**CETECOM™****CETECOM ICT Services**
consulting - testing - certification >>>

TEST REPORT

Test report no.: 1-9837/15-01-05-C

Deutsche
Akkreditierungsstelle
D-PL-12076-01-01

Testing laboratory

CETECOM ICT Services GmbH

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Internet: <http://www.cetecom.com>e-mail: ict@cetecom.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-12076-01-01

Applicant

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Manufacturer

OÜ Eliko Tehnoloogia Arenduskeskus

Mäealuse 2/1 (3rd floor)

12618 Tallinn / ESTONIA

Test standard/s

Part 15F

Ultra-Wideband Operation

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

Test Item

Kind of test item: ToF real time positioner (UWB)**Model name:**

Anchor CS4, Kio Anchor C4, Kio Tag CS4, Kio Tag C4 and Kio Tag B4

FCC ID:

2AF2IKIO4

Frequency:

3.3 GHz – 4.45 GHz

Technology tested:

UWB

Antenna:

Integrated antenna

Power supply:

5 V DC by power supply, USB or battery

Temperature range:

-10°C to +55°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:

Karsten Gerald
Lab Manager
Radio Communications & EMC

Test performed:

Benedikt Gerber
Testing Manager
Radio Communications & EMC

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2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CETECOM ICT Services 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 1-9837/15-01-05-B and dated 2016-05-24.

2.2 Application details

Date of receipt of order:	2015-07-08
Date of receipt of test item:	2015-07-28
Start of test:	2015-09-28
End of test:	2016-06-28
Person(s) present during the test:	Arthur Randjärv

3 Test standard/s

Test standard	Date	Test standard description
Part 15F	2012/10	Ultra-Wideband Operation

4 Test environment

Temperature :	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests -/- °C during high temperature tests -/- °C during low temperature tests
Relative humidity content :		55 %
Barometric pressure :		not relevant for this kind of testing
Power supply :	V_{nom} V_{max} V_{min}	5.0 V DC by power supply -/- V -/- V

5 Test item

5.1 General description

Kind of test item :	ToF real time positioner (UWB)
Type identification :	Anchor CS4, Kio Anchor C4, Kio Tag CS4, Kio Tag C4 and Kio Tag B4
S/N serial number :	Radiated test samples: 0xEE85000000004003 (CH4), 0xEE8500000000407B (CH2), 0xEE85000000004038 (CH2, retest, 26.06.2016) 0xEE8500000000409B (CH4, retest, 26.06.2016)
HW hardware status :	E06501204
SW software status :	003r
Frequency band :	3.3 GHz – 4.45 GHz
Type of radio transmission :	UWB
Use of frequency spectrum :	
Type of modulation :	BPSK/BPM
Number of channels :	2 channels tested
Antenna :	Integrated antenna
Power supply :	5 V DC by power supply, USB or battery
Temperature range :	-10°C to +55°C

5.2 Operating conditions

A special test software with a worst case duty cycle is used.

The DUTs tested with this software shall represent a worst case scenario for the KIO product family (see ch. 5.1, Type identification).

The following channels and software settings are tested:

- Ch2, 850 kbps, 1 ms preamble, power setting in firmware: 6e
- Ch2, 110 kbps, 1 ms preamble, power setting in firmware: 6d
- Ch4, 850 kbps, 1 ms preamble, power setting in firmware: 8e
- Ch4, 110 kbps, 1 ms preamble, power setting in firmware: 8d

5.3 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: 1-9837/15-01-05_AnnexC
1-9837/15-01-05_AnnexF
1-9837/15-01-05_AnnexG

Photos of the Kio product family provided by manufacturer are included in test report 1-9837/15-01-05_AnnexH

6 Test laboratories sub-contracted

None

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

7.3 Sequence of testing radiated spurious 1 GHz to 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 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).

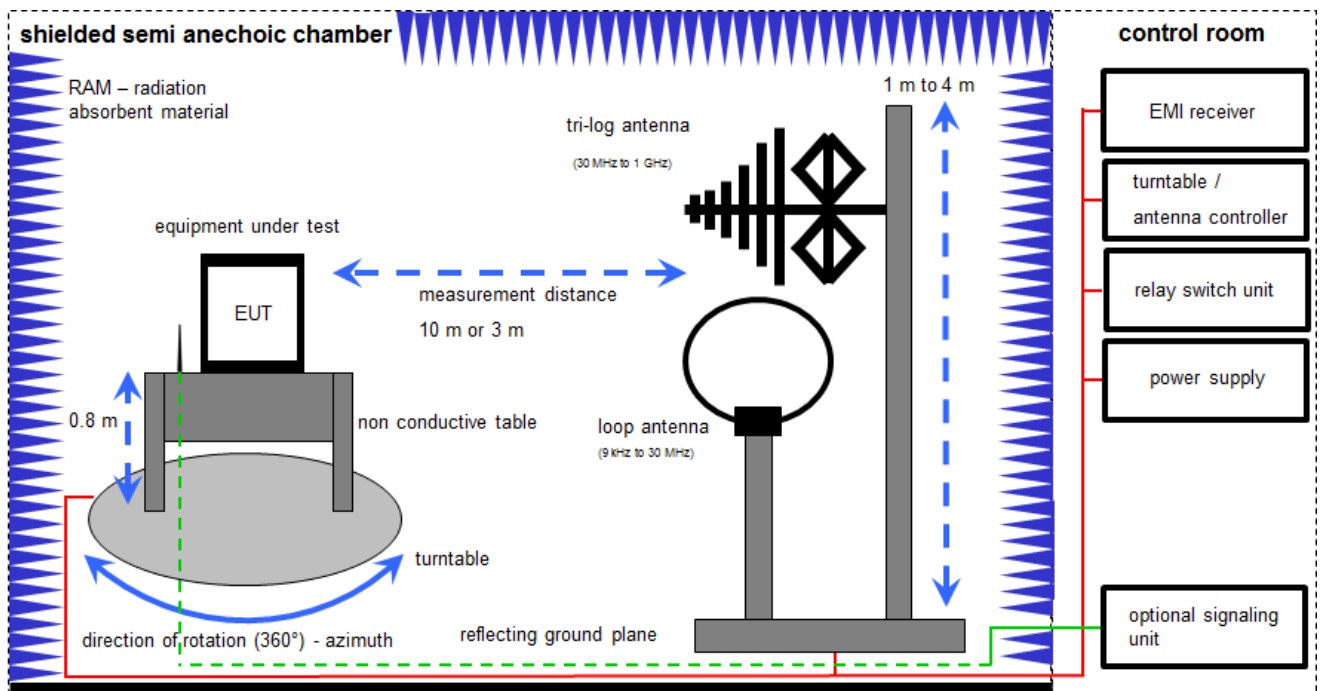
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
v/k!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

8.1 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 C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices. 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. 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.



$$FS = UR + CL + AF$$

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

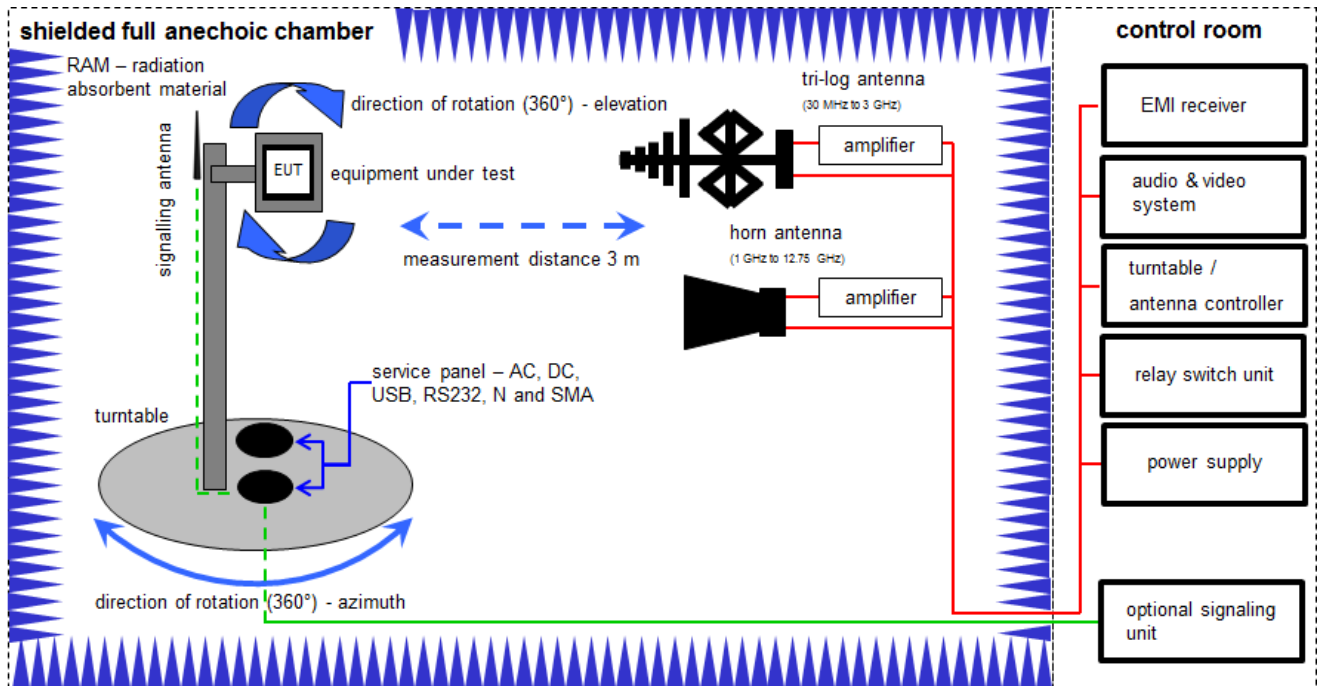
Example calculation:

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	45	Switch-Unit	3488A	HP	2719A14505	300000368	ev		
2	50	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne		
3	n. a.	software	SPS_PHE 1.4f	Spitzenberger & Spiess	B5981; 5D1081;B5979	300000210	ne		
4	n. a.	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	26.01.2015	26.01.2016
5	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	Ve	11.02.2014	11.02.2016
6	n. a.	Amplifier	JS42-00502650-28-5A	MITEQ	1084532	300003379	ev		
7	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw		
8	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw		
9	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw		
10	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	22.04.2014	22.04.2016
11	n. a.	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	26.01.2015	26.01.2016
12		EMV-Software	EMC32	R&S	9.15	300004788	ne		

8.2 Shielded fully anechoic chamber



$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;
G-antenna gain+amplifier gain; CA-loss signal path)

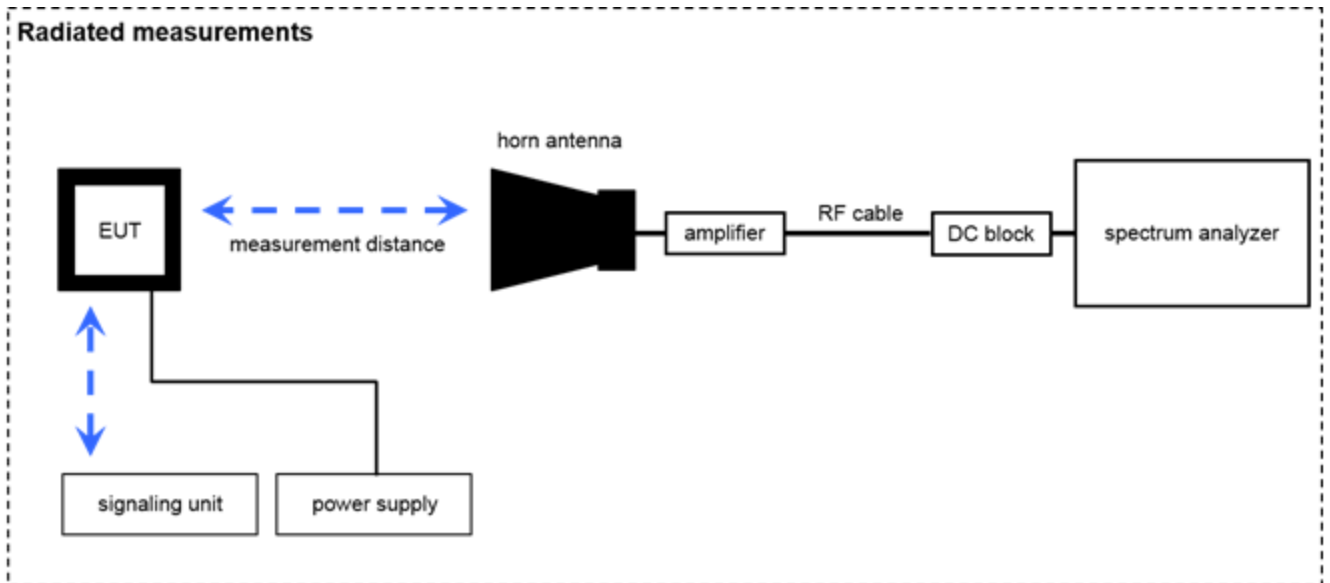
Example calculation:

$$OP \text{ [dBm]} = -65.0 \text{ [dBm]} + 50 \text{ [dB]} - 20 \text{ [dBi]} + 5 \text{ [dB]} = -30 \text{ [dBm]} \text{ (1 } \mu\text{W)}$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Ultra Stable Notch Filter	WRCD1887.82/1889.55-5EE	Wainwright	1	300000115	ne		
2	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	22.01.2015	22.01.2016
3	n. a.	Tunable Band Reject (FDD I)	WRCT1850/2170-5/40-10EEK	Wainwright	7	300003386	ne		
4	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne		
5	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	318	300003696	k	22.04.2014	22.04.2017
6	n. a.	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	26.01.2015	26.01.2016
7	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22050	300004482	ev		
8	n. a.	Broadband Amplifier 5-13 GHz	CBLU5135235	CERNEX	22011	300004492	ev		
9	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000032	300004510	ne		
10	n. a.	Messrechner und Monitor	Intel Core i3 3220/3,3 GHz, Prozessor	Agilent Technologies	2V2403033A5421	300004591	ne		
11	n. a.	NEXIO EMV-Software	BAT EMC	EMCO	2V2403033A5421	300004682	ne		

8.3 Radiated measurements > 18 GHz



$$FS = UR + CA + AF$$

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

Example calculation:

$$FS [dB\mu V/m] = 40.0 [dB\mu V/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dB\mu V/m] (6.79 \mu V/m)$$

