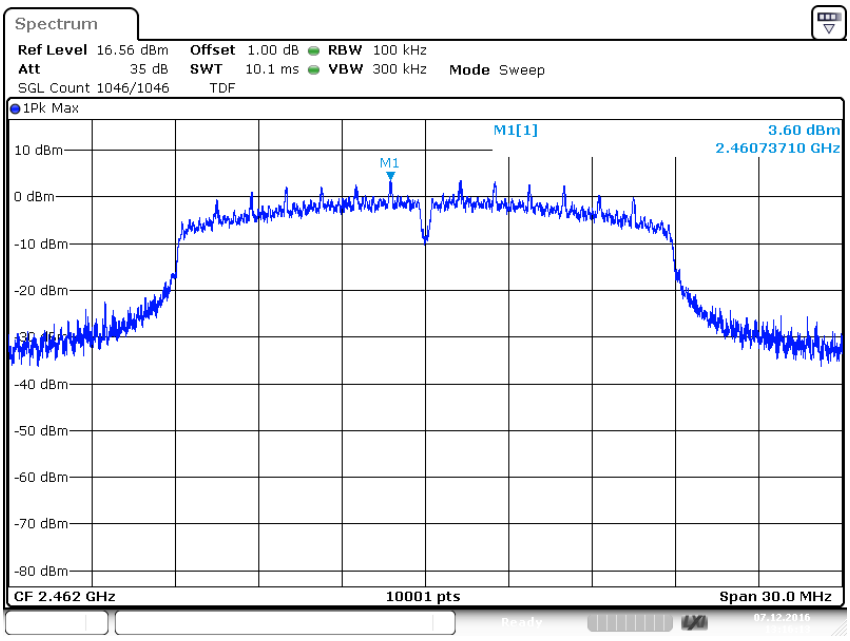
Date: 7.DEC.2016 12:33:22

Plot 2: Middle channel



Date: 7.DEC.2016 12:54:17

Plot 3: Highest channel



Date: 7.DEC.2016 13:16:14

11.6 6 dB DTS bandwidth

Description:

Measurement of the 6 dB bandwidth of the modulated signal.

Measurement:

Measurement parameter	
According to DTS clause: 8.1	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	500 kHz
Span:	30 MHz / 50 MHz
Trace mode:	Single count with 200 counts
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Limits:

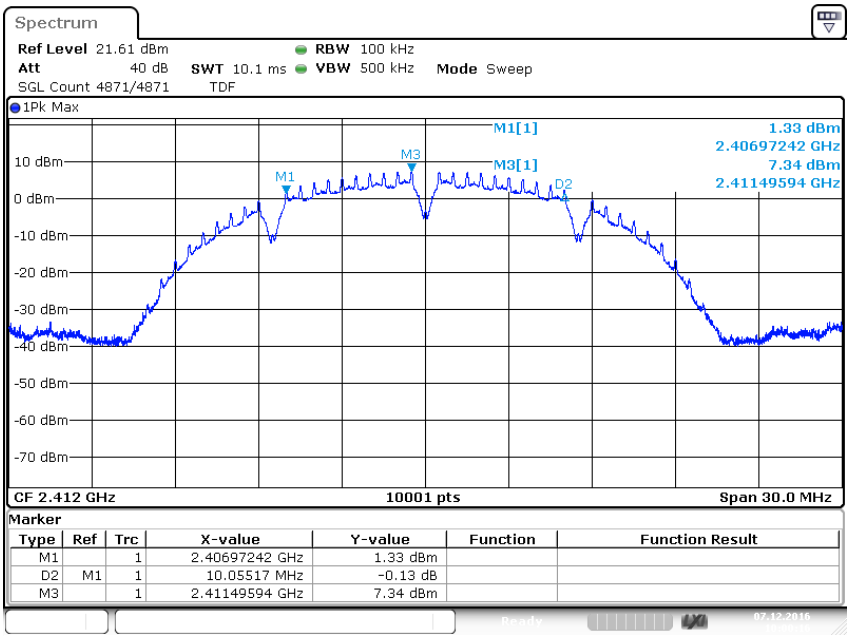
FCC	IC
Systems using digital modulation techniques may operate in the 2400–2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz.	

Results:

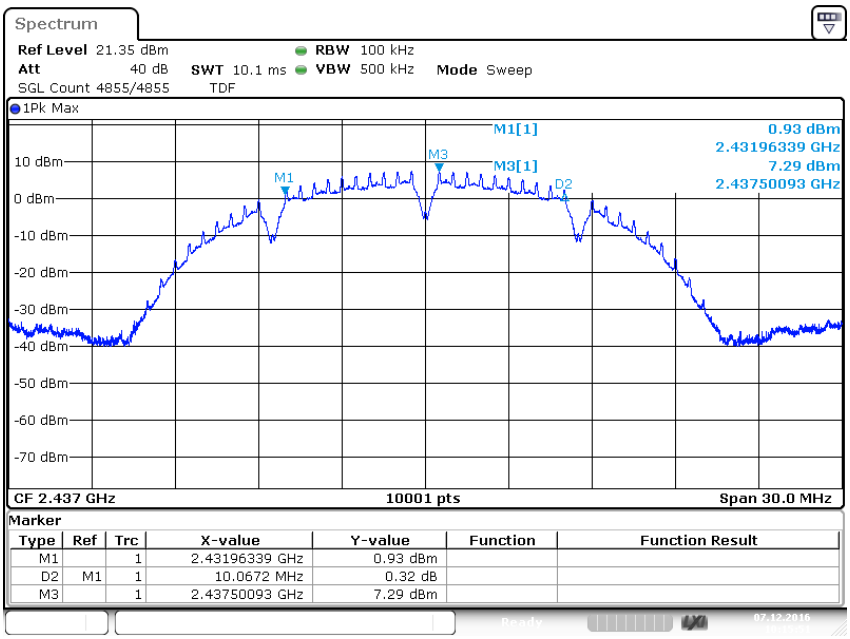
Frequency	6 dB DTS bandwidth [kHz]		
	2412 MHz	2437 MHz	2462 MHz
DSSS / b – mode	10055	10067	10070
OFDM / g – mode	15100	15100	15106
OFDM / n HT20 – mode	15100	15100	15101

Plots: DSSS / b – mode

Plot 1: Lowest channel

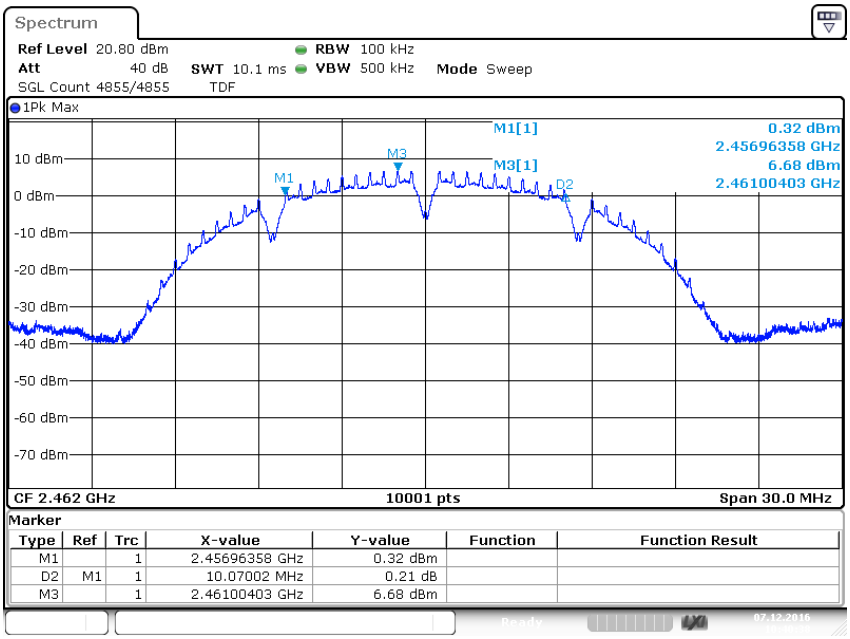


Plot 2: Middle channel



Date: 7.DEC.2016 10:15:51

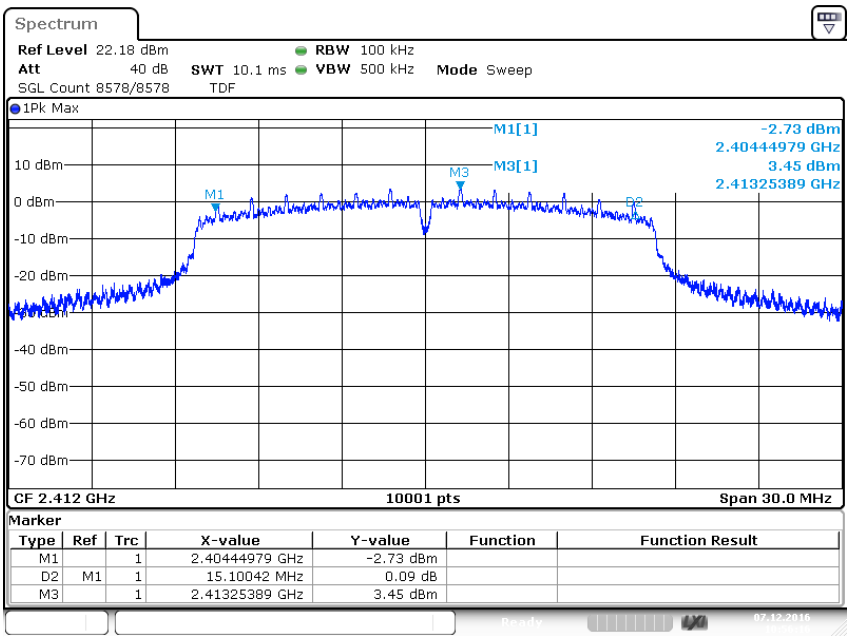
Plot 3: Highest channel



Date: 7.DEC.2016 10:40:39

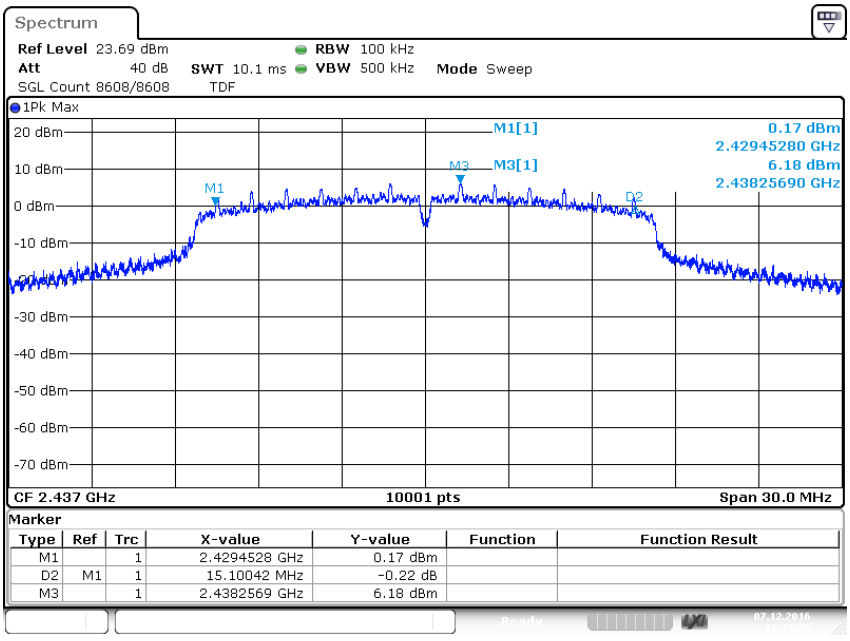
Plots: OFDM / g – mode

Plot 1: Lowest channel



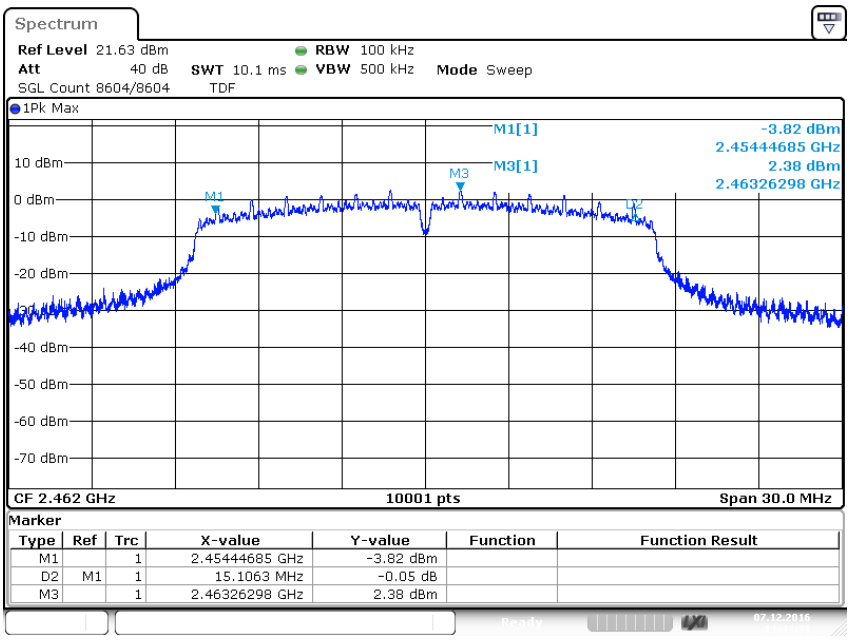
Date: 7.DEC.2016 10:56:16

Plot 2: Middle channel



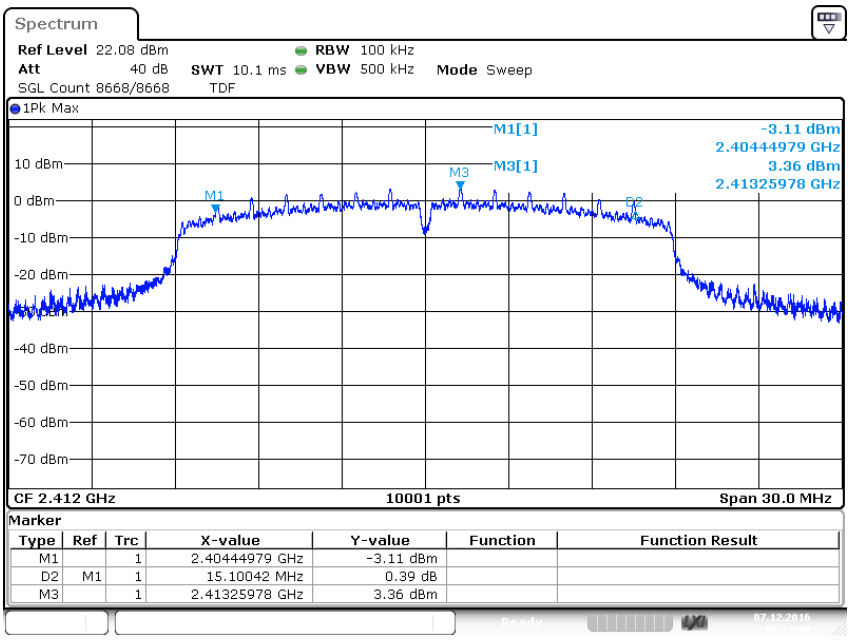
Date: 7.DEC.2016 11:17:06

Plot 3: Highest channel



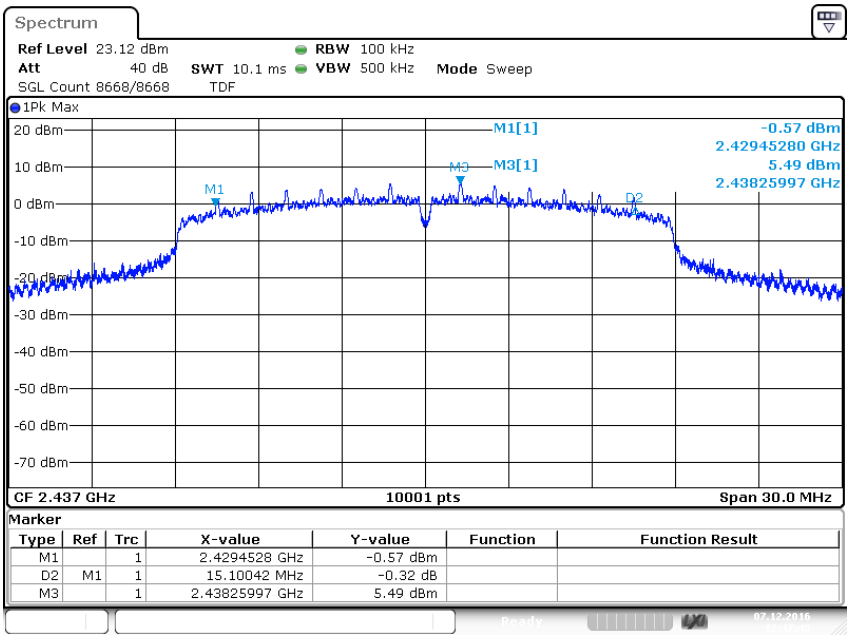
Plots: OFDM / n HT20 – mode

Plot 1: Lowest channel



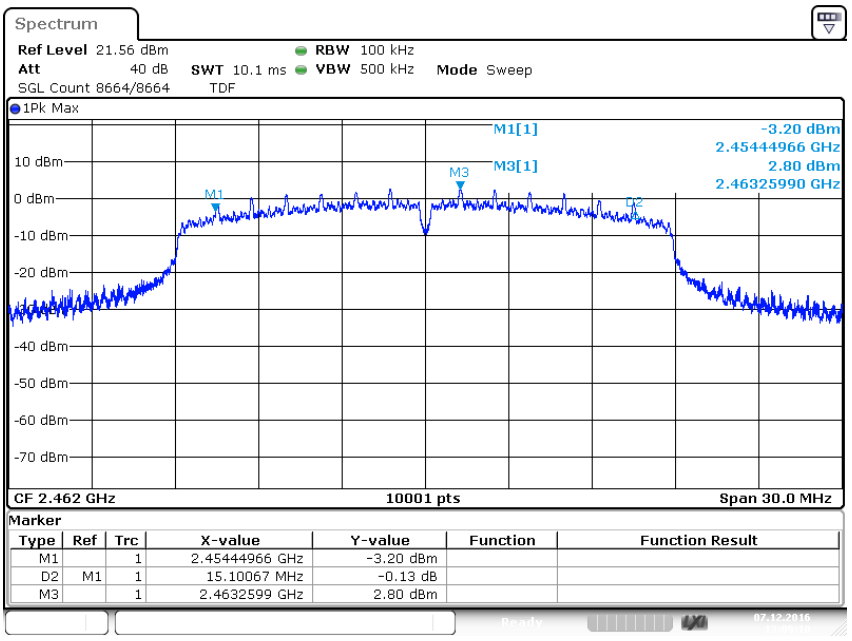
Date: 7.DEC.2016 12:27:04

Plot 2: Middle channel



Date: 7.DEC.2016 12:47:46

Plot 3: Highest channel



Date: 7.DEC.2016 13:09:11

11.7 Occupied bandwidth – 99% emission bandwidth

Description:

Measurement of the 99% bandwidth of the modulated signal acc. RSS-GEN.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	300 kHz
Video bandwidth:	1 MHz
Span:	30 MHz / 50 MHz
Measurement procedure:	Measurement of the 99% bandwidth using the integration function of the analyzer
Trace mode:	Single count with 200 counts
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Usage:

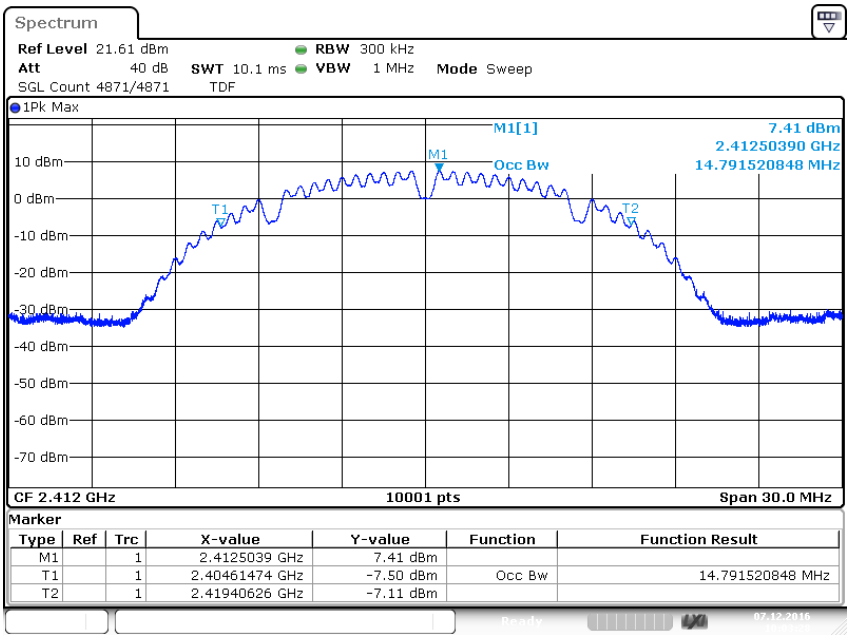
-/-	IC
OBW is necessary for Emission Designator	

Results:

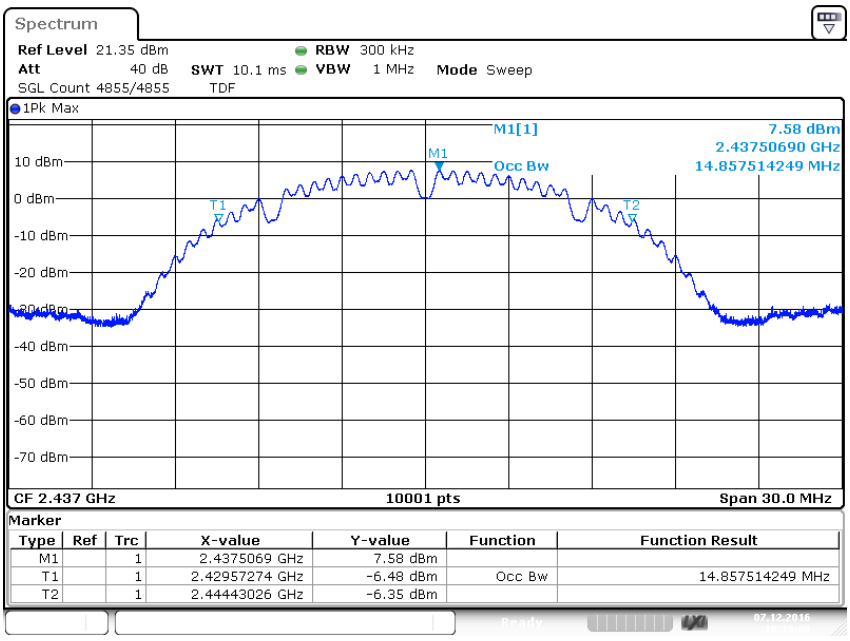
Modulation	99% bandwidth [kHz]		
Frequency	2412 MHz	2437 MHz	2462 MHz
DSSS / b – mode	14792	14858	14780
OFDM / g – mode	16561	18592	16474
OFDM / n HT20 – mode	17620	18364	17596

Plots: DSSS / b – mode

Plot 1: Lowest channel

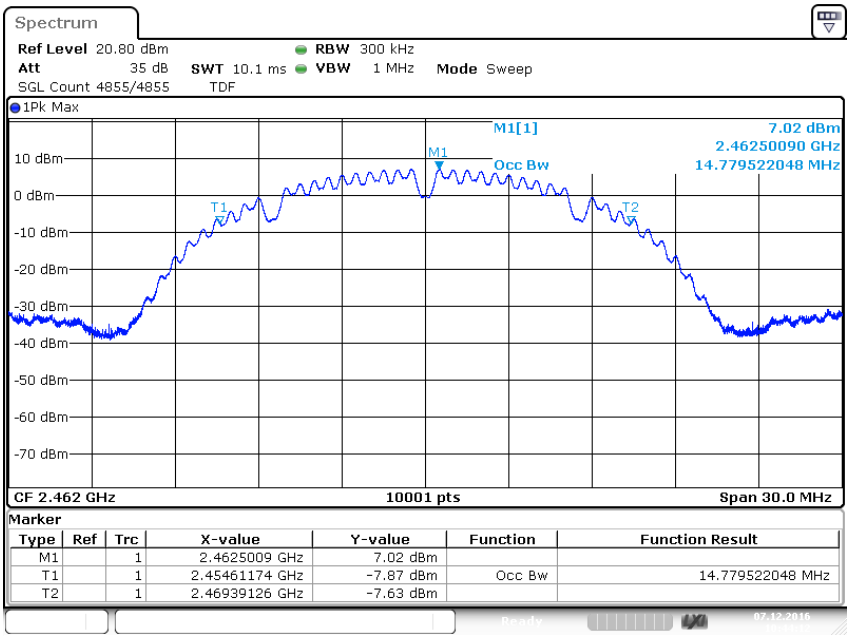


Plot 2: Middle channel



Date: 7.DEC.2016 10:19:10

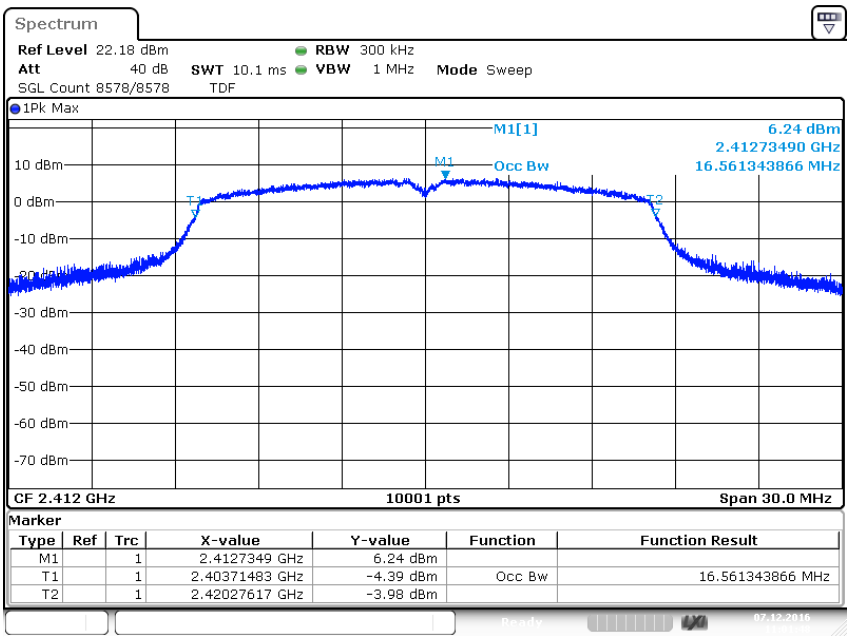
Plot 3: Highest channel



Date: 7.DEC.2016 10:44:13

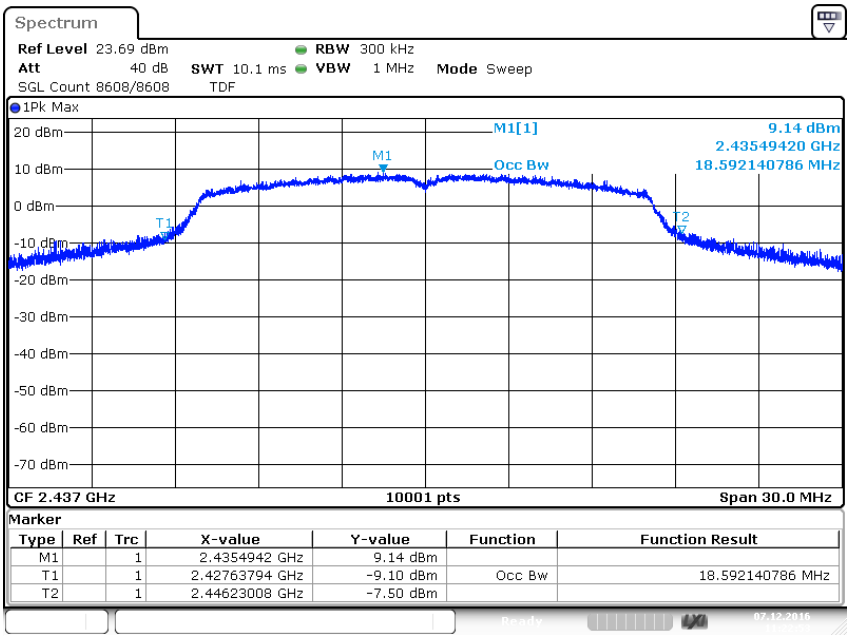
Plots: OFDM / g – mode

Plot 1: Lowest channel



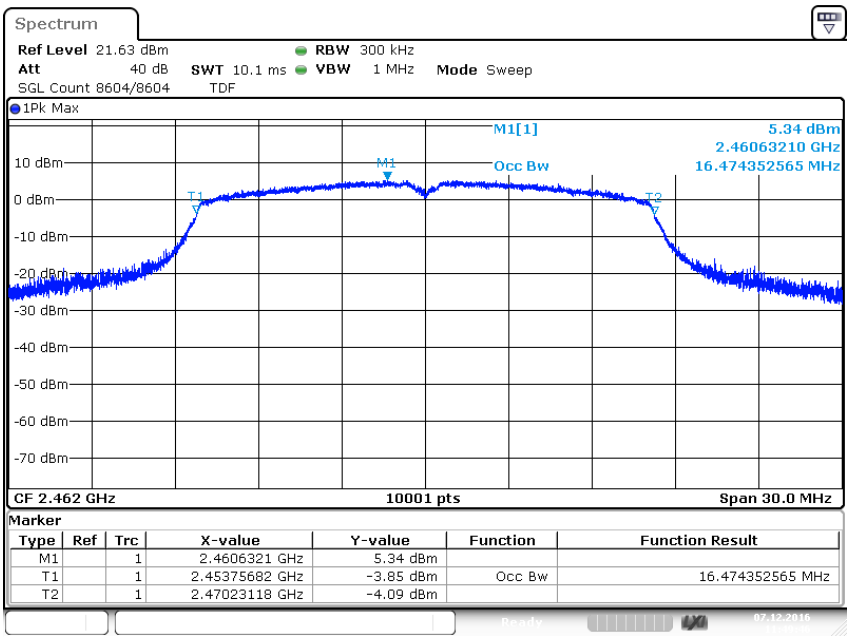
Date: 7.DEC.2016 11:01:49

Plot 2: Middle channel



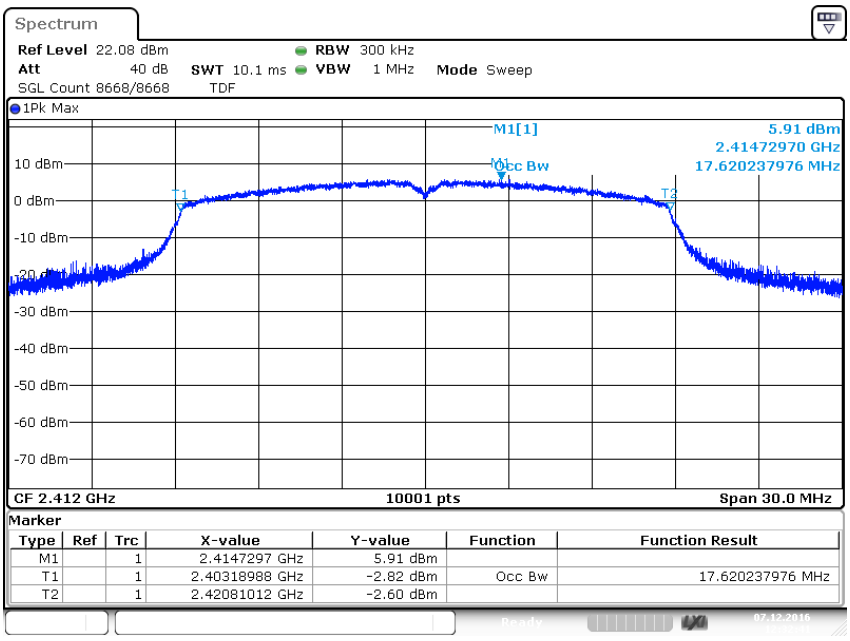
Date: 7.DEC.2016 11:22:54

Plot 3: Highest channel



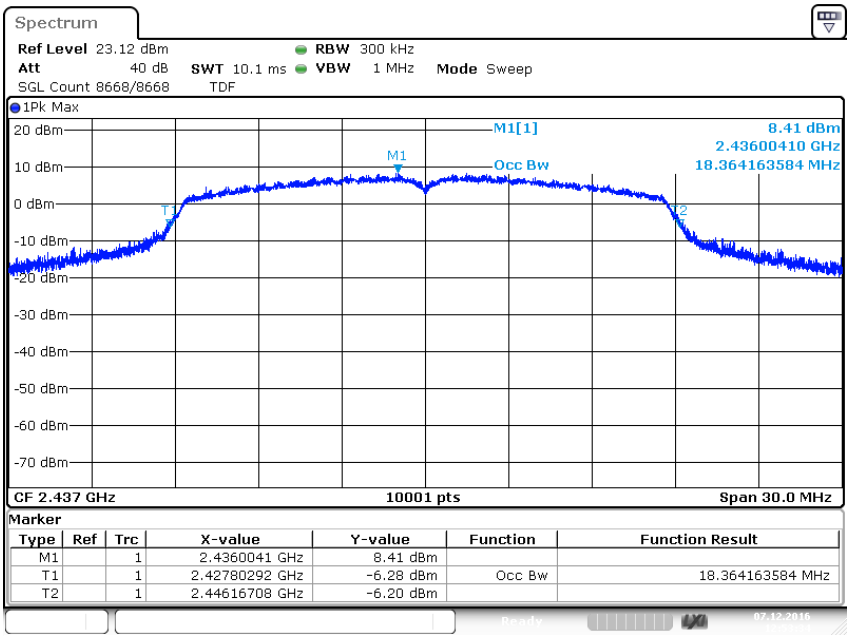
Plots: OFDM / n HT20 – mode

Plot 1: Lowest channel



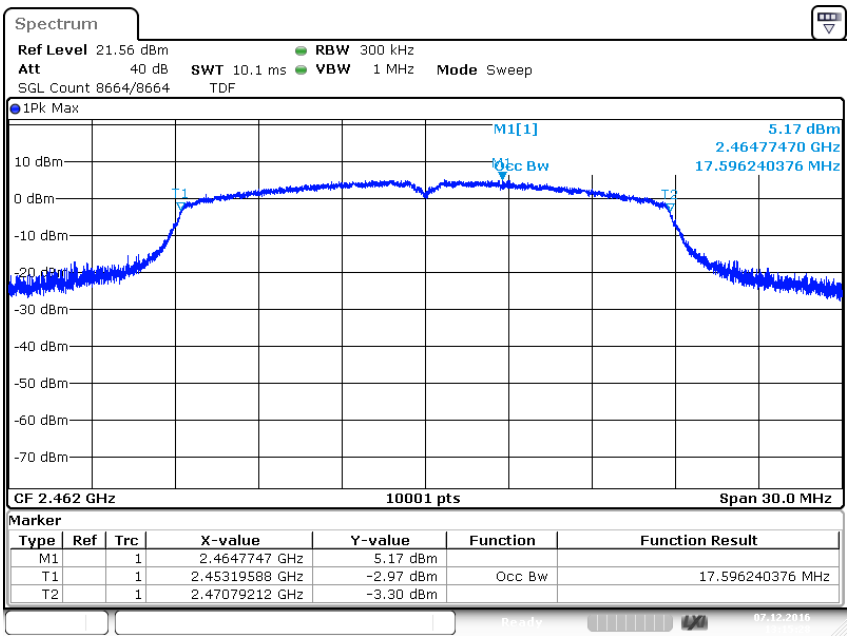
Date: 7.DEC.2016 12:32:41

Plot 2: Middle channel



Date: 7.DEC.2016 12:53:35

Plot 3: Highest channel



Date: 7.DEC.2016 13:15:28

11.8 Occupied bandwidth – 20 dB bandwidth

Description:

Measurement of the 20 dB bandwidth of the modulated carrier.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	500 kHz
Span:	30 MHz / 50 MHz
Trace mode:	Single count with min. 200 counts
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Usage:

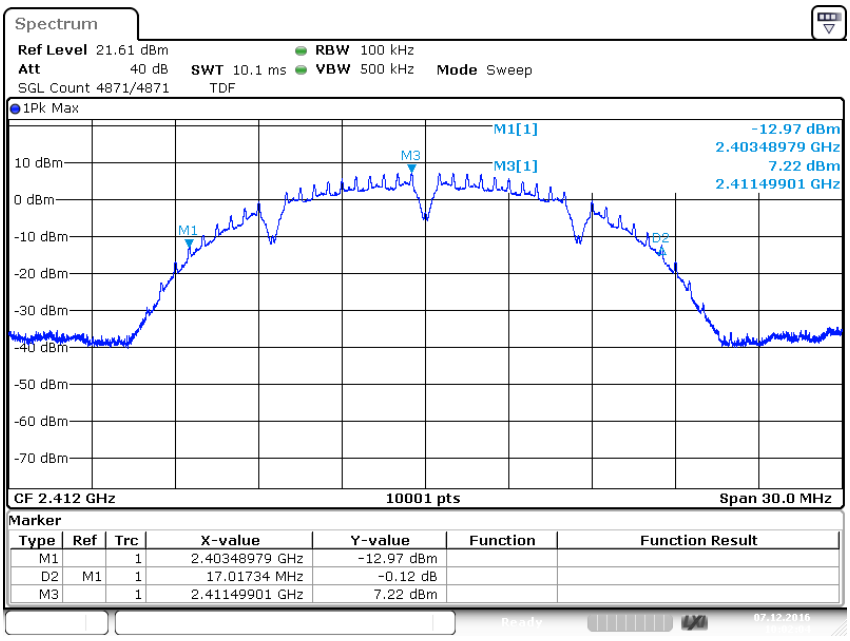
-/-	IC
Within the used band!	

Results:

Modulation	20 dB bandwidth [MHz]		
Frequency	2412 MHz	2437 MHz	2462 MHz
DSSS / b – mode	17.02	17.04	17.04
OFDM / g – mode	17.17	19.76	17.13
OFDM / n HT20 – mode	18.33	18.73	18.33

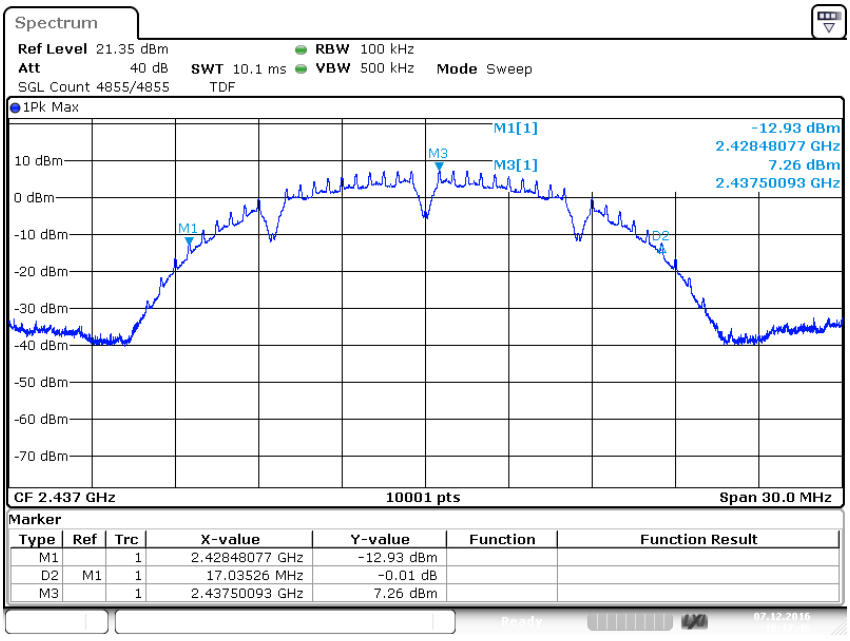
Plots: DSSS / b – mode

Plot 1: Lowest channel



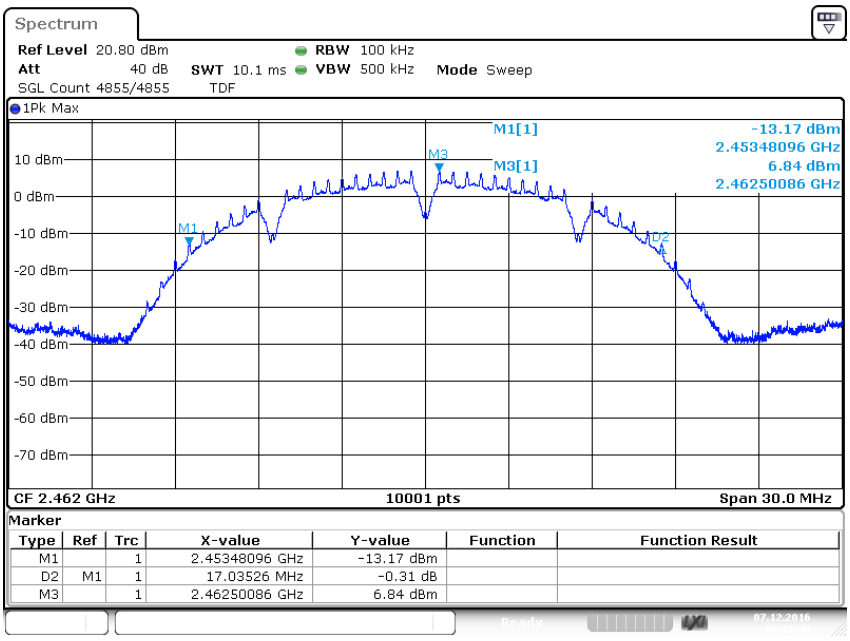
Date: 7.DEC.2016 10:02:05

Plot 2: Middle channel



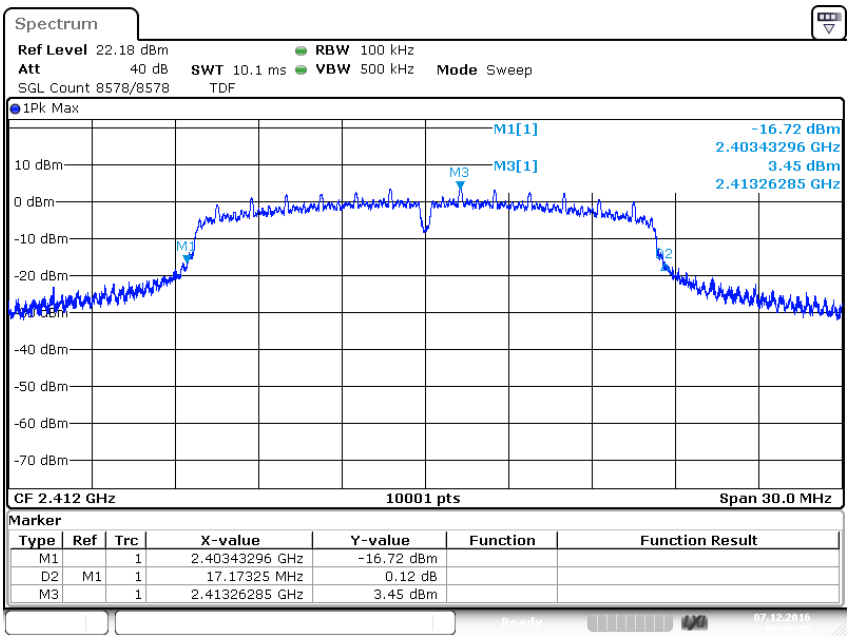
Date: 7.DEC.2016 10:17:47

Plot 3: Highest channel



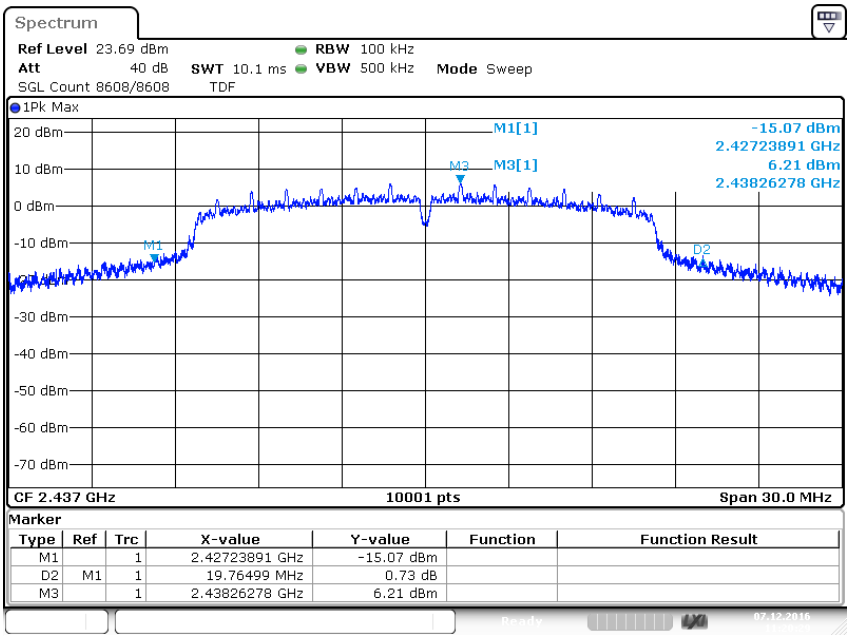
Plots: OFDM / g – mode

Plot 1: Lowest channel



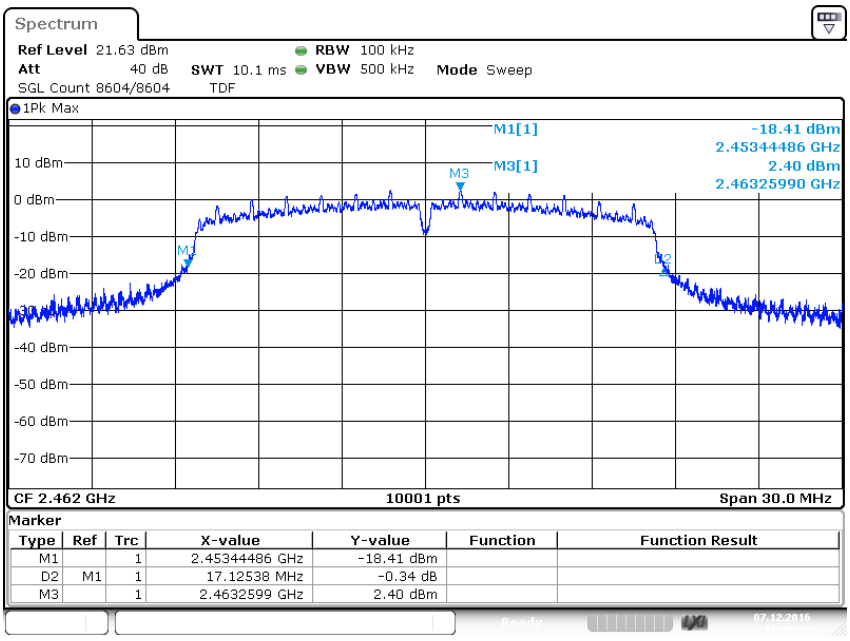
Date: 7.DEC.2016 10:59:25

Plot 2: Middle channel



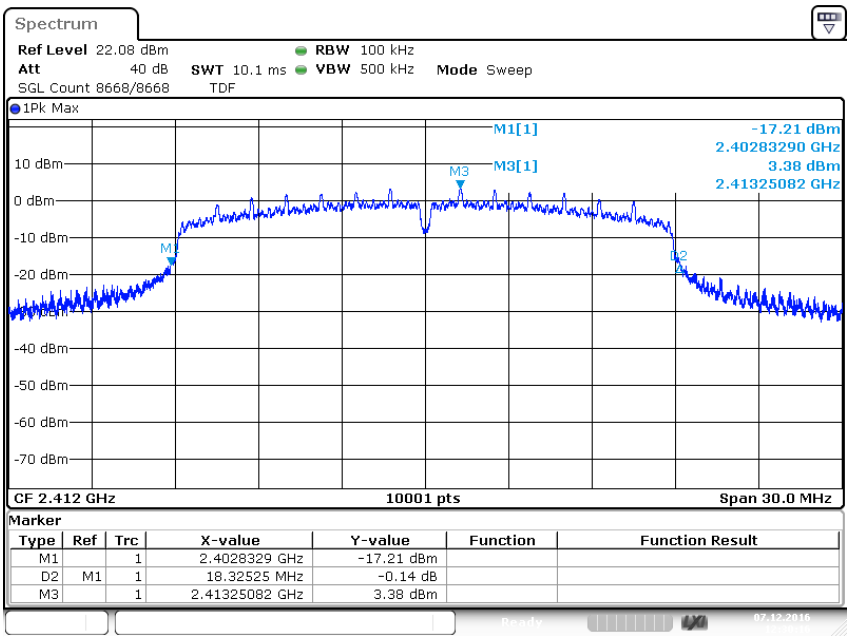
Date: 7.DEC.2016 11:20:30

Plot 3: Highest channel



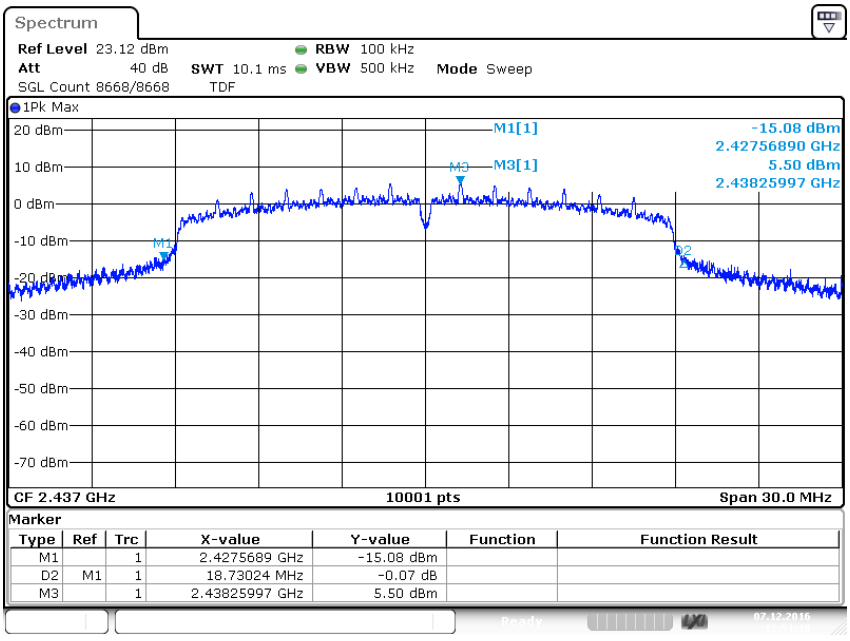
Plots: OFDM / n HT20 – mode

Plot 1: Lowest channel



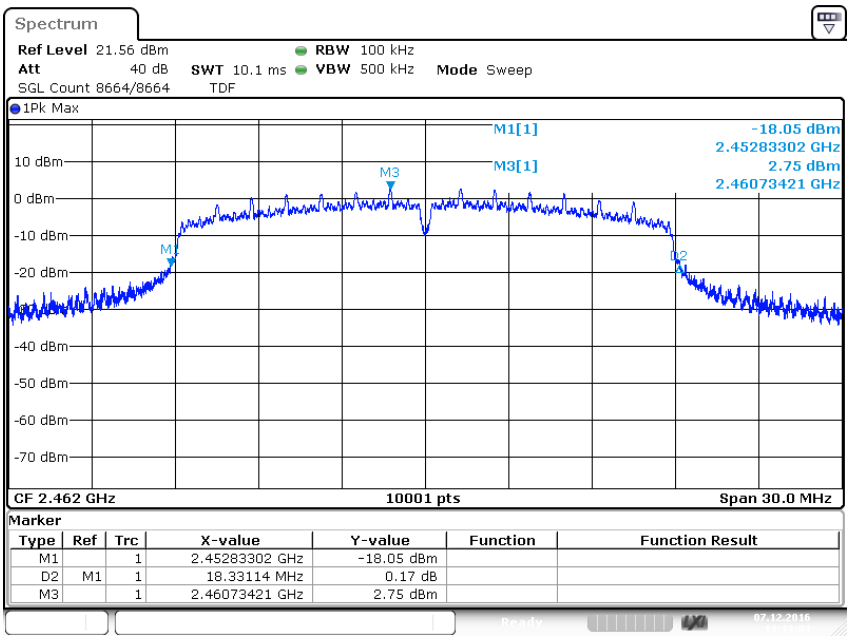
Date: 7.DEC.2016 12:30:16

Plot 2: Middle channel



Date: 7.DEC.2016 12:51:10

Plot 3: Highest channel



Date: 7.DEC.2016 13:13:03

11.9 Band edge compliance radiated

Description:

Measurement of the radiated band edge compliance. The EUT is turned in the position that results in the maximum level at the band edge. Then a sweep over the corresponding restricted band is performed. The EUT is set to channel 1 for the lower restricted band and to channel 11 for the upper restricted band. The measurement is repeated for all modulations. Measurement distance is 3 m.

Measurement:

Measurement parameter for peak measurements	
Detector:	Peak / RMS
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	1 MHz
Span:	See plot!
Trace mode:	Max Hold
Test setup:	See sub clause 6.2 - A
Measurement uncertainty	See sub clause 8

Measurement parameter for average measurements	
According to DTS clause: 13.3.2	
Detector:	RMS
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Span:	2 MHz
Trace mode:	RMS Average over 101 sweeps
Test setup:	See sub clause 6.2 - A
Measurement uncertainty	See sub clause 8

Limits:

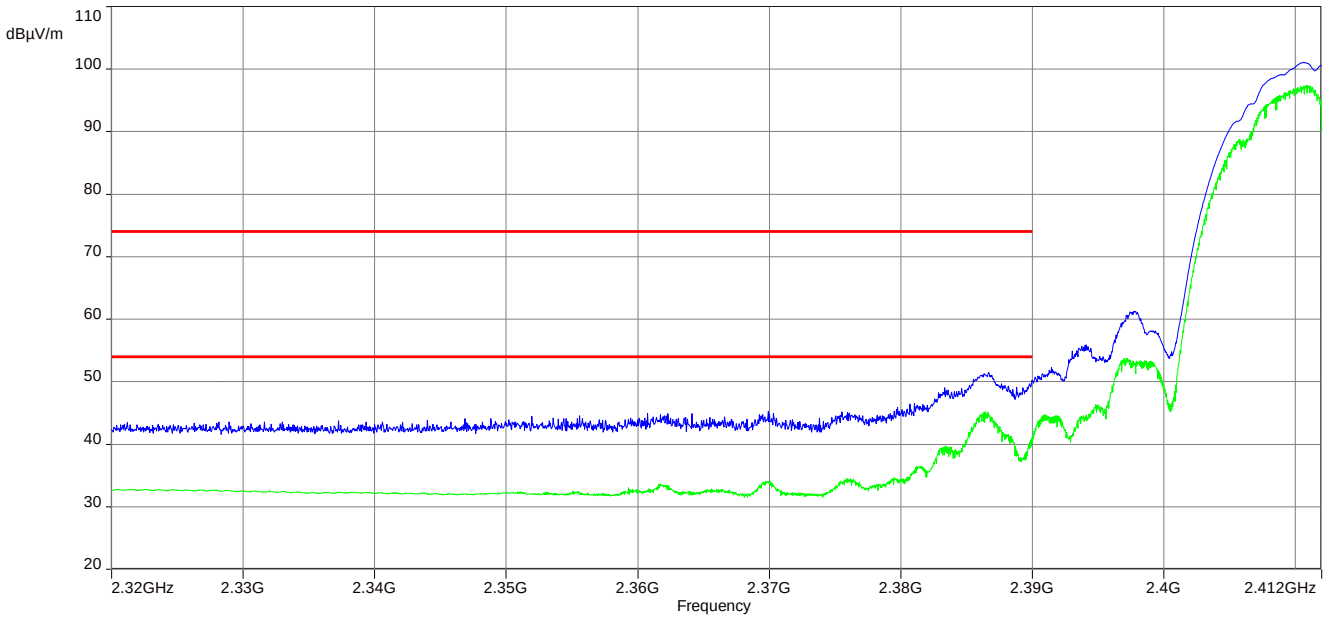
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains 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. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).	
74 dBµV/m Peak 54 dBµV/m AVG	

Results:

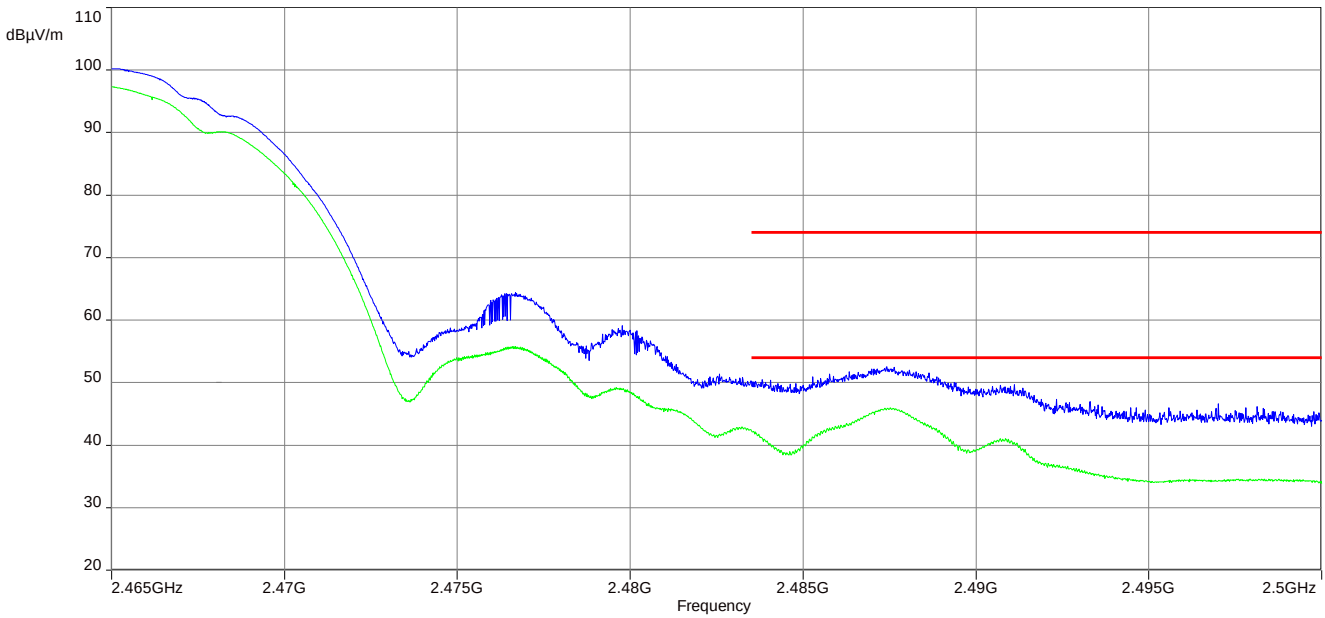
Scenario Modulation	Band edge compliance radiated [dB]		
	DSSS	OFDM (20 MHz bandwidth)	OFDM (40 MHz bandwidth)
Lower band edge	> 20 dB (Peak) > 20 dB (AVG)	> 20 dB (Peak) > 20 dB (AVG)	-/-
Upper band edge	> 20 dB (Peak) > 20 dB (AVG)	> 20 dB (Peak) > 20 dB (AVG)	-/-