$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

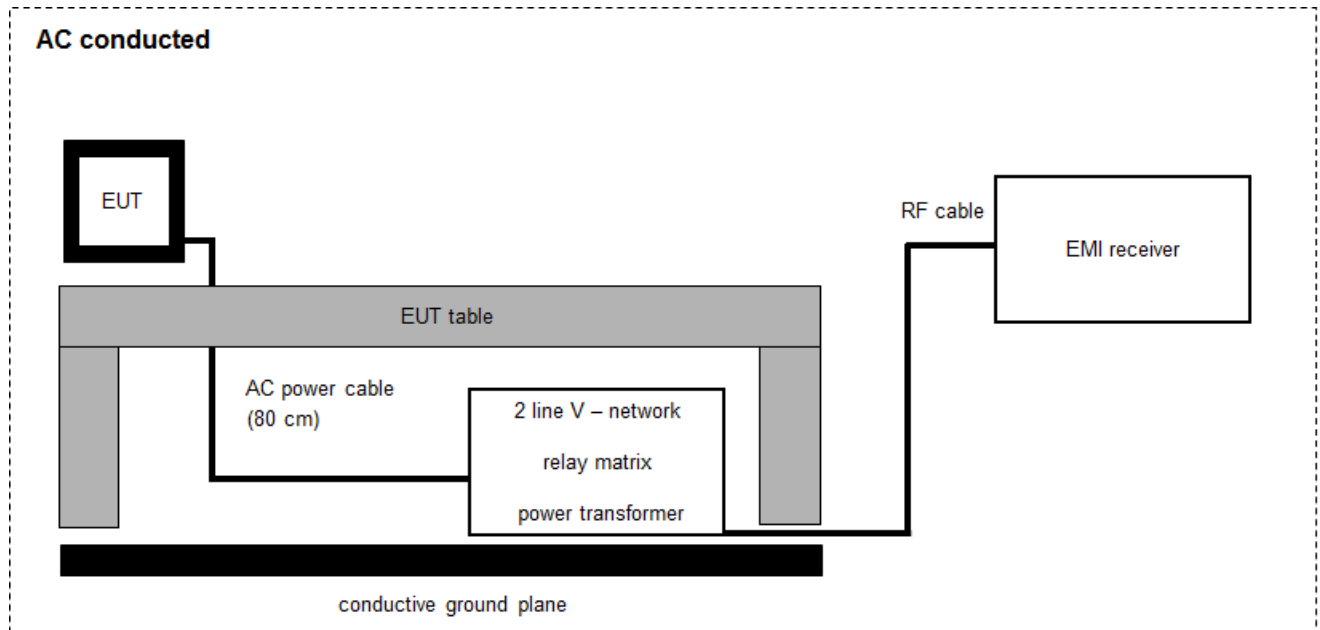
Example calculation:

$$OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 \mu W)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	CR 79	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	7911	300001751	ne		
2	11b	Microwave System Amplifier, 0.5-26.5 GHz	83017A	HP	00419	300002268	ev		
3		Microwave System Amplifier, 0.1-26.5 GHz	83006A	HP	00499	300000211	ev		
4	C101	Cable SMA	ST18/SMAm/SMAm/72	Huber&Suhner	Order:84004007 Batch:699714		ev		
5	C2019	Cable K-Type	KPS-1533-390-KPS	Insulated Wire Inc	101995	300002288	ev		
6	A026	Std. Gain Horn Antenna 12.4 to 18.0 GHz	639	Narda	8402	300000787	NK!		
7	A029	Std. Gain Horn Antenna 18.0 to 26.5 GHz	638	Narda	8205	300002442	NK!		
8	A029	Power Supply	LA30/5GA	Zentro	2046	300000711	NK!		
9	A037	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3089	300000307	Ve	02.10.2014	02.10.2016
10	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev		

8.4 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:

$$FS [dB\mu V/m] = 37.62 [dB\mu V/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dB\mu V/m] (244.06 \mu V/m)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No Cetecom	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	Netznachbildung	ESH3-Z5	R&S	892475/017	300002209	k	17.06.2014	17.06.2016
2	68	EMI-Receiver	8542E	HP	3617A00170	300000568	k	28.01.2015	28.01.2016
3	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	Ve	11.02.2014	11.02.2016
4		EMV-Software	TILE!	ETS Lindgren	7.1.3.3		ne		

9 Summary of measurement results

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

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	CFR Part 15	see table	2016-06-30	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Pass	Fail	NA	NP	Remark
§15.503(d)	UWB Bandwidth (10dB Bandwidth)	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complies
§15.517(c)(e)(d) §15.209	TX Radiated Emissions	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complies
§15.109	RX Radiated Emissions	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complies

Note: NA = Not Applicable; NP = Not Performed

10 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: None

Test mode: ☐ No test mode available.

☒ Special software is used.
EUT is in a continuous transmission mode

11 Measurement results

11.1 UWB Bandwidth

Description:

§15.503 (a): For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as abased on complete transmission system including antenna.

Measurement:

Measurement parameter	
Detector:	RMS
Sweep time:	1 s
Video bandwidth:	1 MHz
Resolution bandwidth:	3 MHz
Span:	1.9 GHz / 200 MHz
Trace-Mode:	Max Hold

Test Setup: 7.3

Limits:

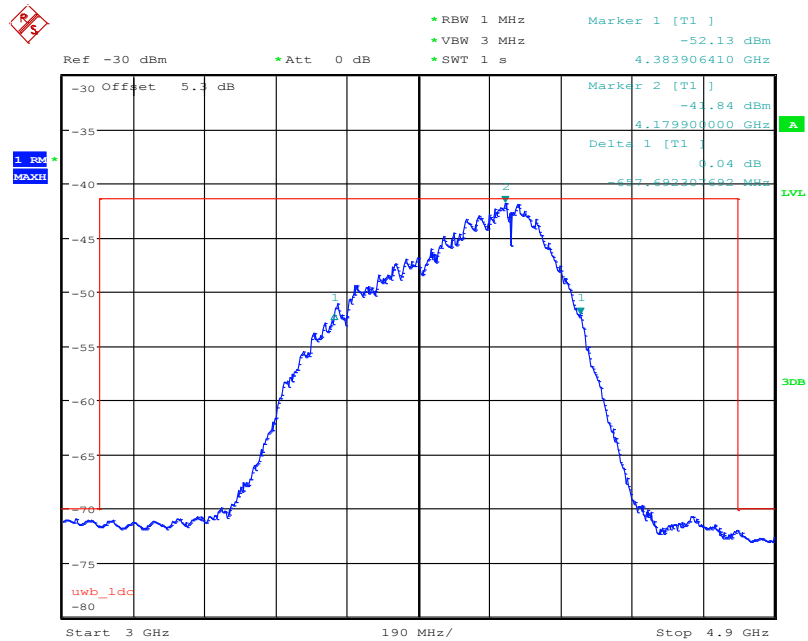
§15.503 (d): *Ultra-wideband (UWB) transmitter*. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

Results:

Channel	Lower -10 dB point [GHz]	Higher -10 dB point [GHz]	UWB bandwidth [MHz]
CH2 850 kbps	3.72622	4.38391	657.69
CH2 110 kbps	3.76969	4.36264	592.95
CH4 850 kbps	3.30495	4.13620	831.25
CH4 110 kbps	3.57397	4.44785	873.88