Plots: DSSS - peak / average

Plot 1: TX mode, lower band edge, vertical & horizontal polarization

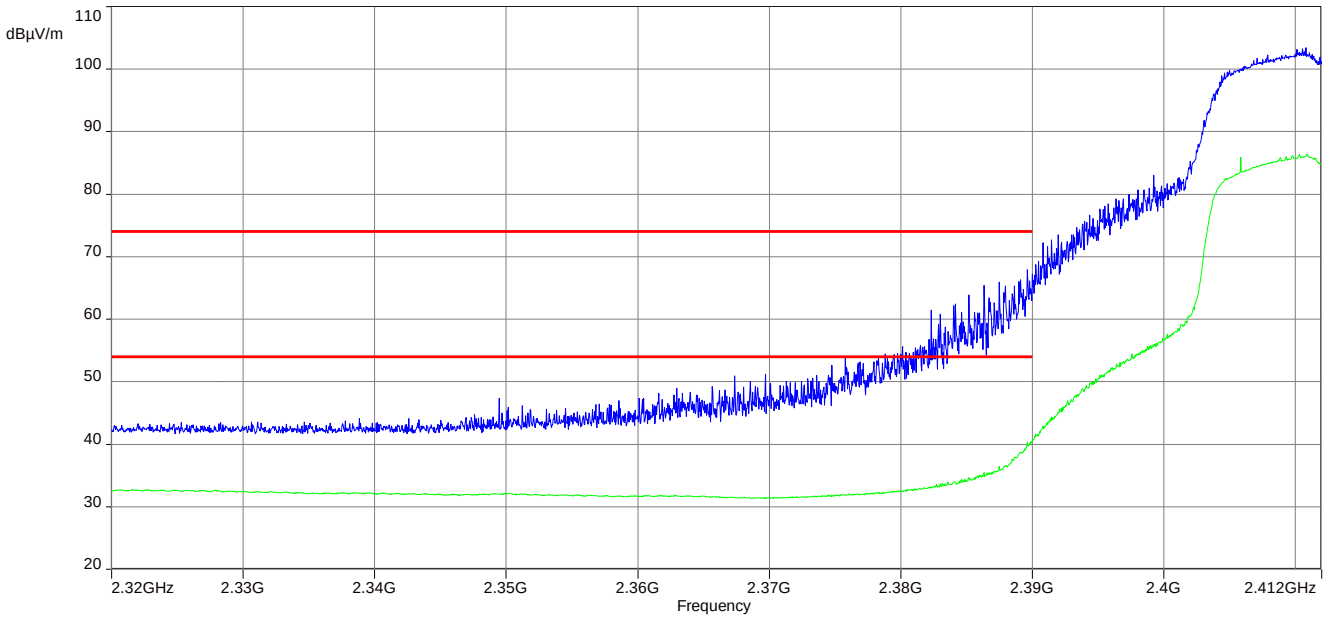


Plot 2: TX mode, upper band edge, vertical & horizontal polarization

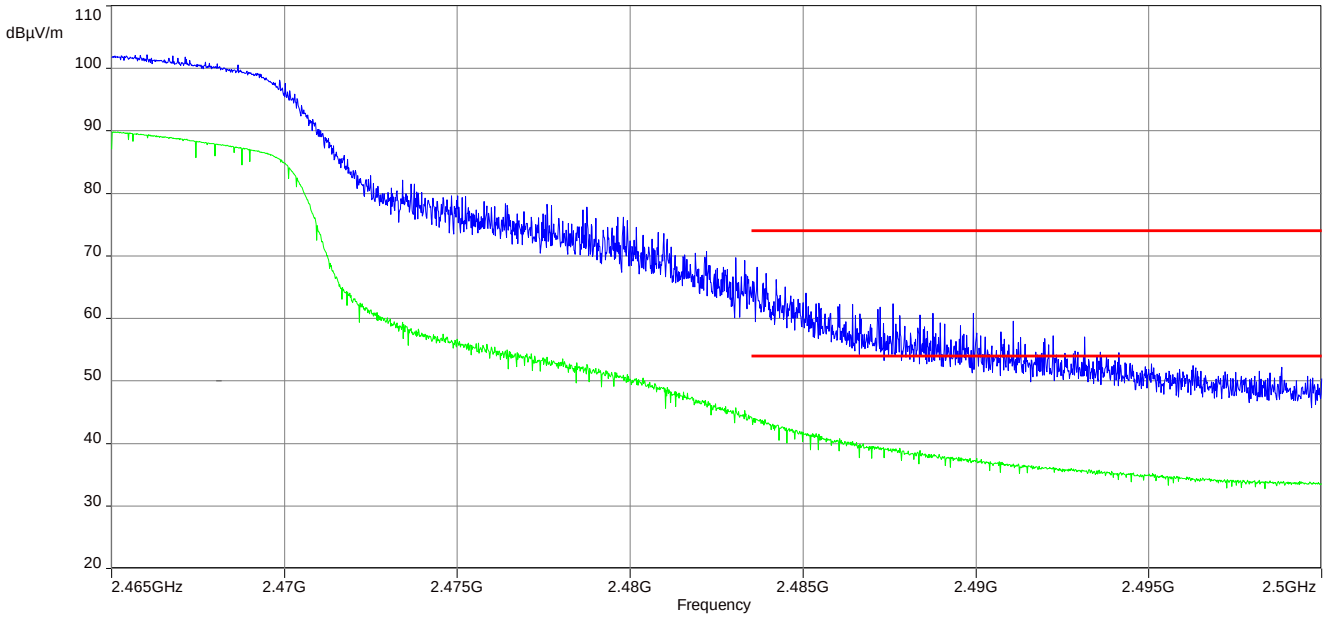


Plots: OFDM (20 MHz bandwidth) - peak / average

Plot 1: TX mode, lower band edge, vertical & horizontal polarization



Plot 2: TX mode, upper band edge, vertical & horizontal polarization



11.10 Band edge compliance conducted

Description:

Measurement of the radiated band edge compliance with a conducted test setup.

Measurement:

Measurement parameter for measurements	
According to DTS clause: 13.3.2 and clause 12.2.2	
Detector:	RMS
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Span:	Lower band edge: 2388 MHz to 2390 MHz (2 MHz) Upper band edge: 2483.5 MHz to 2485.5 MHz (2 MHz)
Trace mode:	Trace average with 200 counts
Test setup:	See sub clause 6.4 – A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
-41.26 dBm	

Results:

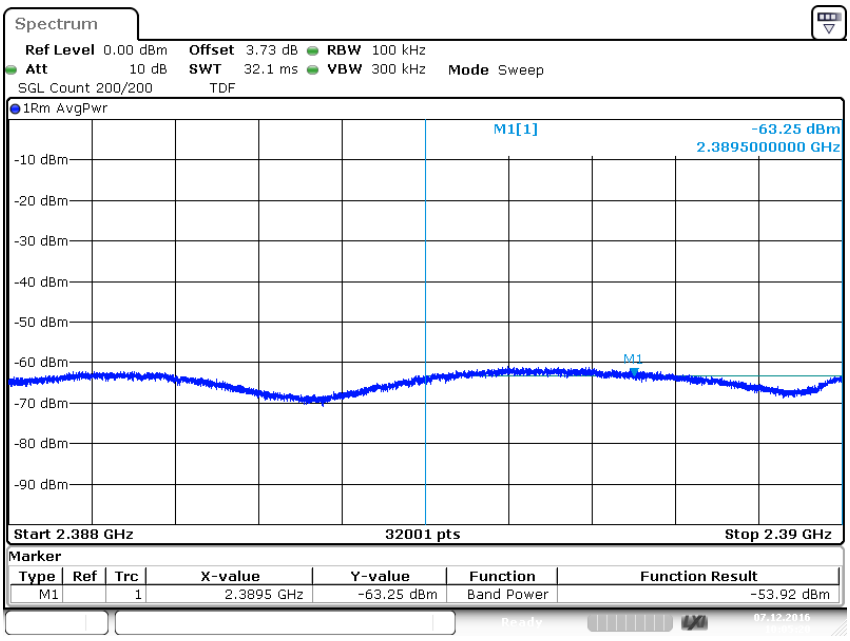
Scenario Modulation	Band edge compliance [dBm] (included antenna gain)			
	DSSS / b – mode	OFDM / g – mode	OFDM / n HT20 – mode	OFDM / n HT40 – mode
Max. lower band edge power	-61.65	-51.30	-49.78	-/-
Max. upper band edge power	-58.80	-55.24	-52.20	-/-

Results:

Scenario Modulation	Band edge compliance [dBm] (gain calculation)			
	DSSS / b – mode	OFDM / g – mode	OFDM / n HT20 – mode	OFDM / n HT40 – mode
Max. lower band edge power conducted	-63.25	-52.90	-51.38	-/-
Antenna gain	1.6			
Max. lower band edge power radiated	-61.65	-51.30	-49.78	-/-
Max. upper band edge power conducted	-59.70	-56.14	-53.10	-/-
Antenna gain	0.9			
Max. upper band edge power radiated	-58.80	-55.24	-52.20	-/-

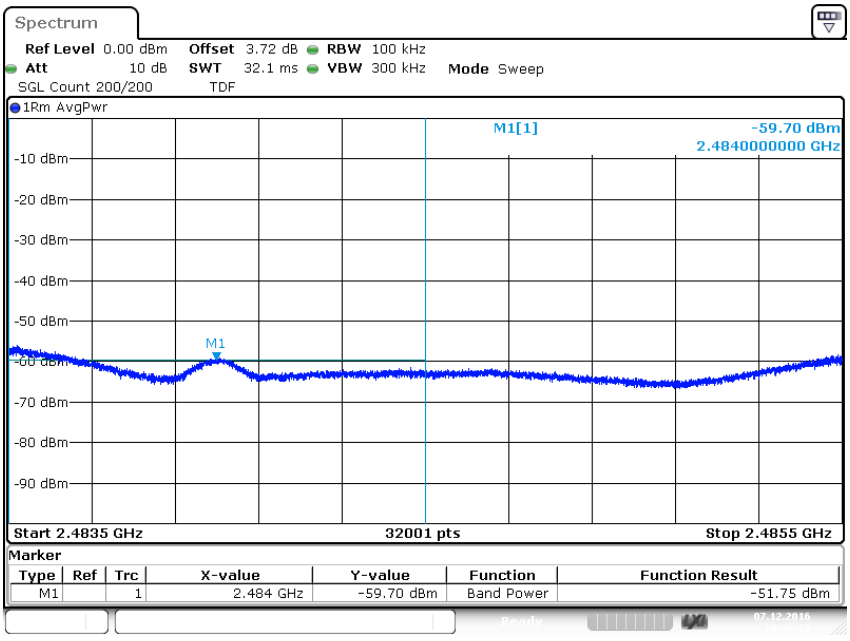
Plots: DSSS / b – mode

Plot 1: Lower band edge



Date: 7.DEC.2016 10:05:20

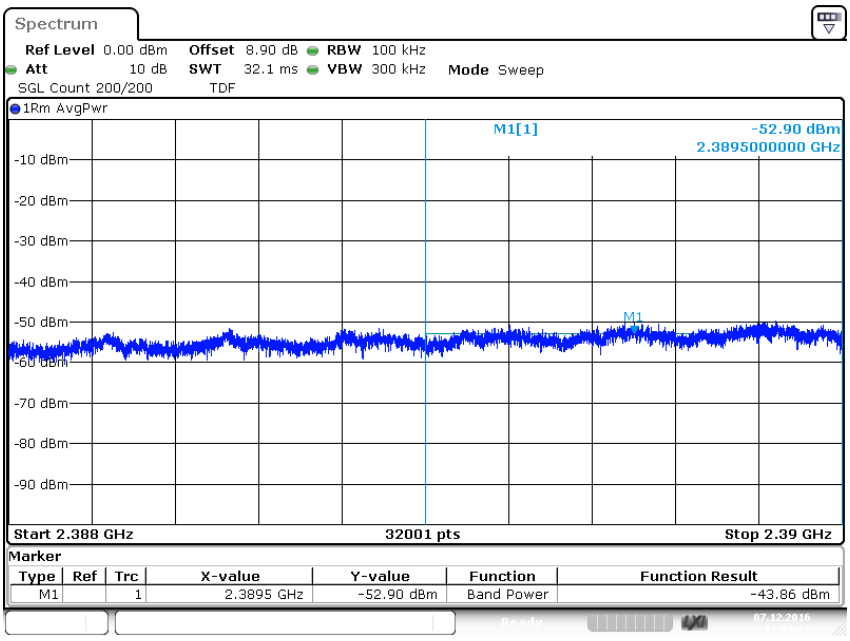
Plot 2: Upper band edge



Date: 7.DEC.2016 10:46:23

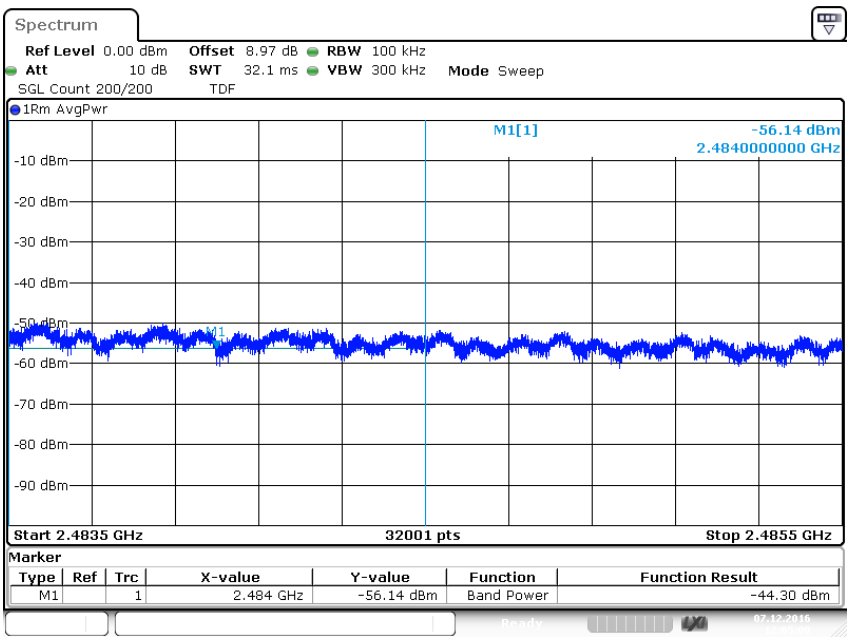
Plots: OFDM / g – mode

Plot 1: Lower band edge



Date: 7.DEC.2016 11:03:28

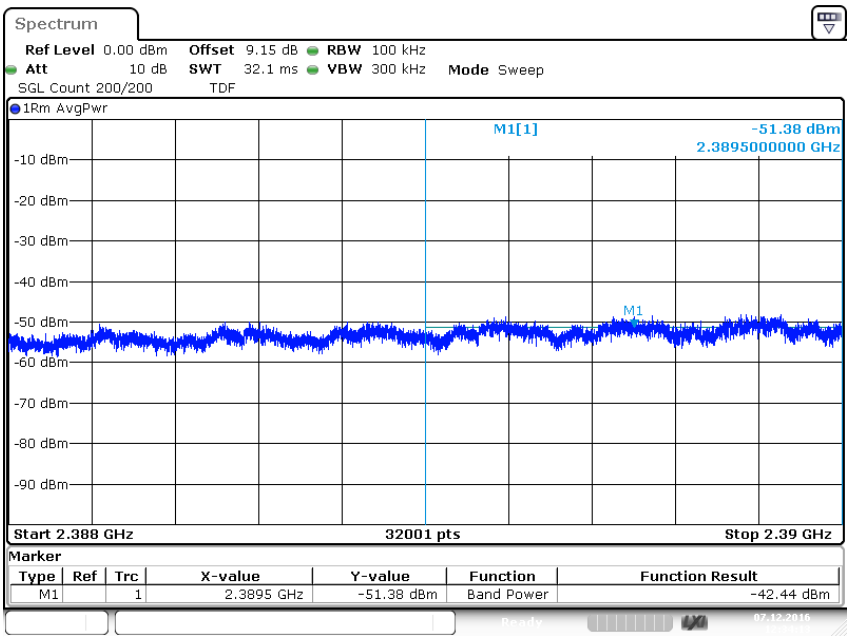
Plot 2: Upper band edge



Date: 7.DEC.2016 12:05:00

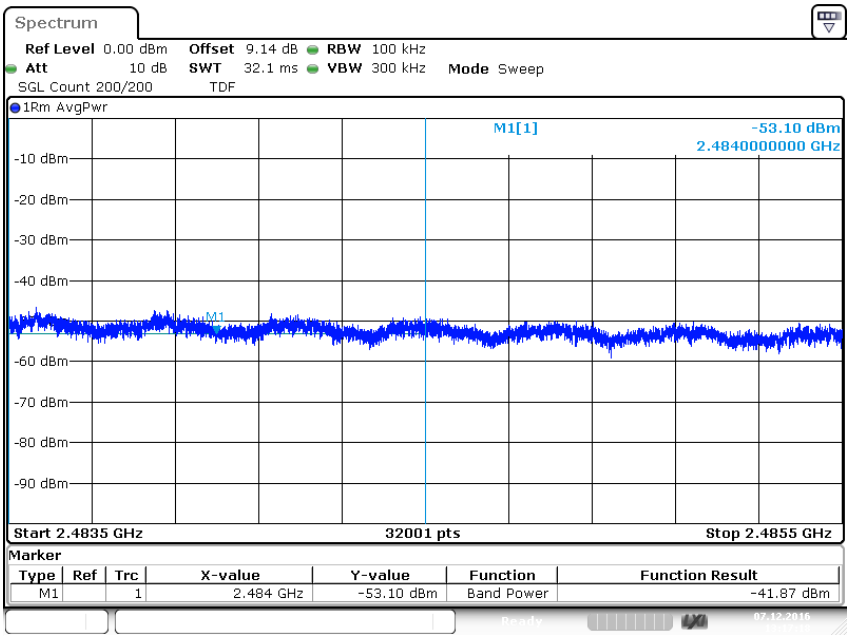
Plots: OFDM / n HT20 – mode

Plot 1: Lower band edge



Date: 7.DEC.2016 12:34:13

Plot 2: Upper band edge



Date: 7.DEC.2016 13:17:18

11.11 Spurious emissions conducted

Description:

Measurement of the conducted spurious emissions in transmit mode. The measurement is performed at channel 1, 6 and 11. The measurement is repeated for all modulations.

Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	100 kHz
Video bandwidth:	500 kHz
Span:	9 kHz to 25 GHz
Trace mode:	Max Hold
Test setup:	See sub clause 6.4 – 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 30 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: DSSS / b – mode

TX Spurious Emissions Conducted					
DSSS / b – mode					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2412		7.6	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2437		7.2	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2462		7.3	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant

Results: OFDM / g – mode

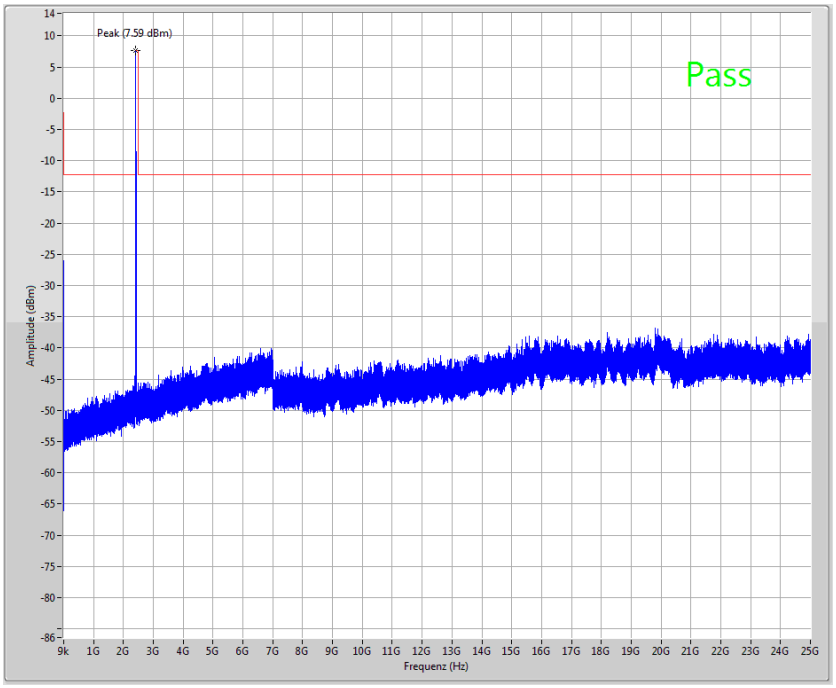
TX Spurious Emissions Conducted					
OFDM / g – mode					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2412		4.6	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2437		5.7	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2462		2.3	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant

Results: OFDM / n HT20 – mode

TX Spurious Emissions Conducted					
OFDM / n HT20 – mode					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2412		4.3	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2437		4.9	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant
2462		2.5	30 dBm	>20 dB	Operating frequency
No peaks detected			-20 dBc (peak) -30 dBc (average)		compliant

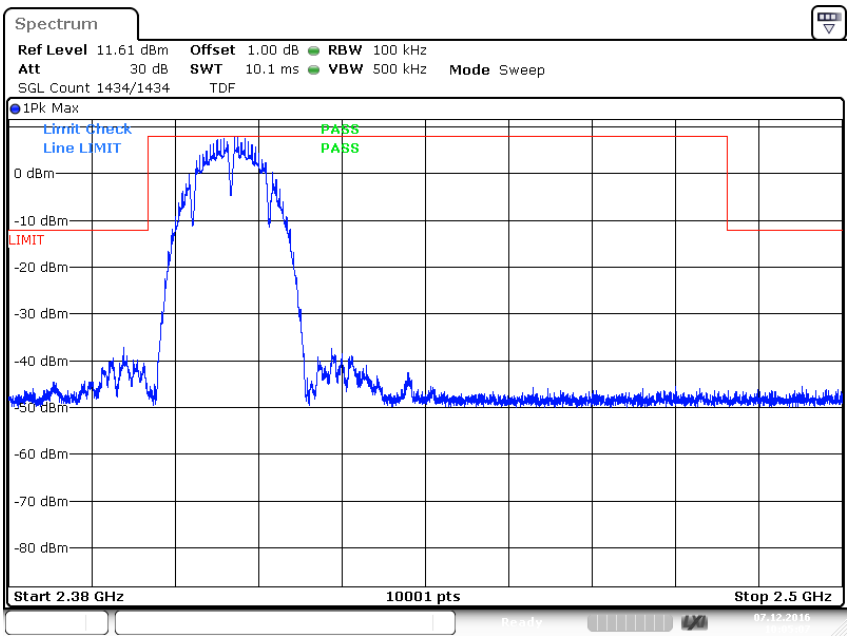
Plots: DSSS / b – mode

Plot 1: Lowest channel, up to 25 GHz



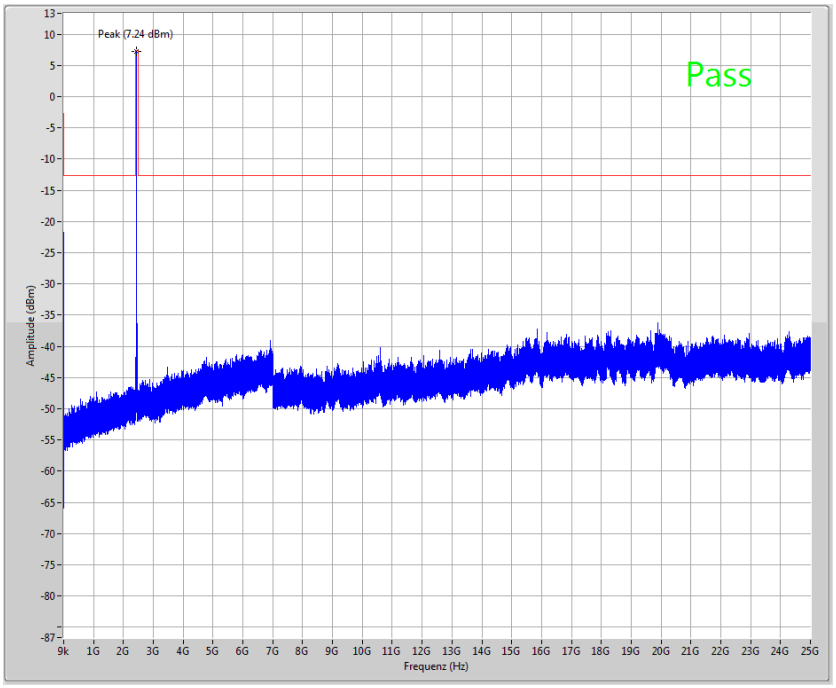
The peak at the beginning of the plot is the LO from the SA.

Plot 2: Lowest channel, zoomed carrier



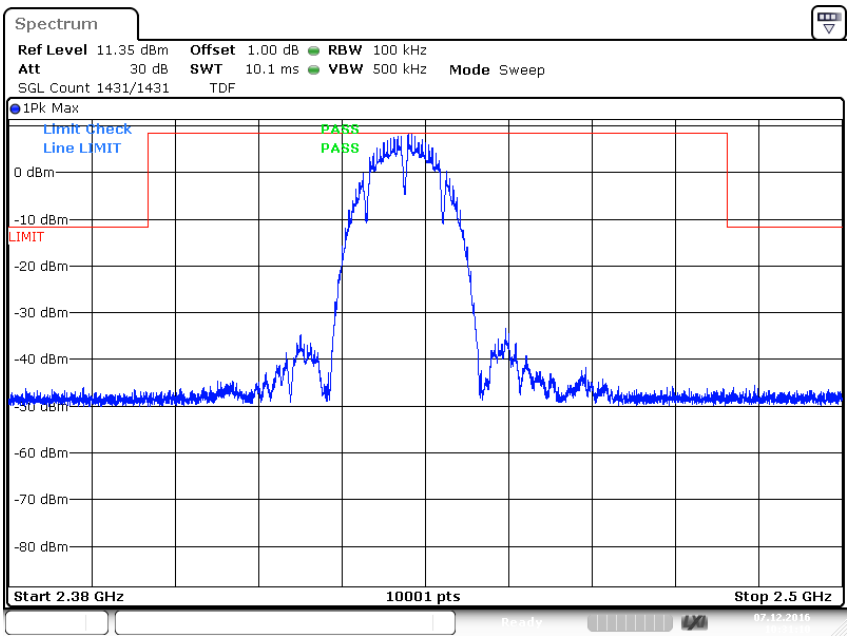
Date: 7.DEC.2016 10:05:07

Plot 3: Middle channel, up to 25 GHz



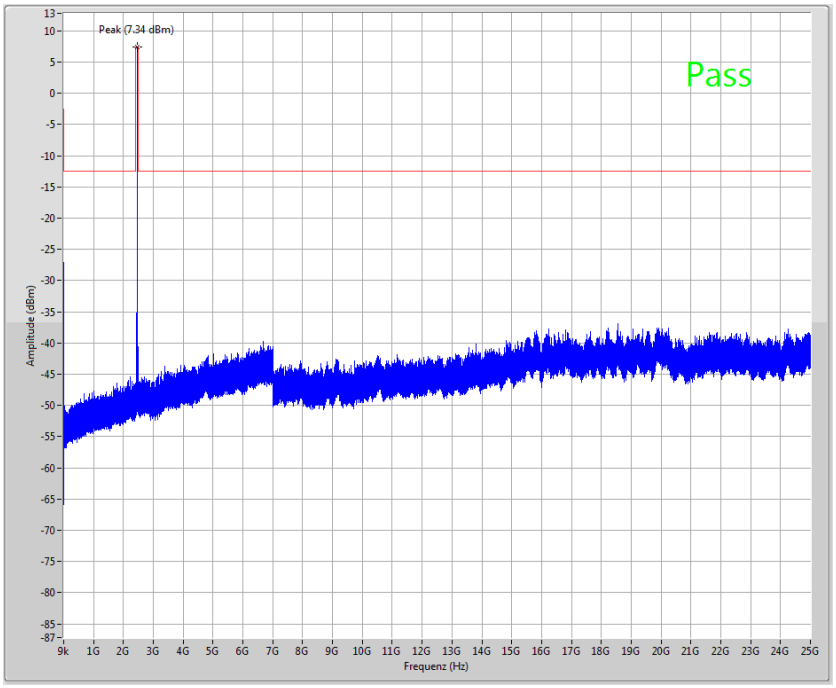
The peak at the beginning of the plot is the LO from the SA.

Plot 4: Middle channel, zoomed carrier



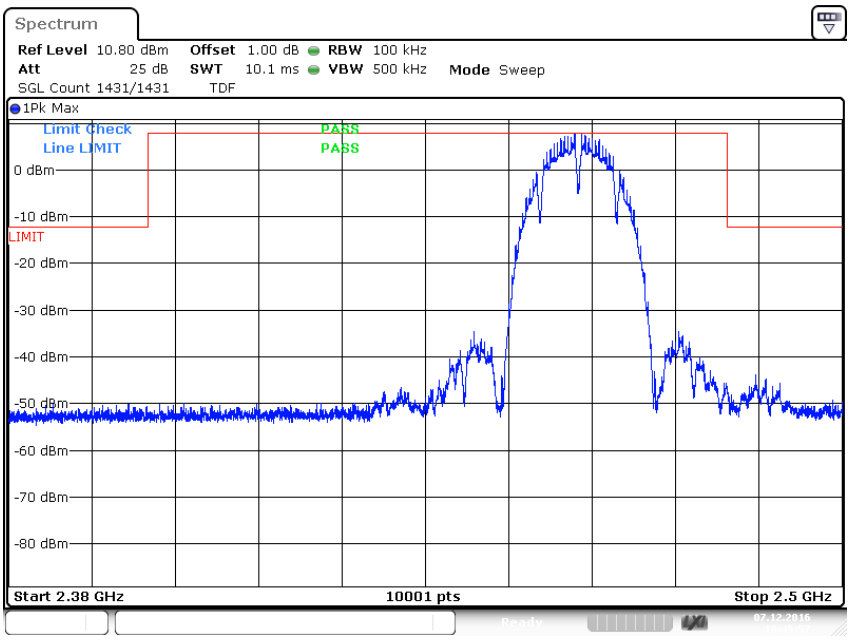
Date: 7.DEC.2016 10:31:11

Plot 5: Highest channel, up to 25 GHz



The peak at the beginning of the plot is the LO from the SA.