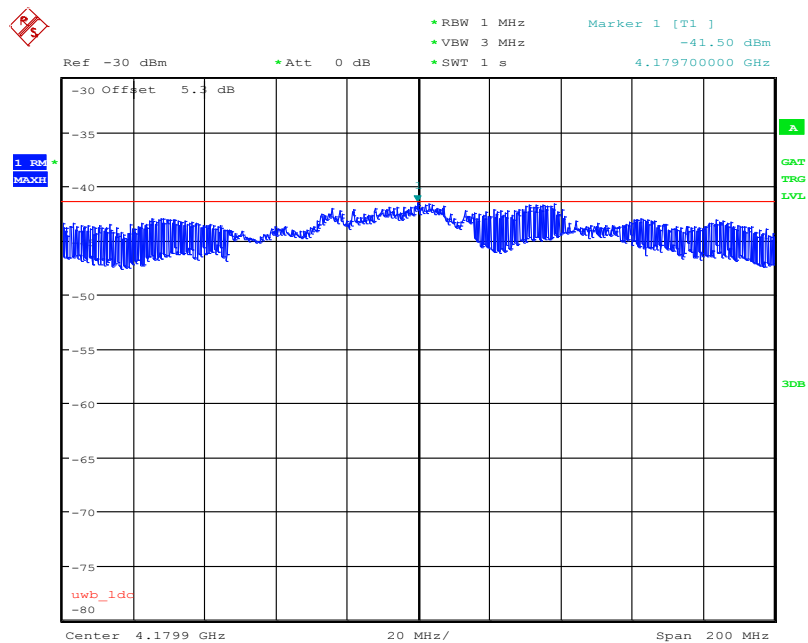
Verdict: Compliant

Plot 1: CH2 850 kbps, 3 GHz – 4.9 GHz, MAX EIRP, UWB Bandwidth



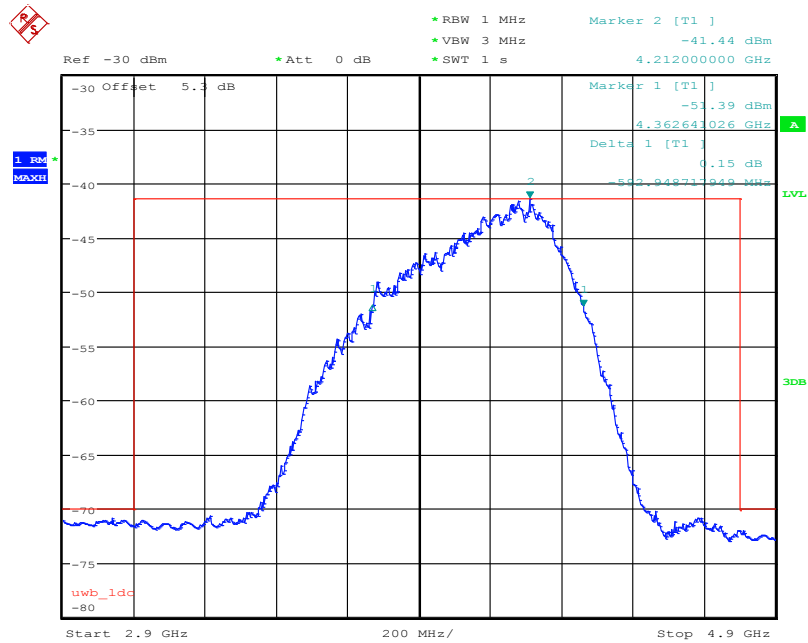
Date: 26.JAN.2015 12:45:28

Plot 2: CH2 850 kbps, MAX EIRP



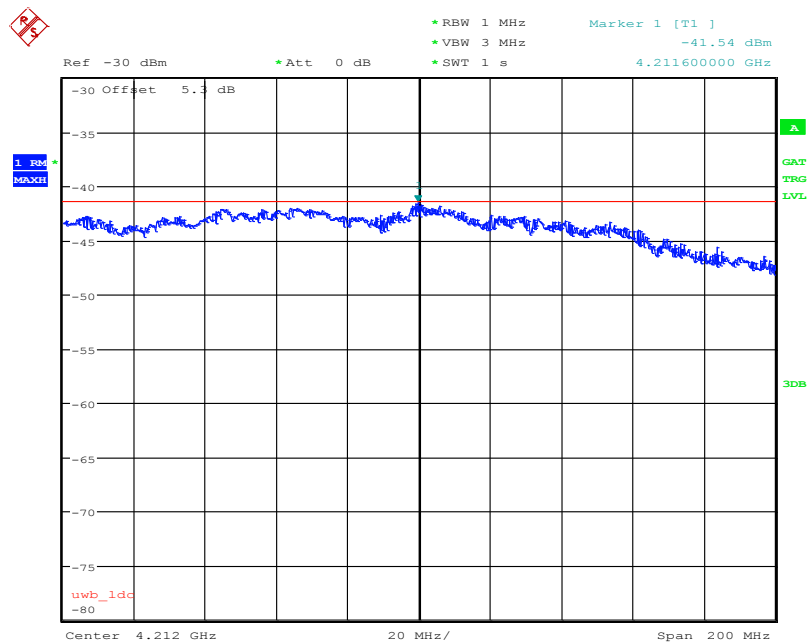
Date: 26.JAN.2015 12:47:57

Plot 3: CH2 110 kbps, 3 GHz – 4.9 GHz, MAX EIRP, UWB Bandwidth



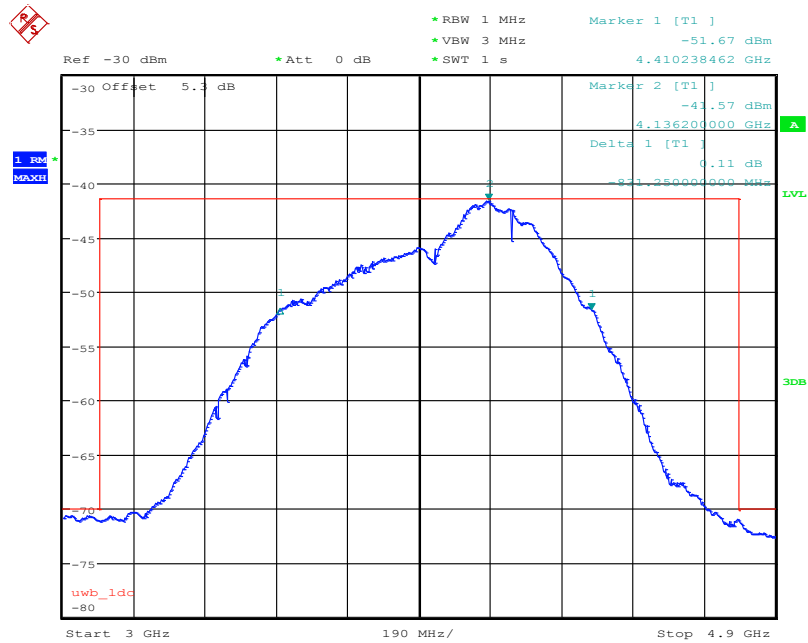
Date: 26.JAN.2015 12:35:03

Plot 4: CH2 110 kbps, MAX EIRP



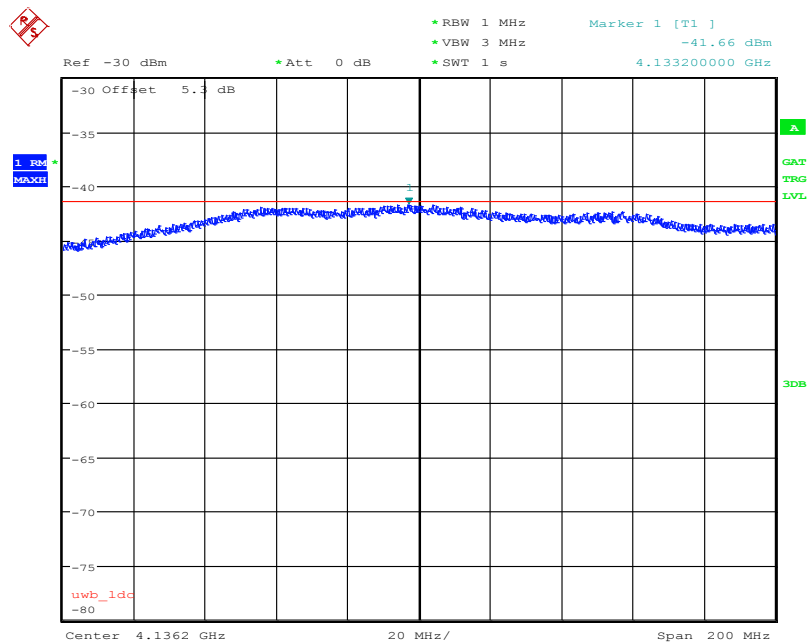
Date: 26.JAN.2015 12:36:46

Plot 5: CH4 850 kbps, 3 GHz – 4.9 GHz, MAX EIRP, UWB Bandwidth



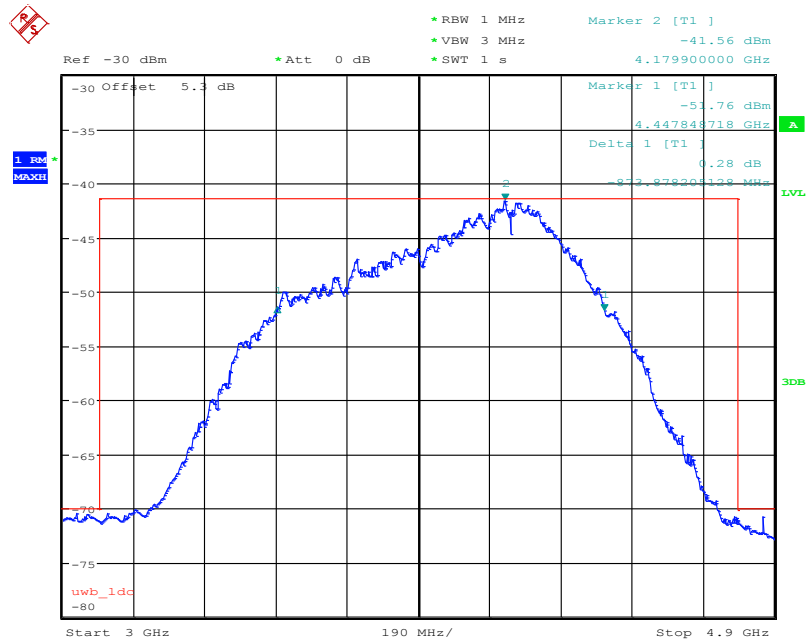
Date: 28.JAN.2015 09:18:12

Plot 6: CH4 850 kbps, MAX EIRP



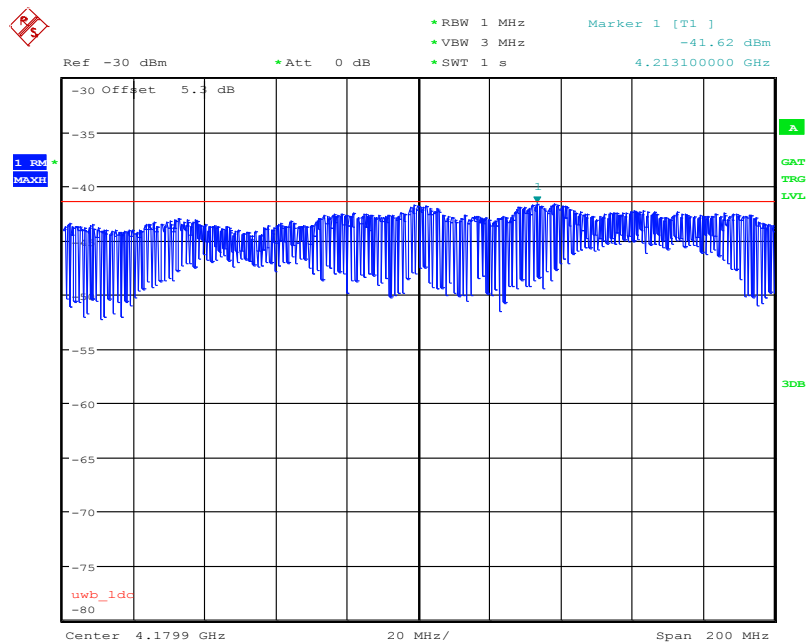
Date: 28.JAN.2015 09:20:43

Plot 7: CH4 110 kbps, 3 GHz – 4.9 GHz, MAX EIRP, UWB Bandwidth



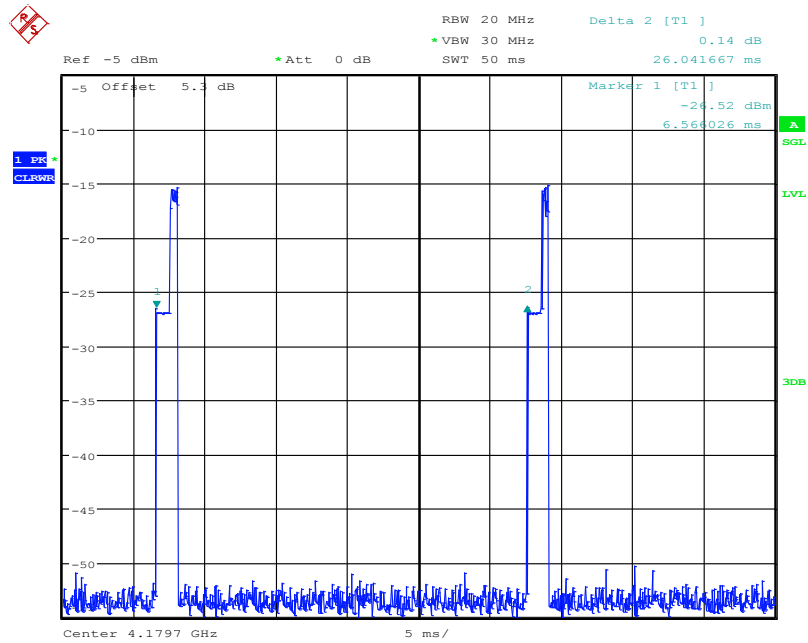
Date: 26.JAN.2015 11:40:34

Plot 8: CH4 110 kbps, MAX EIRP



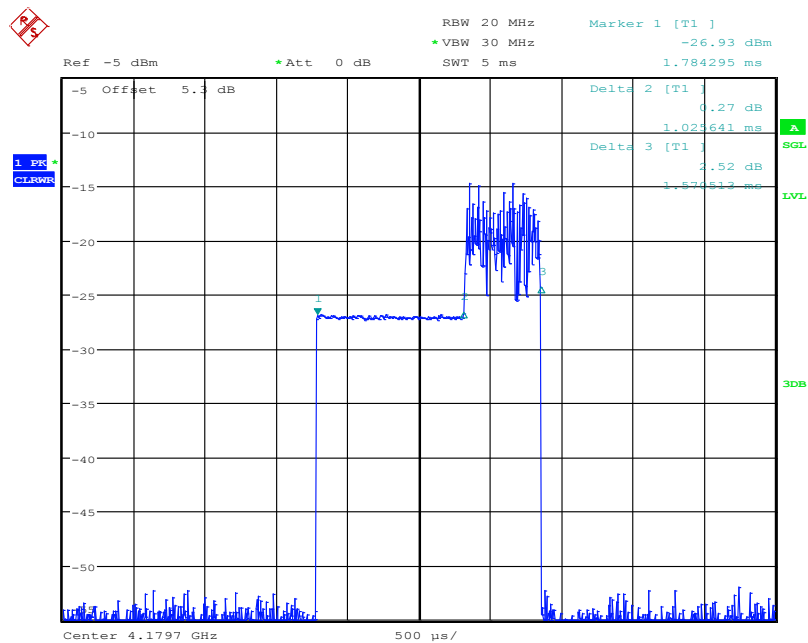
Date: 26.JAN.2015 11:45:04

Plot 9: CH2 850 kbps, Zerospan1



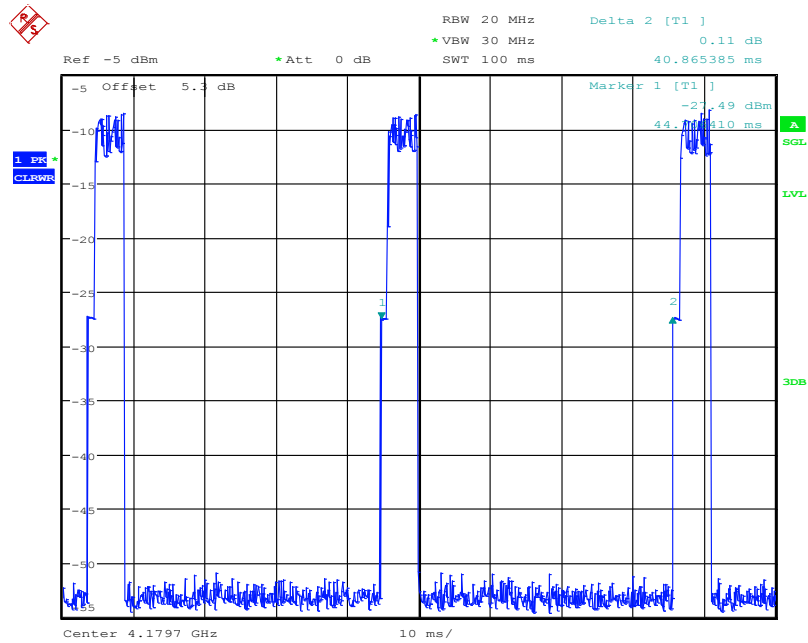
Date: 26.JAN.2015 12:52:09

Plot 10: CH2 850 kbps, Zerospan2



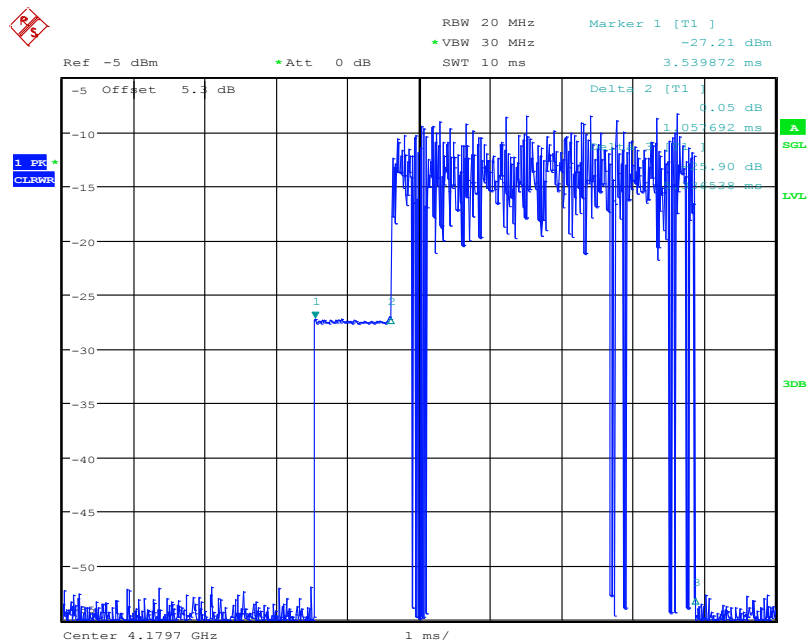
Date: 26.JAN.2015 12:53:15

Plot 11: CH2 110 kbps, Zerospan1



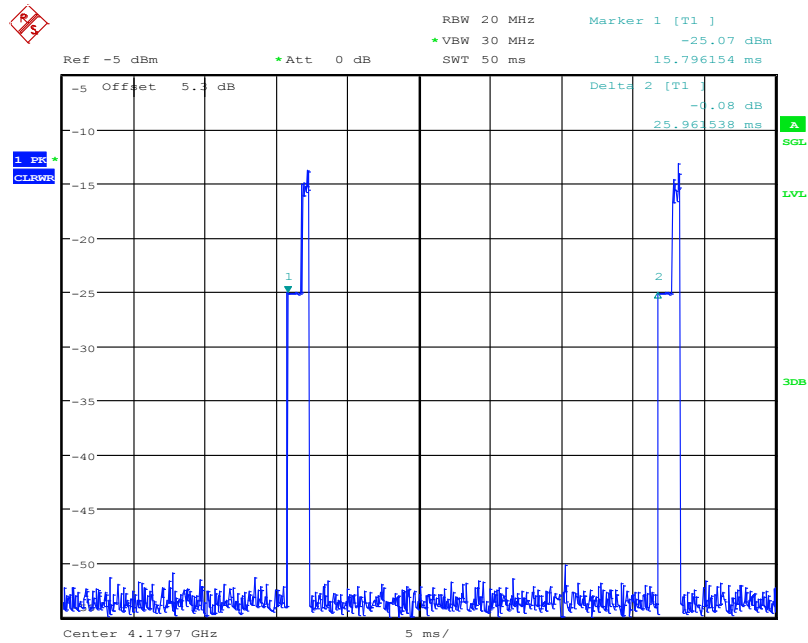
Date: 26.JAN.2015 12:58:52

Plot 12: CH2 110 kbps, Zerospan2



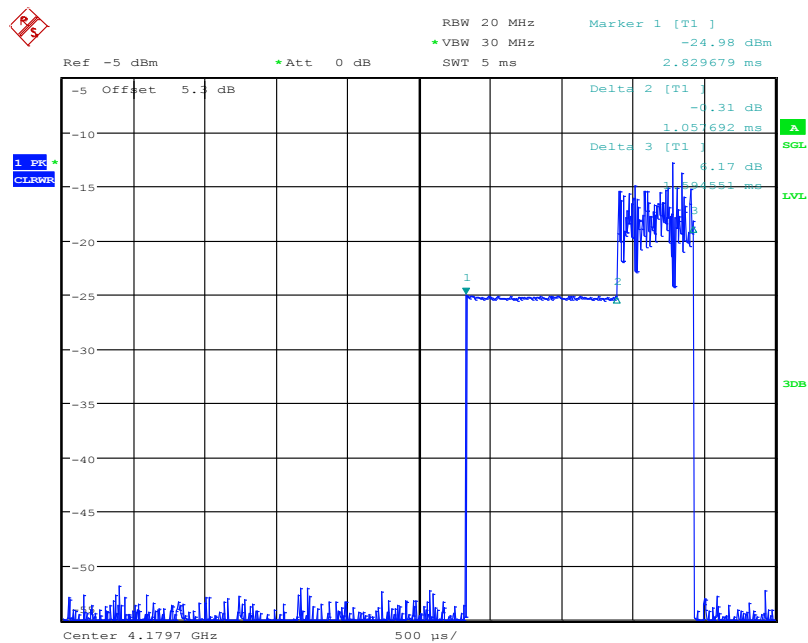
Date: 26.JAN.2015 12:59:56

Plot 13: CH4 850 kbps, Zerospan1



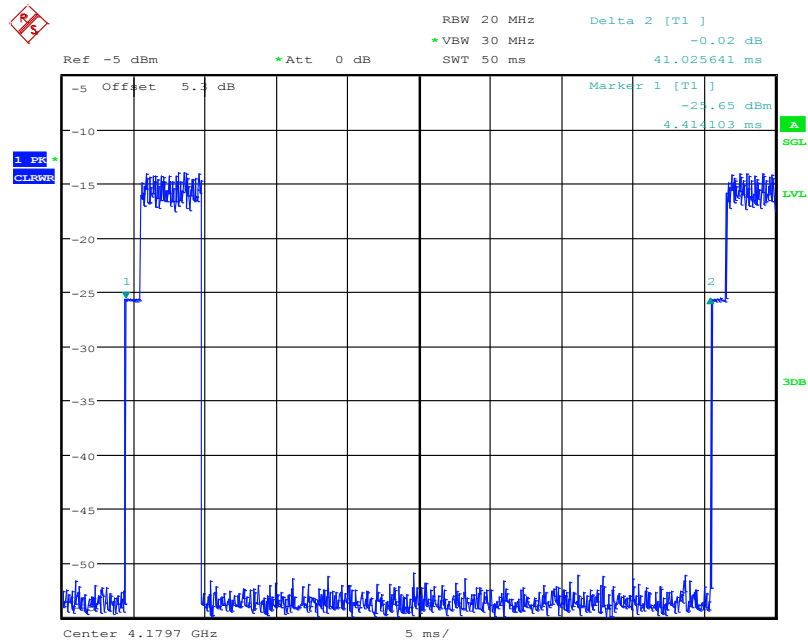
Date: 26.JAN.2015 13:15:40

Plot 14: CH4 850 kbps, Zerospan2



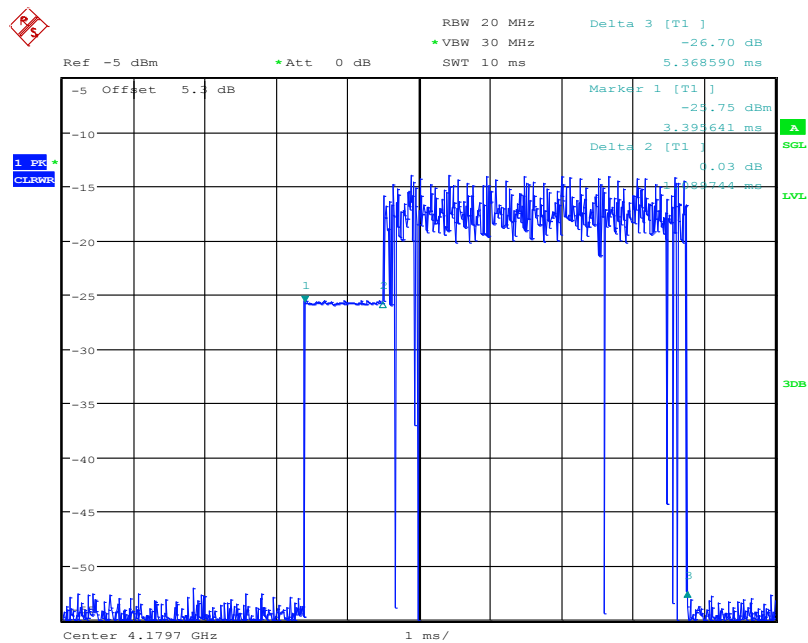
Date: 26.JAN.2015 13:16:35

Plot 15: CH4 110 kbps, Zerospan1



Date: 26.JAN.2015 13:03:13

Plot 16: CH4 110 kbps, Zerospan2



Date: 26.JAN.2015 13:02:31

11.2 TX Radiated Emissions

Description:

Measurement of the radiated spurious emissions in transmit mode.