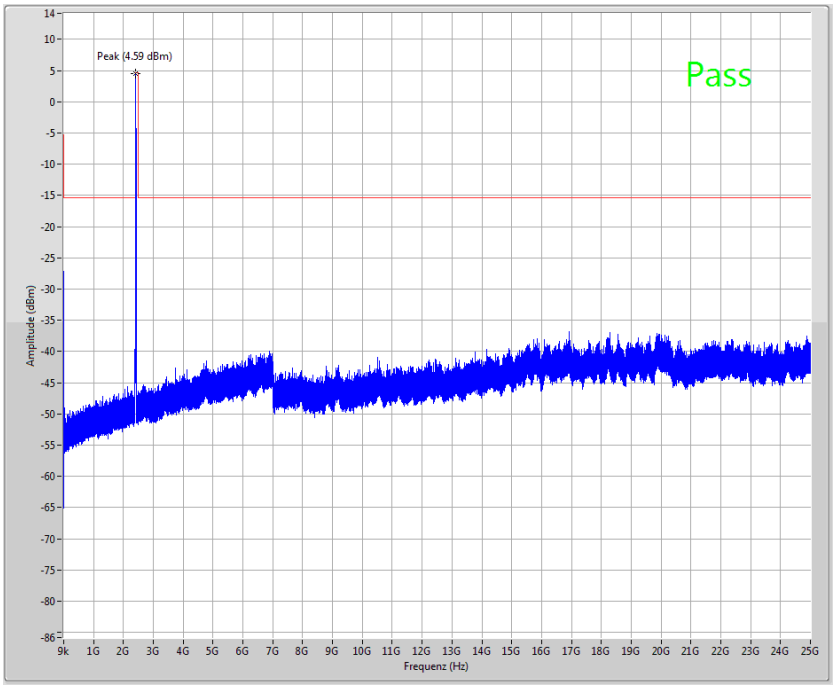
Plot 6: Highest channel, zoomed carrier



Date: 7.DEC.2016 10:45:58

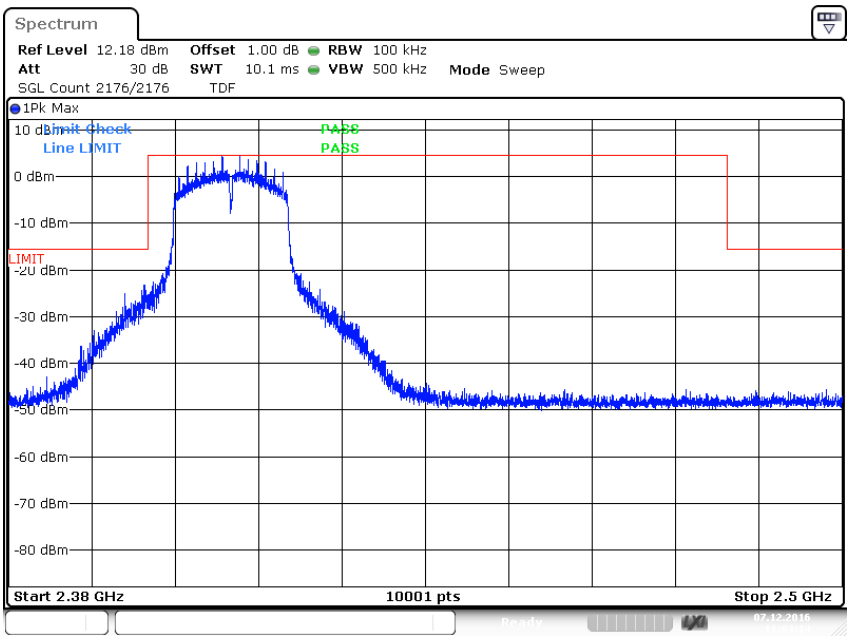
Plots: OFDM / g – mode

Plot 1: Lowest channel, up to 25 GHz



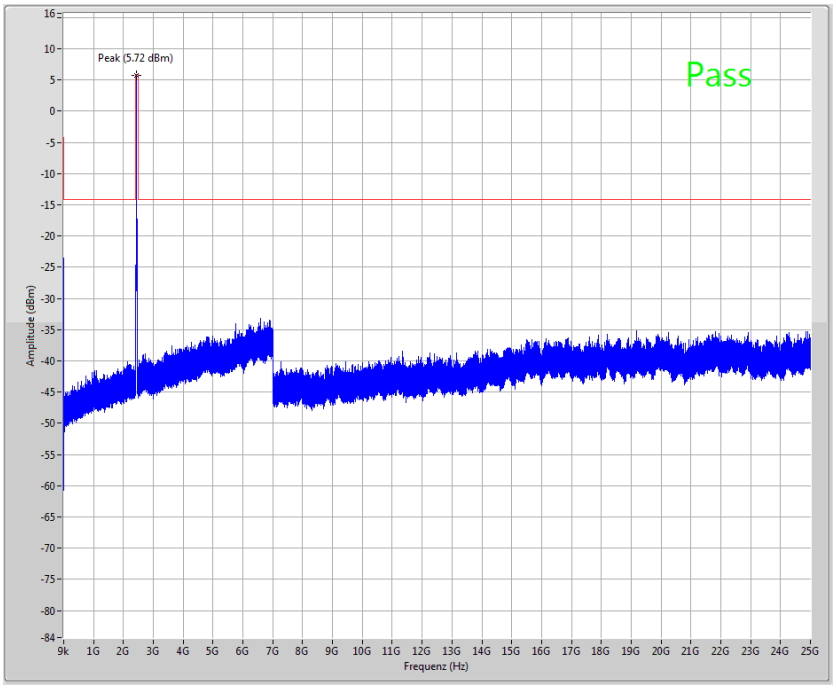
The peak at the beginning of the plot is the LO from the SA.

Plot 2: Lowest channel, zoomed carrier



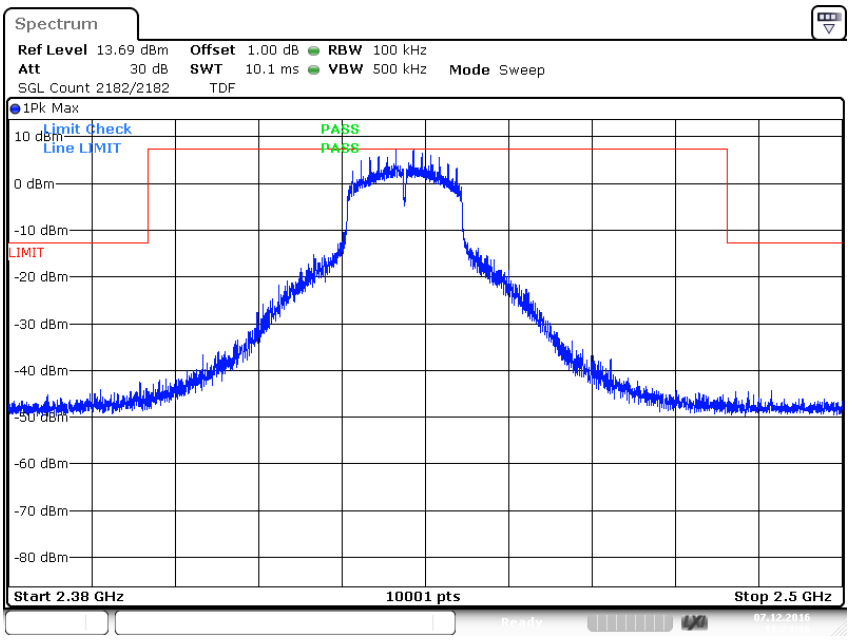
Date: 7.DEC.2016 11:03:15

Plot 3: Middle channel, up to 25 GHz



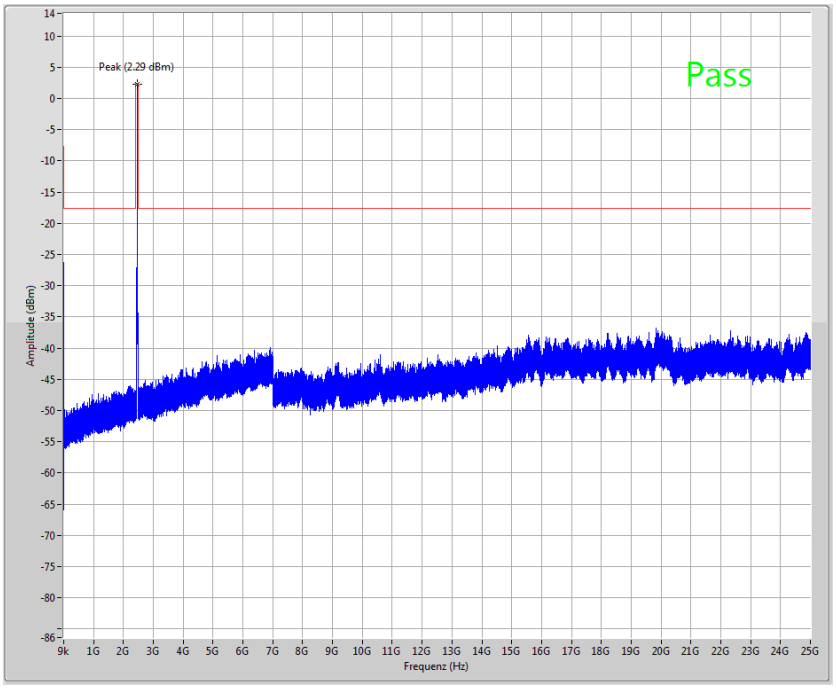
The peak at the beginning of the plot is the LO from the SA.

Plot 4: Middle channel, zoomed carrier



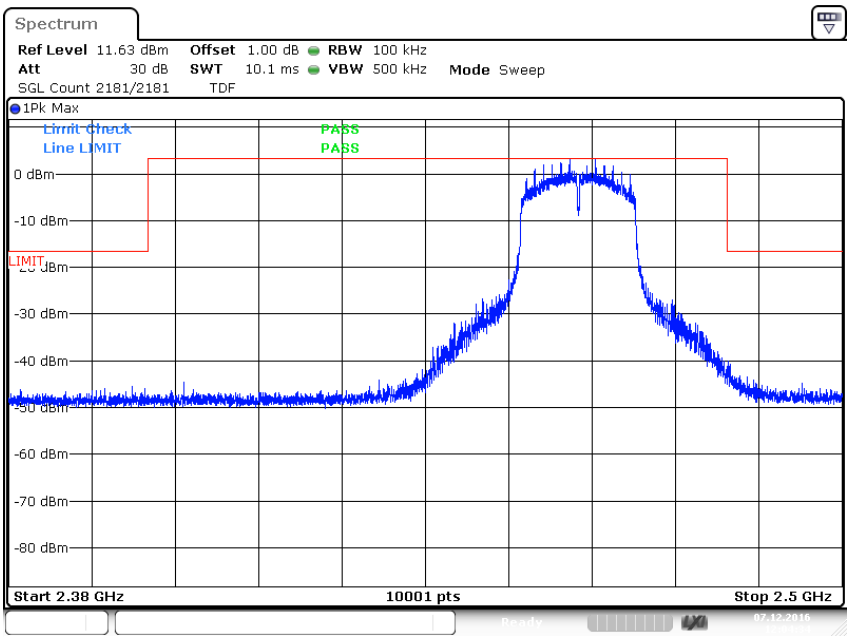
Date: 7.DEC.2016 11:24:17

Plot 5: Highest channel, up to 25 GHz



The peak at the beginning of the plot is the LO from the SA.

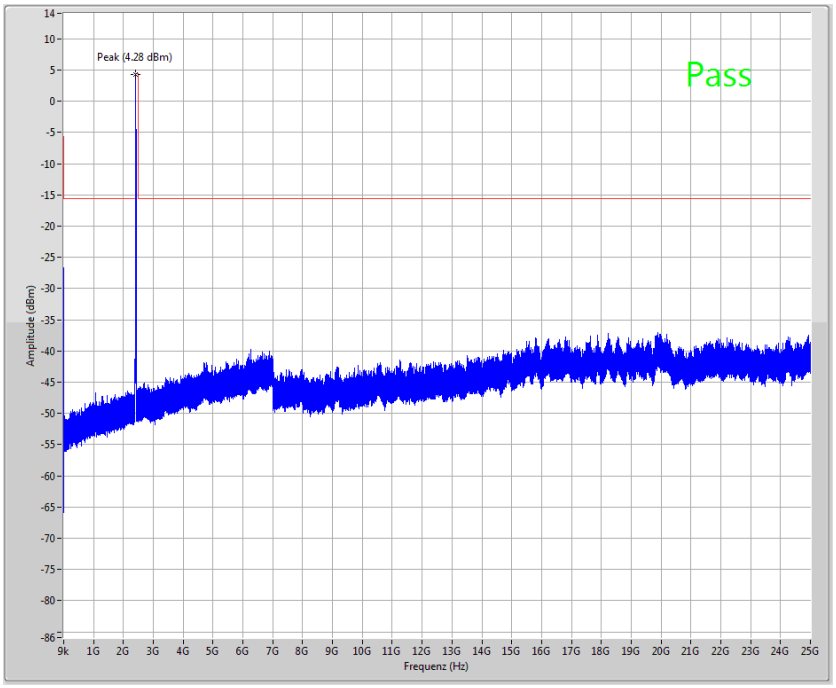
Plot 6: Highest channel, zoomed carrier



Date: 7.DEC.2016 12:04:35

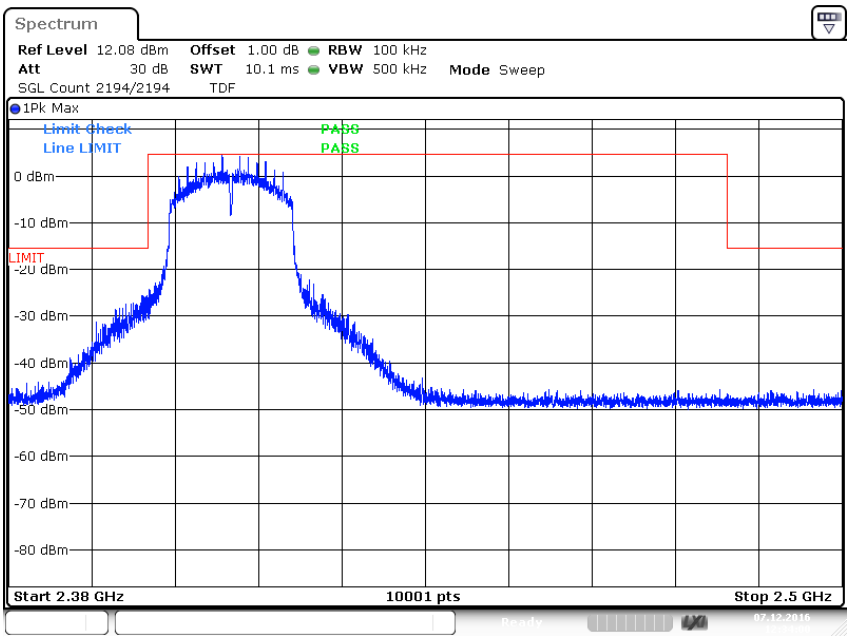
Plots: OFDM / n HT 20 – mode

Plot 1: Lowest channel, up to 25 GHz



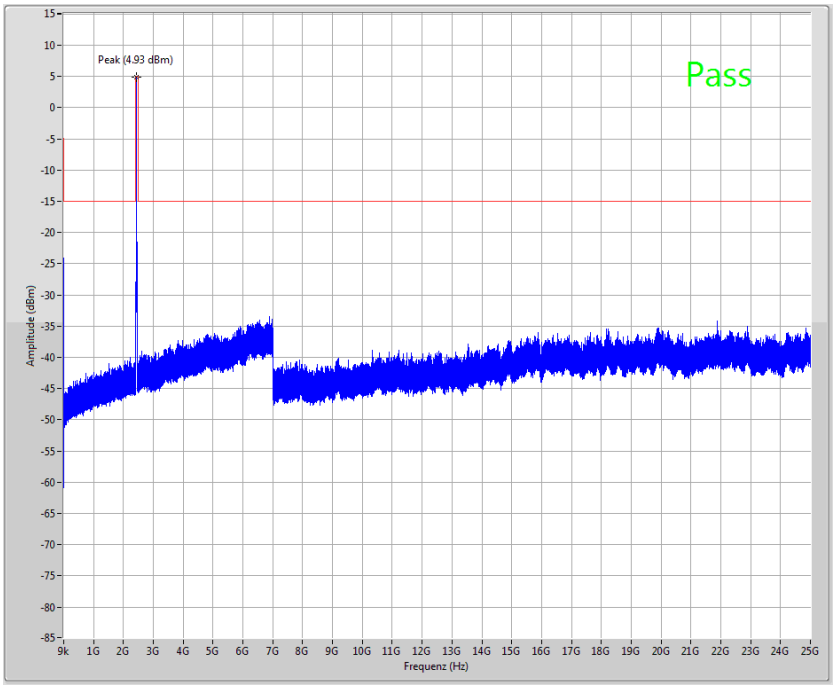
The peak at the beginning of the plot is the LO from the SA.

Plot 2: Lowest channel, zoomed carrier



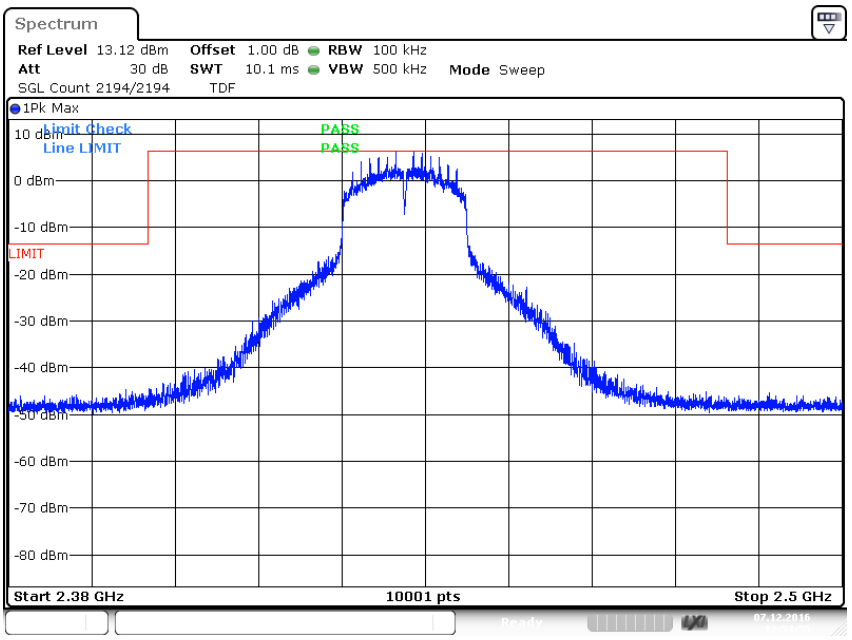
Date: 7.DEC.2016 12:34:01

Plot 3: Middle channel, up to 25 GHz



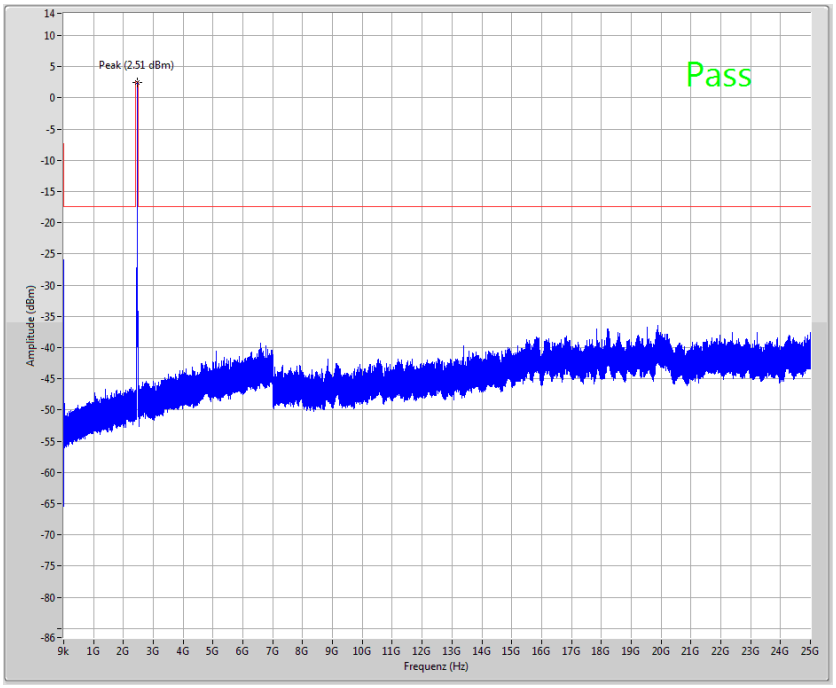
The peak at the beginning of the plot is the LO from the SA.

Plot 4: Middle channel, zoomed carrier



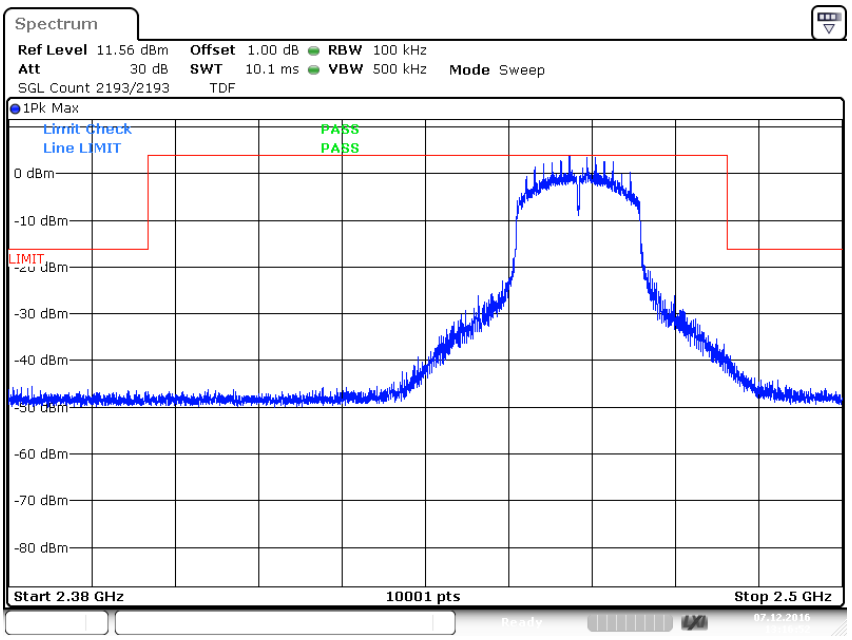
Date: 7.DEC.2016 12:54:56

Plot 5: Highest channel, up to 25 GHz



The peak at the beginning of the plot is the LO from the SA.

Plot 6: Highest channel, zoomed carrier



Date: 7.DEC.2016 13:16:52

11.12 Spurious emissions radiated below 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to channel 6. This measurement is representative for all channels and modes. If peaks are found channel 1 and channel 11 will be measured too. The measurement is performed with the data rate producing the highest output power. 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
Resolution bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace mode:	Max Hold
Measured modulation	☒ DSSS b – mode ☒ OFDM g – mode ☐ OFDM n HT20 – mode
Test setup:	See sub clause 6.2 - A
Measurement uncertainty	See sub clause 8

Limits:

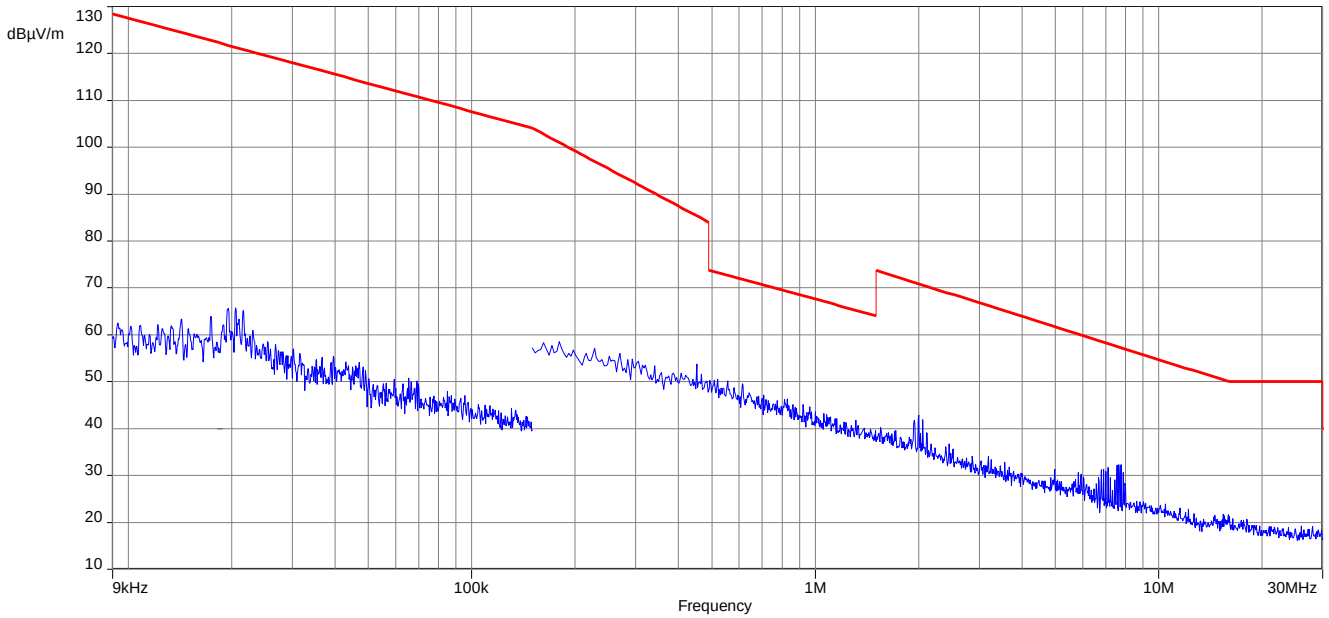
FCC		IC
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results:

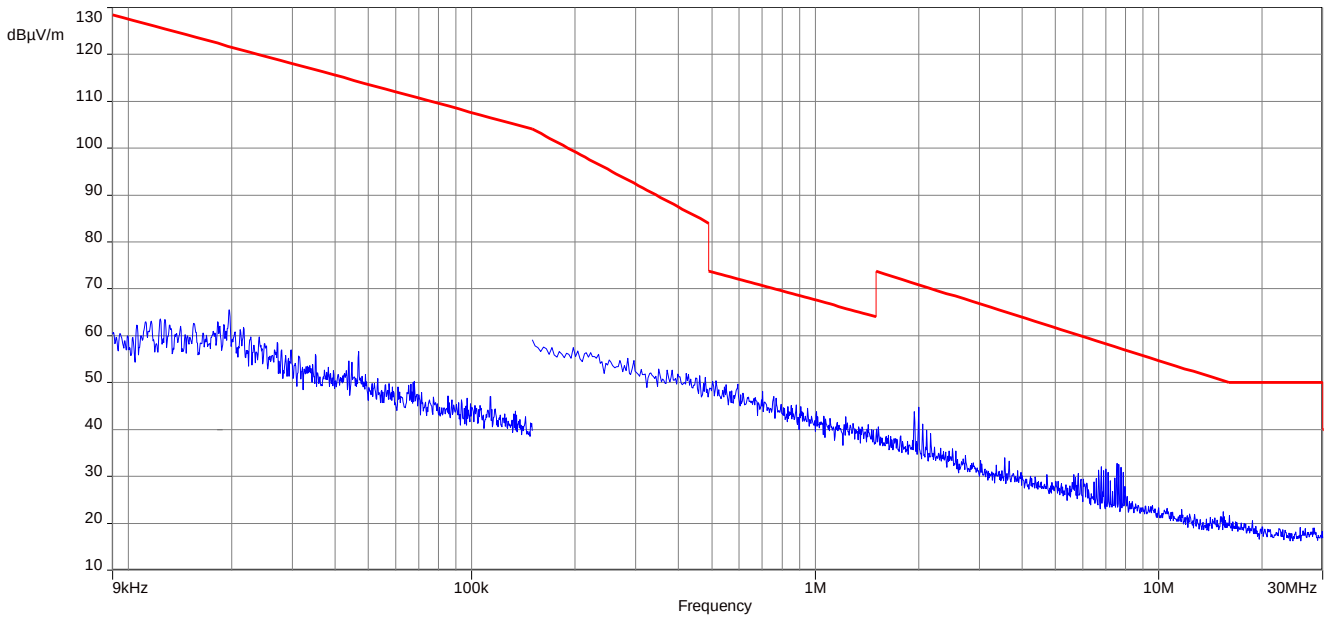
TX Spurious Emissions Radiated < 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected peaks are more than 20 dB below the limit.		