Measurement:

§15.517 (c):

Average Measurement parameter	
Detector:	RMS
Sweep time:	1 ms/pts
Number of points	1001/10001
Video bandwidth:	1 MHz
Resolution bandwidth:	3 MHz
Trace-Mode:	Max Hold

§15.517 (e):

Peak Measurement parameter	
Detector:	Max Peak
Sweep time:	1 s
Video bandwidth:	20 MHz
Resolution bandwidth:	30 MHz
Span:	Zero span
Trace-Mode:	Max Hold

§15.517 (d):

Average Measurement parameter	
Detector:	RMS
Sweep time:	1 ms/pts
Number of points	10001
Video bandwidth:	1 kHz
Resolution bandwidth:	3 kHz
Trace-Mode:	Max Hold

Bandwidth correction factor for peak measurements: $20 \cdot \log(50/20) = 7.96$ dB

Limits:

§15.517 (c): The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960 to 1610	-75.3
1610 to 1990	-63.3
1990 to 3100	-61.3
3100 to 10600	-41.3
Above 10600	-61.3

§15.517 (d):

In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164 to 1240	-85.3
1559 to 1610	-85.3

§15.517 (e): There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and correspondingly different peak emission limit, following the procedures described in §15.521.

Result:

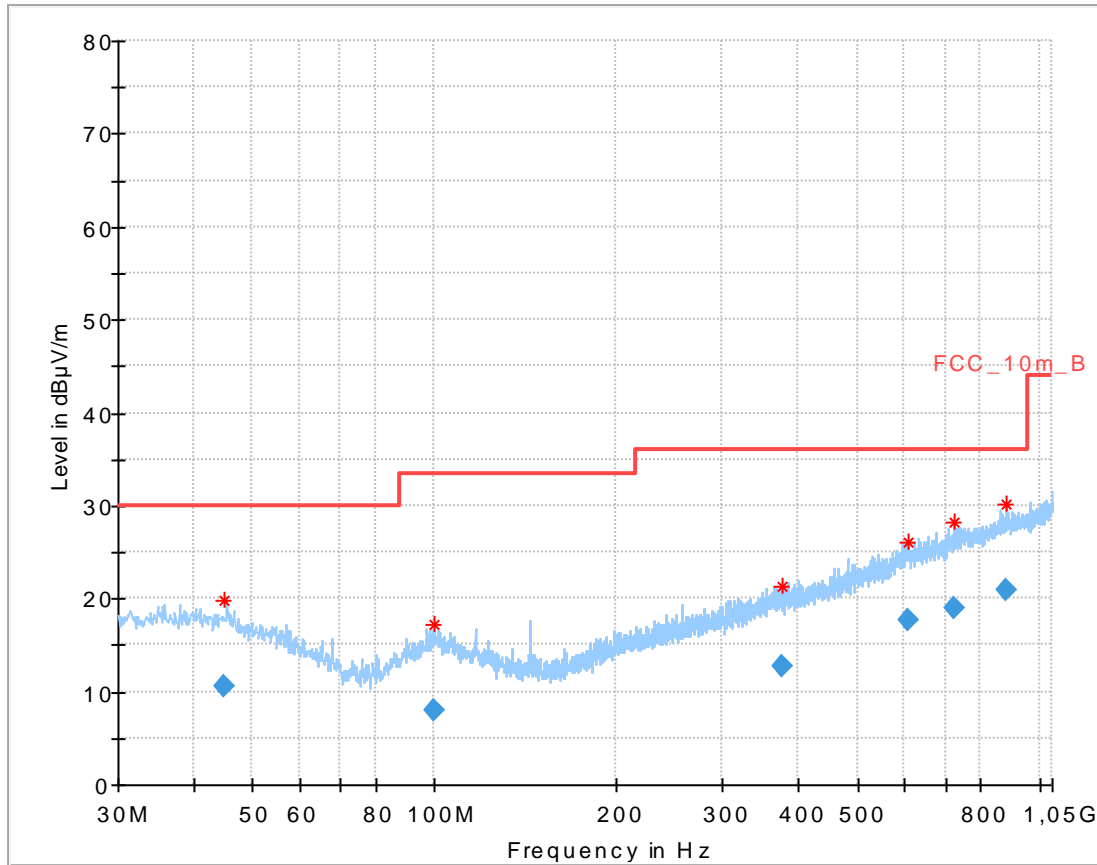
	Channel	Frequency /GHz	Max e.i.r.p. / dB
Maximum value of average power	CH2 850 kBps	4.17970	-41.5
	CH2 110 kBps	4.21160	-41.5
	CH4 850 kBps	4.13320	-41.7
	CH4 110 kBps	4.21310	-41.6
Maximum value of peak power	CH2 850 kBps	4.17970	-5.9
	CH2 110 kBps	4.21160	-1.7
	CH4 850 kBps	4.13320	-6.8
	CH4 110 kBps	4.21310	-6.7
Measurement uncertainty		± 3 dB	

Note:

After the response of FCC to Inquiry (Tracking Number 815222) regarding missing plots to show compliance to part 15.517 (d), additional tests with a second pair of DUTs have been performed on the 27th of June 2016. The results of these Measurements are shown in plots 21 to 26 of this chapter.

Verdict: **complies**

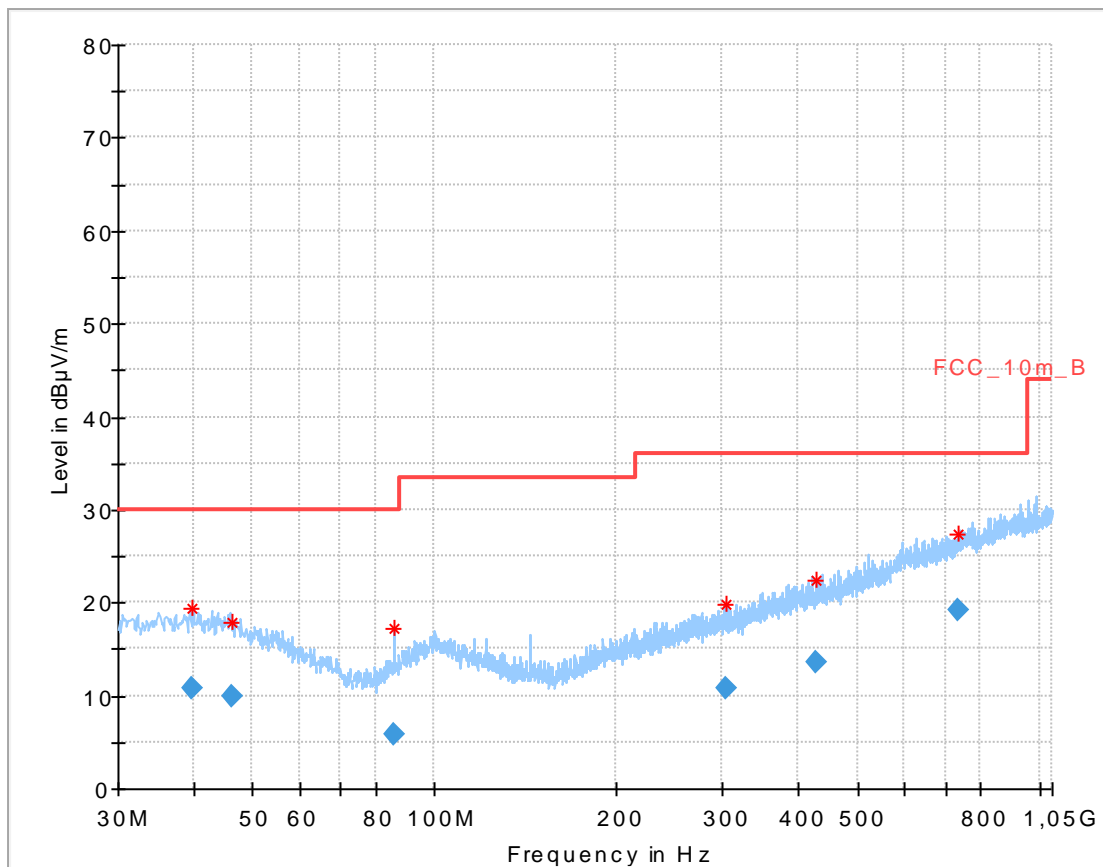
Plot 1: CH2 850 kbps, 30 MHz – 1 GHz



Final_Result

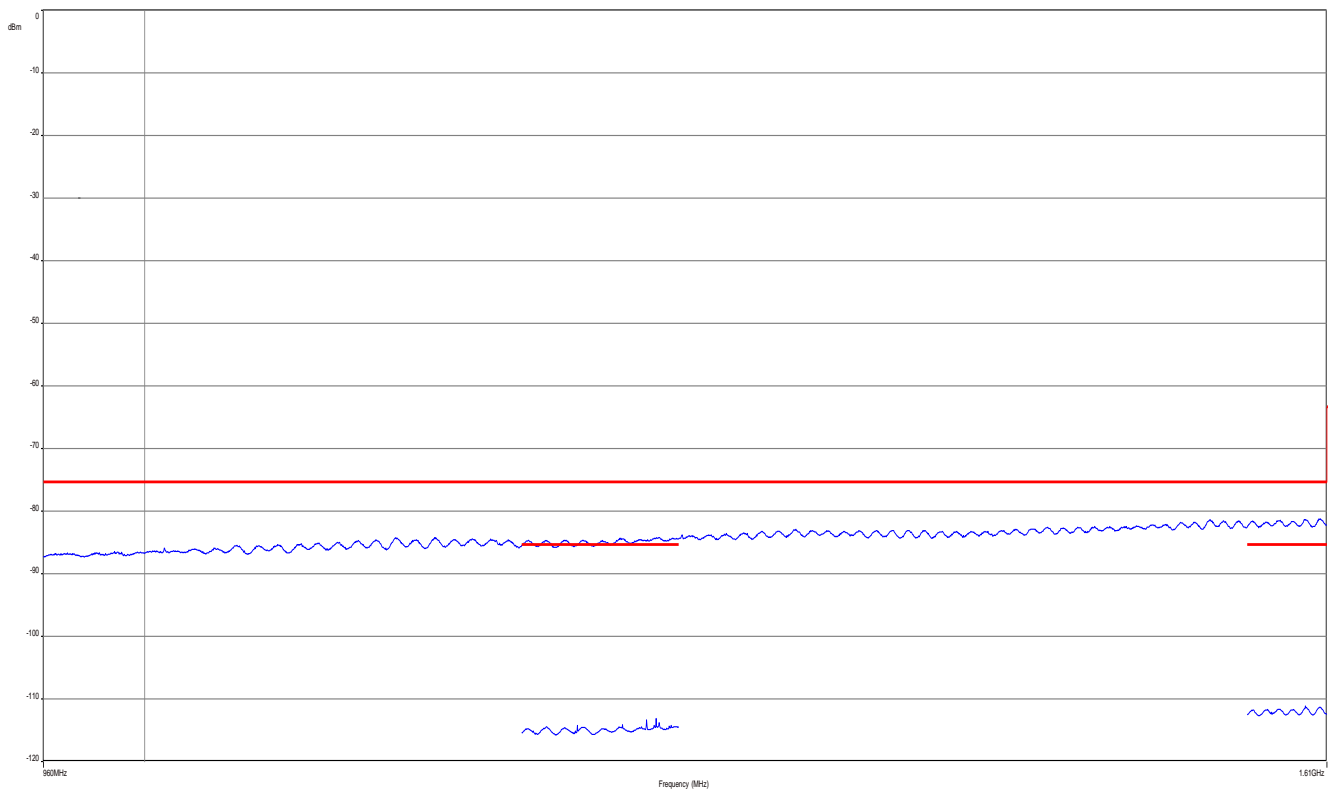
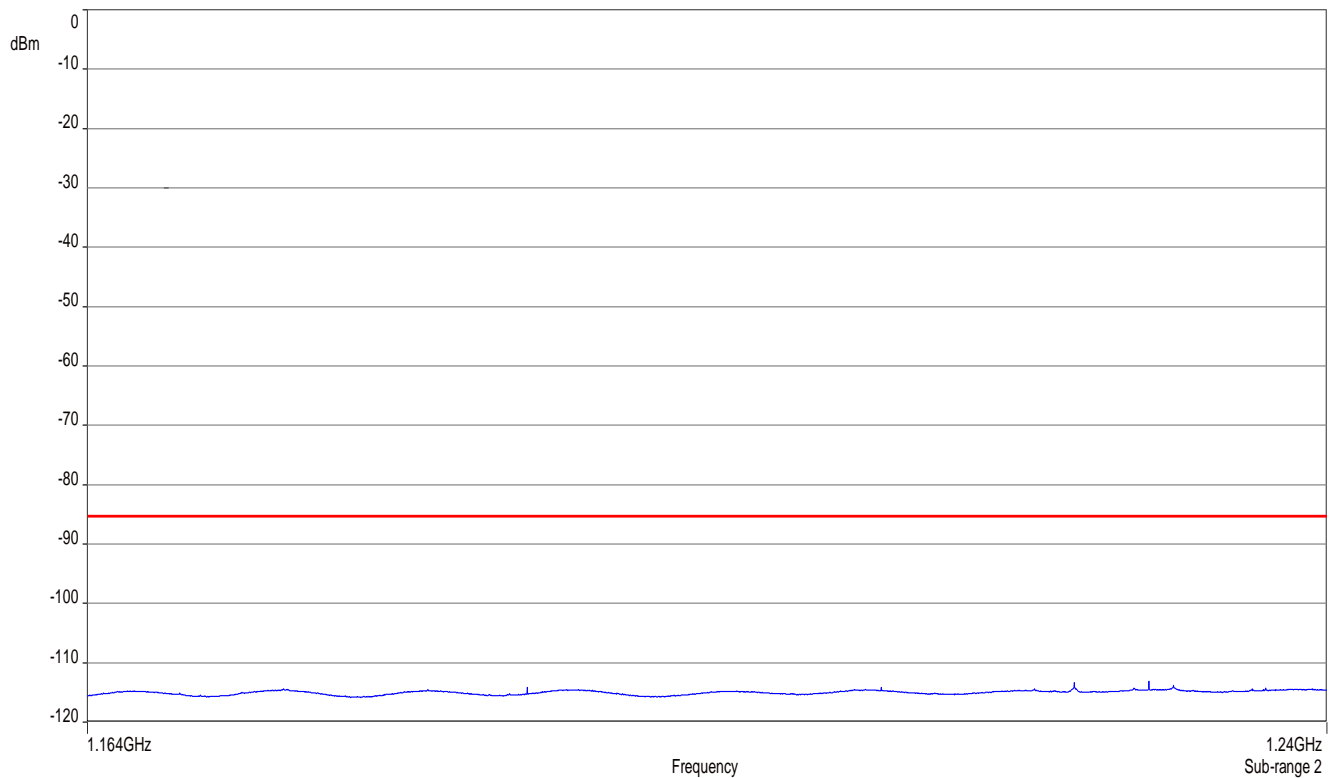
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
44.757900	10.46	30.00	19.54	1000.0	120.000	101.0	V	325	13.9
99.710250	7.99	33.50	25.51	1000.0	120.000	101.0	V	180	12.1
374.372250	12.75	36.00	23.25	1000.0	120.000	170.0	H	268	16.4
605.071500	17.60	36.00	18.40	1000.0	120.000	101.0	H	244	20.8
724.237650	18.97	36.00	17.03	1000.0	120.000	101.0	H	122	22.1
882.750300	20.95	36.00	15.05	1000.0	120.000	170.0	H	358	23.9