Plots: DSSS

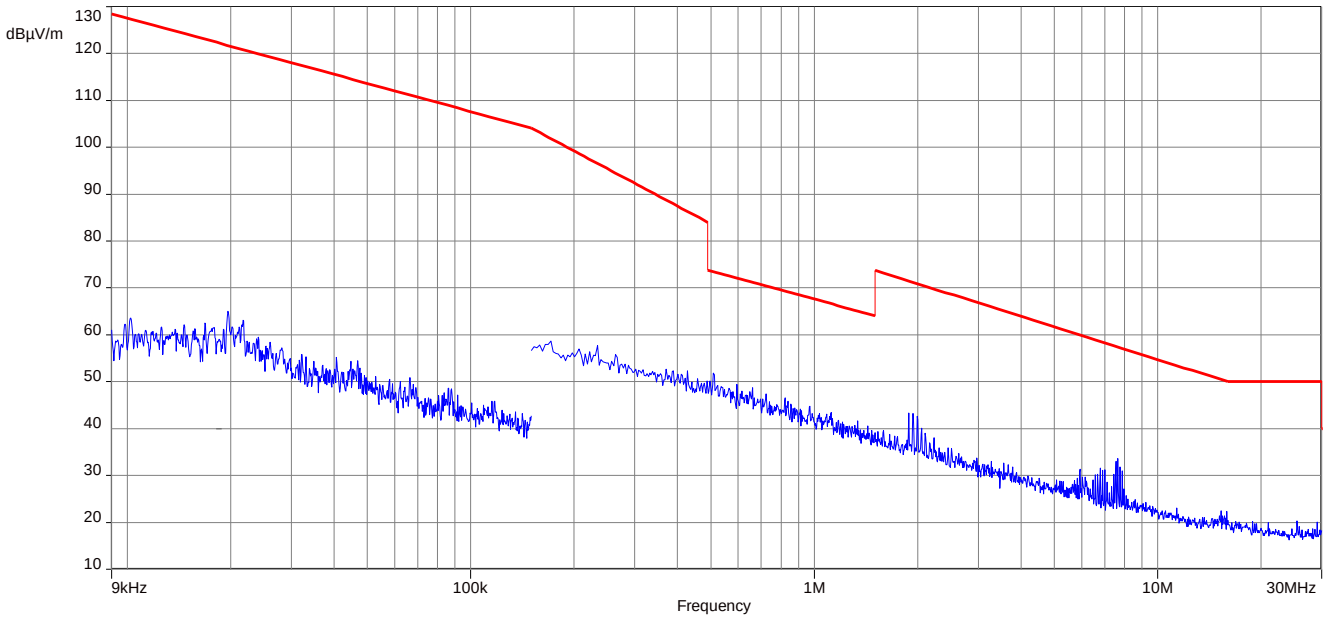
Plot 1: 9 kHz to 30 MHz, low channel



Plot 2: 9 kHz to 30 MHz, mid channel

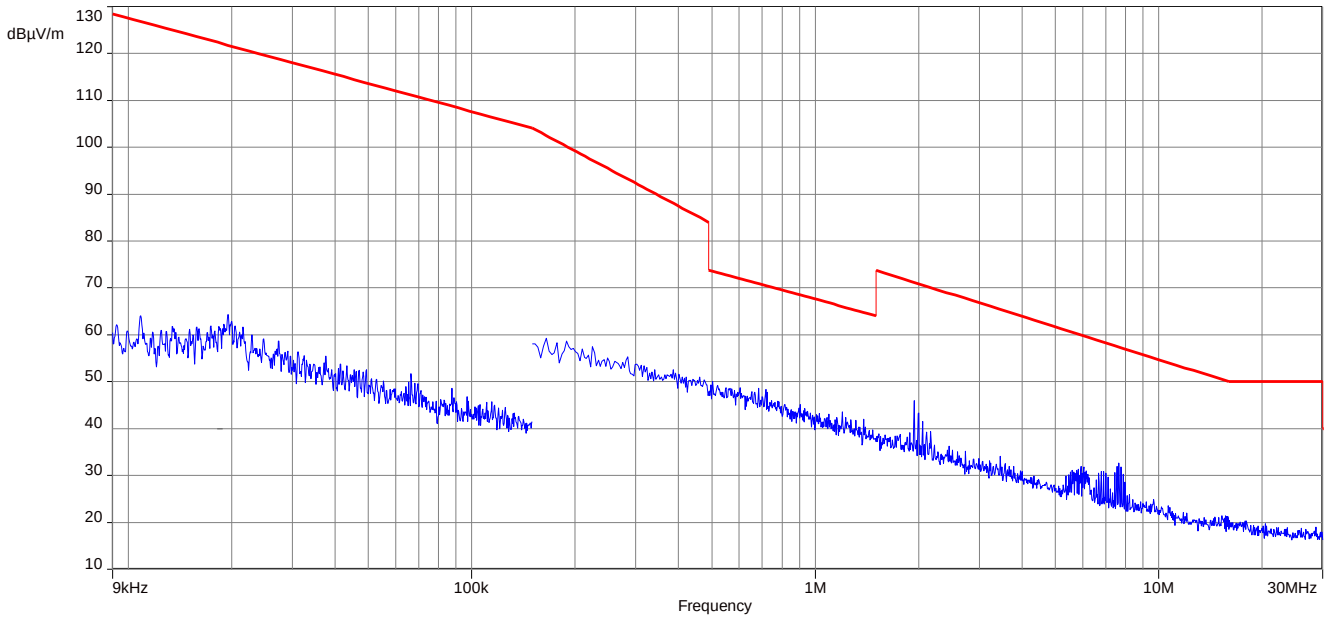


Plot 3: 9 kHz to 30 MHz, high channel

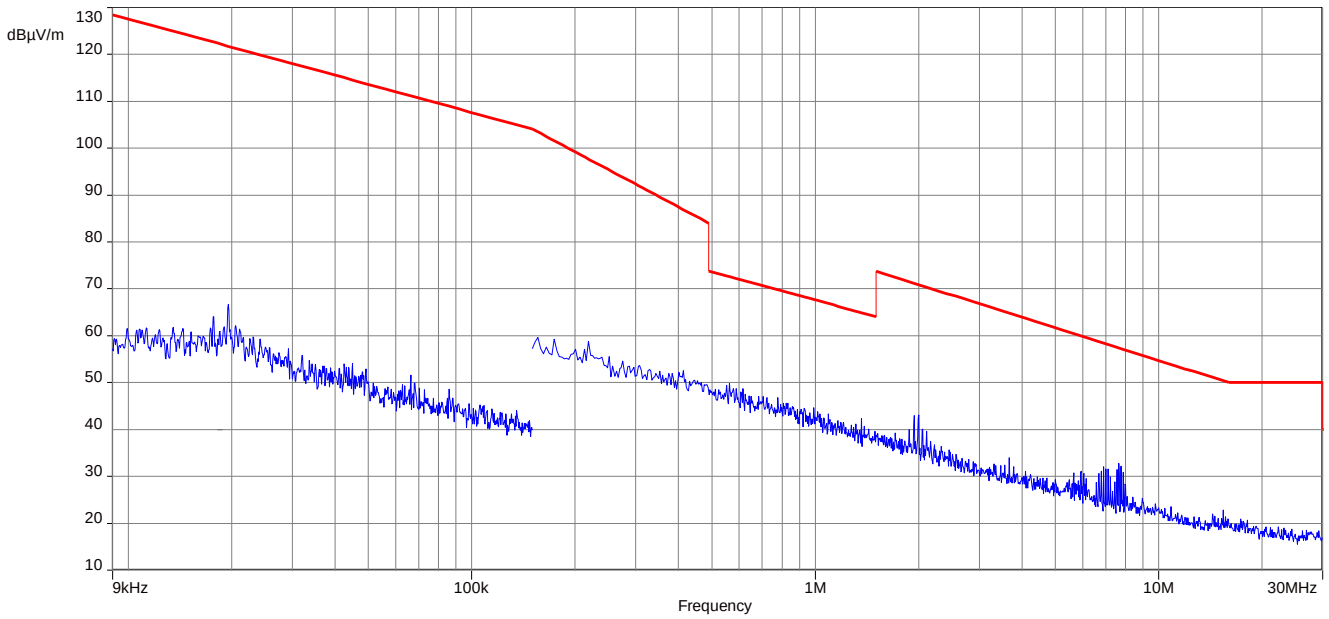


Plots: OFDM (20 MHz bandwidth)

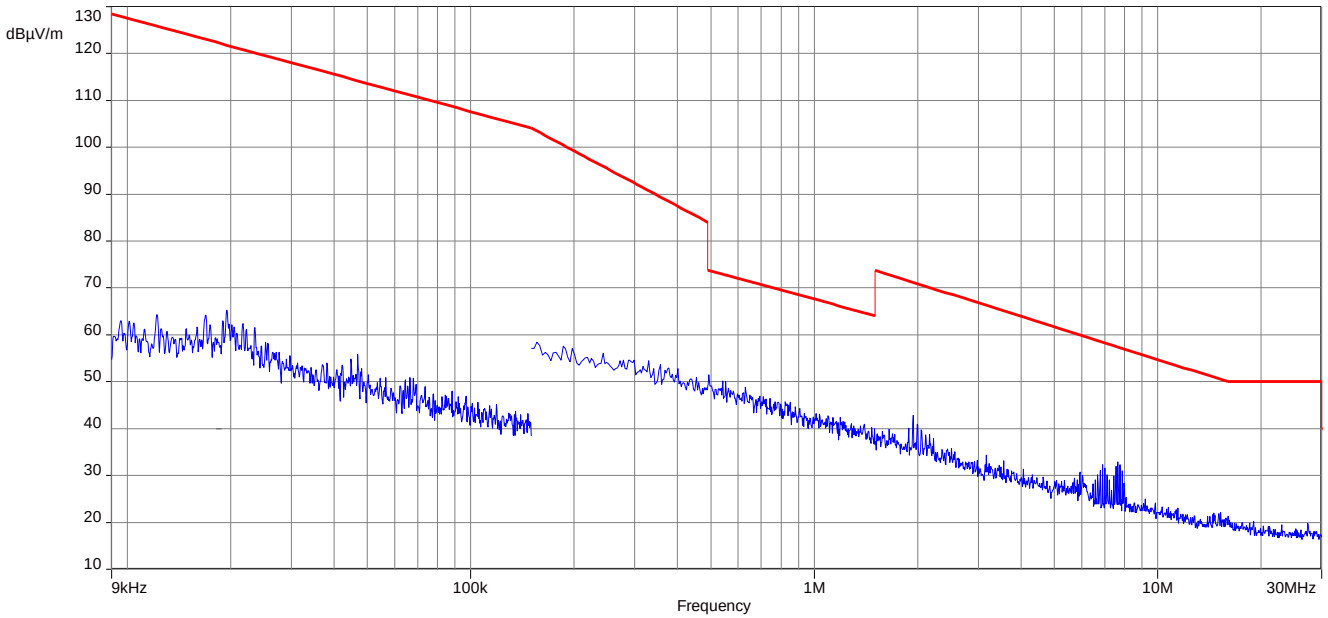
Plot 1: 9 kHz to 30 MHz, low channel



Plot 2: 9 kHz to 30 MHz, mid channel



Plot 3: 9 kHz to 30 MHz, high channel



11.13 Spurious emissions radiated 30 MHz to 1 GHz

Description:

Measurement of the radiated spurious emissions and cabinet radiations below 1 GHz.

Measurement:

Measurement parameter	
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	☒ DSSS b – mode ☒ OFDM g – mode ☐ OFDM n HT20 – mode ☒ RX / Idle – mode
Test setup:	See sub clause 6.1 - A
Measurement uncertainty	See sub clause 8

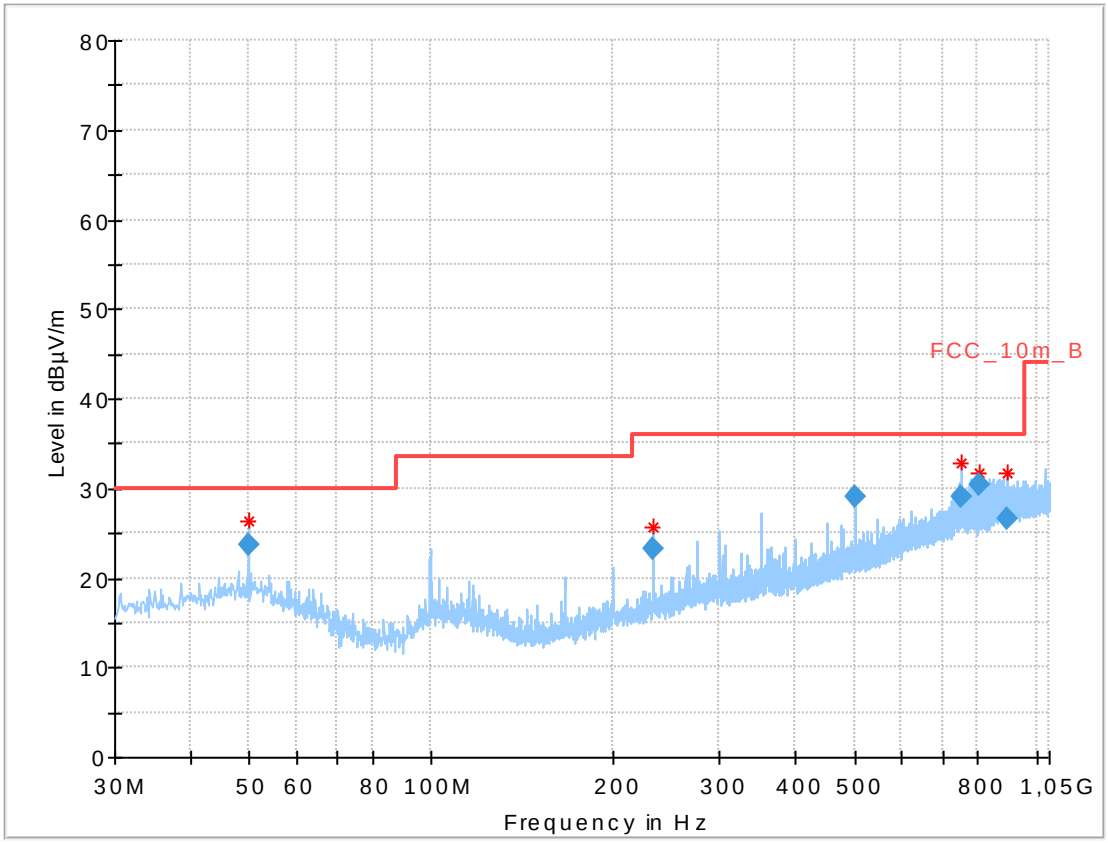
The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

Limits:

FCC	IC	
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)).		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
30 - 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10

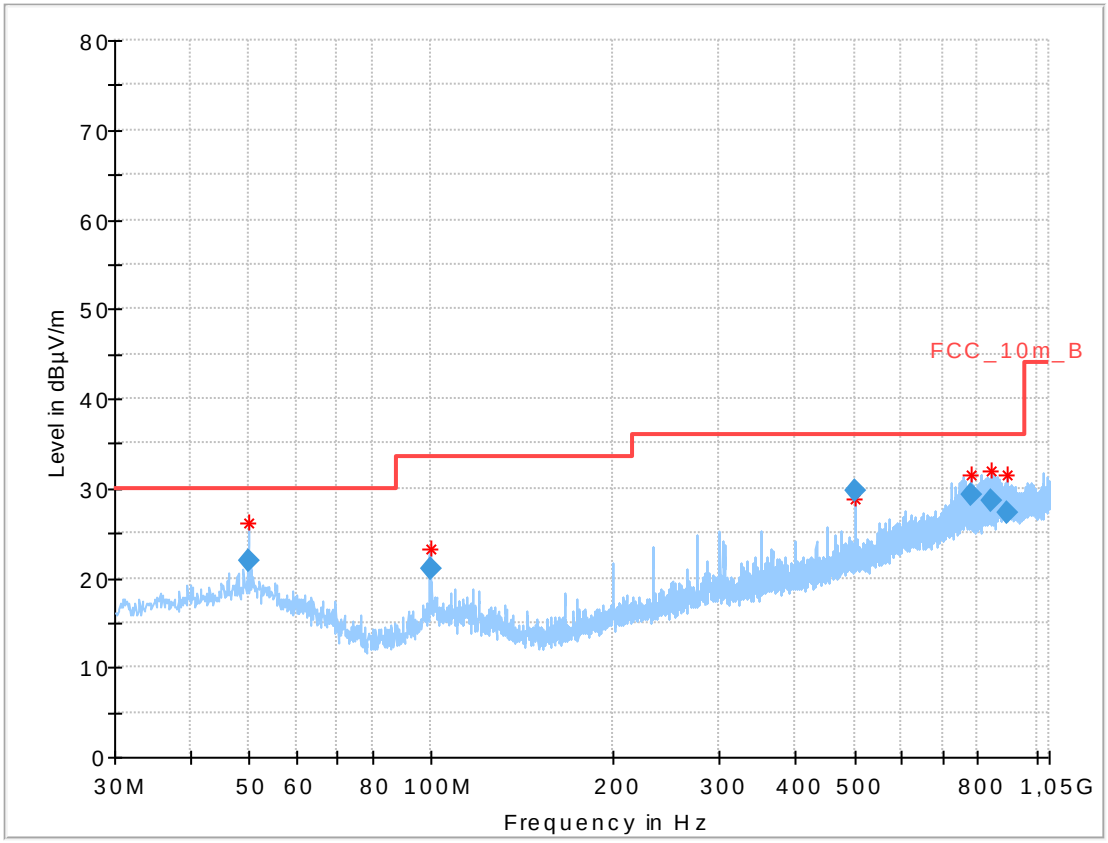
Plot: DSSS

Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization, low channel



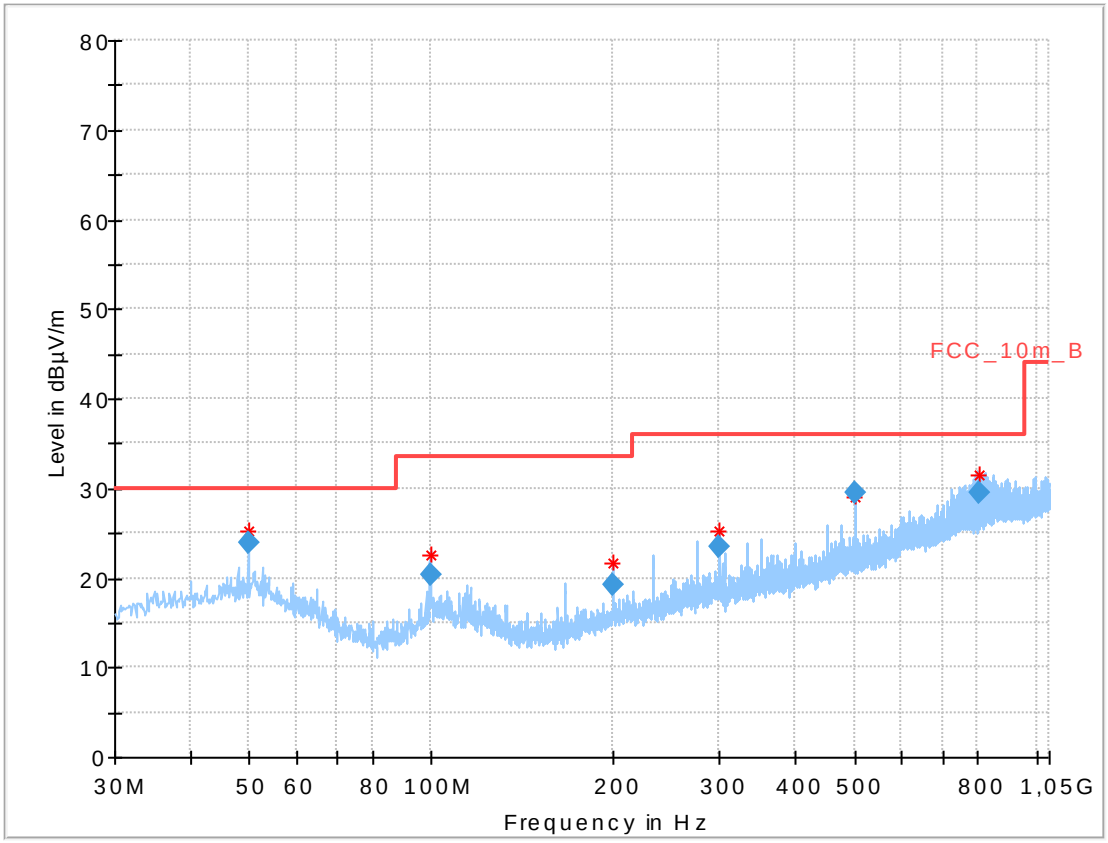
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
50.000250	23.79	30.00	6.21	1000.0	120.000	98.0	V	275.0	13.7
232.797300	23.31	36.00	12.69	1000.0	120.000	98.0	V	153.0	12.9
500.002650	28.96	36.00	7.04	1000.0	120.000	177.0	H	185.0	18.7
751.897950	29.05	36.00	6.95	1000.0	120.000	101.0	H	212.0	22.7
804.031950	30.28	36.00	5.72	1000.0	120.000	98.0	H	0.0	22.8
894.436800	26.67	36.00	9.33	1000.0	120.000	100.0	H	19.0	24.1

Plot 2: 30 MHz to 1 GHz, vertical & horizontal polarization, mid channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
50.037450	21.91	30.00	8.09	1000.0	120.000	101.0	V	1.0	13.7
99.769500	21.09	33.50	12.41	1000.0	120.000	98.0	V	69.0	12.1
499.996800	29.79	36.00	6.21	1000.0	120.000	185.0	H	76.0	18.7
781.834050	29.20	36.00	6.80	1000.0	120.000	101.0	H	352.0	22.7
839.600850	28.52	36.00	7.48	1000.0	120.000	98.0	H	352.0	23.4
894.018300	27.31	36.00	8.69	1000.0	120.000	101.0	H	14.0	24.1

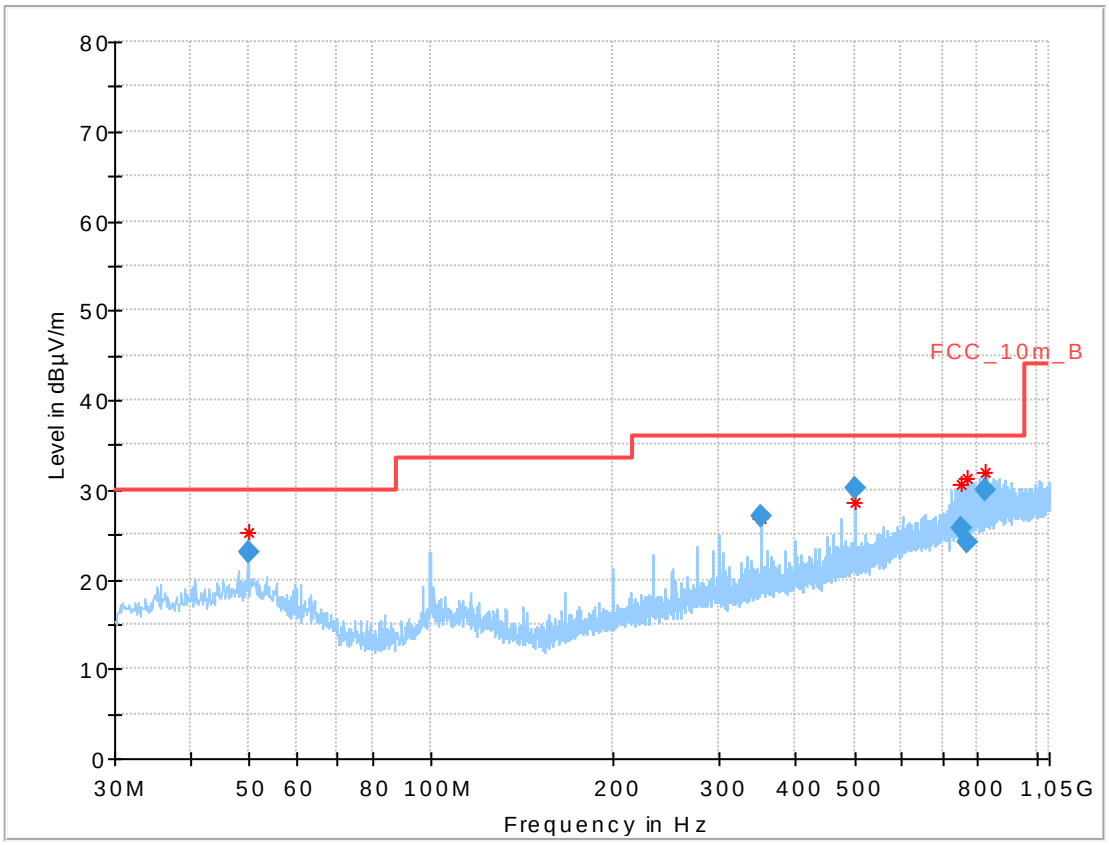
Plot 3: 30 MHz to 1 GHz, vertical & horizontal polarization, high channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
50.006550	23.93	30.00	6.07	1000.0	120.000	98.0	V	24.0	13.7
99.764700	20.27	33.50	13.23	1000.0	120.000	98.0	V	0.0	12.1
199.983300	19.24	33.50	14.26	1000.0	120.000	98.0	V	206.0	11.9
299.336400	23.38	36.00	12.62	1000.0	120.000	101.0	V	175.0	14.4
499.988100	29.59	36.00	6.41	1000.0	120.000	185.0	H	195.0	18.7
802.761300	29.49	36.00	6.51	1000.0	120.000	98.0	H	206.0	22.8

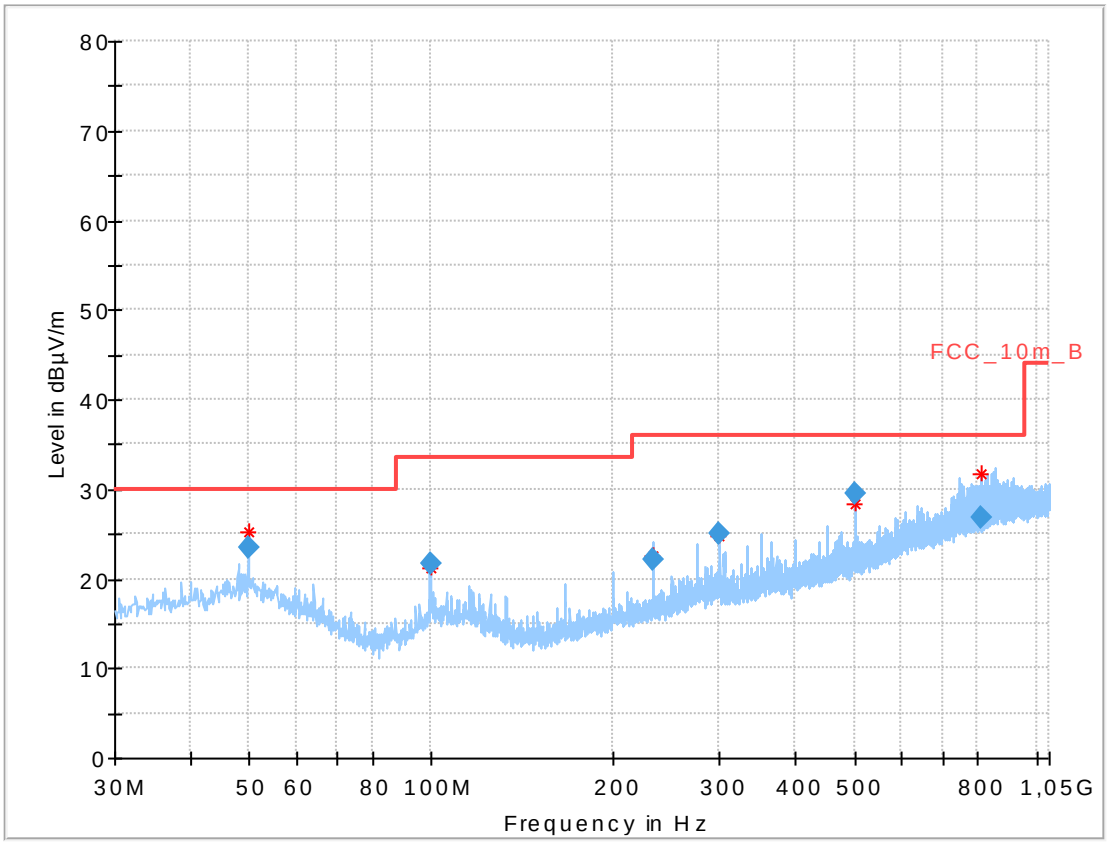
Plot: OFDM (20 MHz bandwidth)

Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization, low channel



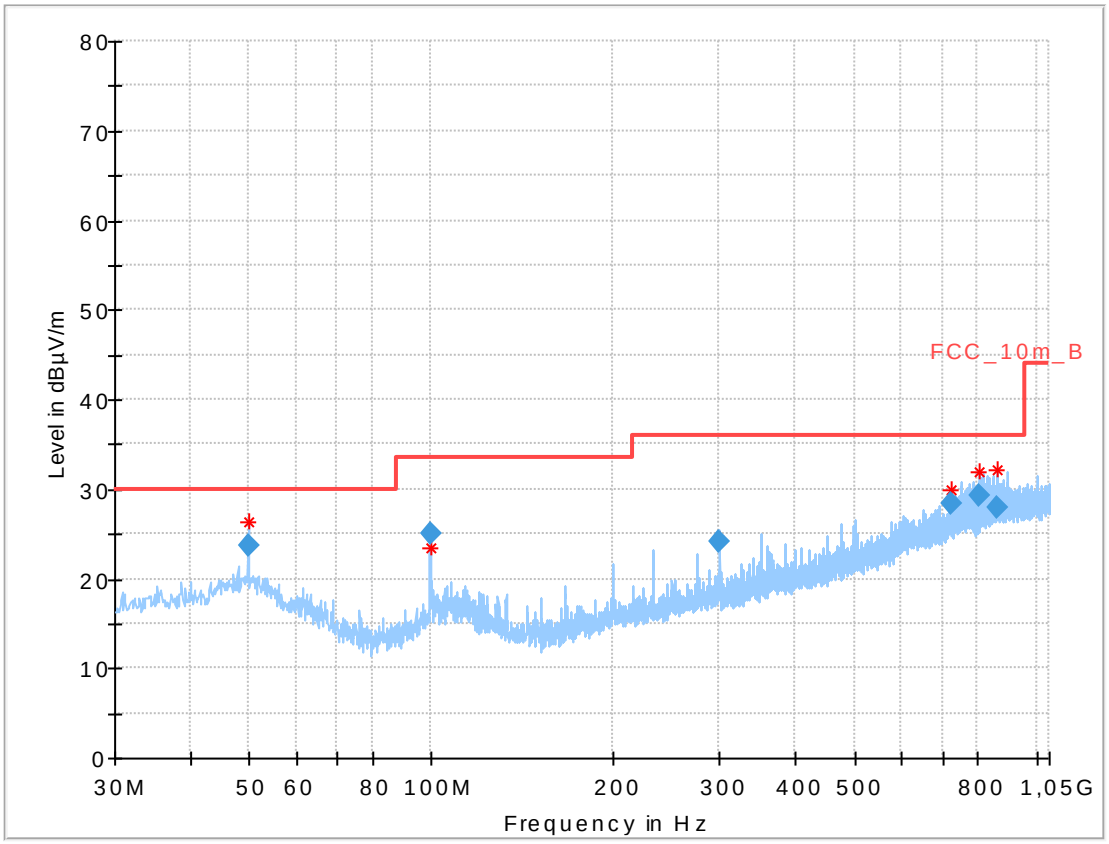
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
50.016300	23.10	30.00	6.90	1000.0	120.000	101.0	V	248.0	13.7
350.010900	27.00	36.00	9.00	1000.0	120.000	185.0	H	197.0	16.0
500.004450	30.07	36.00	5.93	1000.0	120.000	179.0	H	72.0	18.7
752.352900	25.67	36.00	10.33	1000.0	120.000	98.0	H	225.0	22.7
771.102600	24.17	36.00	11.83	1000.0	120.000	98.0	H	349.0	22.7
824.739750	29.97	36.00	6.03	1000.0	120.000	101.0	H	197.0	23.1

Plot 2: 30 MHz to 1 GHz, vertical & horizontal polarization, mid channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
49.984050	23.53	30.00	6.47	1000.0	120.000	98.0	V	353.0	13.7
99.743100	21.64	33.50	11.86	1000.0	120.000	100.0	V	21.0	12.1
232.803900	22.22	36.00	13.78	1000.0	120.000	98.0	V	164.0	12.9
300.002550	24.92	36.00	11.08	1000.0	120.000	98.0	V	180.0	14.4
500.007900	29.47	36.00	6.53	1000.0	120.000	185.0	H	196.0	18.7
808.903800	26.84	36.00	9.16	1000.0	120.000	98.0	H	212.0	22.9

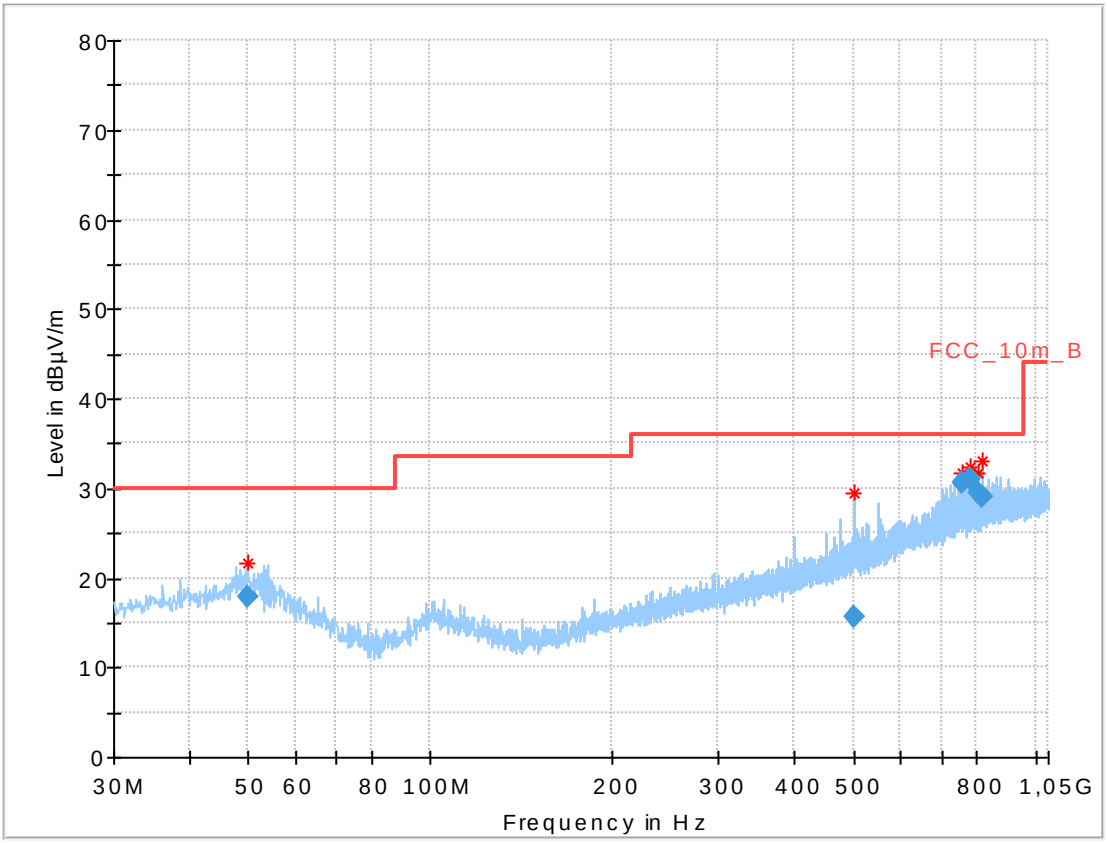
Plot 3: 30 MHz to 1 GHz, vertical & horizontal polarization, high channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
49.981950	23.77	30.00	6.23	1000.0	120.000	98.0	V	350.0	13.7
99.611850	25.12	33.50	8.38	1000.0	120.000	98.0	V	58.0	12.0
300.015600	24.07	36.00	11.93	1000.0	120.000	98.0	V	350.0	14.4
724.993800	28.31	36.00	7.69	1000.0	120.000	101.0	H	218.0	22.1
801.626850	29.29	36.00	6.71	1000.0	120.000	98.0	H	198.0	22.8
862.486050	27.84	36.00	8.16	1000.0	120.000	98.0	H	198.0	23.7

Plot: RX / Idle mode

Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
49.979550	17.84	30.00	12.16	1000.0	120.000	101.0	V	153.0	13.7
499.981500	15.61	36.00	20.39	1000.0	120.000	185.0	H	1.0	18.7
756.920550	30.71	36.00	5.29	1000.0	120.000	98.0	H	172.0	22.7
780.205500	31.10	36.00	4.90	1000.0	120.000	98.0	H	178.0	22.7
803.418600	29.60	36.00	6.40	1000.0	120.000	98.0	H	190.0	22.8
815.067900	29.02	36.00	6.98	1000.0	120.000	98.0	H	172.0	23.0

11.14 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions above 1 GHz in transmit mode and receiver / idle mode.

Measurement:

Measurement parameter	
Detector:	Peak / RMS
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	3 x RBW
Span:	1 GHz to 26 GHz
Trace mode:	Max Hold
Measured modulation	☒ DSSS b – mode ☒ OFDM g – mode ☐ OFDM n HT20 – mode ☒ RX / Idle – mode
Test setup:	See sub clause 6.2 - 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 30 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)).		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
Above 960	54.0	3

Results: DSSS

TX Spurious Emissions Radiated [dBµV/m]								
2412 MHz			2437 MHz			2462 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
1437.5	Peak	38.2	4874.0	Peak	43.9	17950.4	Peak	55.9
	AVG	-/-		AVG	-/-		AVG	44.8
4824.1	Peak	44.0	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

Results: OFDM (20 MHz bandwidth)

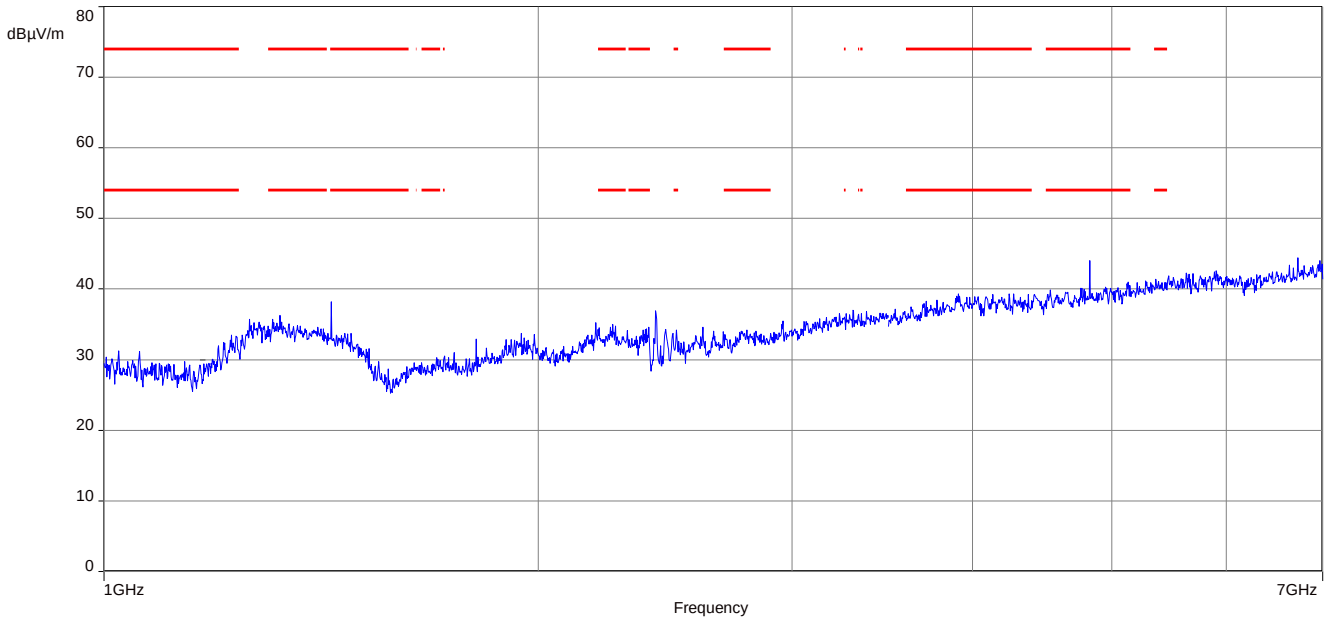
TX Spurious Emissions Radiated [dBµV/m]								
2412 MHz			2437 MHz			2462 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
1437.5	Peak	38.2	4874.0	Peak	43.9	17951.8	Peak	56.1
	AVG	-/-		AVG	-/-		AVG	44.8
4824.1	Peak	44.0	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

Results: RX / idle – mode

TX Spurious Emissions Radiated [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
17951	Peak	56.2
	AVG	44.9
-/-	Peak	-/-
	AVG	-/-

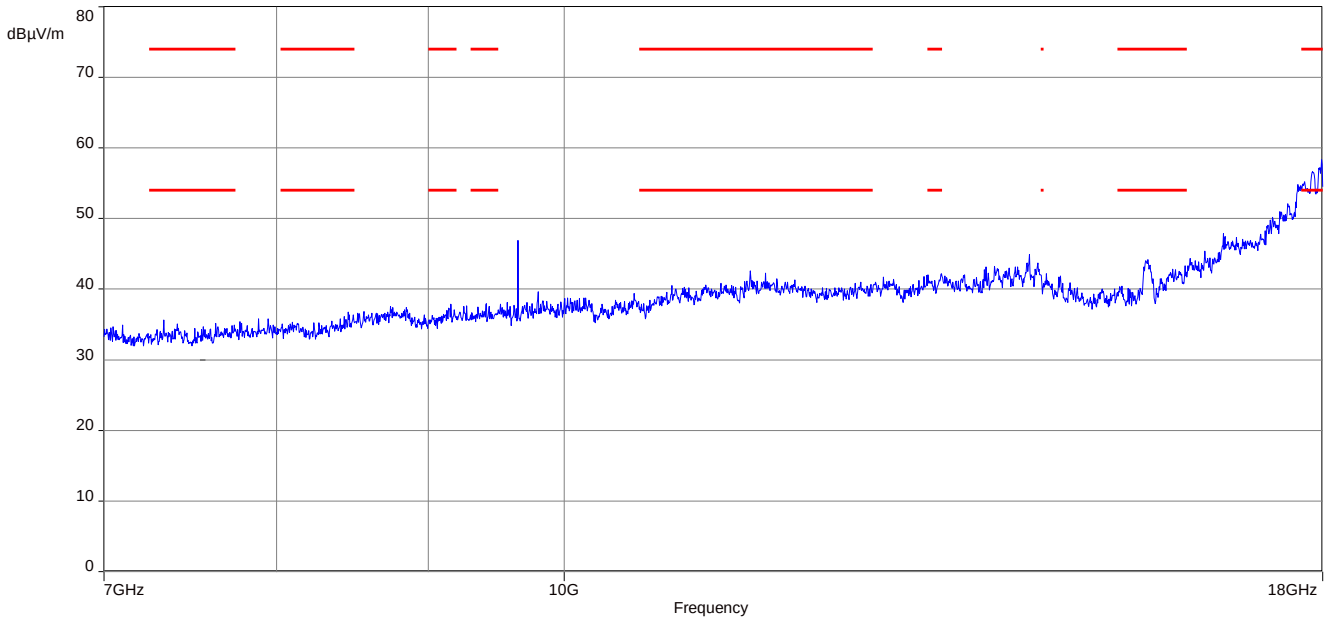
Plots: DSSS

Plot 1: Lowest channel, 1 GHz to 7 GHz, vertical & horizontal polarization

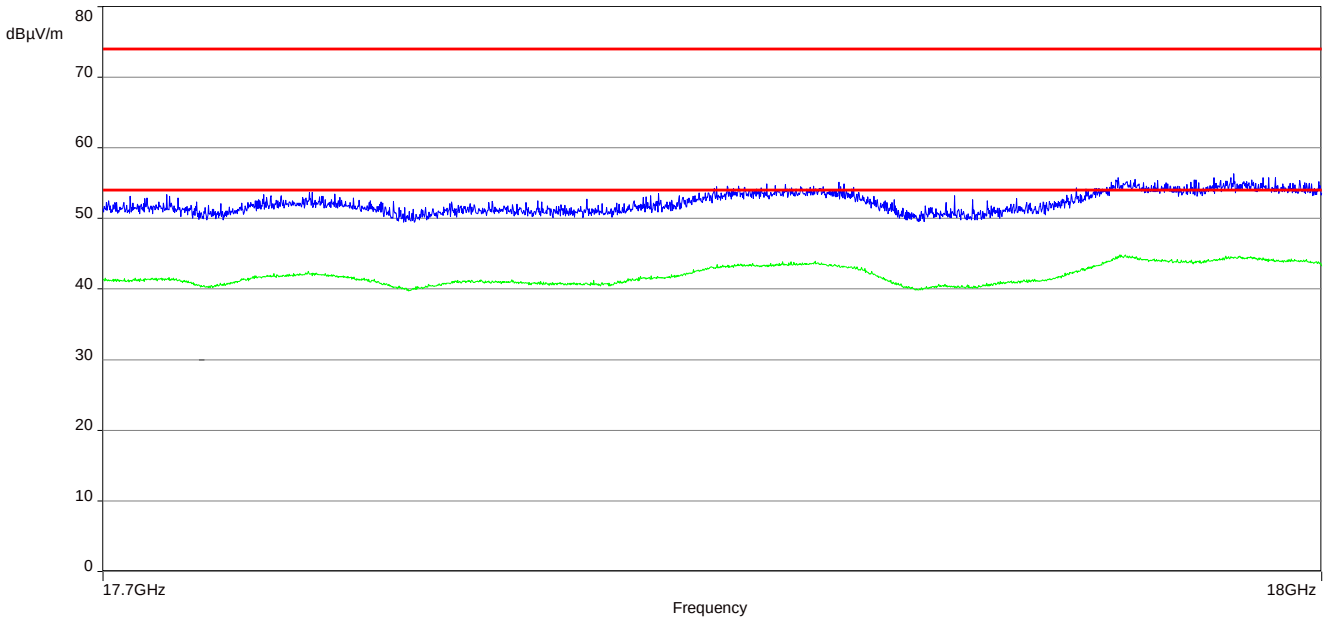


The carrier signal is notched with a 2.4 GHz band rejection filter.

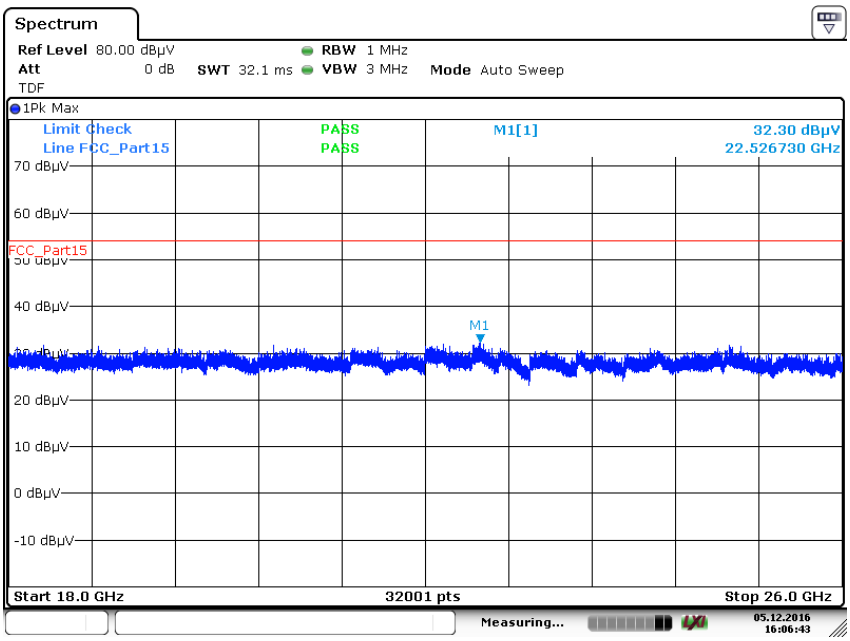
Plot 2: Lowest channel, 7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



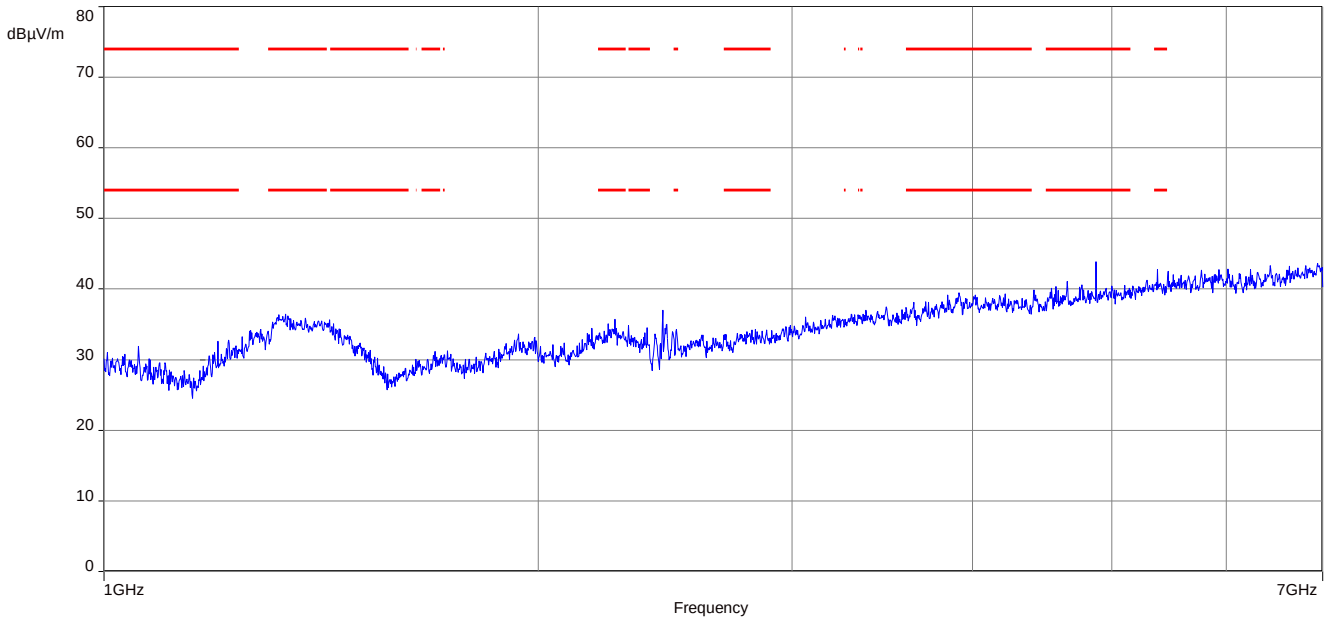
Plot 3: Lowest channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



Plot 4: Lowest channel, 18 GHz to 26 GHz, vertical & horizontal polarization

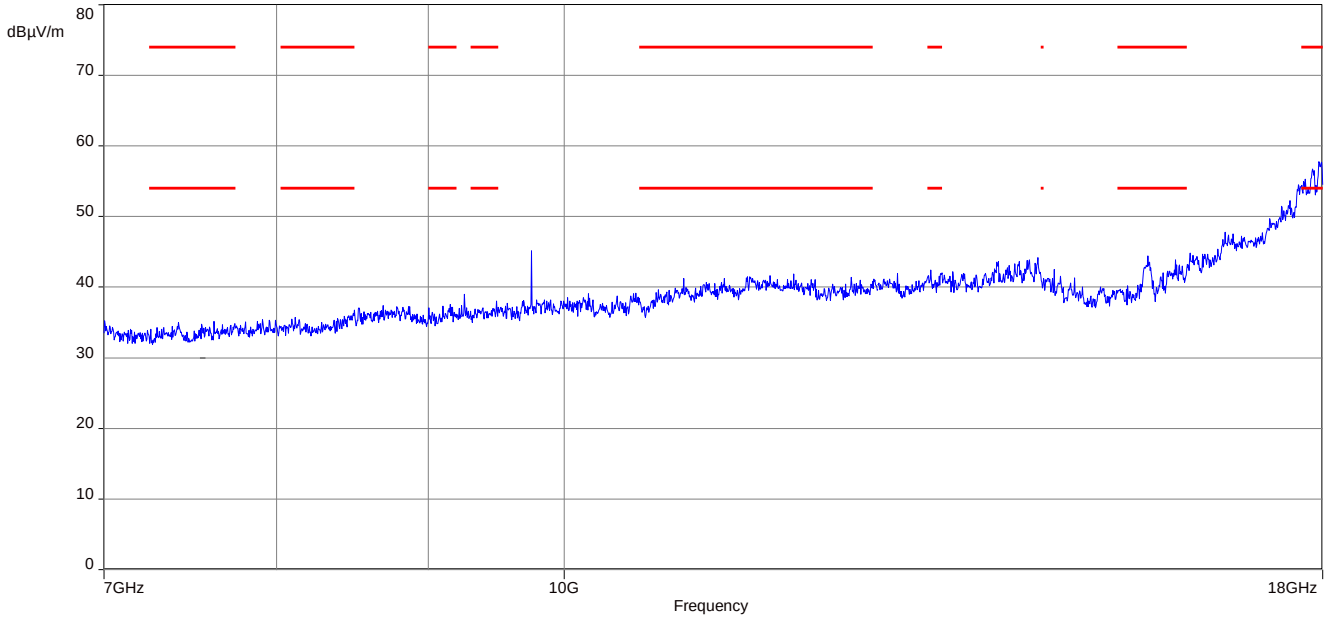


Plot 5: Middle channel, 1 GHz to 7 GHz, vertical & horizontal polarization

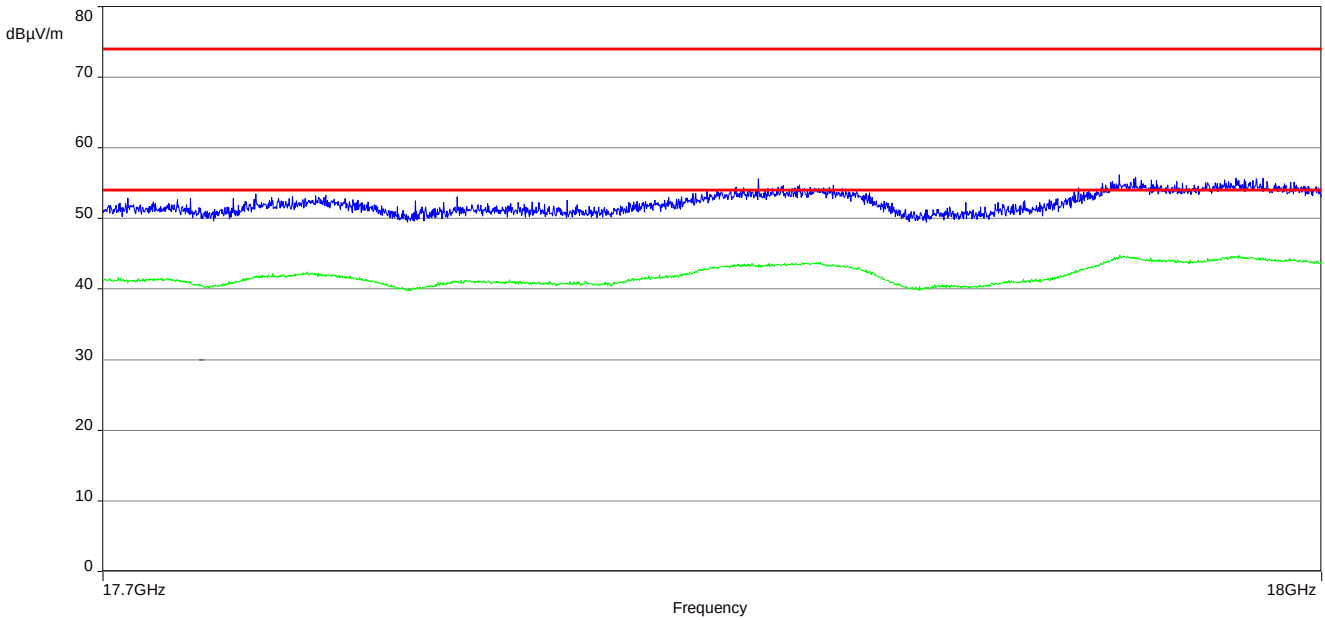


The carrier signal is notched with a 2.4 GHz band rejection filter.