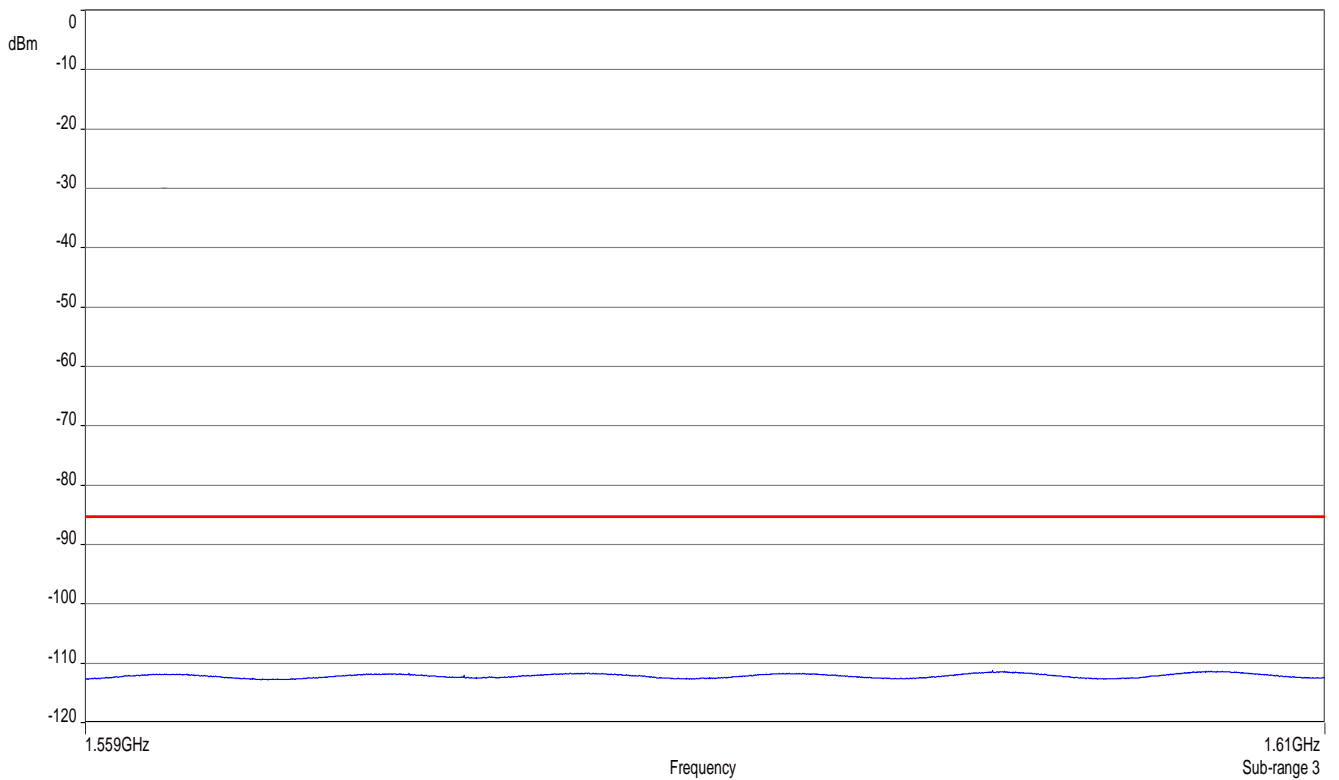
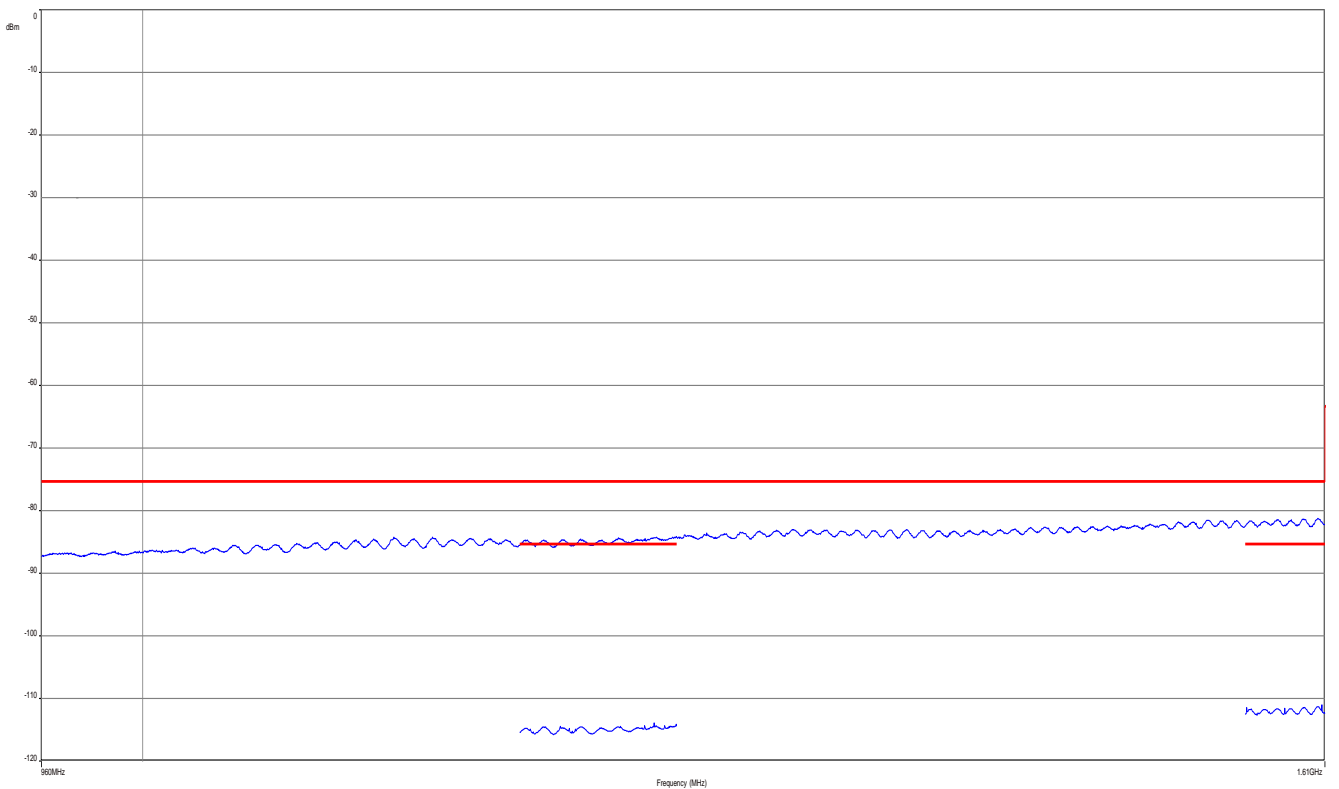
Plot 2: CH4 110 kbps, 30 MHz – 1 GHz

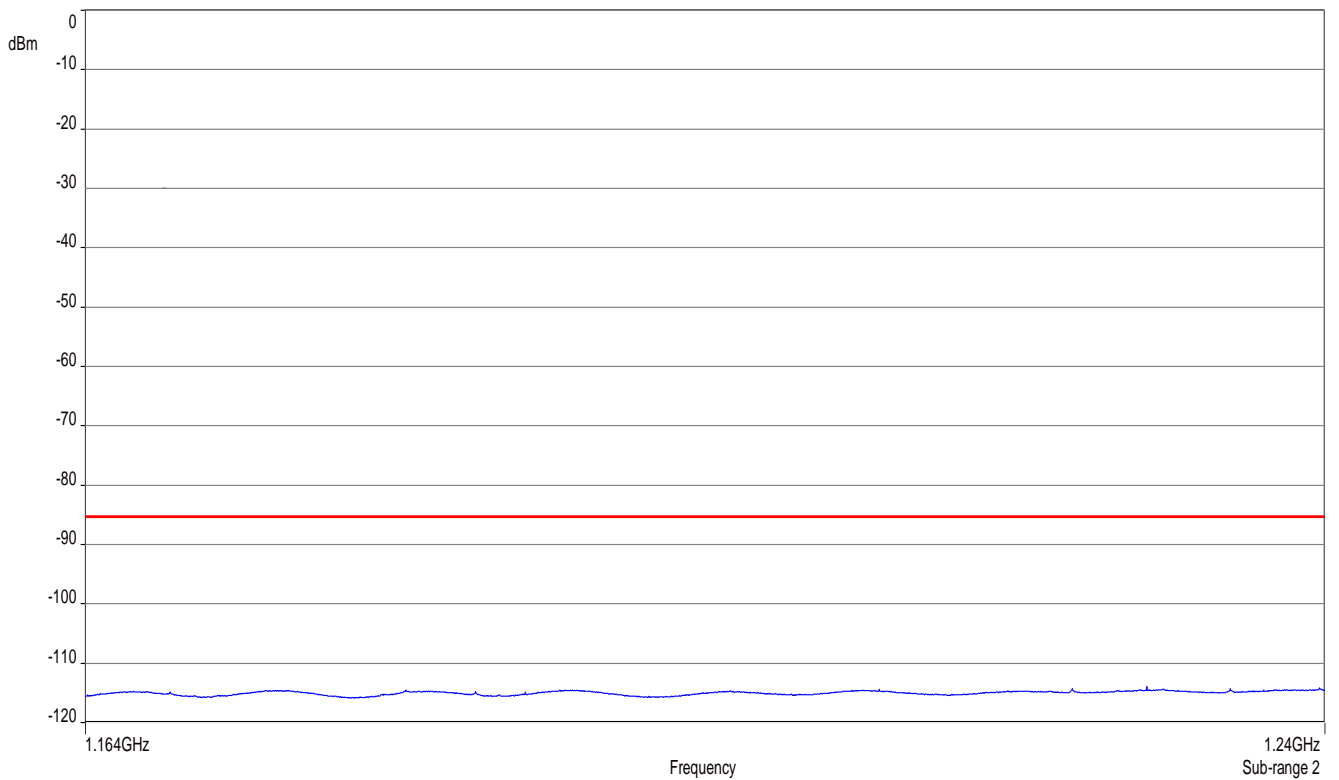
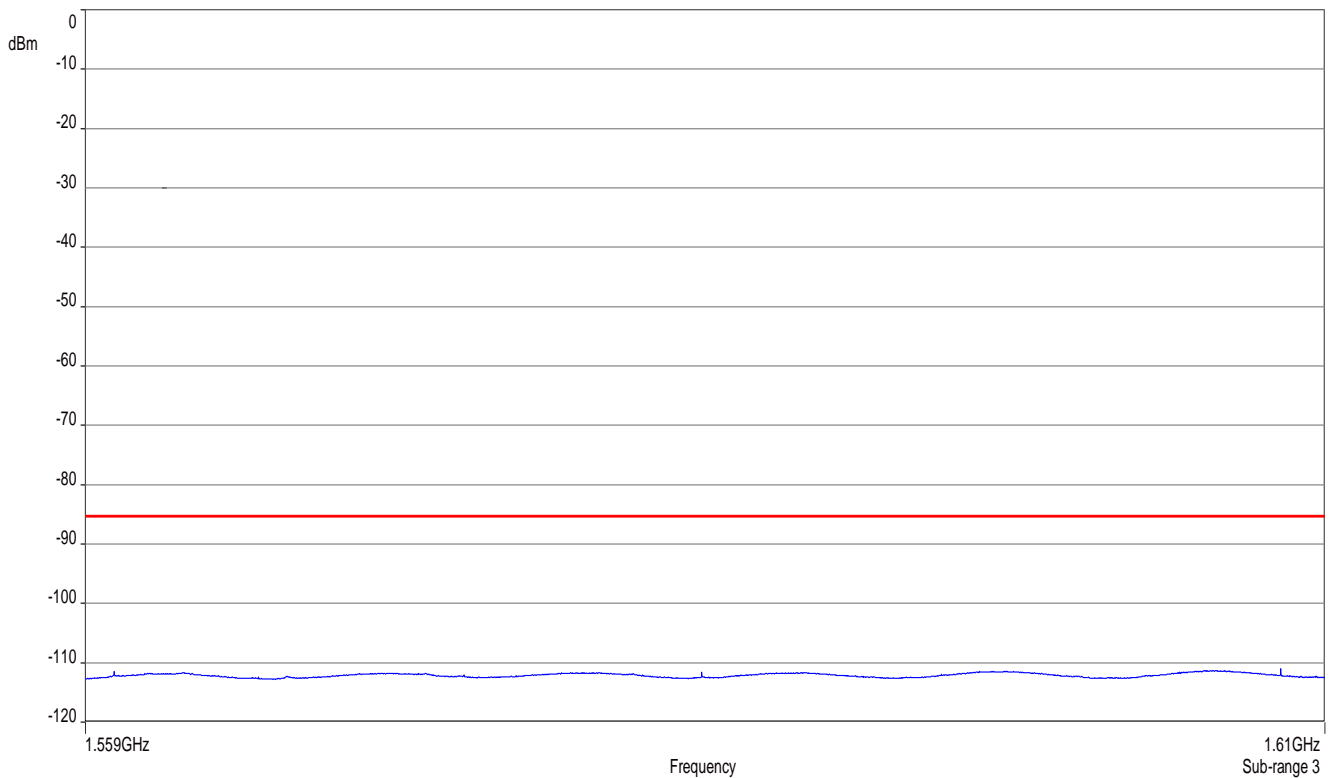


Final_Result

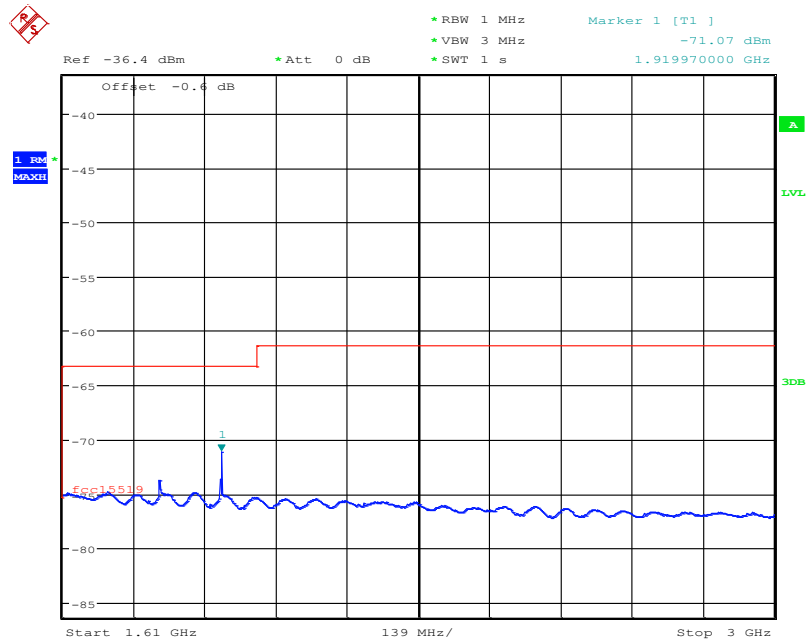
Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
39.837300	10.81	30.00	19.19	1000.0	120.000	170.0	V	294	14.0
46.304700	10.00	30.00	20.00	1000.0	120.000	101.0	H	203	13.5
86.102250	5.84	30.00	24.16	1000.0	120.000	101.0	V	117	9.6
303.612300	10.82	36.00	25.18	1000.0	120.000	98.0	V	42	14.6
426.995850	13.54	36.00	22.46	1000.0	120.000	98.0	H	9	17.3
734.657100	19.28	36.00	16.72	1000.0	120.000	101.0	H	226	22.3

Plot 3: CH2 850 kbps, 960 MHz – 1.61 GHz, RBW: 1MHz/1kHz, VBW: 3MHz/3kHz**Plot 4: CH2 850 kbps, 1.164 GHz – 1.24 GHz, RBW: 1kHz, VBW: 3kHz**

Plot 5: CH2 850 kbps, 1.559 GHz – 1.61 GHz, RBW: 1kHz, VBW: 3kHz**Plot 6: CH4 110 kbps, 960 MHz – 1.61 GHz, RBW: 1MHz/1kHz, VBW: 3MHz/3kHz**

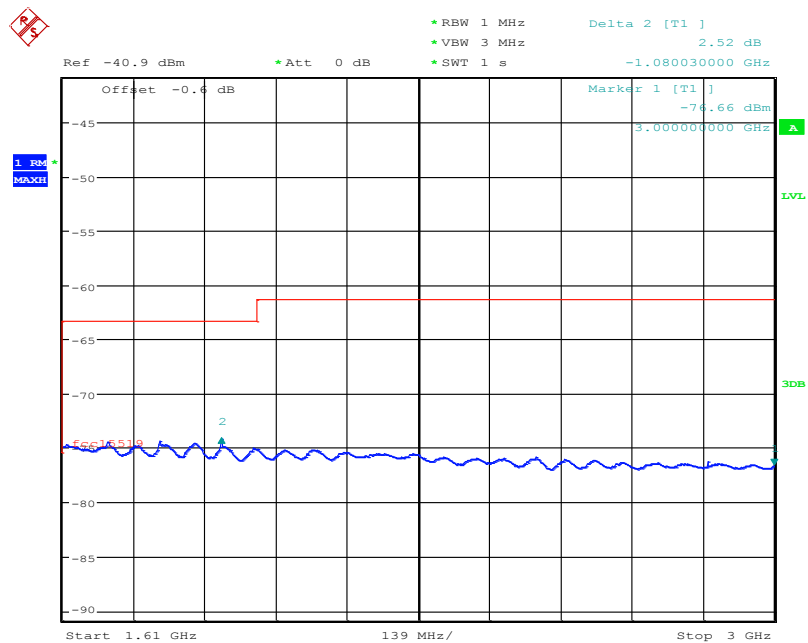
Plot 7: CH4 110 kbps, 1.164 GHz – 1.24 GHz, RBW: 1kHz, VBW: 3kHz**Plot 8: CH4 110 kbps, 1.559 GHz – 1.61 GHz, RBW: 1kHz, VBW: 3kHz**

Plot 9: CH2 850 kbps, 1.61 GHz – 3 GHz



Date: 27.JAN.2015 13:09:34

Plot 10: CH4 110 kbps, 1.61 GHz – 3 GHz



Date: 27.JAN.2015 10:03:46

Ref -26.4 dBm *Att 0 dB *RBW 1 MHz Marker 1 [T1] -65.81 dBm
 *VBW 3 MHz *SWT 1 s 7.470400000 GHz

Offset 9.4 dB

1 PM
MAXH

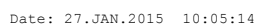
30dB

1

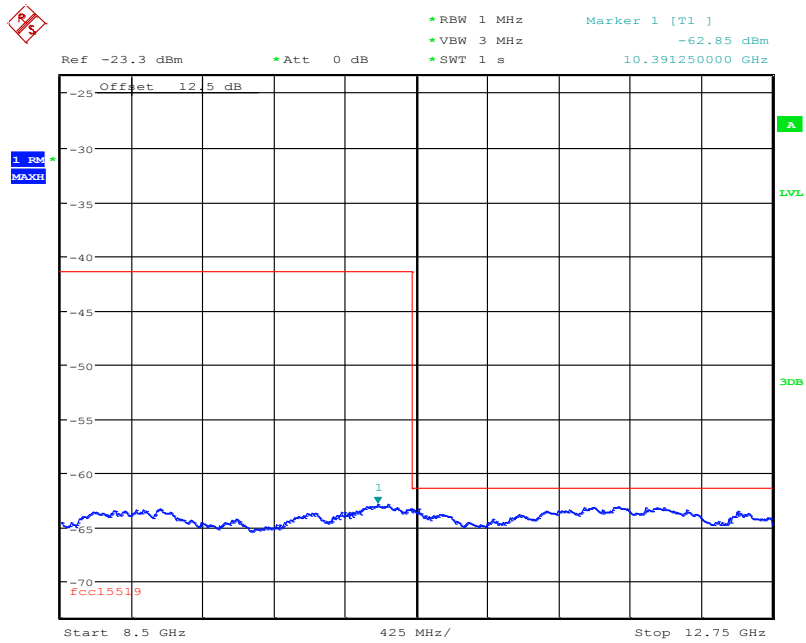
fcc15519

Start 4.9 GHz 360 MHz/ Stop 8.5 GHz

Plot 12: CH4 110 kbps, 4.9 GHz – 8.5 GHz

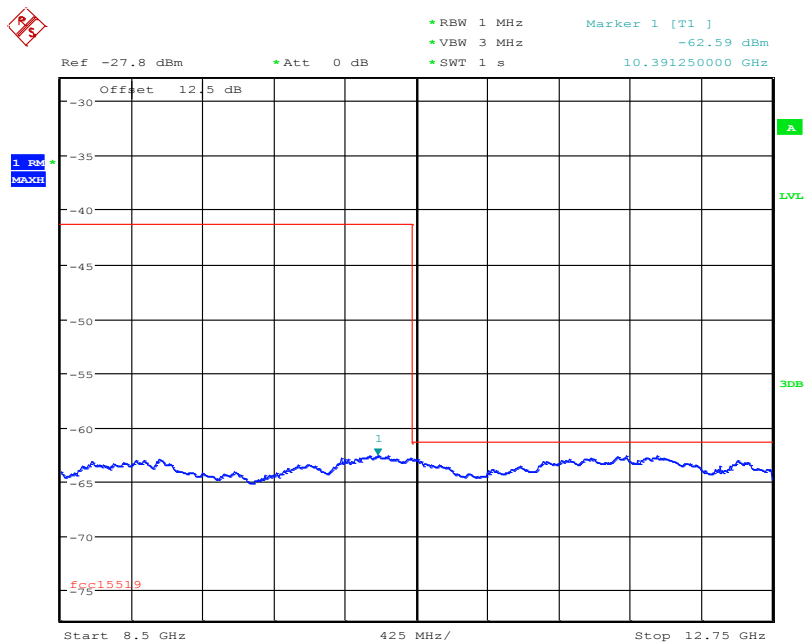


Plot 13: CH2 850 kbps, 8.5 GHz – 12.75 GHz



Date: 27.JAN.2015 13:07:37

Plot 14: CH4 110 kbps, 8.5 GHz – 12.75 GHz



Date: 27.JAN.2015 10:06:19

Ref -55 dBm *Att 0 dB *RBW 1 MHz Marker 1 [T1] -80.09 dBm
 *VBW 3 MHz *SWT 1 s 13.296000000 GHz

Center 15.375 GHz 525 MHz/ Span 5.25 GHz

Ref -55 dBm Att 0 dB RBW 1 MHz VBW 3 MHz SWT 1 s Marker 1 [T1] -80.09 dBm 13.29600000 GHz

-55 Offset -4.2 dB

1.700 MHz MAX11

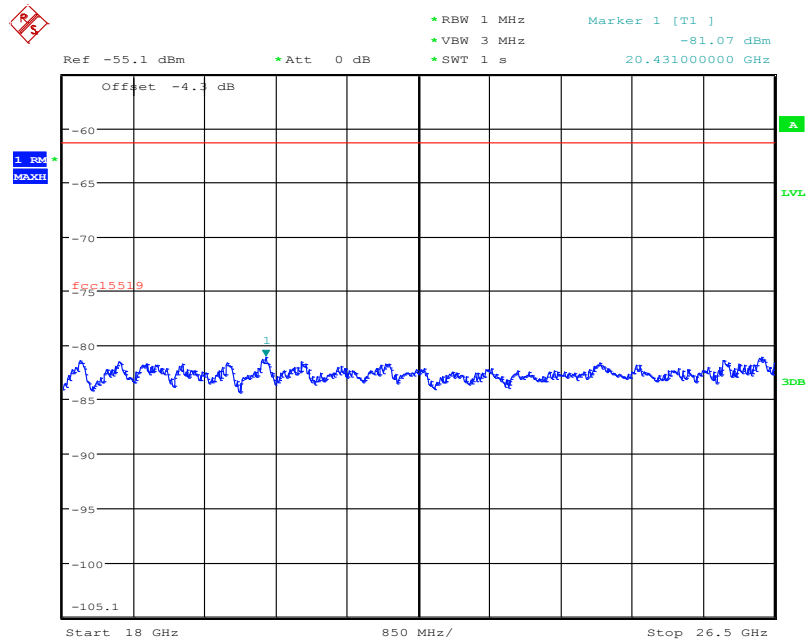
1

15519

Center 15.375 GHz 525 MHz/ Span 5.25 GHz

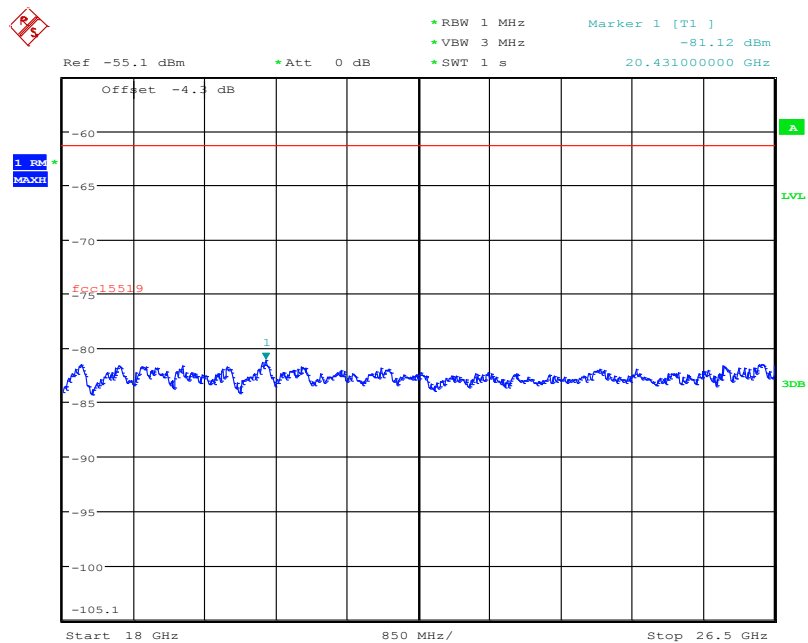
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Plot 17: CH2 850 kbps, 18 GHz – 26.5 GHz