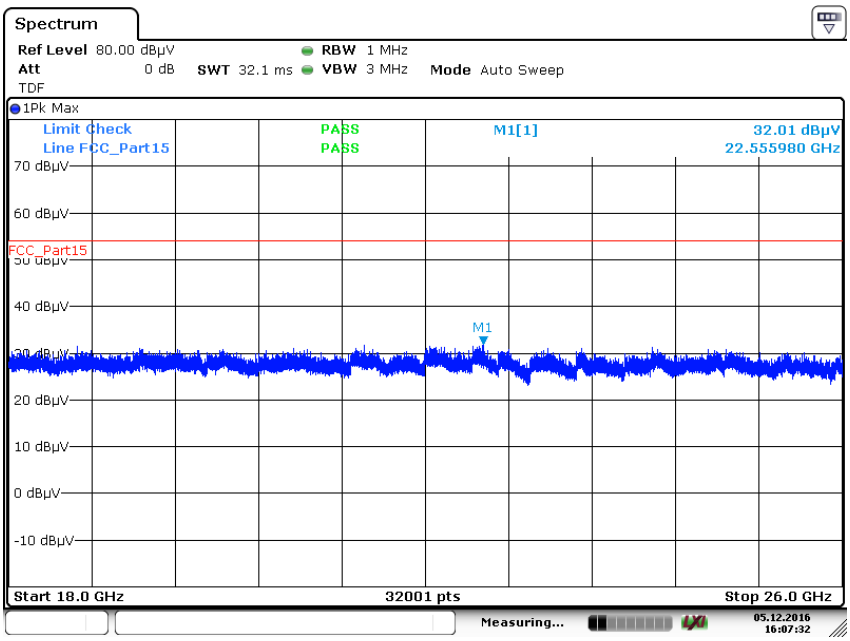
Plot 6: Middle channel, 7 GHz to 18 GHz, vertical & horizontal polarization



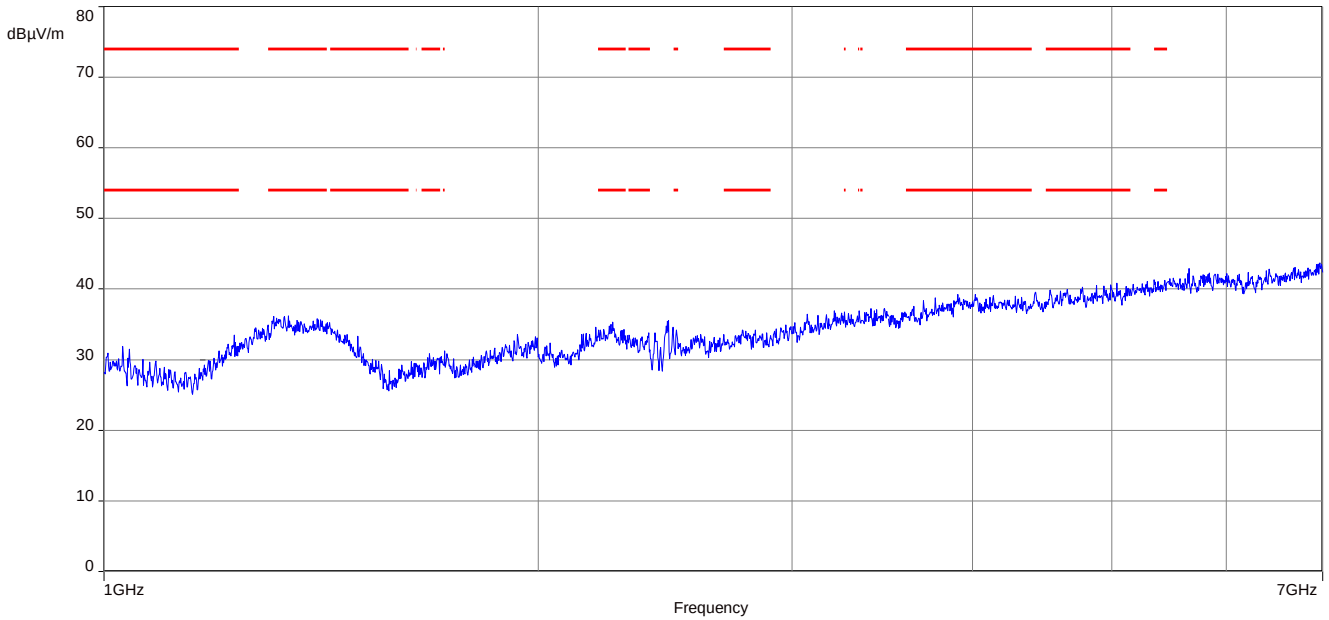
Plot 7: Middle channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



Plot 8: Middle channel, 18 GHz to 26 GHz, vertical & horizontal polarization

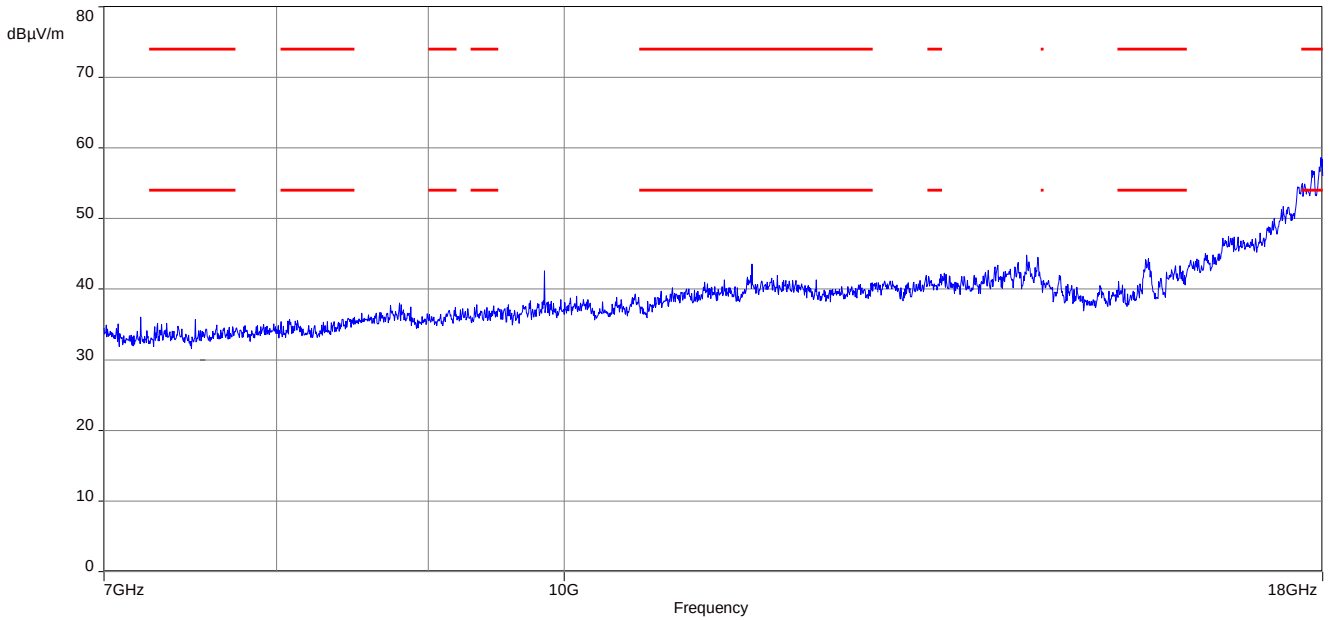


Plot 9: Highest channel, 1 GHz to 7 GHz, vertical & horizontal polarization

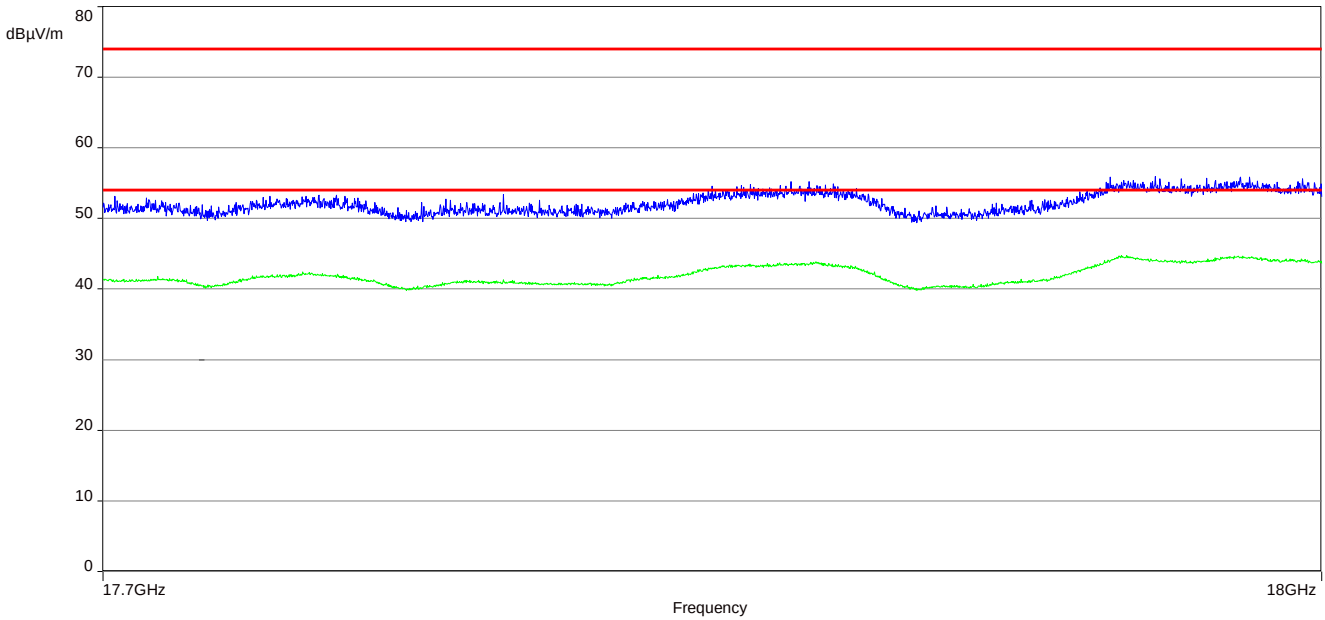


The carrier signal is notched with a 2.4 GHz band rejection filter.

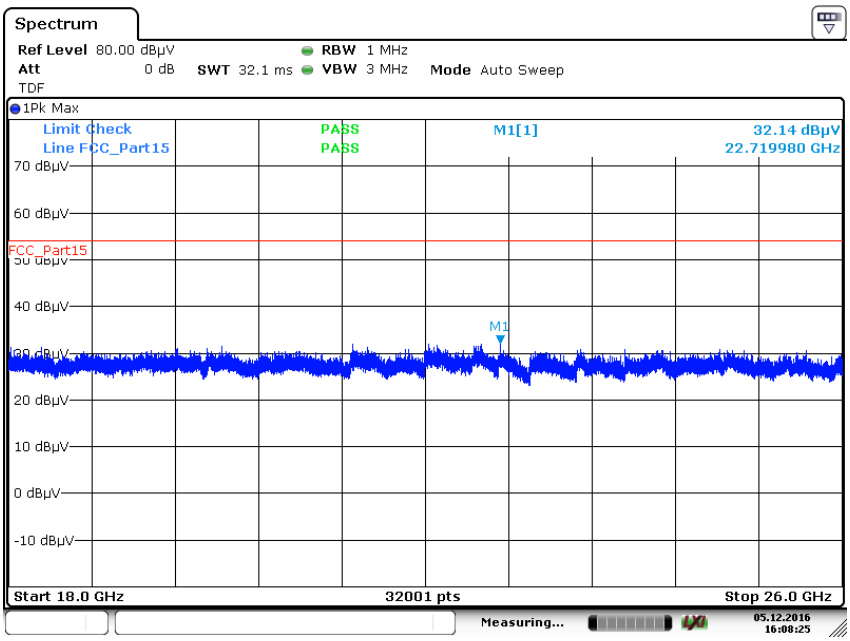
Plot 10: Highest channel, 7 GHz to 18 GHz, vertical & horizontal polarization



Plot 11: Highest channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



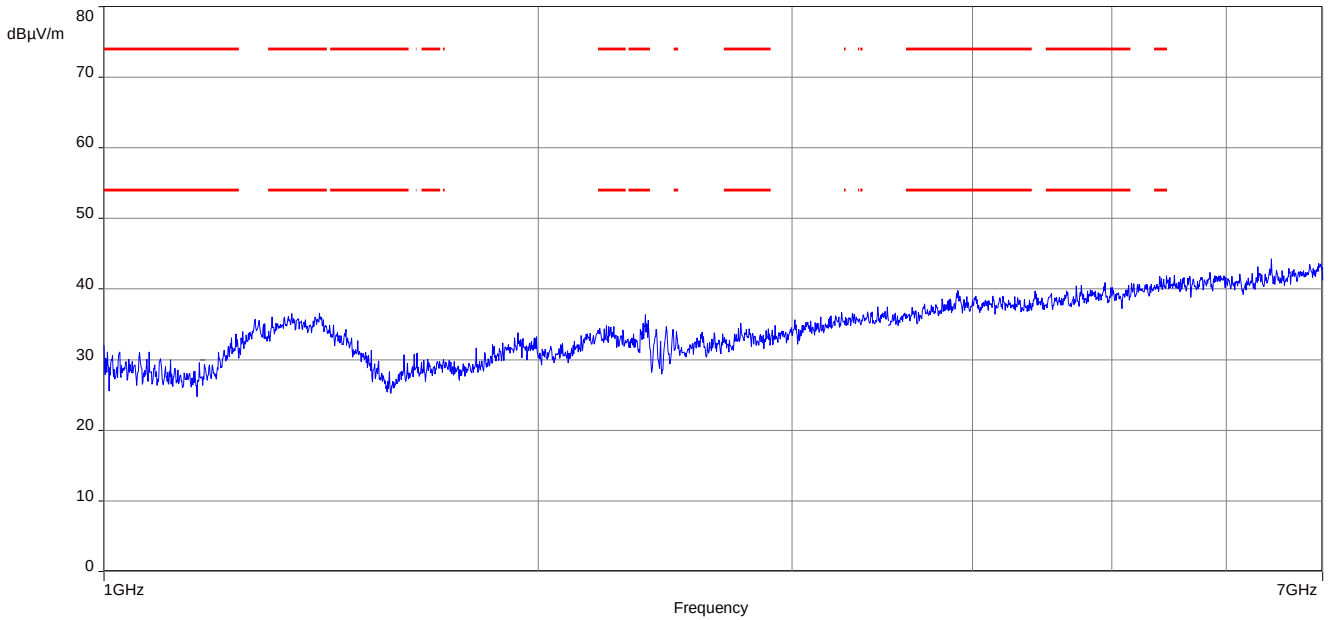
Plot 12: Highest channel, 18 GHz to 26 GHz, vertical & horizontal polarization



Date: 5.DEC.2016 16:08:25

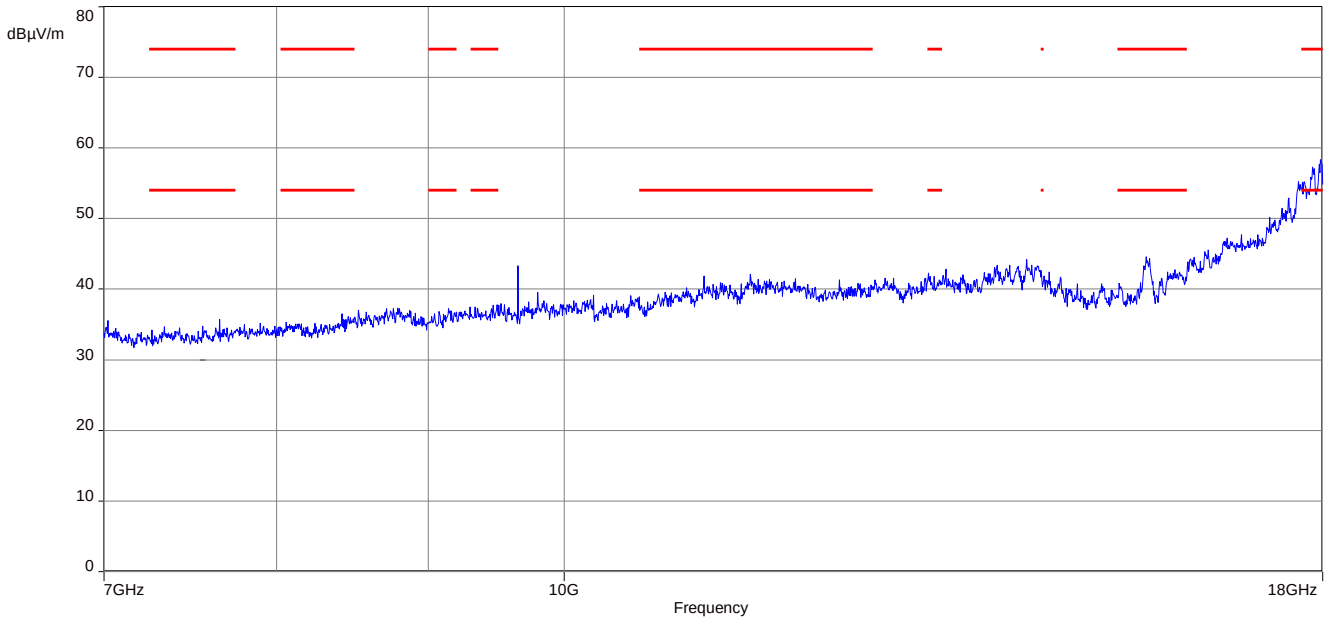
Plots: OFDM (20 MHz bandwidth)

Plot 1: Lowest channel, 1 GHz to 7 GHz, vertical & horizontal polarization

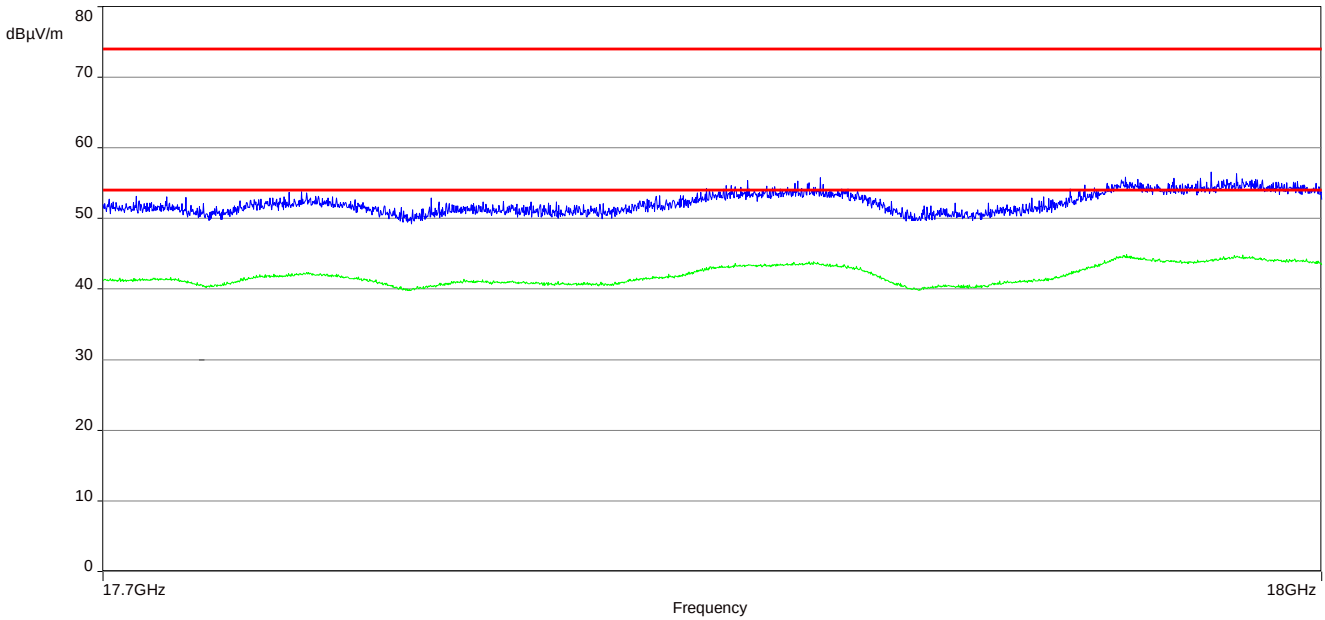


The carrier signal is notched with a 2.4 GHz band rejection filter.

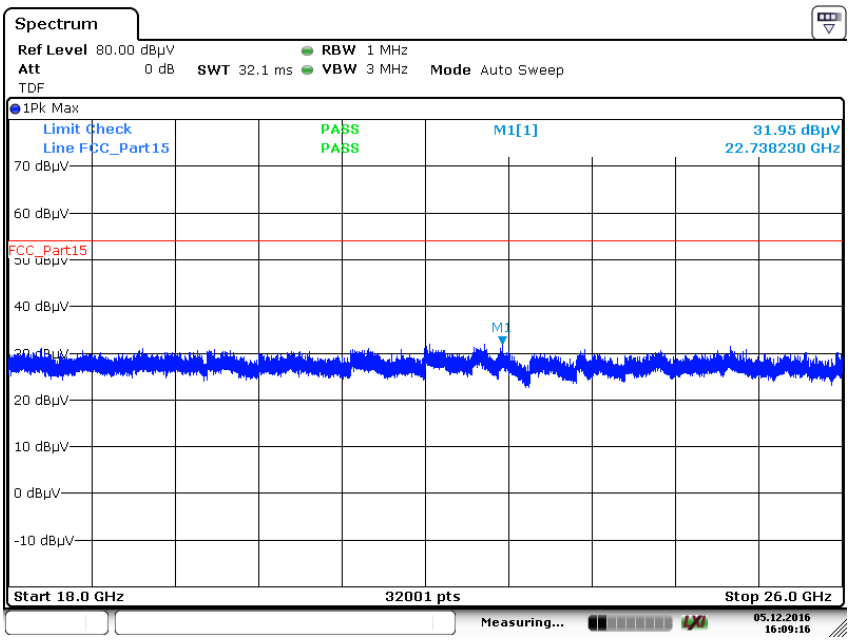
Plot 2: Lowest channel, 7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



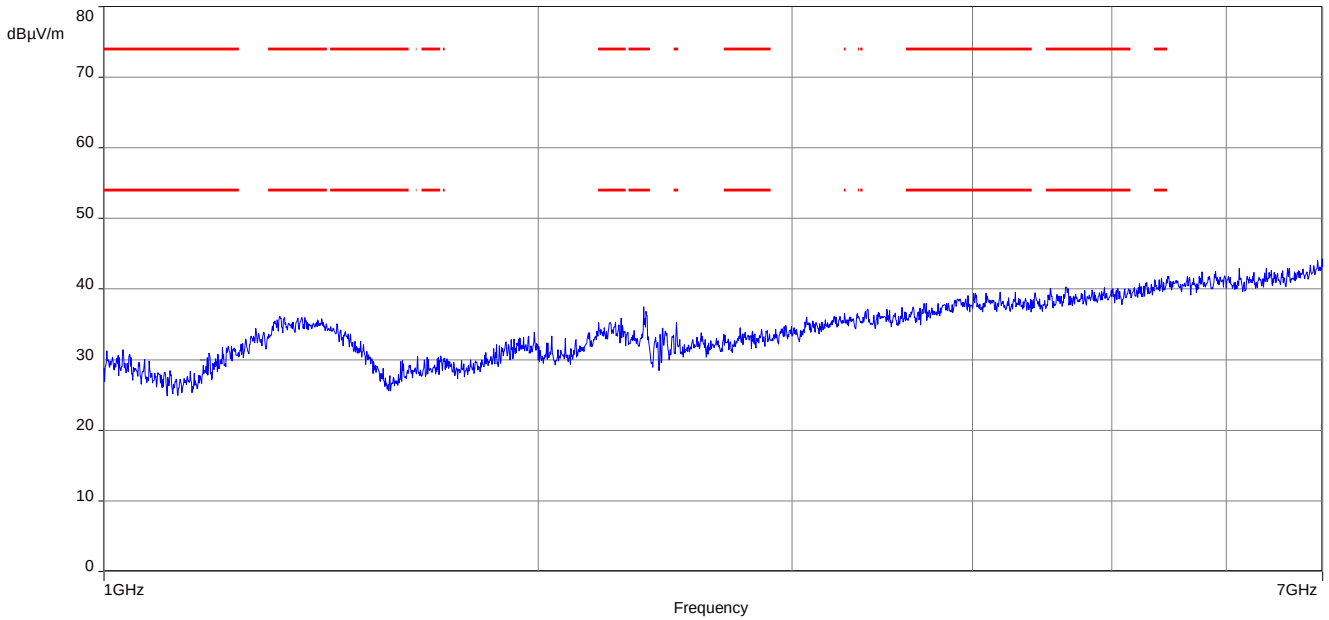
Plot 3: Lowest channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



Plot 4: Lowest channel, 18 GHz to 26 GHz, vertical & horizontal polarization

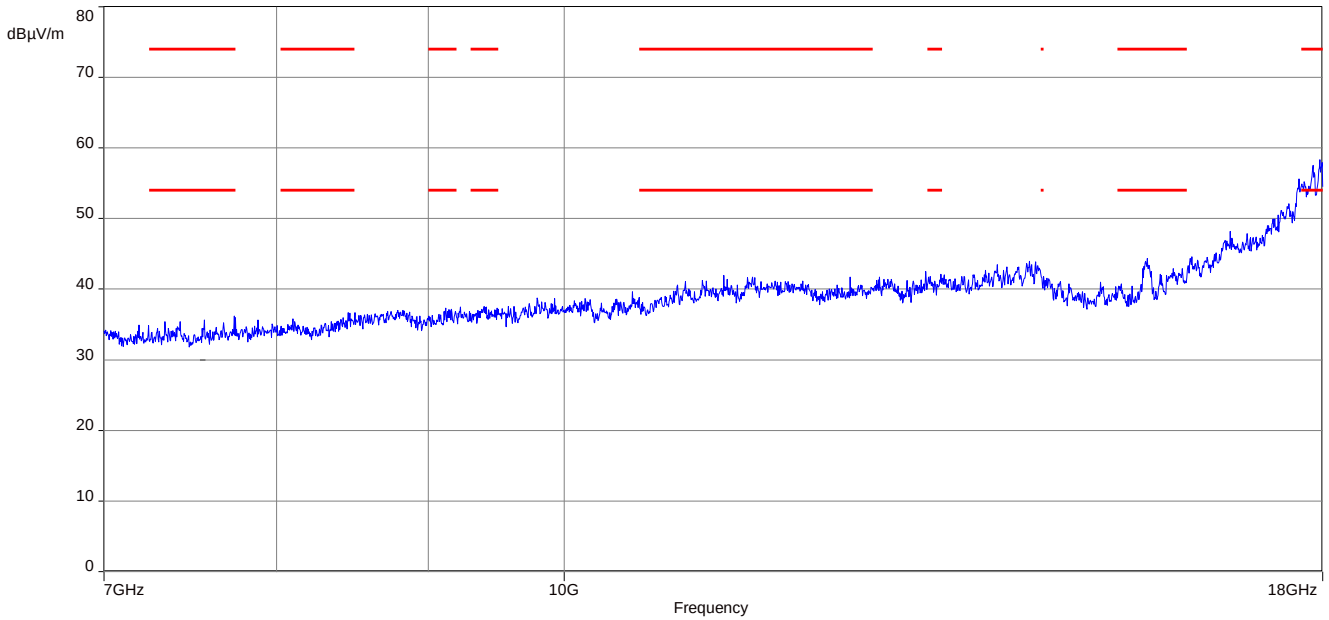


Plot 5: Middle channel, 1 GHz to 7 GHz, vertical & horizontal polarization

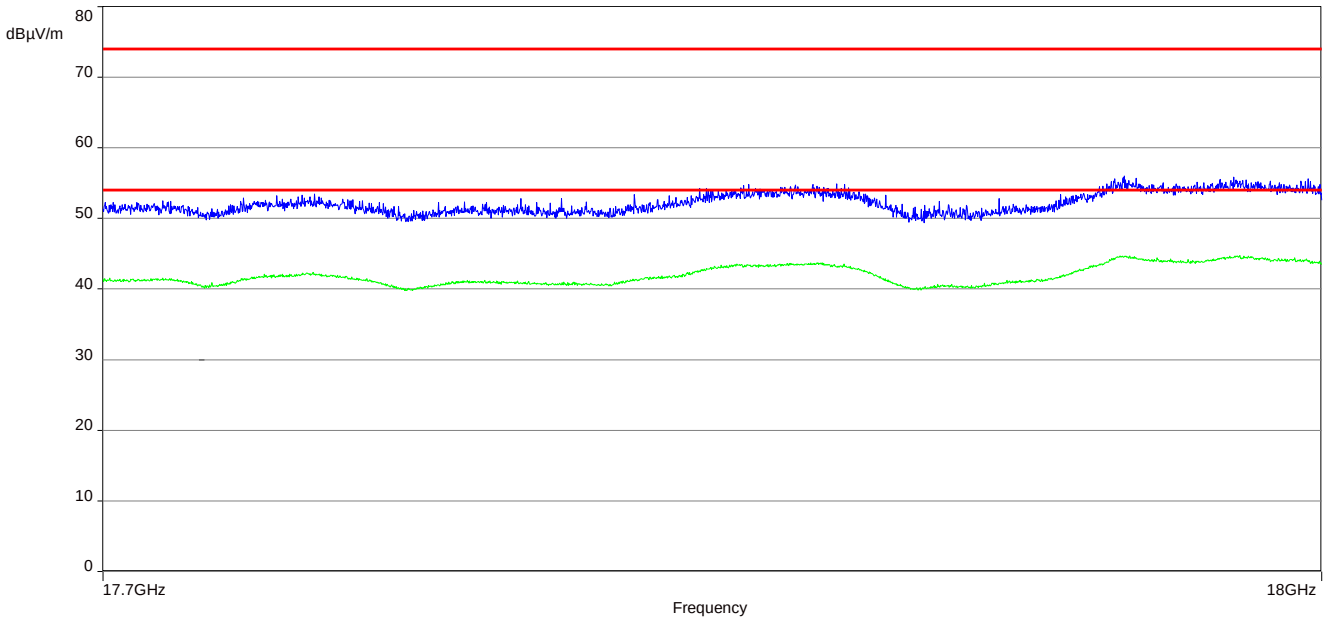


The carrier signal is notched with a 2.4 GHz band rejection filter.