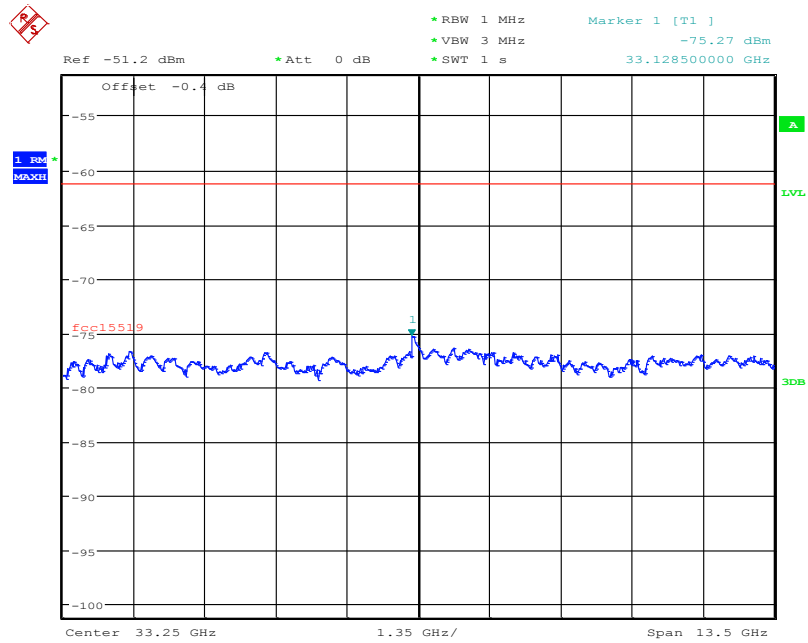
Date: 27.JAN.2015 12:24:27

Plot 18: CH4 110 kbps, 18 GHz – 26.5 GHz



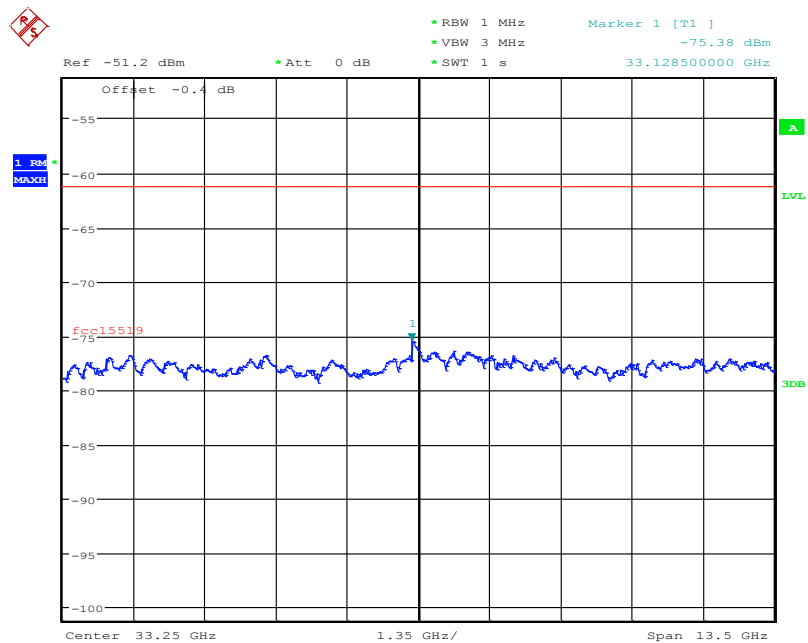
Date: 27.JAN.2015 12:30:33

Plot 19: CH2 850 kbps, 26.5 GHz – 40 GHz



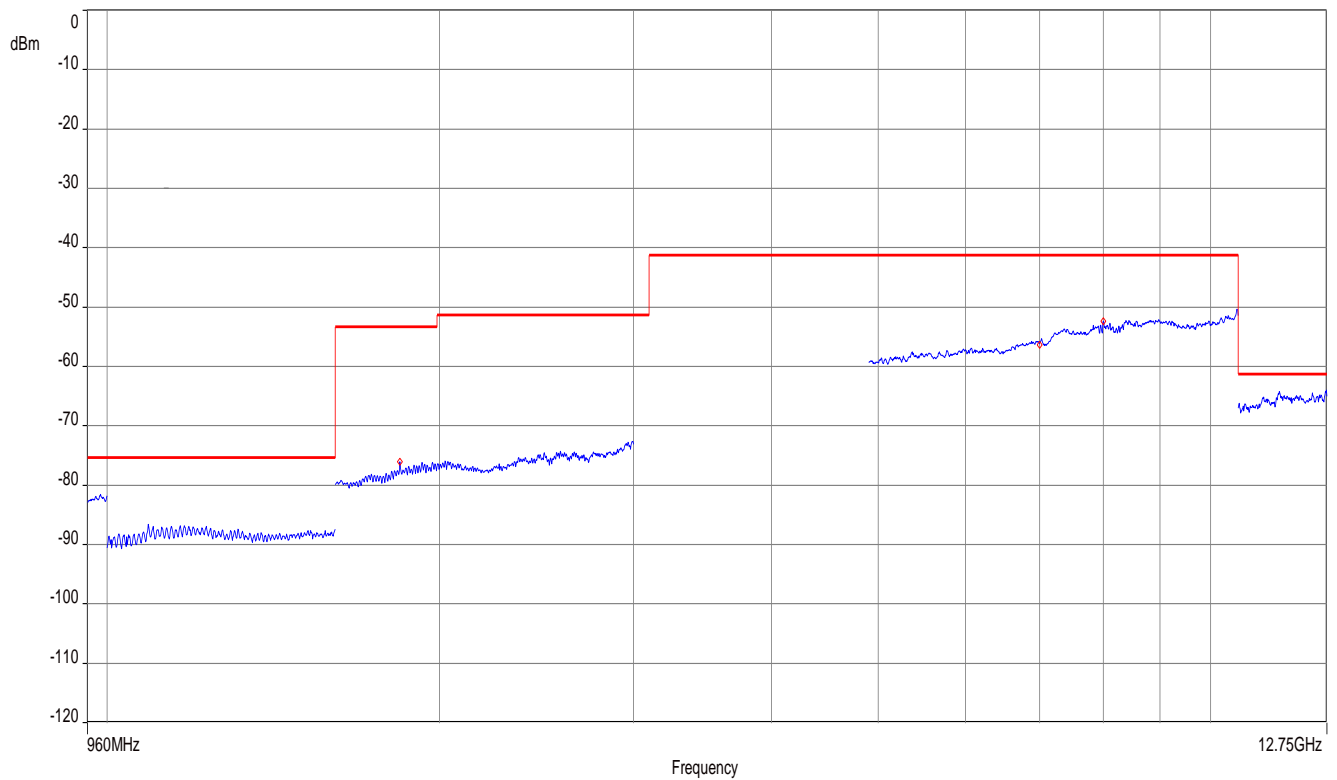
Date: 27.JAN.2015 12:27:30

Plot 20: CH4 110 kbps, 26.5 GHz – 40 GHz



Date: 27.JAN.2015 12:29:16

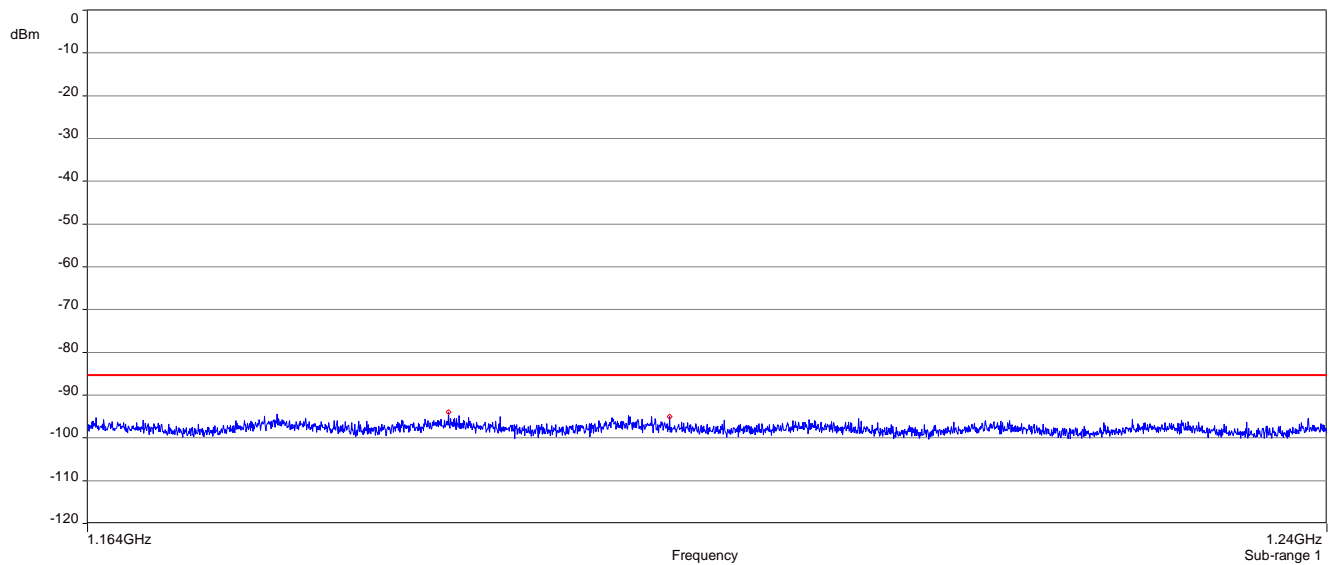
Plot 21: CH2 110 kbps, 1 GHz – 12.75 GHz, RBW: 1 MHz, VBW 3 MHz



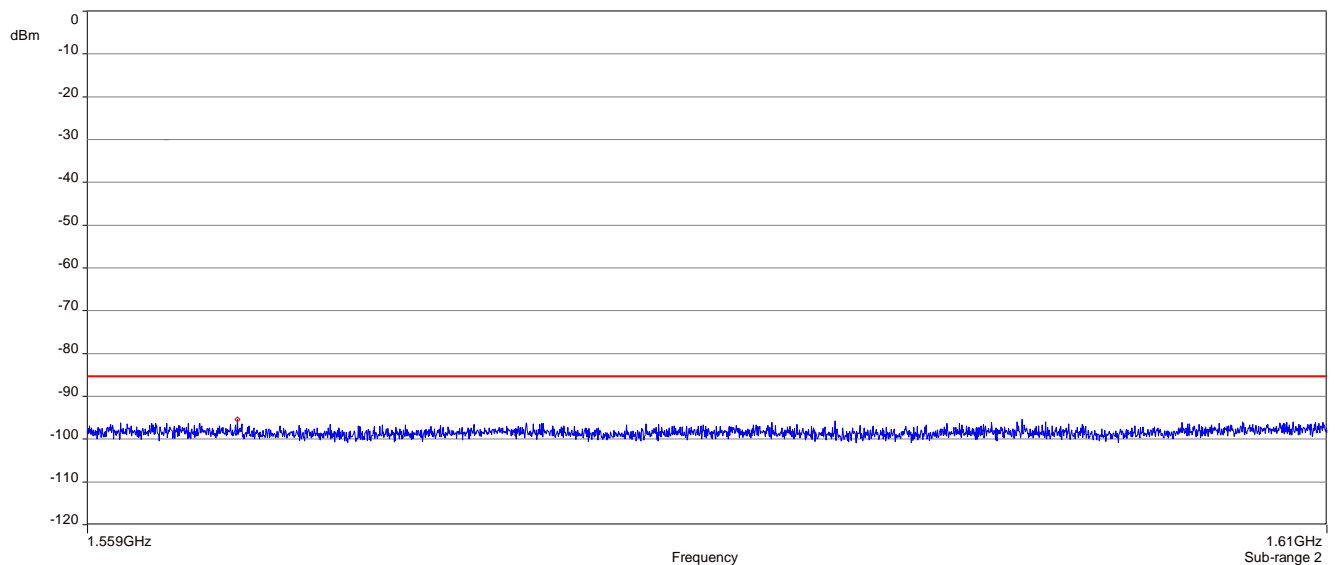
Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms/pt)	Bandwidth (MHz)	Antenna Polarization	Positioner (deg)	Turntable (deg)	Corr. (dB)
1842.2922	-74.6	-53.0	21.6	1.0	1.0	V	0	188	-11.05
7000.3600	-55.9	-41.3	14.6	1.0	1.0	H	120	3	18.32
7999.4599	-52.0	-41.3	10.7	1.0	1.0	V	120	97	22.97

Plot 22: CH2 110 kbps, 1.164 GHz – 1.24 GHz, RBW: 1kHz, VBW: 3kHz



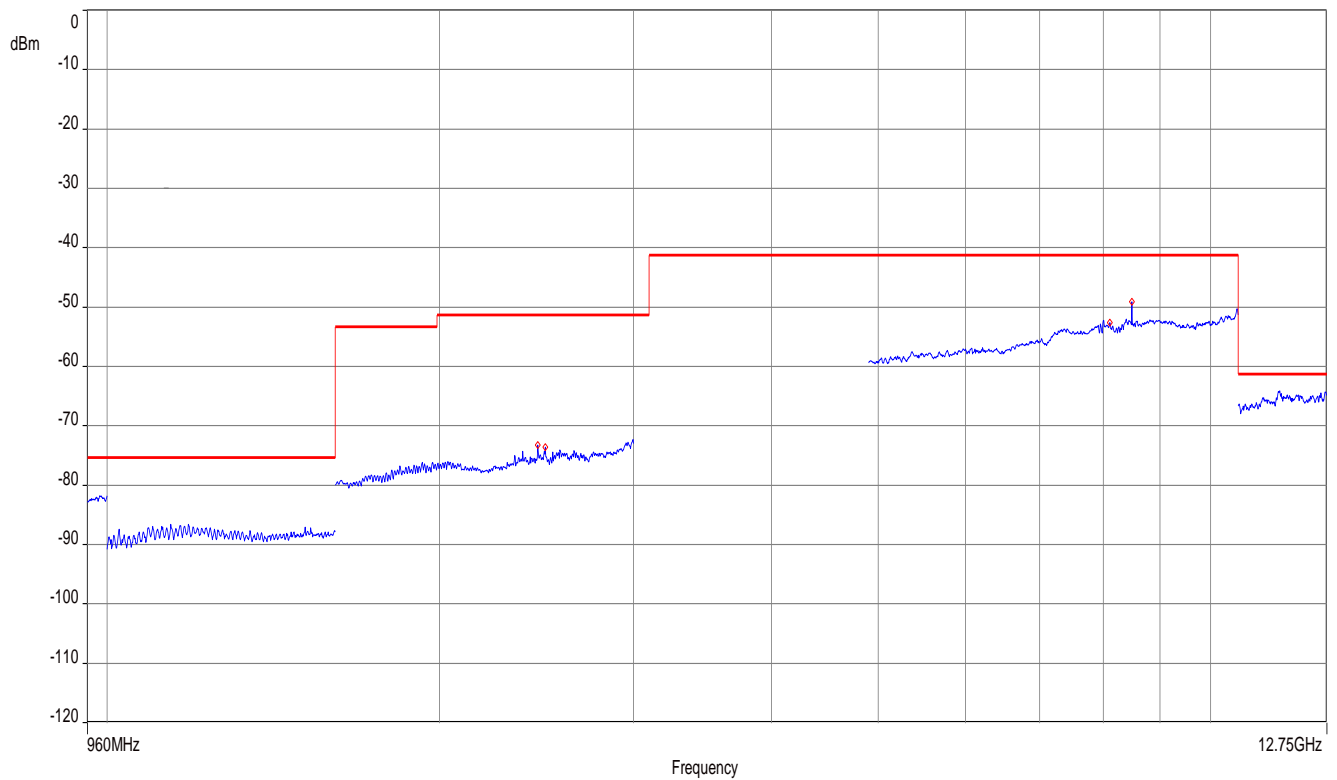
Plot 23: CH2 110 kbps, 1.559 GHz – 1.61 GHz, RBW: 1kHz, VBW: 3kHz



Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms/pt)	Bandwidth (kHz)	Antenna Polarization	Positioner (deg)	Turntable (deg)	Corr. (dB)
1185.6318	-89.9	-85.3	4.6	1.0	1.0	V	60	260	-3.23
1199.1003	-90.6	-85.3	5.3	1.0	1.0	V	120	279	-3.31
1565.0798	-92.2	-85.3	6.9	1.0	1.0	H	150	77	-4.56

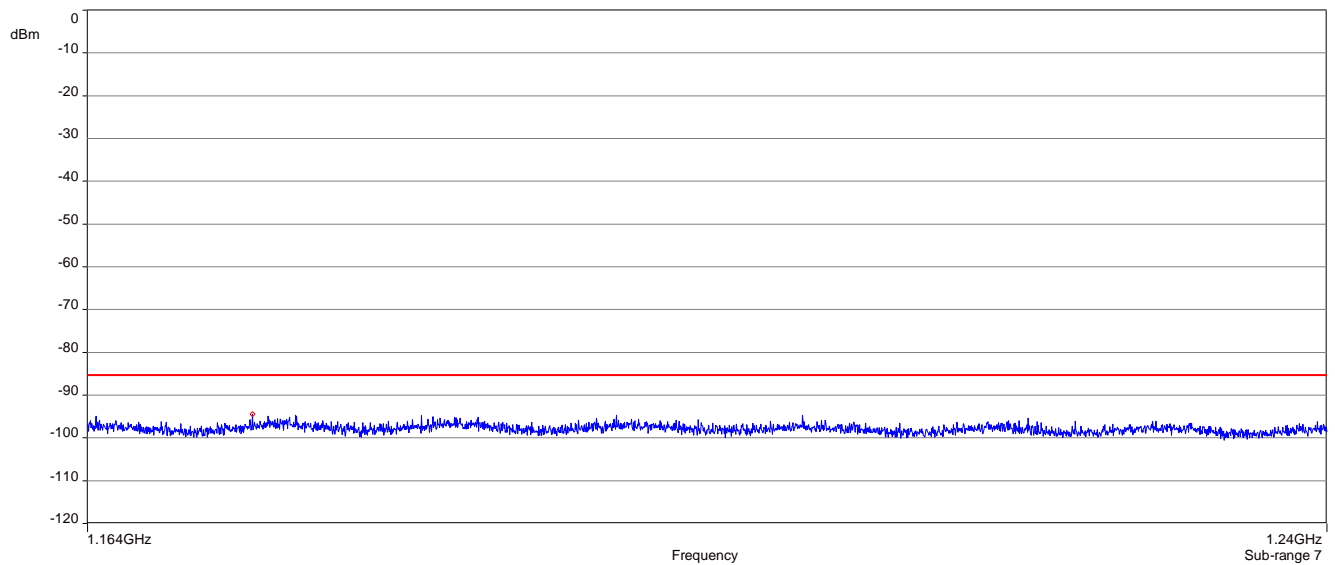
Plot 24: CH4 850 kbps, 1 GHz – 12.75 GHz, RBW: 1 MHz, VBW 3 MHz



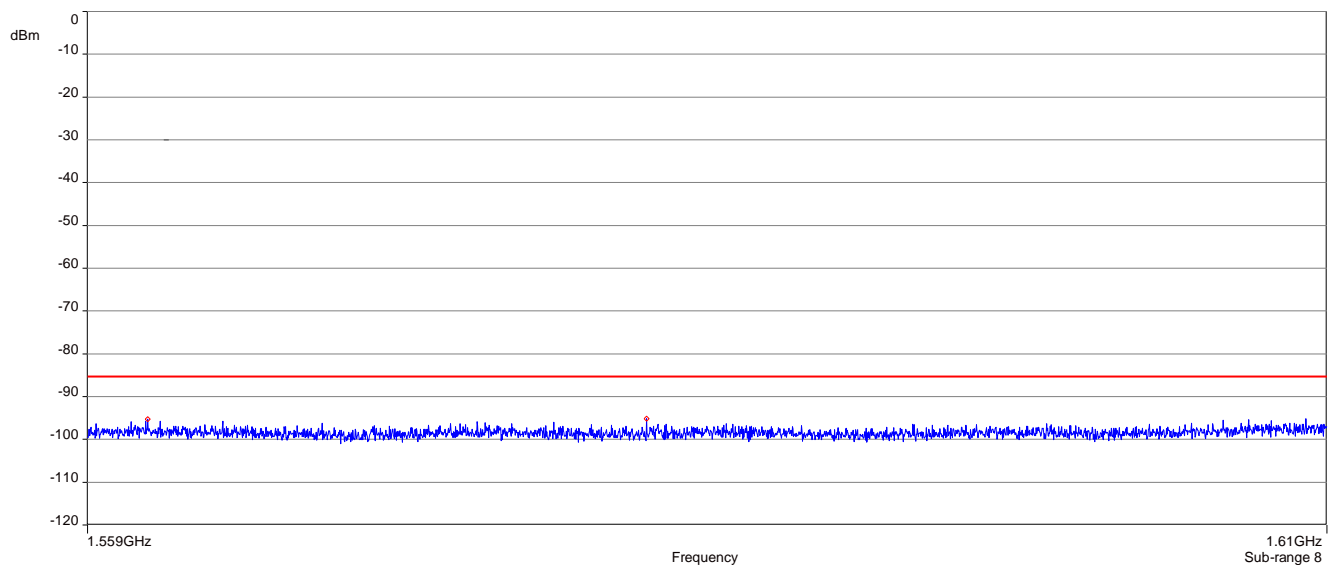
Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms/pt)	Bandwidth (MHz)	Antenna Polarization	Positioner (deg)	Turntable (deg)	Corr. (dB)
2457.7068	-73.0	-51.3	21.7	1.0	1.0	V	0	1	-7.83
8106.7507	-52.7	-41.3	11.4	1.0	1.0	V	60	206	22.49
8486.2286	-43.3	-41.3	2.0	1.0	1.0	V	120	78	22.99

Plot 25: CH2 110 kbps, 1.164 GHz – 1.24 GHz, RBW: 1kHz, VBW: 3kHz



Plot 26: CH2 110 kbps, 1.559 GHz – 1.61 GHz, RBW: 1kHz, VBW: 3kHz



Final_Result

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms/pt)	Bandwidth (kHz)	Antenna Polarization	Positioner (deg)	Turntable (deg)	Corr. (dB)
1173.8506	-90.4	-85.3	5.1	1.0	1.0	V	0	0	-3.33
1561.4380	-91.5	-85.3	6.2	1.0	1.0	H	120	45	-4.40
1581.7942	-92.3	-85.3	7.0	1.0	1.0	H	120	308	-4.62

11.3 RX spurious emissions AC line conducted < 30 MHz

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The EUT is set to Idle mode. 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

Limits:

FCC		IC
CFR Part 15.107(a)		ICES-003, Issue 5
RX Spurious Emissions Conducted < 30 MHz		
Frequency (MHz)	Quasi-Peak (dB μ V/m)	Average (dB μ V/m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

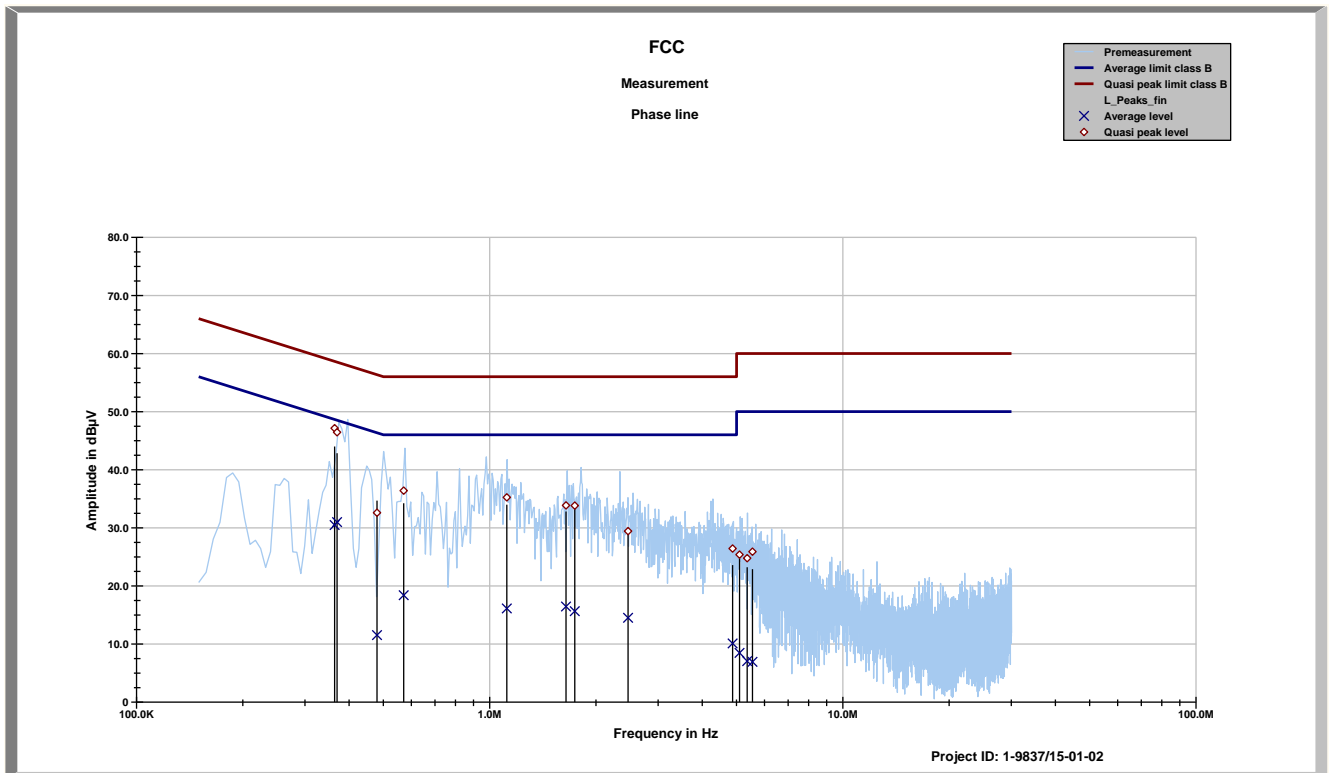
*Decreases with the logarithm of the frequency

Result:

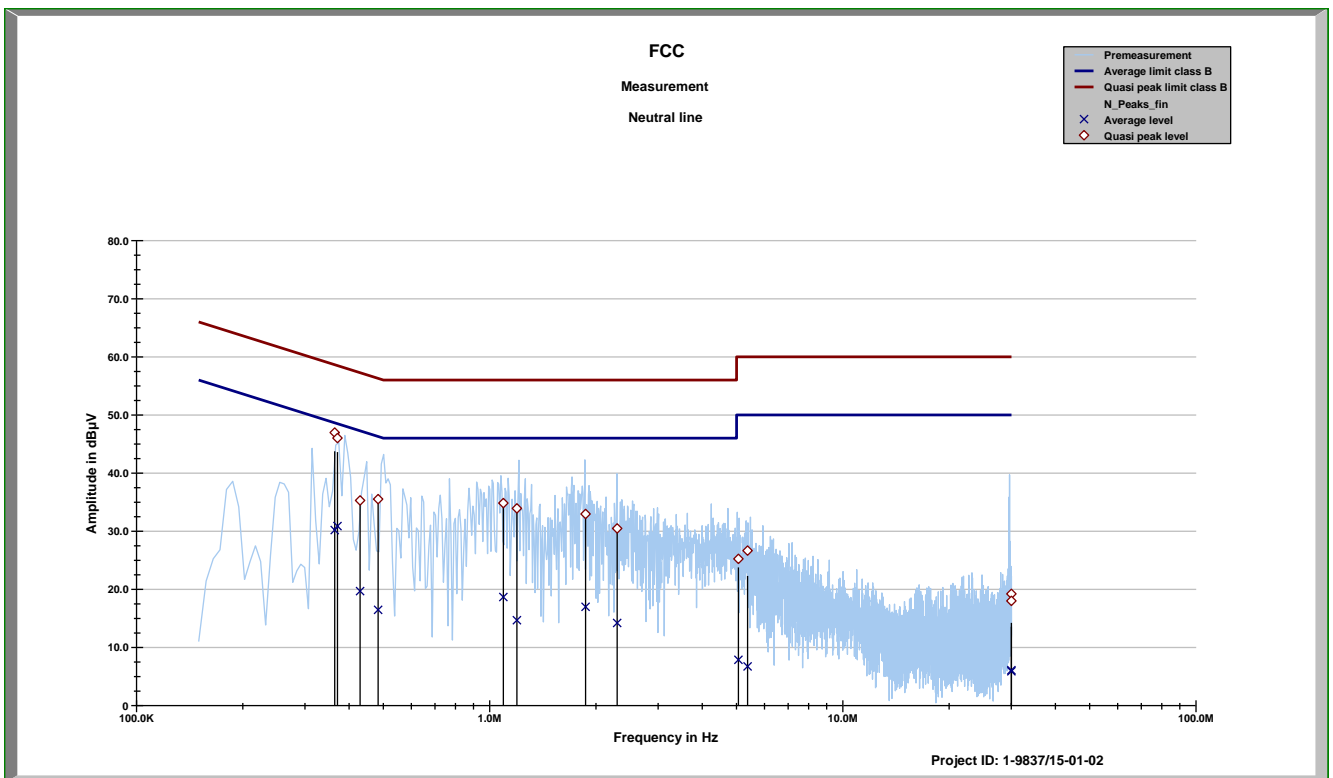
RX Spurious Emissions Conducted < 30 MHz [dB μ V/m]		
F [MHz]	Detector	Level [dB μ V/m]
No critical peaks detected!		
Measurement uncertainty	± 3 dB	

Verdict: **complies**

Plot 1: 150 kHz to 30 MHz / Phase Line



Plot 2: 150 kHz to 30 MHz / Neutral Line



11.4 RX spurious emissions radiated

Description:

Measurement is performed with transmitter turned off.

Measurement:

Measurement parameters	
Detector:	Below 1 GHz Peak / QuasiPeak Above 1 GHz Peak / Average
Sweep time:	2 sec
Video bandwidth:	Below 1 GHz / 100 kHz Above 1 GHz 1 MHz
Resolution bandwidth:	1 MHz
Span:	100 MHz Steps
Trace-Mode:	Max Hold

Limits:

FCC		IC	
CFR Part 15.109 CFR Part 2.1053		RSS Gen, Issue 4, Section 4.10 ICES-003 Issue 5	
Spurious Emissions Radiated – Receiver Mode			
Frequency (MHz)	Field Strength (dBμV/m)	Measurement distance (m)	
30 – 88*	30.0	10	
88 – 216*	33.5	10	
216 – 960*	36.0	10	
Above 960*	54.0	3	

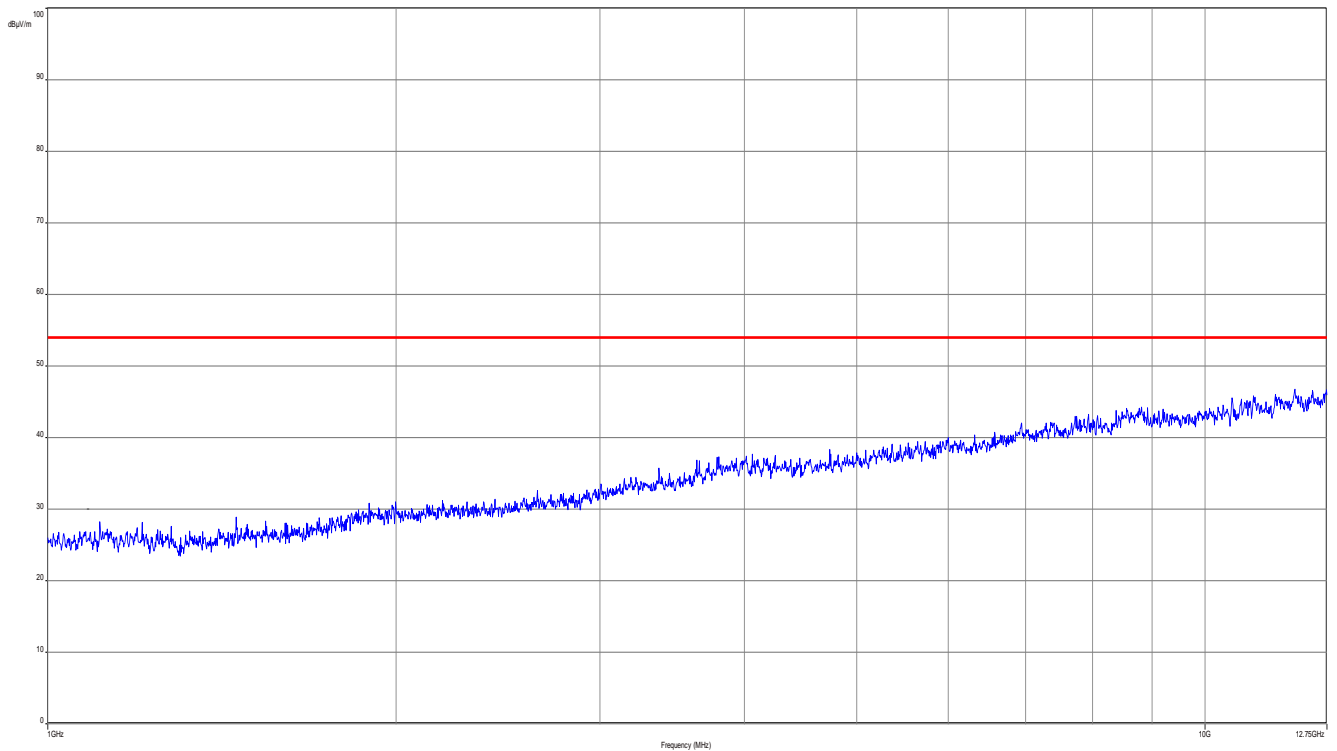
*Measurements below 1 GHz are covered with the TX measurements according to §15.209 in chapter 10.2

Results: (see also chapter 10.2, plots 1 and 2)

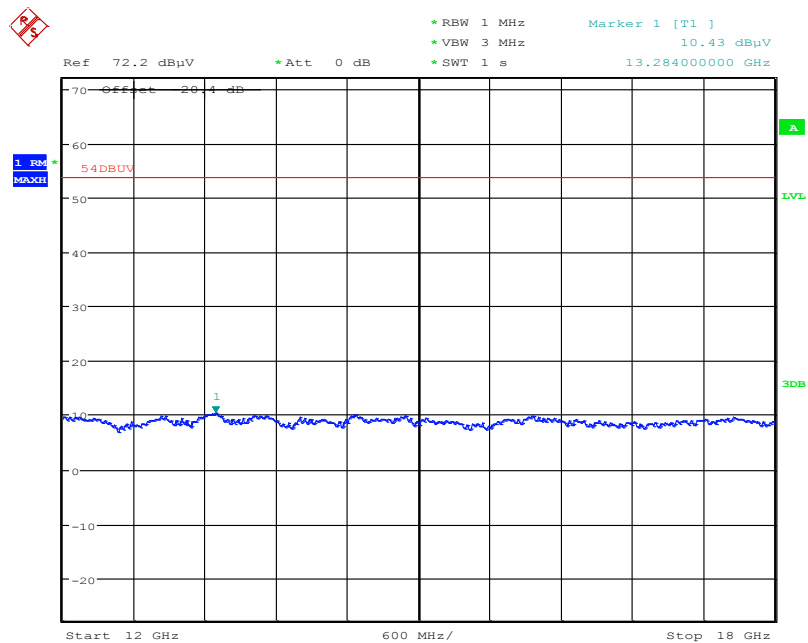
Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
44.757900	10.46	30.00	19.54	1000.0	120.000	101.0	V	325	13.9
99.710250	7.99	33.50	25.51	1000.0	120.000	101.0	V	180	12.1
374.372250	12.75	36.00	23.25	1000.0	120.000	170.0	H	268	16.4
605.071500	17.60	36.00	18.40	1000.0	120.000	101.0	H	244	20.8
724.237650	18.97	36.00	17.03	1000.0	120.000	101.0	H	122	22.1
882.750300	20.95	36.00	15.05	1000.0	120.000	170.0	H	358	23.9

Verdict: **complies**

Plot 1: Receive mode 1 GHz to 12.75 GHz

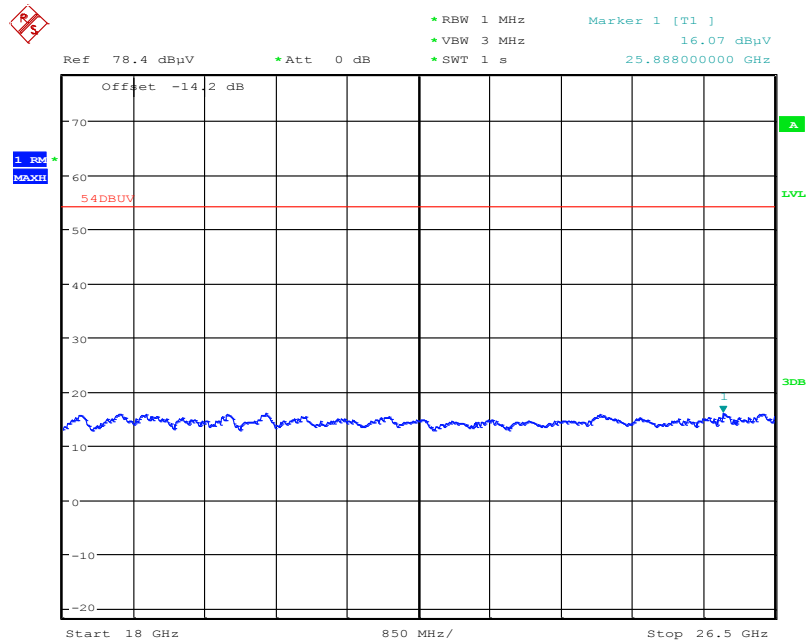


Plot 2: Receive mode 12.75 GHz to 18 GHz



Date: 28.JAN.2015 06:13:38

Plot 3: Receive mode 18 GHz to 26.5 GHz



Date: 28.JAN.2015 06:12:14

12 Document history

Version	Applied changes	Date of release
	Initial release	2015-11-04
-A	minor changes (spectrum analyzer settings added, changed part 15.509 to 15.519)	2015-11-30
-B	changed §15.519 to §15.517 changed Type Identification removed conducted samples from photo annex note on test software in chapter 5.2 added photo annex H added	2016-05-24
-C	Chapter 7, Sequence of testing added Correction of frequency range in Chapter 8.2, Description of the test setup §15.517(d) added in Chapter 9, Summary of test results Note in chapter 11.2 Tx Radiated Emissions added (page 28) Chapter 12.2, plots 4, 5, 7, 8 and 21 - 26 added to show compliance to part §15.517(d)	2016-06-30

13 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

14 Accreditation Certificate

Front side of certificate



Deutsche Akkreditierungsstelle GmbH

Beliehene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV
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Akkreditierung



Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

CETECOM ICT Services GmbH
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Im Auftrag Dipl.-Ing. (FH) Ralf Egnor
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