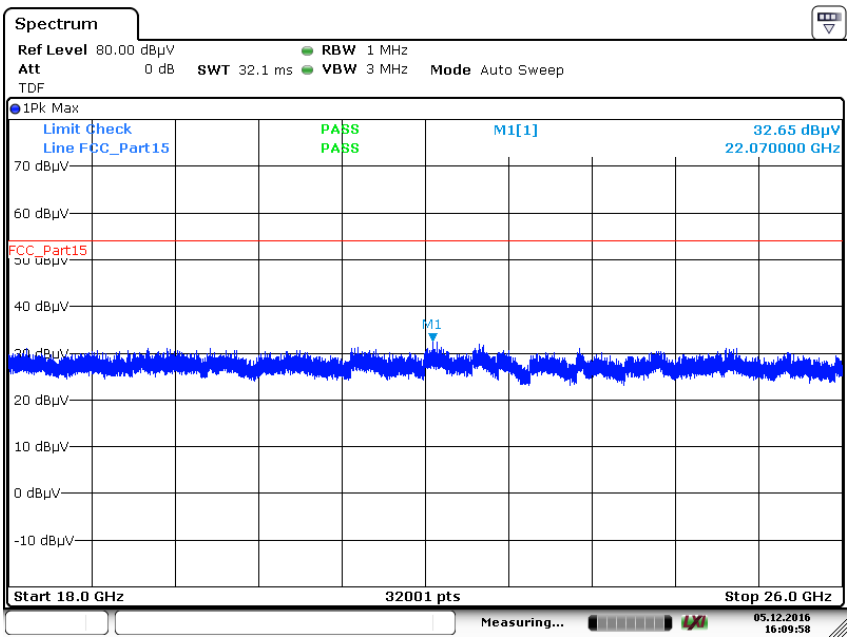
Plot 6: Middle channel, 7 GHz to 18 GHz, vertical & horizontal polarization



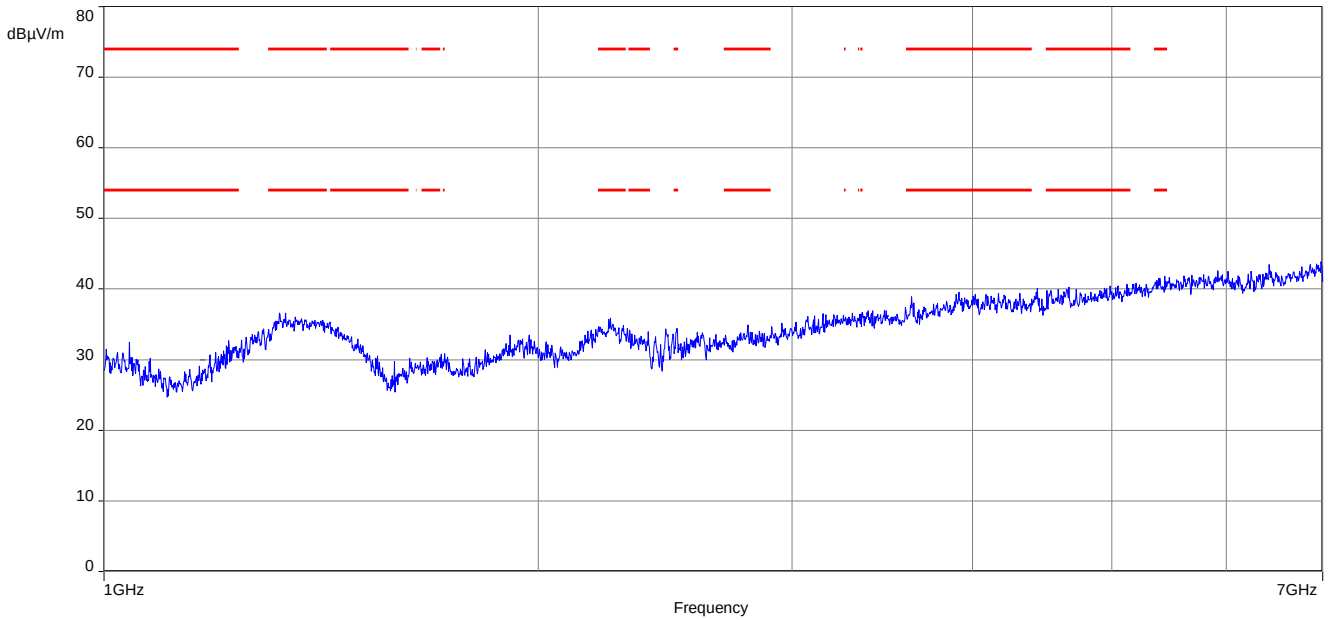
Plot 7: Middle channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average



Plot 8: Middle channel, 18 GHz to 26 GHz, vertical & horizontal polarization

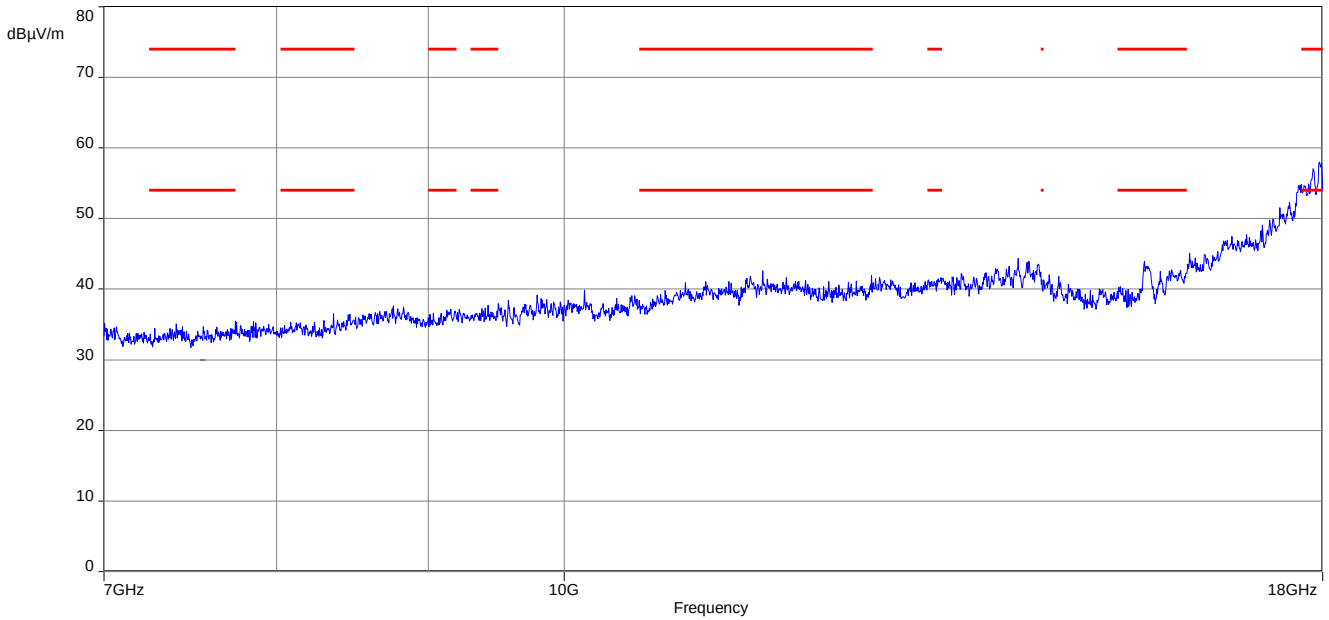


Plot 9: Highest channel, 1 GHz to 7 GHz, vertical & horizontal polarization

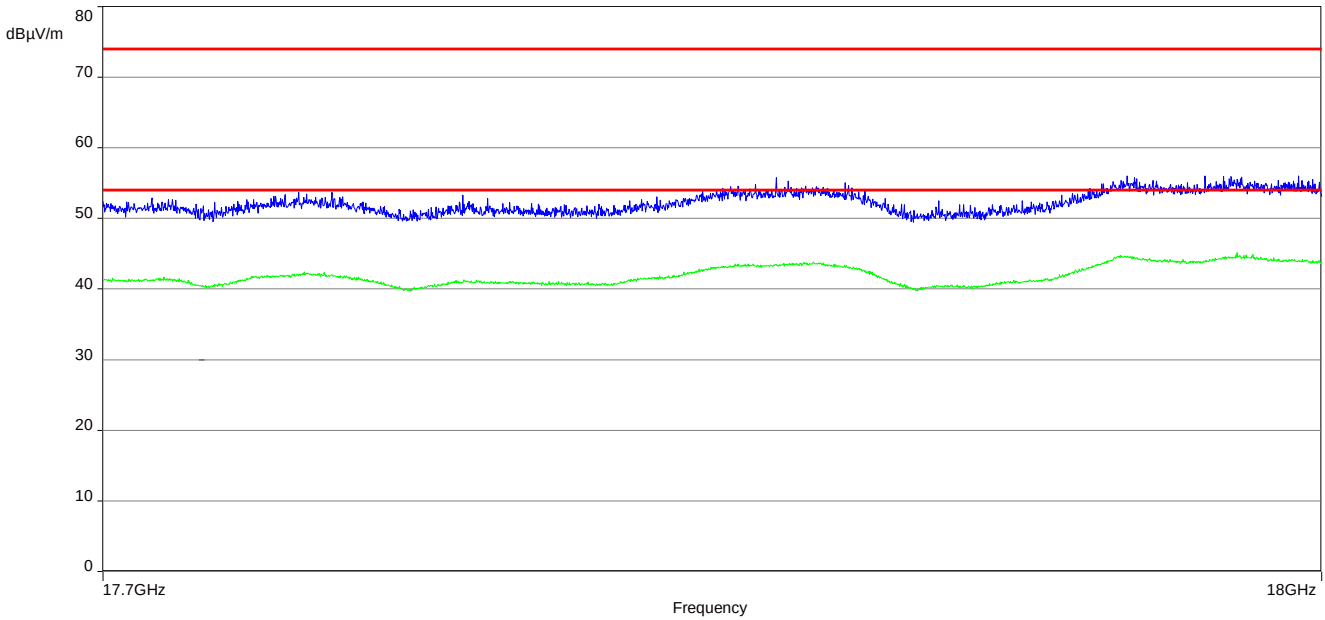


The carrier signal is notched with a 2.4 GHz band rejection filter.

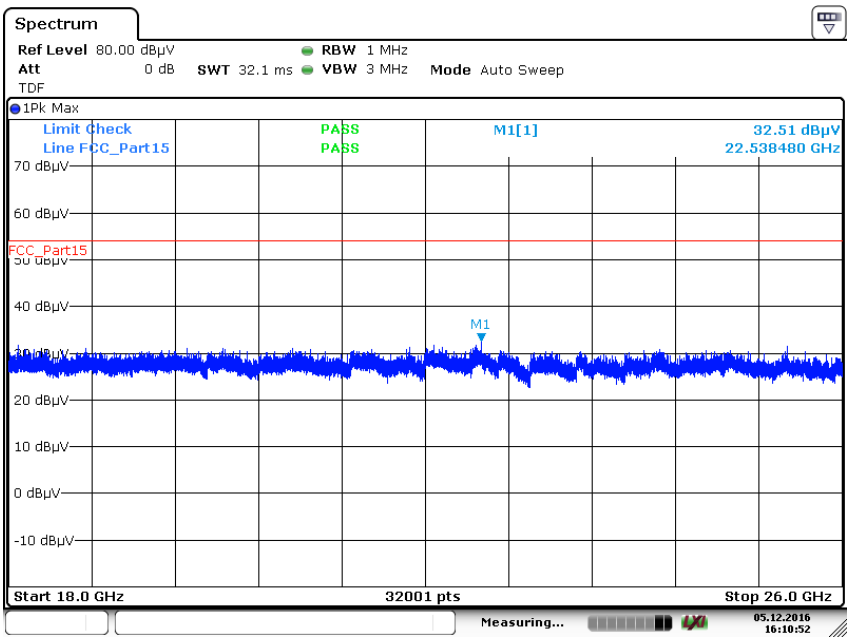
Plot 10: Highest channel, 7 GHz to 18 GHz, vertical & horizontal polarization



Plot 11: Highest channel, 17.7 GHz to 18 GHz, vertical & horizontal polarization, peak & average

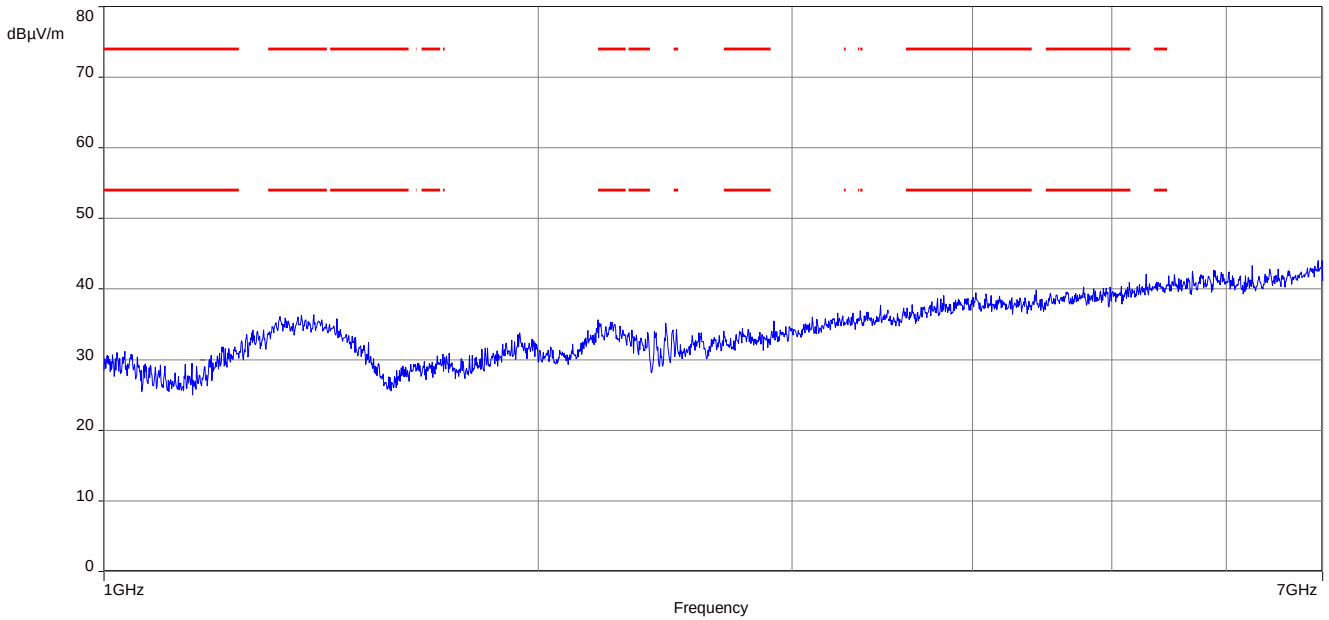


Plot 12: Highest channel, 18 GHz to 26 GHz, vertical & horizontal polarization

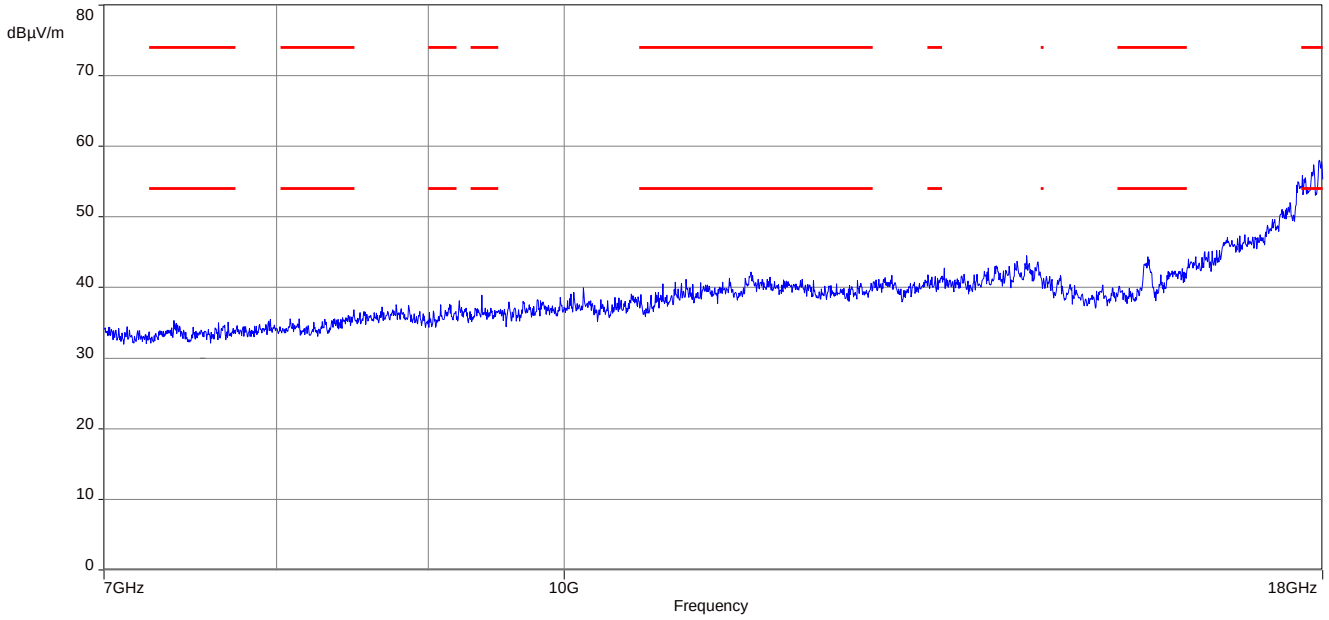


Plots: RX / idle mode

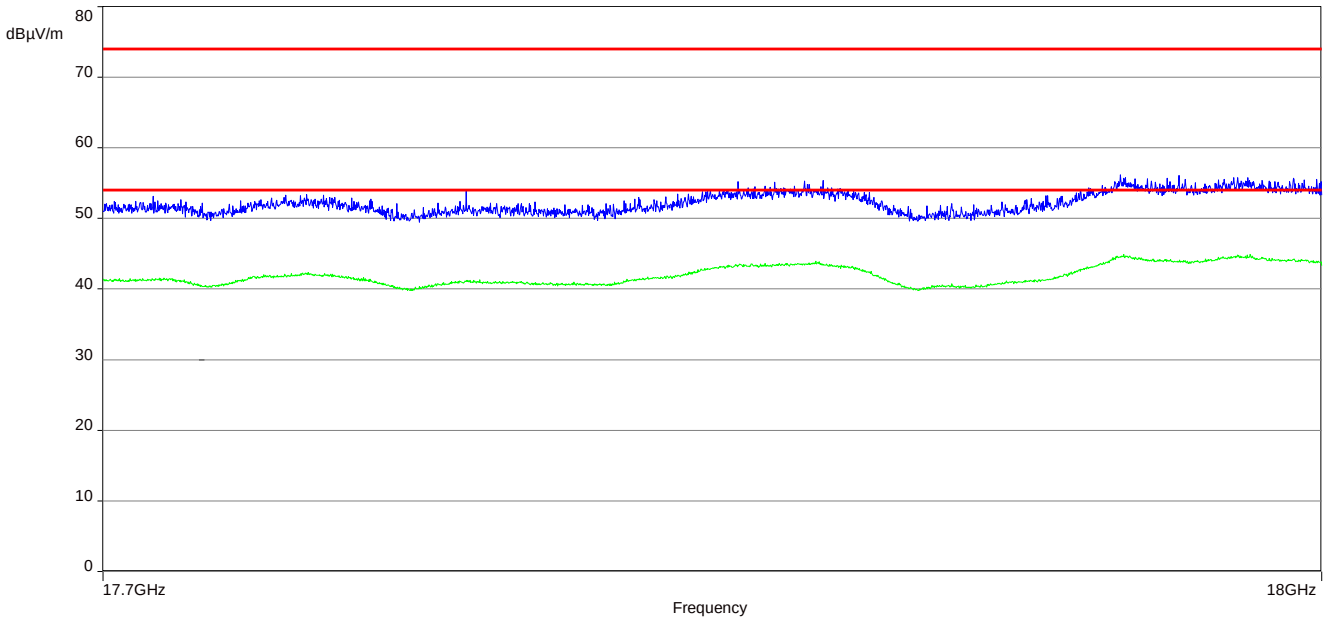
Plot 1: 1 GHz to 7 GHz, vertical & horizontal polarization



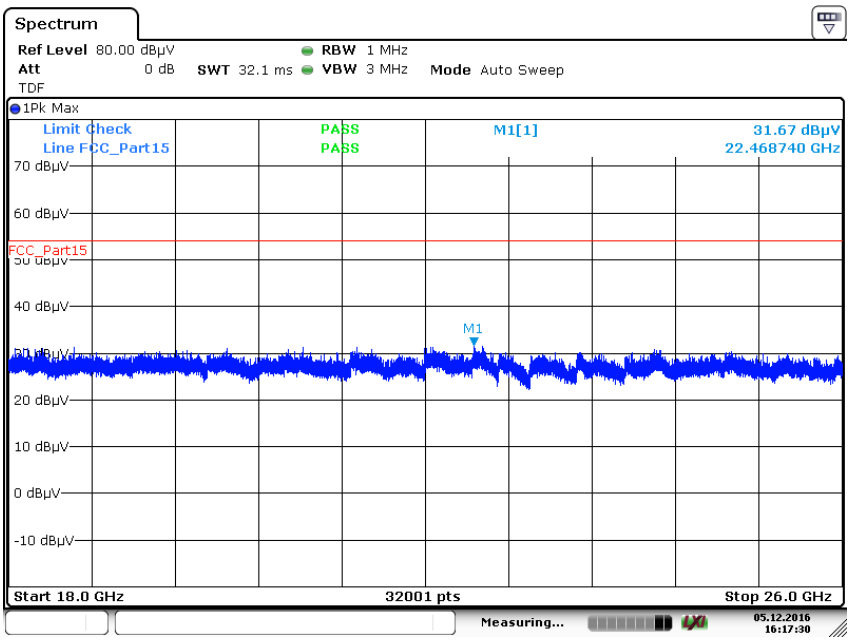
Plot 2: 7 GHz to 18 GHz, vertical & horizontal polarization



Plot 2: 17.7 GHz to 18 GHz, vertical & horizontal polarization



Plot 3: 18 GHz to 26 GHz, vertical & horizontal polarization



11.15 Spurious emissions conducted below 30 MHz (AC conducted)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The EUT is set to channel 6. This measurement is repeated for DSSS and OFDM modulation. If peaks are found channel 1 and channel 11 will be measured too. 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 re-measured with average and quasi peak detection to show compliance to the limits.

Measurement:

Measurement parameter	
Detector:	Peak - Quasi Peak / Average
Sweep time:	Auto
Resolution bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace mode:	Max Hold
Test setup:	See sub clause 6.5 - A
Measurement uncertainty:	See sub clause 8

Limits:

FCC		IC
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

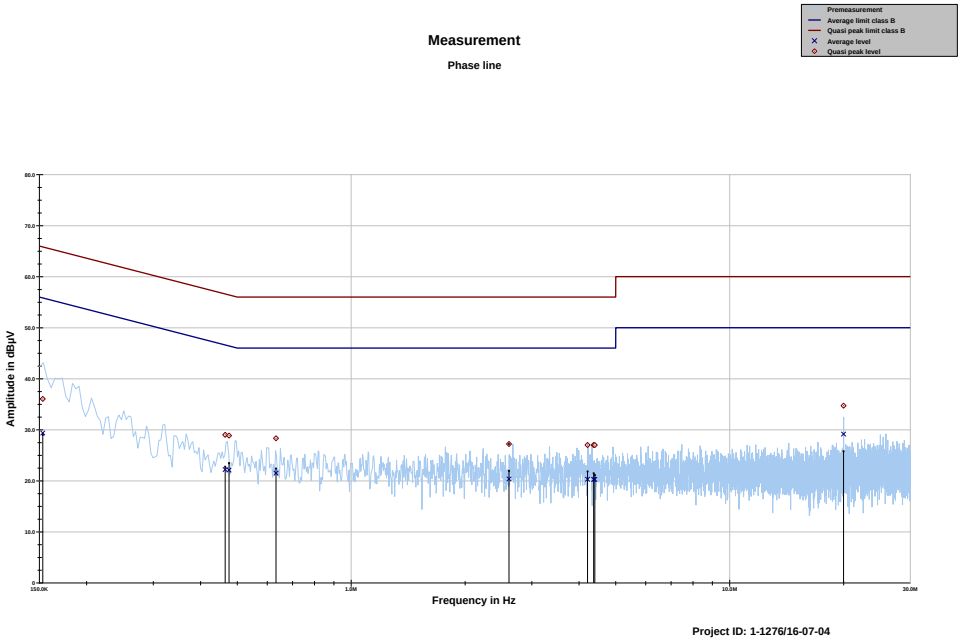
*Decreases with the logarithm of the frequency

Results:

TX Spurious Emissions Conducted < 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected peaks are more than 20 dB below the limit.		

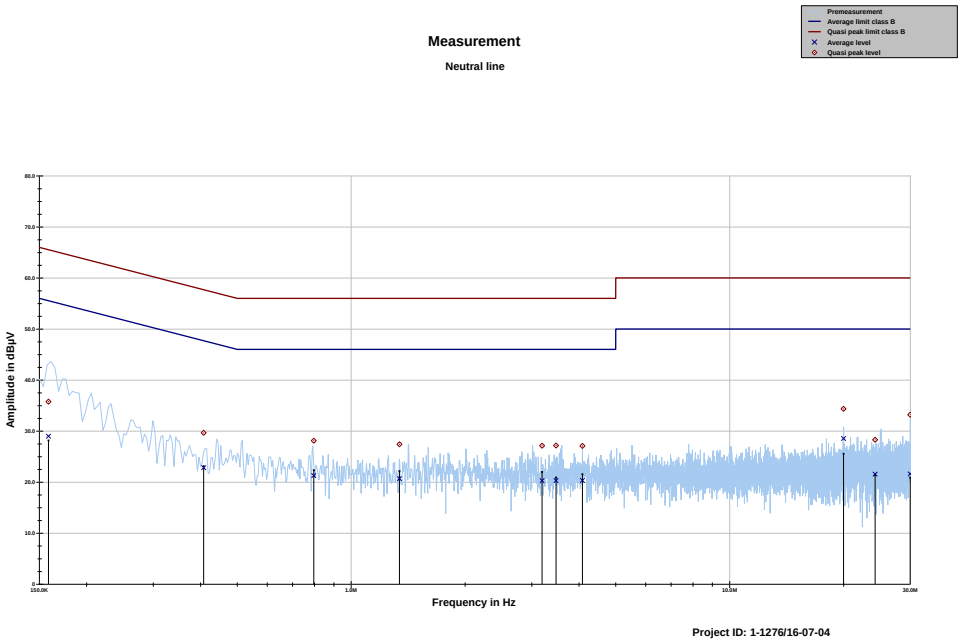
Plots:

Plot 1: 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
0.153221	36.05	29.77	65.824	29.37	26.54	55.908
0.464674	29.00	27.61	56.609	22.21	24.80	47.009
0.475686	28.86	27.56	56.414	22.10	24.60	46.695
0.633024	28.33	27.67	56.000	21.51	24.49	46.000
2.612268	27.21	28.79	56.000	20.38	25.62	46.000
4.212442	27.02	28.98	56.000	20.32	25.68	46.000
4.372908	27.02	28.98	56.000	20.27	25.73	46.000
4.404116	27.01	28.99	56.000	20.27	25.73	46.000
19.998050	34.72	25.28	60.000	29.15	20.85	50.000

Plot 2: 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
0.158598	35.76	29.77	65.537	28.99	26.76	55.754
0.407709	29.66	28.03	57.695	22.84	25.80	48.637
0.796422	28.11	27.89	56.000	21.27	24.73	46.000
1.341543	27.42	28.58	56.000	20.69	25.31	46.000
3.194609	27.13	28.87	56.000	20.29	25.71	46.000
3.478554	27.17	28.83	56.000	20.31	25.69	46.000
4.083421	27.11	28.89	56.000	20.32	25.68	46.000
19.997515	34.35	25.65	60.000	28.55	21.45	50.000
24.232431	28.30	31.70	60.000	21.57	28.43	50.000
29.998950	33.21	26.79	60.000	21.60	28.40	50.000

12 Observations

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

Annex A Document history

Version	Applied changes	Date of release
	Initial release	2017-01-12
-A	FCC ID change	2017-03-06

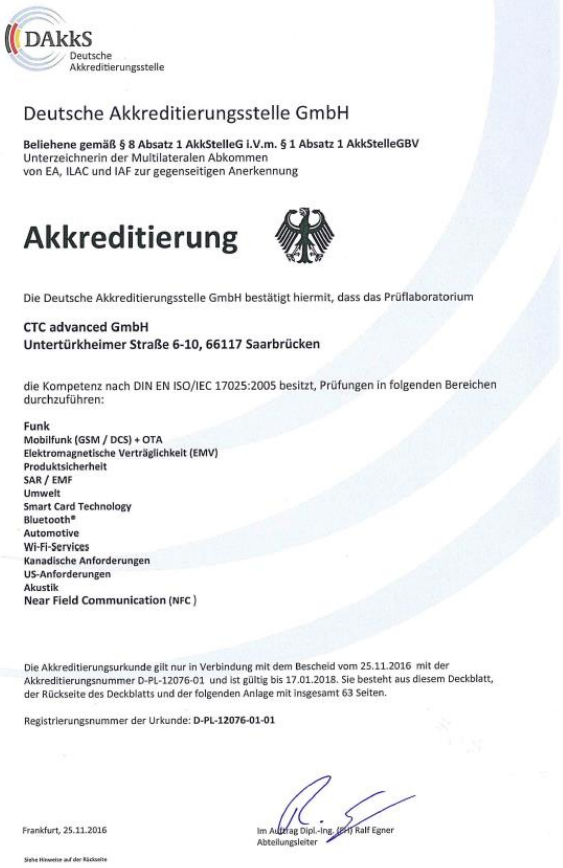
Annex B Further information

Glossary

AVG - Average
DUT - Device under test
EMC - Electromagnetic Compatibility
EN - European Standard
EUT - Equipment under test
ETSI - European Telecommunications Standard Institute
FCC - Federal Communication Commission
FCC ID - Company Identifier at FCC
HW - Hardware
IC - Industry Canada
Inv. No. - Inventory number
N/A - Not applicable
PP - Positive peak
QP - Quasi peak
S/N - Serial number
SW - Software
PMN - Product marketing name
HMN - Host marketing name
HVIN - Hardware version identification number
FVIN - Firmware version identification number
OBW Occupied Bandwidth
OC Operating Channel
OCW Operating Channel Bandwidth
OOB Out Of Band

Annex C Accreditation Certificate

first page



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Automotive
Wi-Fi-Services
Kanadische Anforderungen
US-Anforderungen
Akustik
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Frankfurt, 25.11.2016

Im Auftrag Dipl.-Ing. (FH) Ralf Egner
Abteilungsleiter

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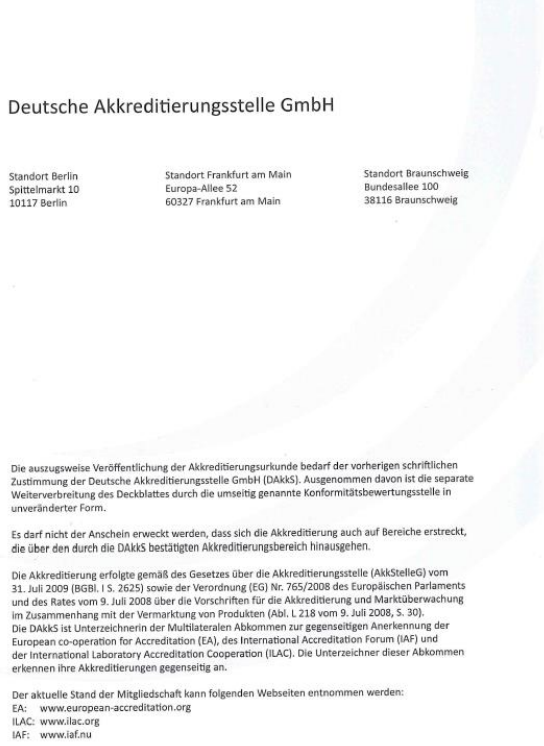

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